Energy of the 2p1h intruder state in ^{34}Al: an extension of the « island of inversion »?

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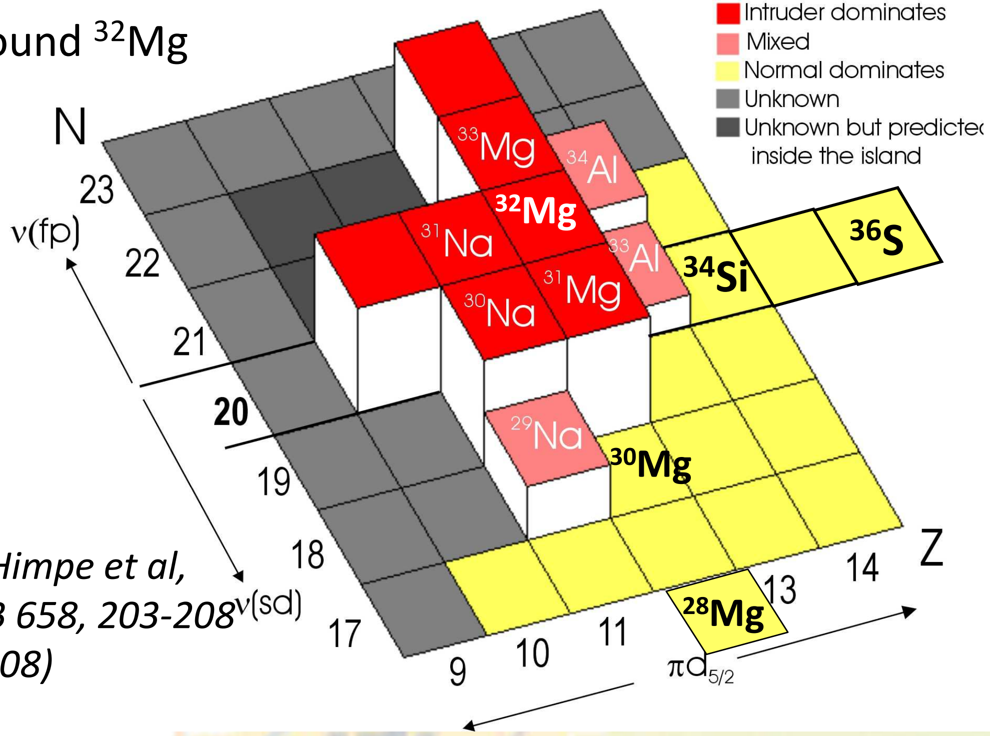
ISOLTRAP

Max-Planck-Institut für Kernphysik

ISOLDE

Island of inversion around N = 20

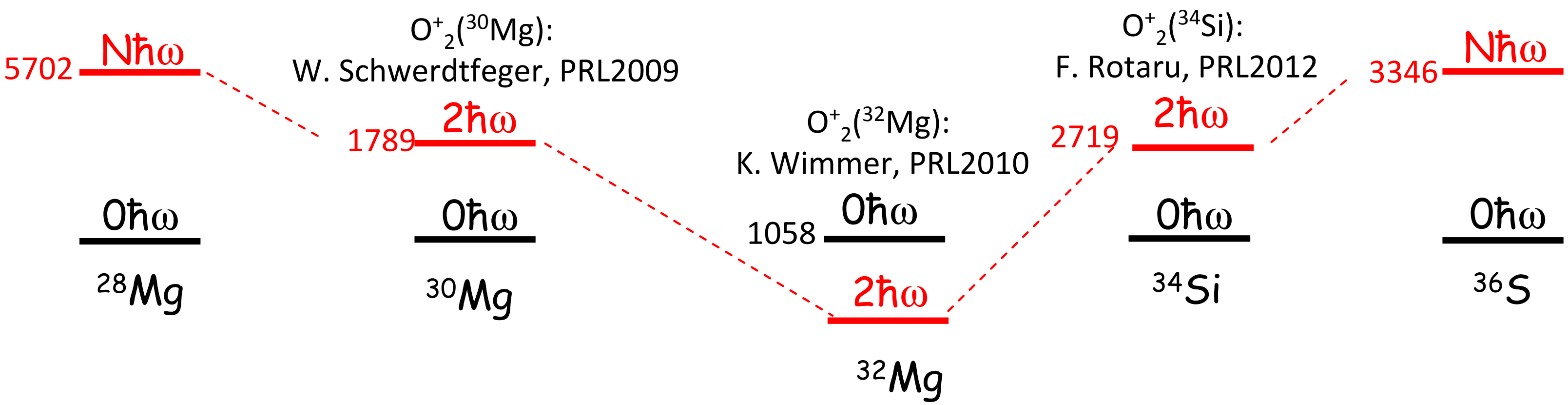
The island of inversion around ^{32}Mg



P. Himpe et al, PLB 658, 203-208 (2008)

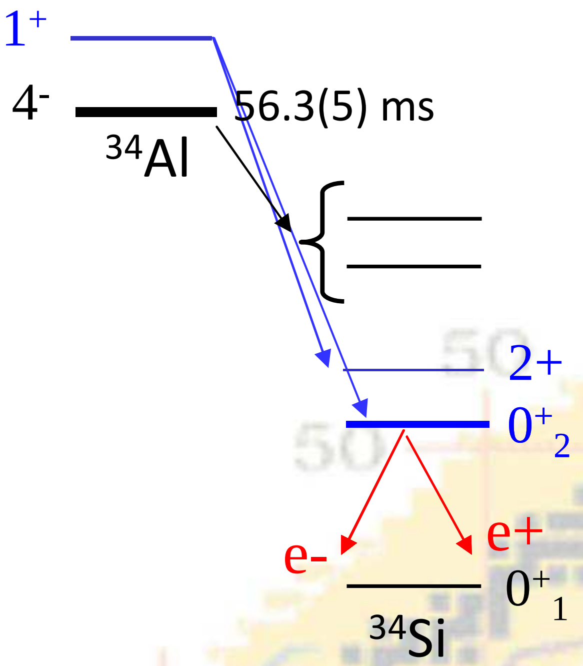
Follow the evolution of the "excited" configurations from the stability towards the Island of Inversion

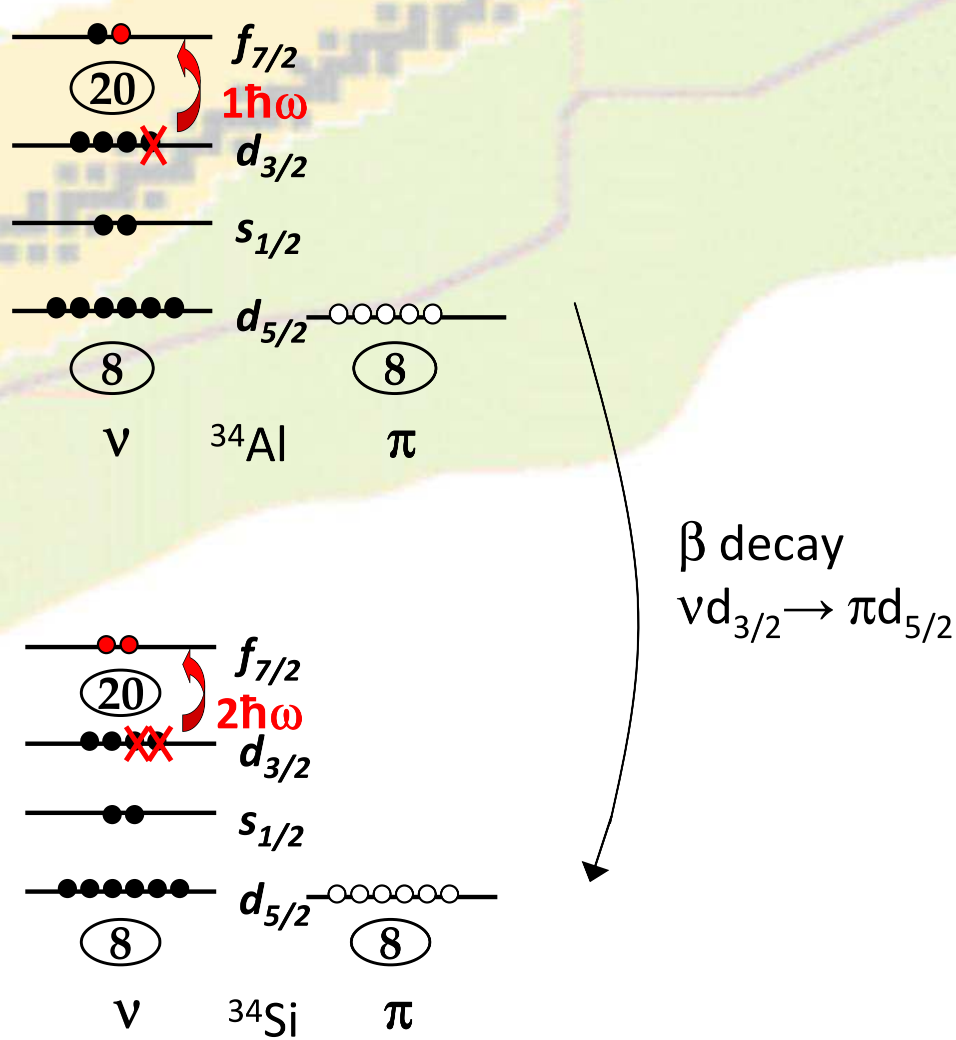
→ Study the evolution of the excited 0^+ states



Discovery of the 0^+_2 state in ^{34}Si

Hypothesis: the 0^+_2 could be **directly** populated through the β-decay of a **predicted** isomeric 1^+ state in ^{34}Al.





F. Rotaru et al, PRL 109 (2012)

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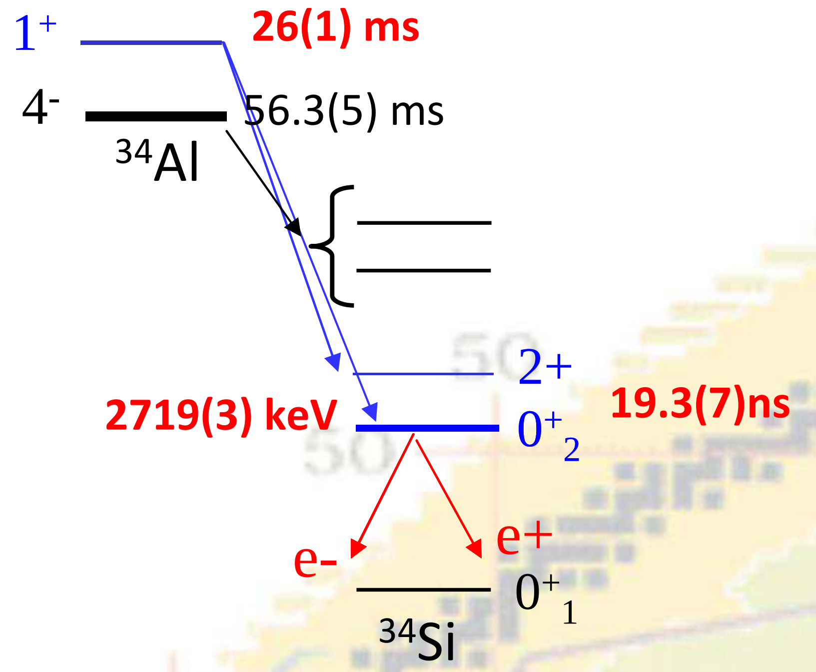
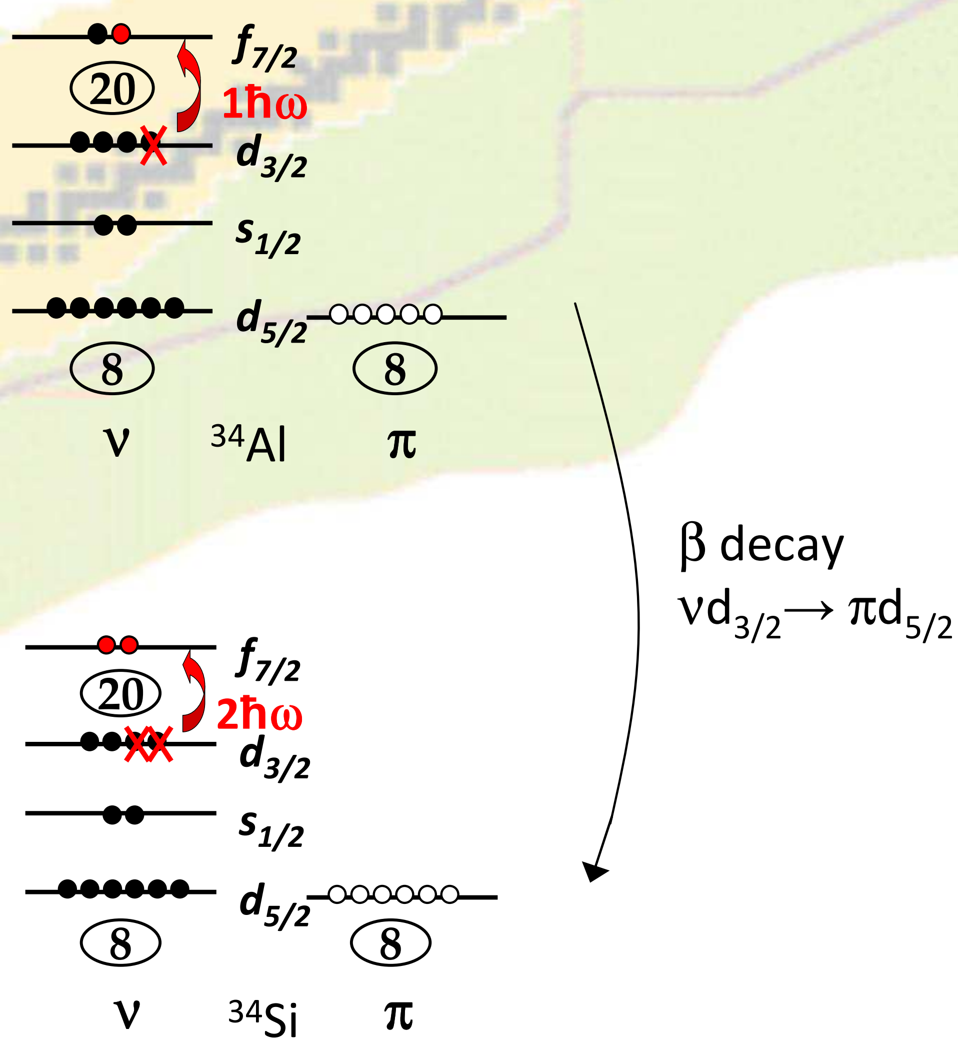




BUT no measurement of the excitation energy of the 1^+...

F. Rotaru et al, PRL 109 (2012)

ISOLDE IS-530 Experiment

Aim: Study the properties of low-lying intruder states in ^{34}Al and ^{34}Si sequentially populated in the beta-decay of ^{34}Mg

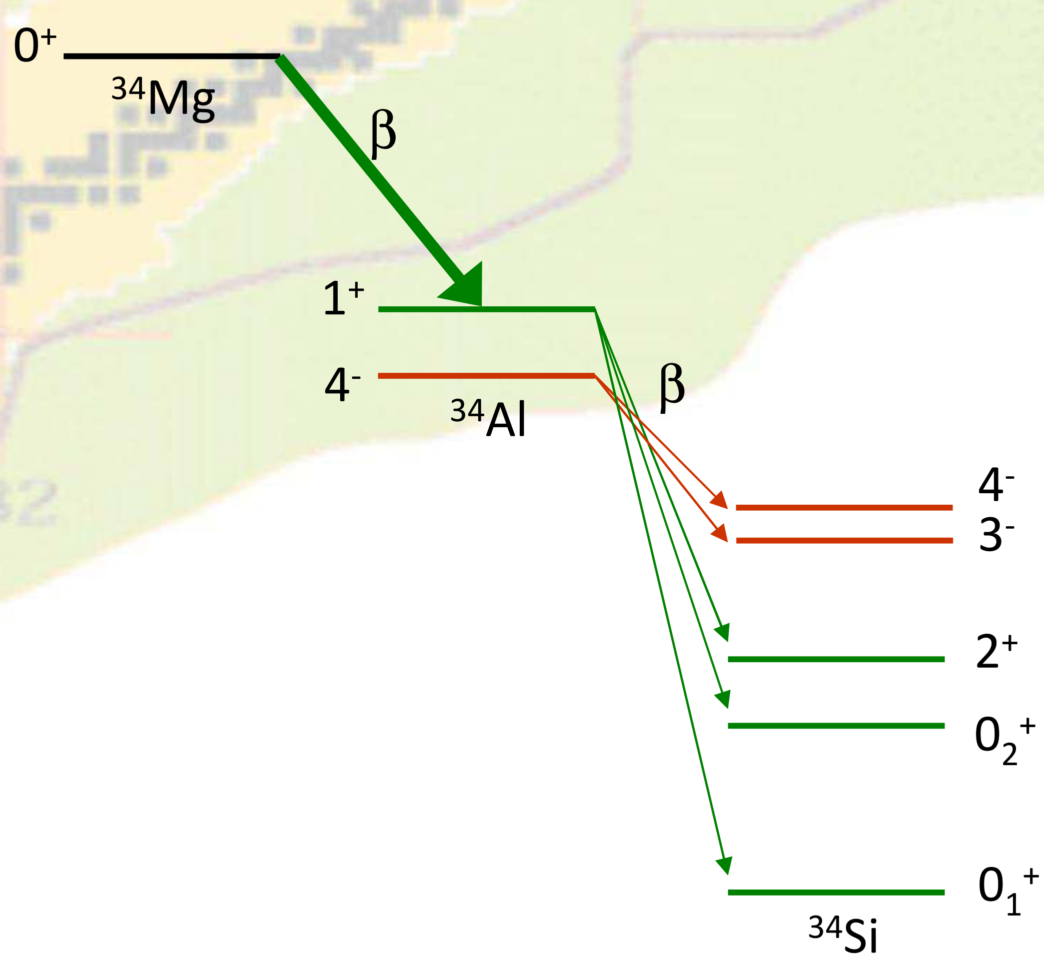
No γ transitions corresponding to the states populated by the β decay from the 4^- state (3^-, 4^- in ^{34}Si) were observed

→ The 4^- state was not populated

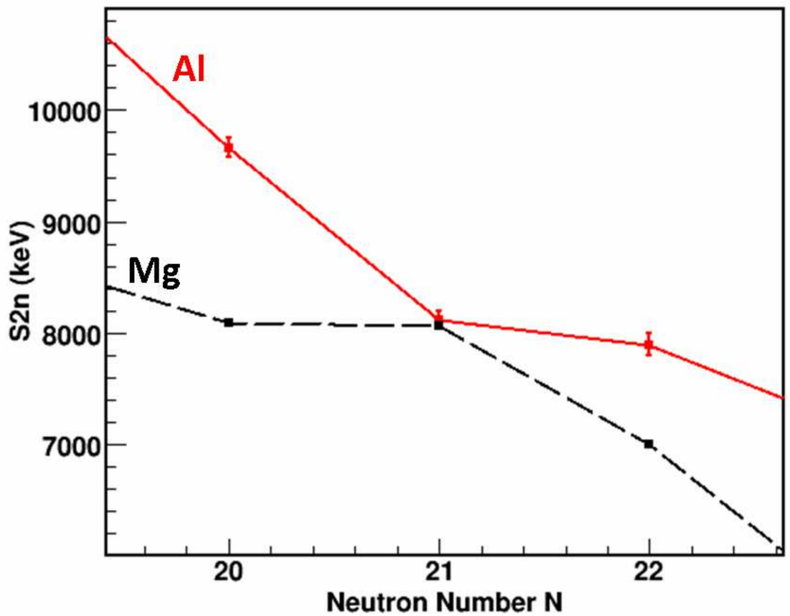
No way to measure the energy of the isomer

This experiment showed that the decay of ^{34}Mg populates mostly the 1^+ state of ^{34}Al

→ Other possibility to measure this energy: mass measurement after the β decay of ^{34}Mg



Two-neutron separation energies around this region



Data from AME2012
G. Audi et al, Chinese Phys. J. C 36, 1287 (2012)

S_{2n}(Al) and S_{2n}(Mg) coincide at N=21!

Recent mass measurements at TITAN (better precision) shows that S_{2n}(^{34}Al) is actually 100 keV lower than that of ^{33}Mg *J. Dilling, Private communication*

→ proton-neutron interaction repulsive??

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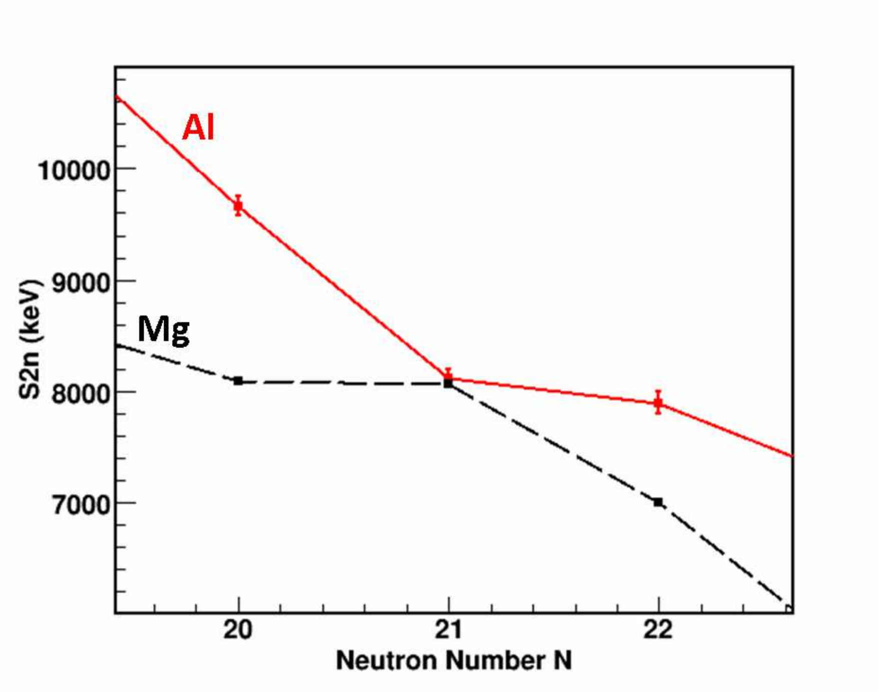

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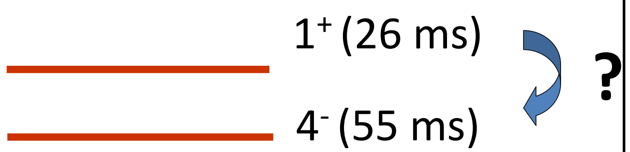
… And if the 4^- state measured was actually the isomeric state?



Mass measurement of the 1^{+} and 4^{-} states in ^{34}Al

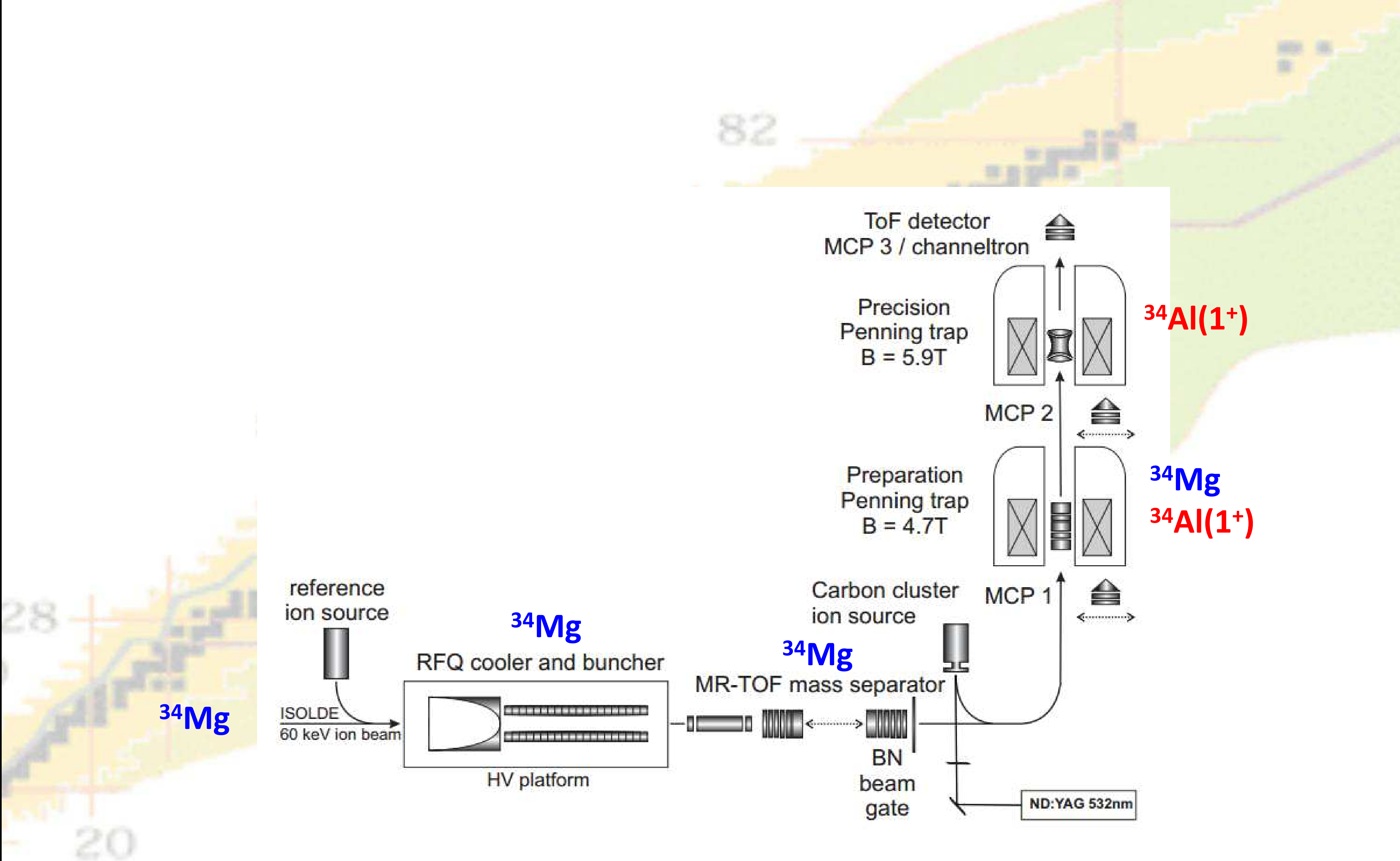
→ Measure the energy of the 1^{+} in ^{34}Al populated by the β decay of ^{34}Mg **^{34}Mg beam**

→ Re-measure the energy of the 4^{-} state in ^{34}Al **^{34}Al beam**

- Assign the isomeric states and the ground states
- Measure the excitation energy of the isomer

- If the intruder state is the ground state → ^{34}Al is part of the island of inversion (not expected)
- Important constraints for the models in this region

In-trap decay experiment at ISOLTRAP



M. Mukherjee et al., Eur. Phys. J A 35, 1-29 (2008)
A. Herlert et al., Eur. Phys. J. A 48, 97 (2012)

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In trap-decay

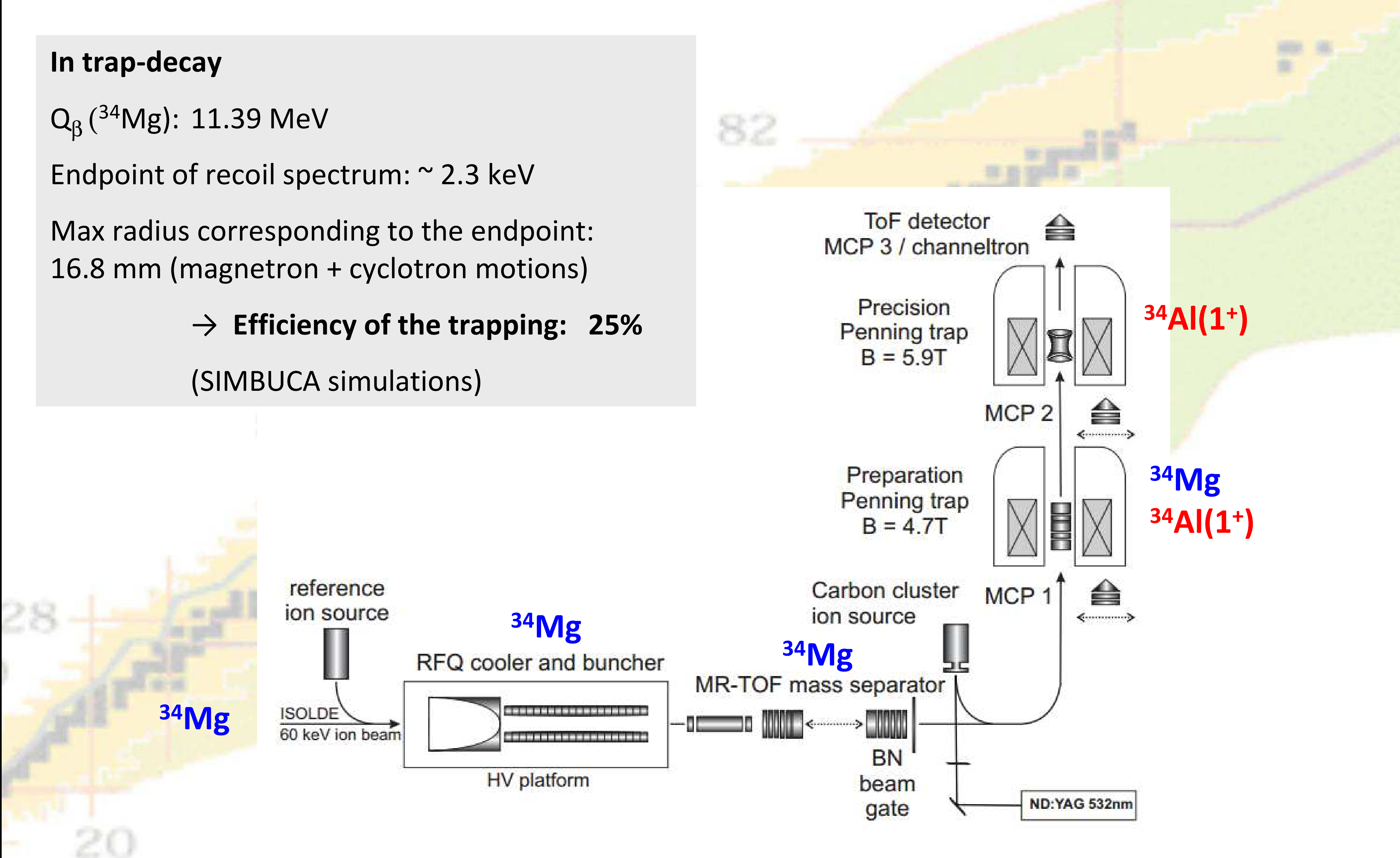
Q_{β} (^{34}Mg): 11.39 MeV

Endpoint of recoil spectrum: ~ 2.3 keV

Max radius corresponding to the endpoint:
16.8 mm (magnetron + cyclotron motions)

→ **Efficiency of the trapping: 25%**

(SIMBUCA simulations)



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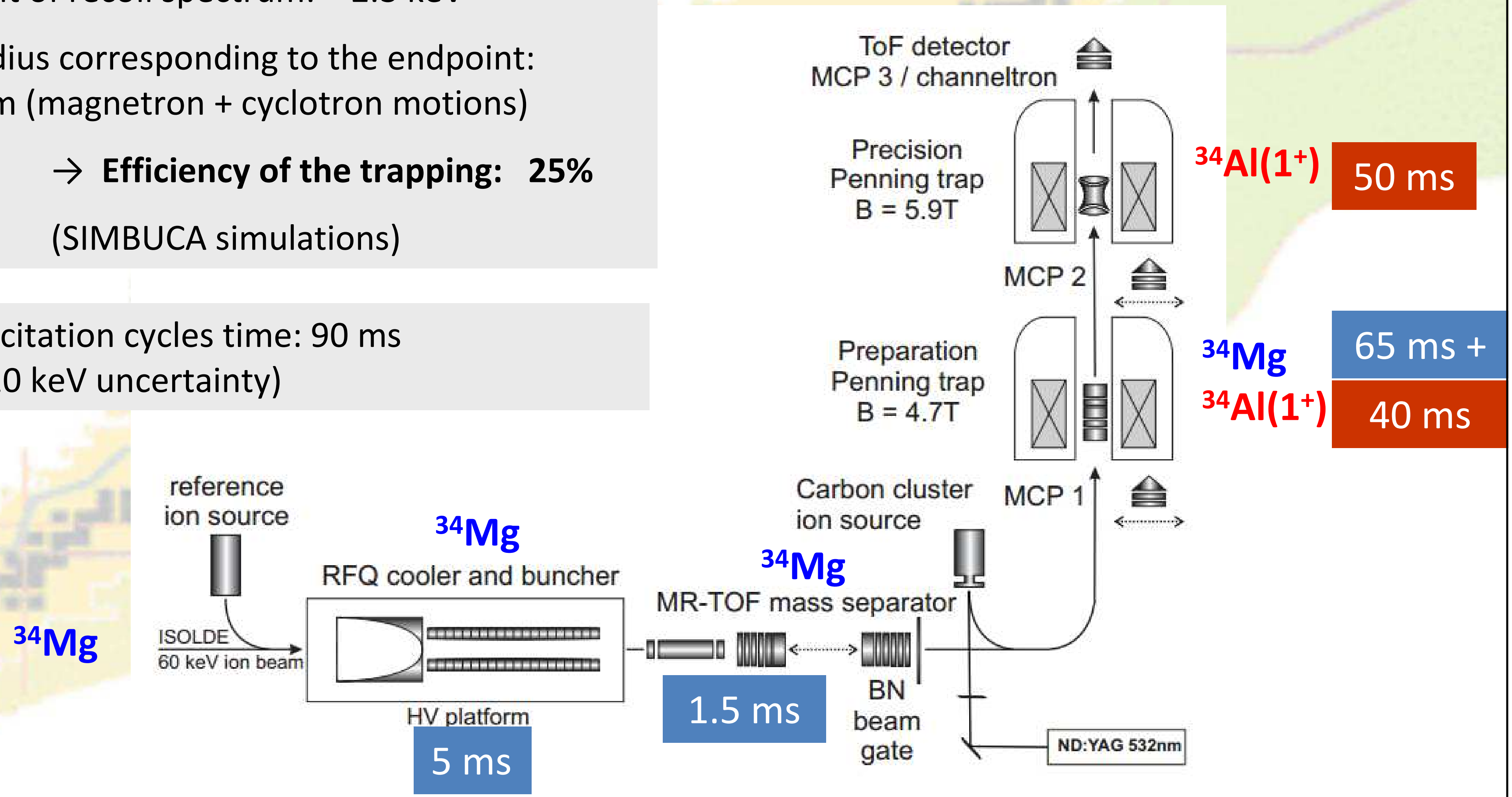
$T_{1/2}(^{34}Mg)$: 63(1) ms

$T_{1/2}(^{34}Al)$: 26(1) ms

Total excitation cycles time: 90 ms
(~ few 10 keV uncertainty)



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Beam requests

- **^{34}Mg run**

Production yield using RILIS: 600 ^{34}Mg / proton pulse (from IS-530 experiment)

ISOLDE-RFQ efficiency: 90%

ISOLTRAP overall transport efficiency: 1%

Accumulation in the RFQ: ~ 40%

RFQ cooling time + MR-TOF: ~ 95%

In-trap production of ^{34}Al: ~ 20%

Recoil ion trapping efficiency: ~ 25%

Excitation cycles: ~ 9% → 10 ions every hour detected on the channeltron detector

12 shifts are requested for the mass measurement of the 1^+ state

- **^{34}Al run**

Production yield using RILIS: 86 * 5 = 430 ions/ μC *(lower than in the proposal because of a misunderstanding of RILIS enhancements)*

4 shifts are requested for the mass measurement of the 4^- state

Beam requests

➢ **14 shifts** for the measurement on the 1^+ state in ^{34}Al: ^{34}Mg at maximum yield, first users on the target

- 1 shift for the stable beam tuning
- 1 shift for the optimization for the in-trap production of ^{34}Al
- 12 shifts for the mass measurement (1^+ in ^{34}Al)

➢ **5 shifts** for the measurement on the 4^- state in ^{34}Al: ^{34}Al at maximum yield, first users on the target

- 1 shift for the stable beam tuning
- 4 shifts for the mass measurement (4^- in ^{34}Al)

UCx target, laser ionisation with RILIS, HRS and the slits (suppressing ^{34}Al contaminants in the ^{34}Mg run) are requested

In total, 19 shifts are requested

P. Ascher[1], D. Atanasov[1], B. Blank[2], K. Blaum[1], Ch. Borgmann[3], M. Breitenfeld[5], S. George[1], M. Gerbaux[2], S. Grévy[2], F. Herfurth[4], A. Herlert[4], M. Kowalska[5], S. Kreim[1,5], R. Lica[6], D. Lunney[7], V. Manea[7], N. Marginean[6], S. Naimi[1], F. Negoita[6], D. Neidherr[4], M. Rosenbusch[8], F. Rotaru[6], L. Schweikhard[8], F. Wienholtz[8], R.N. Wolf[8], K. Zuber[9]

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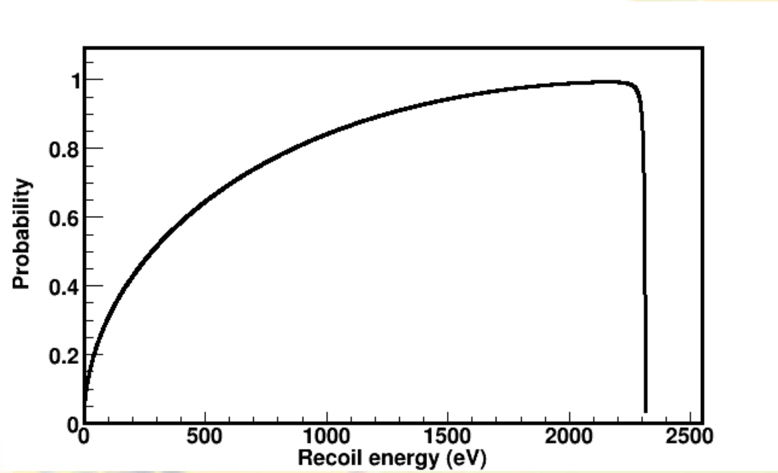
Principle of the SIMBUCA simulations

➢ « Real » ISOLTRAP electric field implemented in the code

➢ Initial energy distribution for the beta decay



➢ Simulations of 100 000 ions

→ 75% of the ions are lost within the first 10 μs

ISOLTRAP Potential simulated by COMSOL implemented in the SIMBUCA program