

HPPT: High-power targets for parity-violating electron scattering

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JGU Mainz

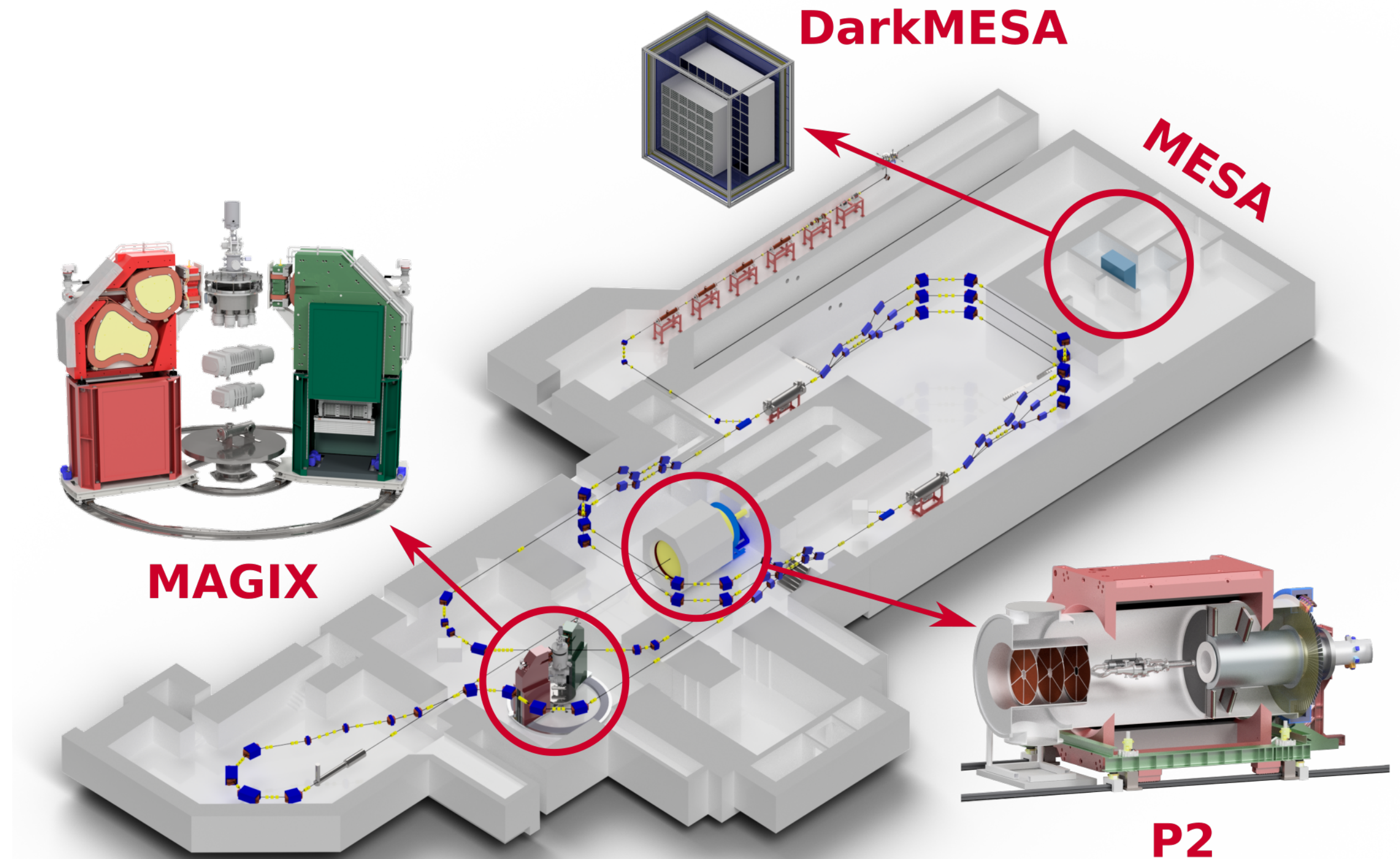
Hadron Physics in Horizon Europe

Town meeting

July 1-3, 2025

Mainz Energy-Recovery Superconducting Accelerator (MESA)

- Under construction in Mainz
- Broad hadronic physics program driven by international collaborations

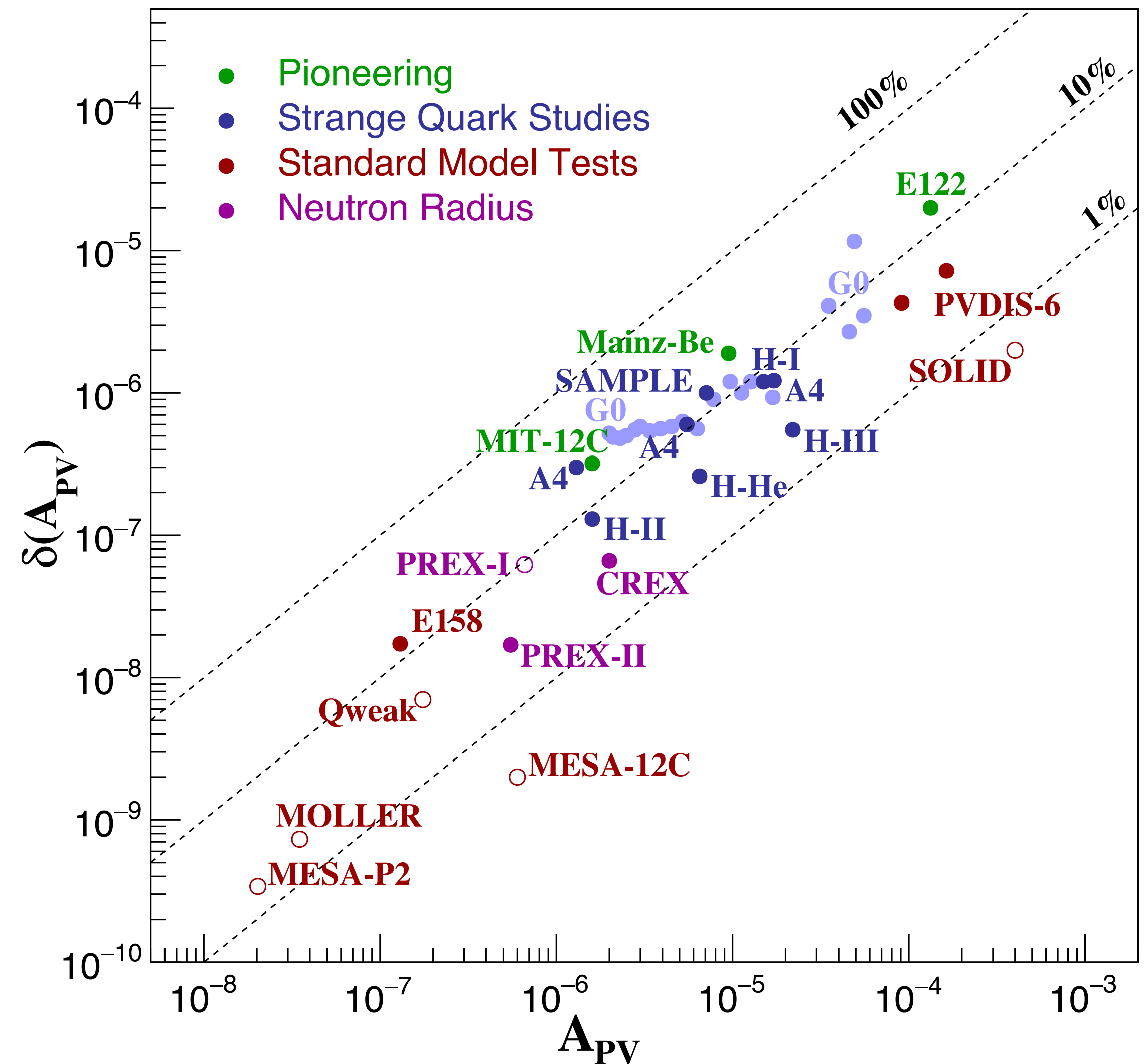


Parity-violating electron scattering fundamental element of physics programs at MESA and beyond

- Measure parity-violating asymmetry:

$$A_{PV} = \frac{\sigma_L - \sigma_R}{\sigma_L + \sigma_R}$$

- Well-established technique employed at JLab, MAMI/MESA, S-DALINAC...
- Far-reaching physics impact, including:
 - Weak charge of e^- , p , ^{12}C (precision SM tests)
 - Nuclear weak form factor (nuclear EoS, corrections for V_{ud} from β -decay)
 - Novel probes of QCD (parton distribution functions, higher-twist effects) with PVDIS
 - Multi-photon exchange

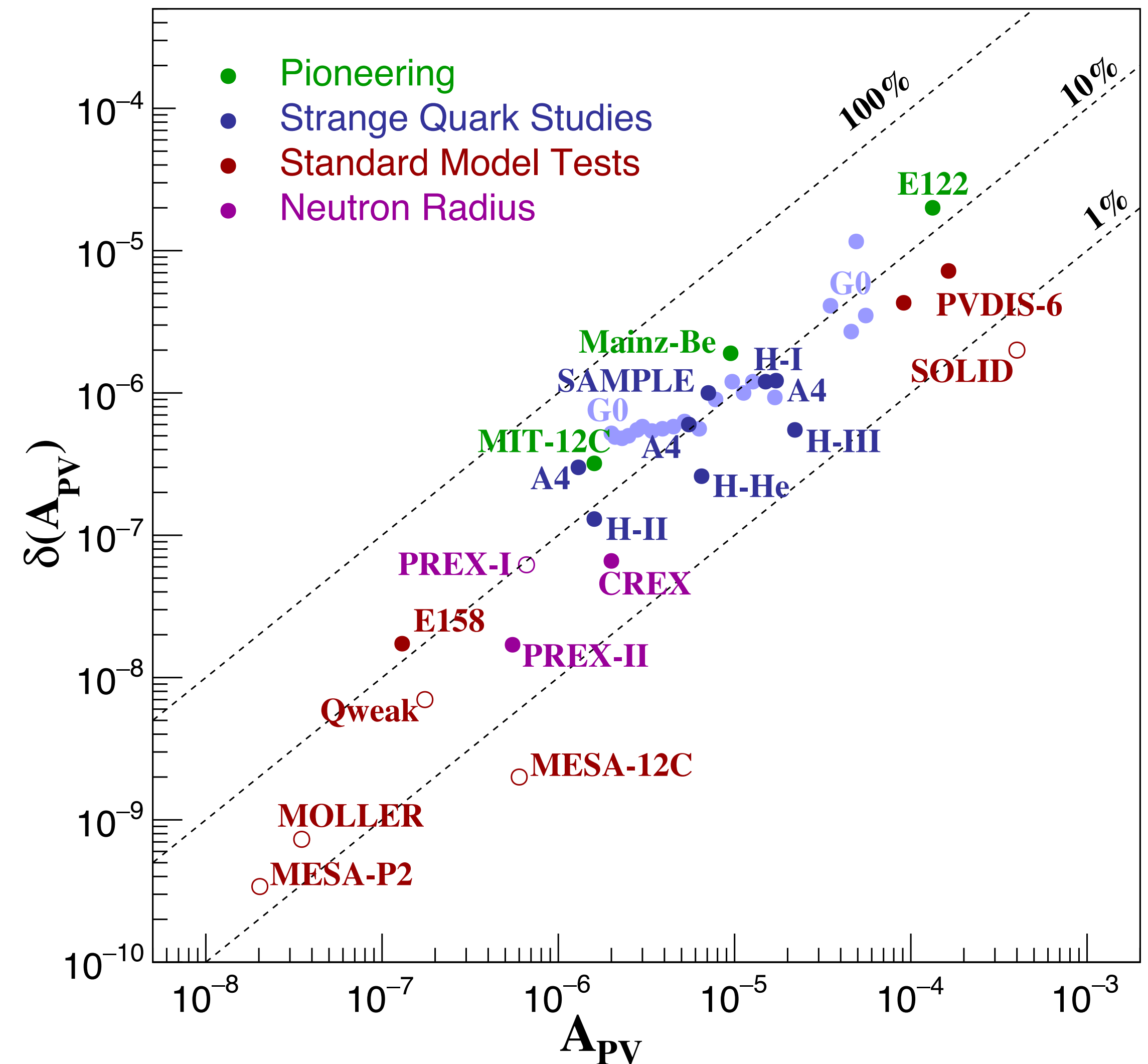


Parity-violating electron scattering fundamental element of physics programs at MESA and beyond

- Measure parity-violating asymmetry:

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- History of PVES: continuous improvement in accelerator and detector technology
- State of the art: *sub-ppb* statistical reach and systematic control



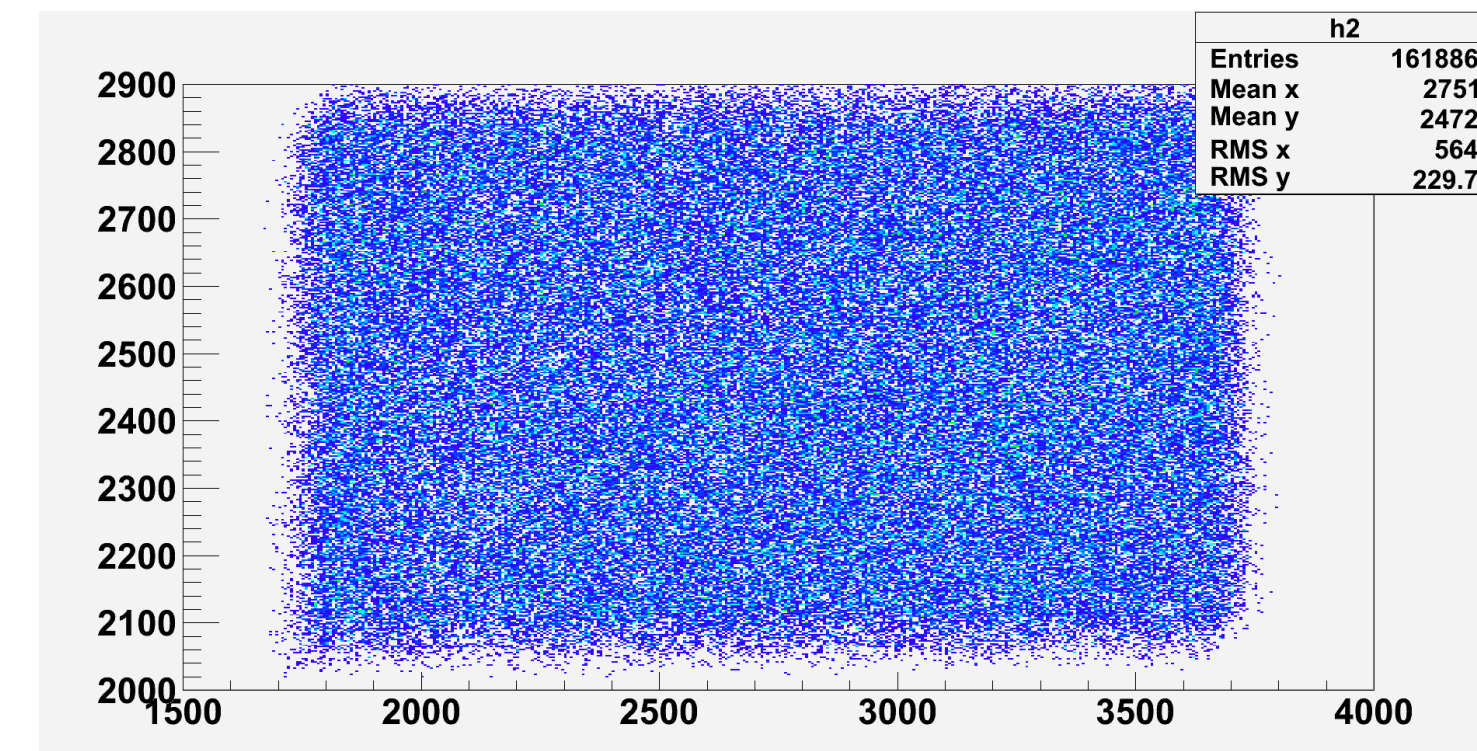
Challenges in the precision frontier...

- Sub-ppb precision requires enormous statistics (up to 10^{20} events)
- Need to push limits of experimental rate...
higher beam currents, thicker targets
- Large power deposition (up to several kW) can quickly lead to target instability, degradation

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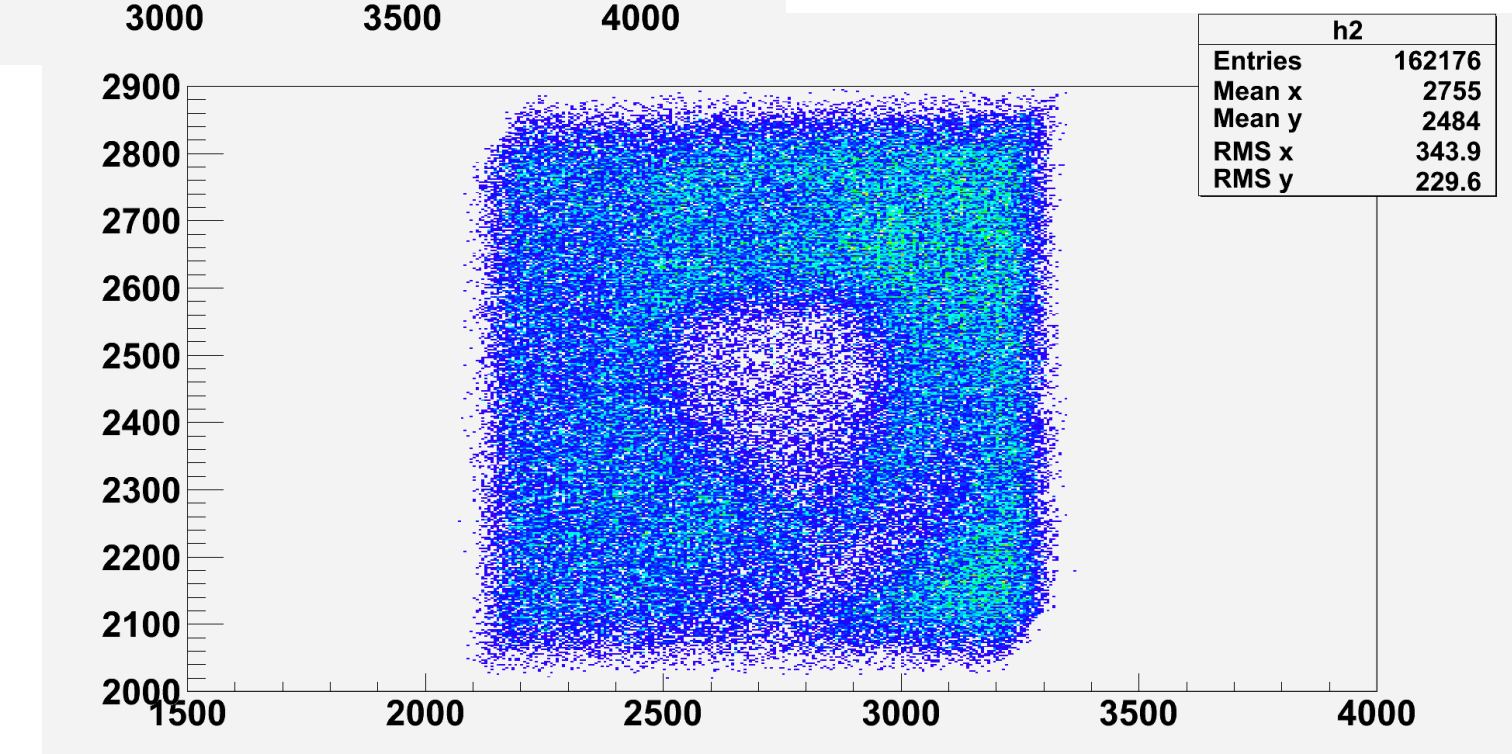
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From PREX at JLab



New ^{208}Pb target

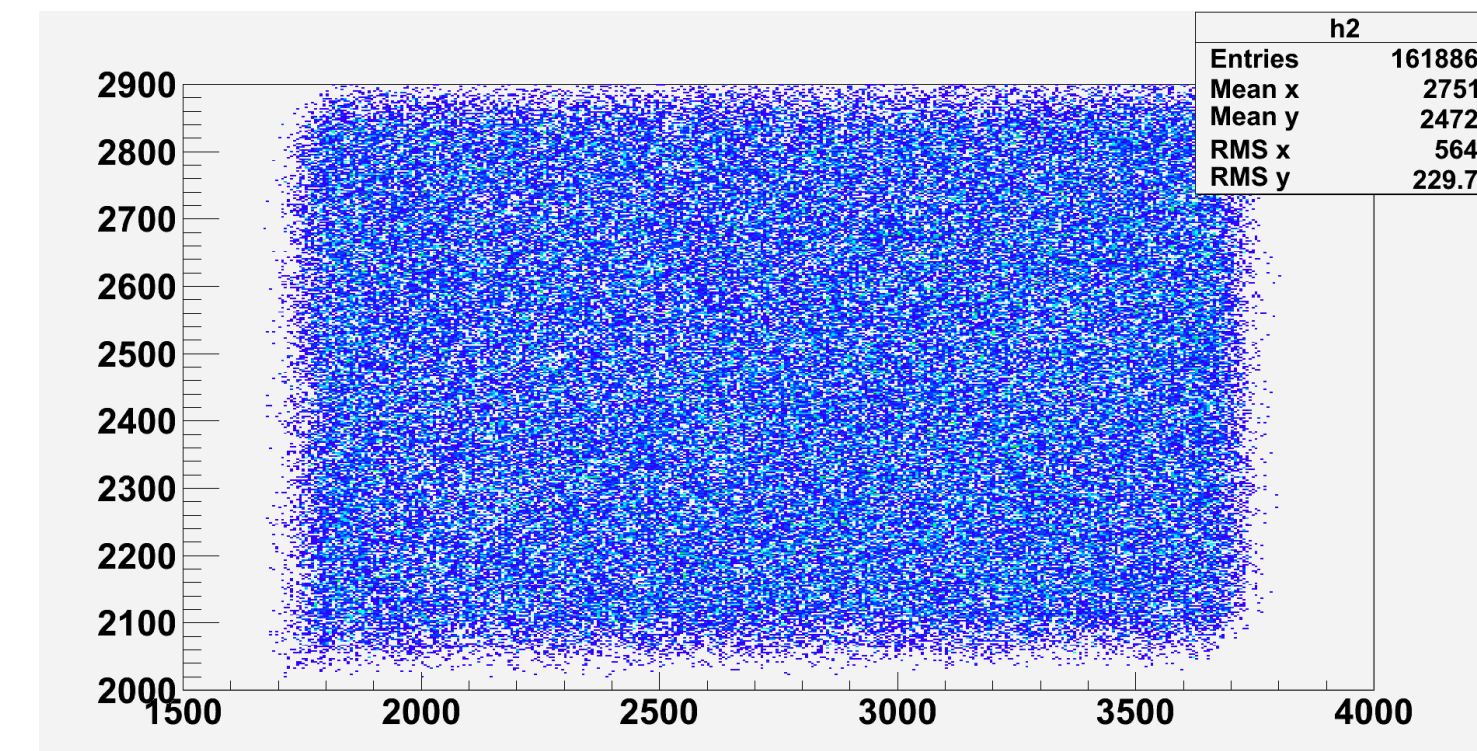
After 1 week at $70\ \mu\text{A}$



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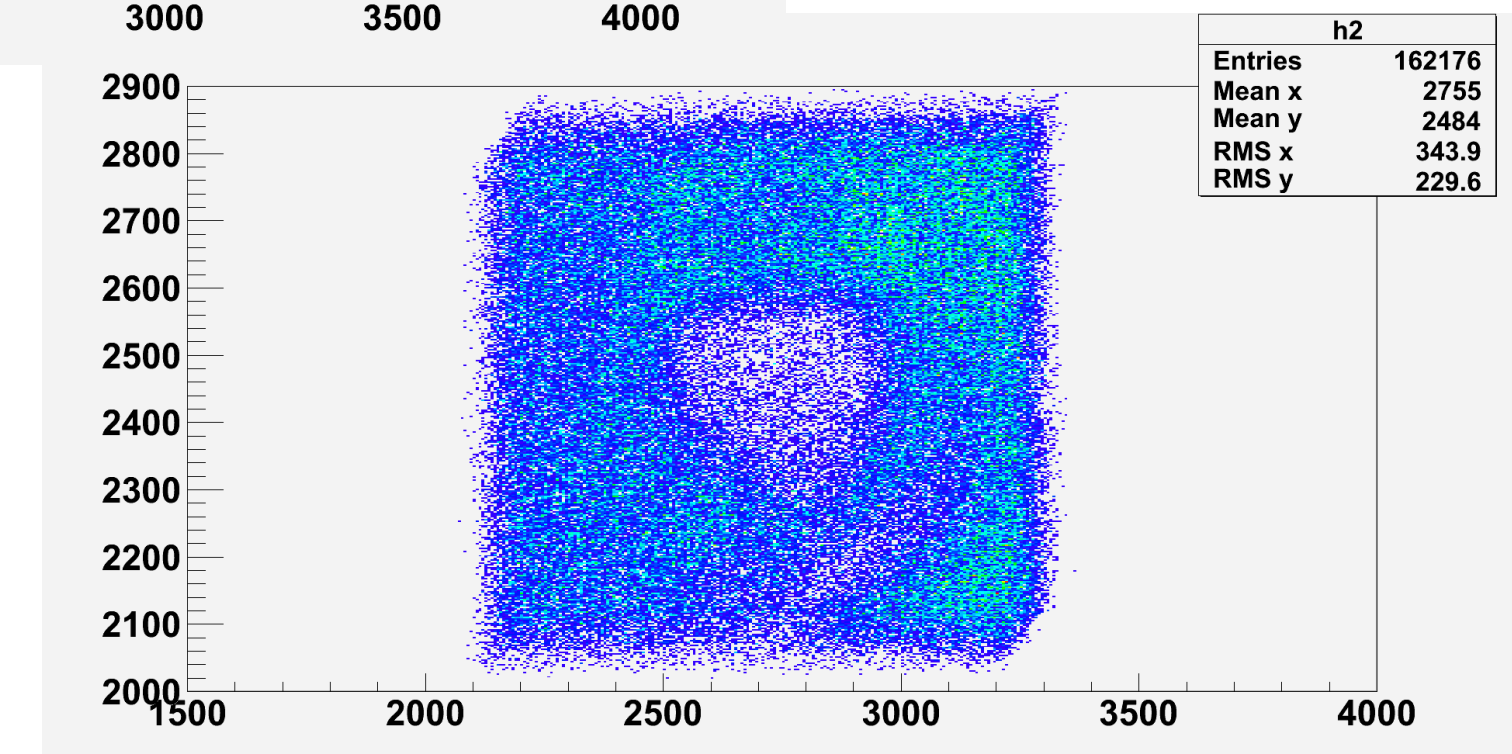
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- *Implementing methods to mitigate these effects is critical!*

From PREX at JLab



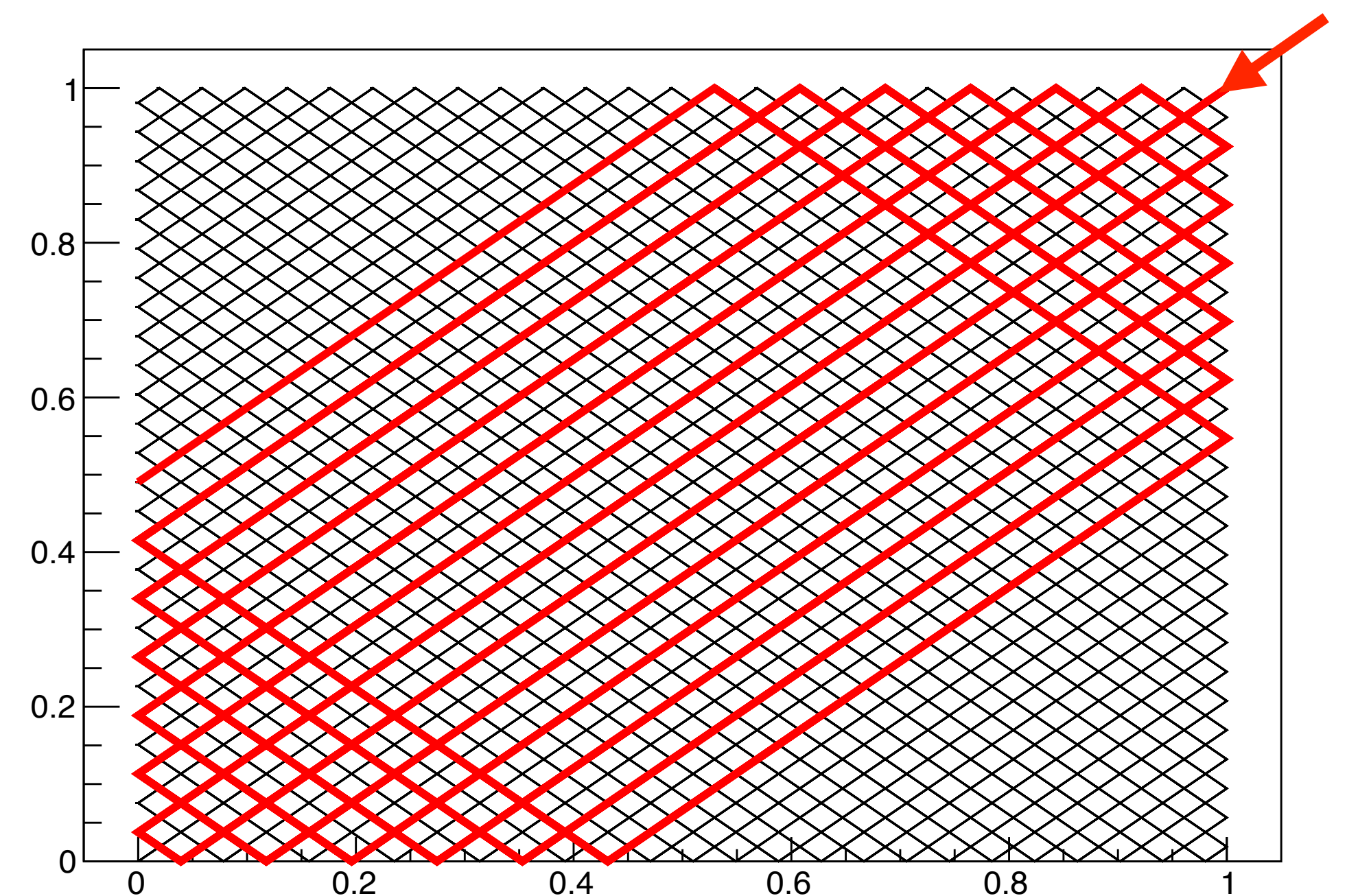
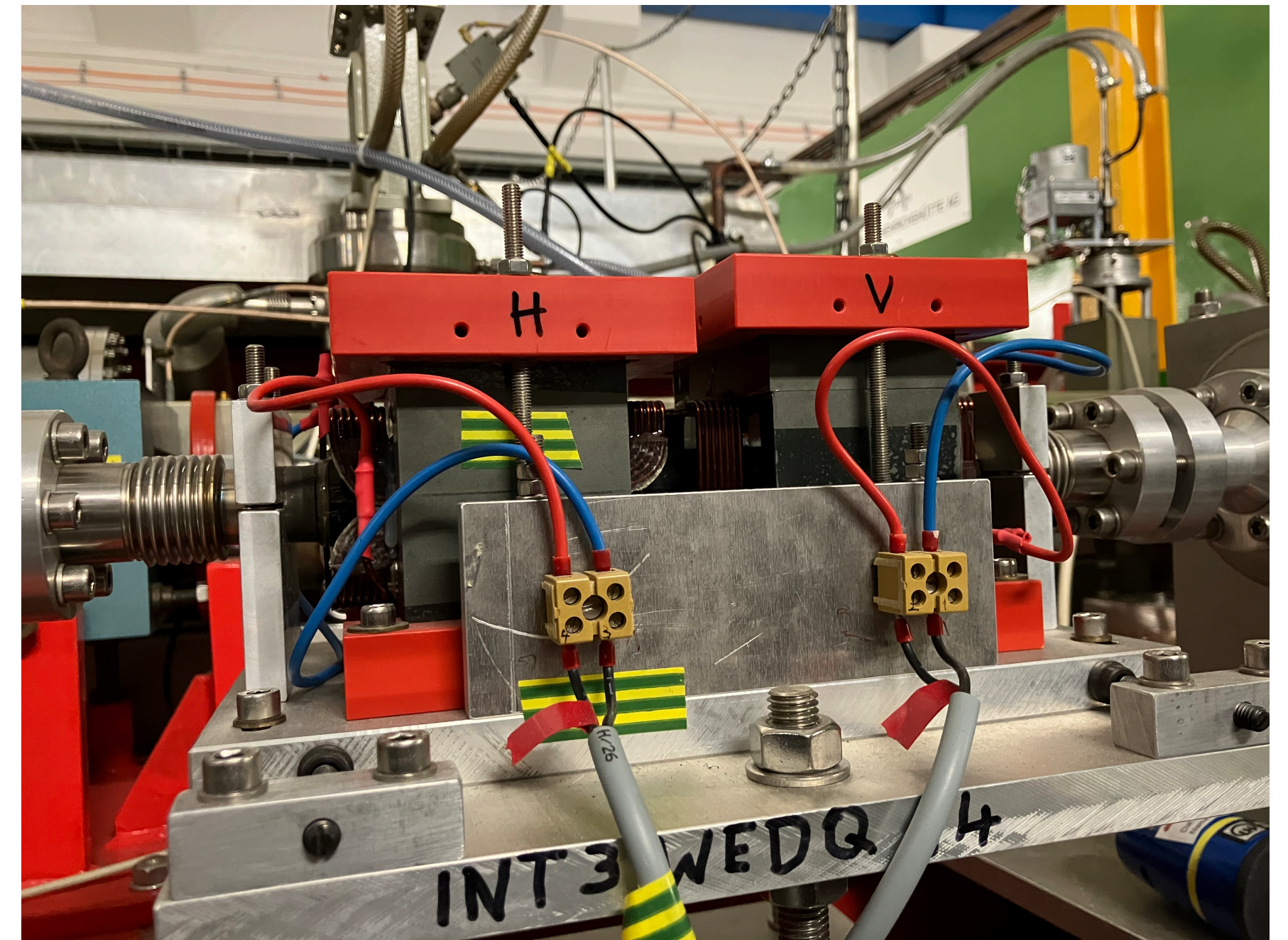
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Beam rastering

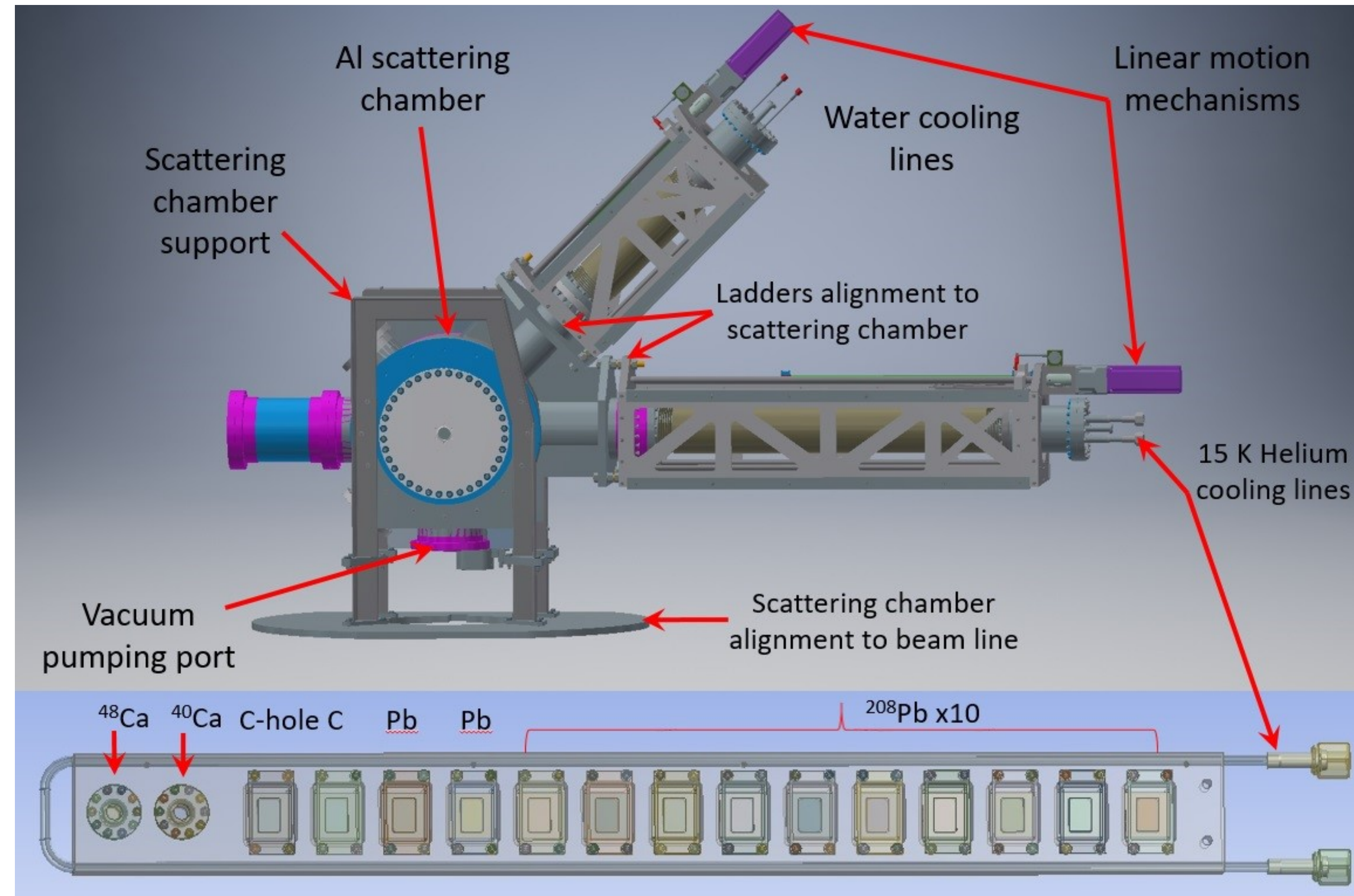
- Fast-steering magnets raster beam on target
 - Distributes power, reducing target degradation
 - *Must be carefully synchronized with beam helicity to reduce systematics!*
-
- Implemented at JLab, MAMI
 - Rastering system for MESA required to support parity program



Multi-purpose cooled systems for solid targets

- Solid target requirements:
 - Cooled frame (different nuclear targets have different cooling requirements)
 - Multiple target windows (redundancy, calibration/systematic studies)
 - Special considerations, e.g. magnesium targets must deal with oxidation, fire hazard
- Flexible target systems support efficient execution of diverse physics program

Example: PREX-II at JLab



Proposed program

Objectives:

- Develop and construct a beam raster to support parity program at MESA
- Develop target ladder suitable for PVES measurements on magnesium (V_{ud} corrections)
- Take advantage of existing expertise at JLab!

Partner institutions:

Johannes Gutenberg-Universität Mainz

Helmholtz-Institute Mainz

IRFU CEA-Saclay

University of Massachusetts Amherst

University of Manitoba

Jefferson Laboratory

Requested resources:

1 PhD student for 3 years (180.000 EUR)

0,5 postdoc for 3 years (120.000 EUR)

10.000 EUR for travel to JLab

Direct cost: 310.000 EUR

Total cost: 387.500 EUR