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Rev. 1

Notes from 24 Feb. 2005 Telephone Meeting Regarding 2 mrad Crossing Angle Design

Present: Rob Appleby, Philip Bambade, Olivier Napoly, Brett Parker, Mikhail Kostin, Deepa Angal-Kalinin, Olivier Dadoun, Andrei Seryi, Yuri Nosochkov, Cherrill Spencer, Takashi Maruyama, Lew Keller

The discussion followed the order of the notes from the 23 Feb. phone conference review of European work in progress which Bambade circulated just before our meeting.

There is concern about calculating correctly the off-axis extracted beam through the final doublet and beyond. Appleby has gotten "slightly different" results from the MAD deck Nosochkov posted about 10 days ago. Appleby is using the BETA program from CEA combined with MAD. Seryi suggested that this cross check should be repeated using Nosochkov's latest extraction model. Nosochkov will post his latest MAD optics on the web and tell everyone where to find it.

Bambade asked about the possibility of putting SD0 inboard from QD0. Seryi said he had tried this idea and found that SD0 needed to be very strong since the incoming beam dispersion was smaller at that location, but someone should check this work using the entire final focus optics including the upstream sextupoles.

Bambade asked if a QFX triplet was really an advantage over a single QFX. Nosochkov said the 20 mrad extraction line experience showed that the outgoing low energy tail was better contained with a multi-quad system vs. a single quad. Bambade said that including an SFX and a QFX triplet could be studied by a Valencia group (Faus-Golfe and student).

Bambade said a look at backgrounds has been started using BDSIM, but there are some technical problems with using BDSIM which first must be fixed. The loss calculations done previously by Appleby for radiative bhabha's from perfectly head-on bunches have been extended to include the worst case vertical bunch offset. It was pointed out that the increase in power in the low energy tail because of vertical bunch separation is compensated by the reduction of radiative bhabha lumonsity.

There was a discussion of design conditions for studying 2 mrad extraction: Starting w/ the most difficult case of 1 TeV CM as the European group has done or starting with an easier case of 0.5 TeV w/ the goal of extending to 1 TeV as the US group has done. Seryi pointed out that there are a large number of possible parameter sets at both CM energies, and we should give the parameters group feedback about the parameter sets which make extraction more difficult for all crossing angles. Bambade pointed out that there is the possibility of 1 TeV CM at reduced bunch charge early in the life of the collider which shouldn't be ruled out for the initial installation, and this would require the final doublet to be approximately twice as long. This design strategy needs a full discussion re: ranges of magnet apertures and fields.

There was a discussion of Seryi's work on 2 mrad extraction using a MATLAB/MAD/TURTLE package routine to do optics and plot tracked beam in magnets automatically. Seryi said that, except for QF1, he and Nosochkov had abandoned the "pocket quads" (i.e. sending the extracted beam through the coil pockets) of quadrupoles and sextupoles because the fields were too high and couldn't be magnetically shielded. There was discussion of Parker's superconducting, super septum quad concept for the extraction quads. Parker said the field in the 50x50 mm hole through the flux return for the incoming beam was only a rough guess but that the end effects were probably the biggest worry. He called this an "extreme" design and said it would be better if these could be a warm magnets. Seryi agreed that the fringe field at the ends of the hole was the biggest worry and that a few gauss field in the hole could be corrected upstream.

Bambade wondered about the strong field in the coil pocket of QF1, and how well do we really know this field in the simulations. Seryi replied that adjustability for this can be built into SD0 by splitting SD0 into two independent magnets for optimizing both the incoming and outgoing beams.

There was discussion about synchrotron radiation. Parker pointed out that this could be a big deal in superconducting magnets because of the high critical energies which aren't nearly as easy to mask as the much lower energies we normally deal with. (See the appended email from Parker sent after the meeting).

Discussion of further work on 2 mrad:

Bambade asked about the BeamCal hole size. Maruyama said he has used a 2 cm radius hole for his pair calculations, but that this was not optimized. He said that for a 1.5 cm radius vertex detector, the hole would need to have a smaller radius than 1.5 cm to keep photons off the vertex beam pipe, and that if there is a low-Z material on the face of the BeamCal hole to contain backscattering from pairs, then the low-Z hole would be even smaller. Bambade asked how many photons can we tolerate hitting within the IP region including the beampipe.

Bambade said they are studying the power losses in the extraction line using the full optics all the way to the dump. Appleby is doing this using weighted DIMAD tracking. The plan is also to include the sections planned for diagnostics. In addition, studies of backgrounds in the detector from backscattering due to lost particles are also starting using BDSIM, in collaboration with Grahame Blair's group at RHUL. Regarding beam dumps, Bambade said we need feasibility, not full design at this time. It was noted that the 2 mrad extraction line is ~600 m to the dump compared to ~200 m in the 20 mrad extraction line.

Action items:

0. Nosochkov post the latest MAD optics for checking with other codes.

1. Contact the parameters group: Bambade will speak to D. Schulte, Seryi will speak to Raubenheimer.

2. Appleby and Angal-Kalinin check putting SD0 inboard of QD0, but need full FF optics including the upstream sextupoles.

3. All: Start including synchrotron radiation in the extracted beam design. What tools? At minimum can at least trace photon fans from the charged particle trajectories. Parker said he would contact Christoph Montag to look at this with his method and Seryi said he would consider using MATLAB.

4. e-e-: Bambade said it was not obvious to him that e-e- should have to be accommodated in both IR's, maybe it is enough to only require it in the gamma-gamma IR. Seryi said someone (who?) should at least check the lumonosity in the 2 mrad IR with the final doublet polarities reversed for e-e-.

5. Frank Jackson and Angal-Kalinin will check the collimation requirements for the latest version and various parameter sets.

LCWS Meeting in March:

We should have another phone meeting sometime in the week before LCWS.

Addendum:

Sent by Brett Parker just after the meeting: Classification of SC magnets

I would like to put forth the following (very personal) scale for comparing my perception of relative difficulty (and risk). My categories run from 4 (hard) to 1 (easy) as follows:

4) The double aperture quadrupoles, sextupole-like for opposite sign and octupole-like for same sign gradients, that I studied a while ago were fun to consider but I really would not want to have to build such a magnet without a very extensive R&D program. There are fundamental issues that would have to be addressed to produce such magnets.

   Still the exercise was interesting in that it turned out in discussions with Animesh that we are able to set very general limits on how good the field quality can be in such magnets. It turned out that my hand optimized coils were not so far from the ultimate limit.

   The message for this class of magnet is that if there is no other way to achieve the physics goals then we could consider using these as a last resort. But then be prepared to mobilize resources to do a proper design.

3) In this class I put the super septum magnets and the high-field (tail-folding) octopoles. Here the

basic principles of the magnetic design are clear but many novel engineering details would have to be worked out to produce a final product. So some R&D is needed to verify that the final performance will be as advertised.

The main issues for this class of magnet have less to do with traditional magnet design than with additional considerations or constraints. For instance using rare earth elements for the octupole pole insert may not end up being practical from a materials viewpoint so we end up substituting another material (the concept may be sound but implementation details end up impacting final performance). Or for the septum magnets details that emerge once the energy deposition (say from synrad spray) is known end up driving the final design.

2) Here I include magnets like the high-field sextupole and the large aperture extraction line (compensating) magnets for gamma-gamma. Here we may have confidence both in the magnetic field calculations and the engineering issues are fairly straightforward. But still we are pushing limits compared to what has been done before and prudence suggests early prototyping (so there are no surprises). For the sextupole the final parameters adopted implicitly determine the choice of magnet production technology (i.e. direct wind or custom Rutherford cable design) that can be used.

For the gamma-gamma magnet a solution that brings the field seen by the spent beam down to a few hundred gauss level is easier than one that has to do a more complete compensation down to lower field levels. So in this case the final specifications end up impacting the final cost and complexity of the magnet even if the original design principles are straightforward.

1) Finally I come to the compact superconducting QD0 design. This magnet is only a very modest extrapolation from what we have done before and we expect to be able to make a short prototype coil in the near future.

The main issues here are a combination of imposing new requirements (i.e. vibration stability) and the realization that for such a critical element of a multi-billion dollar project we do not want to overlook anything.

> Since I'm sure that before anything will be designed
> and installed for the final linear collider project
> it have to be extensively reviewed, I don't really
> think there is too much risk of something being
> forgotten; however, at this early stage it is still
> good to do our best to anticipate what issues we can
> because they can have non-trivial impact on MDI.

I hope this helps to put various magnets into perspective. For instance returning again to the high-field large aperture sextupole, with the present parameters it looks like it can be done but we are close enough to natural design limits that is certainly prudent to reduce its peak field etc. (as you have done) in order to keep this magnet from becoming a full R&D project in its own right (i.e. not that the original magnet is impossible).