SiD Workshop, SLAC, March 2-4, 2009

LoI FCAL

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SLAC

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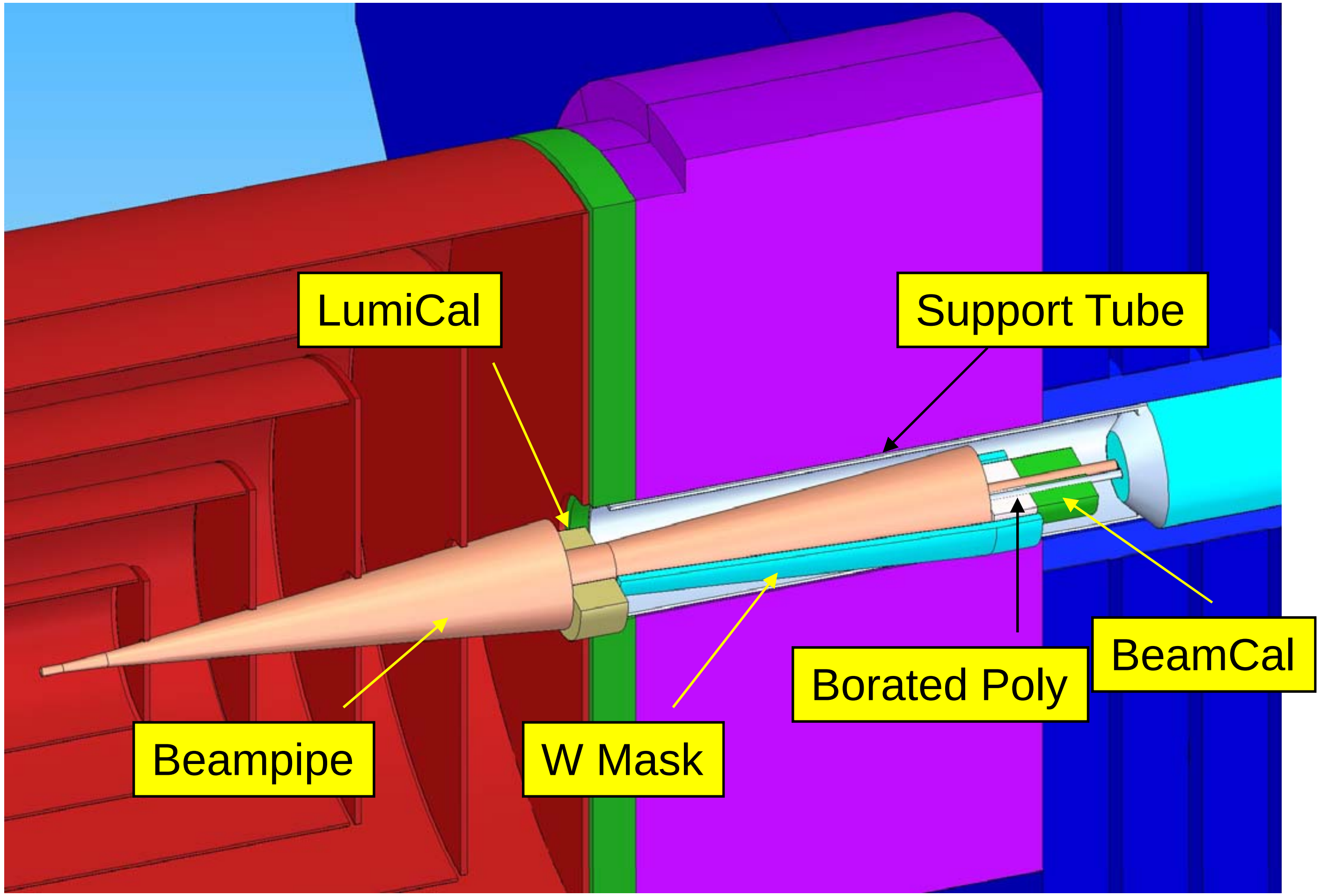
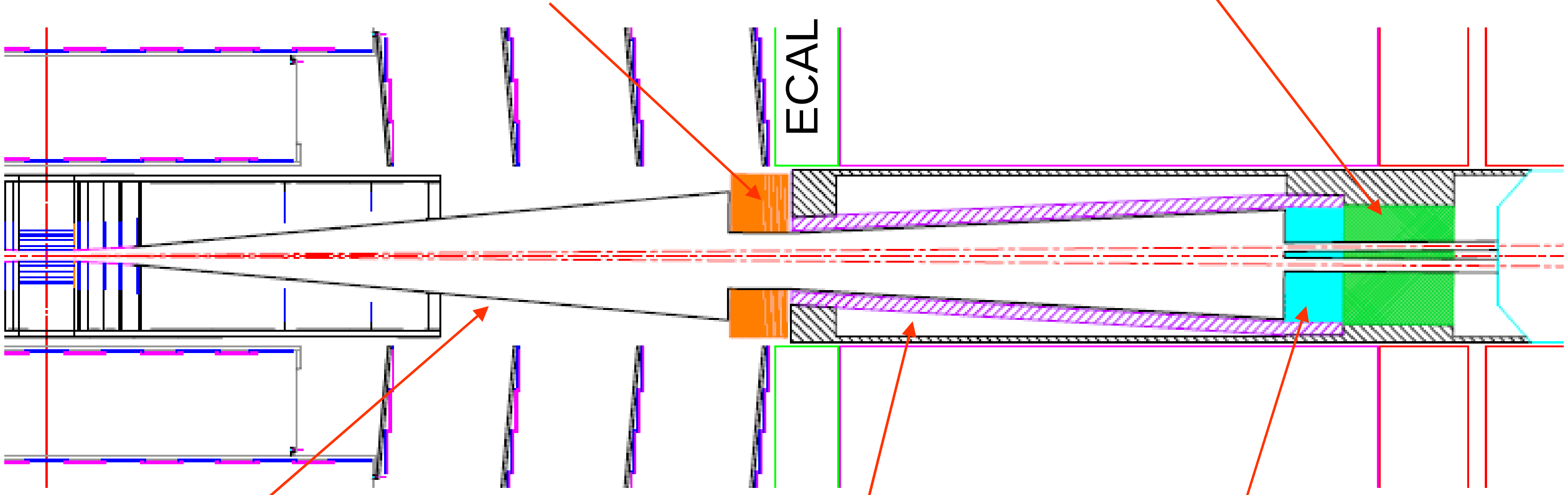
SiD Forward Region



SiD Forward Region

LumiCal
20 layers of 2.5 mm W +
10 layers of 5.0 mm W

BeamCal
50 layers of 2.5 mm W



Beampipe
+/- 94 mrad (detector)
+101 mrad, -87mrad (ext. line)

3cm-thick Tungsten Mask

13cm-thick BoratedPoly

Centered on the outgoing beam line

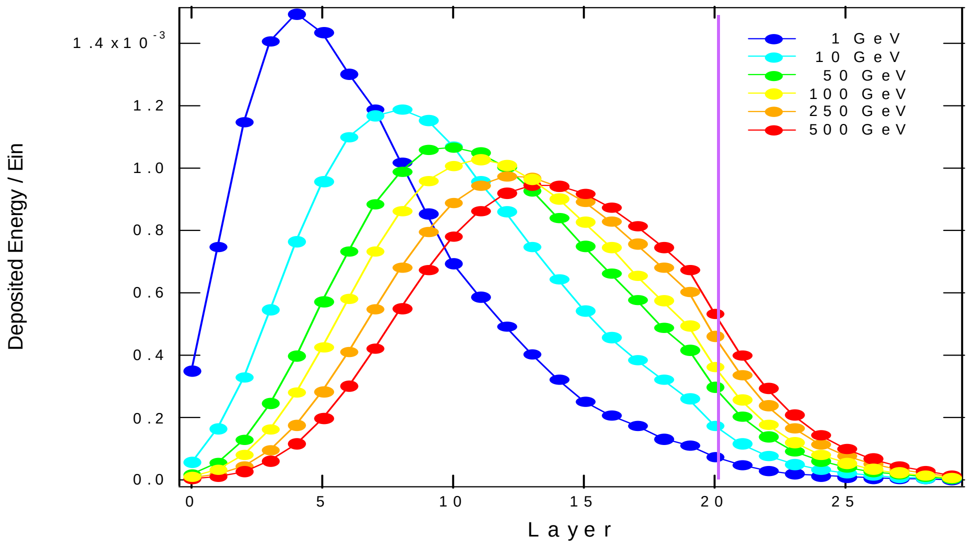
LumiCal

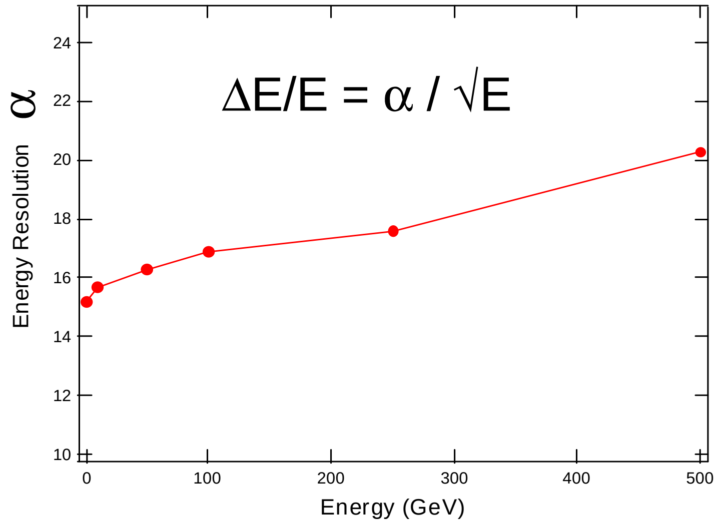
- Calorimeter coverage
  - $41 < \theta < 120$ mrad
- Precision integrated luminosity measurement
  - Fiducial volume: $46 < \theta < 86$ mrad
- Luminosity spectrum dL/dE
  - $\sqrt{s}$ is not monochromatic due to beamstrahlung emission

Energy resolution

20 layers of 2.5mm W+
10 layers of 5.0mm W

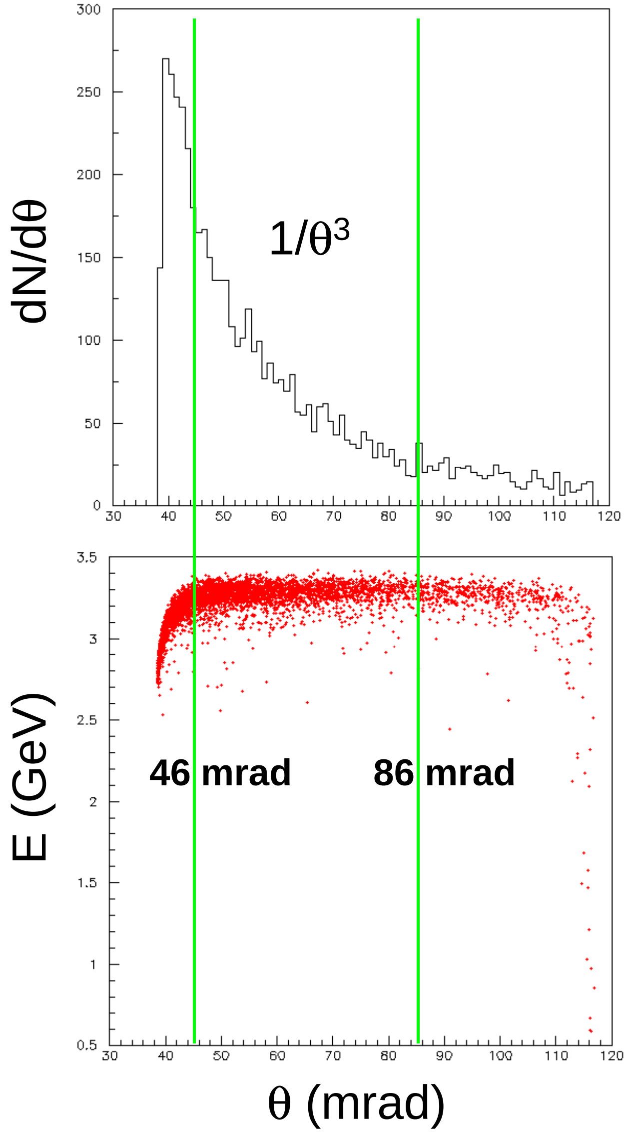
- Energy resolution parameter is dependent on energy
  - 15%/√E at low energy
  - 20%/ √E at high energy
- Energy leakage is small even at 500 GeV.





Luminosity measurement

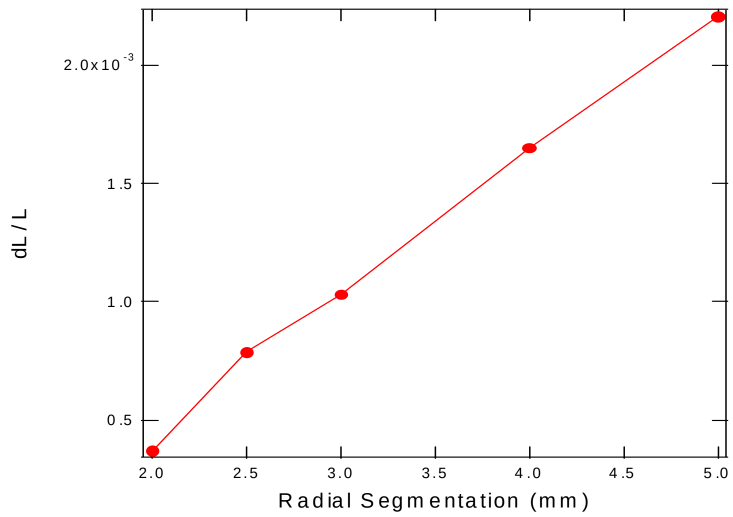
- Luminosity precision goal $\Delta L / L < 10^{-3}$
  - 10^6 W^+W^- events in 5 years (500 fb^{-1})
- $\Delta L/L=(N_{rec}-N_{gen})/N_{gen}$
  - Bhabha $d\sigma/d\theta \sim 1/\theta^3$
  - $\Delta L/L \sim 2\ \Delta\theta/\theta_{min}$, $\Delta\theta$ is a systematic error.
- $\Delta\theta$ must be less than ~20μrad to reach $\Delta L/L = 10^{-3}$.
  - Detector radial location must be know within 30μm.
- Bhabha event rate
  - N_{ev} / BX @ILC 500 Nominal= 5.9 $[1/\theta^2_{min} - 1/\theta^2_{max}]$ (θ in mrads)
  - 30 ev/sec for θ_{min}=46 mrad, θ_{max}=86 mrad



$\Delta L/L$ vs. segmentation

Radial segmentation $N\phi = 32$

Δr (mm)	$\Delta\theta$ (mrad)	$\sigma(\theta)$ (mrad)	$\Delta L/L$
2.0	0.008	0.042	3.3×10^{-4}
2.5	0.017	0.046	7.9×10^{-4}
3.0	0.023	0.050	1.0×10^{-3}
4.0	0.036	0.058	1.7×10^{-3}
5.0	0.049	0.069	2.2×10^{-3}



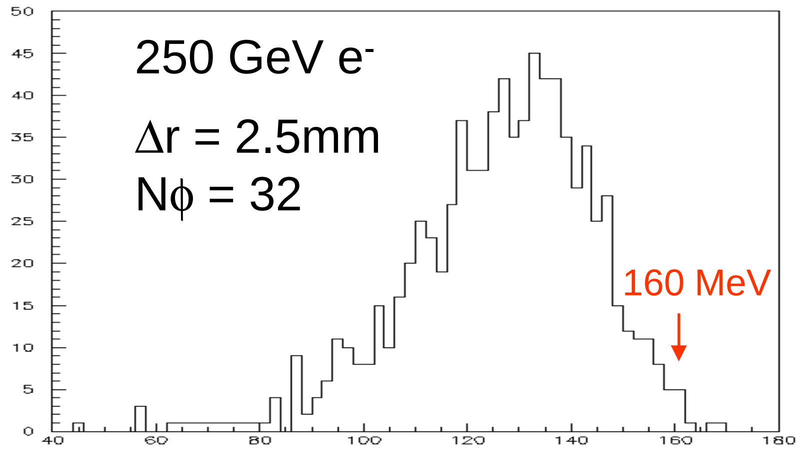
ϕ segmentation $\Delta r = 2.5$ mm

$N\phi$	$\Delta\theta$ (mrad)	$\sigma(\theta)$ (mrad)	$\Delta L/L$
16	0.017	0.046	7.7×10^{-4}
32	0.017	0.046	7.9×10^{-4}
48	0.017	0.045	7.6×10^{-4}
64	0.014	0.045	6.6×10^{-4}

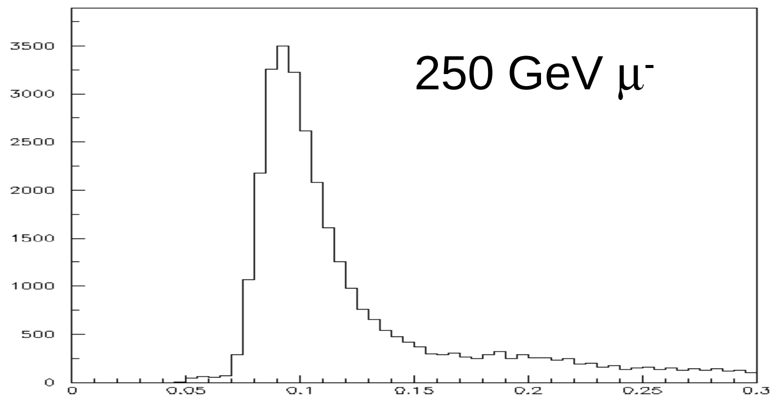
- $\Delta L / L < 10^{-3}$ can be reached by $\Delta r < 3$mm.
- Finer ϕ segmentation helps, but not much.
  - Finer ϕ segmentation will help shower separation.

Max Energy Deposition in Si channel

- Max energy deposition
  - 160 MeV (7010 fC*)
- MIP
  - MPV~0.0925 MeV (4.1 fC)
- Bhabha ~ 1710 MIP
- If we want S/N ~ 10 for MIP, we need 17,000 dynamic range.
  - 2 gains + 10 bit ADC



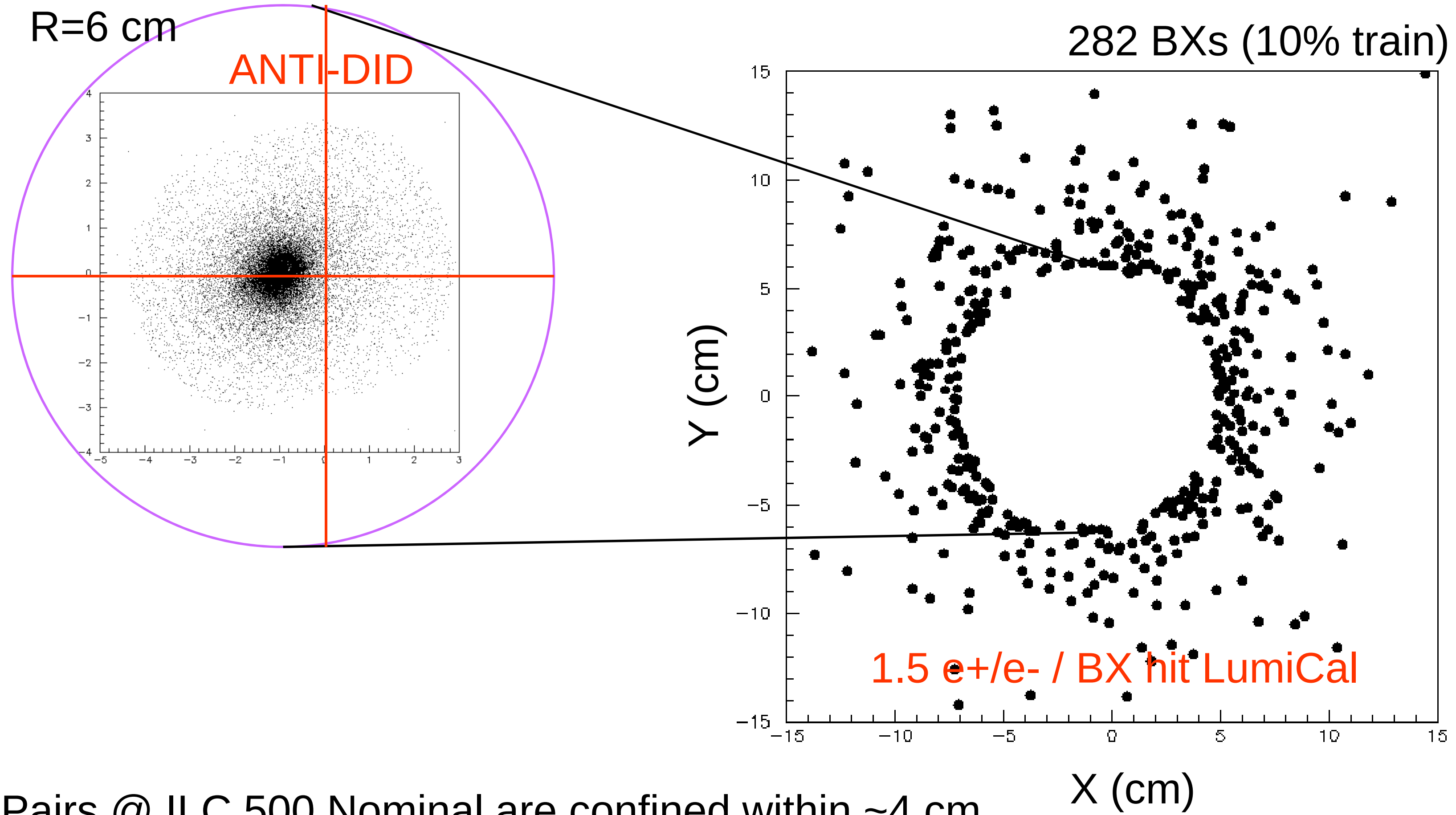
Max Energy Deposition (MeV)



Energy Deposition (MeV)

* 3.65 eV to generate e-h pair

Pairs in LumiCal

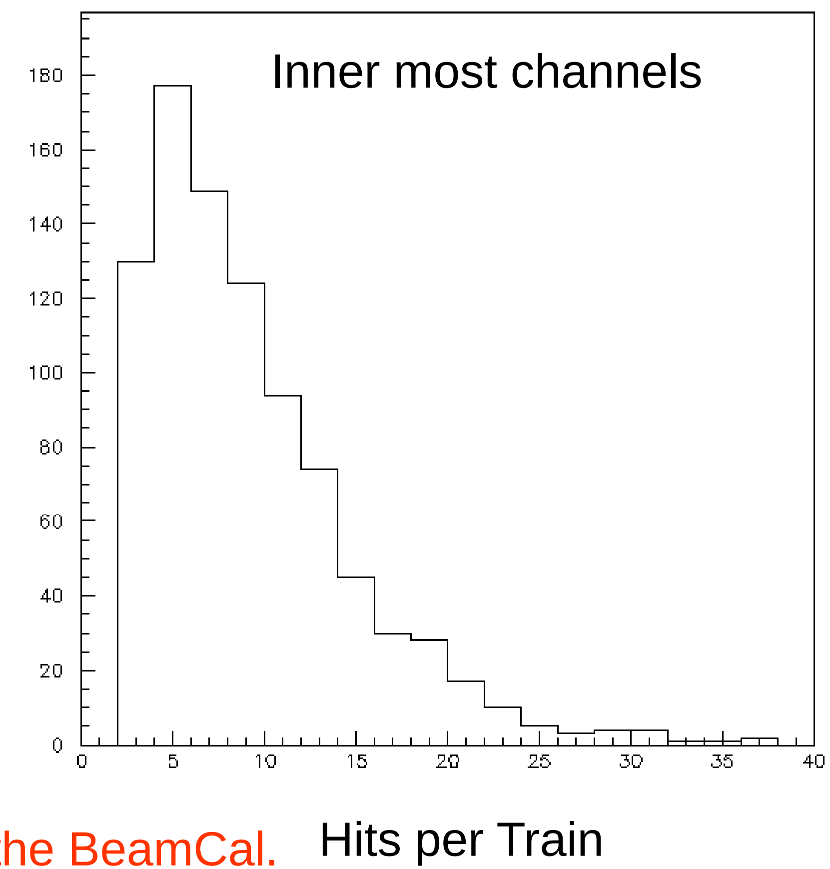


Pairs @ ILC 500 Nominal are confined within ~4 cm.
However, there are pairs outside the ring of death,
and >4000 e+/e-/train hit the LumiCal.

Pair occupancy in LumiCal

- 1.5 e+/e- / BX reaching LumiCal
- Hits are mostly in the front ~10 layers.
- Inner most channels have more than 4 hits.

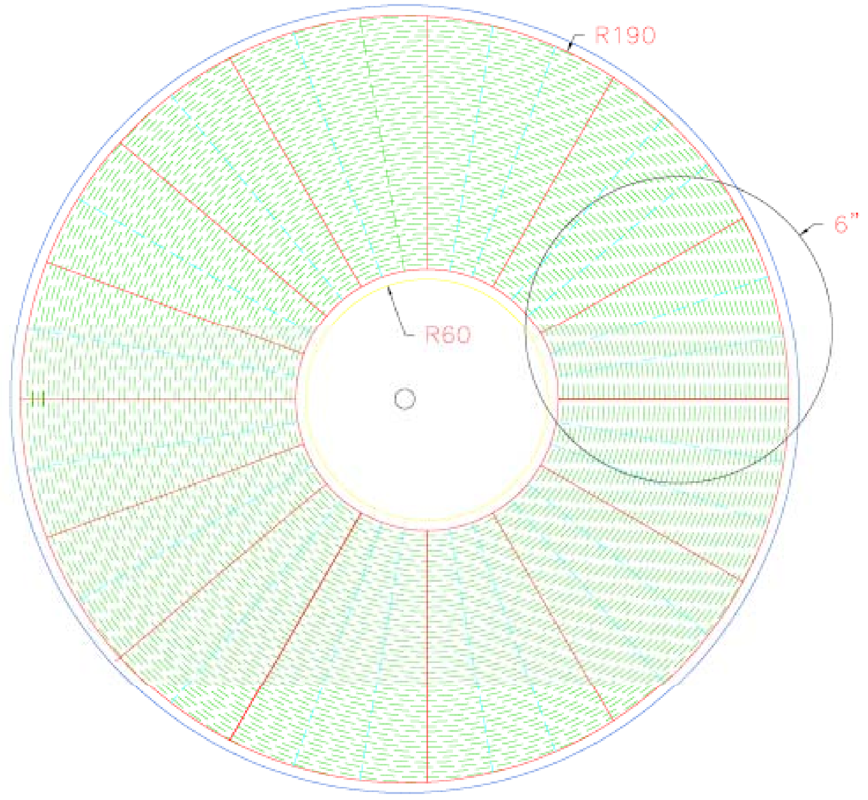
Δr = 2.5 mm, $N\phi$ = 32



KPiX has only 4 buffers.
Need a new chip being developed for the BeamCal.

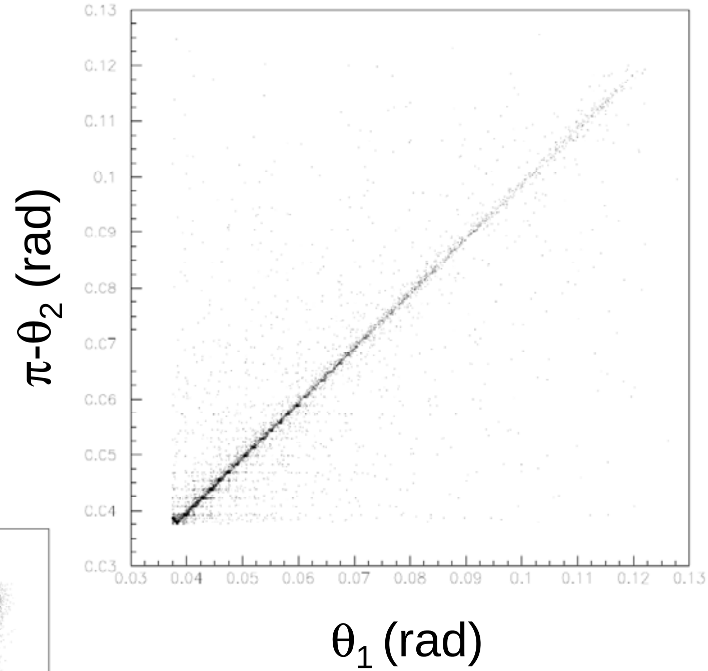
LumiCal sensor design

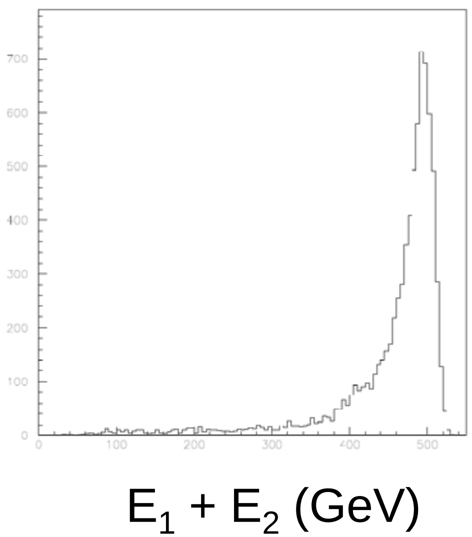
- Based on 6” wafer.
- The inner radius centered on the out-beam, while the outer radius on the detector.
- 14 petals are all different; need different Masks.
- $\Delta r = 2.5$ mm, $\Delta\phi = 10°$
- Radial division varies from 46 to 54 channels.
- Non-projective geometry; same sensors in depth-wise.

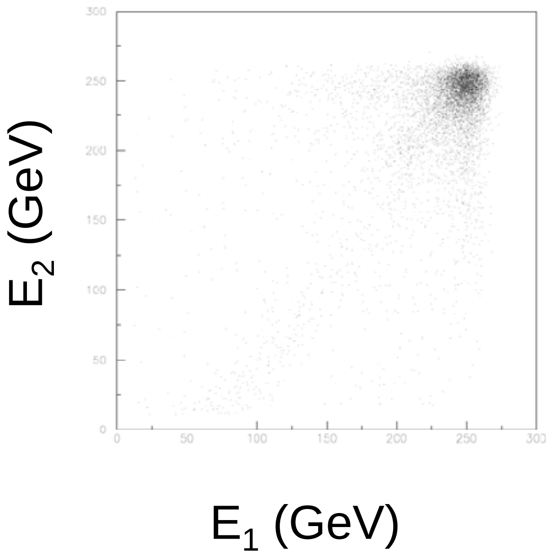


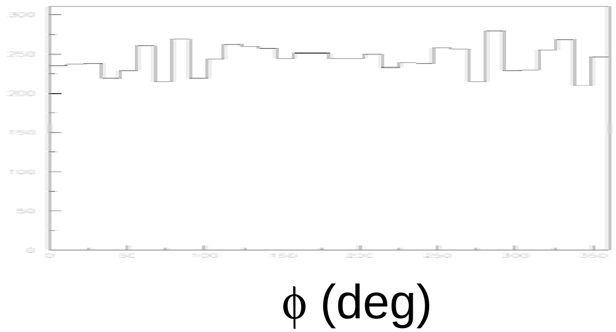
Bhabha events in LumiCal

- BHWIDE to generate Bhabha events
- Move to 14 mrad crossing angle system
- Simulate LumiCal response
- Reconstruct showers
- Move back to CM system
- Look at the distributions









BeamCal

- Extend calorimeter coverage to small angle
  - $7 < \theta < 44$ mrad
- High energy electron detection
  - Provide two-photon veto for new particle searches
- Instantaneous luminosity measurement using beamstrahlung pairs
  - Pair production is proportional to luminosity

$\gamma\gamma$ Veto in Pair Backgrounds

- Under SUSY dark matter scenarios, slepton & neutralino masses are nearly degenerate.

M. Battaglia et al. hep-ph/0306219

- Search & measure stau with $\Delta m = 3 - 9$ GeV

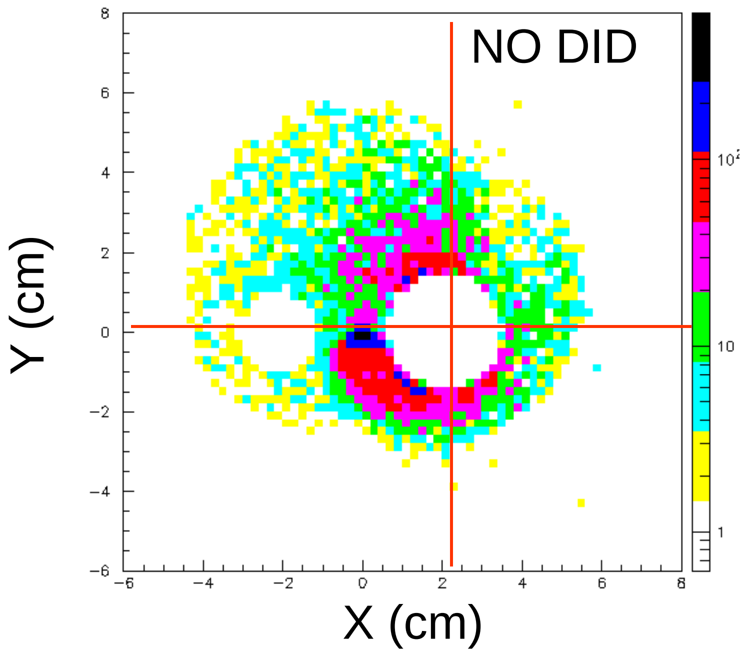
P. Bambade et al. hep-ph/0406010

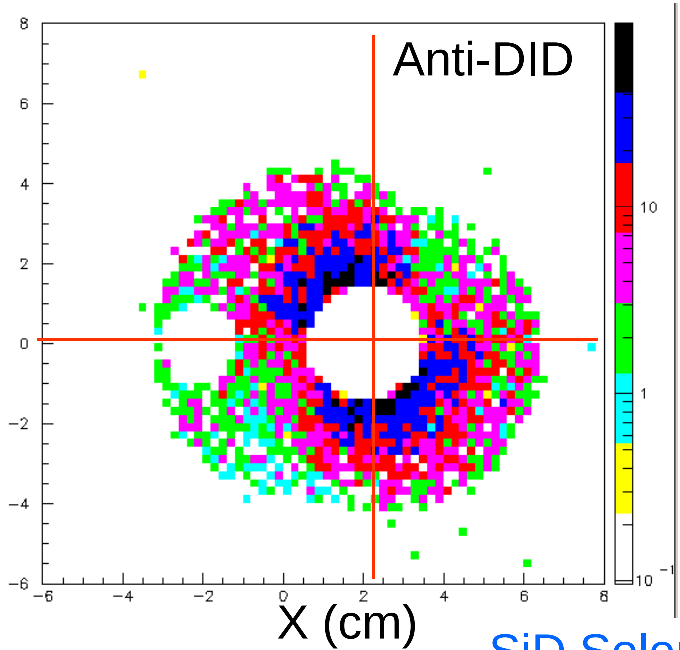
Signal	Major background
$ee \rightarrow \tau\chi\tau\chi$	$ee \rightarrow (e)(e)\tau\tau$
$\sigma \sim 10$ fb	$\sigma \sim 10^6$ fb

- $\gamma\gamma$ veto is crucial.
  - High energy electron detection in beamstrahlung pair background

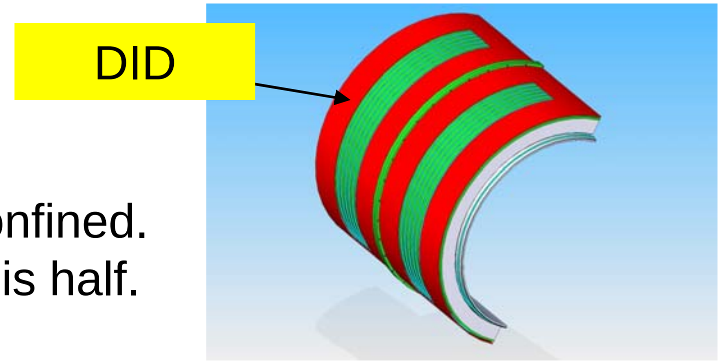
Detector-Integrated-Dipole

Pair energy distribution





SiD Solenoid



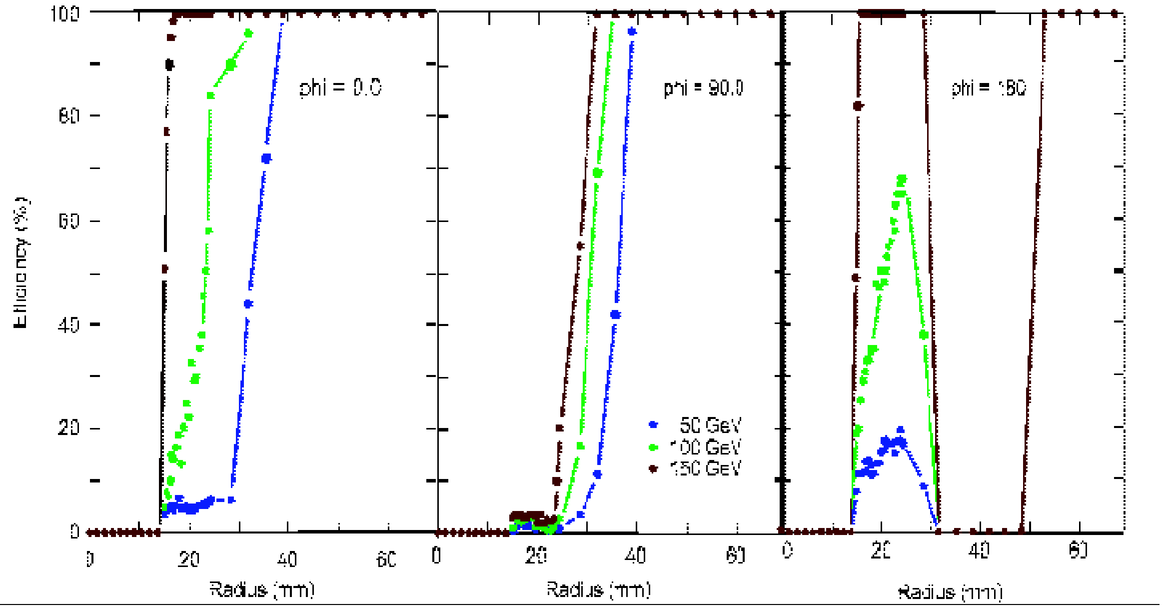
We want Anti-DID.

- Total pair energy into BeamCal is half.
  - 10 TeV/BX vs. 20 TeV/BX with NO-DID.
- Pair distribution is symmetric and more confined.
- No. photons backscattering to the tracker is half.

High energy electron detection

- **A lookup table to correlate energy deposition and incident energy.**
  - **θ , φ dependence**
  - **Geometry dependence**
- **Overlay high energy electron shower and one bunch crossing of beamstrahlung background.**
- **Subtract average beamstrahlung energy.**
- **Cluster algorithm to find high energy electron.**

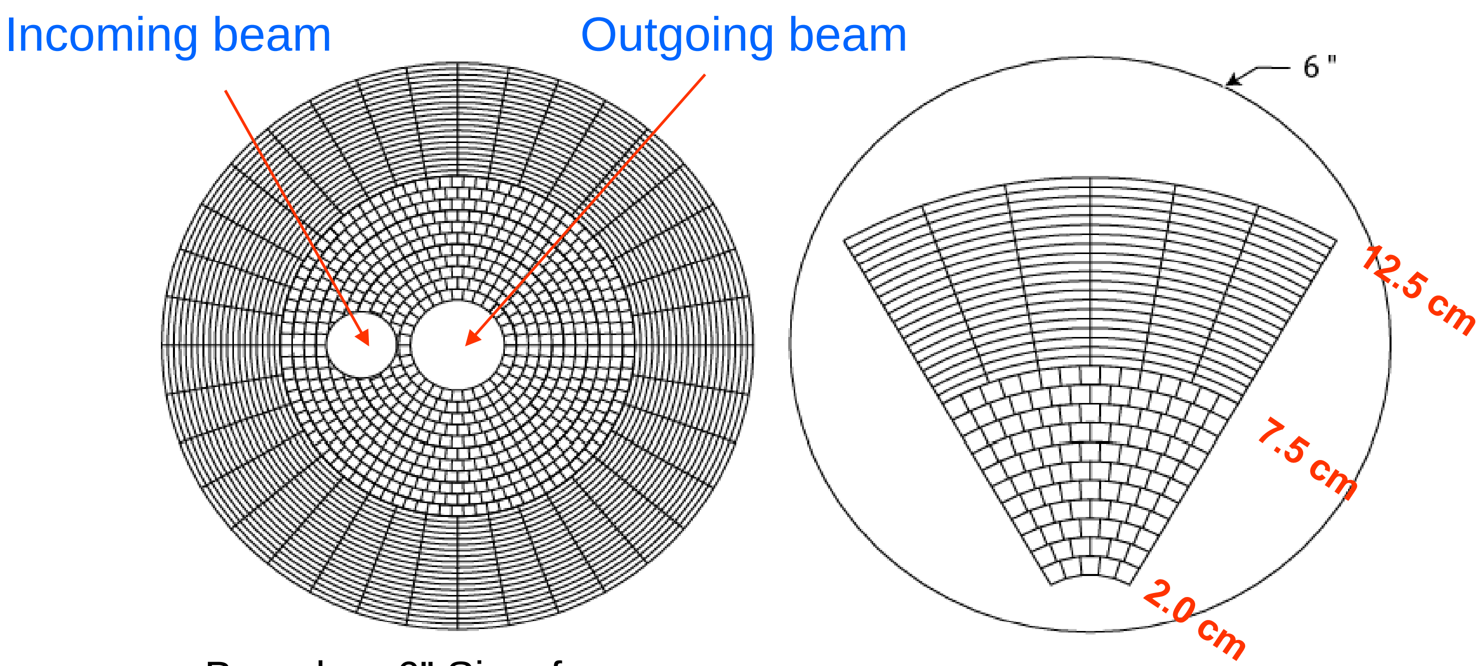
Detection efficiency



Two talks in Parallel session by Jack Gill and Gleb Oleinik

http://hep-www.colorado.edu/~uriel/Beamstrahl_TwoPhoton-Process/grp_results.html

BeamCal Sensor



- Based on 6” Si wafer
- Centered on the outgoing beam line
- Two regions
  - R=2.0 - 7.5 cm (7 mrad – 25 mrad)
    BeamCal where beamstrahlung pairs hit.
  - R=7.5 - 12.5 cm (25 – 42 mrad)
    LumiCal extension, no beamstrahlung pairs

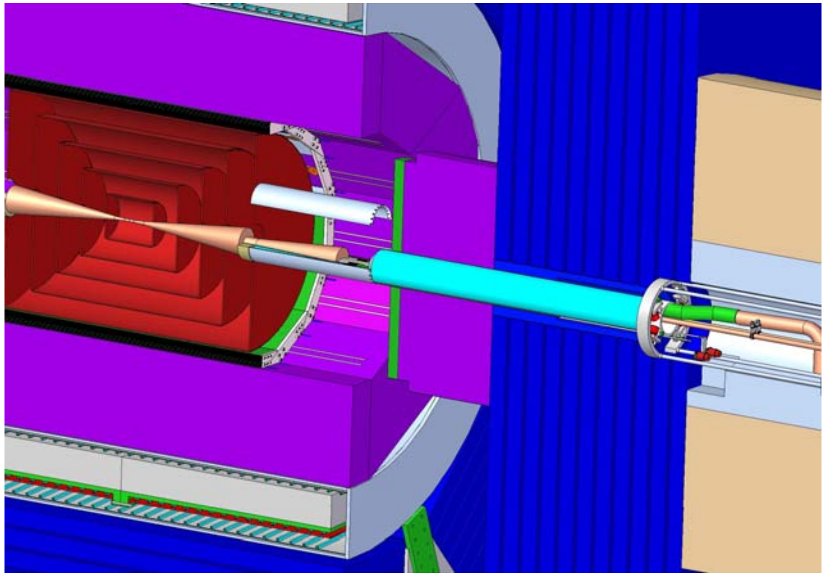
High occupancy and high radiation

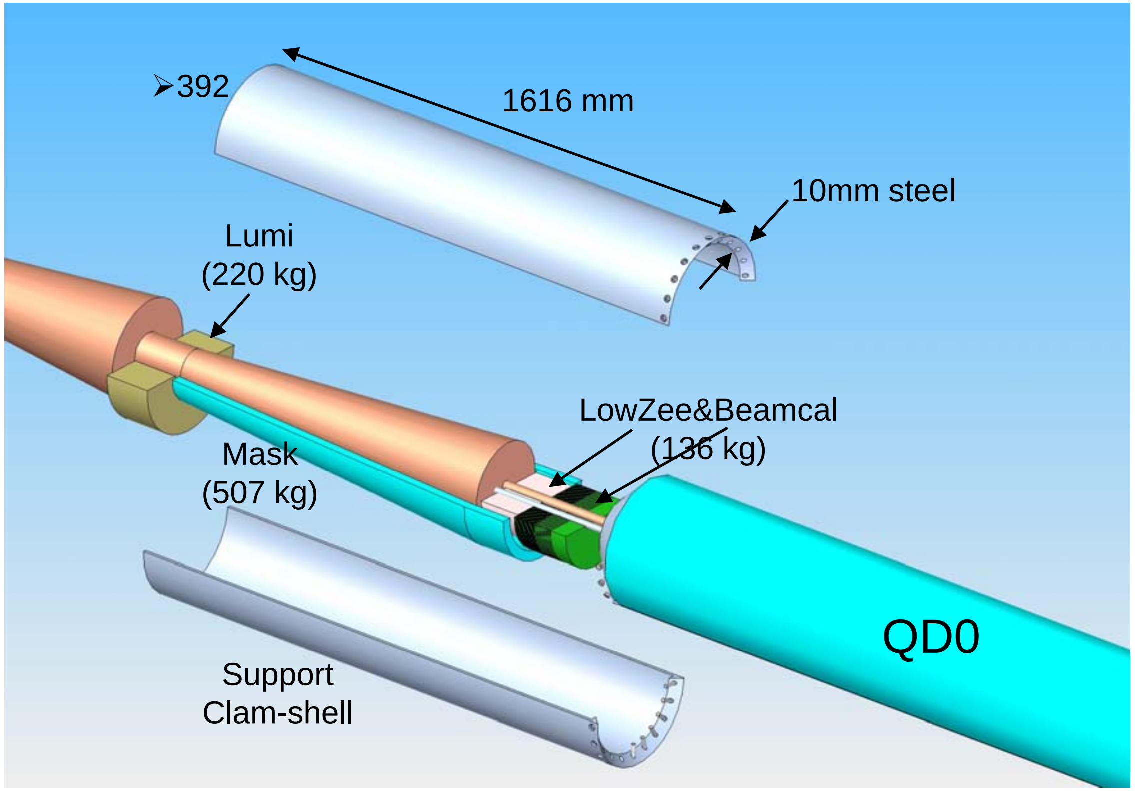
- 100% occupancy R < 5 cm.
  - Need a new chip to store every bunch crossing. → R&D
- Highest radiation dose ~100 MRad/year.
- Neutron fluence 5×10^{13} n_s/cm^2/year
  - Need radiation hard sensors. → R&D

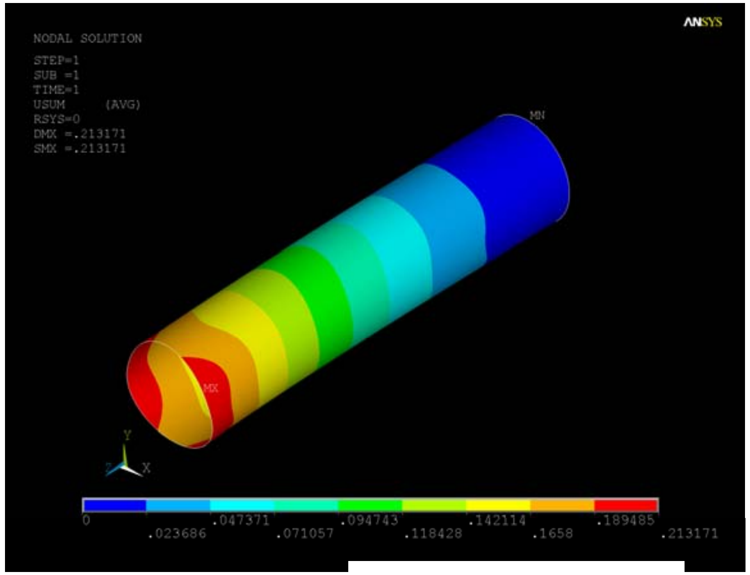
Unresolved Issues

- LumiCal
  - Readout design
  - Petal-to-Petal dead space
  - Reproducible alignment to < 30 um and verification
- BeamCal
  - Choice of sensor
  - Readout design
  - Petal-to-Petal dead space
  - Electronics cooling
- BeamPipe
  - HOM heating, cooling & wakefields due to abrupt radial transitions
- Global FCAL
  - Integration
  - Installation and servicing

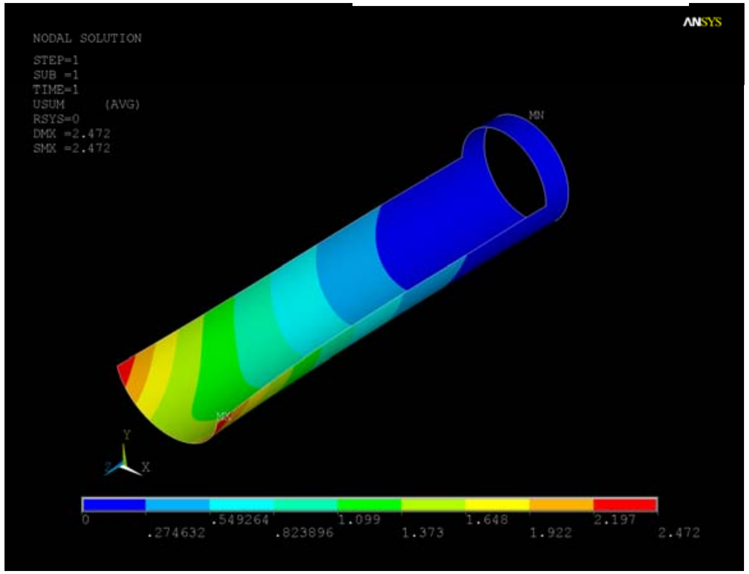
Forward Integration







Deformations in mm



Summary

- Good enough progress has been made to write the LoI.
- We still have to resolve many issues before we can write TDR.