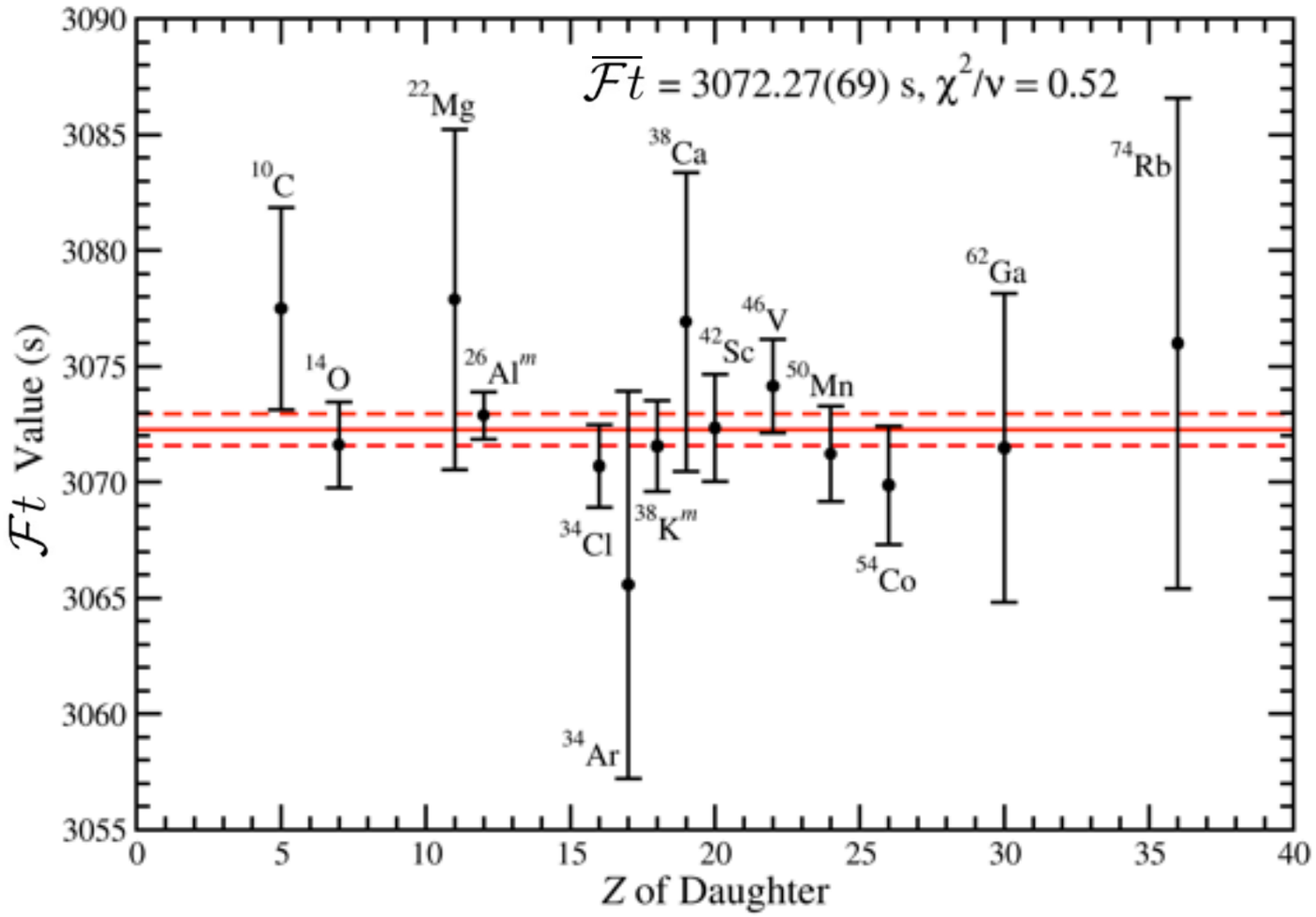
High-Precision Branching Ratio Measurement of the Superallowed Fermi β Emitter ^{18}Ne

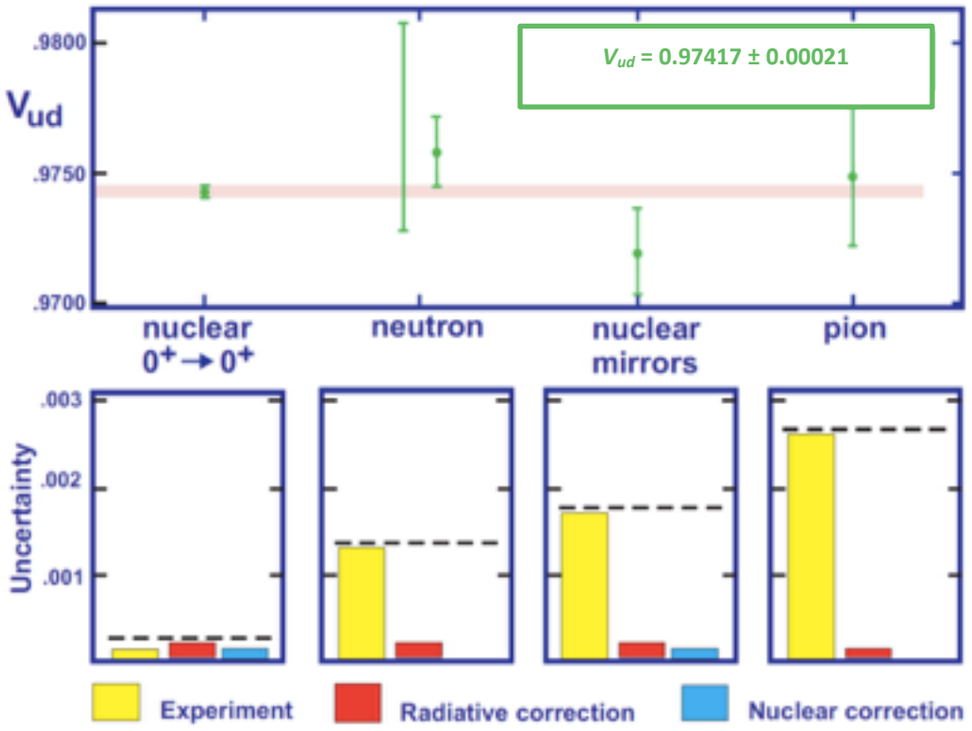
Spokesperson: **Alex Laffoley (GANIL)**

Collaboration: M. Aouadi[2], P. Ascher[2], M. Babo[1], G.C. Ball[3], B. Blank[2], G. de France[1], P. Delahaye[1], F. de Oliveira Santos[1], A. de Roubin[2], M.R. Dunlop[4], R. Dunlop[4], P. Finlay[5], P.E. Garrett[3], M. Gerbaux[2], J. Giovinazzo[2], T. Goigoux[2], S. Grévy[2], G.F. Grinyer[1], J. Grinyer[1], T. Kurtukian-Nieto[2], A.T. Laffoley[1], C. Magron[2], B. Mauss[1], T. Roger[1], C.E. Svensson[4], J.C. Thomas[1]

1 – GANIL, France 2 – CENBG, France 3 – University of Guelph, Canada 4 – TRIUMF, Canada 5 – K.U. Leuven, Belgium

Corrected $\mathcal{F}t$ Values





$$\mathcal{F}t = ft(1+\delta'_R)(1+\delta_{NS}-\delta_C) = \frac{K}{2G_V^2(1+\Delta_R^V)} = \text{constant}$$

Calculated corrections (~1%) (nucleus dependent)

Inner radiative correction (~2.4%) (nucleus independent)

Reach of superallowed & mirror research programme

^{33}Cl

$T_{½}$ (2015) [J. Grinyer *et al.*, PRC 92. 045503 **(2015)**]

^{37}K

BR & $T_{½}$ (2014) [article in preparation, to be submitted to JPG]

^{38}Ca

BR & $T_{½}$ (2009) [B. Blank *et al.*, EPJ A 51, 8 **(2015)**]

$T_{½}$ (2007) [B. Blank, EPJ A 44, 363 **(2010)**]

^{27}Si

BR & $T_{½}$ (2013)

^{26}Si

BR (accepted)

^{30}S

BR (accepted)

^{22}Mg

BR (accepted)

$T_{½}$ (2016)

^{23}Mg

BR & $T_{½}$ (2013)

^{21}Na

$T_{½}$ (2015) [J. Grinyer *et al.*, PRC 91, 032501R **(2015)**]

^{18}Ne

BR (2012) [H. Bouzomita-Zran, *Ph.D. Thesis (2015)*]

$T_{½}$ (2014) [A.T. Laffoley *et al.*, PRC 92, 025502 (2015)]

^{17}F

$T_{½}$ (2015) [J. Grinyer *et al.*, PRC 92, 045503 **(2015)**]

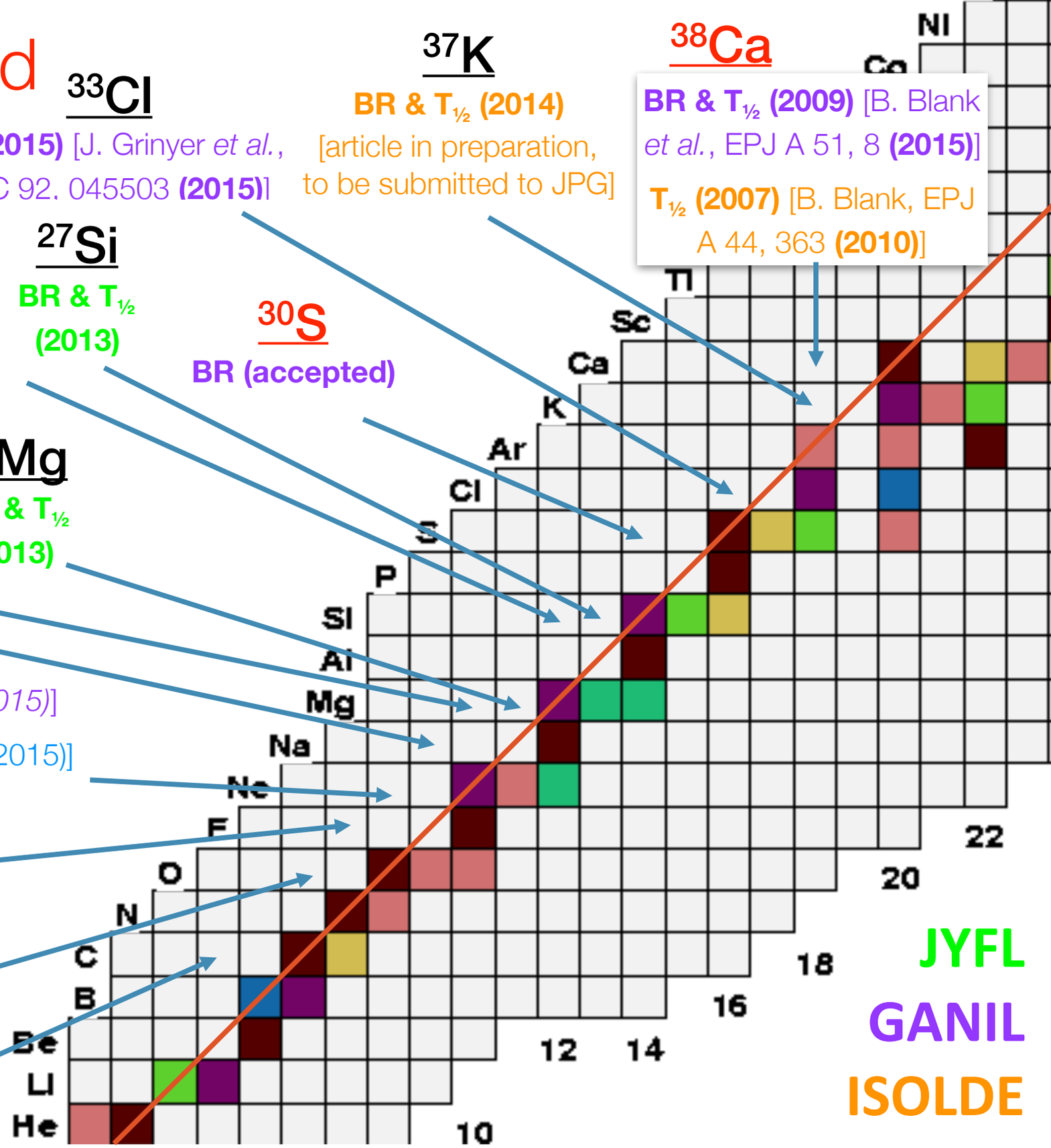
^{14}O

$T_{½}$ (2011) [A.T. Laffoley *et al.*, PRC 88, 015501 **(2013)**]

^{10}C

BR (2015)

$T_{½}$ (2014) [M.R. Dunlop *et al.*, PRL 116, 172501 **(2016)**]



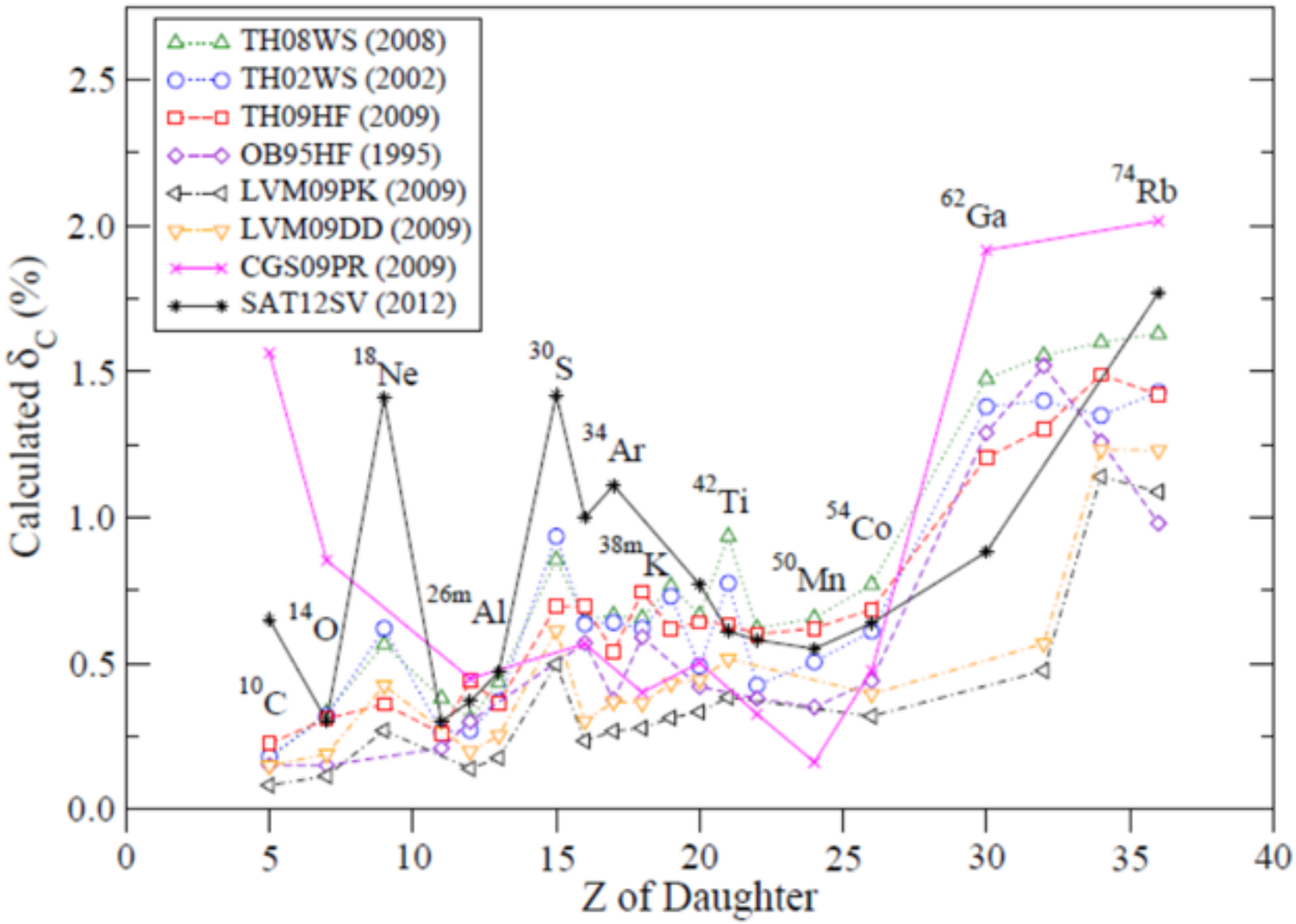
JYFL

GANIL

ISOLDE

TRIUMF

Isospin Symmetry Breaking Correction



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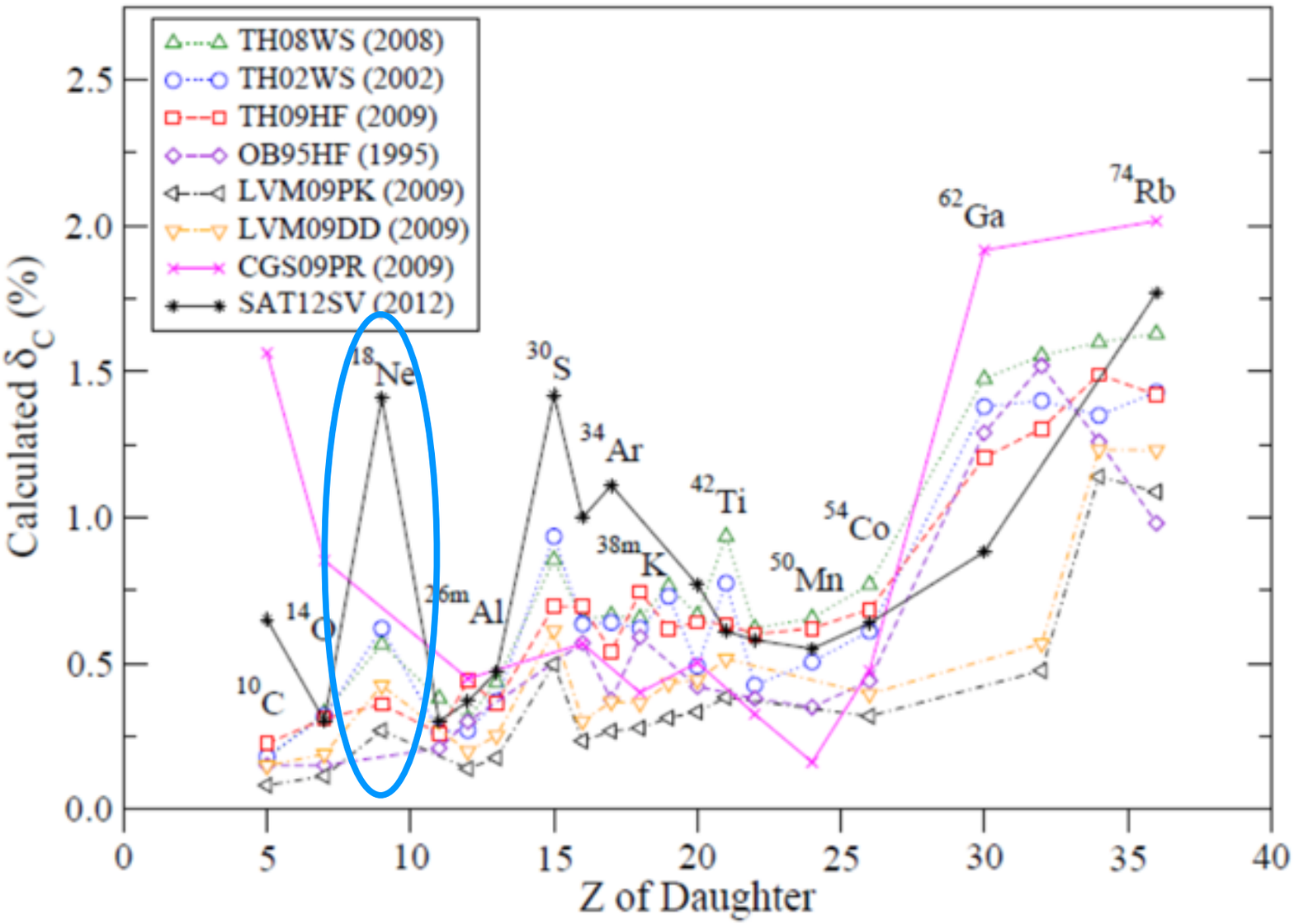

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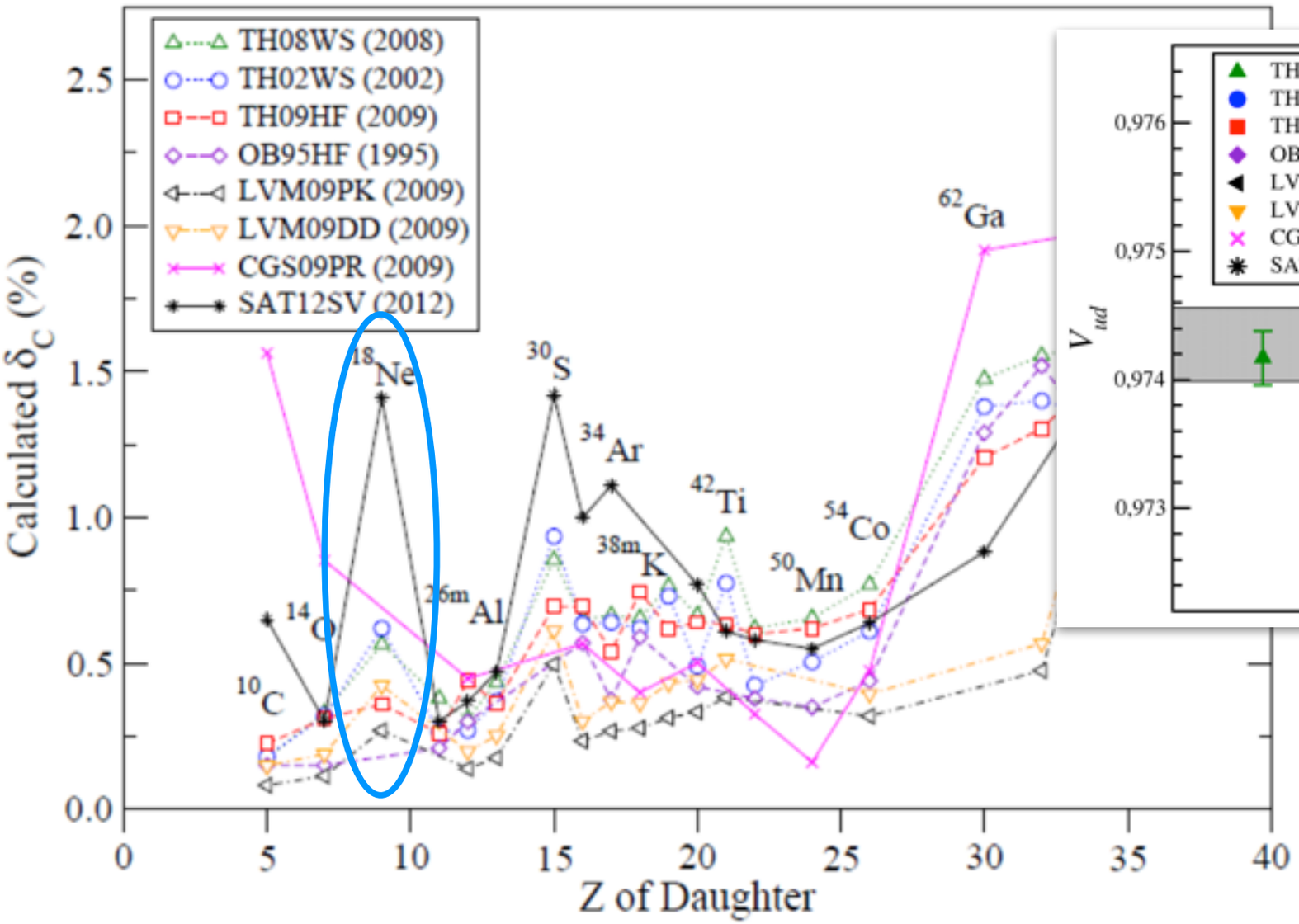

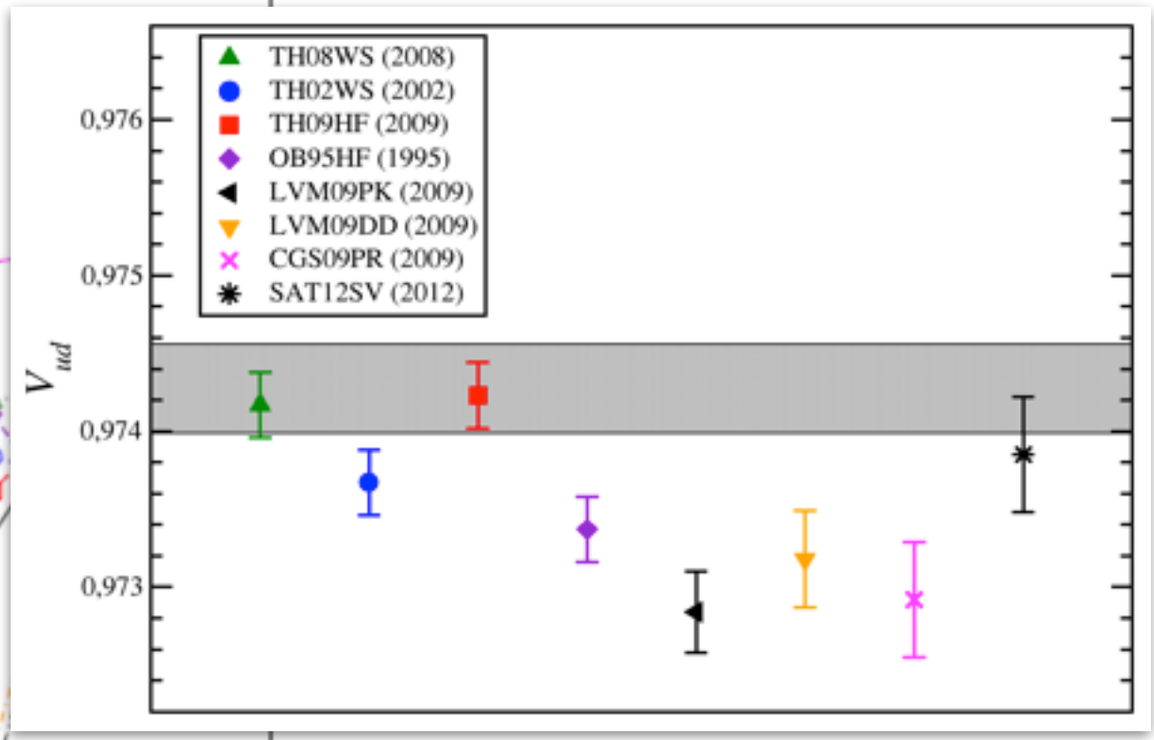

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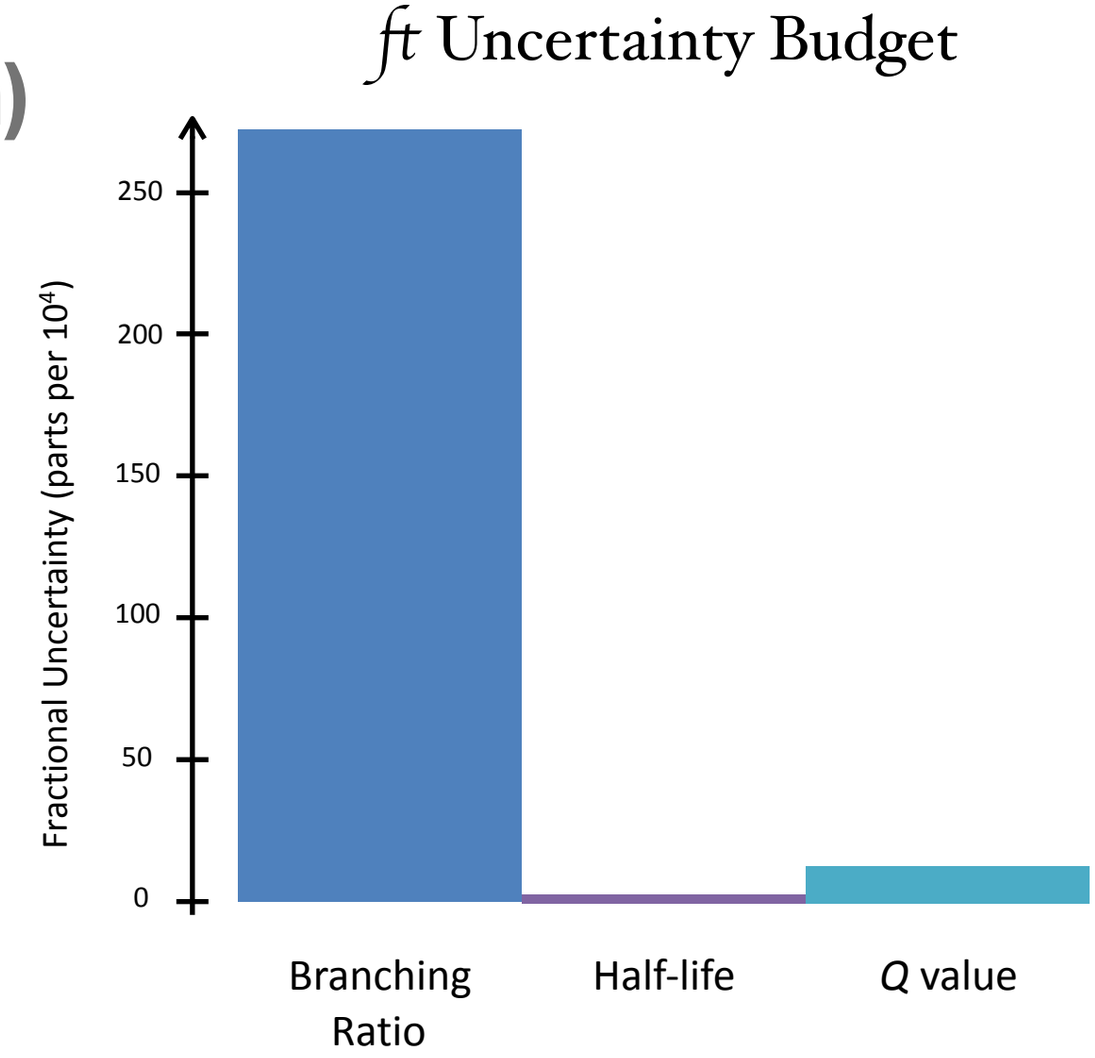
Status of ^{18}Ne

- Previous measurement by J.C. Hardy *et al.* (1975)
  - 7.66 ± 0.21% **(2.7% precision)**



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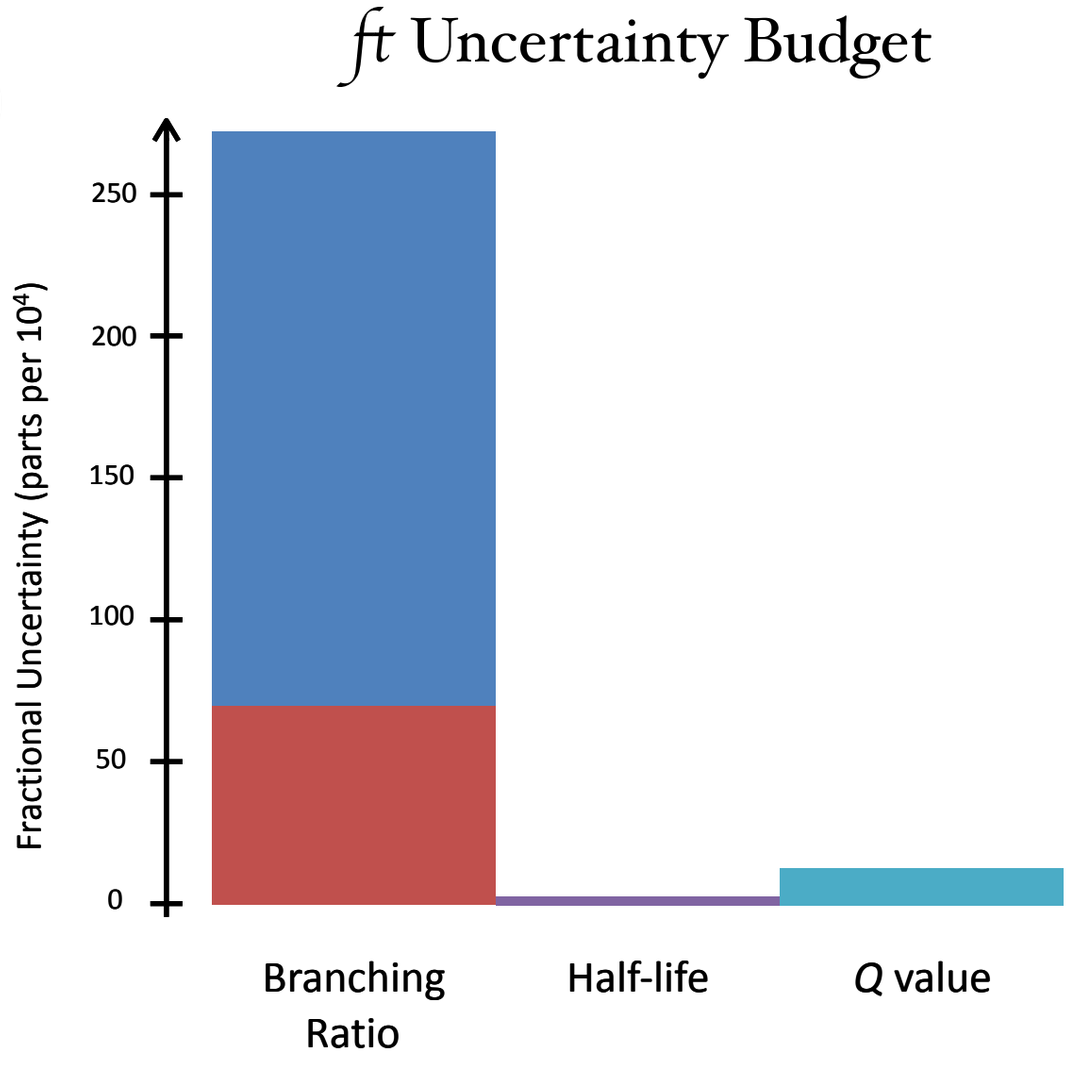

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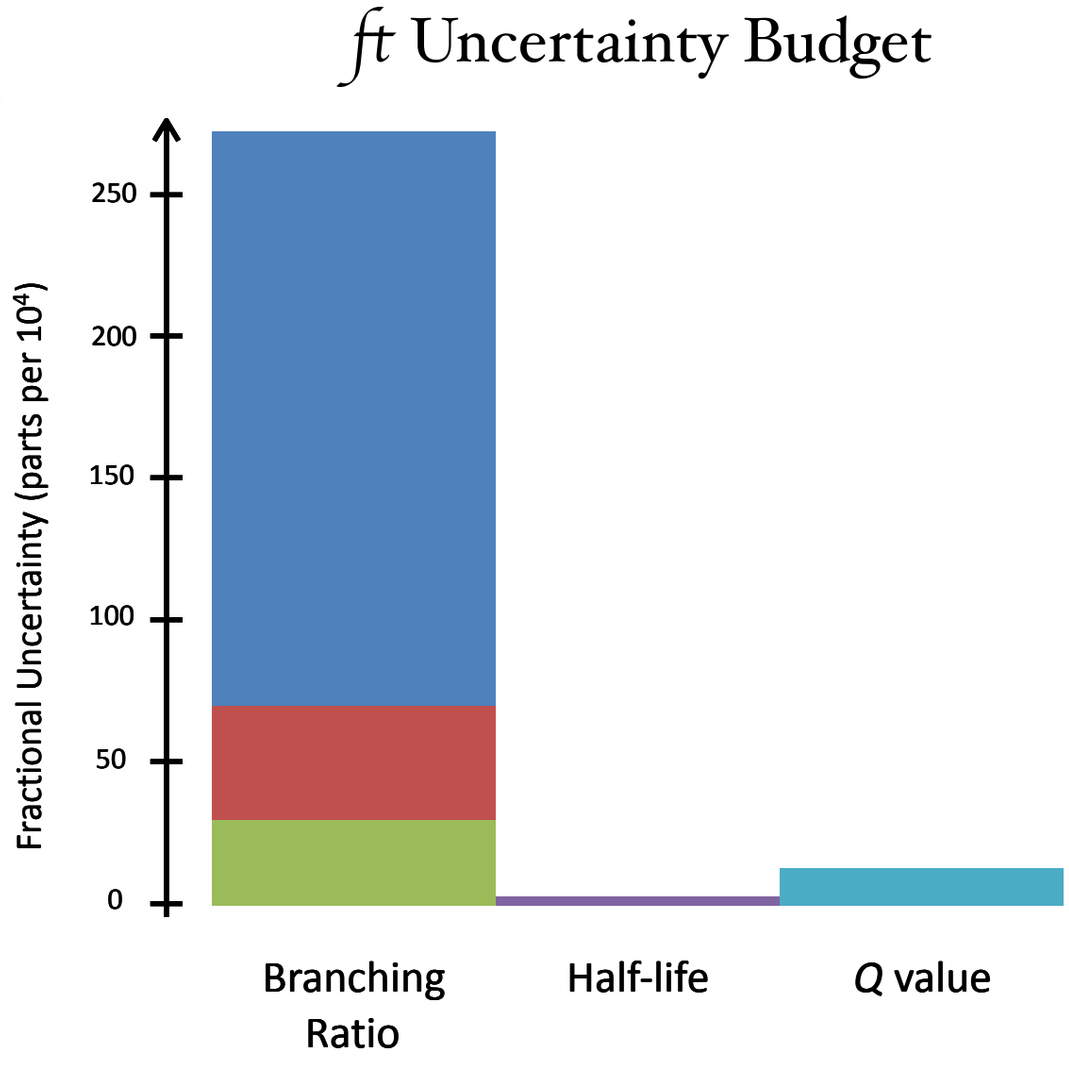
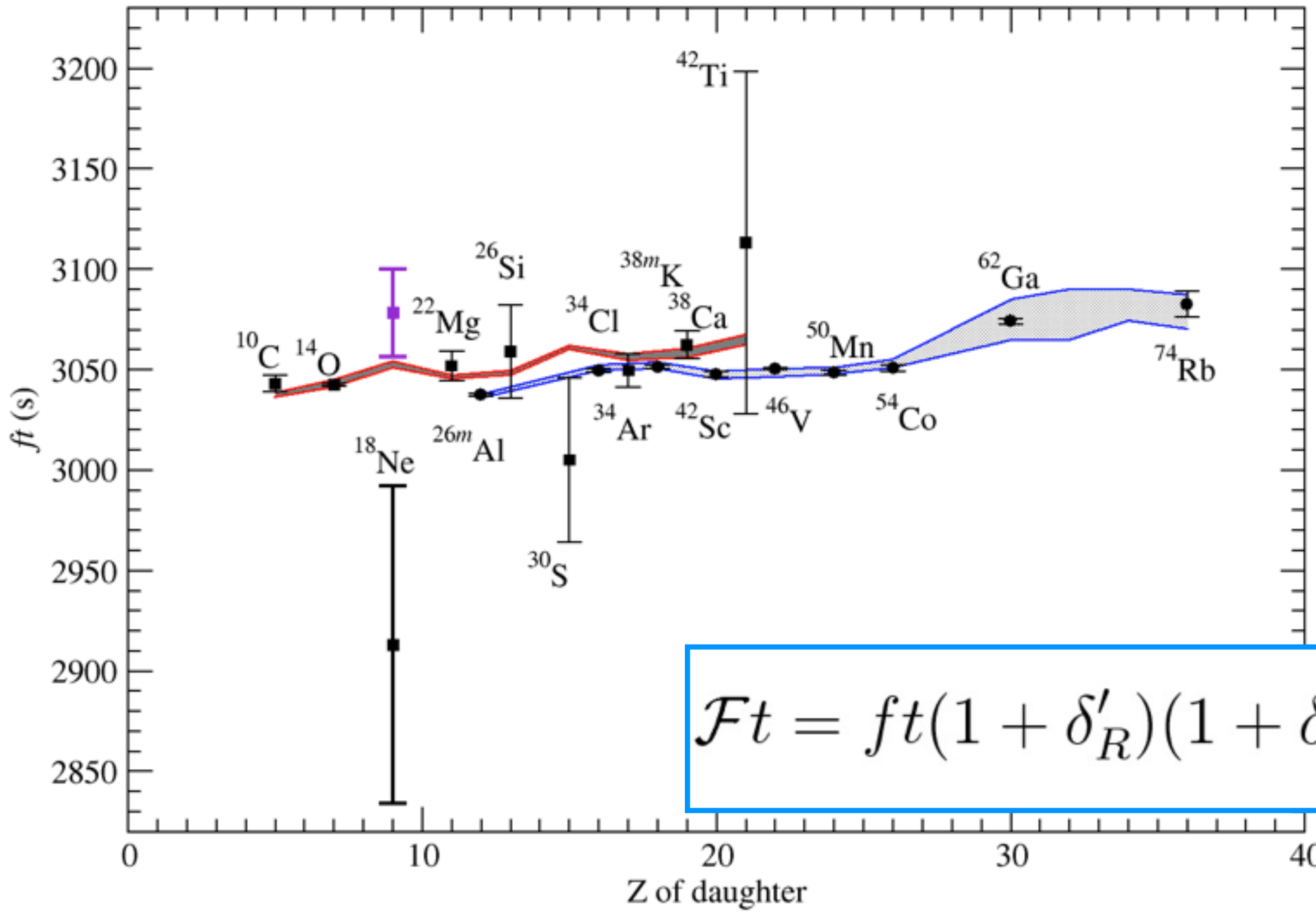
- **Goal: 0.3% precision**



Experimental δ_C vs $\mathcal{ft}$ values



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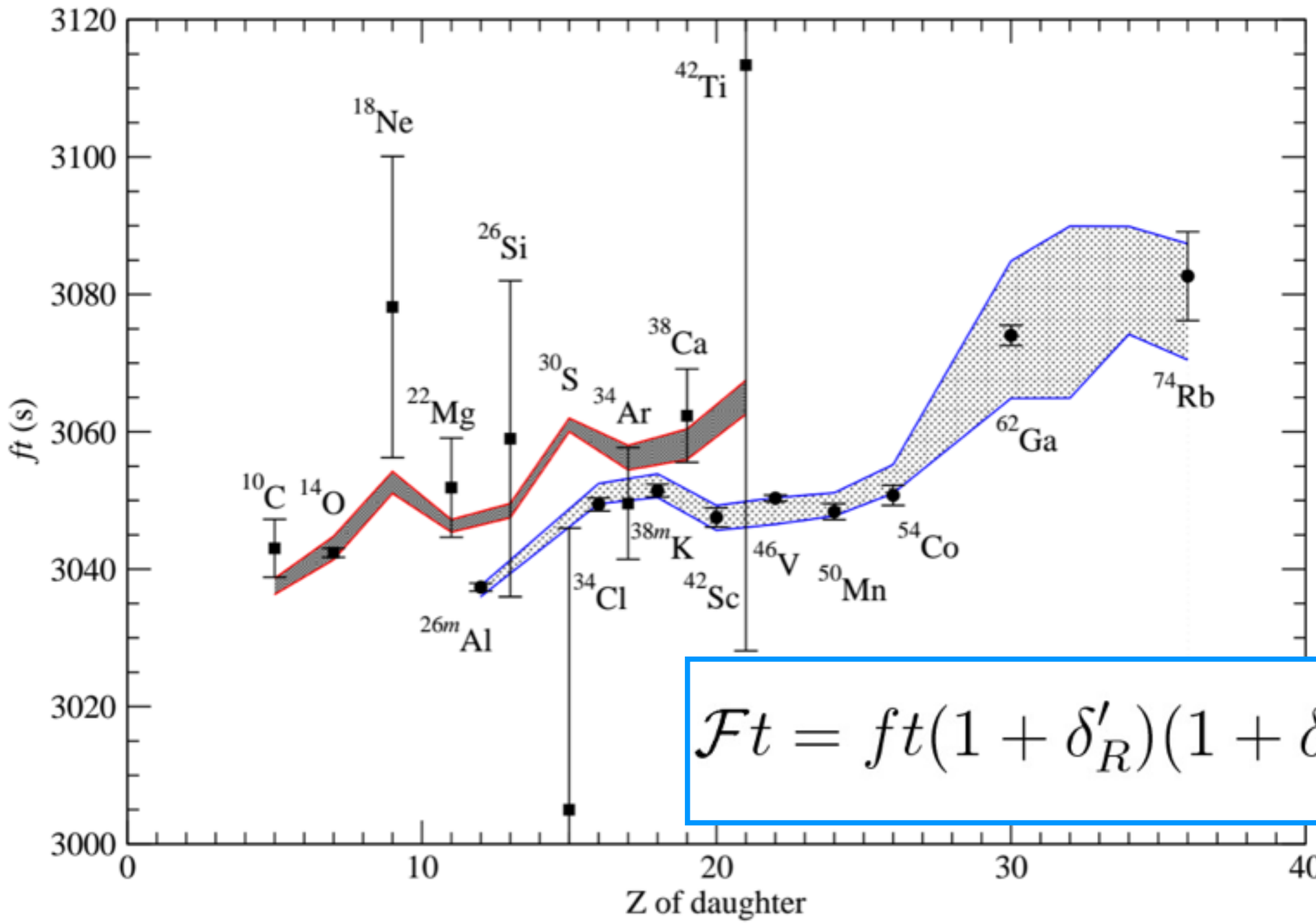

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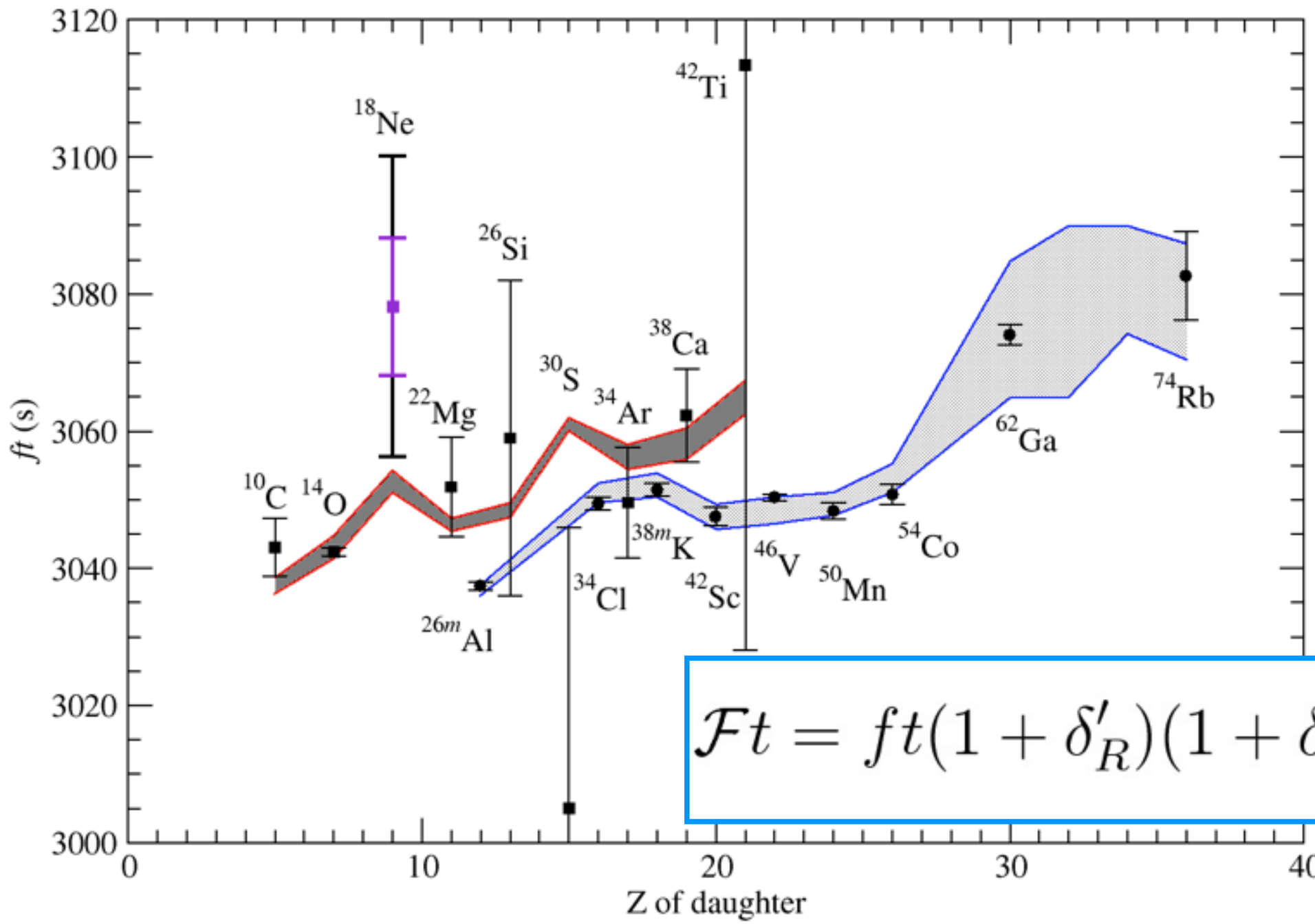

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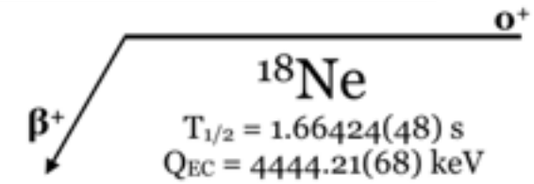
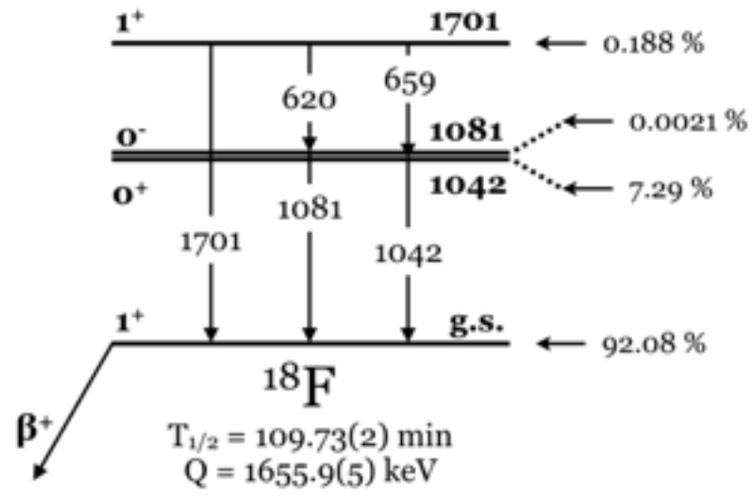
Detector Set-Up

- Need to measure 7.3% branch directly via β-$\boldsymbol{\gamma}$

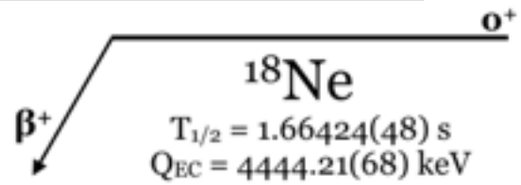


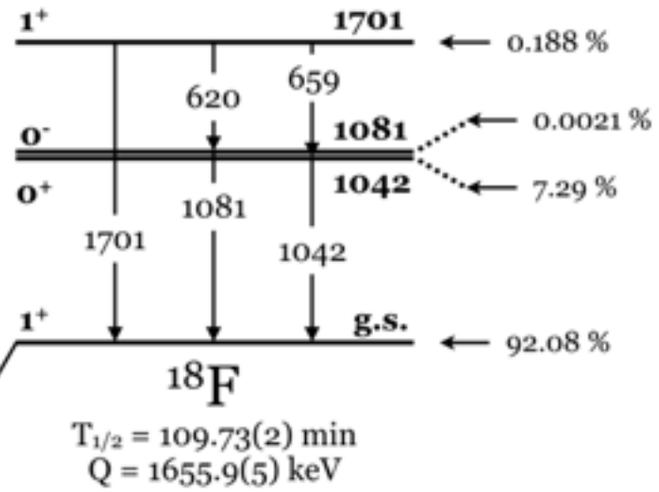


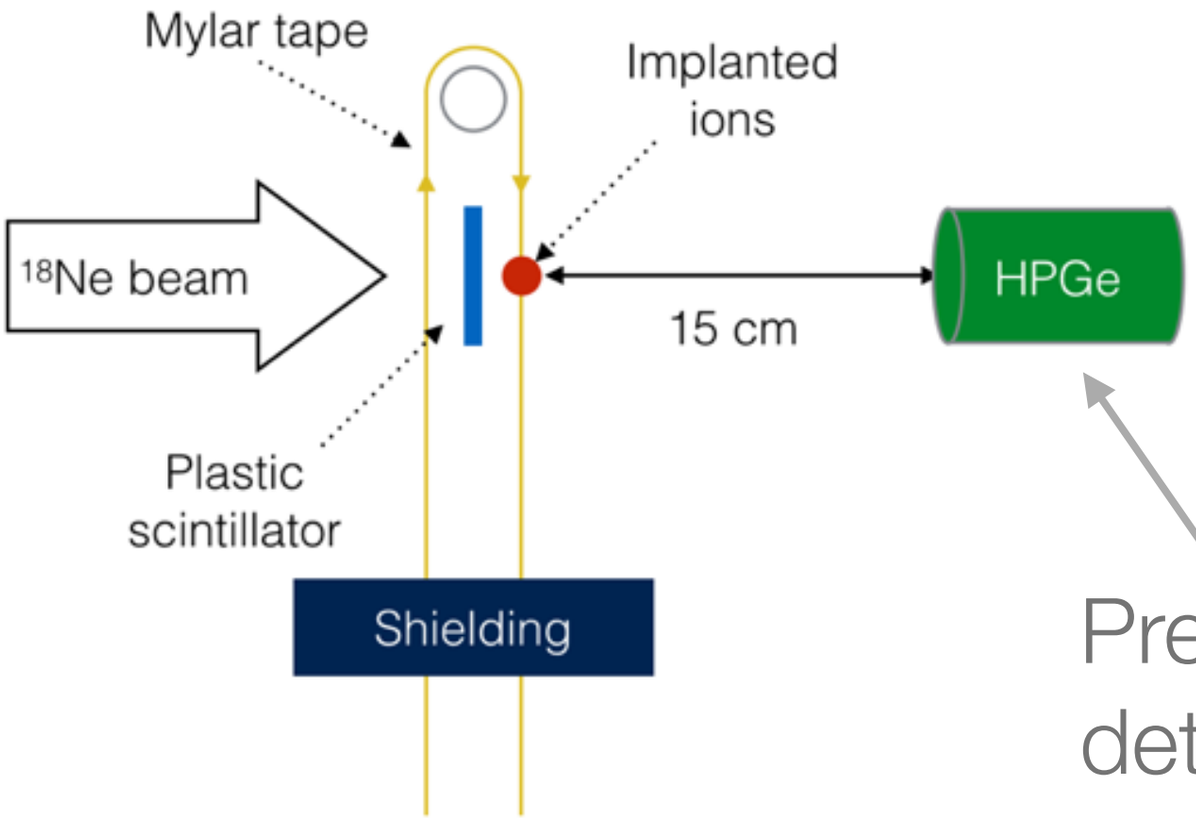
Detector Set-Up

- Need to measure 7.3% branch directly via β-**γ**

- Similar to set-up used for IS603 (^{10}C BR, 2015), ready







Precisely calibrated HPGe detector from CENBG

Beam-time Request

- ^{18}F contaminant at ≲1% level (T. Stora) ✓
  - Plasma cooled transfer line

- Limit plastic scintillator to 20 kHz (variable beam on time/cooling of sample)

Needs

- >10^5 ^{18}Ne/s (primary beam)
- <10^4 ^{18}F/s (contaminant)

- 2 shifts for **beam tuning** and optimisation
- 11 shifts for **branching ratio** measurement of **^{18}Ne**
- 0.5 shifts for **half-life** measurement of **^{18}Ne**
- 0.5 shifts for **half-life** measurement of **^{19}Ne**

14 total shifts

Additional Slides

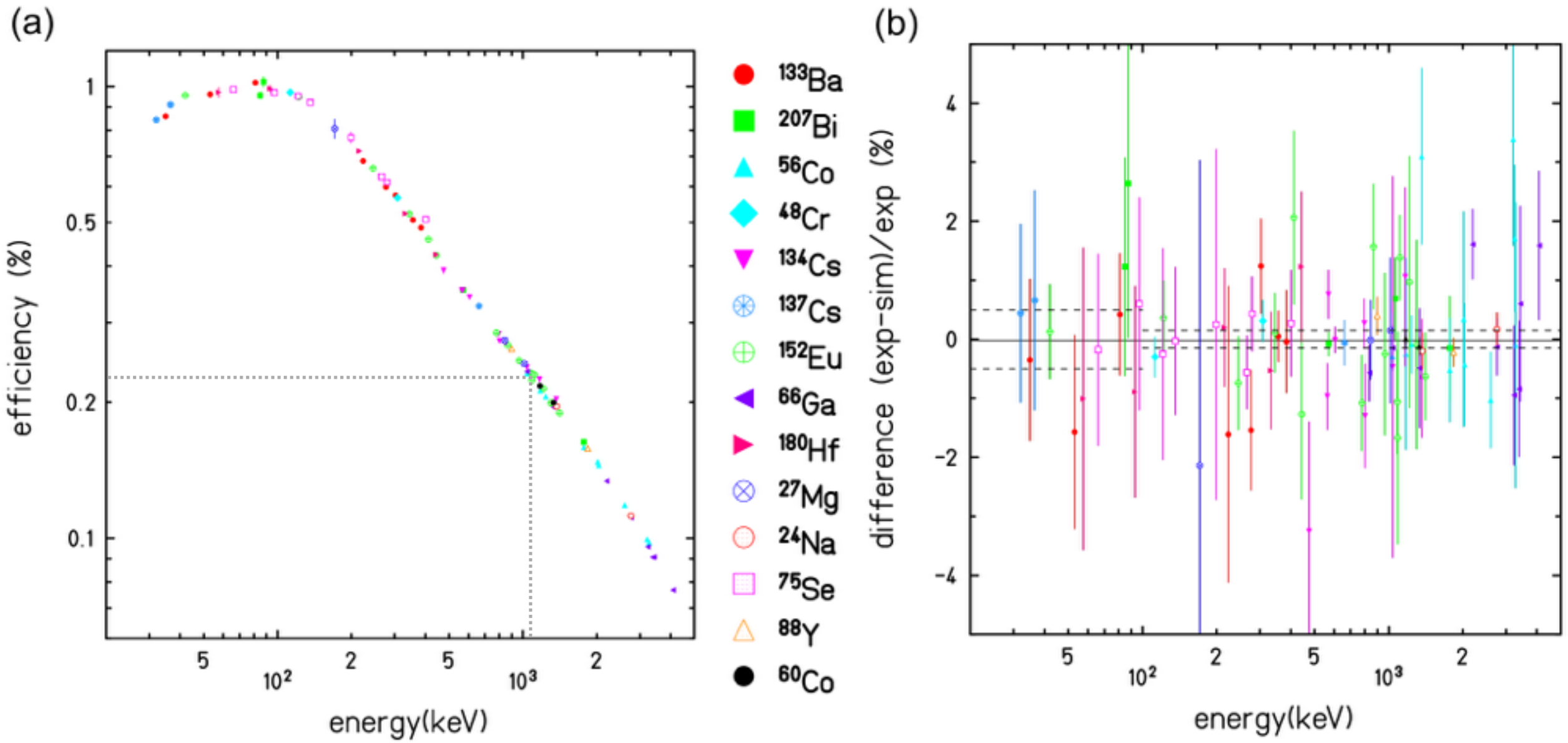
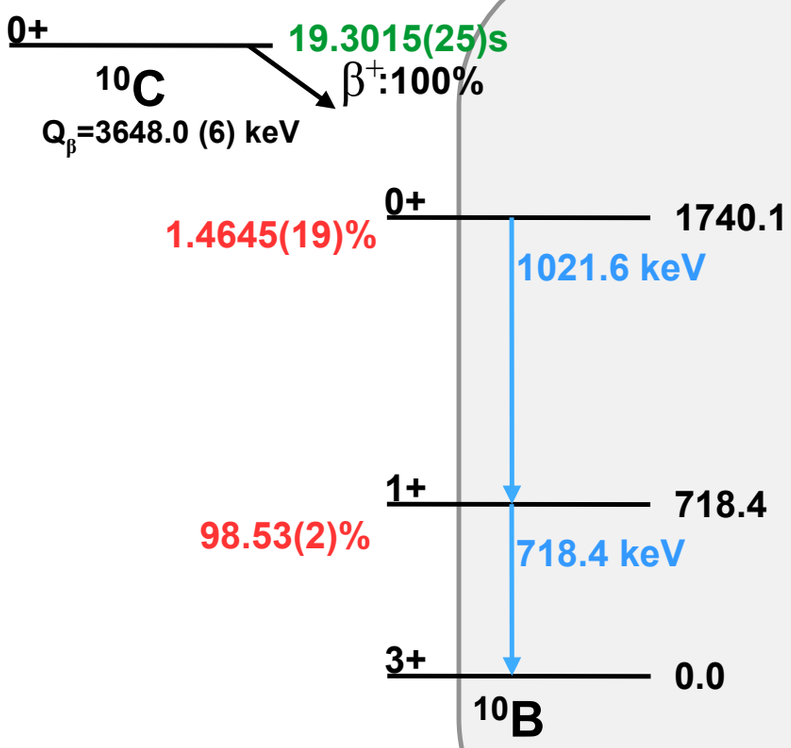


Fig. 11. (a) Absolute γ-ray efficiency at a distance of 15 cm between the source and the detector entrance window. As explained in the text, the shape of the curve is determined with the γ rays given in Table 2, whereas the absolute height of the curve was determined by means of ^{60}Co sources. The curve is not completely smooth, as what is presented is not the single γ-ray efficiencies, but full-energy peak efficiencies determined with the complete decay schemes from the sources. (b) Relative differences (in %) between the experimental data and the simulations with the detector model are presented. The dashed lines give the final precisions adopted.

Taken from B. Blank *et al.*, NIM A 776, 34 (2015)

IS603 : Measurement of the super-allowed branching ratio of ^{10}C

Decay from ^{10}C to ^{10}B



Branching ratio for ^{10}C

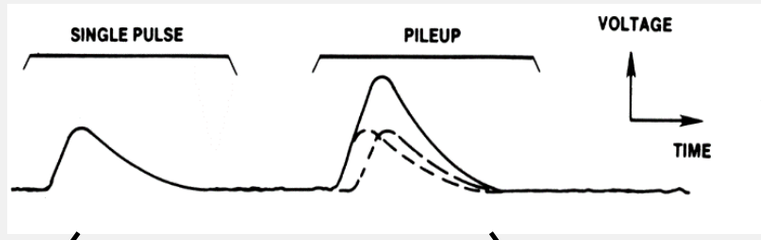
$$BR = \frac{I(1022)\,\epsilon_{718}}{I(718)\,\epsilon_{1022}}$$

We want to determine the branching ratio of 0+ → 0+ state of ^{10}C by counting 718 and 1022 keV γ's.

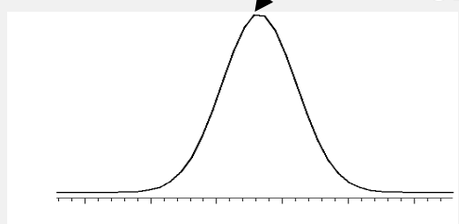
But 1022 keV is also equal to 511 + 511 keV which is the energy of electron-positron annihilation

The pile-up mechanism

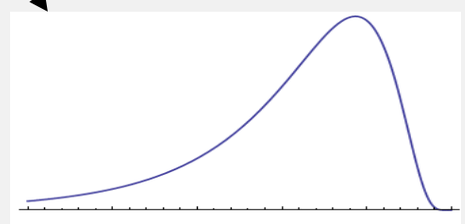
For the signal :



Yield for the energy spectra



« Normal » gaussian shape



Gaussian with tail shape

So 2 differents settings :

→ ^{19}Ne (quite similar to ^{10}C but no « real » 1022 keV gamma, only pile-up) to define the shape due to pile-up

→ ^{10}C to determine the branching ratio

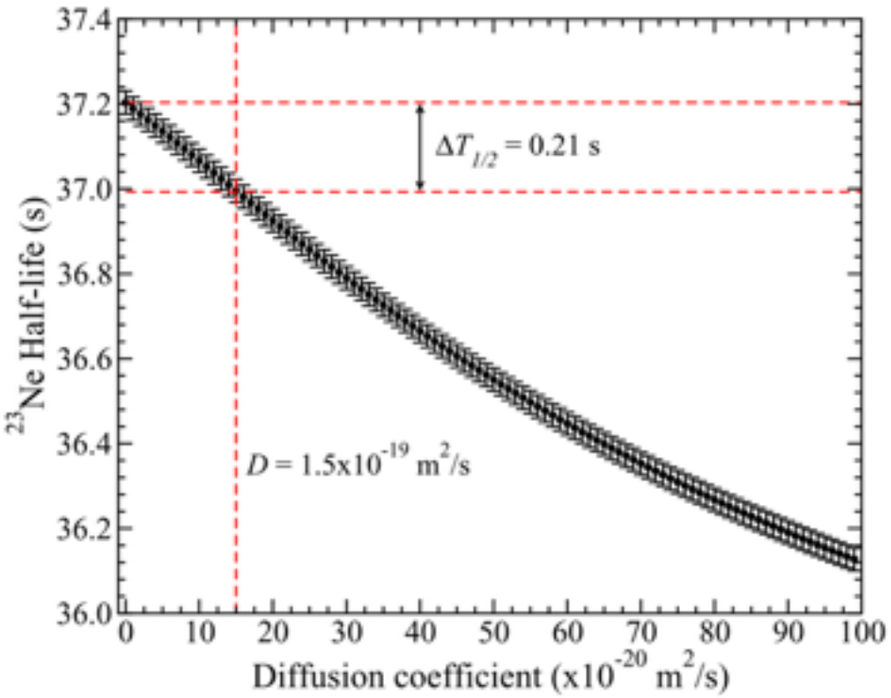
In order to define correctly the pile-up, we also used two differents shaping time because pile-up count rate also depends on the shaping time. **Analysis on-going….**

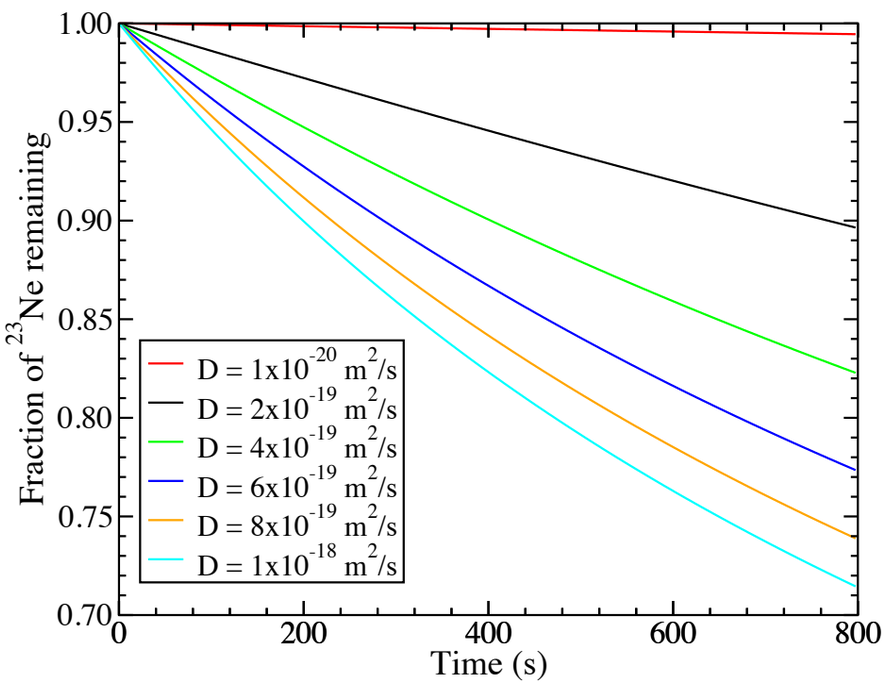
Diffusion Measurements

- GEANT4 simulations were performed to estimate the size of diffusion effects (<0.1% with 25% of sample diffusing)

- Half-life measurements give access to diffusion parameters

- ^{19}Ne ($T_{1/2}$ = 17.22 s) is more sensitive to diffusion on long(er) time scales





Sensitivity to δ_C Correction