Lifetime measurement of the first 2^+ state in ^{112}Te

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Lifetime measurement in neutron-deficient Te isotopes

- ***Motivation, why Te isotopes?***
- ***Experimental details***
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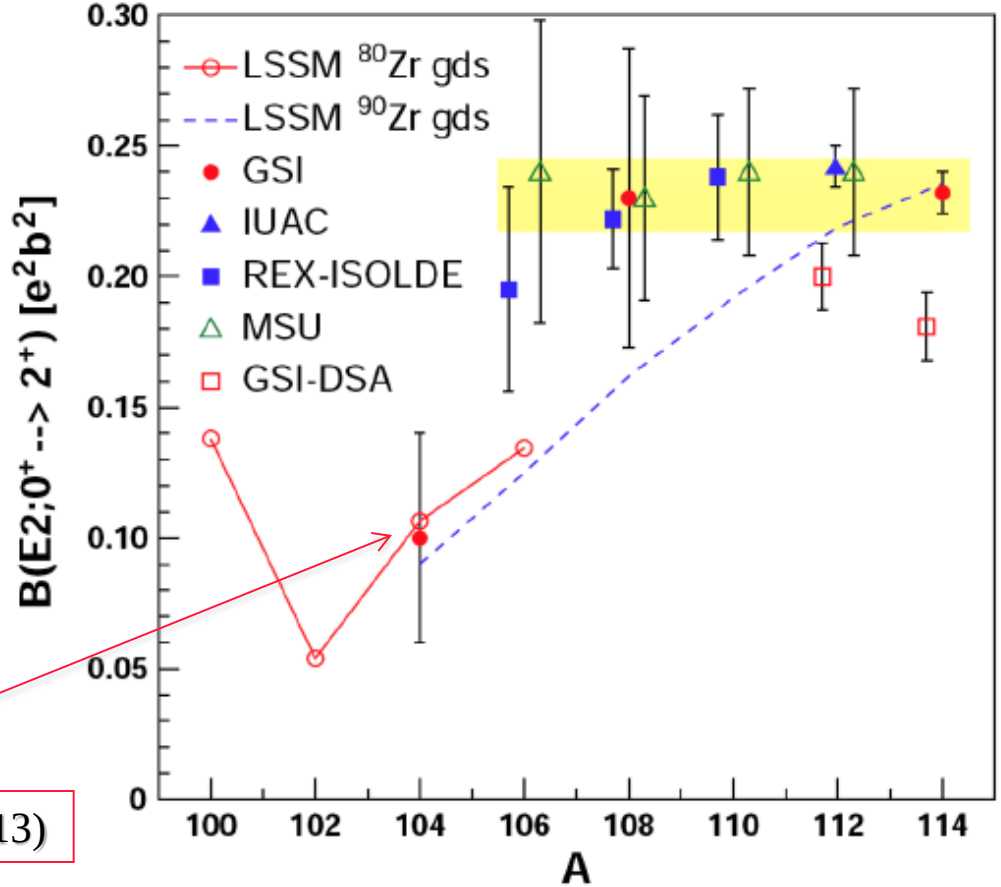
Why Te isotopes?

Evolution of the collectivity for nuclei approaching N=Z
N=50 shell gap weakening??

Evolution of the collectivity in light Sn isotopes



^{104}Sn, PRESPEC, Guastalla et al., PRL 110, (2013)

Why Te isotopes?

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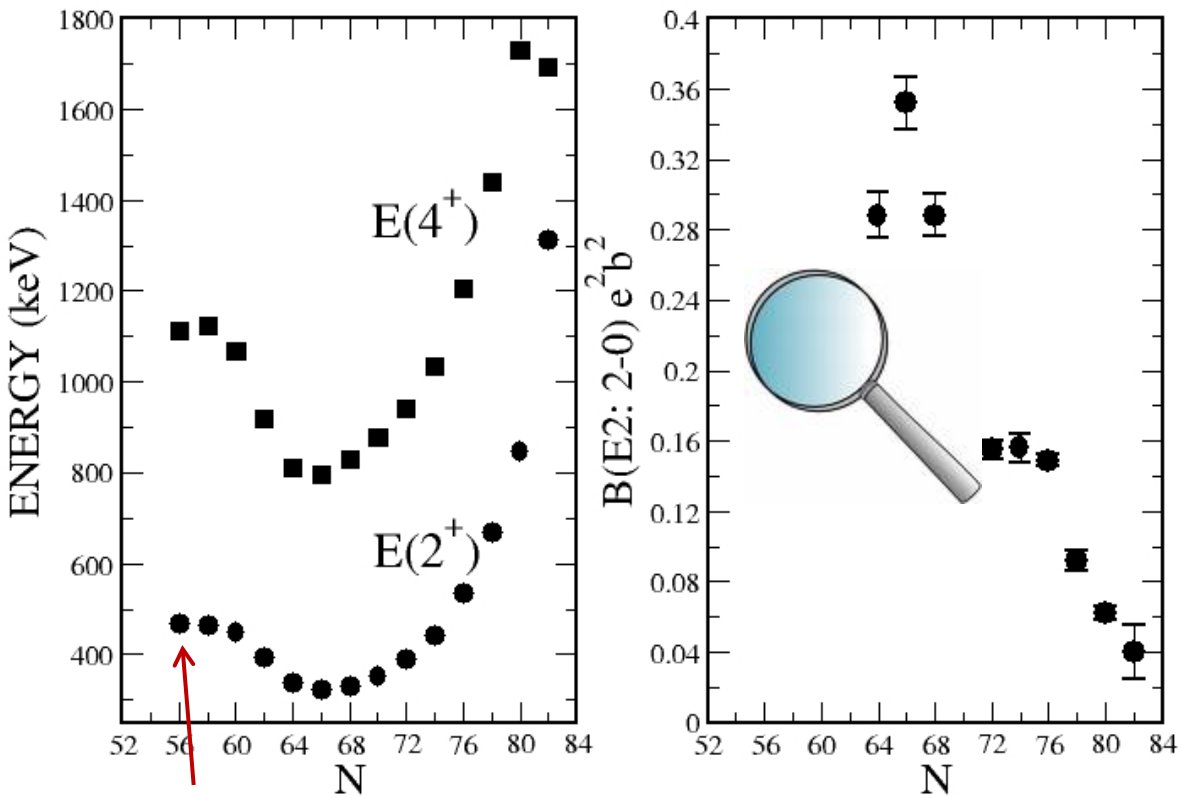
Evidence for enhanced collective strength in Te and Xe nuclei approaching N=Z

Xe experimental $E(2^+)$ and $B(E2; 2^+ \rightarrow 0^+)$ systematics



T_Z=1 nucleus ^{110}Xe; M. Sandzelius, B. Hadinia,, B. Cederwall *et al.*, Phys. Rev. Lett. 99, 022501 (2007)

Why Te isotopes?

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Evidence for enhanced collective strength in Te and Xe nuclei approaching N=Z

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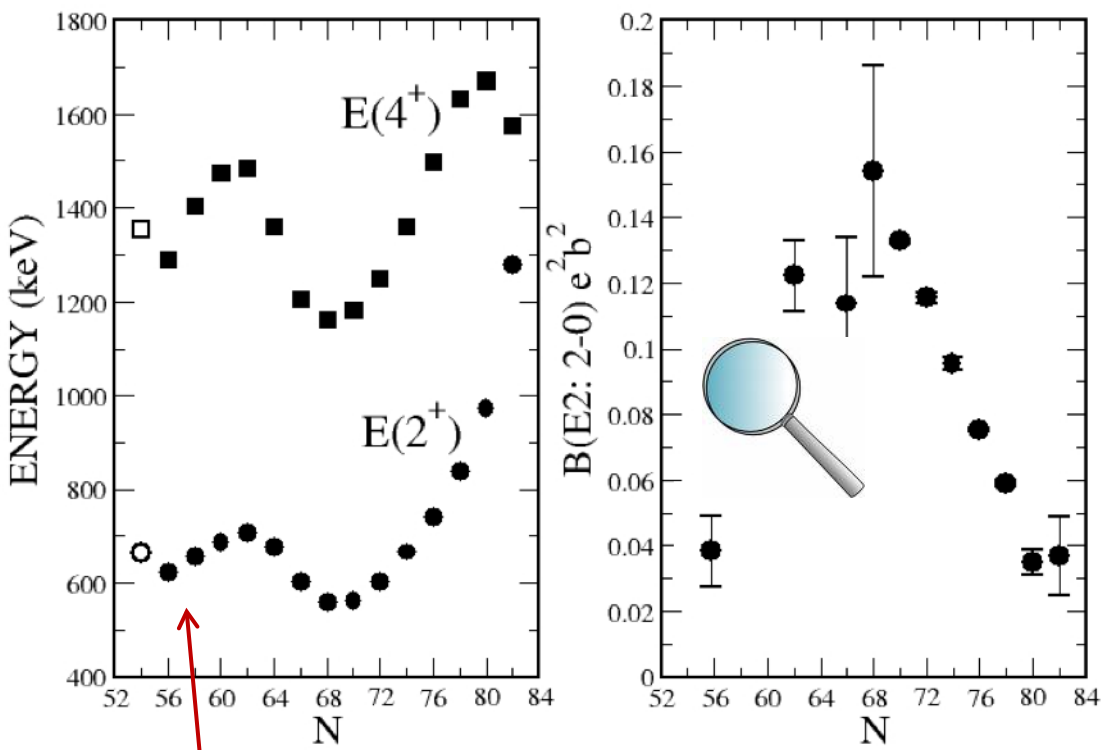


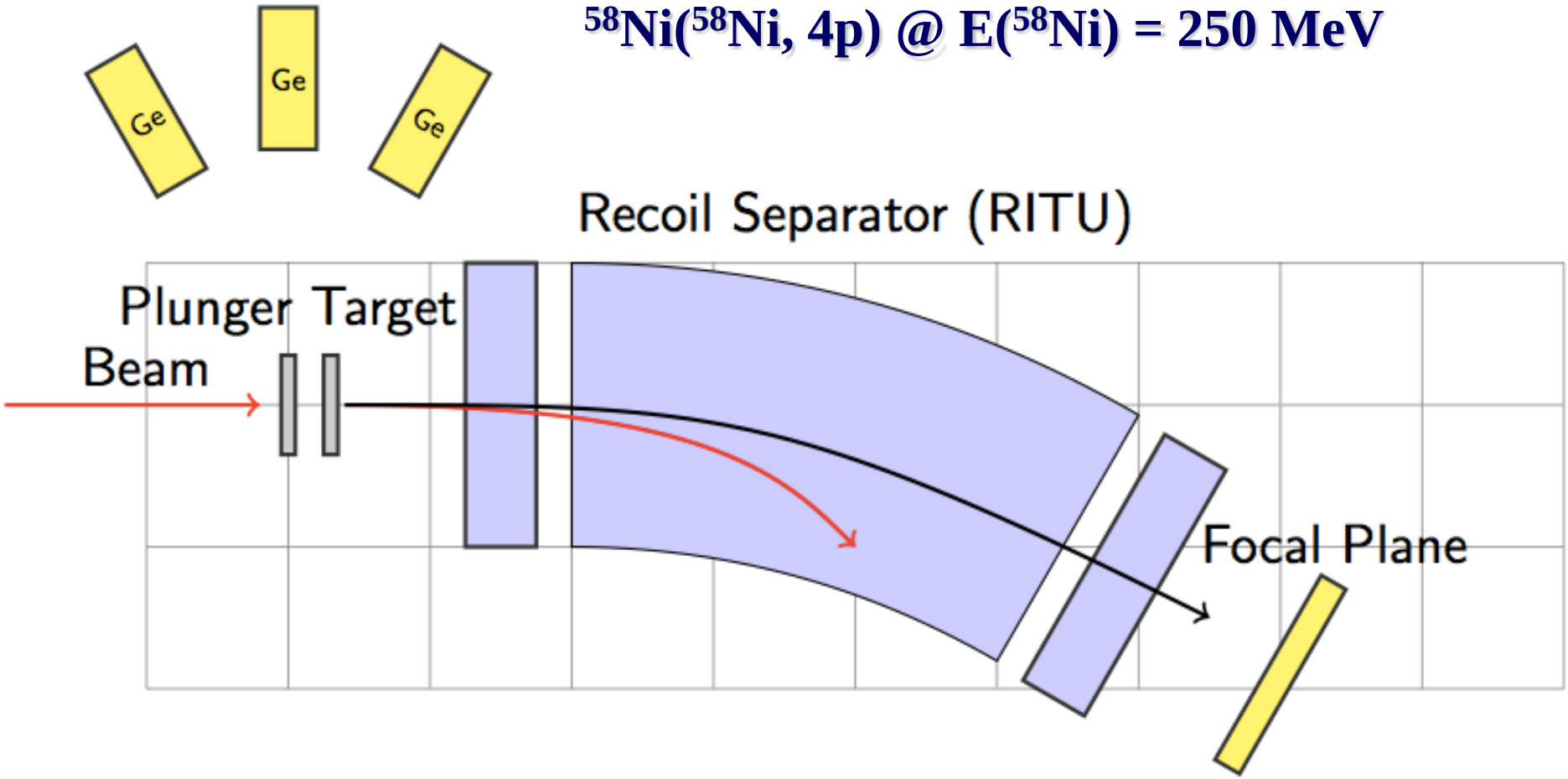
T_Z=1 nucleus ^{106}Te : B. Hadinia, B. Cederwall *et al.*, Phys. Rev. C 72, 041303 (2005)

Experimental setup

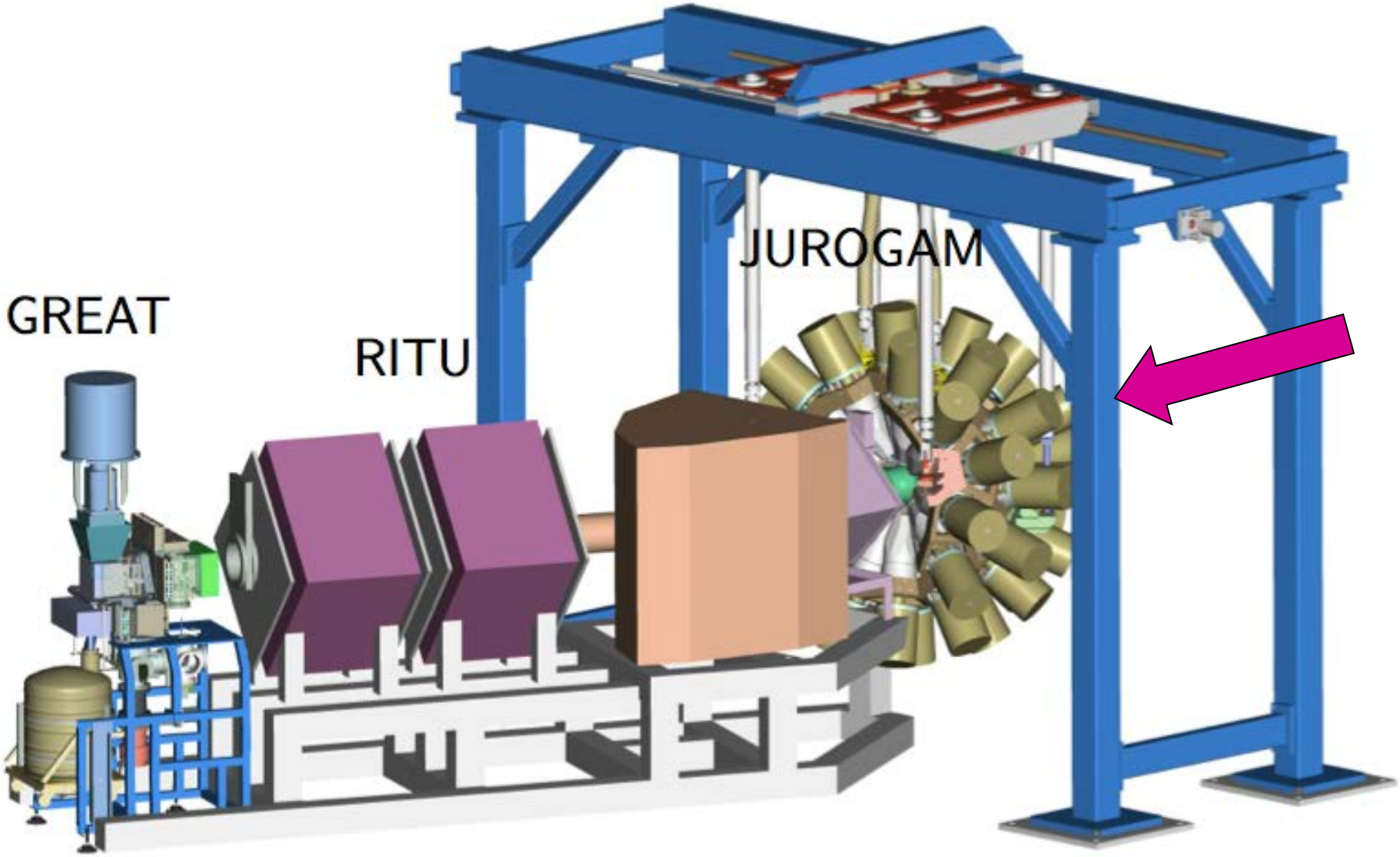
JUROGAM II coupled to RITU and GREAT + DPUNS plunger

Fusion-evaporation reaction

^{58}Ni(^{58}Ni, 4p) @ E(^{58}Ni) = 250 MeV



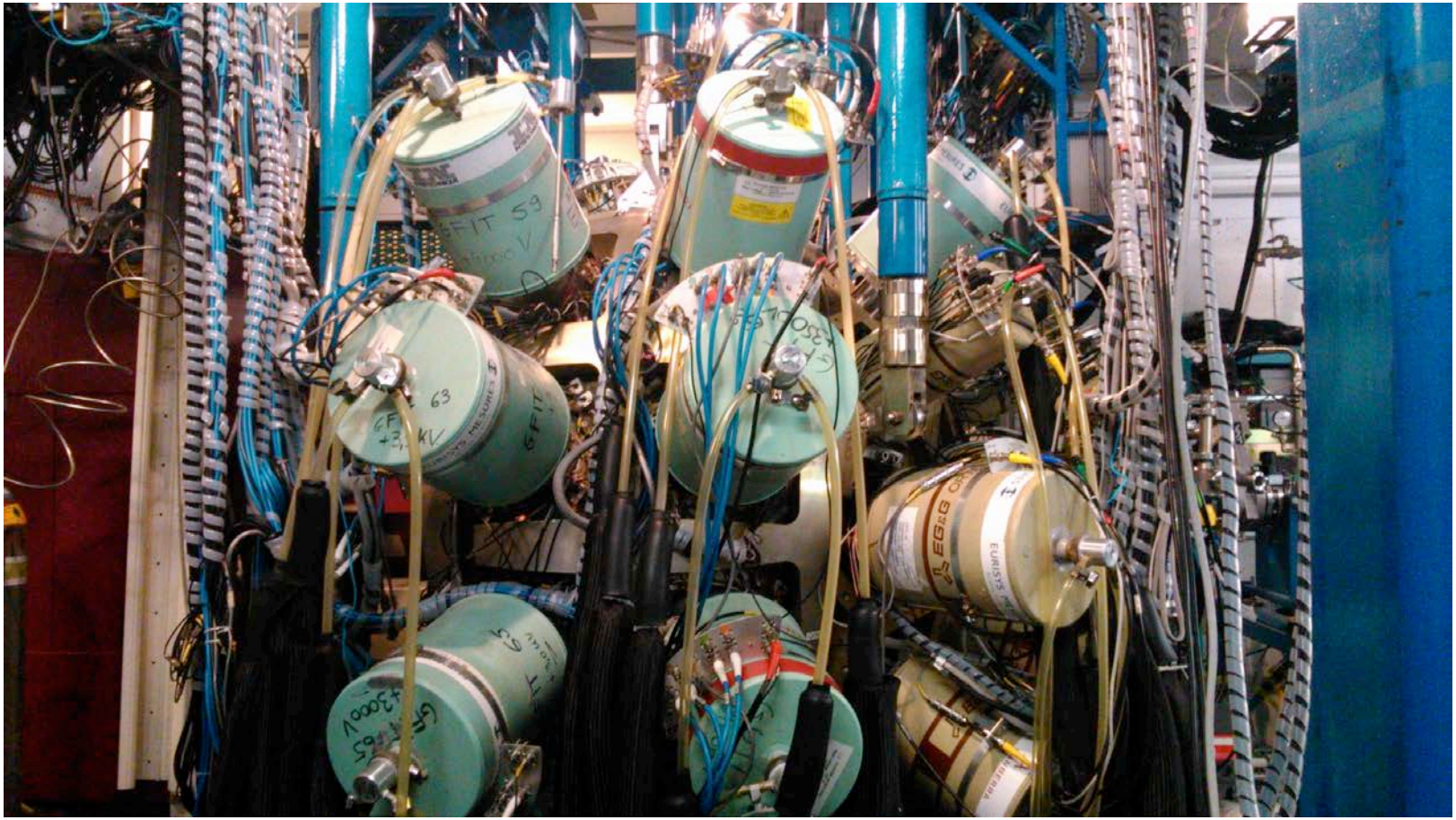
Experimental setup



JUROGAM II

39 HPGe detectors in 4 different rings (24 Clovers + 15 Ph-1 detectors)

Gamma efficiency at 1.3 MeV ~ 6%



JUROGAM II

39 HPGe detectors in 4 different rings (24 Clovers + 15 Ph-1 detectors)

Gamma efficiency at 1.3 MeV ~ 6%

RITU (Recoil Ion Transport Unit)

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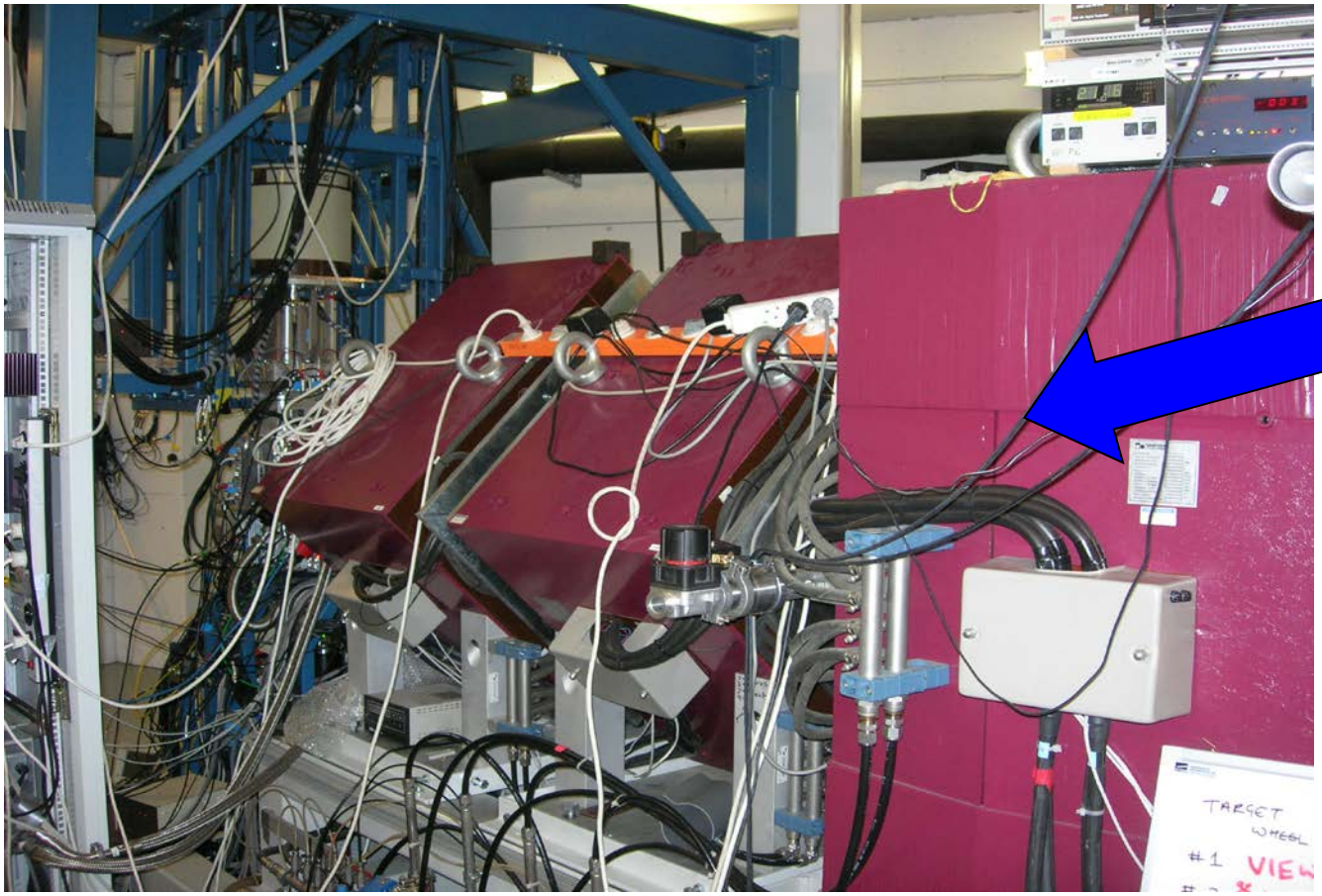
Recoil transport efficiency 20 ~ 40 %

QDQQ system



GREAT (Gamma Recoil Electron Alpha Tagging)

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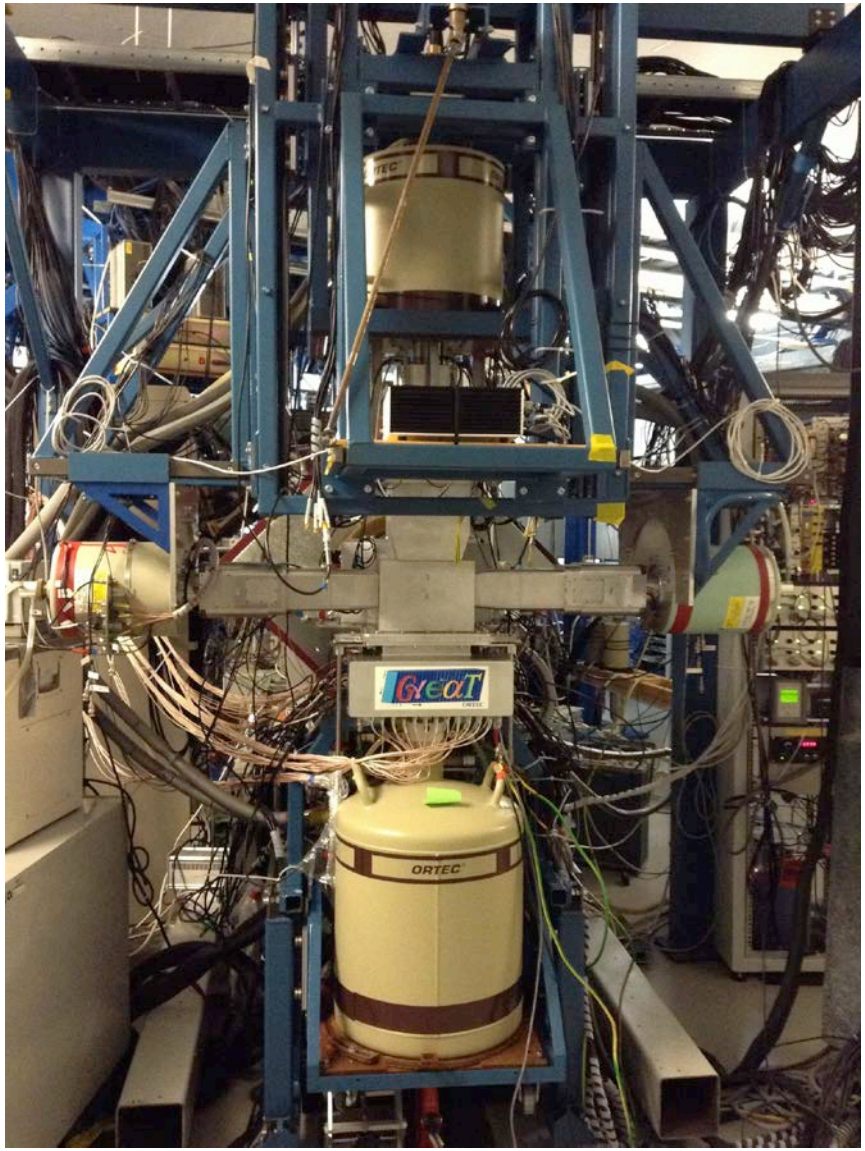
2 DSSD: 60*40 mm^2
4800 pixels
Rate up to 5 kHz

Multiwire proportional counter (MWPC)

Array of 28 Si-PIN photodiodes

Planar Ge strip detector (X-rays, β)

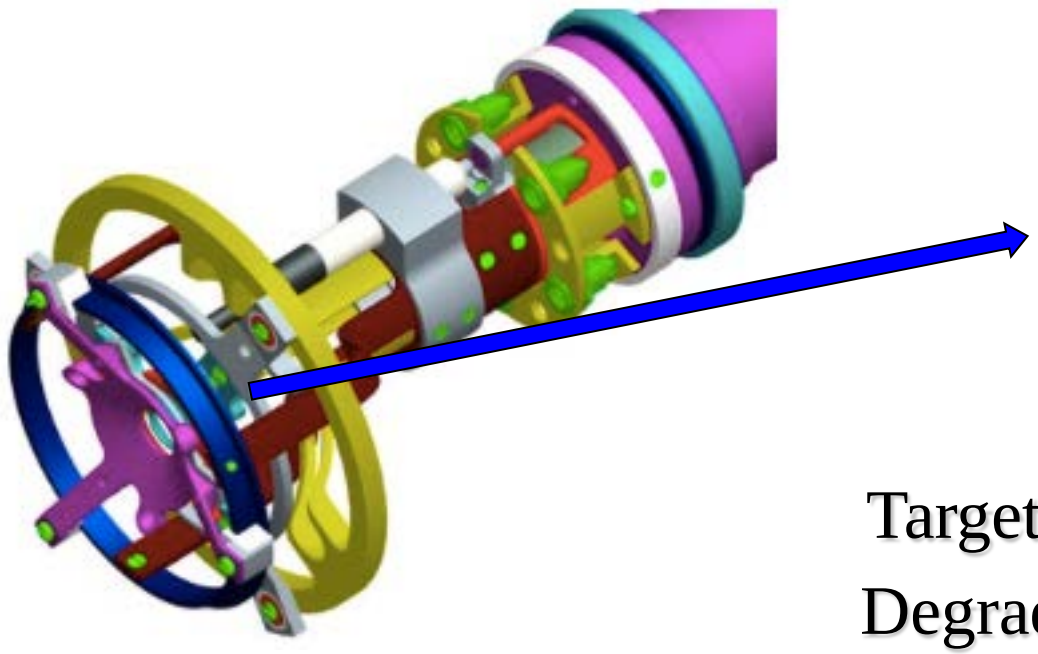
3 Segmented Ge Clover (γ decay)

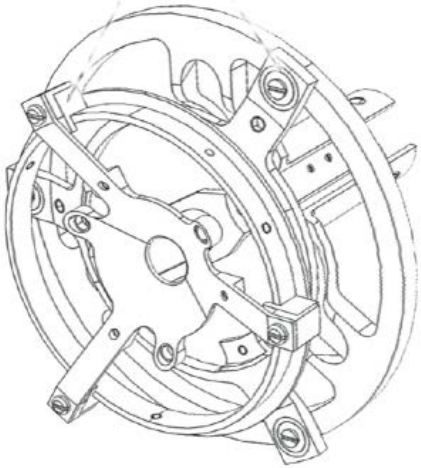


DPUNS (Differential Plunger for Unbound Nuclear States)

Differential plunger device to measure lifetimes of nuclear states beyond the proton drip line developed by the University of Manchester

M. J. Taylor et al., NIMA 707, 143 (2013)



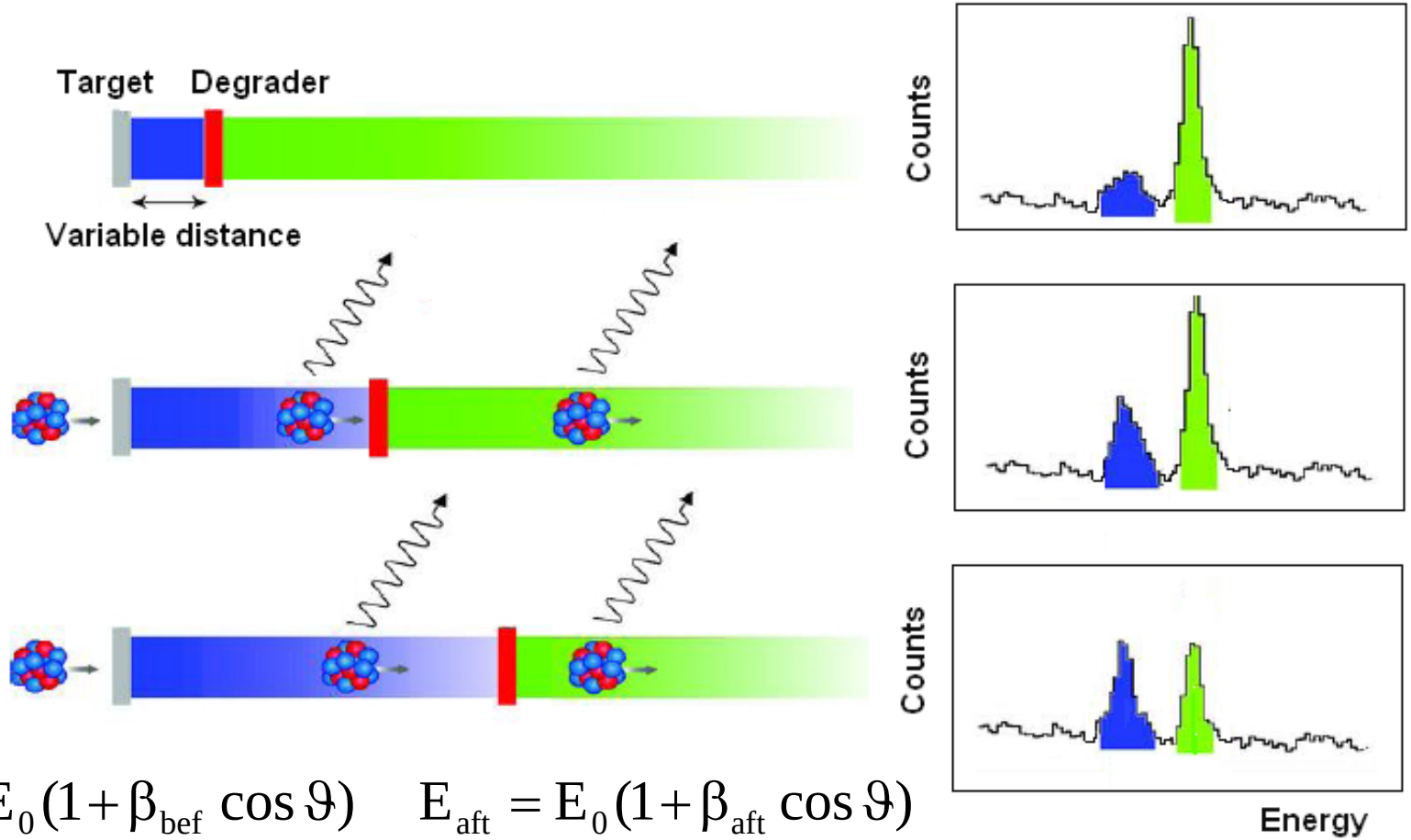


Target: ^{58}Ni 1.05 mg/cm^2

Degrader: Mg1.2 mg/cm^2

Distance range: 5 – 1000 μm

Recoil Distance Doppler Shift Method (RDDS)



$$E_{bef} = E_0(1+\beta_{bef}\cos\vartheta) \qquad E_{aft} = E_0(1+\beta_{aft}\cos\vartheta)$$

Only the Ph-1 detectors placed in rings at 134° and 158° are used for the lifetime determination

Recoil Distance Doppler Shift Method (RDDS)

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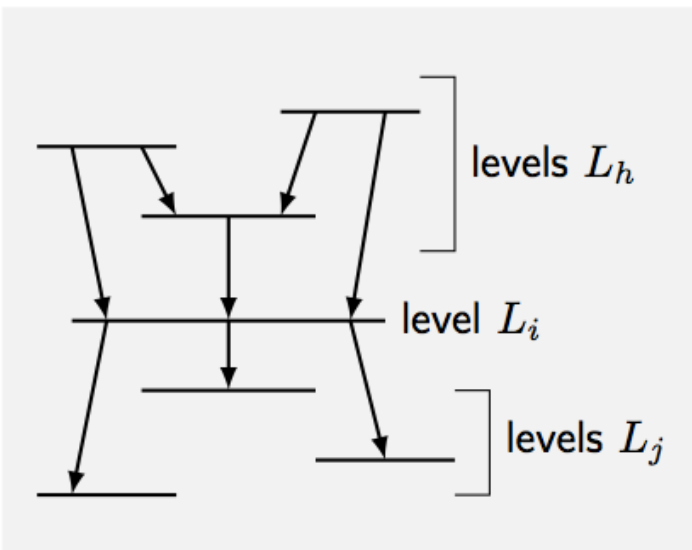
Differential Decay Curve Method (DDCM)

(A. Dewald et al., Z.Phys.A **334** (1989))

The numbers $n_i(t)$, of nuclei in state L_i, etc, at time t, obeys:

$$\frac{\mathrm{d}n_i(t)}{\mathrm{d}t} = -\lambda_i n_i(t) + \sum_h \lambda_h n_h(t) b_{hi}$$



We define the *decay function*, R:

$$R_{ij}(t) = \lambda_i b_{ij} \int_t^\infty n_i(t)\mathrm{d}t$$

$$\frac{\mathrm{d}R_{ij}(t)}{\mathrm{d}t} = -\lambda_i \left[R_{ij}(t) - b_{ij} \sum_h R_{hi}(t) \right]$$

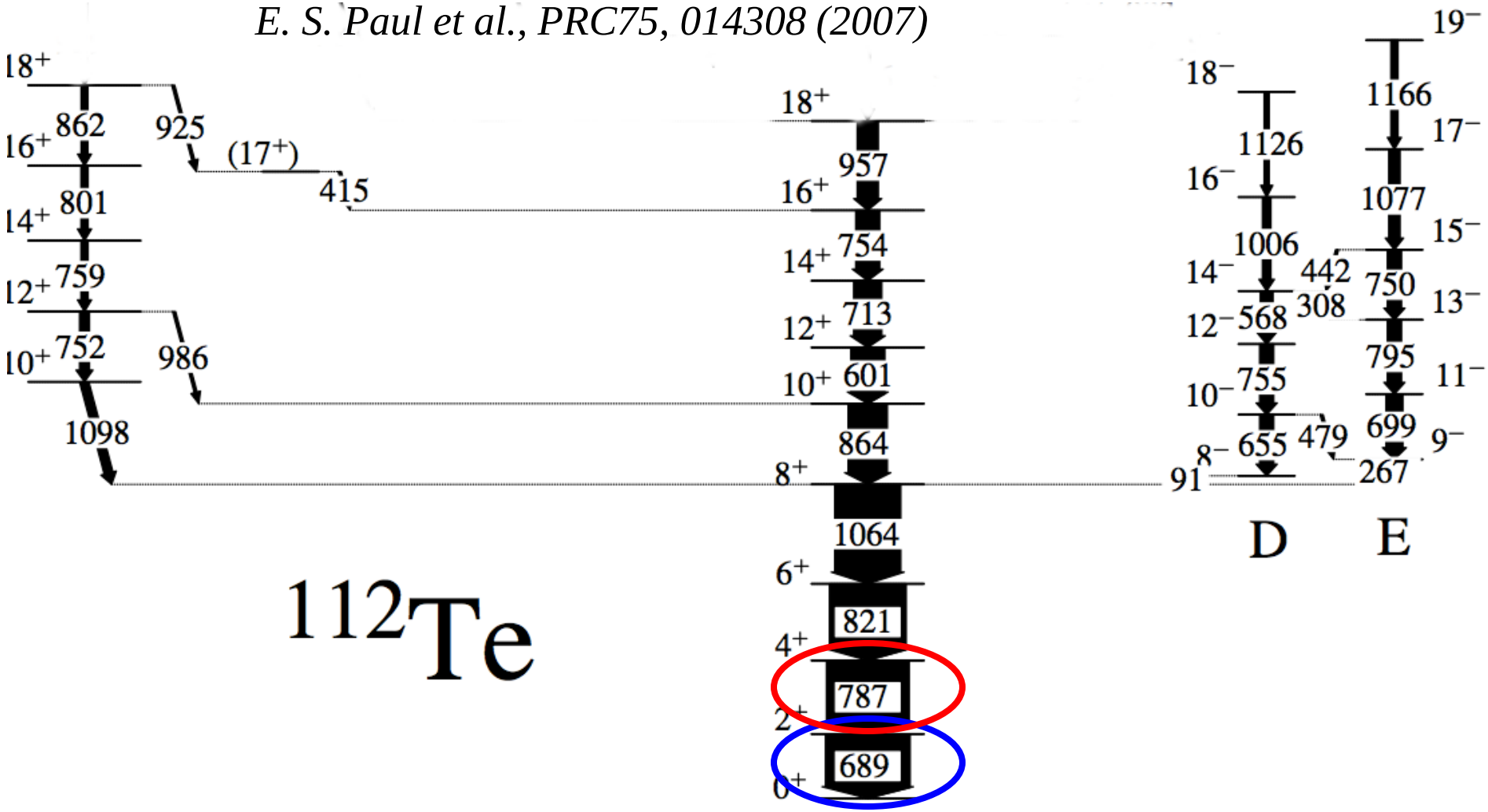
Using $t = x/v$, we can write:

$$Q_{ij}(x) = \frac{R_{ij}(x)}{R_{ij}(0)} = \frac{I^u_{ij}(x)}{I^u_{ij}(x) + I^s_{ij}(x)}$$

$$\tau_i(d) = -\frac{Q_{ij}(d) - b_{ij} \sum_h \left[\frac{J_{hi}}{J_{ij}} \right] Q_{hi}(d)}{v \left[\frac{\mathrm{d}Q_{ij}(d)}{\mathrm{d}x} \right]}$$

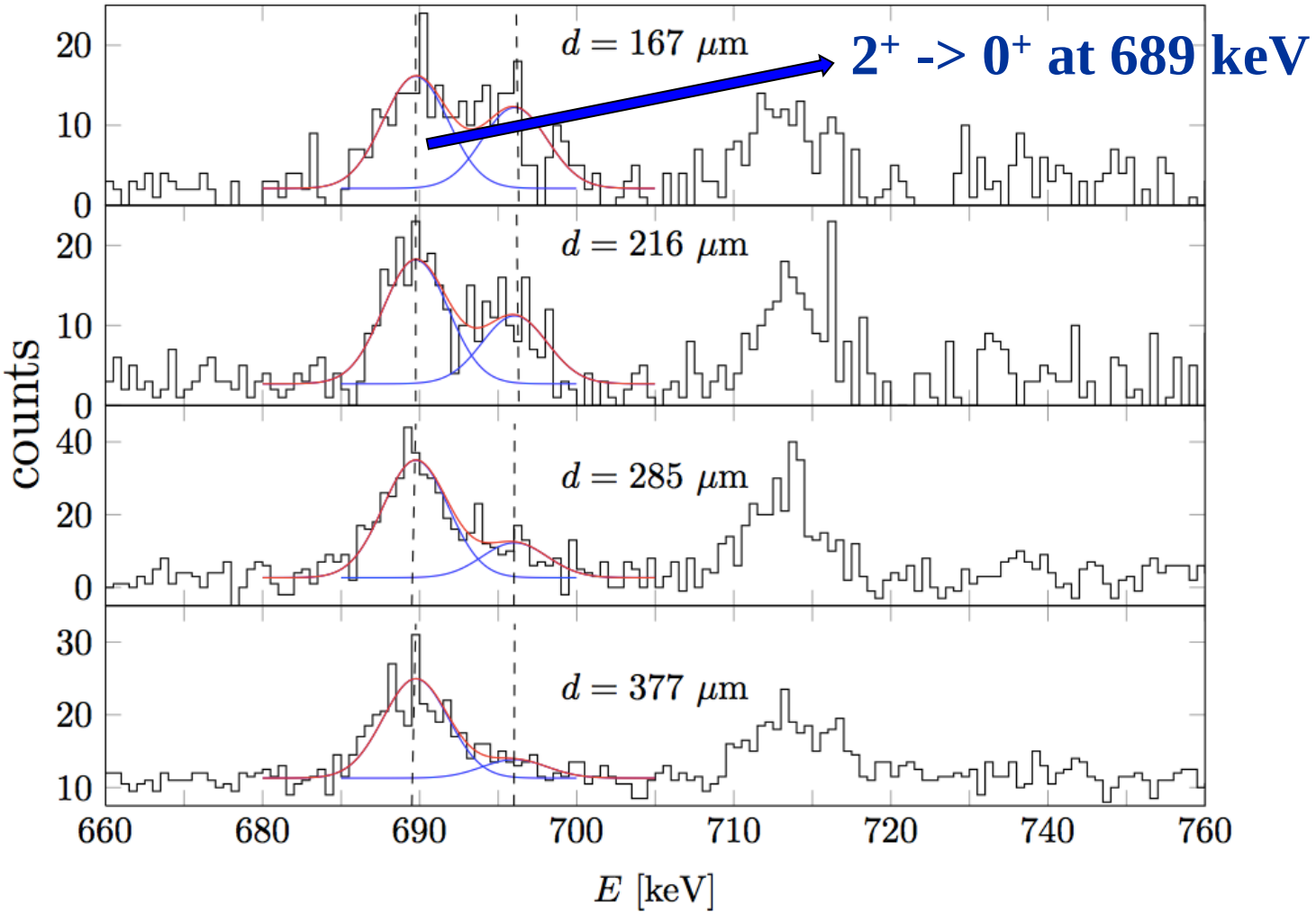
Lifetime of the 2^+ state in ^{112}Te

E. S. Paul et al., PRC75, 014308 (2007)



Gate in the 4^+ state (red) to look at the lifetime of the 2^+ state (blue)

Data analysis



Doppler shift for the 2^+ -> 0^+ transition in the sensitivity region

Experimental results: ^{112}Te

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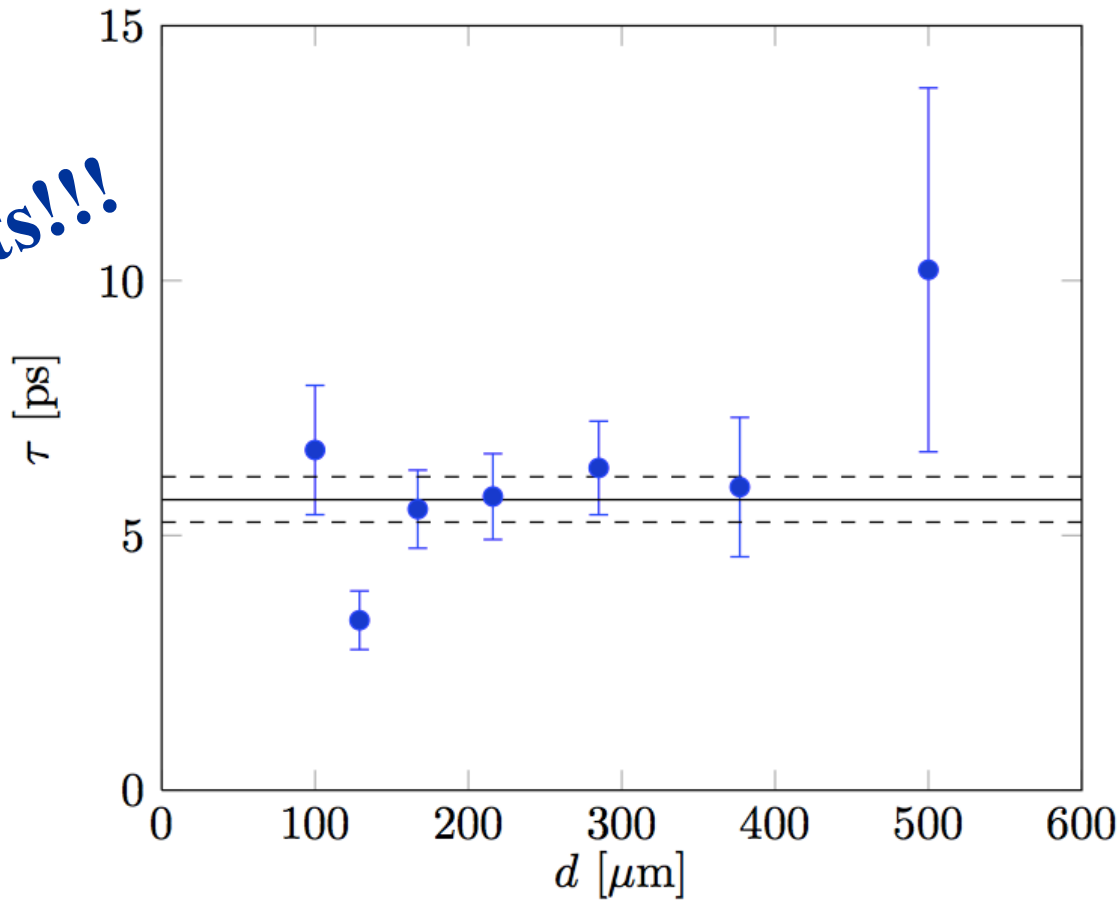
Preliminary results!!!

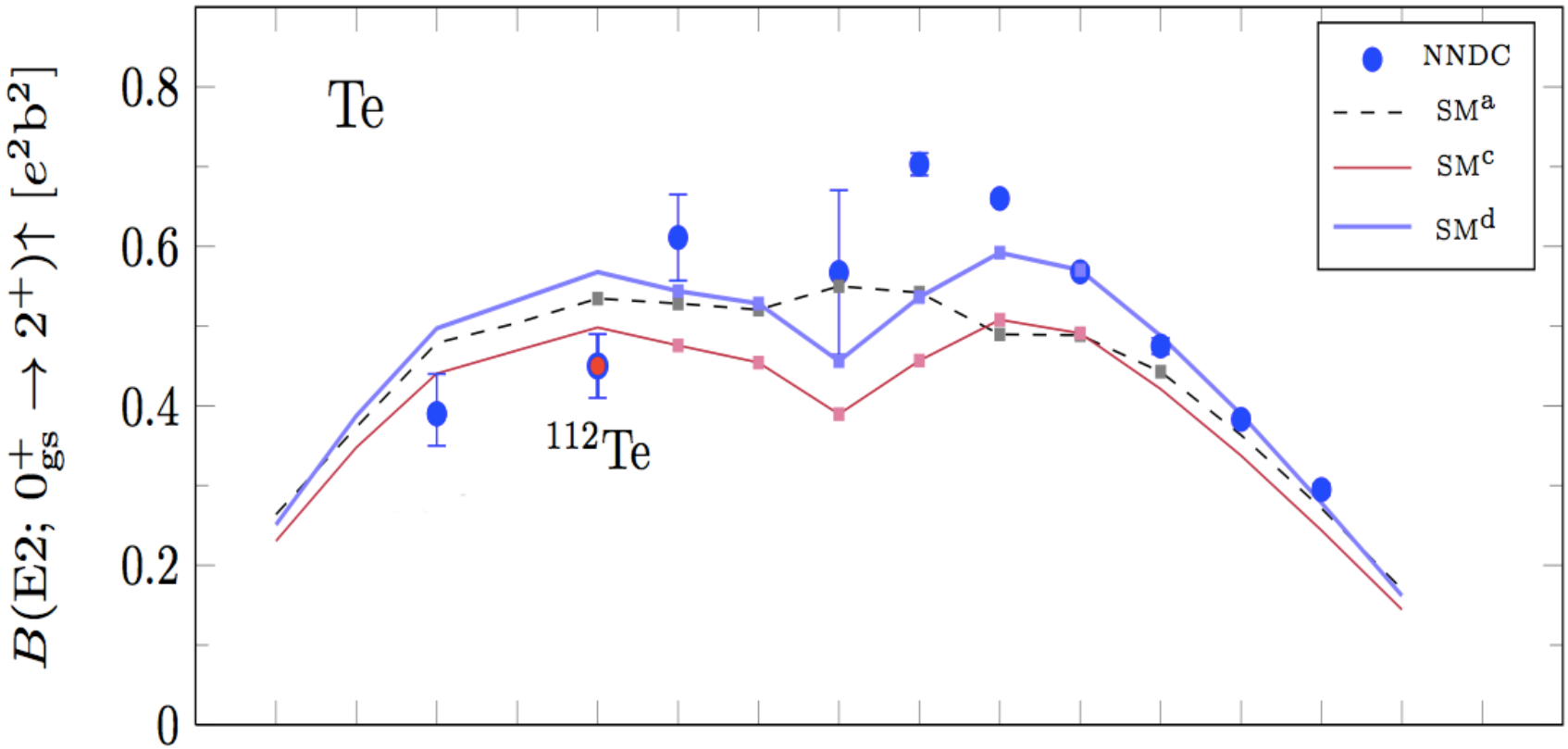


$\tau = 5.8 \pm 0.4$ ps

$B(E2;\ 0^+ \rightarrow 2^+) = 0.46 \pm 0.04\ e^2b^2$

Shell model calculations

^{112}Te full valence space considered for π and ν ($g_{7/2}$, $d_{5/2}$, $d_{3/2}$, $s_{1/2}$ and $h_{11/2}$)



SM^a: CQ, 2011 with old interaction and s.p.e. of Banu, $\varepsilon_p = 0.8, \varepsilon_p = 1.5$
SM^c: CQ, 2014, new interaction, $\varepsilon_p = 0.8, \varepsilon_p = 1.5$
SM^d: CQ, 2014, new interaction, $\varepsilon_p = 0.9, \varepsilon_p = 1.5$

Conclusions

The lifetime of the 2^+ state at 689 keV of the ^{112}Te isotope has been measured using the JUROGAM II array coupled to the RITU spectrometer and the DPUNS plunger setup through the Recoil Distance Doppler Shift method.

The measured value for the reduced transition probability is in good agreement with the shell-model theoretical calculations in the very large *gdsh* valence space.

Thank you!!

M. Doncel[1], T. Back[1], B. Cederwall[1], C. Qi[1], R. Liotta[1], D. Hodge[2], D. Cullen[2], M. J. Taylor[2], M. G. Procter[2], J. Pakarinen[3], T. Grahn[3], P. T. Greenlees[3], K. Auranen[3], U. Jakobsson[3], R. Julin[3], S. Juutinen[3], A. Herzáñ[3], J. Konki[3], M. Leino[3], J. Partanen[3], P. Peura[3], P. Rahkila[3], P. Ruotsalainen[3], M. Sandzelius[3], J. Sarén[3], J. Sorri[3], S. Stolze[3], and J. Uusitalo[3]

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