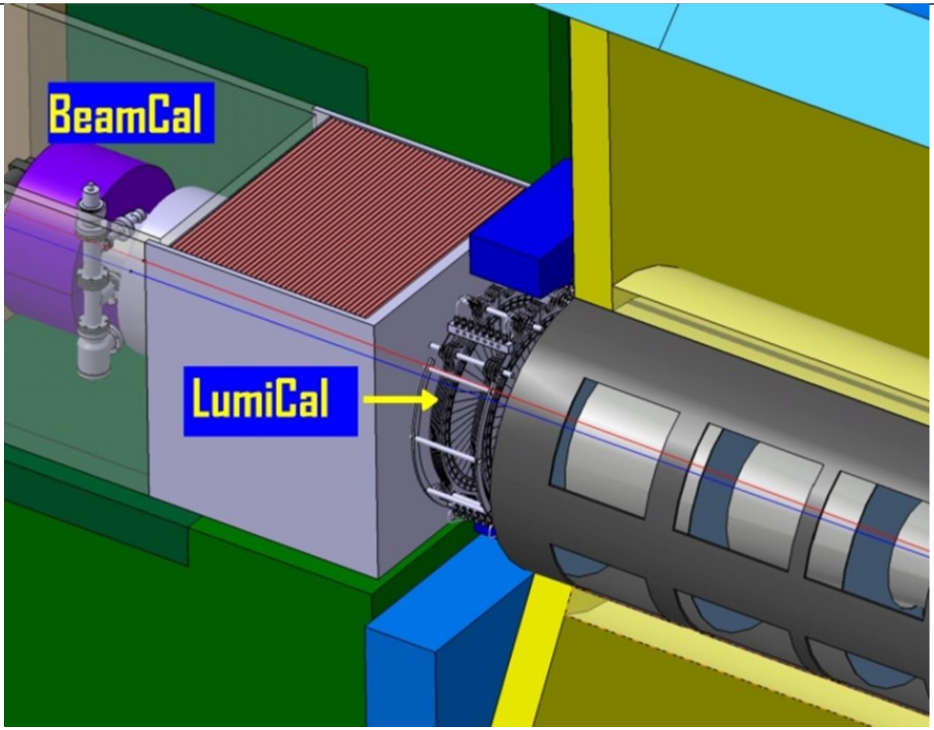
Design of ILD forward region for reduced L*

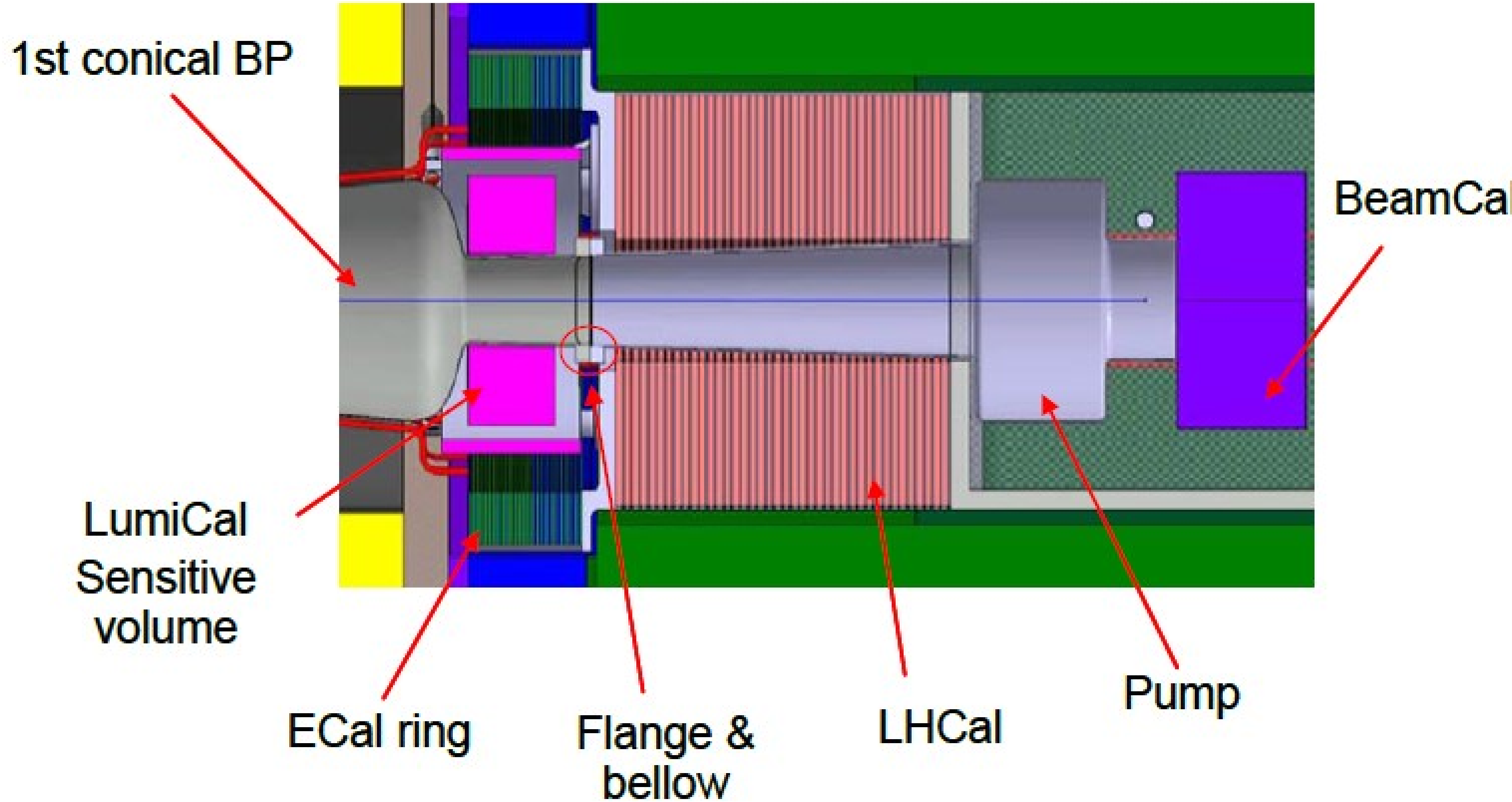
Sergej Schuwalow, DESY Hamburg



Contents

- ILD forward region (TDR/DBD design)
- Detectors in the very forward region
- BeamCal option based on sapphire sensors
- L* reduction 4.4 m -> 4 m option
- LHCal new design (first steps)
- Pair background
- Conclusions and outlook

Forward region design (TDR/DBD)



Forward region design (TDR/DBD)

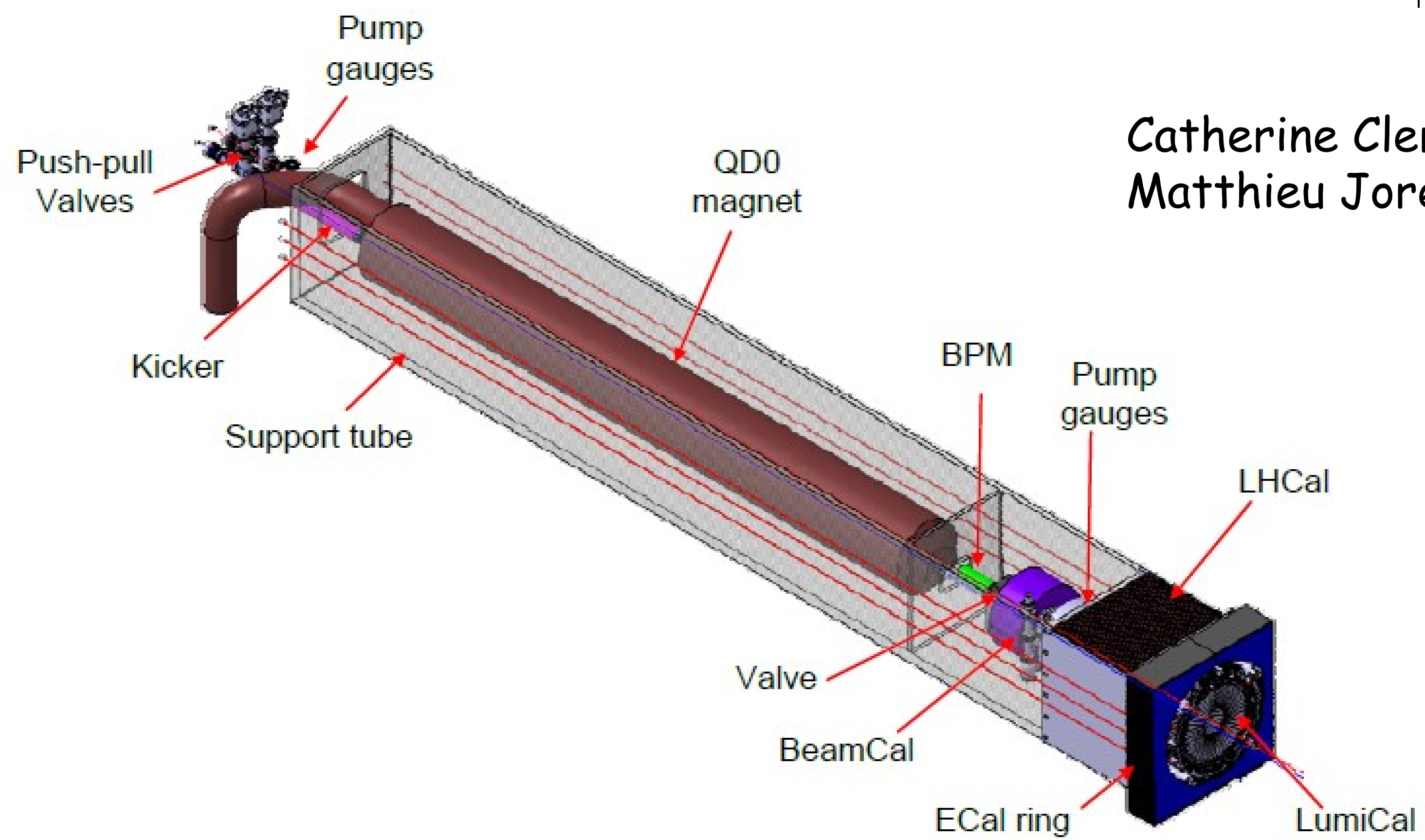
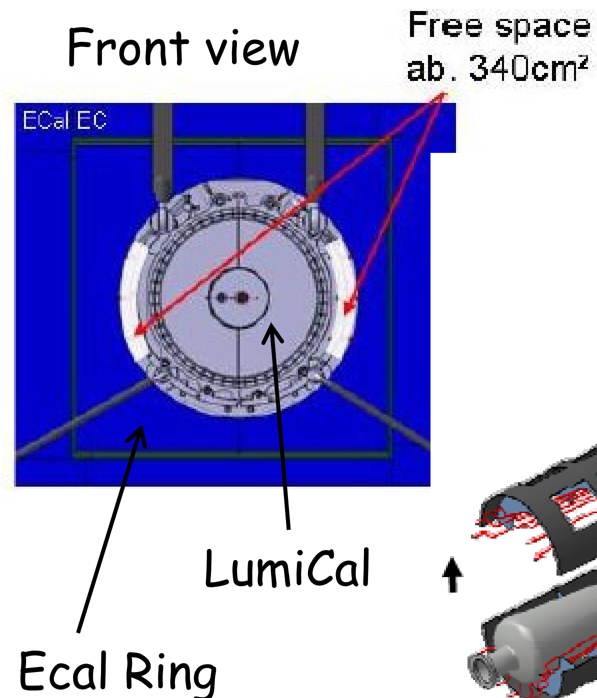


FIGURE 2.4.1.1 Forward region components

Catherine Clerc, Matthieu Jore

Forward region design (TDR/DBD)

Front view



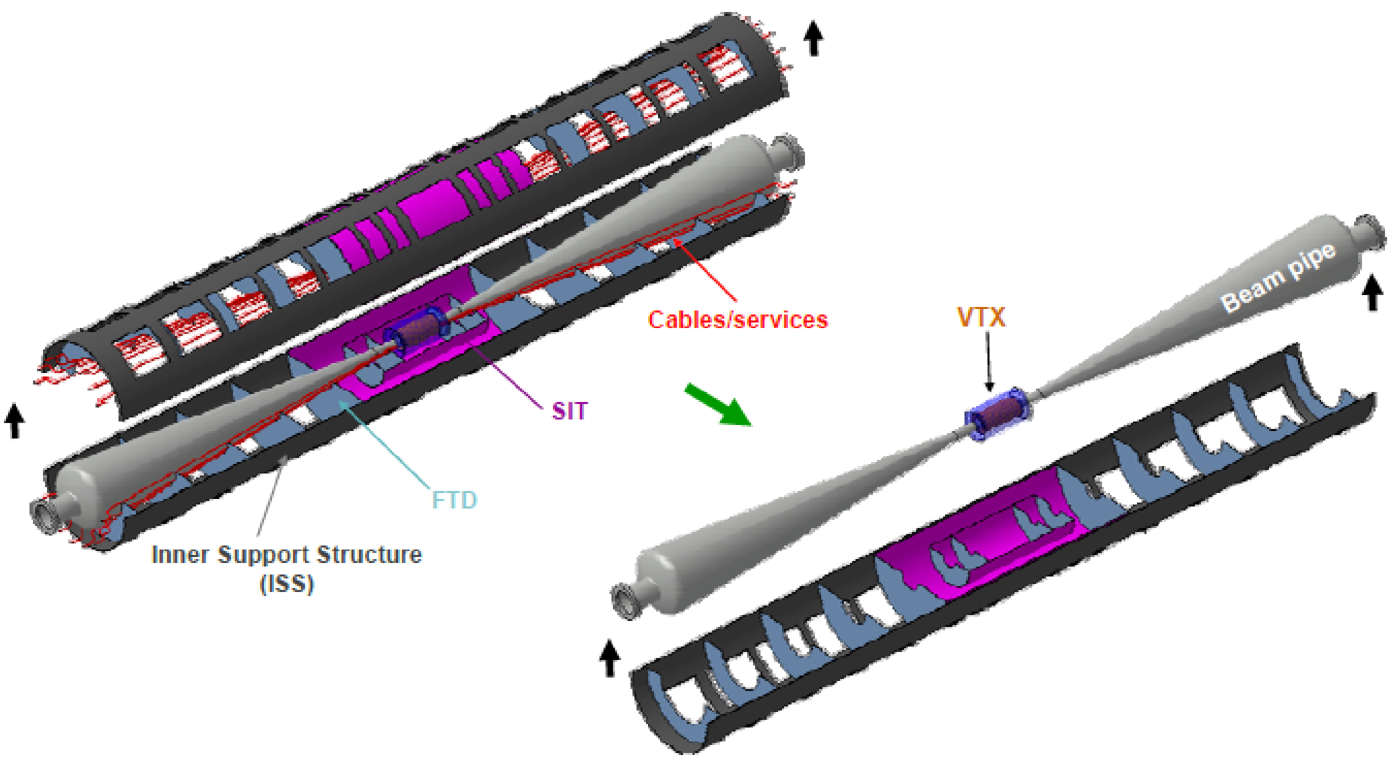


FIGURE 4.2.2.1 Maintenance scenario for Vertex detector

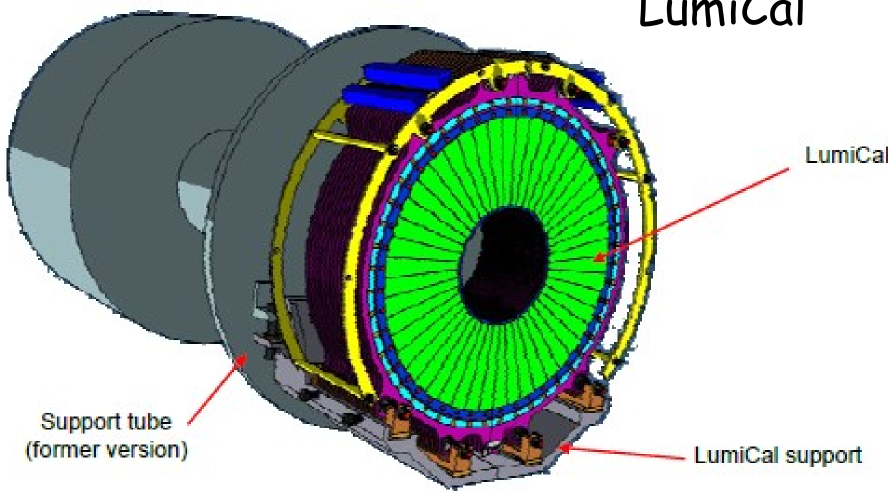
Forward Detectors

- LumiCal – precision integrated luminosity measurement (Bhabhas), and hermeticity
- $dL/L < 10^{-3}$ for $\sqrt{s}$ = 0.5-1TeV
- $dL/L < 2\times10^{-4}$ for GigaZ – very challenging!
- LHCal – PID behind LumiCal, hermeticity
- BeamCal – instantaneous luminosity optimization (beam-strahlung pairs) and hermeticity
- Tracking/spectrometers:
- Pair monitor – luminosity optimization
- GamCal - instantaneous luminosity optimization

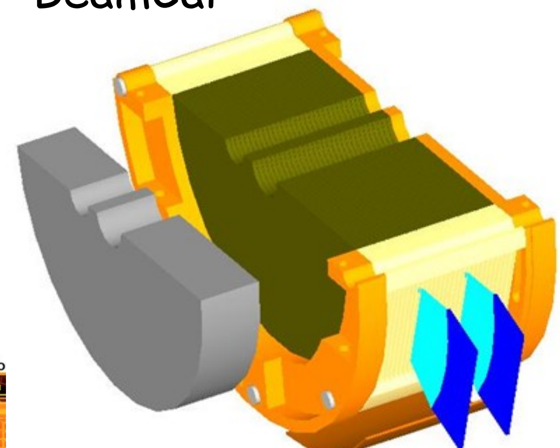
  (beam-strahlung γ detector at $z \approx 190$m)

Forward Detectors

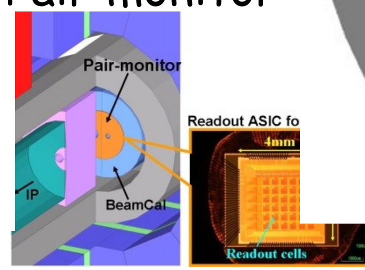
LumiCal

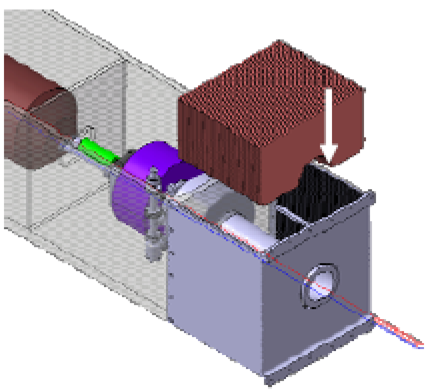


BeamCal

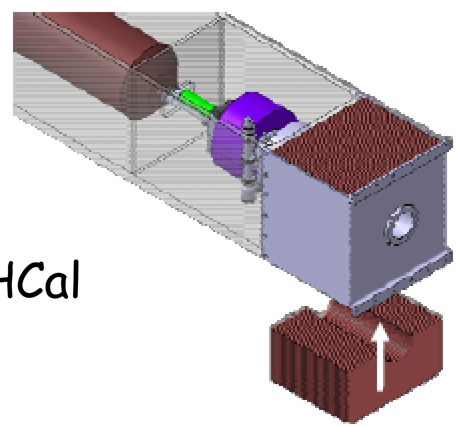


Pair monitor

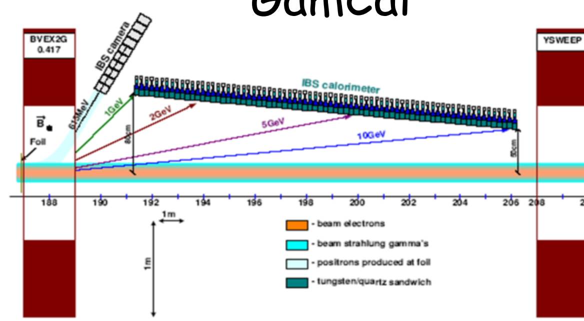




LHCal



GamCal

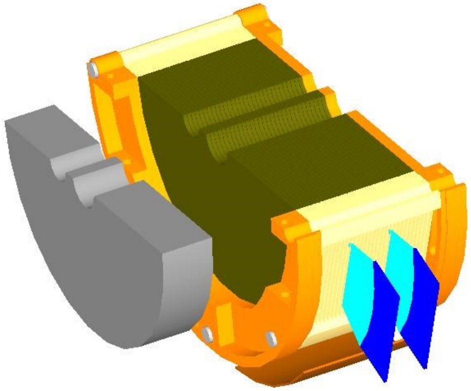


BeamCal sensor material properties

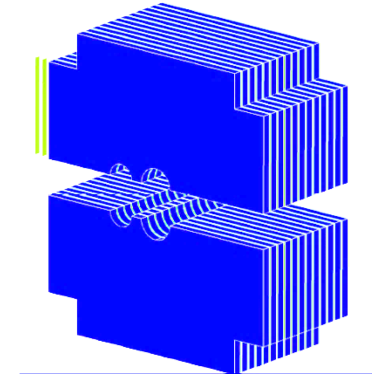
	Sapphire	Diamond	GaAs	Si
• Density, g/cm^3	3.98	3.52	5.32	2.33
• Dielectric constant	9.3 – 11.5	5.7	10.9	11.7
• Breakdown field, V/cm	$\sim 10^6$ *	10^7	$4 \cdot 10^5$	$3 \cdot 10^5$
• Resistivity, $\Omega \cdot cm$	$>10^{14}$	$>10^{11}$	10^7	10^5
• Band gap, eV	9.9	5.45	1.42	1.12
• El. mobility, $cm^2/(V \cdot s)$	>600 **	1800	~8500	1360
• Hole mobility, $cm^2/(V \cdot s)$	-	1200	-	460
• MIP eh pairs created, eh/μm	22	36	150	73

* Typical operation field $\sim 1\text{-}2 \cdot 10^4$ V cm^{-1}

** at 20ºC, ~30000 at 40ºK

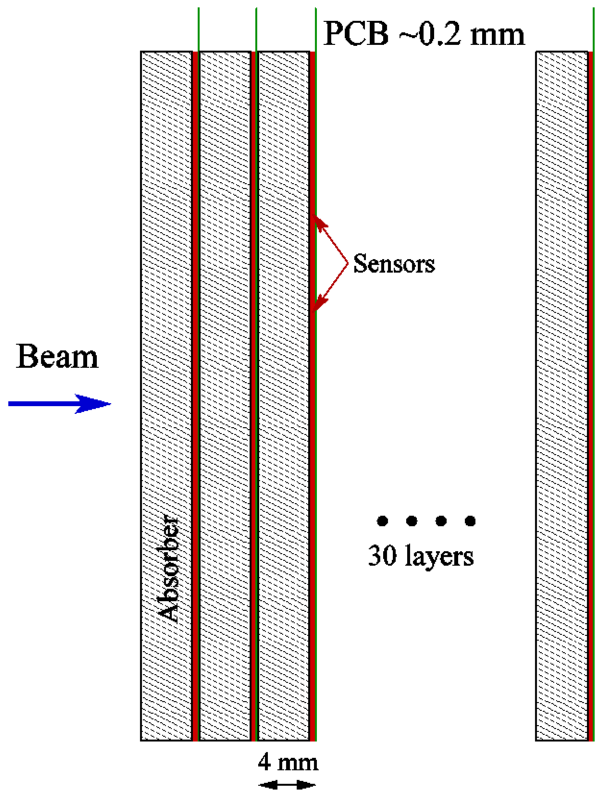


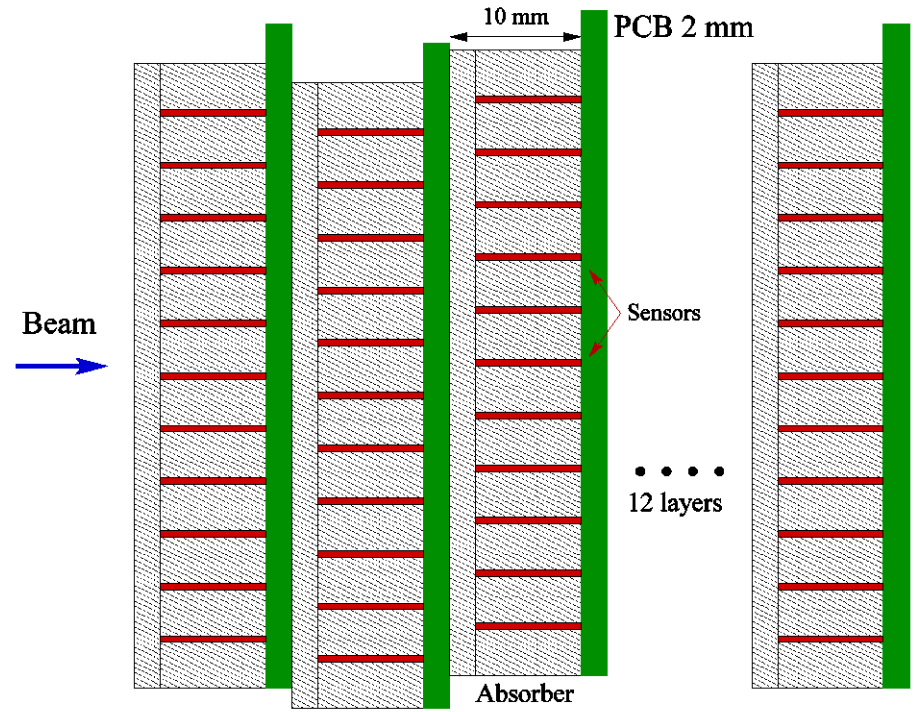
Modification of BeamCal design for sapphire sensors application



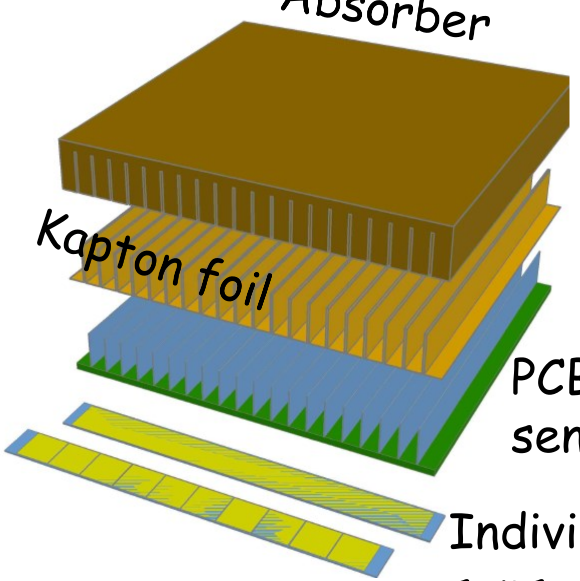
Old

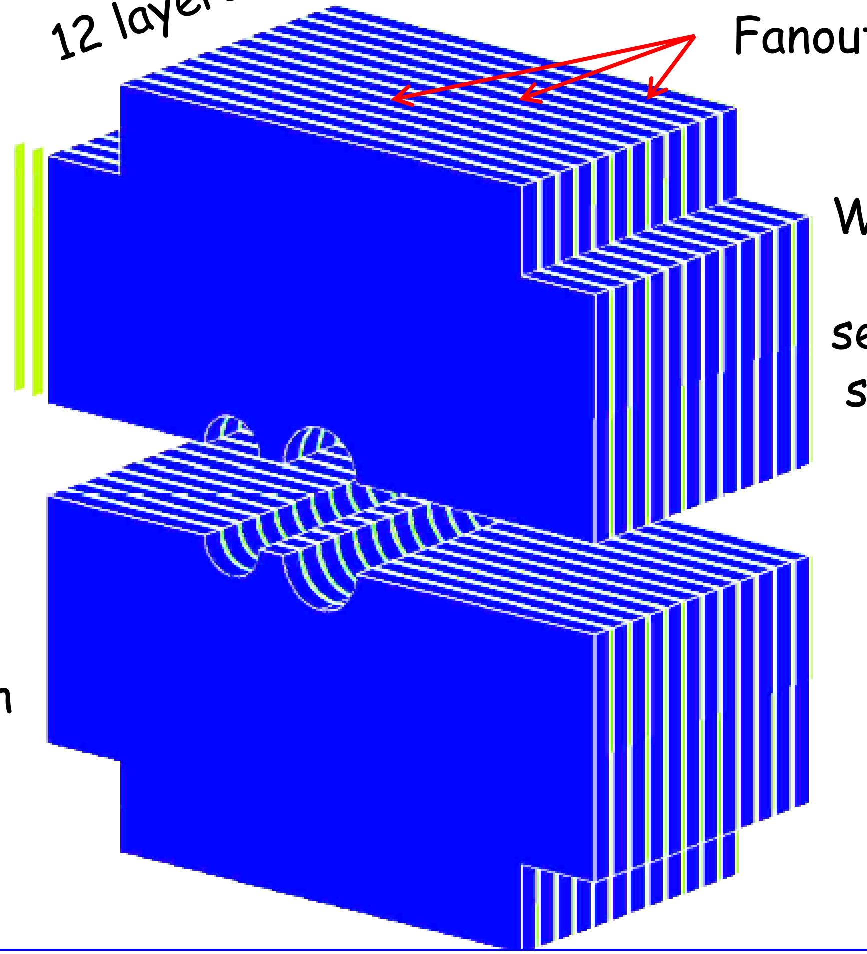
New





BeamCal – sapphire based design





New vs Old BeamCal design

Pro:

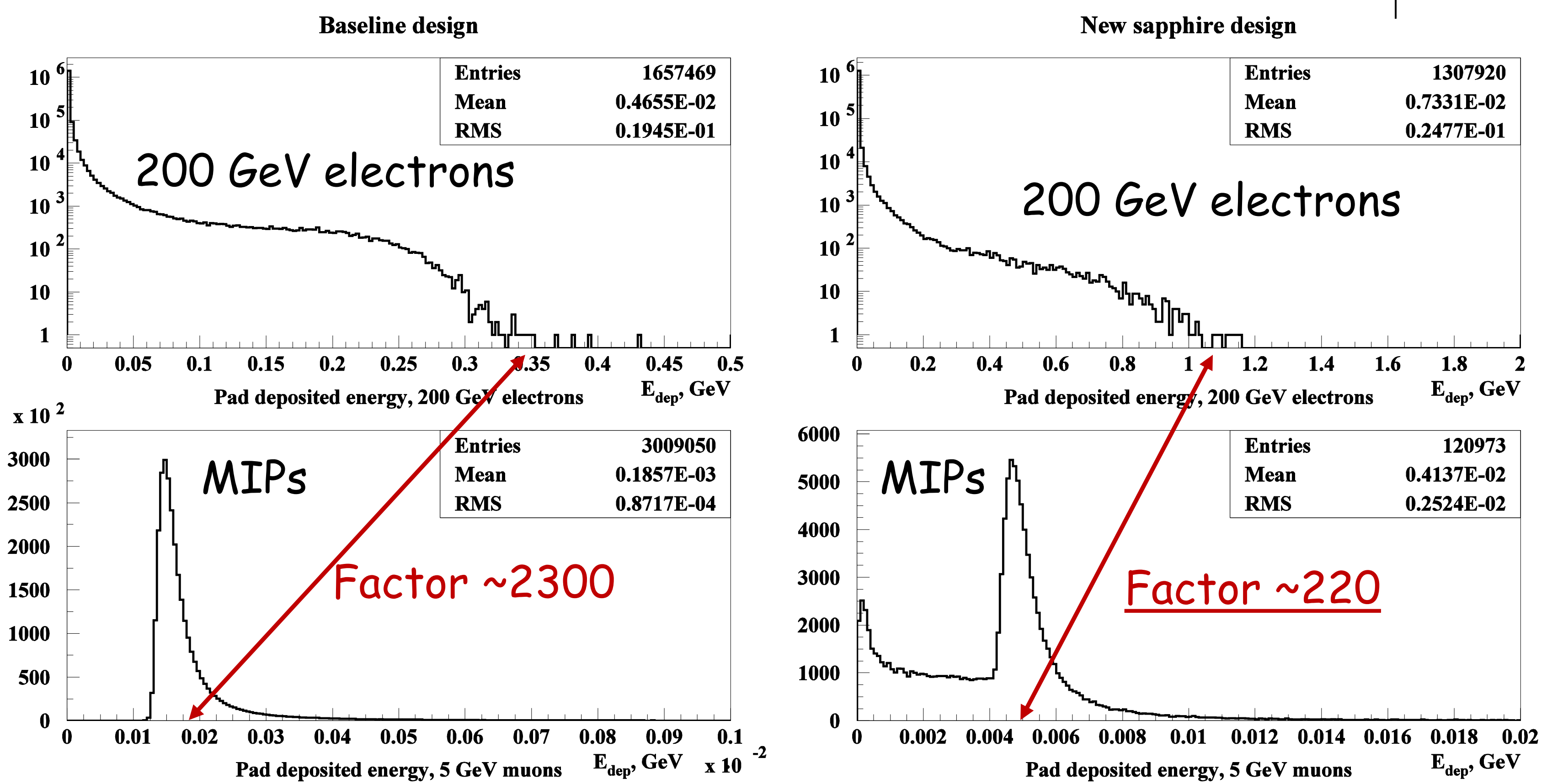
- Better radiation hardness (new sensors) x10
- Easier physical calibration and radiation damage monitoring
- Reduced required R/O dynamic range x10

Contra:

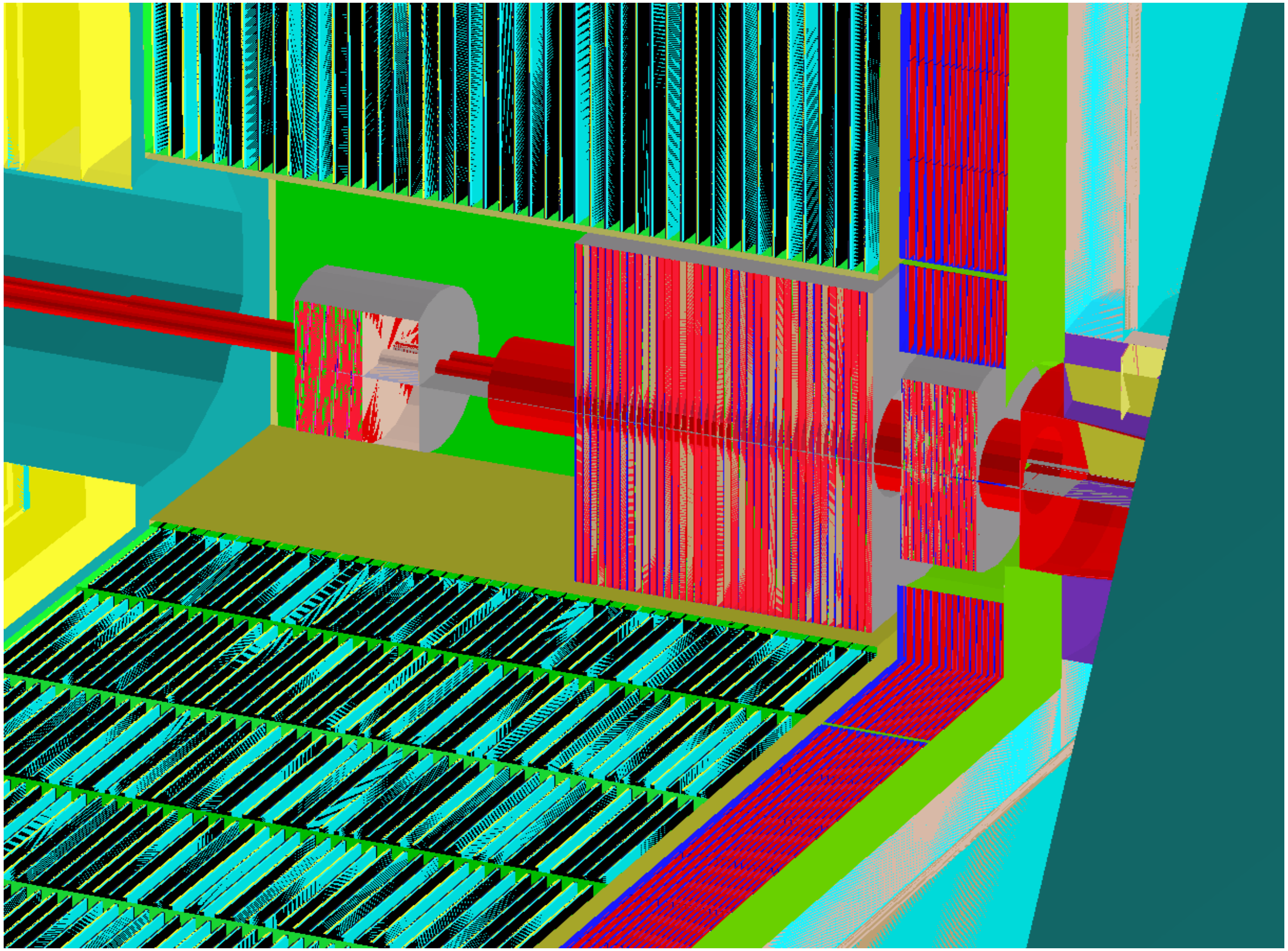
- Worse spatial uniformity
- Worse energy resolution

Impact on physics to be understood

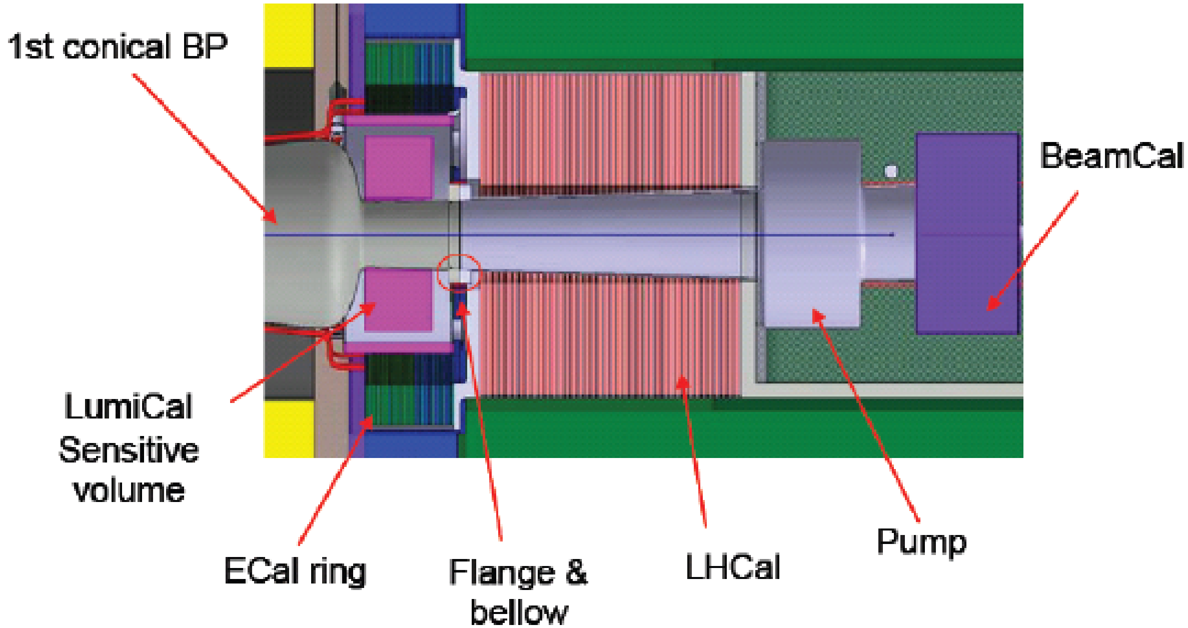
Dynamic range needed for BeamCal Readout (high energy electrons/MIPs)



ILD Mokka model → DD4HEP, L*=4.4 m

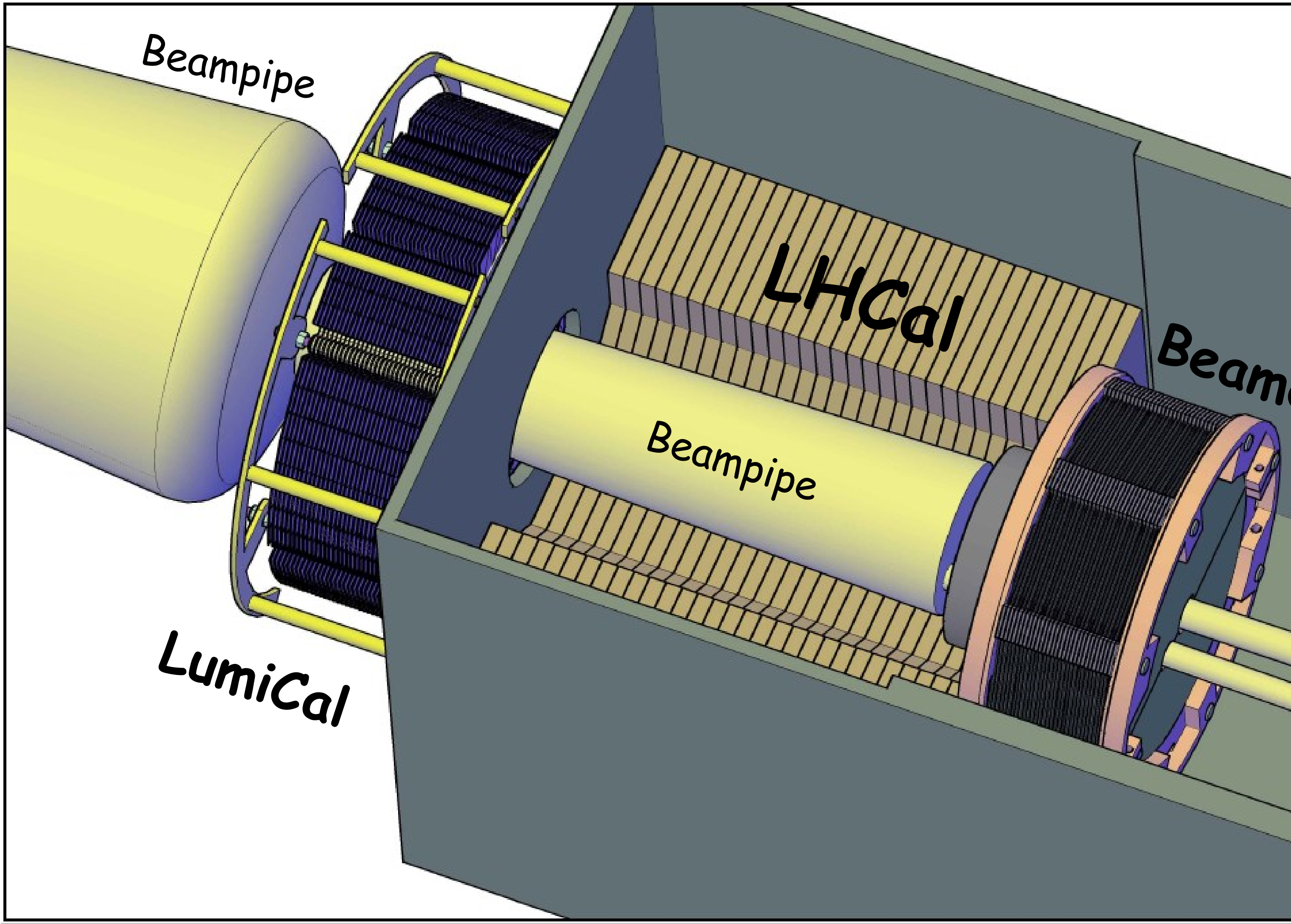


Forward Region - possible changes towards L*=4m

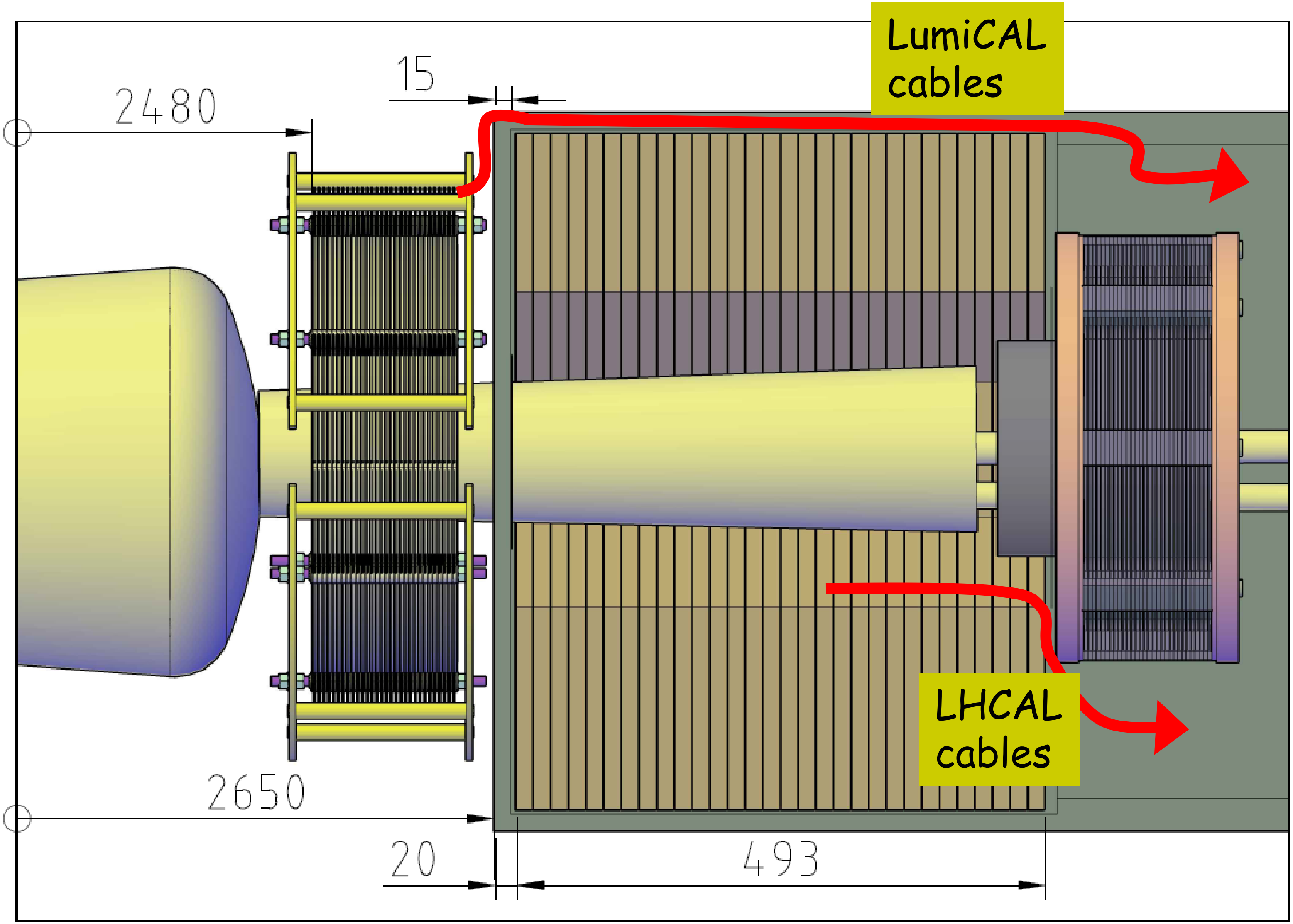


- Need to find ~40cm in current design
- Look into design optimisations of all structures
  - maybe find some 10cm there, but more?
- Biggest devices:
  - Pump in front of BeamCal (30cm)
  - LHCAL (~50cm)

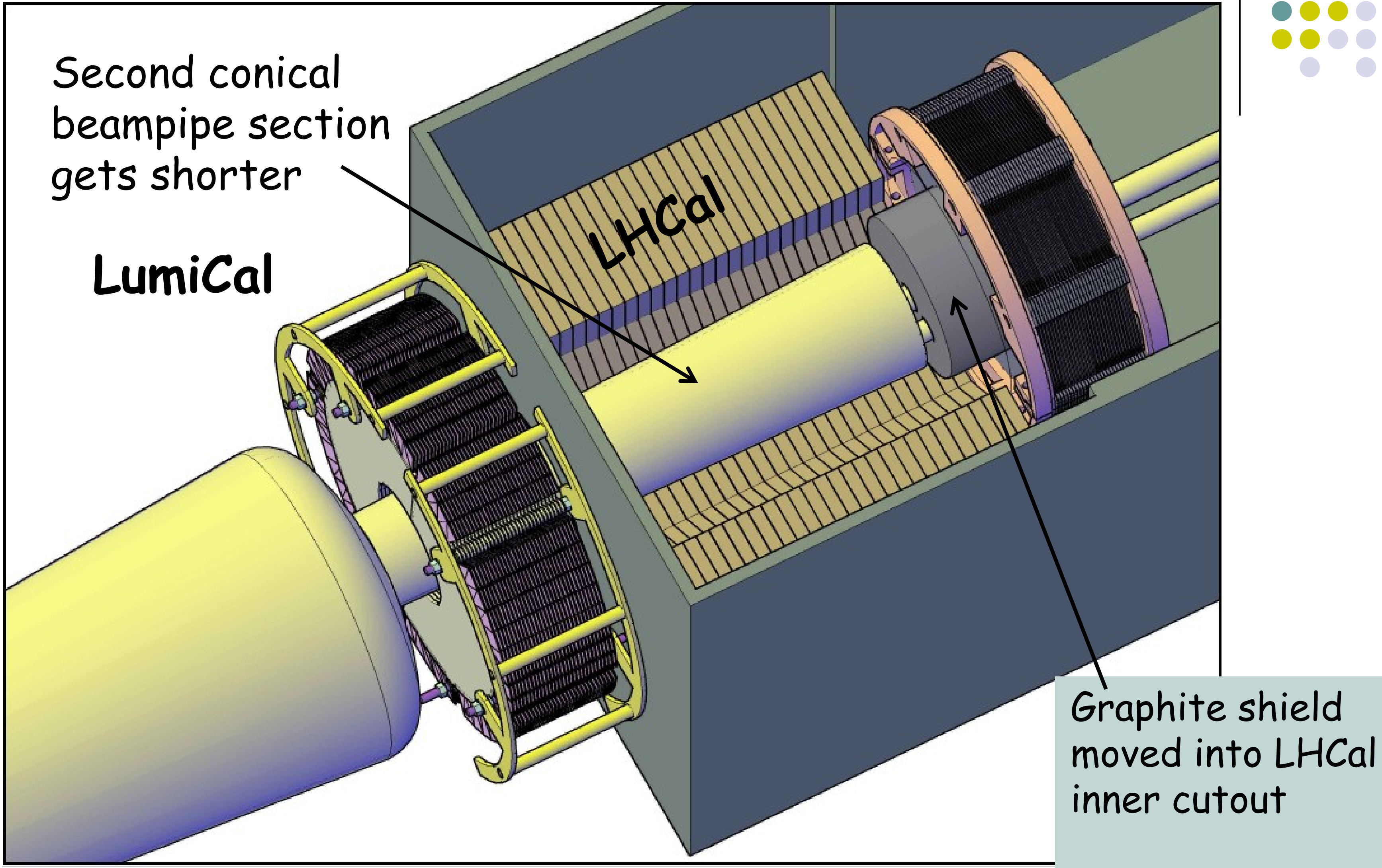
Forward region, reduced L* = 4m (1)



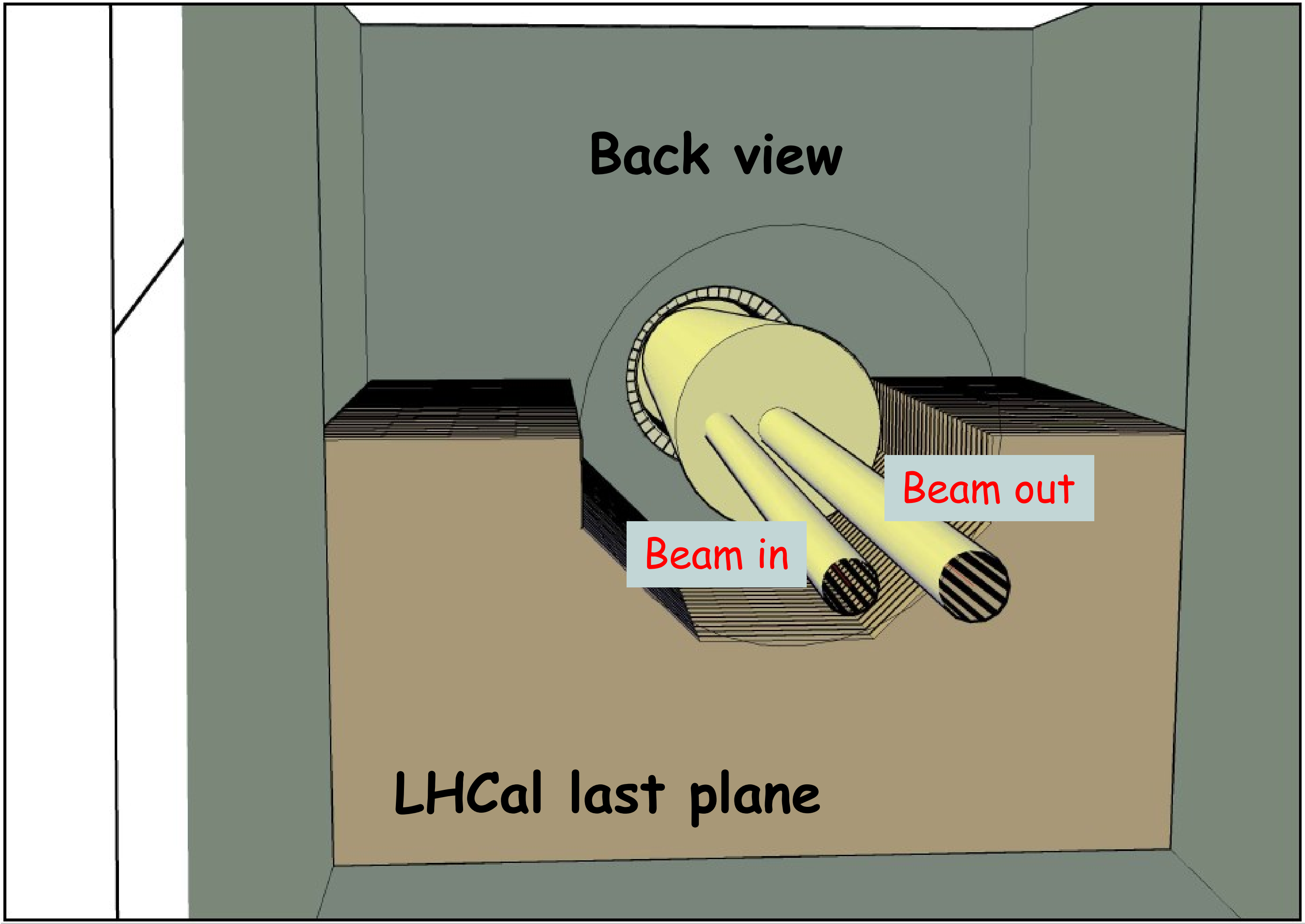
Forward region top view, reduced L*=4m (2)



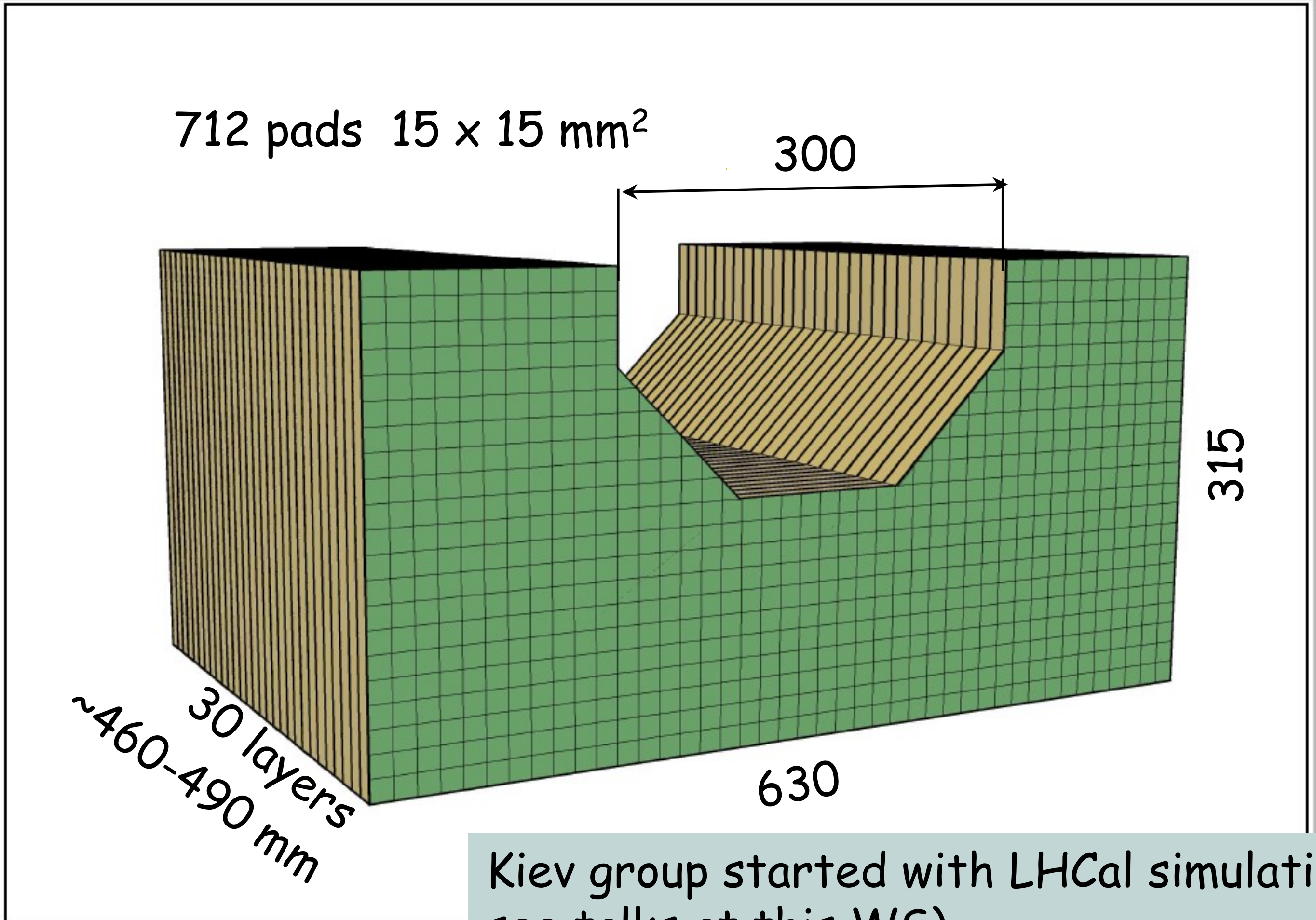
Forward region, reduced L*=4m (3)



Forward region, LHCal(1/2) and beampipe



LHCal Layout (bottom half)

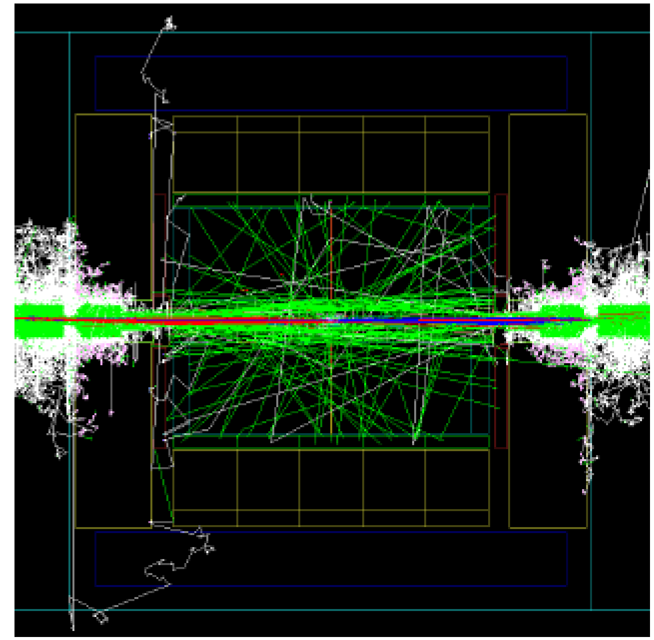


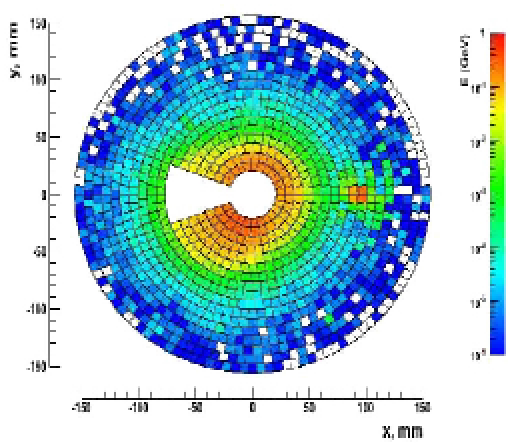
Sensors: Si pads, R/O electronics similar to ECAL

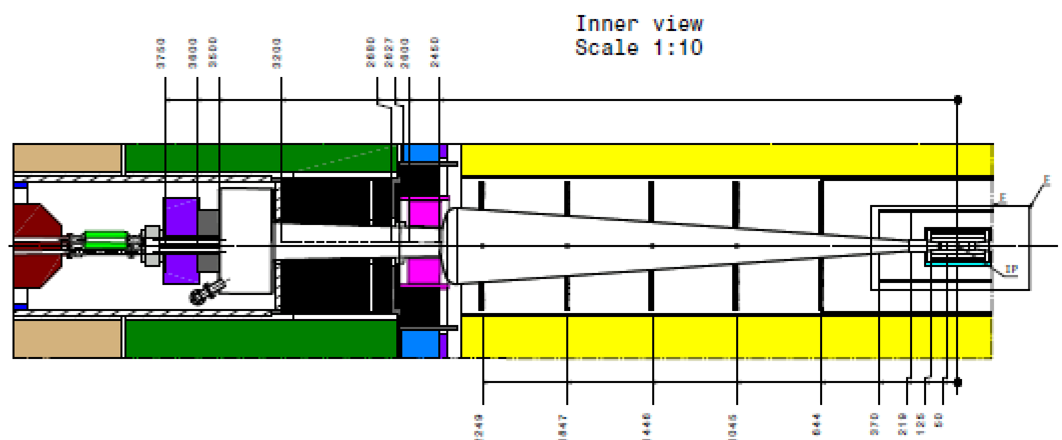
Kiev group started with LHCal simulations (first results, see talks at this WS)

Pair Background Backscattering

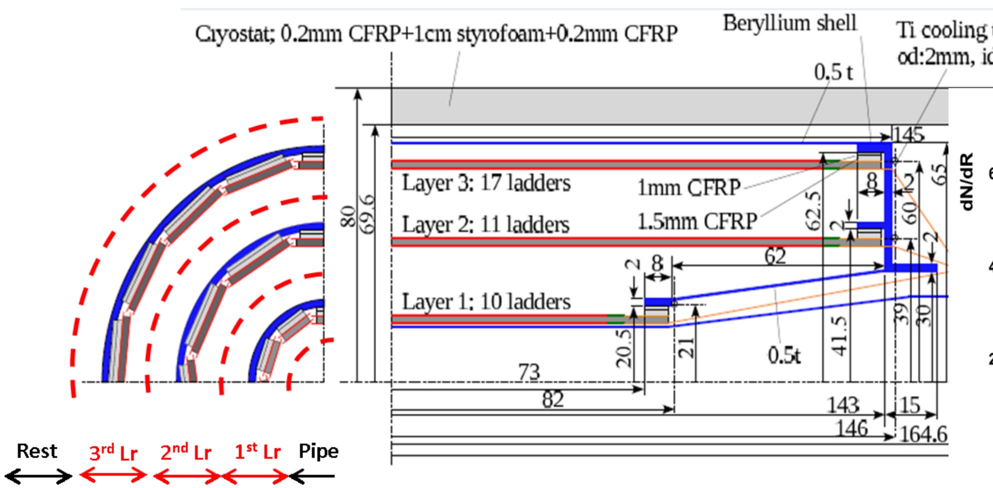
- Pairs from Beamstrahlung hit forward region, mostly BeamCal
- Backscattering leads to background in the ILD tracking system
    - charged particles in SI
    - photon conversions in TPC
    - neutrons in calorimeter endcaps
- Need to redo the background simulations if forward region design changes



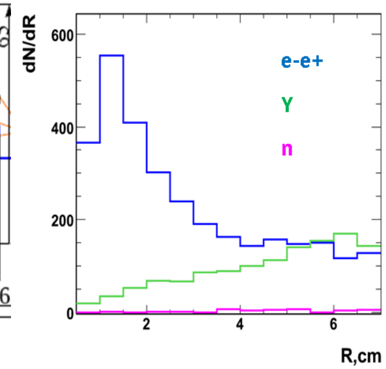


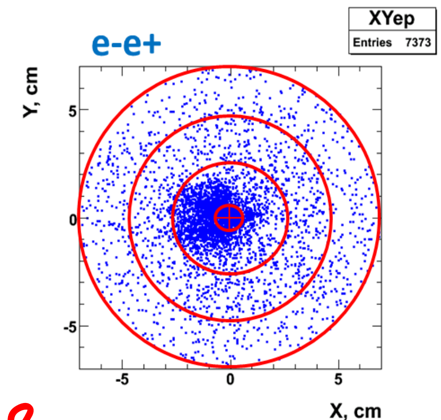


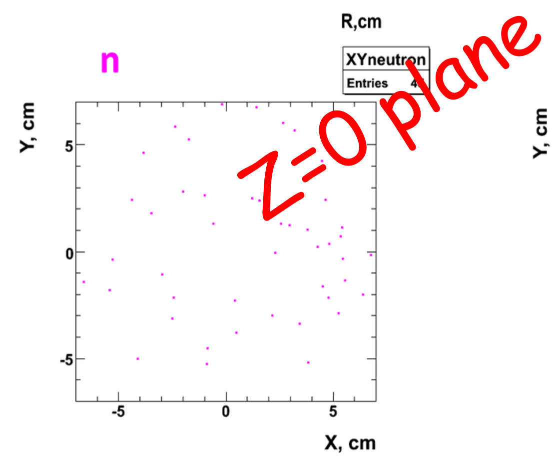
Backscattering from BeamCal, reduced L*

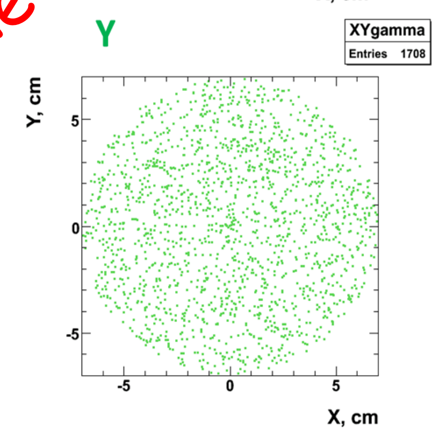


Vertex detector









- For reduced L* background is larger by 20-40% depending on inner BeamCal cutout
- Asymmetry in horizontal plane for backscattered electrons – subject of DID optimization

Conclusions and outlook

- Design of the ILD forward region revisited to match L*=4 m
1. BeamCal shifted by 40 cm in the IP direction
2. Vacuum pump moved behind QD0
3. Graphite absorber placed inside LHCal inner cutout
- MC simulations of LHCal started at Kiev (first results on steel and tungsten options performance, see talks at this WS)
- Study of BeamCal sapphire version is ongoing
- Pair background simulations are done for new BeamCal location
- Background from backscattered particles is a subject for future optimization (Anti-DID as well) for the whole ILD
- GamCal design should be reconsidered (sapphire tracker?)
- DD4HEP MC model of forward region should be revisited soon

Thank you