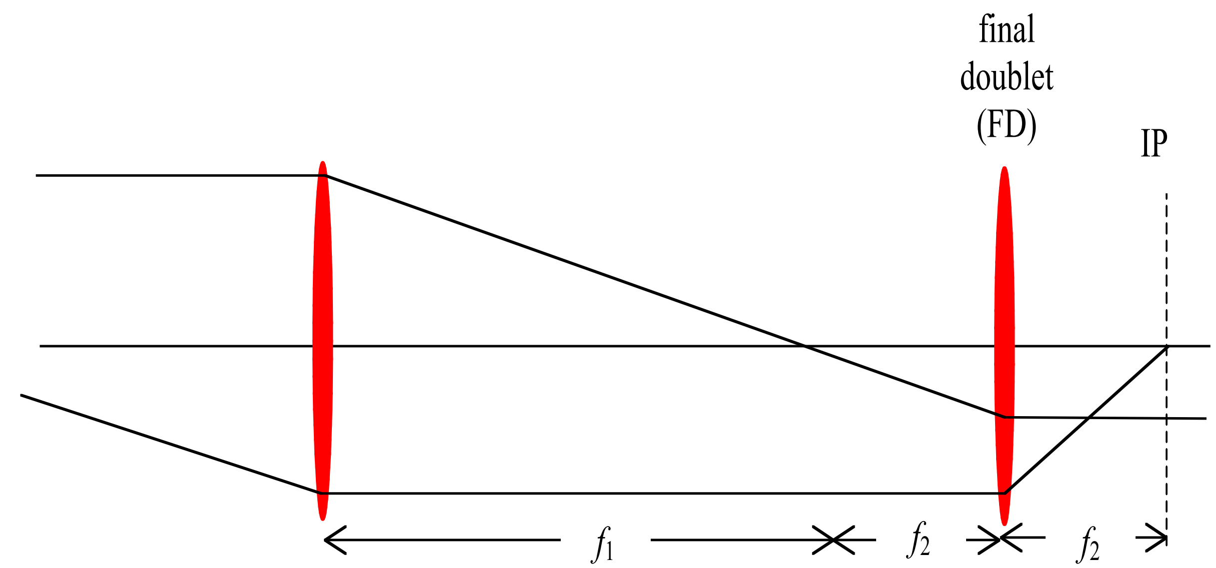
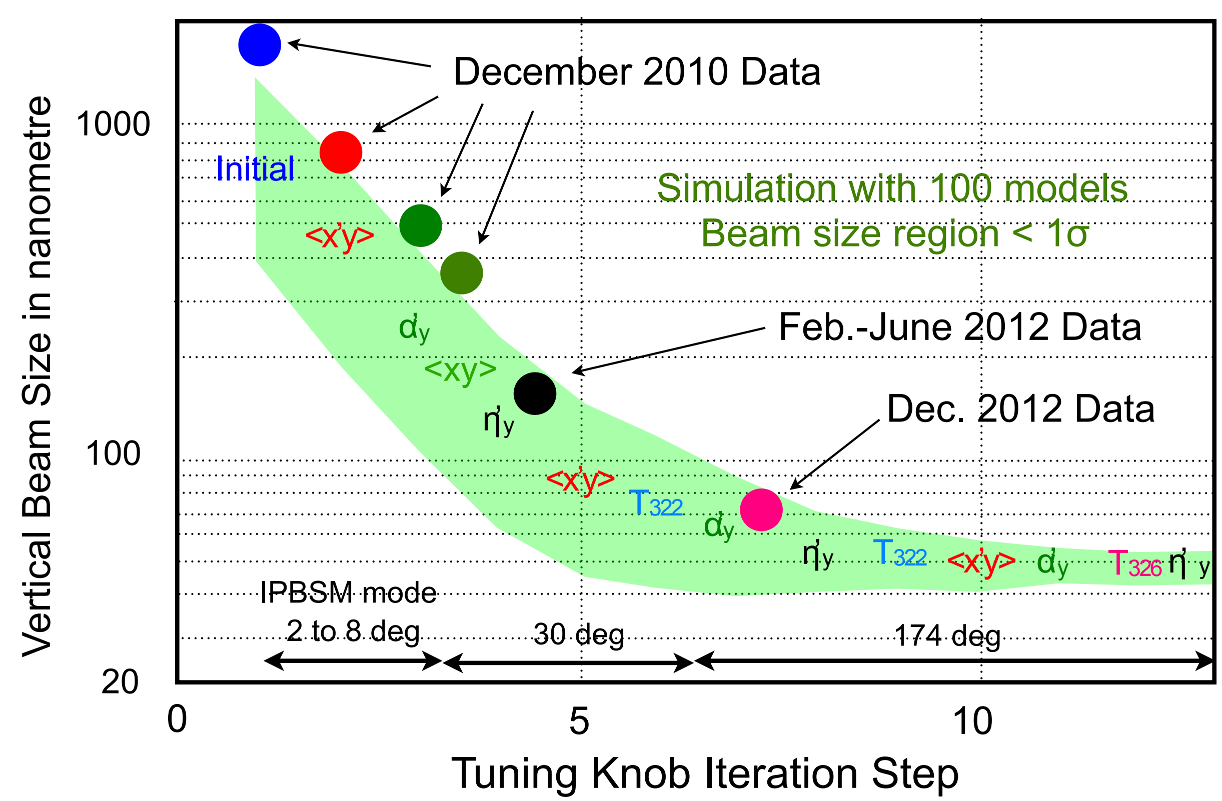
QD0 L^* at ILD

Karsten Buesser
24.11.2014

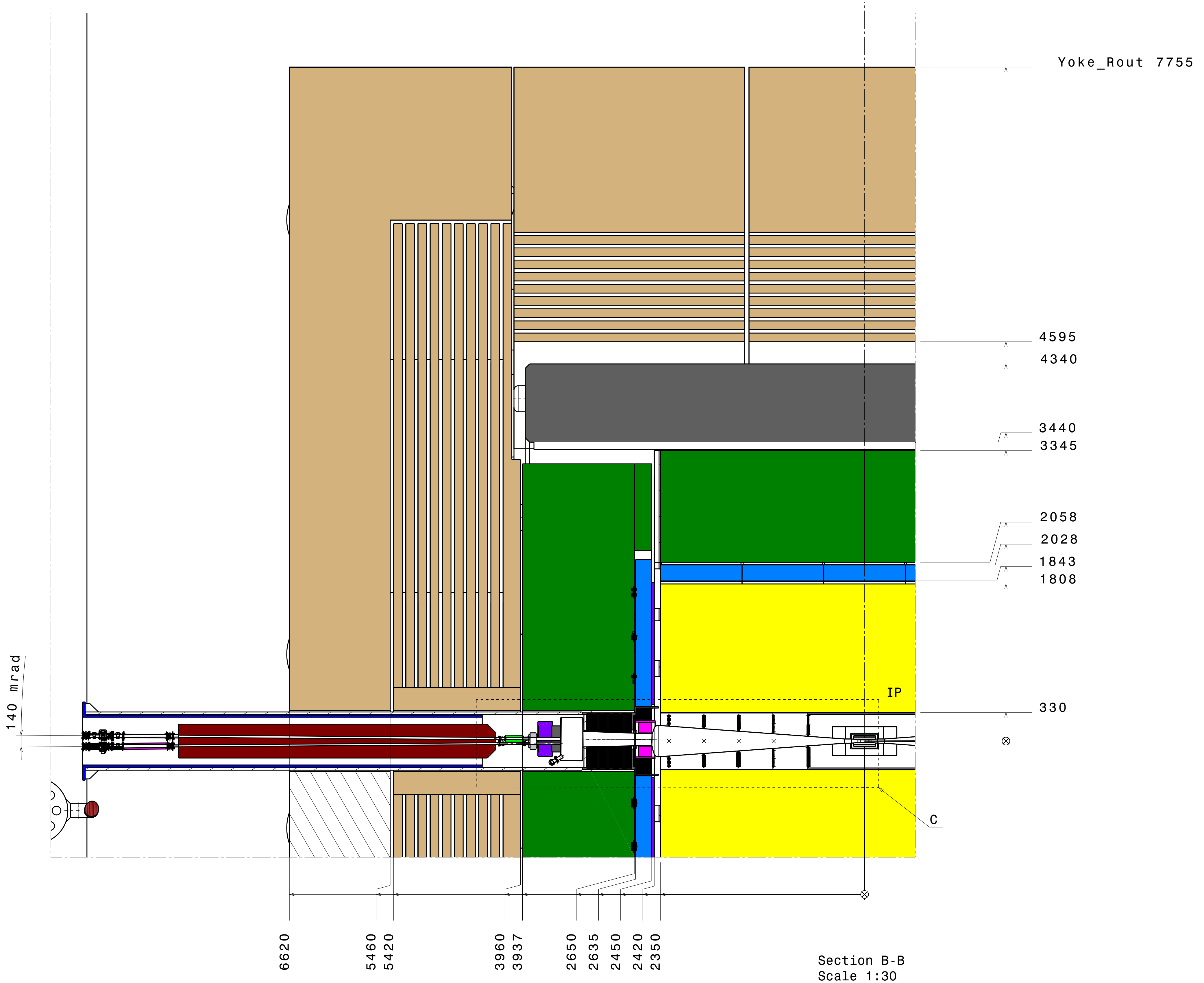
Final Focus at ILC

- Use telescope optics to de-magnify beam by factor $m = f_1/f_2$
  - typically m=300
  - f2 = 3m ⇒ f1 = 900m
- L* is the distance between the final quadrupole field edge and the IP
  - for infinite thin lens, L*=f2
- More complicated: corrections for chromatic and geometric abberations
- Final-focus test experiment at ATF2 facility at KEK
  - reached ~44 nm spot size, design is 37 nm
  - on-going work

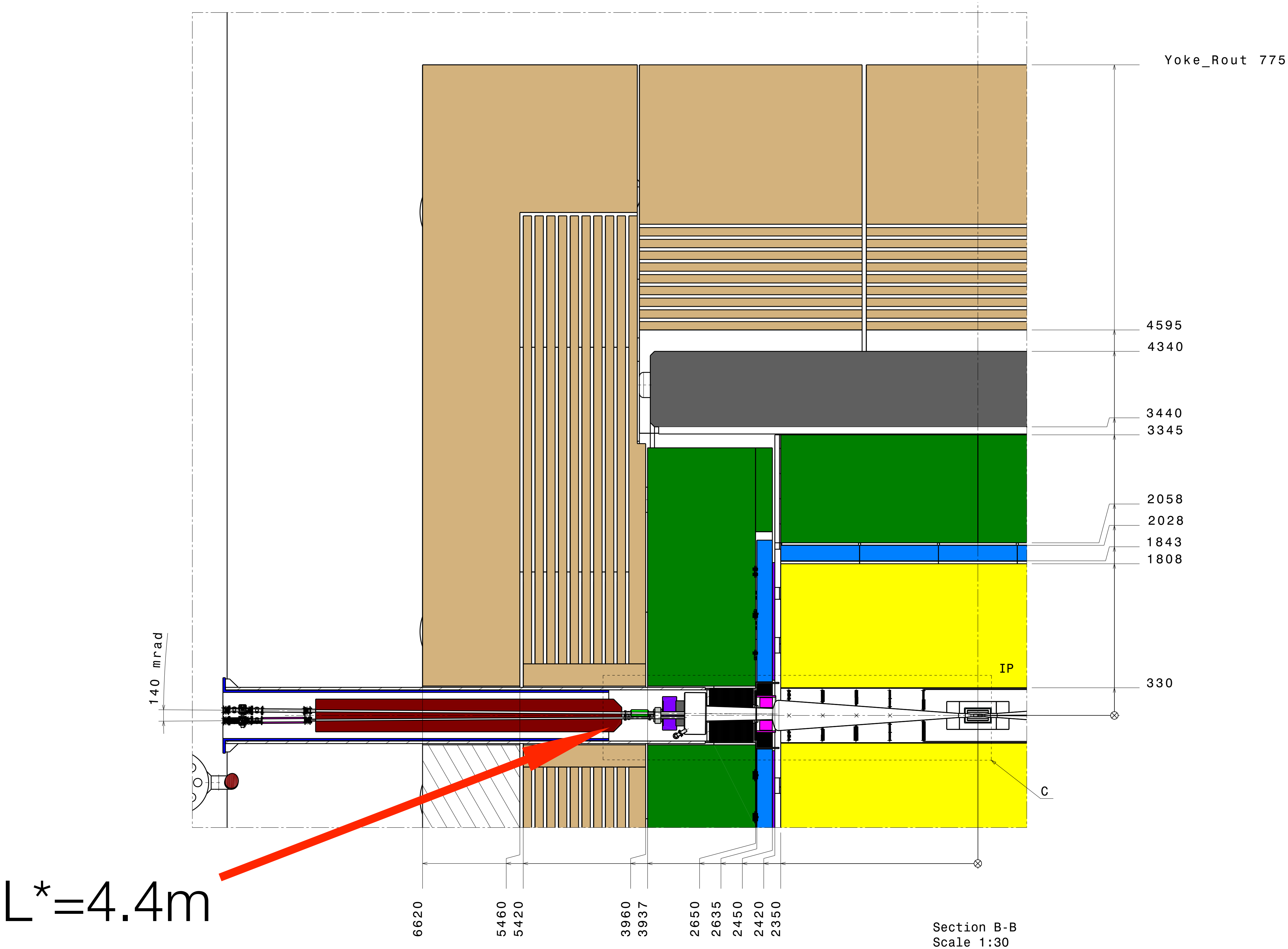




ILD Dimensions

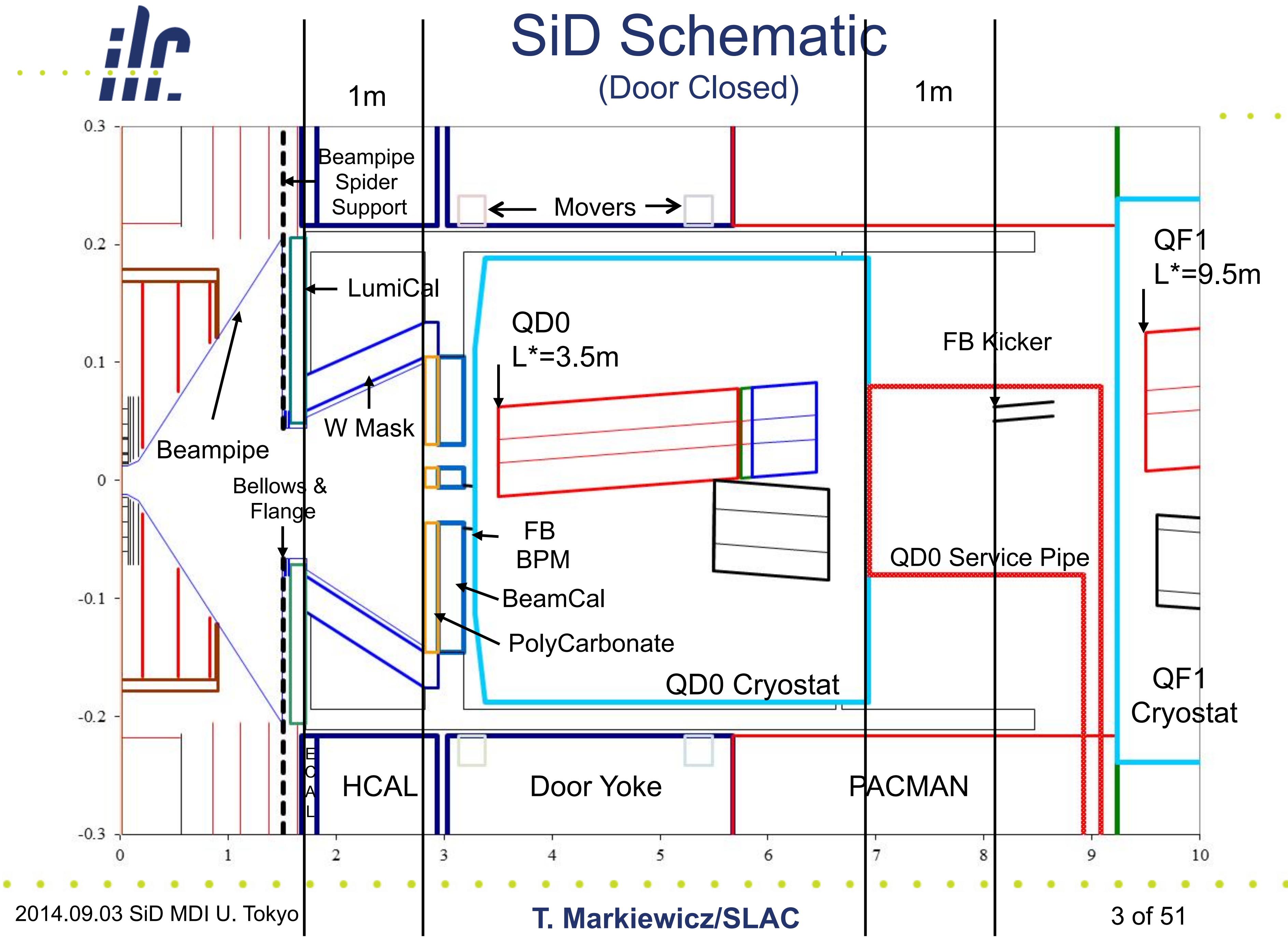


ILD Dimensions



L* at SiD

- SiD has actually L*=3.5m
- Can accommodate anything between 2.6 and 4.5m
    - but prefers smaller L* values



ILC Change Control Process

- ILC Baseline Design as described in TDR is now under change control
- Design changes need to follow a defined process and need approval by LCC directorate

1. Proposing a design change

- Change Request (CR)
- Change Request Creater (CRC)
- Written document
- Submitted to Change Management Board (CMB)

2. Expert review

- Reviewed by CMB with additional experts as needed
- CMB defines the scope of the review
- Communication with all stakeholders
- Capture relevant documents

3. Decision

- Results with recommendation from (2) presented to ILC Director
- Written summary document
- ILC Director (in consultation with the CMB) makes final decision, or
- Decision is escalated to LCC directorate.

4. Updating TDD to reflect the change

- CMB identiifies team (and team leader) to implement change.
- Generate scope of work
- Develope implementation plan
- Release of updated TDD

Change Management Board

- Members:
  - M. Harrsion (BNL, chair)
  - H. Hayano (KEK)
  - V. Kuchler (FNAL)
  - B. List (DESY, change manager)
  - J. List (DESY, PD-Physics, ILD)
  - T. Markiewicz (SLAC, PD-MDI, SiD)
  - M. Ross (SLAC)
  - N. Solyak (FNAL)
  - N. Terunuma (KEK)
  - N. Walker (DESY)
  - A. Yamamoto (KEK)
  - K. Yamamoto (KEK)
- Final decision is made by CMB chair
- Can be escalated to LCC directorate, e.g. by PD director

Change Request No 2: Common L*<= 4m

CHANGE REQUEST NO. ILC-CR-0002	EDMS No: **D*01082495**	Created: **02-09-2014** Last modified: **09-09-2014**

BASELINE OPTICS TO PROVIDE FOR A SINGLE FFS L* (QD0 EXIT – IP DISTANCE) OPTICS CONFIGURATION

The final focus system (FFS) and beam dump extraction system (EXT) baseline design is to provide a standard optics with fixed L* (yet to be determined, but provisionally assumed to be ≤4m). This optics solution is to be common to both detectors.

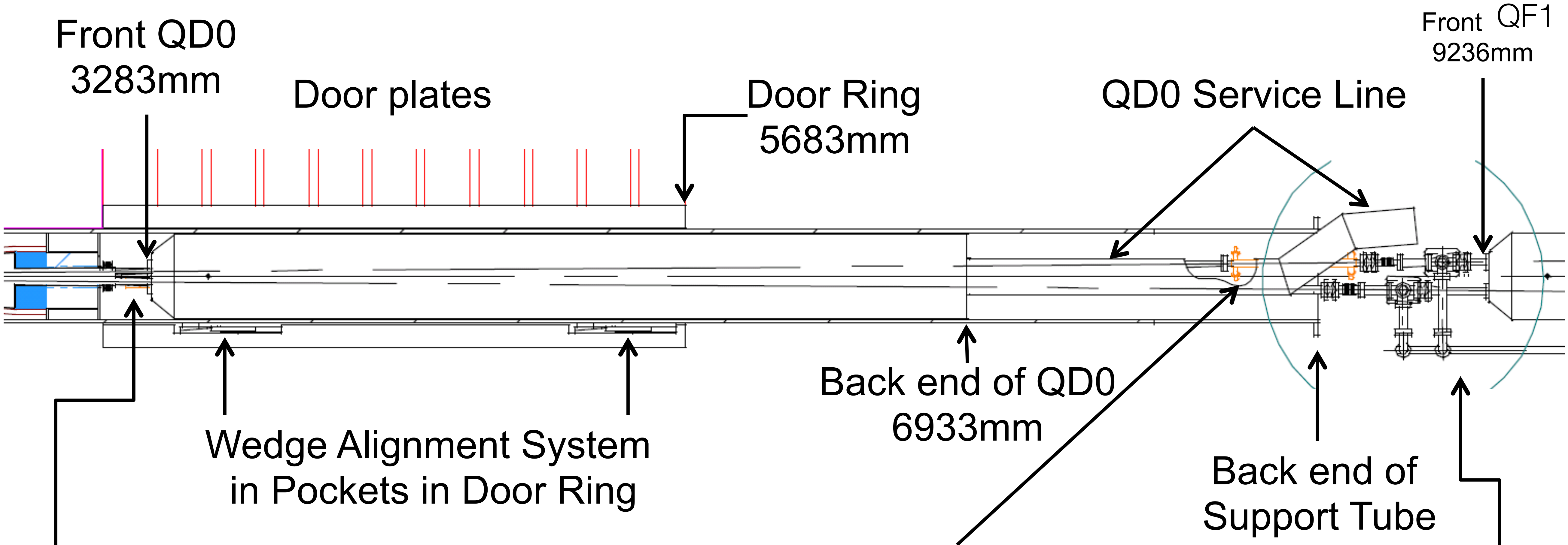
- Submitted by Glen White (BDS WG leader) in September 2014
- Change Management Board has formed a Change Review Panel for this request:
    - T. Markiewicz (SiD), N. Terunuma, N. Walker, G. White, KB (MDI, ILD)
    - CRP has agreed to come to a suggestion at the time scale of the next ILC workshop (April 2015, Tokyo)
    - CMB will decide eventually

General Considerations / Comments

- Unequal L* is not a *fundamental design or cost issue*
  - We have feasible optics solutions!
- Primary issue is operational lumi performance and risk mitigation
  - harder to quantify, so arguments tend to be more fuzzy
- L* is a fundamental parameter that drives many critical design features of the BDS. As L* gets longer
  - Chromatic (and geometric) corrections become more challenging
  - Overall larger beta functions drive tolerances (field and alignment) become more demanding
  - Shielding IR from SR fan becomes harder
    - collimation depth becomes tighter for fixed IR apertures
    - tighter collimation tighter jitter tolerances from wakefields etc.
- Bottom line: for the accelerator, shorter is better, and
- Having different L* will cause significant tuning differences between detectors
  - both lumi and background
  - negative impact on push-pull recovery times
  - difficult to guarantee equal luminosity performance!

Evolution of QD0-QF1 region

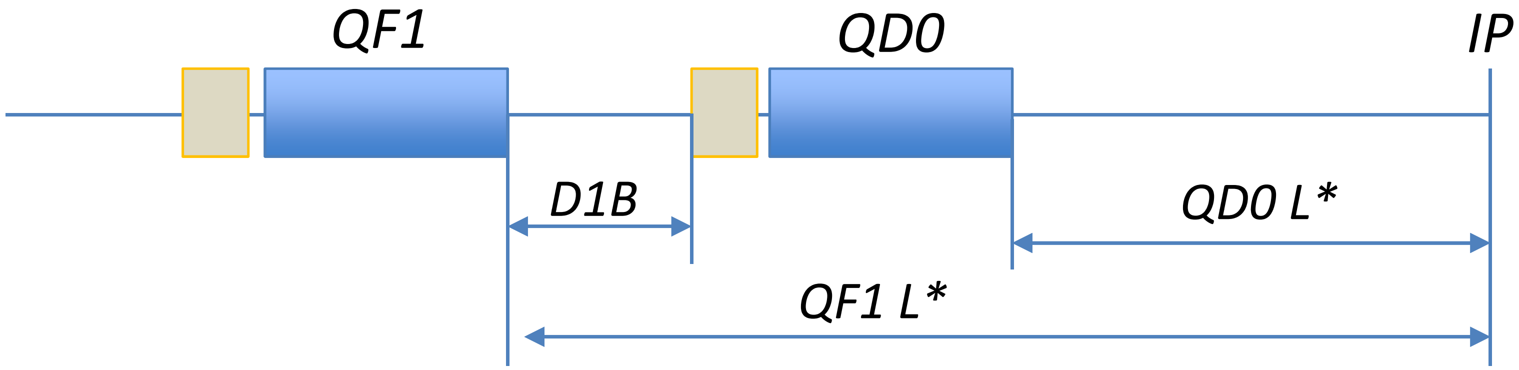
- Valve/Pump Out/RGA assemblies near QF1 end
- QD0 Service Line to 2K chiller extended maximally to rear
- Support tube behind QD0 extends to allow 2.8m door opening transitioning to a half-cylinder for access



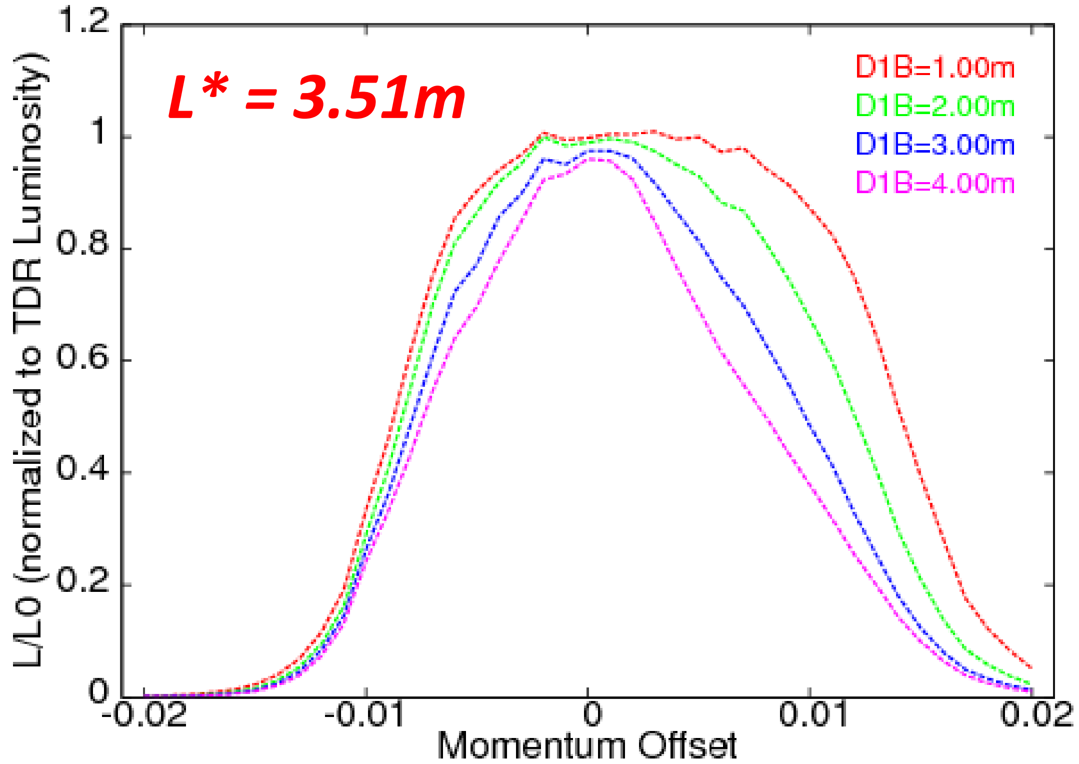
G. Anzalone/SLAC

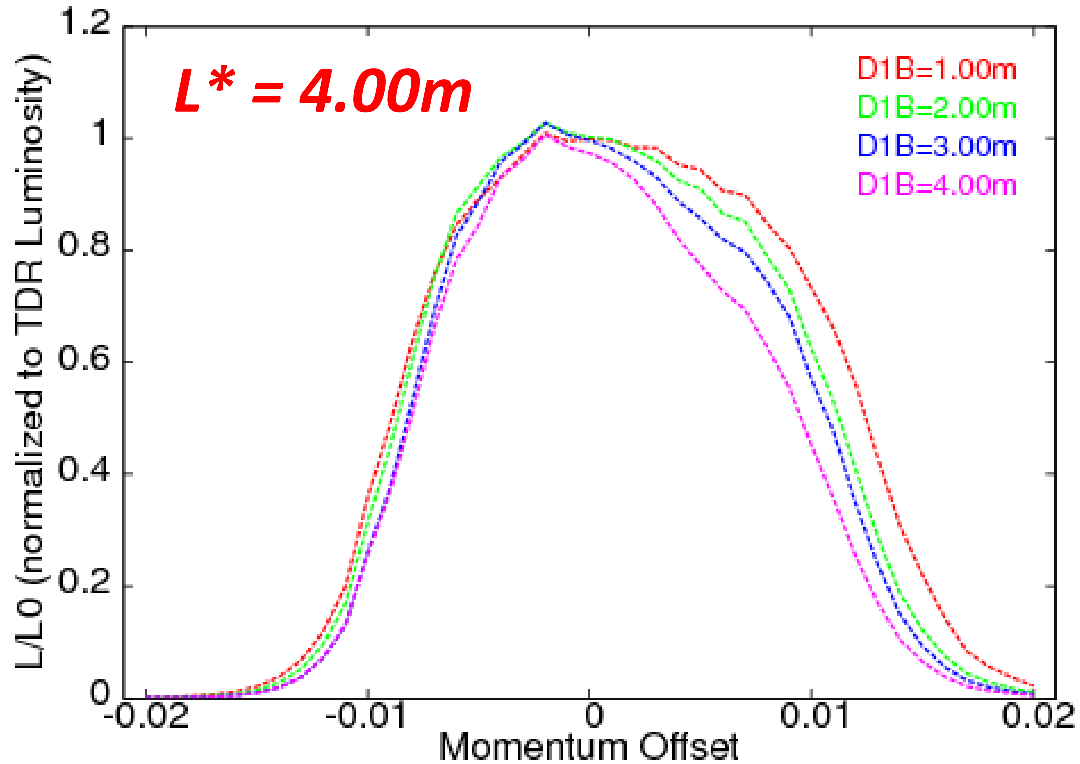
Introduction

Presented at BDS meeting at 2014/09/04 by T.Okugi



Bandwidths for optimized optics (not only strength of quad, but also quad location)



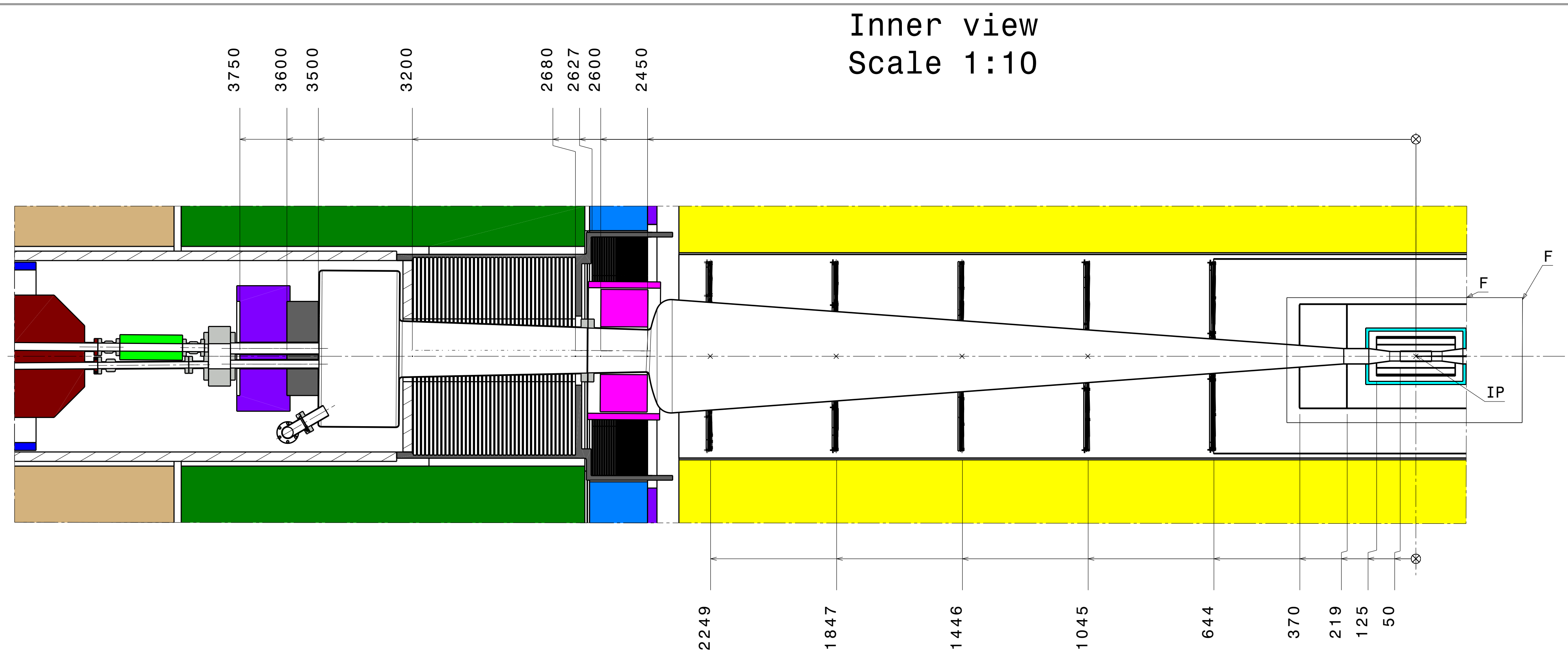


Not only QD0 L, but also QF1 L* is important.*

The QF1 L is set to 9.5m for push-pull scheme.*

Can the QF1 L make shorter ?*

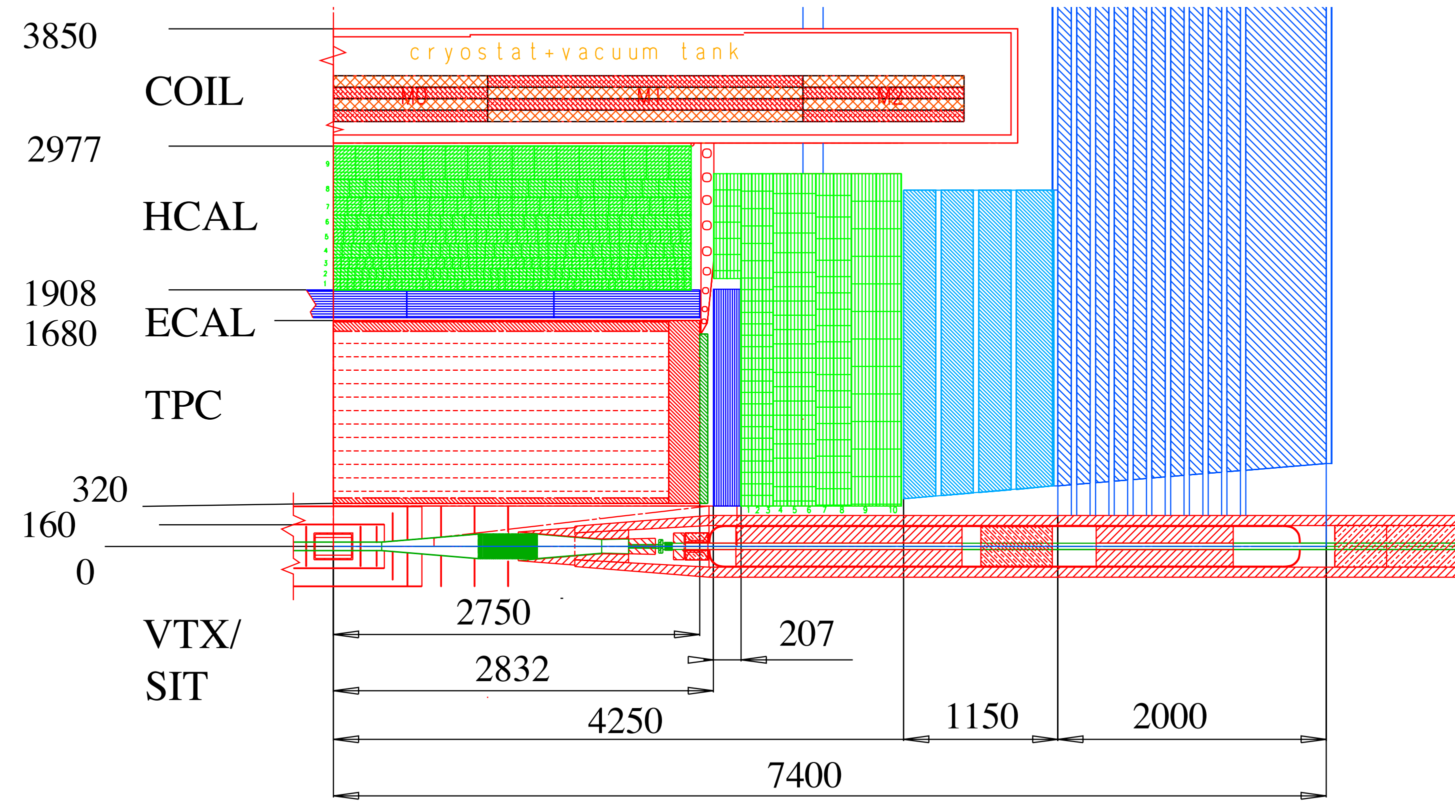
ILD: Current Lower Constraints on L*

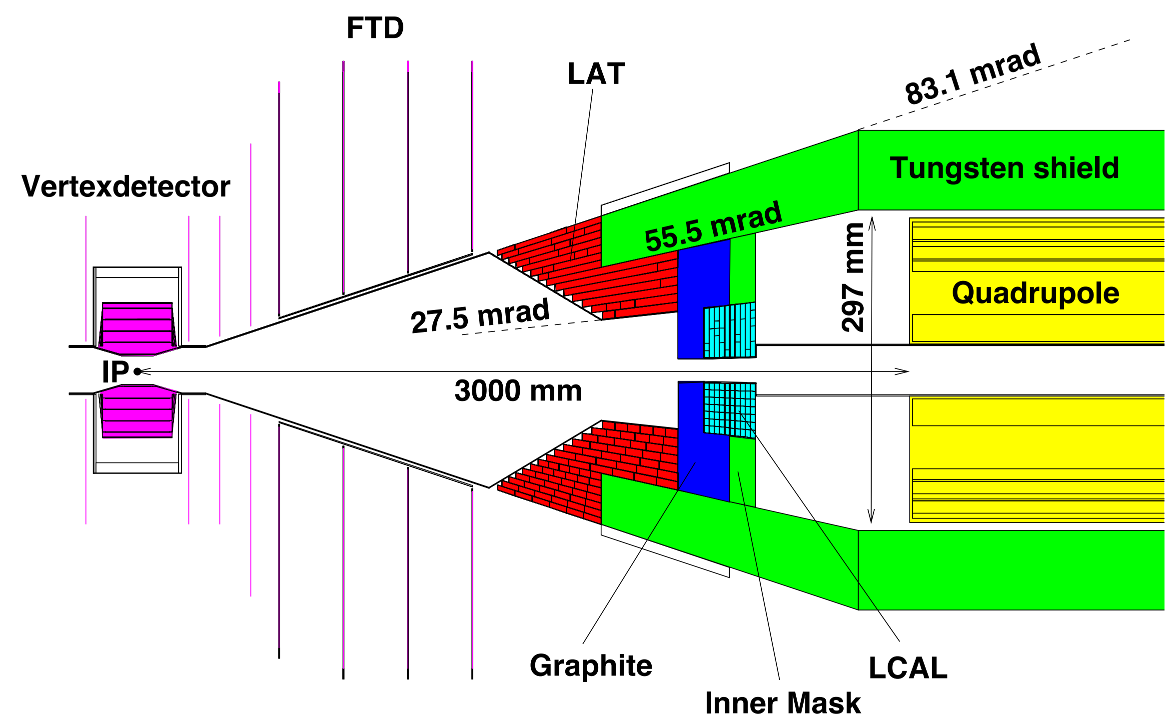


- Detailed design of forward region:
  - LumiCal, LHCAL, BeamCal
  - Beam Pipe, Bellows, Flanges, Vacuum Pumps
  - Optimised (many FTEs in the last ~10y) for
    - operations: no FCAL or masks inside the tracking volume
    - assembly and maintenance
    - physics: VTX (occupancies and layer radii), FCAL performance, hermeticity

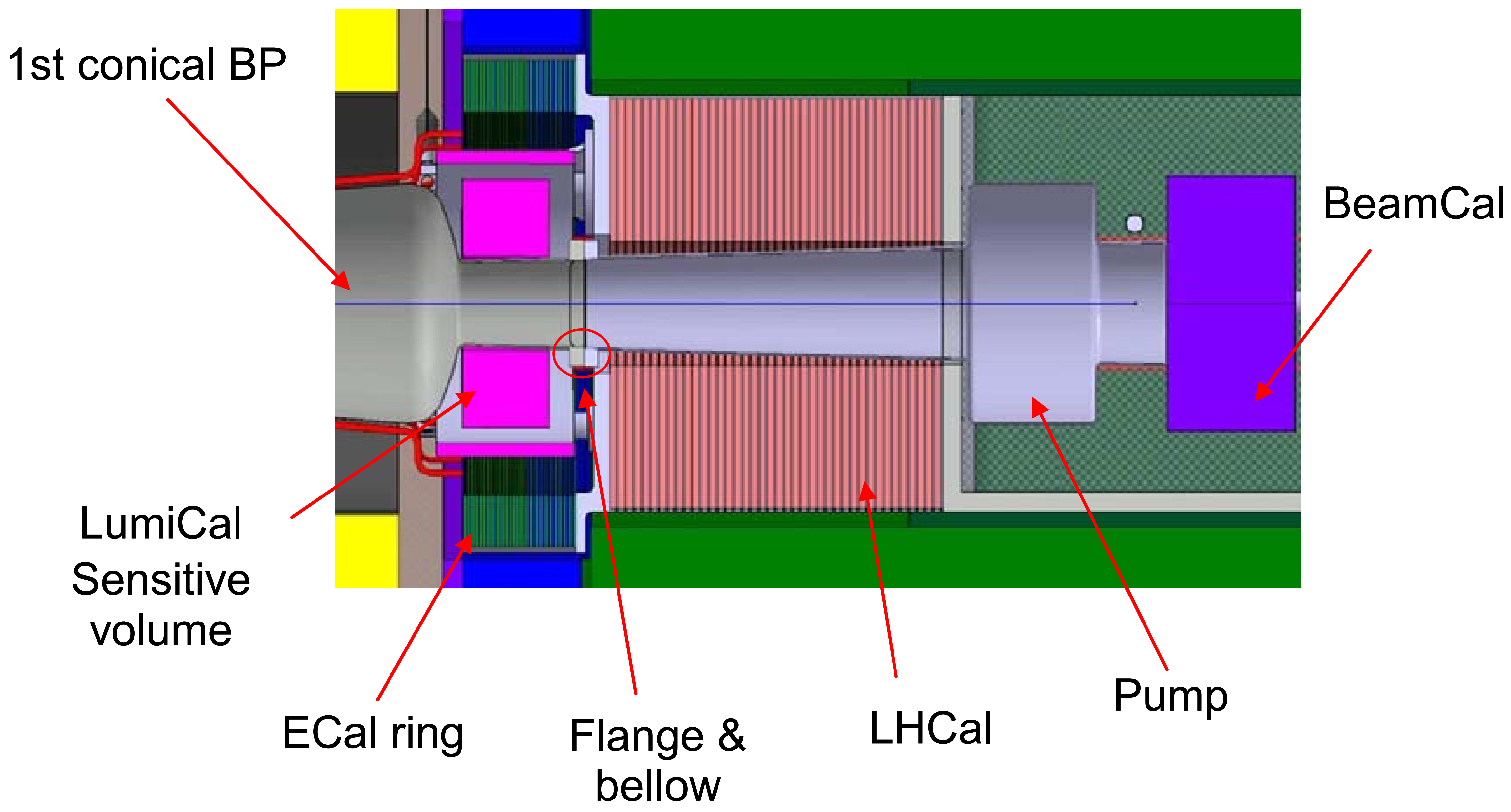
TESLA History

- TESLA QD0s hat L*=3.0 m
- TESLA detector was similar to ILD
- Mask and forward calorimeters were sticking into the tracking volume
- Machine induced backgrounds were under control
- But tungsten shield and FCAL inside the tracking volume were a big problem for the particle flow performance: high energetic particles from the IP strafing the mask and showering into ECAL…
- Assembly and maintenance was problematic
- No detailed design of LumiCal and BeamCal

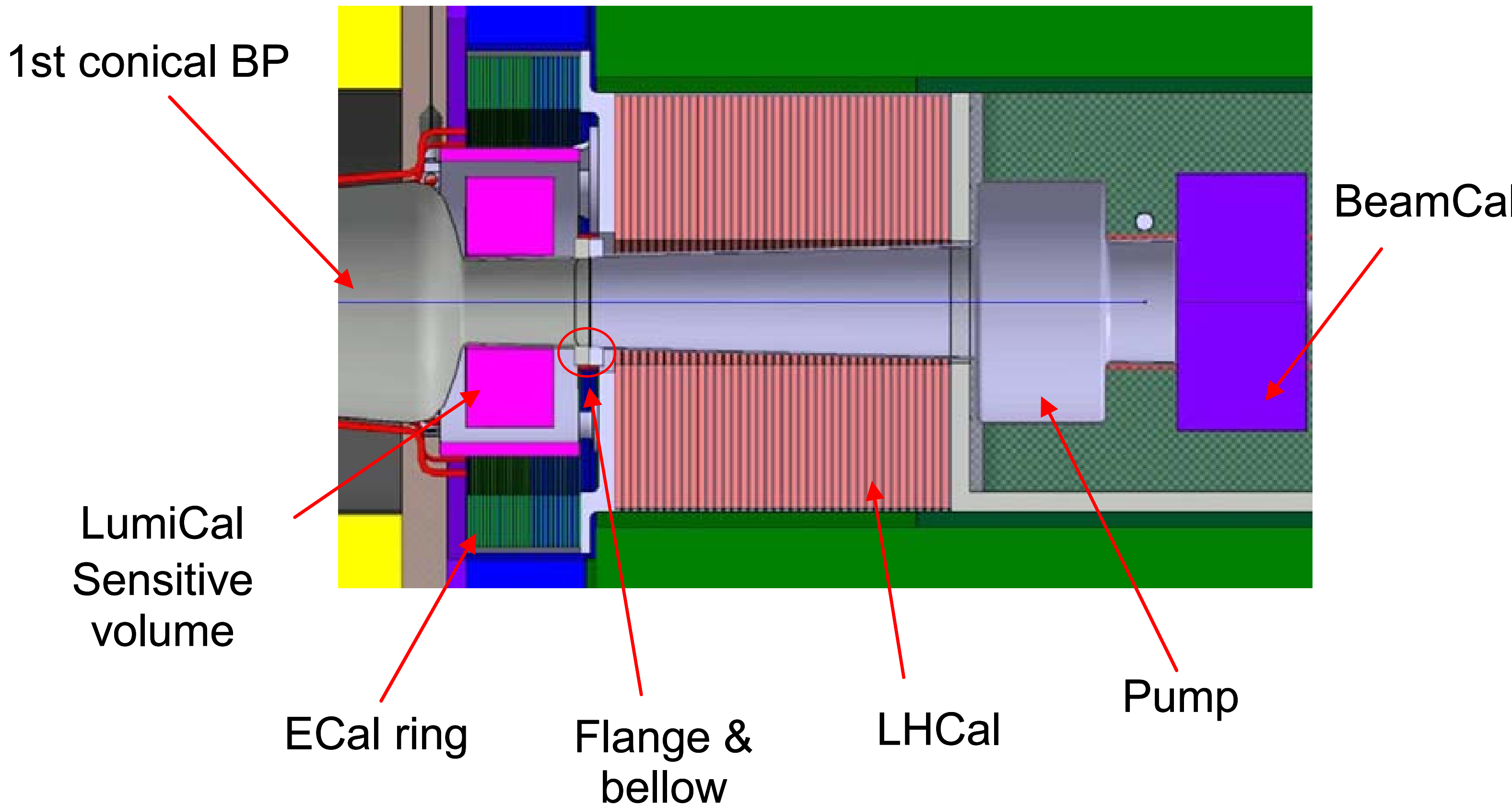




ILD: Forward Region



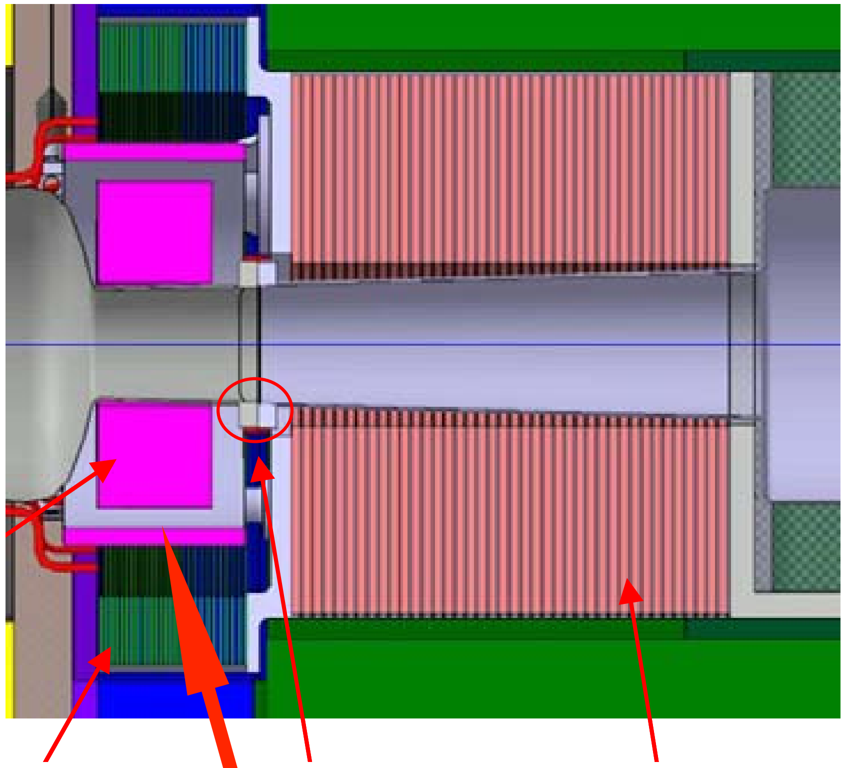
Forward Region - possible changes towards L*=4m

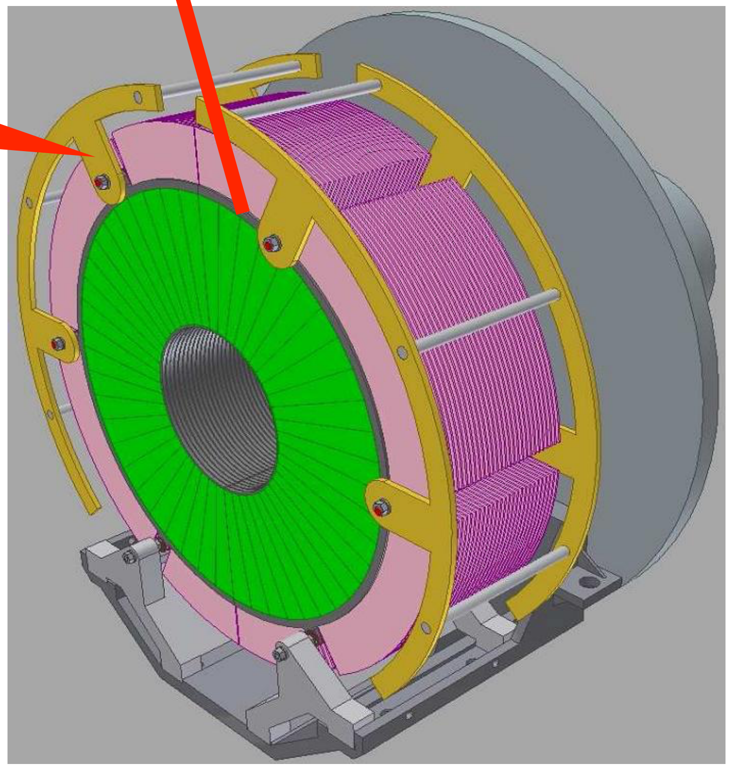


- Need to find ~40cm in current design
- Look into design optimisations of all structures
  - maybe find some 10cm there, but more?
- Biggest devices:
  - Pump in front of BeamCal (30cm)
  - LHCAL (~50cm)

Low Angle Hadronic Calorimeter LHCAL

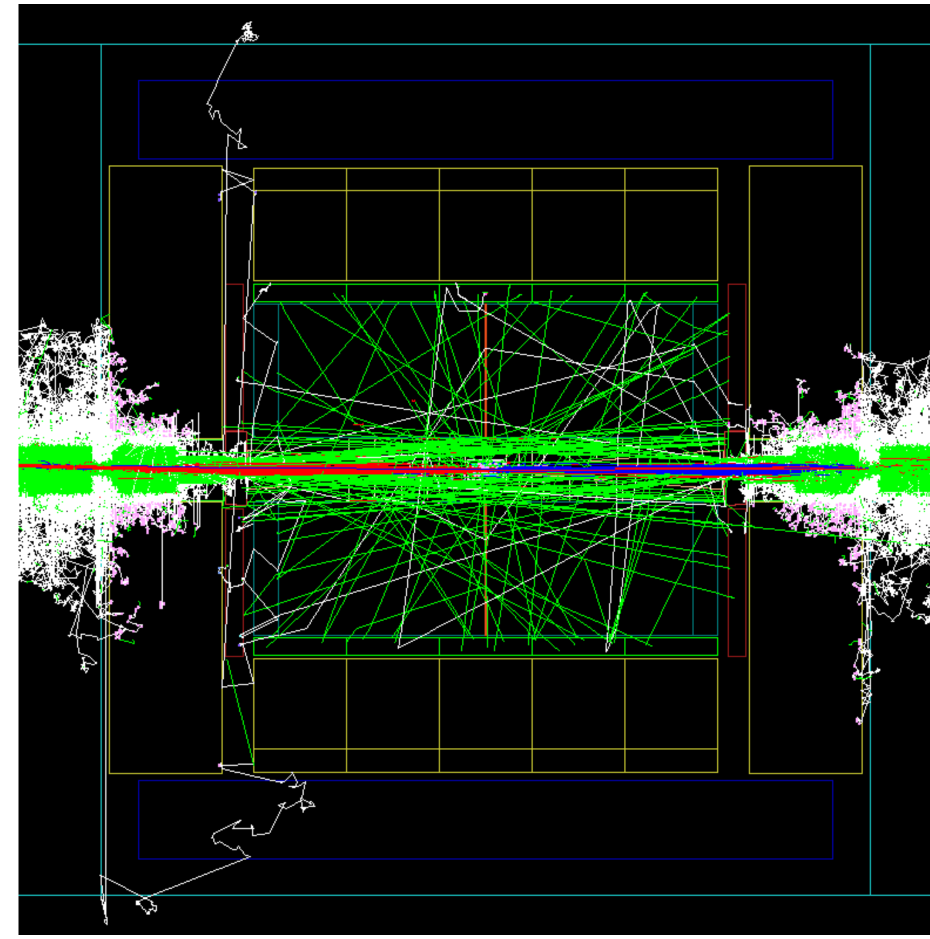
- Currently not much more than a placeholder in the ILD design
- Reasoning:
    - HCAL coverage at low angles
    - close acceptance gap in ILD forward region between LumiCal and ECAL ring
        - LumiCal electronics
- Need to do optimisation study with somewhat realistic design of LHCAL
- Can the LumiCal electronics be modified to cover less space?

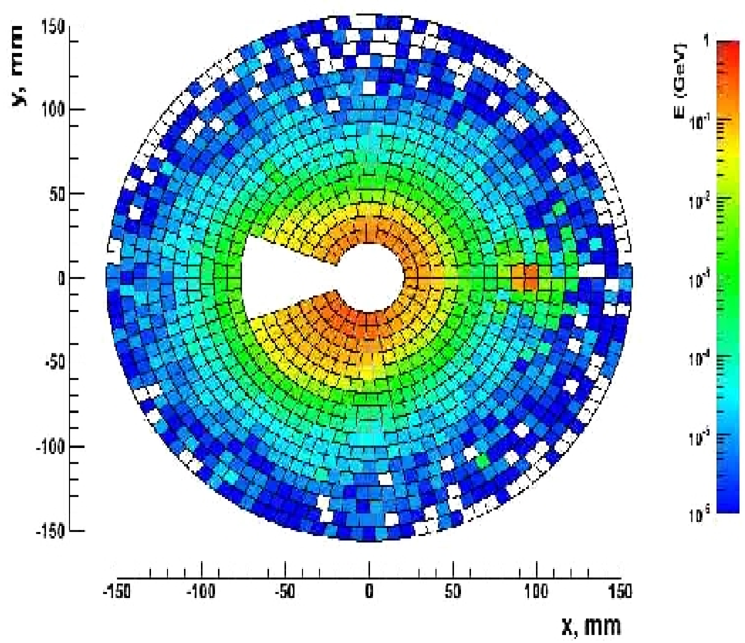


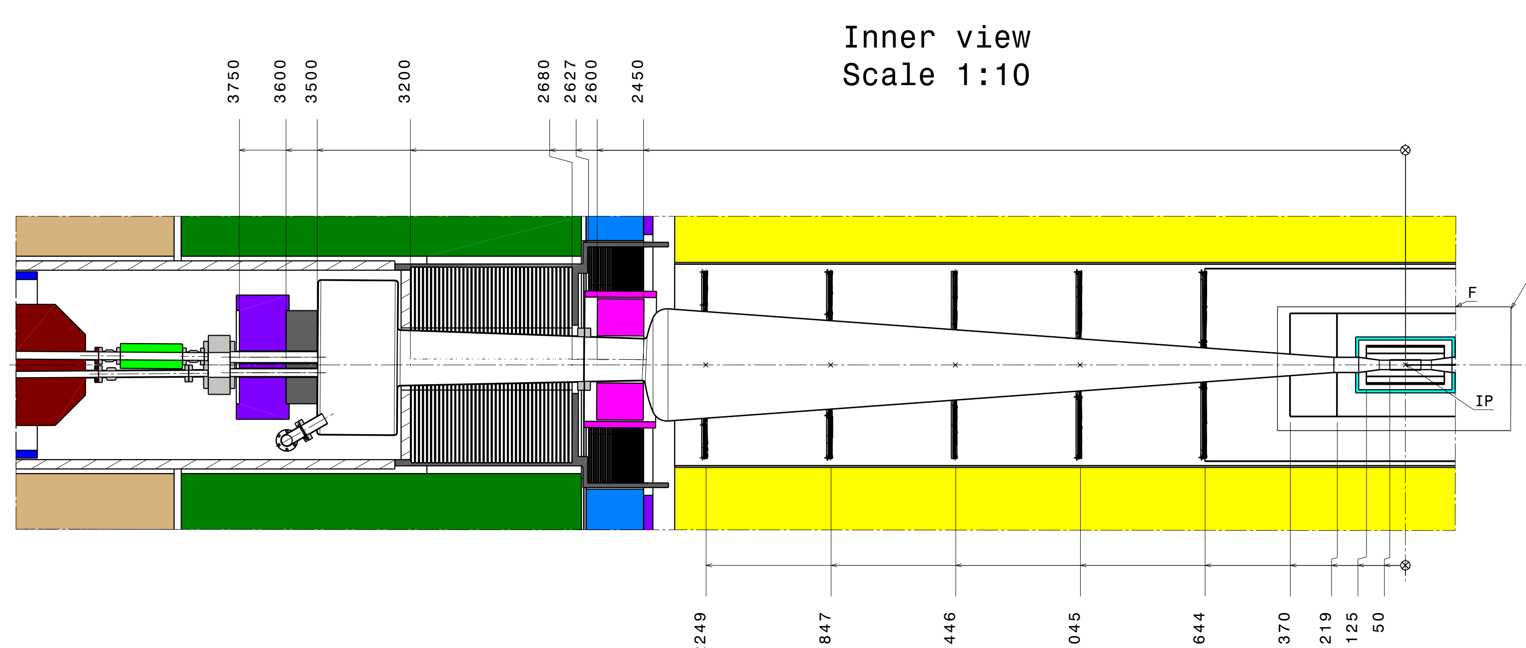


Pair Background Backscattering

- 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







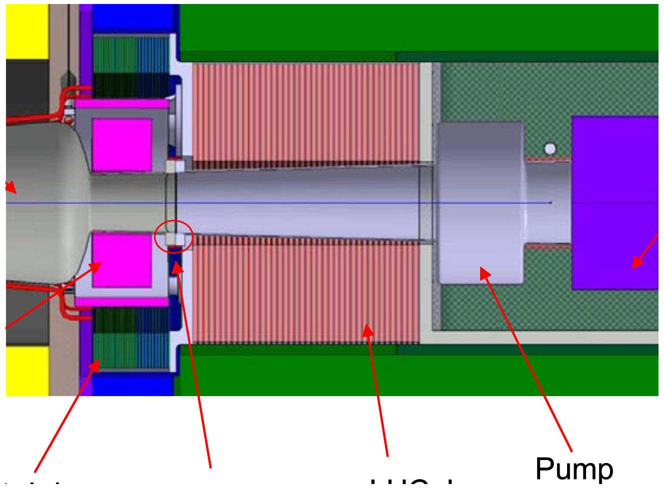
Forward Region - Things to Do

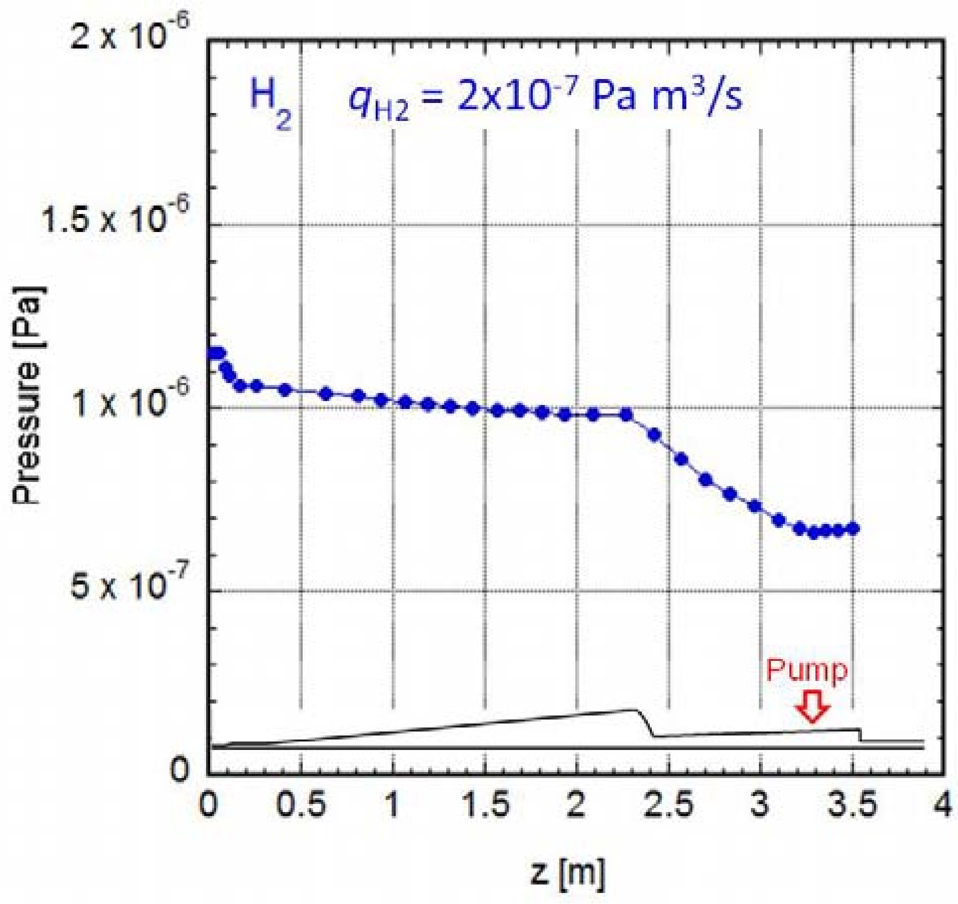
- Revisit FCAL design and look for possible space savings
  - any cm helps
- Do a coherent study of LHCAL design
  - physics requirements
  - technical design
- Change BeamCal design at new location (holes for incoming/outgoing beams)
- Eventually redo the pair background simulations with new BeamCal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

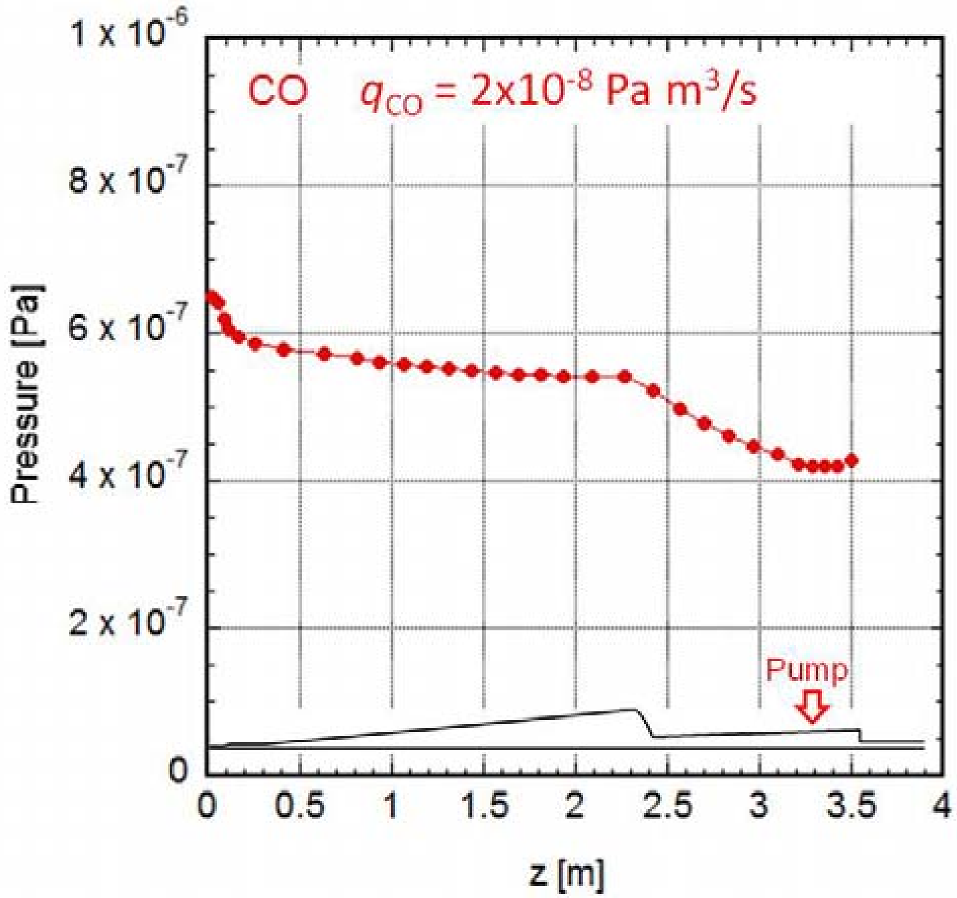
- All tasks need to be worked on, FCAL could help here out…

Vacuum Conditions

- What about the vacuum pump?
- SiD has no pump in front of QD0, but behind
- ILD vacuum studies done for LoI
  - Y. Suetsugu,"Technical Note for ILD Beam Pipe":
  - 6E-7 Pa (6E-9 mbar, ~4.5 nTorr) for CO
  - 1E-6 Pa (1E-8 mbar, ~7.5 nTorr) for H_2



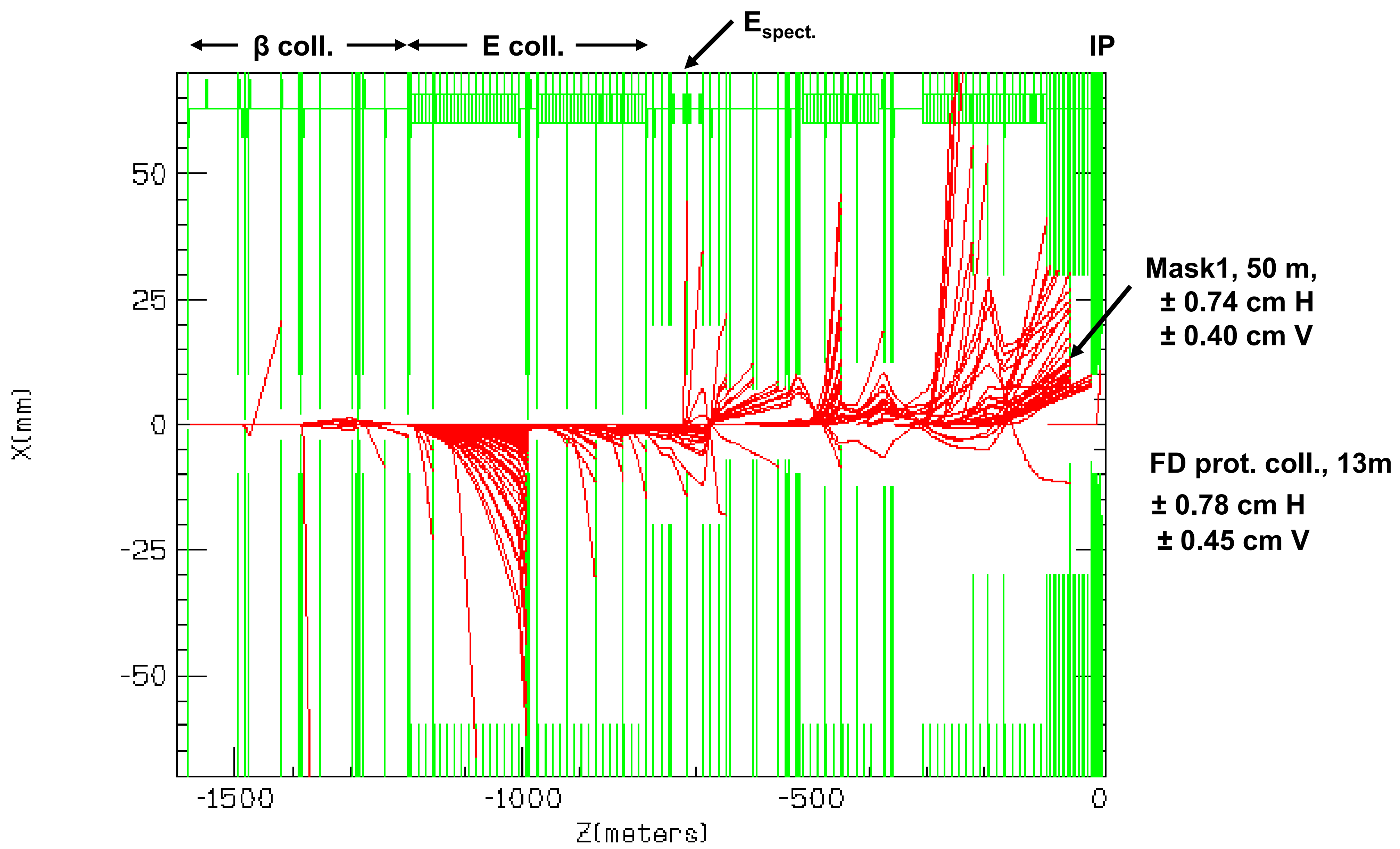




Vacuum Requirements

- L. Keller, T. Maruyama, T. Markiewicz - ILC-Note-2007-016

Loss pts. of 150 random beam-gas brem. trajectories in the BDS using LP TURTLE



Vacuum Requirements

- L. Keller, T. Maruyama, T. Markiewicz - ILC-Note-2007-016

Summary of Hits/bunch and Hits/160 bunches (TPC) – both beams, 10 nTorr

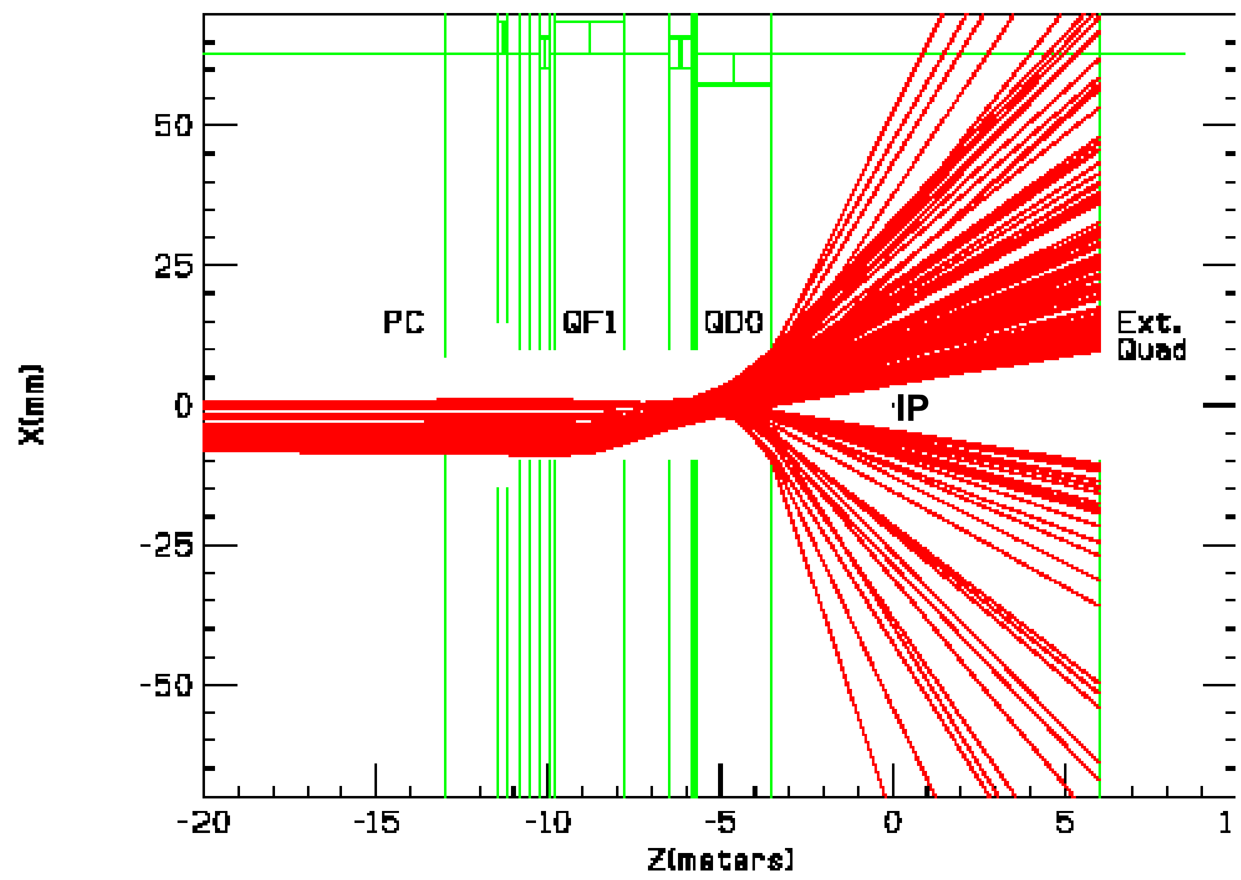
Hits/bunch   Hits/160 bunches (TPC)

Hit Location	GEANT3 Beam-gas brem (charged)	TURTLE Beam-gas brem (charged)		TURTLE Beam-gas brem (photons)		TURTLE Coulomb (charged)	
	Hits	Hits	<E>	Hits	<E>	Hits	<E>
FD Prot. Coll. (13 m) |x| > 0.74 cm |y| > 0.45 cm Origin 0-800m from IP	0.22 35	0.17 27	235 GeV	0.056 9.0	~50 GeV	0.009 1.4	250 GeV
Inside F.D. (10 – 3.5 m) (QF1 to QD0) Origin 0-100m from IP	0.014 2.2	0.006 1.0	~100 GeV	0	-	0	-
IP region (± 3.5 m) (R > 1 cm at Z = 6.0 m) Origin 0-200m from IP	0.04 6.4	0.02 3.2	~100 GeV	0	-	0	-

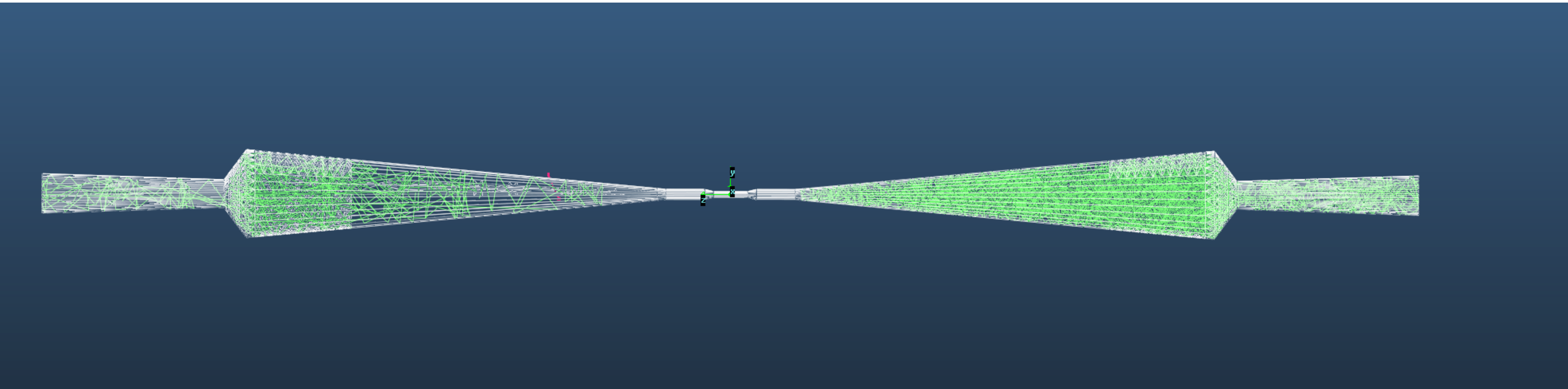
GEANT3 simulations show that only hits in the IP region (± 3.5 m) cause problems for the vertex detector

How relevant is the Vacuum inside the detector?

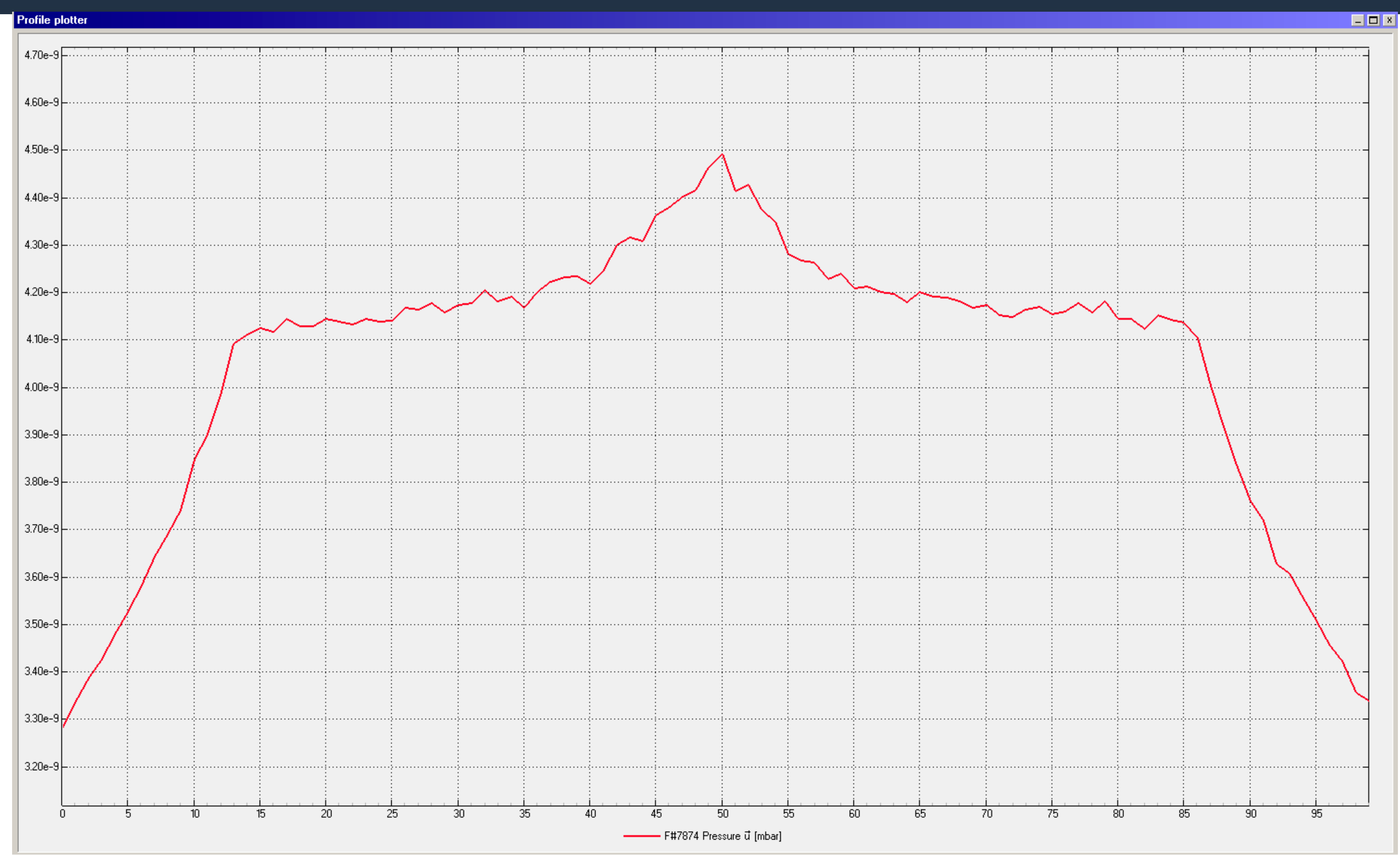
- Beam-Gas scattering in the BDS upstream is relevant for detector backgrounds
- O(10 nTorr) is the required vacuum level up to +- 200m
- Beam-Gas background produced inside the detector is mostly forward peaked - leaves the detector through the beam pipe
- So in theory, vacuum level inside the detector could be much higher
- To be checked with full detector simulations!



Check Vacuum Conditions

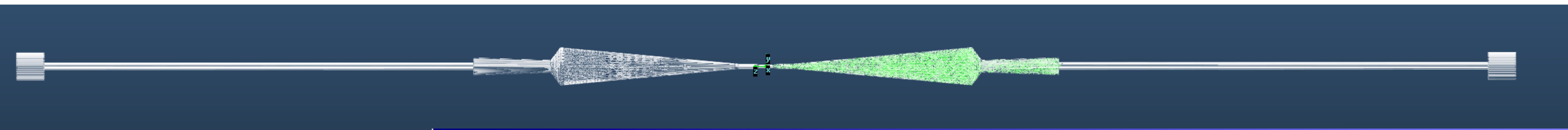


- MolFlow+ (CERN)
- Molecule tracker for given gases, materials and geometries
- For CO: 4.5E-9 mbar
  - Suetsugu: 6E-9 mbar

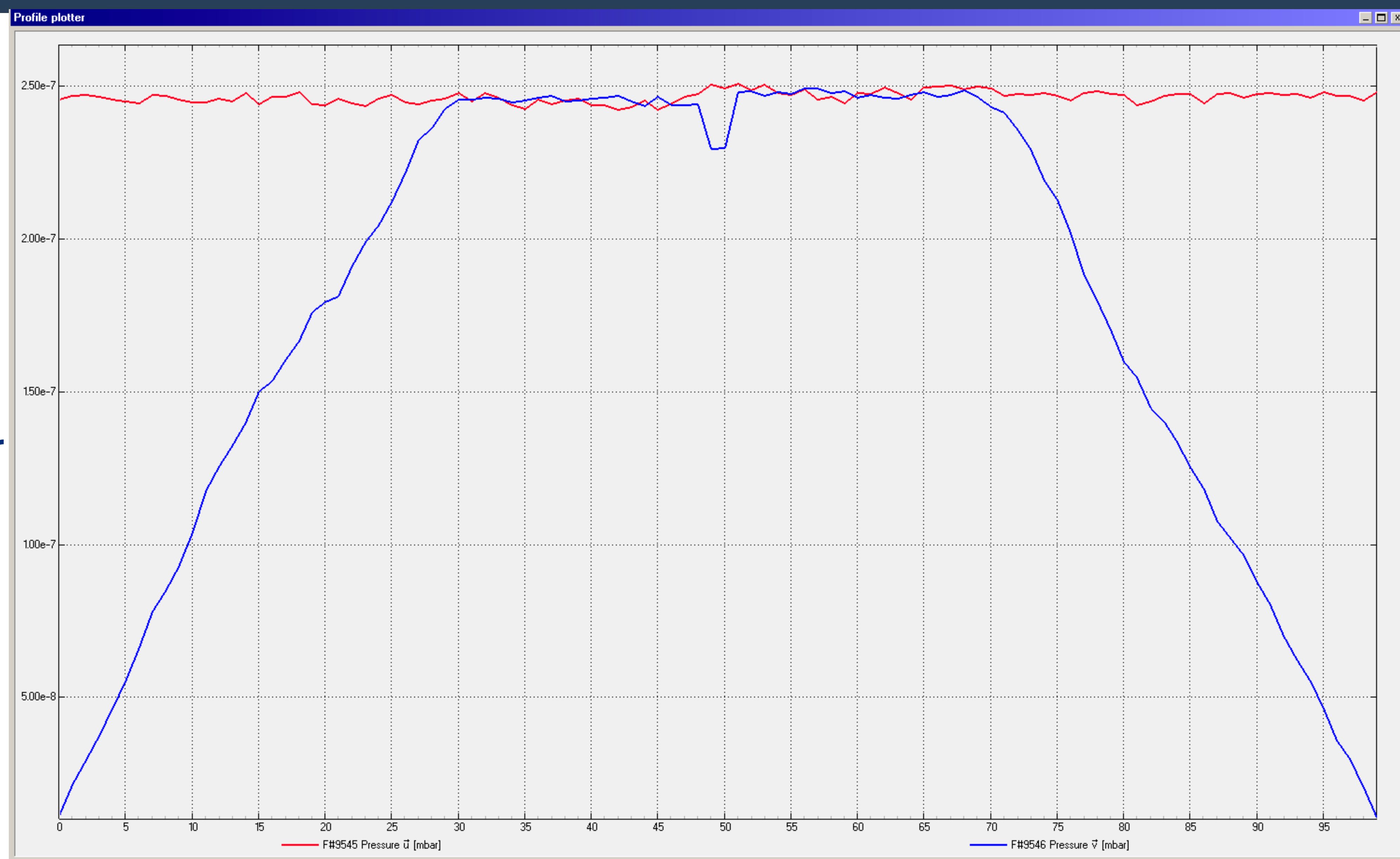


New Vacuum Geometry

- 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



Vacuum - Things to Do

- Simulate vacuum conditions for relocated pump geometries
  - all relevant gases (H_2, CO, CO_2)
  - check influence of cold QD0 magnet - acts like a cryo pump…
  - think about other solutions
  - work in progress (DESY, LAL)

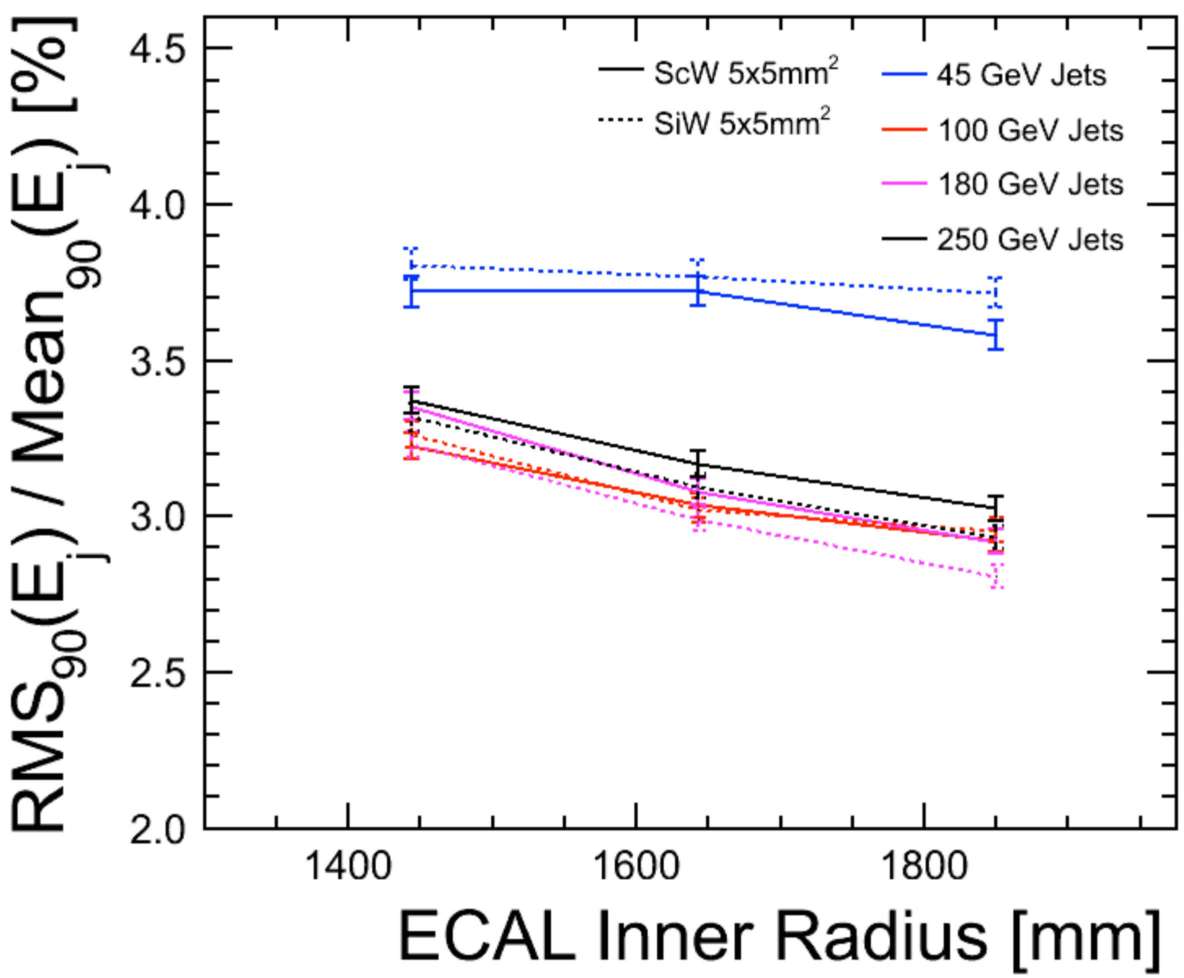
- Do a full detector simulation study with different levels of rest gas in the beam pipe
  - urgent need for help (volunteers?)

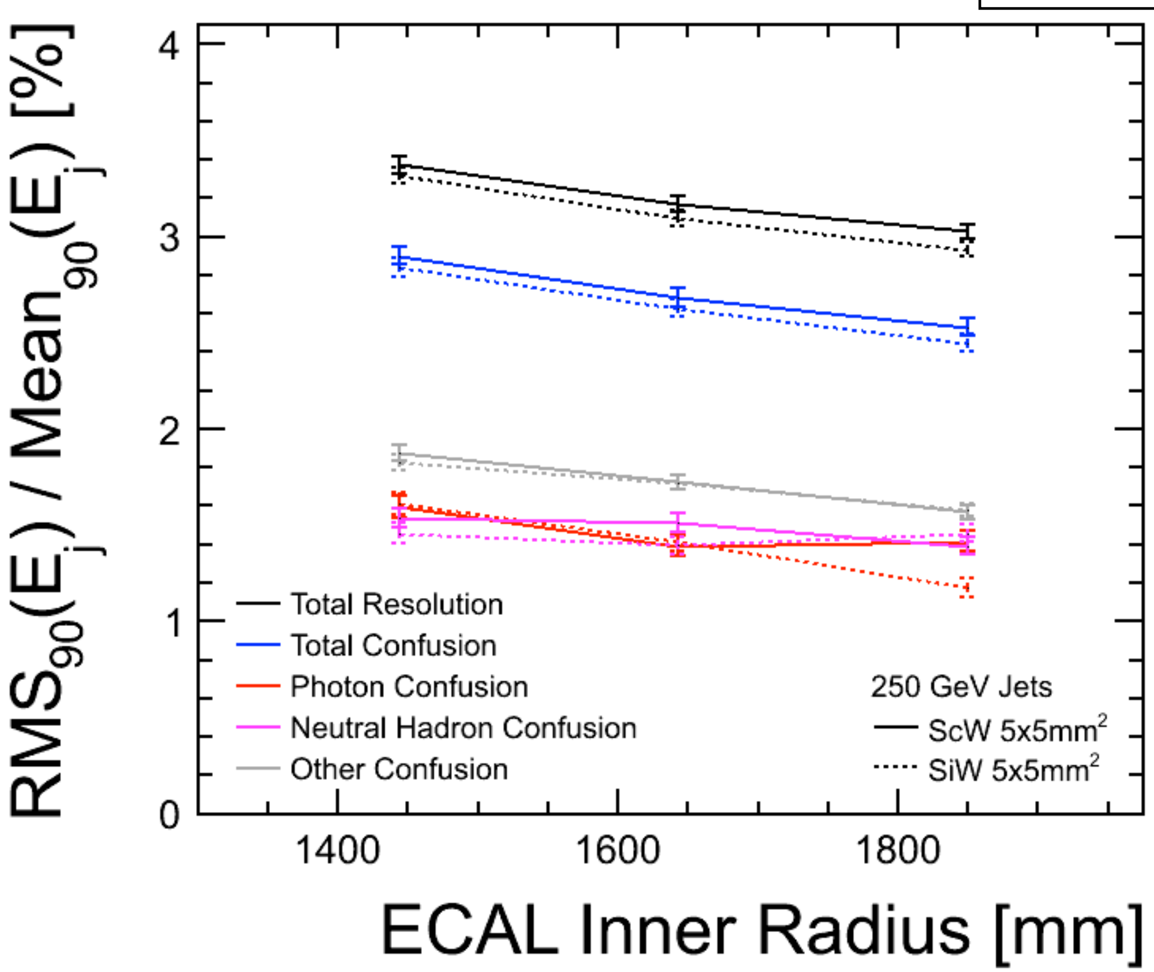
- Agree on tolerable level for residual gas pressures

ILD Global Optimisation

- ILD is undergoing next round of optimisation that also takes into account economical arguments
- Maybe the outcome is an ILD detector with a smaller TPC outer radius
- If the aspect ratio (length/radius) is kept, then ILD will also get shorter
  - this would allow for shorter L* automatically
- NB: this would require a complete technical re-design of ILD, including all sub-detectors

Marshall





Summary

- An official change request for a common L*<= 4m for SiD and ILD has been submitted
- A review process has been initiated that should come to a conclusion by April 2015
- ILC BDS group is working on understanding the impact of QD0 and QF1 locations to stabilities, bandwidths and collimation depths
    - main arguments actually are based on experience, less on quantifiable numbers
- SiD has no problems to accommodate an L* of 4m (but actually prefers smaller values!)
- ILD needs to do homework for this:
    - re-visit forward region design including background simulations
    - do a technical study on LHCAL
    - re-check vacuum conditions and requirements; this includes full detector simulations of beam-gas interactions close to the IP
- ILD optimisation studies might result in a smaller L* automatically, but until April?
- Decision on change request will take place on high levels, ILD has to deliver…