MDI Issues: Crab Crossing Issues

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Huge Detector Study Meeting, TV, KEK
FFIR Working Group of ACFA-LC
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http://acfahep.kek.jp/subg(ir/talks.html
Notes from Philip:

i) discussion and exchanges on BDIR/MDI topics to be studied jointly -> KEK
   ILC/WG4 convenors (all attended the meeting) suggest to use this as input towards the
   organization into sub-groups and tasks which they are setting up, including listing the
   critical issues in each. Confirmation that the crossing-angle issues will be discussed
   primarily in WG4, with also maybe a common WG1/WG4 session.

ii) master list of available resources (funded commitments, on-going work, expression of interest)
   per topic/theme to be compiled by Tom Markiewicz (continued from the file already circulated)
   and brought to the KEK meeting to support the work of WG4 -> needs to be more widely circulated
   and agreed among the institutes and groups concerned.

iii) decision to have a workshop focused on the MDI topics of the above list, in the form of a
   "working meeting" with sub-groups and group summary talk sessions, early January, possibly
   6-8/1/2005 at SLAC just before the accelerator school to be held at San Francisco. Other locations
   can also be considered, especially if it can be coupled to another meeting in planning during the
   same period, such as the global LC detector concept meeting now being discussed. The goal is to bring
   together both accelerator and detector/physics experts from the 3 regions, as relevant for each topic,
   to review/cross-scrutinize in detail each-others designs. The outcome should be the definition of
   common specifications, organization and (first sharing of) work. A preliminary plan for the topics
   to be addressed should be prepared which can later be amended following the discussions at KEK.

iv) encouragement (from Marc Ross) for MDI to "invent itself in creative way, possibly beyond traditional
    boundaries/ways" as group straddling the detector and machine communities, in view of the organization
    which will be set up for the machine and detector collaboration. Besides the importance of achieving
    optimal "coupling" between the two communities, there are also political arguments to consider,
    concerning funding, training of young people, careeers, etc....

v) one more phone conference meeting scheduled before the KEK ILC workshop, on Wednesday 27/10 7(6)am in
   Europe(UK), 2pm in Japan and Tuesday 26/10 10pm in America (Pacific time) to review:
   1. progress setting up the WG4 tasks and list of critical choices within (WG4 convenors)
   2. progress and review of master list of available resources to be brought to the KEK meeting
      (Tom Markiewicz et al.)
   3. preliminary plan for the topics of the MDI January workshop, decision on location and dates,
      status on informing IFCA/ILCSC/
   4. further thoughts on the positioning of the MDI activity in the organization, between the
      detector and machine
vi) additional "critical choices" that we discussed:
- maximum energy can have a significant impact on collimation and backgrounds
- impact of options (e-e-, gamma-gamma, e+ pol)
- impact of luminosity upgrade
- IP apertures
- bunch spacing impact on Detector and beam instrumentation

vii) Prior to next phone meeting we should continue to exchange by email ideas on MDI Workshop, updating topics, critical choices and Tom's spreadsheet.

viii) Defining BDIR and MDI.
a) BDIR. Agreement that BDIR is everything downstream of Linacs, consistent with WG4 definition for ILC Workshop at KEK. (Do we use "Beam Delivery" or "BDIR"?)
b) MDI. Converging on agreement of definition.
Still under discussion, but main 2 definitions were:
- "Impact on BDIR from Experiment" + "Impact on Experiment from BDIR"
- "Impact on Accelerator from Experiment" + "Impact on Experiment from Accelerator"
these primary definitions can be further refined, for example by excluding global design parameters such as luminosity and energy
Proposed BDIR Critical Choices (from Markiewicz list)

1. Crossing angles
2. Final doublet technology
3. L*
4. VXD radius
5. Collimation:
   - material and shape
   - passive or consummable
   - before/after IP switch
   - order of betatron, energy collimation
6. MPS: # bunches allowed to hit collimator
7. IP Collision stabilization: yes/no for following
   - feedback stabilization only
   - active final doublet stabilization
   - support tube
   - additional fast feedback in Linac, start of BDS
8. Detector questions (ex. EMI, gamma-gamma)
9. Beam instrumentation (ex. energy spectrometer)
10. Risk mitigation (beam tests)
IR: Crossing Angle Issue

\[
\frac{2\sigma_x}{\sigma_z} = 4.4 \times 10^{-3}
\]

Small angle: \( \phi \lesssim \frac{2\sigma_x}{\sigma_z} \),
Large angle: \( \phi \gtrsim \frac{2\sigma_x}{\sigma_z} \)

Why Small Crossing Angle?
- Detector \( \cos \theta \) coverage
- Timing of crab cavity
- Radiation in the solenoid magnet
  \( \sigma(\delta y) \propto \phi^{5/2} = 0.074 \text{nm with } \phi = 20 \text{ mrad} \)

Why Large Crossing Angle?
- Background to the detector
- Multi-bunch crossing instability
- Design of the final quadrupole magnet
- Layout of the beam dump

\( \frac{\Delta y}{\sigma_y} = 1.8 \text{ vs } 0.6 \)

at \( L^* = 3.5 \text{m} \)
(\( \Delta y^0 = 0.5 \sigma_y \))

K. Yokoya
Extraction line (head-on) at TESLA-TDR

The electric separator is 20m long with a divergence of 0.8 mrad. It has a loss of 0.01%. Further downstream, there is another loss of 0.1%. The photons are detected by a mirror with an angle of 15 mrad. The mirror is placed close to the electric separator, and the divergence of the beamstrahlung photons is 0.2 mrad (1 cm at 50 m). This divergence is too small for the mirror to detect the photons.
Set-up for TESLA at $E_{\text{cms}} = 500$ GeV

Super-Q with large bore  Conventional Q
QD (r=24mm)  QF (r=7mm)

$l^*=4.1\,\text{m}$

$1\,\text{m}$

$1.5\,\text{m}$

$R_{22} = 3$ from IP to QD exit

Total angle of 6 mrad between incoming and outgoing beam lines

Beamstrahlung cone at $2\,\text{mrad} \pm 2\sigma_x$, spent beam ($\leftrightarrow 2 \pm 0.5\,\text{mrad}$)

in "realistic conditions" means 10-16 mm extension at QF
Luminosity loss without crab-crossing for 2 mrad horizontal crossing angle

\[ \frac{L}{L_0} \approx 0.85 \]

Geometric formula $\rightarrow 0.88$
Proposed Design for $l^* \geq 4.05$ m

Design by Achim Stahl
QC1 (QD)

JLC: $L^*=2m$
$\theta_c=8\text{mrad}$
$L/L_0=0.6$
$6\sigma_x \ 40\sigma_y$

ILC: $L^*=5m$
$\theta_c=3.2\text{mrad}$
$L/L_0=0.7$
$7.8\sigma_x \ 42.4\sigma_y$

New design

Revival!
A. Miyamoto, June 2000
QC1 Coil Size
(unit: cm)

Z: 200cm to 420cm
Field Gradient: 226.03T/m
Current Density: 6.7 MA/m²
SF6 (Fe-Co Alloy)
Halo Collimation

- VTX with $r = 14$ mm requires mask with $r = 12$ mm
- Collimation required:
  - $x$: $7.8\sigma$ [TDR 13$\sigma$]
  - $y$: $42.4\sigma$ [TDR 81$\sigma$]
- Collimation requirements about a factor 2 tighter!
- Collimator wakefields?
- Reconsider choice of $L^*$
- Tail folding octupoles
Extraction Line: $\theta_c = 7\text{ mrad} \rightarrow 3.2\text{ mrad}$

- Opposite beam
- Beamstrahlung
- Water Dump: $1.6\phi \times 10\text{ m}$
- Free space: $301.8\text{ m} \sim 331.7\text{ m}$
Summary

Crossing Angle Choice

- Configuration of the Huge Detector
  - size (B-field), minimum veto angle etc.
- BDSIM simulation (GEANT4) for background estimation
  - $L^*$ (support of FQ)
  - collimation depth (synchrotron radiation profile)
  - layout of extraction line
- Crossing angle - small or large