ILD and Machine Elements

Report from MDI/CFS Meeting

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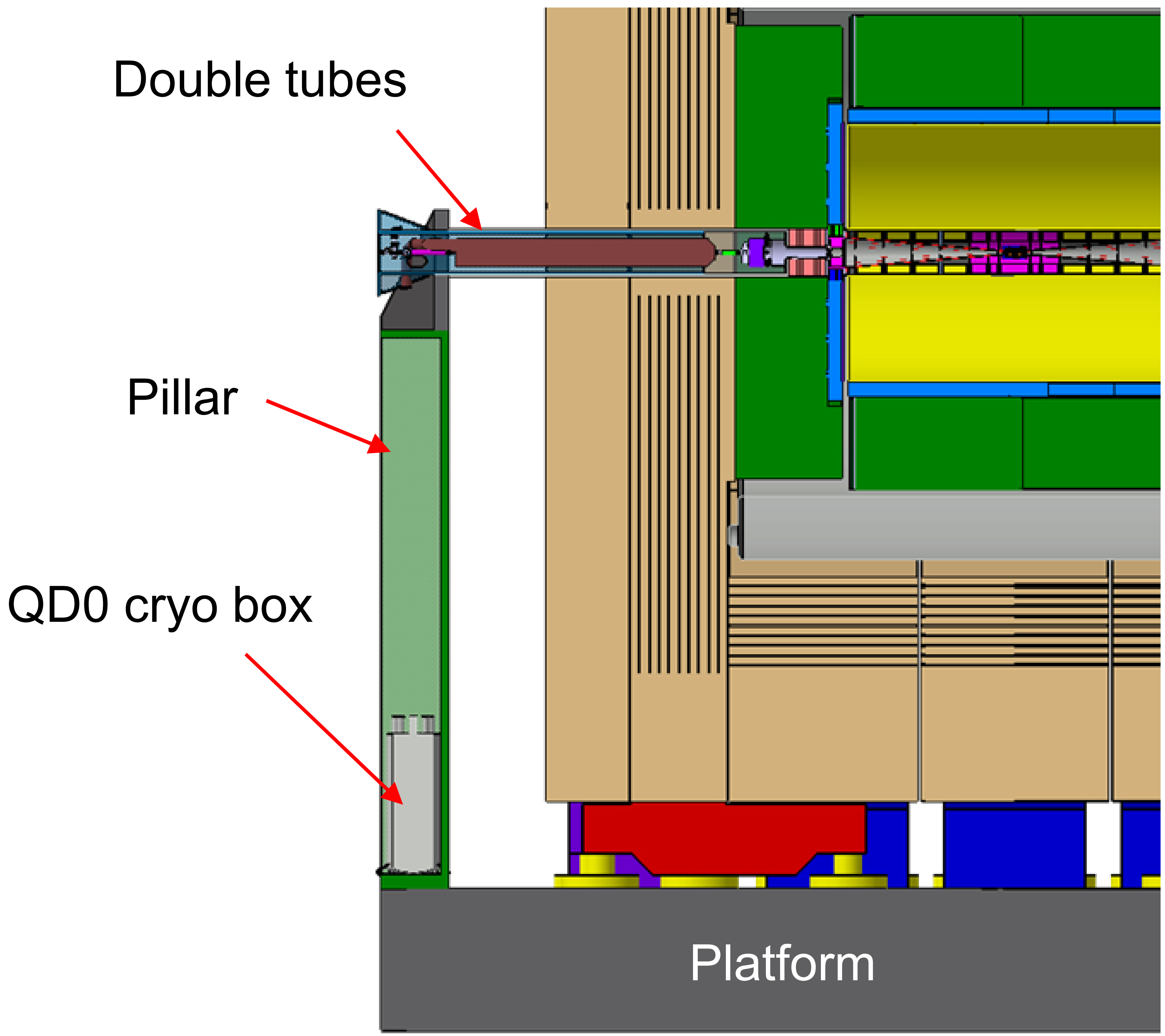
ILD Workshop Oshu City

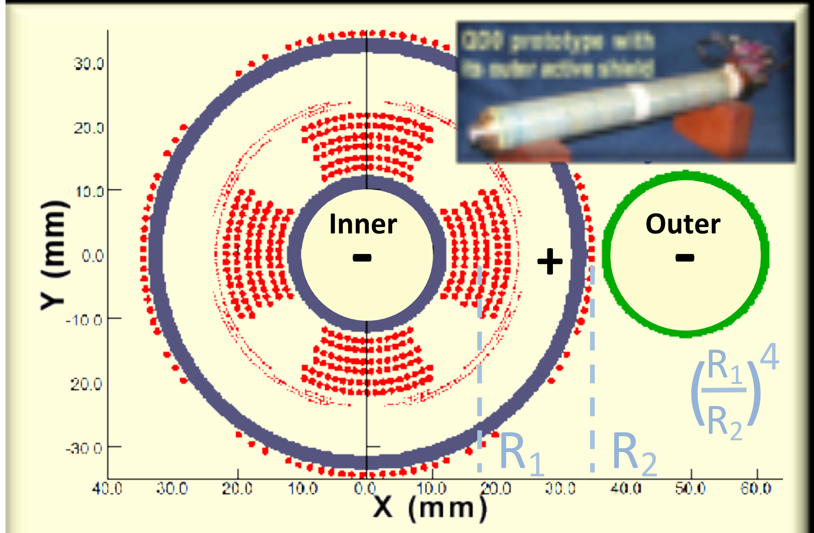
ILD QD0 Integration



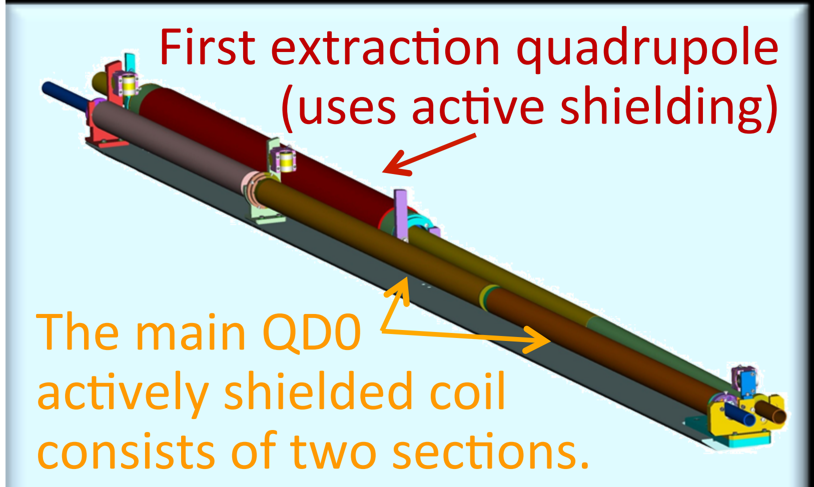
Possible Change of Crossing Angle

Current QD0 Design (BNL)

Some relevant facts re. present 14 mrad baseline.



ILC Actively Shielded QD0

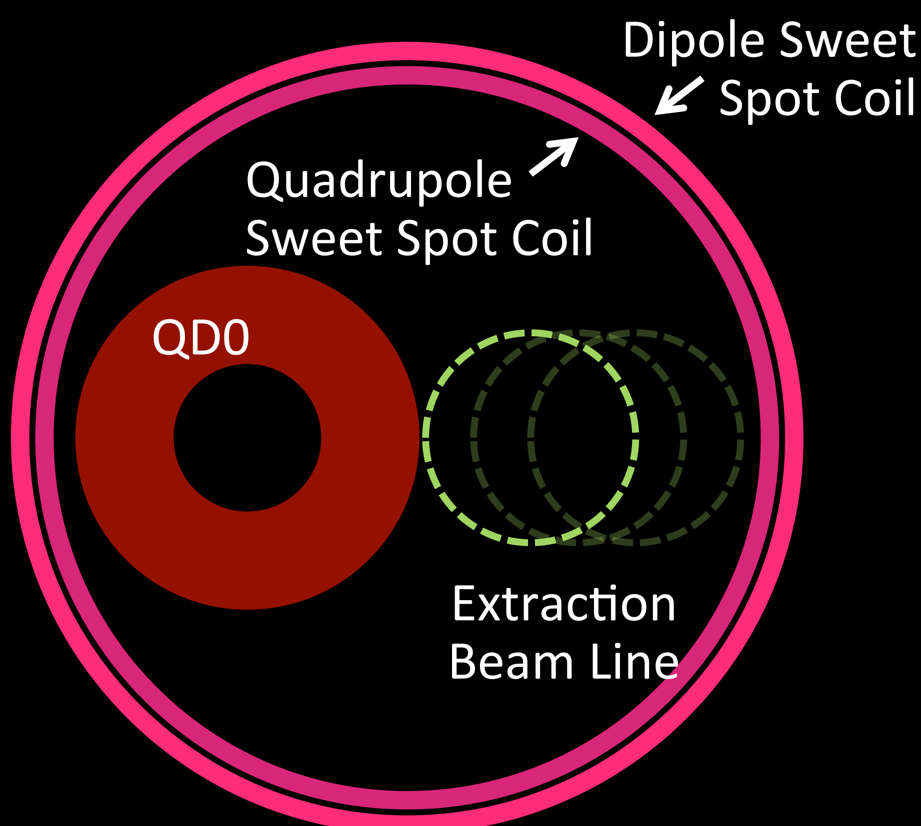


Two Part "Split QD0 Coil"

- QD0 uses an "active shielding concept" that reduces the B-field in both the inner and outer regions but fields adds between coils.
- But it naturally preserves good field quality (maintains proper quadrupole symmetry).
- Combined quad and dipole external fields give low-field "sweet spot" outside coils.
- So passive shielding works without spoiling field inside the main aperture.

New QD0 Design Ideas (B. Parker)

So why does this work and how do we use it?

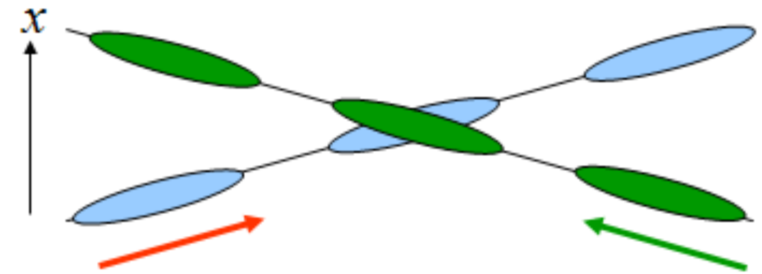


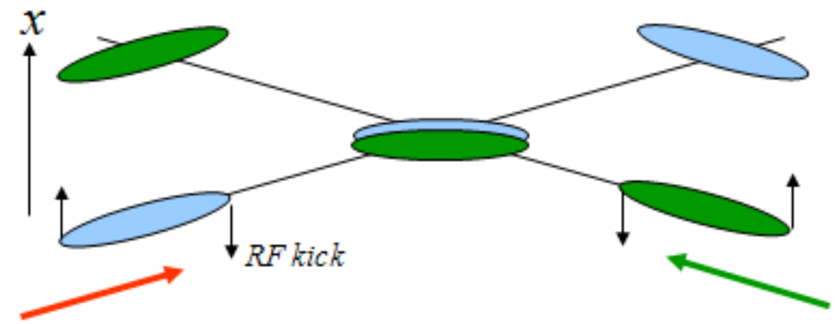
ILC QD0 Sweet Spot Coil Schematic

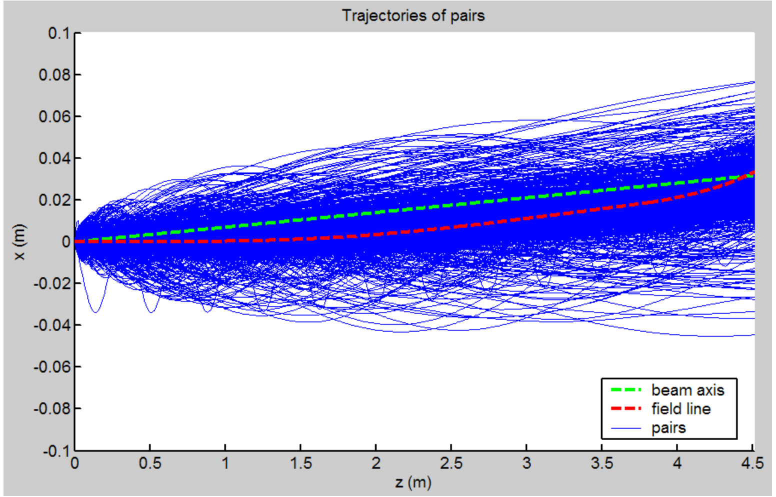
- By construction the combined sweet spot coil fields are zero at the QD0 axis but non-zero at the extraction beam line axis.
- The sweet spot coil strength is thus independently adjustable from QD0.
- Unlike using an active cancel coil the sweet spot coil does not "weaken" QD0; the QD0 coil has more margin.
- Now there is some focusing at the extraction line that starts with the same L* as the main QD0 field (reduced extraction line beam loss?).
- The extraction line beam pipe can be made with quite large but...
- The outer coil size (& QD0 cryostat) diameter can still be made smaller.

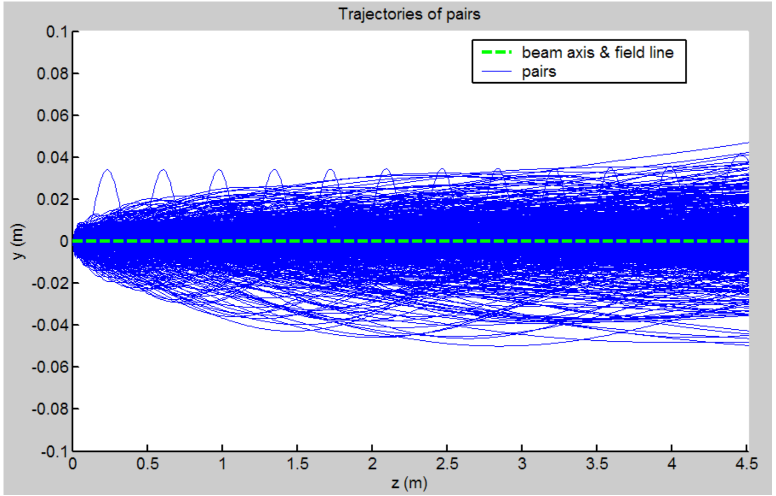
Crossing Angle and ILD

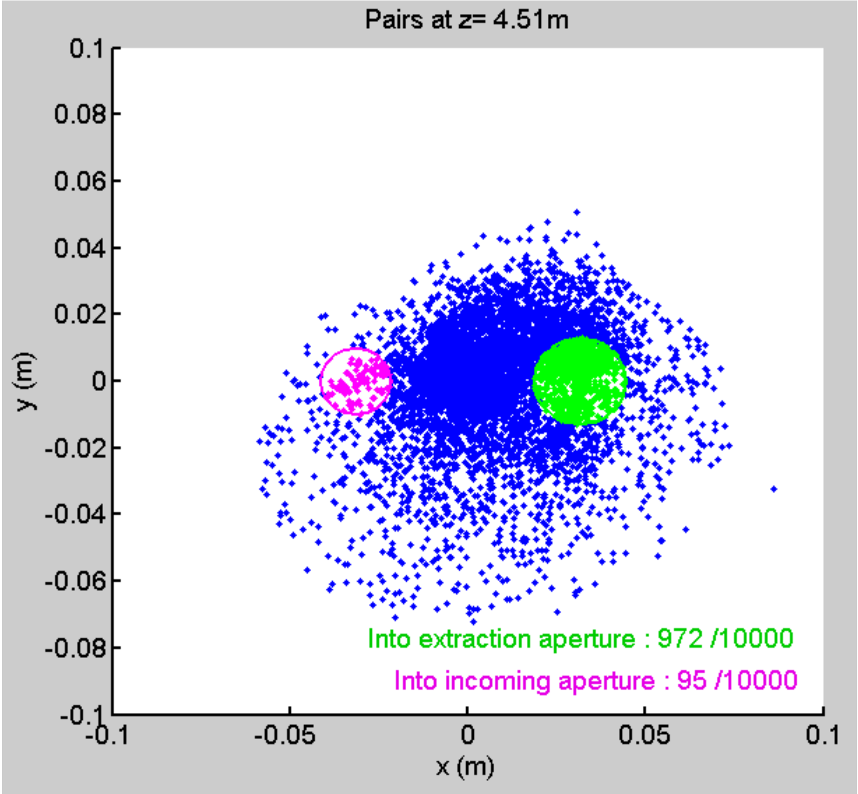
- New QD0 design could reduce crossing angle from 14 mrad to ~10 mrad
- Possible benefits for ILC/ILD:
  - Crab crossing cavities could run with less voltage - less risk
  - Reduce need for anti-DID?
    - probably still required - need further studies…

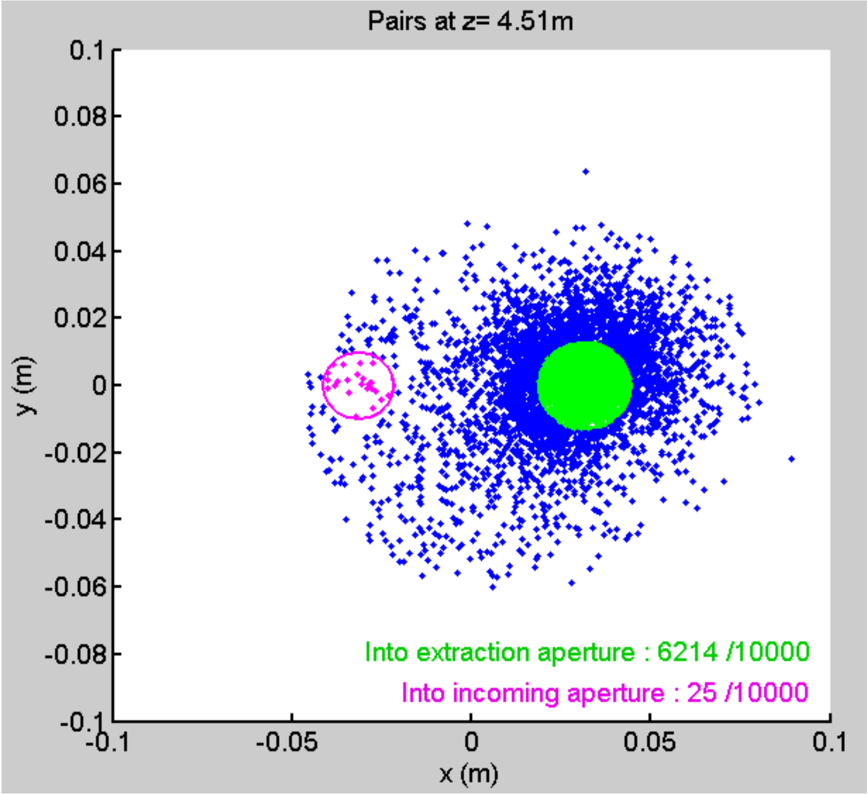










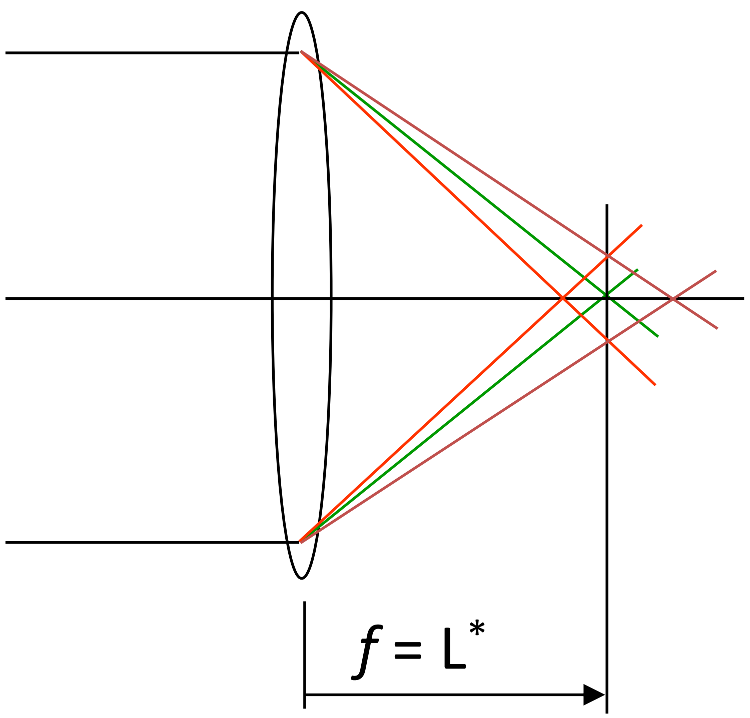


The Push to Smaller L*

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!

Effects of L*



$\xi_y^* \equiv L^*_y / \beta^*_y$

$\Delta\sigma/\sigma \sim \sigma_E . L^*/\beta^*$
(9.0-11.6) *for ILC baseline*

- Larger L* -> less (uncorrected) lumi through chromatic dilution of beam size
- Compensate with FFS optics design using high order magnets
  - Sextupoles, Octupoles
- Correction involves “balancing act” using quads, sextuples, octupoles to very precisely cancel chromaticity as well as up to 3rd or 4th order geometric & chromo-geometric terms introduced by the correction itself.
- Errors are introduced into lattice in real machine (alignment, finite accuracy magnet fields, unwanted higher-order field components in magnets, orbit errors etc) and must be compensated using pre-defined tuning algorithms based on experimentally observable parameters.
- In general terms, smaller L* = better expected luminosity performance.

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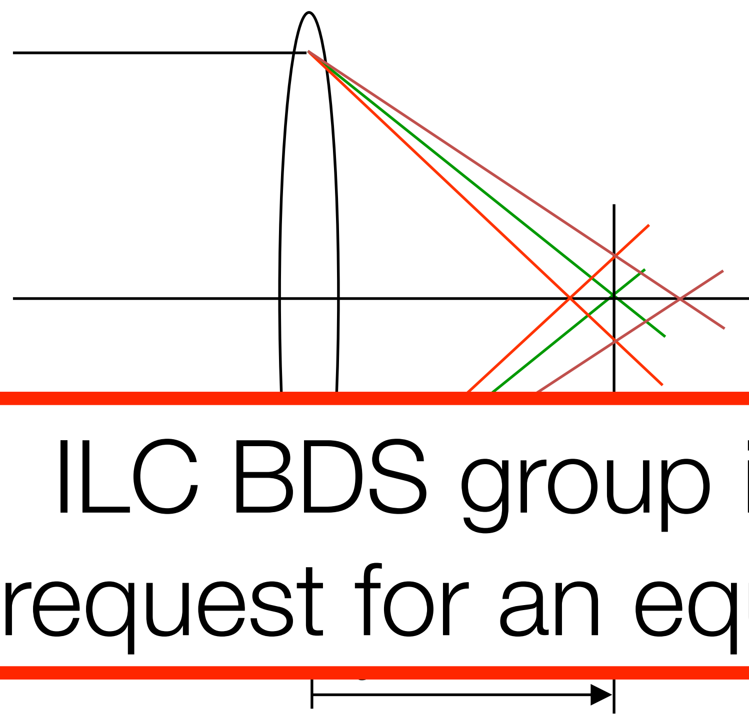

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- Compensate with FFS optics design using high order magnets
  - Sextupoles, Octupoles
- Correction involves "balancing act" using ... sely ... 4^{th} ... ms

ILC BDS group is preparing an official change request for an equal L^{*}<= 4m for both detectors

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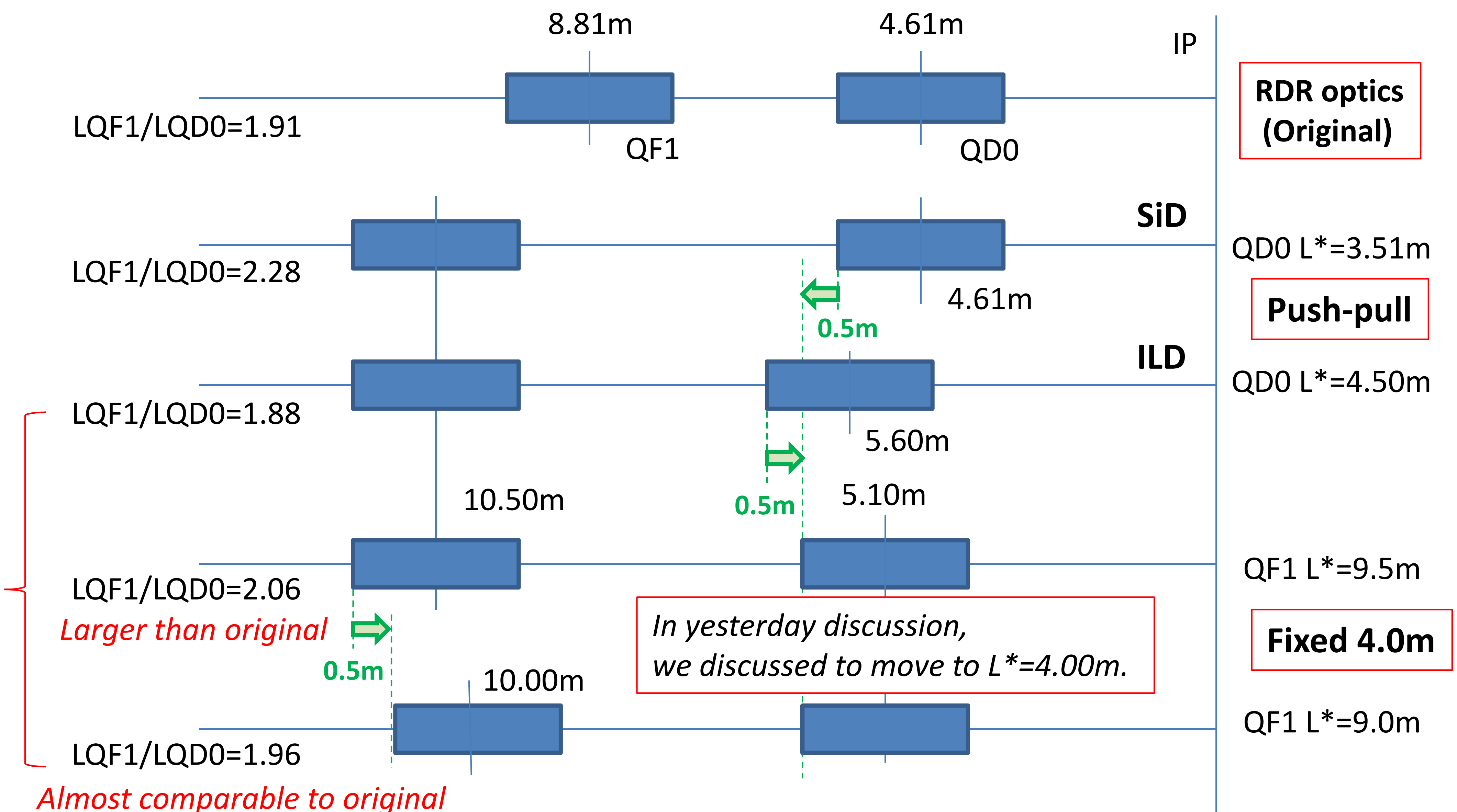
QF1/QD0 Configuration Discussion within BDS

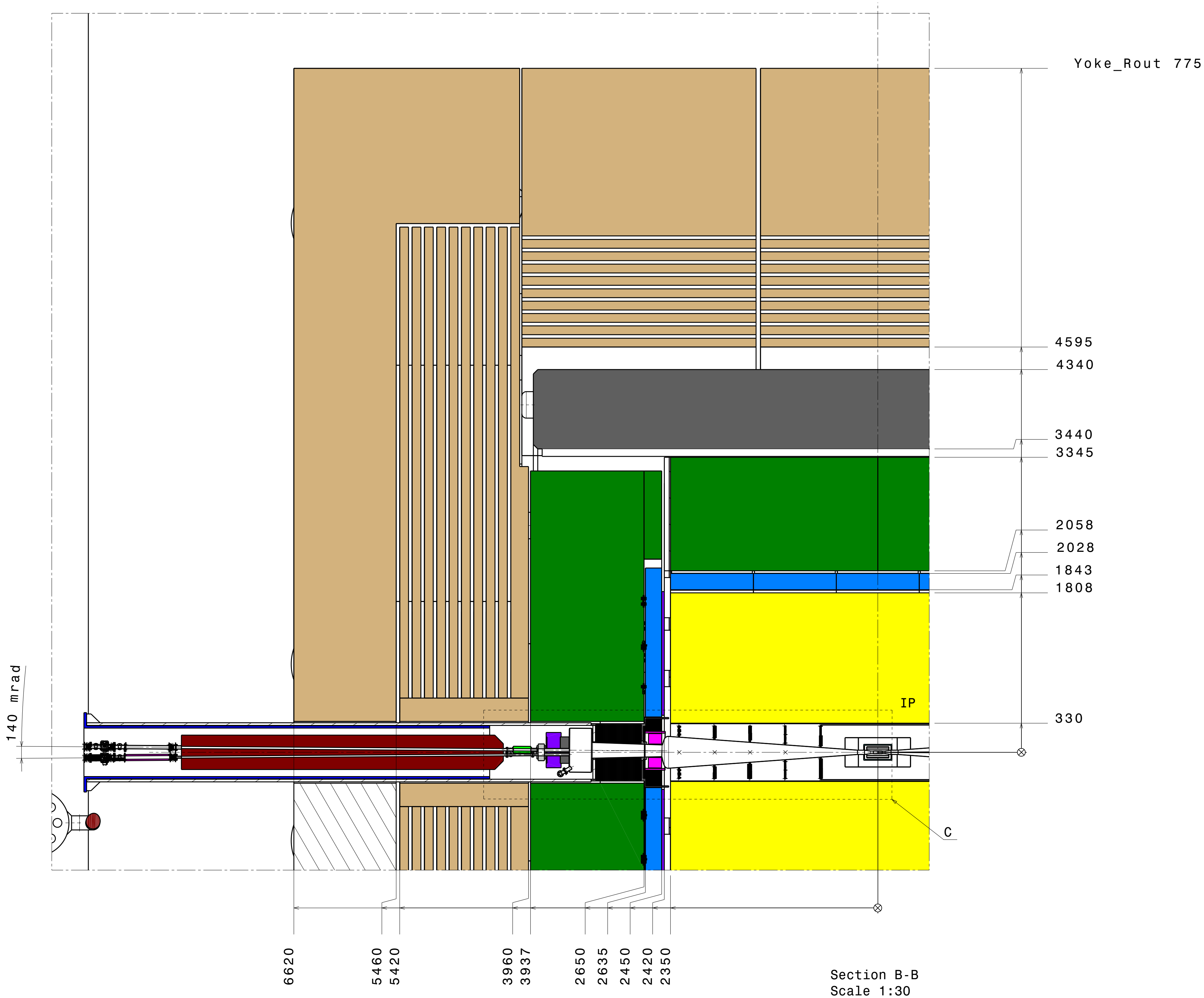


When we can move QF1 upstream by 0.5m for L=4.00m,*
I think L=4.0m is better than L*=4.5m (we need check whether this assumption is correct or not).*

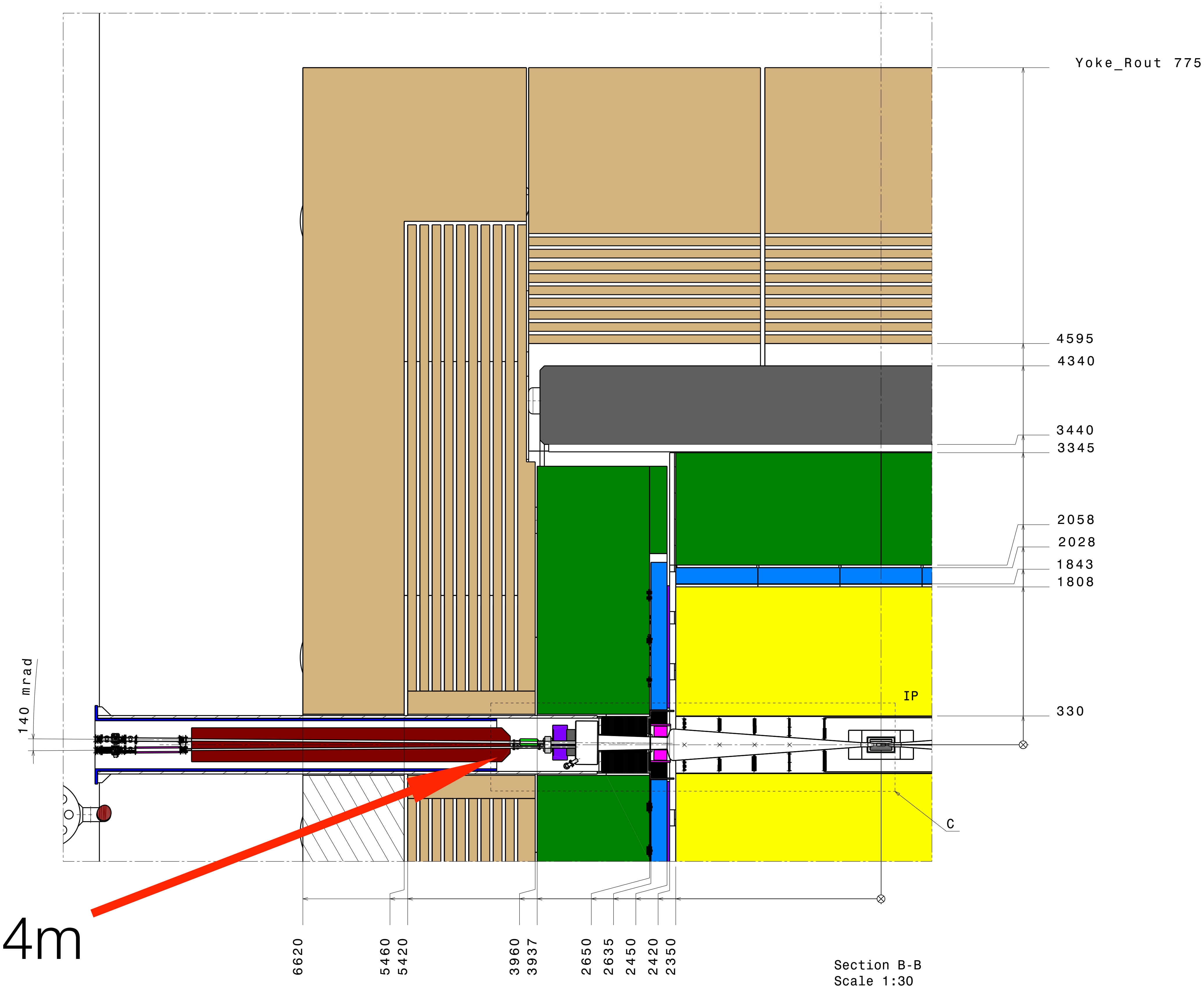
But, I'm not sure which are better for (QD0 L=4.50m, QF1 L*=9.5m) or (QD0 L*=4.0m, QF1=9.5m).*

Shall we decide at LCWS ?
If YES, I will investigate the tolerances for above 3 optics by the LCWS.

ILD Dimensions



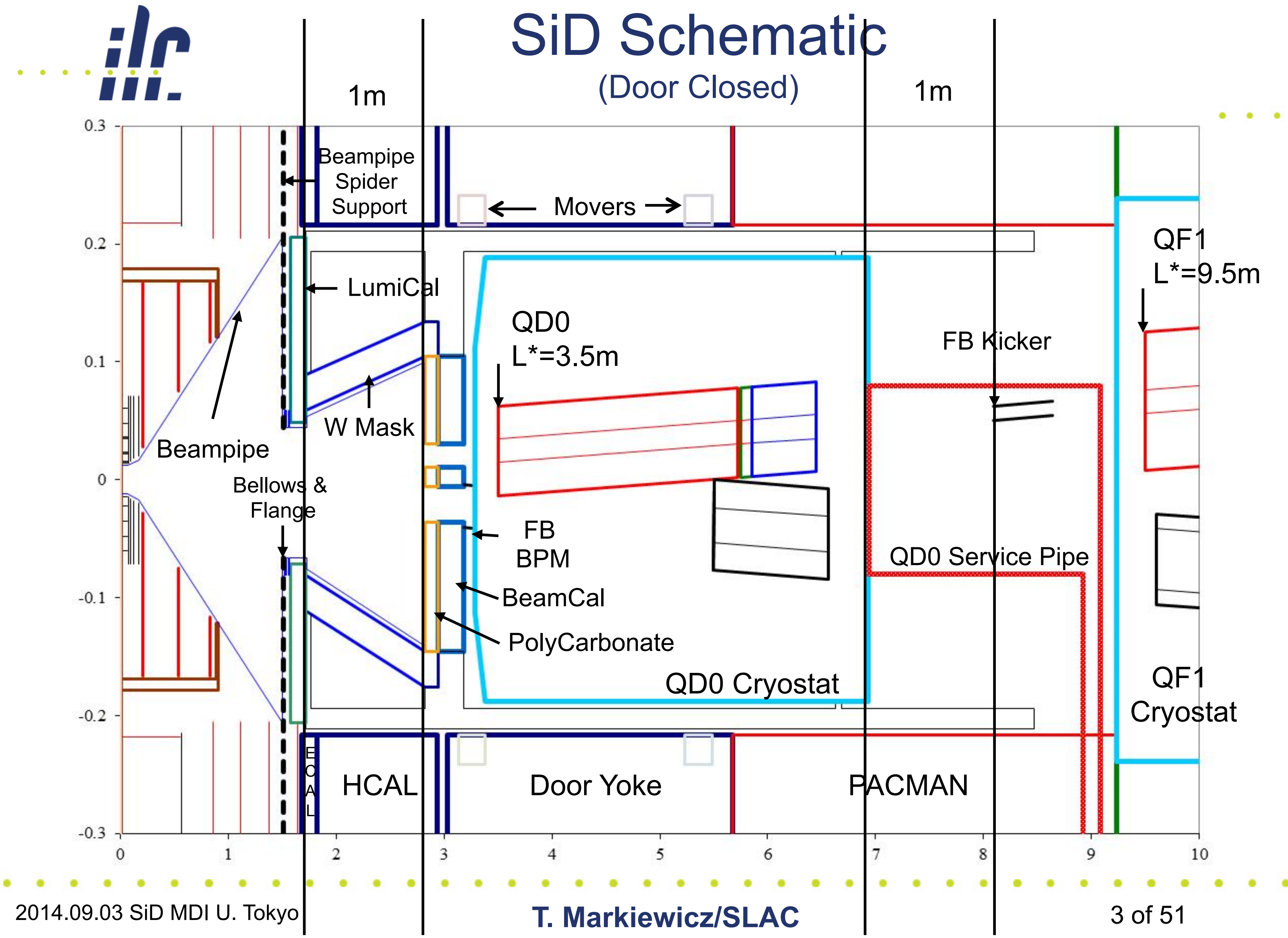
ILD Dimensions



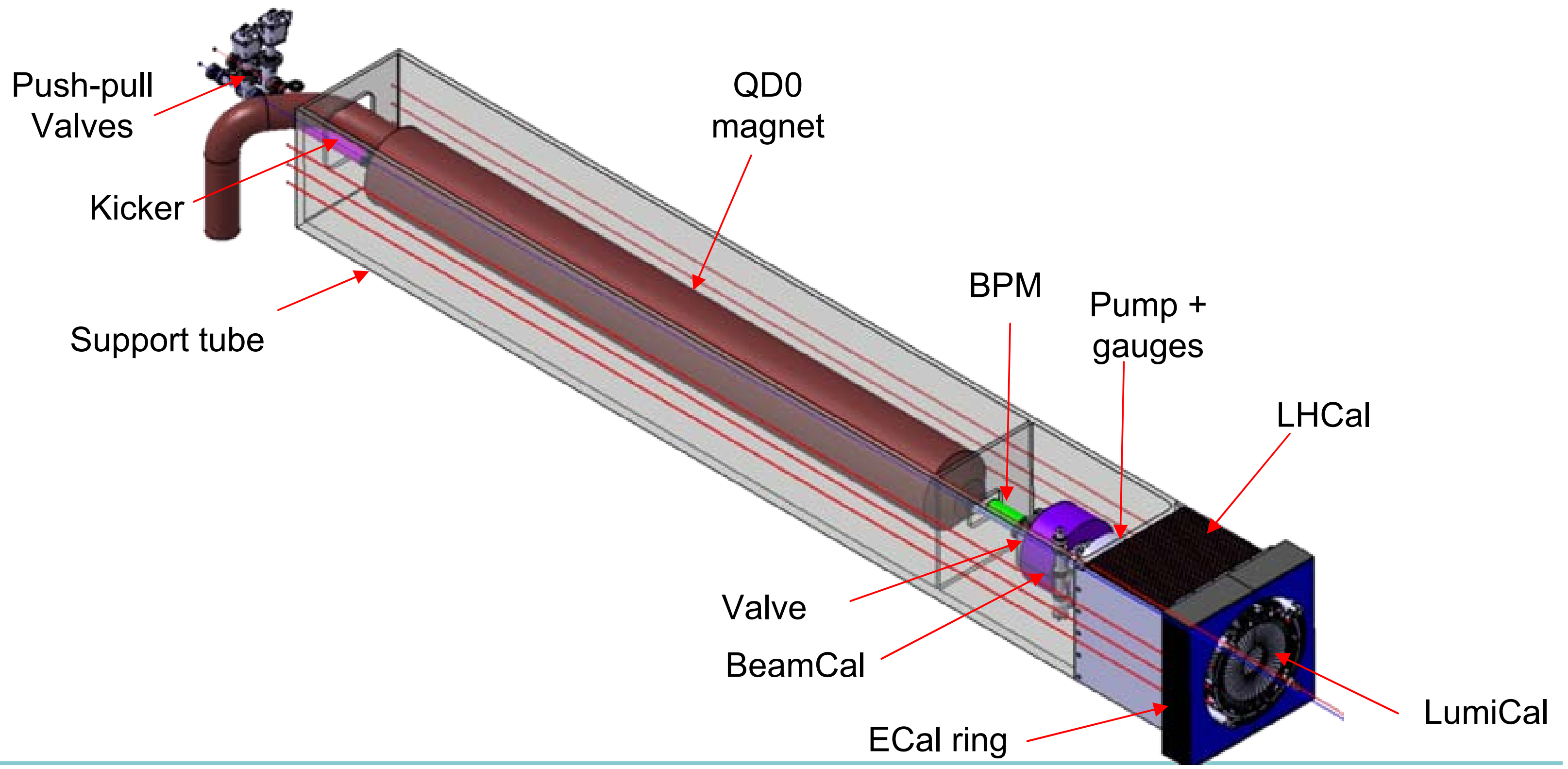
L*=4.4m

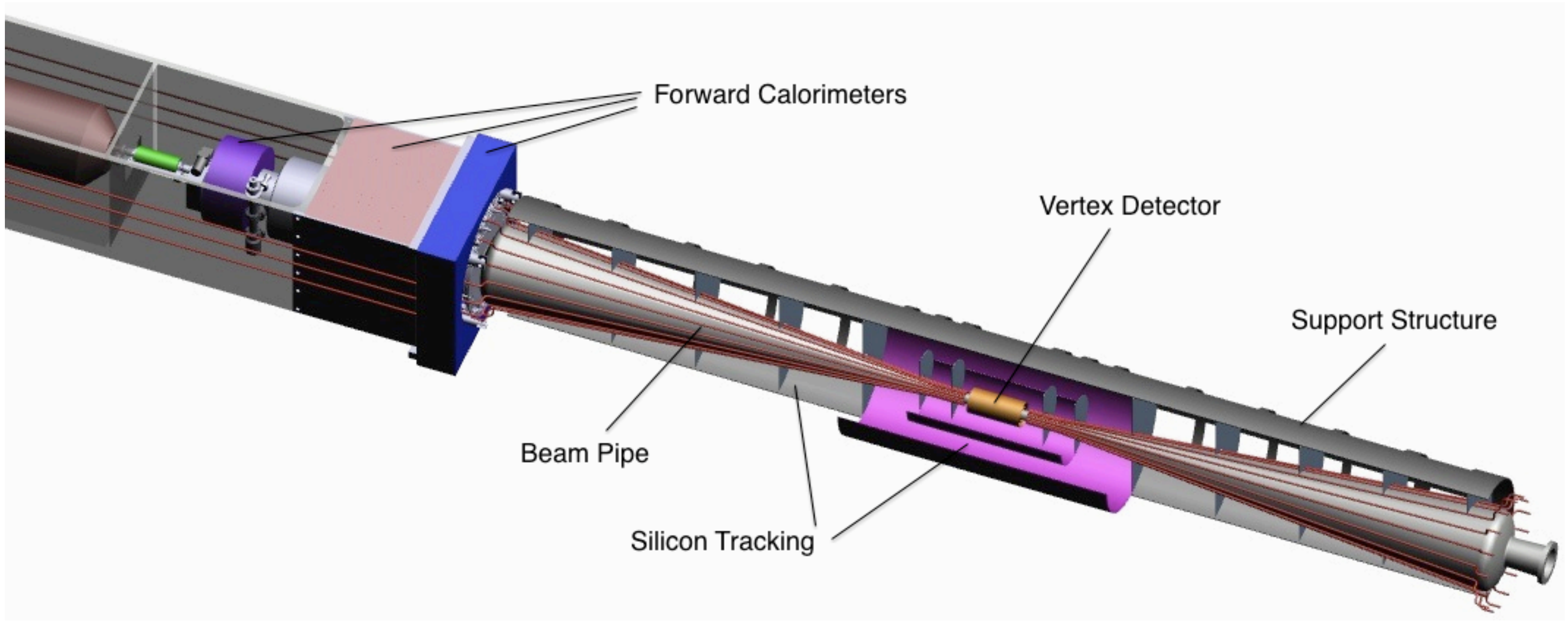
L* at SiD

- SiD has actually L*=3.5m
- Can accommodate anything between 2.6 and 4.5m
- SiD supports the ILC change request and pushes for small L*

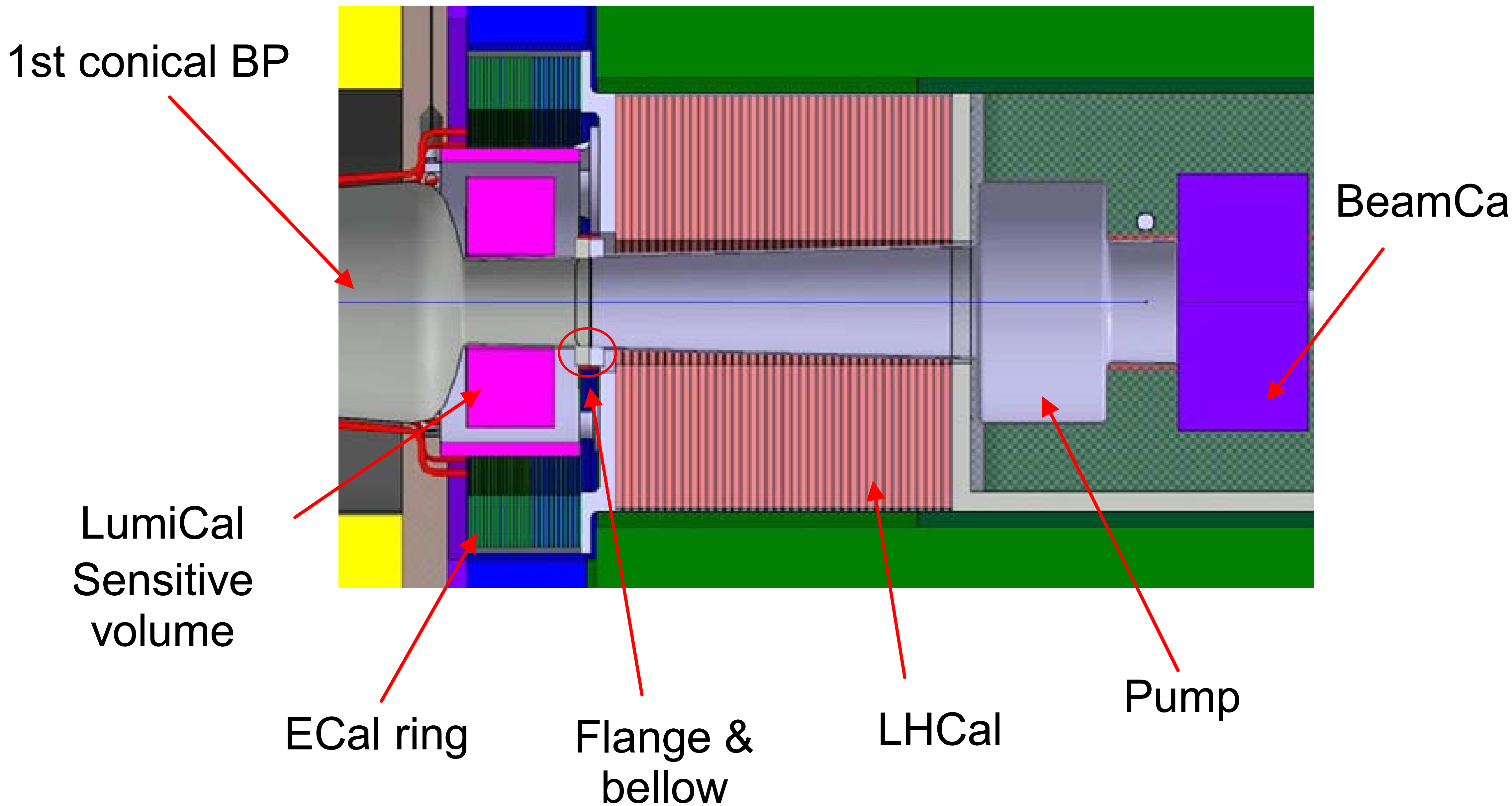


QD0 and FCAL Support in ILD

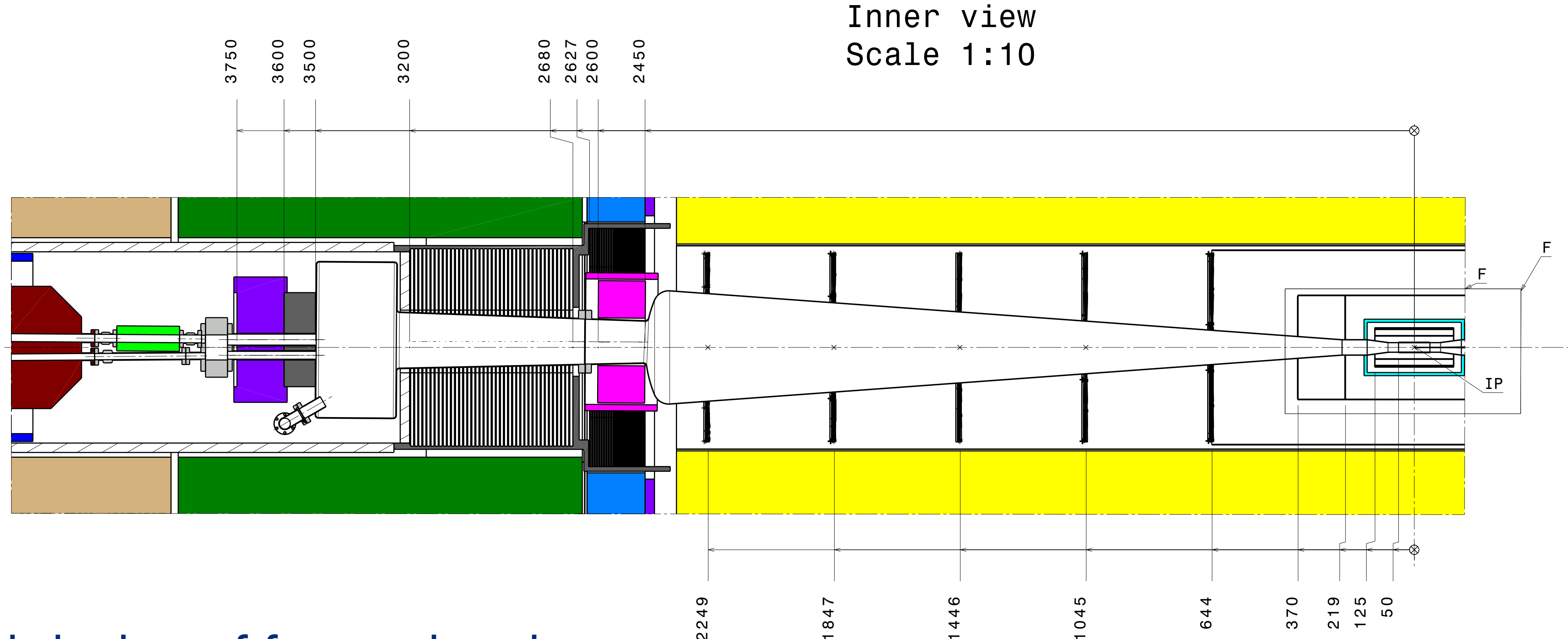




ILD Forward Region

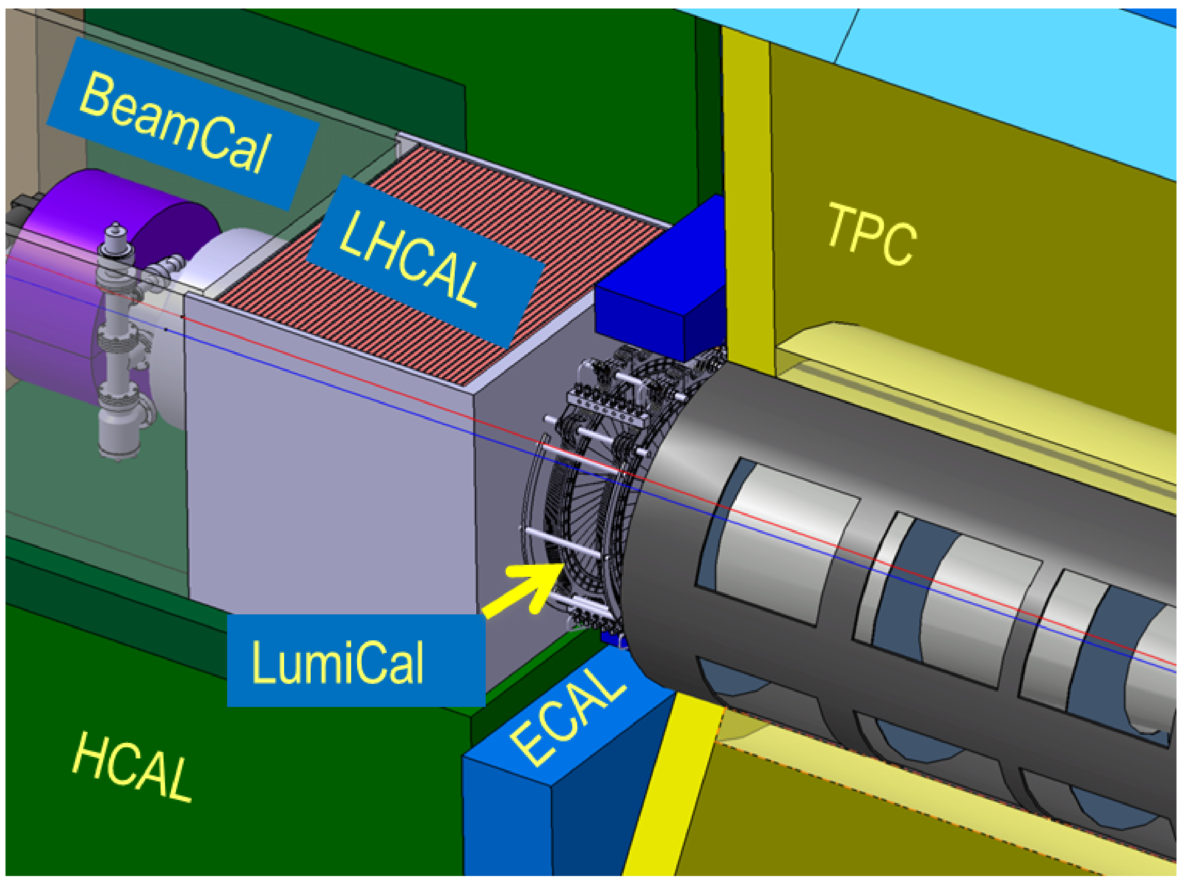


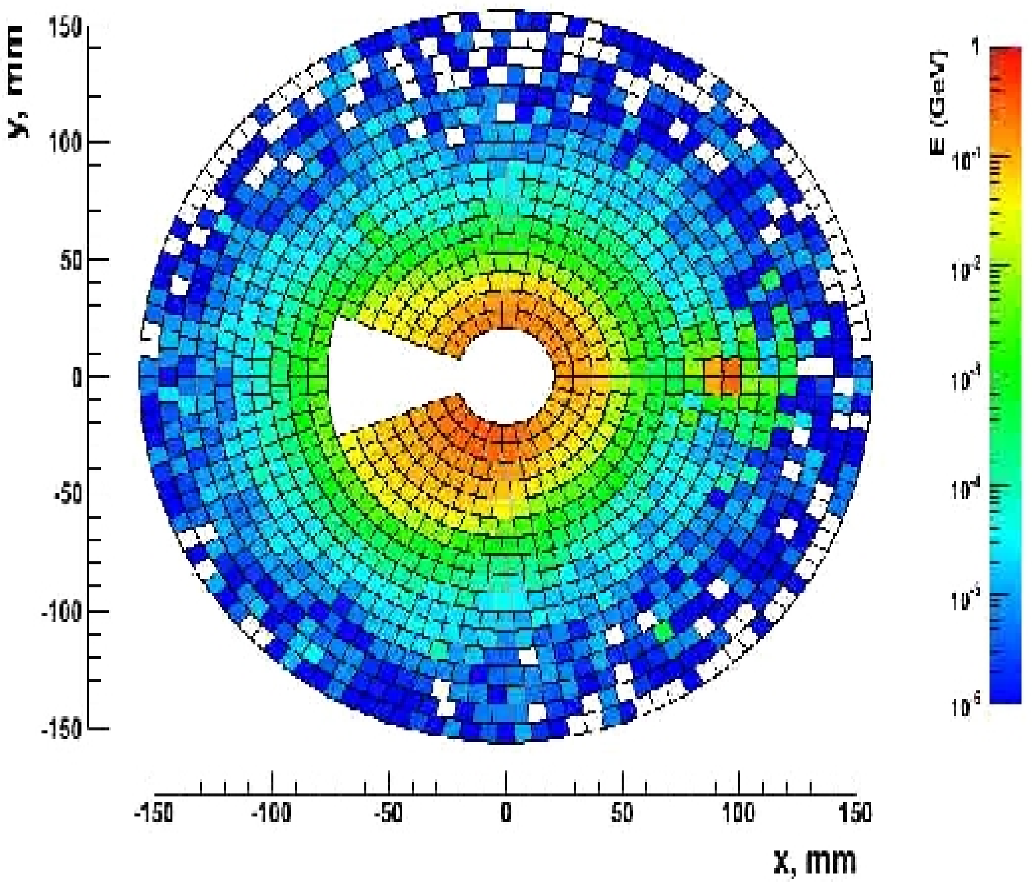
Current Lower Constraints on L*



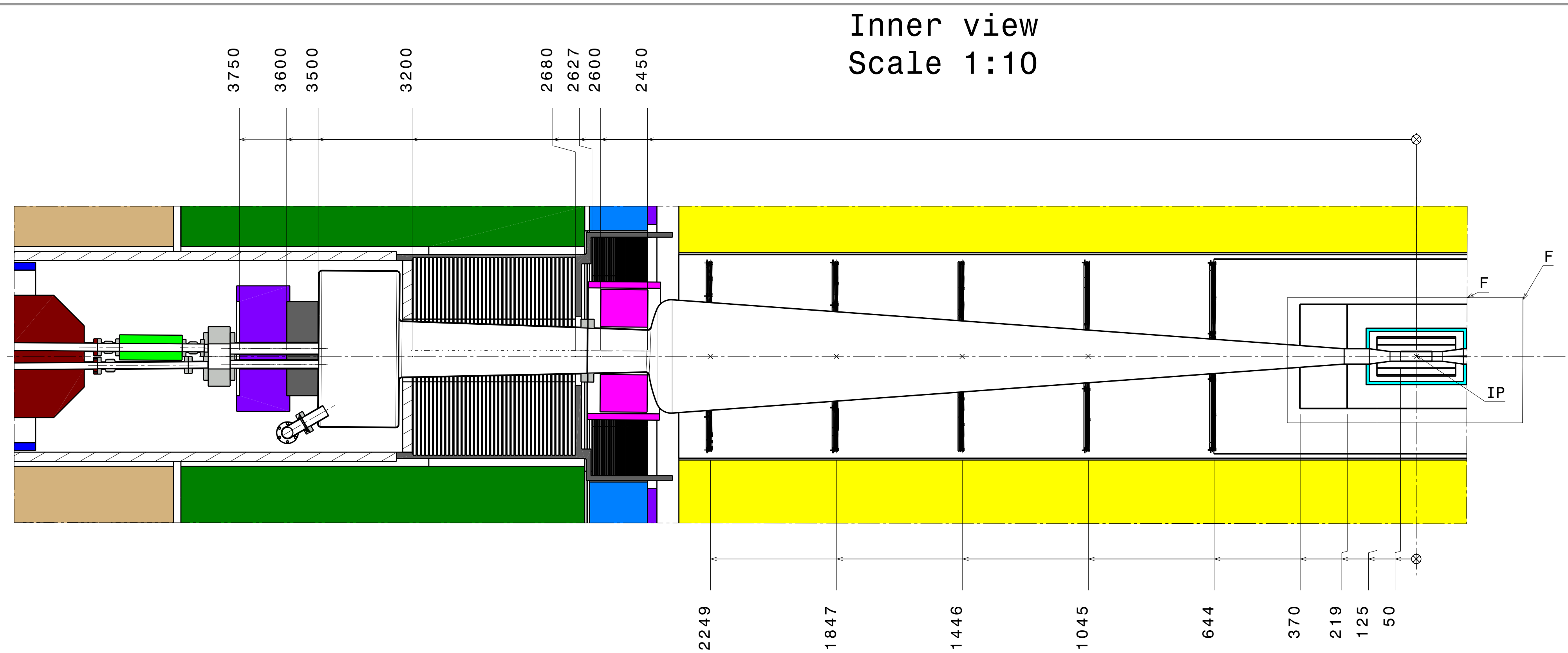
- Detailed design of forward region:
  - LumiCal, LHCAL, BeamCal
  - Beam Pipe, Bellows, Flanges, Vacuum Pumps
  - Optimised (many FTEs in the last ~10y) for
    - operations: no FCAL or masks inside the tracking volume
    - assembly and maintenance
    - physics: VTX (occupancies and layer radii),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

FCAL Integration





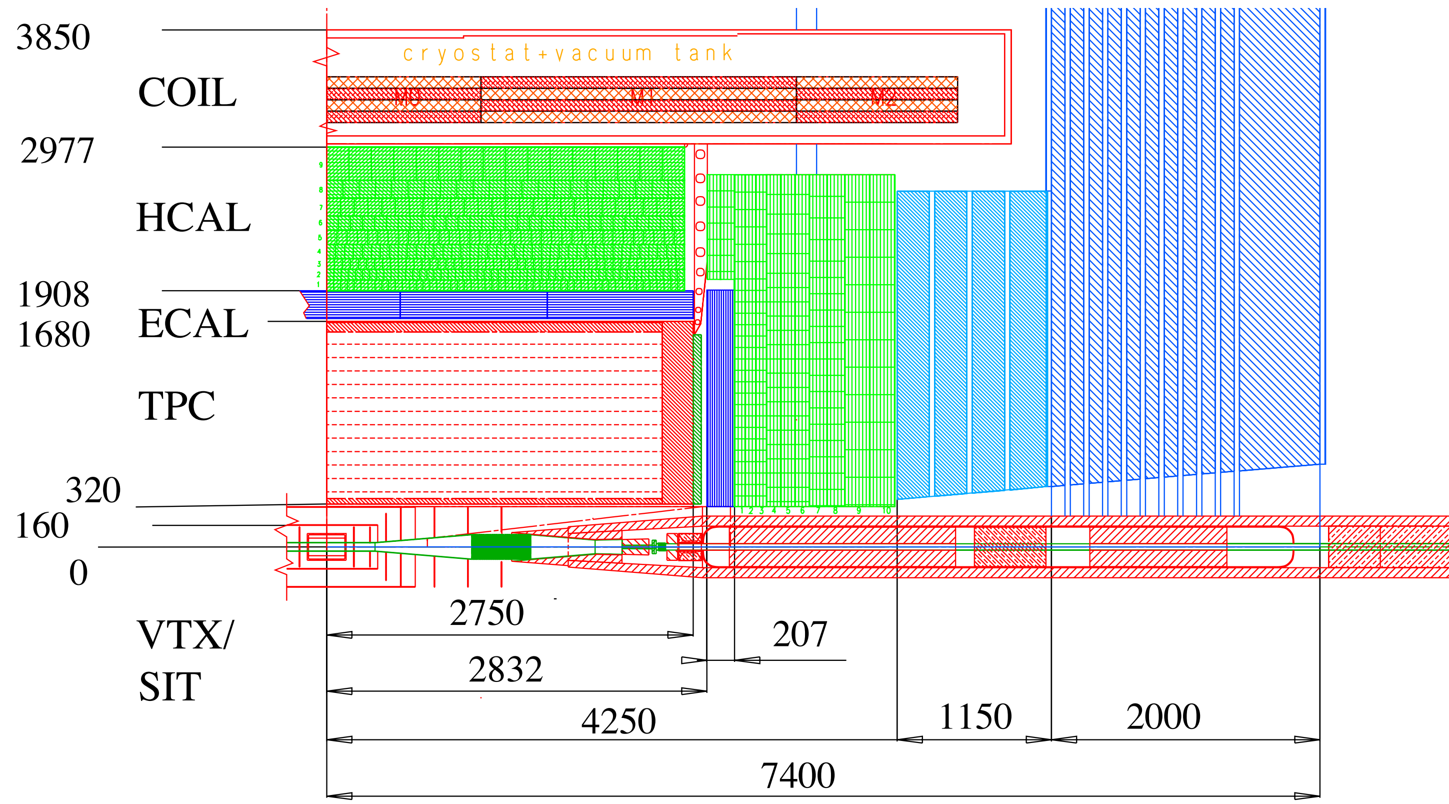
How to make L* smaller?

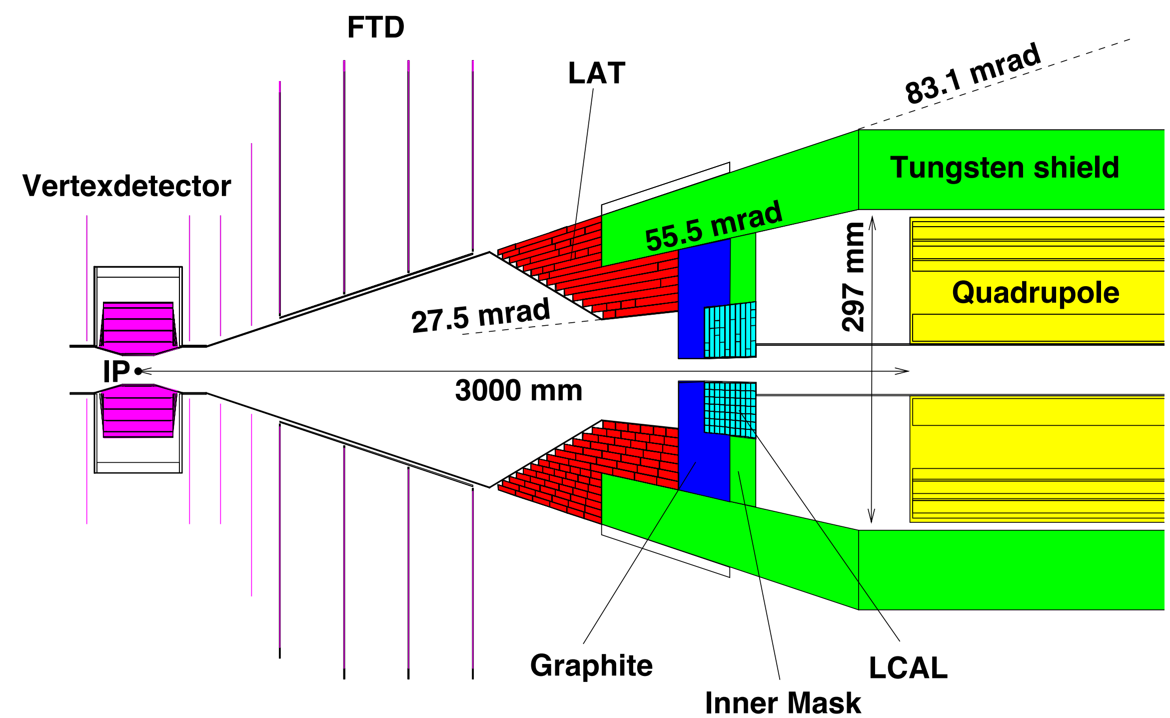


- If we keep the dimensions of the detector and want to keep the forward calorimeters and masks out of the tracking volume:
  - very little maneuvering room:
    - reduce space for pumping, flanges?
    - remove LHCAL? physics implications not known…

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



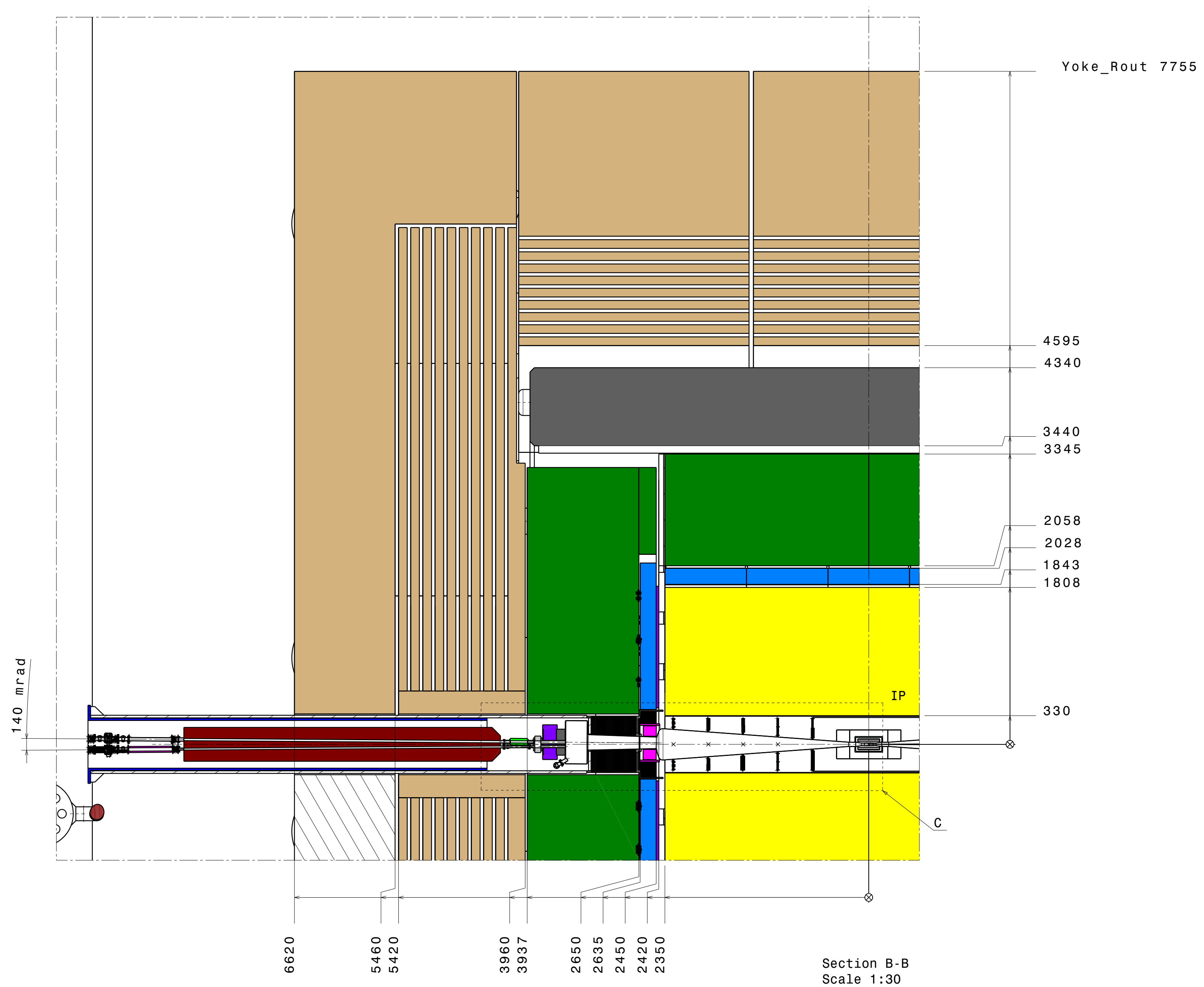


Way forward?

- Easy solution: keep L* where it is… ruled out by imminent change request from ILC BDS
- Make L* smaller: re-design forward region
  - major effort: physics performance, backgrounds, engineering design
- But: what if ILD would become smaller?
  - Effort within the ILD performance group to look into smaller radius for the TPC
  - If aspect ration is kept, this will make also the length of ILD smaller….
  - Many aforesaid arguments still valid: major re-design needed
  - But: might result in significant cost savings for all of ILC… so it is worth to look into it
- Or maybe make L* bigger (CLIC proposal)? (also ruled out by change request)
  - this makes sense if it is so big that QD0 would not be a part of the detector anymore:
    - only one set of stationary QD0s that stay connected to the machine during push-pull
    - if we gain more integrated luminosity by making push-pull easier than we lose by all other problems, it might be worth it…. if….
  - ILC BDS group sees this not as a viable way forward

Smallest big L*

- L*>7.0 m if ILD geometry is kept
  - if ILD would shrink, this would go down as well…



Beam Commissioning

IP beam tuning

- General philosophy: establish collisions ASAP and use beam-beam
  - Start with "micron" scale beams
  - One bunch (assuming beam jitter is small enough)
  - Or short train for feedback
  - (long enough train for single-pulse scans)
- At AWLC we discussed having a "temporary" Shintaki monitor @ IP
  - Impractical (IMO) [unless detectors are delayed]
  - Beam-beam much better
- 2-beam tuning: beam-beam scans and then luminosity

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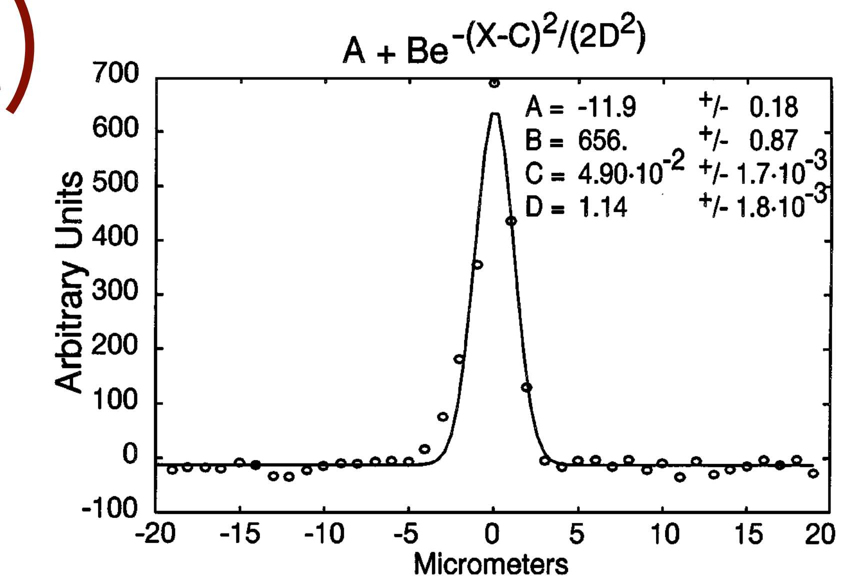
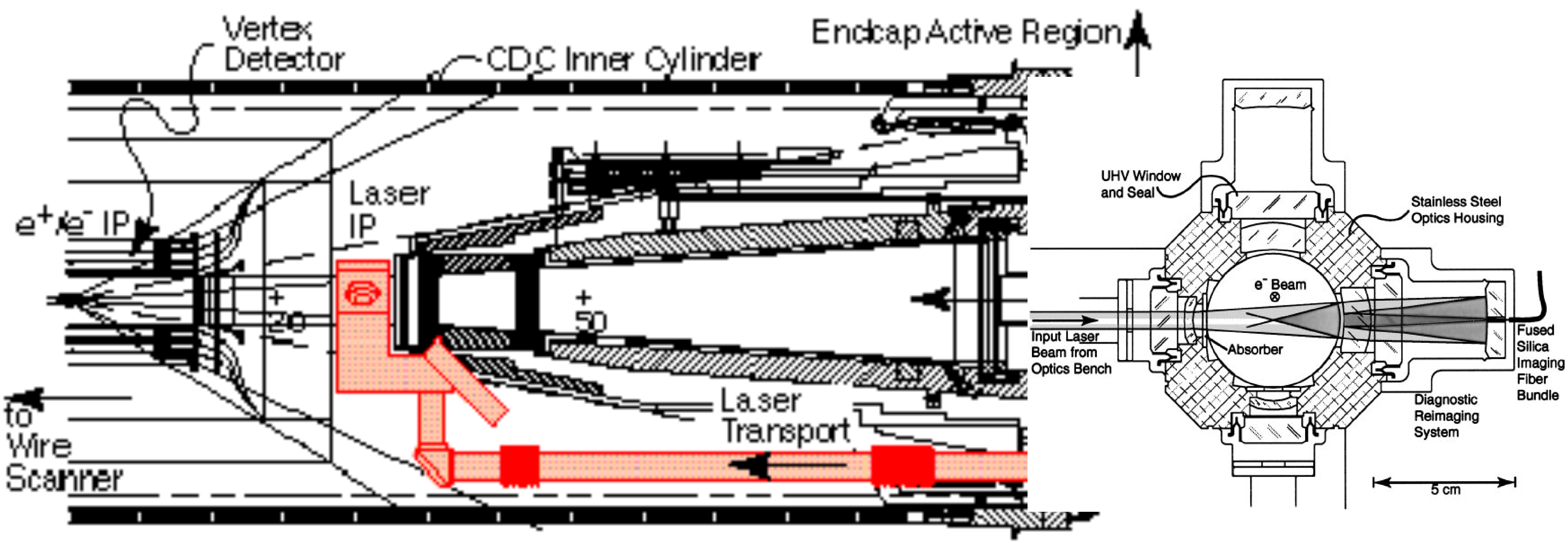
Beam commissioning relies on having a detector in place - SiD volunteered to do this at AWLC14….

IR laser wire? (SLD did it)

Profile monitor "close" to IP?
Probably can't do better than 250nm?
Need to "move waist" to ±X cm?
Useful? (Q to machine) Feasible? (Q for Det)





Summary

- BNL group is working on new QD0 design that could give a smaller crossing angle
  - lowers risk in crab crossing, probably no big other advantages for ILD
- Current ILD design relies on L*=4.4 m
- ILC machine is pushing for common L*<=4m for ILD and SID
- Making L* smaller at ILD is possible but not easy:
  - re-design of forward region might reduce L* by O(0.3)m
  - go back to TESLA-like solution with FCAL inside the tracking volume
  - make ILD smaller
- A larger L* makes only sense if it is big enough to keep QD0 stationary during push-pull
  - in current ILD design >7.0m
  - might shrink if ILD should shrink…
- We might be asked to put some beam diagnostic devices into already crowded areas of ILD…