

The MAGIX experiment at MESA.

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<https://agenda.infn.it/event/45343/>



Greetings from Mainz.

Carnival



bistummainz.de

Printing & Johannes Gutenberg



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Mainz



Adobe stock

Wine

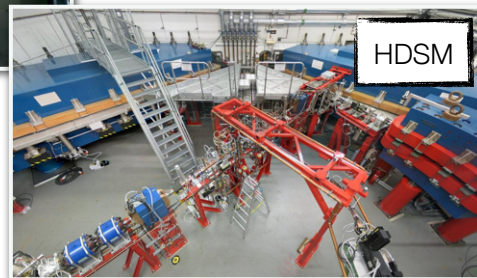
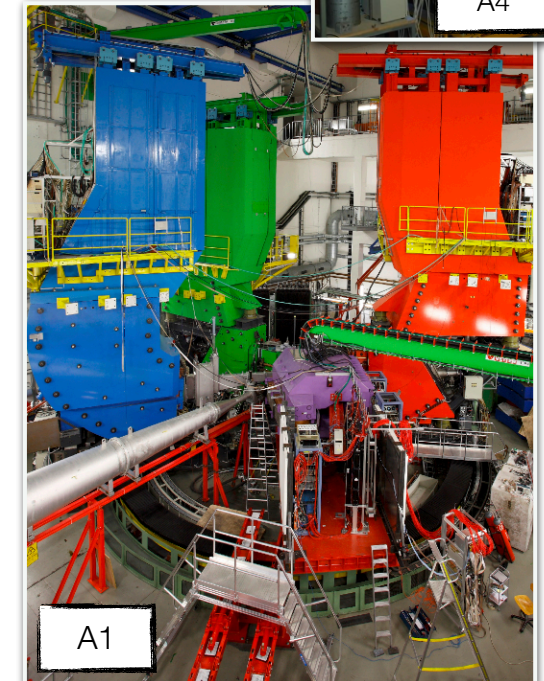
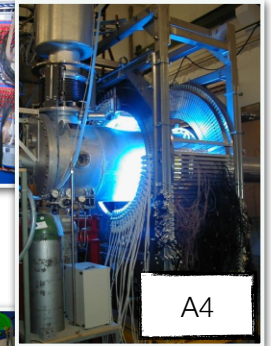
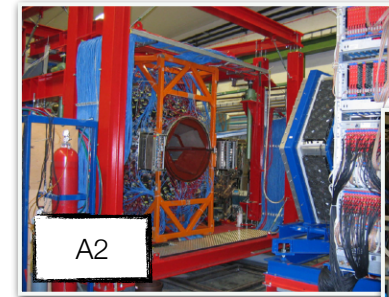
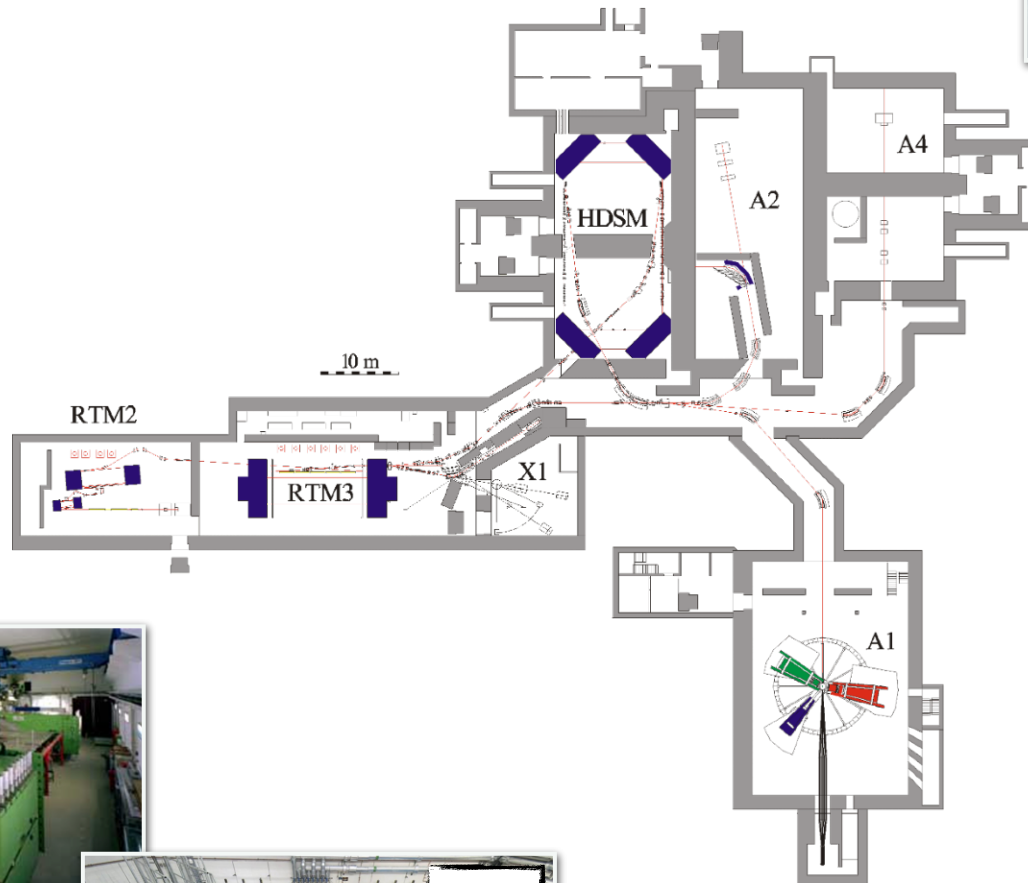


christophorus-hof.de



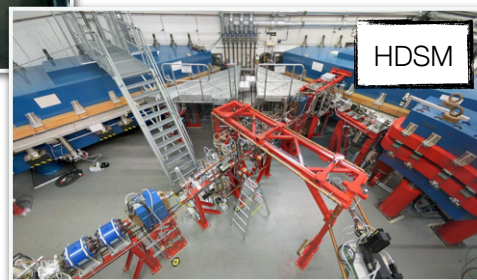
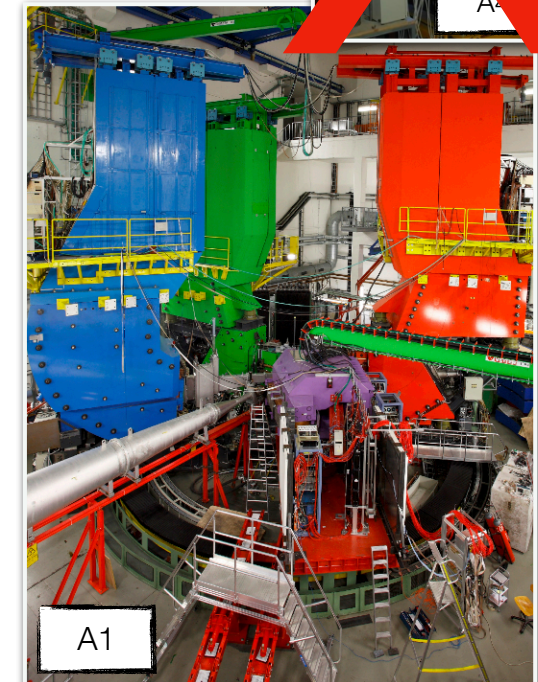
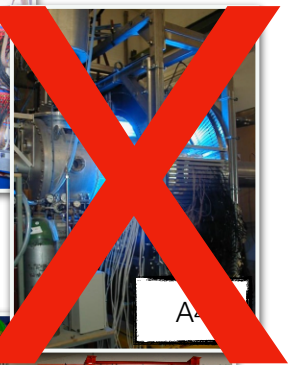
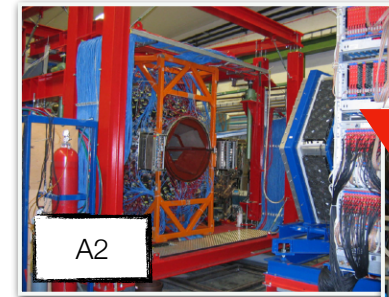
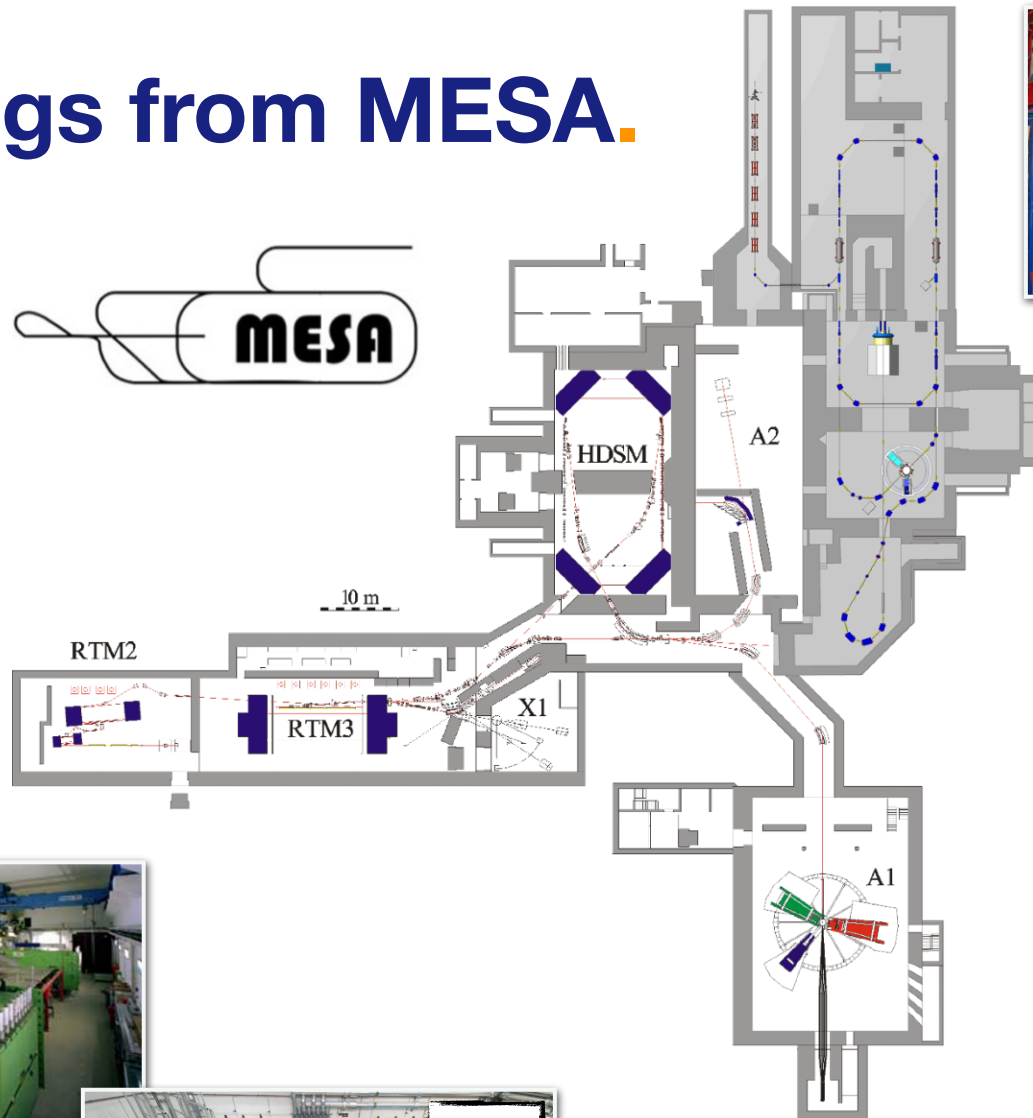
mainz-tourismus.com

Greetings from MAMI.



- Mainz has a [long history of electron accelerators](#) (linac in the 1960s, MAMI since the 1990s)
- **MA**inzer **MI**crotron, energies $\leq 1600 \text{ MeV}$, currents $\geq 100 \mu\text{A}$

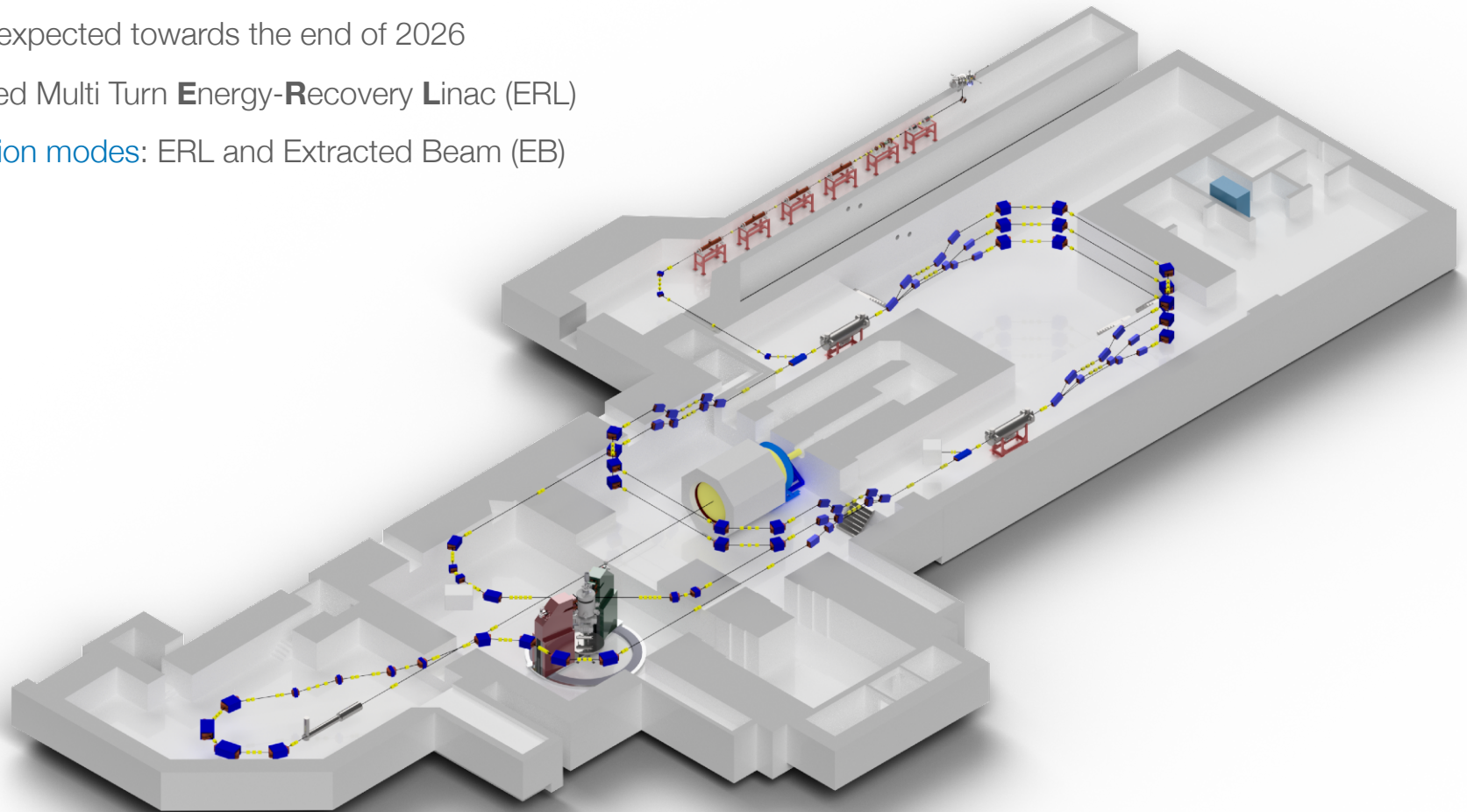
Greetings from MESA.



- The A4 experiment has been finished several years ago
- MESA will be the next-generation electron accelerator in Mainz with lower energies and higher intensities compared to MAMI

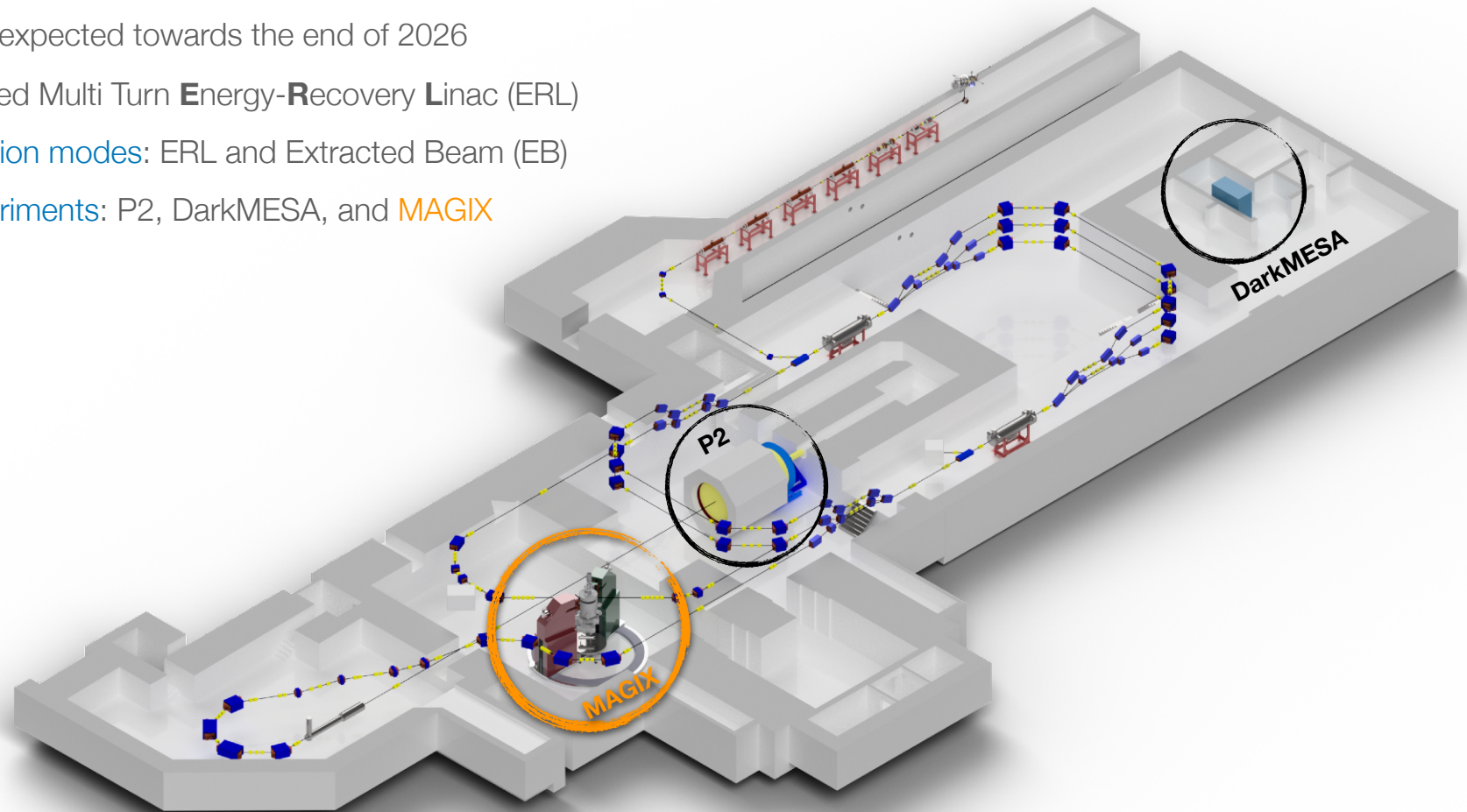
The MESA accelerator.

- Mainz **E**nergy-Recovering Superconducting **A**ccelerator
- Beam energies from 20 MeV to 155 MeV
- Beam currents of $\geq 1\text{ mA}$
- First beam expected towards the end of 2026
- Double-sided Multi Turn **E**nergy-**R**ecovery **L**inac (ERL)
- **Two operation modes**: ERL and Extracted Beam (EB)



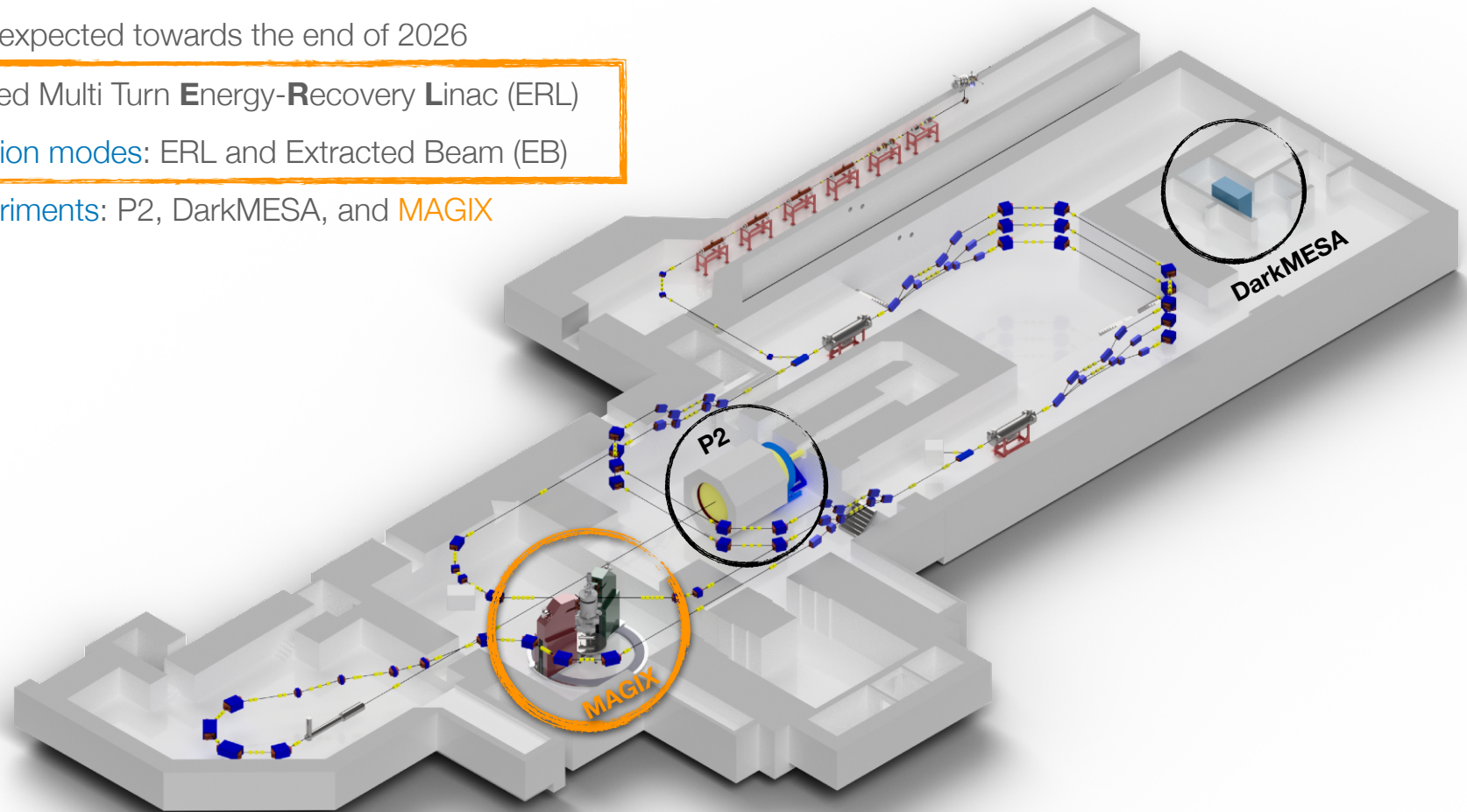
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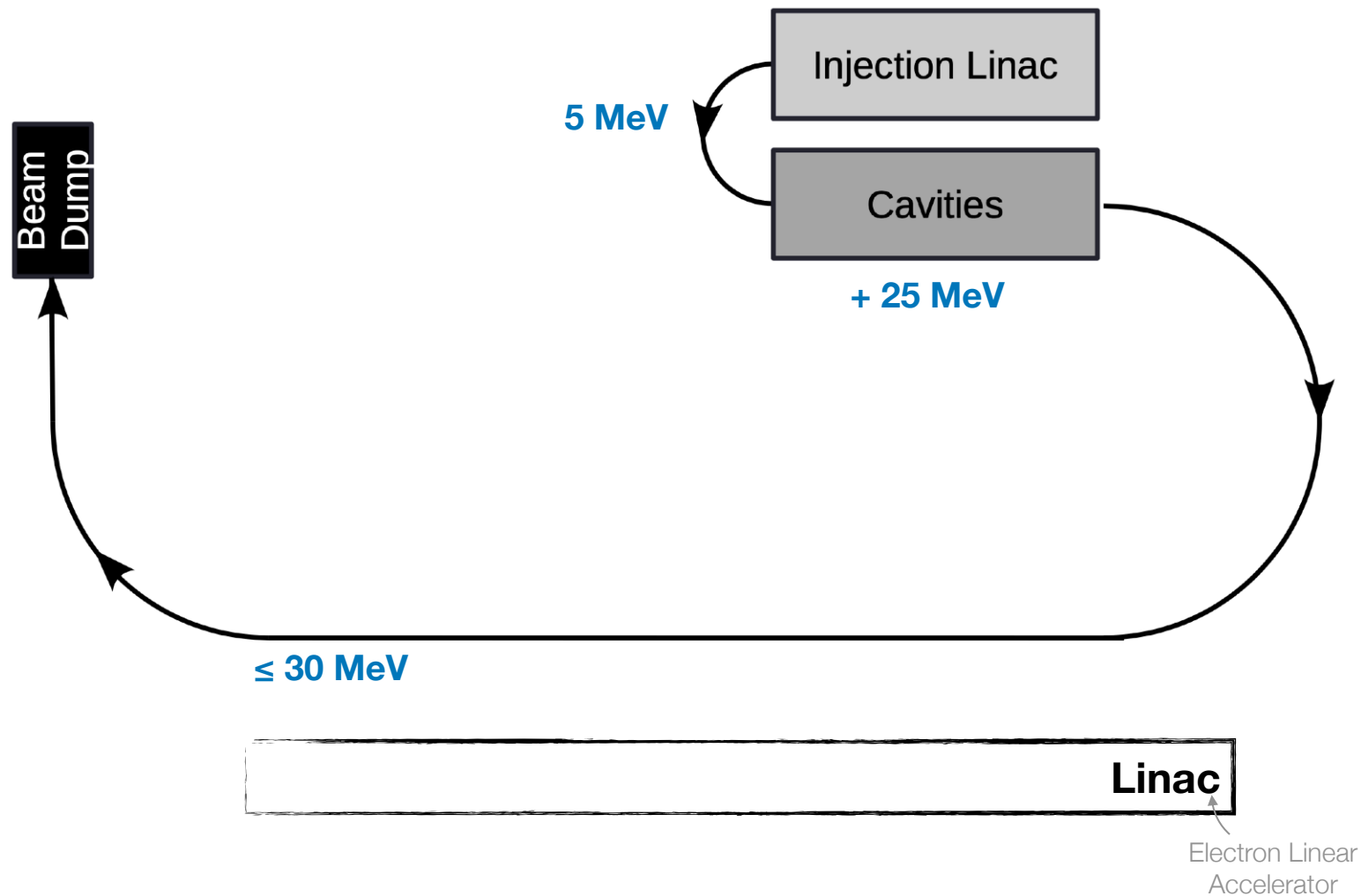


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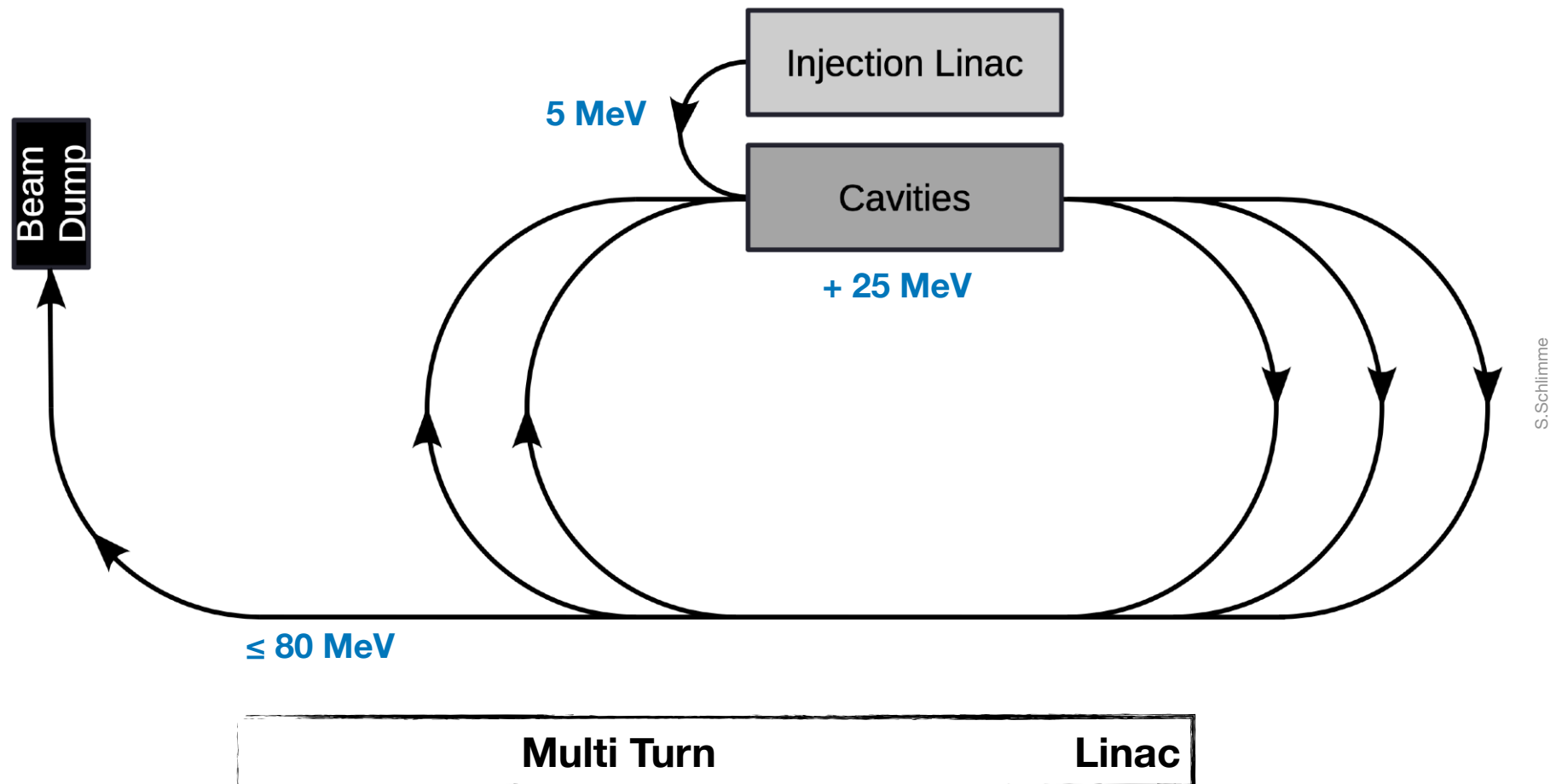


Let's build MESA (1/7).

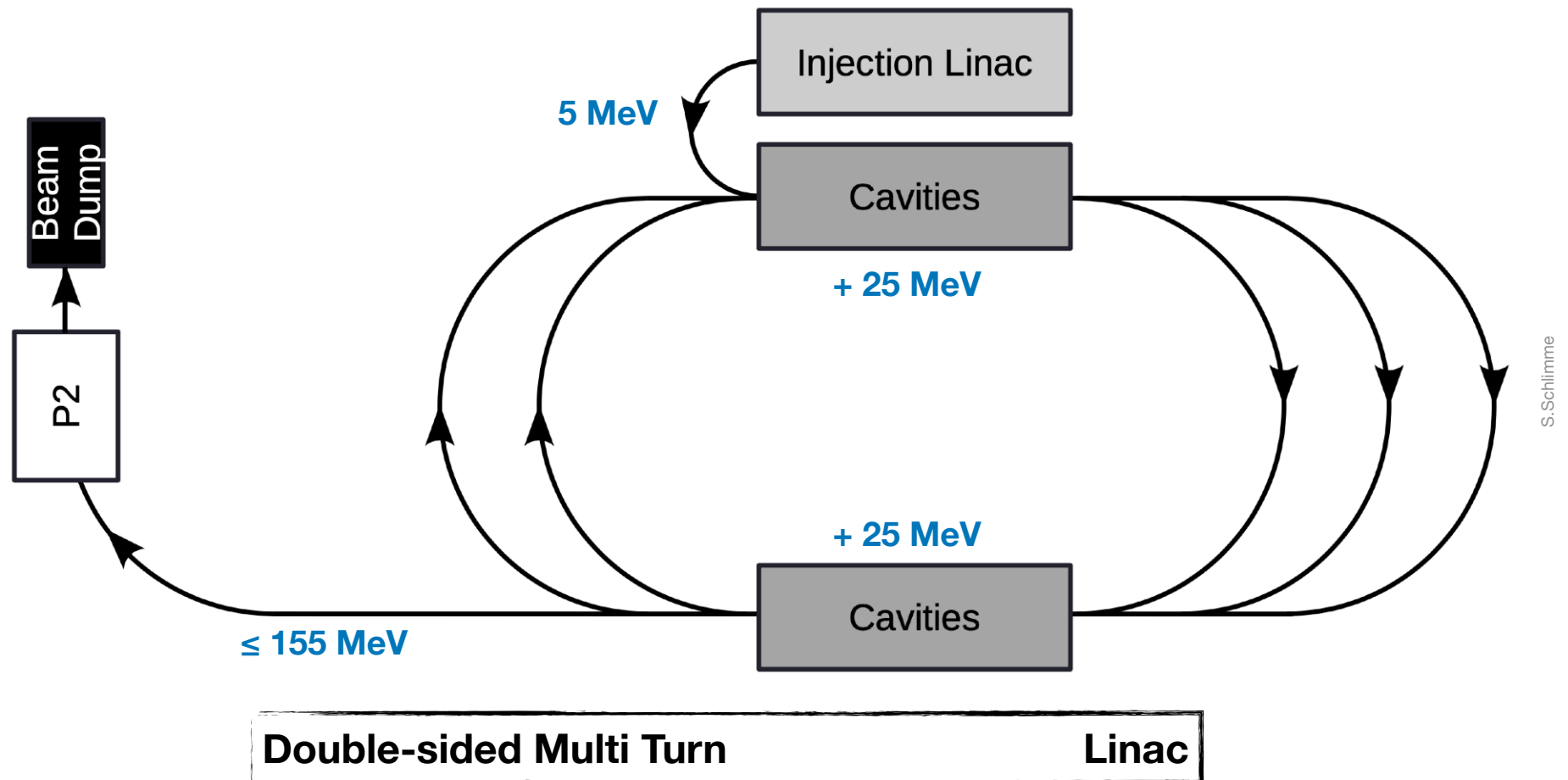


S. Schlimme

Let's build MESA (2/7).

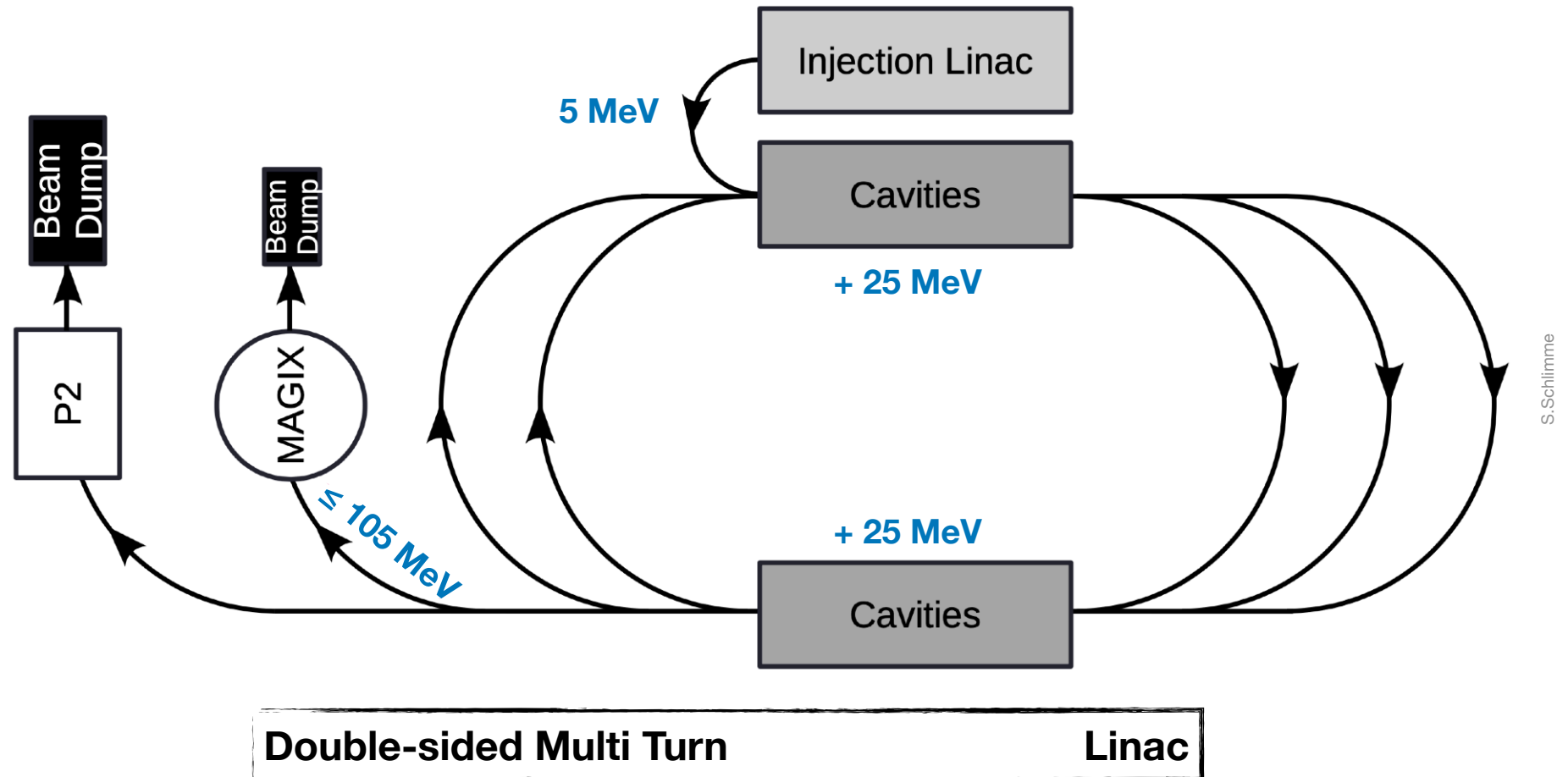


Let's build MESA (3/7).



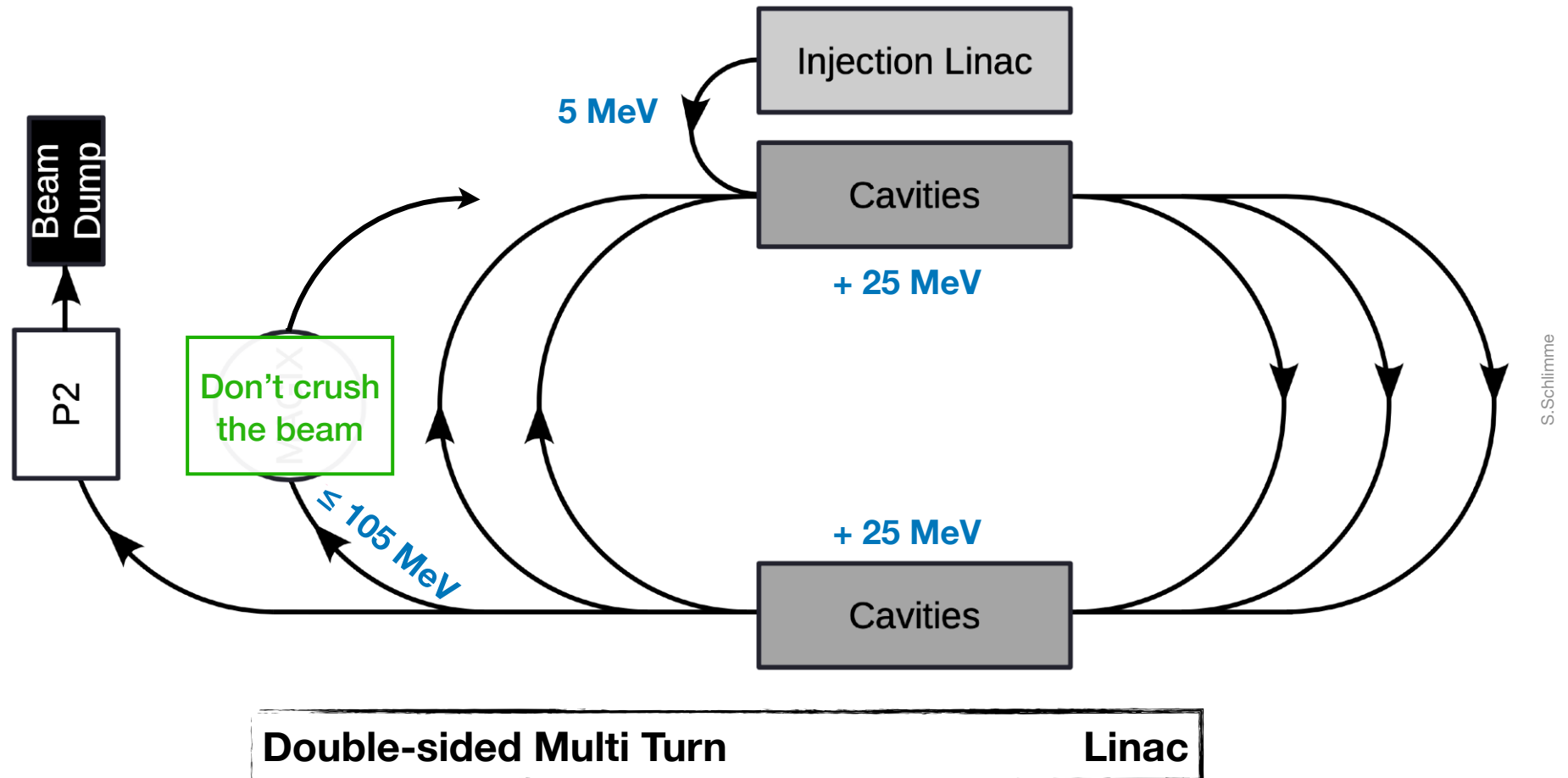
Extracted Beam (EB) mode - P2 experiment

Let's build MESA (4/7).



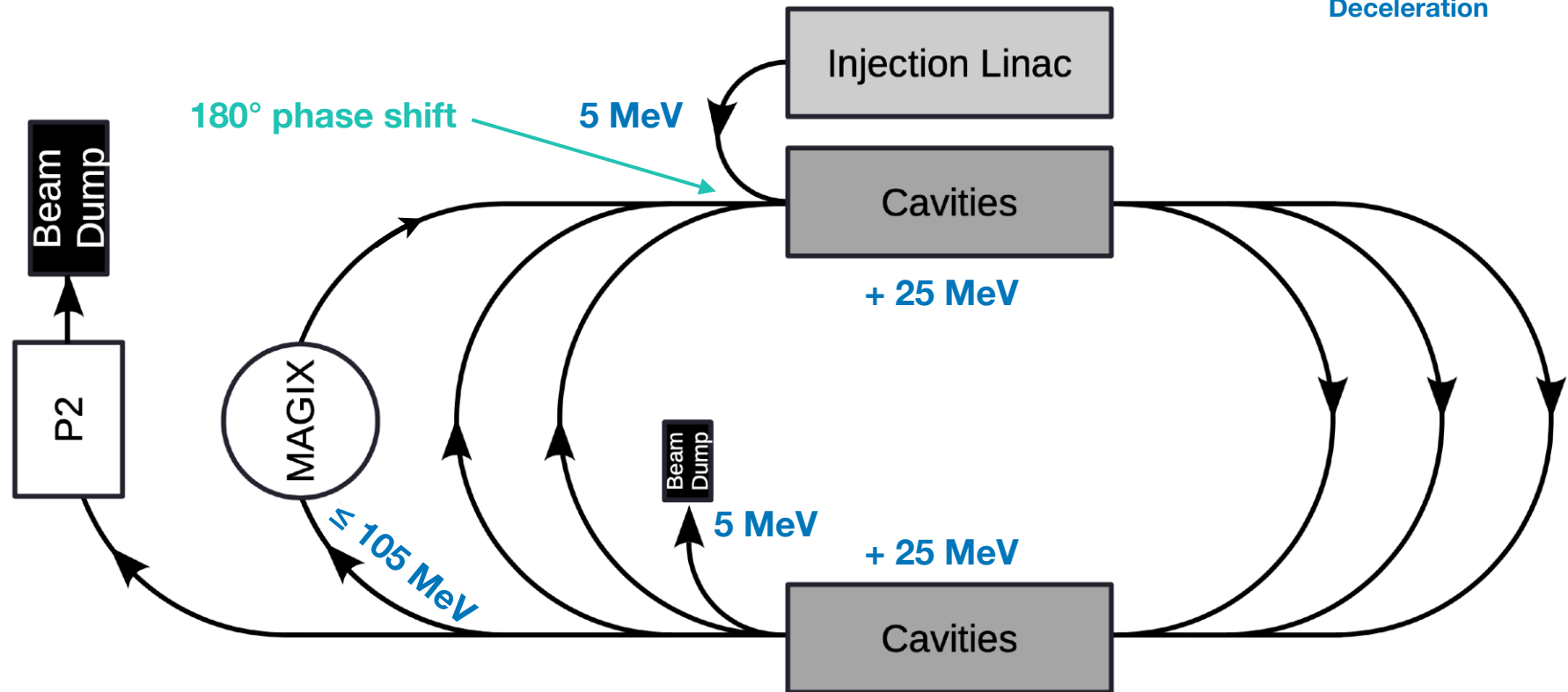
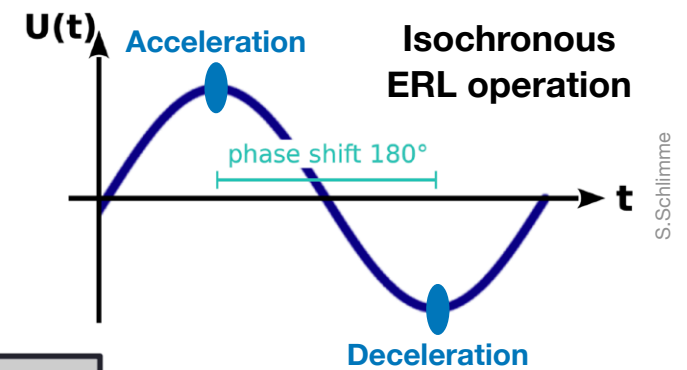
Extracted Beam (EB) mode - MAGIX experiment

Let's build MESA (5/7).



Energy-Recovery...

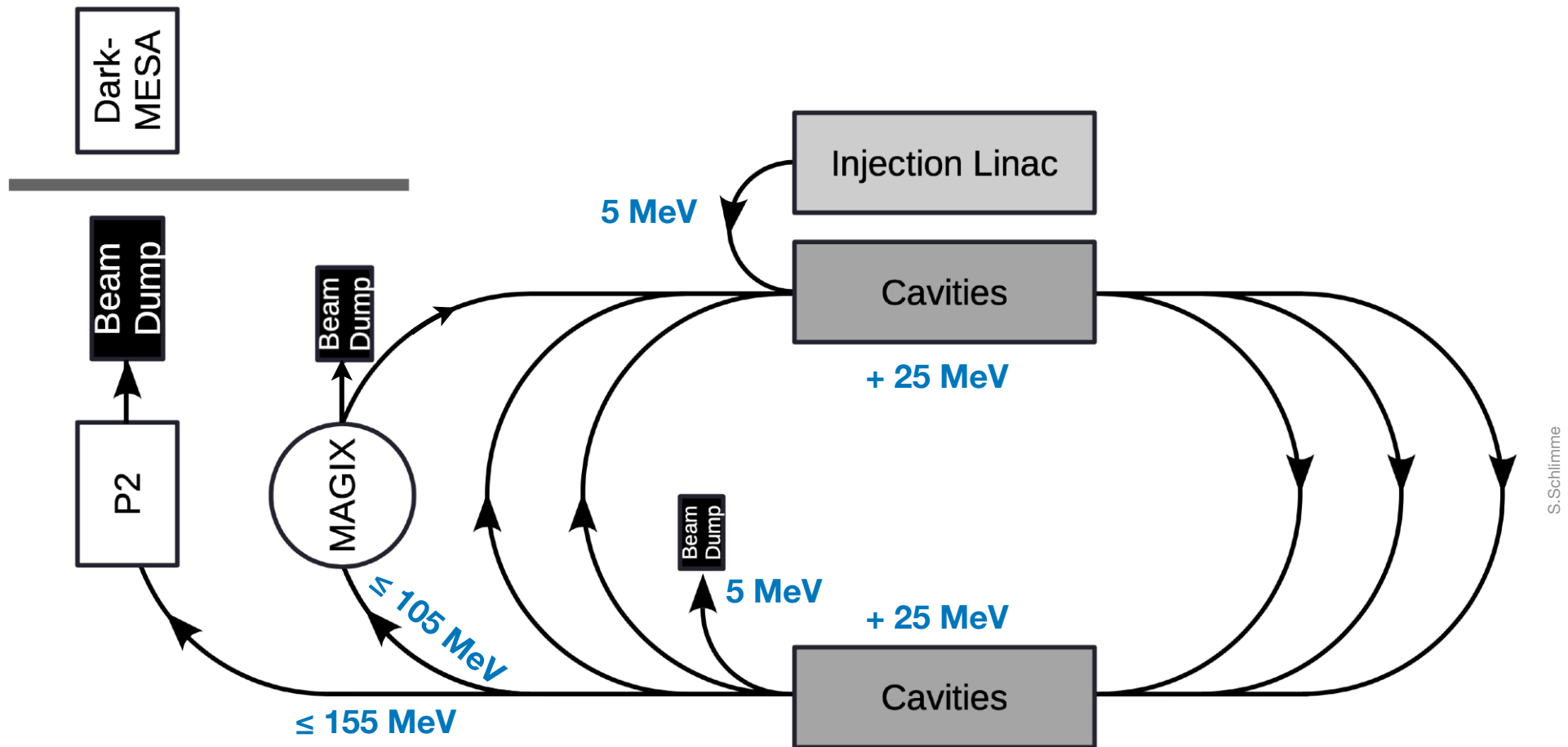
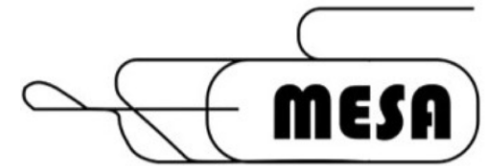
Let's build MESA (6/7).



Double-sided Multi Turn Energy-Recovery Linac

Energy-Recovery Linac (ERL) mode - MAGIX experiment

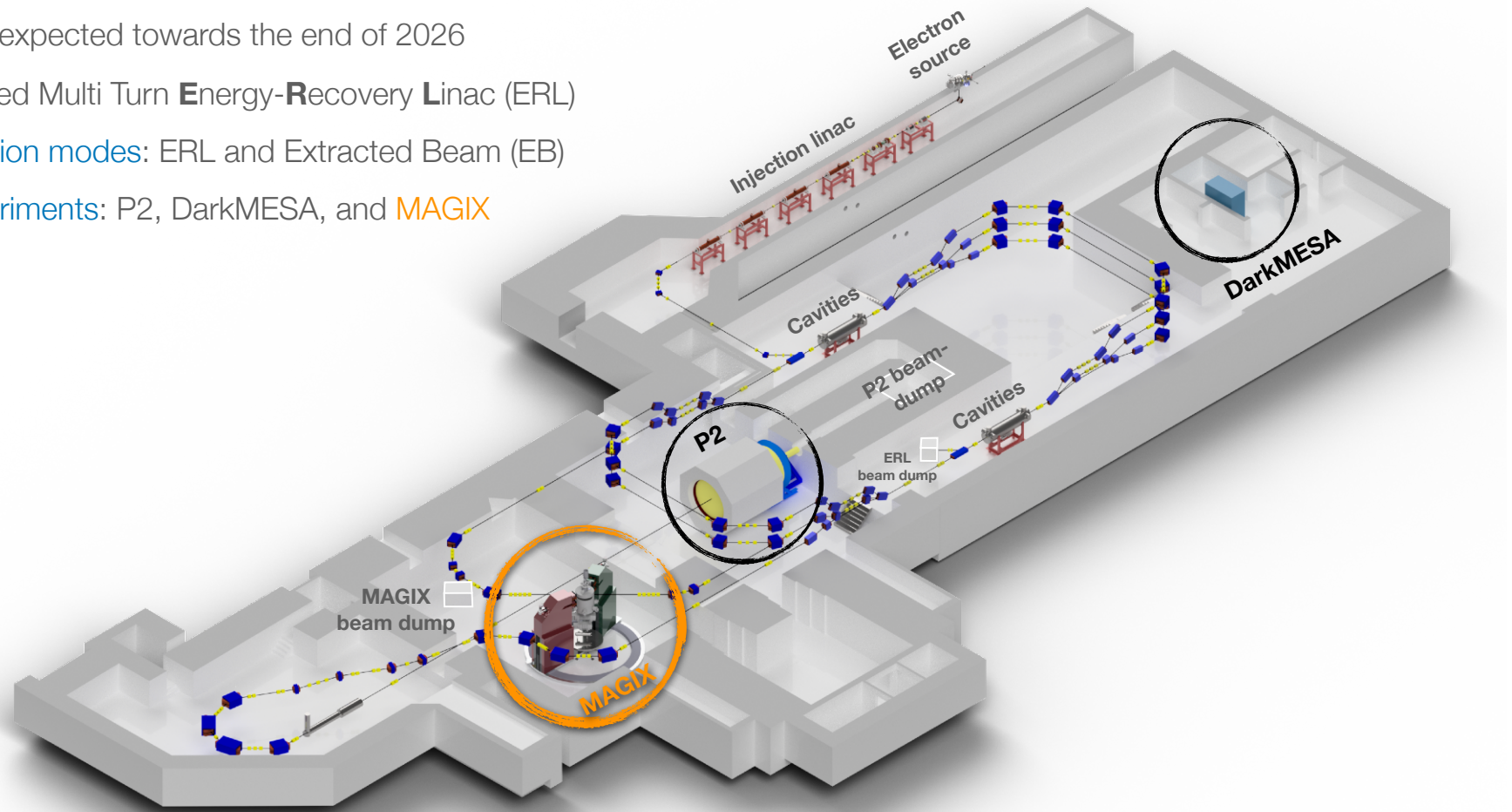
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Mainz **E**nergy-recovering **S**uperconducting **A**ccelerator

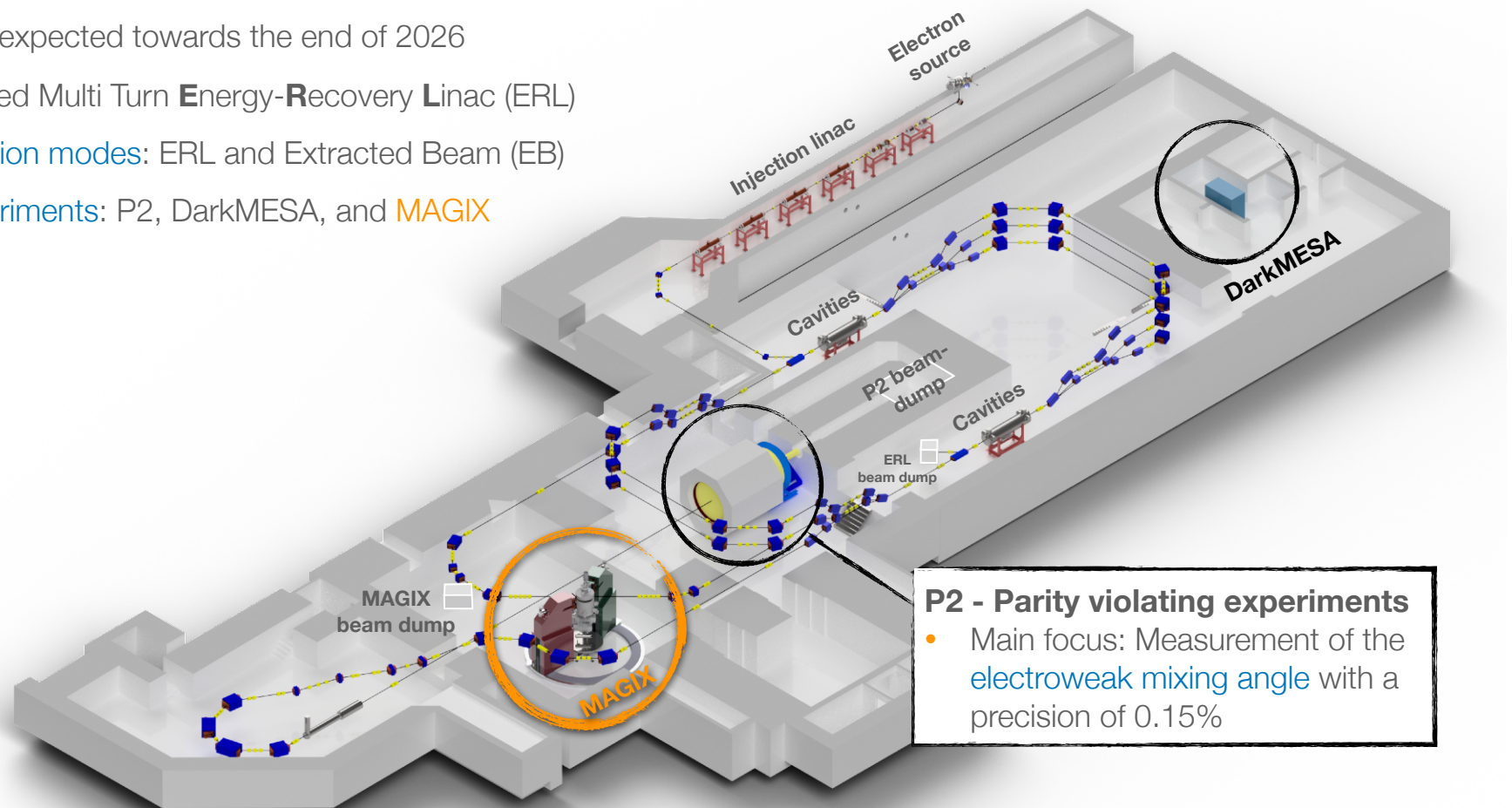
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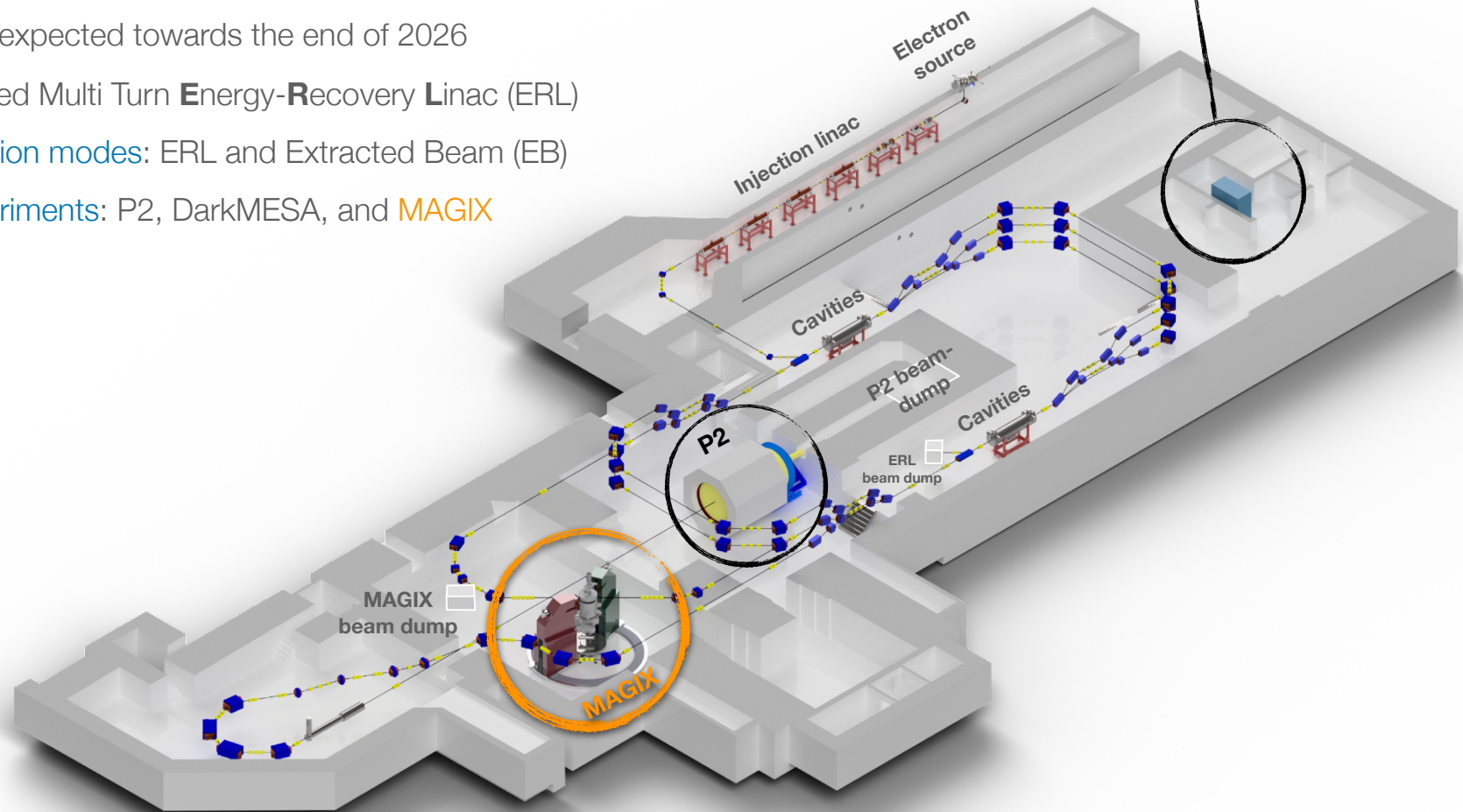


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The beam-dump experiment DarkMESA

- Direct search for **light dark matter** (LDM) particles

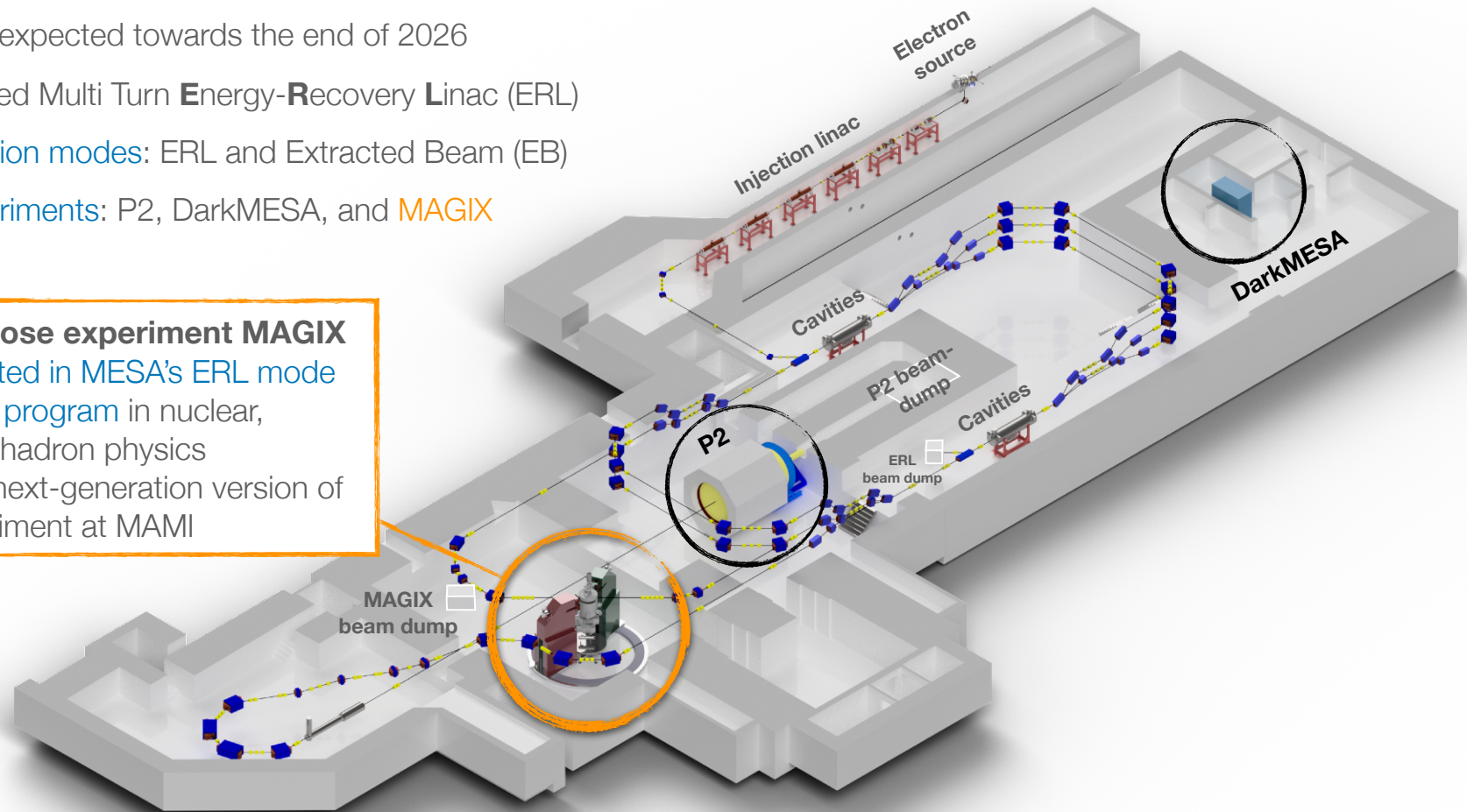


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The multi-purpose experiment MAGIX

- Mainly operated in MESA's ERL mode
- **Rich physics program** in nuclear, particle, and hadron physics
- A compact, next-generation version of the A1 experiment at MAMI

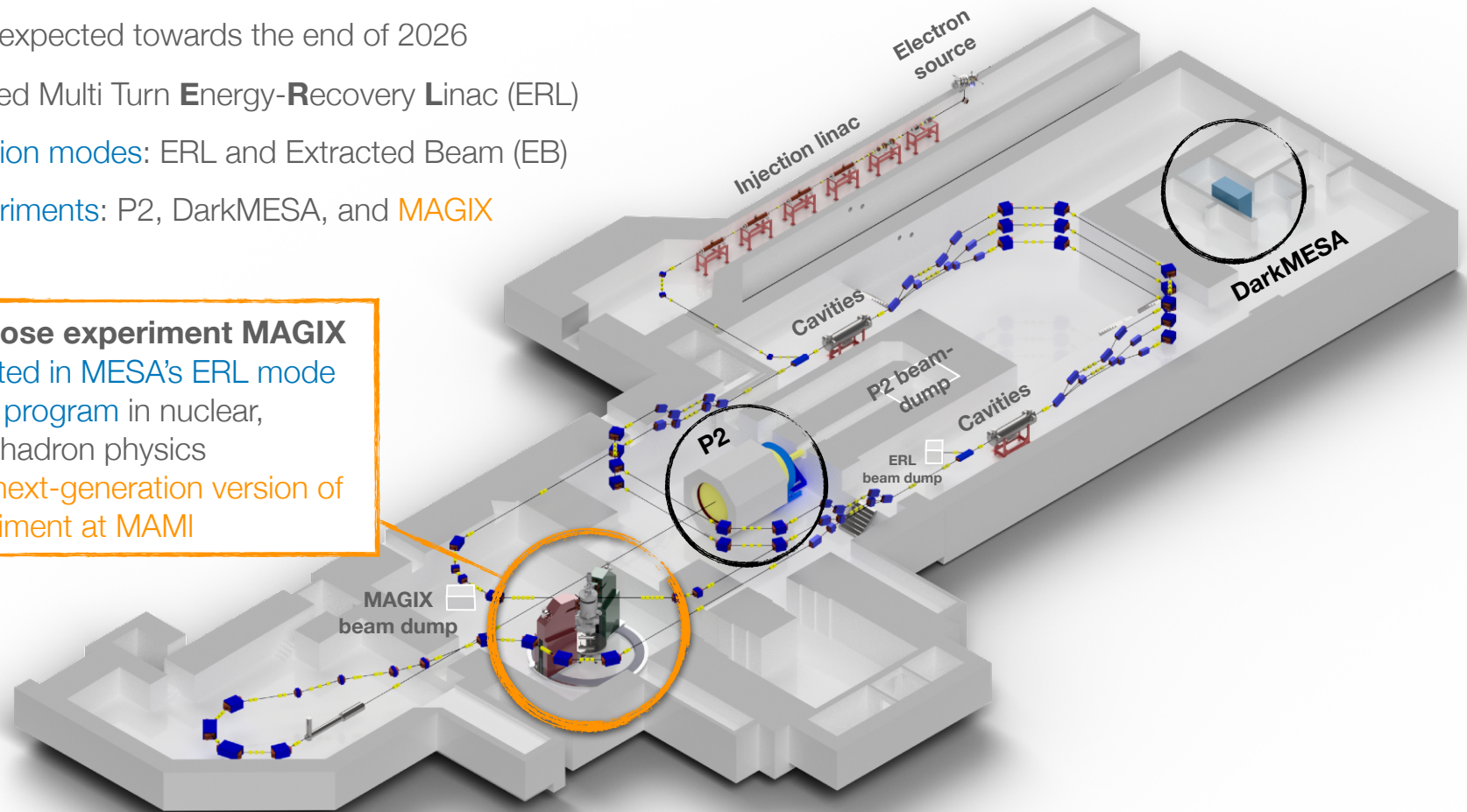


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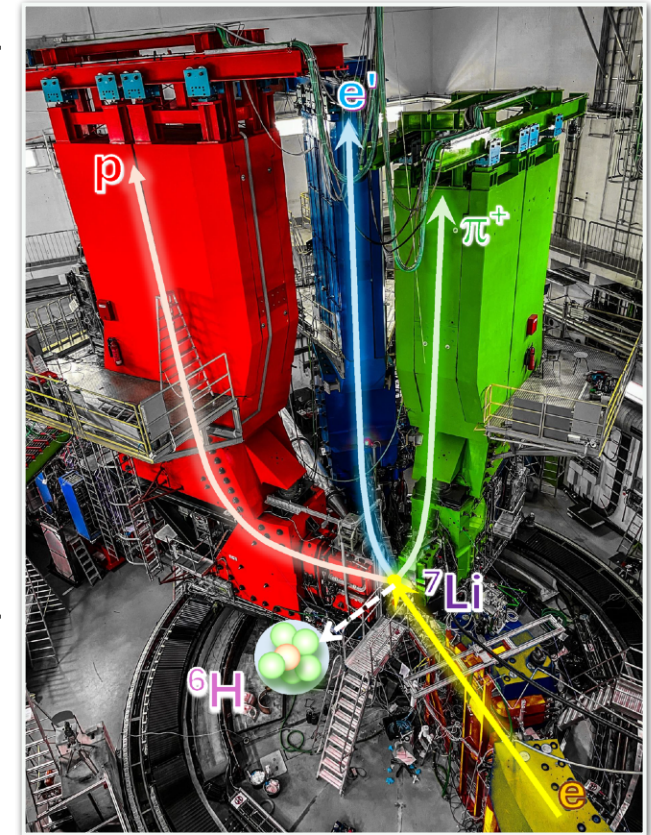
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The A1 experiment at MAMI.

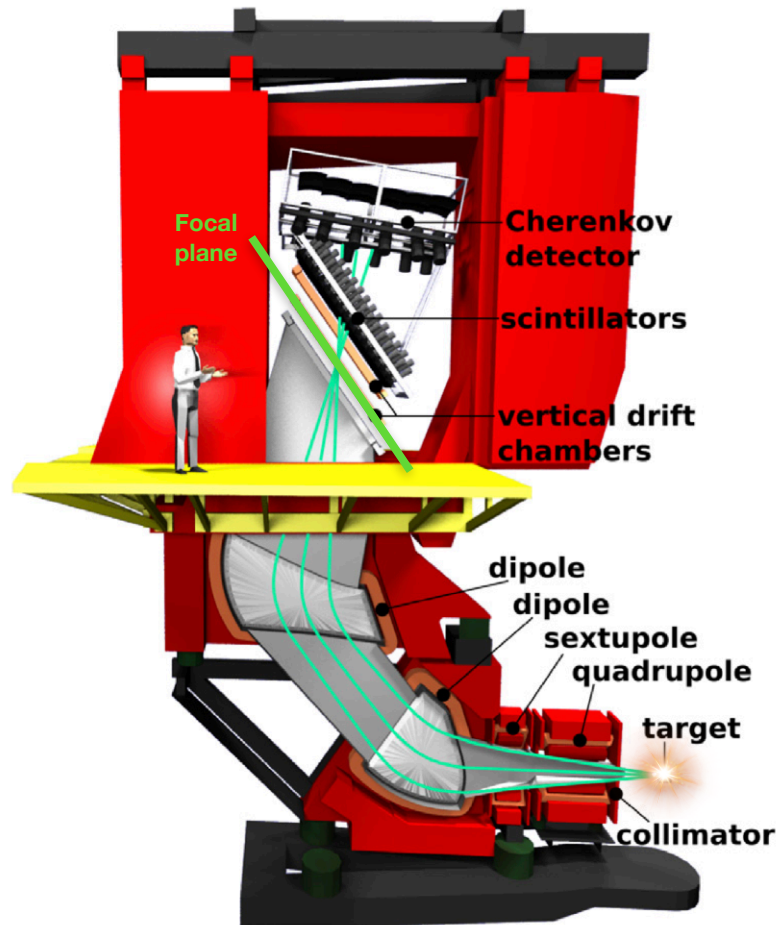
- Three high-resolution, focusing magnetic spectrometers
- Exceptional momentum resolution of $\Delta p/p < 10^{-4}$
- Solid angle acceptance of 28msr and momentum acceptance of 25%

15 m

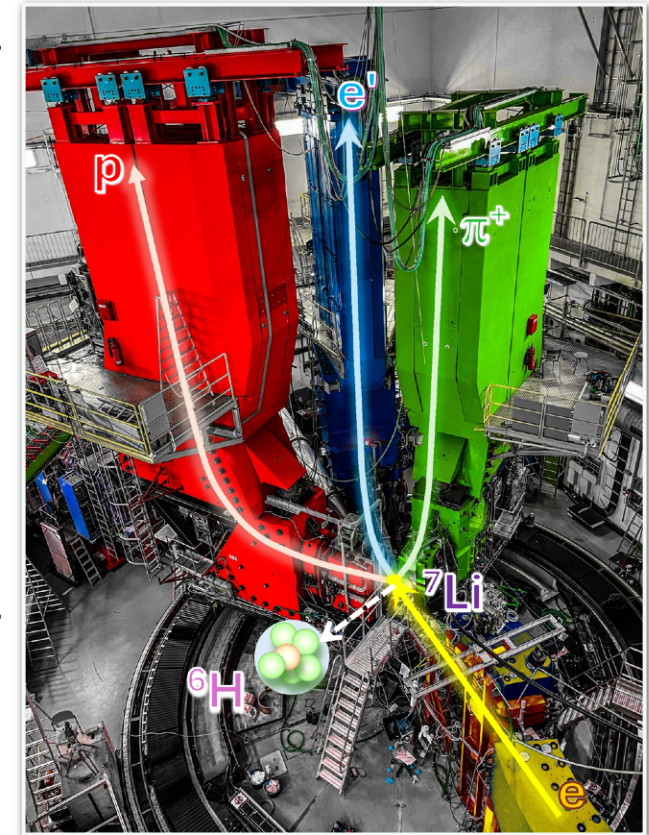


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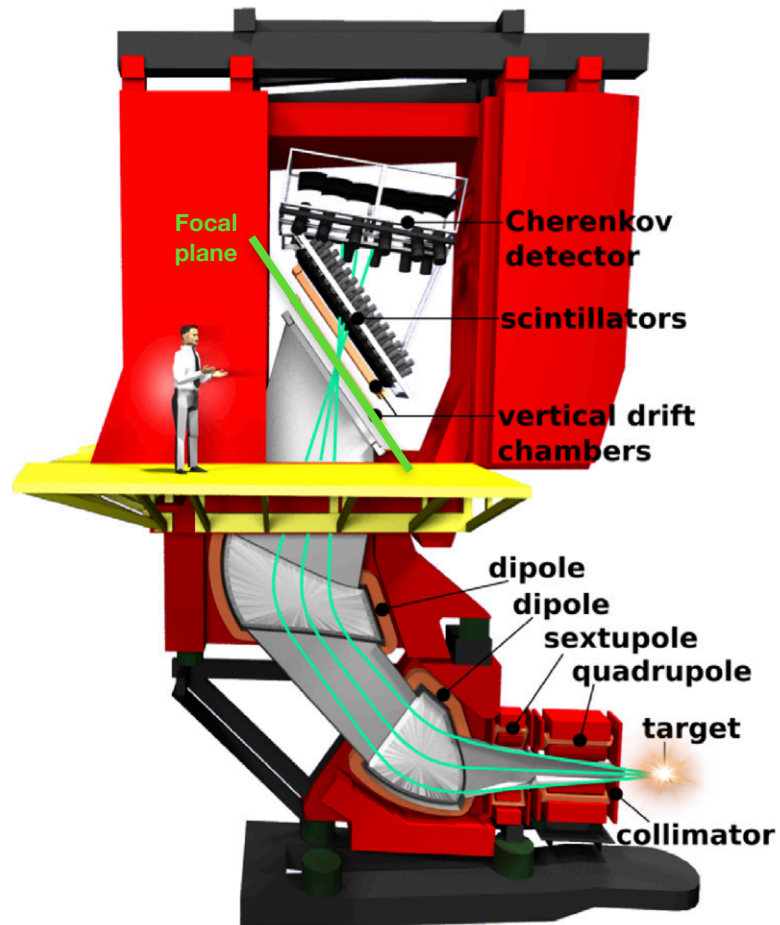


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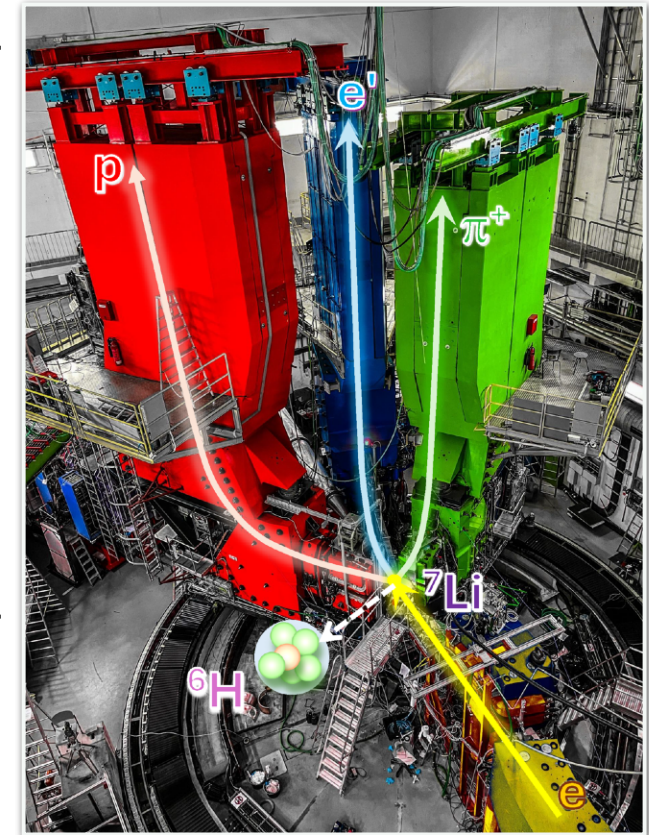


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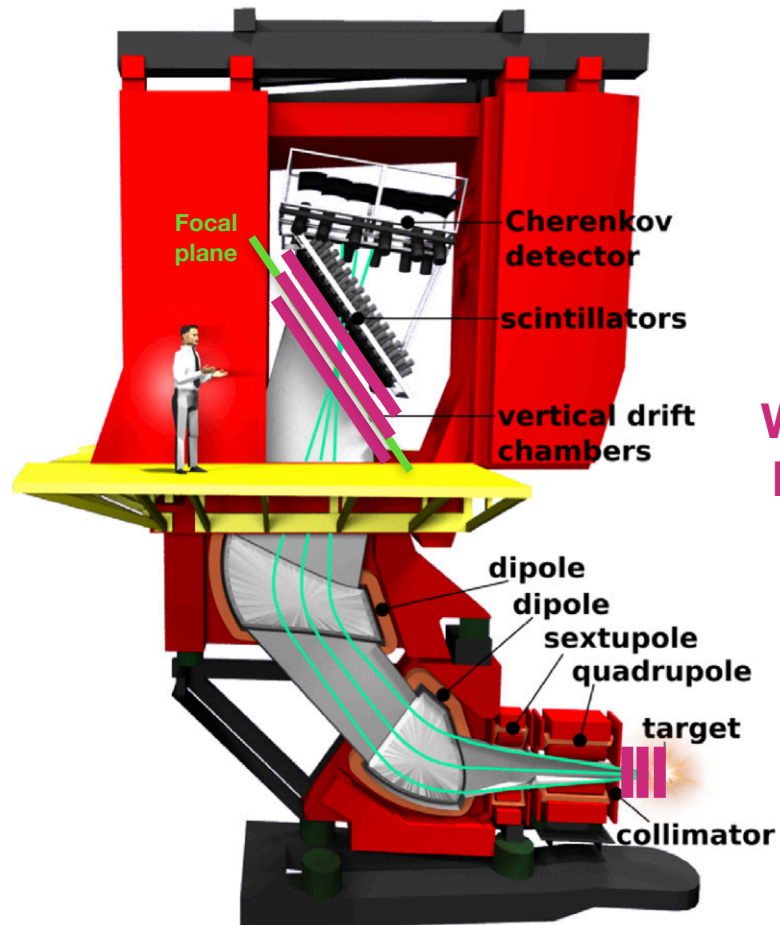


Biggest achievements

- Measurement of the ground-state energy of ${}^6\text{H}$
- High-precision measurement of the proton charge radius
- Search for light massive gauge bosons (dark photons) in the mass range $40 - 300 \text{ MeV}/c^2$

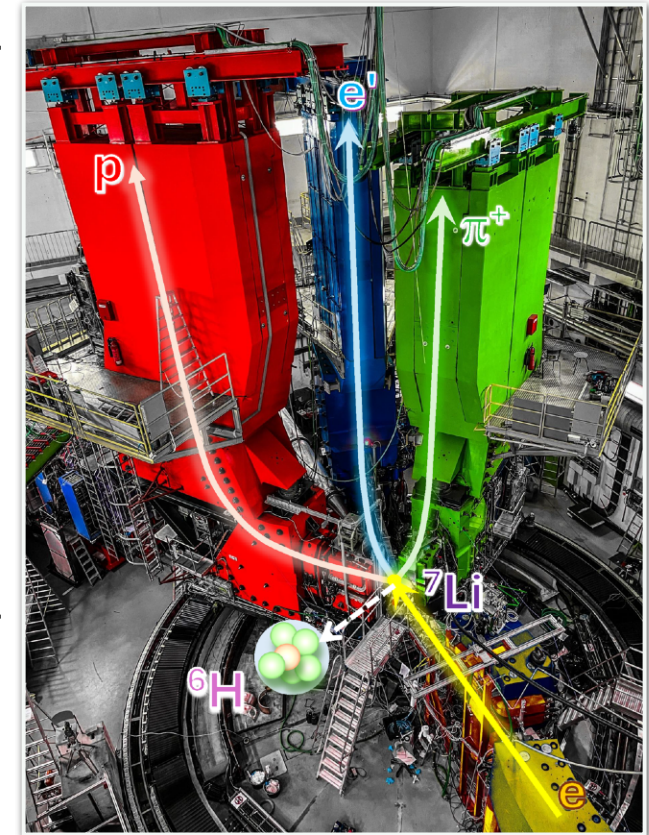
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Way too many foils for MESA's low energies!

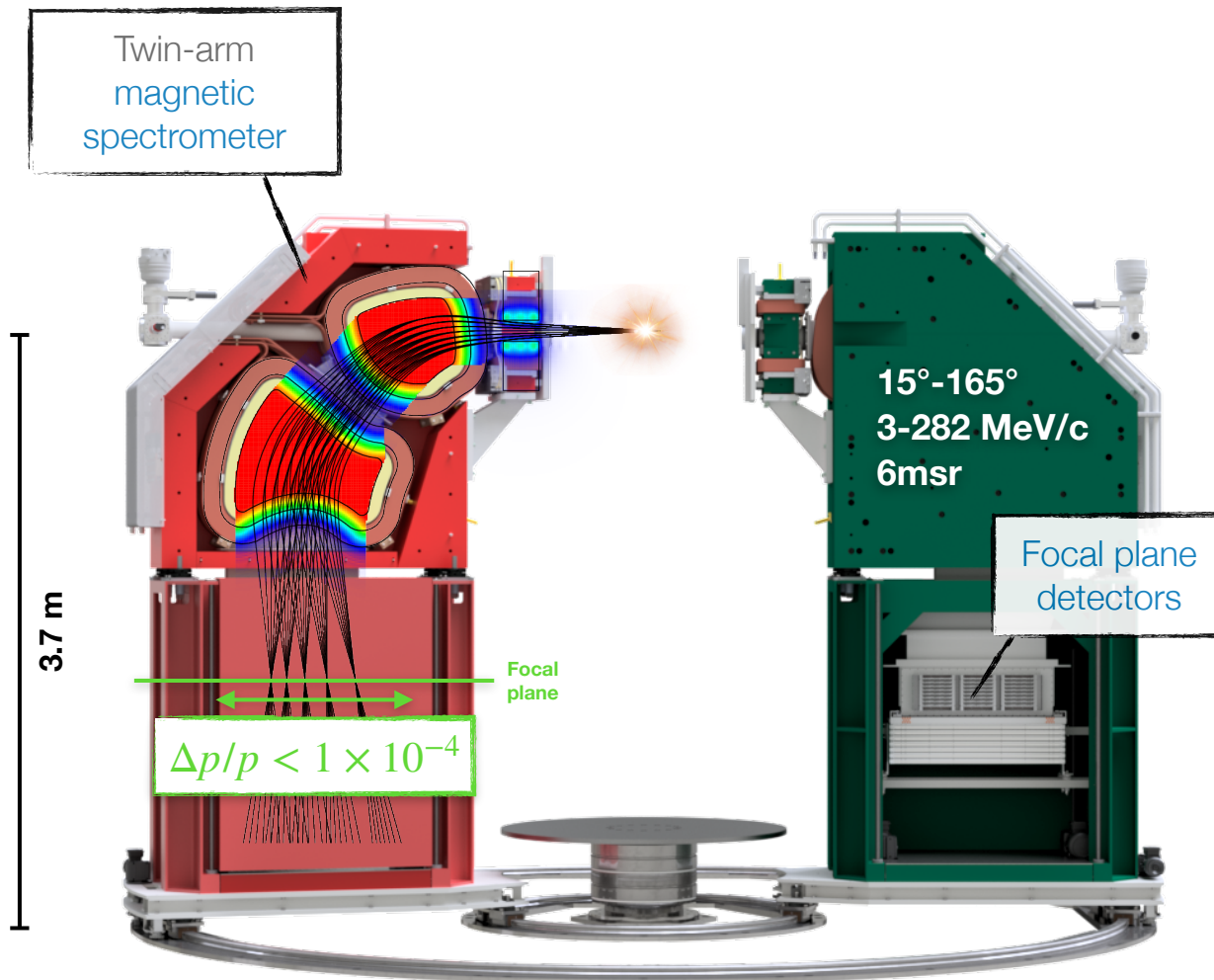
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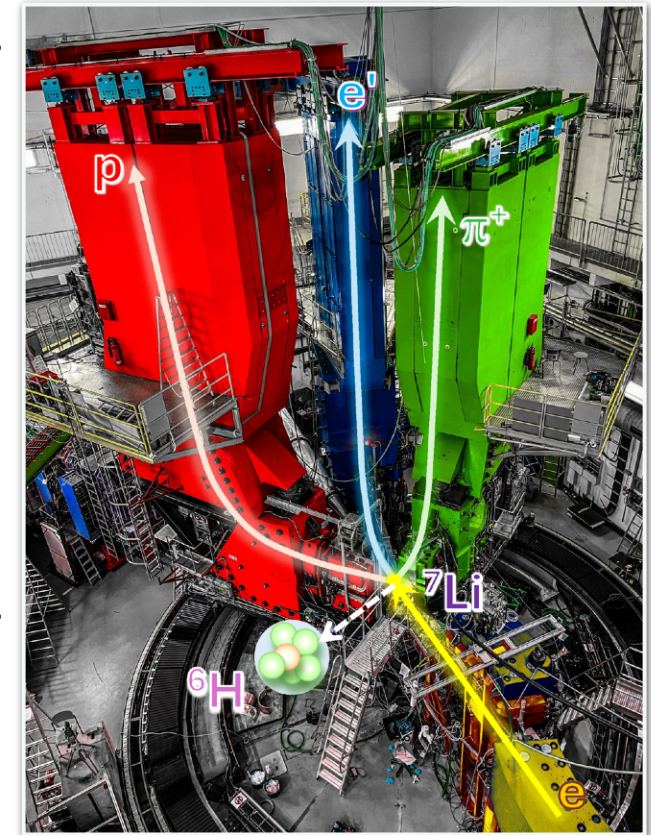
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MAGIX vs. A1.

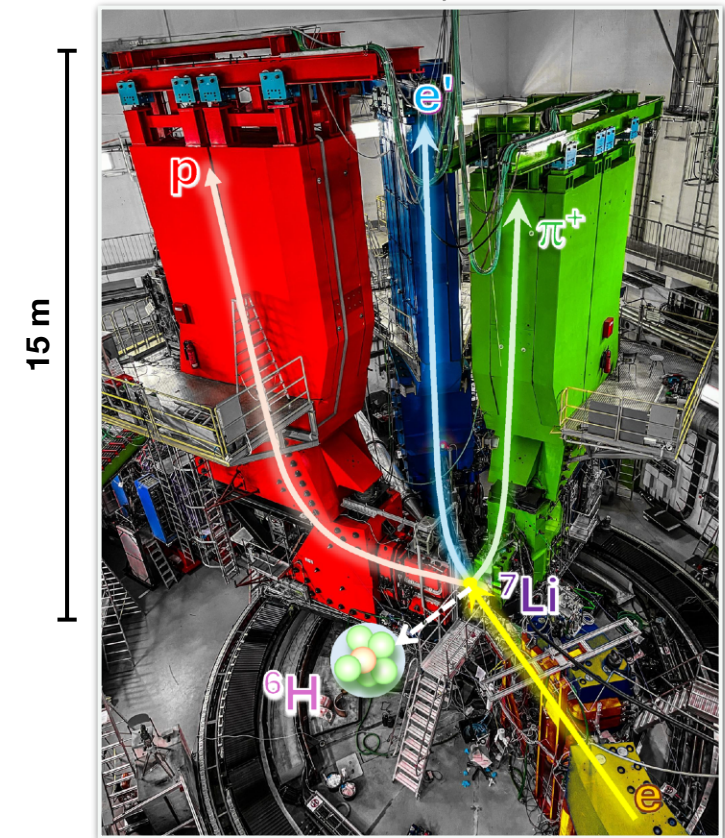
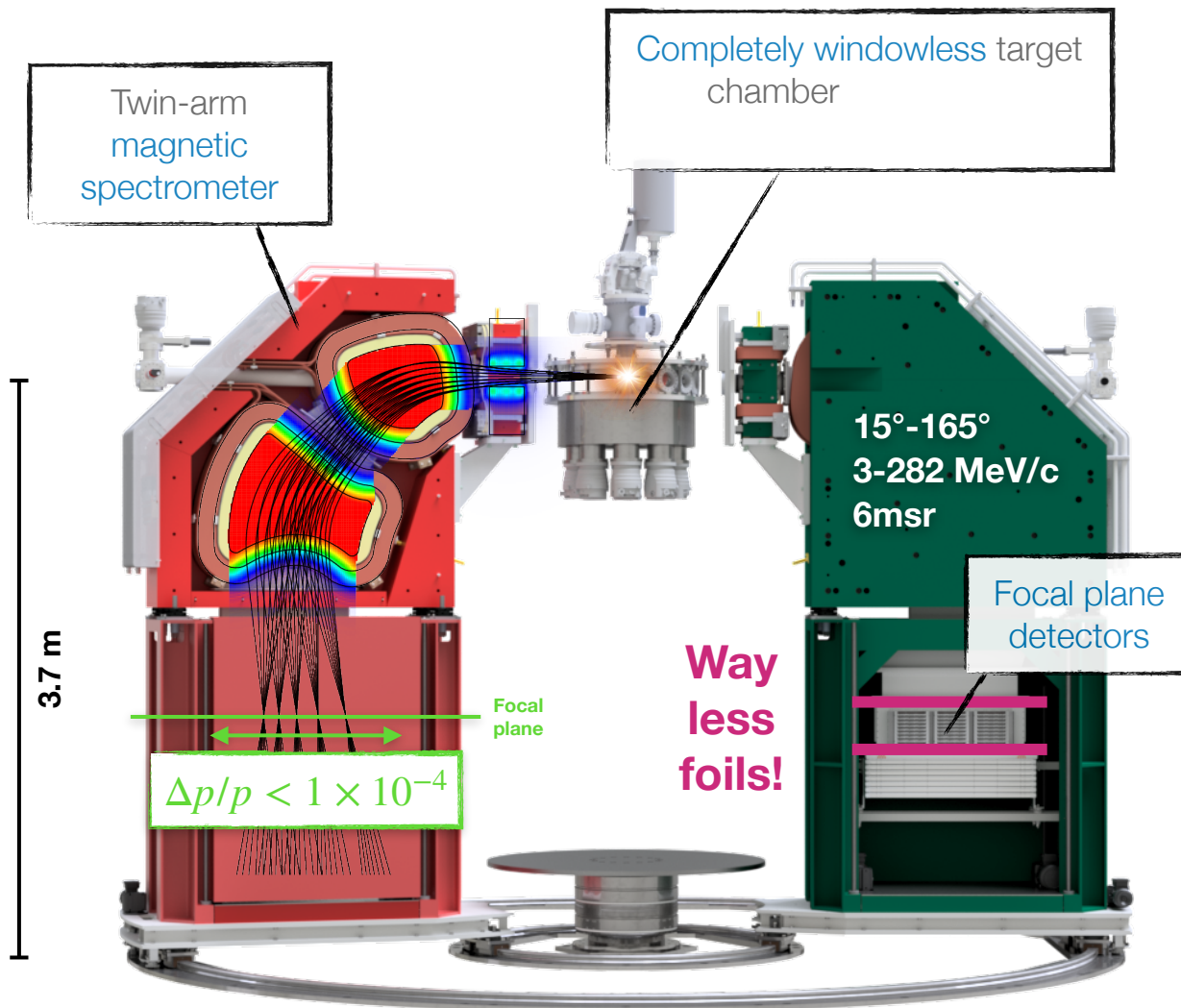


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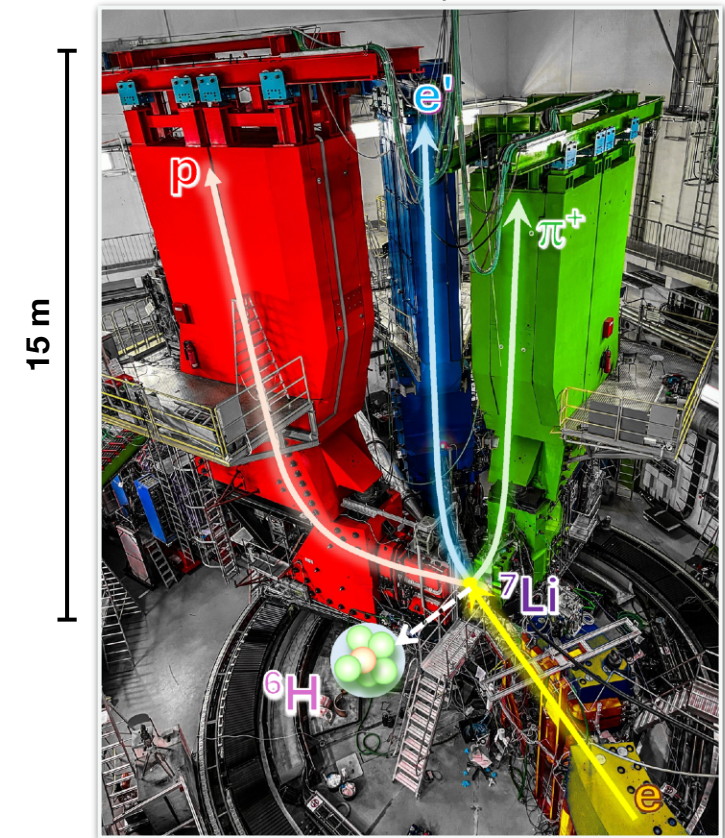
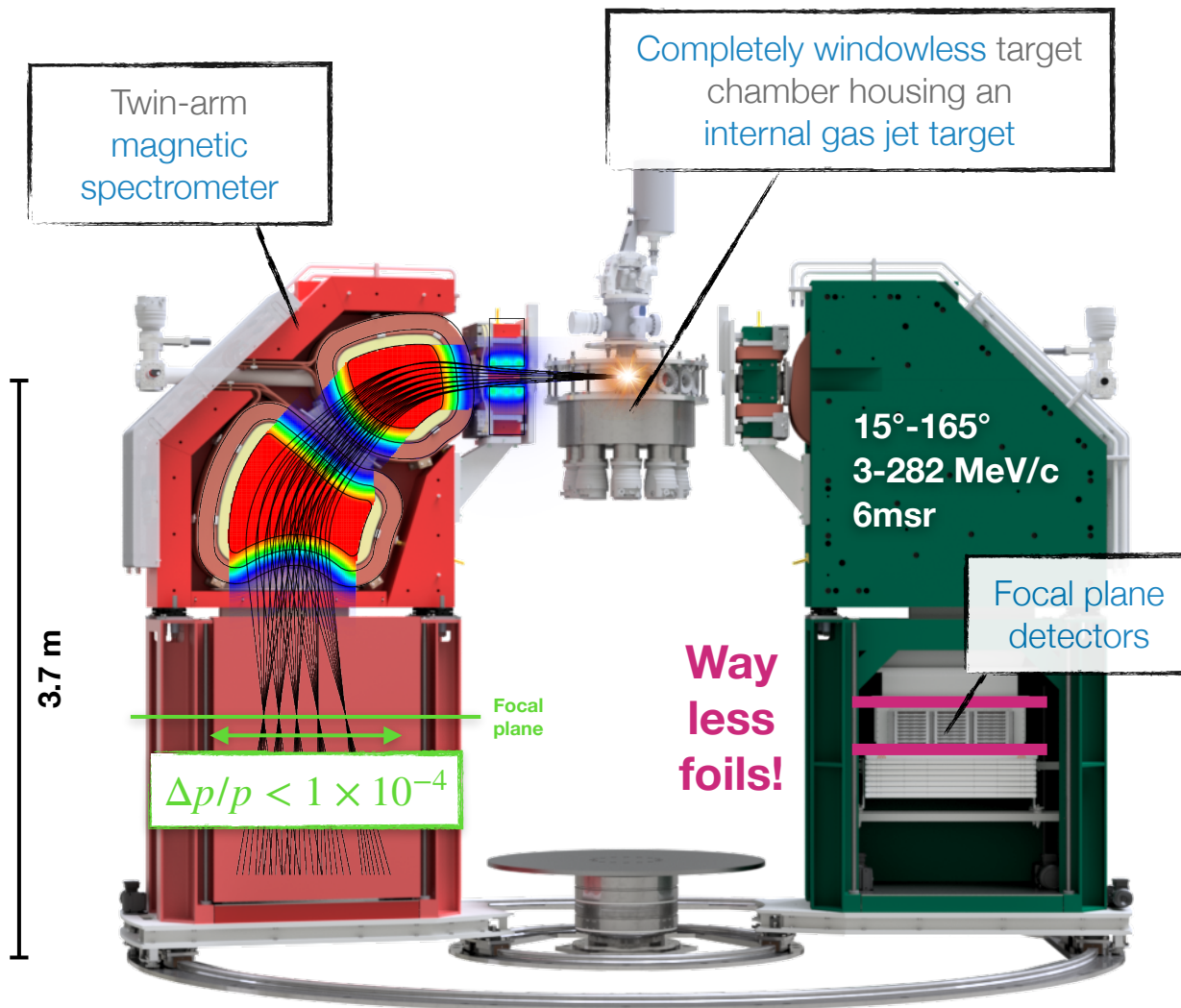


T. Shao et al., 10.1103/PhysRevLett.134.162501

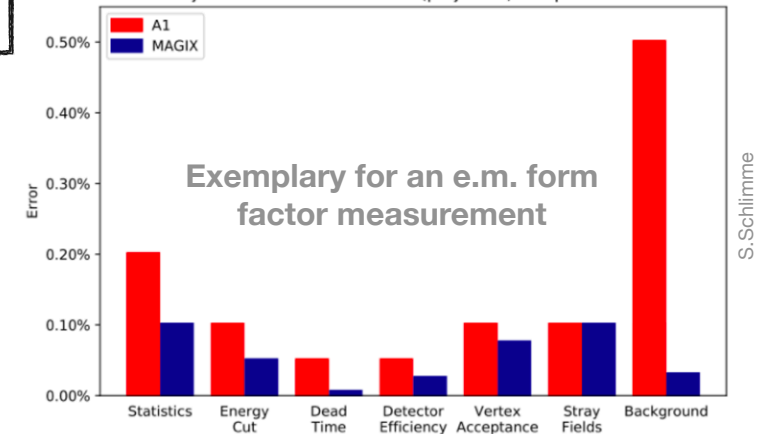
MAGIX vs. A1.



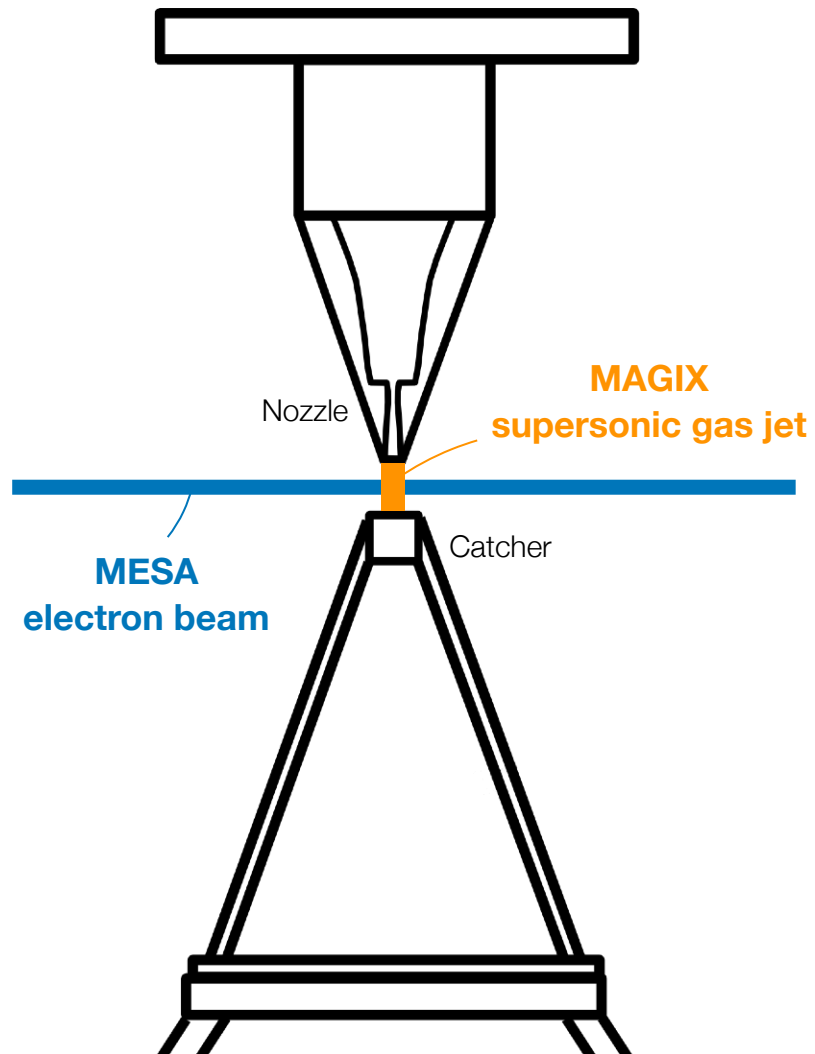
MAGIX vs. A1



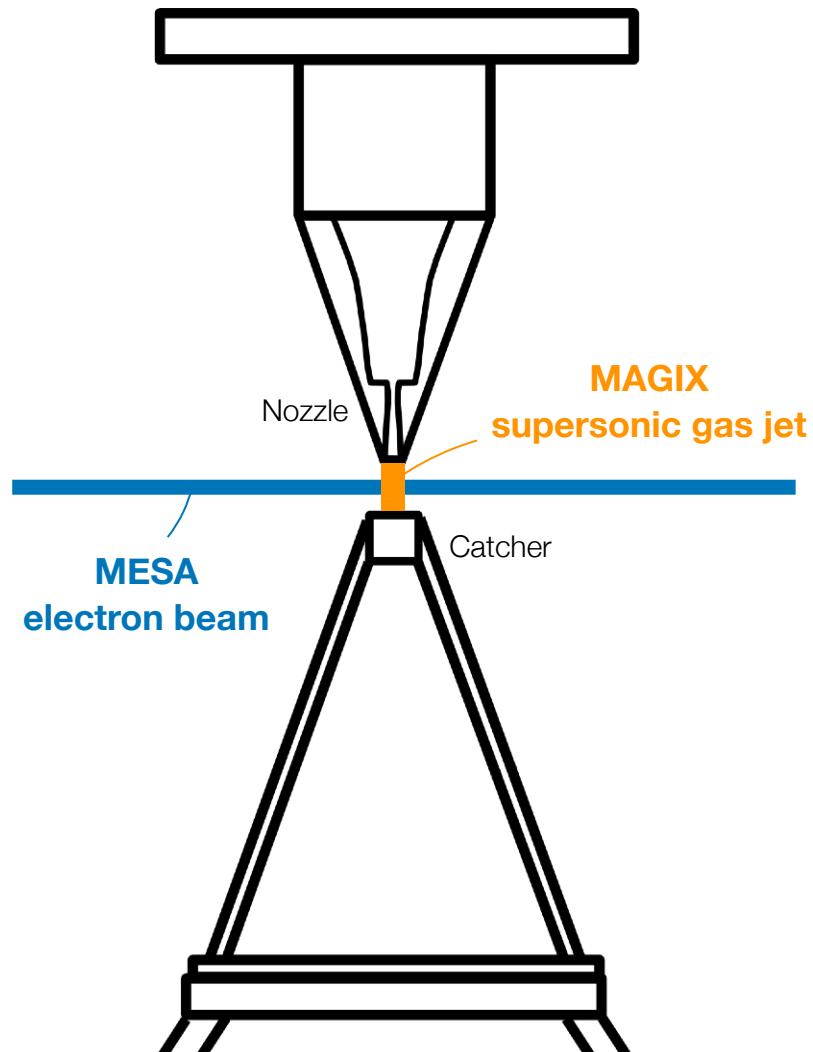
Major error sources at MAGIX (projected) compared to A1.



The basic idea of MAGIX.



The basic idea of MAGIX.

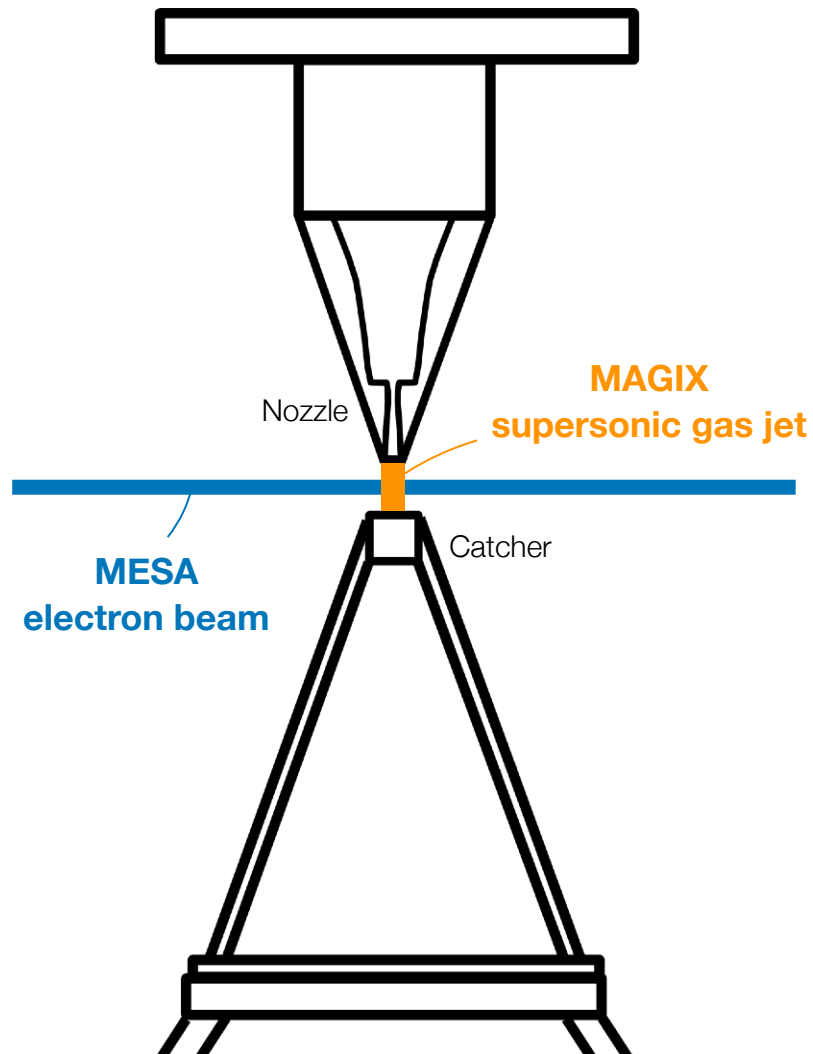


**Windowless
gas jet target**
and minimal material budget

+

**High-intensity
electron beam**
in the low-energy regime

The basic idea of MAGIX.



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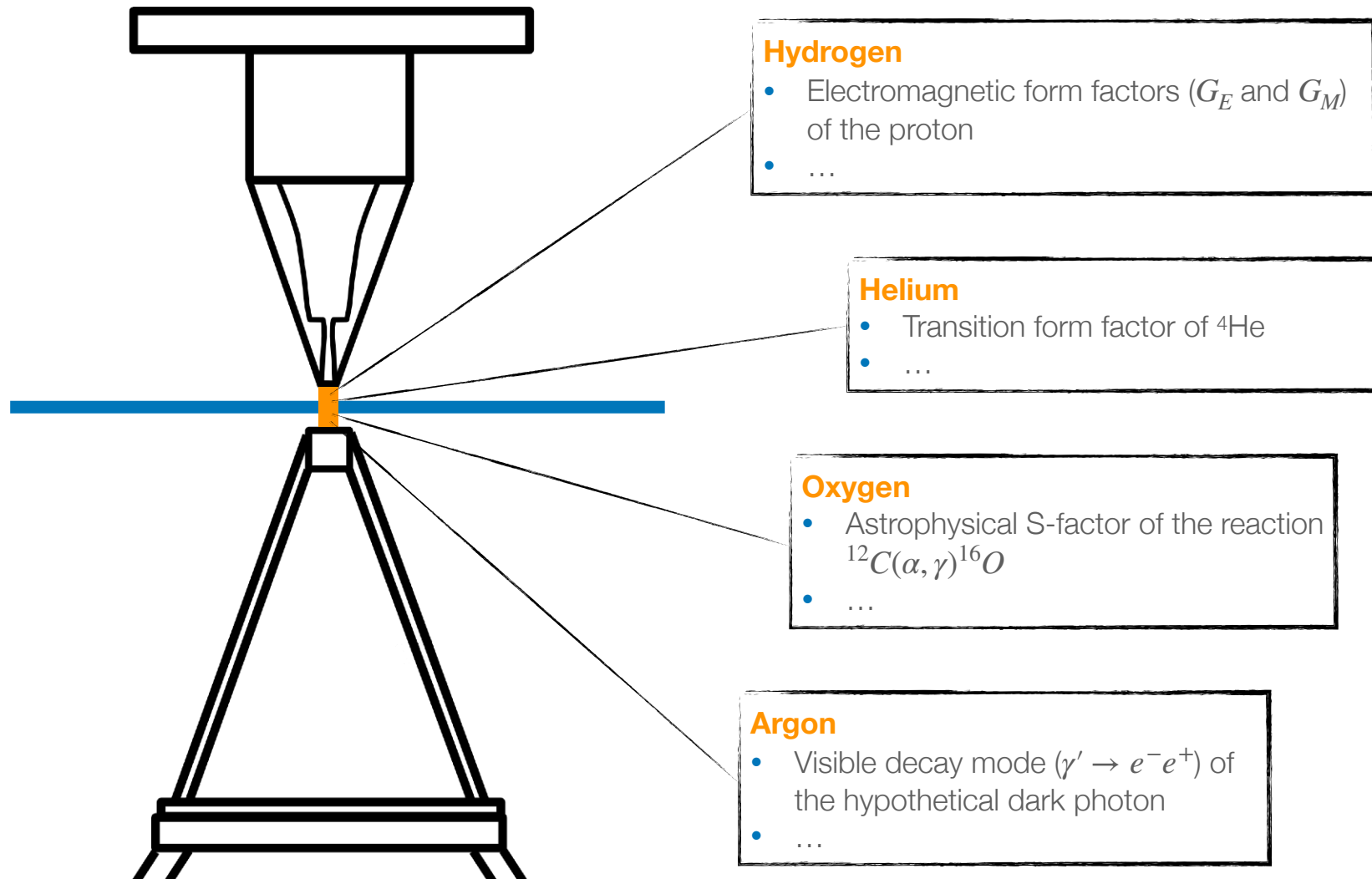


**Clean
experimental
environment**
with drastically reduced particle
interactions prior to detection

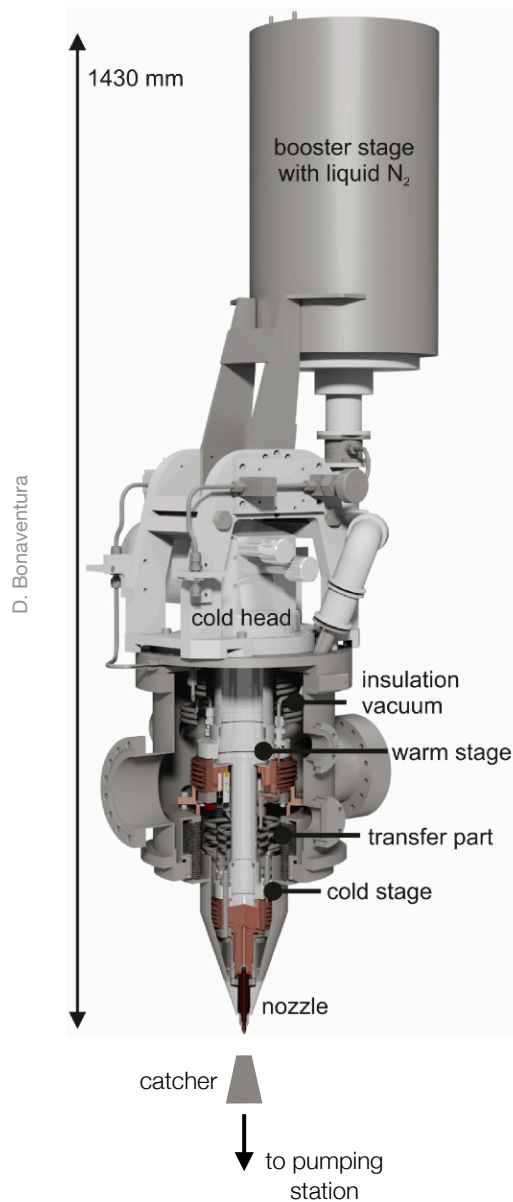
+

**Competitive
luminosities**
in the order of $10^{35} \text{ cm}^{-2}\text{s}^{-1}$

A versatile physics program.

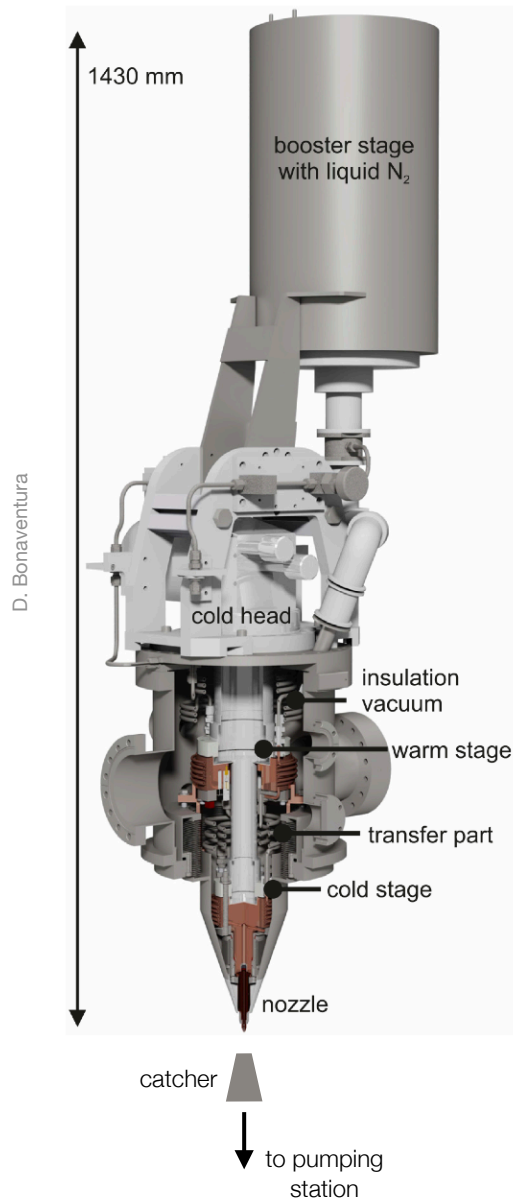


The MAGIX gas jet target.

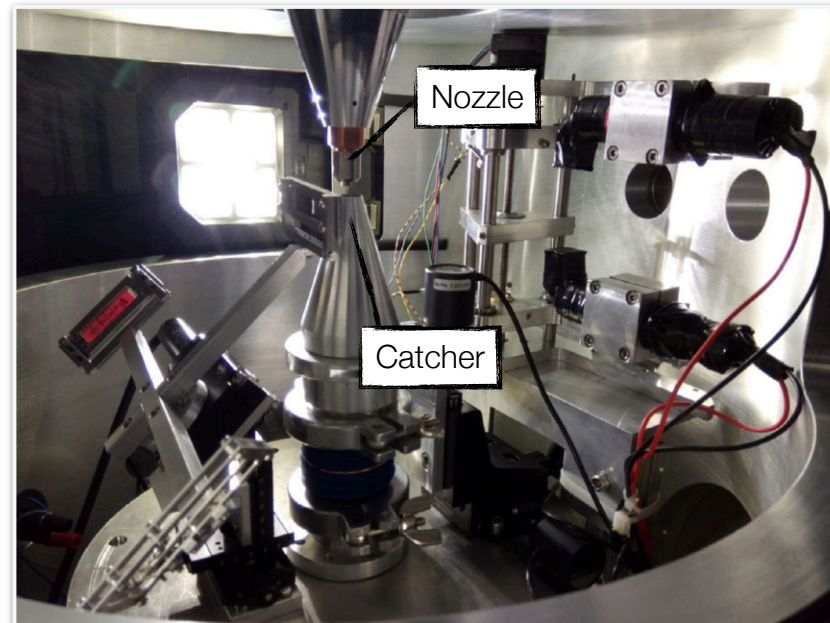


- Developed and constructed by AG Khoukaz at WWU Münster, Germany
- Windowless, thin, point-like jet target

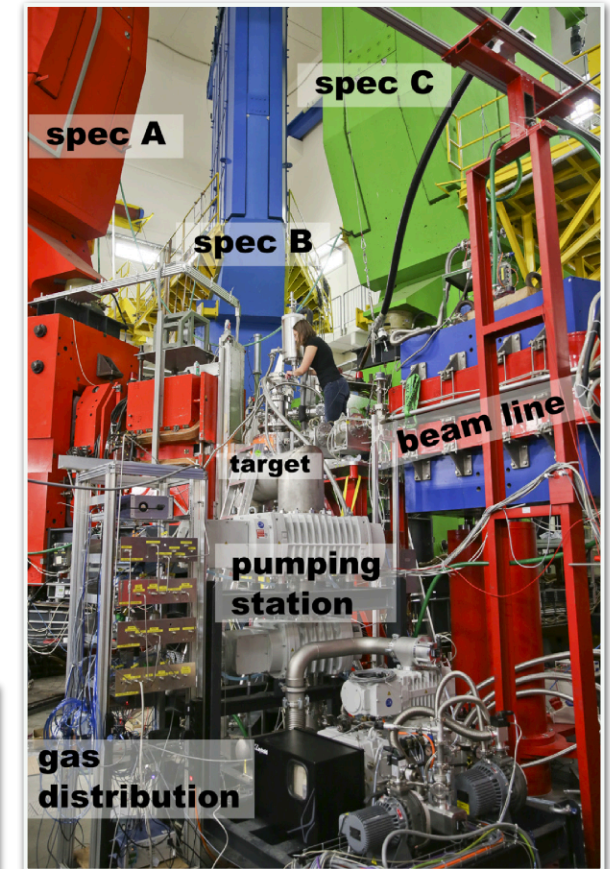
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- Already commissioned at A1 with hydrogen...



S. Schlimme et al., 10.1016/j.nima.2021.165668

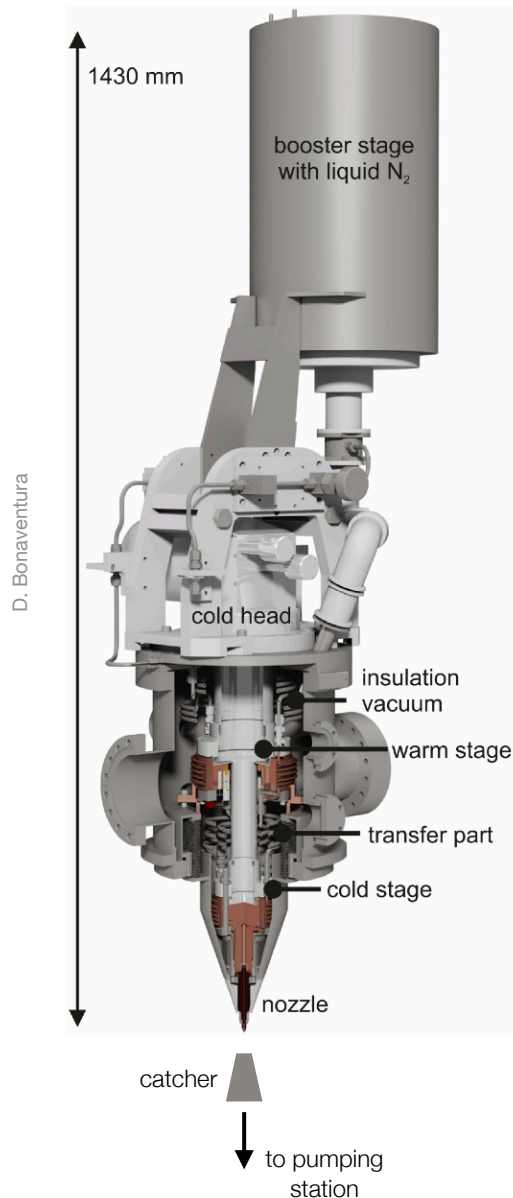


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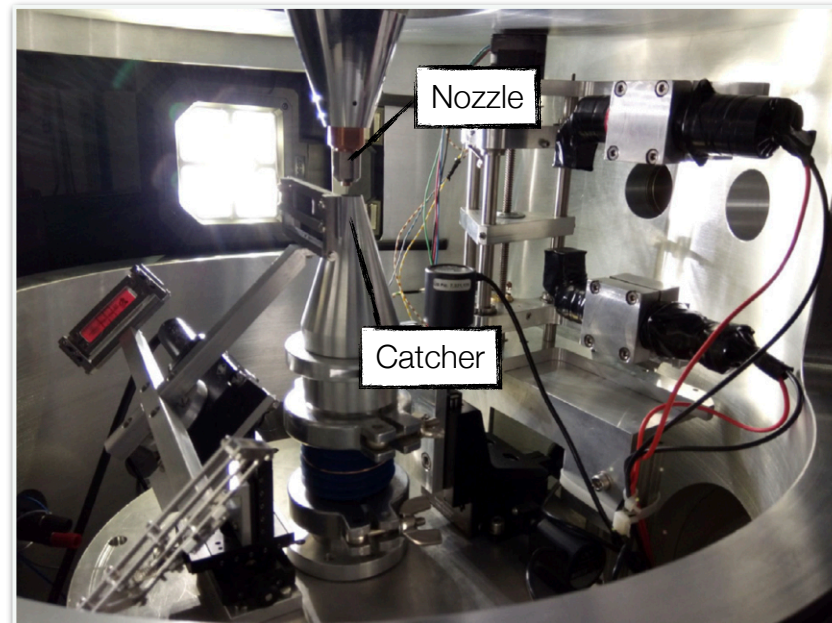


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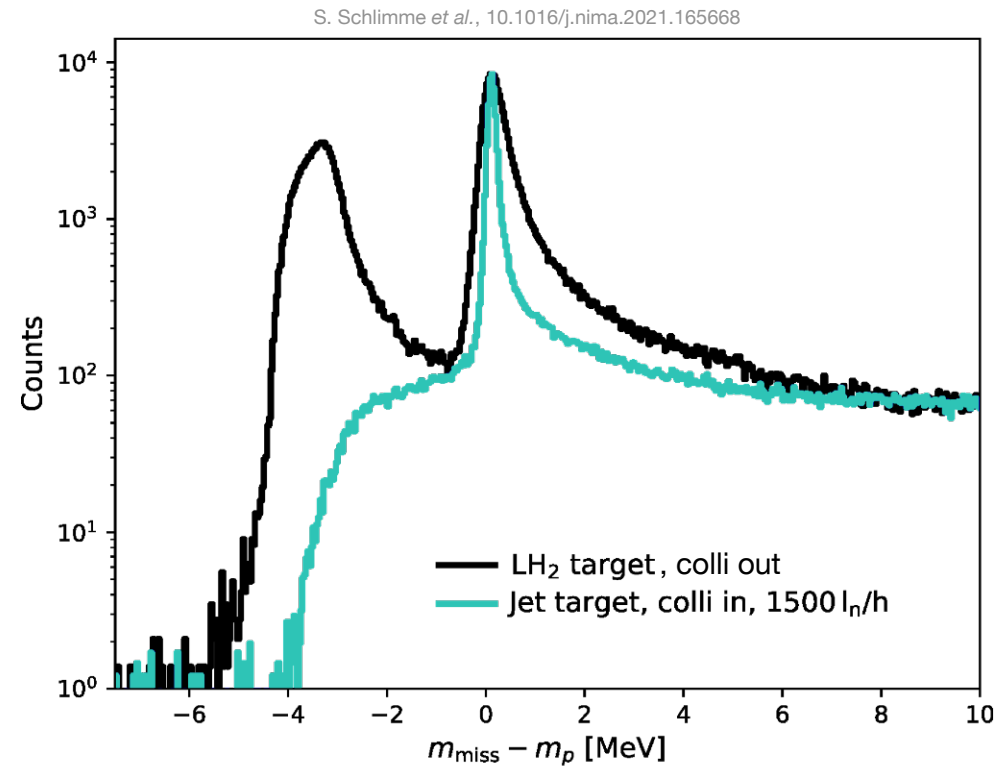


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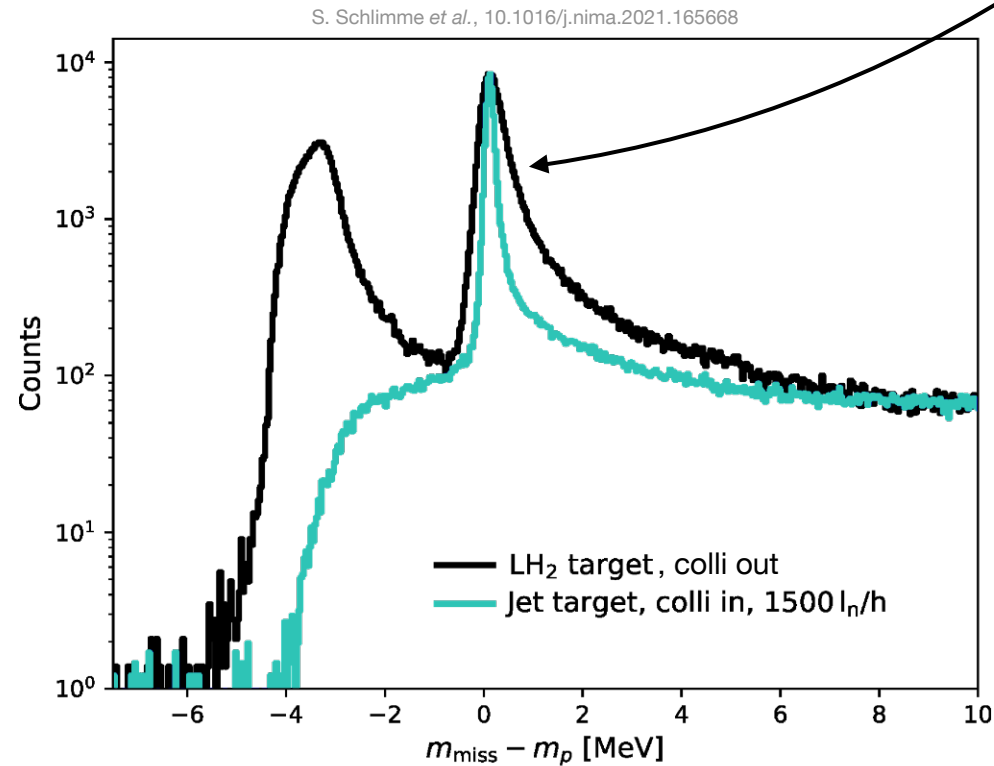
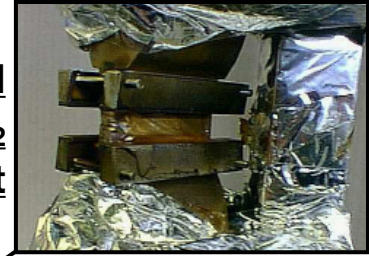
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Benefits of a gas jet target.



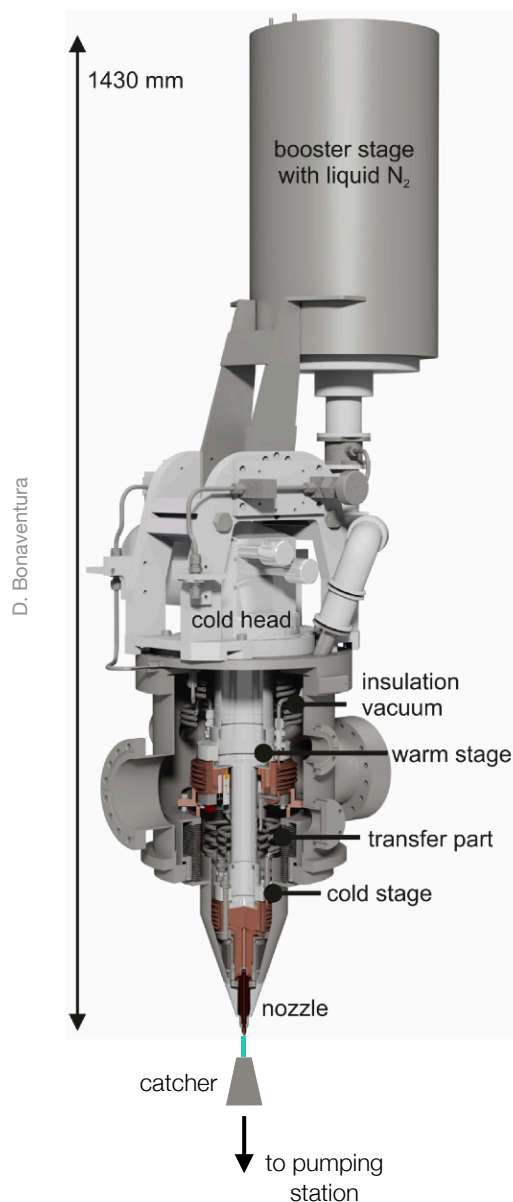
Benefits of a gas jet target.

Typical
liquid H₂
target



- Large energy straggling and multiple scattering
- Background from target foils

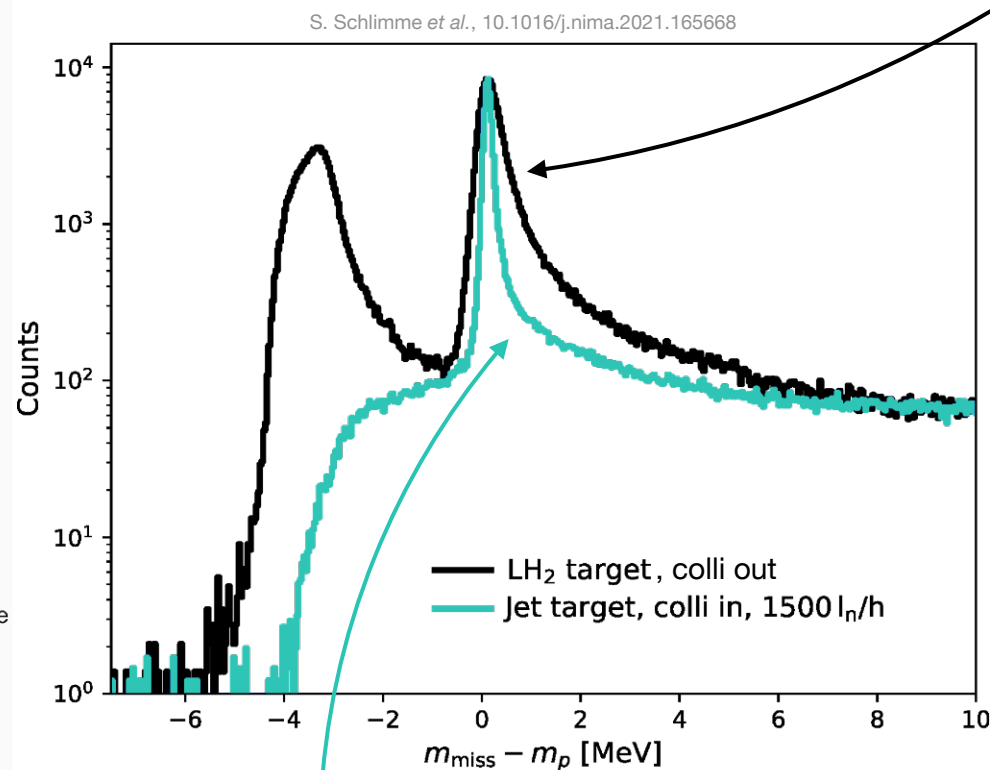
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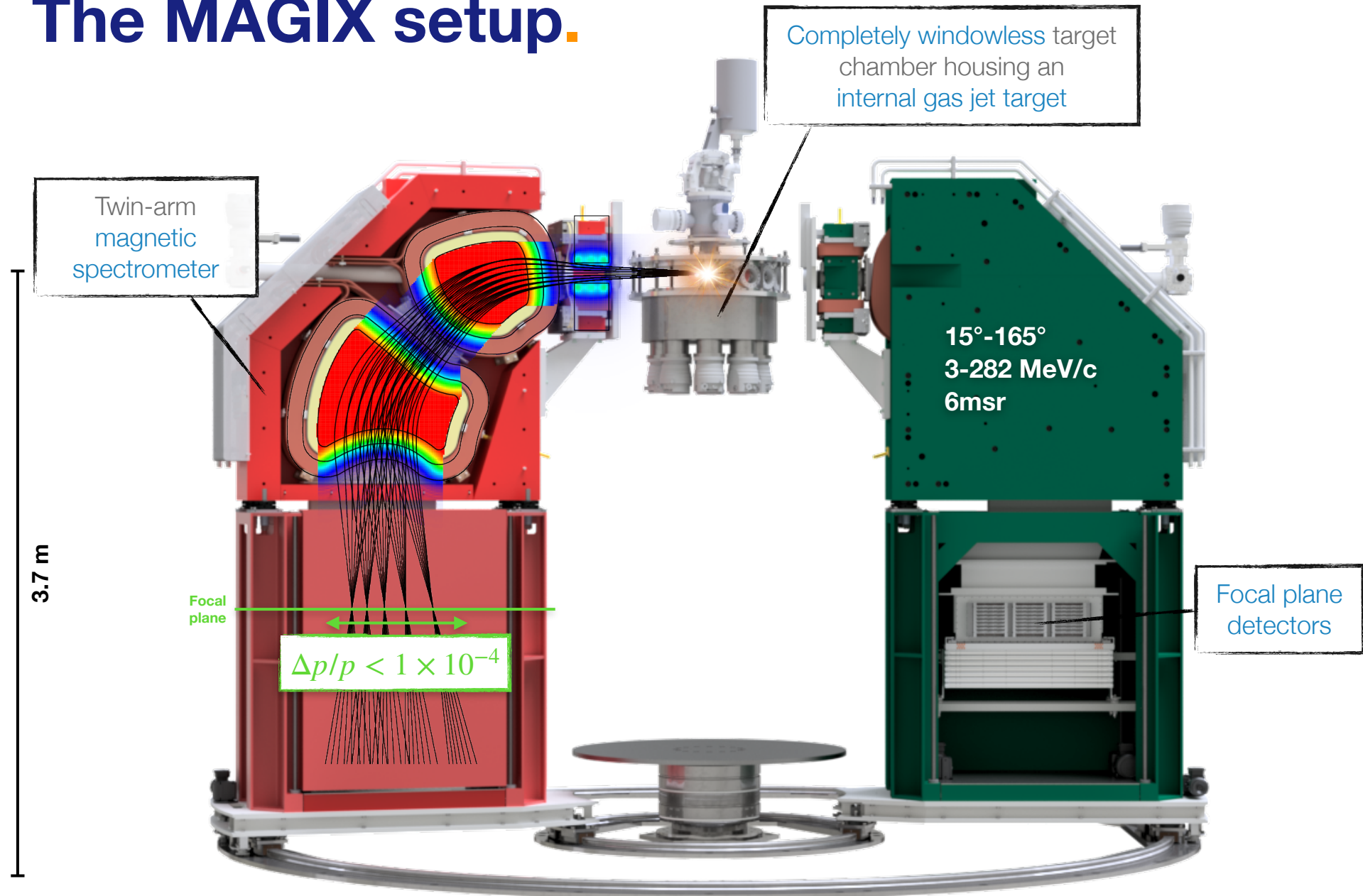


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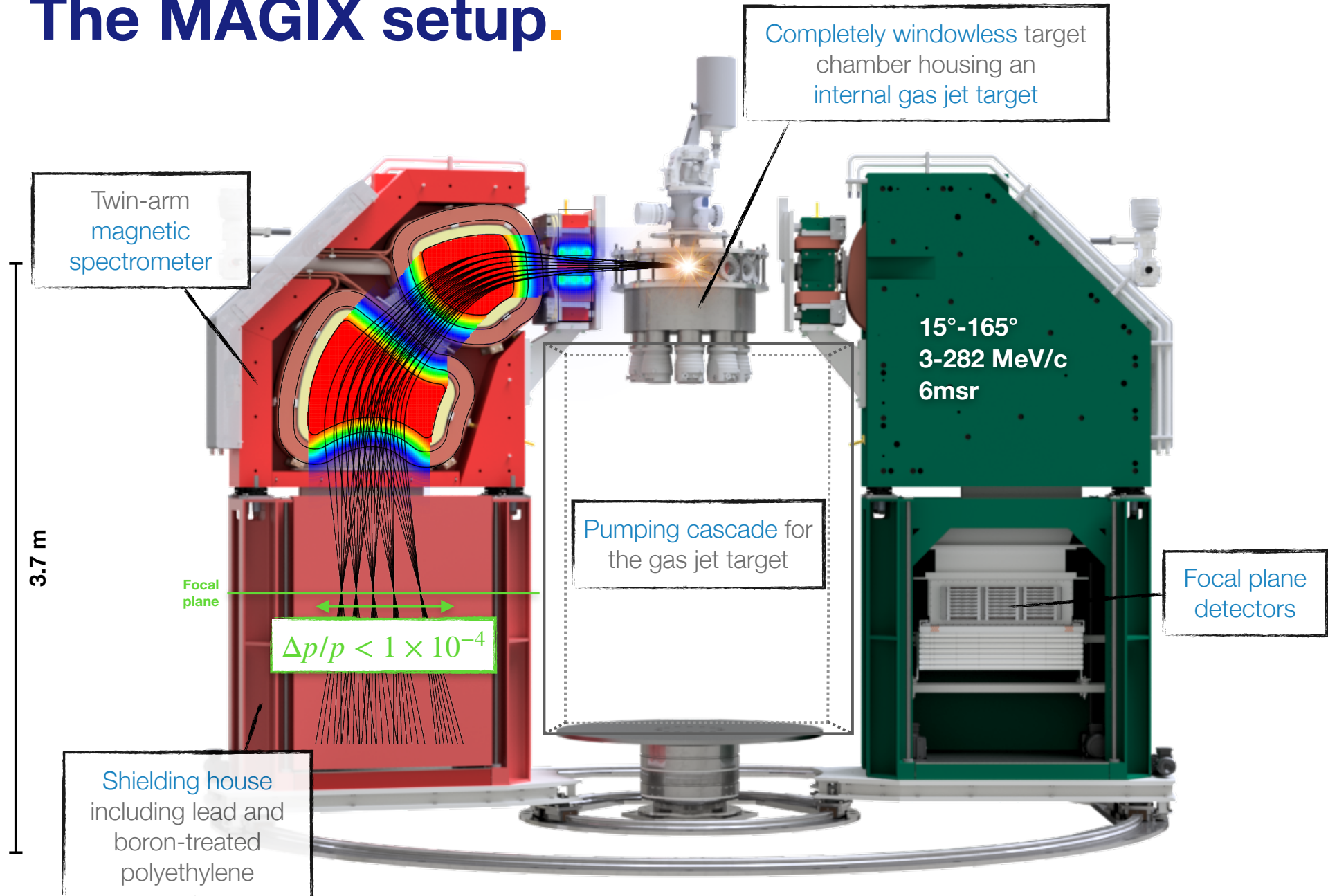


- Sharper elastic peak in electron-proton scattering
- Background effects drastically reduced

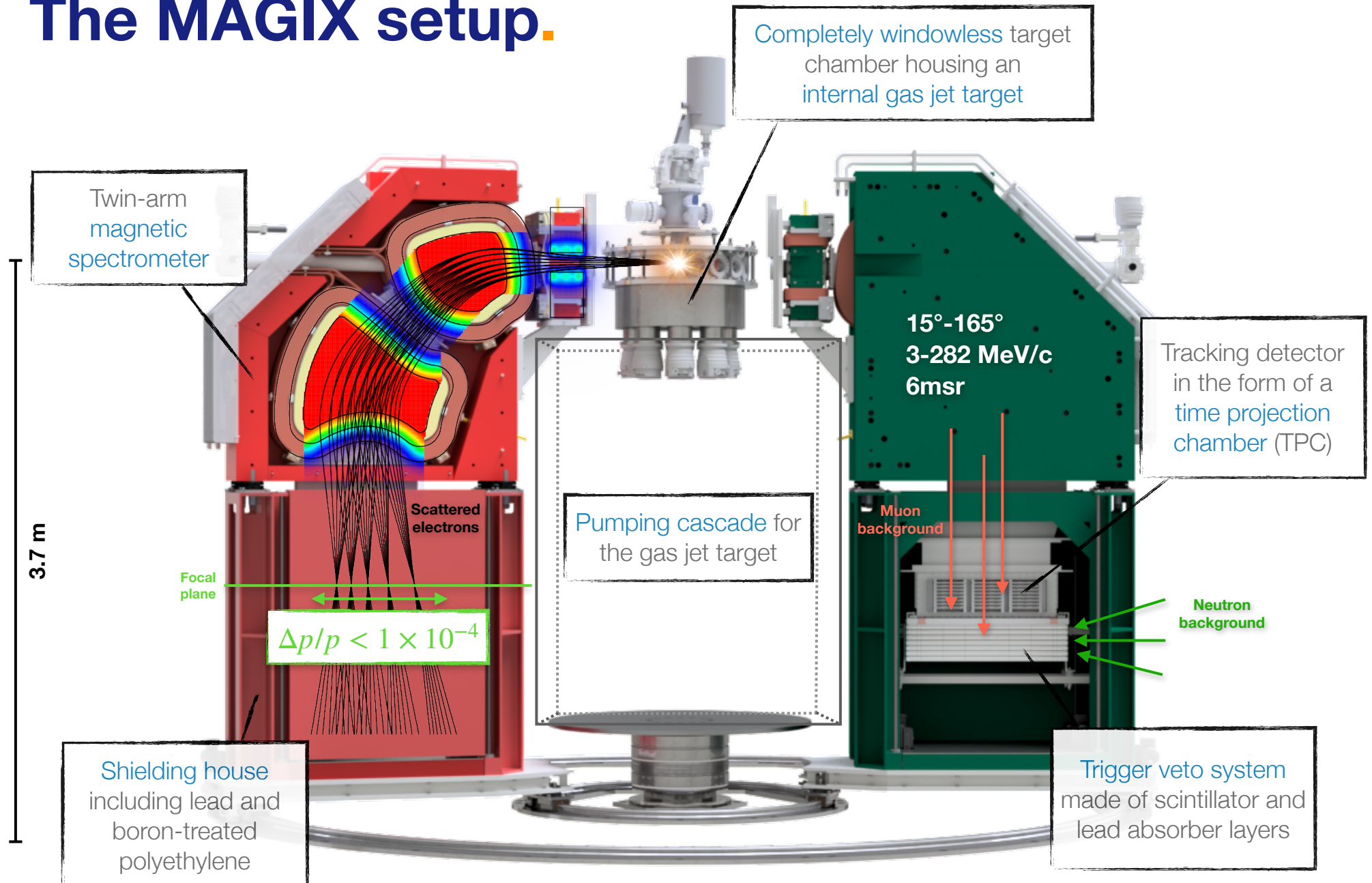
The MAGIX setup.



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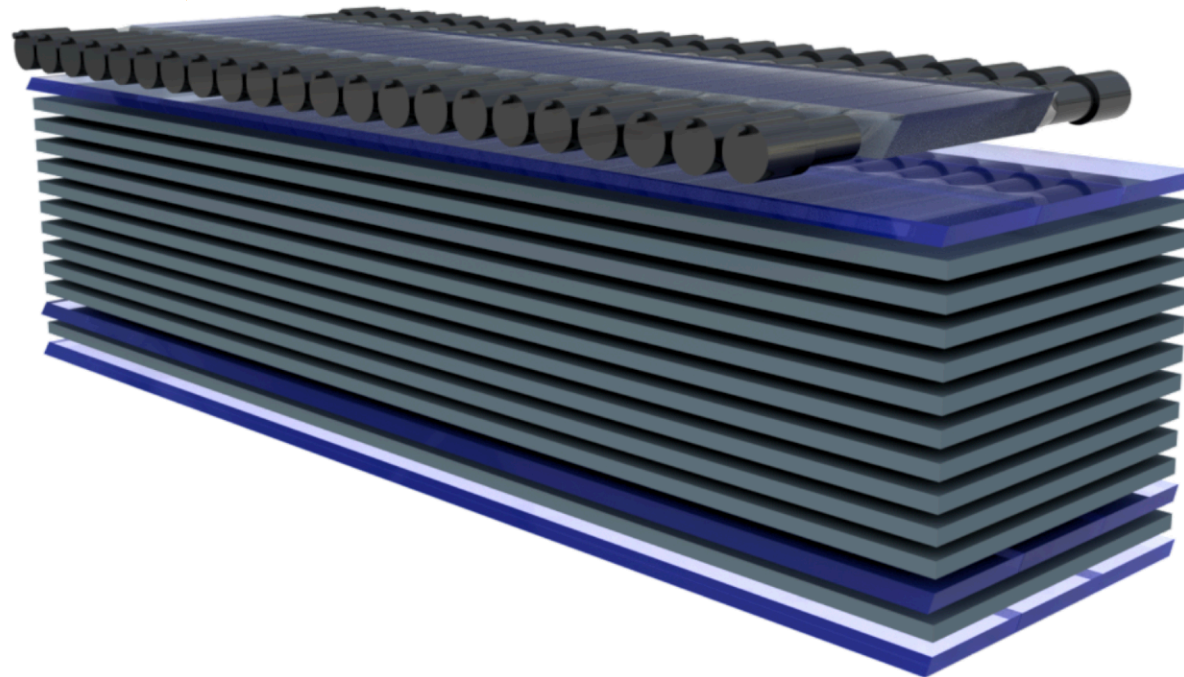
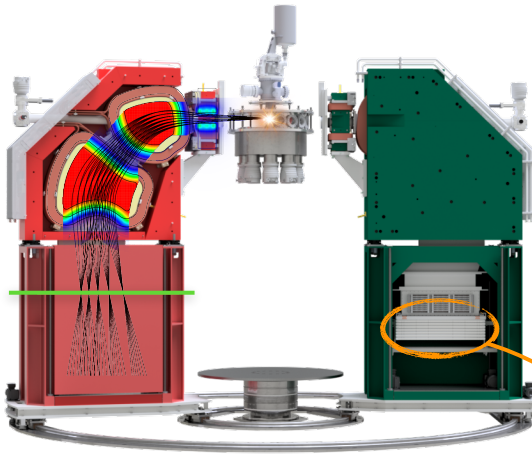


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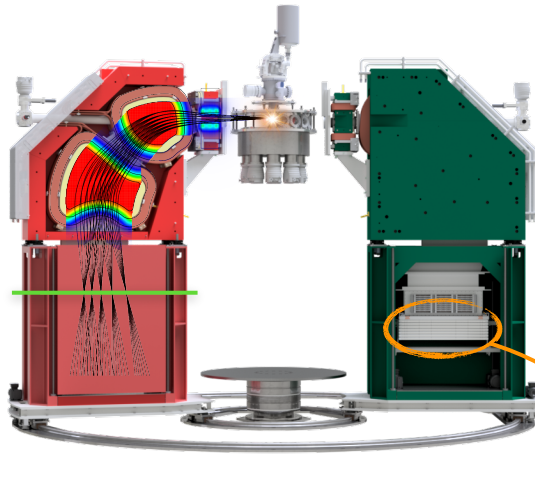


The MAGIX trigger veto system.

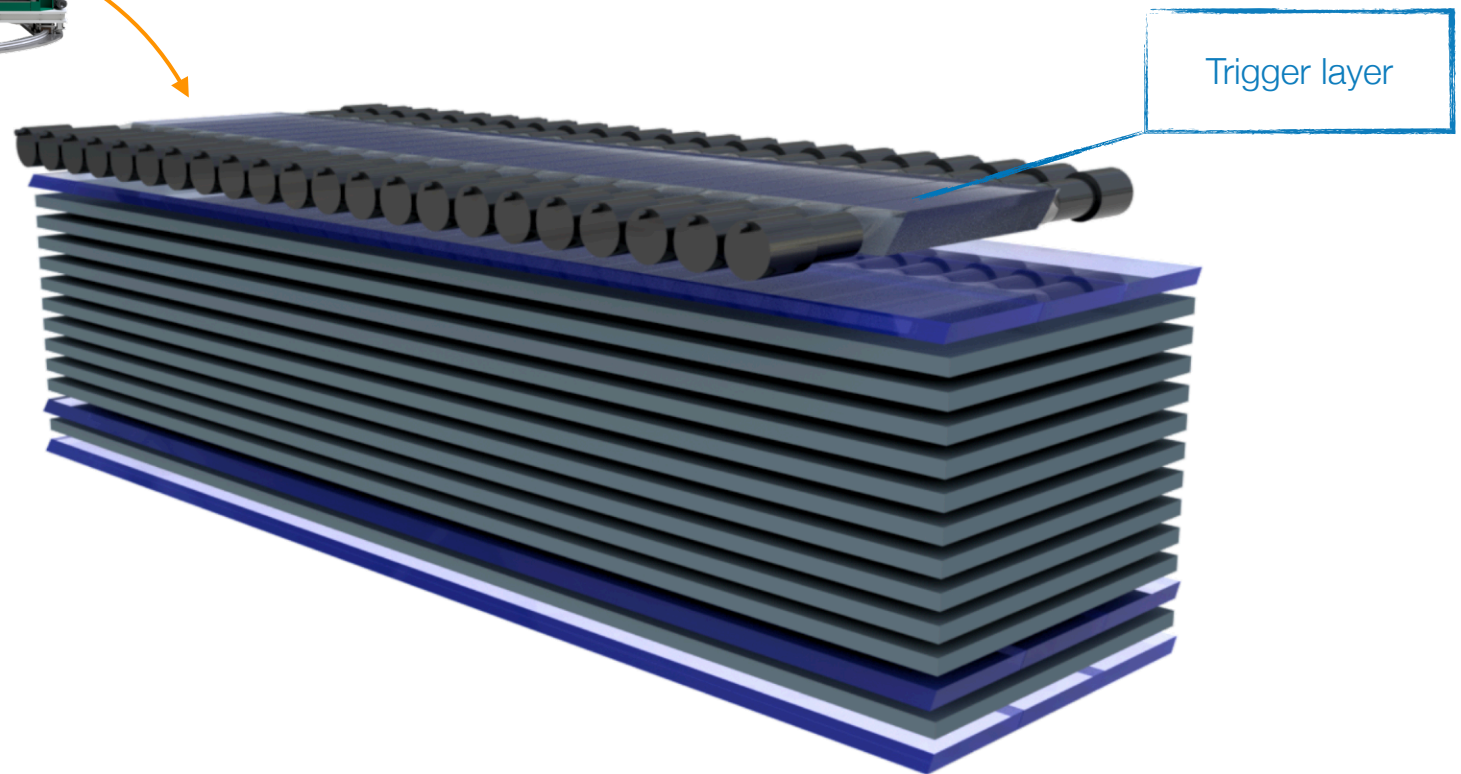
- Combine triggering and PID in one modular system



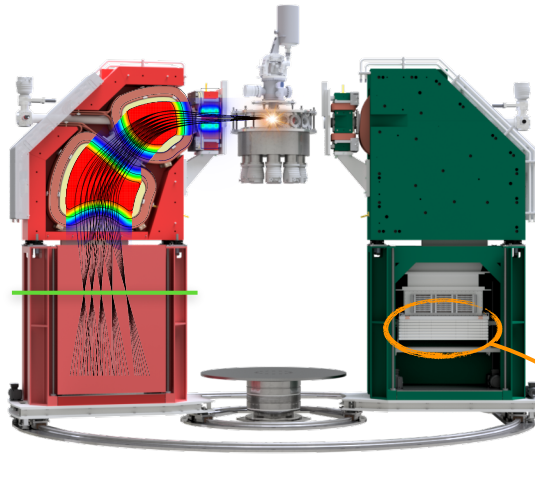
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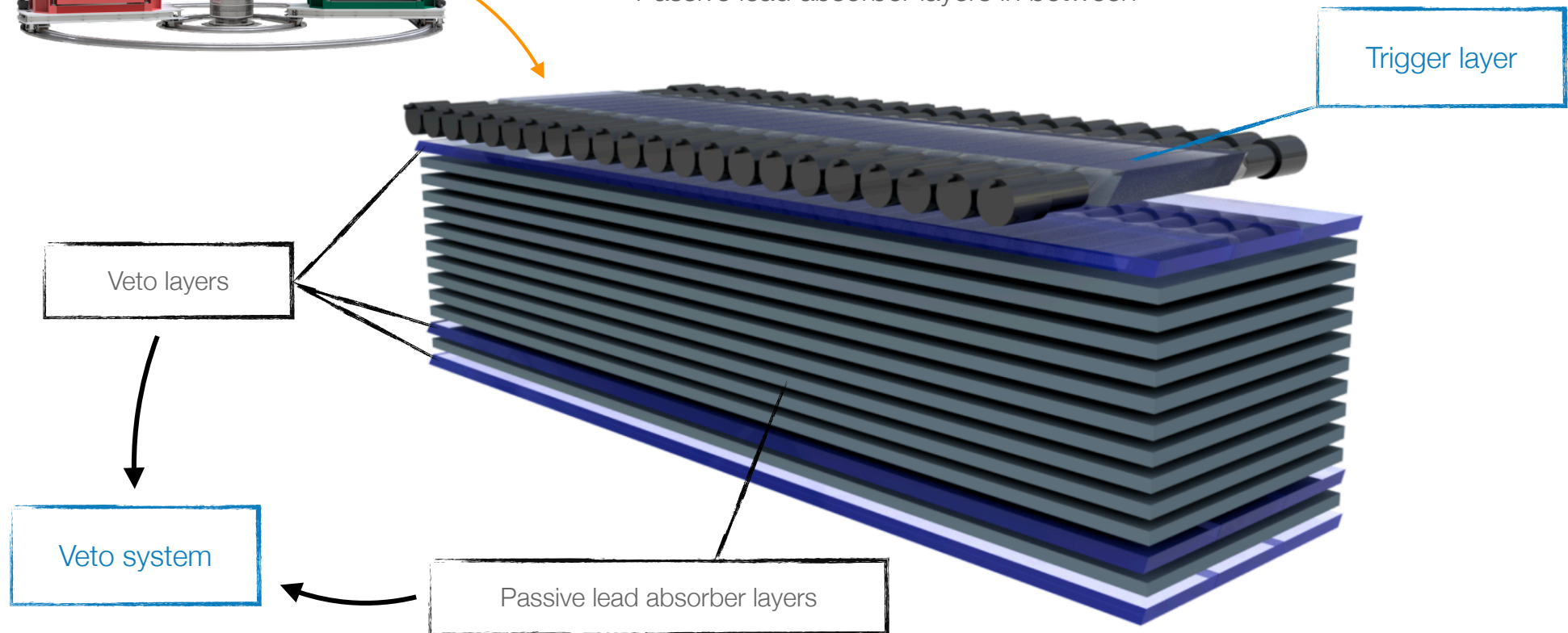
- Combine triggering and PID in one modular system
- Segmented **trigger layer** at the top, made of plastic scintillators read out by PMTs



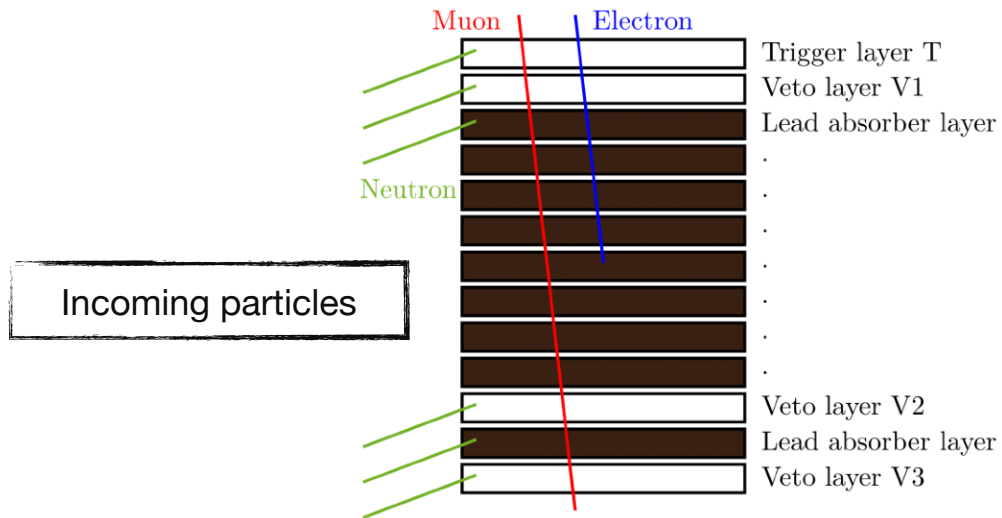
The MAGIX trigger veto system.



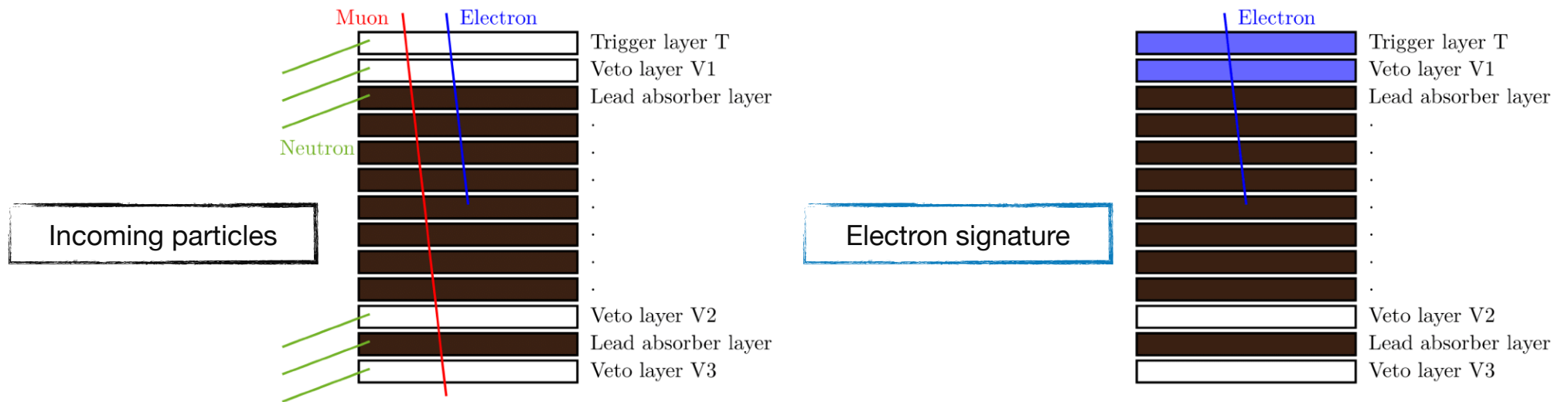
- Combine triggering and PID in one modular system
- Segmented **trigger layer** at the top, made of plastic scintillators read out by PMTs
- A flexible **veto system** underneath, built from:
 - Several veto layers, made of plastic scintillators read out by SiPMs
 - Passive lead absorber layers in between



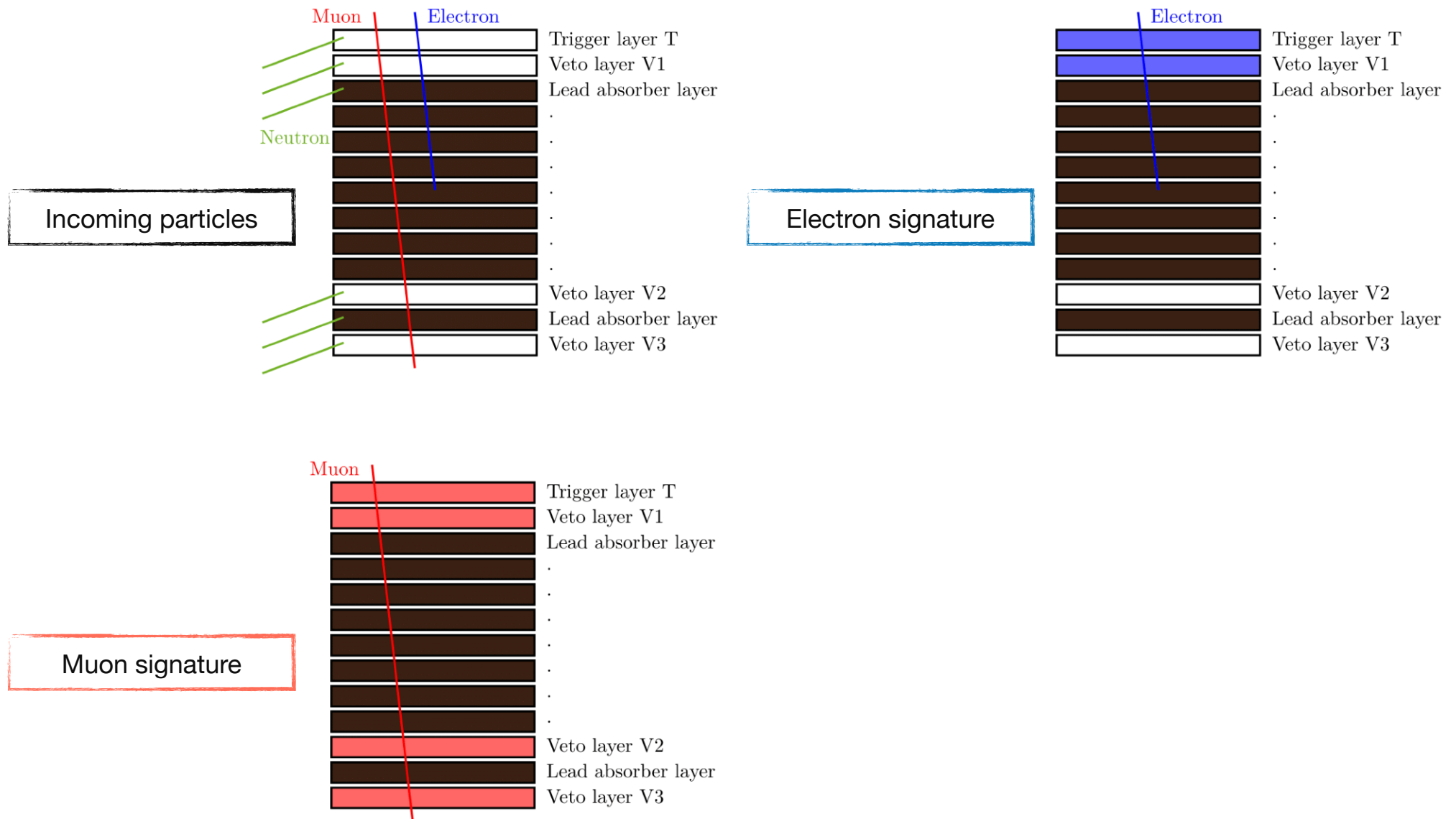
Working principle of the trigger veto system.



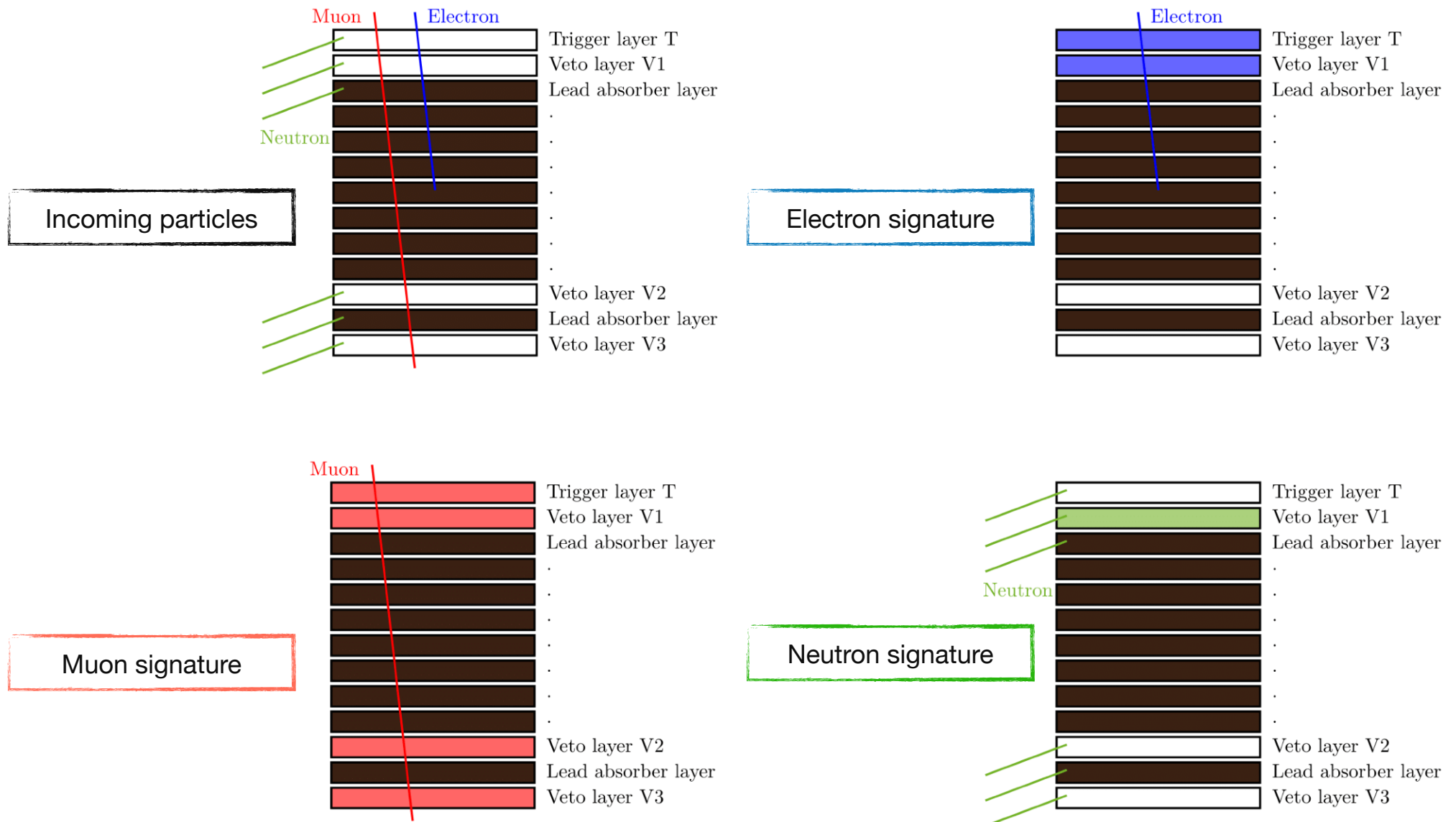
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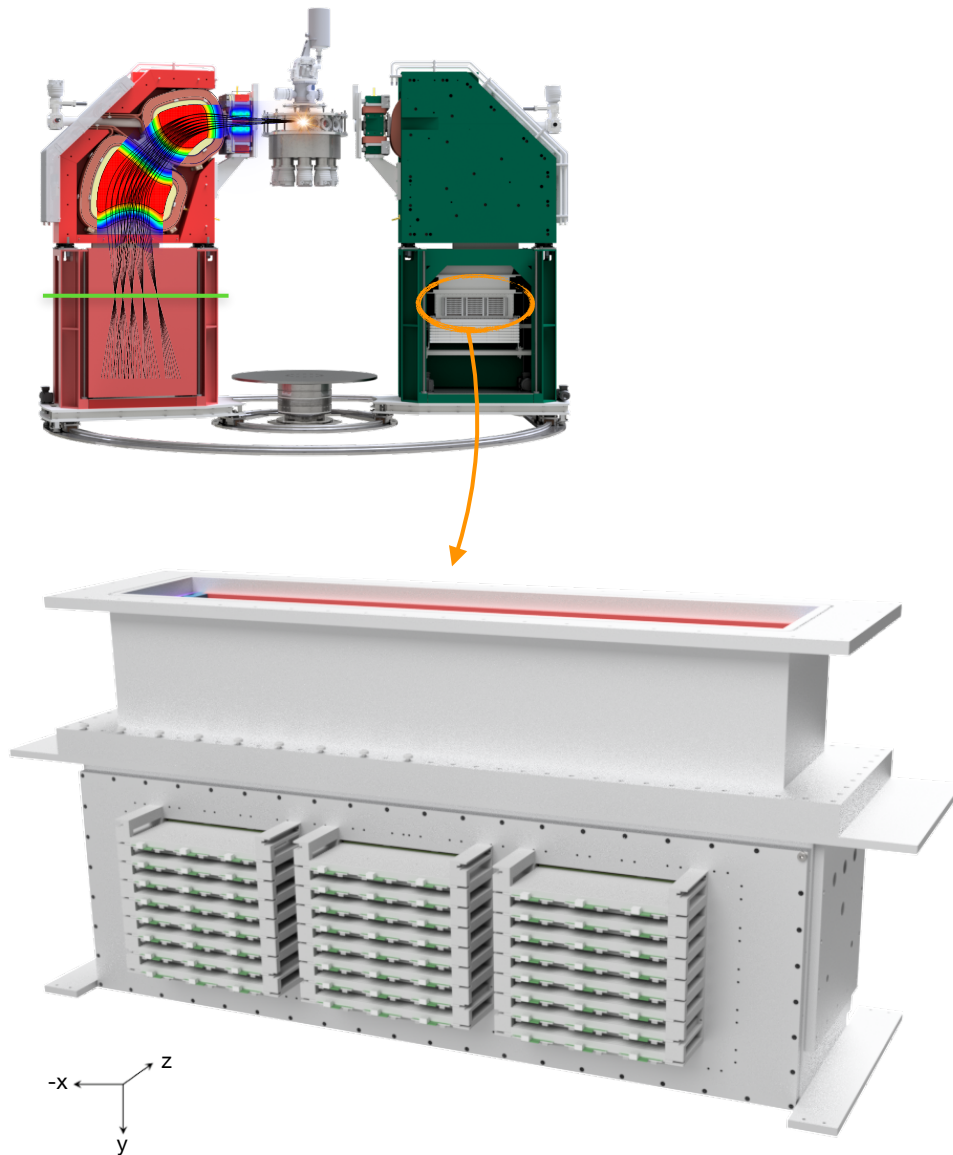
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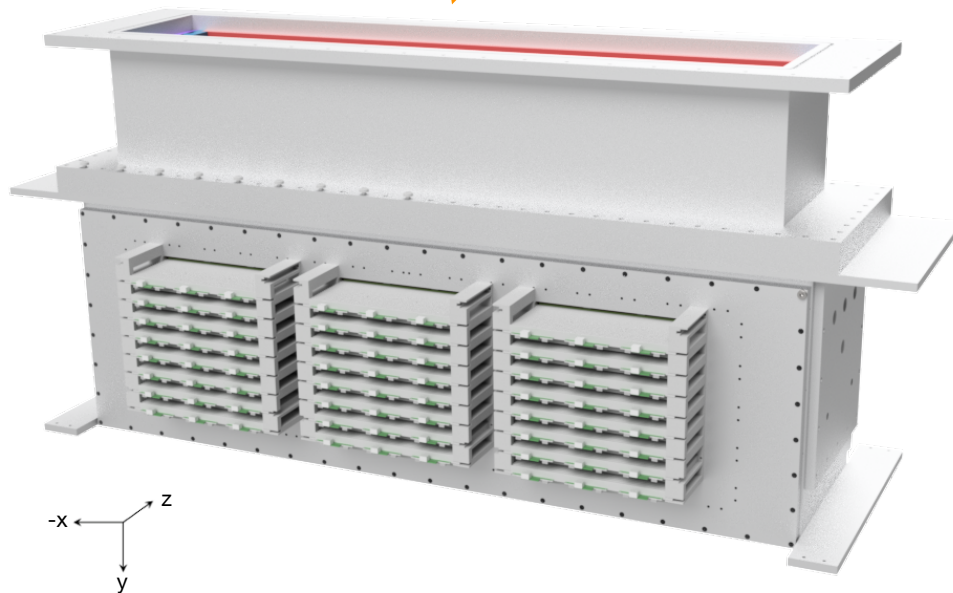
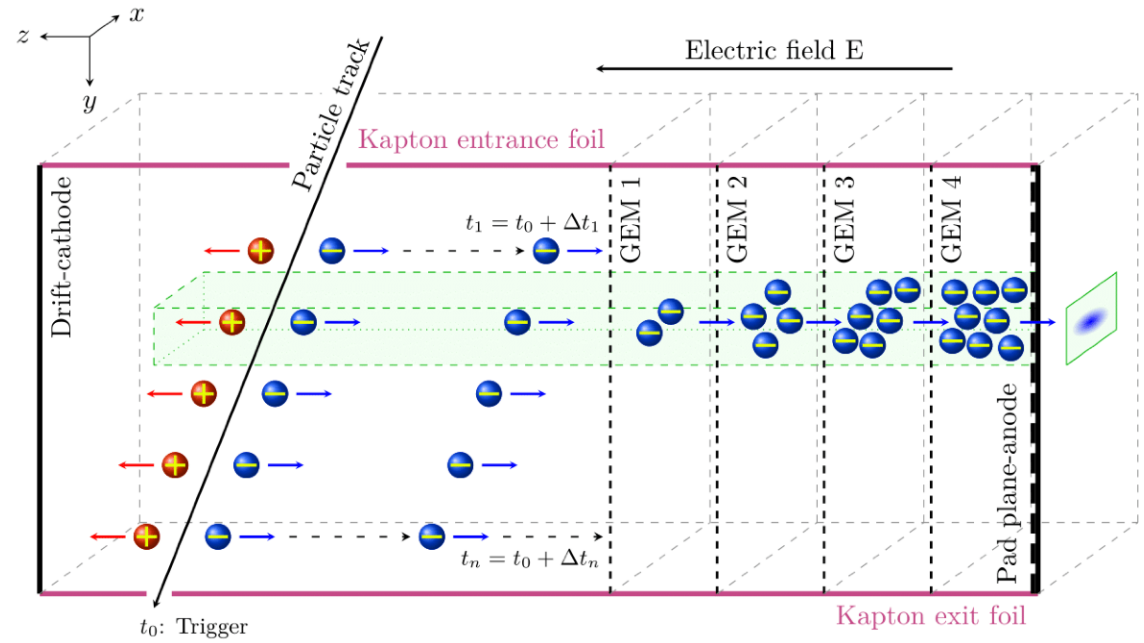
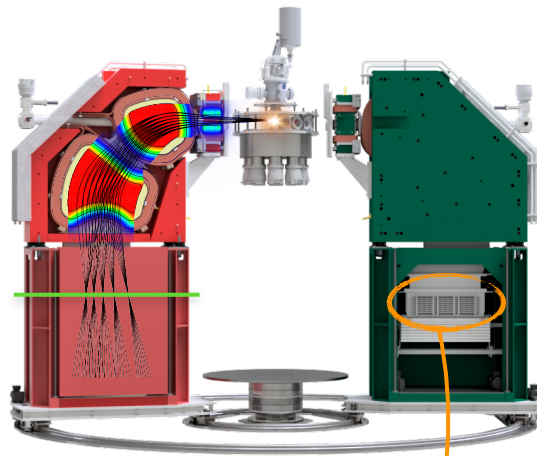
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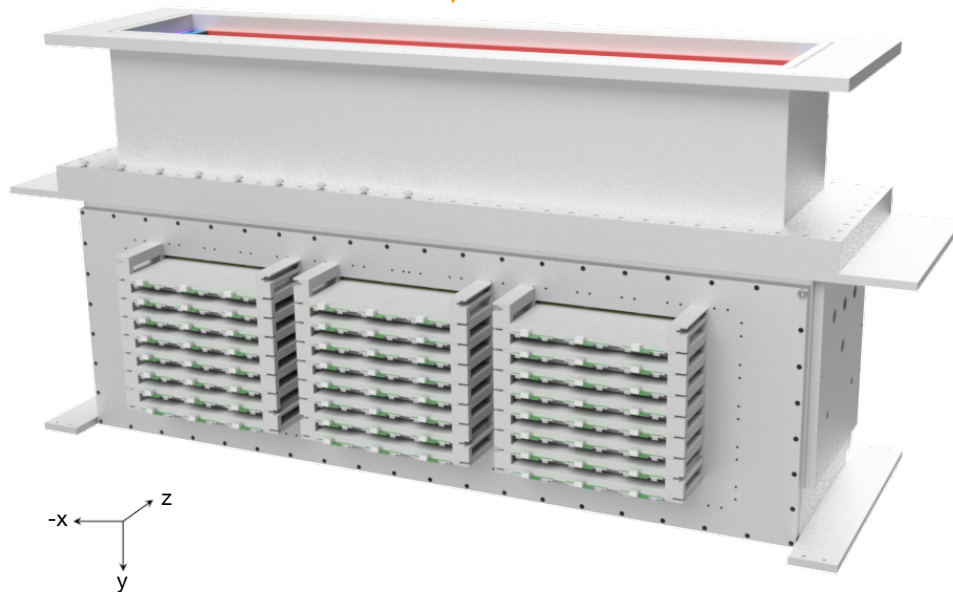
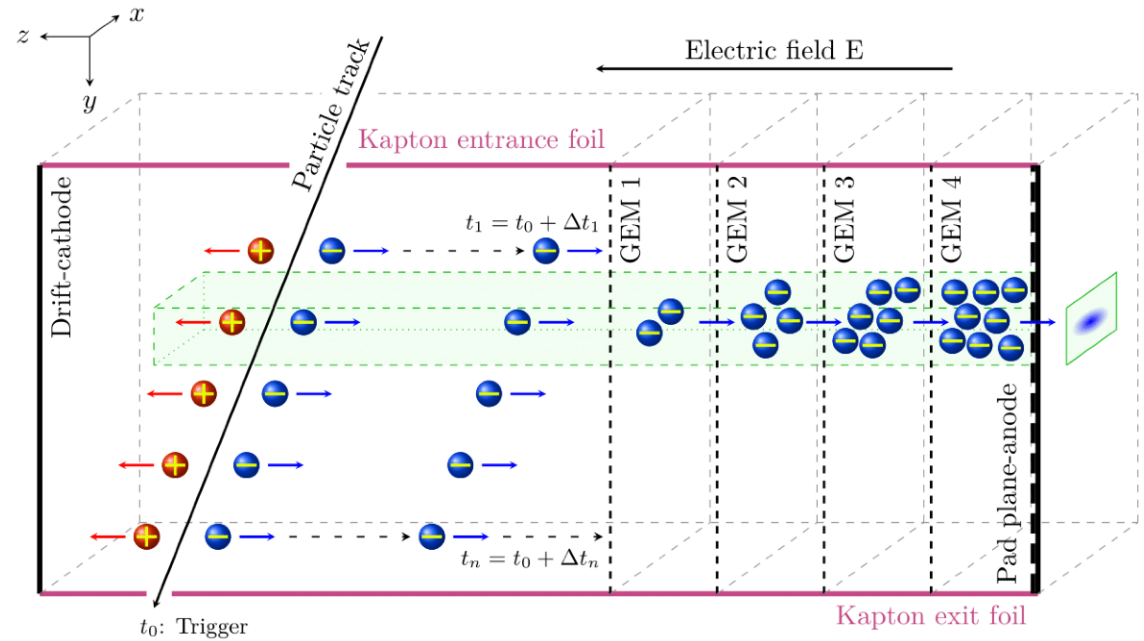
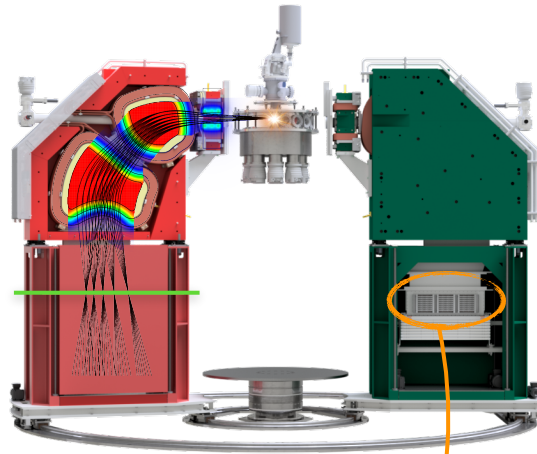
The MAGIX TPC.



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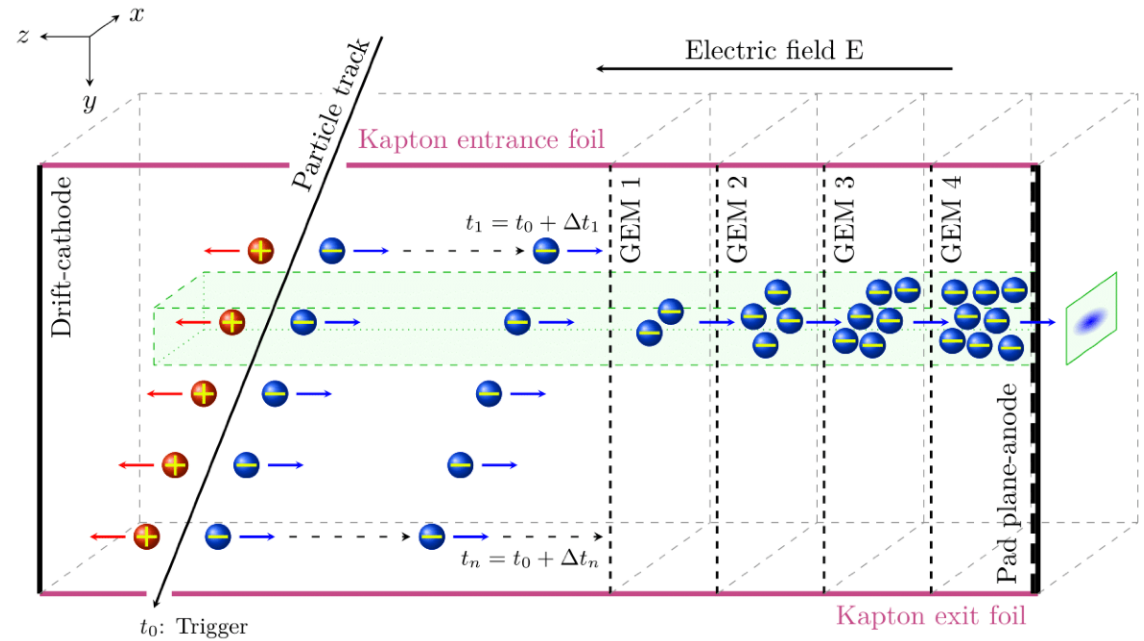
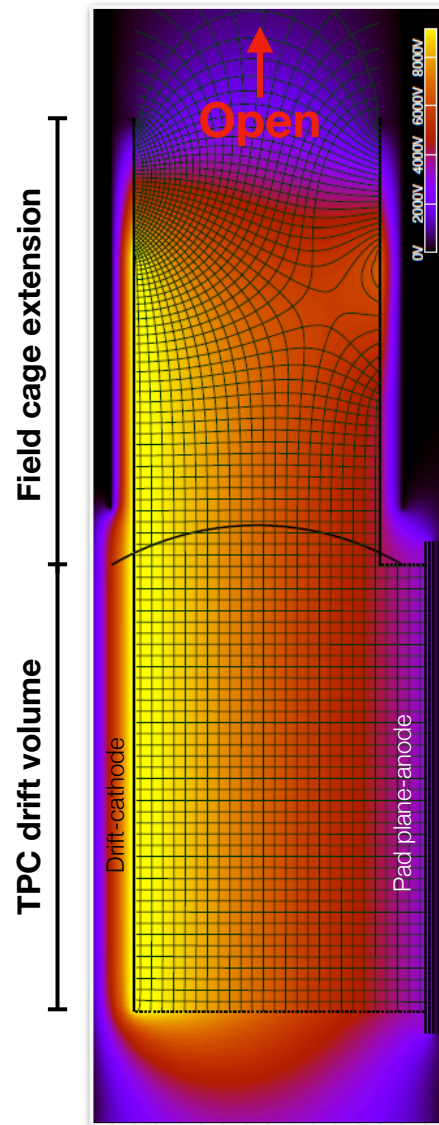


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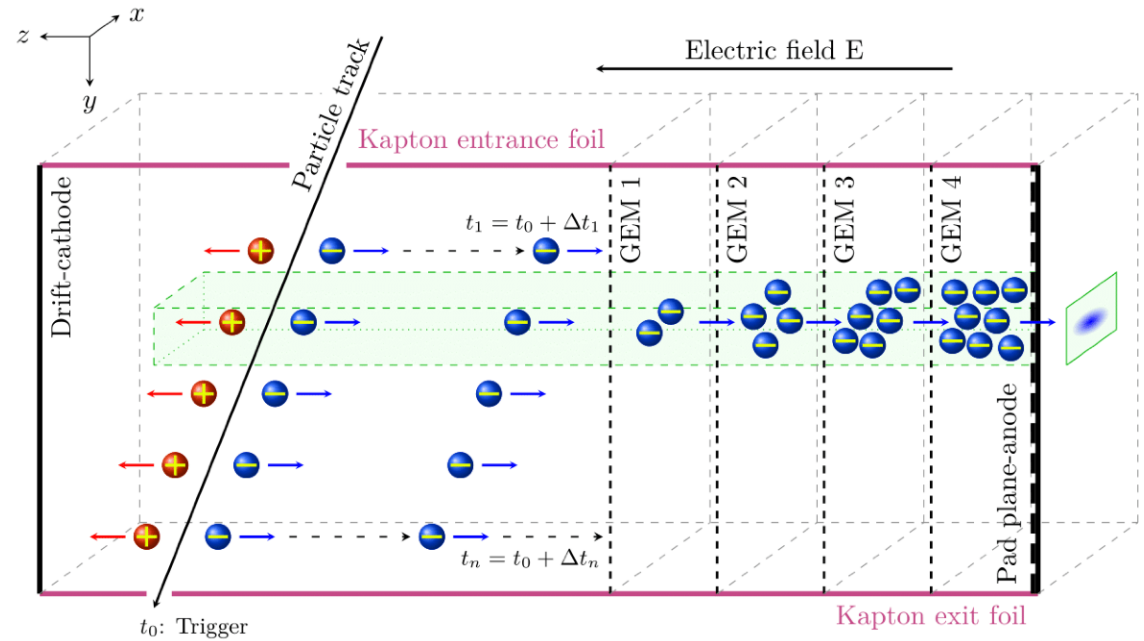
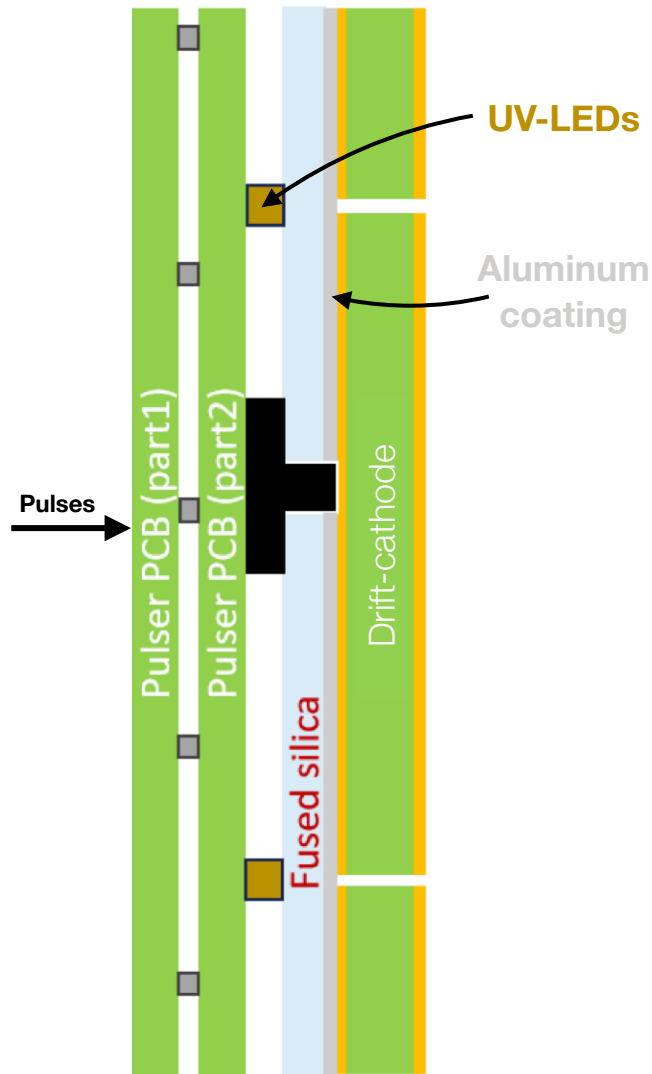
- TPC based on a stack of four Gas Electron Multipliers (GEMs)
- Segmented readout at the pad plane-anode
- 3D track reconstruction via projection on pad plane-anode (2D) plus drift time (1D)

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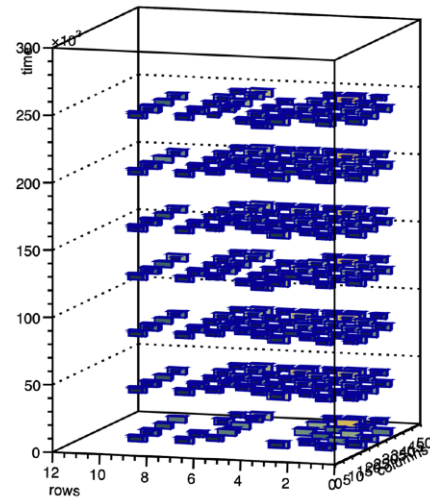
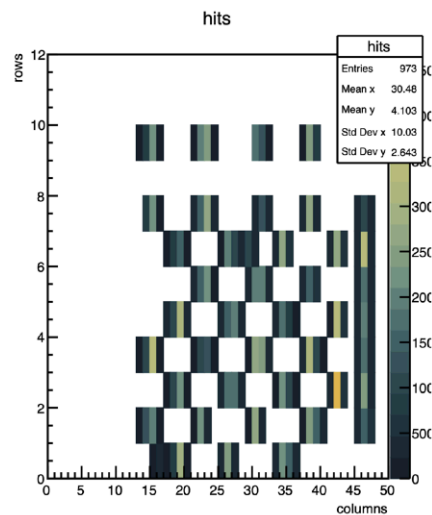
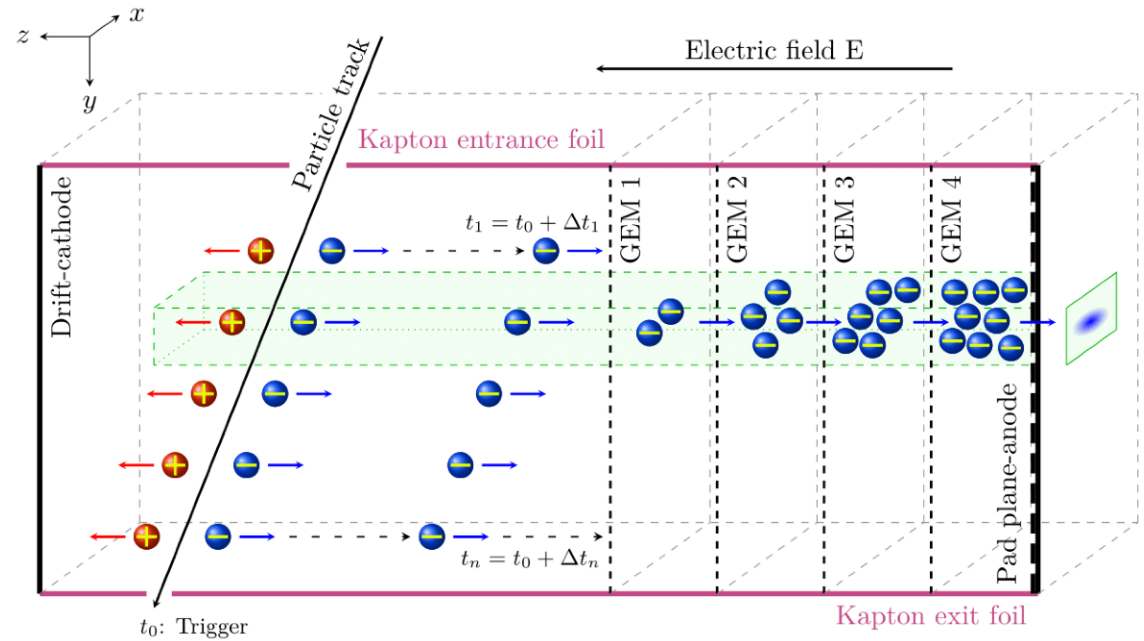
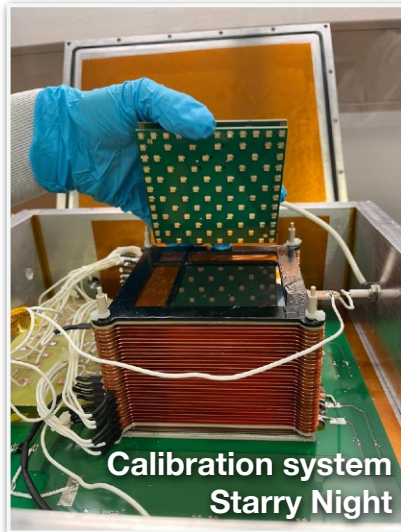
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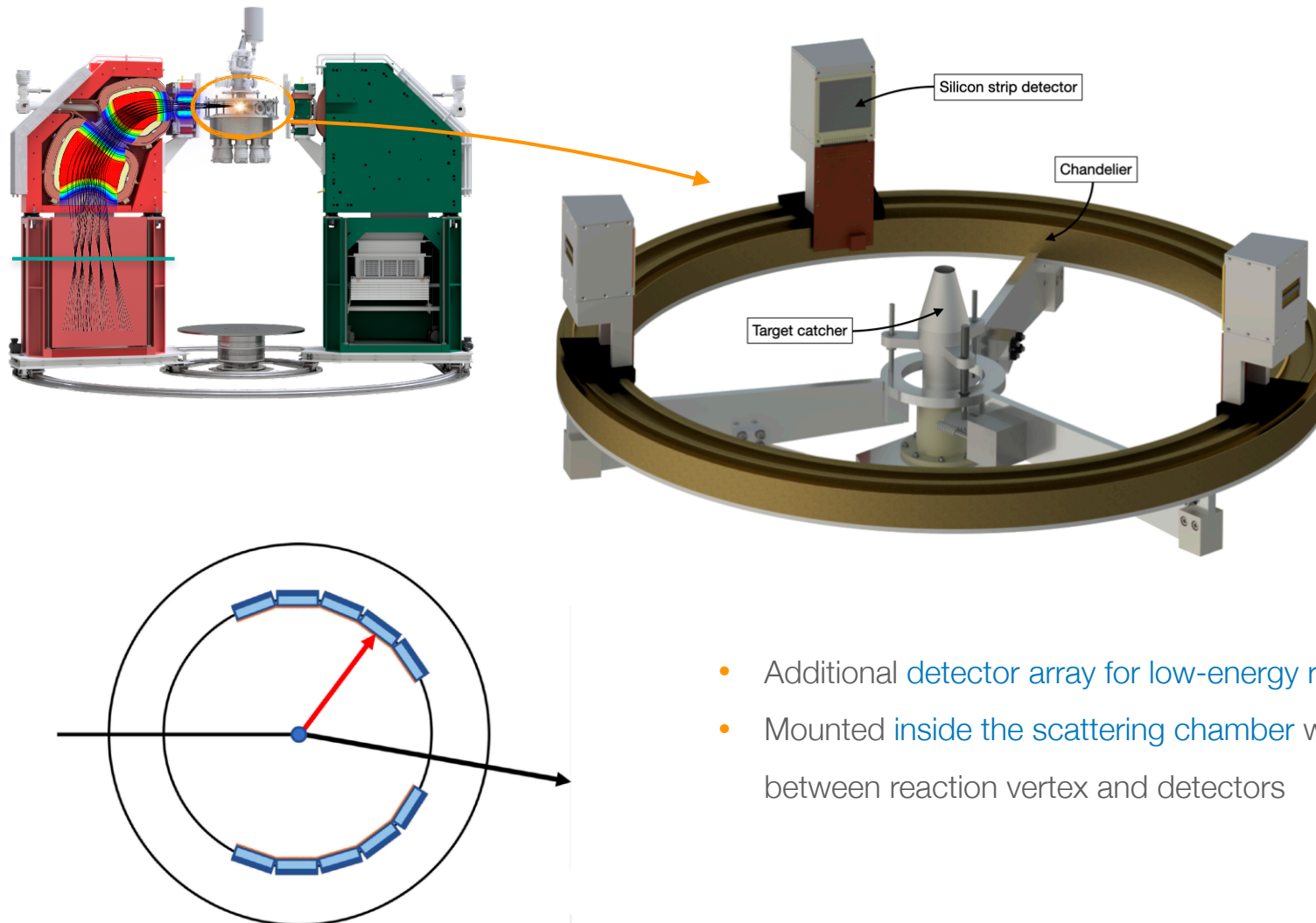
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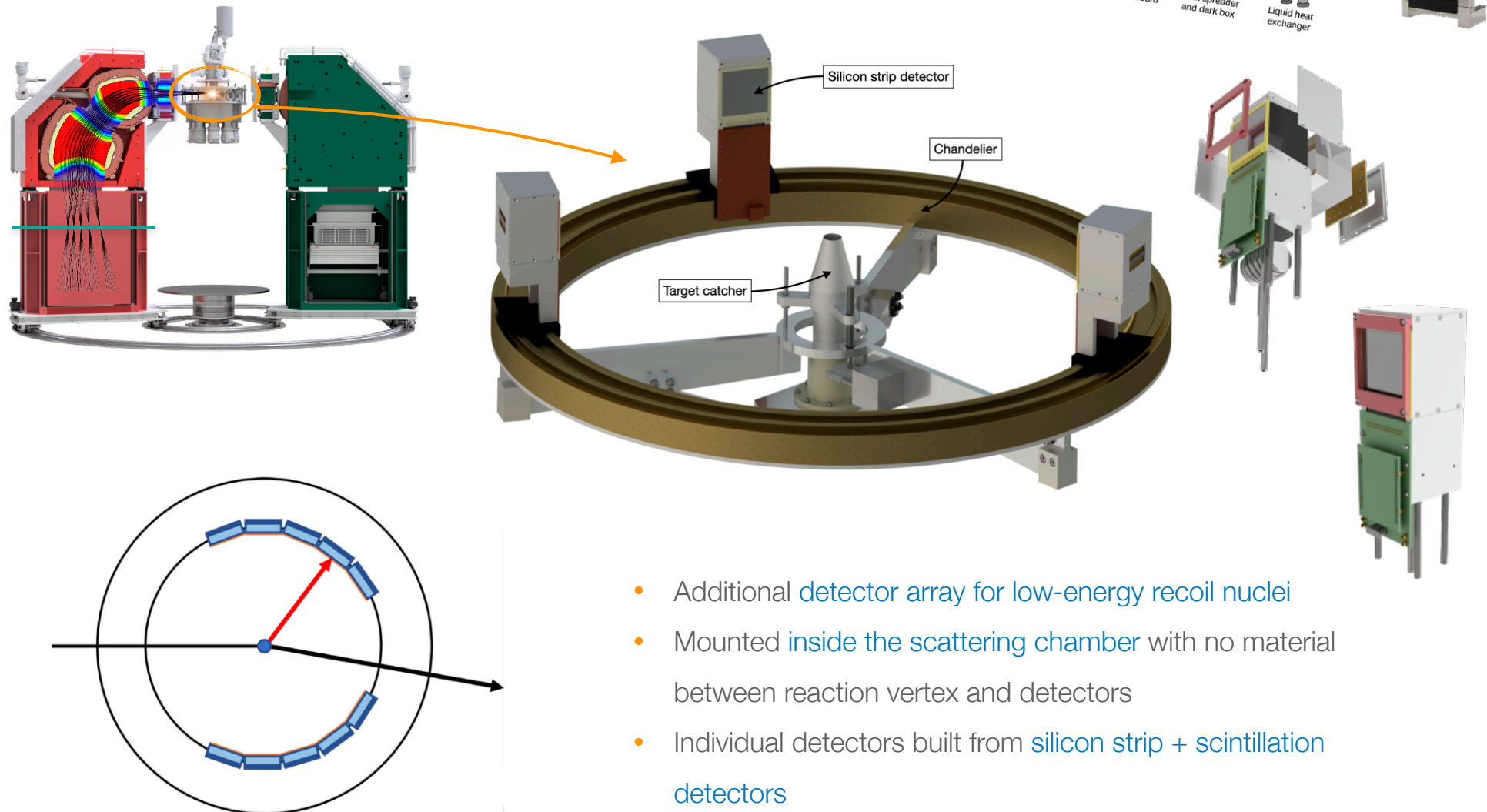
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Recoil detector array.

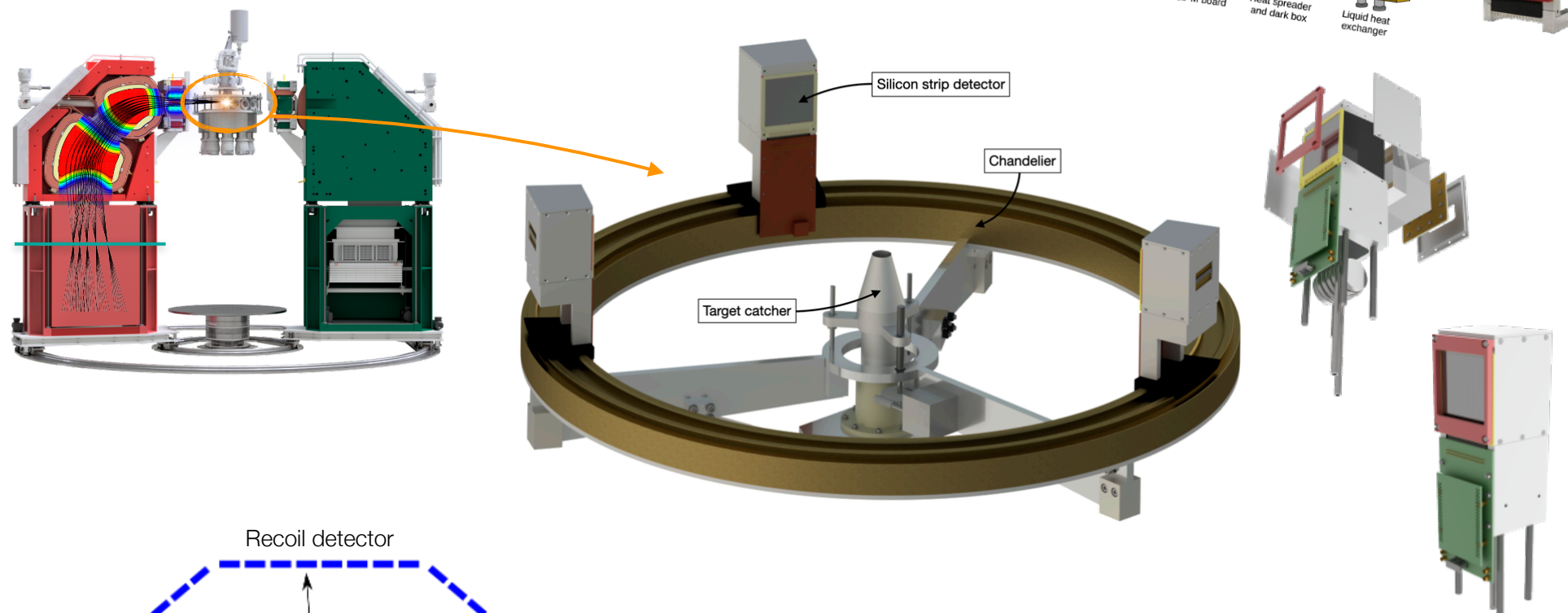


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- Mounted inside the scattering chamber with no material between reaction vertex and detectors

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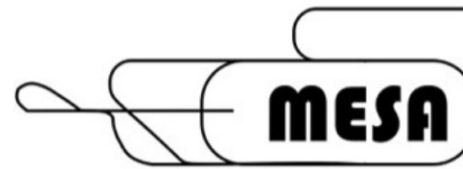


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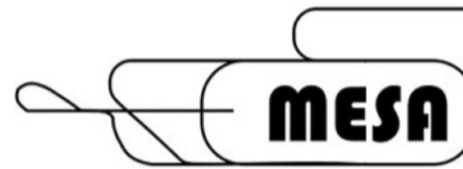
- Additional [detector array](#) for low-energy recoil nuclei
- Mounted [inside the scattering chamber](#) with no material between reaction vertex and detectors
- Individual detectors built from [silicon strip + scintillation detectors](#)
- Important for studying reactions like $^{12}\text{C}(\alpha, \gamma)^{16}\text{O}$

Summary



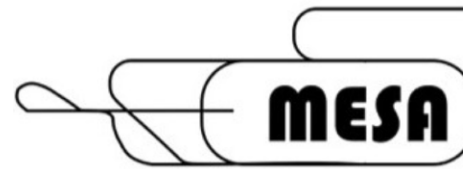
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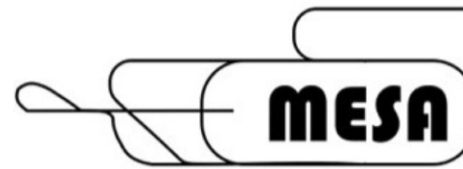
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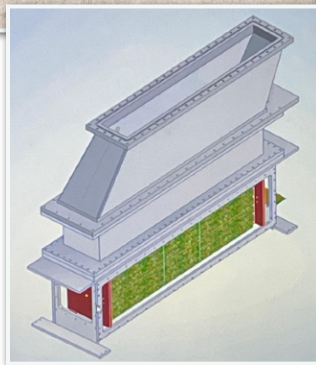
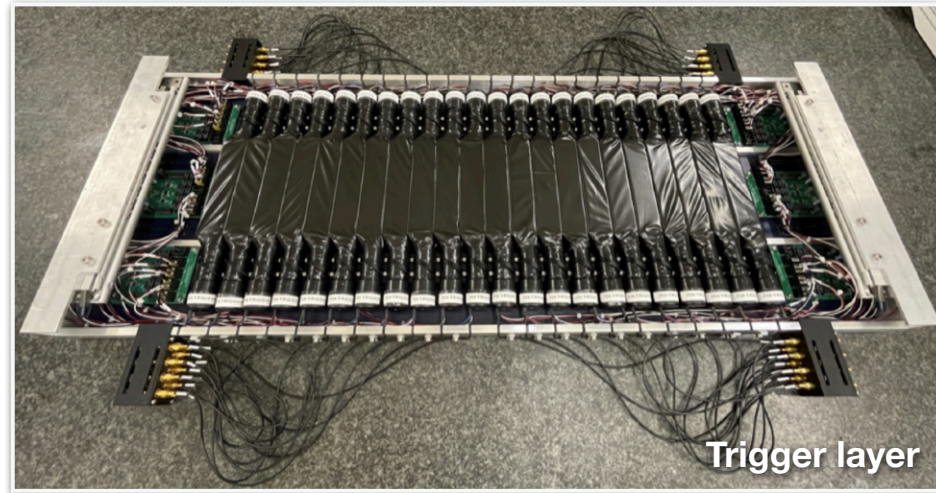
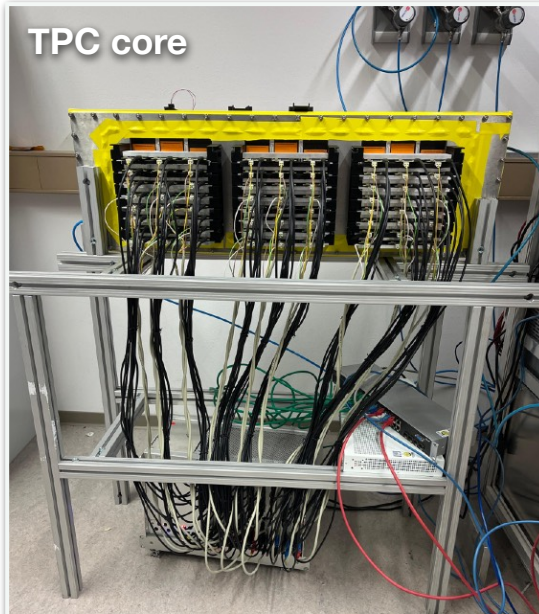
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Summary



- The low-energy, high-intensity electron accelerator MESA is currently being built and the first beam is expected towards the end of 2026
- MAGIX is a multi-purpose electron scattering experiment that will be operated in MESA's ERL mode; MAGIX is designed for a rich physics program in nuclear, hadron, and particle physics
- The MAGIX setup minimizes background contributions by using a completely windowless design and an internal gas jet target
- The focal plane detectors of MAGIX encompass the MAGIX TPC for tracking and the MAGIX trigger veto system for triggering and PID; additional recoil detectors will be installed inside the scattering chamber

Impressions.



Impressions.



Thanks for your attention!

Contact

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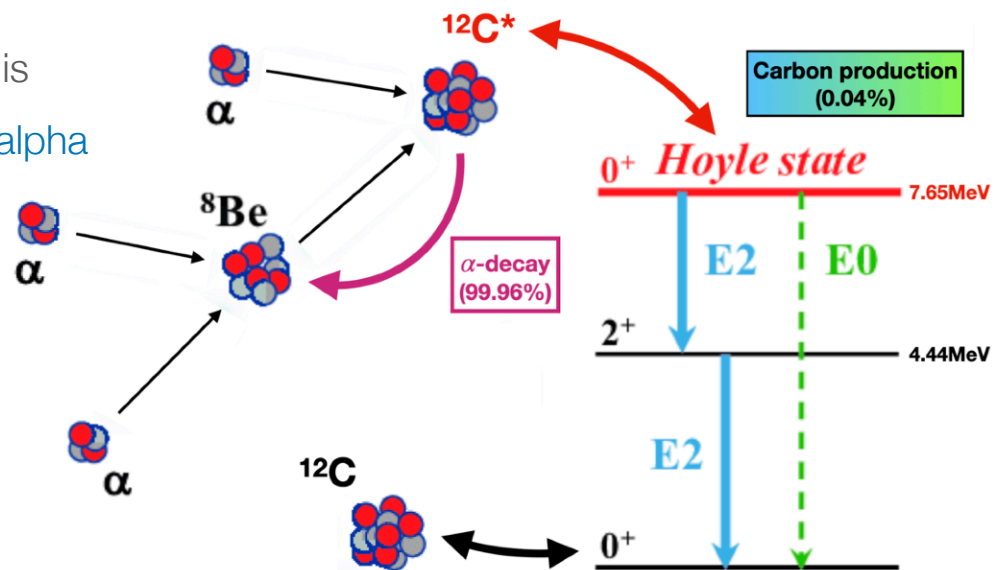
**Backup
slides.**

The first measurement at MAGIX.

- MAGIX can also be operated in MESA's EB mode, and during MESA's commissioning phase, this is even without an alternative
- But: We can do interesting physics already at this stage, integrated with setup commissioning and calibration

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