GDE Baseline Assessment Workshop
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Background studies

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Introduction

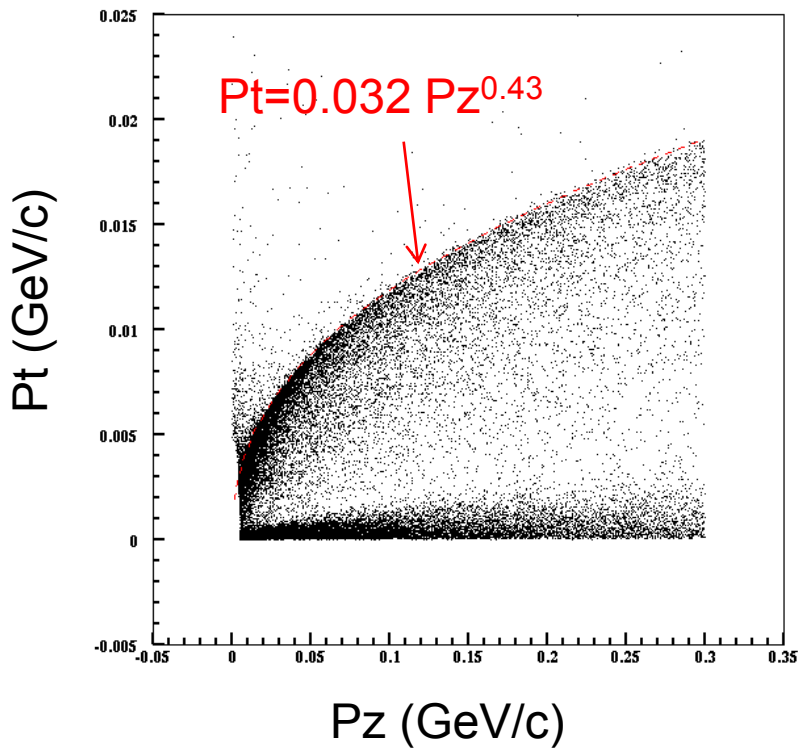
- Beam-beam pairs are the largest detector background and are critically dependent on the IP beam parameters.
  - Beam pipe design
  - Vertex detector background
  - BeamCal energy and radiation level
- Due to its larger IP angle in the SB2009, the beam collimation is tighter.
  - Muon background and sync radiation.

IP parameters and pairs

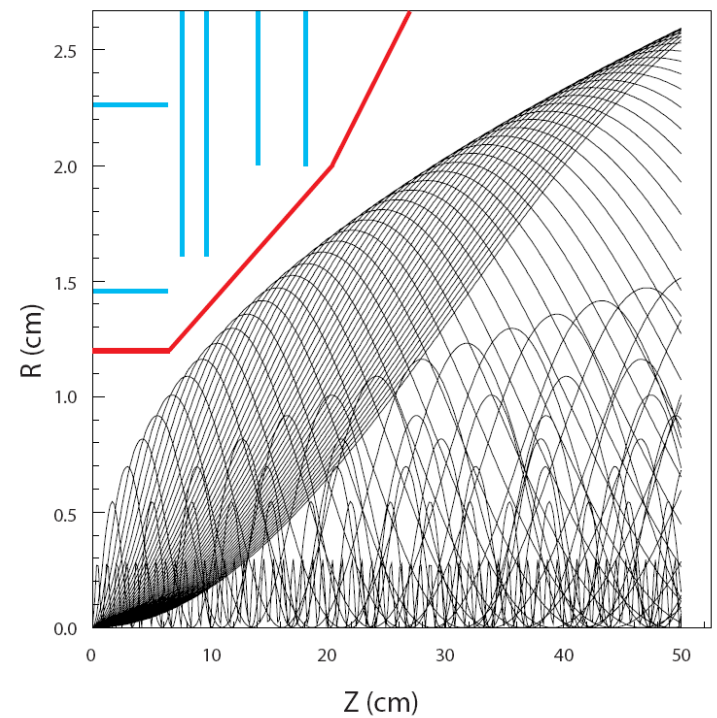
	250GeV TF	250GeV NoTF	350GeV TF	350GeV NoTF	500GeV RDR	500GeV TF	500GeV NoTF	1000GeV TF	1000GeV NoTF
Collision rate (Hz)	5	5	5	5	5	5	5	4	4
Bunch population ($\times 10^{10}$)	2	2	2	2	2	2	2	2	2
Number of bunches	1312	1312	1312	1312	2625	1312	1312	2625	2625
RMS bunch length (mm)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Horizontal emittance (mm-mrad)	10	10	10	10	10	10	10	10	10
Vertical emittance (mm-mrad)	0.035	0.035	0.035	0.035	0.040	0.035	0.035	0.035	0.035
Horizontal beta function (mm)	16	16	12	12	20	11	11	30	30
Vertical beta function (mm)	0.20	0.48	0.20	0.48	0.40	0.20	0.48	0.20	0.30
Number of pairs/BX ($\times 10^3$)	88.9 $\pm$ 0.8	67.9 $\pm$ 0.5	110 $\pm$ 1.0	85 $\pm$ 0.7	100 $\pm$0.9	232 $\pm$ 2.5	178 $\pm$ 1.8	204 $\pm$ 1.9	172 $\pm$ 1.7
Total energy/BX (TeV)	71 $\pm$1.0	52 $\pm$ 0.9	137 $\pm$ 2.7	102 $\pm$ 2.2	200 $\pm$ 3.8	583 $\pm$ 11.1	430 $\pm$ 8.1	1244 $\pm$ 19.7	1024 $\pm$16.5

Pair edge and Beam pipe design

- Pairs develop a sharp edge and the beam pipe must be placed outside the edge.
- Find an analytical function of the edge in Pt vs. Pz space.
- Taking into account the crossing angle and solenoid field, draw helices in R vs. Z space.

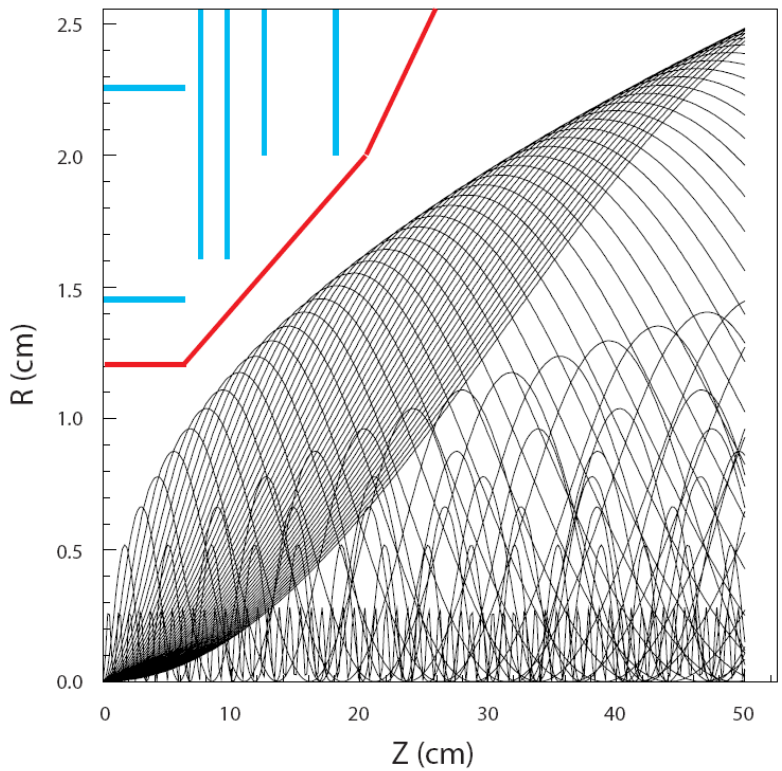


SB2009 500 GeV TF

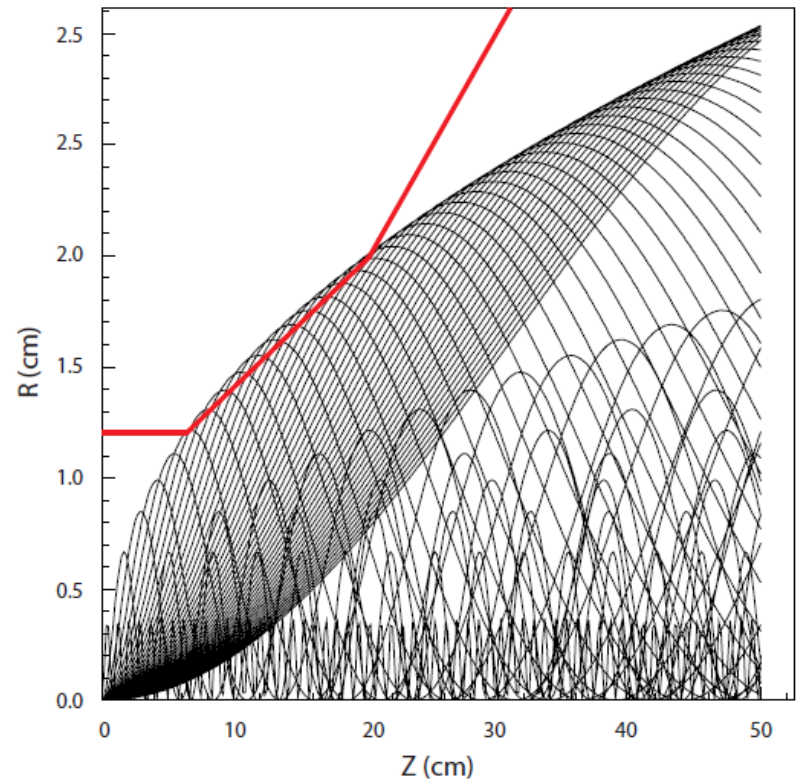


SiD beam pipe and pairs edge

500 GeV RDR Nominal



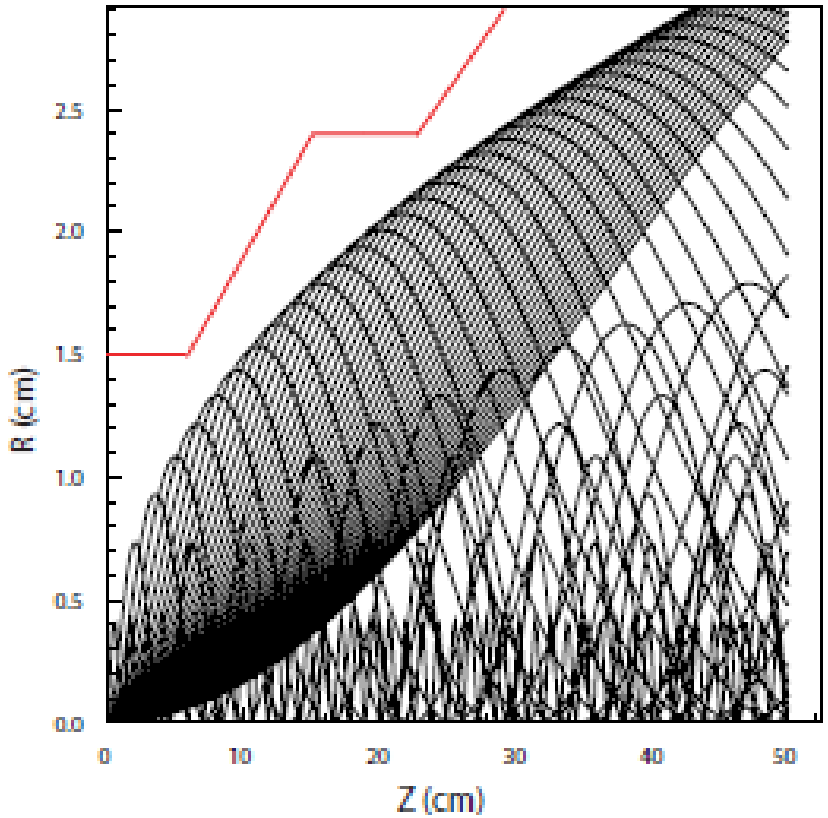
500 GeV RDR Low P



Beampipe design and pair edge

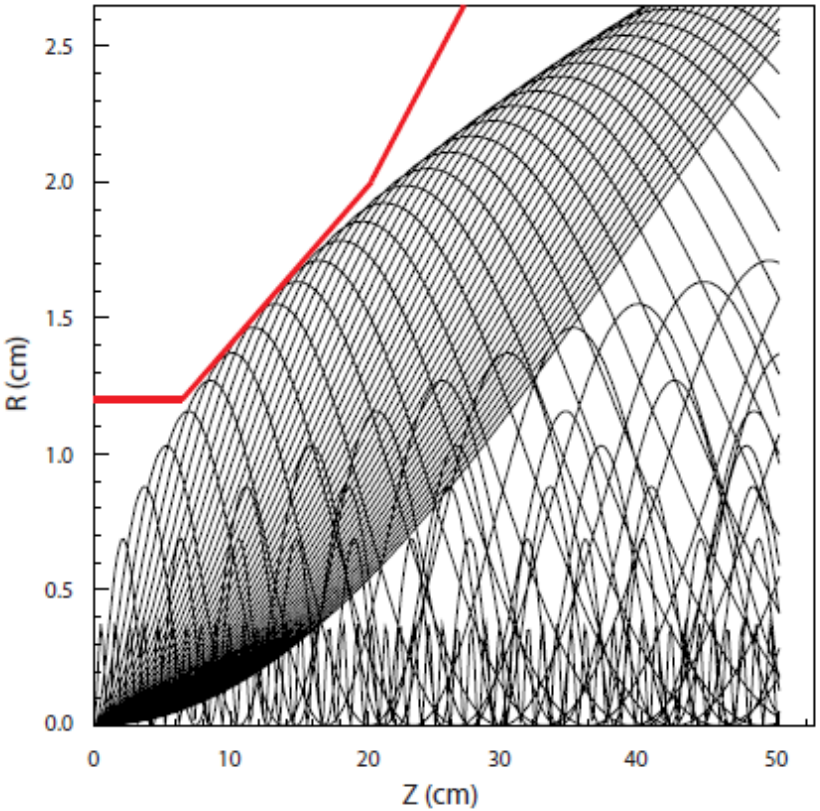
ILD Beampipe and 3.5 Tesla

SB2009 500 GeV TF



SiD Beampipe and 4 Tesla

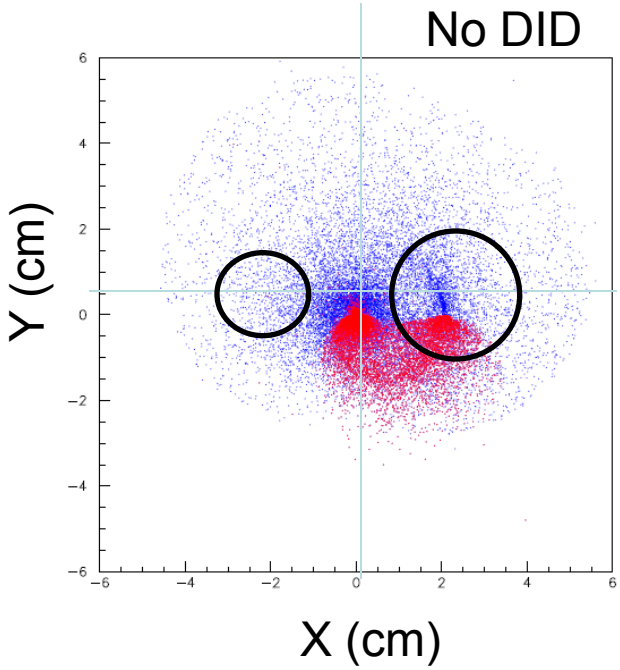
SB2009 500 GeV TF

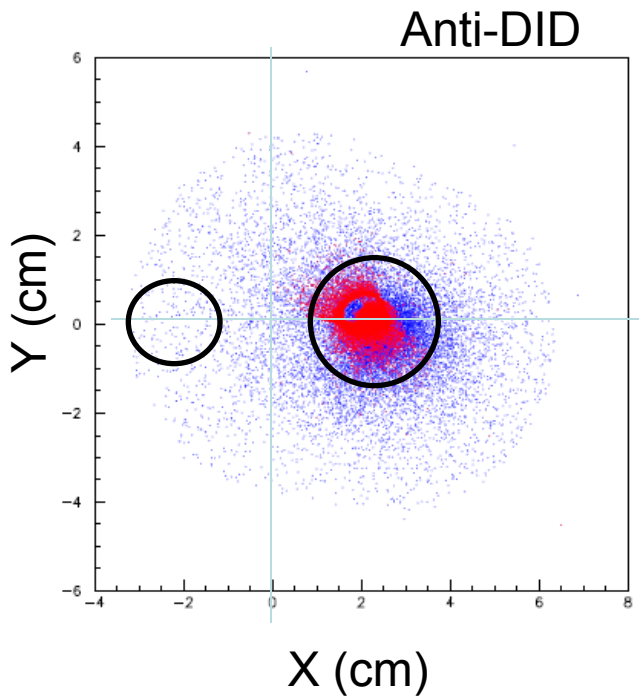


VXD Hits

- There are many e+/e- outside the edge, which hit the vertex detector directly.
- Some vxd hits are due to low energy e+/e- produced in the BeamCal and backscattered toward the IP.
- Full detector simulation is required.
  - Solenoid field map
  - DID field

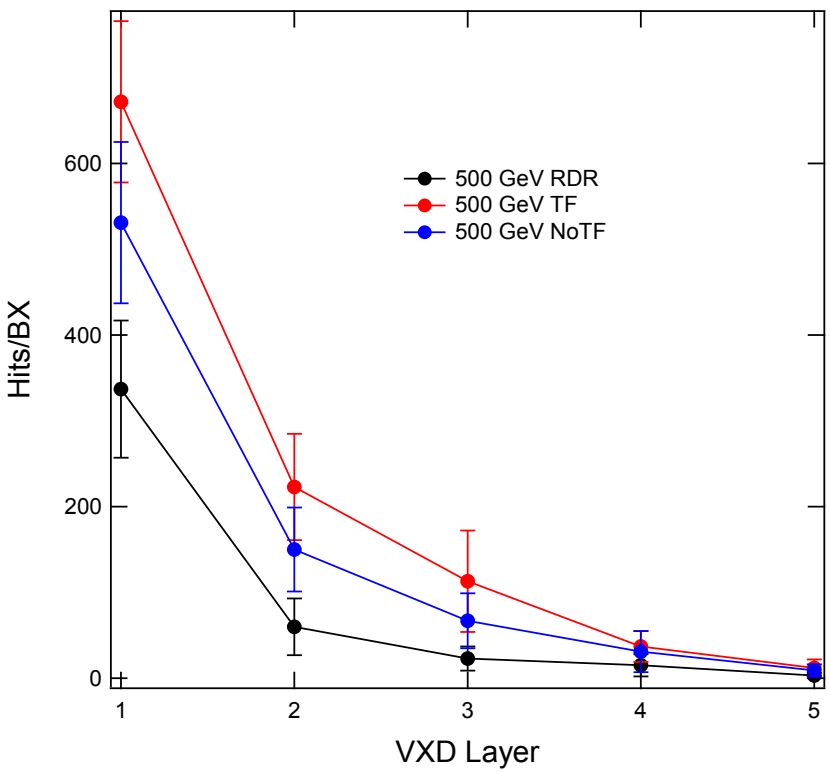
Pairs at the face of BeamCal





VXD hits

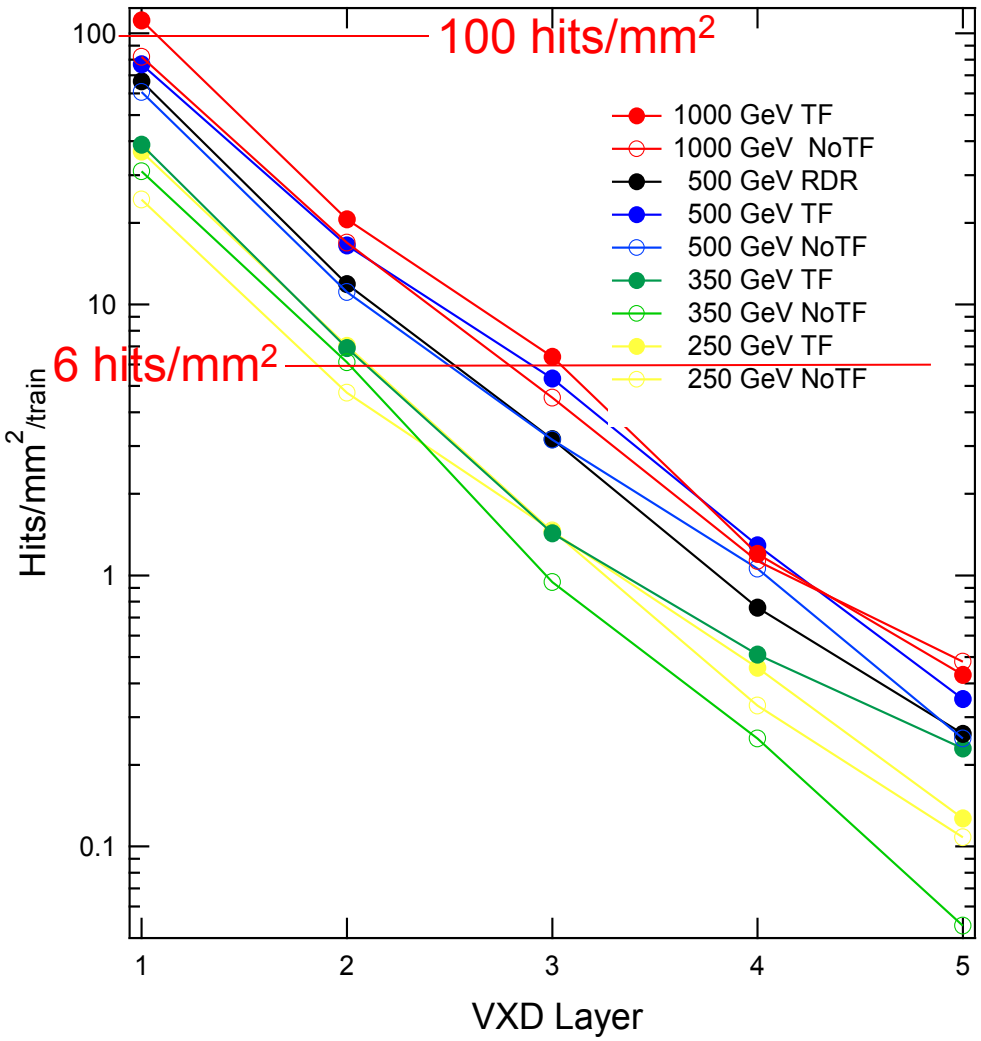
- e+/e- hits at 500 GeV



- Average and RMS from 20 bunches.
- 500 GeV TF ~ 2 × 500 GeV RDR
- Bunch-to-bunch variation is more than 15% due to some e+/e- spiraling the vertex detector layers and producing multiple hits.
- Anti-DID vs. No DID difference is smaller than the bunch-to-bunch variation.

VXD hit density / train

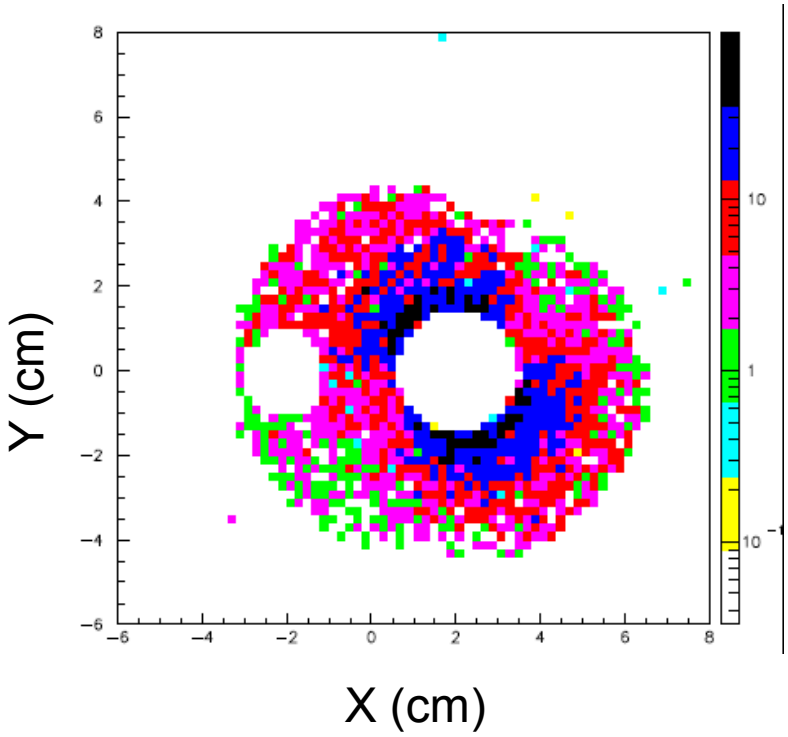
- Detector tolerance
- Use generic 1% pixel occupancy
- Dependent on sensor technology and readout sensitive window.
  - Standard CCD 20μm x 20μm
    - 2500 pixels/mm^2
    - 6 hits/mm^2/sw (assuming 1 hit→ 4 pixels)
  - Fine pixel CCD 5μm x 5μm
    - 40000 pixels/mm^2
    - 100 hits/mm^2/sw (assuming 1 hit→ 4 pixels)



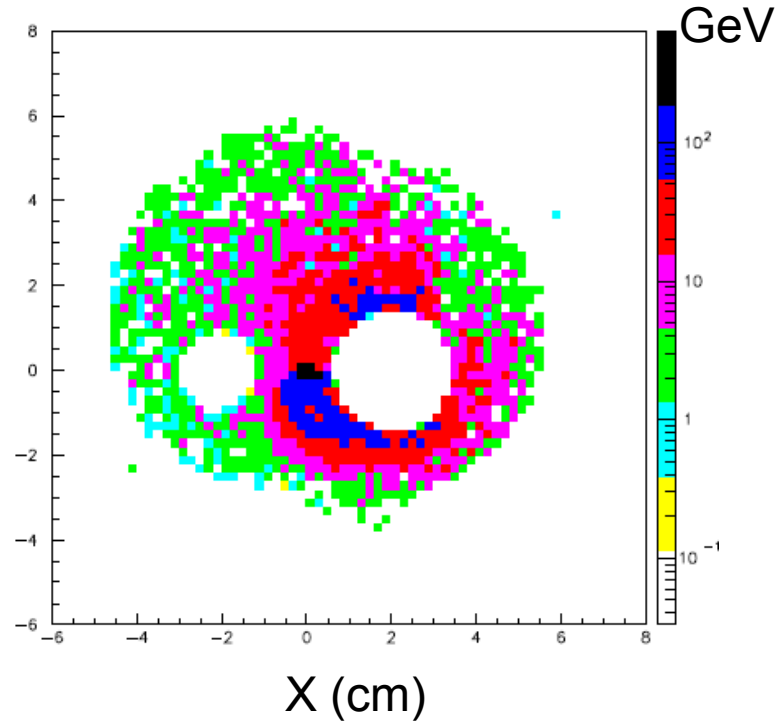
BeamCal energy

One side energy/(2mm×2mm) per bunch crossing

RDR 500 GeV Anti-DID



RDR 500 GeV DID



BeamCal Energy

	250GeV TF	250GeV NoTF	350GeV TF	350GeV NoTF	500GeV RDR	500GeV TF	500GeV NoTF	1000GeV TF	1000GeV NoTF
NO-DID Energy (TeV)	12.9	9.8	20.5	15.5	20.9	58.8	45.3	49.4	43.5
Anti-DID Energy (TeV)	6.5	4.8	11.1	8.3	12.0	38.2	29.1	32.0	28.8
Anti-DID radiation (Mrad/year)					100	160	120		

- Total pair energy going into the BeamCal is dependent on the DID field.
  - ANTI-DID ~ ½ NO-DID
- 500 GeV TF has x3 more energy/BX than RDR
  - More difficult to tag high energy e-.
  - SUSY search sensitivity is reduced.
- Yearly radiation level is about 50% more in 500 GeV TF.

Summary

- The beam pipe design in both SiD and ILD is compatible with the SB2009 beam parameters.
  - The pair edge does not depend on the beam focus scheme (TF vs. NoTF).
- There are x2 more VXD hits in 500 GeV TF but the detector tolerance is dependent on the pixel size and readout time.
- x3 more energy per bunch crossing in the BeamCal.