Recent developments with the GTS-LHC ECR ion source at CERN

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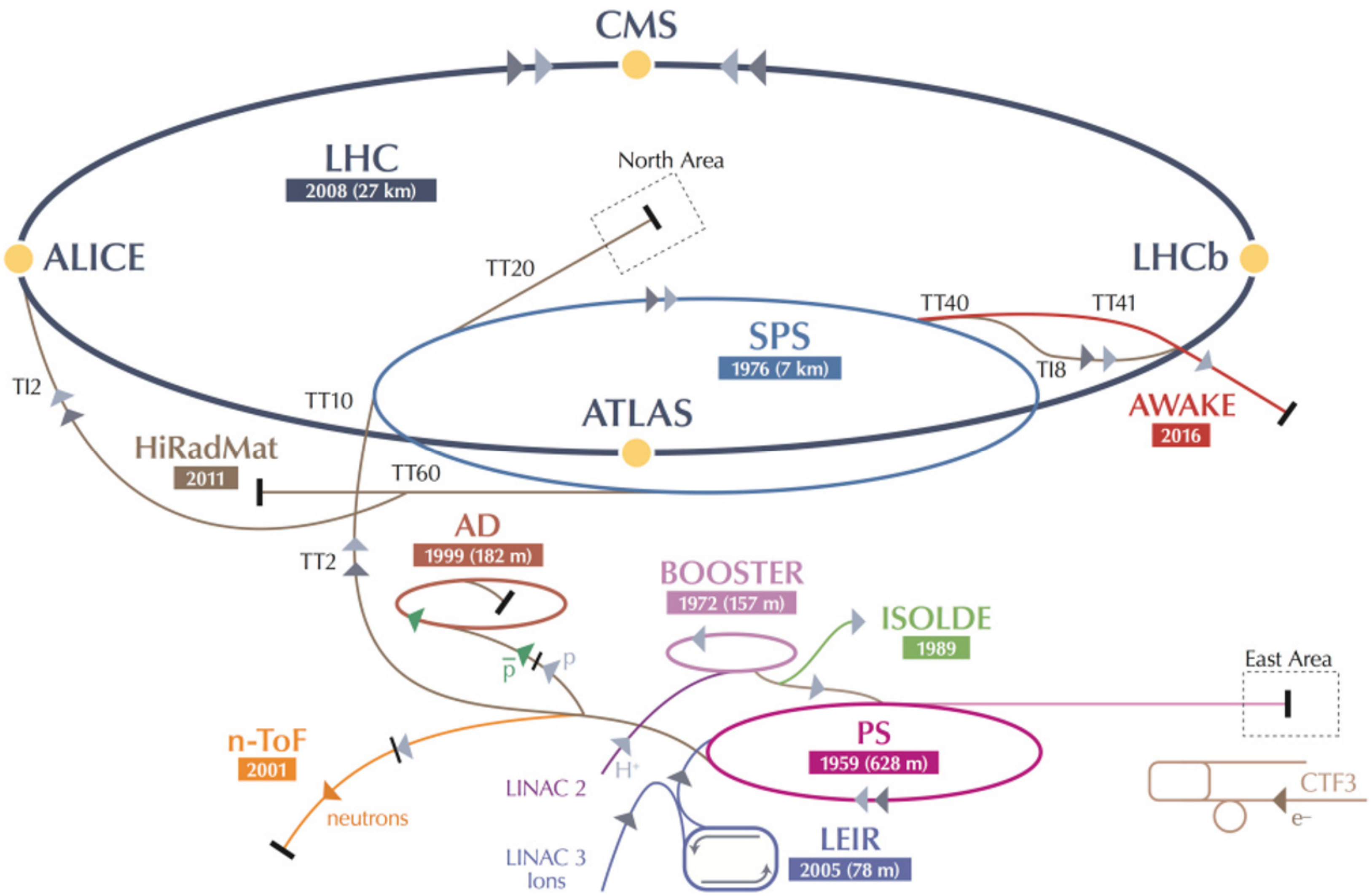

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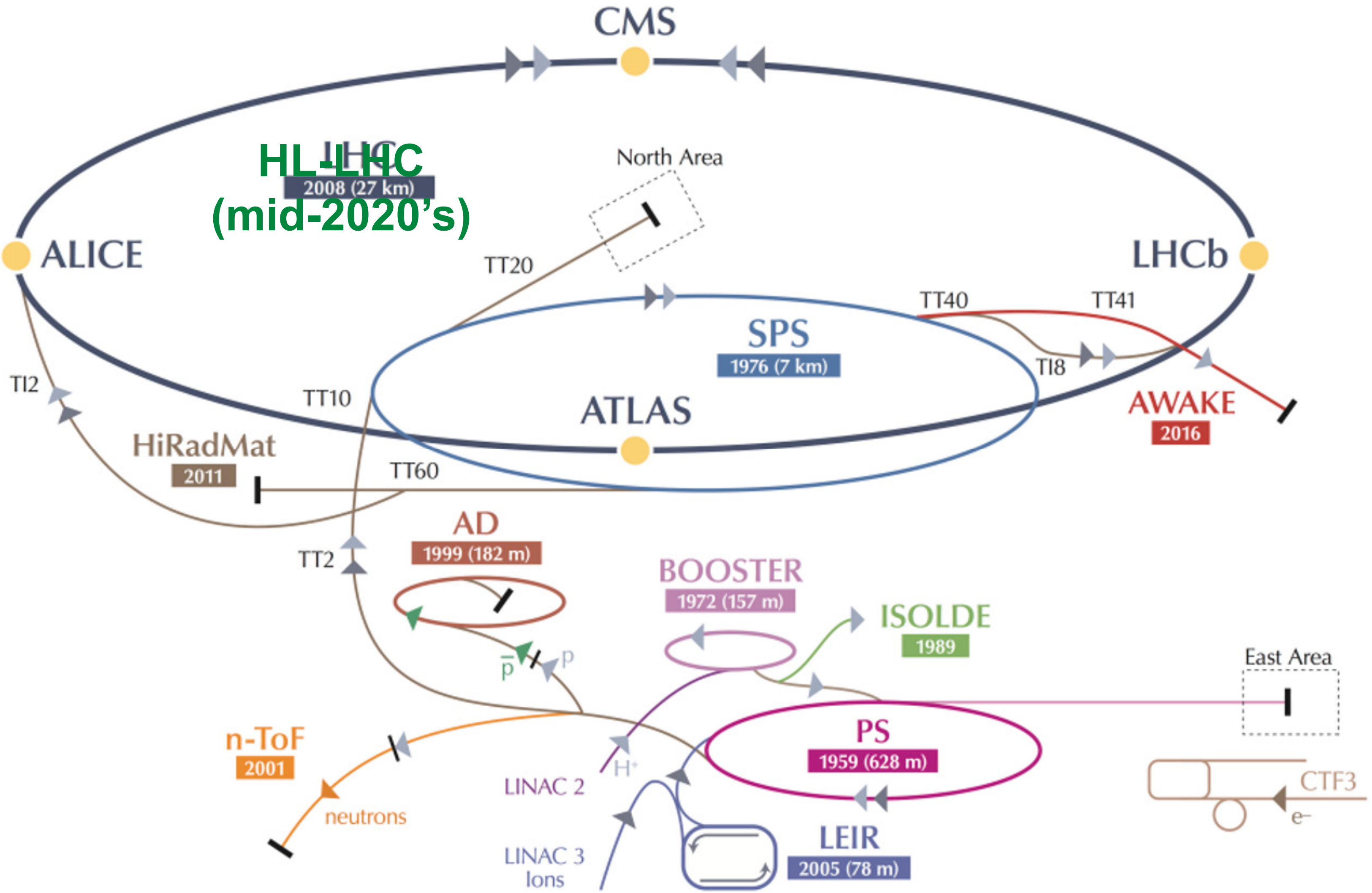

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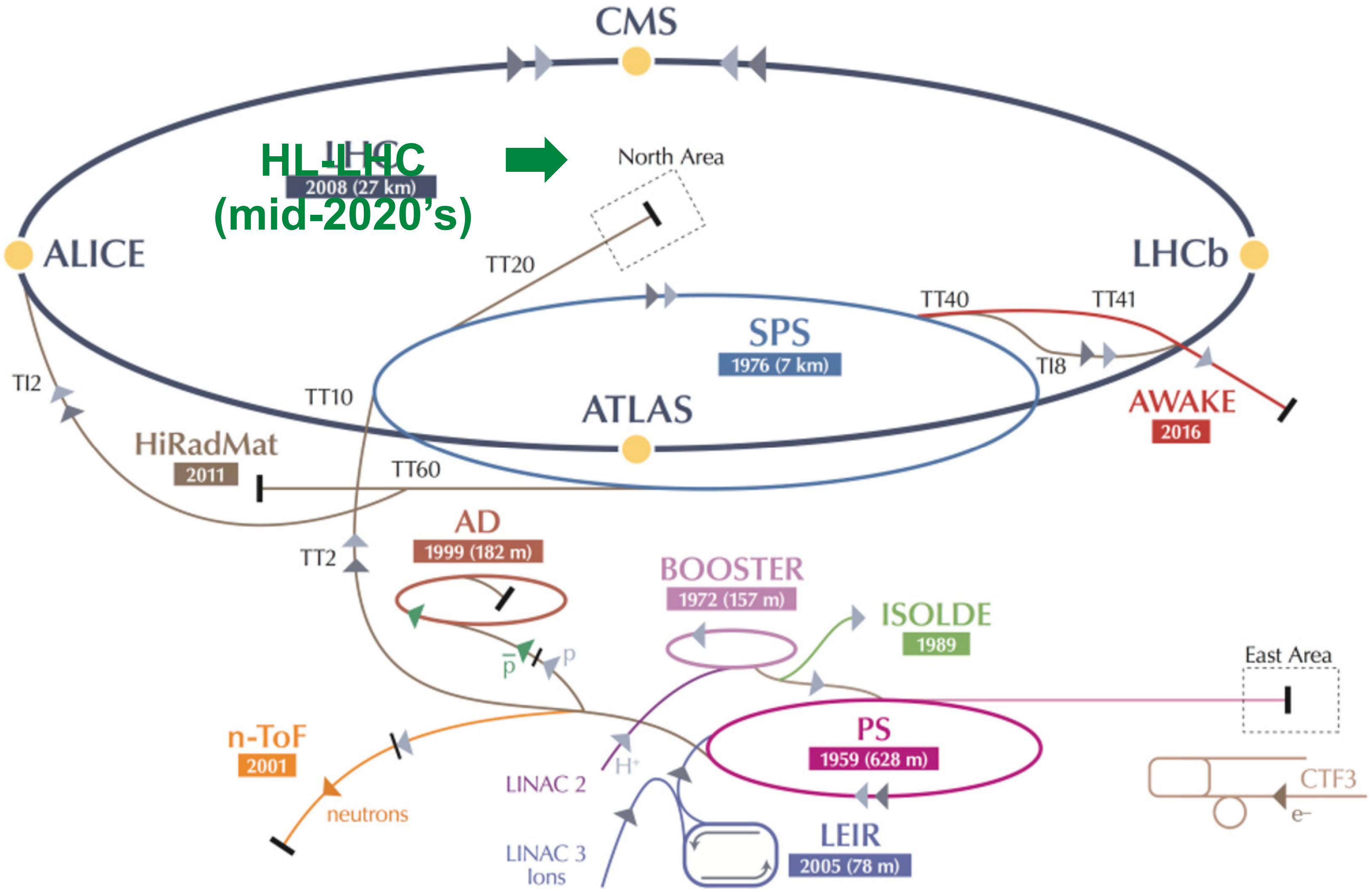

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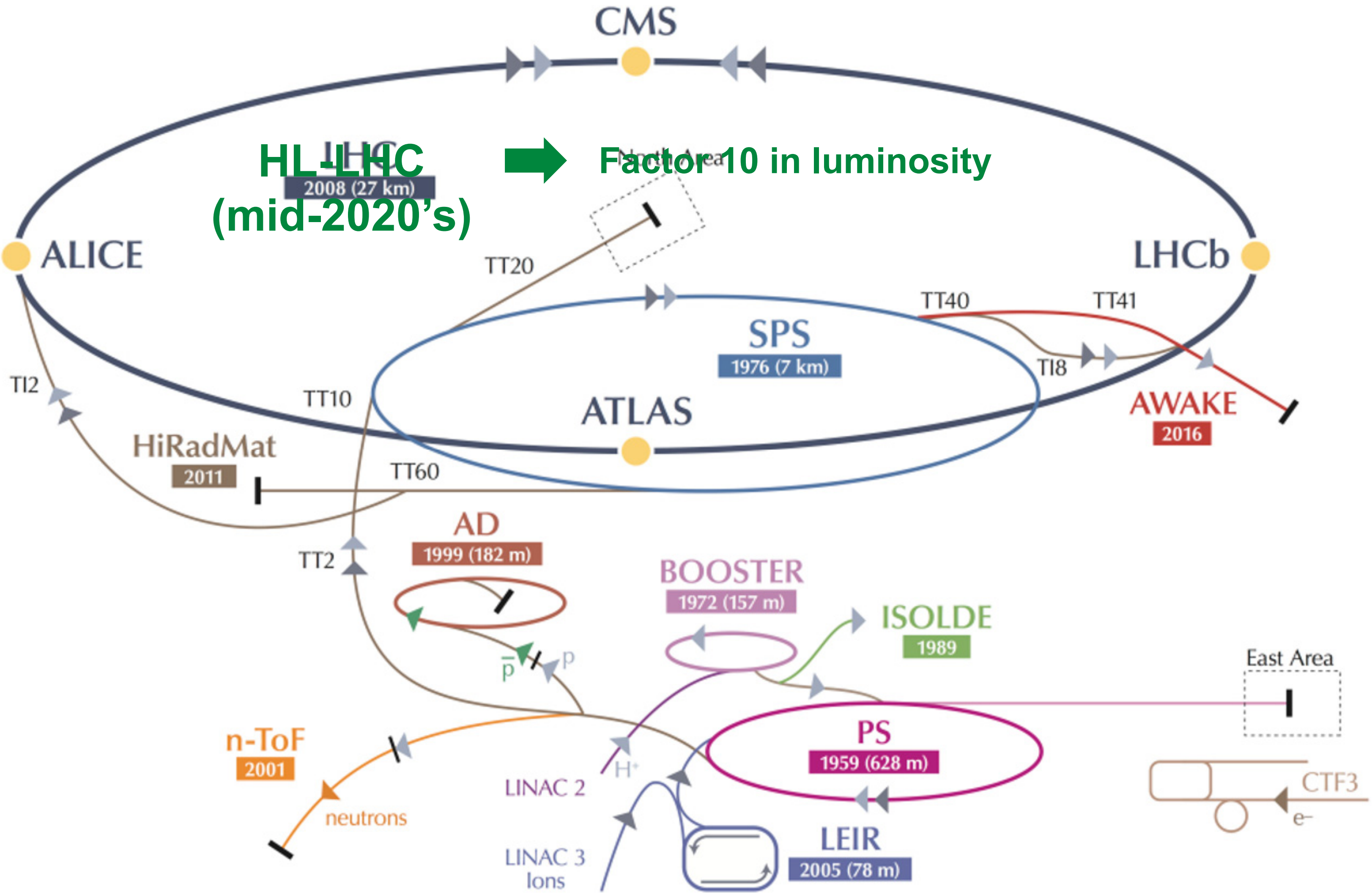

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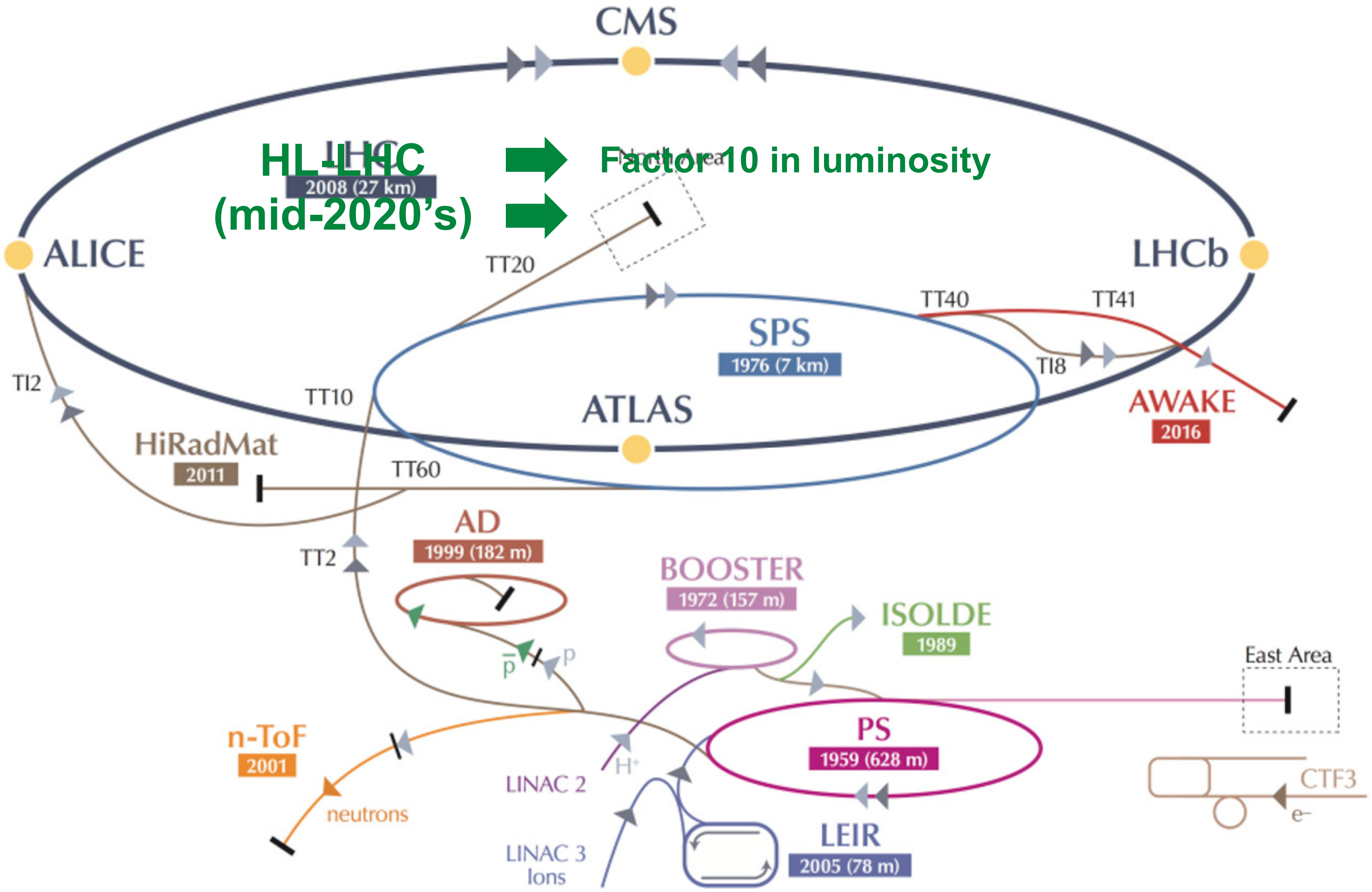

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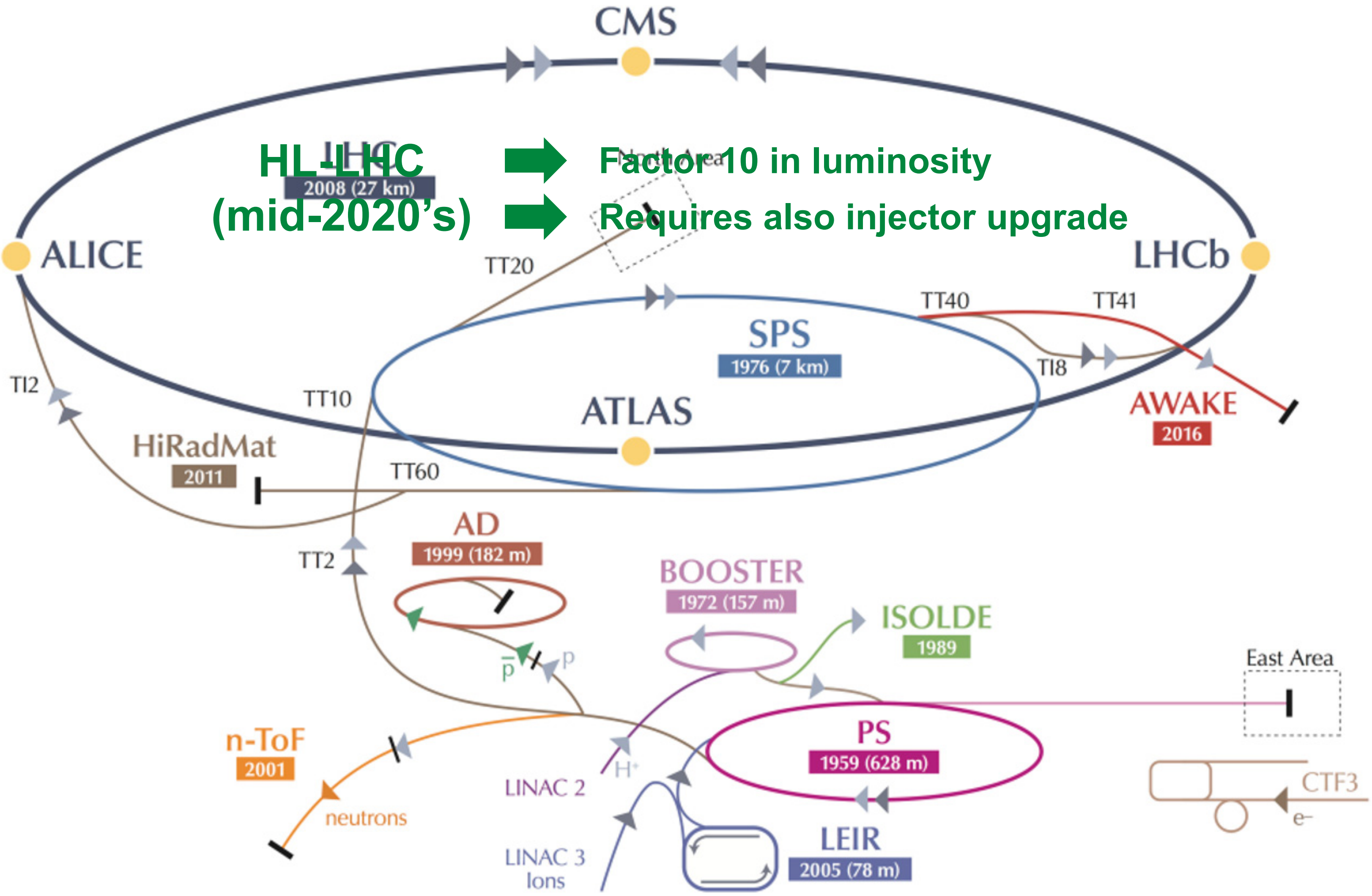

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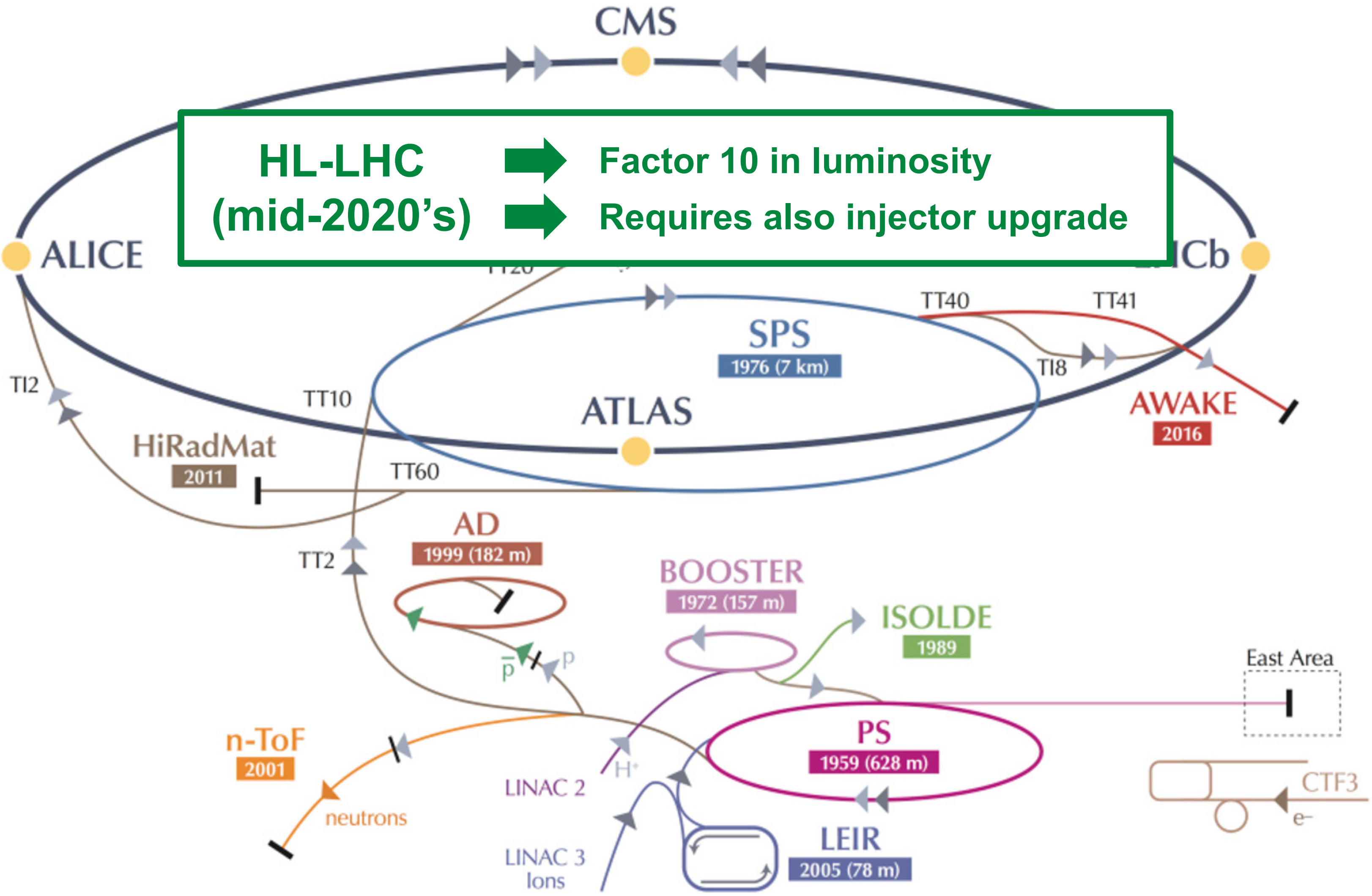

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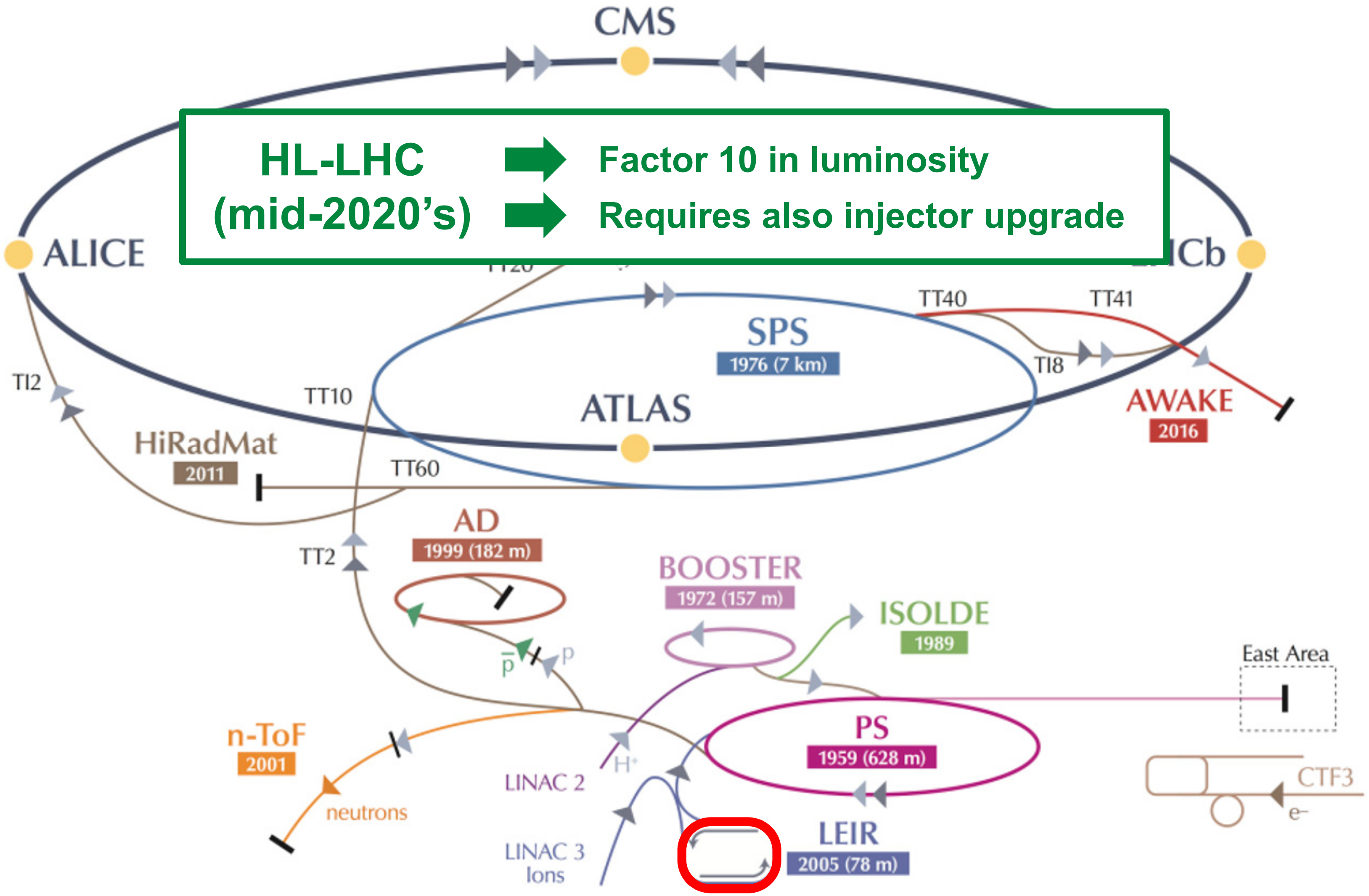

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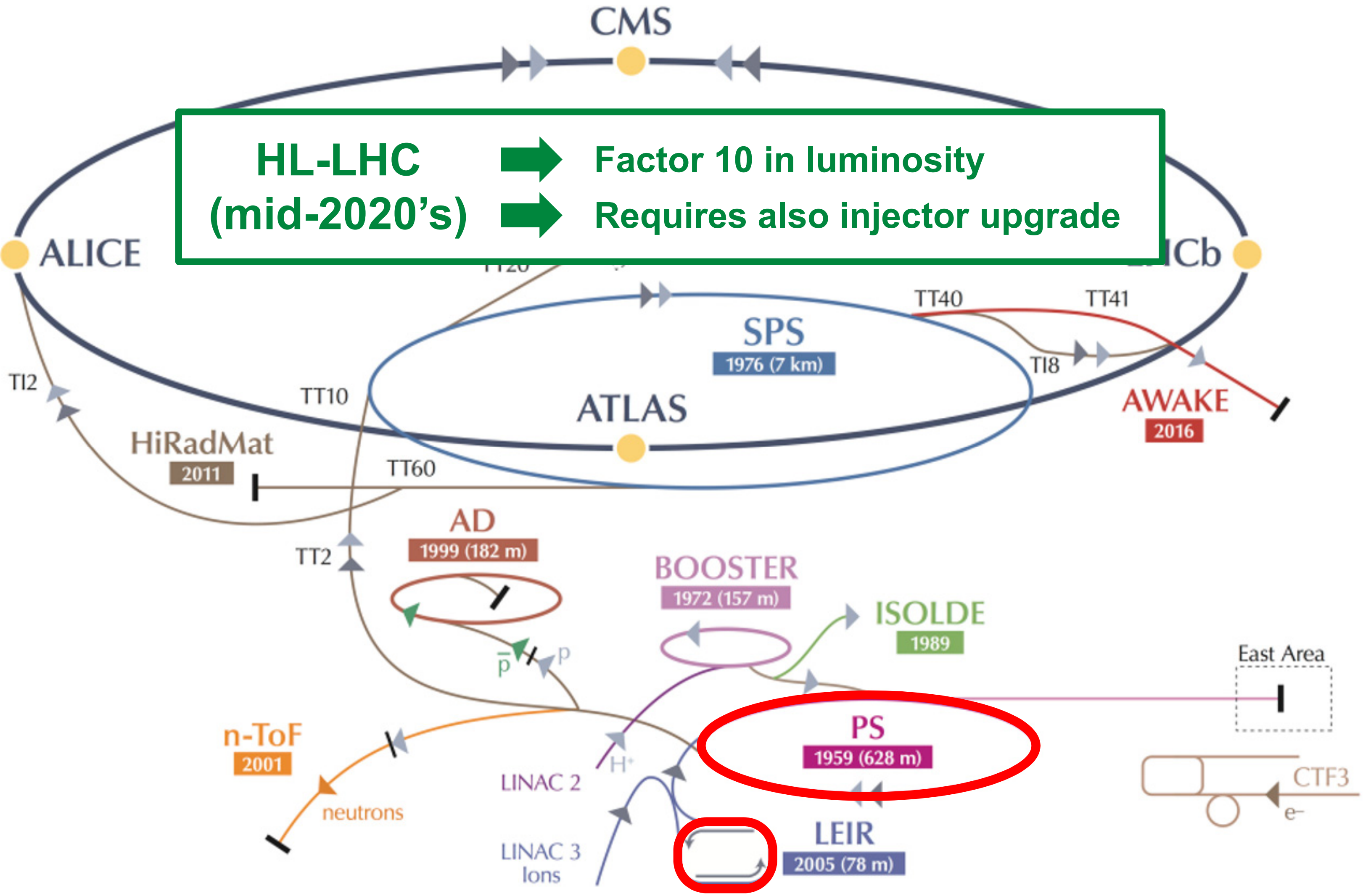

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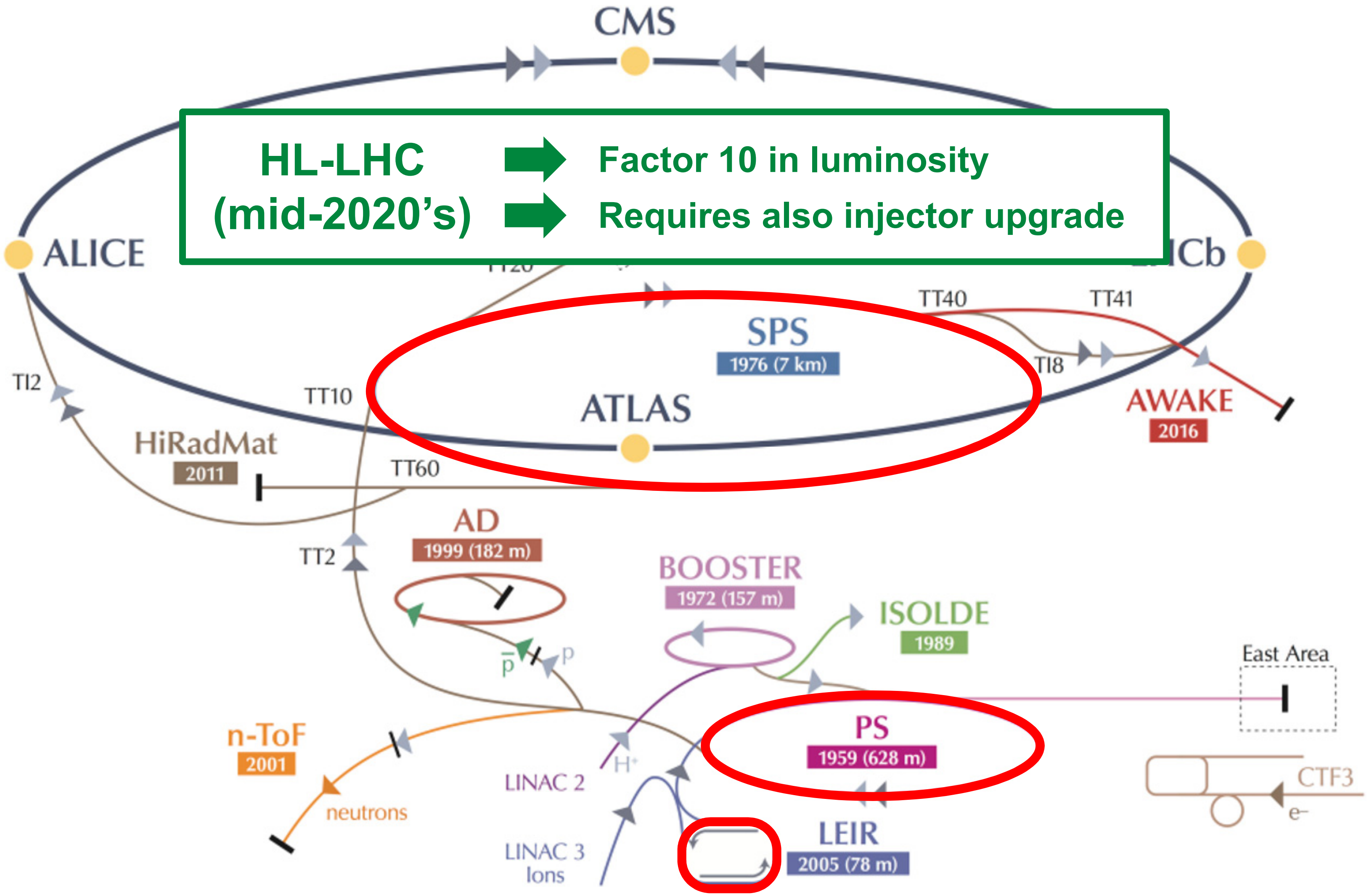

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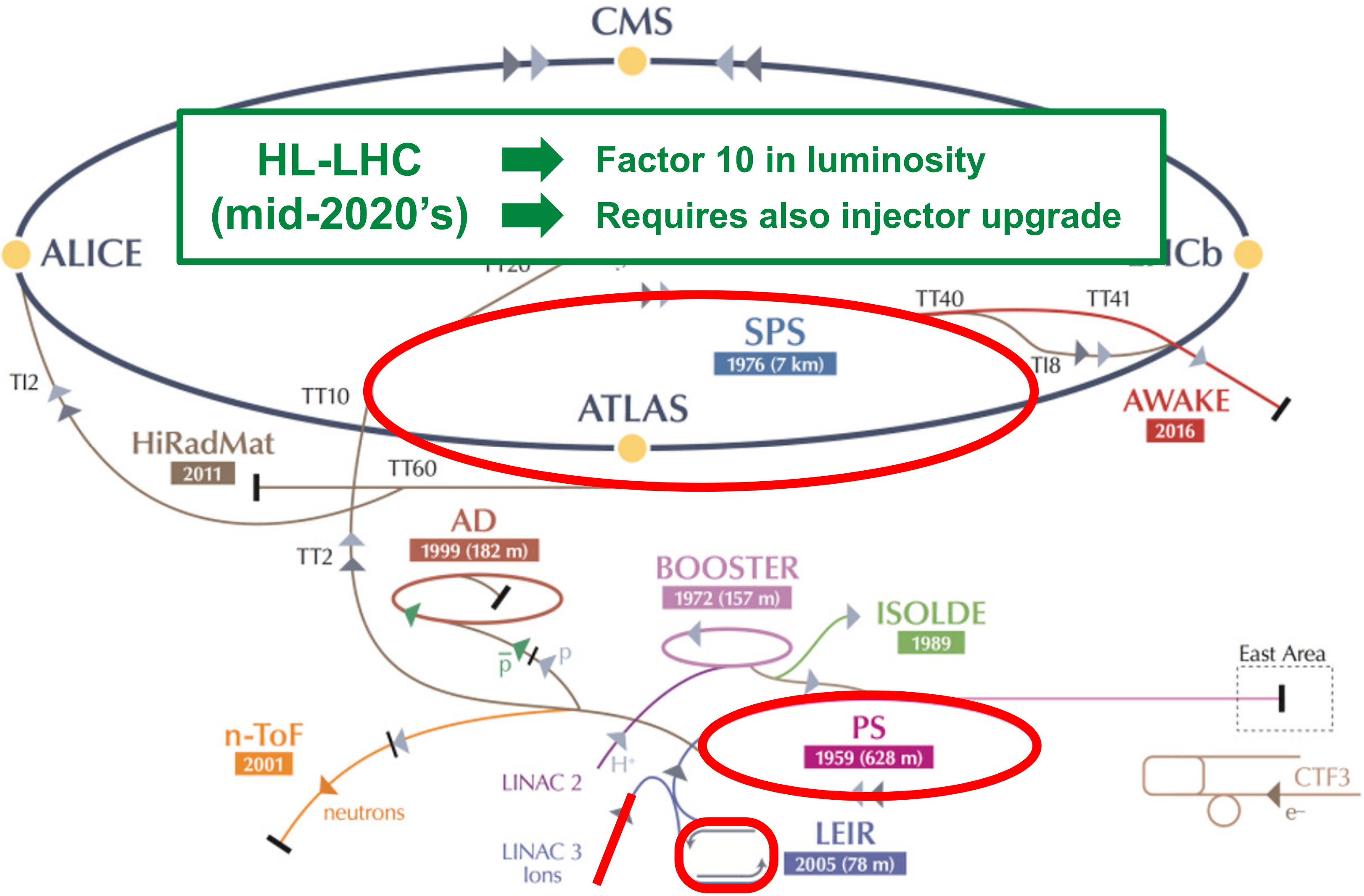

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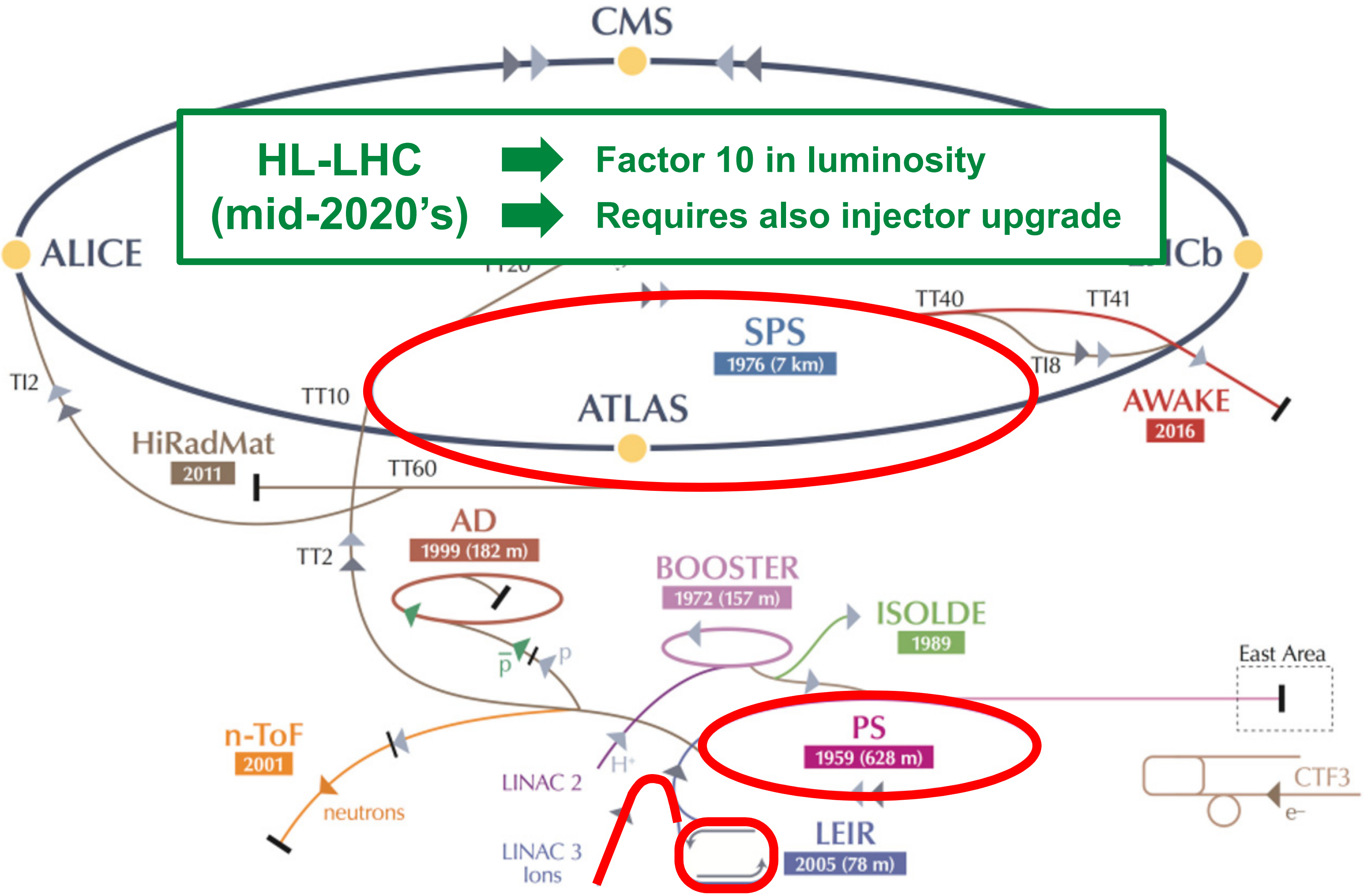

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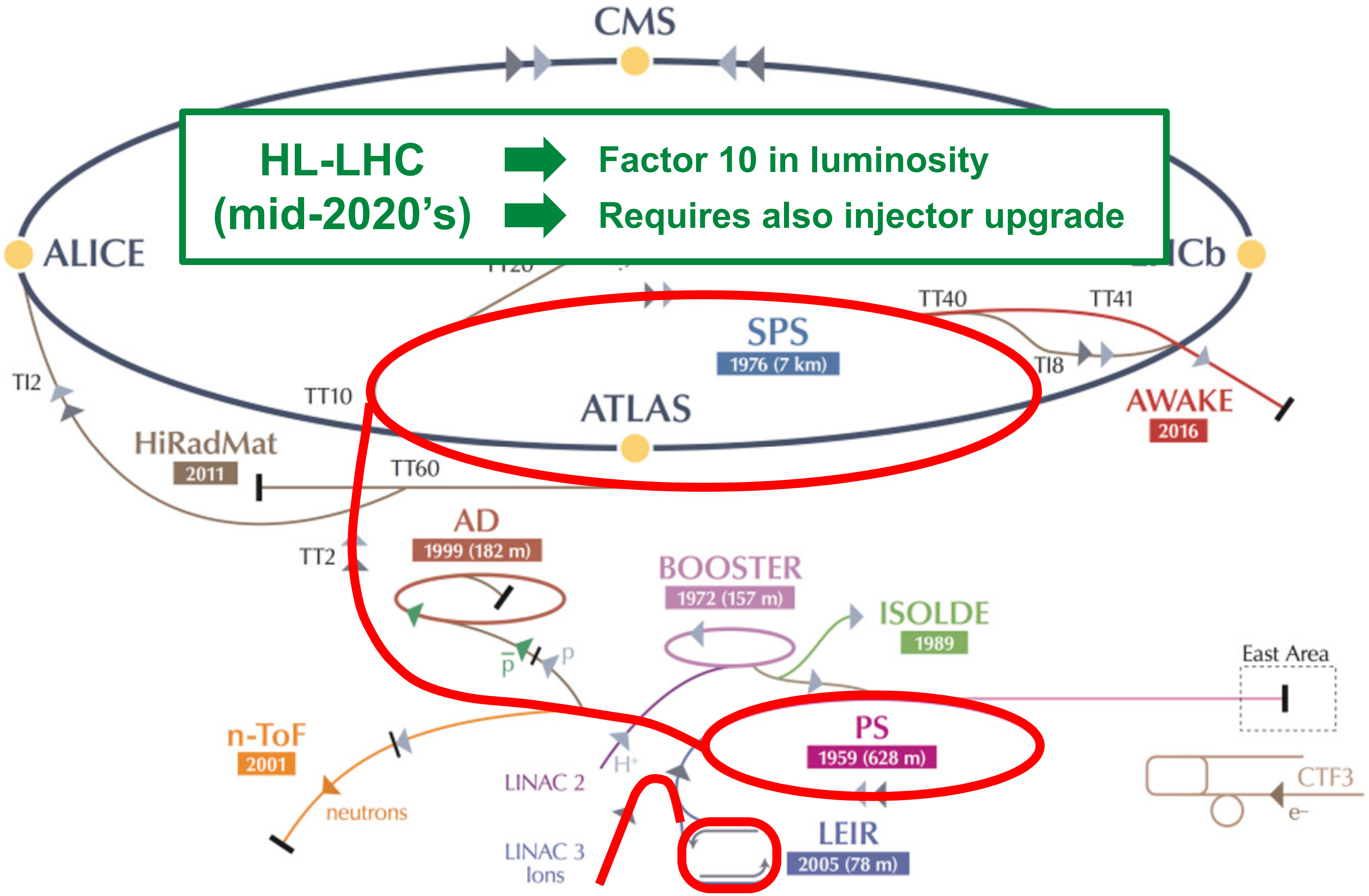

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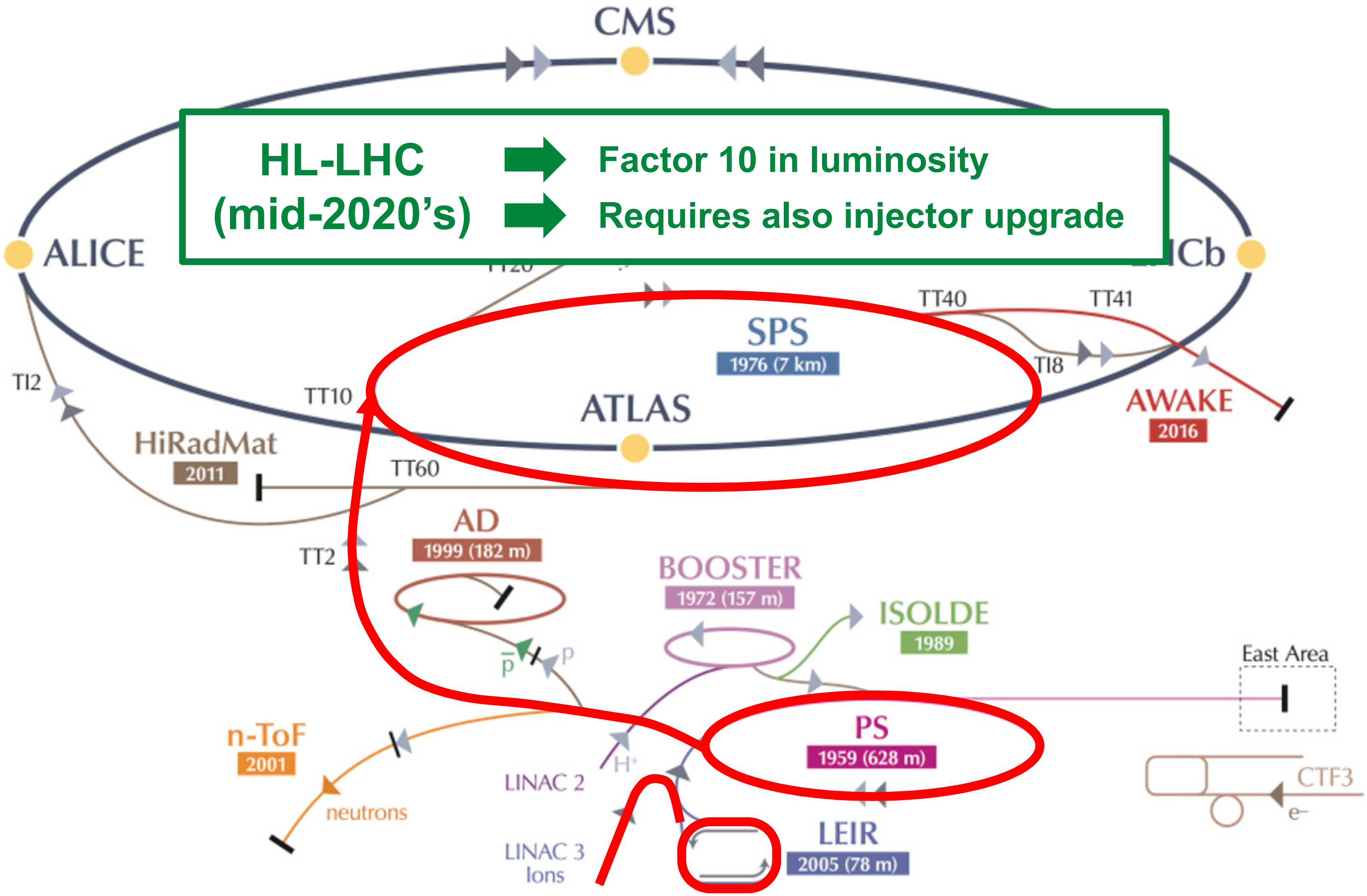

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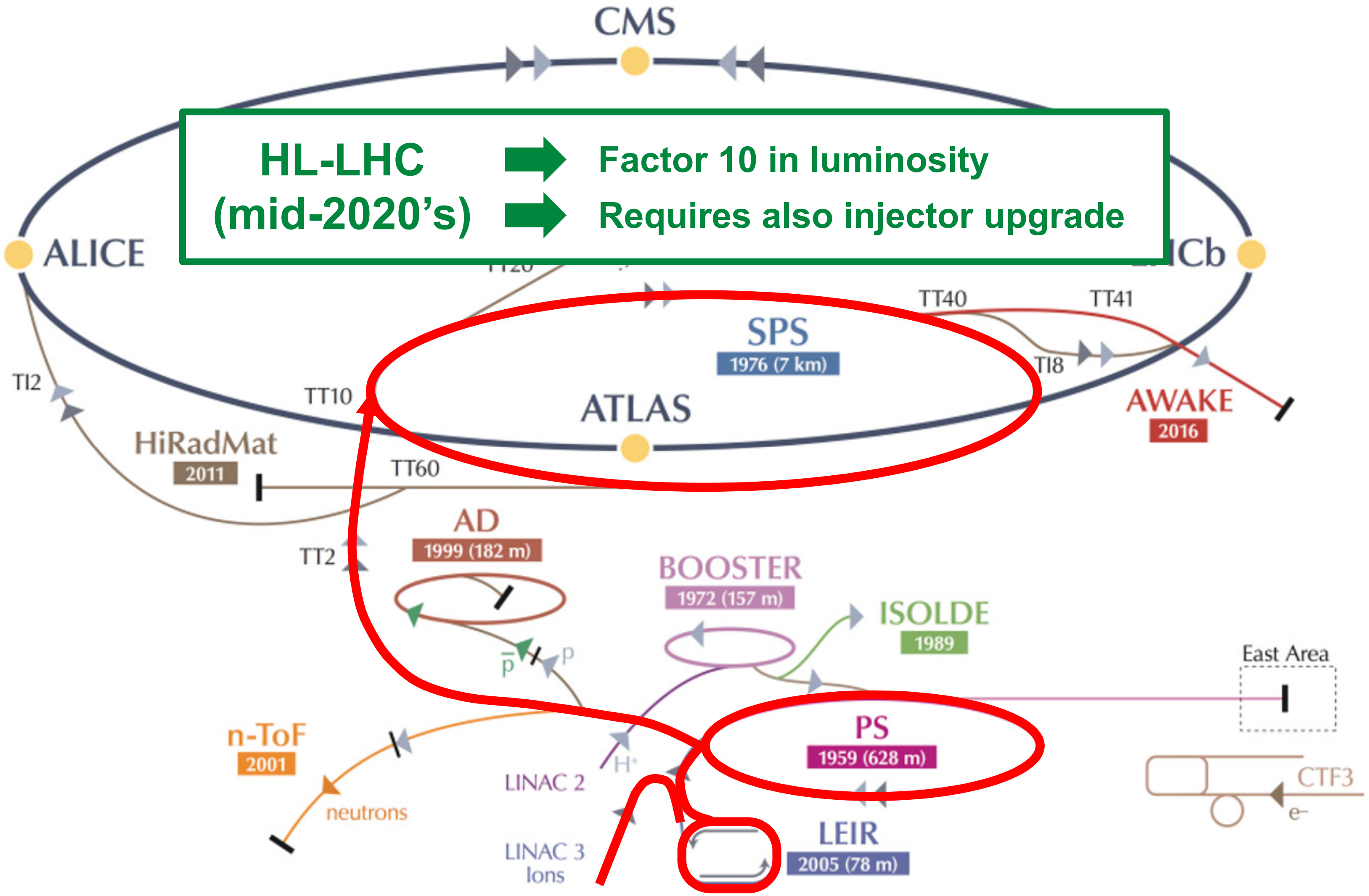

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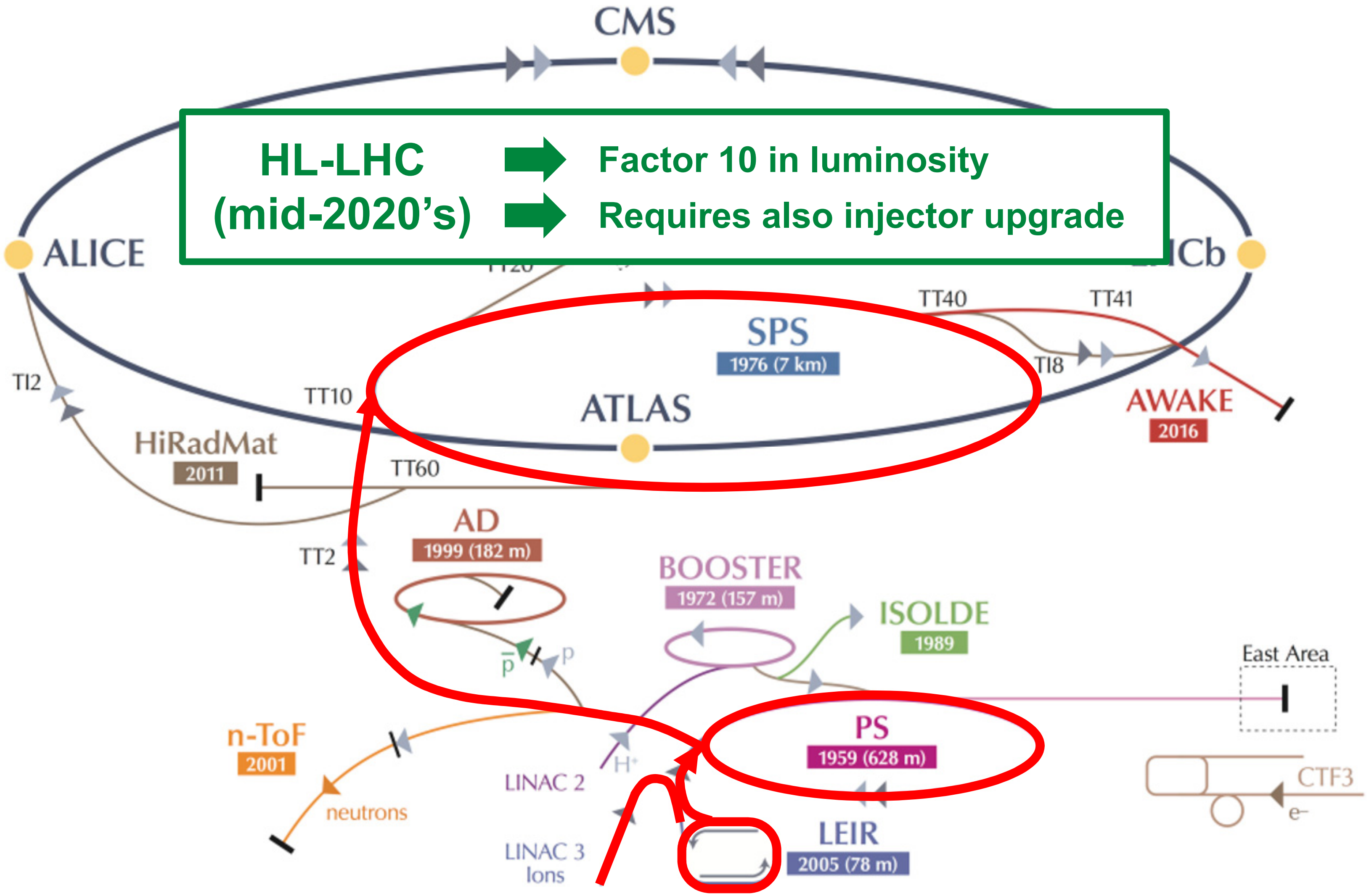

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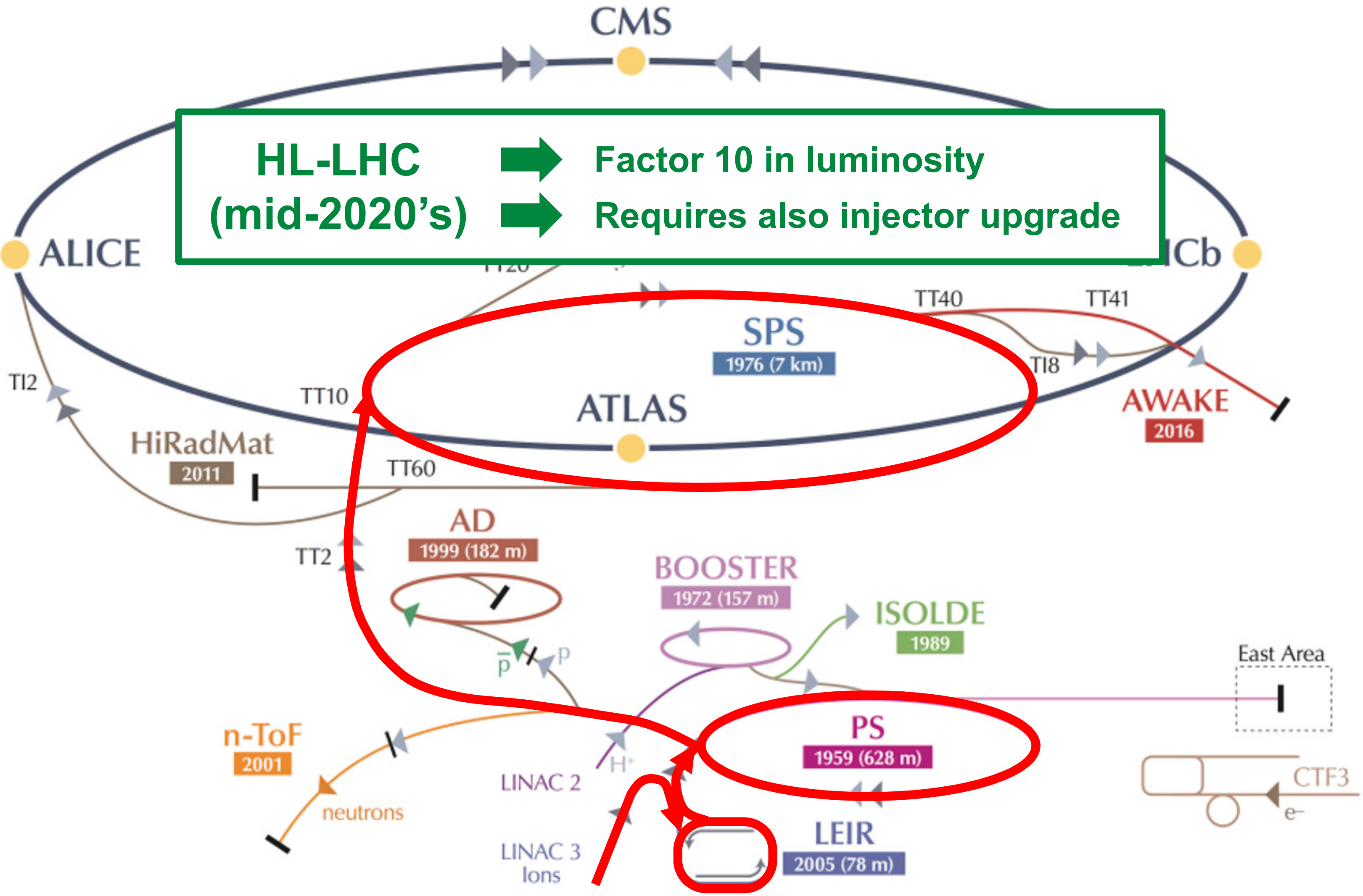

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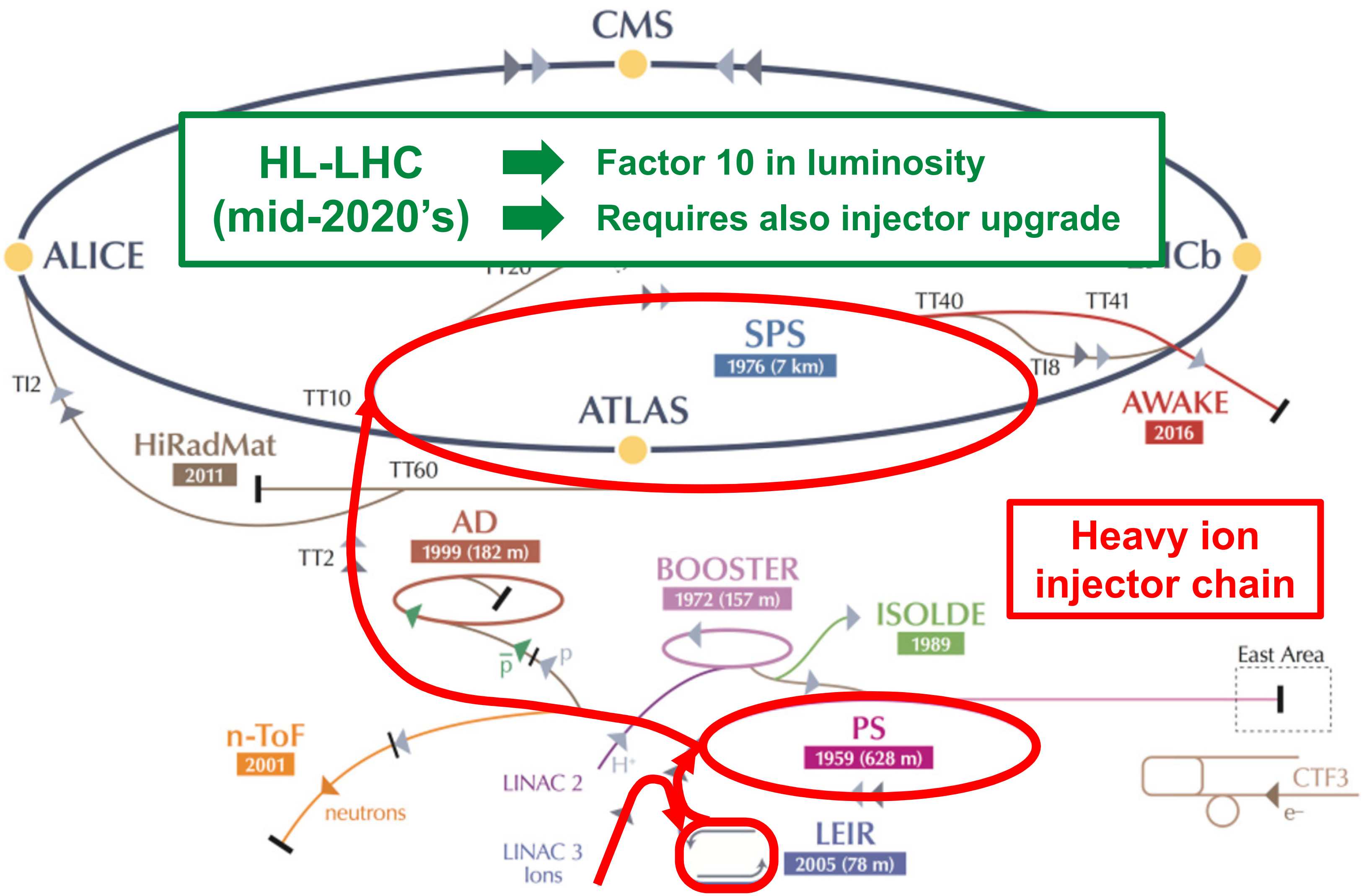

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Heavy ion injector chain

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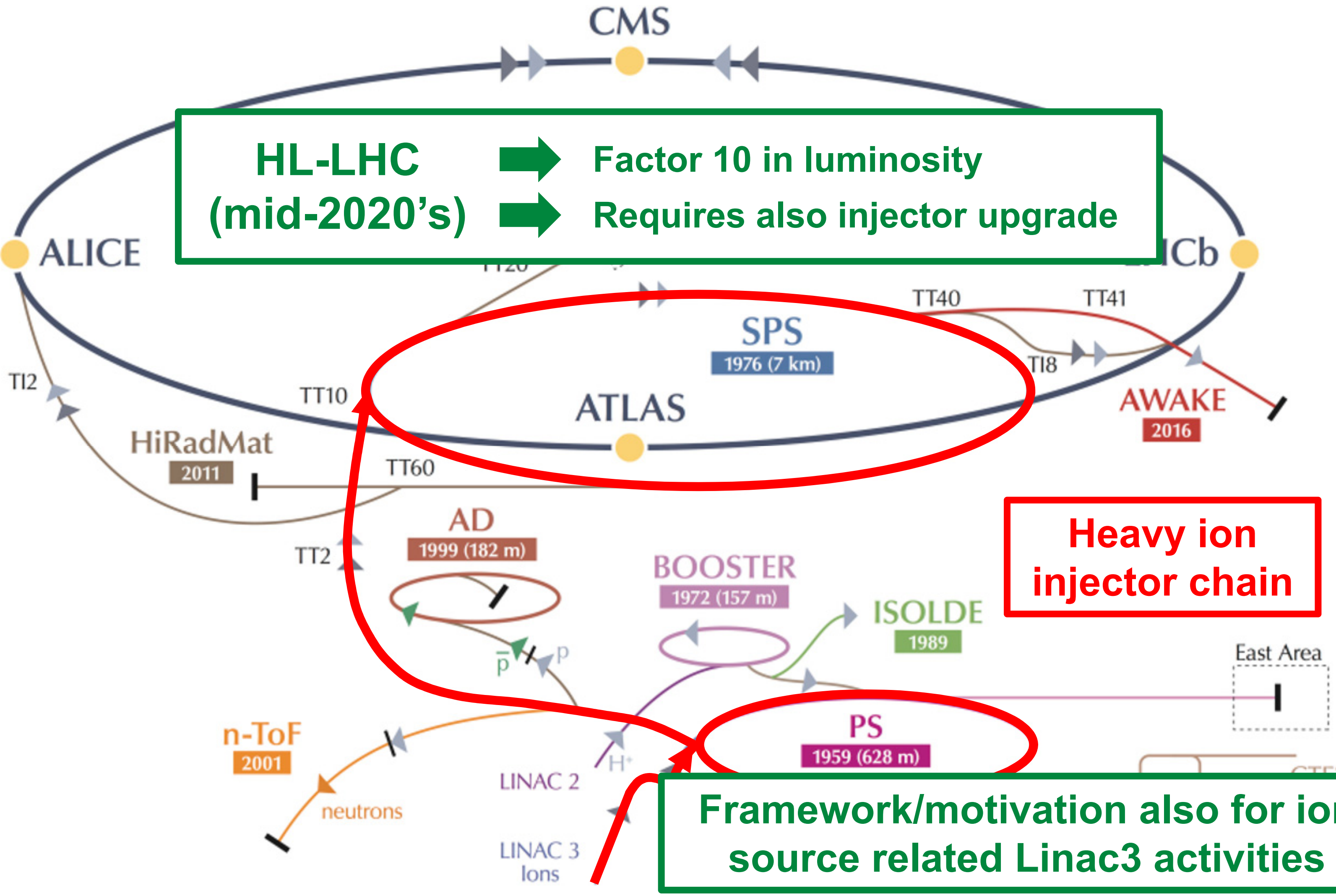

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Framework/motivation also for ion source related Linac3 activities

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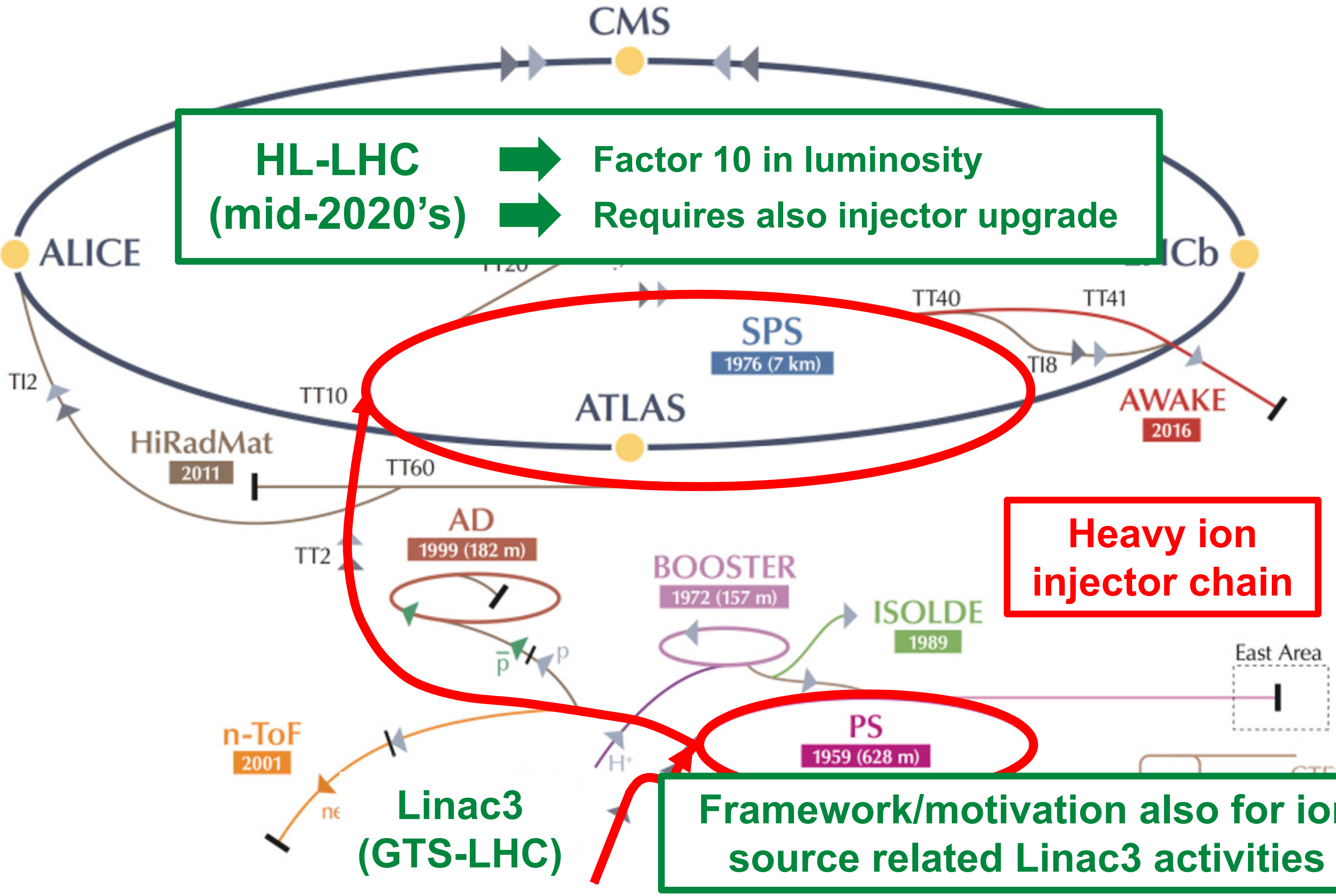

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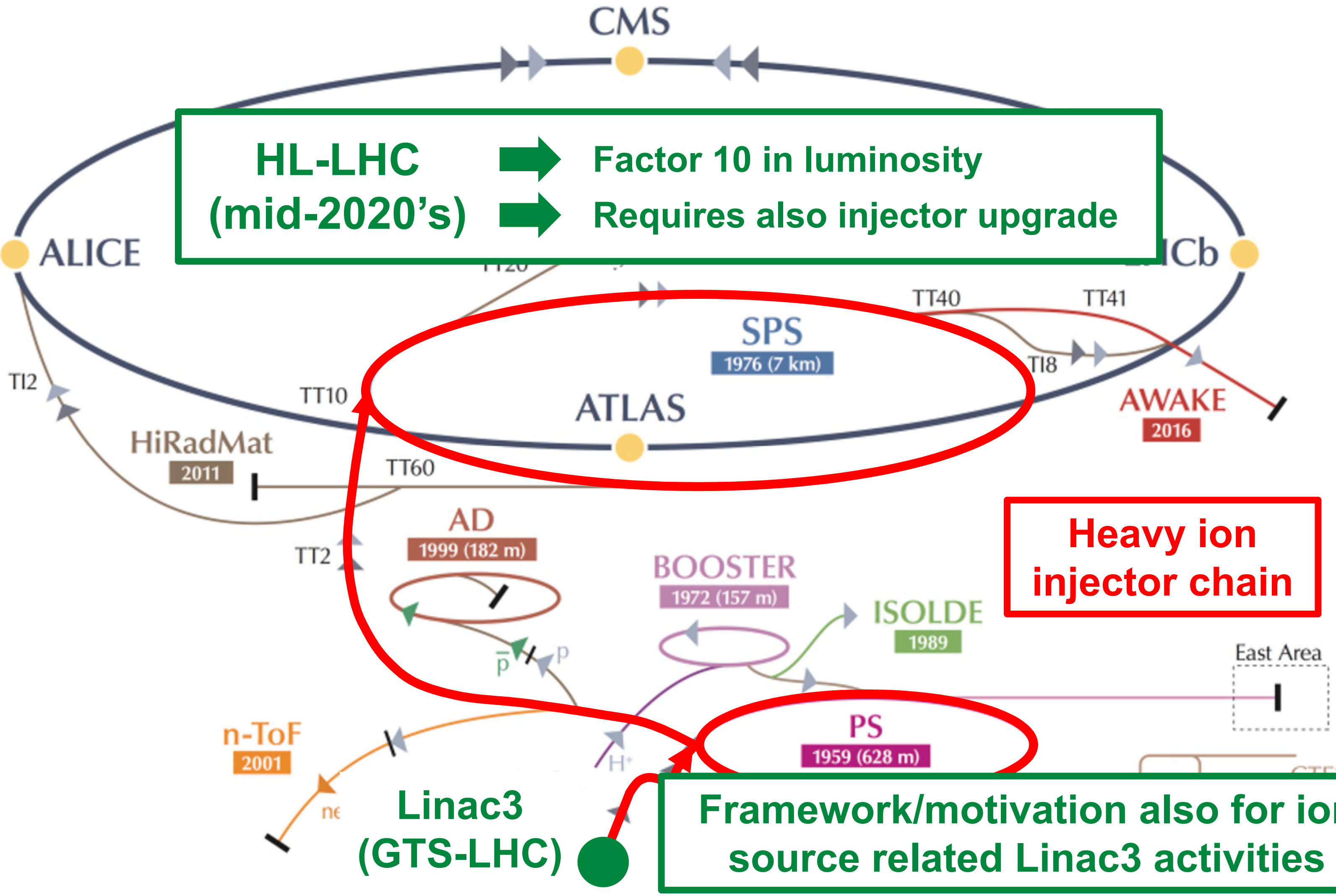

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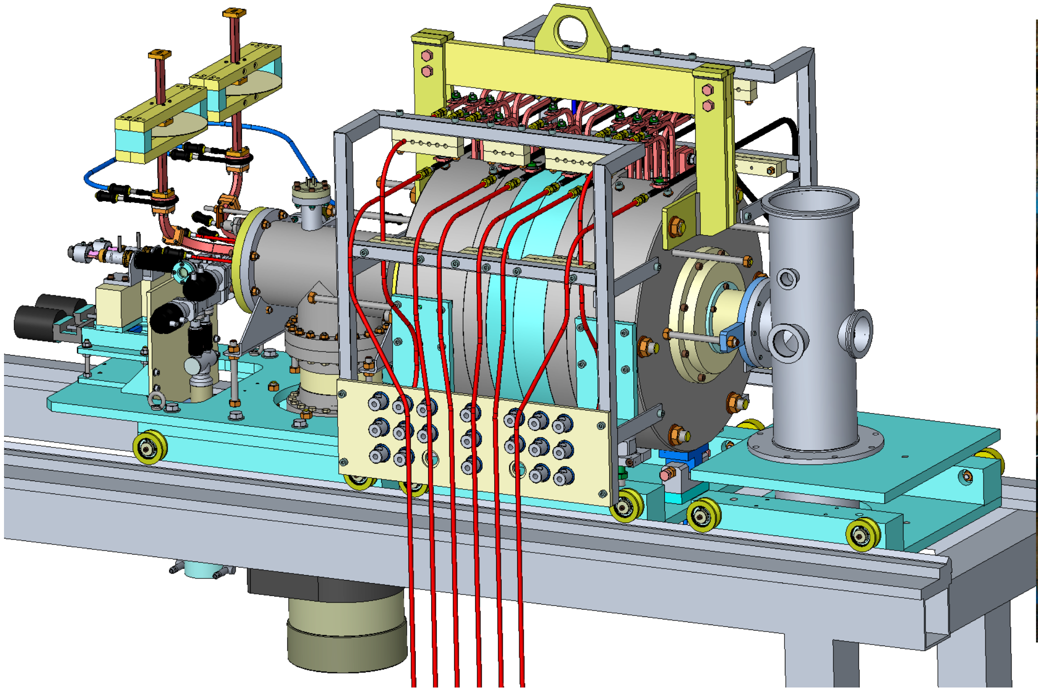
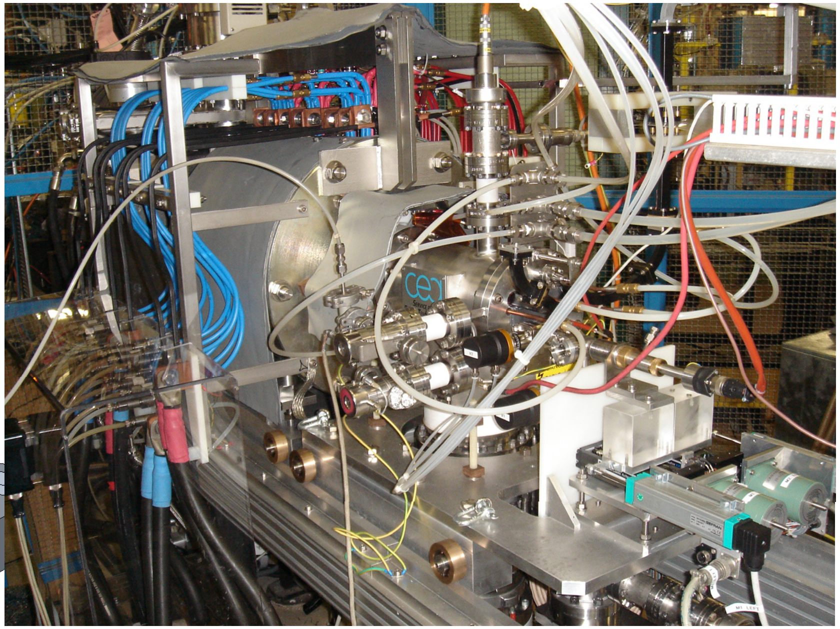
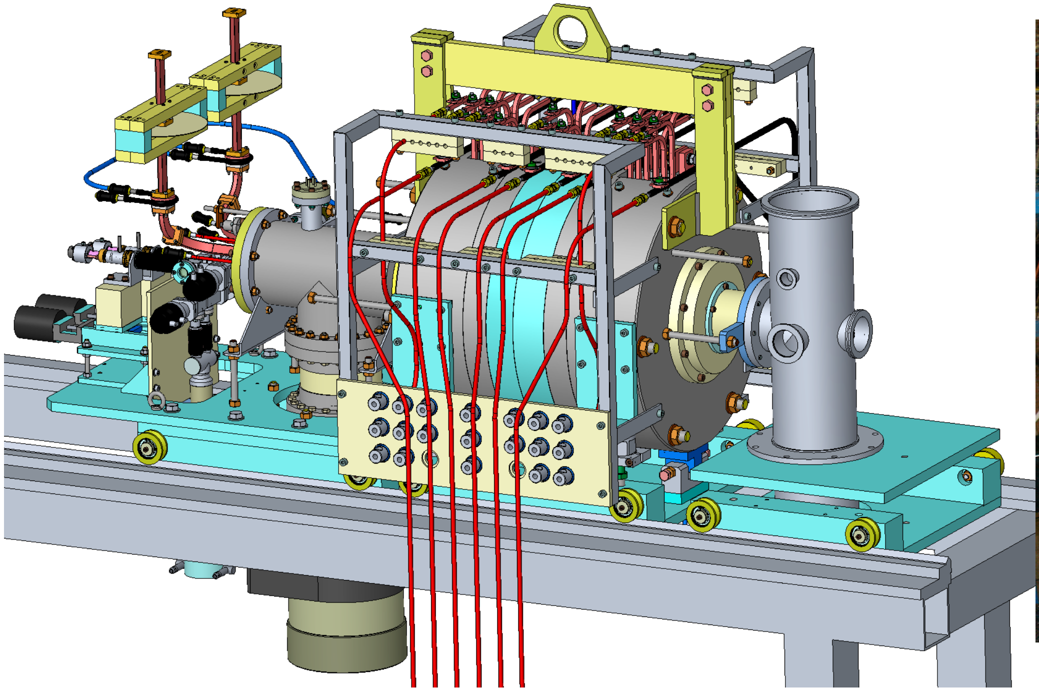
GTS-LHC ECRIS

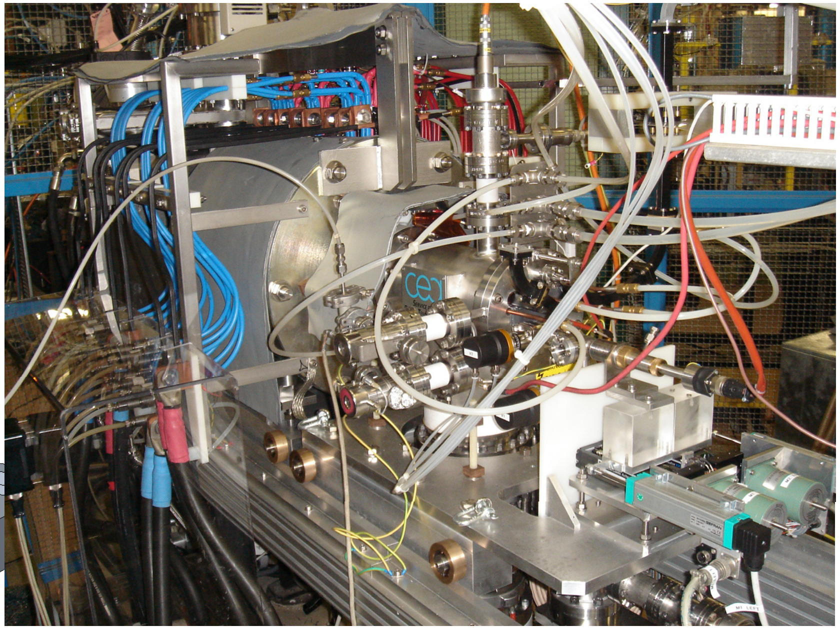




GTS-LHC ECRIS

- 14.5 GHz room temperature ECR ion source based on Grenoble Test Source (GTS) by CEA, Grenoble
- Operated exclusively in afterglow (10 Hz, 50% duty cycle)
- Predominantly Pb^{29+} beams (Ar in 2015, Xe planned for 2017)





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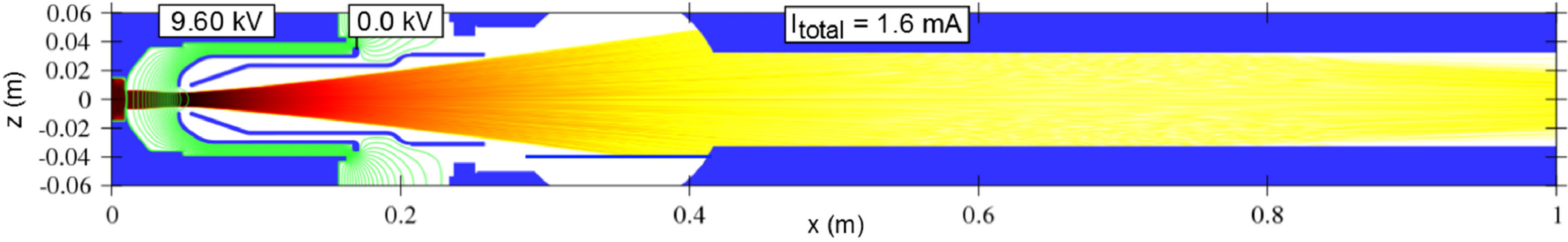

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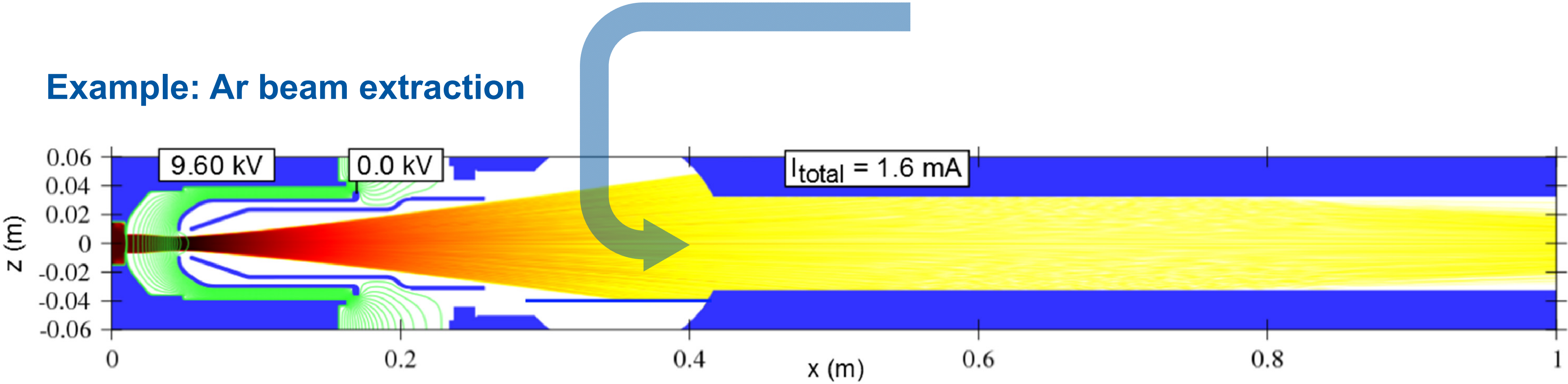

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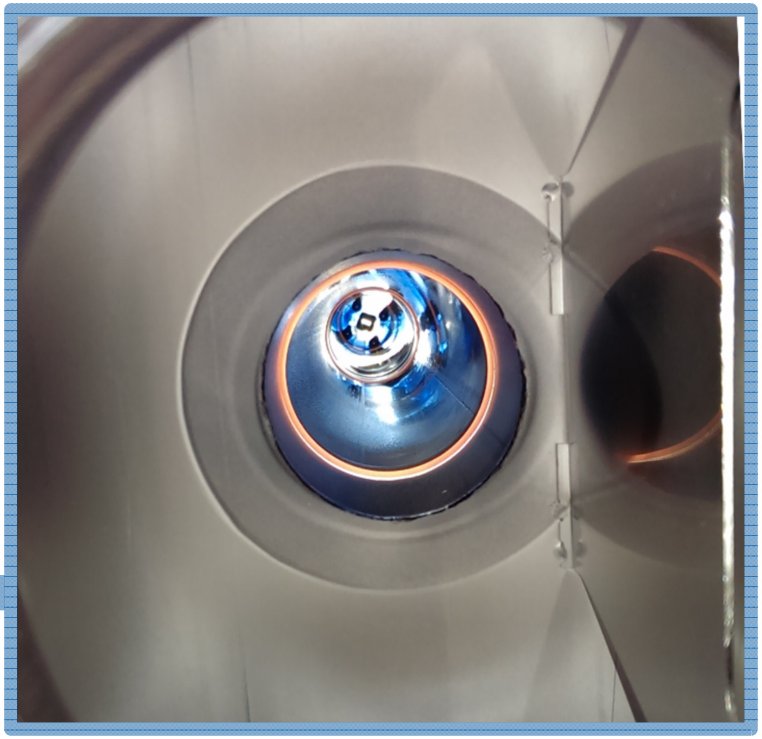

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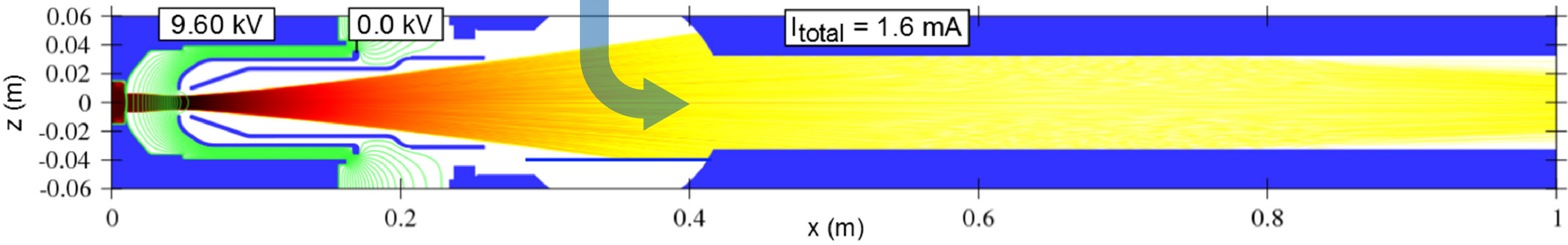

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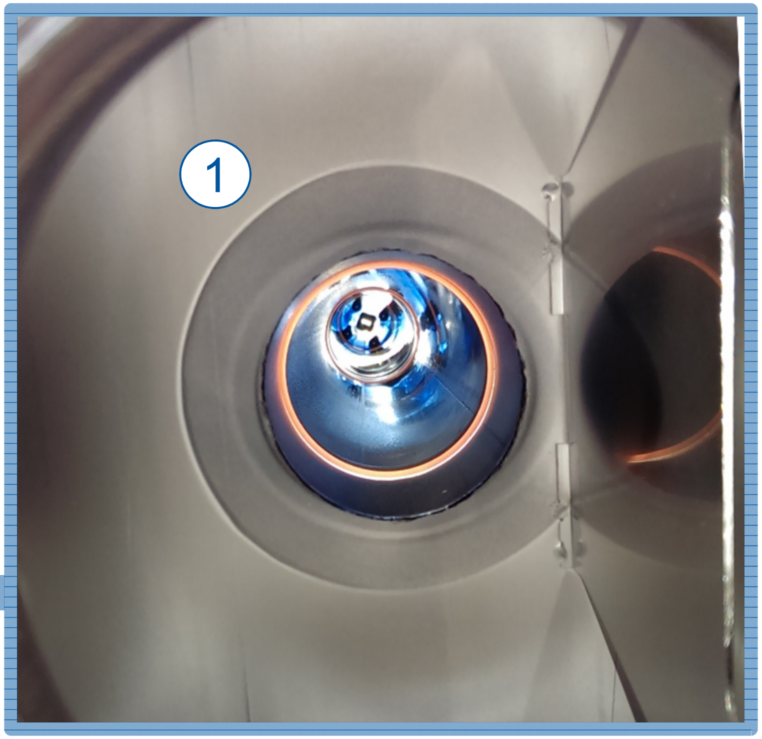

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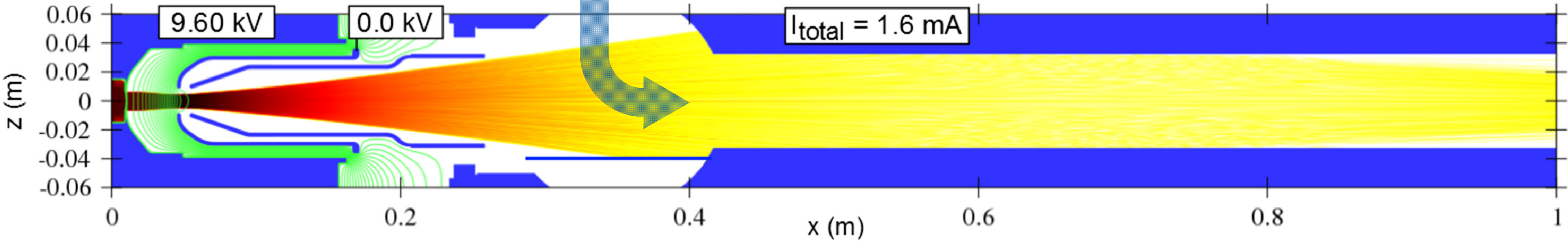

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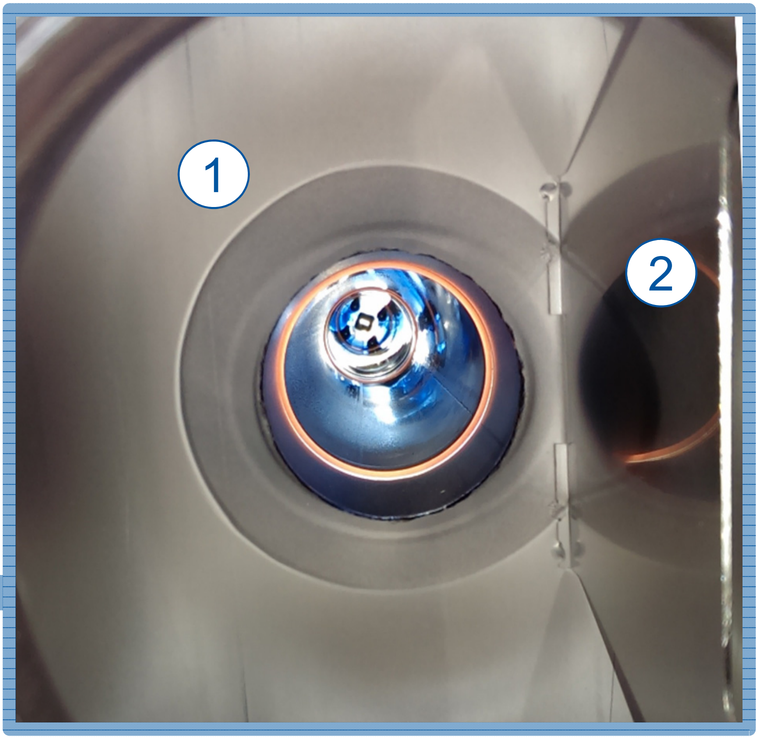

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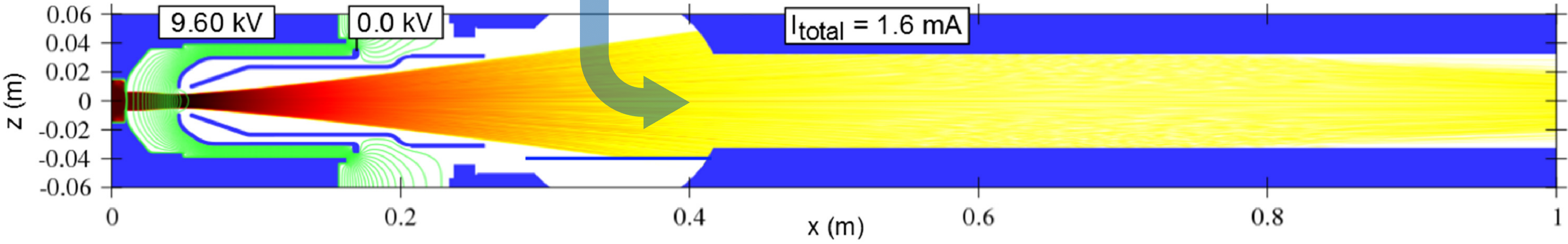

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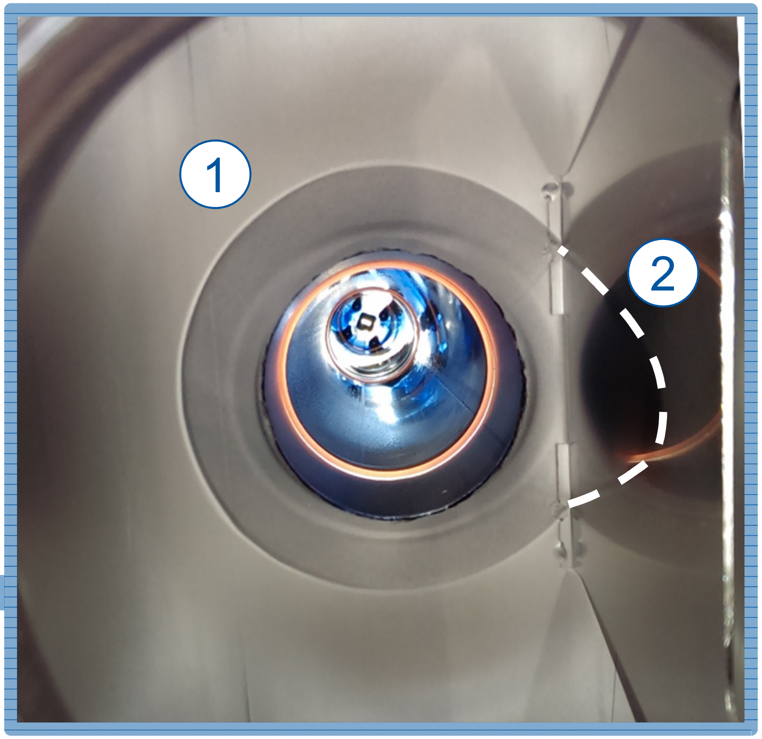

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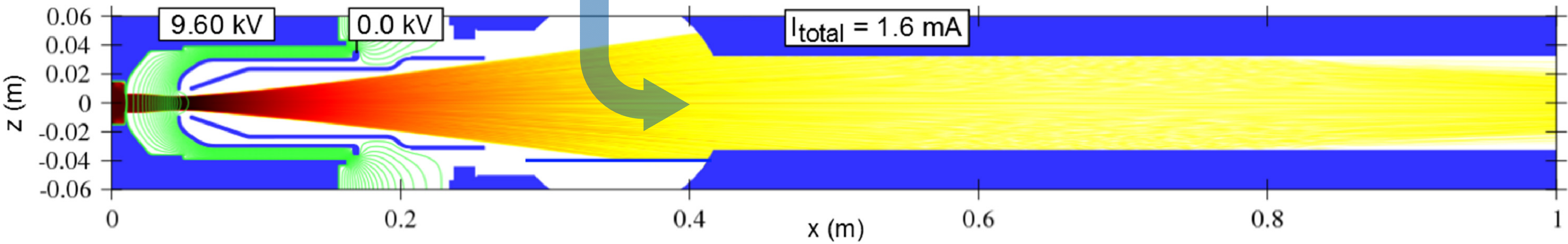

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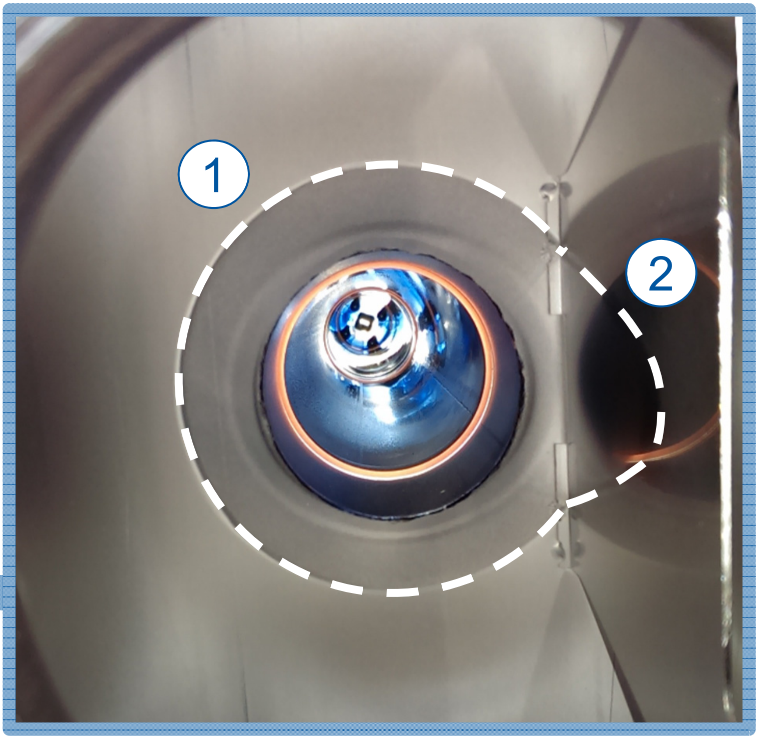

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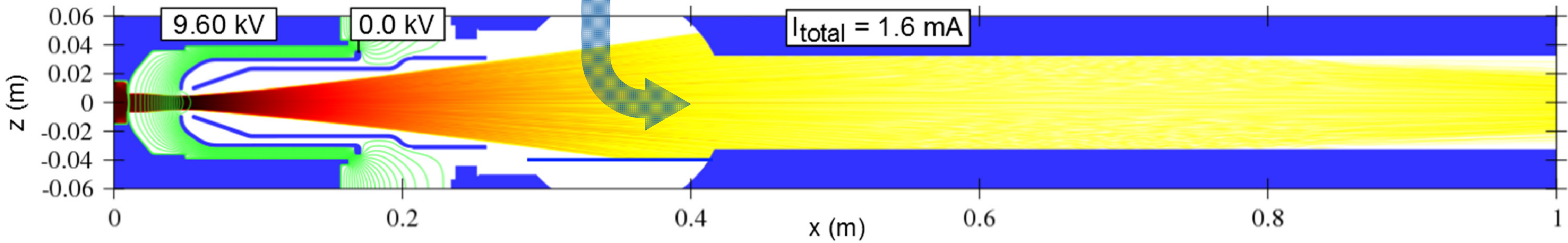

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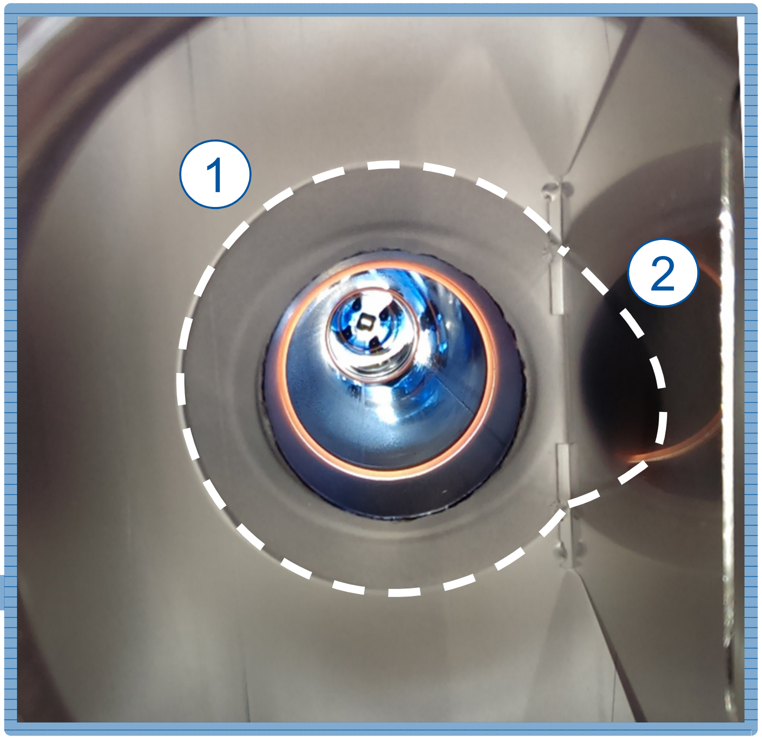

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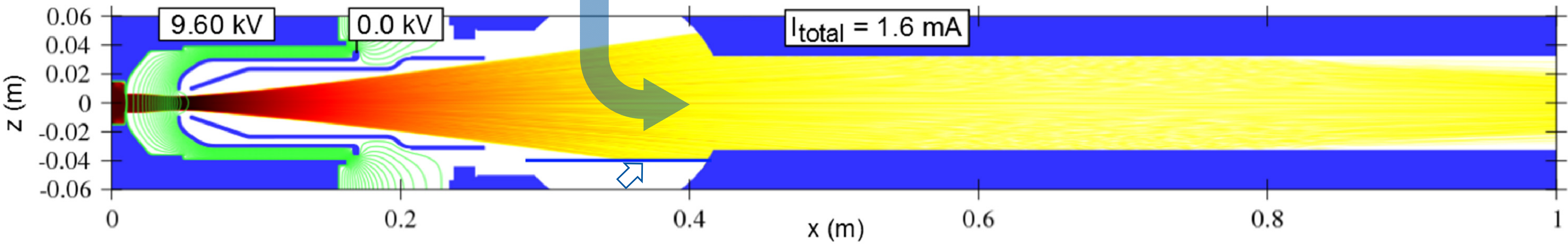

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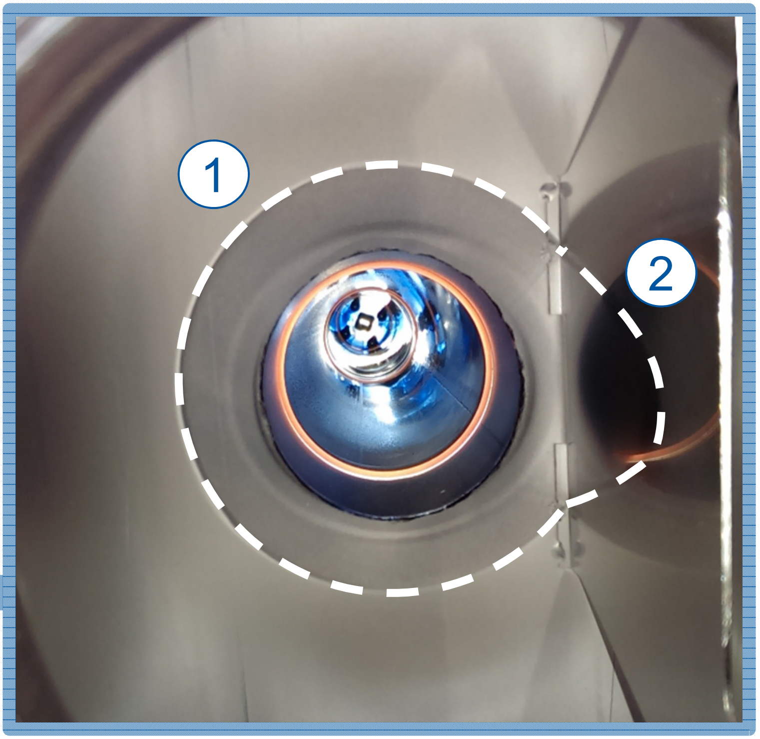

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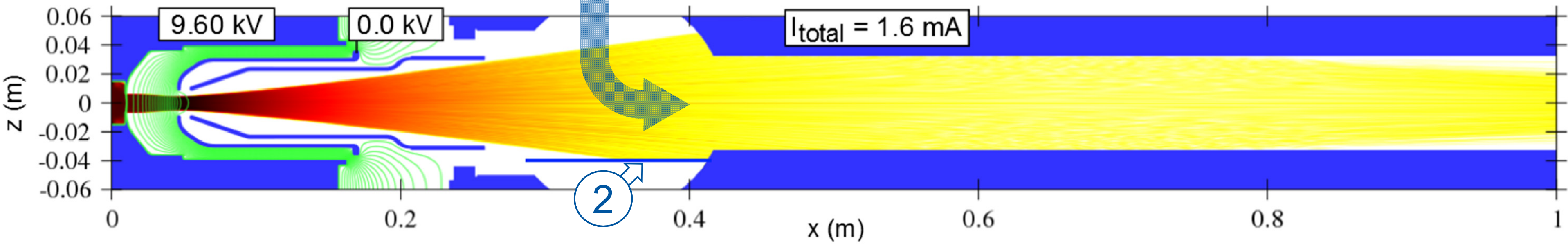

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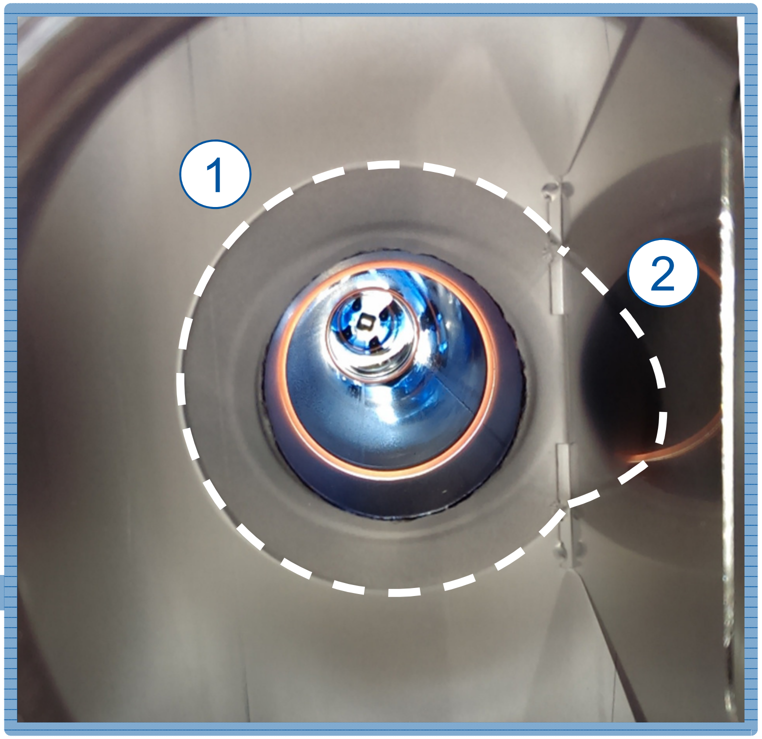

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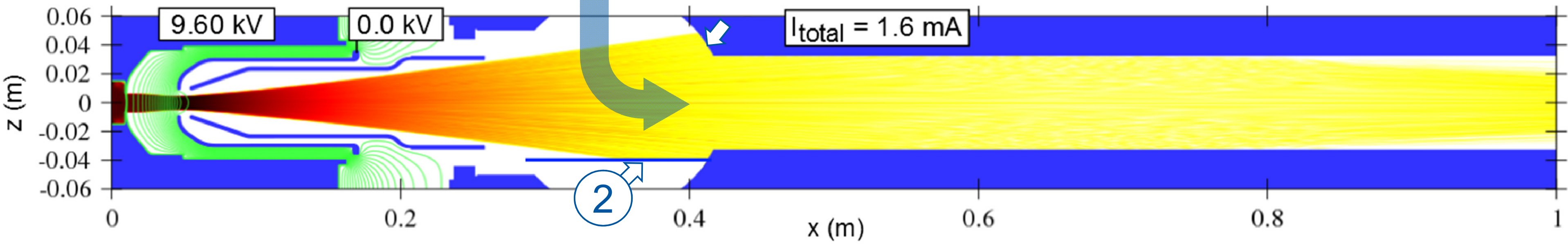

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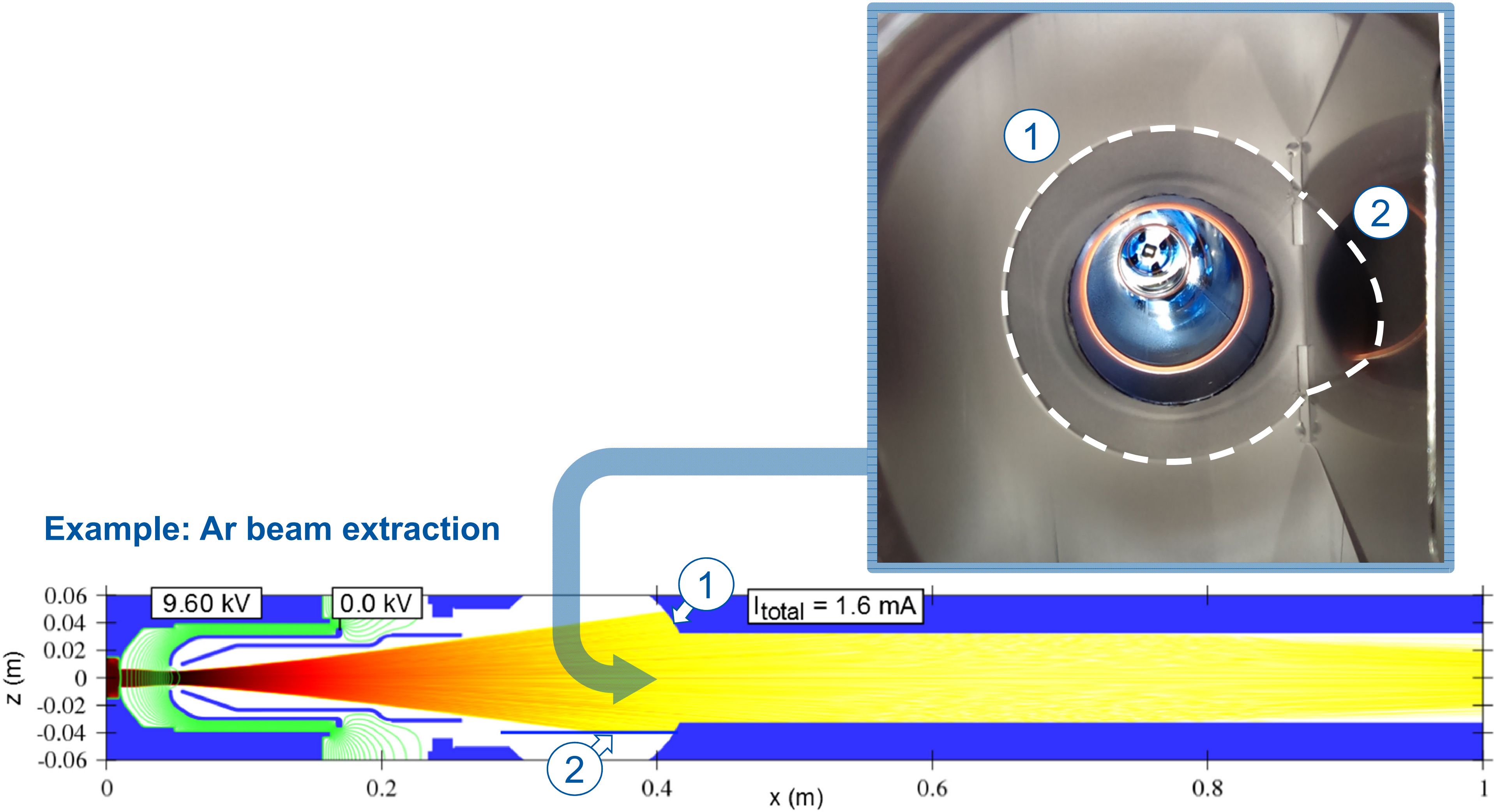
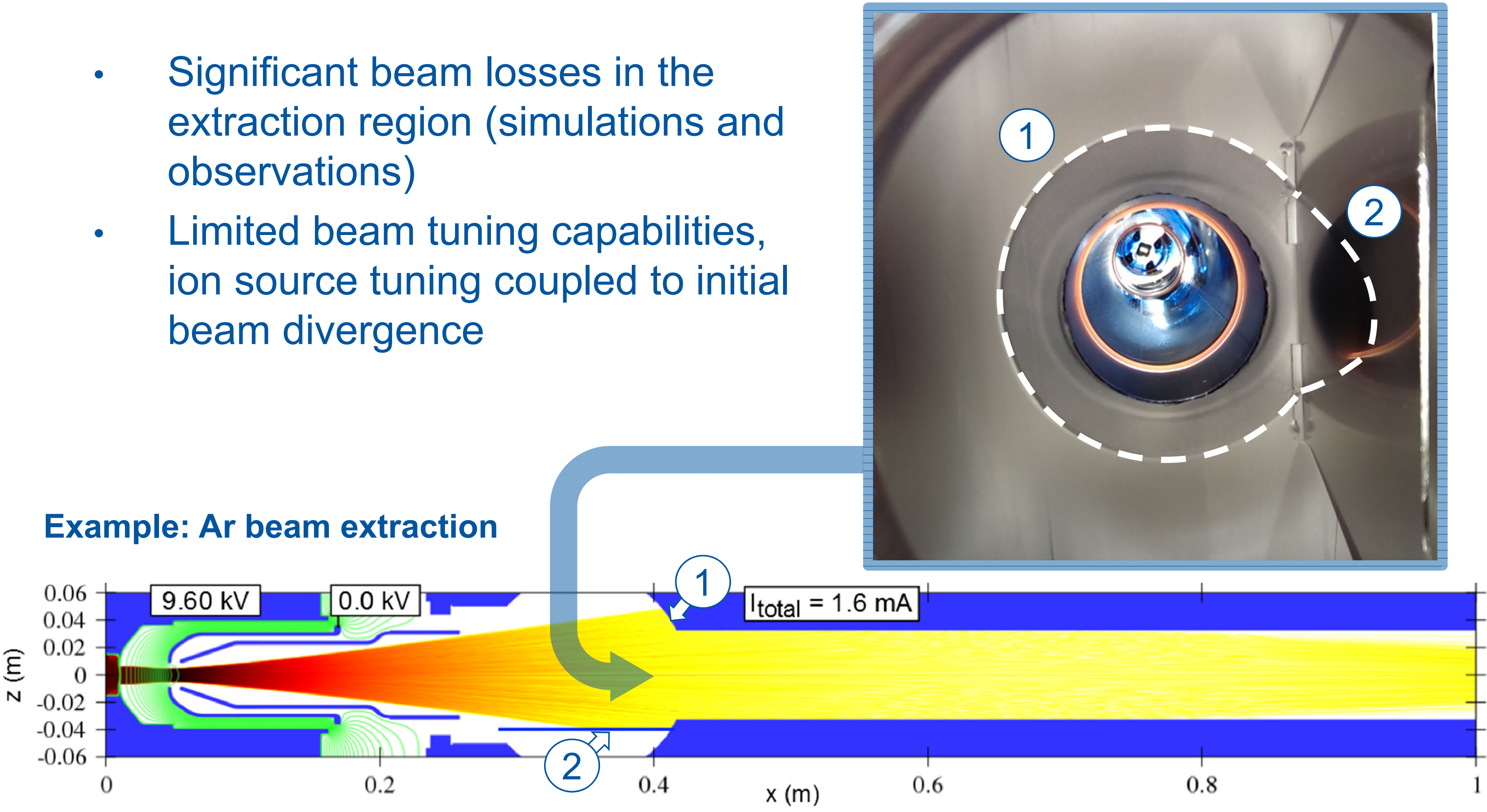


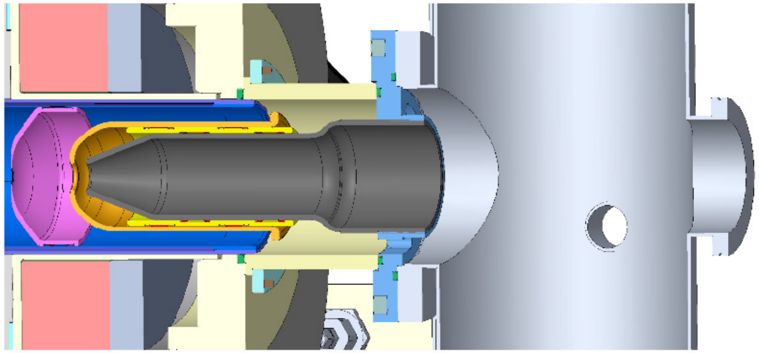
Motivation: extraction region issues

- Significant beam losses in the extraction region (simulations and observations)
- Limited beam tuning capabilities, ion source tuning coupled to initial beam divergence

Example: Ar beam extraction



Two main modifications



The original system

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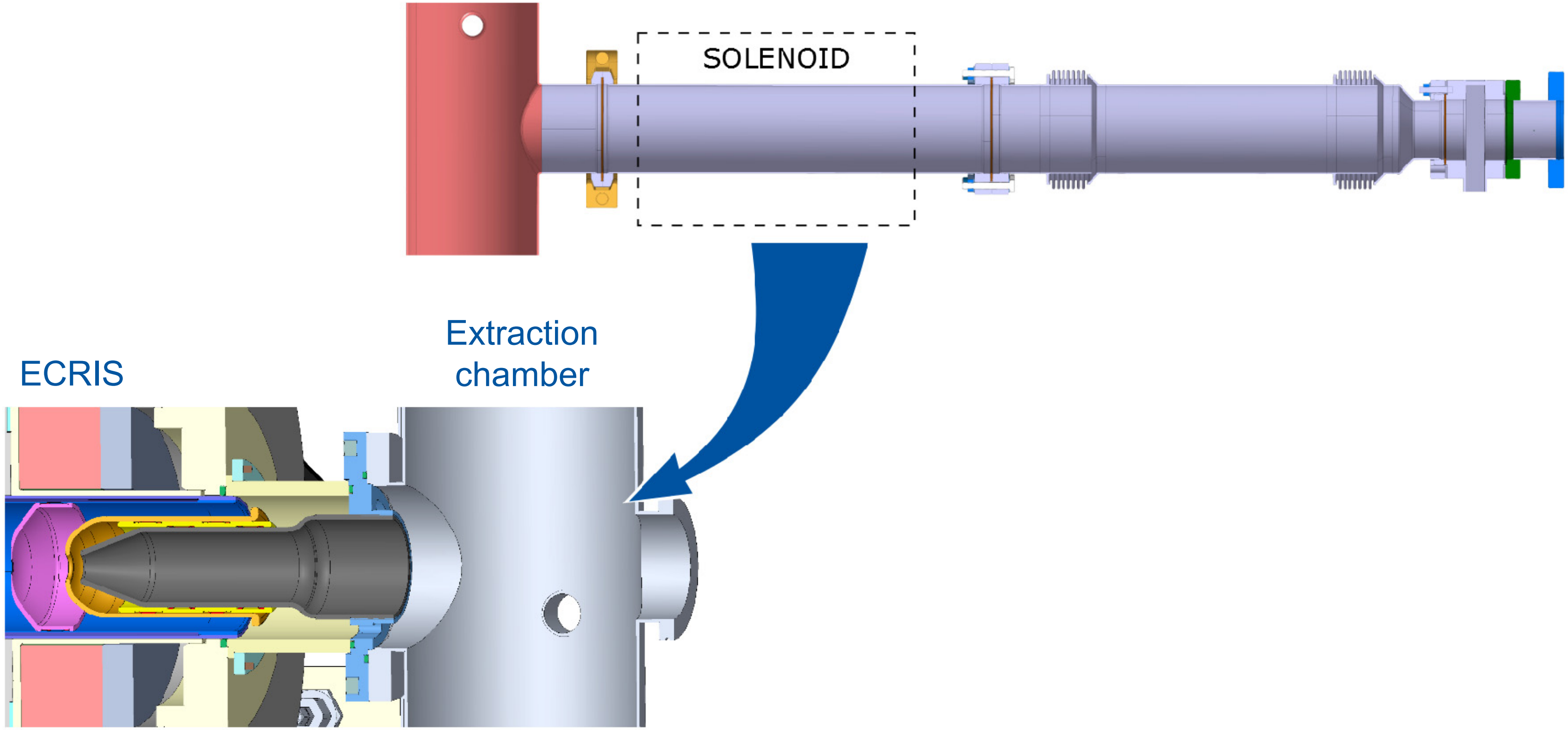

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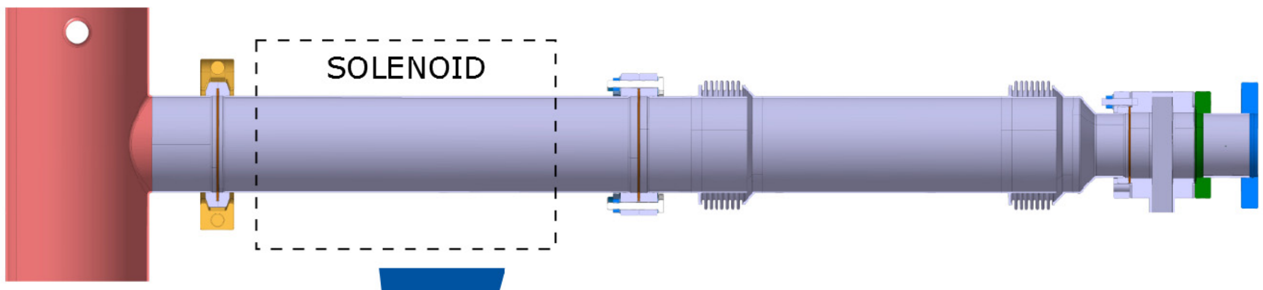

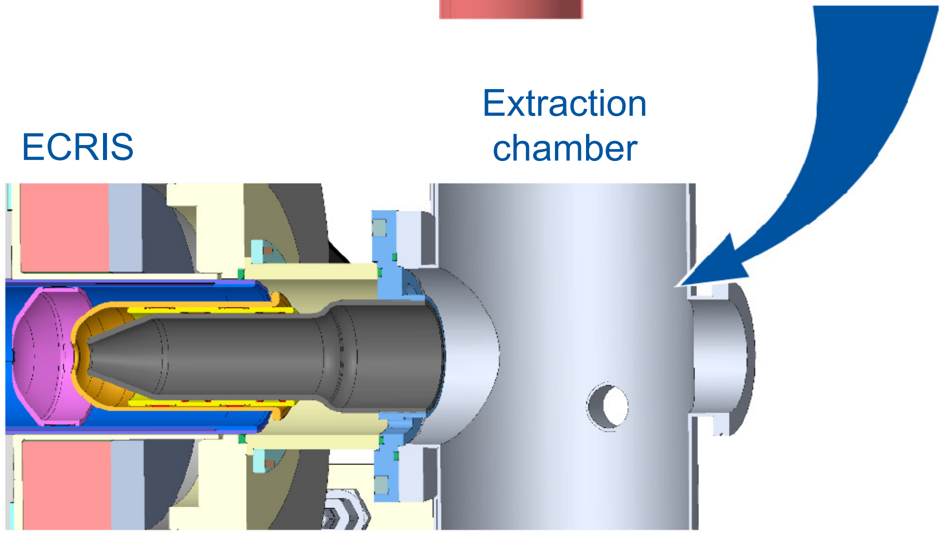

The original system

Removal of aperture restrictions
- Reduces losses
- Increases flexibility in beam transport

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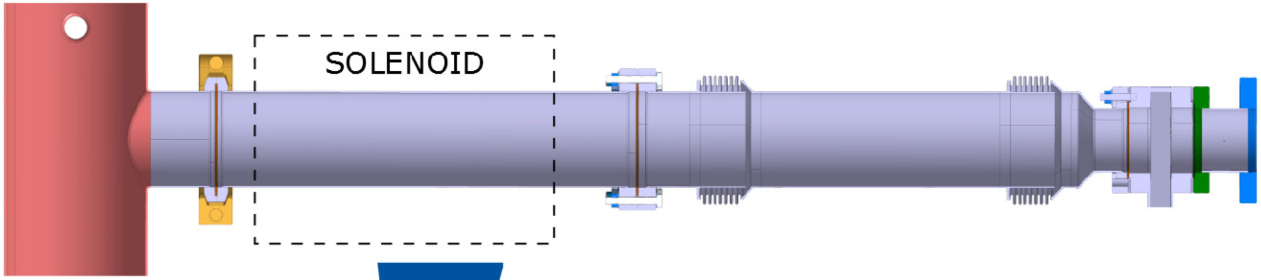

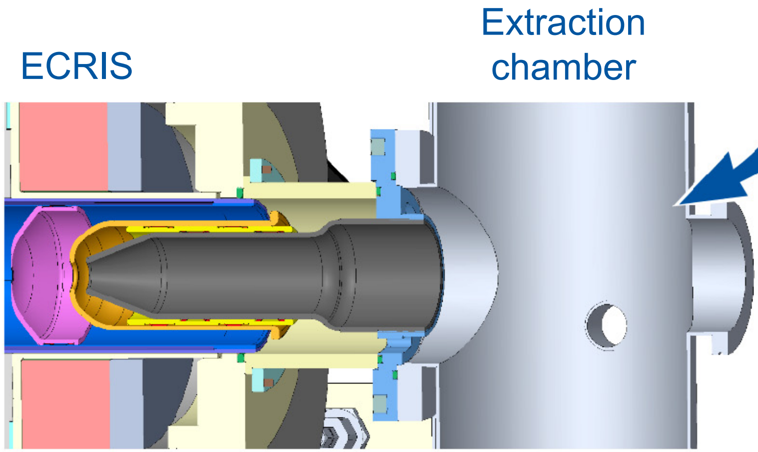

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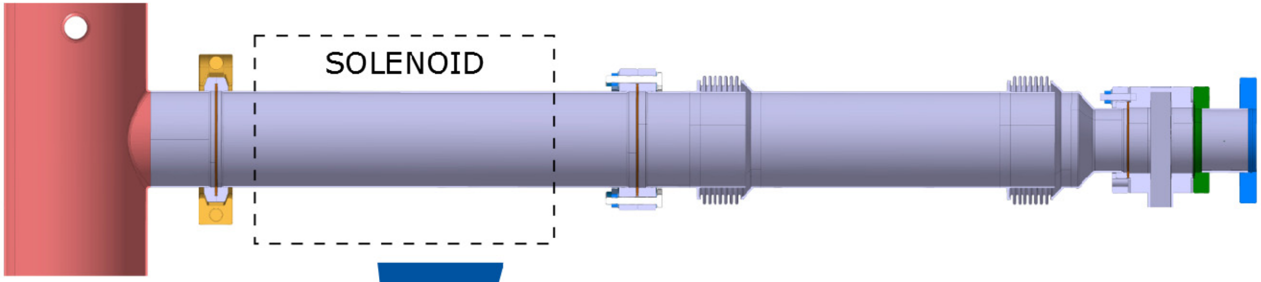

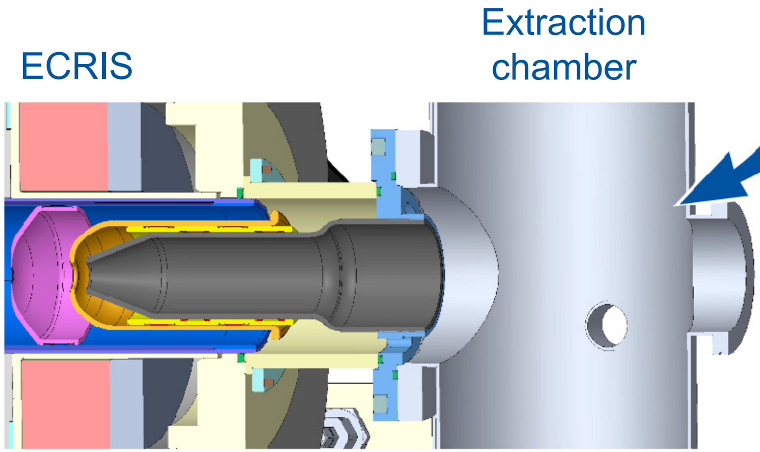

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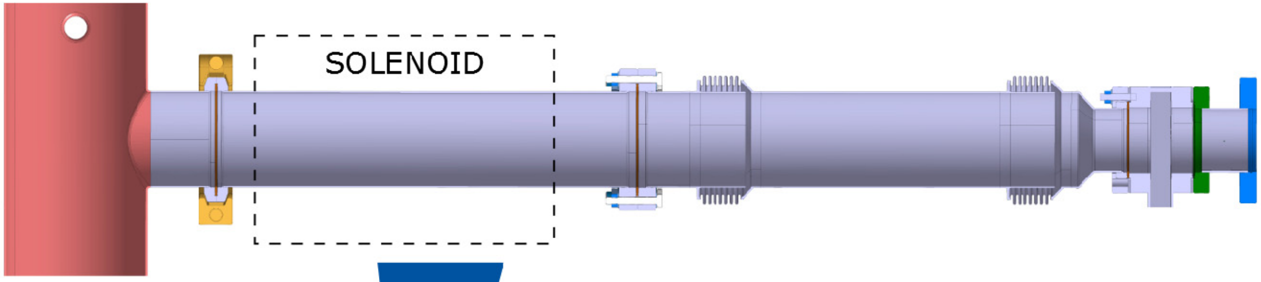

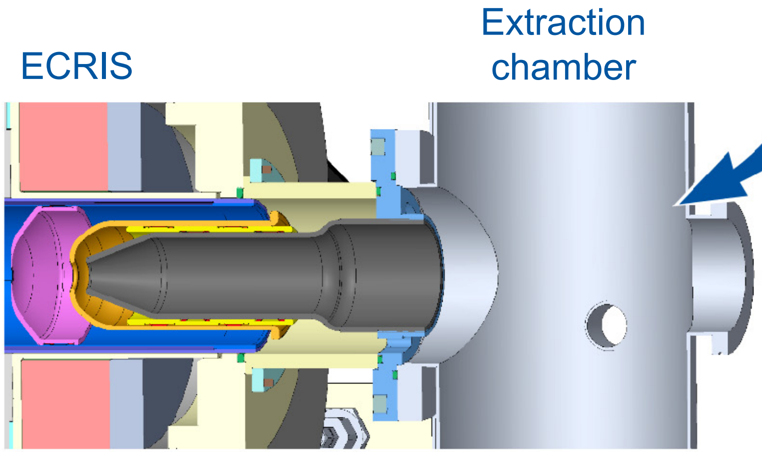

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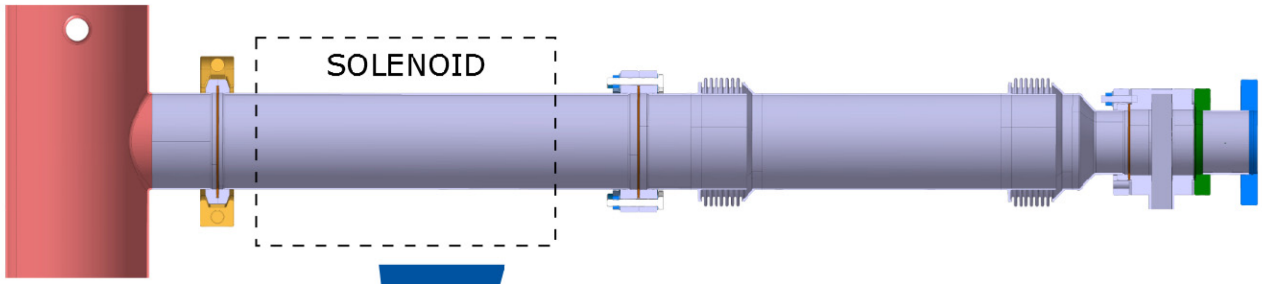

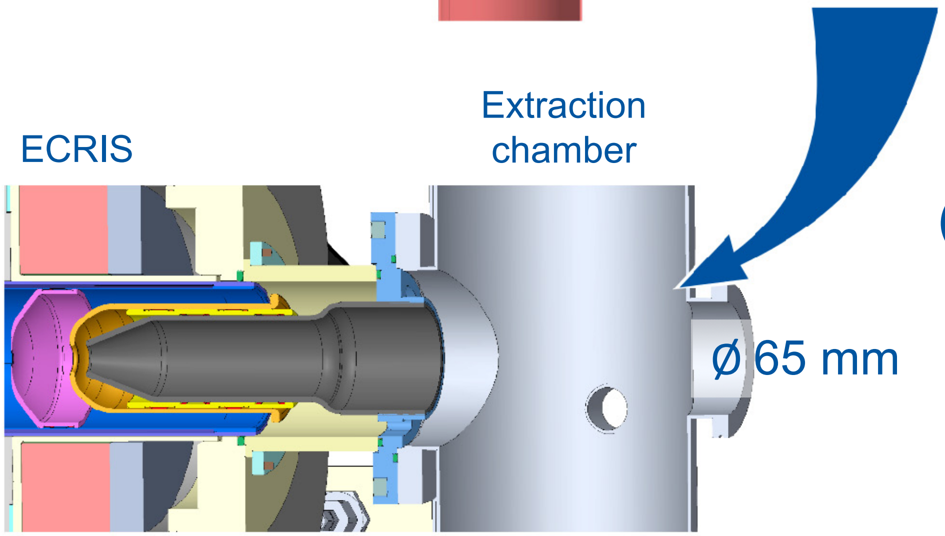

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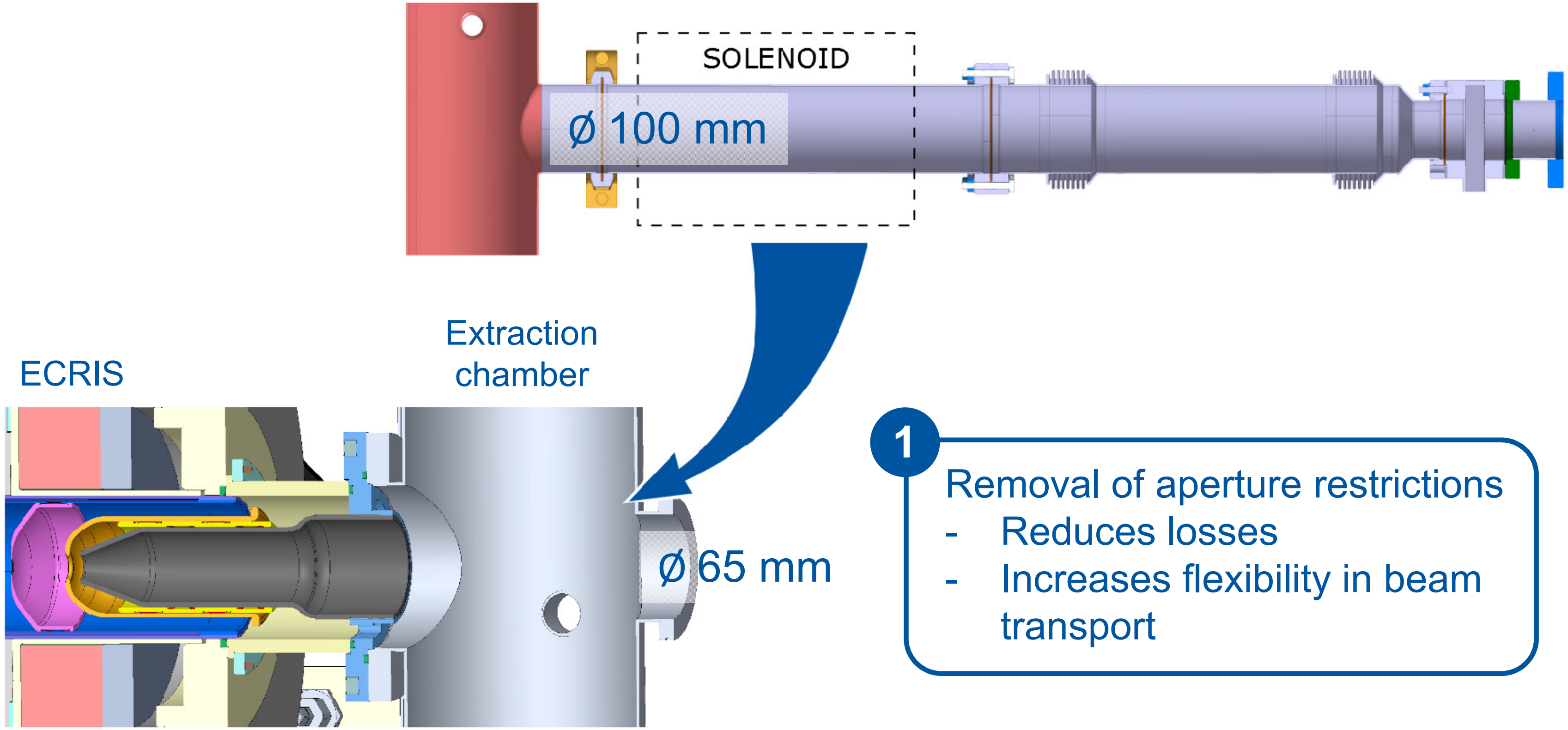

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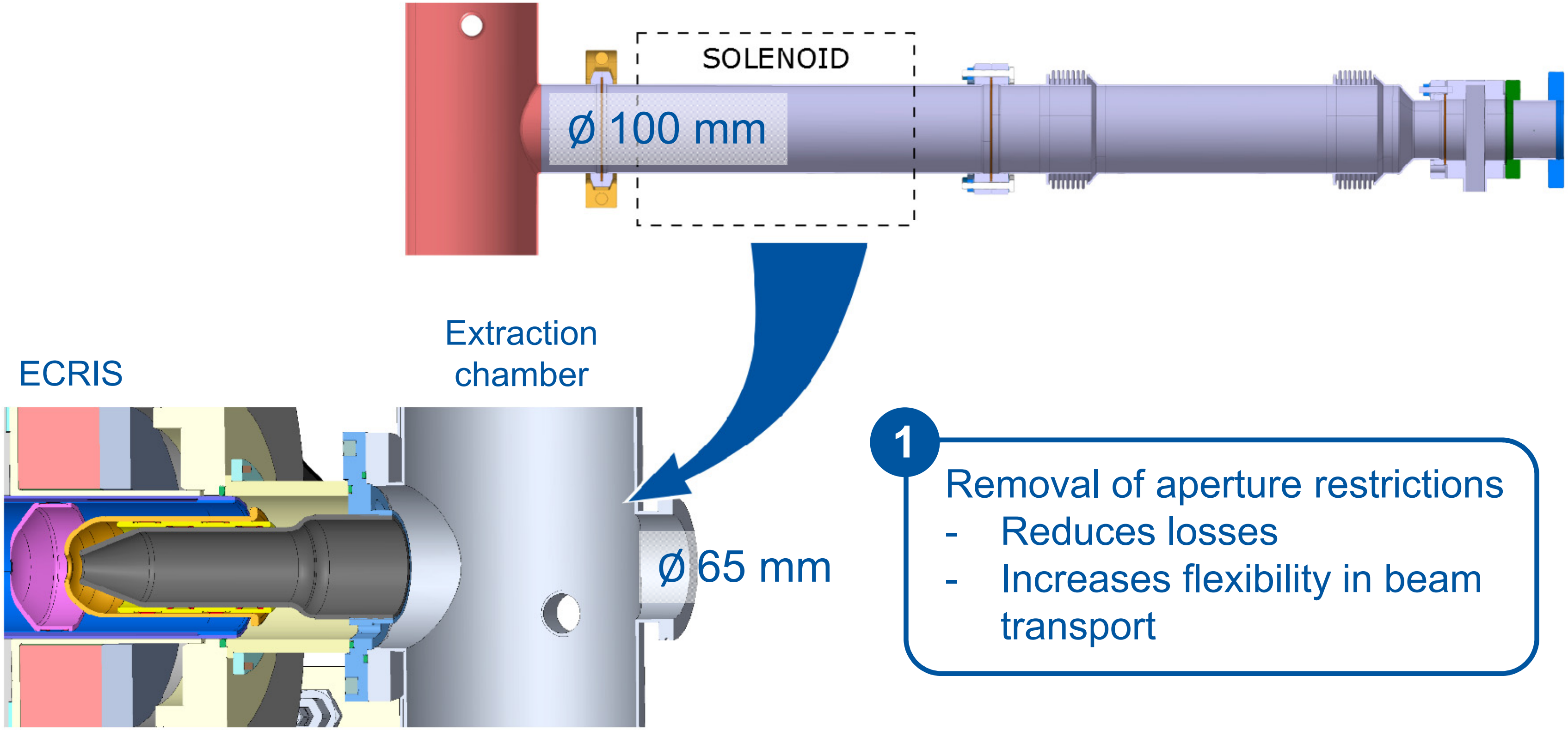

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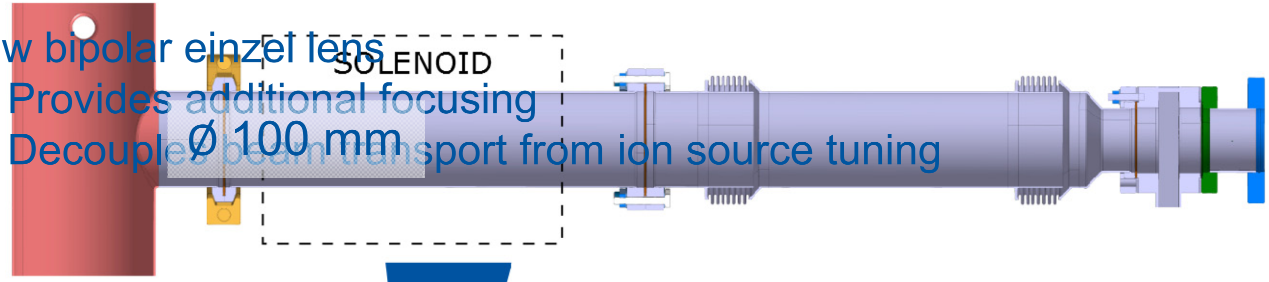
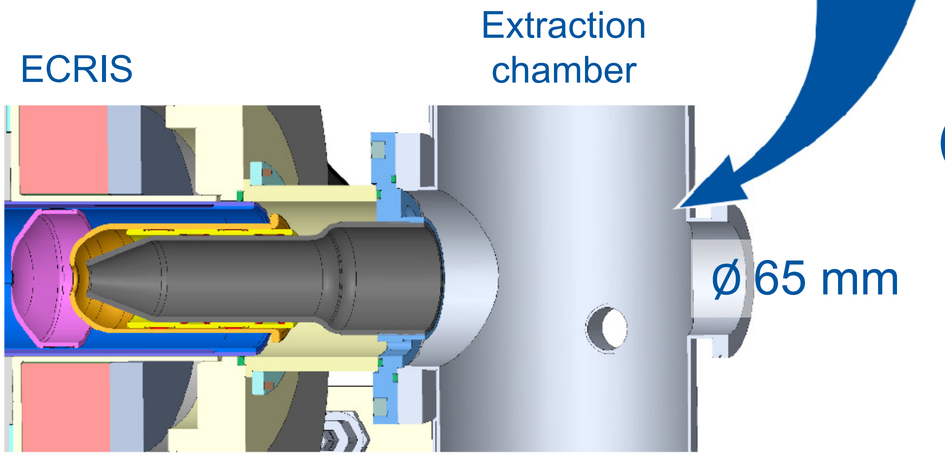


New bipolar einzel lens
- Provides additional focusing
- Decouples beam transport from ion source tuning

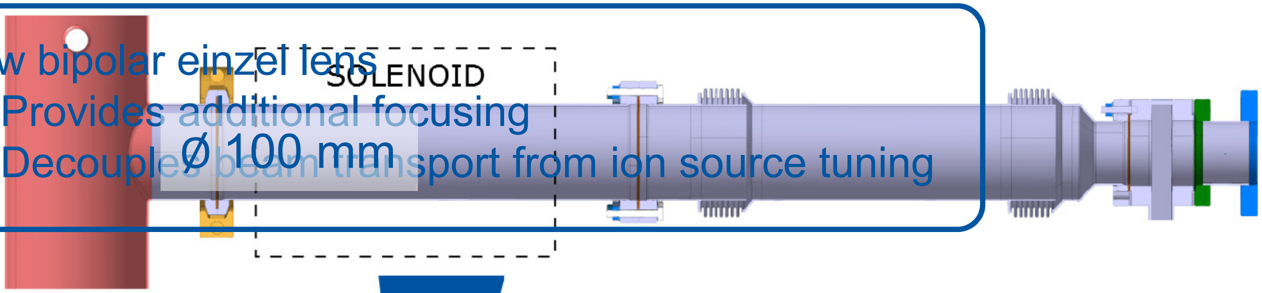


The original system

1

Removal of aperture restrictions
- Reduces losses
- Increases flexibility in beam transport

Two main modifications



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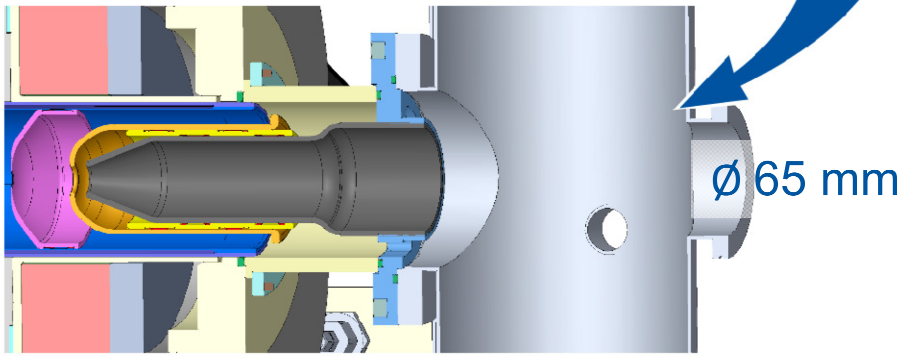

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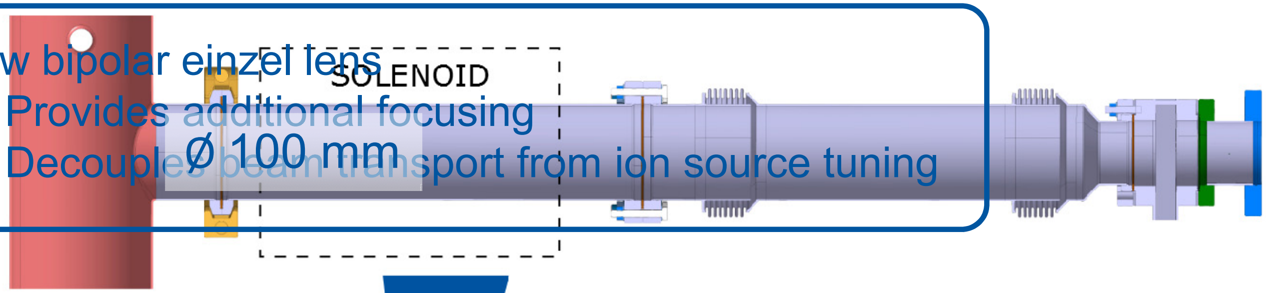

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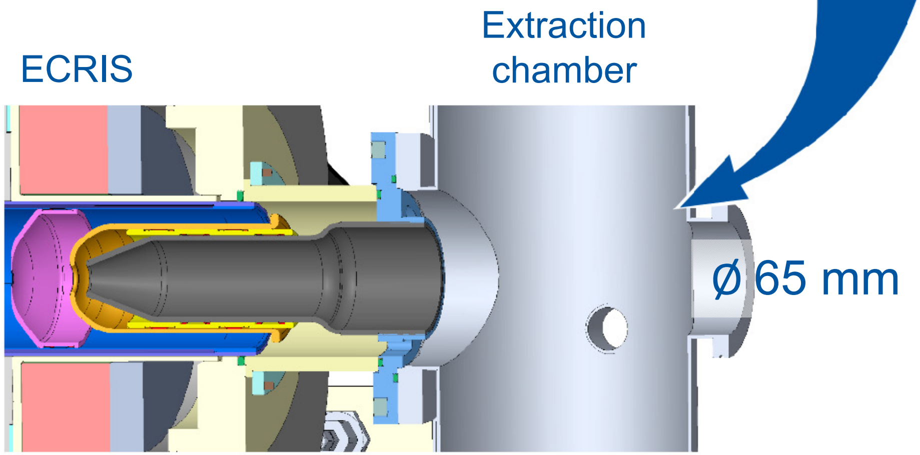

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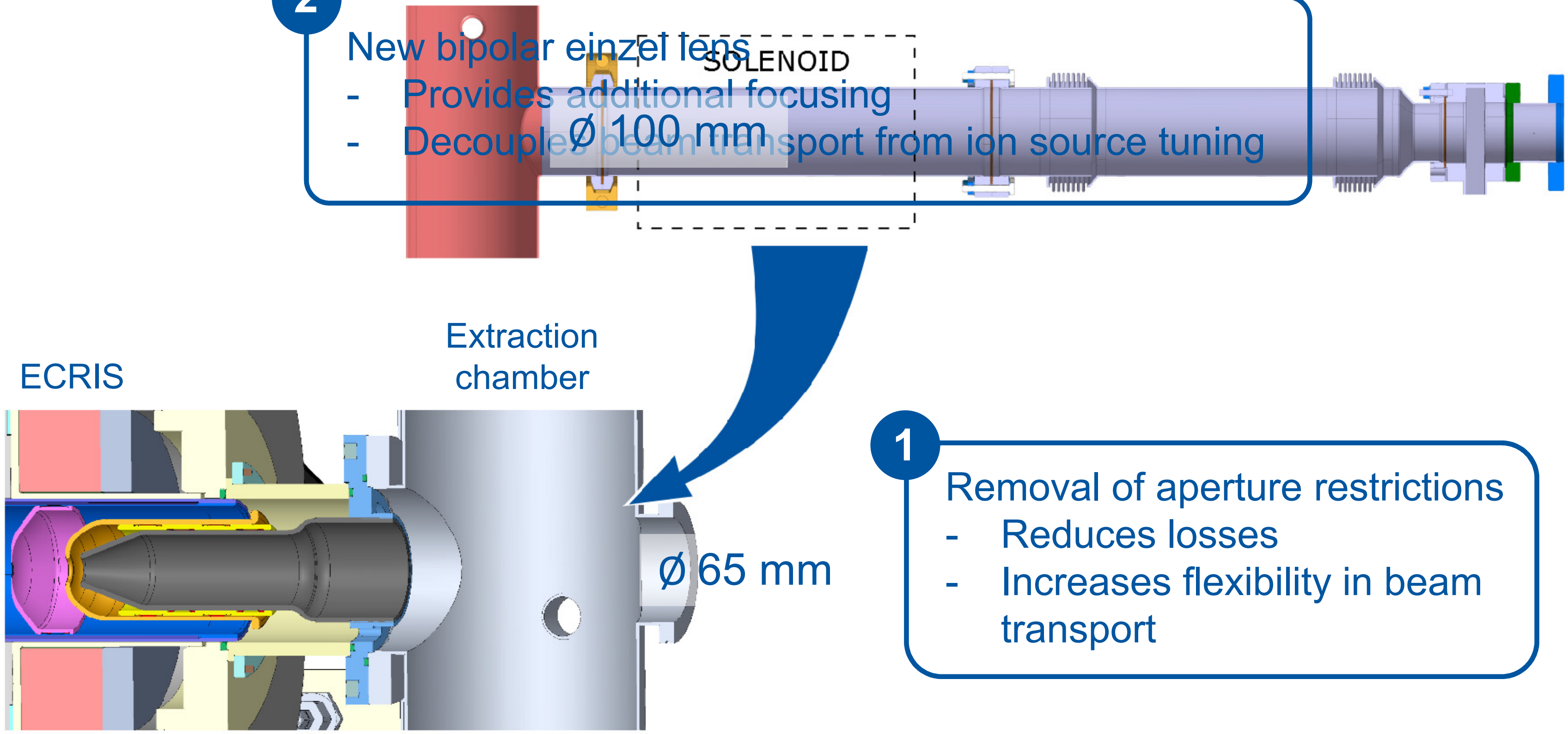

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The original system

Results after upgrade

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- Performance has improved steadily as experience is gained on how to optimize the source matching to the new transport conditions
- Comparison of beam performance before and after the upgrade:

- Also other benefits from improved flexibility in ion source tuning
  - Improved beam stability
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Ion species and location	***Original (2015 run)***	***Upgraded***	***Improvement***
Pb^{29+} out of ion source	170 μA	210 μA	24 %
Pb^{54+} out of Linac3	25 μA	35 μA	40 %

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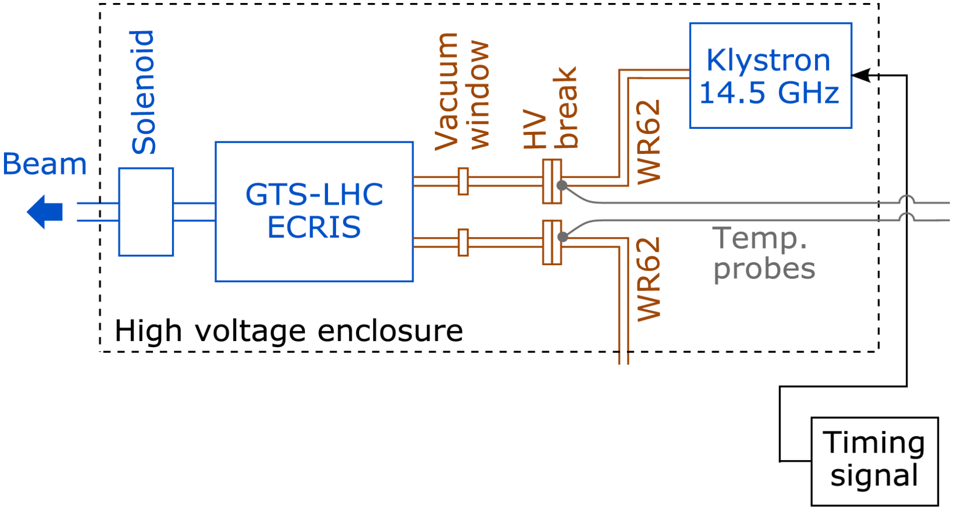

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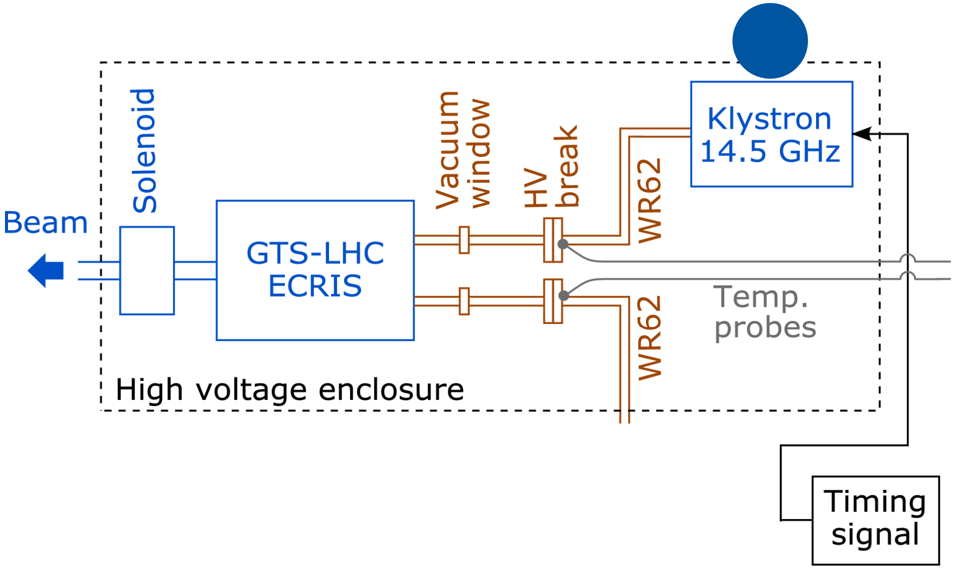

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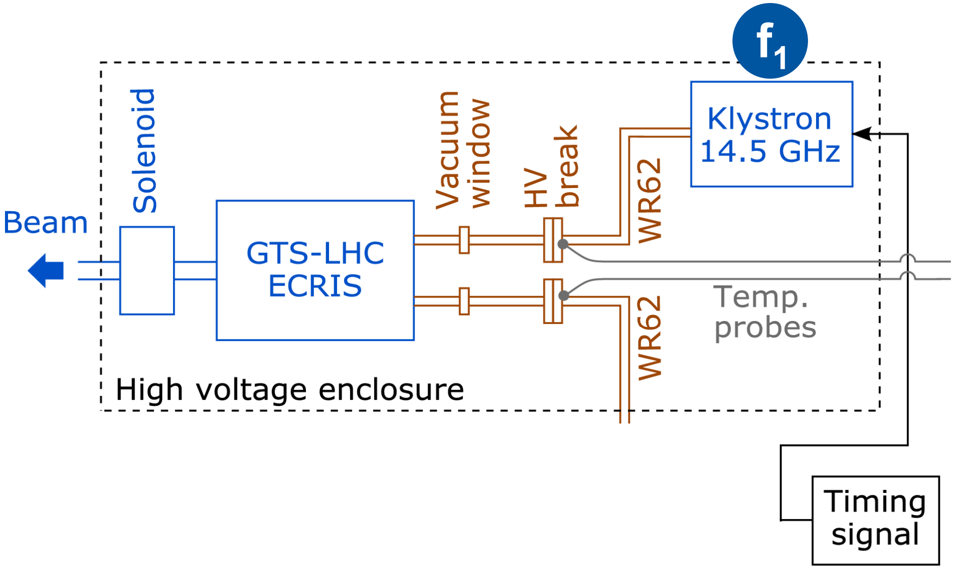

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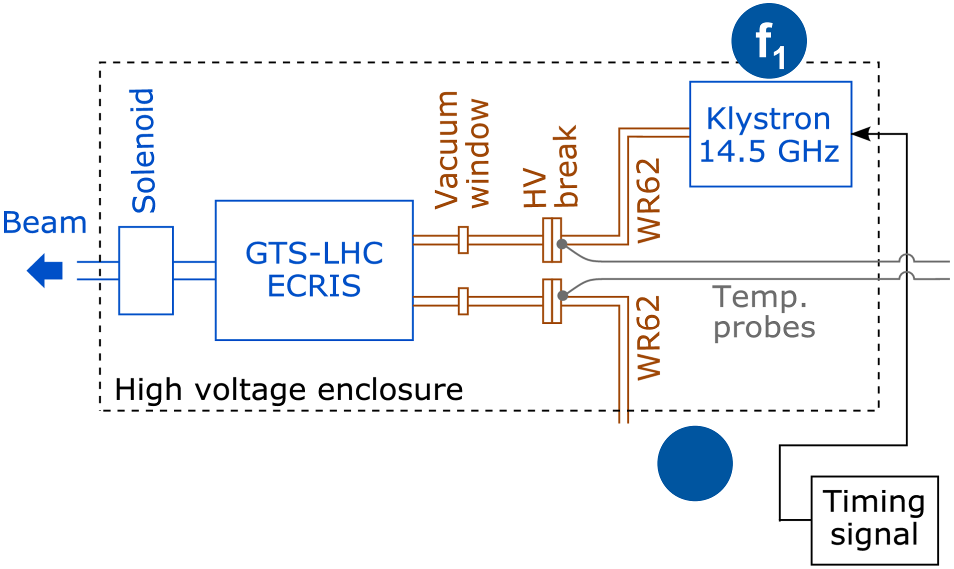

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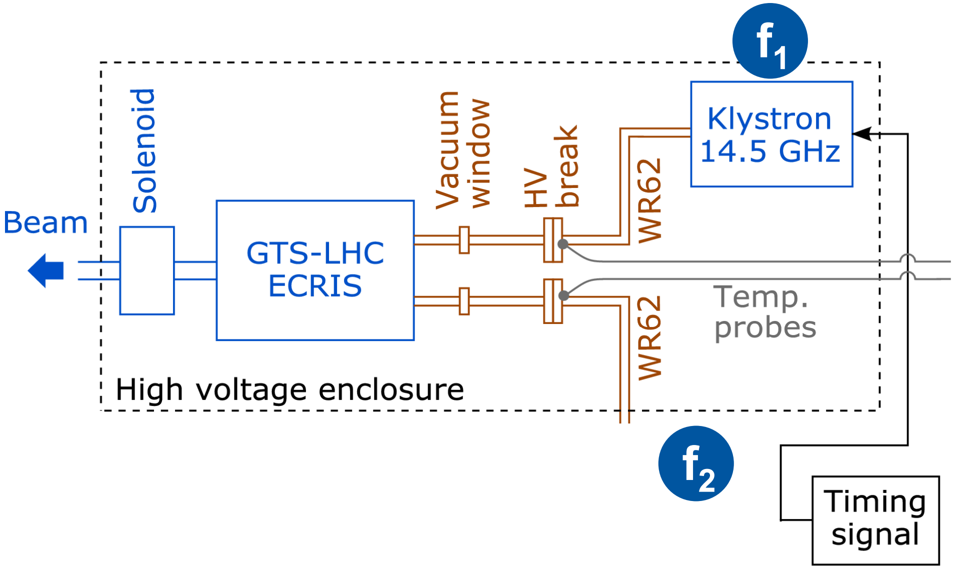

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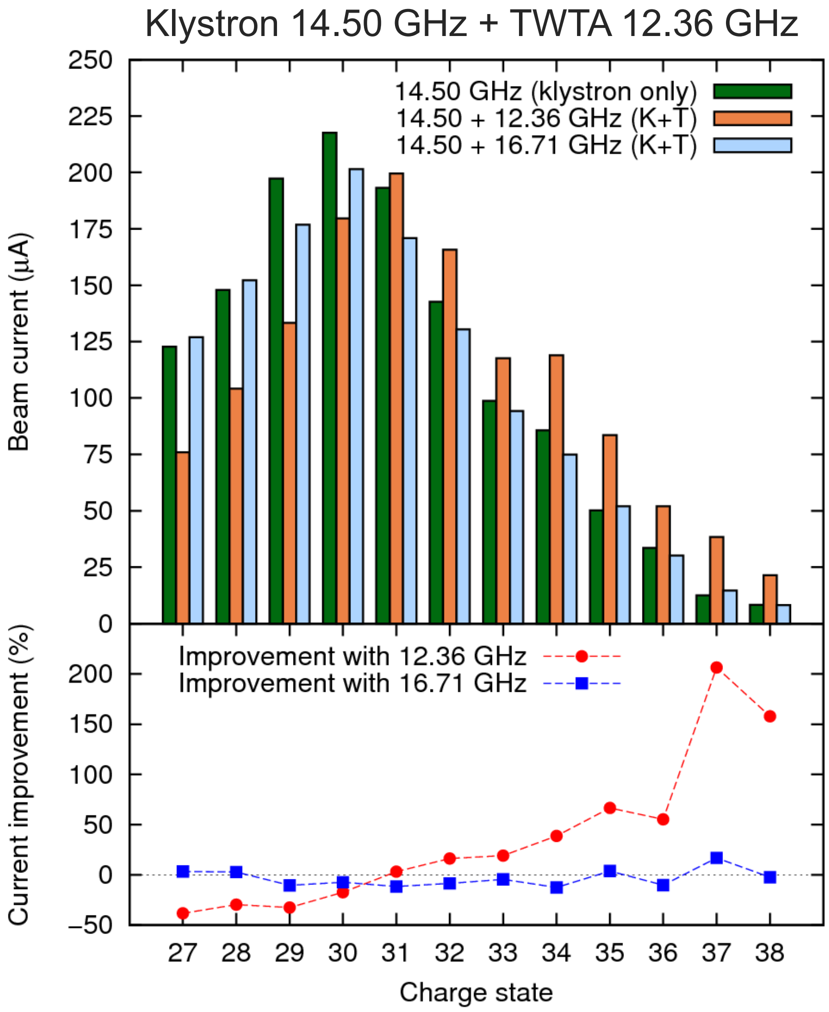

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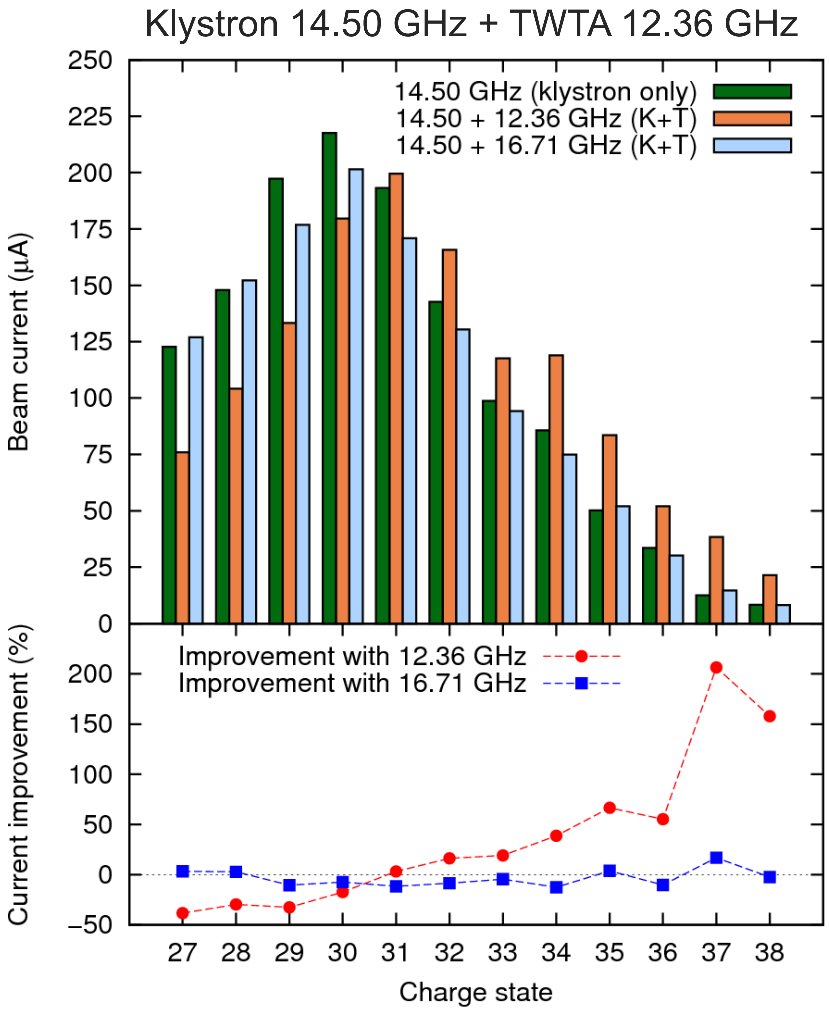

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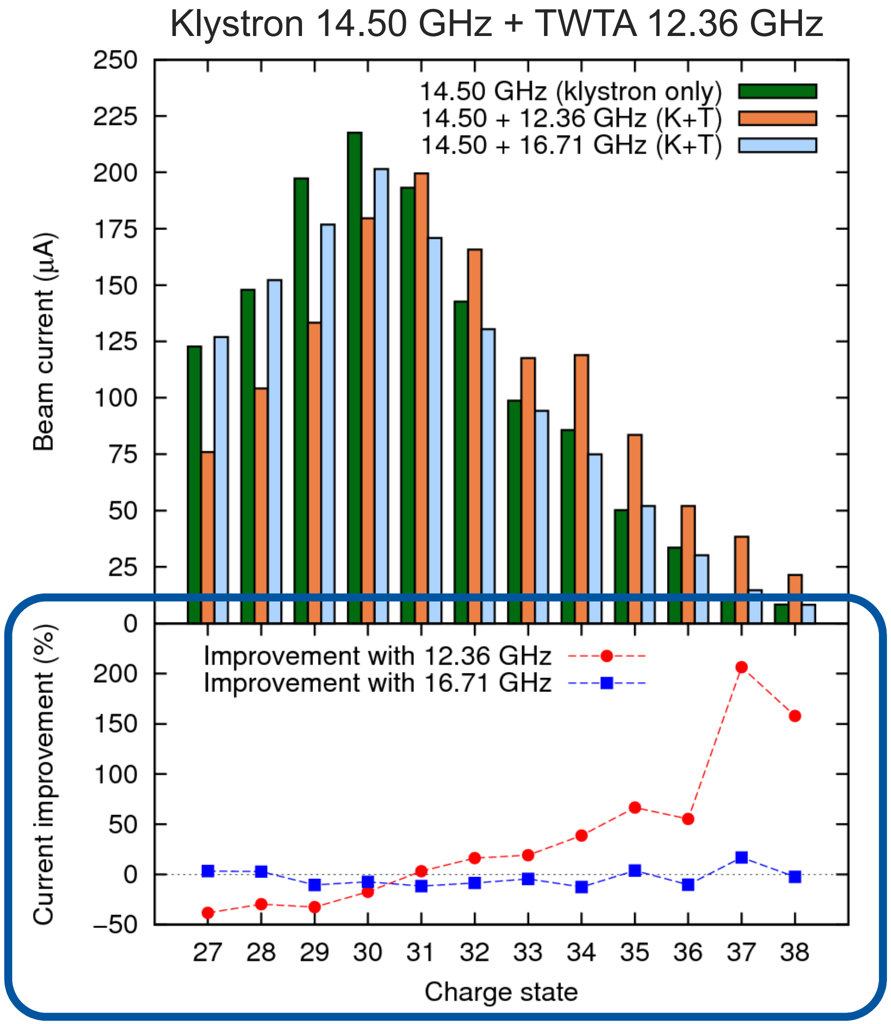

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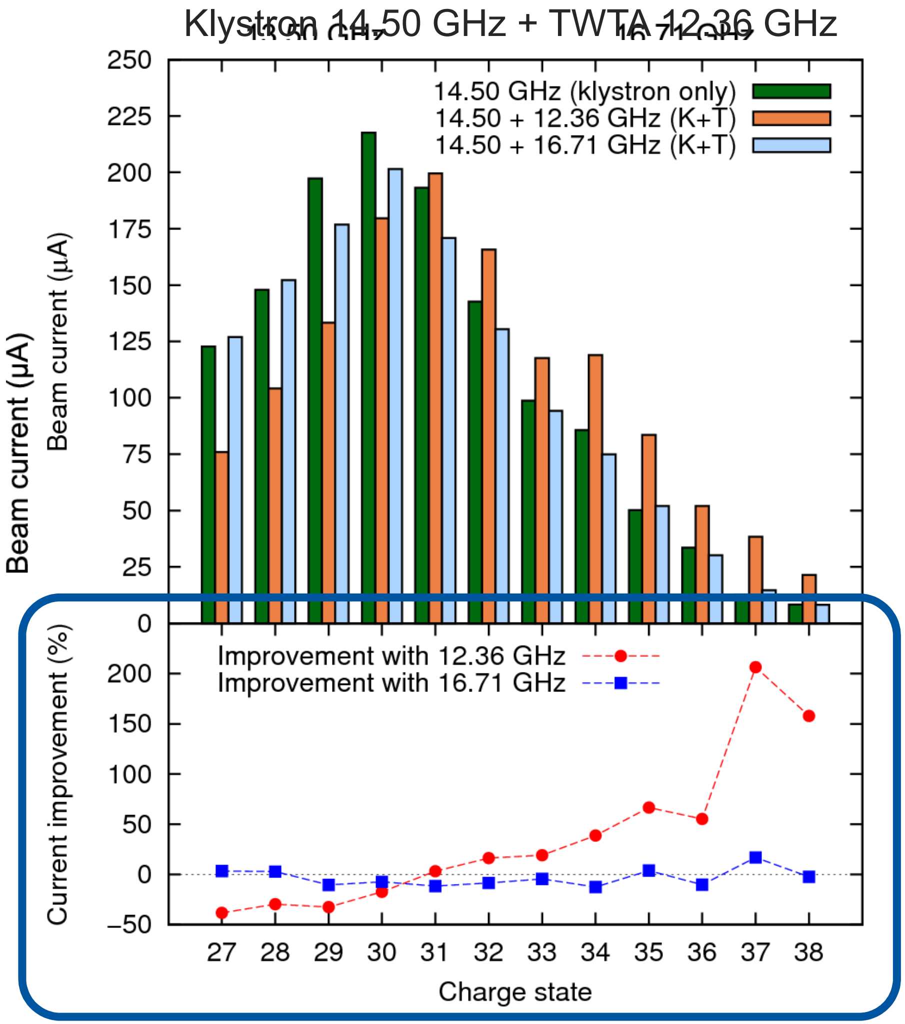

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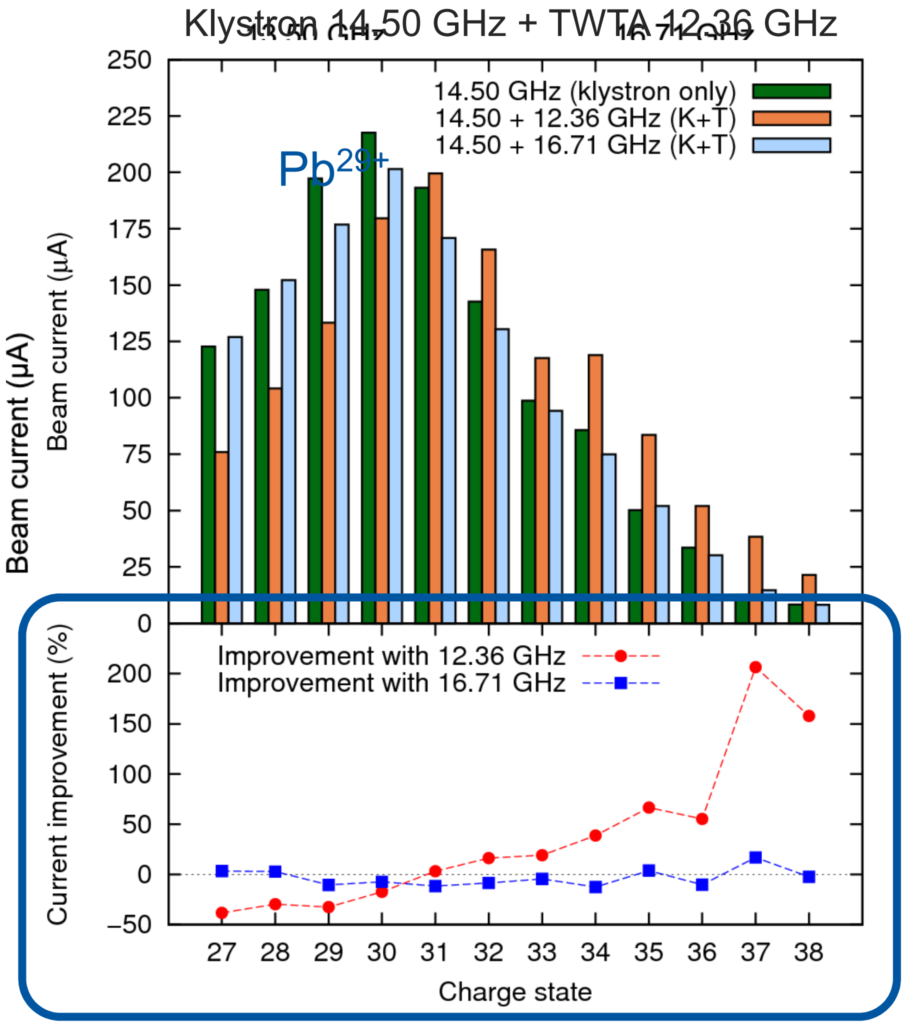

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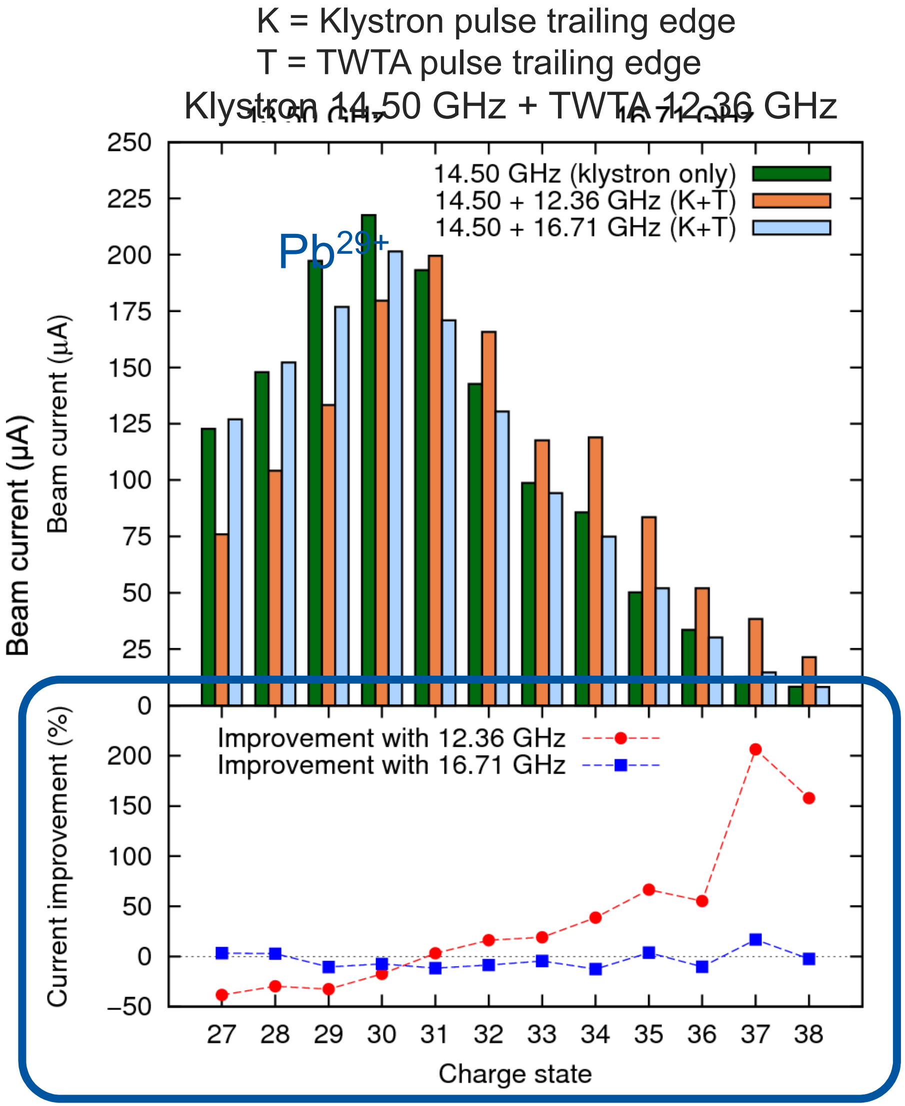

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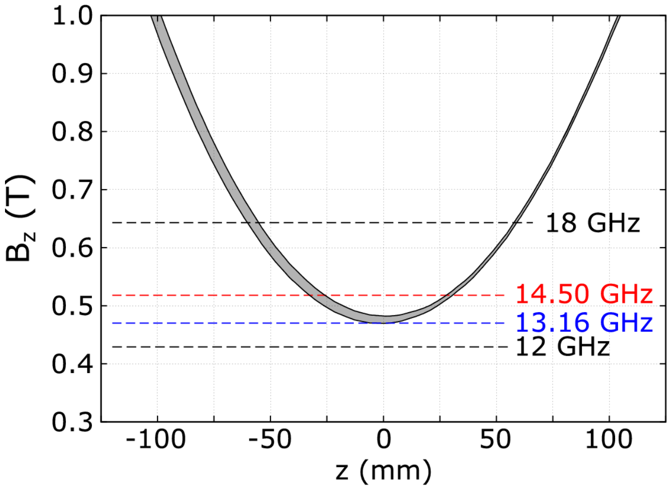

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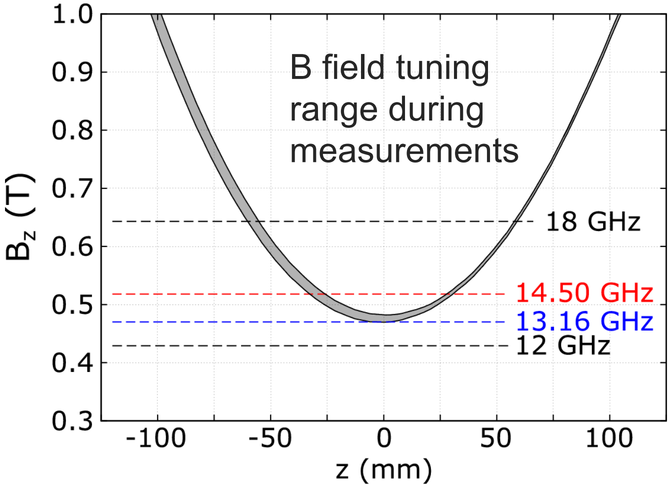

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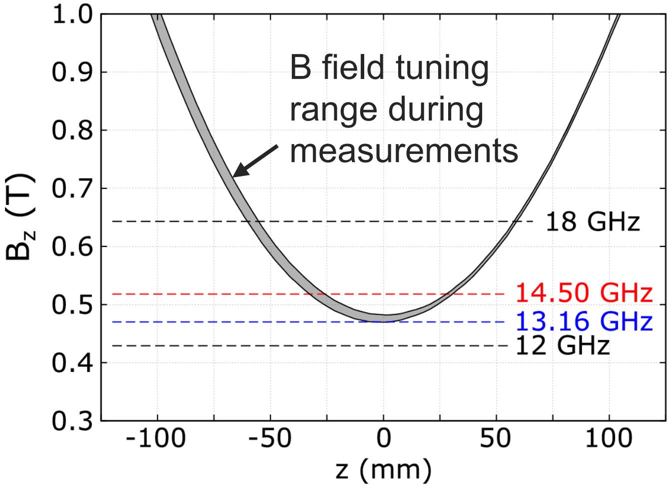

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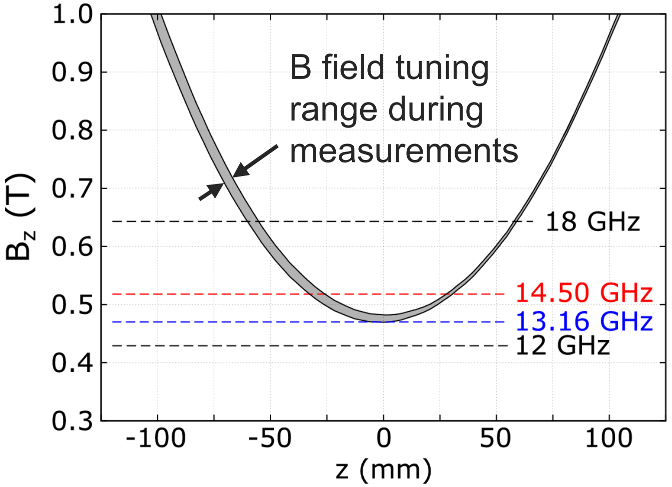

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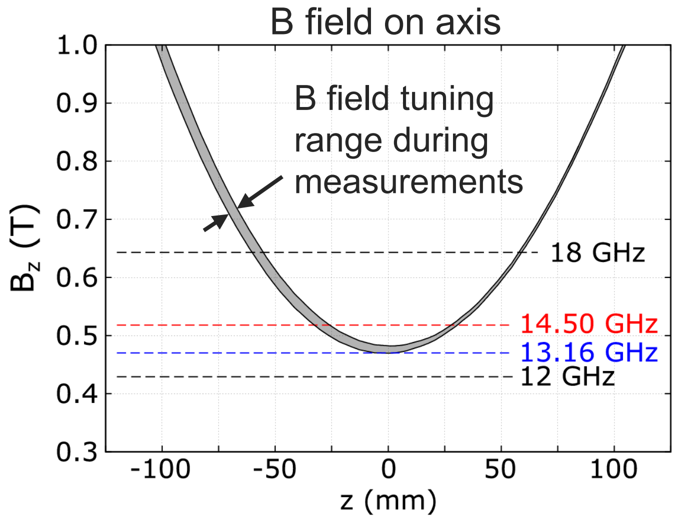

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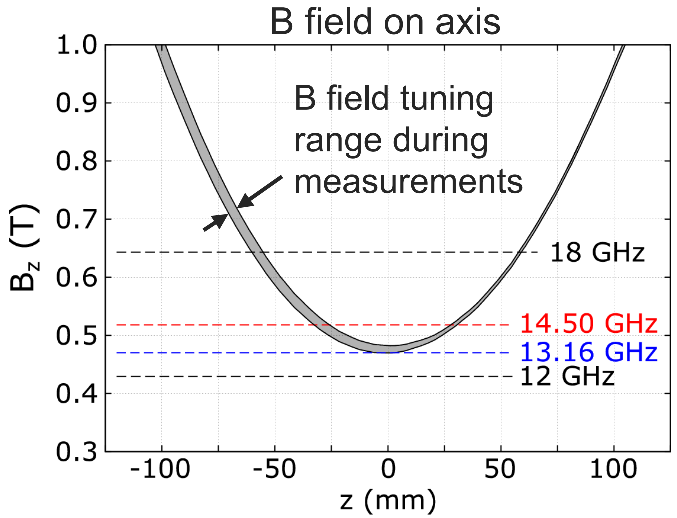

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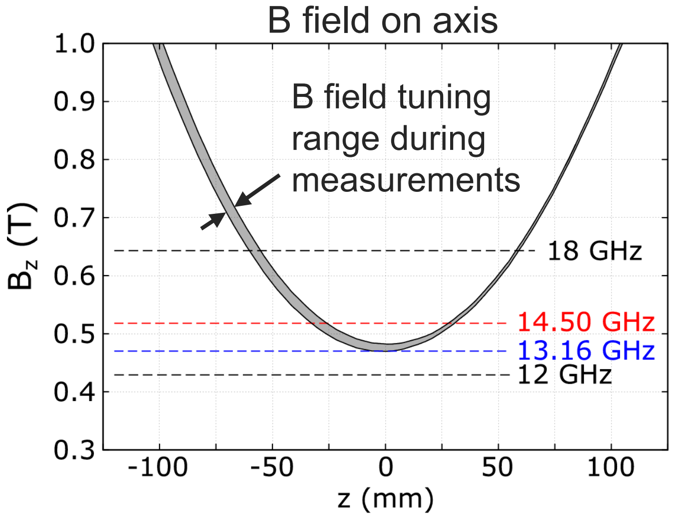

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*V. Skalyga et al., Phys. Plasmas 22 (2015) 083509

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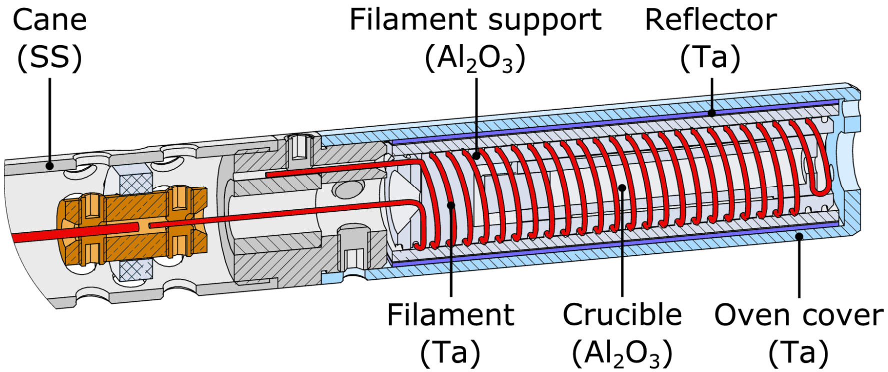

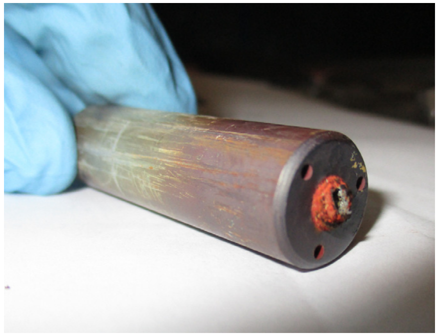

GTS-LHC miniature oven

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  - Increased time between refills (presently 2 weeks)
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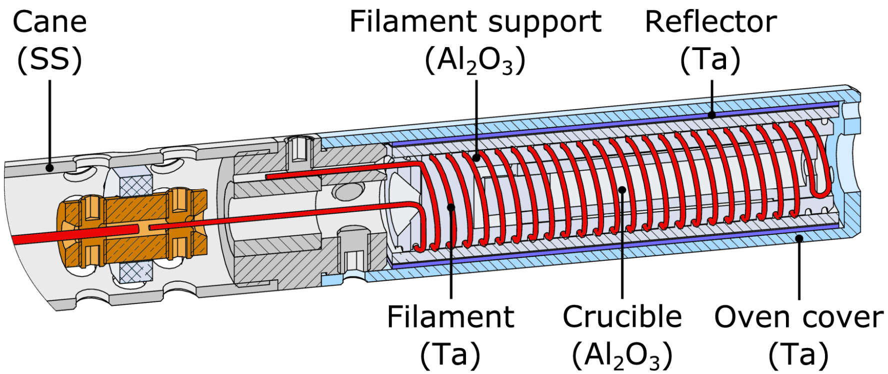
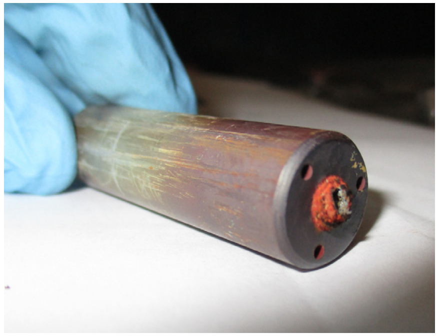
  - Basic characterization of oven





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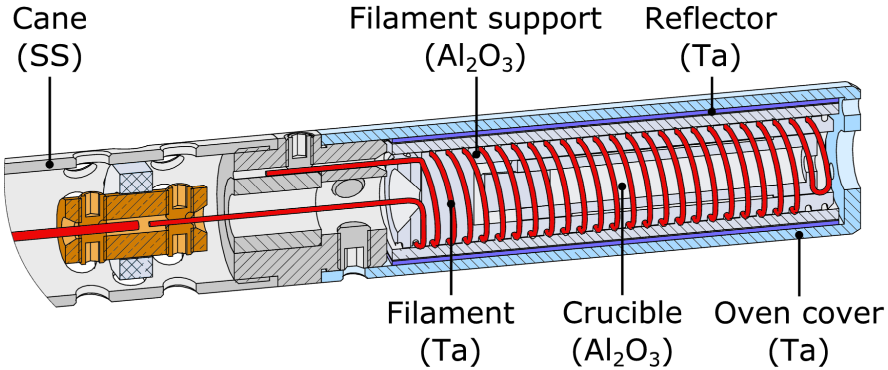
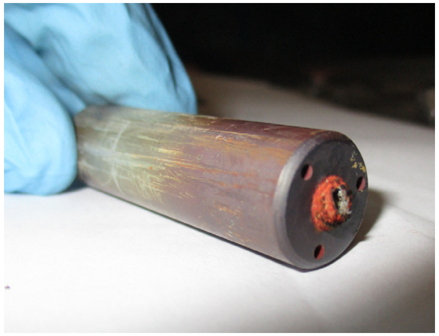
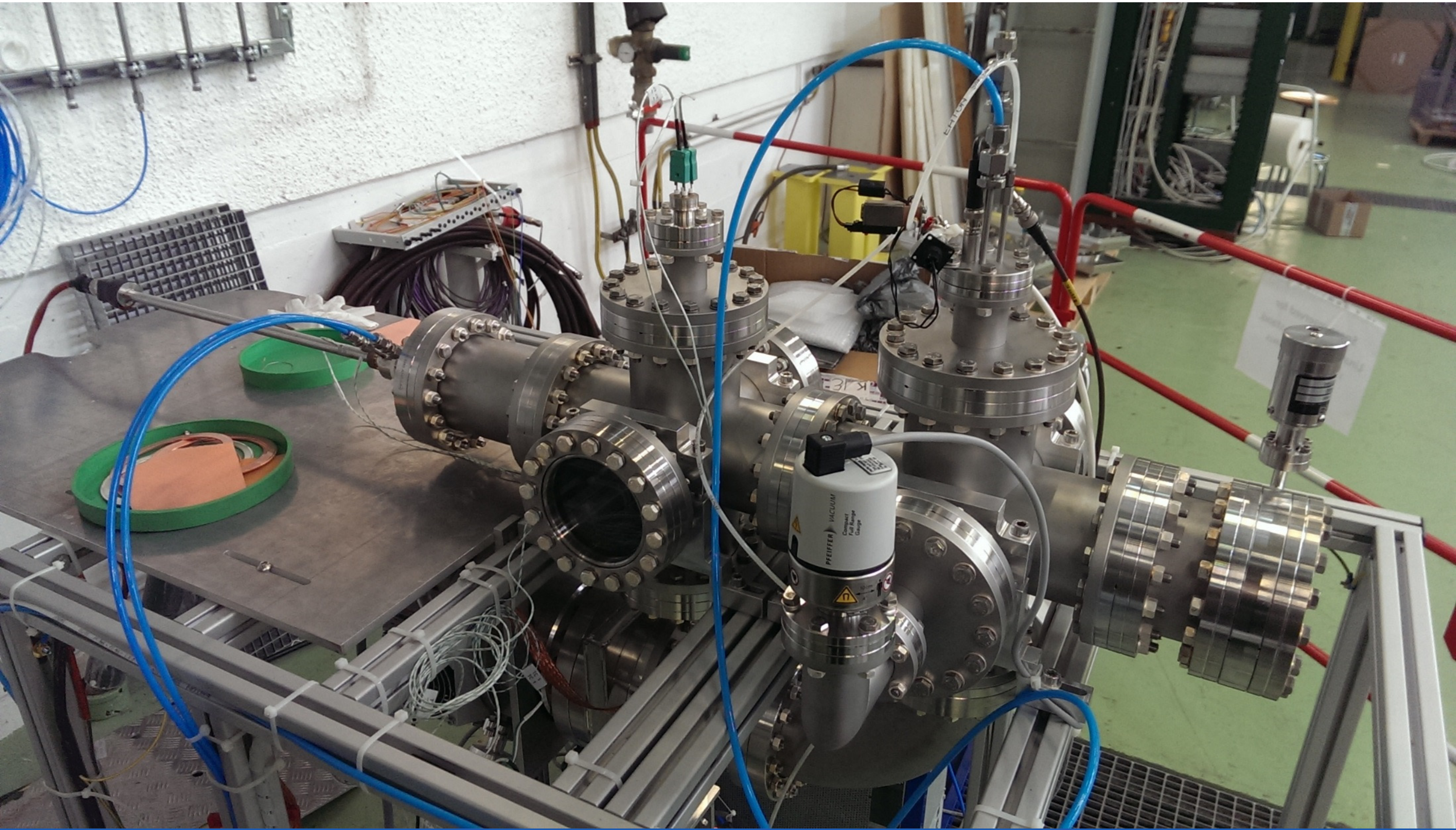
- Dedicated test stand built for oven studies

- Thermal model to complement measurements





Oven test stand



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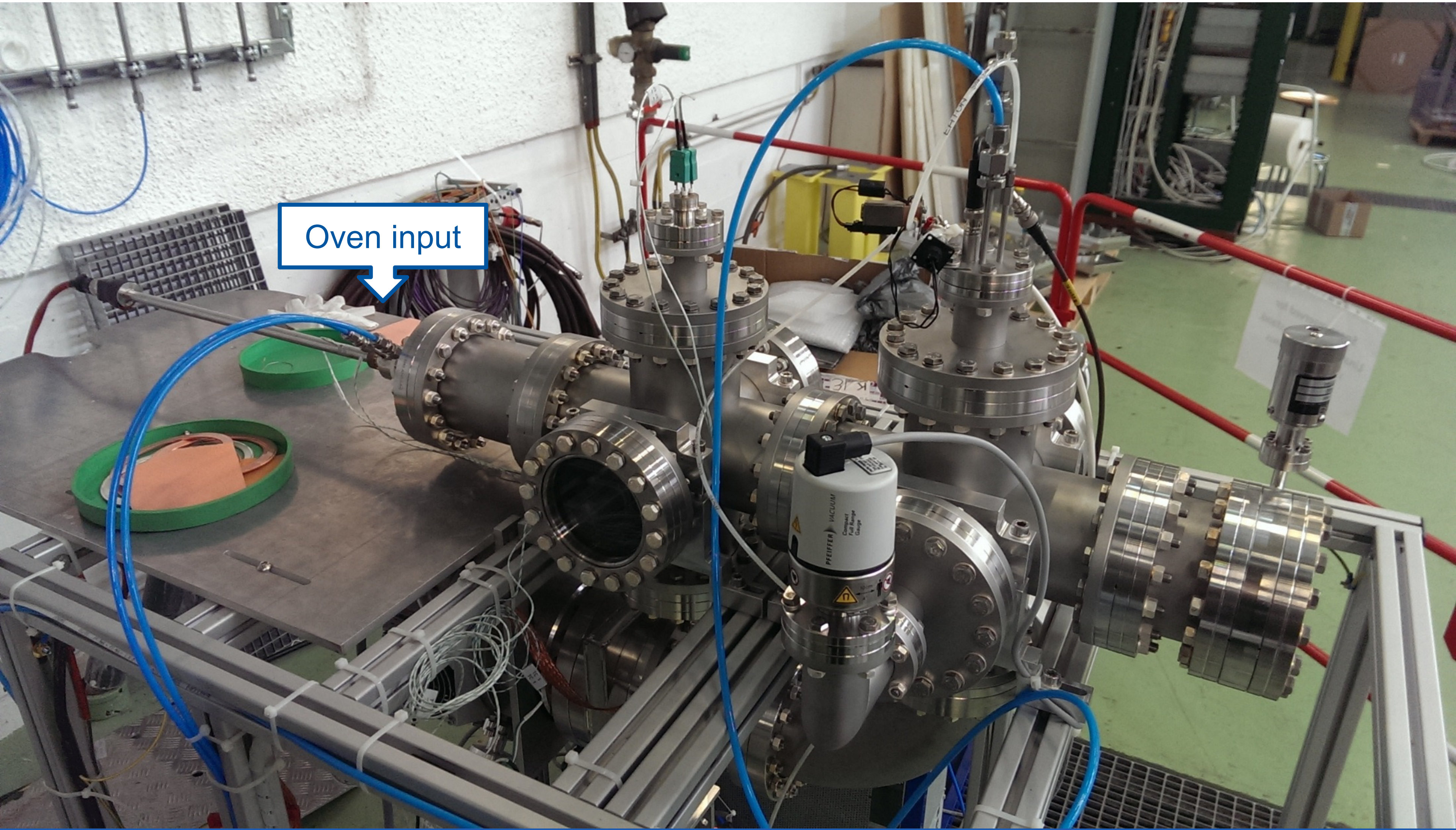

Oven input

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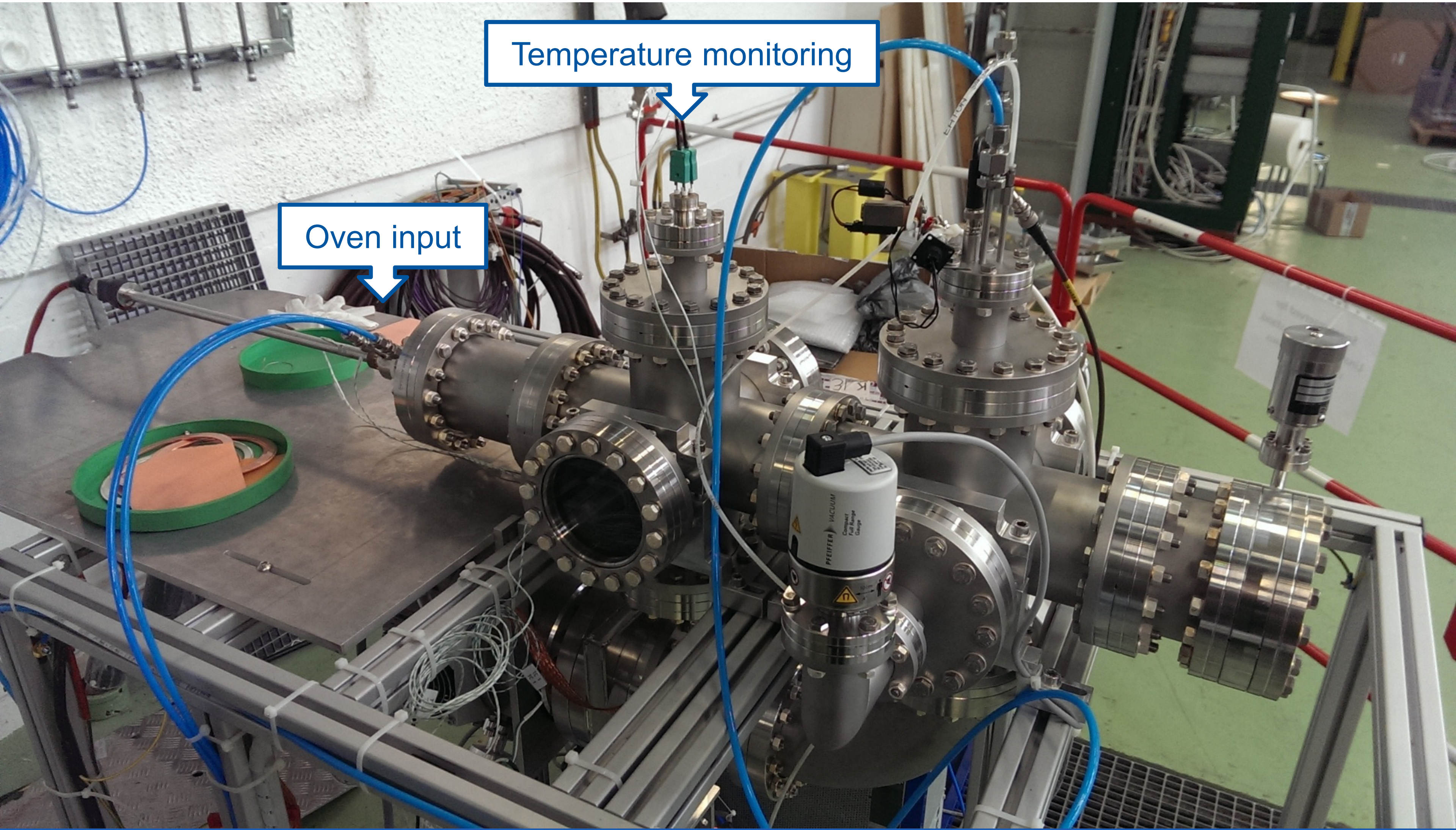

Temperature monitoring

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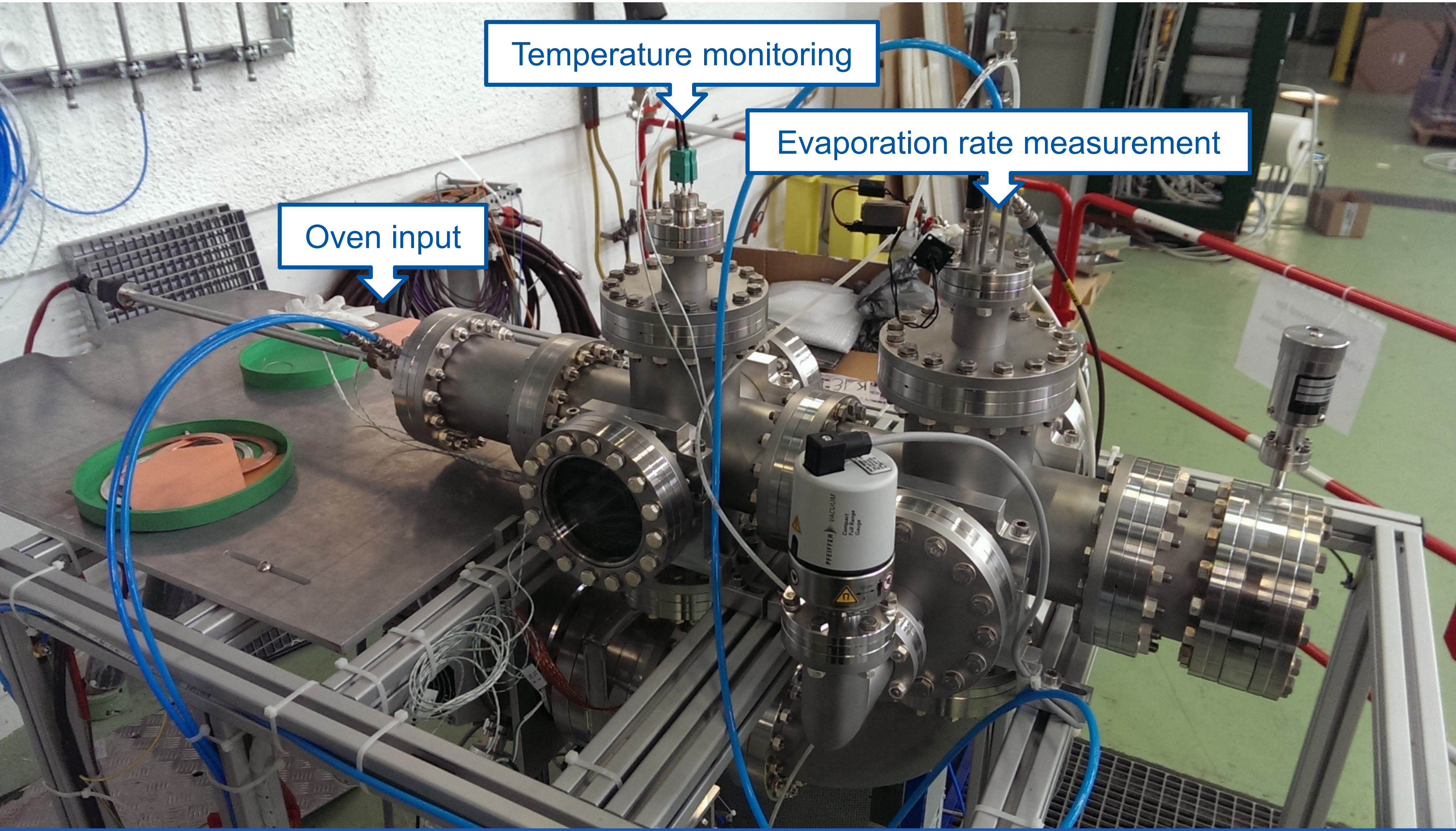

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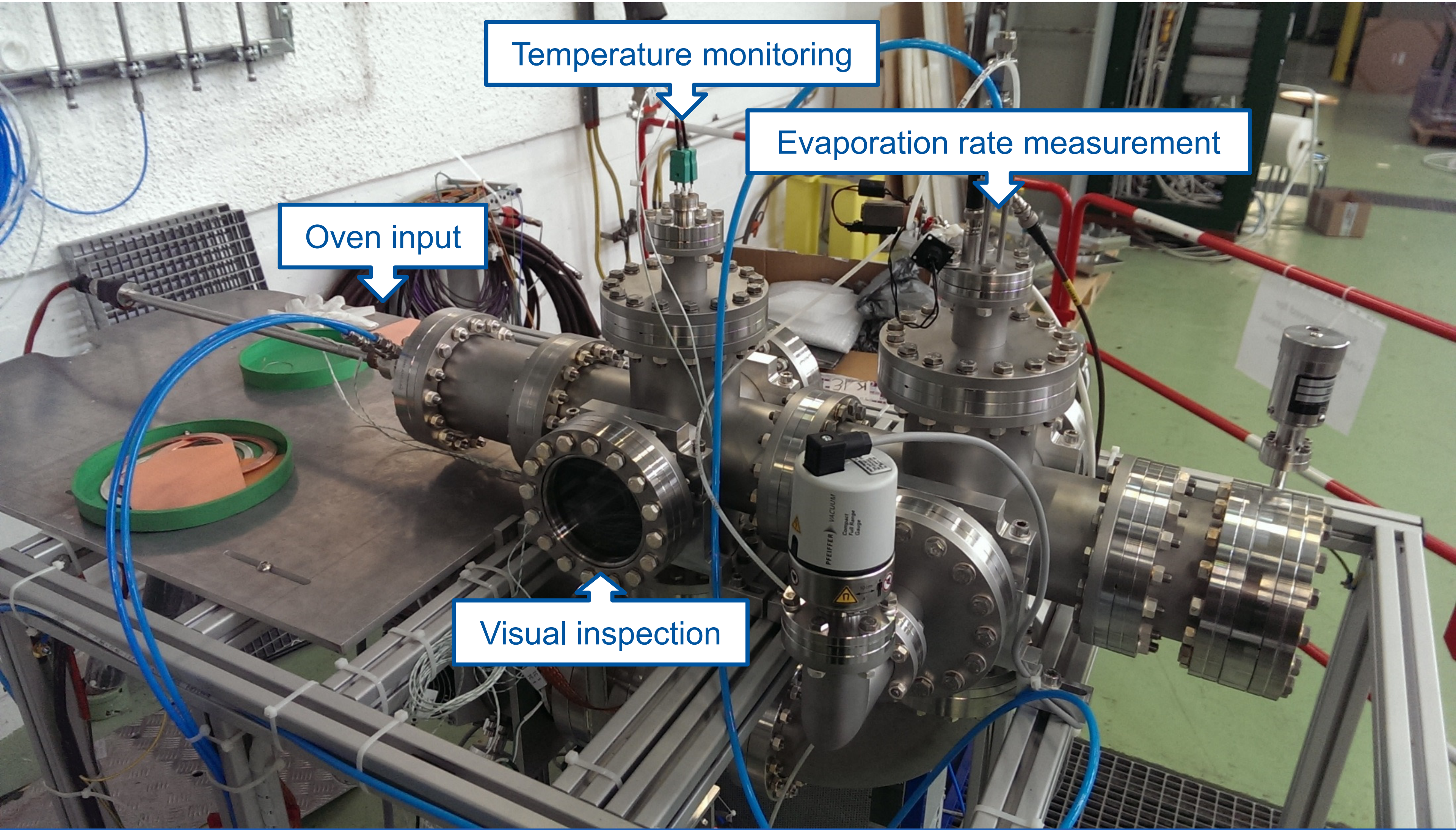

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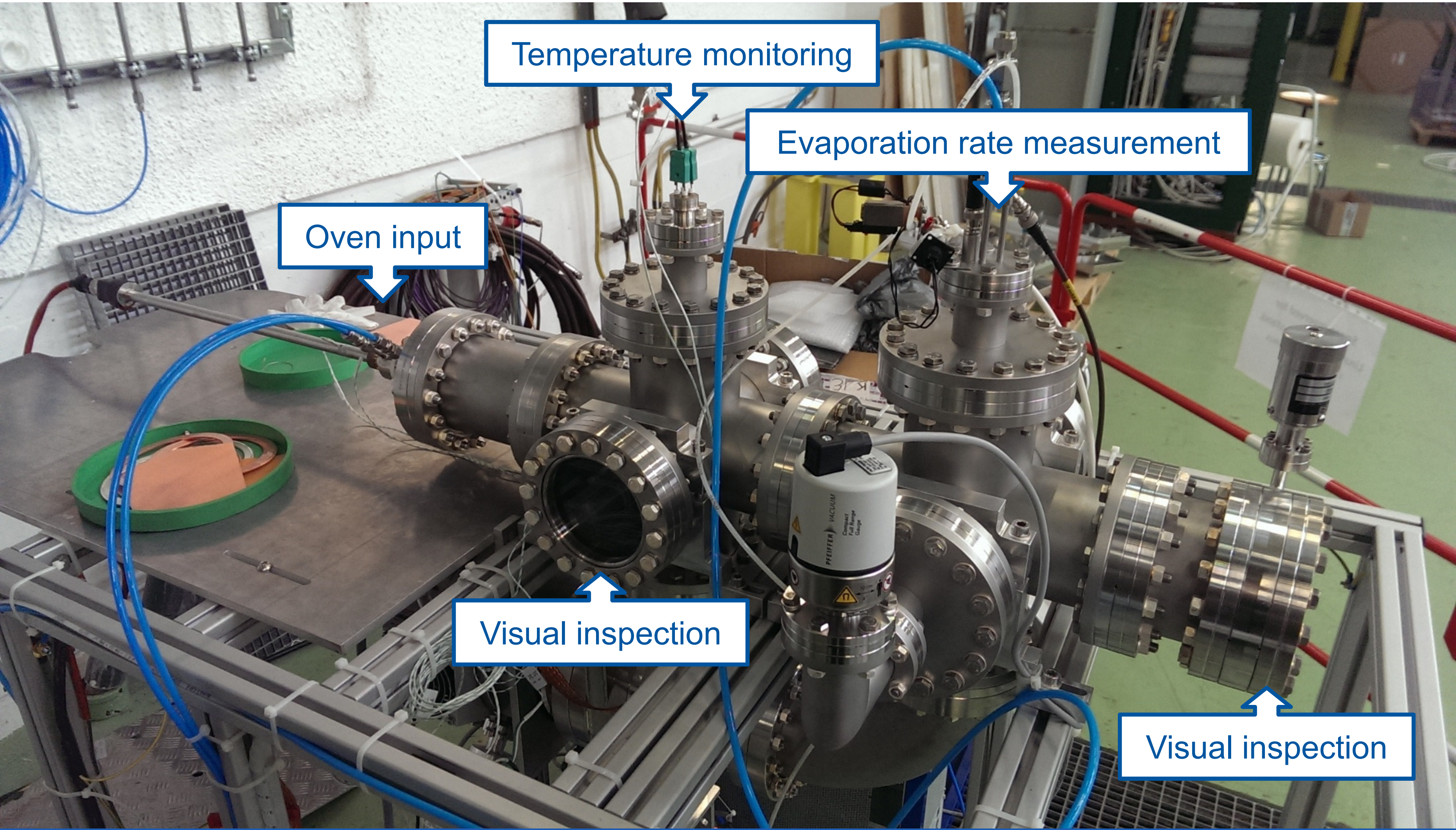

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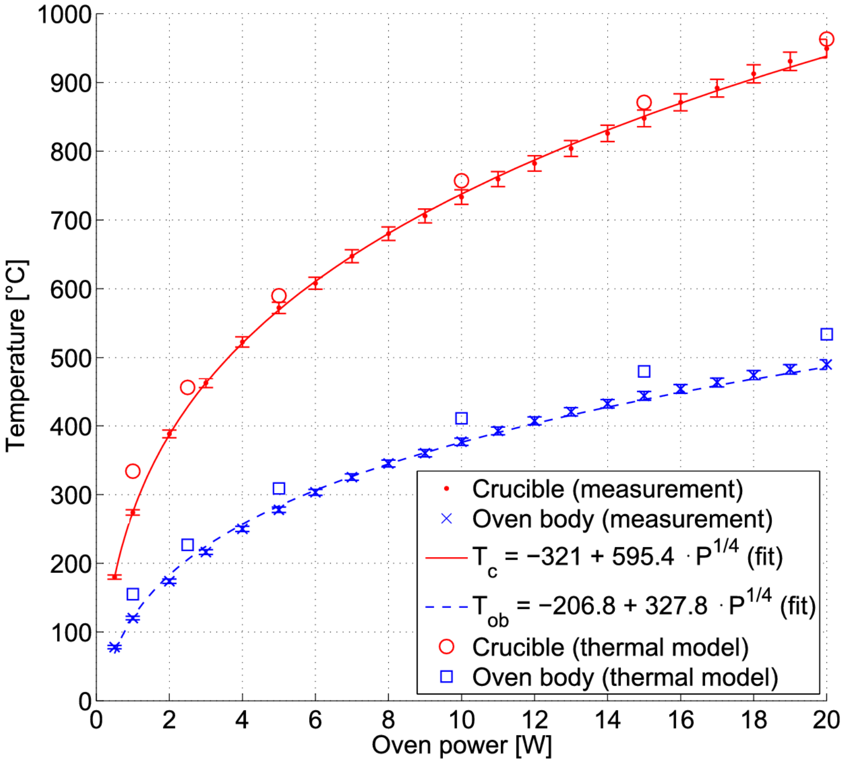

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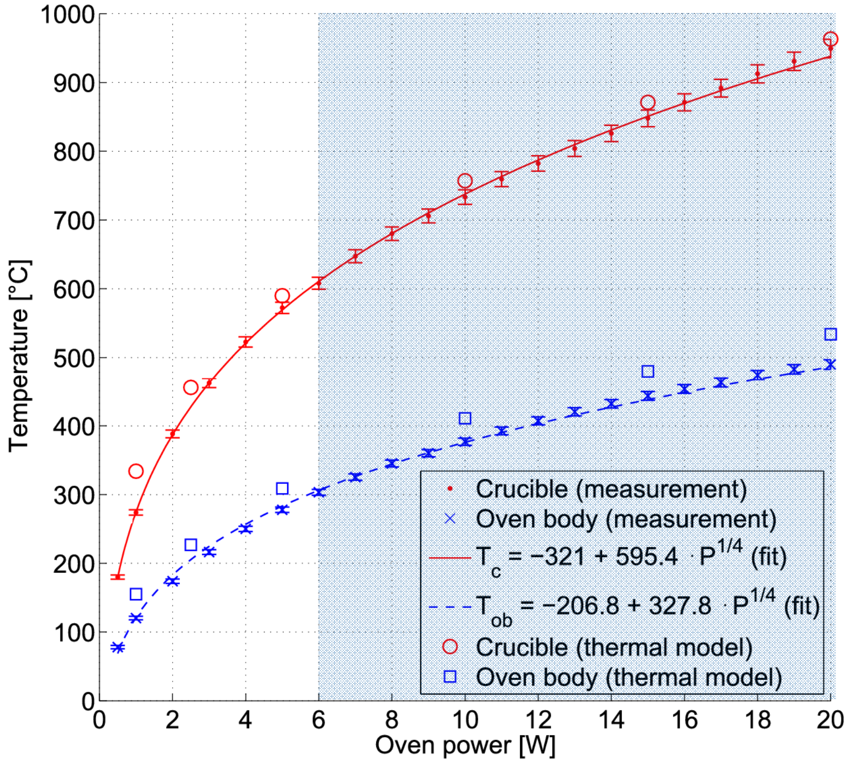

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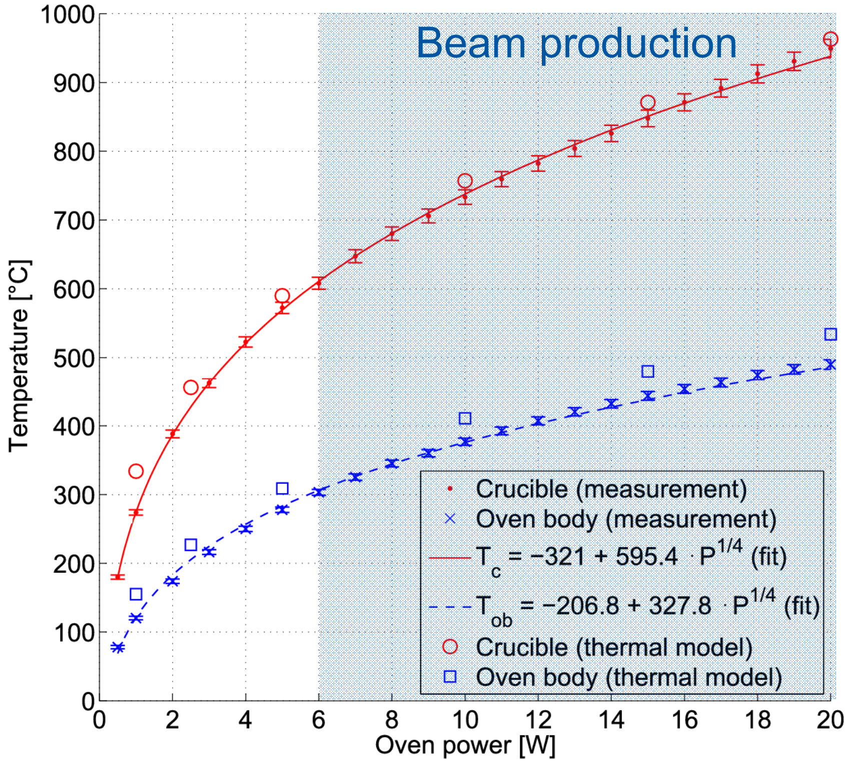

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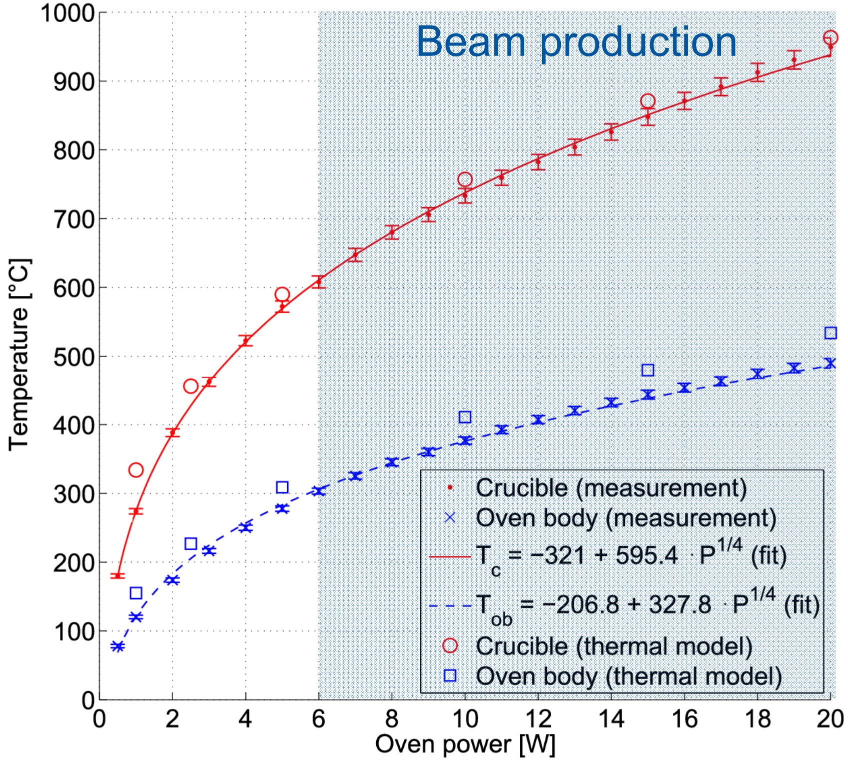

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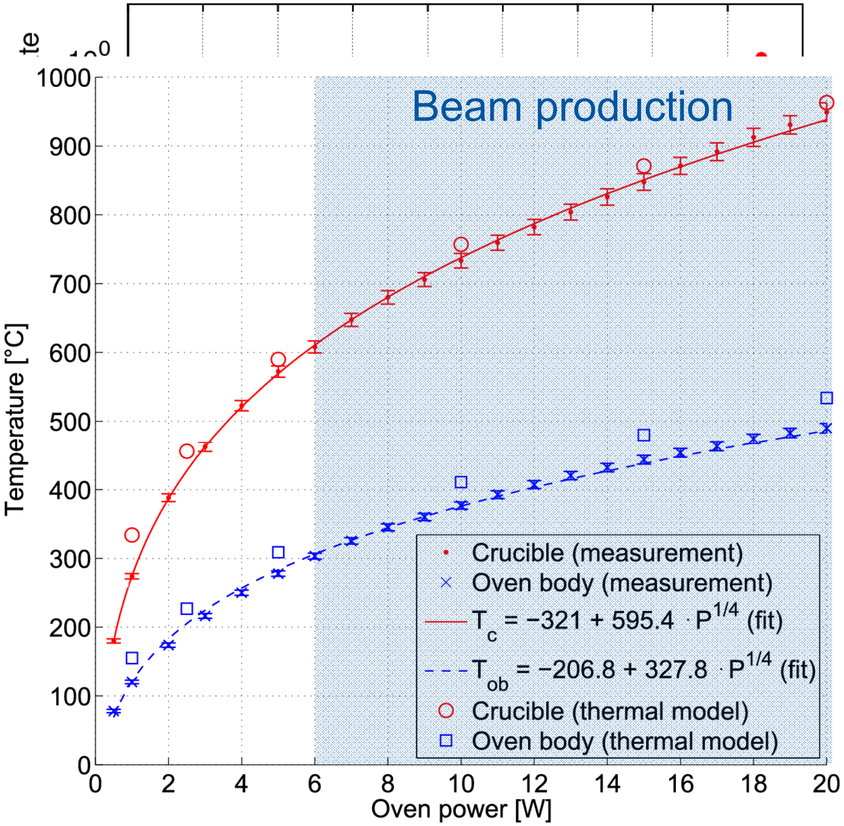

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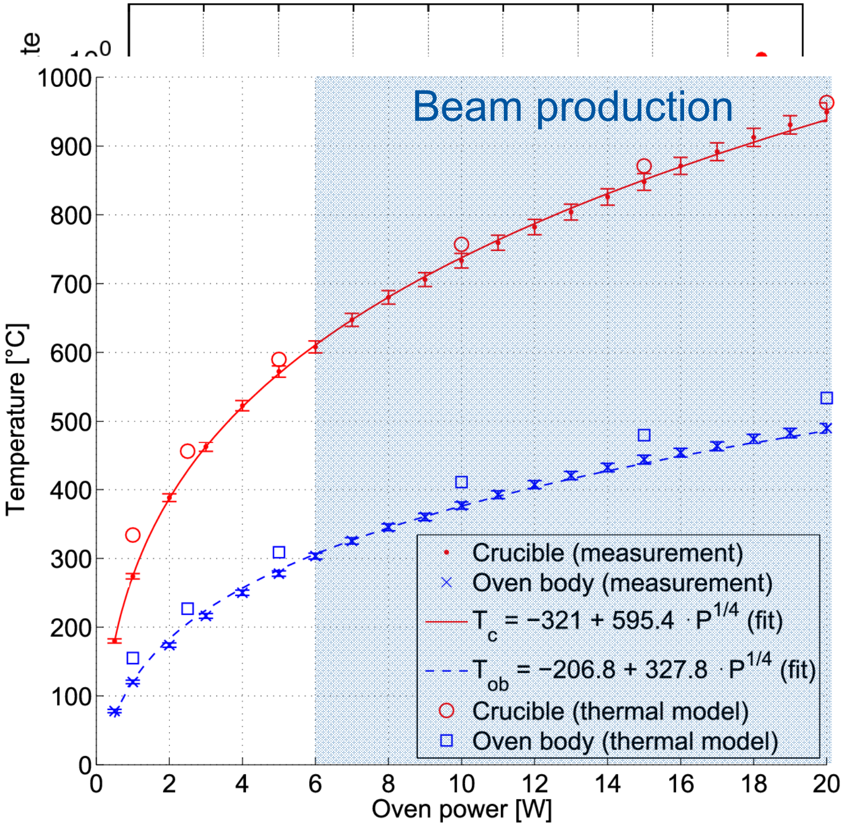

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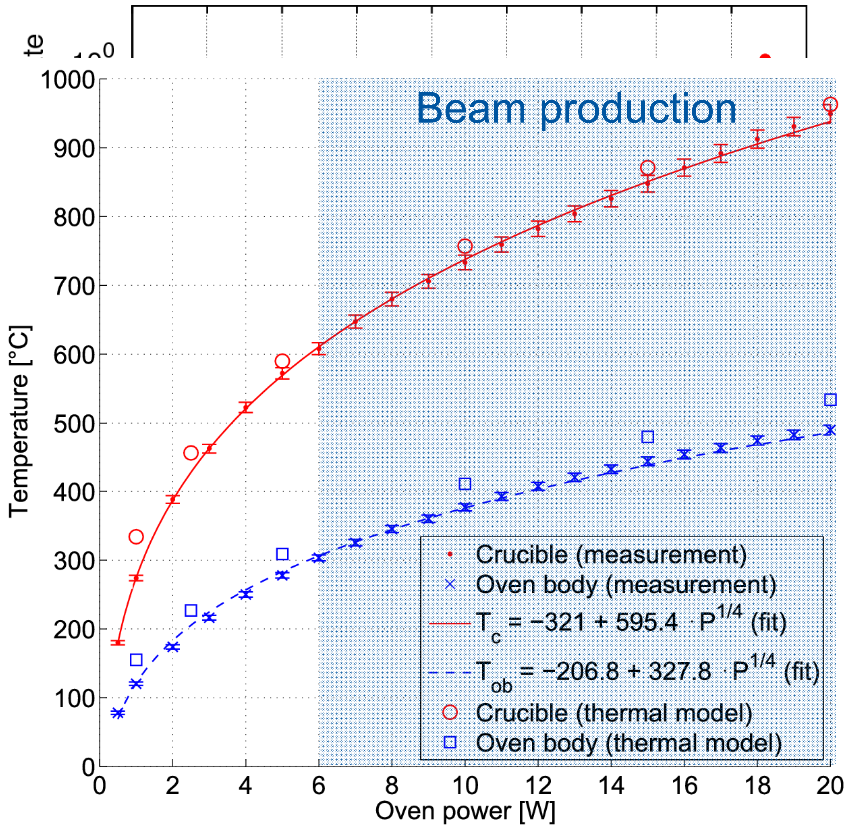

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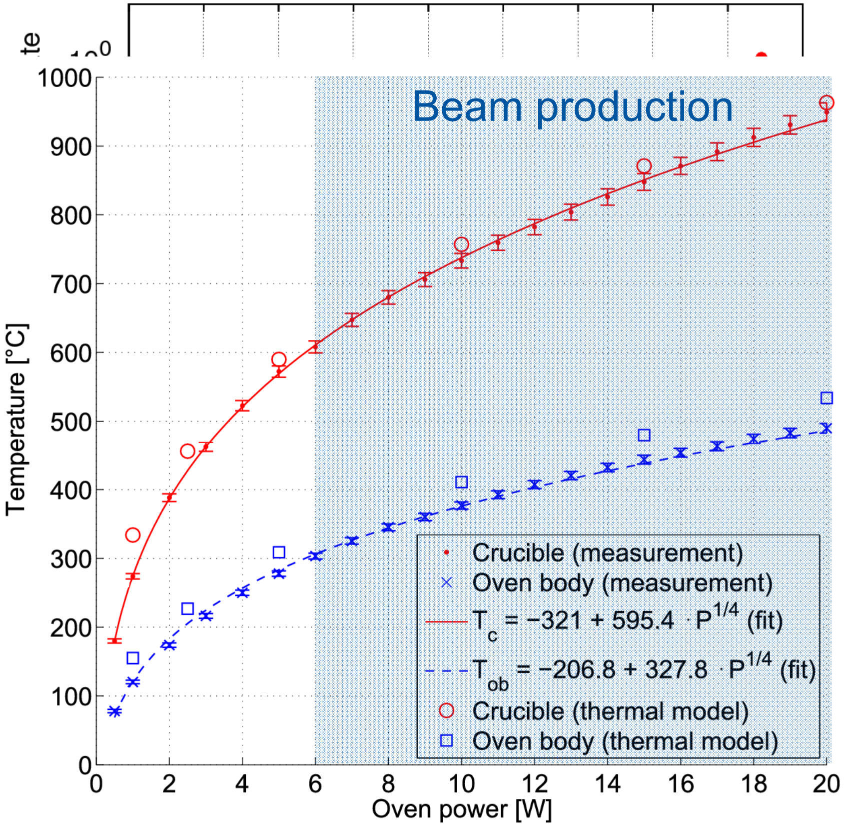

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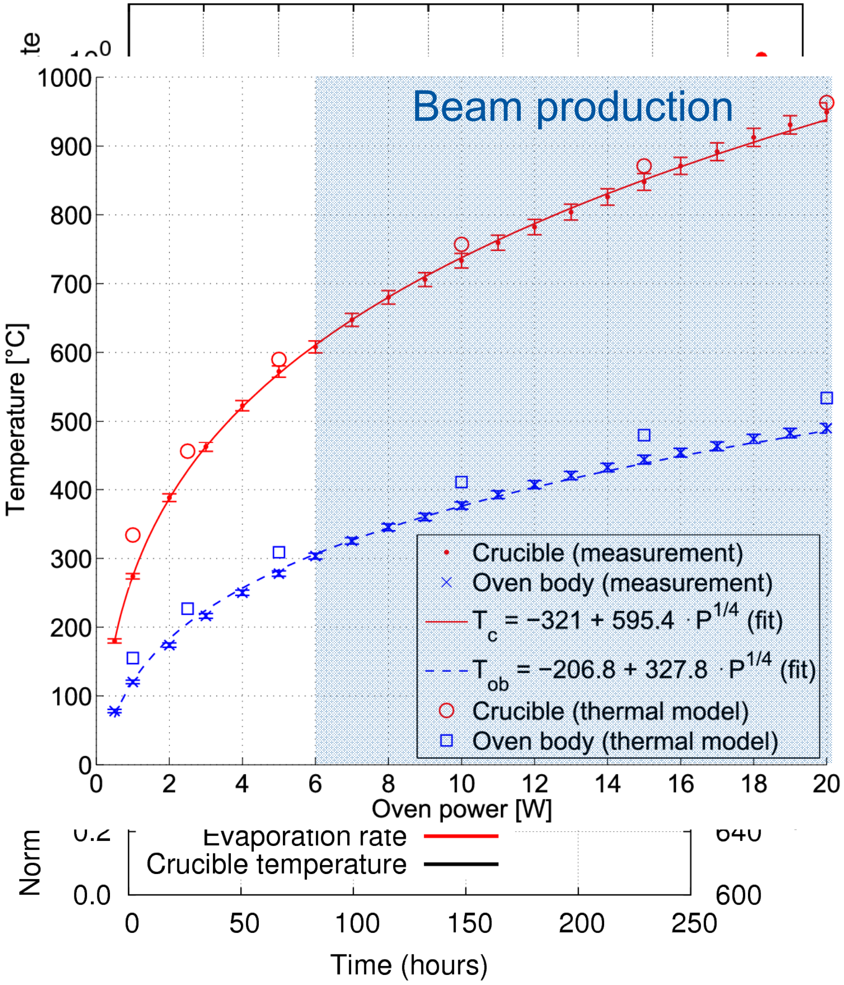

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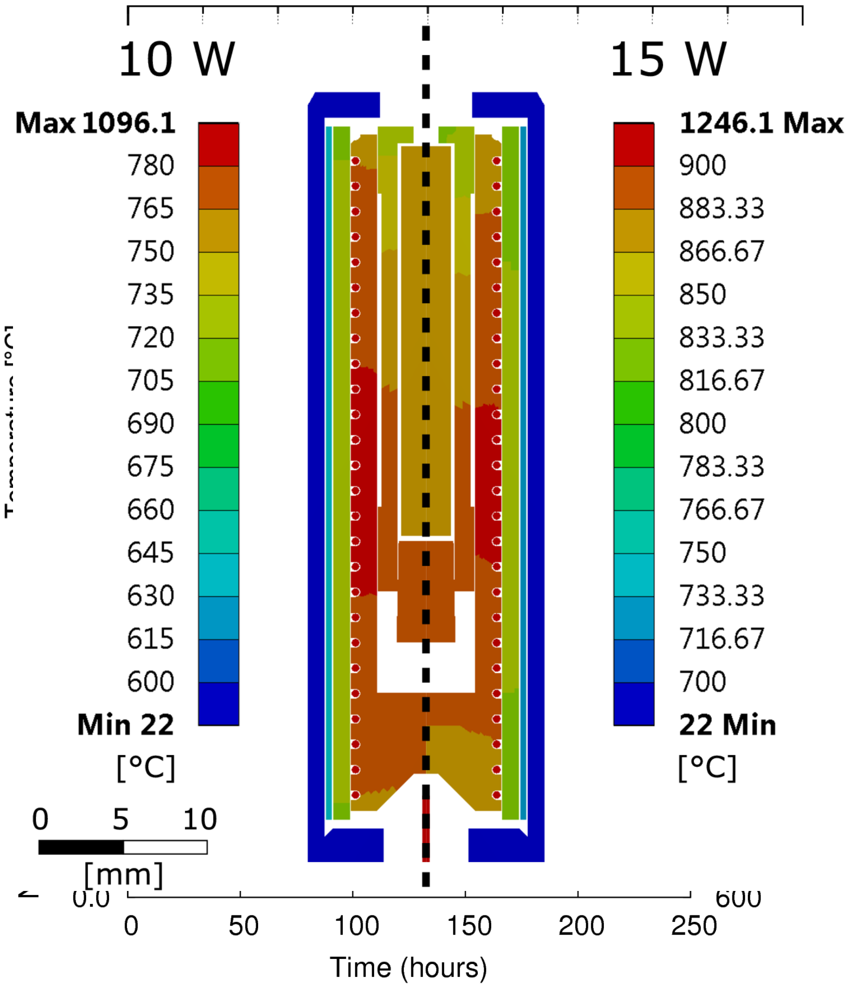

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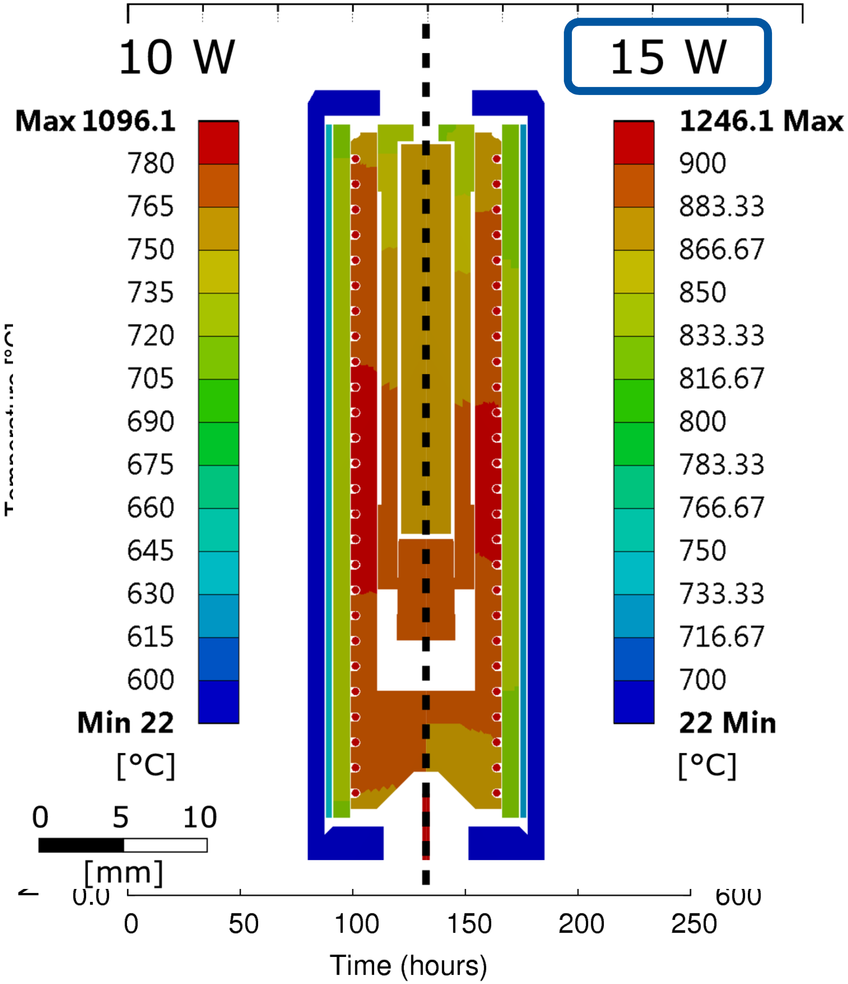

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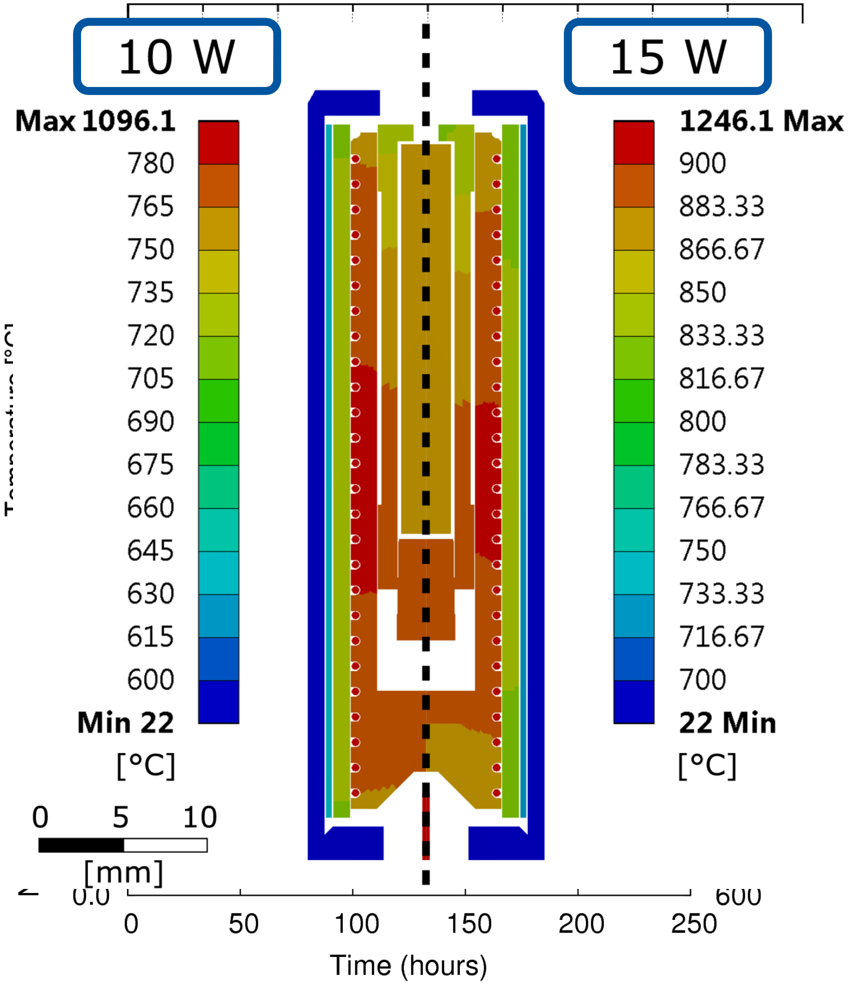

Contents

Summary

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- The GTS-LHC extraction region upgrade was a great success
    - Improved performance in terms of output current, beam stability and operation flexibility
    - Linac3 output improvement fulfils the goal set in LIU

- Combining afterglow with double frequency heating is a viable way to improve pulsed HCI performance
    - Future studies in preparation to assess if this would be suitable option for routine Linac3 operation

- Basic oven characterization done
    - Future studies will focus on failure mechanisms and different factors impacting the oven performance