4-TH CONCEPT MDI ISSUES AND IP DESIGN

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http://physics.uoregon.edu/~lc/wwstudy/concepts/

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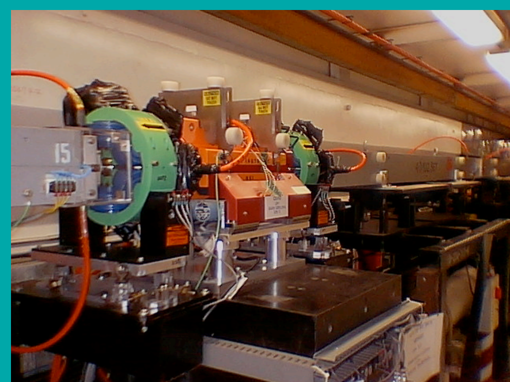
PREVIOUS ACHIEVEMENTS OF FINAL FOCUS DESIGN TAKEN INTO ACCOUNT

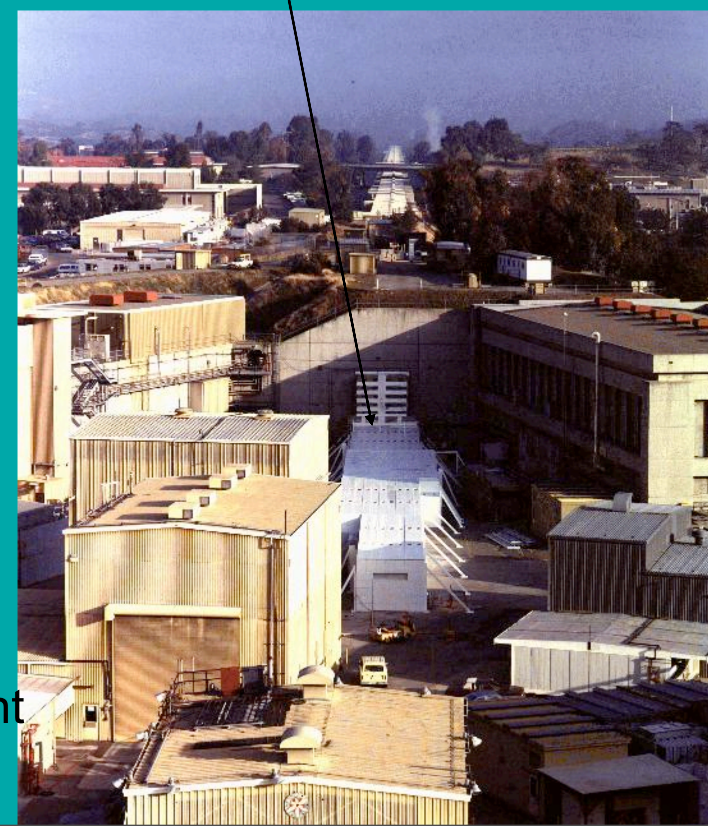
Beam delivery system –Final Focus Test Beam Facility- **FFTB**- was constructed to test FF optics concepts, stabilization, beam size measurements, magnet technology, 1993.

International project with participation of **France, Germany, Japan, Russia, USA.**

Located at the end of SLAC linac in a specially build extension housing. Total length ~200m; Compensation of chromaticity of FF doublet done by sextupoles.

Vertical beam size ~70nm was measured at IP – **Phys.Rev.Lett.74:2479-2482,1995**
Obtained substantial experience in Final Focus design





In particular,

- Tested stabilization of few long strings of magnets, representing functional electro-optical blocks (such as final telescope etc) with stretched wire.
- Tested active magnet alignment.
- Introduced and tested ballistic method for FF alignment
- Tested new-type beam size monitor for nm scale

BASIC PRINCIPLES OF 4TH , AFFECTING MDI

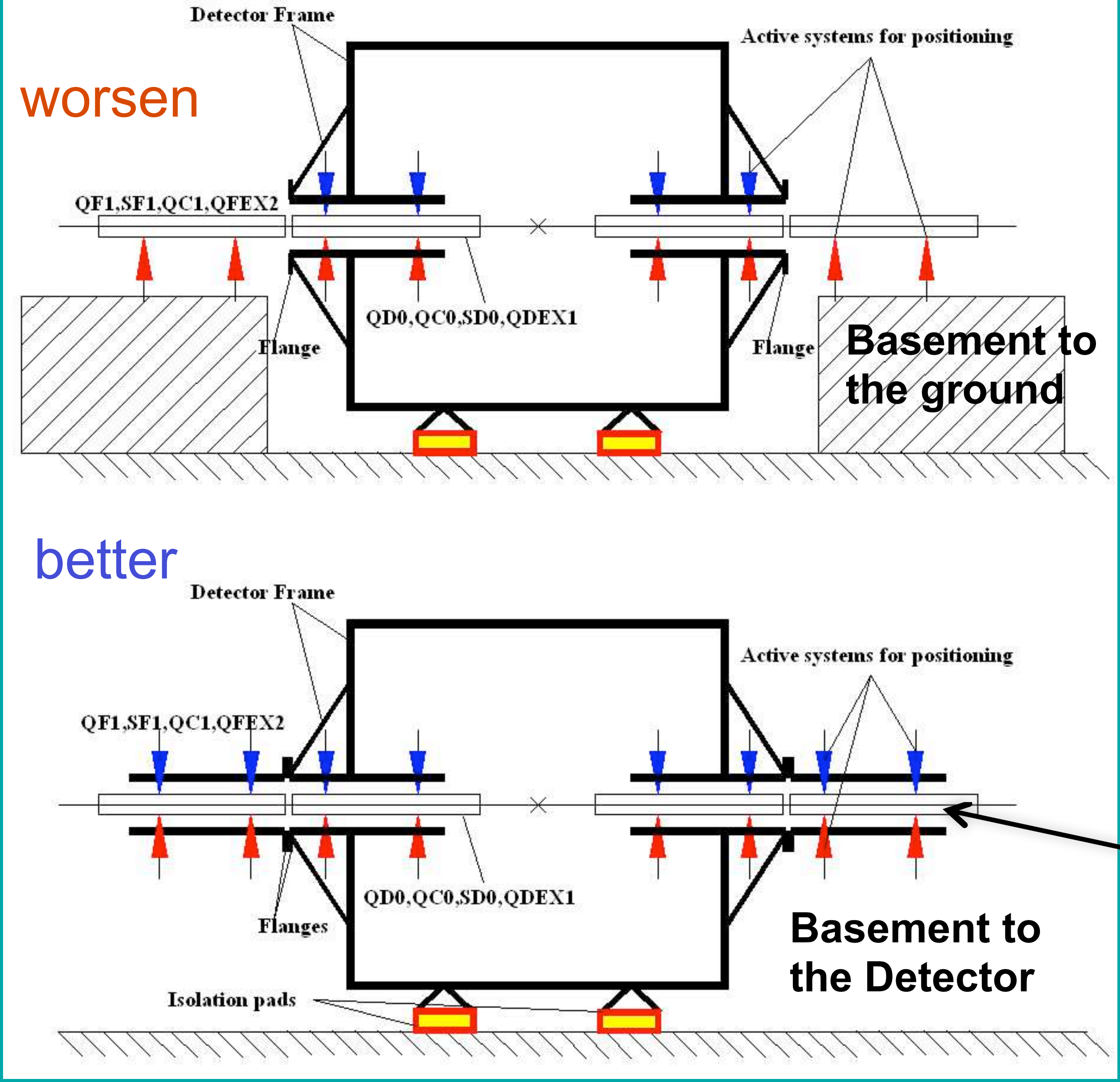
- **Beam-optical system incorporated in Detector**
- **Iron is omitted as it adds ~15% to the field value only (field outside of long solenoid is zero). Homogeneity restored by adding currents at the ends of main solenoid.**
- **Second solenoid closes the flux (minimal configuration).**
- **Muons can be identified with dual-readout calorimeter and tracker-calorimeter-muon spectrometer.**

Usage of dual solenoidal system plus end wall current system allows:

1) Strict confinement of magnetic field inside limited region
2) Spectroscopy of muons in magnetic field between solenoids
3) Incorporate FF optics in mostly natural way
4) Modular design which helps in modifications and re-installations
5) lightweight detector having flexible functionality and remarkable accuracy
6) Easiest incorporation of laser optical system for gamma-gamma collisions

- **Push-pull concept (baseline) is easily satisfied.**

CONCEPTS OF FF OPTICS INSTALLATION AND BASEMENT



Active systems for positioning include

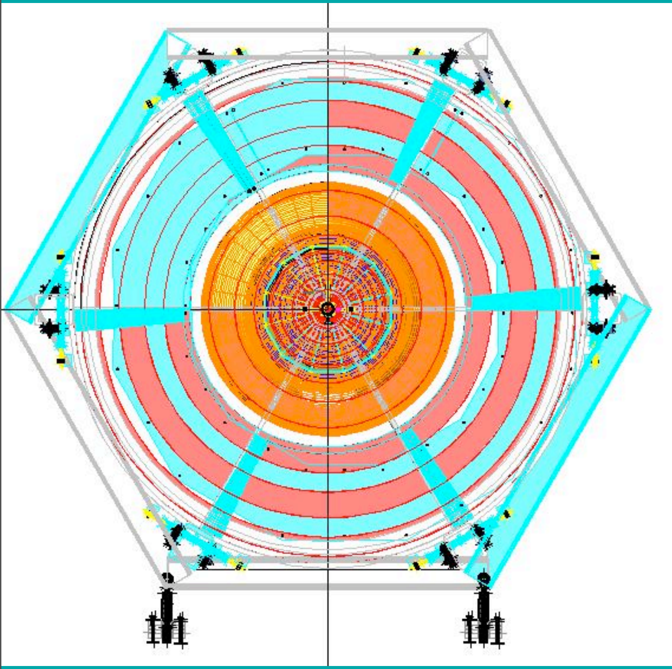
- Stepping motor-driven micro-positioning movers (tested at FFTB);
- Piezoelectric fast movers with active feedback;
- Dipole windings in each quadrupole for equivalent shift of quadrupole axis in both transverse directions (tested at FFTB).

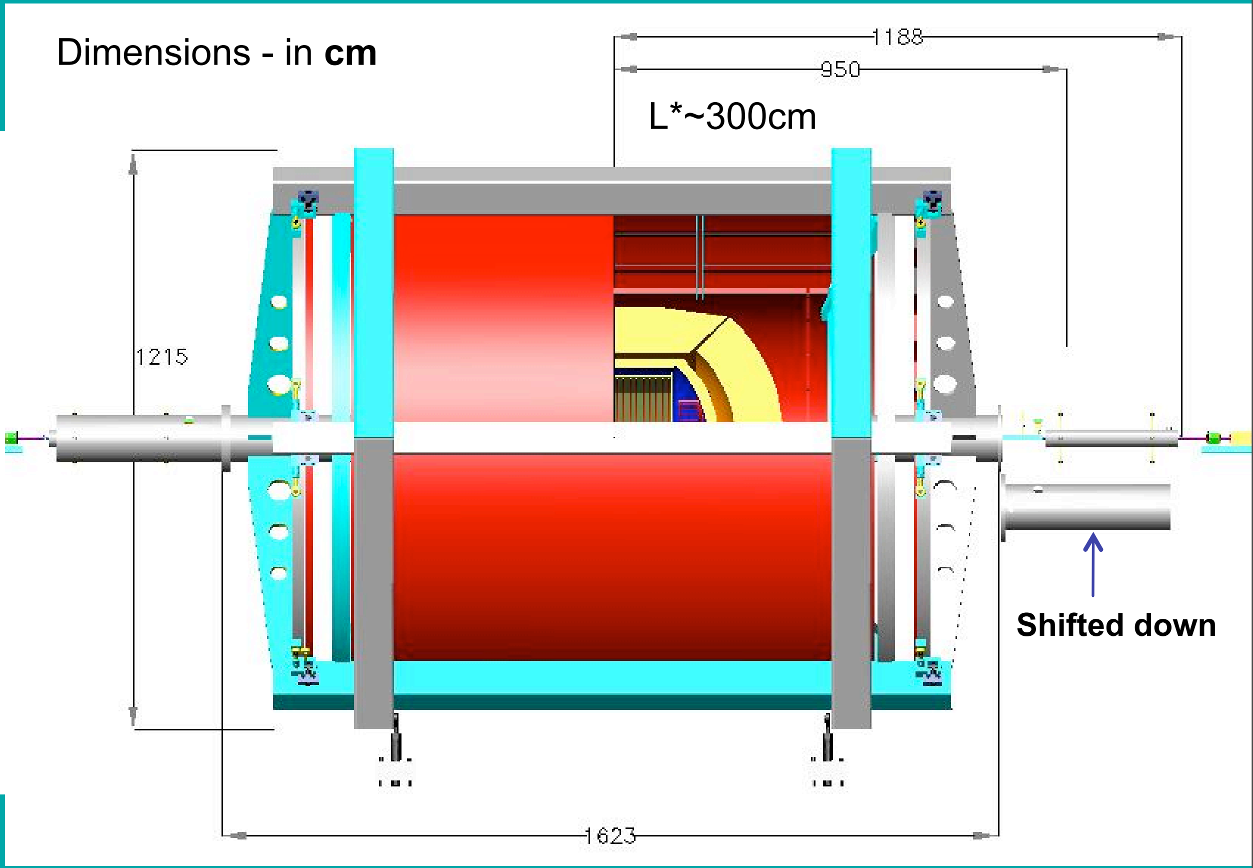
Attachment of cryostat with QF1 to the detector frame could be done after positioning detector in place

DETECTOR CARRIES FINAL FOCUS OPTICS. MORE DETAILED VIEW

Total stored energy~2.77 GJ

FF optics has trimming possibilities-mechanical and magnetic

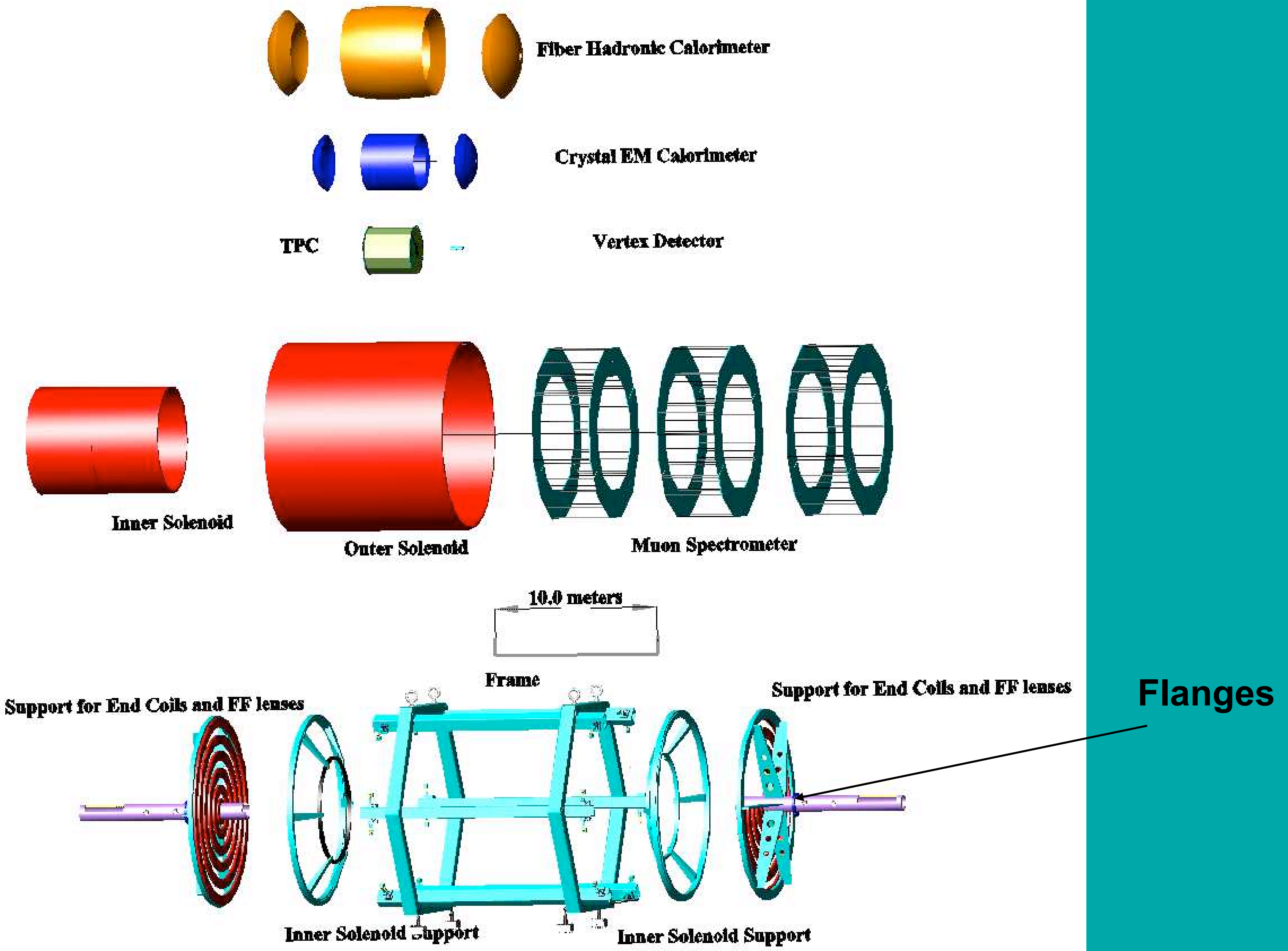




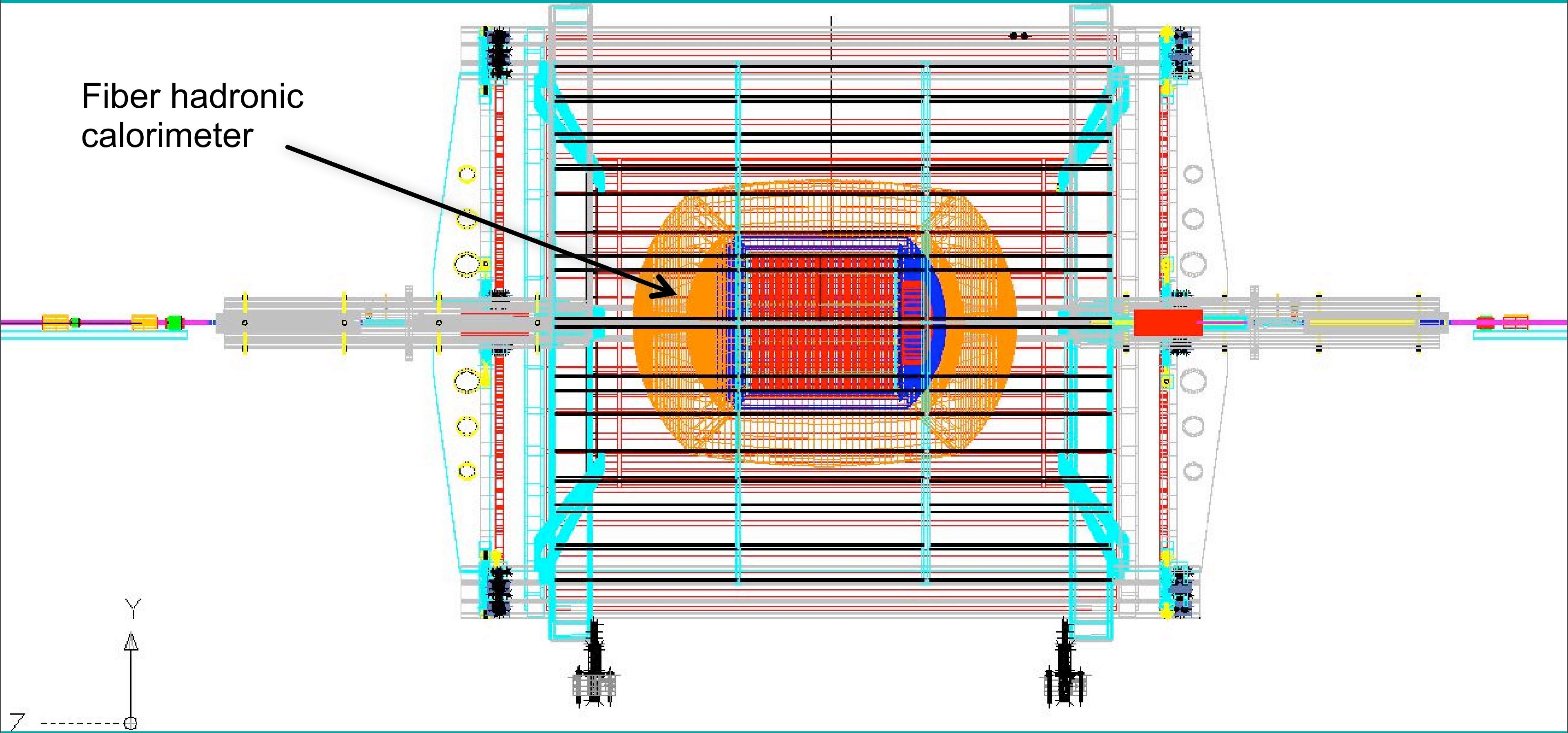
Thanks to the absence of iron all elements are visible from single point.

Total weight majorettes by 300 tons in optimistic estimation, so E/M ratio ~10kJ/kg

DETECTOR IS WELL STRUCTURED-MODULAR



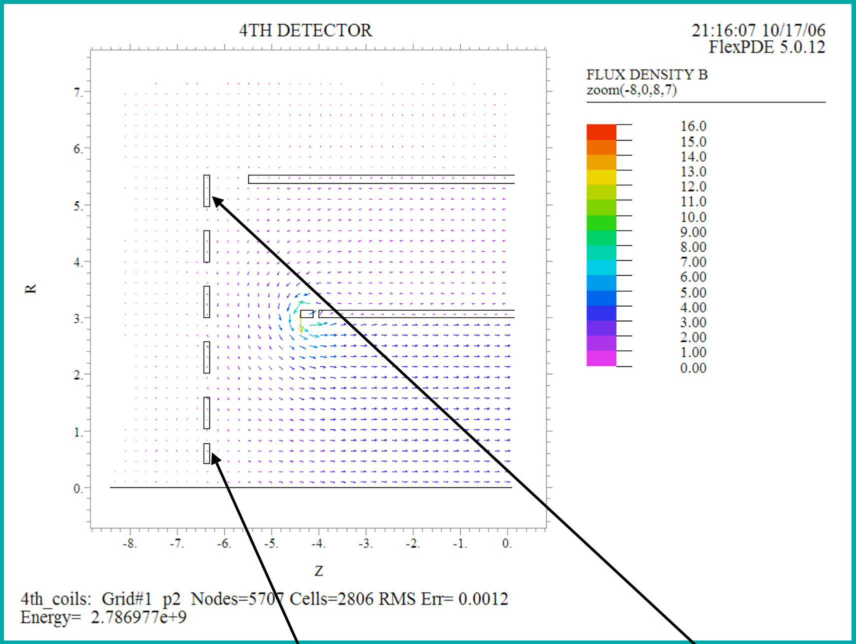
TRANSPARENT VIEW OVER DETECTOR

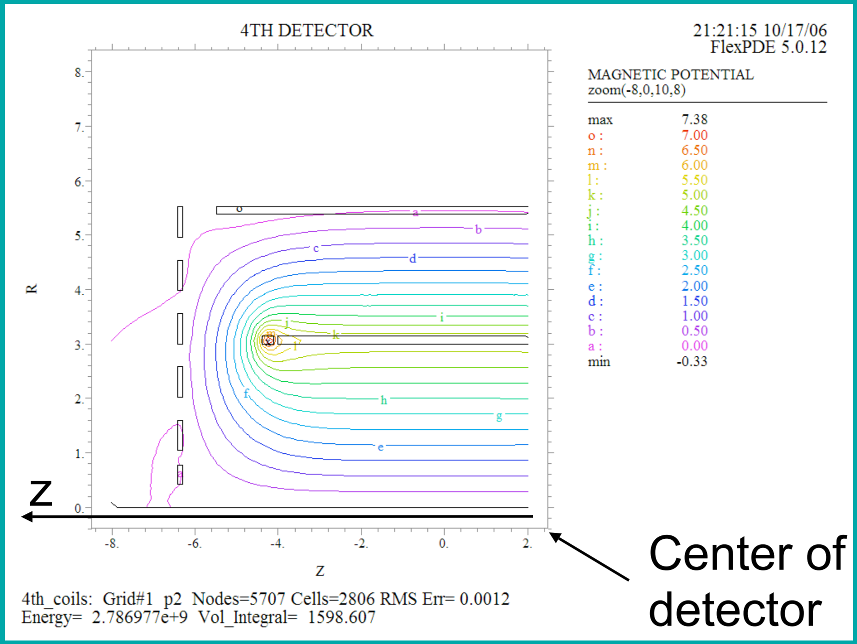


Detector Integrated Dipole (DID) could be easily implemented here

WALL OF COILS

Axis-symmetrical system of coils restricts propagation of field out of detector





All side coils are **room-temperature** ones; have ~same current density; water cooled

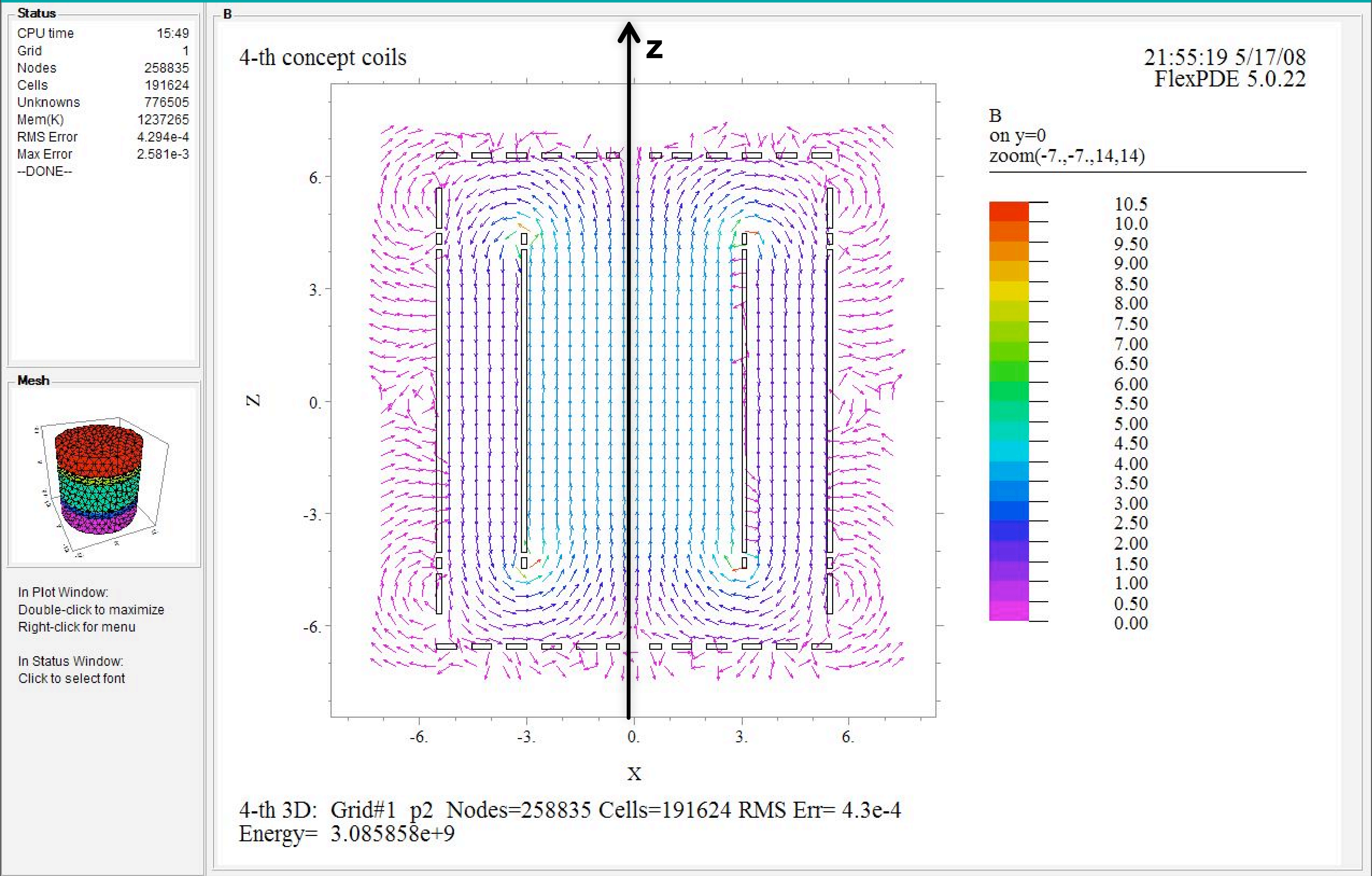
Current density: 1; 8; 4.2; 3.3; 3.7; 1.7 A/mm^2

Forces :1.75; 102; 131; 135; 111; 10 tons

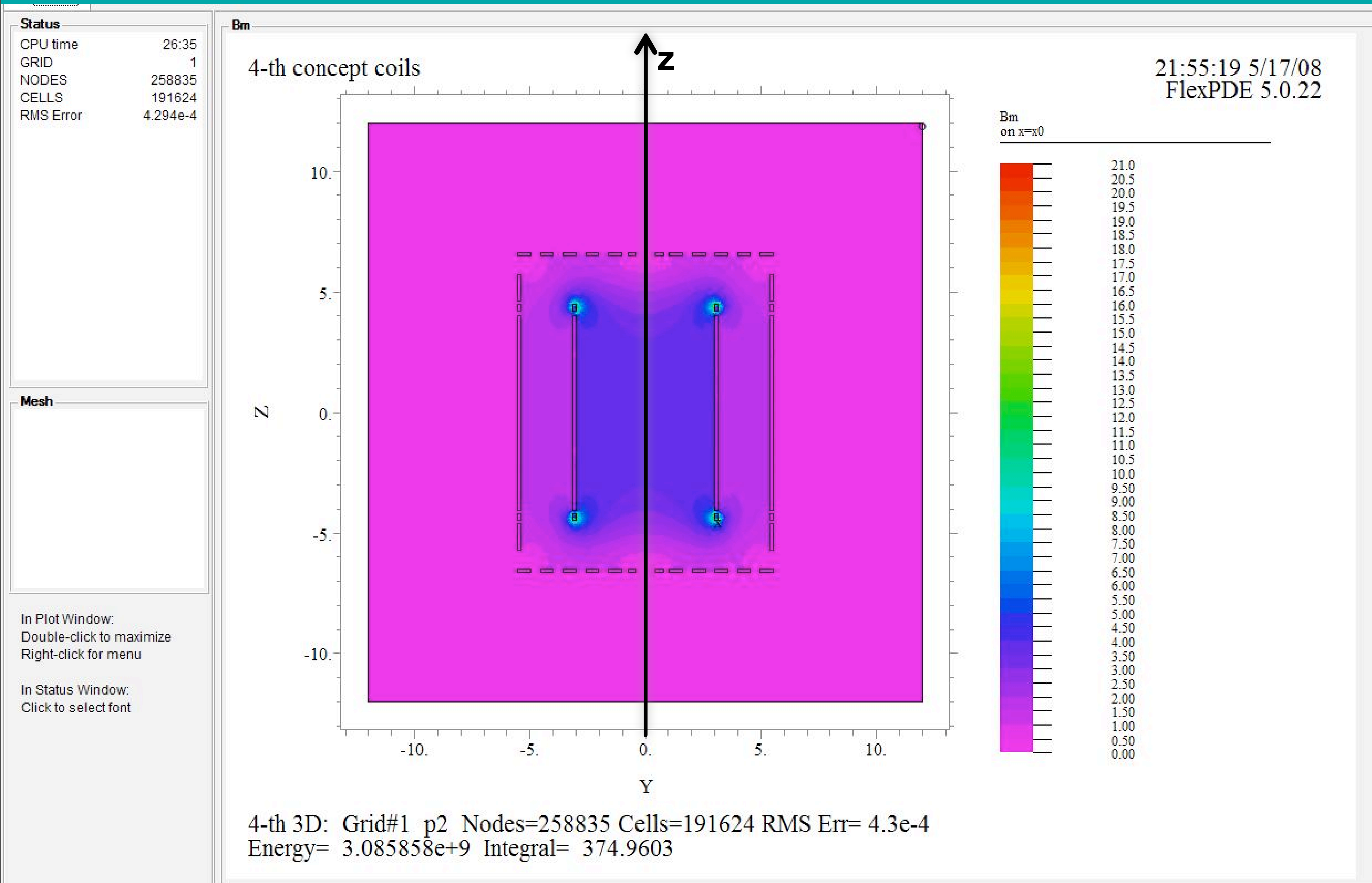
Field outside detector can be zeroed to any level by proper current distribution;
Coils can be fixed easily at the end plates

(Effective CMS Current density ~14.2 A/mm^2 (with stabilizer area). meanwhile typical practical current density in directly cooled SC wire is 1500A/mm^2 for 3.5 T field--- lot to think about)

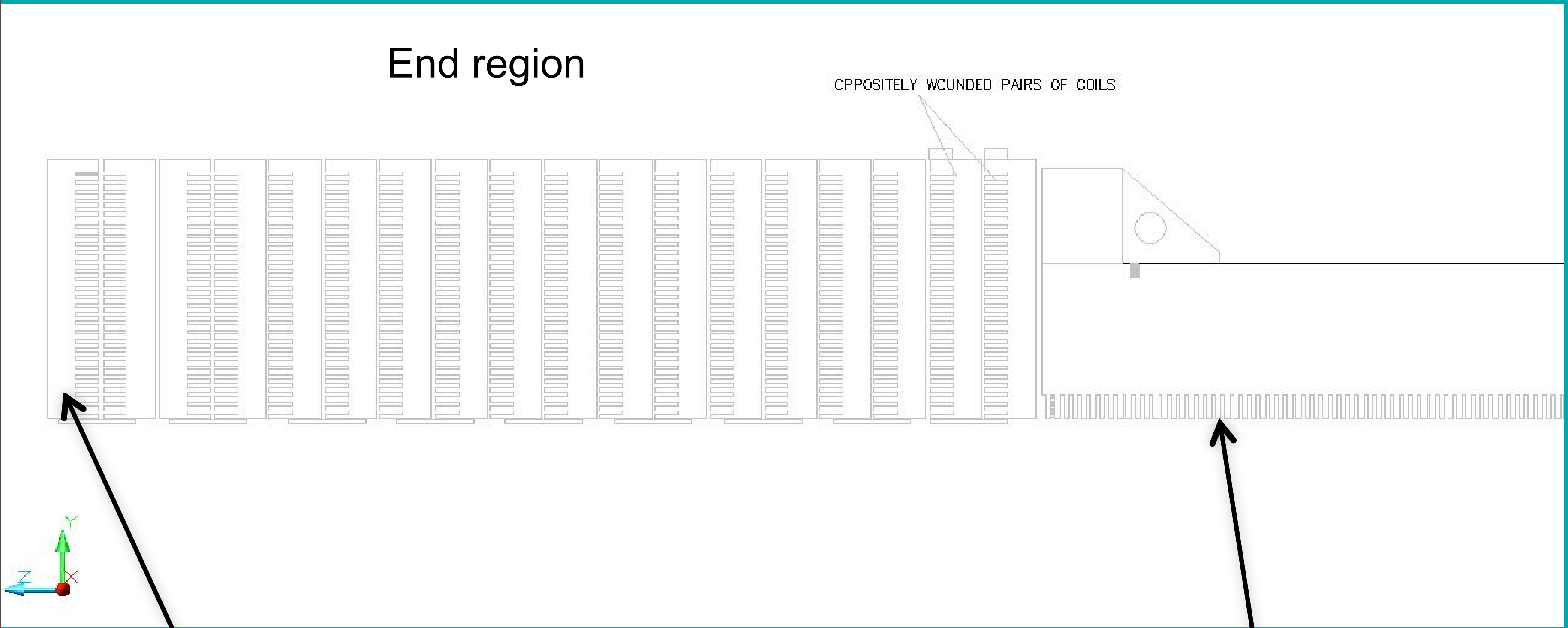
MAGNETIC FIELD VECTORS, 3D CALCULATION

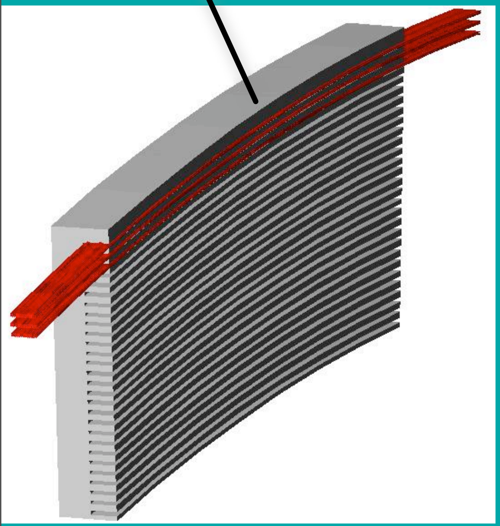


FIELD HOMOGENITY MAP



MAIN SC COIL SCHEMATICS



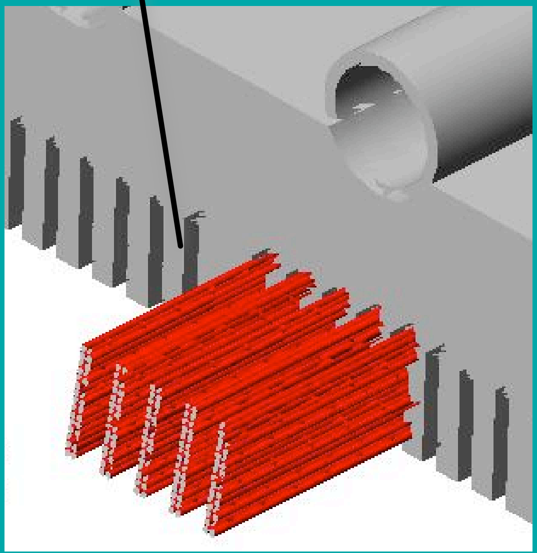


Used indirect cooling

SC cable embedded into grooves made in Al cylinders (discs)

Coil is sectioned

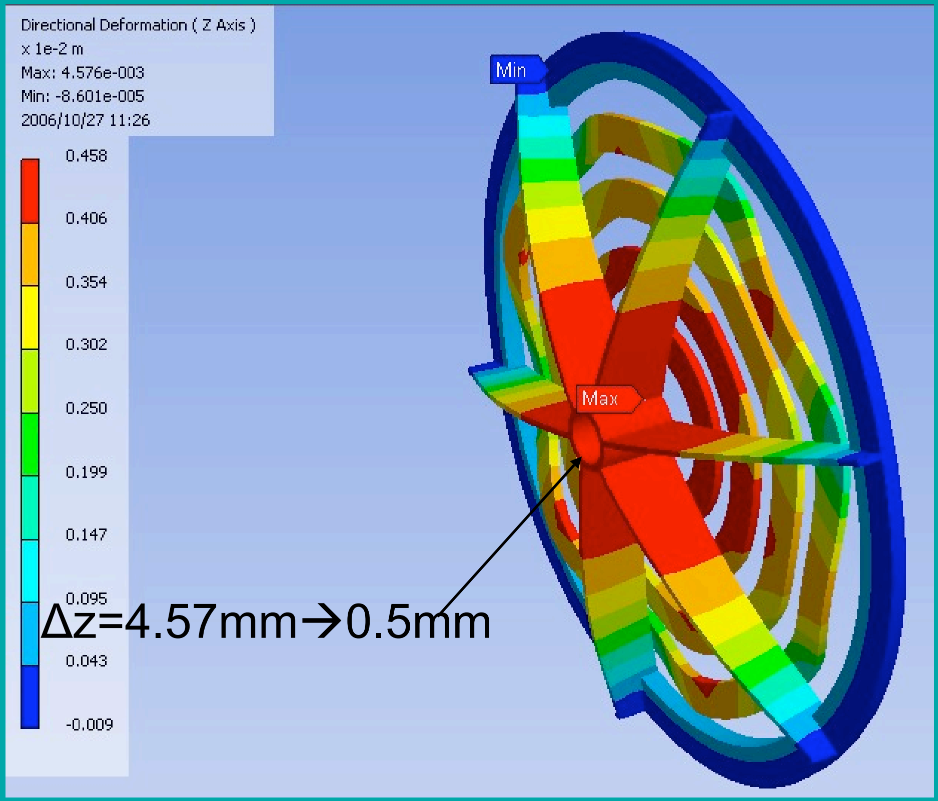
Cable 20x2 - Ø1mm NbTi wires

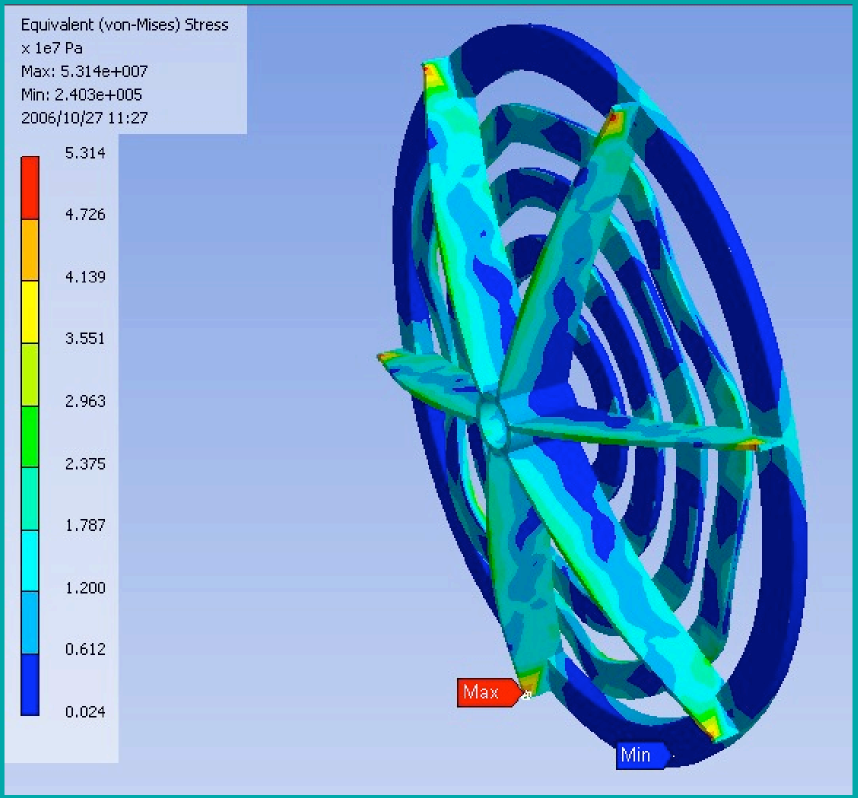


DEFORMATIONS OF END PLATES

Maximal deformation is in the middle of holder. It is below 5mm (V.Medjidzade, B.Wands).

Active movers of FF lenses will compensate this effect easily.

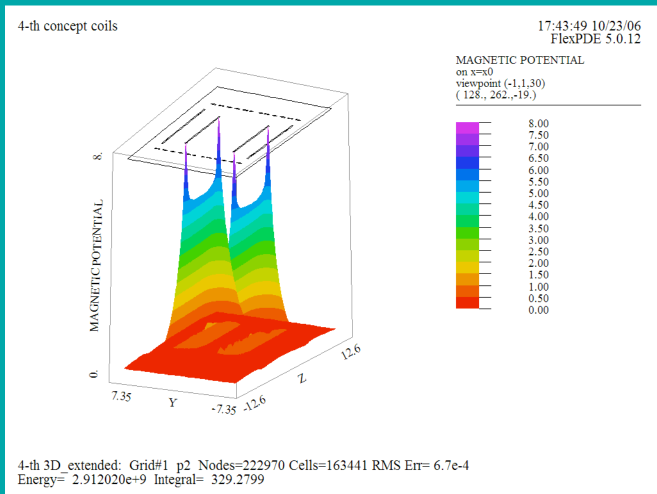




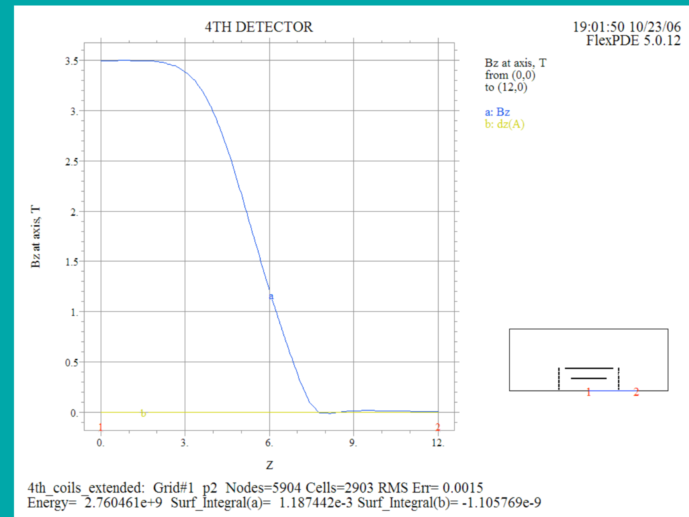
Deformation of FF holder is in z-direction. Reinforcement can be done as well.

LATEST OPTIMIZATIONS REDUCED THIS DEFORMATION ~TEN TIMES

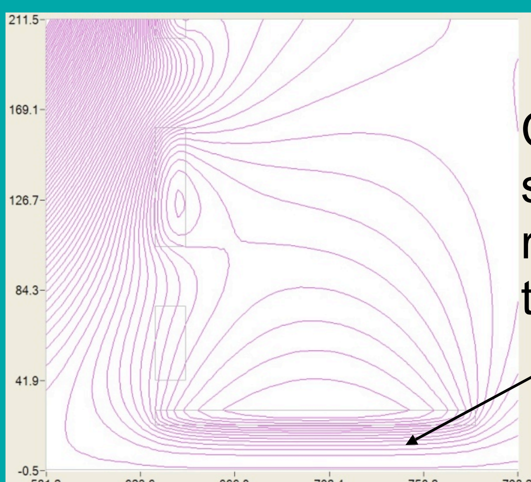
For homogeneity a Helmholtz-type system with increased current at the ends used here.



Magnetic potential

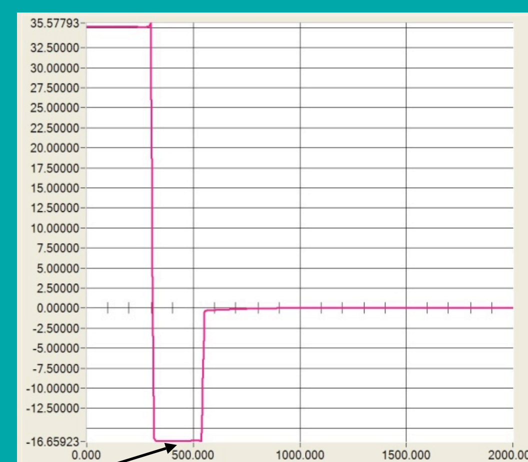


Stored energy is ~2.77GJ for 3.5T axial field



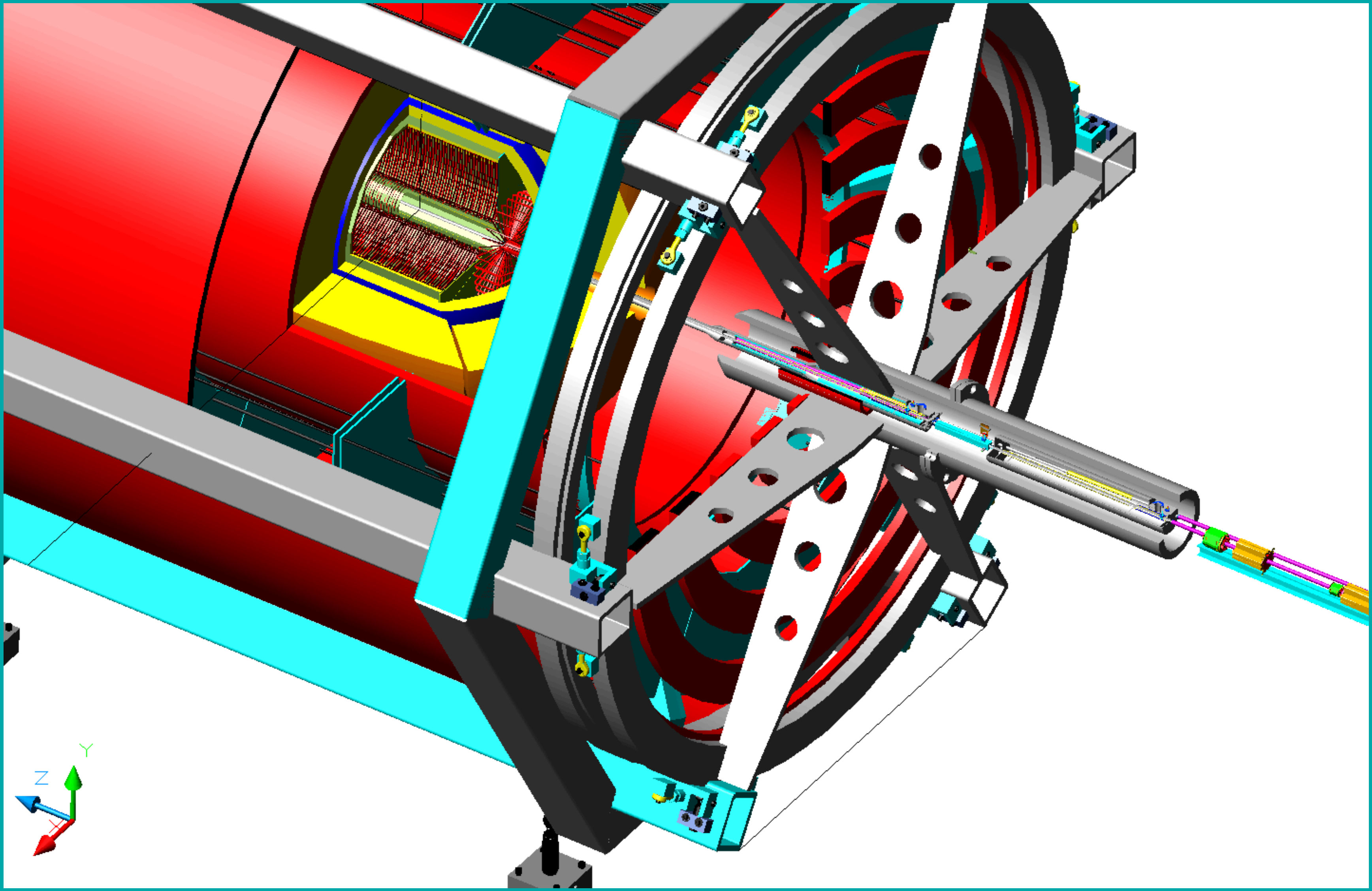
Compensational solenoid deals with residual part of transverse kick

Field used for spectrometry of muons



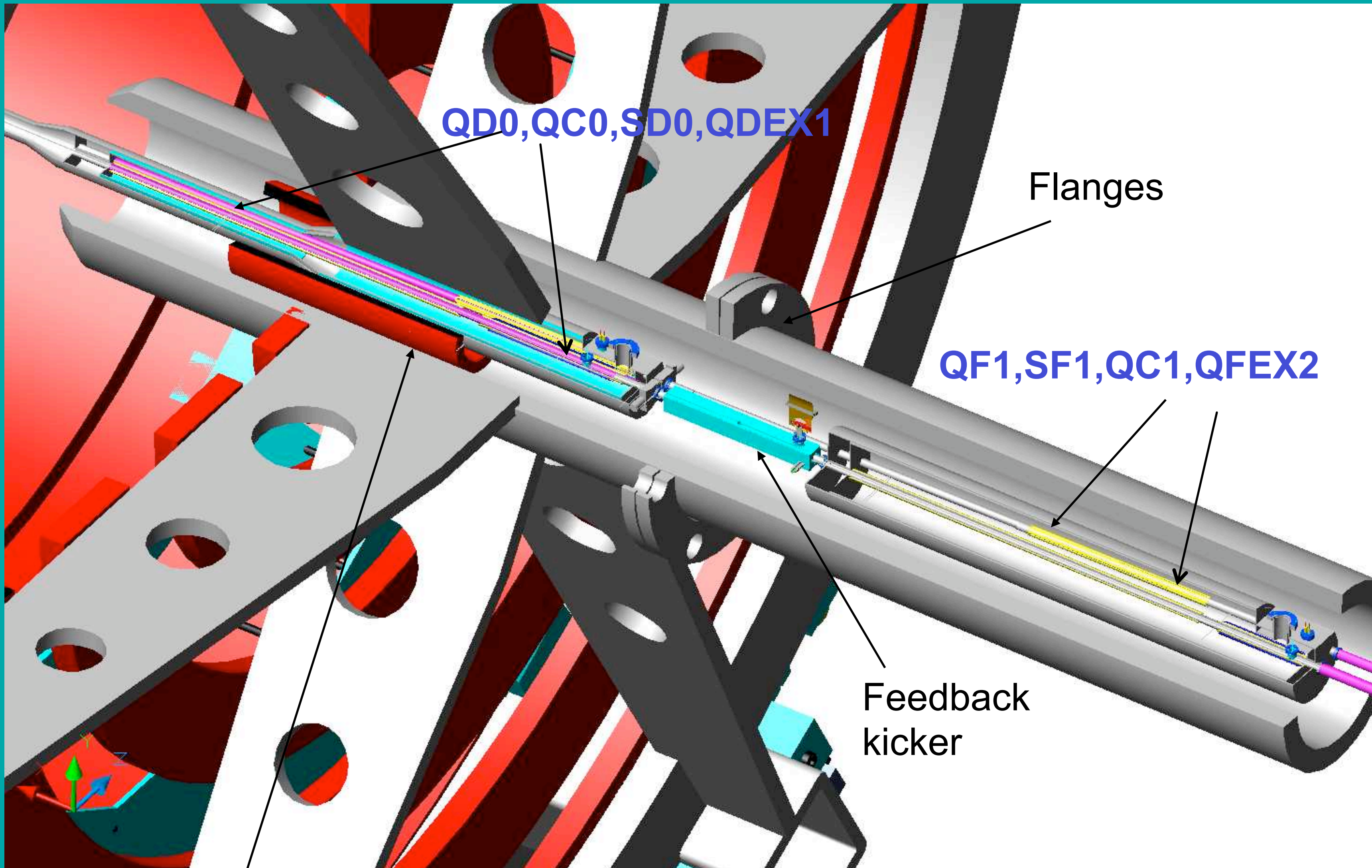
Field across detector

14 mrad CROSSING ANGLE (BASELINE)

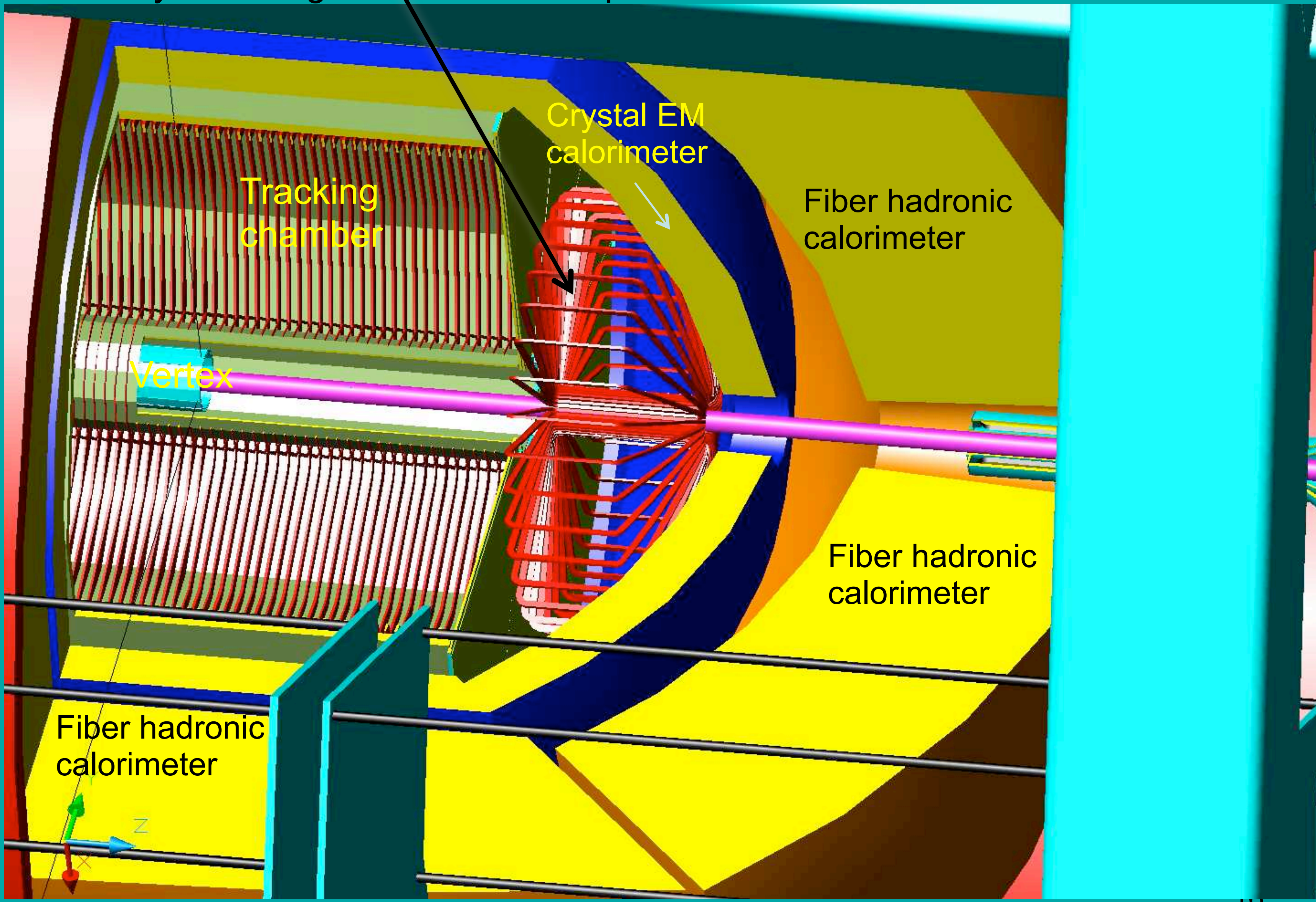


Open space allows easy modifications for gamma-gamma option

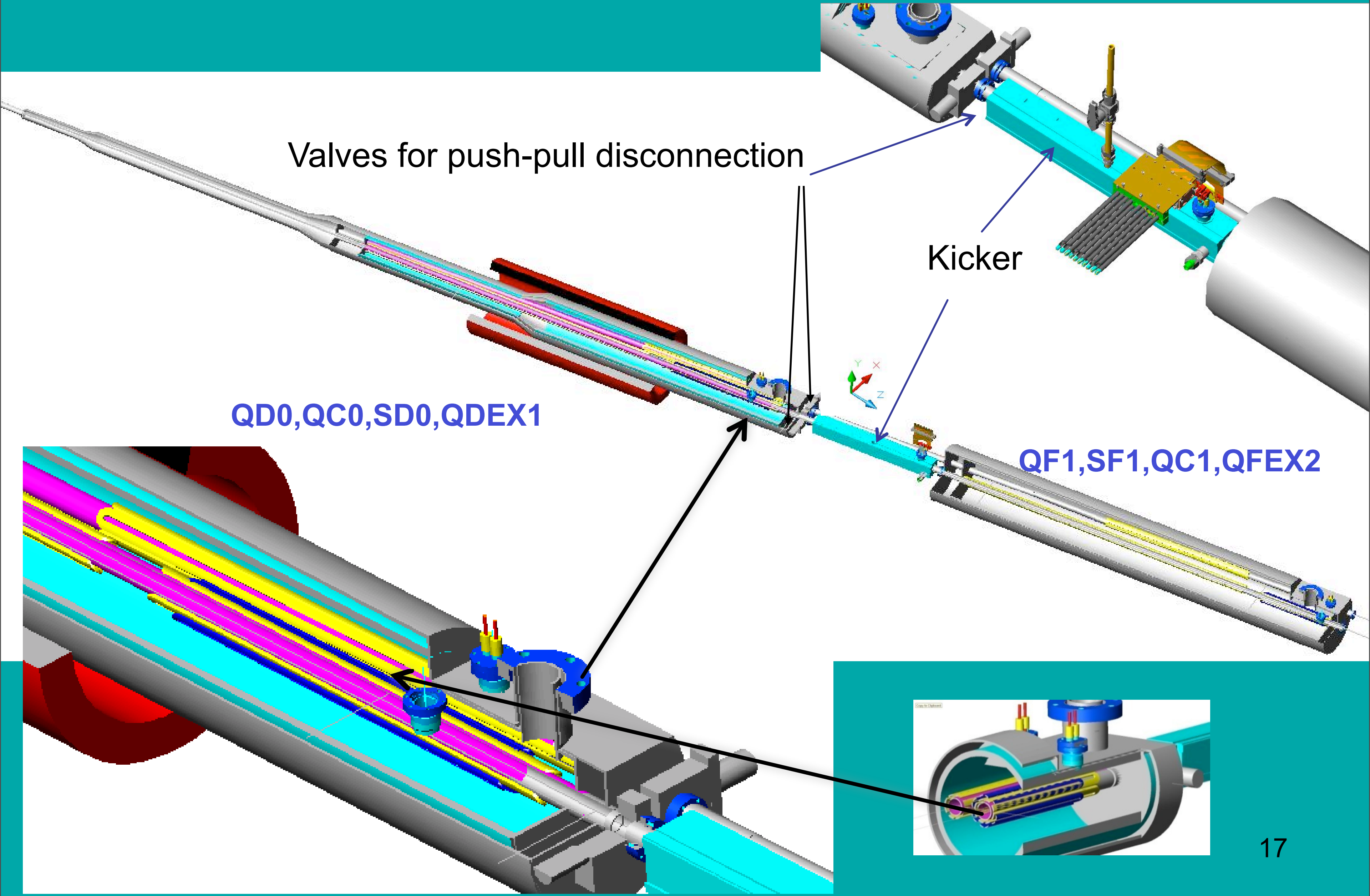
14 mrad crossing angle optics fragment



Recent addition – toroid between TPC and calorimeter for increase of momentum resolution for particles with small angle. TPC will come to r=20cm radially and extend to z=1.7m axially including the readout end plates.



FINAL DOUBLET (IN/OUT), SEXTUPOLES

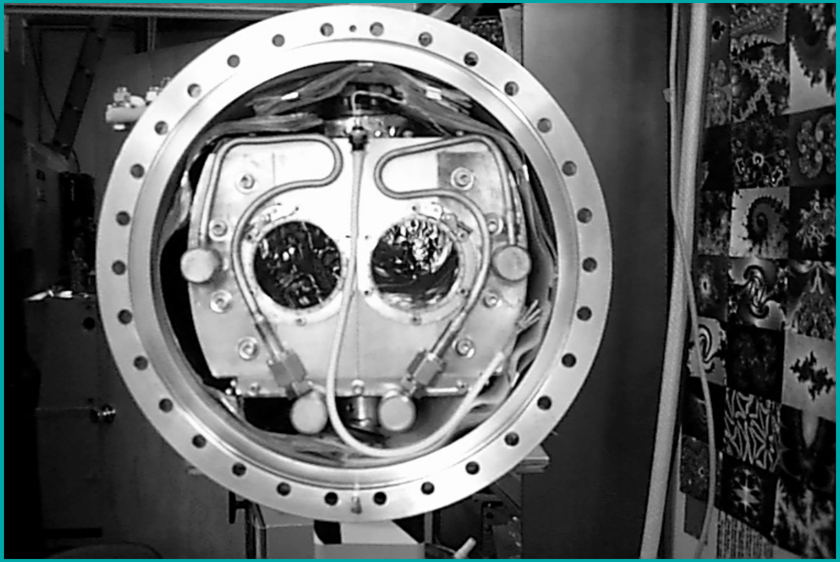


Active systems move the lenses centroids in transverse plane using dipole windings in lenses +mechanical movers

Windings for generation of Skew-quadrupole fields

Cancellation of influence of deformations induced by ponderomotive forces

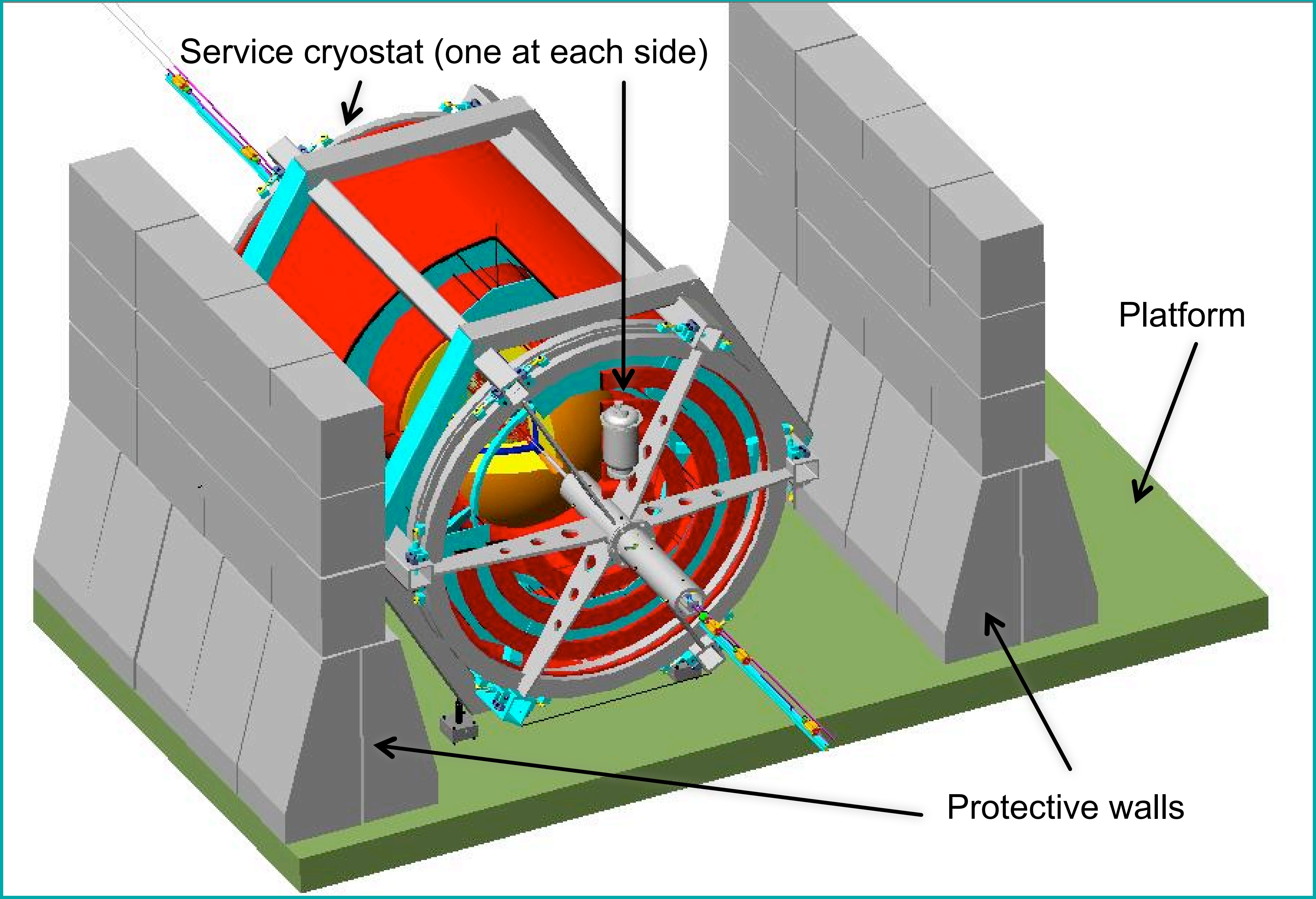
Cancellation of influence of ground motion



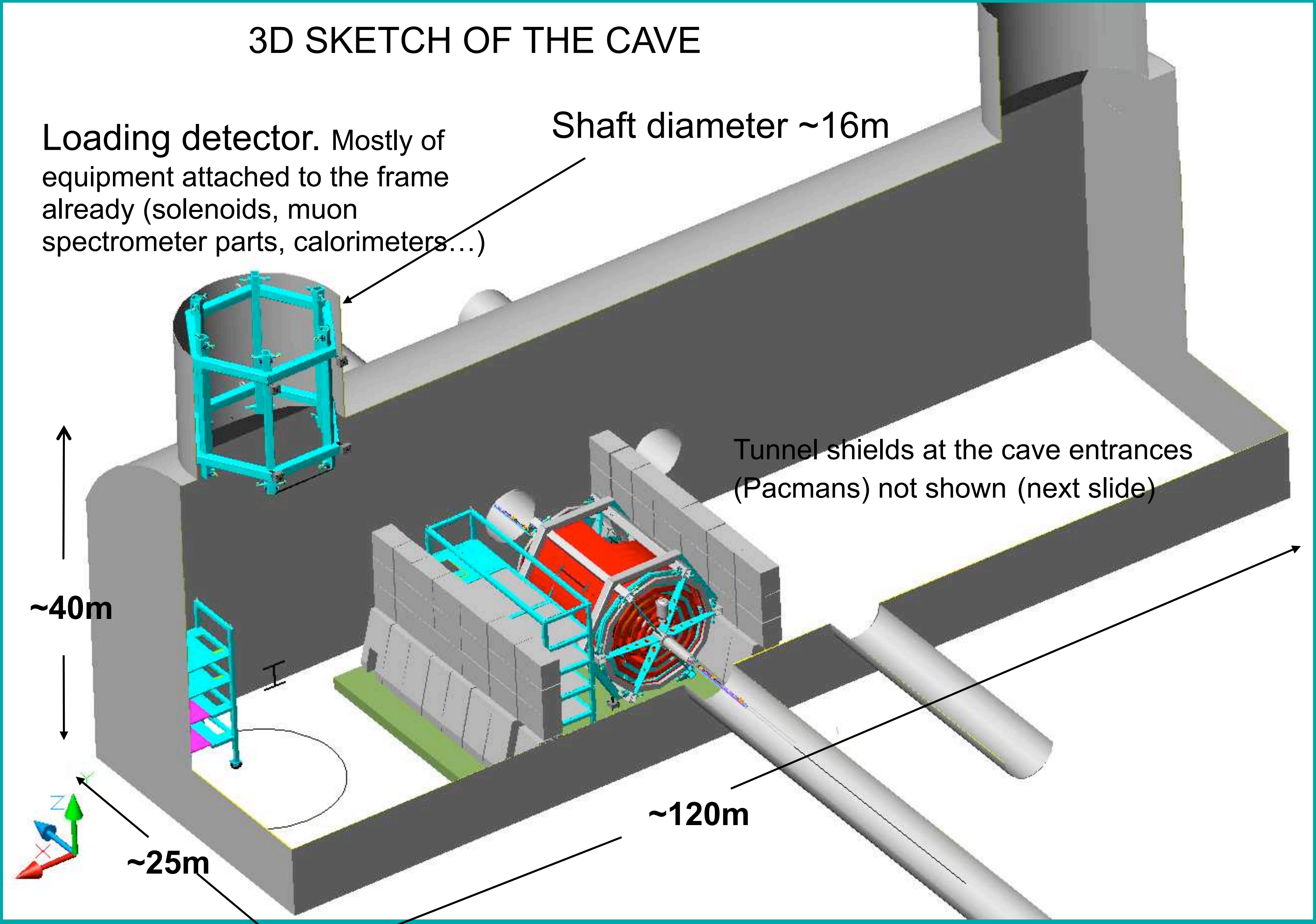
Dual bore SC quadrupole developed and tested at Cornell as an example.
Distance between room temperature walls ~25mm
Septum between SC apertures~5 mm

In addition to standard optics we are considering the adiabatic final focusing (**multiplet** of lenses, rather than a doublet) with local compensation of chromaticity and residual dispersion at IP for reduction of the length of Beam Delivery System

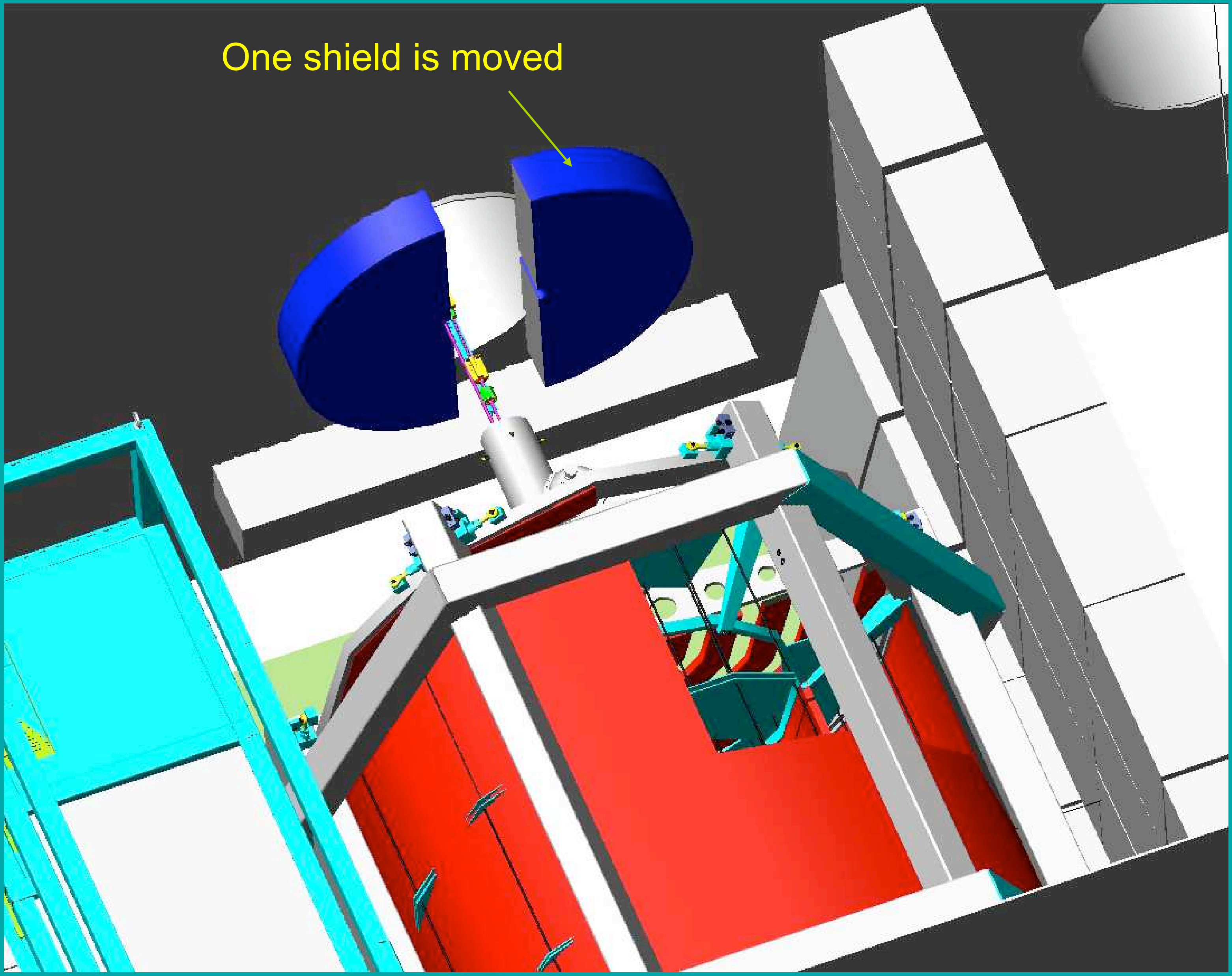
INSTALLATION ON A PLATFORM



3D SKETCH OF THE CAVE

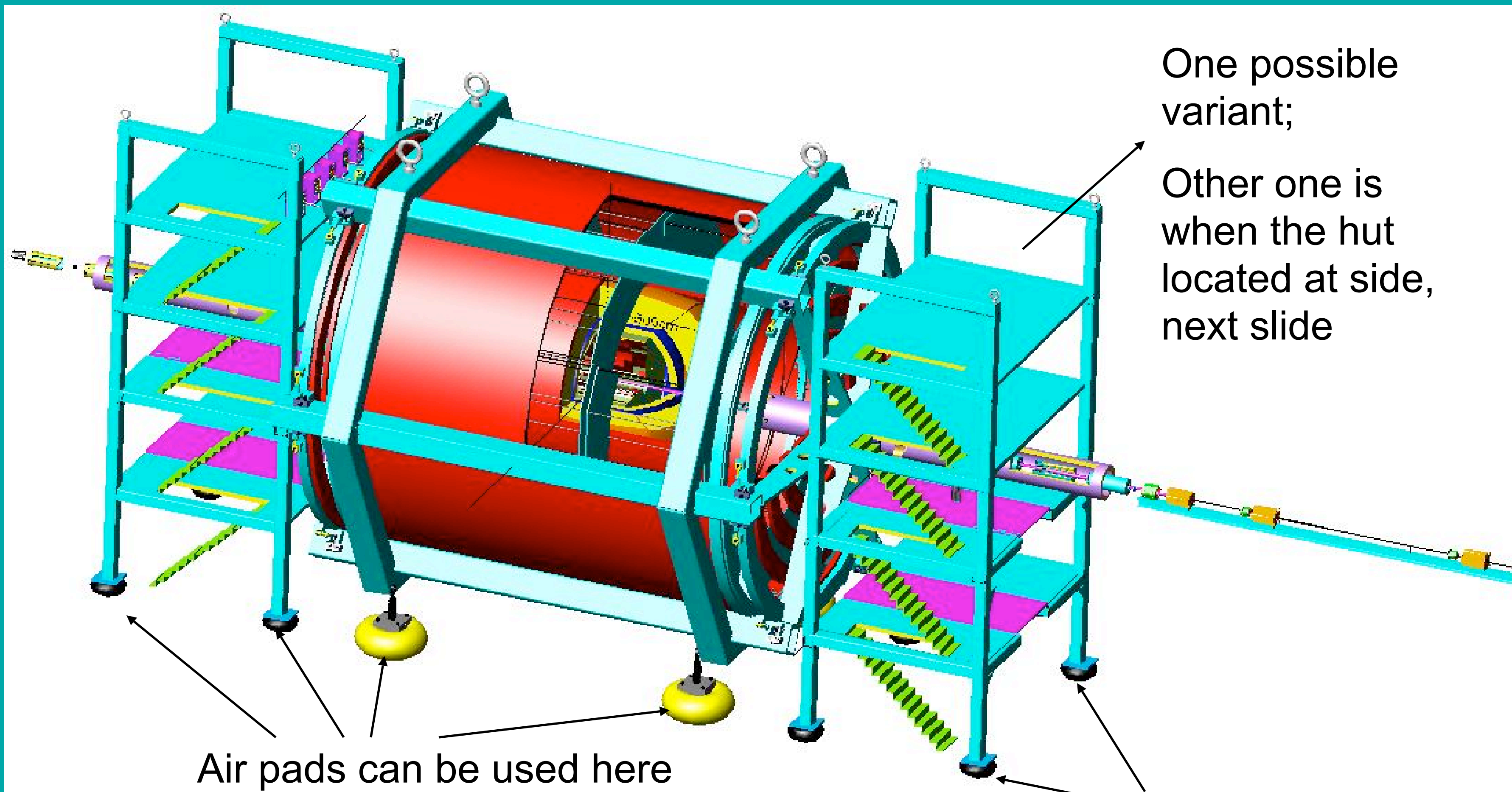


Cryogenic system must allow simultaneous operation of two detectors



No interference with detector

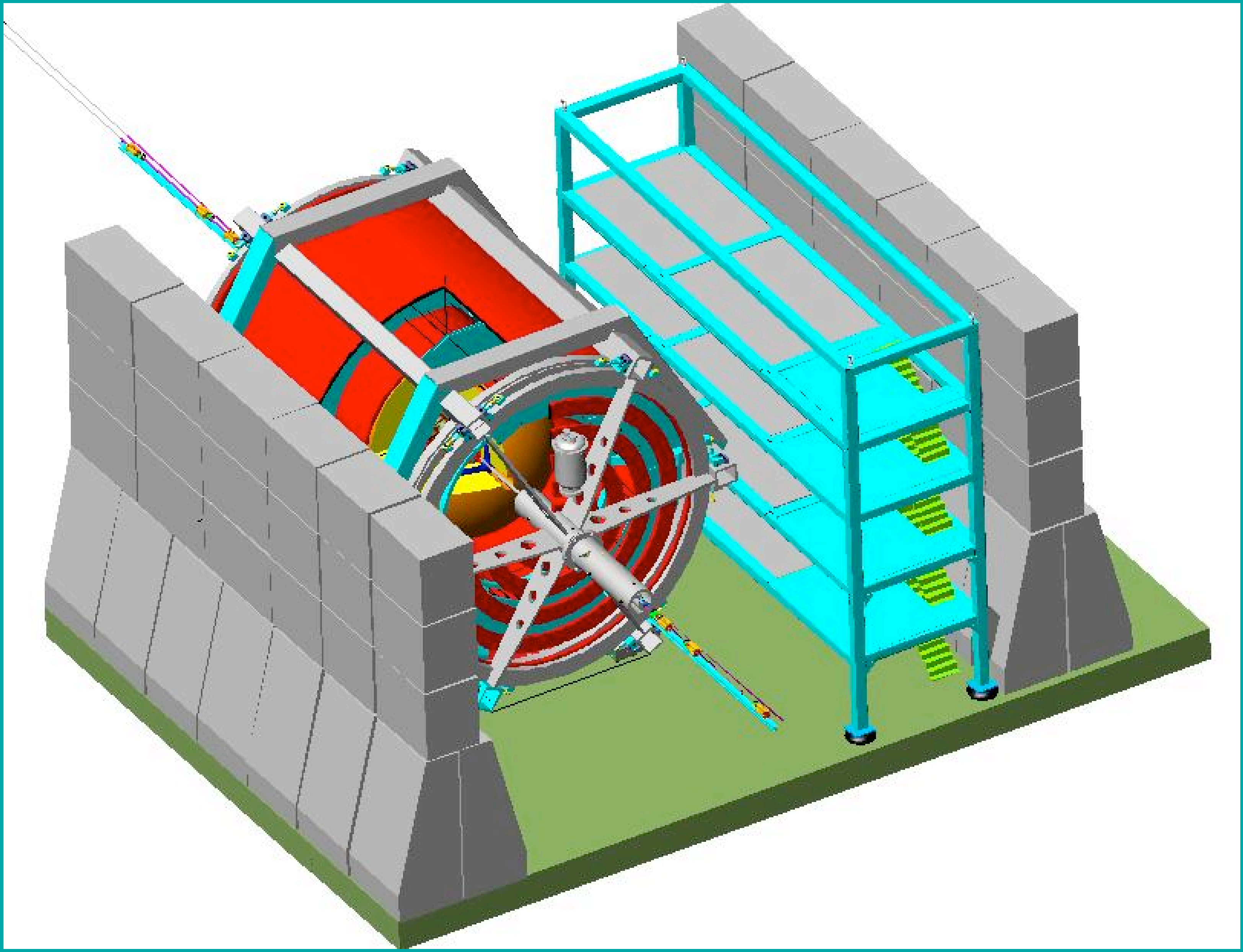
Detector front-end electronics might be installed on the separately standing consoles (huts) In line with detector



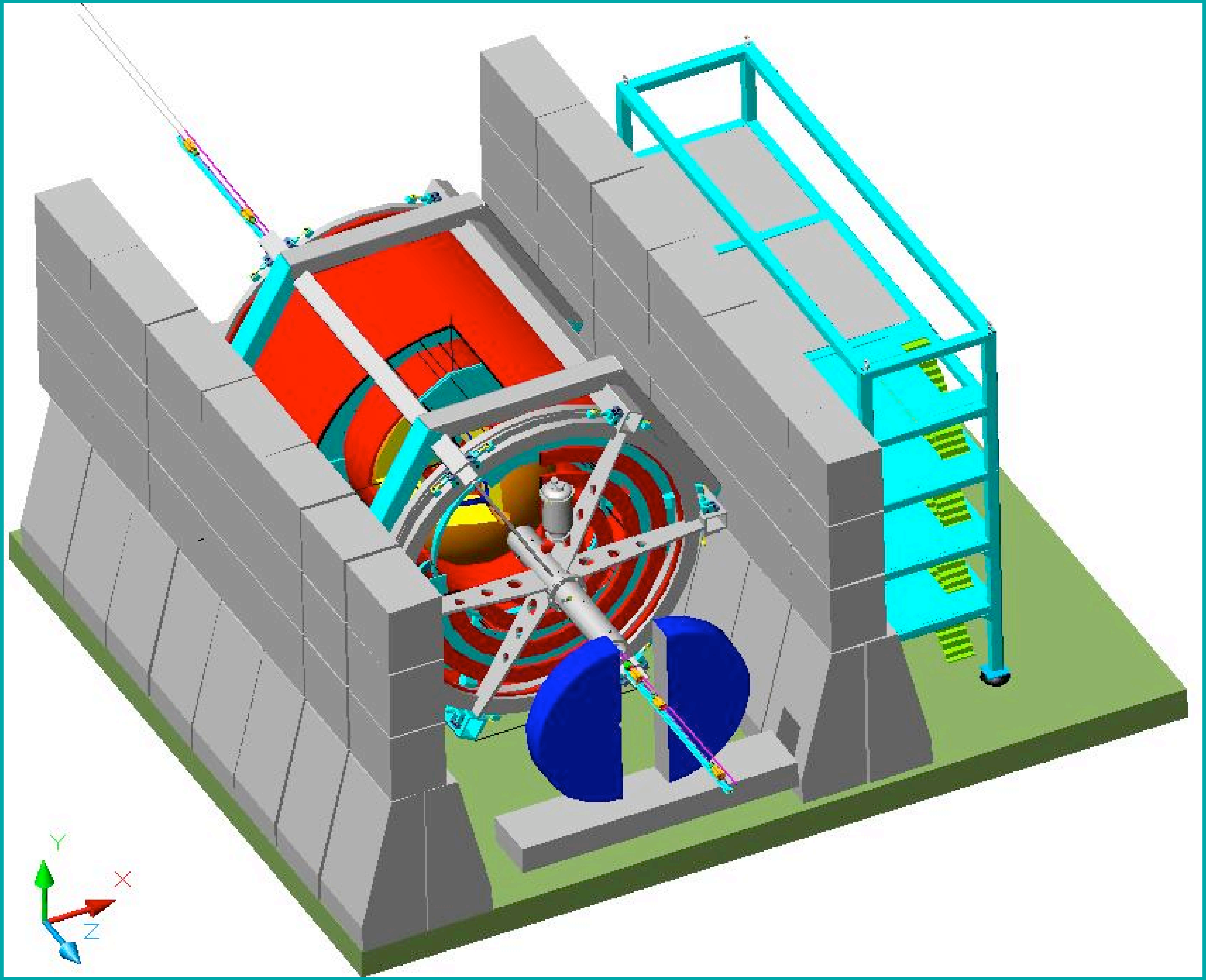
Console (hut) has anti-vibration footers.

During movement some restraints could be applied

Hut for electronics could be installed aside of detector close to it or…



The hut could be installed behind the wall also



4-th concept detector can easy accommodate any beam optics,

It can be easily installed in cave as **it has no heavy Iron;**

All MDI questions answered

4th-concept allows easy motion into cave for push-pull operation;

Elements of FF optics mounted on detector frame allow better protection against ground motion;

Field can be made homogeneous to satisfy tracking requirements and measured accurately as, again, there is no interference from Iron (10^{-4});

Easy upgrade for gamma-gamma if necessary

A few topics for further work ...

Different energy of colliding beams. It is natural to keep such possibility for ILC. Here all background products generated off-center in contrast with asymmetric B-factory.

ILC accelerating structure is a standing wave type; it allows acceleration in *both* directions. One can consider the possibility to work at *double energy with a stationary target*. For this action, the beam accelerated in the first linac is redirected through IP into another one. The phasing could be arranged; the optics needs to be tuned.

Zero crossing angle. Nonzero angle initiated by NLC/JLC type machines. Crossing angle vas not required for TESLA, VLEPP. Zero angles give advantages in optics, preventing from SR in magnetic field of detector and degradation of luminosity. So we think, that this option must be kept in detector design as alternative.

Monochromatization –the ability to arrange collision at IP in such a way, that low energy particles from the first beam collide with the higher energy ones in the opposing beam. This idea was considered for circular machines a long time ago. For a single pass system, as the ILC is, realization of such program becomes much easier procedure. Despite significant SR energy spread generated during collision, this might be important for measurements at narrow resonances, including low energy option (Giga-Z).

Work with nonzero dispersion at IP. This might be useful for monochromatization and to simplify the FF optics.

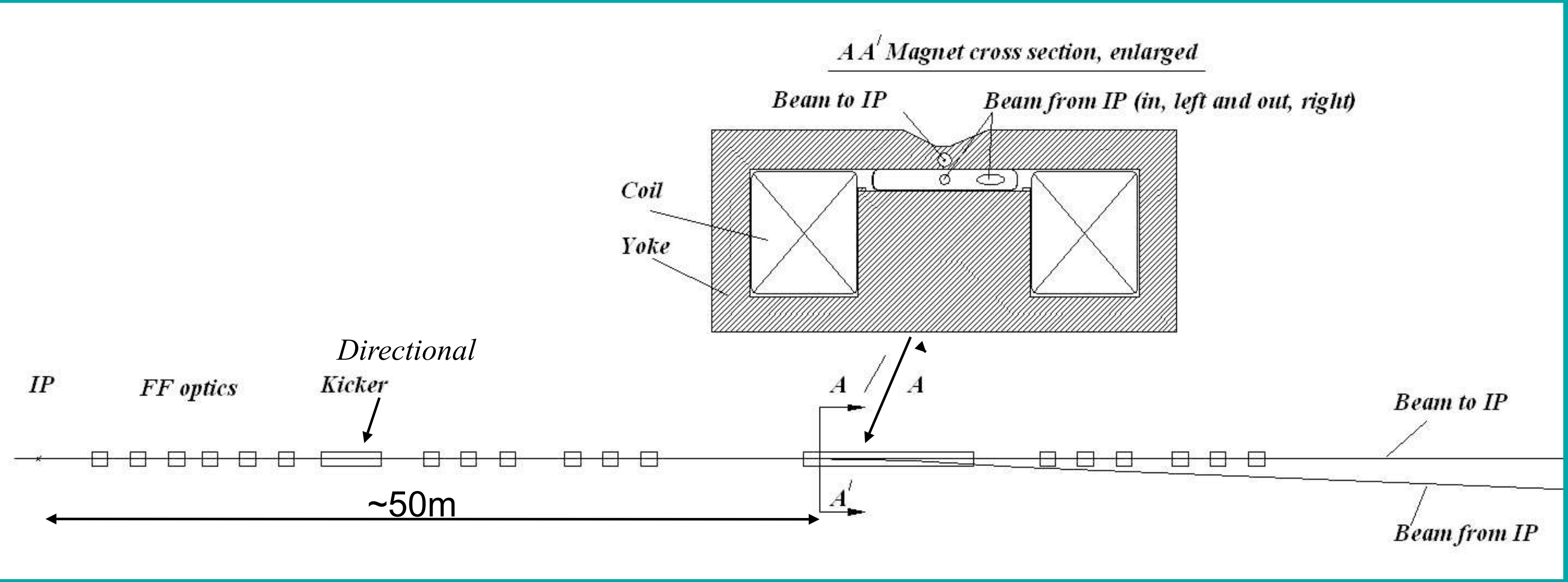
Adiabatic focusing at IP. Focusing arranged with *multiplet* of quadrupoles, rather than a doublet so that the strength of the lenses changes slowly from lens to lens.

Peculiarity for registering of collisions with *both polarized beams*. Registration of back-forward asymmetries of secondary products is the main task for operation with polarized particles. This question requires special attention. 4-th magnet allows easy swap polarity.

ALTERNATIVE HEAD ON COLLISION SCHEME

Directional kicker used for separation of beams
Kicker is **TEM** type**,** kicked by electrical **and** magnetic fields;
So the kicker hits the **counter-propagating beam** only

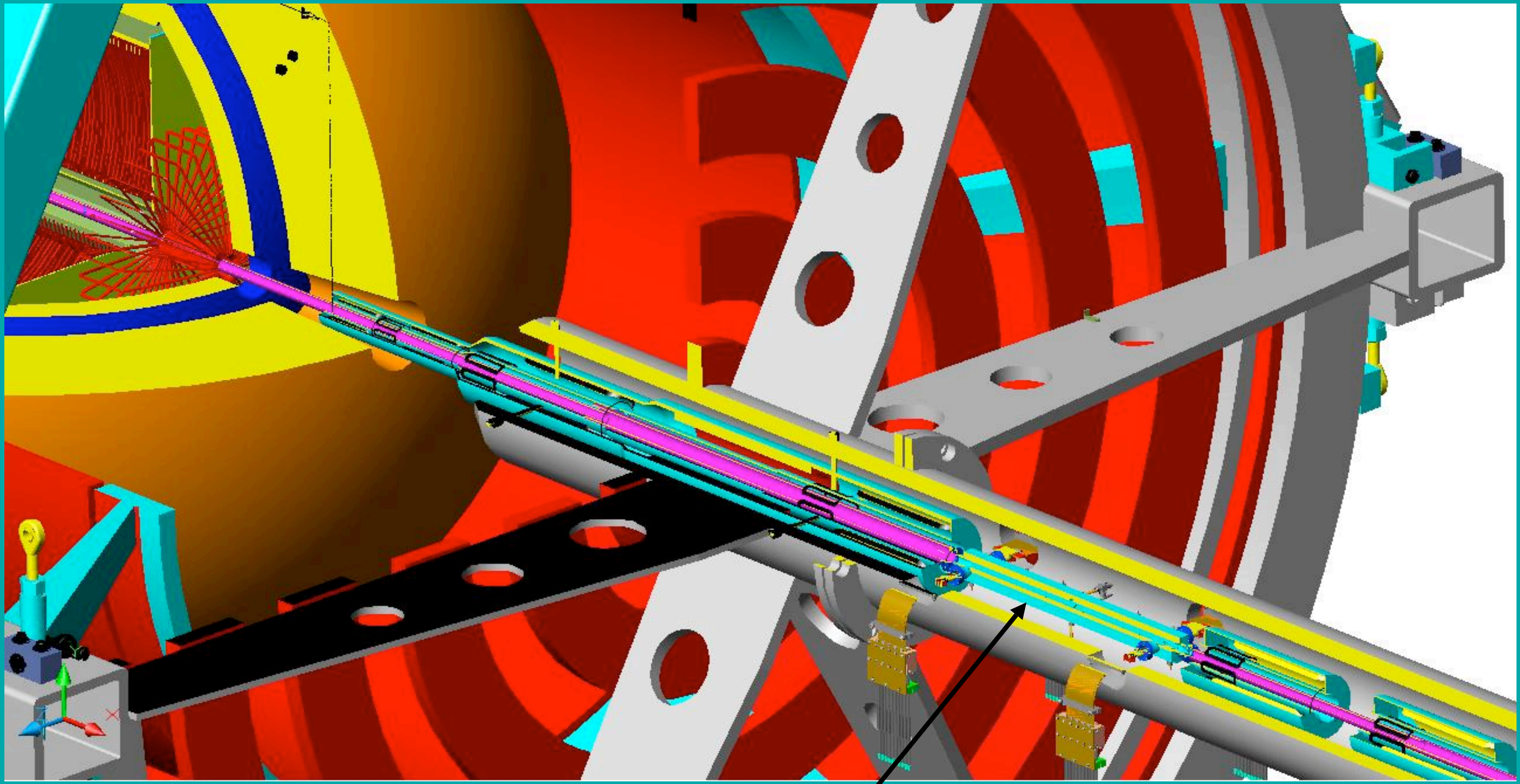
Magnetic field between wide current sheets does not depend on distance between them
This opens a possibility for relatively long pulse, ~1msec scale



Zero crossing angle scheme, top view. Kicker operates in vertical direction (out from the view to the plane of Figure). Distance between kicker and the Lambertson/ Picconi magnet ~40m. Scaled cross section of this magnet is represented in upper part of Figure.

This promises drastic reduction of BDS length (down ~ten times)

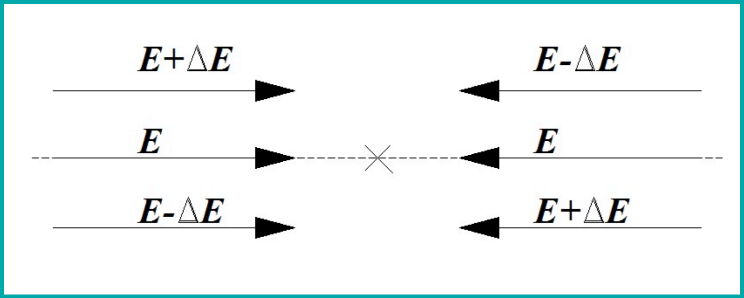
OPTICS WITH ZERO CROSSING ANGLE

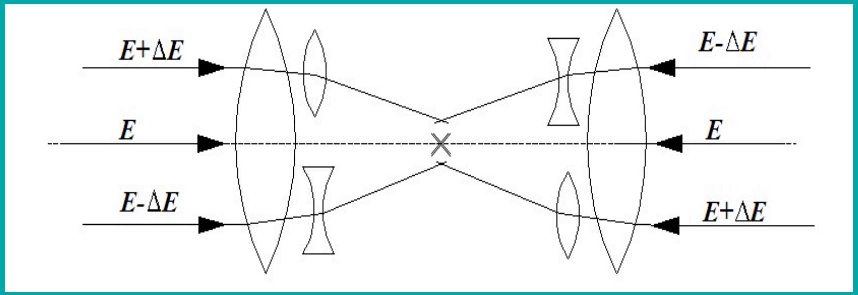


Directional kicker with TEM wave

Head on collision scheme if accepted, delivers undoubted benefits for HEP and for the beam optics.

Monochromatization (–working with 14 mrad also)



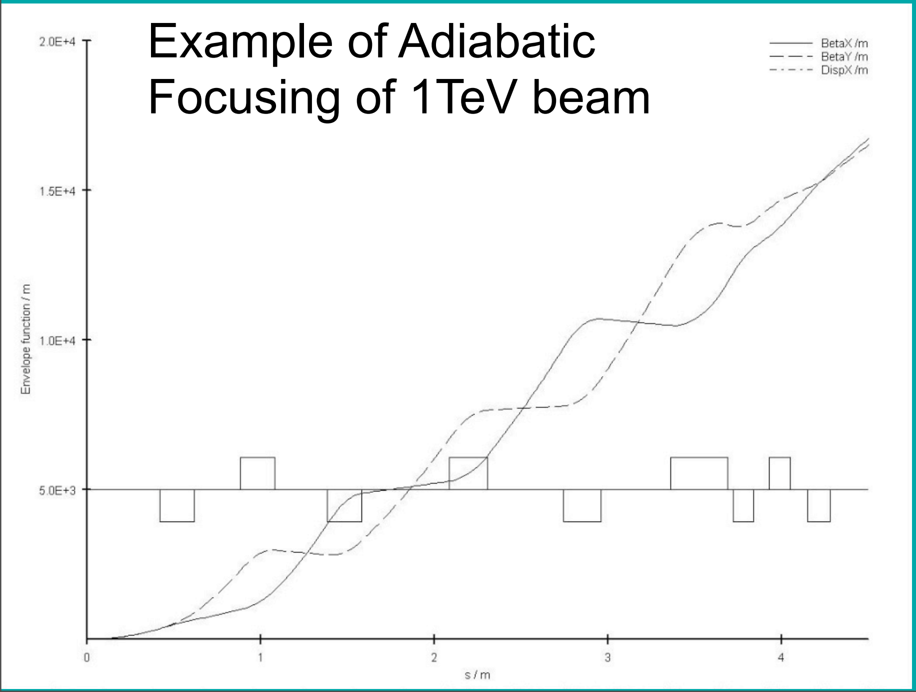


Residual chromaticity at IP is a positive factor for monochromatization

Adiabatic focusing (–working with 14 mrad also)

Strength of the lenses deceasing from the strongest -near IP to the weakest

Local compensation of chromaticity and residual dispersion at IP for wider energy acceptance



Envelope function behavior for the multiplet of lenses around IP. IP supposed to be at *s*=0, left point at abscise axis. Beta-functions for x and y directions at IP in this example is chosen equal the same with values 0.05cm.

Chromaticity $\cong -\frac{1}{4\pi(HR)}\int G(s)\beta(s)ds$

gradient $G(s)$ varies, β *~const,* so the chromaticity could be lowered significantly by neighboring lens

CONCLUSIONS

4th-concept allows easy installation into cave as **it has no heavy Iron;**

Elements of FF optics mounted on detector frame allowing better protection against ground motion;

Field can be made homogeneous to satisfy tracking requirements and measured accurately as there is no interference (or movement) from Iron (10^{-4});

Measures against vibrations force to locate front end electronics in a separate hut installed on vibration-isolative footers;

Modular concept of 4-th detector allows easy exchange of different equipment, such as TPC, vertex detector, sections of calorimeter, gamma-gamma collisions etc.;

Detector could be manufactured at low cost;

Detector can be reassembled quickly to take benefits from different energy of colliding e^+e^- beams;

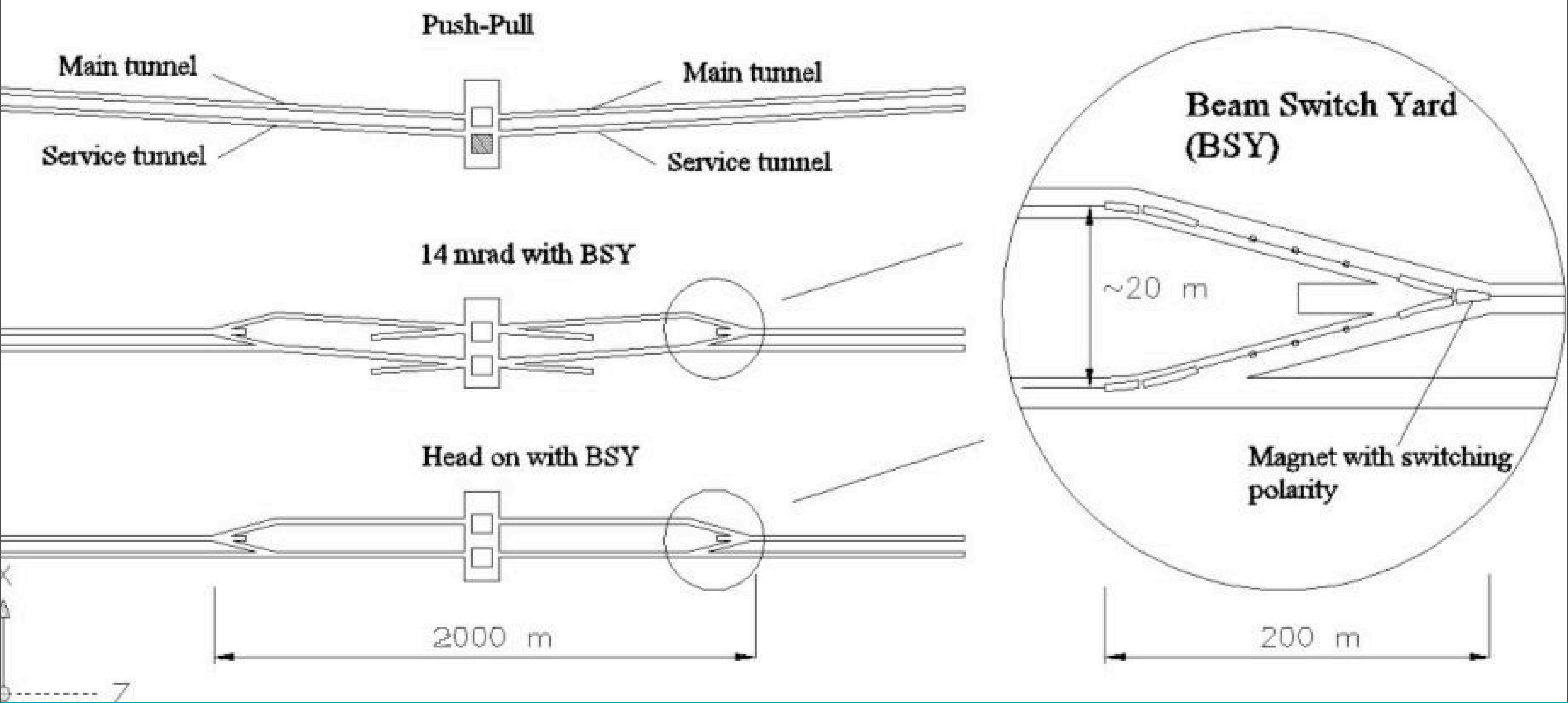
Detector allows relatively quick flip of magnetic field orientation for calibration of asymmetry; this is beneficial for collisions with polarized beams.

4th concept easily accommodates 14 mrad optics as well as zero crossing angle.

Further work required for possible reduction of the BDS length (and cost). Maybe two detector scheme with beam switch yard will emerge as an option in the future.

Backup slides

4-TH FITS INTO ANY SCENARIO OF FF ARRANGEMENTS



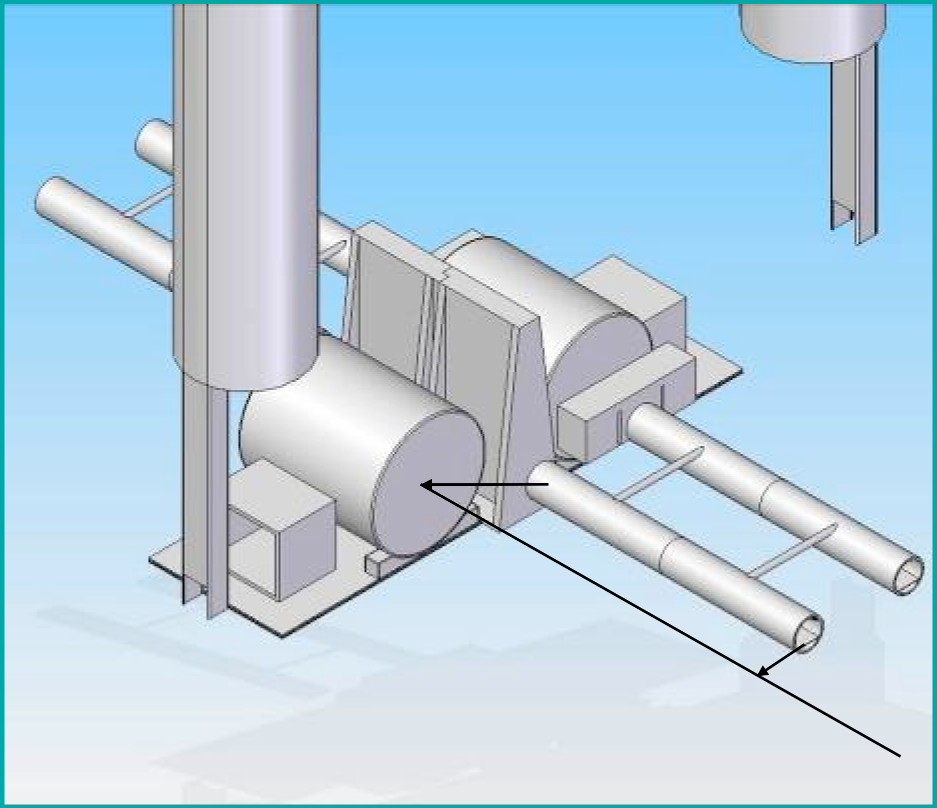
Scenario with Beam Switch Yard allows independent operation of detectors

Cost of additional optics is comparable with all push-pull complications

FF lenses are mostly expensive and every detector has these lenses already

4th CD can be easily fit into this scenario

One recommendation…



The service tunnel must be shifted so its axis runs through the center of second detector even the only one detector will be in operation at the beginning.