Machine Detector Interface

Andrei Seryi
SLAC
PAC review,
November 2, 2009
Plan

• **IR integration**
  - Push-pull, detector moving system, stability
  - Final doublet & detector integration and prototype

• **Other MDI related systems**
  - Beam dump
  - Upstream & downstream diagnostics

• **SB2009**
  - parameters
  - optics and layout
Beam Delivery & MDI items

1 TeV CM, single IR, two detectors, push-pull

- Diagnostics Switch Yard
- Polarimeter
- Collimation: β, E
- E-spectrometer
- Tune-up & emergency Extraction
- Tune-up dump
- Final Focus
- 14 mr IR
- Main dump
- Muon wall
- Extraction with downstream diagnostics

- Optimize IR ensuring the needed detector performance & efficient push-pull operation
- Agree on division of responsibilities for space, parameters and devices

- Grid: 100m x 1m
- Sacrificial collimators

PAC Review, Nov/2/09 A. Seryi, MDI: 3
IR integration

- Machine – Detector work on Interface issues and integration design is a critical area and a focus of efforts
- IR integration timescale
  - **EPAC08 & Warsaw-08**
    - Interface document, draft
  - **LCWS 2008**
    - Interface doc., updated draft
  - **LOI, April 2009**
    - Interface document, completed
  - **Apr.2009 to ~2012**
    - design according to Interface doc.

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Functional Requirements on the Design of the Detectors and the Interaction Region of an e+e- Linear Collider with a Push-Pull Arrangement of Detectors

B. Parker (BNL), A. Mikhailichenko (Cornell Univ.), K. Buesser (DESY), J. Hauptman (Iowa State Univ.), T. Tauchi (KEK), P. Burrows (Oxford Univ.), T. Markiewicz, M. Oriunno, A. Seryi (SLAC)

Abstract
The Interaction Region of the International Linear Collider [1] is based on two experimental detectors working in a push-pull mode. A time efficient implementation of this model sets specific requirements and challenges for many detector and machine systems, in particular the IR magnets, the cryogenics and the alignment system, the beamline shielding, the detector design and the overall integration. This paper

Example of MDI issues we are working on

Detector motion system with or without an intermediate platform

Detector and beamline shielding elements

 Significant progress in design of these systems over summer 2009
 (Working mtg of CERN, DESY, SLAC, FNAL colleagues)
Example of system where initially different designs converged on a single compatible solution: CMS-Inspired Hinged PacMan w/ Cut-outs for ILD Pillar and Plugs.

SiD  ILD

M.Oriunno, H.Yamaoka, A.Herve, et. al
Detector support and motion system

- The Summer working meeting, also focused on detector support and motion system
- Starting assumptions
  - ILD (segmented): use of a platform
  - SiD: without platform
- First step: aim to find a technical solution compatible with two presently different assumptions
- A solution was found (next slides)
- Conclusion: further progress depend on understanding how platform change detector and FD stability
- Consequently, detailed studies of detector stability have started
All detectors without / with platform
Half Platform w/ Pocket Storage

A.Herve, M.Oriunno, K.Sinram, T.Markiewicz, et al
First look of platform stability look rather promising: resonance frequencies are rather large (e.g. 58Hz) and additional vibration is only several nm.
First analysis shows possibilities for optimization
- e.g. tolerance to fringe field => detector mass => resonance frequency
Free vibration modes of SiD

1st Mode, 2.38 Hz
2nd Mode, 5.15 Hz
3rd Mode, 5.45 Hz
4th Mode, 6.53 Hz
5th Mode, 10.42 Hz
6th Mode, 13.7 Hz

Vertical motion

M. Oriunno
QDO supports in ILD and SiD
ILD FD stability analysis results

Results: Responded amplitude at each resonance.

@ KEK-ATF
0.1Hz  1e-5m/s²
1Hz    6e-4m/s²
10Hz   6e-4m/s²
100Hz  2e-3m/s²

Hiroshi Yamaoka, KEK
Stability studies at BELLE

Measurement: B
How is the coherency between the tunnel and floor?

Perpendicular to beam line

Beam direction

Vertical direction

Hiroshi Yamaoka, KEK

- Horizontal dir.: 0~Hz, ~3Hz
- Vertical dir.: 1 ~ 20Hz
CMS top of Yoke measurement

PSD of the signals Vertical direction

Detector vibrations and QD0 support

Alain Herve (ETH Zurich)

PSD of the signals Beam direction

Cooling system OFF

100 nm
ATF2: model of ILC beam delivery

goals: ~37nm beam size; nm level beam stability

- Dec 2008: first pilot run; Jan 2009: hardware commissioning
- Feb-Apr 2009: large $\beta$; BSM laser wire mode; tuning tools commissioning
- Oct-Dec 2009: aim to commission interferometer mode of BSM, sub $\mu$m beam
ATF2 final doublet

ILC Final Doublet layout
SC Final Doublet and ATF2 tests

- SC FD prototype at BNL
  - make long coil test of ILC-like FD prototype; long cold mass & its field tests
  - ILC-technology-like SC Final Doublet for ATF2 upgrade
  - Will test FD SC stability at BNL and system test with beam at ATF2
SC FD for ATF2

BNL & KEK are working on joint design of FD cryostat and cryo-system

273 mm Cryostat OD

57.2 mm Bore Warm Beam Tube

Cold Mass

Heat Shield

Cross Section View at Support Location

Long coil winding

View Inside Cryostat of Support Structure

Brett Parket, et al, BNL

QD0 R&D - “First Layer”
Start of ATF2 coil production & measurement

First quadrupole coil set

First sextupole coil set

Sextupole Close Up

Quadrupole Close Up

BNL, Brett Parker et al
Cryogenic system design

- Design of cryogenic system is critically important
- KEK and BNL colleagues started series of working meetings to develop complete cryogenic system / FD cryostat design
  - Proposal for the cooling scheme @ ATF2: Re-condensation cooling type with low vibration cryo-coolers.
  - Modification of design to the FD cryostat, to reduce heat load is considered, for better match to the cryo-system solution
- Joint plan / budget / schedule will be developed

N. Kimura, A. Yamamoto, T. Tomaru, K. Tsuchiya, and T. Tauchi (KEK), B.Parker, A.Marone, (BNL) et al
18MW Beam dump

- BARC, India, & SLAC, collaboration

Steady state temperature distribution at z=2.9m (Max. average temperature 127°C)

Dieter Walz, Ray Arnold, Satyamurthy Polepalle (BARC, India), John Amann, at SLAC beam dump area (February 2008)

Had working meeting of the task force at SLAC in June 2009, have advanced the work on beam dump design and on its technical design report
Beam dump design

Vessel Shell

Window Cooling Nozzle Supply Pipe

Inlet Headers

Thin Window

Outlet Header

Flat Heads

Window Cooling Nozzle

Thin Window

Window cooling simulation

SLAC National Accelerator Laboratory:
J. Amann, R. Arnold, D. Walz, A. Seryi

Bhabha Atomic Research Centre:
P. Satyamurthy, P. Rai, V. Tiwari, K. Kulkarni
Energy and Polarization diagnostics

- **Upstream and downstream diagnostics:**
  - control systematics, measure effects of beam-beam interaction
  - R&D: system integration tests, reduction of systematic effects

Accuracy driven by Physics:

- $\Delta E_{\text{beam}}/E_{\text{beam}} \sim 100-200$ ppm
  - precision measurements of particle masses
  - Spectrometer techniques
- $\Delta P/P \sim 0.25\%$
  - Precision EW
  - Evolution of SLC polarimeter
  $\Rightarrow$ lower systematics
E & P diagnostics: recent R&D

Prototype, measure & correction non-linearities to sub-percent level

Corrected values 24 hours after calibration

Installed straightness monitor at ATF2 for studies of E-spectrometer position stability

D. Kaefer et al

M. Hildreth et al
## SB2009 Parameters (WA)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>RDR</th>
<th>SB2009</th>
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</thead>
<tbody>
<tr>
<td>No. of bunches</td>
<td>2625</td>
<td>1312</td>
</tr>
<tr>
<td>Bunch spacing (ns)</td>
<td>370</td>
<td>740</td>
</tr>
<tr>
<td>beam current (mA)</td>
<td>9.0</td>
<td>4.5</td>
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<tr>
<td>Avg. beam power (250 GeV)</td>
<td>10.8</td>
<td>5.4</td>
</tr>
<tr>
<td>Accelerating gradient (MV/m)</td>
<td>31.5</td>
<td>31.5</td>
</tr>
<tr>
<td>$P_{\text{fwd}}$ / cavity (matched)</td>
<td>294 kW</td>
<td>147 kW</td>
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<tr>
<td>$Q_{\text{ext}}$ (matched)</td>
<td>$3 \times 10^6$</td>
<td>$6 \times 10^6$</td>
</tr>
<tr>
<td>$t_{\text{fill}}$ (ms)</td>
<td>0.62</td>
<td>1.13</td>
</tr>
<tr>
<td>RF pulse length (ms)</td>
<td>1.6</td>
<td>2.0</td>
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<tr>
<td>RF to beam efficiency (%)</td>
<td>61%</td>
<td>44%</td>
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</table>

### IP Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Norm. horizontal emittance (mm.mr)</td>
<td>10</td>
</tr>
<tr>
<td>Norm. vertical emittance (mm.mr)</td>
<td>0.040</td>
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<tr>
<td>bunch length (mm)</td>
<td>0.3</td>
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<tr>
<td>horizontal b* (mm)</td>
<td>20</td>
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<tr>
<td>horizontal beam size (nm)</td>
<td>640</td>
</tr>
<tr>
<td>vertical $\beta^*$ (mm)</td>
<td>0.40</td>
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<tr>
<td>vertical beam size (nm)</td>
<td>5.7</td>
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<tr>
<td>$D_v$</td>
<td>19</td>
</tr>
<tr>
<td>$dE_{BS}/E$</td>
<td>2%</td>
</tr>
<tr>
<td>Avg. $P_{BS}$ (kW)</td>
<td>260</td>
</tr>
<tr>
<td>Luminosity $cm^{-2} s^{-1}$</td>
<td>$2 \times 10^{34}$</td>
</tr>
</tbody>
</table>
**e+e- pairs**

- Edge of pairs distribution in $\theta$-$P_t$ important for VX background
- RDR Low P: edge higher $\Rightarrow$ unfavorable for background
- New Low P: edge location similar as RDR Nominal

Pairs above the line increase background in VX detector

Edge of distribution is lowered. Number of pairs similar as in RDR Low P
• SB2009 is being studied by detector groups, to evaluate effects on detector performance
  – For particular case of VX hits by pairs, it is expected that the number will be between RDR nominal and RDR Low P

• Beamstrahlung – behaves as $1/\sigma_x^2$ (while $L \sim 1/\sigma_x$) $\Rightarrow$ can decrease $dE/E$ for certain physics processes with small $L$ loss
Low P Parameter Set with Traveling Focus

- Higher Disruption
  - Higher sensitivity to $\Delta y$
  - Intratrain Feedback more challenging
  - Vertical bunch-bunch jitter to be <200pm for <5% lumi loss
  - However, twice longer bunch separation will help to improve bunch-bunch uniformity & jitter

- $\beta_x$(LP)$\sim50\%$, $\beta_x$(RDR)$\beta_y$(LP-TF)$\sim50\%$, $\beta_y$(RDR)
  - Collimation depth 1.4x deeper (smaller apertures)
  - May have more muons
  - however, have space to lengthen muon walls if needed
BDS changes for SB2009:
- modify e- side to allow central region integration
- separate combined functionalities of upstream polarisation measurements + laser wire detection + MPS
SB2009 lattice, e- side

Fast abort line

Undulator

Dogleg

Photon target + remote handling

Sacrificial collimators + chicane to detect off energy beams

400m

DC Tuning line

To be done: insert polarimeter chicane; shorten ff without layout modification

Deepa Angal-Kalinin & James Jones
ASTeC, Daresbury Laboratory & The Cockcroft Institute

PAC Review, Nov/2/09 A. Seryi, MDI: 32
SB09 optics of e- BDS from exit of Linac to IP
The 250GeV CM luminosity is roughly half of what was projected for RDR 250GeV CM parameters.

Presently studying the way to recover the luminosity loss at 250 GeV, with use of tighter focusing and/or travelling focus.

### SB2009 at 250 GeV CM

<table>
<thead>
<tr>
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<th>RDR.250</th>
<th>SB09.250_1</th>
<th>SB09.250_2</th>
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<tbody>
<tr>
<td>Ecms [GeV]</td>
<td>250</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>N e-</td>
<td>2.E+10</td>
<td>2.E+10</td>
<td>2.E+10</td>
</tr>
<tr>
<td>N e+</td>
<td>2.E+10</td>
<td>1.E+10</td>
<td>2.E+10</td>
</tr>
<tr>
<td>nb</td>
<td>2625</td>
<td>1312</td>
<td>1312</td>
</tr>
<tr>
<td>f [Hz]</td>
<td>5</td>
<td>5</td>
<td>2.5</td>
</tr>
</tbody>
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Summary

- The Machine Detector Interface team is focused on
- IR integration
  - Push-pull, detector moving system, stability
  - Final doublet & detector integration and prototype
    - Fruitful collaboration with CLIC MDI team
- Other MDI related systems
  - Beam dump, upstream & downstream diagnostics
- Optimization of parameters, optics and layout