Proton Irradiation Site for Si-Detectors at the Bonn Isochronous Cyclotron

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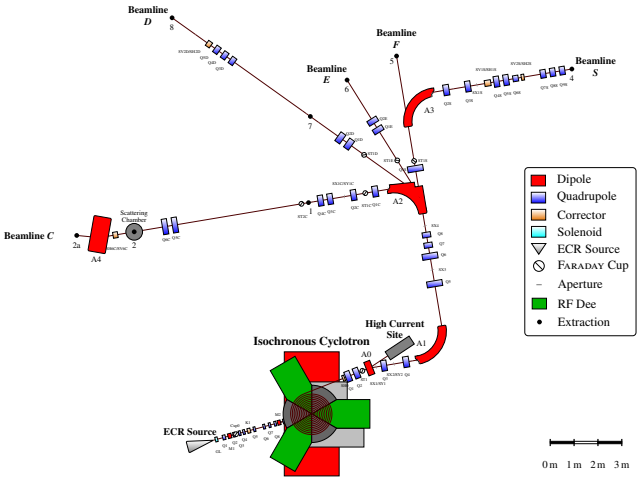
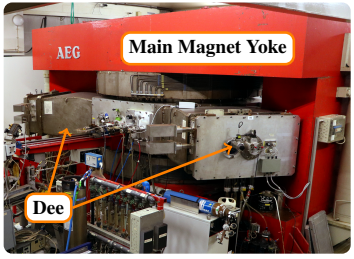
Cyclotron Facility in Bonn



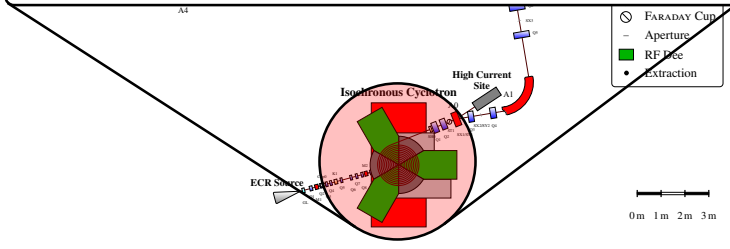
Cyclotron Facility in Bonn - Cyclotron

Isochronous Cyclotron:



- Vertical injection into the cyclotron.
- Six-sector Hill-and-Valley magnetic guiding field (max. 0.7 T to 1.9 T).
- Particle acceleration by three RF Dees within ≈ 120 revolutions (20 MHz to 29.8 MHz, max. 40 kV).
- Extracted beam current ≤ 10 µA with $\Delta E/E \approx 4$ ‰.

Particle	p	d	α
E / MeV	7 to 14	14 to 28	28 to 56



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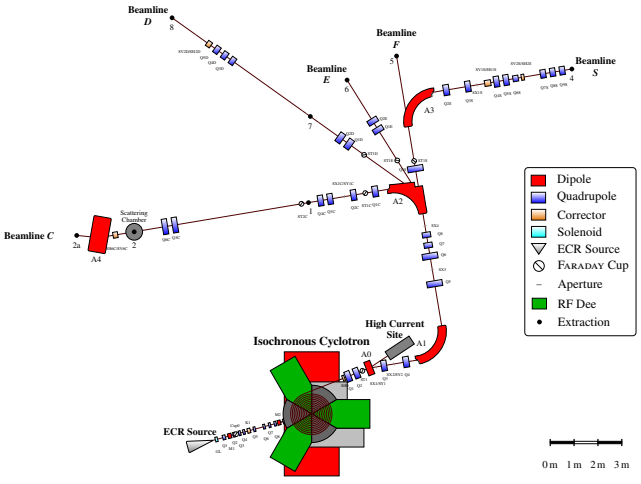

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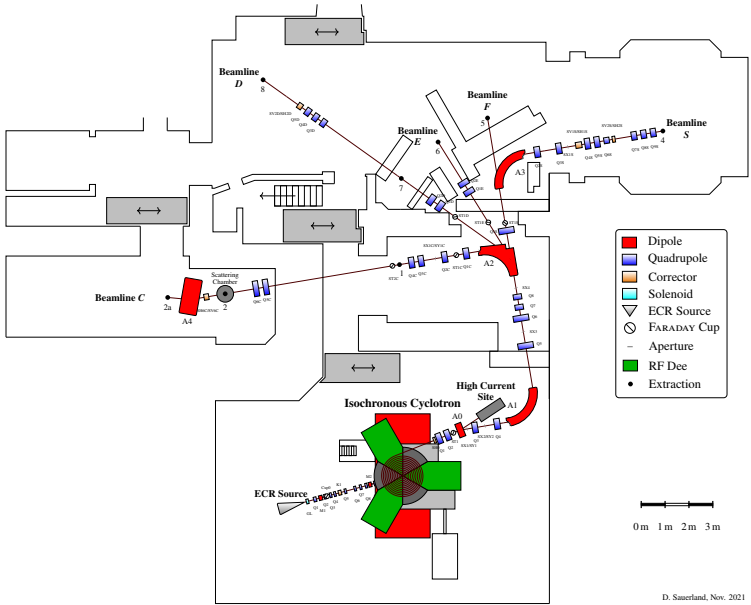
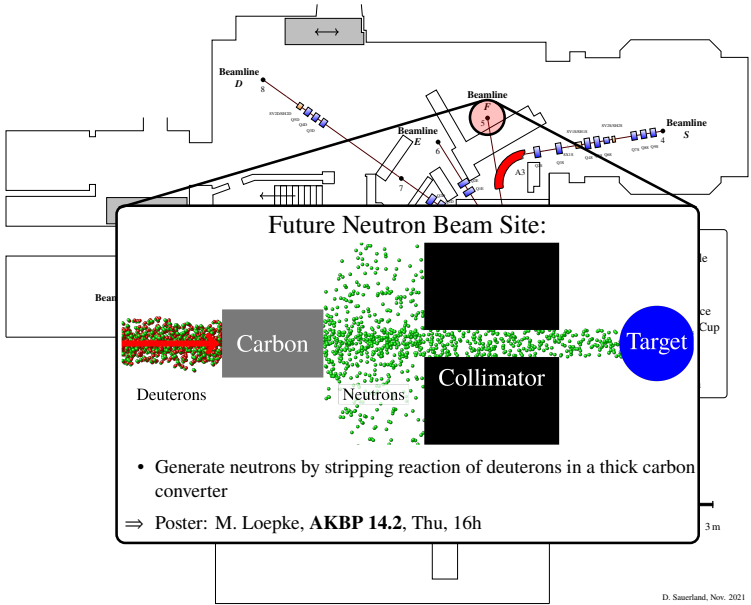
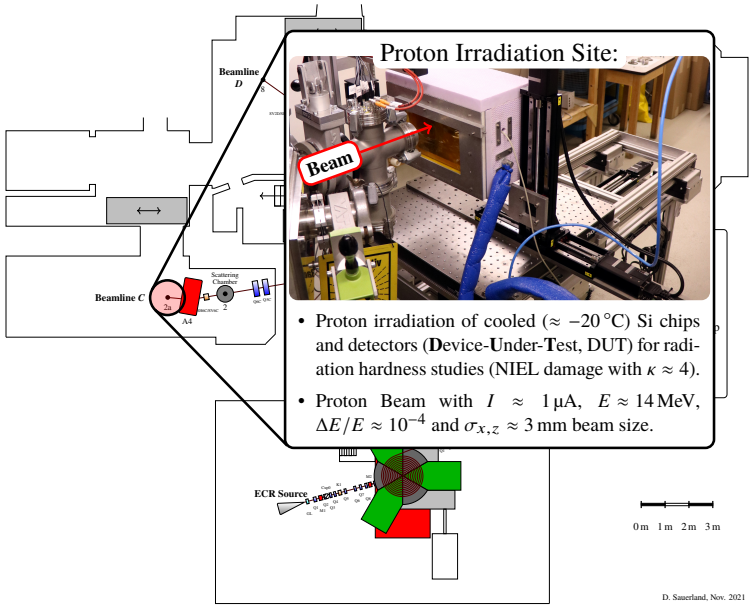


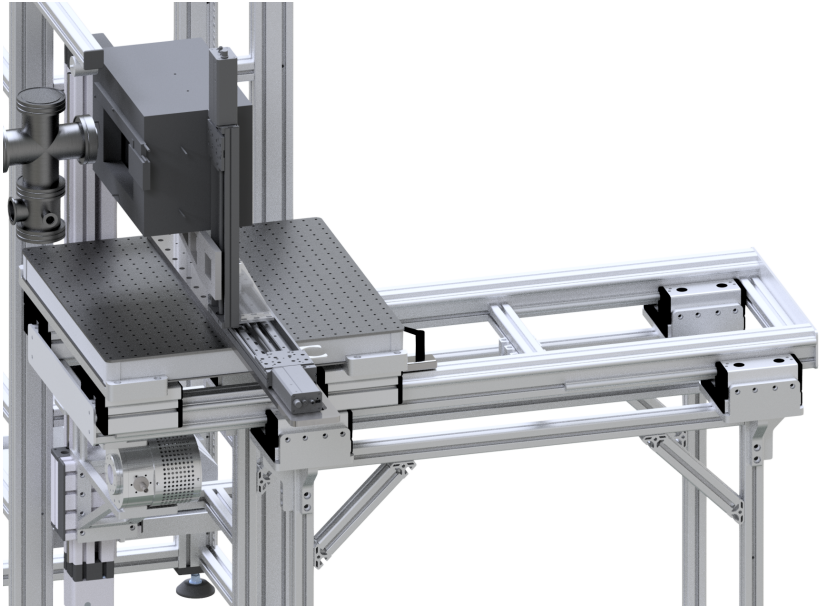
Cyclotron Facility in Bonn - Neutron Beam Line (planned)



Cyclotron Facility in Bonn - Proton Beam Line



Irradiation Site



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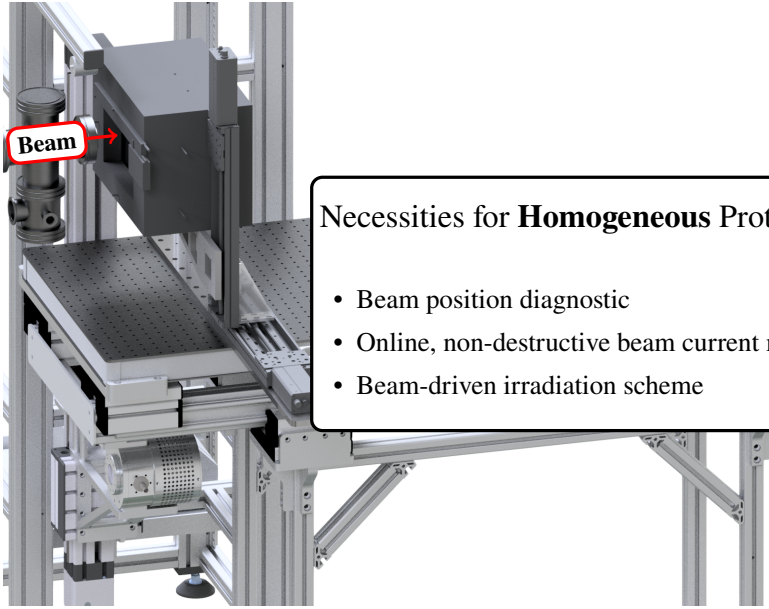
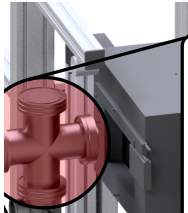


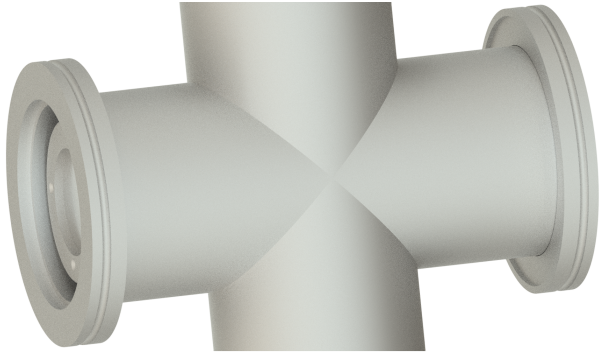
Necessities for **Homogeneous** Proton Fluence:

- Beam position diagnostic
- Online, non-destructive beam current measurement
- Beam-driven irradiation scheme

Irradiation Site - Beam Monitor

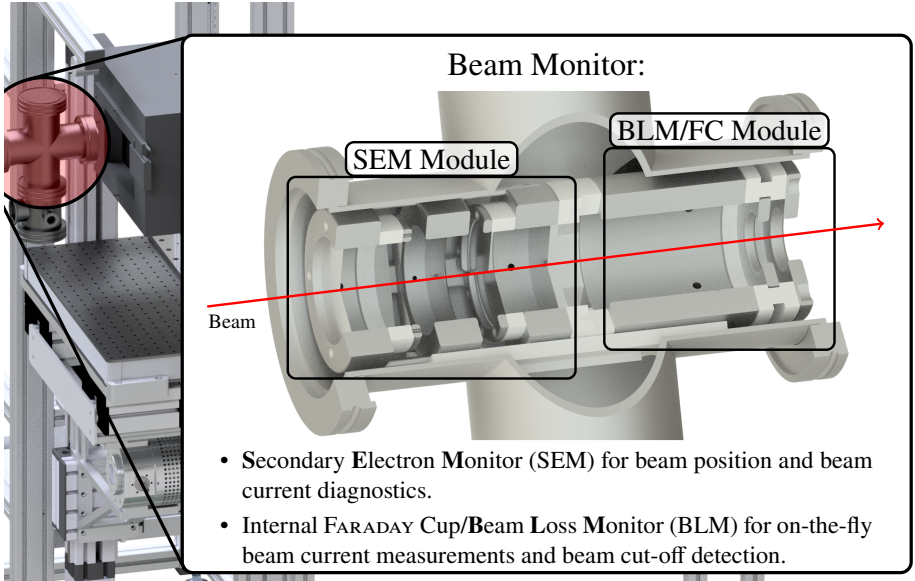


Beam Monitor:



- **S**econdary **E**lectron **M**onitor (SEM) for beam position and beam current diagnostics.
- Internal FARADAY Cup/**B**eam **L**oss **M**onitor (BLM) for on-the-fly beam current measurements and beam cut-off detection.

Irradiation Site - Beam Monitor



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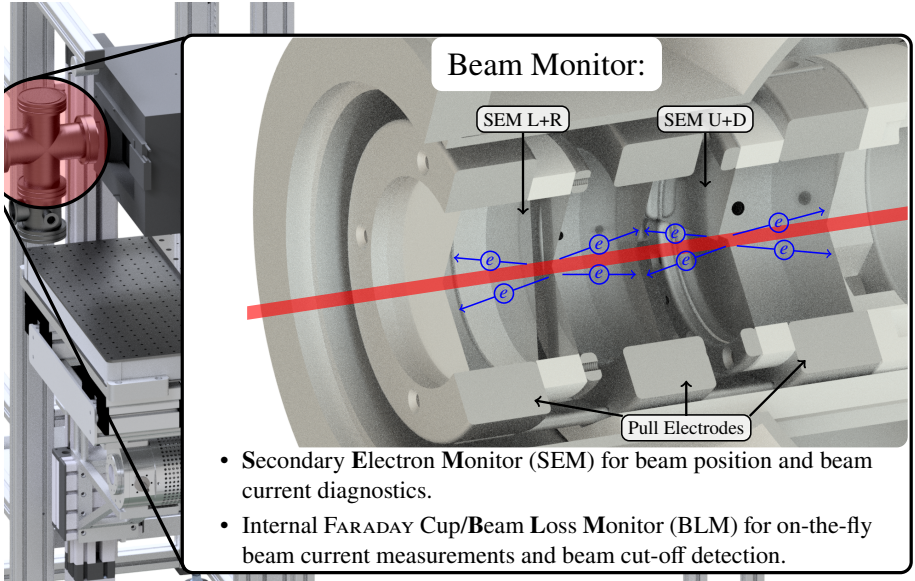
Irradiation Site - Beam Monitor (SEM)



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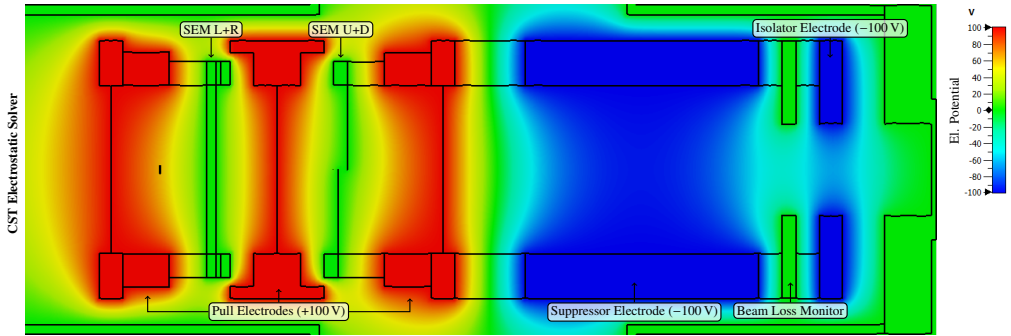
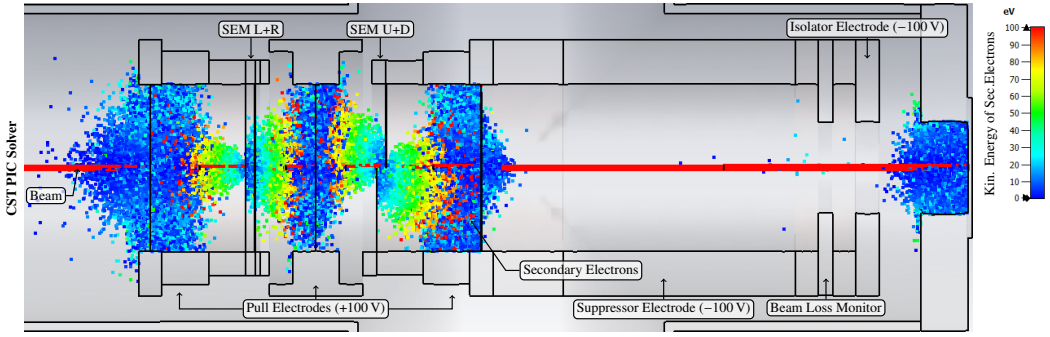


- Use carbon-coated Al foils (≈ 70 nm layer thickness) to anticipate foil-carbonization with time.

Irradiation Site - Beam Monitor (SEM)



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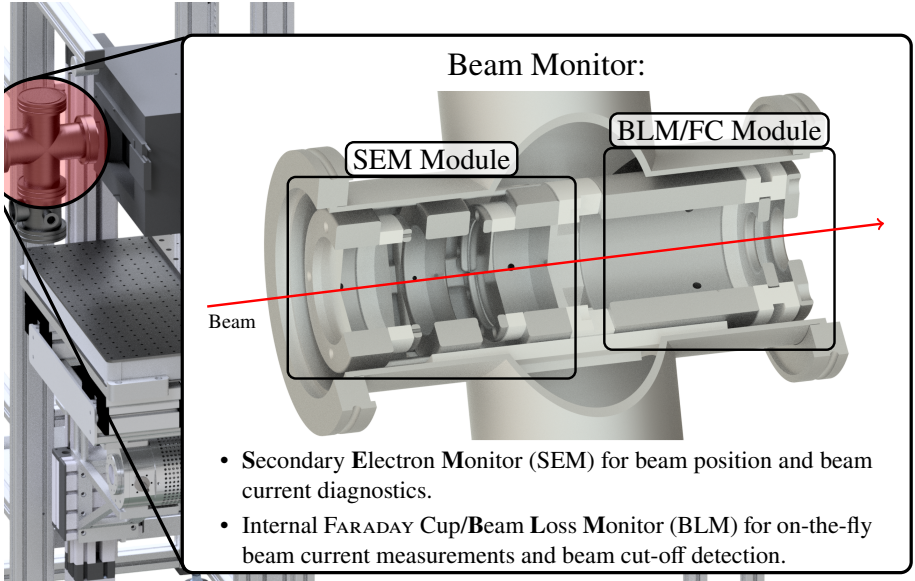
Irradiation Site - Beam Monitor (BLM)



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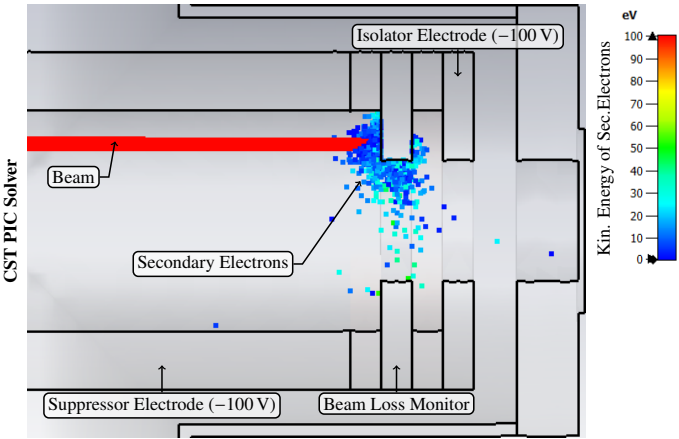
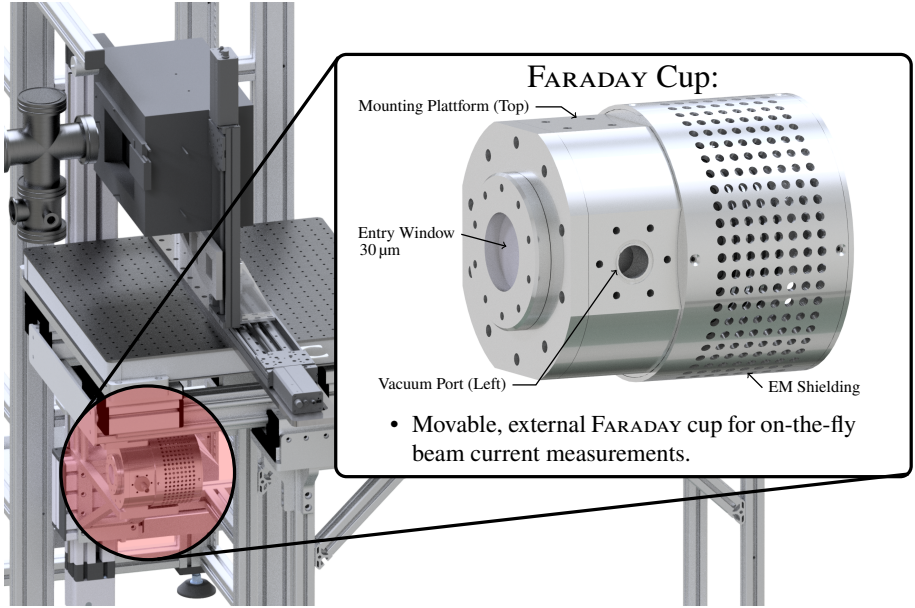
Irradiation Site - Beam Monitor (BLM)

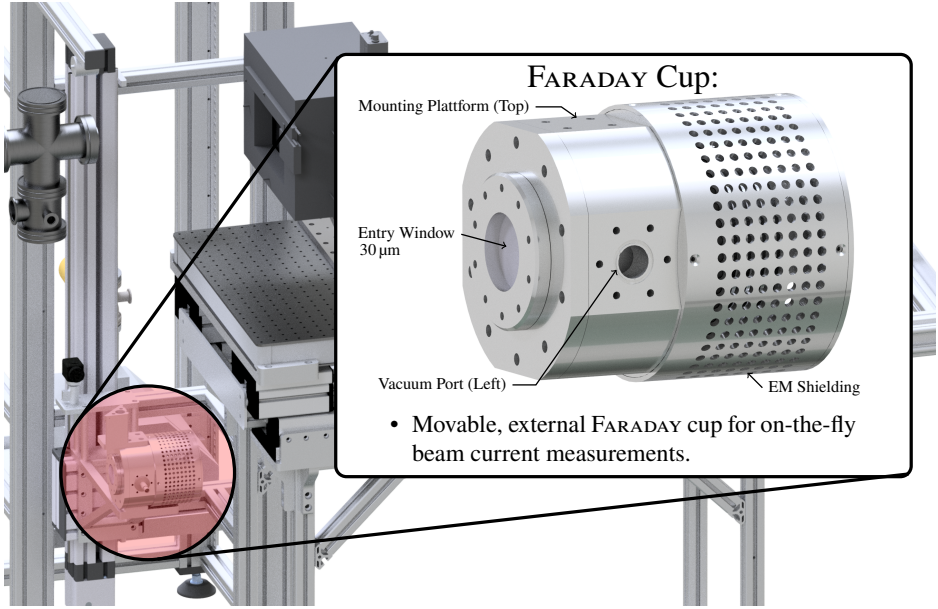
- Charge collection efficiency of internal FARADAY cup: $> 99\,\%$
- Isolator electrode prevents secondary electrons from exit window to reach BLM.



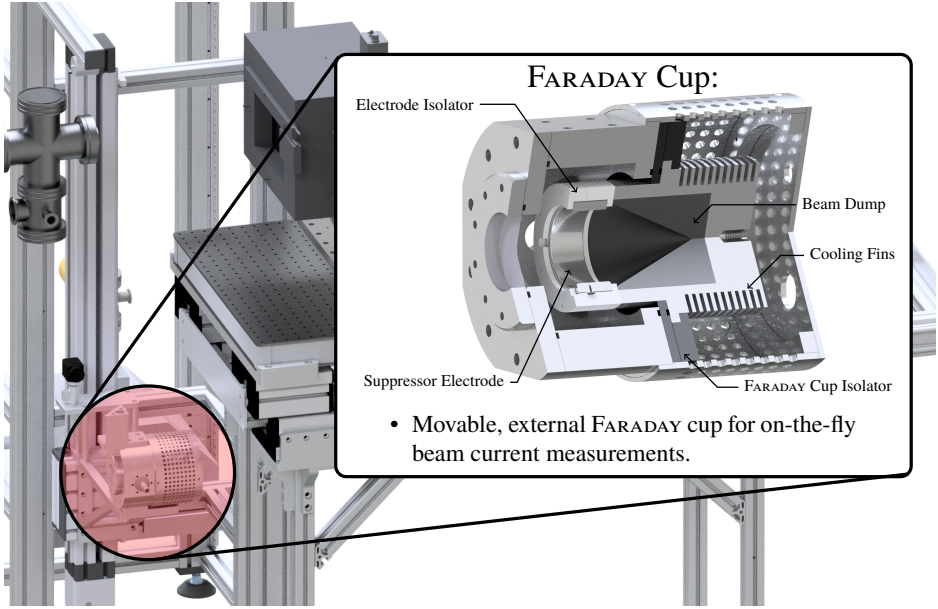
Irradiation Site - Faraday Cup



Irradiation Site - Faraday Cup



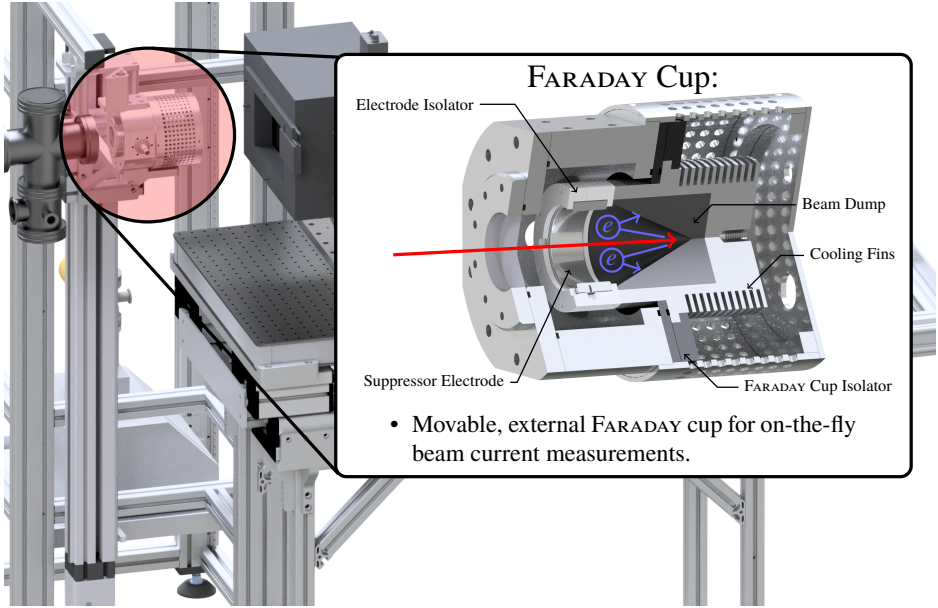
Irradiation Site - Faraday Cup



Faraday Cup:

- Movable, external Faraday cup for on-the-fly beam current measurements.

Irradiation Site - Faraday Cup



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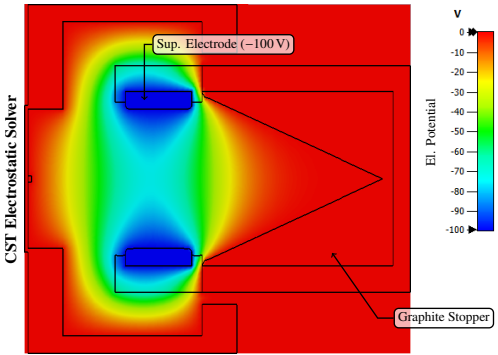
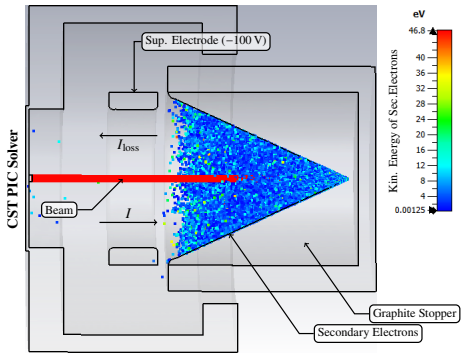
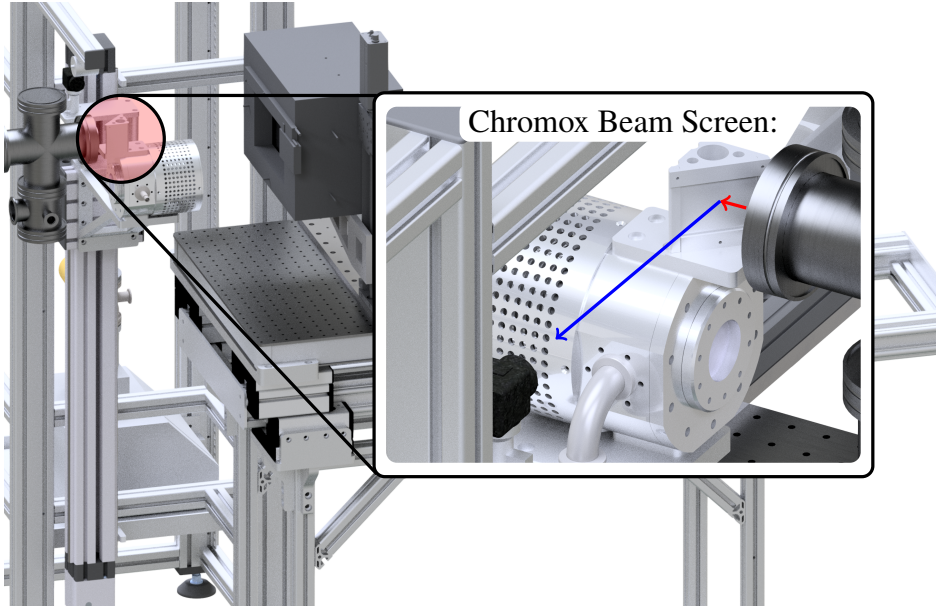
Irradiation Site - FARADAY Cup



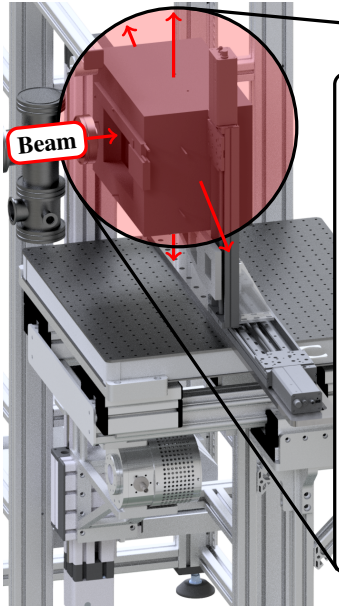


- Charge collection efficiency of FARADAY cup: $> 99.9\,\%$, $\left(\frac{I_{\text{loss}}}{I} \approx 1 \cdot 10^{-6}\right)$

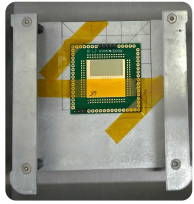
Irradiation Site - Chromox Screen

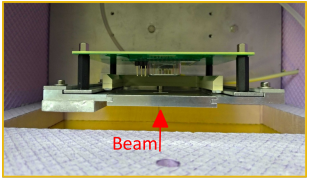


Irradiation Site - Irradiation Setup



Insulation Box with DUT:



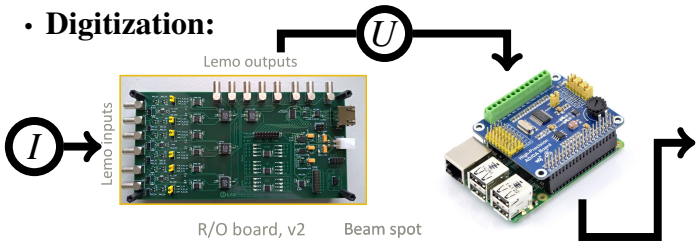


Top view of DUT mounted behind shield

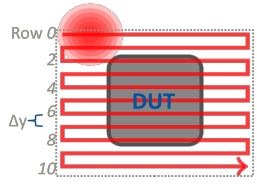
- Transversely movable box with partly-shielded DUT

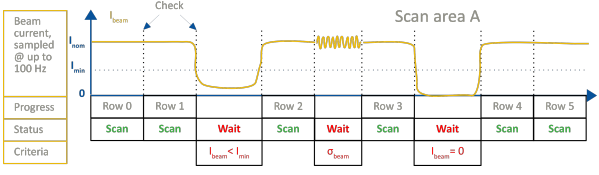
Irradiation Site - Irradiation Procedure

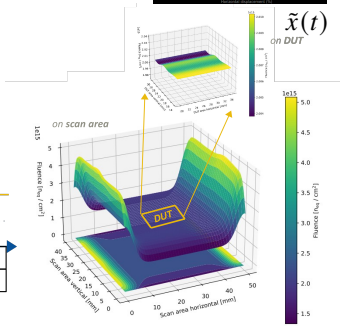
- **Digitization:**



- **Beam-driven irradiation:**





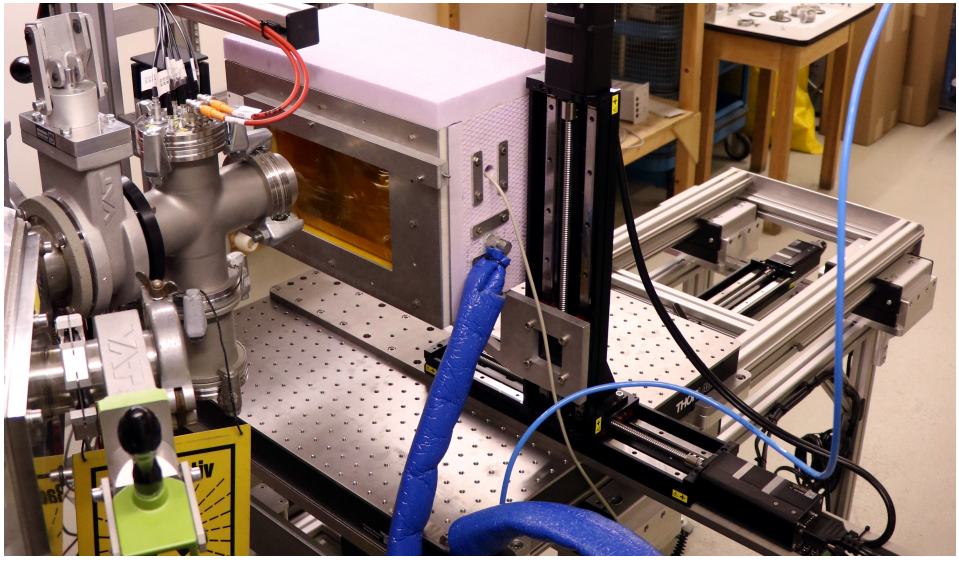


Thank you
for
your attention!

irrad_control software: ▸ www.github.com/SiLab-Bonn/irrad_control

✉ sauerland@hiskp.uni-bonn.de

Appendix: Real Stuff



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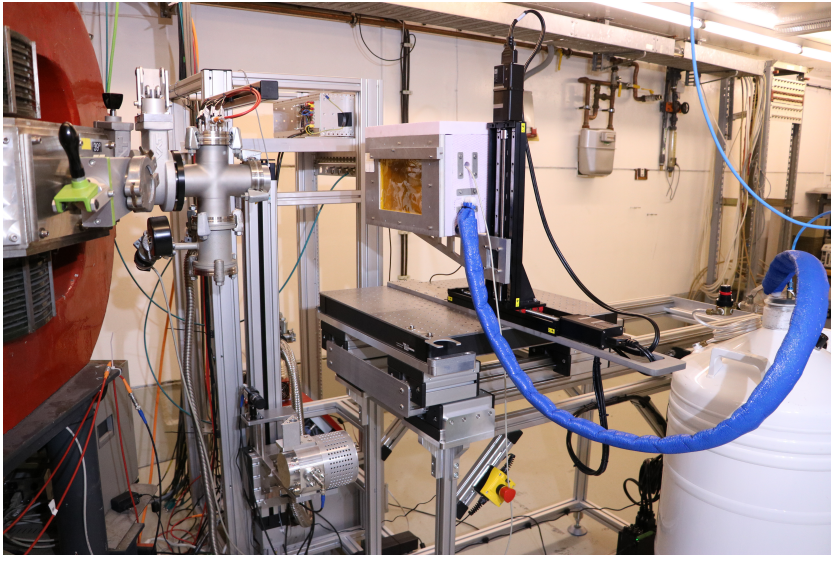

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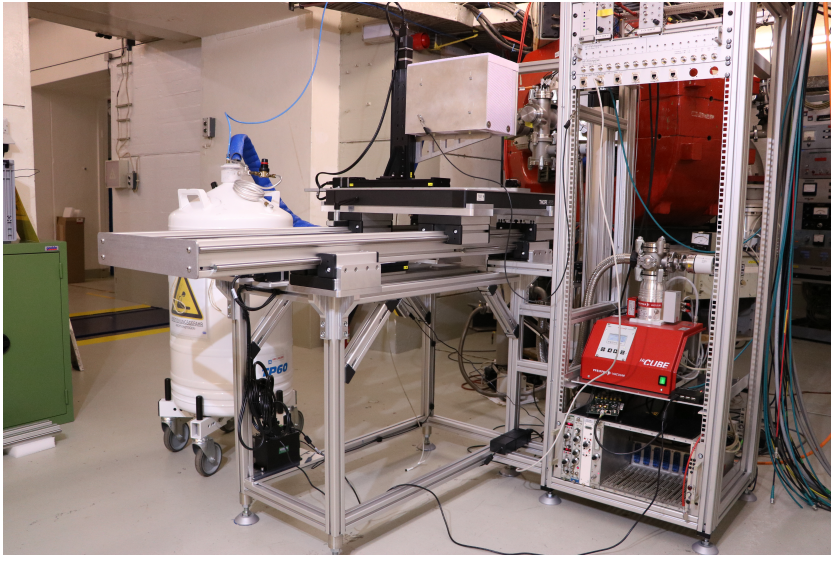
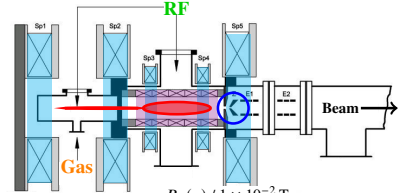
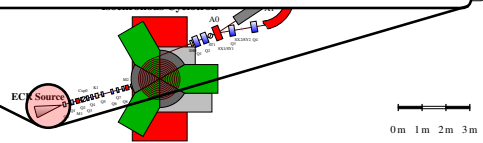


Appendix: ECR-Source

Electron Cyclotron Resonance Source:

- Two stage ECR source where electromagnetically confined plasma is heated by 5 GHz RF and ionizes injected gas.
- Extraction by HV electrodes provides a p, d or α particle beam of 4 to 8 keV.
- Additional ECR source for polarized p or d beam below the cyclotron.





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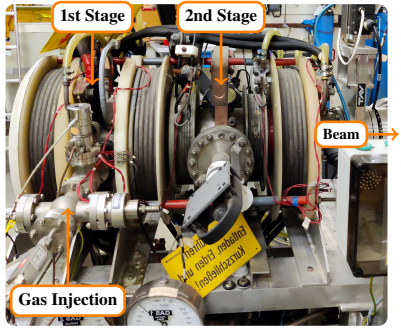
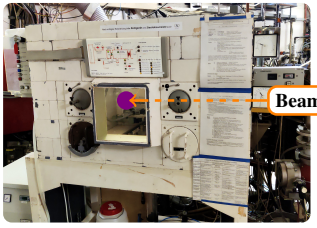


Appendix: High Current Site

High Current Site:



- Use the extracted beam with $\leq 10\,\mu A$ to induce radioactivity into material.
- Examples:

Isotope	Reaction	$t_{1/2}$
^{11}C	$^{14}N\,(p,\alpha)\,^{11}C$	20 min
^{74}As	$^{74}Ge\,(p,n)\,^{74}As$	17.8 d