



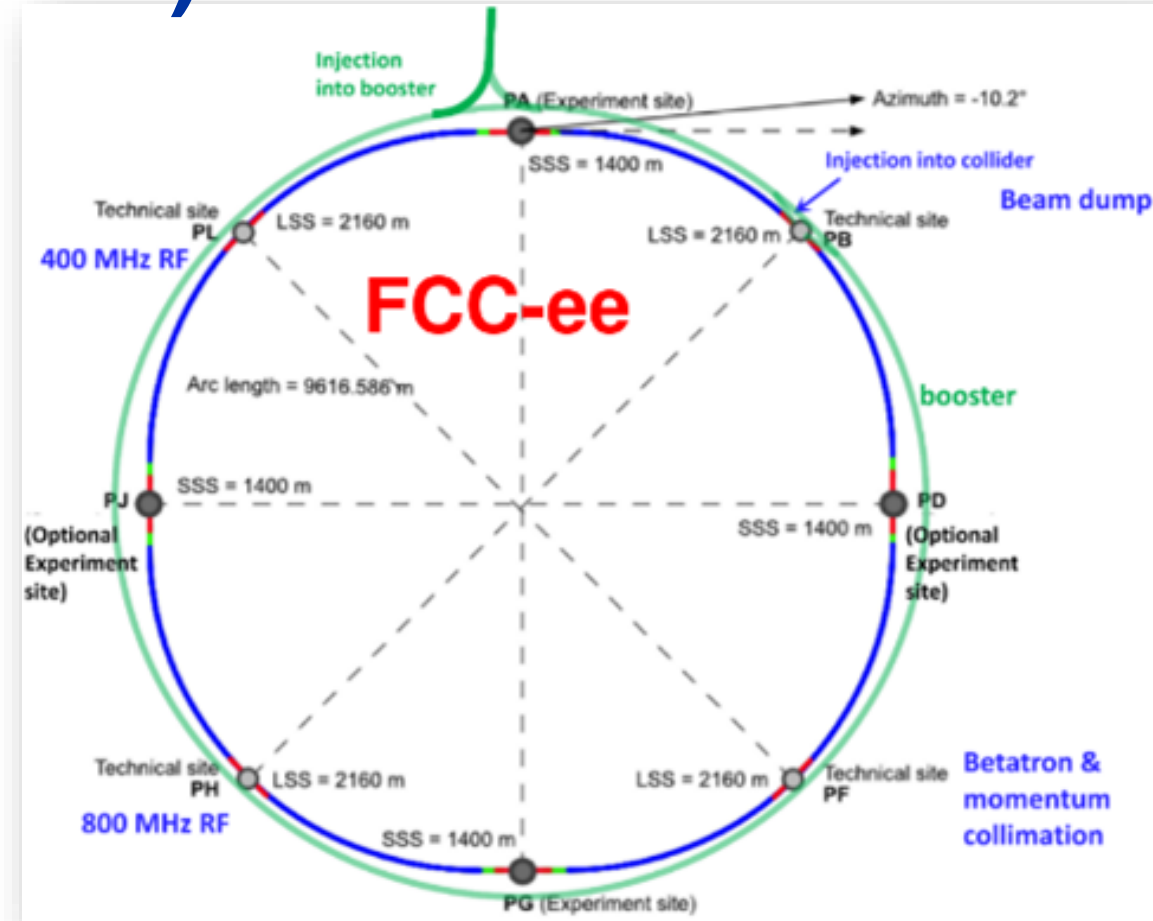
Technical Challenges and Required Studies for FCC-ee BIDs

Antonio PERILLO MARCONE (on behalf of SY-STI)

06/06/2023 – FCC Week 2023

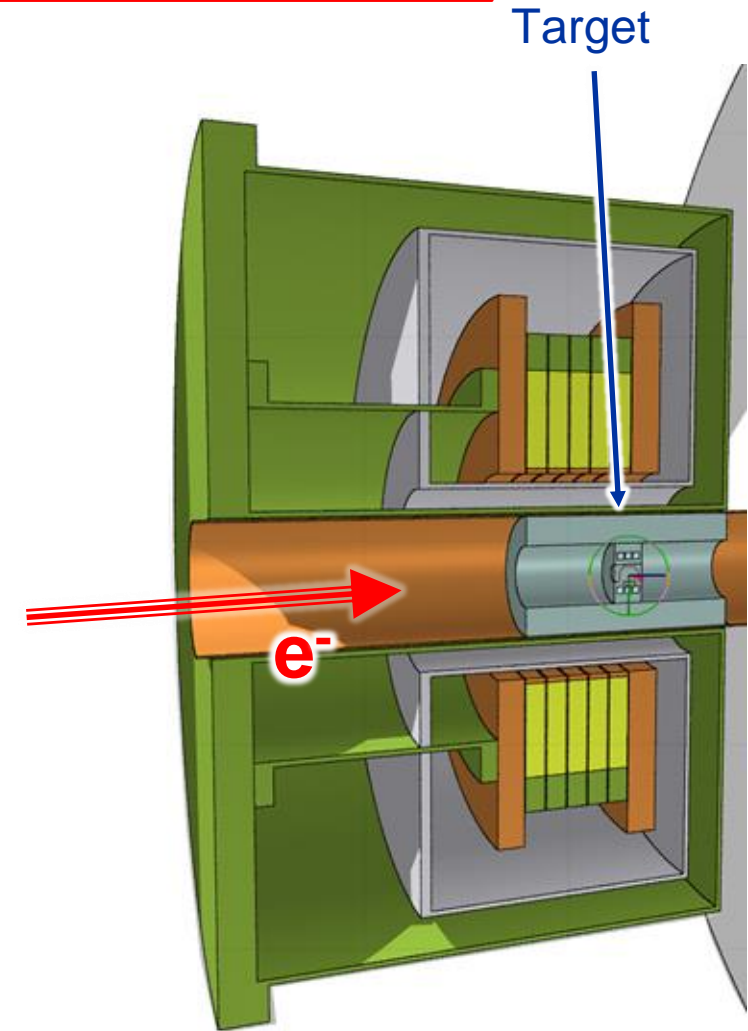
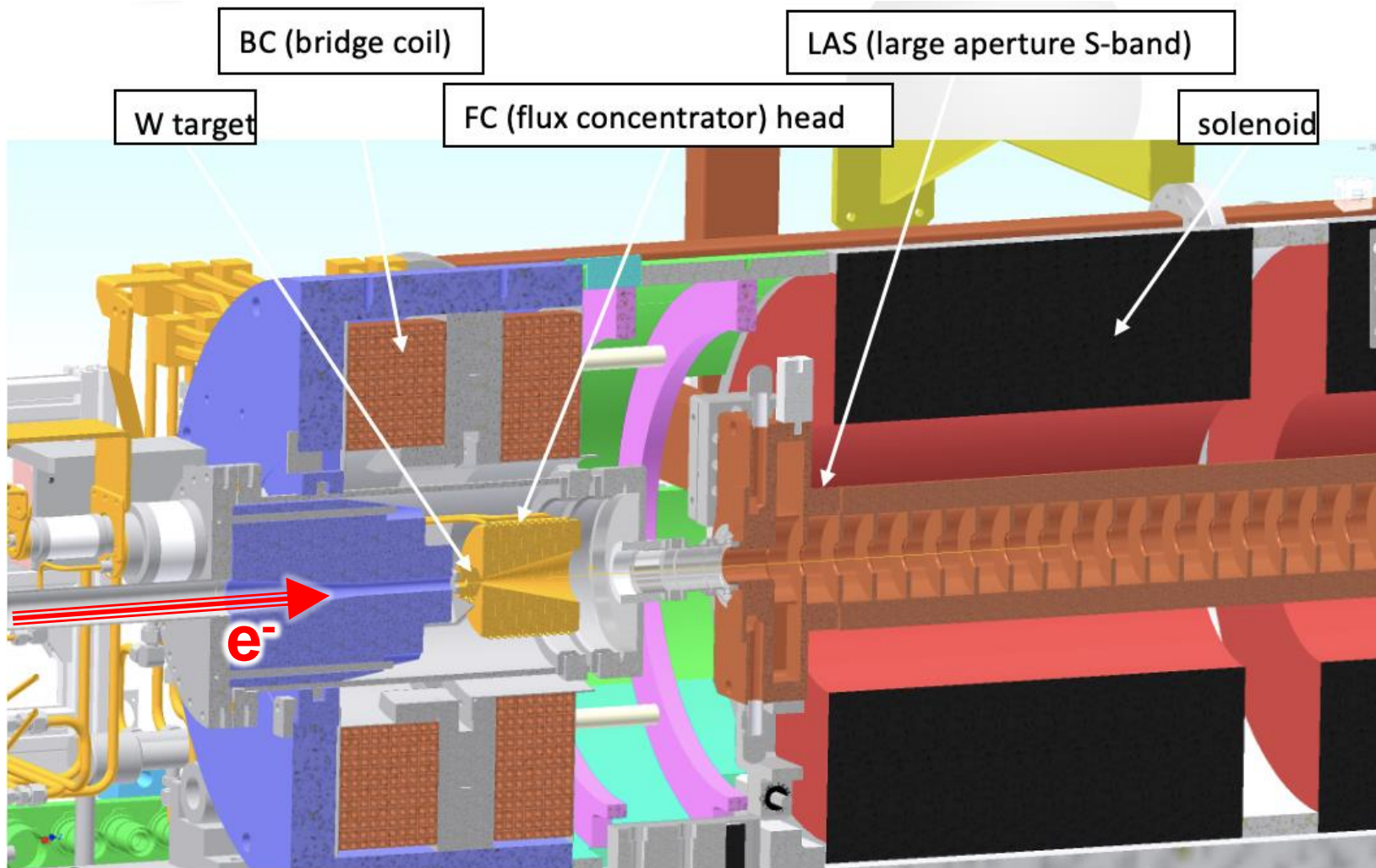
Known Beam Intercepting Devices (BID) for FCC-ee (excluding injectors and booster)

1. Positron Source
2. Extraction dump + spoilers (colliders)
3. Beamstrahlung dump
4. Betatron and momentum collimators
5. SR collimators
6. IR masks
7. Injection protection devices (TDIS-type)
8. Extraction protection devices (TCDQ/TCDS type)



Positron Source

See details in Ramiro Mena's and Iryna Chaikovska's presentations



Target for P³ (PSI)

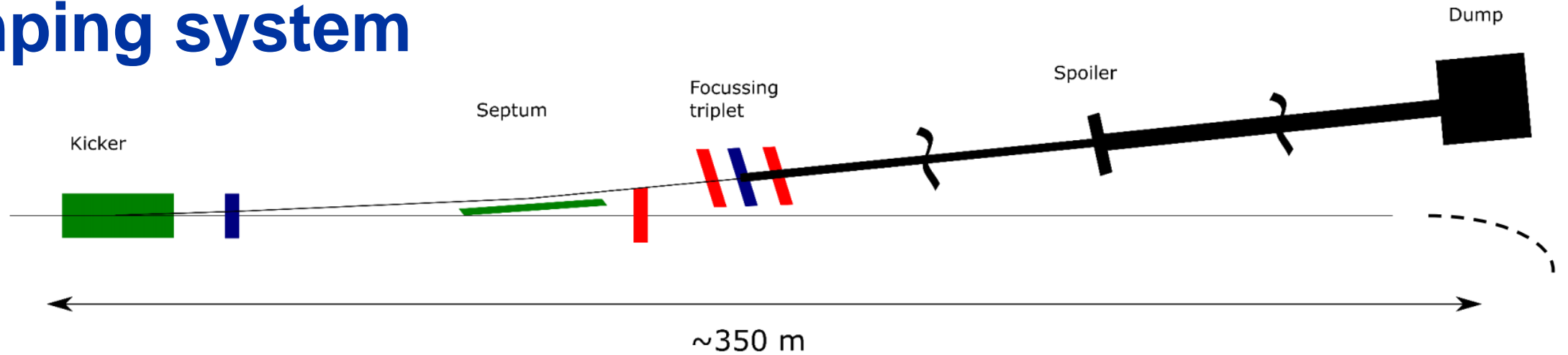
- Collaboration between CERN and PSI (FCCee – CHARM)
- CERN (SY-STI-TCD) to design and build the P³ target (to be installed in April 2025)
- Significant effort/resources invested in this project
- Viewed also as prototype for FCCee positron target
- Important lessons learnt expected from this work

See details in Paolo Craievich's poster

Positron Source – Challenges and Required R&D

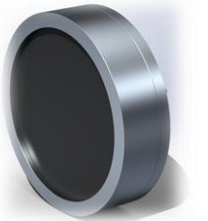
1. **Testing/characterisation of W-Cu bonding**
2. **Exploring and testing the production of W part with embedded pipes**
3. **Production of target (small target dimensions → prototype can be of full scale)**
4. **Thermo-mechanical testing with available e-beams.**
5. **Irradiation testing (characterisation after few DPA)**
6. **Comprehensive design study of the entire target area**
7. **Optimisation studies (including thermo-mechanical calculations) to define dimensions and all required systems**
8. **Visit to SuperKEKB (and possibly SLAC) to learn from their experience**

Main Extraction Dump – a semi-passive beam dumping system



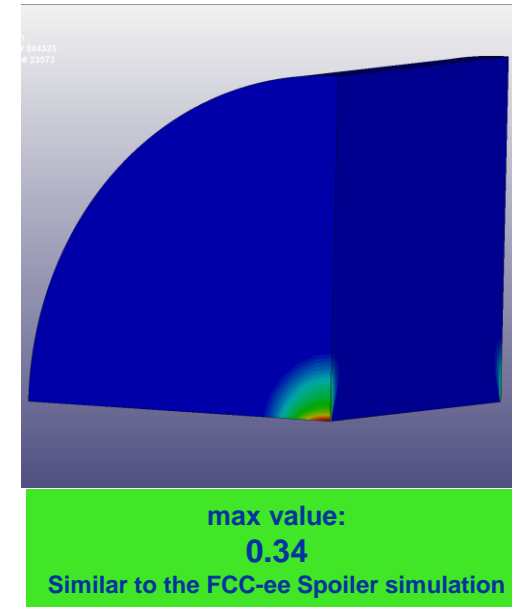
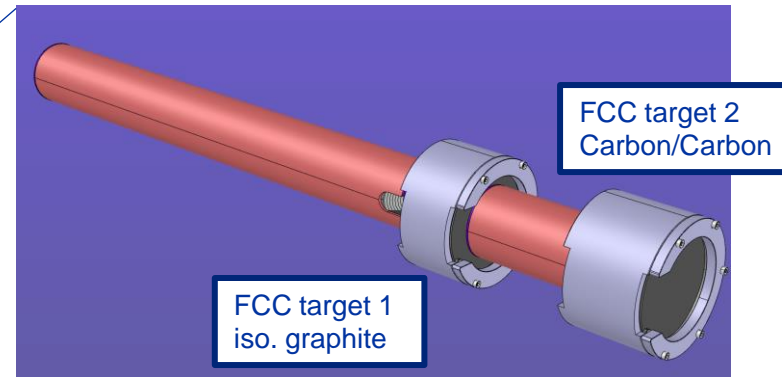
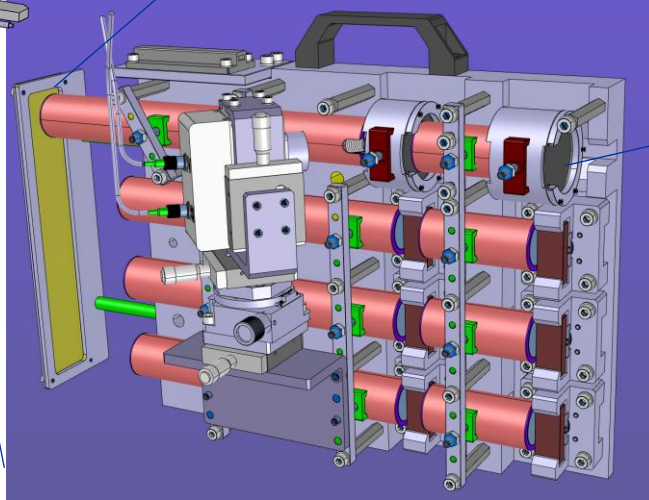
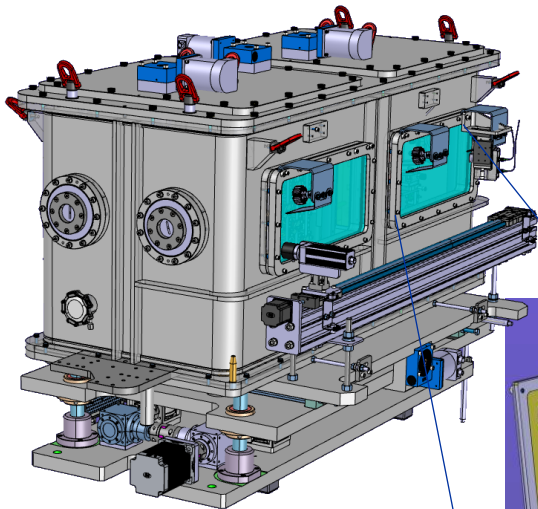
- Multiple spoilers to decrease the peak load

- High density (1.7-1.8 g/cm³) graphite
- 3 cm thick
- 30 cm diameter
 - Corresponding to $\sim 15 \sigma$ horizontally
- Aluminium support



HiRadMat validation of diluters

HiRadMat HRMT-56



Isotropic Graphite
(SGL R7550)



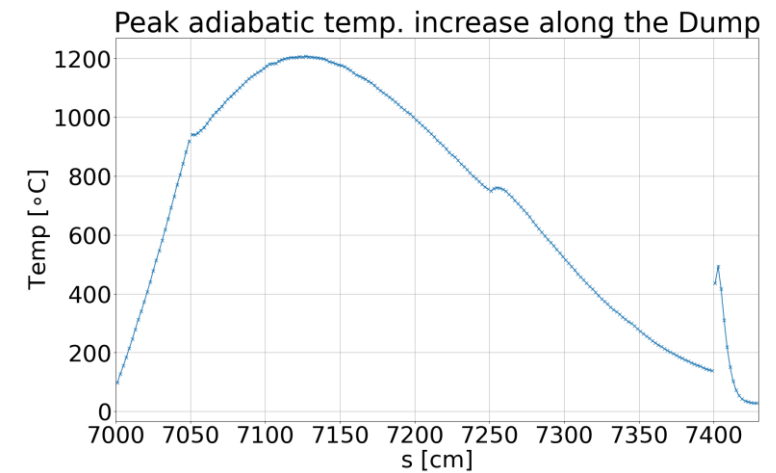
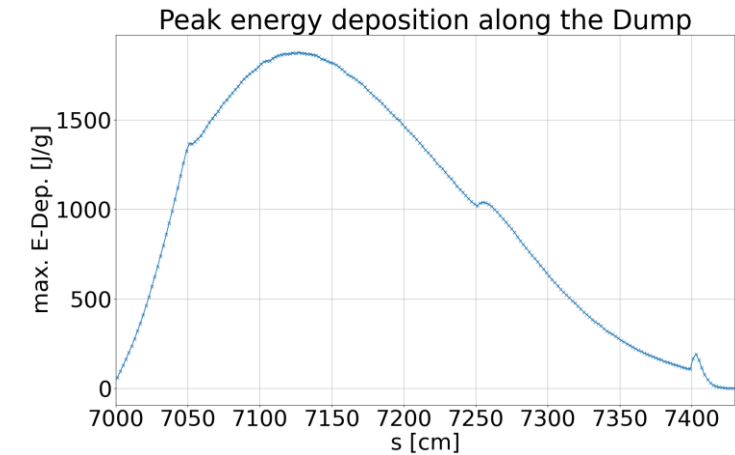
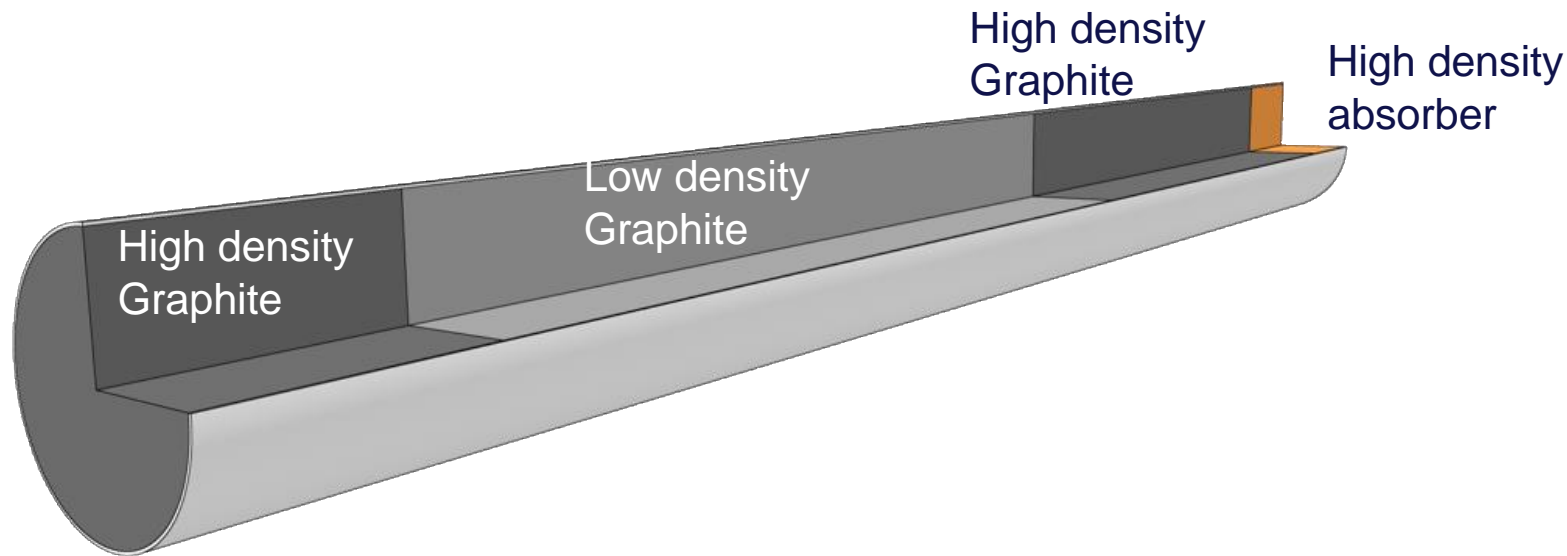
Carbon/Carbon
Composites
(AG S332)



Work done by Alexander Krainer

The FCC-ee Beam Dump Core

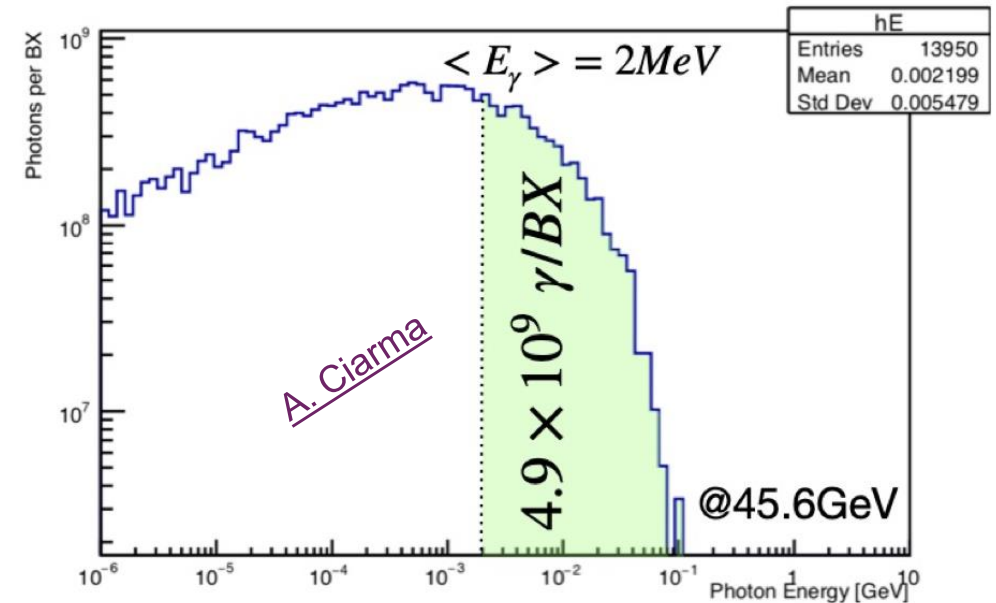
- Similar approach as the current LHC Dump
- Multiple sections with different densities for the Dump core
- **Design and material choice to be optimized following the findings of the HiRadMat High Energy Dumps Experiment**



Beamstrahlung Dumps

- A **significant fluence of photons is generated at the IPs** in the forward direction by different mechanisms (beamstrahlung, SR, Bhabha, etc.)
 - ± 2 MeV average, extending up to 100 MeV
 - **~ 450 kW** in few cm^2
- To be absorbed reliably and safely

See details in Alessandro Frasca's presentation



- Interest in **monitoring the incoming photon fluence for physics**

Beamstrahlung Dumps - Options

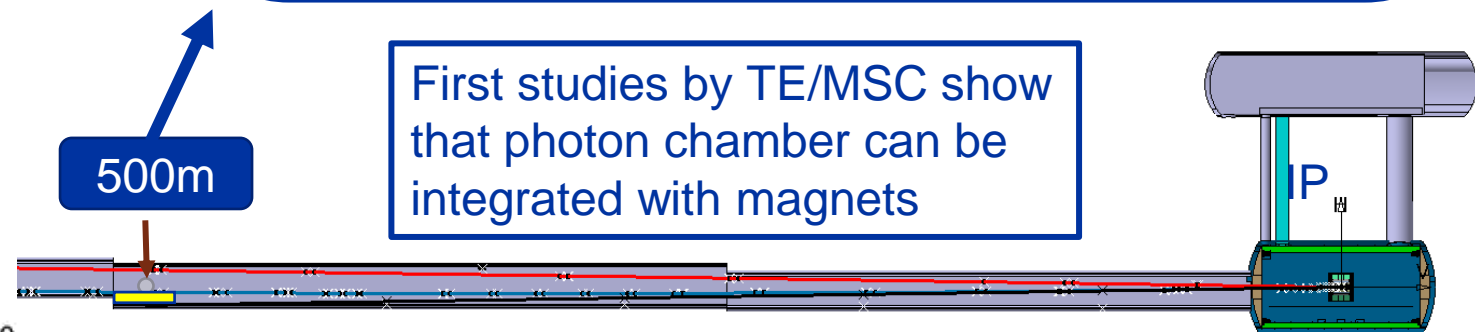
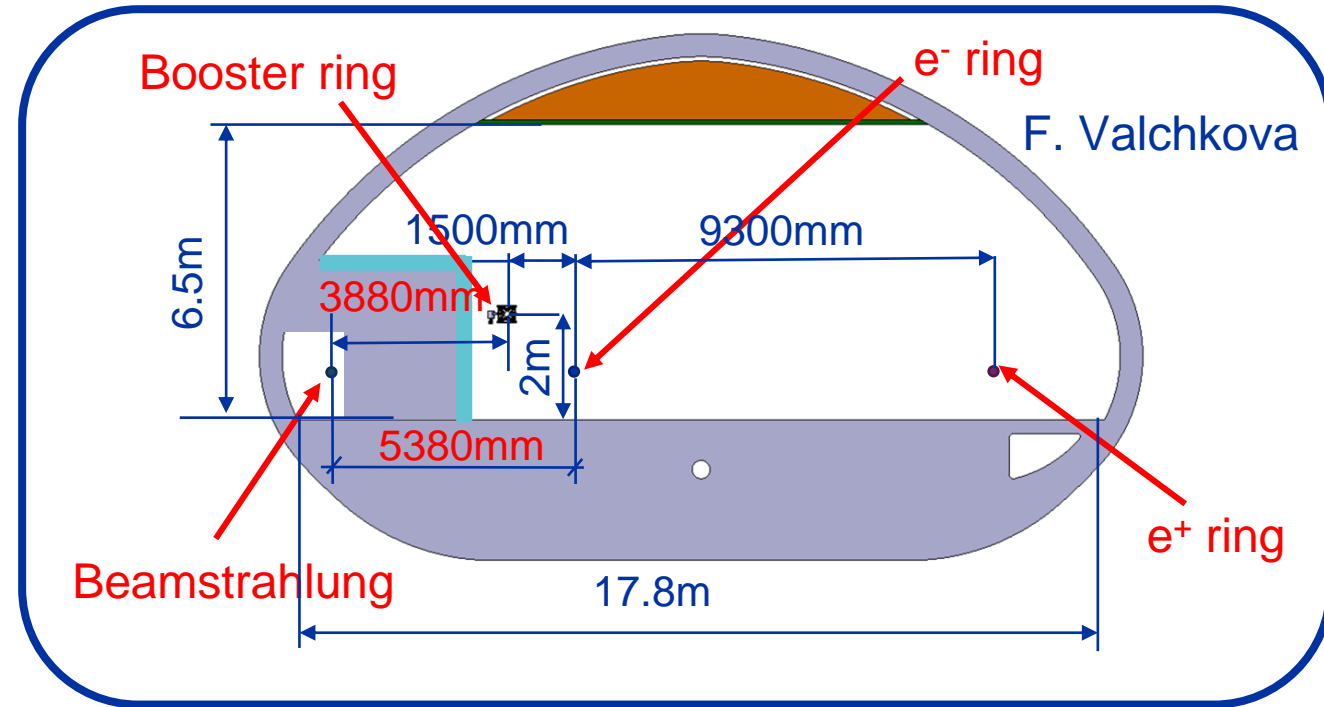
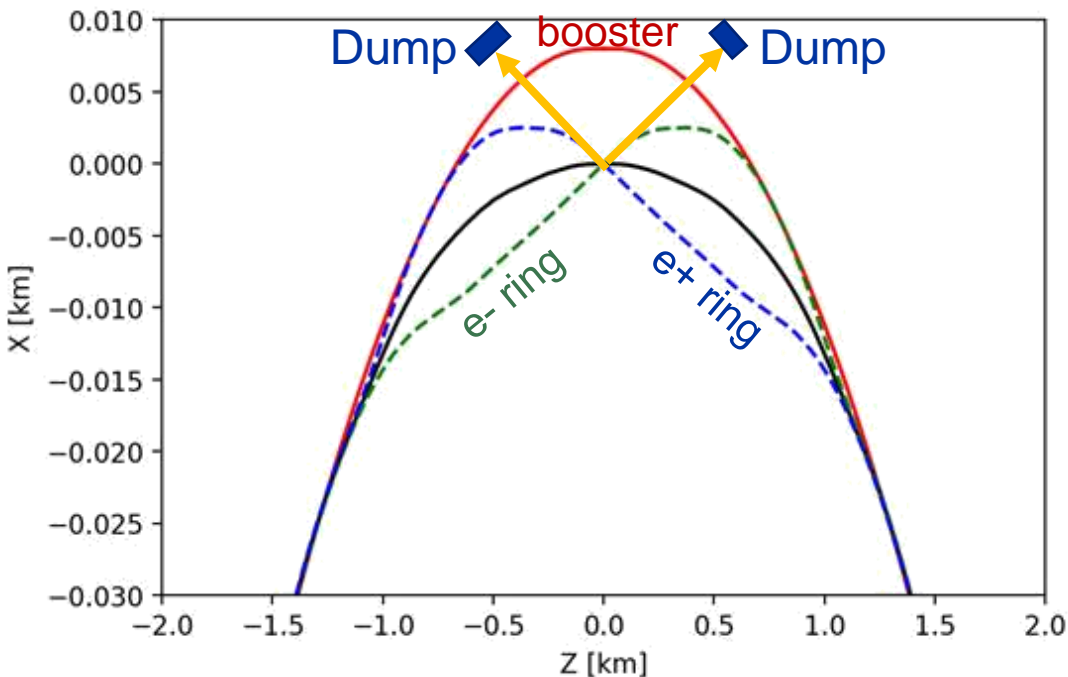
- 1) **Graphite core** (monolithic or tilted to dissipate energy) is a primary option given the robustness (but thermal conductivity is not the best). **Probably not optimum for such high-power density and type of beam**
- 2) **Water** absorber could also be a possibility (à-la ILC photon dump). **Several drawbacks and risks**
- 3) **Liquid metal (e.g. Pb or PbBi)** could also be an opportunity for a very compact design (line of R&D shared with other activities at CERN) – synergies with ENEA (framework agreement for BDF and MUC). **Preferred option**

Proposition to study all options to qualify (or exclude) them, taking into account current experience and knowhow elsewhere

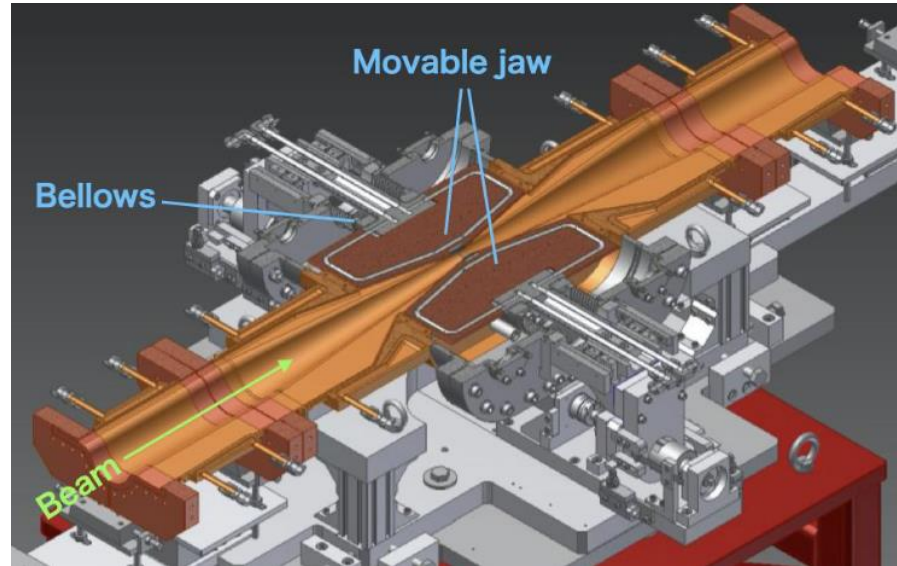
Highly critical element !

Beamstrahlung dumps location

- Internal high-power dump on beamline has many disadvantages
- External dump preferred → in order to have enough separation between dump and collider+booster, **need 500 m extraction line**

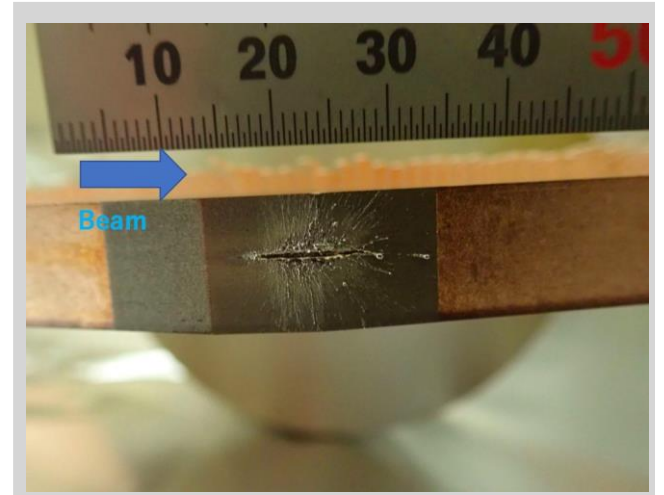


Collimators

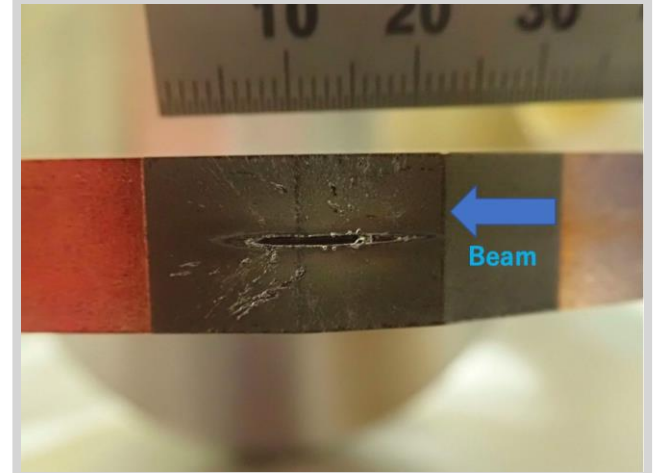


Main requirements

- Short jaw length → Minimise impedance
 - High electrical conductivity → Minimise impedance
 - Low enough density → Minimise energy deposition
 - Good thermal conductivity → Efficiently extract deposited heat
- To guarantee sufficient cleaning efficiency and robustness under failure scenarios, a good compromise must be found between all the above parameters.



D02V1 bottom side ($38 \mu\text{Sv/h}$)



D02V1 top side ($95 \mu\text{Sv/h}$)

Accidental beam impact at
Super KEKB

Challenges related to collimators materials

- Carbon most promising material in case of beam trajectory failure.
- However, all carbon/graphite grades have low electrical conductivity
- High-conductivity 3D CfC could be feasible (to be investigated)
- Prototype and testing would be required to study new materials
- Robust coatings (if applicable)

Long experience with LHC collimators in term of complexity and required R&D

Injection Protection Device

Extremely challenging beam

- High stored energy (1/10 of FCC full intensity)
- High brightness

Need to define failure scenarios and machine functional requirements

Extraction Protection Devices

Several studies required to understand failure scenarios

- **Iterations between different teams to determine requirements based on position, devices to protect, integration...**
- **Materials and design will probably be a challenge as beam is undiluted (although swept)**

Other BIDs

Linac (or other options like SPS) and booster require several BIDs

- **Booster and transfer lines**

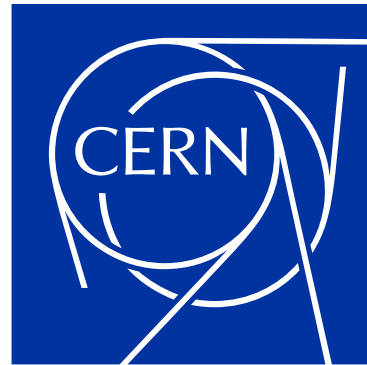
- Dumps
- Beam stoppers
- Slits/scrapers
- Collimators
- Injection protection devices

- **Linac**

- Dumps
- Beam stoppers

General Remarks

- **Several challenging innovative/unique BIDs required for FCCee**
- **Significant technical challenges**
- **R&D, prototyping and testing required**



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