FCC

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INFN LNF CERN

MDI STATUS AND PLANS

Manuela Boscolo and Mike Sullivan

3 December 2021
FCCIS WP2 workshop

Agenda

MDI Part 1		
09:00 - 09:20	MDI status and plans	Manuela Boscolo
09:20 - 09:40	Mechanical model	Francesco Fransesini
09:40-10:00	CAD integration	Luigi Pellegrino
break		
10:15 – 10.40	Alignment system in the MDI	Leonard Watrelot
10:40 – 11:00	Vibration tolerance for iP and arc magnets, feedback performance criteria	Katsunobu Oide
11:00 – 11:20	Strategy for vibration suppression	Laurent Brunetti
11:20 – 12:00	MADX simulations of vibration in the MDI	Eva Montbarbon
Lunch		

MDI Part 2		
13:30 – 14:00	Low angle radiative bhabha monitor	Alain Blondel
14:00 – 14:30	CCT magnet design	Mike Koratzinos
break		
15:15	CCT magnet tour	

MDI main tasks

1. **Engineering mechanical model with assembly concept**
2. Backgrounds, beam loss and radiation
3. **Conceptual design of IR elements/systems**
4. **Alignment tolerances & vibration control**
5. Heat load assessment

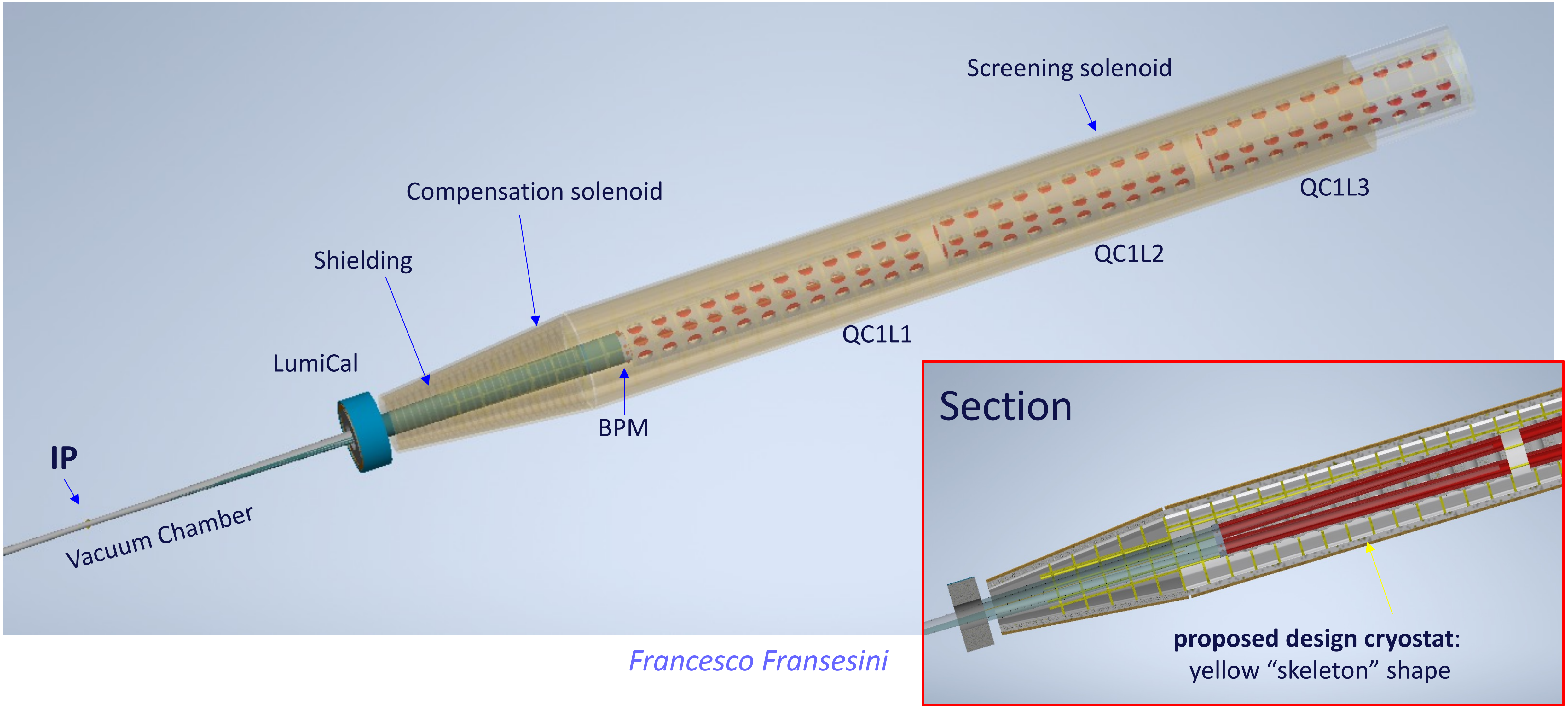
1. Engineering mechanical model with assembly concept

- Beam pipe design
- Magnets integration
- Cryostat integration
- Shielding
- IP detectors integration
- Vacuum system integration
- Supporting structures
- Thermal simulations
- Management of electrical and hydraulic connections/routing
- Mechanical IR assembly, disassembly & repair procedures
- Project Design Management

Proposed related goals and deliverables
- 3D CAD model of the whole IR
- Preliminary structure design including detector support and maintenance
- Thermal and mechanical simulations
- Civil engineering requirements
- Prototypes:
  - IR central chamber
  - alignment devices?

CAD integration, next presentation by L. Pellegrino

3D View of the MDI

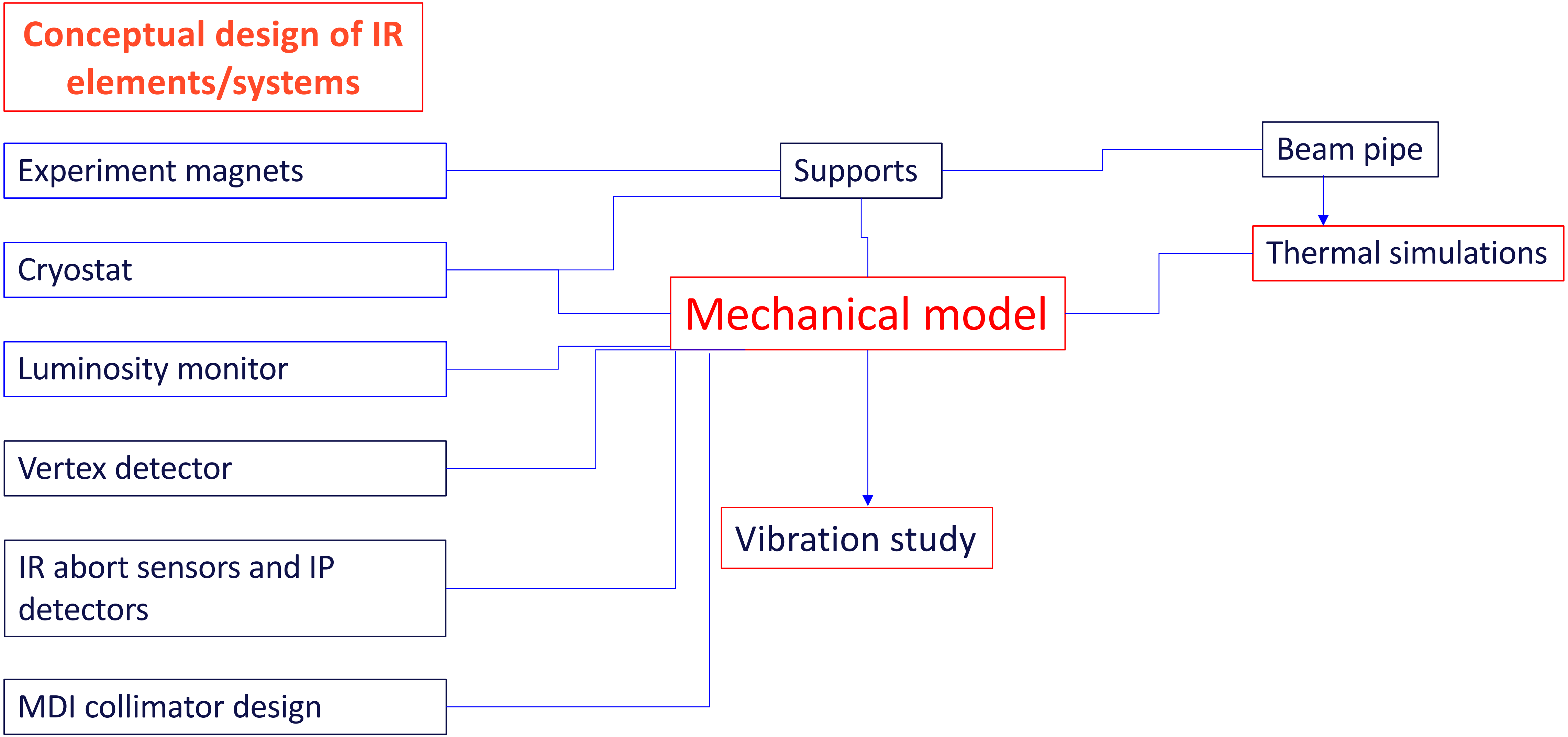


Francesco Fransesini

Mechanical model and integration

	Comments
Mechanical IR assembly, disassembly & repair procedures	LNF will integrate the systems as they are ready
beam pipe design	
Magnets integration (QC1, solenoids)	*cryomagnet volume, weight, essential to design the supports, required to start with vibration analysis and progress on the MDI assembly*
Cryostat integration	
luminosity calorimeter, vertex detector integration	Concept in CDR, need an engineered design
Shielding	input from backgrounds simulations
Vacuum system integration	proposal of R&D on remote vacuum connection
Supporting structures	*dependent on cryomagnet engineer and cryogenic engineer. Essential to start with vibration studies*
Thermal simulations	*dependent on pipe and systems design*
Management of electrical and hydraulic connections/routing	

Engineering mechanical model with assembly concept



Alignment tolerances & vibration control

- Alignment specifications
- Alignment /survey strategy, space requirements
- Vibration study, stabilization strategy, space requirements
- Feedback systems for beams collision adjustment; ; feedback to maintain luminosity with top-up injection

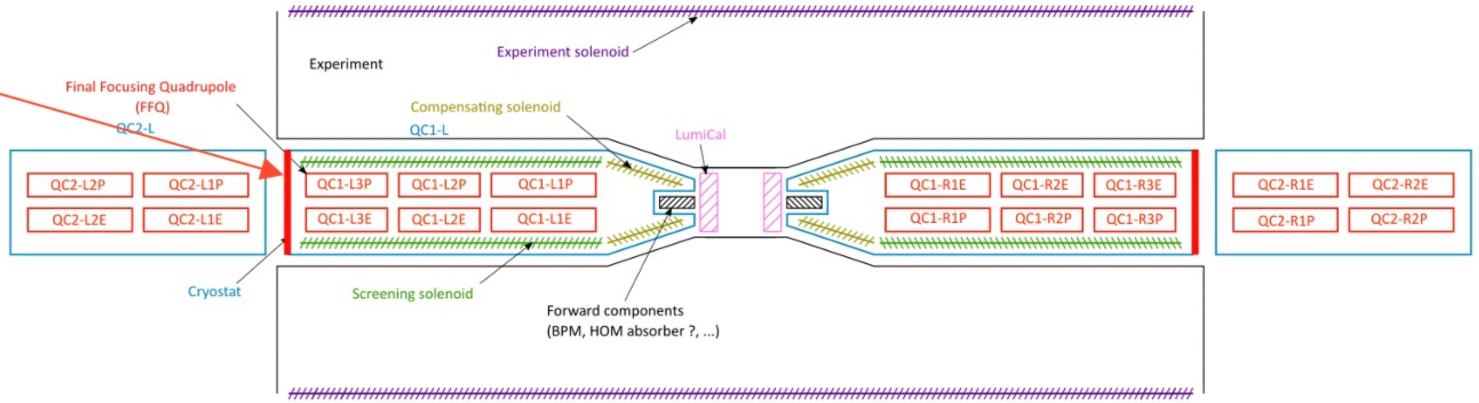
Heat load assessment

- Resistive wall
- Geometric impedance, HOM heat load, HOM absorbers
- Heat load from synchrotron radiation, Beamstrahlung, radiative Bhabhas
- Electron clouds
- Cooling of detector elements

Léonard Waterlot

Alignment

Strategy under study



Two systems to monitor the MDI:
- external monitoring system
- Internal monitoring system

The interface would be monitored from the outside of the experiment.
This will allow the alignment of the interfaces of the two sides of the detector.

The interface would serve as a origin to compute the deformations of the cryostat and/or skeleton and the position of the inner elements.

Requirements on position measurements

- **Lumical** lumical-IP at 50 μm, two faces lumical at 100 μm
- **Final focus quads and sextupoles** radially 75 μm, longitudinally 100 μm
- **BPM** radially 40 μm, relative to quad displacement 100 μm

Final Focus quadrupole canted cos-theta design

M. Koratzinos

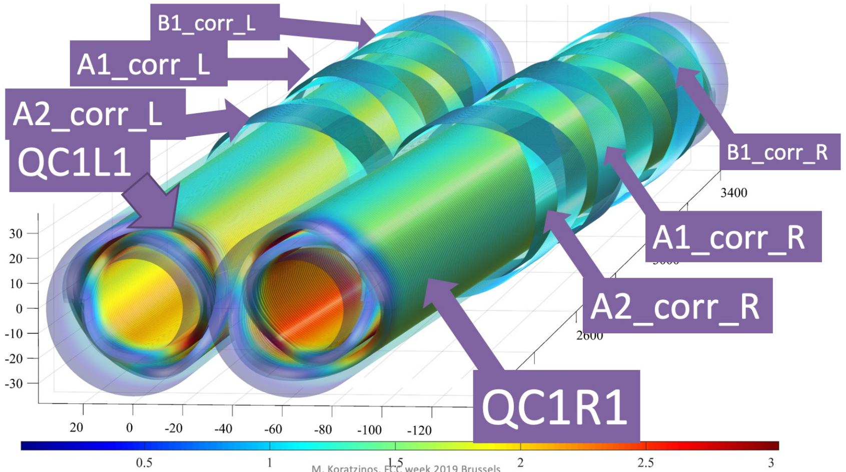
Iron-free design,it can provide an excellent field quality
One prototype designed, manifactured, assembled and tested at warm at CERN

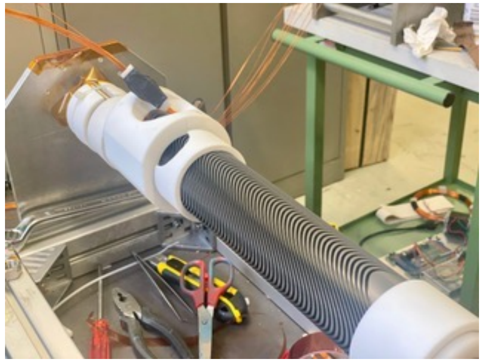
- Conductor technology NbTi
- The maximum field gradient is 100 T/m.
- QC1 inner diameter of beam pipe 30 mm
- (minimum distance between the magnetic centers of e+/e- for QC1L1 is only 66 mm)

QC1 will be embedded in the screening solenoid and cryostat, all inside the detector

Open points & next steps:

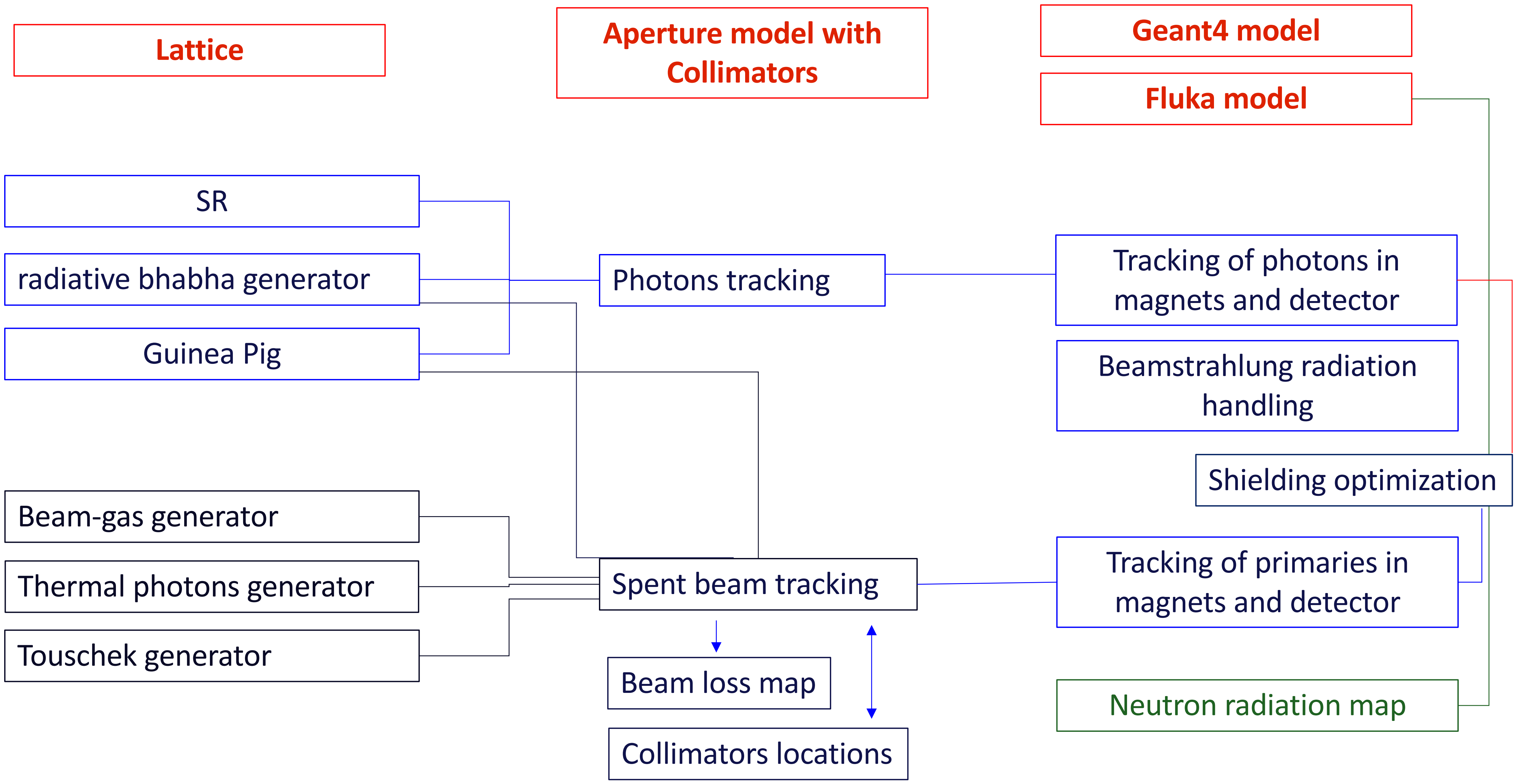
- Cold test on the prototype
- Cryostat engineered design
- Proper shielding to avoid quenches
- Supports for vibration mitigation studies





prototype
during construction

Backgrounds, beam losses and radiation



Background control, beam loss and radiation

- Simulation evaluation of backgrounds in detectors and their mitigation
- SR backgrounds with masking & detector shielding optimization
- Other single-beam backgrounds (residual gas, Thermal photons and Touschek) collimators & detector shielding optimization
- Luminosity backgrounds
- Top-up injection background including beam-beam and dedicated collimation, masking and shielding
- Neutron radiation in the IR
- Machine and detector protection strategy

Related goals of the study

- Masking, shielding;
- collimation systems;
- Injection scheme(s);
- Backgrounds sustainability by detectors;
- Machine and detector protection strategy

SR backgrounds with masking & detector shielding optimization

- Tolerances in orbit in combination with top-up injection might lead to additional radiation effects.
- Optics changes with potential impact on the SR reaching the IR require new SR simulations. One example is a shift of the last dipole for the insertion of the polarimeter.
- Tail collimation.
- SR collimators in the MDI area, definition of location through the ring. Collimators hardware design.
- SR mask hardware design.
- SR from realistic solenoidal field, using map field.

Goal: solid knowledge of the characteristics of the emitted photons , and a carefully designed system of radiation masks and collimators

Next step on evaluation of detector backgrounds due to beam-related phenomena in the MDI area

0. Target: evaluation of detector backgrounds and occupancies indices by beam-related phenomena in the MDI region (interaction area plus neighbourhood).

1. Method: identify relevant processes and understand relevant codes; make them usable, publicly available and documented.

'Understand' means

a. finding the optimal input configurations for each energy point and making then easy to include/use

b. understand the output formats

2. Provide readers for the above mentioned out formats to inject these events into FCCSW/key4hep

3. Identify and provide an essential analysis and metrics allowing to measure the level of background corresponding to a given MDI configuration and a given detector concept (hit density in tracker, etc etc)

Status: work started with GuineaPig, concentrating mostly on incoherent pair production. A first version of MDIReader understanding GP events is available and has been used for a first estimation of hit densities in the CLD detector (CLIC detector for FCC-ee). Radiative Bhabhas (BBBrem) and SR codes are not being considered.

G. Ganis

Some present hot topics

Flow chart

Prioritization of topics as well as dependencies with other groups in view of the timeline:

- February 2022: 5th Physics workshop, Liverpool
- May/June 2022: FCC WEEK 2022
- June 2023: Mid-term review
- 2025: end of FS

CAD files server – common framework

Cryostat design

MDI collimators and beam loss map have a great impact on the MDI design

Additional topics to be addressed in this FS

Look at each machine for each energy run individually to optimize layout accordingly.

Follow-up of SuperKEKB problems and progress

Additional slides

FUTURE CIRCULAR COLLIDER

News – EPJ+

- M. Boscolo, H. Burkhardt, K. Oide and M.K.Sullivan,
  “IR challenges and the machine detector interface at FCC-ee”,
  EPJ+ (2021) 136:1068 (Essay in Part II) https://doi.org/10.1140/epjp/s13360-021-02031-5

- M. Boscolo, H. Burkhardt, G. Ganis and C. Helsens,
  ”Review and outlook of accelerator-related codes and their interplay with the experiments software”,
  EPJ+ (2021) (Essay in Part IV) 2111.09870

- M. Boscolo *et al., “Challenges for the Interaction Region design of the Future Circular Collider FCC-ee”,*
  Contribution to IPAC 2021 (May 2021), e-print: 2105.09698

Task3. Conceptual design of IR elements/systems

- Experiment magnets design with field map (solenoid compensation), spatial tolerance, electromagnetic forces, operational conditions
- Cryostat design, dimensioning cooling systems
- Luminosity calorimeter & luminosity measurement, including alignment with the rest of the detector
- Vertex detector
- IR beam abort sensors for detector protection
- Other IP detectors
- IR vacuum system, coatings & possible HOM absorbers
- Remote vacuum connection
- Beamstrahlung monitor
- MDI collimator design