MDI REGION MODELING IN KEY4HEP

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MDI region elements

The design of the FCCee Machine-Detector Interface region is **rapidly evolving** and it is necessary to keep the Key4hep model used for simulations up to date with the most recent modifications to the parts.

An accurate description of these elements is important to correctly estimate **material budget**, **power deposition** and **backgrounds**.

- Beampipe
- Magnetic elements
- Bellows
- Services
- Cryostats
- Shieldings
- …

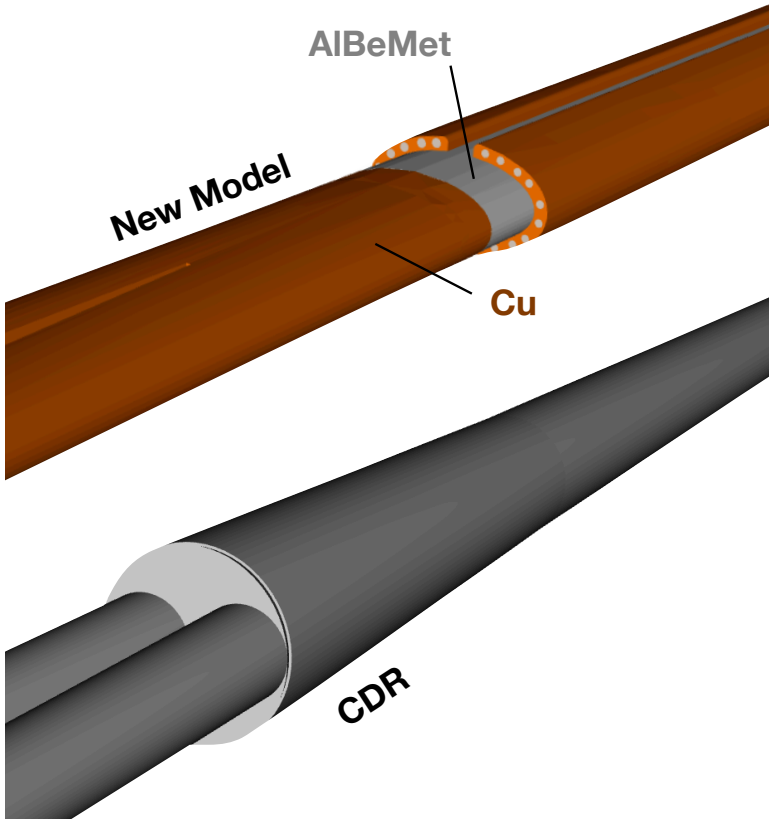
IR Beam Pipe CAD Model in key4hep

Current DD4hep beam pipe description is basically unchanged since CDR and uses only **euclidean** geometries.

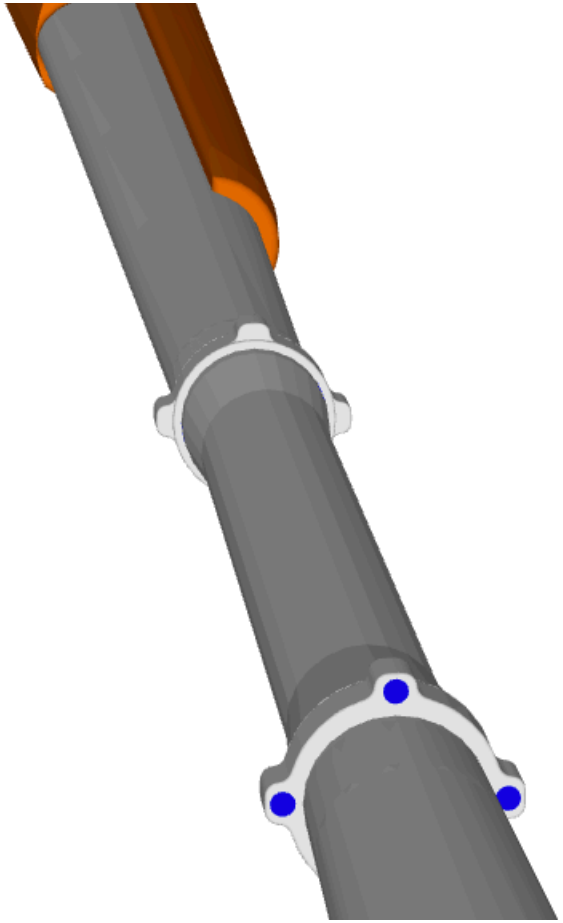
This can lead to **unrealistic representation**, in particular in the beam pipe separation region.

The **engineered CAD design** of the IR beam pipe (F. Fransesini INFN-LNF) is being **imported in key4hep** (k4Geo PR #283).

CAD design includes a detailed model of **AlBeMet** beam pipe (|z| < 1.2m), and a **Cu** beam pipe (1.2m < |z| < 6.0m) based on **impedance calculations**.



all images taken from geoDisplay



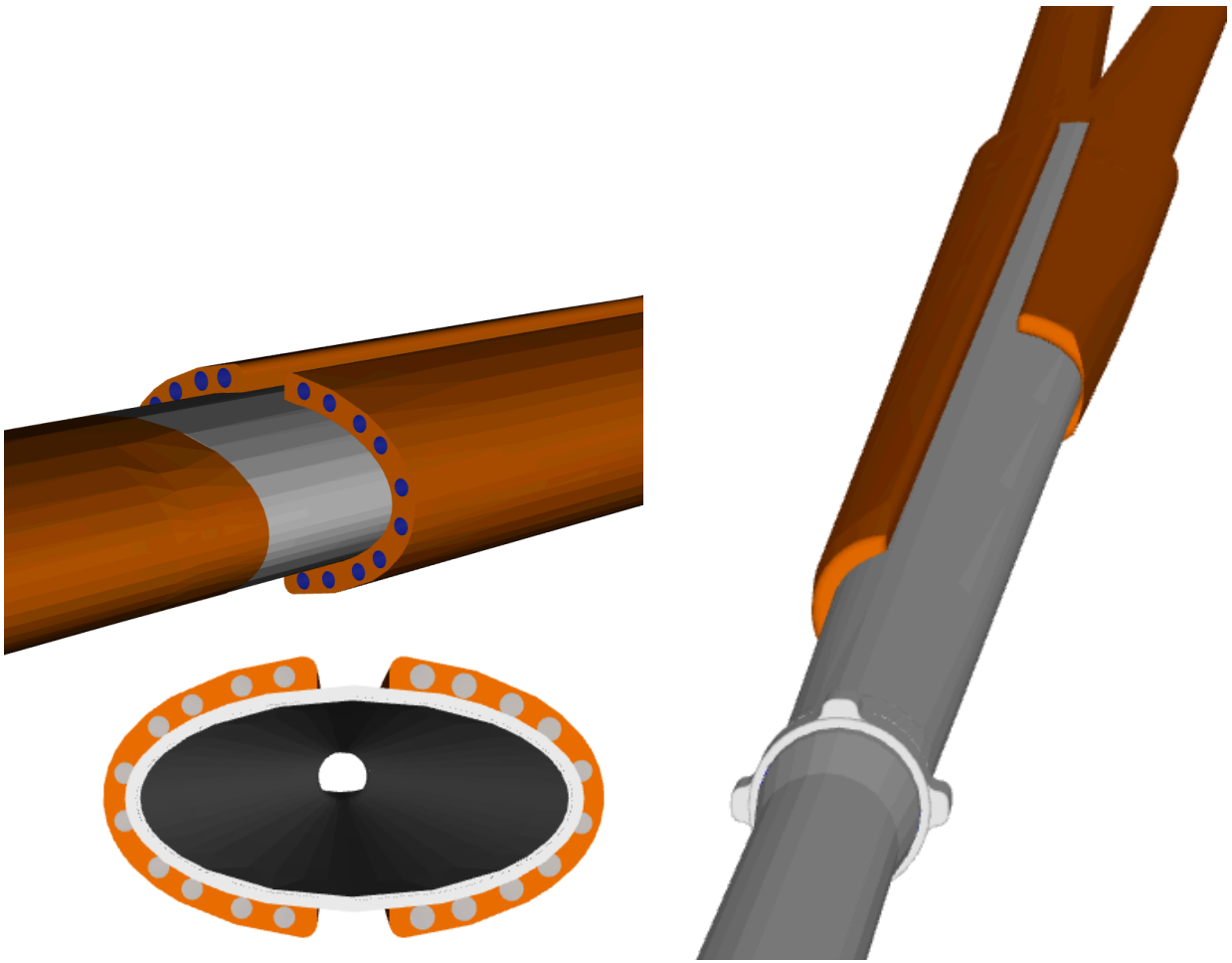
Central Chamber

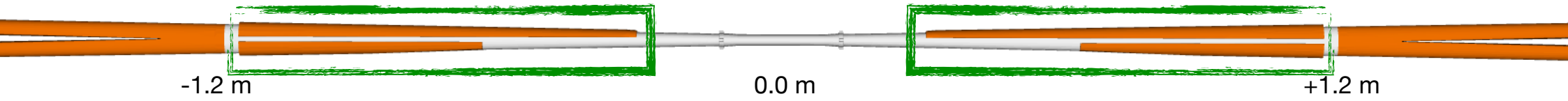
- 10mm radius, 180mm length AlBeMet162 cylindrical pipe
- Double layer for **Paraffine cooling**, with AlBeMet **inlet/outlet** for coolant
  - 2x 0.35mm AlBeMet jackets, 1.00mm Paraffine layer
- Thin **Gold layer** for photon absorption

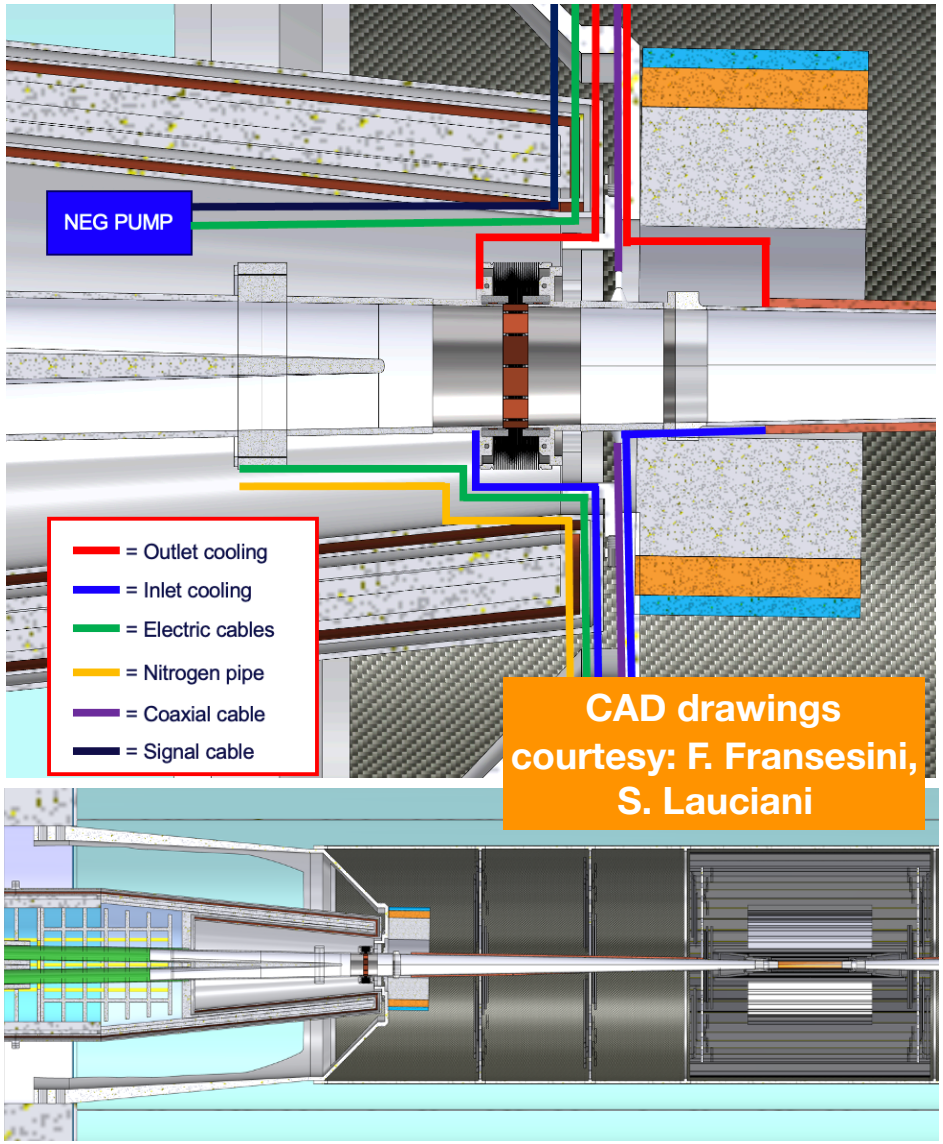
-1.2 m 0.0 m +1.2 m

Trapezoidal Chamber

- AlBeMet pipe with **realistic outline** smoothly transitioning to beam pipe separation
- Copper cooling manifolds tapered to stay **outside the LumiCal acceptance**
- **Water channels** included in the model







What's left?

The work on the MDI region engineered design is going on (F. Fransesini, S. Lauciani). Elements under development are:

- Service cables for cooling (paraffine and water), vacuum and electronics
- Remote vacuum connection
- Bellows
- Vertex Detector Support Cylinder
- BPMs

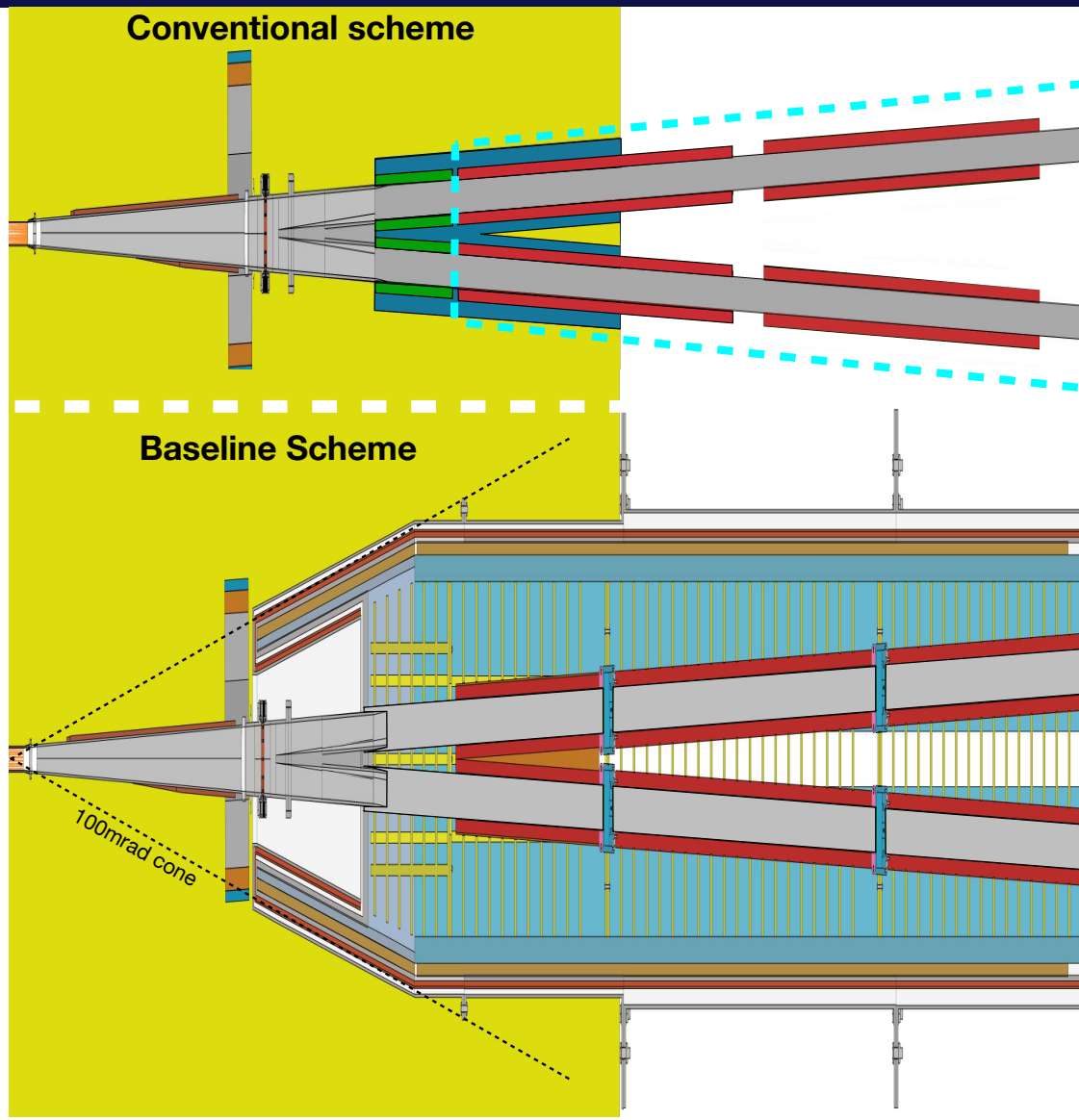
As stable designs for these elements are produced, the CAD models can be imported in key4hep too.

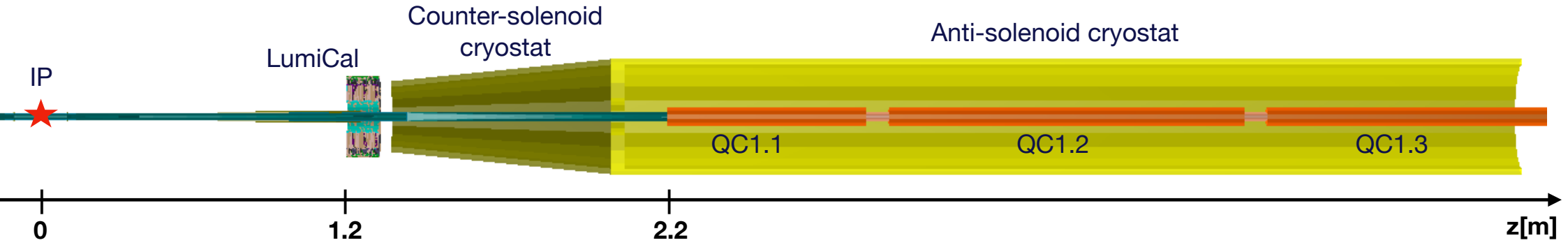
Conventional Solenoid Compensation Scheme

A compensation scheme similar to that used in DAΦNE would allow for the **removal of the IR anti-solenoids**, resulting in benefits such as **increased available space** in the MDI area.

- Rotation of FFQs to fit beam orientation
- Skew quadrupoles
- Vertical correctors in the IR

Antisolenoids **far from the IP** to cancel $\int B_z ds$

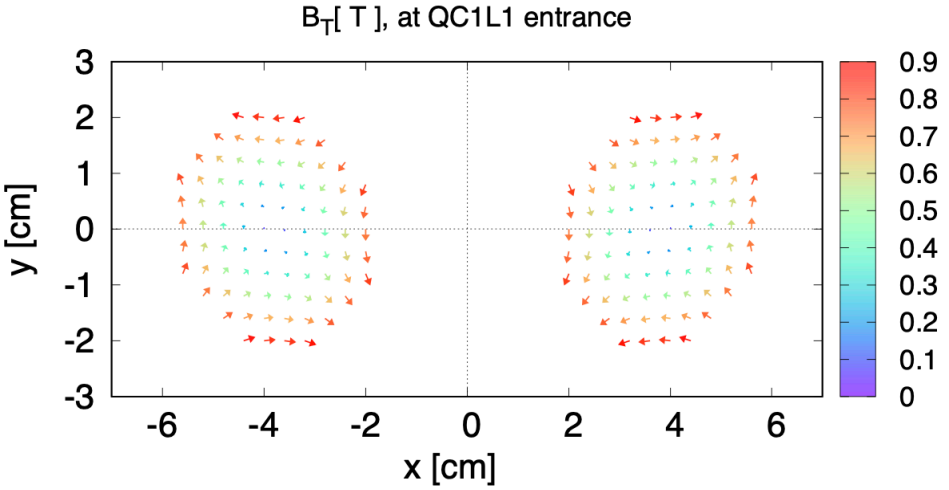




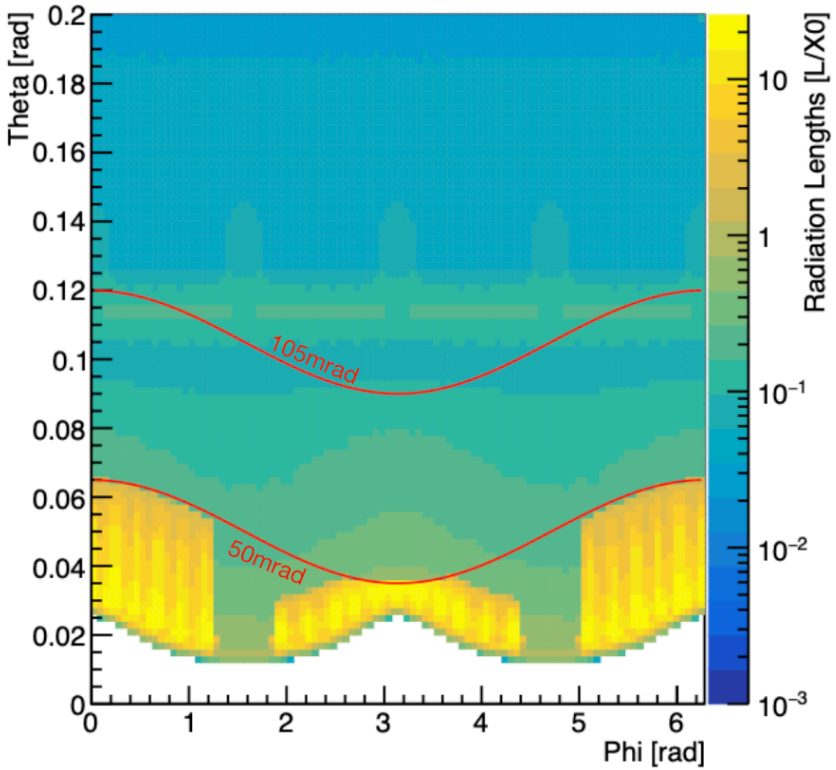
Final Focus Quadrupoles

A model of the Final Focus Quadrupoles is being added in key4hep (aciarma:quadfield, **PR not ready yet**).

- Cylinder made of real model **equivalent material** and **overall dimensions**
- Quadrupolar field coming from **latest MAD-X sequence**
  - particle tracking in field benchmarked w/ MAD-X

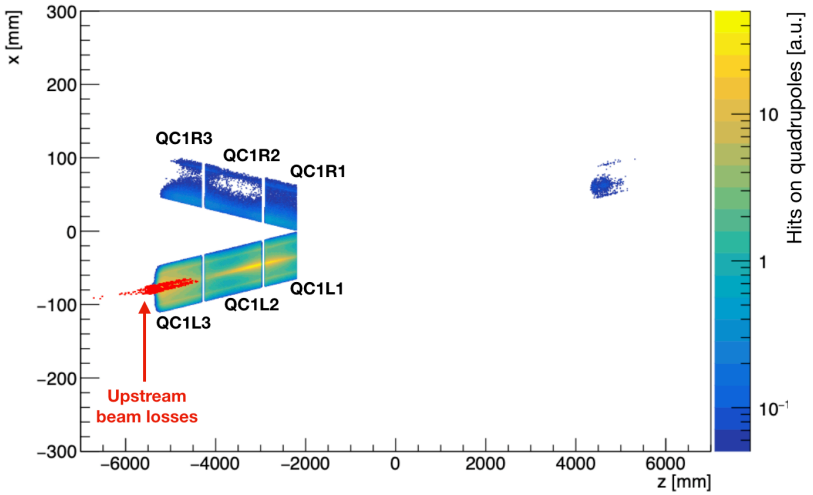


Example of applications



Even if the PRs are not yet included in the main repository, I've already used these addition to perform some studies:

- **Material budget** from the realistic beam pipe and cooling mainfolds estimation
- **Power deposition on the SC FFQs** due to beam losses and Radiative Bhabhas



Summary

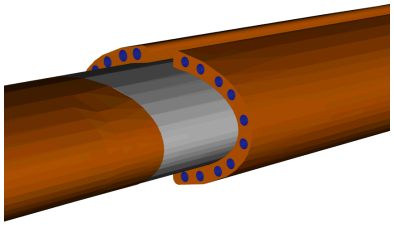
- Engineered **CAD model of the IR Beam Pipe** implementation in key4hep ongoing
  - Model already used to perform background studies and **material budget** estimation
  - PR #283 almost ready
- Simple model for **Final Focus Quadrupoles** added w/ magnetic field
  - Model already used for **power deposition** in the SC elements
  - PR not available yet
- Other elements will be added as the CAD models will be ready
- New **alternative solenoid compensation scheme** may allow to remove the antisolenoids in the IR

IR Beam Pipe CAD Model in key4hep

Engineered CAD model of IR beam pipe imported in Key4hep (k4geo)

- Detailed model of AlBeMet beam pipe in ±1.2m region
- Central chamber with inlets and double layer for Paraffine cooling, and gold layer
- Copper manifolds in trapezoidal chamber for Water cooling
- Simple model for Cu beam pipe (1.2m < |z| < 6.0m) based on impedance calculations
- Tungsten SR mask at 2.12m upstream

Next steps include realistic bellows before beam pipe separation



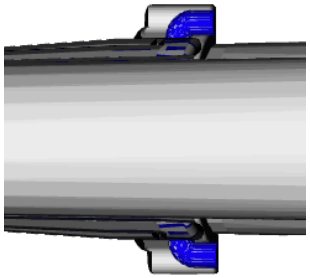
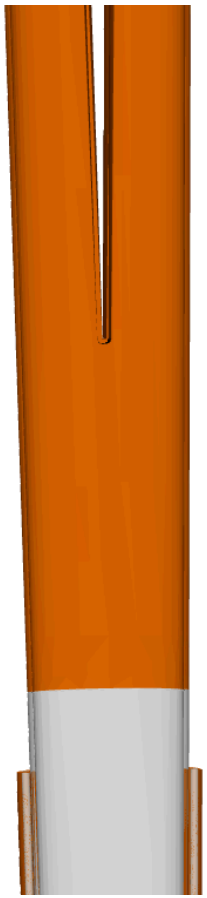
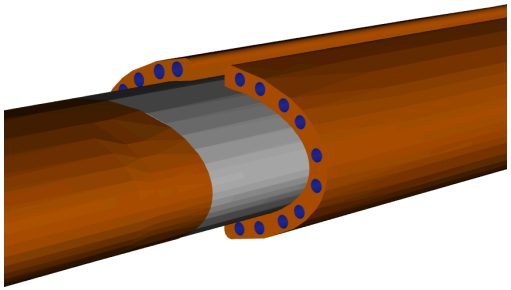
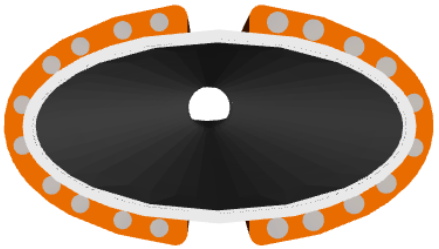
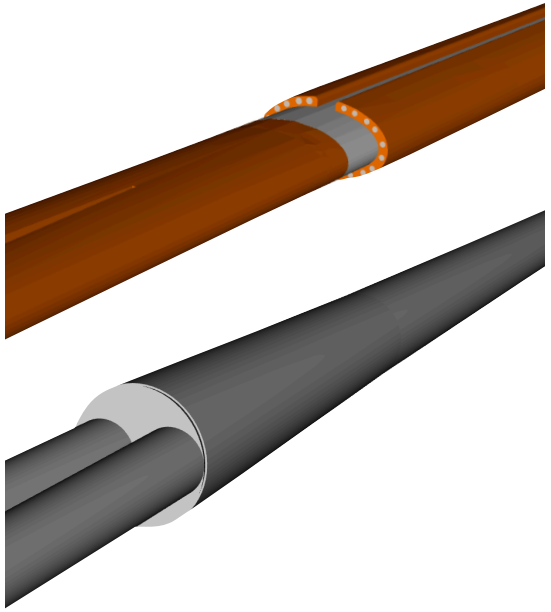


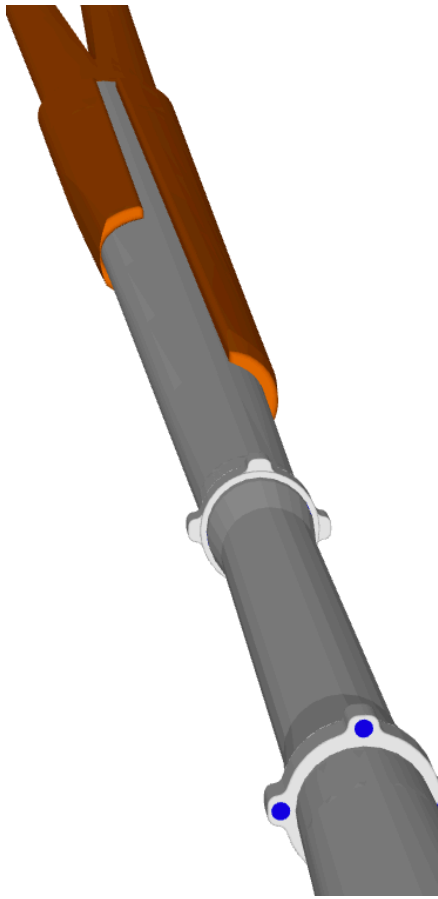
FOTO DELLA MASK

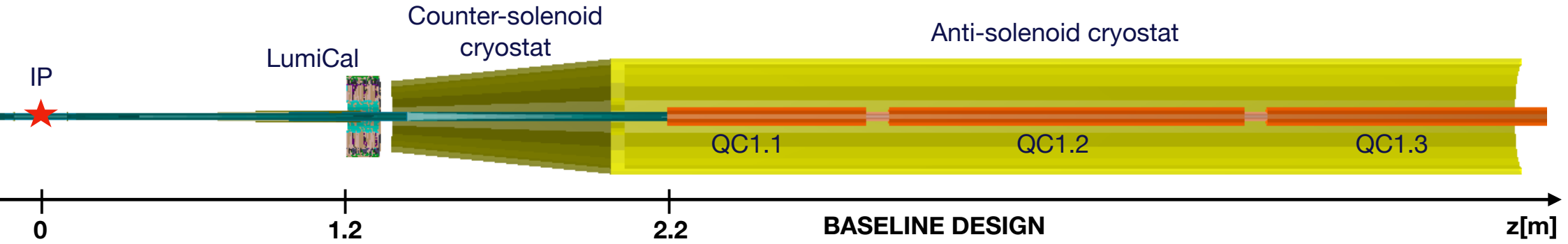


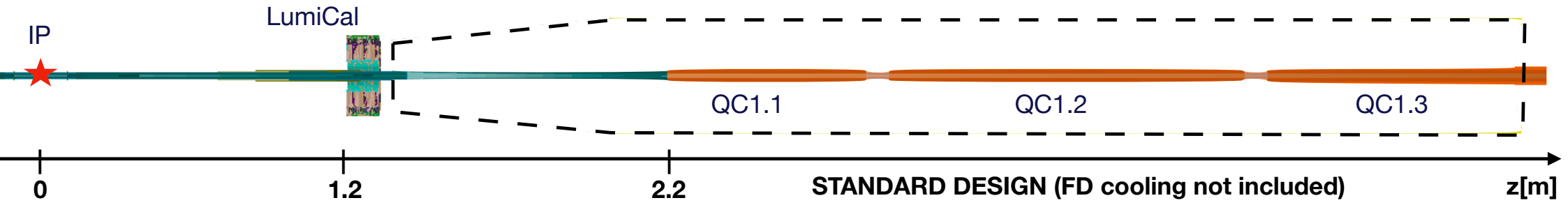


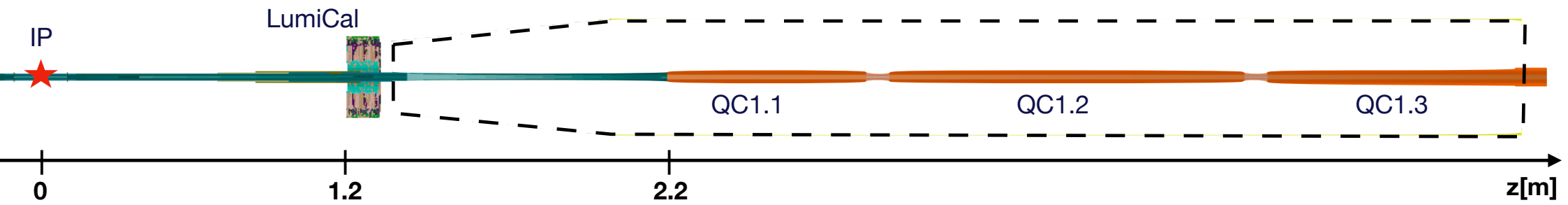







Counter-solenoid cryostat
Anti-solenoid cryostat
LumiCal
IP
QC1.1
QC1.2
QC1.3
0
1.2
2.2
BASELINE DESIGN
z[m]


LumiCal
IP
QC1.1
QC1.2
QC1.3
0
1.2
2.2
STANDARD DESIGN (FD cooling not included)
z[m]



Other IR Elements

Currently present in the Key4hep description:

- Simple **quadrupole** geometry for power deposition studies
- **LumiCal** detailed description
- Cryostats for antisolenoids: **hollow shell** with 2cm thick walls

A more detailed description of the anti-solenoid **cryostats** and **support structures** for the various subdetectors is necessary for a better estimate of the **secondary showers** which can be produced by background particles in that region (e.g. from beam losses in the FF quads).