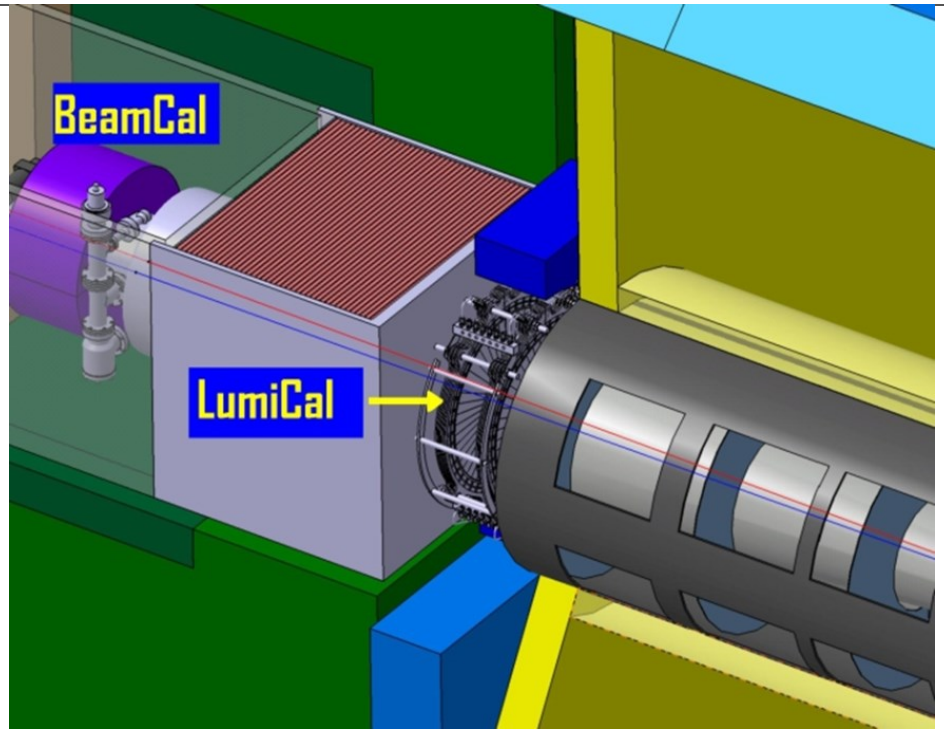
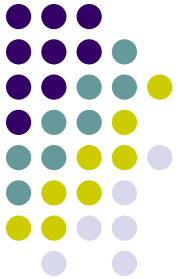
Possible changes in ILD forward region design due to the reduced L*

Sergej Schuwalow, DESY Hamburg

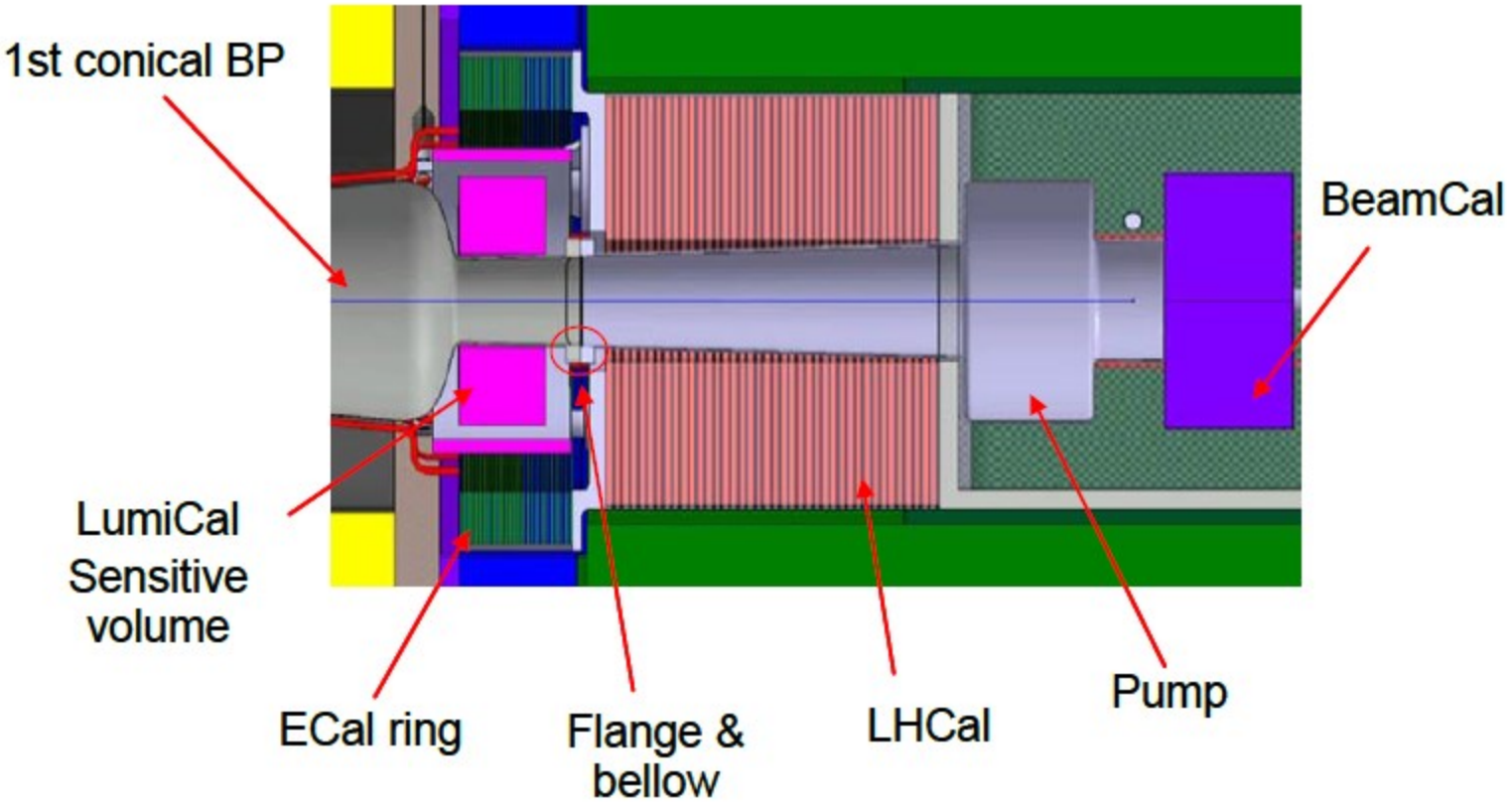


Contents

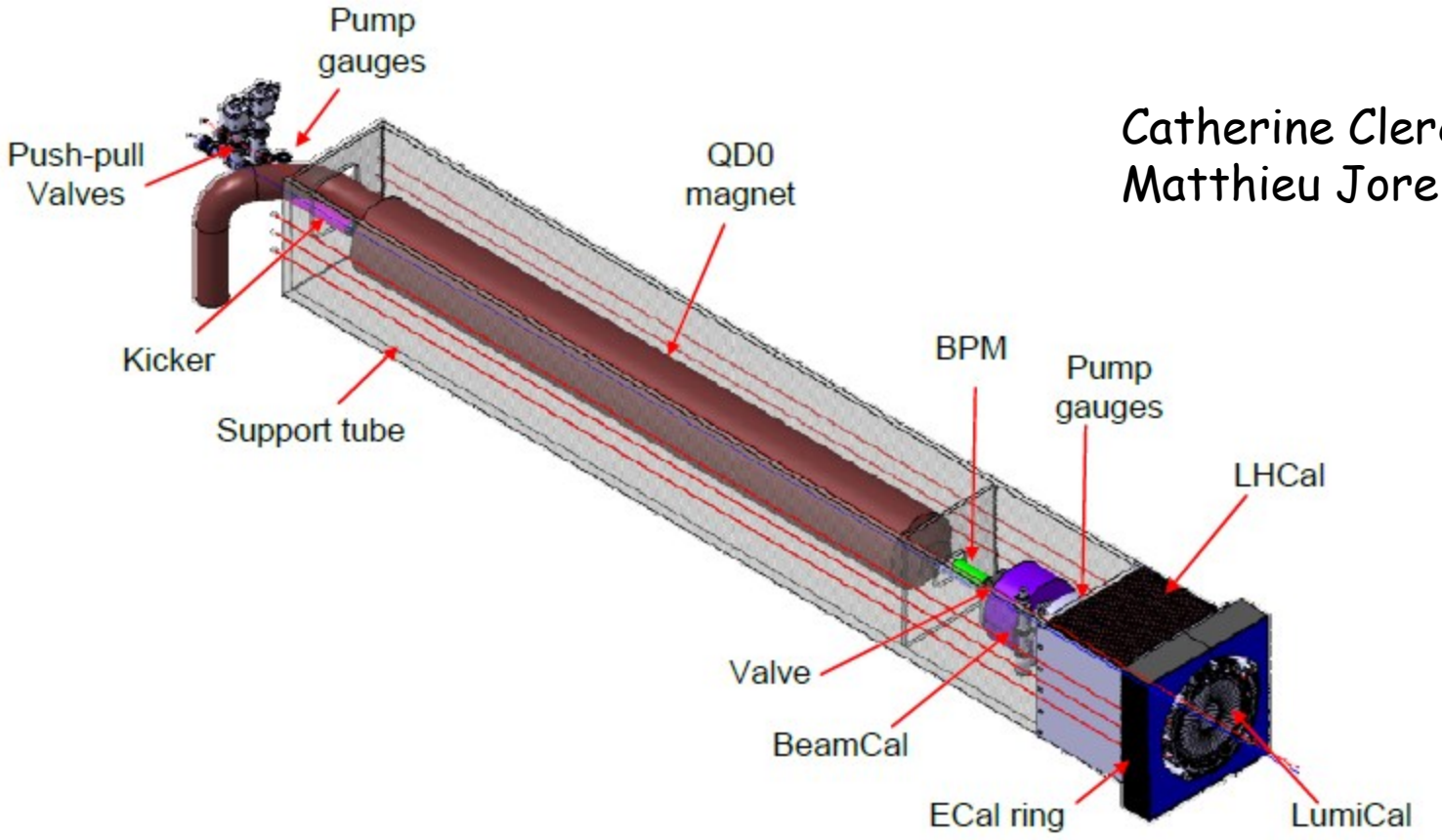


- ILD forward region (present design)
- Detectors in the very forward region
- BeamCal option based on sapphire sensors
- GamCal – possible developments
- L* reduction 4.4 m -> 4 m option
- LHCal new design (first steps)
- Pair background
- Conclusions and outlook

Forward region design - side view



Forward region design



Catherine Clerc,
Matthieu Jore

FIGURE 2.4.1.1 Forward region components

Forward region design

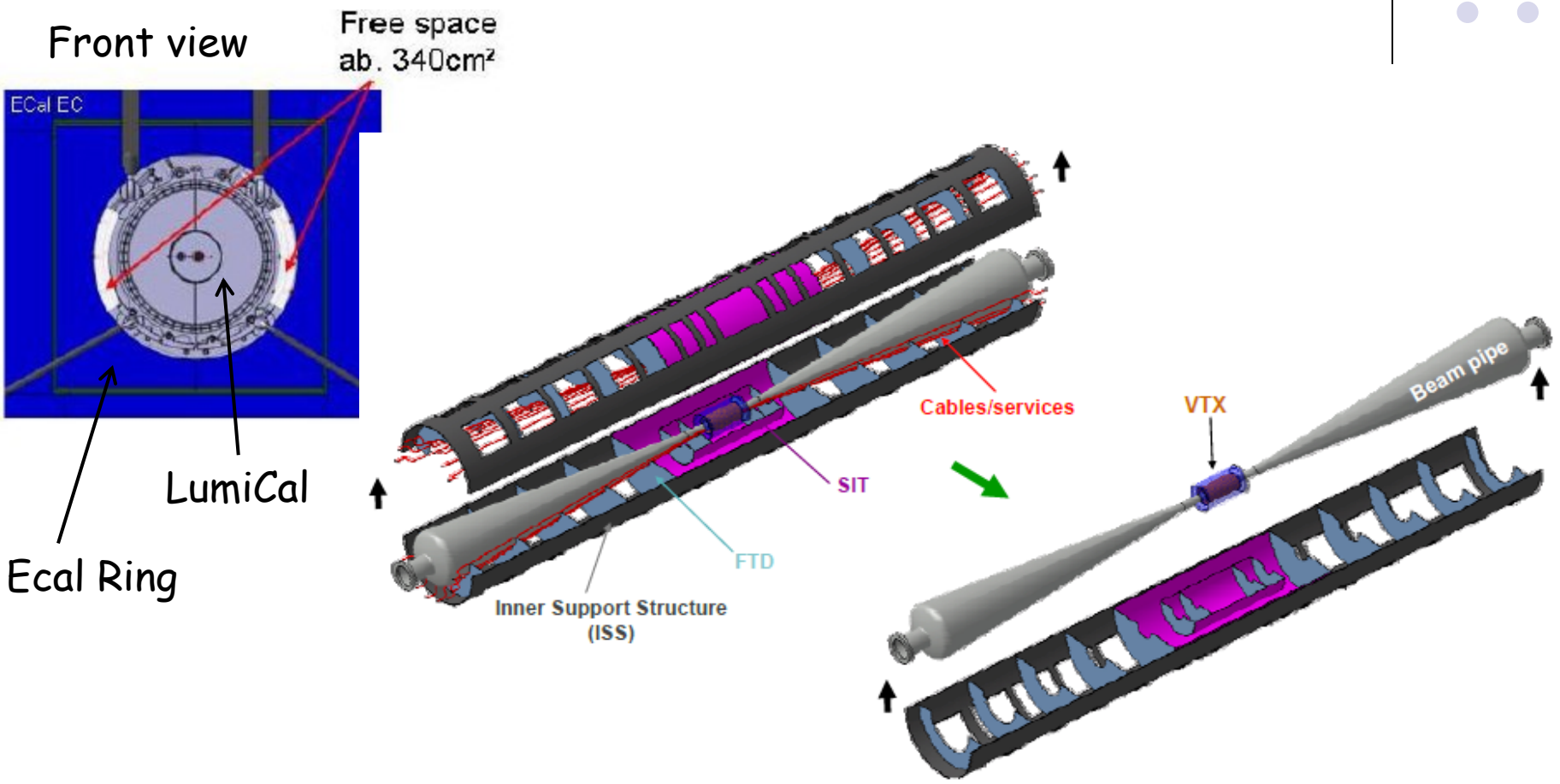


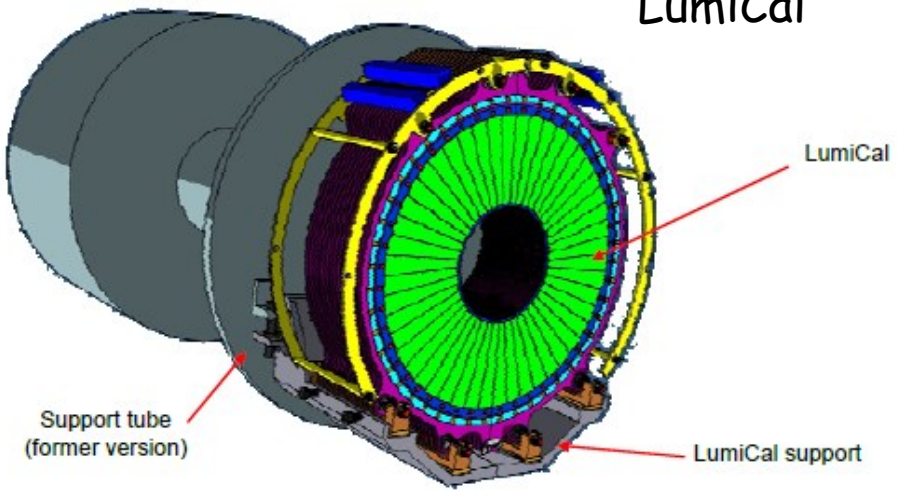
FIGURE 4.2.2.1 Maintenance scenario for Vertex detector

Forward Detectors

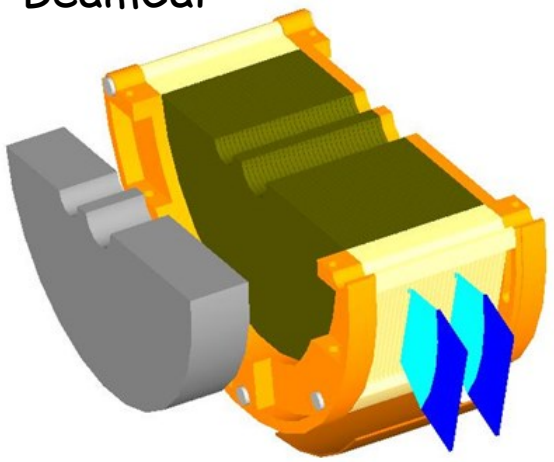
- LumiCal – precision integrated luminosity measurement (Bhabhas), and hermeticity
- $dL/L < 10^{-3}$ for $\sqrt{s}$ = 0.5-1TeV
- $dL/L < 2 \times 10^{-4}$ for GigaZ – very challenging!
- LHCal – PID behind LumiCal, hermeticity
- BeamCal – instantaneous luminosity optimization (beam-strahlung pairs)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

Forward Detectors

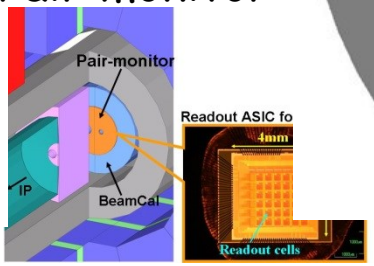
LumiCal

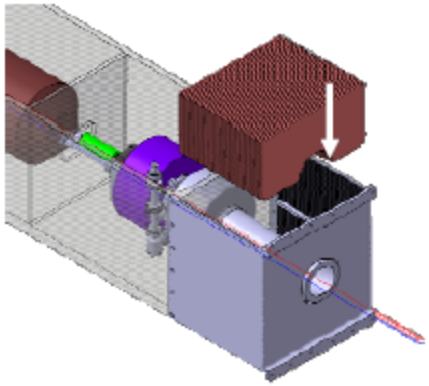


BeamCal

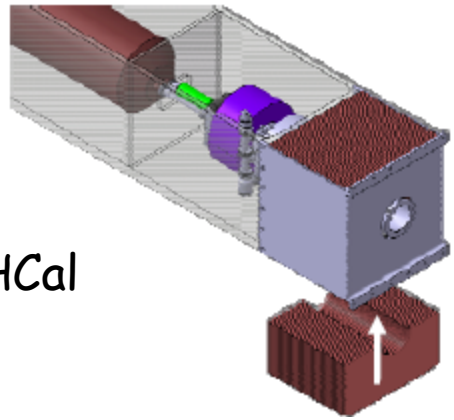


Pair monitor

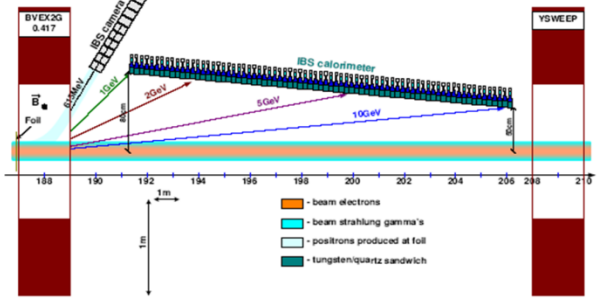




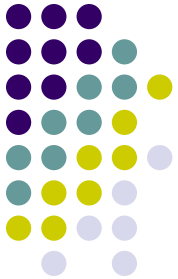
LHCal



GamCal



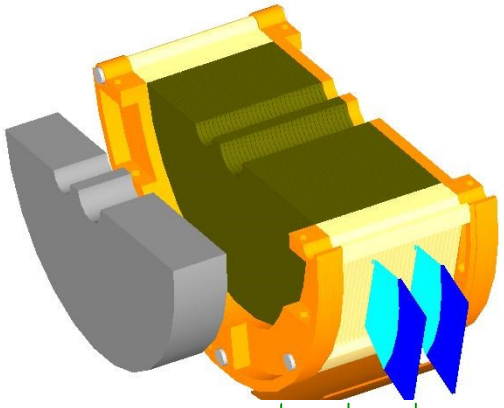
Sensor material properties



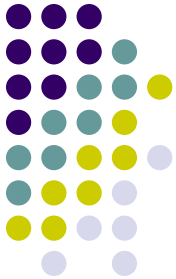
	Sapphire	Diamond	GaAs	Si
• Density, g/cm^3	3.98	3.52	5.32	2.33
• Dielectric constant	9.3 – 11.5	5.7	10.9	11.7
• Breakdown field, V/cm	~10^6 *	10^7	$4 \cdot 10^5$	$3 \cdot 10^5$
• Resistivity, Ω·cm	>10^{14}	>10^{11}	10^7	10^5
• Band gap, eV	9.9	5.45	1.42	1.12
• El. mobility, cm^2/(V·s)	>600 **	1800	~8500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

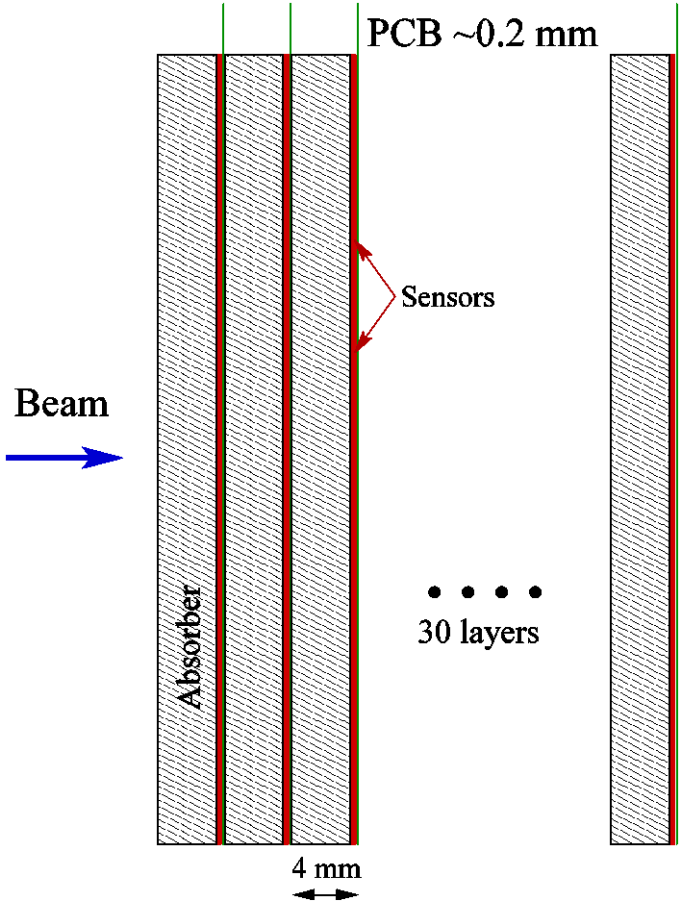
* Typical operation field ~1-2·10^4 V cm^{-1}

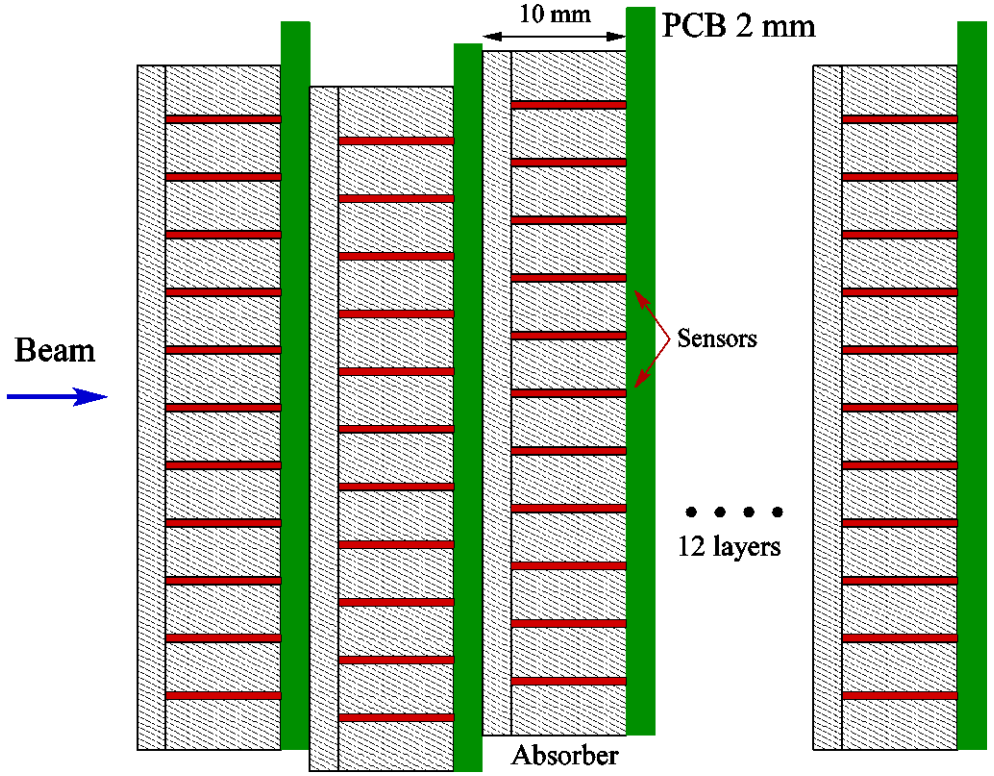
** at 20ºC, ~30000 at 40ºK



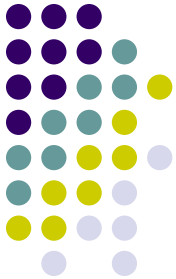
Modification of BeamCal design for sapphire sensors application

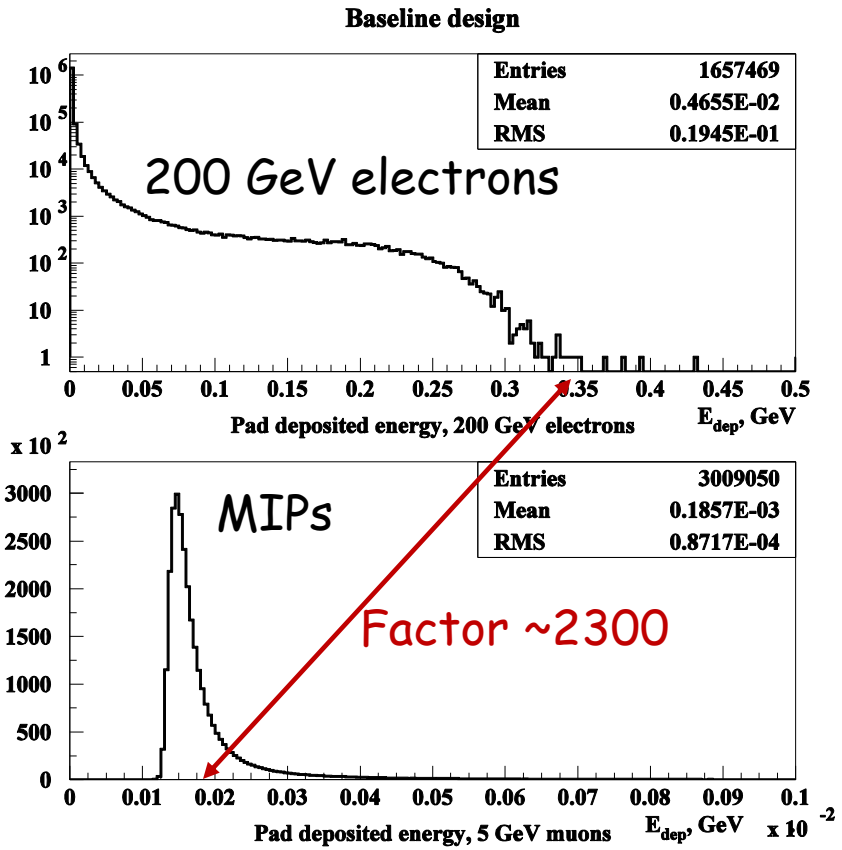


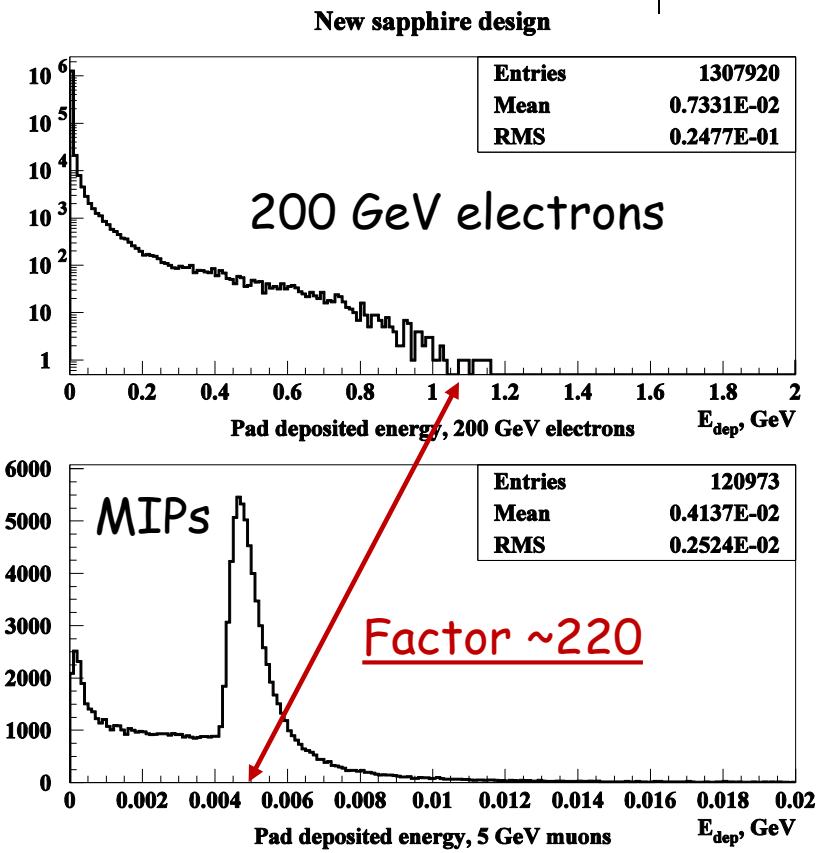




Dynamic range needed for BeamCal Readout (high energy electrons/MIPs)

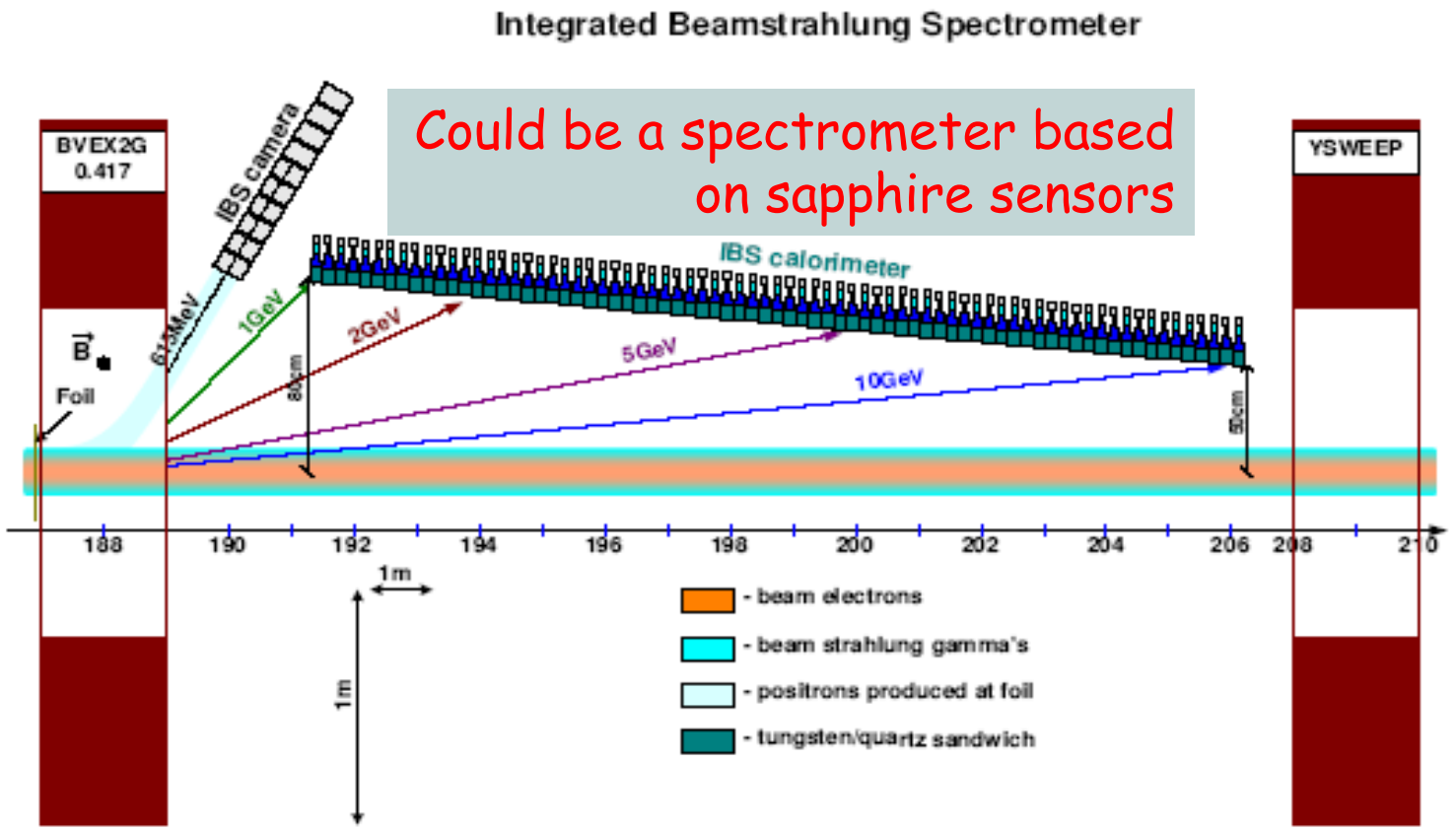






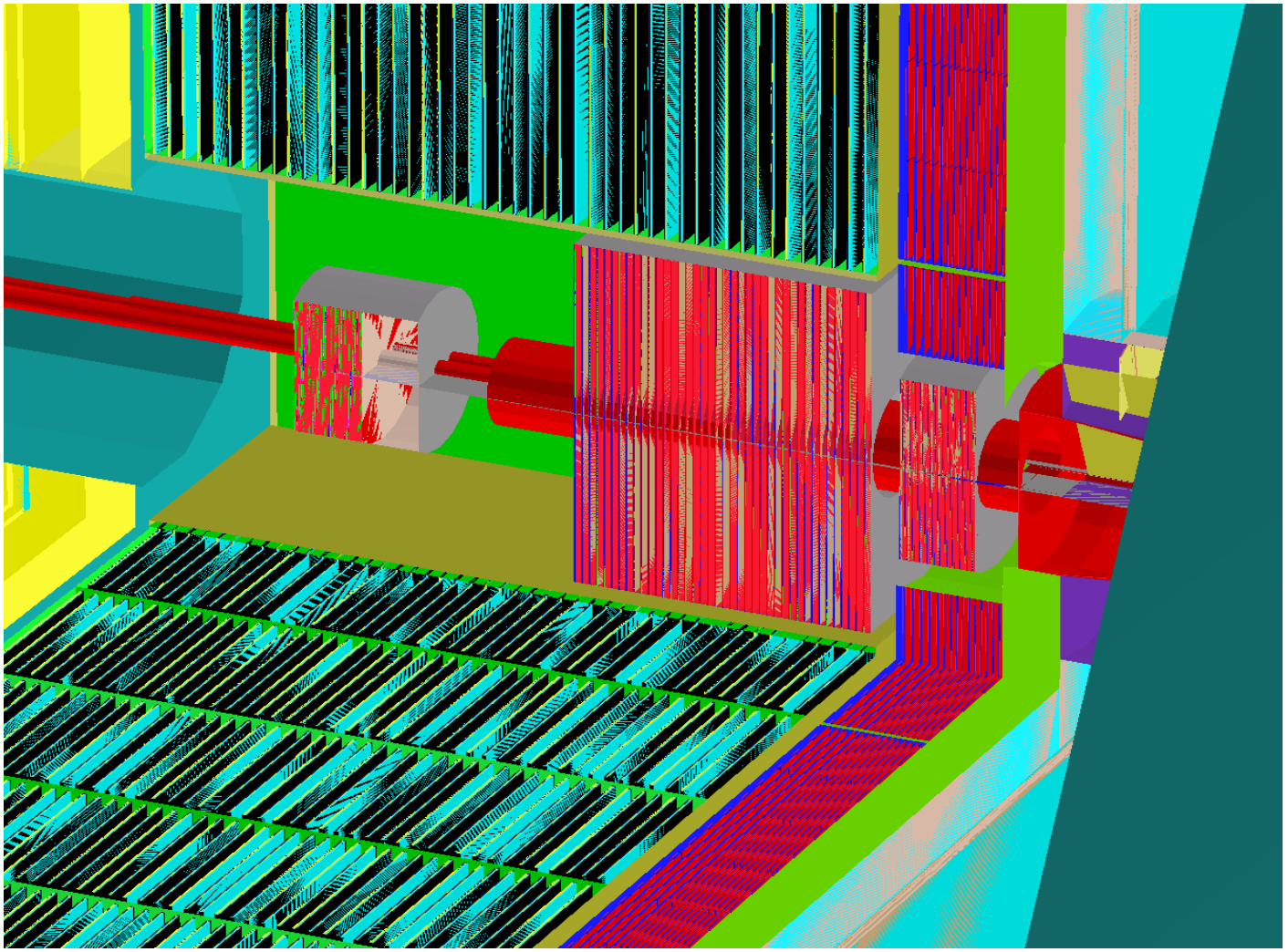
GamCal – Yale Group Design,

no new developments since 2007

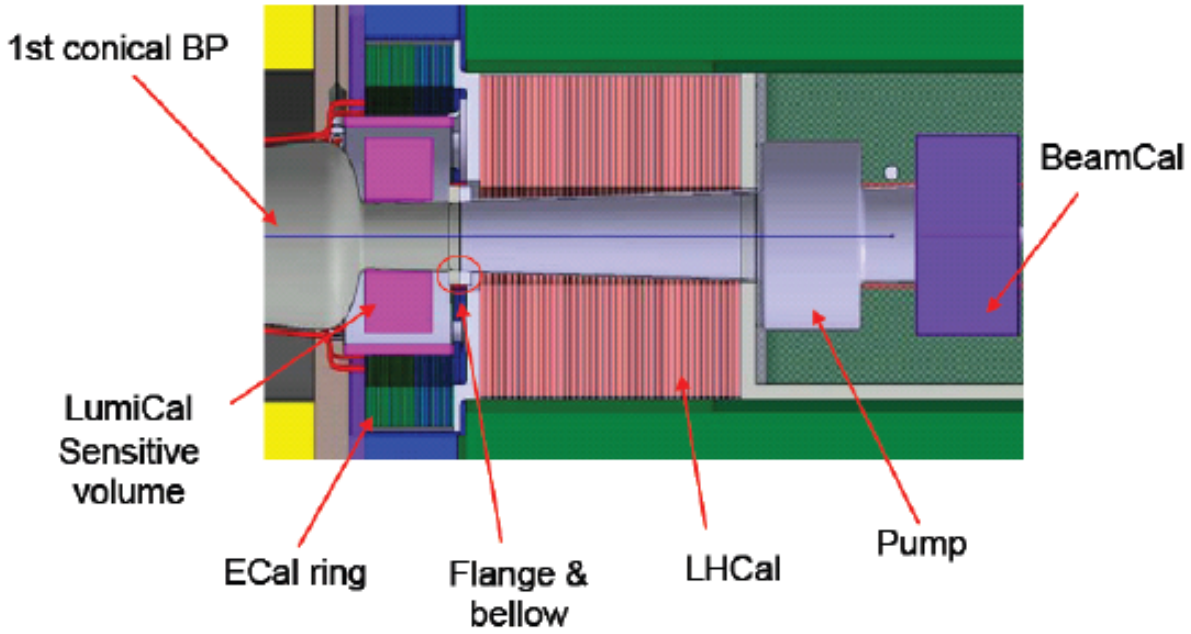


W.Morse - BNL

ILD Mokka model → DD4HEP, L*=4.4 m



Forward Region - possible changes towards L*=4m



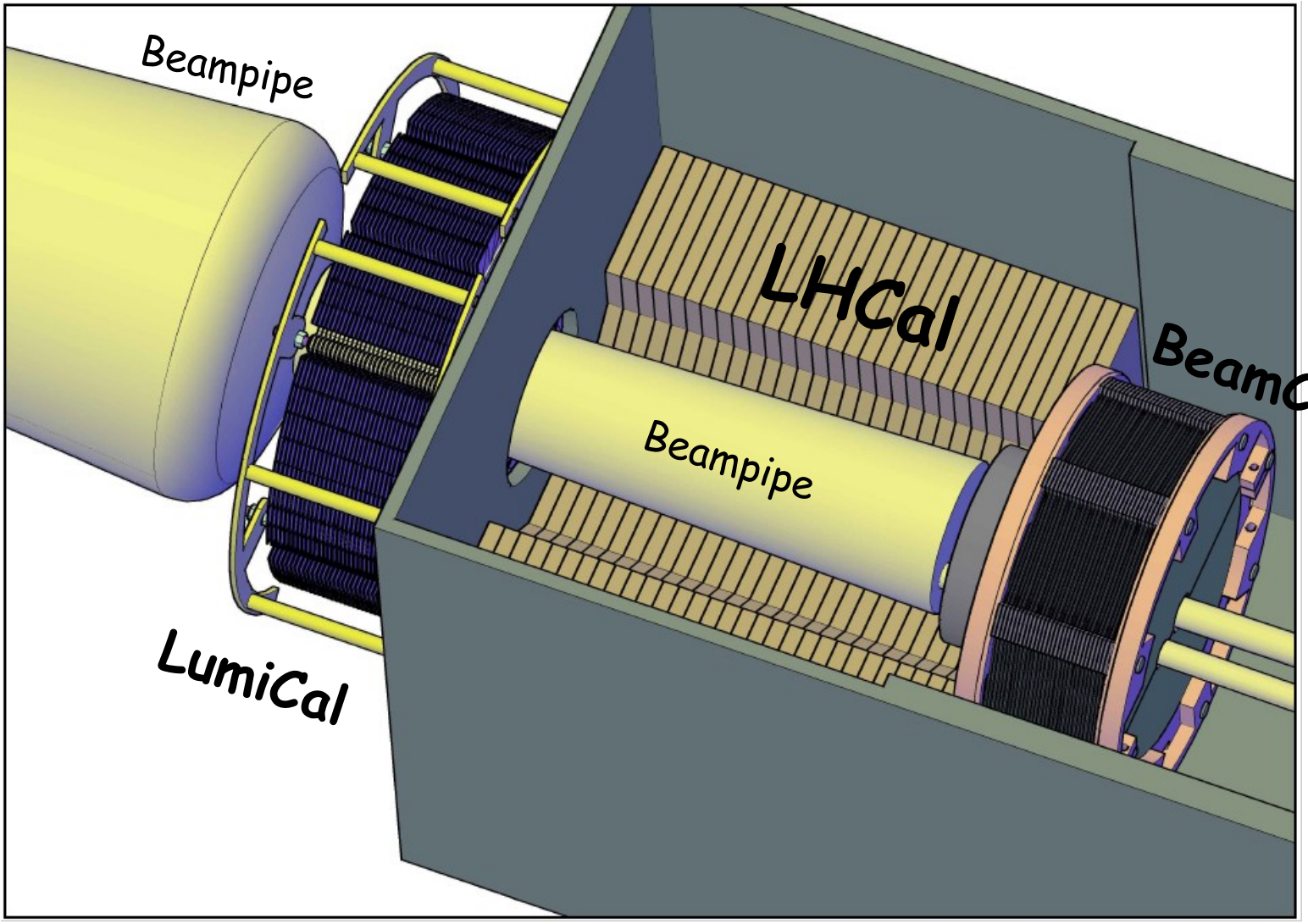
- Need to find ~40cm in current design
- Look into design optimisations of all structures
  - maybe find some 10cm there, but more?
- Biggest devices:
  - Pump in front of BeamCal (30cm)
  - LHCAL (~50cm)

Forward Region - Things to Do

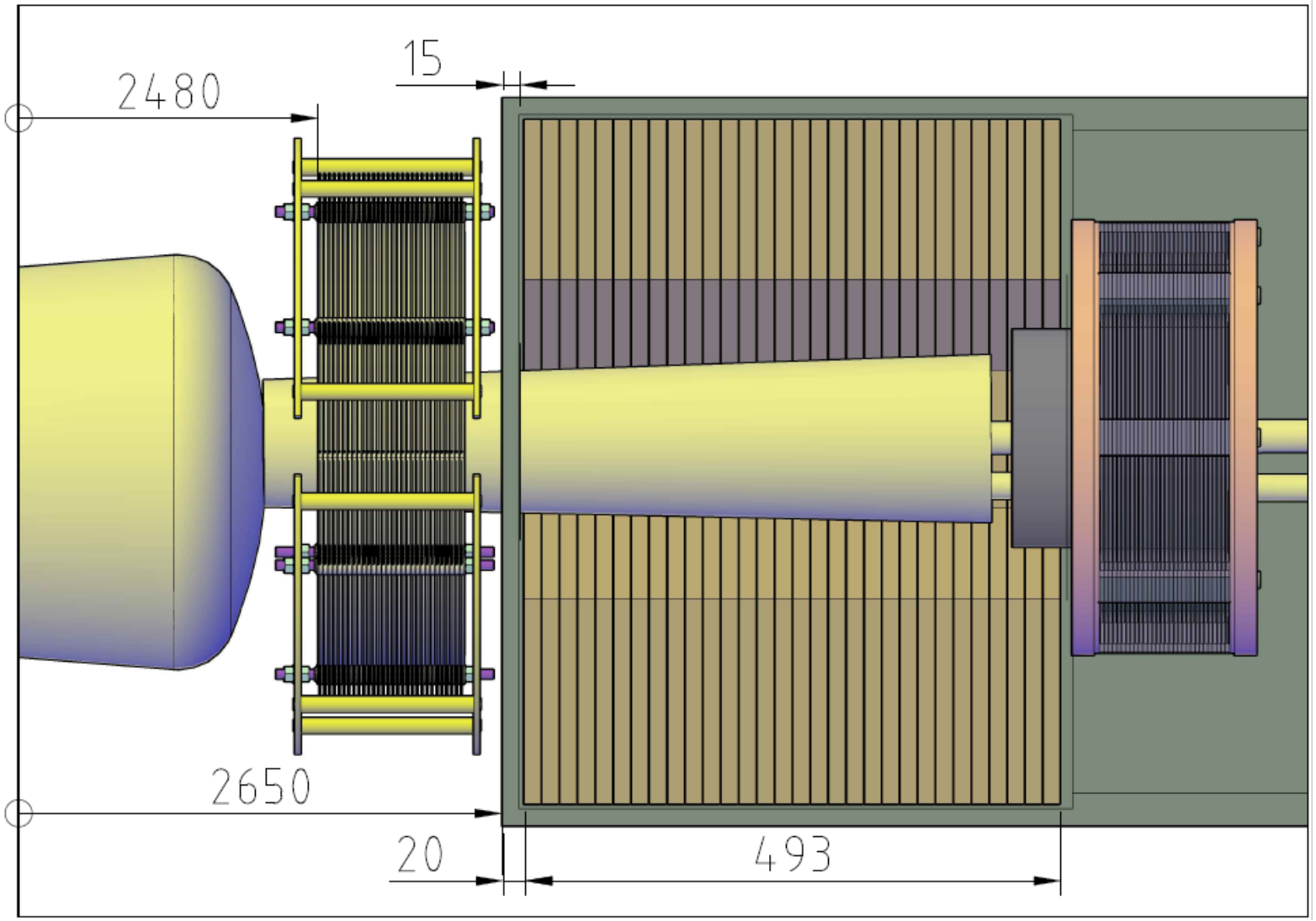
- Revisit FCAL design and look for possible space savings
  - any cm helps
- Do a coherent study of LHCAL design
  - physics requirements
  - technical design
- Change BeamCal design at new location (holes for incoming/outgoing beams)
- Eventually redo the pair background simulations with new BeamCal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

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

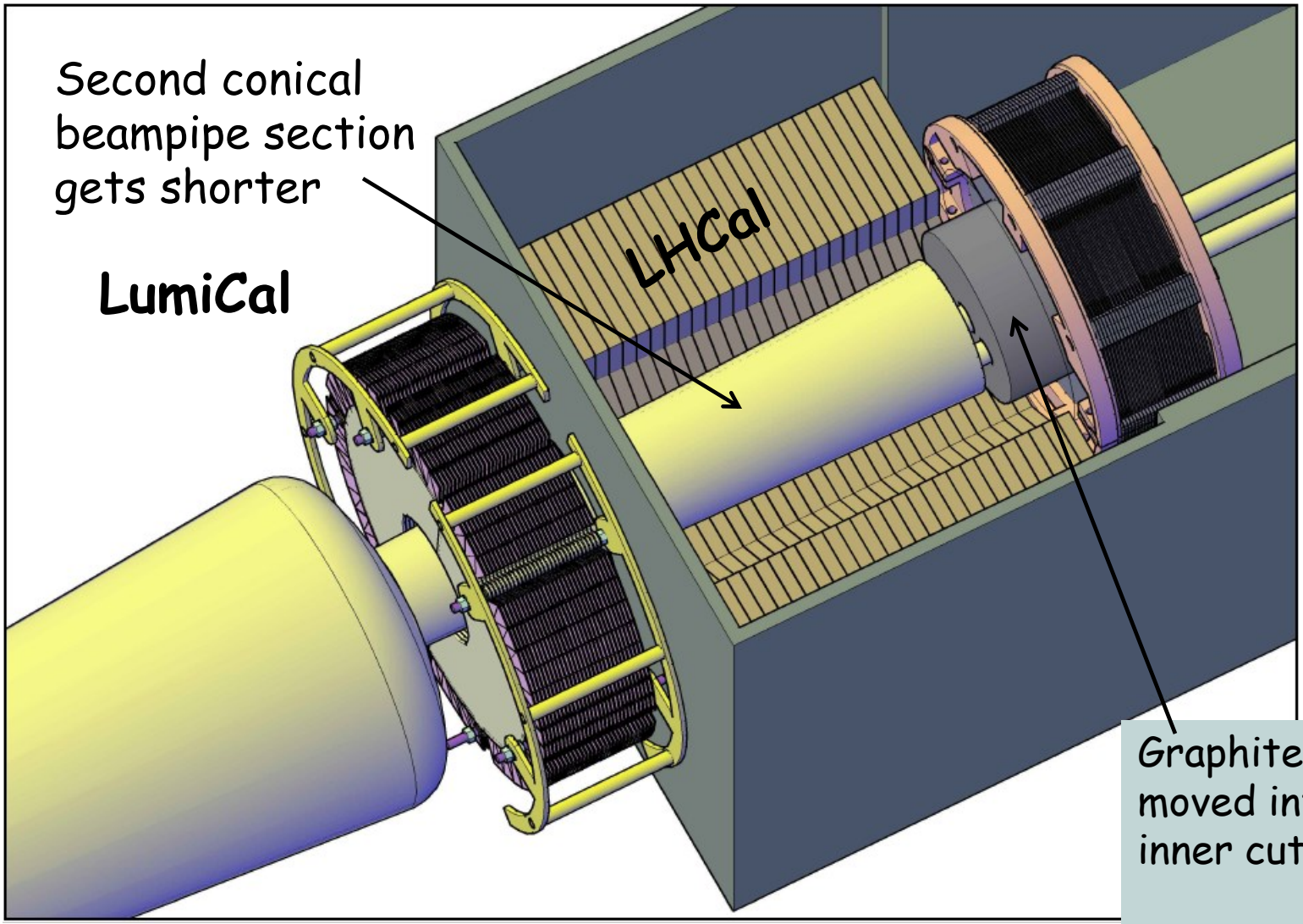
Forward region, reduced L* = 4m (1)



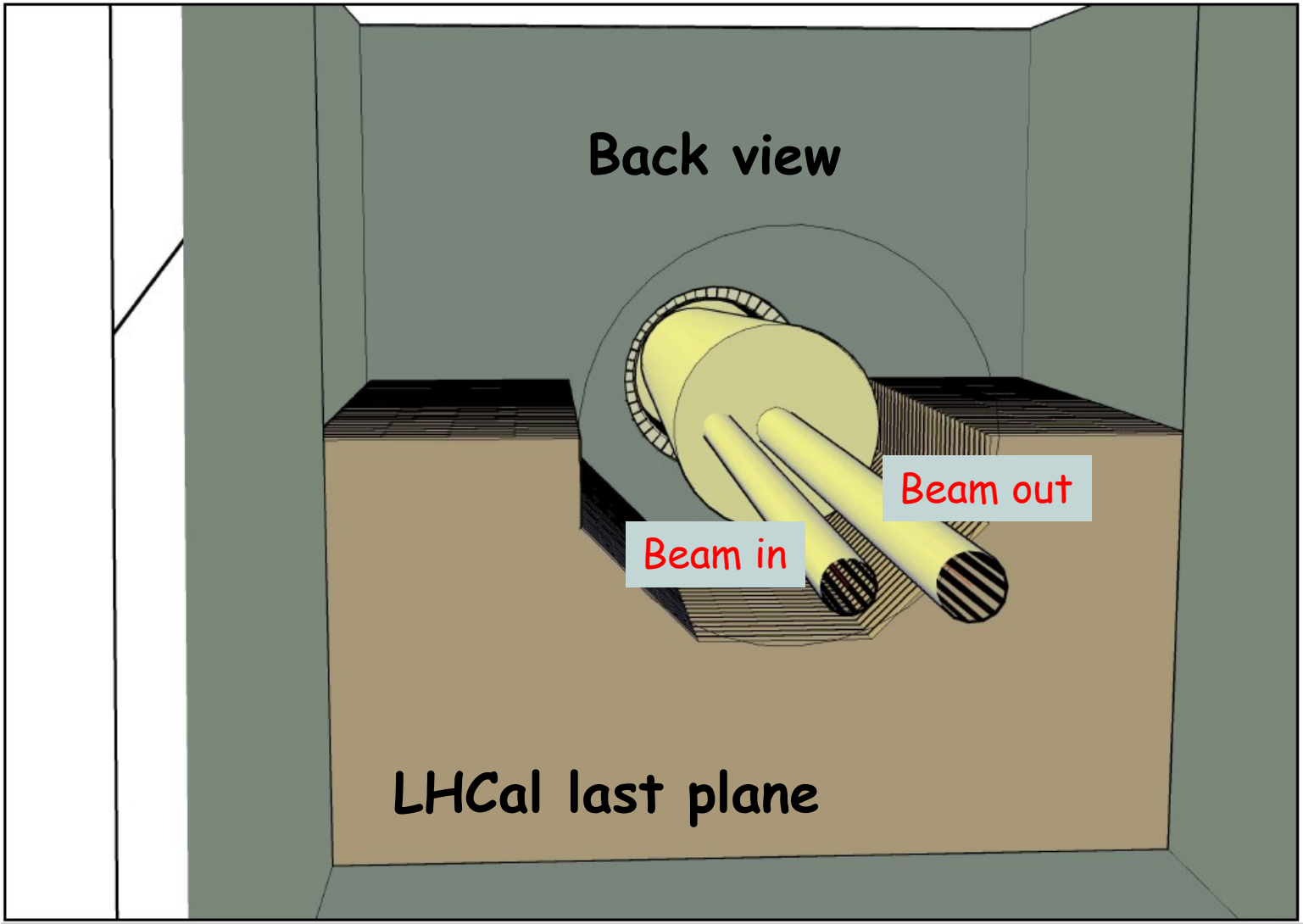
Forward region top view, reduced L*=4m (2)



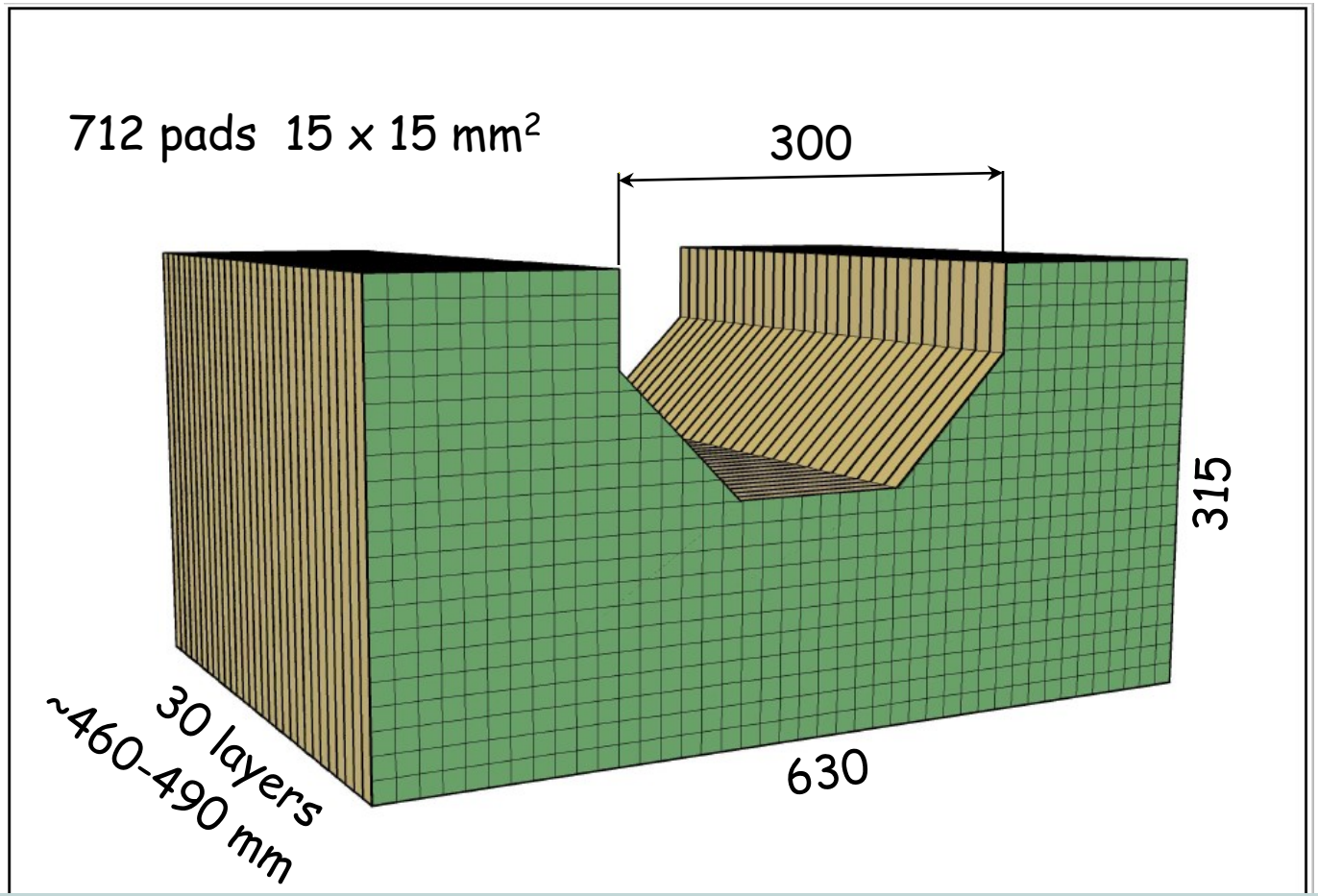
Forward region, reduced L*=4m (3)



Forward region, LHCal(1/2) and beampipe



LHCal Layout (bottom half)



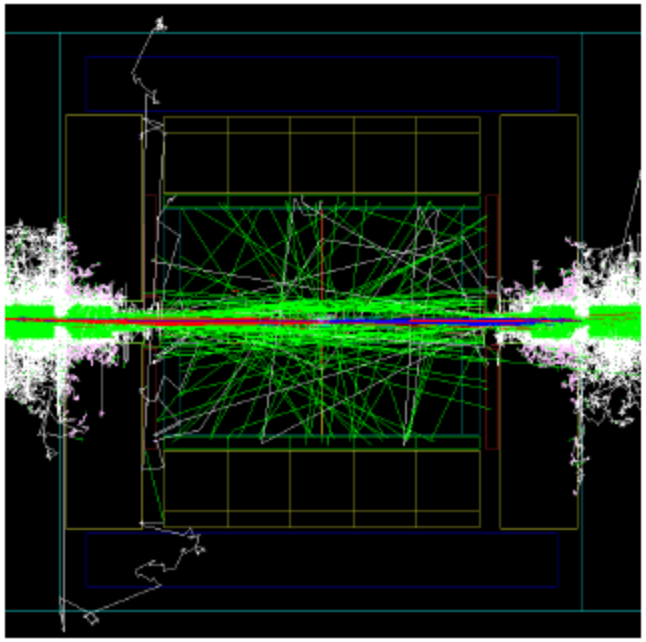
Sensors:
- Si (~ECal)
- Sci+SiPM (~AHCal)

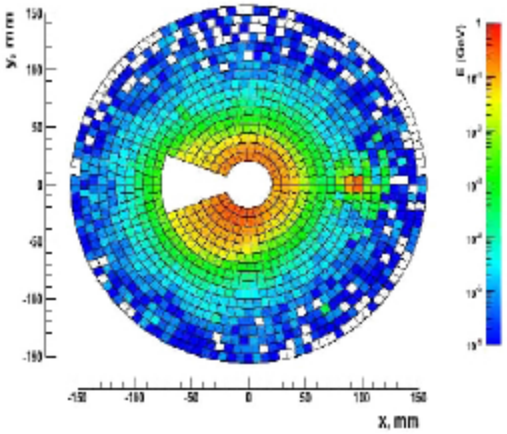
Kiev group started with LHCal simulations (see talk at this WS)

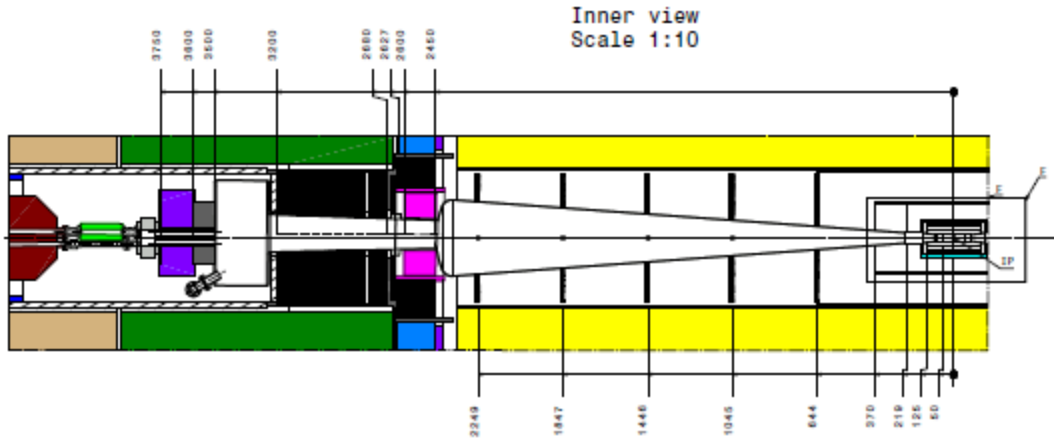
Pair Background Backscattering

- 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

(See talk by Lucia Bortko at this WS)



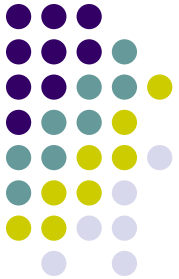




Conclusions and outlook

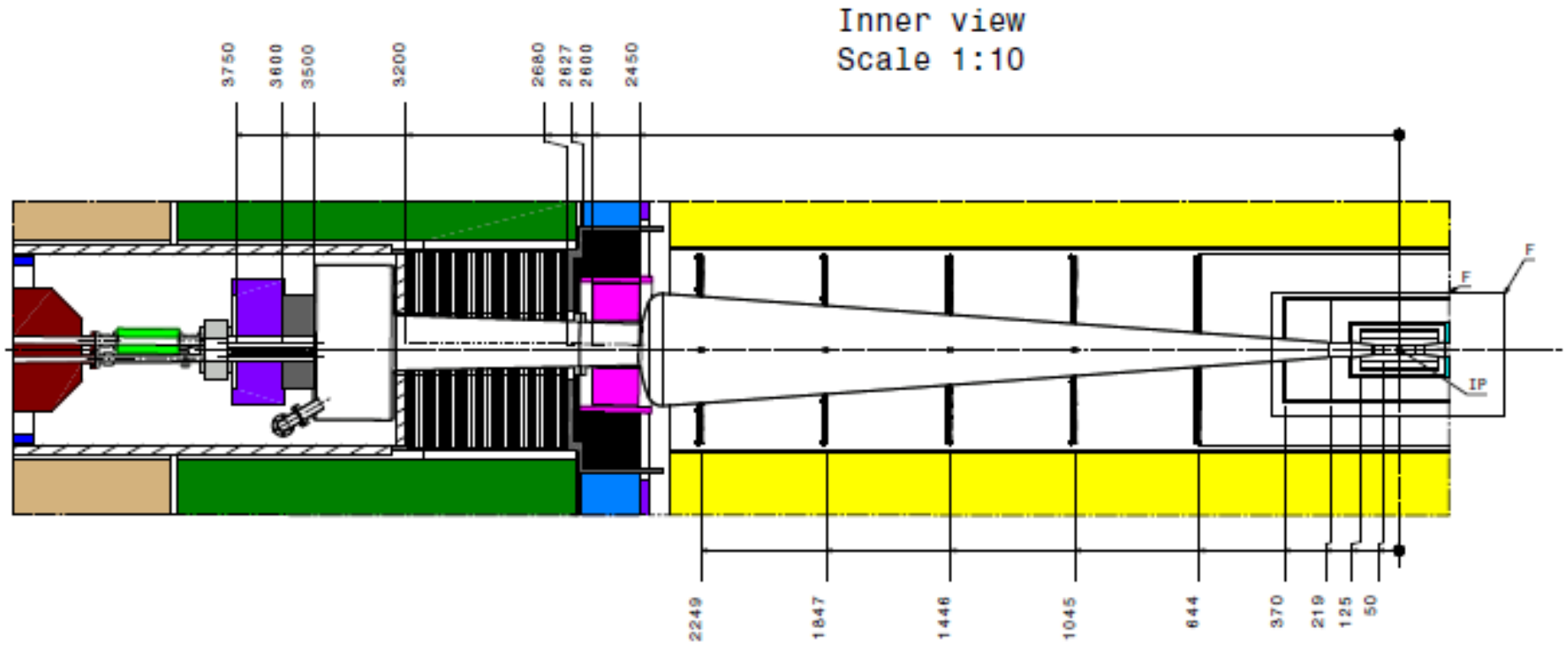
- Design of the ILD forward region revisited to match L*=4 m
1. BeamCal shifted by 40 cm in the IP direction
2. Vacuum pump moved behind QD0
3. Graphite absorber placed inside LHCal inner cutout
- MC simulations of LHCal started at Kiev (first results on tungsten option performance)
- Study of BeamCal sapphire version is ongoing
- Pair background simulations are done for new BeamCal location
- GamCal design should be reconsidered (sapphire tracker?)

- Schedule? Resources? Manpower? - not clear….

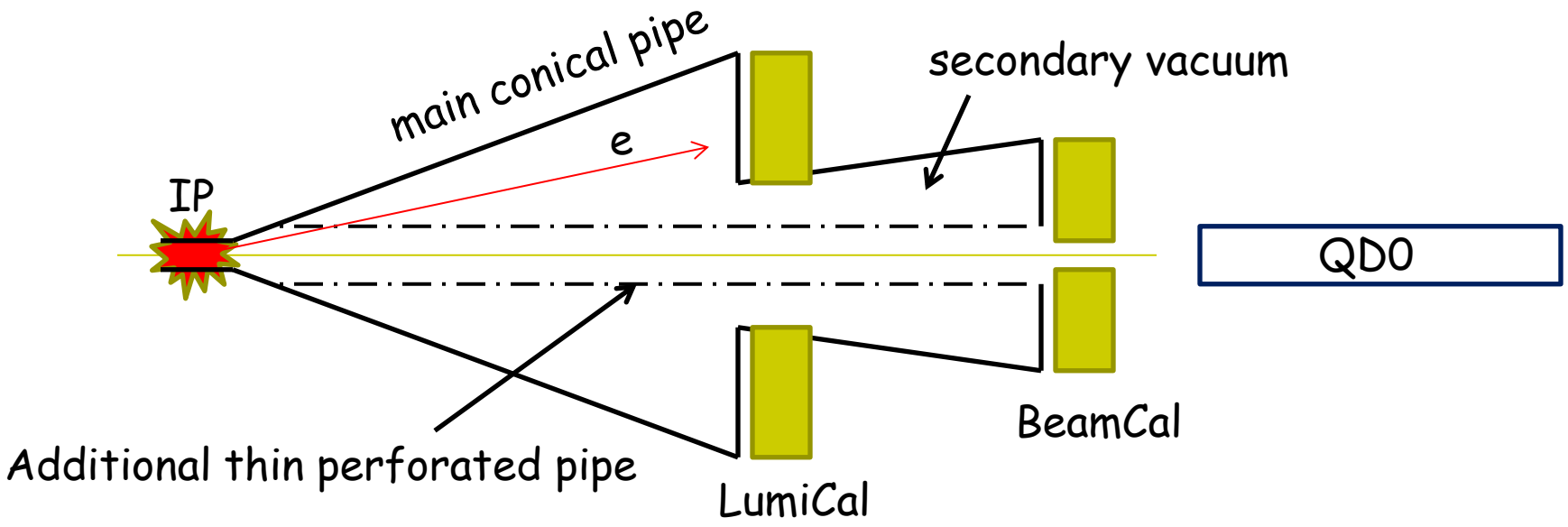


Thank you

Beam Pipe

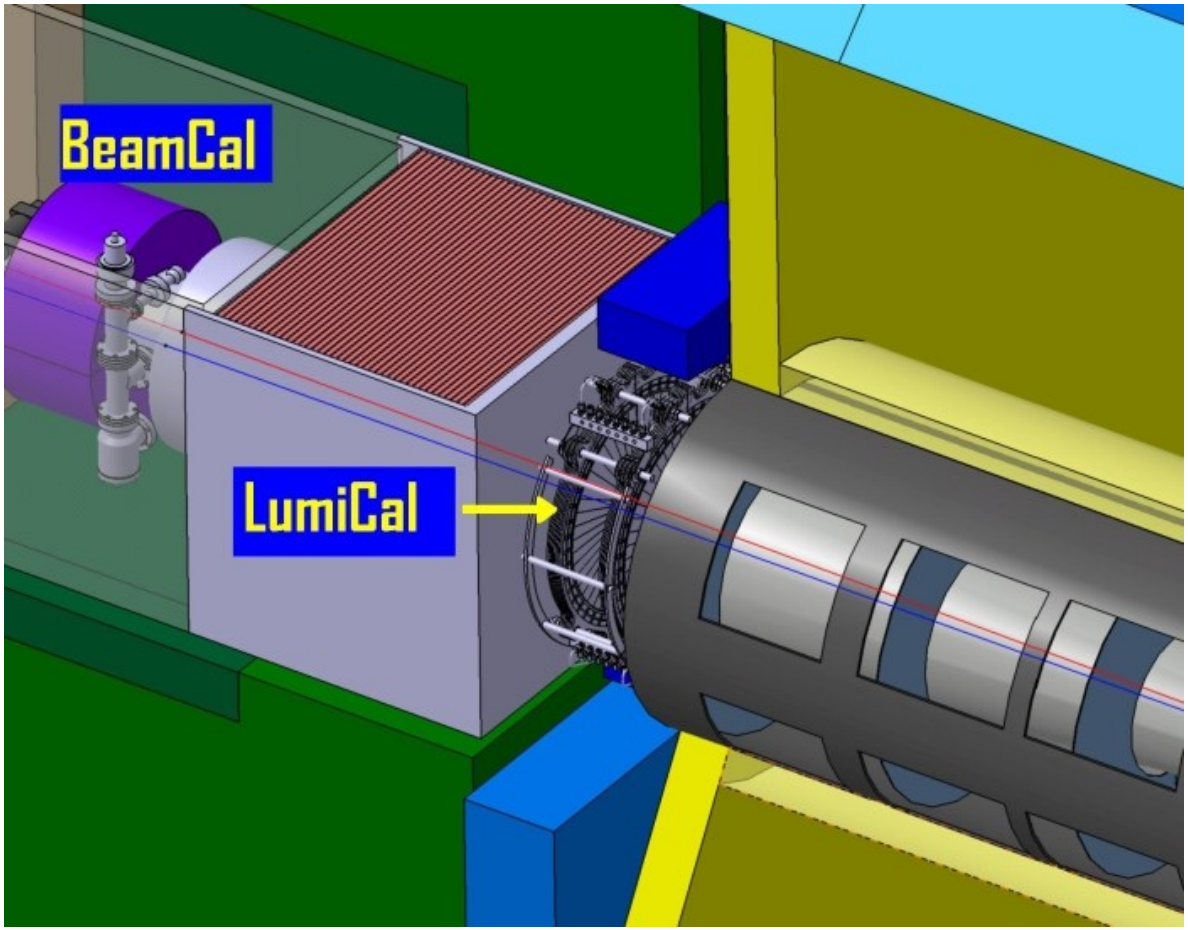

Inner view
Scale 1:10
3750
3600
3500
3200
2680
2627
2600
2450
F
F
IP
2249
1847
1446
1045
844
370
219
125
50

Possible vacuum problem solution?



To be checked….

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

BeamCal – sapphire based design