Hot Topics in ILD MDI

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international linear collider

ILD Meeting

Chicago

20.11.2008

MDI Issues

- Hitoshi‘s List:
  - Push-pull
    - Stability and speed of switch
  - Detector assembly and integration
    - Surface assembly, etc.
  - IR components and support structures
    - Beampipes, final quads, support tubes, etc.
  - Forward detectors
    - FCAL, BCAL, GAMCAL, LCAL, etc.
  - Energy-Luminosity-Polarization
    - Upstream and downstream measurements
  - Beam diagnostics near IP
    - Beam profile measurements, etc.
  - Machine backgrounds
    - SR, pairs, beam particles, neutrons, muons, EMI…
- We (ILD-MDI) are working only on some of that points
- What is relevant for the LoI?

Integration Issues

- Detector Integration
  - How to bring everything together
  - Opening/closing concept
- Subdetector Integration
- Shielding
  - Radiation
  - Magnetic Fields
- IR design
  - QD0 support
  - Beam pipe design incl. vacuum concept
  - Inner detector support (SIT, FTD, VTX)
- Push-pull concept
  - Platform design
  - Alignment
  - Movable helium supply, cables, electronics, etc.

LoI Goal

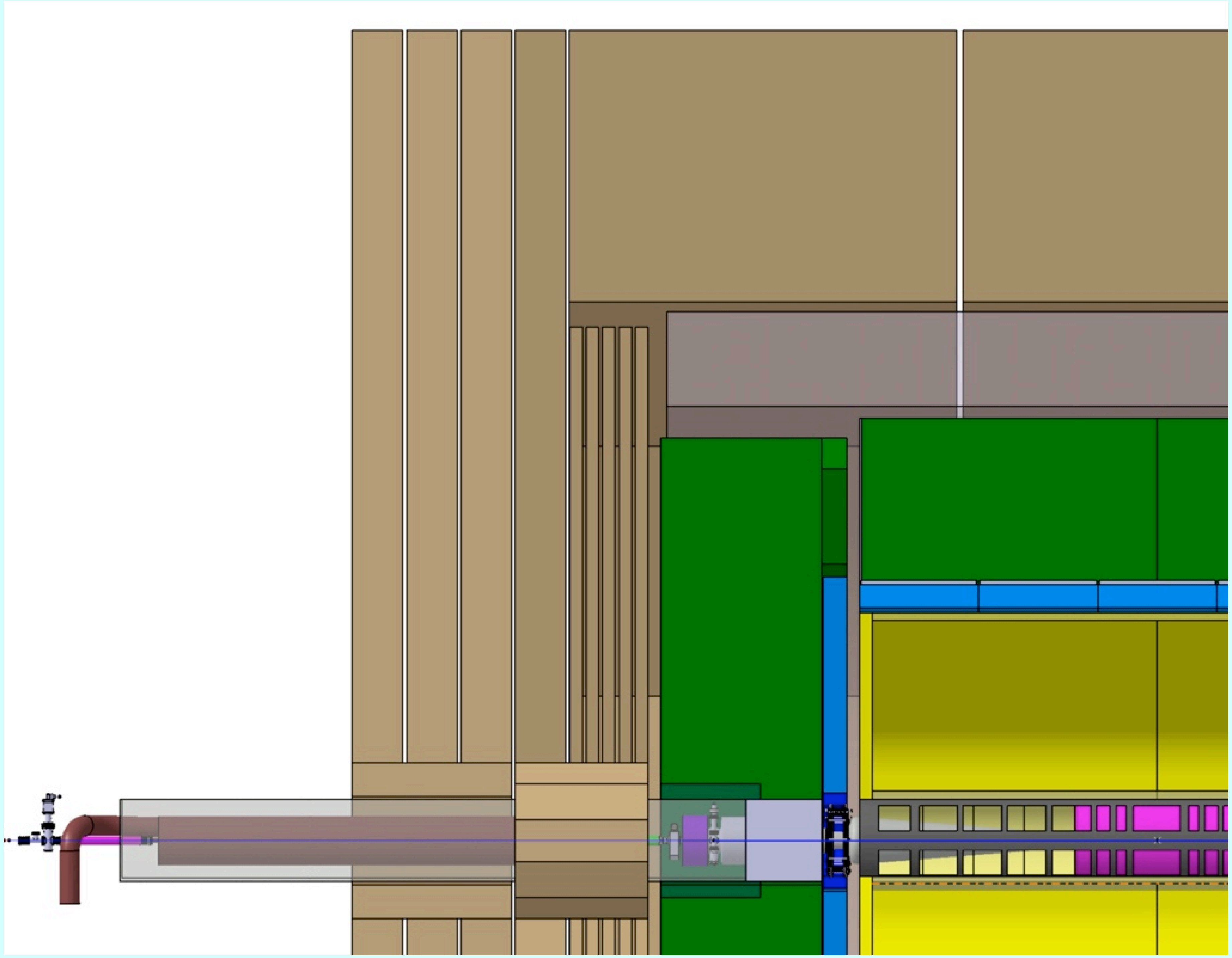
- We cannot answer all mentioned questions on engineering detail level until April 2009!

- Agreement: show that no show-stoppers exist and provide plausible conceputal detector design

- Concentrate on most relevant issues
  - Impact on realisation
  - Impact on cost

ILD0 CAD Model

- We have an ILD model!



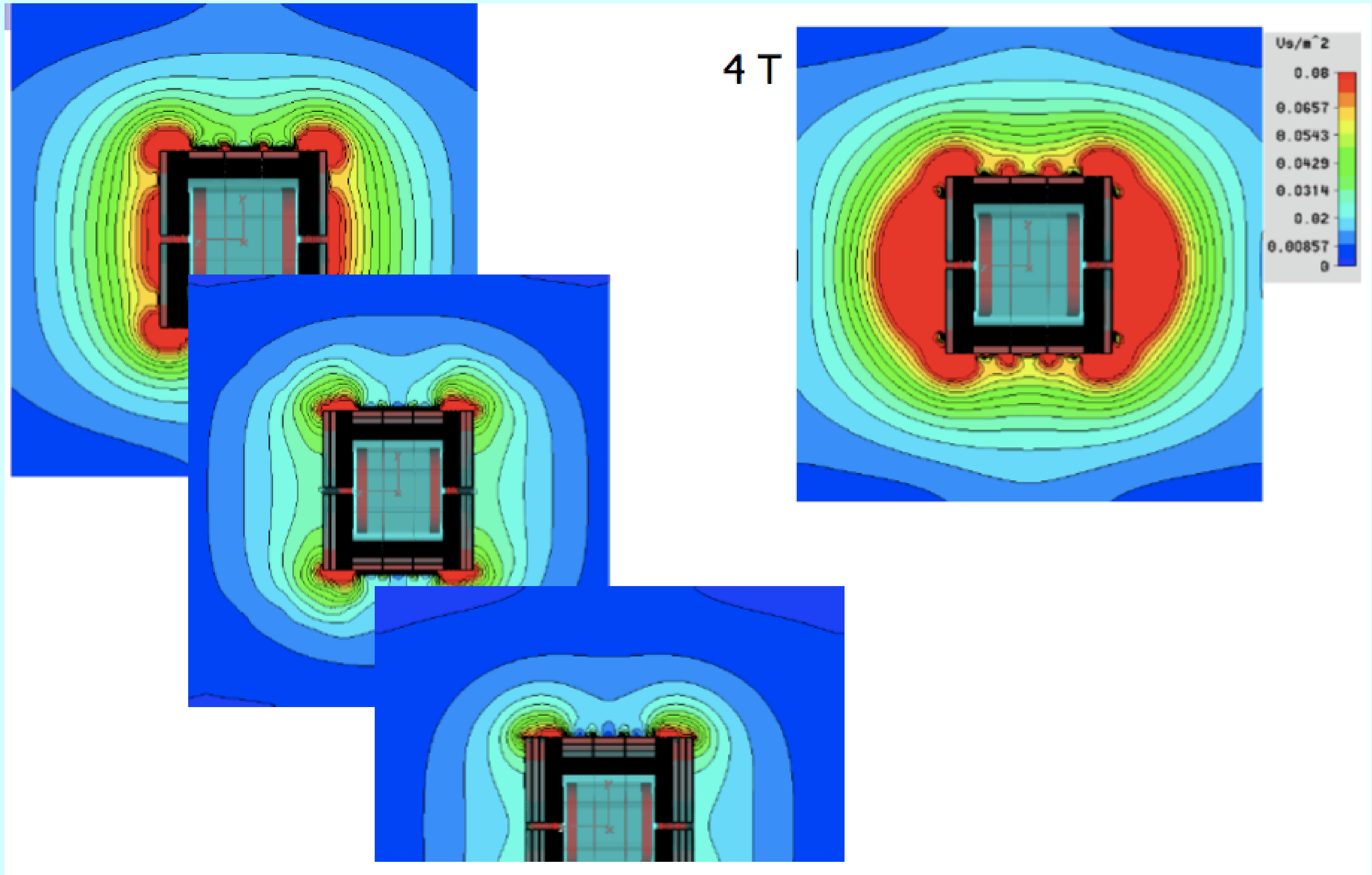
Return Yoke Design

- Three basic questions drive the complete design of the yoke/coil system:
  - What are the requirements on the magnetic fields inside and outside of the detector? This includes Anti-DID!
  - How to access and open the detector?
  - How to push and pull?
- The answers to these questions rely on extensive simulations of
  - Magnetic fields with 3d simulations
  - Magnetic forces (and stresses!) using FEM simulation tools
  - Vibration studies (for push-pull)
- This can only be done by developing a complete engineering design of the yoke/coil system
- On the LoI timescale we will only have partial answers to these questions!

Yoke Design

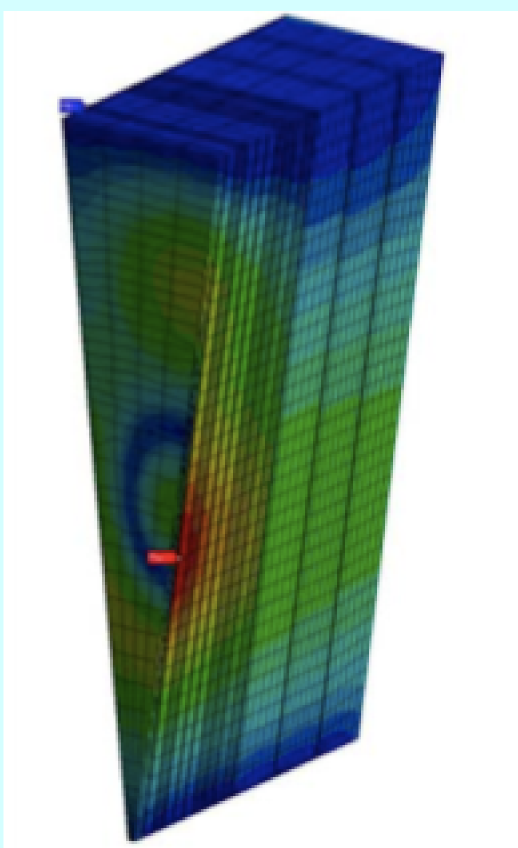
- Iron thickness is driven by stray field requirements
  - Baseline requirement: < 200G outside 1m of detector
  - CMS experience: everything above 50G will get more and more problematic, above 200G really difficult

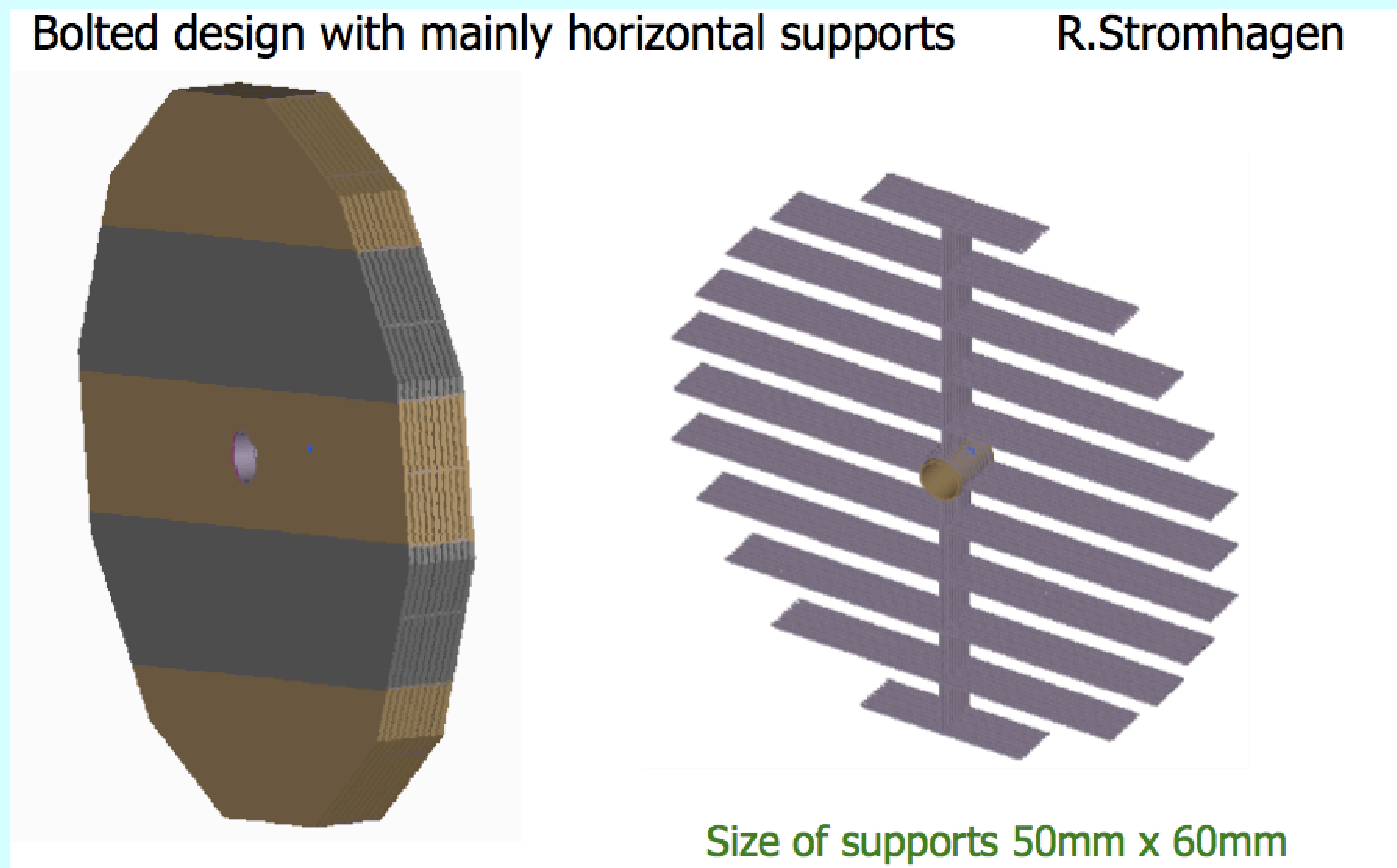
- Simulations show 200 G at ~8m, 50G at ~12m from the beamline doable with a total iron thickness of 2.7m



Yoke Endcap Design

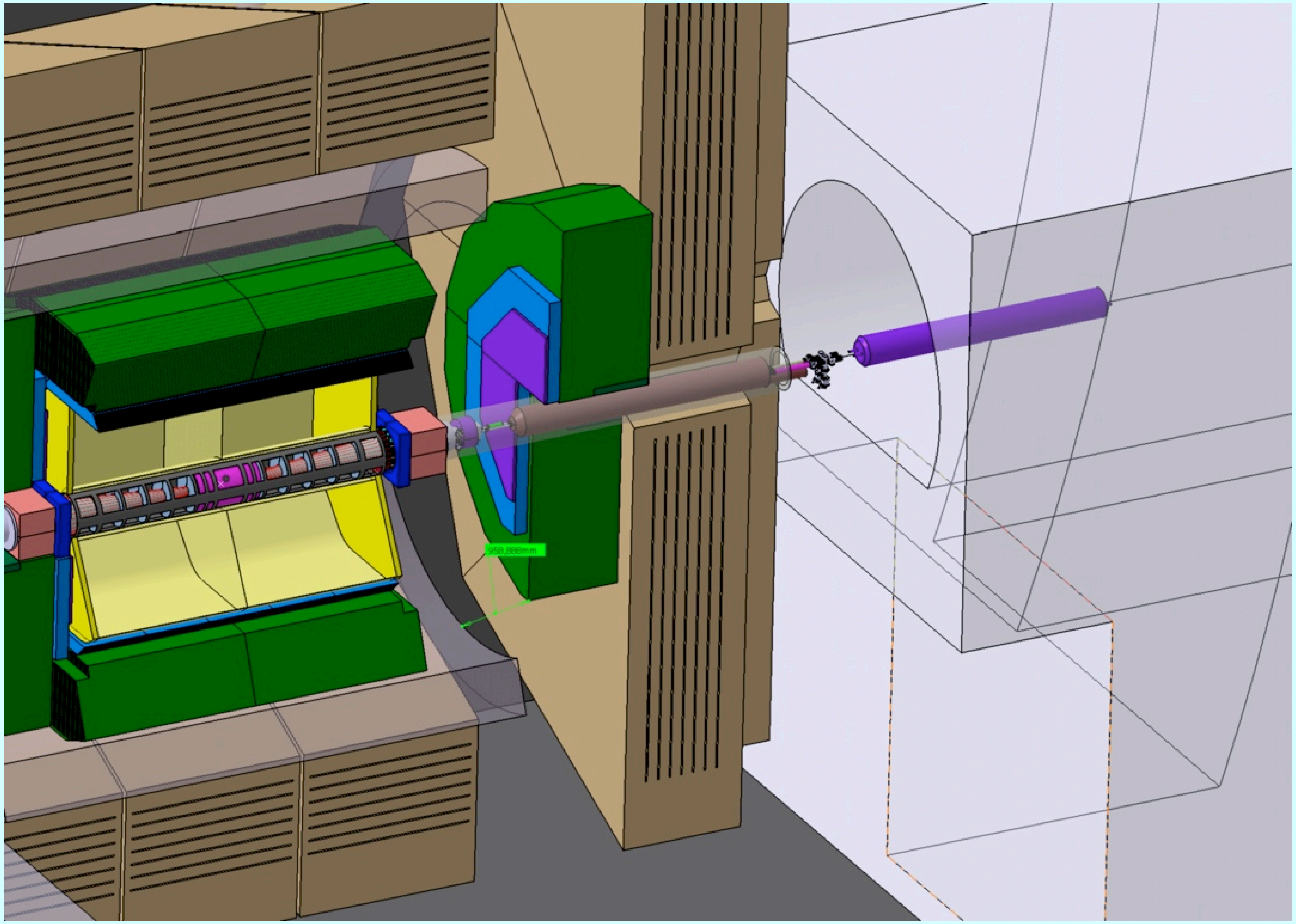
- Endcap design is highly non-trivial
  - Total magentic forces on one endcap ~25000t
- Working design foresees 10 slits for muon/tail catcher chambers
  - by request of the ILD EB, for simulation purposes
  - Who is working on the subdetector design?
  - Guidance on segmentation urgently needed!



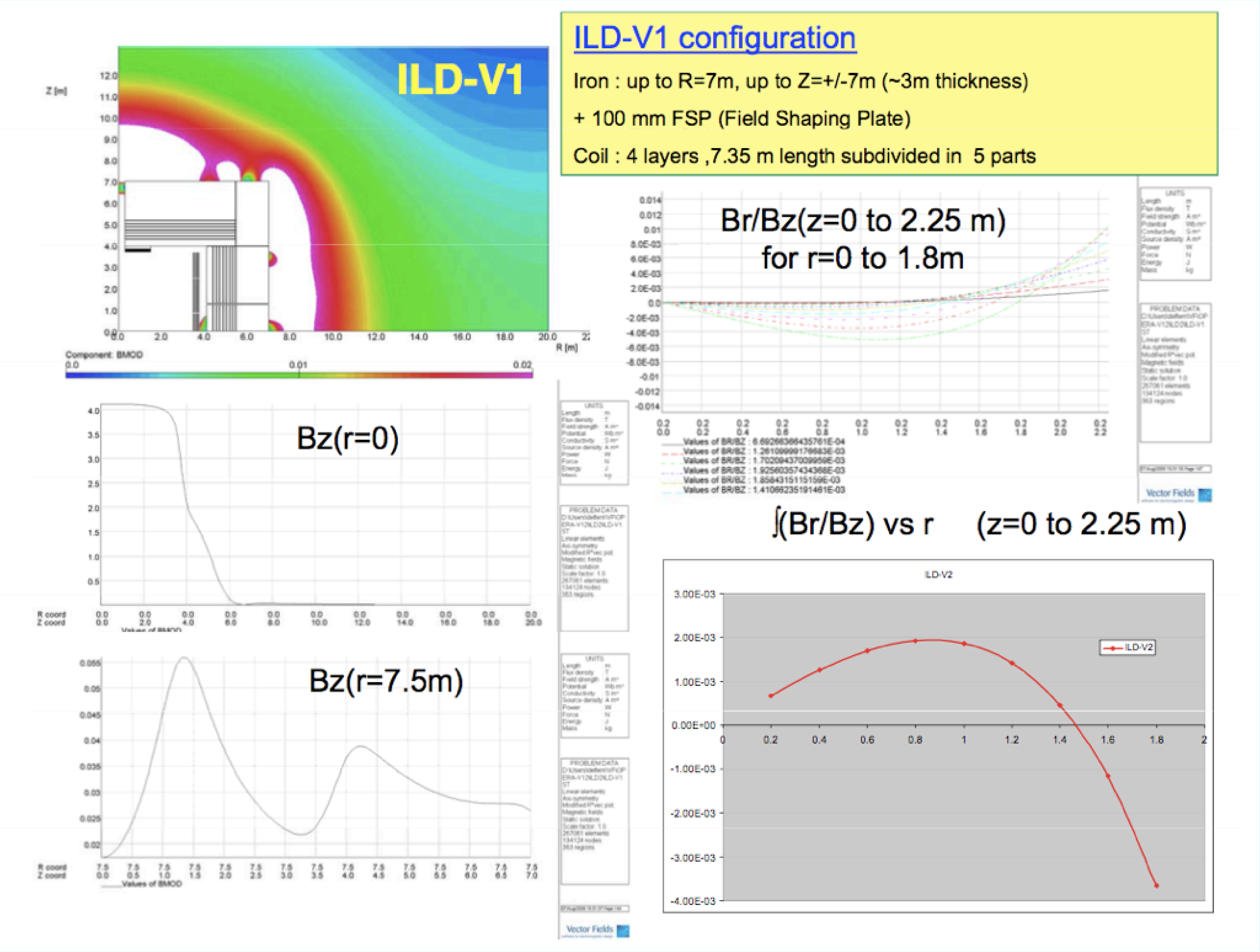


Opening Procedure

- Opening procedure depends on the thickness of the yoke endcap
- If stray fields require thick endcap, it needs to be splitted
- Impact on stability under large magnetic forces!



- Design of the coil exists:



ILD-V1 configuration

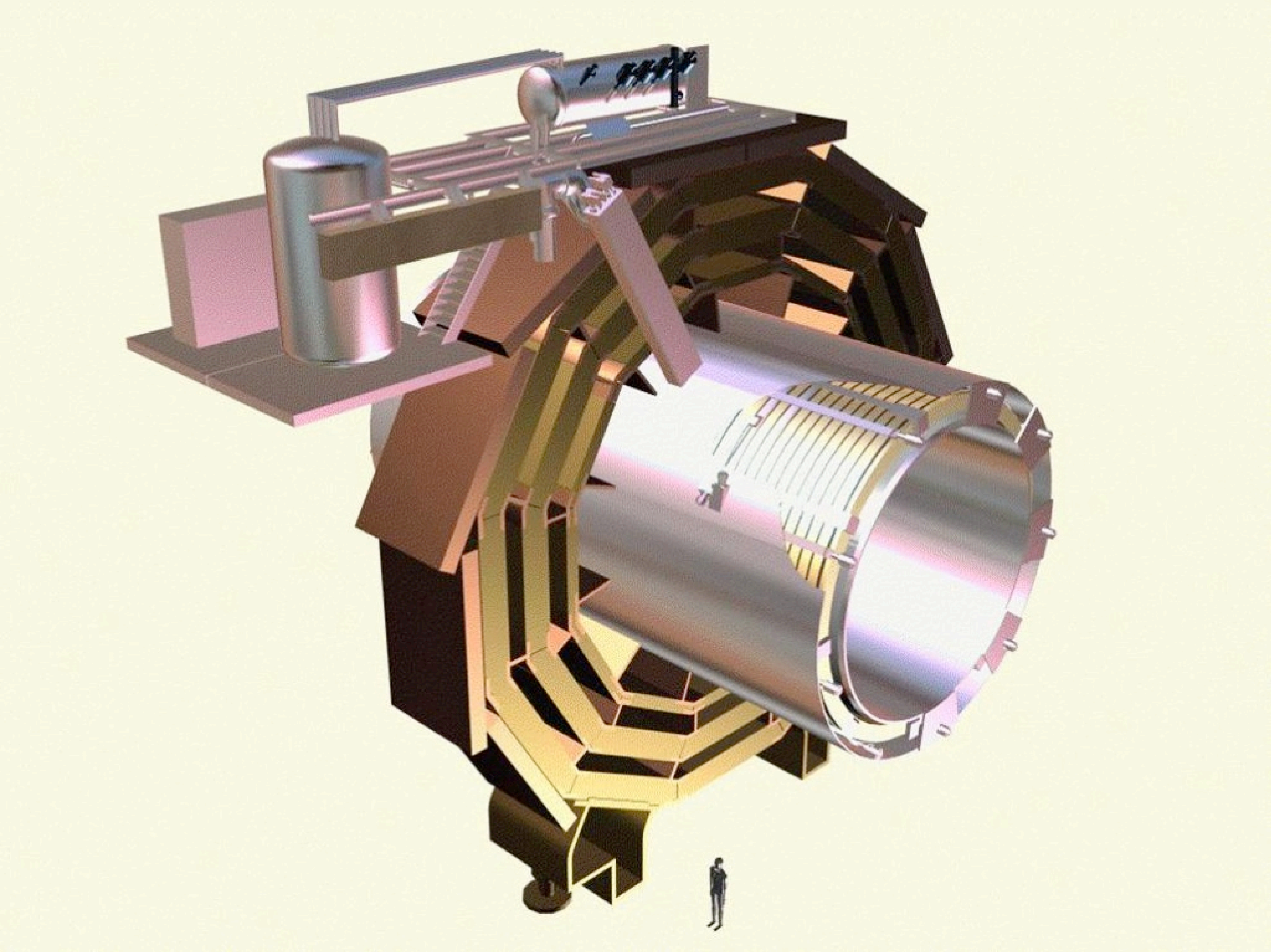
Iron : up to R=7m, up to Z=+/-7m (~3m thickness)

+ 100 mm FSP (Field Shaping Plate)

Coil : 4 layers ,7.35 m length subdivided in 5 parts

Magnet Design

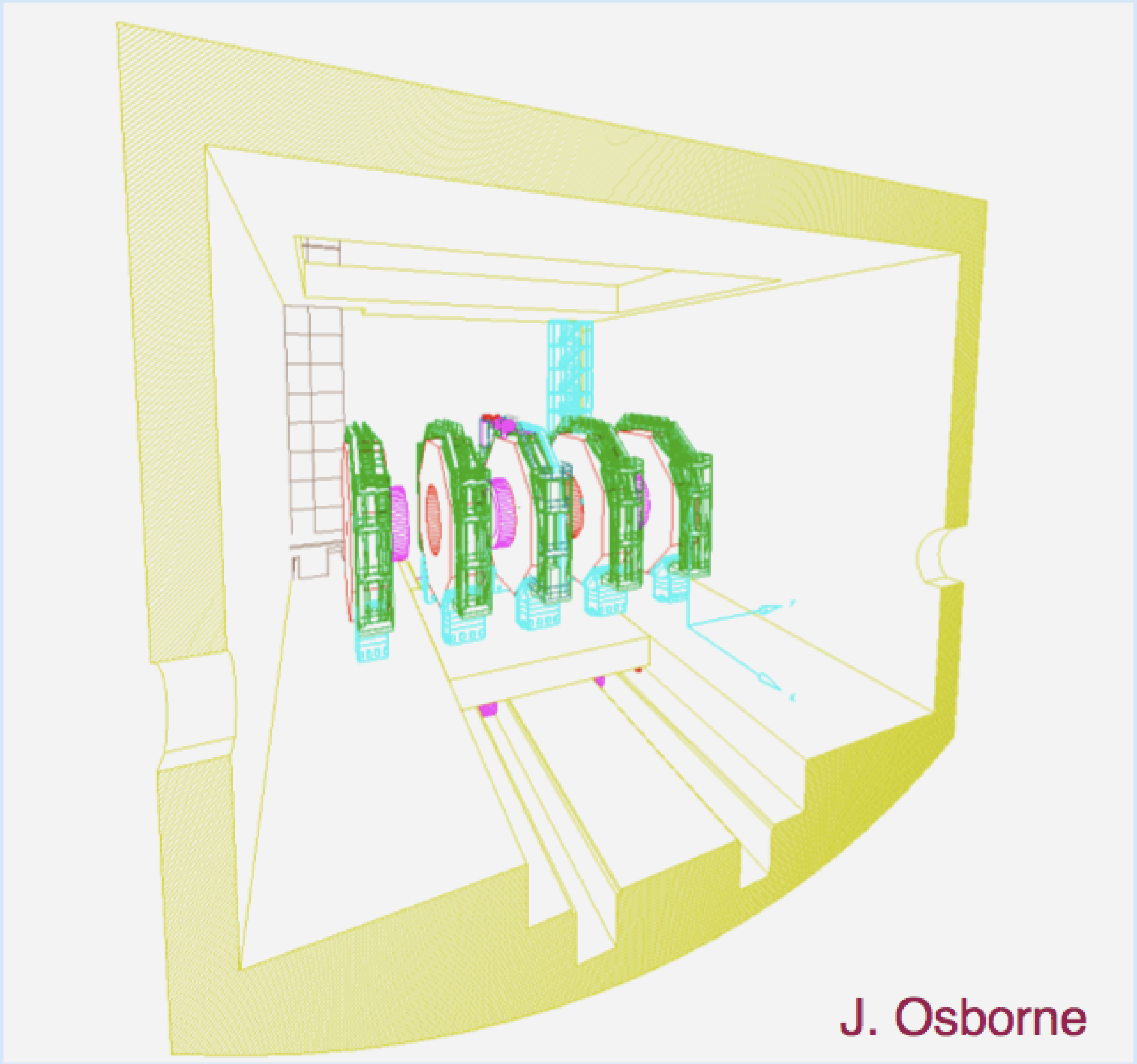
- Many other parts of the magnet need to be designed (or adapted from CMS), e.g.:
  - Vacuum tank
  - Helium supply for push-pull



- No work done so far for ILD

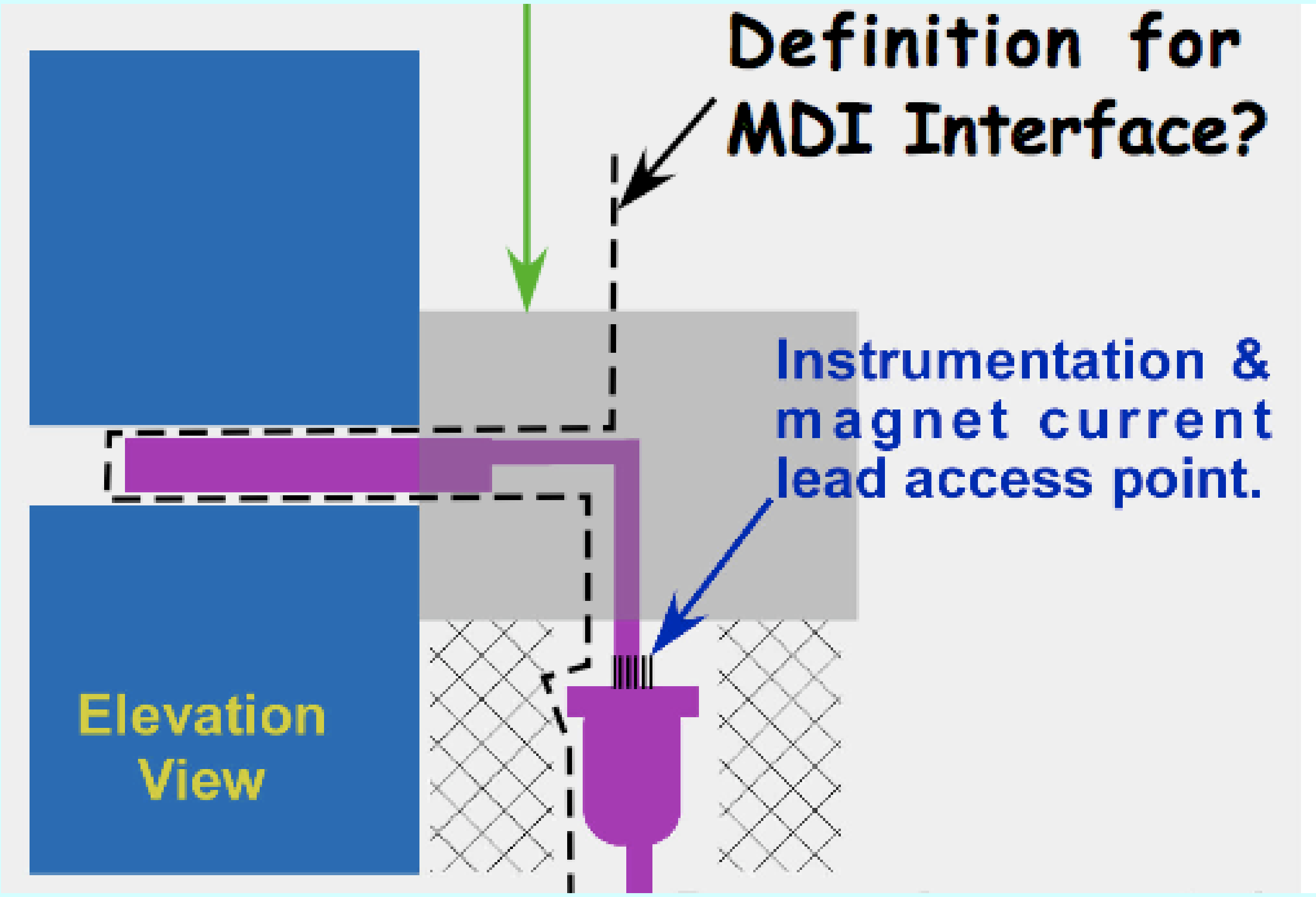
Push-pull

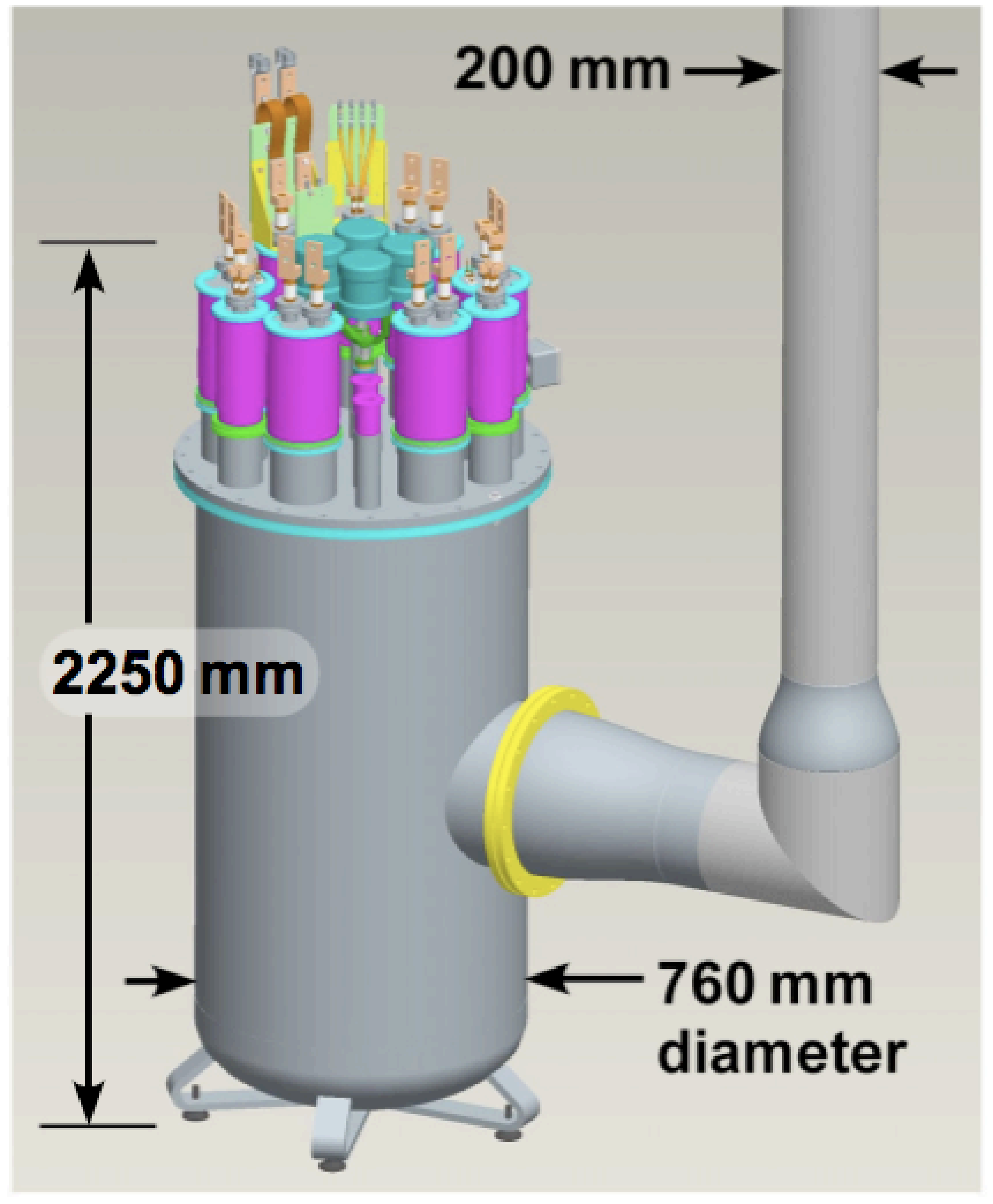
- Assumption: we use a platform
- Many open questions, e.g.:
  - how to move platform
  - what services need to be transported: cables, coo-ling
  - how to open detector on the platform
  - Cryogenics:
    - for QD0
    - for main solenoid
    - cryostats design, etc.
  - Stability requirements, vibrations, etc.
  - How to meet alignment requirements for detector and magnets?
- Just very little - most conceptual - work has been done



Moving S/C Magnets

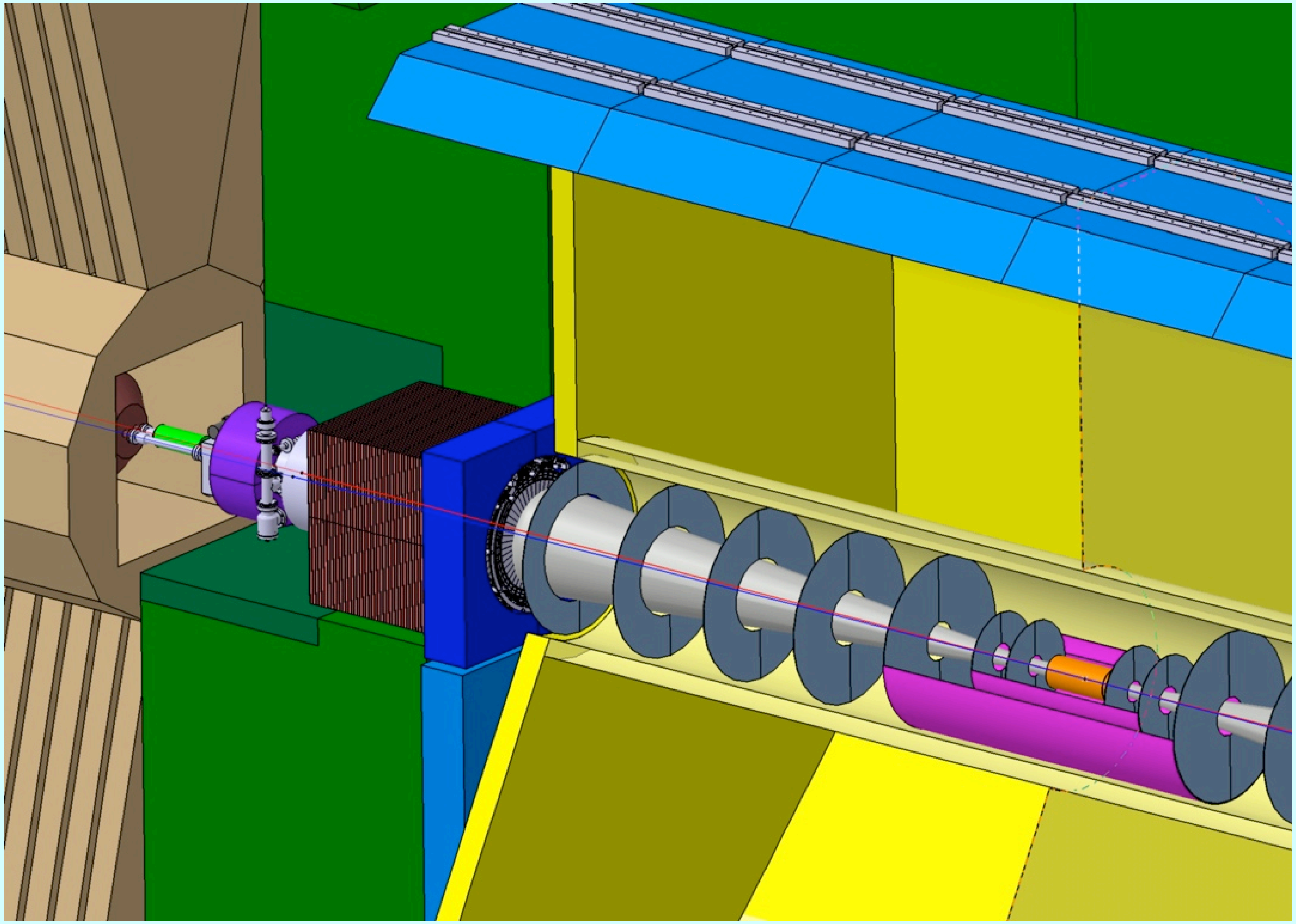
- Engineering design work is being performed at BNL for QD0/QF1
- We have no such design for the detector solenoid!!!





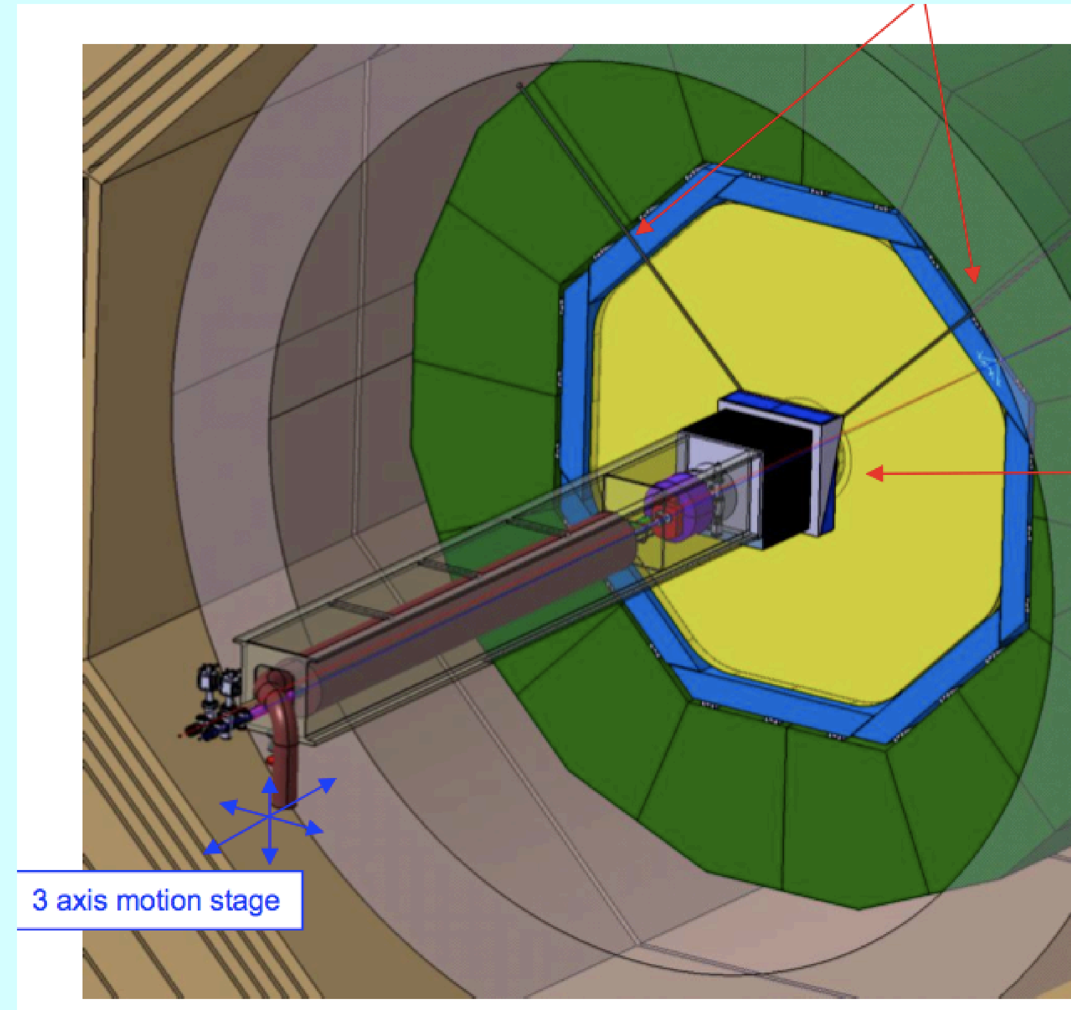
Inner Detector Support

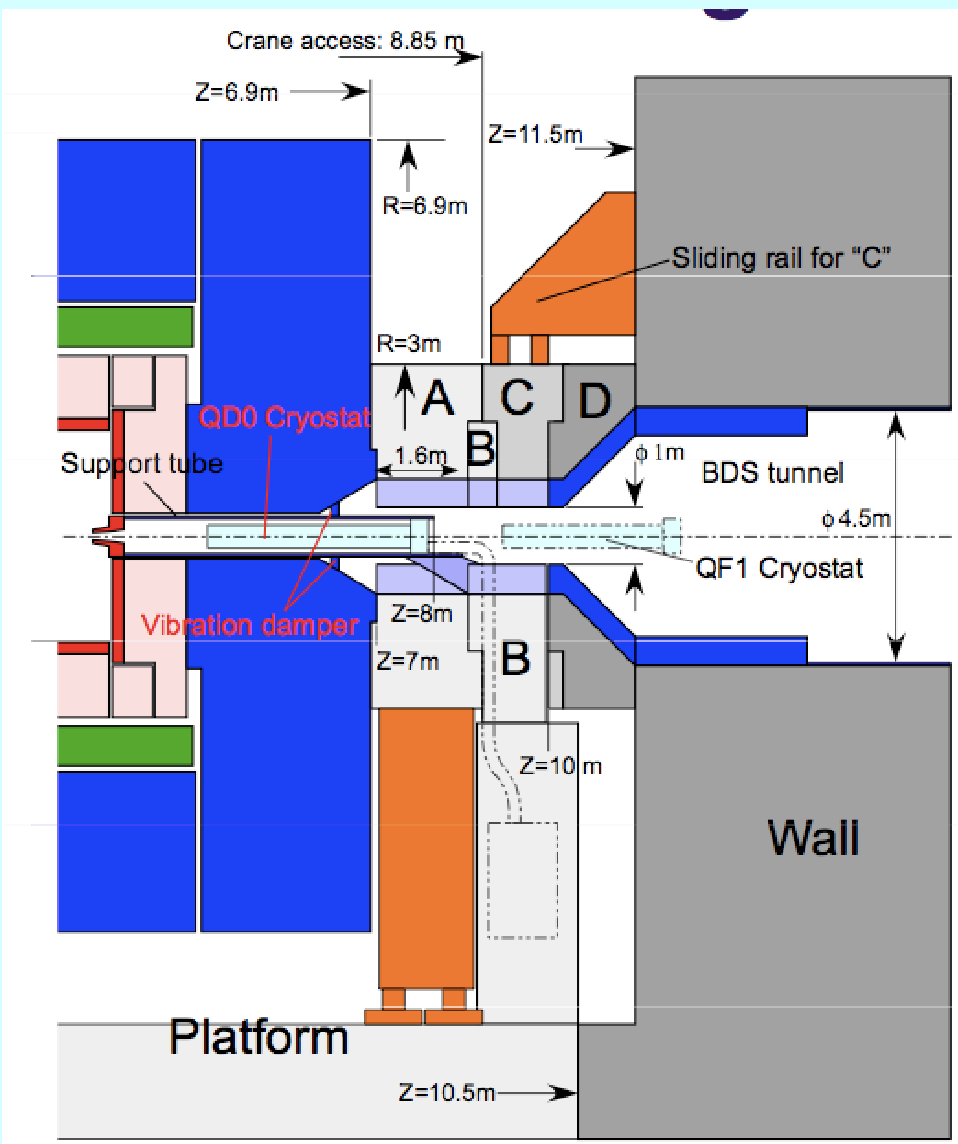
- No study of the inner detector support yet
- Important to understand the support of the beam pipe, stability, vibrations, etc.

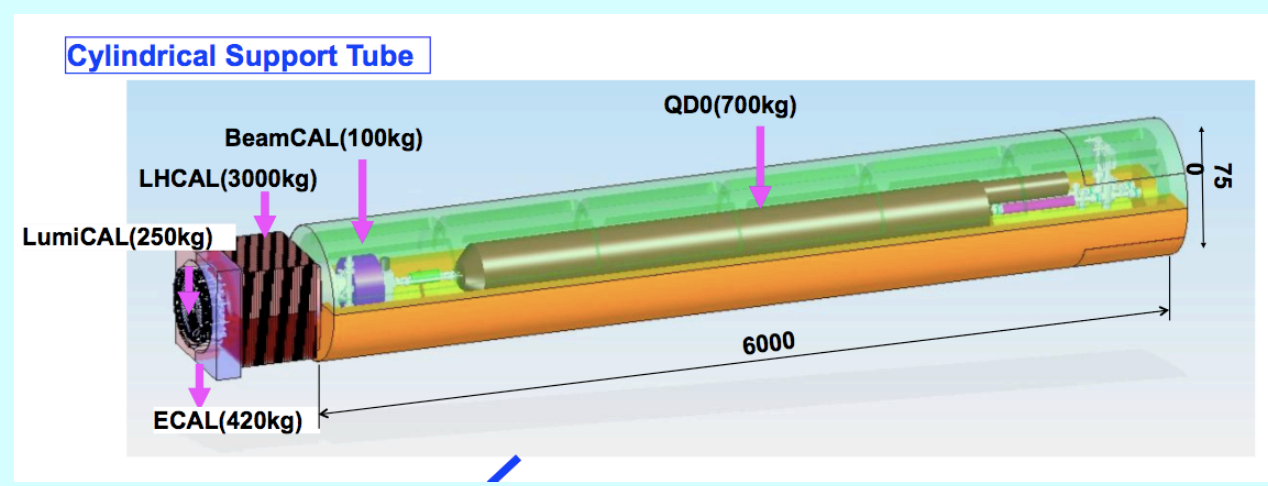


QD0 Support and Shielding

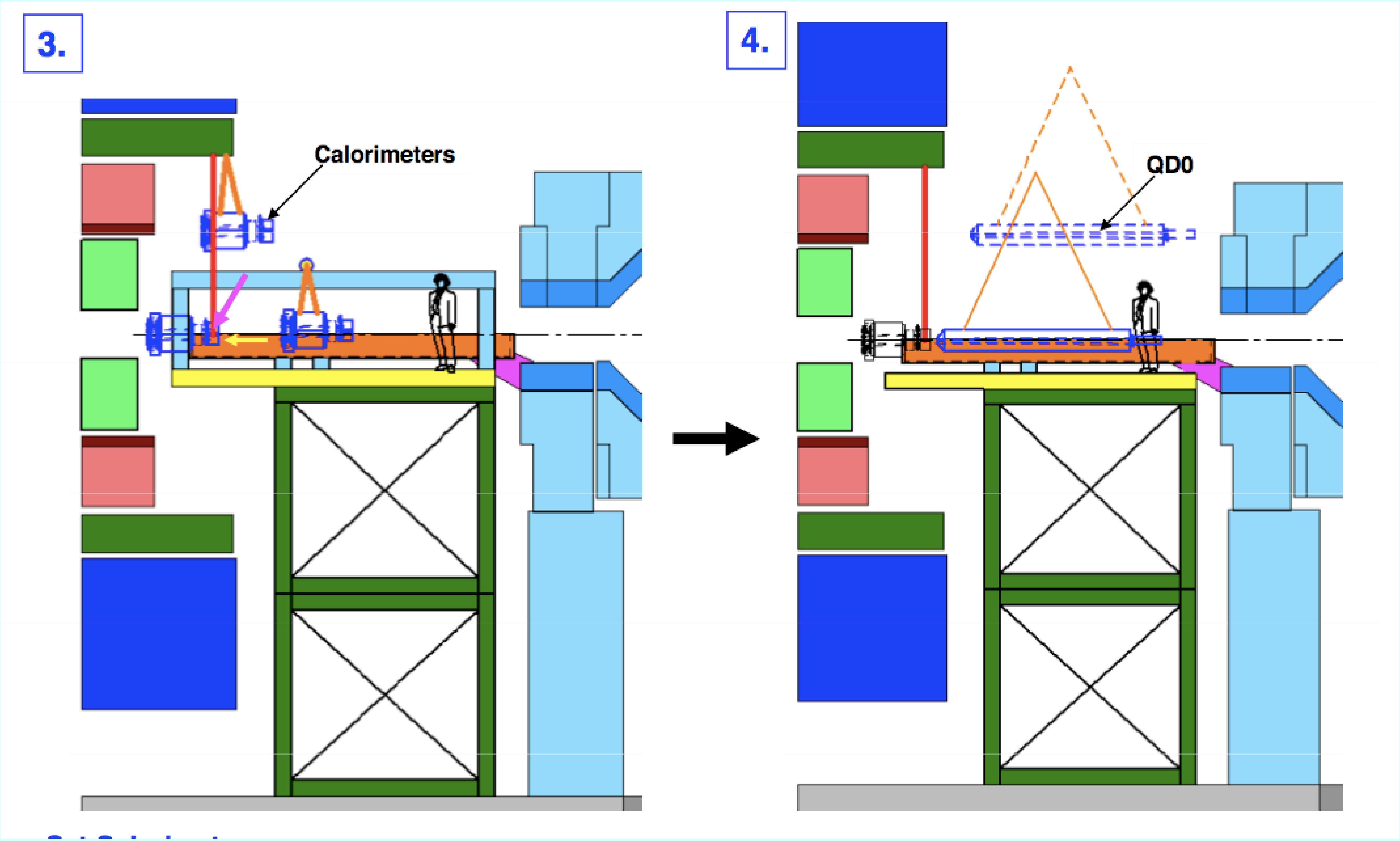
- Two studies for QD0 support tube: square or cylindrical tube
- ‚Pacman' shielding conceptual study
- Pacman needs to fit to both detectors!







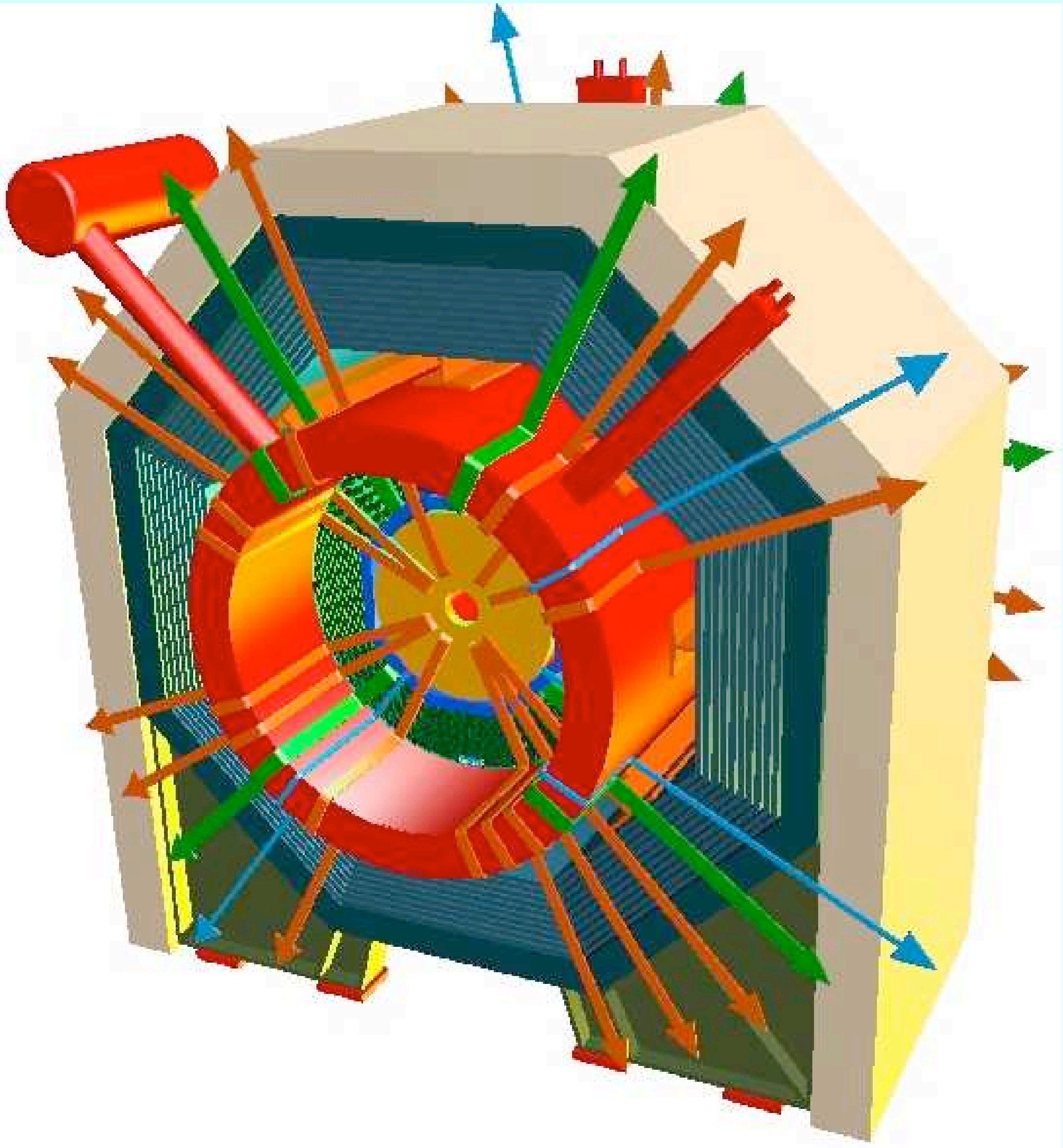
QD0 Installation



Cabling Concept

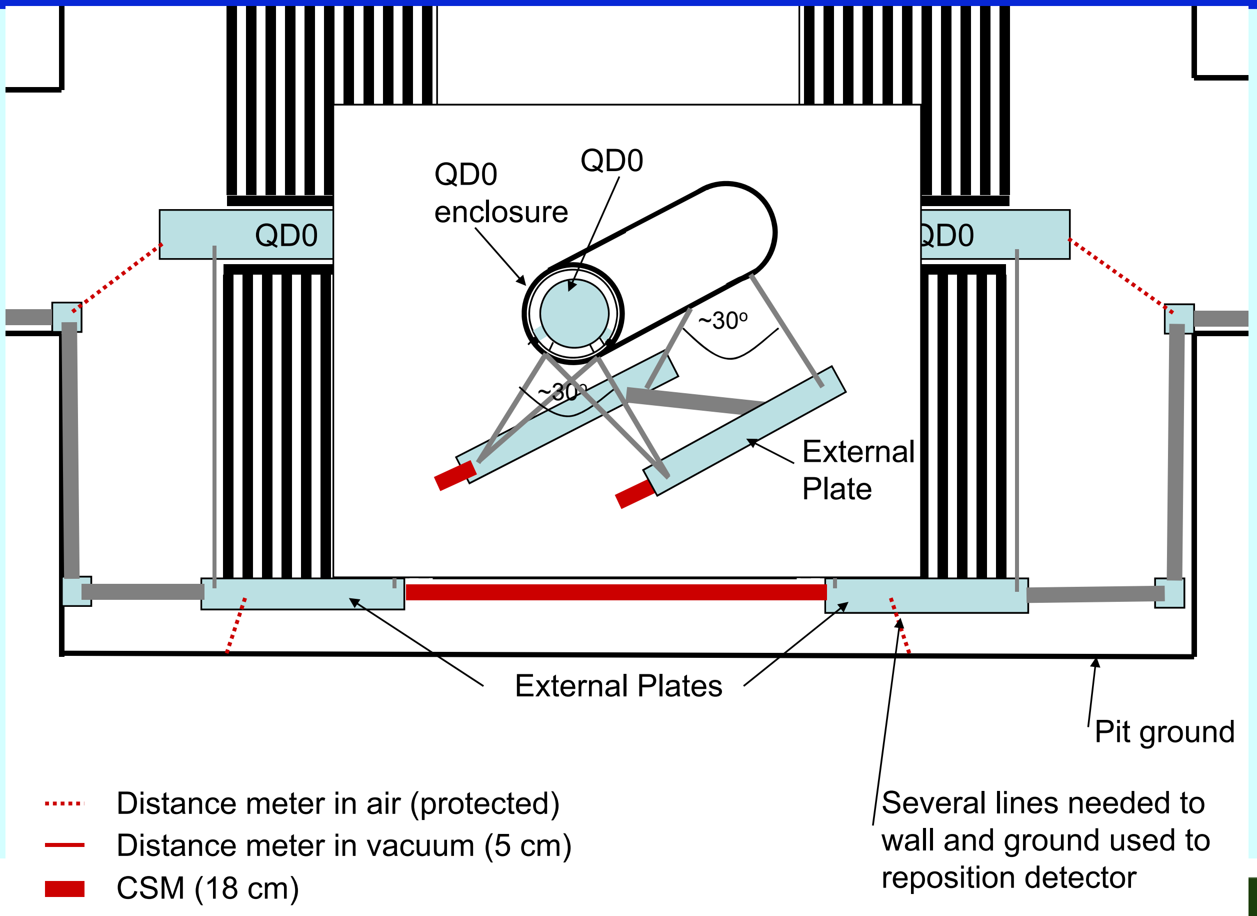
- Summarising the requirements on cables and other supplies has started
- Integrated cabling concept is needed
- Space needed for cables will influence stray fields and self shielding capacity of the detec-tor

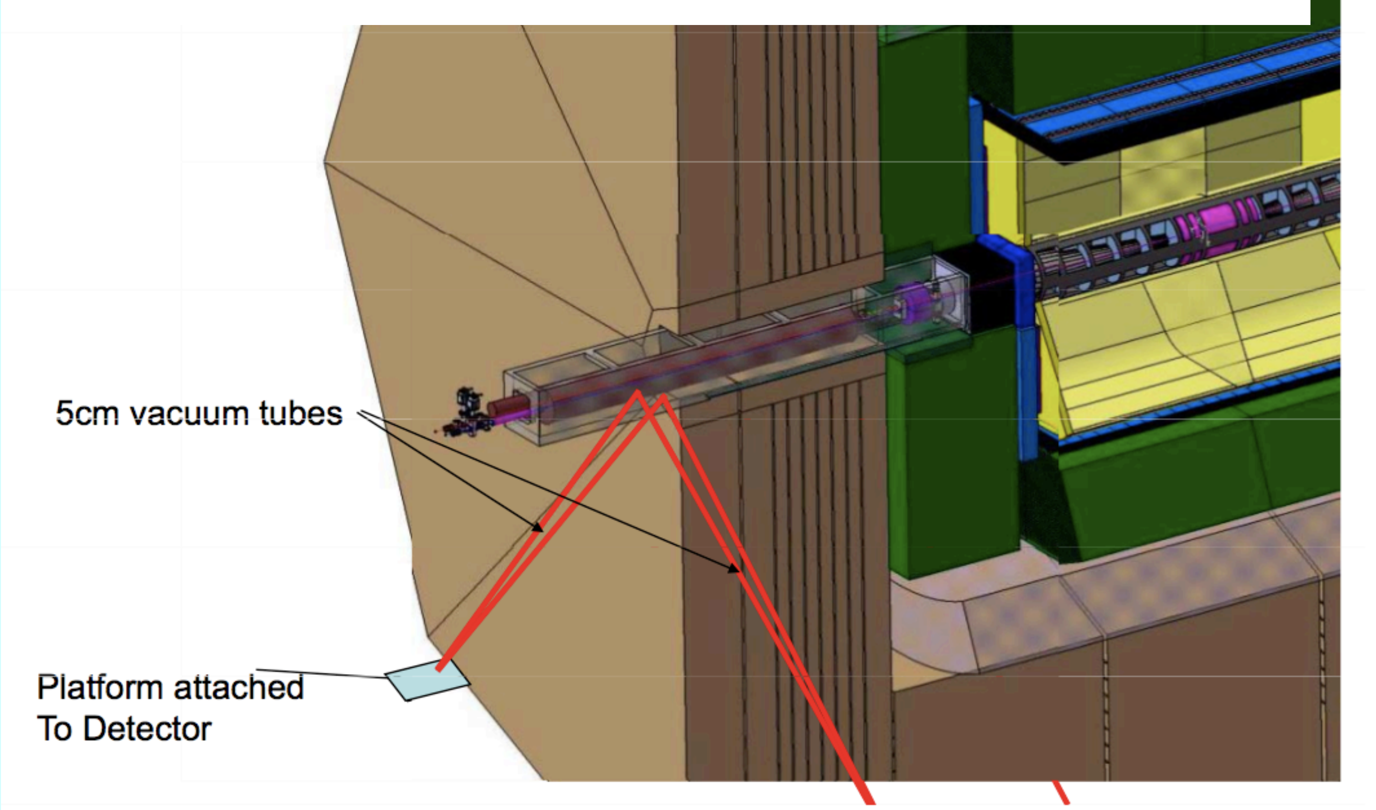
	d(mm)	
▪ Component services	34	
▪ Barrel yoke vertical deformation	6	taken from CMS
▪ Assembly tolerances	5	
▪ Deformation of outer cryostat	10	CMS
▪ Clearance for moving barrel ring	50	CMS
▪ Space for inner muon chambers	50	
Sum	155	



Alignment

- MONALISA interferometric laser system could be used to align both QD0 magnets with respect to each other and to the beam axis
- Could also be used to align the detector itself
- Conceptual studies have started
- Again, full engineering study is needed to study access of laser beams in vacuum to the magnets





IR Interface Minimum Requirements

ILC-Note-2008-nnn
December 2008
Version 0, 2008-11-16

Functional Requirements on the Design of the Detectors and the Interaction Region of an e^+e^- Linear Collider with a Push-Pull Arrangement of Detectors

B.Parker (BNL), A.Mikhailichenko (Cornell Univ.), K.Buesser (DESY), B.Ashmanskas (Fermilab), T.Tauchi (KEK), P.Burrows (Oxford Univ.), T.Markiewicz, M.Oriunno, A.Seryi (SLAC)

- Define minimum requirements which need to be respected by all detector concepts:
  - Available space for detectors
  - Requirements on alignment and vibrations for machine magnets
  - Time methodologies for push-pull
  - Radiation environment
  - Beam parameters
- Requirements have been already discussed at Warsaw
- New - partially very controversial - draft presented here in Chicago
- Needs ILD action

Beam Parameter Discussion

- Controversial statement in the acutal draft:

Beam-Beam parameter space
Each detector concept must be able to function in a beam-beam parameter space defined by the ILC Chief Accelerator Physicists. For the LOI, each concept should demonstrate that beam clearances are sufficient to allow operation with the nominal, Low N, Large Y and Low P parameter sets defined in the RDR [1].

- T. Markiewicz (BDS/MDI Session):

Each concept's design should be evaluated by the IDAG

(or IDAG appointed consultants)

as to whether it complies with functional requirements

- Will be discussed in the RD's MDI group
- Already brought to the attention of S. Yamada
- Will definitely not work that way....

ILC RDR Parameter Sets

Low-P Parameter Set:

- Half the number of bunches
- Less RF needed
- Luminosity recovered by squeezing bunches harder at the IP
- Beamstrahlung losses larger (factor 2)
- Pair backgrounds larger
- Potential large cost savings!
- E. Paterson:
  - Low P looks interesting if one makes maximum use of lower power in beam in all systems from beginning to end.
    - This includes installed electrical distributions, cryo-systems, RF power, Beam dumps etc etc

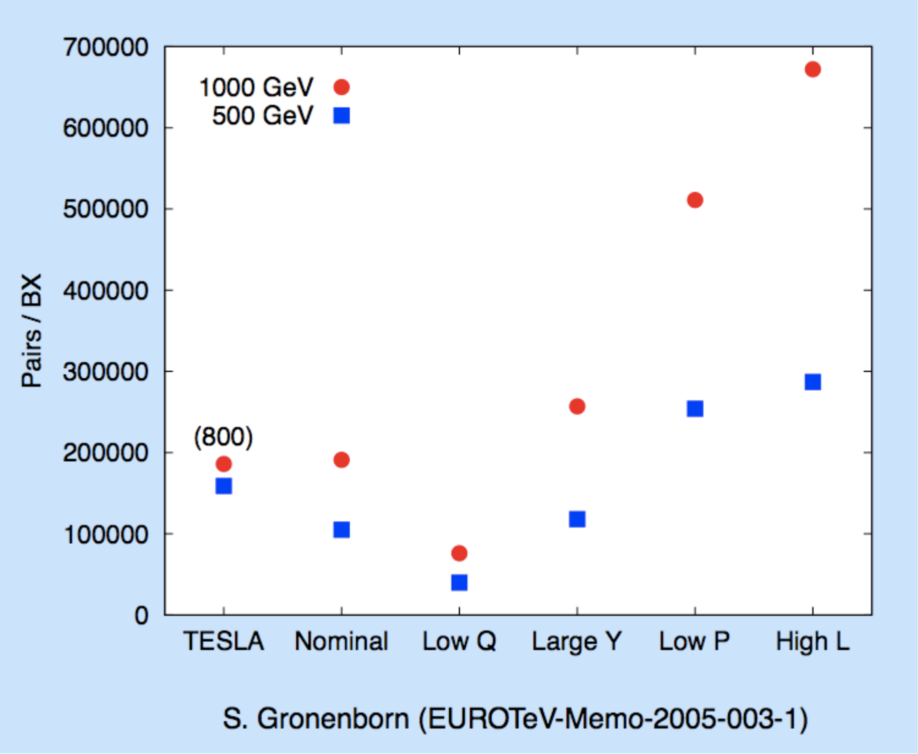
TABLE 2.1-2
Beam and IP Parameters for 500 GeV cms.

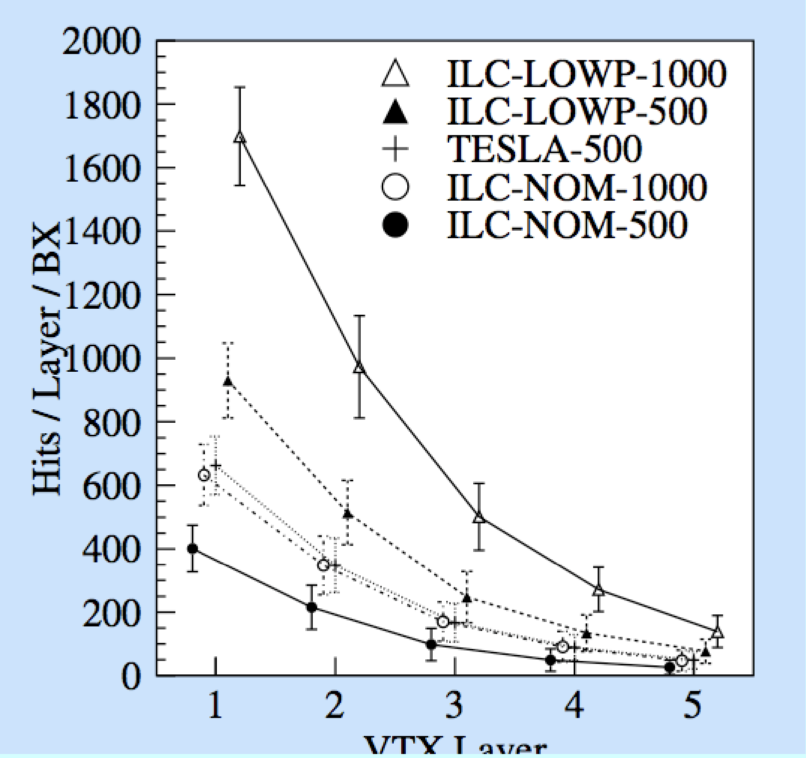
Parameter	Symbol/Units	Nominal	Low N	Large Y	Low P
Repetition rate	f_{rep} (Hz)	5	5	5	5
Number of particles per bunch	N (10^{10})	2	1	2	2
Number of bunches per pulse	n_b	2625	5120	2625	1320
Bunch interval in the Main Linac	t_b (ns)	369.2	189.2	369.2	480.0
in units of RF buckets		480	246	480	624
Average beam current in pulse	I_{ave} (mA)	9.0	9.0	9.0	6.8
Normalized emittance at IP	$\gamma\epsilon_x^*$ (mm·mrad)	10	10	10	10
Normalized emittance at IP	$\gamma\epsilon_y^*$ (mm·mrad)	0.04	0.03	0.08	0.036
Beta function at IP	β_x^* (mm)	20	11	11	11
Beta function at IP	β_y^* (mm)	0.4	0.2	0.6	0.2
R.m.s. beam size at IP	σ_x^* (nm)	639	474	474	474
R.m.s. beam size at IP	σ_y^* (nm)	5.7	3.5	9.9	3.8
R.m.s. bunch length	σ_z (μm)	300	200	500	200
Disruption parameter	D_x	0.17	0.11	0.52	0.21
Disruption parameter	D_y	19.4	14.6	24.9	26.1
Beamstrahlung parameter	Υ_{ave}	0.048	0.050	0.038	0.097
Energy loss by beamstrahlung	δ_{BS}	0.024	0.017	0.027	0.055
Number of beamstrahlung photons	n_γ	1.32	0.91	1.77	1.72
Luminosity enhancement factor	H_D	1.71	1.48	2.18	1.64
Geometric luminosity	$\mathcal{L}_{geo}$ 10^{34}/cm^2/s	1.20	1.35	0.94	1.21
Luminosity	$\mathcal{L}$ 10^{34}/cm^2/s	2	2	2	2

- ILC GDE studies for the Minimal Machine will take Low-P parameters into account

Low-P Background Numbers

- Number of produced pairs per BX is ~2 times larger than at nominal ILC parameters (here w/o travelling focus)

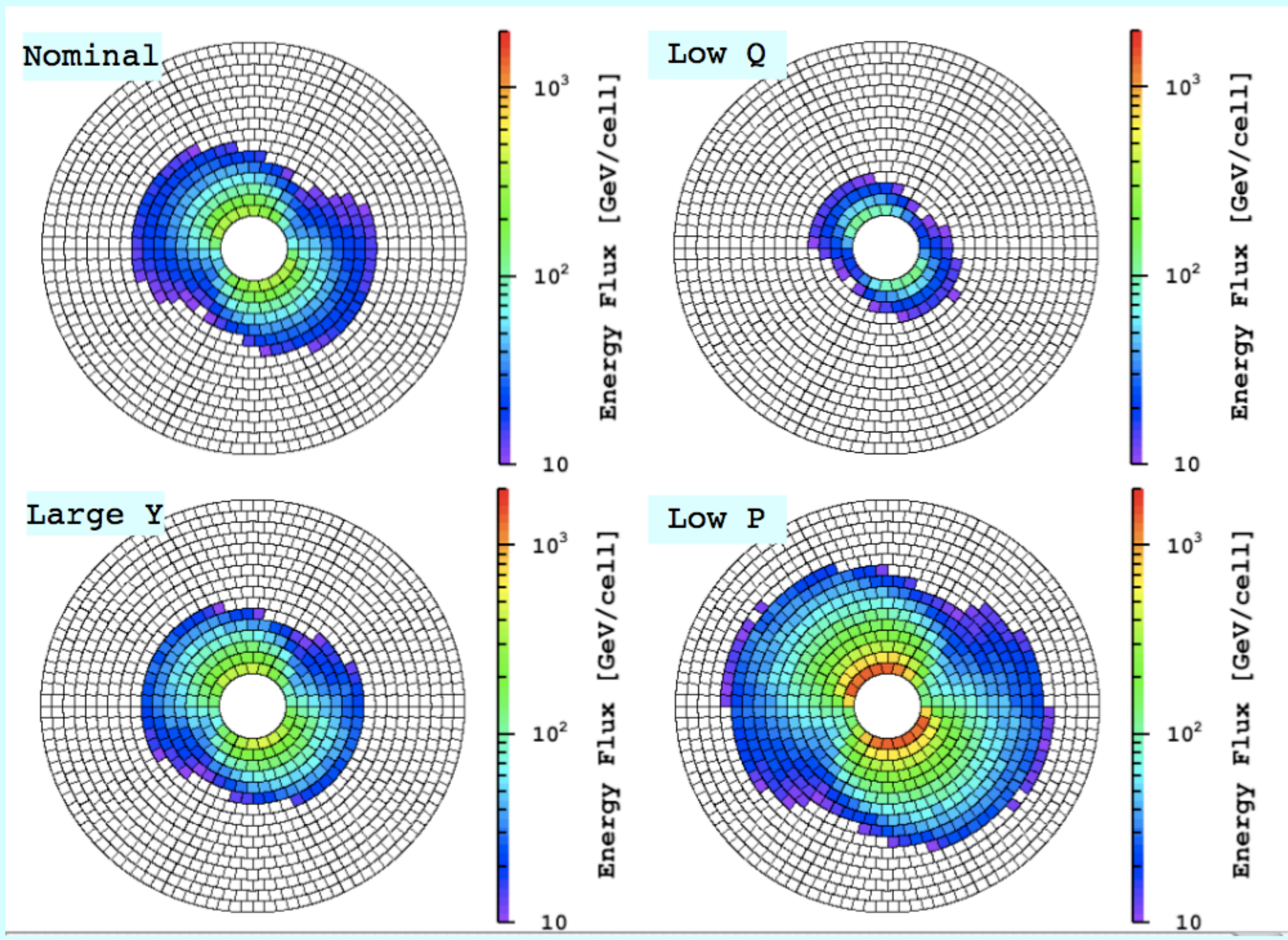


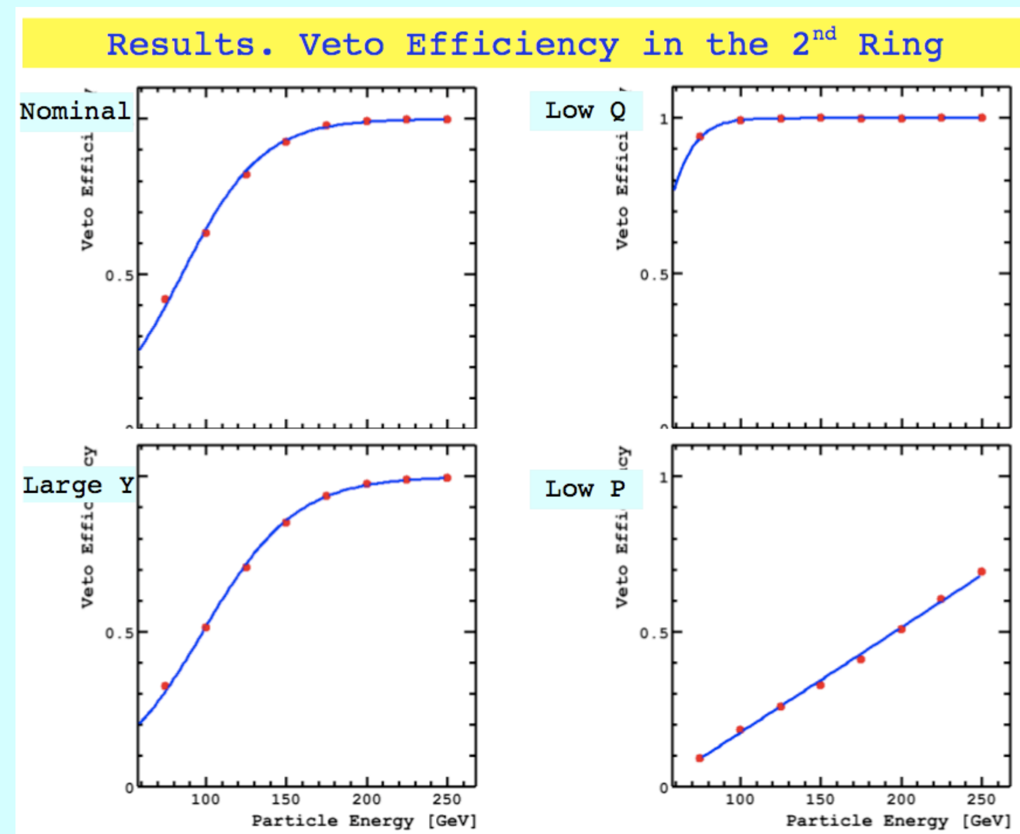


- Total number of hits on vertex detector is 2.5 times larger than at nominal ILC parameters
- But the number of bunches per train is only half!
- Integrated backgrounds depend on integration times:
- full bunch train: background numbers per readout are roughly the same
- couple of bunches: integrated numbes scale with bunch distance times (370/480)
- but backgrounds per luminosity will stay at 2.5!
- What are the relevant numbers?

Impact on Subdetectors

- Detectors which will be read out every BX will see more backgrounds. Example Beamcal (V. Drugakow, LCWS2006):





After all cuts applied except veto ($L=500fb^{-1}$):
2-photon events ~ $2.7\cdot10^5$
SUSY events ~ 20
SUSY analysis is done by Z.Zang(LAL)

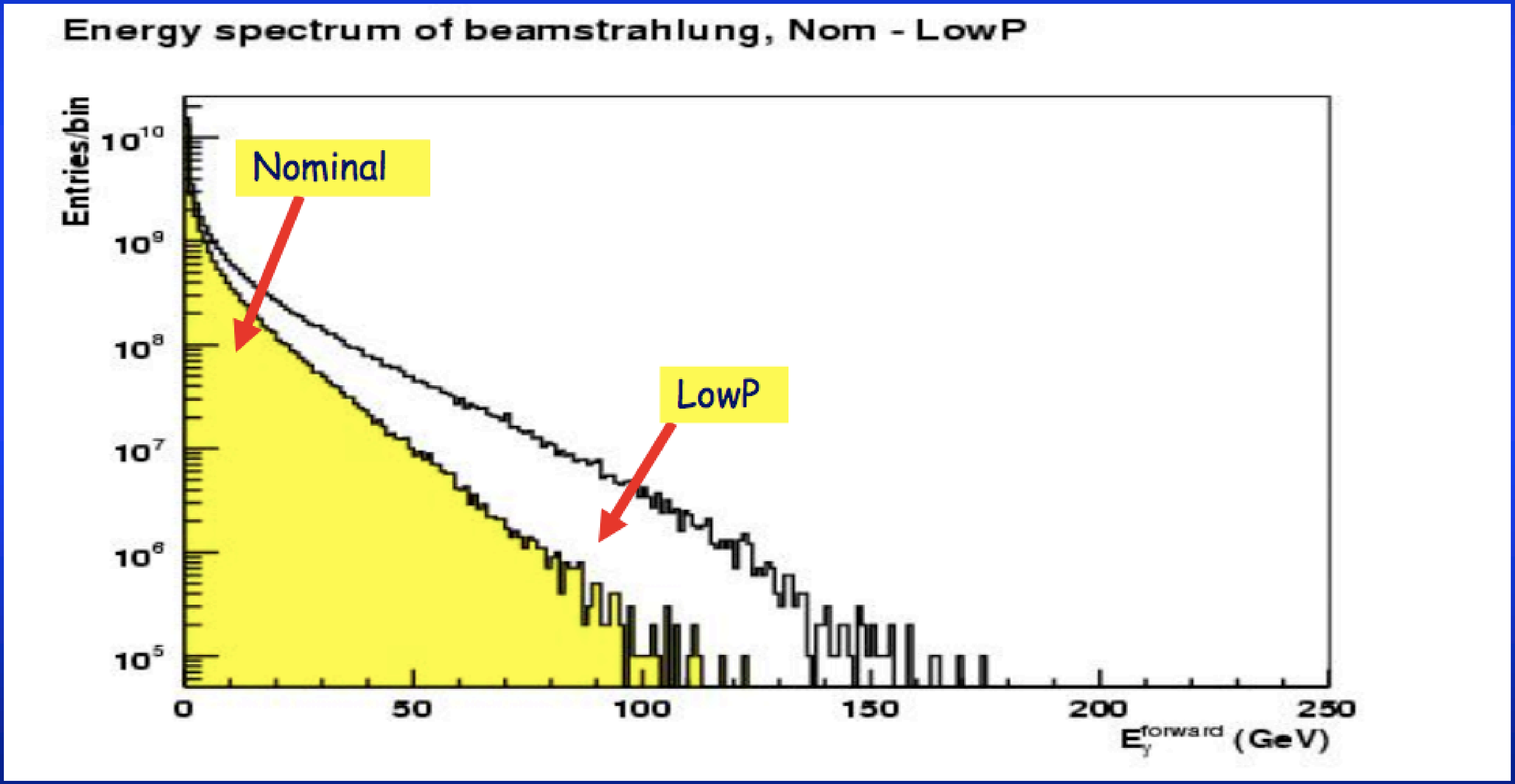
Number of unvetoed **2-photon events:**

Veto Energy Cut, GeV	75	50
Nominal	45	5
Low Q	40	0.1
Large Y	50	9
Low P	364	321

Dilution of Luminosity Spectrum

Nominal parameters : Eγ = 1.16 x 10^{11} GeV per bX

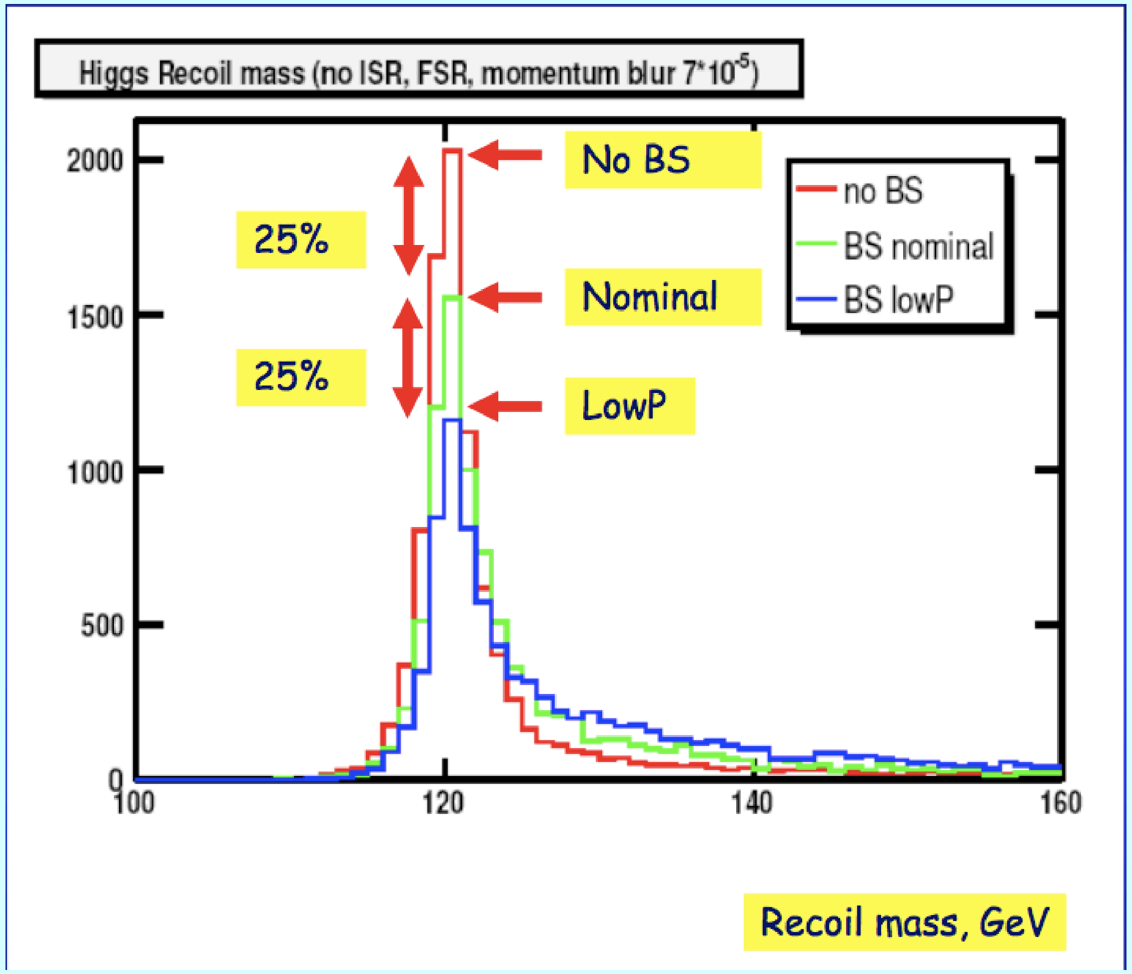
LowP parameters : Eγ = 2.94 x 10^{11} GeV



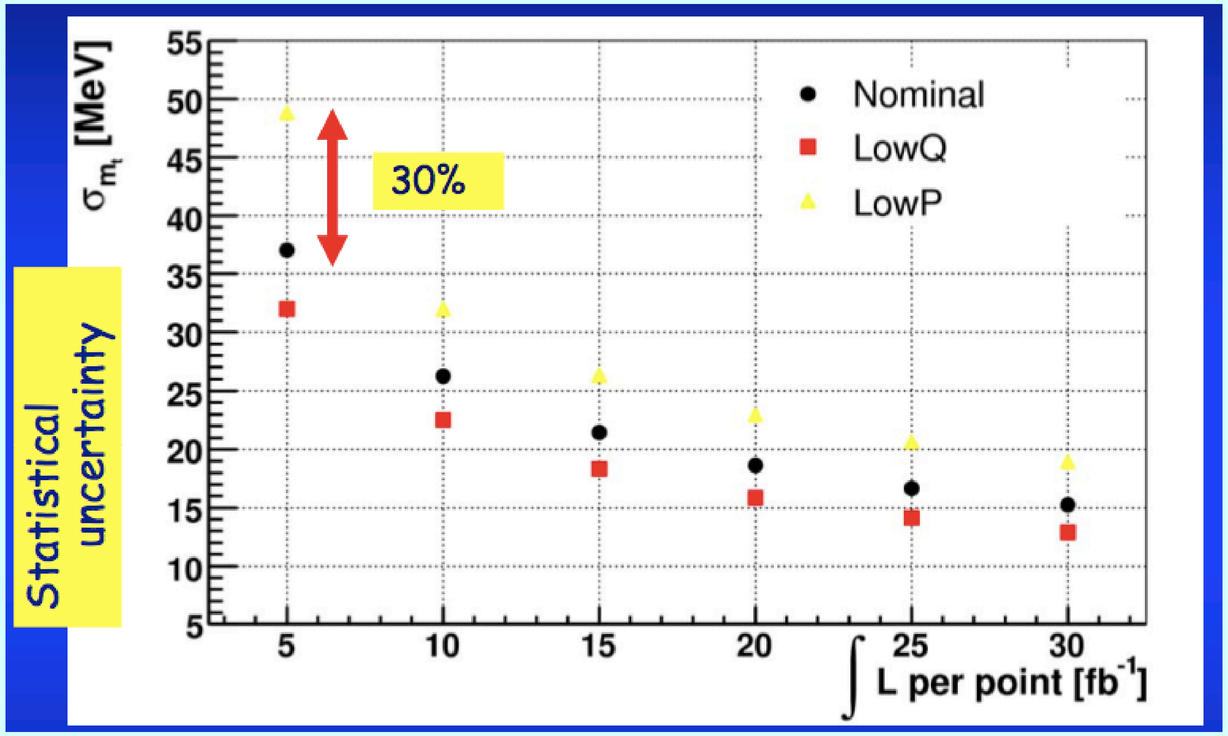
November, 2006 ECFA Valencia meeting

Impact on Physics (W. Lohmann, ECFA-WS Valencia 2006)

- Example Higgs Recoil Mass:

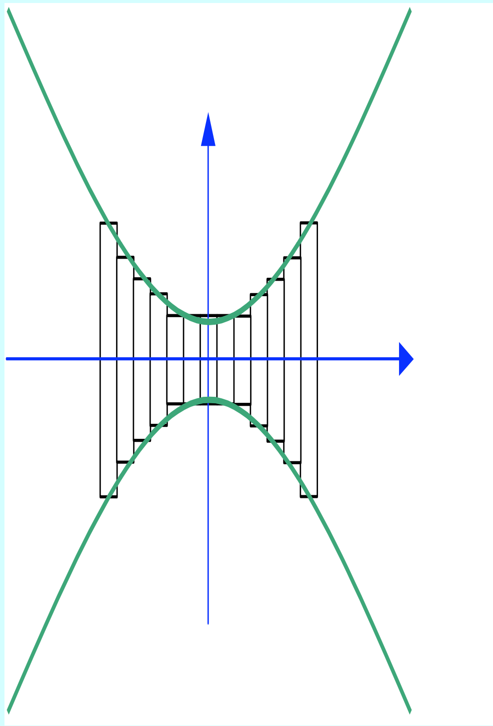


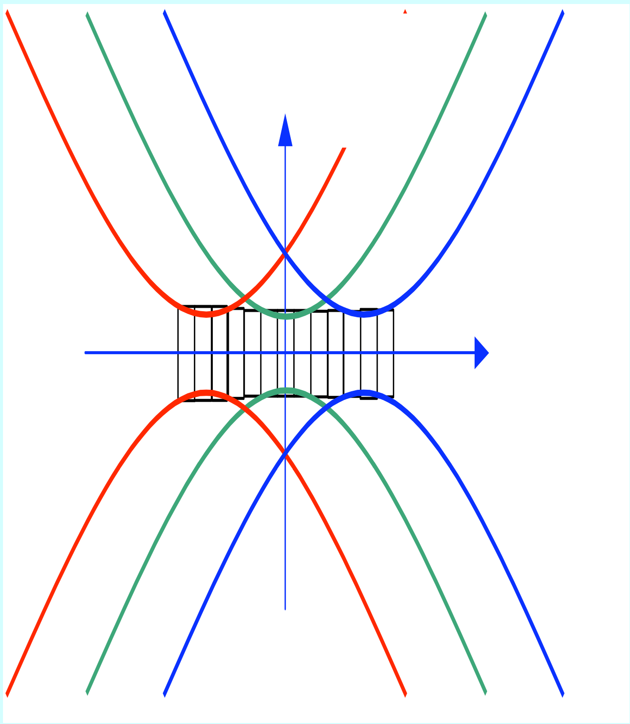
- Example top threshold scan:



Travelling Focus Concept

- Idea:
  - Arrange for finite chromaticity at the IP
  - Create z-correlated energy spread along the bunch
- Beats the hourglass effect at the IP, increases luminosity!
- Could help to ease the effects of the Low-P parameters by allowing for larger bunch length
- Needs more studies





Low-P and Travelling Focus

- Preliminary study (A. Seryi):

	Nom. RDR	Low P RDR	new Low P
Case ID	1	2	3
E CM (GeV)	500	500	500
N	2.0E+10	2.0E+10	2.0E+10
n_b	2625	1320	1320
F (Hz)	5	5	5
P_b (MW)	**10.5**	**5.3**	**5.3**
$\gamma\varepsilon_X$ (m)	1.0E-05	1.0E-05	1.0E-05
$\gamma\varepsilon_Y$ (m)	4.0E-08	3.6E-08	3.6E-08
βx (m)	2.0E-02	1.1E-02	1.1E-02
βy (m)	4.0E-04	2.0E-04	2.0E-04
Traveling focus	No	No	**Yes**
Z-distribution *	Gauss	Gauss	Gauss
σ_x (m)	6.39E-07	4.74E-07	4.74E-07
σ_y (m)	5.7E-09	3.8E-09	3.8E-09
σ_z (m)	3.0E-04	2.0E-04	**3.0E-04**
Guinea-Pig $\delta E/E$	0.023	0.045	0.036
Guinea-Pig Lumi ($cm^{-2}s^{-1}$)	**2.02E+34**	**1.86E+34**	**1.92E+34**
Guinea-Pig Lumi in 1%	1.50E+34	1.09E+34	1.18E+34

Summary

- ILD Integration and MDI issues are a major engineering endeavour
  - but engineering resources are limited
- We are confident that we will have a conceptual idea of the detector design which is ready for an LoI
- Many isolated engineering studies still need to be put together into the integrated detector model
- Most urgent points to be done:
  - complete yoke design incl. opening procedure
  - define cabling concept
  - define push-pull procedure
  - adapt mechanical design of magnet to ILD
  - finalise inner detector and QD0 support
  - define on how to integrate common MDI issues (i.e. LEP) to the LoI
  - how to integrate all subdetectors into the detector model
- IR Interface document needs critical review and eventually approval from ILD