MDI working meeting 9 – 20 September

https://indico.cern.ch/event/839155

organized by Manuela Boscolo

23 registered + many more attending participants

39 contributions

M. Boscolo and F. Zimmermann, 20 September 2019

Monday 9 September		
14:00:14:45	Introduction with workshop goals	Manuela Boscolo
14:45-15:45	Issues of 4 IP collision	Katsunobu Oide
15:45-17:30	Discussion	
Tuesday 10 September		
9:00-10:00	FCC-ee Overview	Frank Zimmermann
10:00-10:45	MDI Status	Manuela Boscolo
10:45-11:15	The CLD detector and MDI elements	Konrad Elsener
11:15-11:45	MDI aspects for the IDEA detector	Attilio Andreazza
Wednesday 11 September		
9:30-10:30	Heat load and HOM analysis in the MDI area	Alexander Novokhatski
10:30-11:30	MDI mechanical design, integration and assembly at DAFNE/KLOE with the crab-waist configuration	Luigi Pellegrino
11:30-12:00	Luminometer	Mogens Dam
12:00-12:30	Summary and Comments on Machine Detector Interface	Anton Bogomyagkov
Thursday 12 September		
9:30-10:30	Preliminary result of beam loss due to radiative Bhabha using BBBrem+SAD	Katsunobu Oide

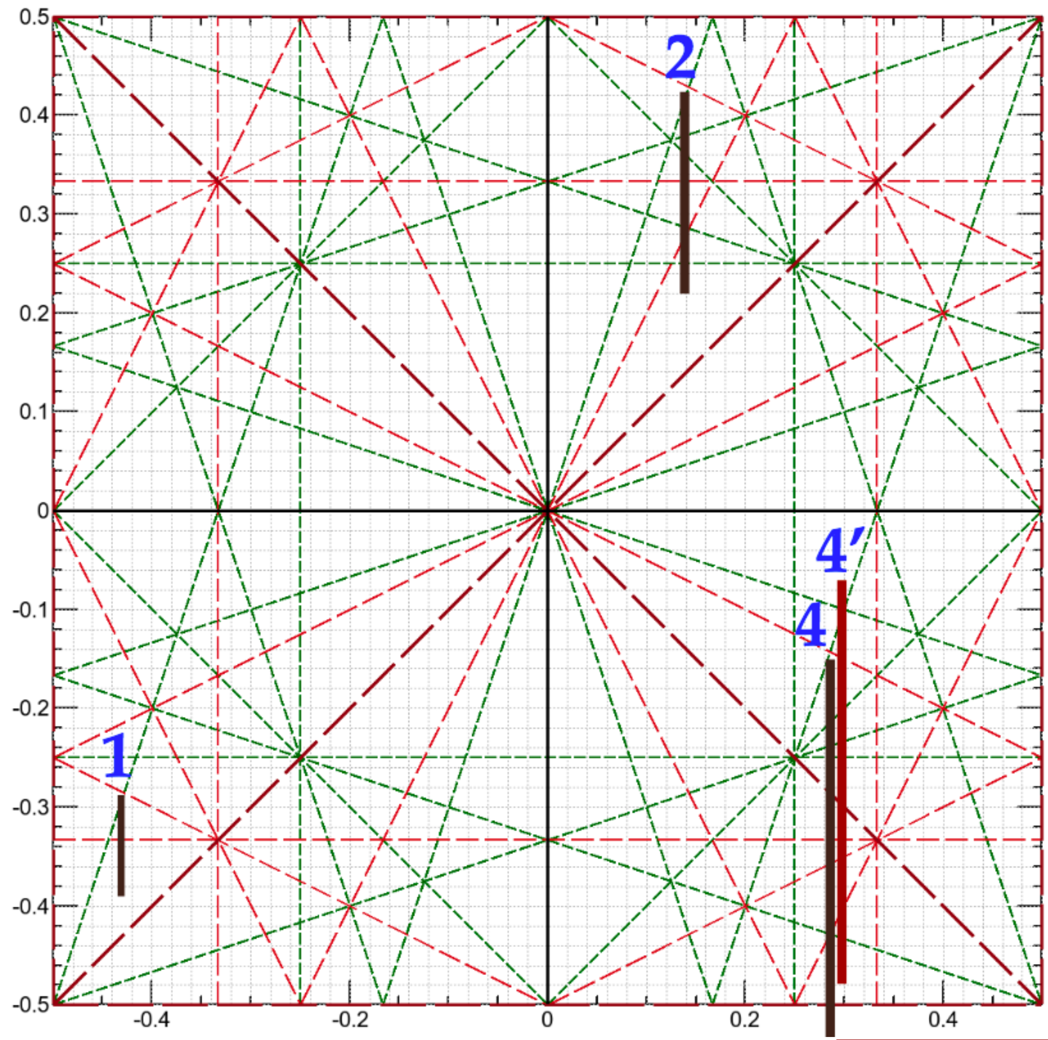
Thursday 12 September cont'd		
10:30-11:00	Polarization requests on beam controls etc...	Alain Blondel
11:00-11:30	Beam dynamics: vertical emittance blow-up, 3D magnetic field map	Sergey Sinyatkin
11:30-12:00	Summary from first days discussion (9-11 September)	Luigi Pellegrino et al.
12:00-13:00	Discussion	
Friday 13 September		
9:30-10:30	Alignment in the MDI area	Mark Jones
10:30-11:00	Review of vibration and stabilisation studies at LAPP laboratory	Laurent Brunetti
10:00-11:45	Emittance tuning for FCC-ee	Tessa Charles
11:45-12:30	Discussion	
Tuesday 17 September		
09:00-09:30	SuperKEKB superconducting magnet quench (remote)	Norihito Ohuchi
09:30-10:30	Recent developments in direct wind IR magnet production at BNL	Brett Parker
10:45-11:15	CCT design for IR final focus quadrupole	Mike Koratzinos
11:15-12:15	SR backgrounds with smaller central beam pipe	Michael K. Sullivan
12:15-12:45	SR collimation in the IR using MDISim	Marian Luckhof

Tuesday 17 September cont'd		
15:30-10:00	Follow-up of the mechanical design & alignment & vibration control related issues	
Wednesday 18 September		
09:30-10:00	Beam backgrounds and IR related losses	Helmut Burkhardt
10:00-10:30	Multi-turn particle tracking for FCC-ee background studies: first results for Coulomb scattering beam losses	Andrea Ciarma
10:30-11:00	Integration of MDI software tools with FCCSW	Gerardo Ganis
11:00-12:30	Discussion on software tools	
15.30-17:00	Brainstorming meeting on FCC-ee IR magnet cryostat	
Thursday 19 September		
9:30-10:00	SuperKEKB IR pressure analysis	Roberto Kersevan
10:00-10.30	Considerations from PEP-II experience on the mechanical design	Mike Sullivan
Friday 20 September		
09:30-10:00	Progress with IR SR study	Mike Sullivan
10:30-11:30	Workshop Summary	Manuela Boscolo, Michael Benedikt, Frank Zimmermann

a few highlights

Optics with 4 IPs

- Issues with the large tune footprint for 4 IPs
- If the periodicity is violated due to machine errors such as by β-beat and x-y couplings, the effective footprints become larger for 2 IP and even more for 4 IP.
- Some mitigation is possible (see 4' avoiding vertical tune ν_y = -0.5 resonance). Still many other resonances are crossed, the strength of which depends on the errors and corrections of the lattice.



Oide, Shatilov

- ➢ More studies are needed in order to understand the relevance of such an issue, especially looking at β-beats and x-y couplings as well as vertical emittance.
- ➢ Too early to consider 4 IPs as baseline at this moment.

MDI Design

We are trying to concentrate our efforts in 4 main areas:

- Beam physics (optics, beam dynamics, collective effects)
- Experimental environment, beam induced backgrounds & luminosity measurement
- Software for simulation tools
- Engineering (mechanical, magnets, diagnostics, vacuum, cooling, ...)

- ➢ Input and strong collaboration from all areas of expertize are crucial to optimize the promising studies presented in the CDR and finalize them for the TDR phase.

- ➢ Our goal is to have a feasible and well engineered design that meets the requirements of optics, beam dynamics and high current, foresees tolerable radiation and meets as well the mechanical requirements in terms of integration, stability, assembly.

IR and its mechanical interface with detector

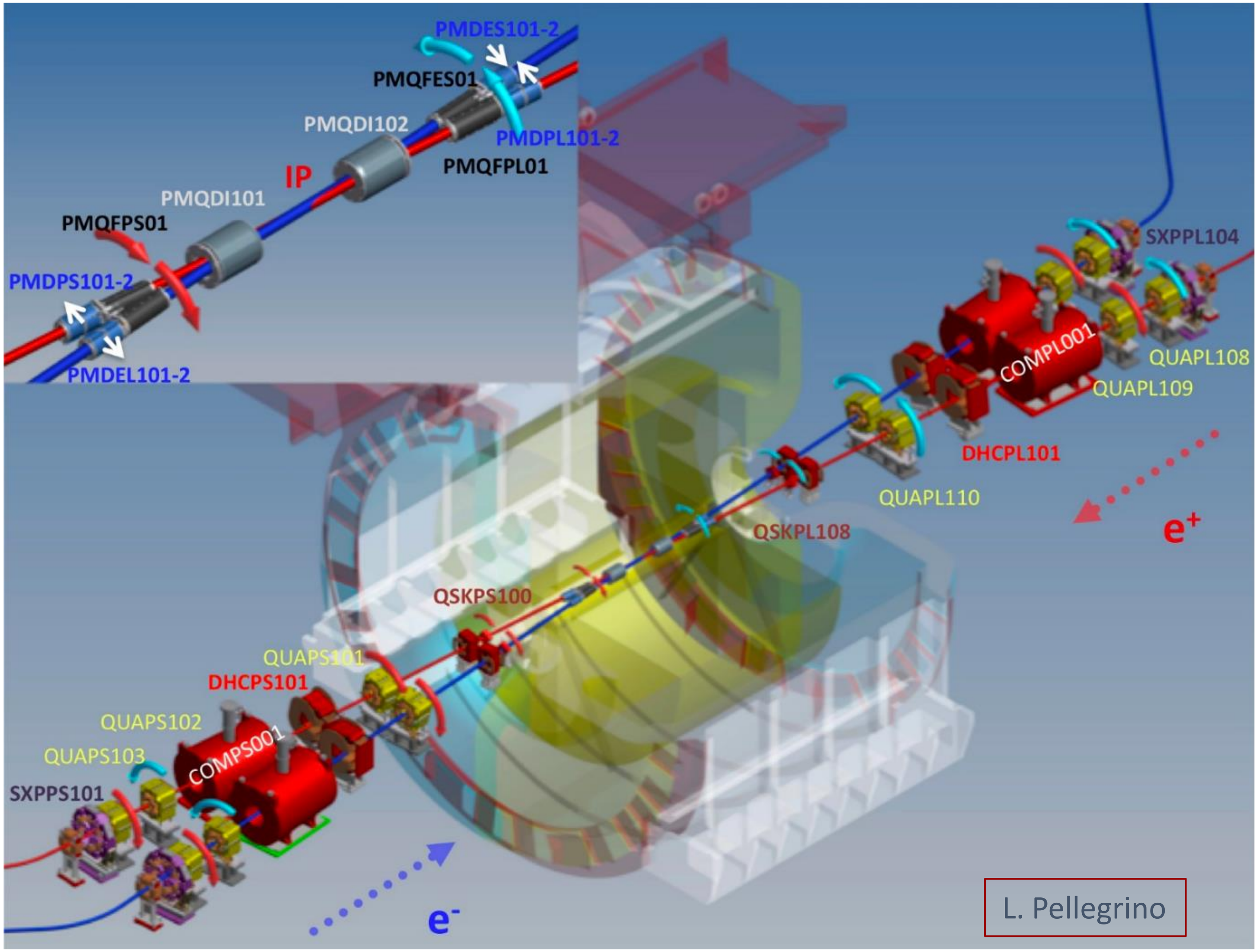
We have been discussing two approaches:

1. Confine all IR elements and detector elements (with their services) within a certain radius from the beam line in a mechanically compact cylinder whose connections in Z are accessible outside the detector (Dafne for example)

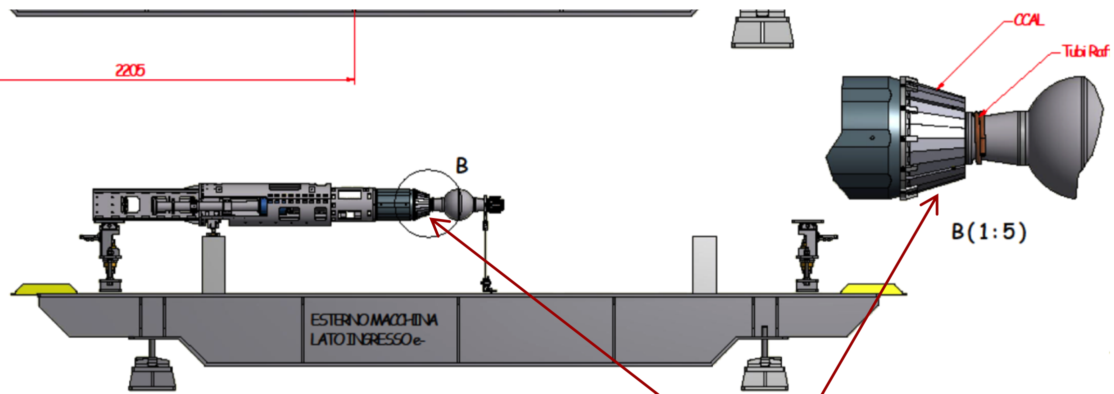
2. Confine the IR elements in a conical structure supported at each end separately and move them in from both side with remote controlled flanges (KEKB for example)

- From a detector point of view both cases should be analyzed starting from a 3D drawing of the IR region combined with the detector.
- Choice should be driven by optimizing accessibility, ease of installation, sufficient space for services (cables, cooling etc.) mechanical stability and maintenance issues
- From the detector point of view it seems attractive to be mechanically independent from machine elements (quenching, heating, vibration of cryostat etc.). Feasible ?

IR and its mechanical interface with detector (KLOE)



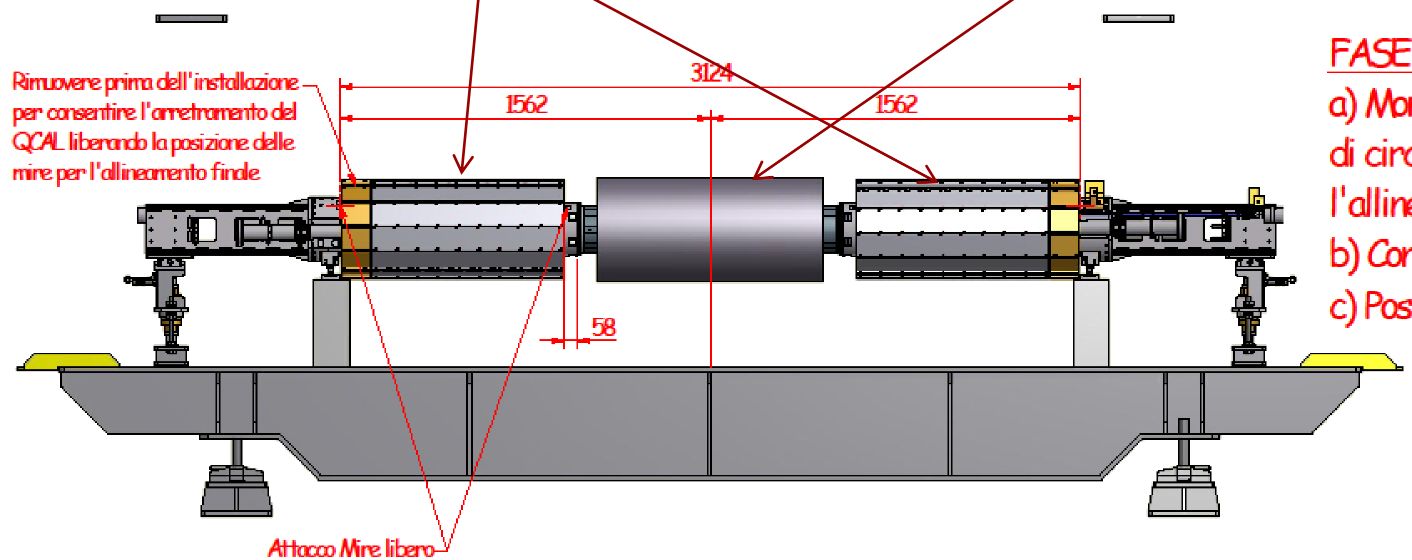
IR and its mechanical interface with detector (KLOE)



Inner Tracker

QCAL

CCAL



FASE 5:

a) Montaggio QCAL in posizione arretrata di circa 100 mm per consentire l'allineamento finale delle due sezioni

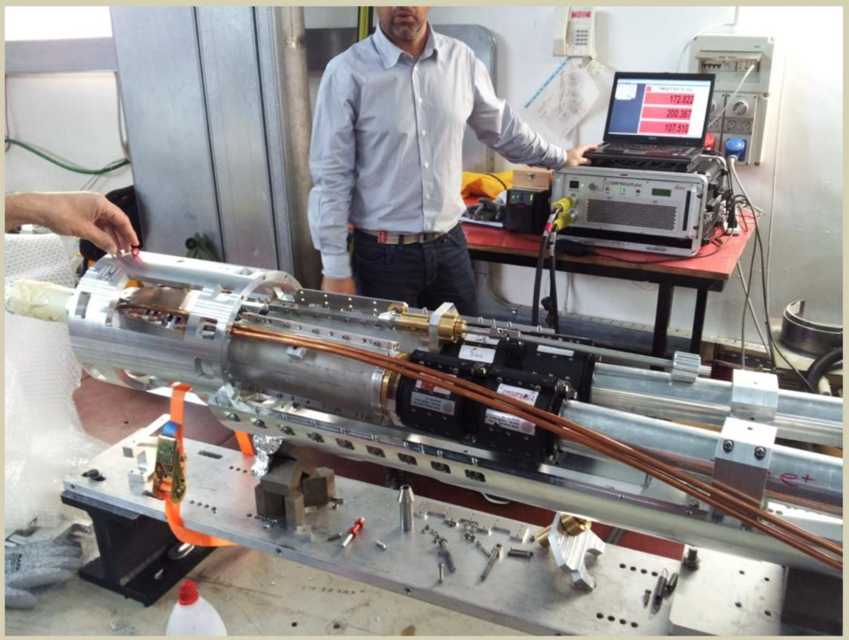
b) Controllo Allineamento

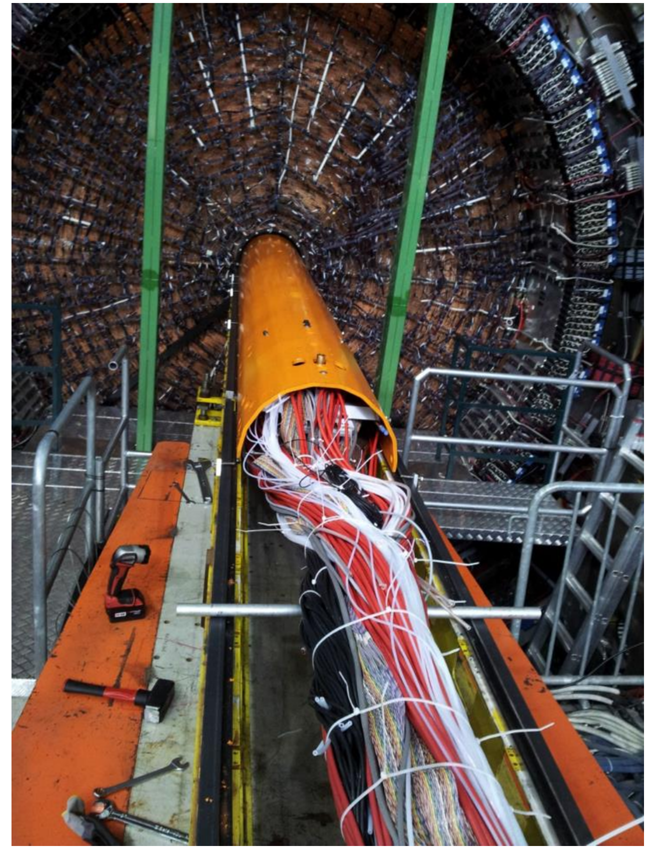
c) Posizionamento finale dei QCAL

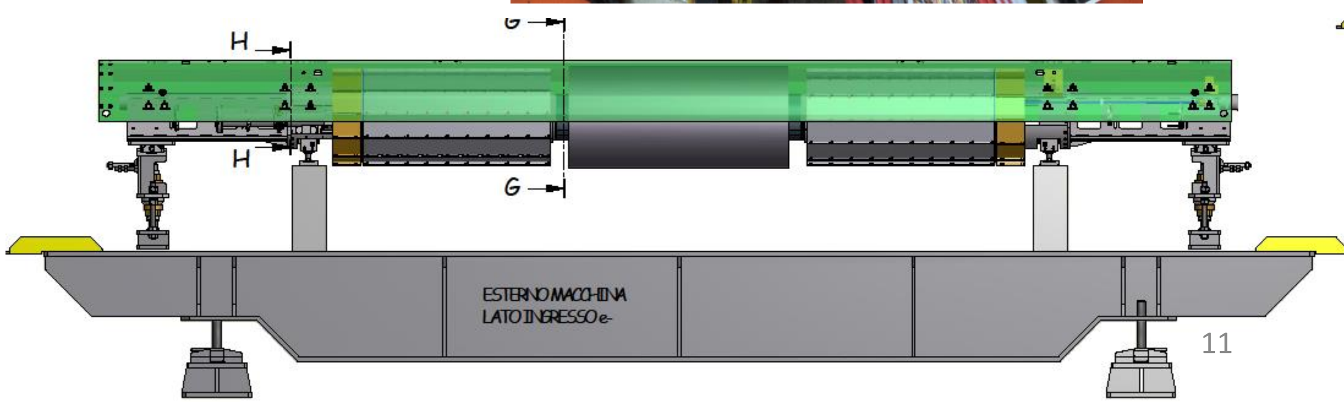
L. Pellegrino

IR and its mechanical interface with detector (KLOE)

Alignement on the bench

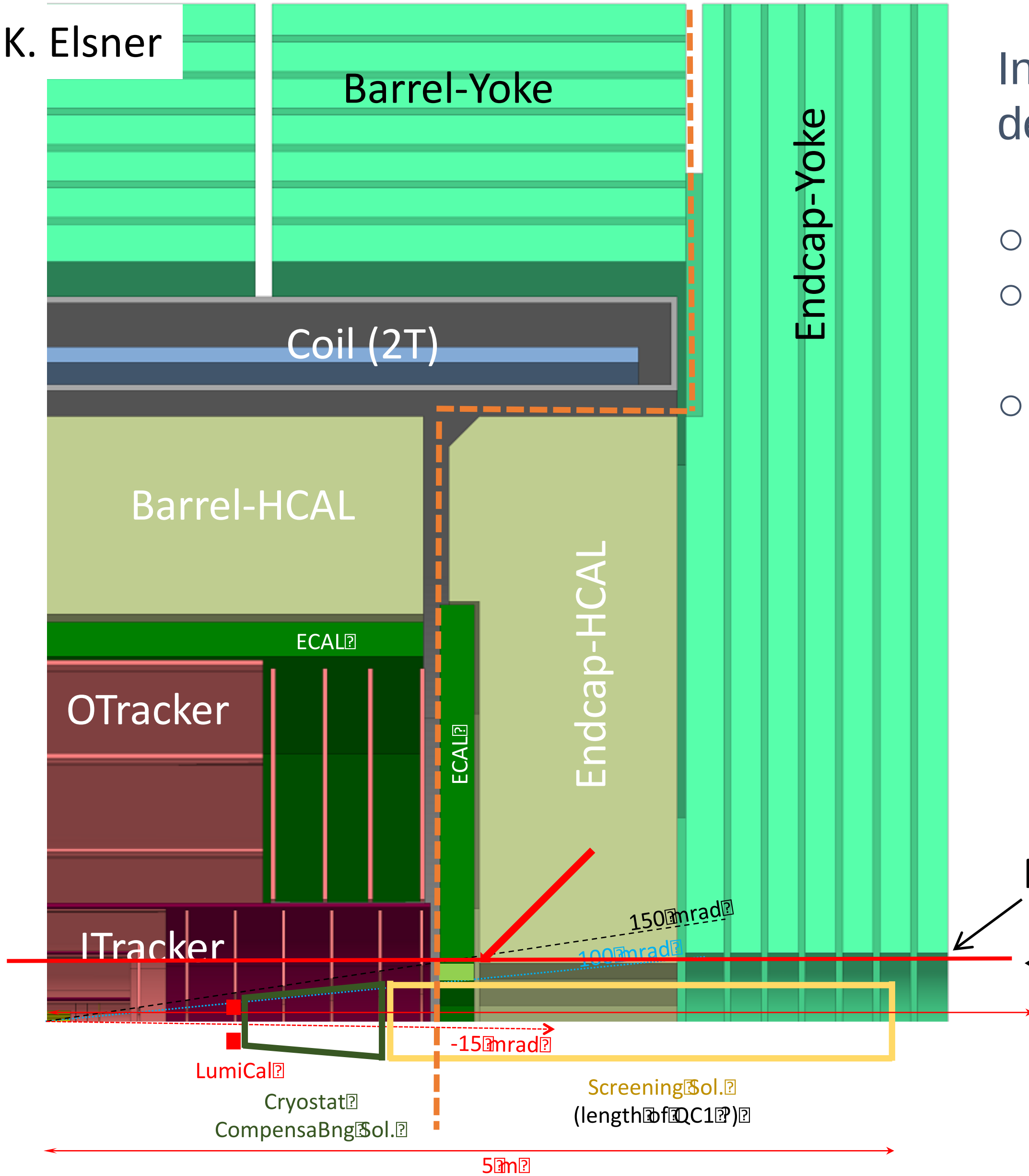






L. Pellegrino

IR and its mechanical interface with detector (CLD)



In case of a cylindrical IR + Inner detector assembly:

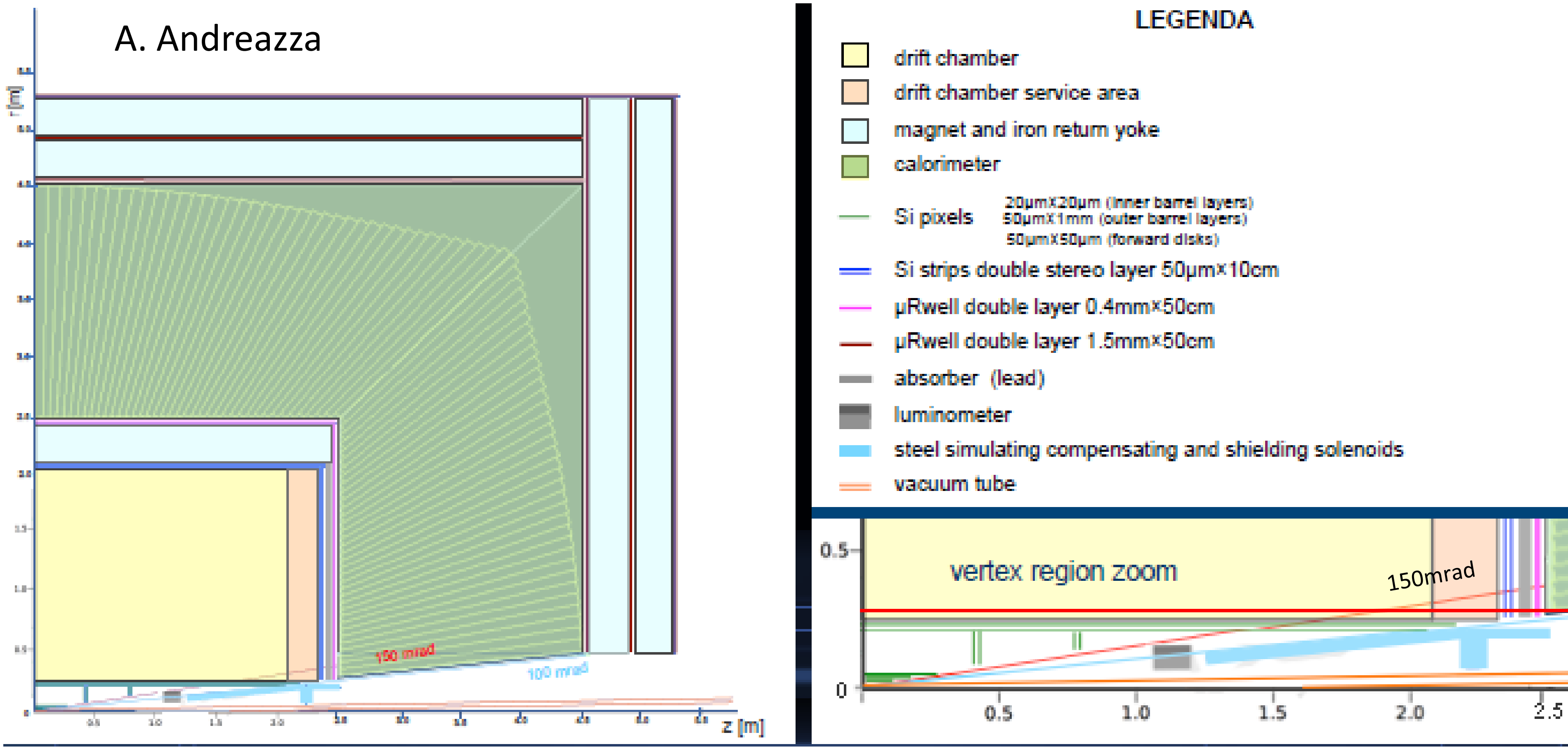
- Inner tracker to be re-designed
- Close the gap between 100mrad and 150mrad?
- Boundary between endcap and barrel to be re-optimized ?

Possible inner bore opening ?

Necessary gap for:

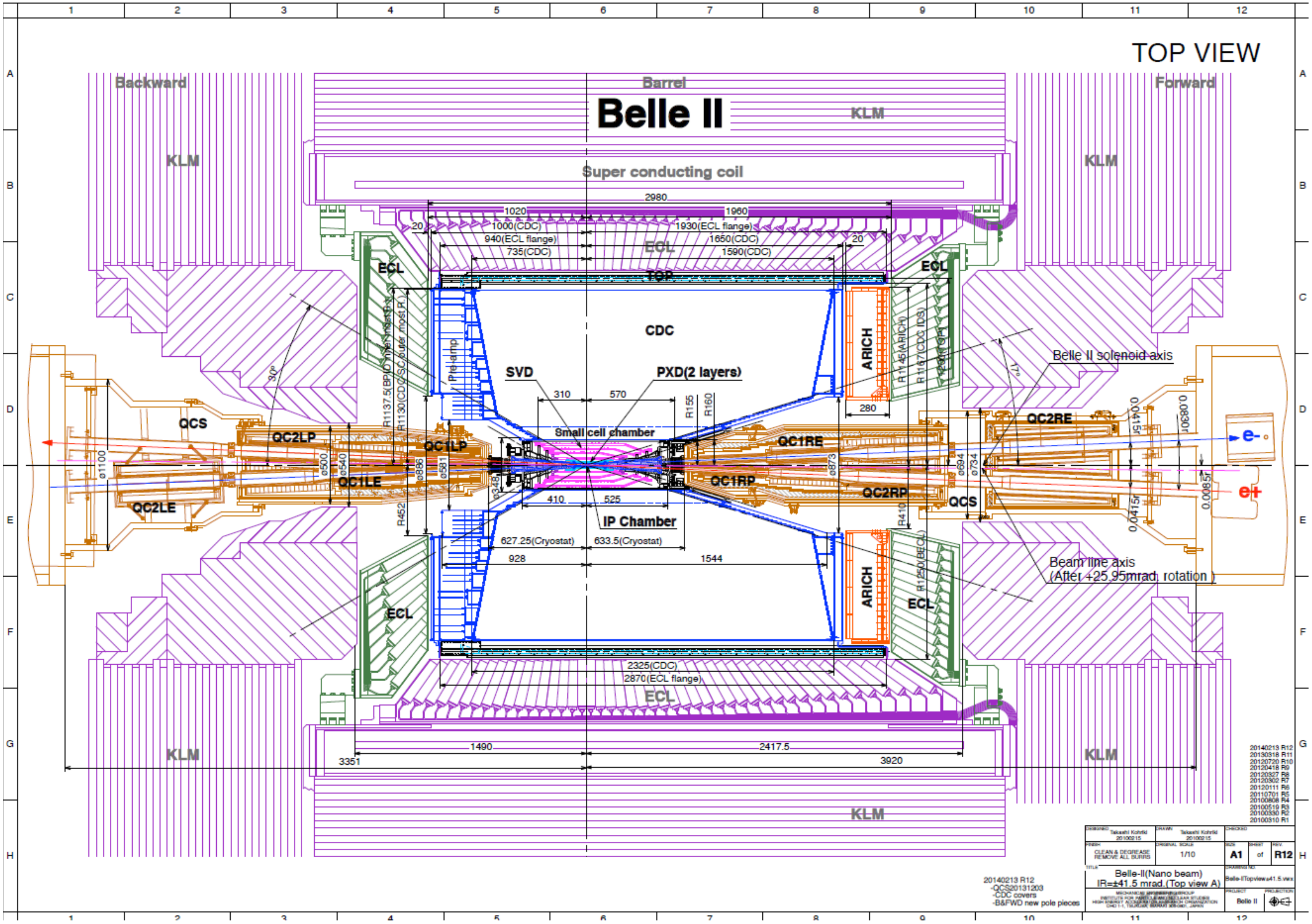
1. mechanical supports
2. Clearances
3. All services of IR+inner detectors

IR and its mechanical interface with detector (IDEA)

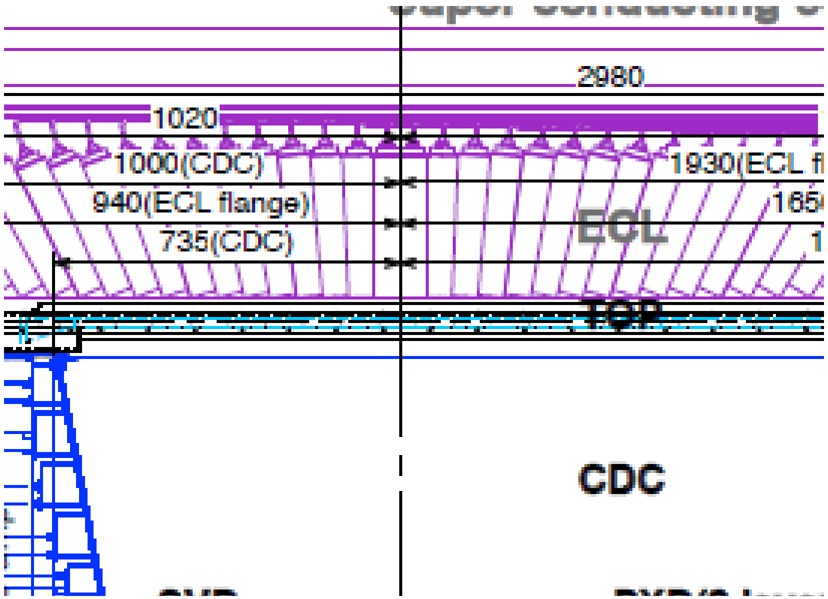


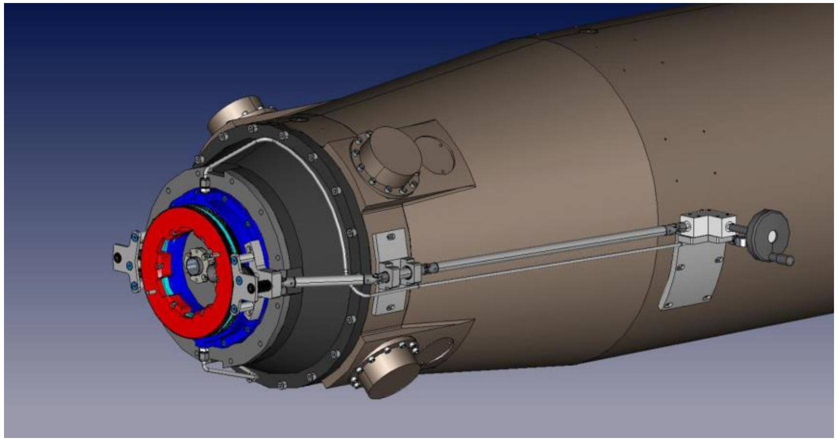
Similar issues for IDEA

IR and its mechanical interface with detector (BelleII)



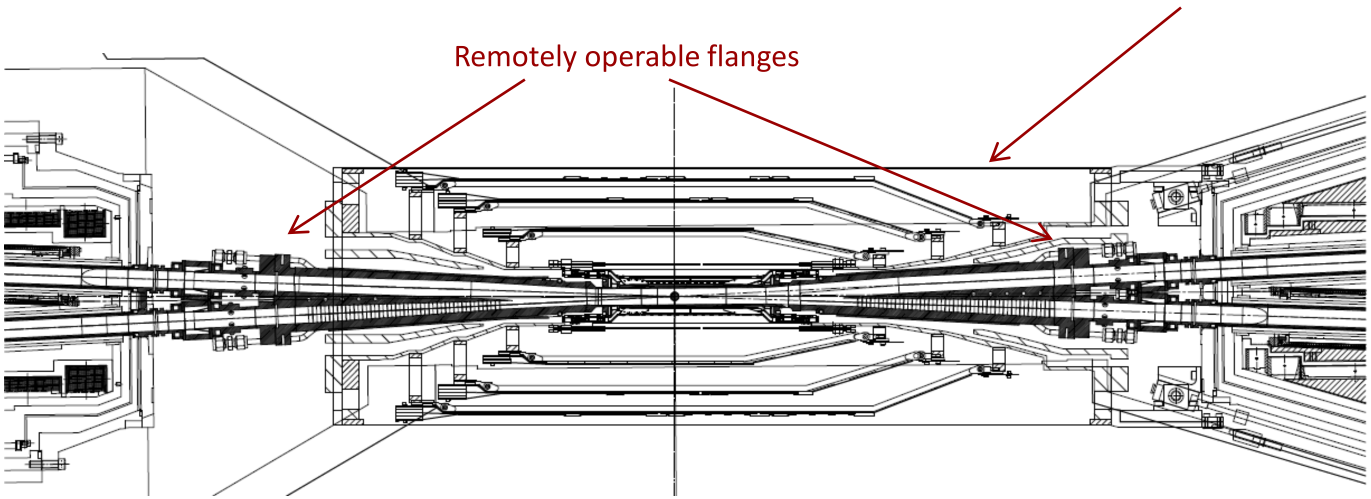
IR and its mechanical interface with detector (BelleII)





Central part supported by the Detector ?

Remotely operable flanges



Vacuum chamber

A. Bogomyagkov

Geometry of the IR vacuum chamber optimized from the wake fields and trapped modes point of view.

DIMENSION

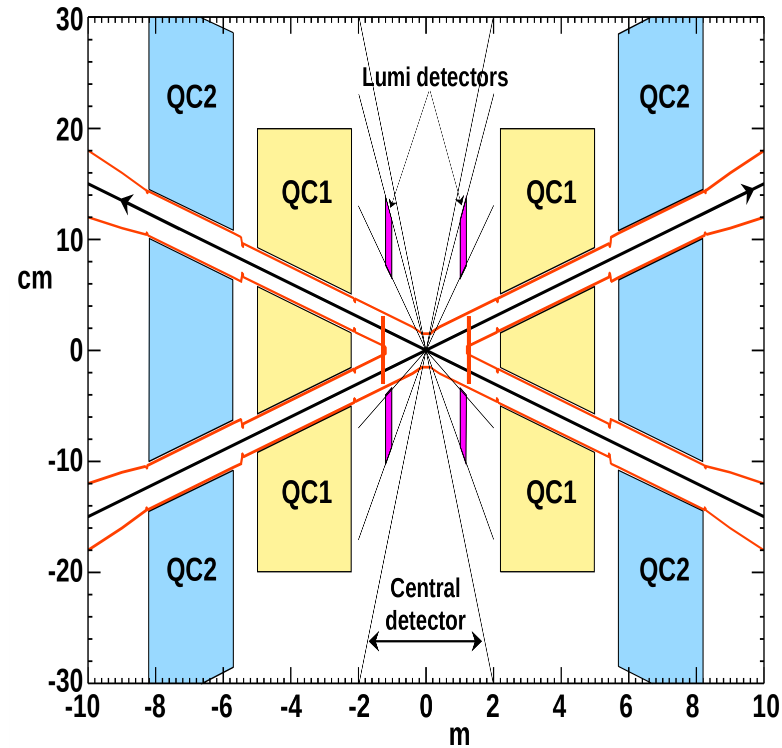
- Central beam pipe has 3 cm diameter
- Entering and exiting beam pipe through QC1 (3cm diameter)
- Pipe size increases to 4cm diameter in QC2
- Size outside QC2 is 7 cm diameter (but 6 cm in plot)

SR MASK TIPS

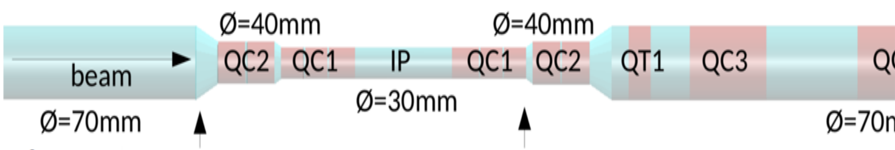
- +/-12 mm radius at Z= +/-2.1 m and +/-5.44 m
- +/-18 mm radius at Z= +/- 8.27 m
- Vert. 10 mm; 5 mm thickness

MATERIAL

- **Be** from about +/-80 cm to accommodate LumiCal
- **Cu** afterwards



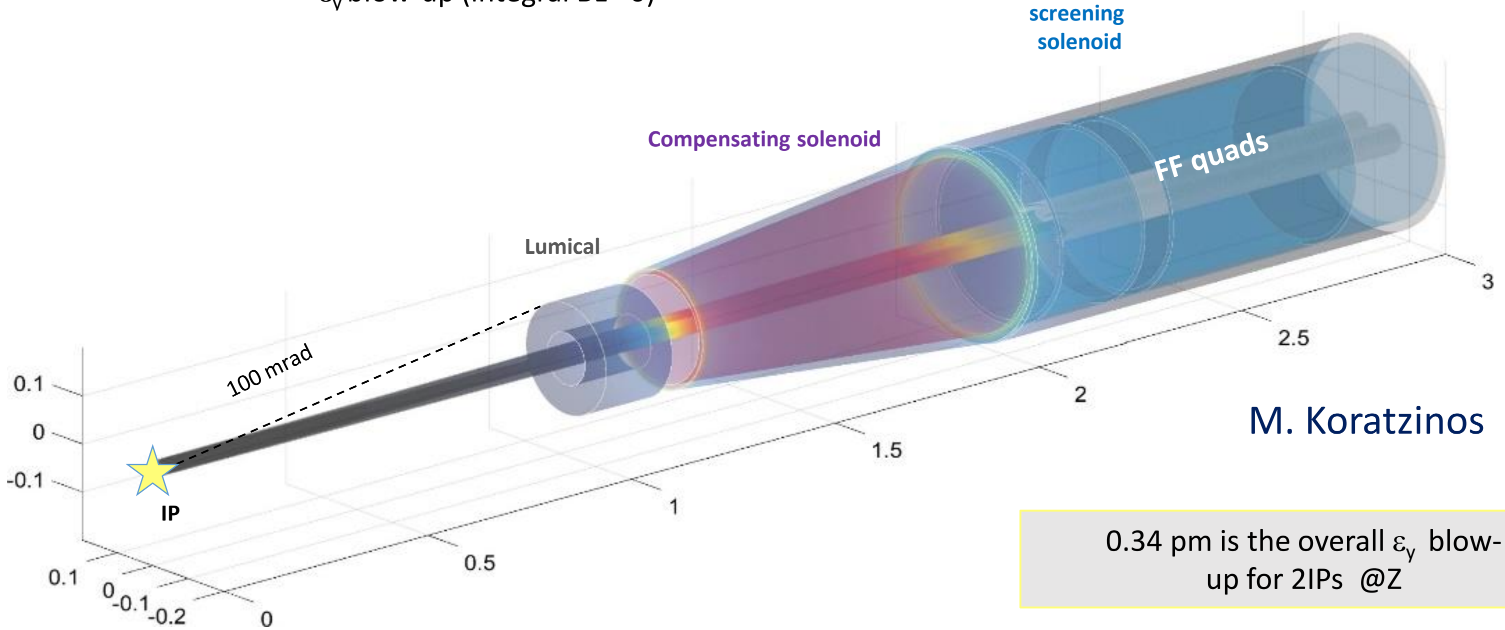
- **warm** beam pipe, liquid cooled (similarly to SuperKEKB) to cope with SR and HOM heating



Be and Cu pipes may be welded together but similar solution to SuperKEKB using also Ti being considered

Baseline for FCC-ee Solenoid Compensation Scheme

- **screening solenoid** that shields the detector field inside the quads
  (in the FF quad net solenoidal field=0)
- **compensating solenoid** in front of the first quad, as close as possible, to reduce the ε_y blow-up (integral BL~0)



M. Koratzinos

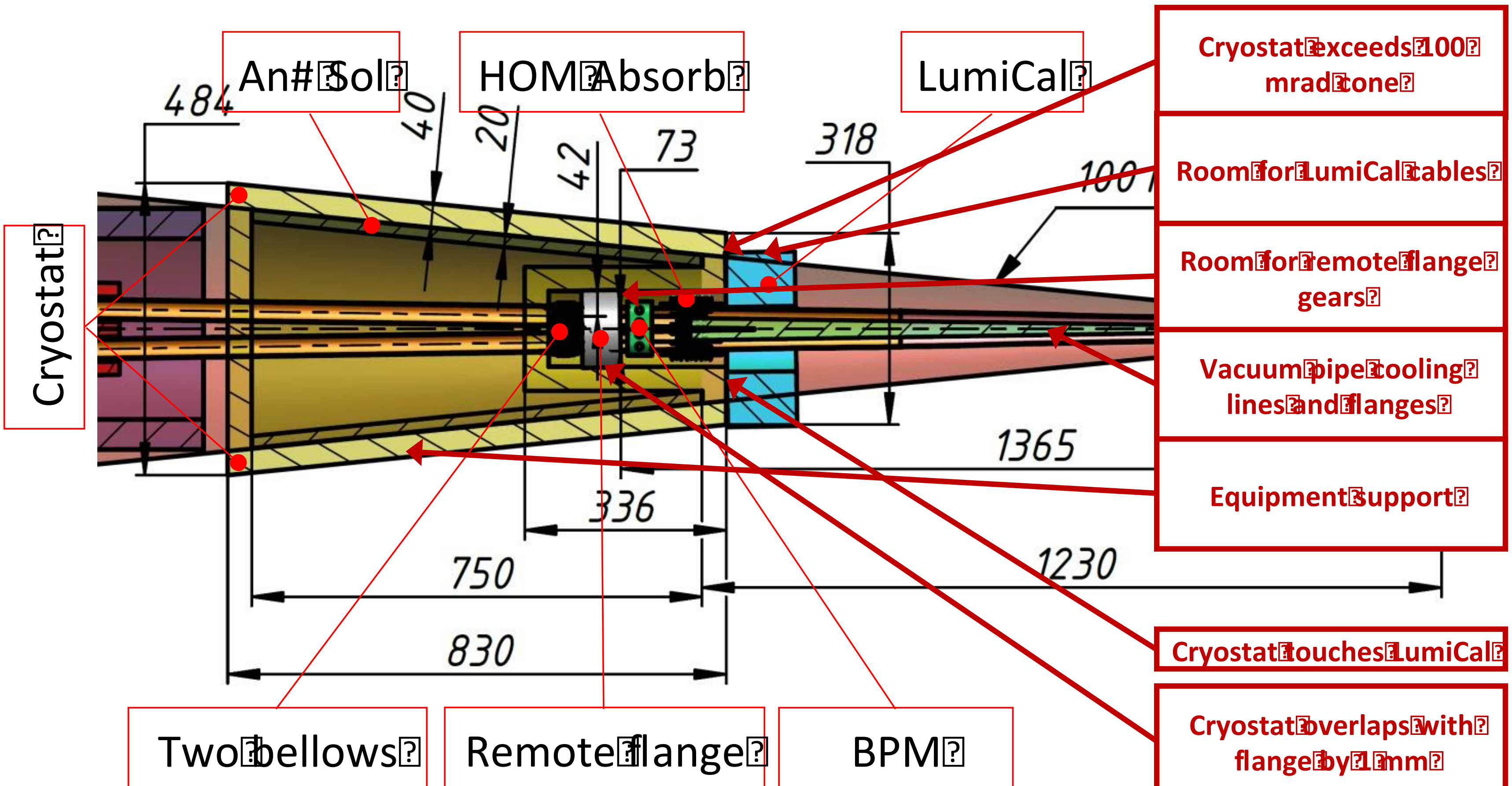
0.34 pm is the overall ε_y blow-up for 2IPs @Z

detector solenoid dimensions 3.76m (inner radius) (outer radius 3.818m) × **4m** (half-length)
drift chamber at z=2m with 150 mrad opening angle (IDEA design)

Syniatkin

Issues with baseline design

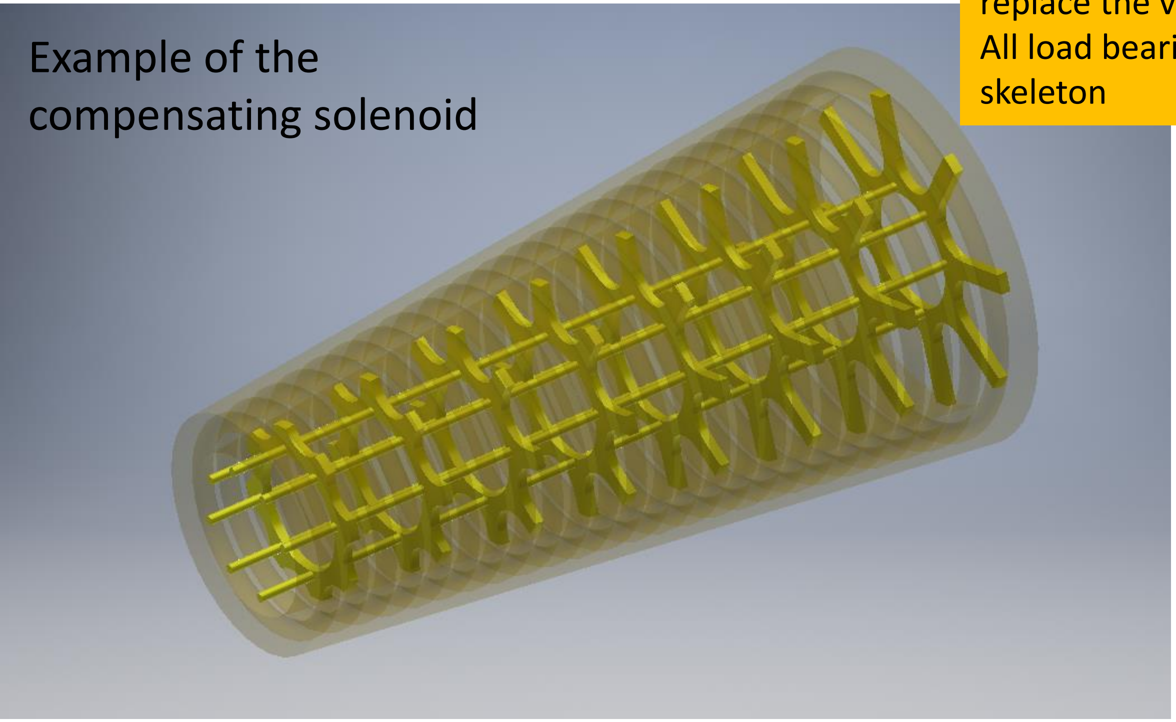
Issues with the present cryostat and IR elements design



Perhaps we can reduce the space for the solenoids by rely on a stiff internal skeleton

M Koratzinos

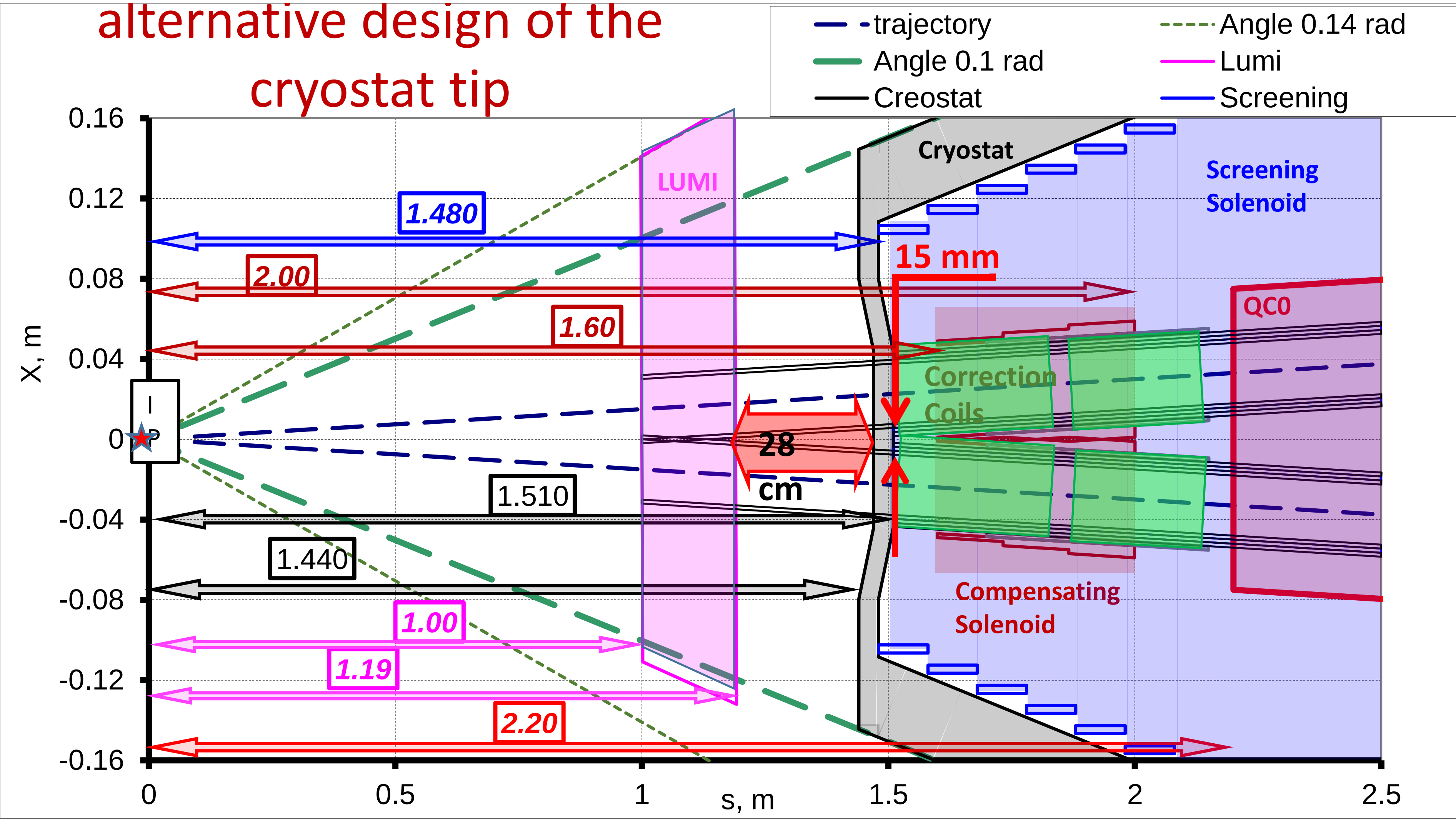
The idea is to use a stiff skeleton which will replace the very heavy cryostat.
All load bearing capability will rely on this skeleton



- FCC-ee FF quad prototype using CCT technology is progressing smoothly
- Forces and twists of the magnet system have been calculated
- A (possible) mechanical design using an (endo)skeleton has been presented

- Forces: 30 tons on compensating solenoid, 8 tons on screening solenoid
- Torque: 1000 Nm on screening solenoid
- Misalignment: 10mm on both solenoids, plus 100mrad twist of compensating solenoid: 1300 Nm on screening solenoid

Alternative design for the cryostat

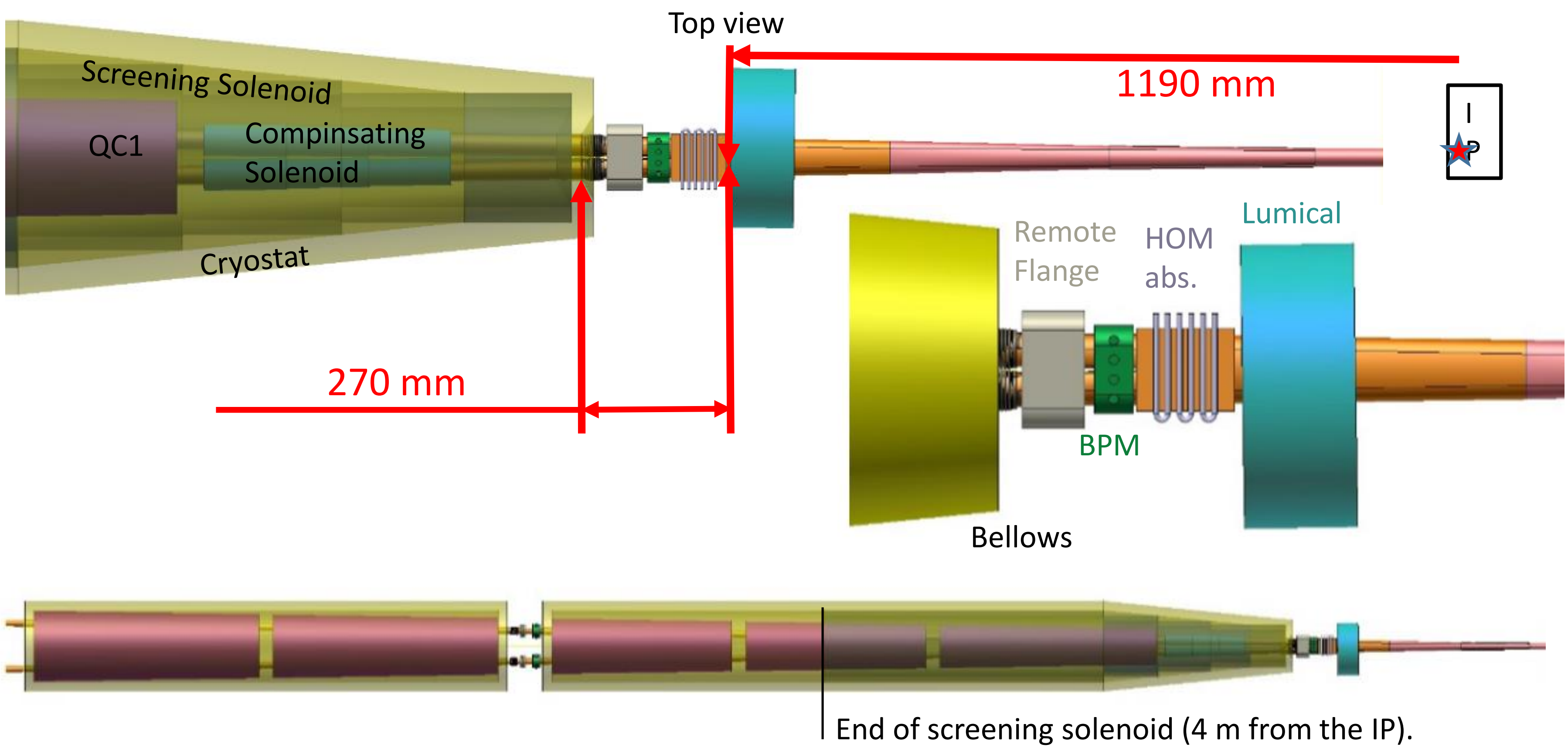


Sinyatkin

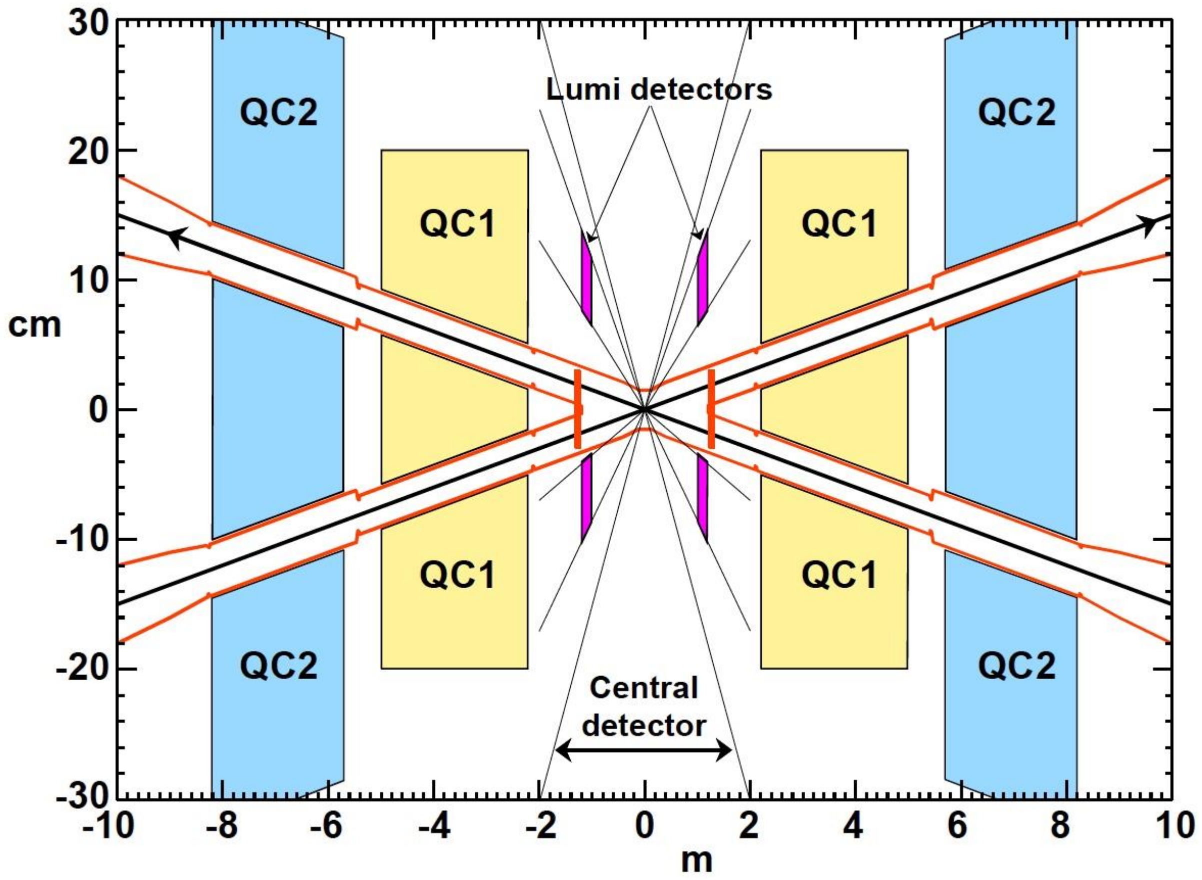
Screening solenoid is extended to 1.5m and the compensating solenoid moves inside the screening solenoid

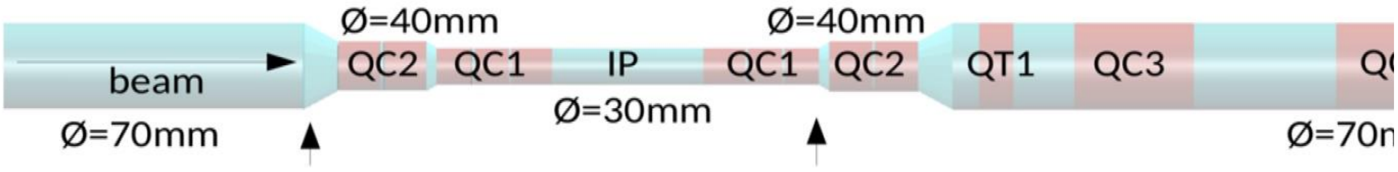
Alternative design for the cryostat

3D views II



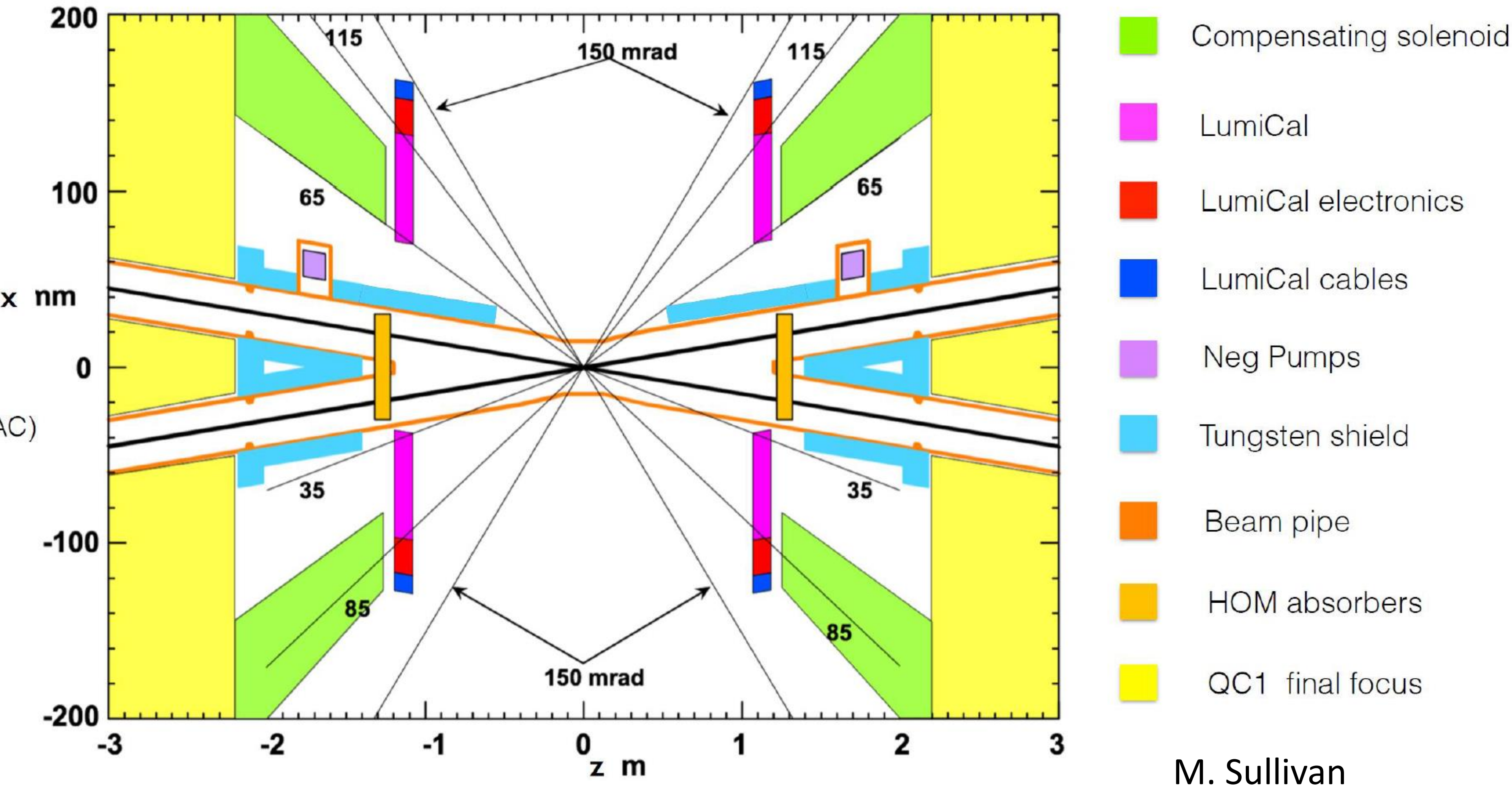
Baseline IR





M. Sullivan

Baseline IR



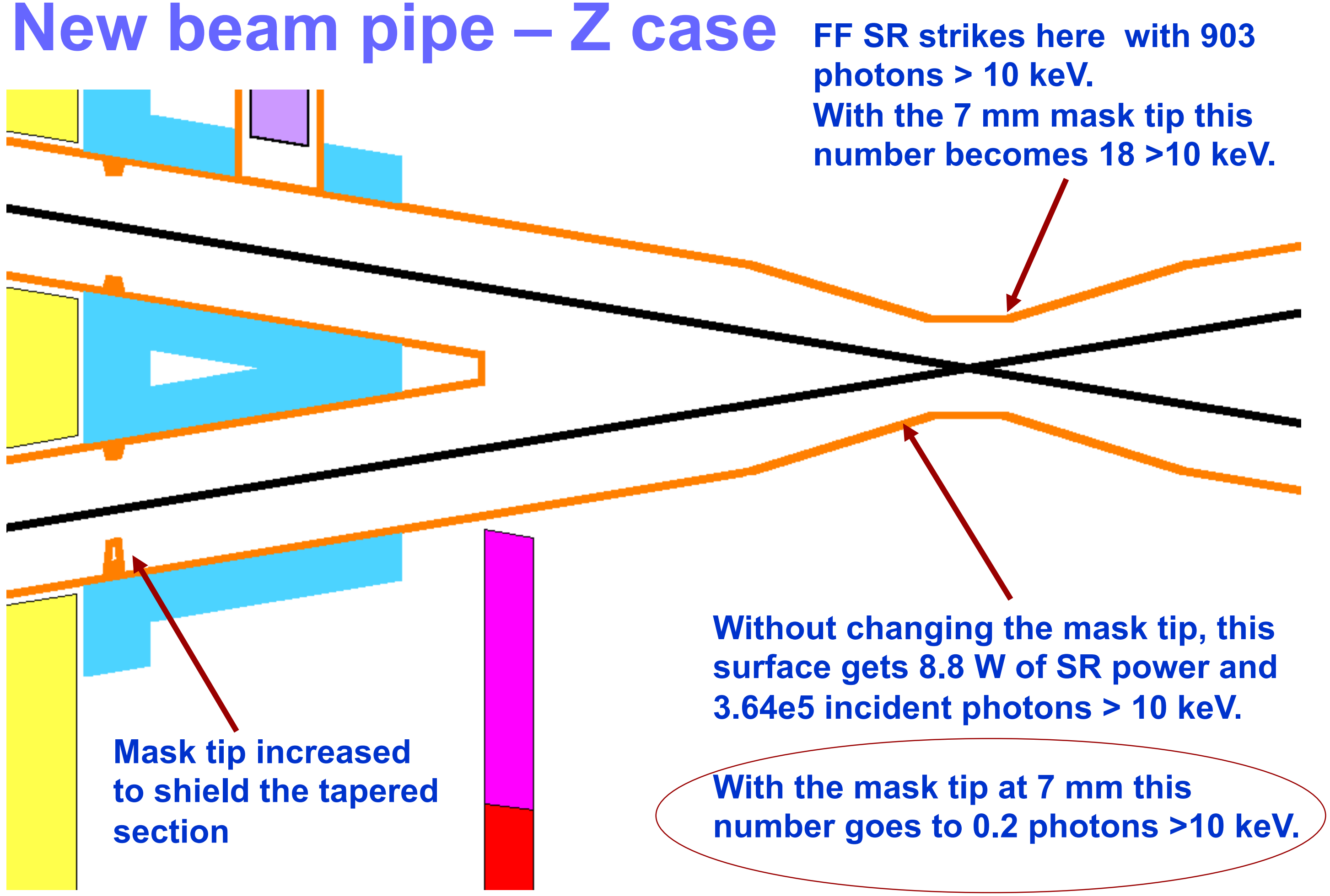
M. Sullivan

Baseline IR with central beam pipe 30mm diameter

Smaller central beampipe

- The SR fan from the last bend magnet misses the central chamber only if we increase the mask tip from 10 mm to 7 mm from the beam line
- The central chamber is then shadowed by the larger mask tip
- There is some quadrupole radiation from the FF quads now striking the downstream part of the central chamber

New beam pipe – Z case



Central pipe with 20mm diameter and cylindrical length shorten from 25 cm to 18 cm

M. Sullivan

Smaller central beampipe

- We have looked at **changing the central beam pipe radius from 15 mm to 10 mm** and shortening the Z length from 25 cm to 18 cm

- The **new beam pipe now intercepts SR from the FF quadrupoles and also intercepts bend radiation** from the last soft bend before the IP

- The bend radiation can be masked away by reducing the mask radius at -2.1 m from 10 mm to 7 mm

- The quadrupole radiation cannot be totally masked away even with a 5 mm radius mask at -2.1 m

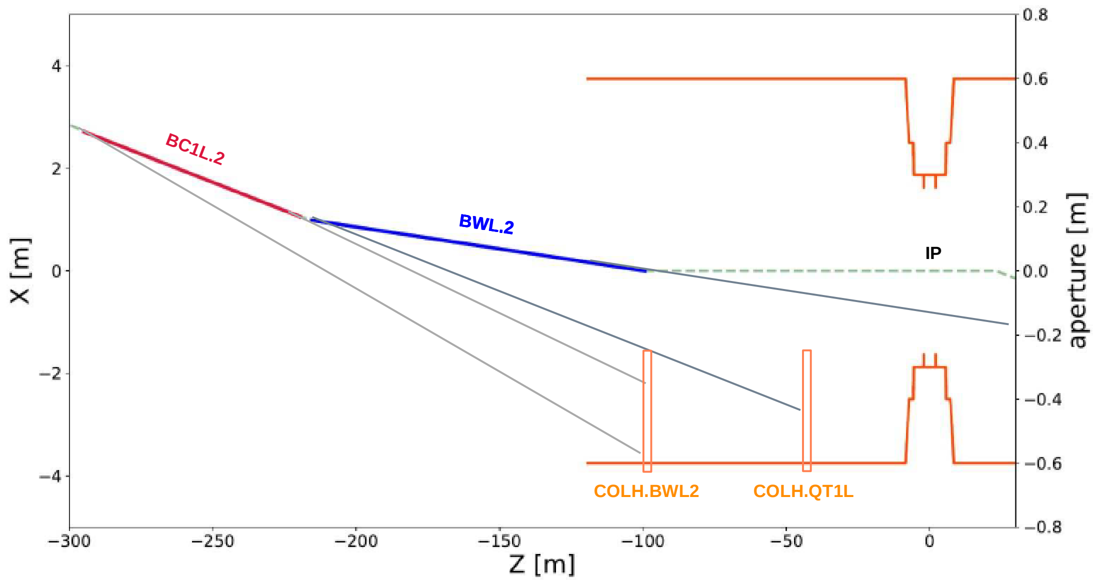
Smaller central beampipe

- A smaller beam pipe for the Z running looks possible
- A 1cm radius beam pipe for the ZH running is more problematical but with careful design work should be possible
  - The detector occupancy will be higher – may be still OK?
  - The IR design becomes more sensitive to the high sigma beam tail distributions
  - This also means that the IR design is more sensitive to β^* changes in the machine lattice

M. Sullivan

Collimator studies

Work on optimizing upstream collimators in order to minimize SR from reaching the IR continues using MDISim



2D view of SR cones from the last 2 bends and proposed collimator position

- Collimation study in very early phase:
  - no misalignments
  - scattering has to be considered
  - **reflection**
- Collimator study - Optimize:
  - position
  - setting
  - combination
  - material
- Coordinate with beam dynamics (lifetime)
- MDISim still under development
- Benchmark attempt with SuperKEKB ongoing in parallel

M. Luckhof

HOM absorber

Based on the property of the trapped mode we have designed a special HOM absorber.

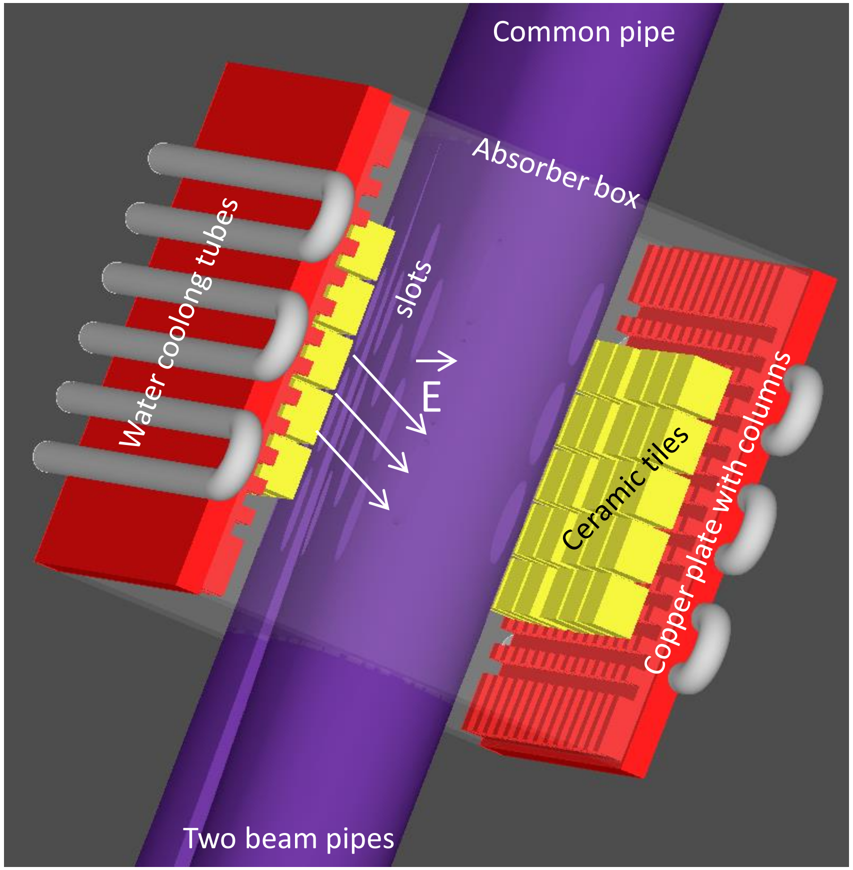
The absorber vacuum box is placed around the beam pipe connection. Inside the box we have ceramic absorbing tiles and copper corrugated plates .

The beam pipe in this place have longitudinal slots, which connect the beam pipe and the absorber box. Outside the box we have stainless steel water-cooling tubes, braised to the copper plates.

The HOM fields, which are generating by the beam in the Interaction Region pass through the longitudinal slots into the absorber box.

Inside the absorber box these fields are absorbed by ceramic tiles, because they have high value of the loss tangent.

The heat from ceramic tiles is transported through the copper plates to water cooling tubes.



Resistive heat loads with smaller beam pipe

Comparison of <u>resistive</u> heat loads (Be pipe) and temperatures

Beam pipe diameter [mm]	Heat load [W/m]	Max Temp. [K] without cooling
30	97	88
20	145	198
10	290	792

Max temperature was calculated by formula

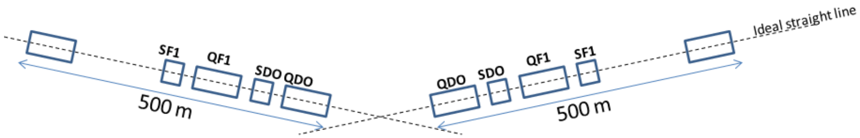
$$\Delta T_{[K^\circ]} = \frac{P_{[W]} * L_{[m]}}{k_{[W/(K^\circ m)]} * 2\pi R_{[m]} \Delta r_{[m]}}$$

For the pipe length L of 125 mm (half of the Be pipe) with thickness Δr of 1 mm and Be thermo-conductivity of 182 W/m/K

FCC-ee Position Monitoring & Alignment

MDI: left side w.r.t. right side

M. Jones

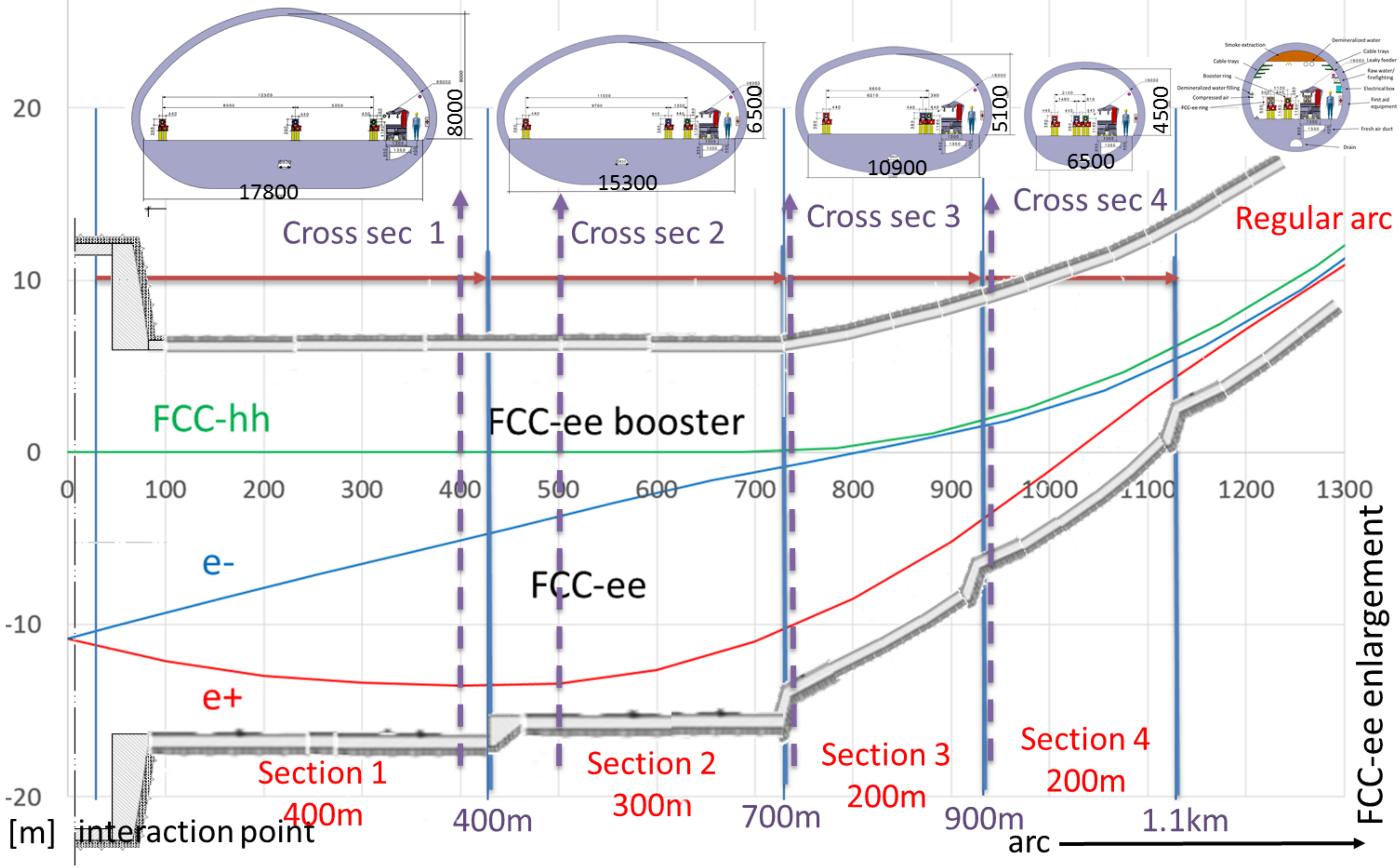


Requirements :

- Position of the zero of QD0 w.r.t ideal straight line of the 500 last meters of BDS: ± 10 µm rms (including fiducialisation), also needed for ILC (± 20 µm not including fiducialisation)
- Longitudinal relative position between QD0 and QF1: ± 20 µm rms (CLIC)

- Experience based on HL-LHC, CLIC and ILC development work
- Few tents of microns relative alignment of FF quads possible
- Solution Requires:
  - Additional space inside the experiment
  - Sensors, lines-of-sight, position adjustment system
  - Strong position and orientation links between accelerator elements in the cavern and those in the tunnels
  - Internal metrology for “encapsulated” elements inside cryostats, or detectors
- The application, adaptation, and integration of alignment and internal metrology components into a single system needs to be studied

Cross section of the tunnel toward IP



M. Jones

FURTHER MATERIAL

work plan / roadmap

✓ improved IR beam pipe and masking (Luigi, Mike S., Sasha) – *in progress*

initial 3D IR model :

- draft cryostat design (Vittorio & Mike K.)
- weight of elements (Mike K., Vittorio, Anton?, Brett?)
- electromagnetic static forces from magnet interaction (Luigi, Mike K.?)
- assembly concept (one side, two side, auxiliary equipment)
    → pre-dimensioning support structure (Luigi)
        → input to stability/vibration analysis (Maurizio / LAPP team)
- thermal power budget
    - synchrotron radiation (Marian, Mike S., Roberto, Helmut), resistive wall, HOM (Sasha) – *in progress*
    - local heat loads from beamstrahlung, radiative Bhabha scattering (Helmut, Katsunobu, Andrea)
- pre-dimensioning of cooling systems (Luigi)
- vacuum chamber details, vacuum pumping, gauges, remote flanges if needed (prototyping?) (Roberto)
- HOM absorbers (Sasha) – *in progress*
- pre-dimensioning of cabling & alignment/surveying space requirements (Mark)
- verification of MDI space allocation (interaction with detector experts)

design feasibility, refinement & alternatives:

- confirming possibility of non-cylindrical Be beam pipe
- magnet quench management (forces, gas venting)
- choice of coolant (paraffin & water?)
- alternative BINP model with round solenoid??

beam dynamics, polarization and background simulations:

- code development / simulation strategy – optics & beam-beam (Tessa, Leon, Tatiana)
- alignment & stability (?) tolerances (Tessa), and vibration tolerances from simulations (Maurizio)
- MDI background code developments (Katsunobu, Marian, Andrea …)
- linking common software framework FCCSW and MDI codes (Gerardo)
- strategy for energy calibration / polarization ?

magnet system:

- magnet system design including corrector systems, and production / assembly techniques (Mike K., Brett, BINP?)
- 3D magnetic field map

benchmarking:

- pressure & conditioning benchmarking at SuperKEKB (Roberto)
- SuperKEKB vibration monitoring & beam control (Laurent)
- IP aberration control at SuperKEKB (Philip, Cecile?), possible test at DAFNE?

Common repository:

- mechanical design
- 3d field map, simulation codes, ...

next FCC-ee MDI working meeting
in May or June 2020