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Full simulation study of e^+e^- pairs and of LumiCal performance

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Outline

FCCee detector model

Software

Simulation / reconstruction of e^+e^- pairs

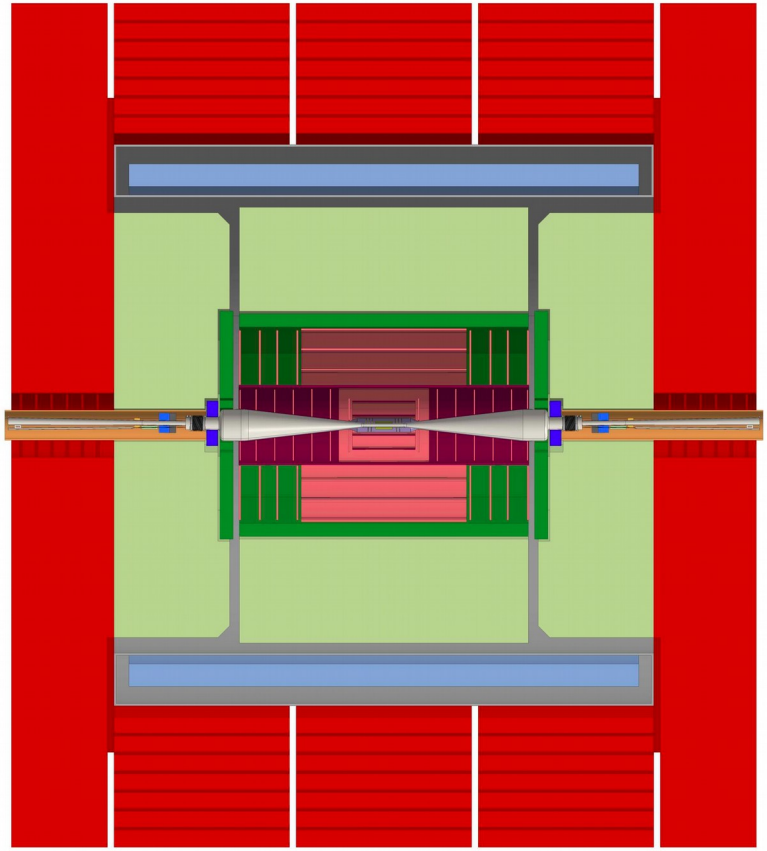
- Estimation of hit density & occupancy

First look at LumiCal performance

From CLIC detector ...

The CLIC detector

- Full Silicon tracking
  - Pixel VXD
  - Inner/Outer trackers with elongated pixels (strip-like)
- B=4T
- Calorimeters inside the solenoid



… to FCCee detector

Adaptation of the CLIC detector

Implementation in DD4hep from Emmanuel

IR

- Following Mike Sullivan design
- L* ~ 2.2m, LumiCal closer (~1m) to the IP, no BeamCal
- Beam pipe radius at 2cm made of 0.5 mm Be
- Ta shield of 0.5 mm around BP apart of the central region (|Z| < 25 cm)
  - Respective changes to VXD, innermost layer at 2.2cm

Magnetic field

- 2T main field
- + fields from shielding and compensating solenoids

Software framework

We currently use ILCSoft

- Mature & validated software tools

Detector description & simulation in dd4hep

- Realistic description
  - Support & services (cabling, cooling etc) are included
- No segmentation in pixels / strips
  - We deal with this only in digitisation level

Marlin processors for digitisation / reconstruction

Digitisation

- Gaussian smearing according to sensor's resolution (technology agnostic)

Various pattern recognition algorithms

- For the time being we use a track cheater

Overlay processor

- Merges “physics event” hit collections with pairs, according to each subdetector readout time

Pairs generation with Guinea Pig

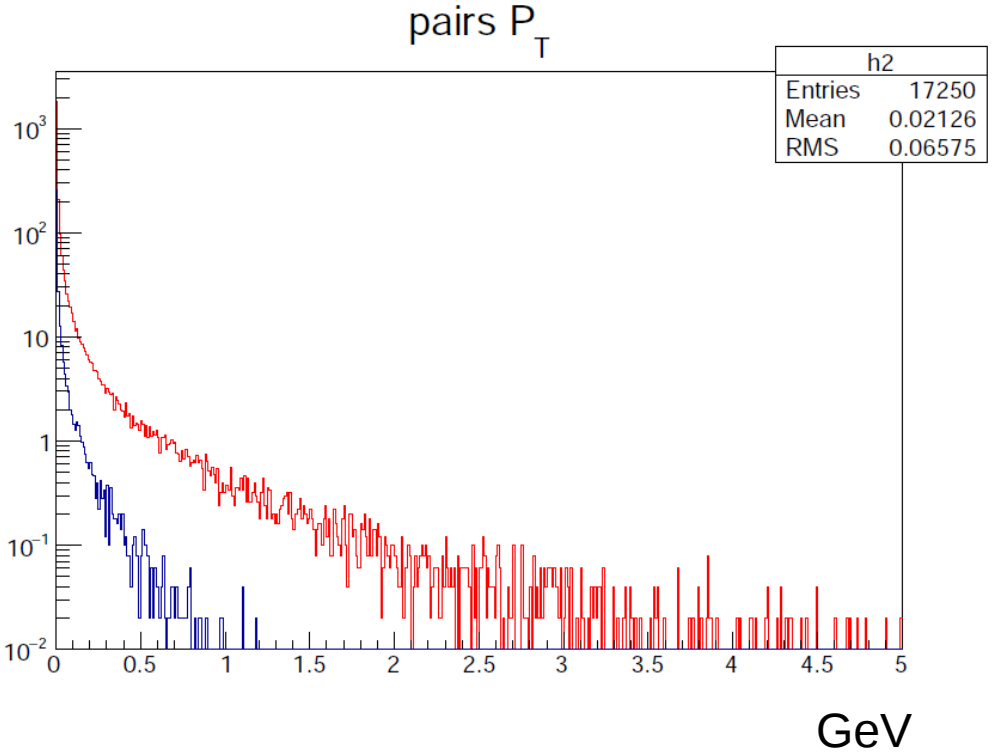
Guinea Pig is an e^+e^- beam-beam interaction generator

- Output file with the 4-vectors of the produced pairs

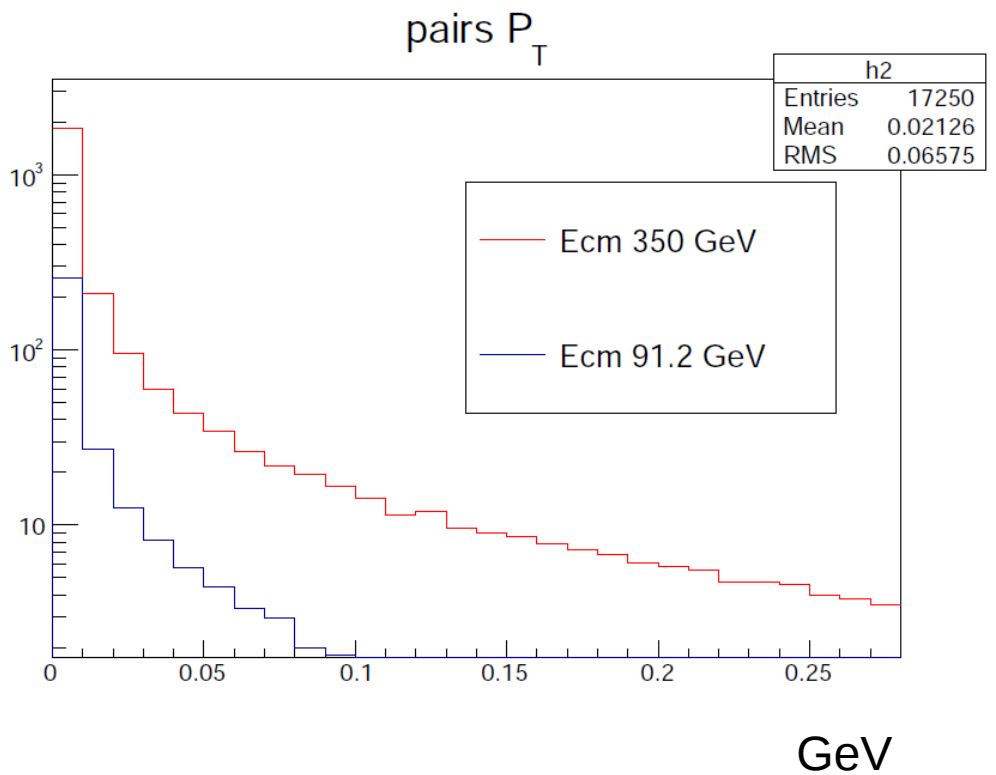
~300 BXs at Z peak (Ecm=91.2GeV) and 135 BXs at top (Ecm=350GeV)

- Top: 4000 pairs / BX, ~4 TeV of energy
- Z: ~ 350 pairs / BX, < 500 GeV of energy

Focus on Ecm = 350 GeV in these slides



Zoomed

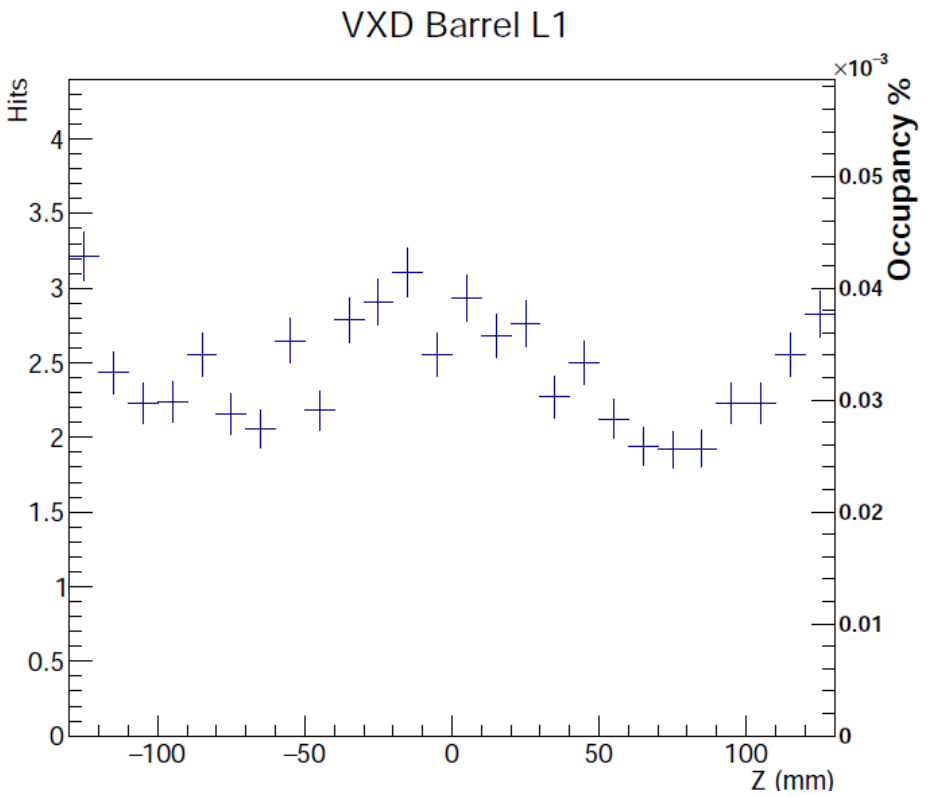


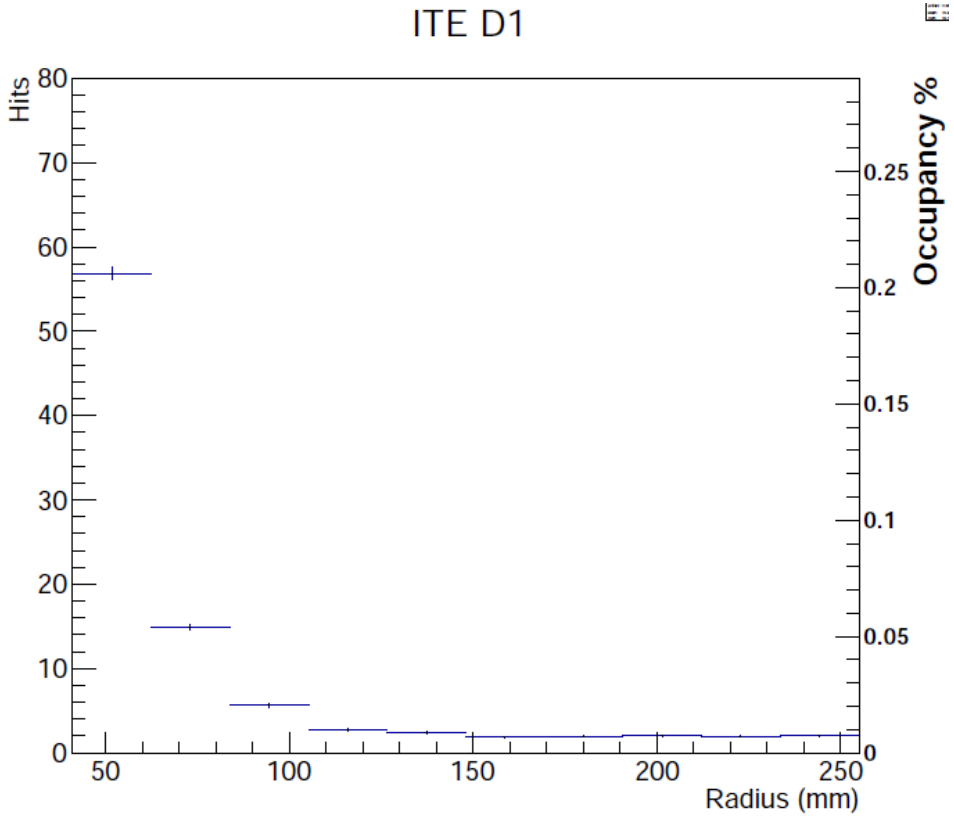
Pairs induced occupancy for E_{cm} = 350 GeV

~ 70 hits / BX at innermost VXD layer

Some remarks on occupancy calculation

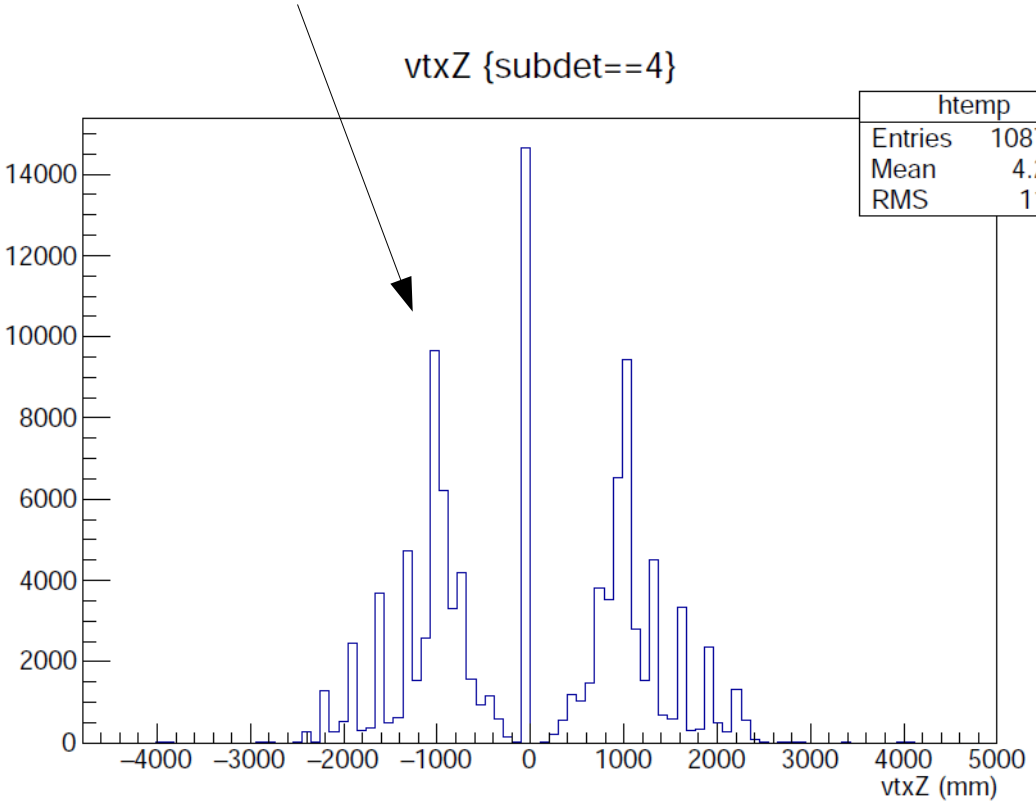
- 20x20 μm² pixels in VXD, 0.024x10 mm² in tracker
- Assumed time resolution of 1BX
- Assumed cluster multiplicity of 1
  - Underestimation of occupancy
  - Can reach 0.6 % at ITE D1 for multiplicity ~ 3

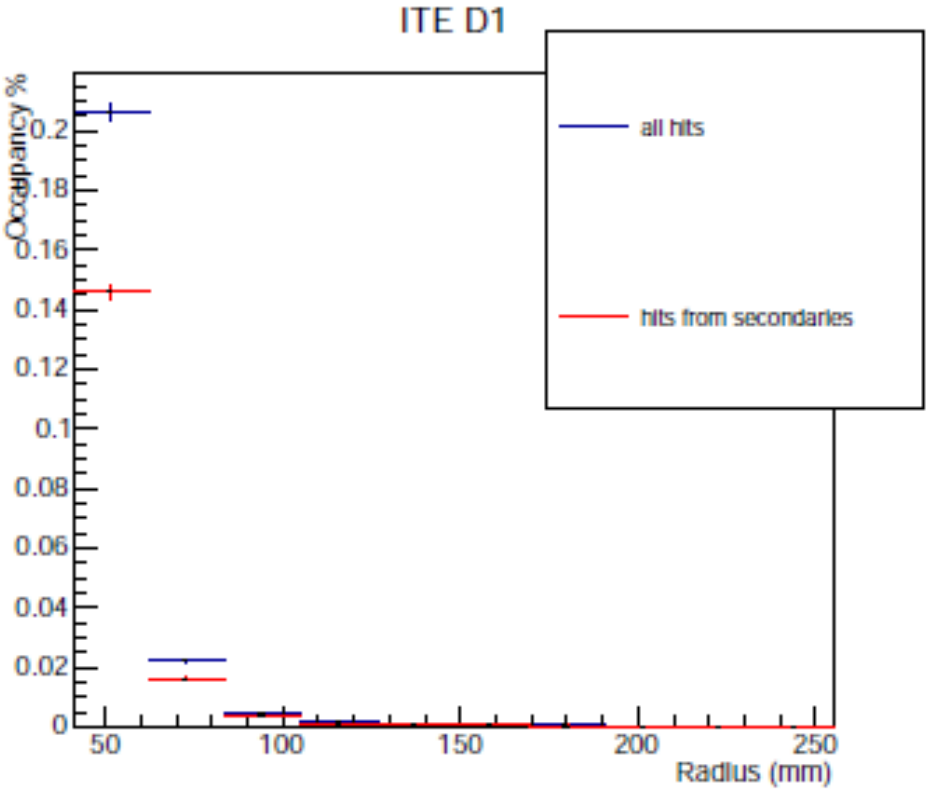




Origin of the pairs – induced hits

Beam pipe splitting ~ 1m along Z





Most of the hits on forward trackers are coming from secondaries

Largest source of secondaries is the beam splitting region, at Z ~ 1m

Reconstructed tracks from e^+e^- pairs

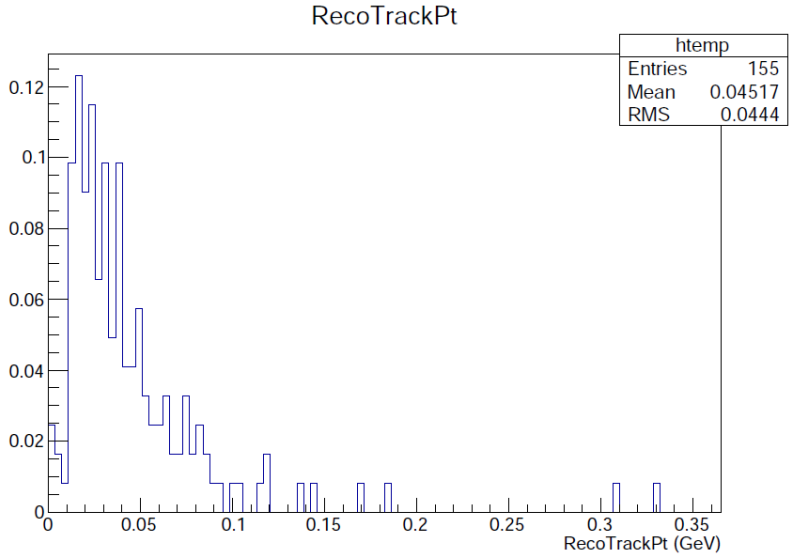
Ideal pattern recognition (uses MC info from hits)

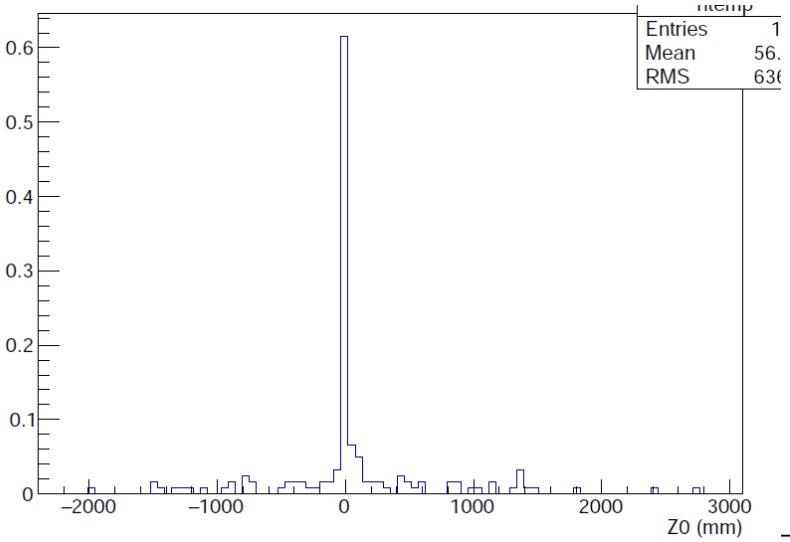
Ecm = 350 GeV

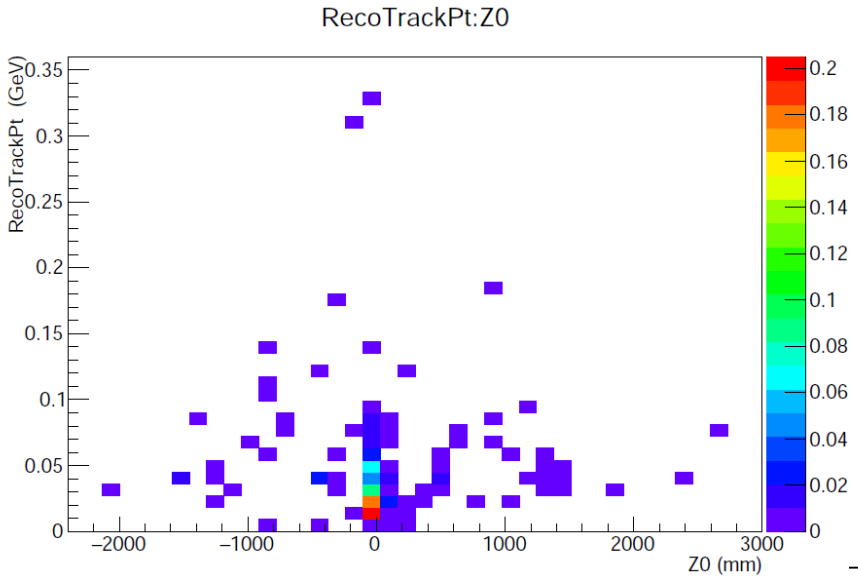
Time resolution of VXD / trackers 1BX

Tracking can give us an extra handle in understanding the effect of pairs

- Pairs might be an issue if a tracking with high purity and efficiency at very low P_T (< 100 MeV) is required







LumiCal study

Generation of bhabha events using BHWIDE

Full simulation with DD4hep (adapted from CLIC det)

Reconstruction using CLIC clusterer

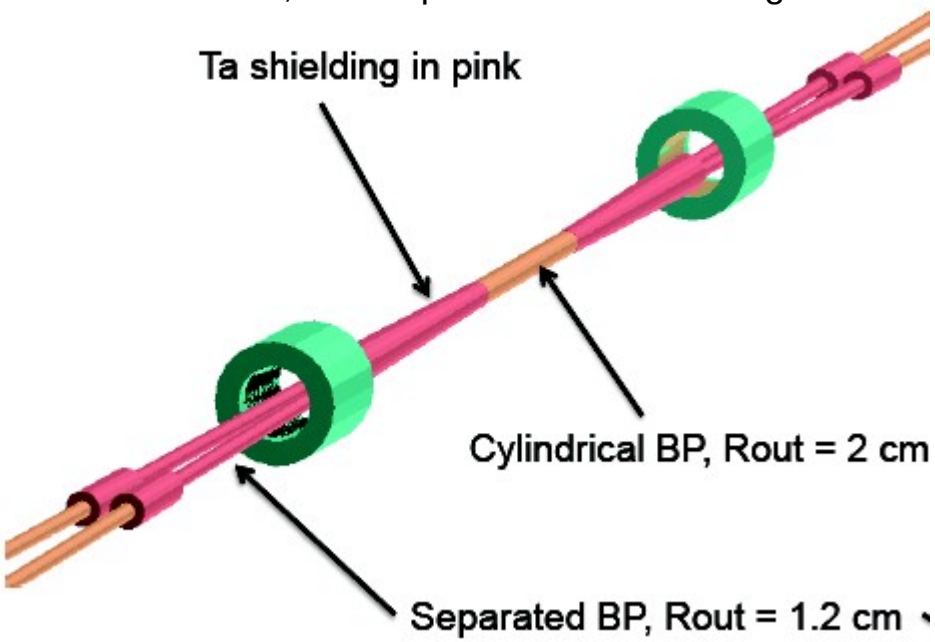
Objectives so far

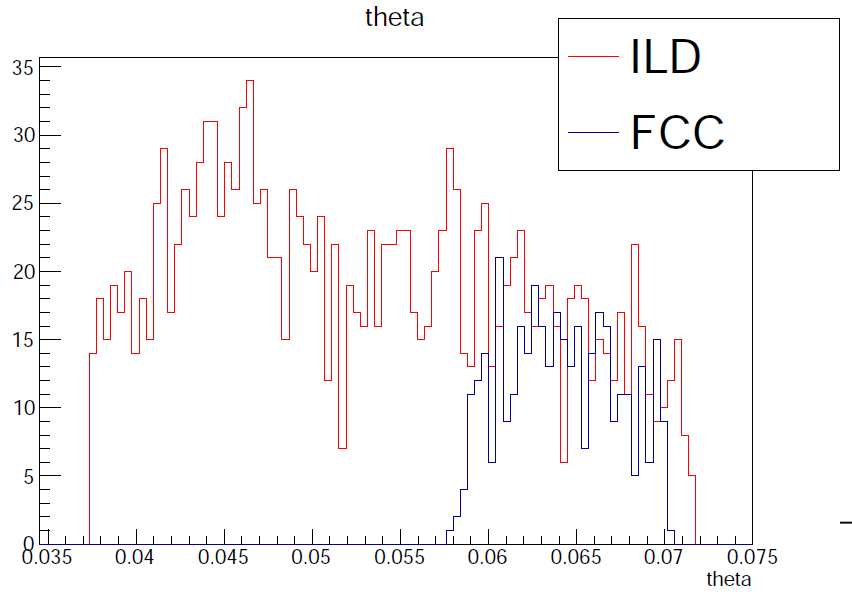
- Impact of small L*
- Effect of Tantalum shield on resolution
- Effect of pair bkg

Comparison with ILD LumiCal

	ILD	FCC
Inner R	80 mm	55.7 mm
Outer R	195.2	190
Min Z	2500	1090
Max Z	2630	1290

From Emmanuel, from a previous MDI meeting





LumiCal resolution & Ta shield

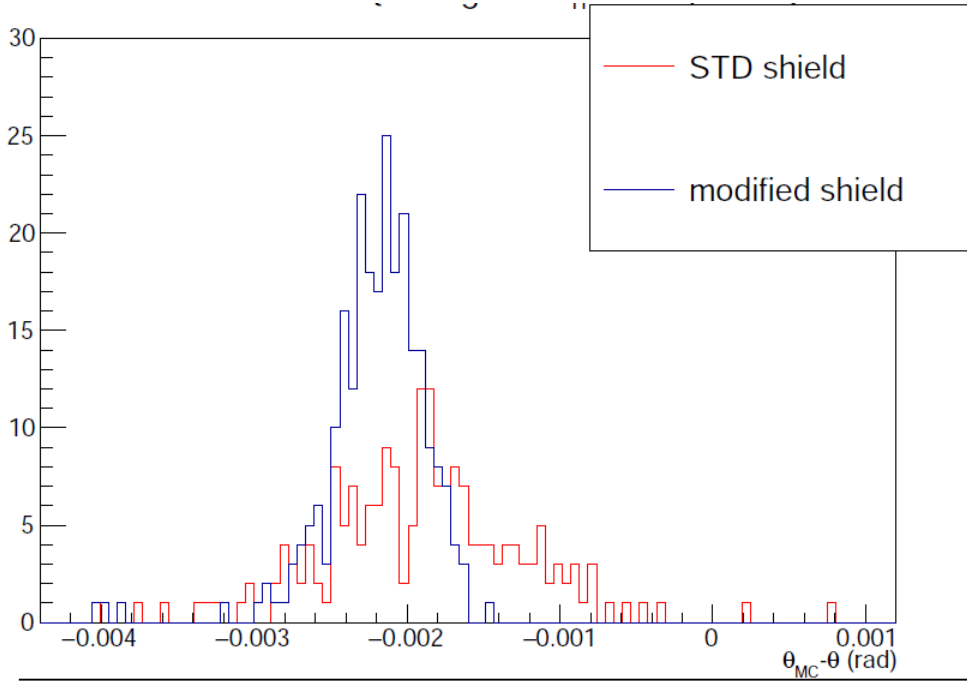
Ta shield significantly degrades LumiCal resolution

Important improvement if we remove the shield of the largest part of central BP

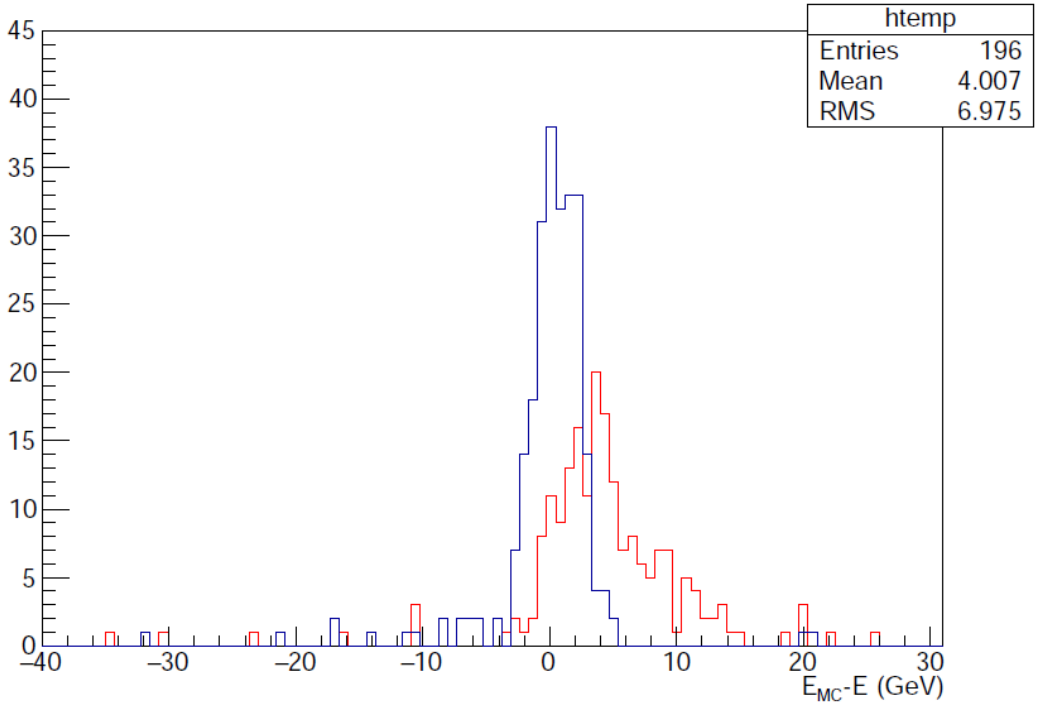
- Nominal shield at central BP: 25 cm – 100 cm
- Modified one: 81 cm – 100 cm

Preliminary studies, further optimisation could be possible

θ residual



energy residual



Preliminary conclusions

Very low (~10^{-5} – 10^{-6}) occupancy for √s 91.2 GeV

For √s 350 GeV, occupancy can go at per mil level at forward trackers

However pairs shouldn't be considered as a negligible bkg

- √s 91.2 GeV: 2.5 (7.5) ns BX spacing →very fast detectors
- Cluster multiplicities were not accounted for
- Accumulation of hits from various bkg sources
- Simulation uncertainty
- Etc…

So pairs might be a worry, depending on what physics we want to do

Lumical

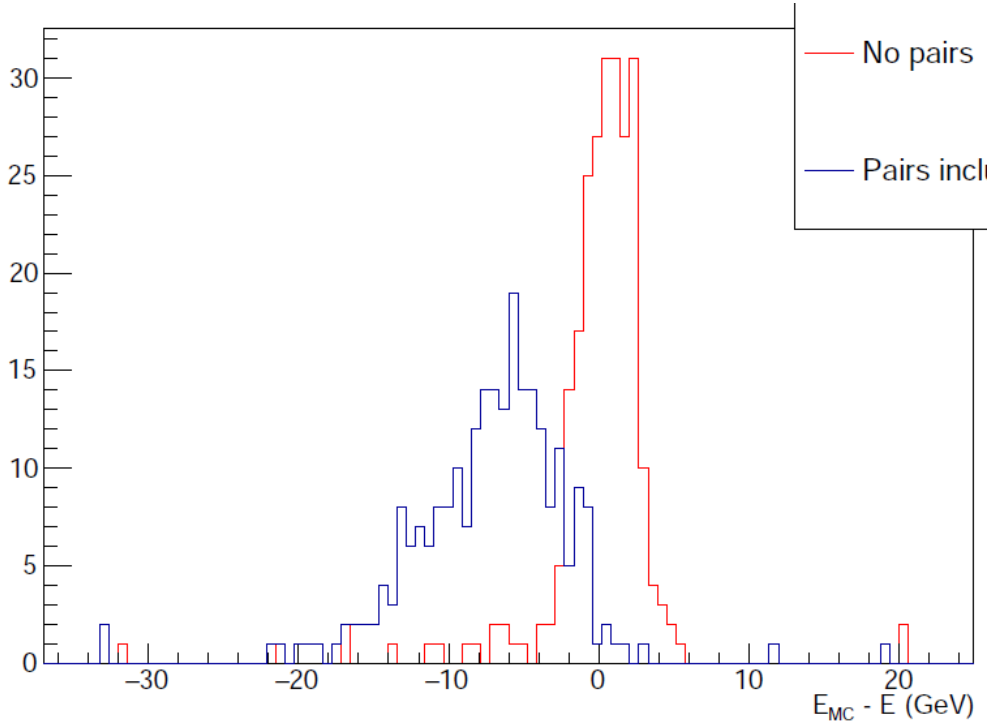
- Small L* → relatively low statistics
- Ta shield has a non – marginal impact on resolution
- Pairs seems to degrade LumiCal's resolution
  - Degradation possibly could be alleviated via the clusterer optimisation

backup

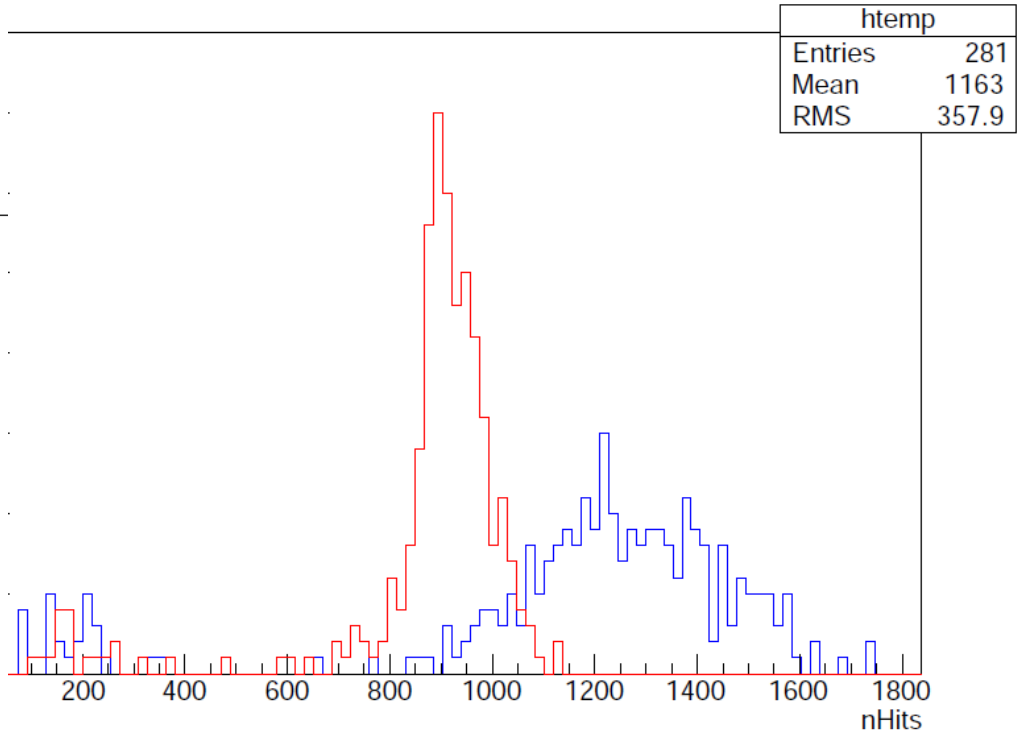
LumiCal resolution & pair bkg

Very preliminary results

Effect of pairs should be partially alleviated after optimisation of the clusterer



Energy residuals



# of hits