ILC Work Plan for the LCC Phase

It is amusing to note that essentially all of the PAC recommendations from the TDR review are addressed in one way or another in this work plan i.e. we agreed with the PAC on the major issues.

SRF, Cryomodules and the XFEL

In terms of cryomodule design issues there was a general consensus that we should continue to develop the alternative KEK coupler which should prove cheaper and more reliable than the current designs. This new design will be investigated jointly by KEK and DESY and will be available for the cryomodule design review later this year. The coupler development will be done at KEK. It will be modified to have a "plug compatible" 40 mm iris aperture. We can expect a coupler to test in ~2 years. The XFEL startup experience emphasizes the couplers as a potential problem.

I think it is prudent to pursue an alternative design given the current XFEL problems with the modified TYPE-III coupler. However, it is not correct to assume that the alternative is cheaper or more reliable. Ironically the current TYPE-III is cheaper than the only known cost (admittedly a Japanese cost, which tends to be higher at first), and reliability needs definition. What is important is to first identify what our goals are for the coupler. And not to follow an R&D path independent of the existing (and rapidly growing) knowledge base with the existing coupler. We have indeed identified the coupler cost as a primary area of future focus. But to me this suggests design for manufacture, and (important) looking beyond the cost of the coupler itself to understanding how the design influences testing, conditioning and finally string assembly. Second, the XFEL coupler works. We have many of them. It is true that they have not been tested at 400 kW for 1.5m for long operational periods, but they have sustained up to 1MW for short pulses. During the 9mA operation only one coupler (an original FNAL coupler which has since been removed) caused any problem what so ever. The problems with the coupler began when we asked industry to try and mass produce them. Therefore I would strongly urge that any future coupler programme be made with a strong involvement of industry from the start. In order to gauge cost and "reliability" benefits, several prototypes need to be constructed, preferably by more than one vendor. This is beyond the basic R&D goals of a design which meets the technical specs of power, heat load etc.

A "shorter" version of the XFEL tuner consistent with the current ILC slot length will be both cheaper and more reliable than the S1 global style blade tuner. It will need some redesign work and the suggestion is to see whether CERN and CEA-Saclay could help with this. There was some discussion about

the desirability of making the motor more accessible if possible. The consensus was that we adopt this as a goal.

The XFEL cost which is quite low suggests that an XFEL-like tuner would be cheaper. We have of course no data either way to suggest anything about reliability. (Yes there is the FLASH experience with tuners, but this is still rather low statistics). What is probably important is that 800 of these tuners will be deployed and after some operational period will tell us a great deal about reliability, and if indeed they need to be modified for ILC. A question here is whether or not we can wait this long (>2016).

The tuner needs to go through a complete FMEA to really understand which failure modes are critical. This is very important for the discussion on access to motors. The discussion needs to be made with consideration of pre-assembly testing and 'burn in' and indeed our approach to cryomodule testing. For cost, as with the coupler we need to also include the broader picture of the tank design (and magnetic shield design – not mentioned any where in this document), as well as influence on string assembly. Finally I believe the slot length constraint is not strictly justified at this time. Even if we can make a 'thinner tuner' the impact on string assembly should be considered. I note in passing that Lyn did mention getting CERN interested in this (also for the coupler I believe).

The cryomodule quadrupole package is not yet demonstrated. L-band prototype BPM's are under fabrication by KEK & KNU (korea). This will include electronics. A conduction-cooled SC quadrupole is under fabrication at Fermilab with KEK and is to be installed and tested at the STF CM-1 at KEK in 2014.

One comment of caution is the BPM needs to be 'cleanable' to ILC standards (what ever they are). In the past the 'cold vacuum' police here at DESY were very strict about such things. They were particular suspicious of re-entrant designs (for example).

There is no official baseline cryomodule design. At this time the Fermilab type IV is probably the closest, and we will need a complete drawing package before contemplating production. Possibly a team from CERN, KEK and/or Fermilab could be asked to do this.

While this is possibly true at the M3 nut and bolt level, it does sound rather negative and in my opinion gives a false impression. Especially as we are telling everybody we are ready to go. Many of the features of the cryomodule (top-level parameters) are baselined. We don't have a final 'ready for production' ILC prototype, that is for sure. But you wont have that in a hurry.

Lyn wants to review the cryomodule design (tuners, couplers, etc..) How do we go about this. The suggestion was that we should try to schedule a cryomodule review around the Tokyo workshop. This has the benefit of minimizing travel but results in an extended trip. If we are going to have a cryomodule design review then we will need to have an official working design. We need to have reasonable time and homework assignment to generate the necessary designs. We should try to resolve 5K shield finally one way or another. The removement will be beneficial to save the production cost and to improve accessibility in case of maintenance with minor additional load in thermal balance

For the review you should have the best experts available who would be willing to participate. Beyond KEK I would assume that includes the DESY, CERN and FNAL experts who are not strictly working on ILC and would not normally attend an ILC workshop. I would suggest to make a list of the 'reviewers' and goals for the meeting. and then consider location and timing.

Note that we have 'reviewed' the cryomodule many times. I often get 'groundhog day' syndrome as we debate the same concepts, relive the same arguments and drag up the same history and rationales. In order to make solid and technically driven decisions based on factual evidence there needs to be more data. Certainly once decided prototypes needs to be build to show that the assumptions were indeed valid. The Type-IV was proposed in 2005 at Snowmass. Have we built one yet? (I guess CM2 is close?)

While I don't disagree on the concept of a review, we should note that the best time to have one would again be after the 100 hundred modules for the XFEL are complete. We can have one now, but I can't believe we will not want to have another one once we have all that experience and data at hand.

Are hub labs the best way to proceed ? Yes

How to benefit from XFEL production, how can we help XFEL (a win-win is obviously the best solution). The proposed plan involves providing additional manpower at DESY led by Nick to allow additional QC analysis from the GO/NOGO project based XFEL approach. Joachim Mnich later confirmed that some help was possible in this regard. Production issues will need to wait for additional experience.

Not sure what "GO/NOGO" or "Production issues will need to wait for additional experience" here means. But I can at least tell you what we are planning. I have started discussion with the cavity database people here about supplying top-level tables of key

production parameters which we can monitor for trends and correlations. This includes non-conformities right across the production process. The resource issues still need to be discussed, but right now we have quite some people thinking about which 'signals' to monitor and correlate. Our plan is to produce updated statistics over time. Some sensitivity to vendor data which needs to be resolved. See related comments below. We need to extend this to the CM assembly at Saclay, but that needs some discussion with Olivier how best to implement that.

The cavity R&D effort will continue in Japan but with limited statistics (~ several cavities in coming years, and ~ 10 cavities in two years) and will provide cavities for CM-2a and 2b after the CM1-cavities already tested and counted/evaluated in yield statistice.

Personally I think XFEL is our cavity programme, or at least will possible drive it, beyond just continually making cavities in the other regions for cryomodules. At least with respect to achieving the required first (and even second pass) yield we have boasted about in the TDR. Without a doubt achieving the cost reduction factor we put into the TDR should also be a goal: this will be strongly influenced by how we now study the IKC and the 'real manufacturing' models we assume - i.e. not just basic R&D.

Field emission and in particular fixing an FE criteria for acceptance testing standards that can consistently applied across infrastructures is also a TDR recognized goal.

Picking up on some of the cost-saving production ideas from the industrial studies would also need R&D. We should catalogue them and see if we can learn something from the XFEL (who are clearly not going to change their process). In the end though any new or modified process needs statistics, and that has always been our problem.

Lastly, R&D for very high gradients and Q0 should be supported, not least because this is what cavity R&D people really want to do, so it will keep them involved. We will likely get the high Q0 work for free, given the interest in it for cw light source machines. Our excuse here is naturally the TeV upgrade.

The EU hi-grade programme has not started yet but will in the foreseeable future. Since the XFEL is currently testing all cavities to quench what will the hi-grade program actually do ? (who is running this – Eckhard ?)

Technically ILC-Higrade finished last year – at least the funding! The cavities that it paid for are now arriving. Two already here and the next two arrive next week. Two per month (on per vendor) from now on. These cavities are delivered without the helium tank, which allows us to do much more with them than is foreseen for the XFEL production. After their initial VT test they are essentially available to our R&D

programme. We can do T-mapping and second-sound measurements, look at them with the KEK/Kyoto camera. After removal of the HOM we can also do complete mode measurements on them. Finally, they are available for additional surface prep (EP or CBP), grinding or other 'fixes'. They will add 24 cavities to our existing R&D database of experience. They are of course also free to be shipped to other labs if that would be beneficial. Eckhard is technically in charge of this programme, which has several post-docs and students working on it.

In the US we have a recent batch of 10 cavities delivered but no plans for additional ones after that. At this time it is not obvious that all 10 cavities will be processed and tested. The 1.3 GHz program will be de-emphasized with respect to the lower frequencies needed for Project X.

Rongli has indicated that he wished to step down from running the cavity R&D meetings and the proposal is to have Hitoshi take over for the next 1 to 2 years and then Kirk. Since everyone agrees that the cavity R&D team has been very successful; we choose to preserve their autonomy. Akira and Mike have drafted a letter asking Hitoshi to take over from Rongli. The letter is to be sent to the KEK management. This letter will outline those technical areas of ILC interest that we would like the R&D team to pay attention to.

Implications of a phased proposal

The proposal is to recommend the approach of leaving the "empty" tunnel closest to the IP. Although it is the most expensive solution at 75% of the final project cost (the cheapest is ~68%) there are many advantages: adiabatic energy upgrade allows for more aggressive gradient goal, low rate CM/HLRF production over many years is attractive for vendors, beam dynamics better (high energy transport), tunnel utilities available.

The 10Hz scheme required for low energy operation is "unattractive and expensive". This suggests we revisit the conventional (non-polarised) alternative. We should also see if the shorter pitch undulator R&D can be started somehow in the UK or the US without any money.

Some recent work at DESY hints that the 10Hz operation may not be necessary with the existing baseline hardware. We should review this anecdote.

Martin Gasol looked at the schedule impact and there is little difference (a few months) between any of the phased approaches.

We should agree on a required cryomodule production rate based on these schedules.

We will write a short document (~10 page) to describe the issues and justify the conclusion. Nick is the lead on this.

Design Issues & Technology

The biggest technical issue at this point is positron production. The rotating target R&D has stopped due to lack of money in the US and may remain that way for a while. The preliminary results did not validate the 100 m/s target concept.

Work on a non-polarised conventional source has continued at KEK (and DESY). We agree that we should look more closely at the implications for a conventional source. What is the correct way to proceed on this ? a workshop ? KEK will support further conventional source R&D, based on the consensus derived during the workshop.

As usual you need to get all the 'stake holders' in the room, and this one will be interesting. A workshop would seem the best approach, providing it is carefully orchestrated. This is really an AD&I issue as things go beyond just the source per se. We need to understand the implications for the DR for one, and we need warm linac experts (CLIC?) to discuss the challenges of both the e- production beam accelerator and the e+ 5 GeV booster accelerator. Beyond that the R&D on targets etc needs to be carefully scrutinized. Finally cost of the facility should be addressed (including operational costs), and this will include CFS. I certainly think a hard look at this alternative source is overdue, because it looks promising. However, we should be cautious in saying that is a viable option for ILC – we may just swap one set of problems for another. Whatever we do R&D funding is needed badly for the source.

I note also in passing that there are ideas for a 1.5ms pulse 5Hz conventional source from John Sheppard which might also be worth a look at. John always thought it was feasible.

People are looking at the possibility of a common BDS design for both machines. Current BDS design does not include lessons learned from ATF2. We intend to continue with beam-based alignment studies if possible at the SLAC facilities.

I'm not sure what you expect from ATF2 that might cause a change of design for ILC. The tuning algorithms being developed will certainly be brought over. The current focus on wakefields is more a lesson forgotten by ATF2 than a lessor learnt for ILC (there were quite some studies for the RDR). Possibly the addition of skew-sextupoles to the ILC lattice could be considered but this is quite trivial. The instrumentation and software development is the biggest contribution – beyond of course the basic demonstration that the optics work.

It is important that an individual (with some resources to support him/her) is clearly identified as being responsible for the ILC BDS design. This is what has really been missing in the last few years. There are many design/integration issues that need attention, in particular in the IR region which requires coordination with the detectors. Some of the issues that Olivier and I alluded to could be considered, but they would reflect major changes in the lattice – how far down this road do we want to go? The whole FD stability tolerances and beam-beam feedback implementation needs some scrutiny in my view. The compact local-correction scheme is still tricky to tune and needs many iterations. A FFTB-like system – although longer – may prove easier to implement in this respect. Also removing the very strong sextupoles from the FD loosens their vibration tolerances considerably – always considered a major cold-linac advantage. Much could be benefitted from carefully and unbiased studies of these alternatives.

In general start-to-end beam dynamics has suffered though lack of resources. There are probably a list of studies do be done under the heading of 'bringing up to date'. With a complete lattice now in place – and if we could find the people – a repeat of past studies would be quite useful.

Other hardware items which fall into the cost containment (value engineering) category include the HLRF distribution system, modulators, short pitch undulators, and RTML HTS quadrupoles.

Are the benefits of HTS just in power consumption? There are quite some stability requirements on these quads since BBA needs to be made using quad shunting. All this would need to be considered in any design. In the past we did discuss a DC bus approach to the RTML as used for the DR: is this sill worth looking at? Potentially also the BDS?

We plan to continue to operate the major beam test facilities: ATF2, CESR-TA, FLASH, as well as the systems tests at Fermilab and KEK. XFEL commissioning will become relevant towards the latter part of this work plan.

I recently proposed the expand the "9mA collaboration" to include NML and STF2 when they are available for studies. I think there was some resonance from the mailing list. This group could coordinate the studies which have been to-date all at FLASH,

suggesting studies to be done at one facility which could not be made at the others (for what ever reasons). It would also promote the exchange of the LLRF experts between the three labs. Once XFEL really gets going, all will be welcome to help commission it. Indeed If I can get this help, I will have little to bargain with when we start to ask for beam time for machine studies. We are not 'guaranteed' such time on XFEL as we are in FLASH (and even for FLASH this is currently being scrutinized, with no guarantee of the outcome).

We specially encourage that ATF2 effort to reach the goal of the anticipated beam size of 37 nm which correspond to the ILC goal with 5 nm in vertical size, as well as the beam position stability level of 2 nm.

We will continue the low-emittance transport studies with focus on integrated start-to-end simulations. All errors, both static and dynamic, and feedback/feedforward control will be included. The beam dynamics team will include KEK, DESY and CERN and hopefully SLAC and Fermilab.

Site Specific Issues

The Japanese preferred site will be announced in July. The site will be validated by some form of Directorate Committee of LCC and further (LCB). How this involves the TB and the ILC box is not clear at this time.

There are two categories of site specific issues: CFS related such as access tunnel layout, geo-technical like vibration, flooding, and utilities roads, power etc.. The other class of issues are straight technical such as the impact of a tunnel slope, installation of pre-assembled components. Also noted were possible implementation issues as outlined in the PIP. The demonstration of the CM operation with a tilti of up to 0.5 % will be important to verify the appropriate cooling stability using saturated superfluid helium. KEK will plan a demonstration using the Quantum-Beam CM hopefully in the coming one year.

The proposal is to define the scope of work through the TB and prepare the CFS group to start when the preferred site is known .i.e. do not wait for any LCC site validation. We (the TB) will discuss the plan of action with the CFS WG before the end of July. We do not yet have any estimate yet as to how long it will take to evaluate the site specific design.

The general engineering team should be re-arranged and established to prepare for engineering drawings and EDMS. It should be emphasized to

establish the baseline coordinate as worldwide ILC standard for all accelerator system to minimize any confusion in future.

Baseline & Cost

We will be proceeding from this point with the baseline design under change control. The TB will act as the change control board for internal machine items. We need to establish a mechanism with the experimental community to address items of common interest. EDMS (at DESY) will be mechanism to maintain the baseline.

The cost information associated with the baseline will also be maintained in EDMS. This process has started. It will be updated as necessary.

We will establish an ILC specific design & cost team to perform these activities. Initial victims would include Benno, Tetsuo, & Gerry.

As I mentioned in one of our meetings, having a cost group is mandatory. Benno can certainly provide the technical support for the cost basis (under lock and key in EDMS), and also help in preparing scenario studies (scaling) as Gerry has done in the past. But he can't do this alone, and certainly we need to implement some formality into anything that affects our cost basis.

Beyond ad hoc studies, this really relates to the bigger issue of change control, which I promised to send you some thoughts on. I'll try and do that next week. But in summary, we need to understand how we want to use the technical documentation we have painfully accrued in EDMS. "Maintaining the baseline" is really about maintaining the documentation. A formal change in the baseline will require updating of documents. It is quite an eye opener when you follow the paper trail, and see how even a relatively small change could require updating many documents in EDMS – including the cost. There are many ways to approach this and we need to make some decisions up front. Also we need to put something in place that can be flexible and hopefully evolve into an engineering database for the construction project. Or we can of course do what we did with the RDR, which was to leave the data to fester over the next years, only to find that it is all hopelessly out of sync and just needs updating en mass. More on this next week.