Properties of low-lying intruder states in ^{34}Al and ^{34}Si populated in the beta-decay of ^{34}Mg

Presented by

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IS530 Collaboration

ISOLDE Workshop and Users meeting, 25-27 November 2013, CERN

Contents

- Scientific motivation
  - N=20 Island of inversion
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- Experimental Setup & DAQ (IS530)
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Scientific motivation

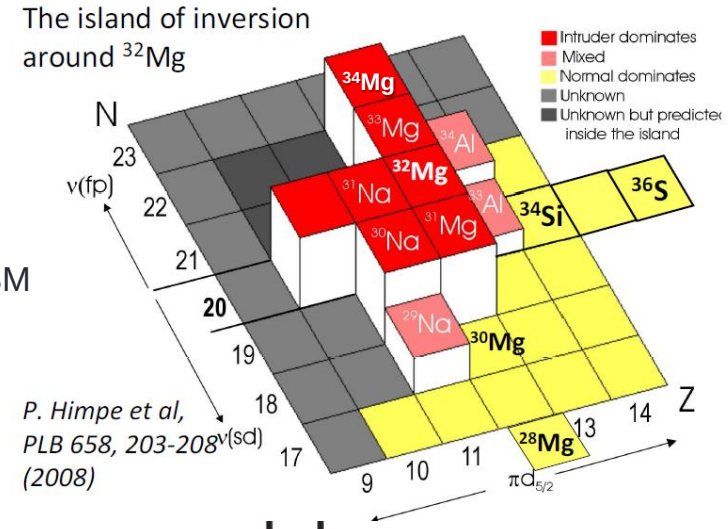
- N=20 Island of Inversion

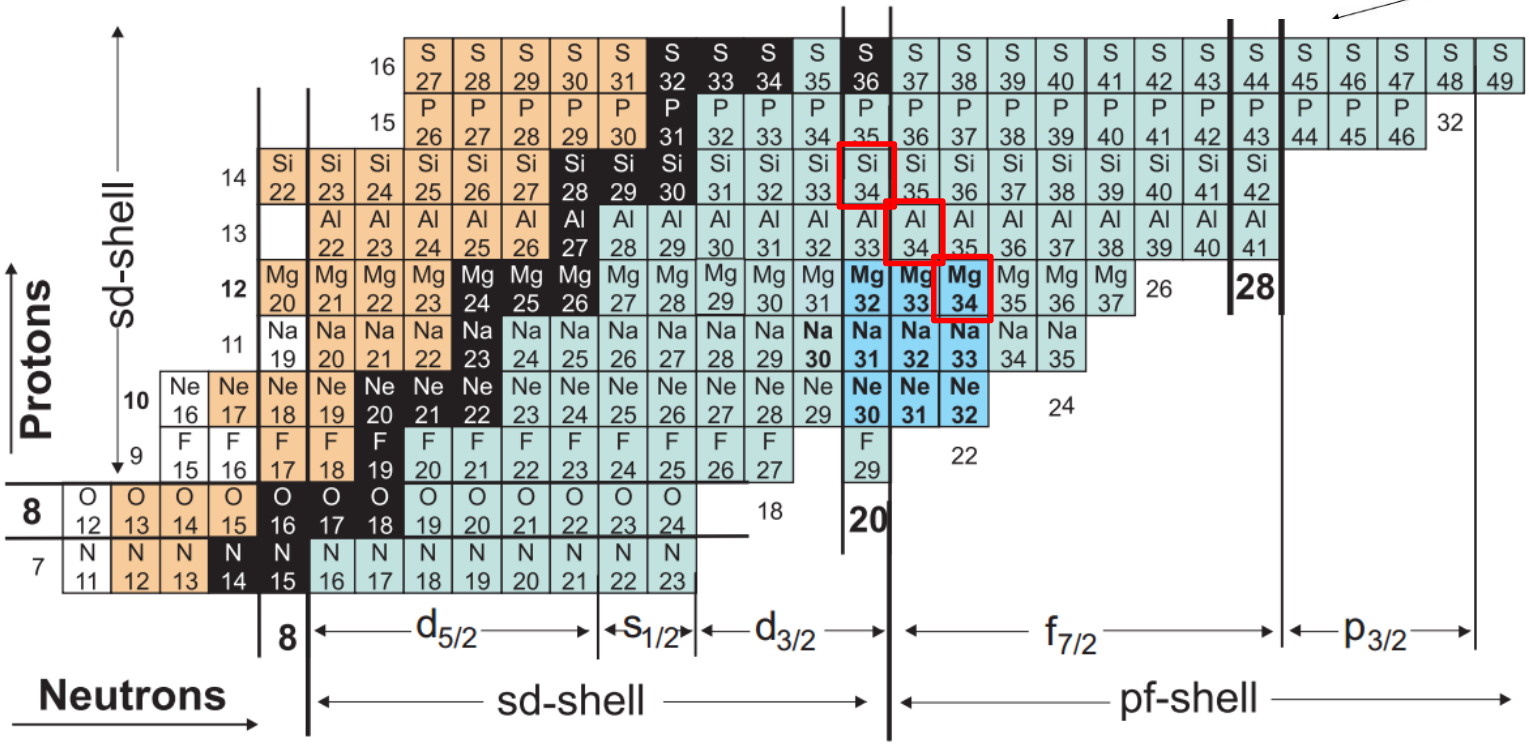
(Introduced by C. Thibault et al. Phys. Rev. C 12 (1975), 644.)

- High deformation for low energy states not predicted by the SM
- Presence of "*intruder states*" due to particle-hole excitations

Explanation:

- lowered sd-pf shell gap
- large correlation energy for deformed intruder states





M. Kowalska, PhD Thesis

Scientific motivation

- Recent ^{34}Si measurement at GANIL-LISE

PRL **109,** 092503 (2012) PHYSICAL REVIEW LETTERS week ending 31 AUGUST 2012

Unveiling the Intruder Deformed 0_2^+ State in ^{34}Si

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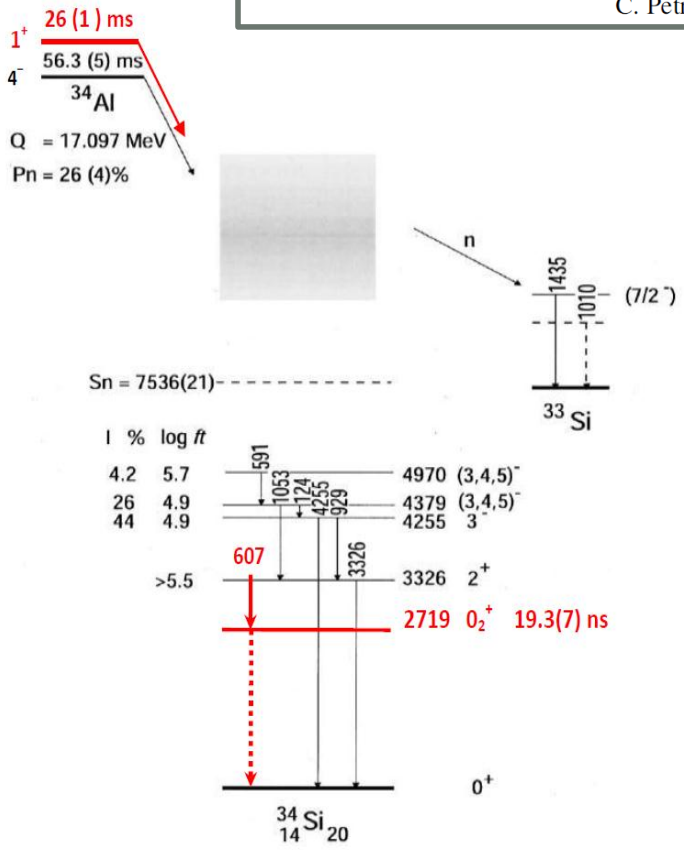
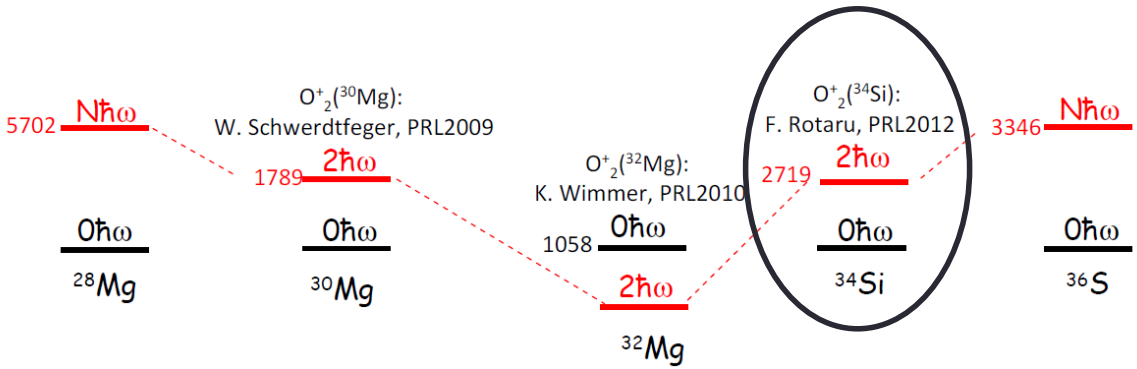
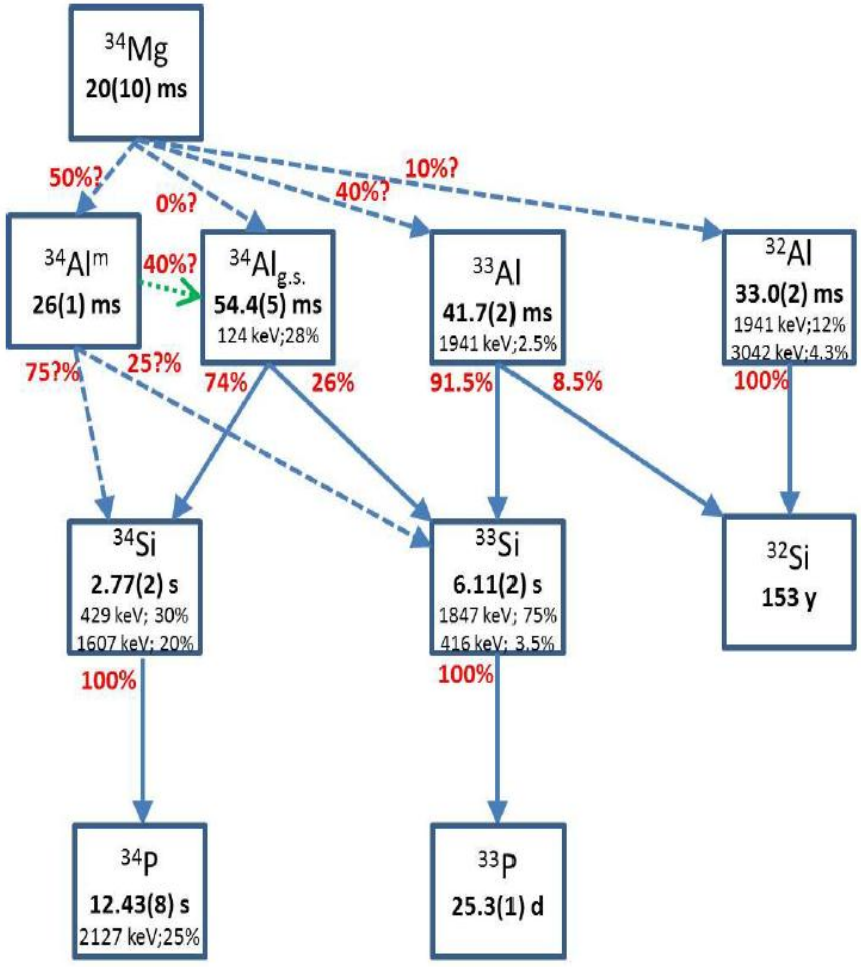


- Reports a low-lying long-lived isomer in ^{34}Al
- Obtained the energy excitation of the 0_2^+ state in ^{34}Si, deduced from electron-positron pairs energy measurement (2719 keV)
- Measured the half-life (19.3(7)ns) of 0_2^+ in ^{34}Si
- Deduced the 1^+ character of the beta-isomer in ^{34}Al and measured its half-live of 26(1) ms

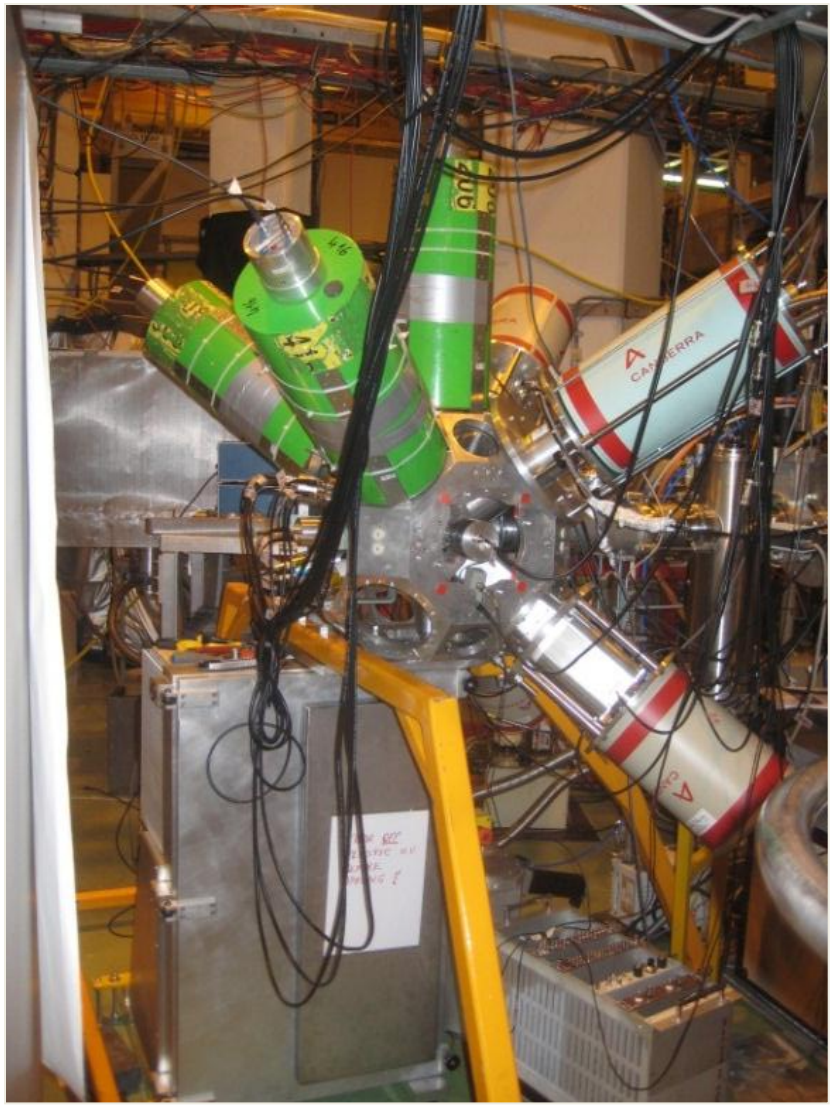


Objectives before the experiment

- First time measurement of the gamma rays following the β- decay of ^{34}Mg
- Build the first level scheme for ^{34}Al
- Measure the excitation energy of the newly observed 1^+ isomer;
- Measure the intensity of the ($2^+ \rightarrow 0_2^+$) transition in ^{34}Si

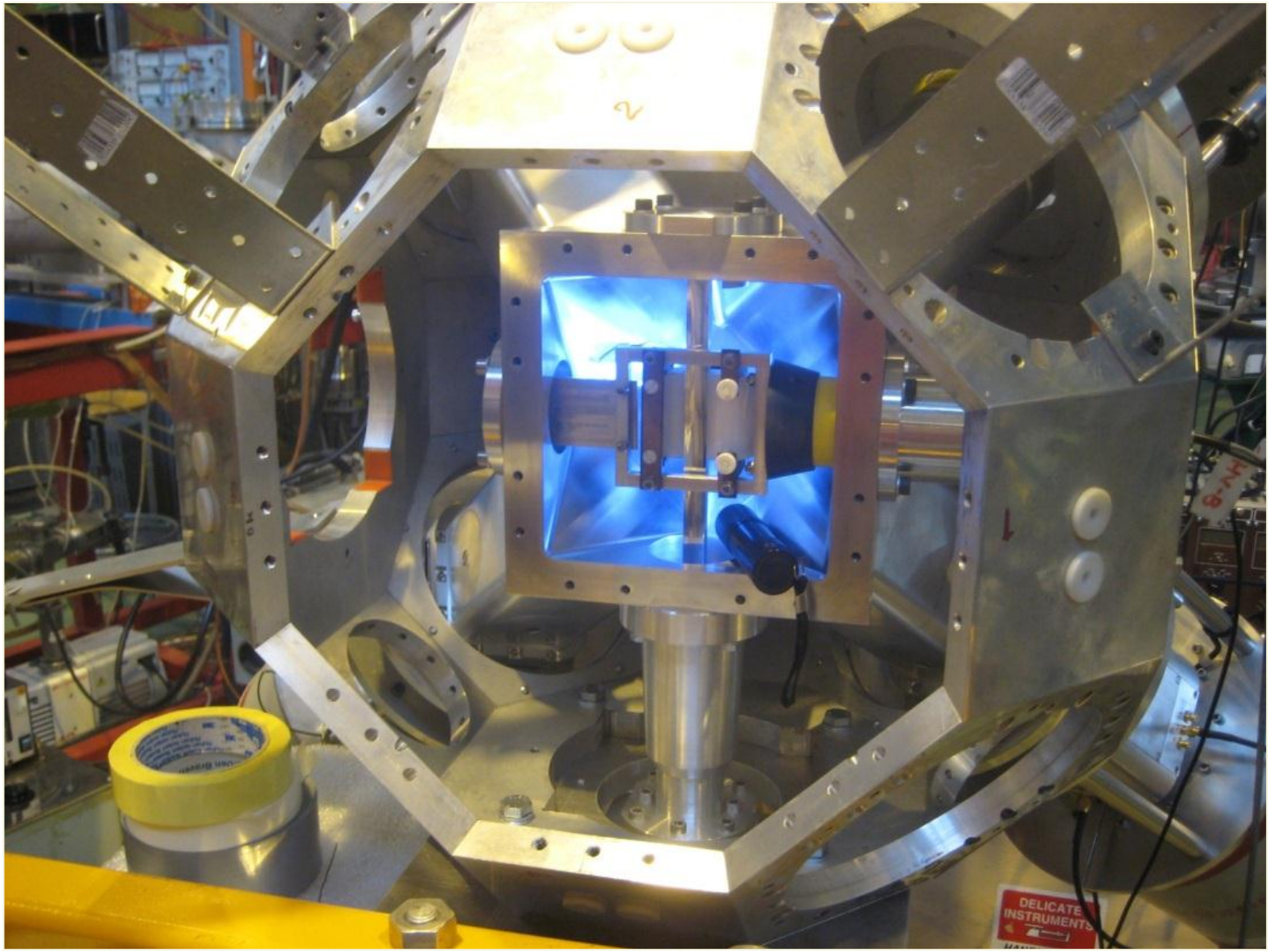


IS530 (Sep 2012) - Experimental setup



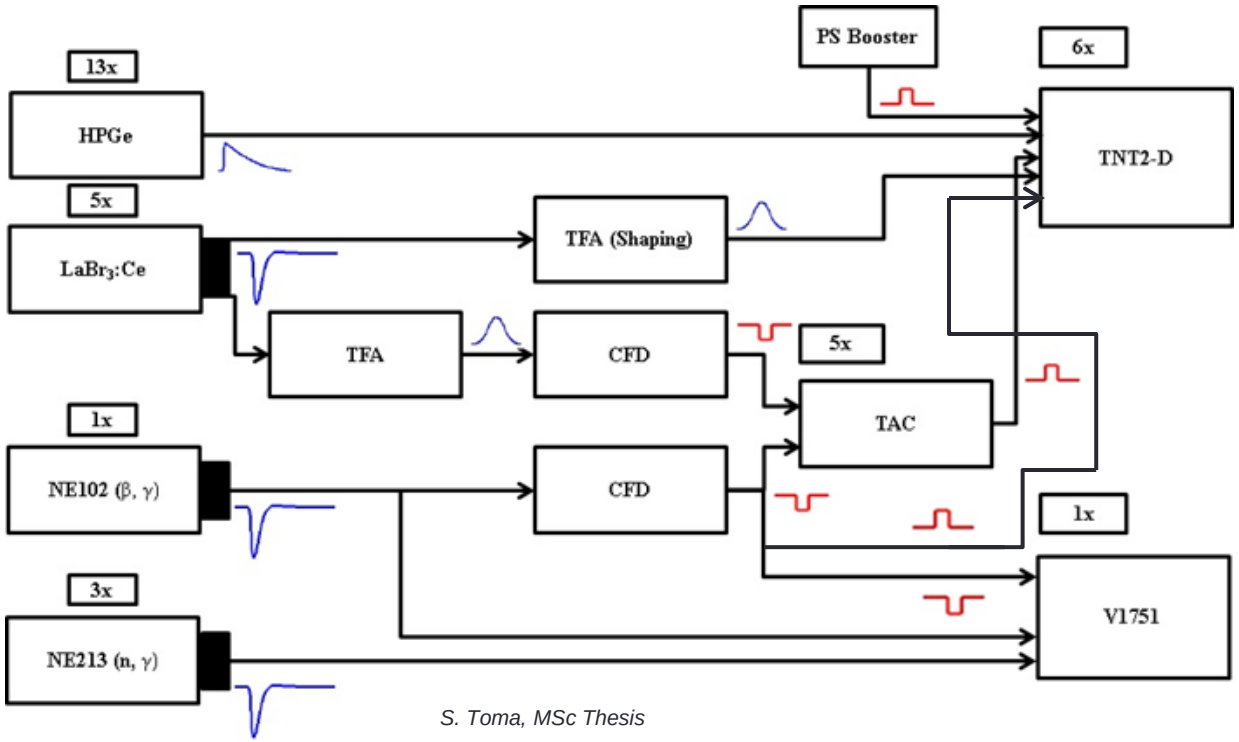
- Structure – based on OSIRIS (Bucharest)
- 3 CLOVER detectors (Bucharest)
- 1 HPGe detector (90%) (Strasbourg)
- 5 $LaBr_3$ detectors (4 Legnaro, 1 Bucharest)
- ~4π NE102 plastic scintilator (Bucharest)
- 3 neutron detectors (NE213 DEMON, Strasbourg)
- Tape station (Strasbourg)
- Data ACQ (Bucharest)

IS530 (Sep 2012) - Experimental setup



IS530 (Sep 2012) - DAQ

- 6x **TNT2-D** 100MS/s fADCs for γ-setup
- 1x **CAEN V1751** 1 GS/s fADC Fast β-n Discriminator
- Event Builder Software developed at IFIN-HH
- Analysis Software – GASPware + ROOT



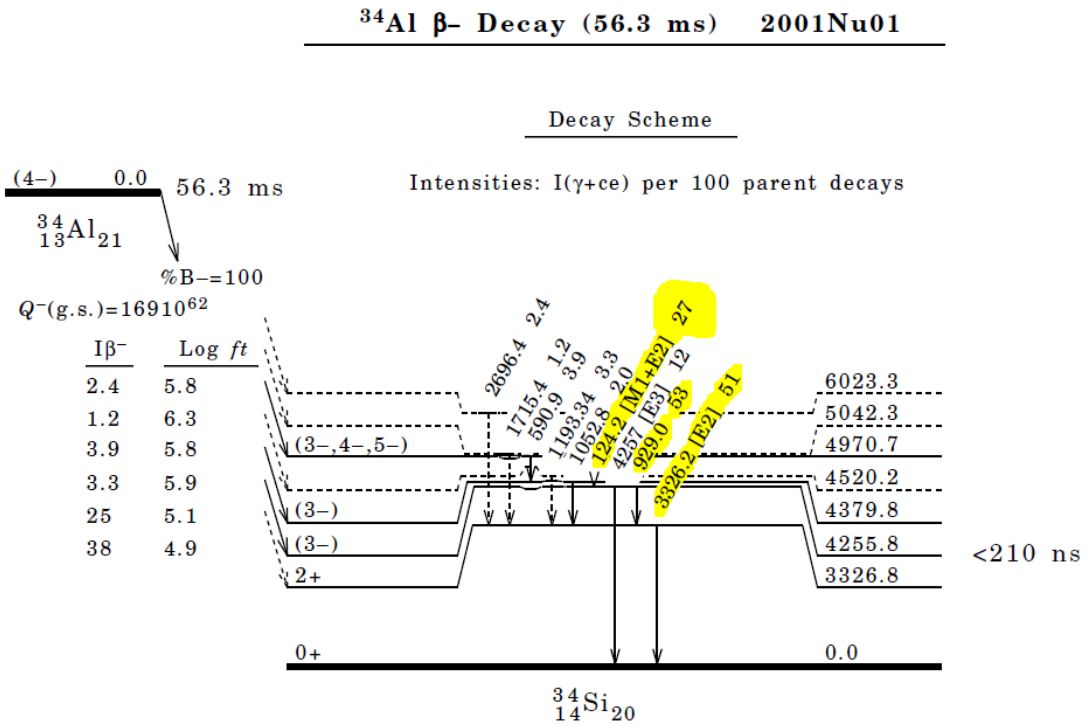
S. Toma, MSc Thesis

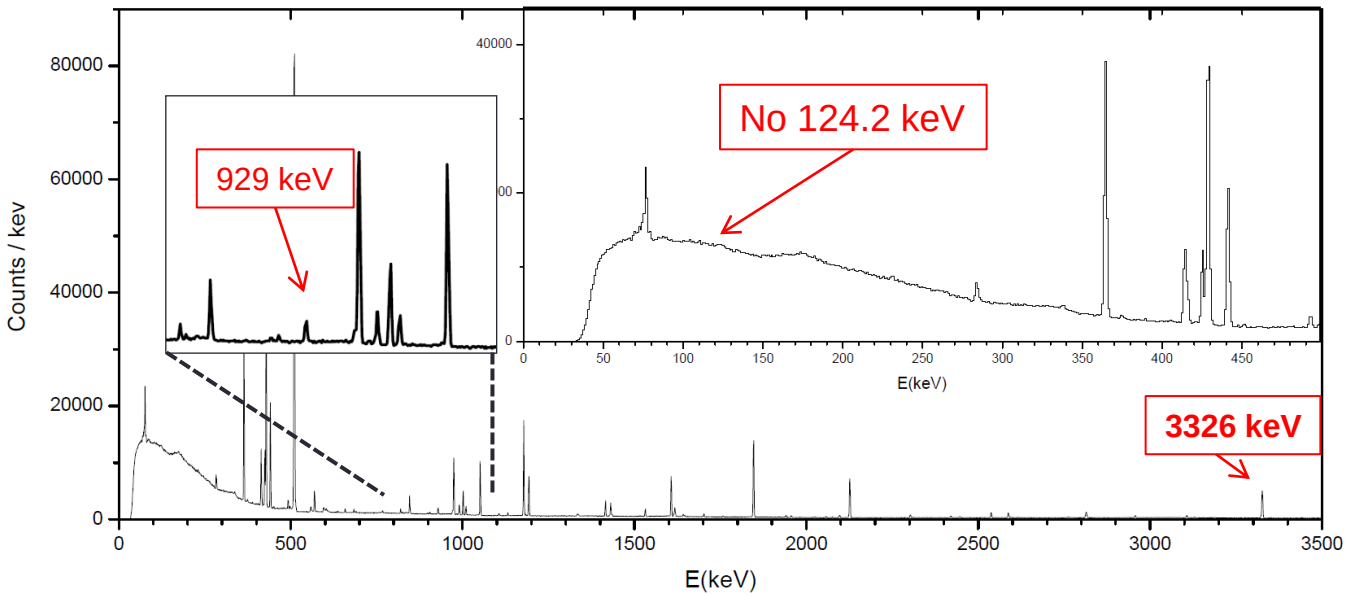
IS530
Experimental Results

^{34}Si

- Very weak (~zero) population of the 4$^-$ state in ^{34}Al suggested by the weak population of the high spin states (3$^-$, 4$^-$, 5$^-$) in ^{34}Si

$$\frac{I_\gamma(929)}{I_\gamma(3326)} \approx \begin{cases} 0.06(IS530) \\ \neq \\ 1.04(Nu01) \end{cases}$$

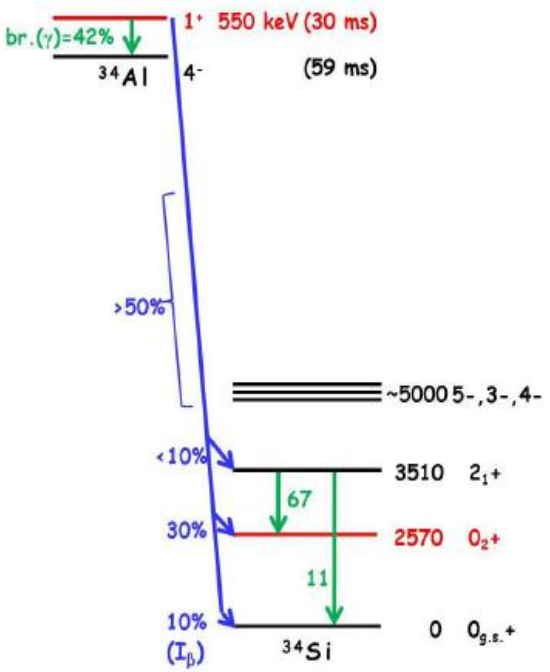




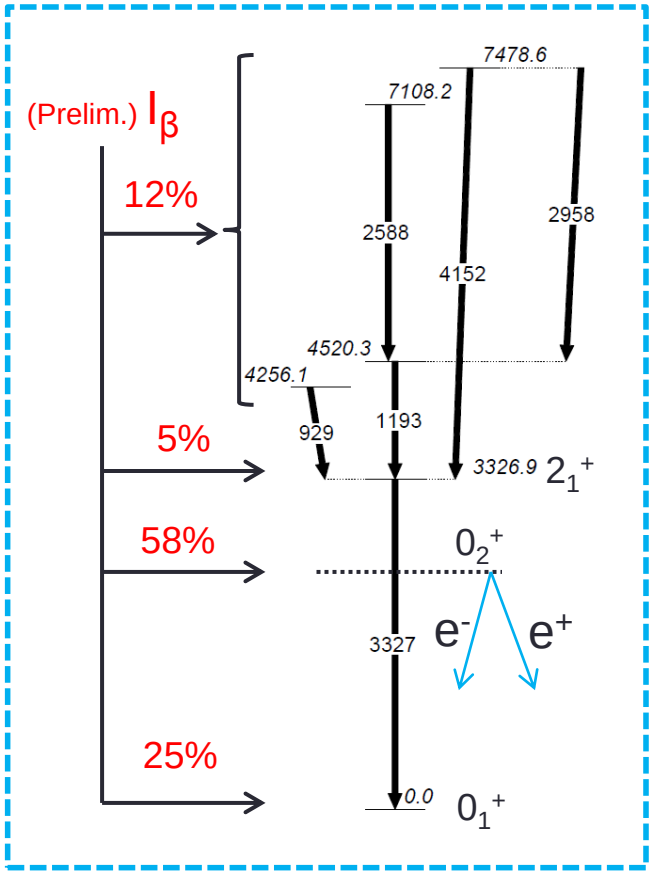
IS530 beta-gated HPGe spectra

^{34}Si

- Shell Model calculations (Antoine) using a modified SDPF-U-SI interaction for the decay of the 1^+ from ^{34}Al.
- IS530 – new gammas in coincidence with previous ones from ^{34}Si. Rough estimations for beta feedings.
- Measurement of double hit events in the plastic scintillator - beta electron followed by e^-e^+ pair from the E0 ($0_2^+ \rightarrow 0_1^+$)

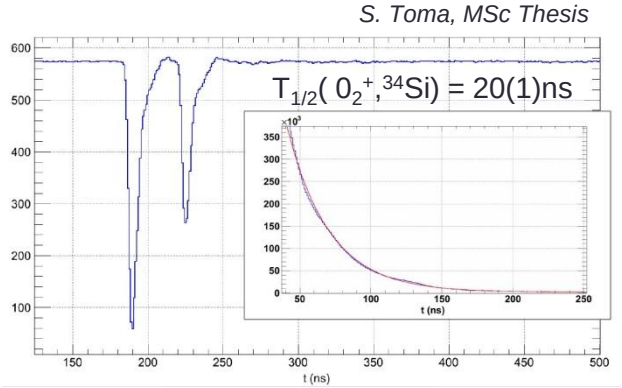


A. Poves, Private Communication



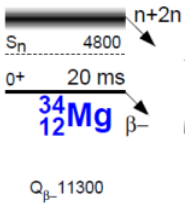
^{34}Si (IS530)

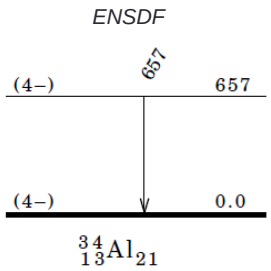
S. Toma, MSc Thesis



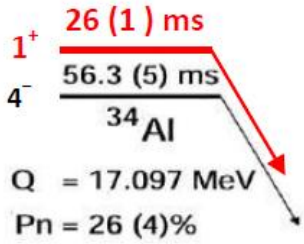
Double hit event (decay of 0_2^+)

^{34}Al

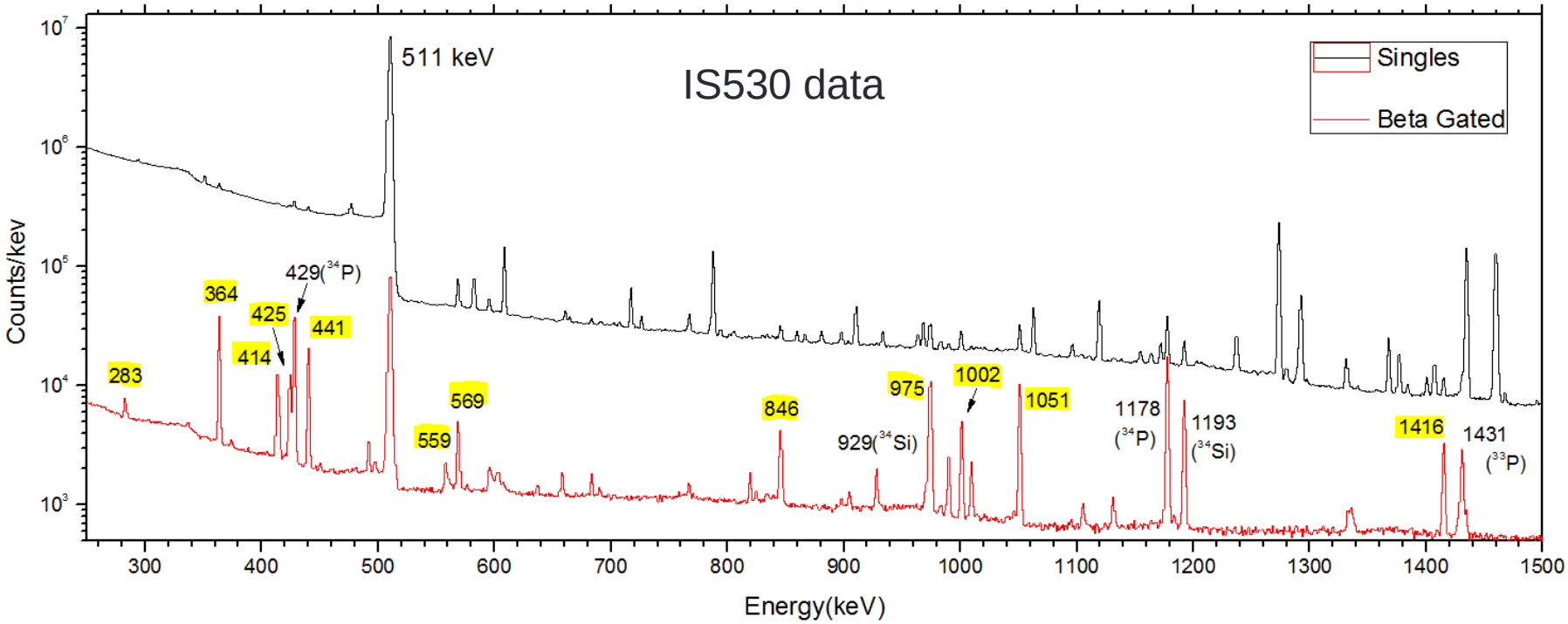




F.Rotaru et al., Phys. Rev. Lett. 109, 092503 (2012)

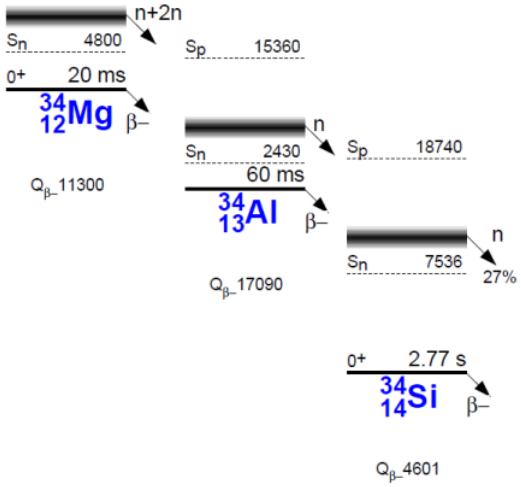


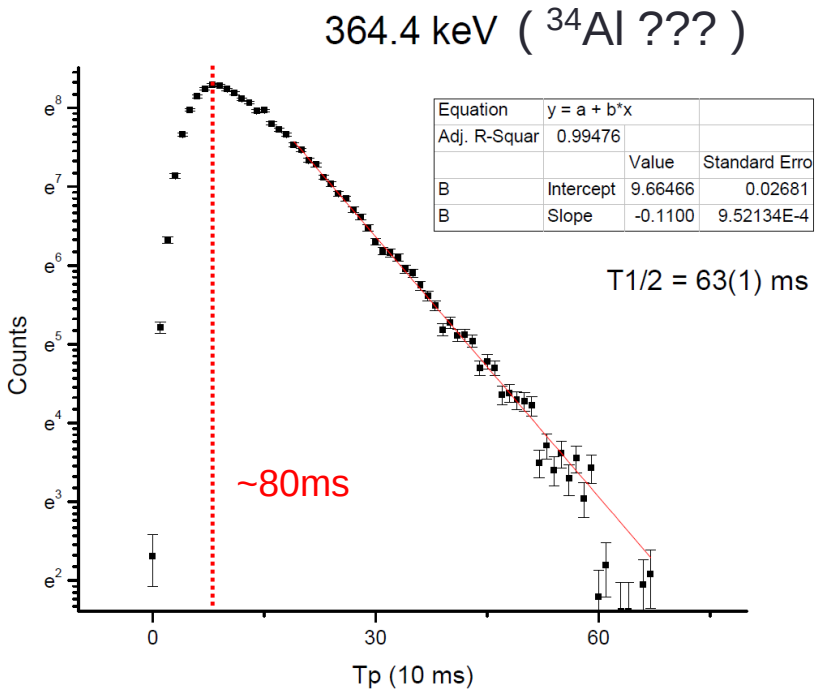
- Scarce information for ^{34}Al in ENSDF (Coul.Ex.)
- Many strong unassigned gammas observed in the beta gated HPGe spectra

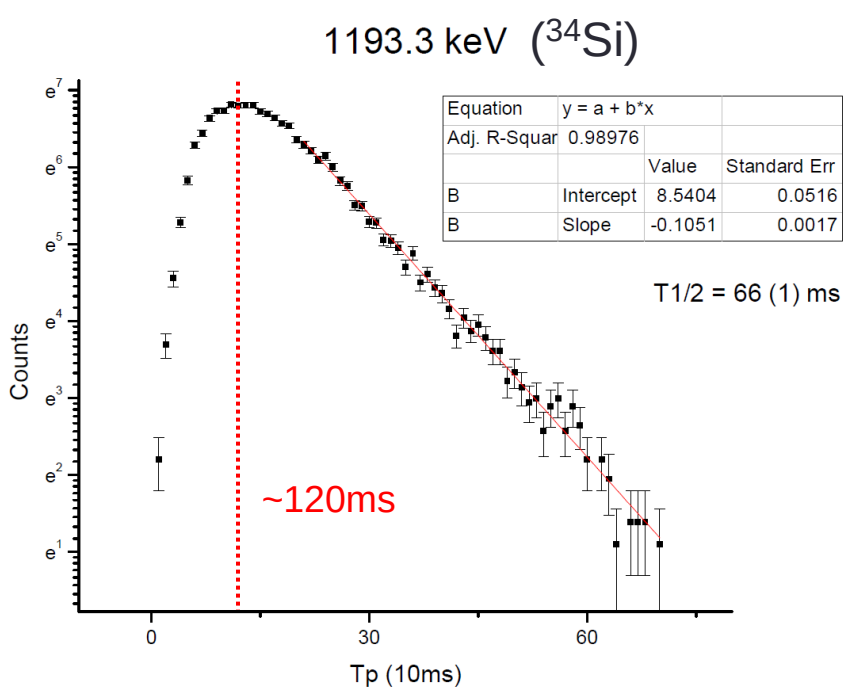


^{34}Al

- By analyzing the time distribution of a gamma decay relative to the proton bunch:

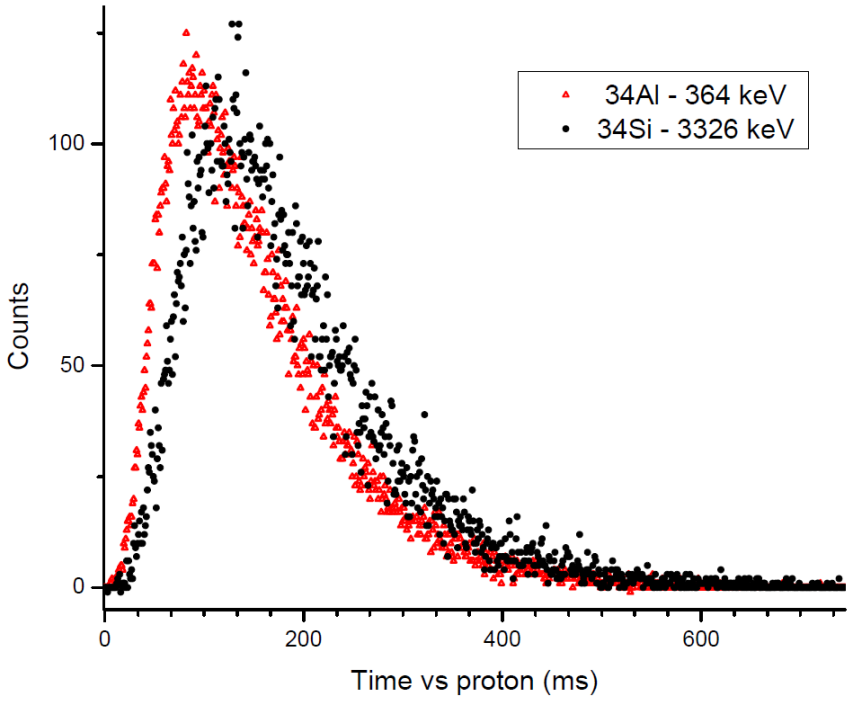




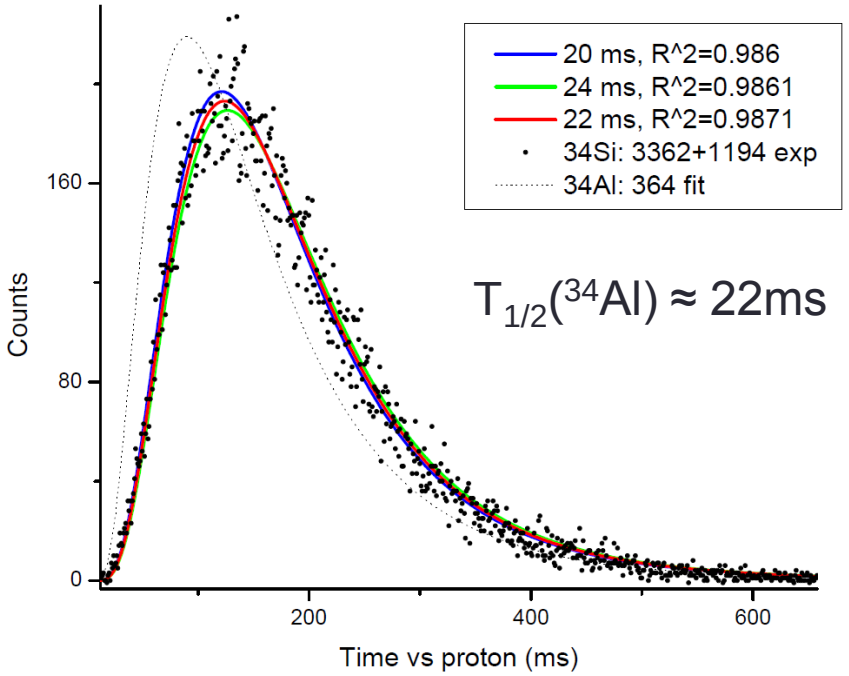


^{34}Al

Normalised time distributions

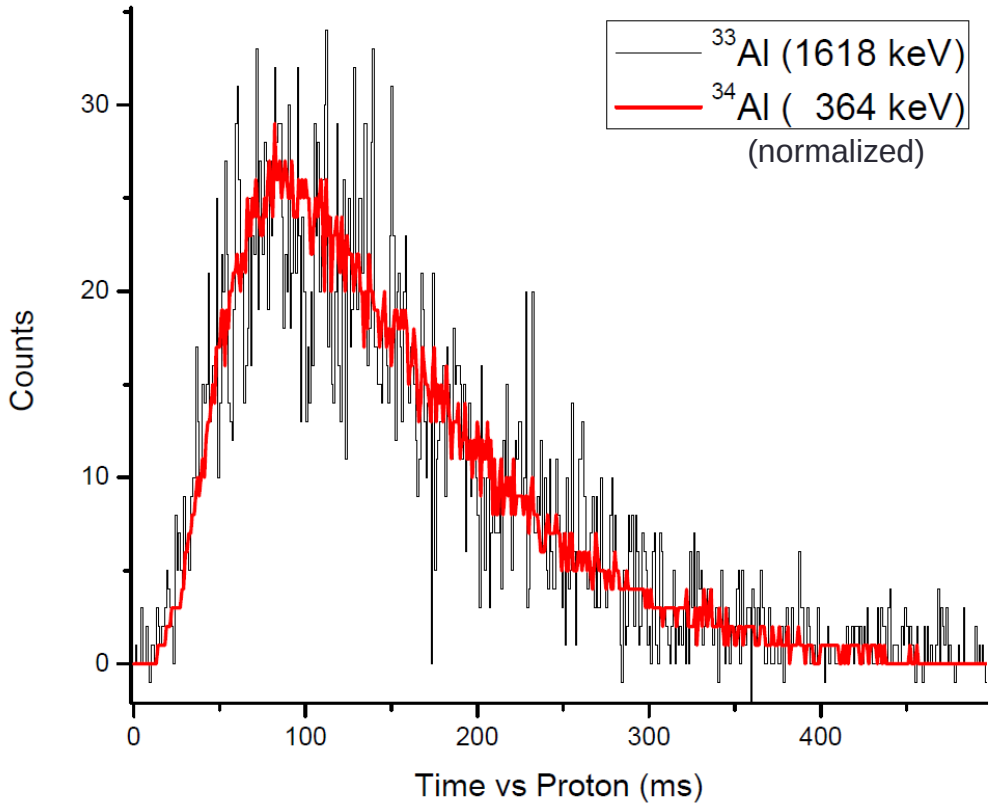


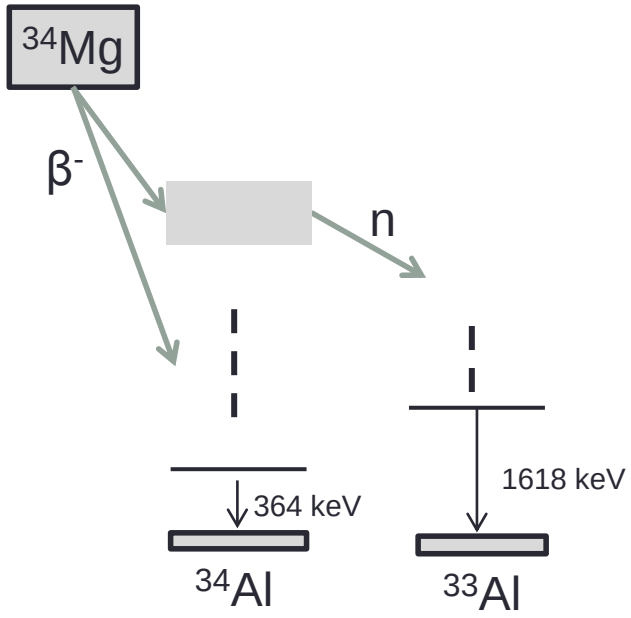
Exponential decay convolution



^{34}Al

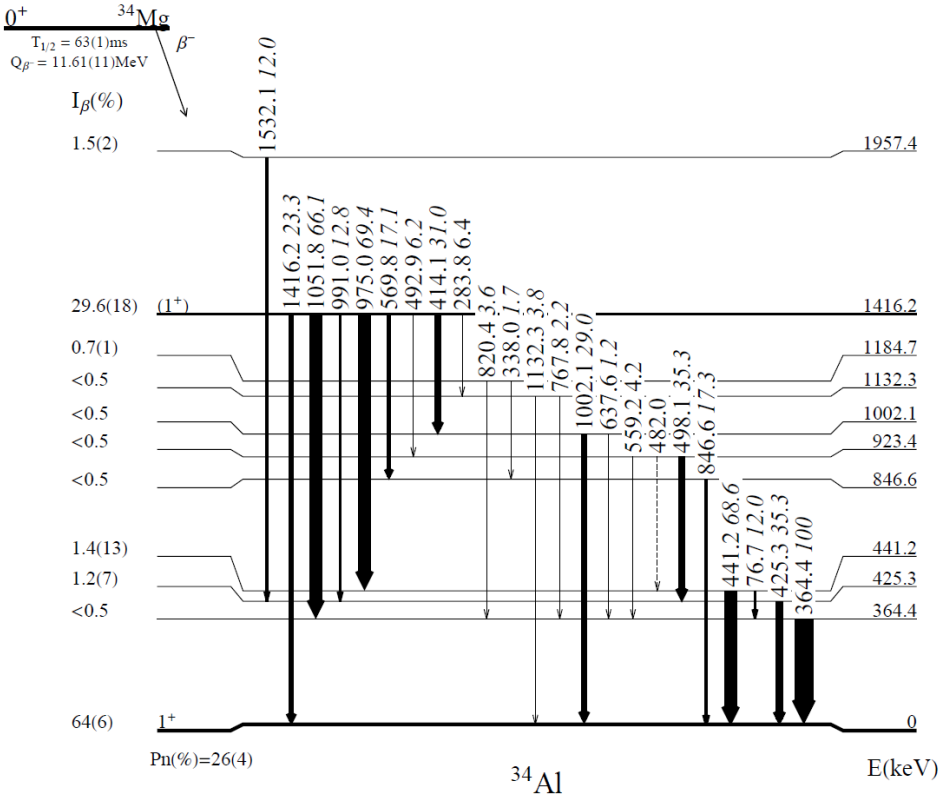
Comparison between ^{33}Al and ^{34}Al gammas:

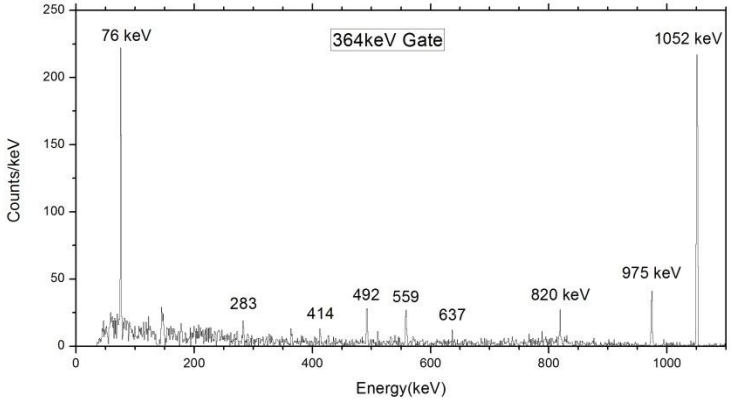


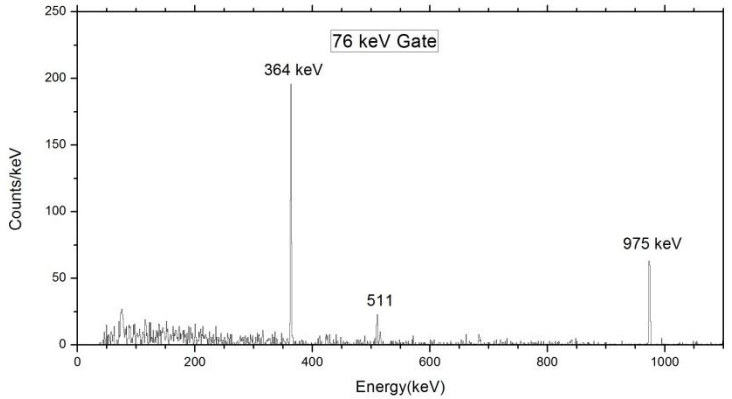


^{34}Al

- By analyzing β-γ-γ coincidences many of the short lived unassigned transitions were placed in the **first level scheme of ^{34}Al**.
- By normalizing to the known transitions in ^{34}P we can estimate absolute intensities and ground state feeding. Pn(%) taken from *S. Numella et al, Phys Rev C63, 044316 (2001)*





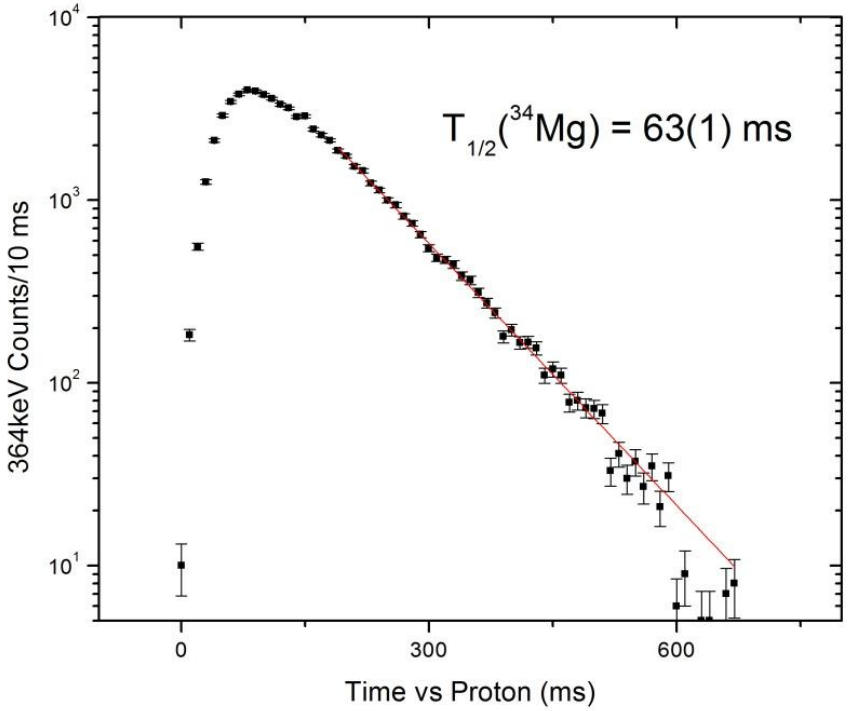


^{34}Mg

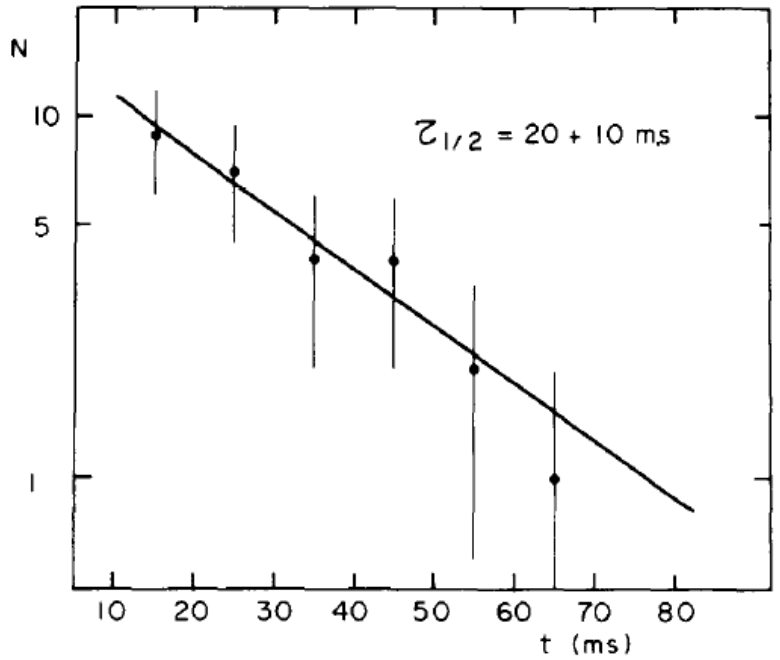
- Beta decay half-life:
  - different from the adopted value
  - measured by analyzing the time difference between beta gated ^{34}Al transitions and proton bunch time (T_0)
  - to be confirmed by the new mass measurement experiment at ISOLTRAP for the next campaign

(P. Ascher, ***CERN-INTC-P-372***)

IS530



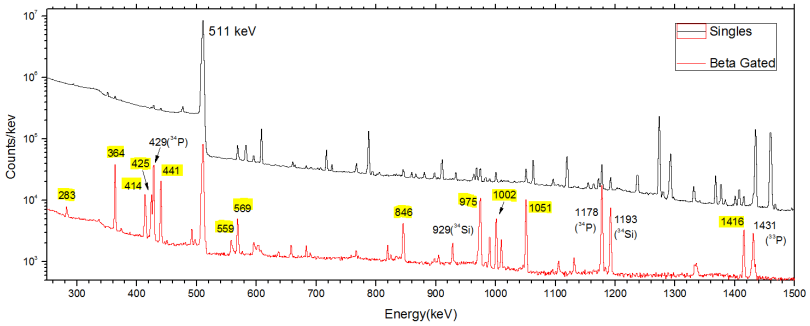
*M. Langevin et al., Nucl. Phys. **A414** (1984) 151-161*

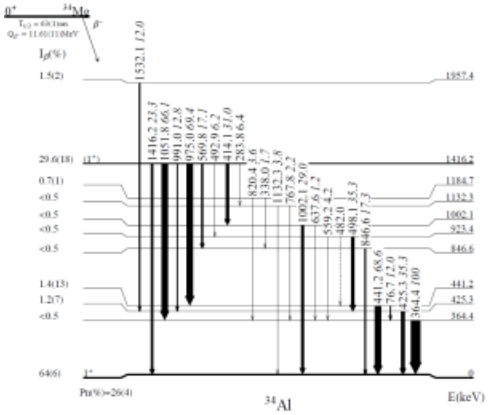


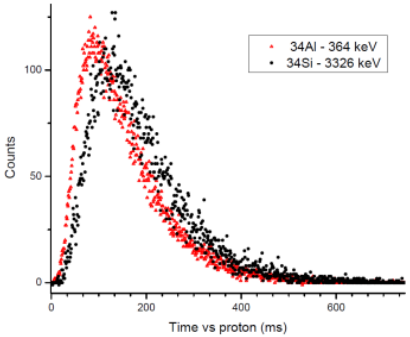
Time dependence of β-coincident neutron counting for the ^{34}Mg descendant.

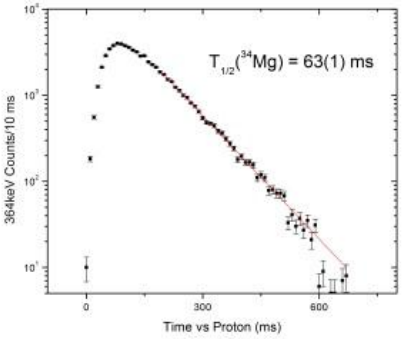
Conclusions

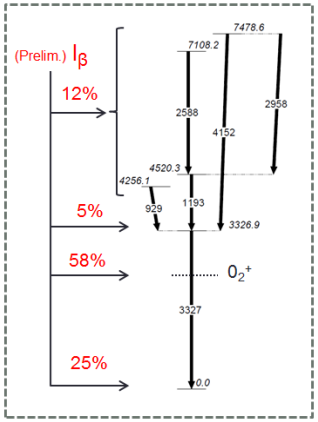
- ✓ **First time measurement of the gamma rays following the β-decay of ^{34}Mg**
- ✓ **The first level scheme for ^{34}Al**
- ✓ **New half-life for ^{34}Mg – 63(1)ms**
- ✓ **Improved level scheme for ^{34}Si**







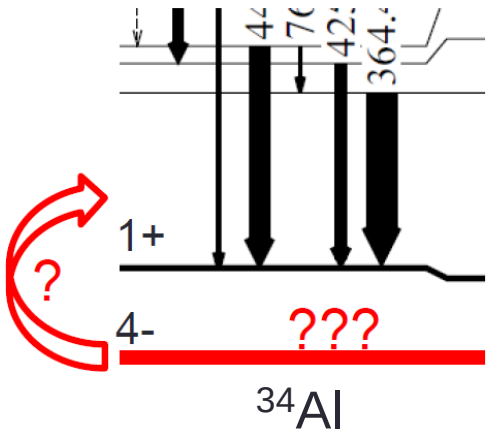




Future work

- Continue the measurement with the remaining requested shifts.
- Finalize the data analysis (neutron-gamma coincidences, $LaBr_3$:Ce fast-timing information) and publish
- New ISOLTRAP mass measurement of ^{34}Mg and ^{34}Al (1^+ and 4^-)

(P. Ascher, ***CERN-INTC-P-372***)



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Remark:

- Known transitions in daughter nuclei can be used in order to measure I_β values for the parent nuclei

- The ENSDF data for ^{33}P is contradictory with our measurement

IS530: $I_{\beta(gs)} \sim 0$ %
ENSDF: $I_{\beta(gs)} = 93.7$ %

→ We cannot measure P_n and I_β values for ^{34}Mg, ^{34}Al, ^{33}Al (can only estimate)

→ **A measurement for ^{33}Si beta decay should clarify this disagreement.**