LINAC2020
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Q&A Booklet

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The Cockcroft Institute of Accelerator Science and Technology

UKRI Science and Technology Facilities Council

JAI John Adams Institute for Accelerator Science

Tuesday 1st September TUA Opening session 1:30pm

Chair: Graeme Burt (Cockcroft Institute/Lancaster University)

The Compact Linear Accelerator for Research and Applications (CLARA) at Daresbury Laboratory
Susan Louise Smith - STFC/DL/ASTeC

Q – Is it possible to collaborate any areas of theoretical understanding of XFEL and THz based particle accelerators at CLARA?
A – Yes, it is, the work what we do is in collaboration with a number of bodies both nationally and internationally. We work with academics in the Cockcroft Institute and the John Adams Institute. So, in these particular areas of XFEL and THz, we have academics working on the theoretical side as well as experiments on CLARA. If you are interested in this research you can drop me an email at susan.smith@stfc.ac.uk and I can put you in contact with the leads in these areas.

Q – What is the macro-pulse width in CLARA?
A – We are actually doing single bunch work in CLARA, we are not working with trains of bunches.

Q – Have you had any opportunities for undergraduate students to be engaged with the research at CLARA?
A – Yes, through the Cockcroft Institute we have a number of graduates working with us and we have undergraduates with STFC in the form of what we call one-year industry students. So, we take people who wish to have experience working with researchers from either engineering or technical backgrounds and they spend a year working with us as part of the undergraduate programme.

Q – If the UK does go ahead and build the UK free electron laser, would CLARA be retained as an R&D facility for FEBE?
A – Yes, CLARA has already established its use for research outside of the FEL range and these wider range of science that can use the dedicated beams, so as long as we are getting the quality science experiments proposed for exploitation on that facility, it would certainly be retained. If we fulfil our ambition to put 100 TW class laser on that facility, it should be a huge opportunity for working in that area in the future, as well as purely working with the electron beam. So, a lot of potential for that facility to be exploited in conjunction with the Free Electron Laser but independent from it as well.

Q – Is CLARA on emergency power for uninterrupted treatment of cancer? And are there any special facilities required for human treatment?
A – On CLARA, with the very high energy electron experiment, we are doing radiobiological experiments, so it doesn't actually include either humans or animals at this stage. We don't need that sense of rigor that you would in a clinical facility, however some of our systems will be on an uninterruptible power supply for the convenience of not having to re-establish those in the event of a power supply, it's not to do with health and safety though.

Q – How is beam tuning done, is it an automated algorithm or is it done manually?
A – First, we have automated algorithms for them, for like a phase scan and so on, so this has all been prepared and loaded up, so of course the first time was a learning curve. First, we used automated algorithms with pre-calculated settings, which worked out very well and we needed almost no correctors. The alignment is quite good and we can get a beam through and at the end we tune one by one the cavities with a face scan. It took us a few weeks, then afterwards, as I mentioned in my talk, we can then turn on each cavity in a few seconds meaning we can turn all the hundred cavities on in two minutes, because they are automated.

Q – What type of beam diagnostic devices are employed, if conventional diagnostics are used, would radiation be an issue?
A – Yes, mostly they are conventional diagnostics, except the requirements on the response time are quite stringent because we need to turn off the beam within ten microseconds. That is mostly from a machine protection point of view. So, time response is quite strict. For example, when we use the full machine protection, we do use differential shells on regular beam current monitors, which of course needs to be radiation resistant in different shell mode. All electronics are at a surface level where the diagnostics are in the tunnel, to prevent damage from radiation.

Q – How often are you warming up the cavities?
A – Never, we never warm up cavities. Since 2018 the whole system has been cold, we have warmed up once but that is because we have a new construction in the experimental area that we needed to time, so we expect to have one thermo-cycle. But in general, the whole facility is kept at a cold temperature all year long.

Q – What technology are you using for your superconducting magnets, what material and what is the dipole field?
A – All solid Niobium (Nb), typically 3 mm thickness for all the cavities. For the cryomodule, they have cavities made out of solid Nb of3 mm thickness, running at 2K. The focusing solenoids are also contained inside the cryomodule and runs at 4.5K. All cryomodules are separated by a warm section. We call this the diagnostics box: it is a wall, very short, about 40cm long.

Q – What is the maximum loss during beam transport?
A – Right now, uncontrolled beam loss is pretty much undetectable. This is of course, because we are running at low intensity. We either have to run the CW beam at low intensity or we run full peak intensity but for a very short duty cycle and they are on a temporary beam dump. Next year we plan to commission a target and the beam dump, by that time we can start to ramp up beam power.

Q – Do you observe already cavity performance degradation with time?
A – We have seen over the last couple of years a few cavities that have spontaneously started to produce field emission. It starts like a spark-like event but there is not much we can do about this. Sometimes we can live with them or like I discussed in the talk, we can detune them completely. The black and white answer is yes, but fortunately, not too much so far.

Q – Is it planned to correct beam transverse kick with correction magnets?
A – We do, we have this feedback system at the end of the machine to straighten the bunch train.

Q – Are you at some point planning to upgrade to solid state modulators for your klystrons?
A – No, that would be a major investment. Originally, we had these bouncers like pulse home network modulators but the ones we eventually ended up with are mostly solid-state modulators, but if you consider solid state being more like a MARX modulator, we are not quite there yet. We wouldn't go beyond that.

Q – Have you tried to use any machine learning to further optimise your control of the accelerator?
A – We are just seriously getting into that field, that's a whole area that personally interests me quite a lot and we have a lot of move in that direction at DESY but it's a young field for us now, and I hope we are going to get more into that. Particularly for fault diagnostic and fault tracking and fault prediction.

Q – Considering downtime statistics if you scale XFEL to ILC what are the lessons learned to achieve ILC performance requirements?
A – I think the lessons learned for XFEL here are for the most part extremely positive for ILC. In terms of availability and reliability it's very positive and that scales with the machine because single trip in our station is meaningless. I only see positives coming out of XFEL for ILS. There are so many lessons learned in terms of operation close to limits, things we already knew about when we were discussing the design of the ILC and the gorilla in the room is the gradient. So the state of the art as of today is 23 MV/m.

Q – When you used the Piezo system to reduce the misalignment issues of the transverse kicks, does this impact on the wakefield issues and how do you handle them?
A – First and foremost, the piezo system simply maintains the cavity on resonance but by doing that, they actually reduce these coupler kicks. There is always a DC kick from the couplers which kicks the entire bunch train left or right and then this is just steered out. But the time variation across the bunch train is the thing we need these fast feedback systems to correct and it causes us some problems. So yes, at some level the wakefield effects do kick in, we studied that for the ILC and put quite a tight tolerance on that. For the XFEL we had one PhD student spend quite a lot of time analysing that and said that there would be an influence on SARS, but I have to say so far turning the piezos on and off I've not really seen any real evidence of that.

Q – You've got so many contributions from all over the world from different international partners. How are you maintaining quality over so many contributions?
A – We have put in place a very rigorous systems engineering management plan, part of which is an equally rigorous quality assurance and control plan and which we share with all our partners. Each one of our own partners then develops their own plan for quality assurance. First of all, all the partners and Fermilab agree on the systems engineering and we all adopted a common set of technical design review plans, so we have uniformity all the way.

With respect to quality, each partner institution develops and documents their own quality plan which is consistent with the requirements that we have at Fermilab, in order to be able to operate and maintain their deliverables that we received according to the Fermilab specifications, but also consistent and aligned with their own home institutions quality and safety requirements. This is an ongoing discussion and another very specific way to address that is that in addition to having a quality assurance manager, we are hiring specific quality people who are in SME's. For example, in the ESRF, in accelerator systems and so on, their focus is to connect the framework and the principals of the quality assurance and control, and translate it down to the working level. These are some of the methods we are using: in short, very rigorous systems shared between all our partners.

Q – Does PIP-2 present any new difficulties for resonance control of the RF cavities?
A – It does, the low beta cavities have a very narrow bandwidth and very stringent requirements for stability of phase amplitude and we plan to operate PIP-2 in CW RF mode so the challenge is not as great in that regime because we do not have to deal with resonance fine tuning. So, at the moment we plan to use algorithms that are primarily used at LCLS-2 for resonance control and amplitude and field control. As a second phase we are also very interested, our partners and ourselves, in pulsed RF operation and for that the low-level RF requires development in terms of the algorithm and firmware. At the moment we try to attack the problem both by designing the cryomodule in a way that minimises the vibrations, as well as the algorithm firmware point of view.

Tuesday 1st September TUP 3:50pm

Chair: Sami Tantawi (SLAC)

Status and Perspectives of the ESS Linac
Hakan Danared - ESS

Q – What's been the most significant Covid-19 related impact experienced at ESS?
A – We are suffering like everybody else from this pandemic, we have been working from home largely for the last 6 months. We are still doing that to a large extent and since we are in a phase where we're installing and testing equipment, building an accelerator, it's clear it's not easy to make rapid progress from home, so this applies to our in kind partners as well and their suppliers. On top of that we depend on our in kind partners coming to ESS to assemble and install what they are delivering to us and travel has been inhibited. So for all these reasons, we expect to have accumulated over six months delay.

Q – Where are you getting your modulators done? which type?

A – The modulators are an in-house development at ESS, by Carlos Martins, our modulator expert. So, these have actually been produced by JEMA Energy in Spain and we now have all the modulators in house for the normal conducting linac and for the medium beta section for the superconducting linac, so this has worked out very well. We are also about to procure the modulators for the first part of the high-beta section as we have a budget for this right now. And these are SML topology, which is a special development for ESS.

Overview of High Power RFQ issues and solutions
Andrea Pisent - INFN/LNL

Q – At CERN we have seen quite impressive signs of RF breakdown in our RFQ, which is oxygen-free e-copper. We are also investigating how H- beams at low energy can blister copper. Do you have any experience between different materials on RFQ performance, including long-term robustness?
A – The debate over electron damage is very important. We are currently doing calculations to better understand the effects of various ions on electrodes. The experimental feedback is particularly important in order to get experimental evidences. One of the possible scenarios for the CW RFQs is to substitute one or few modules, because the losses are concentrated at a certain point at the end of the gentle buncher or even to go to more consistent materials on the electrodes. This is what we are thinking about, but we don't have immediate experiences at this moment.

Q – What is the expected damage of the electrodes due to beam losses, sputtering for example?
A – We are considering sputtering as a first approximation and this would be consistent with the experience that there is worse damage with the heavy ions, like at GSI. But, of course, the phenomenology is probably more complicated because there is also interaction with these charges that make worse the surface and the larger discharges which damage the surface. This is an experiment we have a lot to learn about with regards to the best strategy to overcome this.

Q – LIPAc RFQ accelerated 125 mA beam, how about acceleration and transmission efficiency? It's pulsed beam, when may you start CW beam commissioning?
A – The transmission was in accordance to the simulation, above 90%. This was very accurately simulated as you need to take one measurement of the two transformers but then also to consider what are the various species in there. All the best hypothesis about D2+ put the transmission above90%

Transition between different acceleration sections of Hadron Linacs
Michele Comunian - INFN/LNL

Q – If you increase the beam radius, what would be the effect on beam quality?

A – Of course when you increase the beam size, you are going from linear to a nonlinear zone in your accelerator facility. For example, in normal conducting you are getting more nonlinear effects, for example in Bessel, nonlinear part of the electric and magnetic field; it's the same when you pass through your monitor near to the border you get more nonlinear effects, so a large part of the beam is going to a nonlinear zone. Going to a nonlinear zone, you are typically getting an emittance growth.

MYRRHA superconducting linac and fault-tolerant Design
Frederic Bouly - LPSC

Q – How can this project be useful for medical isotope production? Can you share some information?
A – I'm not leading this project, it's a question that should be asked SCK CEN lab and to the leader of the project.

Q – For the parallel redundant system at low energy, is the spare beam always running, or in what state is it before switching in case of failure?
A – So the plan is to have a spare beam, that will be done, but at the lowest possible energy, possibly in the LEBT, with a Faraday cup you can quickly remove in case you need resume the beam.

Q – Do you see the fault recovery technique extendable also in high power existing facility?
A – Yes, possibly, the method that we are trying to develop is aimed to be as generic as possible so it can be used on different linacs.

High Power normal-conducting linacs upgrade in US
Deepak Raparia – BNL

Q – What would be the electron bunch length and beam radius at average current 250 μA in your project goal?
A – It is not electron but H-, and the bunch length for the micro bunch length will be 900 μs. for 250 μA average current.

Q – Is LANSCE upgrade limited by the target other than other issues with regards to the current of 300 μA?
A – 300 μA is for the isotope production, it is working. So, this is proton and proton losses is much lower than the H-minus, so it can go up to 500 μA. As far as the other 800 MeV/1MV program, it will be limited by the Klystron power.

Q – Is there any update planed for the EIC?
A – Yes this is an official project and it is getting built, and going on now.

Q – For LANSCE linac what types of isotopes are produced, what can be achieved with higher current?
A – Basically, LANSCE and Brookhaven do the same type of isotope: strontium, actinium. Research isotope does include several cities of several isotopes, it is R&D now. The products are strontium and actinium, 2.25.

Overview of linacs for compact neutron sources
David Baxter – IUCF

Q – I think conventional methods are not used for acceleration of neutrons, what other methods are used for acceleration of the neutron and maximum energy obtained of neutrons?
A – I think this question might have been prompted by a slip of the tongue I had in the middle of the presentation. Of course, the accelerators that we are using here are accelerating charged particles, either protons as we have at LANSCE, or electrons in other facilities as they have at some of the other facilities. I slipped and talked about the energy of the neutrons simply because in these CANS type facilities the maximum energy available for the neutron is fairly tight to the energy of the proton accelerator that you're using. So, by going to a 13 MeV proton beam we are limited to 11 MeV for the neutrons. But we don't accelerate the neutrons themselves, we can only collimate them and make a few tricks with magnetic fields, that just sort of changes their trajectory it doesn't really accelerate them.

SNS Proton Power Upgrade (PPU) and Operational Experience
Mark Champion - ORNL

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Q – With the second target, do you still need a 2 MW target?
A – No, the second target station will take a maximum of 800 kkW of beam power. We plan to use a solid rotating target within that facility.

Q – Among all the programmes in the PPU and SNS, which might bring the project the biggest uncertainties?
A – Okay, so our biggest risk is an unplanned shut down of SNS due to some failure. For example, if the cryogenic plant were to go down and remain down for many months then that would impact our schedule for project completion. Another big risk, which is outside of operations is simply funding, will the project receive the funding that is needed to efficiently execute the project?

Q – Is there any ongoing R&D on laser stripping as an alternative to stripping foil in accumulator ring for future upgrade?
A – Yes, there is. We have a quite active laser stripping R&D programme that's progressing. Of course, to take that to production levels for SNS operations, you need quite a powerful laser, but there is very promising work to date on that topic.

Q – For the 50% beam current increase, can you clarify up to where this has been demonstrated so far (on linac or test-bench)?
A – It's been demonstrated in the linac at a very low duty factor already, and in the ring, so we are quite comfortable with that parameter.

Wednesday 2nd September WEP 3:35pm

Chair: Fulvia Pilat (ORNL)

Women in Science and Engineering (WISE): Should I stay or should I go now?
Join us on Wednesday 2nd September 2020 for a panel discussion on improving retention and career advancement for women working in the field of particle accelerators. We will explore the role the organisation, and workplace culture, can play in addressing the retention and advancement issue in STEM. The panel discussion will be followed by a moderated real-time question and answer session. Participants of all genders and career stage are welcome to attend.

The current confirmed panellists are:
- Camille Ginsburg, Director of Accelerator Operations at Jefferson Lab
- Manjit Dosanjh, Senior Advisor for Medical Applications at CERN
- Ling-an Wu, Chinese Academy of Sciences
- Susan Smith, Director Daresbury laboratory and STFC Accelerator Centre
- Claire David, Assistant Professor at York University (Canada) and Associate Scientist at FNAL.
- Session chair and discussion moderator is Fulvia Pilat, Research Accelerator Division Director at Oak Ridge National Laboratory.

CBETA: The First Multipass Srf Based ERL
Colwyn Gulliford - Cornell University (CLASSE)

Q – You indicated that you have about 101% energy recovery so where did the extra 1% come from?
A – So that's per cavity and each cavity doesn't have to be exactly energy balanced in order to have the beam go back down to the right energy at the end of the linac pass. So, you could be transferring energy from the injector or from one of the other cavities. In fact, I think that the machines that we had set up for that particular measurement did not have the cavities 100% balanced individually, but the balance for the whole turn was 100%.

Q – What is the plan of attack for your transmission challenge?
A – So the machine was designed by using Bmad for which we did not use 3D field maps for all the magnets, so we are going to go back and do more careful simulation studies and make sure that we have precise control. Its basically only in that one splitter line that we think there's a problem. So, go back and make sure that all is understood and possibly resurvey that line.

Q – What codes did you use for simulations?
A – So for start to end, the injector and through the linac, are simulated in GPT so we have 3D space charge using that code. After the linac, the beams at 42 MEV so space charge is less of an effect. We then switch to Bmad. So, Bmad was used primarily then and it formed the basis for our online model, but the cell design FFA cells were also simulated with 3D field maps in Zgoubi, and also another code that was developed by Scott Berg at Brookhaven National Lab.

First linear acceleration of relativistic electrons using THz waveguides
Darren Mark Graham - The University of Manchester

Q – How do you fabricate THZ waveguides and to what tolerances and what is the material?
A – The material used is copper and its made in two halves, the top and bottom half with locator pins and its simply made by CNC machining, the tolerance doesn't have to be too great. So were talking about the kind of micron scale tolerances. That's the benefit of terahertz radiation, because of the long wavelength, it doesn't require the tolerances you would for optical for example.

Q – What breakthrough is required to actually bring the technique?
A – For us, the next big thing is the development of the higher THZ pulse energy sources. The sources are a kind of key limitation at the moment. We can see now in literature sources that are being produced that look like they will deliver on these high fields that are required to achieve acceleration. So, we are quite hopeful that substantial gains are there to be had in the near future.

Attosecond Microbunching with On-Chip Accelerators
Dylan Savage Black - Stanford University

Q – How much charge is there in the micro-bunch?
A – Right now we operate with macro bunch charges of less than one electron per shot to keep our signals noise as best as possible. At the moment our current compact guns can produce roughly 10 – 100 electrons per macro bunch, which would give us an average of about 0.1 electrons per micro bunch. Not very many is the answer, we're working to improve that.

Q – As a wild guess, what do you imagine the timescale to be for making this commercially available?
A – I would say, if you wanted to commercialise some aspects of this technology it wouldn't be that hard, its relatively easy to produce a wave guide coupled accelerator that will modulate electron beams at a laser frequency using current technology. We are currently fabricating some of these at commercial foundries right now, that's not so hard. Producing a beam line that has say, greater than one MeV of energy, if you're not starting from an RF gun, that's a lot trickier and there's lots of problems there that we haven't solved.

Particularly in relation to transferring from these low energy stages which we have to make out of silicon to high energy stages, which we make out of fused silica to harness their damage threshold; so that one, I'm going to speculate around 5 years or so. Let's say 10 years as a reasonable estimate.

Q – What sort of current densities are possible in DLA, and what about the possibility for proton acceleration?
A – DLA's are interesting because they already work sort of like ion accelerators, but for electrons, the energy gained per stage is really small. So, if you were to use proton, you can of course accelerate any charged particle but you need a really long accelerator. It doesn't work great for protons and so for that reason we use electrons.

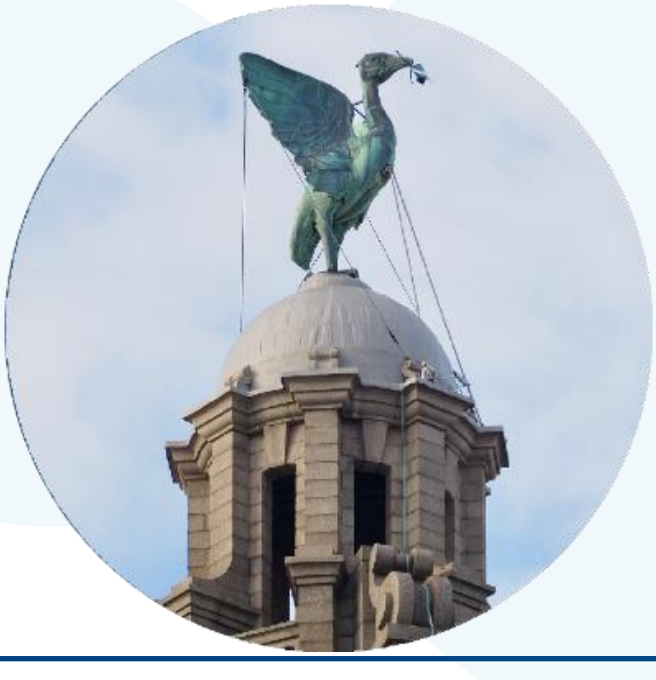
Currently we are not trying to scale our current as our primary focus. We are using as low currents as we can measure for the best signal to noise but we can scale the current in our current accelerators up to about a single digit pA. So, since we're using SEM columns, we're building our own SEM columns for these things, in principal you should be able to get sub hundred nanometre beams. Currently our beam is 200-300 nanometres. So, I think that's the order of magnitude you're talking about currently and for the next gen systems, Pico AMP's in hundreds of nanometre beams and we are trying to scale that up, through various methods such as fabricating many of these things next to each other on a chip and having parallel accelerators. You can cheat a little bit and increase current that way.

***Q* – What is the contrast for the drive laser used in this experiment? I meant the ratio of the intensity between the post trailing pulse to the main laser pulse?**

A – There is no trailing pulses in the experiment. There are five pulses involved. There's the electron pulse that gets micro bunched and then there is two pulses each for each accelerator stage and this particular experiment or laser pulses, they all have equal strength, except the electron pulse.

Q – What's the power of the laser?

A – The average power is usually in the couple of milliwatts range, so about five milliwatts. For the silicon, since the damage threshold is lower than fused silica, we try not to run them above 500 megavolt per meter incident fields, so that corresponds to 300 femtosecond laser pulse and about five milliwatts of average power. For fused silica, you can run them much higher up to 9-10 gigavolt per meter incident fields.



Thursday 3rd September THA 1:30pm

Chair: Lars Groening (GSI)

Commissioning of simultaneous top-up injections into 4 + 1 storage rings at KEK injector linac
Fusashi Miyahara - KEK

Q – The emittance goals that you observed that you did not see in the simulation, could it be due to some beam coupling that you get with the target when the solenoid field is not reading zero when your converting electrons into positrons?
A – No, because we checked the solenoid field using the beam test.

High-efficiency ultra-short pulses from infrared FEL oscillators for an attosecond X-ray source with high-harmonic generation
Ryoichi Hajima – QST

Q – What is the longitudinal electric field of the cathode in the proposed new gun?
A – The design is still being worked on so we have not yet fixed the cathode gradient, but it is a very standard BNL type 1.6 S band RF gun.

A high brightness RF gun development for the Super KEKB collider
Xiangyu Zhou – KEK

Q – Why do you not Cu as photocathode as QE of "Ir_5Ce" is similar to Cu? Why not use CsTi which has QE~10%?
A – First we used LaB_6 but the lifetime is not enough so we chose the iridium cerium because it can be laser cleaned to restore the QE.

Q – You say low emittance, what are the factors which you optimise to get low emittance?
A – Firstly, it depends on the cathode and the cavity but when the cathode and the cavity are already developed so what we can do is only the laser source. We must reshape the laser source as the quality of the laser beam is very important. I mention that in the time domain and in the profile. We must reshape the pulse to the flat top in both the profile and the time domain. We use the flat top see that it is very clean and there is no discharge that is vert important. For the low emittance we just calculated that the flat top is better than the gaussian for the low emittance but we didn't test it. In the next commissioning we will see if the emittance is better.

Q – Can you comment on the shot-to-shot energy stability?
A – I would say less than 30% I think

Q – You said you do the UV conversion in the tunnel. Do you see effects from ionizing radiation in the tunnel on the crystals?
A – yes, we have the camera in the tunnel so we have come up with a remote system so we can control it and calculate the best adjustments for the parameters. So we don't need to physically be in the tunnel, we can see this from the control room.

High repetition rate RF guns
Boris Leonidovich Militsyn - Cockcroft Institute

***Q* –Do you foresee any RF pickup for LLRF field control?**
A – Yes, we do, we assume to have an RF pick up to characterise field inside the cavity. It actually differs our project at Daresbury is actually developed from a previous project at Diamond light source group.

***Q* – In DLS gun do you use the magnetic focussing?**
A – Yes, any gun which is going to operate at 100s pC regime needs to be immersed in the magnetic focusing.

***Q* – What temperature are the cold cathodes at the final matrix? Are they cryocooled copper?**
A –Its very interesting technological question because if we want to cool the cavity you should keep the temperature of the photocathode a bit higher so it doesn't serve as an effective cryogenic pump.

***Q* – Your comments on VHF gun for MHz operation rate?**
A – We have been thinking about this. Bruce Dunham from SLAC, later today, will hopefully give a very comprehensive talk which covers this subject.

Commissioning of High-Power linear induction accelerator (LIA) for X-ray flash radiography at BINP, SB of RAS
Danila Nikiforov - on behalf of LIA Team

Q – Do you also have a proton acceleration using a linear inductance accelerator, if yes what is the minimum energy level?
A – So no, we use only the electron for the acceleration.

Novel Experiments at CLARA
Deepa Angal-Kalinin - STFC/DL/ASTeC

Q – You said in your first beam time already you had far more applications for beamtime with respect to the experiments that you really could conduct. How is the ratio in this period between real beam on target, lets say accelerator R&D and small breaks for maintenance?
A – Very tricky question. It is quite difficult to do that as we have recently commissioned the machine and so a lot of machine development program is still ongoing. What we did in the first period is we actually gave around ten hours for users and then in the evening we dedicated some programme for machine development. In the second run we are planning to have dedicated blocks of user run and machine development.

Q **– How do you foresee promise of VHEE over proton?**
A – This is a very new field, new modality of radiotherapy.   There is obviously potential in terms of the high gradient which is the topic of this conference, obviously normal conducting linacs reaching the high gradients.

The beauty about VHEE which is being explored is that the focusing can be done more easily with electron beams rather than proton beams. So, in principal, it can be focused at the location where the tumour is and the dose delivery can be quite fast. So, the tissues of inhomogeneities of which I gave the reference to earlier, it describes in detail how VHEE is insensitive to inhomogeneities. So, for some cancers and because of breathing cavities, the dose distribution from proton beams could be delivered at higher radiation dose, although VHEE is still in very early stages and machine development needs to be developed further. Also, in terms of FLASH radiotherapy

Thursday 3rd September THP 3:50pm

Chair: Marion White (ANL)

Superconducting Twin-Axis Cavities - Development and Applications
HyeKyoung Park – ODU

Q –How the deformation due to Lorentz detuning can be cylindrically symmetric, between two apertures? Can it be negligibly small and ignored?
A – So I didn't present the Lorentz detuning here, but it can actually be calculated from the past results. I'm going to go back to our results and try to get the quantitative answer. For the single cell cavity, we put in a stiffening plate between the two beam pipes, that was helping, after the mechanical analysis that was to help the mechanical deformation and also to help the Lorentz force detuning, but I don't have the quantified answer to your question.

Q – Passband mode structure may be complicated?
A – Absolutely, yes. That goes with the HOM as well. The cavity becomes the multi cell cavity, that's what we have to deal with and how close together it would be. That would be some issues for the operation today.

Q –What was the exact motivation of eliminating EP step? Is the 800 Celsius baking for 3 hours enough? How is baking time determined?
A – We didn't exactly eliminate it because the EP posed a little bit of tool development time, as we had to modify our existing EP machine, so we wanted to see how it performs without EP. Of course, you can go and add more surface treatment like we can add the electro polishing and then we can add some other currently developing method like Nb3Sn coating. That's how we could see a very bottom line performance of the cavity, to convince people that such geometry is possible and to think about going into the real machine.

Secondly, for the heat treatment, especially at Jefferson Lab we have quite well accumulated with test data. We used to do 600 Celsius and 10 hours of heat treatment but then later we found 800 or even slightly higher temperature and shorter time has the equivalent results and 800 seems to be a little better. You also have to consider how your cavity is made though, if your cavity has some kind of connection, it prohibits the really high temperatures; then you are limited by that.

Particulate field emitters in CEBAF: from root-cause studies to mitigation solutions
Rong-Li Geng - JLab

Q – Can we keep the concept of the main section between each cryomodule, in our future scope from a view point of complete mitigation of field emission?
A – Yes, those lessons we are learning right now and hopefully we can provide input for the future on larger scale installation. This is a problem that can be predicted and controlled.

Q – Do you have any results from your institute removal technique?
A – For our new technique no, not yet. We have been building a test bed since the end of last year, which we are still working on but COVID-19 has really slowed us down. We do have a plan to recover though and do some single cell demonstration first.

Q – How can you make sure the particles you collected and found are the sources of field emission in the modules?
A – This is basically based on the automated performance loss, not really a direct cause to our

studies. The data is like the fingerprint of the particles found on the cavity surface and they highly match those found elsewhere in the warm sections. Its indirect, but this is not a controlled study, its more an understanding based on what we are learning.

Q – What is the response time of the tripping interlocks?
A – The definition of a trip is that the protection is triggered and then recovered within five minutes. If the recovery time is longer than five minutes then it is considered something else. Sometimes the FFA320 cavities they can be recovered in about 20-30 seconds. For FFA100 cavities takes longer to recover.

Plasma processing programmes overview
Marc Doleans – ORNL

Q – How will you remove silicon from oxygen plasma? Are you using laser-based plasma processing?
A – Actually, we have done one test and we do suspect some silicon from a pump that was back streaming in an offline cavity and I think we have seen some silicon particulates elsewhere. So, these silicon particles are not generated or induced through the plasma processing itself but our contaminants have been induced in the cavities from other sources. The issue is that the oxygen itself then is not a good chemical process, the oxygen plasma to attack and remove these particulates so I think, right now I think other people use various ideas, I think one at least shows some other institute techniques helium processing is a different one lasers also can be fit through more aggressive plasmas so there are other technique when particularly the oxygen plasma processing is not tailored or meant to attack these other contaminants it's not something that can solve every single problem so I think the silicon particulates is an example of particulate that oxygen plasma would not help solve.

Q – Can you give a formula or chart of the combination s or ions used to remove absorbed gas as well as just surface particles?
A – The main cleaner is basically atomic oxygen, it's not even an ion at that point. We have shown actually an interesting study that the plasma itself it's not occurring everywhere in the cavities but the important chemicals like atomic oxygen, even if its release nearby where the contaminant is, if it's not an active discharge it's still going to do cleaning because it can migrate to a part that the plasma is not. So as long as you are not too far, recombination is an issue. So, for us oxidation of hydrocarbons, by-products typically that you can see through residual gas analysis is water and CO and CO2. There are some nice things that you can do as the active discharge is ongoing and you see some of these by-products through pumping you can actually see these peaks appear in your RGA and as the surface is depleted of these contaminants. These by-products decay in the RGA and you know when your cell is in a cleaner state where you can basically turn off your plasma.

Q – Thanks Mark for the great overview. What is the next step to introduce more automation in the cleaning process?
A – We haven't done automation. We have thought about it but as we were getting close to our goals, we decided that it would take quite a bit of manpower so we are still doing the ignition and the tuning; basically, they operator driven. I do know colleagues at Jefferson Lab who are making some nice progress with automation processes though. I think that this automation is very nice in a fact that it offers speed, and you can avoid errors too. At the same time the plasma process itself is the longest part; actually, the setup originally wanted the cryomodules in one frame under one hub. All these side tasks that are needed for the process are also time consuming. So, automation is a nice addition, but it doesn't completely speed up the process. There is just some time that is needed for the cleaning.

Q – How is the processing of Nb3Sn cavity different from processing conventional bulk Nb cavity?
A – When we process multipacting we're sort of cleaning up the surface. What we expect to be doing is reducing the secondary electron yield. So, this secondary electron yield tells us if an electron impacts the surface, what is the expected number of electrons coming off. Essentially its energy dependent and if its above one you start to worry that you're going to get some resonant feedback and build-up of many electrons. So, when you just have a recently cleaned surface the secondary electron yield can be fairly high but as it gets sputtered the secondary electron yield is smaller. And so Nb3Sn is a little bit higher in terms of secondary electron yield than Nb so one could ask will one be able to process multipacting effectively. That wasn't entirely clear; the surface can be very different for these different materials. And for example, for MgB2 we expect a significantly higher secondary electron yield and so it wasn't a given that we would be able to do this and we were happy to see that we were able to do that. And for example, with Nb cavities we regularly have to do this, especially with certain shapes

Q – If operated at pulse mode, how high gradient can the 1.3 GHz cavity maintain instead of the 24 MV/m in CW mode? What can be the next step to exceed > 30 MV/m and higher within a capacity with Nb3Sn?
A – Let me start with the pulse mode question. So, what we find is that we can quench the cavity repeatedly with CW powers so it doesn't look like this is a thermal limitation in terms of something that could be outpaced by using a standard pulse. But on the other hand, one thing we have done in the past is to apply very high powers to cavities in our tests. This is not the kind of thing you would normally do in an accelerator, but we might apply megawatt of power to a single cell cavity. When we do that, we find that we can outpace thermal timescales.

Another thing we found in the past is that with a cavity that was limited to say 15 MV/m, we would go to something like 25, we have not yet done that on the shiny cavities, but we would like to do that. We are establishing a test to do this at Fermilab and also in collaboration with Cornell. It's a great question, one I would like to know the answer to and one that I hope I will have the answer to within the next year. For the other question about pushing gradients further, one thing we are looking at is surface roughness. You saw with the shiny cavity, we had improved surface roughness. We are looking to try and improve surface roughness even more.

One way we are looking at this is doing some sort of post coating removal. Typically, we just take our cavities high pressure instrument and assemble them, we don't do any electro polishing like we would with Nb. One thing we want to develop is a process that works with Nb3Sn to smooth the surface. Electron polishing usually removes microns of material with Nb. We haven't found a good way to just remove vitamins and material with Nb3Sn that produces good performance.

There is something called oxypolishing where you ionise the surface and then remove that oxide that was grown with hydrofluoric acid but that seems to degrade performance and it seems to leave some residue on the surface. So, one of the research directions that we are pursuing is trying to understand what that residue is, why the performance is being degraded and if we can find a different removal process that will prevent that degradation from happening.

SRF R&D for the LCLS-II High Energy Upgrade

Daniel Gonnella – SLAC

Q – Could you elaborate a bit on the "improved cap installation" for the doping?
A – This improved procedure is really to bring the vendors in line with what we are doing at partner labs and to have a better process control. One of the big things we are doing for the LCLS-II-HE is improved process control and improved QA and being very strict about following procedures. So, ensuring that vendors follow the procedures that we specify, to make sure the caps are properly installed.

Q – Do you have plan to use mid-temperature baking or mid-temperature annealing for the LCLC-II-HE cavities?
A – Yes, so the mid temperature bake has some interesting results recently for good high Q performance with high gradient. Unfortunately, we are not pursuing that for HE. The technology is just not developed enough yet, whereas doping we have a really good understanding of how to make good doped cavities, especially at the vendors. We have a lot of statistics on this. Until we have similar levels of statistics with other methods, I don't think we can pursue that, especially when the needs can be met with doping.

Q – Why specifically 2/0 and 3/60 vs any of the other infinite possibilities?
A – This was our first shot on it, our plan was to do a much more exhaustive parameter search and the first two recipes we picked produced really good results and so that motivated us to study that a little bit more and moving to nine cells quickly. So, it is possible that there are other recipes that could produce better results, but we got excellent results and are moving forward with those.

Q – When will the LCLS-II SRF linac start commissioning and have first beam?
A – I believe the LCLS-II linac will start commissioning around this time next year.

1st Student Prize Winner Talk (Sponsored by the IET)

Distributed coupling Linacs from room temperature to Superconducting

Mamdouh H. Nasr - SLAC

Q – Where is the split plane and the O-ring with the respect to the aperture? As shown, it seems that there is some interference.
A – The view angle isn't great actually so I can show you a quick picture (refer to slides). So, it's a 3D one. In the O-ring there is like an opening, a circular part at the end, and when we put the two pieces together they fit perfectly.

Q – What's your target gradient for SRF version?
A – So for the X band versions that we are developing, we have a target gradient for 20 MV/m.

Q – What are the difficulties in keeping the cavities phased correctly when using distributed coupling?
A – Actually there is no difficulties at all because the distribution feeding network is like a waveguide which is very immune to tolerances
Q – How is field emission at high field with low temperature compared to room temperature?
A – Because at lower temperatures we are able to go to higher gradients, we had more field emission, but we started to have field emission at higher gradient levels because of the increased conductivity of the surface.

Q – In terms of production, how would you envision producing these and for what purpose do you intend the first application?
A – We have many applications in mind. We have what we call CQ, which is basically a cryogenic version of a C-band distribution coupling linac for linear collider applications. We have also a program called the phasor program, with the medical school at Stanford for radiation therapy where we are using distribution coupling technology for radiation treatment. So basically, we are going into different applications. Of course, we added also the superconducting applications because if we can achieve superconductivity and have successful demonstration at X-band this will be a huge motivation to include this technology with much optimised geometries in different studies. We can study what are the doping effects or how we can make it use different frequencies for creation and so on.

CW RF Gun Development
Bruce Dunham – SLAC

Q – Can you say more about dark current for LCLS-ii GUN?
A – It's been an issue with the copper gun, seems to be coming from the nose cone of the gun not the cathode itself. We have a spec of about 400 nA, at the moment and it's above a μA and it's been increasing rather than getting better so it's certainly an issue and we need to deal with. For a new gun we are looking at ways to redesign it, reduce the fields and maybe use different materials.

Q – Could you comment on the direction to improve thermal emittance?
A – Well I think that's pretty well known these days; there is a lot of R&D in this direction, particularly with alkali cathodes now that we don't need to run nC for most applications. We can run a hundred pC so we don't need super high quantum efficiencies. So, if you take a cathode like CsK2Sb and use a laser wavelength near the bandgap you can get very low thermal emittances, Room temperature numbers 25 MeV or less and you can also cool them to cryogenic temperatures and get even lower. So not having to deliver high nC bunch charges really relieves some of that and gives you a lot more options than in the past

Friday 4th September FRA 1:30pm

Chair: Peter McIntosh (Cockcroft Institute/STFC)

Beam reliability and stability studies at 25 MeV CW superconducting proton linac in Lanzhou
Yuan He - IMP/CAS

Q – What were the fundamental challenges that you had, to achieve the performance capabilities that you highlighted?
A – The operator cavities peak at 20.

Q – What is the maximum E-Peak for the cavities?
A – The operator cavities peak at around 25 megawatts per meter

Q – Field omission is mentioned as one of the major hindering processes for the half way resonator in stability, is there any multifactor observed and how is this impacting?
A – No, it appears low. The vibration is high enough.

Commissioning of Superconducting Linac Booster for Heavy-Ion Linac at RIKEN Nishina Centre
Osamu Kamigaito - RIKEN Nishina Centre

Q – What is the motivation to use the adjustable coupler?
A – Well I think this is a normal way to prefer an adjustable coupler. If the violation is too heavy we have to choose the extra key value from large to very small and if it is wide we need a larger one. So that we do not compromise the operating conditions, this is why we choose an adjustable coupler

Q – What is the operating temperature, 4k or 2k?
A – It is 4k

Q – Did you face quench of any of the cavities?
A – Yes, a few times, but not too often

Q – Congratulations, how about RF phase stability and voltage stability for the SRF?
A – The voltage stability is less than 0.1% and the phased stability is 0.3%

Q – What about the total efficiency from the iron source from Q entrance during routine operation
A – Well at present it is 50% because the laboratory has not been optimized so far

Q – Were the cavities baked at 120 degrees Celsius?
A – Some were baked at 120 but some were also baked at 80 degrees Celsius

Demonstration of High Current Deuteron Acceleration for the LIPAc 5MeV RFQ
Keishi Sakamoto - QST

Q – What's the radiation dose level at the low energy beam transport when the deuteron beam was CW at 100 milliamps?
A – 1.2 x 10^9 neutrons per second.

Q – Did longitudinal emission measured after the RFQ?
A – It is underway.

Q – What is the RFQ transmission and energy spread?
A – Energy spread is not measured precisely, moving forward this is something we will measure

Q – What about the CWRF voltage or power you have applied to the RF conditioning of the RFQ?
A – we are now in the conditioning phase for the for CW. This is our next target.

Beam commissioning of SPIRAL2 linac
Robin Ferdinand – GANIL

Q – Concerning the superconducting linac, what is the sum of the installation and commissioning?
A – Commissioning itself lased for 4 months, from July to October last year and then one month for the beam commissioning and the experiment. Then for installation itself, we started in October 2012 and we had the first linac pole down in 2016, so about 4 years.

Q – What is the level of field emission when the cavity is operation at 8 megabits per meter?
A – We have beam loss monitor on the wall, so the number is related to those measurements. Its about 2 meters from the cavity. At 8 megavolt per meter we usually get something around 1 millisievert (mSv) *per hour or so, while on the CMA 11 the one which is not so easy to operate we get about 80* millisievert (mSv) *an hour.*

Q – What kind of beam loss monitors do you use for the SRF section during beam conditioning?
A – There are senator, a very specialist devise

Brilliant beam acceleration at longitudinal phase advances far beyond 90°
Anna Rubin – GSI

Q – Do you define the longitudinal phase advance with respect to the radial FDDF lattice? If yes is this a mistake?
A – We do not have a radial FDDF lattice, we have quadrupole, this is a quadrupole channel.

Q – So you focused on protons, this should be possible for heavy ions too, is that correct?
A – If you have technical conditions, because for example, our unilap is designed for heavy ions and we cannot increase more our voltage or quadrupole.

Q – Will this lead to more compact linacs?
A – Probably, if we deal with proton beam is it important to increase voltage and if we increase the longitudinal phase we solve this problem.

Q – So which lattice for the longitudinal faded phase advance?
A – I can just build it as a focal length, for example, 120-degree longitudinal phase advance is about 1.1 meter, phenomenal is about 9.5 meter.

Q – Have you looked into challenges in deploying radiotherapy machines in Asian countries such as India?
A – Yes in the very first meeting we had, we had people from India, Pakistan, Far East and also Nepal and so it's obviously a global problem, it's not just an African problem. We started with Africa because we were able to get funding through STFC for the other countries, but the idea of improving the design getting input defining parameters should be and is going to be relevant everywhere. Even places like Australia and in the US in the remote regions where they have similar challenges. So yes, we are looking around the world for this.

Q – The numbers that you quoted, can they only be cured by radiotherapy or are alternative therapies available that will also provide appropriate treatments?
A – So, actually, cancer can be treated, of course, by a number of methods using radiation therapy, chemotherapy, surgery and some new methodologies that are coming in. But when I am talking about these numbers, I'm talking about the recommendation of more than 50%, at least half the patients should be treated radiation therapy. So, these statistics, relate to the patients that should be treated with it.

Q – How do diagnosis rates compare within low- and middle-income countries, is the general healthcare access problem, diagnosis, pre-treatment and post treatment and palliative care, is It all associated issues?
A – This is an interesting question because for quite some time, because the diagnostic tools were not available and actually there still is a limit in a large number of countries, most of the time you didn't actually know that people had cancer. Secondly, by the time cancer is detected the tumours are very large so you can almost see them on the surfaces, its really shocking sometimes what you see. So, at that stage you are looking at palliative care, basically pain relief, you're not really looking at cure rates. So absolutely, the idea of having really good detection and early detection for better outcomes is key. Of course if you can detect earlier, your outcomes are better but tools and technologies go hand in hand and some of the new methodologies we are talking about in so called high income countries such as guided radiation therapy or MRI guided therapy and even talking about particle therapy using the Bragg peak, all of those rely on really good imaging and targeting, trying to look at organ motion, limiting healthy tissues, so yes I think it's not just treatment itself, when we talk about linac its going to be the whole system from detection, delivery follow up and good clinical and biological aspects. It's a multifaceted problem but also a multifaceted solution.

Q – Is there any international support for ITAR?
A – At the moment what we have is, ITAR is funded by STFC, so we have a large number of people from the UK including Peter and Graham and the Oxford team etc, we are working closely with the US with a Non-Governmental Organisation, which is the International Cancer Call, The Medical Physicists without borders from Canada, as well as mostly African countries. What we don't have at the moment, is a lot of international funding, but it is clear that funding and collaboration support will help us to move faster. Of course, we have support from CERN because this project, originally the first meeting was hosted at CERN and because of that we felt somehow bringing people together and looking at the original solution was the key to moving forward. We would like more is what I'm saying.

Q – Do you have any comments on cancer treatment using lasers?
A – Well this is it, if we mean lasers in terms of time of radiation, one thing if we are talking about lasers to make more compact machines so that they are cheaper, faster, easier and so on; I think both modalities are necessary and there's a lot of research going on, but at the moment we don't really have a machine which is robust, reproducible, widely used, which can easily replace the current linac technologies. They are the major modality and certainly such type of techniques for them to be available or actually widely used in low income countries where the infrastructures are very weak, I think we need some time to make them suitable for this environment.

Q – What are the timescales for the design and delivery of this project and when you do force the first prototype design?
A – The prototype depends on the resources, both financial and people, so we are thinking two to three years for the first prototype. But of course, this could be reduced, depending on our funding and resources available, but maybe Peter can comment on that too?
Peter – Well, I can only reiterate what you have said, its driven by money and resources and we are on standby with resources. It's the money that we are trying to get, that's the current bottleneck at the moment.

Q – In order to improve cost and reliability without radical new technology, it would probably be necessary to sacrifice dose rate or system size, so how willing are low income countries to accept this?
A – Okay, so the thing is, I'm not just going to talk about radiation therapy, I'm talking about health care in general and also new technologies. We already know from our previous experiences and other fields, that developing countries, and quite rightly so, do not want to feel they are a second-class citizen, like they're getting second class treatment.

So, I understand that, of course, one of the ways of reducing cost is reduce dose or reduce the size, but actually, I'm not sure that the size is such a big issue in developing countries because real estate is not the big challenge, actually its people training, expertise, electric power, all sorts of other things which claim more drive and so on, and then I think that we already know from some of the new research that's going on, using hadron therapy and using flash, that reducing dose is not really the best way to improve treatment and outcomes. So, I'm not sure that reducing the dose is the best thing. But if we talk about rather than using variable energies, trying to come up with one particular energy range where you could treat more than 90% 95% of the patients and it would make the machine more reliable and less complicated and so on. Then that would work and this is one of the things that we are looking at.

Friday 4th September FRP Closing session 3:50pm

Chair: Graeme Burt (Cockcroft Institute/Lancaster University)

ERLs for Cooling High Energy Electron-Ion Colliders
Stephen Vincent Benson – Jlab

Q – What type of electron beam is used partially or totally polarised and what's the mechanism for polarizing ion beam generation?
A – So in the collider we do have polarised beams and those are created just using a Polaris laser on a gallium arsenide cathode, you just have to preserve it up to the collider. For cooling, the spin of the electrons it is irrelevant, so that beam is completely unpolarised and we use a high quantum efficiency cathode usually caesium potassium.

Q – In the coherent electron cooling scheme, how sensitive is the cooling performance on the arrival time of the electron and hadron beams?
A – It's not very sensitive to timing and in fact, sometimes you can use the small dither in the timing to create a more gaussian cooling distribution. One of the problems that you tend to have is that the tails tend to be cooled less than the core and so sometimes you actually want to dither the beam a little bit to get more cooling and the tales of the less cooling in the core, it is extremely sensitive to energy, so your energy stability has to be really excellent.

Q – How much is the ion beam by the magnetic field used to bend the electron beam?
A – It is because the ions are at least a factor of 2000 higher momentum than the electrons. The effects of the magnets that are used to bend the electrons are very, very small and you can use some upstream correctors to counter those bends fairly easily. For some ions, its more than a factor of 10-20,000.

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S30XL (aka DASEL): a new beamline for dark sector exploration
Thomas Markiewicz – SLAC

Q – What is the wavelength and power of the laser used for generation of the electron bunch and what is the length of the electron bunch?
A – Well we are going to start with just dark current and there is no laser yet. I will need to get back to you with the exact answer for what the exact power of the amplifier that we've had the amplitude company prototype.

Q – Do you have any problems with dark current coming from the main linac at different energies?
A – I doubt it because the collimation system should be able to make sure things are on energy. Our biggest fear is that as the system is so well designed that there won't be any dark current at the point we put our kicker. We wanted to begin this project with a laser, its expensive and it decreases our potentially harmful interaction with LCS2 and so it was decided that to do this thing in phases, so that we can understand what our needs were before approaching the project with that request.

Q – With the electron gun, normally they are trying to get as, much dark current gone as possible to minimise it. Did you specifically ask the designers "can you design a gun with more dark current?
A – Absolutely not, we'll take what happens.

Q – During the new injector commissioning, have you measured the transverse emittance and energy spread and can they reach their requirements for LCLS2
A – For the injector commissioning part we are still in the low energy range that is below MeV. we cannot measure the standard transverse emittance which we define as normalised because it is in a speed charge dominated regime. What we did is measure energy, we measured thermal emittance with very low charge, at the pC level or even sub-pC level. So, the thermal emittance characterisation was done based upon 0.8 micron per millimetre which is the expected level. So, the energy spread we didn't know at this moment how we raise the requirement for LCLS-II, and that we will be commissioning at the early stage when we restart with the first cryomodule, where the energy will be at the 100MeV level. We have a diagnostics station at the off-axis diagnostic beam line to do the full characterisation for the injector beam.

Q – What is the RF amplitude and phased stabilities for the normal conducting RF gun?
A – So for the Gun gradient it is 20 MV/m I think. So, they are designed to get to 750 KW. For the specs for the stability I need to check the details. So basically, the present commissing, in terms of the RF parts we achieved the RF capability as the ion source, the energy gain and the jitter level is basically within our specs.

Q – Do you have plans for at looking at novel FEL methods such as harmonic generation, polarisation control or two-colour outputs
A – Yes, actually we do have different groups investigating the new capabilities for the future, that definitely includes the two colour operation with a dechiper to do fresh bunch mode and all the other ways, so at this moment the commissioning team and the project team are focusing on the baseline configuration to reach the beam energy to achieve the good quality electron beam for FEL lasing in SASE modes, but the specs and the design are resolved for future upgrades with new capabilities.

Q – I'd seen there had been some very good R and D on your dechirper that you had just mentioned, will that be baseline or just an alternative?
A – No. So, the dechirper on the hard x-ray line is still there, so we should be able to use it if – the first thing is the radiation consideration. Rather, we will not use it when we start commissioning. Once we have established everything within the beam loss requirements, the dechirper can be tested directly on the hard x-ray line. The soft x-ray line – there was a project but so far it has been deferred. We will see the experience in the hard line for the existing dechirper, to see how much improvement of control upgrades are needed to install the new dechirper in the soft x-ray line.

2nd Student Prize Winner Talk (Sponsored by the IET)

High Power Conditioning and Breakdown Studies in Coupled Accelerating structures
Lee Millar (Lancaster)

Q – Do your think model will be able to predict an optimise how the optimal algorithms for conditioning structures and speed up the time it takes to speed up the structure in the future?
A – Yes, that's one of the goals of the model. We haven't tried it yet, we are still working on trying to fix a few bugs but later this year we plan to trial various different algorithms to condition the structures because its much cheaper and faster to place those into a model that runs in minutes as opposed to running a full structure test. The end goal would be to find some sort of optimized approach through the simulation and then to trial that in the test stand.

Science case for FELs
Jonathan Philip Marangos - Imperial College of Science and Technology

Q – What are your opinions about laser produced plasma channels as an undulator and conventional undulator for FEL?
A – We have certainly look at the current state of laser produced plasma, laser accelerators and Plasma Wakefield accelerators. I think there is a very strong synergy with the project which we discussed in some detail for development of a plasma Wakefield test facility. The level of maturity of laser acceleration does not seem sufficient to base future technology on very seriously. So, for that reason it wouldn't be possible to have a concept design based on current technology, they are still very much under development.

Q – You seem to favour option to the hybrid option. Do you have any rough ballpark figures for the cost of this?
A – No, we simply don't have a reliable cost model and we wouldn't like to suggest figure. There are some internal estimates but I don't think they are fit for public consumption

Q – With the several FEL's that you already mentioned, are already in existence. For these future concepts that you have talked about is there an advantage to building a new facility from scratch like the UK FEL as opposed to upgrading an existing facility?
A – Yes, in terms of having a complete blank sheet to start with, you can figure things how you like, you don't have space constraints which are rapidly inevitable in any existing facility. They are hardwired into the facility so I can certainly foresee huge opportunities in terms of additional functionality at end stations which can themselves require quite significant infrastructures. I don't just mean high power lasers, but for instance terahertz sources and electron beam sources, so I think upgrading is always an option and we have look at that and discussed that but I don't think that will deliver the full range of science that we have included in that science.

Overview of machine learning effort for particle accelerators. Andreas Adelmann – PSI

Q – I was very interested in the virtual diagnostics; what sort of inputs went into that in order to predict the transverse profile?
A – You put the transverse deflecting cavity (TDC) in and you do some measurements. You scan your machine, you use your measurements so you have a label data set. The Y's is basically whatever you want you measure with the TDC and the X's are the settings that steer your accelerator. This is basically the basis of the model and then you can construct a surrogate for the diagnostics and then you take the diagnostics out and run the machine on different settings and the model will redeploy for you.

Q – Is there a coordinated effort to apply these methods to test machines that have more beam time available?
A – With the deep neural networks you need a sizeable training set. If you have a production machine this is sometimes not possible to get beam time, this is why we use the AWA machine at Argon, that's a research machine. For these type of pilot studies, to see if its goes somewhere, these pilot machines are very helpful.

Q – Do you have any recommendations for organising any disciplinary work as university sites with separate physics, computer science departments may make this challenging?
A – I know many of the colleagues that are using machine learning, they work very close with the university because usually they are the people that do that for their life. Machine learning is the primary subject, so we try to use the techniques they development for our purpose. So, in general in our community has a lot of very fruitful collaboration going on between universities and in our field. The nice thing is, if you have data, the real estate of all machine learning is data so if you have the data and you can share the data, the acceleratory community can benefit nicely.

Q – How far away are we from being able to have a machine learning design a whole accelerator?
A – I'm doing a data set at the moment and the phases are bound, the laser spot size is bound, the pulse length is bound and within this relatively large space, I can do fantastic interpolation. But, if you start on a green field that's a totally difference question, because in such a case I don't want to have bounds, so what I would need to have is a template. Your template would probably be some Hamiltonian, and this Hamiltonian describes an accelerator in some glorious detail. So we have a master equation and then I'm learning this master equation. So that would be your dream right there. I'm optimistic and there is a lot of potential that we can or should exploit to have a possible machine learning model that starts on Greenfield.

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