Tesla-Converter:
A high power water cooled Bremsstrahlung Converter

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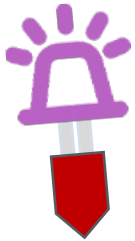
Matthias Lüthi[a], Andreas Türler[b], Christian Kottler[a], Peter Peier[a]

[a]Federal Institute of Metrology (METAS), Switzerland,

[b]Department of Chemistry, Biochemistry, and Pharmaceutical Sciences (DCBP),University of Bern, Switzerland

Theranostics: ^{225}Ac



Ga-68-PSMA

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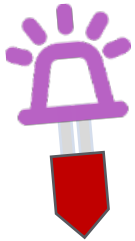

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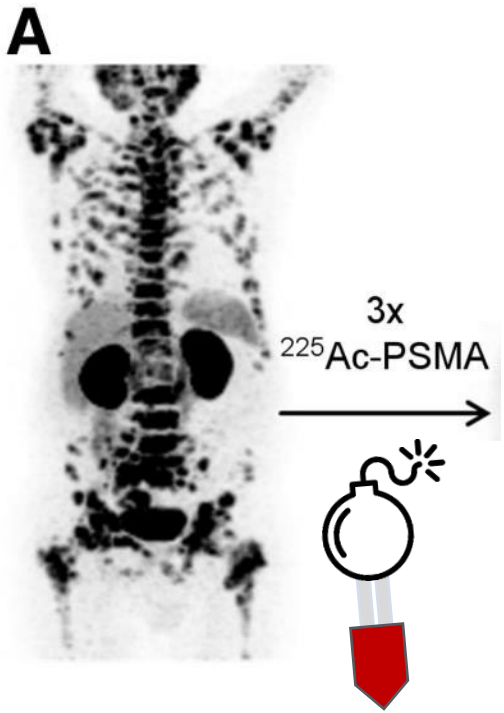

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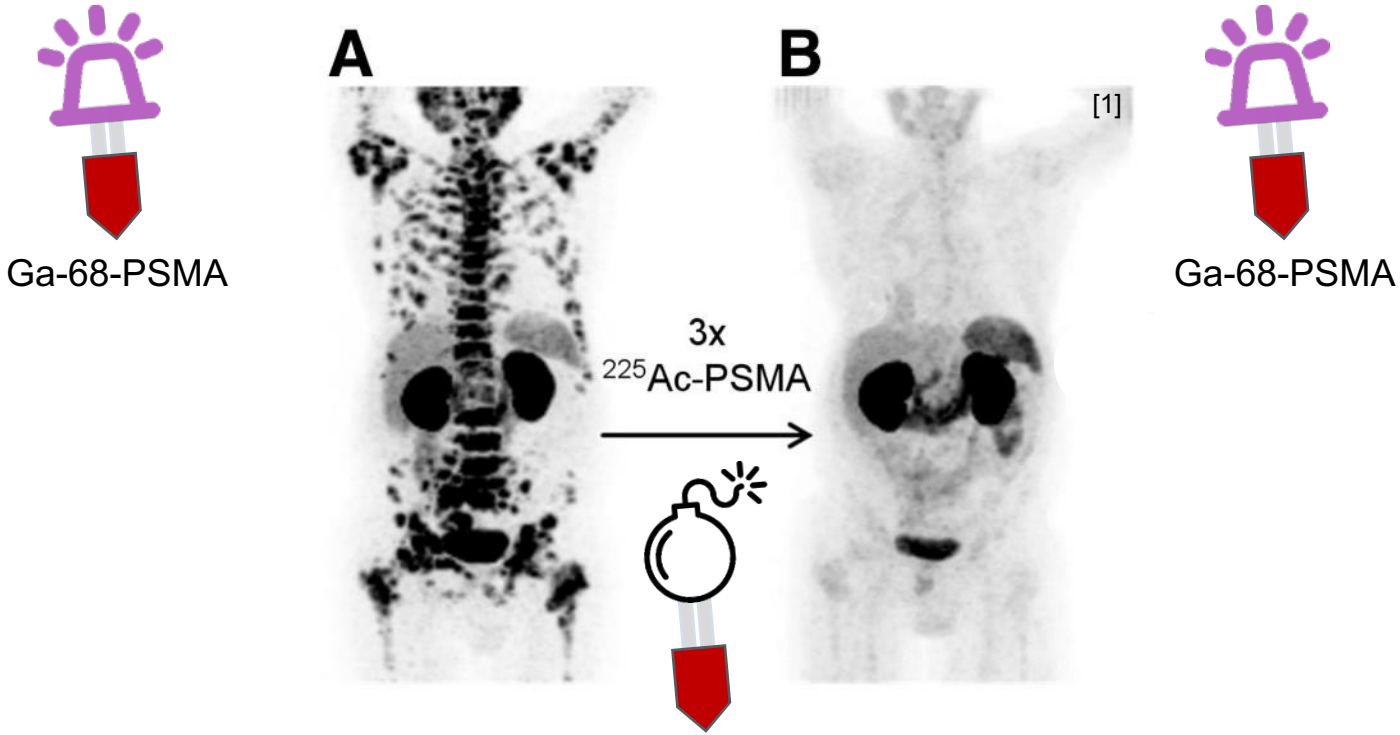
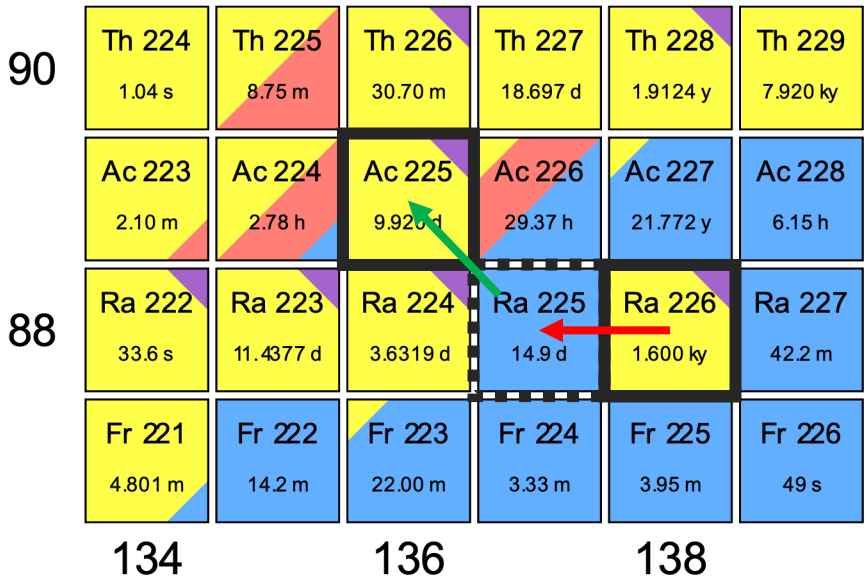
METAS

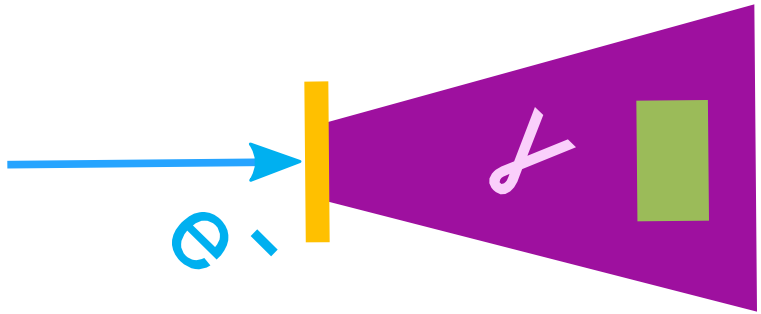


Photonuclear Production Route

$$^{226}Ra + \gamma\ (\sim 15MeV) \rightarrow {}^{225}Ra + n$$
$$\hookrightarrow {}^{225}Ac + \beta^-$$



Photonuclear Production Basics



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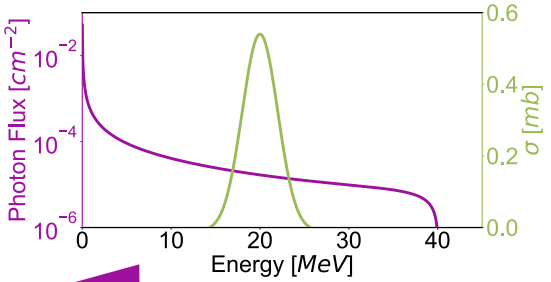
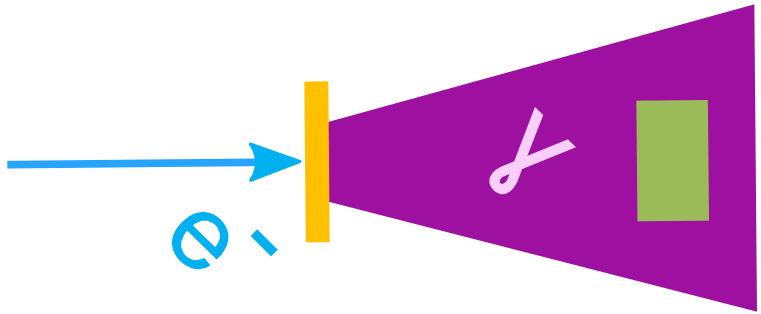


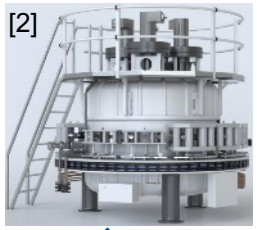


Photonuclear Production Basics

METAS

Rhodotron:

- I_{pulse} = 25 mA
- t_{pulse} = 2.5 ms
- R = 50 Hz
- E_{pulse} = 2500 J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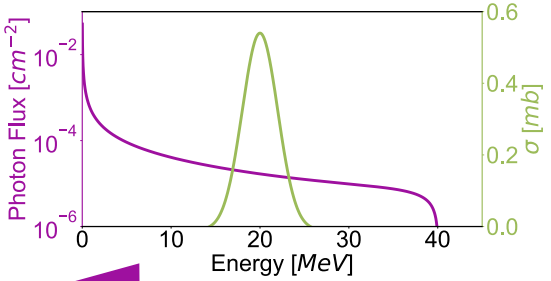
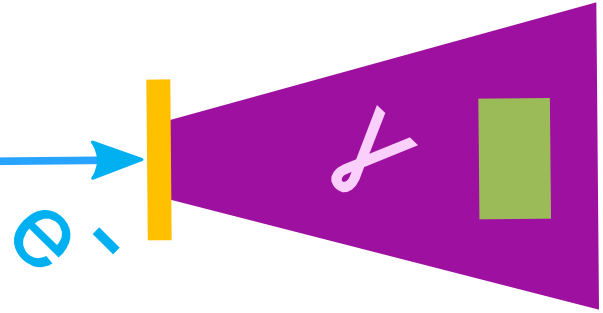
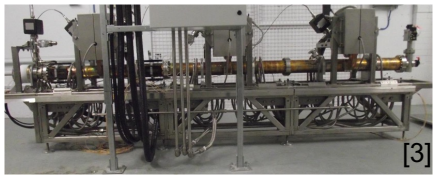


- E_{beam} ≈ 35-40 MeV
- I_{Mean} ≈ 3 mA
- P_{Mean} ≈ 100-120 kW



Linear Electron Accelerator:

- I_{pulse} = 250 mA
- t_{pulse} = 15 µs
- R = 800 Hz
- E_{pulse} = 120 J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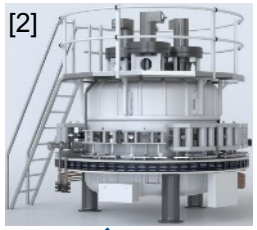
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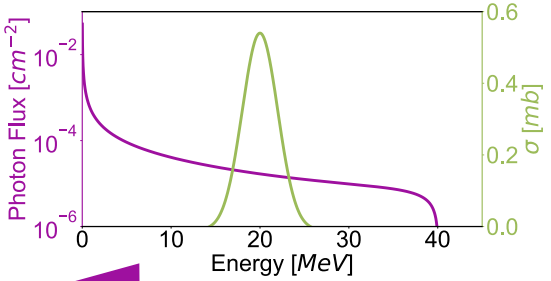

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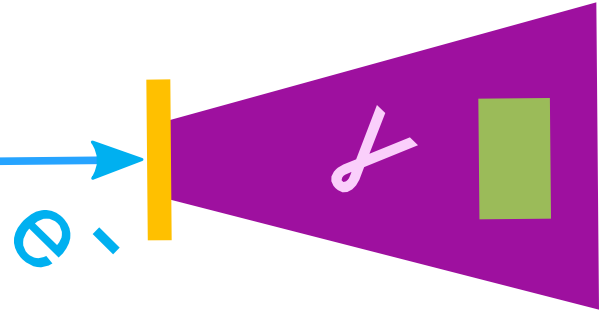

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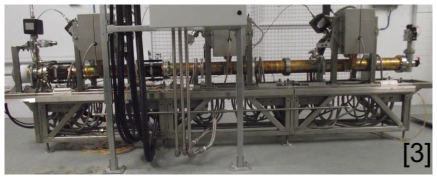
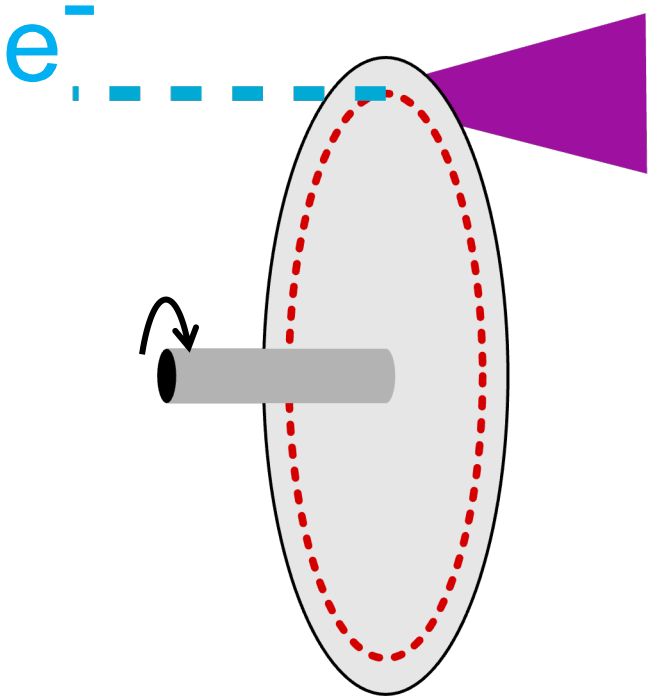

[3]

Bremsstrahlung Converer

- High-Z: Tantalum, Tungsten, …
- d = 1-2 X_0 = 5-10 mm
- E_{heat}/E_{beam} = 0.4 → 50 kW thermal load
  → Water flow $\dot{m} \approx 240\ {}^{g}/_{s}$ for $\Delta T = 50\ °C$

Tesla-Converter: Principle



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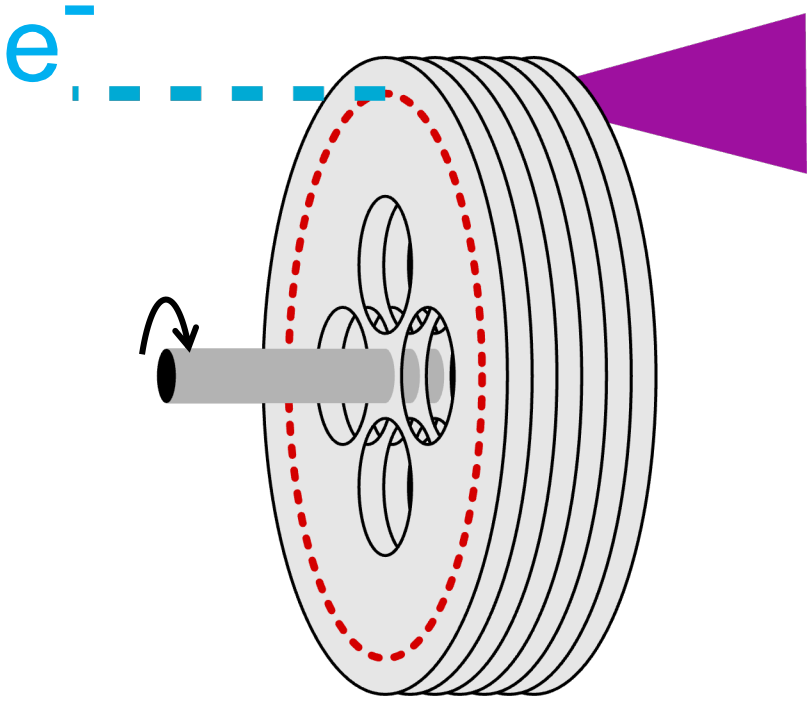

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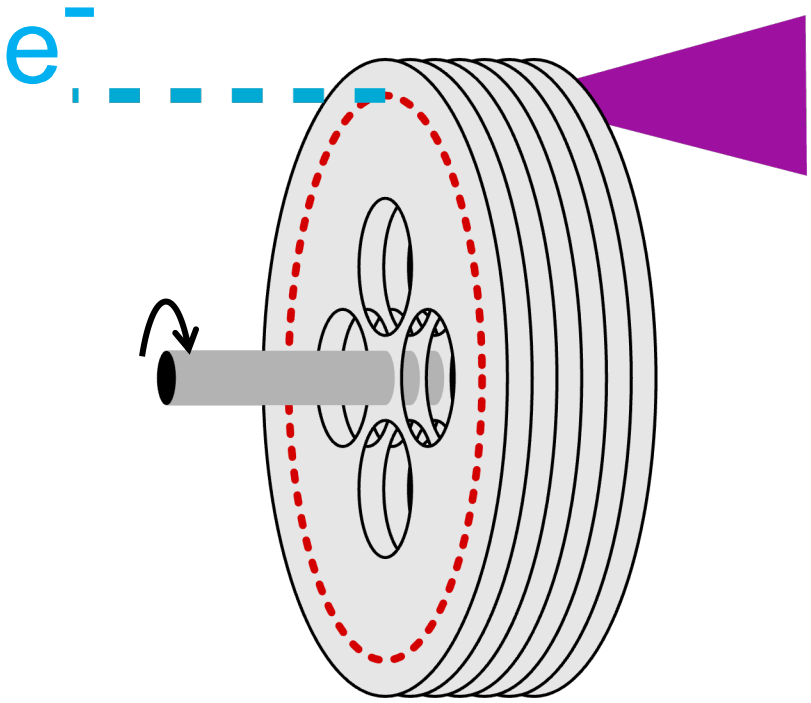

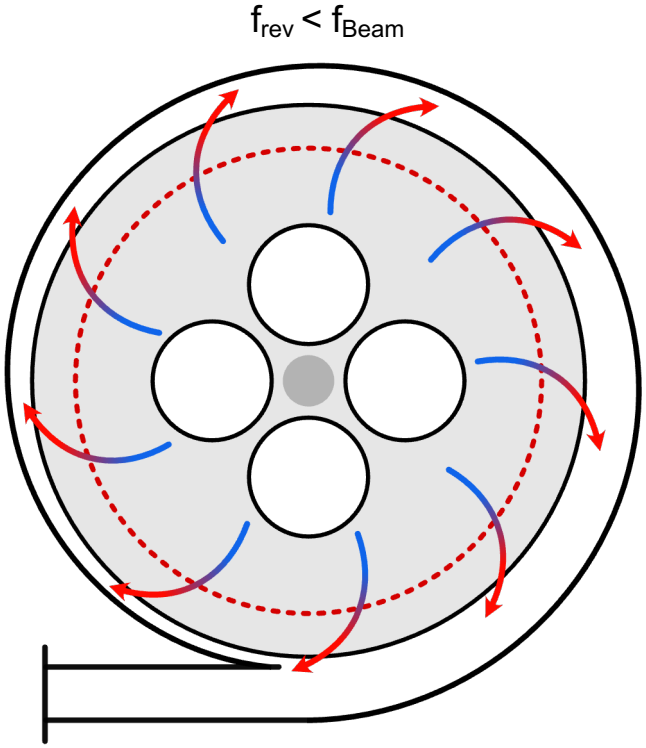

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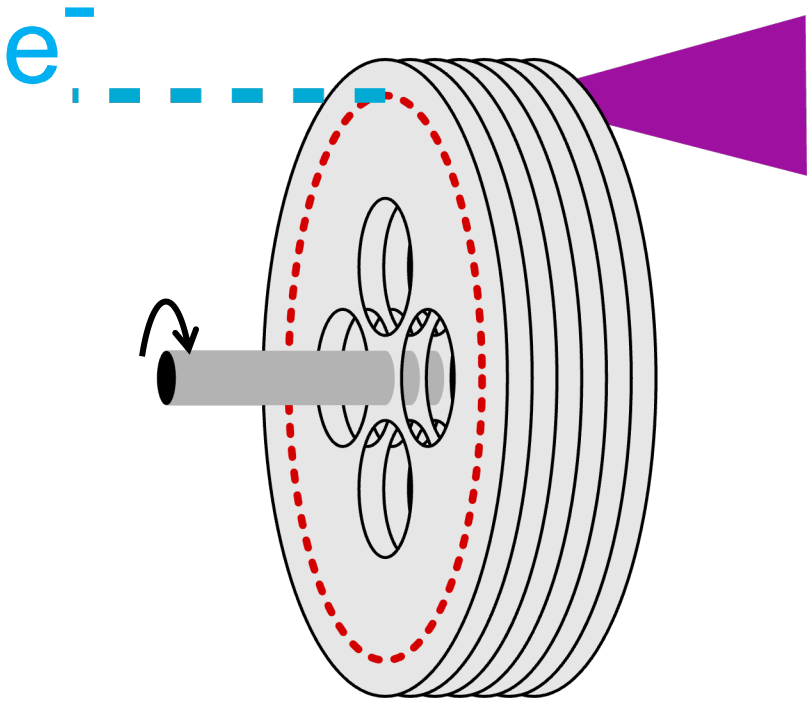
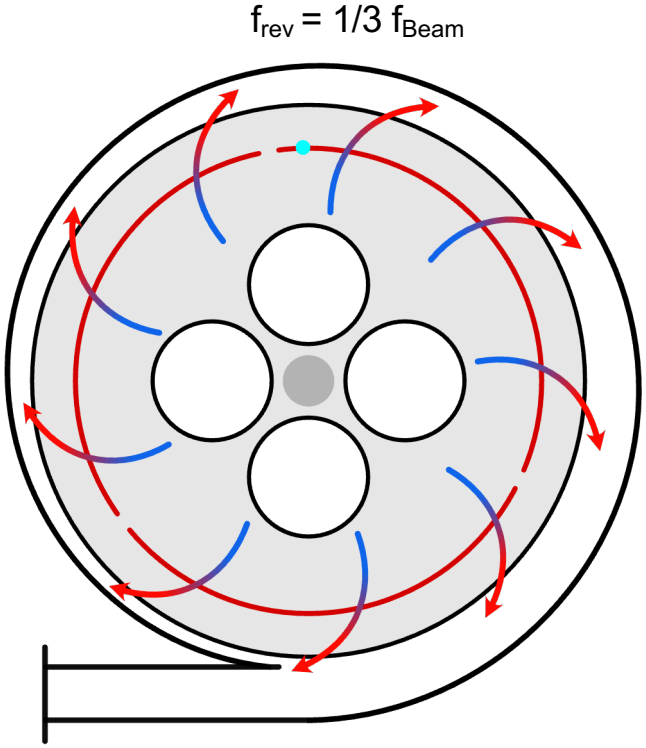
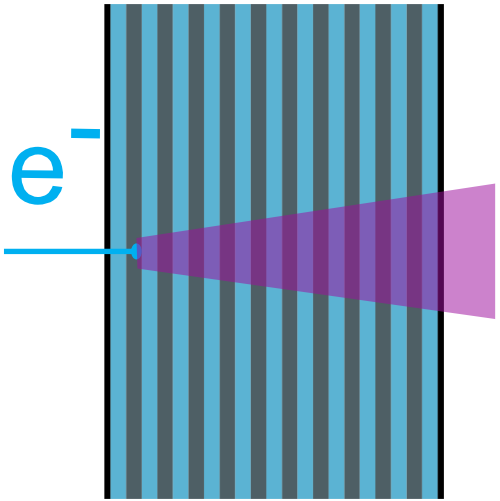
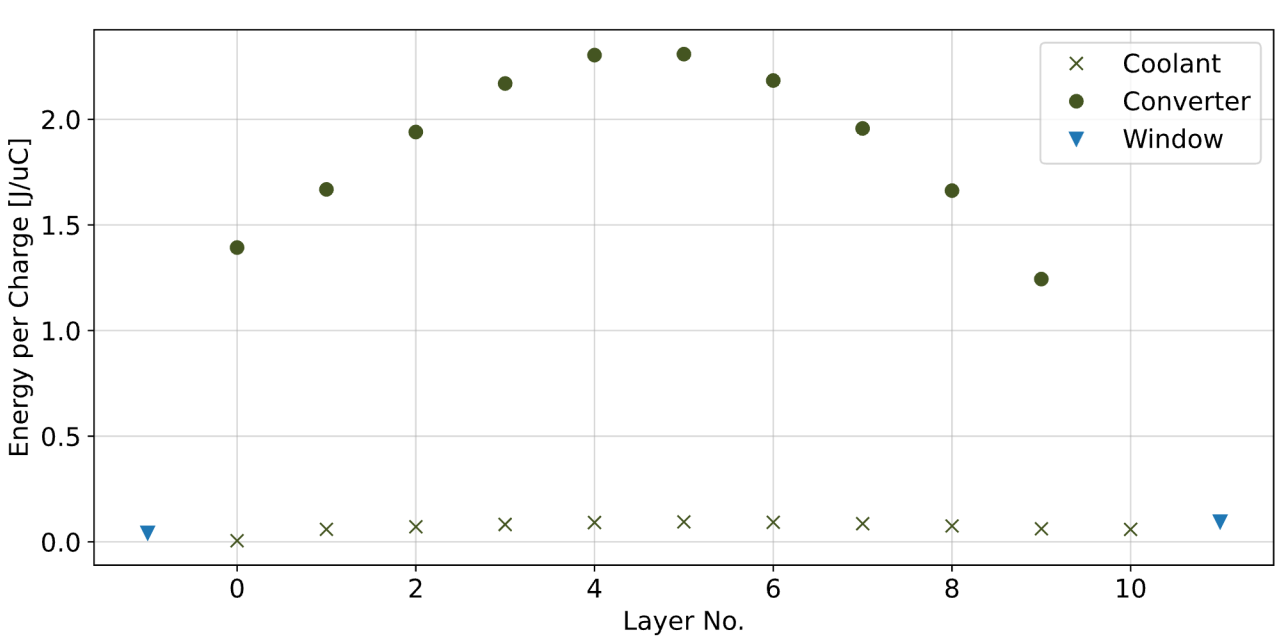




Tesla-Converter: Design Optimization

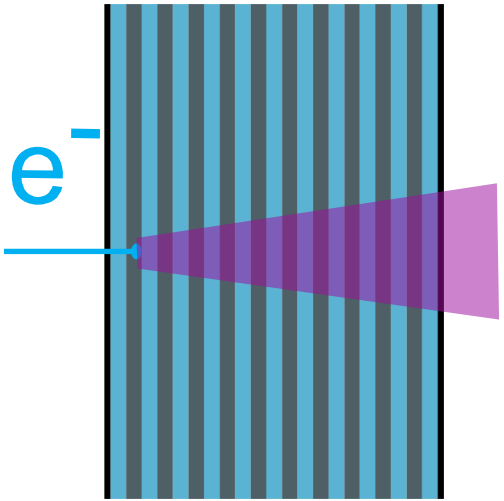


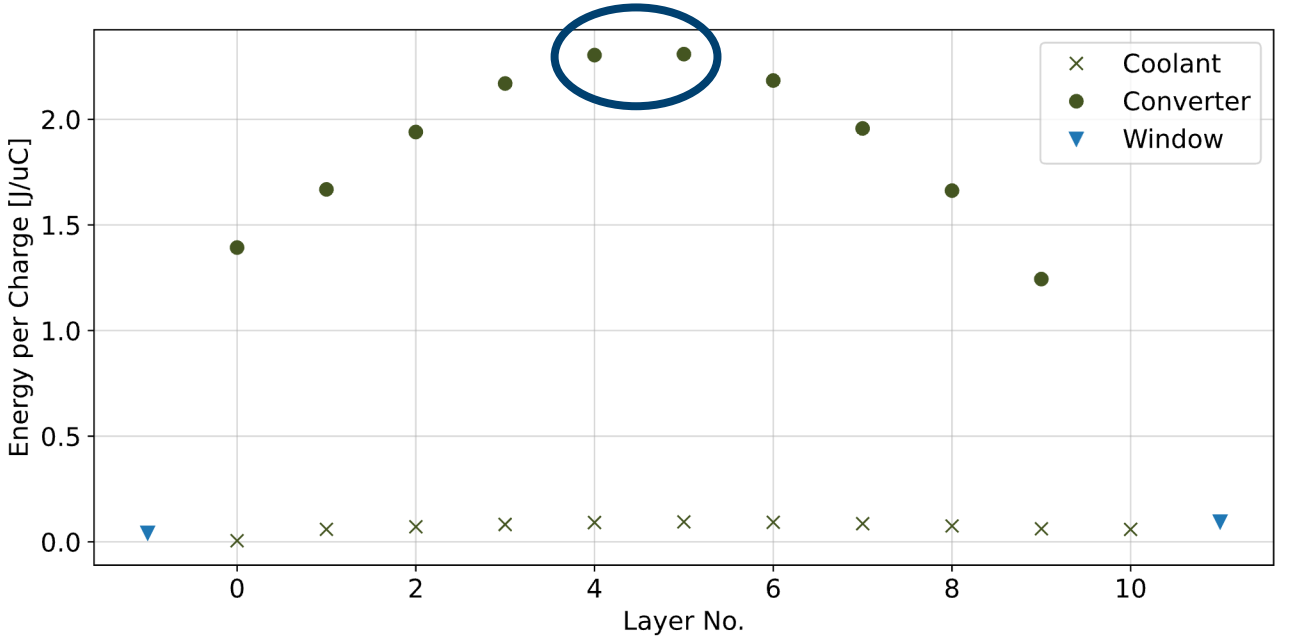
- D_{disc} = 0.5 mm
- $D_{cooling}$ = 0.5 mm
- D_{window} = 0.2 mm



Tesla-Converter: Design Optimization

- $E_{dep,max}$ = 2.3 J/uC → P_{max}= 7.5 kW
- E_{dep}/E_{beam} = 0.47





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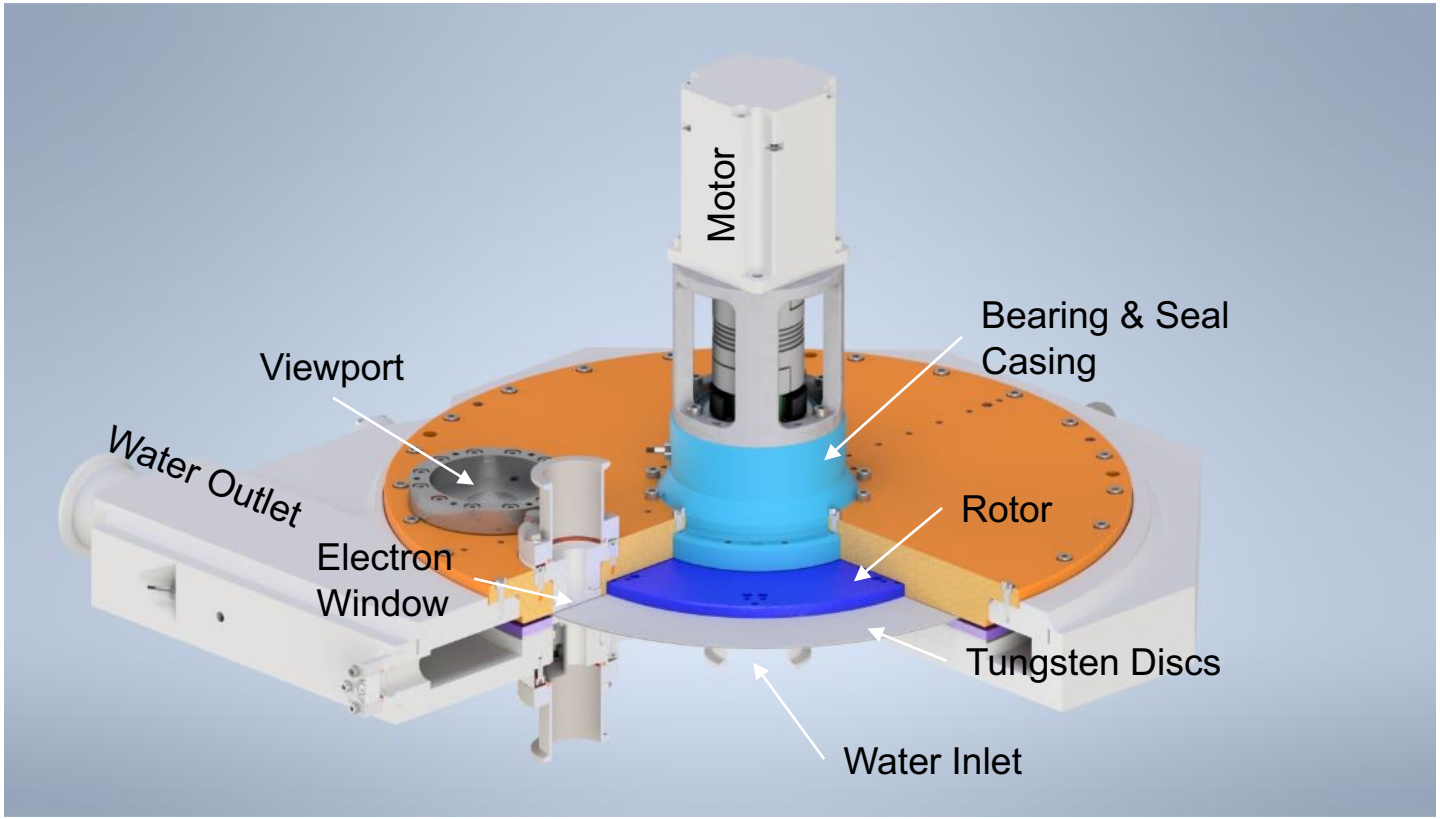
Tesla-Converter: Realisation



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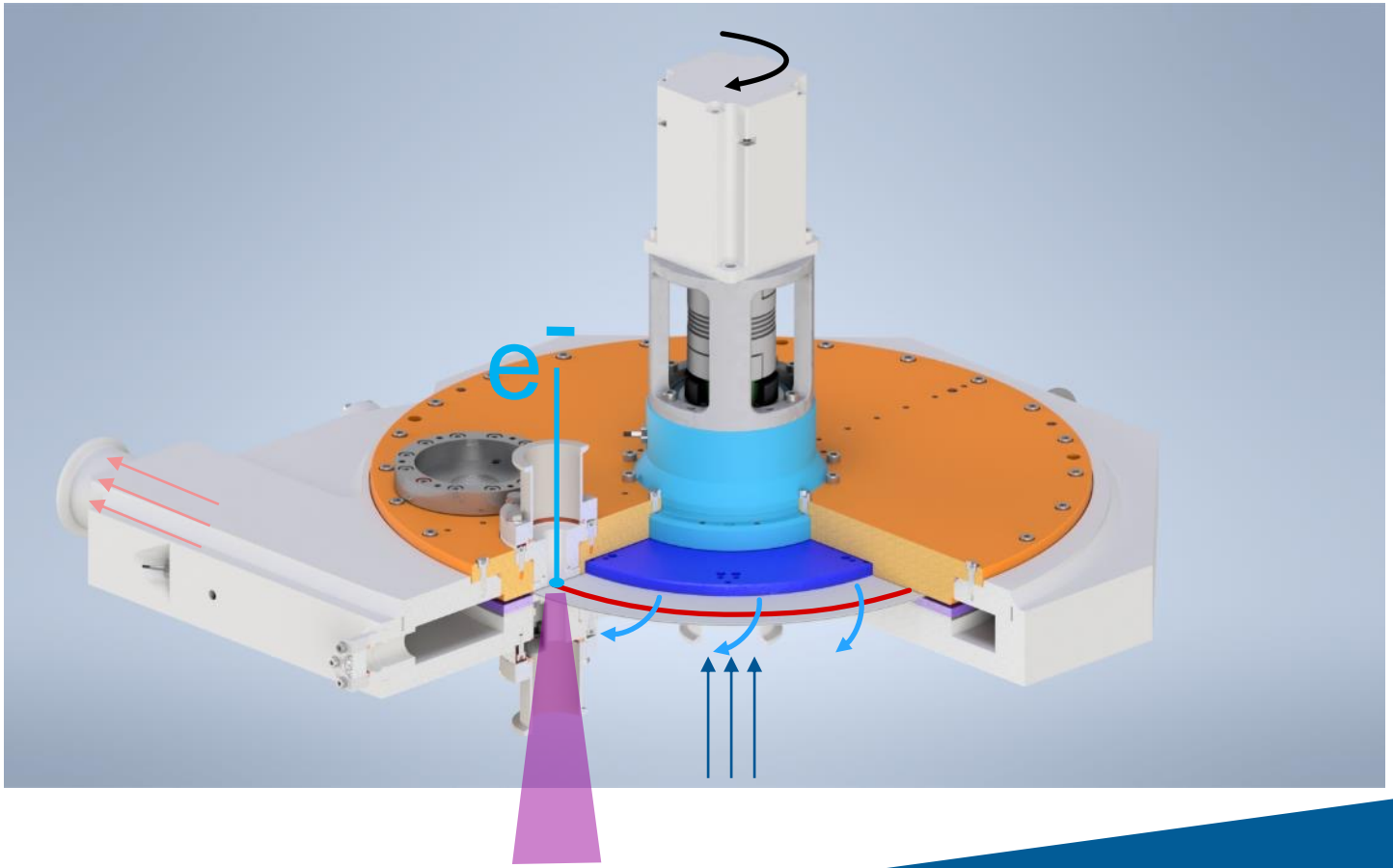

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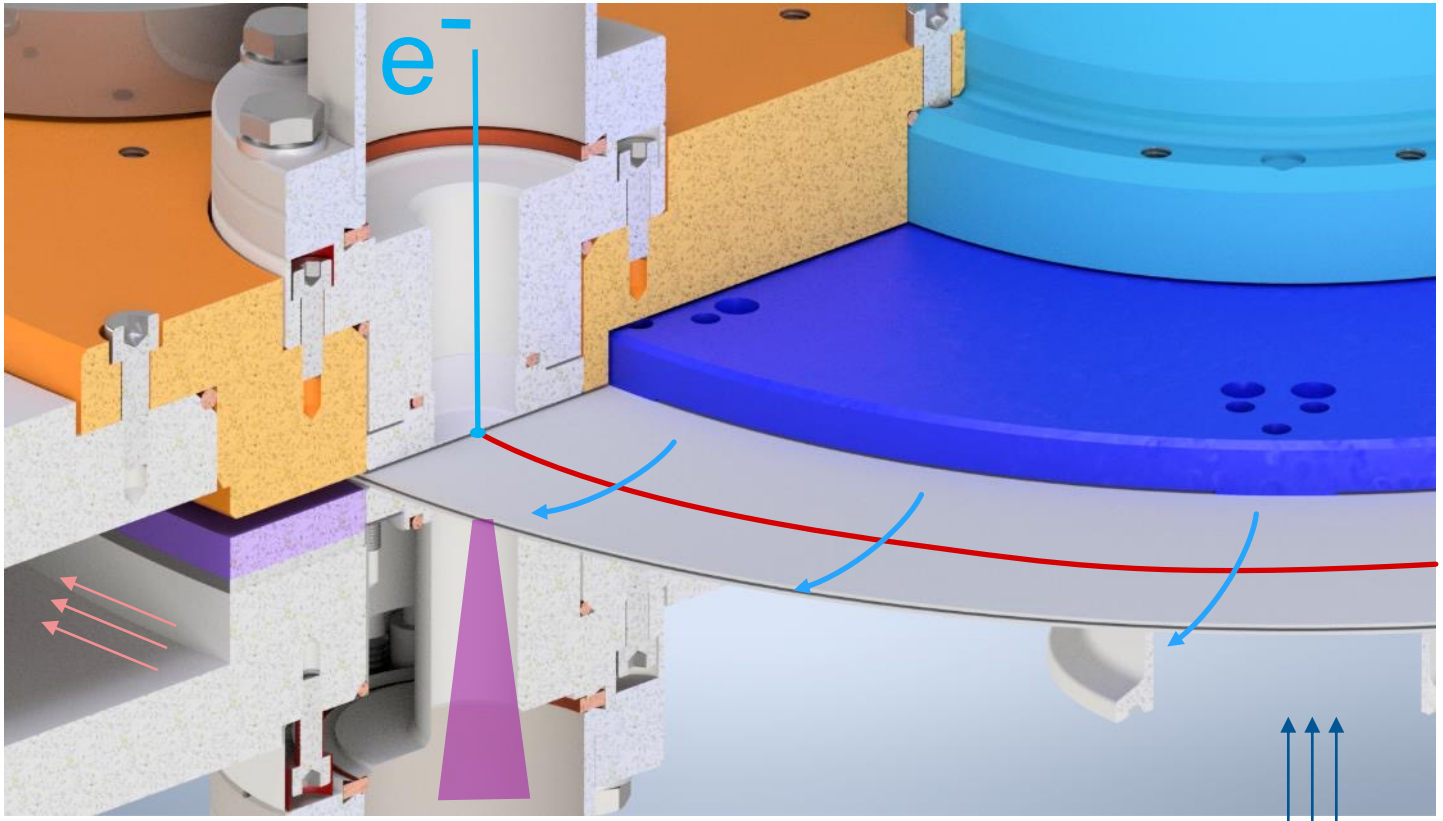

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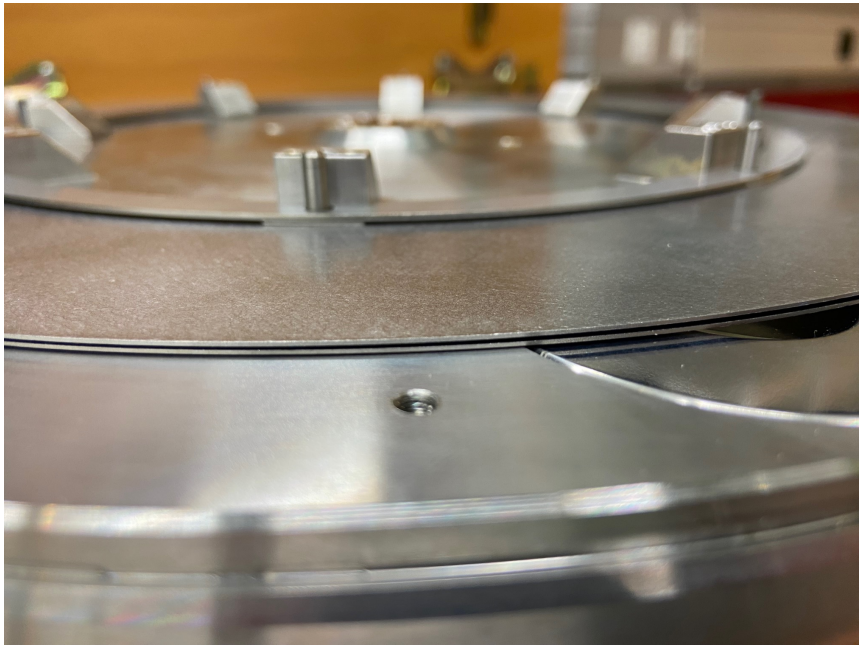
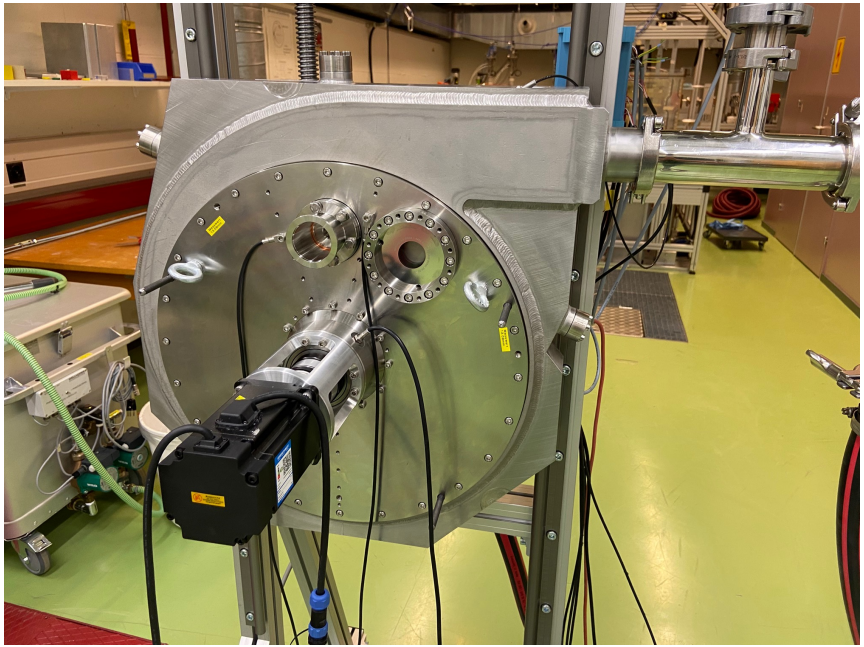
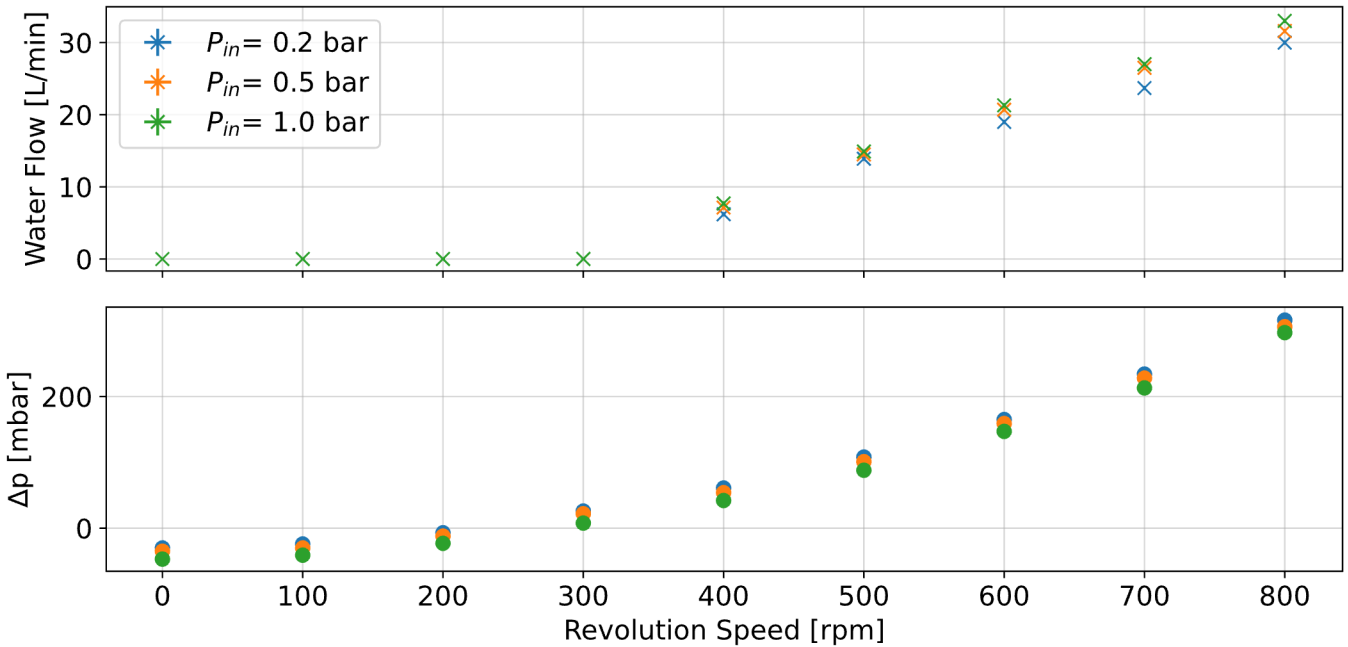




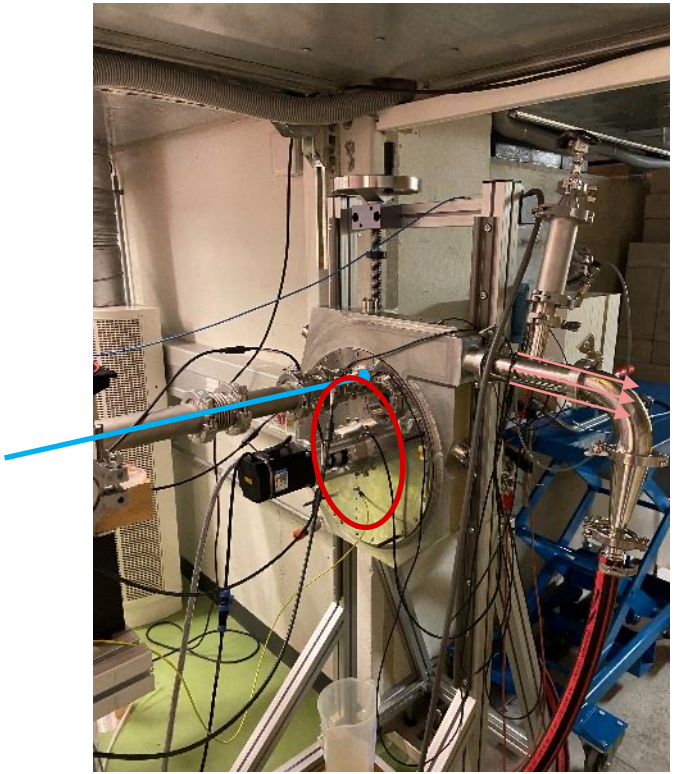
Cold Performance: Pumping



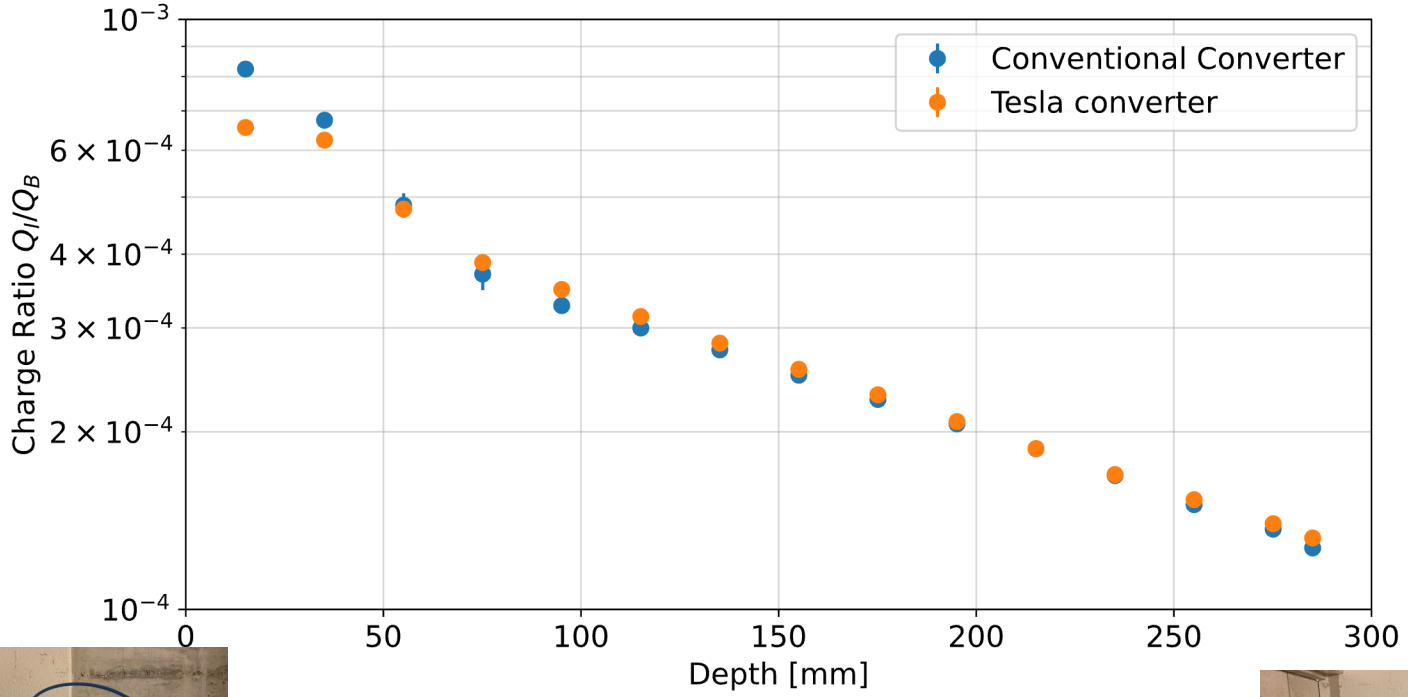
Tesla-Converter: In Beam

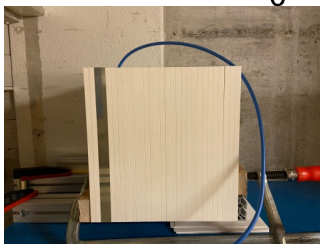
Beam @ METAS: 21MeV Microtron

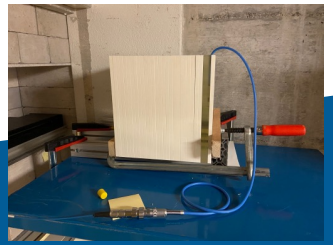
- I_{beam} = 30 – 35 mA
- f_{rep} = 0 – 250Hz, t_{pulse} = 3 us



Hot Performance: Depth Profile

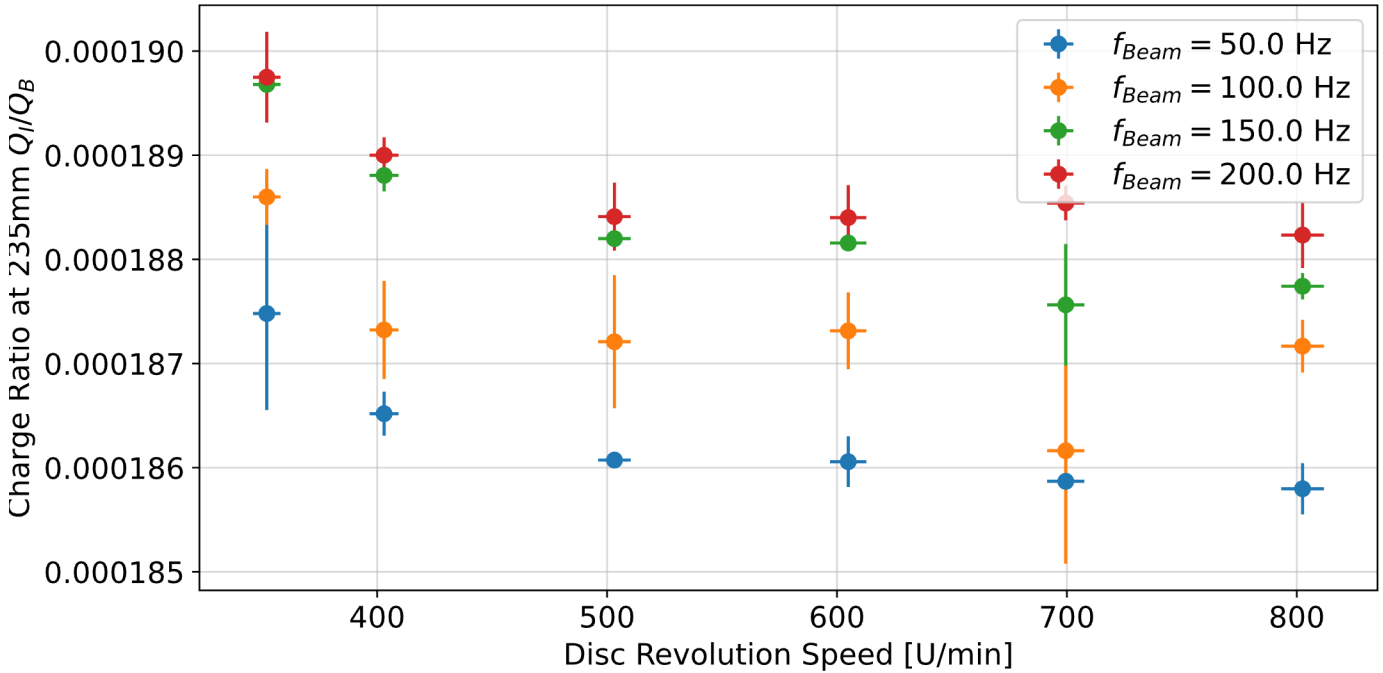




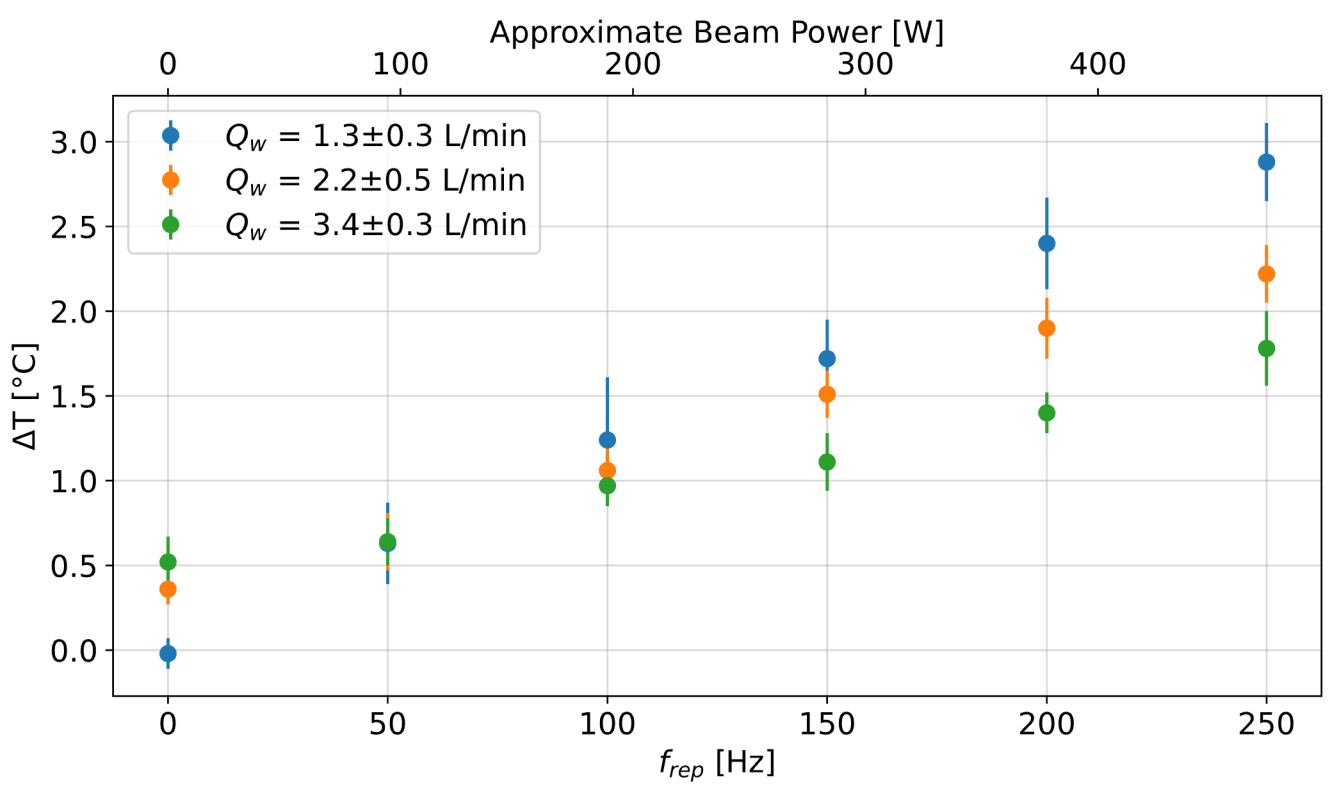


Hot Performance: Rotation Dependance?

METAS

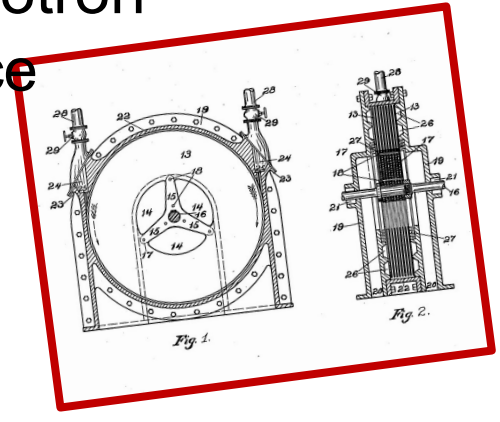


Hot Performance: Cooling



Summary

- Designed a fully functional shear-force pump Prototype
- Validated our design using the METAS Microtron
  - Photon beam profile comparable to reference
  - Rotation independent photon beam
  - Sublime cooling performance



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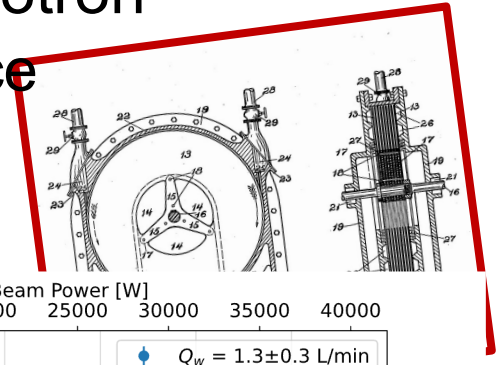
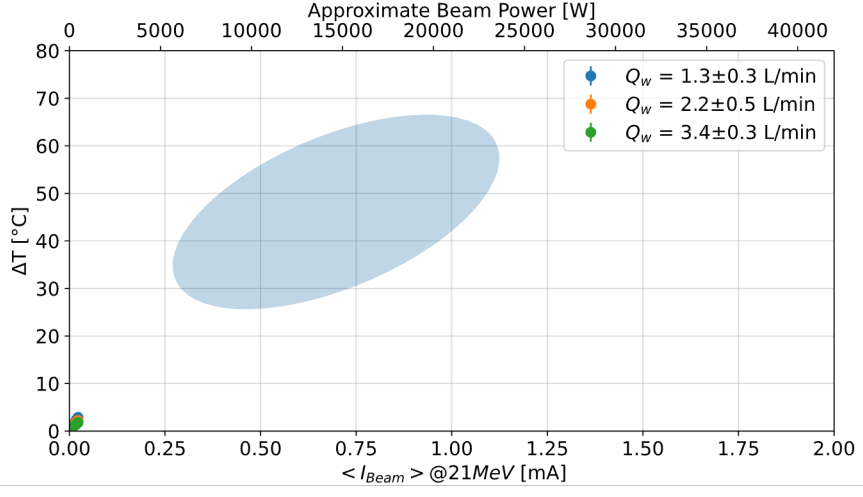


Outlook

- Need more Power!
- Simulate Transient Loads
- Comments & Remarks highly appreciated!



Thank You

METAS
Ihre Referenz.

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Eidgenössisches Institut für Metrologie METAS

References:
[1] Journal of Nuclear Medicine Dec 2016, 57 (12) 1941-1944; DOI: 10.2967/jnumed.116.178673
[2] https://www.iba-industrial.com/accelerators
[3] https://indico.cern.ch/event/275412/contributions/1617663
[X] EP21212627.0 and EP23159029.0 of University of Bern / METAS

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M.Ritschard and S.Russi for the engineering work of the converter.

METAS
Ihre Referenz.

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Eidgenössisches Institut für Metrologie METAS