MEASUREMENTS OF THE β-DECAY Q VALUES OF ^{66}As & ^{70}Br WITH MLLTRAP AT DESIR

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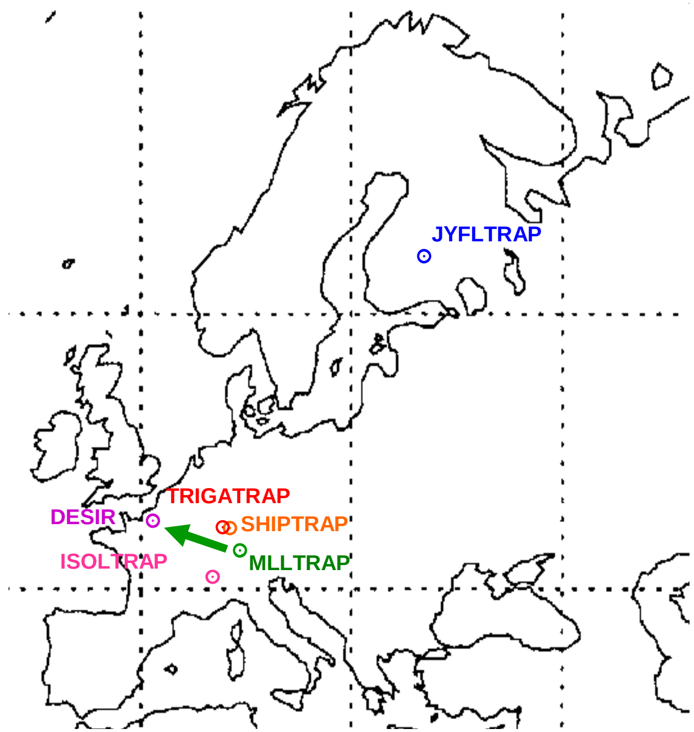
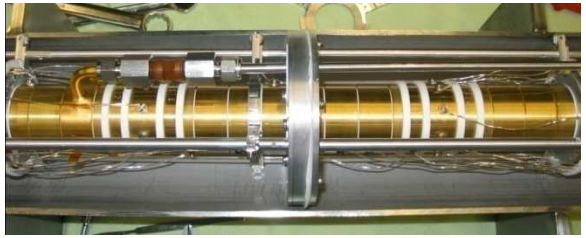


OUTLINE

- INTRODUCTION

    - TEST OF CONSERVED VECTOR CURRENT HYPOTHESIS (CVC)
    - UNITARITY OF THE CKM MATRIX



PENNING TRAPS

- MOTIVATION FOR FURTHER NUCLIDES: ^{66}As and ^{70}Br

- CURRENT STATUS ON ^{66}As and ^{70}Br

- ESTIMATE ON A MEASUREMENT

MCP DETECTOR

SUPERALLOWED β DECAYS & CVC

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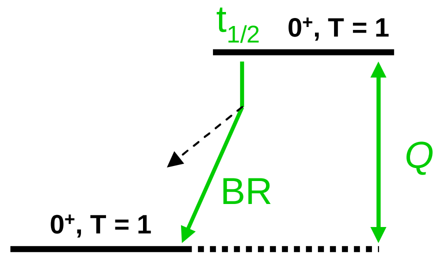


decay strength of superallowed **(0$^+$, T = 1)** decay:

$$ft = \frac{K}{G_V^2 \, M_F^2}$$

- G_V : vector-coupling constant
- M_F: Fermi matrix element

experimental quantities:

- transition energy $(Q_{EC})^5$ - statist. rate fct. **f**
- half-life $t_{1/2}$ &
- branching ratio BR } - partial half-life **t**

$$Ft \equiv ft\,(1+\delta_R')\,(1+\delta_{NS}-\delta_C) = \frac{K}{2\,G_V^2\,(1+\Delta_R^V)}$$

are nuclear-structure dependent

δ_C : isospin – symmetry – breaking correction

Δ_R^V : transition – indep. radiat. correction

transition – dependent radiative corrections :

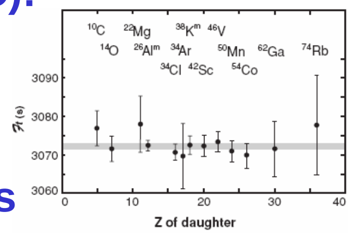
δ_R' : nuclear – structure independent

δ_{NS} : nuclear – structure dependent

conservation of the vector current (CVC):

↓

corrected *Ft* values are consistent with each other



J.C. Hardy & I.S. Towner, Phys. Rev. C **79**, 055502 (2009).

Q DATA FOR THE WORLD-AVERAGE *Ft* VALUE

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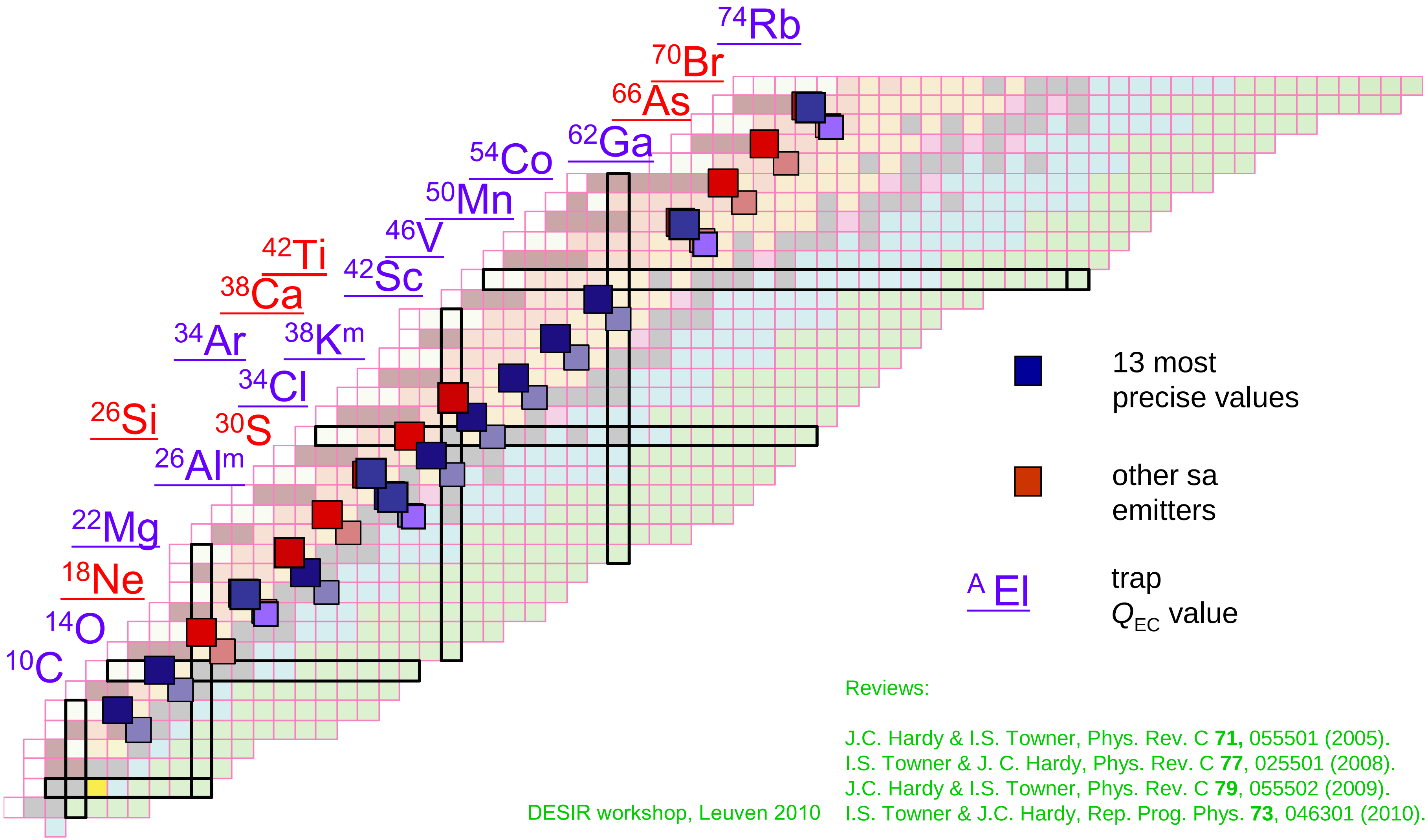
$$Ft \equiv ft\,(1+\delta_R^{'})(1+\delta_{NS}-\delta_C) = \frac{K}{2G_V^2\,(1+\Delta_R^V)}$$

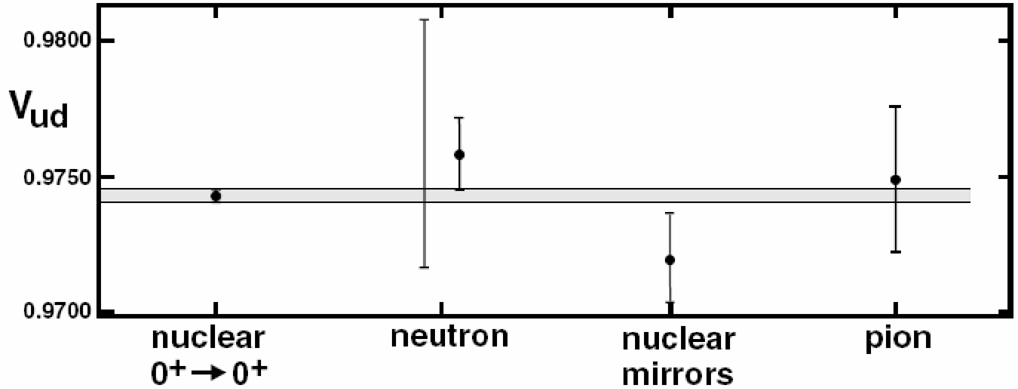
- transition energy $(Q_{EC})^5$ - statist. rate fct. **f**
- half-life $t_{1/2}$ &
- branching ratio R } - partial half-life **t**



Reviews:

J.C. Hardy & I.S. Towner, Phys. Rev. C **71,** 055501 (2005).
I.S. Towner & J. C. Hardy, Phys. Rev. C **77**, 025501 (2008).
J.C. Hardy & I.S. Towner, Phys. Rev. C **79**, 055502 (2009).
I.S. Towner & J.C. Hardy, Rep. Prog. Phys. **73**, 046301 (2010).

TEST OF THE UNITARITY OF THE CKM MATRIX



Towner & Hardy Rev. Prog. Phys. **73** 046301 (2010)

$$|V_{ud}|^2 + |V_{us}|^2 + |V_{ub}|^2 = 1$$

$$G_V = G_F \cdot V_{ud}$$

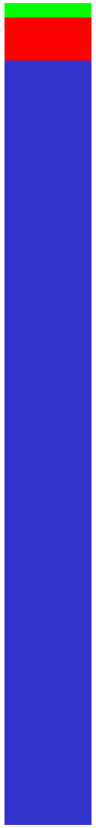
G_F from G_μ: *from muon decay*

$$V_{ud}^2 = \frac{K}{2G_\mu^2(1+\Delta_R^V)\overline{\mathcal{F}t}}$$

V_{ud} (s.a. β decays) = 0.97425(22)

V_{us} (kaon decay) = 0.2247(12)

V_{ub} (B meson decay) = 0.00393(35)



V_{ub}^2: 0.001%

V_{us}^2: 5%

V_{ud}^2: 95%

J.C. Hardy, I.S. Towner Phys. Rev. C **79**, 055502 (2009)
Towner & Hardy, Rev. Prog. Phys. **73**, 046301 (2010)

$$|V_{ud}|^2 + |V_{us}|^2 + |V_{ub}|^2 = 0.99990(60)$$

Present status: Unitarity is fulfilled with a precision of 0.06 %

RE-CALCULATION OF ISOSPIN-SYMMETRY CORRECTION δ_c & PENNING TRAP Q_{EC} VALUES

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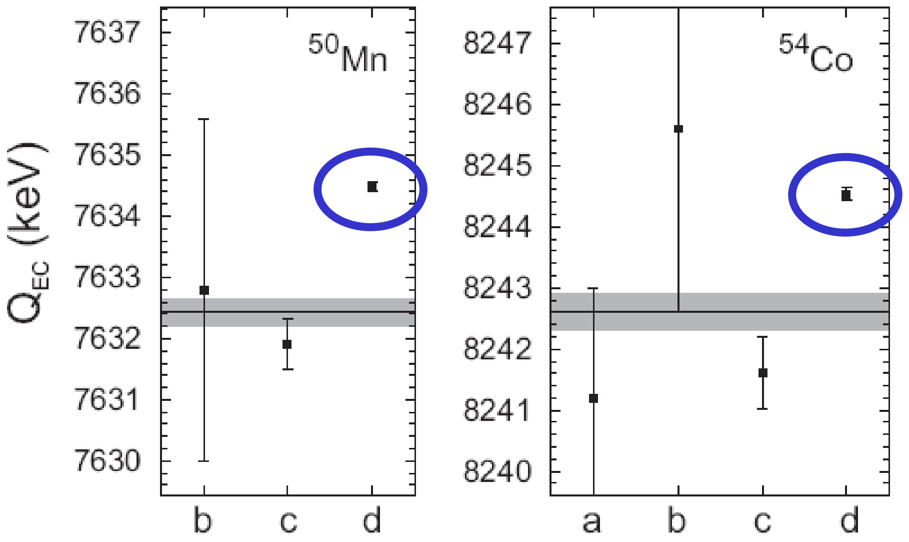
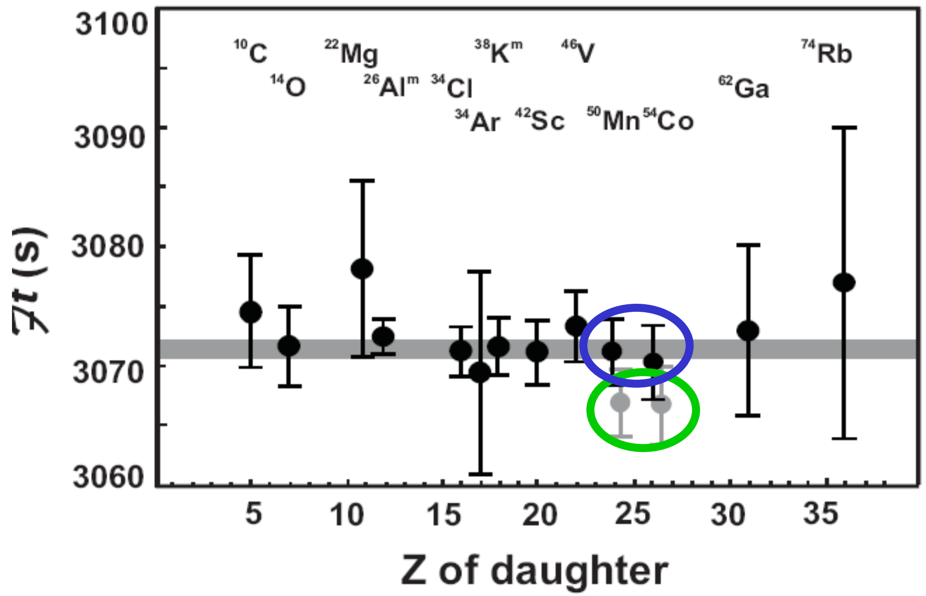


a: Hoath et al. b: Hardy et al.
c: Vonach et al. d: JYFLTRAP

I. S. Towner and J. C. Hardy, Phys. Rev. C **77**, 025501 (2008).

$$\overline{Ft} = 3071.4(8)\ \mathrm{s}$$
$$\chi^2/N = 0.6$$



T. Eronen et al., Phys. Rev. Lett. **100**, 132502 (2008).

$$\overline{Ft} = 3072.2(8)\ \mathrm{s}$$
$$\chi^2/N = 0.22$$

REFERENCES: CPT, ISOLTRAP, JYFLTRAP, & LEBIT RESULTS:

^{34}Ar: F. Herfurth *et al*., Eur. Phys. J. A **15,** 17 (2002)

^{22}Mg: M. Mukherjee *et al*., Phys. Rev. Lett. **93,** 150801 (2004)

^{46}V: G. Savard *et al*,, Phys. Rev. Lett. **95,** 102501 (2005)

^{38}Ca: G. Bollen *et al*., Phys. Rev. Lett. **96,** 152501 (2006)

^{66}As: P. Schury *et al*., Phys. Rev. C **75**, 055801 (2007)

^{50}Mn,^{54}Co: T. Eronen *et al.,* Phys. Rev. Lett. **100**, 132502 (2008)

^{74}Rb: A. Kellerbauer *et al*., Phys. Rev. Lett. **93**, 072502 (2004)

^{22}Mg: G. Savard *et al*., Phys. Rev. C **70**, 042501 (2004)

^{62}Ga: T. Eronen *et al*., Phys. Lett. B **636**, 191 (2006)

^{26}Al^m, ^{42}Sc, ^{46}V: T. Eronen *et al*., Phys. Rev. Lett. **97,** 232501 (2006)

^{38}Ca: S. George *et al*. Phys. Rev. Lett. **98**, 162501 (2007)

^{34}Cl, ^{38}K^m: T. Eronen *et al*., Phys. Rev. Lett. **103**, 252501 (2009)

MEASUREMENTS FOR FUTURE TESTS

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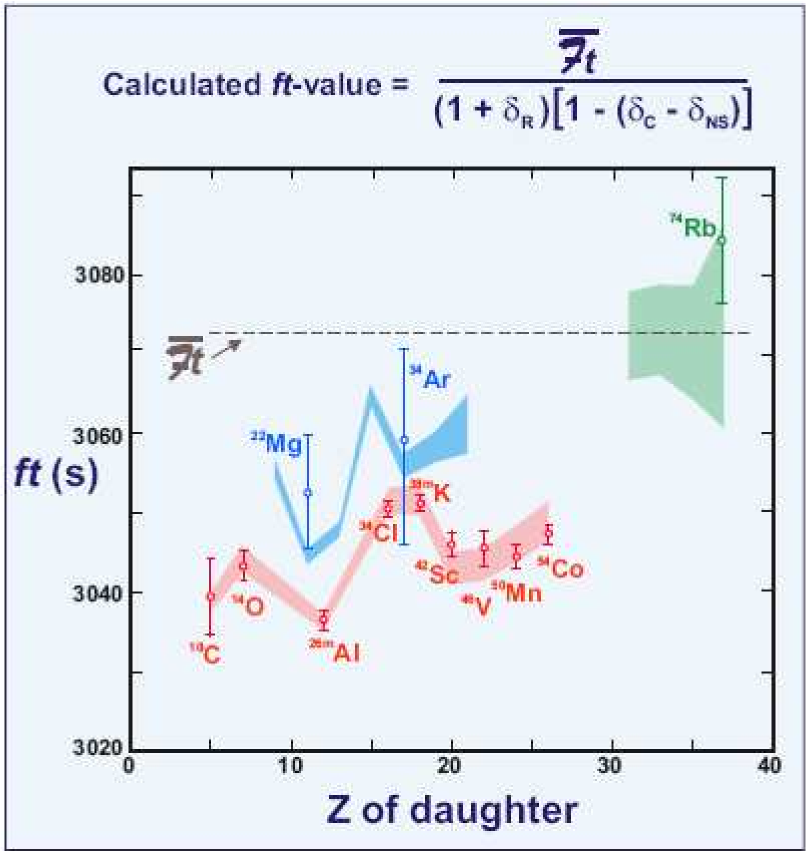

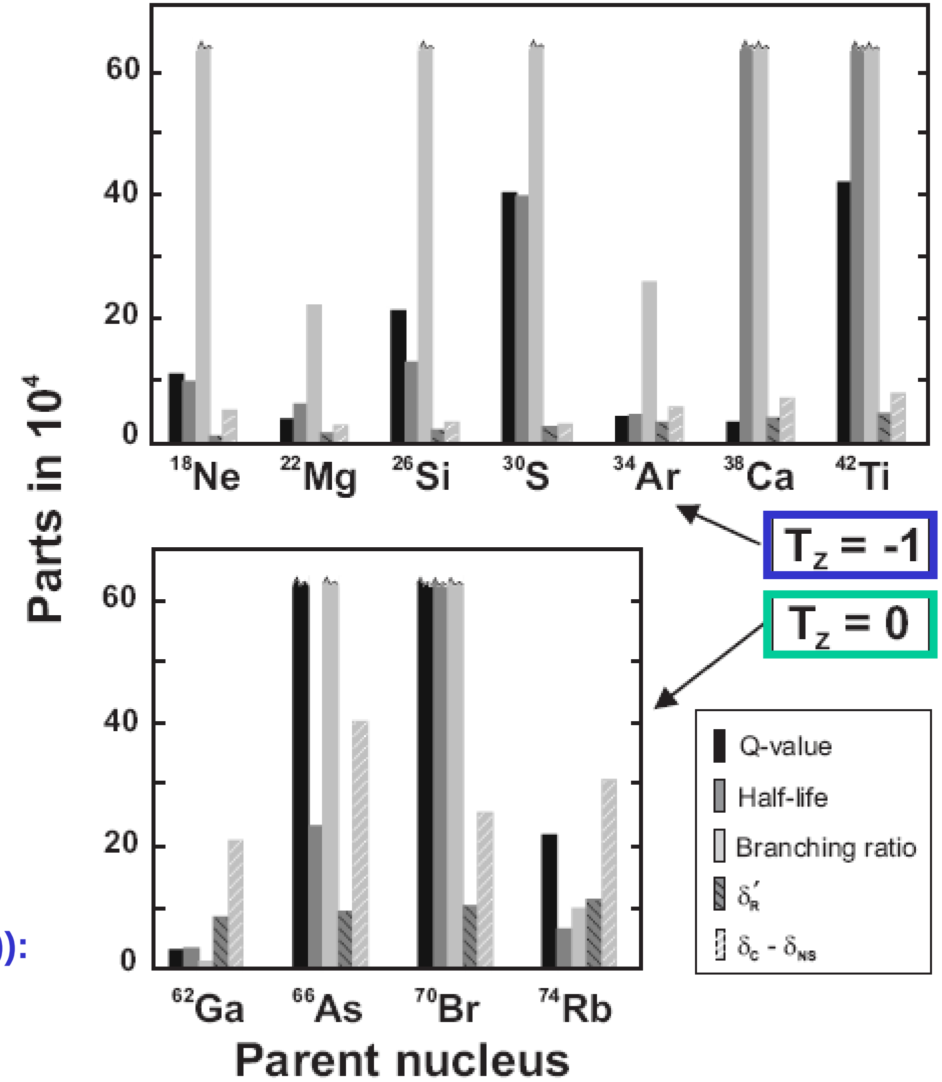

FUTURE TESTS REQUIRE (Hardy, Towner (2009)):

- **improve the precision of 9 best values**
- **T_z = -1 nuclides [18 < A < 42]   (nuclear structure corrections)**
- **T_z = 0 nuclides [A > 62]   (test structure-dependent corrections, IMME coefficients)**

STATUS ON ^{66}As AND ^{70}Br Q-VALUE DATA

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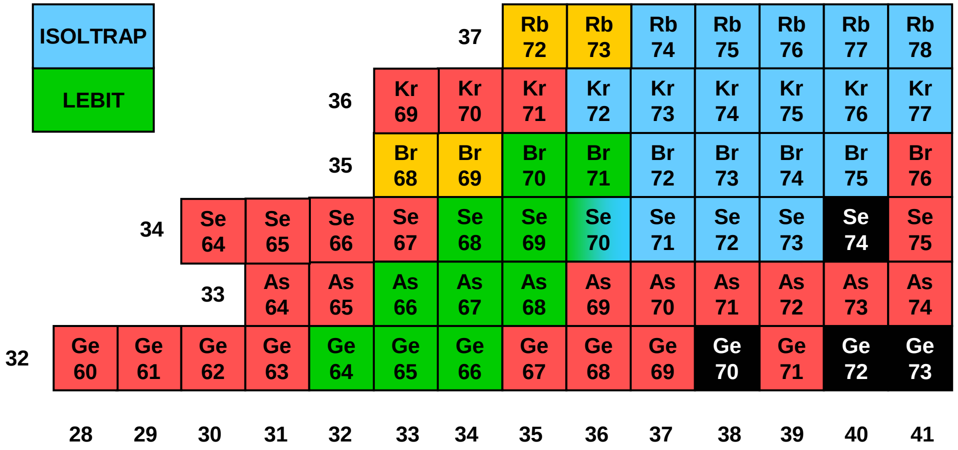

- **via reference nuclide ?**

$$m = \frac{\nu_{c,REF}}{\nu_c}\left(m_{REF} - m_e\right) + m_e$$

- **direct doublet available ?**

$$Q = (m_M - m_D) = \left(\frac{\nu_D}{\nu_M} - 1\right)\cdot(m_D - m_e)$$

NUCLIDES & ISOMERIC STATES	T_Z	HALF-LIFE $T_{1/2}$	MASS EXCESS (keV)	Eex (keV)	Q (keV)	Q (keV)
^{66}As	0	95.79 ms	-52018(30)[a]		9589(30)	9579(26)[d]
^{66}Ge	1	2.26 h	-61607.0(2.4)[a]			
^{70}Br	0	79.12 ms	-51425(15)[b]			
^{70}Br^m (9+)		2.2 s		2292.2(0.8)[c]	10504(15)	9970(170)[d]
^{70}Se	1	41.1 m	-61929.7(1.6)[b]			

Data from:
[a] P. Schury, *et al.*, Phys. Rev. C **75**, 055801 (2007).
[b] J. Savory, *et al.*, Phys. Rev. Lett. **102**, 132501 (2009).
[c] D.G. Jenkins et al., Phys. Rev. C **65**, 064307 (2002).
[d] J.C. Hardy & I.S. Towner, Phys. Rev. C **79**, 055502(2009).

A POSSIBLE TIMING CYCLE OF AN INDIVIDUAL FREQUENCY MEASUREMENT

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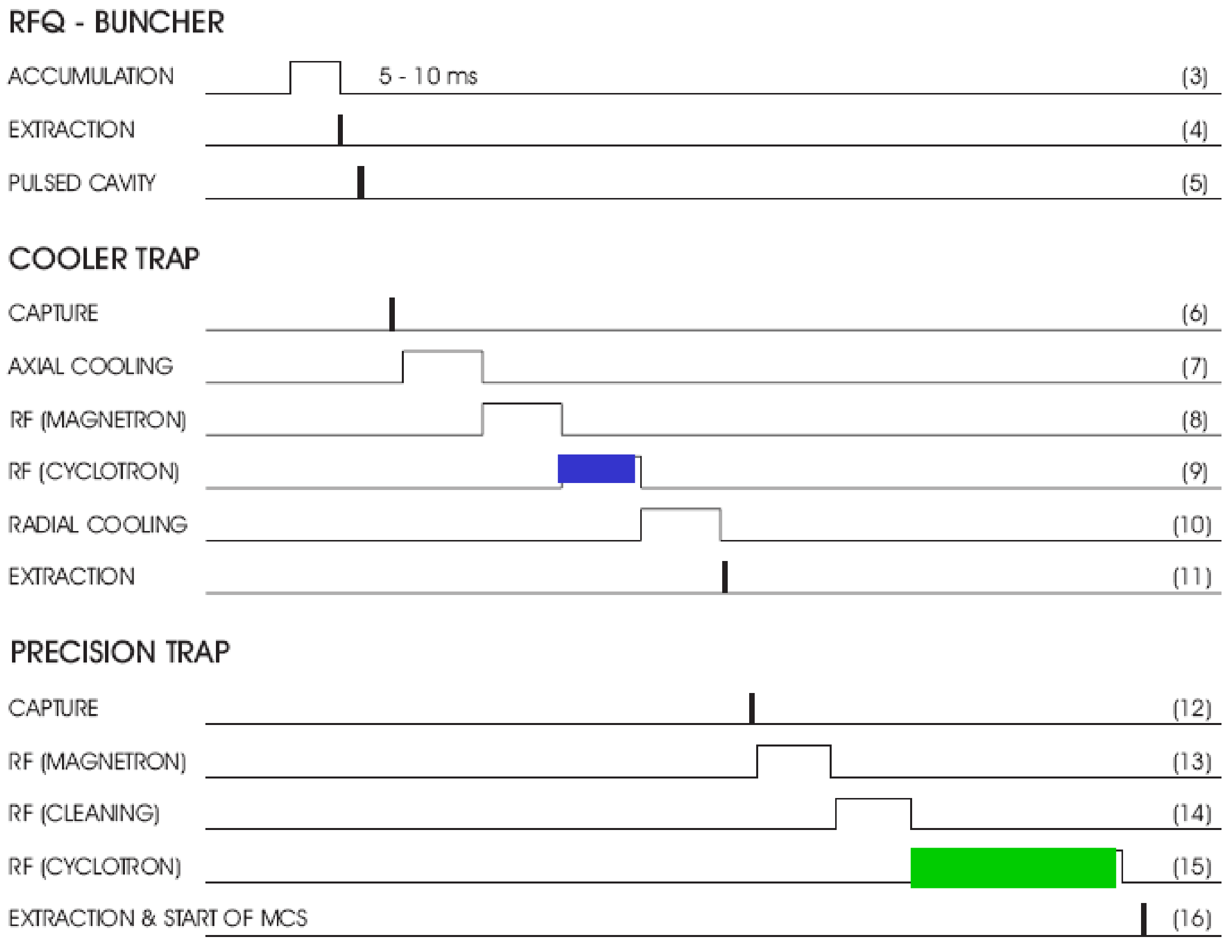


^{66}As 96 ms	^{70}Br 79 ms
10	10
20	15
10	10
35	35
10	10
10	10
160	120
255	**210**

FWHM :
1 – 1.1 MeV

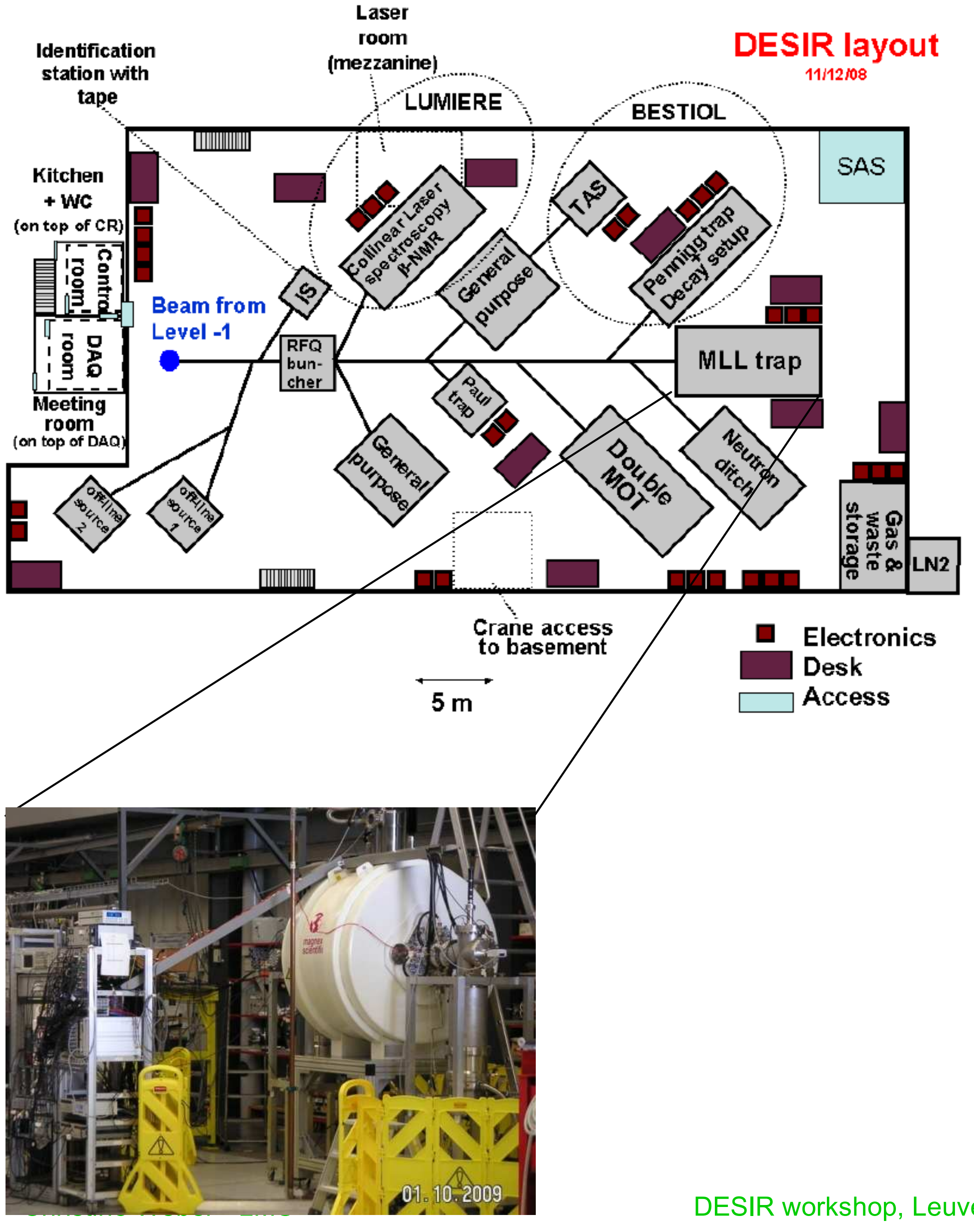
↓

^{70}Br^{m}

$\delta\nu/\nu$:
3 – 4 * 10^{-7}

A total time of about 2.7 half-lives -> Masses (Q values) within few keV precision

MLLTRAP AT DESIR - ESTIMATES



On ^{66}As (^{70}Br ?)

- Production (@ Spiral 1) :
- 10^6 nuclides at target
- $10^2 - 10^3$ pps

with efficiency (~ 5%)

- few 10 pps available

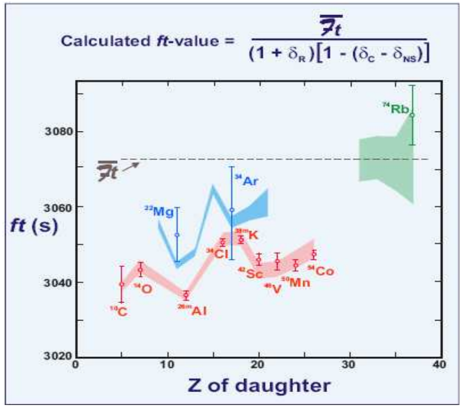
  for a mass measurement

- Production (@ S3)

^{66}As : 4 * 10^6 pps

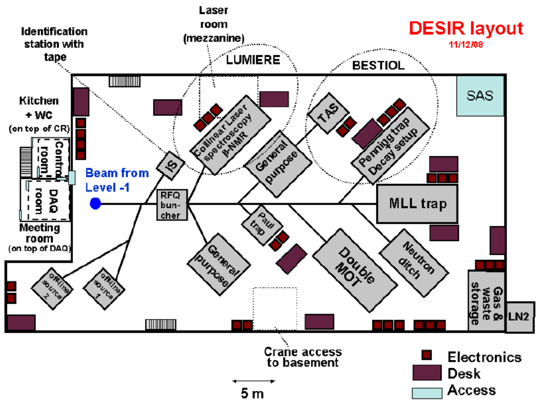
^{70}Br: 7 * 10^6 pps

SUMMARY



• CVC hypothesis is confirmed & the unitarity of the CKM matrix is fulfilled.

• Future measurements on **new** superallowed beta emitters are needed to verify the theoretical corrections (δ_C - δ_{NS}) .



• Heavy (A > 62), T_z = 0 nuclides, like ^{66}As and ^{70}Br, become available at DESIR

-> precise mass / Q-value determination of the superallowed decay with MLLTRAP.

THANKS TO

Eva Gartzke	Dieter Habs
Veli Kolhinen	Kevin Krug
Andreas Malecki	Robert Meißner
Jerzy Szerypo	Peter Thirolf

THANKS FOR YOUR ATTENTION !!