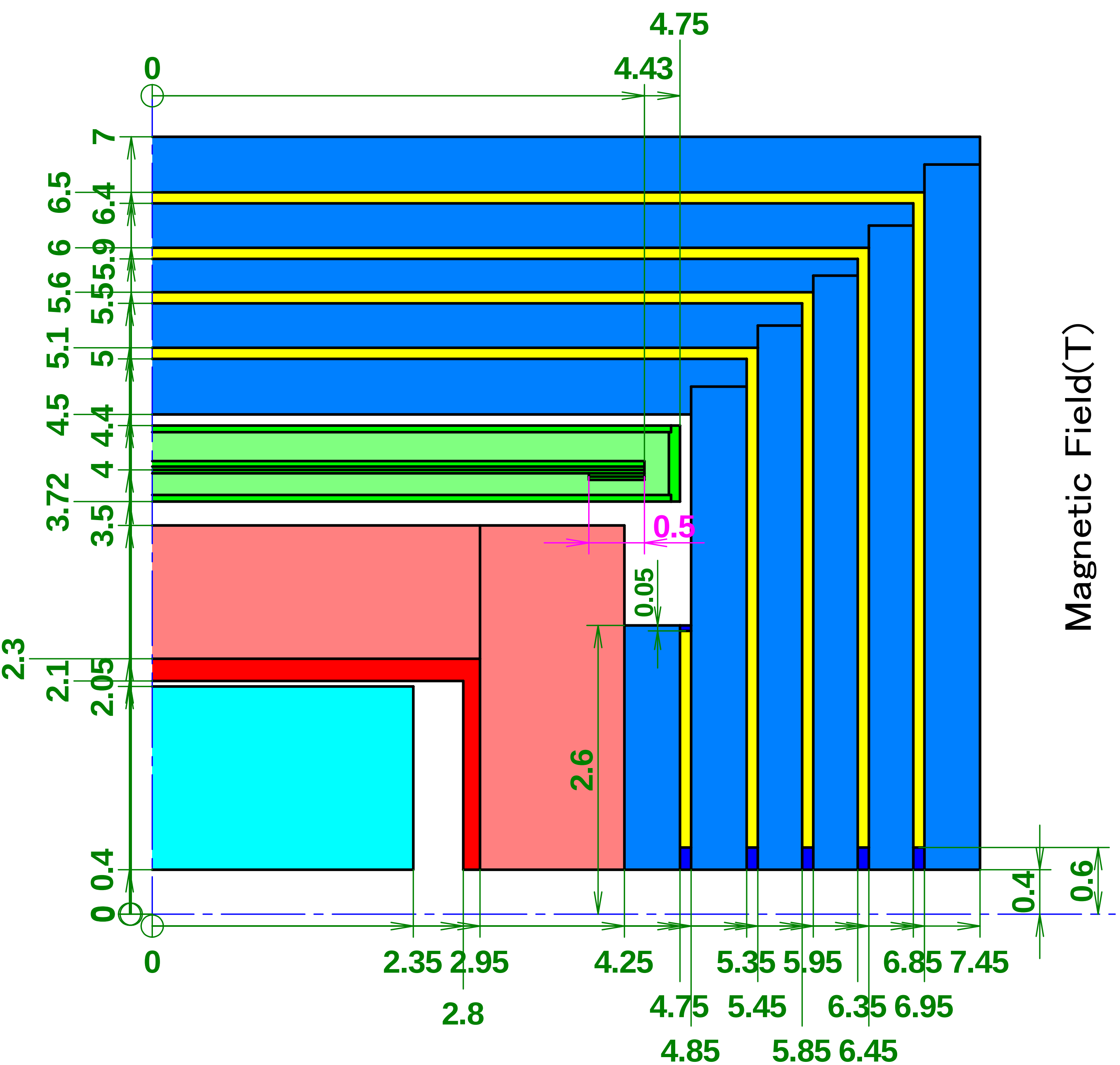
WWS/Urgent MDI questions

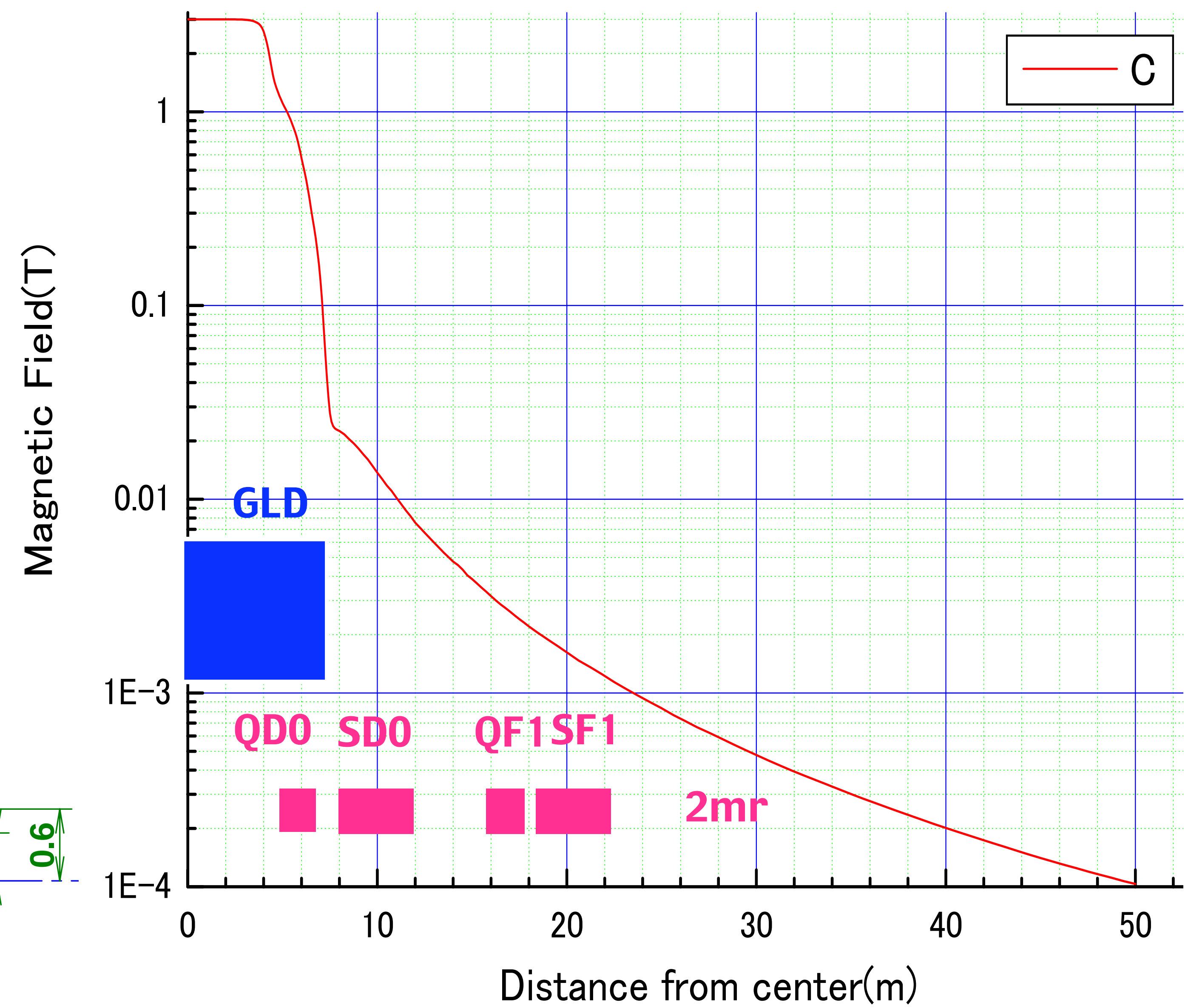
T.Tauchi, GLD-MDI session, SNOWMASS,
17 August 2005

Q1: What factors determine the strength and shape of the magnetic field in your detector? Give a map of the field, at least on axis, covering the region up to +-20 m from the IP. What flexibility do you have to vary the features of this field map ?

- PFD : BR^2,(separation of h&γ) larger R with modest B-field; R=2.1m (Ecal) and B=3T
- TPC : resolution = BL^2 , smaller diffusion with larger B and uniform B field, $\int[Br/Bz]dz$ <2mm
- Pair background in VTX : larger B
- Technical feasibility and cost issue : modest B

GLD Detector and Solenoid Field





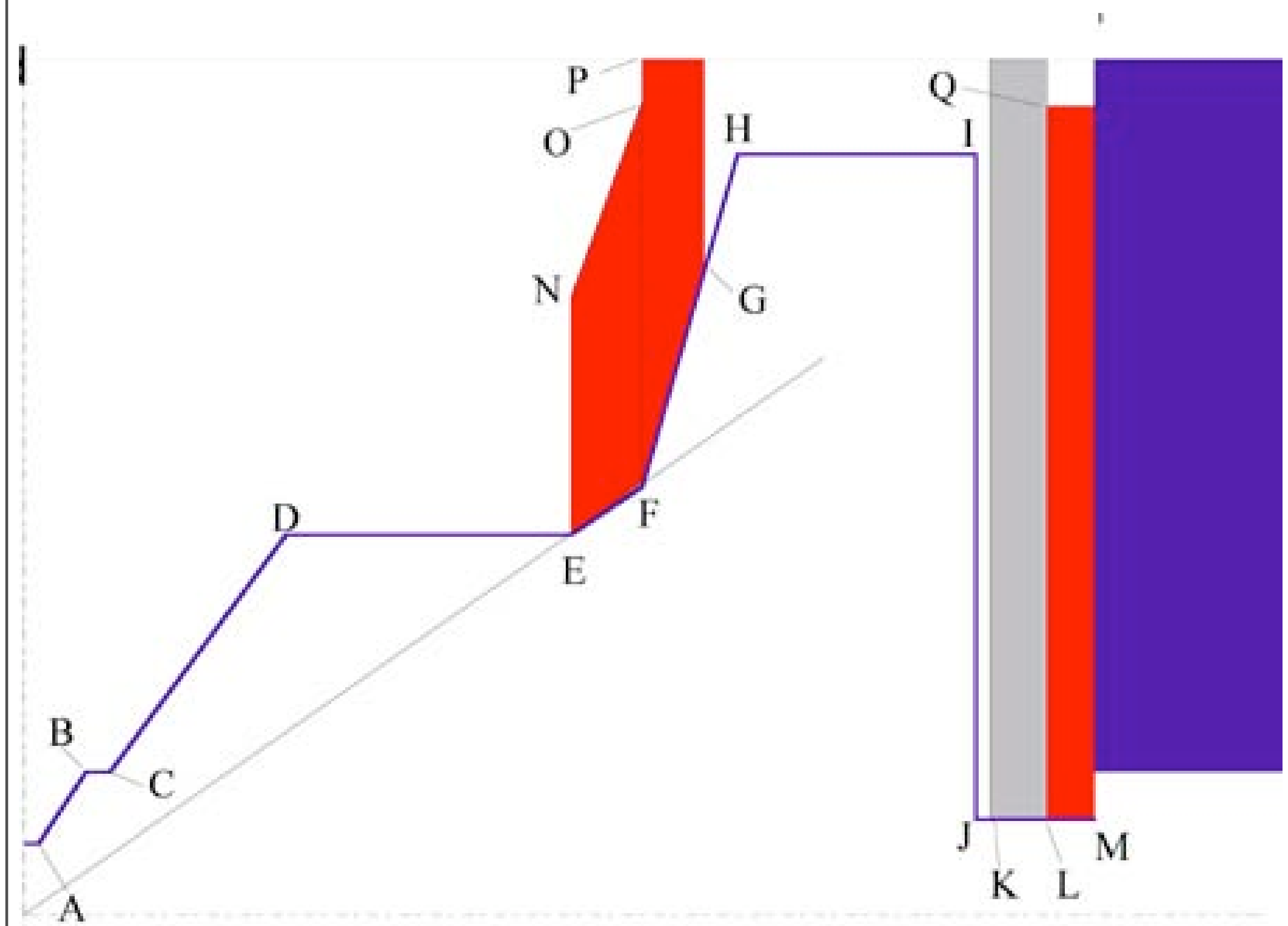
Q2: Provide a GEANT (or equivalent) geometry description of the detector components within 10 meters in z of the IP and within a radial distance of 50 cm from the beamline.

- Detector geometry in http://ilcphys.kek.jp/soft/
- The IR geometry, especially beam pipe and VTX innermost radius, depends on the machine parameters. Assuming that the accelerator will seamlessly operate in these parameter sets including the high luminosity one at one center-of-mass energy, the present baseline design should be optimized for the "worst" one which is the high luminosity at ECM=500GeV. Thus, we have the baseline design of beampipe and final quadrupoles in both cases of 2mr and 20mr crossing angles.

GLD-IR Deign :L*=4.5m, B=3T, HighLum

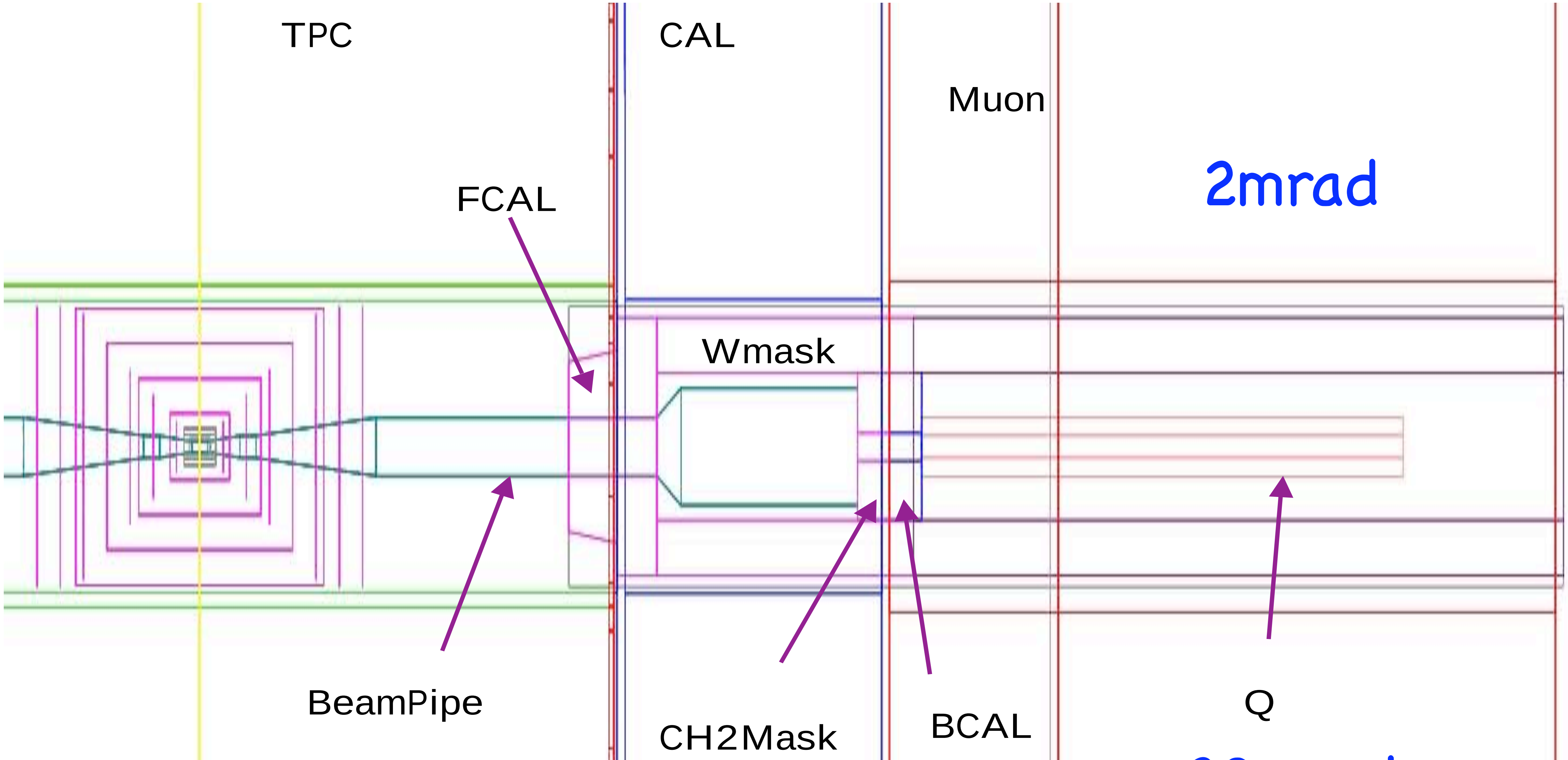
GLD-IR Baseline Design with L*=4.5m, B=3T and High lum Parameter set

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)@20mr	R(cm)@2mr	R(cm)@20mr
core		11	12.5	11.5	13.5
TPC-shielded		55	62	58	64
VTX		2.4	2.4	2.4	2.4

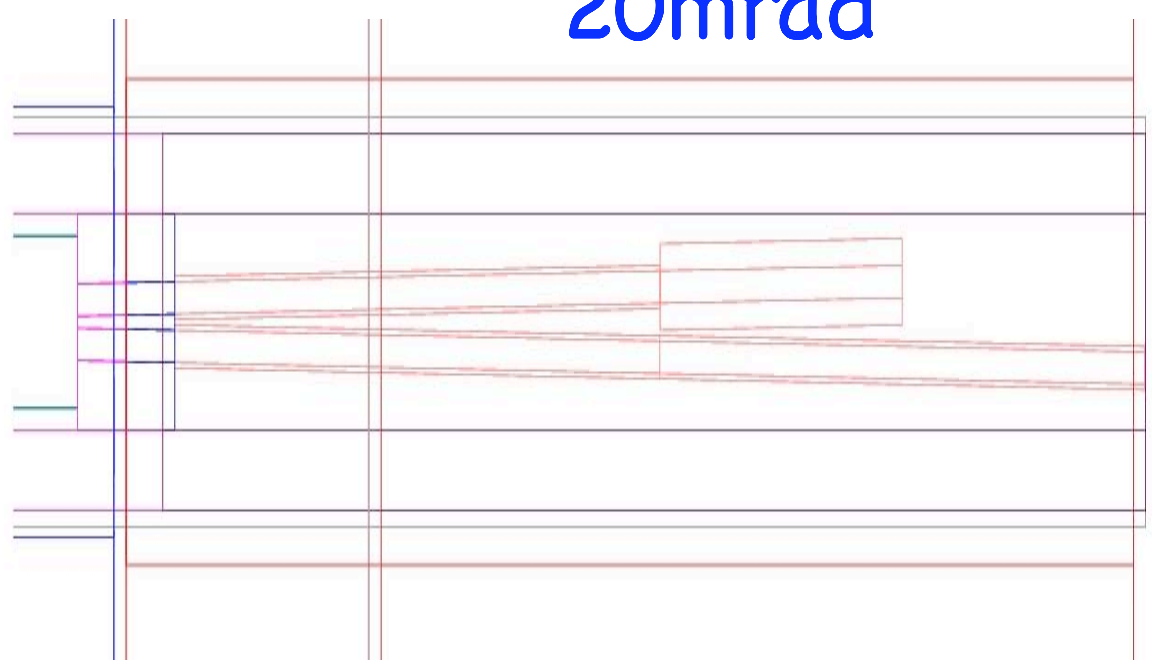


,where red-region is calorimeter, the grey one is a CH_2 (low Z) mask and the blue is the final quadrupole magnet.

IR Geometry in Jupiter



20mrad



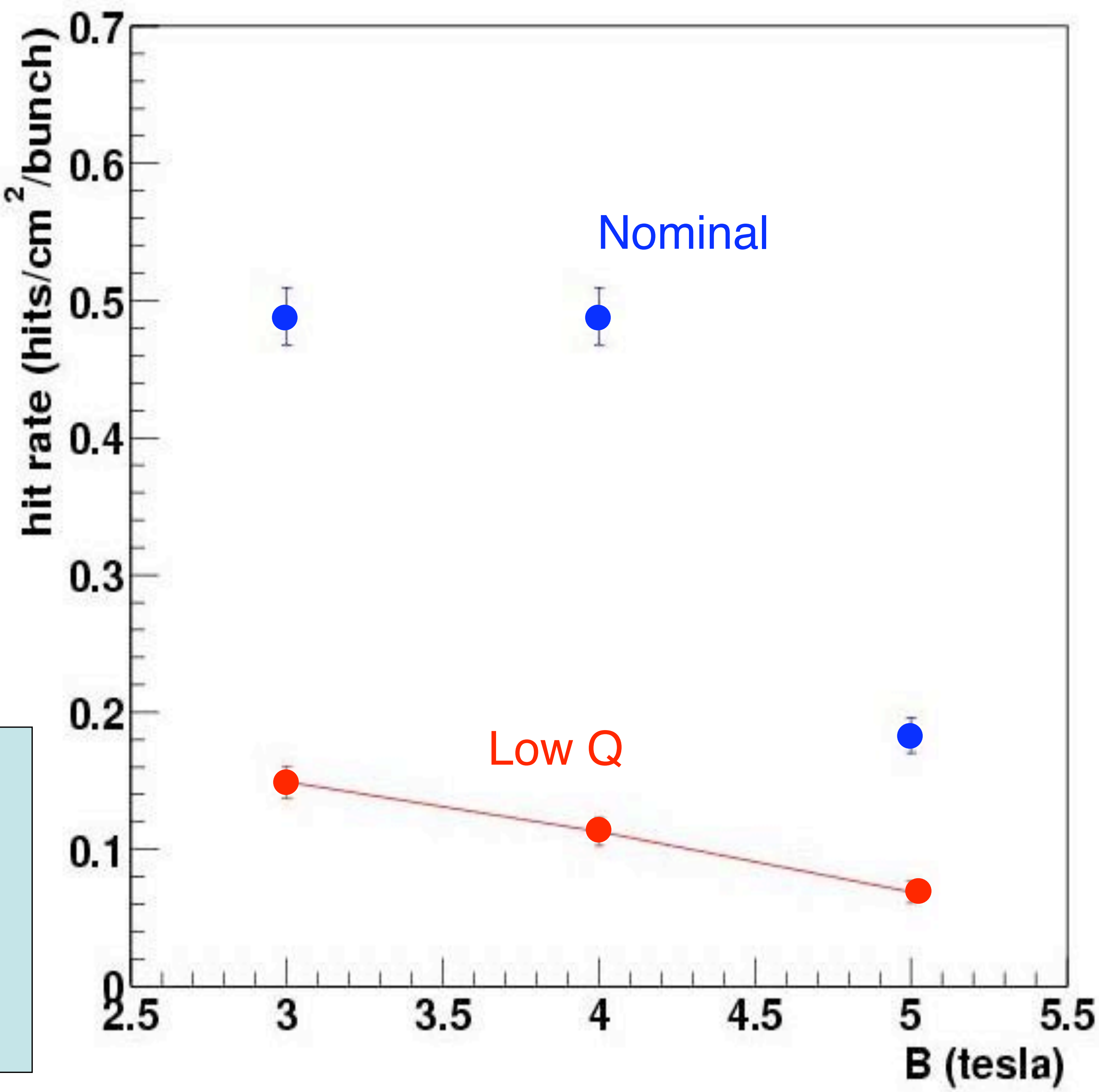
Q3: LowQ : Would you mind if the baseline bunch-spacing goes to ~150 ns instead of ~300ns; with ~1/2 the standard luminosity per crossing and twice as many bunches ?

- CAL & VTX : no problem for the DAQ will be sufficiently fast.
- TPC : no problem for the timing resolution of 1.5nsec and typical readout time of 50usec is common for 150 and 300nsec bunch-spacing

Simulation Study

- Pair background hit rate on the 1st layer of the Vertex Detector (R=24mm)
- Simulation using CAIN and JUPITER
- Hit rate of the Low Q option is ~1/3 of the nominal option, as expected

Pair B.G. hit rate (/cm^2/bunch)		
B(tesla)	Nominal	LowQ
3	0.488	0.149
4	0.48	0.113
5	0.183	0.069



Q4 :For each of your critical sub-detectors, what is the upper limit you can tolerate on the background hit rate per unit area per unit time (or per bunch) ? Which kind of background is worst for each of these sub-detectors (SR, pairs, neutrons, muons, hadrons) ?

- VTX : 1×10^{4}/cm^{2}/train for pair background : tracking; 1×10^{10}/cm^{2}/year for neutron : radiation damage
- CAL : 1 (MIP) /cm^{2} /train, 2820 - 5640 bunches/train
- TPC : The tracking has been studied for the warm machine (NLC), where 20 times more hits than the "nominal" was OK, so it need to be updated for the ILC. Backgrounds : photons and neutrons.

Q5 : Can the detector tolerate the background conditions for the ILC parameter sets described in the Feb. 28, 2005 document at www-project.slac.stanford.edu/ilc/acceldev/beamparameters.html ? Please answer for both 2-mrad and 20-mrad crossing angle geometries. If the high luminosity parameter set poses difficulties, can the detector design be modified so that the gain in luminosity offsets the reduction in detector precision ?

- We would need to run background simulations for the different parameter sets, which is under study. Some of results are expected to be presented at SNOWMASS.

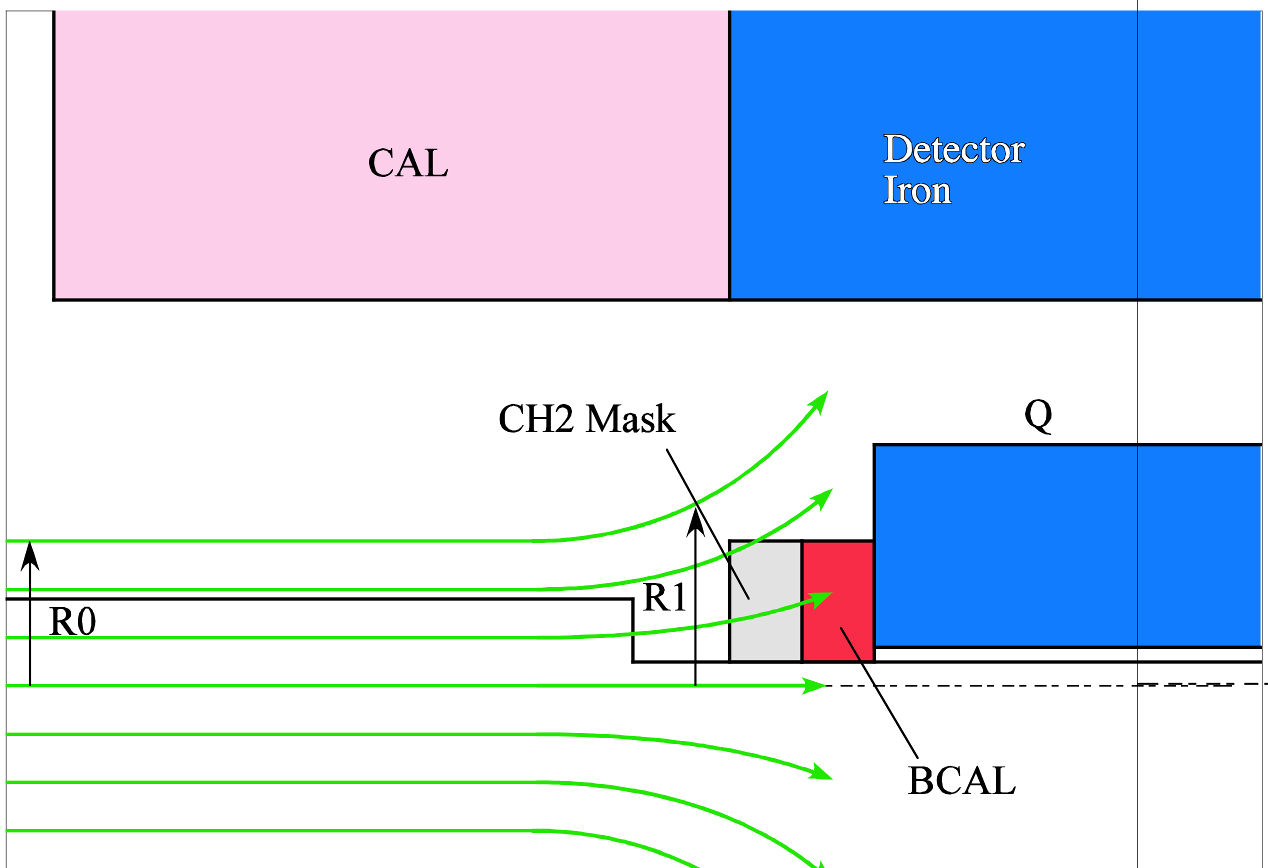
Q6: What is your preferred L^*? Can you work with $3.5m < L^* < 4.5m$? Please explain your answer.

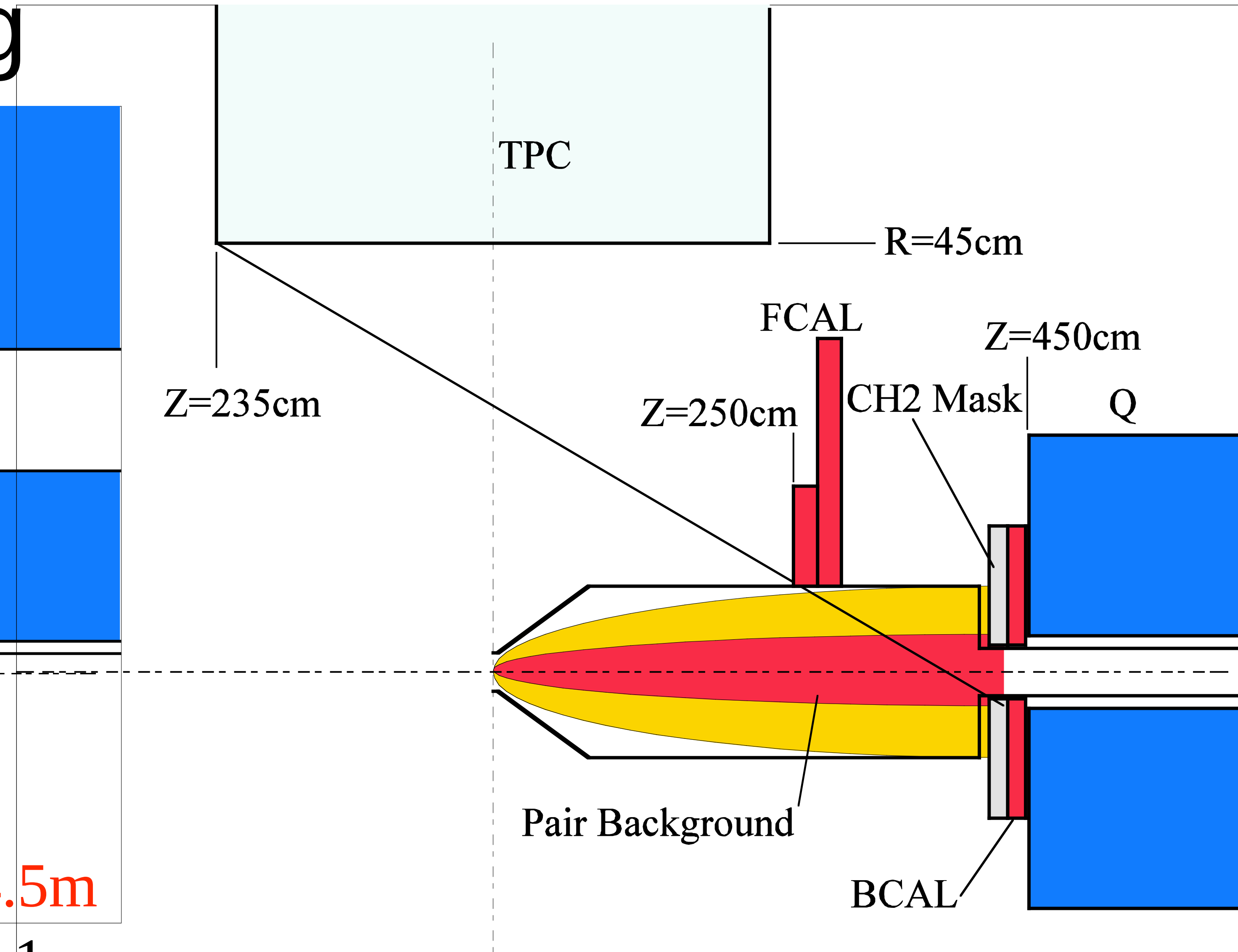
- We prefer L^*=4.7m with 20cm warm-cold transition of super-Q for (1) confinement of low-energy electrons, which are backscattered at BCAL with 4cm diameter bore, within the beam pipe; i.e. r=1.6, 1.92 and 1.99cm at L^*=4.5, 4.1 and 3.5m, respectively. (2)FCAL/mask to shield TPC active region against the backscattered photons.
- Need full simulation

GLD : Preference of L* > 4.7m

γ back scattering

e+/e- backscattering





$$R0/R1 = \sqrt{B1/B0} = 1.6/2.0 \quad L^*=4.5\text{m}$$

(Z1=4.3 m)

1.92/2.0 L*=4.1m

1.99/2.0 L*=3.6m

Q7 : What are your preferred values for the microvertex inner radius and length? If predicted backgrounds were to become lower, would you consider a lower radius, or a longer inner layer? If predicted backgrounds became higher, what would be lost by going to a larger radius, shorter length ?

- The preferable innermost radius of VTX might be less than 2cm and the polar angular coverage must be $|\cos\theta| < 0.95$, for good tagging efficiency of charm and bottom quarks as well as jet charge determination.

- If the background is high, the inner radius of the VTX must increase by 10 to 20%. This increase affects the impact parameter resolution and the flavor tagging efficiency, while the effect would be at most 10 to 20% change.

- SiD: r= 1.4 cm, z=+/-6.5cm with r=1.2cm beam pipe of 400um Be at B=5T

- LDC: r=1.5cm at B=4T

Q8: Are you happy that only 20mr and 2mr crossing angles are being studied seriously at the moment? Are you willing to treat them equally as possibilities for your detector concept ?

- We prefer the smallest crossing angle even including headon with acceptable backgrounds, an extraction line including polarimeter and energy spectrometer, while as well known the 2mr and 20mr have been determined to be strawman's crossing angles by the ILC-WG4, November 2004. If the 2mr encounters a serious difficulty, we would like to suggest a further study on the minimum crossing angle in the range of 2 and 20mr.

Q9 :Is a 2mr crossing angle sufficiently small that it does not significantly degrade your ability to do physics analysis, when compared with head-on collisions ?

- Since the present BCAL can cover the angular region down to 5mr with the 2mr crossing angle, there is expected to be no difference between headon and 2mr crossing angle in term of the minimum veto angle measurement. However, we would like to reserve the headon scheme for physics studies on extremely precision measurements, e.g. Z-pole, SUSY, luminosity measurement, and there is active group (Kyoto university) for R&D on RF kicker which may realize the headon scheme.

Q10 : What minimum veto and/or electron-tagging angle do you expect to use for high energy electrons ? How would that choice be affected by the crossing angle ? How does the efficiency vary with polar angle in each case ?

- Minimum angular acceptance of the BCAL is 5mrad in both crossing angles, although the 20mr crossing angle scheme has less efficiency of tagging electron in small angles. Need full simulation to verify the experimental feasibility of detection efficiency in huge pair background as a function of crossing angle, which is under study;
- quick results

Energy deposit (TeV)/bunch of pairs at BCAL

E_{CM} (GeV)	500		1000	
Crossing angle	2mr	20mr	2mr	20mr
nominal	20.8	44.3	53.9	98.1
lowQ	6.1	15.7	16.3	34.9
HighLum	119	184	303	416
HighLum 1			141	
HighLum 2			106	

, where BCAL has 4cm diameter beam pipe(s). The headon collision has the same energy deposit as the 2mr crossing angle with this geometry; i,e, 4cm diameter beam pipe at BCAL (z=4.3m).

The hit distribution is shown in a figure as a function of energy, with 2mrad crossing angle and the 500GeV nominal parameter set, where the solid and dash lines show the hits without/with the beampipe hole in BCAL.

Q11 : What do you anticipate the difference will be in the background rates at your detector for 20mr and for 2 mr crossing angle? Give your estimated rates in each case.

- Also, full simulation studies are necessary, which is under study.

Q12 : DID : What is your preliminary evaluation of the impact of local solenoid compensation (see LCC note 143) inside the detector volume, as needed with 20mr crossing angle, on the performance of tracking detectors (silicon, and/or TPC, etc.) ?

- We expect that TPC is the most sensitive detector for good momentum resolution. The DID effect in TPC is evaluating by Ron Settles who will write a LCC note on the effect.
- It can be manageable with the field mapping.

Q13 : Similarly, what is you preliminary evaluation of the impact of compensation by anti-solenoids (LCC note 142) mounted close to the first quadrupole

- Also, full simulation studies are necessary, especially on background such as backscattered low-energy particles.

Q14: Do you anticipate a need for both upstream and downstream polarimety and spectrometry? What should be their precision, and what will the effect of 2 or 20 mr crossing angle be upon their performance.

- Generally, both polarimetry and spectrometry are desired for complementary measurements in order to estimate effects during collisions at IP. Detailed evaluation should be required at upstream and downstream cases for any depolarization in long beam line and experimental feasibility with huge background of disrupted/beamstrahlung beam, respectively.

Q15: Is Z-pole calibration data needed? If so, how frequently and how much? What solenoid field would be used for Z-pole calibration? Are beam energy or polarization measurements needed for Z-pole calibration

- What is luminosity-scale ?; it may be linear L $=10^{33}/cm^2/s$ with enough position source.
- VTX : 1 / fb / year, 100/pb/month? (10days)
- CAL : 10 / fb with only muon pairs ! (100days)
- TPC : 10/pb at the beginning of a year, and one run of 1/pb during a year (a few hours)

We are evaluating these issues for each detector. Also, we need how much luminosity is extected on Z-pole during the usual experimental run at ECM=500GeV. At present, we assume the luminosity(L) of $10^{33}/cm^2/s$ for VTX and CAL calibration runs, while L= $10^{32}/cm^2/s$ is assumed in the TPC calibration. Preliminary results are listed below;

VTX; If we have 1 fb^{-1} integrated luminosity, which can be achieved by 10 days run with 10^{33} luminosity, we can accumulate $3x10^6$ muons (50M Z). Then we can get 1000hits/cm^2 at the outermost layer of the VTX. This number would be enough to get precise position calibration of the VTX. So we would like to propose to have;

1 fb^{-1} Z-pole run: Once per run period (=one year?) and 100 pb^{-1} Z-pole run : Once per month.

CAL requires sufficient number, about 100, of MIP particles passing in every 1cm x 1cm segmentation for 100 m^2 scintillator in the electromagnetic calorimeter. If muon pairs are only used (BR is 3.3%) on Z-pole, integrated luminosity of 10 fb^{-1} would be necessary, i.e. 100 days with L= 10^{33}!. CAL group must study seriously if hadronic events can be used for the calibration, or some clever method.

TPC by R.Settles and M.Thomson: The answer needs a guess at how often problems with the detector will occur that require calibration data. To not just make a blind guess, we took the data from Lep2 running, where this procedure (Z pole running for calibration) was used several times when detector problems cropped up. The last year of Lep2 running (2000), where things were really being pushed by the machine, the track record was: Z Running needed at Lep2: =>per detector<= 3/pb at the beginning of the year, and one run of 0.5/pb during the year. So, we propose then to use the following working hypothesis: Z Running for ILC: =>per detector<= 10/pb at the beginning of a year, and one run of 1/pb during a year , since the detector(s) will be more complicated. If I remember correctly, the projected Z-pole luminosity for Tesla for "calibration" (i.e. no special beam gymnastics to push up the luminosity like would be needed for the "GigaZ") would be $10^{32}/cm^2sec$ so that calibration at the beginning of the year would take =>per detector<= 30hours of beam and during the year =>per detector<= 3hours of beam. To repeat, this is just a guess, but at least it is based on past experience. At the very beginning of the ILC operation, much more Z running would be needed for calibration of the detector(s). This will mainly be determined by the calorimeter; Calice has studied this but I don't remember what their number is, maybe somebody else does...

Q16: Would you like te e-e- option to be included in the baseline, and if so what minimum integrated luminosity would you want ?

- Probably no, since there is no strong desire in GLD group at present. However, the e-e- option may be kept for the physics motivation may become relevant in future, in such way as SUSY or new physics would demand.

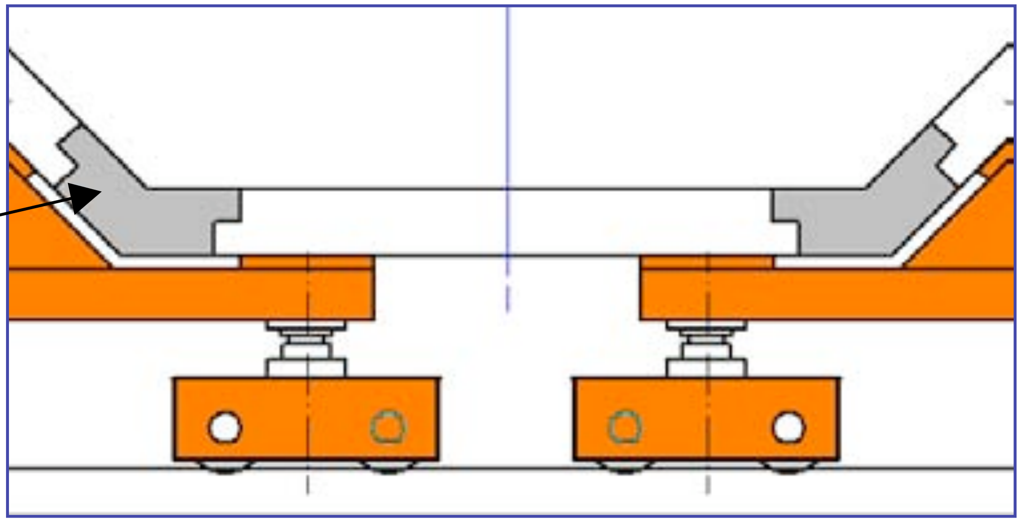
Q17 : What will be your detector assembly procedure?

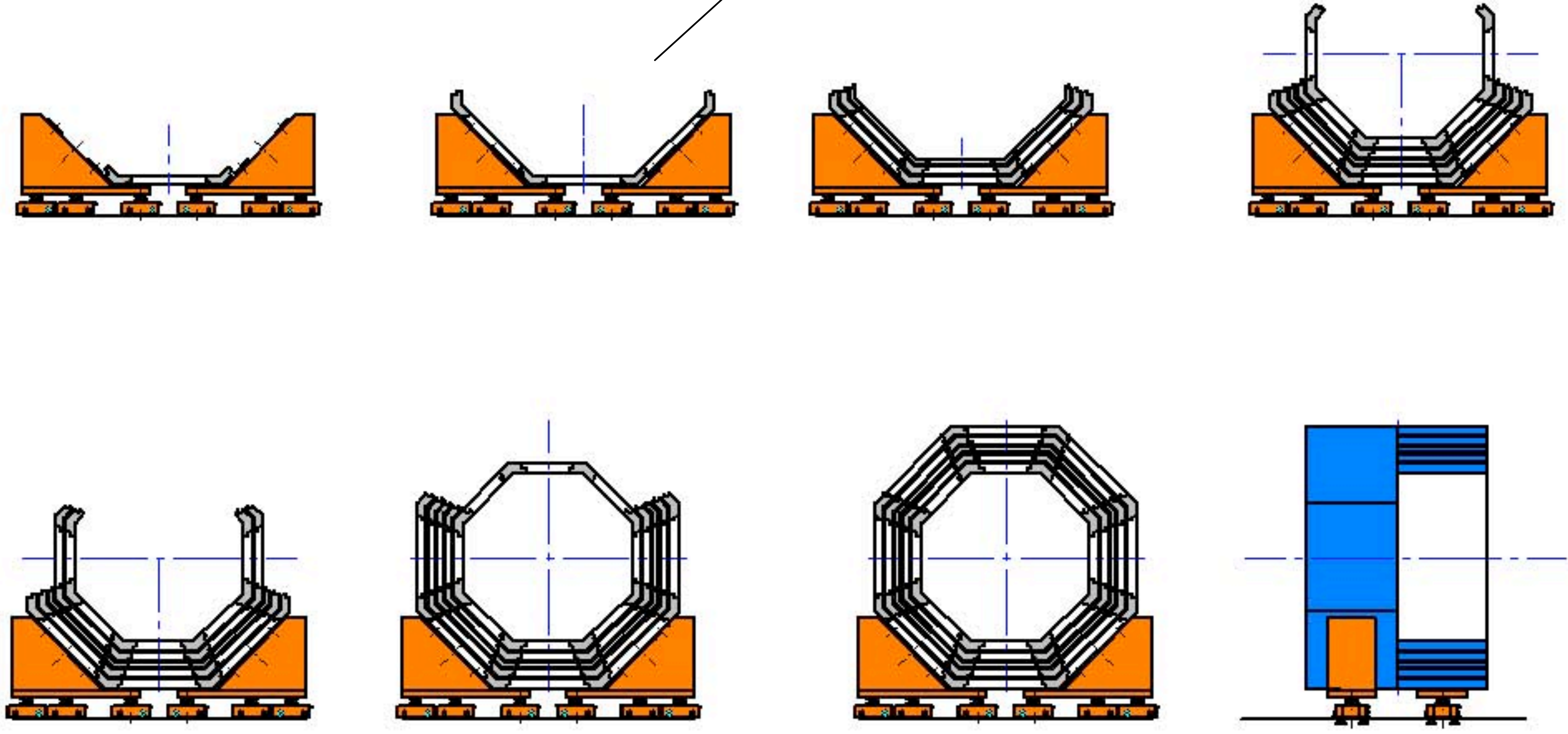
- Order of assembling detectors will be as follows; Iron structure-bottom -> Solenoid -> Iron structure-top -> CAL -> TPC-> Support tube for QC, BCAL, FCAL -> TPC slide out -> VTX, IT -> TPC slide back in -> Close endcap. Before an installation of TPC, magnetic field of the solenoid has to be mapped in details together with the DID as well as the final quadrupole and the anti-solenoid if necessary.

Barrel Yoke

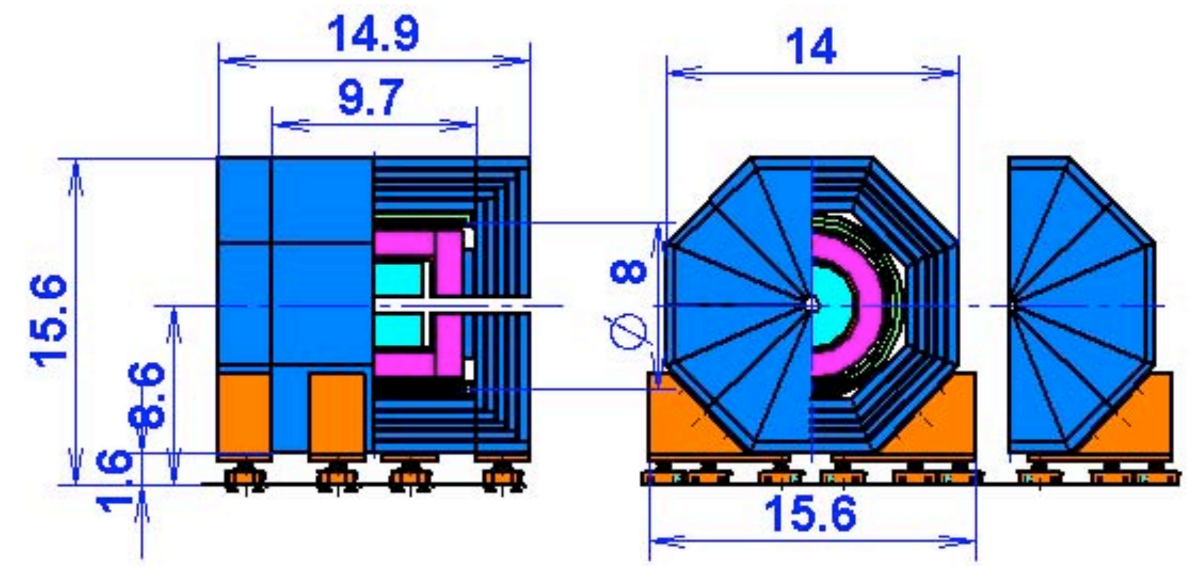
Iron plates to be bolted on the support frame

Support jig at each corner

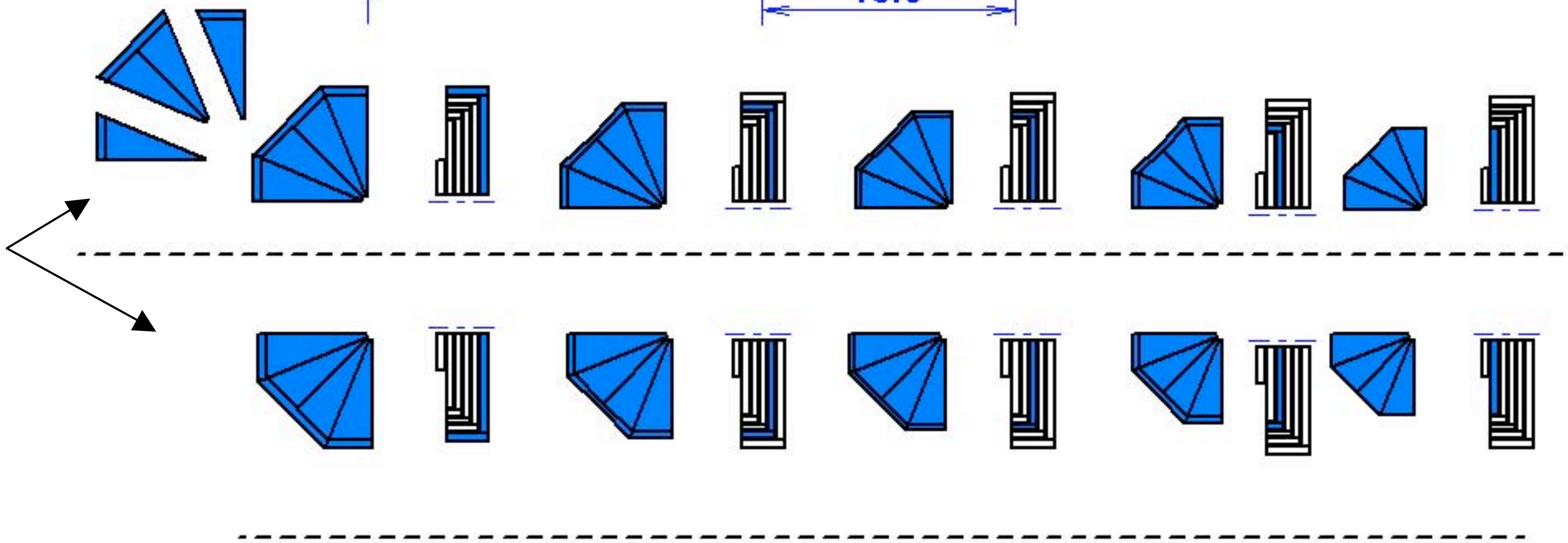




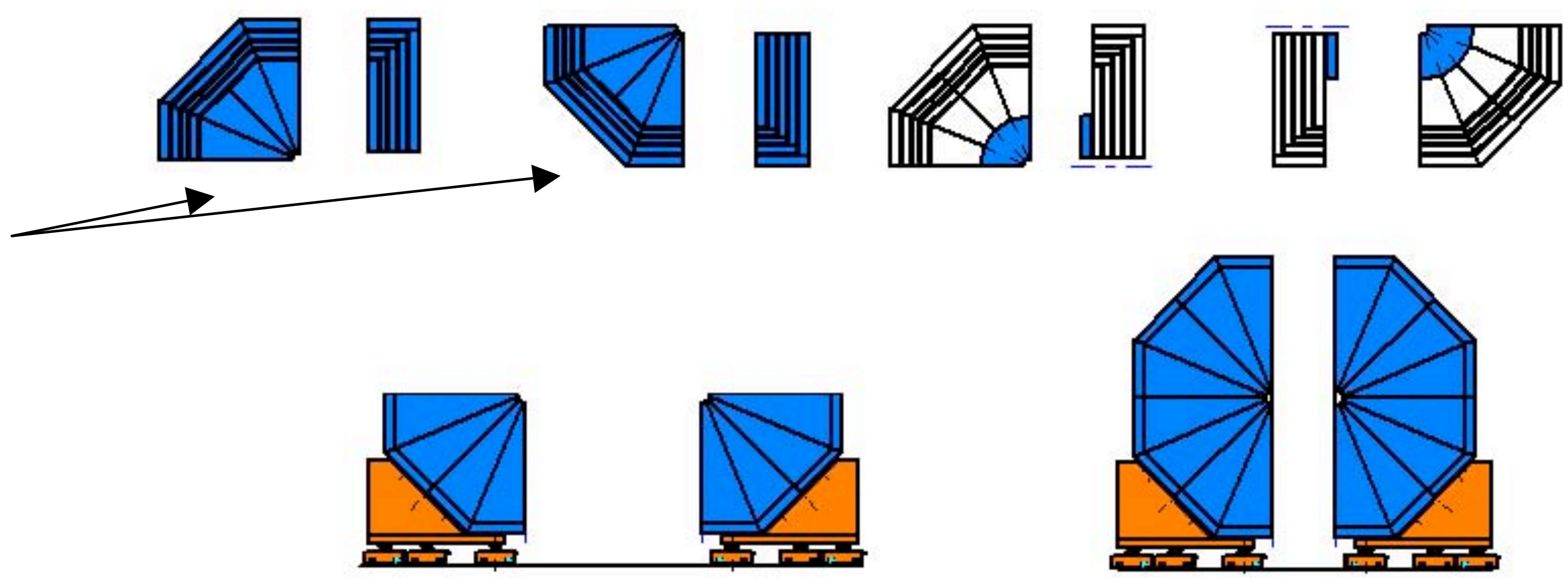
End Yoke



Iron plates (blue parts) are welded



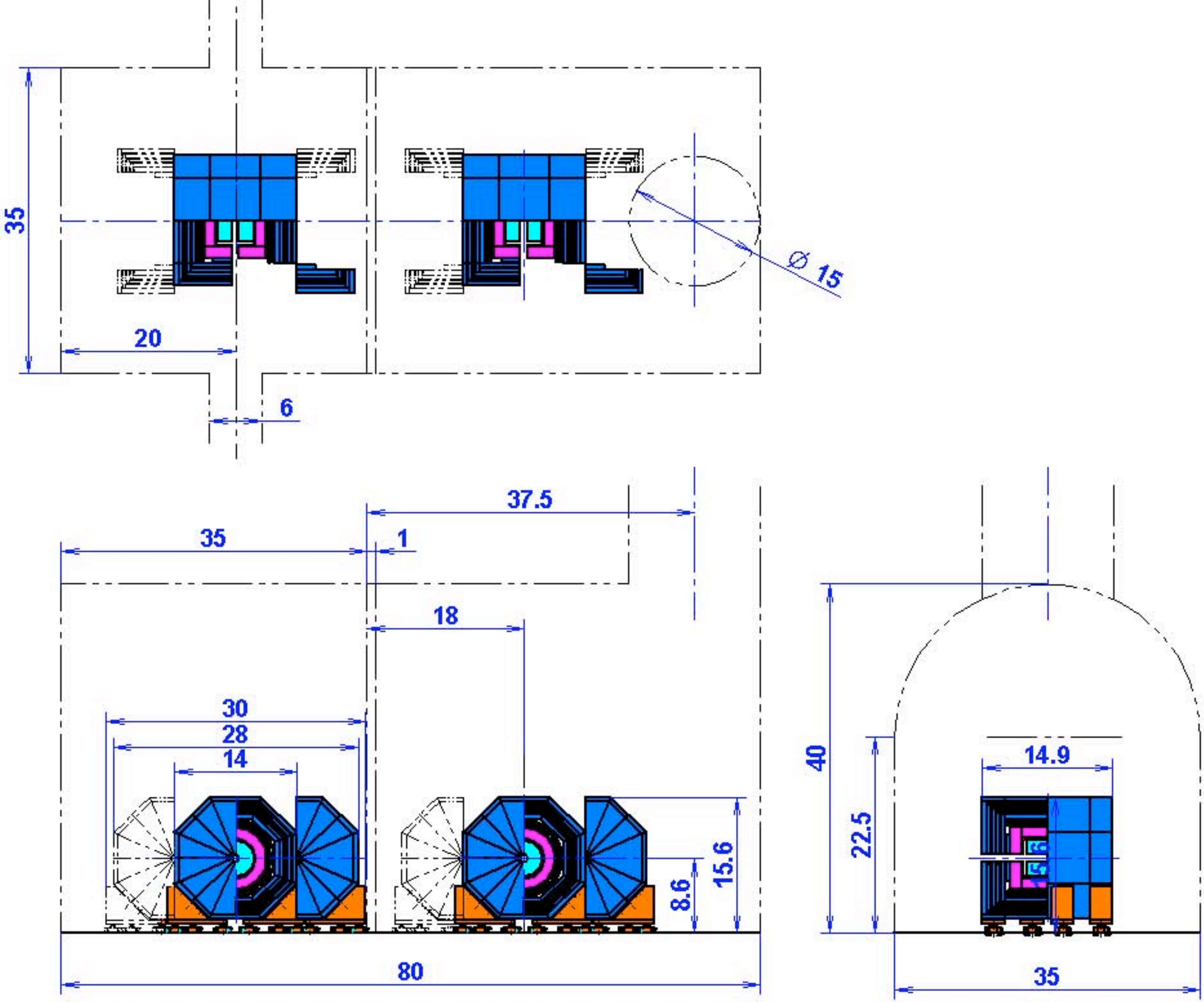
Upper and bottom end yorks are welded



Put them on the support frame

Q18 : What size is required for the detector hall ?

- Under following assumptions; (1) Superconducting solenoid is constructed on the surface ground and put down through the vertical shaft of 15m diameter since no space is available for the construction in the cavern; (2) Detector assembly is done beside the beam line; (3) Machine study will be conducted without the detector / with the dedicated detector ; (4) Detector assembly can be conducted during the machine study; (5) The endcap can be opened sideway at the beam line for the maintenance; and (6) Space for the electronics hut is negligible; an area for the experimental hall is estimated to be 35m (width, along the beam line) x 80m (length) x 40m (height) .


35
20
6
Ø 15
37.5
35
1
18
30
28
14
8.6
15.6
80
40
22.5
14.9
35

Task in SNOWMASS

- Full simulation of Jupiter
- Background estimation in TPC and VTX with 2mr and 20mr crossing angle; effect of DID (to be sensitive to TPC by LDC)
- LCBDS simulation with L^*=4.5m and 2mr crossing angle as well as L^*=3.5m, 2mr, 20mr crossing angle