Forward Detectors and Beam-Beam Background at CLIC

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FCAL Collaboration Meeting

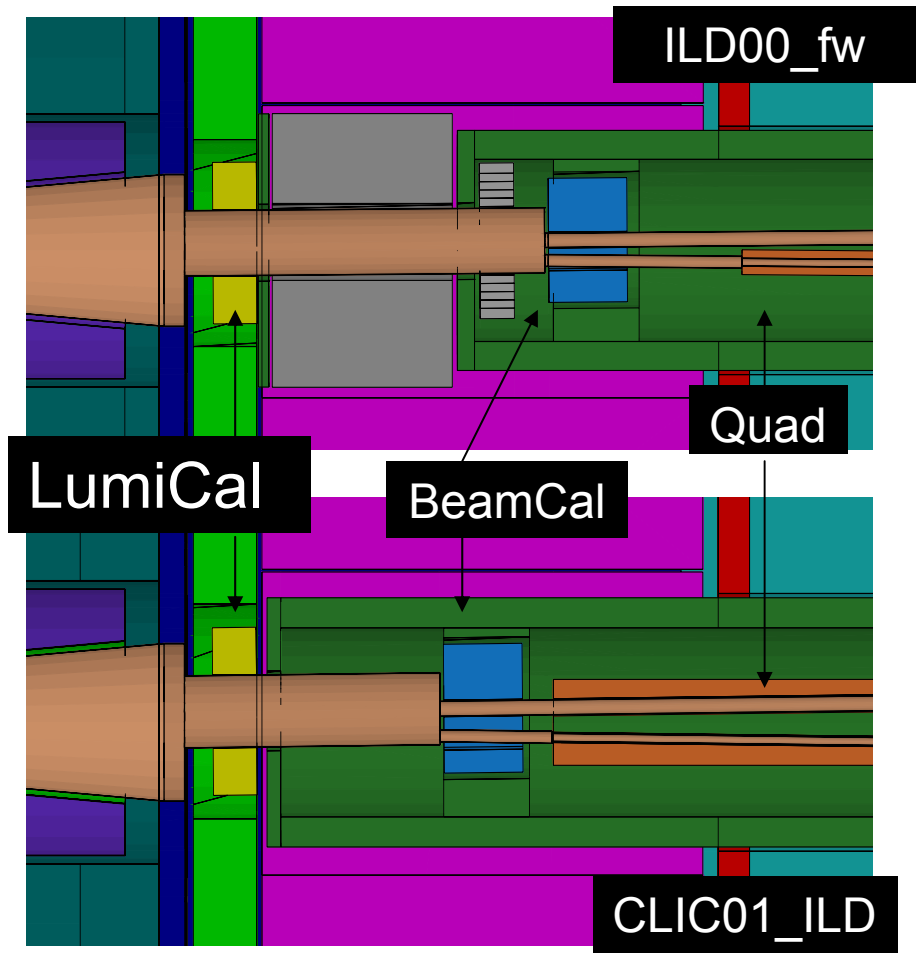
Zeuthen: 29th June 2009

Overview

- Detector Model: From ILD to CLIC
- Beam-Beam Background at CLIC
- Background from Backscattering
- Background in the Vertex Detector
- Radiation Dose
- Summary and Outlook

Changes in the Forward Region compared to ILD

- Crossing Angle
  - From 14 to 20 mrad
- Final Quadrupole
  - L* = 3.5 m
- ➢ Removed LHCal
- ➢ Move BeamCal to z=3.2m
- To be done:
  - Change Radii for LumiCal and BeamCal
  - Deeper LumiCal and BeamCal (40 layers)
  - Graphite Layers before LumiCal?
  - More Masking?
- This model will still undergo many changes

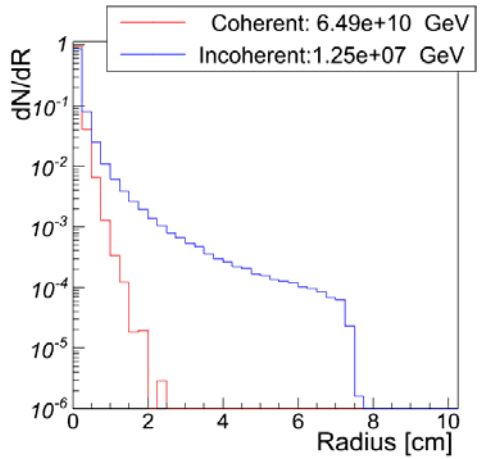


Changes in the “Central” Detector

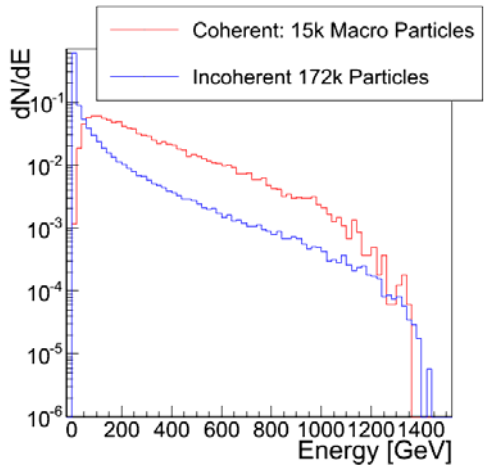
- Vertex Detector
  - Layers at R=31/45/60mm
  - All layers 25cm long
  - Rate of background hits in the Vertex Detector (VXD) otherwise too large
- 4 Tesla magnetic field
- Hadronic Calorimeter
  - Deeper: 8.5λ
  - Absorber: Tungsten, 1cm thick, 77 layers

Beam-Beam Background compared to ILC

- More e+e- Pairs are created
  - Smaller bunch sizes (45nm by 1.0 nm)
  - Higher energy
  - Coherent pairs ~10^8 particles, but smaller production angles than incoherent pairs
  - Therefore only looking at incoherent pairs
- More background (BG) accumulated during one train
  - Smaller bunch spacing: 0.5ns
  - 312 Bunches per train
  - 50 Trains per Second
  - Time stamping needed (some tens of BX)



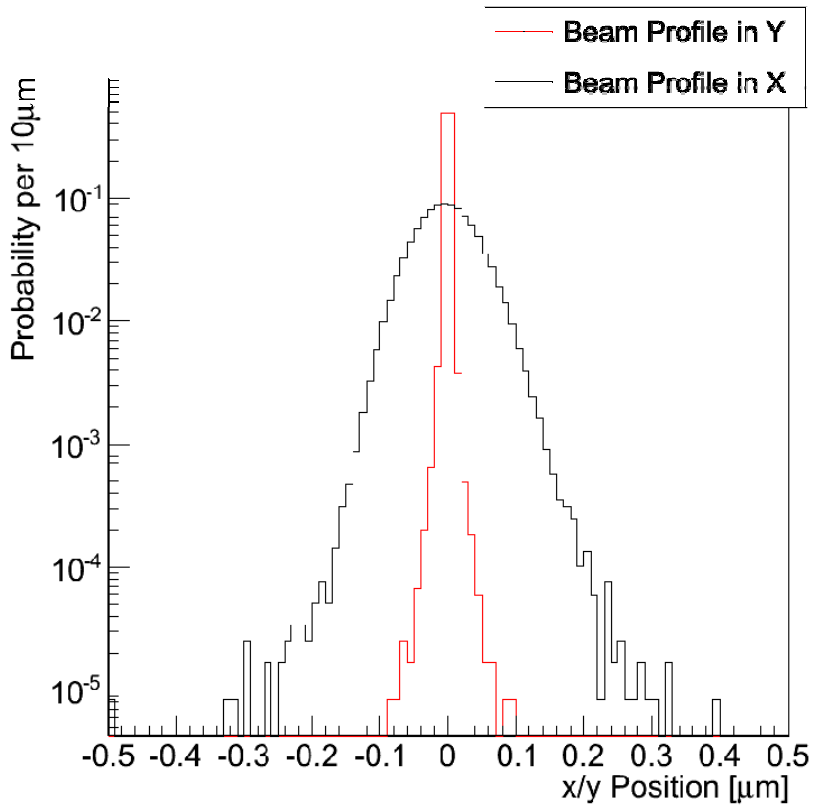
Radial distribution of coherent and incoherent pairs at z~3m, 4Tesla, AntiDID, normalized, 1 BX



Energy distribution for coherent and incoherent pairs for CLIC at 3 TeV, 1 BX

Incoherent Pair Generation

- Simulated with GuineaPig
  - Non Gaussian particle distributions
  - From simulation of bunches passing the accelerator
  - Fluctuations small, because only one particle distribution used (per side)
  - Using 10 BX



Background Simulation

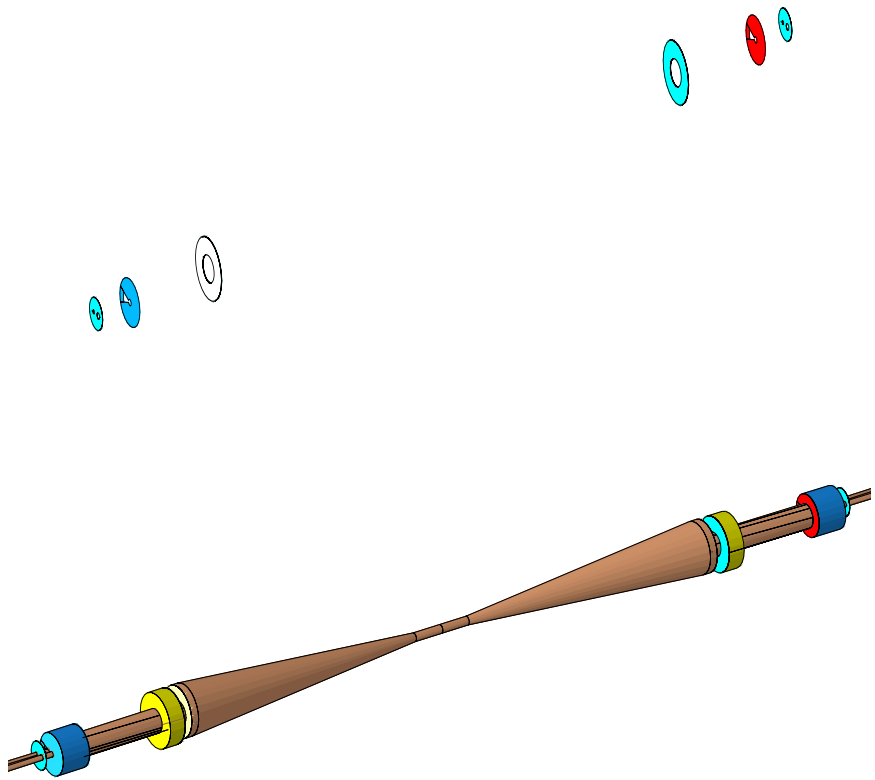
- Detector Simulation
  - Mokka v06-08
  - New R-Phi-field-map Driver
    - Scaled to 4 Tesla
- The simulations are done for
  - AntiDID, DID, and without a DID field
  - The LDC 20mrad AntiDID-field-map is used
  - There is a ~20% decrease in luminosity due to AntiDID [B. Dalena, CERN, Synchrotron Radiation Studies in the CLIC BDS and Interaction Region, ILC-CLIC LET Beam Dynamics Workshop]

Background Studies

- What background level, from beam-beam interaction, can be expected at CLIC?
  - Impact on forward region as well as vertexing and tracking
- Can the same detectors be used as for the ILC?
  - E.g.: Radiation hard LumiCal?
- Are extra precautions necessary to manage the background?
  - Graphite layer before LumiCal?
  - More shielding?
  - ➢ Where do the background particles come from?

Where do the hits come from?

- Added Recording Planes
- A thin sheet of sensitive air before LumiCal, BeamCal and Quadrupole (QD0)
- Also made parts of the beam tube sensitive
- No thresholds
- Records everything that passes
- Does not change simulation
- Output in LCIO format

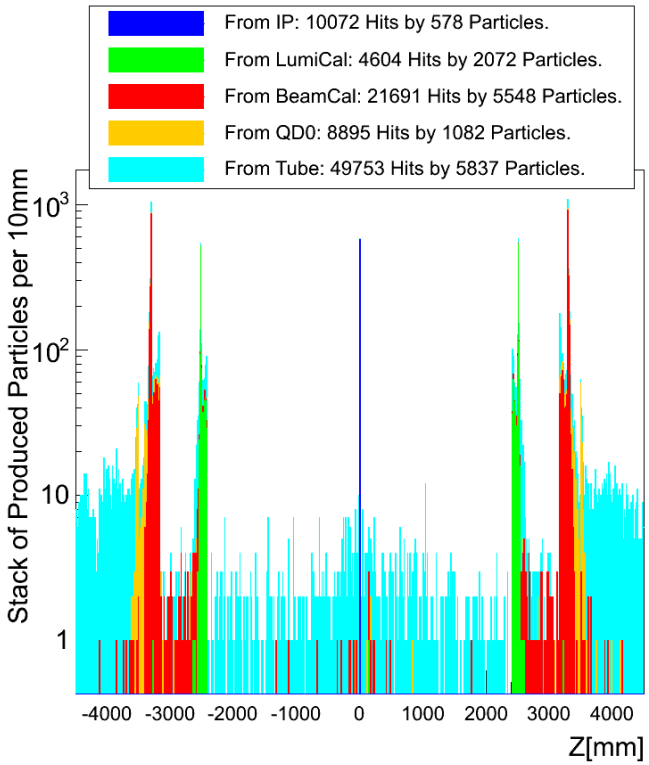


Identification Algorithm

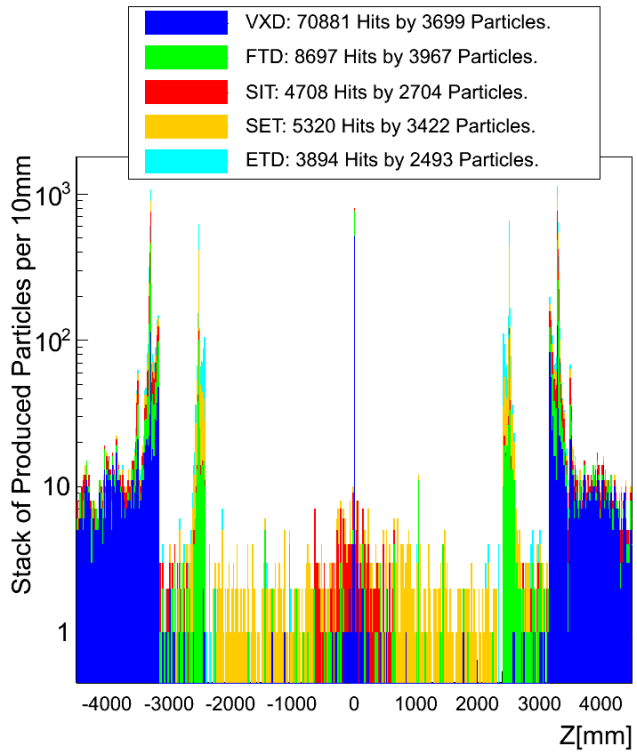
- Recording Planes are used to identify the source of backscatters
- Using MC information
- Did the particle causing a hit in the (e.g.) VXD hit a recording plane?
- If not, check parent particle(s)
- If hit was recorded, hits are attributed to this Backscatter source
  - LumiCal, BeamCal, QD0, Tube
  - If nothing was found: IP

Source of (Back)Scattered Particles

Origin and Identified Source of BG hits:
Z Position corresponds well to the position of the Forward Calorimeters

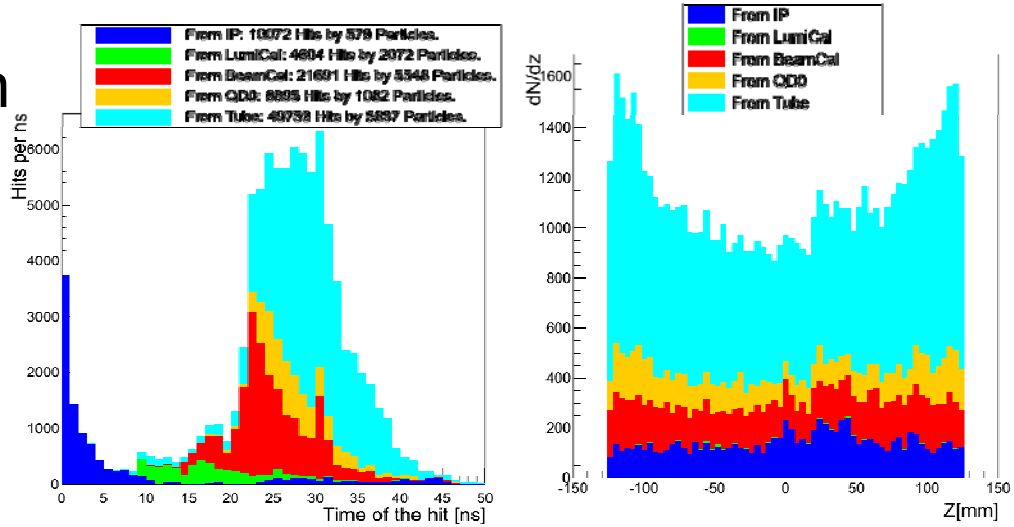


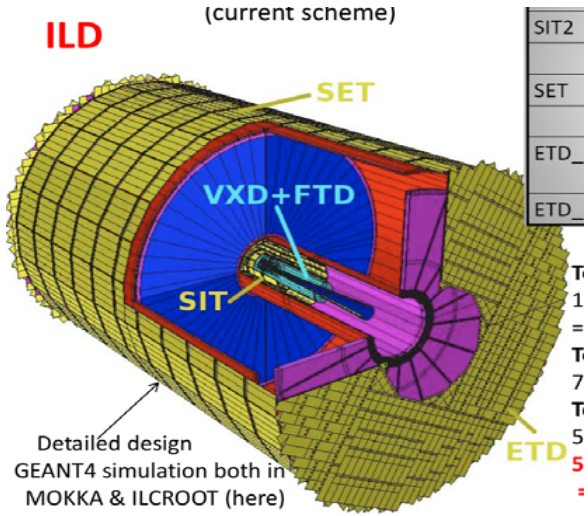
Origin of particles causing hits above threshold in the Tracking Detectors



Origin of the Background

- Easier to identify the main cause of backscattering
  - VXD mostly hit from Tube
  - LumiCal has almost no impact on the Vertex Detector
  - Most backscatters from LumiCal go to SET, ETD, FTD
  - No Graphite necessary

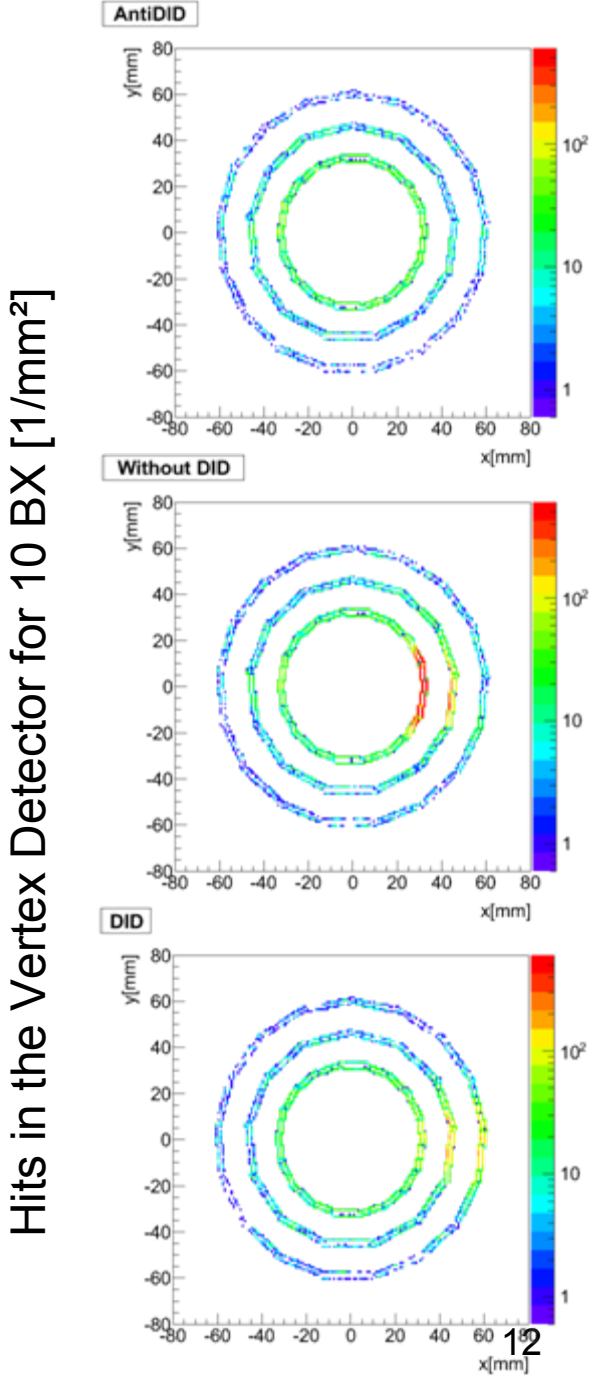




From: A. Savoy Navarro, TILC09

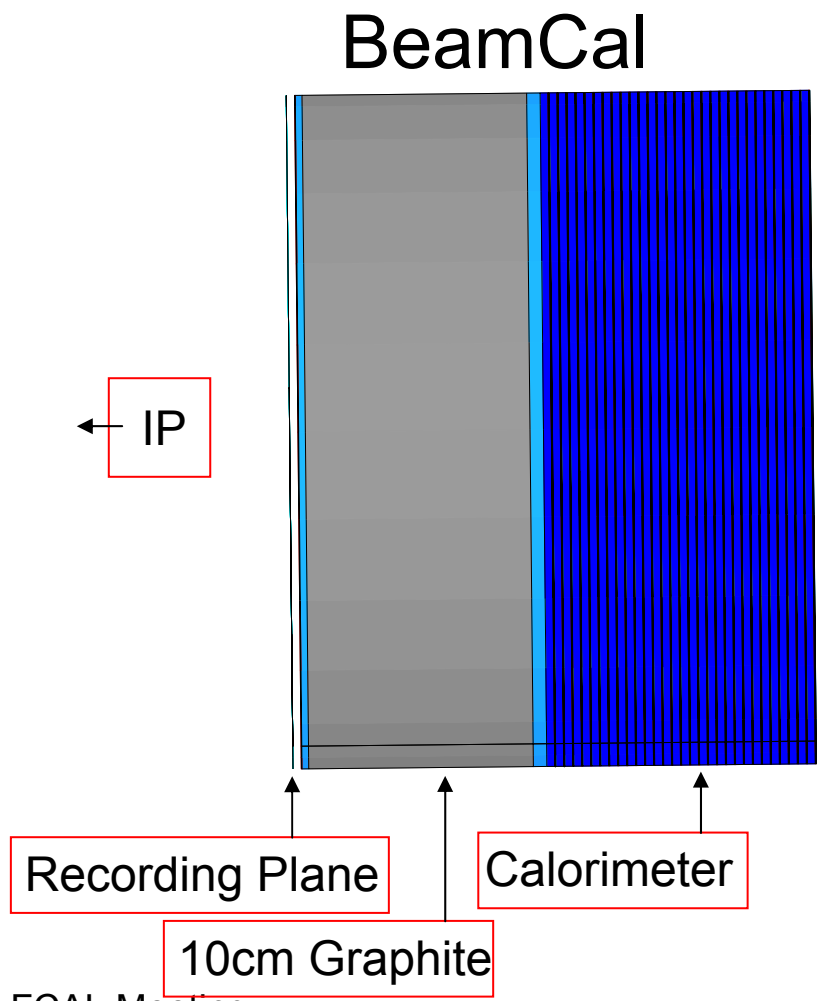
Vertex Detector

- Without DID: Rate in the VXD almost frighteningly high
- Problem is concentration of hits
- From inner edge of BeamCal or beam tube
  - Magnetic field is guiding the backscatters straight to the VXD?
  - Solution: Larger downstream beam tube? (Larger inner BeamCal radius)

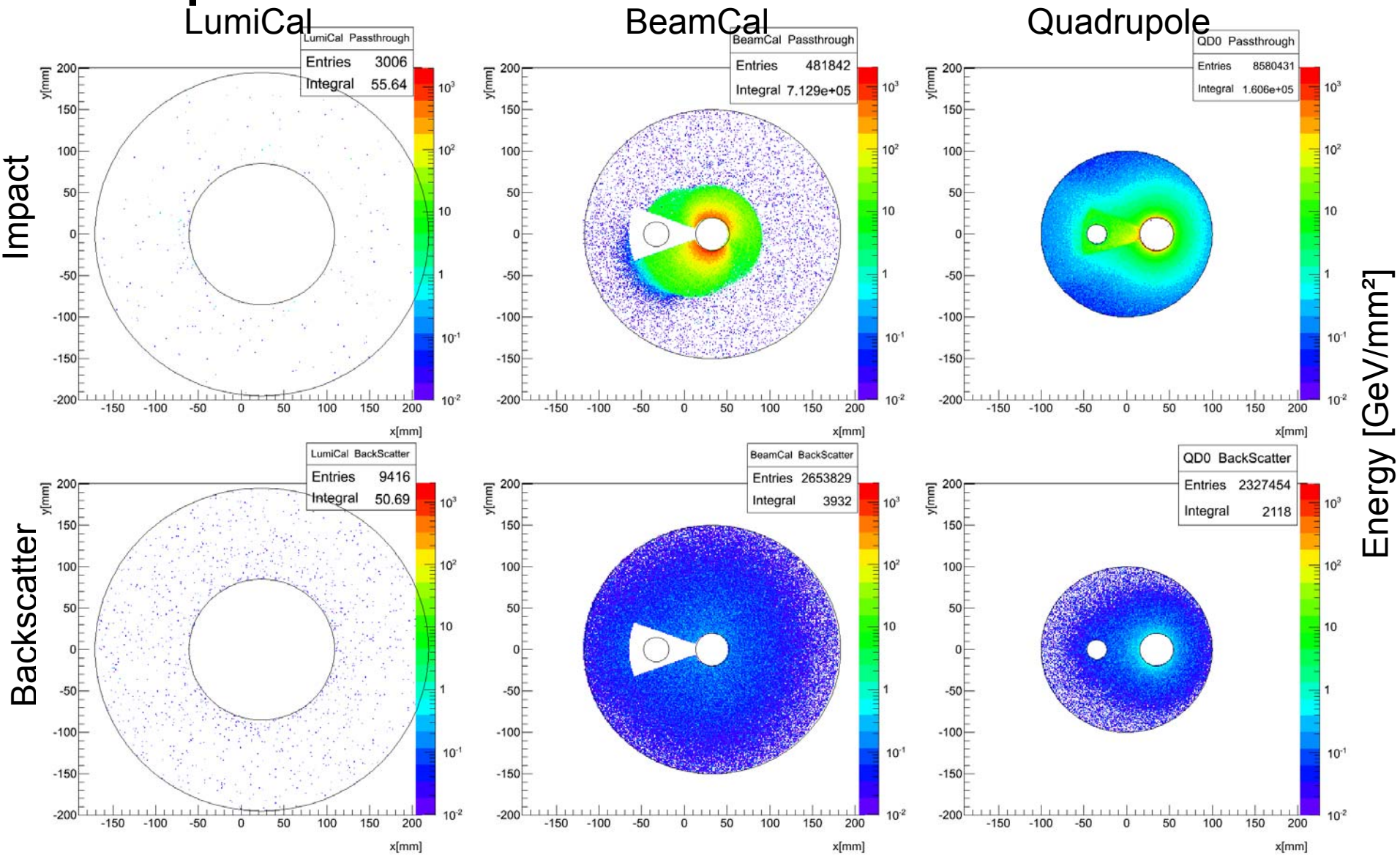


Distribution of Incoherent Pairs on Forward Detectors

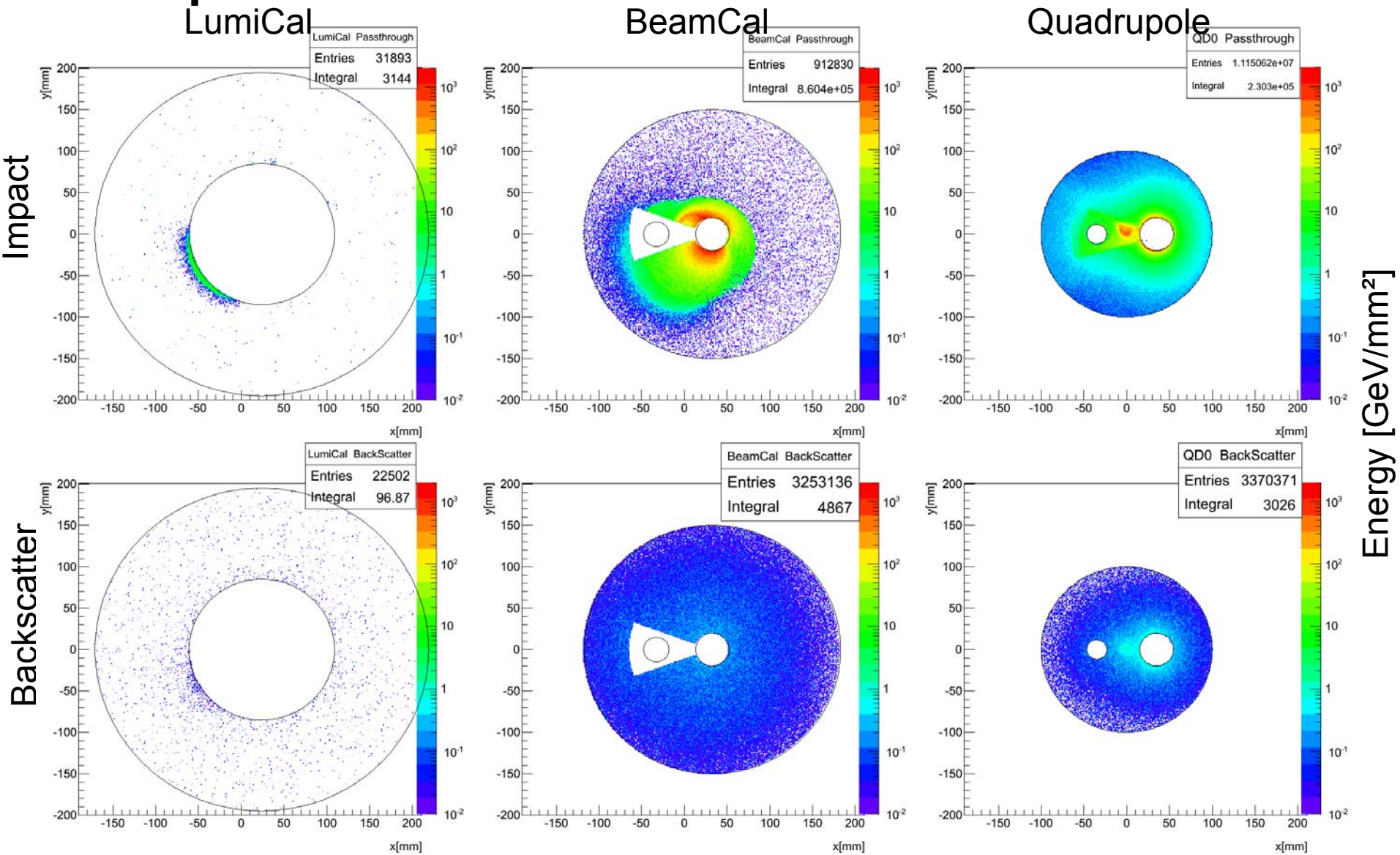
- Recording planes also show the incoming and outgoing particles on LumiCal, BeamCal and Quadrupole
- Next slides show impacts and backscatters for z>0
- 10 bunch crossings



Impacts and Backscatters: AntiDID



Impacts and Backscatters: noDID



Impacts and Backscatters: DID

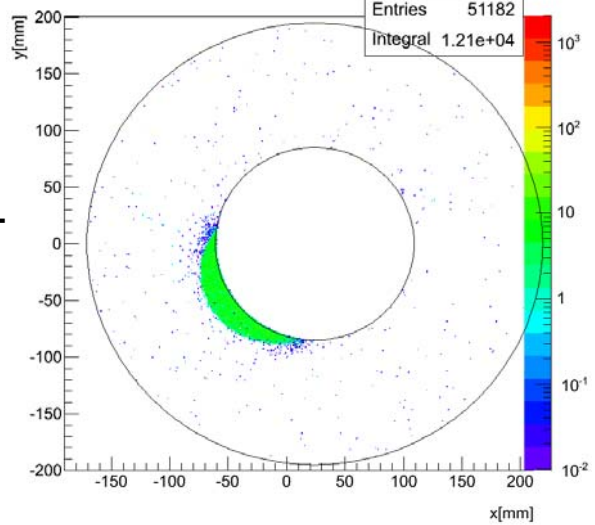
LumiCal

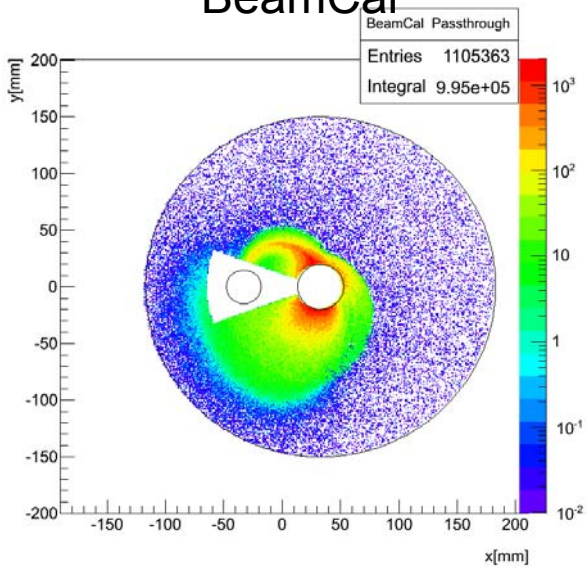
BeamCal

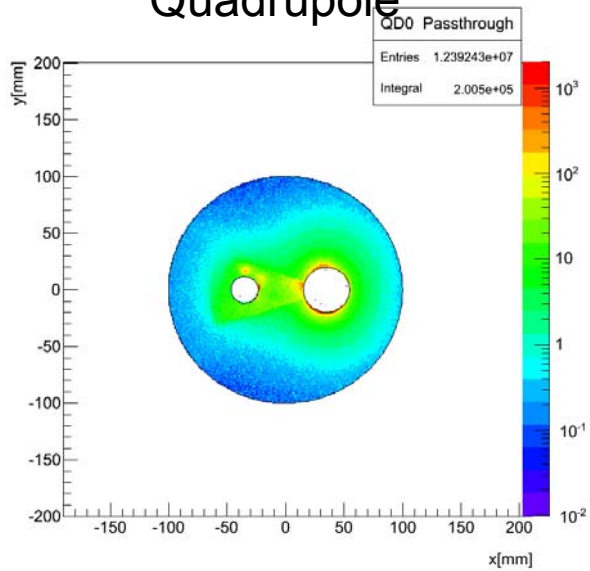
Quadrupole

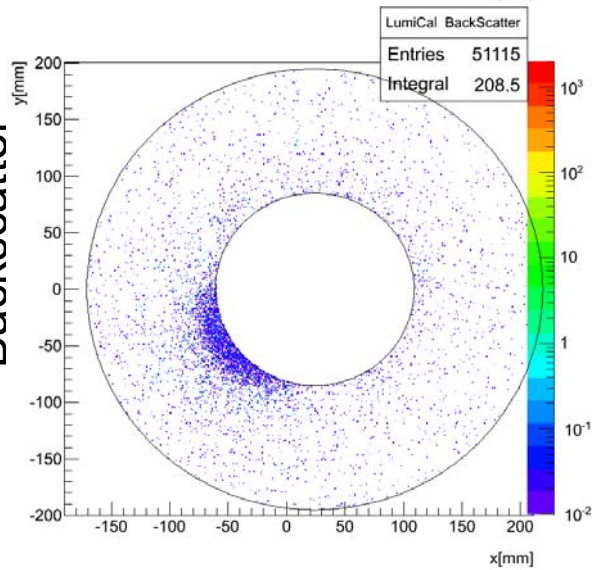
Impact

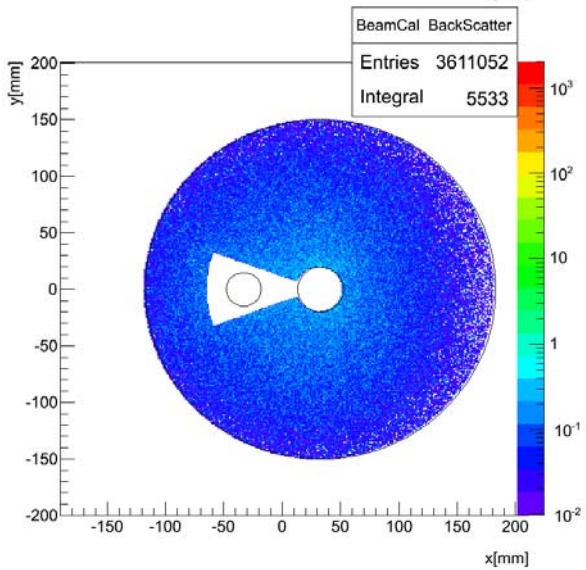
Backscatter

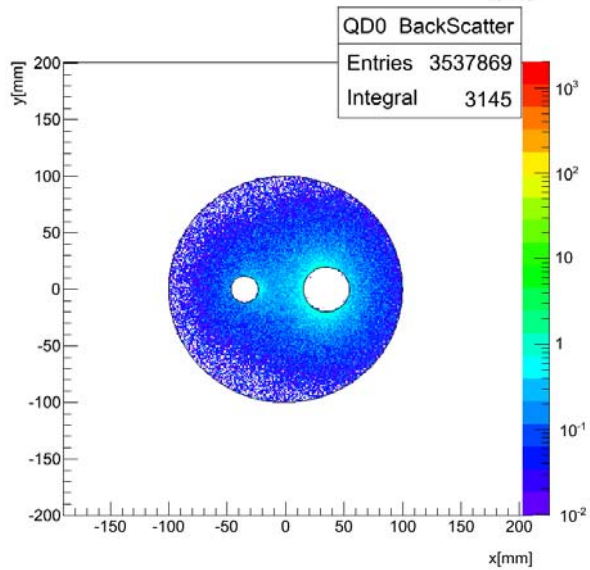












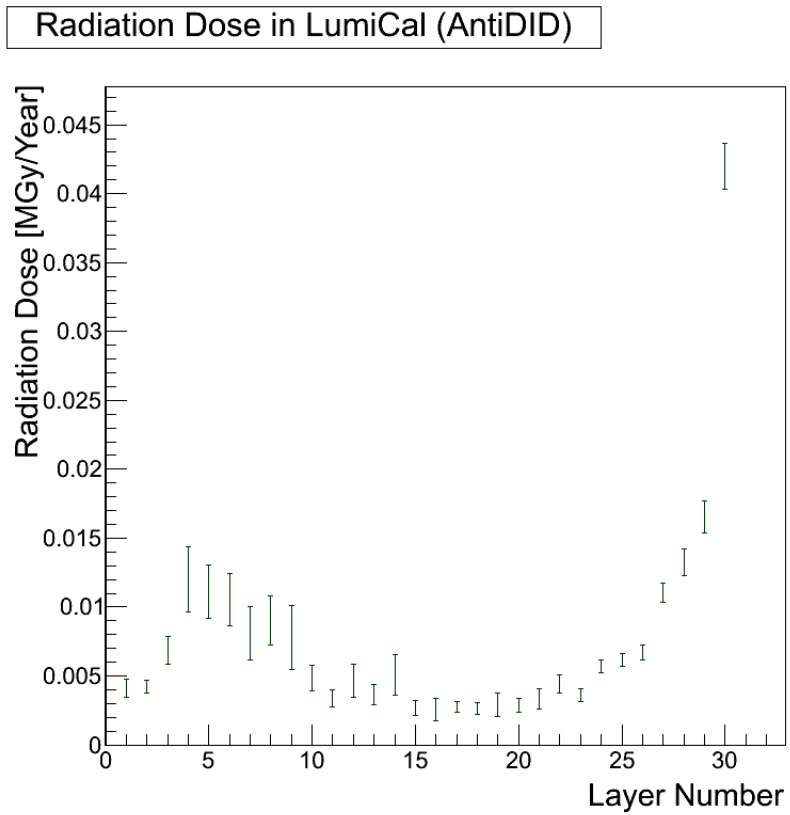
Energy [GeV/mm²]

Background in Numbers

Incoming and Backscattered Energy for 10 BX in GeV				
		AntiDID	w/o DID	DID
LumiCal	In	56	3100	12000
	Out	50	97	210
BeamCal	In	710000	860000	1000000
	Out	4000	4900	5500
QD0	In	160000	230000	200000
	Out	2100	3000	3100
Hits in VXD (all Layers)		19000	71000	32692

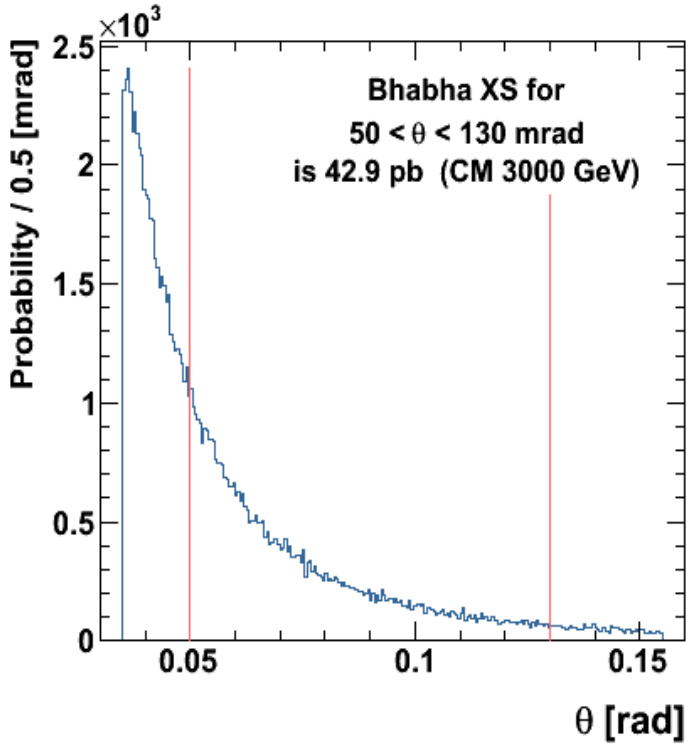
LumiCal and Background

- Larger inner radius needed
- Backscatters from LumiCal are not main source of background
  - Distributed over a large area
  - (I assume) the dose will be reduced with larger radius and more shielding behind LumiCal



Luminosity Measurement

- See Iftach's talk
- Without AntiDID
  - Very rough numbers
  - ➢ Larger inner radius ~12cm?
  - ➢ Fiducial volume starts at ~60mrad
  - ➢ 50% smaller cross section
  - ➢ Bhabha reconstruction problems due to field?

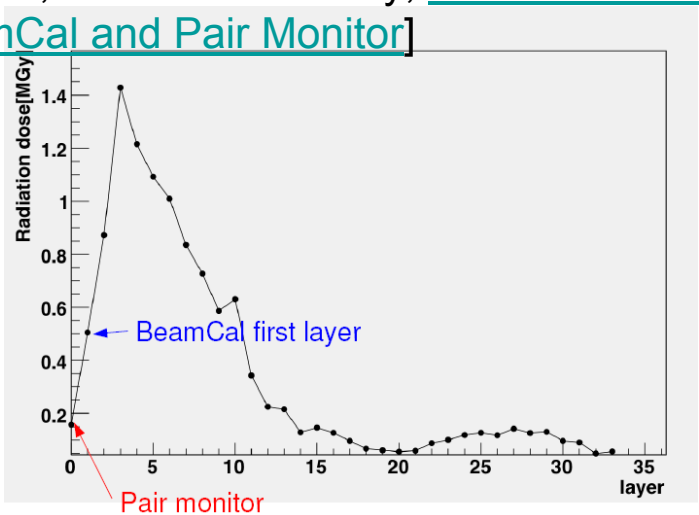


Bhabha cross section at 3TeV CM
[I. Sadeh, Tel-Aviv University, Proposed design of LumiCal at a 3 TeV CLIC, This Workshop]

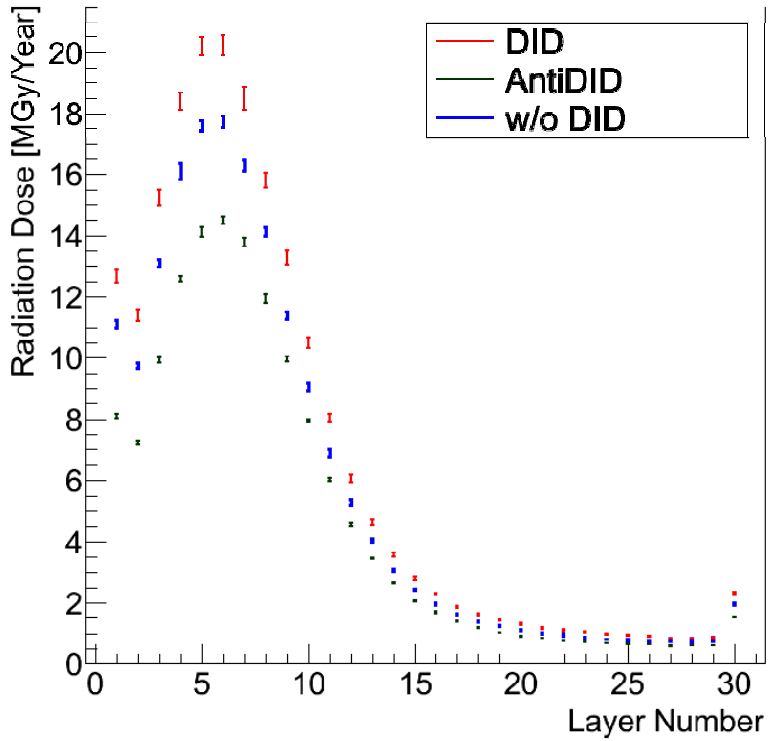
BeamCal

- Dose in BeamCal is ~10 times that in ILC
- Increase inner radius?
  - Might reduce radiation *and* BG

Radiation Dose for BeamCal at ILC
[K. Itoh, Tohuko University, Radiation Dose on BeamCal and Pair Monitor]



Radiation Dose for BeamCal at CLIC



Summary and Outlook

- First model of the forward region for CLIC in the Mokka framework was used for simulation
- Results
  - BeamCal: 10 times higher dose, but at least somewhat usable(?)
  - LumiCal: Without AntiDID, even larger inner radius needed, but Graphite is not necessary
  - Vertex Detector: Background has to be reduced
- To Do:
  - Change inner radius of LumiCal (and BeamCal)
  - Better understanding of the background
  - Try to reduce the background
    - Change masks
  - Add objects for final focus, beam diagnostics, kickers…
    - Additional backscatter surfaces