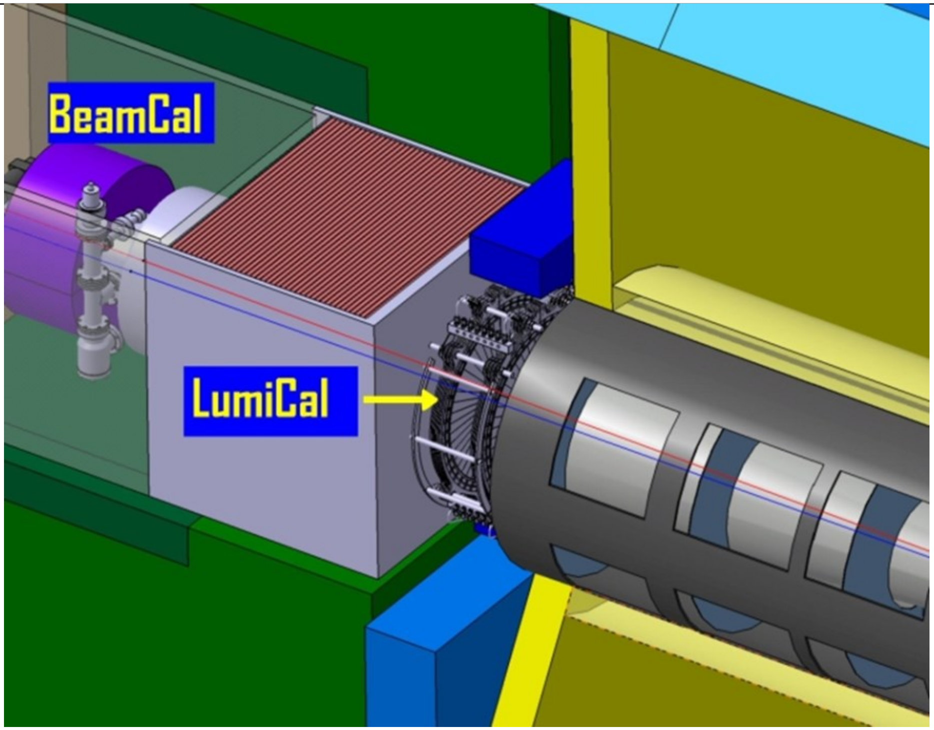
ILD forward region design

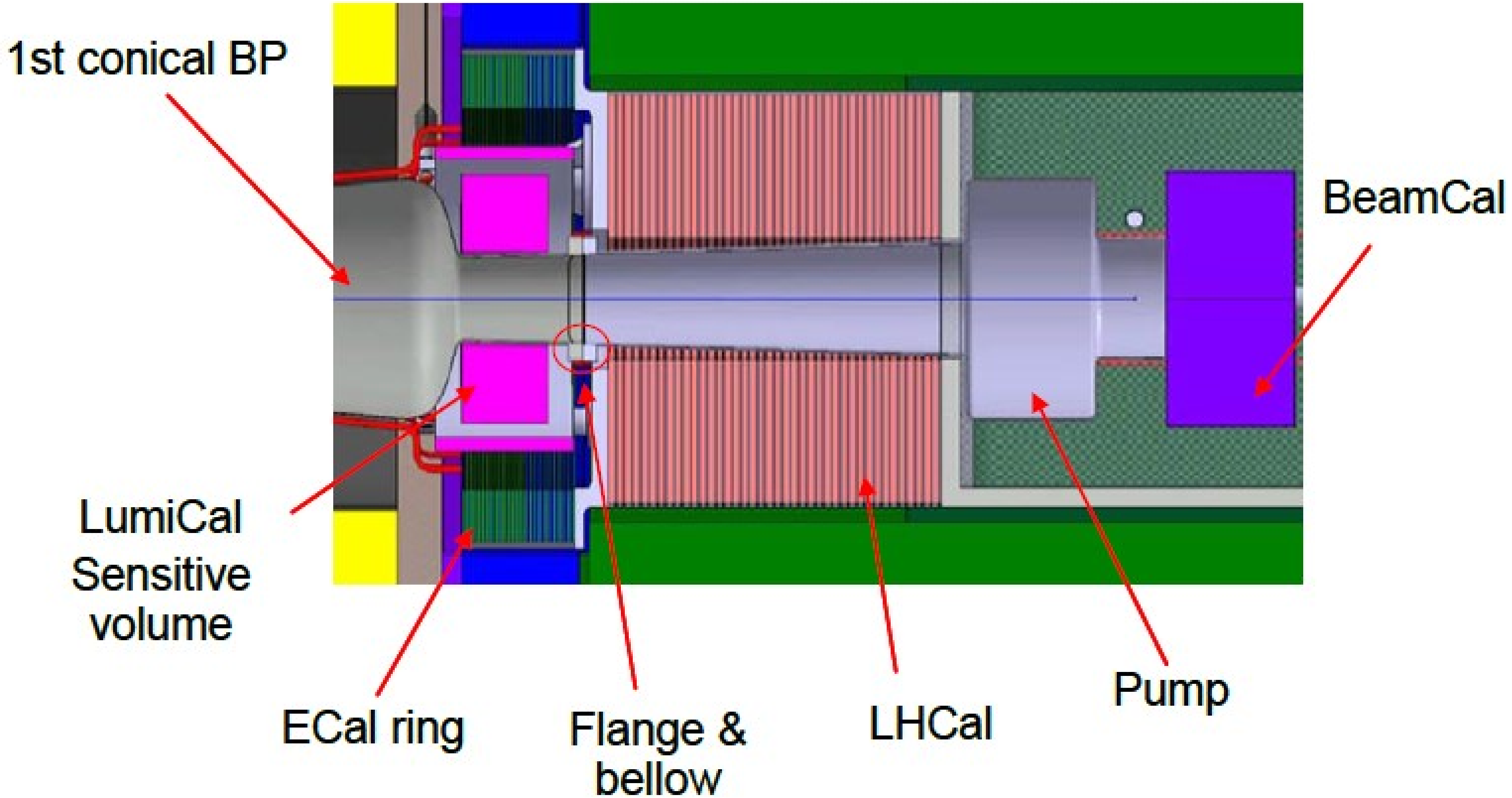
Sergej Schuwalow, DESY Hamburg



Contents

- ILD forward region (present design)
- Reduced L* option
- BeamCal option based on sapphire sensors
- LHCal, GamCal ???
- L* reduction 4.4 m -> 4 m option
- Beampipe
- Conclusions and outlook

Forward region design - side view



Forward region design

Catherine Clerc,
Matthieu Jore

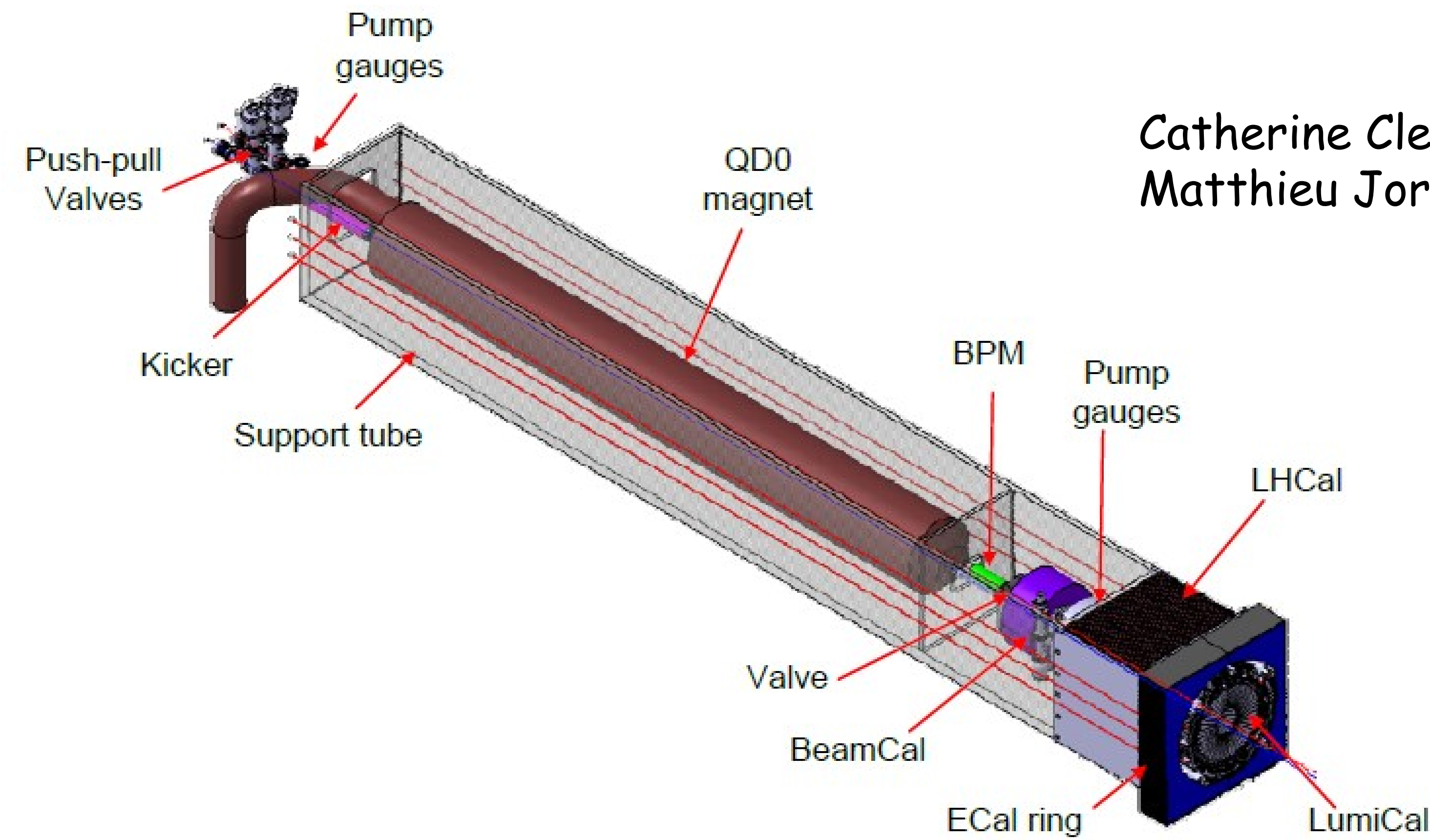


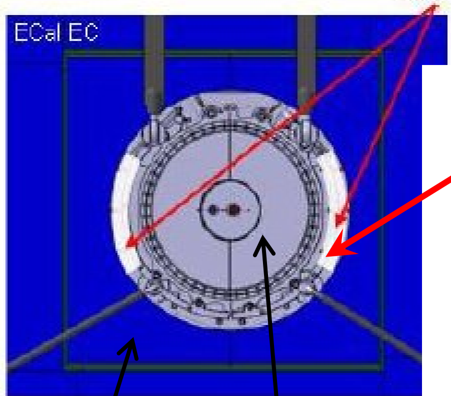
FIGURE 2.4.1.1 Forward region components

Forward region design

Front view

Free space ab. 340cm²

This gap is needed for inner cables



LumiCal

Ecal Ring

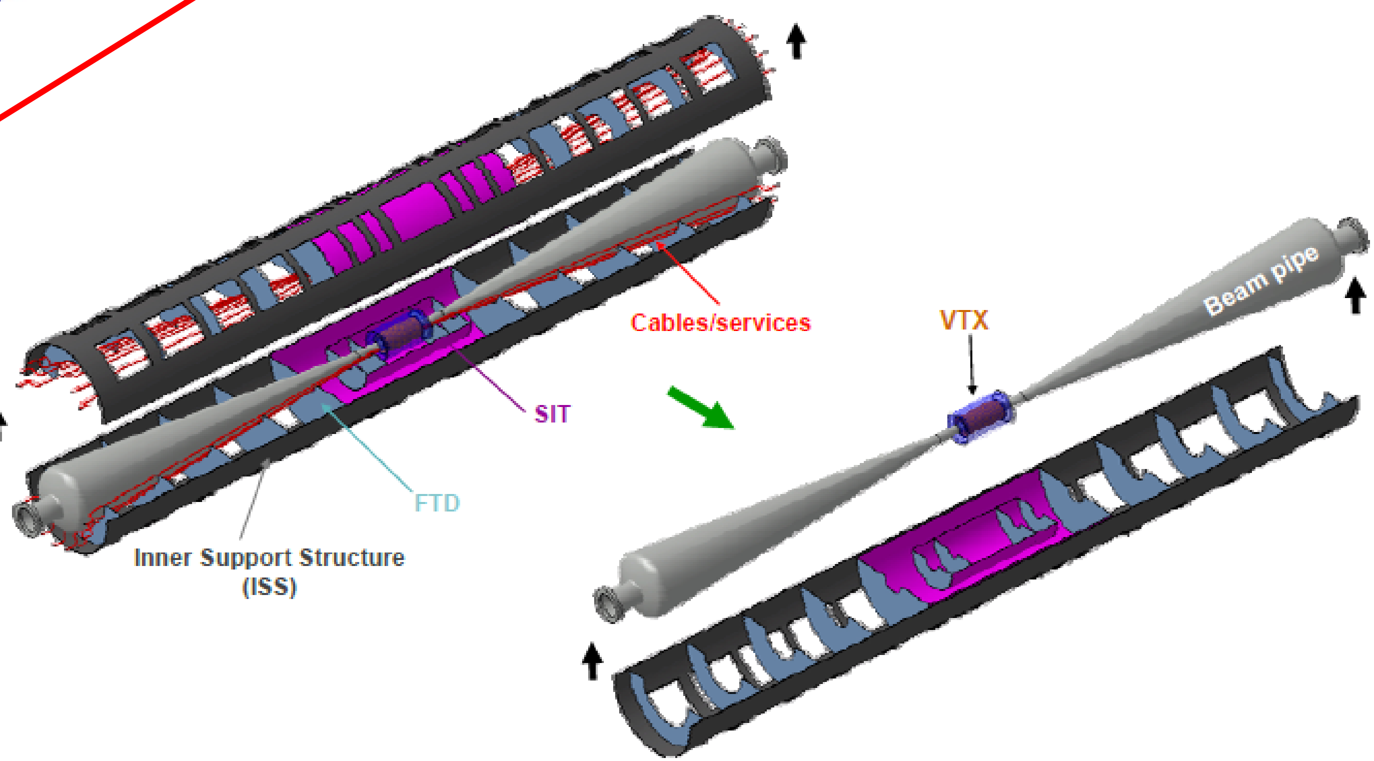


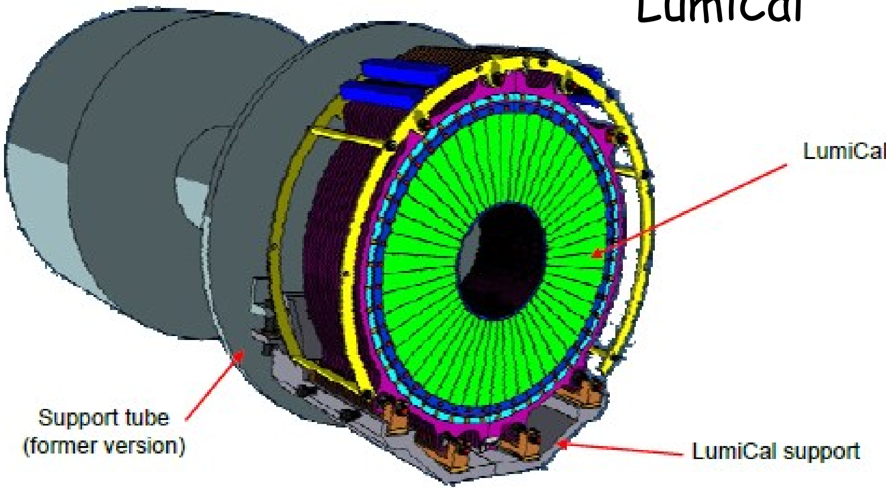
FIGURE 4.2.2.1 Maintenance scenario for Vertex detector

Forward Calorimeters

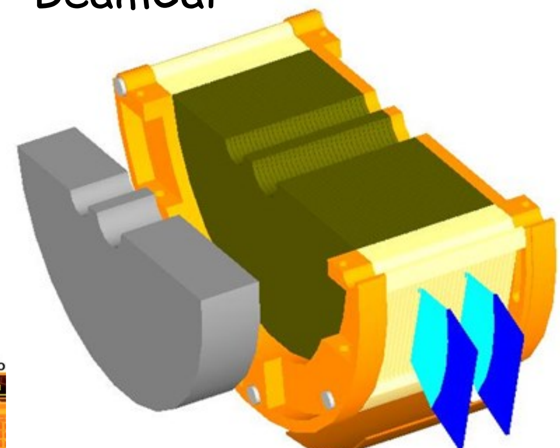
- LumiCal – precision integrated luminosity measurement (Bhabhas), and hermeticity
- $dL/L < 10^{-3}$ for $\sqrt{s}$ = 0.5-1TeV
- $dL/L < 2\times10^{-4}$ for GigaZ – very challenging!
- LHCal – PID behind LumiCal, hermeticity
- BeamCal – instantaneous luminosity optimization (beam-strahlung pairs) and hermeticity
- Tracking/spectrometers:
- Pair monitor – luminosity optimization
- GamCal - instantaneous luminosity optimization (beam-strahlung γ detector at $z \approx 190$m)

Forward Detectors

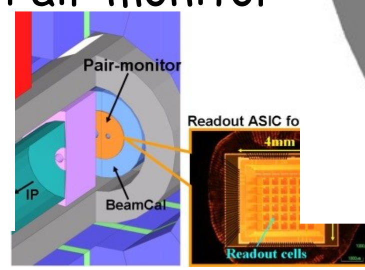
LumiCal

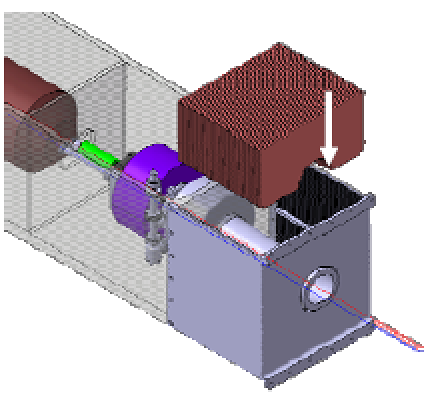


BeamCal

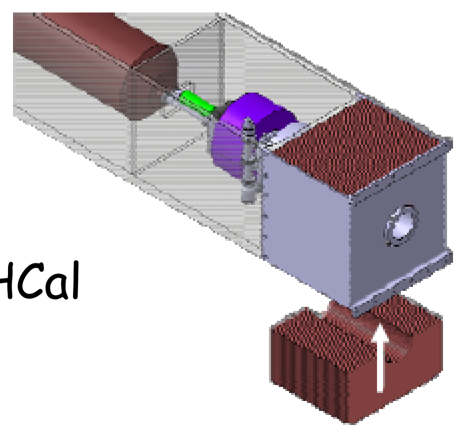


Pair monitor

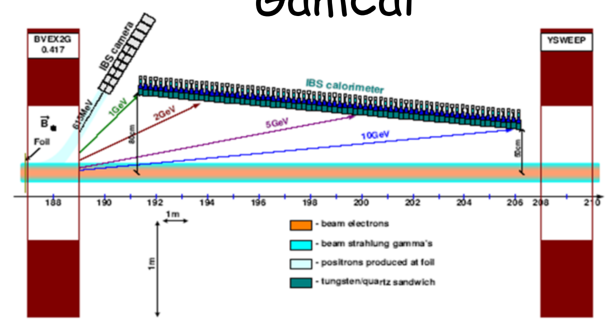




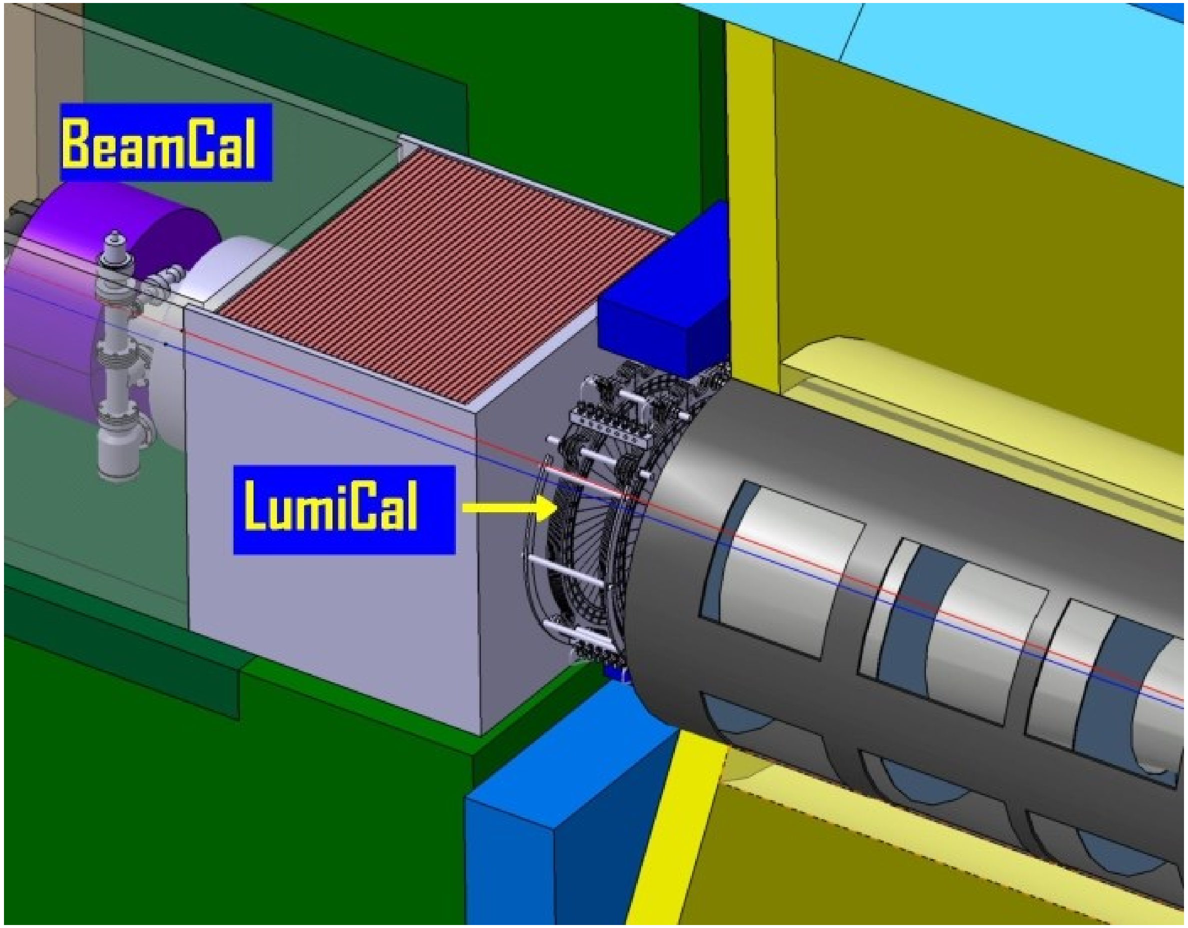
LHCal



GamCal



BeamCal sensor requirements



BeamCal should be compact, small Moliere radius needed:
-sampling calorimeter with solid state sensors, tungsten as absorber.

Severe load at small radii due to beamstrahlung:
- radiation hard sensors (up to 1 MGy annual dose)

Bunch-by-bunch operation:
- fast response of sensors

Test beam studies, physical calibration:
- sensitivity to MIPs

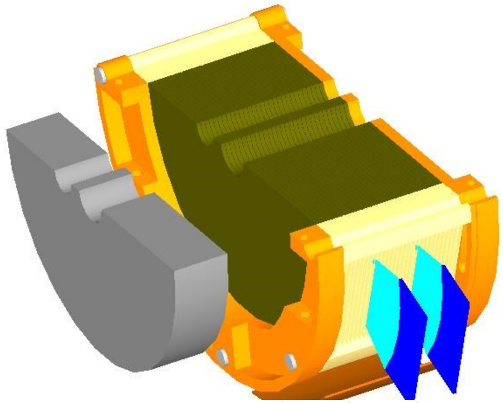
Sensor material properties

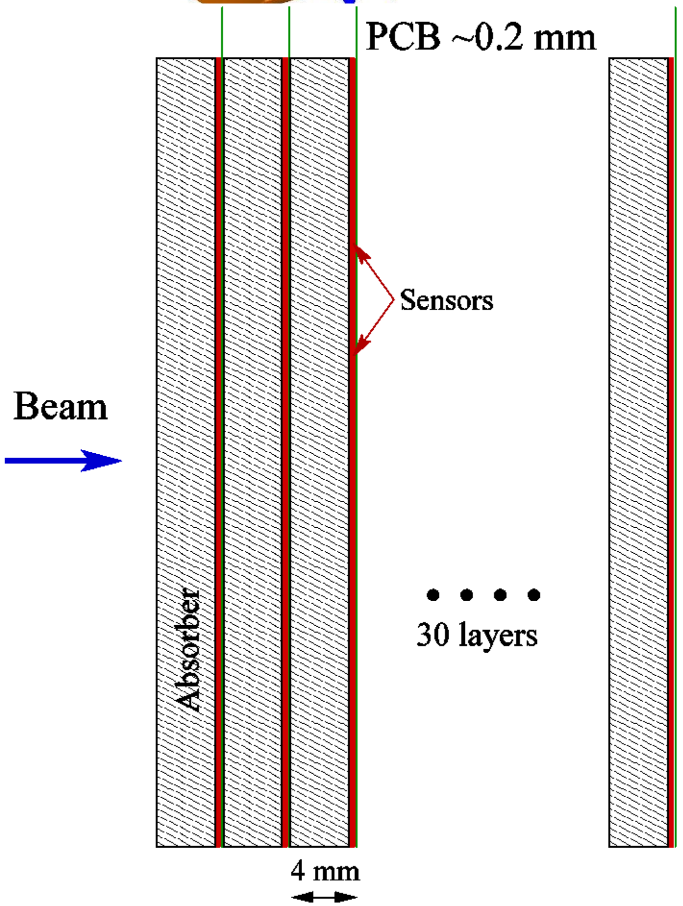
	Sapphire	Diamond	GaAs	Si
Density, g/cm^3	3.98	3.52	5.32	2.33
Dielectric constant	9.3 - 11.5	5.7	10.9	11.7
Breakdown field, V/cm	$\sim 10^6$ *	10^7	$4 \cdot 10^5$	$3 \cdot 10^5$
Resistivity, $\Omega \cdot cm$	$>10^{14}$	$>10^{11}$	10^7	10^5
Band gap, eV	9.9	5.45	1.42	1.12
El. mobility, $cm^2/(V \cdot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

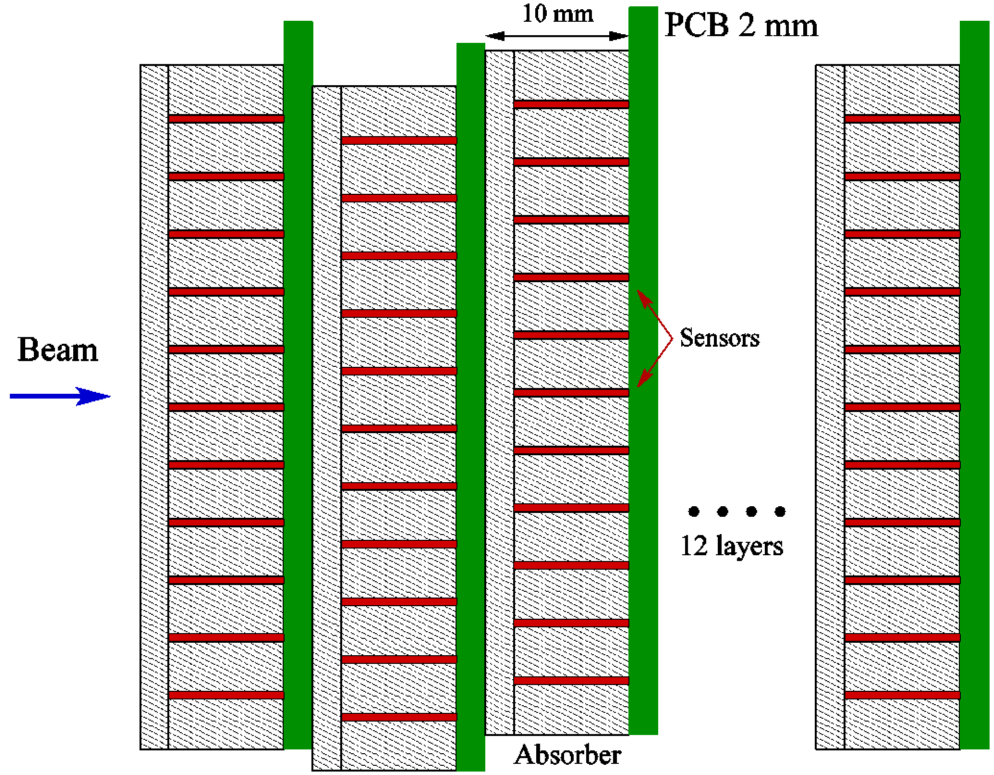
* Typical operation field $\sim 1\text{-}2 \cdot 10^4$ V cm^{-1}

** at 20ºC, ~30000 at 40ºK

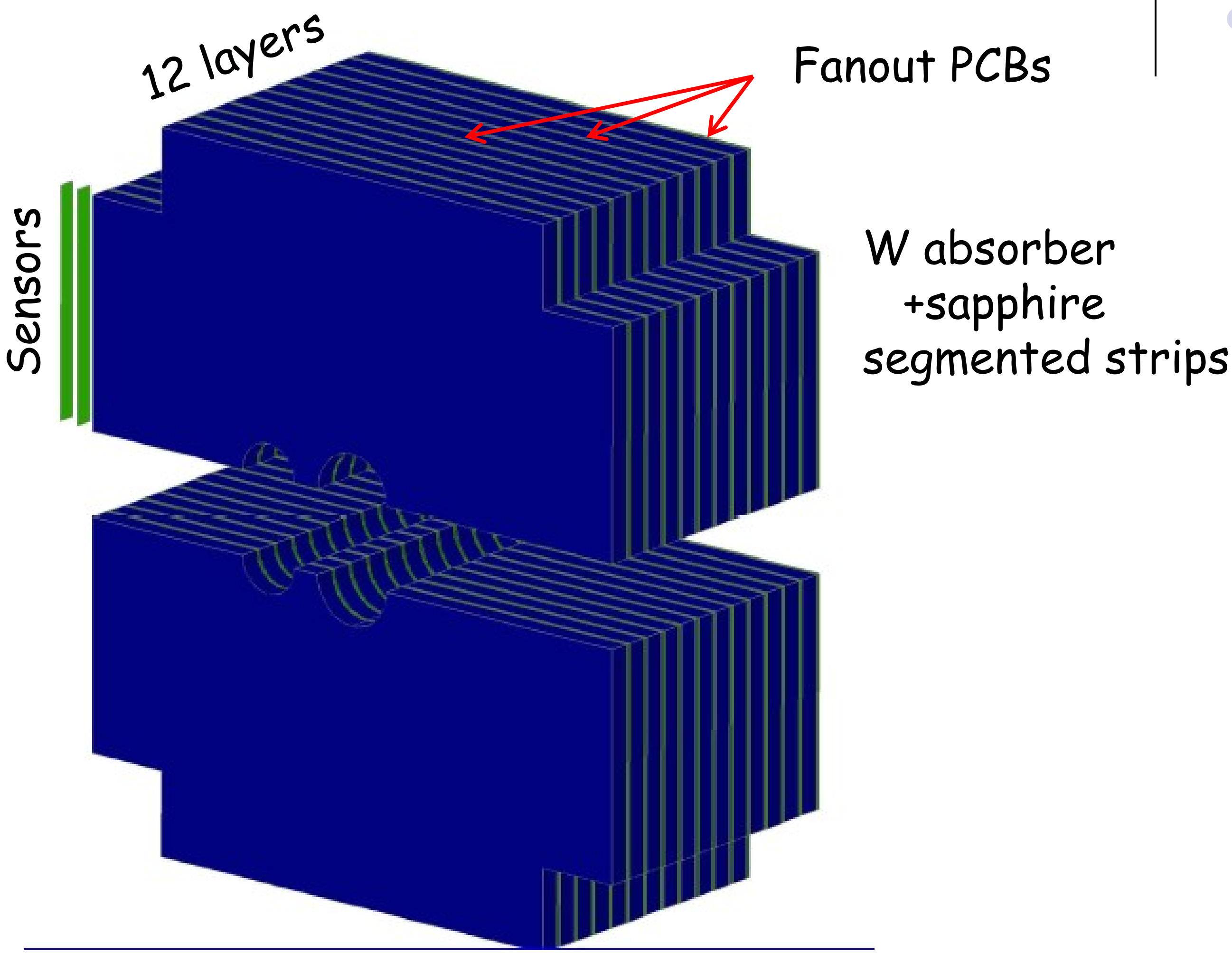
Modification of BeamCal design for sapphire sensors application



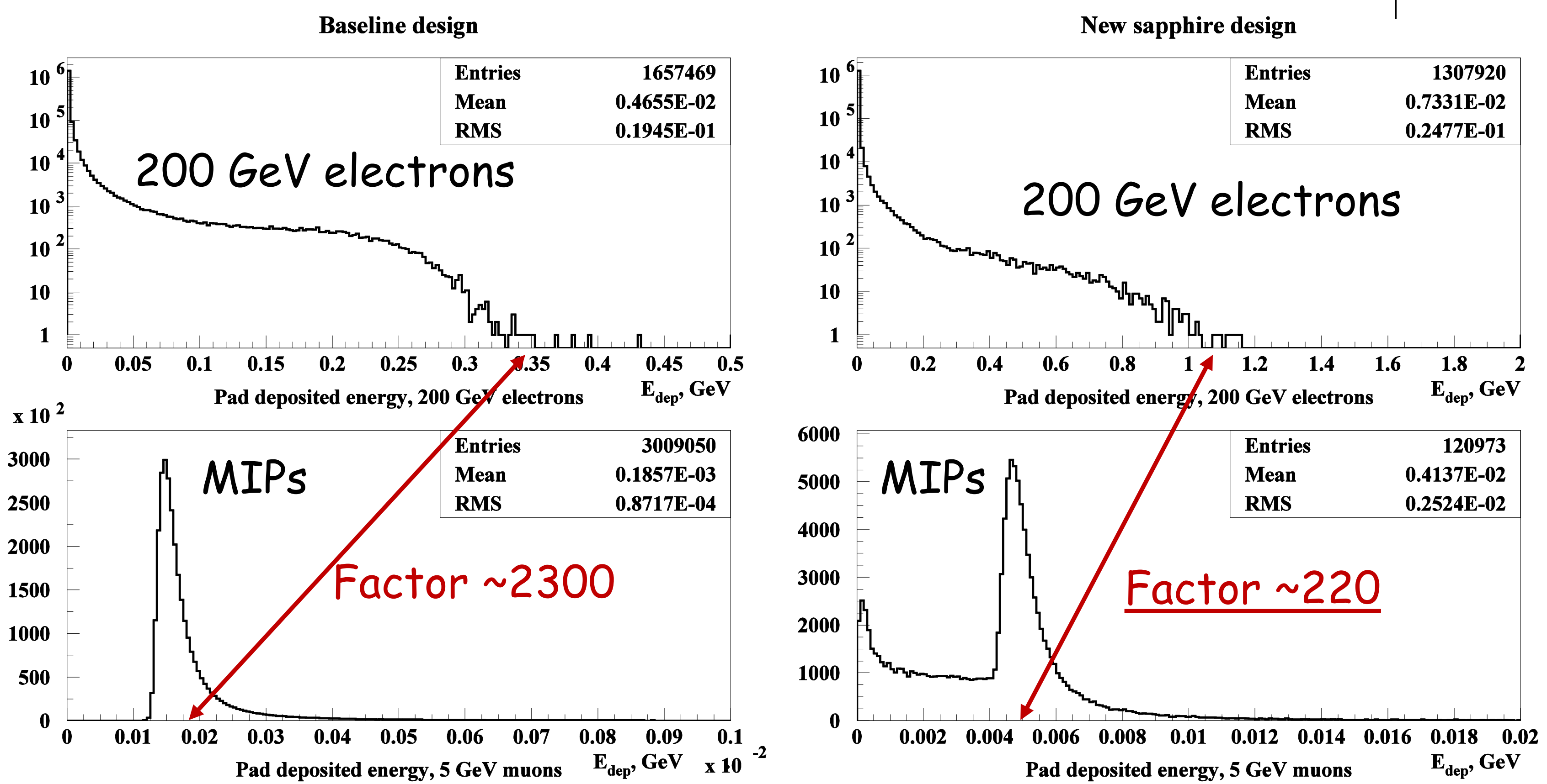




BeamCal – sapphire based design

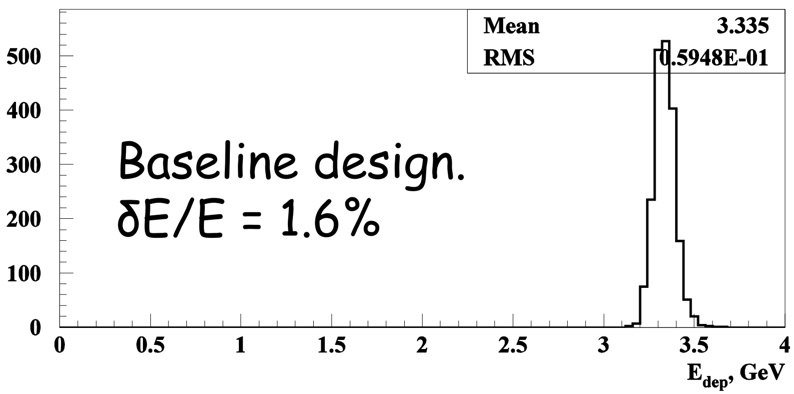


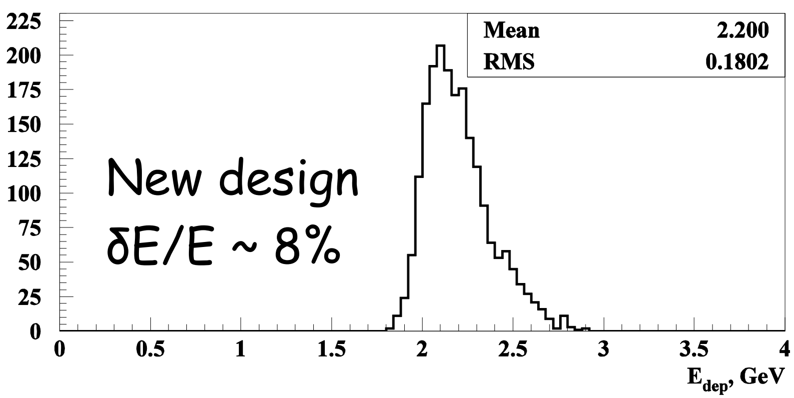
Dynamic range needed for BeamCal Readout (high energy electrons/MIPs)

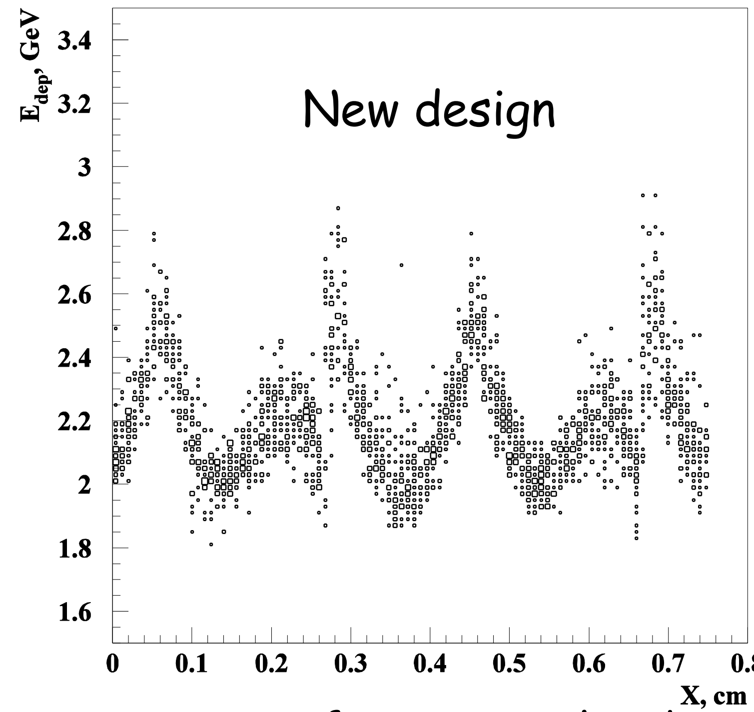


BeamCal energy resolution

200 GeV electrons, GEANT3 Monte Carlo





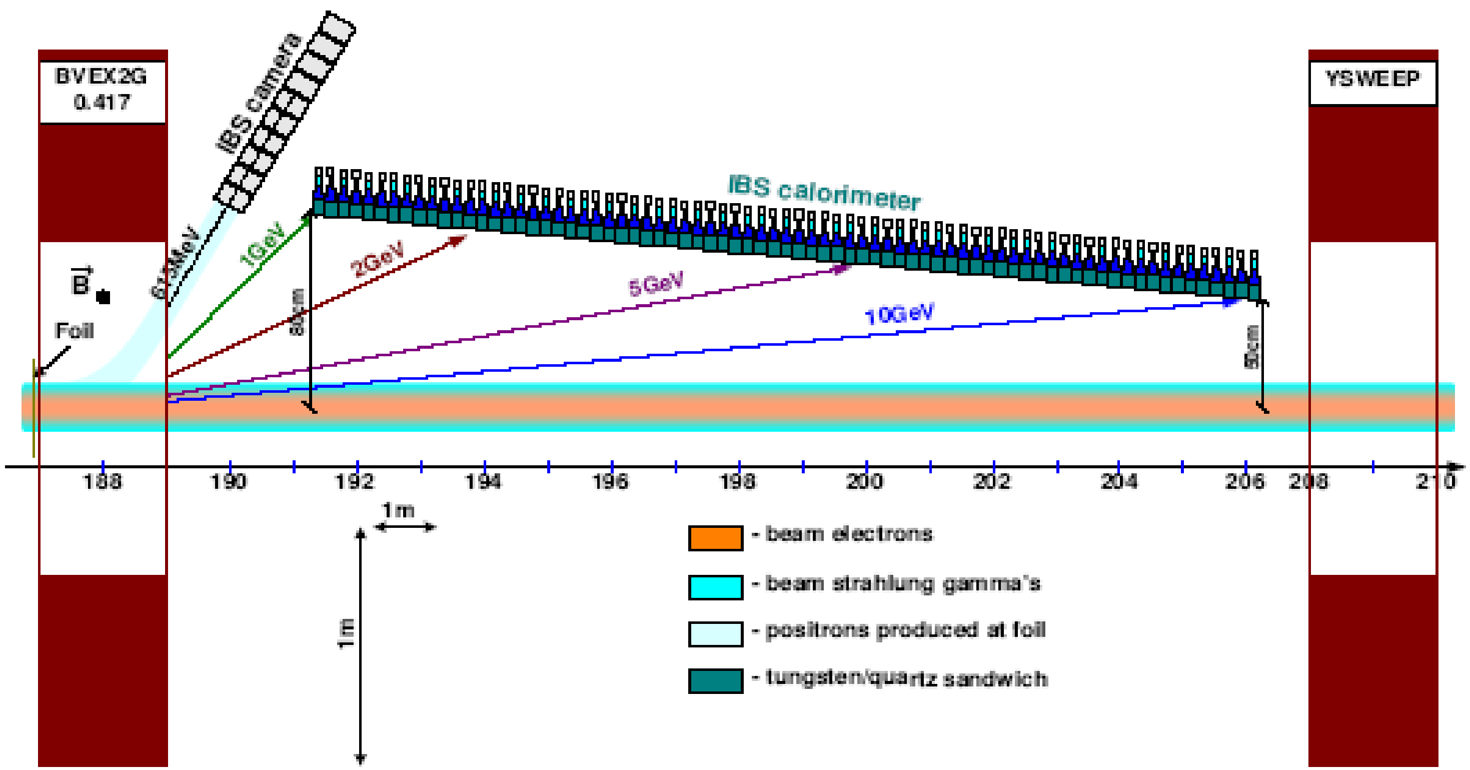


Response nonuniformity in the direction, perpendicular to the strips, depends on relative layer positioning. Further optimization is needed.

GamCal – Yale Group Design,

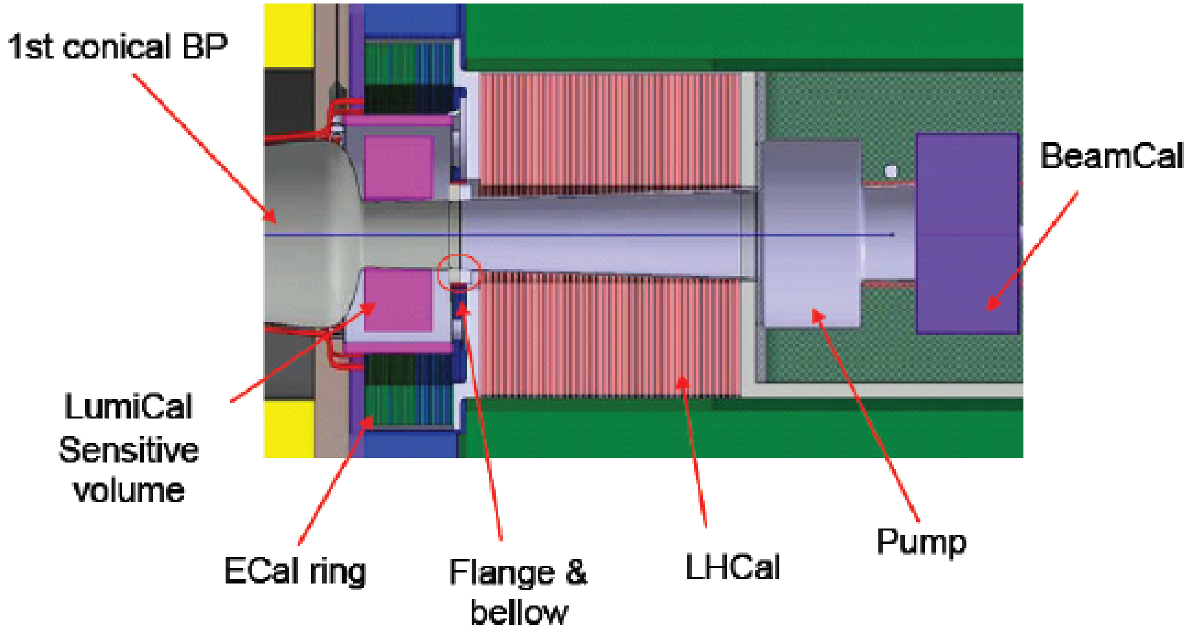
no new developments since 2007

Integrated Beamstrahlung Spectrometer



W.Morse - BNL

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)

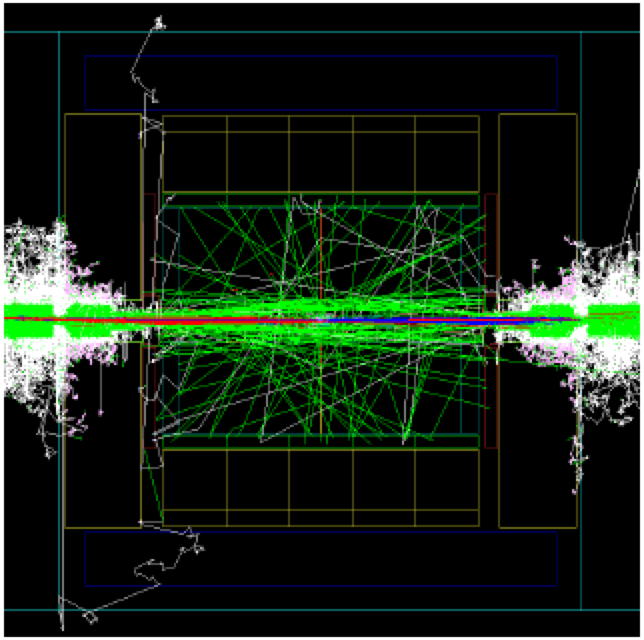
Forward Region - Things to Do

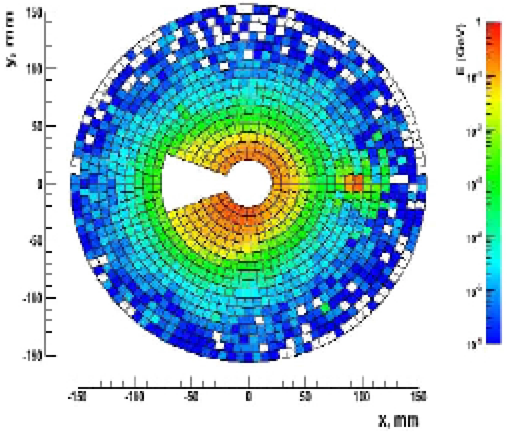
- Revisit FCAL design and look for possible space savings
  - any cm helps
- Do a coherent study of LHCAL design
  - physics requirements
  - technical design
- Change BeamCal design at new location (holes for incoming/outgoing beams)
- Eventually redo the pair background simulations with new BeamCal location

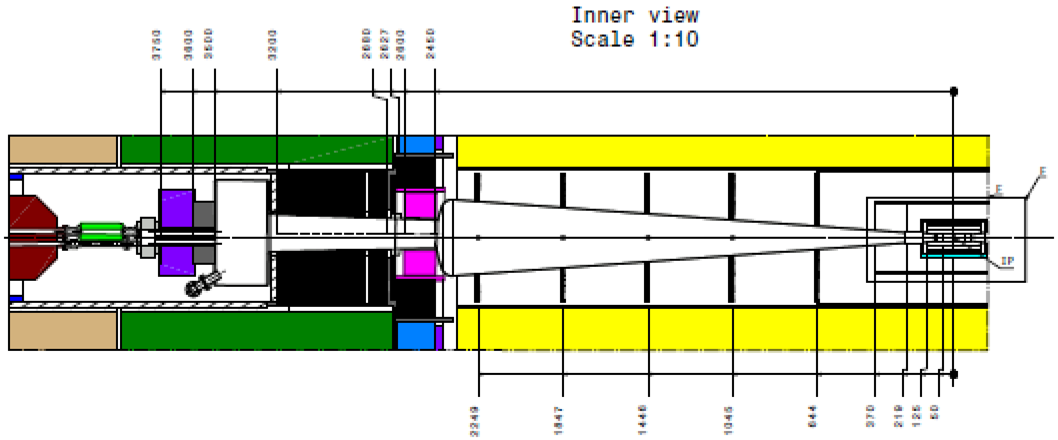
- All tasks need to be worked on, FCAL could help here out…

Pair Background Backscattering

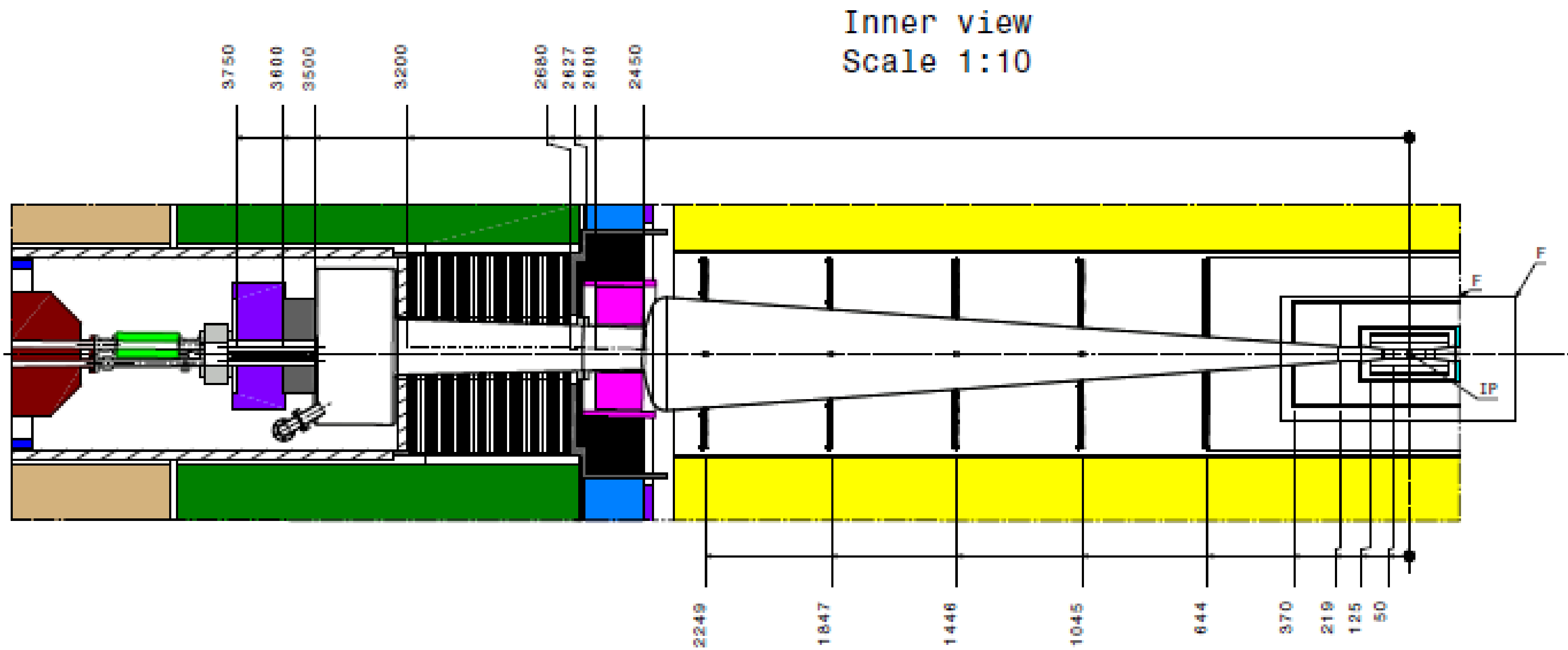
- Pairs from Beamstrahlung hit forward region, mostly BeamCal
- Backscattering leads to background in the ILD tracking system
  - charged particles in SI
  - photon conversions in TPC
  - neutrons in calorimeter endcaps
- Need to redo the background simulations if forward region design changes





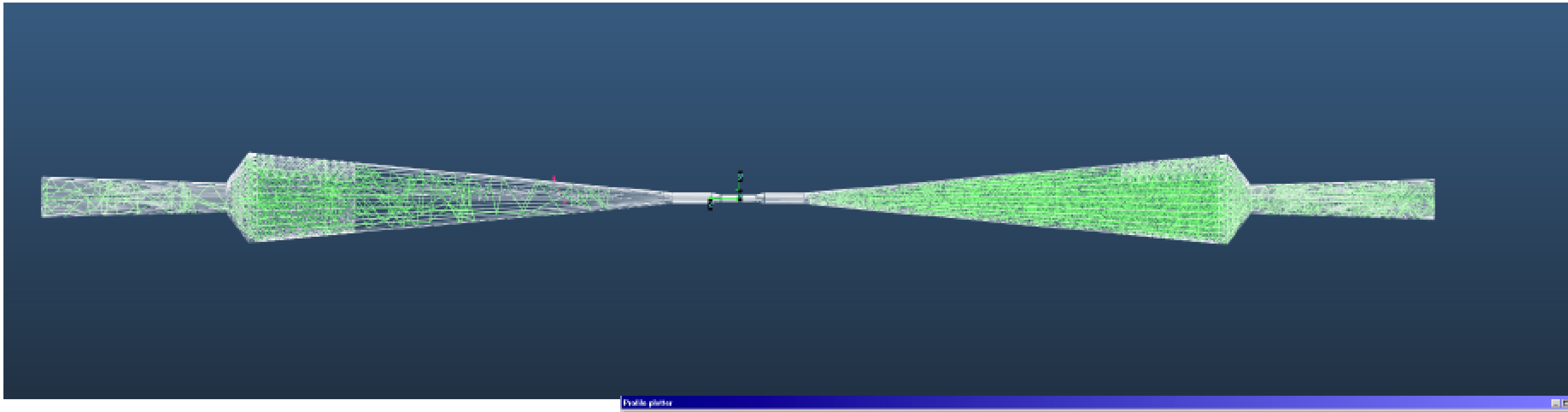


Beam Pipe

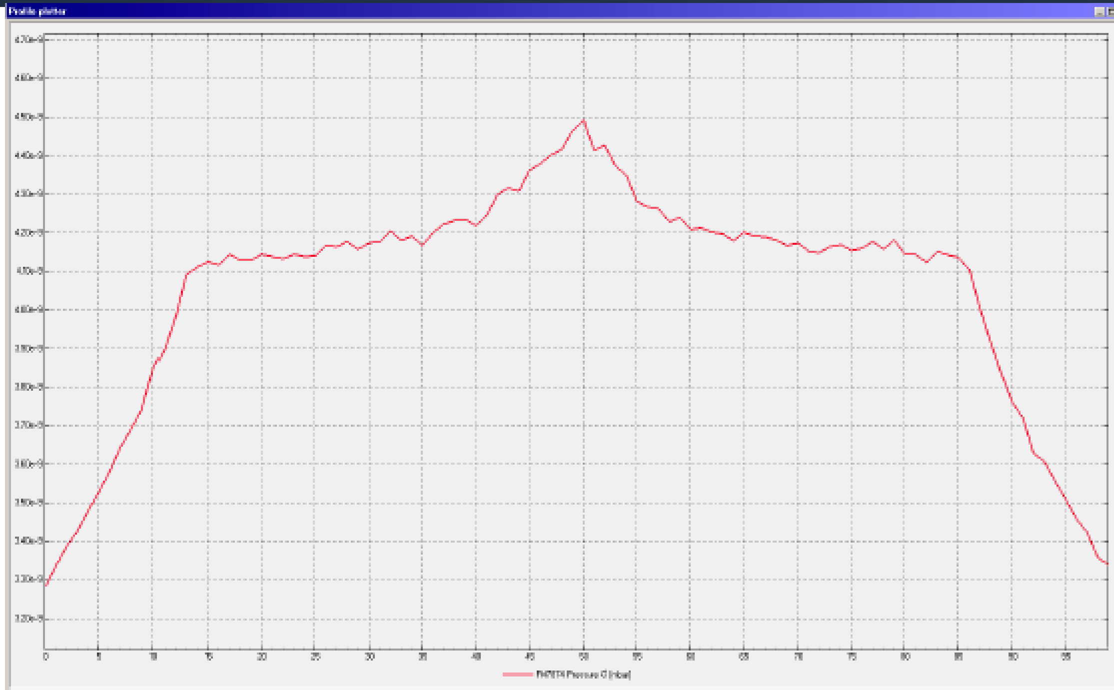


Inner view
Scale 1:10
3750
3200
2450
2249
1847
1045
644
370
125
50
F
F
IP

Check Vacuum Conditions

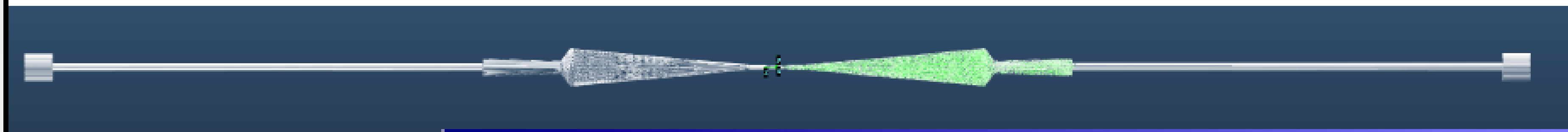


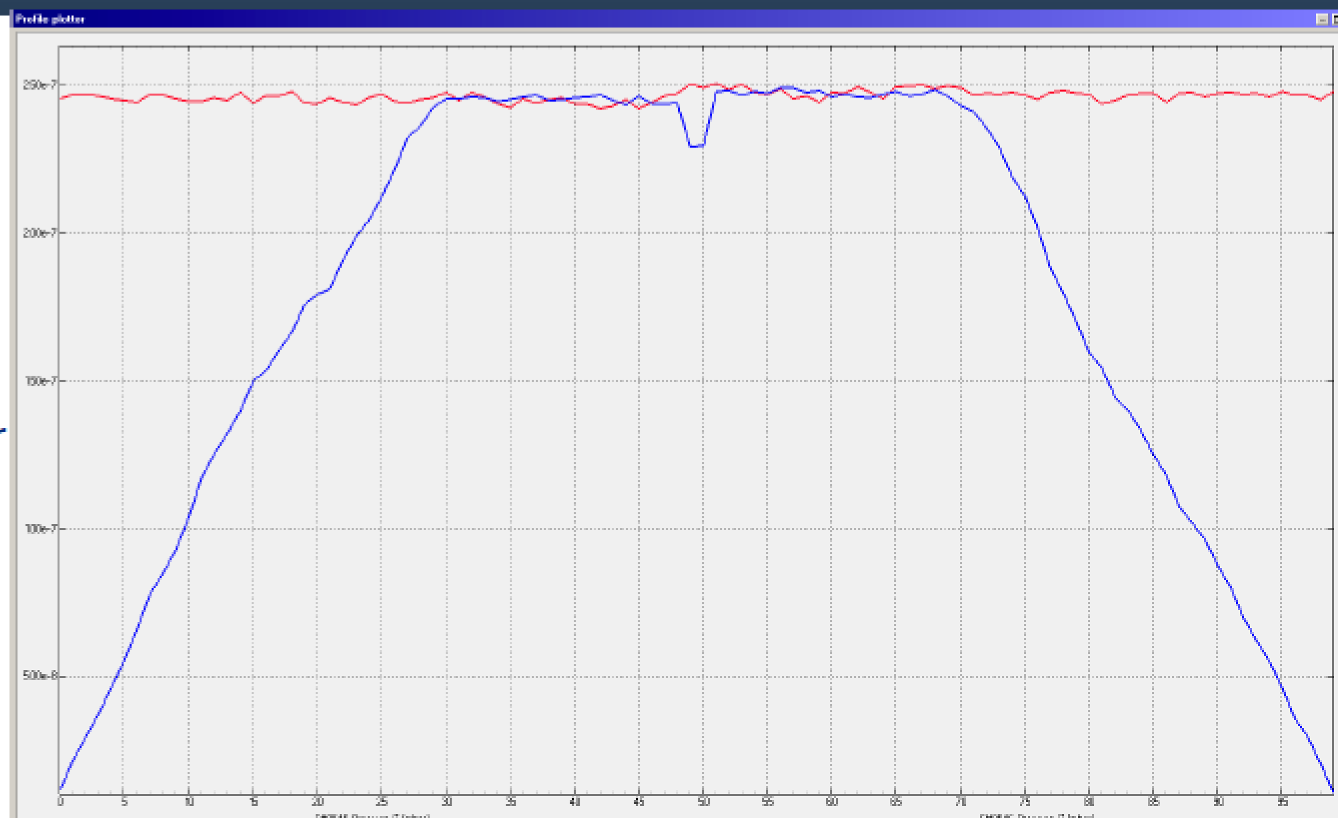
- MolFlow+ (CERN)
- Molecule tracker for given gases, materials and geometries
- For CO: 4.5E-9 mbar
  - Suetsugu: 6E-9 mbar



New Vacuum Geometry

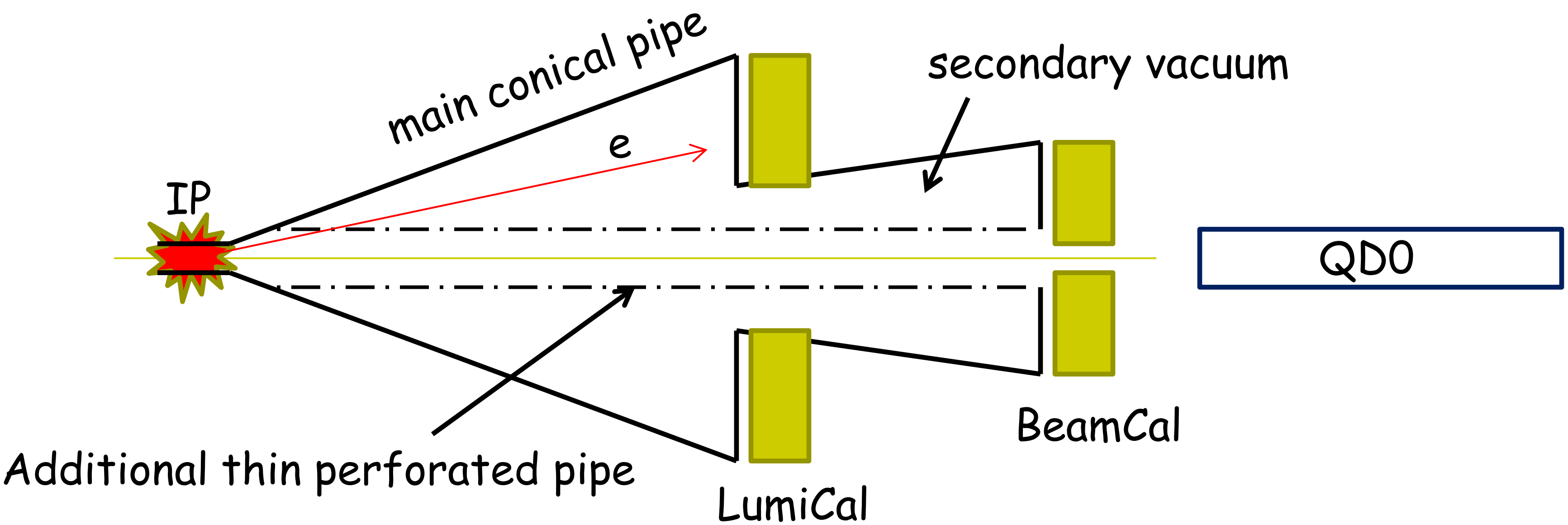
- Moved the pumps to the upstream sides of both QD0s
  - increases pumping lever arm by ~5m on both sides…





- Increases level to 2.5E-7 mbar
  - for CO
- ~200 nTorr
- ~50 times higher than with old pump location

Possible vacuum problem solution?



To be checked....

Thank you