Absolute Beam Monitor

Prototype Development and Testing

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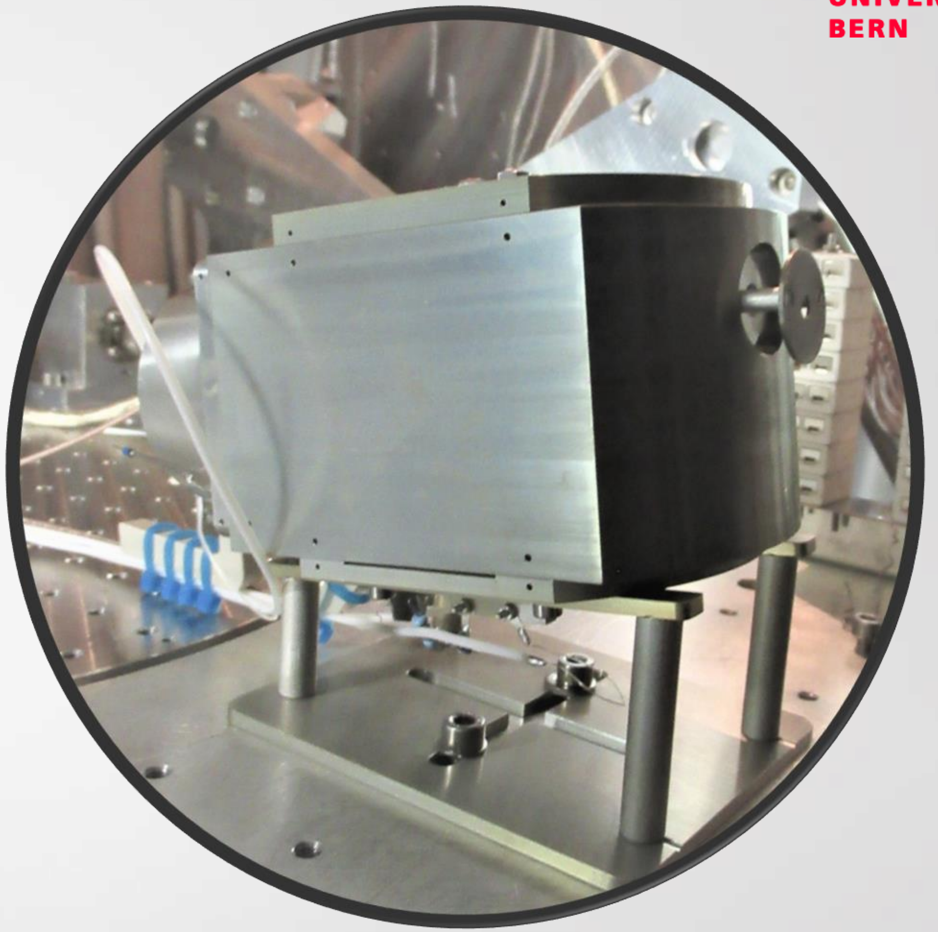
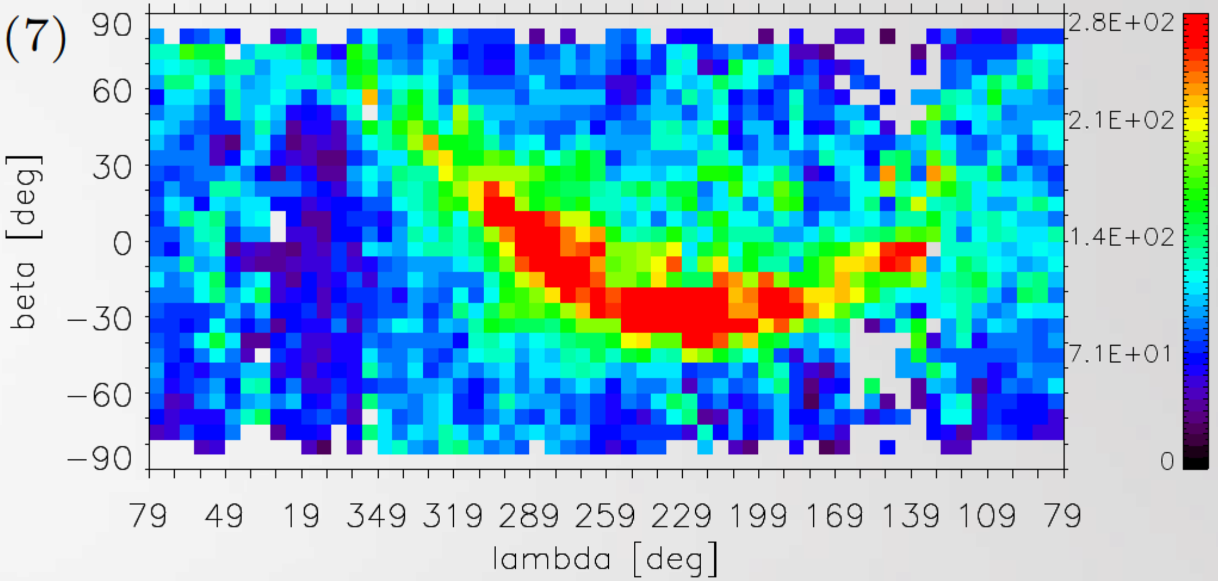


Motivation: Energetic Neutral Atoms

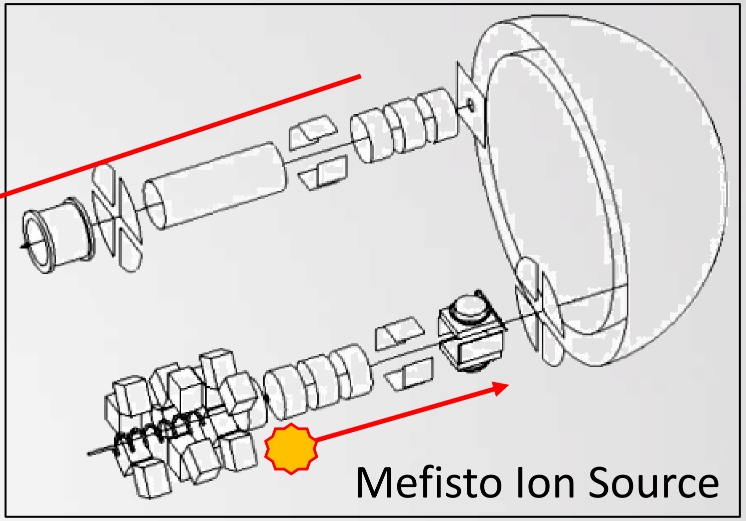
- ENA camera to measure heliospheric ENA's and ISN
    - IBEX-Lo / -Hi
    - **IMAP-Lo**
- MEFISTO: calibration facility for low-energetic neutral particle detectors at UniBe
- Objective:
    - Better quantification of neutral beam
    - Measure absolute beam flux and energy distribution



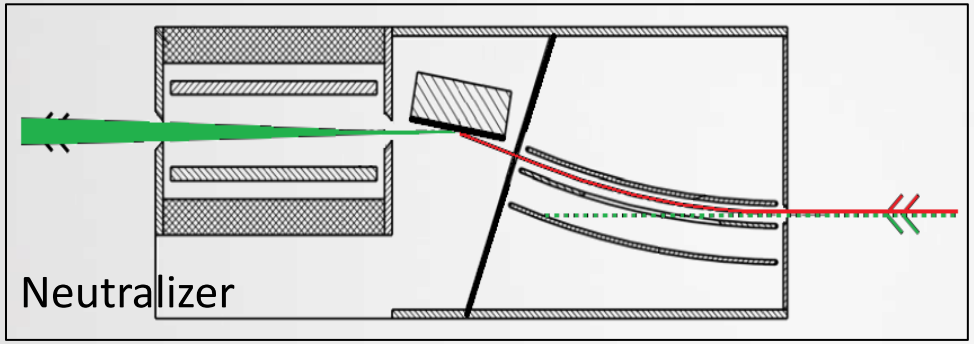
Map of average ENA intensity, measured by IBEX-Lo energy bin 7.
(Galli et al., ApJ 796:9, 2014)

Instrument Calibration

ions (i⁺)



Marti et al., Rev. Sci. Instr. 72, (2001)

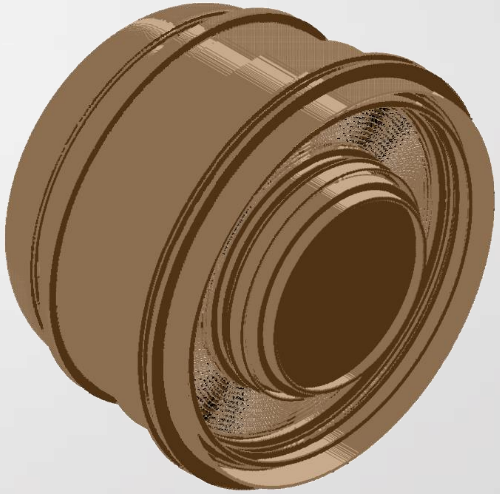


Wieser, Wurz: Meas. Sci. Technol. 16 (2005)

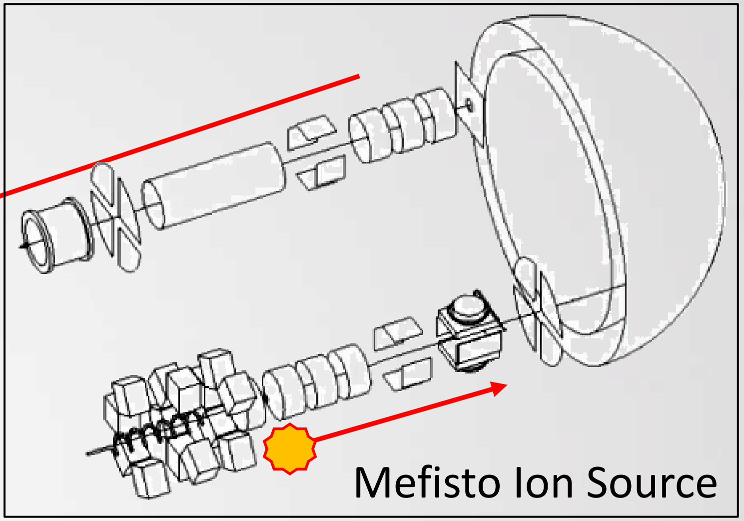
- Testing instrument sensitivity relies on precise knowledge of neutral beam flux

neutrals (n)

ENA Instrument
(e.g. IMAP-Lo)

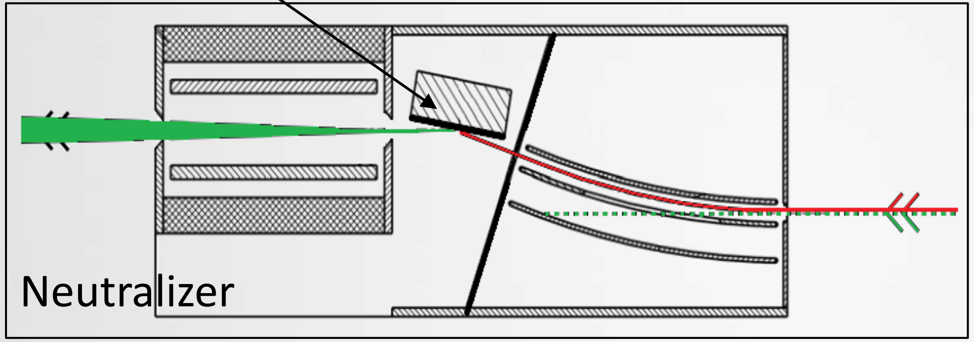


Facility Calibration



Marti et al., Rev. Sci. Instr. 72, (2001)

Conversion Surface (CS)



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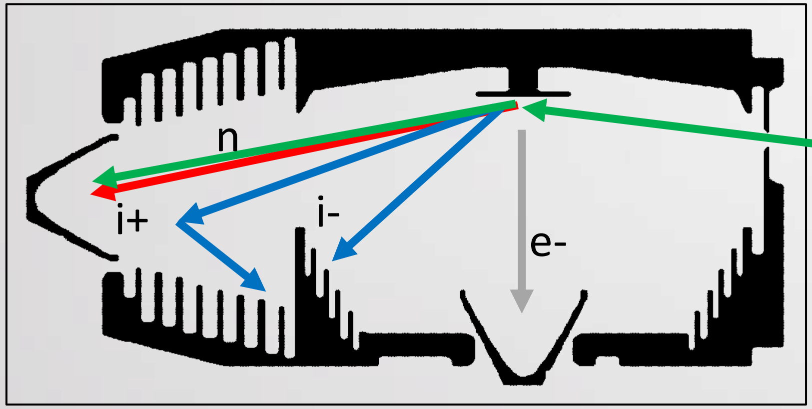


n

Absolute Beam Monitor

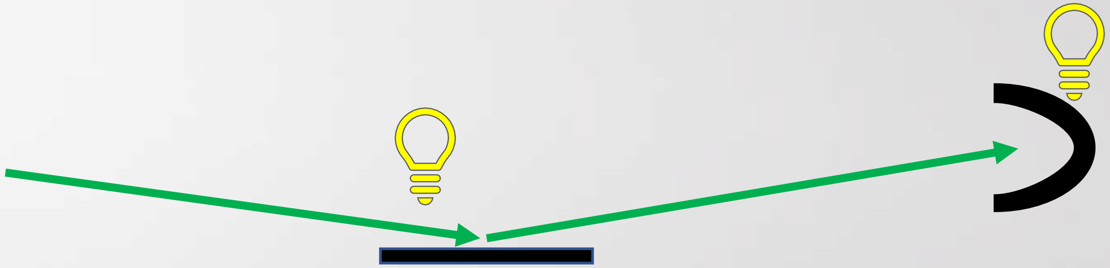
- Use the ABM as a primary standard for the neutral beam
- Gauge the neutral flux to Neutralizer CS current

Questions

- ENA beam characterization
- Absolute neutral particle flux [N cm^{-2} s^{-1}]
  - For neutrals from 10 eV to 3 keV
- Energy and energy distribution of neutrals
  - Determination of energy loss at conversion surface

Measurement Principle

- Neutrals hit a tungsten charge conversion surface (CS) under grazing incidence angle (<10°)
  - Electron release from CS with some probability η_1 → *start signal*
  - Detection of scattered particle with some probability η_2 → *stop signal*
  - Start-Stop coincidence cases: probability $\eta = \eta_1 \cdot \eta_2$
- Infer number of incident Neutrals N from start (e), stop (i) and coincidence (c) counts:
  - $N = \frac{e \cdot i}{c} = (\eta_1 N \cdot \eta_2 N)/\eta_1 \eta_2 N$
- Energy determined by time-of-flight



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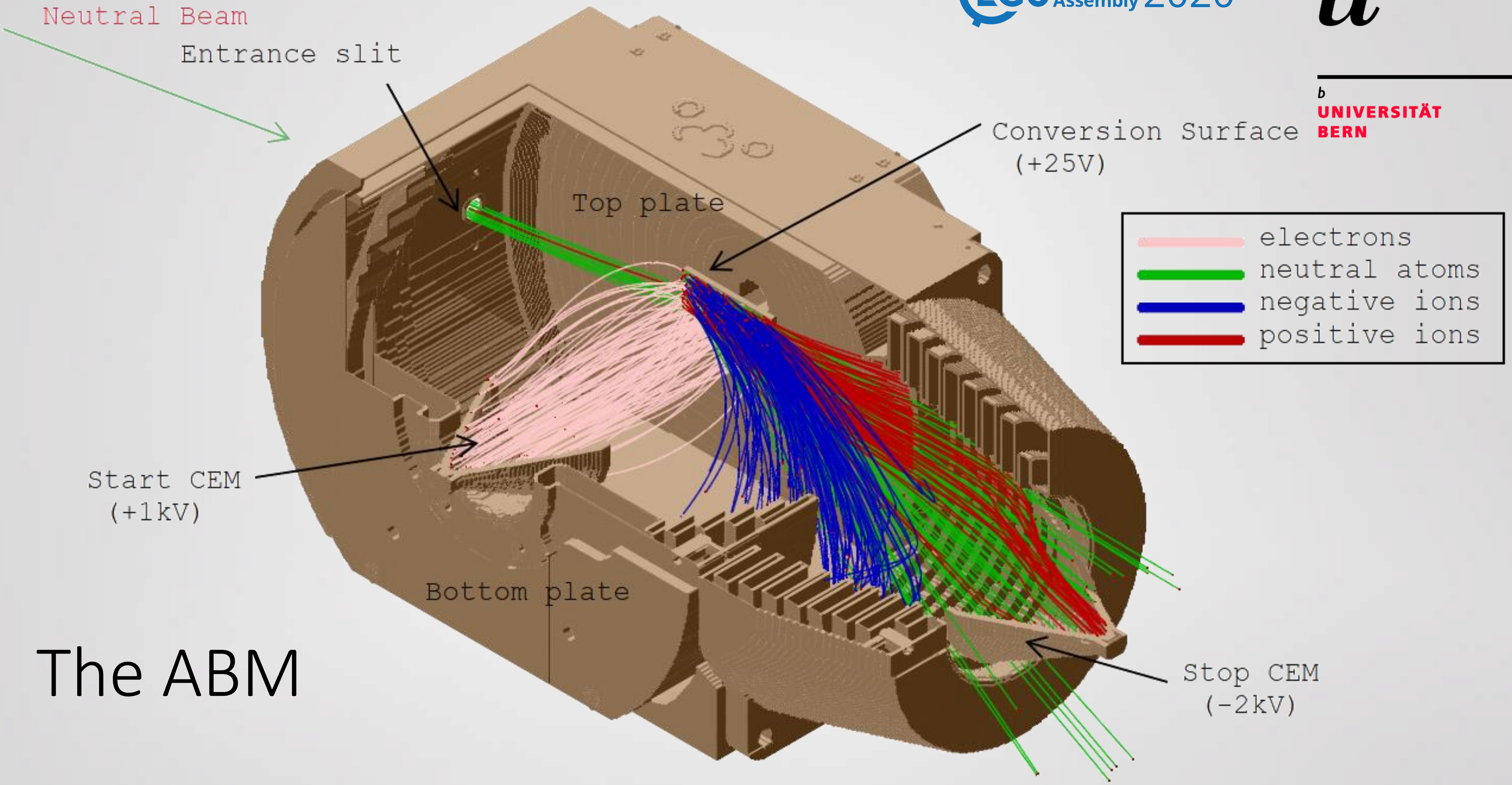
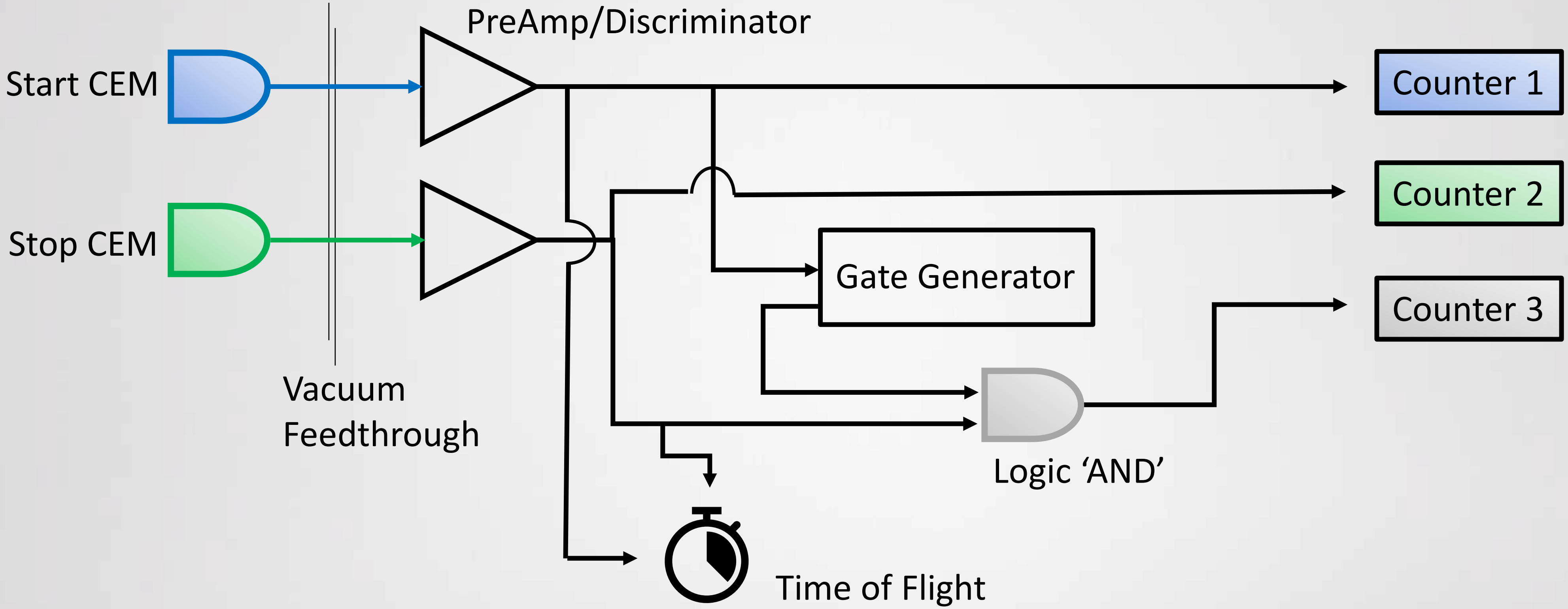
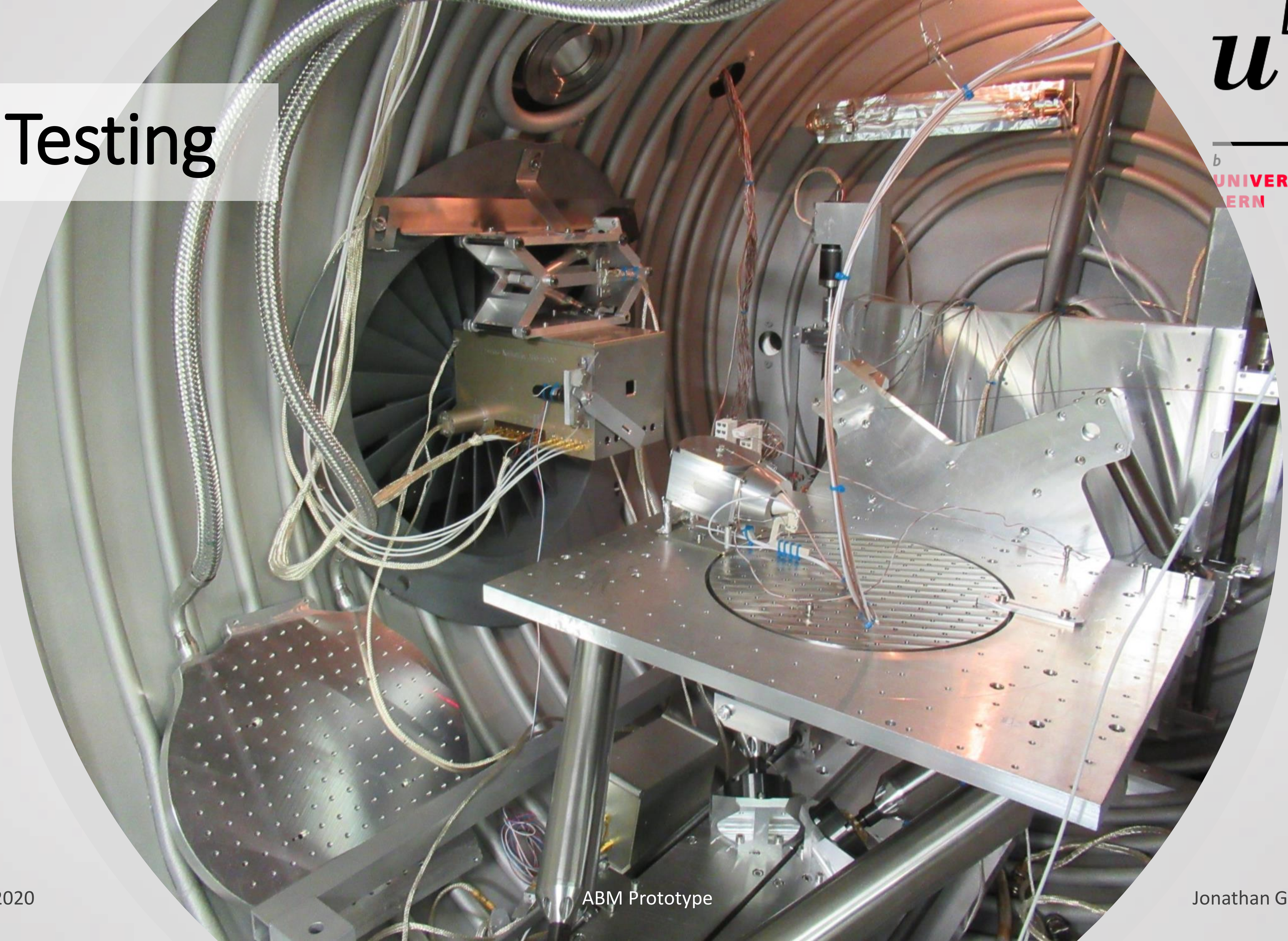
The ABM



Counting Scheme

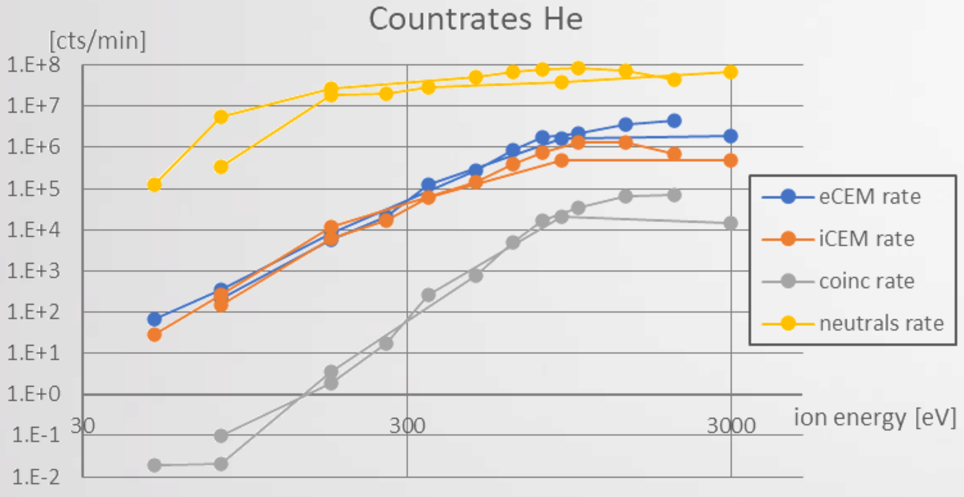


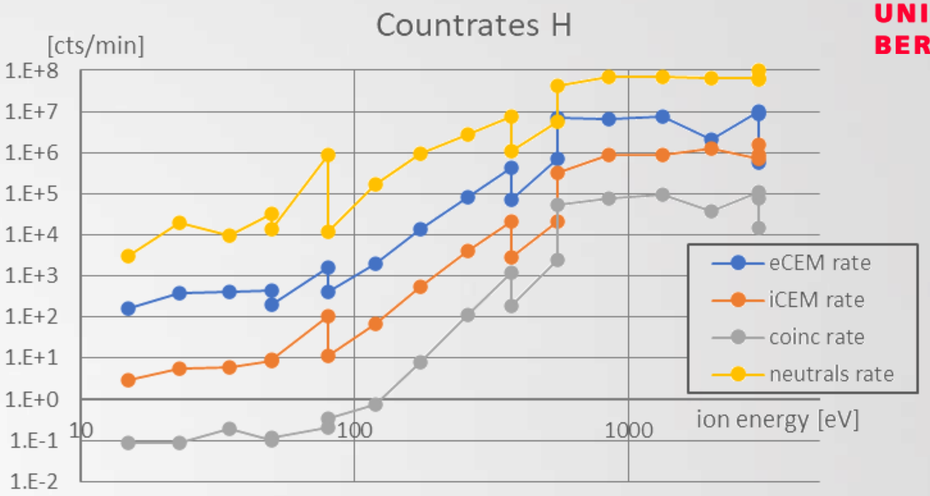
Lab Testing

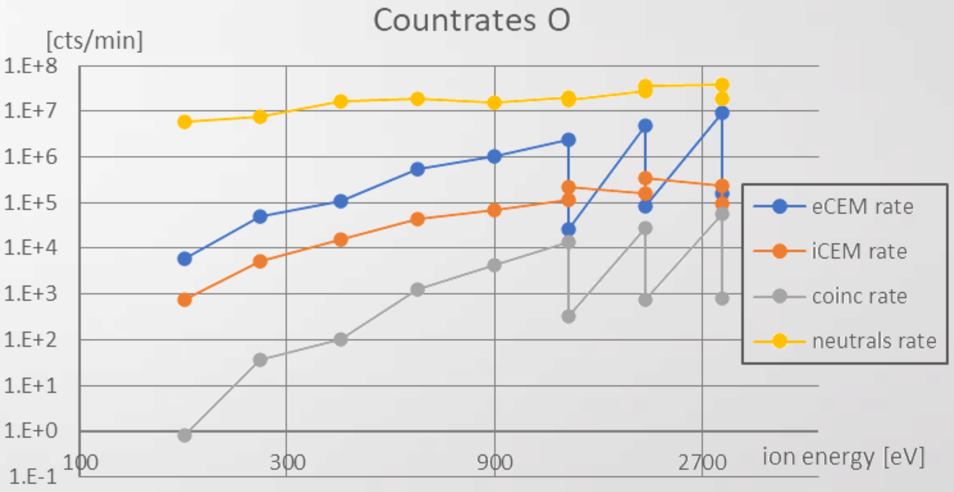


Countrate Measurement

Dark Countrate [cts/min]	
eCEM	3.20 +- 0.021
iCEM	1.40 +- 0.015
coinc	0.0050 +- 0.001

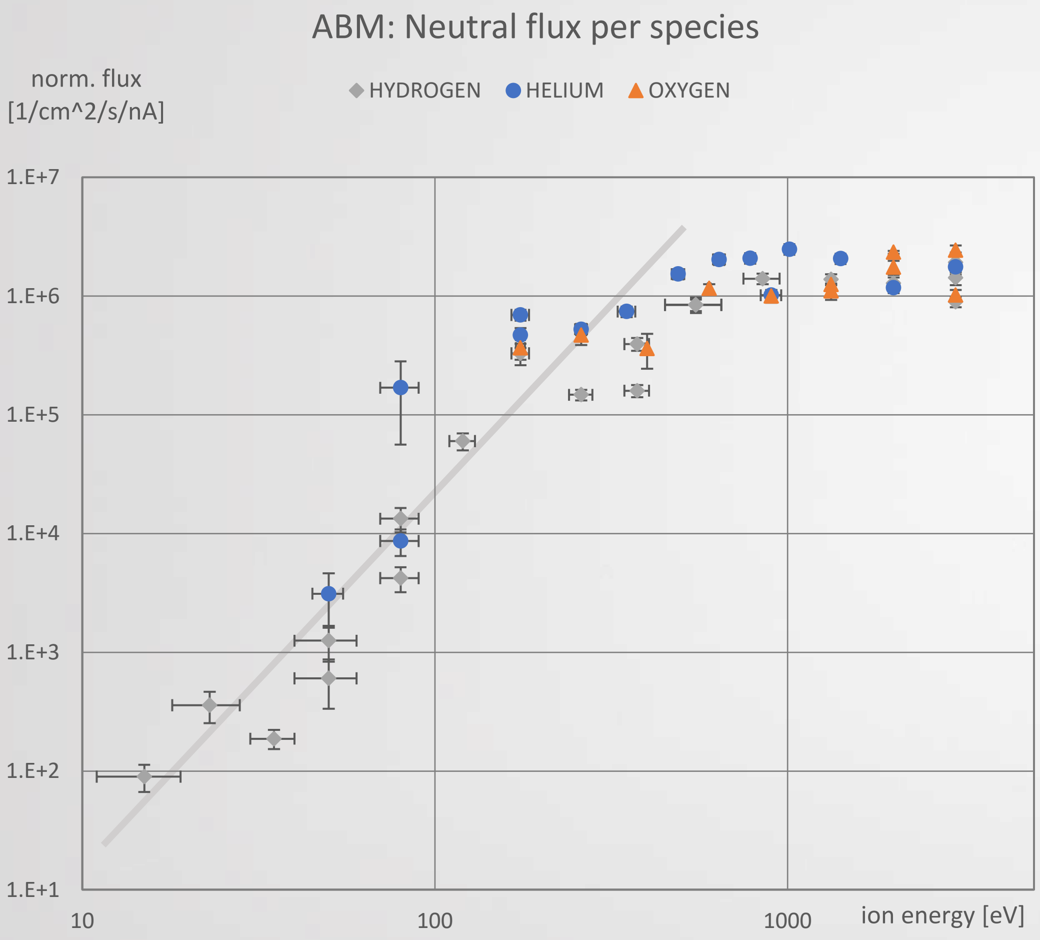






Dark countrates are subtracted from data.

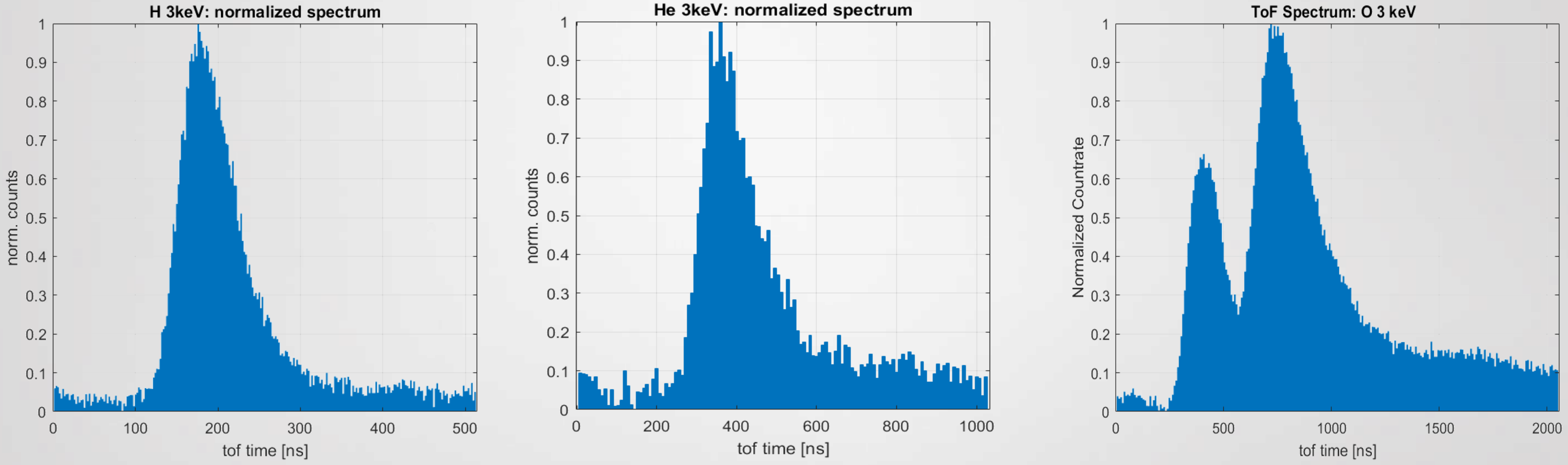
Absolute ENA Flux



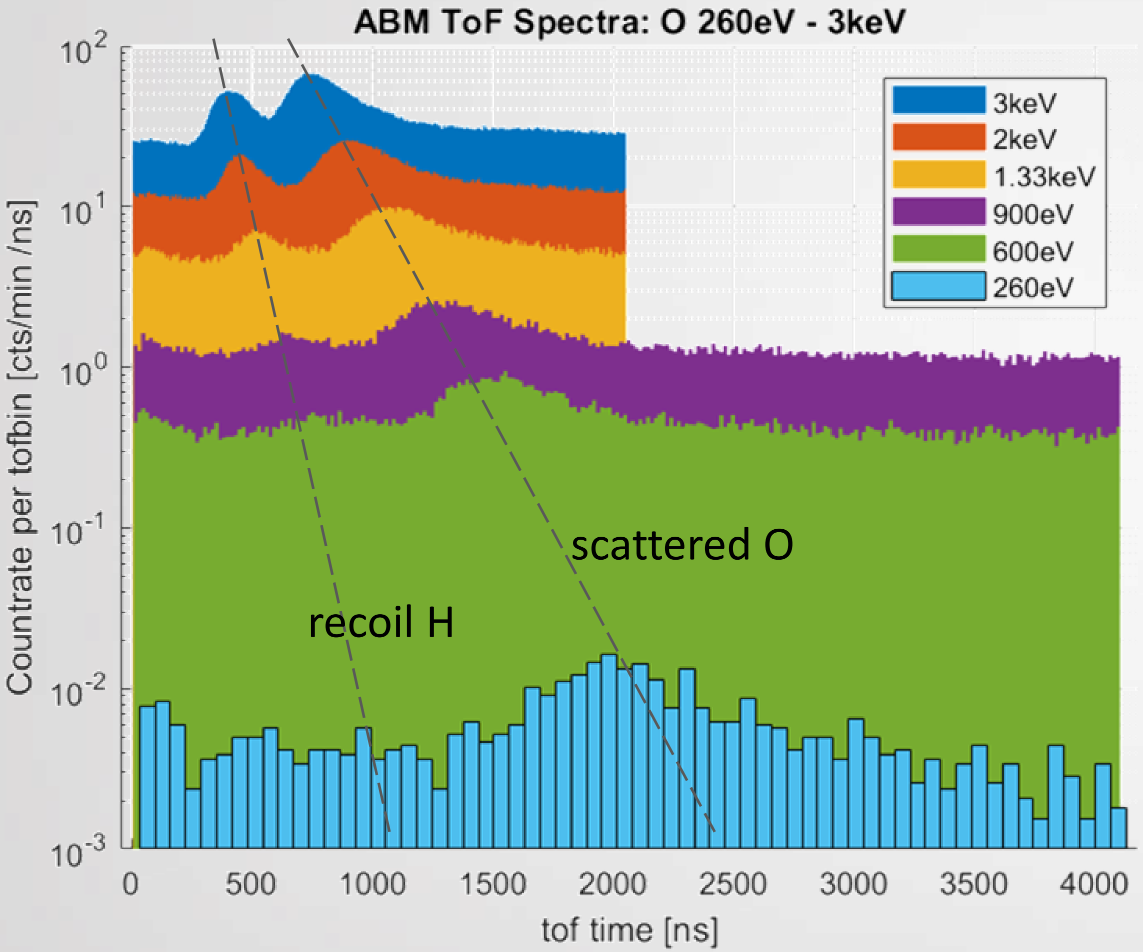
- First data, preliminary results
- ENA flux determined from neutrals countrate and entrance opening
- Flux normalized to ion beam current
- Trend: power law below 500 eV

ToF Spectra at 3 keV

- Flight time scales with atomic mass: $t_{tof} \sim \sqrt{m}$
  (as expected)



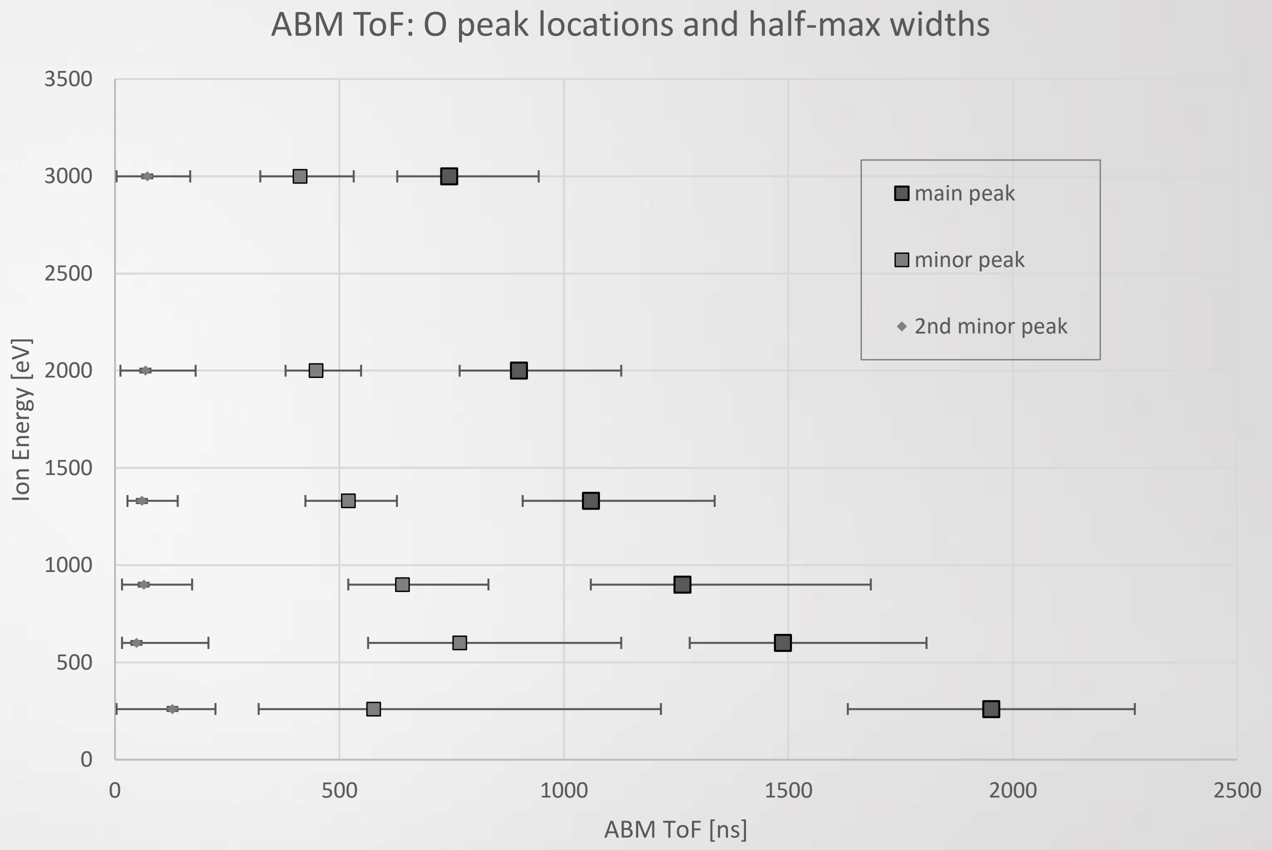
Time-of-Flight Measurement



- ToF spectra example: Oxygen at different energies
- Signal and noise level scale with beam energy
- Main peak: O scattered off the CS
- Recoil peak: sputtered H from water layer on the CS

Time-of-Flight Energies

- Peak location scales as $\sim \frac{1}{\sqrt{E_{ion}}}$ with primary ion beam energy
- Main peak: $\frac{dE}{E} \cong 0.4$
- Recoil peak:
  - Velocity $\frac{v_{H'}}{v_O} = 1.9 \pm 0.1$
  - Compatible with binary collision model expectation $O \rightarrow H$



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Conclusions

- Demonstrated Proof of Principle
  - Measurements down to 30 eV
  - Species: H, He, O
  - ToF energy measurement
- Measured ENA flux: first results (*preliminary*)
- First ToF spectra, retrieved information about energy

Outlook

- Resume ABM Test Series
  - Down to 10 eV
- Evaluate ABM prototype performance
- Characterization of laboratory ENA beam
  - Shape, cross-section, divergence
- Include improved electronics setup
- Work out instrument improvements for next version ABM