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

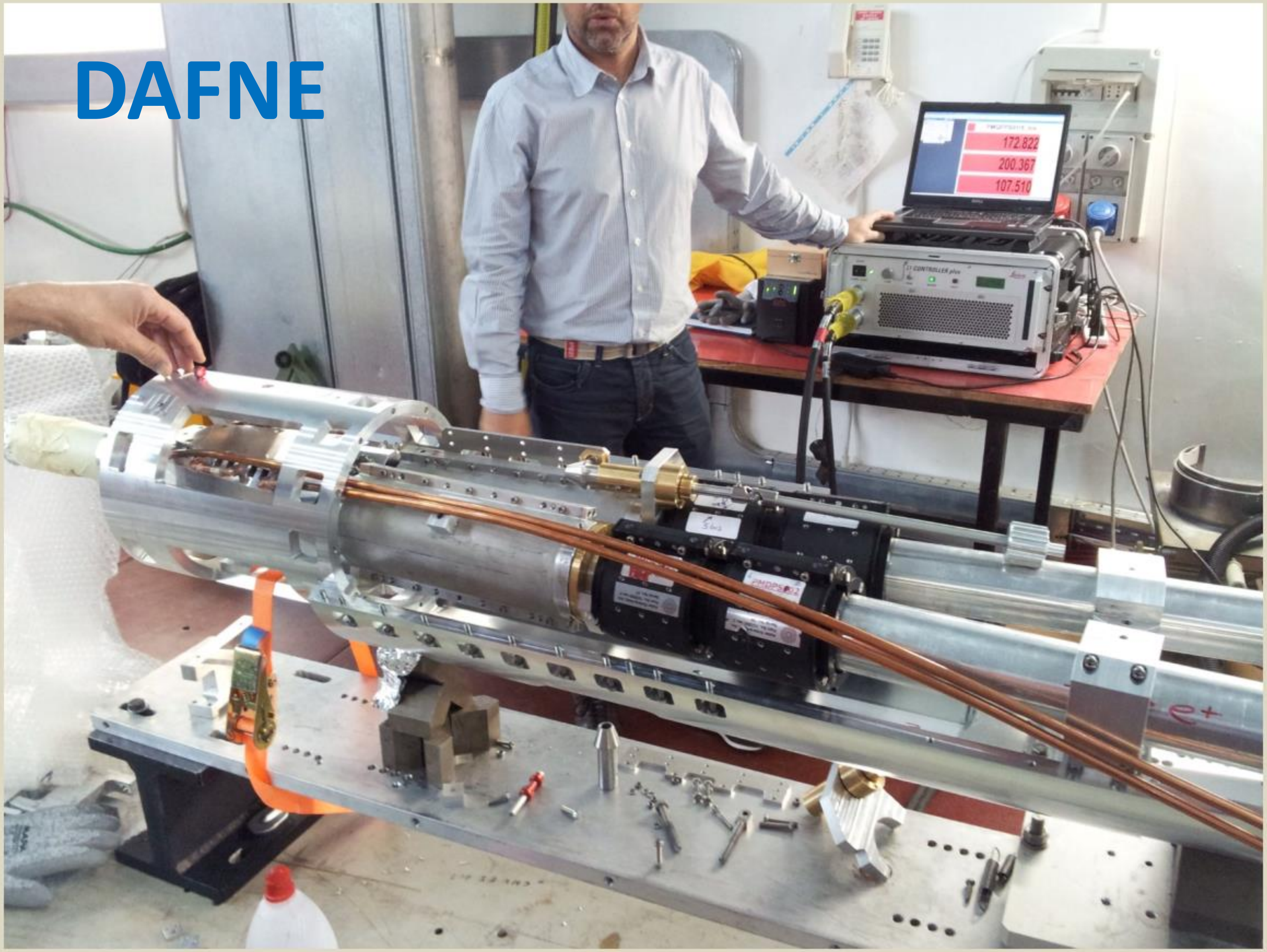
9:30-10:00	SuperKEKB IR pressure analysis	Roberto Kersevan
10:00-10.30	Considerations from PEP-II experience on the mechanical design	Mike Sullivan

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

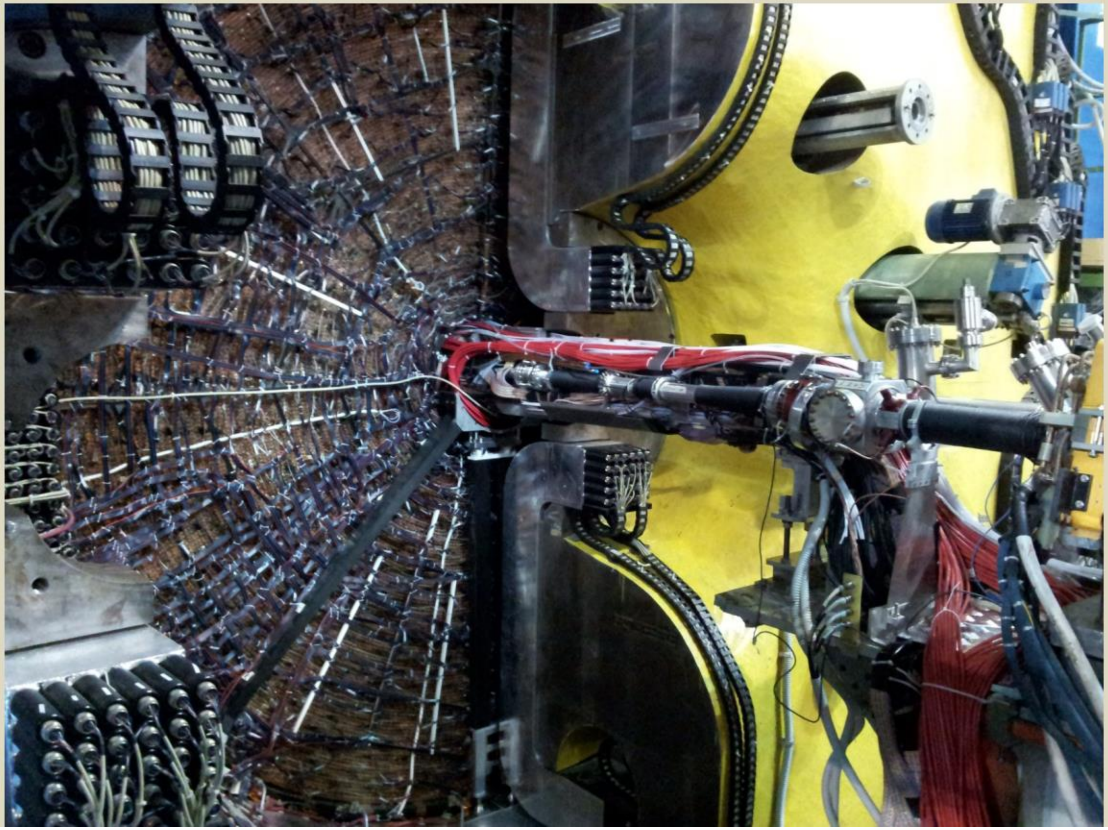
Alignement on the bench



L. Pellegrino

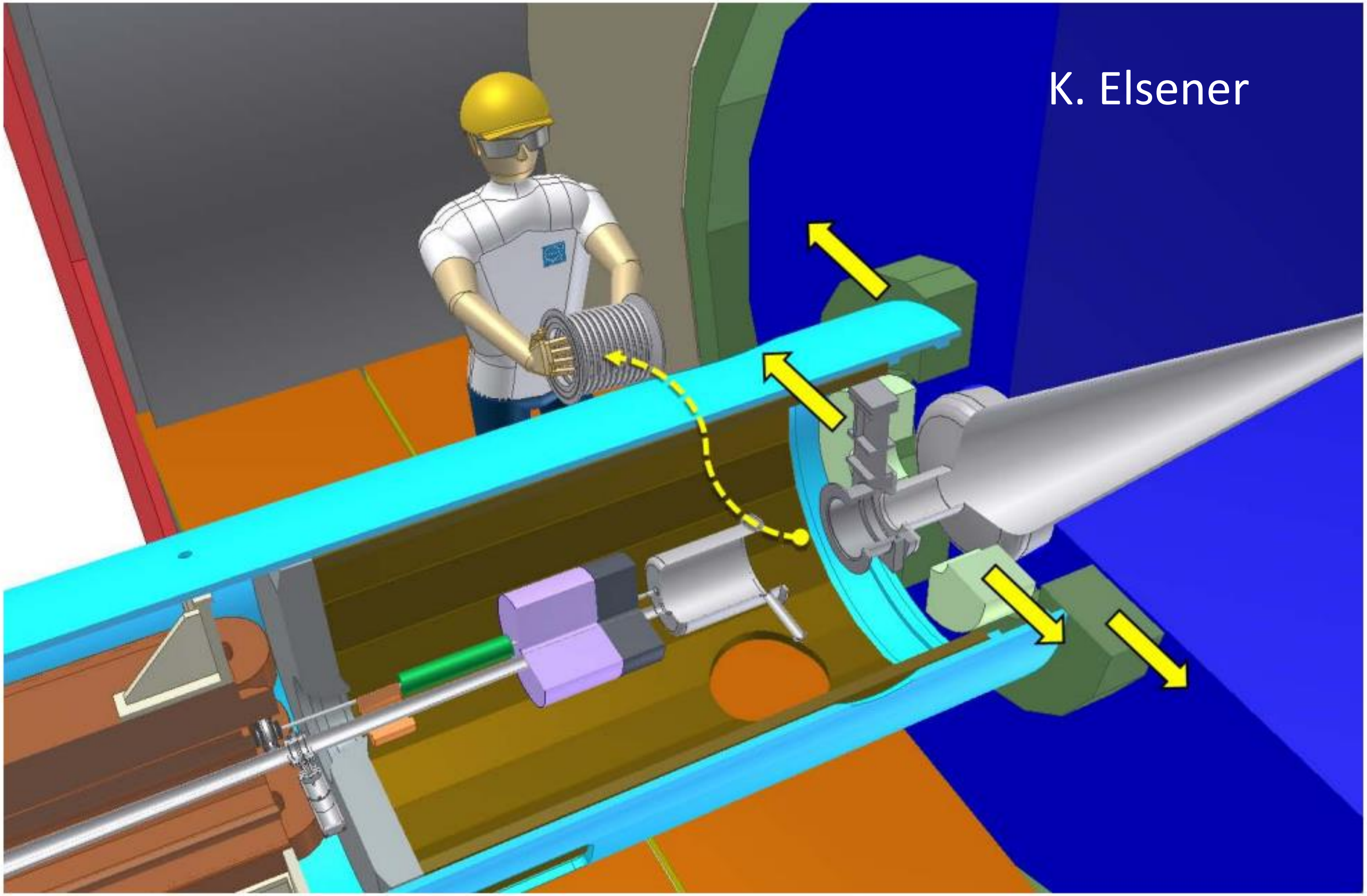
Closing the End Caps

DAFNE



L. Pellegrino

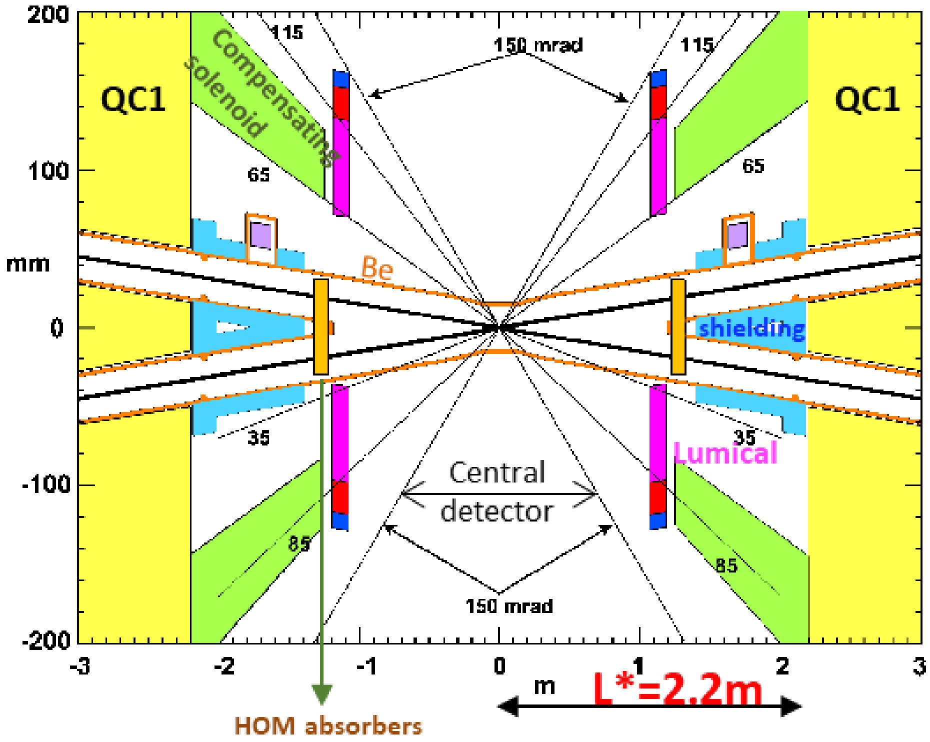
Parenthesis: the situation at CLIC (CDR 2012 – “somewhat outdated”)

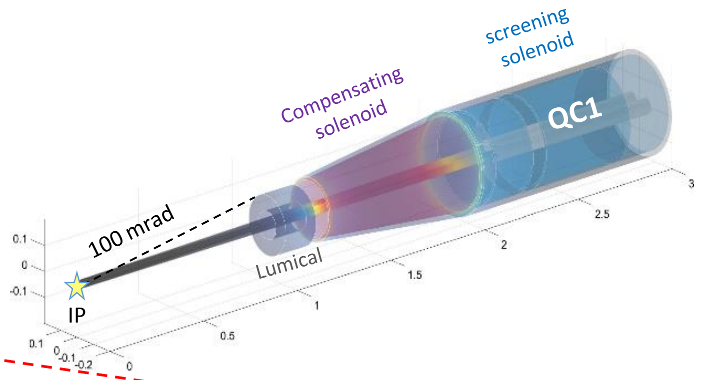


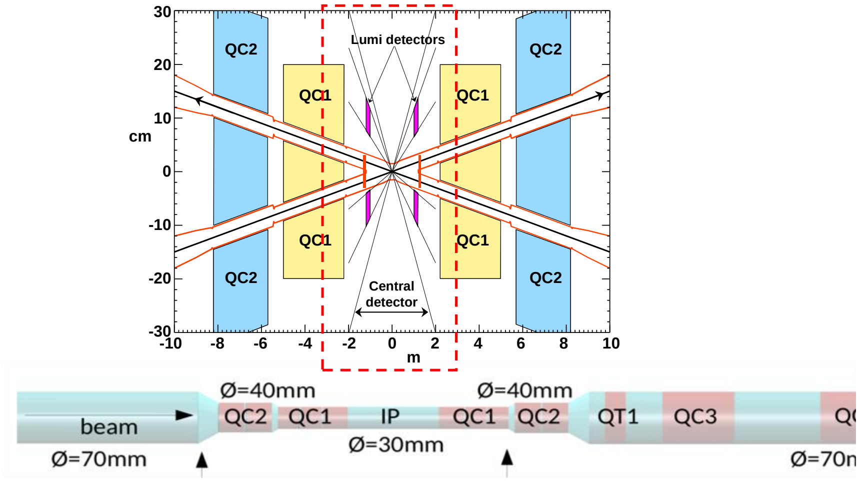
K. Elsener

Fig. 11.21: Opening LumiCal and ECAL plug for the passage of the valve.

FCC-ee Interaction Region Layout


2D-top view with expanded x-coordinate



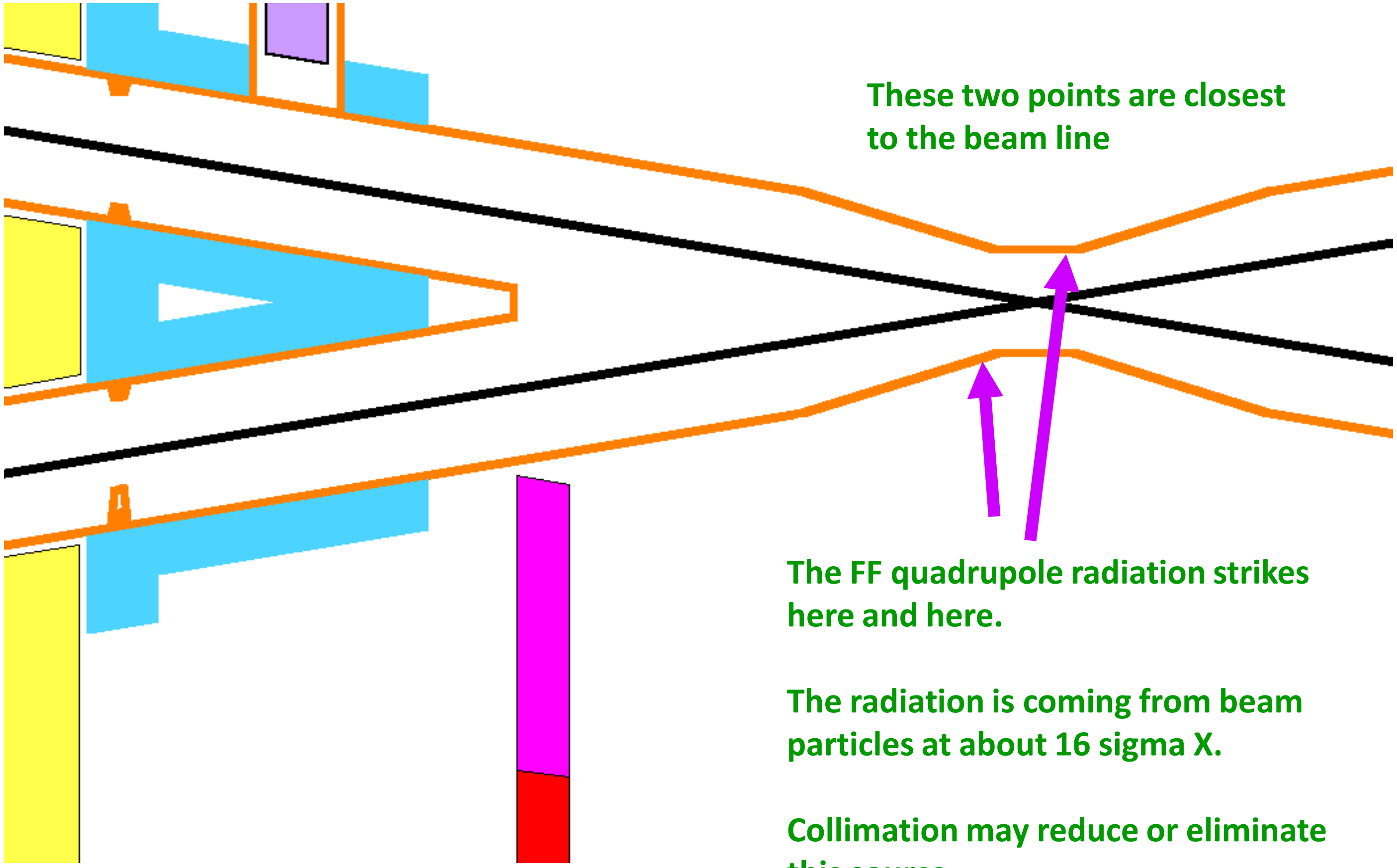


1.5 cm radius z ± 12.5 cm

L* = 2.2 m distance from IP to first quadrupole
2 T detector

smaller central pipe: 1.0 cm for z ± 9 cm
(with taper starting at z ± 40 cm from IP)

FF quadrupole radiation



These two points are closest to the beam line

The FF quadrupole radiation strikes here and here.

The radiation is coming from beam particles at about 16 sigma X.

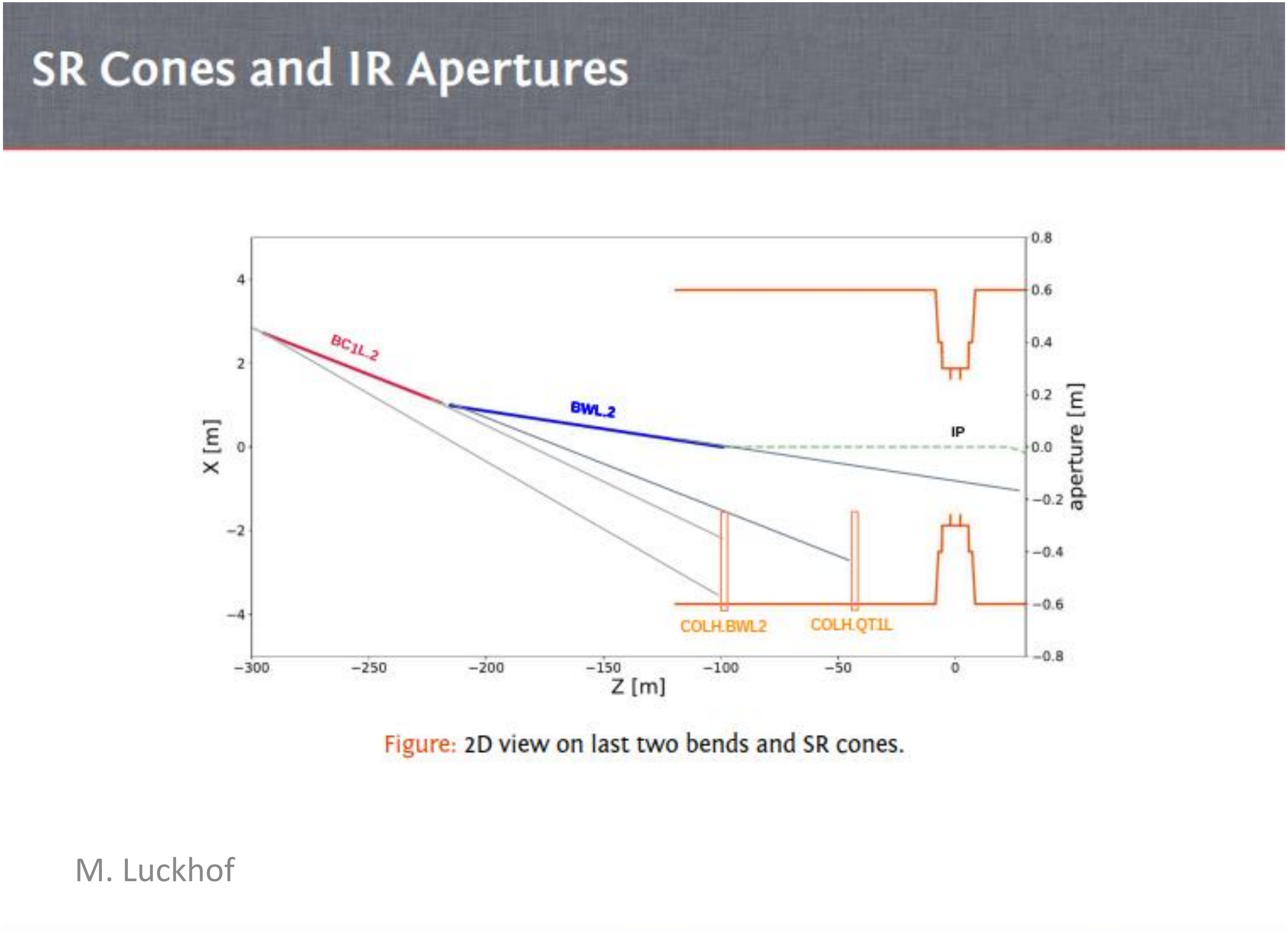
Collimation may reduce or eliminate this source.

M. Sullivan

Summary

- 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

adding upstream collimators



SR Cones and IR Apertures

Figure: 2D view on last two bends and SR cones.

M. Luckhof

The concept of the HOM absorber

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

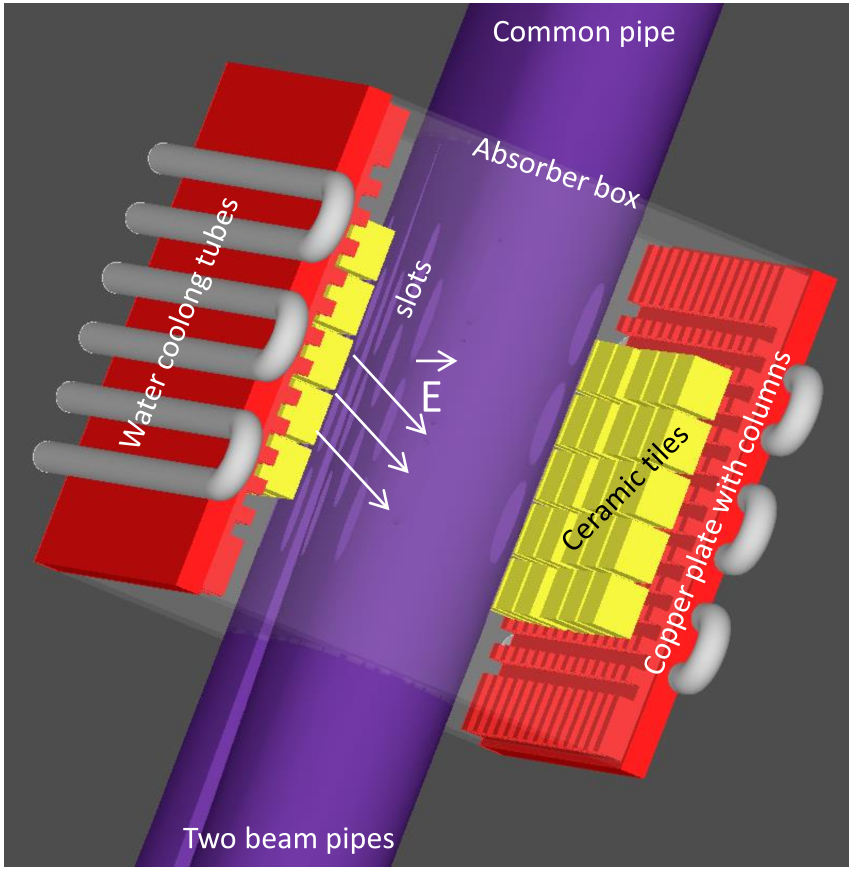
The absorber vacuum box is placed around the beam pipe connection. Inside the box we have ceramic absorbing tiles and copper corrugated plates .

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.



A. Novokhatski

Comparison of resistive heat loads (Be pipe) and temperatures

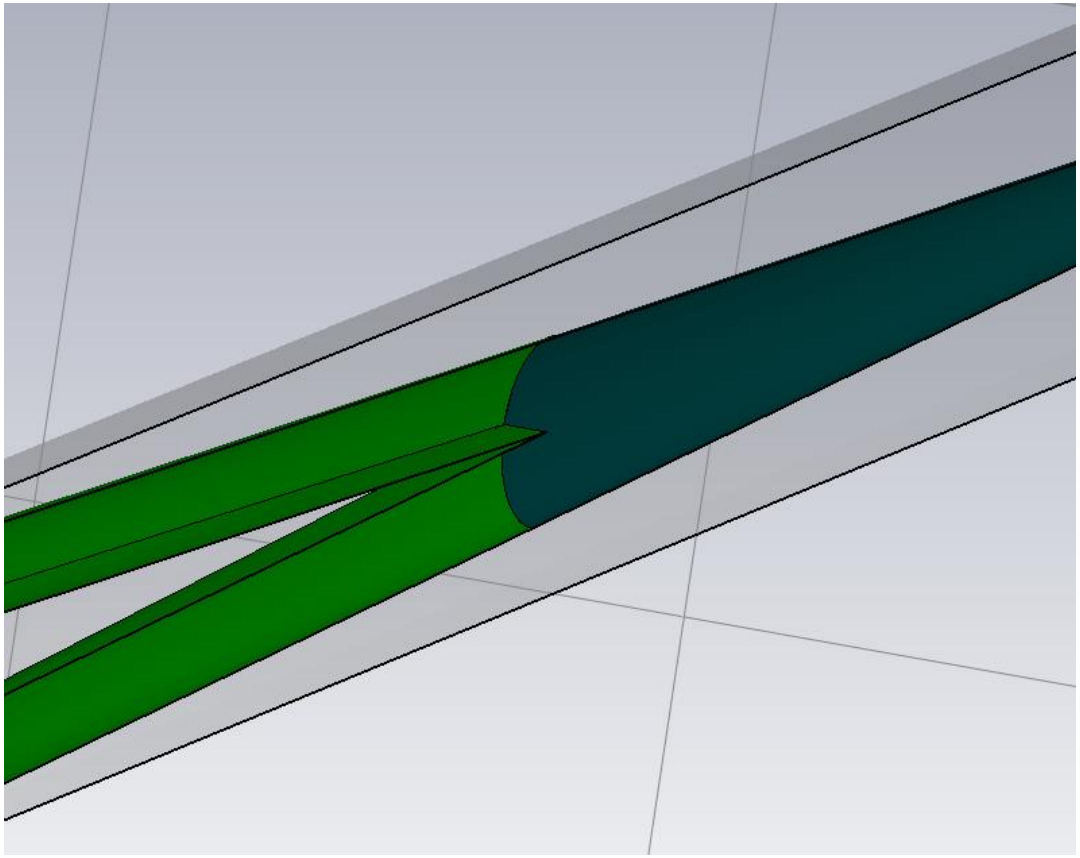
Beam pipe	Heat load	Max Temp. [K]
diameter [mm]	[W/m]	without cooling
30	97	88
20	145	198
10	290	792

Max temperature was calculated by formula

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

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

improved beam pipe model



L. Pellegrino, A. Novokhatski – work in progress

APPROACH

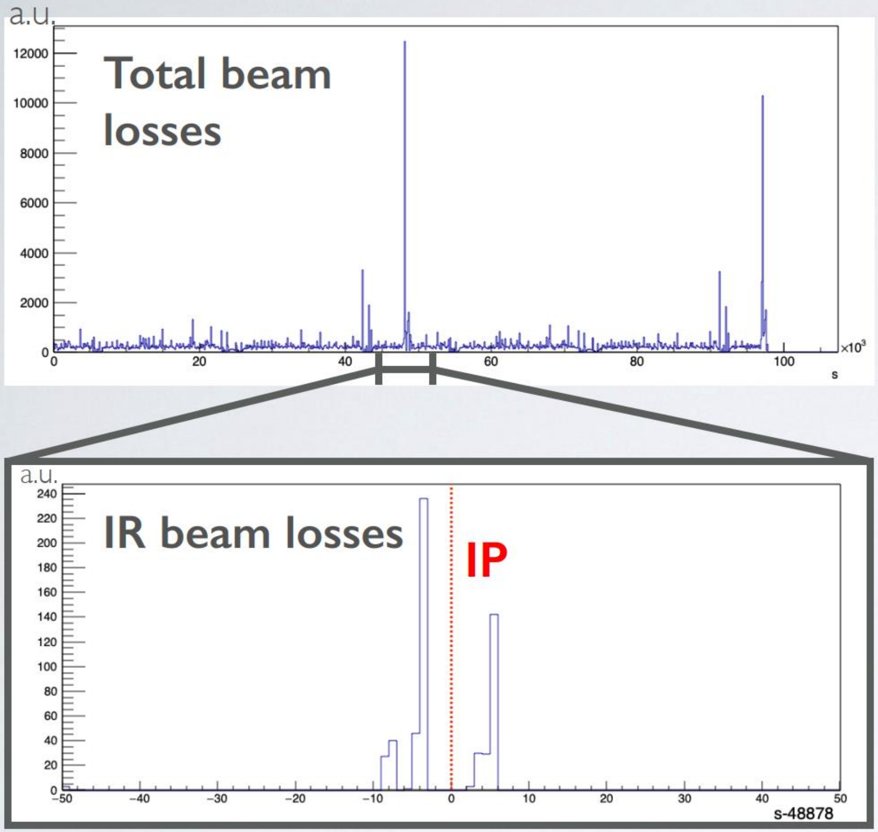
- **MAD-X** for the evaluation of transport matrices
- **Monte Carlo approach** (C++) to track the beam particles that experience:
    - radiative Bhabha
    - beamstrahlung
    - beam-gas (Coulomb and Bremstrahlung)
    - Touschek
    - thermal photon scattering (presented by Helmut)

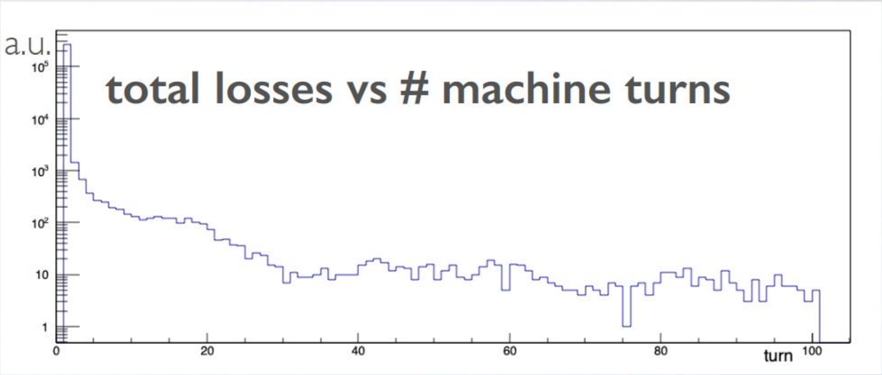
- Particles are **tracked** through the beamline (only few particles in small Regions Of Interest [ROIs])
- **Multiturn tracking** can be performed for through the ring
- **Record 6D coordinates of the lost particles** in .root file

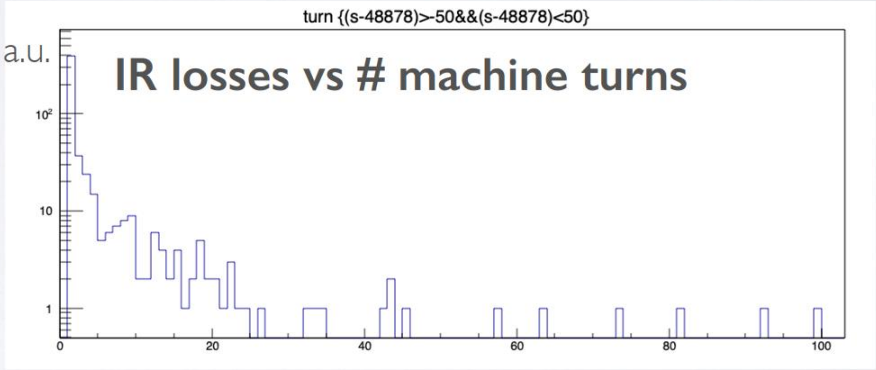
(that can be tracked through the beampipe with G4 for example into detector, lumical,…)

A. Ciarma

FIRST RESULTS: ELASTIC BEAM-GAS







- Most of the particles are lost near the 2 IPs, close to the IR quadrupoles, where the physical aperture gets smaller.
- The losses occur mostly during the first turn, right after the elastic beam-gas scattering.

PRELIMINARY: Note that plots are not weighted!

A. Ciarma

Summary

K. Oide

- BBBrem has been implemented in SAD.
- Estimation of beam loss due to radiative Bhabha has been tried for an FCC-ee Z lattice.
- Beam losses:
    - 4 kW by 400 m downstream the IP.
    - 150 W within the first quad QC1
- The effect of beam-beam is about 20% on the loss at QC1.
- The result is neither sensitive to the misalignment of aperture at QC1, nor to the IP solenoid field.

- The tolerance of the final quadrupole for such amount of beam loss must be examined.
- Cross check with other method is necessary (eg. D. El Khechen's with GuineaPIG++ and SAD, at 94th optics meeting).

EM fields of colliding bunches, Beamstrahlung

FCC-ee IR, complex case, combination of several significant effects :

- ± 15 mrad horizontal crossing angle
- waist $\sigma(s) = \sigma^* \sqrt{1 + \frac{s^2}{\beta^{*2}}}$ $\beta y^* = 0.8$ mm $\sigma z = 12.1$ mm at Z energy with BS
- high $\xi y = 0.133$ implying rather dynamic σy, βy
- solenoid field
- synchrotron radiation in field of opposing beam (Beamstrahlung)
  quick estimate (classical SR and GUINEA-PIG)
  some **MW / IP** with spectrum extending into tenths of MeV
  strongly varying with bb-parameters and residual separation

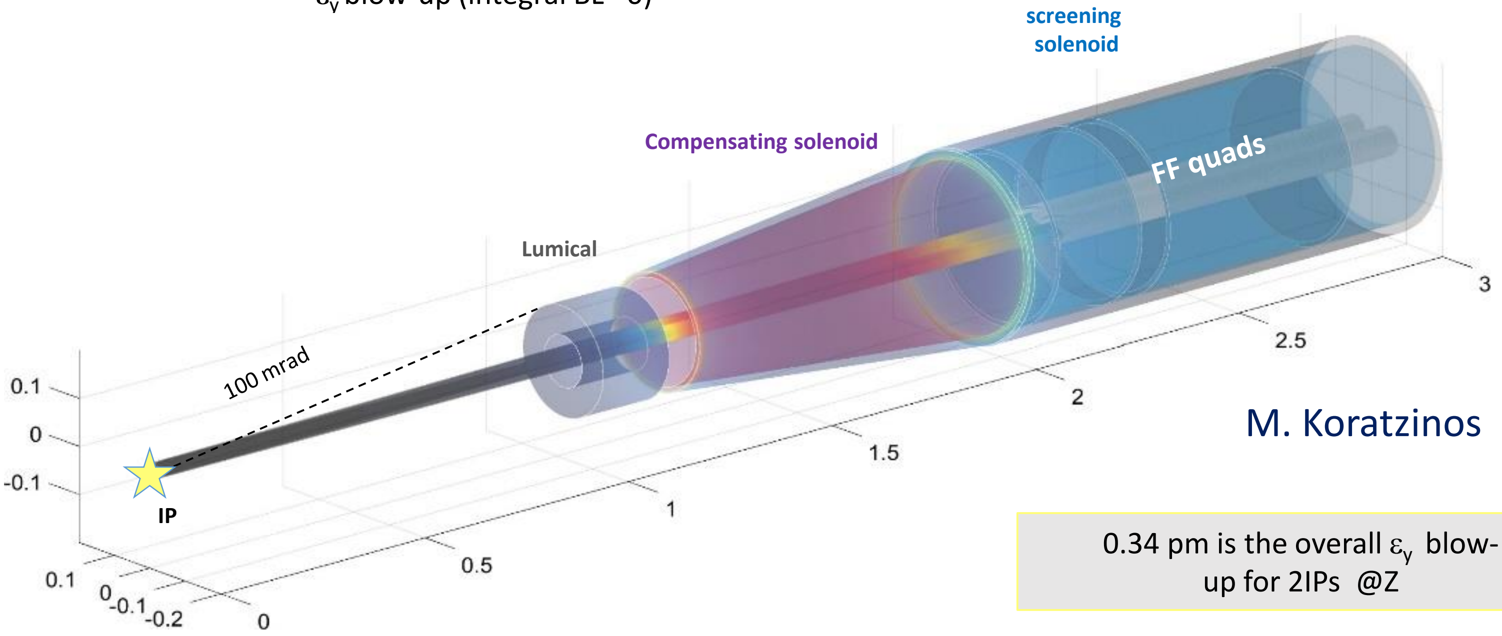
H. Burkhardt

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)

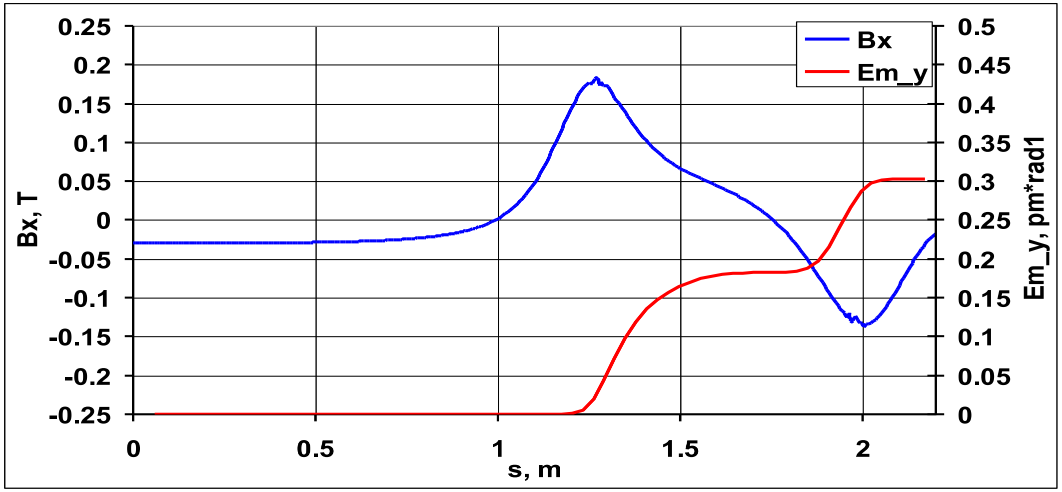


M. Koratzinos

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)

Vertical emittance calculation for baseline



For 2 IPs $I_2 = 5.65 \cdot 10^{-4}\ m^{-1}$ $\beta_y^* = 1$ mm

$$I_{5y} = h_y^3 \oint H_y(s)ds = 6.00 \cdot 10^{-14}\ m^{-1}$$

$$\varepsilon_y = 3.83 \cdot 10^{-13} \cdot \frac{\gamma^2}{J_y} \cdot \frac{I_{5y}}{I_2} = 0.3\ pm*rad$$

$$I_{5y} \sim B_x^5 \sim B_s^5 \qquad \varepsilon_y \sim B_x^5 \sim B_s^5$$

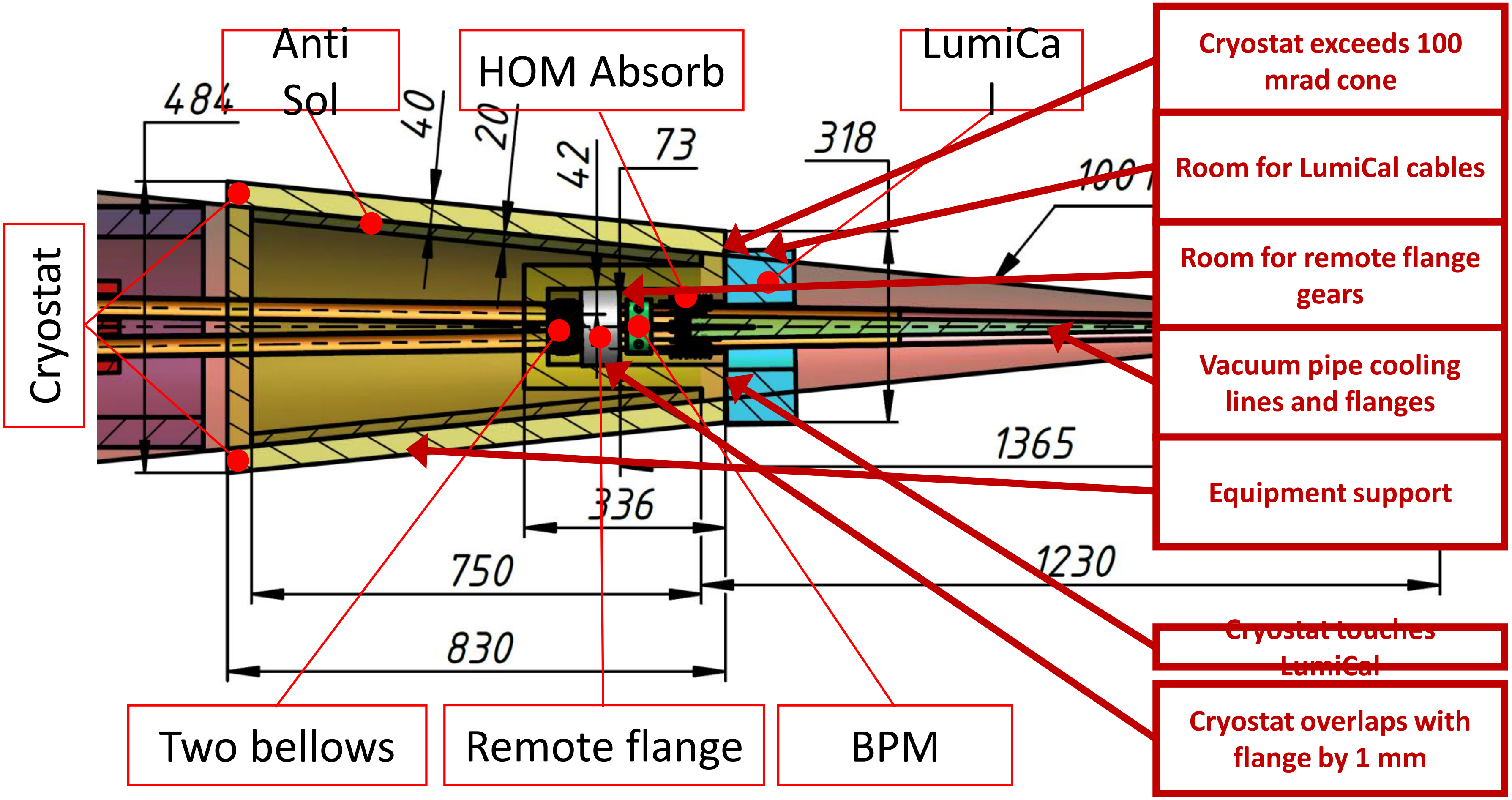
Energy = 45 GeV

βy = 0.8 mm

Ɛy = 0.38 pm*rad

S. Sinyatkin

Baseline (with M. Koratzinos' dimensions)



Anti Sol

HOM Absorb

LumiCa l

Cryostat

Cryostat exceeds 100 mrad cone

Room for LumiCal cables

Room for remote flange gears

Vacuum pipe cooling lines and flanges

Equipment support

Cryostat touches LumiCal

Cryostat overlaps with flange by 1 mm

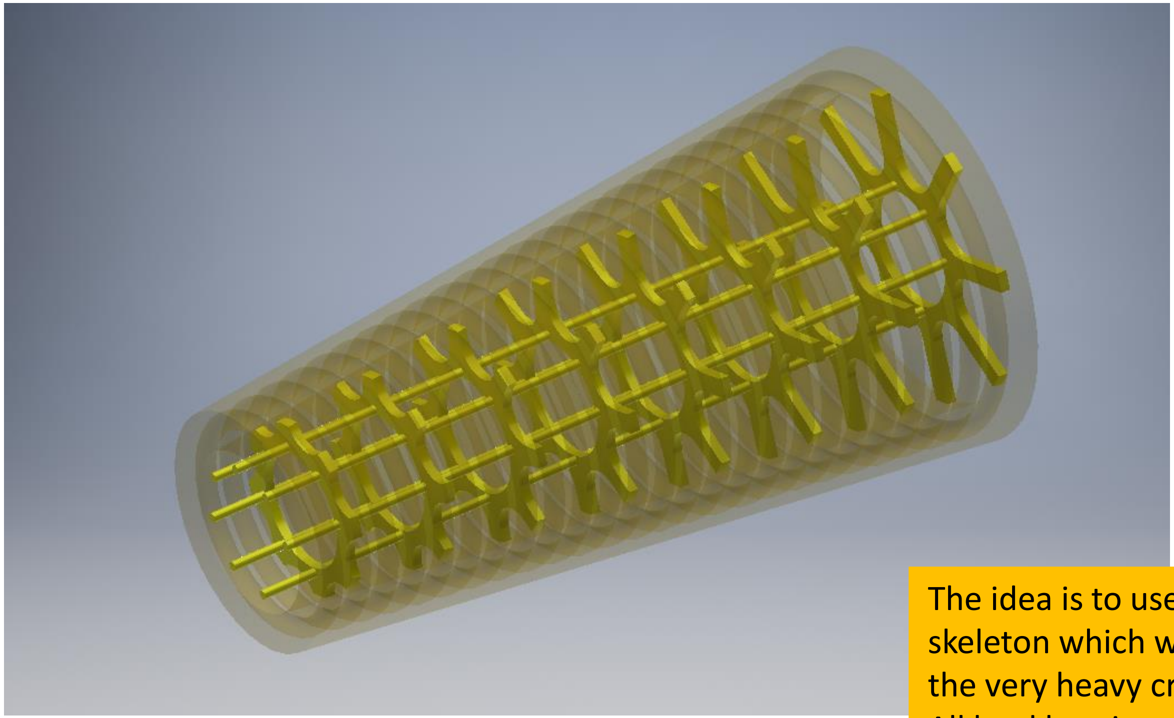
Two bellows

Remote flange

BPM

A. Bogomyagkov

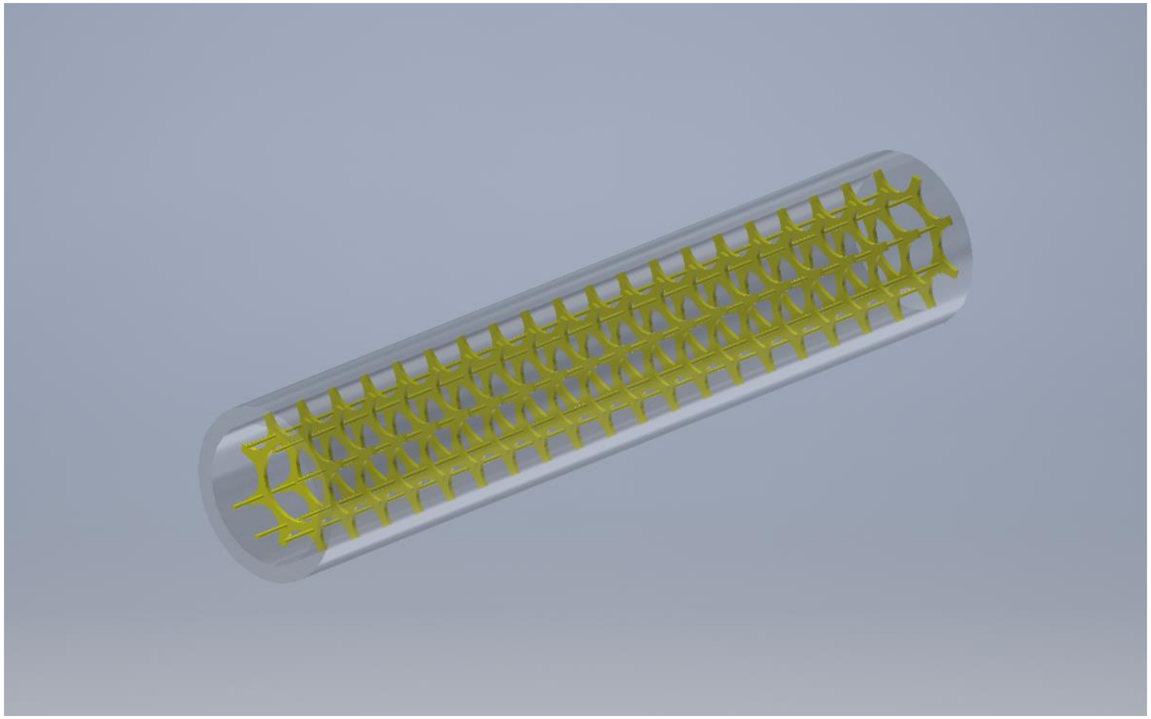
Mechanical design: compensating solenoid



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

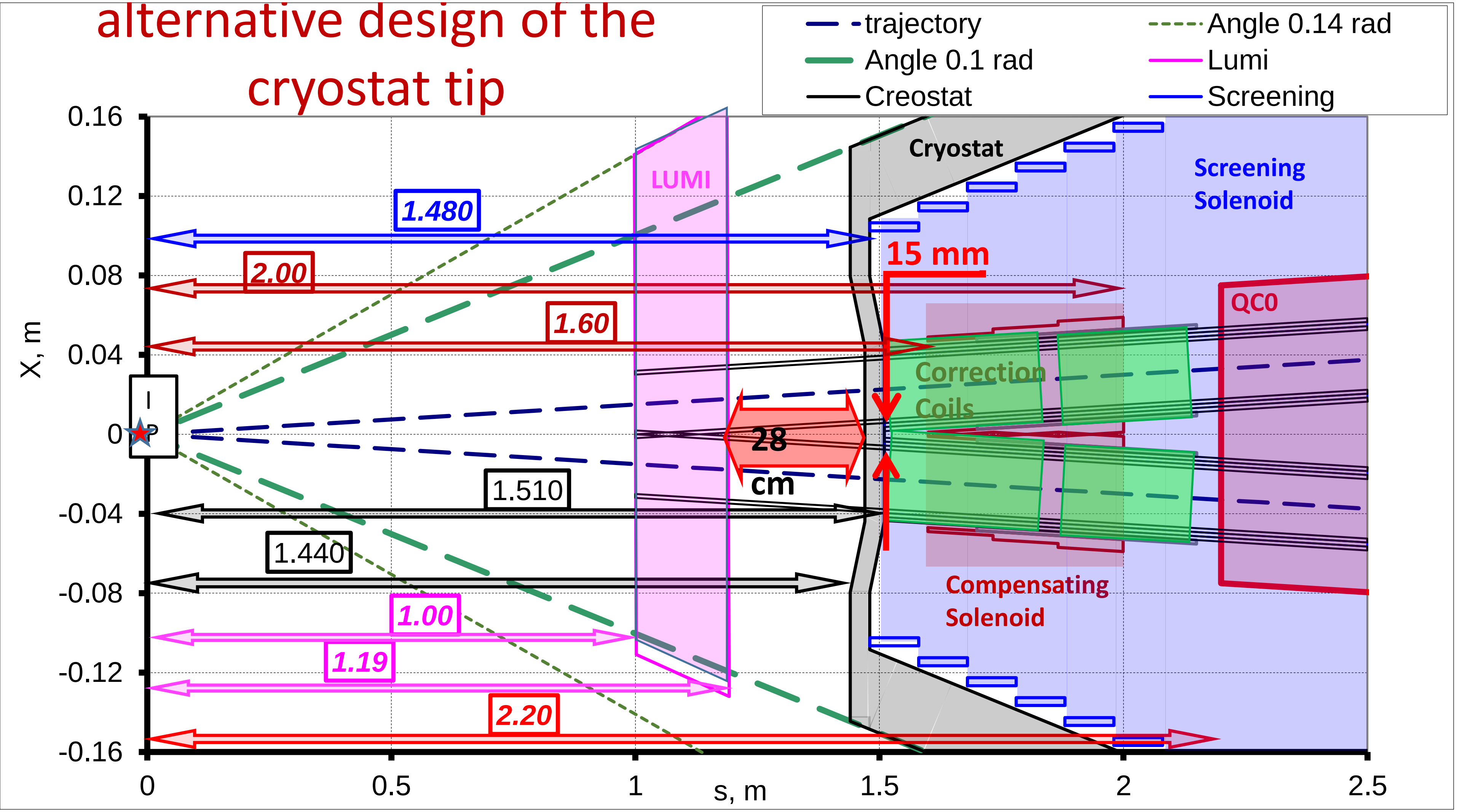
M. Koratzinos

Screening solenoid



M. Koratzinos

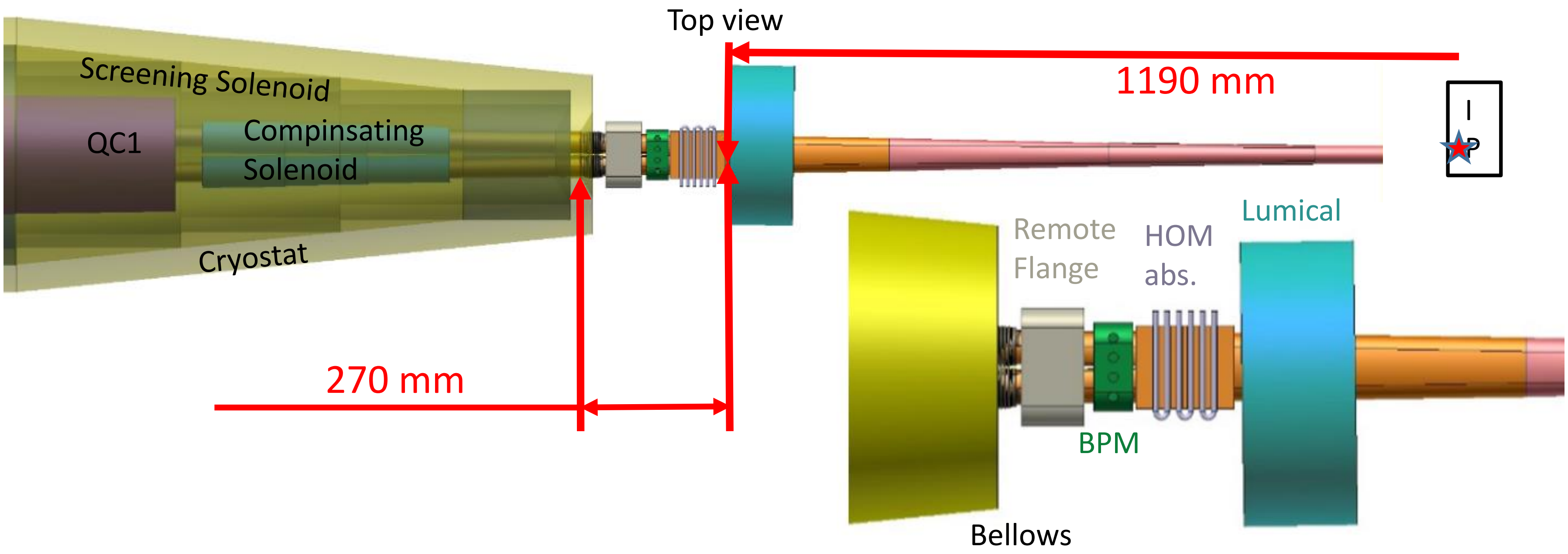
alternative design of the cryostat tip

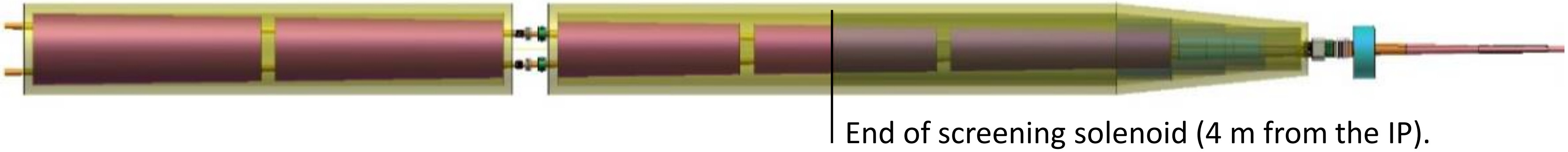


A. Bogomyagkov

3D views II

Alternative design of the cryostat tip

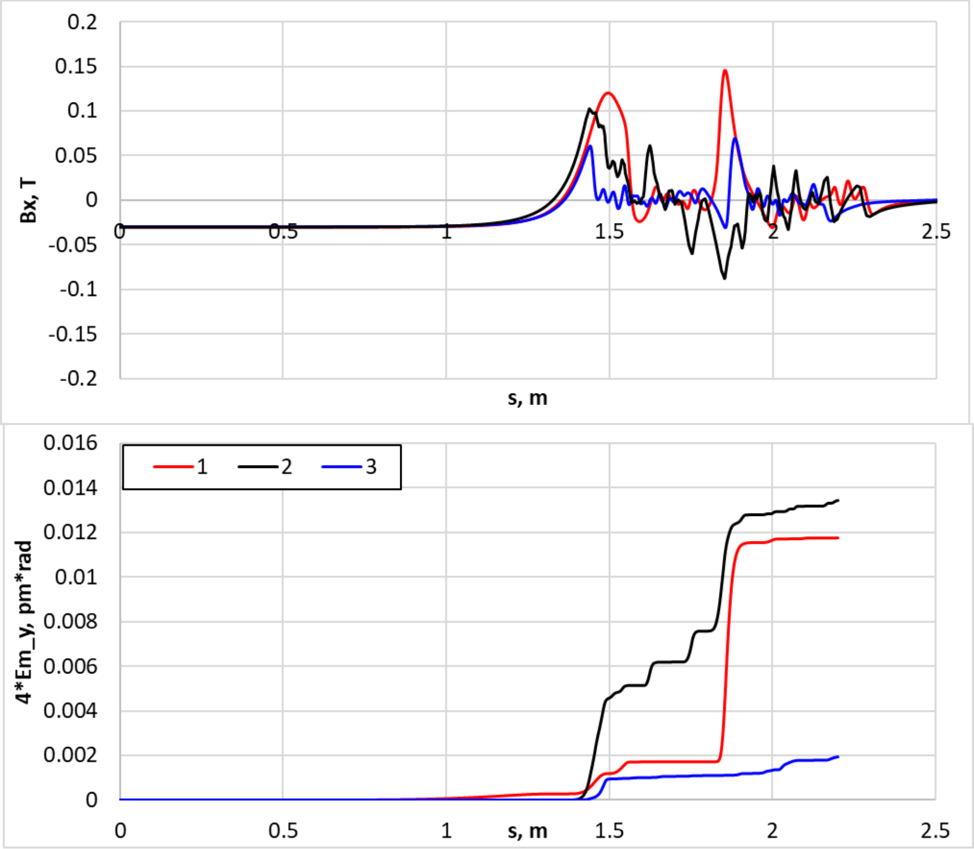




End of screening solenoid (4 m from the IP).

A. Bogomyagkov

Blow-up of vertical emittance (after correction by dipole and skew quads correctors)



1 - Individual cylindrical solenoid for each beam

2 - Cylindrical solenoid for a both beams

3 - Elliptical solenoid for a both beams

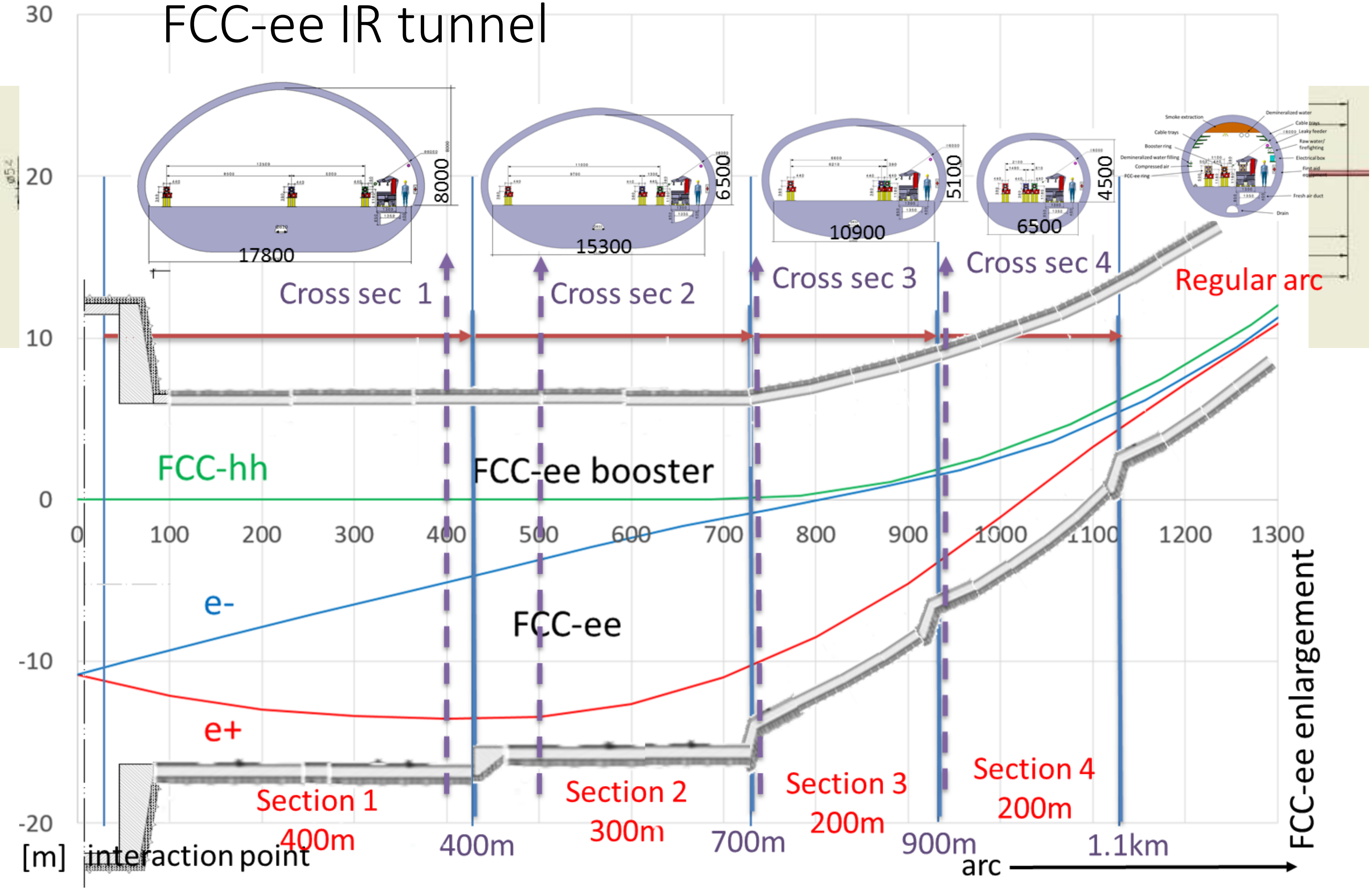
After correction of horizontal magnetic field and betatron coupling by dipole and skew quad coils of compensating solenoids.

Vertical emittance (2IPs):

Em_y < 0.014 pm*rad

S. Sinyatkin

FCC-ee IR tunnel

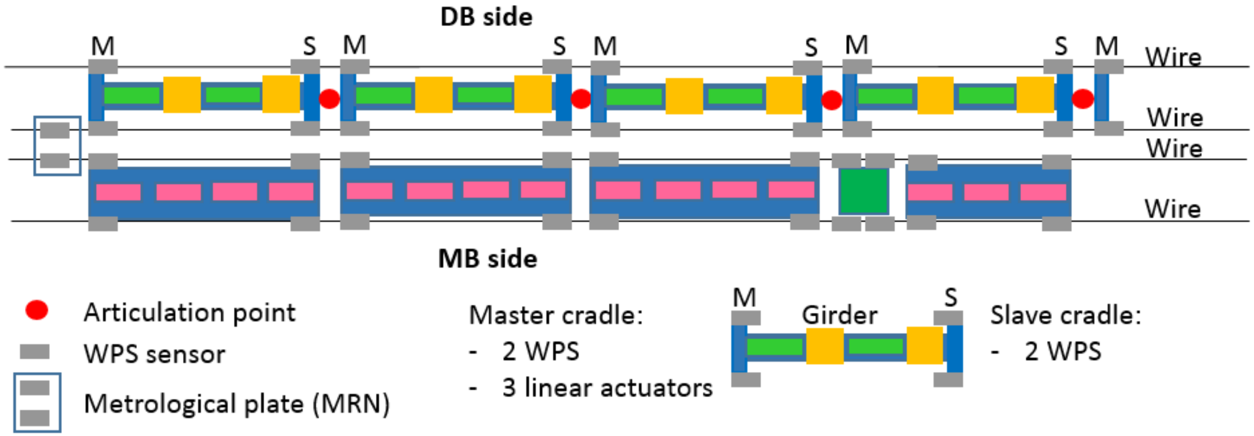


M. Jones

FCC-ee Position Monitoring & Alignment

- Concept based on design for CLIC
  - Full Remote Position Monitoring and Alignment System
  - Wire Position sensors
  - Hydrostatic Levelling sensors
  - Motorised positioning system

Design for CLIC



M. Jones

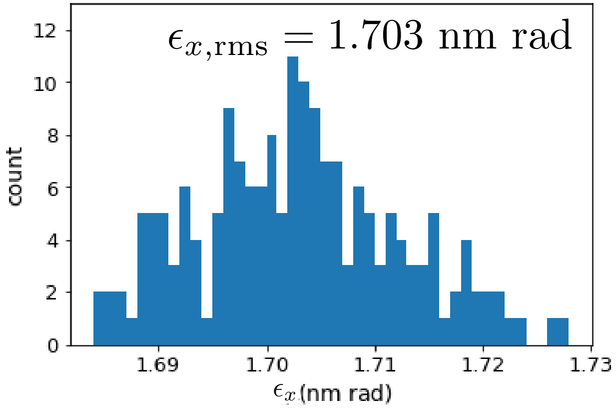
Preliminary corrected 4 IPs lattices, ttbar

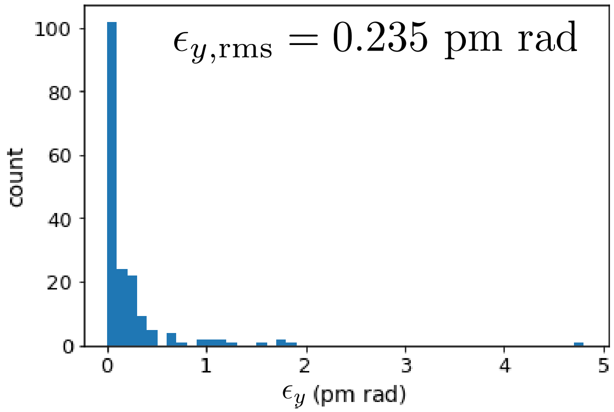
Using the misalignments and roll angles:

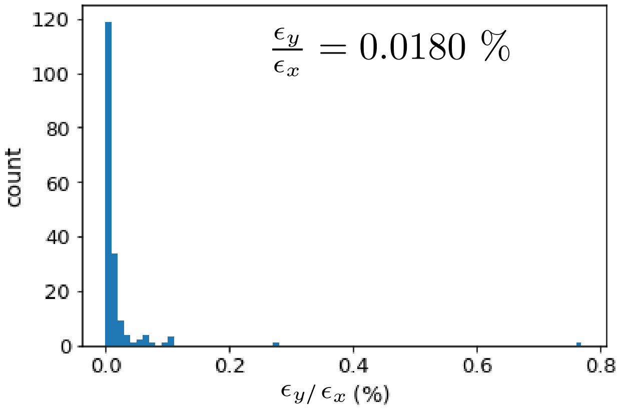
	$\sigma_x(\mu\mathrm{m})$	$\sigma_y(\mu\mathrm{m})$	$\sigma_\theta(\mu\mathrm{rad})$
arc quads	100	100	100
IP quads	100	100	100
sextupoles	100	100	100
dipoles	100	100	100

96% of seeds successful.

After correction:







presently even better than 2 IP solution

T. Charles

IR vacuum modelling for SuperKEKB – important benchmark

- Without taking into account the photon reflection and scattering, **our calculations with SYNRAD+ agree with those in the Belle II design report** (predicting a peak pressure of 6.10^{-5} Pa at the interaction point and 10^{-7} Pa in the ring)
- **Including photon reflection and surface roughness shows that a low, scattered photon flux hits almost every surface in the interaction region**
- **Direct incidence locations** receiving high photon flux condition rapidly during machine conditioning, therefore the molecule yield of **10^{-5} molecule/photon used in the Belle II design report is a valid assumption**
- **On other surfaces**, however, the low photon flux cannot scrub sufficiently during conditioning, and **these areas remain considerable outgassing locations**, elevating the total PSD yield to 2.10^{-4} molecules/photon after 1000 A.h
- **This results in a pressure which is almost an order of magnitude higher than that calculated in the design report after 1000 A.h, and would reach the expected values after 10000 A.h (116 days at full current)**

R. Kersevan

Summary

- The QCS system which consisted of 55 SC magnets was operated with beams in Phase-2 and Phase-3.
  - During the two operations:
    - Phase-2: 25 quench events by beams
    - Phase-3: 3 quench events by beams
- In beam induced quenches (28 events):
  - Main quadrupole + corrector : 10
  - Main quadrupole : 3
  - Corrector : 15
- Quenched magnets were focused on the area of QC1 magnets.
- With the new data logging system, the quench condition can be related with the beam operation.

N. Ohuchi

Winding the SuperKEKB b_5 Cancel Coil 25 September 2013

B. Parker, *et.al.*, "THE SUPERKEKB INTERACTION REGION CORRECTOR MAGNETS," Contribution TUPMB041 to Proceedings of IPAC2016, Busan, Korea, May 2016, pp. 1193-1195.

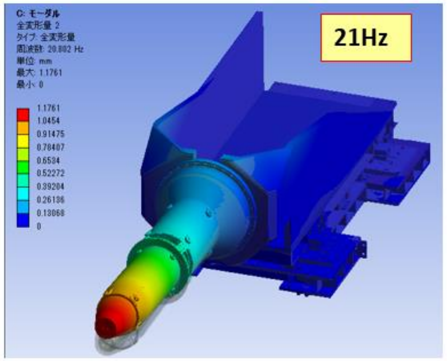
B. Parker, *et.al.*, "SUPERCONDUCTING CORRECTOR IR MAGNET PRODUCTION FOR SUPERKEKB," Contribution THPBA07 to Proceedings of PAC2013, Pasadena, CA USA, pp. 1241-1243.

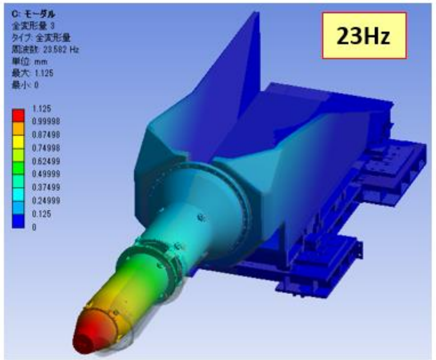
B. Parker, *et al.*, "Direct Wind Superconducting Corrector Magnets for the SuperKEKB IR," Contribution WEEPPB013, to IPAC12, New Orleans, USA, May, 2012.

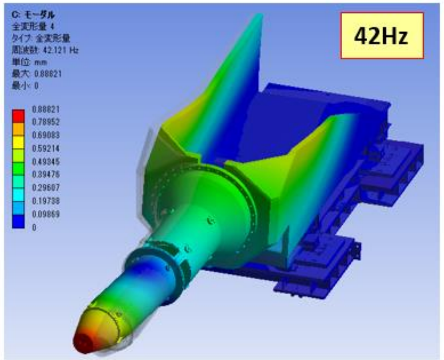
B. Parker

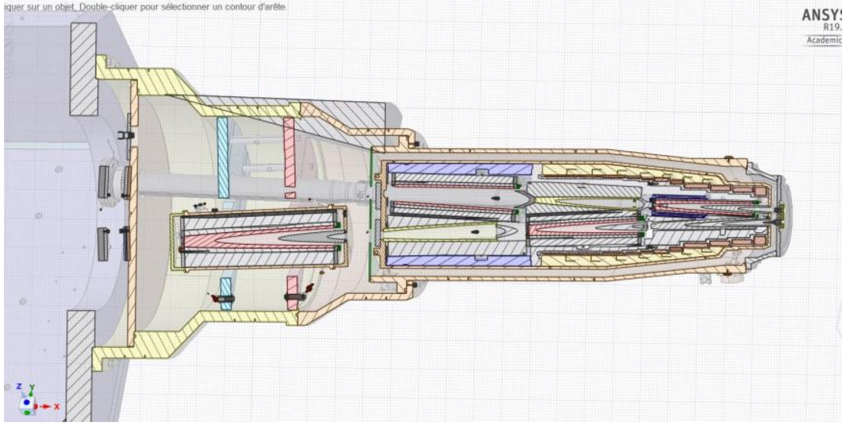
SuperKEKB : MDI area and FF system

- Mechanical Modelling (KEK):





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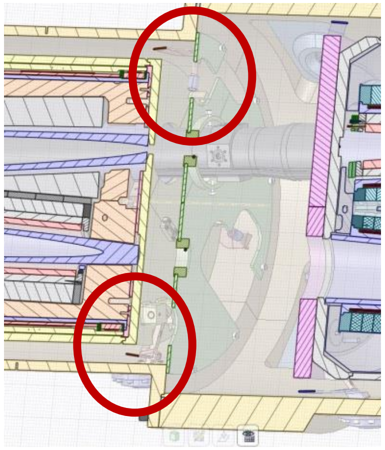

- Complex simulation - lack of experimental measurements (ex: junctions)

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, ...

H2020 DS proposal WP2 - *draft*

Description of work (including tasks, lead partners and roles of participants)
Task 2.1: Work package management (***lead: DESY,*** *participants: CEA, CERN, CNRS, KIT, INFN, UOXF)* DESY with the assistance of CERN coordinates the tasks in this WP to ensure consistency of the work according to the project scope and plan. This includes the organisation of coordination meetings, workshops, management of the scope, progress reviewing, reporting and distribution of information within the WP as well as the management of the interfaces and collaborative work with the other WPs. While DESY, CEA, CERN, KIT and UOXF focus on the overall machine design coordination and INFN coordinates the work around the interaction region with CNRS. CERN coordinates the interfaces with the theoretical and experimental physics communities for requirements finding and for those elements, which are need to be considered for subsequent project preparation and detailed technical design phases. This includes the open documentation of a Product Breakdown Structure (PBS, **M2.1**), the configuration management of design files (document and data repositories, element database) and the editing of the associated key deliverables (see **D5.5** and **D5.8, WP 5**). **Task 2.2: Collider design** (***lead: DESY****, participants: CEA, CERN, CNRS, KIT, UOXF)* Develop the baseline parameters and machine layout, starting with the consideration of the physics programme requirements (**D2.1**). Compute a workable beam optics, integrates the corrections, develops tuning approaches and documents the lattice. Ensure that the design matches the physics programme requirements in an iterative fashion with tasks 2.2 and 2.3. This includes in particular the analysis and mitigation of different impact factors (impedance, single-beam collective effects) in the design. Conceive an effective beam diagnostics architecture, specify the device functions and performances. Develop the concept for the global orbit control system. Verify the beam optics experimentally at ESRF and/or PETRA III (**D.2.2**) and integrate the findings for the main deliverable of the project (**D5.8**). **Task 2.3: Machine detector interface** (***lead: INFN****, participants: CERN, CNRS, DESY, UOXF))* Ensure that the final focus is designed to meet the collider performance goals and develop a suitable machine detector interface coherently with task 2.2. Develop a concept for the luminosity measurement. Analyse the design and propose effective design measures to control the background and to protect the machine. Review the SuperKEK IP feedback, its architecture, performance, merits and limitations. Beam-beam measurements are envisaged at DAFNE INFN-LNF with the crab-waist collision scheme. **Task 2.4:Full-energy booster and top up injection** (***lead: CEA,*** *participants: CERN, …)* Design a full-energy booster and integrated it with the collider using a top up injection scheme. . Document (PBS, **M2.1**) the design, including the necessary equipment elements and expected performances with a level of detail that permits entering the next stage, the detailed technical design. **Task 2.5:Polarisation and energy calibration** (***lead: KIT?,*** *participants: CERN, …)?*

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