SiD Machine Detector Interface Recycled From ALCW 2015, KEK, Japan 23 April 2015

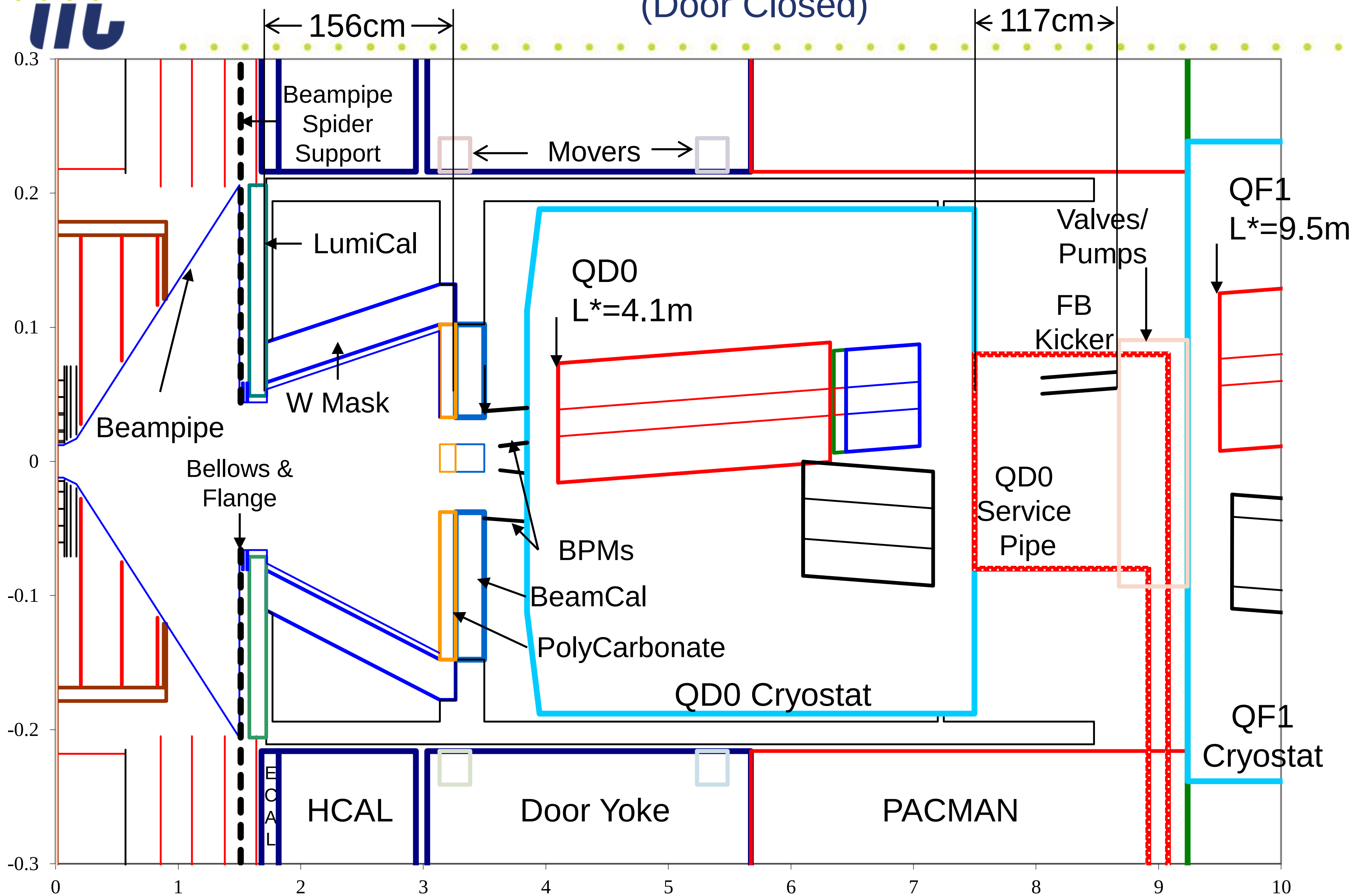
Tom Markiewicz/SLAC

2021-09-17

ILC IDT WG3 MDI-BDS

SiD 4.1/9.5m FD with FB Kicker Behind QD0

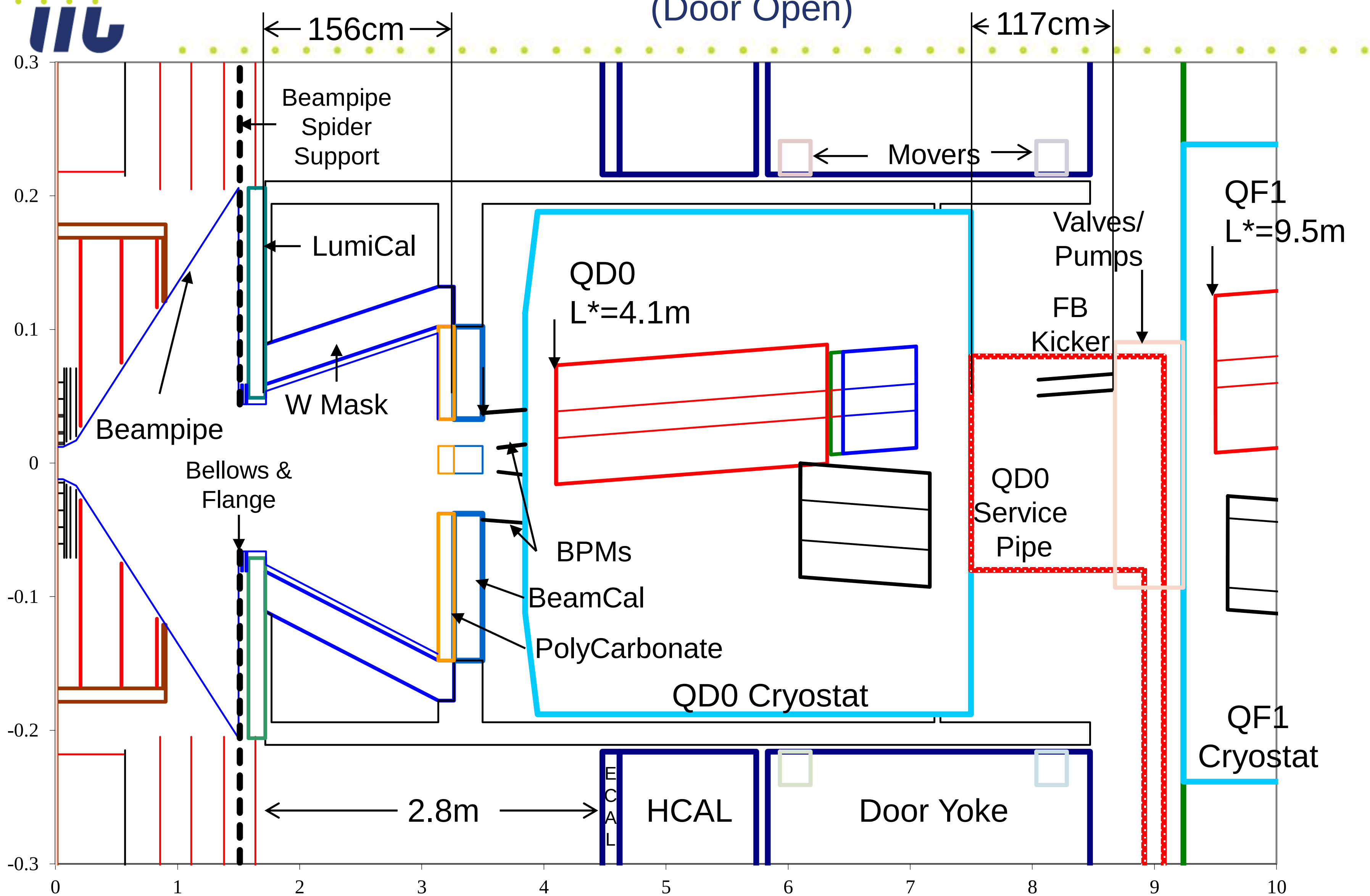
(Door Closed)



T. Markiewicz/SLAC

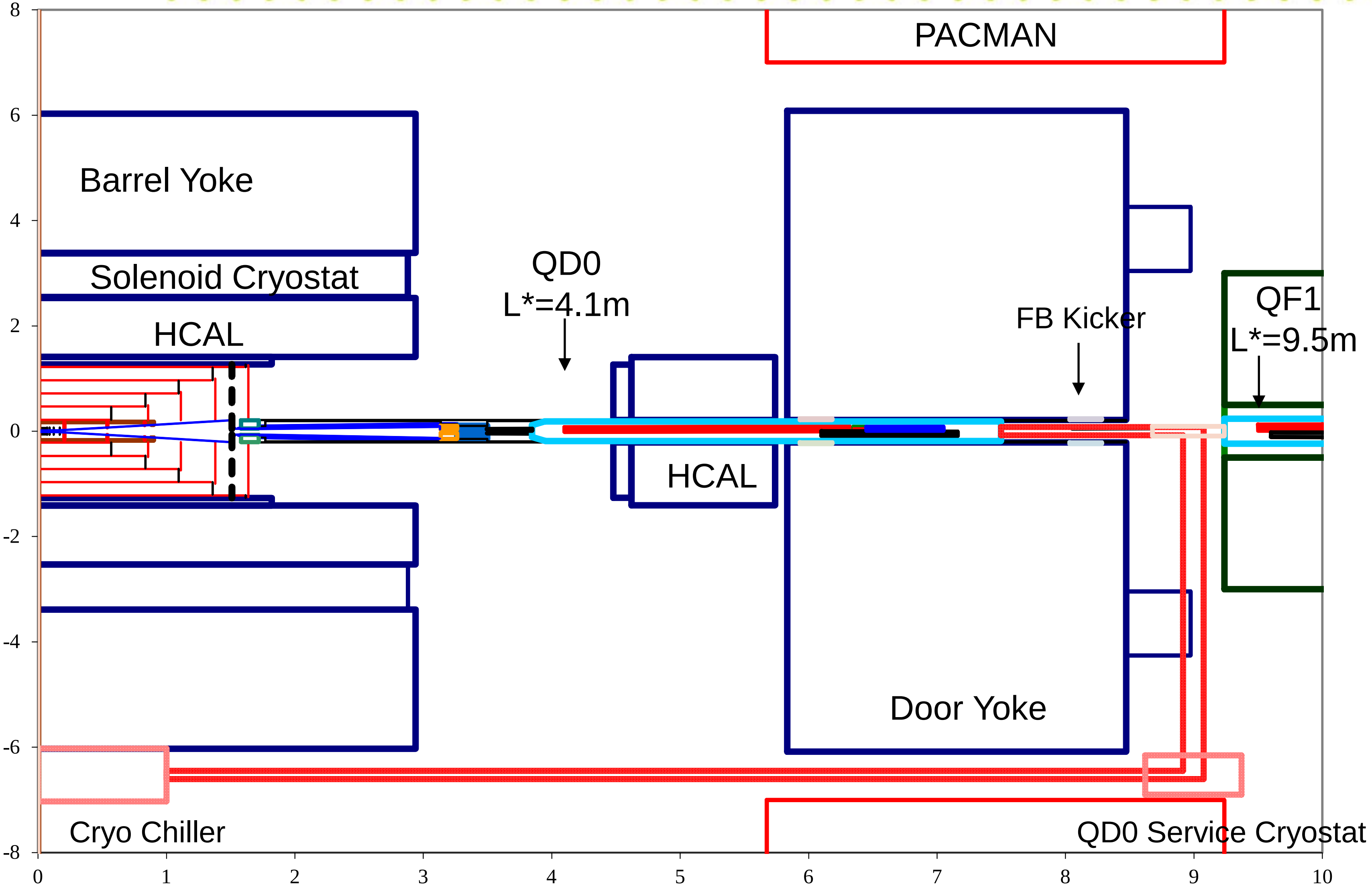
SiD 4.1/9.5m FD with FB Kicker Behind QD0

(Door Open)



SiD Schematic

(Door Open 2.8m)



“Recent(?) Past” MDI Projects

2011-12 for DBD:

- **Add real vacuum components to beamline to make sure it is buildable**
- **QD0 Support Tube and Magnet Mover System**
- **Frequency Scanning Interferometer System**
- **Vacuum and High Order Mode Calculations**

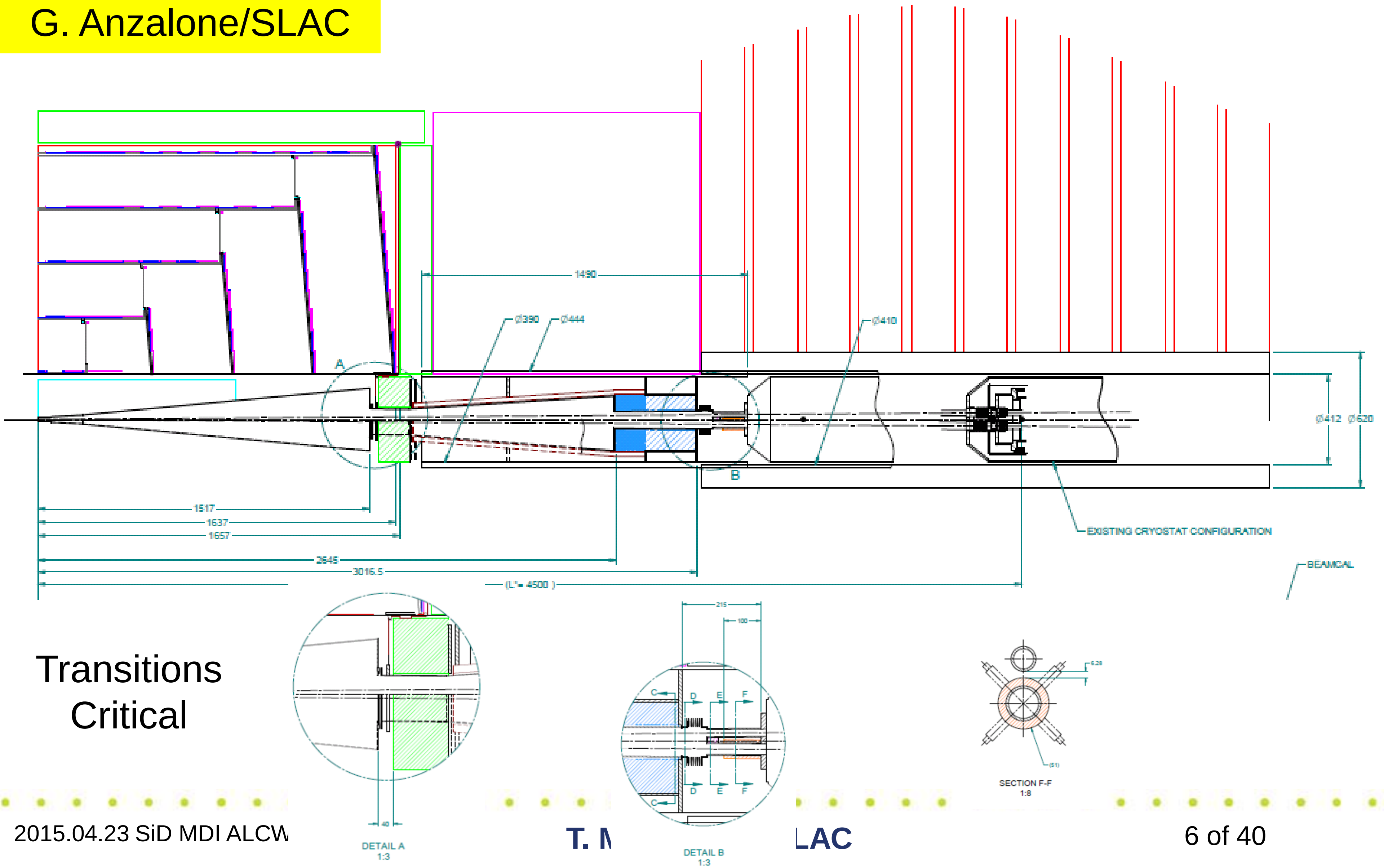
Older:

- **Self Shielding Calculations (2010?)**
- **PACMAN Engineering (2008?)**
- **Beam-Beam Backgrounds, DID/Anti-DID, Apertures (2006 and for “SB2009”)**

Hot Topic Again

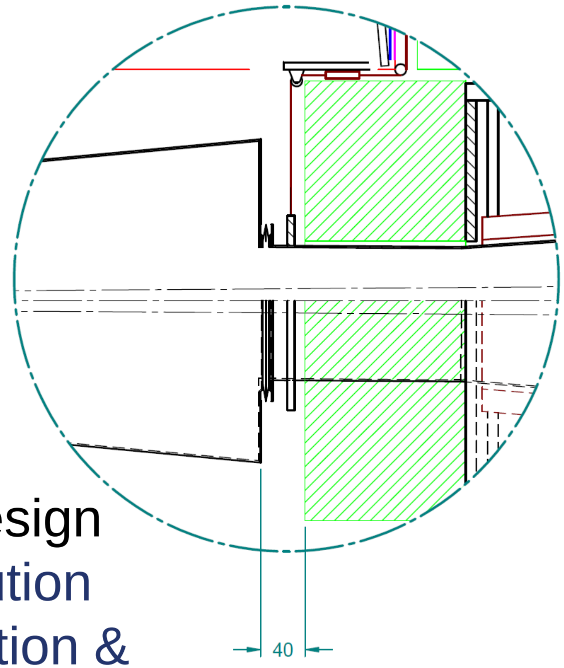
Granada LCWS'11 Engineering Model
Go from PPT Engineering to COTS parts

G. Anzalone/SLAC



Transitions
Critical

More Aggressive Bellows Design



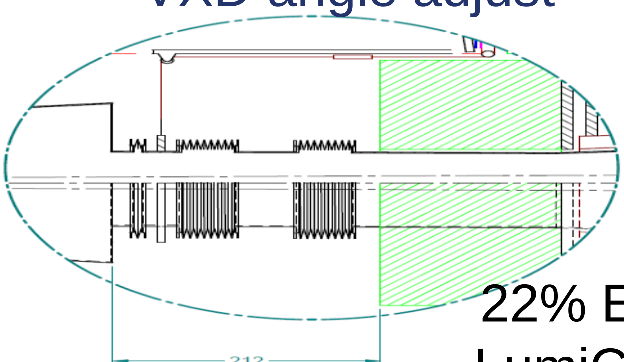
Assume functionality of double multi-convolution bellows provided by bellows outboard of the VXD support

Need to ensure adequate clearance between beampipe and all FCAL components

Suggested that this bellows "comes for free" if back end of cone appropriately engineered

Handshake with QD0/FCAL Support Scheme Essential

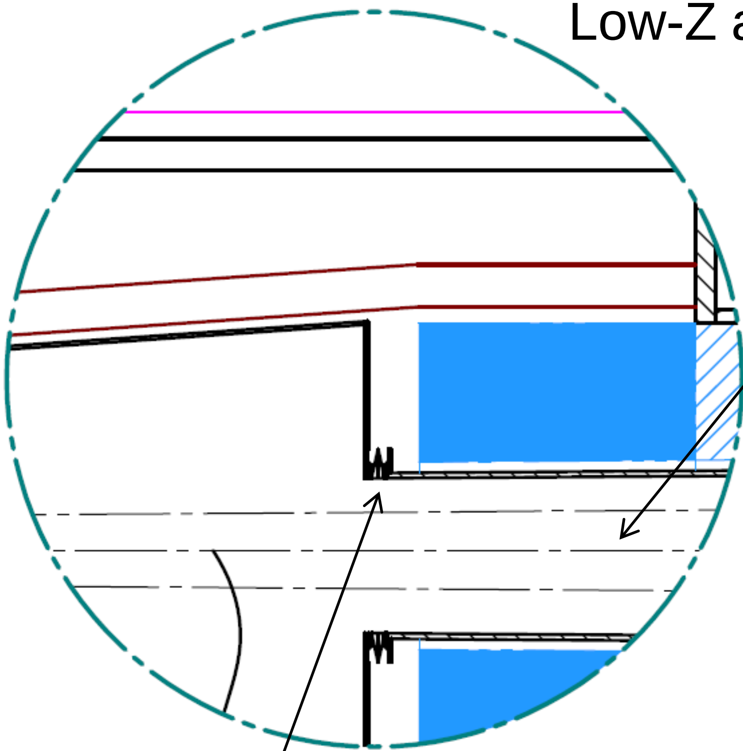
Rejected Conservative Design
2-multi & 1-single convolution bellows to allow FCAL position & VXD angle adjust



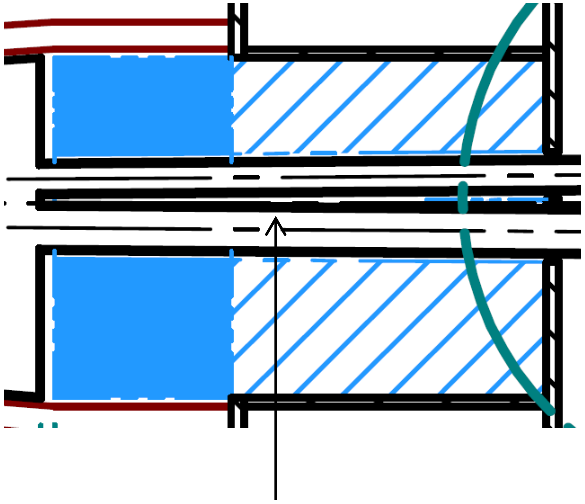
22% Evts in LumiCal lost

Vacuum: Still Assumes QD0 Cryo-Pump Only, But…..

Recent suggestion to eliminate **individual** beampipes within **BeamCal** and the Low-Z absorber for better conductance



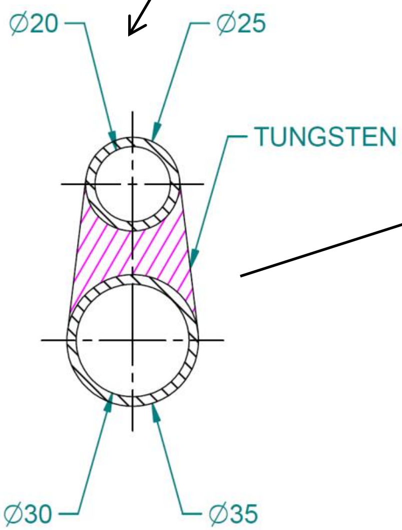
(“Virtual”?) Single Convolution Bellow in front of BeamCAL

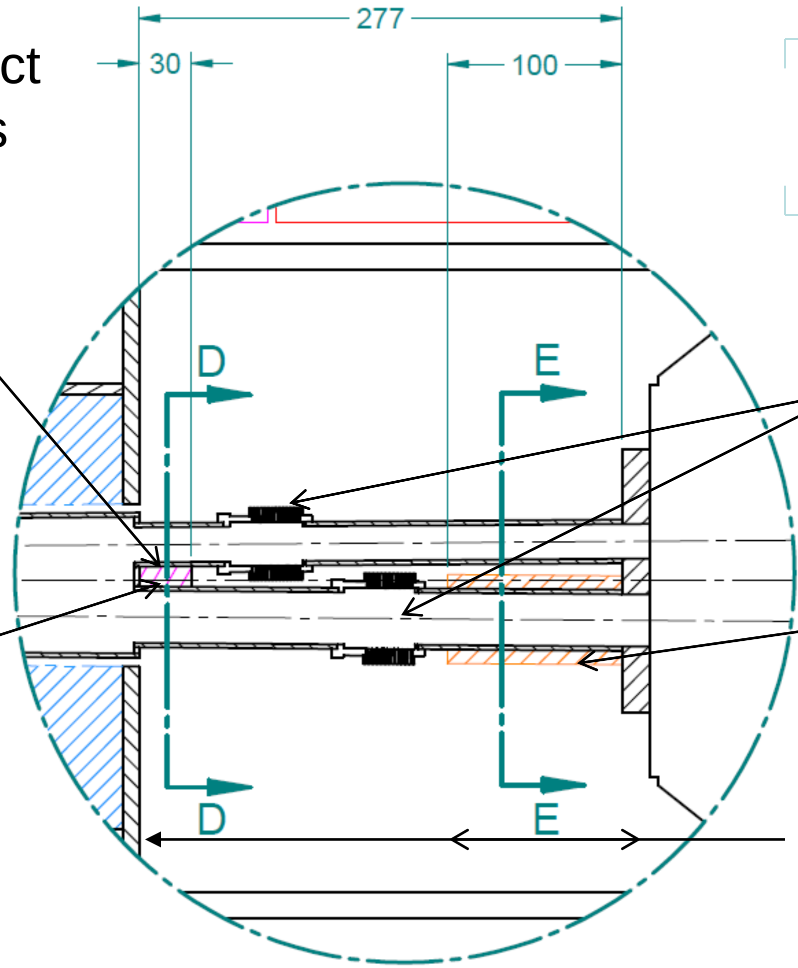


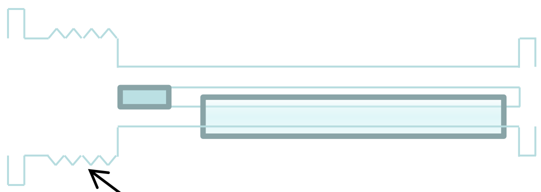
Previous Version Implication to reduced BeamCal acceptance not yet considered

Space Behind BeamCal Increased from 100mm→277mm to accommodate BPM

W-Mask to protect QD0 from Pairs







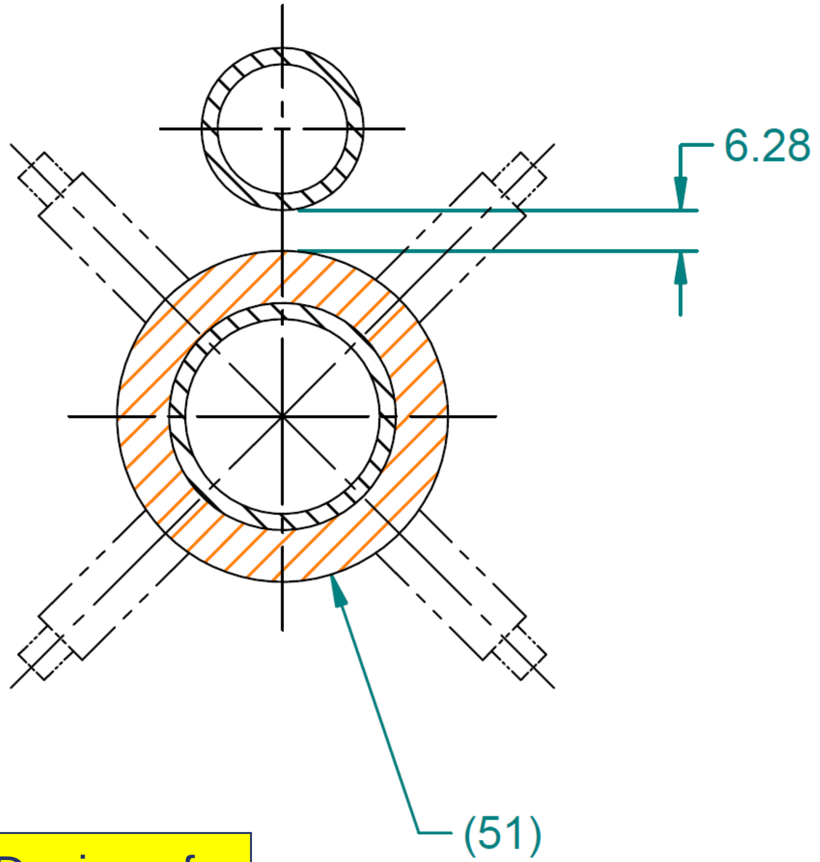
Common or Individual bellows

4-electrode 100mm stripline 1um resolution BPM

(2nd BPM Now Requested)

Increased separation to accommodate bellows, BPM and flanges

Transverse Space Behind BeamCal Tightly Constrained

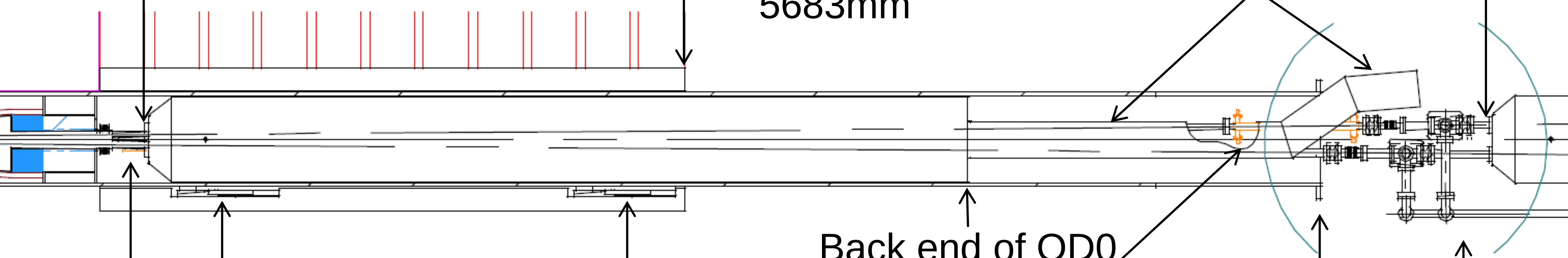


Electro-mechanical Design of
Fast Feedback BPM & Kicker
by S. Smith/SLAC 2006

Evolution of QD0-QF1 region

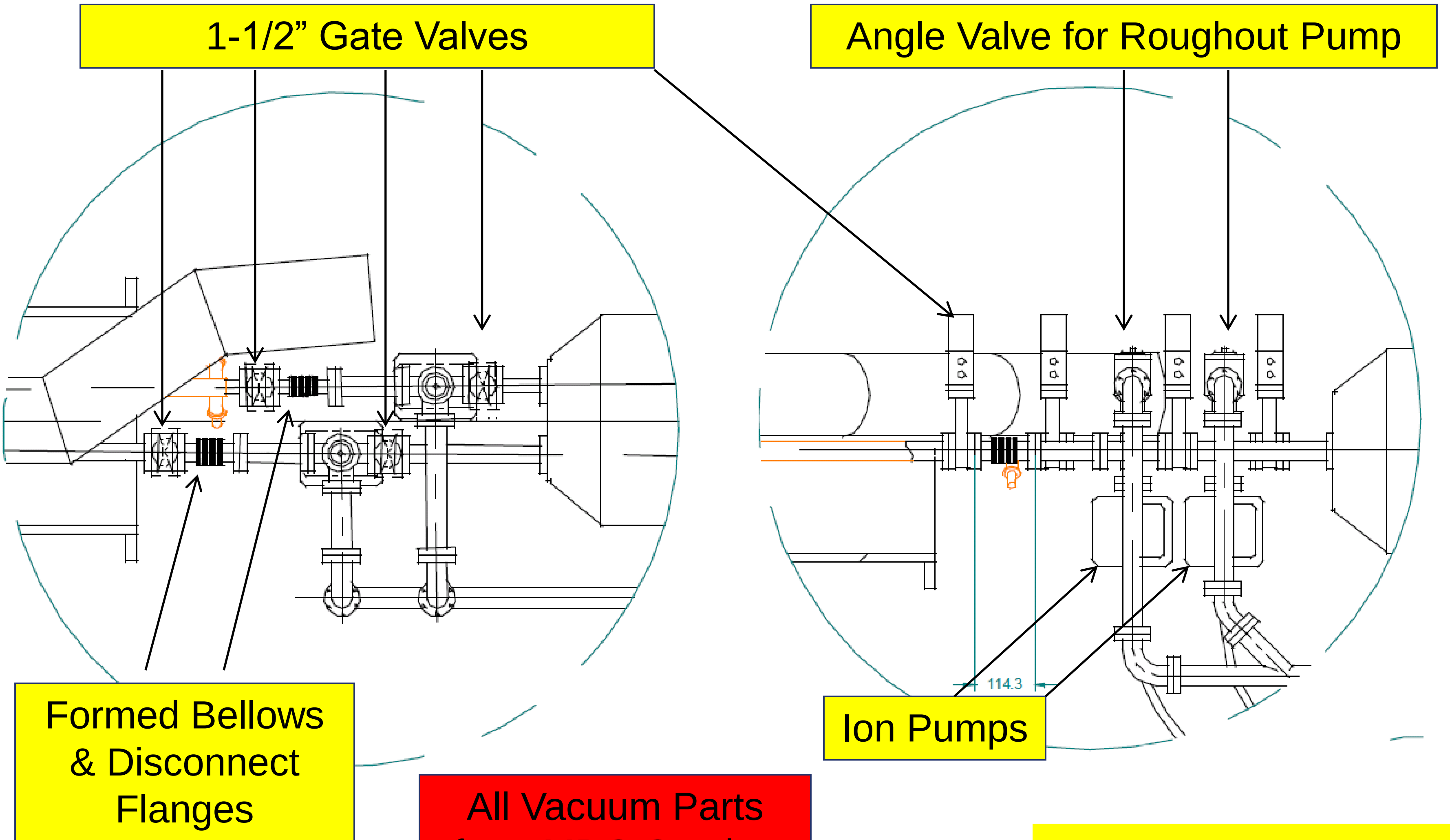
(L* = 3.5m Design; needs updating)

- 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

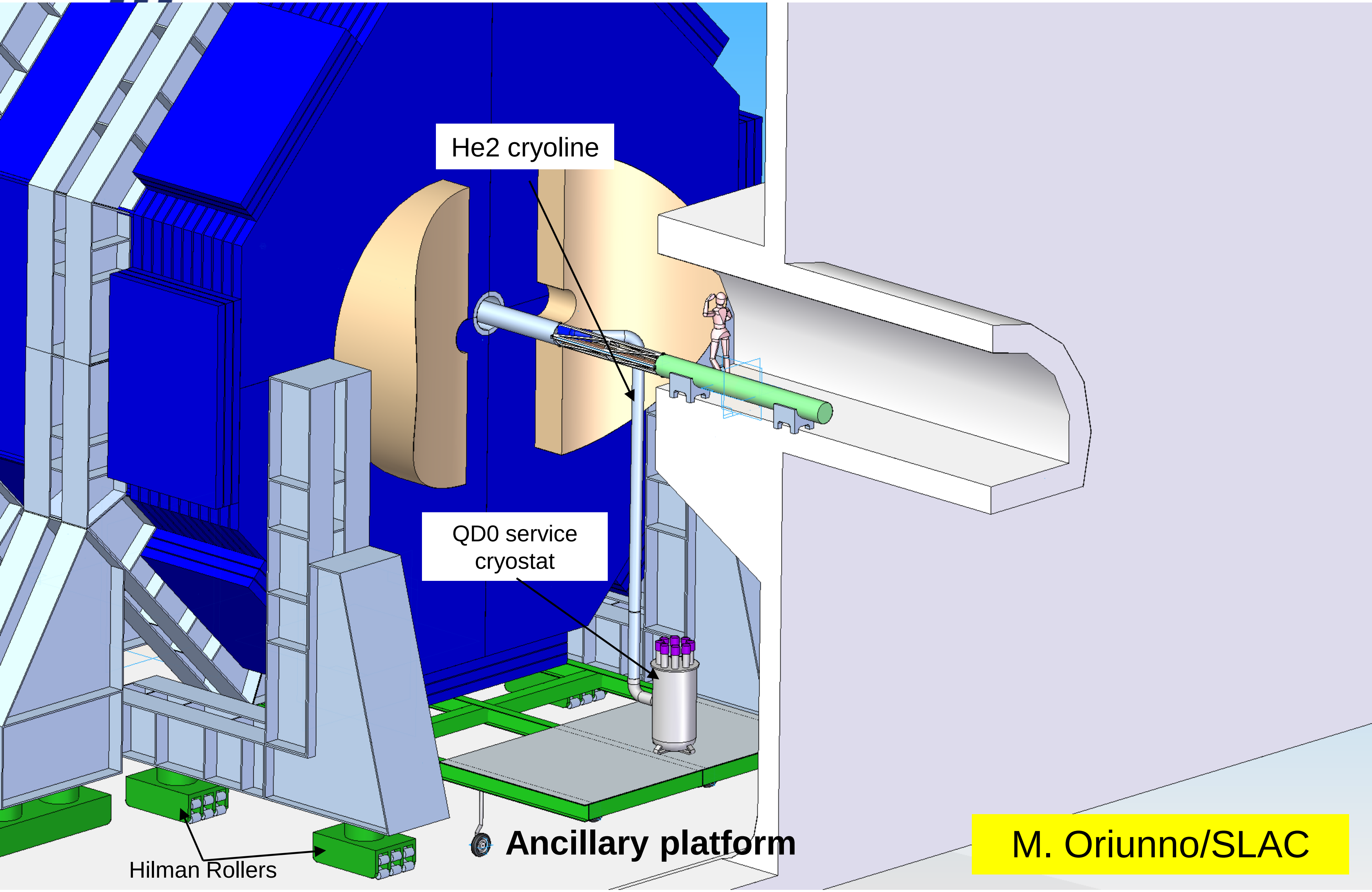
Plan & Elevation Views of Disconnect & Pumpout Valves Required for Rapid Push-Pull



All Vacuum Parts from MDC Catalog

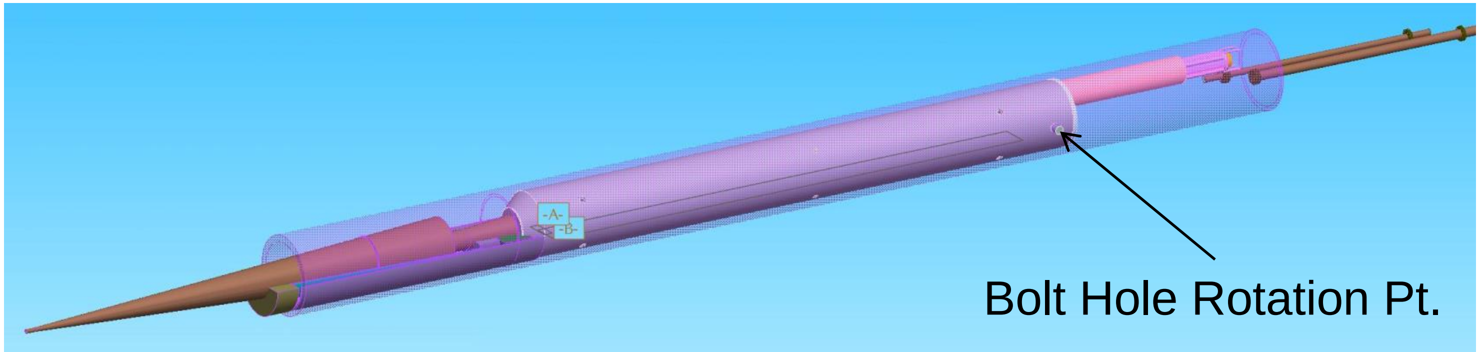
G. Anzalone/SLAC

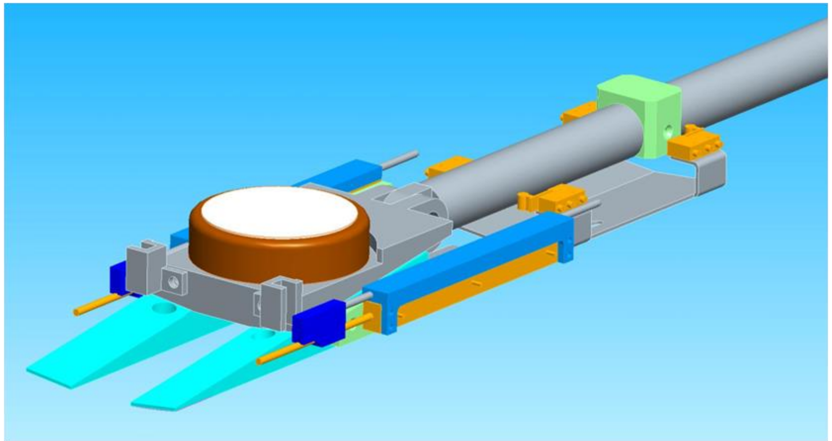
Integration of the QD0 cryoline



BNL Design of QD0 Support and Alignment System

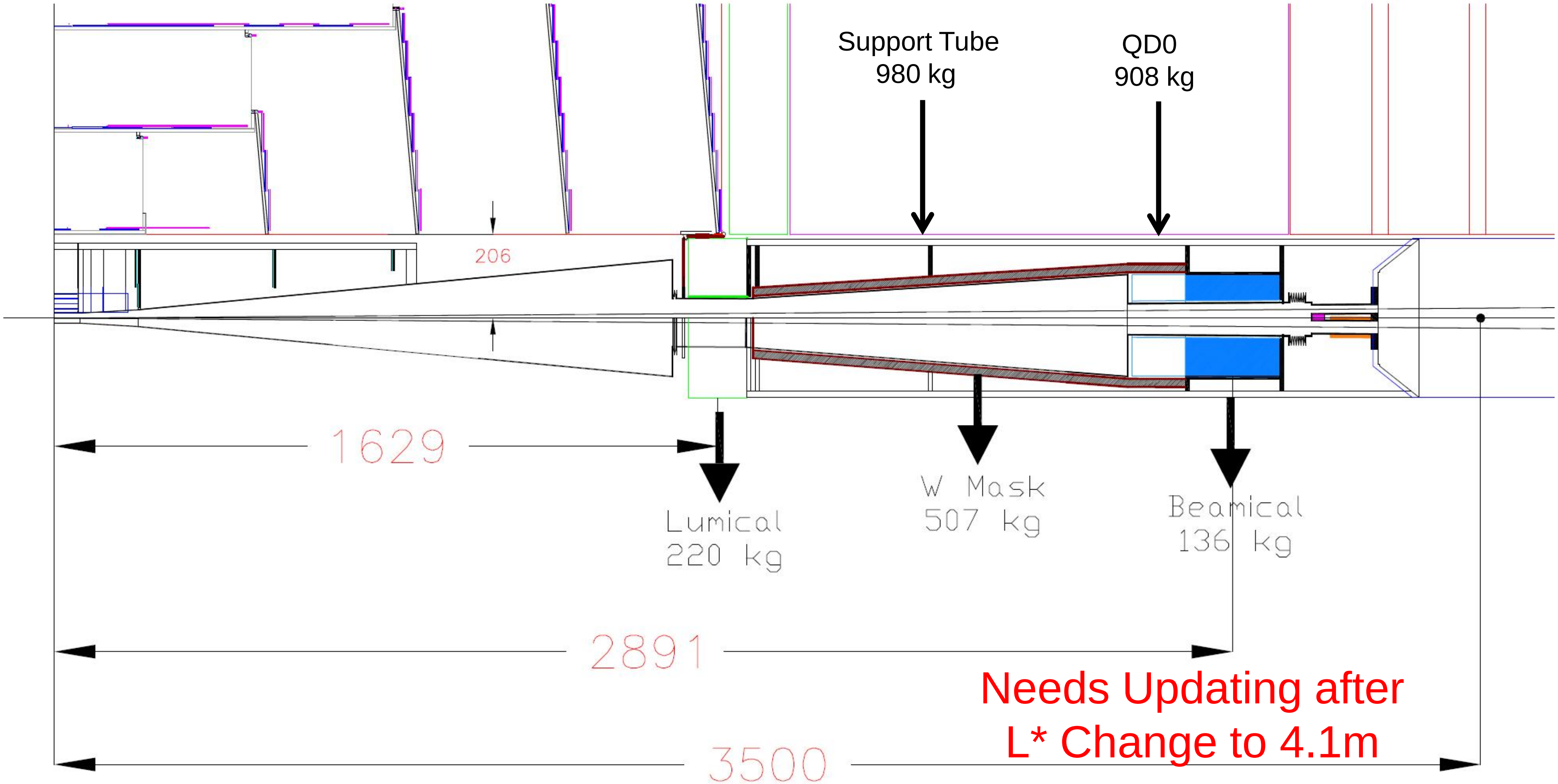
- ANSYS analysis of QD0 outer can in either original 0.25” or suggested 1” thickness shows unacceptable deformation of cold mass support structure
- BNL designed an external support tube and a compact mover system





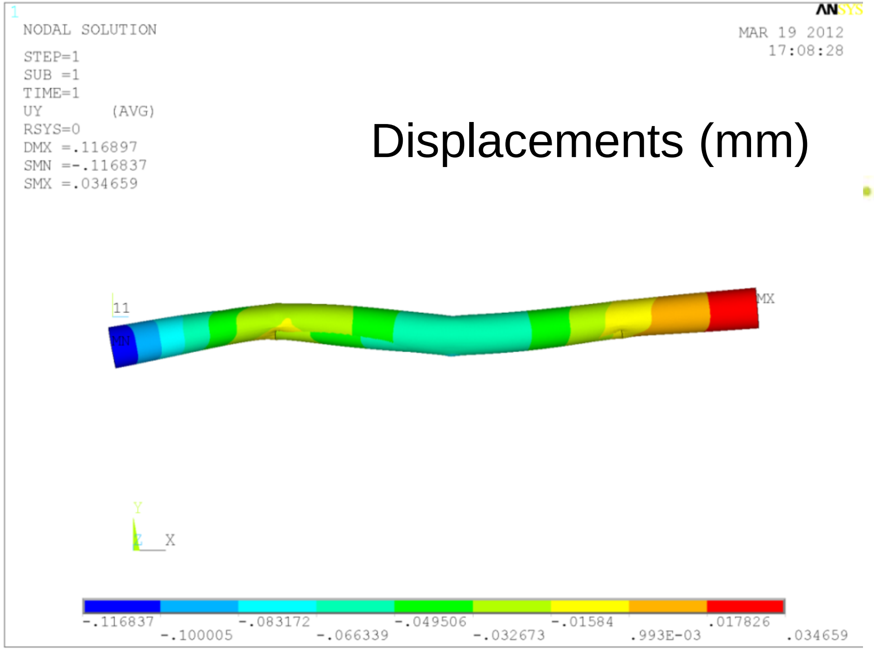
Bill Sporre/BNL

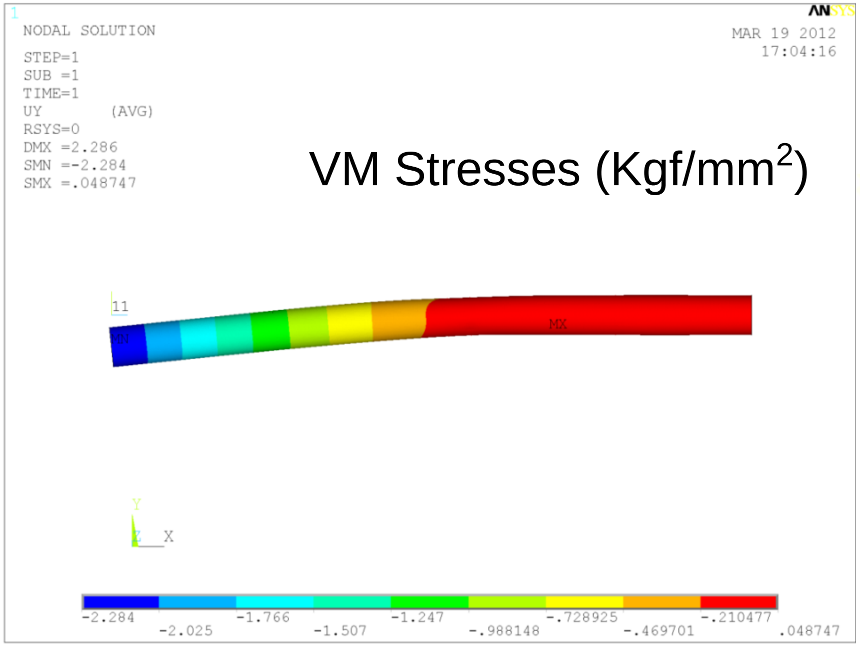
Support Tube Analysis Weight Distribution When LumiCal & BeamCal Supported on Extension of QD0 Cryostat



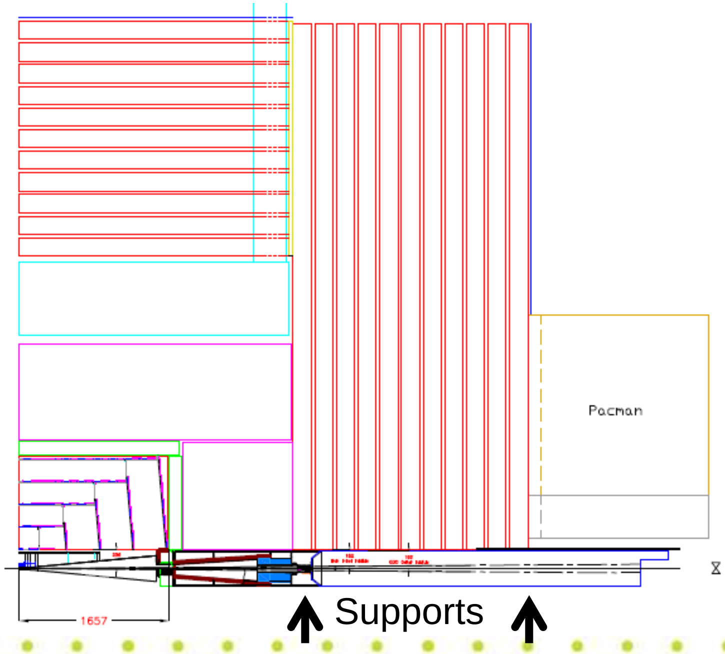
Needs Updating after L* Change to 4.1m

M. Oriunno/SLAC



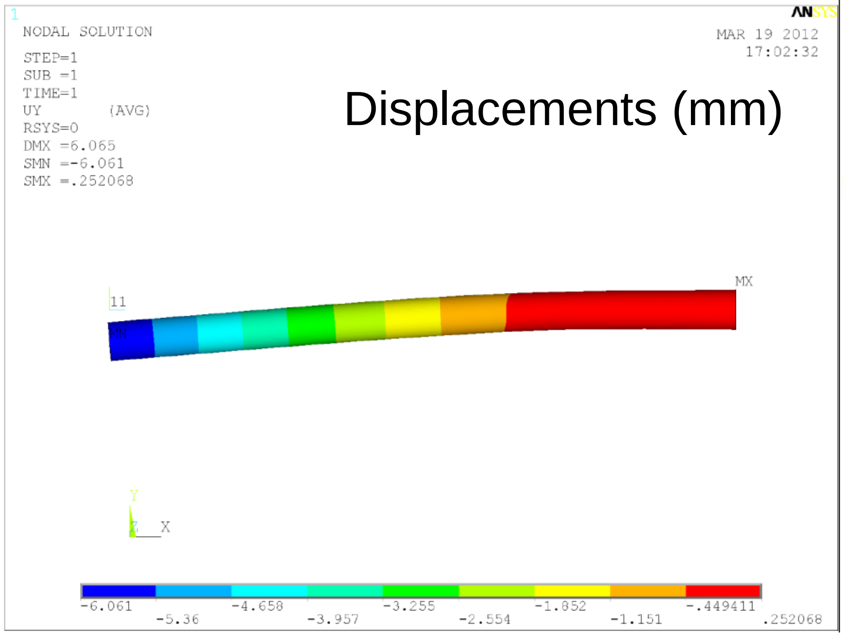


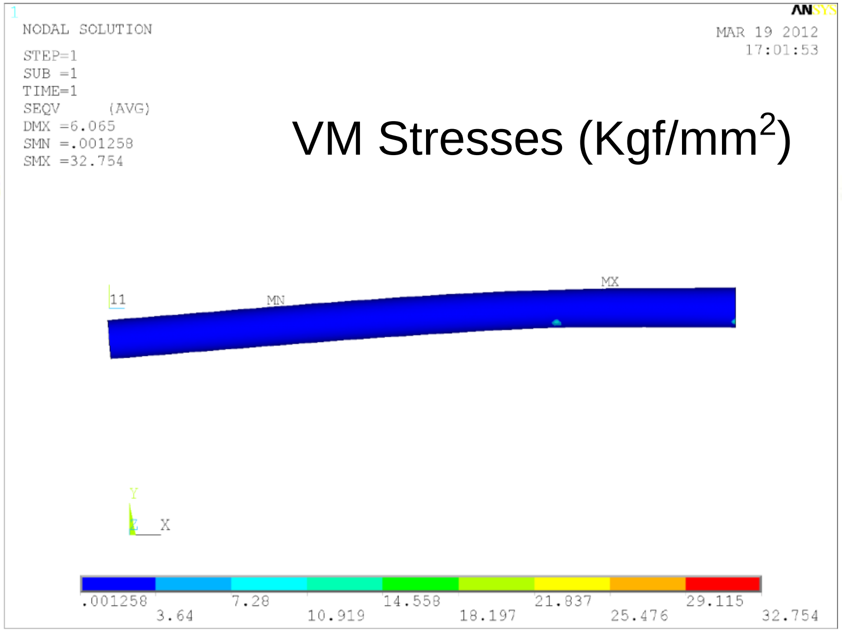
Door Closed:
100um deflection
At LumiCal



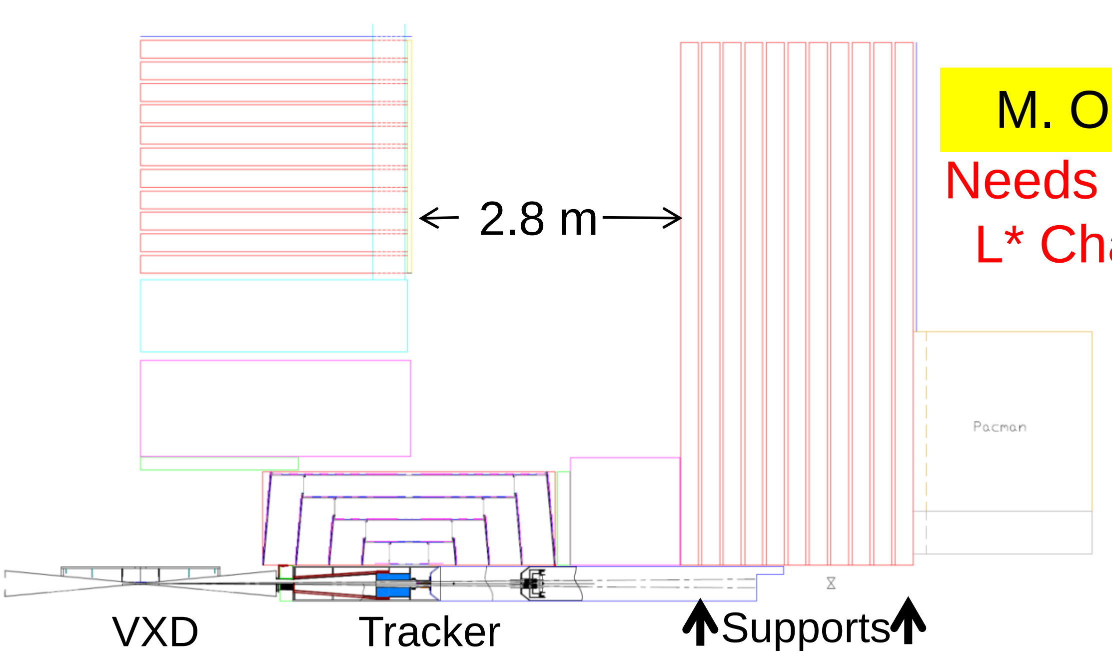
M. Oriunno/SLAC

Needs Updating after L* Change to 4.1m





Door Open 2.8m:
6mm deflection
At LumiCal



M. Oriunno/SLAC

Needs Updating after L* Change to 4.1m

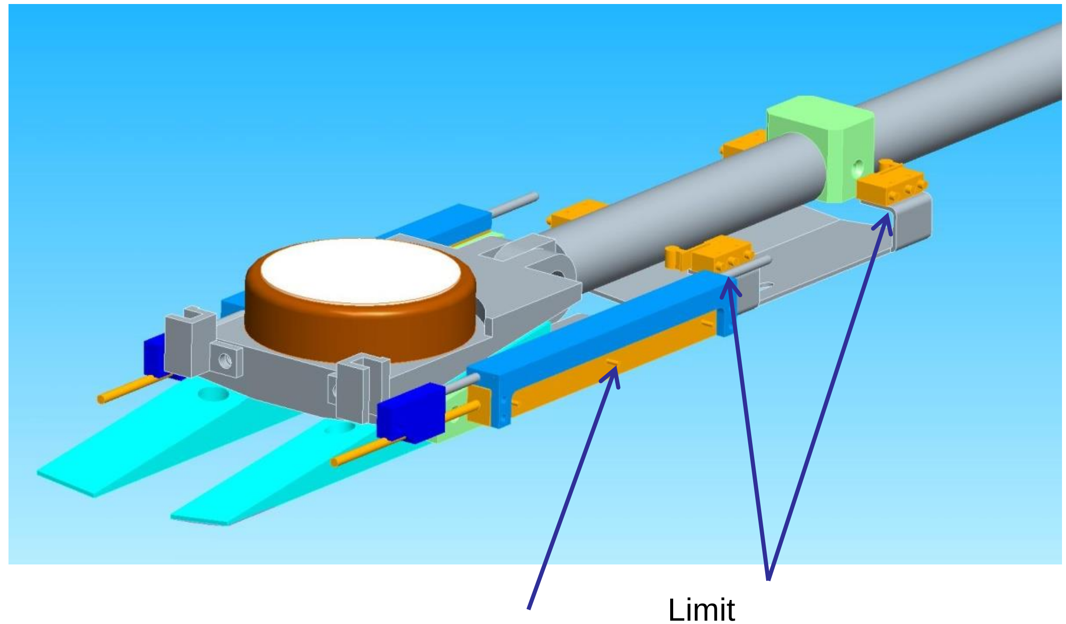
QD0 Wedge Design **Concept**

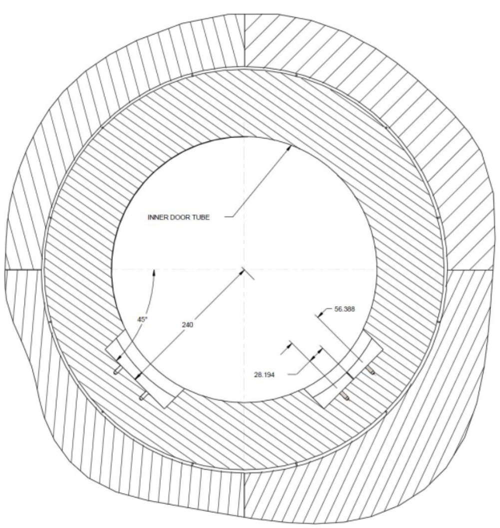
Total Pad Travel as is = .475in

Height of pad and distance of displacement will be changed pending analysis on sagging of beam line.

Conceptual design only at this point

Motor & Drive Rod system not yet done



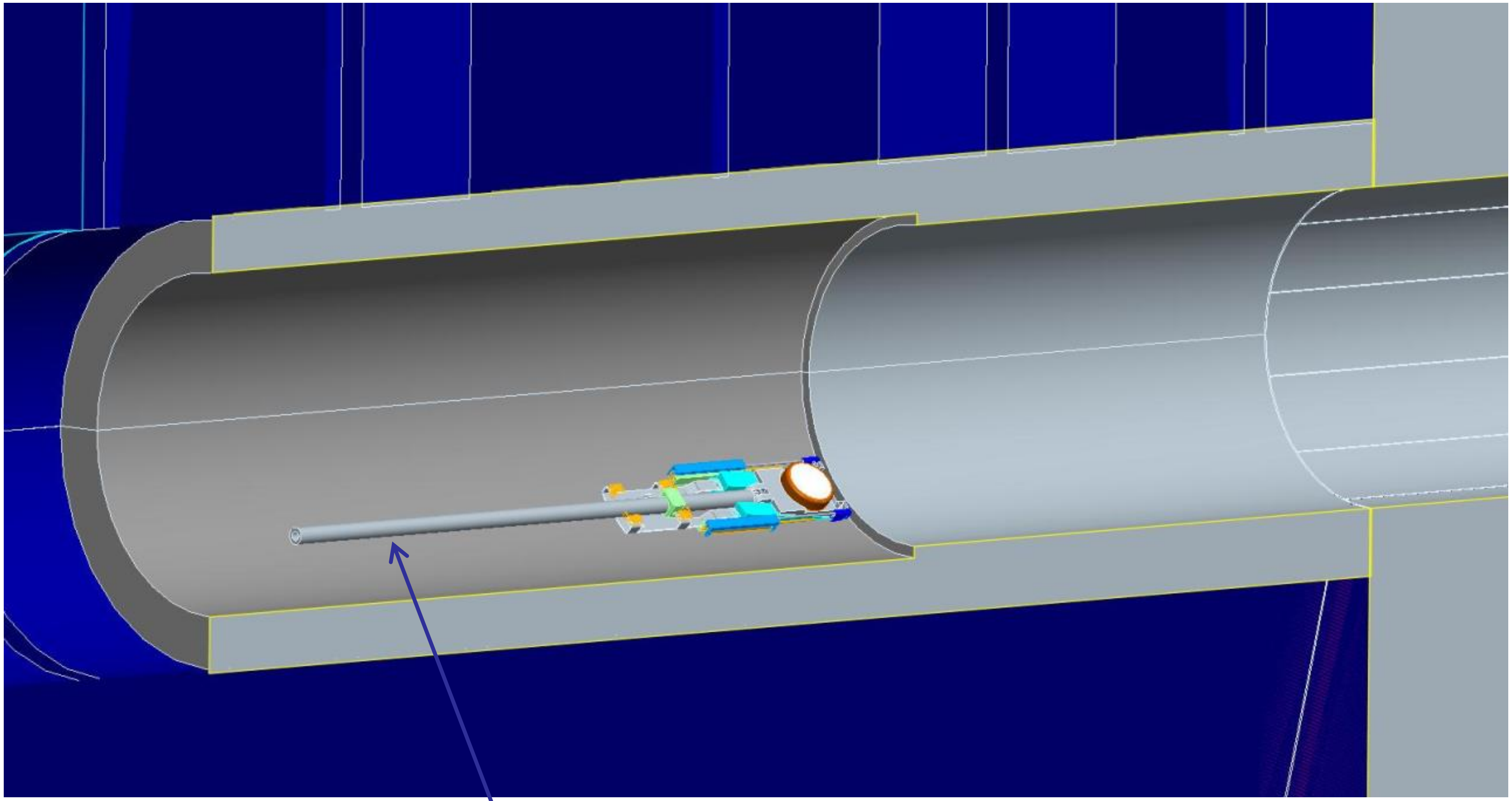


Pads located in cutouts in iron ring to which door plates are welded

216<r<620mm

Bill Sporre/BNL

QD0 Wedge Design Concept

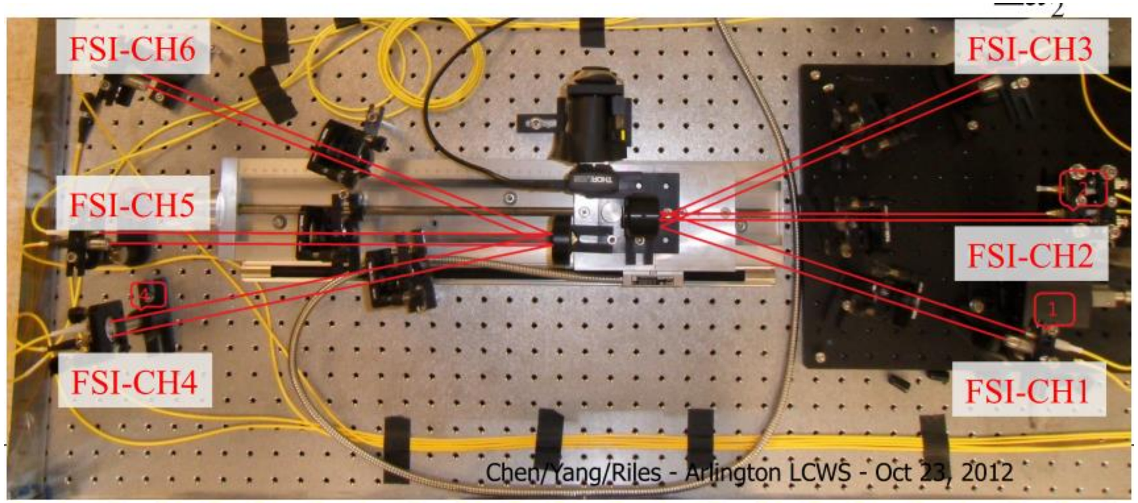


Bill Sporre/BNL

Drive Shaft & motors also need work

Frequency Scanning Interferometry

- Pioneered by Armin Reichold et al at Oxford for ATLAS
  - **Oxford has commercialized a system bought by LCLS to monitor adjustable gap undulator: many heads**
- In SiD context, R&D program by Keith Riles et al at U. Michigan 2003-2007 (for SiD tracker) & 2011-2012 (for QD0)
  - **Established an 8-channel optical table in Michigan lab**
  - **Verified 1-D, 2-D displacement measurements with sub-micron precision**
  - **Available equipment limits 3-D displacement test to few-micron precision, but should be fine**
  - **Developing corner cubes and customized beam launchers**
  - **Currently compact and light enough for MDI application, but not for SiD tracker**



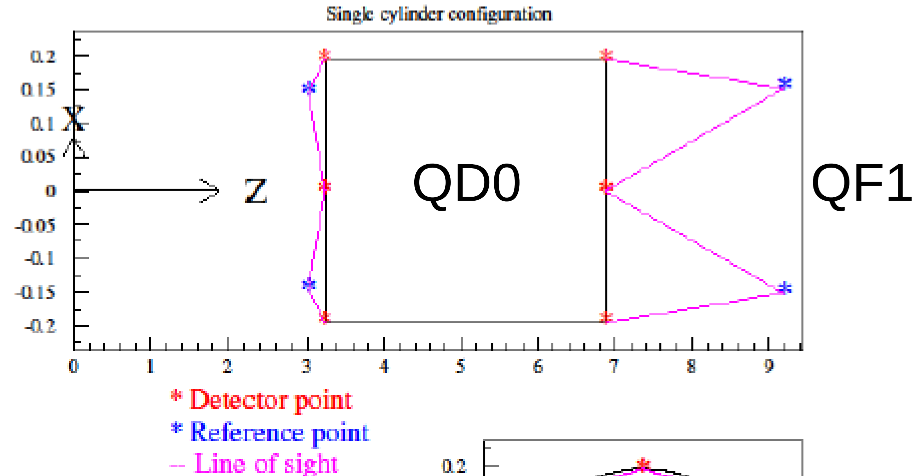
FSI Grid for Monitoring QD0

16 lines probably fine

- Precision better than needed
- Tolerant of channel loss

→ Need four retroreflectors on each end of QD0

→ Need four launch points (2 beams each) on QF1 and Hcal

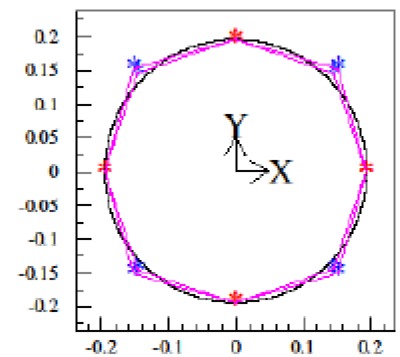


Cylinder dimensions
Radius = 0.195 m
Half-length = 1.825 m

Refer. offsets from cylinder ends
r = 2.0 cm z = 231.4 cm
r = 1.1 cm z = -20.8 cm

CM position precisions (μm)
x = 1.3 y = 1.3 z = 0.1

Axis rotation precisions (μrad)
pit = 0.6 yaw = 0.6 roll = 1.6



Caveats:

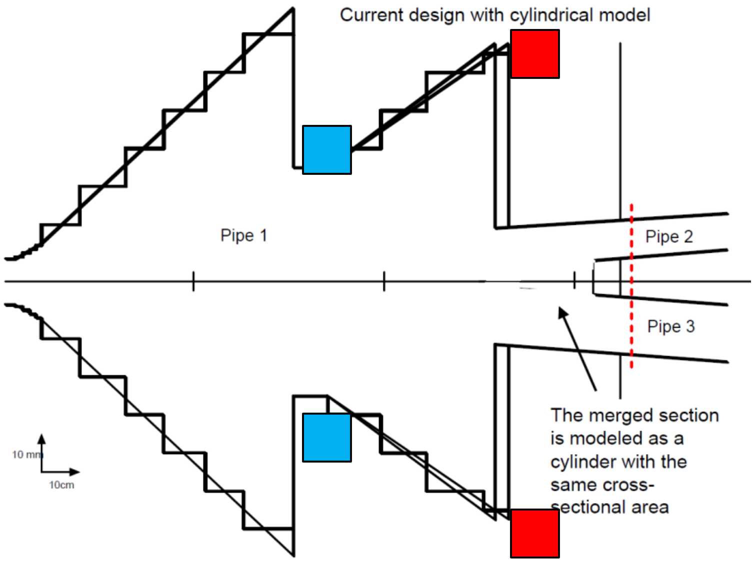
- **Assumes reference points on Hcal known!**
- **Bridging detector gap is important → Future simulation**

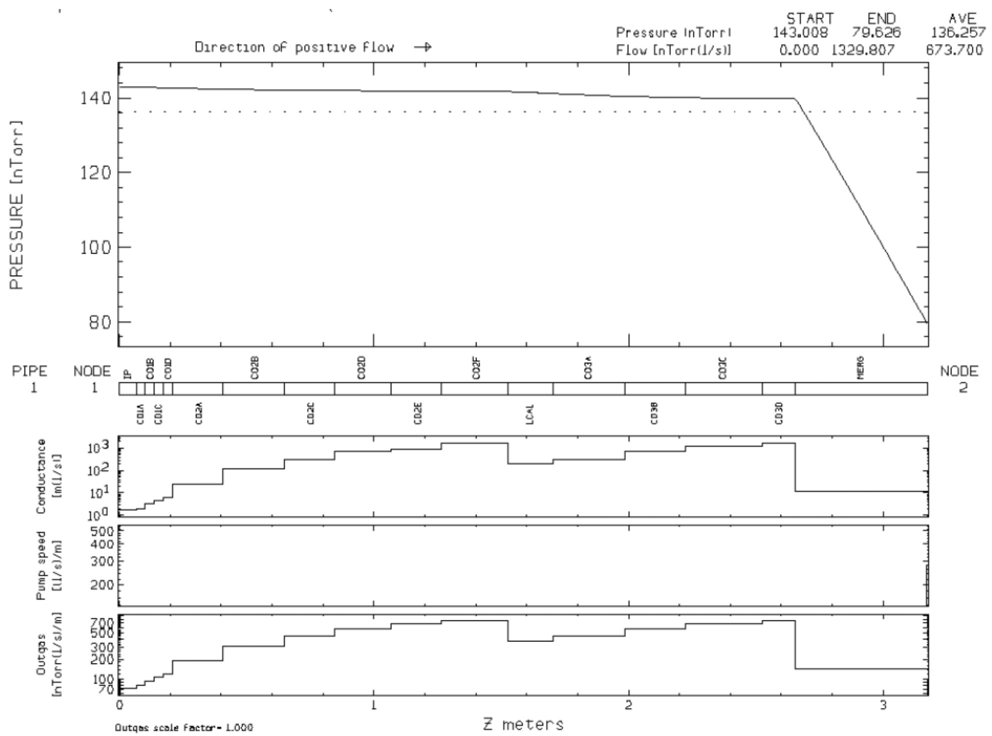
Keith Riles, Hai-Jun Yang/U. Michigan

IP Vacuum

M. Sullivan/SLAC

- VACCALC: " A Method for Calculating Pressure Profiles in Vacuum Pipes", SLAC-PEP-II-APNOTE-6-94
  - The outgassing rate is taken to be 0.1 nTorr•l/s/cm^2.





If cryo-pump only 136 nTorr

- If add 10 l/s pump (red) 69 nTorr
- If add 20 l/s pump (blue) 46 nTorr

Beam-Beampipe Interaction at the IP and in QD0

Beam-induced wakefields result in power loss due to trapped higher order modes and resistive wall heating

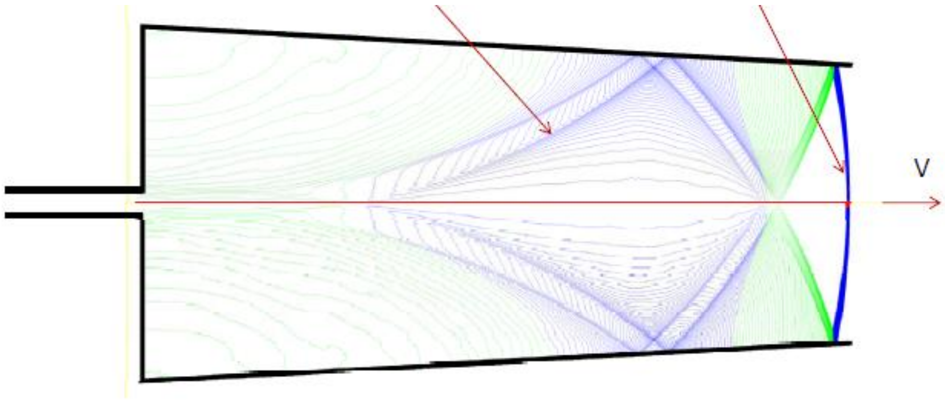
These have been calculated by A. Novokhatski for the current IR geometry using MAFIA and NOVO codes:

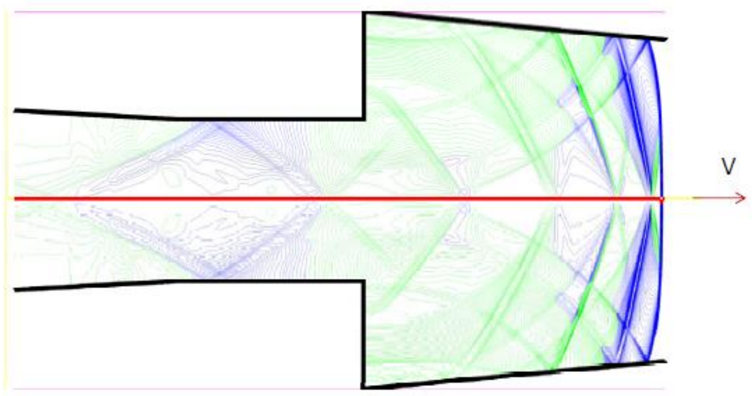
See: http://ilcagenda.linearcollider.org/materialDisplay.py?contribId=2&materialId=slides&confId=5596

Effects are very dependent on exact geometries, materials, shielding schemes and contact resistance

Sasha Novokhatski/SLAC

Wakefields and Bunch field as beam passes BEAMCAL and LUMICAL

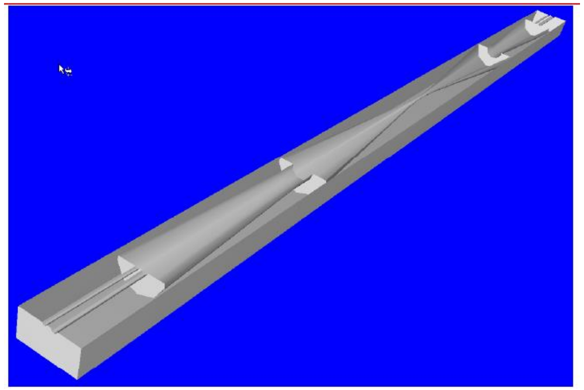


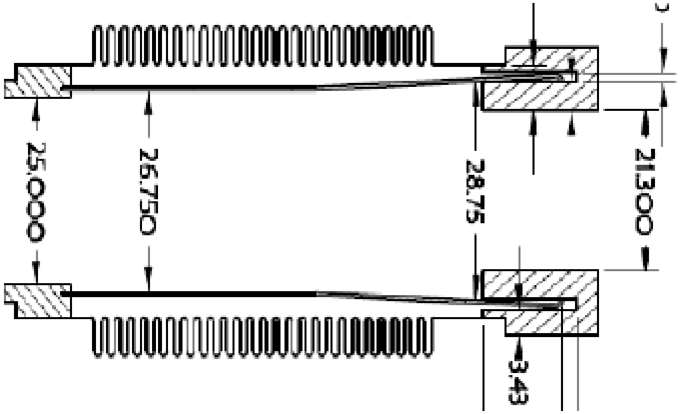


Summary of HOM Heating at IP

- Average power of the wake fields excited in IR is around **30 W** for nominal parameters (6 kW pulsed)
  - **90% from modes excited in pipe (geometry (R/Q) & frequency dependent)**
  - **10% from resistive wall heating**
- In the QD0 region there is an additional ~4W from resistive losses in the pipes and wakefields, excited by pipe diameter changes, due to the shielded bellows
  - **Flange edge size, contact resistance, coatings important**
- Heating from BPMs and kickers must be added

Full 3D LOI Beam Pipe (no bellows, flanges, or pump ports included)

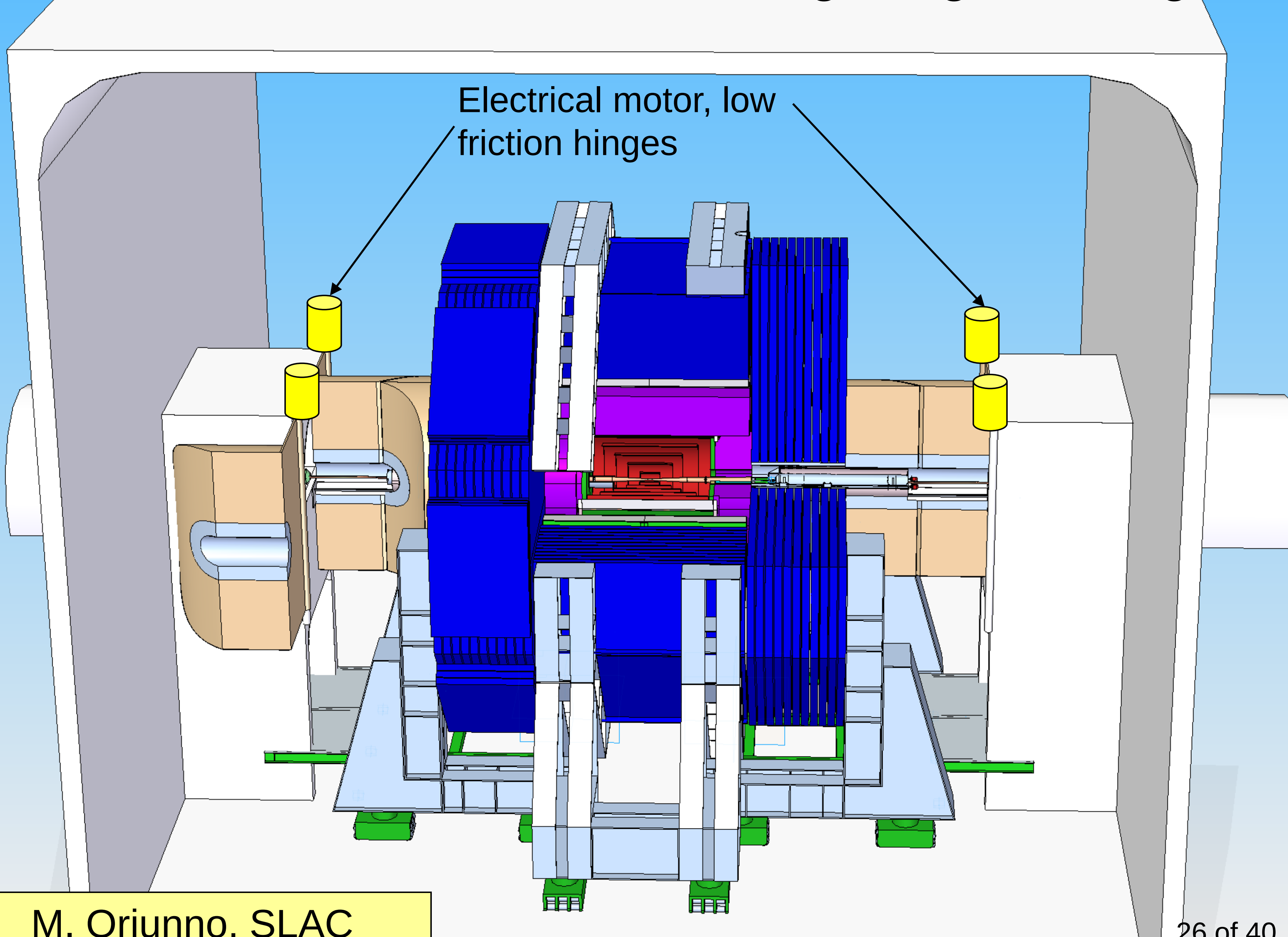




Self-Shielding and PACMAN

- PACMAN shields IR Area between the detector and the beam tunnel
- Current Concept has a SiD-mounted piece and a ILC/SiD common piece to accommodate different detector sizes and QD0 support schemes
- Figures of merit are “Total Dose” and “Dose Rate”
  - **Relevant Japanese authorities need to be educated about the nature of ILC pulsed beams**
  - **Dose Rate limits (which seem artificially low given the short time scale of an “accident” (1ms)”) need to be re-evaluated**
- Handling of PACMAN sub-pieces will likely determine underground crane requirements
- Design of UG IR Hall, tunnel lip that holds QF1, interface with platform motion system, QD0 support and push-pull all argue for active work in this area

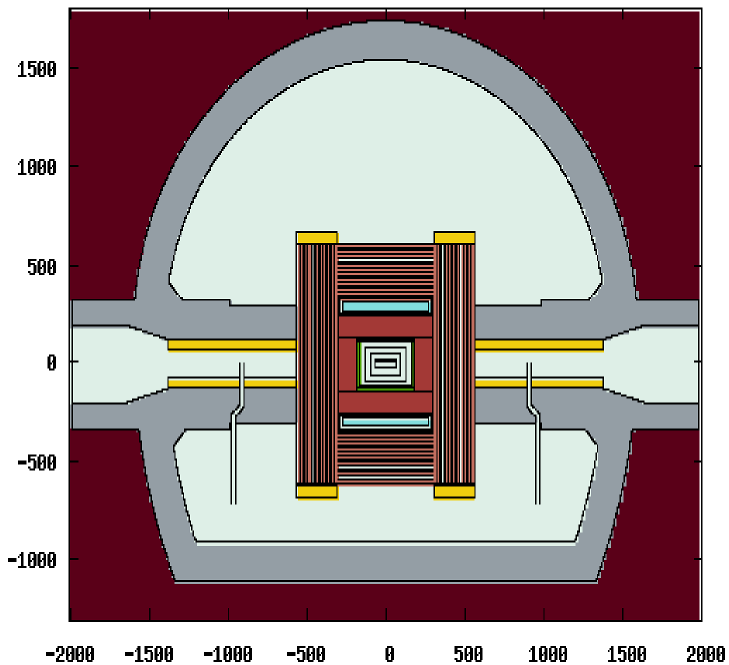
Current SiD “PacMan” Rotating Hinged Design



Geometry: pacman and SiD

B-B'

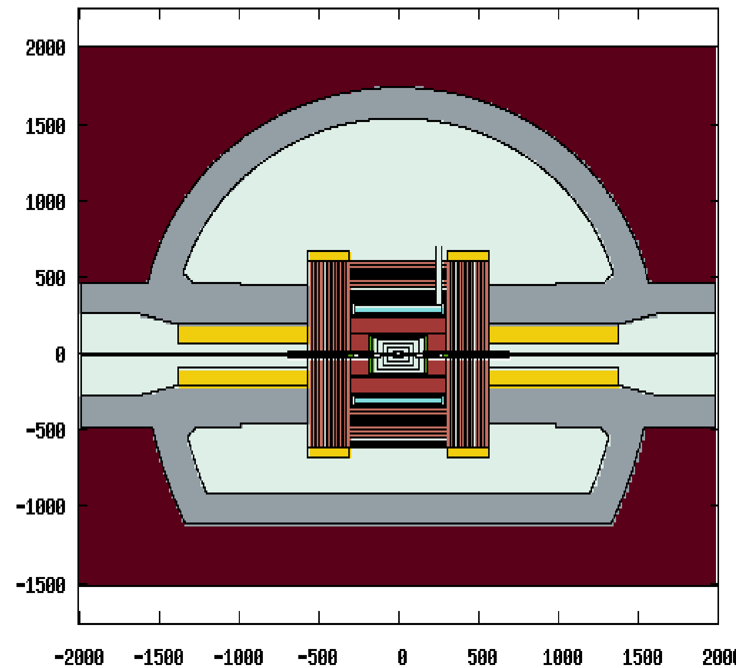
SiD elevation at beam plane
Small PACMAN



50 cm steel +

170 cm concrete

SiD elevation at beam plane
Large PACMAN

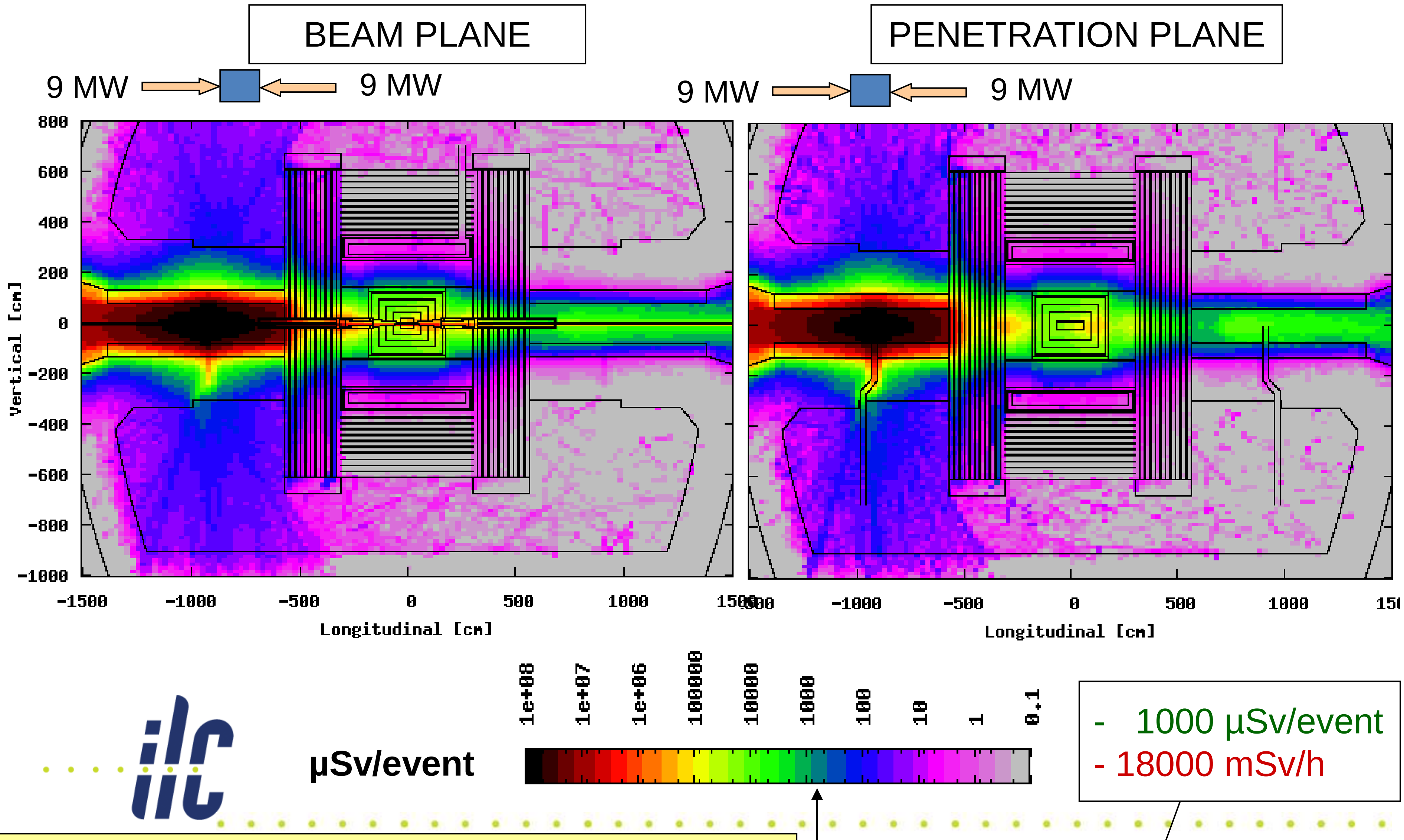


120 cm steel +

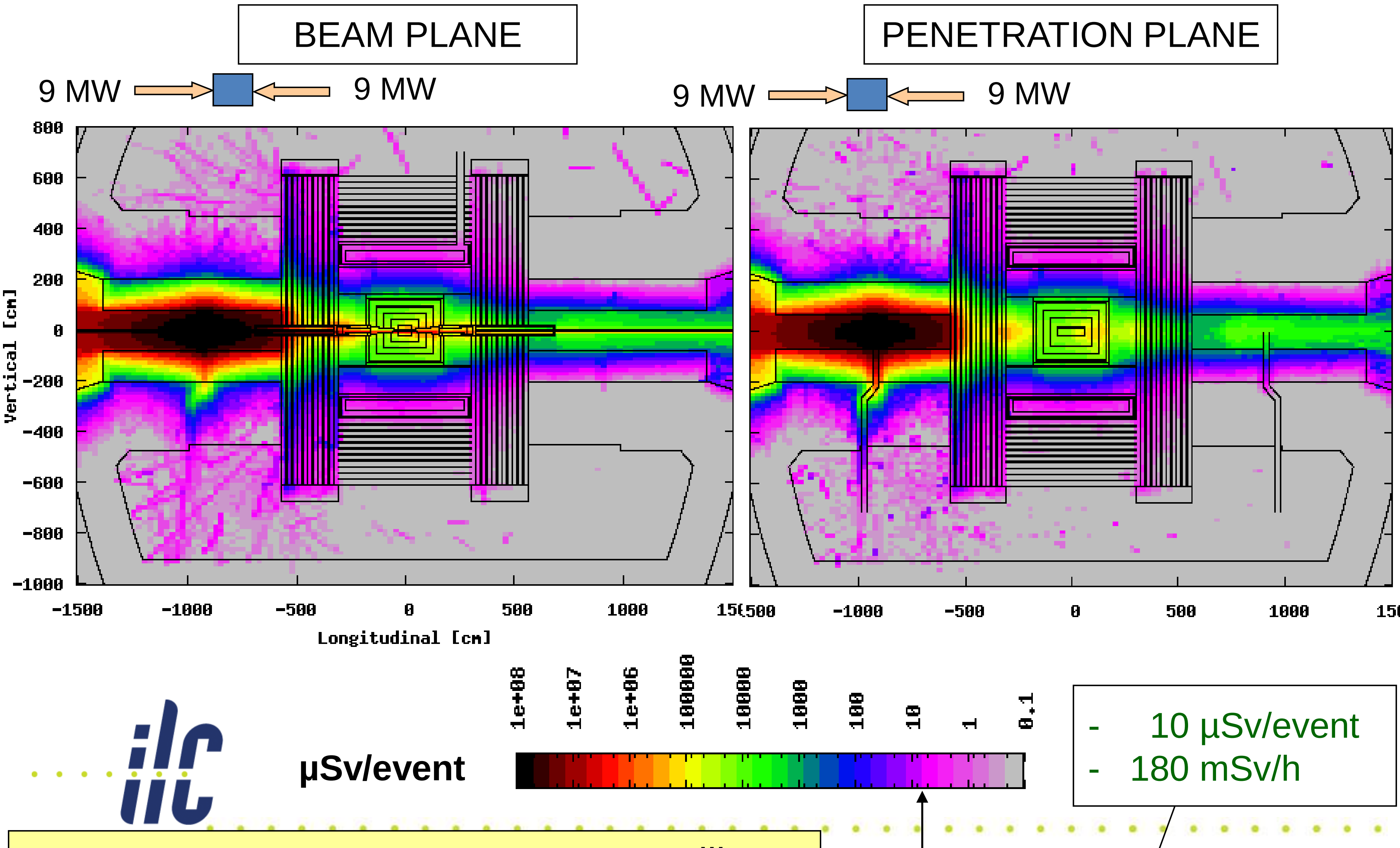
250 cm concrete

M. Santana, SLAC, LCWS 2010

20 R.L. Cu target in IP-9 m. Small pacman.



20 R.L. Cu target in IP @ 9 m. Large pacman.



M. Santana, SLAC - 2010 LCWS Beijing

Provisional conclusions

- Small pacman and pacman-cavern interface are sufficient in terms of *dose per event*.
  - Beam aborted after 1 Train
- However, the *dose rates* for the small pacman are very high:
  - Proven mechanisms should be installed to:
    - avoid these accidents to occur
    - shut off beam after 1 train (200 mS)
  - Possible Debates
- The large pacman complies with all criteria.
- The penetrations in the pacman don't require local shielding.
- The shielding of the detector may be insufficient to comply with dose rate limit. Exclusion area?
- More studies ongoing (mis-steering…)

M. Santana, SLAC

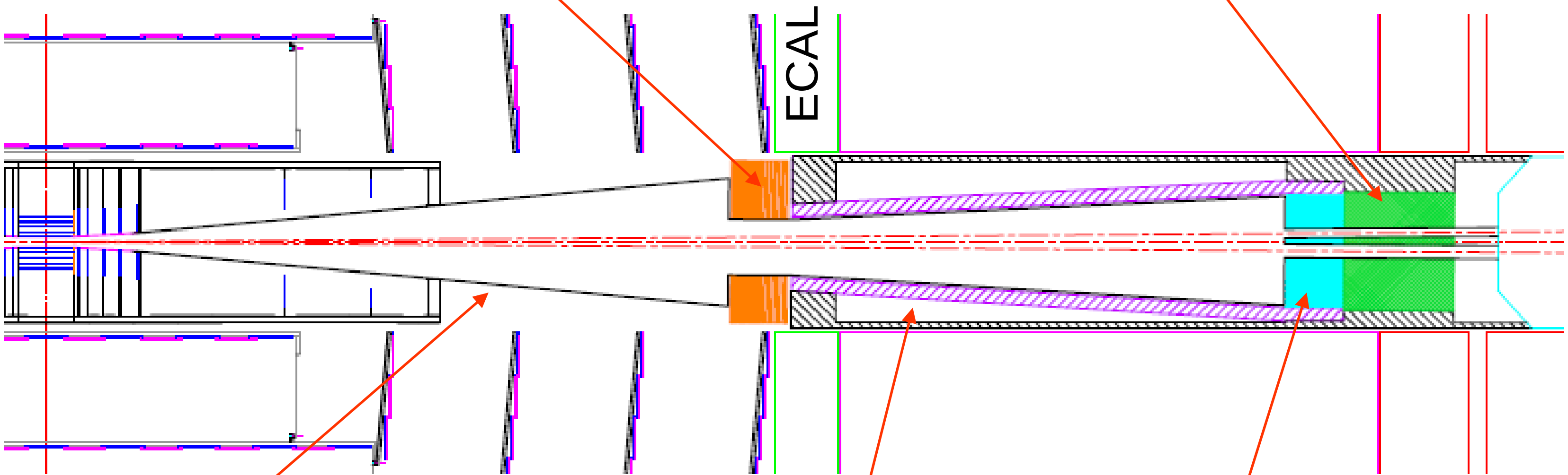
Backgrounds & Forward Calorimetry

- All studies done by T. Maruyama in GEANT3 (pairs, SR) and FLUKA (Neutrons from Dump, Dose Rates)
- Last looked at for "SB 2009" IP Parameters and presented early 2011
- Have not kept up with changes to nominal beam parameters, beam energy variations, or changes to FCAL
- Questions of DID/anti-DID implementation, "bent solenoid", new L*, beampipe variants, etc. should be investigated

SiD Forward Region

LumiCal
20 layers of 2.5 mm W +
10 layers of 5.0 mm W

BeamCal
50 layers of 2.5 mm W



Beampipe
+/- 94 mrad (detector)
+101 mrad, -87mrad (ext. line)

3cm-thick Tungsten Mask

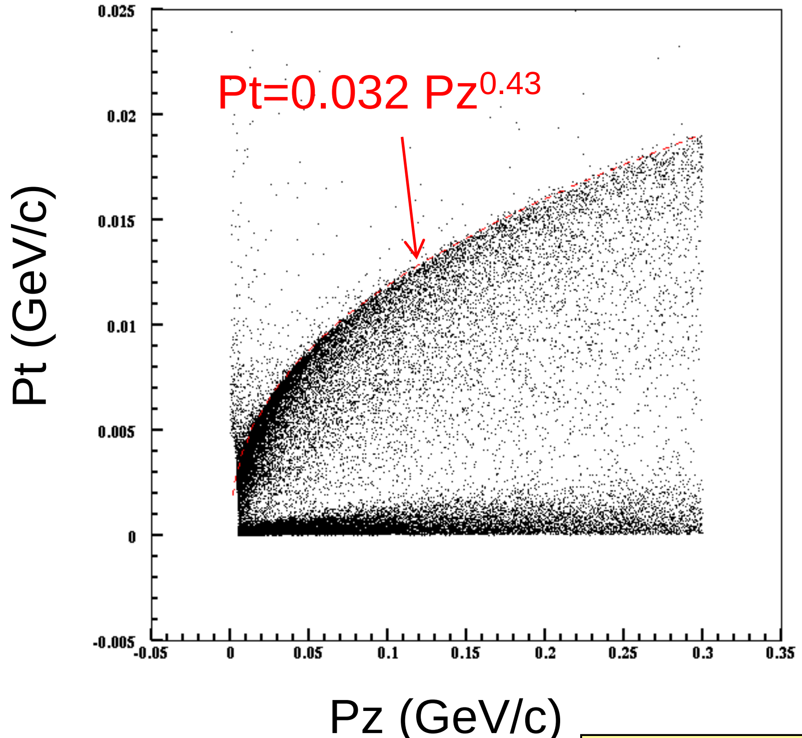
13cm-thick BoratedPoly

Centered on the outgoing beam line

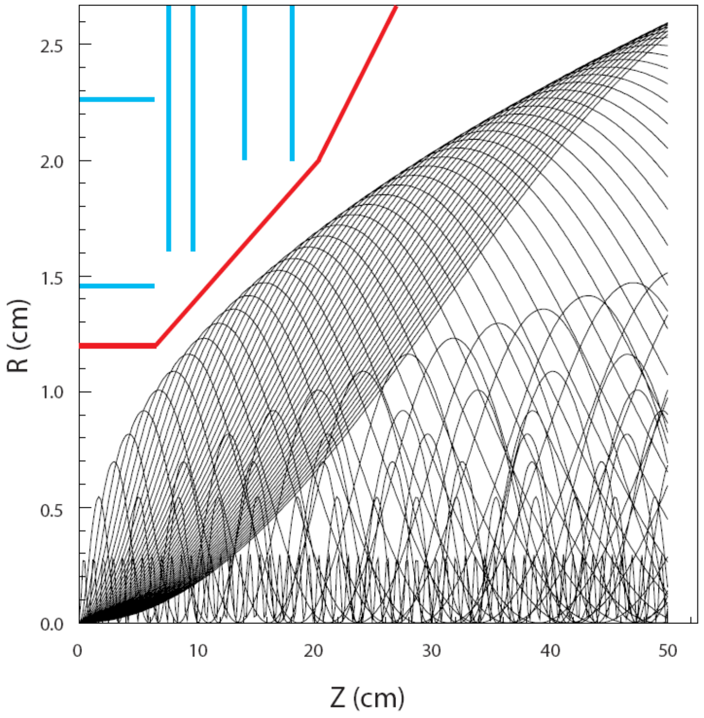
T. Maruyama SLAC

Pair edge and Beam pipe design

- Pairs develop a sharp edge and the beam pipe must be placed outside the edge.
- Find an analytical function of the edge in Pt vs. Pz space.
- Taking into account the crossing angle and solenoid field, draw helices in R vs. Z space.



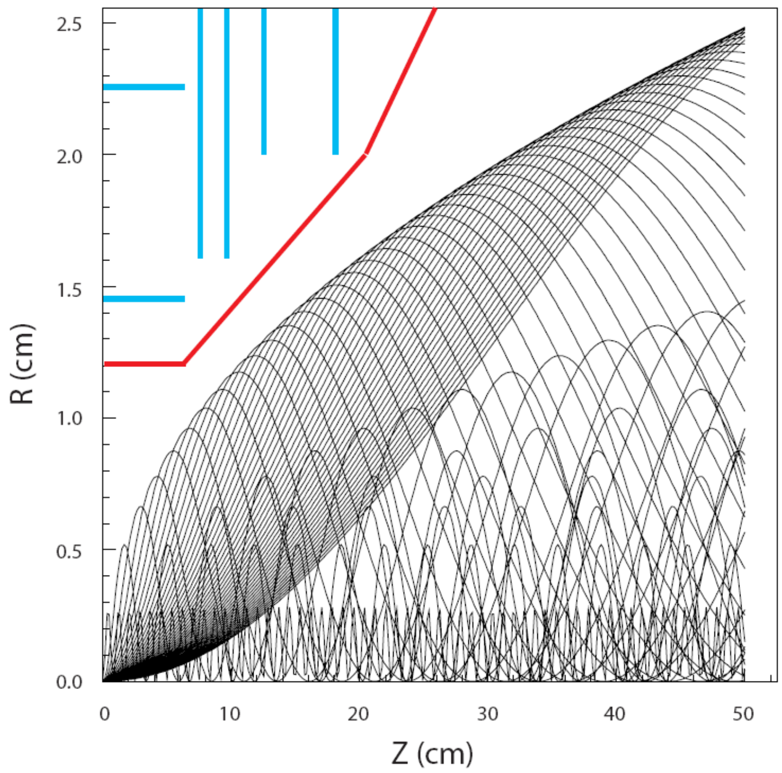
SB2009 500 GeV TF



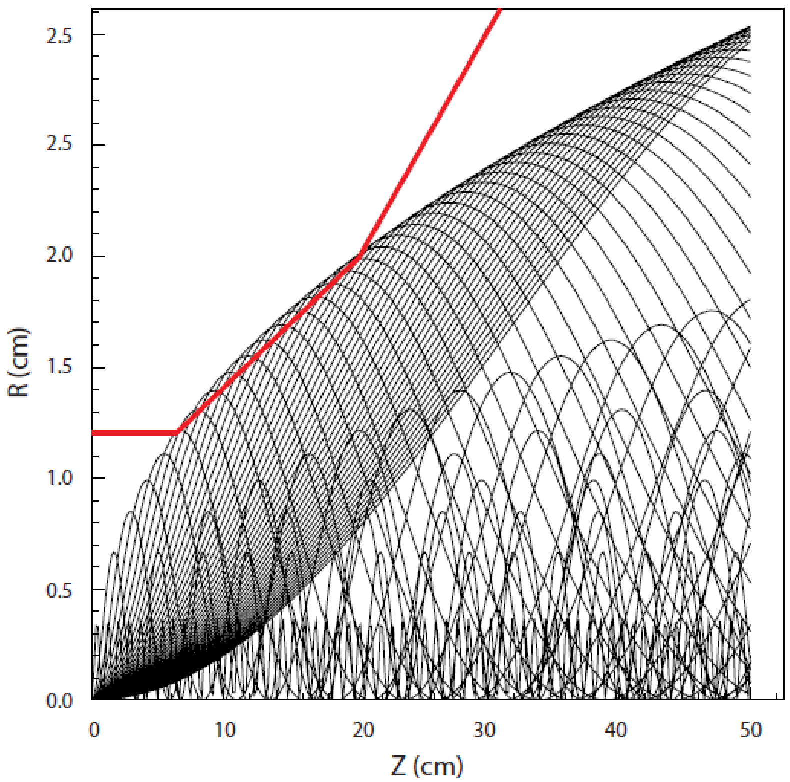
T. Maruyama SLAC

SiD beam pipe and pairs edge
Message: Aggressive Beampipe

500 GeV RDR Nominal



500 GeV RDR Low P



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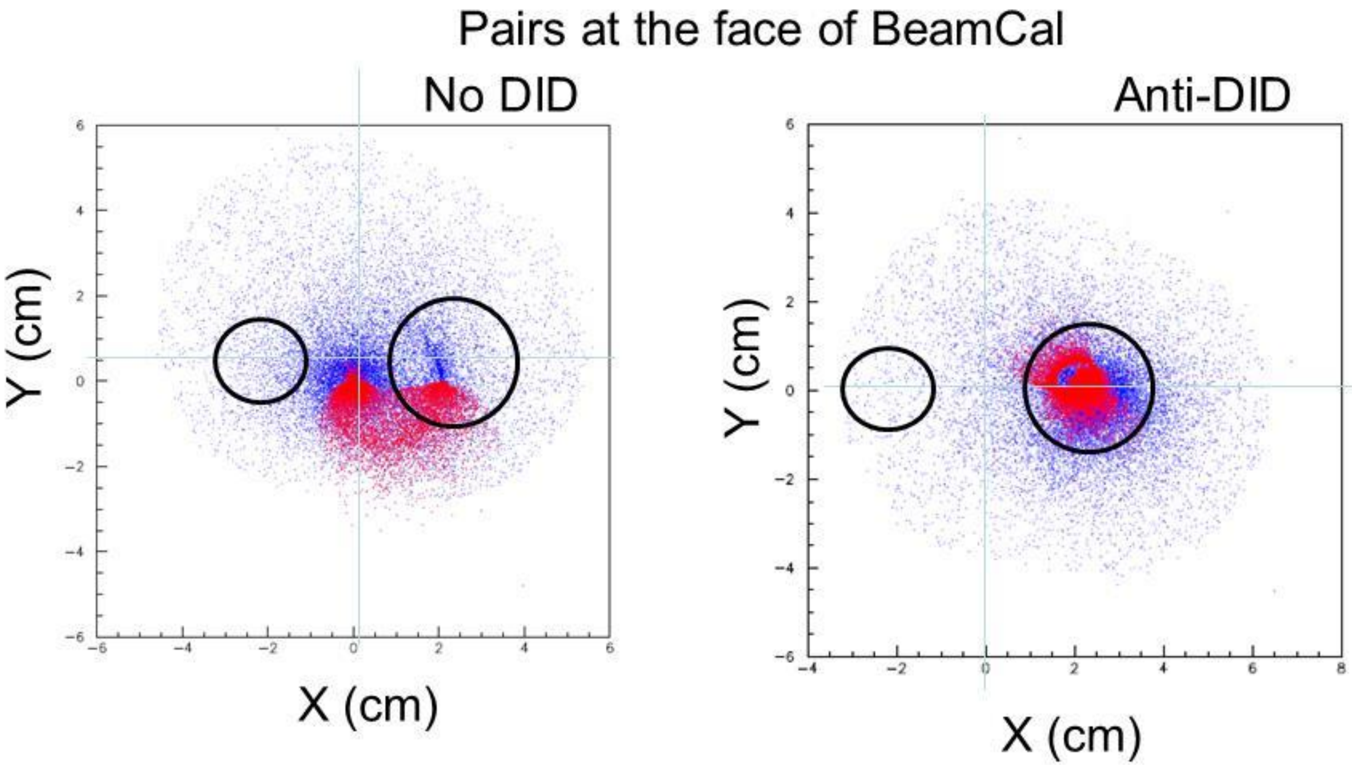
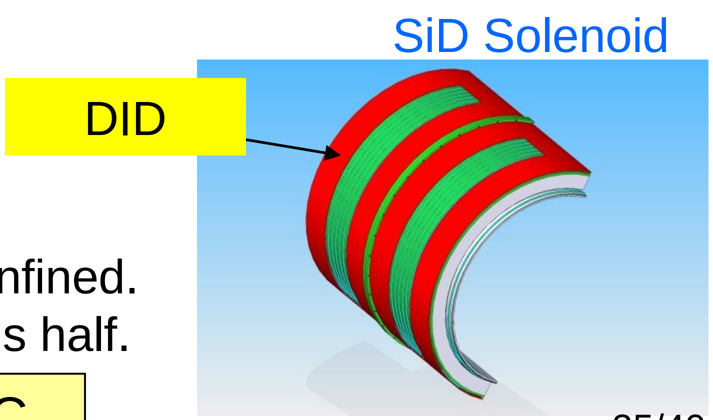
Detector-Integrated-Dipole





We want Anti-DID.

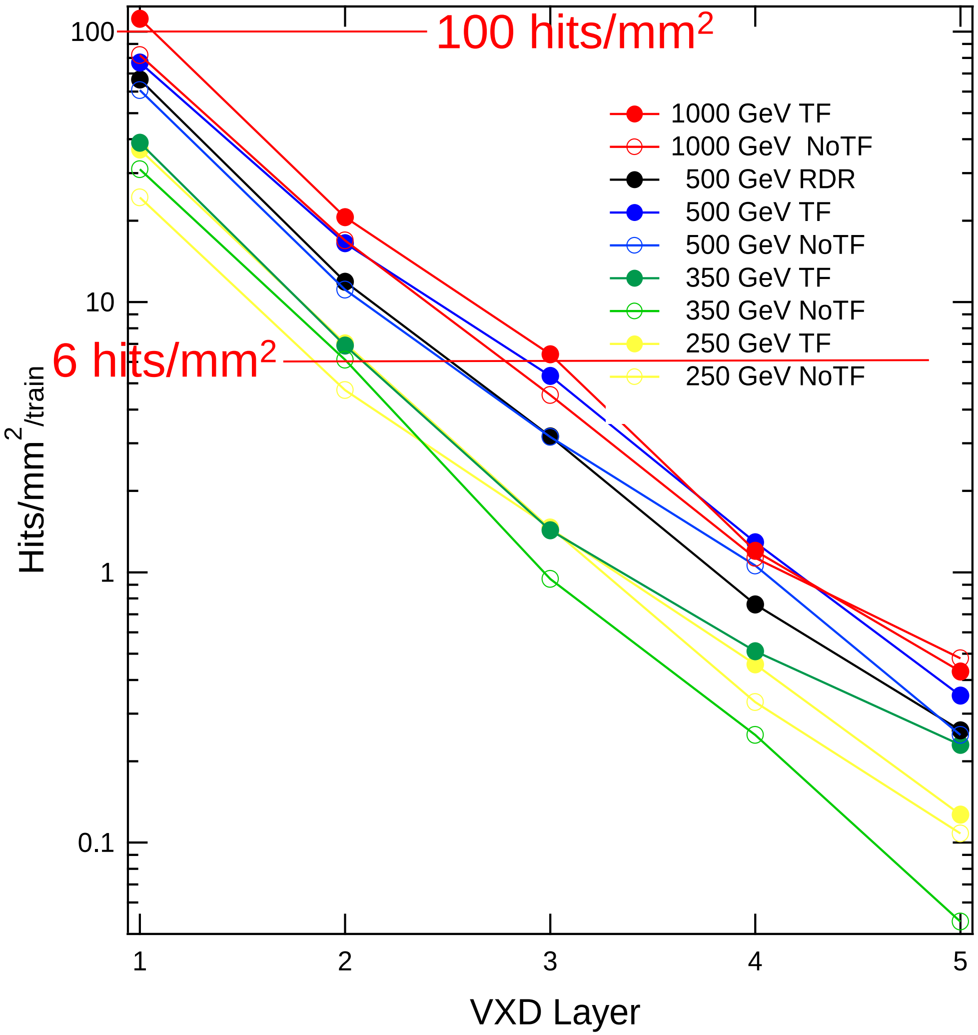
- Total pair energy into BeamCal is half.
  - 10 TeV/BX vs. 20 TeV/BX with NO-DID.
- Pair distribution is symmetric and more confined.
- No. photons backscattering to the tracker is half.

T. Maruyama SLAC

VXD hit density / train

- Detector tolerance
- Use generic 1% pixel occupancy
- Dependent on sensor technology and readout sensitive window.
  - Standard CCD 20μm x 20μm
    - 2500 pixels/mm^2
    - 6 hits/mm^2/sw (assuming 1 hit→ 4 pixels)
  - Fine pixel CCD 5μm x 5μm
    - 40000 pixels/mm^2
    - 100 hits/mm^2/sw (assuming 1 hit→ 4 pixels)

T. Maruyama SLAC



Summary

Every area mentioned would benefit from increased collaboration and fresh ideas

Prototypes and experimental verification of design will eventually be reqired.