The Interaction Region Design of LDC

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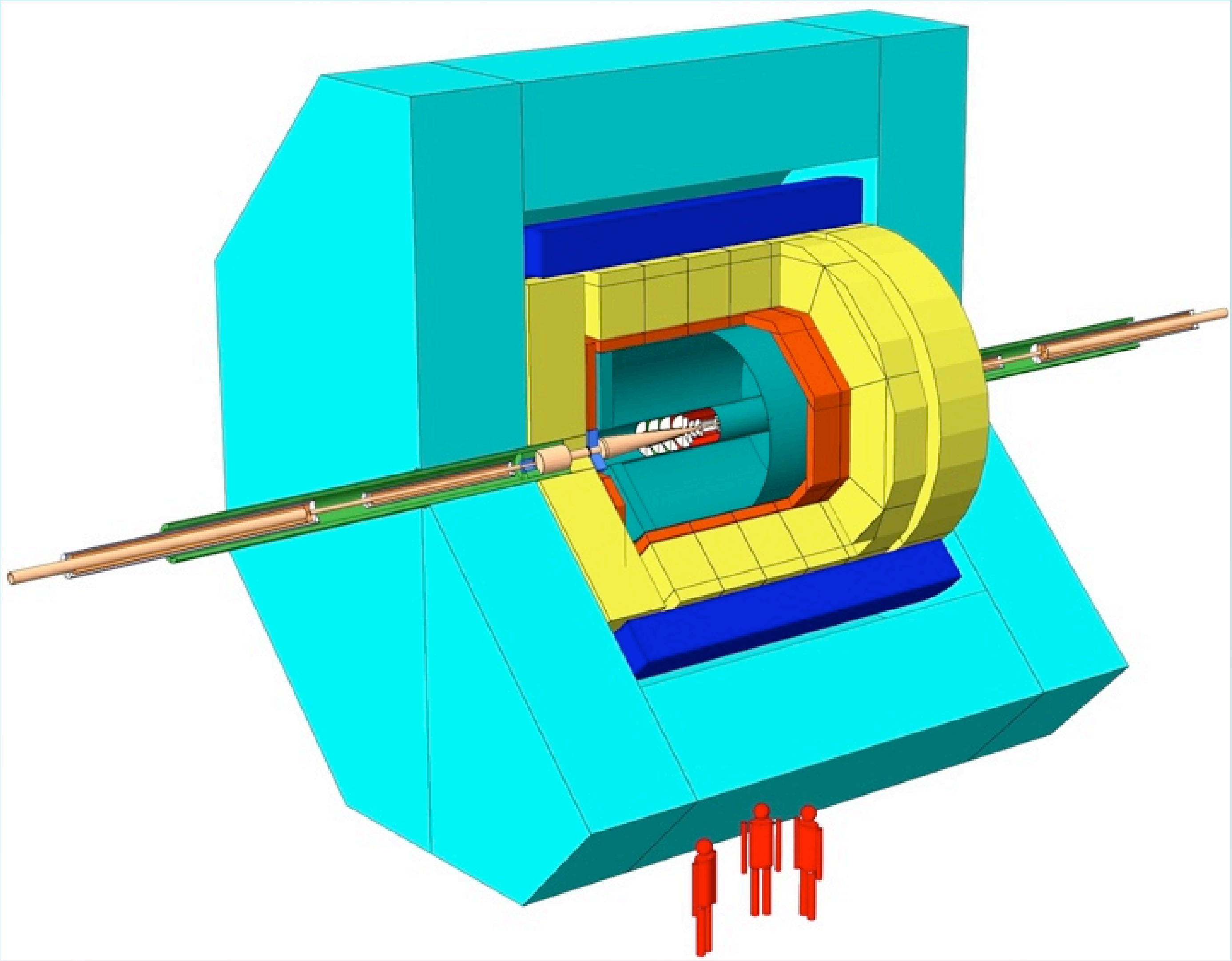
ILD MDI Working Group Meeting

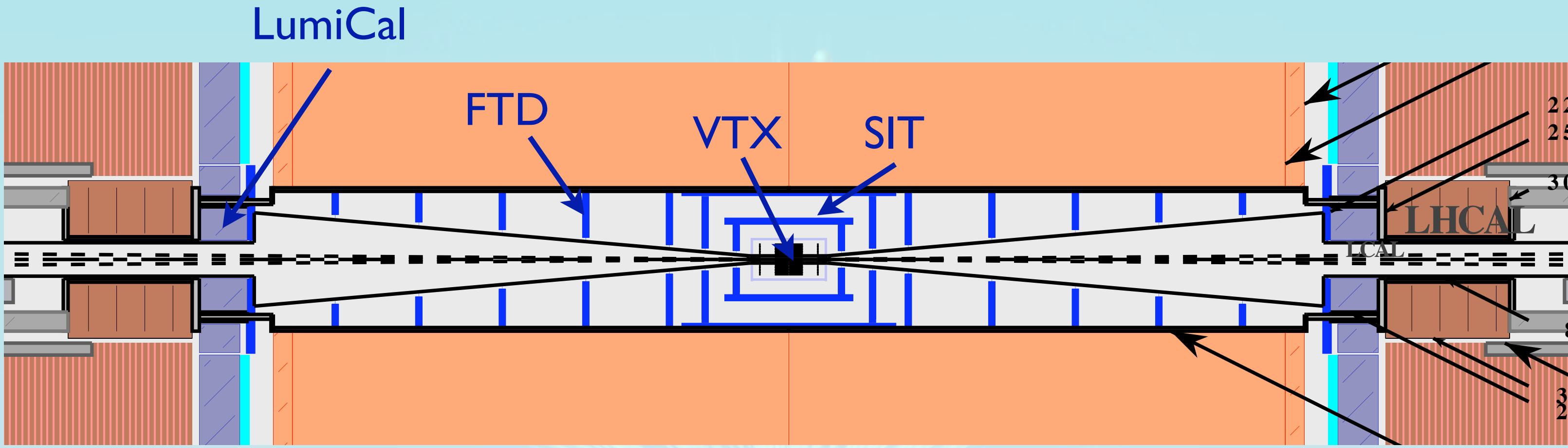
04. October 2007

The Large Detector Concept



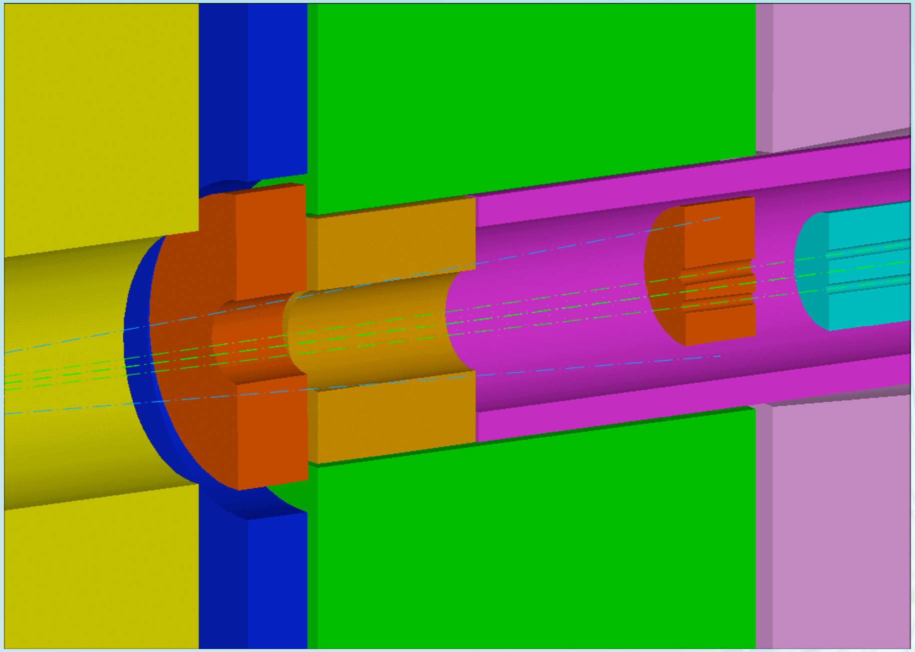
Size: ~12m x 12m x 12m (not that large)

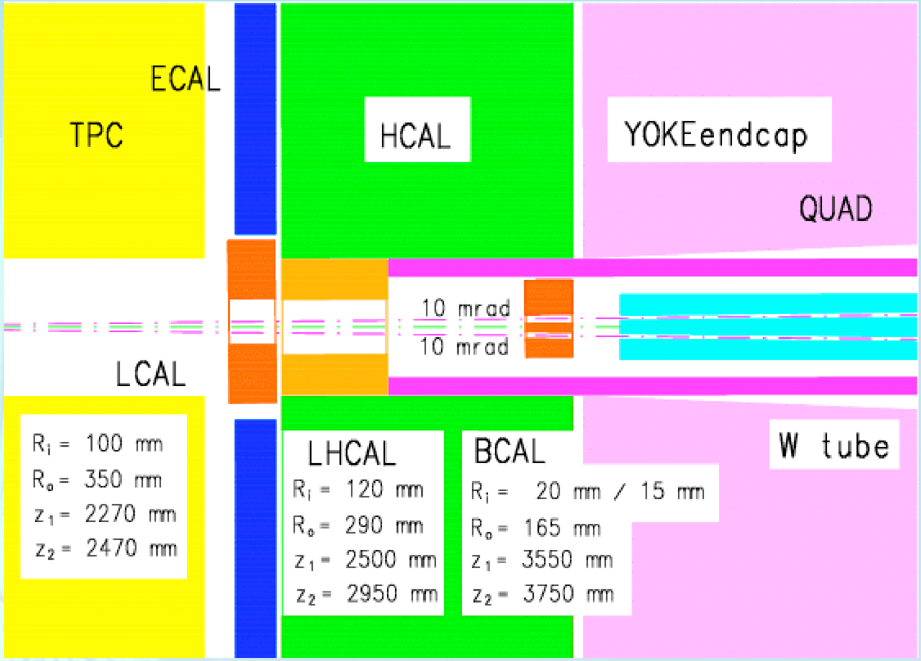
LDC Interaction Region



- Vertex Detector VTX
- Silicon Intermediate Tracker SIT
- Forward Tracking Disks FTD
- Beam pipe design which minimises the amount of material in front of the LumiCal (Bhabha scattering)

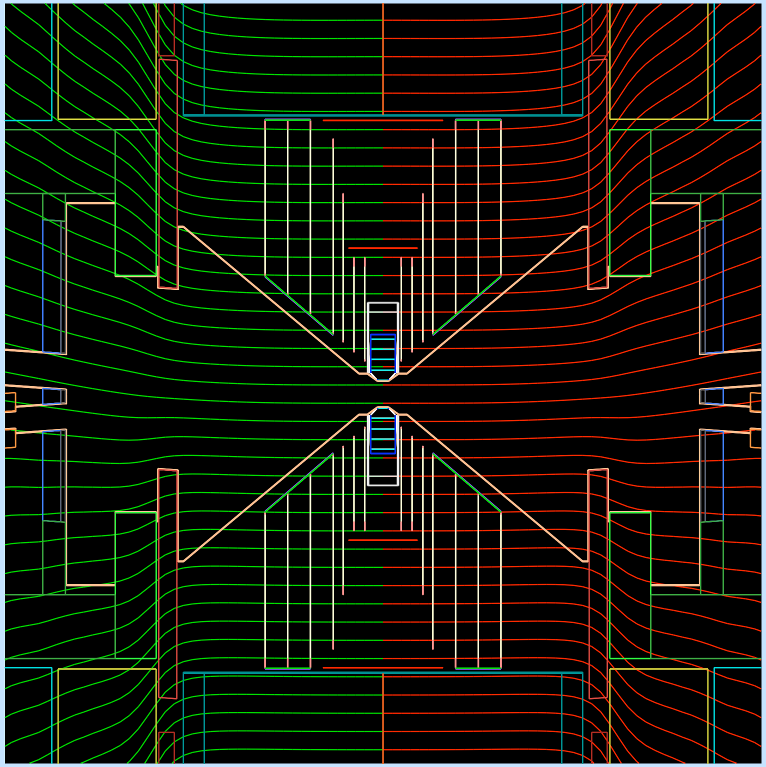
LDC Forward Region



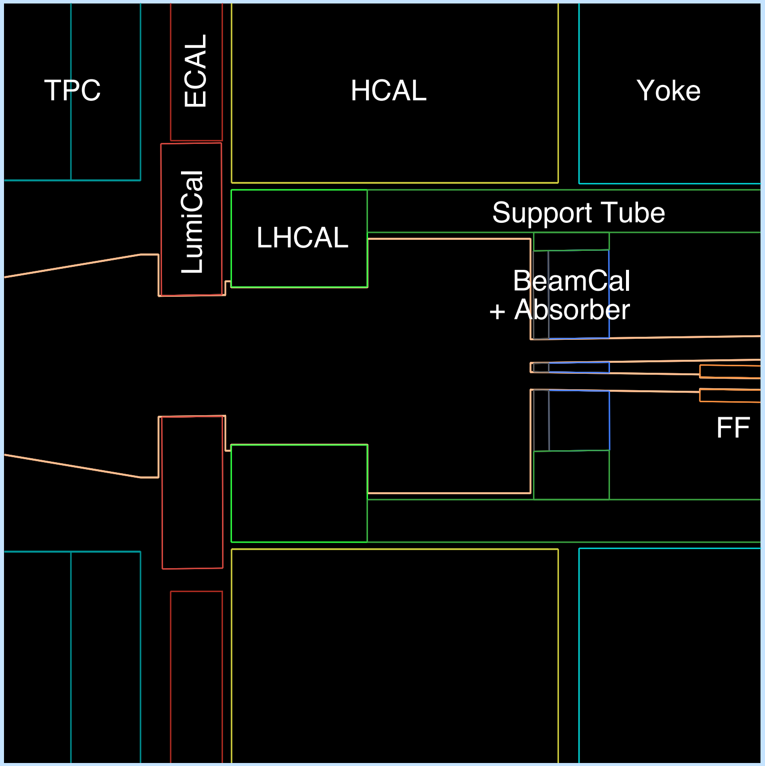


- L*=4.05 m
- 14 mrad crossing angle
  - 2 and 20 mrad exist as alternative
- Tungsten absorber around BeamCal
- LumiCal: precision luminosity measurement via Bhabha scattering
- BeamCal: pair signal measurement, hermeticity to <5 mrad
- Calorimeters centred on outgoing beam
- LowZ absorber

LDC 14 mrad Interaction Region in GEANT4



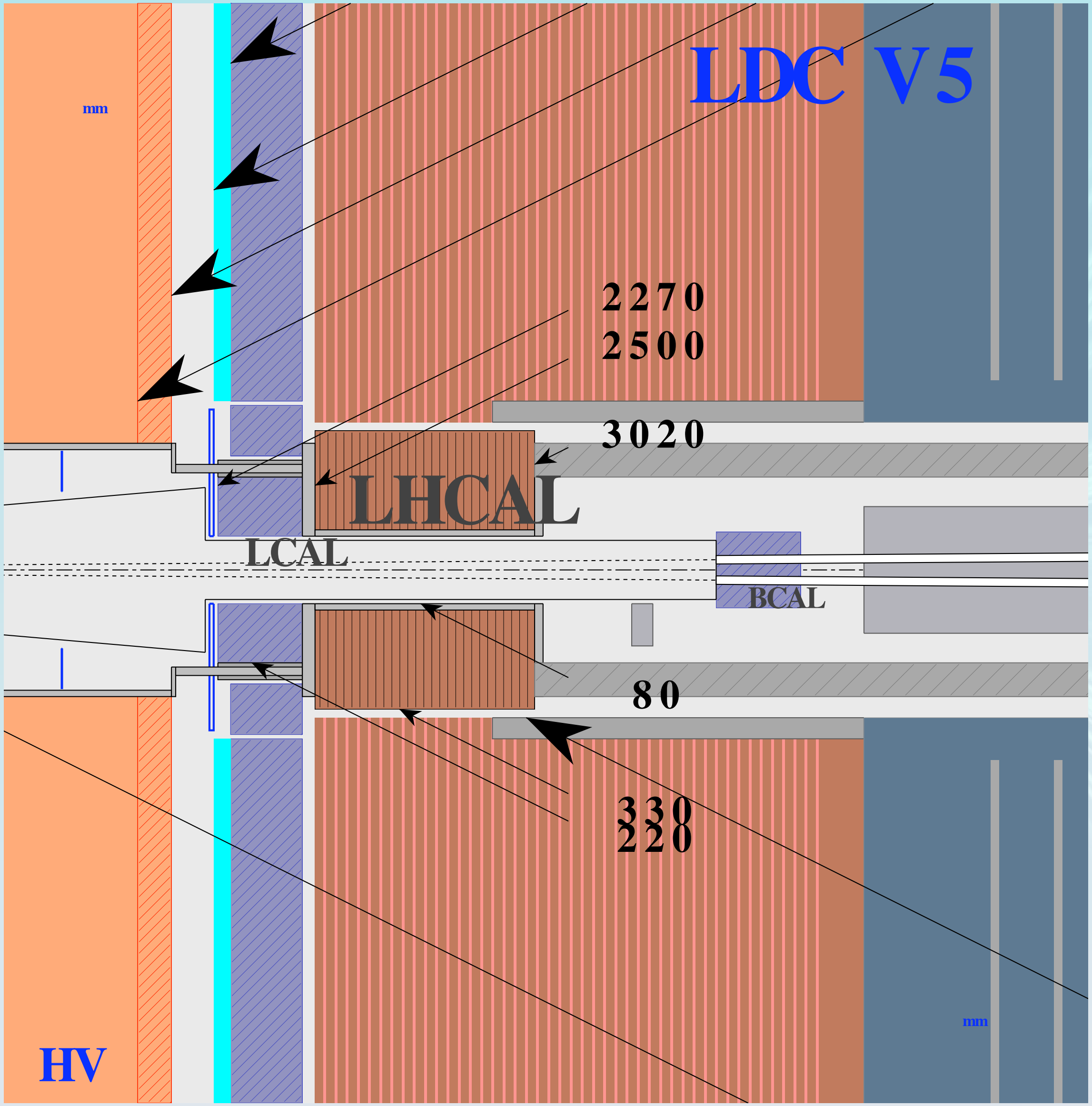
14 mrad crossing angle with anti-DID field (1:10)



Forward region design (compressed view 1:2)

A. Vogel

Forward Region Modification



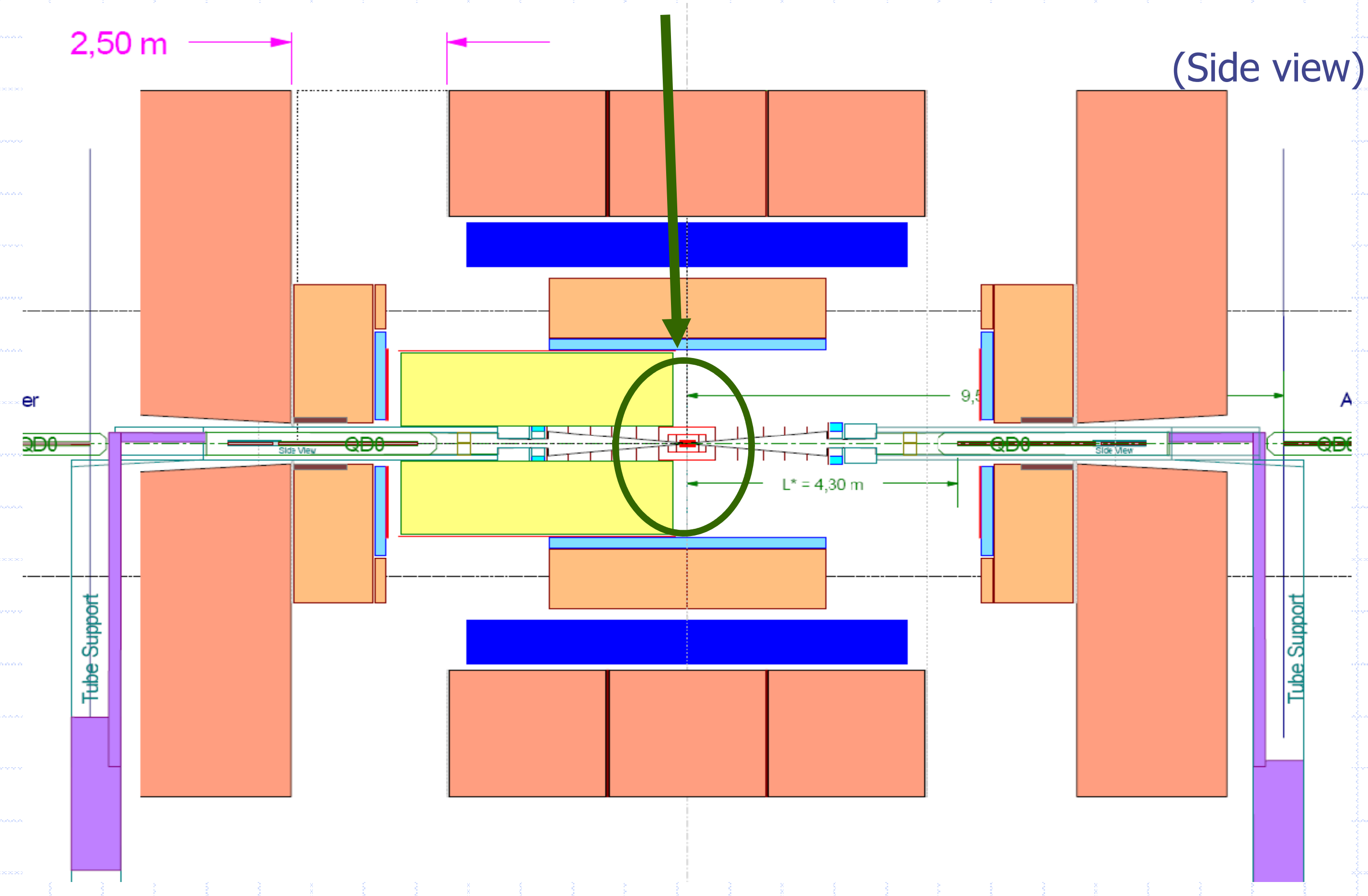
Preliminary changes, need to be studied in detail:

- Modified LumiCal simplifies detector opening procedure
- ECAL ring extends to lower angles to cover the gap between LumiCal and ECAL
- No tungsten tube around BeamCal
- Tungsten shield attached to HCAL

Detector Opening Concept

Detector Opening (Vertex Detector Maintanence)

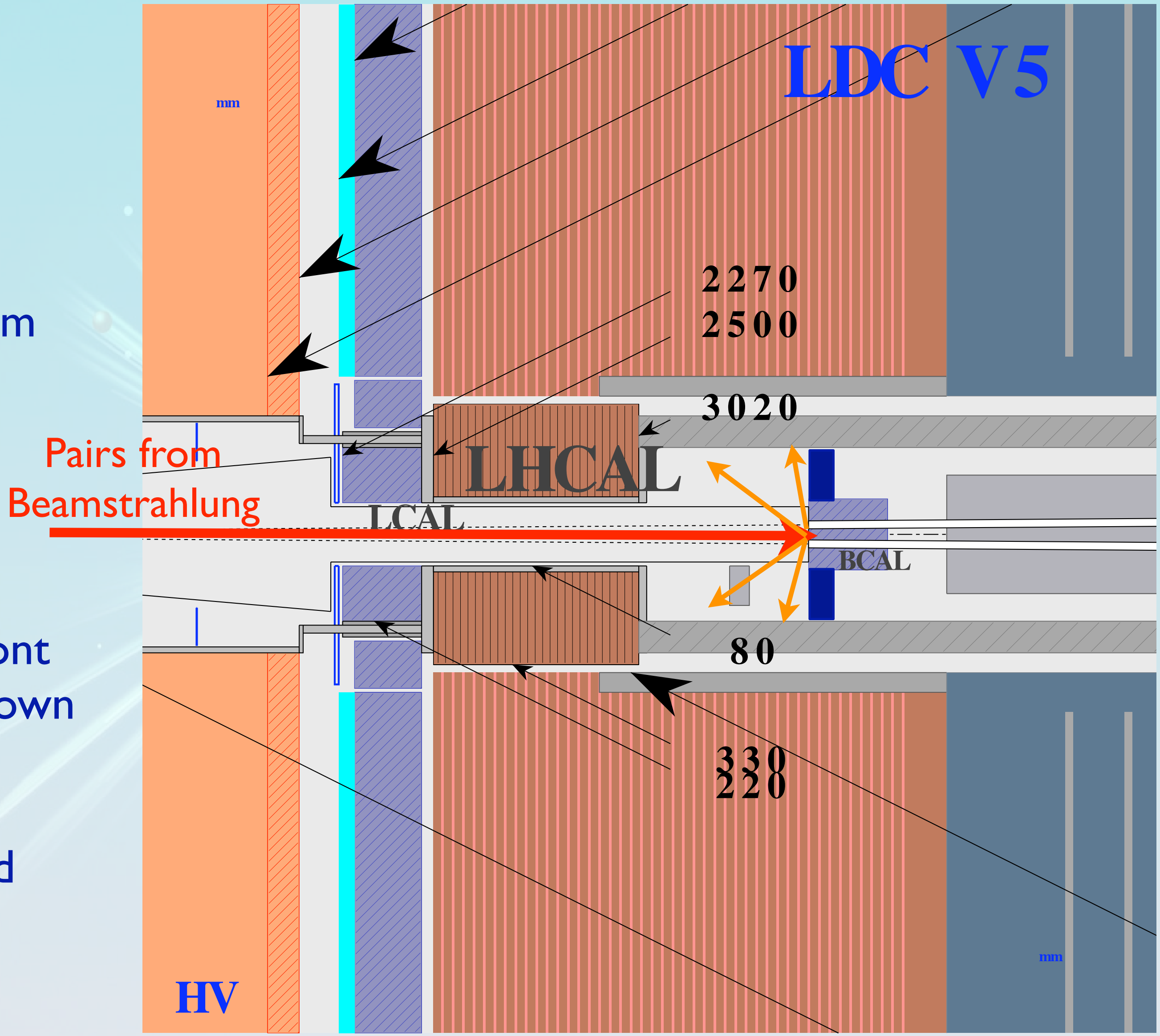
2.5m detector opening would just allow to maintain the vertex detector in the garage posistion without breaking the vacuum.
(Pumping the central beam pipe is assumed to be very time consuming.)



Background Suppression

Forward Region Design Principle:

- Absorb pairs from beamstrahlung on the BeamCal and in the beam pipe
- Trap backscattered particles in the area between LHCAL and BeamCal
- Low-Z absorber in front of the BeamCal (not shown in the figure) reduces backscattering
- Tungsten shield around the hot BeamCal area

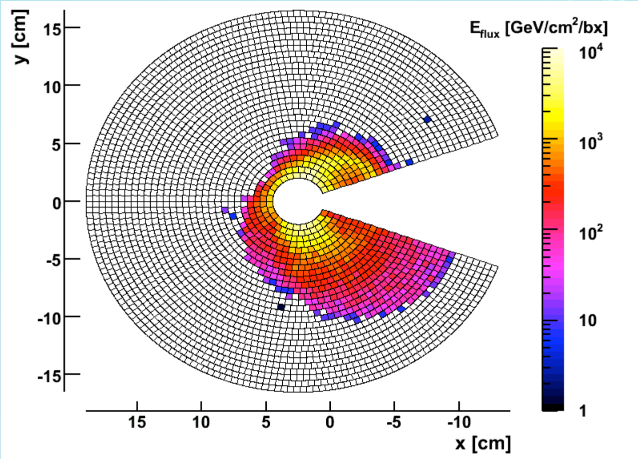


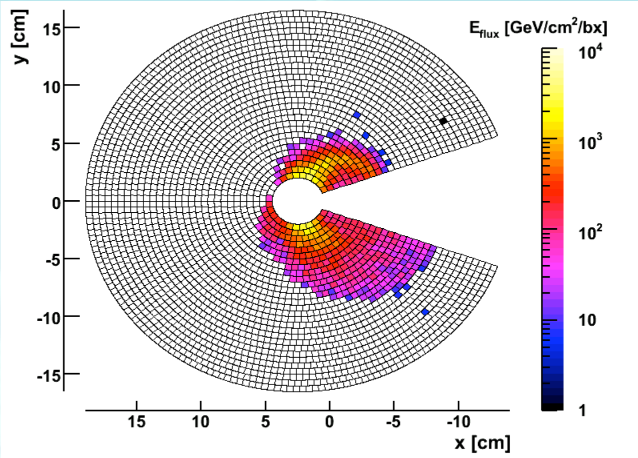
Beamstrahlung Pairs on the BeamCal

LowP

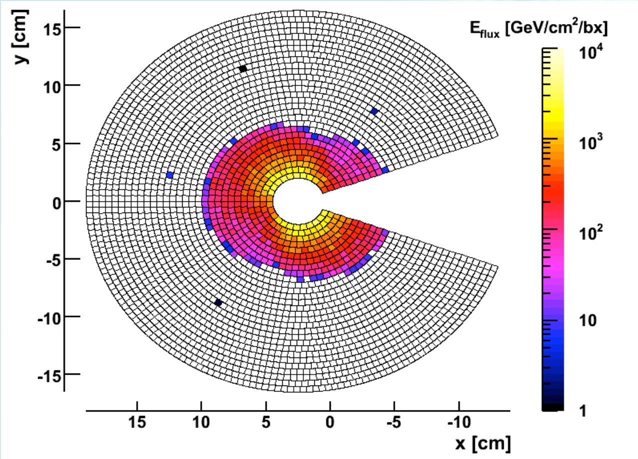
Nominal

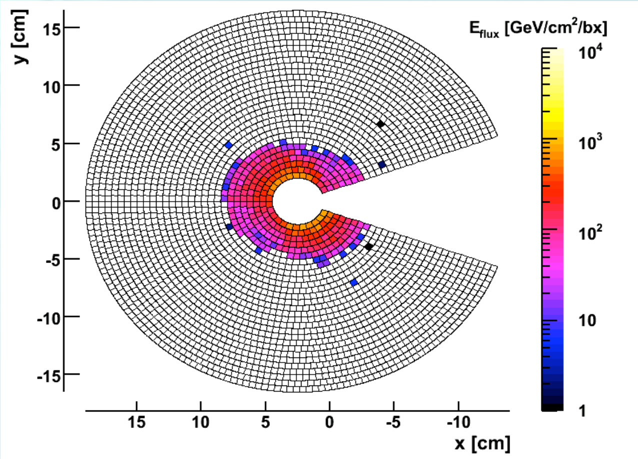
DID





Anti DID

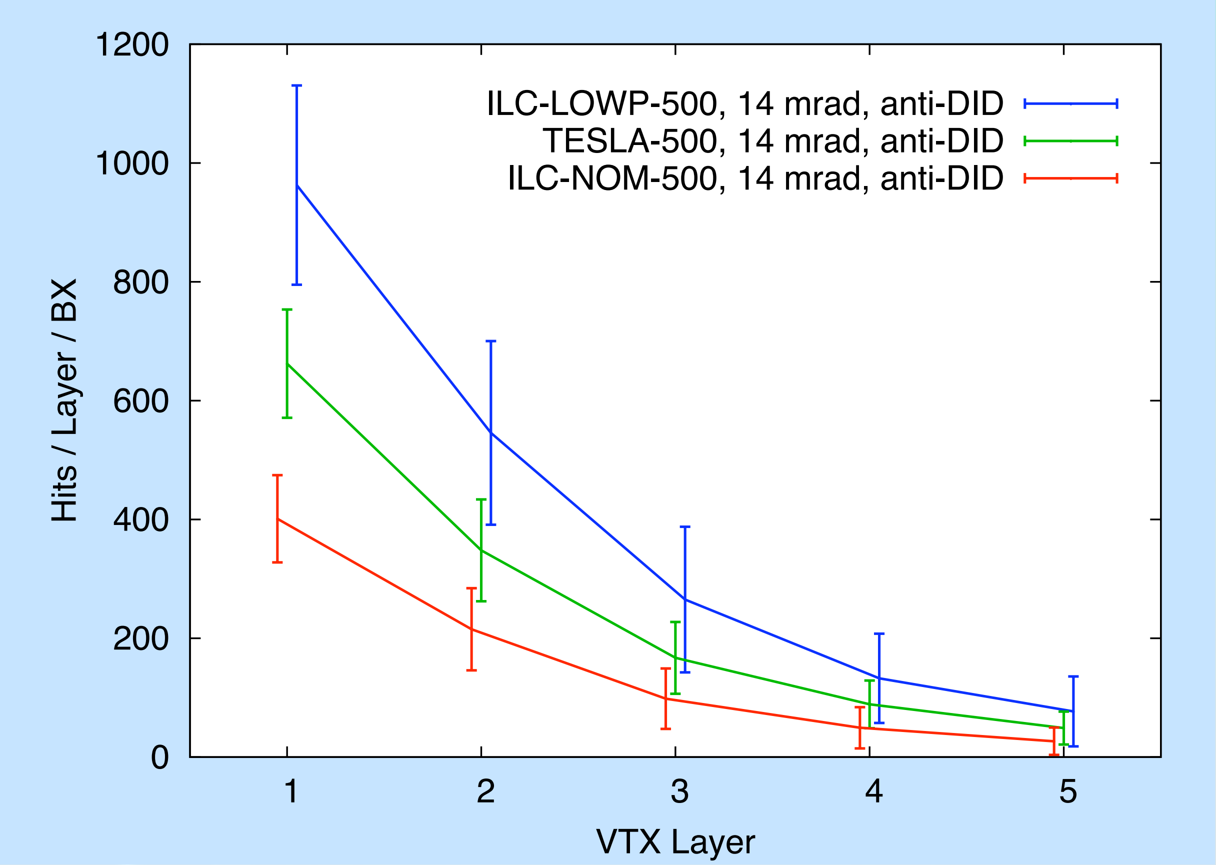




C. Grah

Larger blind area compared to 20 mrad (30° => 40°)

VTX Hits



A. Vogel

Neutrons in the VTX

Neutrons passing any VTX layer (with double counting)

- 1.7 ± 2.9 per BX for ILC-NOM-500
- 8.6 ± 10.4 per BX for ILC-LOWP-500

Normalisation per unit area (total surface is $2.8 \cdot 10^3\,\mathrm{cm}^2$)

Normalisation per nominal run time with $\int \mathcal{L}\,dt = 500\,\mathrm{fb}^{-1}$

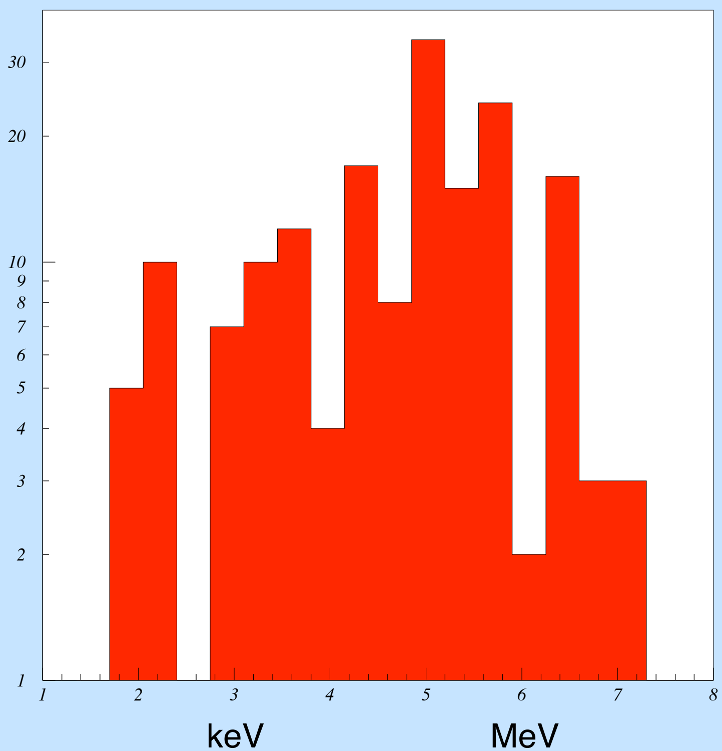
- $3.9 \cdot 10^{11}$ BX in total for ILC-NOM-500
- $2.0 \cdot 10^{11}$ BX in total for ILC-LOWP-500

Neutron fluence (no NIEL scaling applied yet)

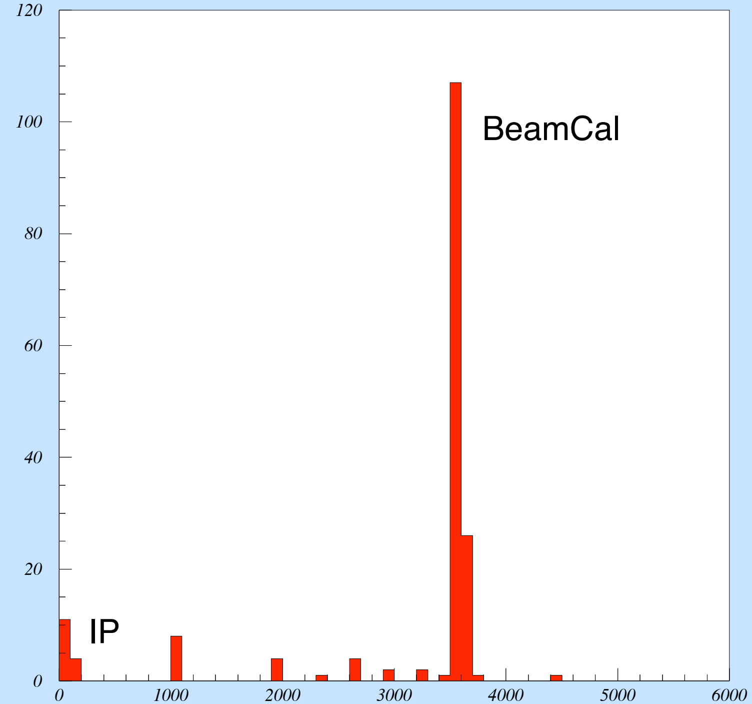
- $(2.3 \pm 4.0) \cdot 10^8$ neutrons / cm^2 for ILC-NOM-500
- $(6.1 \pm 7.4) \cdot 10^8$ neutrons / cm^2 for ILC-LOWP-500

A. Vogel

Statistics for neutrons are rather low . . .



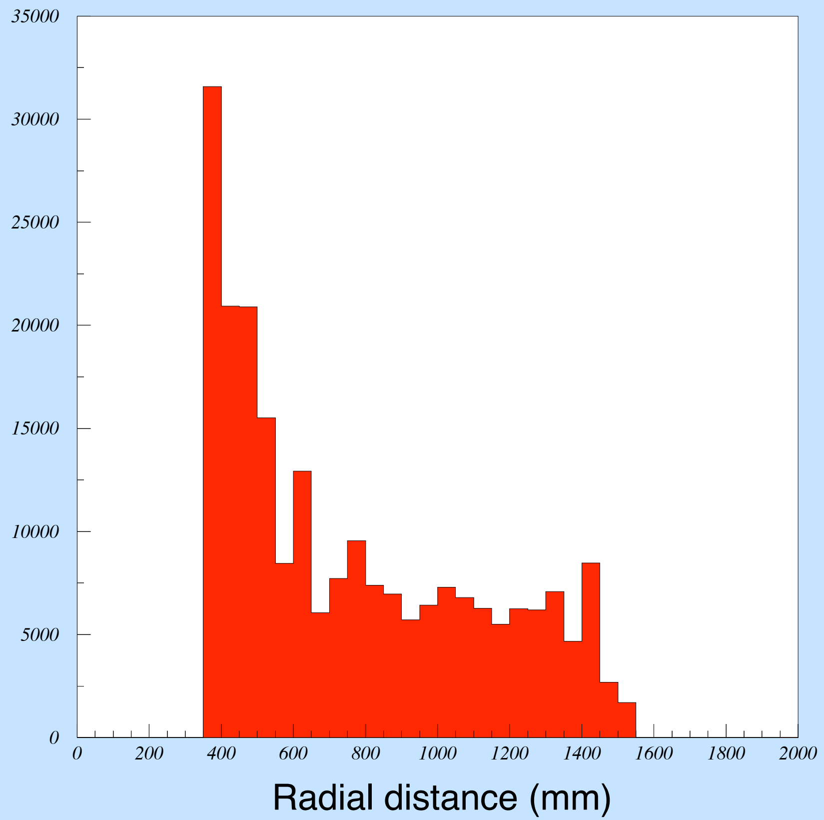
Energy spectrum



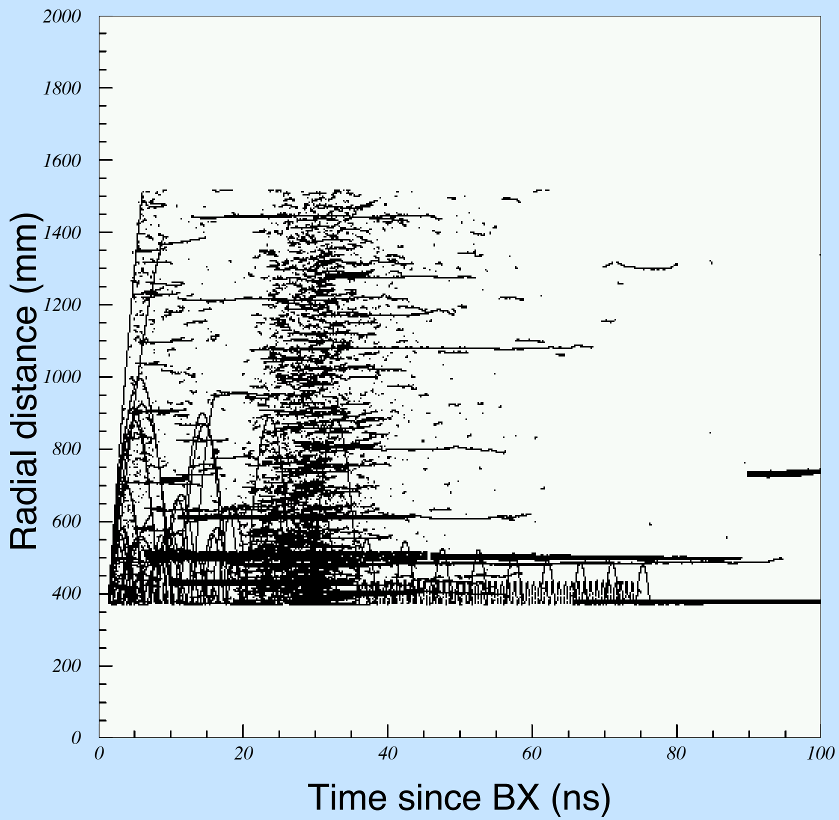
Origins of particles

A. Vogel

Mokka hits in the TPC (overlay of 100 BX)



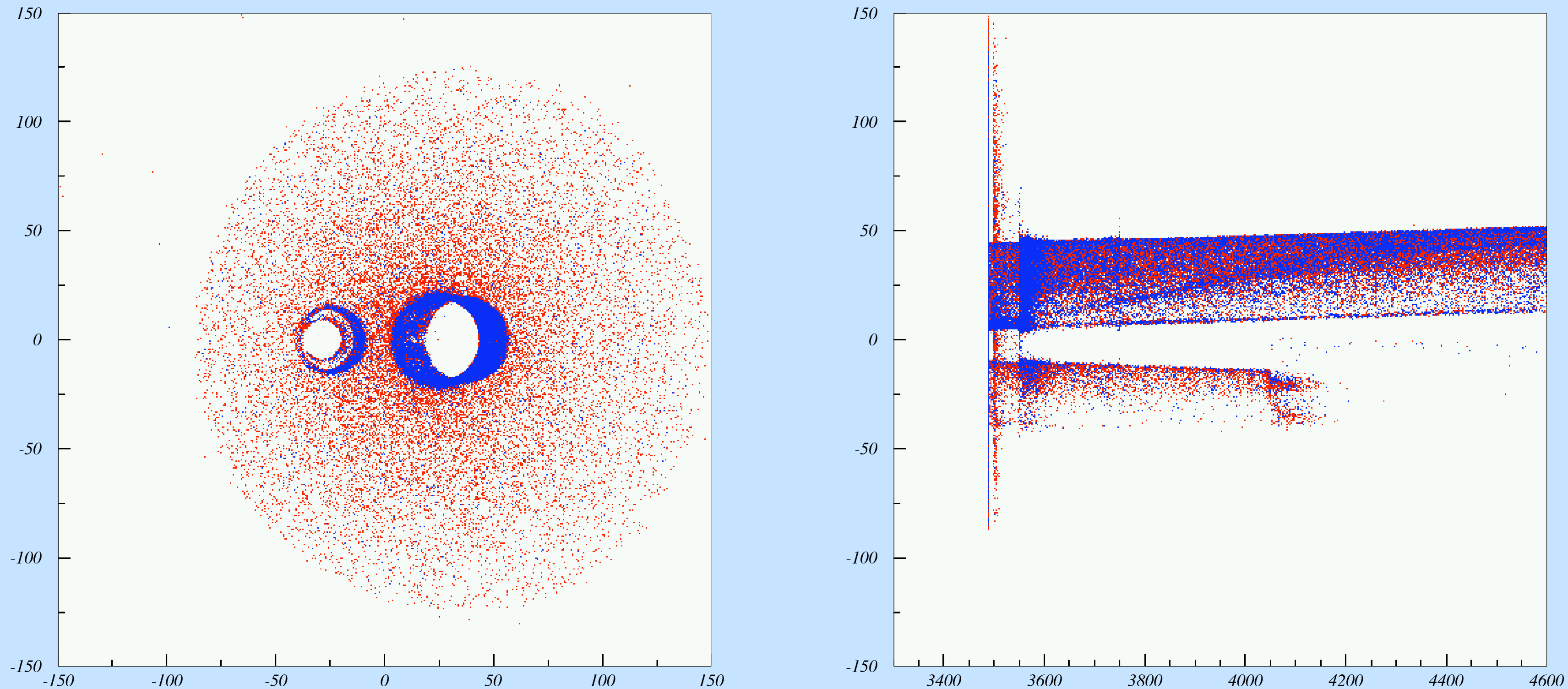
Radial distribution



Time structure

A. Vogel

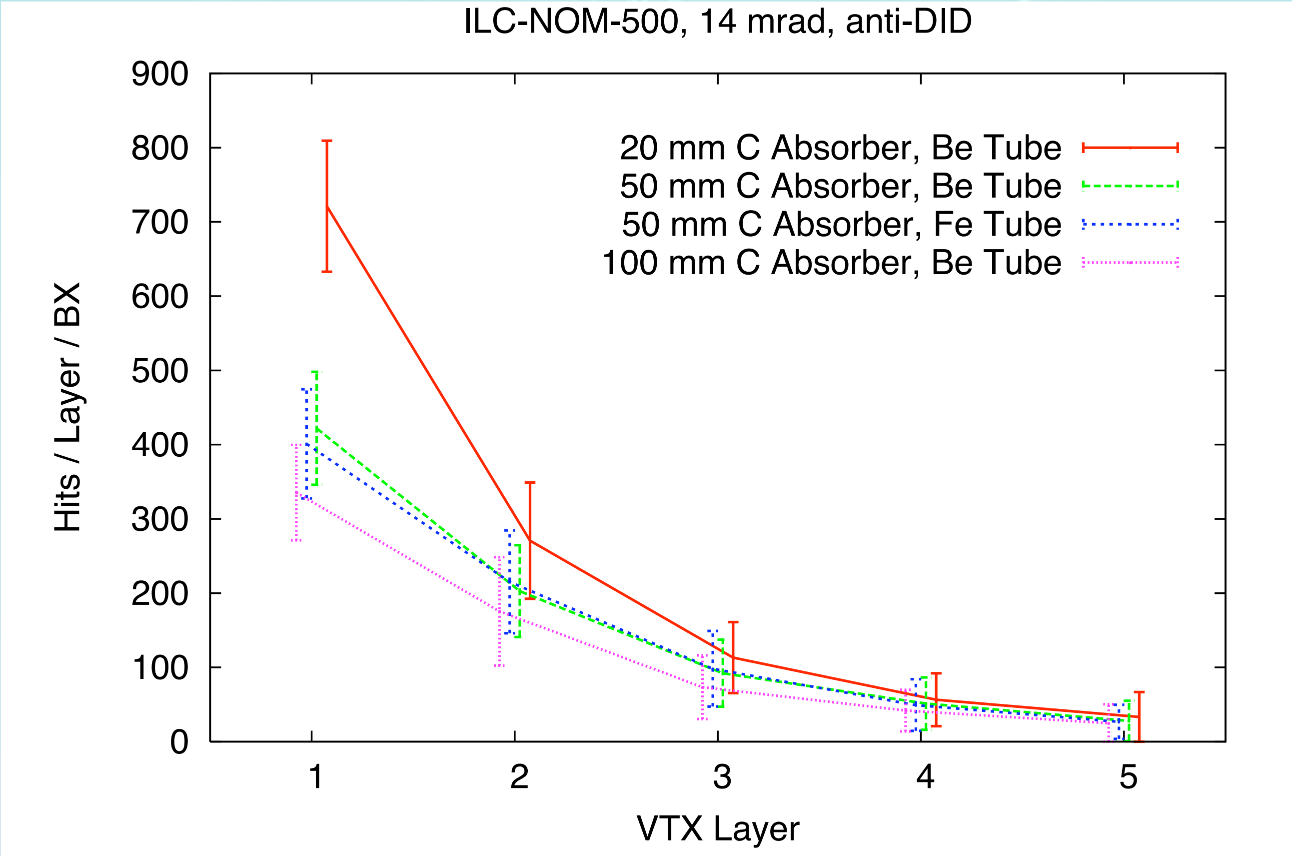
Backscattering Sources



Origins of backscattered electrons and positrons which enter the inner parts of the detector

A. Vogel

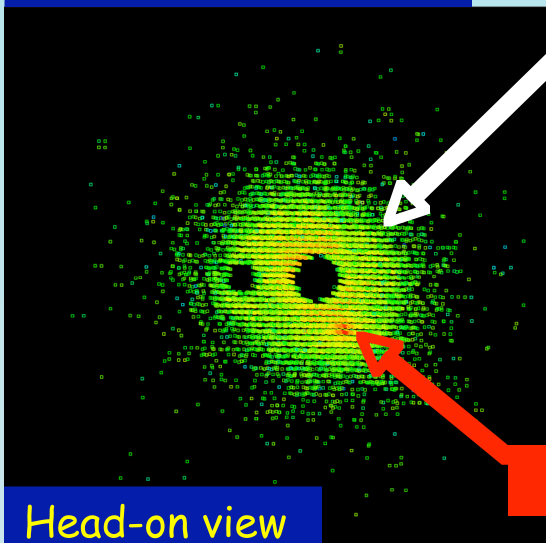
LowZ Absorber Studies



Varying LowZ absorber in front of BeamCal

BeamCal for 2γ Veto

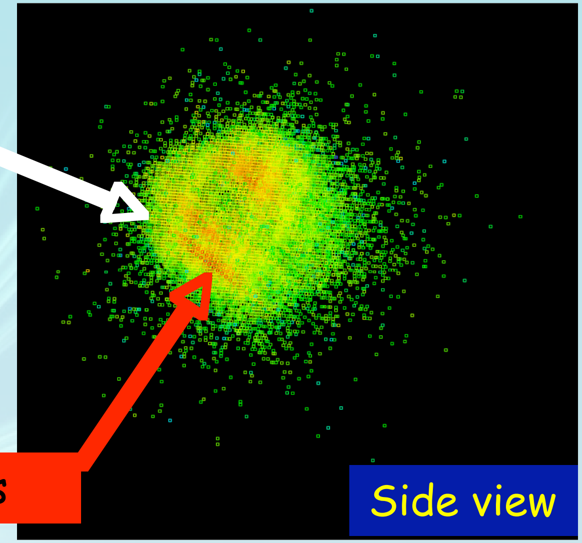
E.g. from UC Boulder



Head-on view

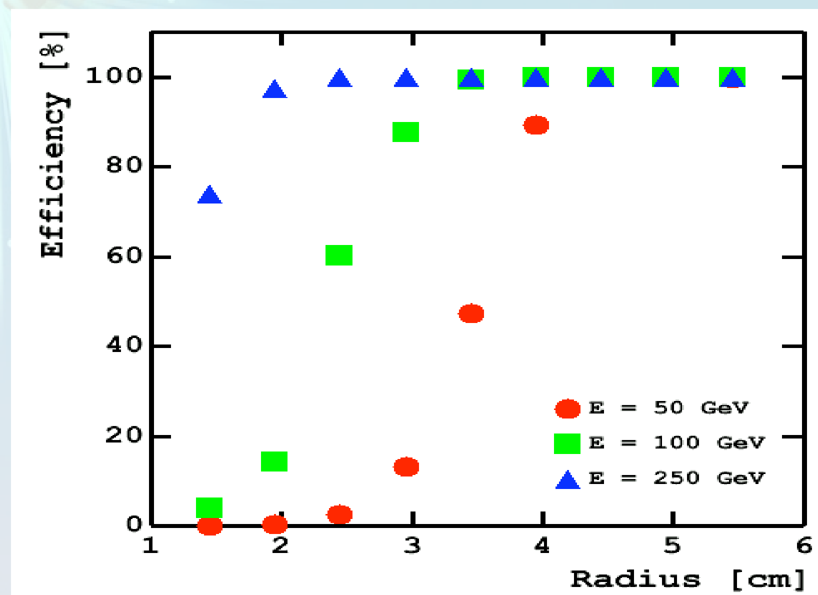
Beamstrahlung
TeV per BX

electron from 2γ process

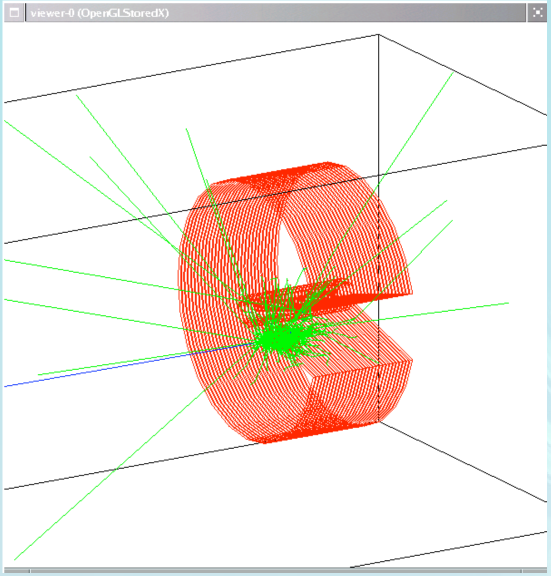


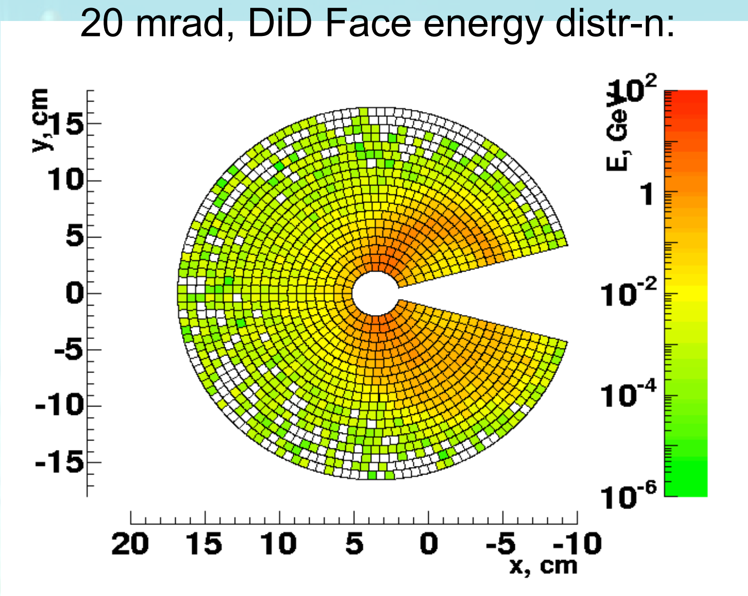
Side view

Efficient detection of high energy electrons is essential for search experiments



BeamCal as Beam Diagnostics Instrument





bp	unit	nom.	reconstructed			
			2mrad*	20mrad DiD	20mrad DiD + E_γ	14mrad antiDiD + E_γ
σ_z	μm	300	300.75 ± **4.56**	307.98 ± **4.72**	299.80 ± **1.69**	301.09 ± **1.65**
ε_x	10^{-6}m rad	10	11.99 ± **7.61**	— ± —	— ± —	9.94 ± **2.16**
Δx	nm	0	4.77 ± **14.24**	4.55 ± **8.14**	4.57 ± **8.13**	-3.84 ± **11.08**
α_v	rad	0	0.002 ± **0.016**	0.010 ± **0.025**	-0.001 ± **0.025**	-0.071 ± **0.017**

- Analysis of pairs energy distribution leads to beam parameter determination
- GammaCal (further downstream) helps with this

Summary

- LDC interaction region design is optimised with respect to
  - Background suppression
  - Low angle instrumentation
- Background suppression works well
- LumiCal: Precision luminosity measurement via Bhabha scattering
- BeamCal:
  - Hermeticity to low angles $\rightarrow 2\gamma$ veto
  - Beam parameter determination
- Detailed design depends on full detector simulations which are very time consuming
- Engineering solutions exist on conceptual level