High-Precision Half-life Measurements for the Superallowed β^+ Emitter ^{18}Ne

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TRIUMF Science Forum

September 25, 2013

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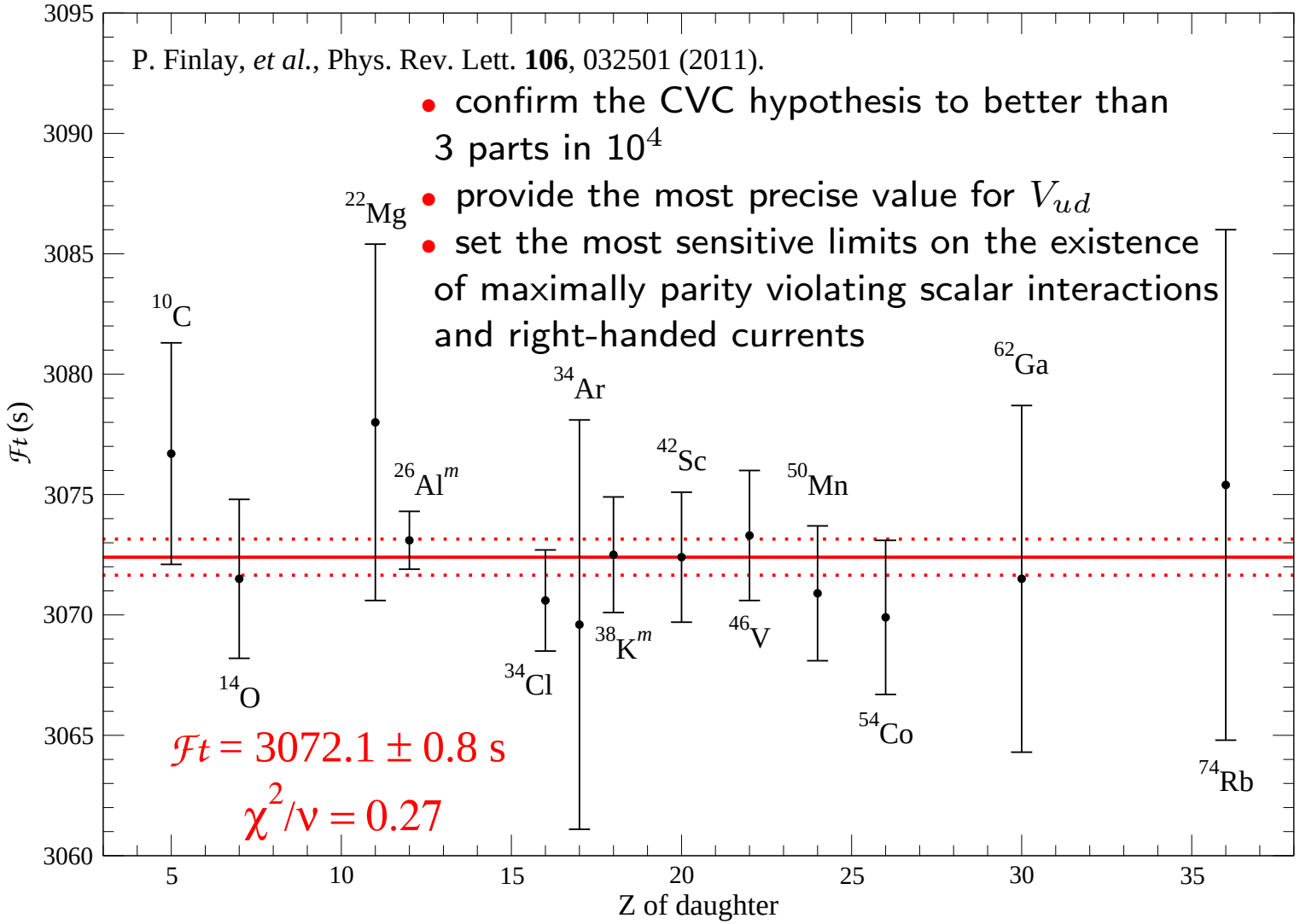
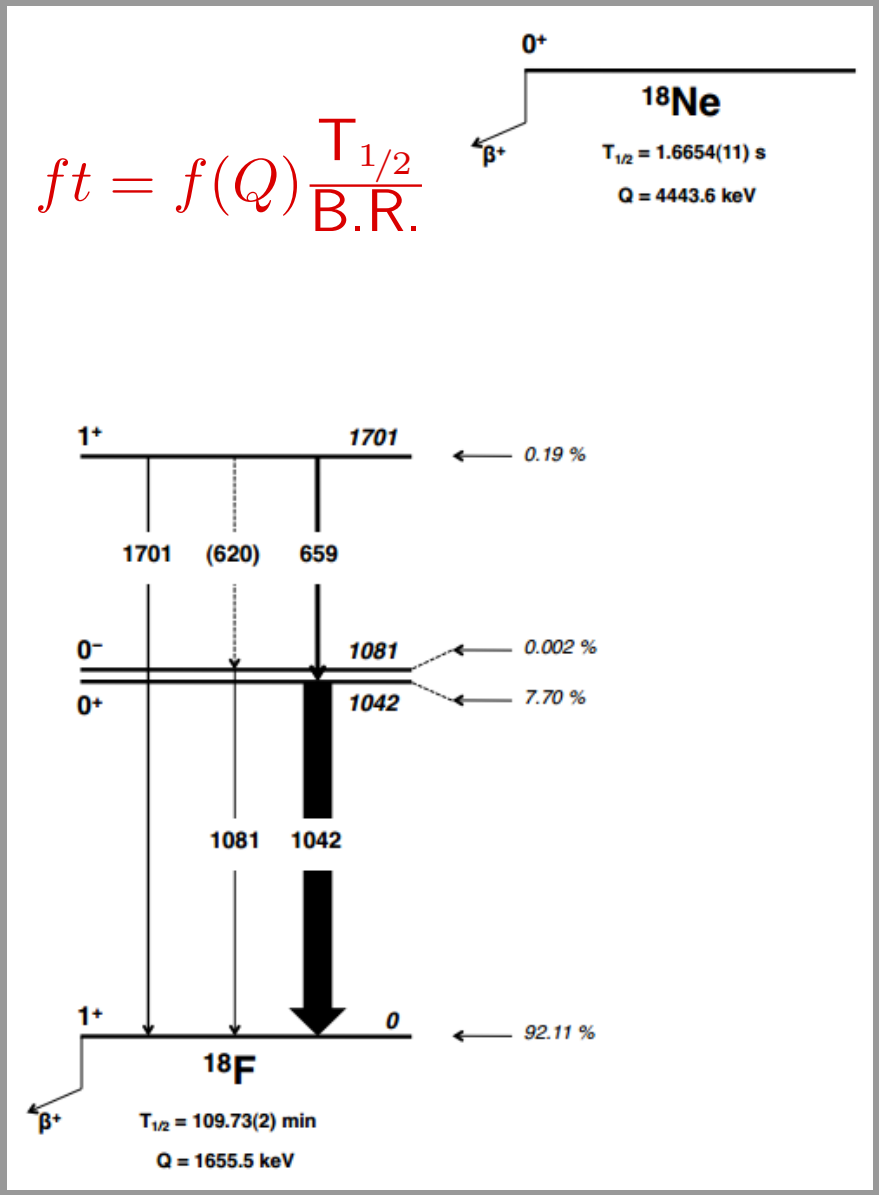
Superallowed Fermi β^+ Decay

- Superallowed Fermi β decays are transitions occuring between nuclear analog states (i.e. $T_i = T_f$) of spin $J^\pi = 0^+$.
- These decays depend uniquely on the vector part of the weak interaction.
- They can be studied almost entirely independently from uncertainties associated with nuclear structure models.
- By measuring the ft values of superallowed β emitters we can directly test fundamental properties of the electroweak interaction and place constraints on possible extensions to the Standard Model.

Corrected ft values



$$ft = f(Q)\frac{T_{1/2}}{B.R.}$$



G.F. Grinyer, *et al.*, Phys. Rev. C **87**, 045502 (2013)

- Must experimentally measure half-lives, branching ratios and decay Q values.
- Corrections must be applied for radiative effects and isospin symmetry breaking.
- Nine superallowed ft values between ^{14}O and ^{62}Ga are known to better than 0.1% precision.

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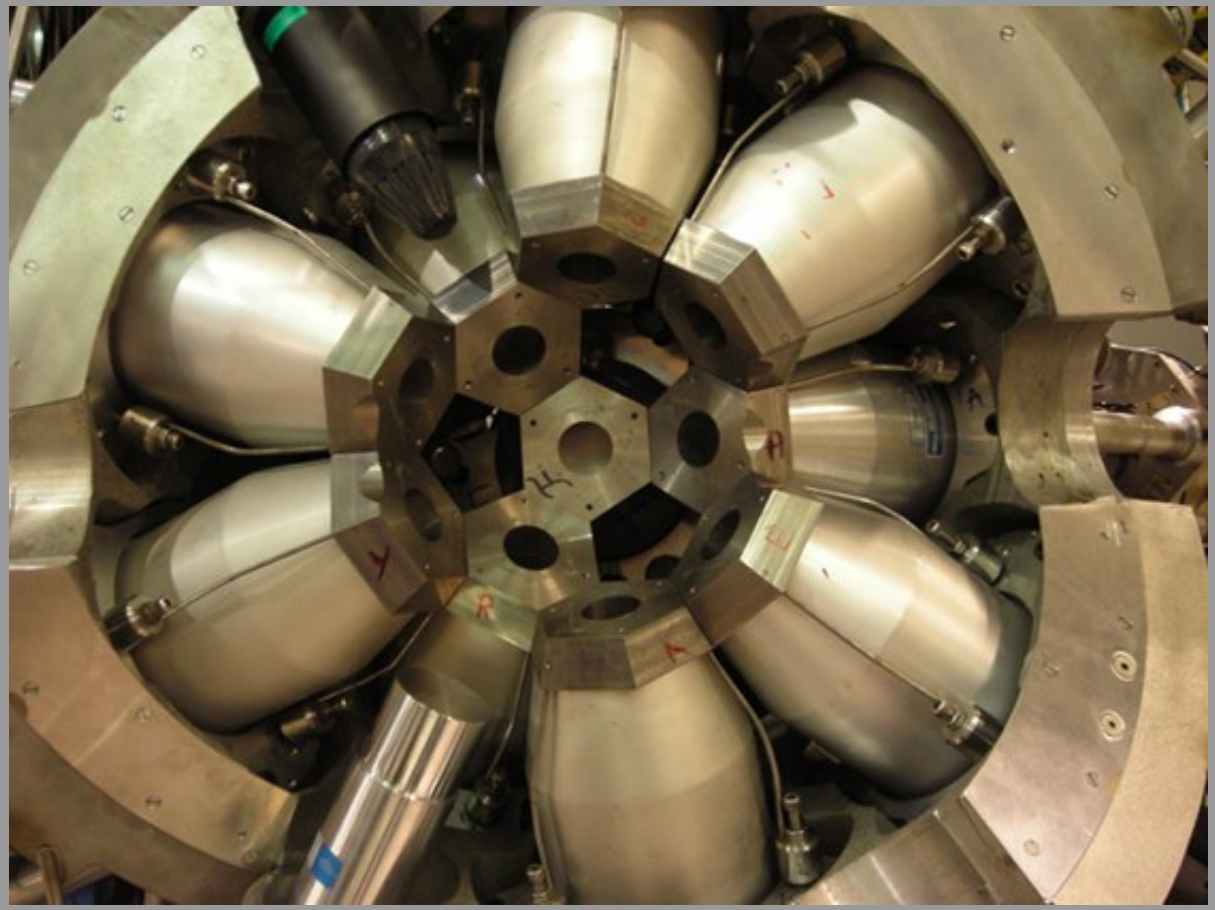
Experimental Overview

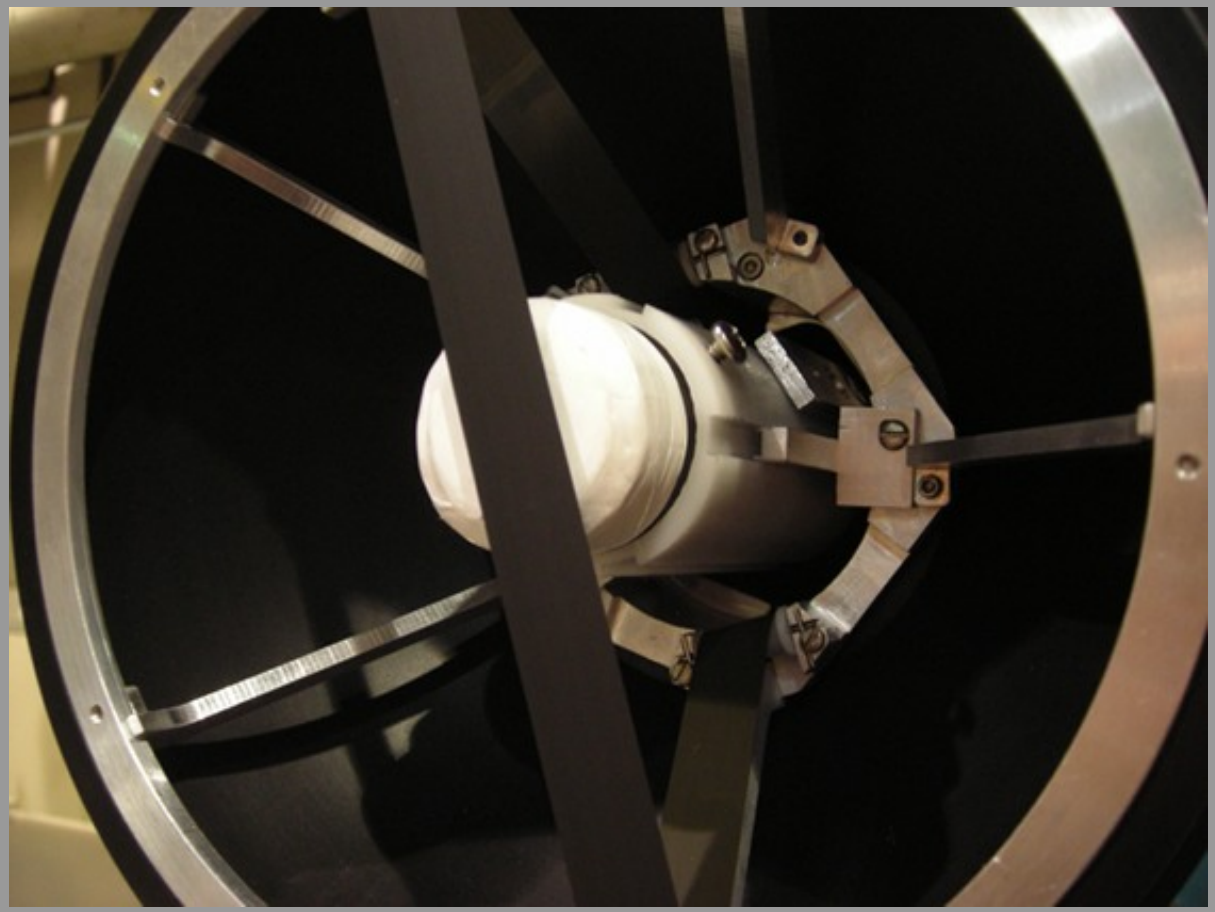
- Beam of ^{18}Ne and contaminant ^{18}F delivered to 8π and GPS
- Implanted on tape for 4–7 s
- Counted decays for 40 s
- Moved tape and contaminants from array
- This constituted one cycle, and $\sim$100 cycles constituted one run ($\approx$1 hour)

8π Spectrometer



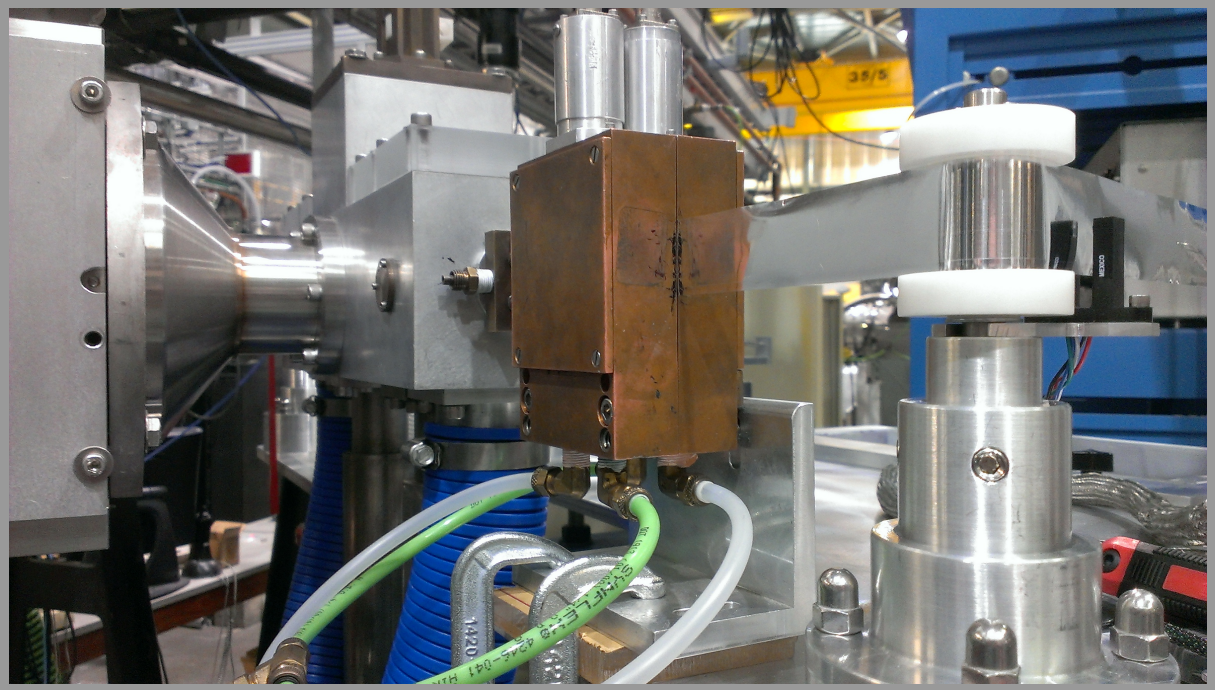
- Spherical array of 20 Compton-suppressed HPGe detectors
- Covers approximately 13% of the 4π solid angle
- Detects γ-rays emitted from excited daughter states

Zero-Degree Scintillator (ZDS)



- Fast plastic scintillator behind implantation site
- Detects β particles directly
- Beam is implanted onto tape, data is recorded, tape is moved once nucleus of interest has decayed

General Purpose Station (GPS)



- A 4π gas-proportional counter
- Directly detects β particles
- New T-Tape system recently installed

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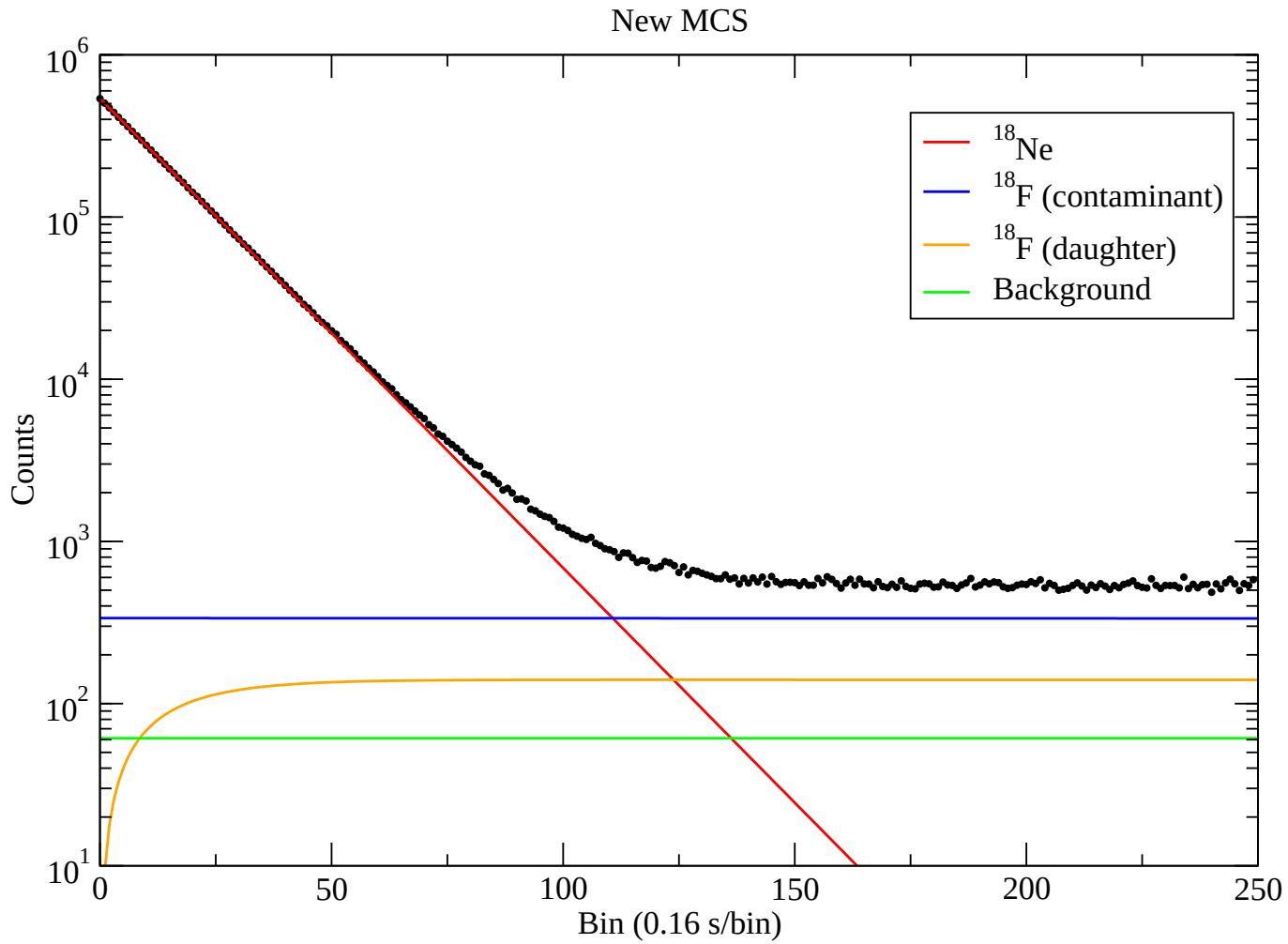
Data Collection

- Data was collected using 2 independent multichannel scaler (MCS) modules
- Fixed, non-extendible dead-times were imposed (and measured via the source-plus-pulser method)
- Data was binned into 250 channels of 160 ms in length
- The fit function used was: 2 exponential decays (^{18}Ne and contaminant ^{18}F); daughter activity (since ^{18}F is the daughter of ^{18}Ne); constant background
- Took ≈ 6 hours of data

Preliminary



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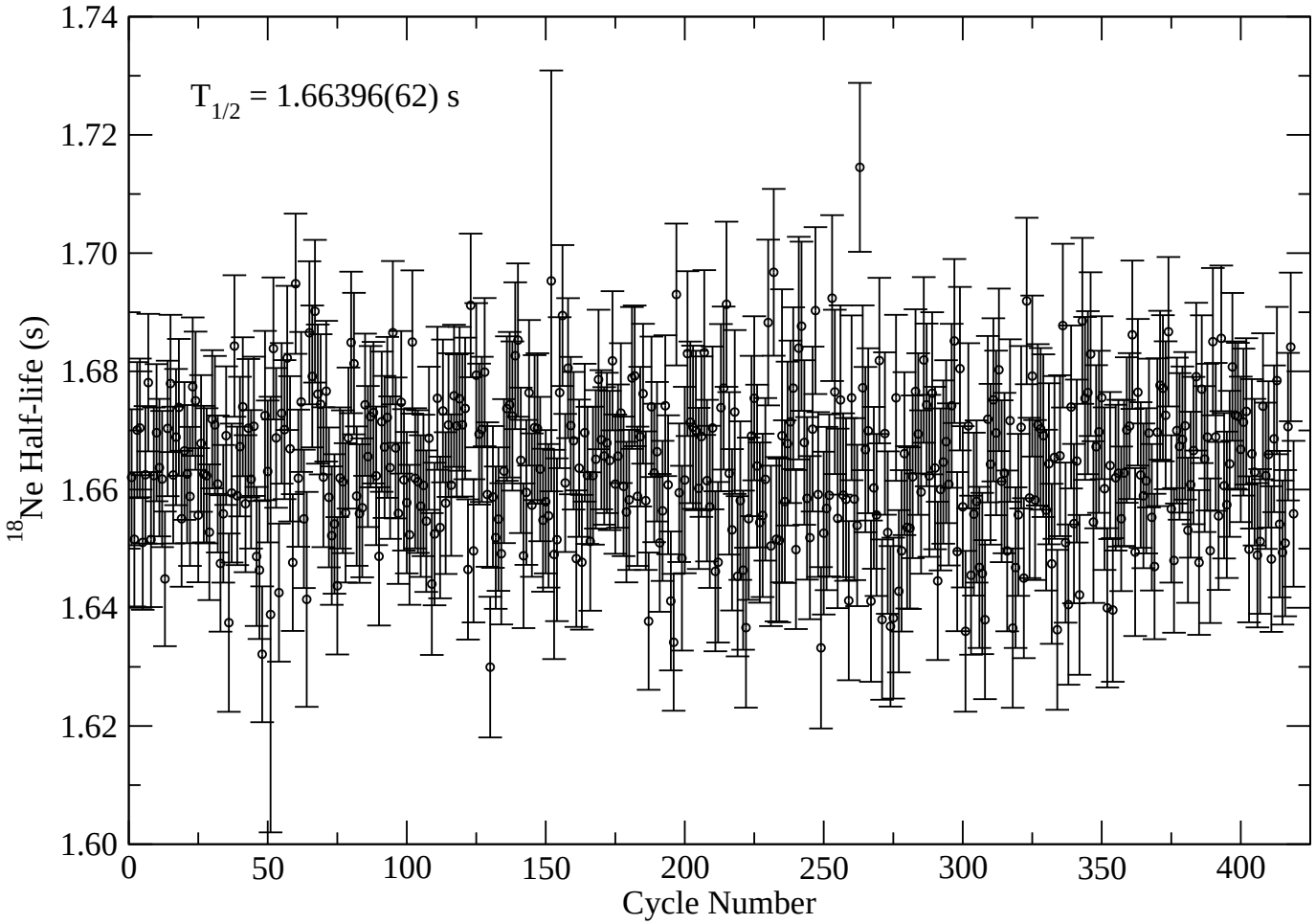

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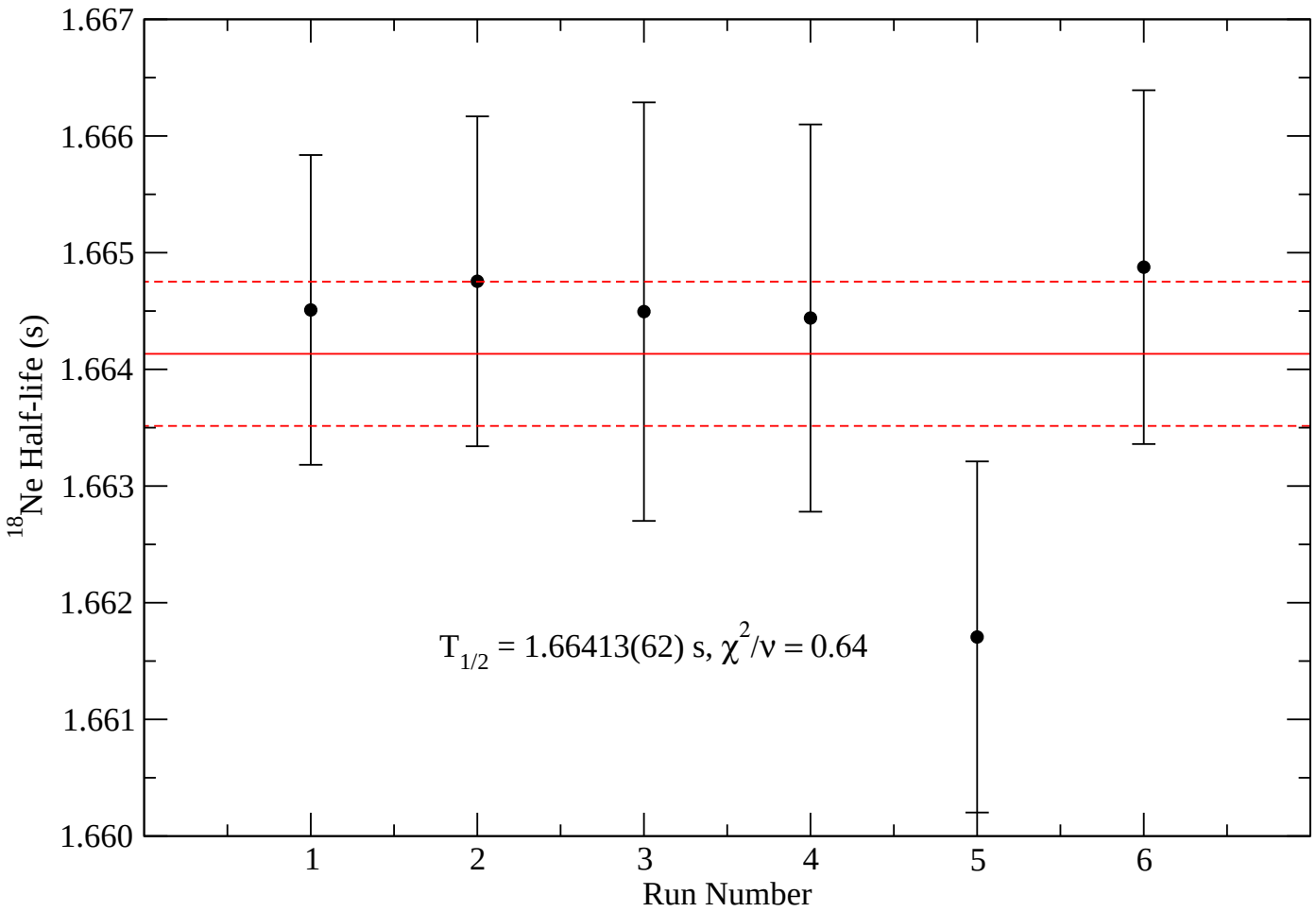

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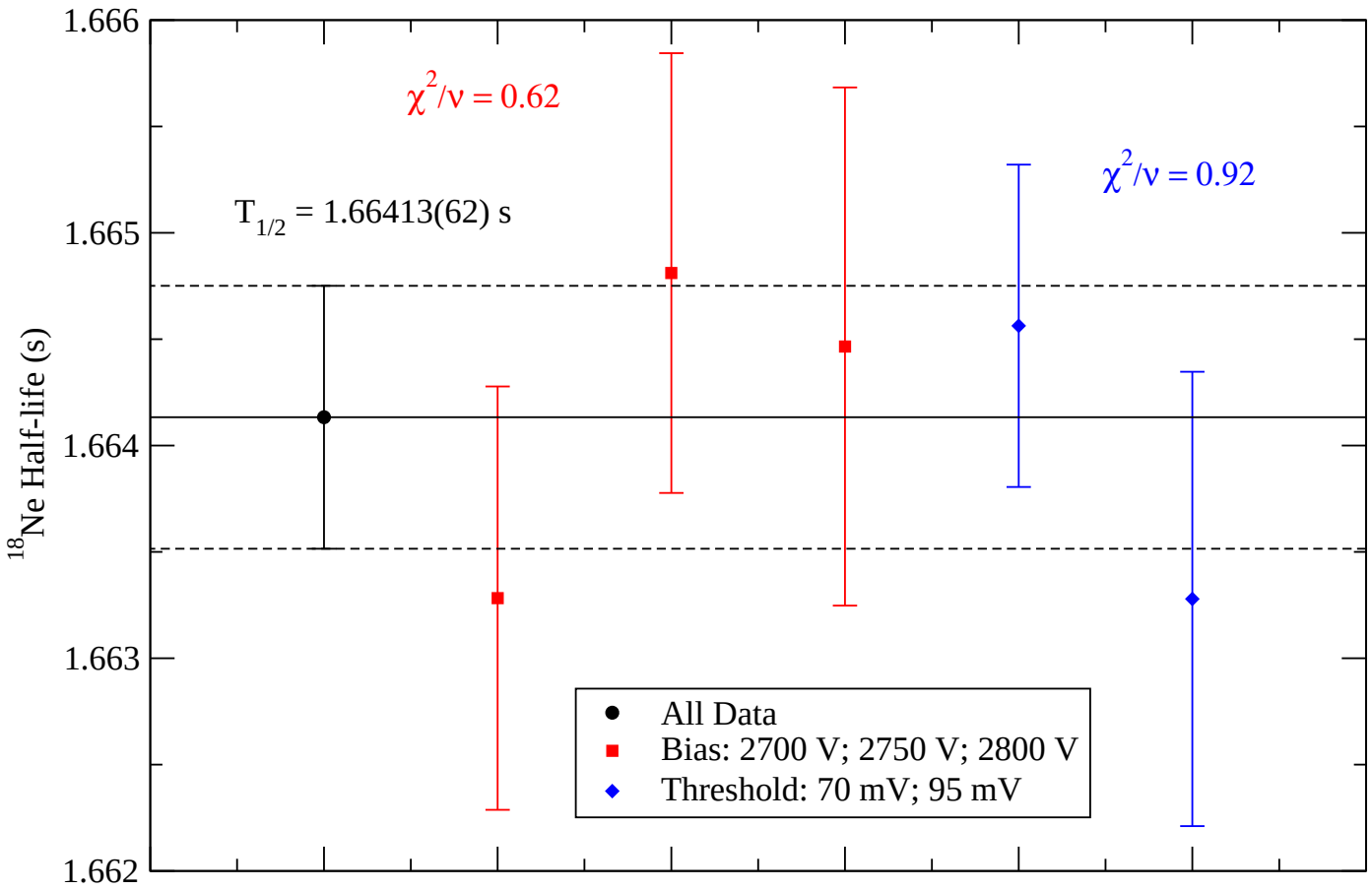

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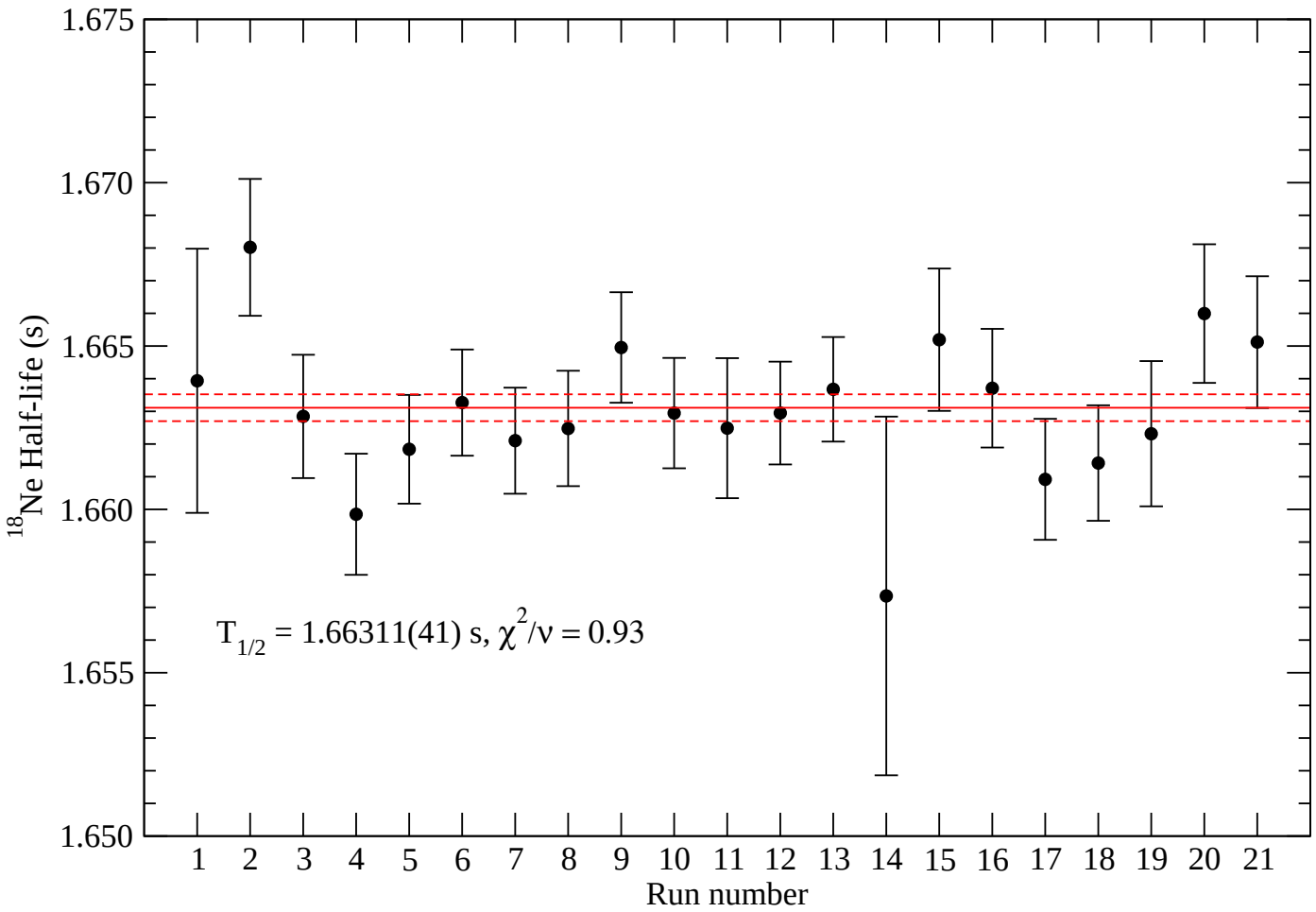

What now?

- Current results from the GPS agree with, but are about a factor of 2 more precise than, previous measurements:

$$T_{1/2}(\text{GPS}) = 1.66413(62)\ \text{s}; \quad T_{1/2}(^{18}\text{Ne}) = 1.6648(11)\ \text{s}$$

- A full systematics analysis of the ZDS data is underway
- ZDS data should have a comparable statistical precision
- Will be used with recent branching ratio measurements to improve the ft value for ^{18}Ne
- Actually measure ^{14}O half-life at the GPS in the spring