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

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


Mefisto Ion Source

ENA Instrument (e.g. IMAP-Lo)
Facility Calibration

- 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 \([N \text{ cm}^{-2} \text{ s}^{-1}]\)
  • 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 $\eta_1 \rightarrow$ start signal
  • Detection of scattered particle with some probability $\eta_2 \rightarrow$ 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
The ABM

Neutral Beam
Entrance slit

Conversion Surface
(+25V)

Start CEM
(+1kV)

Top plate

Bottom plate

Stop CEM
(-2kV)
Counting Scheme

Start CEM

PreAmp/Discriminator

Gate Generator

Logic ‘AND’

Time of Flight

Stop CEM

Vacuum Feedthrough

Counter 1

Counter 2

Counter 3
Lab Testing
Countrate Measurement

<table>
<thead>
<tr>
<th>Dark Countrate [cts/min]</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>eCEM</td>
<td>3.20 +- 0.021</td>
</tr>
<tr>
<td>iCEM</td>
<td>1.40 +- 0.015</td>
</tr>
<tr>
<td>coinc</td>
<td>0.0050 +- 0.001</td>
</tr>
</tbody>
</table>

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
  \[ \sim \frac{1}{\sqrt{E_{\text{ion}}}} \]
  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 \( O \rightarrow H \)
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