MDI Questions to Concept Groups
IR/Detector Design, Geometry, Magnets
Questions 1,2,6,7,8,10,12,13,17,18

Review the Issues
Summarize the Responses

Tom Markiewicz/SLAC
Snowmass 2005
17 August 2005

The Questions

Q1: Strength and Shape of the solenoid field

Q2: Detector components with r<50cm

Q6: L*

Q7: Beampipe radius at IP

Q8: Crossing Angles

Q10: Minimum angle for electron tagging

Q12: Local Solenoid Compensation for crossing angle

Q13: Anti-Solenoids around QD0

Q17: Detector Assembly Procedure

Q18: Detector Hall Size

Q1: Strength and Shape of the Solenoid Field
Q12: Local Solenoid Compensation
Q13: Anti-Solenoids around QD0

Beam optics due to the solenoid field can affect beam position, angle and spot size at the IP

- Details of the correction schemes required to maintain performance
- Possible interference of hardware with detector
- Possible unintended consequences

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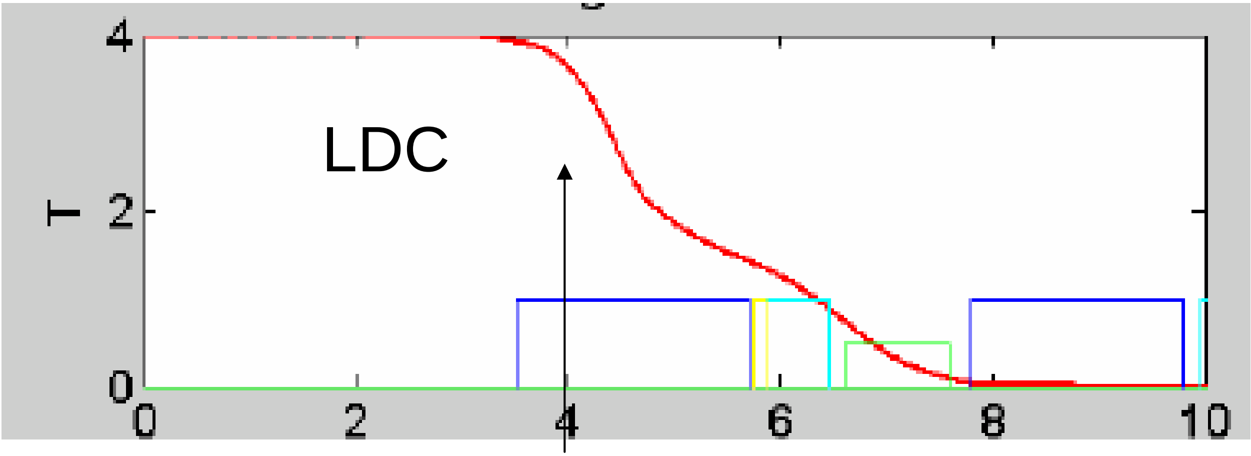
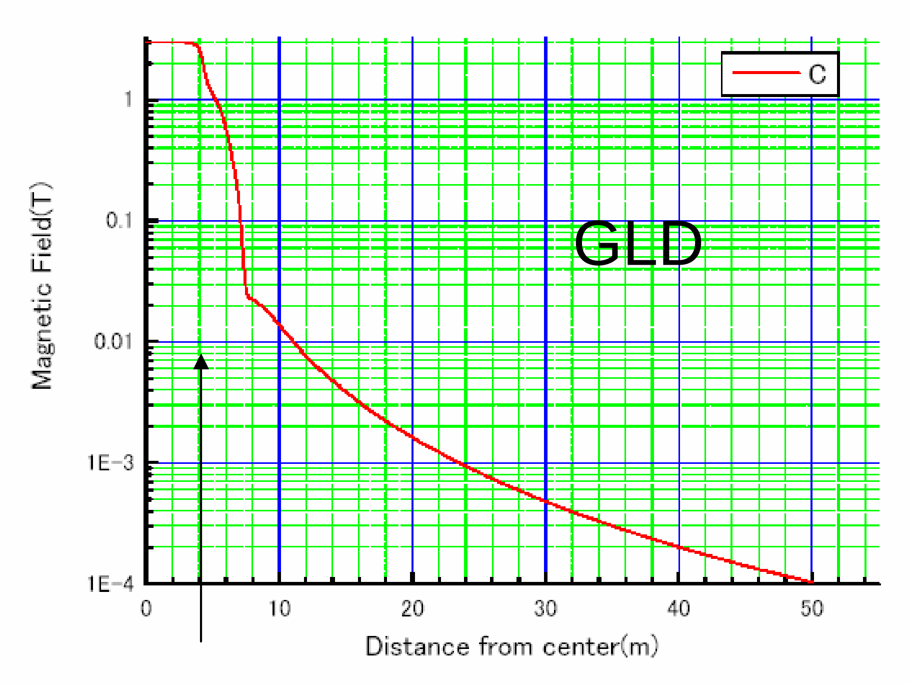
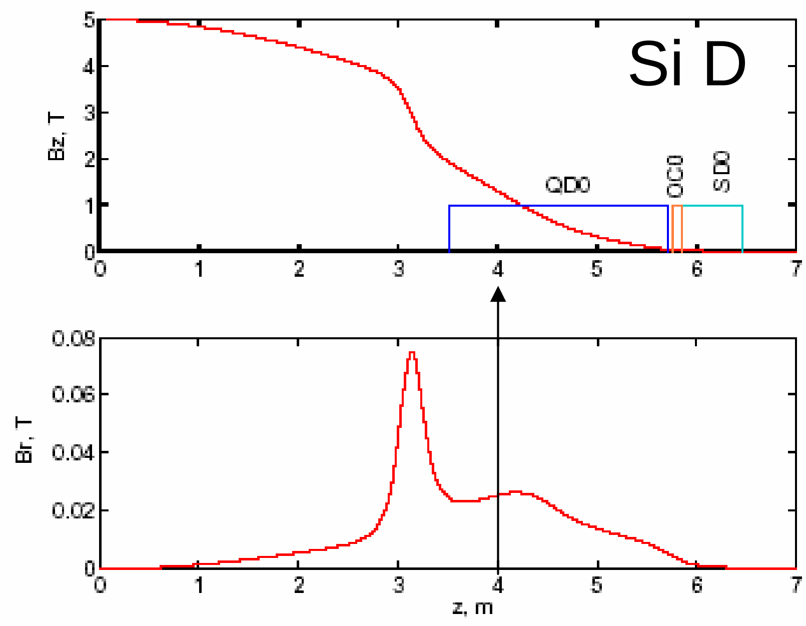
Field Maps: all show substantial overlap with QD0 at ~4m







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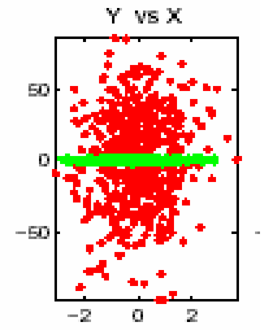
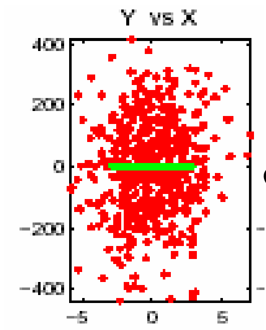
Q13: Anti-Solenoids around QD0

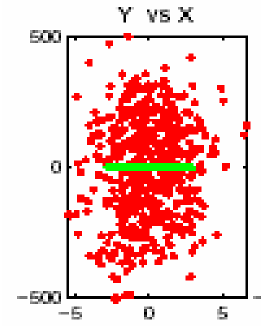
When solenoid overlaps QD0 coupling between y & x' and y & E causes σ_y(Solenoid) / σ_y(0) ~ 30 – 190 independent of crossing angle (green=no solenoid, red=solenoid, note scale)



Si D
$\sigma_y / \sigma_y(0)=32$

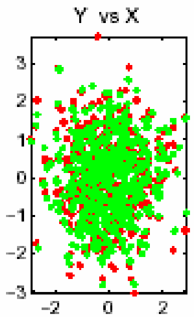


LD
$\sigma_y / \sigma_y(0)=150$

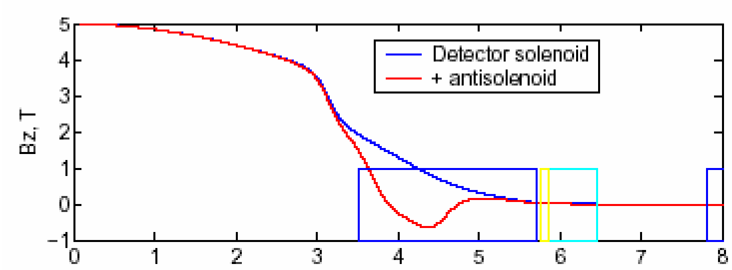


LD, 0° x-ang
$\sigma_y / \sigma_y(0)=190$

A. Seryi & Y. Nosochkov analyzed this (LCC-Note 142) and showed for the then Si D detector and (now defunct) LD concept that even though traditional use of skew quads could reduce the effect **LOCAL COMPENSATION** of the fringe field (with a little skew tuning) was the best way to ensure excellent correction over wide range of beam energies



Si D or LD
$\sigma_y / \sigma_y(0)<1.01$



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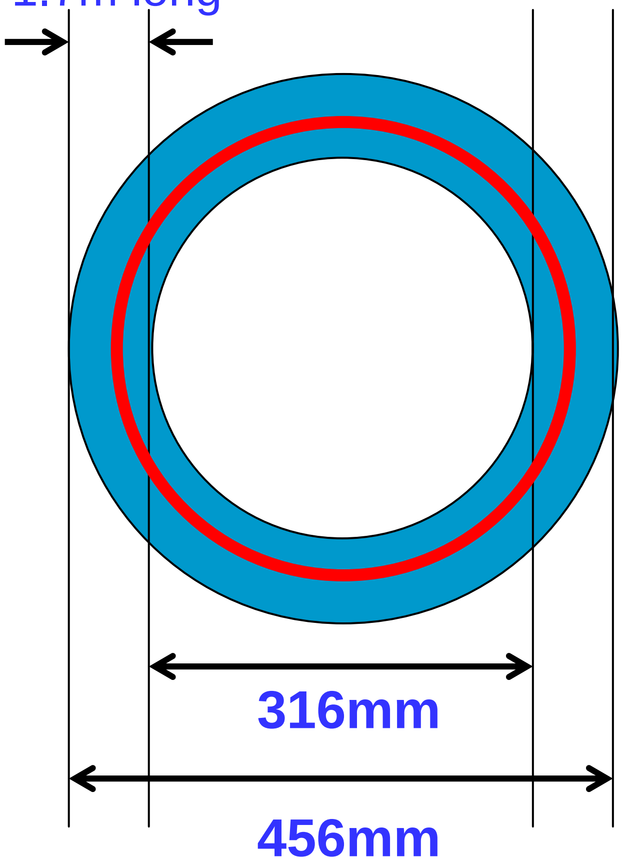
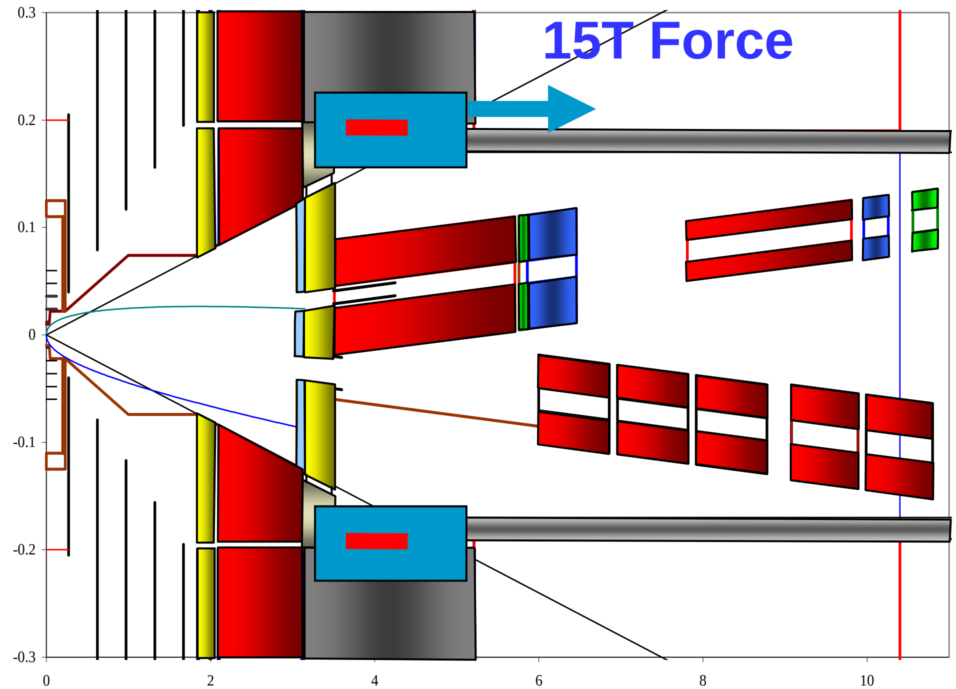
Preliminary Design of Anti-solenoid for Si D (B. Parker)

70mm
cryostat
1.7m long



Four 24cm individual powered 6mm coils,
1.22m total length, r_{min}=19cm



This work needs to be repeated for each detector concept and for each crossing angle FD

Replies from concept groups indicated that work to incorporate these coils needs to be done

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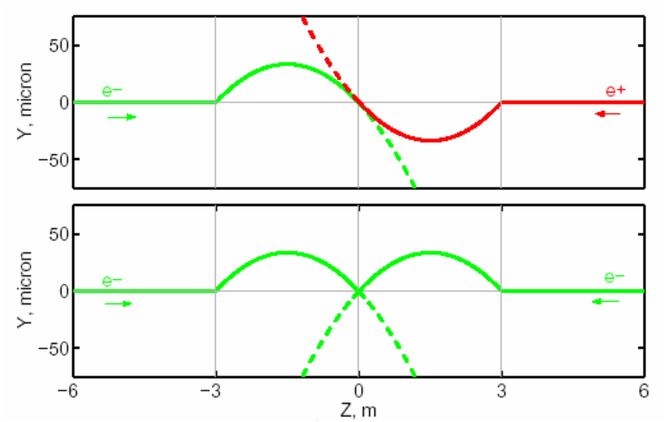
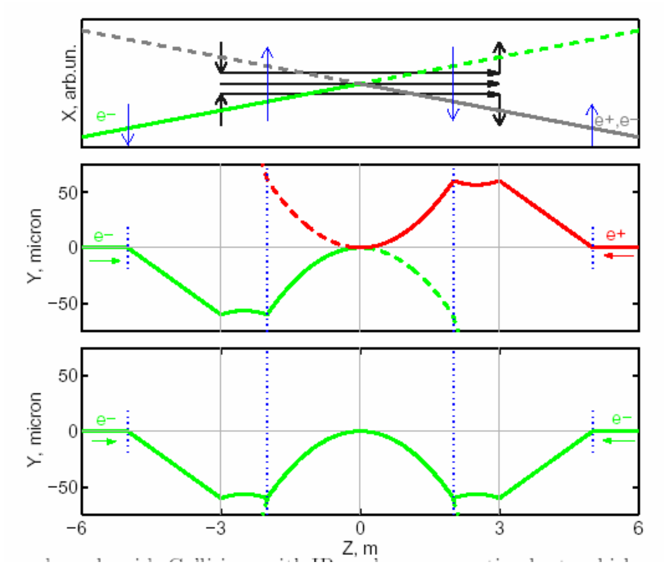
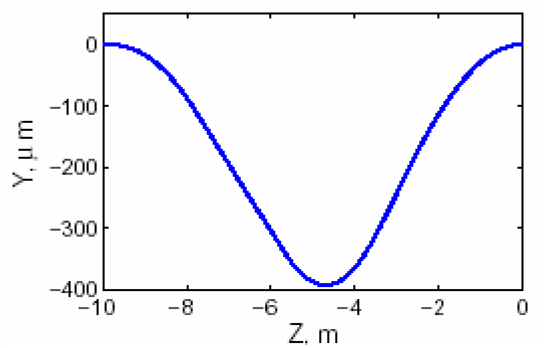
Q12: Local Solenoid Compensation for 20mrad crossing angle

In crossing angle case, if do nothing beams collide at IP but at non-zero angle. If we want to collide at zero angle to preserve angle of polarization vector (as well as e-e- luminosity) can move QD0 and QF1 in x but expense is large orbit variation in y and SR induced beam spot size growth to ~5nm.







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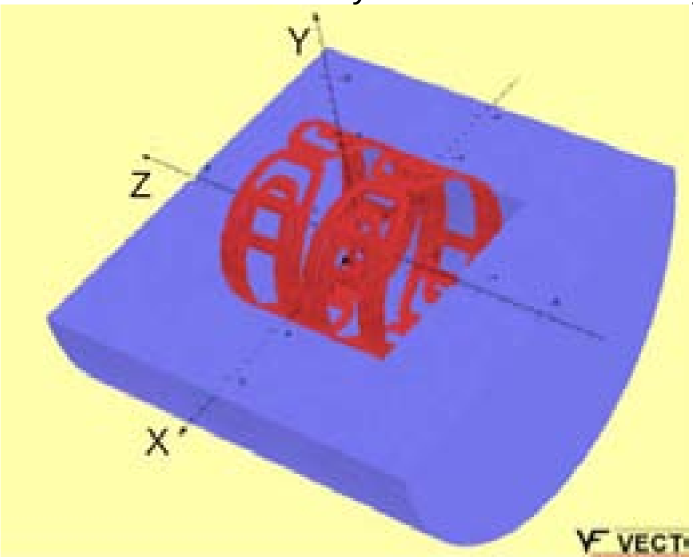
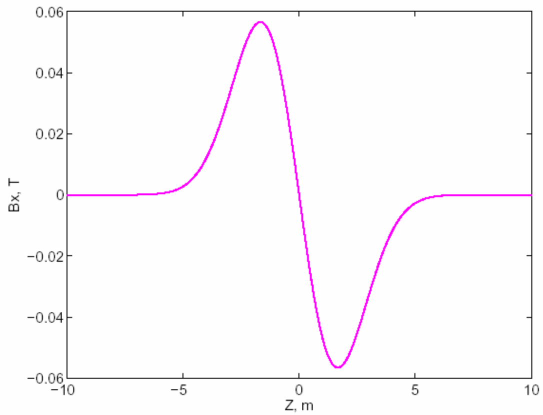
Q12: Local Solenoid Compensation for 20mrad crossing angle

A. Seryi & B. Parker showed (LCC-Note 143) that if the solenoid transverse field component is **locally compensated** with a "Detector Integrated Dipole" (DID) coil wound with the main solenoid then σ_y(Solenoid) / σ_y(0) ~ 1.03



DID Field in Si D



Q12 asks each detector concept if they can deal with it:

- GLD: Work in progress by R. Settles
- Si D: Needs study but gut feeling is that it is OK
- LDC: Tracking issues need study but point to increased TPC backgrounds in current masking due to redirection of e+e- pair background

Q17 & 18: Detector Assembly Procedure & Detector Hall Size

Issues:

- In two-IR layout, detector hall must leave adequate shielding between it and the beamline to other IP
- After installation on beam line access scheme for repair & replacement of components must be consistent with hall
- Will IP be commissioned with detector on the beamline or behind a shielding wall
- Overall detector dimensions, assembly procedure and positioning before final push onto IP

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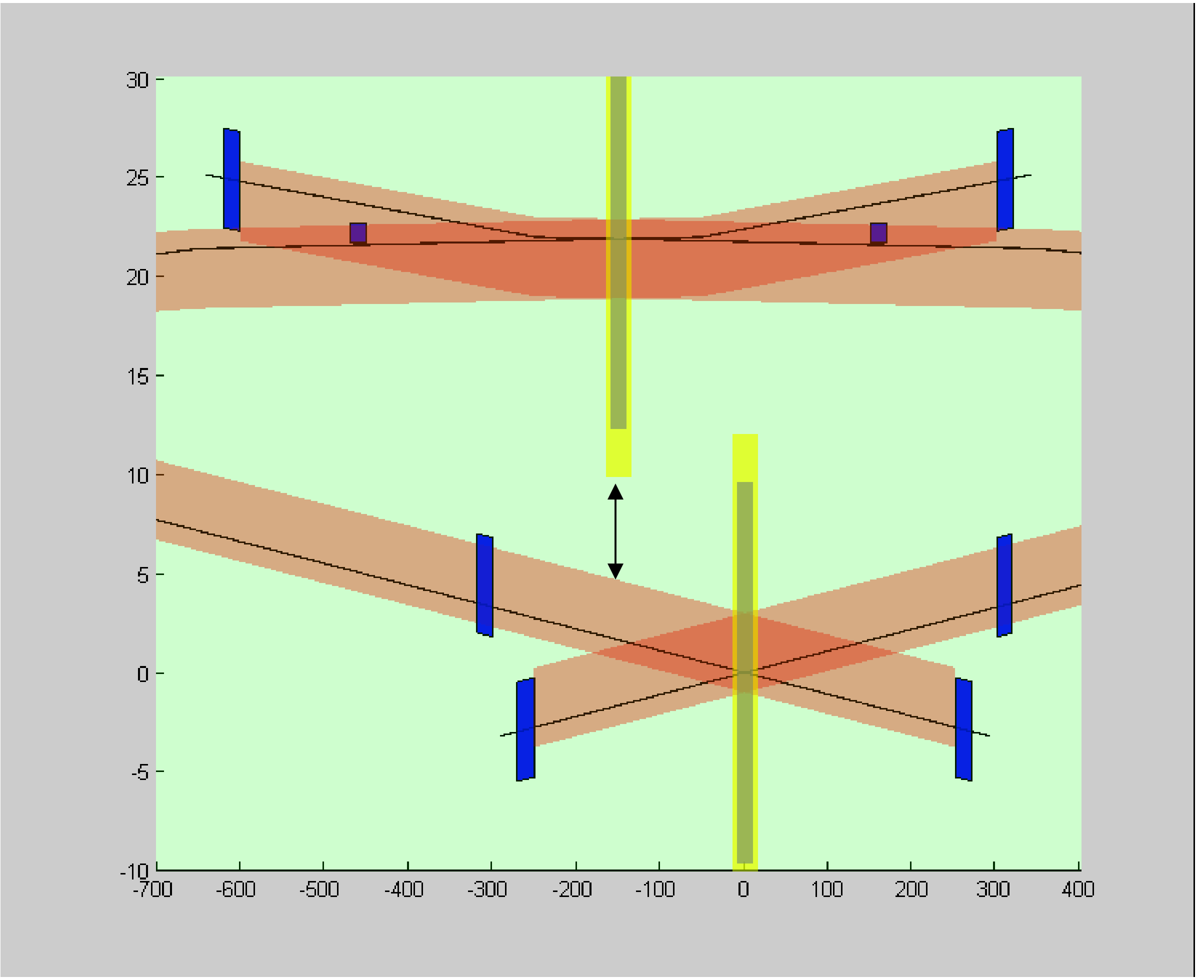
Q17 & 18: Transverse Space Issue

Need to maintain ~5m concrete shielding between one IR hall and tunnel to other IP



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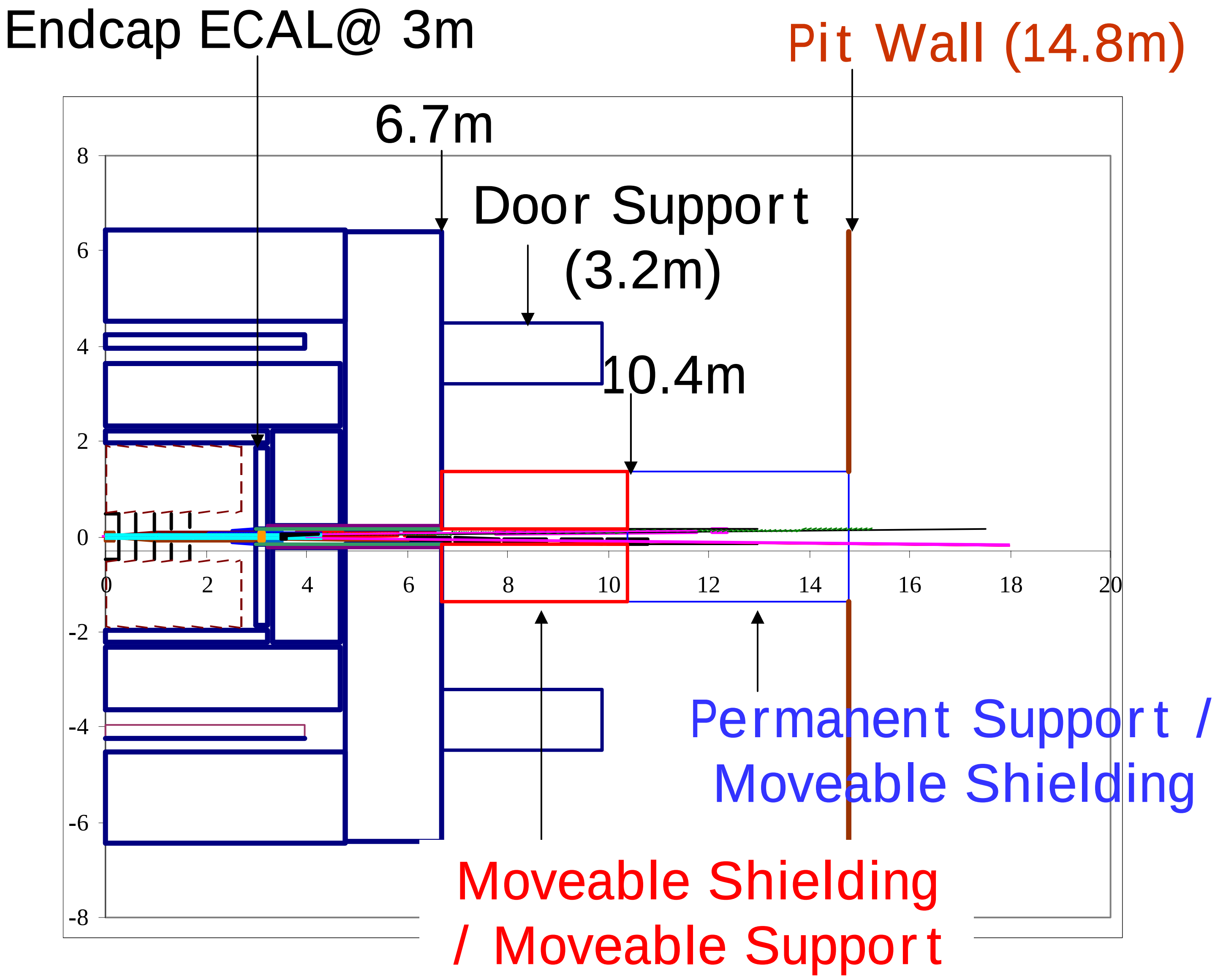
Q17 & 18: Access & Repair Plan (example based on 1999 LD)



- Each door can open 10.4-6.7=3.7m
- TPC can slide 3.7m and access central 1.6m of VXD
- If barrel and one door slid to edge, 5.6m available for replacement of 5.4m TPC

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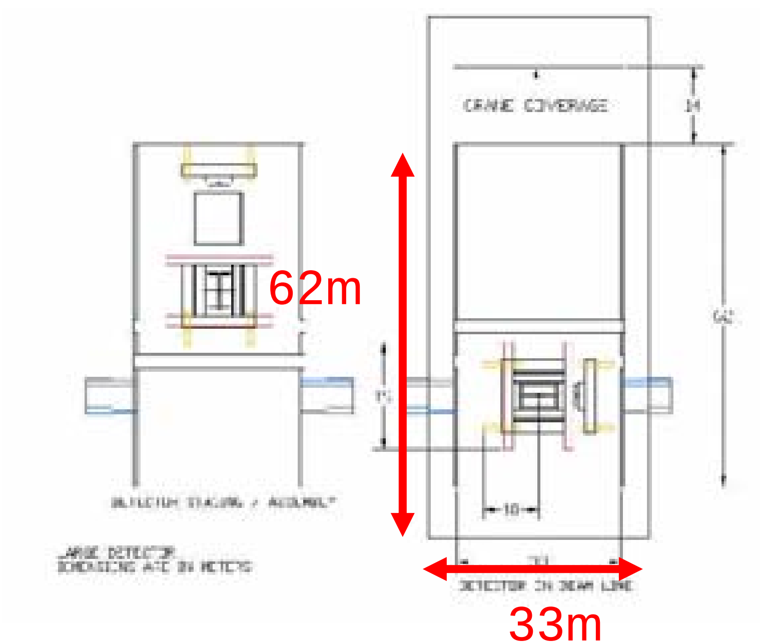
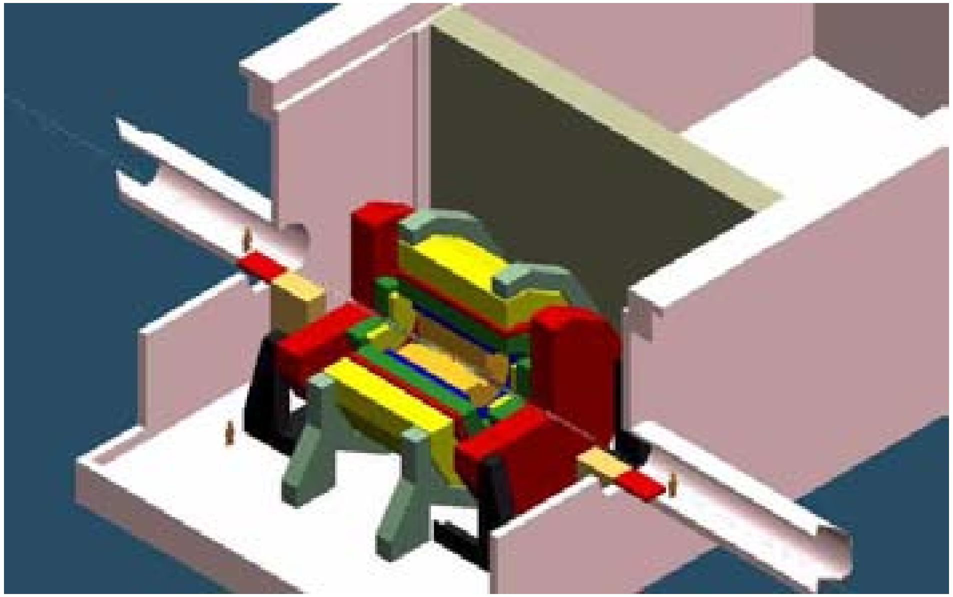
Q17 & 18: Assembly & Commissioning Model (again based on 1999 LD)





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Q17 & 18: Assembly & Commissioning Model

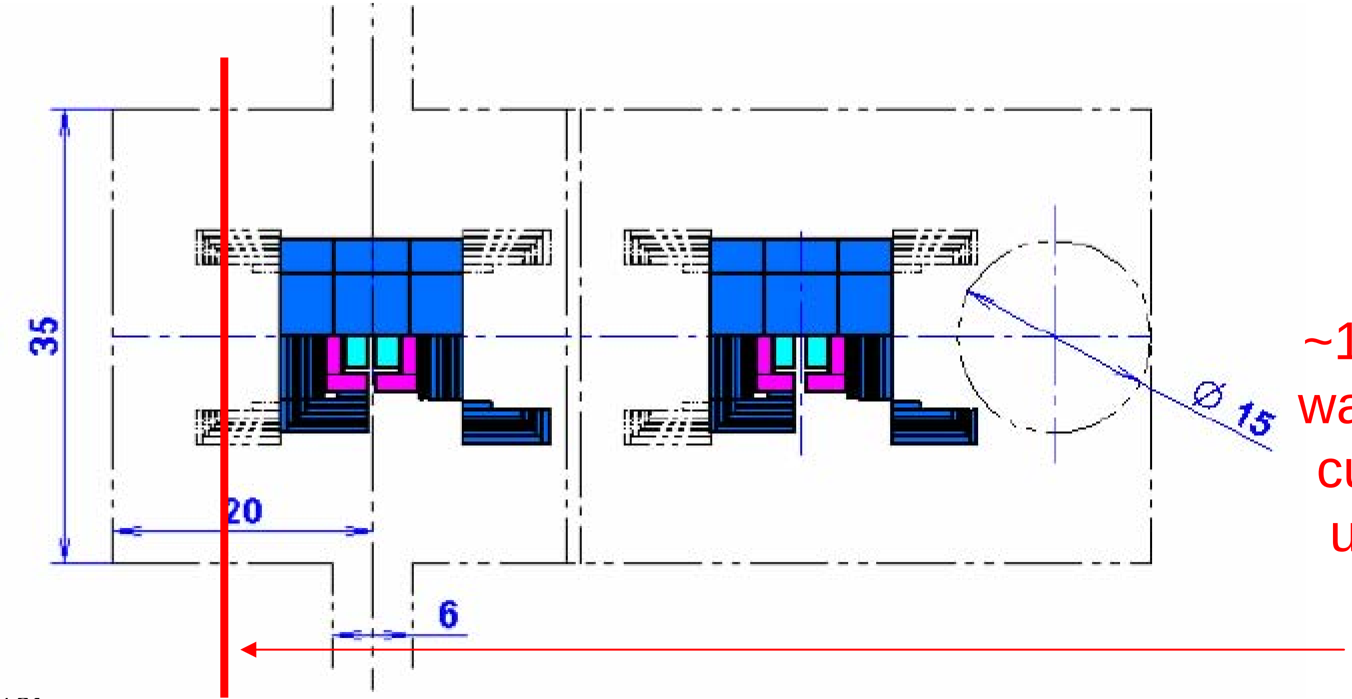
GLD

35m (z) x 80m (x) x 40m (y) cavern with 15m ϕ access shaft

Assembly from "bottoms-up" in "garage"

Repair access by transverse door motion

TPC slides along beam line to access VXD

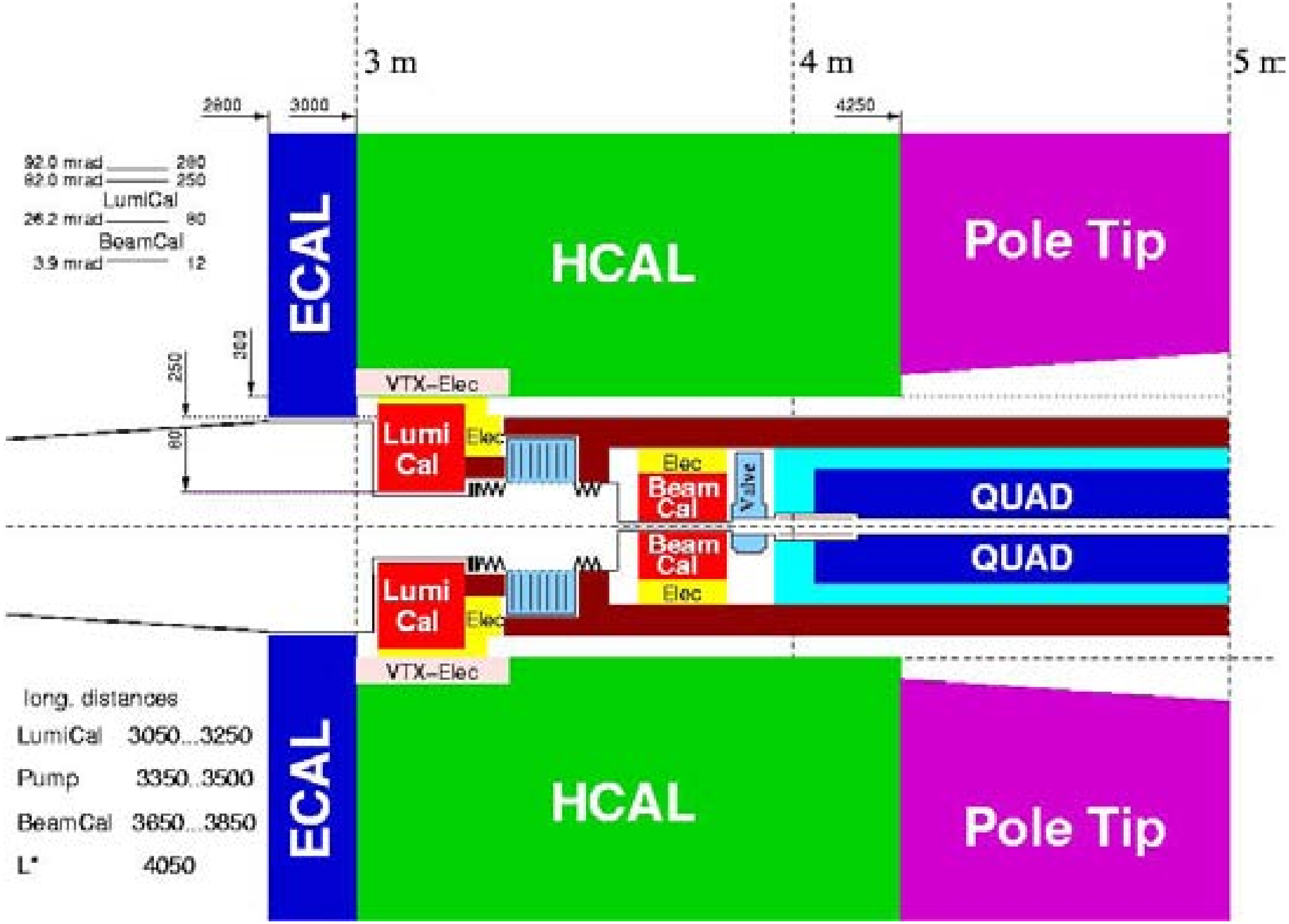


~12m from IP to pit wall available given current lattice and understanding of civil/radiation constraints

Q17 & 18: Si D and LDC Assembly & Commissioning Model

- **Si D:**
  - No current answer
  - Personal guess is that it will be similar to 1999 SD/LD study
- **LDC**
  - Assembly as per TESLA TDR with 2004 addendum for modified forward calorimetry
  - Hall size to be discussed at Snowmass

Q2: LCD Detector components with r<50cm



Work on incorporating current 2mrad and 20mrad optical elements in progress
Most carefully considered engineering model presented to date

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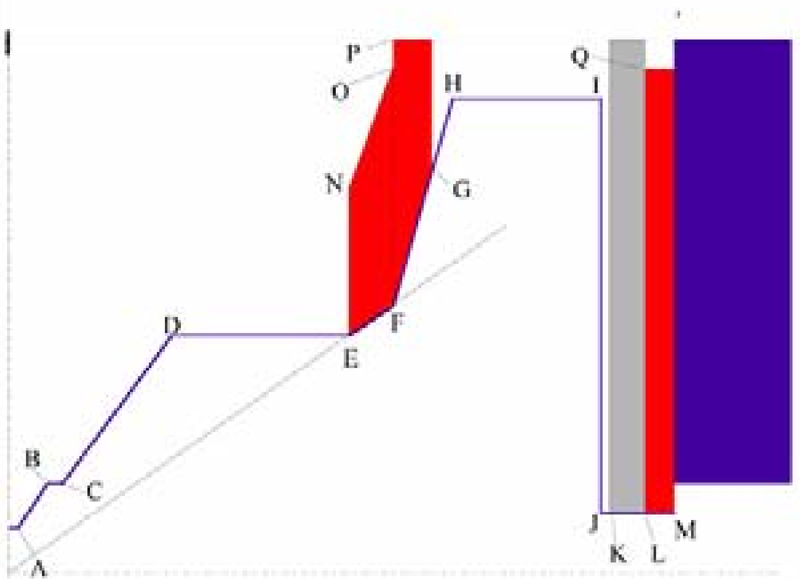
Q2: GLD Detector components with r<50cm

E_{cm}		500GeV		1TeV	
point	z (cm)	R(cm)@2mr	R(cm) @20mr	R(cm)@2mr	R(cm) @20mr
A	5.5	1.8	1.8	1.9	1.9
B	25	4.2	4.2	4.4	4.4
C	35	4.2	4.2	4.4	4.4
D	110	9	10	9.5	10
E	230	9	10	9.5	10
F	260	10.173913041	11.30434783	10.73913043	11.30434783
G	285	12.60144928	13.26086957	12.93115942	13.26086957
H	320	16	16	16	16
I	400	16	16	16	16
J	400	2		2	
K	405	2		2	
L	430	2		2	
M	450	2		2	
N	230	14	15	14.5	15
O	260	19	20	19.5	20
P	260	36	36	36	36
Q	430	20	22	21	22
region		R(cm)@2mr	R(cm)	R(cm)@2mr	R(cm)



,where red-region is calorimeter, the grey one is a CH_2 (low Z) mask and the blue is the final quadrupole magnet.

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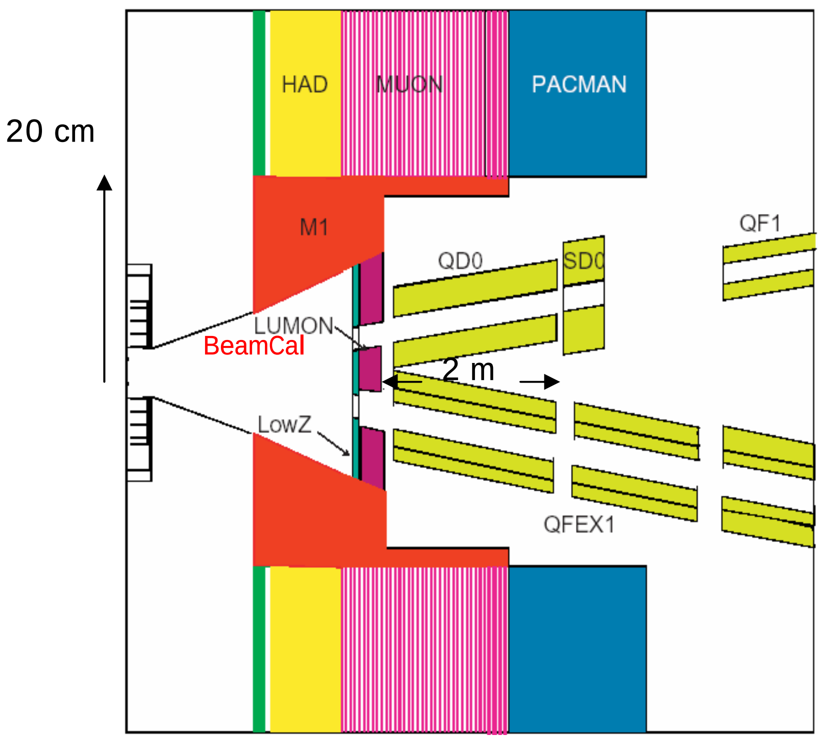
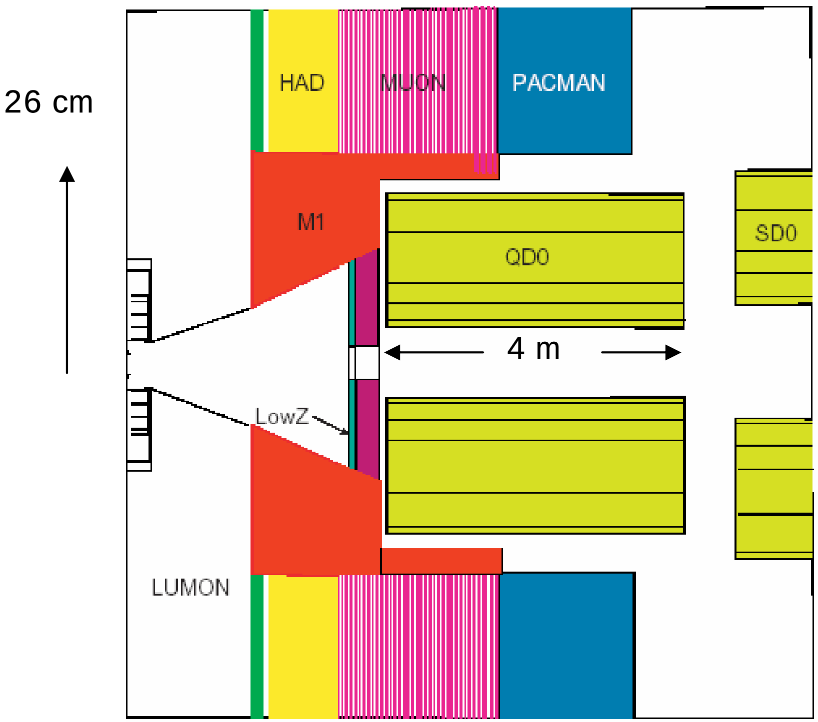
Q2: Si Detector components with r<50cm

20 mrad



2 mrad



Current understanding of 2mrad and 20mrad optical elements incorporated
Solenoid compensator and rudimentary engineering lacking

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Q6: L*

Larger L*

- Puts PairMon-LumMon-Beamcal sufficiently deep in yoke/HCAL that background in central tracker reduced
- Reduces overlap of solenoid field with QD0/QF1
- In larger crossing angle case creates more transverse space for separate incoming & extraction magnets
- Tightens optics tolerances
- Tightens collimation depth

- **GDC**
  - Prefers L*>4.7m
- **LDC**
  - Currently using 4.05m
  - No fundamental reason why could not change but would require extensive reoptimization of IR
- **Si D**
  - Range 3.5<L*<4.5 seems acceptable
  - Optimization work for definitive answer needs to be done

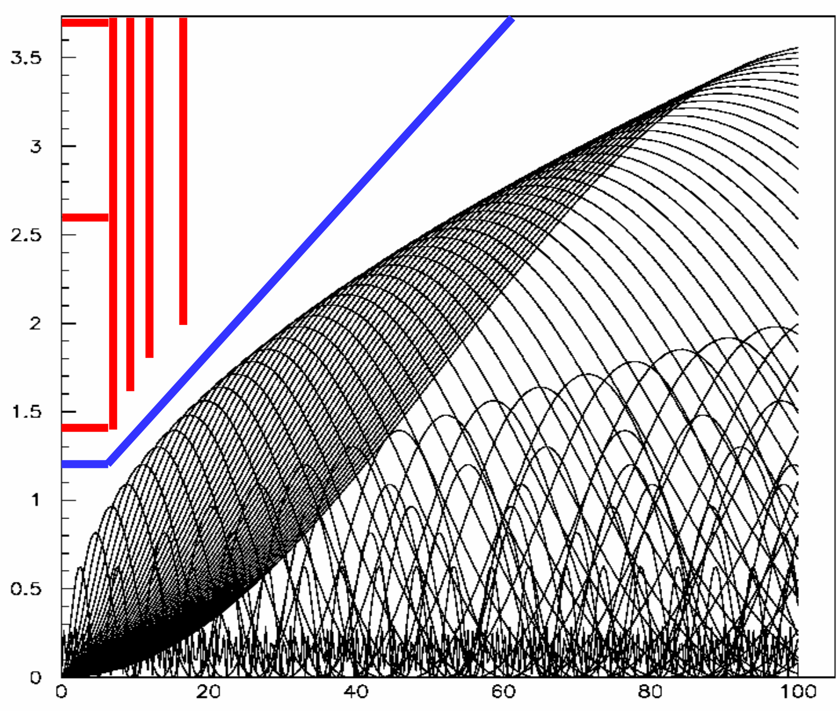
Q7: Beampipe radius at IP

- **Stay safely out of flux of low p_T pairs given B_s**
- **All Synchrotron Radiation from the beam halo in the final doublet leaves IP. Talks to**
  - **Collimation system design & performance**
  - **Magnitude and distribution of non-gaussian beam halo**
  - **Level of aggression in setting collimators and resultant**
    - beam jitter amplification due to collimator wakefields
    - muon production
  - **Level of conservatism**
    - Worst beam conditions system must safely handle
- **Do not sacrifice b and c tagging & jet charge determination unnecessarily**
  - **Effective luminosity loss for key analyses**

Maruyama

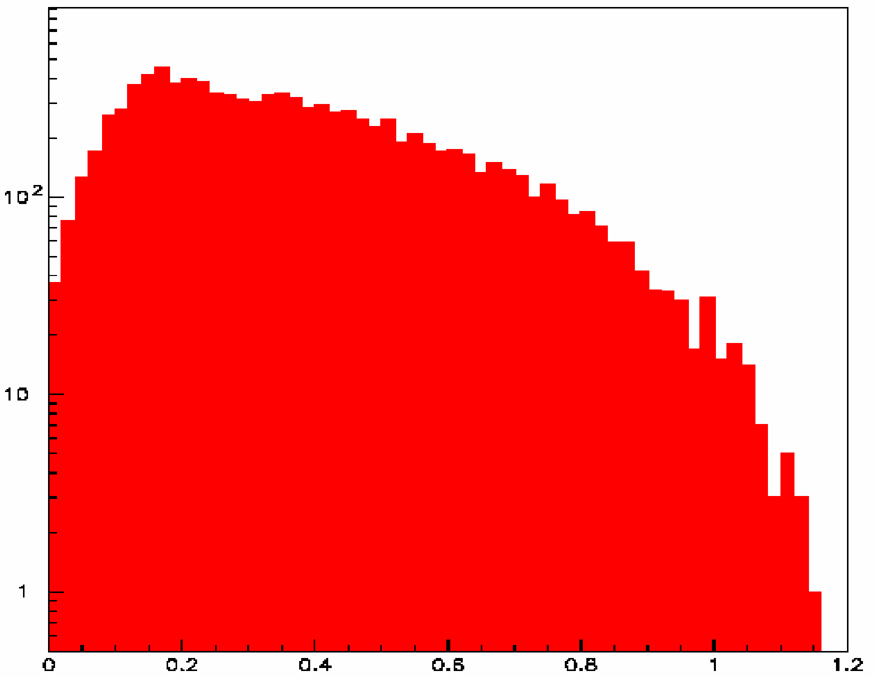
Coherent Pairs & SR in Si D

New SiD VXD with
12mm radius beampipe



Pair region plotted for
ILC Nominal IP Parameters
5 Tesla, 20 mrad

SR Radiation vs. R (cm)
at z = 300 cm



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Q7: Beampipe radius at IP

- **GLD:**
  - **SR handled by collimation system**
  - **R=2.0cm with |cosθ|<0.95 for nominal parameters**
    - +10-20% for more aggressive parameter sets
    - R(vxd)=2.4cm
- **LDC**
  - **R=1.3 cm to balance physics with previous machine constraints**
    - Being revisited both from new physics analyses and updated IR designs
- **Si D**
  - **R=1.2cm currently**
  - **Question premature, requiring much more work on both physics & detector sides**

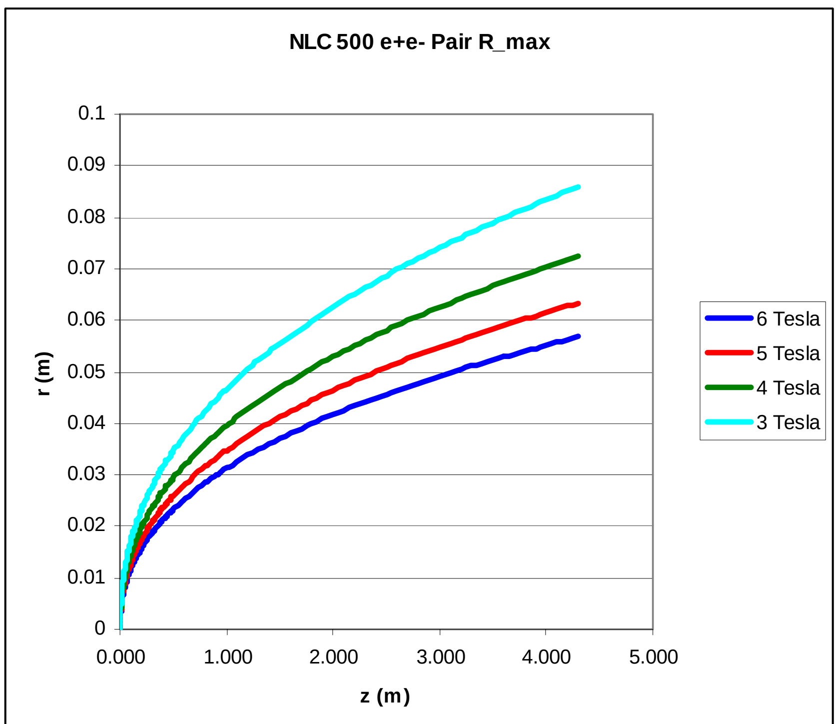
Q8: Crossing Angles

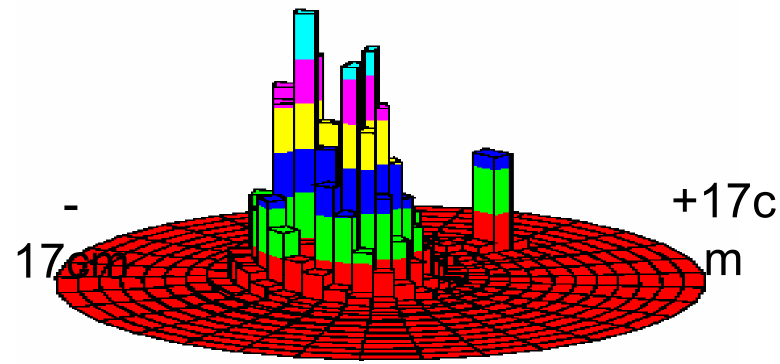
- **GLD:**
  - Prefers the minimum crossing angle possible consistent with acceptable backgrounds and a E,P diagnostics in the extraction line
- **LDC**
  - 2mrad and 20mrad proposed angles are a good starting point and LDC is investigating both
  - Reserve the right to reopen question as more is learned
- **Si D**
  - Current 2/20 proposed baseline strategy is acceptable for now
  - Interested in smallest angle consistent with acceptable backgrounds, good machine reliability & E,P diagnostics in the extraction line
    - If this requires $2<\theta<20$mrad, so be it

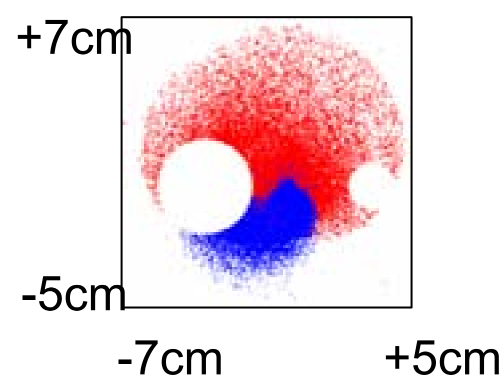
Q10: Minimum angle for electron tagging Issues

Pair / LUMON / Beamcal hammered with e+e- pairs

- **Physics demands**
  - Best hermiticity possible
  - Electron ID to as low an angle & energy as possible
- **Sanity check**
  - “Dead Zone” extends to ~15-20mrad while min. exit ~5mrad







Sid w/ 20 mrad

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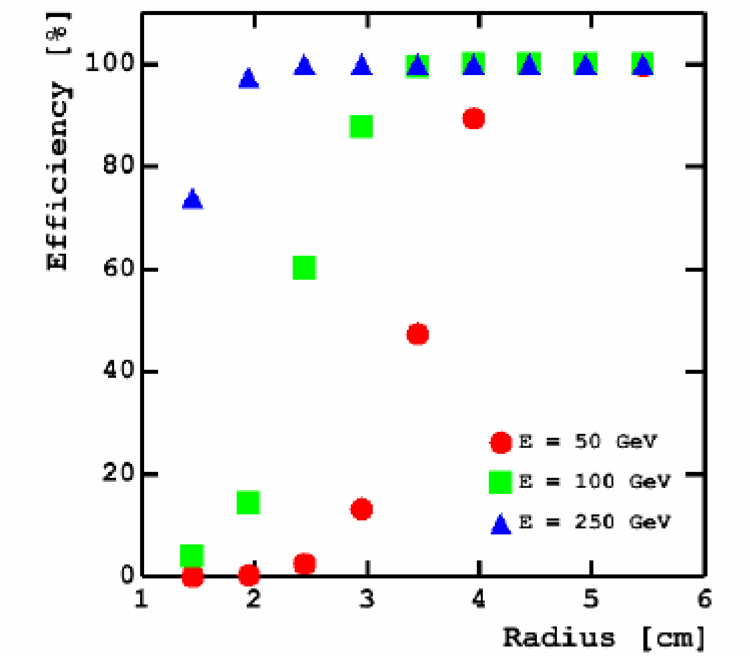
Q10: Minimum angle for electron tagging

- **GLD:**
  - **Minimum angular acceptance of BCAL is 5rad**
  - **Need full simulation to study the efficiency of tagging electrons in high pair background as a function of crossing angle**
    - Under study
- **LDC**
  - **Under study**



- **Si D**
  - **Needs a detailed simulation before can answer**

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Some Comments Regarding Crossing Angles, Magnets & the Extraction Line (1)

- **0 mrad:**
  - **While not being proposed for the baseline, schemes with**
    - RF Kicker
    - Lower field electrostatic kickers aided by dual function magnets developed for 2 mrad line
- **20 mrad**
  - **Allows for clean & separate extraction line with minimal losses to dump**
    - Machine Tuning, MPS, etc. may be as/more important as increased pair backgrounds or loss of acceptance in a limited (~25mrad) and difficult region
  - **BNL compact winding technology now seems the conservative approach to required small bore magnets and offers options**
    - L* extraction = L* incoming for better capture of extracted beam
    - $\gamma\gamma$ at 20 mrad
    - Assuming L* extraction > L* and L* large, θ_C in range <~15 mrad (12?, 10??) possible

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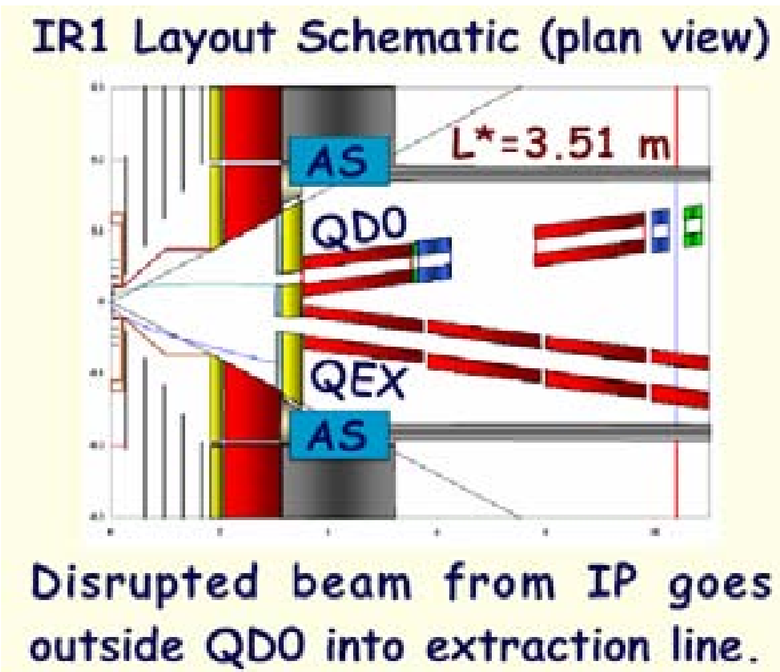
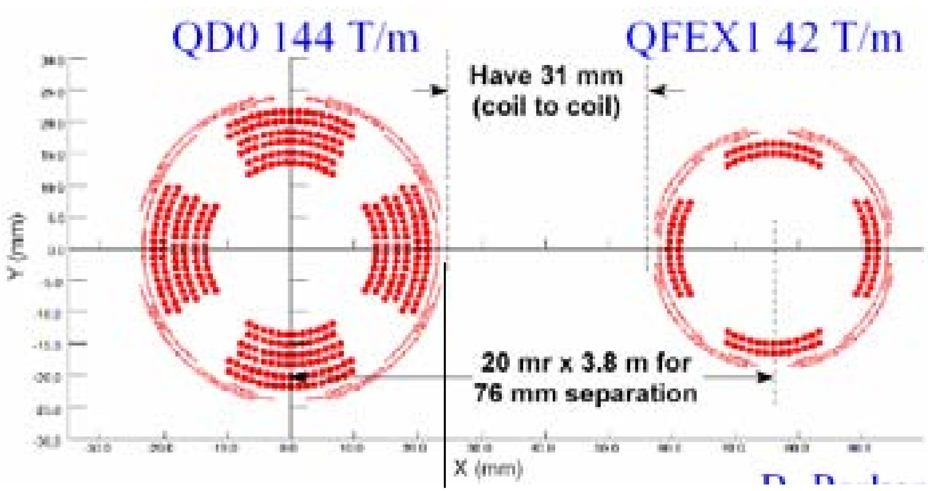
Compact Final Doublet Magnet Design for 20 mrad IR

B. Parker

Successful tests of winding **7-wire cable at 10mm radius** beampipe &
Use of SF **(1.9°K) He-II**
Lead to **MORE COMPACT COIL CONFIGURATIONS** and open up **NEW design options**





25mm coil radius + 15mm for ext. beam at 4.0m is a 10mrad crossing angle

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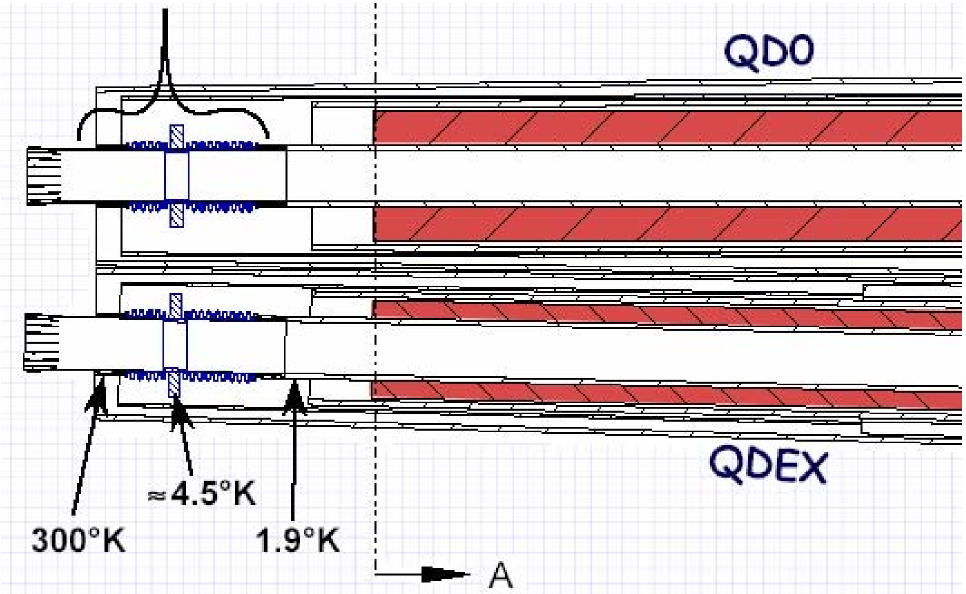
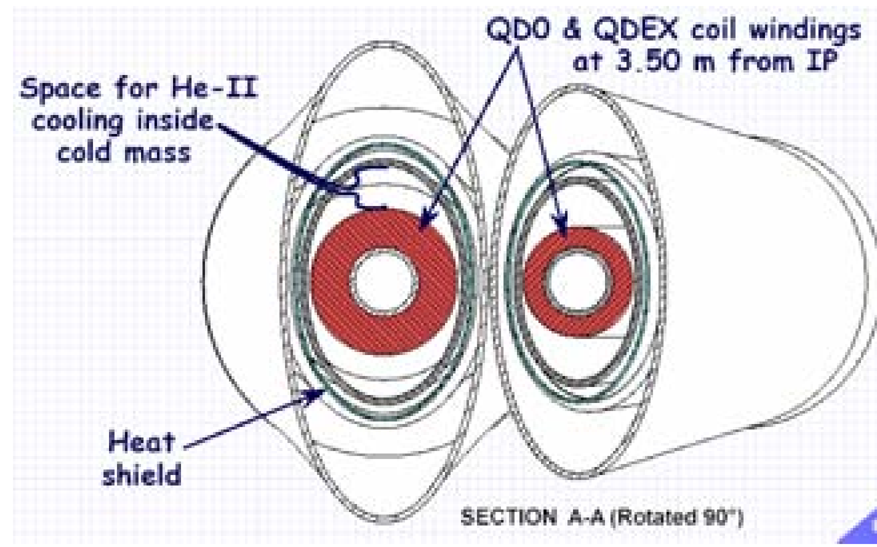
Compact QD0 Mechanical & Cryoengineering and Prototype Test at BNL





380mm QD0 Test Prototype

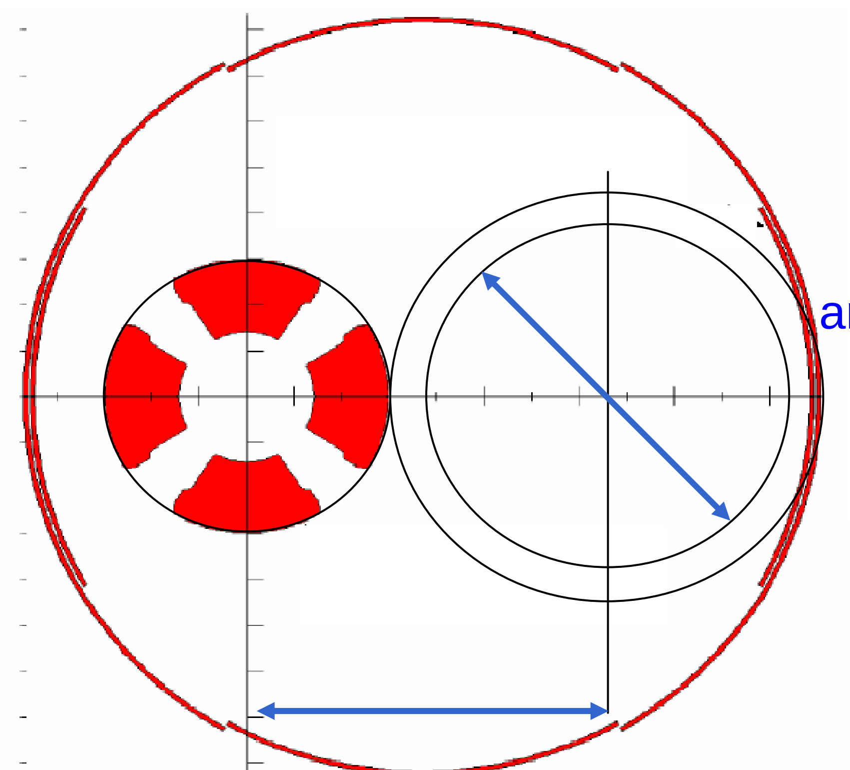
QT Quench Test Results

Background Solenoid (T)	Temp (°K)	Gradient (T/m)
3	4.30	158
4	4.22	139
5	4.22	134
6	3.00	137

γγ accommodated within 20 mrad

B. Parker

Straw-Man Configuration
Discussions on Merits/Risks of 25mrad continue

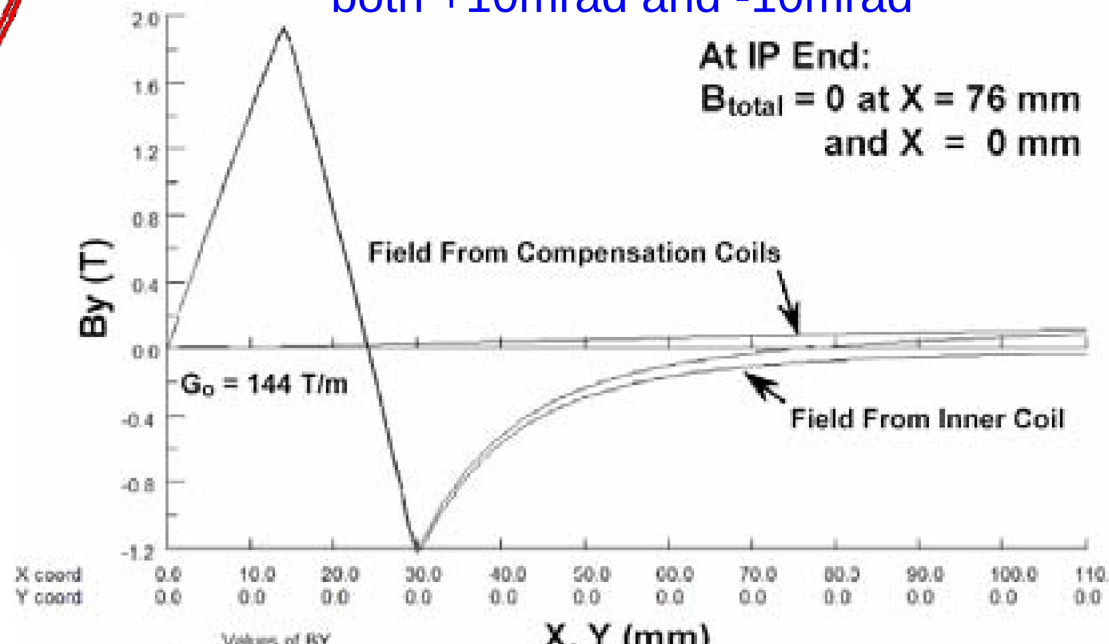


76mm = ±10mrad around extraction line

76mm beam separation at 20 mrad

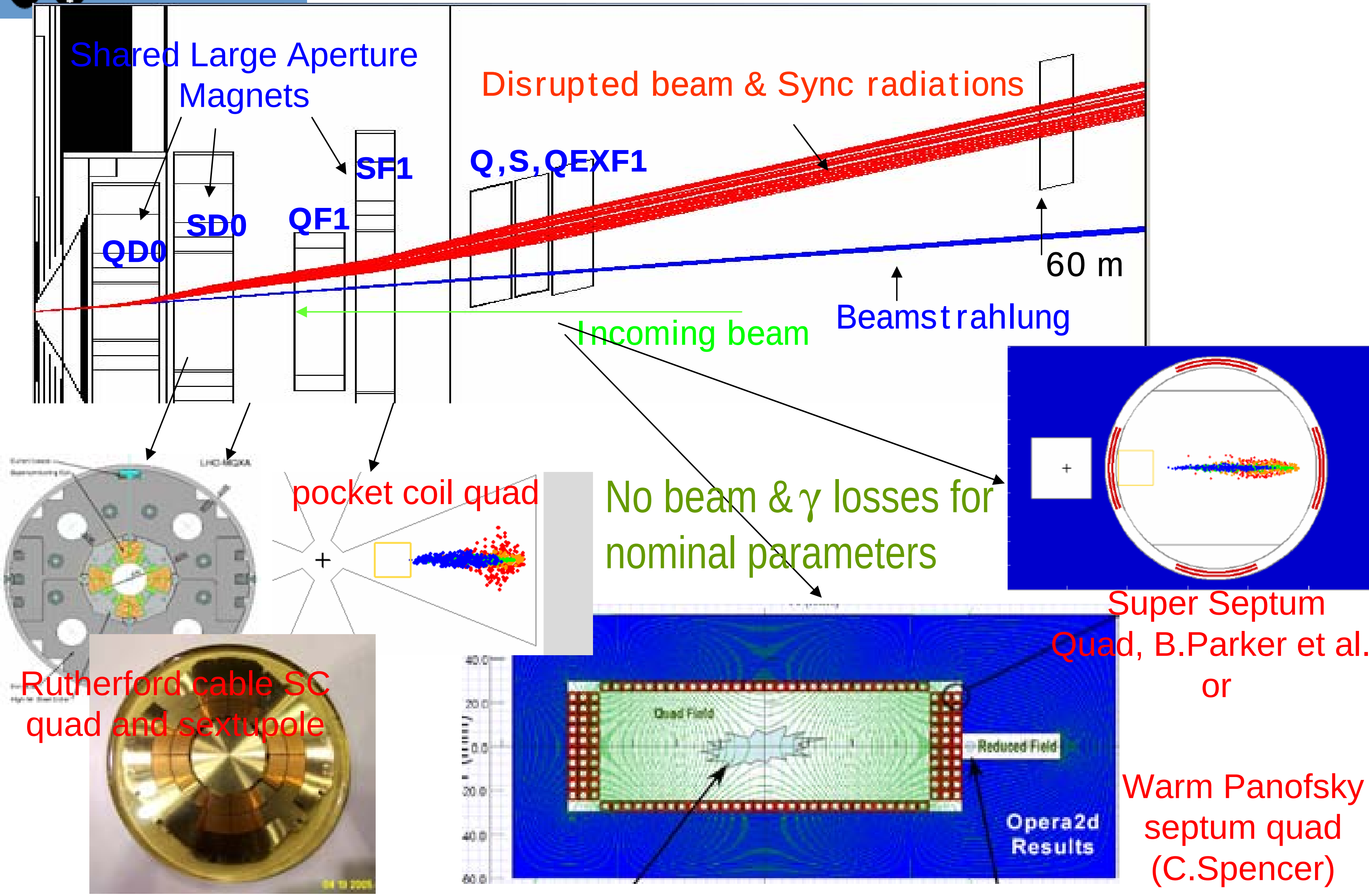
COILS at IP Side of QD0 at z=3.8m

Outer Quad and Dipole Zero By at both +10mrad and -10mrad



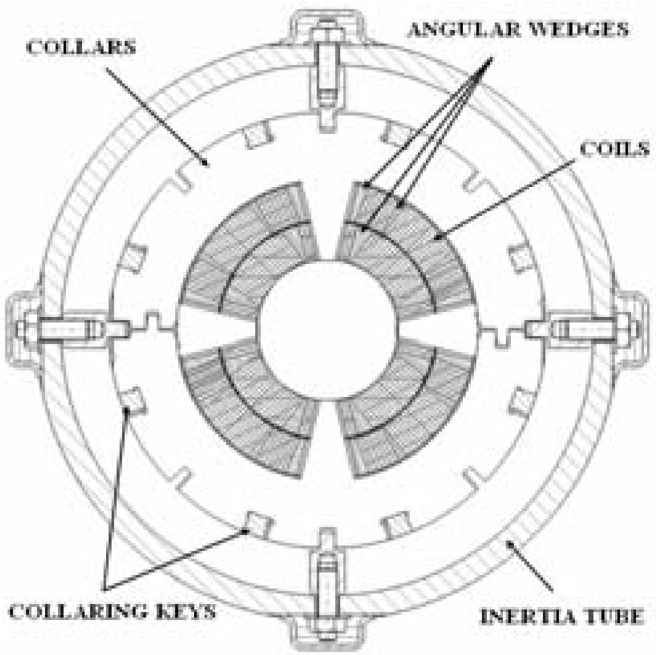
2mrad IP Extraction Line in Geant

SLAC-BNL-UK-France Task Group



Some Comments Regarding Crossing Angles, Magnets & the Extraction Line (2)

- **2 mrad**
  - **We have had less time to study optics, diagnostics, energy loss… but it seems that optics works at nominal 500 GeV and 1 Tev cm parameters with somewhat less margin with higher Lum parameters**
  - **2mrad QD0 more challenging magnet than LHC style TESLA 0 mrad QD0 (See magnet technology talk at RHUL BDIR)**
    - Larger bore, thicker coils, larger outer cryostat size + solenoid compensator, larger cold-warm transition in z
      - NbTi OK for 500 GeV cm but..
    - R&D for QD0 and eventually SD0 at Saclay based on Nb_3Sn Quadrupole Program
  - **Proposers of QEXF1 septum magnets recommend aggressive R&D**
  - **Work needed, no showstopper but may be higher risk**



Personal Conclusion

- Detector Concept Groups are underestimating value of a robust beam delivery / extraction system for a system with less margin for error or uncertainties because of potential physics in a small and very dirty area of phase space

- After absorbing responses I could easily be convinced to change WG4 baseline to ONE IR with whatever minimal crossing angle supports a separate line and a gg very large angle IR to be defined much later