ILD inner region

Mary-Cruz Fouz

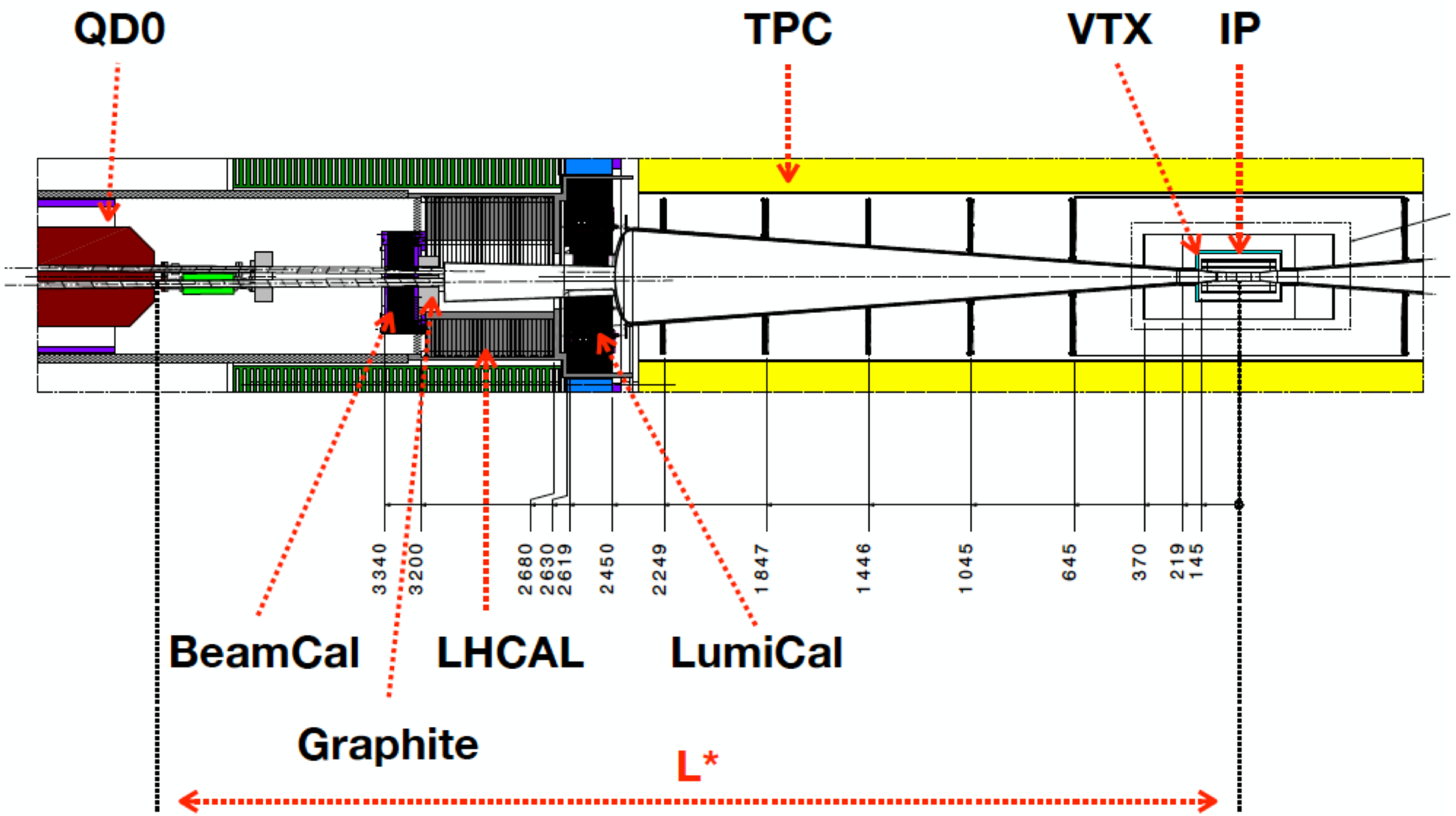
CIEMAT

17th Sep 2021. MDI-Phys - Layout of MDI region

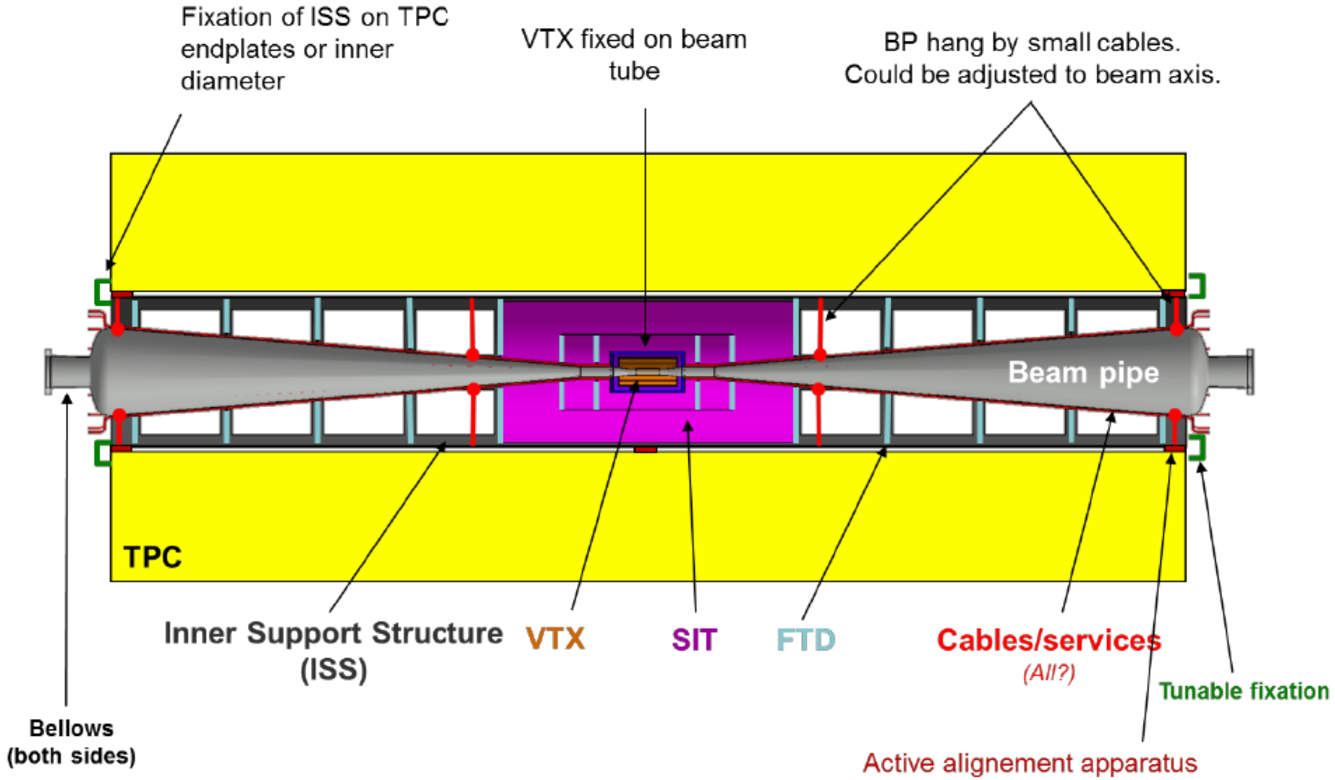
Layout of the ILD inner region

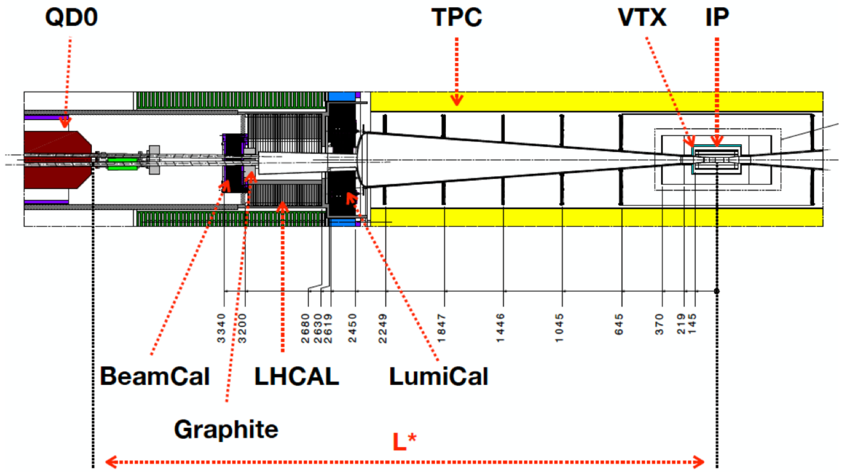
The central interaction region of ILD

- Beam pipe
- Surrounding Silicon detectors
- Forward Calorimeters
- Interface to QD0 magnets

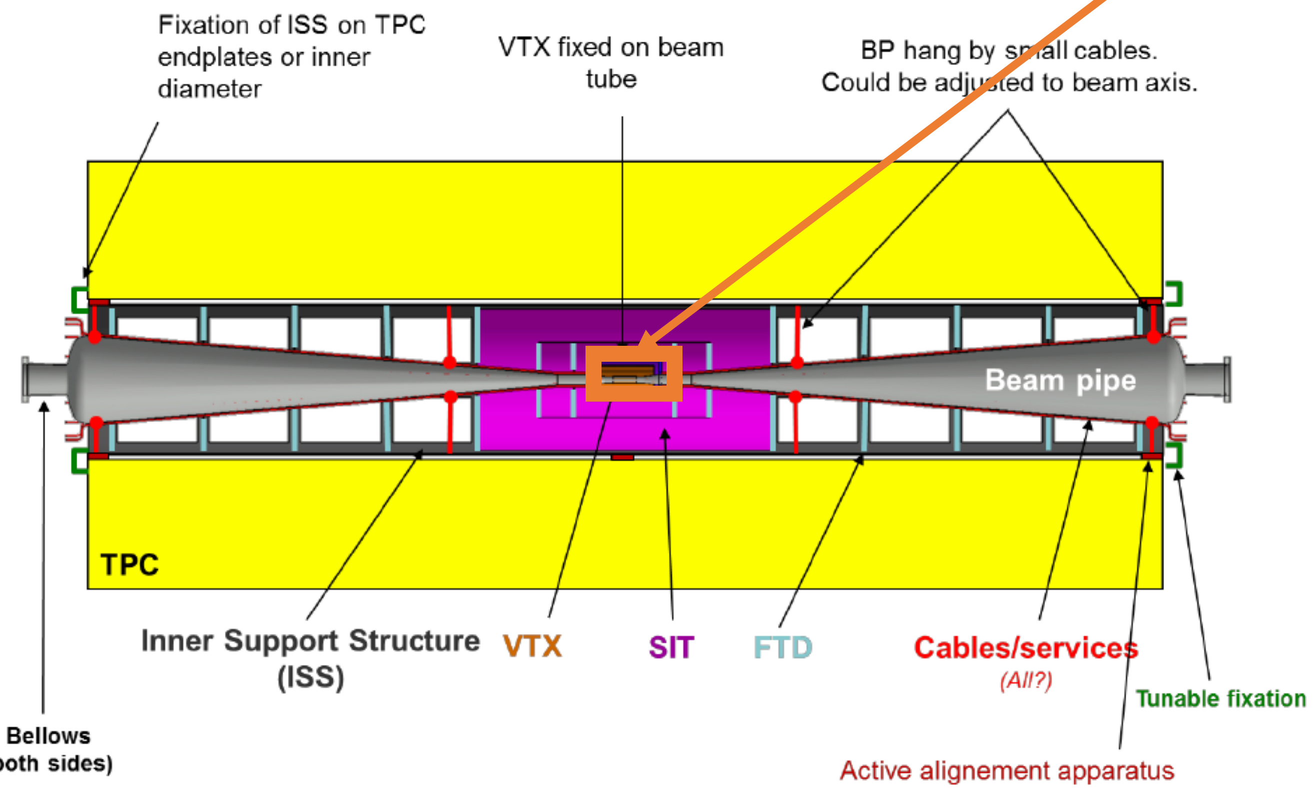


Inner tracking



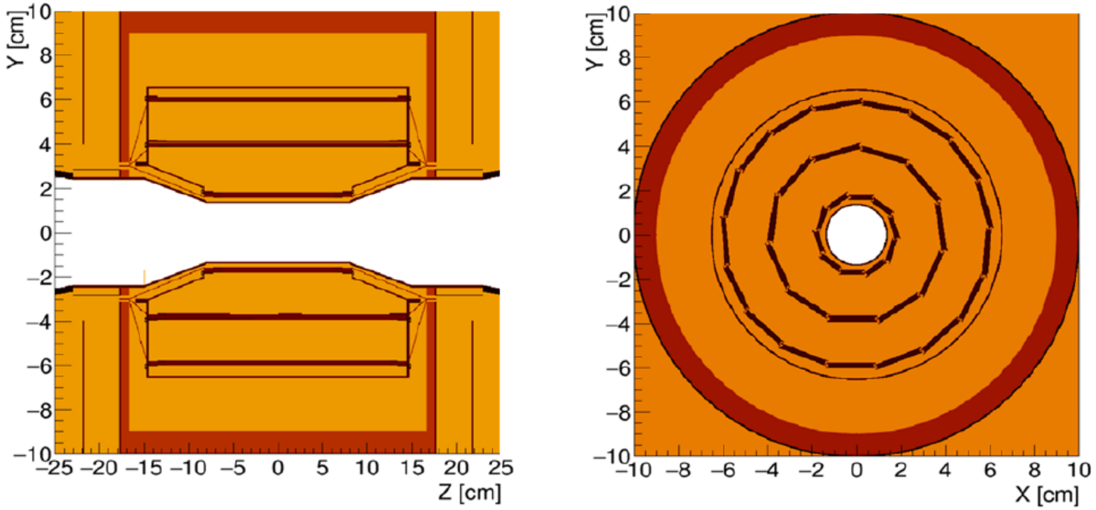


Inner tracking - Vertex



Vertex - VTX

Fixed to Beam Pipe

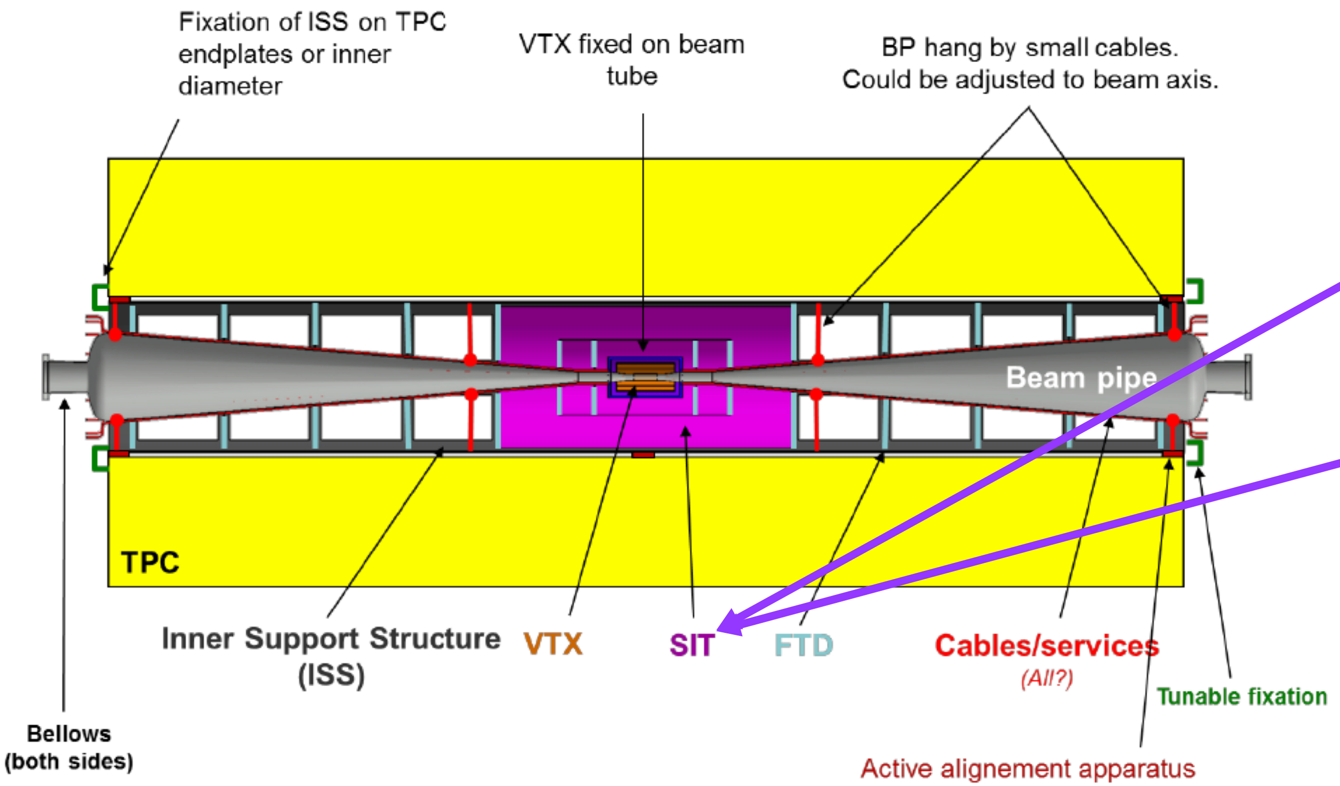


3 double layers of silicon pixel detectors

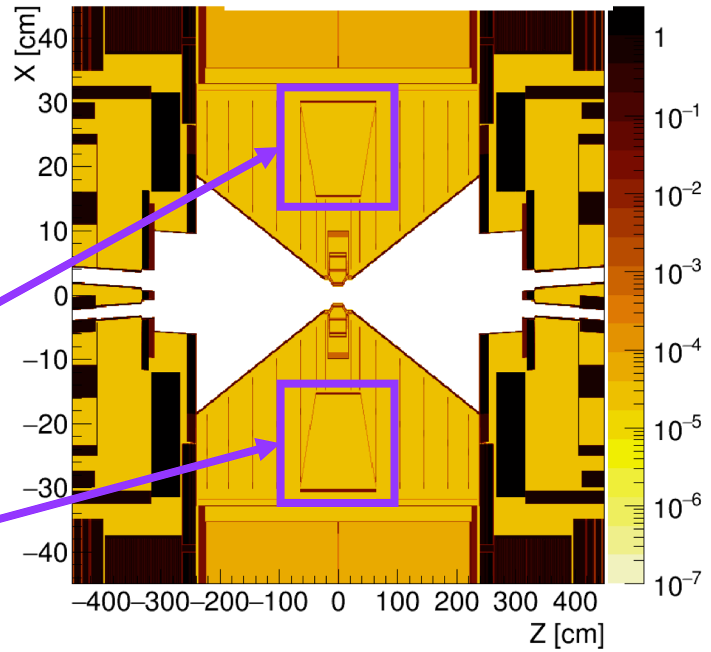
r_{in} = 16 mm
r_{out} = 60 mm
z_{max} = 125 mm

r_o = 16, 37, 58 mm
(layers 1-6)

Inner tracking – Silicon Inner Tracker



Silicon Inner Tracker - SIT

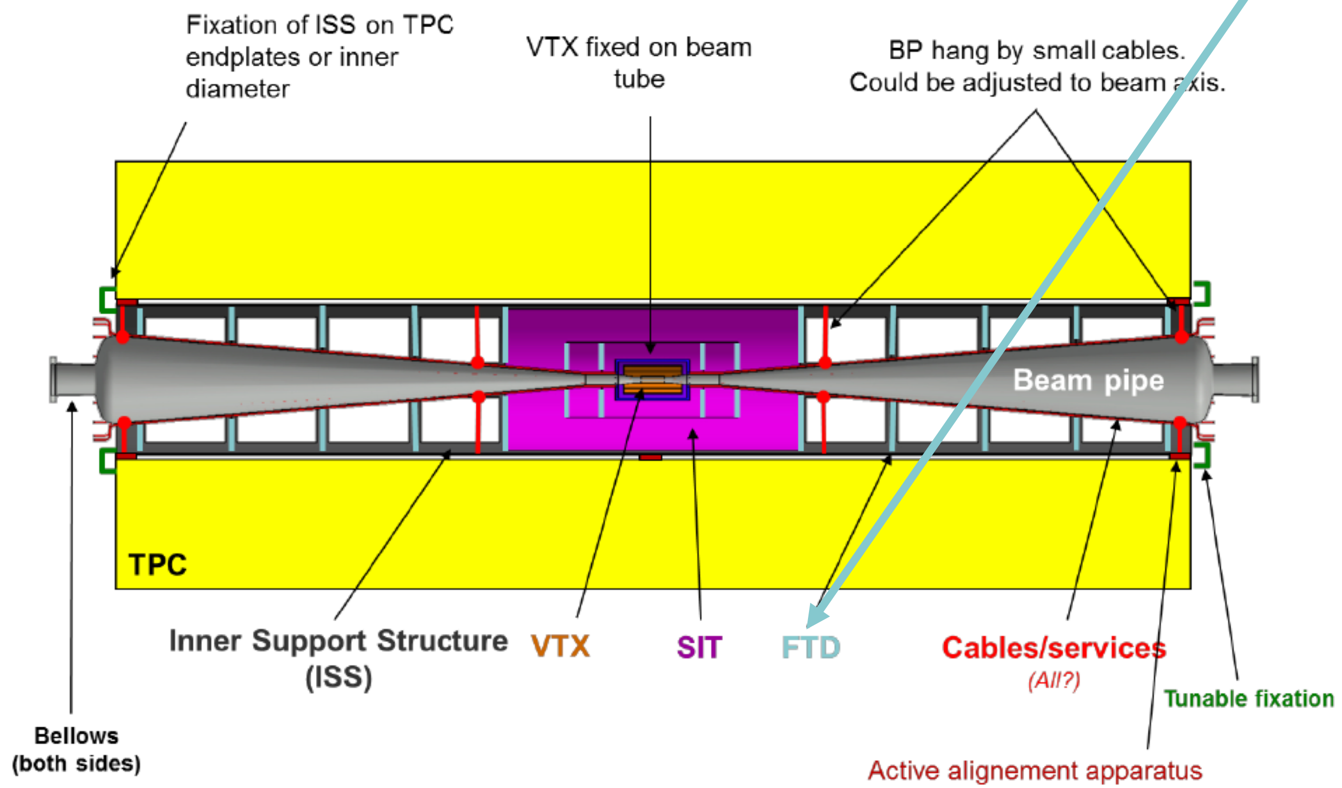


2 double layers of silicon detectors on barrel

r_{in} = 153 mm
r_{out} = 303 mm
z_{max} = 644 mm

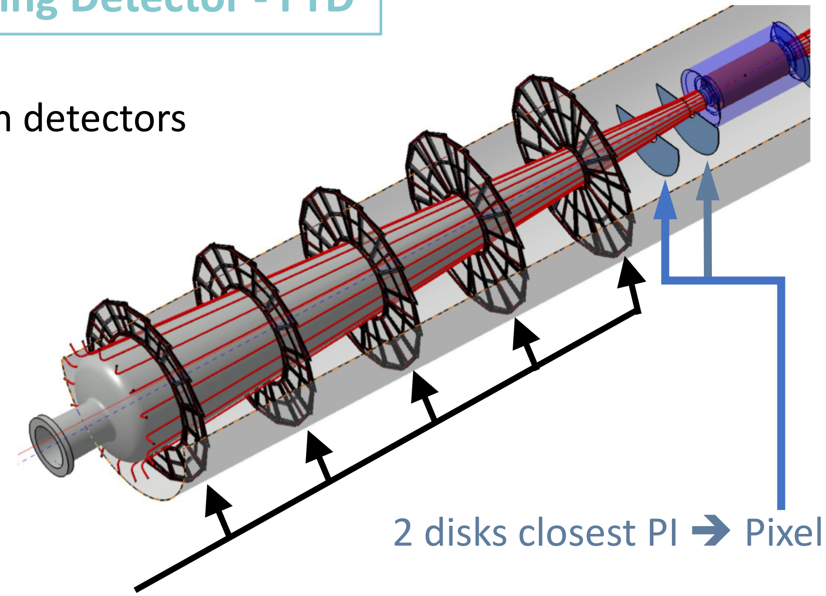
r_o = 155, 301 mm
(layers 1-4)

Inner tracking – Forward Tracking Detector



Forward Tracking Detector - FTD

7 Disks – Silicon detectors

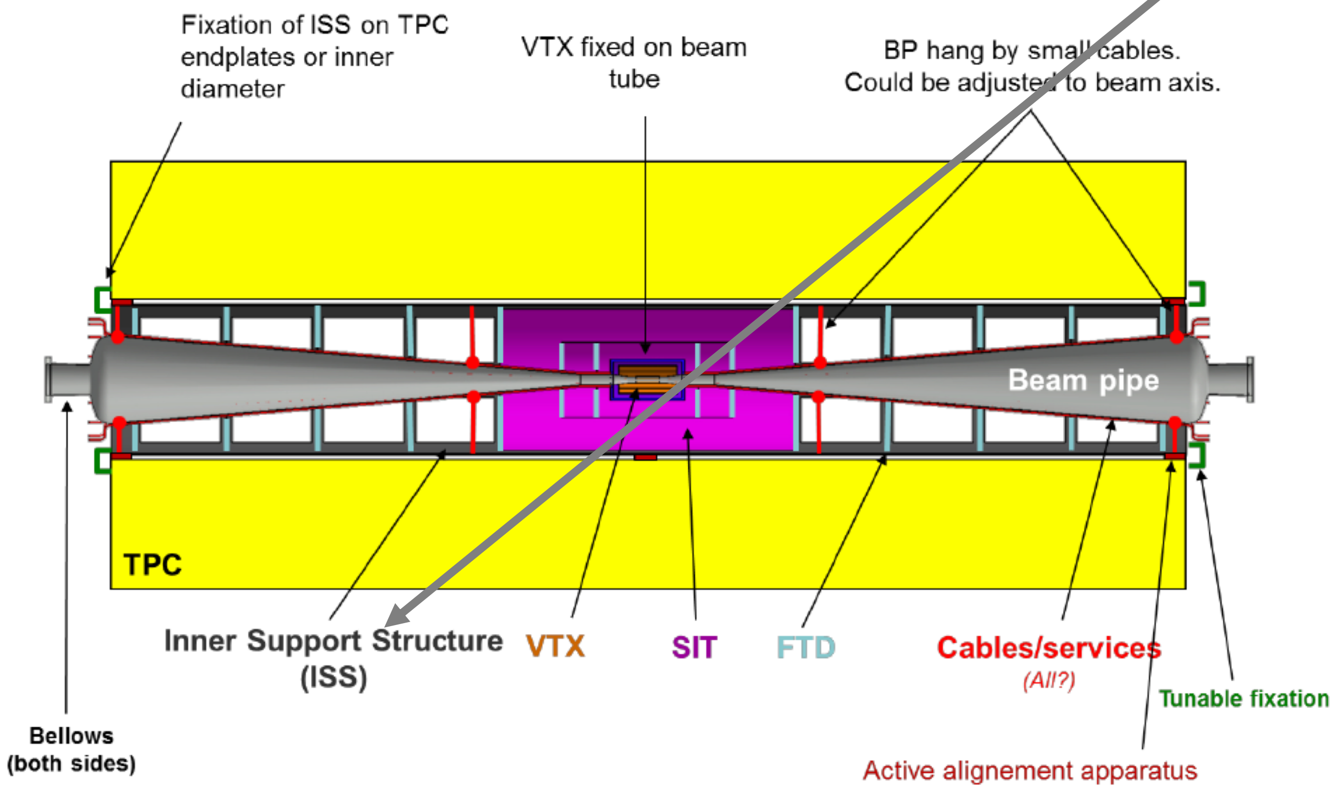


5 double disks ➔ microStrips

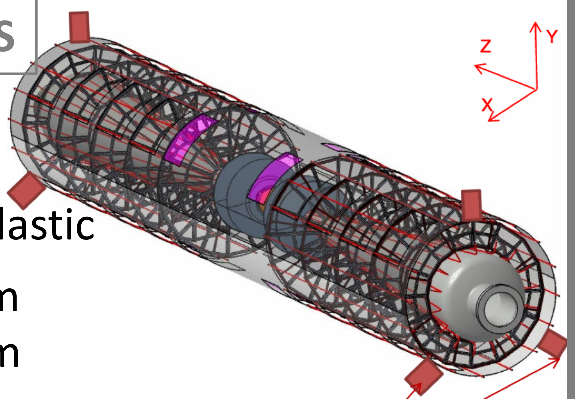
z_{min} = 645 mm
z_{max} = 2212 mm
r_{in} = 300 mm

z_{min} = 220 mm
z_{max} = 371 mm
r_{in} = 153 mm

Inner tracking – Inner Support Structure



Inner Support Structure - ISS



Support tube

Carbon-fiber reinforced plastic

Length: 4700 mm

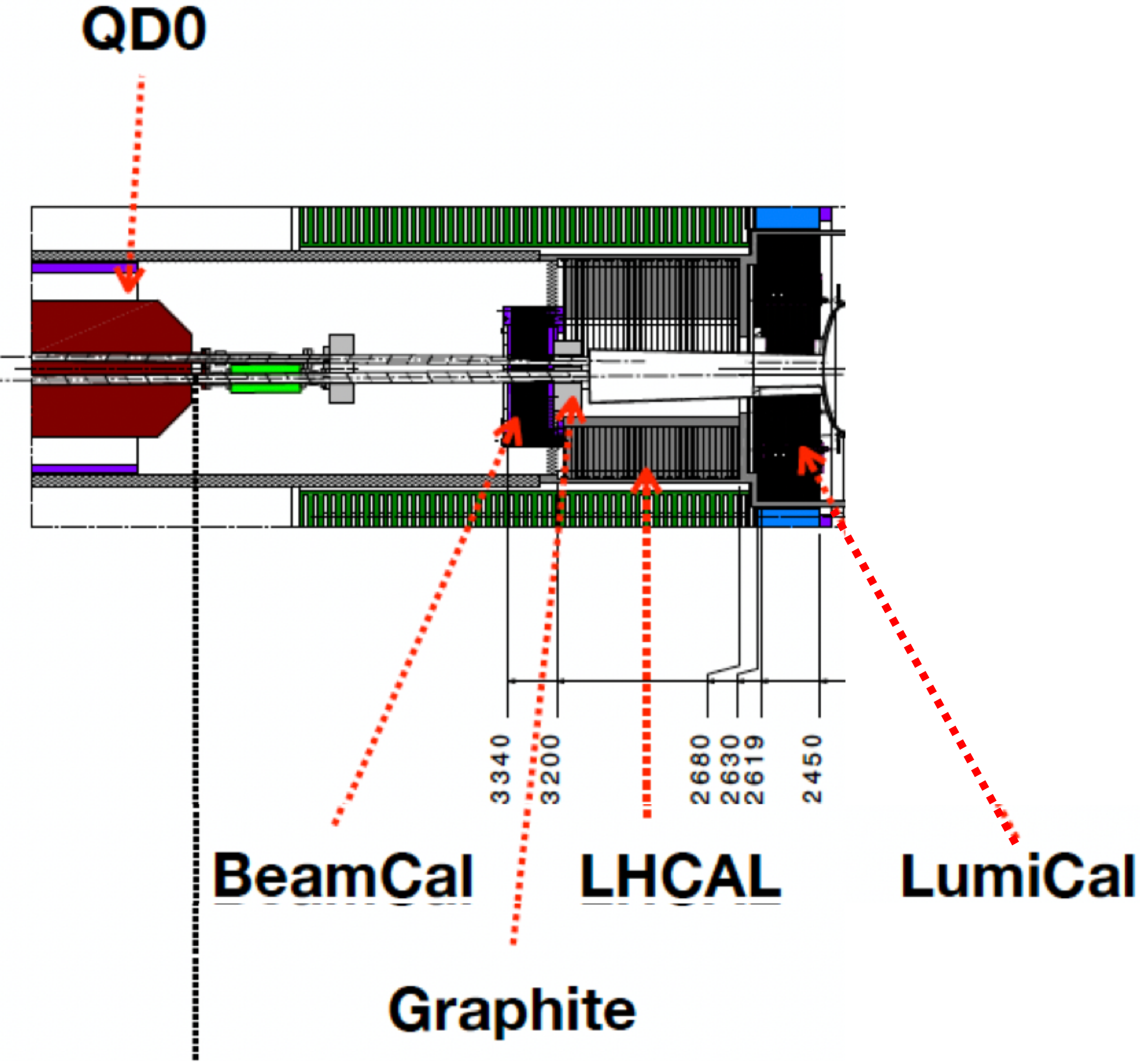
Outer diameter: 650 mm

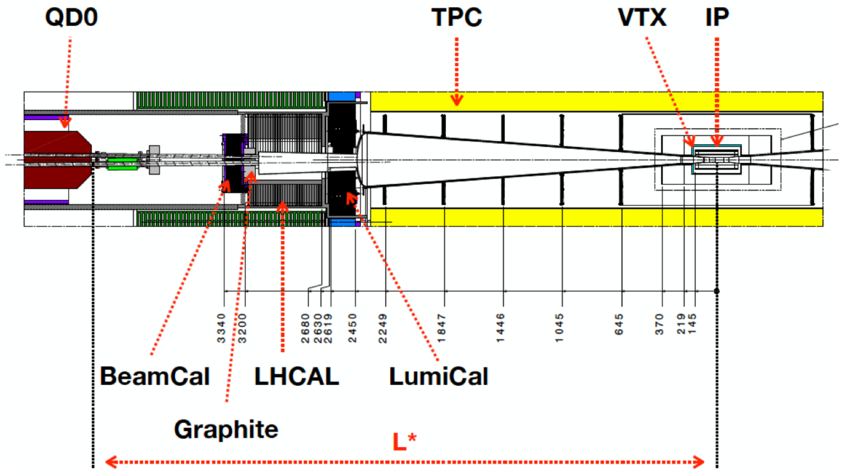
The tube is fixed to the end plates of the TPC

It includes a **piezo-base active alignment system** for its positioning independently of the main ILD structure (precision better than 0.01 mm)

This alignment is required to adjust the beam pipe and the inner tracking devices with respect to the beam axis, to better precision than what can be achieved with the complete ILD detector

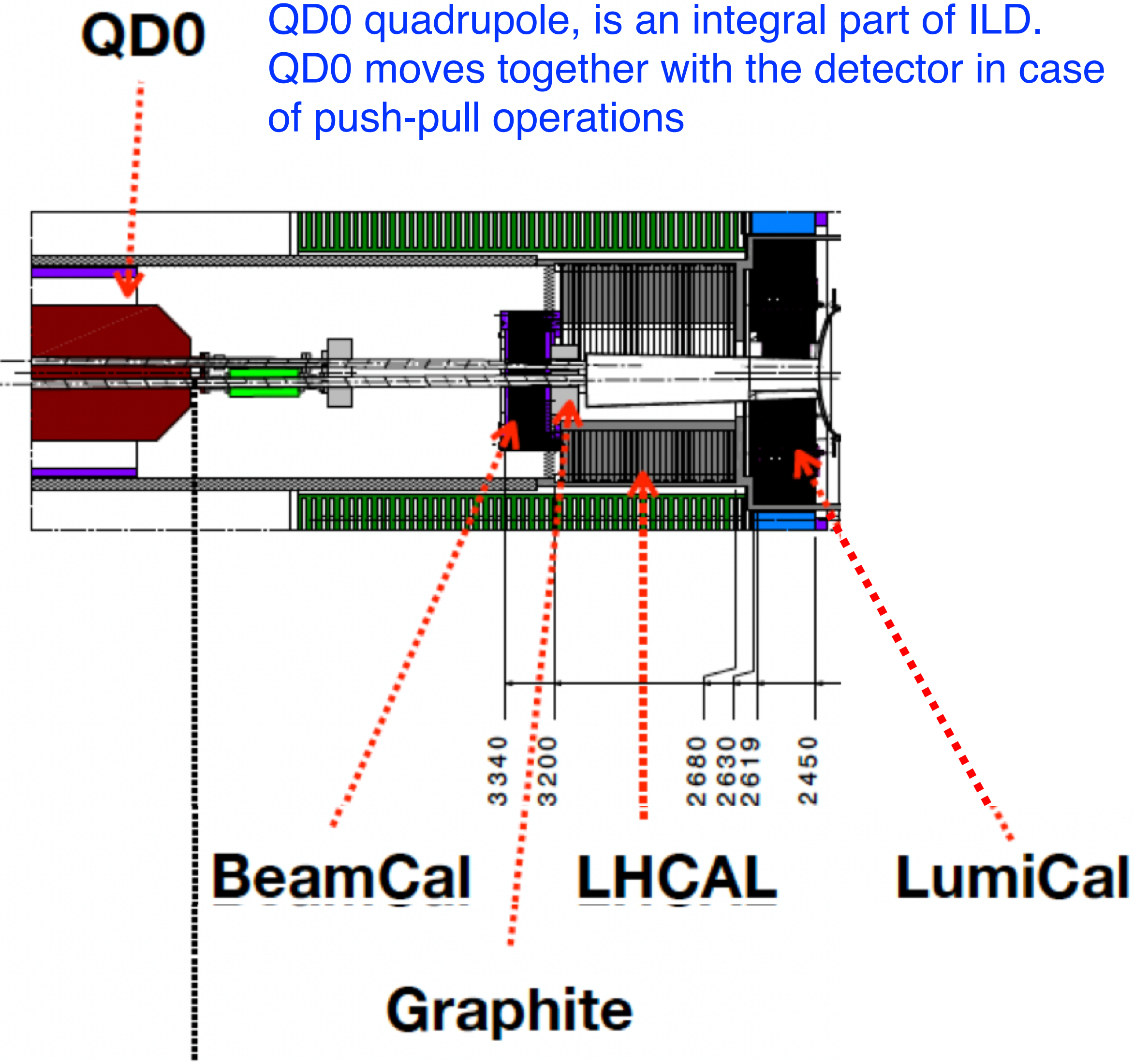
Forward Calorimeters & QD0



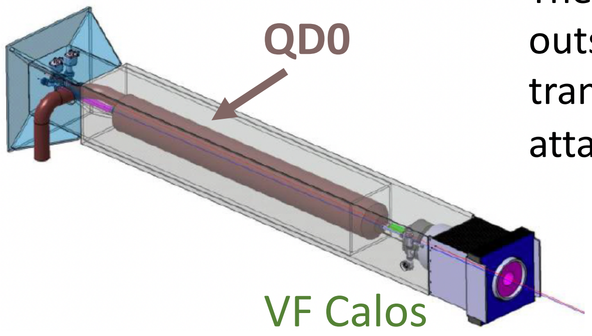


QD0 & support structure

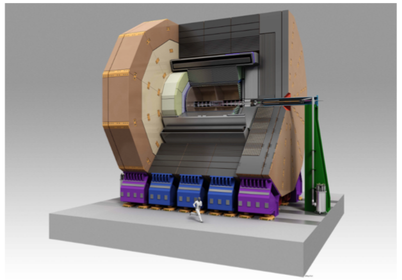
QD0 quadrupole, is an integral part of ILD. QD0 moves together with the detector in case of push-pull operations

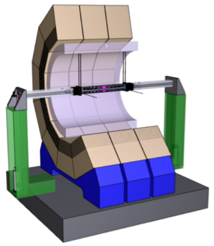


Stainless still support structure carrying the magnet and forward calorimeters



The structure is supported from a pillar outside of the detector standing on the transport platform and with tension rods attached to the coil cryostat

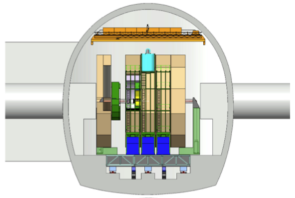




The platform will be aligned in a mm range to the beam axes

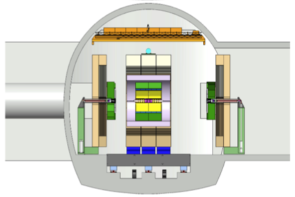
The alignment system of QD0 is under investigation

Requirements:
±50 μm , ± 20 μrad



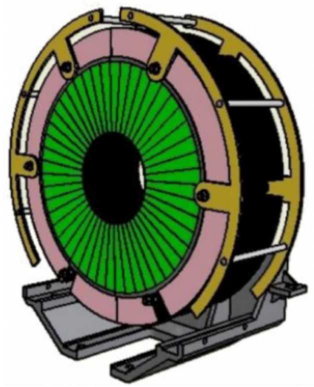
The design allows a limited opening of the endcaps in the beam position without breaking machining vacuum

ILD opened at beam line

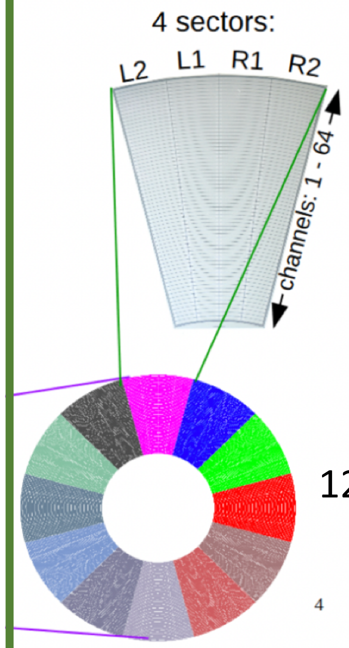


ILD opened in the maintenance position

LumiCal



Si-W sampling calorimeter
30 layers (1 X0 each)
42-67 mrad

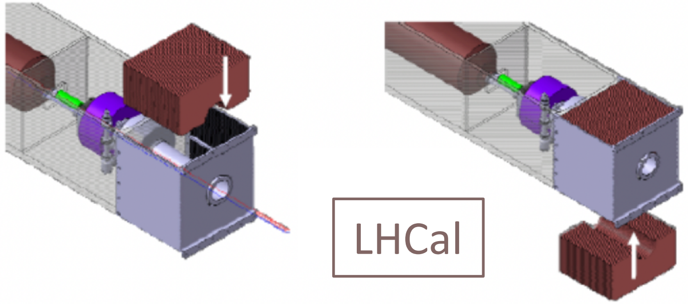


4 azimuthal sectors per tile (each 7.5°)

12 tiles

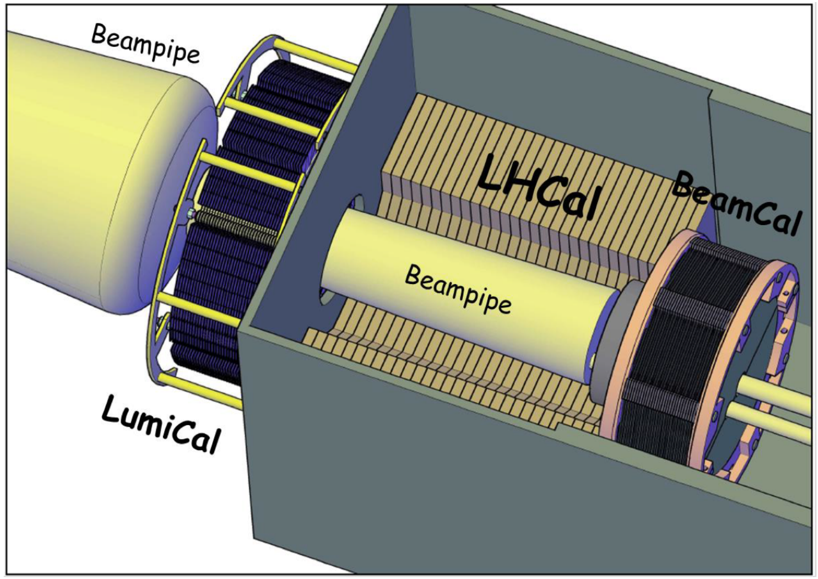
z_{min}	=	2412 mm
z_{max}	=	2541 mm
r_{in}	=	84 mm
r_{out}	=	194 mm

LHCal



z_{min}	=	2680 mm
z_{max}	=	3160 mm

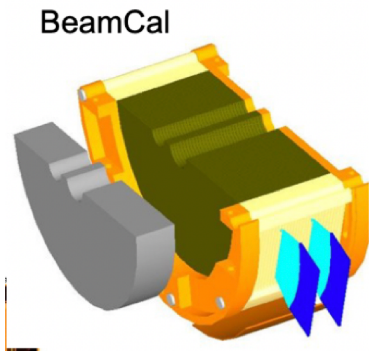
r_{in}	=	130 mm
r_{out}	=	315 mm

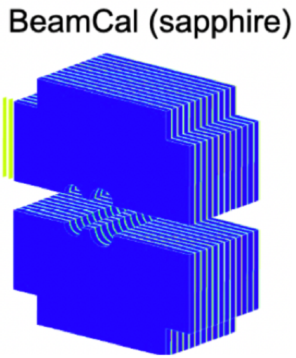


BeamCal

?-W sampling calorimeter
Candidates:
Sapphire, CVD diamond, GaAs

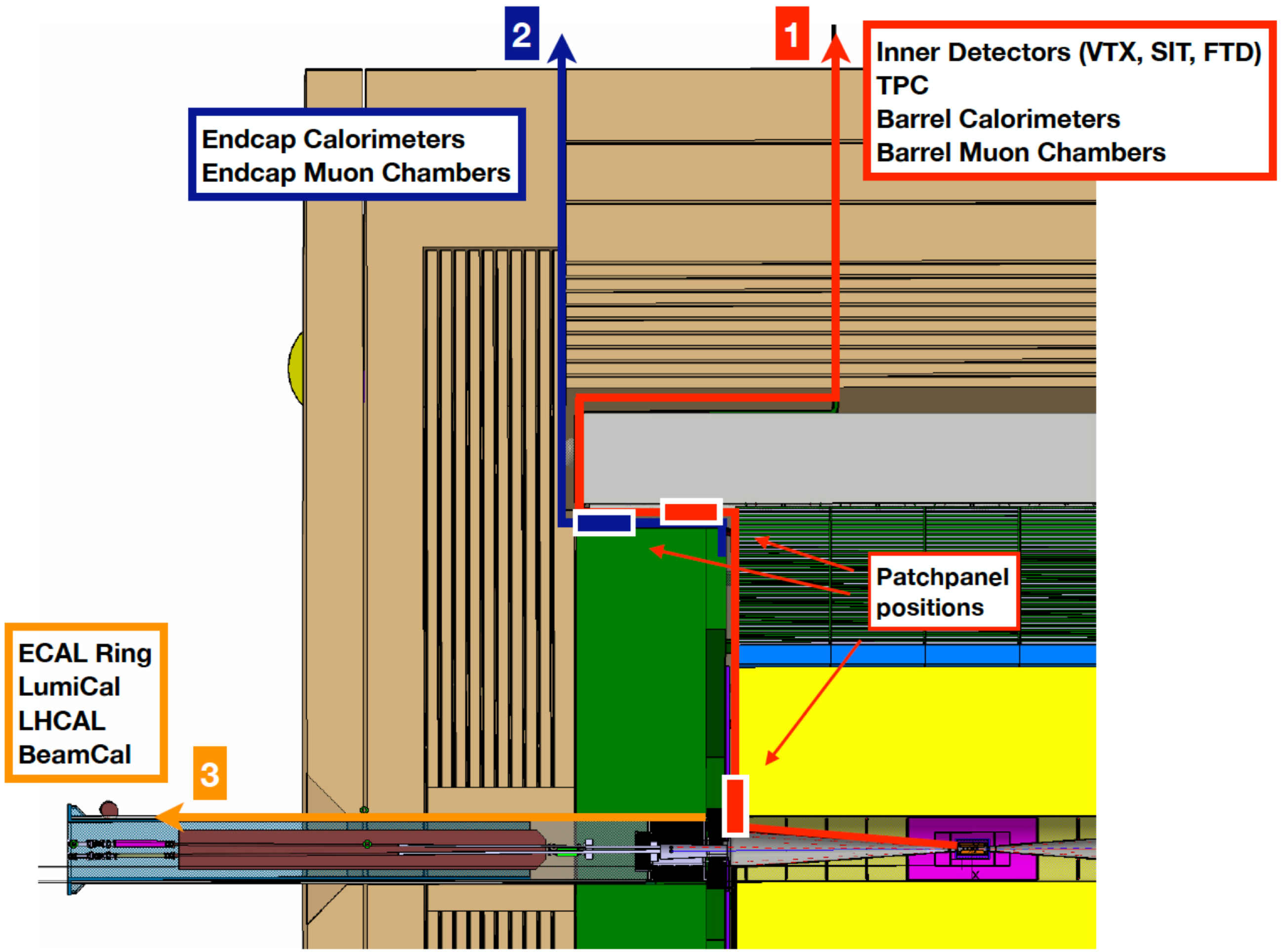
30 layers (1 X0 each)
5-45 mrad

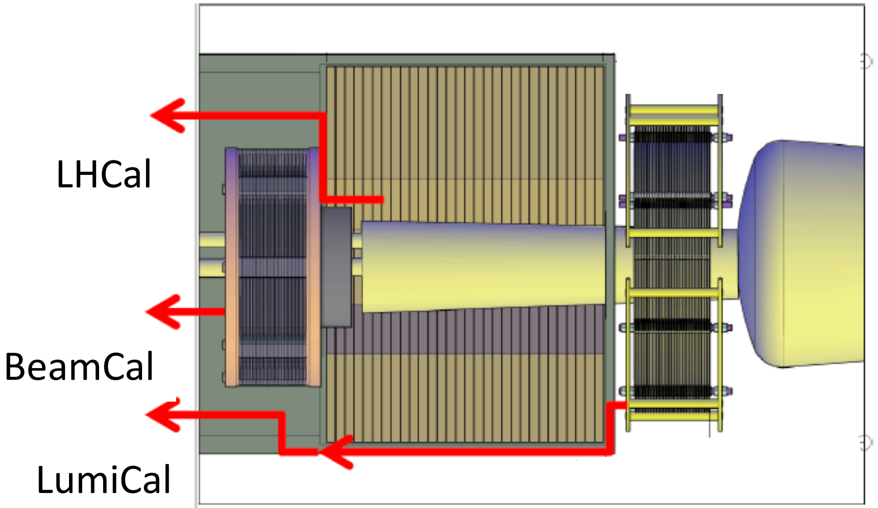


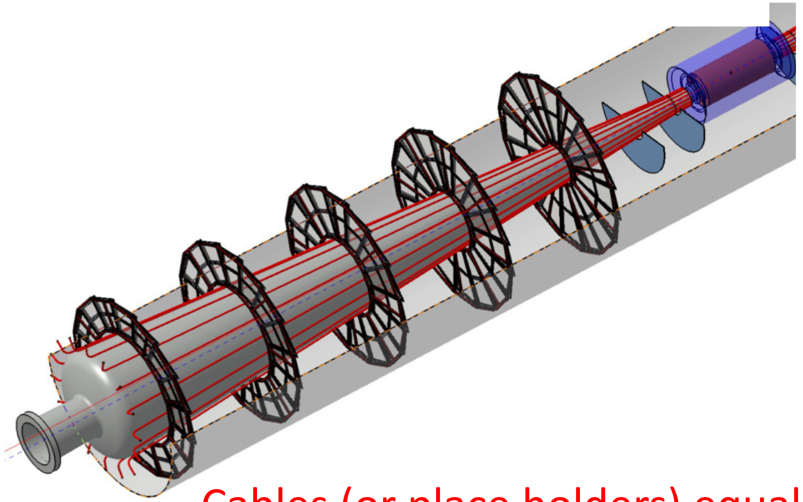


z_{min}	=	3115 mm
z_{max}	=	3315 mm
r_{in}	=	18 mm
r_{out}	=	140 mm

Cabling and cooling pipes



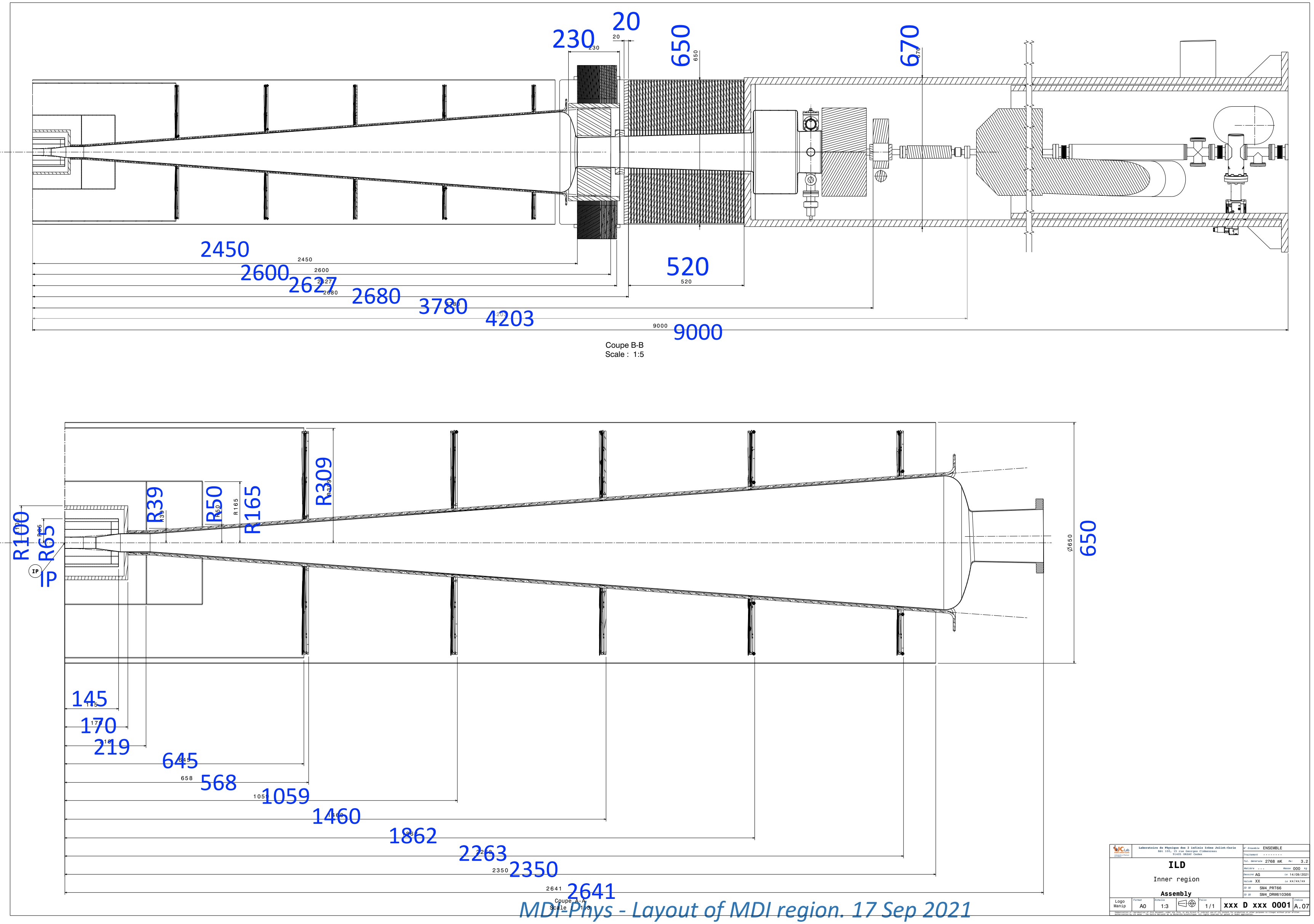




Cables (or place holders) equally distributed around beam pipe

ILD CAD Model

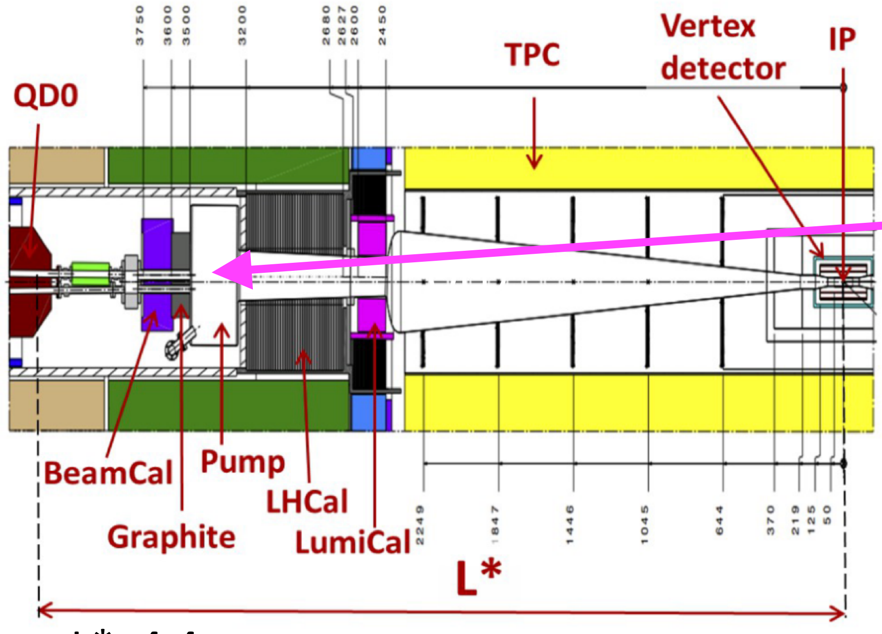
ILC-EDMS



Differences in layout with previous version

Change Request
L*=4.1m
+ additional 10cm for BPM on incoming beam

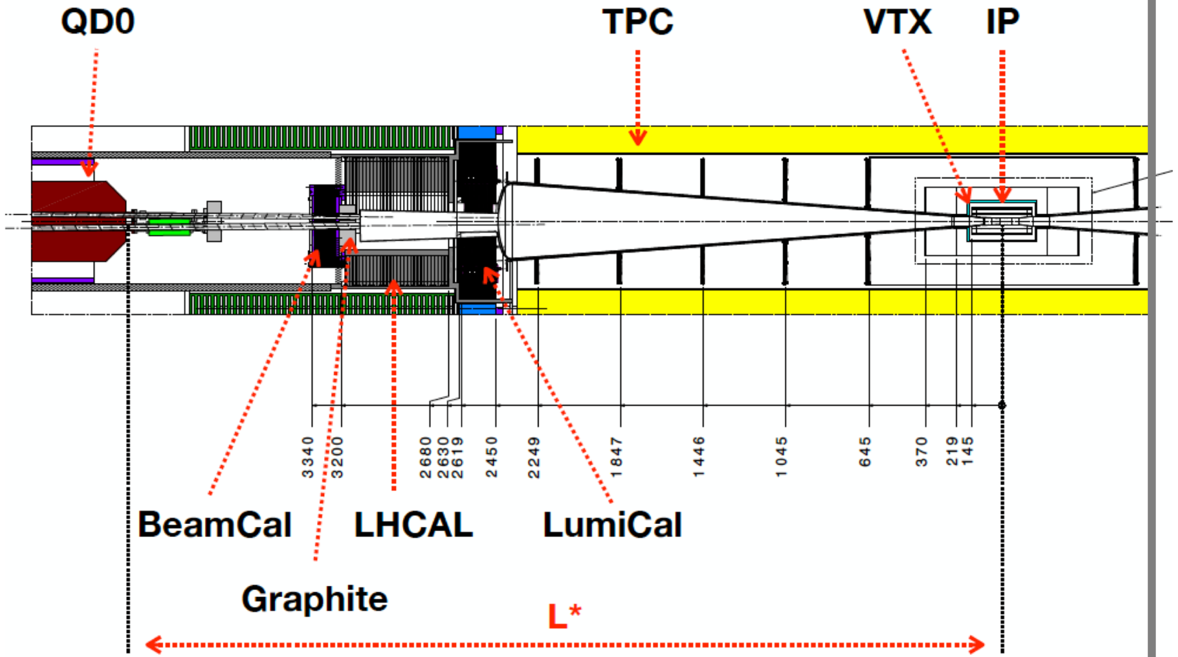
OLD Design



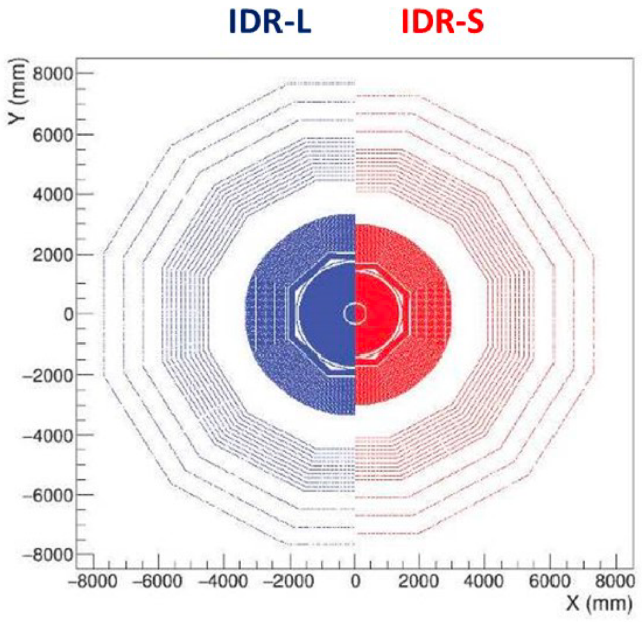
L*=4.4m

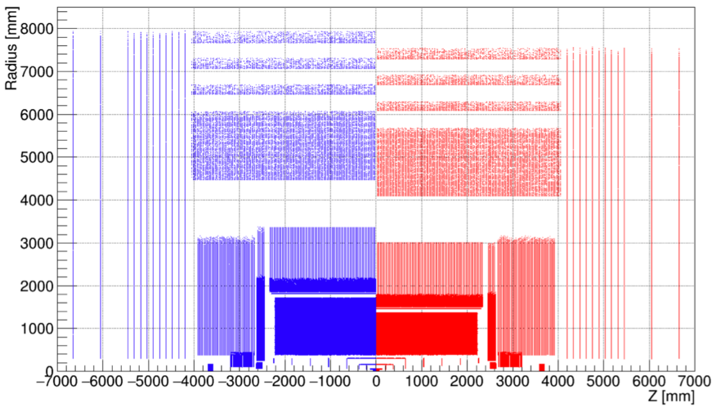
NEW Design

L*=4.1m
Removal of vacuum pump



Simulation model





Detector	IDR-L	IDR-S
B-field	3.5 T	4 T
VTX inner radius	1.6 cm	1.6 cm
TPC inner radius	33 cm	33 cm
TPC outer radius	177 cm	143 cm
TPC length (z/2)	235 cm	235 cm
ECAL inner radius	180 cm	146 cm
ECAL outer radius	203 cm	169 cm
HCAL inner radius	206 cm	172 cm
HCAL outer radius	334 cm	300 cm
Coil inner radius	342 cm	308 cm

ILD_l5_v02 (large), ILD_s5_v02 (small) implemented using DD4hep

Main difference of Small vs Large

reduced radii of the TPC, the barrels of ECAL, HCAL, Yoke and Coil

B-field 4T (instead 3.5T)

No decision taken on which chose

Detailed Bfield map created for each model with and without anti-DID

Impact of vacuum pump removal?

WITH Vacuum pump ➔ 7 nTorr
WITHOUT Vacuum pump ➔ 150 nTorr

Simulations performed

ILD-TECH-PUB-2017-001
12 June 2017

Electromagnetic rate
~every 3 bunches
(~1 photos * 0.05 e created)
Hadronic rate <1 every 100 trains
(~3.3 hadrons created)

In average effect is negligible since the Pair Background is much bigger
But
Individual events in some cases can produce large number of hits

hits expected per bunch

	nTorr	Tracker	Forward Calorimeters	Backward Calorimeters
Total	7	$(600 \pm 5) \cdot 10^{-3}$	$(380 \pm 3) \cdot 10^{-3}$	$(88 \pm 1) \cdot 10^{-4}$
	150	13 ± 0.1	$(800 \pm 5) \cdot 10^{-2}$	$(190 \pm 2) \cdot 10^{-3}$
Pair background		$(4.3 \pm 0.4) \cdot 10^{3}$	$\mathcal{O}(10^4 - 10^5)$	

Mainly due to photons

	Beam-Gas Background		Pair Induced Background
Subdetector	hits/BX [7nTorr]	hits/BX [150nTorr]	hits/BX
VTX	$(390 \pm 6) \cdot 10^{-4}$	0.83 ± 0.01	$(3.2 \pm 0.2) \cdot 10^{3}$
FTD	$(96 \pm 1) \cdot 10^{-3}$	2 ± 0.02	690 ± 40
TPC	$(450 \pm 5) \cdot 10^{-3}$	9.7 ± 0.1	470 ± 400
SIT	$(160 \pm 2) \cdot 10^{-4}$	$(350 \pm 4) \cdot 10^{-3}$	11 ± 9
SET	$(120 \pm 2) \cdot 10^{-6}$	$(250 \pm 3) \cdot 10^{-5}$	1.3 ± 4
BeamCalFront	$(650 \pm 7) \cdot 10^{-4}$	1.4 ± 0.01	$\mathcal{O}(10^4 - 10^5)$

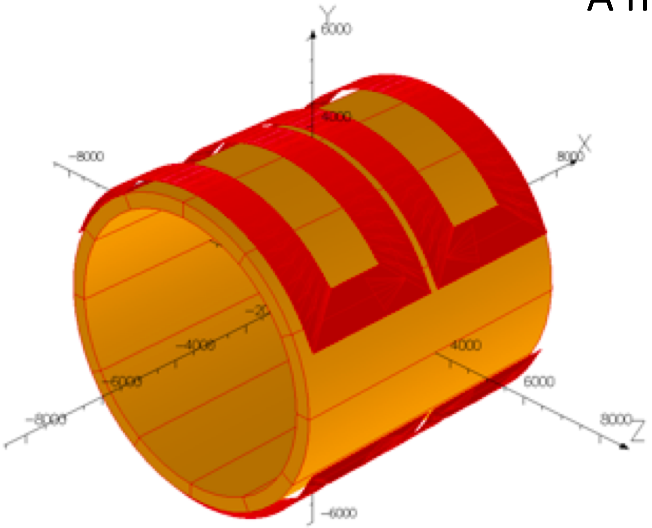
Anti-DID

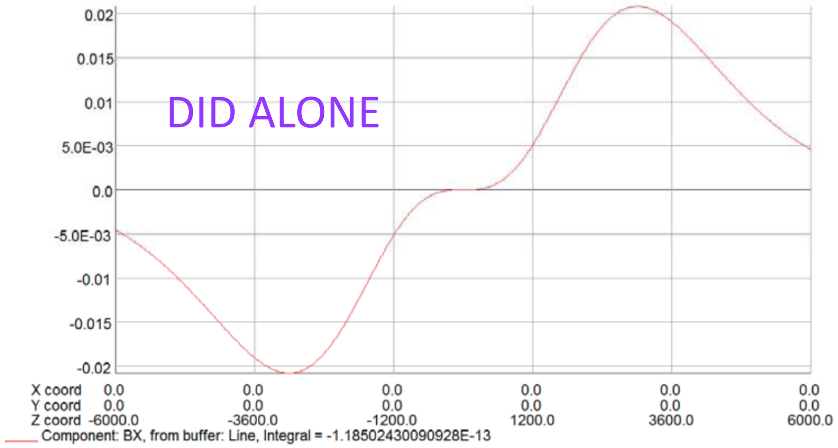
Proposed Anti-DID (2 dipoles centered on the beam axis with magnetic field parallel to outgoing beam)

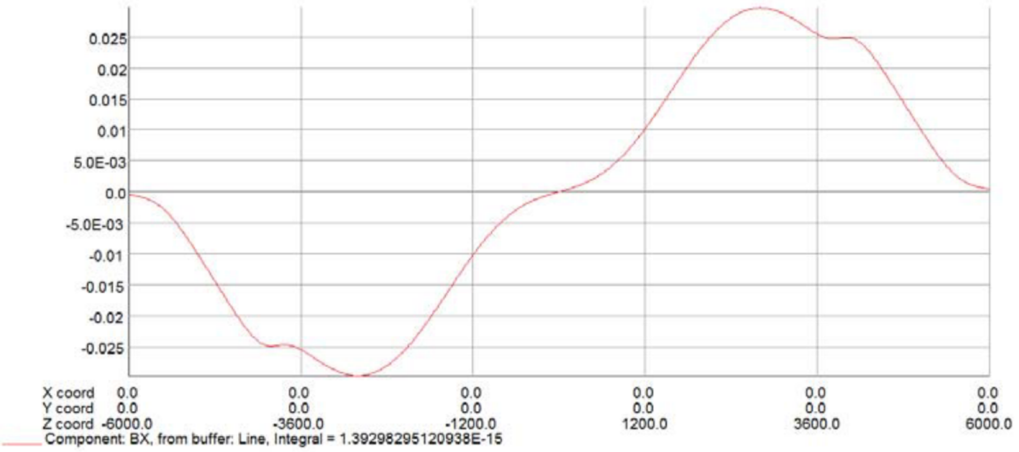
➔ Must reduce background guiding particles towards outgoing pipe

LC-DET-2012-081

A new design (version 2) implemented since DBD

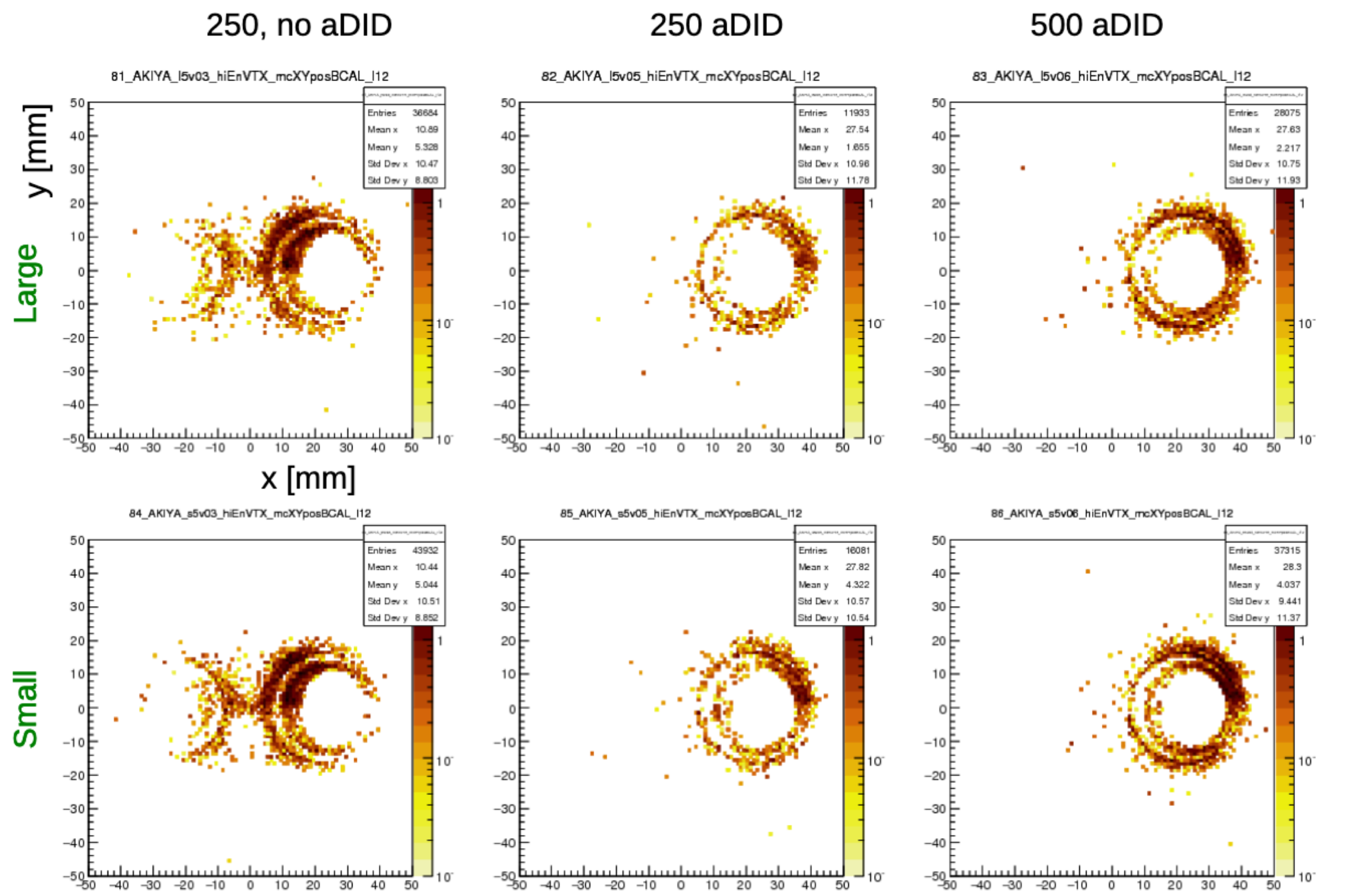


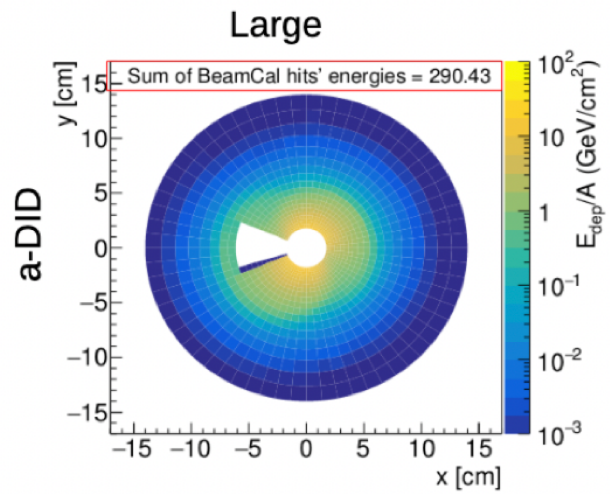




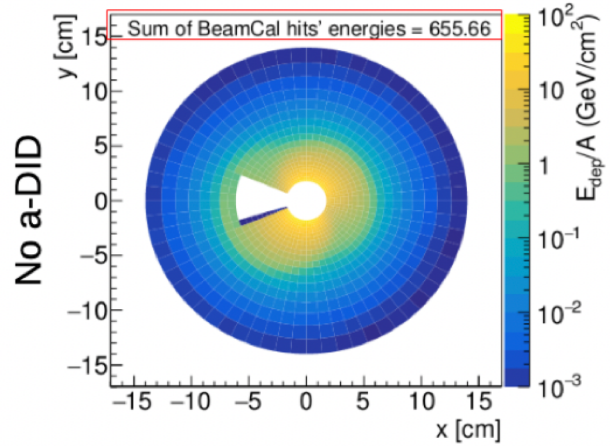
Effects of implementing a anti-DID – forward calorimeter region

Production vertex [in the +z BeamCal region] of particles producing hits in VDX L1,2





Factor 2 reduction



Effects of implementing a anti-DID –tracker region

LAYER:	hits/BX No anti-DID mean ± RMS	hits/BX anti-DID mean ± RMS	$hits/BX/cm^2$ anti-DID mean ± RMS
VXD 1:	1400 ± 780	910 ± 360	6.6 ± 2.6
VXD 2:	970 ± 560	540 ± 210	4.0 ± 1.5
VXD 3:	150 ± 80	130 ± 60	0.21 ± 0.10
VXD 4:	110 ± 60	110 ± 50	0.18 ± 0.09
VXD 5:	44 ± 30	40 ± 26	0.04 ± 0.03
VXD 6:	39 ± 27	34 ± 24	0.04 ± 0.03
FTD 1:	42 ± 30	38 ± 26	0.043 ± 0.030
FTD 2:	27 ± 19	24 ± 15	0.029 ± 0.019
FTD 3:	62 ± 45	40 ± 27	0.014 ± 0.010
FTD 4:	42 ± 33	25 ± 17	0.009 ± 0.007
FTD 5:	29 ± 23	18 ± 13	0.007 ± 0.005
FTD 6:	16 ± 13	9 ± 7	0.004 ± 0.003
FTD 7:	10 ± 8	6 ± 5	0.003 ± 0.003
SIT 1:	51 ± 37	24 ± 16	0.0032 ± 0.0023
SIT 2:	49 ± 36	21 ± 12	0.0029 ± 0.0017
SIT 3:	77 ± 56	34 ± 24	0.0014 ± 0.0010
SIT 4:	71 ± 54	31 ± 21	0.0013 ± 0.0009
SET 1:	39 ± 28	15 ± 10	0.00003 ± 0.00002
SET 2:	46 ± 36	18 ± 12	0.00003 ± 0.00002

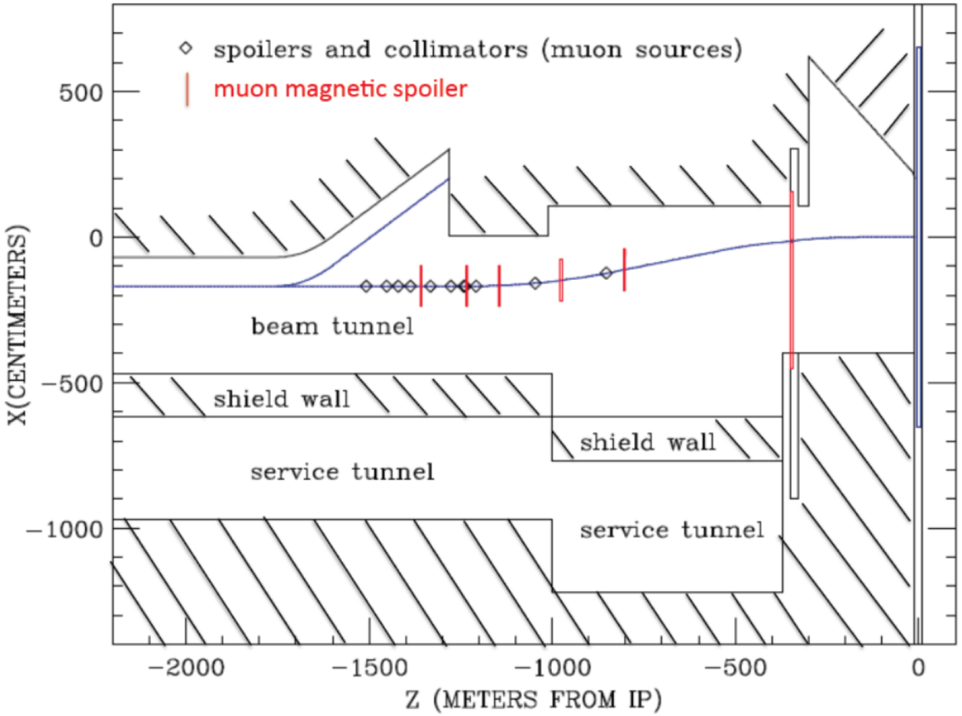
Beamstrahlung hits per BX (ILC250)

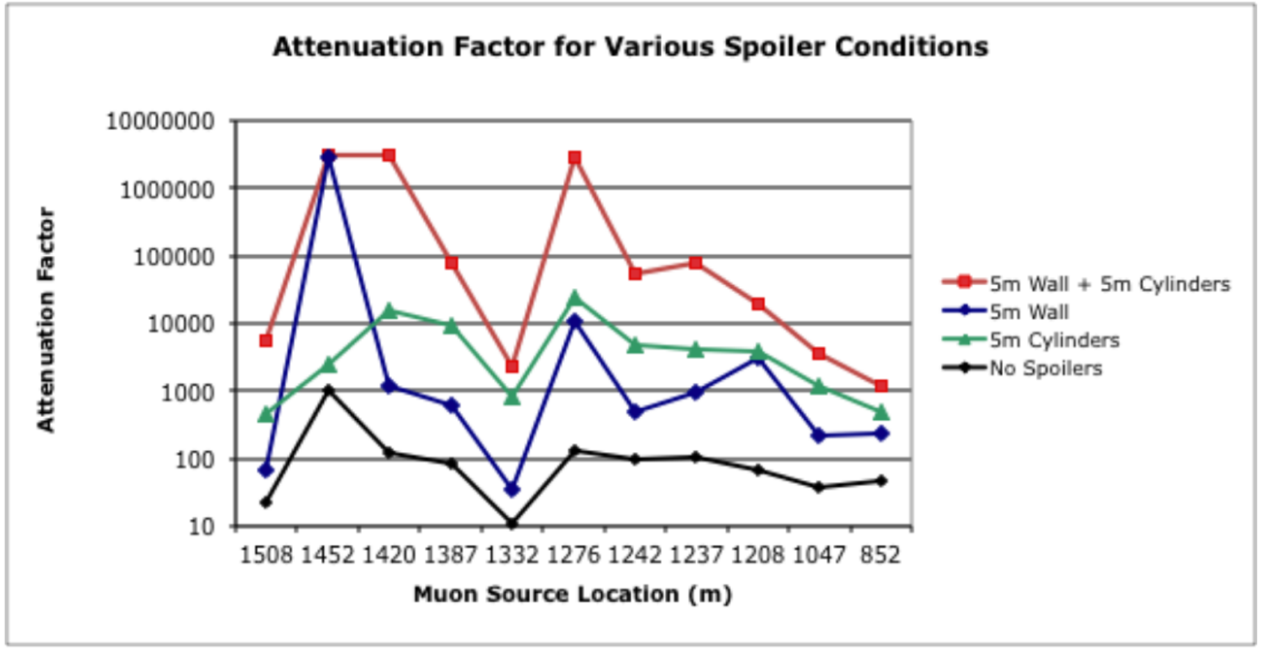
Most hits in the inner vertex layers
The anti-DID reduces the total number of hits by ~35%

Factor 2 reduction, but there are few hits

For the small ILD version the overall hit rates reduced ~10% thanks to better confinement within beampipe due to higher Bfield

Halo muons – Beam halo magnetized spoilers and magnetized Wall





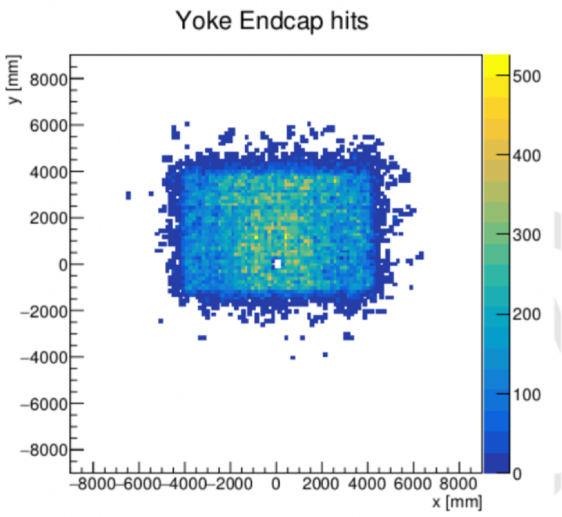
arXiv:1901.06449
SLAC-PUB-17363
January 2019

Simulation of Muon Background at the ILC*

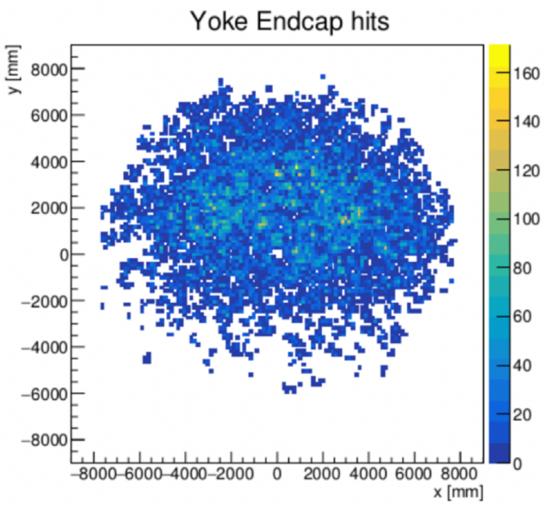
L. Keller and G. White
SLAC National Accelerator Laboratory, 2575 Sand Hill Road, Menlo Park, CA 94025

Effects of Beam Halo spoilers in ILD

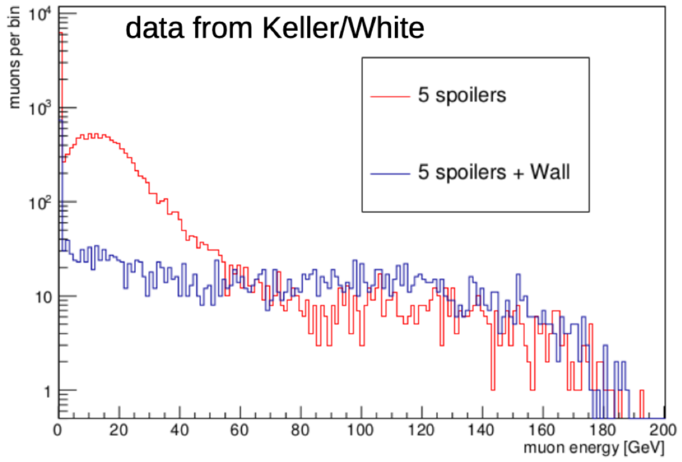
Using previous muon mometa distributions and simulating them for ILD



5 toroidal spoilers



5 toroidal spoilers + “wall”



2625 bunches of ILC-500,
assuming 0.1% of beam interacts in BDS
→ likely very pessimistic

Keller/White

muons per bunch crossing
a 6.5m radius disk at IP ~ detector:

no spoilers	130
5 “donut” spoilers	4.3
+ muon wall	0.6

Final remarks

There are not really final optimization of detectors
Not a detailed description of the cabling, cooling pipes, etc (not even available in many cases)

More studies needed

Main issue→ Manpower