Improving the MTOF instrument function

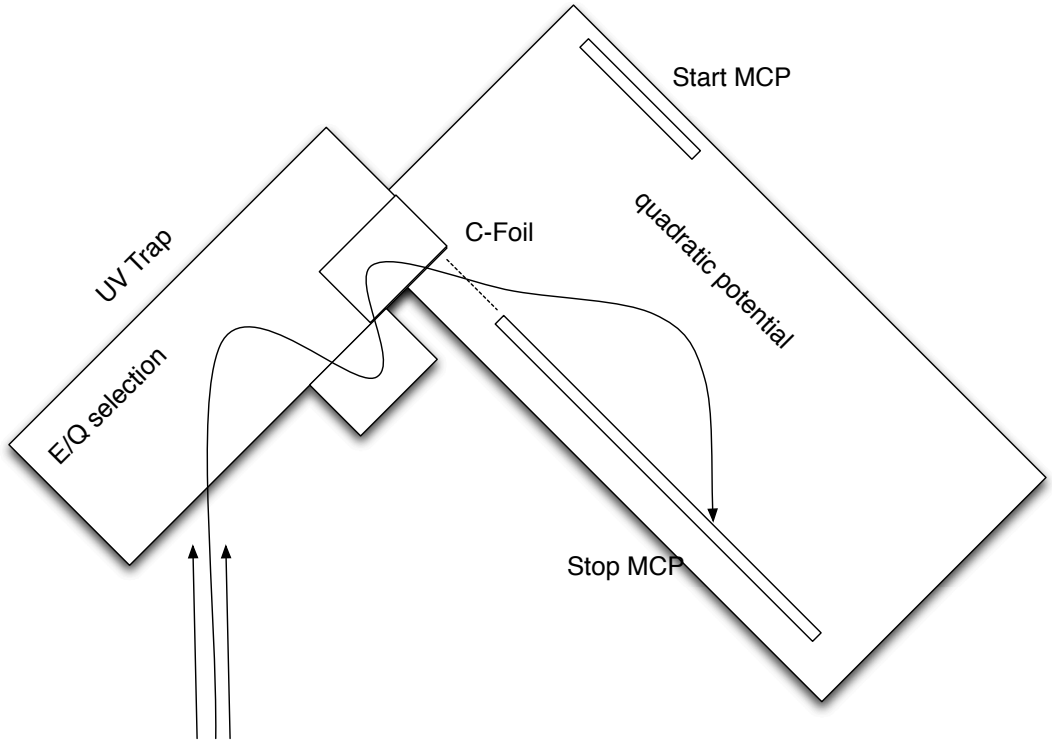
Verena Heidrich-Meisner

August 28th, 2014

Outline

MTOF measurement principle

- Mass Time of Flight spectrometer
- intention: high mass resolution for the price of energy information
- measure: solar wind ions (He < ... $\sim$ Fe) with energies $0.1 keV/amu \ldots 5 keV/amu$
- entrance system relies on same principle as in CTOF



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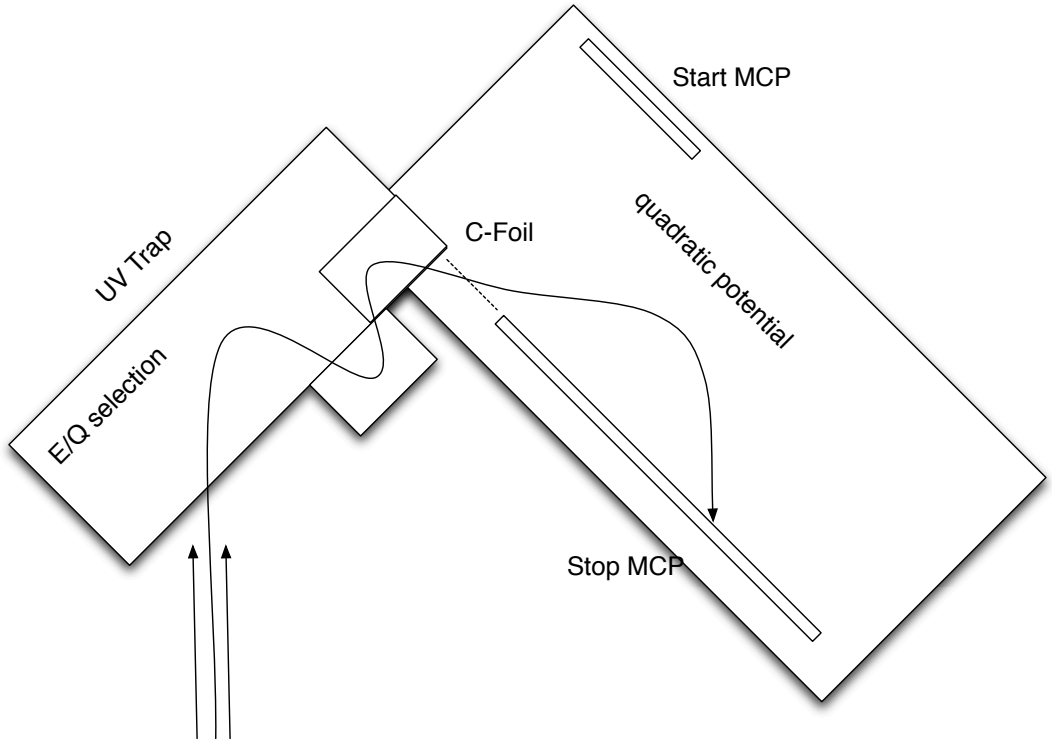

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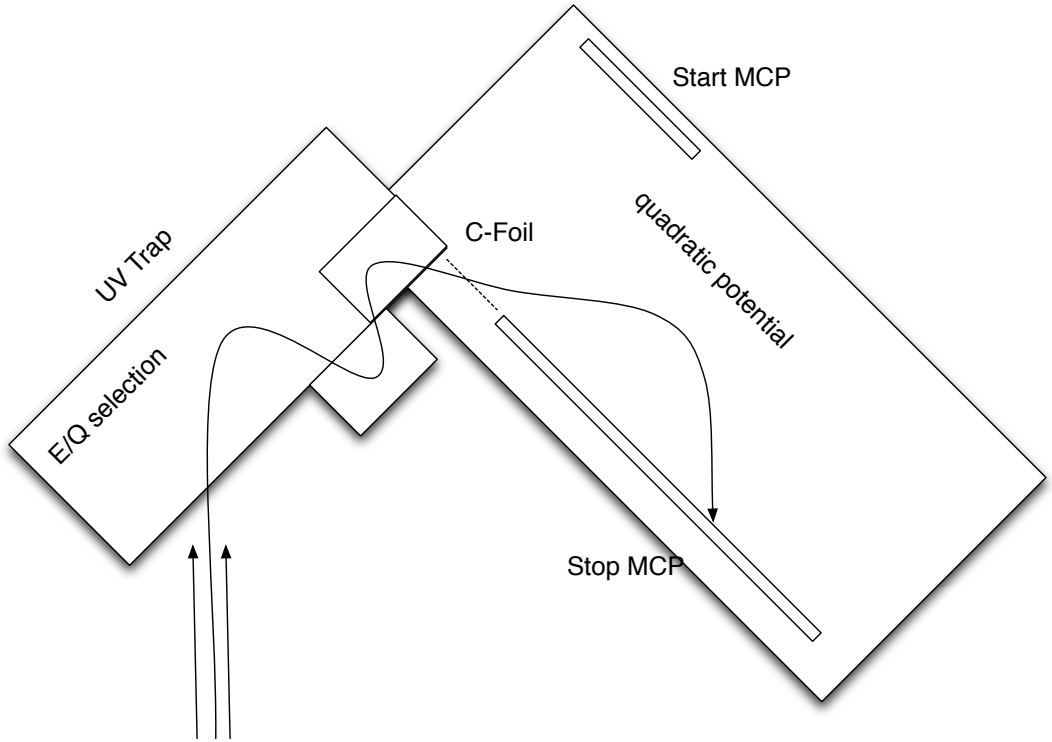

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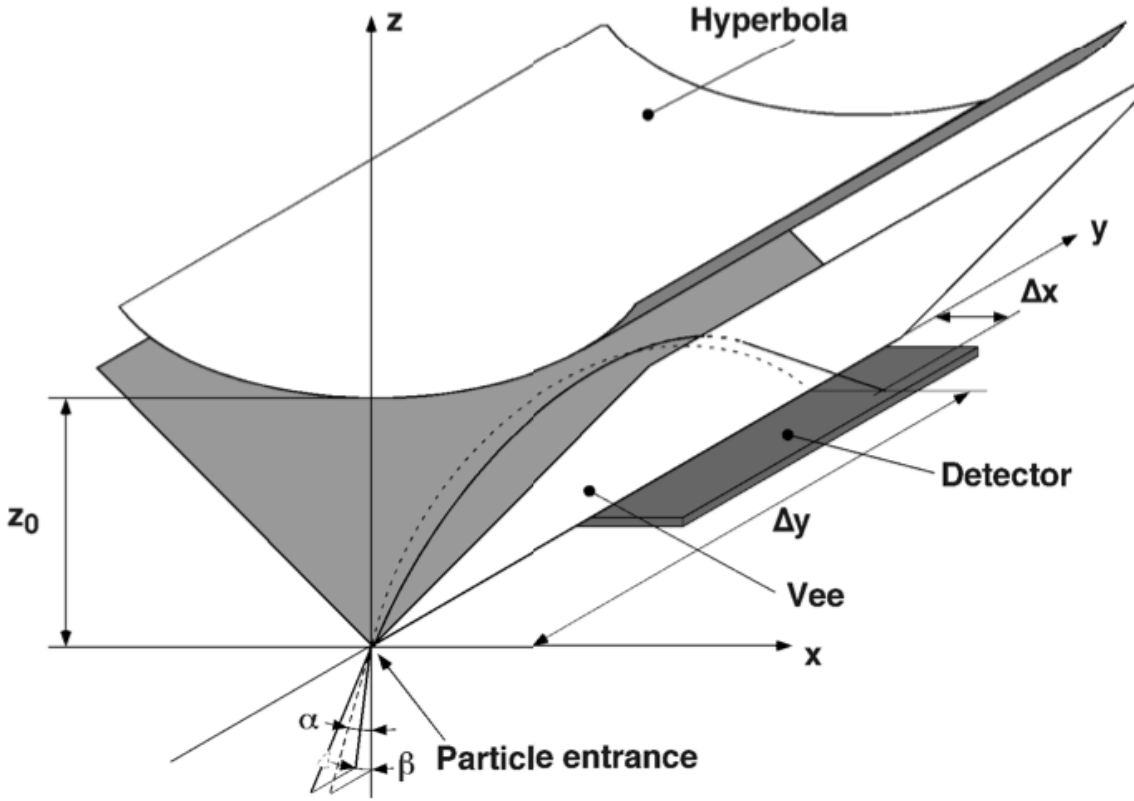

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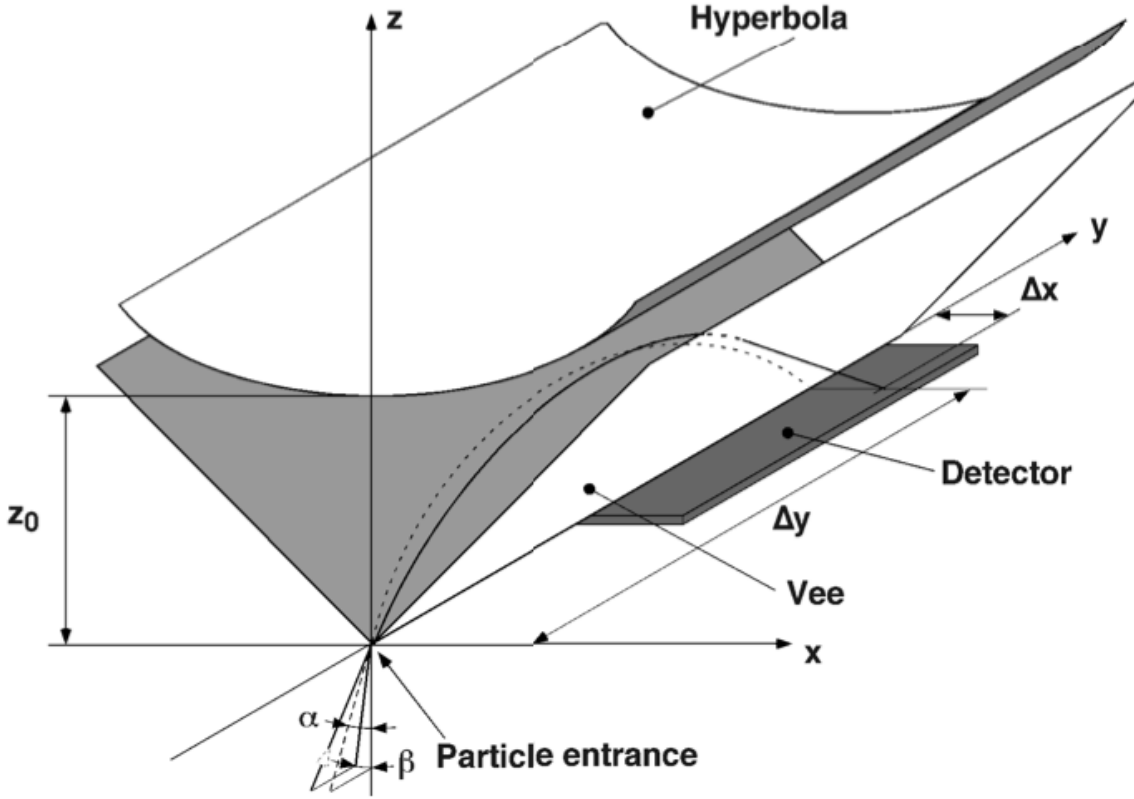

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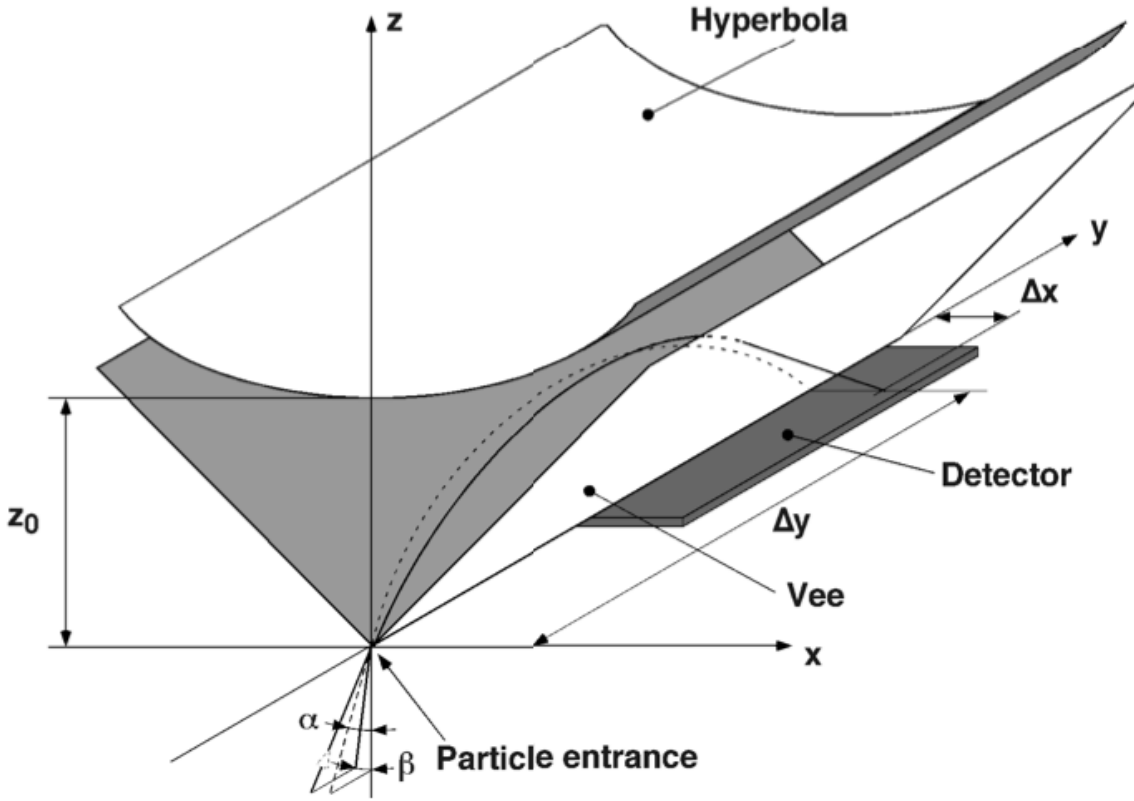
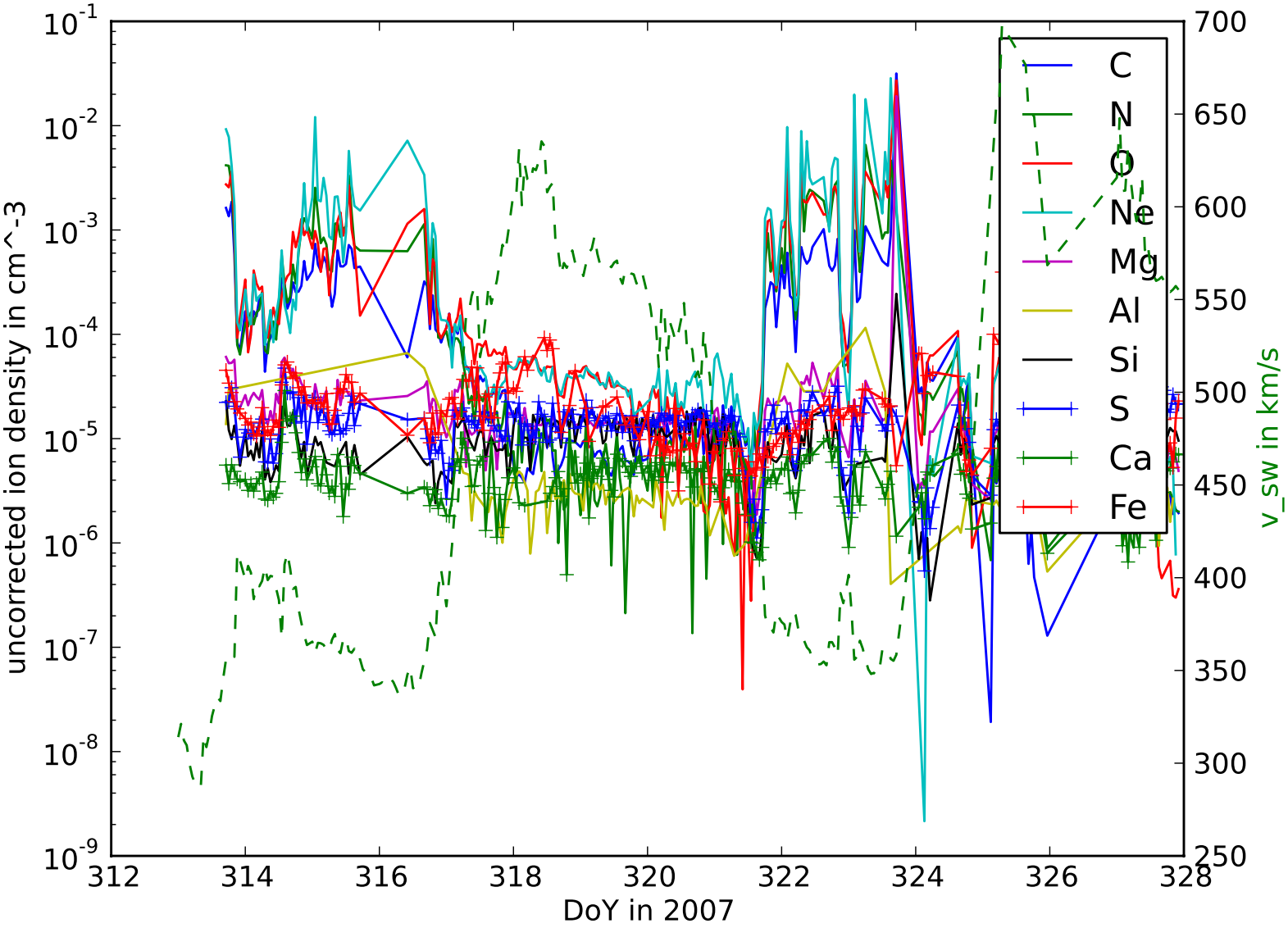
- depends on auxiliary instrument proton monitor (PM) measures proton speed and ecliptic angle



Outline

Uncorrected ion densities



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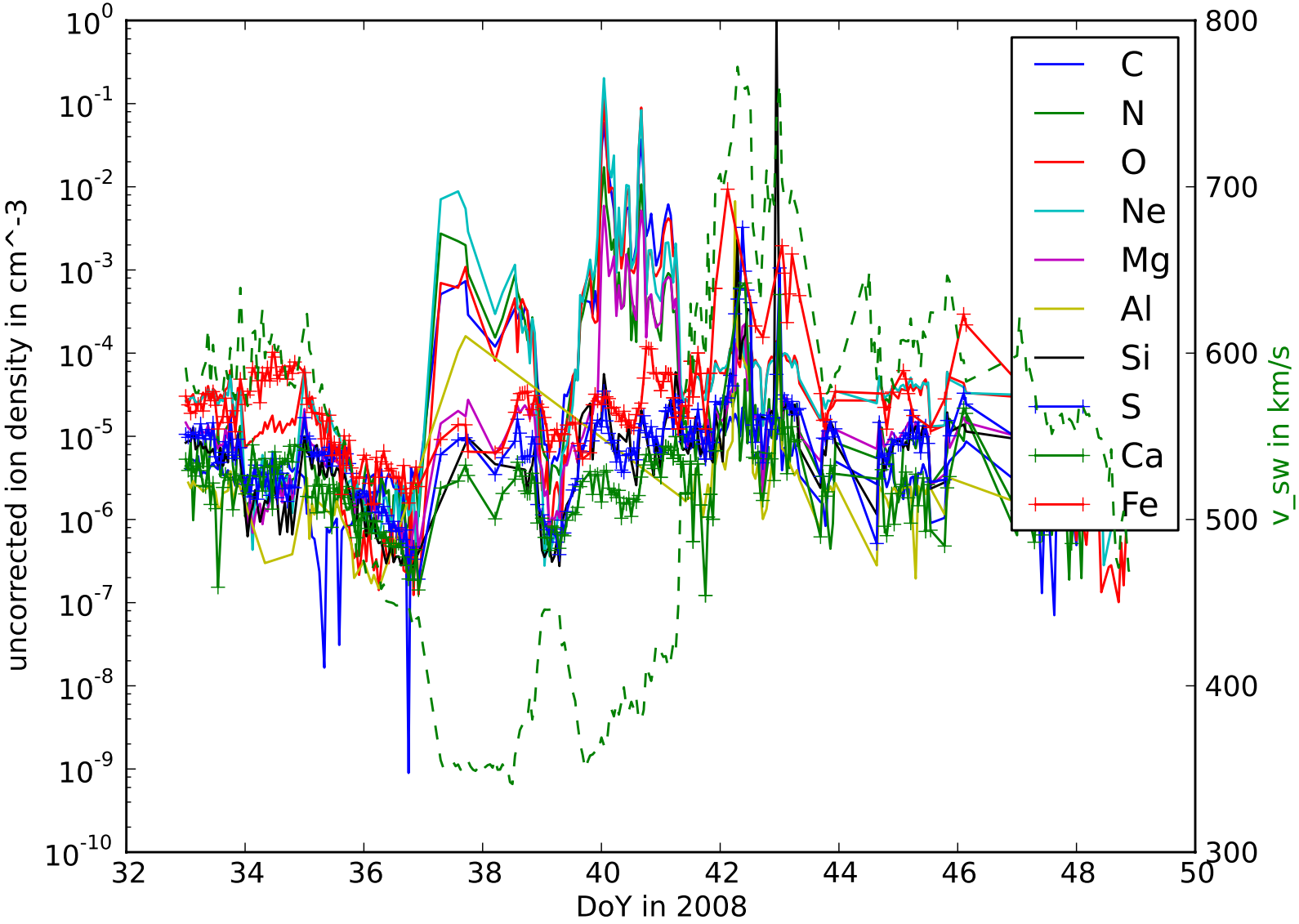

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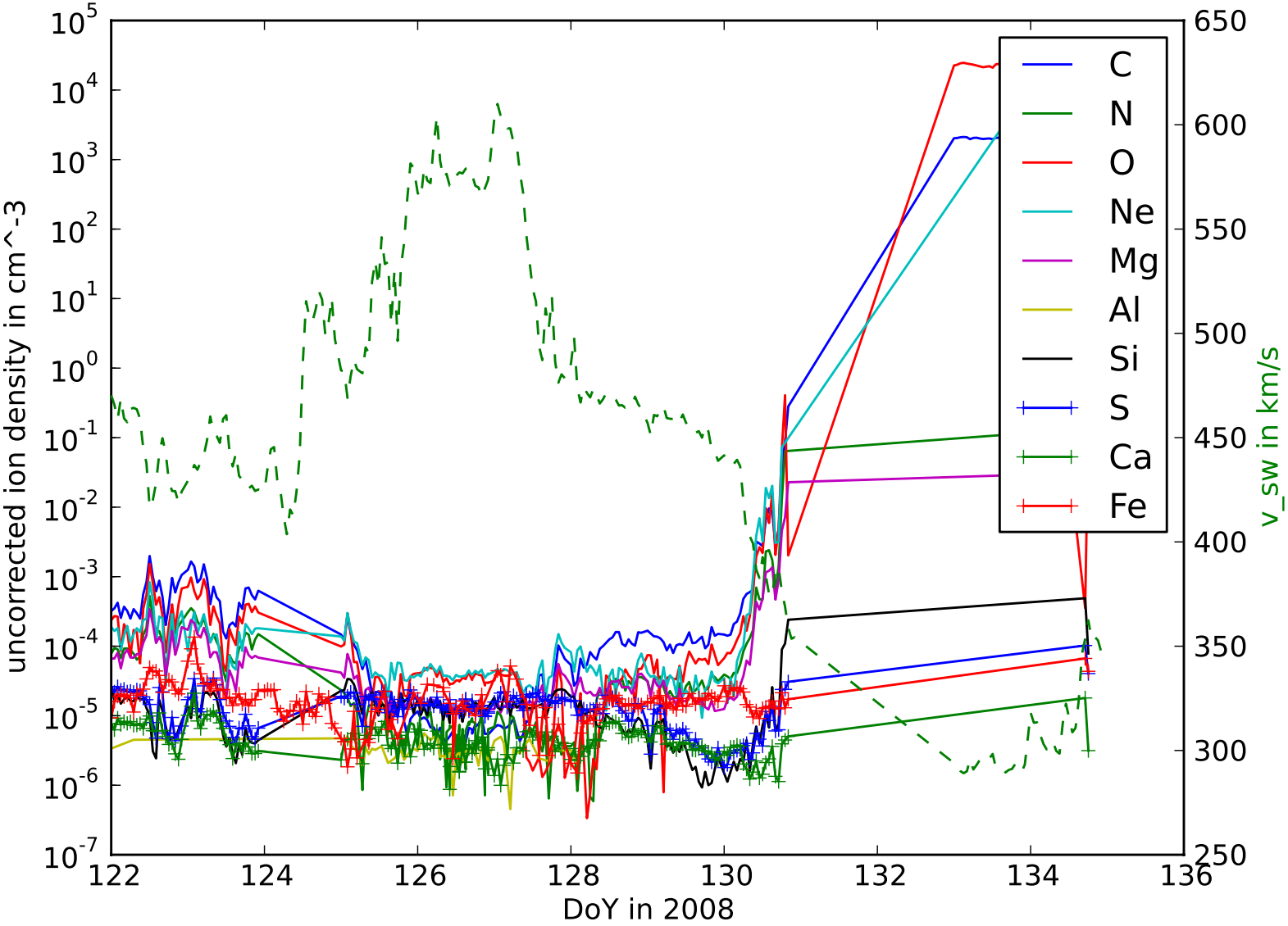

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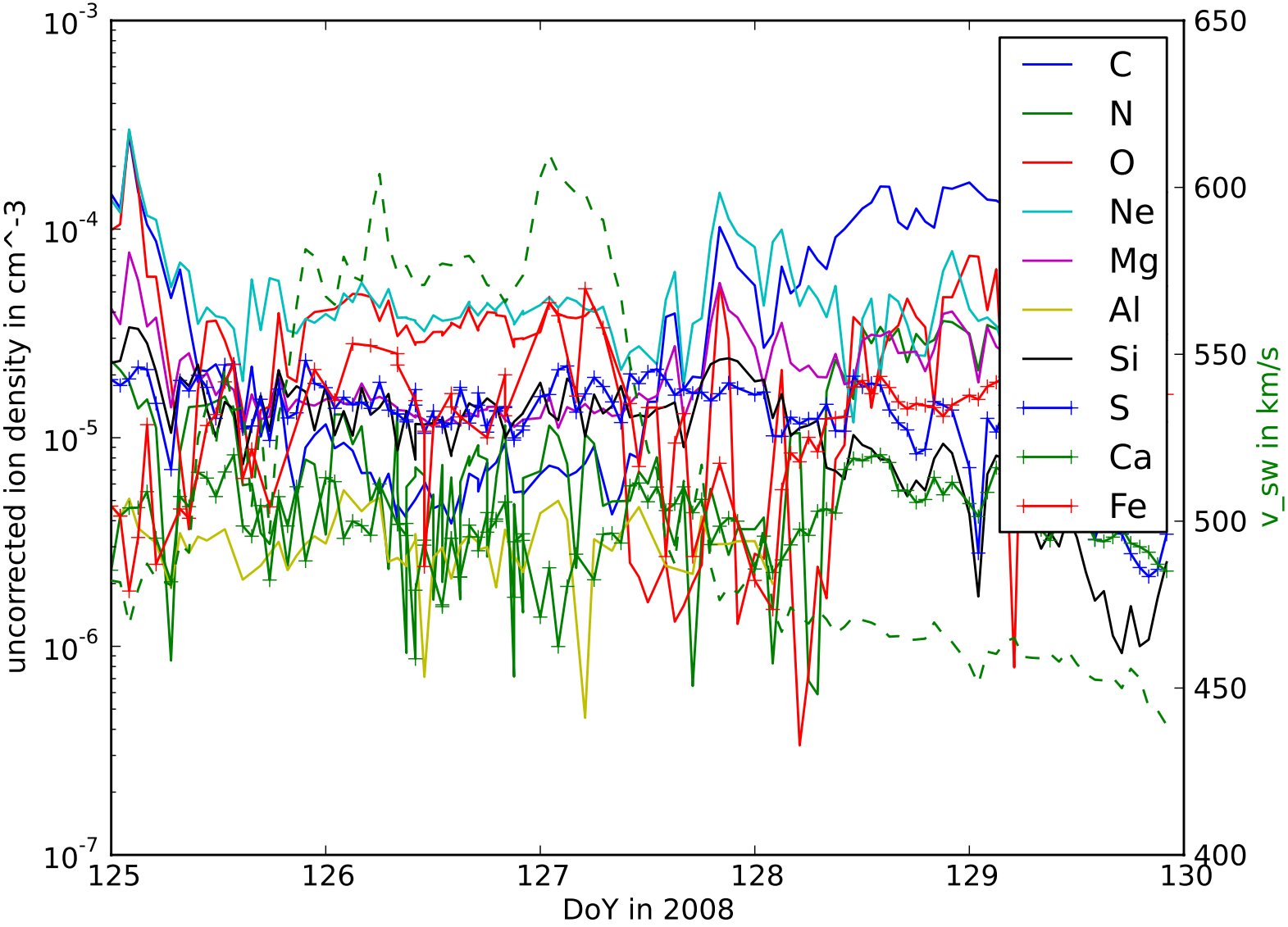
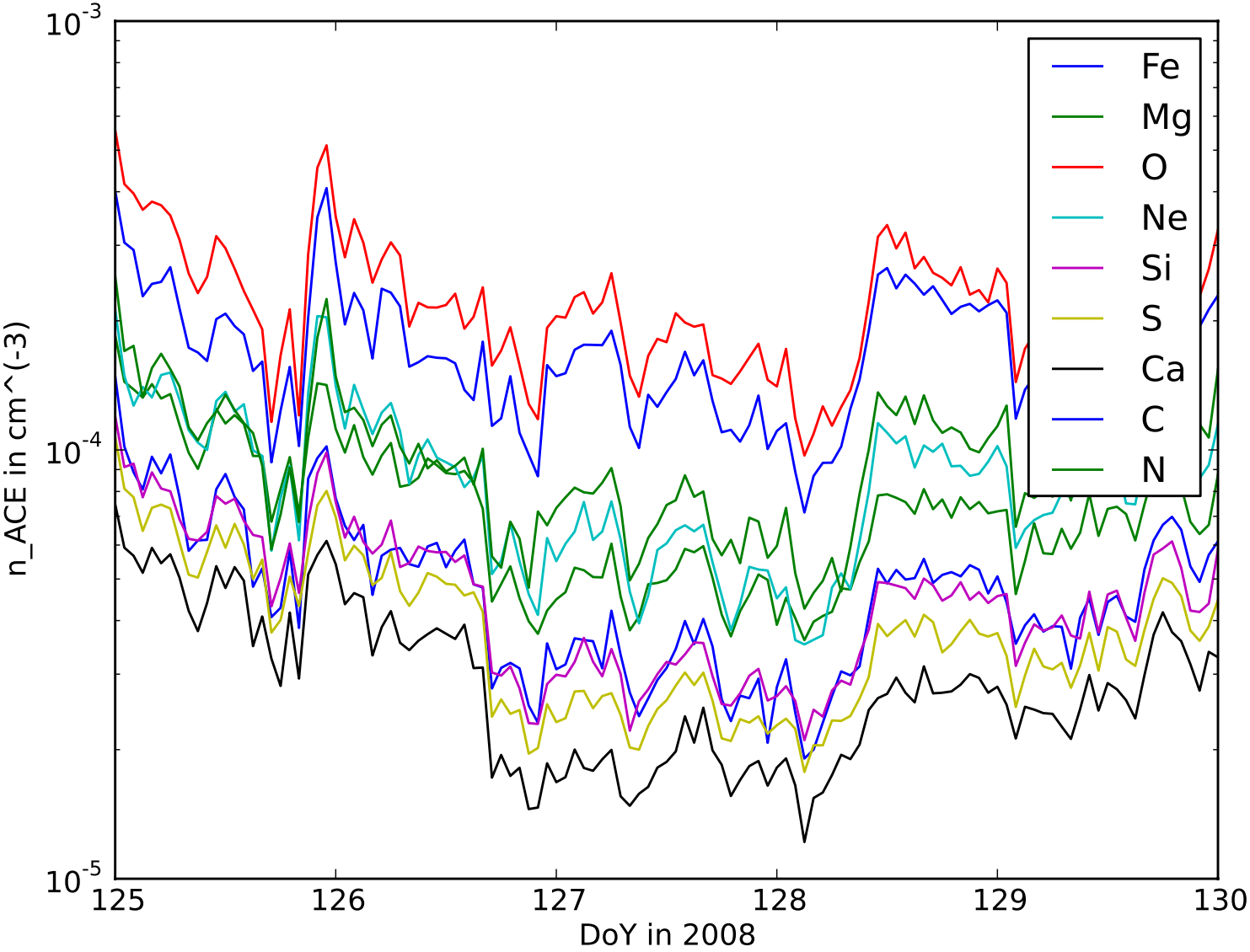


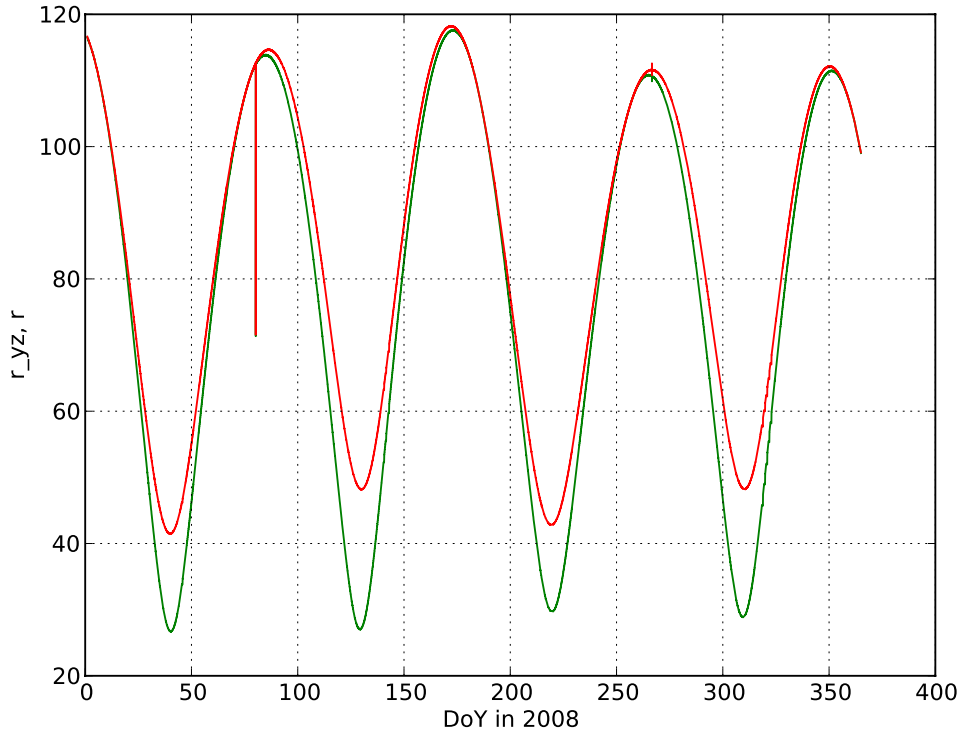
ACE/SWICS data as reference



Exploiting ACE/SWICS

If SOHO and ACE are close together, use ACE/SWICS data for:

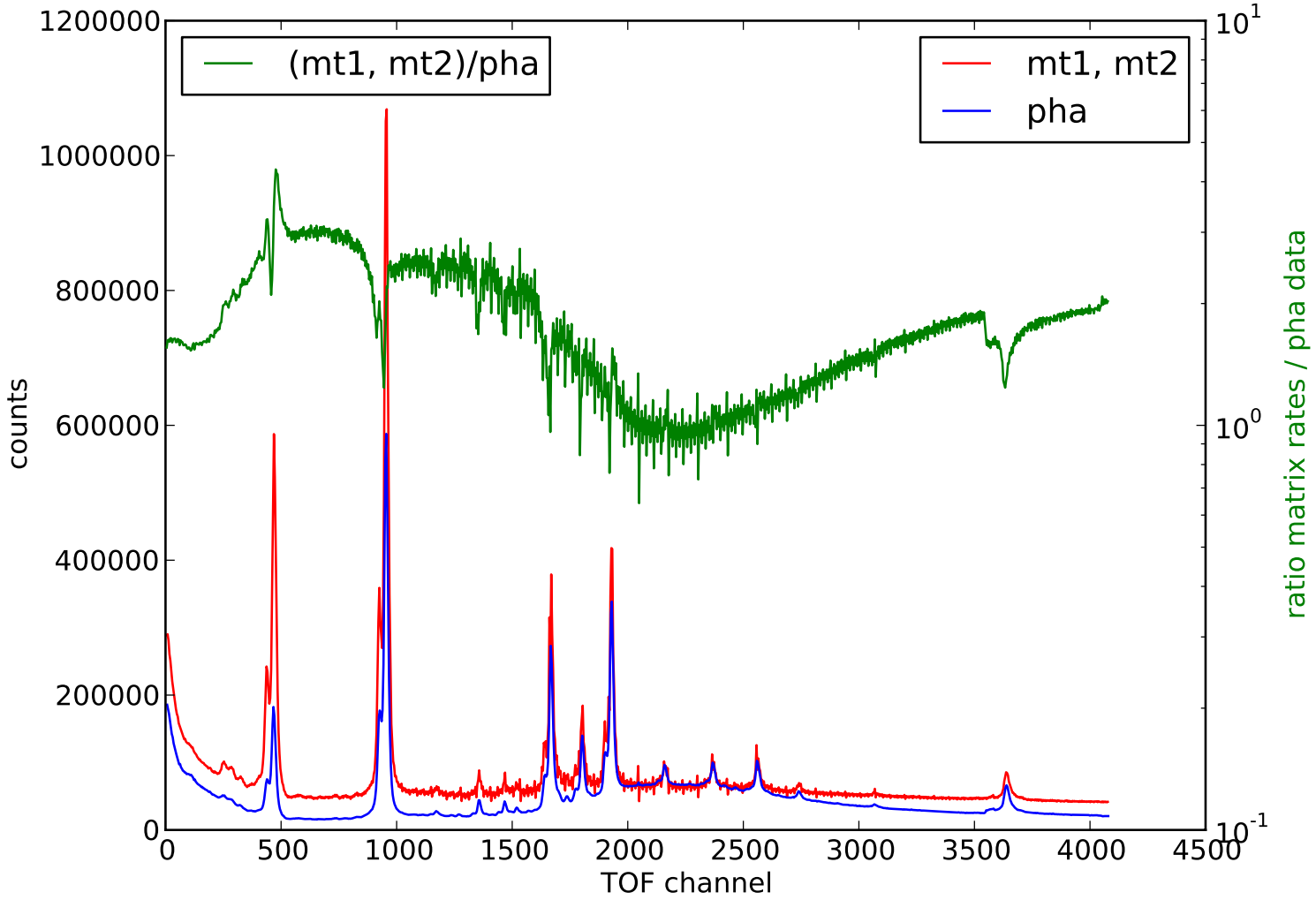
- charge distributions (instead of relying on freeze-in model)
- time-dependent in-flight calibration



Outline

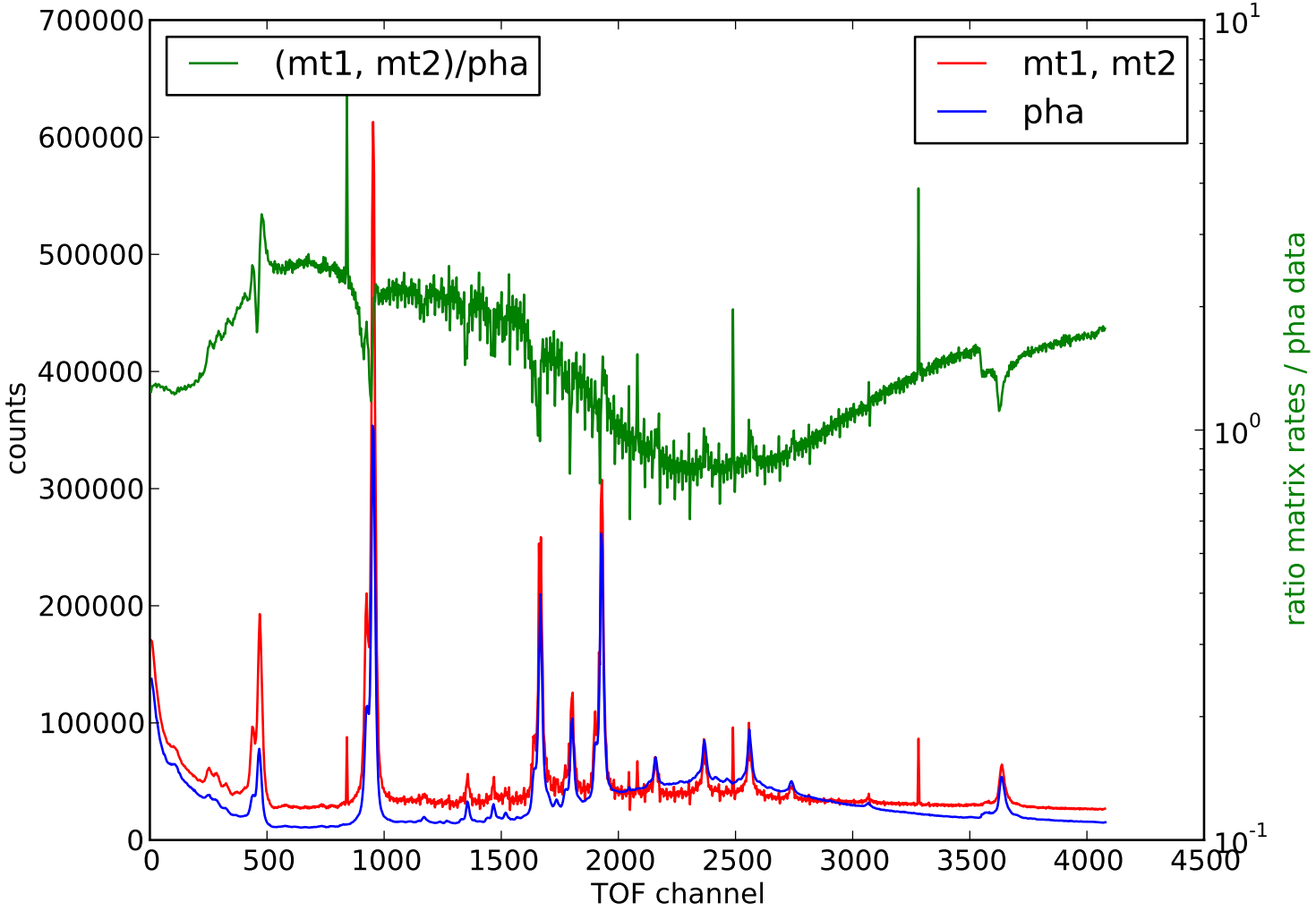
Which data to use?

DoY 1–91 in 2008:



Which data to use?

DoY 91–181 in 2008:



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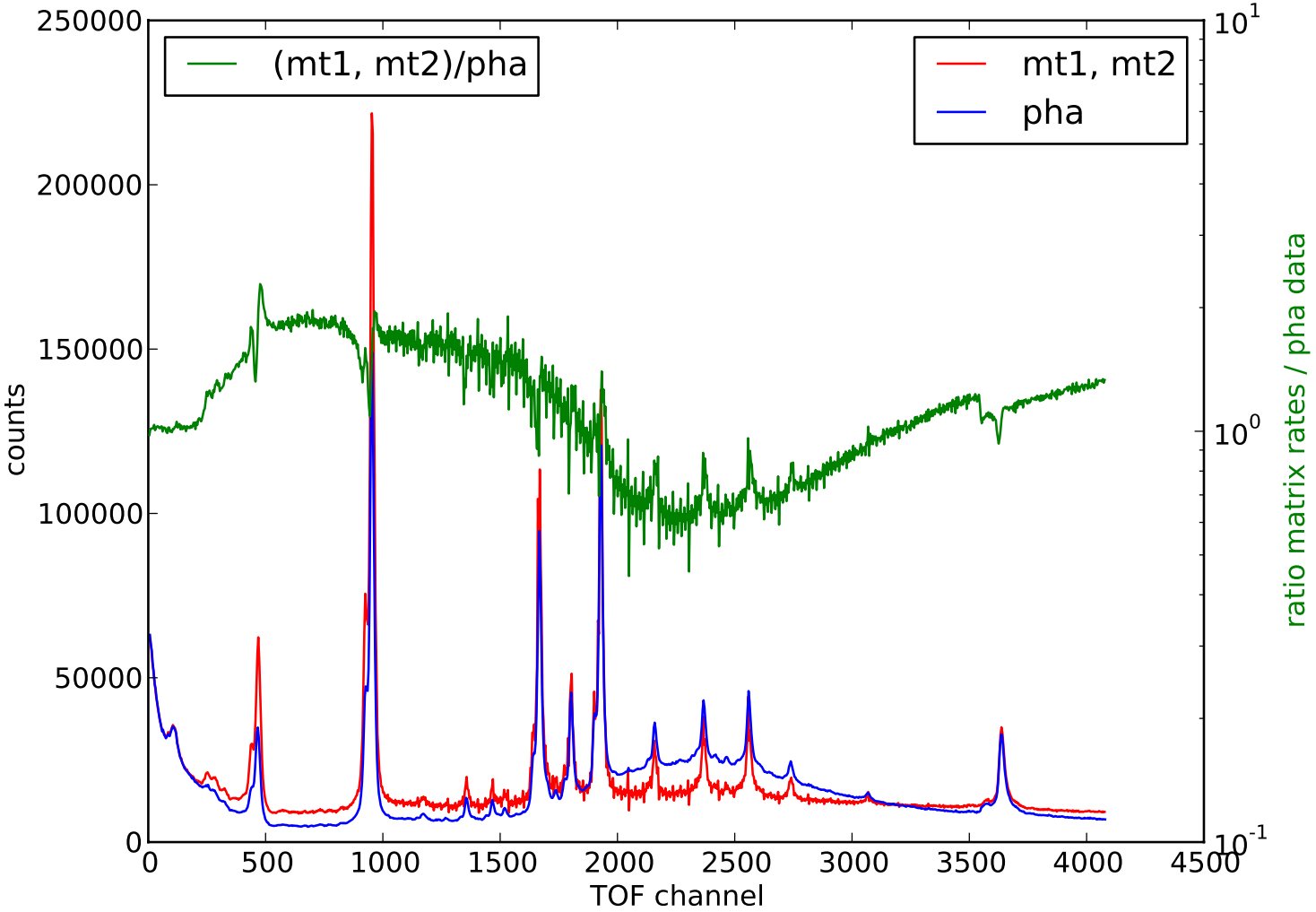
DoY 181–271 on 2008:



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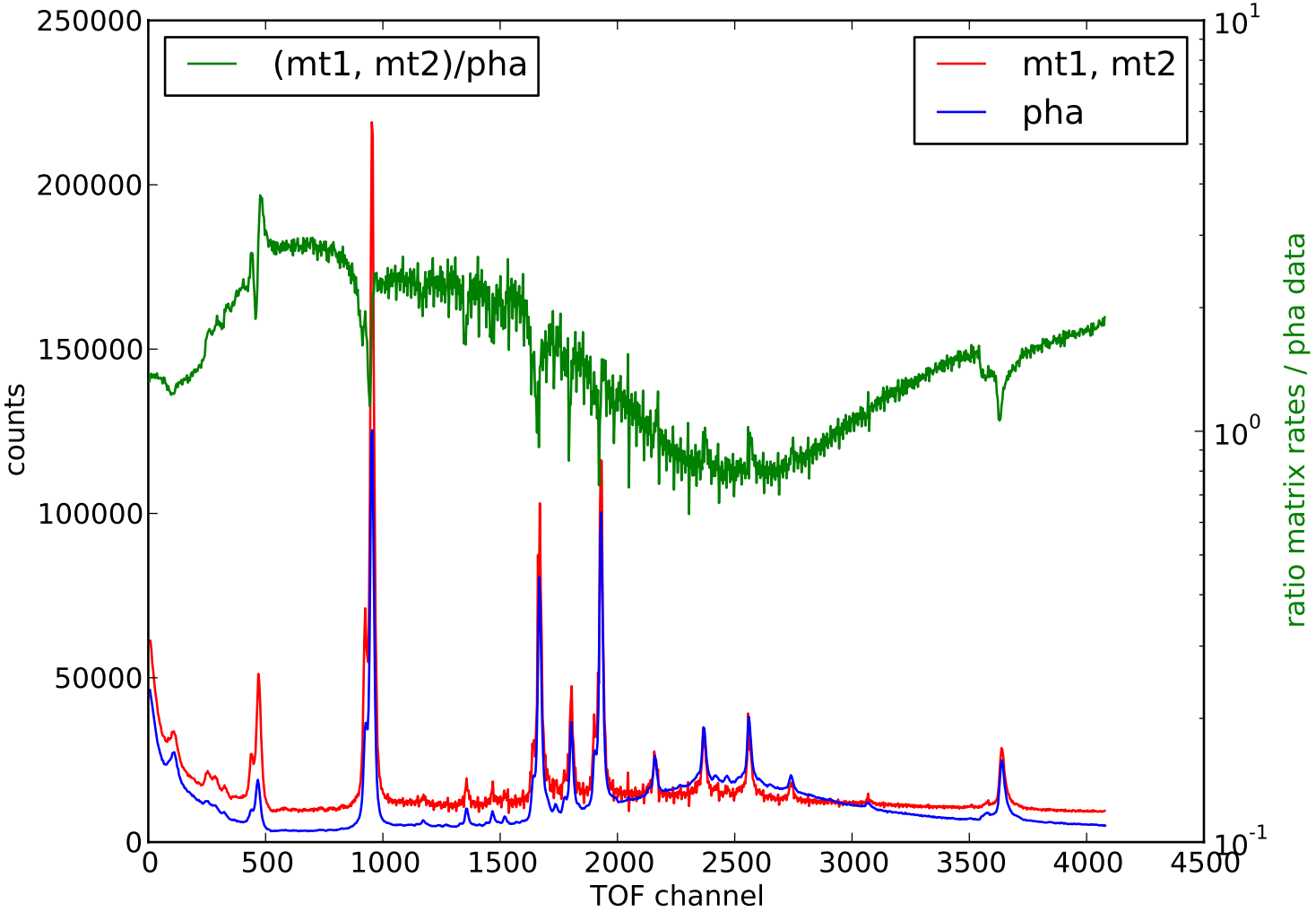
DoY 271–361 in 2008:



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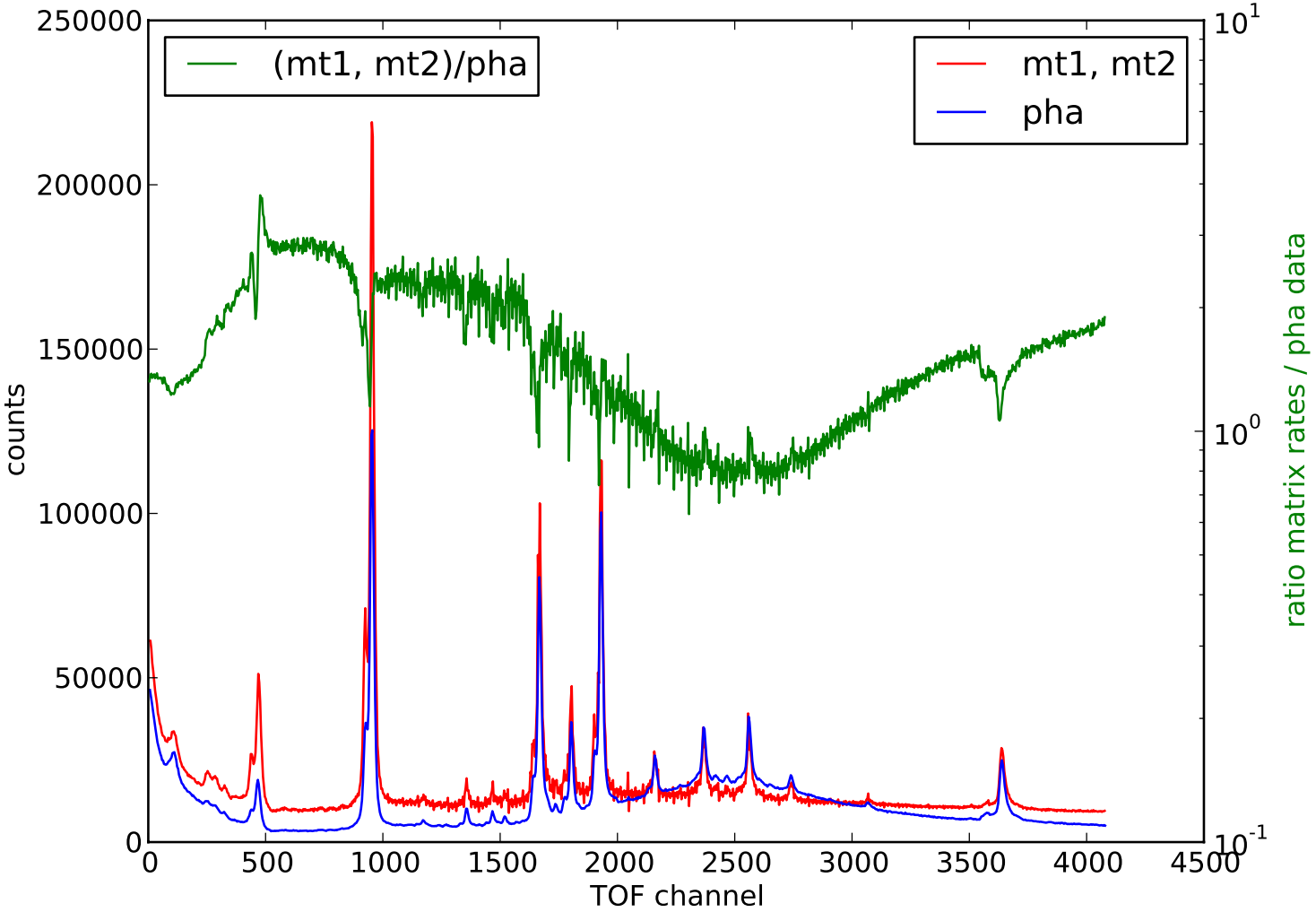
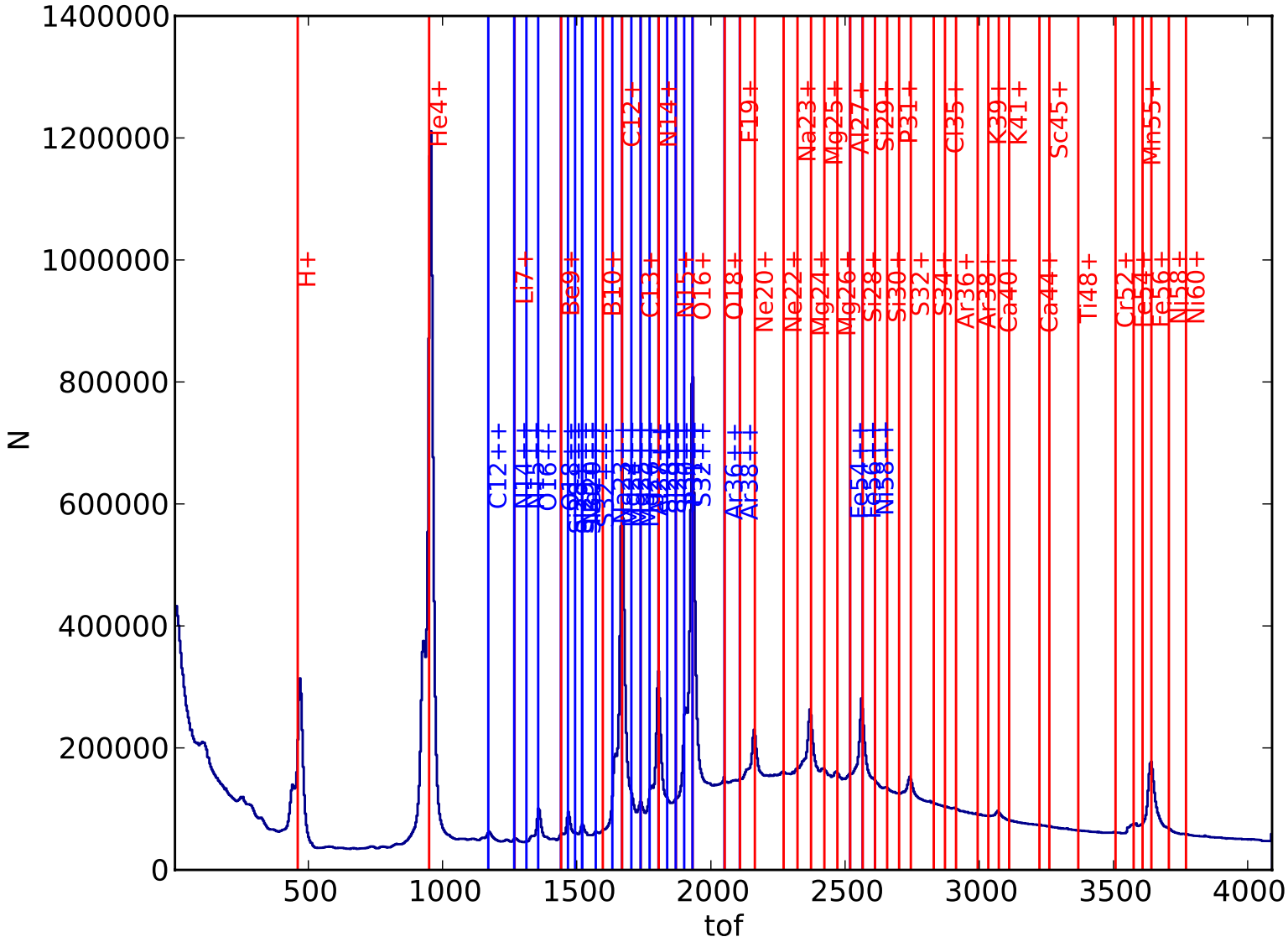


Question: How exactly are the matrix rates obtained?

Outline

Mass resolution and background (2008)



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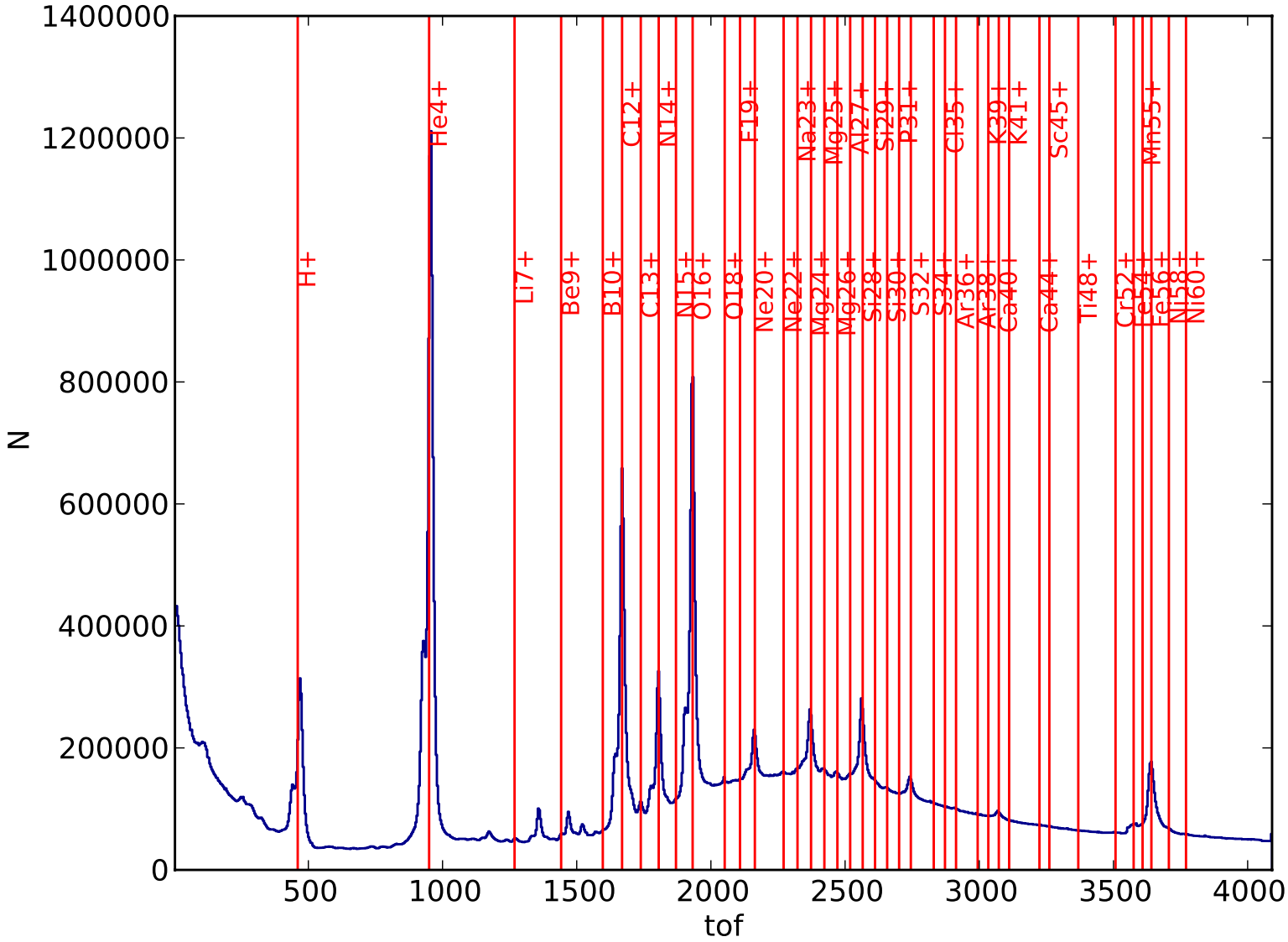

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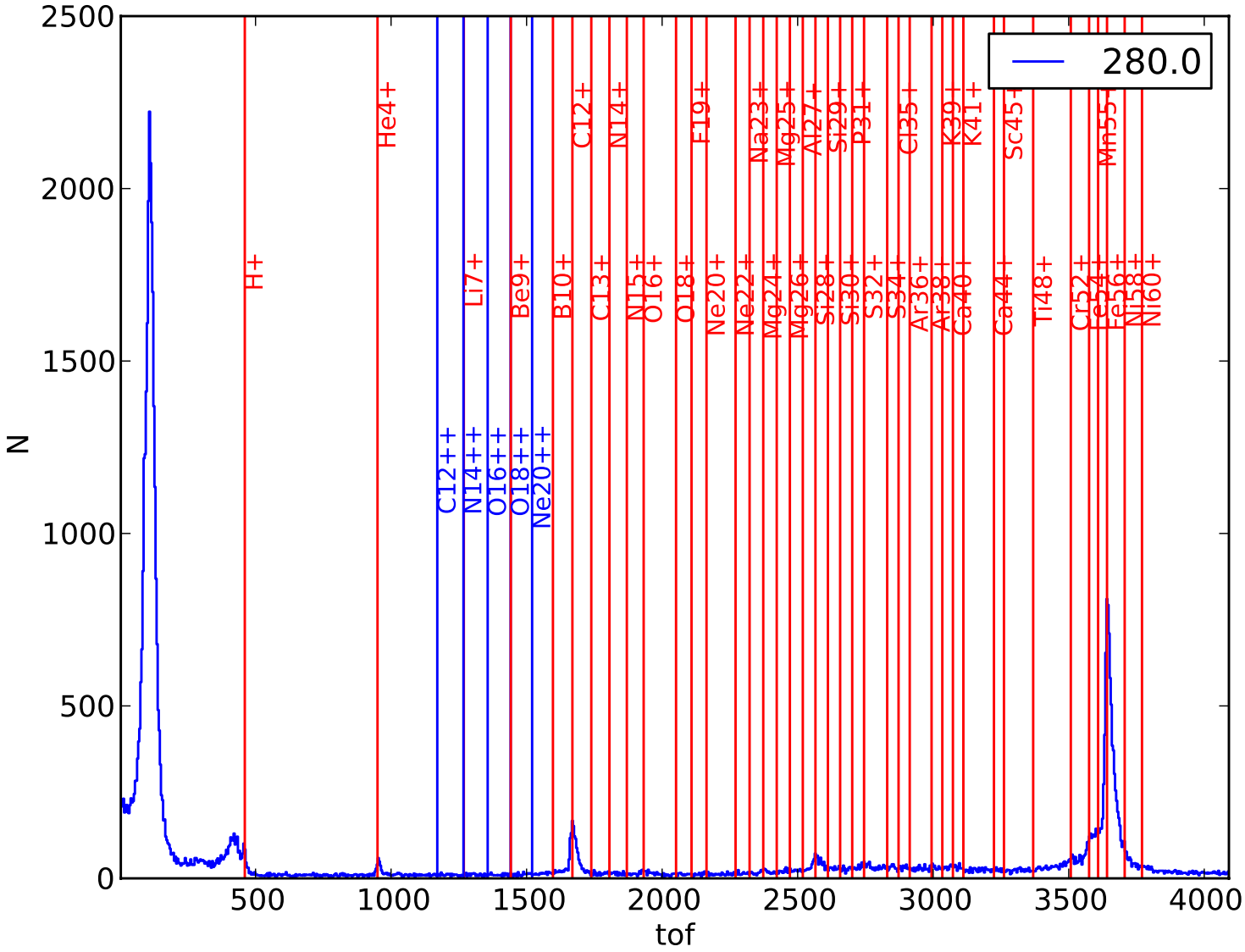

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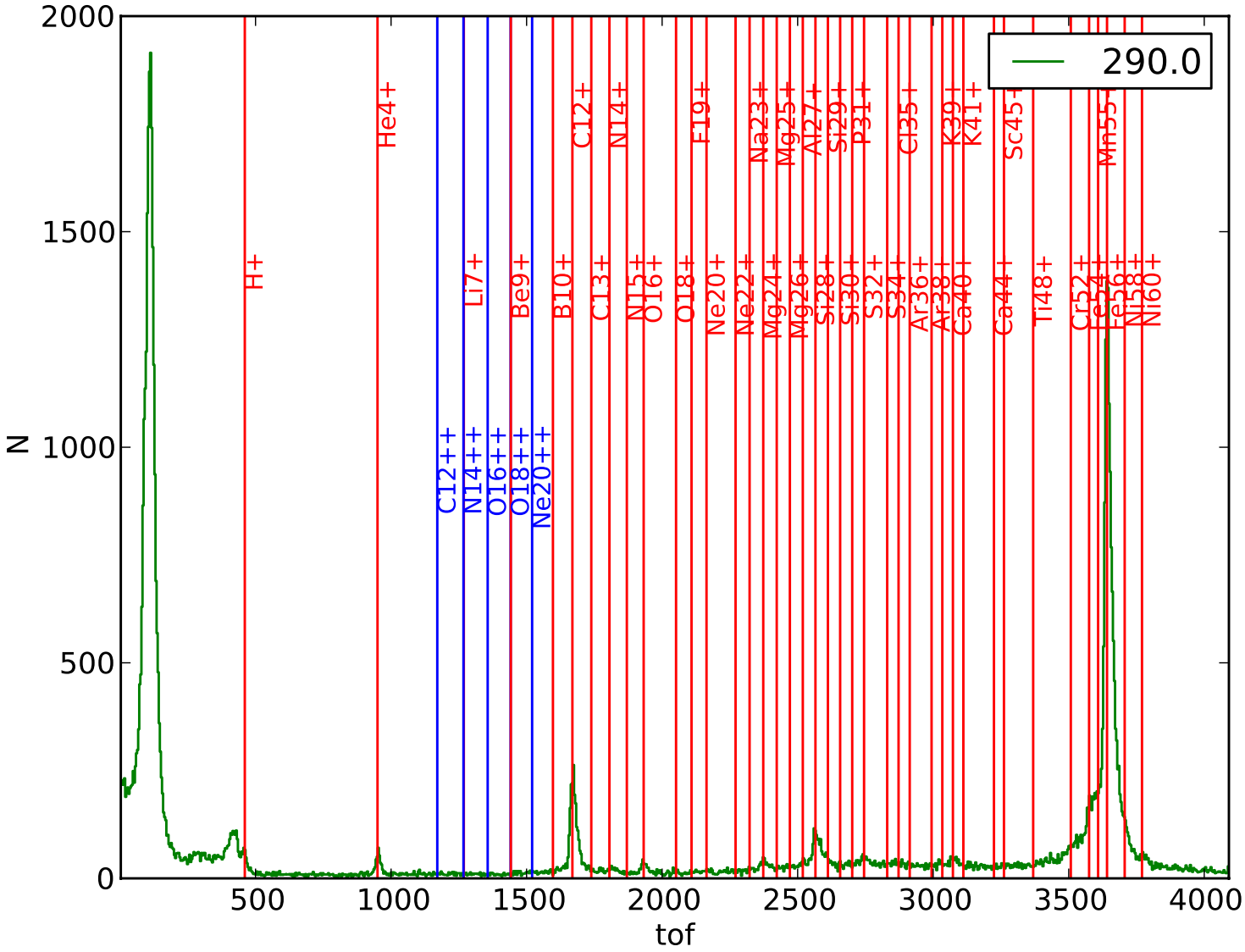

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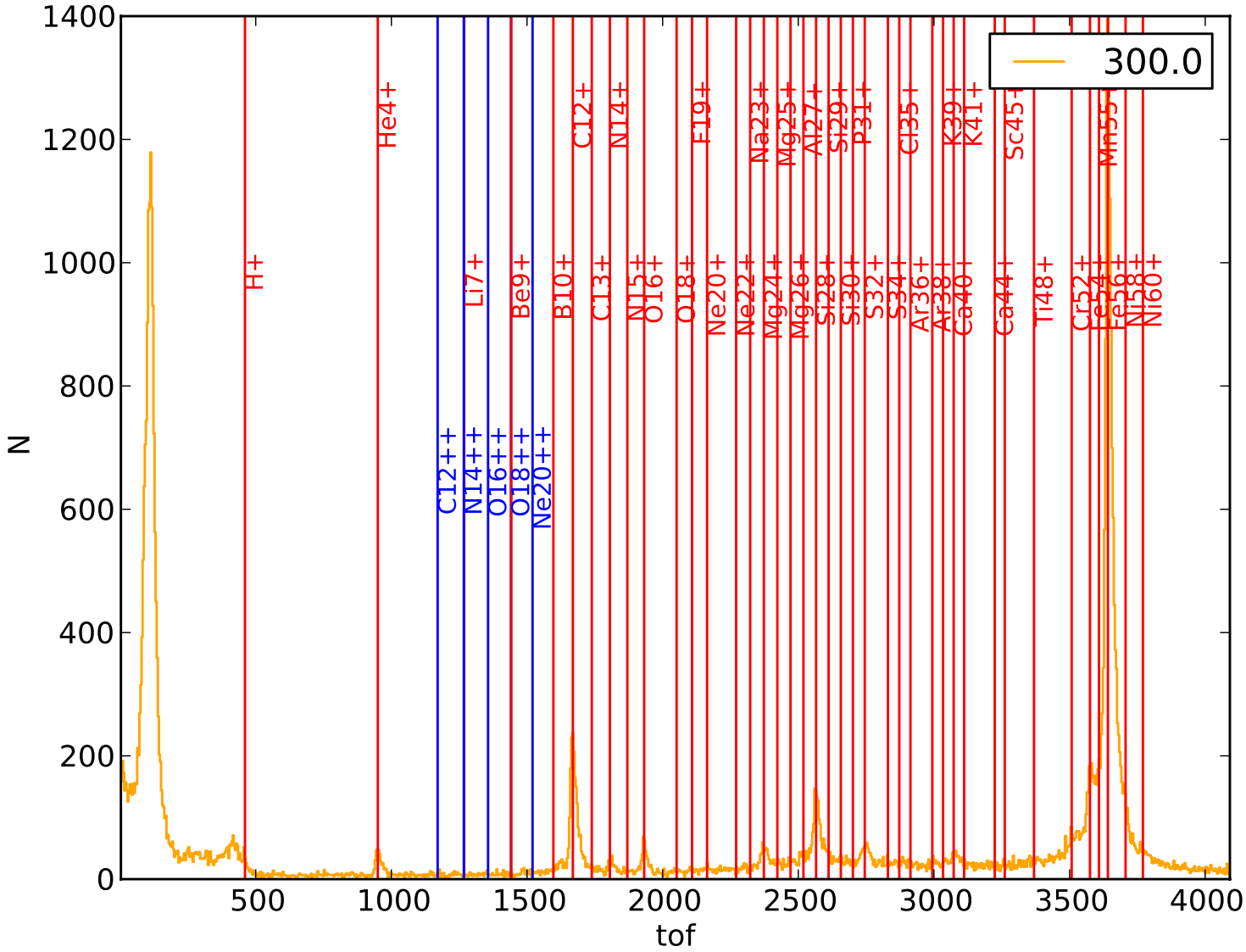

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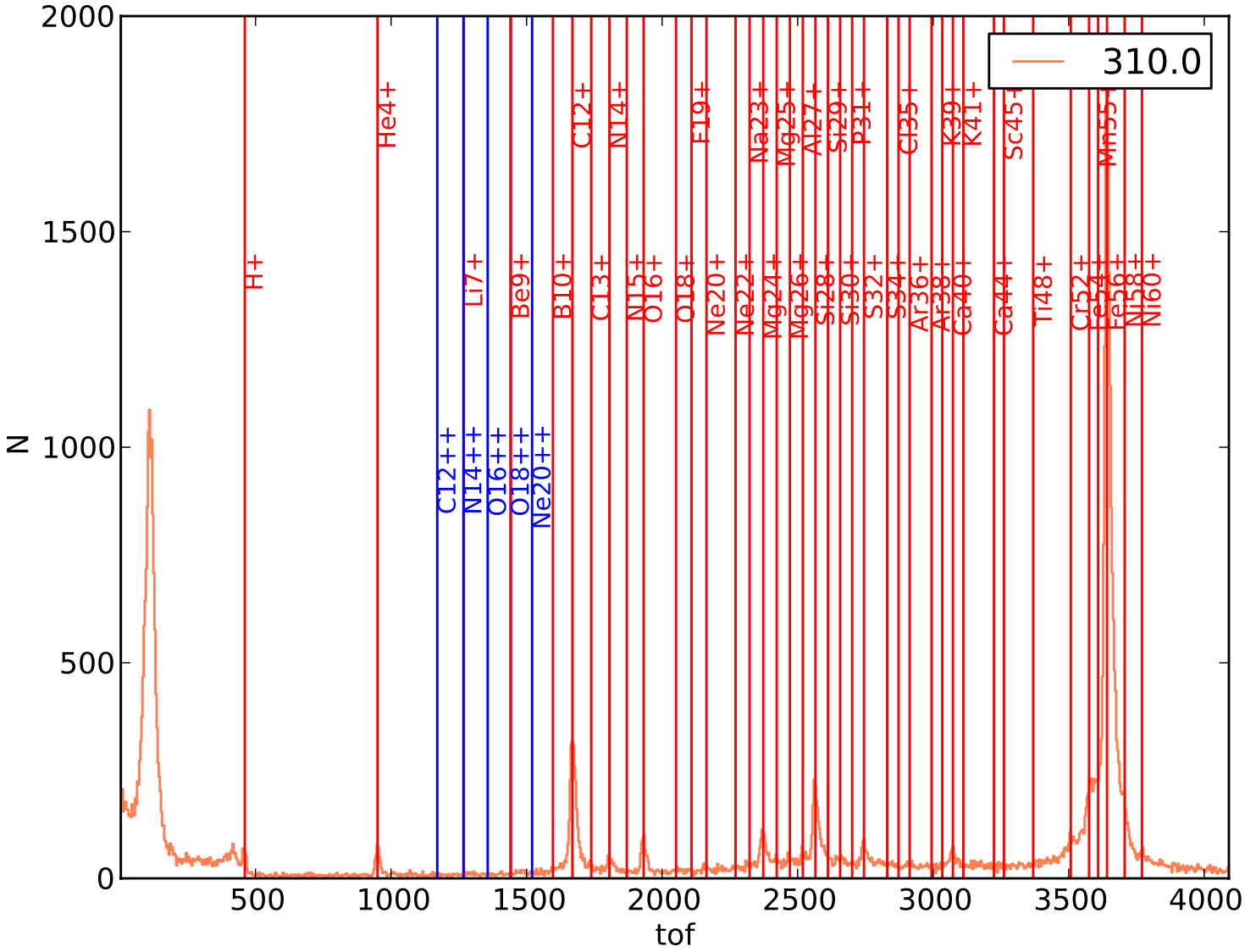

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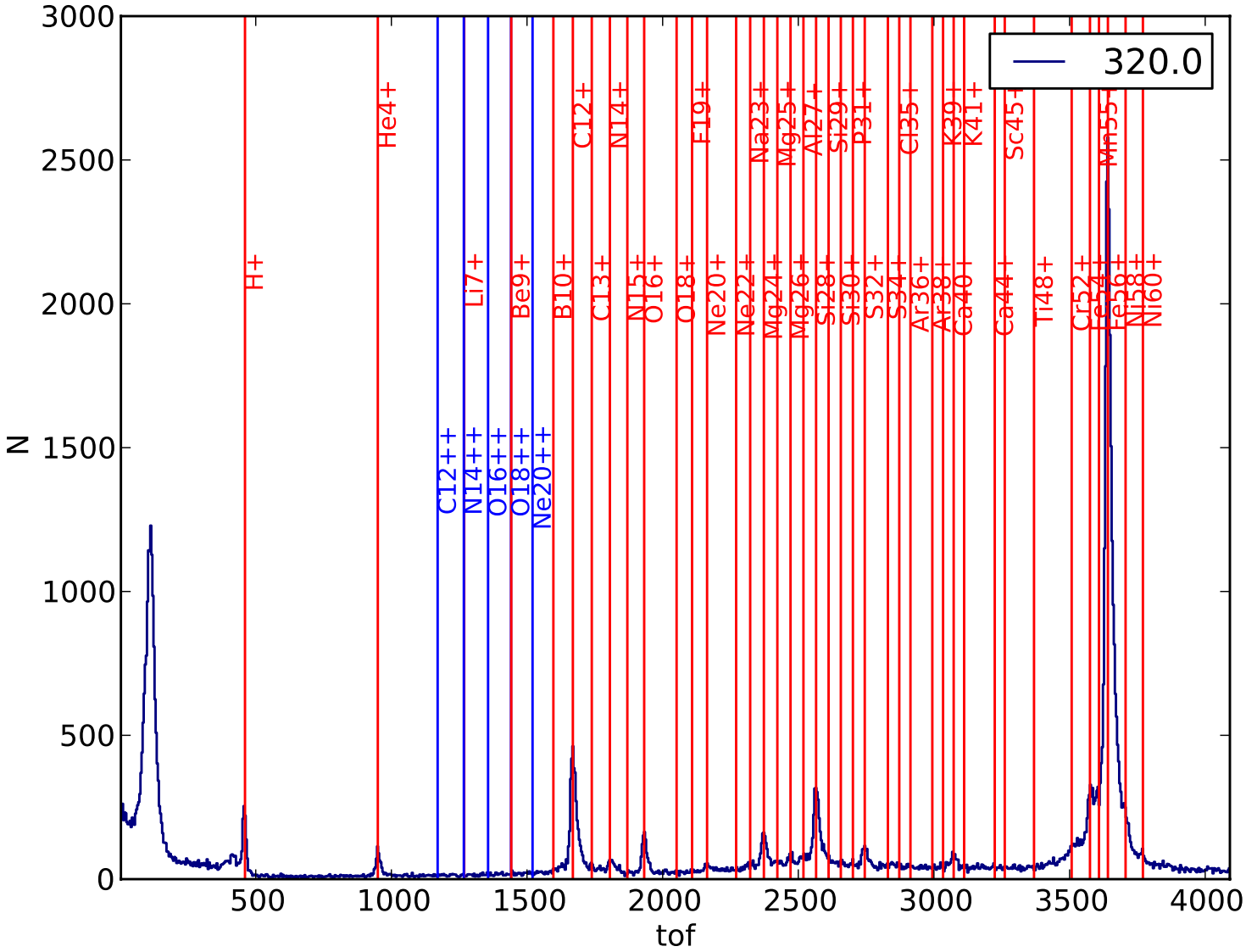

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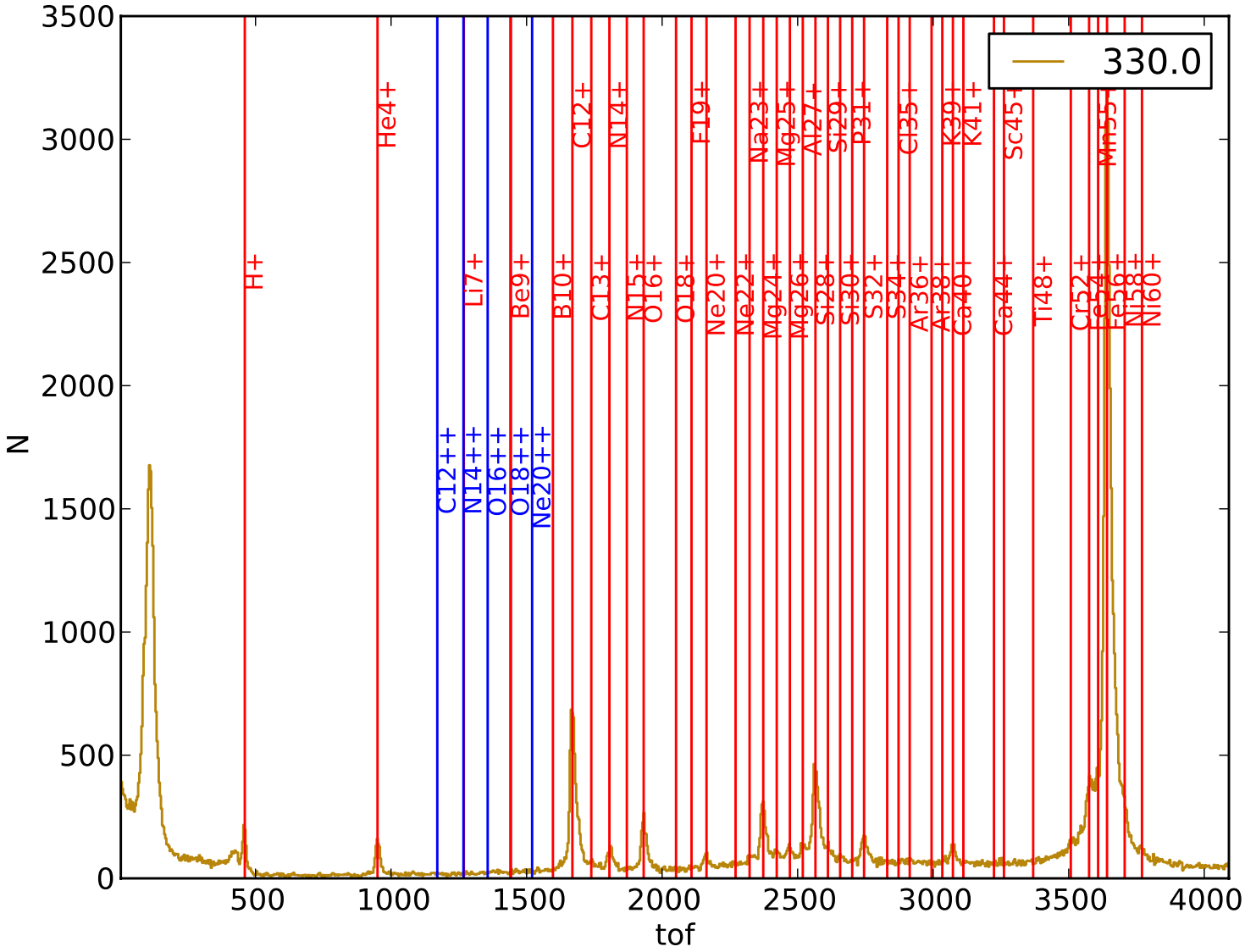

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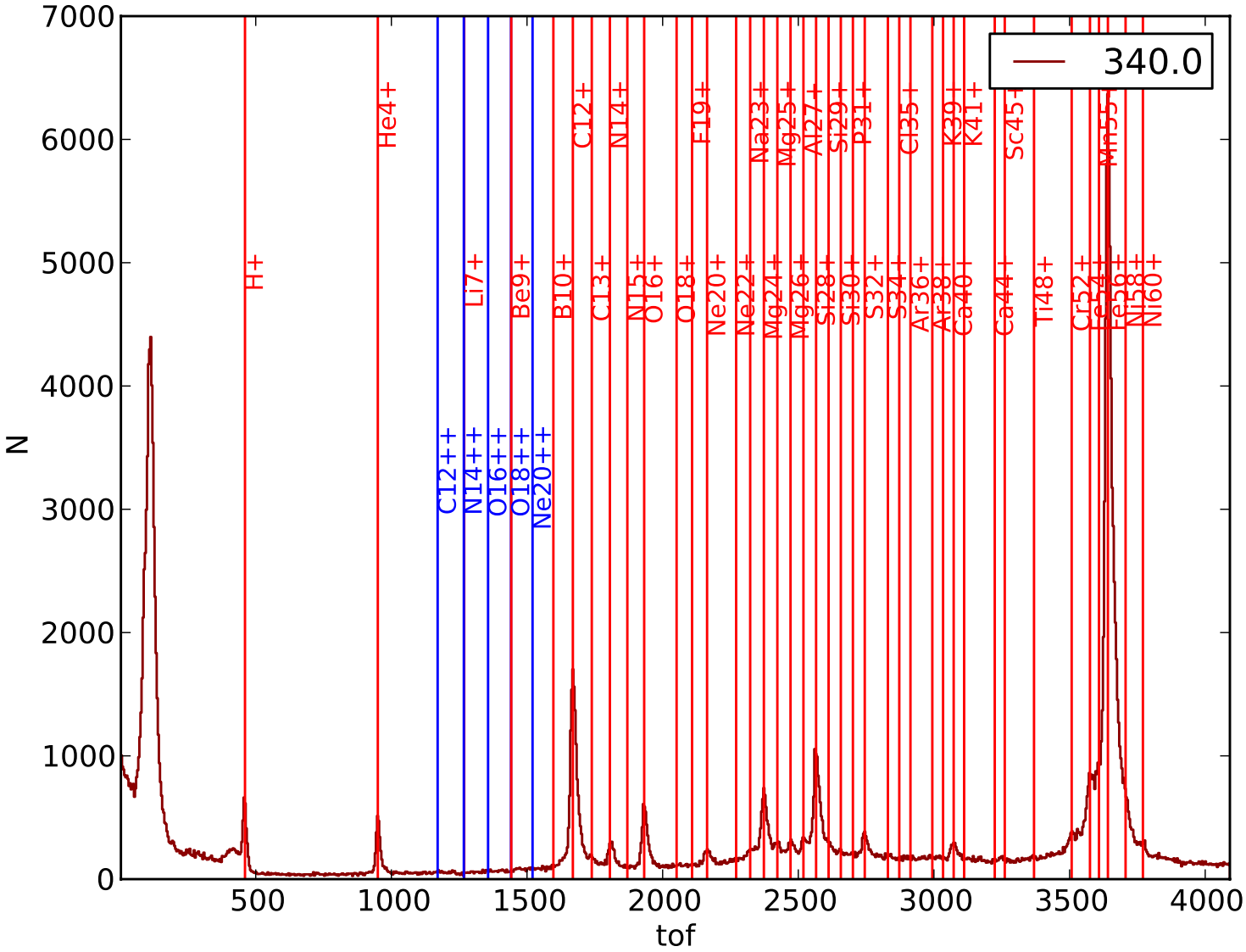

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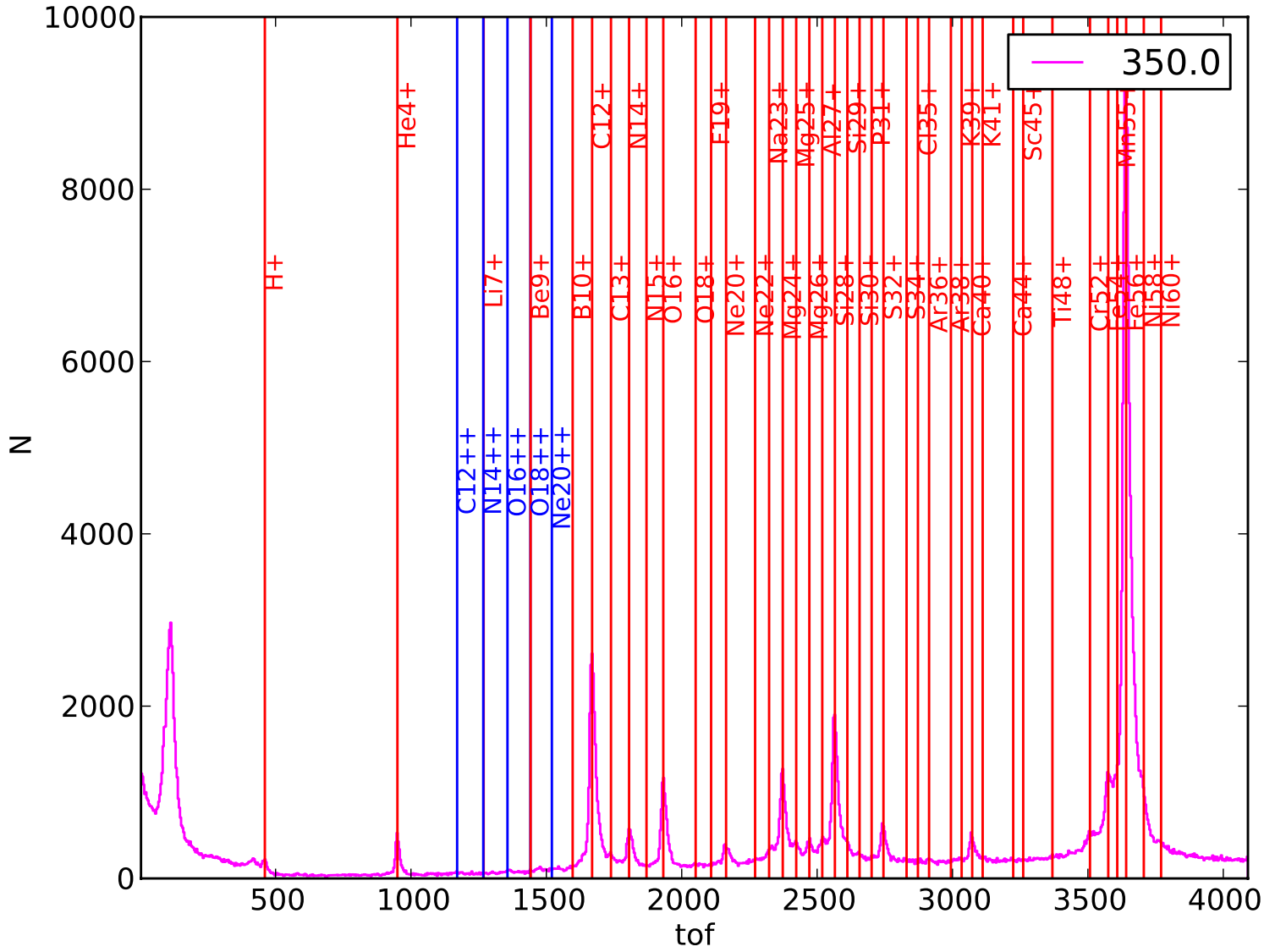

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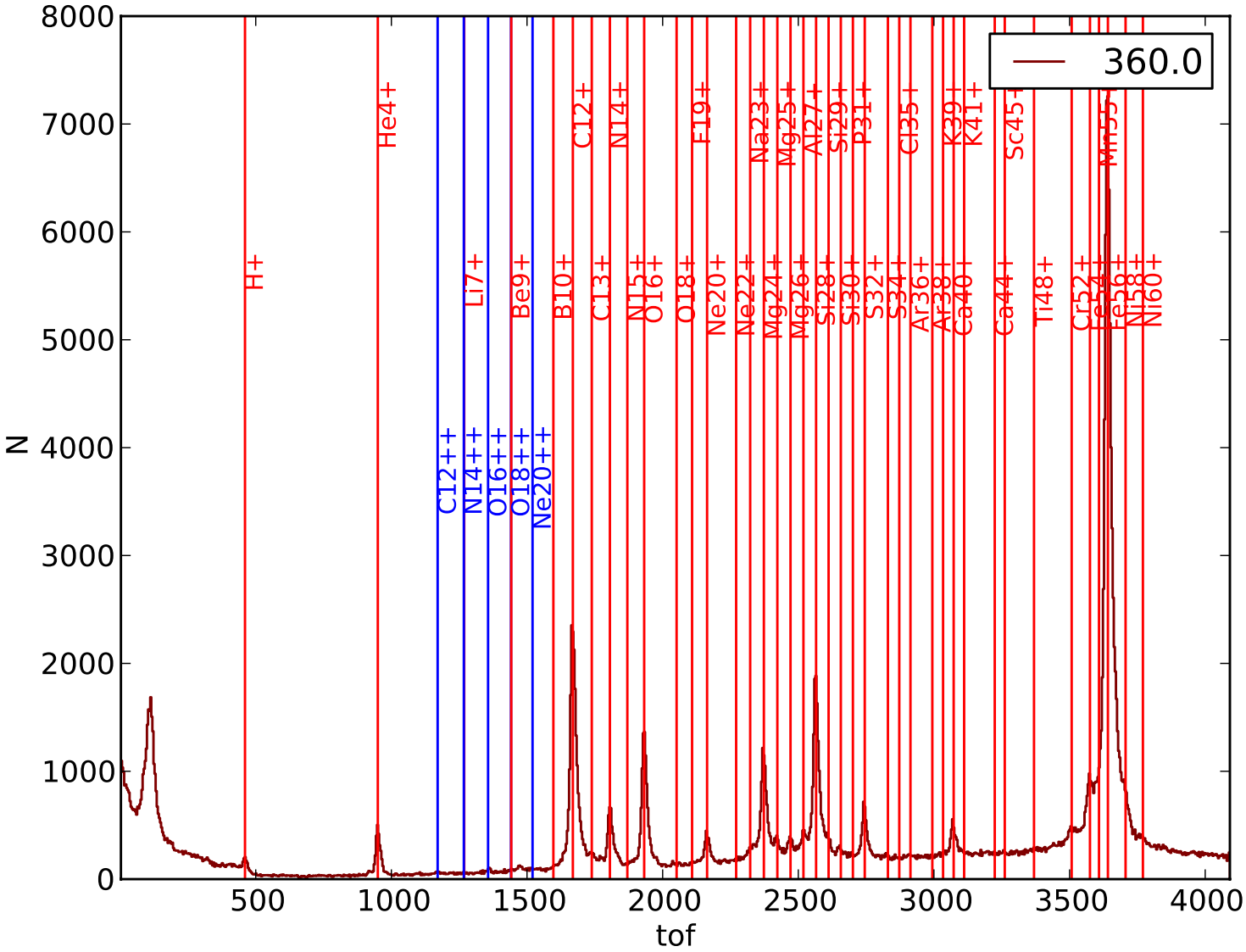

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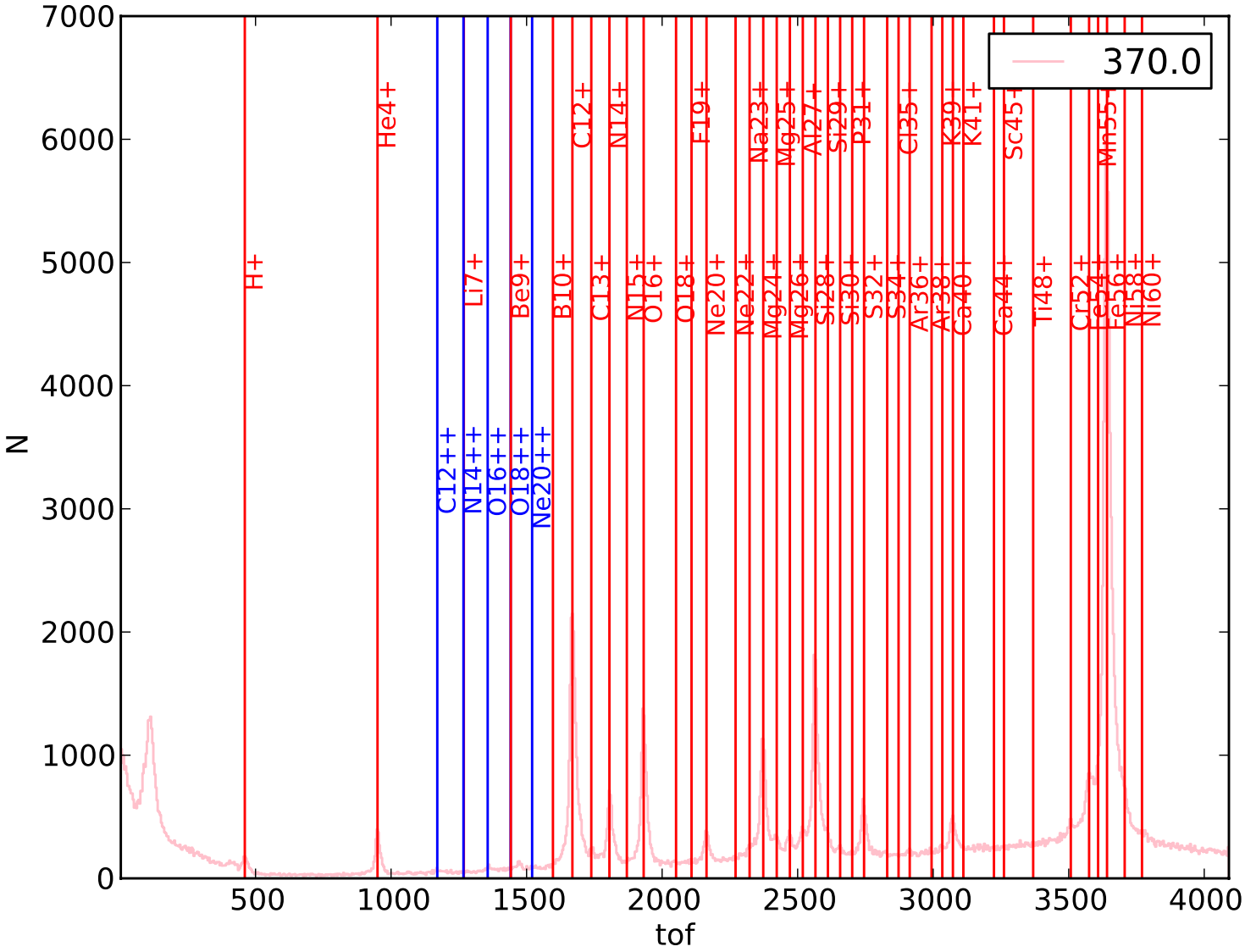

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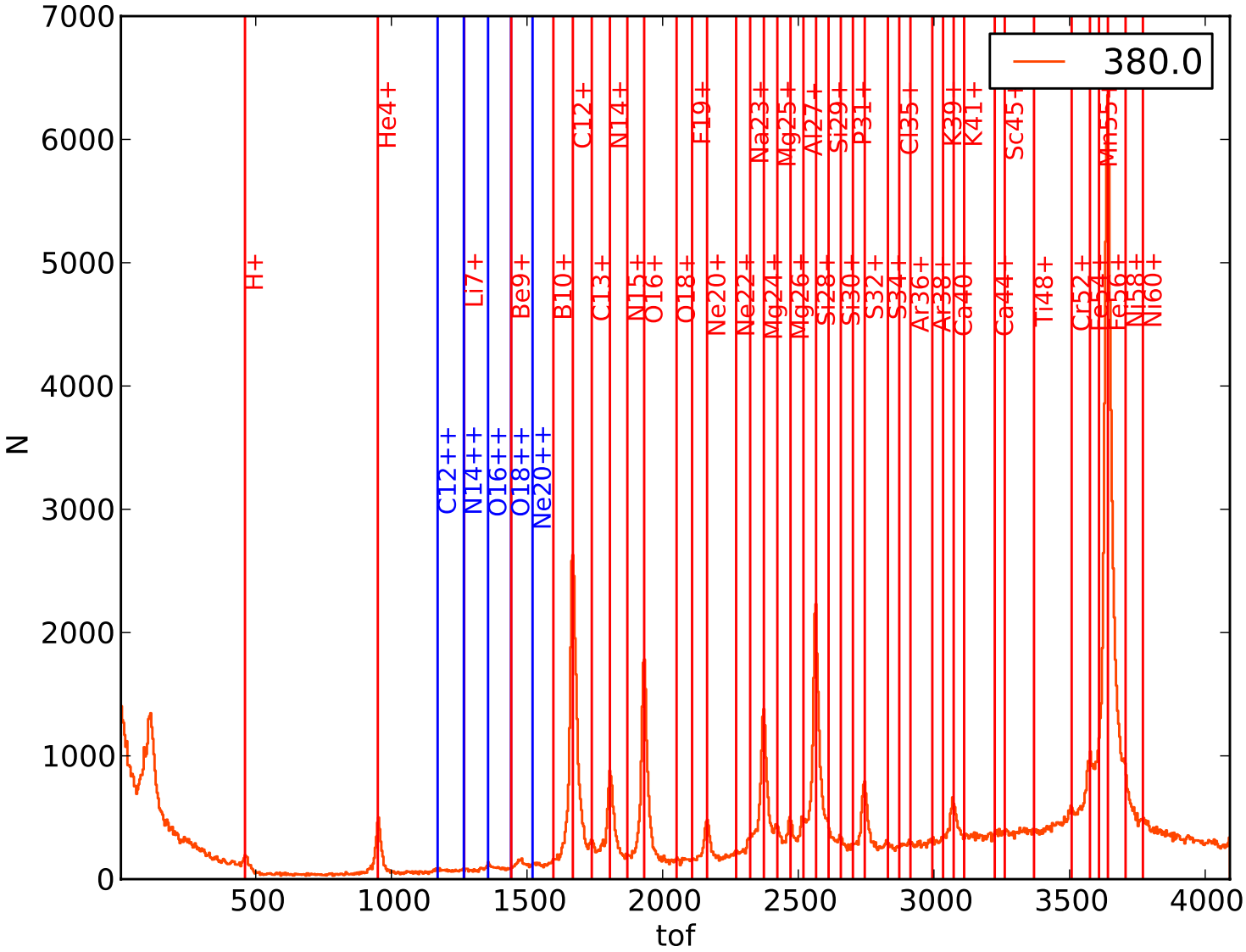

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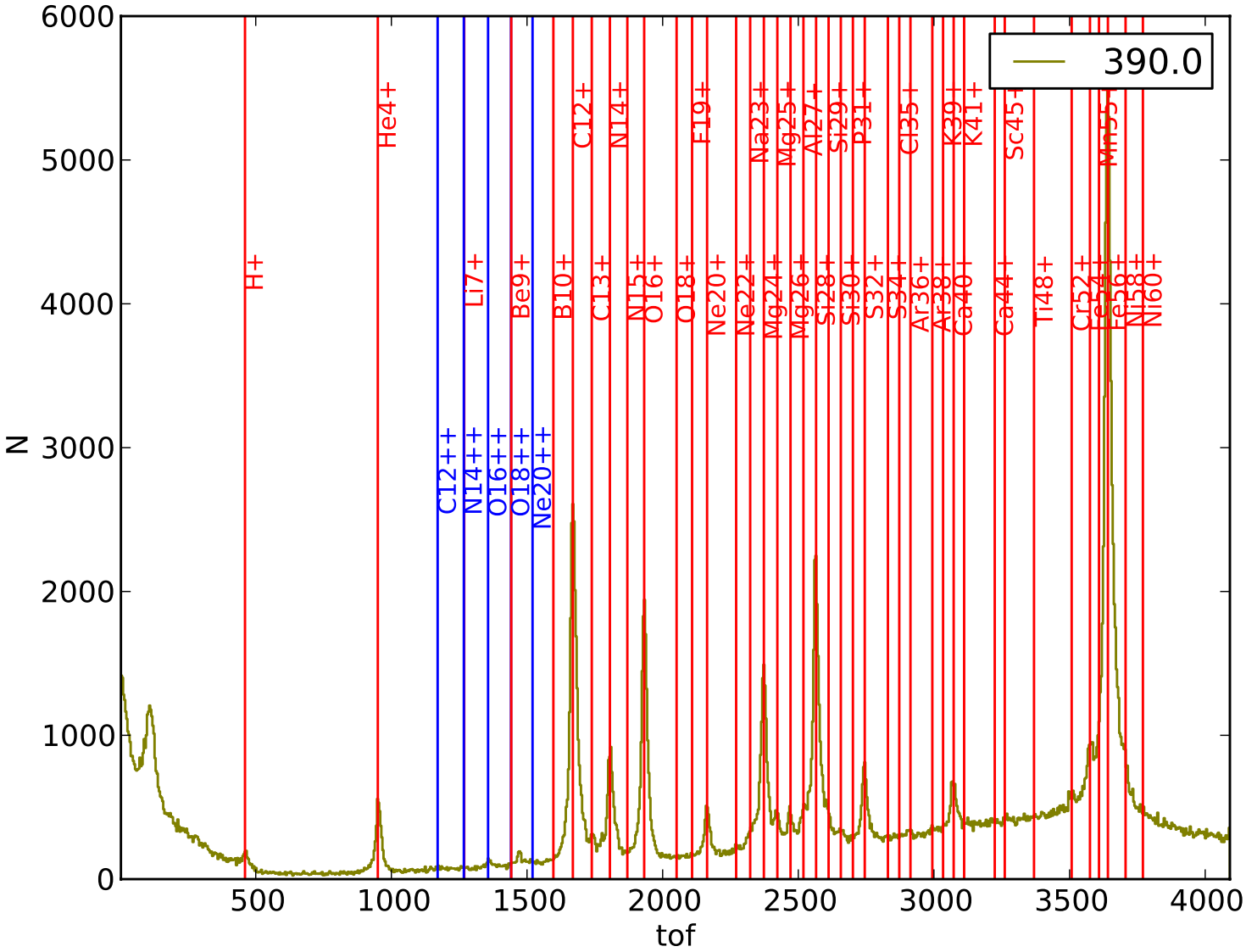

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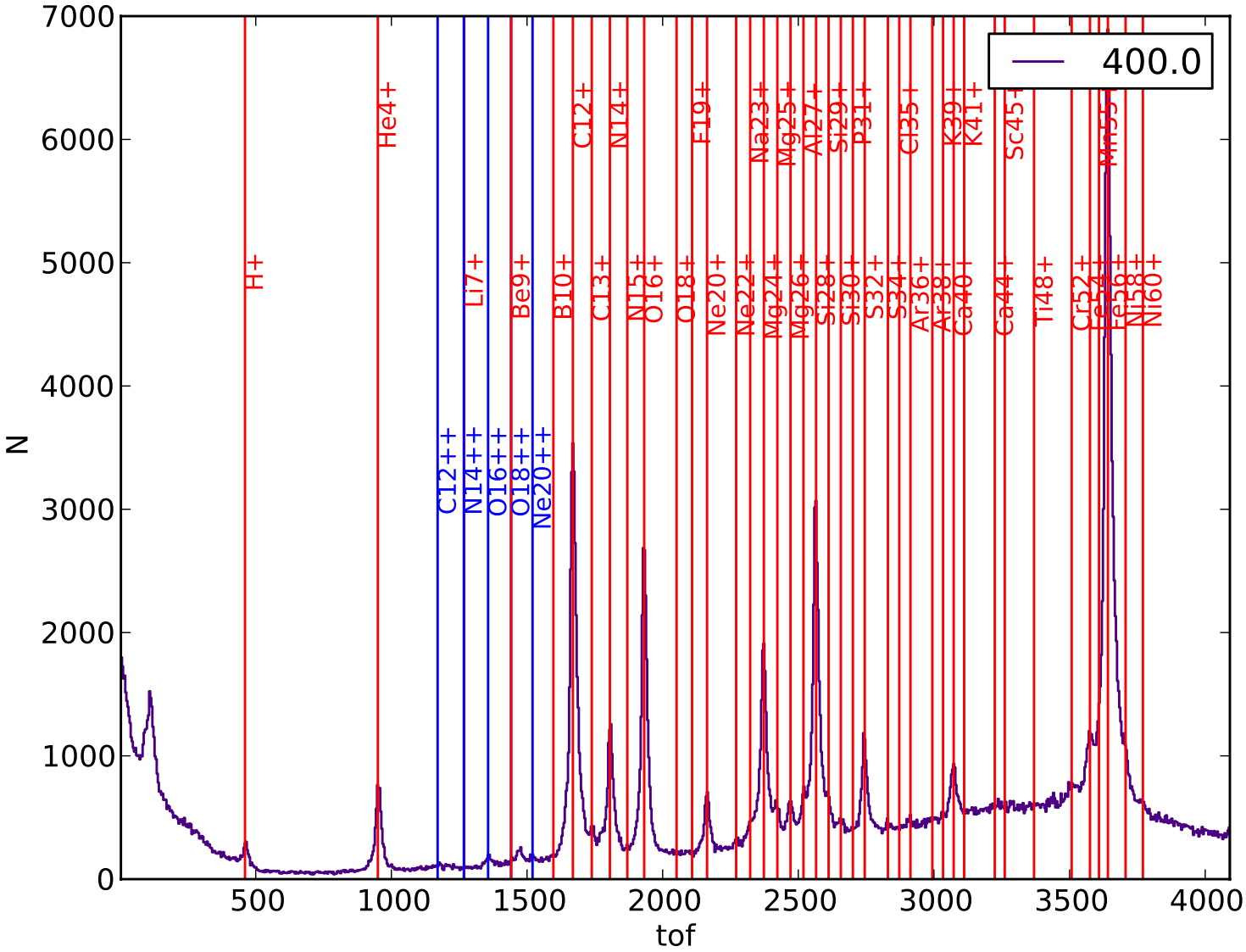

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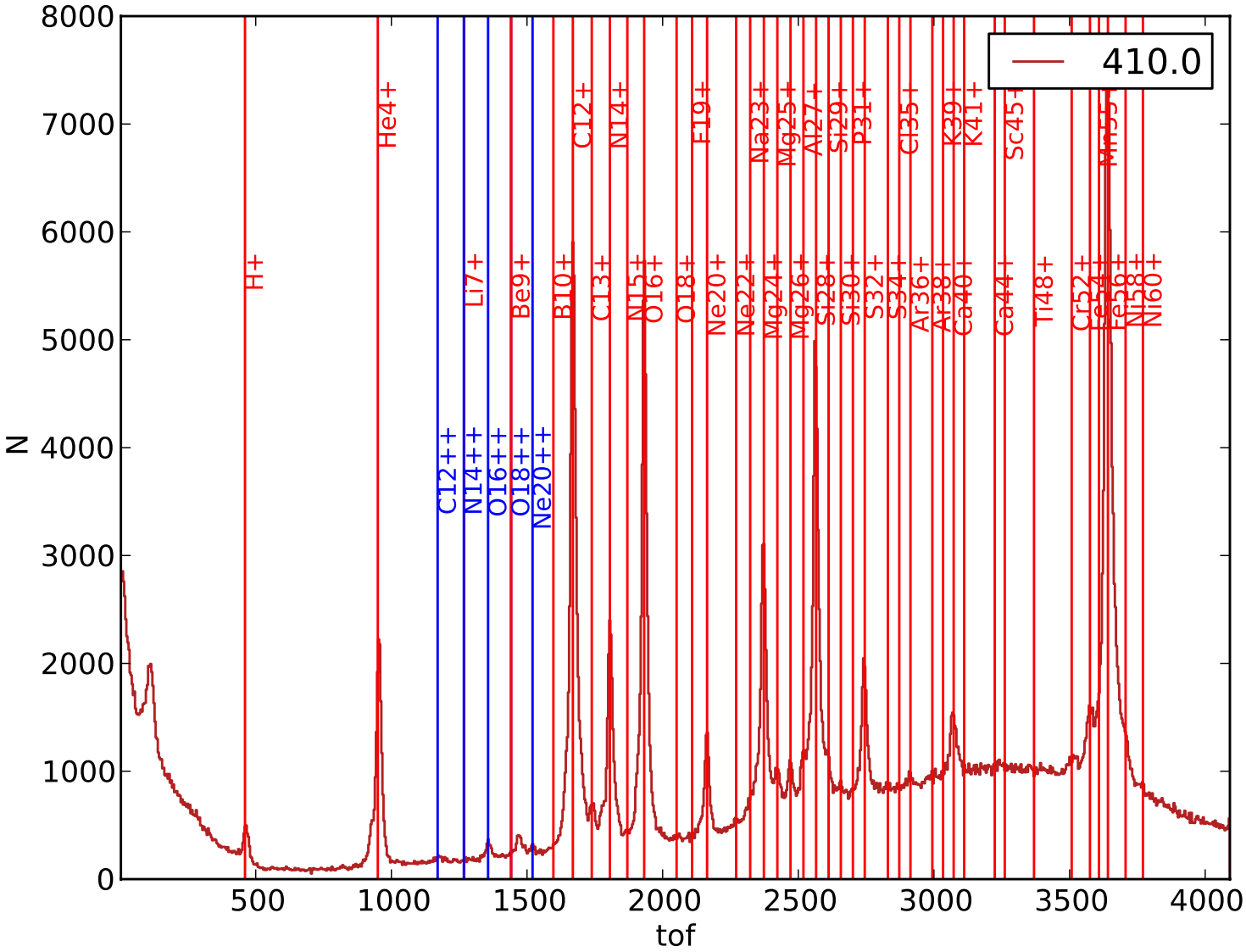

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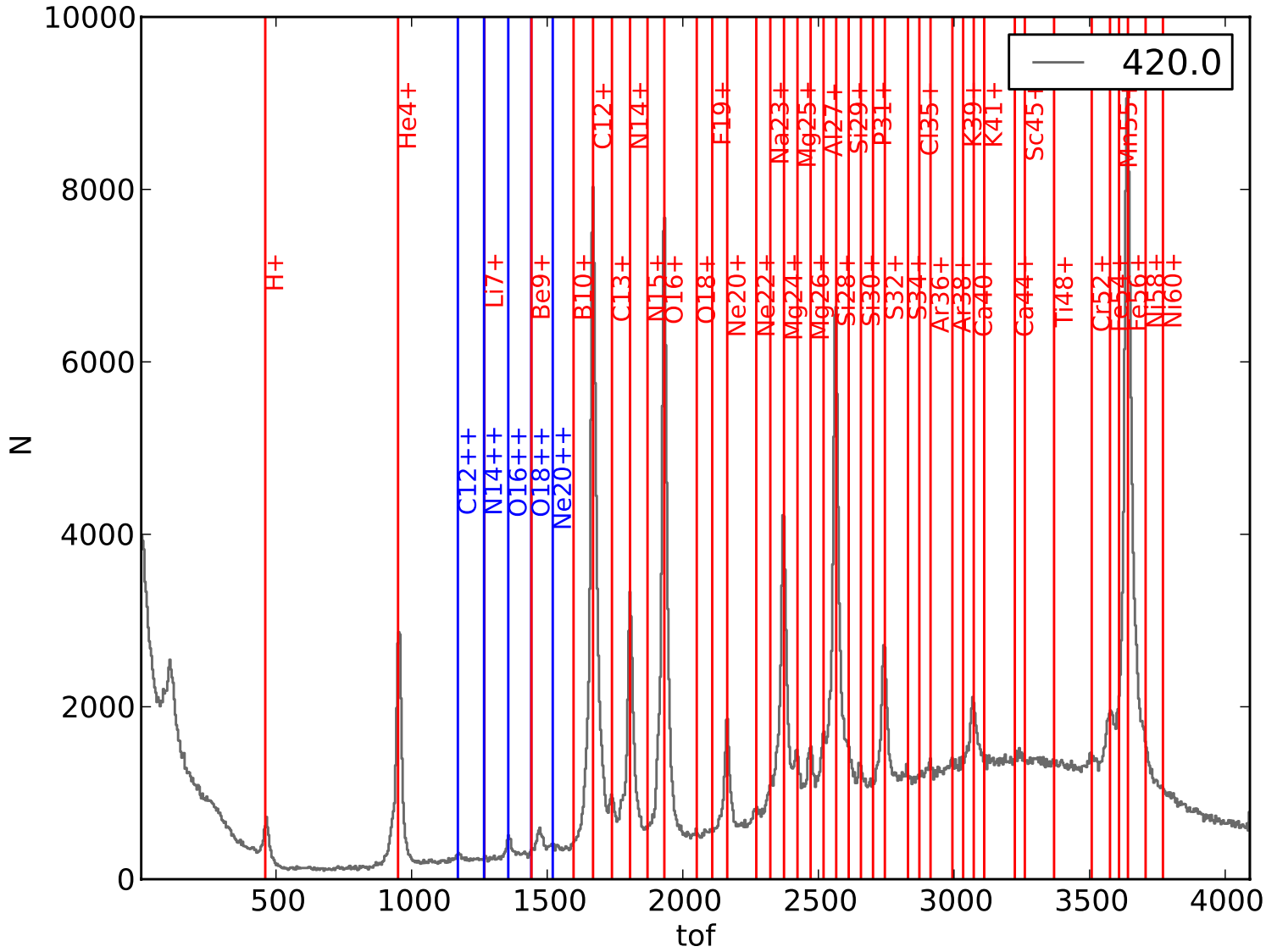

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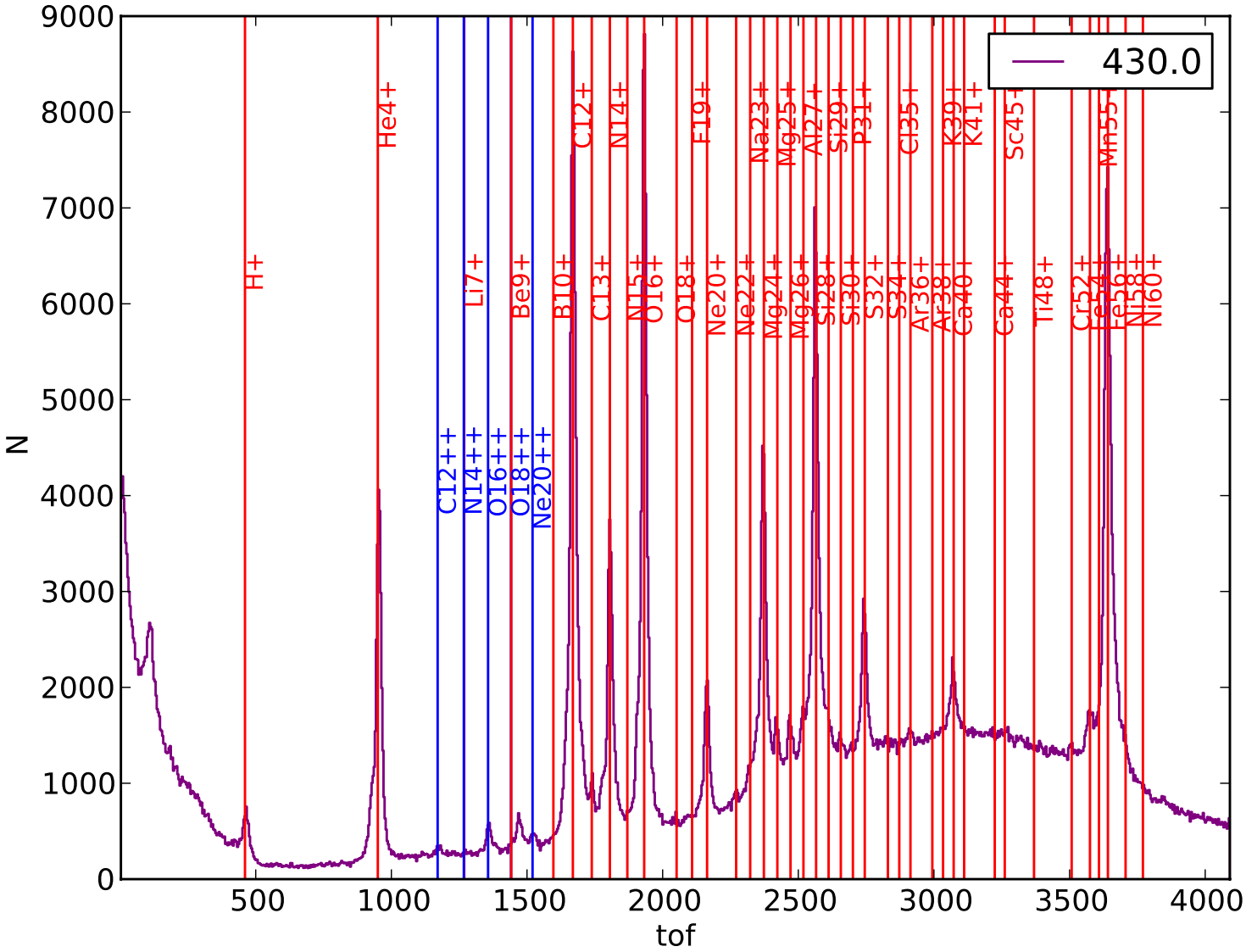

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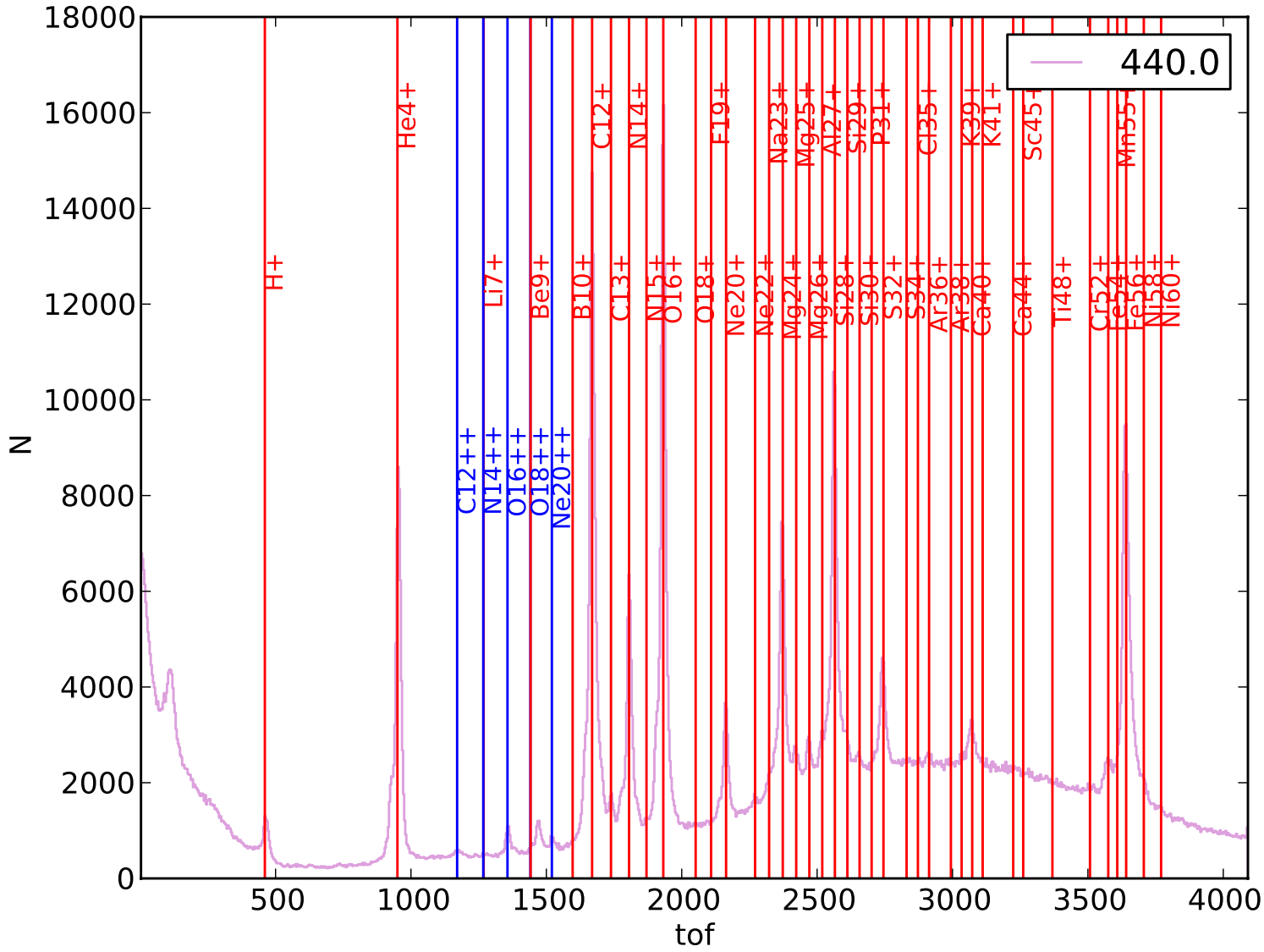

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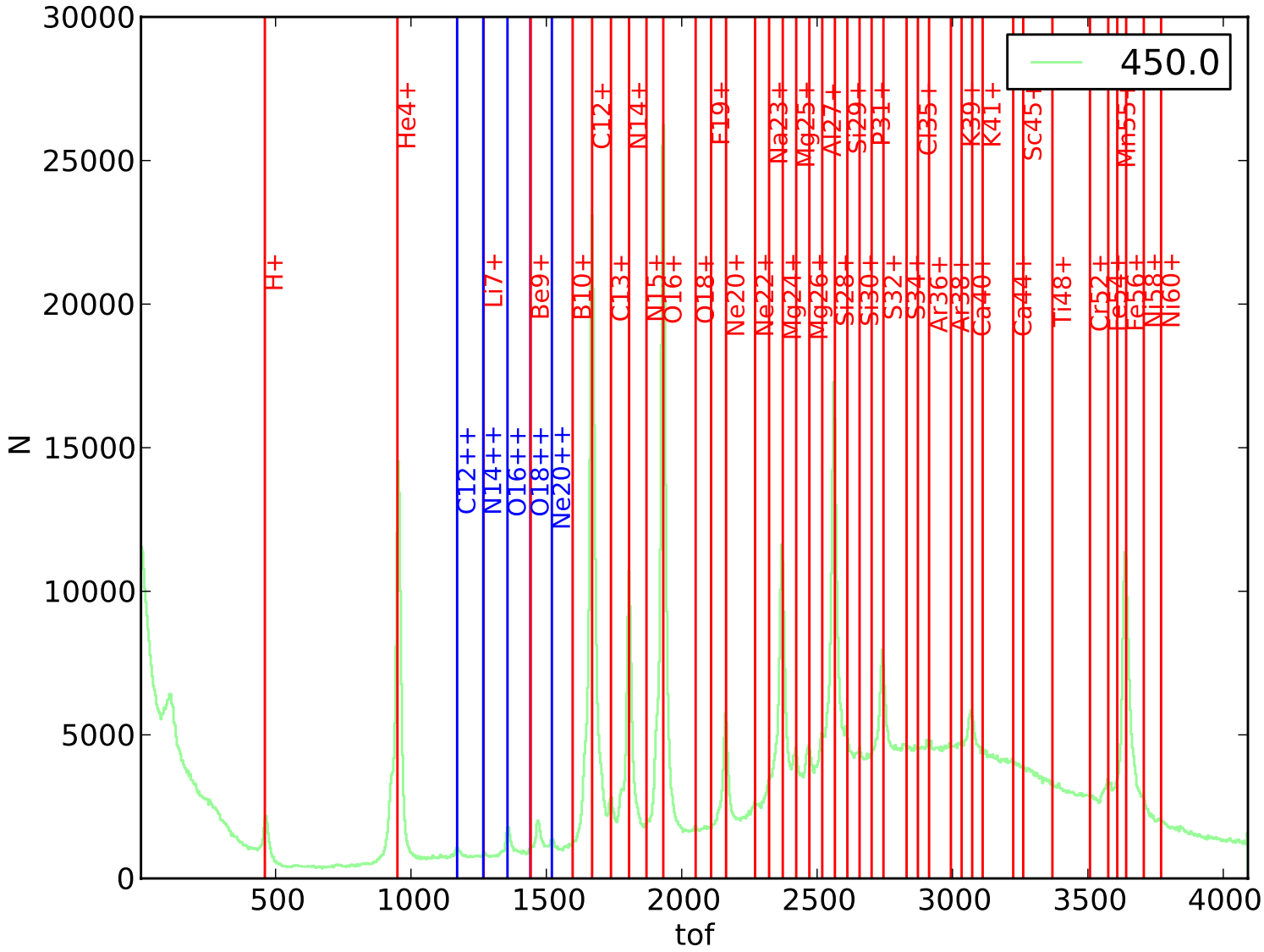

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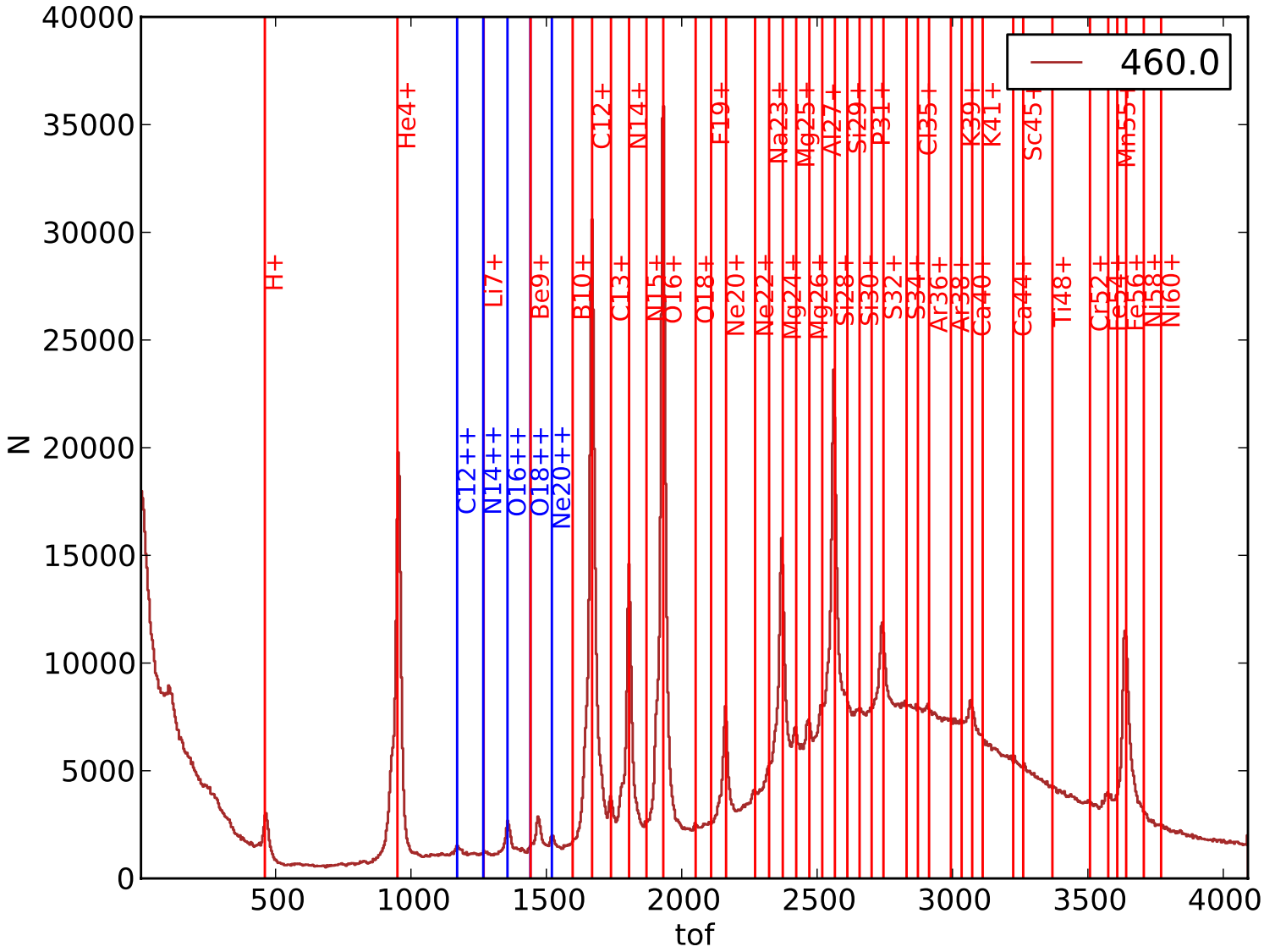

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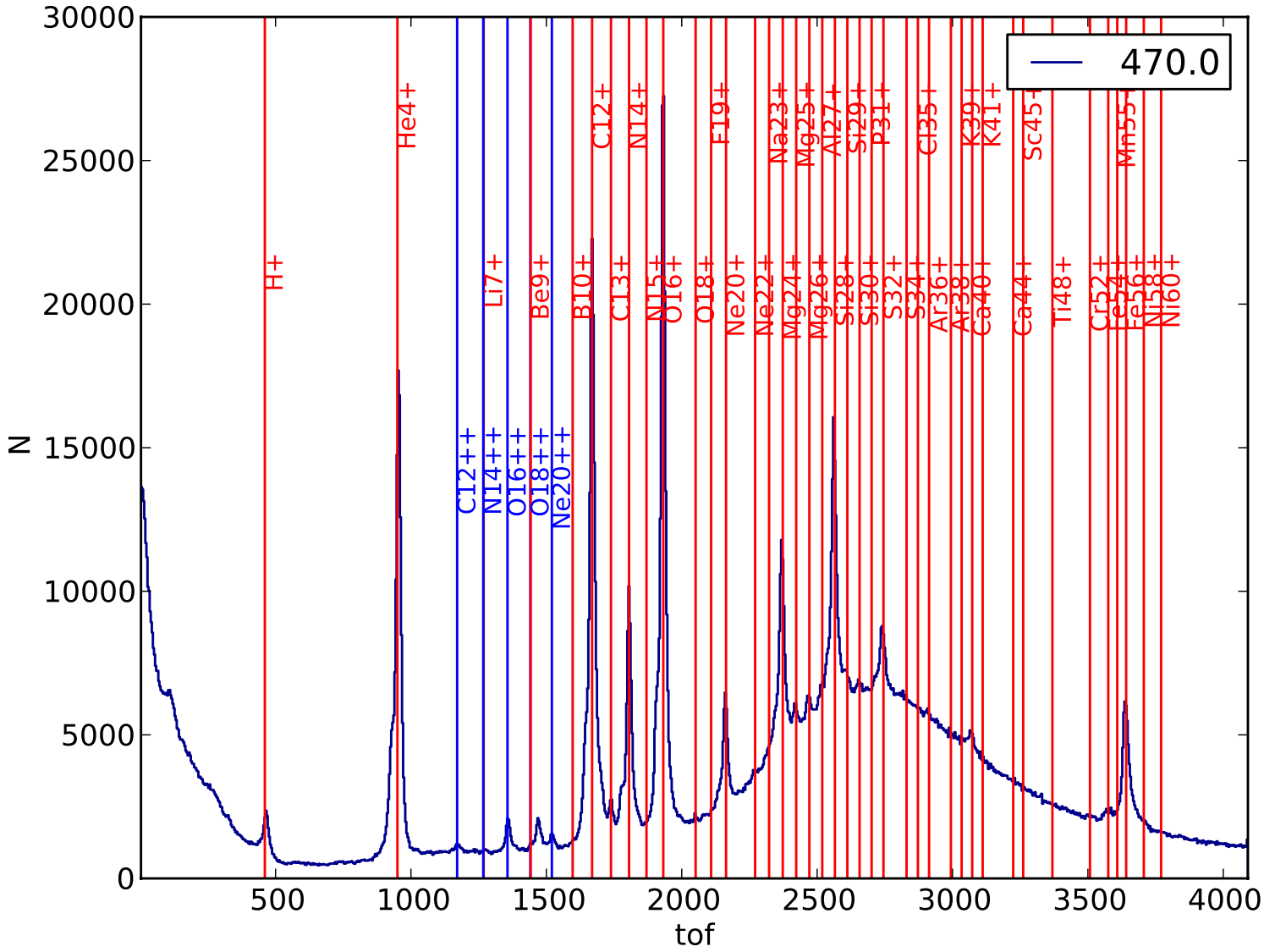

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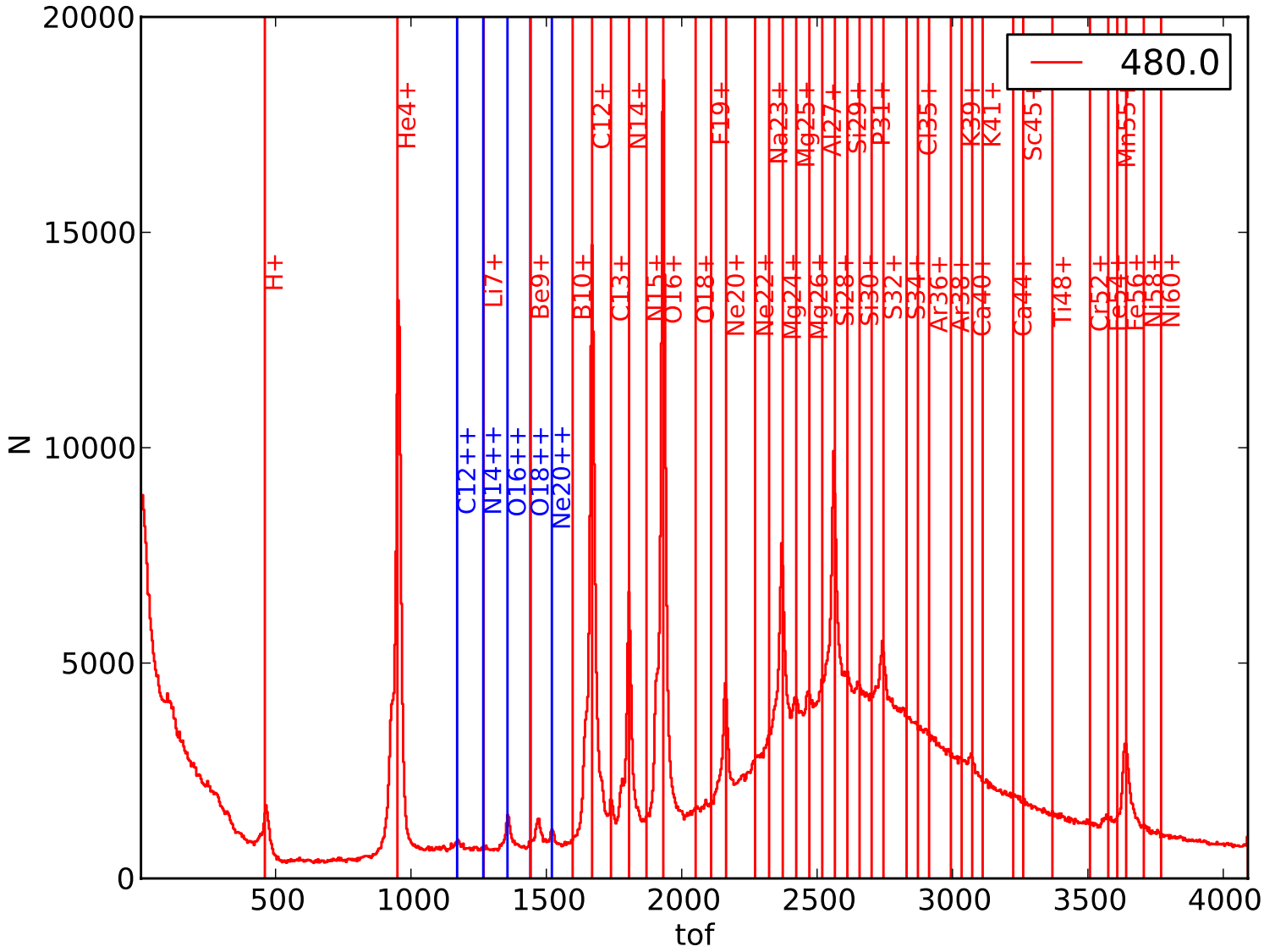

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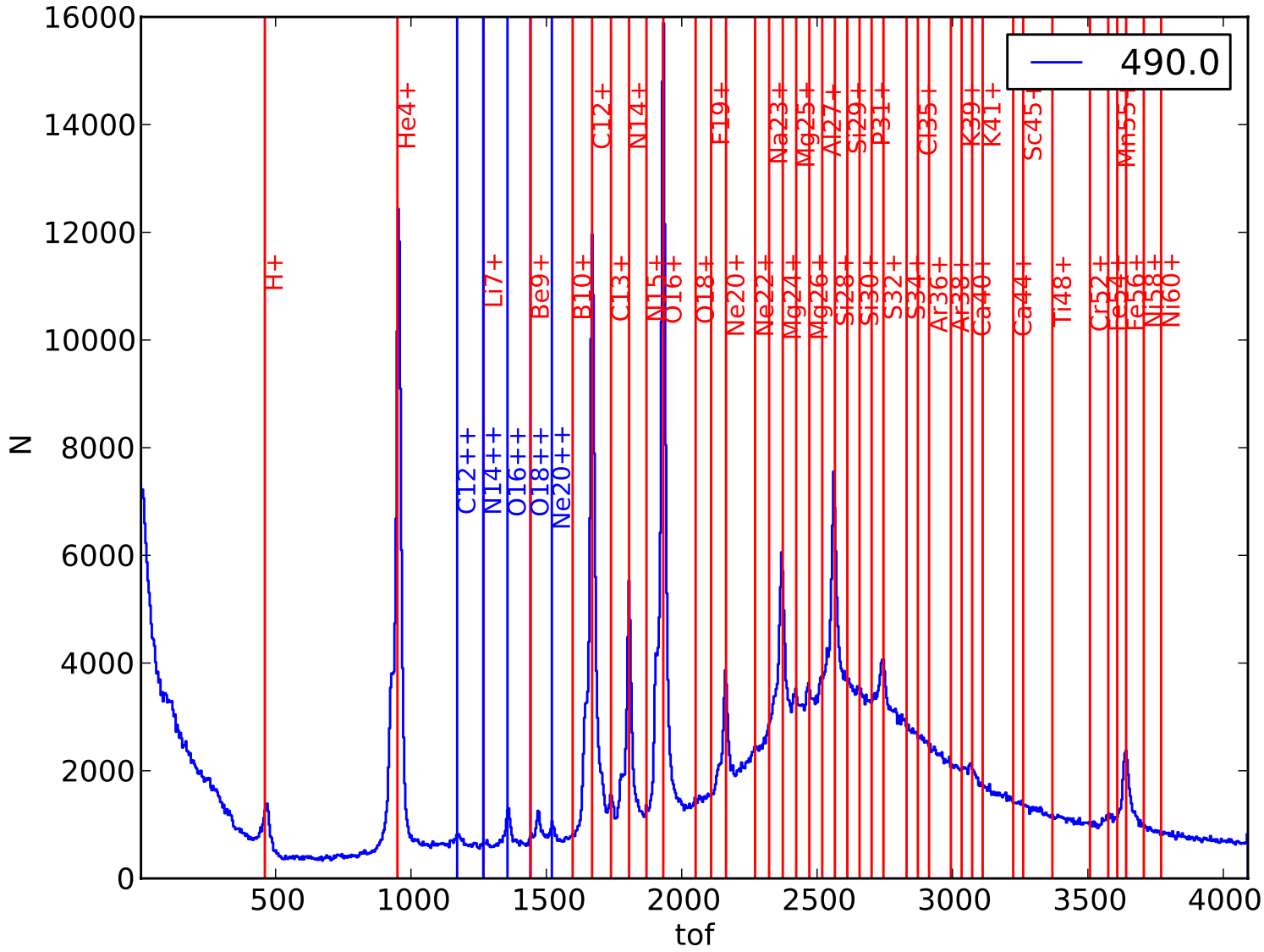

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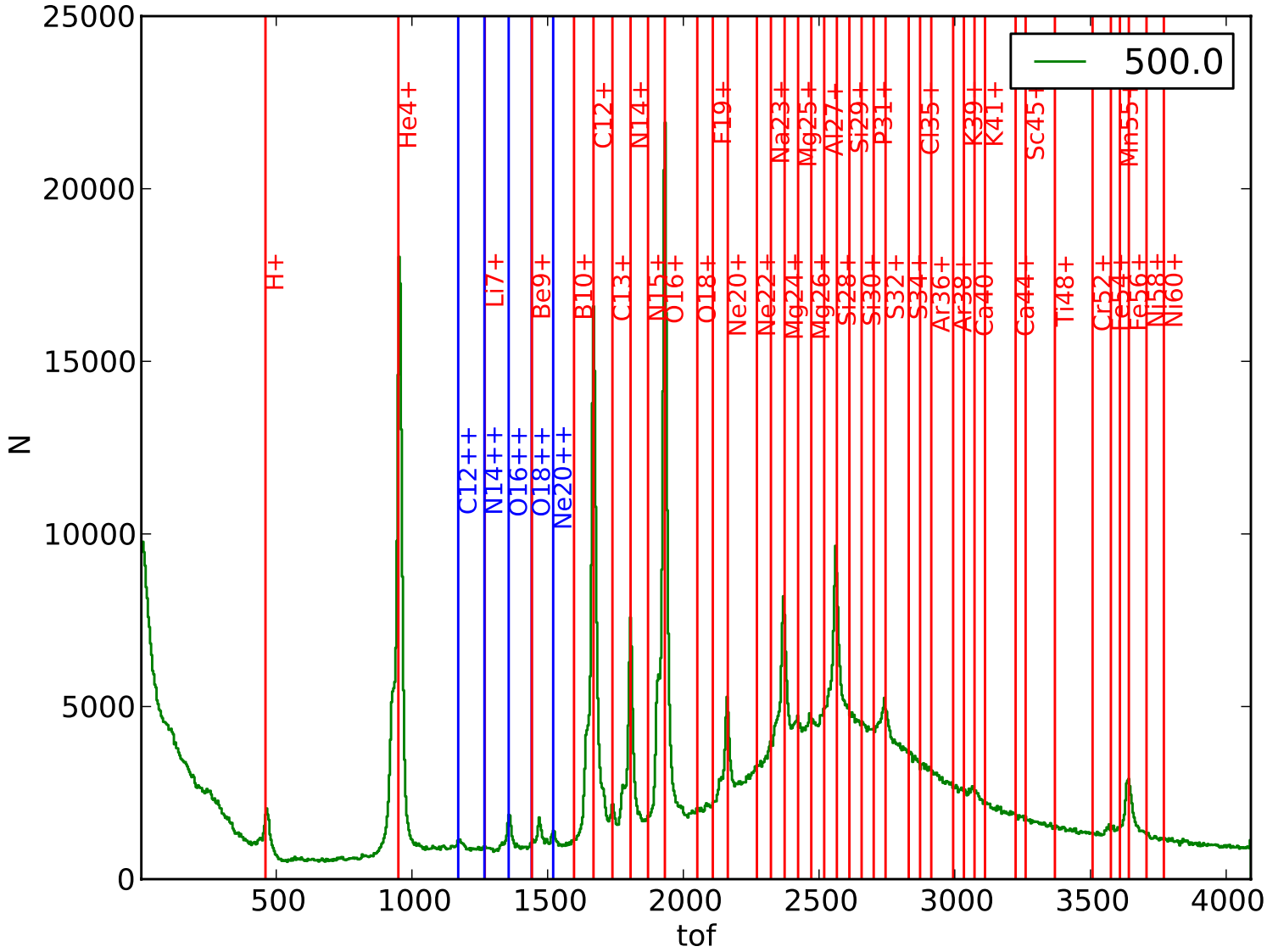

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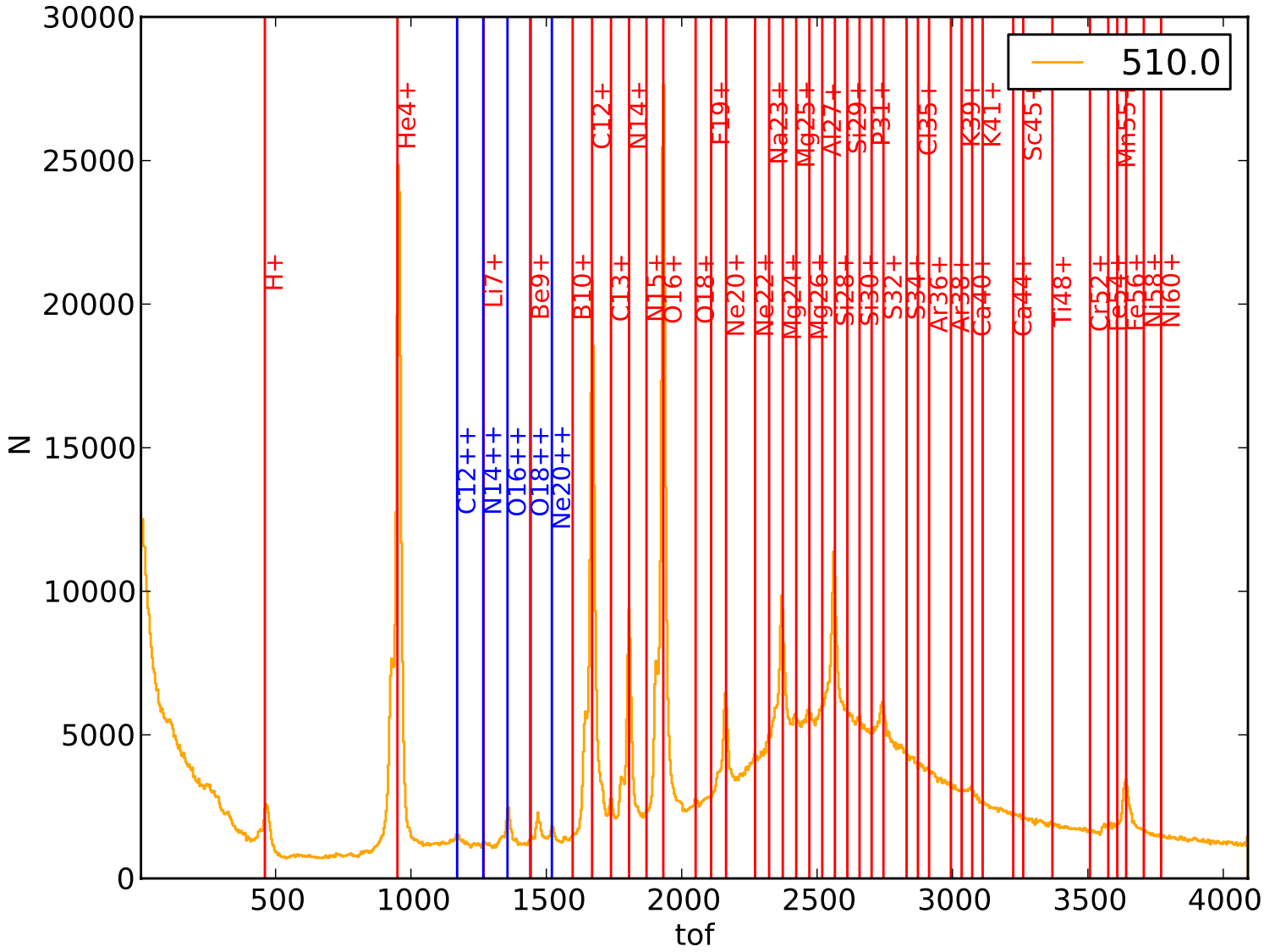

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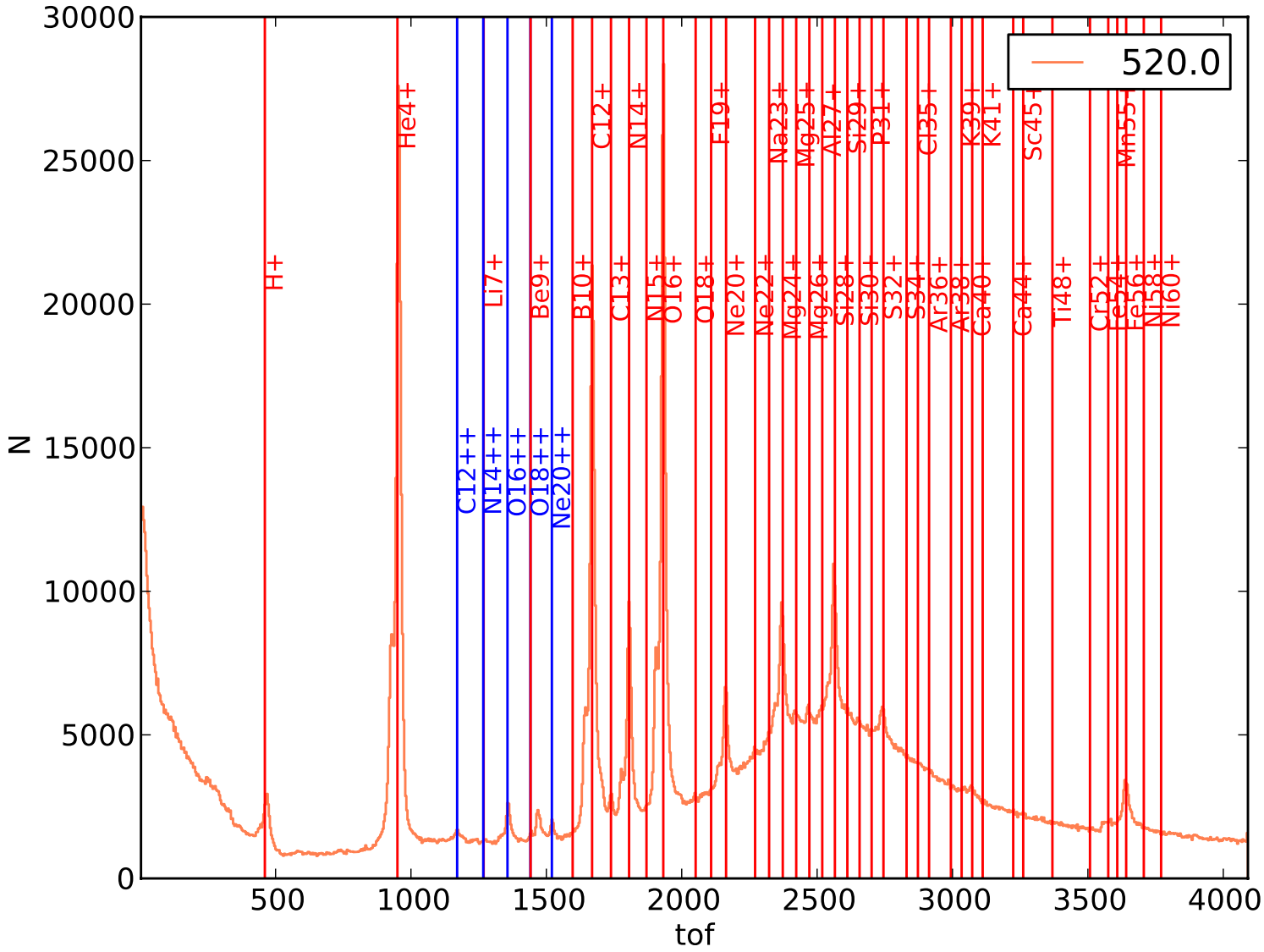

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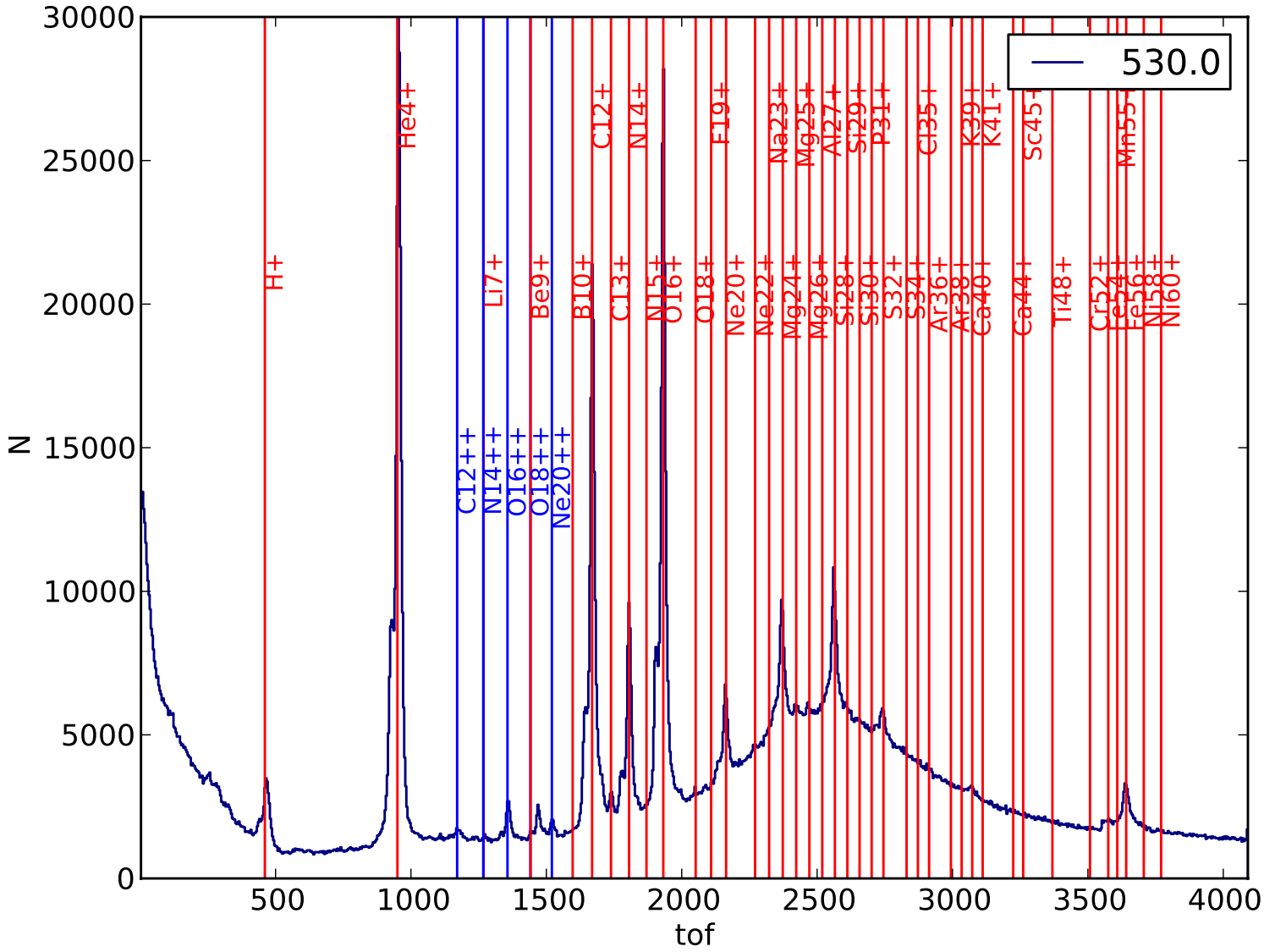

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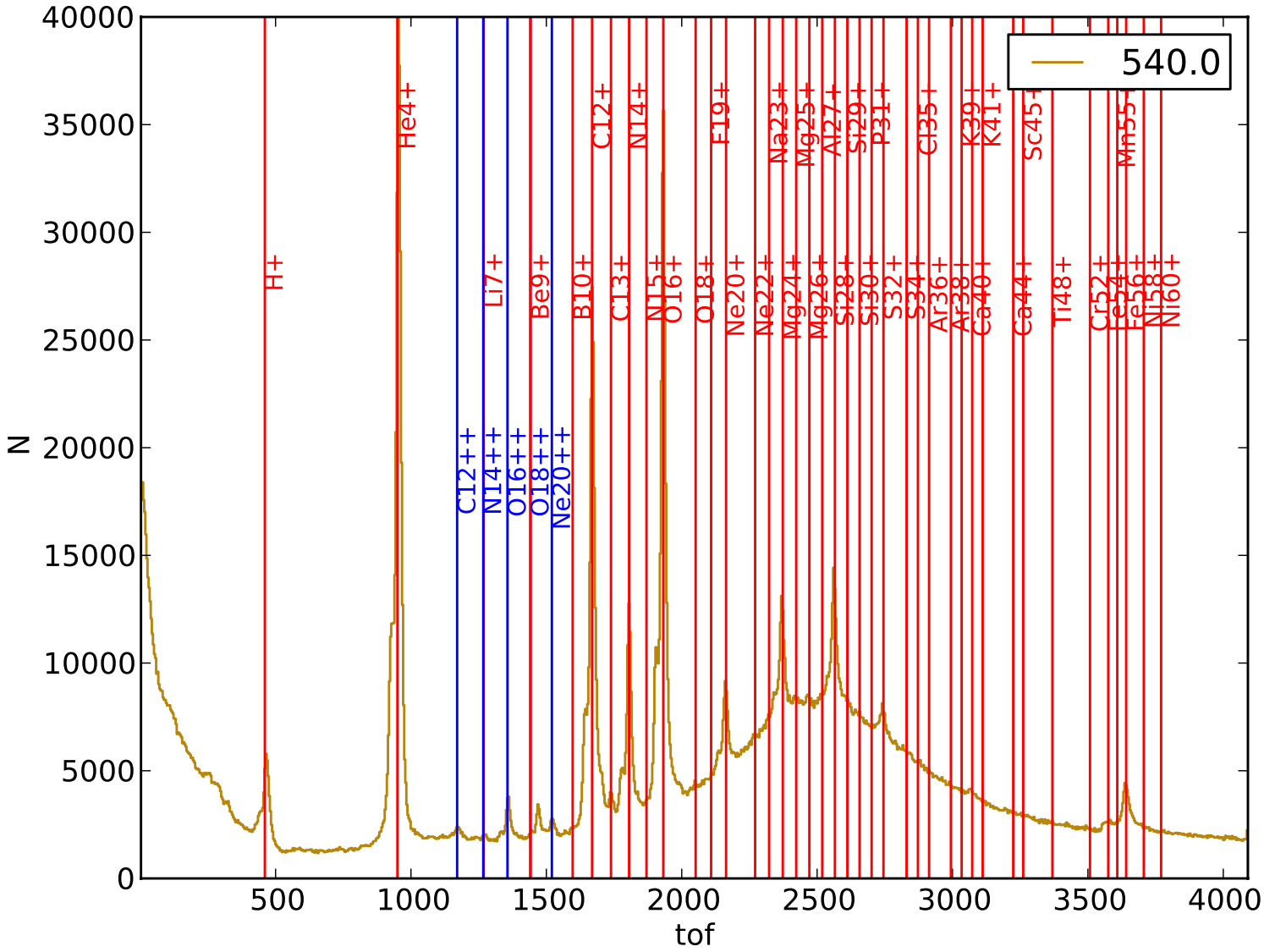

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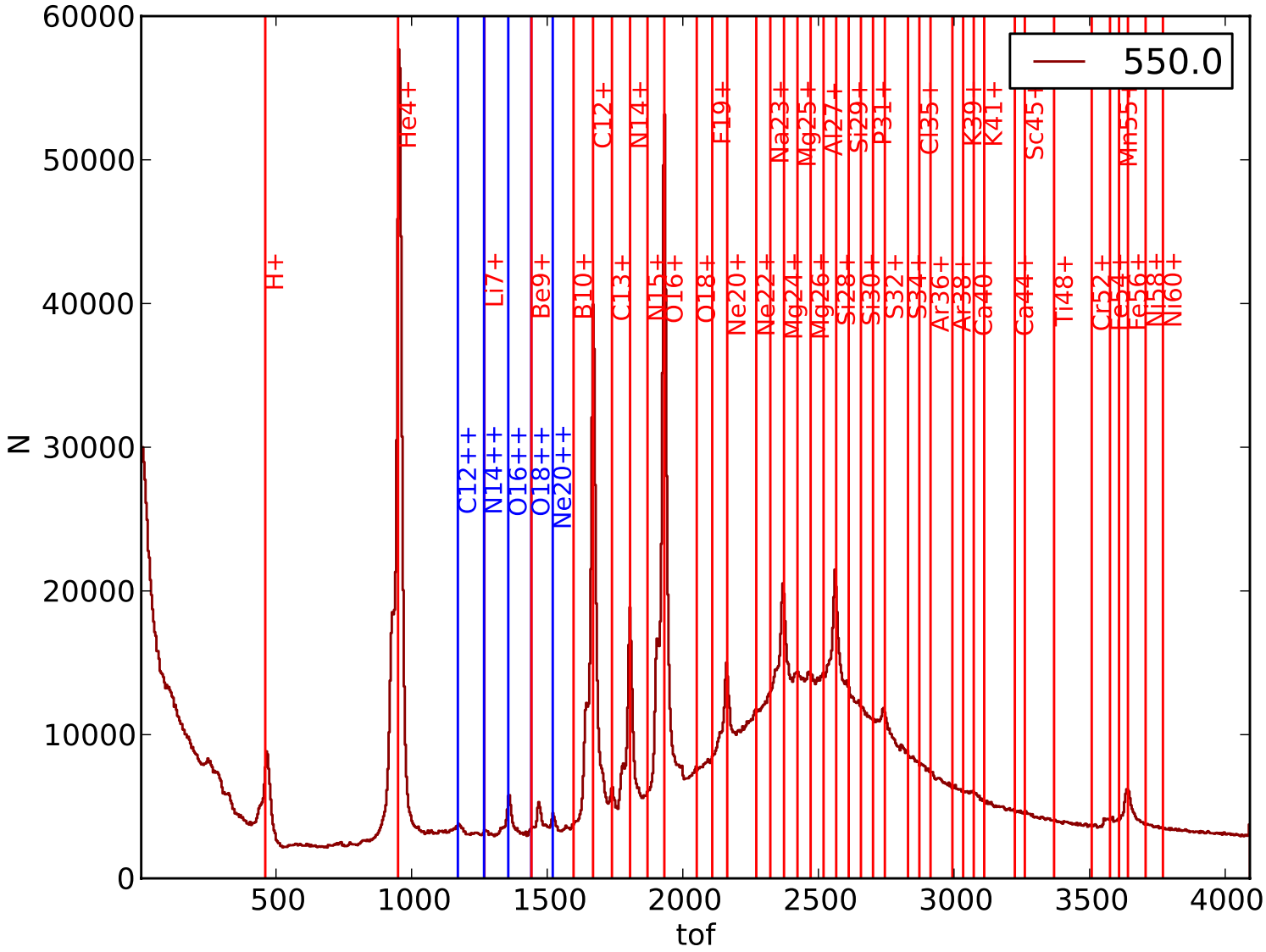

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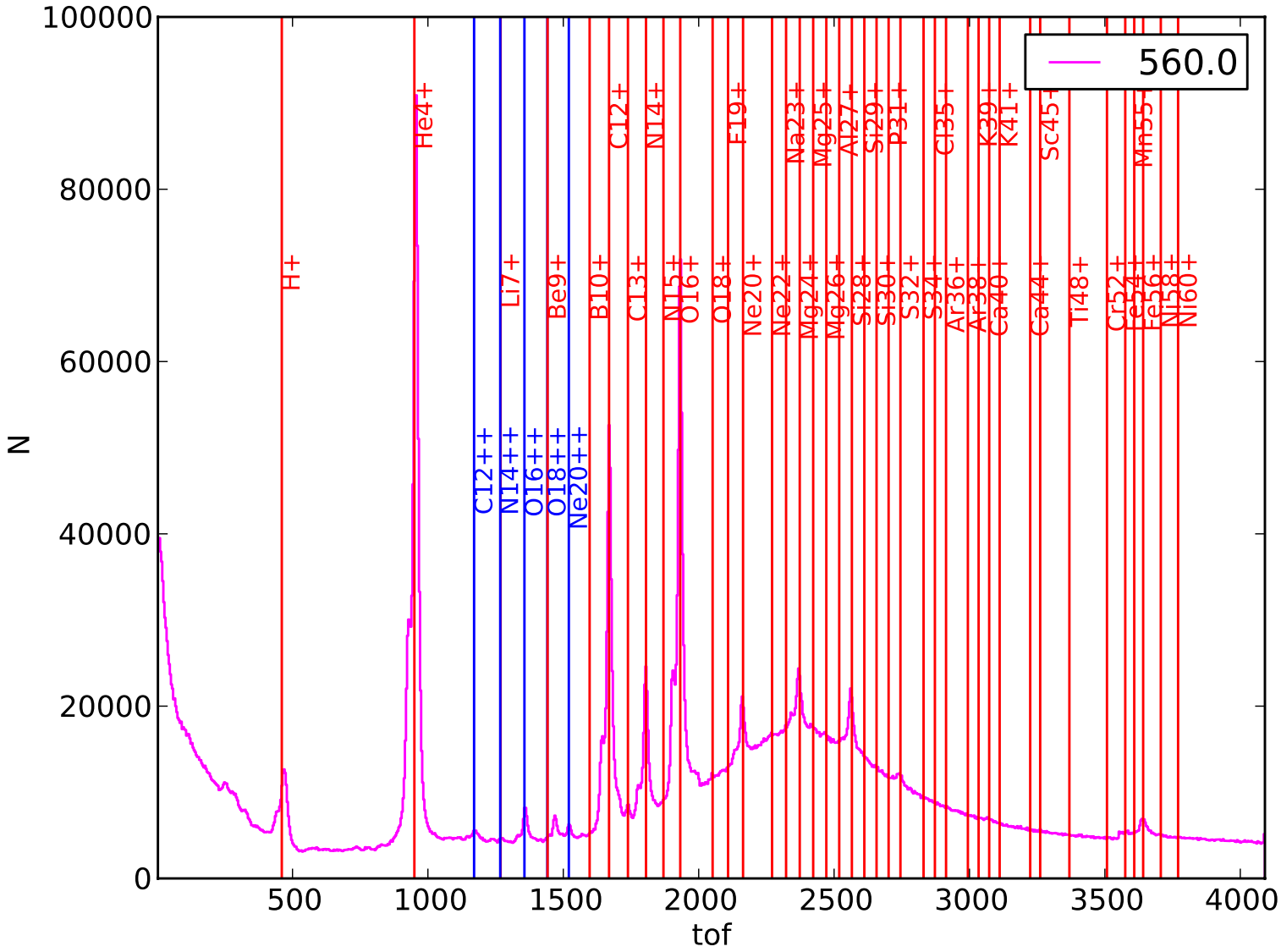

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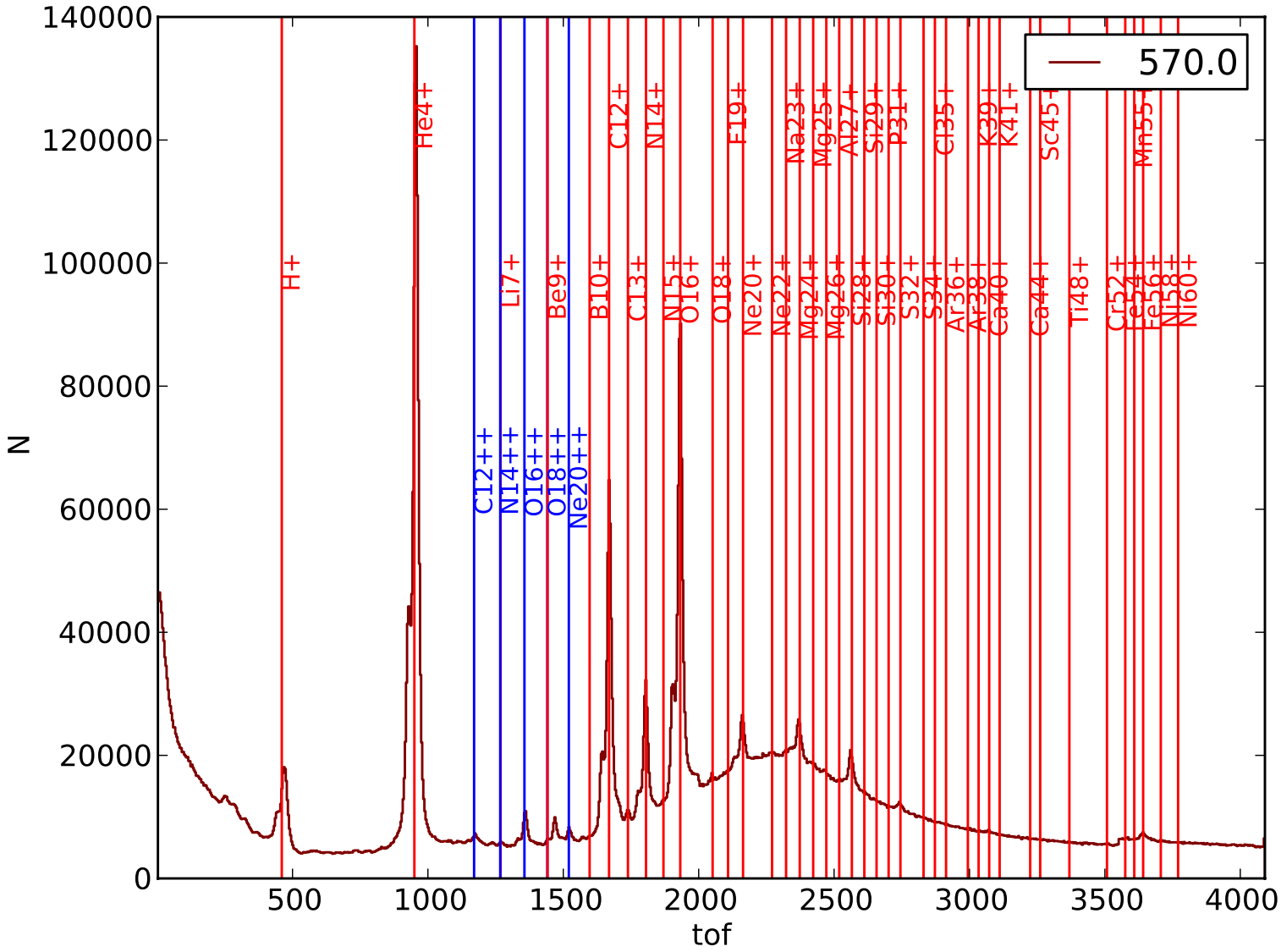

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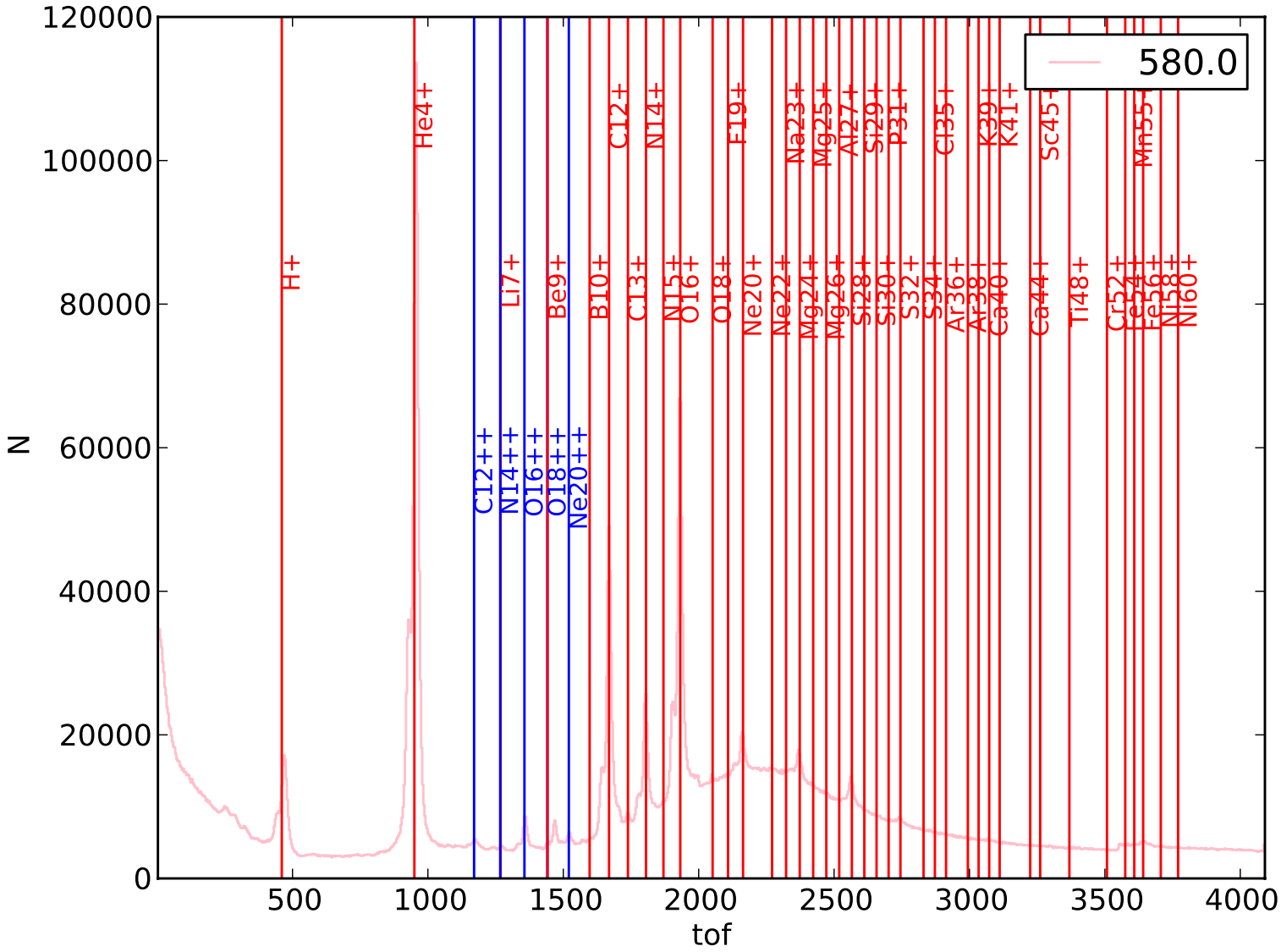

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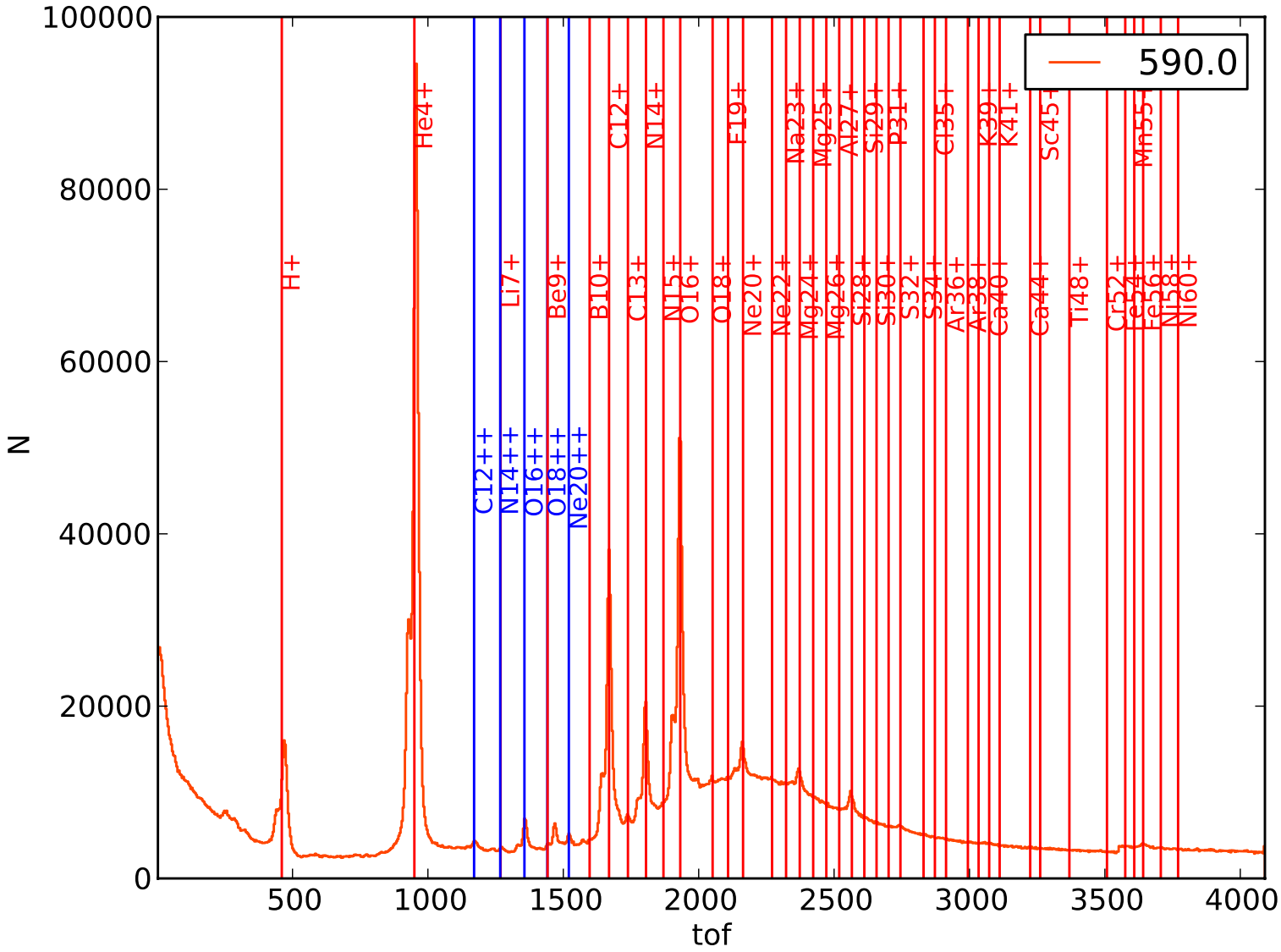

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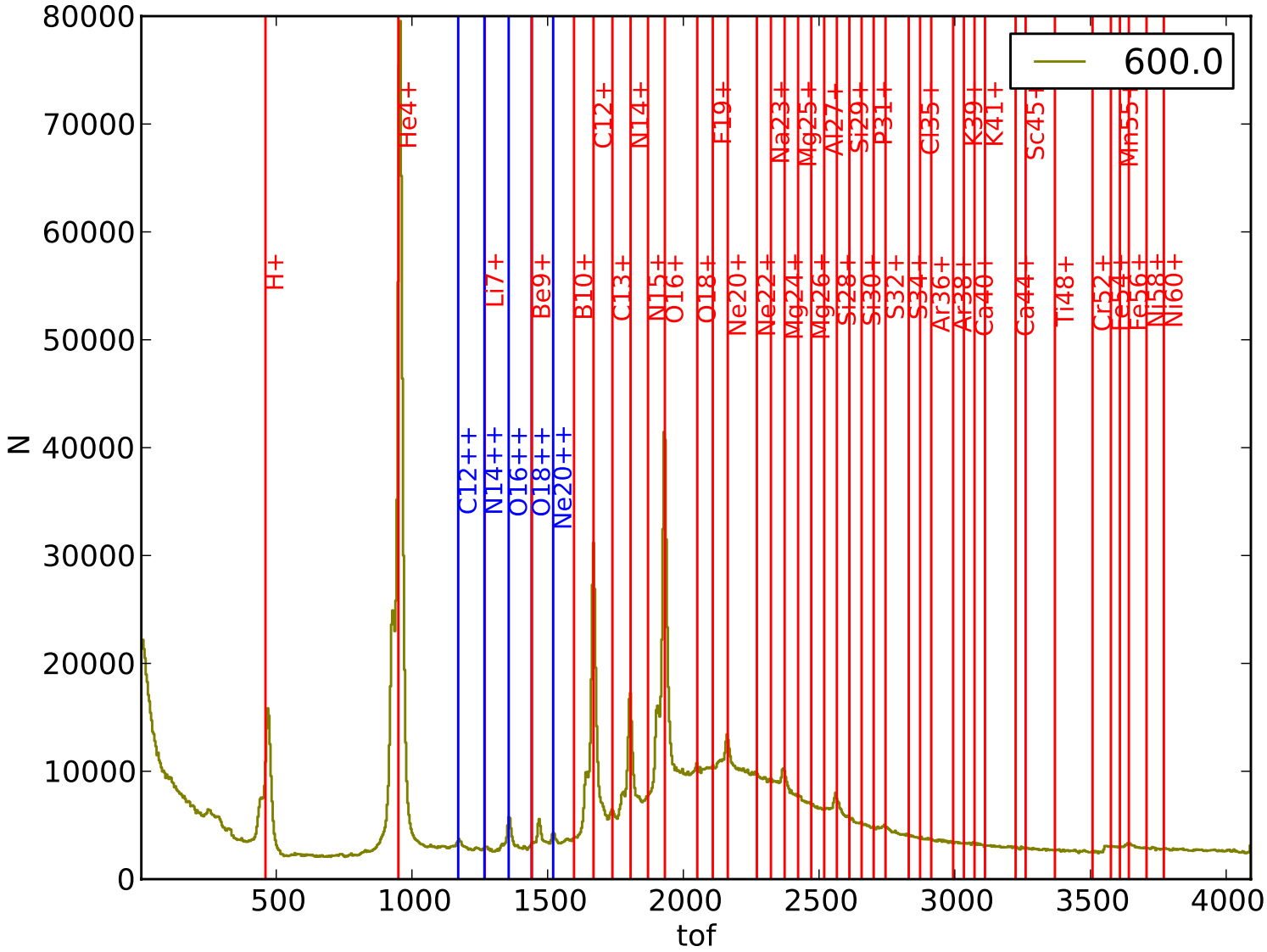
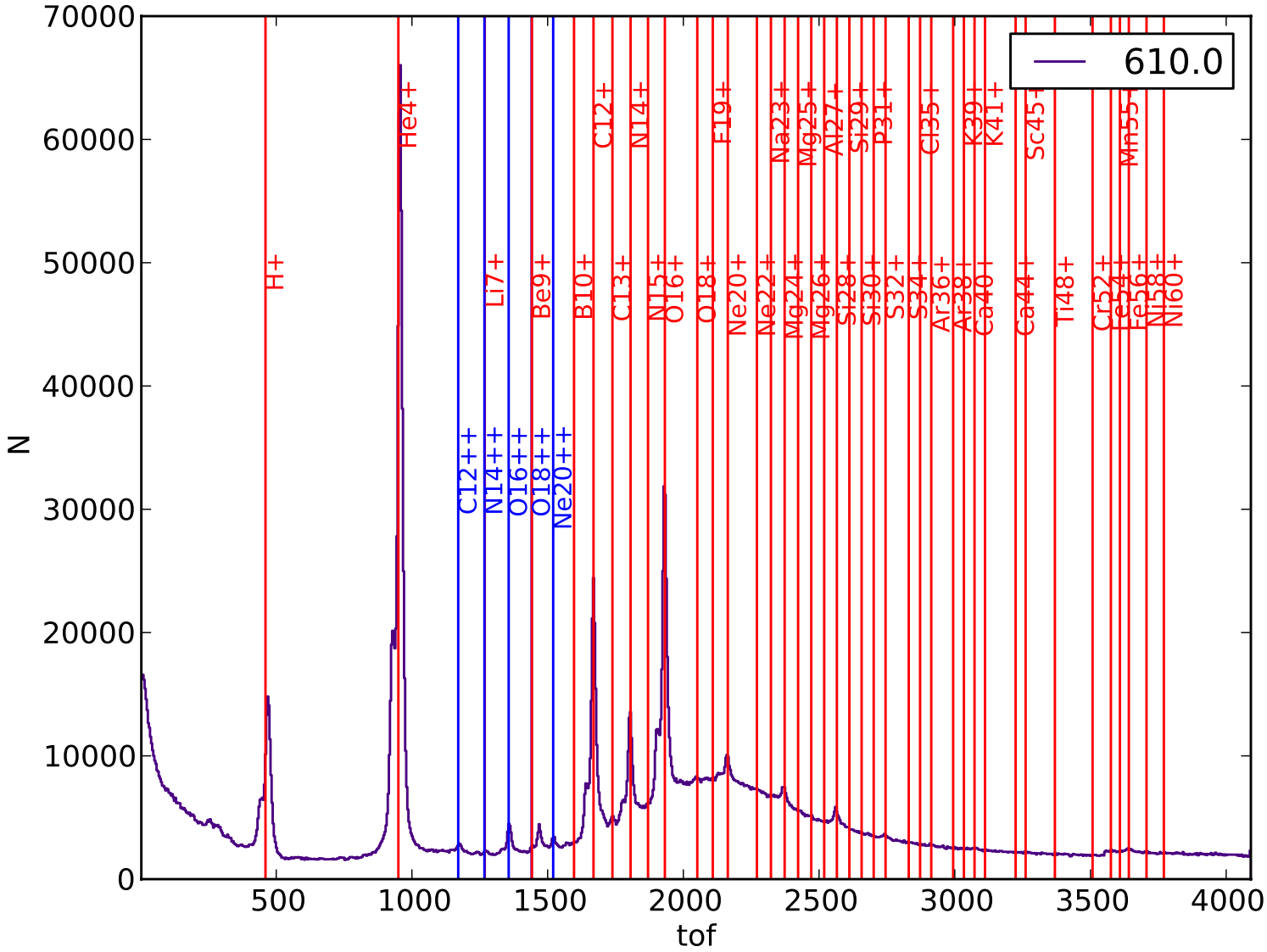


Mass resolution and background (2008)



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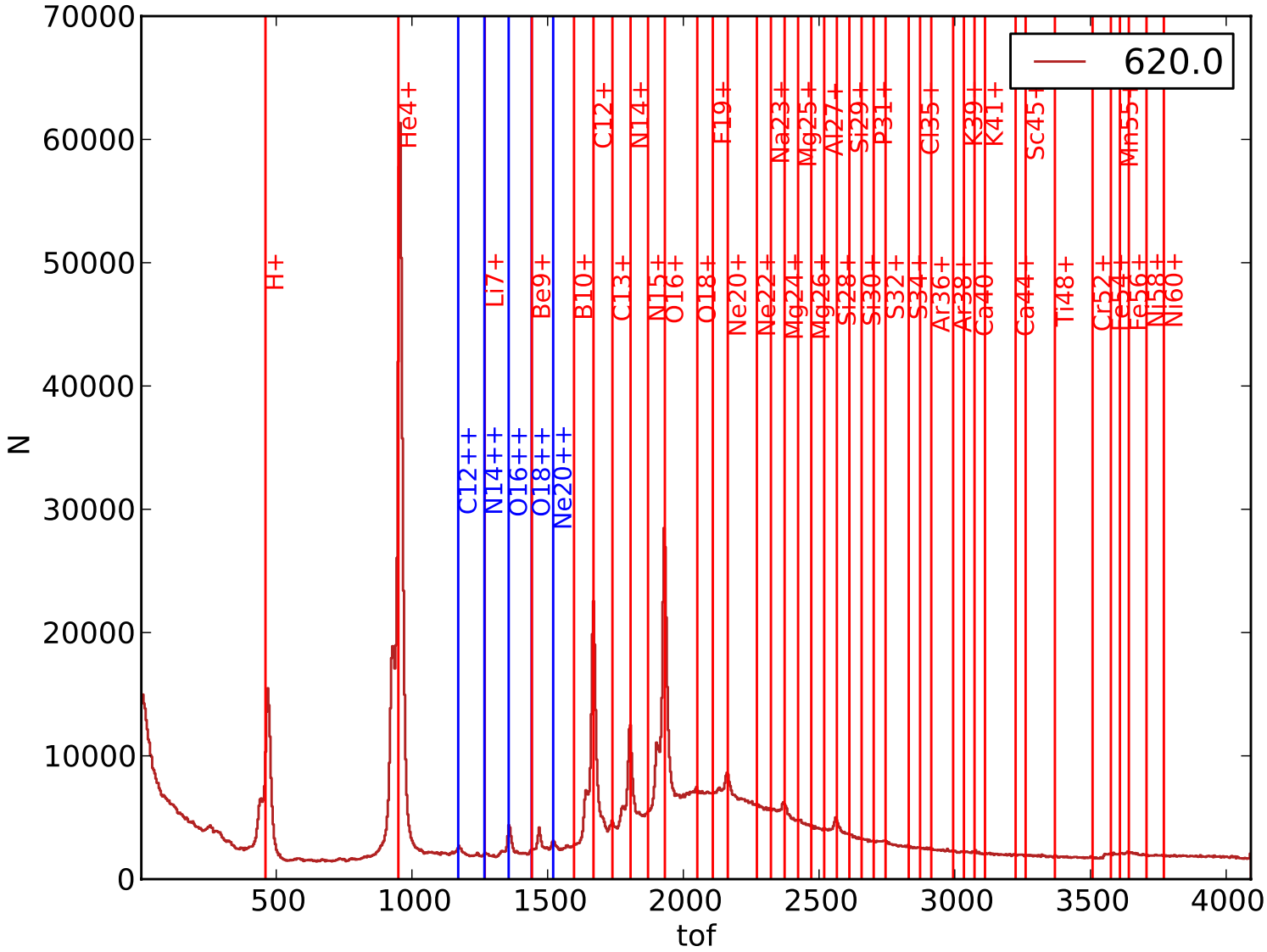

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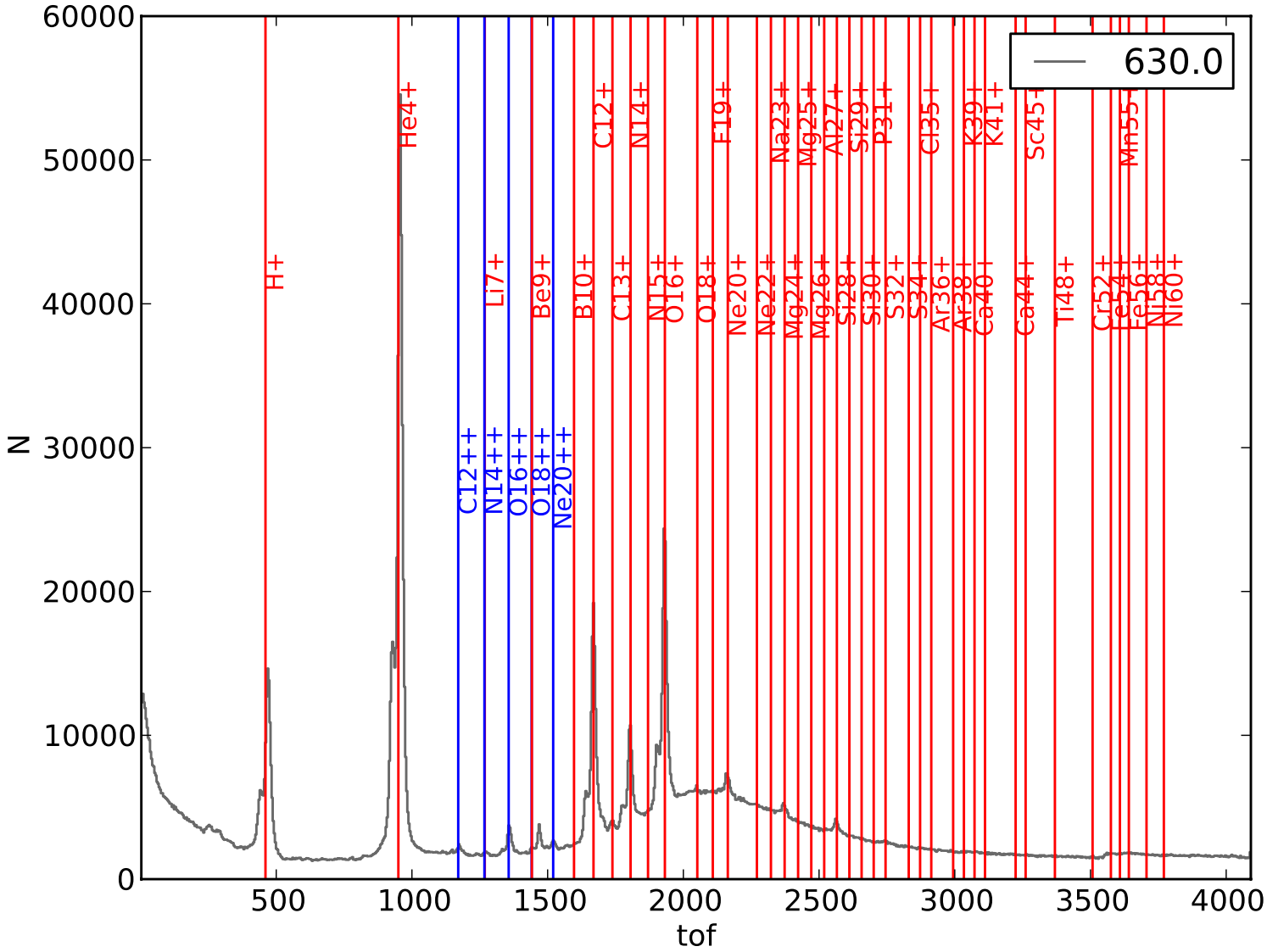

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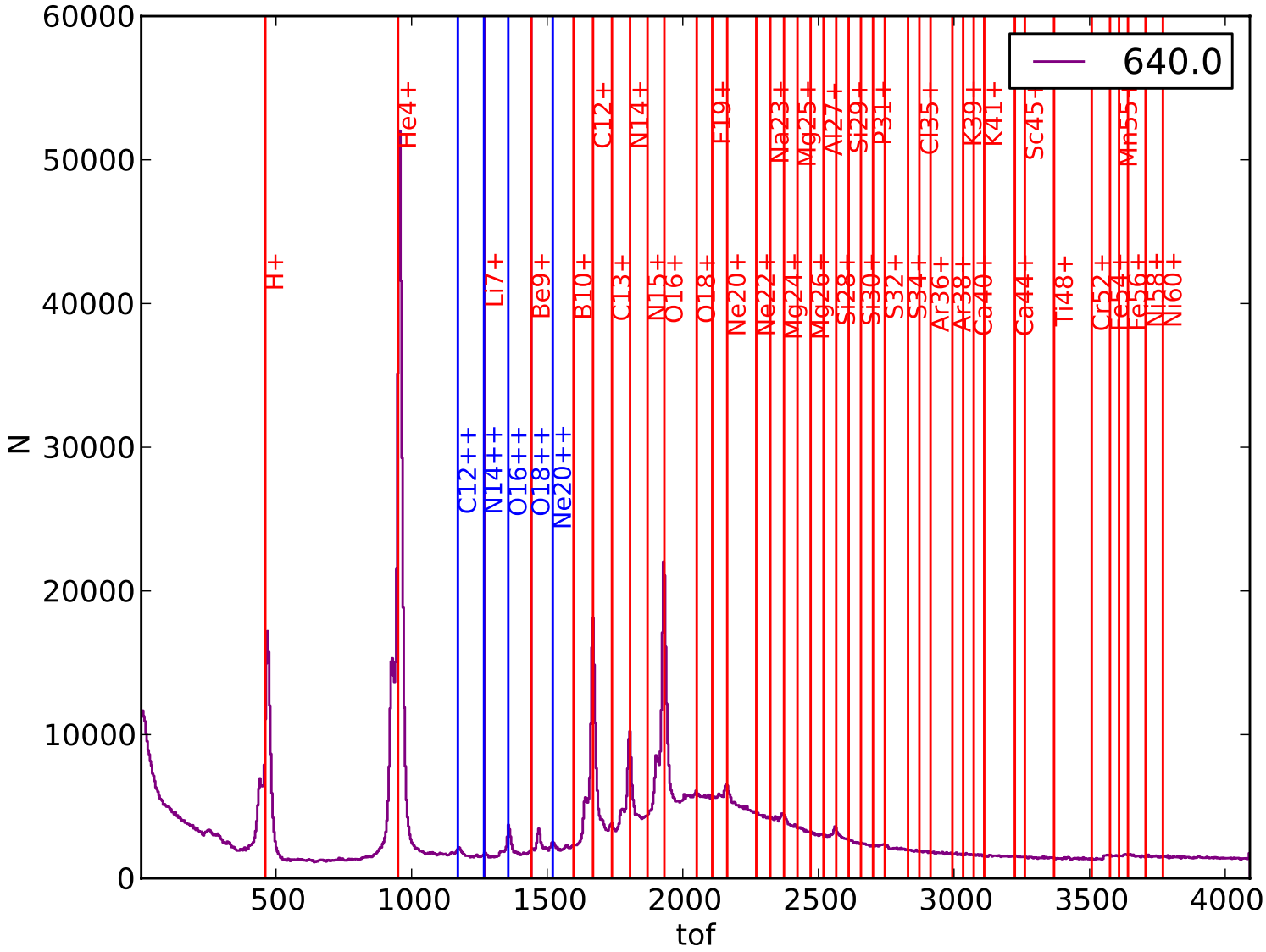

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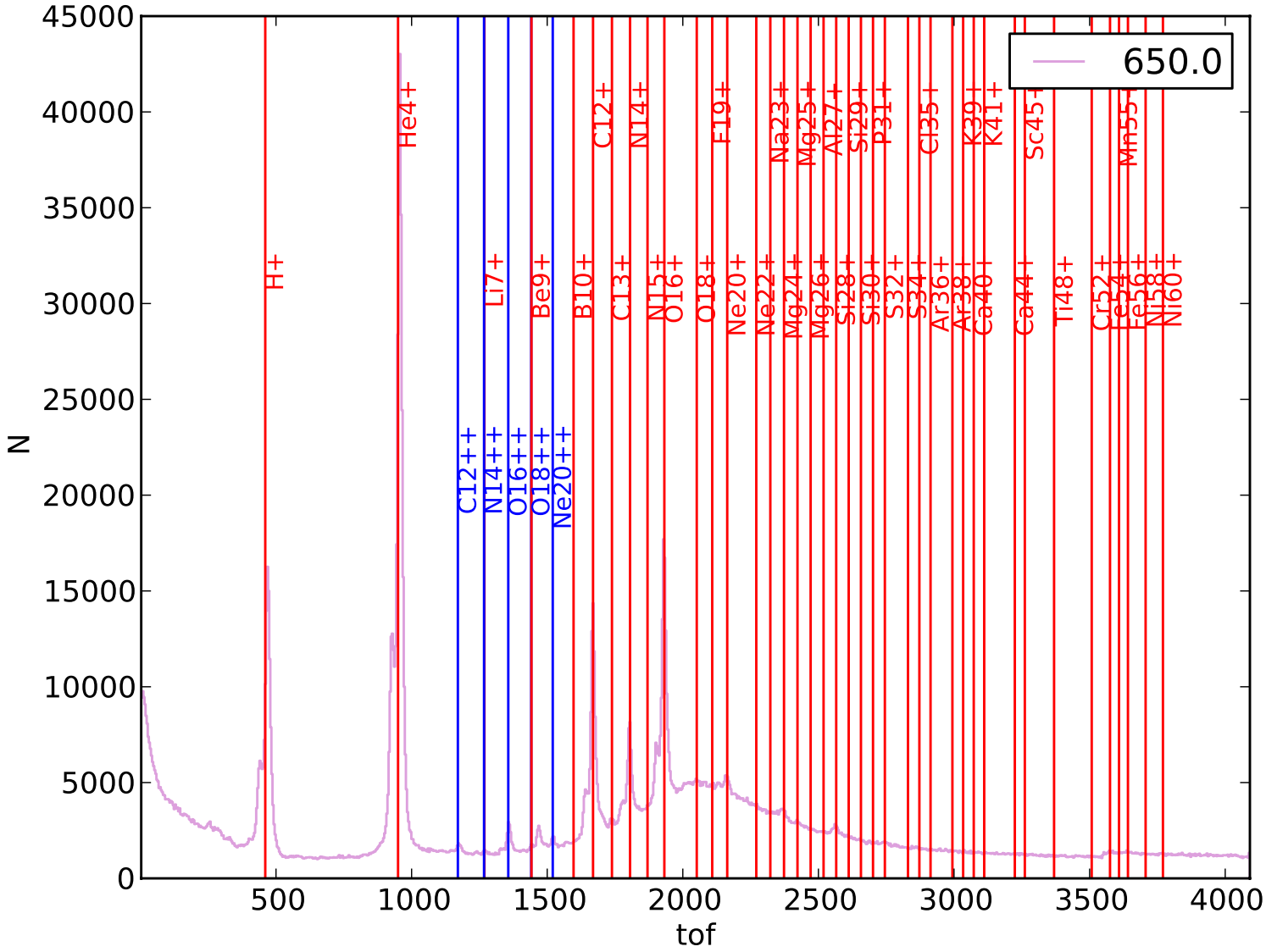

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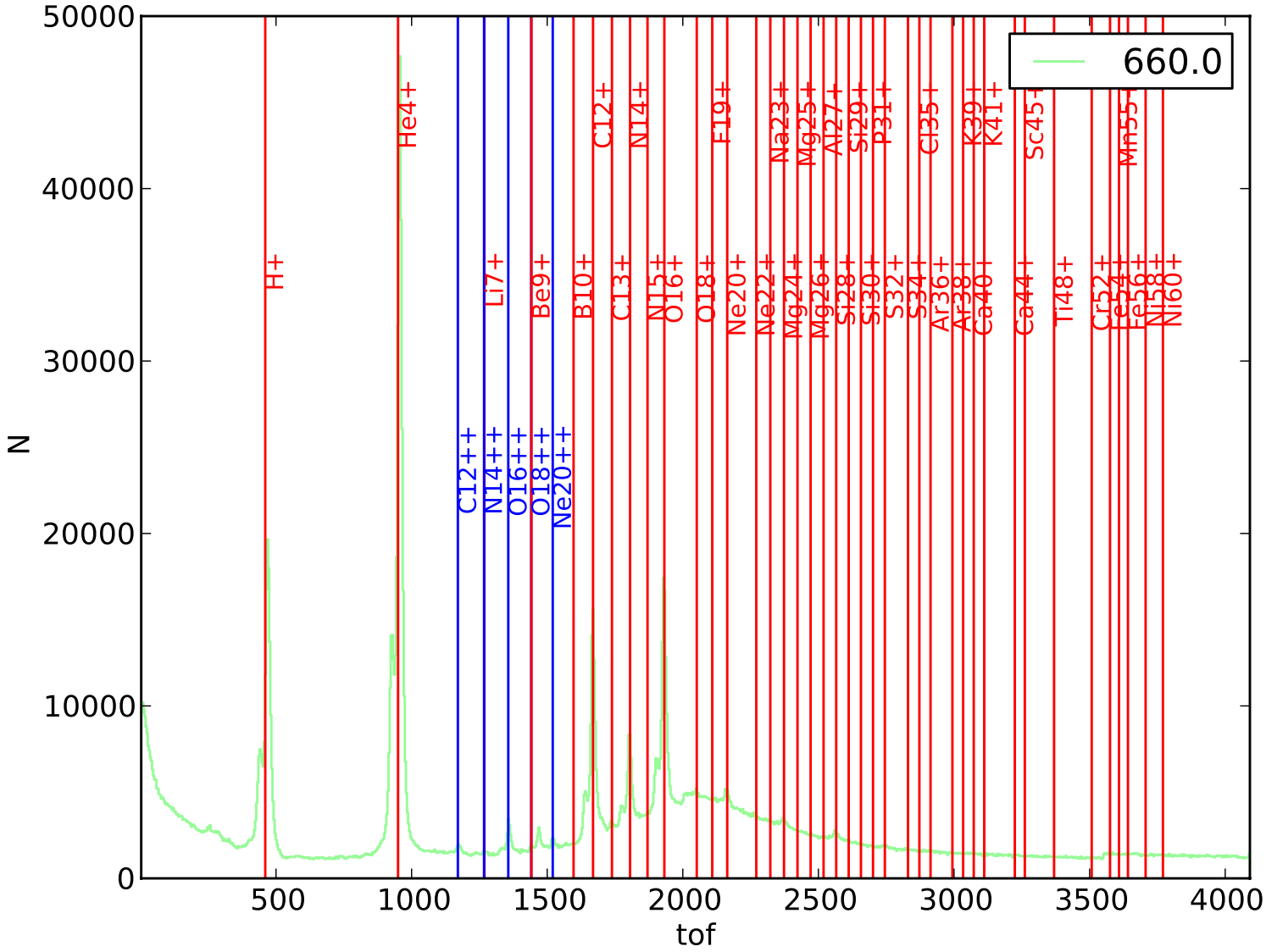

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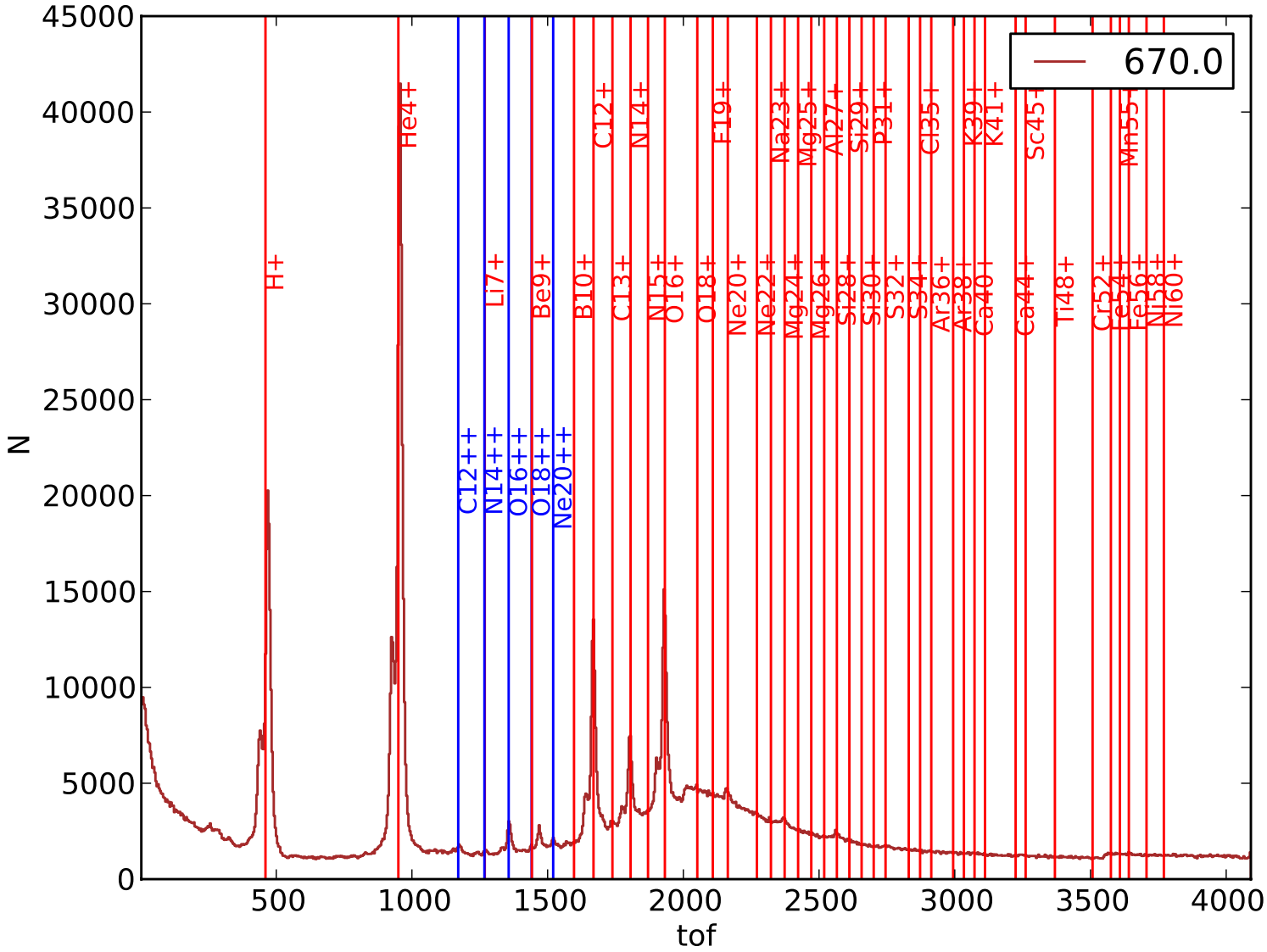

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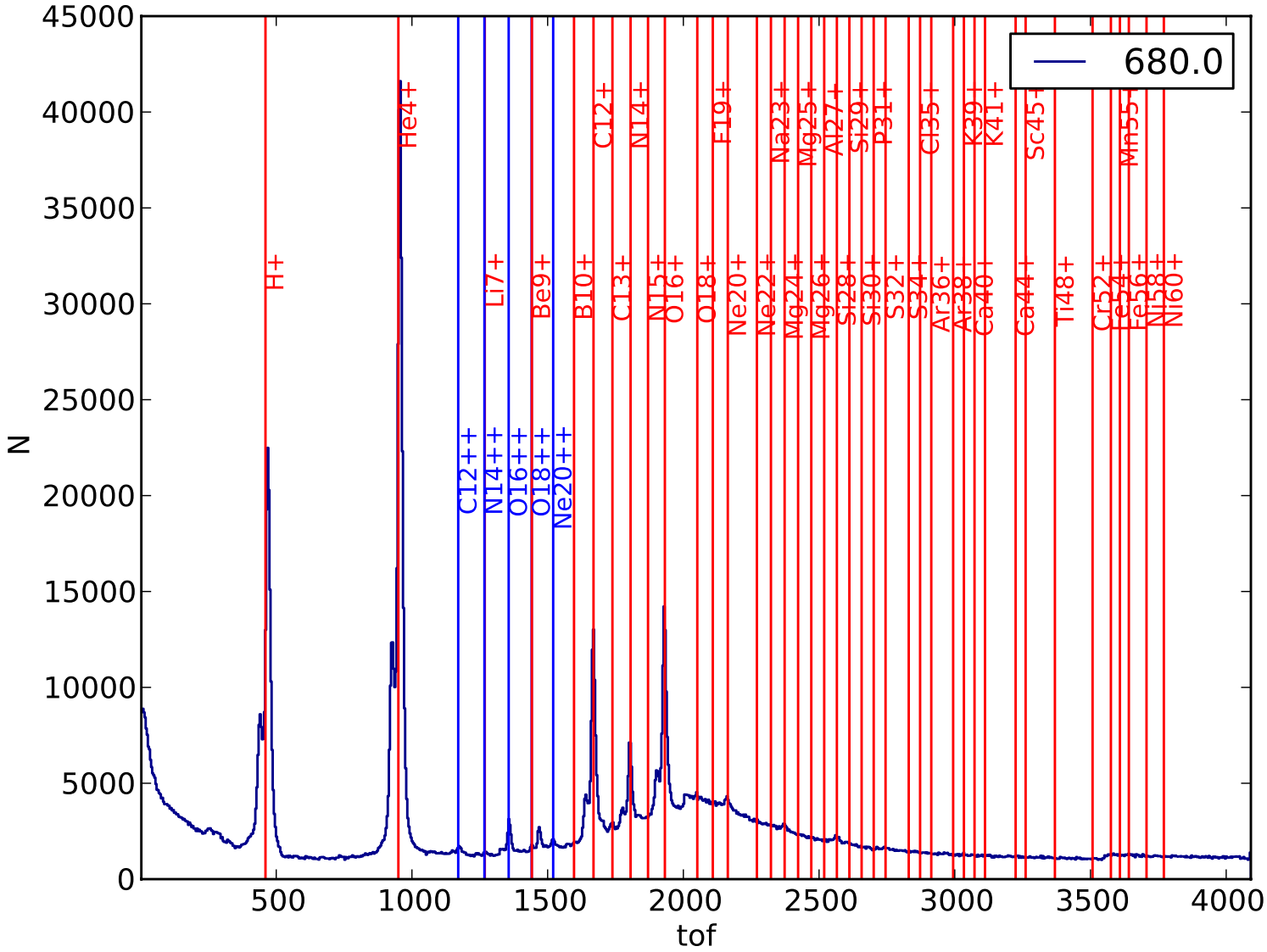

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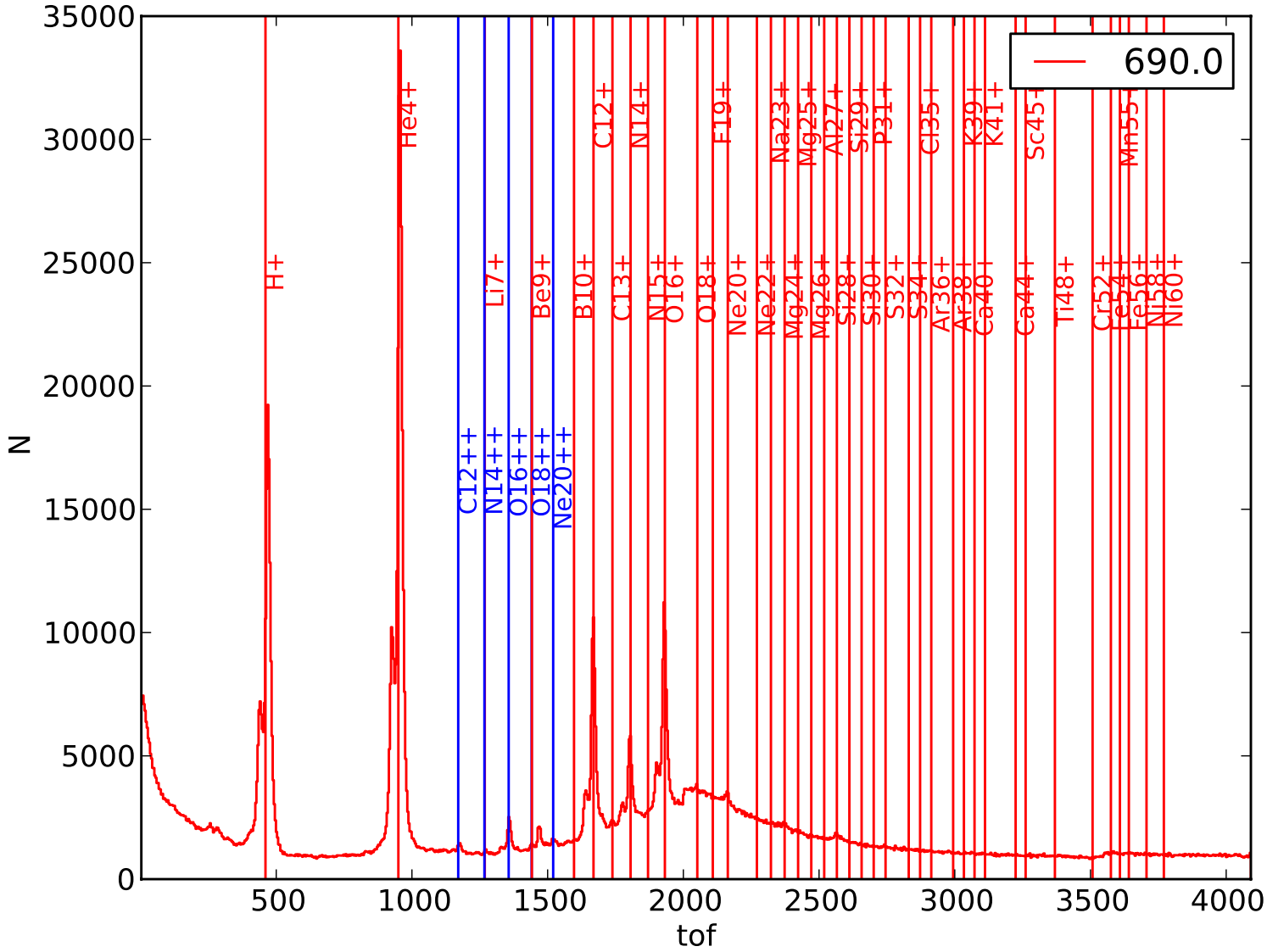

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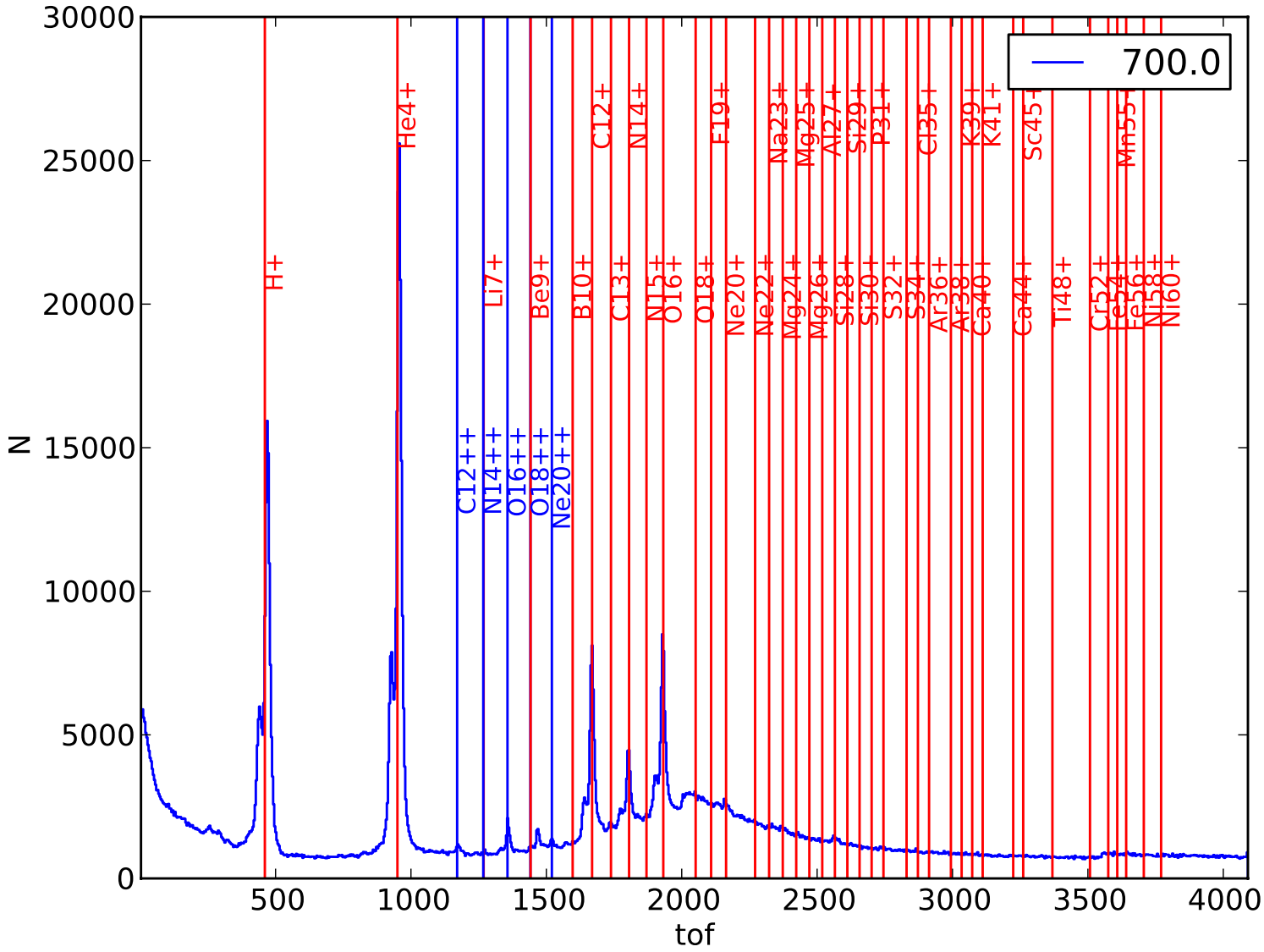

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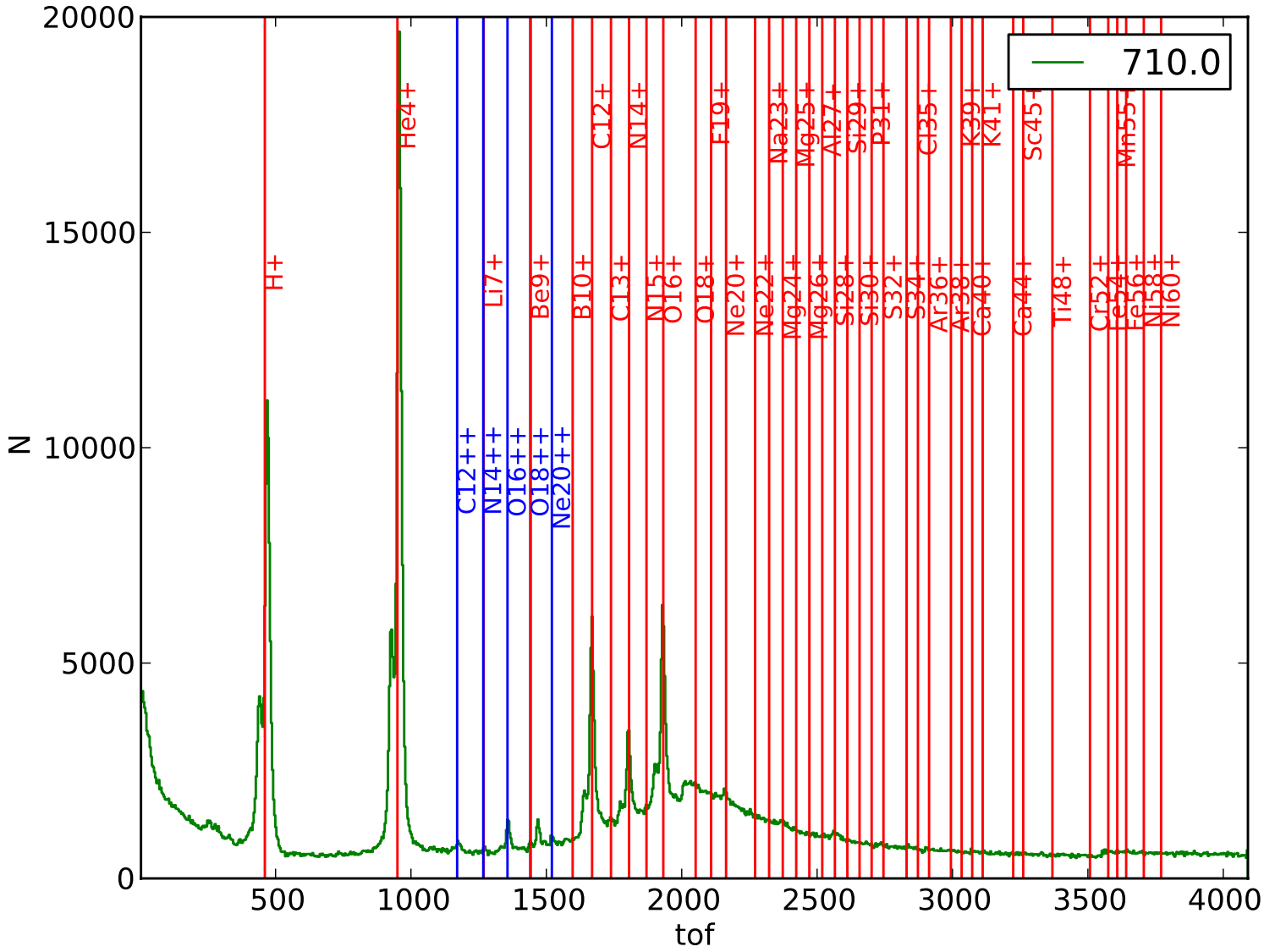

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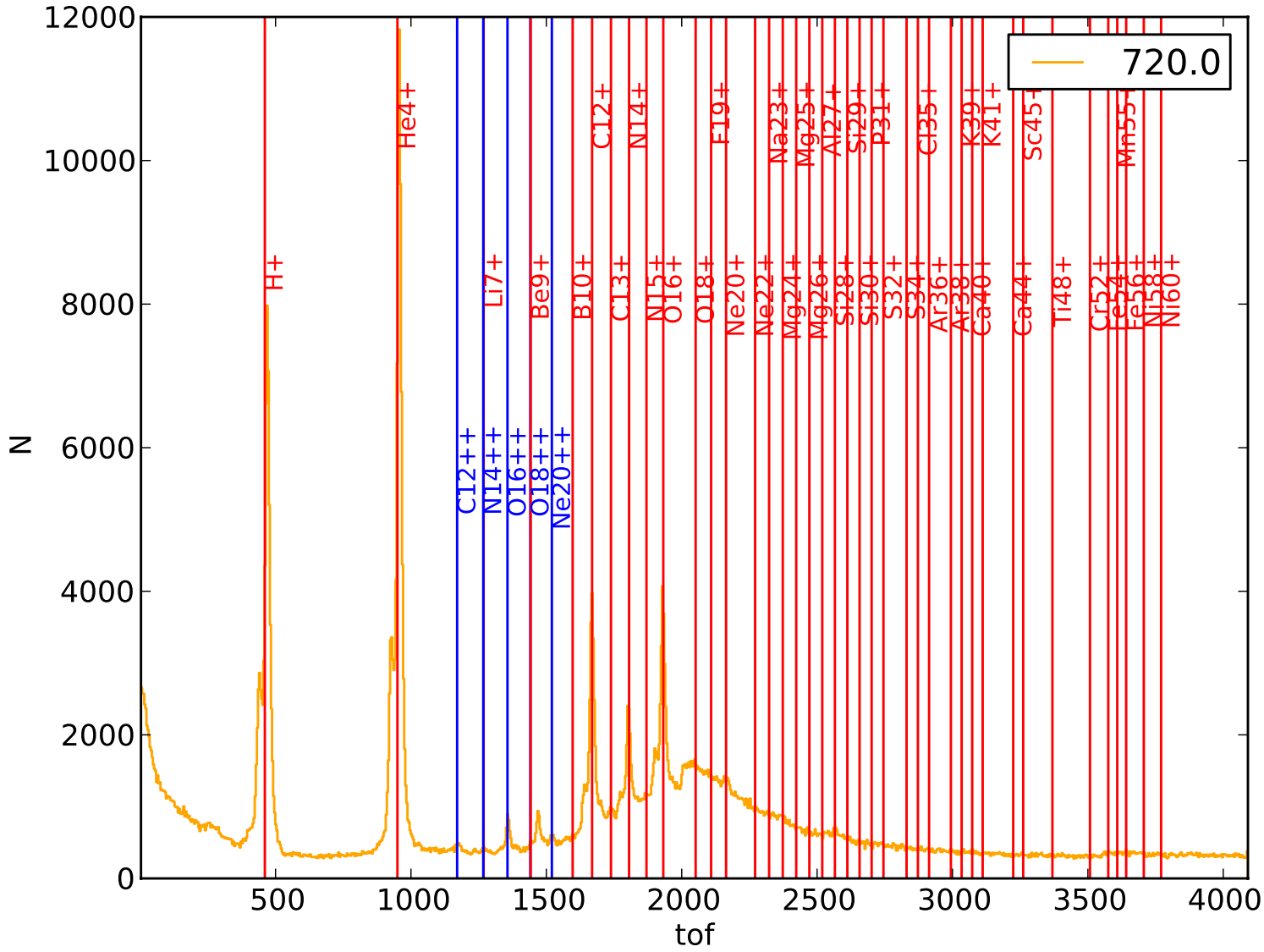

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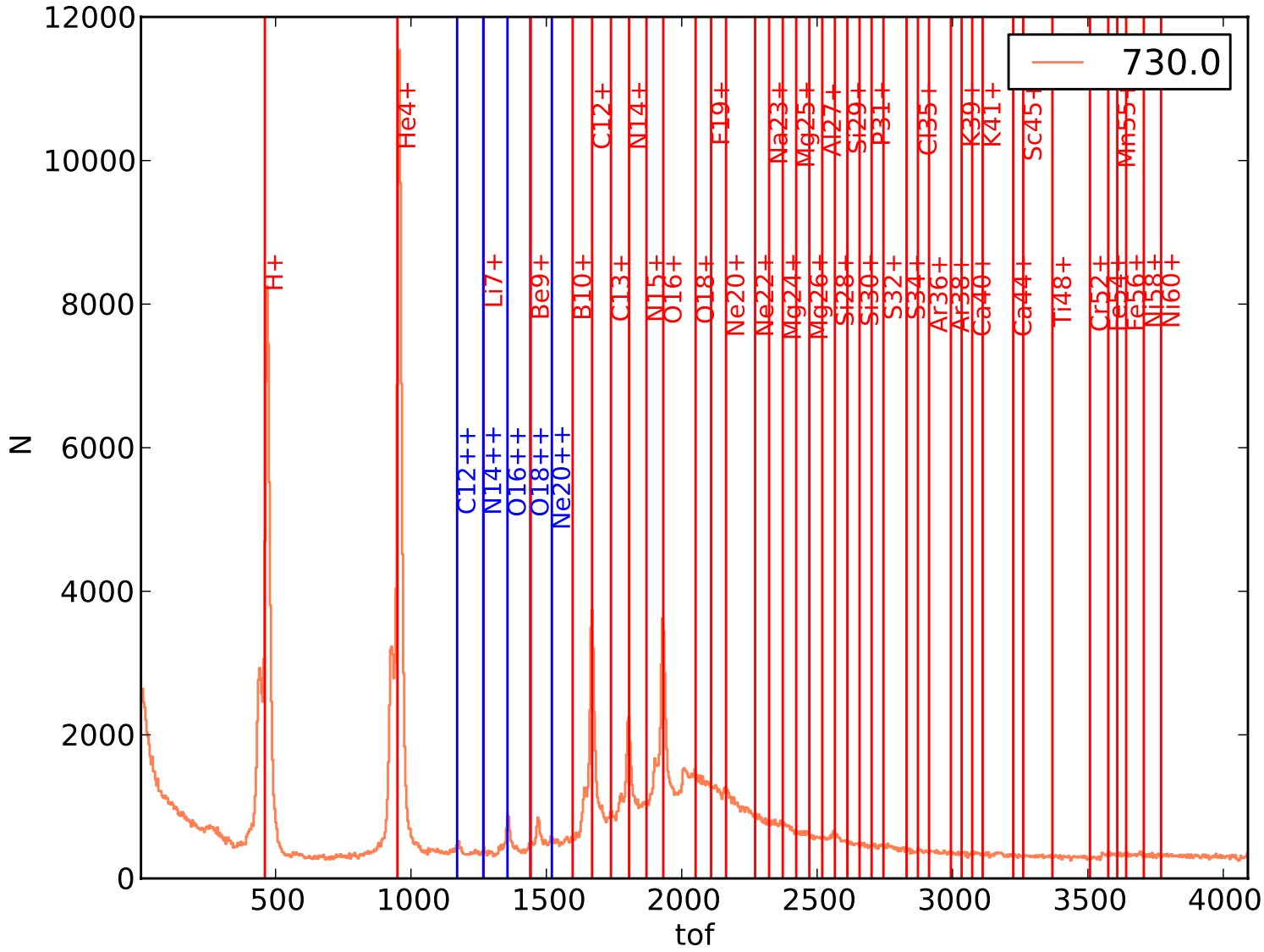

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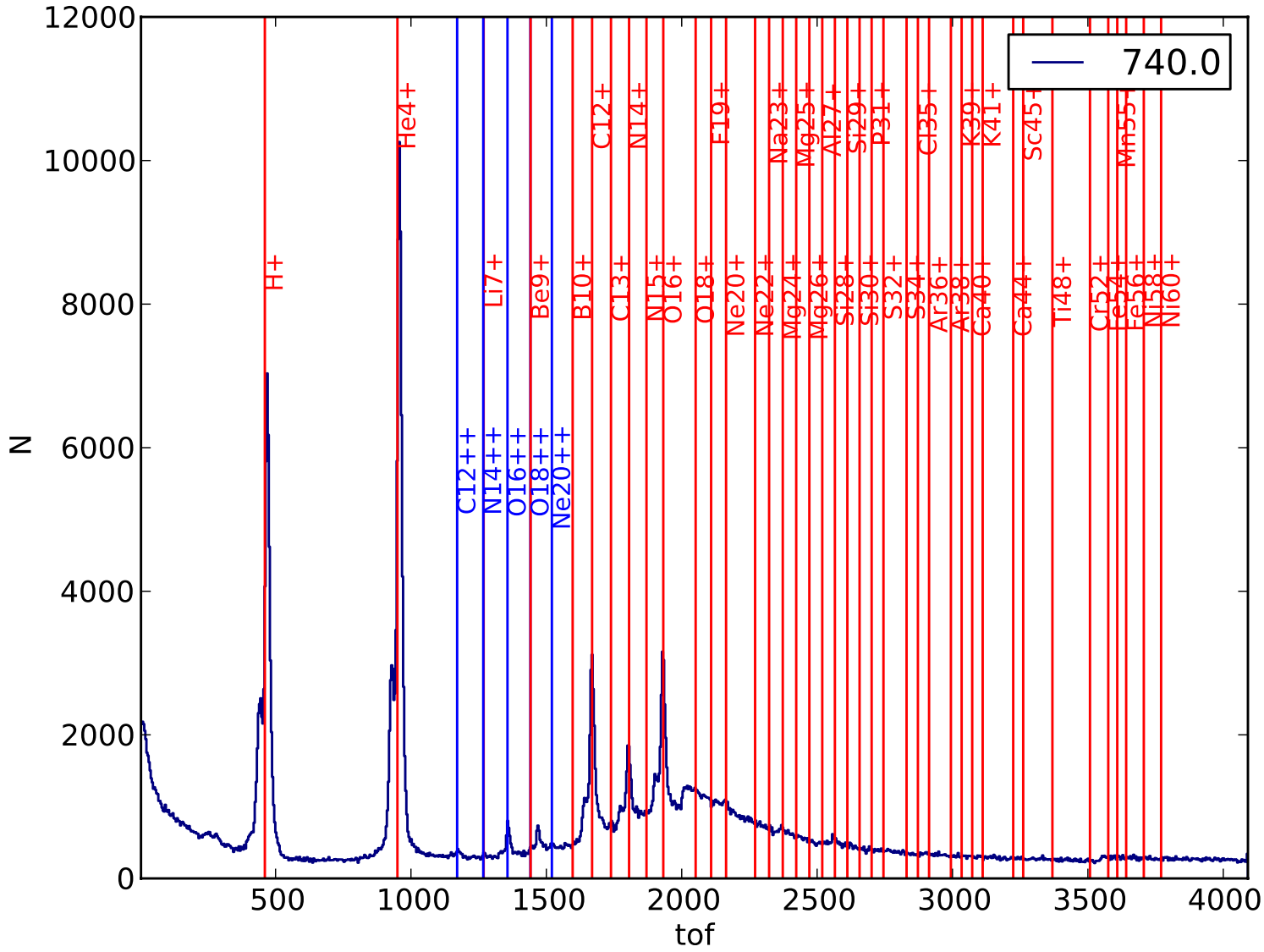

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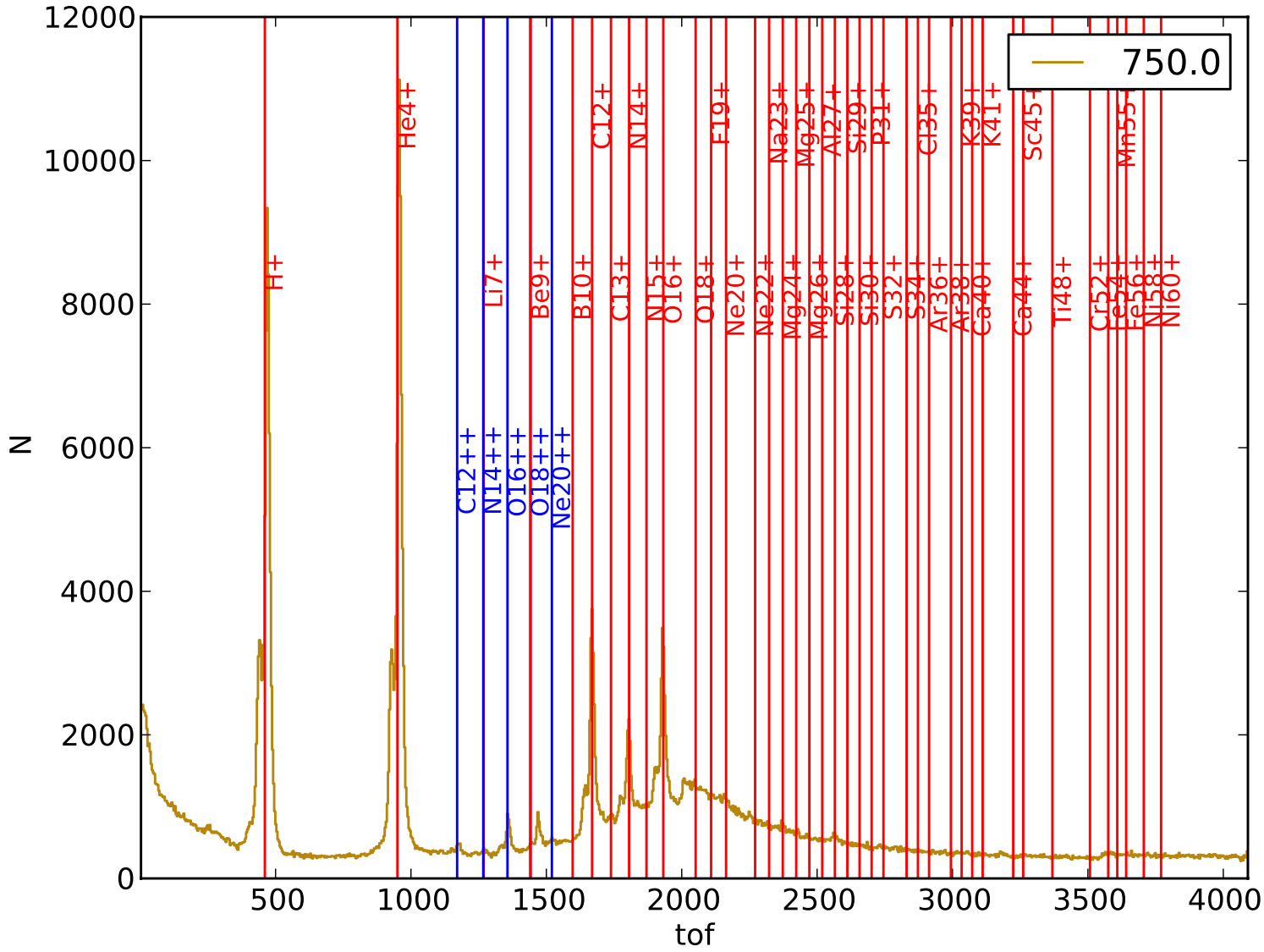

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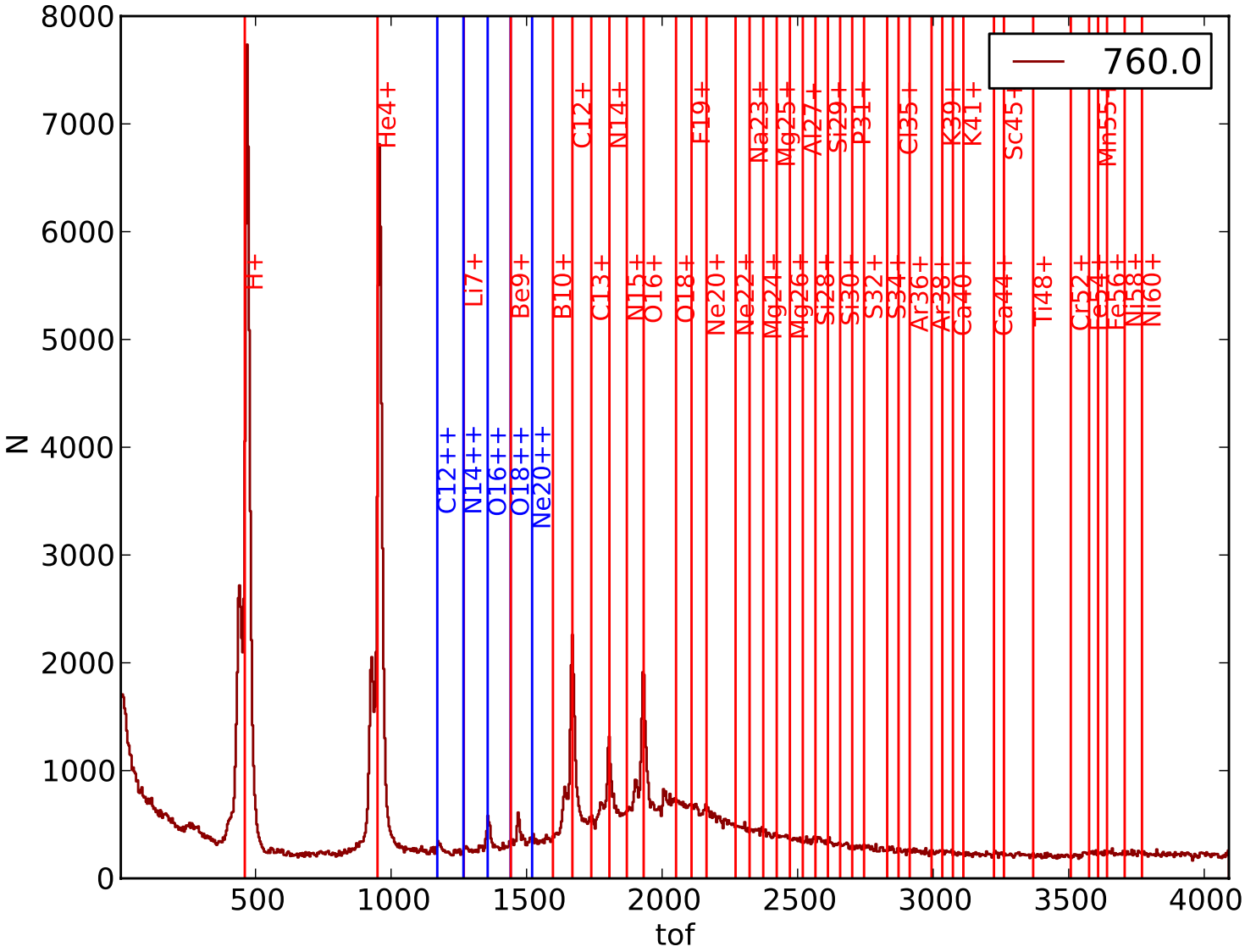

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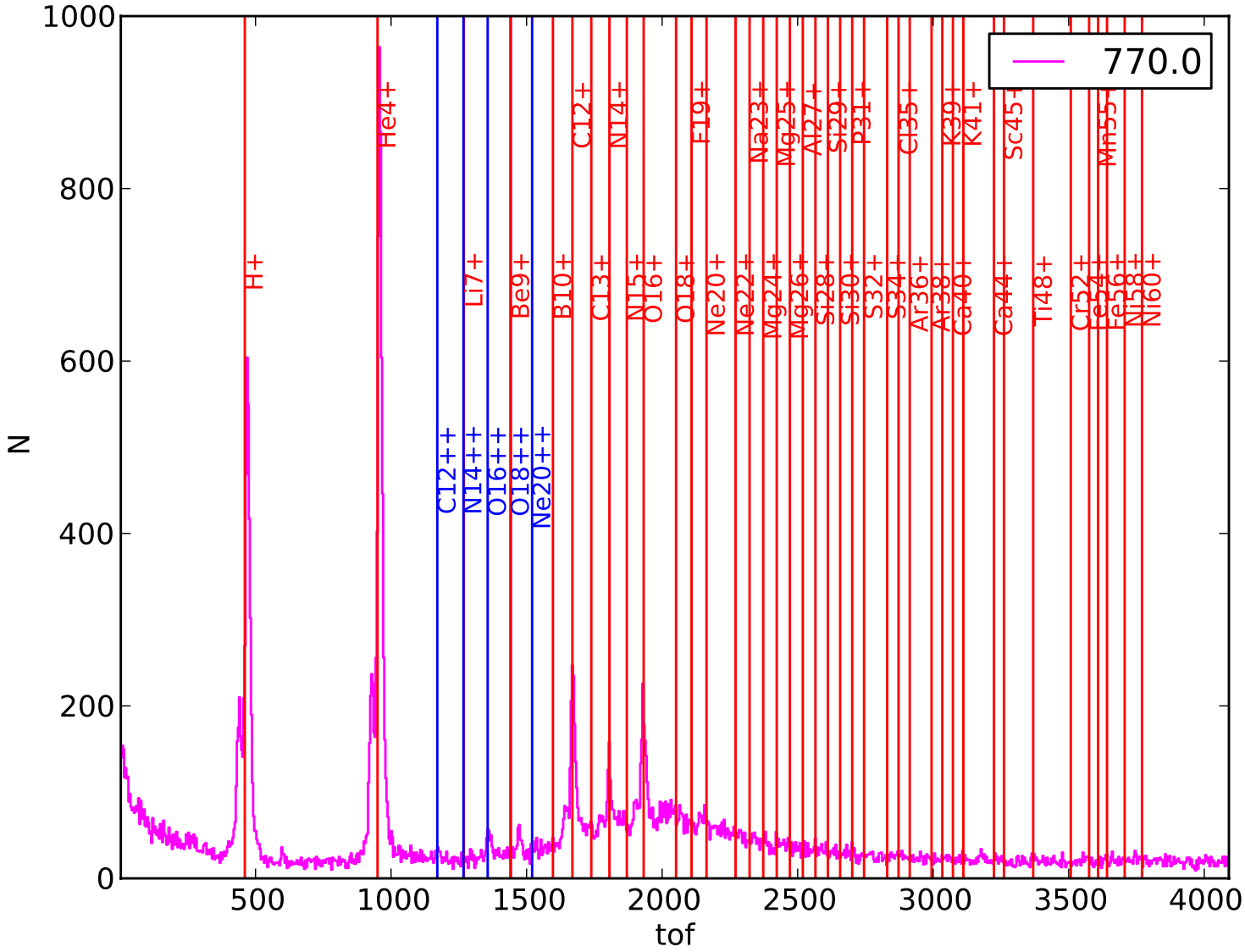

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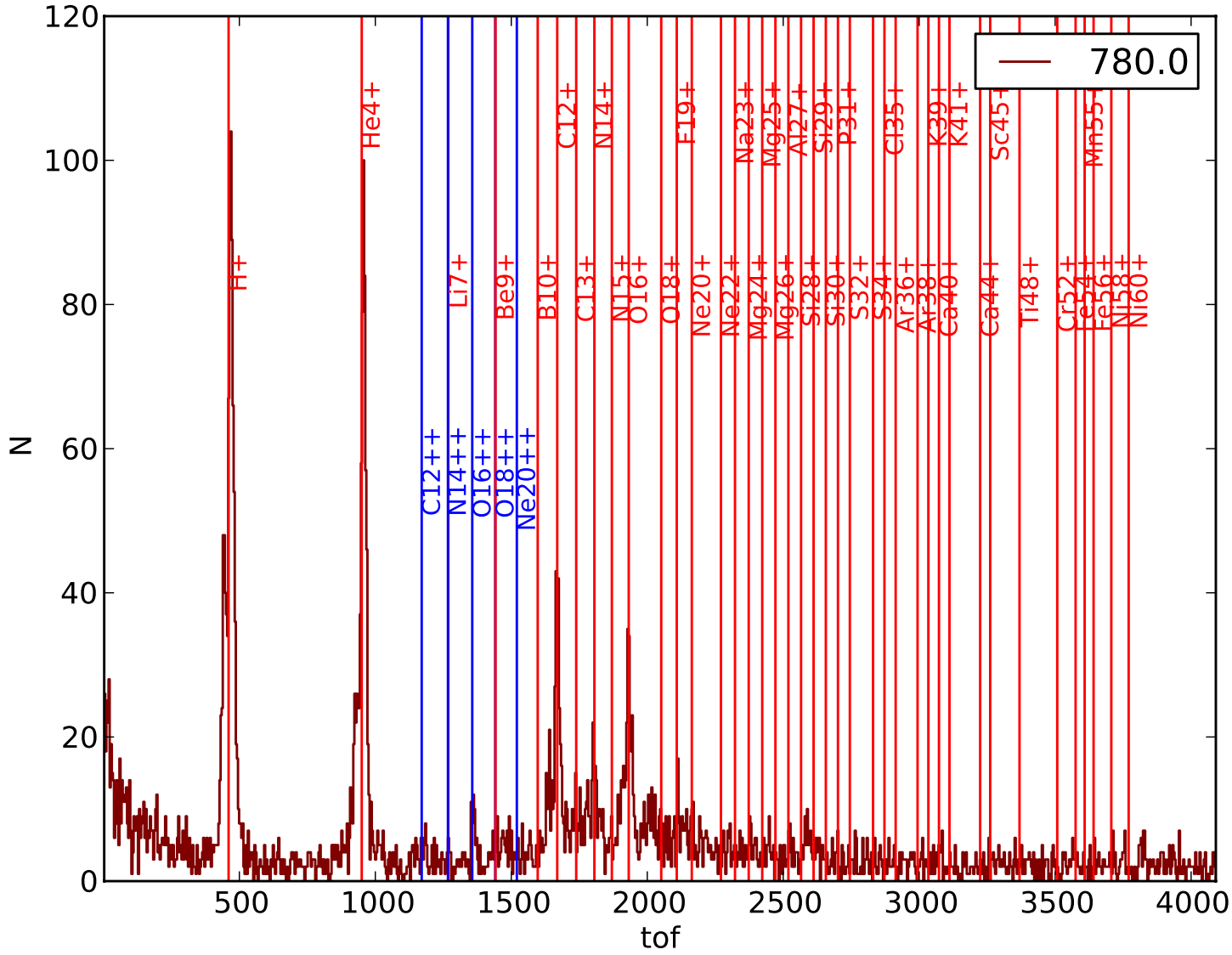
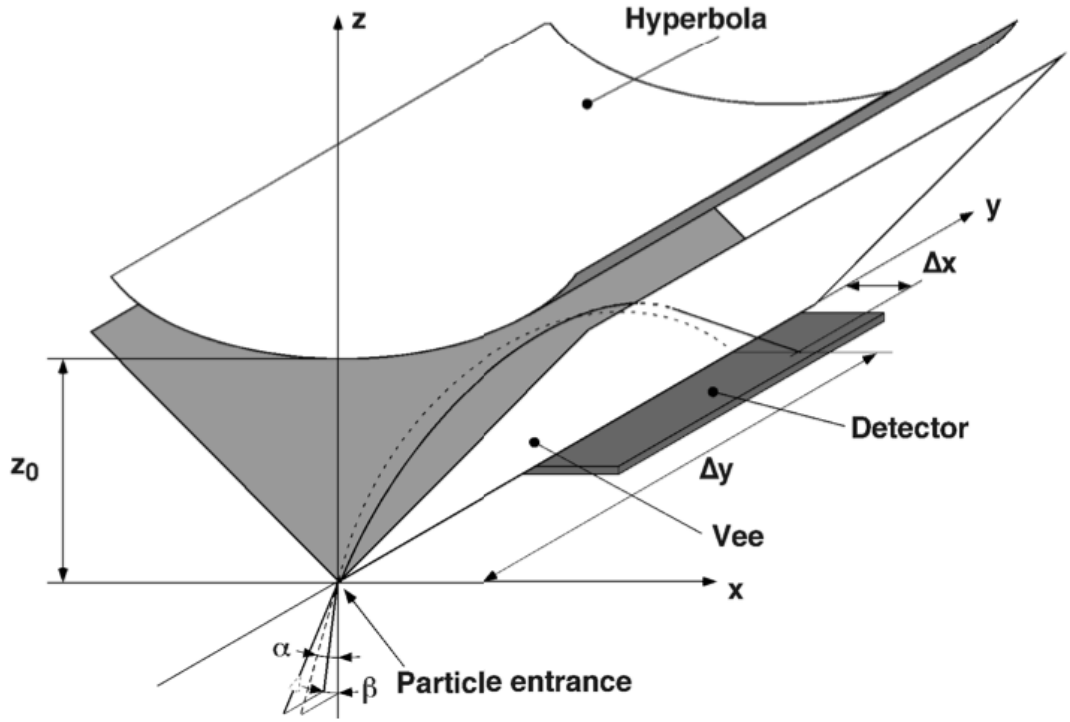


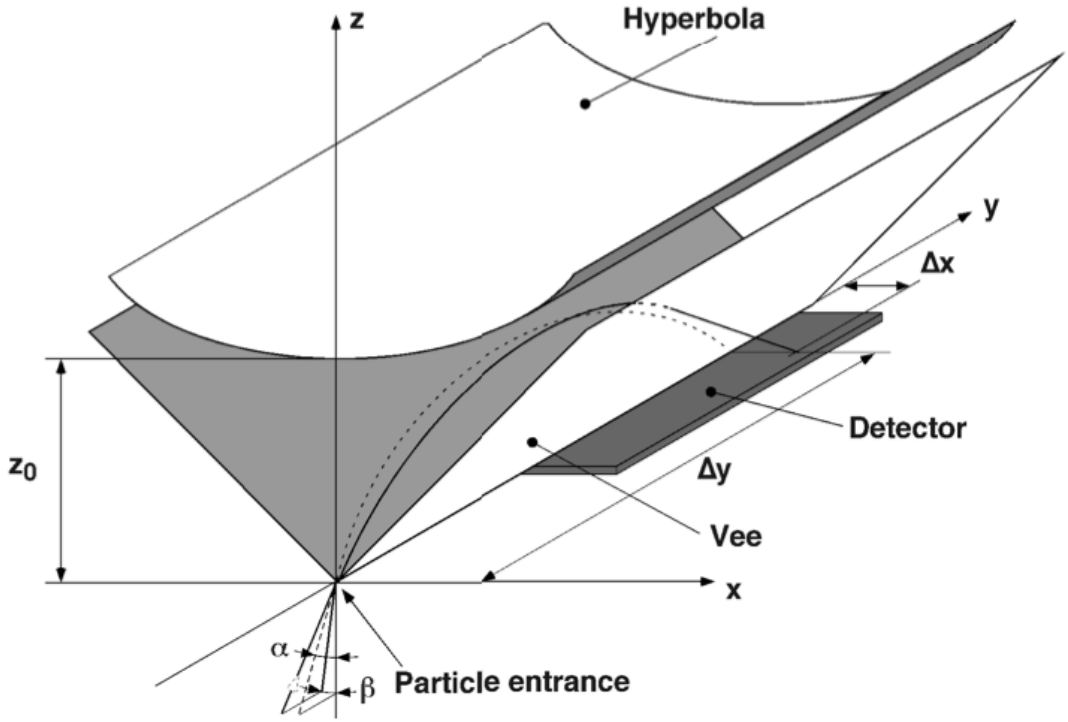
Background peak

- ion hits hyperbola, possibly changes its charge and is reflected down
- very broad peak

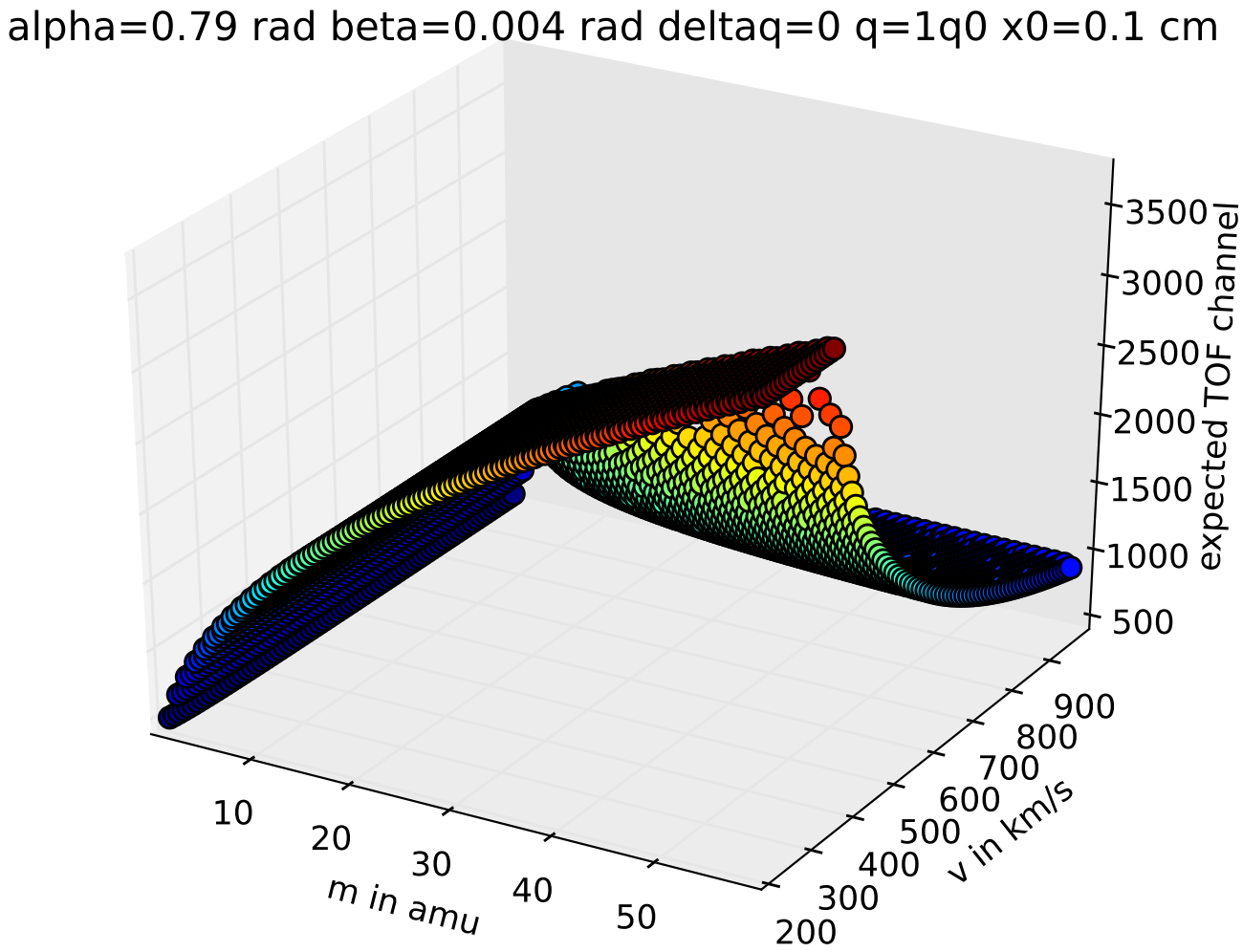


Background peak

- ion hits hyperbola, possibly changes its charge and is reflected down
- very broad peak
- can be (mainly) solved by velocity dependent cross calibration with ACE/SWICS



Predicted TOF channel



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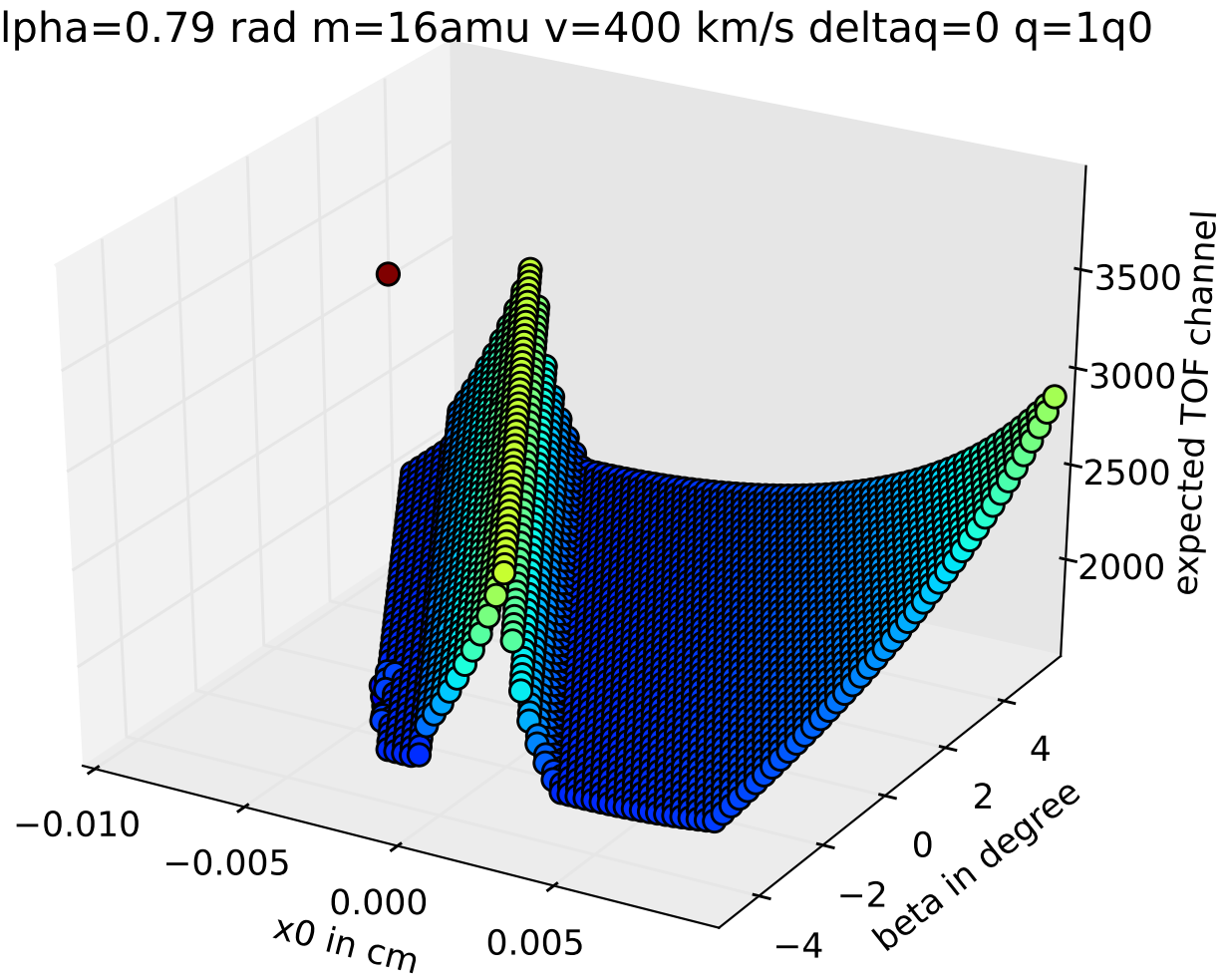
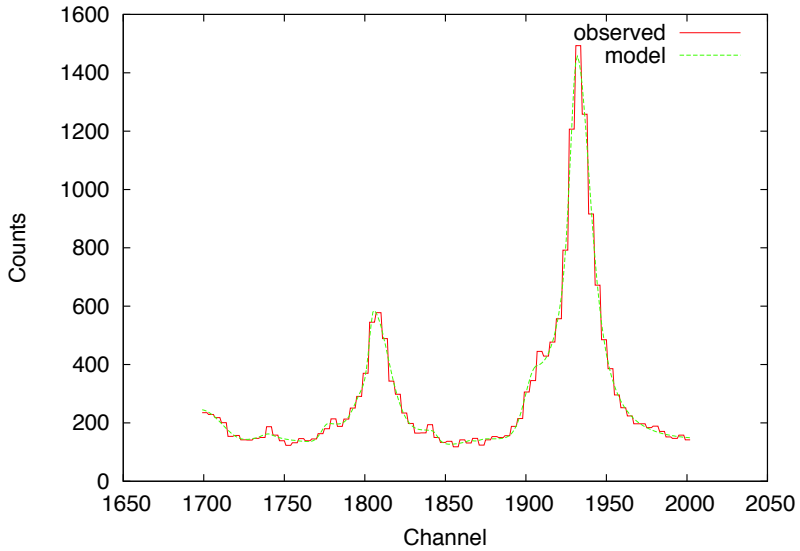


Fitting

- peaks are asymmetric: Gaussian/ kappa peaks
- fit background first, then fit peaks (windowed)
- use CMA-ES (Covariance Matrix Adaptation Evolution-Strategy) for curve-fitting

$$v_p = 522.\ \text{km/s}$$



Hansen, Ostermeier: Completely Derandomized Self-Adaptation in Evolution Strategies. Evolut Comput 9(2), 2001

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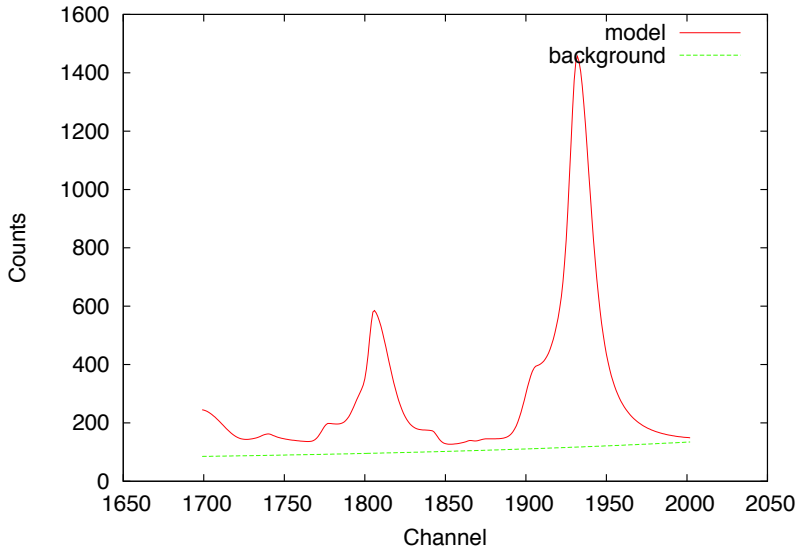

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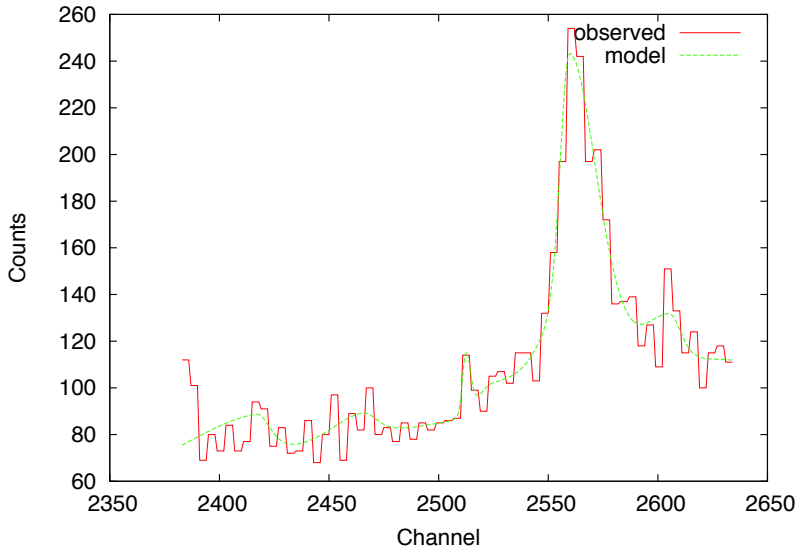
$$v_p = 492.\ \text{km/s}$$



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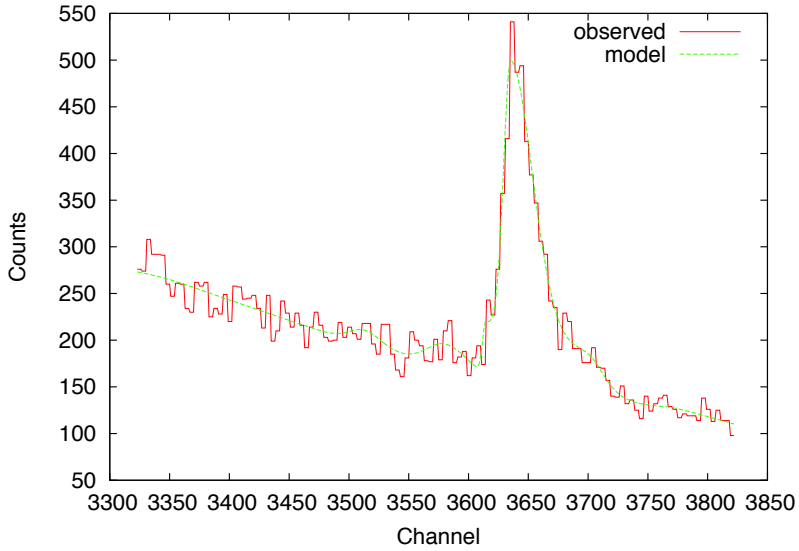

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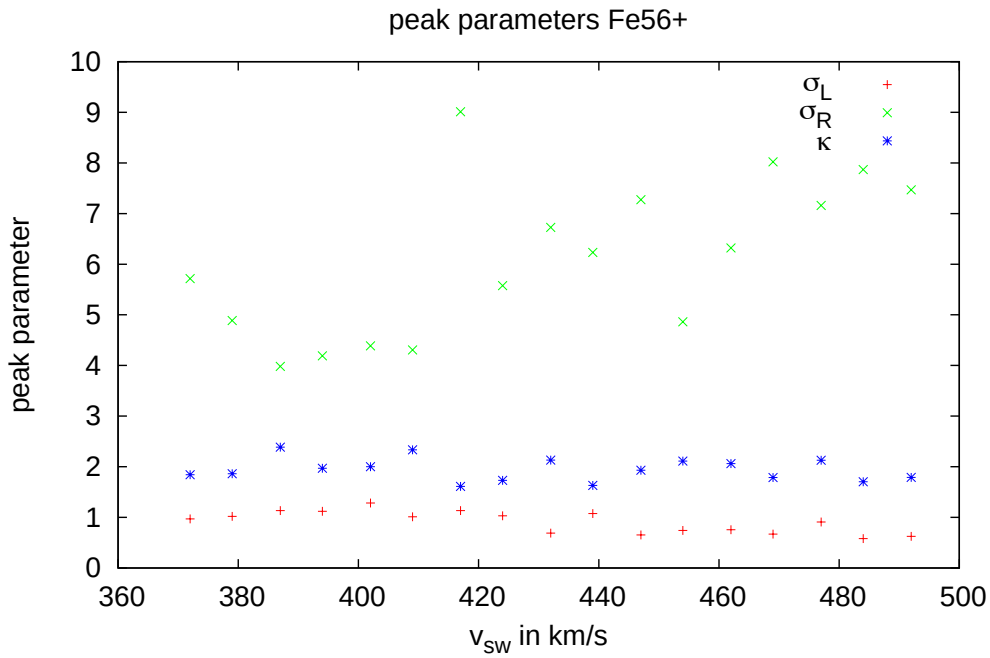
Fitting

- peaks are asymmetric: Gaussian/ kappa peaks
- fit background first, then fit peaks (windowed)
- use CMA-ES (Covariance Matrix Adaptation Evolution-Strategy) for curve-fitting
- background peak also (slightly) distorts the peak form (?)



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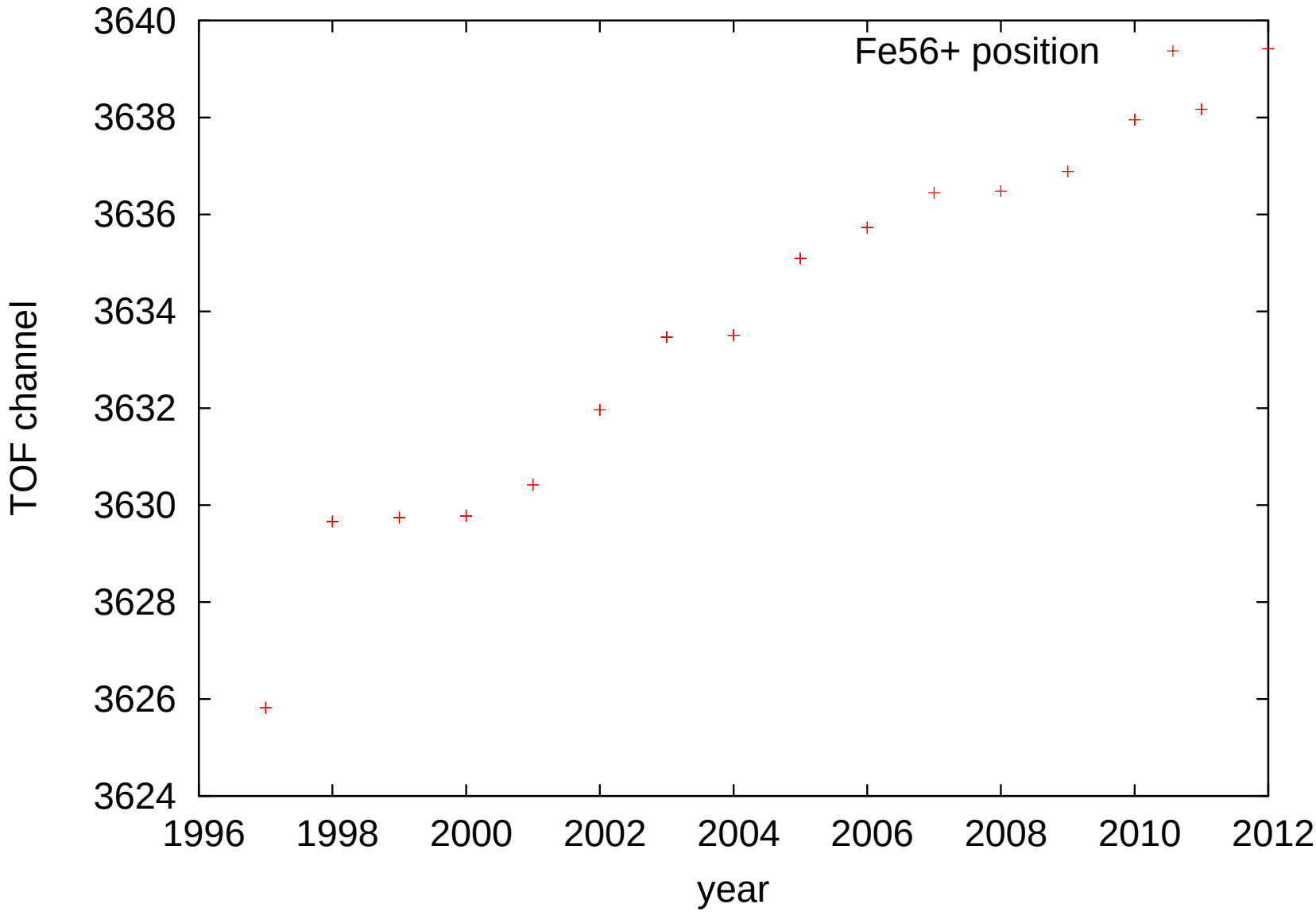
MTOF over the years



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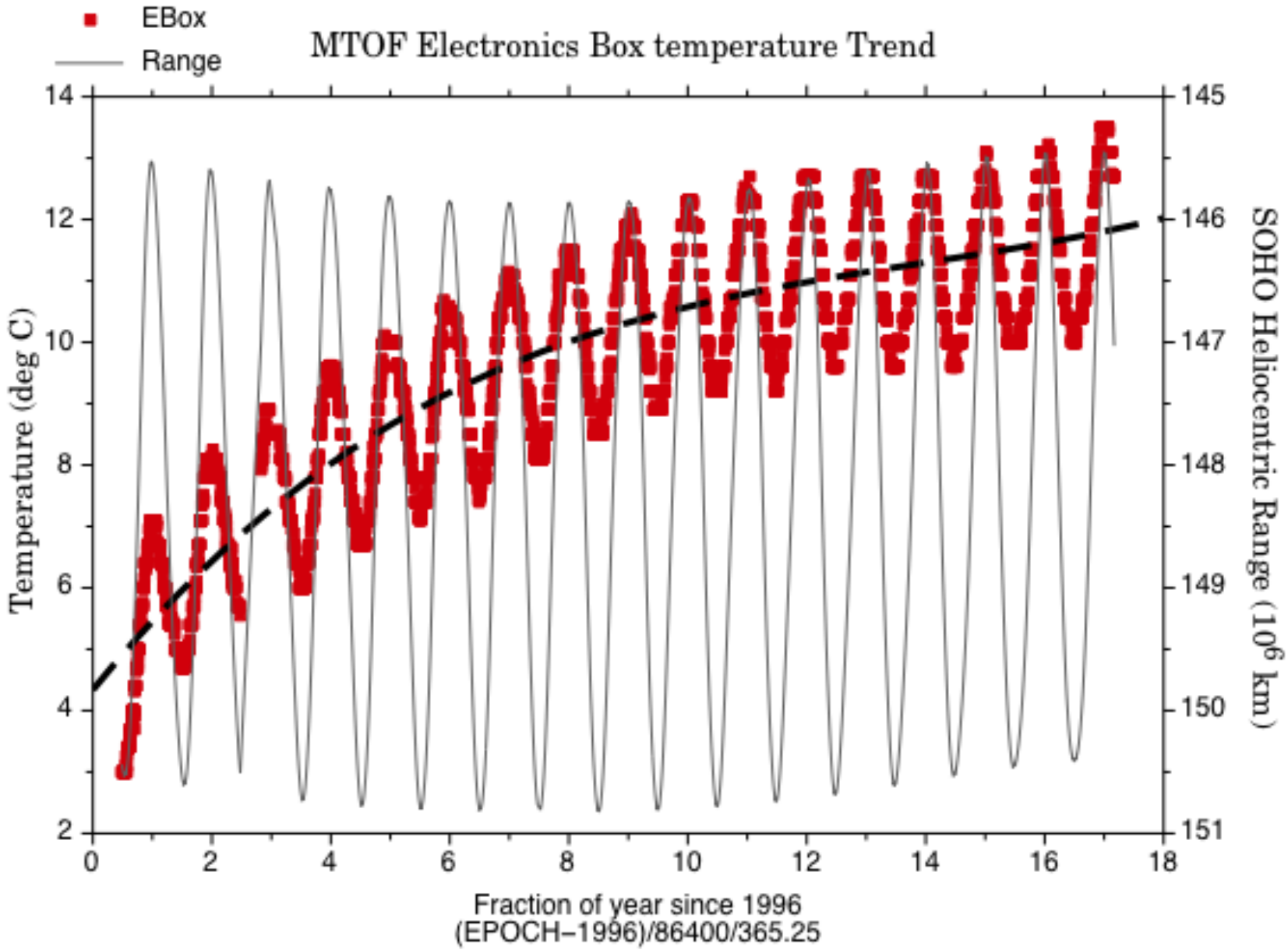
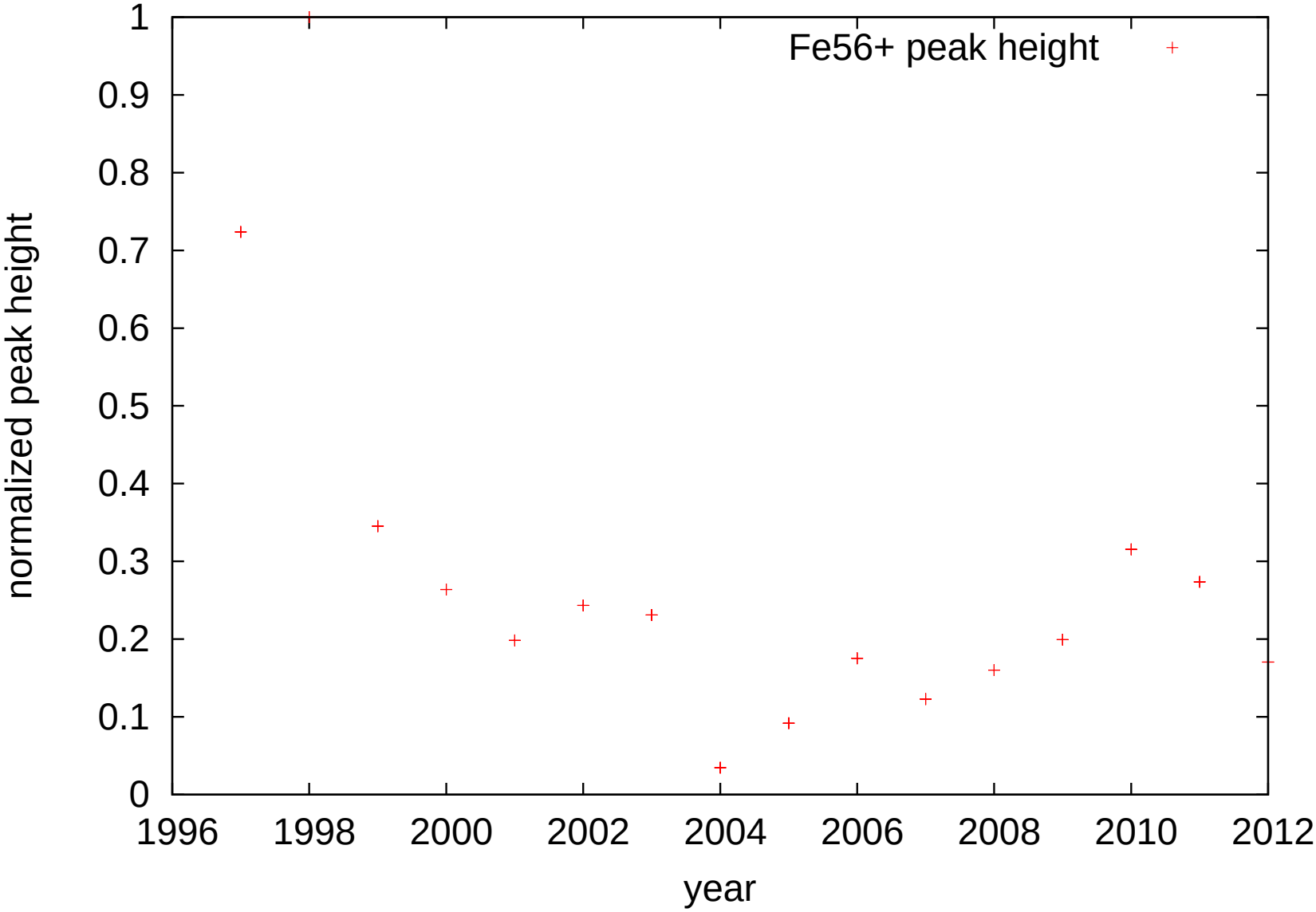


MTOF over the years



Outline

Influences on transmission function

- initial charge states

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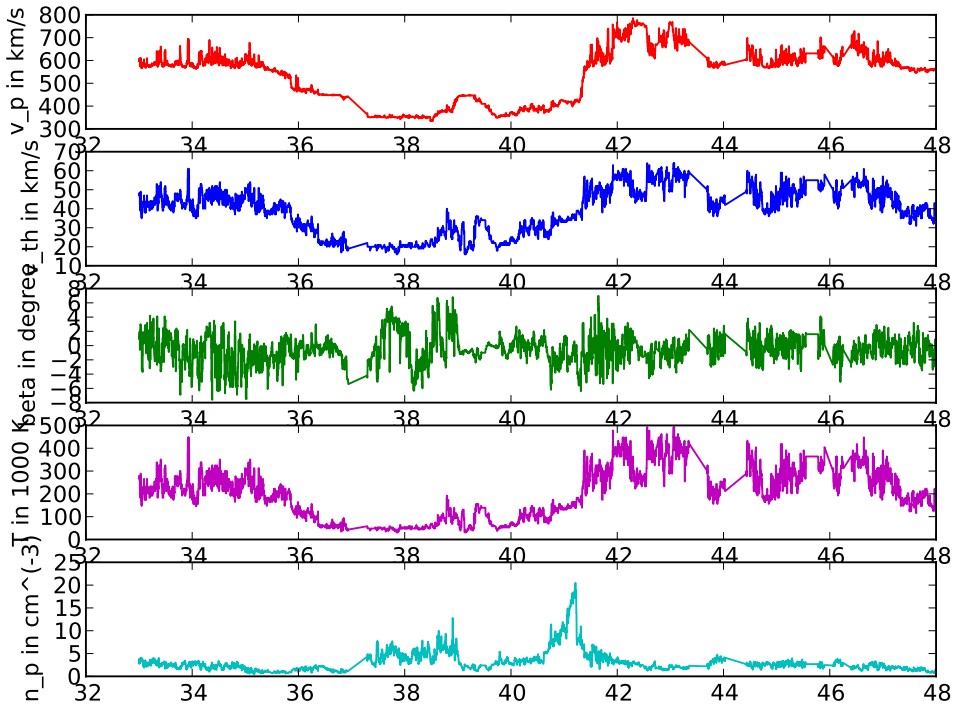
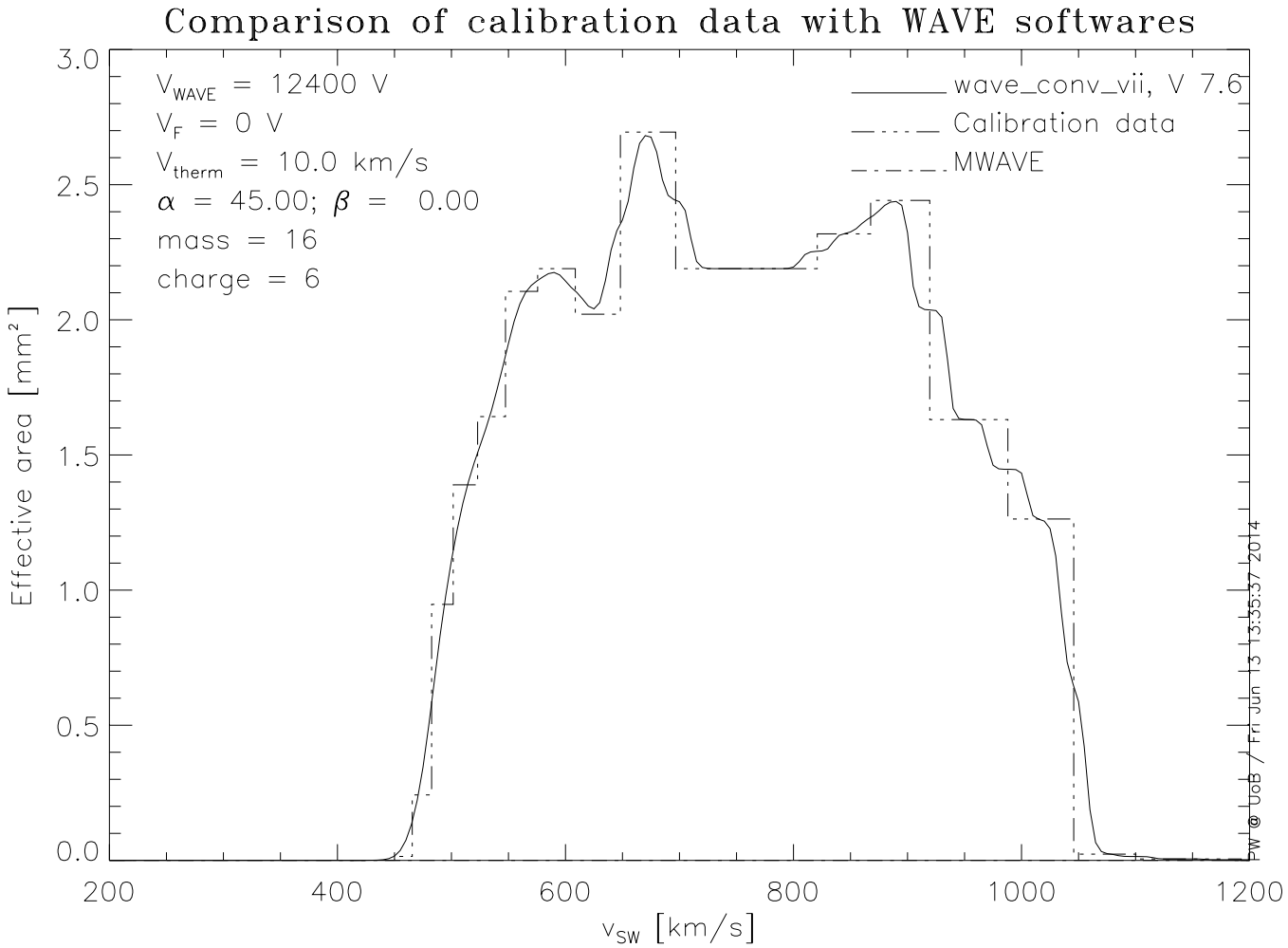
- ecliptic angle taken from proton measurement , angle less variable for heavier ions? Maybe answered by PLASTIC soon



Transmission for the WAVE system



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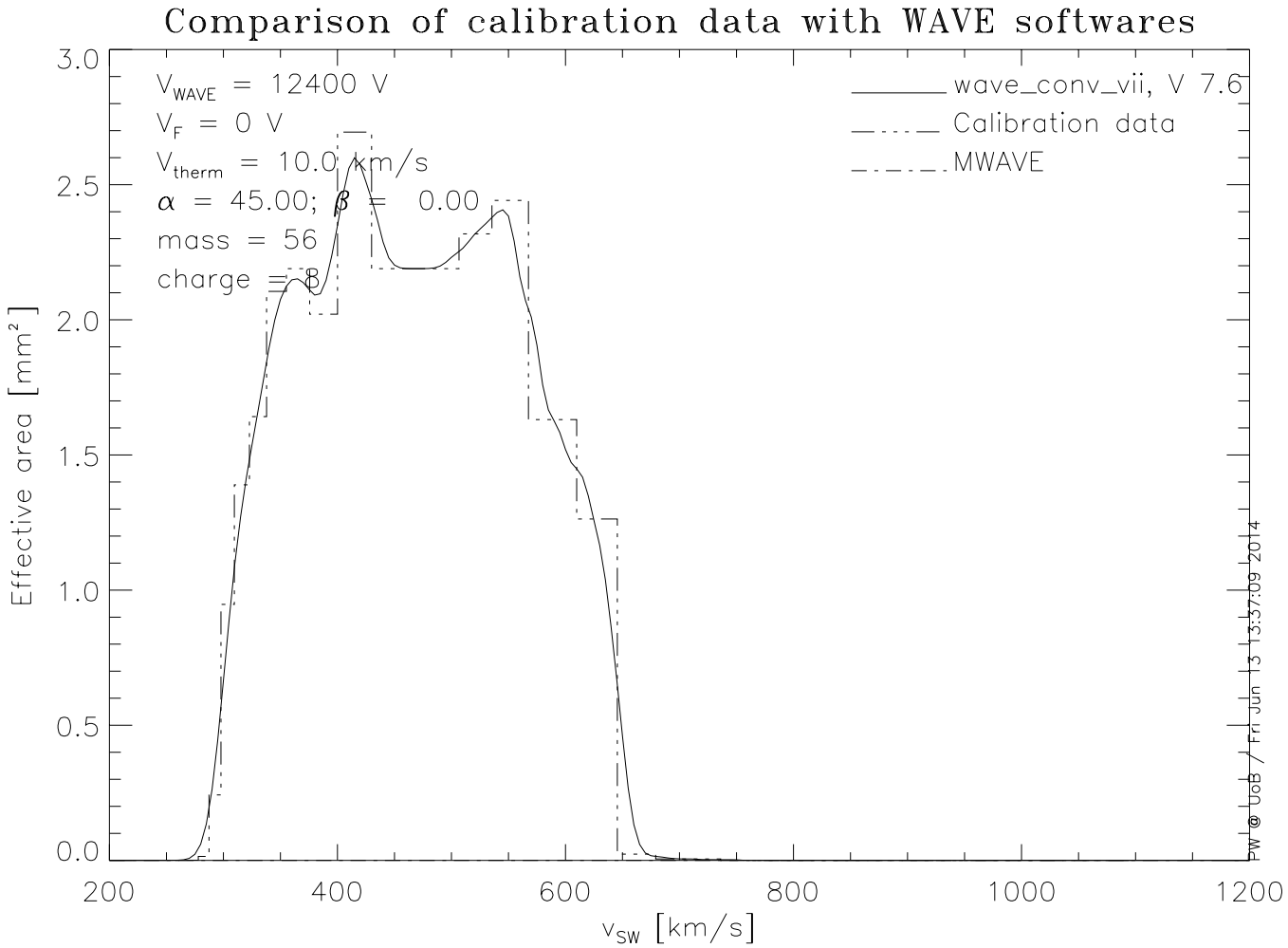
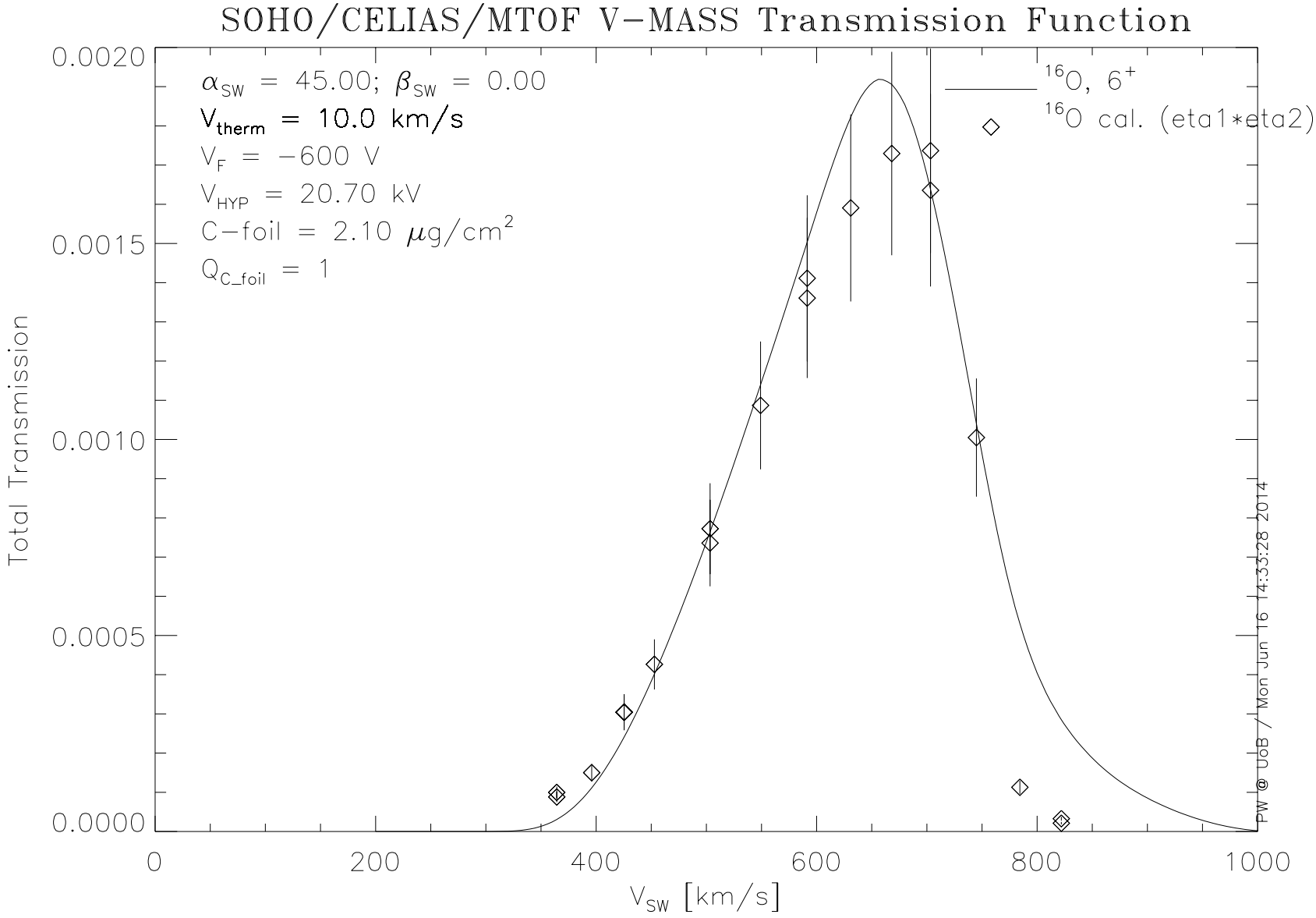


Transmission for the TOF detector



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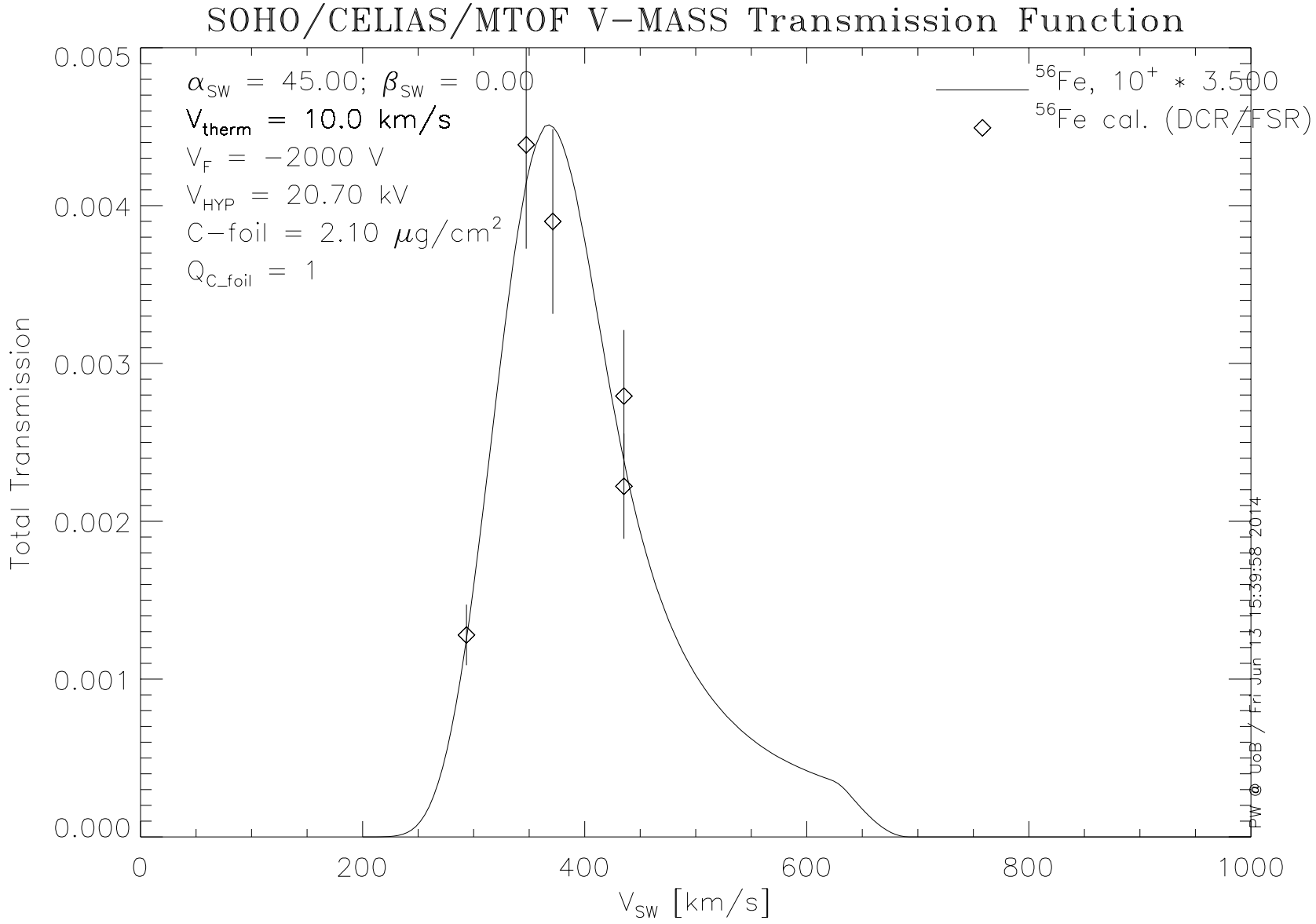

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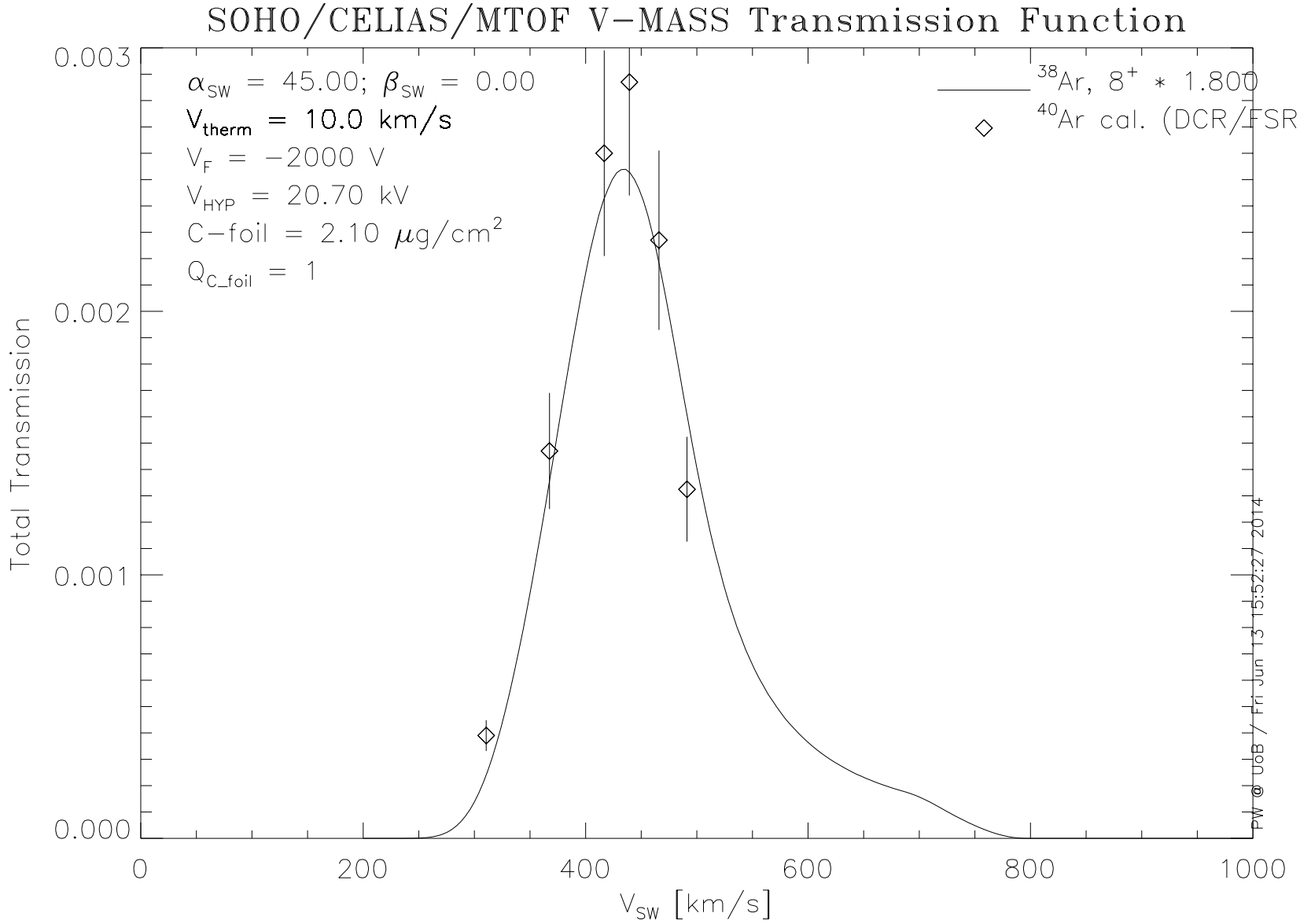

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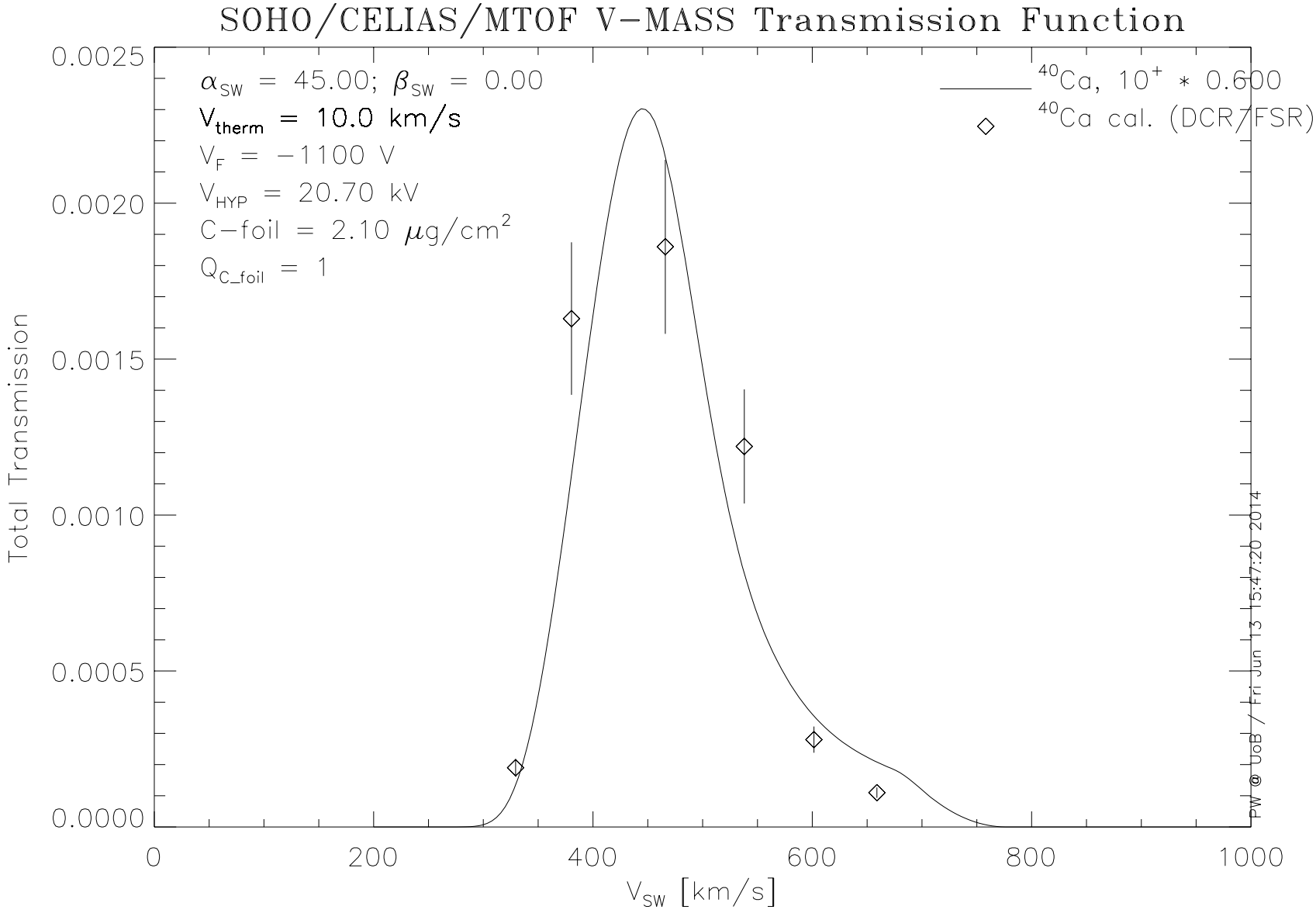

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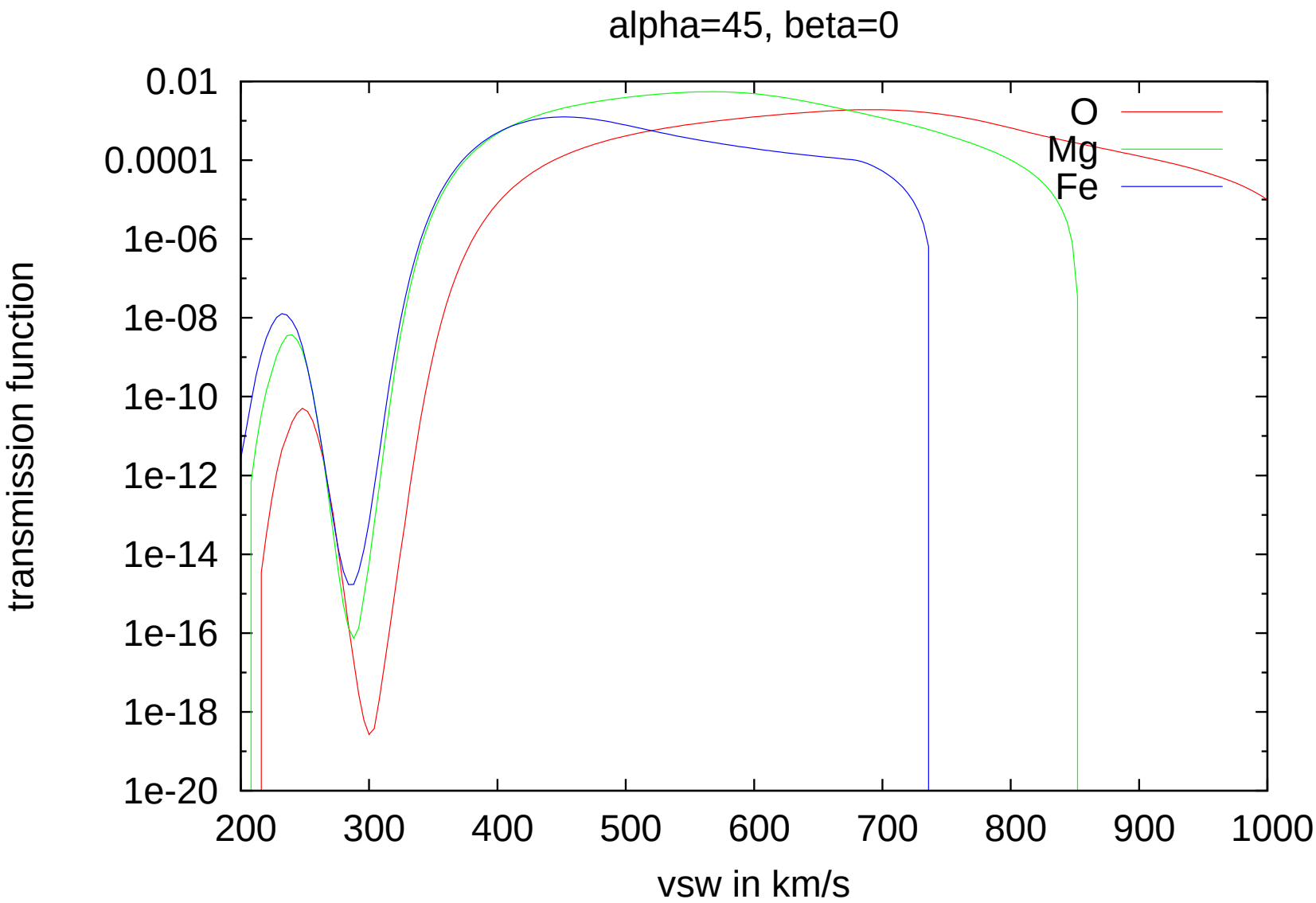

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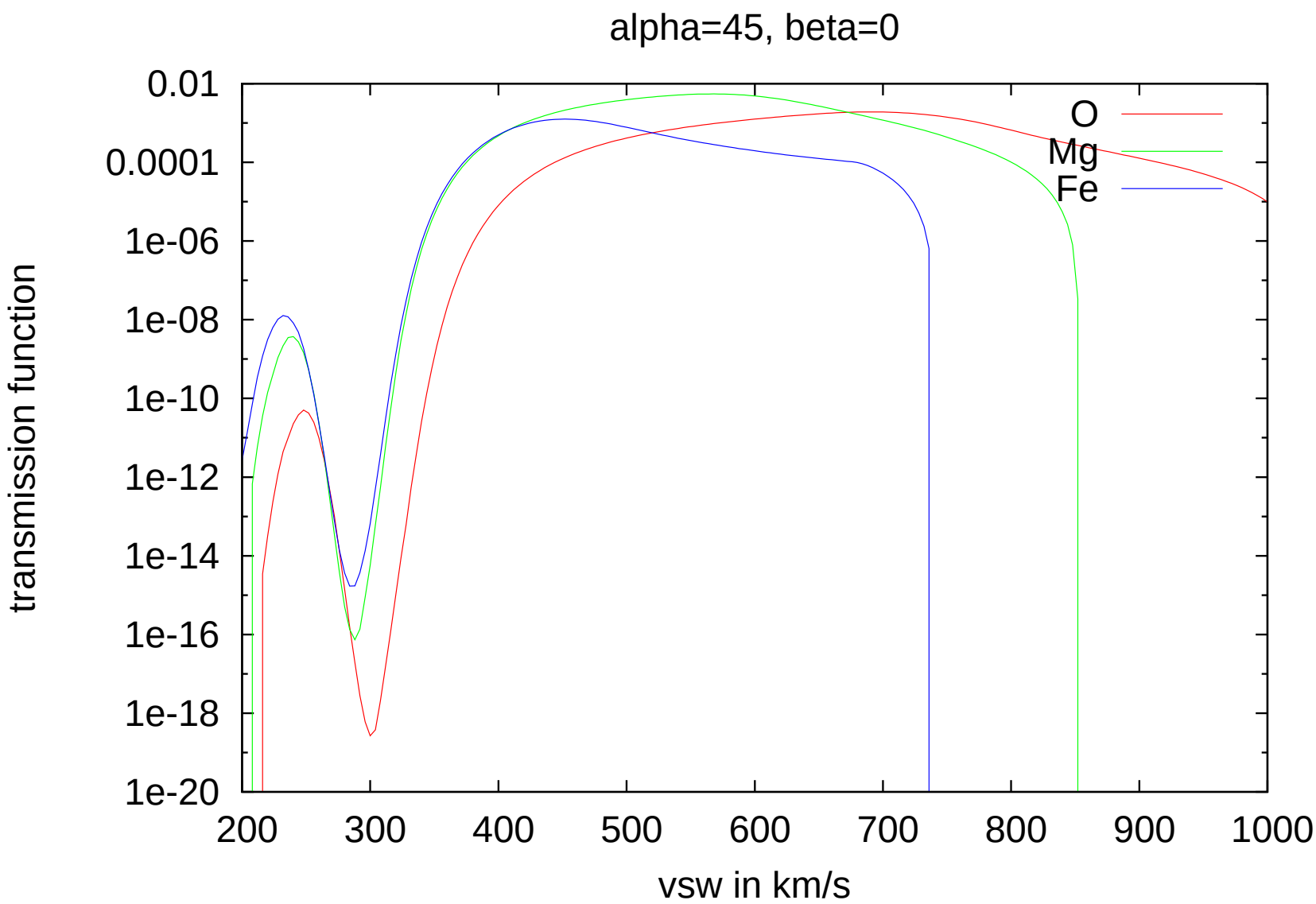

Question: Does more calibration data exist after all? Spare flight-model?

Post-acceleration

- Entrance system in MTOF not used for E/q selection.
- MTOF modus operandi, typical example:
- 12 steps with:

V_f in kV	0	0.98	0	0	0.98	0	0	0.98	0	0	0.98	0V
V_{WAVE} in kV	11.2	11.2	5.8	11.2	11.2	5.8	11.2	11.2	5.8	11.2	11.2	5.8

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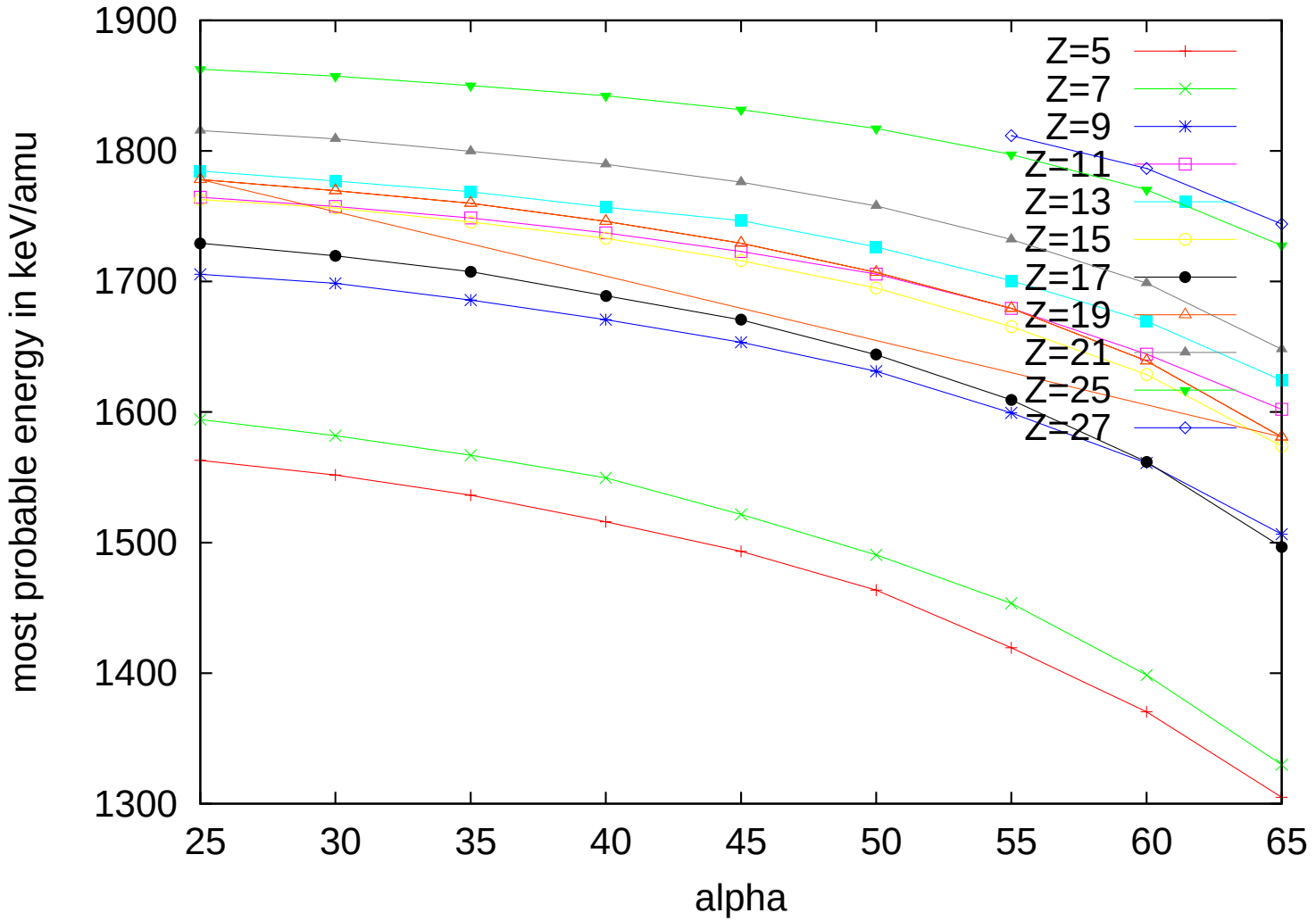
Question: What is the exact geometry of MTOF? In particular, how exactly is the Vee gridded and the Hyperbola finned?

TRIM (Tracking and Range of Ions in Matter), energy loss and alpha “bending”



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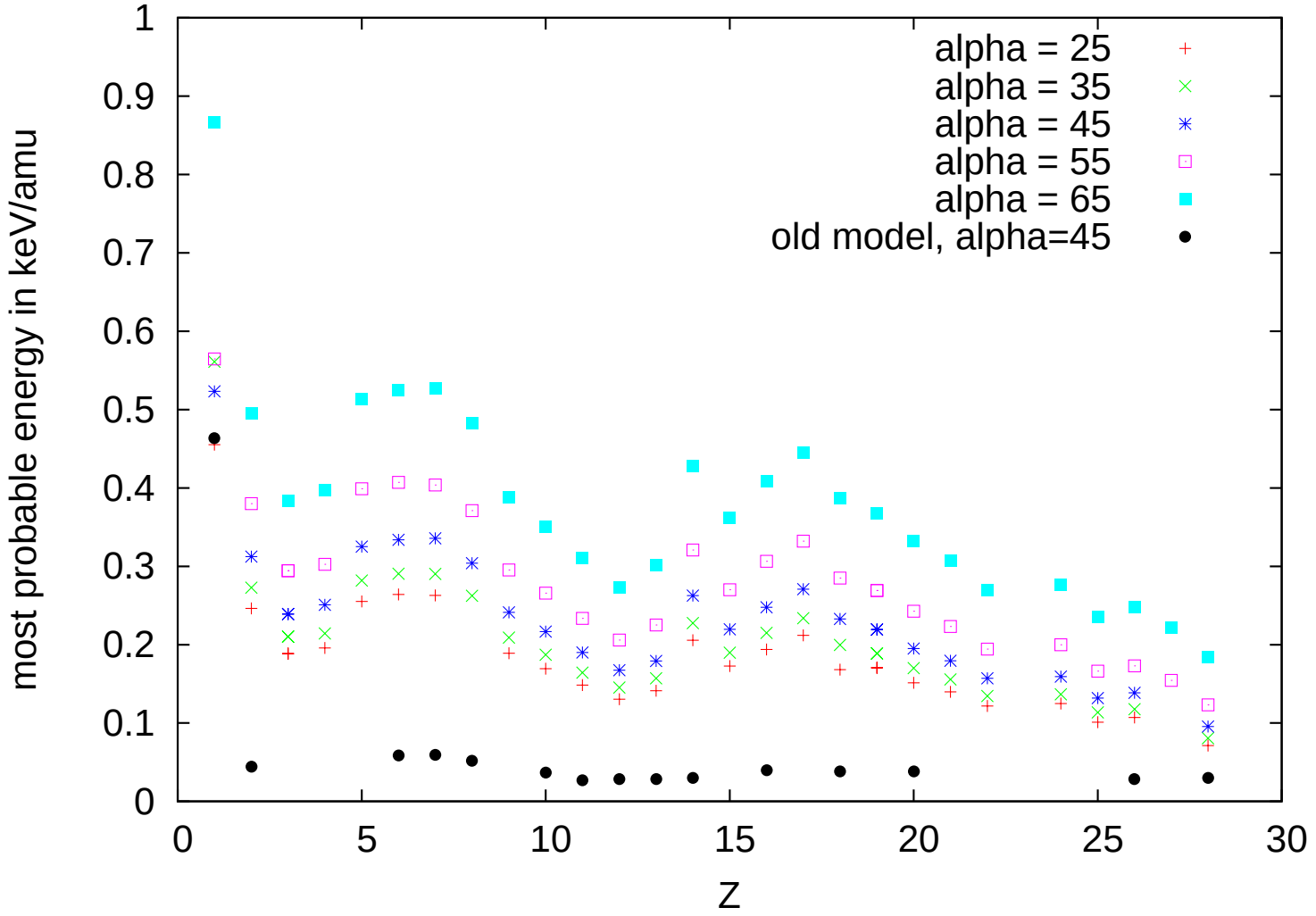

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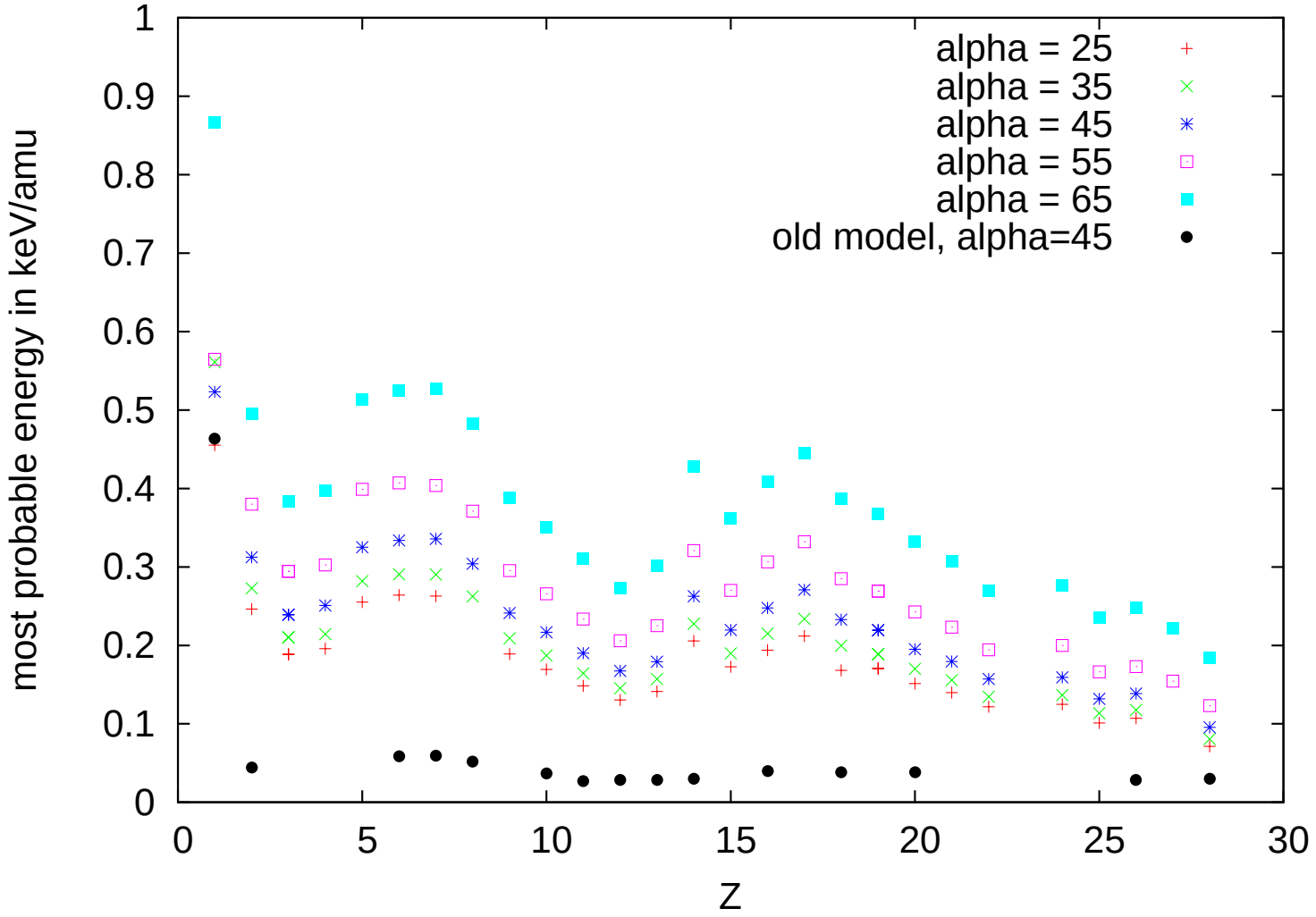

Energy loss was underestimated, in particular for low mass ions.

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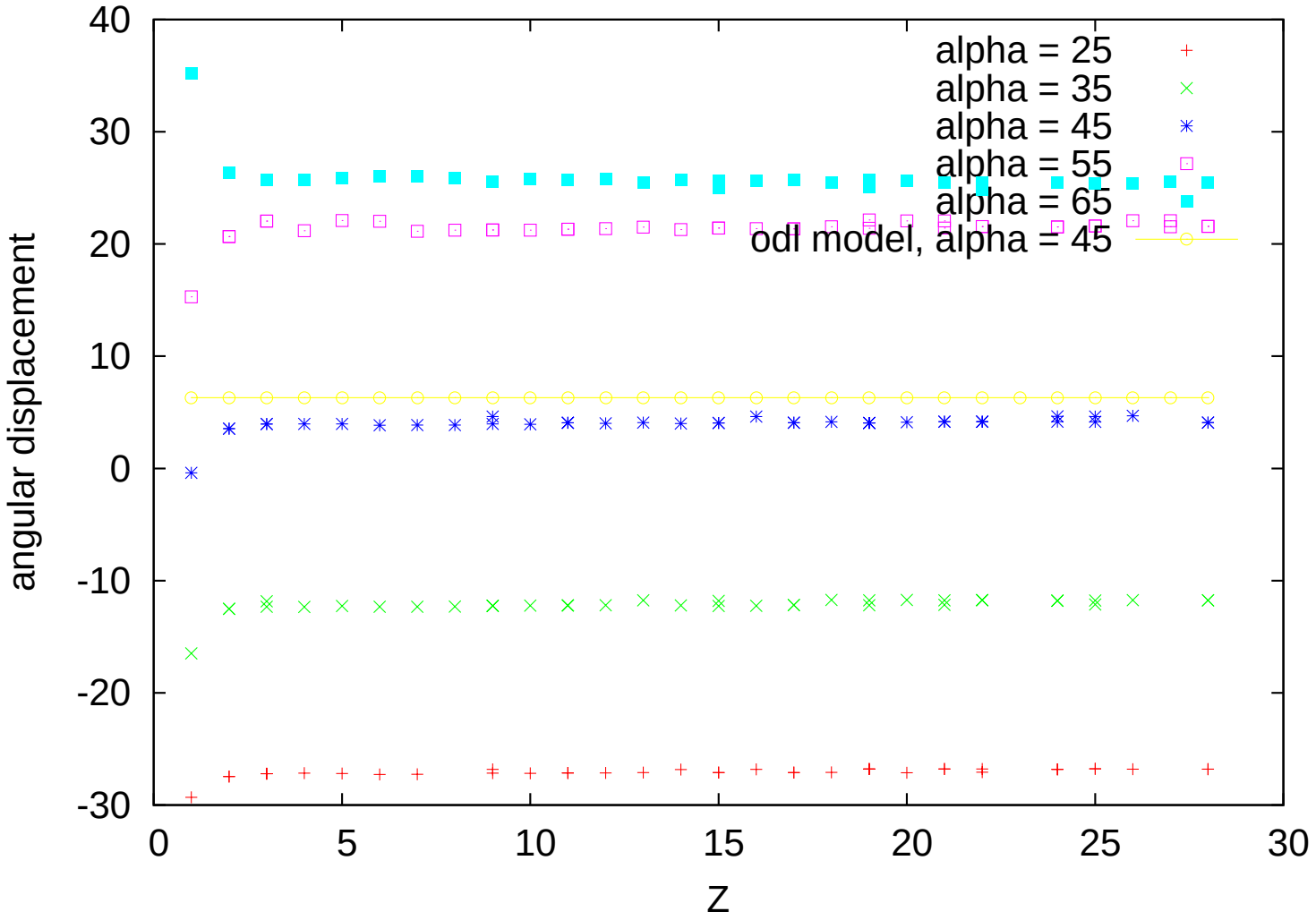

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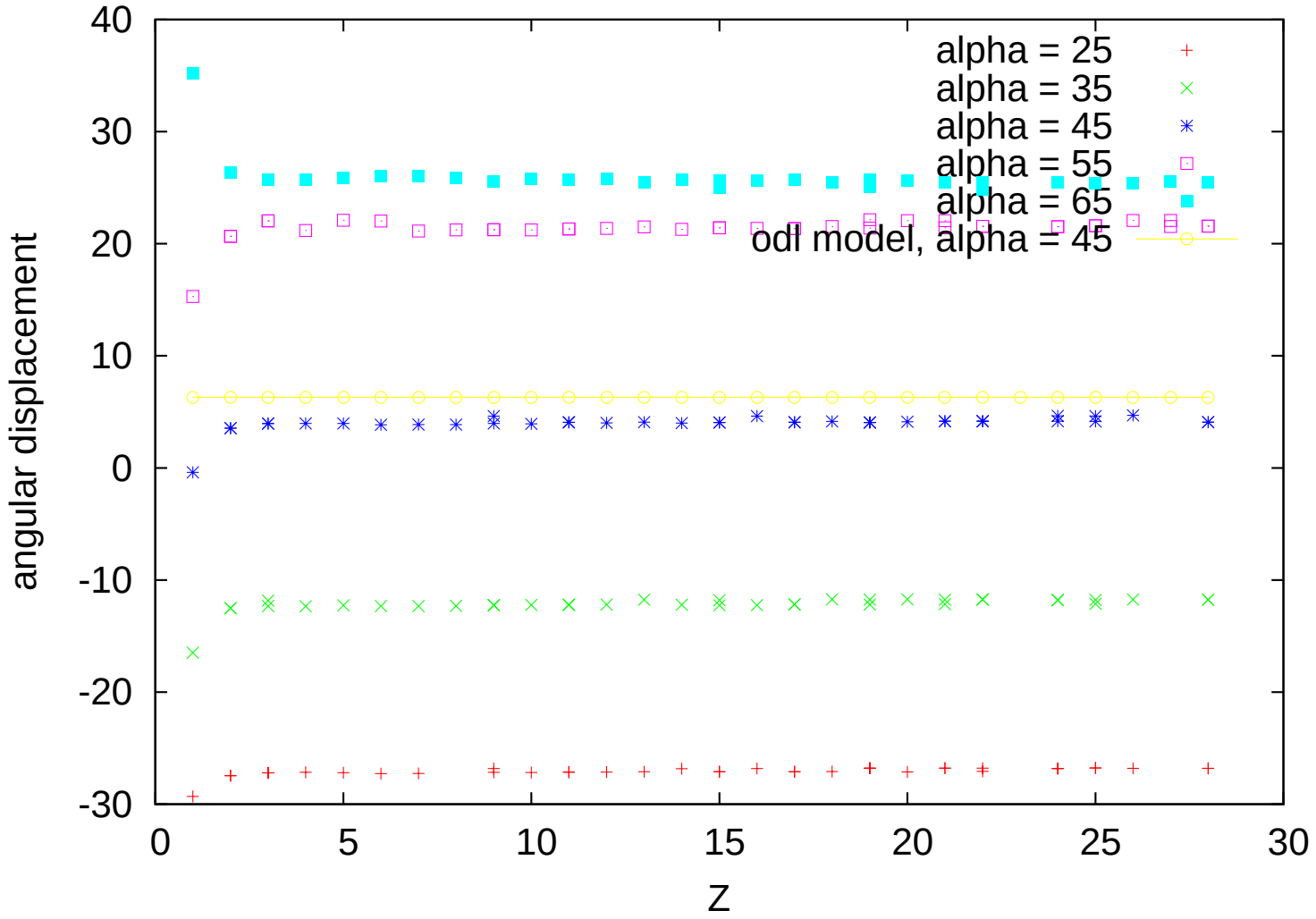

“Bending” at carbon foil slightly overestimated.

Outline

Summary and question highlights

- MTOF data leaves a lot of room for improvement (e.g. by comprehensive TRIM simulations), exceptions are “boring” quiet times and CMEs
- new, more accurate TRIM simulations leads to (hopefully) improved transmission function
- in-flight calibration with ACE/SWICS instead of CTOF

Summary and question highlights

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? How exactly are the matrix rates obtained?

? More calibration data?

? What is the exact geometry of MTOF? In particular, how exactly is the Vee gridded and the Hyperbola finned?

? How is decided how many PHA words are written out? Is there a prioritizing scheme?

? Which problems happened to MTOF in its operation time ?

Summary and question highlights

- MTOF data leaves a lot of room for improvement (e.g. by comprehensive TRIM simulations), exceptions are “boring” quiet times and CMEs
- new, more accurate TRIM simulations leads to (hopefully) improved transmission function
- in-flight calibration with ACE/SWICS instead of CTOF

? How exactly are the matrix rates obtained?

? More calibration data?

? What is the exact geometry of MTOF? In particular, how exactly is the Vee gridded and the Hyperbola finned?

? How is decided how many PHA words are written out? Is there a prioritizing scheme?

? Which problems happened to MTOF in its operation time ?

Thank you for your attention!

Questions?
Answers?