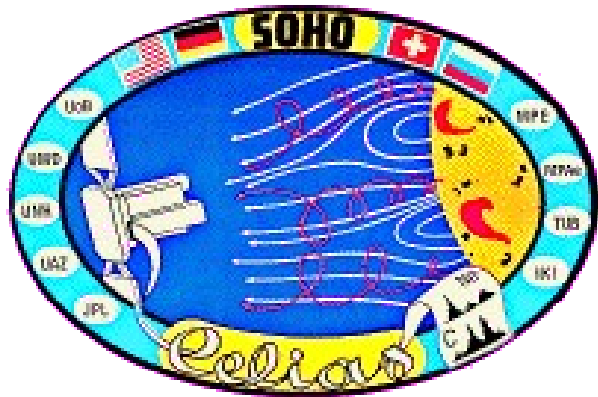
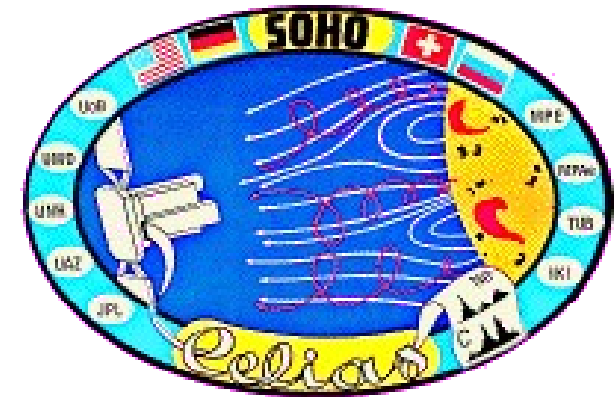




Determination of the $^{12}\text{C}/^{13}\text{C}$ ratio in the solar wind



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SOHO/CELIAS workshop 2014
MPS, Göttingen, August 26-28, 2014



Why did we come to MPS Göttingen?





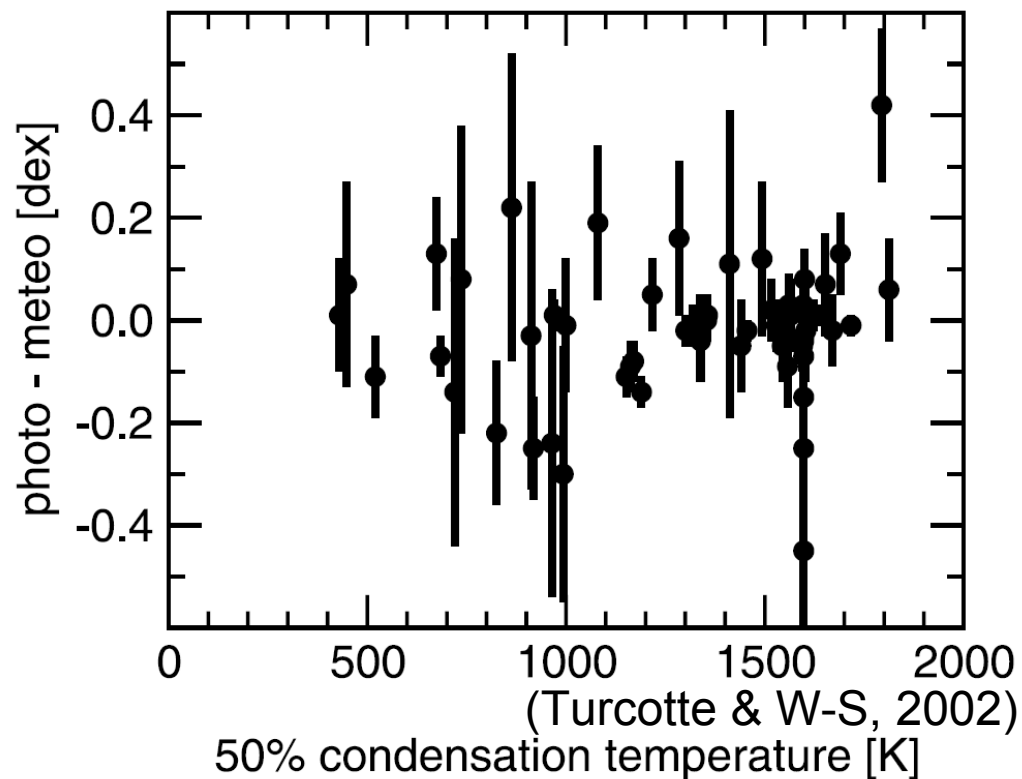
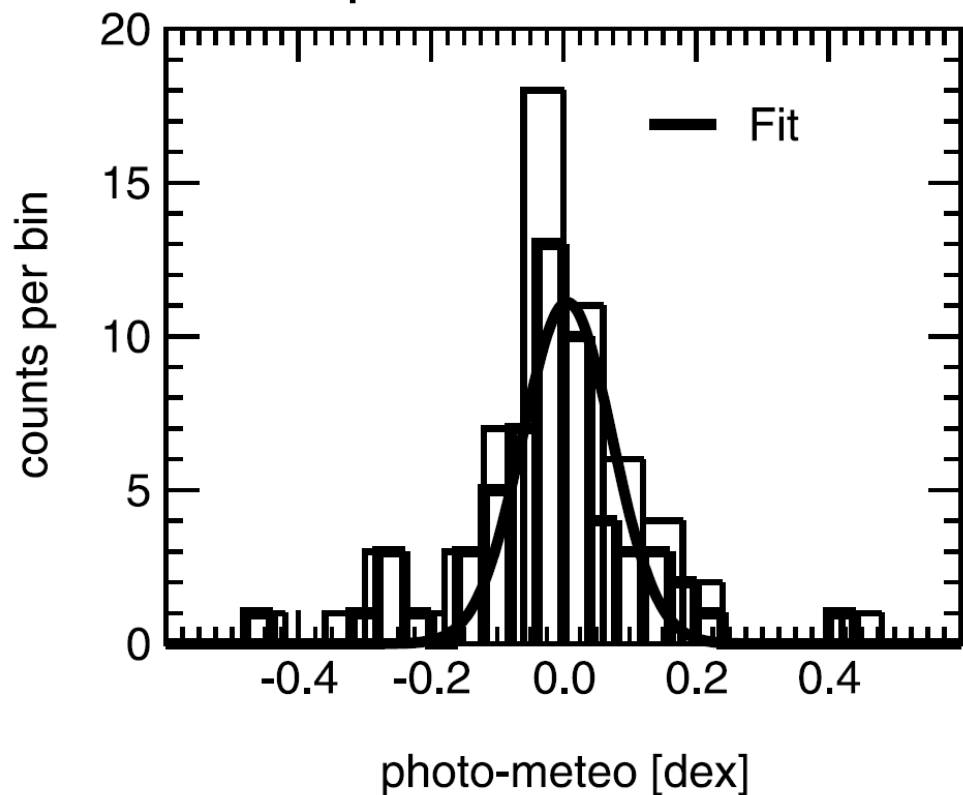
Contents

- Carbon and its isotopes
- ACE/SWICS
- Data analysis
- Results
- Discussion & Conclusions
- Near-term plans



Abundances in the early solar system

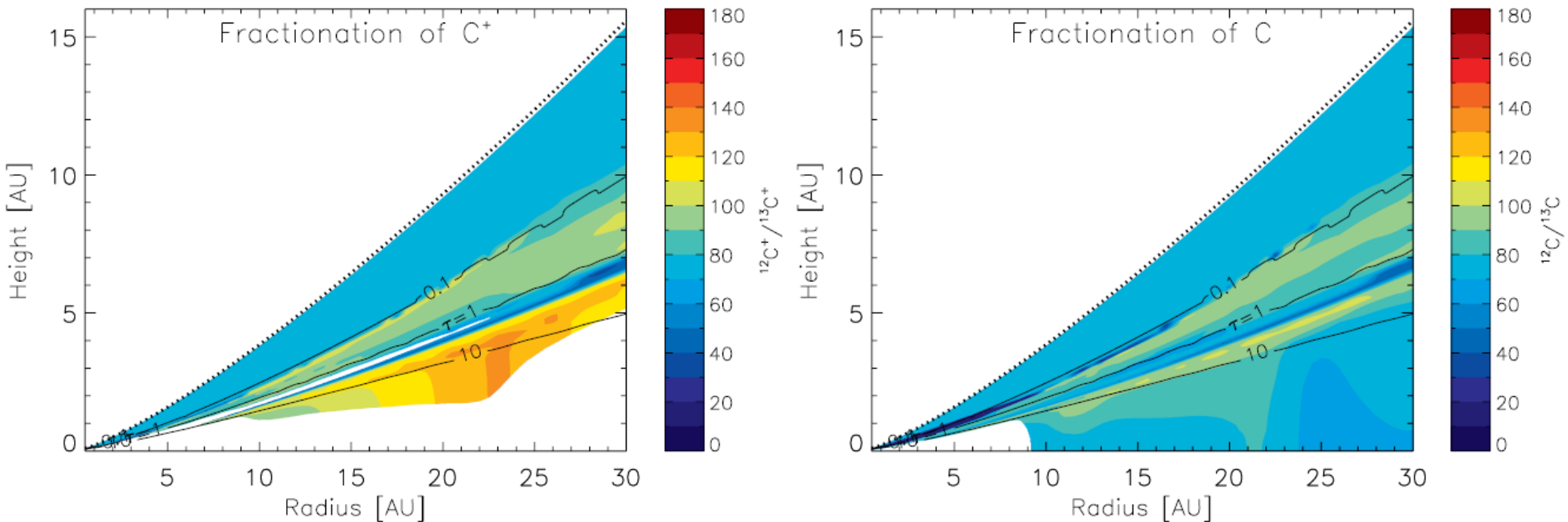
Meteoritic elemental abundances agree well with photospheric ones. Isotopic abundances well-known for meteorites except for noble gases. Solar isotopic abundances mostly unknown (with some exceptions...).



Limits to heterogeneity of proto-solar disk and planet formation



Inhomogeneity of carbon isotopes in a model proto-planetary disk

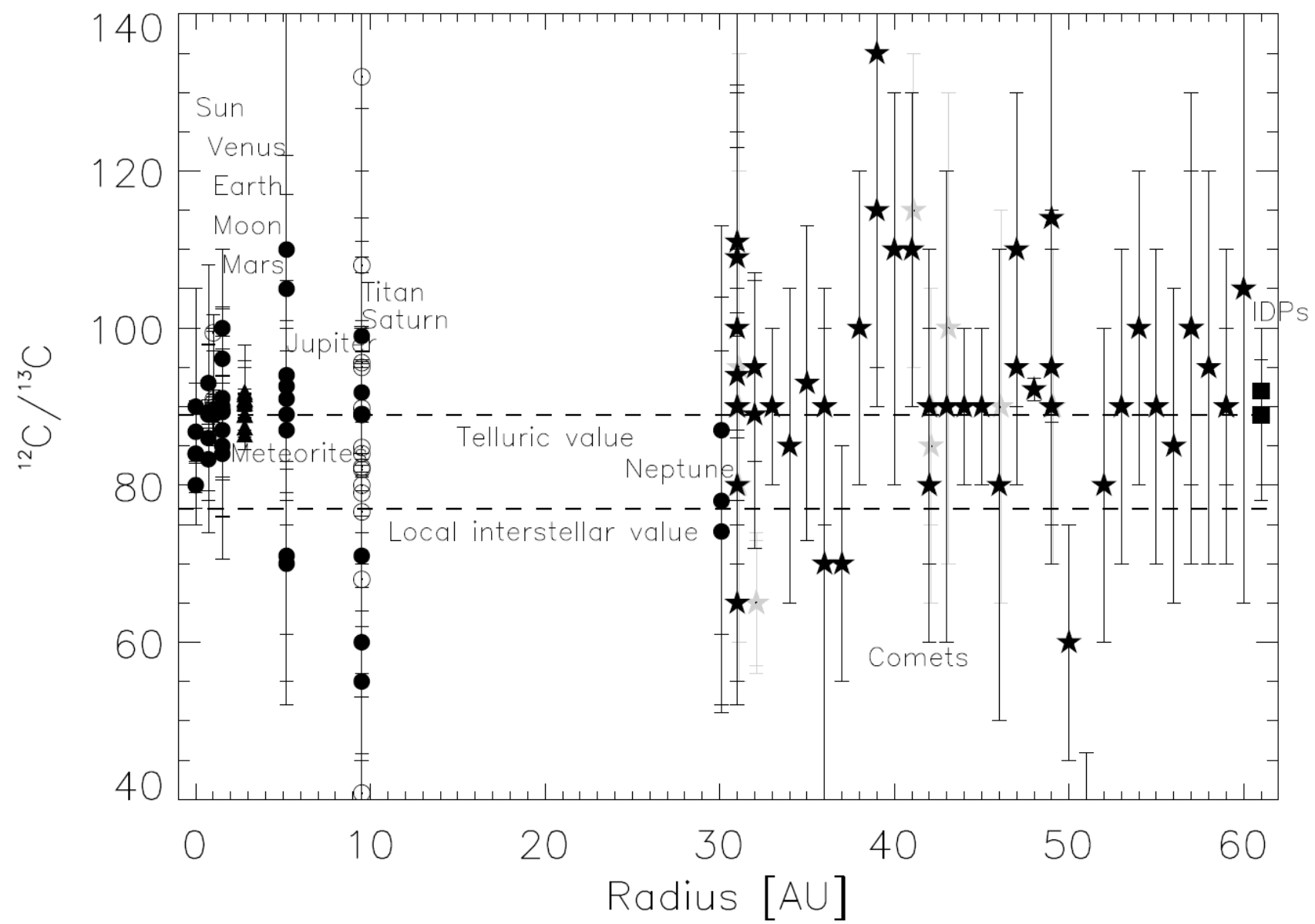


(Woods & Willacy, 2009)

Considerable inhomogeneity is seen throughout the disk.



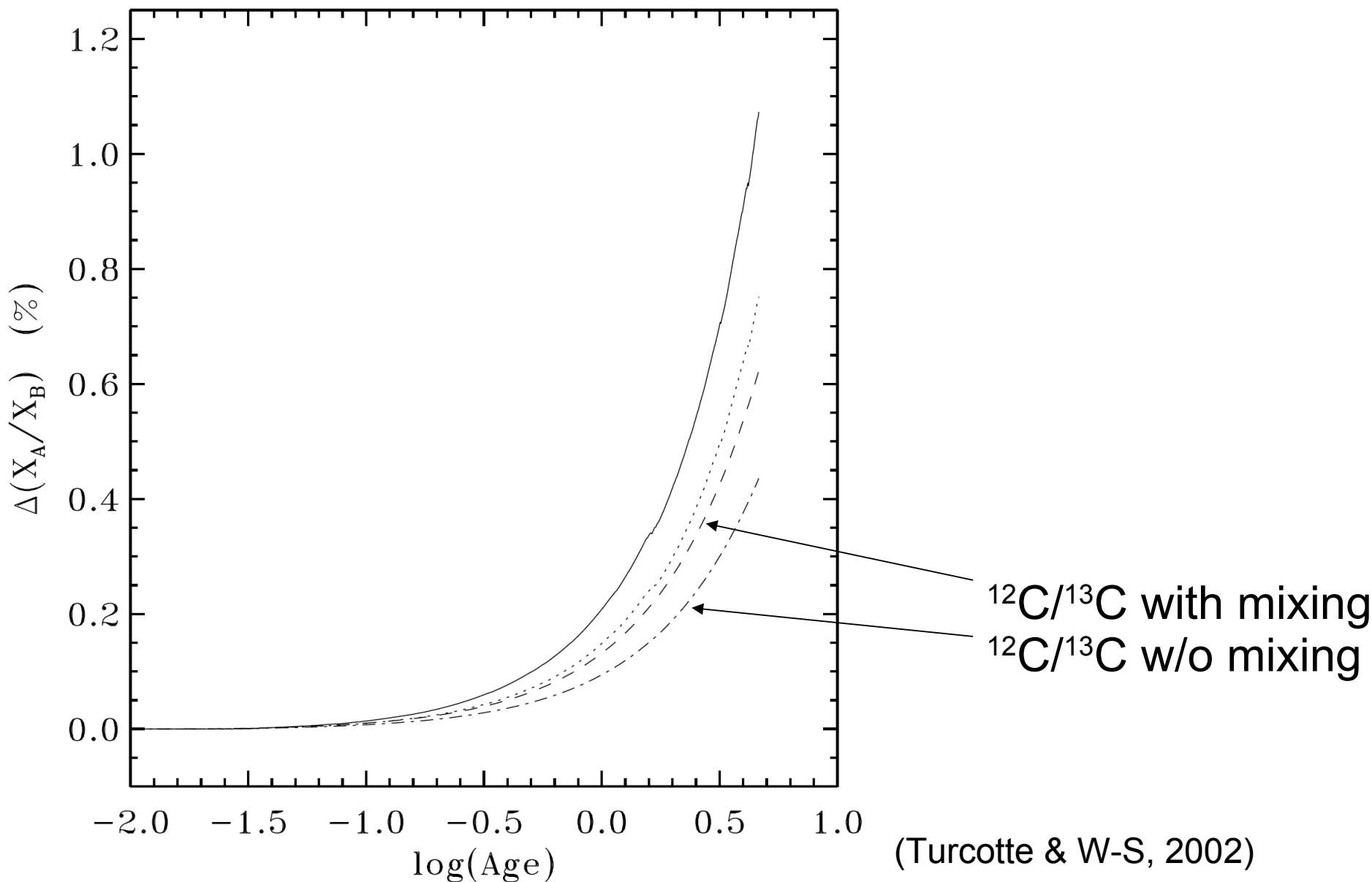
$^{12}\text{C}/^{13}\text{C}$ isotopes in the solar system



(Woods, 2009; Wood & Willacy, 2009)



Carbon isotope evolution in the Sun





The delta-notation is often used to make differences more visible

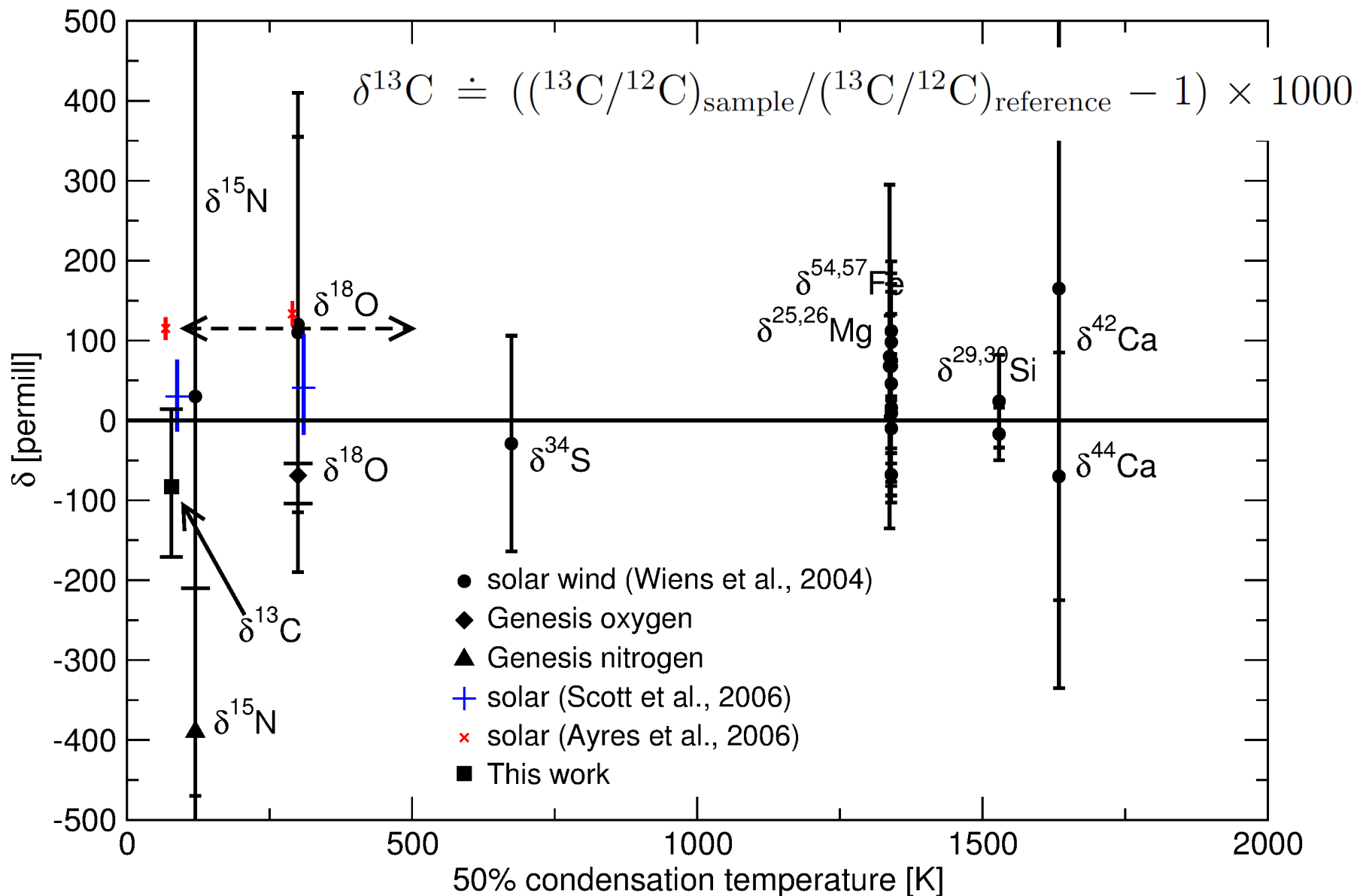
$$\delta^{13}\text{C} \doteq \left(\frac{(^{13}\text{C}/^{12}\text{C})_{\text{sample}}}{(^{13}\text{C}/^{12}\text{C})_{\text{reference}}} - 1 \right) \times 1000$$

↑ ↑ ↑
Your sample standard difference

- In this notation
- the standard has a delta of 0 per mill
 - a doubling of ^{13}C relative to std. leads to a delta of 1000 per mill



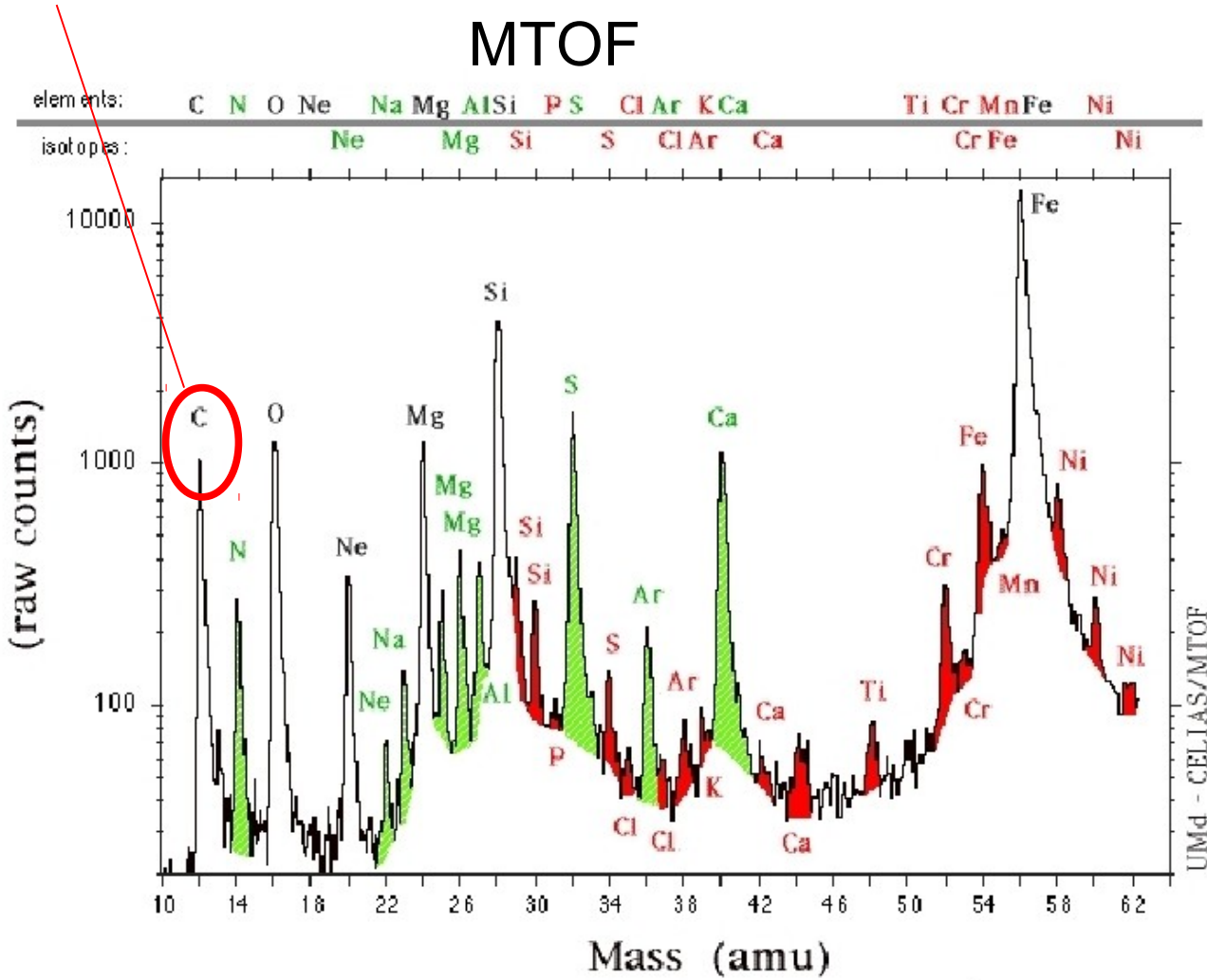
“Solar” isotopic composition





CELIAS/MTOF can't measure $^{12}\text{C}/^{13}\text{C}$, neither can Genesis...

Partially also knock-on C from C-foil

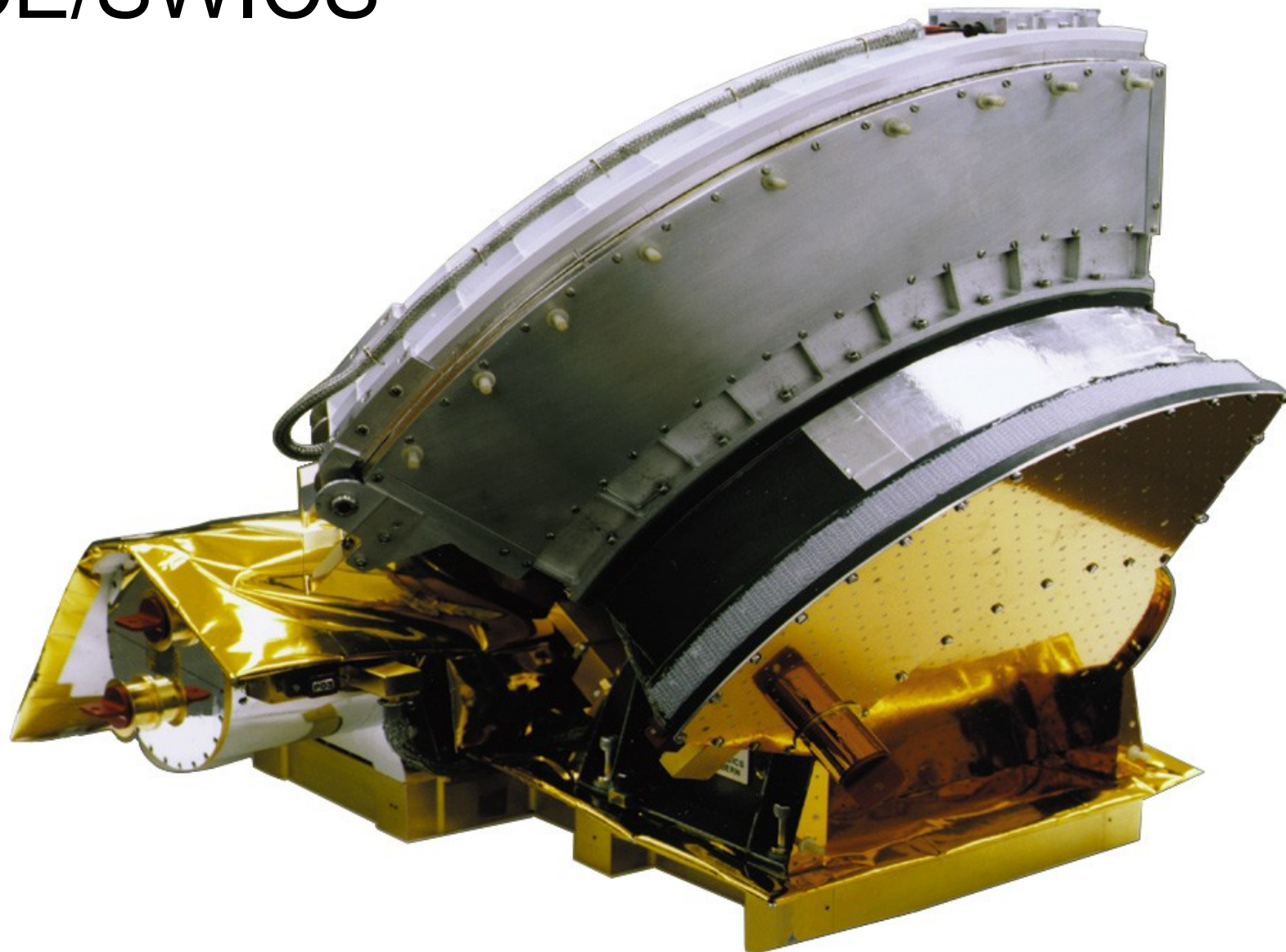


Genesis

- Key issues:
- terrestrial contamination
 - hydrogenated C interferes with ^{13}C

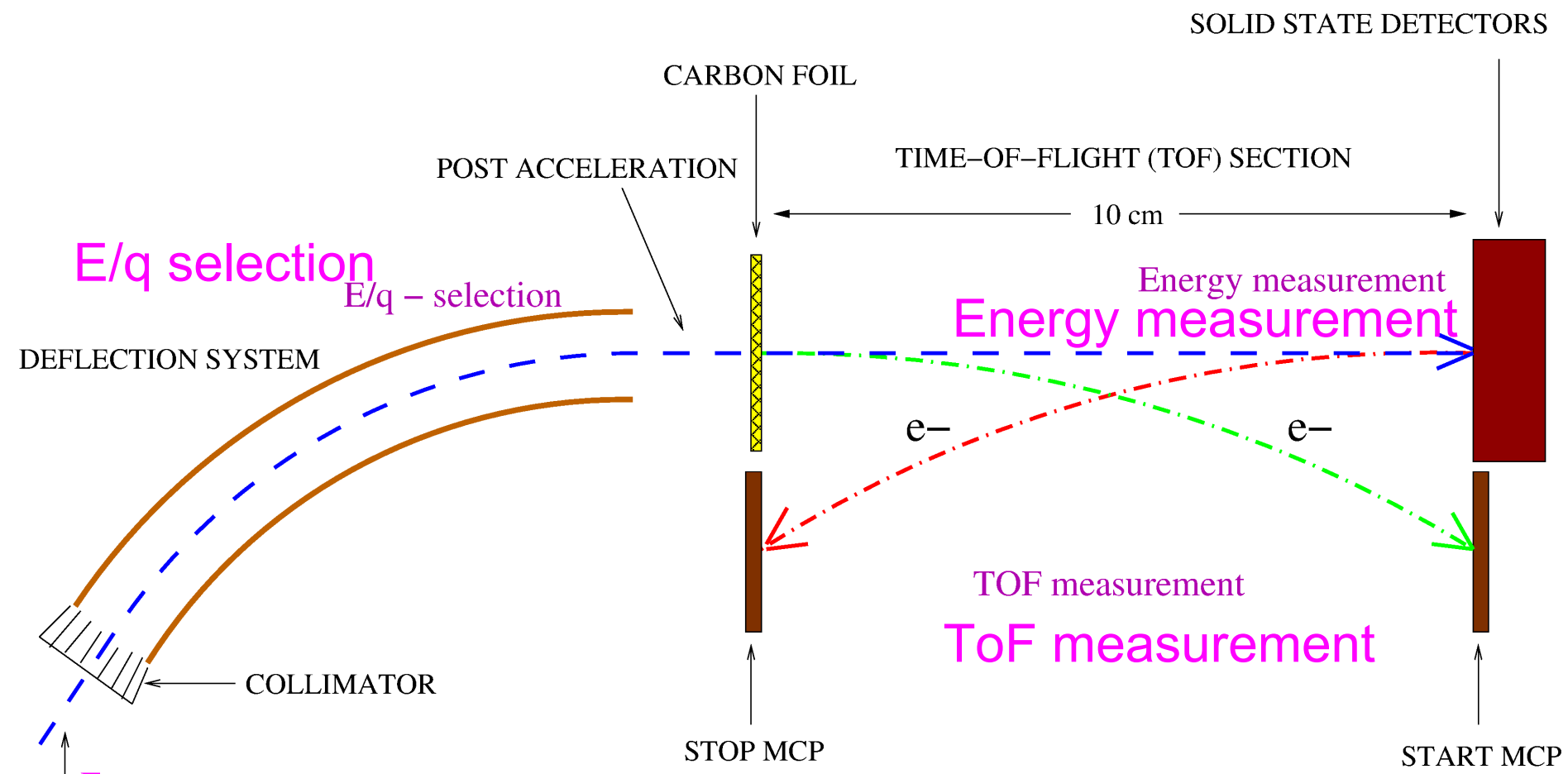


CELIAS workshop, but discuss ACE/SWICS





ACE/SWICS – linear ToF spectrometer



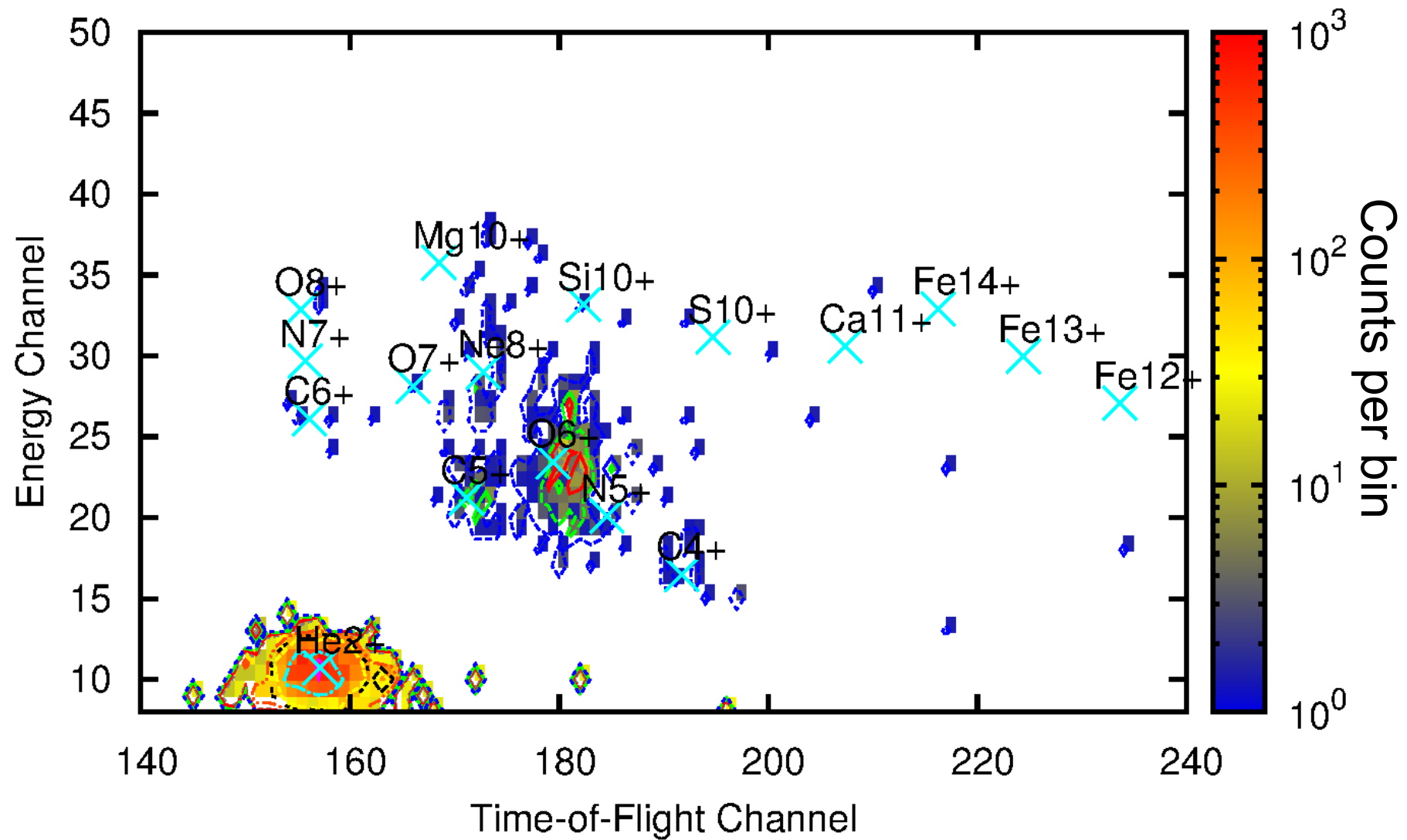
ION BEAM E, q, m

Solar wind ion:
3 unknowns,
 E, q, m

MCP = MICRO CHANNEL PLATE

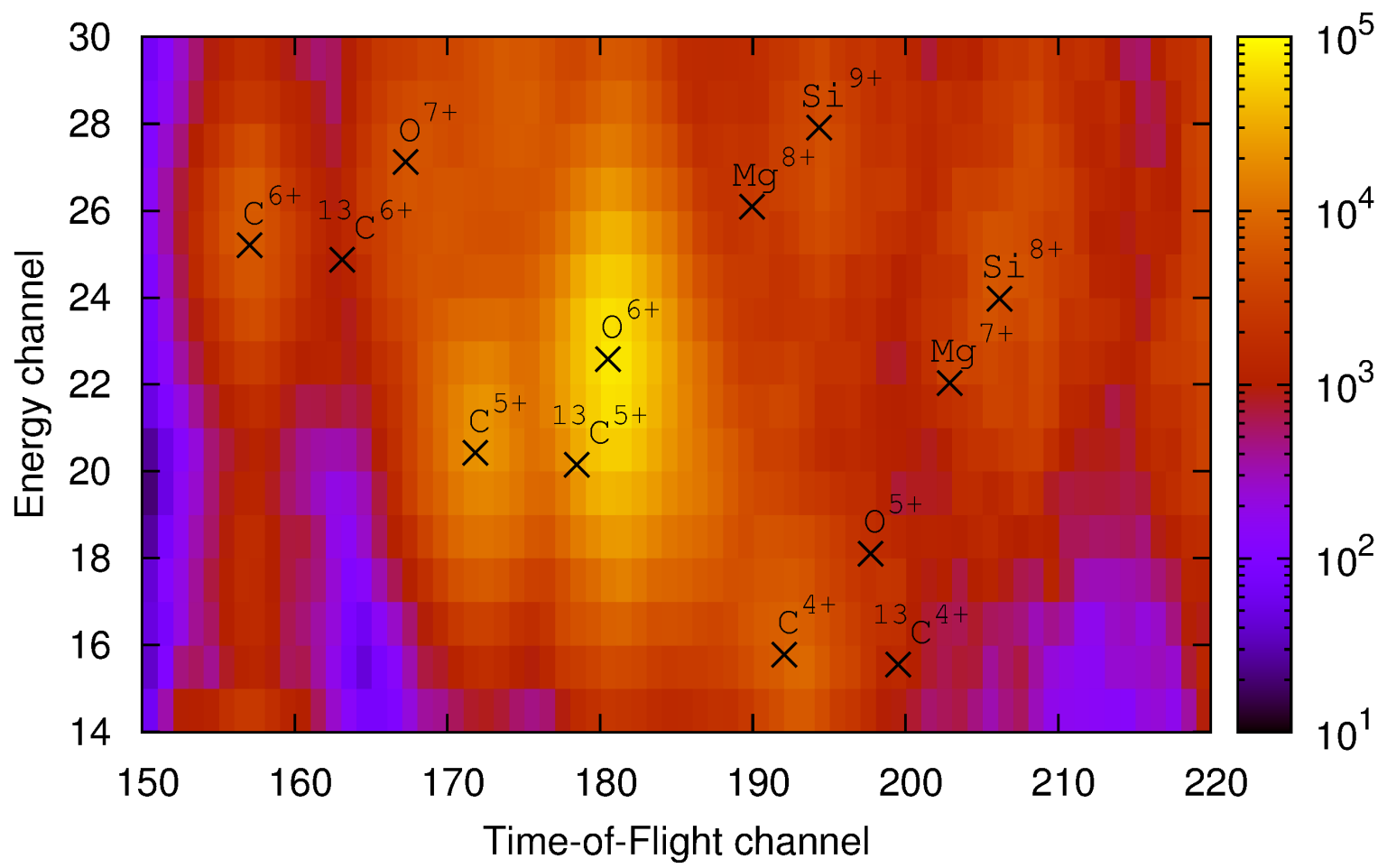


One hour's worth of data for one E/q step





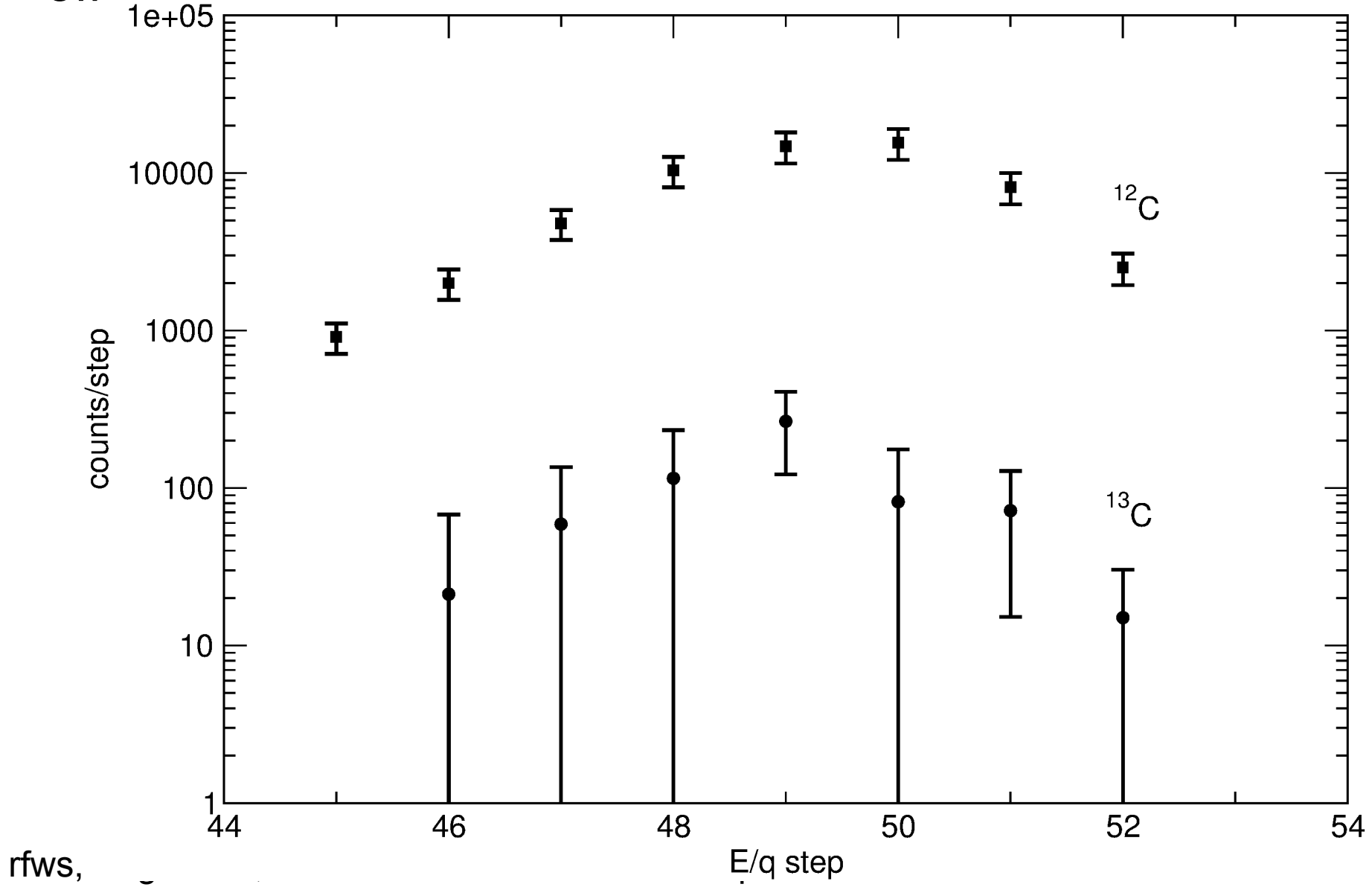
ET-matrix for 2001, 2002, 2004, 2006, and 2007 and E/q step 30



Need to add all years up to 2010

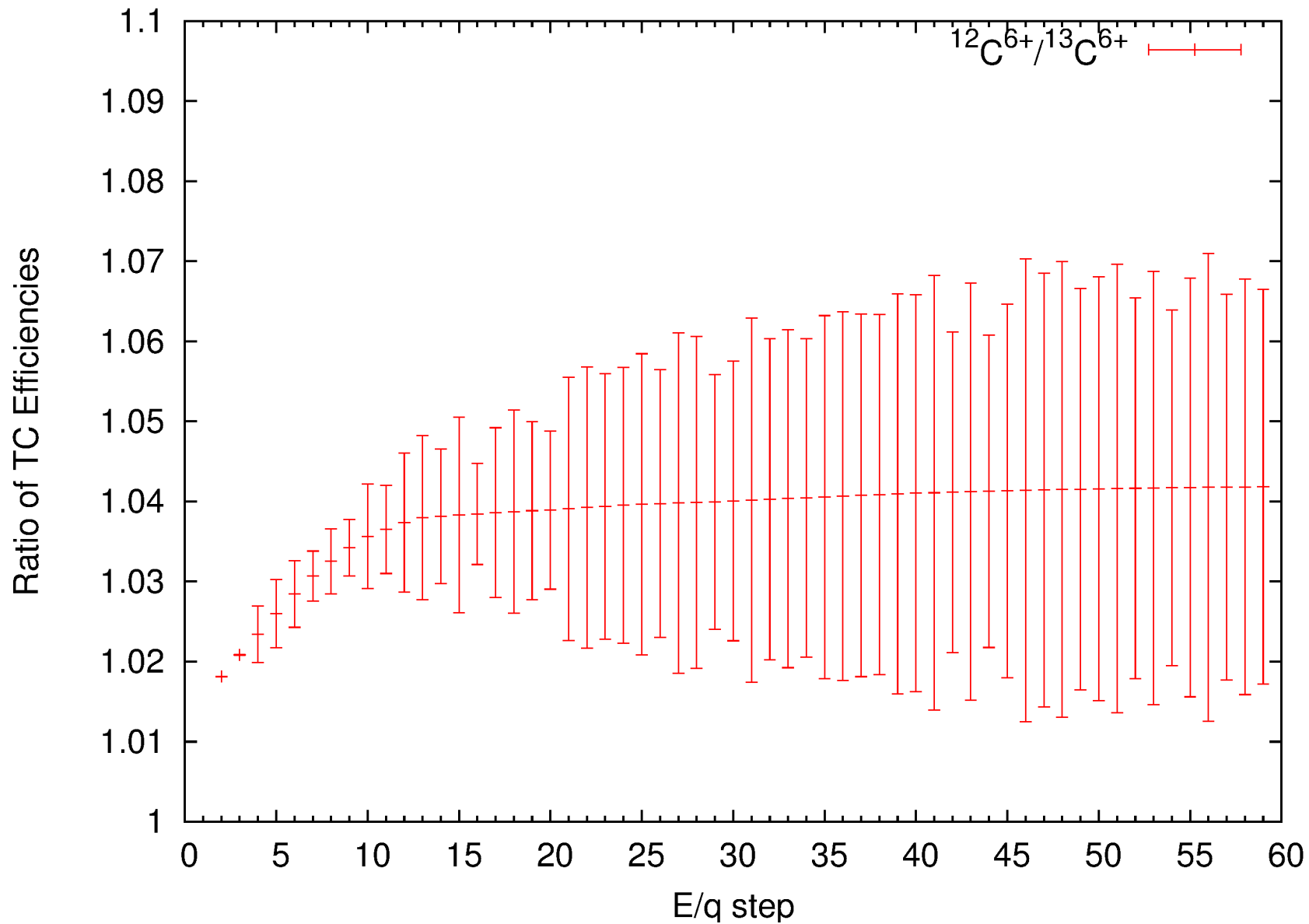


E/q spectrum for ^{12}C and ^{13}C for $v_{\text{SW}} = 360 \pm 20 \text{ km/s}$



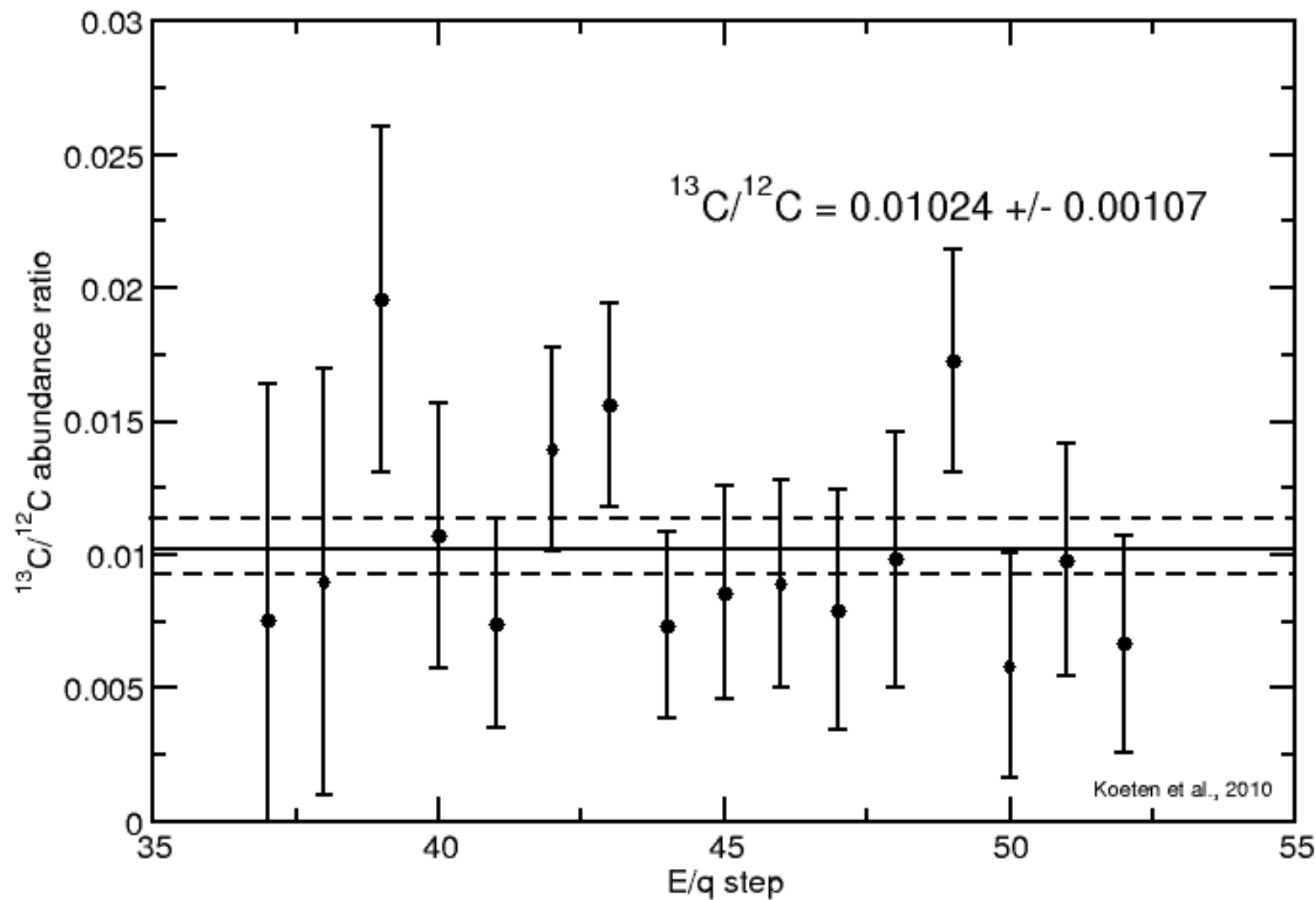


Instrument correction / efficiency



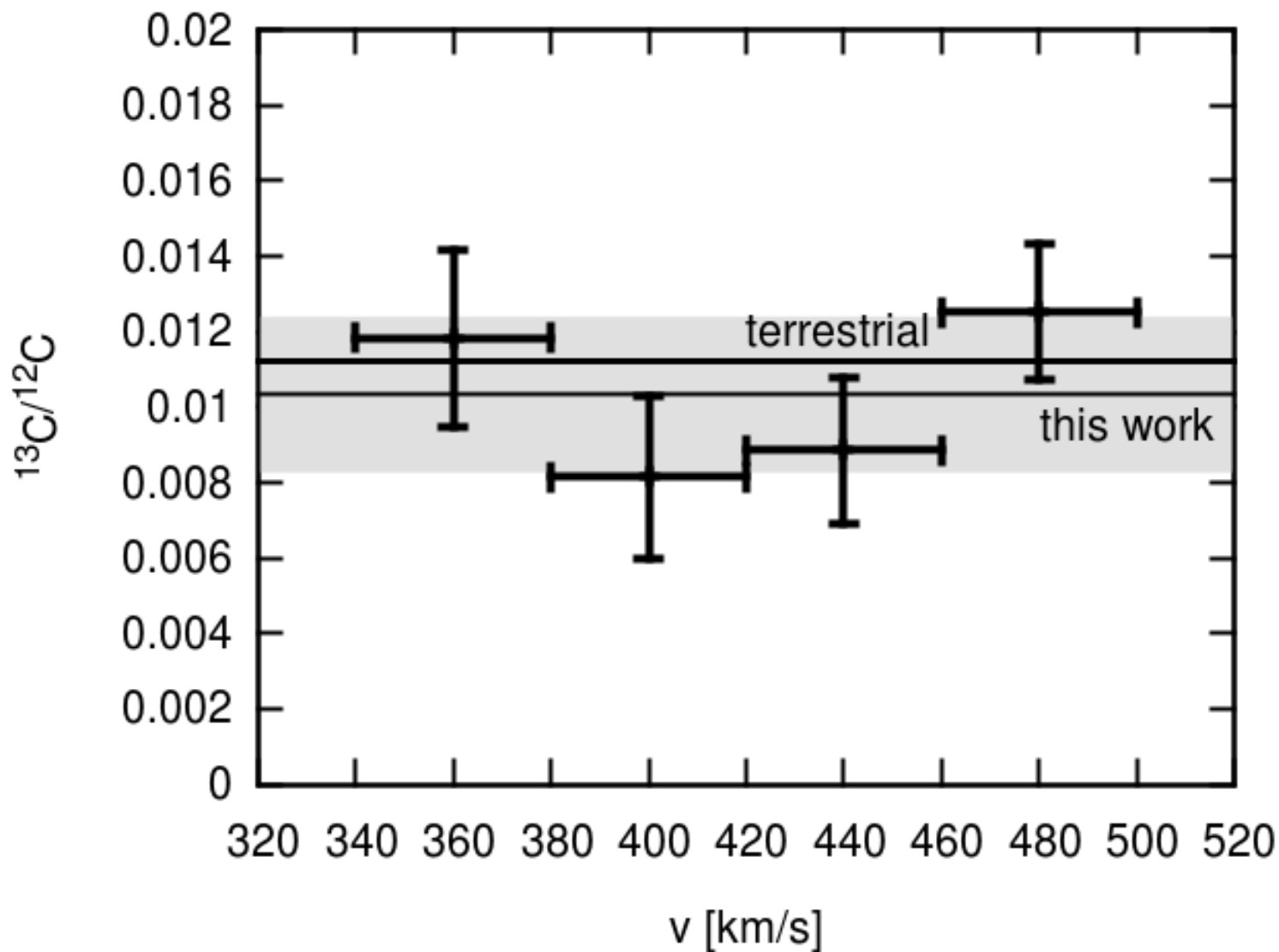


Carbon isotope ratio vs. E/q step



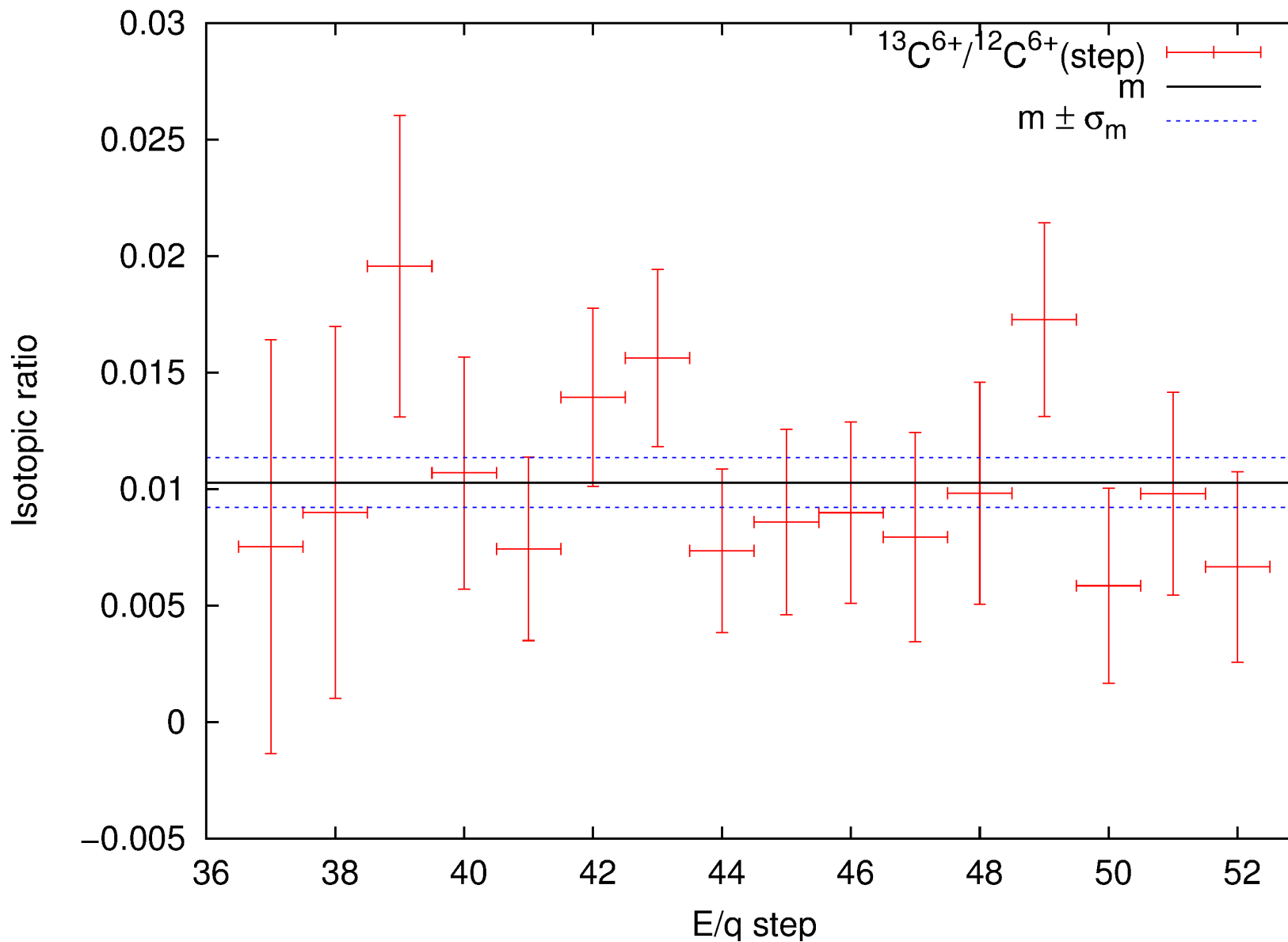


Carbon isotope ratio vs. solar wind speed





Carbon isotope ratio vs. E/q





Discussion & Conclusions

- ^{13}C is visible in ACE/SWICS data and we can obtain E/q spectra
- This can be used to derive isotopic abundance
- Instrumental corrections are relatively small, but still larger than we'd like
- $^{12}\text{C}/^{13}\text{C} = 97.7 (+10.3/-9.3)$ indicative of an isotopically light Sun
- Premature, add more data..., better model for peak shape