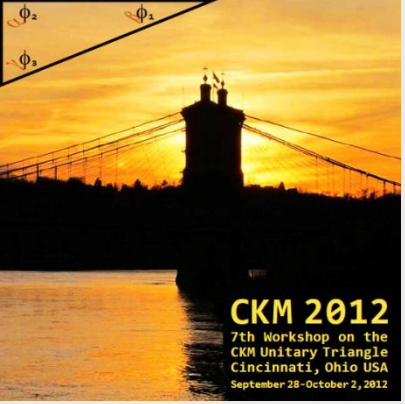
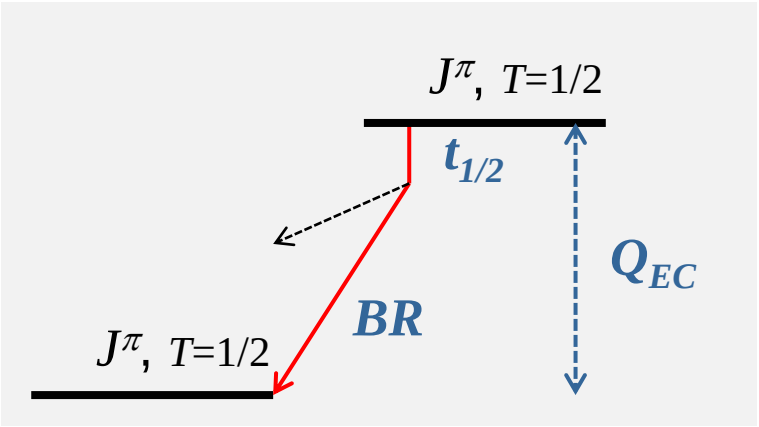


V_{ud} from nuclear mirror transitions

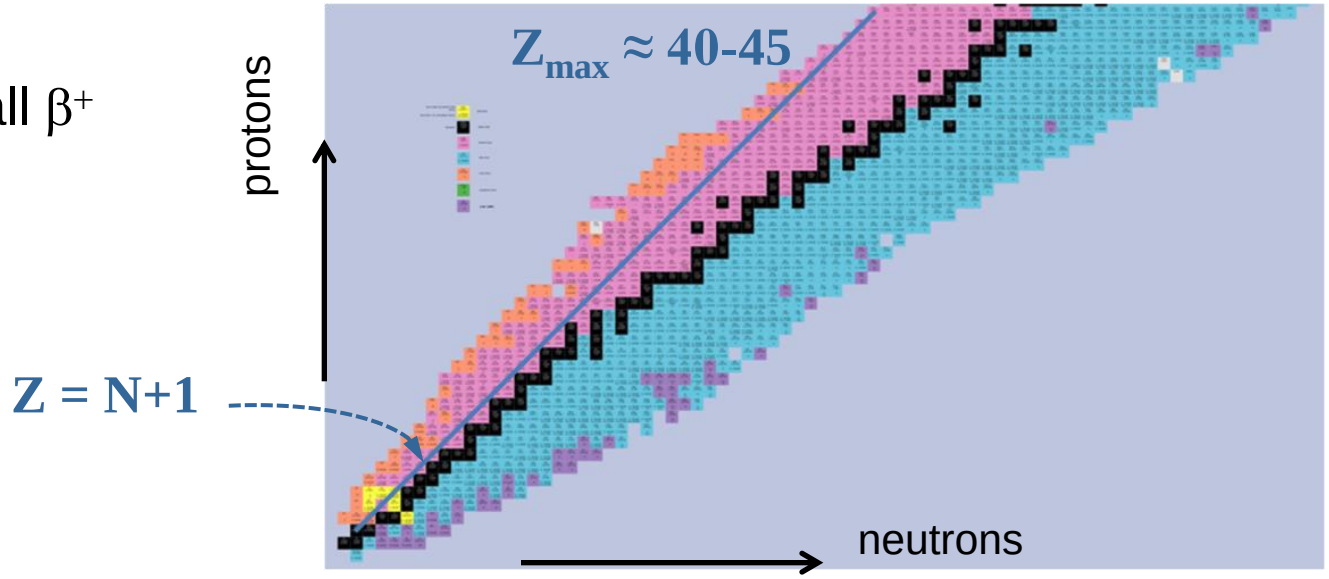
Oscar Naviliat-Cuncic
National Superconducting Cyclotron Laboratory
and Department of Physics and Astronomy
Michigan State University

Nuclear mirror transitions



- Super-allowed transitions between isobaric analogue states with T=1/2.
- Occur in mirror nuclei, between states with same spins and parities.
- Involve the *V* and *A* components of the weak interaction

- Many candidates: all β^+ (except *n* and ^{3}H)



Observable and Status

O. N-C and N. Severijns, PRL**102** (2009) 142302

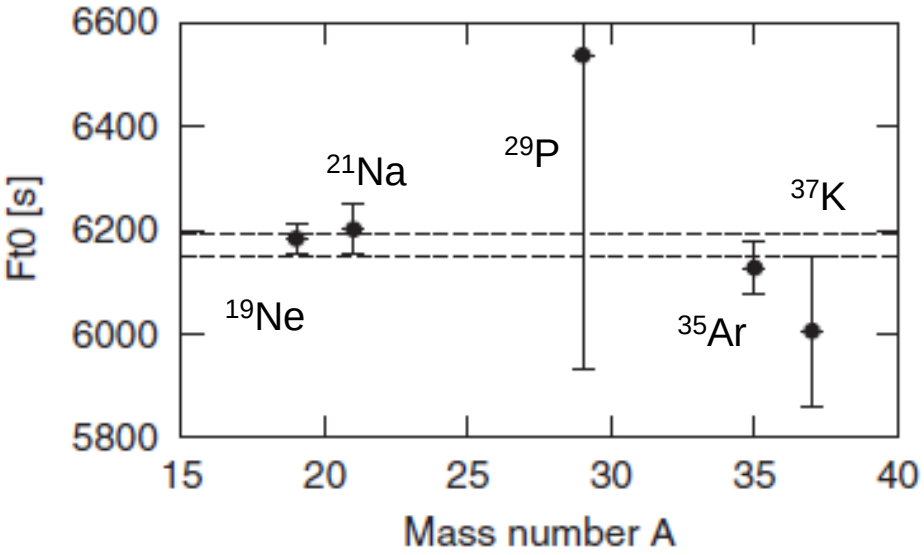
$$V_{ud}^2 = \frac{K}{\overline{\mathcal{F}t_0} G_F^2 (1 + \Delta_R^V)}$$

$$\mathcal{F}t_0 = \underbrace{\mathcal{F}tC_V^2 |M_F^0|^2}[1 + (f_A/f_V)\rho^2],$$

Similar to $0^+ \rightarrow 0^+$ transitions

$$\rho \approx C_A M_{GT} / C_V M_F$$

"Mixing ratio"



$$|V_{ud}| = 0.9719(17)$$

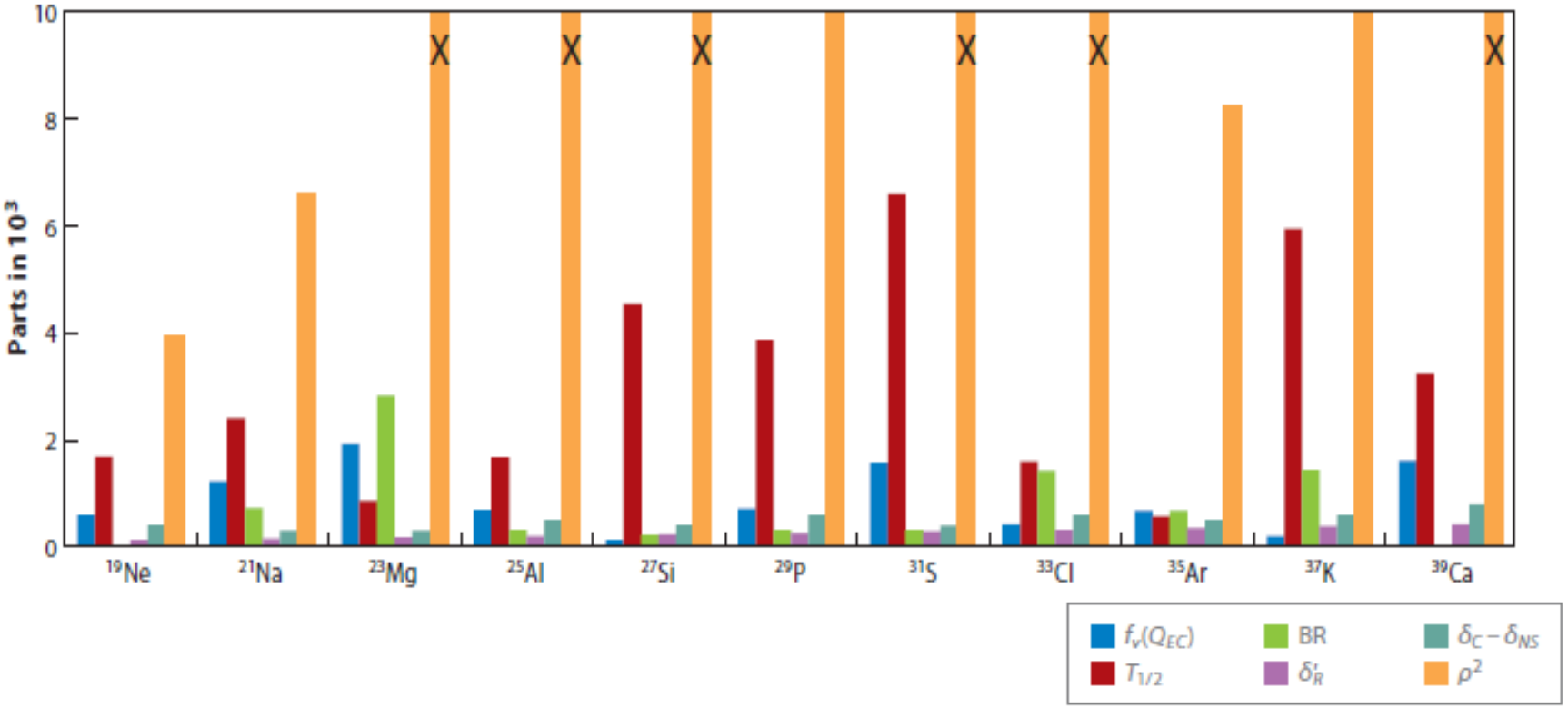
Dominated by experimental errors on ρ

- More precise than π-decay
- Comparable to *n*-decay
- Consistent with Fermi transitions

Error budget in mirror transitions

N. Severijns and O.N-C, Annu.Rev.Nucl.Part.Sci. **61** (2011) 23

X ≡ never measured



(dominated by error on GT/F mixing ratio, ρ)

Remarks

1. (theoretical): Mirror transitions, like other nuclear transitions, require the inclusion of theoretical corrections (isospin symmetry breaking + nuclear structure).

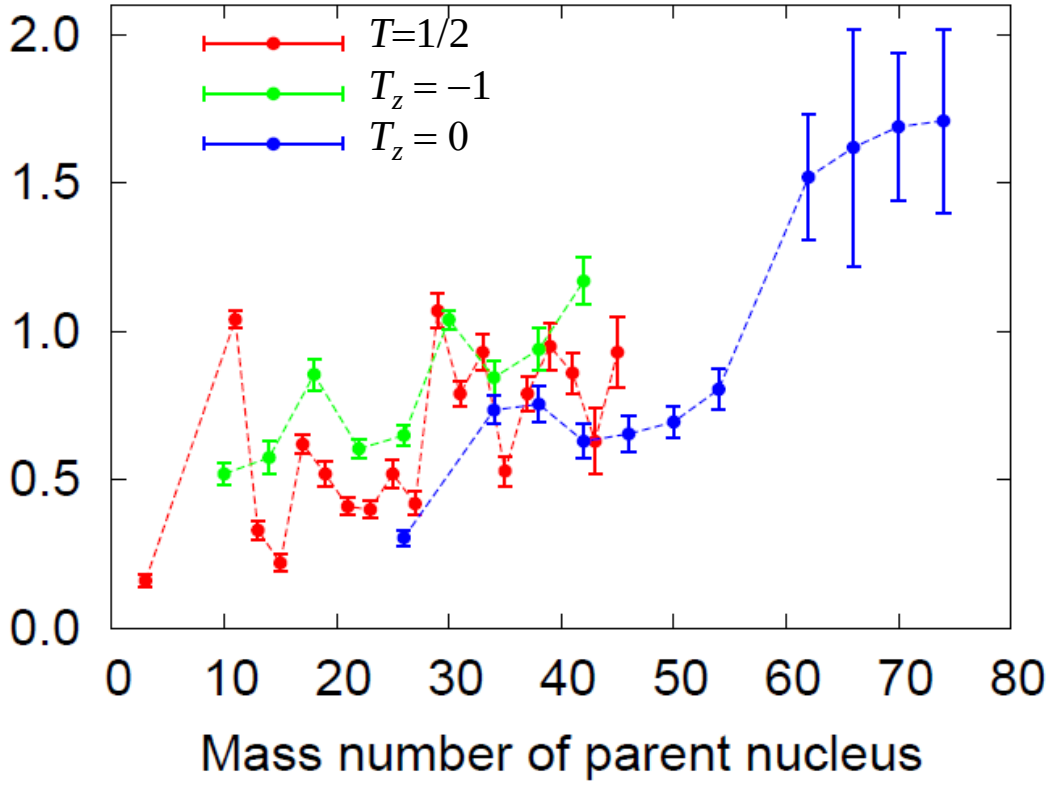
2. (experimental): The transitions involve both, the *V* and *A* interactions: the extraction of V_{ud} requires an additional property to be measured ("correlation" coefficient).

Theoretical corrections

δ_C - δ_{NS} (%)

T=1/2: N.Severijns et al., PRC **78** (2008)055501

$T_z = -1$ and $T_z = 0$: J.Hardy @ I.S.Towner, PRC **79** (2009)055502



- Is there an isospin dependence of the corrections for low masses?

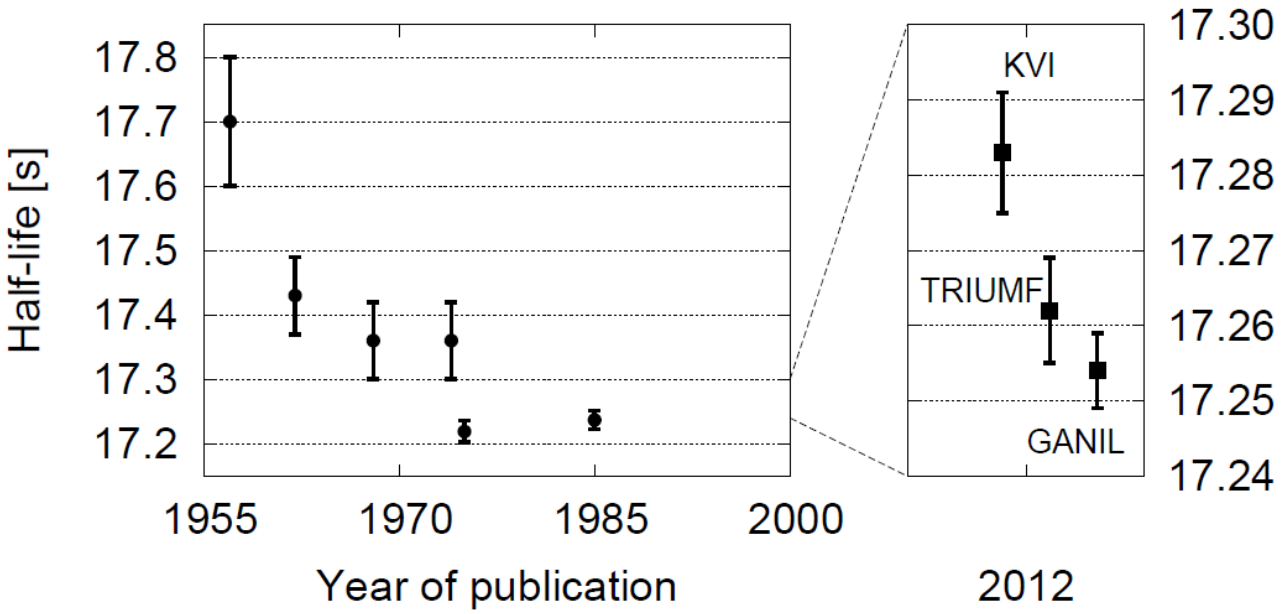
(extending theoretical calculations put models into tests)

Experimental inputs: spectroscopy

$$\mathcal{F}t_0 = \mathcal{F}tC_V^2|M_F^0|^2[1 + (f_A/f_V)\rho^2],$$

$t_{1/2}$, BR, Q_{EC}

Example: ^{19}Ne half-life (s)

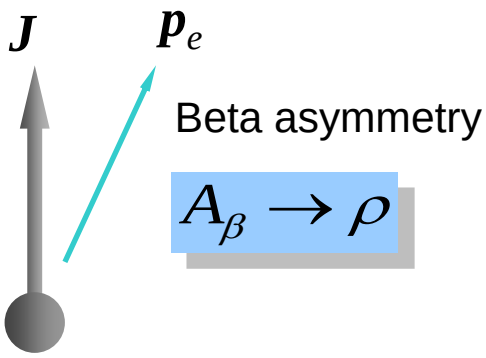


KVI: (PRELIMINARY) L. Broussard, PhD thesis, Duke University, 2012
TRIUMF: S. Triambak et al. PRL**109**(2012)042301
GANIL: (PRELIMINARY) P. Ujic, F. de Oliveira Santos, priv. com.

- Precision: 2.8×10^{-4}
- New proposal to go below the10^{-4} level

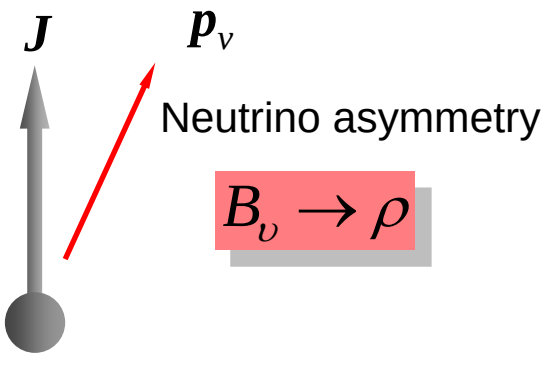
Experimental inputs: correlations

$$\mathcal{F}t_0 = \mathcal{F}tC_V^2|M_F^0|^2[1 + (f_A/f_V)\rho^2],$$



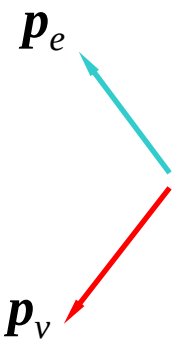
Beta asymmetry

$A_\beta \rightarrow \rho$



Neutrino asymmetry

$B_\upsilon \rightarrow \rho$



$\beta\nu$ angular correlation

$a_{\beta\upsilon} \rightarrow |\rho|$

LPC-Caen trap setup @ GANIL

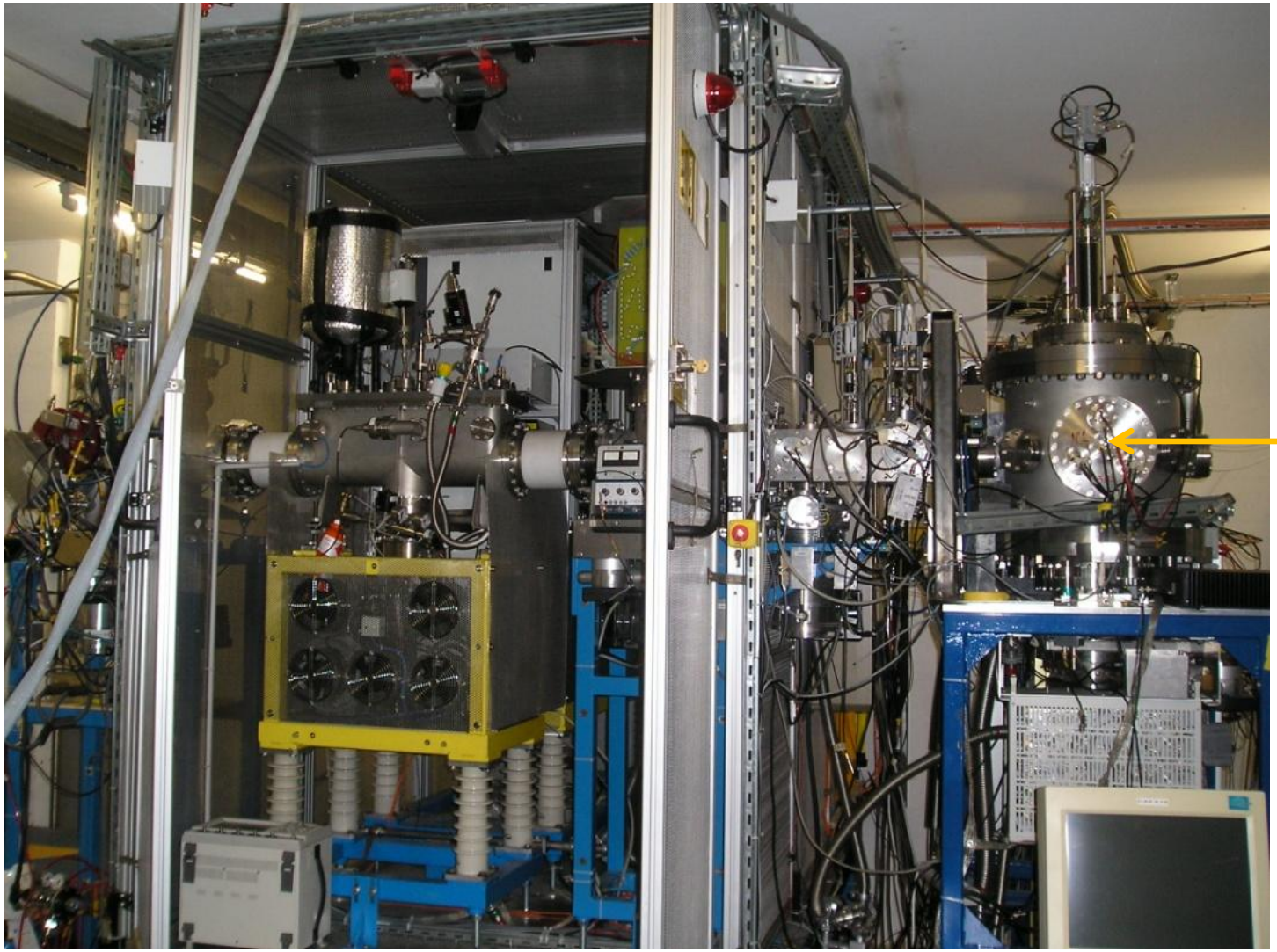
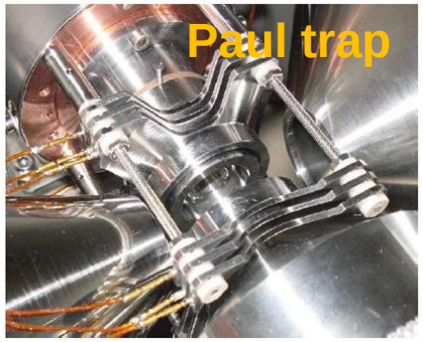


Table top experiment

Measurement of a in ^{35}Ar decay

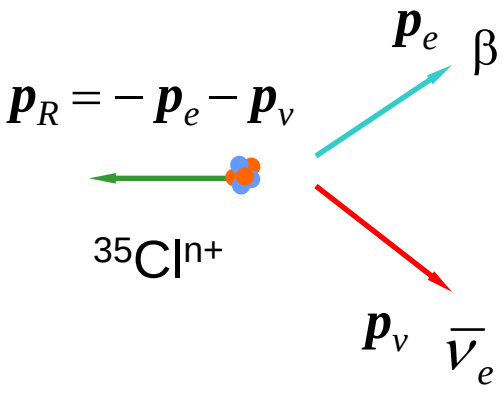
LPC-Caen++ @ GANIL (France)



- Continuous injection/extraction of bunches
- Measure energy and position of β particles
- Measure TOF and position of recoil ions

(over-determined kinematics)

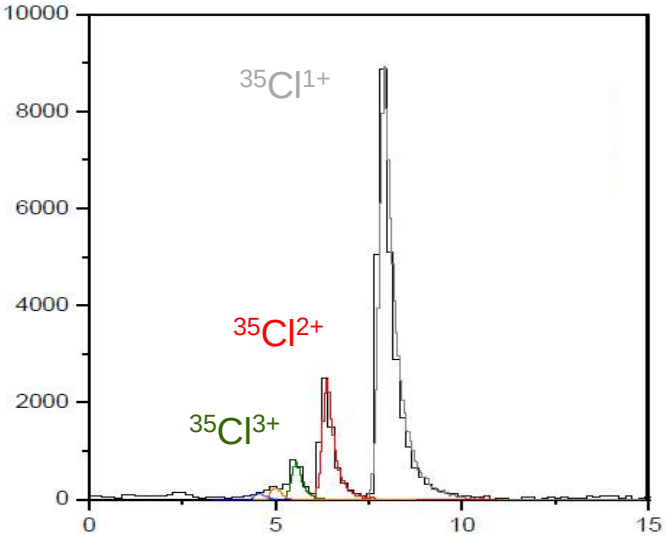
Deduce βν correlation from TOF spectrum of recoiling ions.



- June 2012 run:

$\Delta a/a$ < 0.5 %

- Same setup will be used for ^{19}Ne decay



Current experimental efforts

Parent nucleus	Observable	Group(s)/Lab
^{19}Ne	$t_{1/2}$	TRIUMF([1]); TUNL@KVI([2]); GANIL([2])
	a	LPC-Caen@GANIL
^{21}Na	$t_{1/2}$	TUNL@KVI([2])
	A	NSCL
^{23}Mg	A	NSCL
^{29}P	$t_{1/2}$	CENBG@JYFL
^{31}S	$t_{1/2}$	CENBG@JYFL([2])
	BR	CENBG@JYFL
	Q_{EC}	JYFL([1])
^{35}Ar	a	LPC-Caen([2])
^{37}K	$t_{1/2}$	TUNL@KVI
	a	TRIUMF
	A	NSCL
^{39}Ca	$t_{1/2}$	CENBG@ISOLDE([2])

NEW RESULTS
([1]) published
([2]) available

Summary

• Nuclear mirror transitions have open a new window for the determination of V_{ud}

• The extension requires a robust data set to be built and has motivated numerous new experiments.

• The uncertainties on GT/F mixing ratios are currently the dominant source of error.

• Precision correlation measurements with ion and atom traps and with polarized low energy beams play an important role.