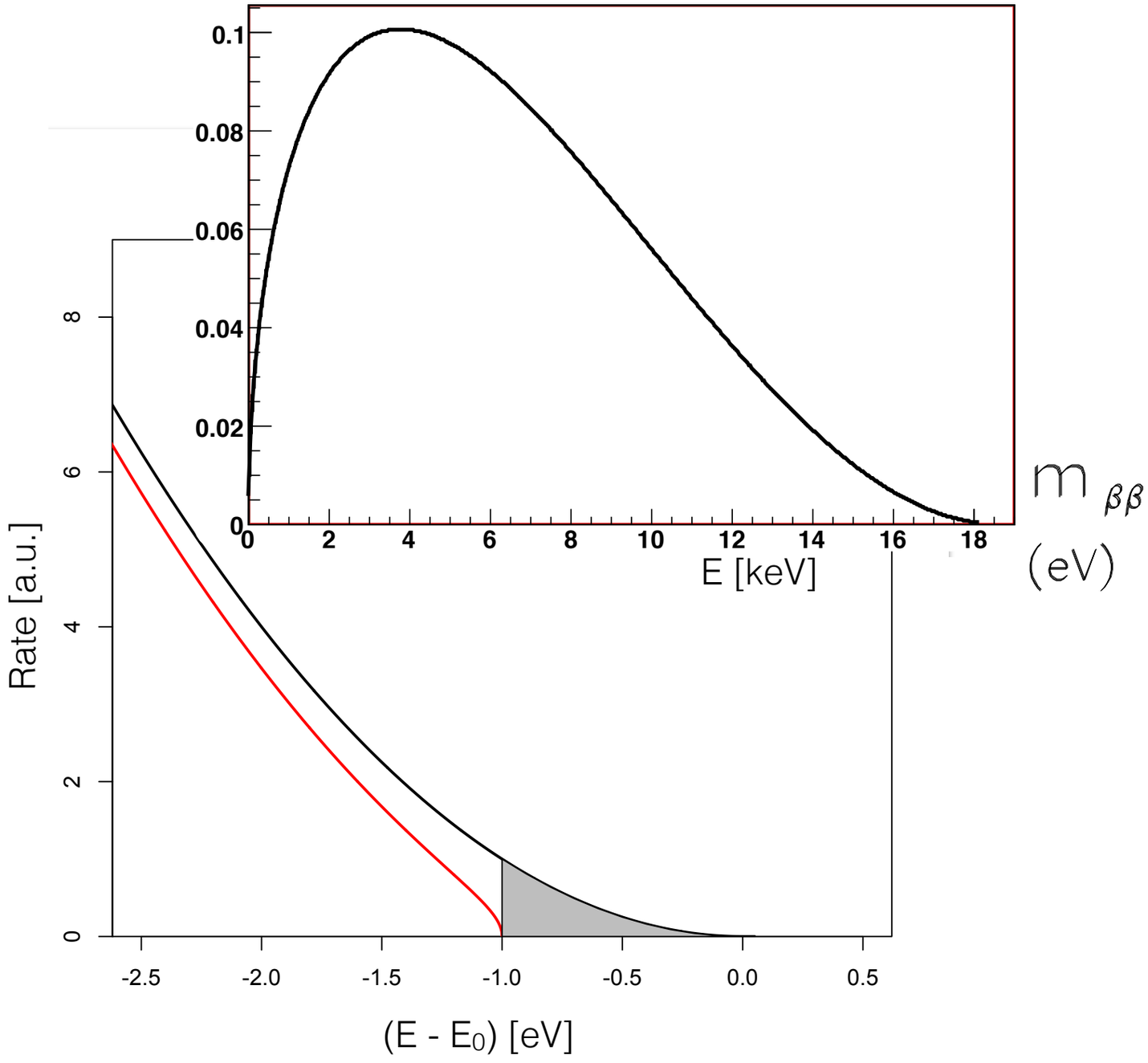
PROJECT 8

Status of the Project 8 Experiment

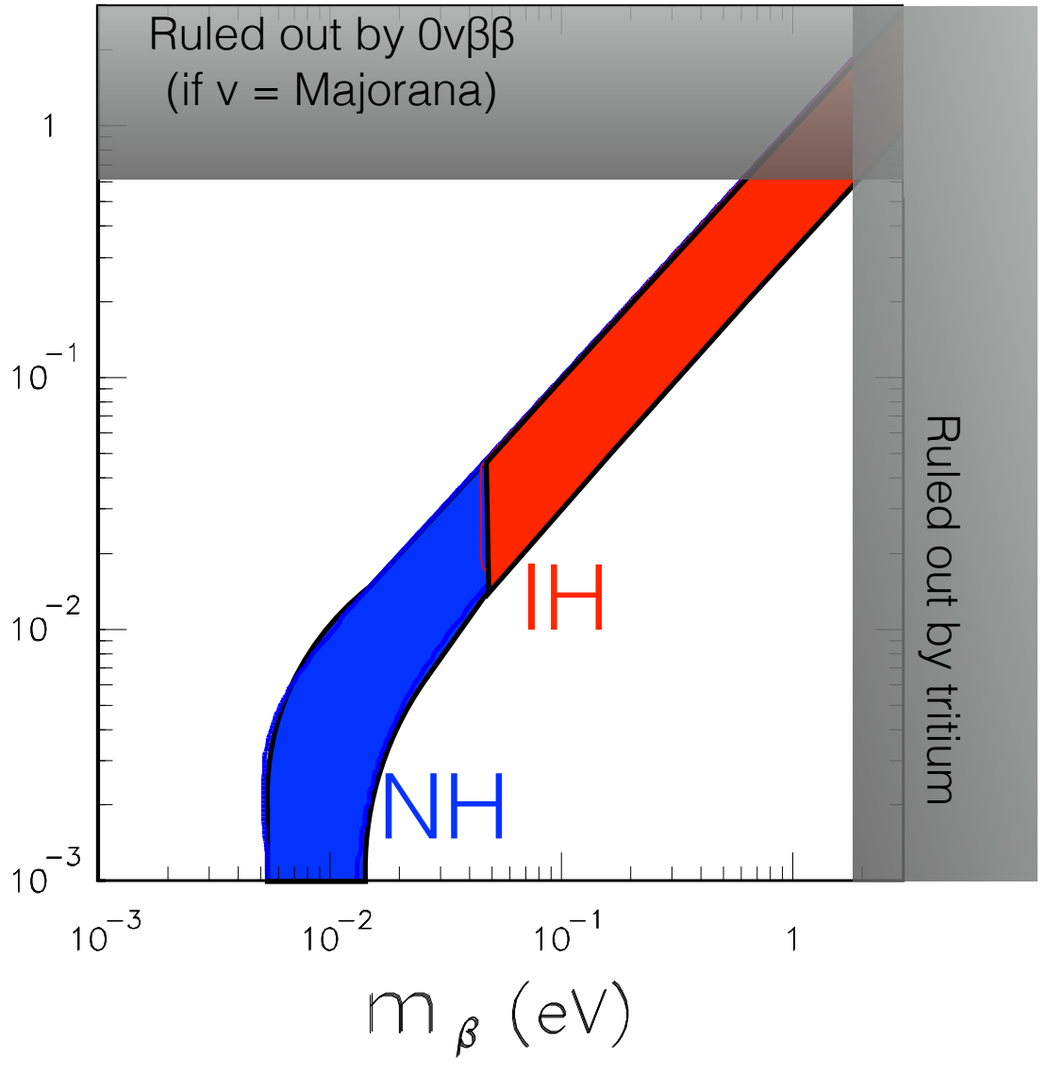
Ben LaRoque, UCSB
For the Project 8 Collaboration

The Tritium-endpoint Method

$$\frac{dN}{d\mathrm{E}} = \frac{G_F^2}{2\pi^3}\cos^2(\theta_c)\,|M|^2\,F(Z,\mathrm{E})\,p\,(\mathrm{E}+m_e c^2)\,(\mathrm{E}_0-\mathrm{E})\,\sqrt{(\mathrm{E}_0-\mathrm{E})^2-m_\nu^2}\,\Theta(\mathrm{E}_0-\mathrm{E}-m_\nu)$$



$m_{\beta\beta}$ (eV)



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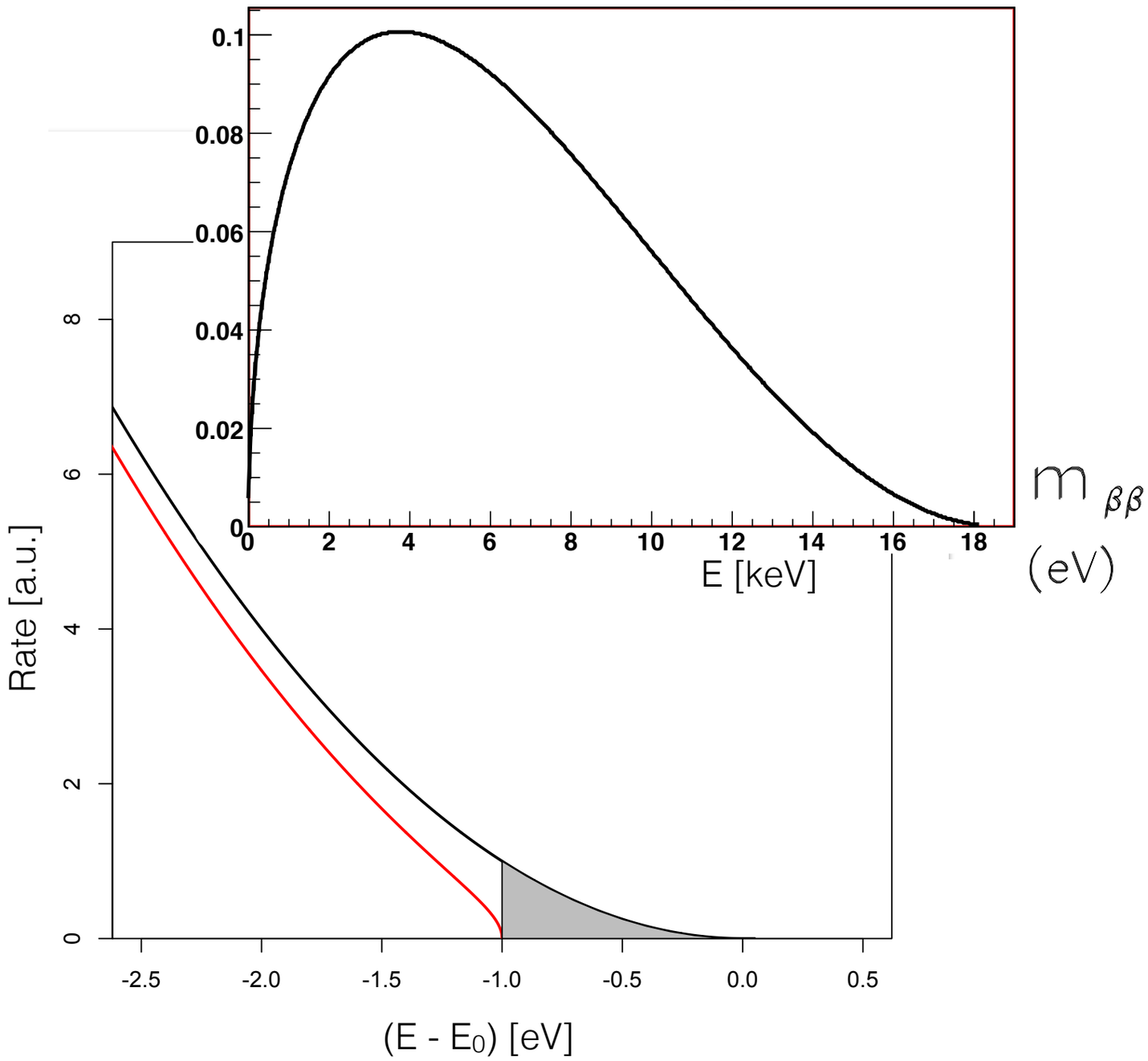

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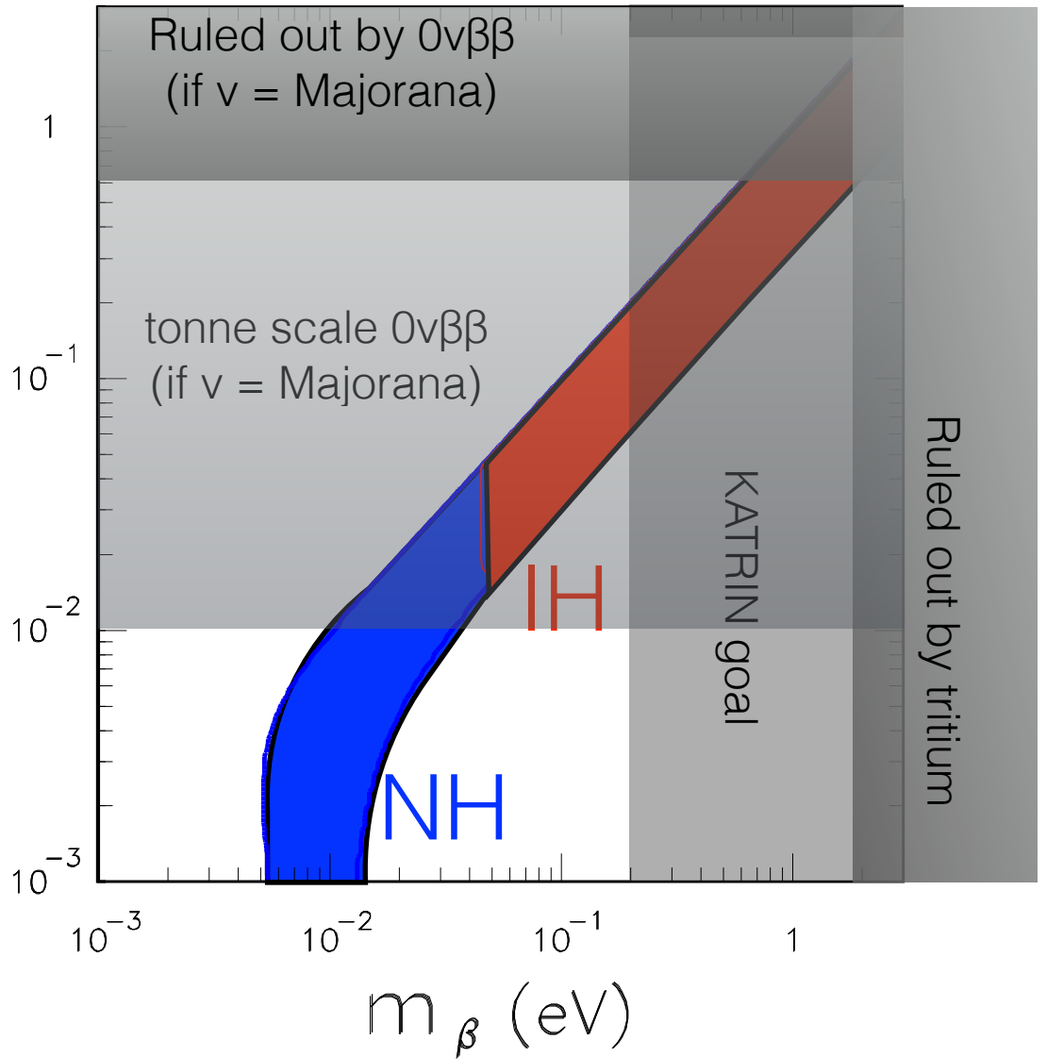
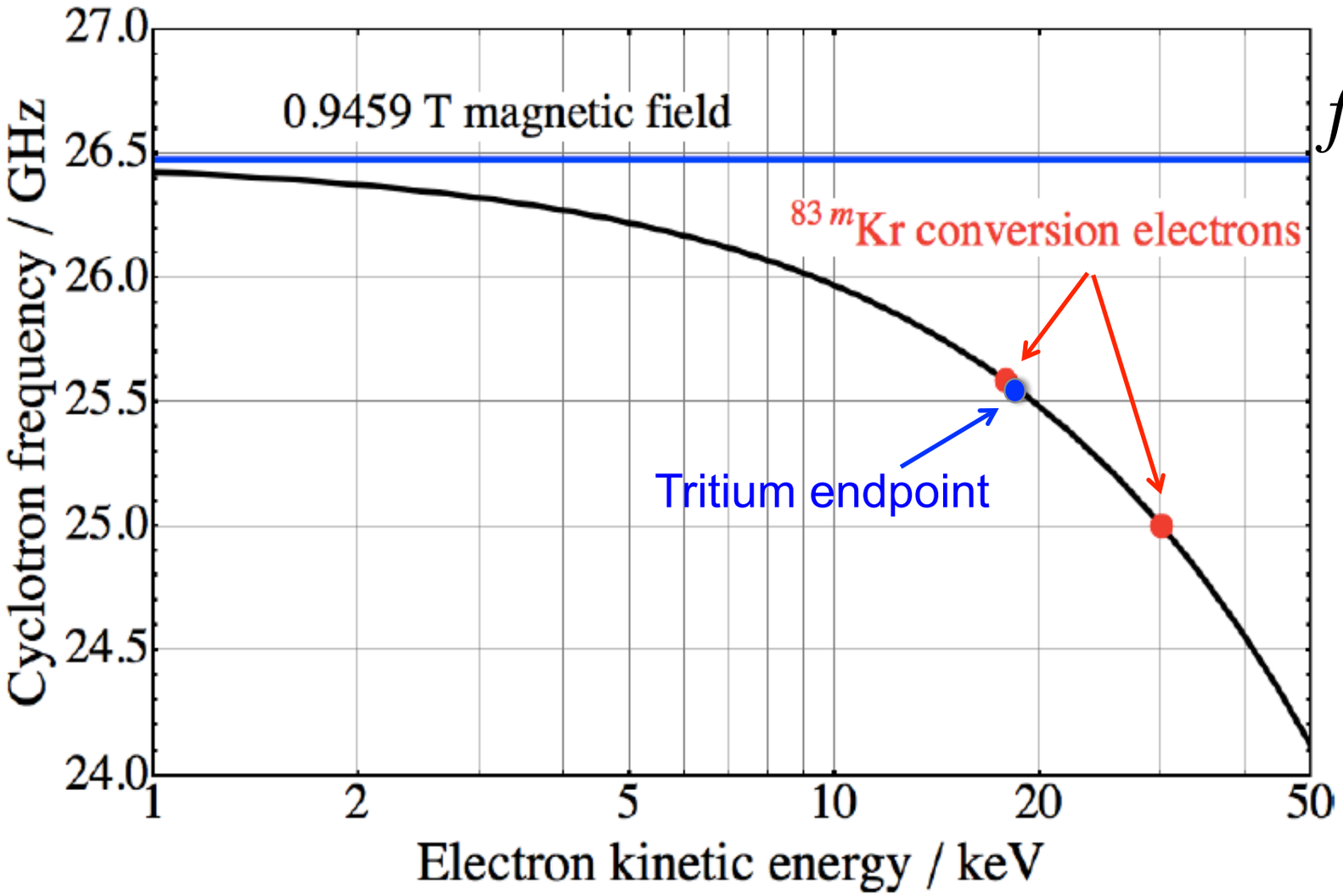


The Project 8 Technique

(B. Monreal and J. Formaggio; Phys. Rev. D 80, 051301, 2009)

$$P(\gamma,\theta) = \frac{1}{4\pi\varepsilon_0}\frac{2}{3}\frac{e^4}{m_e^2 c}B^2(\gamma^2\text{-}1)\sin^2(\theta) \qquad f = \frac{f_c}{\gamma} = \frac{1}{2\pi}\cdot\frac{eB}{\frac{K}{c^2}+m_e}$$

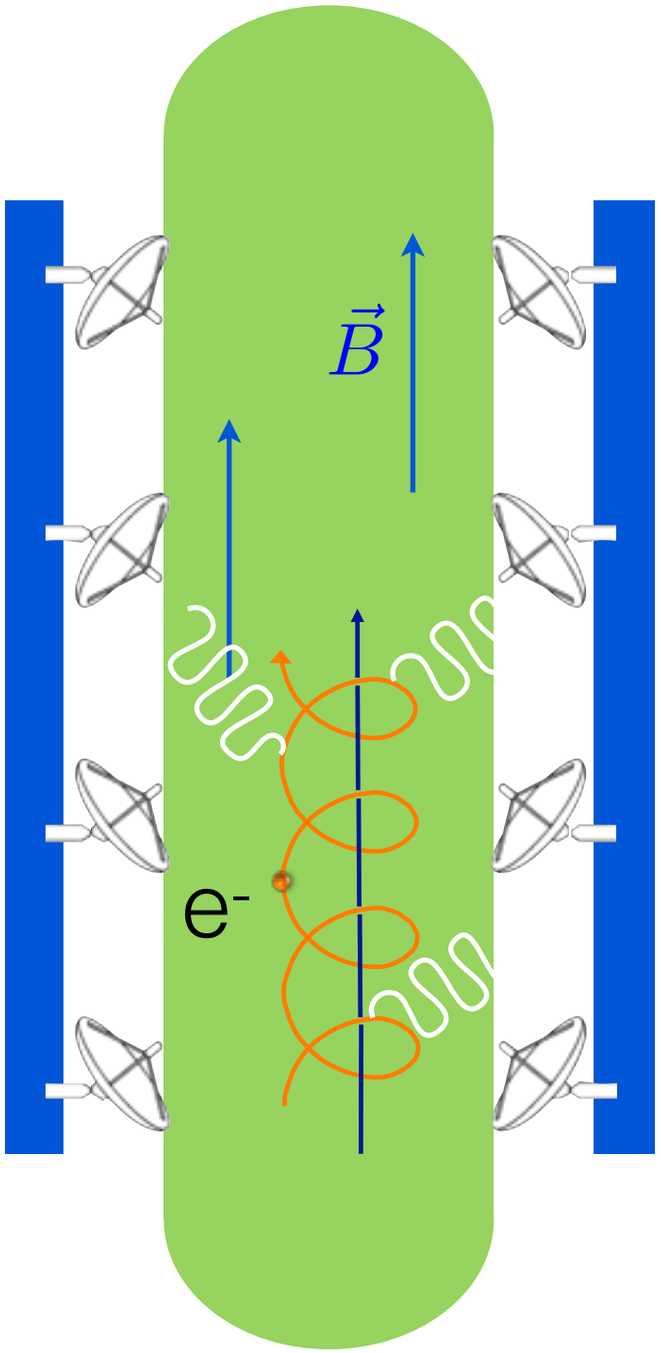


$$f_c = 27992.49110(6)\left[\frac{MHz}{T}\right]$$

17.8 keV
—> 25.6 GHz & 1.0 fW
30.2 keV
—> 25.0 GHz & 1.7 fW

The Project 8 Technique

(B. Monreal and J. Formaggio; Phys. Rev. D 80, 051301, 2009)



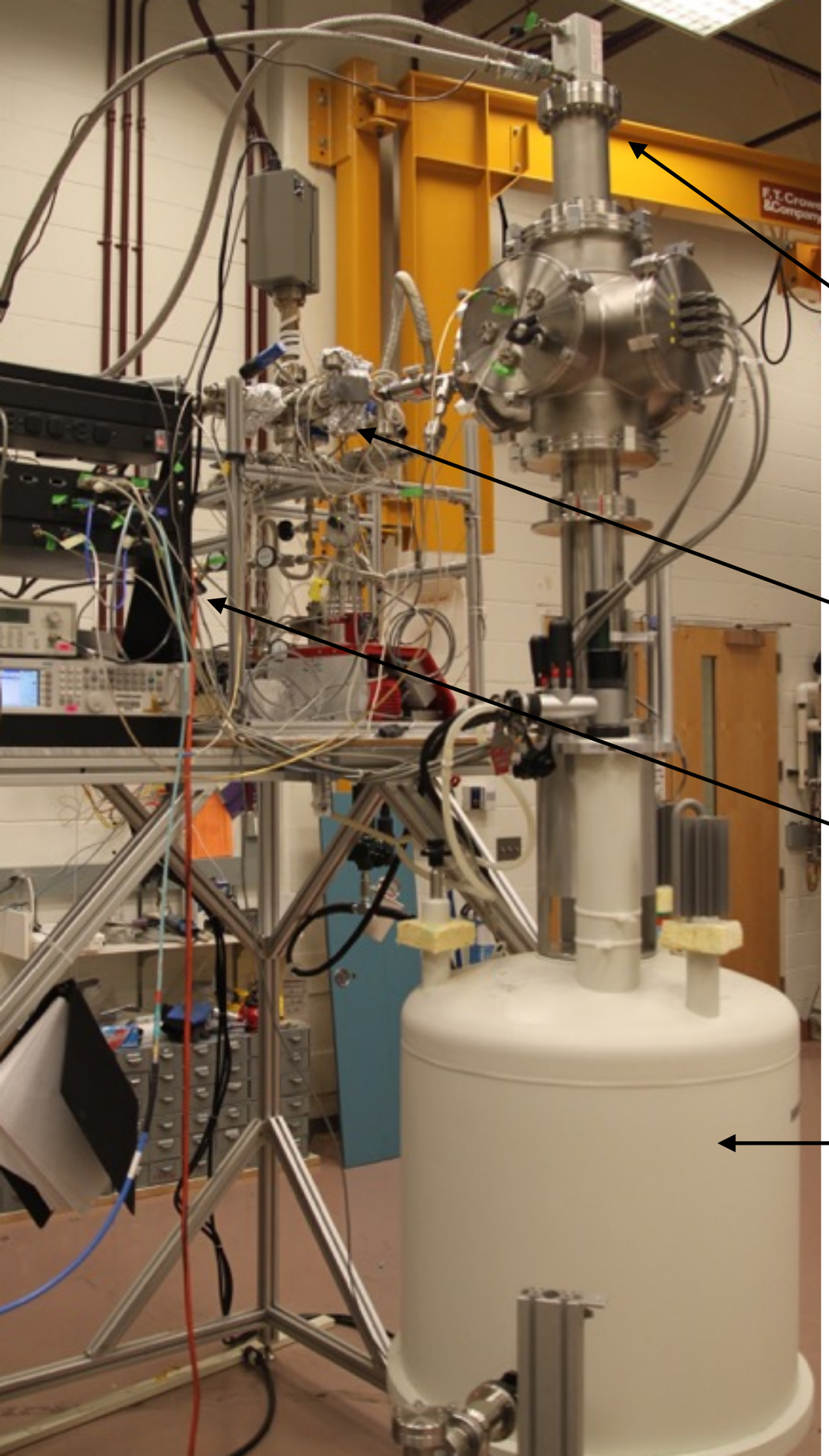
- A gaseous source produces electrons with few tens keV
- 1 eV resolution -> 2ppm in frequency

$$\frac{\delta \mathrm{E}}{\mathrm{E}} = \left(1 + \frac{m_e c^2}{\mathrm{E}}\right) \frac{\delta f}{f}$$

- At these energies, that means a mean free path of a few km (a trap is required)
- This also sets an upper bound on pressure; though detectability generally dominates

The Prototype

(located at UW in Seattle)



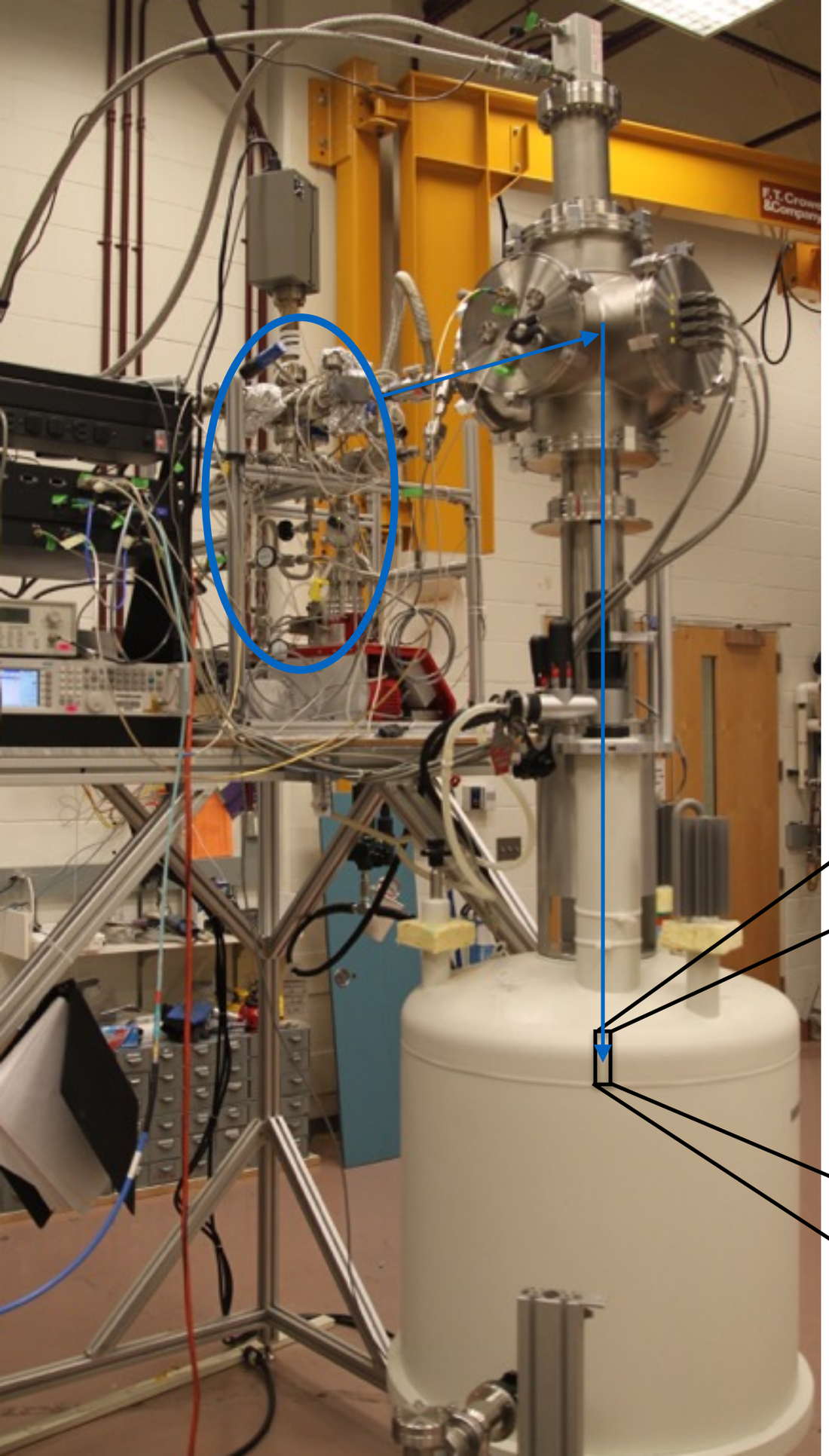
G.M. cooler

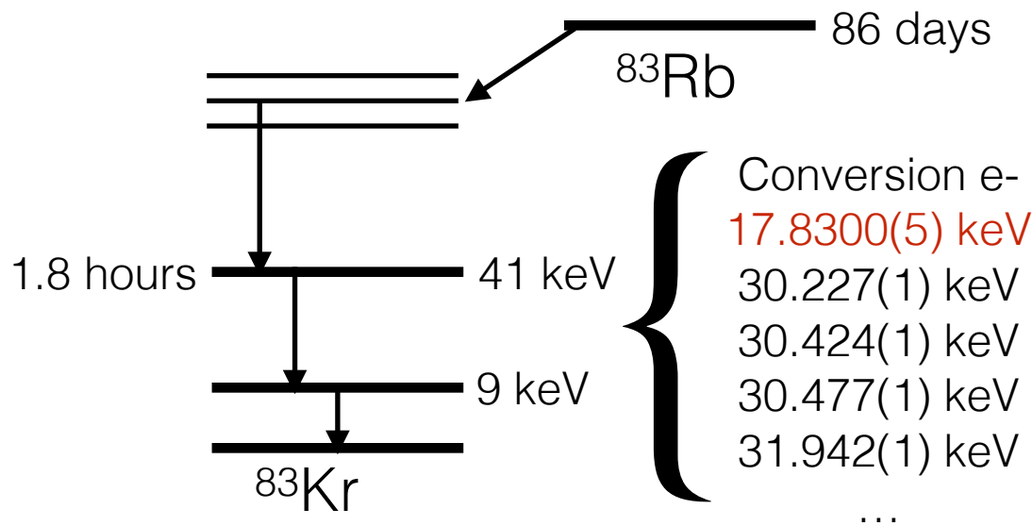
Kr-83m source

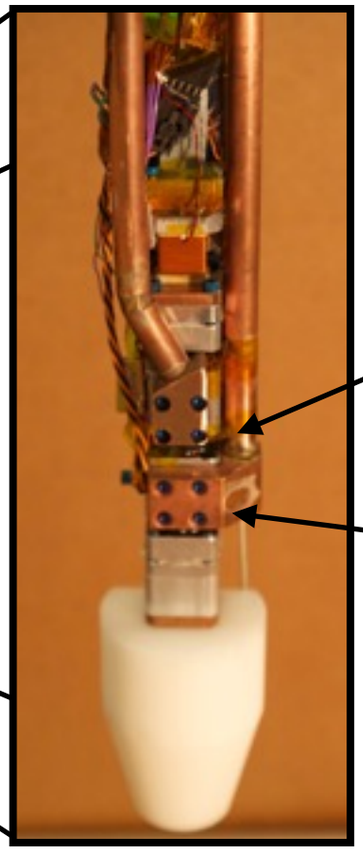
RF electronics

NMR Magnet
(50 mm Bore; 0.95 T)

^{83}Kr Source



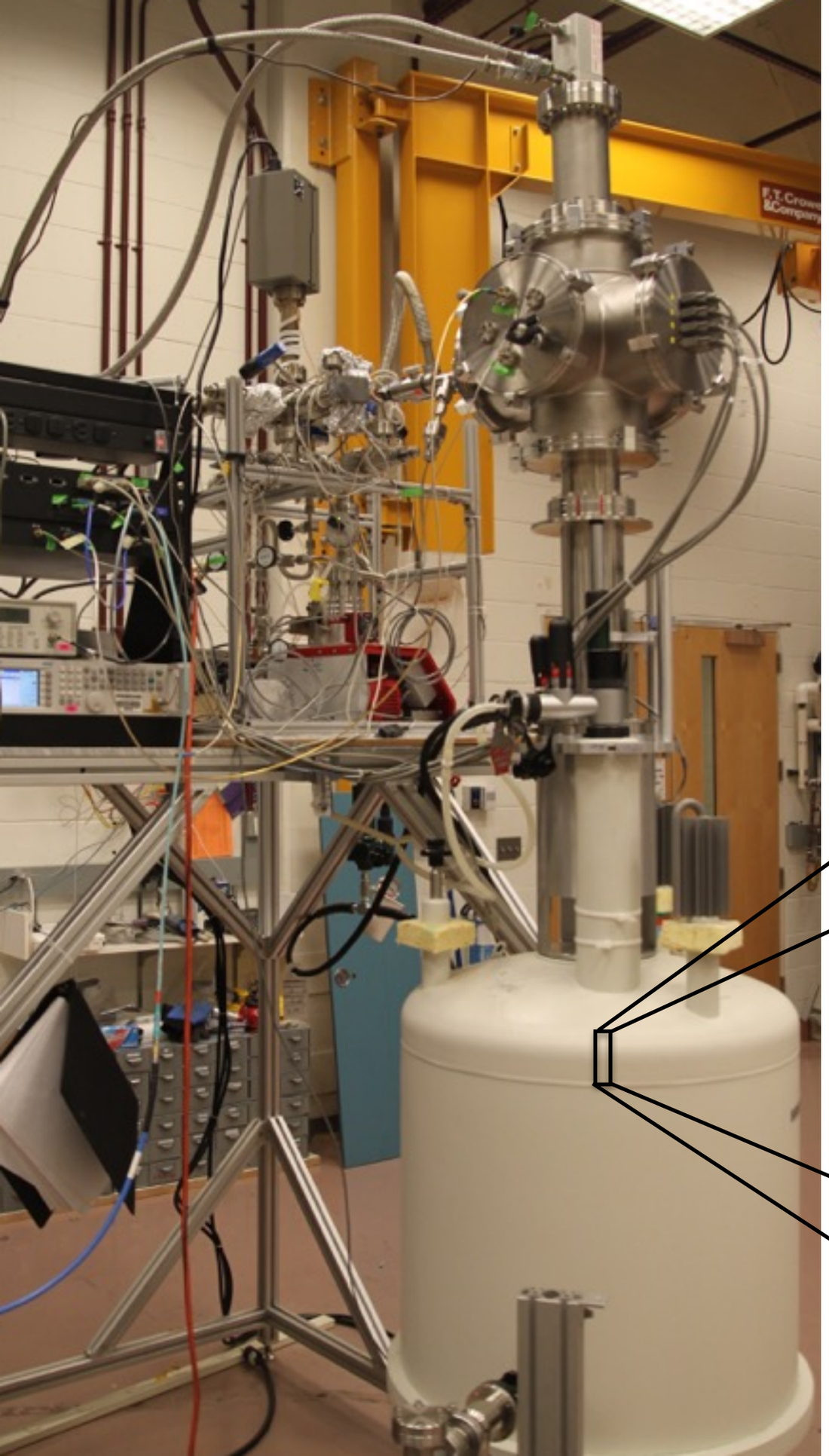

86 days
^{83}Rb
1.8 hours
41 keV
9 keV
^{83}Kr
Conversion e-
17.8300(5) keV
30.227(1) keV
30.424(1) keV
30.477(1) keV
31.942(1) keV
…

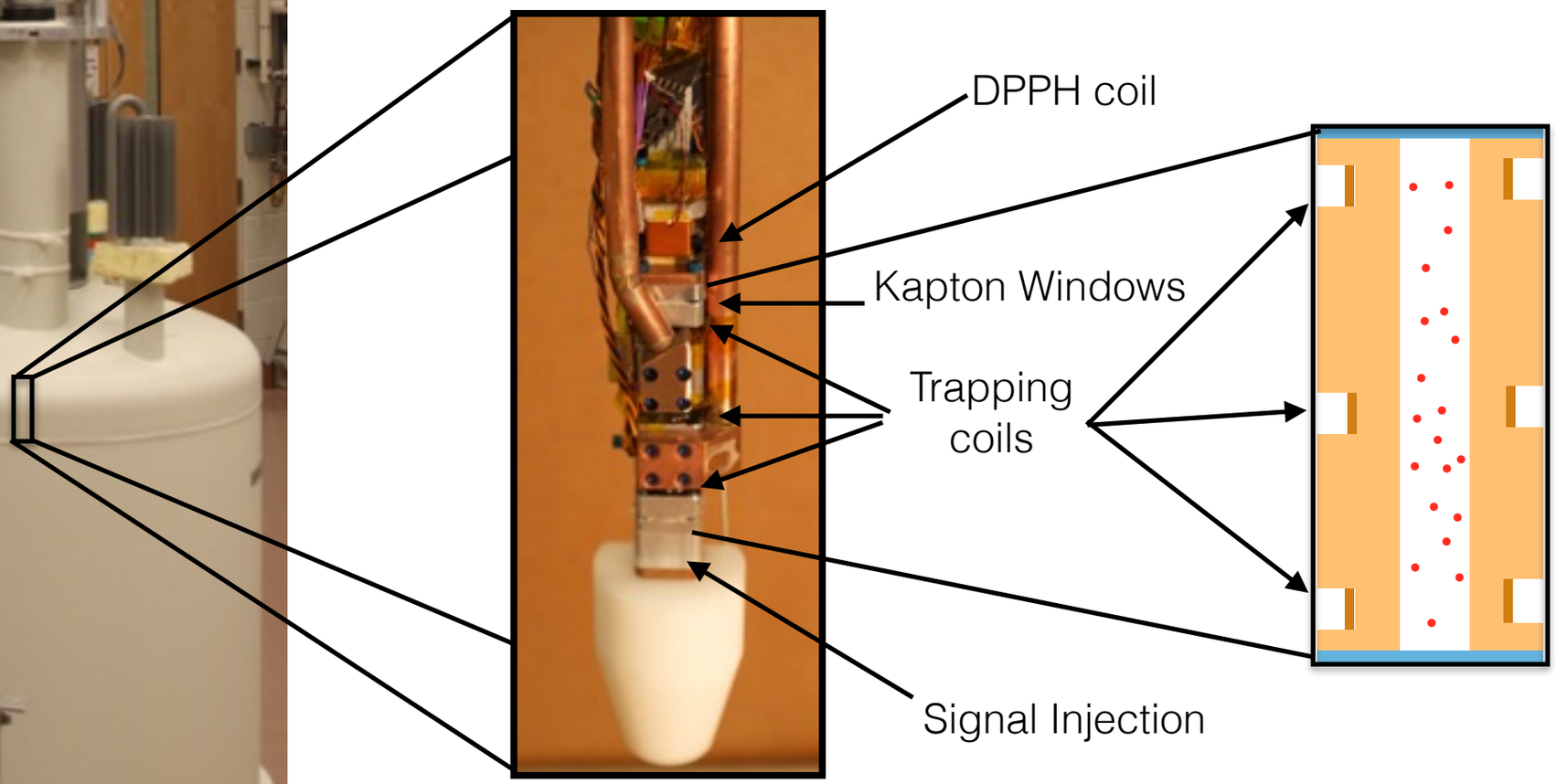

Trapping Region
Source into Cell

Axial Trap

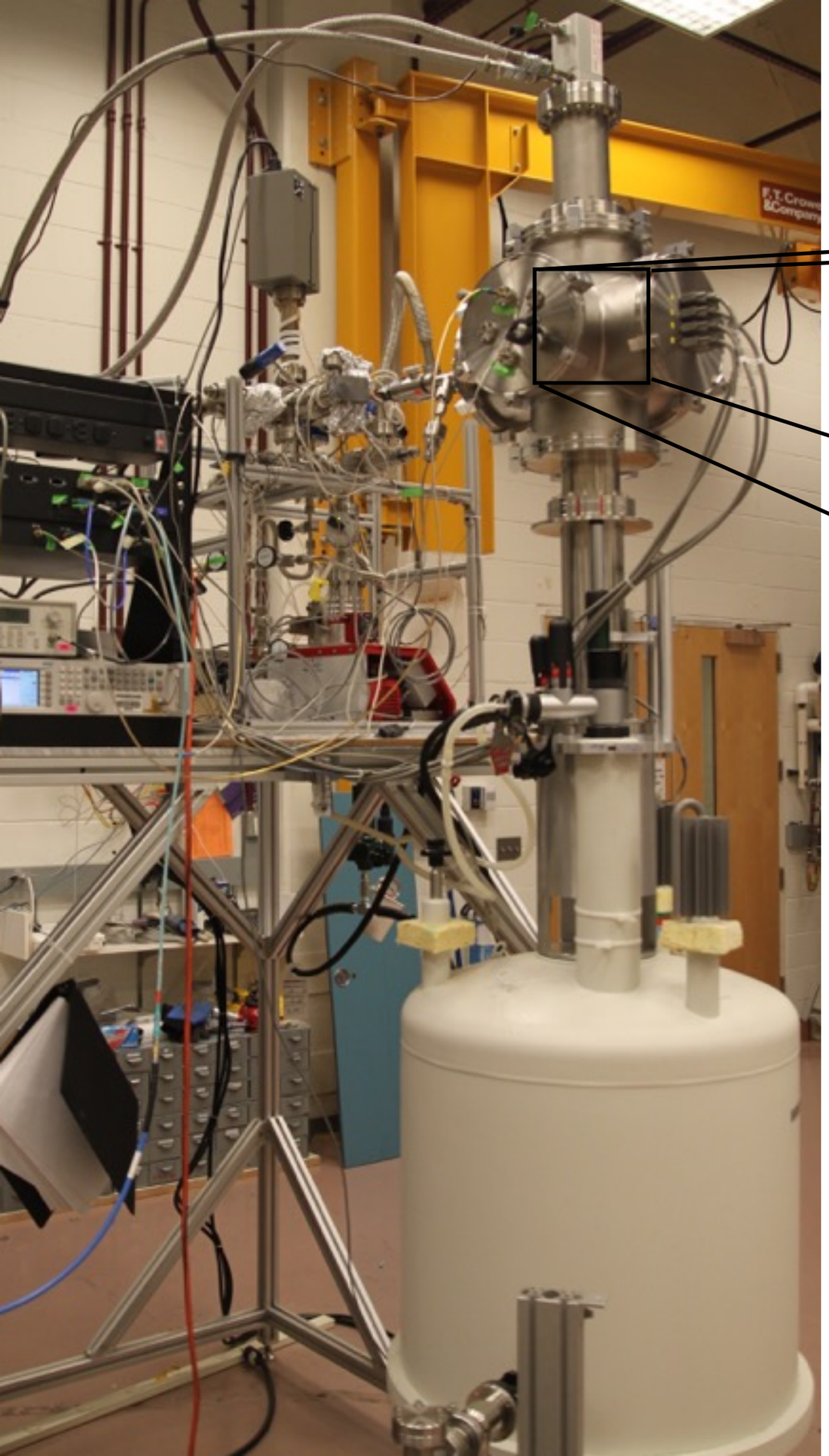
$$\boldsymbol{F} \propto -\nabla \boldsymbol{B}$$

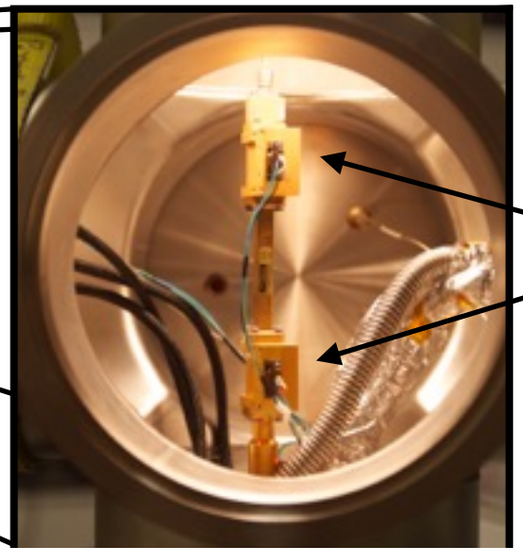
B_{main} (~.95 T) + B_{trap} (~10 mT)



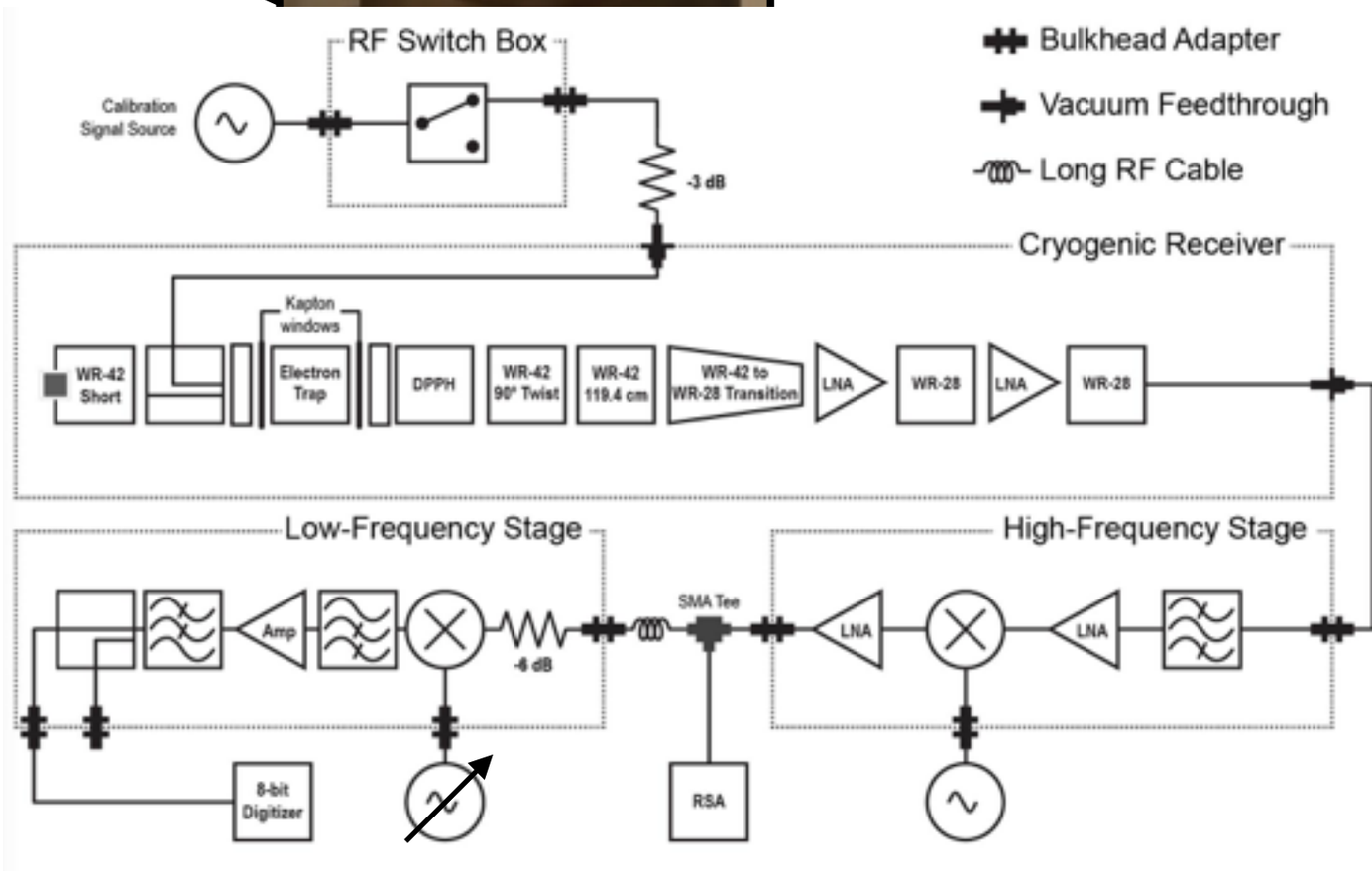


Receiver





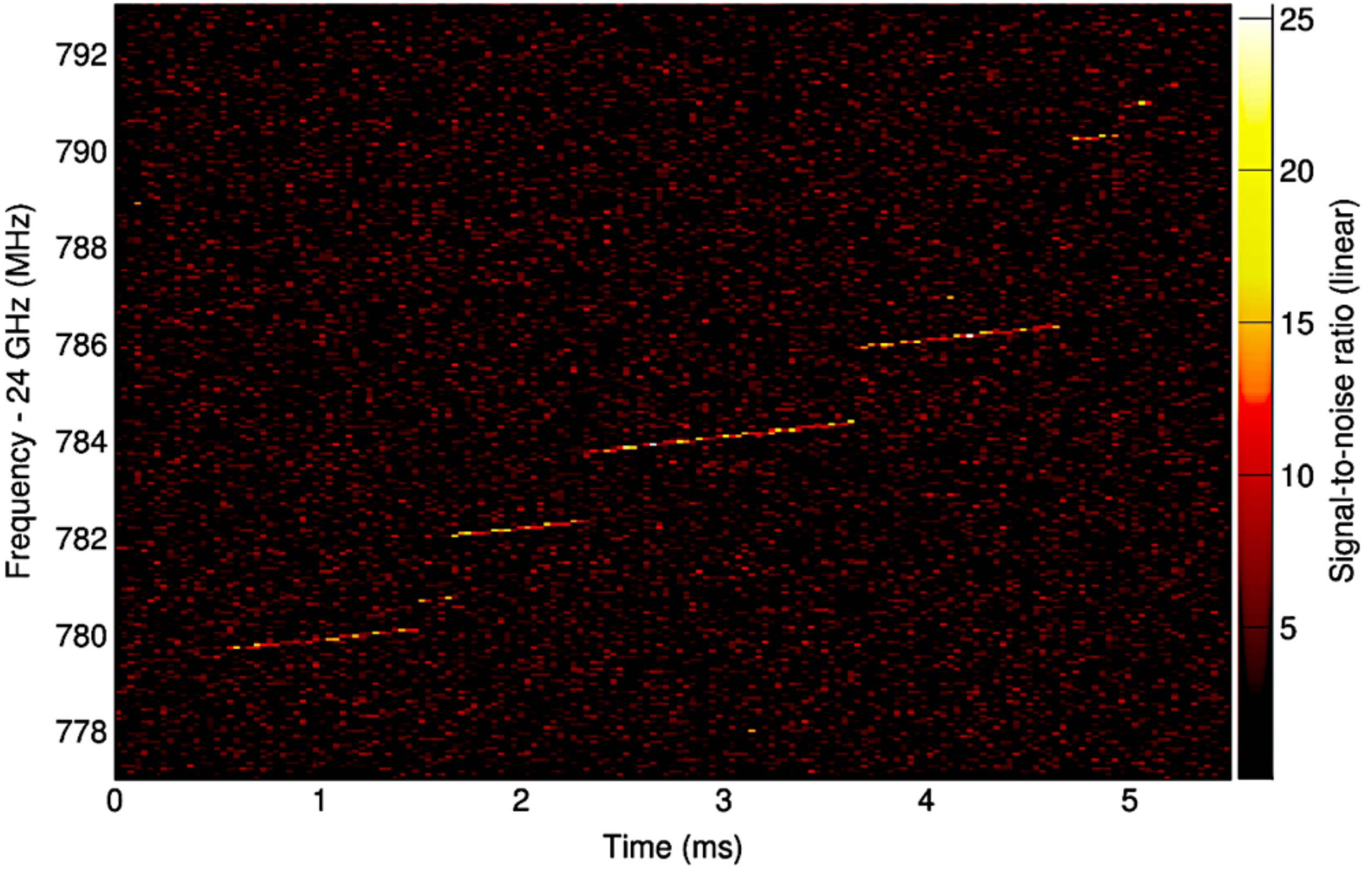
22-40 GHz cryogenic low noise amplifiers



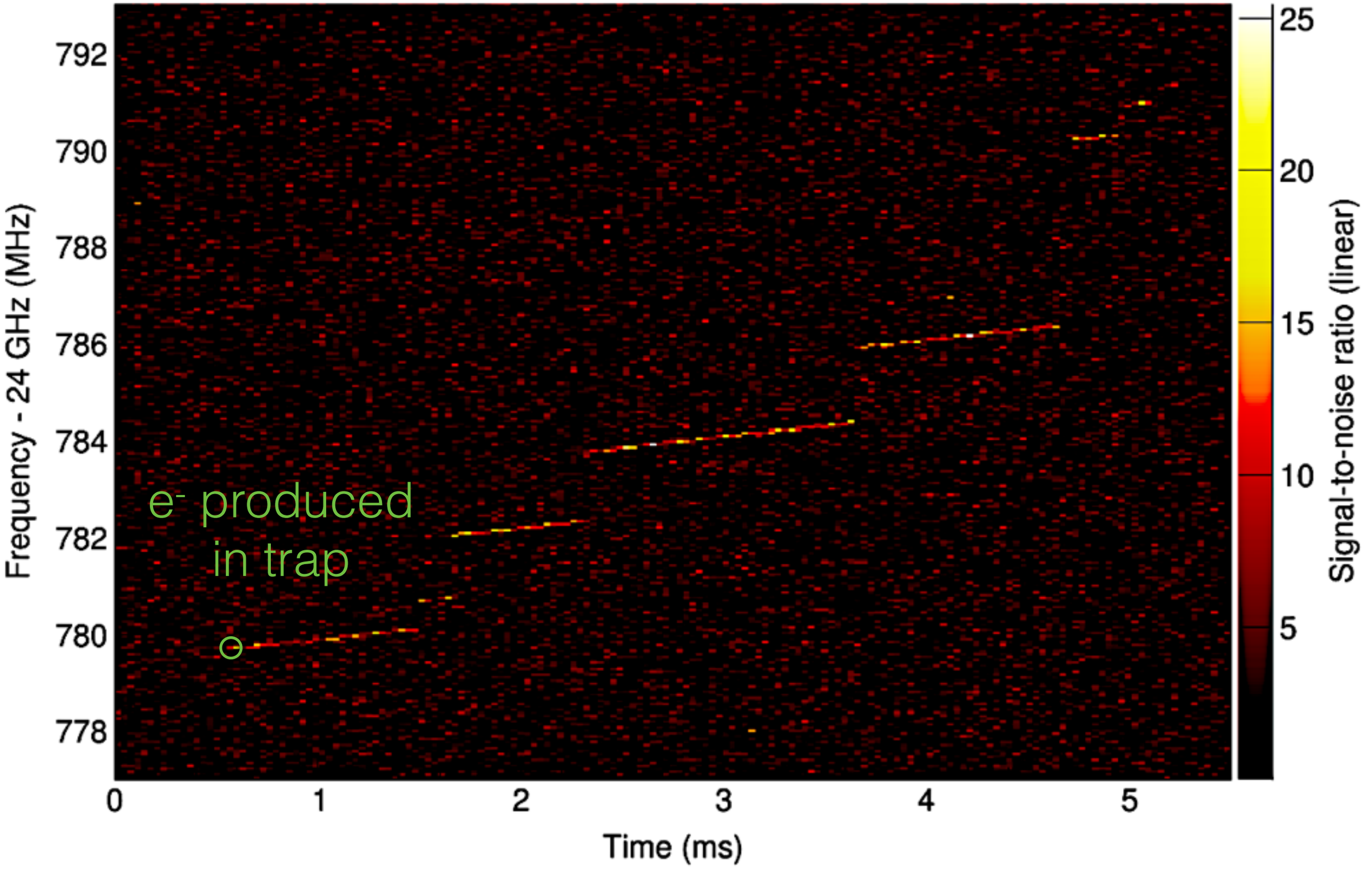
0.6-1.2 GHz

24.2 GHz

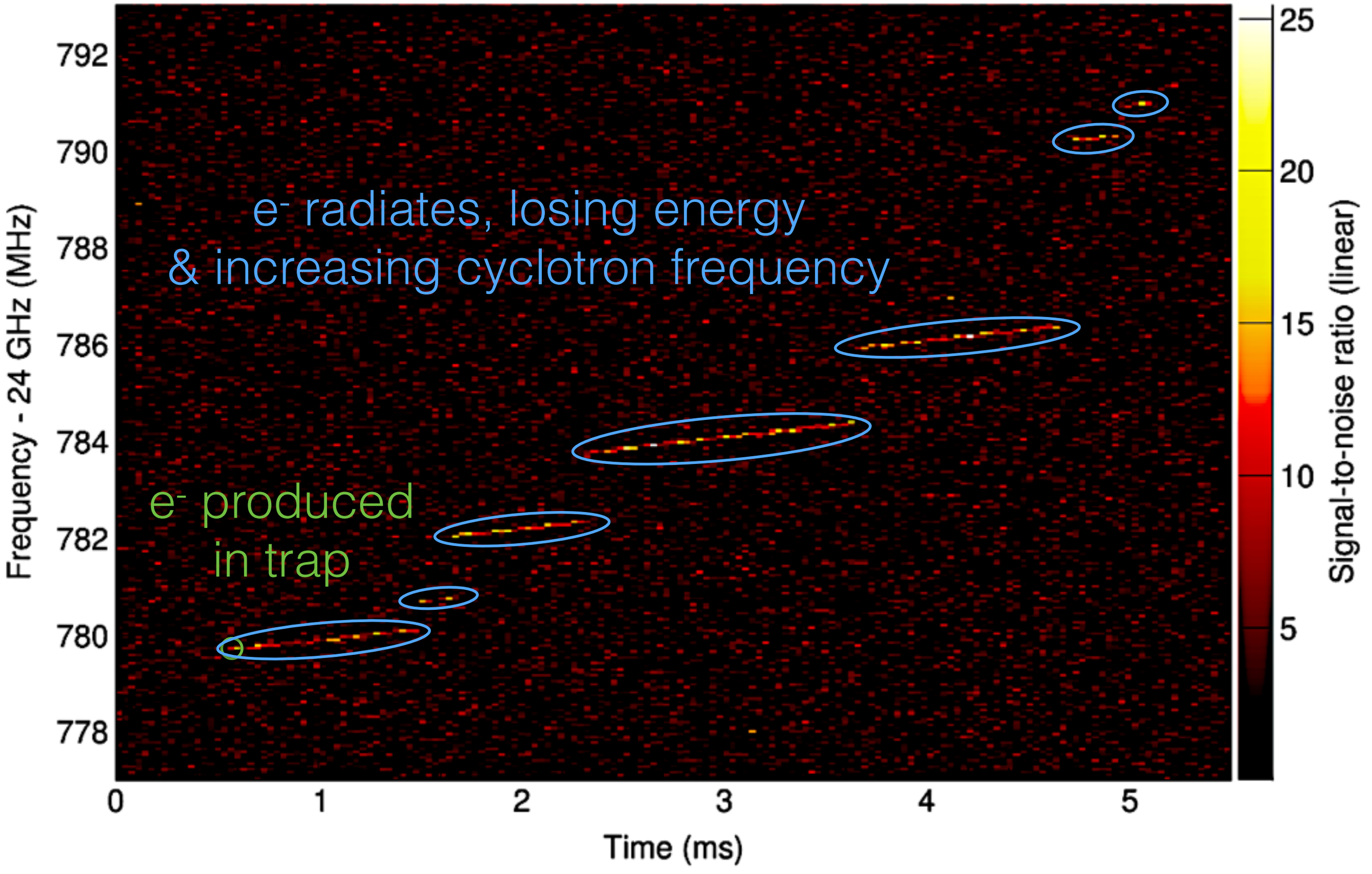
First electron



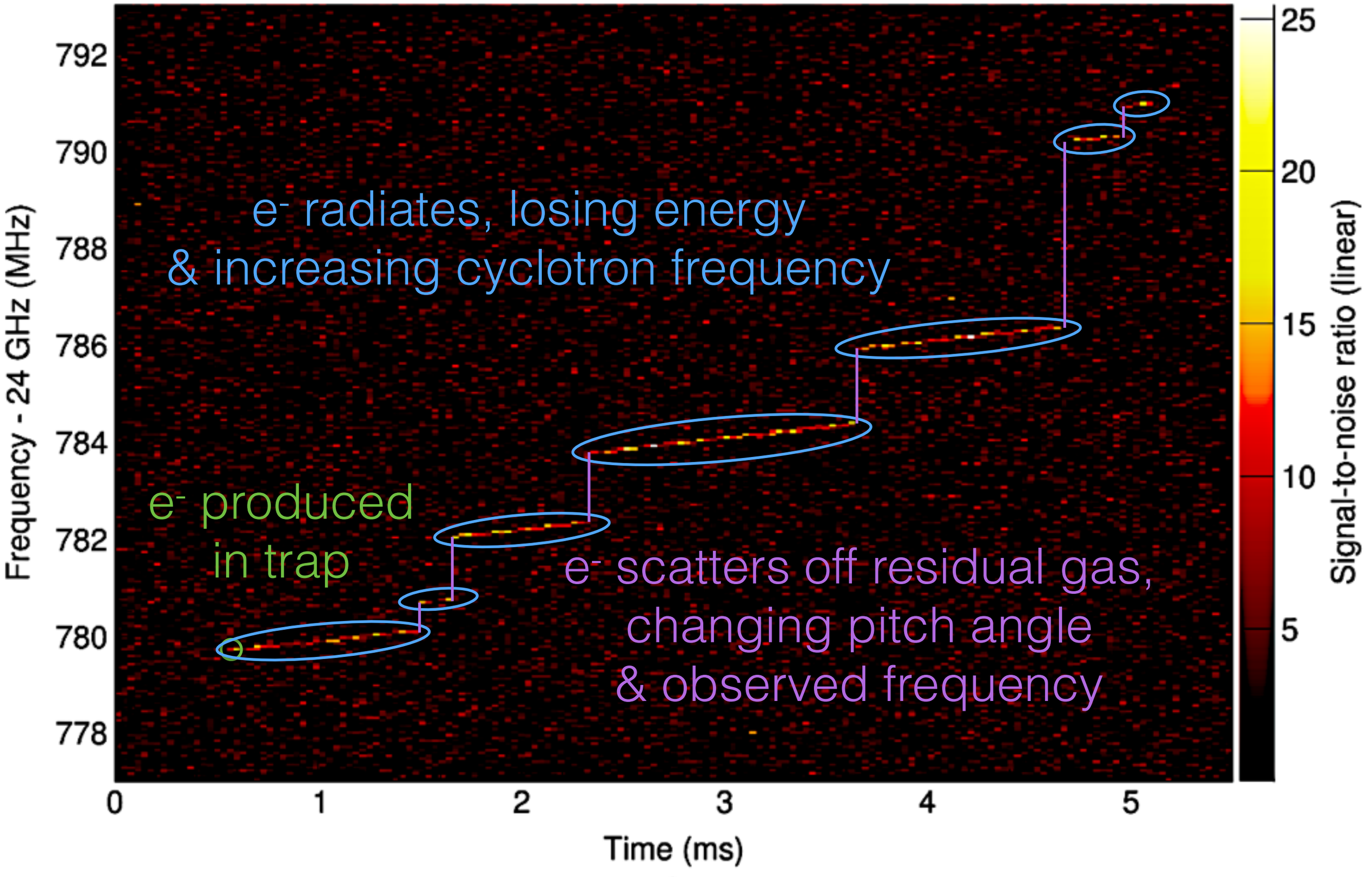
First electron



First electron



First electron



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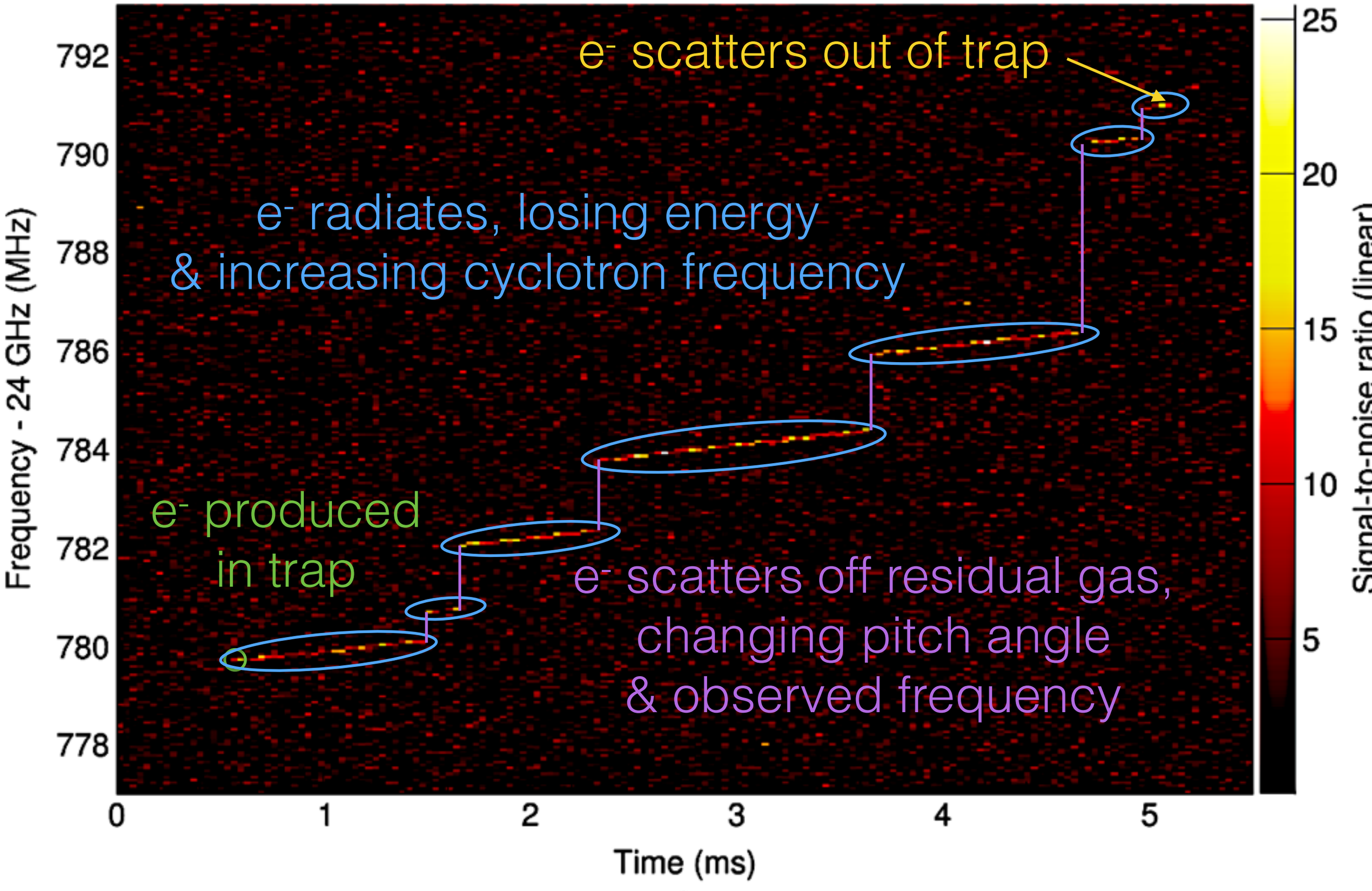
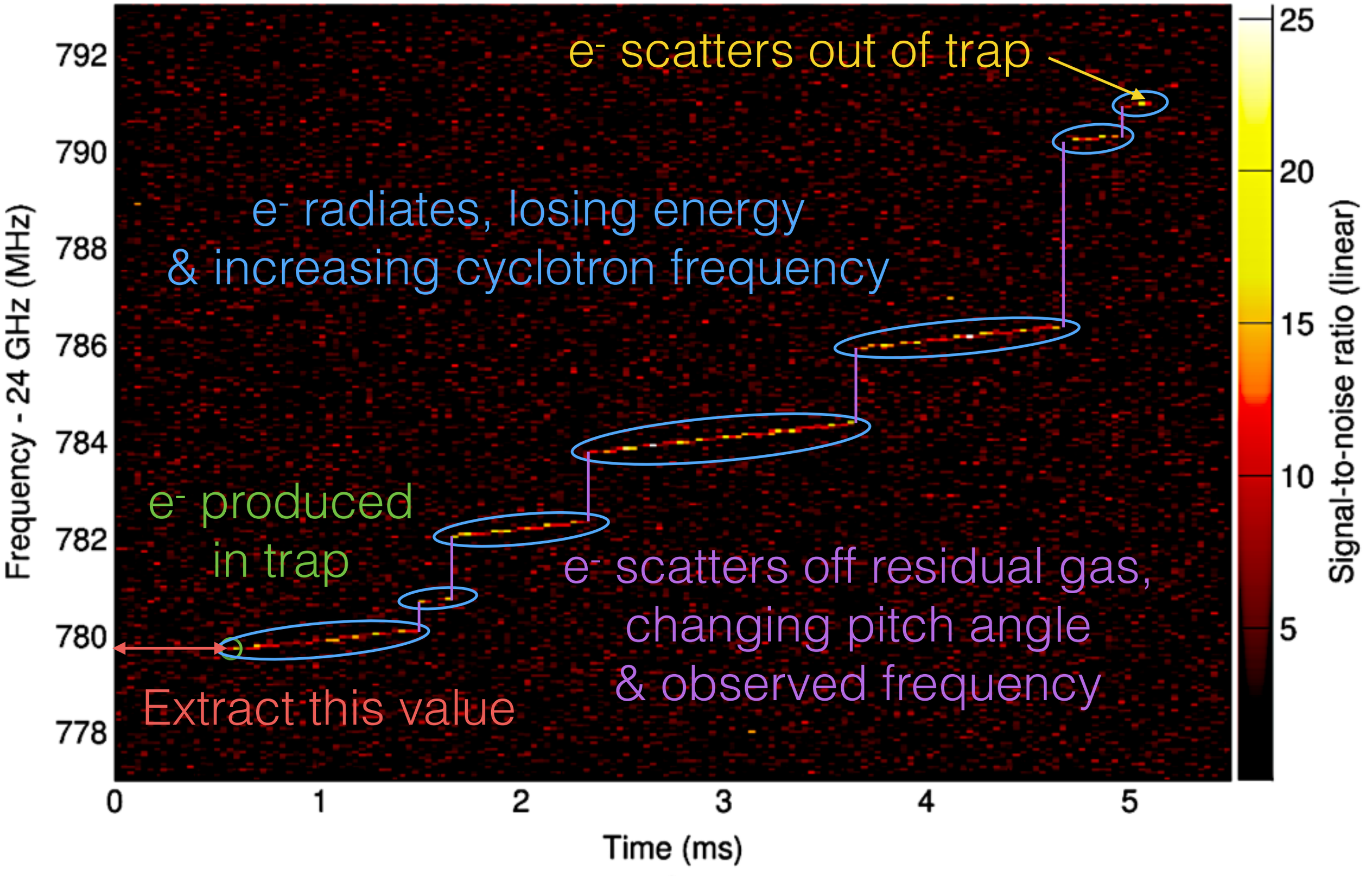
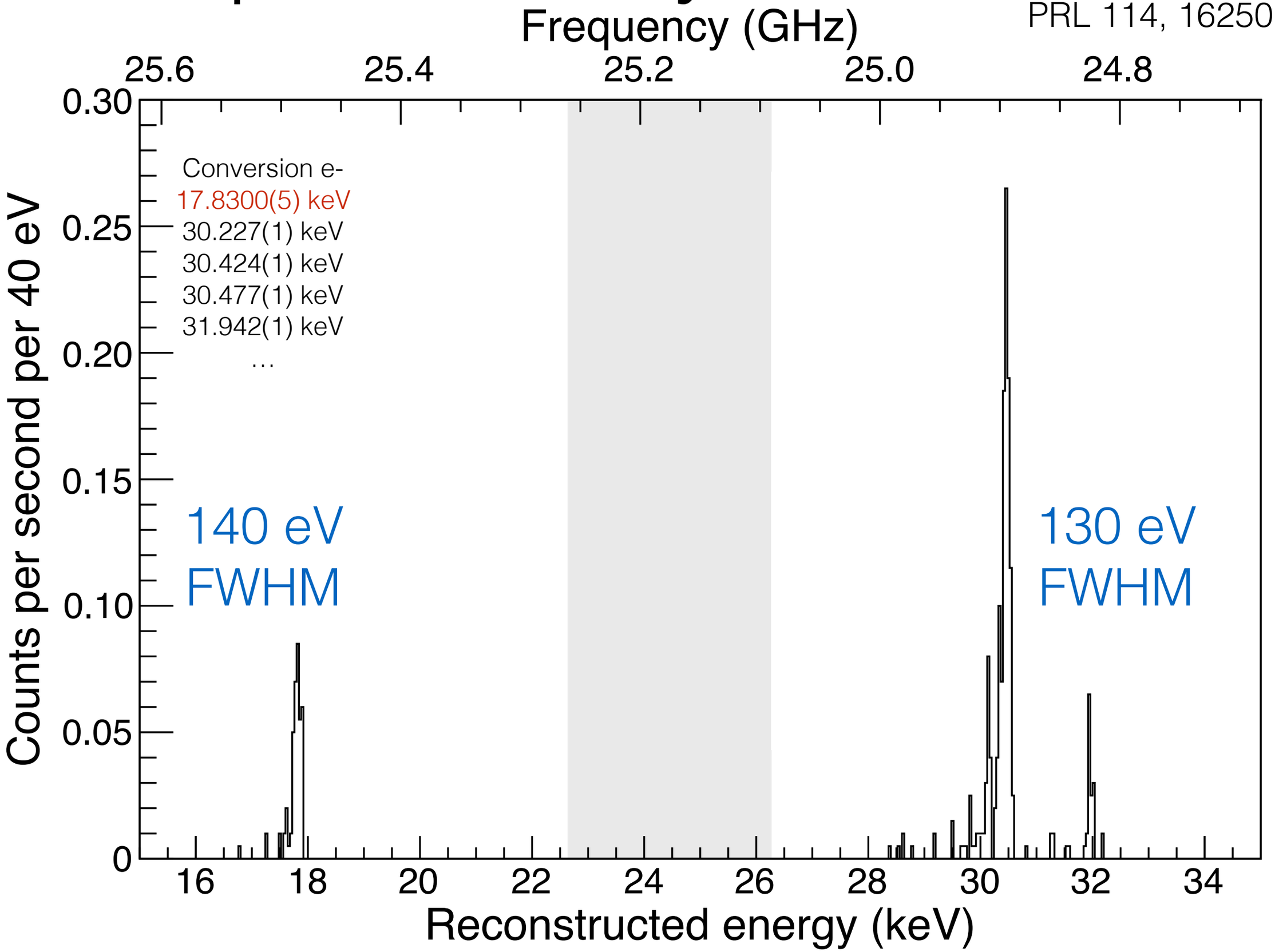


First electron



First Spectrum by CRES

D. M. Asner et. al.
PRL 114, 162501 (2015)



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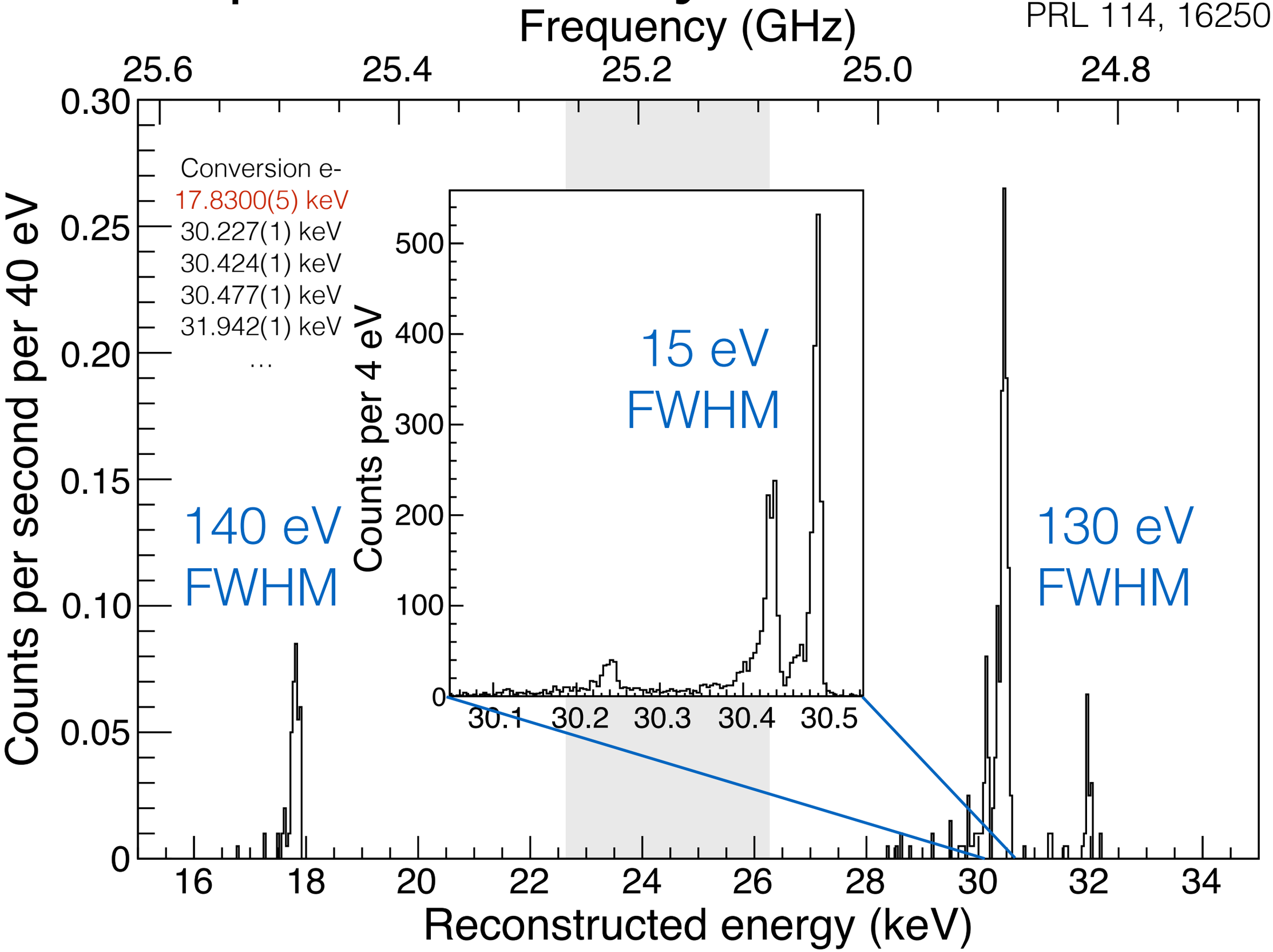

What comes next?

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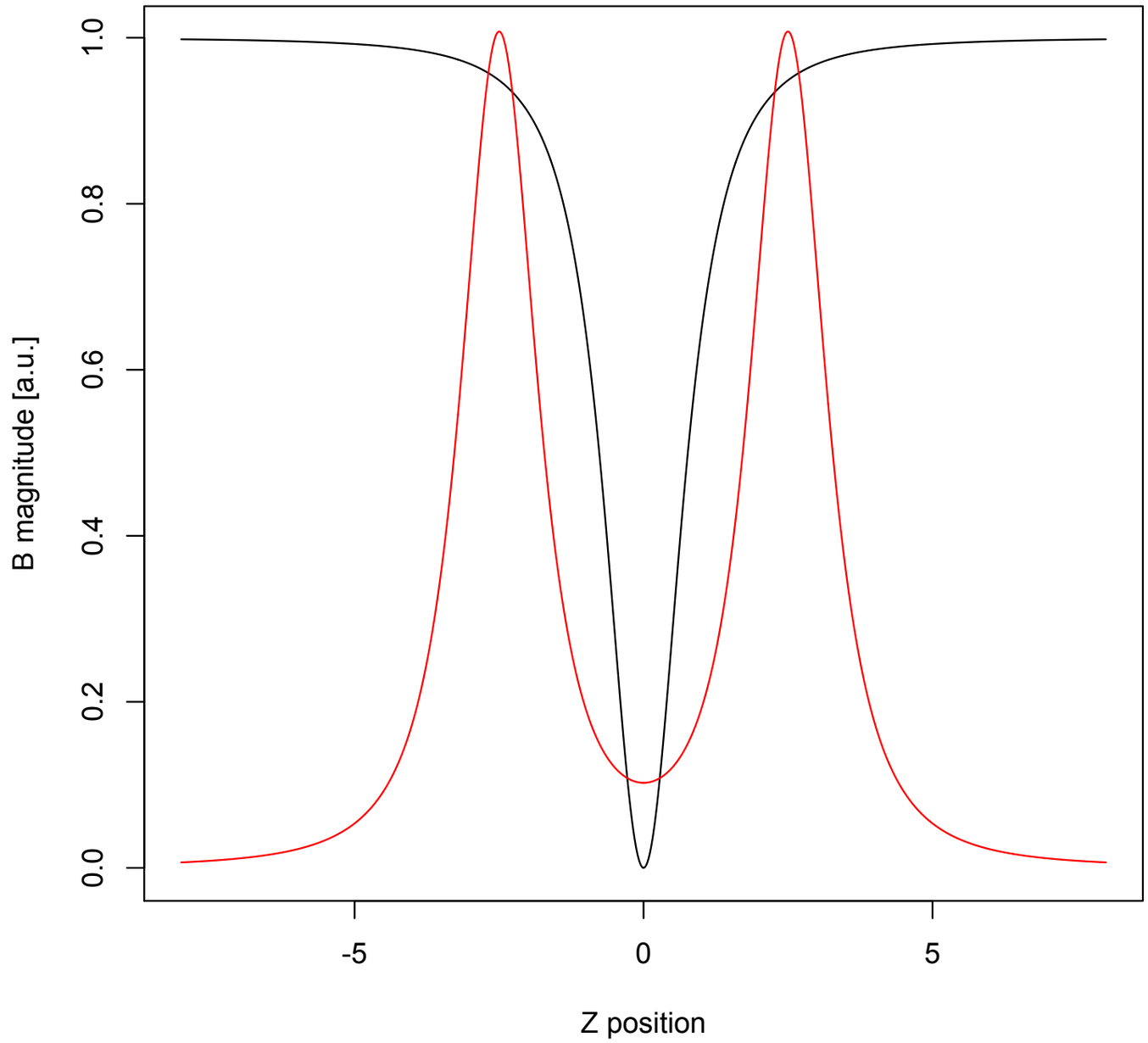
1. axially-extended trap: longitudinal scalability and improved resolution



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1. axially-extended trap:
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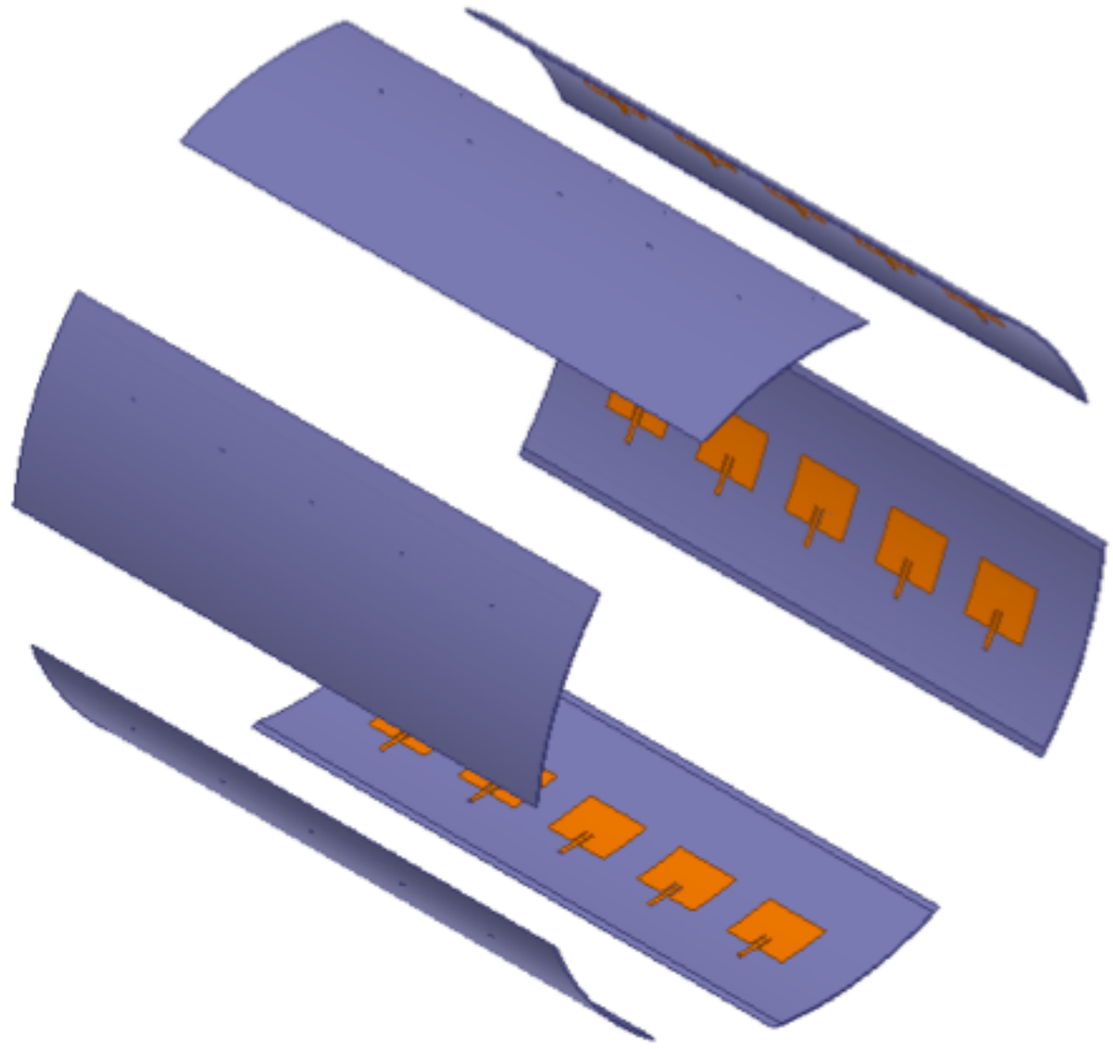
2. patch-array antennas:
   radial scalability and
   fiducialization/pileup rejection

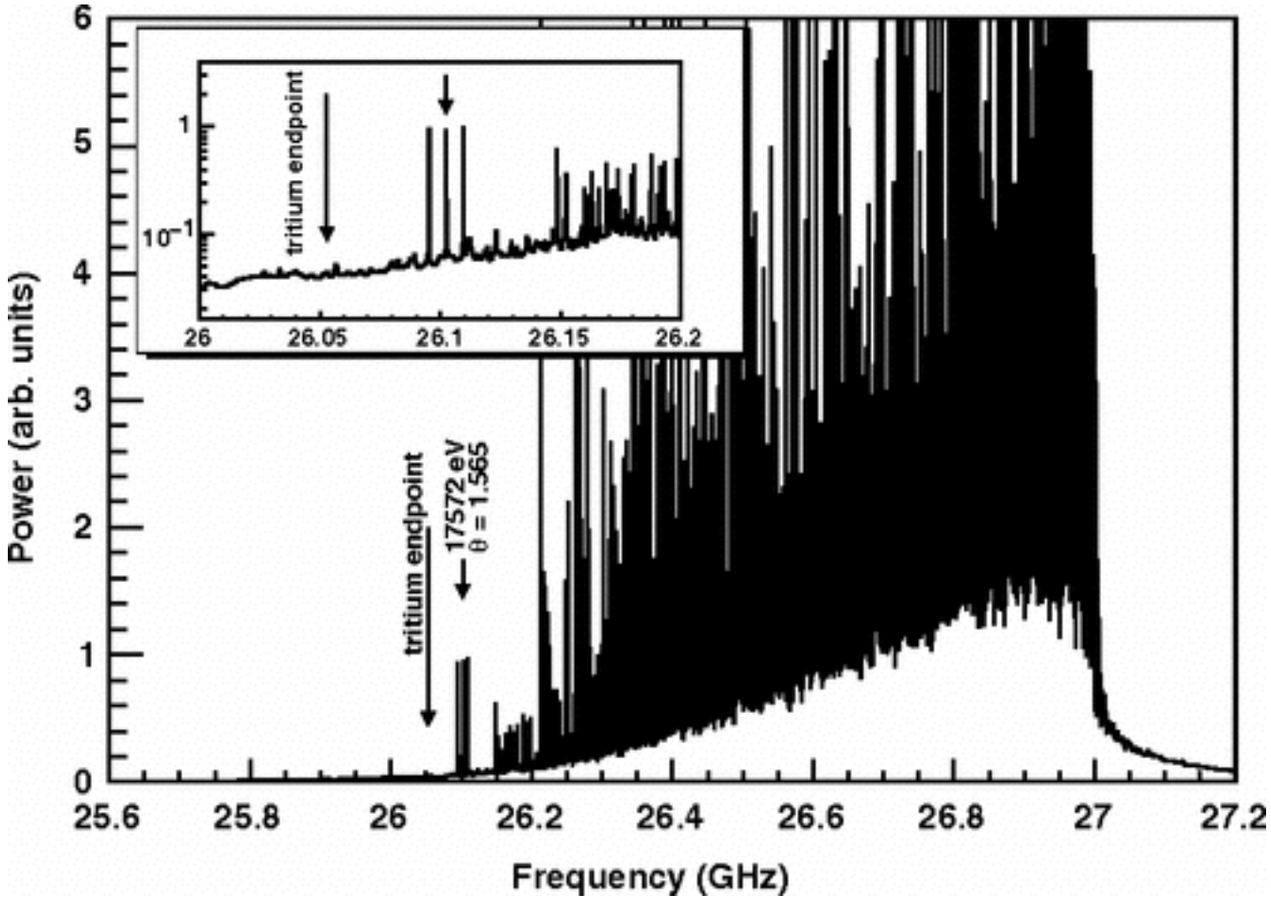


What comes next?

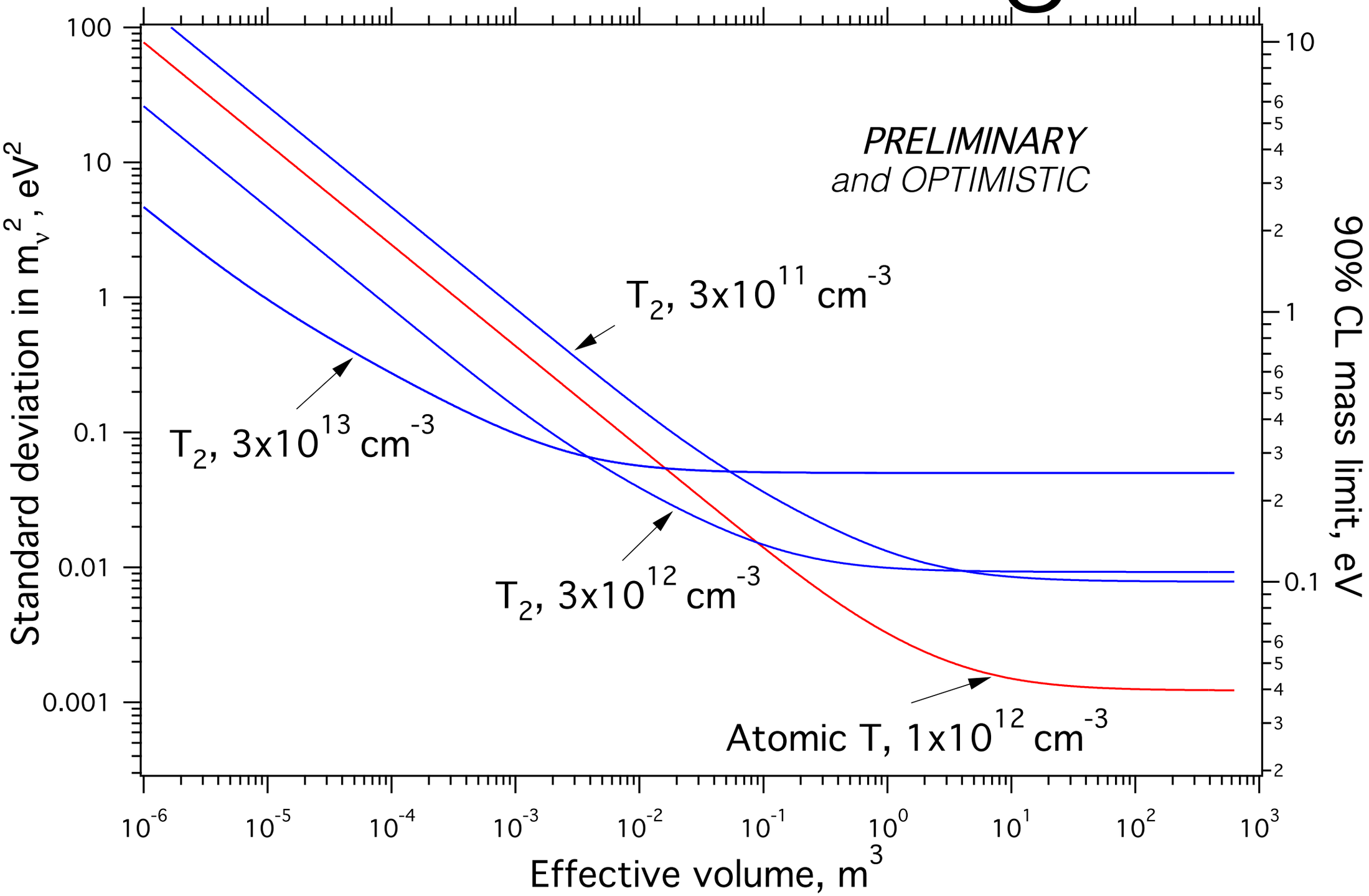
1. axially-extended trap:
   longitudinal scalability and
   improved resolution

2. patch-array antennas:
   radial scalability and
   fiducialization/pileup rejection

3. tritium source:
   study systematics associated
   with continuous spectra, first
   mass limits from CRES



Where can we go?



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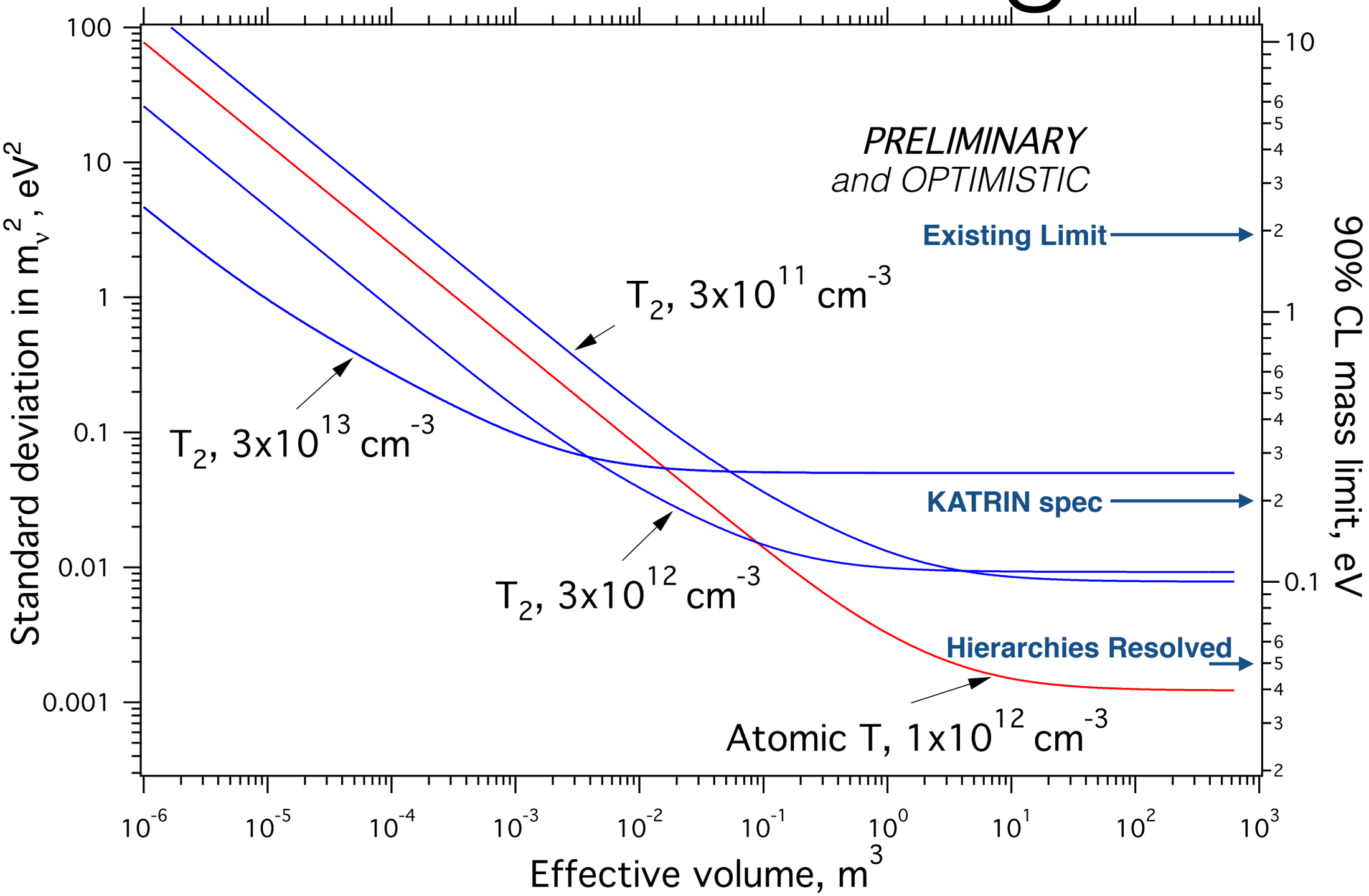

PROJECT 8

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(http://www.project8.org)