General News:

* 1. Detector Concepts Report (CDR) - due in December 2006. Members/writers are John Jaros, Ties Benhke, Chris Damerell.
* 2. "push-pull" group led by Andrei Seryi (SLAC). Charge is to study (cheaper) IR options. This connects almost everything: detector sizes and installation, final focus, machine crossing angles, engineering, etc.
* 3. Shielding, floor loading, installation.

1 Fourth Concept ("4th") Detector

The Fourth Concept detector [1] is deliberately simple, consisting of four essential detector systems, each designed to its maximum capability and integrated and coordinated with the other detectors such that auxilliary detectors, *e.g.* tail-catchers, end cap chambers, silicon strips to aid the gaseous tracker, inter-detector chambers, are all unnecessary. New ideas in calorimetry, muon identification and background rejection, magnetic field configuration, and related machine-detector interface issues are introduced in this concept.

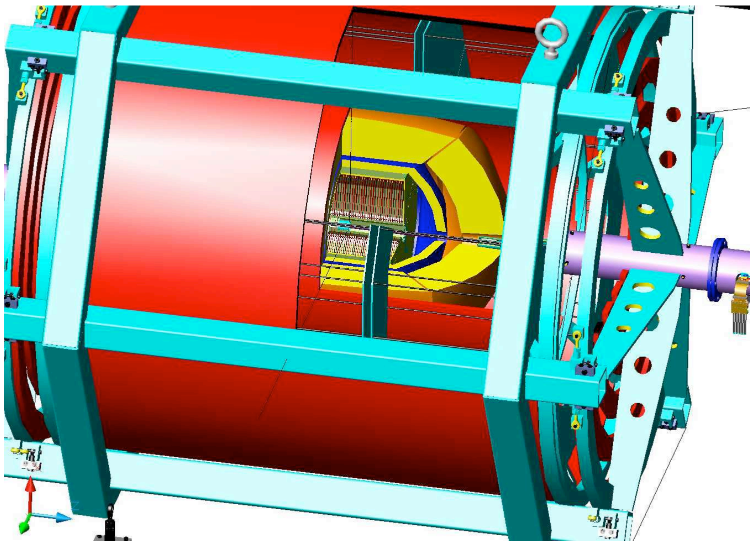


Figure 1: Cut-awat view of pixel vertex (blue), TPC (green), calorimeter (yellow), dual solenoids (red) and supports for muon spectrometer tubes, inside a frame, and the common support for beam line elements (purple).

1.1 Tracking in the 4th Concept

The pixel vertex detector is the same design as the SiD detector being developed at Fermilab, a 50μm thick depletion region with 15μm $\times$15μm pixels and sophisticated front end processing and zero-suppression. Its inner and outer radii are about 1.5 cm and 8 cm, respectively, in a 3.5 T field. This high precision pixel vertex detector is essential for the tagging of b and c quarks and τ leptons, and the suppression of hit occupancies so near to the beam.

A Time Projection Chamber (TPC) is very similar to those being developed by the GLD and LDC concepts, in collaboration with the TPC R&D groups, with sophisticated readout in a 3.5T magnetic field and with a low diffusion gas at moderate electron drift velocity will serve well for the reconstruction and pattern

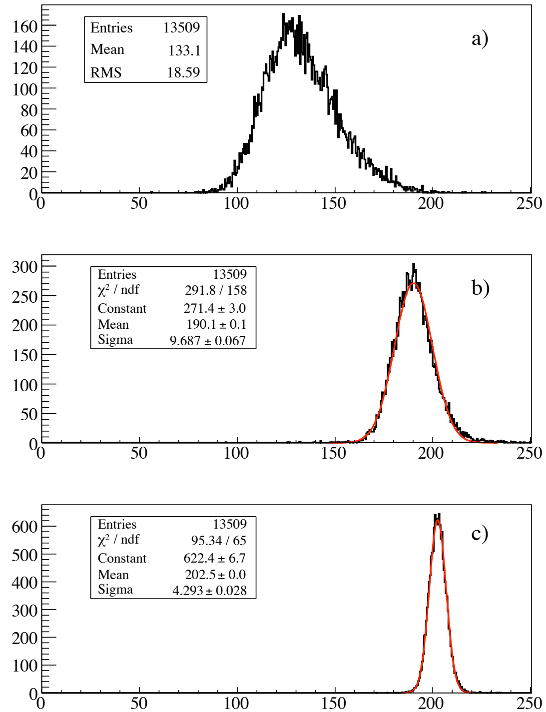


Figure 2: (a) The distribution of the scintillator (S) signal for 200 GeV π^-. This is the raw resolution that a typical scintillating sampling calorimeter would achieve; (b) the leakage-dominated energy distribution using only the S and C (Čerenkov) signals for each event. (c) The energy distribution with leakage fluctuations suppressed using the known beam energy (=200 GeV) to make a better estimate of f_{em} each event [2].

1.3 Magnetic field, muons and machine-detector interface in 4th

The muon system is a dual-solenoid magnetic field configuration in which the flux from the inner solenoid that defines the TPC tracking field is returned through the annulus between this inner solenoid and an outer solenoid oppositely driver with a smaller turn density. The magnetic field in this gaseous tracking volume between the two solenoids will back-bend the muons for a second measurement (after the calorimeter) of the momentum to achieve high precision without the limitation of multiple scattering in Fe, a limitation that fundamentally limits momentum resolution in conventional muon systems to 10%. High spatial precision drift tubes with cluster counting electronics measure tracks in this volume. This dual-solenoid field is terminated by a novel “wall of coils” that provides muon bending down to small angles ($\cos\theta \approx 0.975$) and also allows us to completely control the magnetic environment on and near the beam line.

recognition of tracks in any complicated event. In the new experimental physics regime of a TeV e^+e^- collider, a three-dimensional imaging tracking detector such as a TPC is essential. The low mass it presents to passing particles, its two-track discrimination and spatial precision are ideal for observing long-lived ($\gamma\beta c\tau \approx$ 1-100 cm) decaying states; its essentially complete solid angular coverage contributes to complete physics events; its measurement of ionization allows searches for free quarks at $(1/3)^2$ or $(2/3)^2$ ionization, for magnetic monopoles, and for any other exotically ionizing tracks. In addition, the multiple measurements of the z-coordinates along the trajectory of a track yield a measurement of magnetic charge (m) by $\mathbf{F} = m\mathbf{B}$ bending. Finally, the dE/dx ionization measurement of a TPC will assist physics analyses involving electron identification, discrimination of singly ionizing e^- from a doubly ionizing $\gamma \rightarrow e^+e^-$ conversion for aligned tracks, and other track backgrounds.

In the spirit of simplicity, we seek a TPC with such high precision, *e.g.*, single-electron digital capabilities in a low diffusion gas, that auxilliary detectors such a silicon strips surrounding the TPC on all its boundaries are not required to meet the momentum resolution goal of $\delta(1/p_T) \approx 3 \times 10^{-5}$ (GeV/c)$^{-1}$.

1.2 Calorimetry in the 4th Concept

The calorimeter is a spatially fine-grained dual-readout fiber sampling calorimeter augmented with the ability to measure the neutron content of a shower. The dual fibers are scintillation and Čerenkov for separation of hadronic and electromagnetic components of hadronic showers[2]. We expect to surpass the energy resolution of the tested DREAM calorimeter with finer spatial sampling, neutron detection for the measurement of fluctuations in binding energy losses, and a large enough module to suppress leakage fluctuations. The calorimeter modules will have fibers up to their edges, and constructed for sub-millimeter close packing, with signal extraction on the outside so that the calorimeter system will approach full coverage without cracks. We are studying a separate EM section in front of the dual-readout calorimeter consisting of a crystal calorimeter with (again) dual-readout of scintillation and Čerenkov light to provide better photoelectron statistics and therefore to achieve better energy and spatial resolutions for photons and electrons. The dual readout of these crystals is essential: over one-half of all hadrons interact in the so-called EM section, depositing widely fluctuating fractions of EM and hadronic energy losses.

The energy resolution is shown in Fig. 2 for both leakage-dominated (Fig. 2(b)) and leakage-suppressed (Fig. 2(c)) analyses. The true resolution for a simple dual readout calorimeter is between these two cases.

Finally, and most importantly, the hadronic response of this dual-readout calorimeter is demonstrated to be linear in hadronic energy from 20 to 300 GeV having been *calibrated only with 40 GeV electrons*. We are confident that this critical capability will be of paramount importance at the ILC in which a detector can only be calibrated with 45 GeV objects from Z decay, but must maintain a true energy up to 10 times this energy for physics.

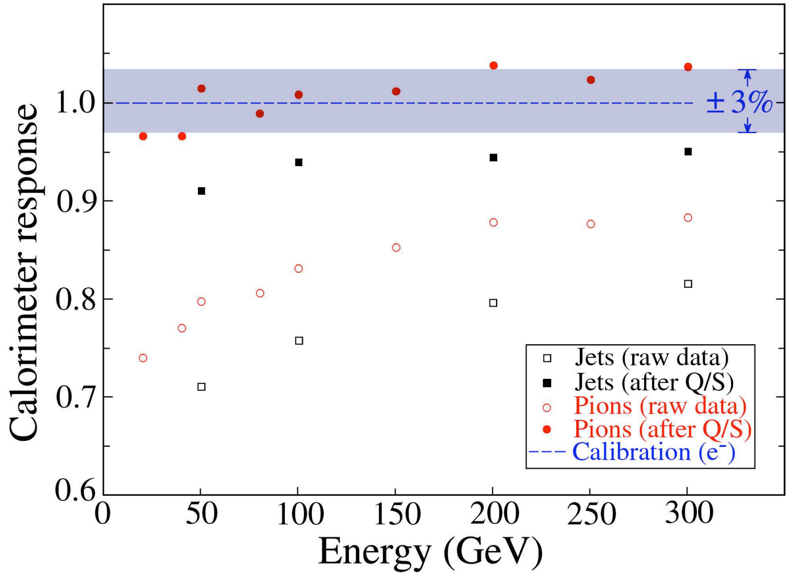


Figure 3: Measured response of the dual readout calorimeter for hadrons from 20 to 300 GeV. The DREAM module was calibrated only on 40 GeV electrons [2].

The path integral of this field in the annulus for a muon from the origin is about 3 T·m over $0 < \cos\theta < 0.85$ and remains larger than 0.5 T·m out to $\cos\theta = 0.975$, allowing both good momentum resolution and low-momentum acceptance over almost all of 4π.

The dual readout calorimeter independently provides a unique identification of muons relative to pions with a background track rejection of 10^3, or better, due to the its separate measurements of ionization and radiative energy losses.

The iron-free magnetic field is confined essentially to a cylinder with negligible fringe fields and with the capability to control the fields at the beam. The twist compensation solenoid just outside the wall of coils is shown in Fig. 4, along with the beam line elements close to the IP. The iron-free configuration [4] allows us to mount all beam line elements on a single support and drastically reduce the effect of vibrations at the final focus (FF), essentially because the beams will coherently move up and down together. In addition, the FF elements can be brought close to the vertex chamber for better control of the beam crossing. The flexibility inherent to an iron-free magnetic field configuration allows any crossing angle, although the 4th Concept prefers zero crossing angle.

The open magnetic geometry of 4th Concept also allows for future physics flexibility for asymmetric energy collisions, the installation of specialized detectors anywhere outside the inner solenoid, and magnetic flexibility for non-zero dispersion FF optics at the IP, adiabatic focussing at the IP, and monochromatization of the collisions to achieve a minimum energy spread [4]. Finally, this flexibility and

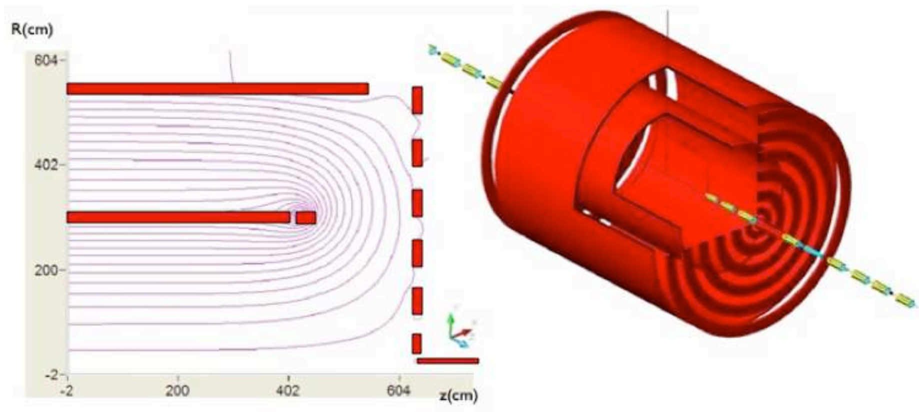


Figure 4: Drawings showing the two solenoids and the "wall of coils" that redirects the field out radially, and the resulting field lines in an $r - z$ view. This field is uniform to 1% at 3.5 T in the TPC tracking region, and also uniform and smooth at -1.5 T in the muon tracking annulus between the solenoids.

openness does not prevent additions in later years to a detector or to the beam line, and therefore no physics [5] is precluded by this detector concept.

1.4 4th summary

These four detectors are integrated, at least at this concepts stage, to achieve high precision measurements of all the partons of the standard model, including $W \rightarrow jj$ and $Z \rightarrow jj$ decays and ν's by the missing momentum vector. The high precision of each detector aids directly in physics analyses for signal definition and background rejection, but also indirectly in the ease of calibrations and inter-calibrations of detectors. This will be an important issue at this machine where the only precision calibration will be with 45 GeV objects from Z decay, whereas invariant mass measurements will be required up to 1 TeV.

References

[1] 4th Concept, Detector Outline Document, http://physics.uoregon.edu/˜lc/-wwstudy/concepts/.

[2] "Hadron and Jet Detection with a Dual-Readout Calorimeter", N. Akchurin, *et al.*, *Nucl. Instrum. and Methods* **A537** (2005) 537-561.

[3] "Muon Detection with a Dual-Readout Calorimeter", N. Akchurin, *et al.*, *Nucl. Instrum. and Methods* **A533** (2004) 305-321.

[4] These issues are addressed in the Note "Few Comments on the Status of Detectors for ILC", A. Mikhailichenko, CLNS 06/1951, 15 January 2006.

Summary of push-pull discussion to this moment

October 16, 2006

Push-pull evaluation

- Detailed list of questions here:

http://www-project.slac.stanford.edu/ilc/acceldev/beamdelivery/rdr/docs/push-pull/

- So far discussed mostly the accelerator design and detector integration question
- The newly formed group of detector experts is expected to help in detailed evaluation of the whole set of issues
- Some tentative conclusions are shown below
- This document is in flux

Some of questions (1)

- *Is there, in the beamline, a natural breaking point?*
  - **yes, it can be arranged, between QD0 and QF1**
- *Do we need to redesign the beamline to optimize location of breaking point?*
  - **yes and a first version of optics already produced**
- *Is part of beamline (part of FD) remains in detector when it moves?*
  - **yes, this seems to be the most optimal way**
- *What vacuum connections are needed in breaking point?*
  - **two vacuum valves with RF-shield, details are being worked out**
- *Do we have to use the same L* for either detector or it can be different?*
  - **Different L* is possible, but same L* gives benefits and may save time**
- *How the connections of electrical, cryo, water, gas, etc, systems are arranged?*
  - **Part of electronics and services can be placed on a platform which moves with detector. Flexible connections to stationary systems needed.**

Some of questions (2)

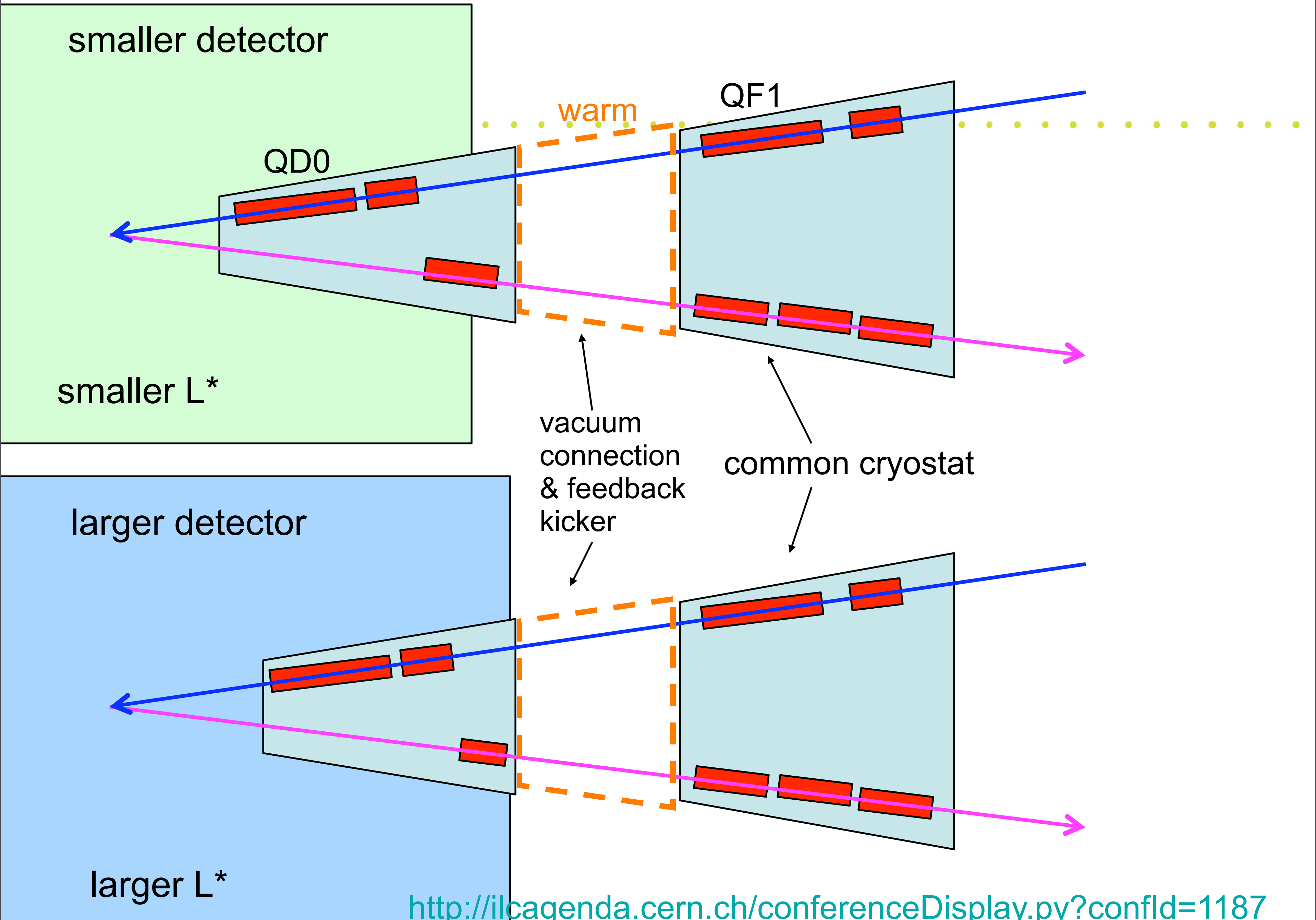
- *What is the suitable way to move (rails, air-pads) the detector?*
  - **air-pads seems as a possibility**
- *For quick change-over, do we need to make detector self shielding?*
  - **It would help, but self-shielding is not absolutely required for quick change-over**
- *What are the design changes needed to make the detector self shielded?*
  - **For GLD, self-shielding has been shown in simulations. For the fourth detector concept (double solenoid with no iron), implementing self-shielding may be difficult**
- *If there is a need in shielding wall between detectors, what is the method of its removal and assembly?*
  - **The shielding wall, if needed, can consist of two parts and move on air-pads in hours**
- *What arrangements or reinforcements (such as imbedded steel) are needed for the floor of the collider hall?*
  - **Steel plates (~5cm thick, welded) to cover the collider hall floor**
- *How the connections of electrical, cryo, water, gas, etc, systems are arranged?*
  - **Part of electronics and services can be placed on a platform which moves with detector. Flexible connections to stationary systems needed.**

Illustrations and references

- Some of these answers are illustrated below
- Note that a lot of what is shown is preliminary and is quite in flux

Different L*

- Next slide shows how different L* can be arranged
- Part of FD which stays with detector is different
- Fixed part of FD is the same
- Optics study show that such change of drift between QD0 and QF1 parts of final doublet is possible
- However, with different L* there could be more time spent for retuning the optics, collimation, etc.
- It may be beneficial to consider a unified L* for push pull design. (E.g. 4.2m?)
- For the moment, still consider L*=3.5m, as moving to longer L* would be only easier



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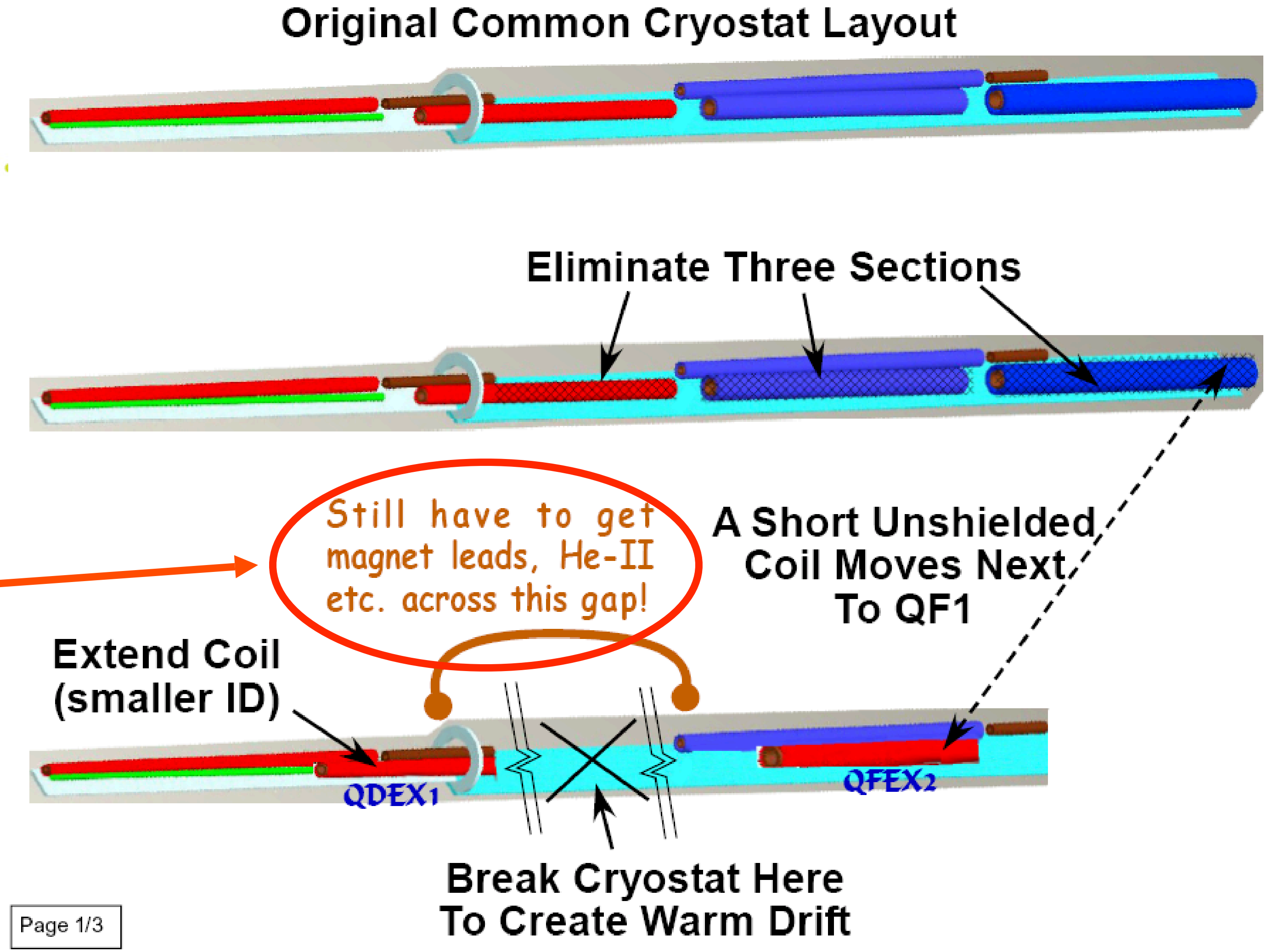
Break point in the FD

- One version is to carry the whole FD with detector, but the FD is long (end at ~11m for L*=3.5m) and it may be too much to carry
- Concentrating on the version when FD is rearranged so that a magnet free section is arranged between QD0-SD0 part and QF1-SF1 parts
- This redesign involved moving the extraction quads which were overlapping which this drift
- Location of this drift roughly correspond to the width of considered detectors and could be somewhat adjusted in further detailed study



- B.Parker, Y.Nosochkov et al. (see ref for details)
- In further discussion realized that this connection should not be used, to allow quick move
- The QD0 part of cryostat will be connected to part of cryo system (2K) attached to detector

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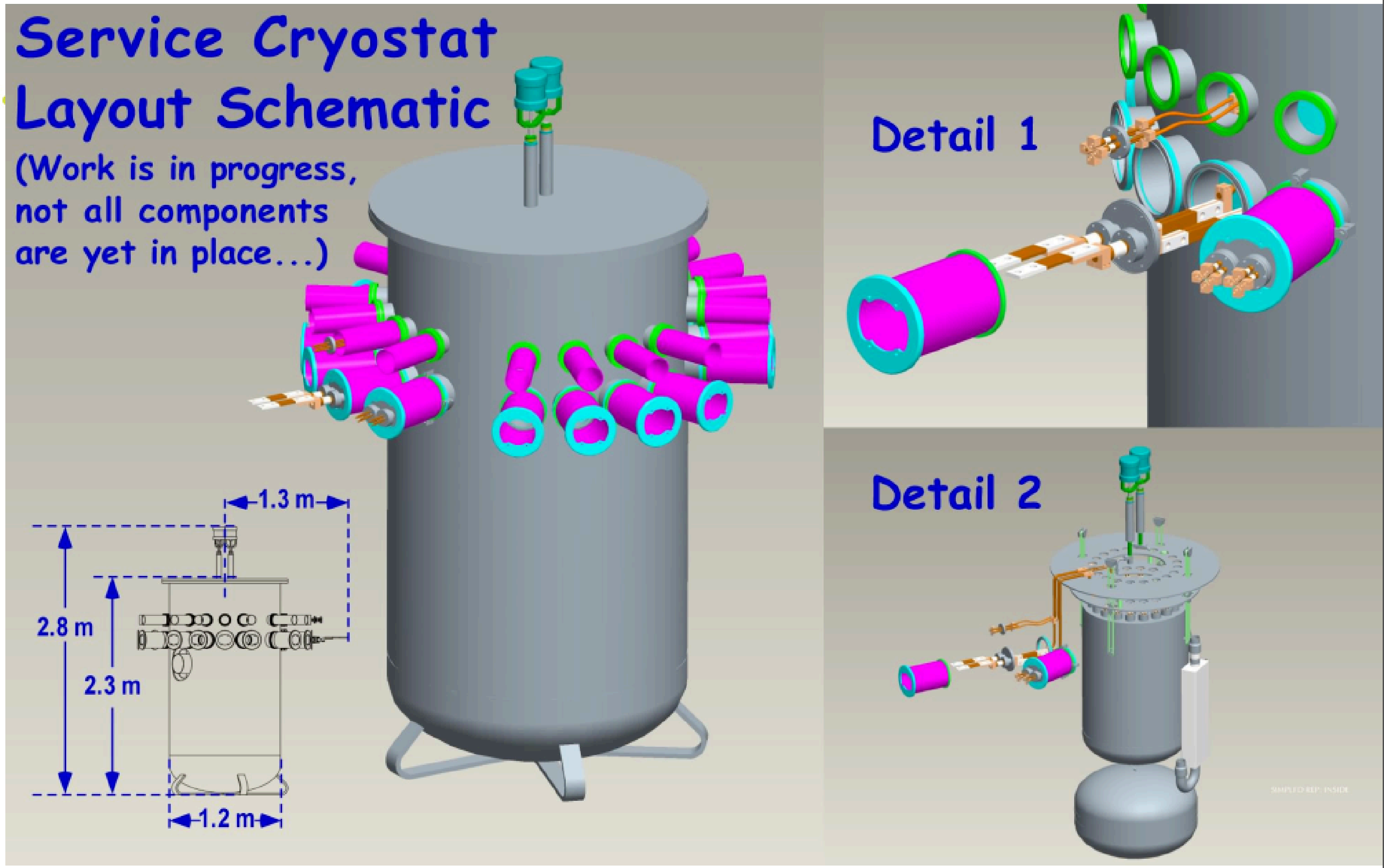
A service cryostat that need to be placed close to QD0 part of FD

Location is being discussed – attached to endcap (close to QD0) or on a moveable platform near detector (see further slides)

It does not have to be accessible during run

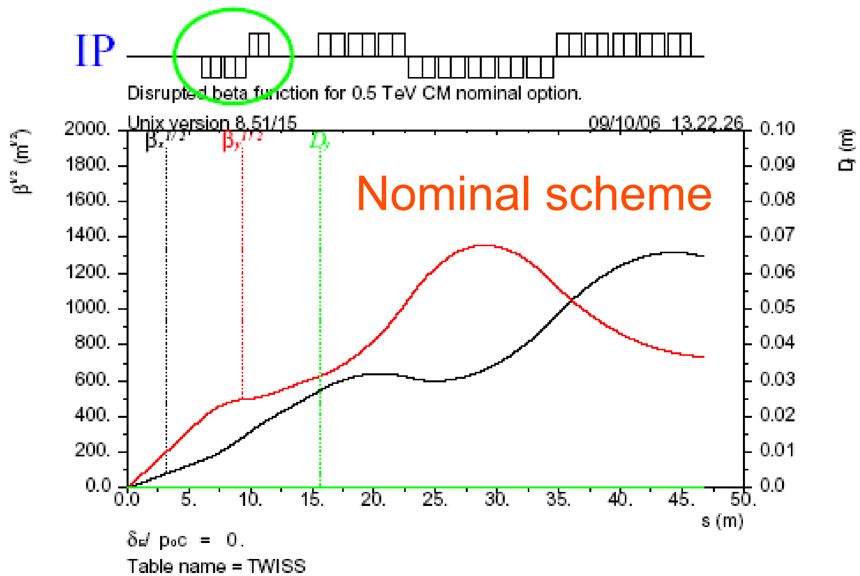


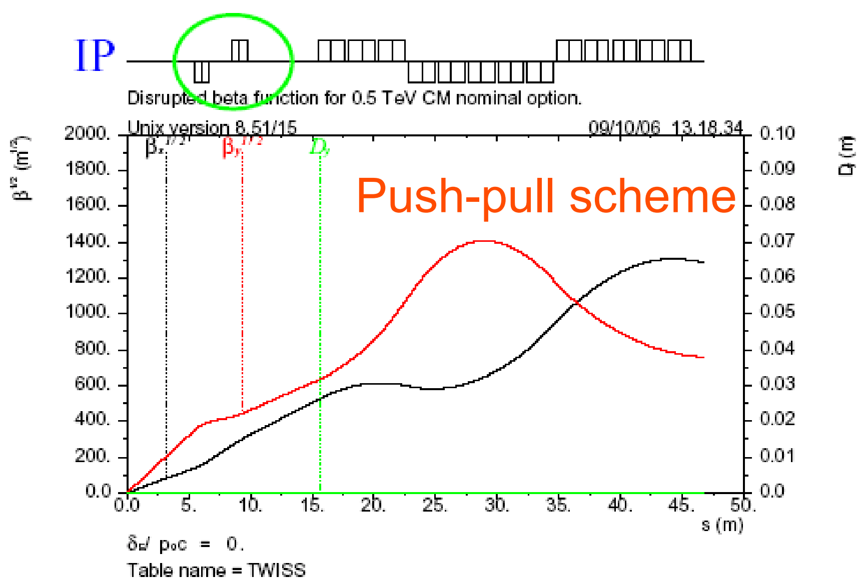
Brett Parker, Mike Anerella, et al. (BNL)

New optics for extraction FD

- B.Parker, Y.Nosochkov et al. (see ref for details)
- Rearranged extraction quads are shown. Optics performance is very similar.
- Both the incoming FD and extraction quads are optimized for 500GeV CM.
- In 1TeV upgrade would replace (as was always planned) the entire FD with in- and outgoing magnets. In this upgrade, the location of break-point may slightly move out. (The considered hall width is sufficient to accommodate this).

Extraction quadrupoles near IP





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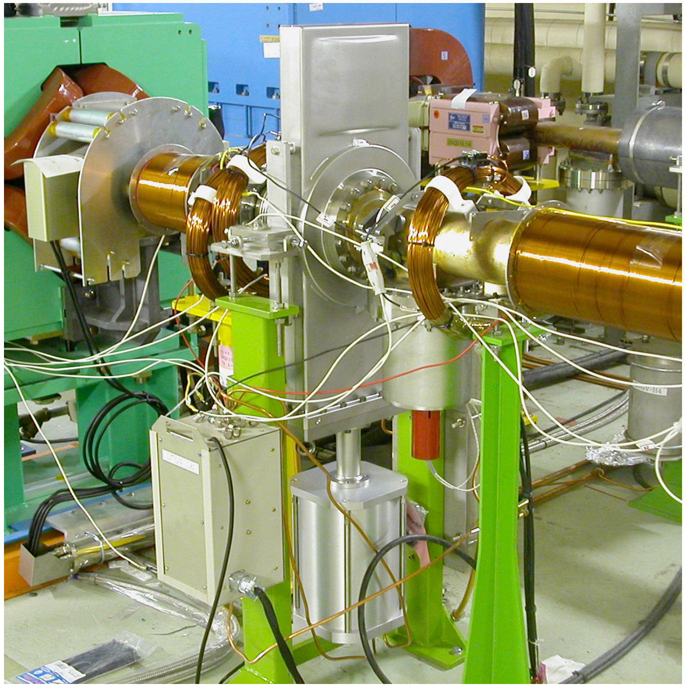
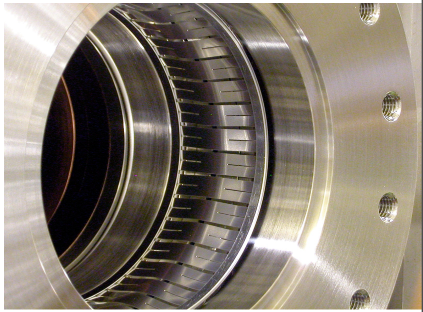
Vacuum connections

- In the warm part between two FD cryostats (QD0 and QF1 parts), a vacuum connection will be made with double valves
- Each valve would have dual apertures (at 7m from IP the beamlines are 10cm apart) or would consist of two independent gates
- RF shield is needed
- Photos show gate valves considered for KEK Super-B [Y.Suetsugu, KEK]
- Application for ILC to be engineered



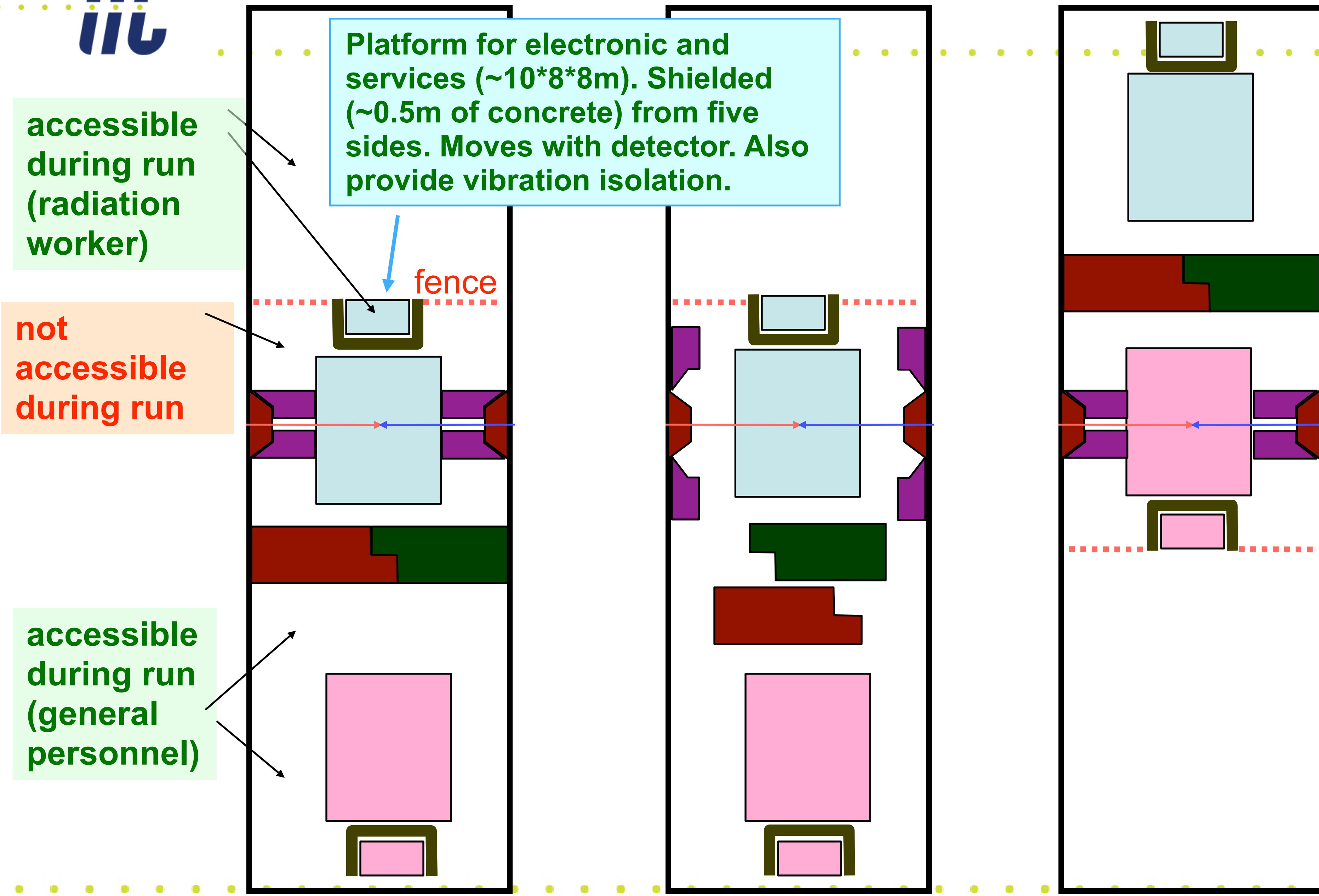


Gate valve with comb-type RF shield and its modifications (Ag plated SS => Cu teeth). Y.Suetsugu, KEK, in collaboration with VAT Co.

Detector design and radiation safety

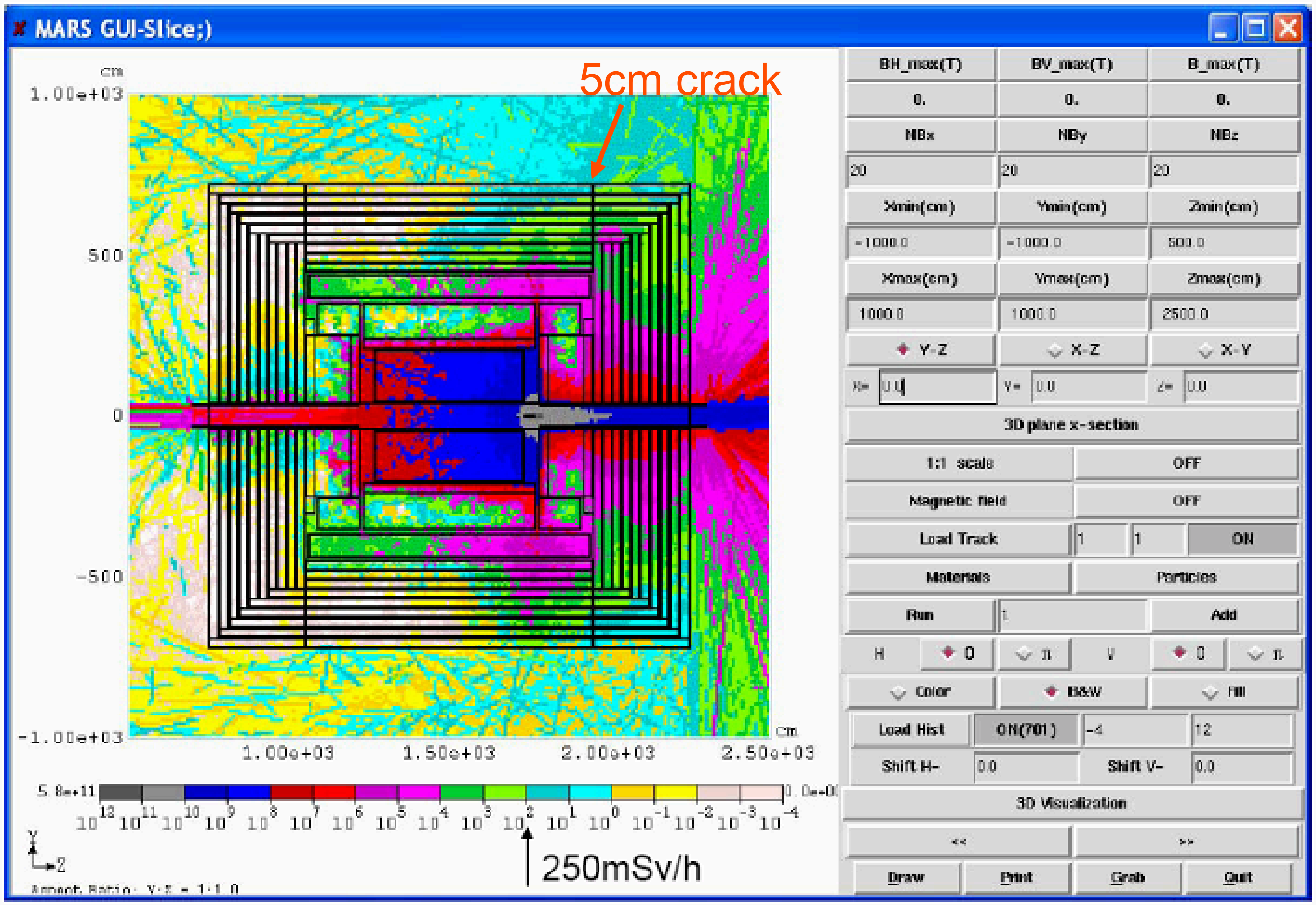
- If the detector electronics or services, or the off-beamline detector need to be accessed during run, the detector need to be self-shielded, or a shielding wall should be used
- Preliminary study indicate that some of detectors considered for ILC can be made self-shielded even for pessimistic assumption of full beam loss (18MW)
- There is significant concern that safety rules may become tighter in time, and that larger gaps (for cables, etc.) would be needed in detector
- The 4th detector concept is more difficult to make self shielded
- Assume the design with shielding wall, while consider self-shielding as possible improvement

Concept which does not rely on self-shielding detector



Self-shielding study of GLD

Result, target at IP+250(z=1750), x-z slice at y=0



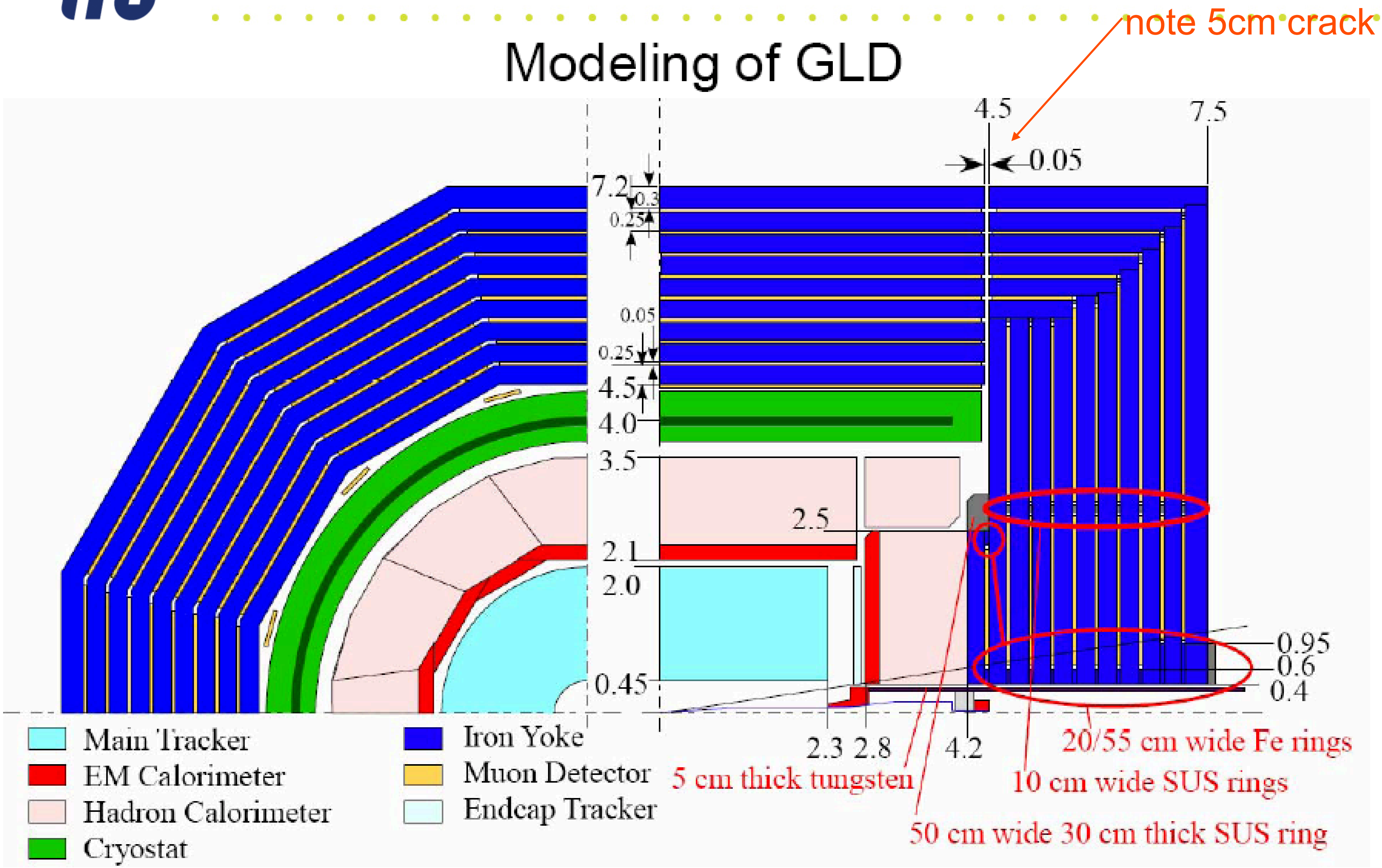
Results show that GLD can be self-shielded even if assume criteria of 25rem/h (250mSv/h) for maximum credible incident [SLAC rule] at any place (=loss of 18MW beam at thick target)

Shield around beamline was not included

T.Sanami
SLAC-RP/KEK-RC

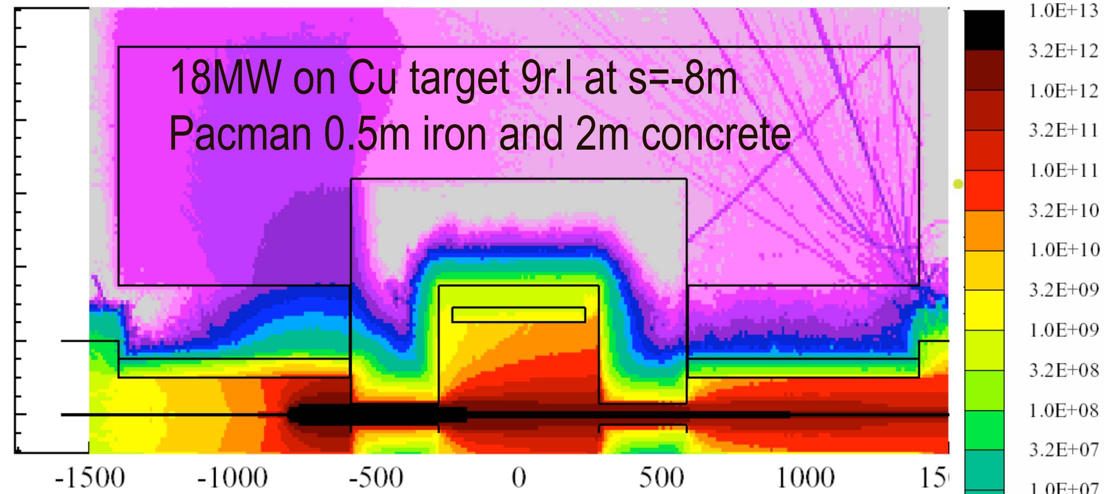
GLD modified to improve self-shielding

Modeling of GLD

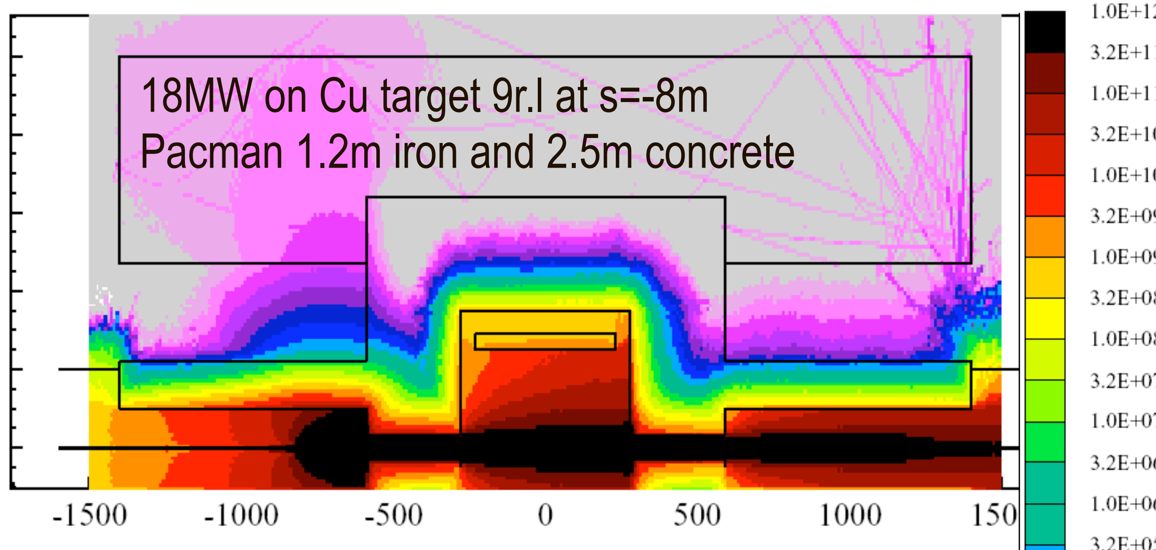


Yasuhiro Sugimoto

Self-shielding study, SiD-like detector



A proper beamline shielding can reduce the dose below 25rem/hr



Desired thickness is in between of these two cases

Alberto Fasso et al

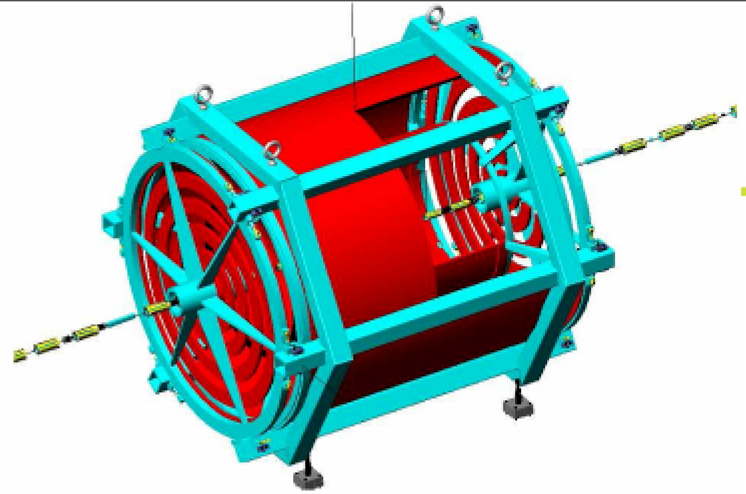
color scale is different in two cases

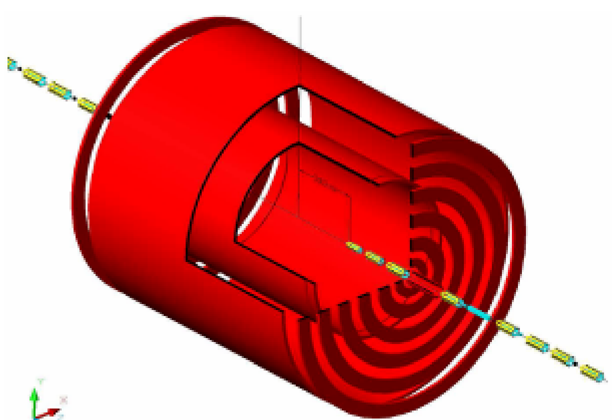
18MW at s=-8m:

Packman	dose at pacman external wall	dose at r=7m
Fe: 0.5m, Concrete:2m	120rem/hr (r=3.5m)	23rem/hr
Fe: 1.2m, Concrete: 2.5m	0.65rem/hr (r=4.7m)	0.23rem/hr

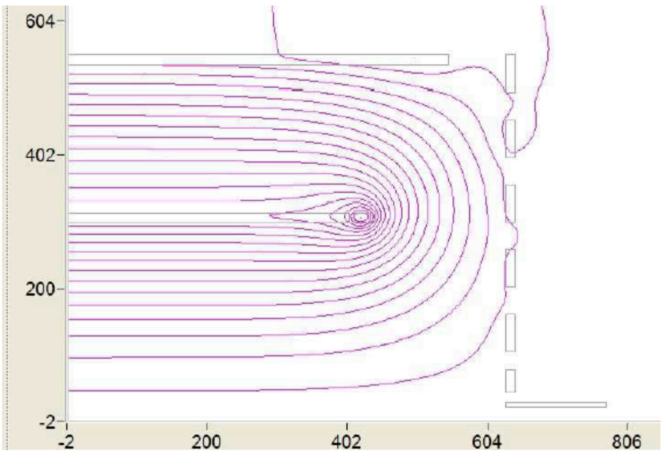
The 4th detector

- Featuring the dual solenoids and no need for the iron return yoke
- The calorimeter, solenoids and supporting structures give some shielding but certainly not sufficient for full self-shielding
- If it were to be made self-shielding, ~2-3m of concrete would need to be added around the detector. Or has to rely on external shielding wall





A cut-away view of the dual solenoids and the “wall of coils” that terminate the solenoid field in the 4th Concept.



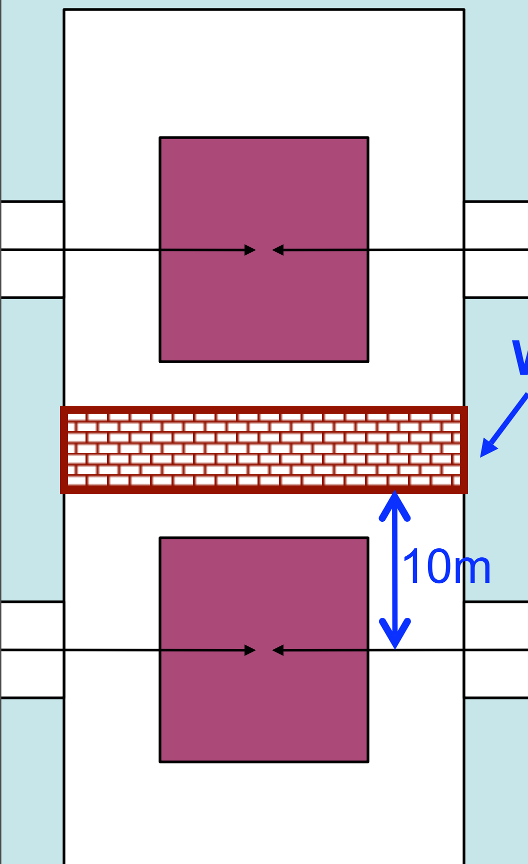
Magnetic field lines of the 4th Concept, showing the dual solenoids and the “wall of coils” on the ends.

Shielding wall

- The following slides show that if detector does not give any shielding, a 3m concrete wall is needed
- If partial shielding is provided by detector, the wall may be thinner
- The wall does not have to be full height
- A curtain wall (movable on crane rails) may or may not be needed to block the gap above the wall

If detector does not provide any radiation protection:

- For 36MW maximum credible incident, the concrete wall at 10m from beamline should be ~3.1m



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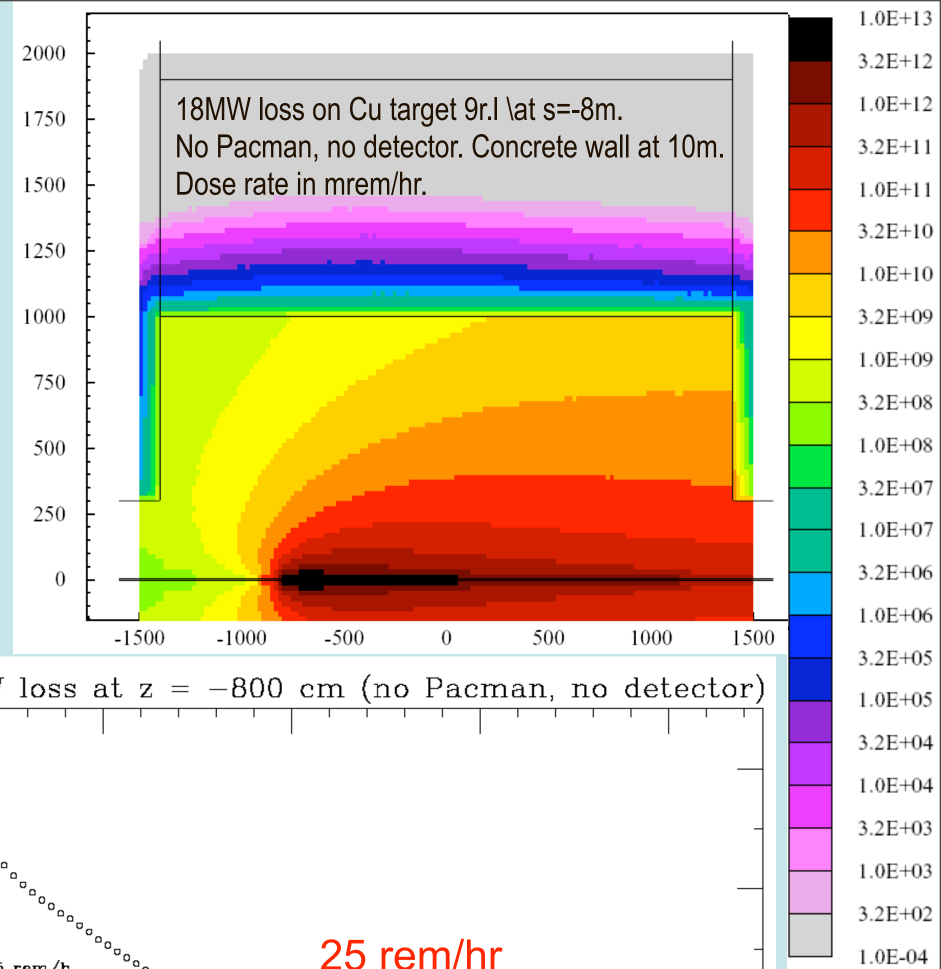
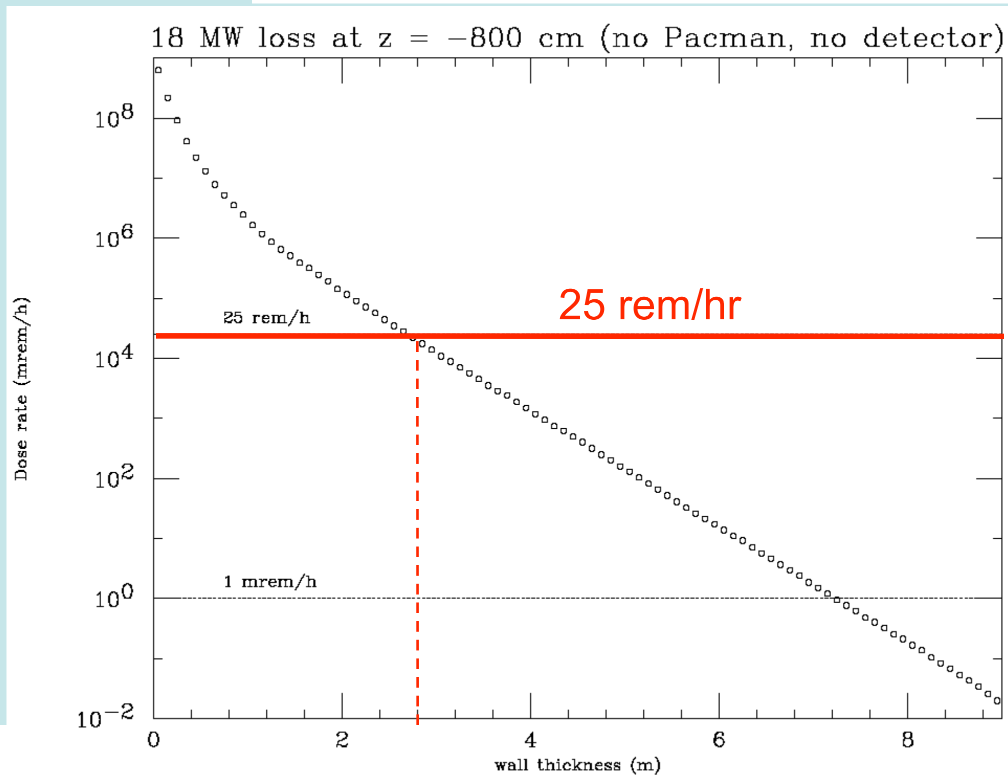
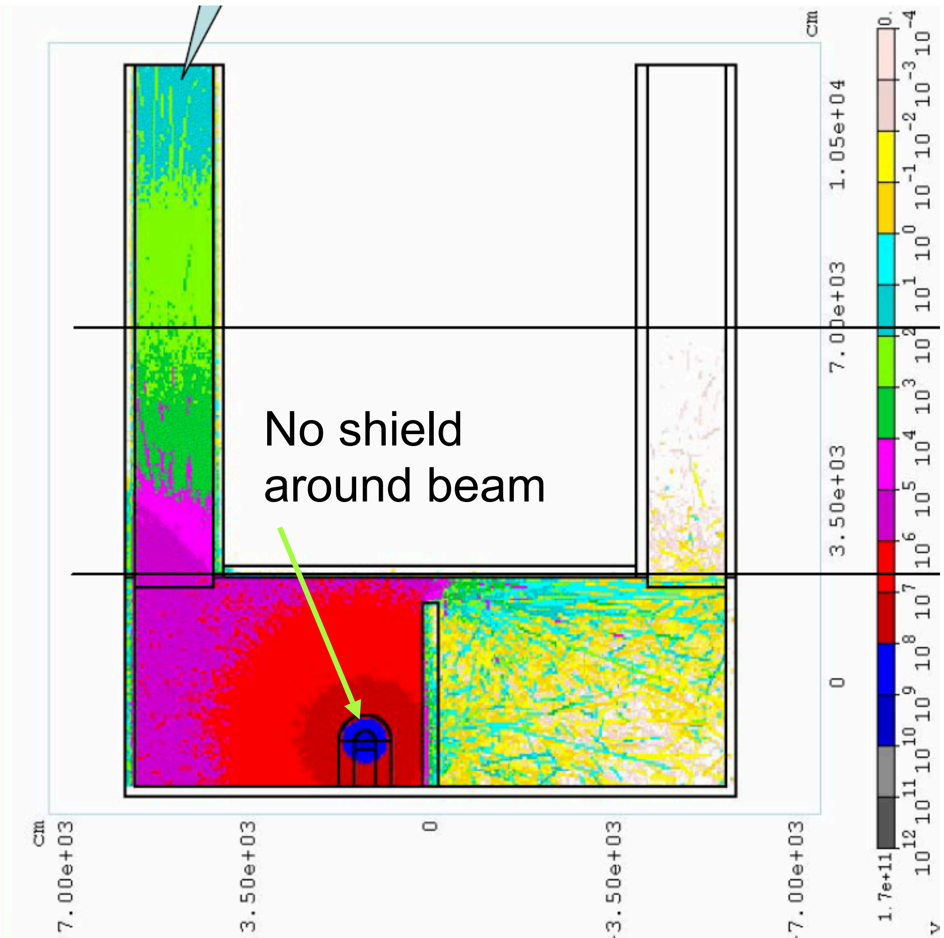
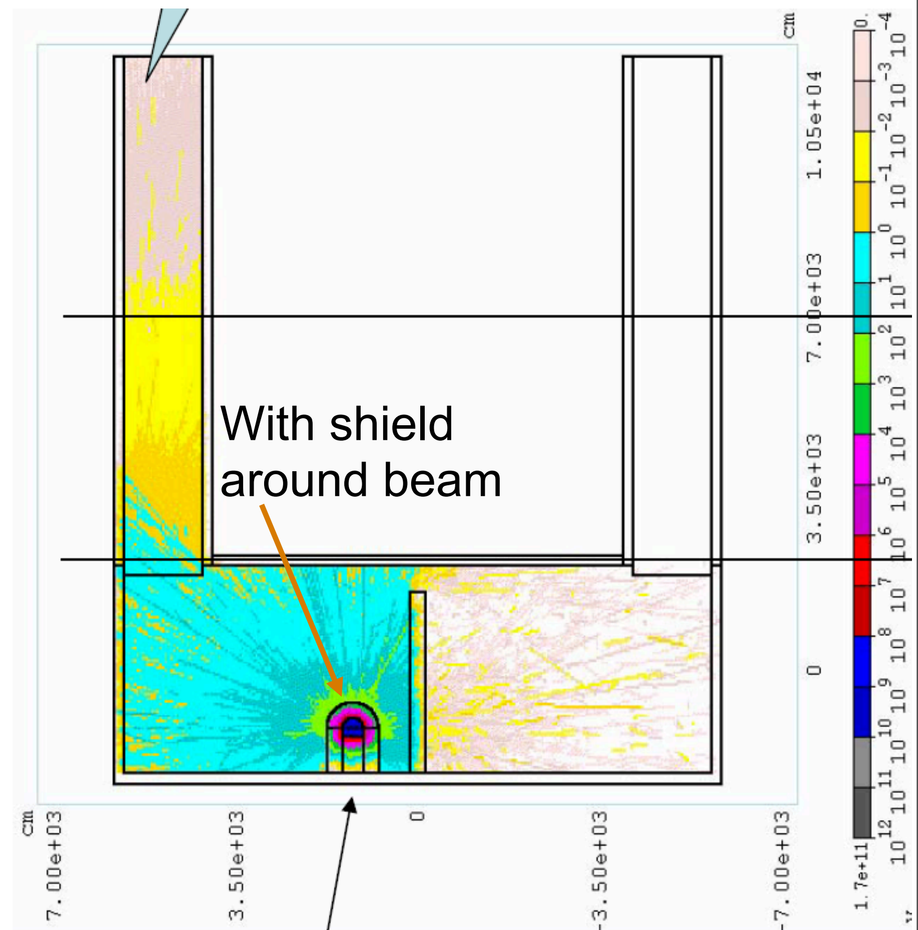




 ush-pull:

IR hall with shielding wall





May need additional curtain wall on top of main wall. May need shaft cover.

Do not need full height wall. The height could be decrease from what shown.

RP T.Sanami and A.Fasso

2006年9月19日

Experience from UA2/UA5

- Peter Jenni (private communication):
- UA5 was a relatively small (light) experiment. It was a streamer chamber, and it was actually just lifted with the surface crane such that UA2 could slide in/out on air-pads.
- This experience may not be of any relevance for detectors of the size we are discussing for ILC

http://cern-discoveries.web.cern.ch/CERN-Discoveries/Courier/experiments/Experiments.html

http://doc.cern.ch//archive/electronic/cern/others/PHO/photo-ex/8710495.jpeg

UA2, CERN