Investigation of beam purity after in-trap decay and Coulomb excitation of ^{62}Mn-^{62}Fe

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IKS, KU Leuven, Belgium
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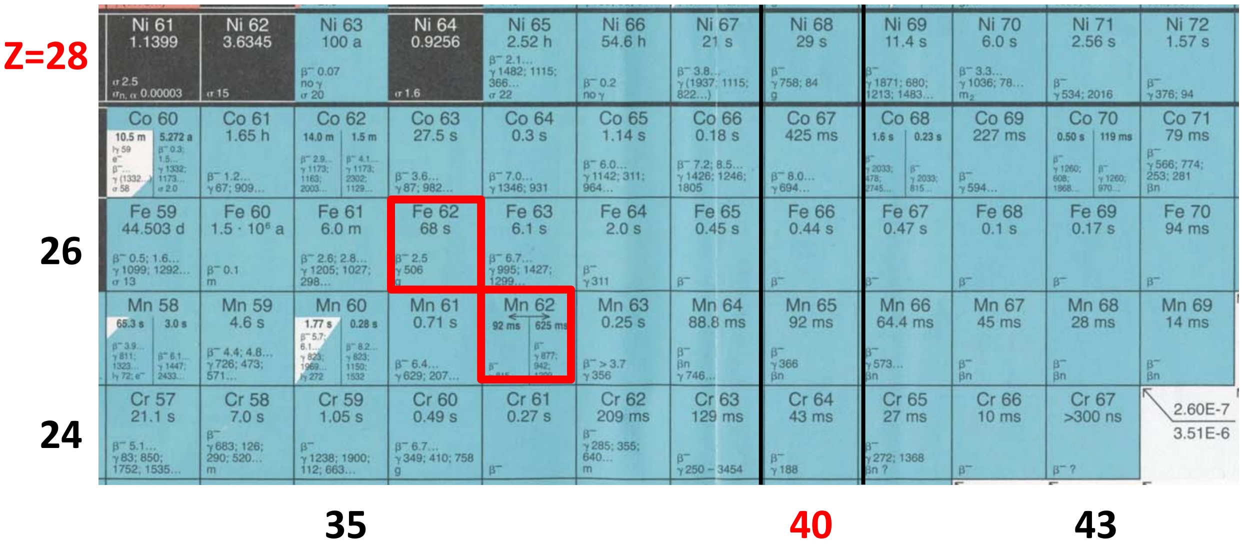
TUM, Garching, Germany
and the MINIBALL collaboration

OUTLINE

1/ In-Trap decay and beam contamination : is there a problem ?

2/ Why investigating it ?

3/ Test beam and application : Coulomb excitation of ^{62}Mn/^{62}Fe



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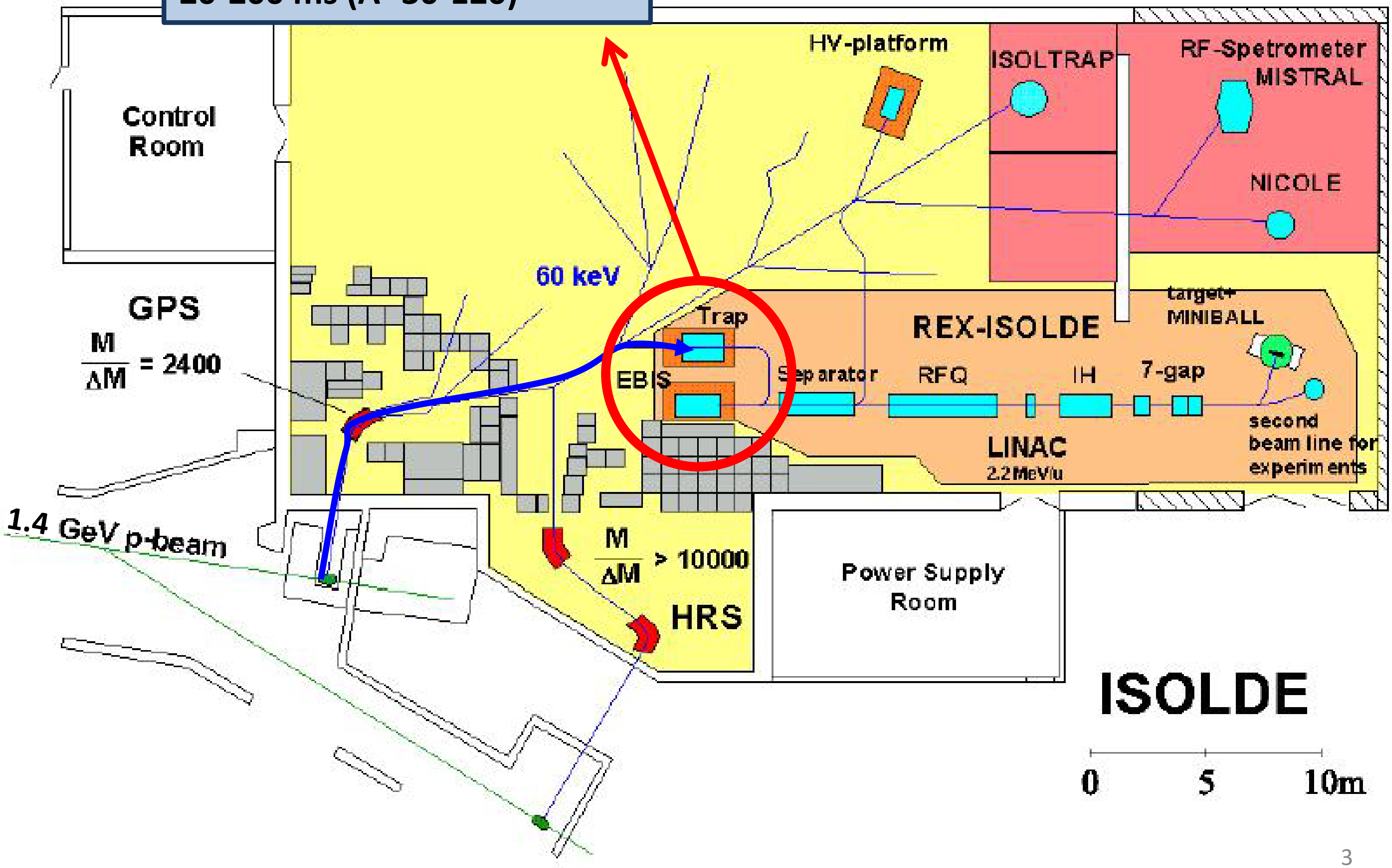
1/ TRAPPING in REXTRAP
2/ CHARGE BREEDING in EBIS

20-200 ms (A≈30-120)



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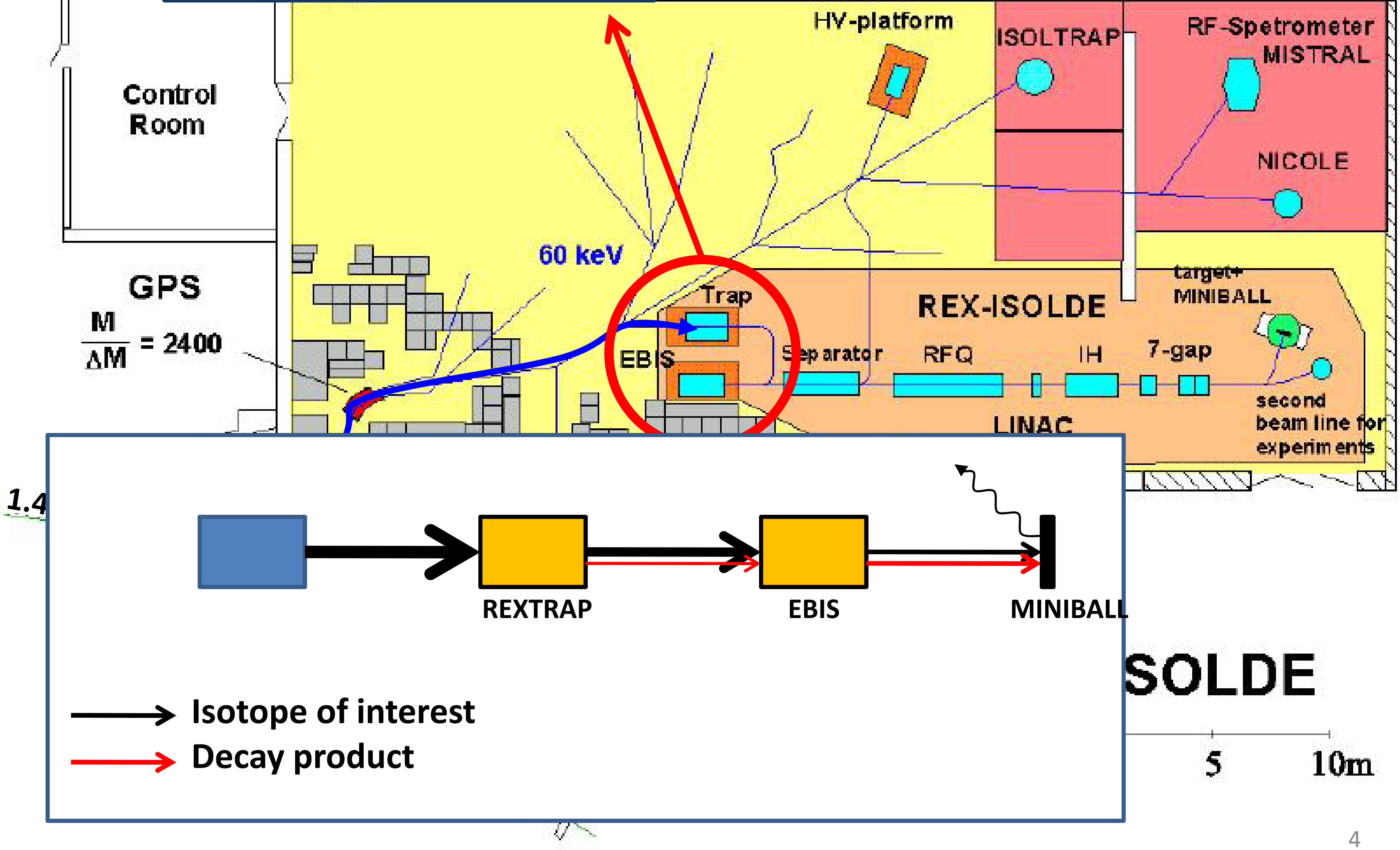
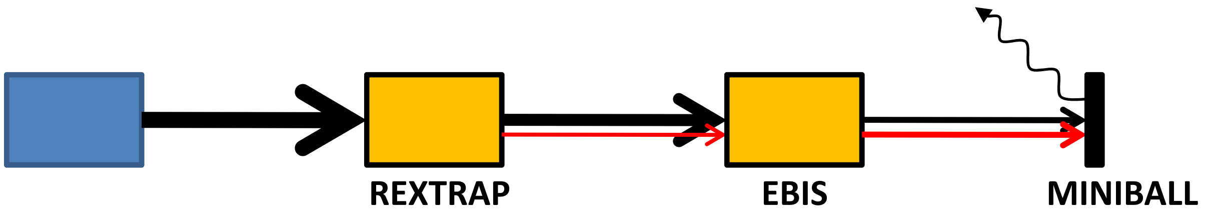


Post accelerated beams < 2008 :

^{31}Mg : 232(15) ms
^{32}Mg : 95(16) ms
^{80}Zn : 545(20) ms
ACCEPTED ^{128}Cd : 280(40) ms



→ Isotope of interest
→ Decay product

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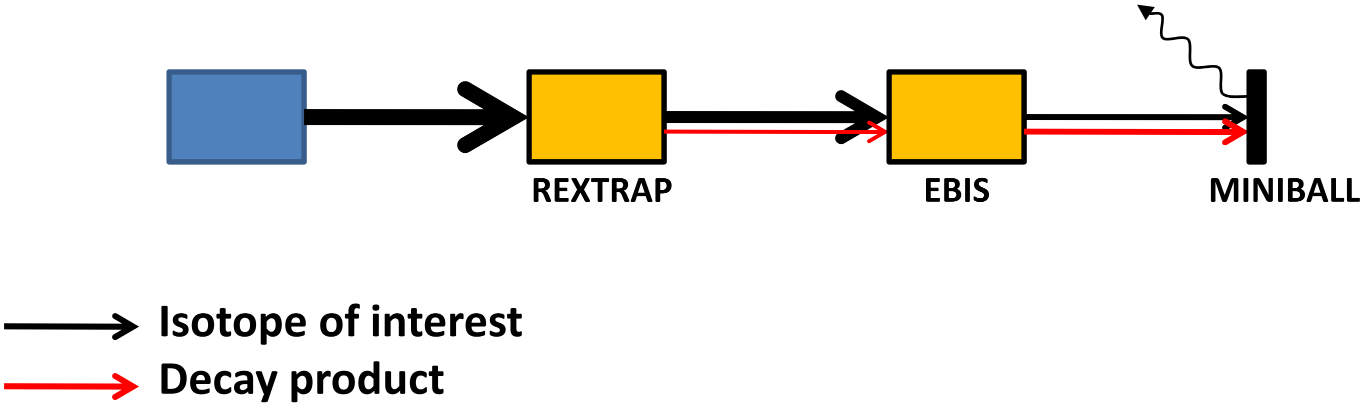

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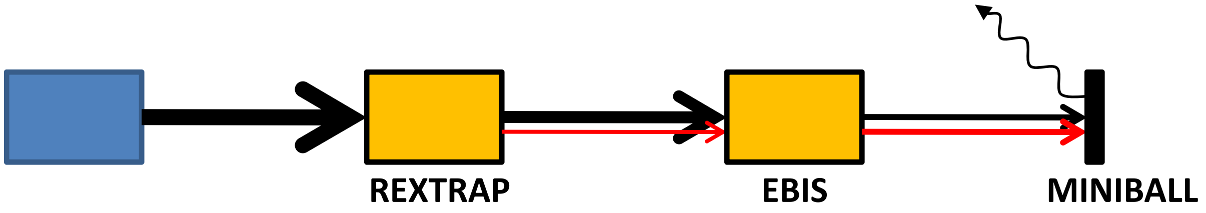

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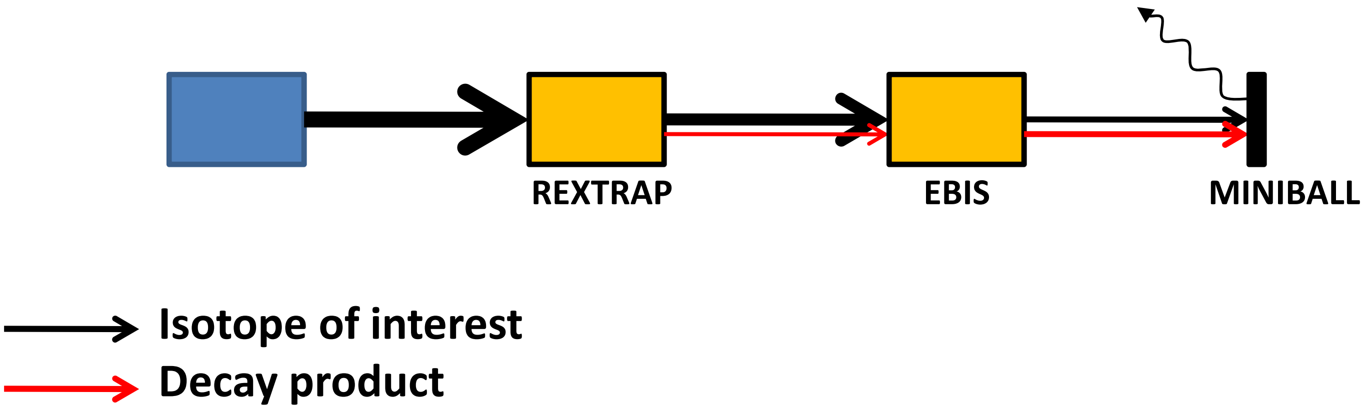
⇒ Why not **benefit from the short half life** …



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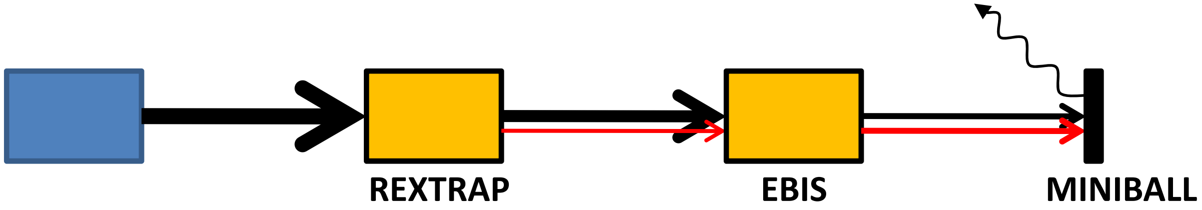

Ex. Fe mass measurements at ISOLTRAP with in-trap decay of mother ions (Mn)

A. Herlert et al. NJP **7** 44 (2005)

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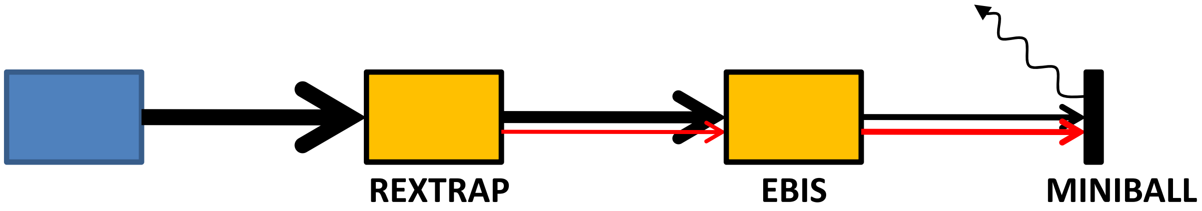
to produce a post-accelerated beam of decay products.



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1/ In-Trap decay and beam contamination : is there a problem ?

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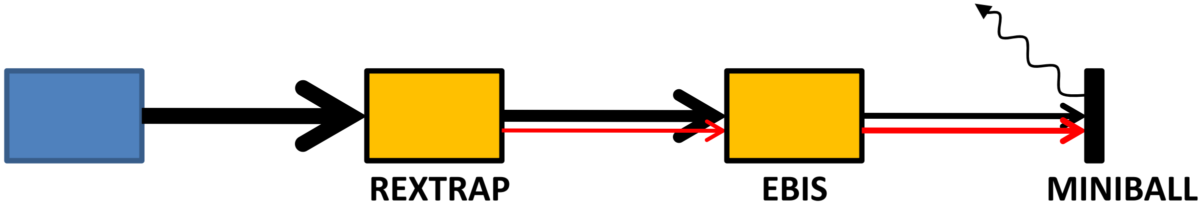
3/ The application : Coulomb excitation of ^{62}Mn/^{62}Fe

WHY ?
1/ Nuclear physics interest in decay products ;

Hard to produce beam …
⇓
produce "easy beam" …
⇓
and let it decay to "interesting beam"

if the "easy beam" is short half life … !!!



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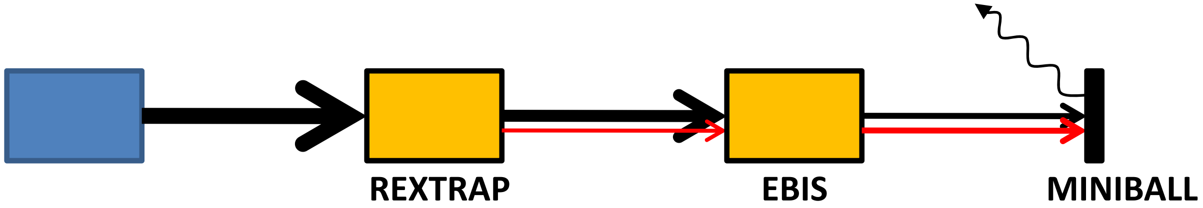
For example :
Ca

K

sufficiently short lived ?



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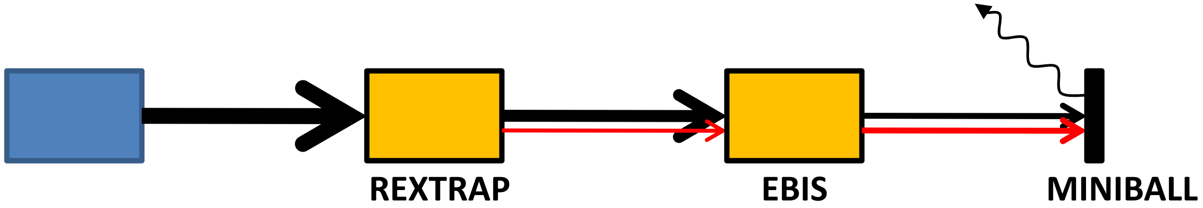

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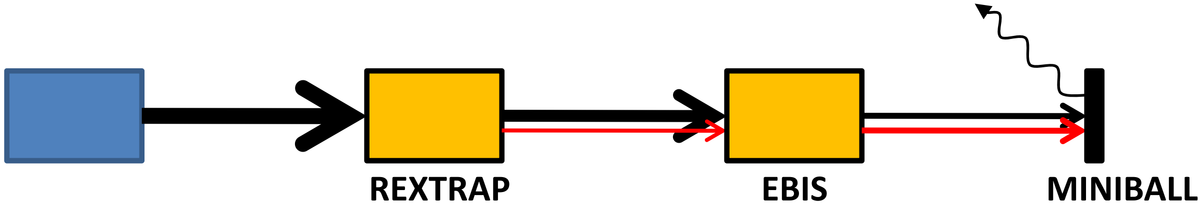
1/ Nuclear physics interest in decay products ;

2/ Gain deeper insight in the (possible) loss of decay products in the REXTRAP/EBIS (crucial for normalization of Coulomb excitation experiments)



WHY ?
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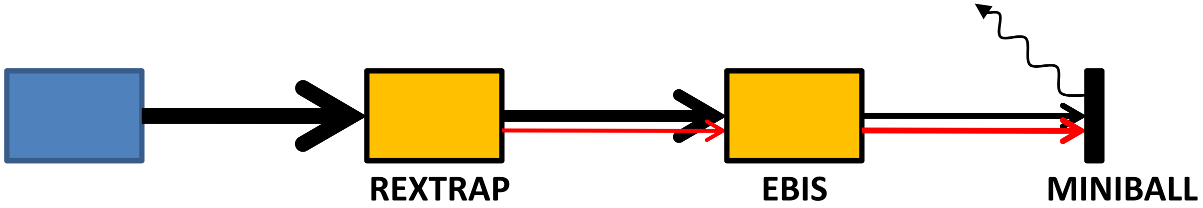
a) Are decay products lost in the REXTRAP/EBIS ?

b) How long can these ions be trapped before there are significant losses ?

c) Can we monitor the change in beam composition with the available beam diagnostics ?



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Ion recoil energy after β-decay $\Rightarrow$ order of few 100 eV (depends on Q-value)
Typical trap barrier height is of the same order of magnitude

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Ion recoil energy after β-decay ⇒ order of few 100 eV (depends on Q-value)
Typical trap barrier height is of the same order of magnitude

1/ Poorly cooled daughter ions ⇒ worse emittance
⇒ worse transmission to EBIS

2/ Recoil energy sufficient to escape longitudinal potential well (~ 100 eV)

3/ Radius of transverse motion increases and collides with the walls
4/ Sideband cooling works for specific A/q (different for daughter product)

⇒Losses of daughter isotopes

b) How long can these ions be trapped before there are significant losses ?

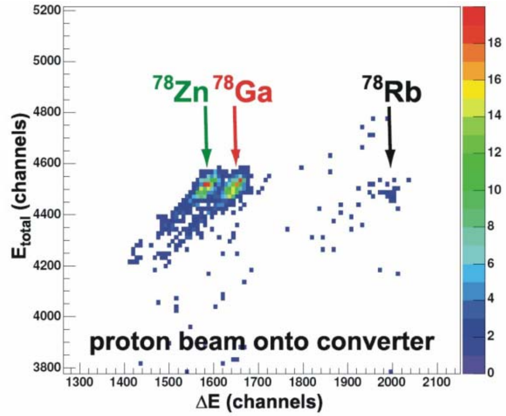
Produce intense beam of daughter isotopes

⇓

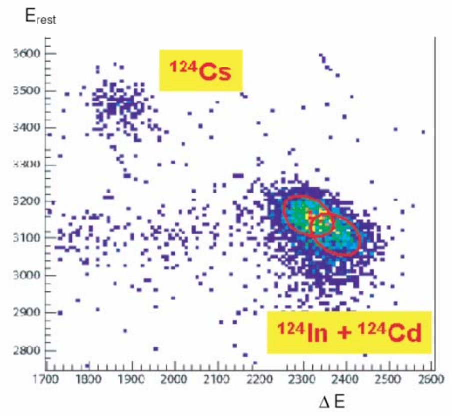
LONGEST POSSIBLE trapping/breeding time

c) Can we monitor the change in beam composition with the available beam diagnostics ?

1/ gas-Si dE-E telescope (zero degree beamline)



Z ~ 30 : ΔZ=1 resolved



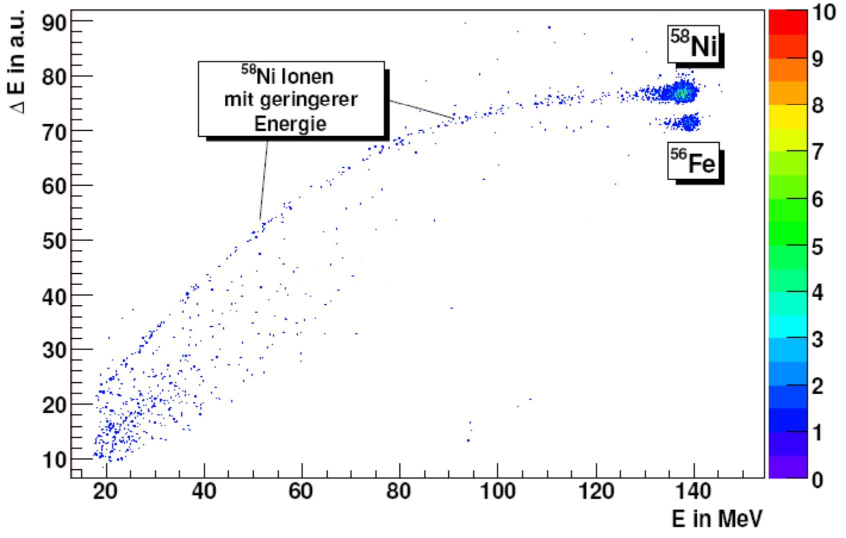
Z ~ 50 : ΔZ =1 not resolved

c) Can we monitor the change in beam composition with the available beam diagnostics ?

1/ gas-Si dE-E telescope (zero degree beamline)

2/ Bragg chamber (in MINIBALL beamdump)

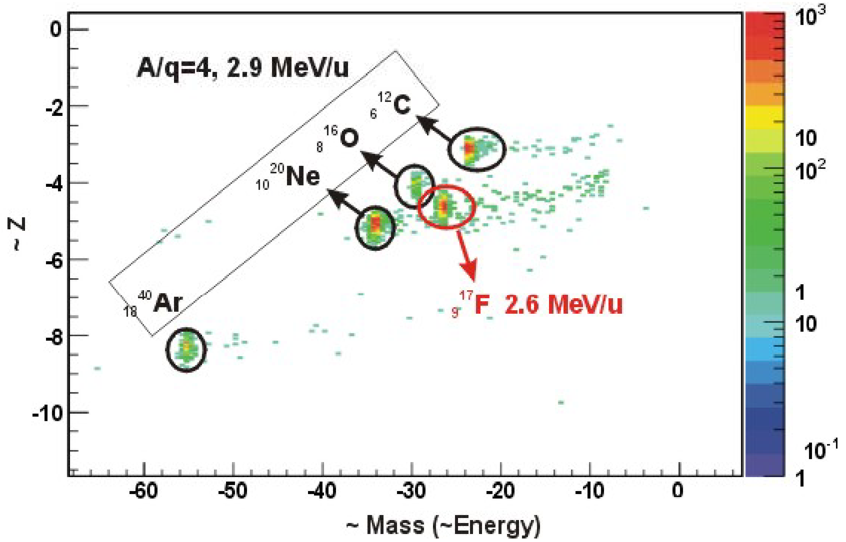
a/ Test at Tandem in Munich



P10 gas,
500 mbar,
^{58}Ni beam on ^{56}Fe target

W. Weinzierl, Diplomarbeit, TUM, Munich, 2006

b/ ONLINE REX 2007



CF4 gas,
400 mbar,
cocktail beam C,O,Ne,Ar

c) Can we monitor the change in beam composition with the available beam diagnostics ?

1/ gas-Si dE-E telescope (zero degree beamline)

2/ Bragg chamber (in MINIBALL beamdump)

3/ Beamdump Germanium detector :

Monitor the change in γ-ray intensities with different trapping/breeding times

1/ In-Trap decay and beam contamination : is there a problem ?
2/ Why investigating it ?
3/ Test beam and application : Coulomb excitation of ^{62}Mn/^{62}Fe

CAN WE PRODUCE A “HARD-TO-GET”
POST-ACCELERATED BEAM OF DECAY PRODUCTS
AFTER IN-TRAP DECAY ???

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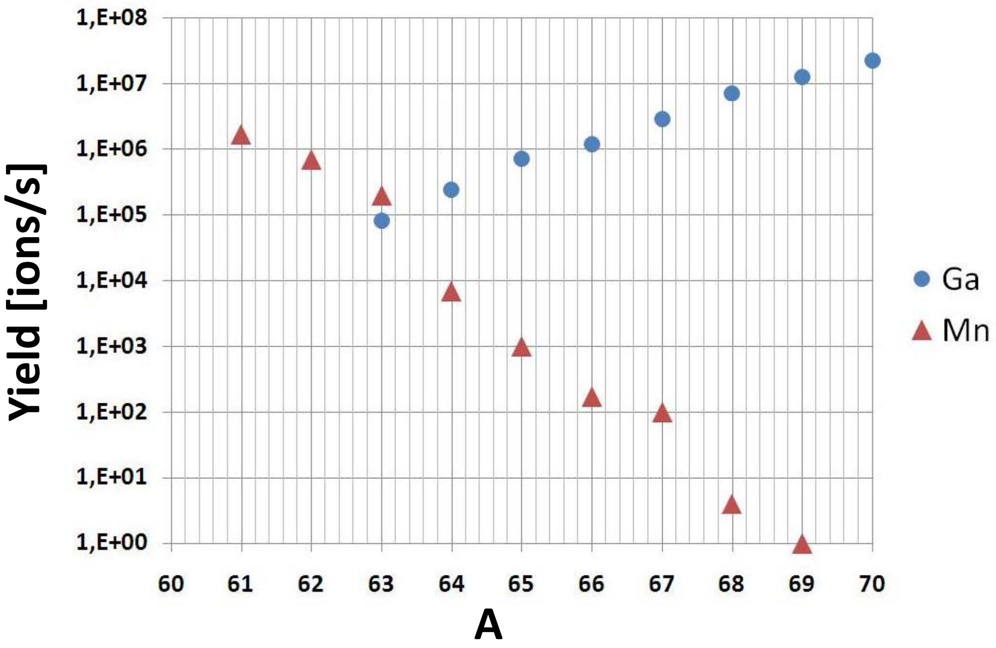
PROOF OF PRINCIPLE WITH **Mn-Fe**

Test beamtime : ^{61}Mn – ^{61}Fe : 4 shifts

✓Yield ^{61}Mn = 1.7E6/μC (UC$_x$ target + RILIS)
✓^{61}Ga ($T_{1/2}$=168 ms) contamination minimal
✓Half life ^{61}Mn = 0.67(4) s



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→Change trapping + breeding time : 50 - 200 - 400 ms
→Change only trapping/breeding time and fix breeding/trapping time
→Test the usage of the RFQ as injector to EBIS

Monitor the change in beam composition

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T [*]	Fe content	
	Analytical	Simulation [**]
50 ms	7%	6%
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[*] T = Trapping time = Charge breeding time
[**] From F. Ohlsson MSc thesis, Chalmers University 2007

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✓^{62}Ga ($T_{1/2}$=116 ms) contamination minimal
✓Half life ^{62}Mn = 0.671(5) s [1] + <u>possible isomeric state of 92(13) ms</u>

↓

(1$^+$) [3] **92(13) ms** [2] **P_n = 2.9(5)%** [1]

(3$^+$) [3] **671(5) ms** [1] **P_n = 6.4(2)%** [1]

Both produced,
7.0E5/μC probably g.s.

[1] M. Hannawald, PhD Thesis, U. Mainz 1999
[2] O. Sorlin et al., NPA 669, 351-367 (2000)
[3] G. Audi et al., NPA 729 ,3-128 (2003)

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→Fix trapping + breeding time to longest possible (≥$T_{1/2}$)

→Check beam composition (no problem with normalization)

→Perform Coulomb excitation on 4.0 mg/cm^2 ^{109}Ag target

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Nuclear Structure Interest

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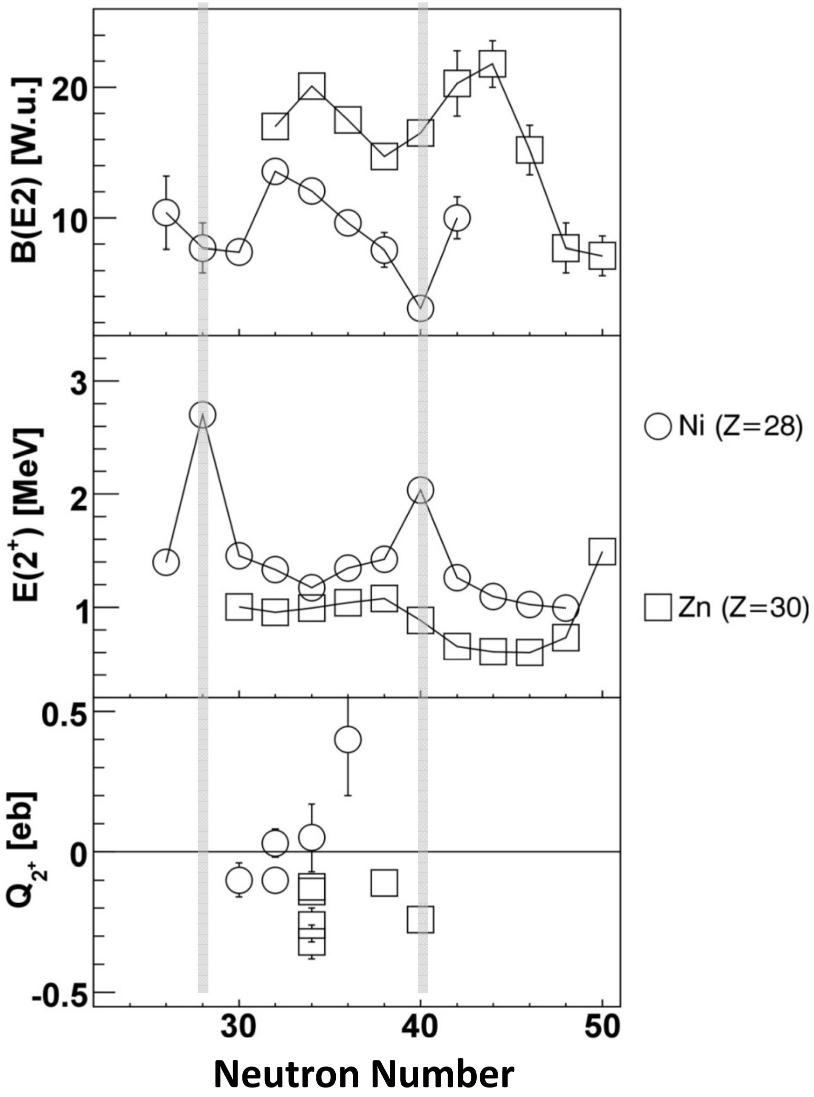

Increased collectivity for Z>28 and 38<N<44

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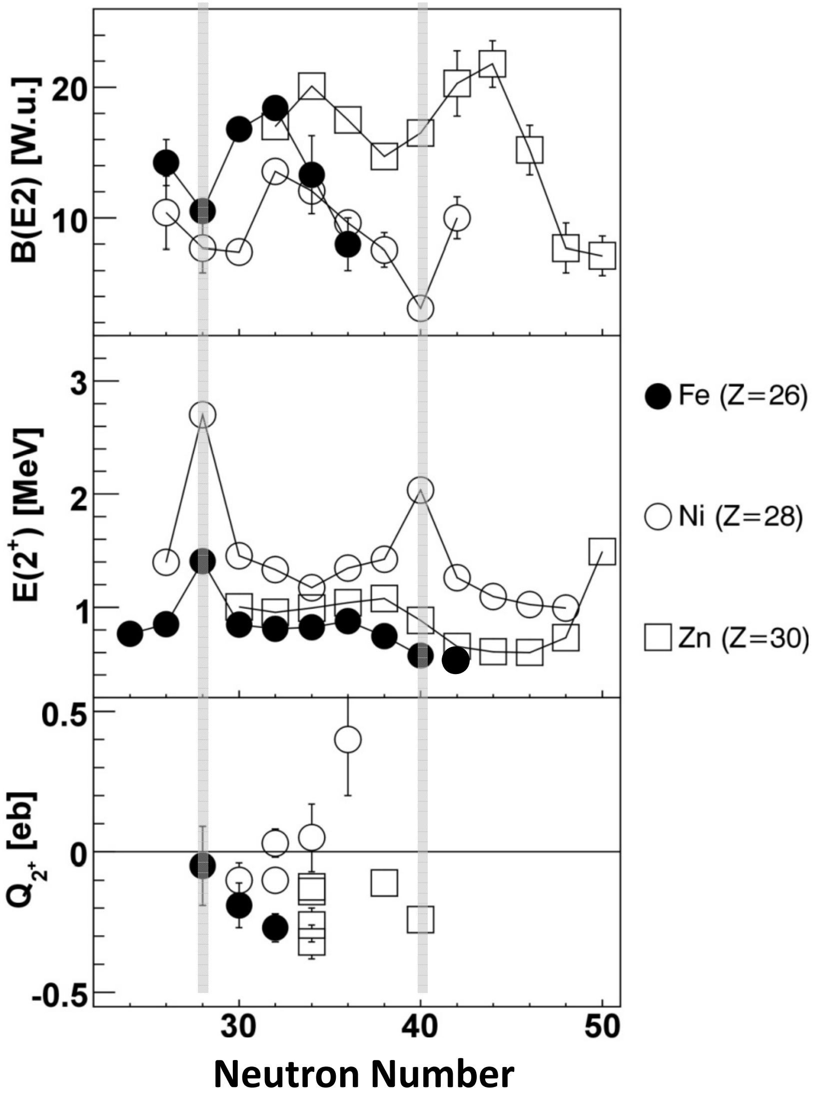

Increased collectivity for Z>28 and 38<N<44

ALSO for Z<28, ex. Z=26 (Iron) And 36<N< ??

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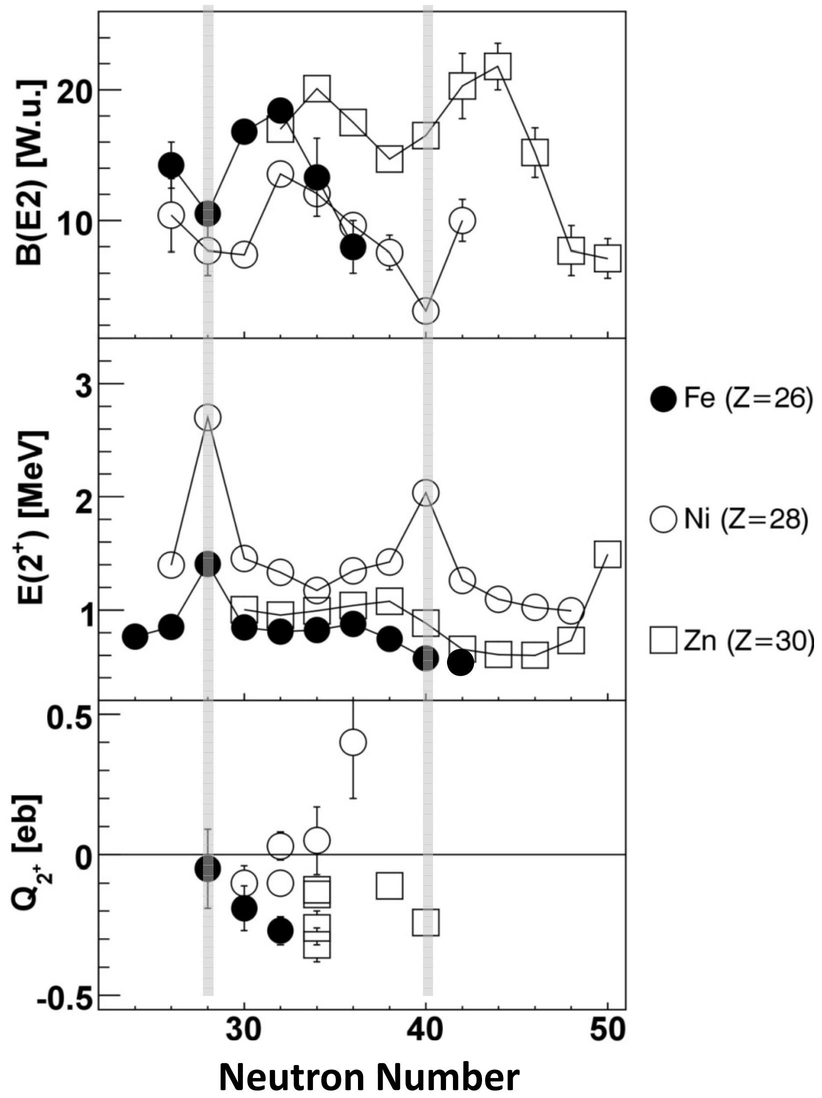

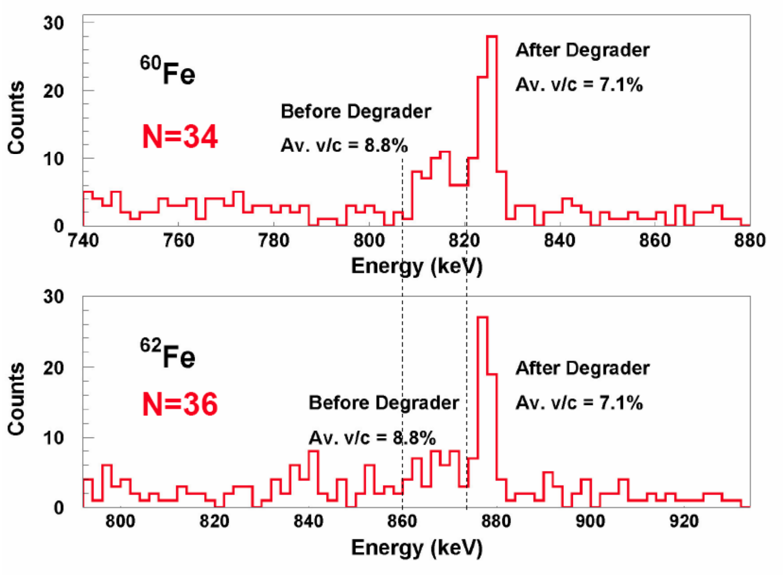

2^+ $T_{1/2}$=9.5(20)ps
B(E2)=8(2) W.u.

Lifetime measurements at Legnaro,

Picture from presentation by
A. Gadea, Conference on Trends in Nuclear Structure,
Zakopane 4-10 sept. 2006

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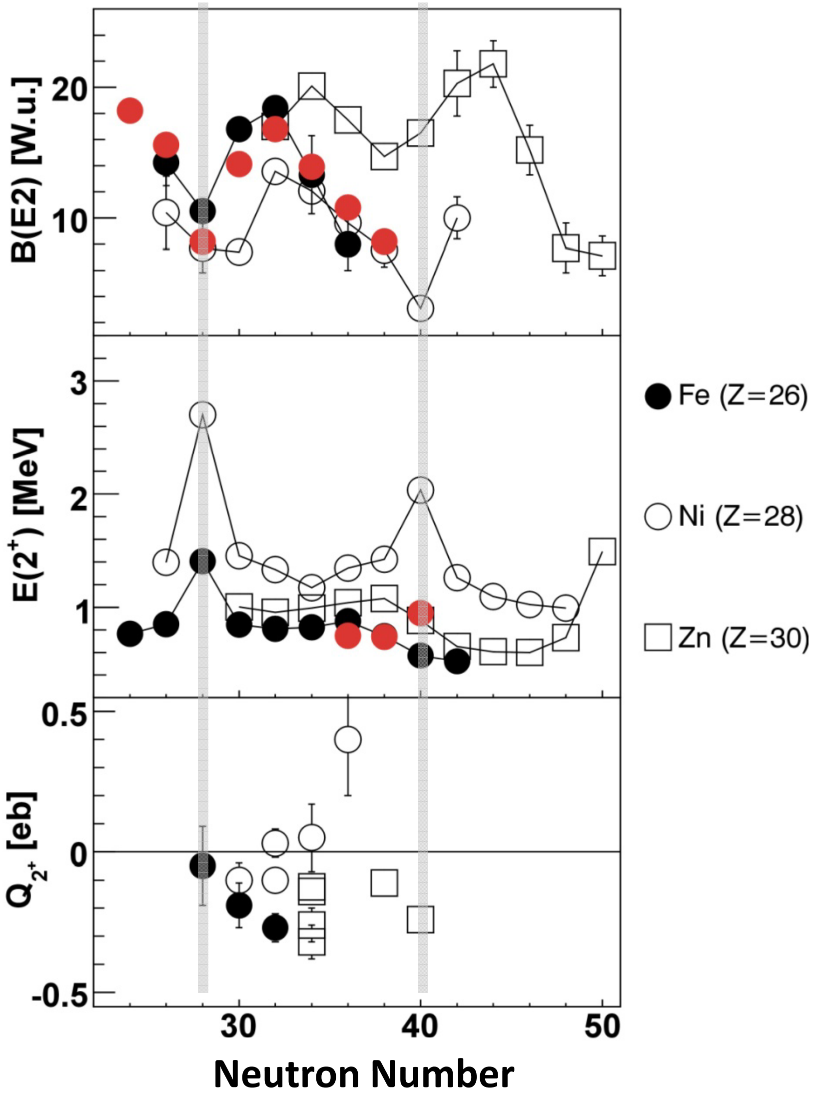

Calculations from Caurier et al.
EPJA, 15, 145-150 (2002)

● pf-shell (KB3G interaction)

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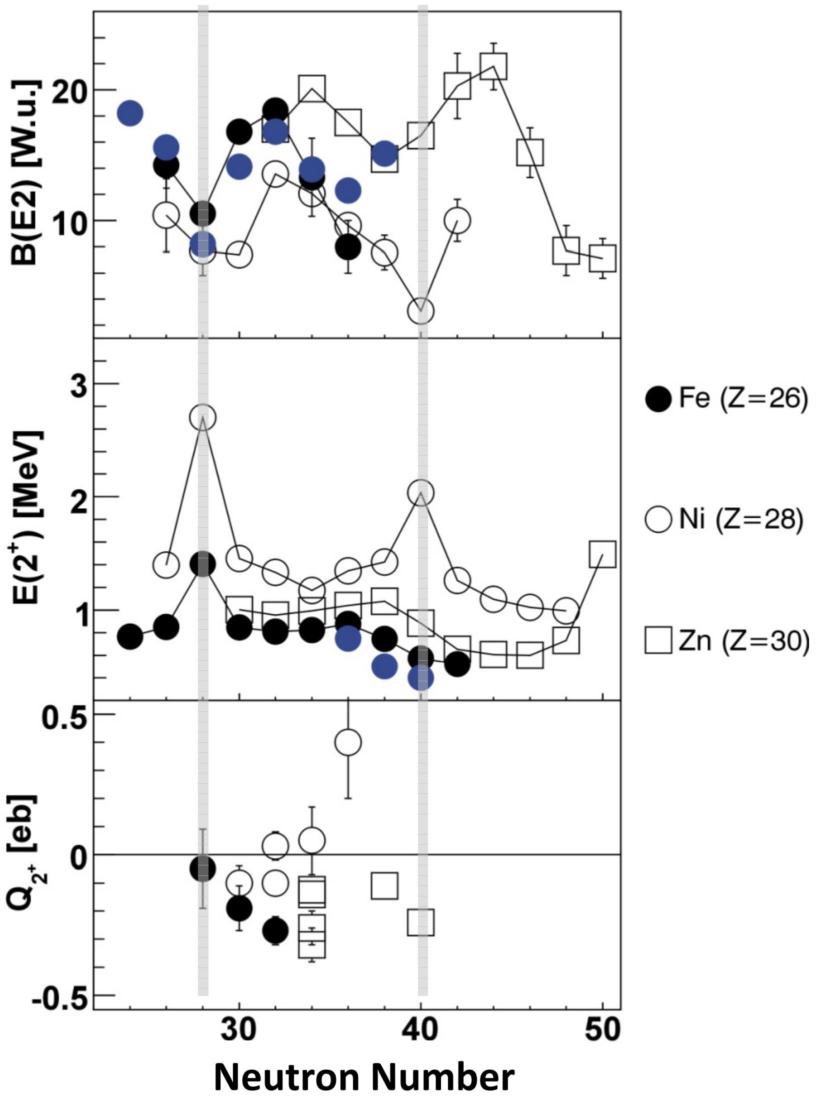

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- 🔴 pf-shell (KB3G interaction)
- 🔵 pfgd (^{52}Ca core)

How do the $1g_{9/2}$ and possibly $2d_{5/2}$ neutron orbitals influence the quadrupole collectivity below Z=28 ?

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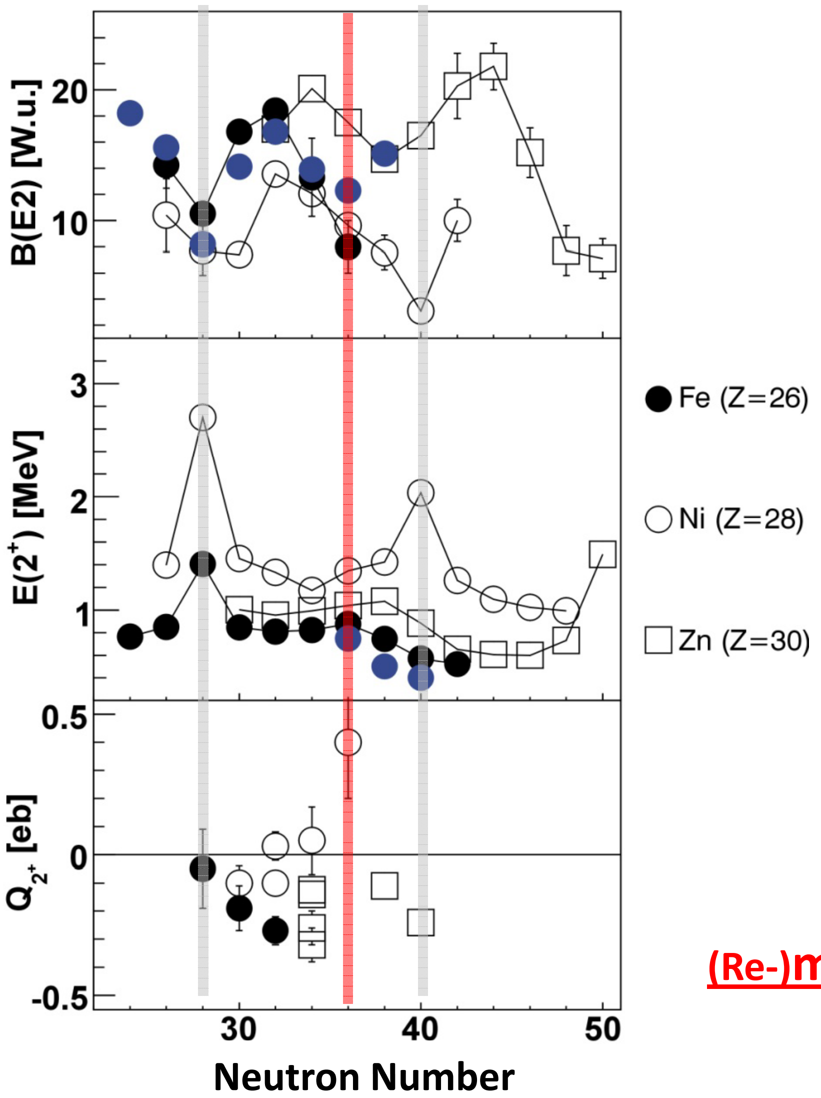

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(Re-)measure the (unpublished) B(E2) value in ^{62}Fe

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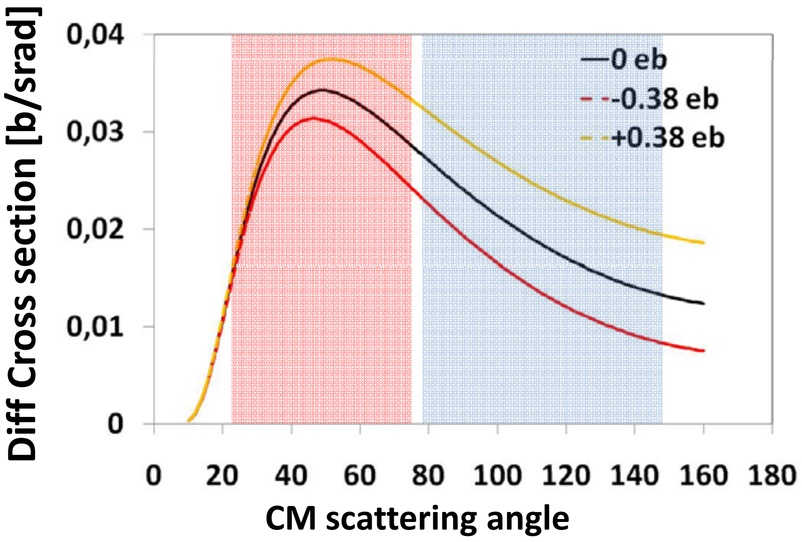

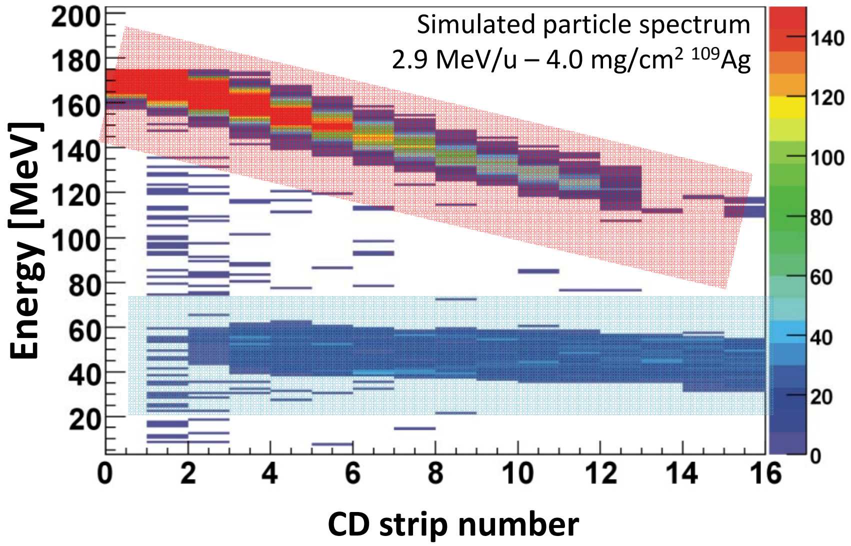

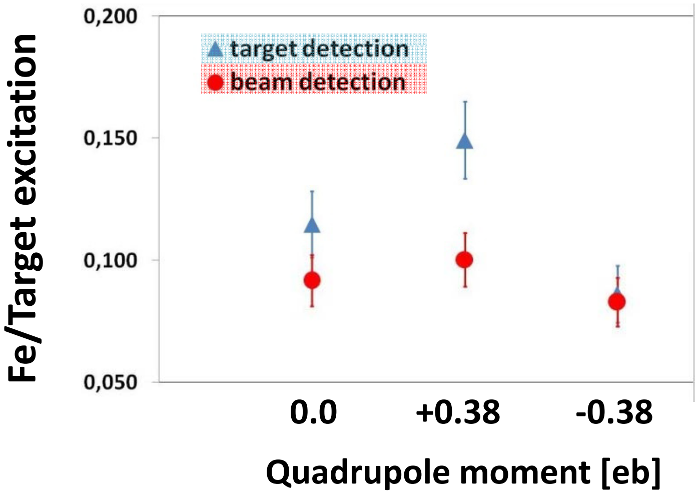

Statistics in 4 shifts assuming :
200 ms trapping and breeding time
2 µA proton beam
4 mg/cm² ^{109}Ag target

Sensitivity to quadrupole moment :

-Target and beam detection in CD detector

-Combination with lifetime measurements

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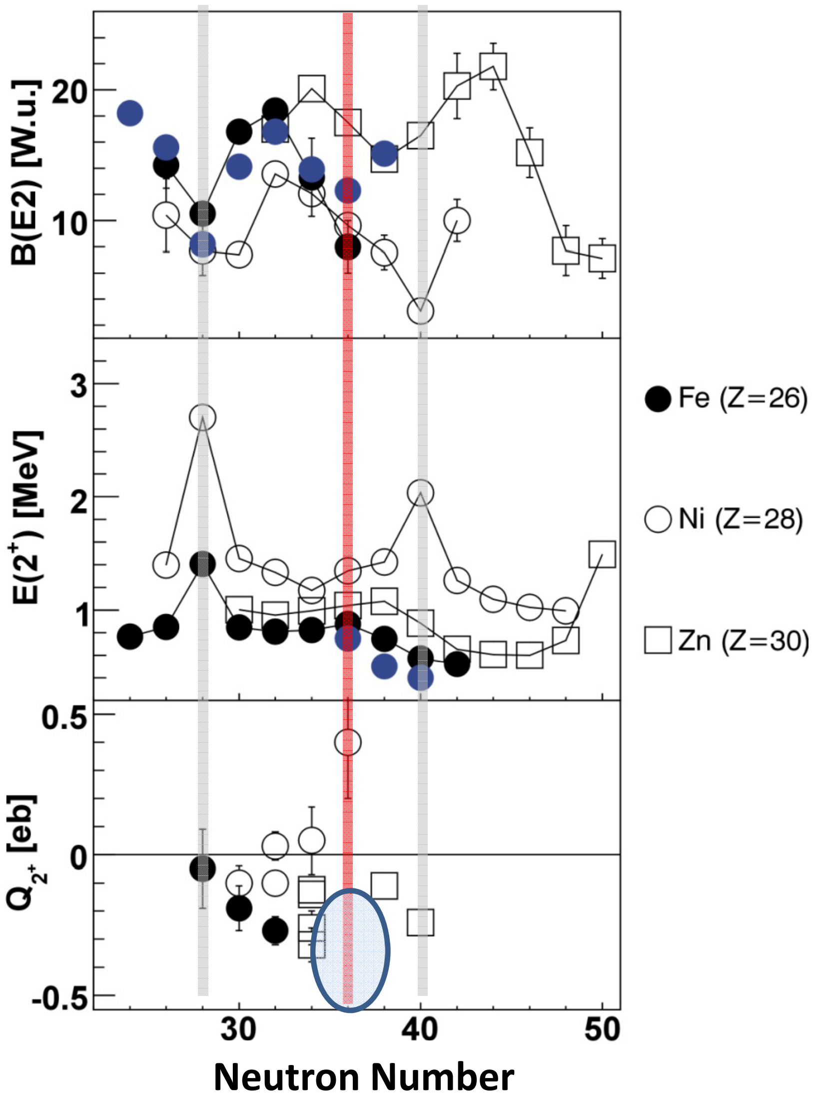

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CONCLUSION : RADIOACTIVE BEAM TIME REQUEST : 8 SHIFTS

4 shifts :

- ^{61}Mn
- 1 shift optimization Bragg chamber + dE-E
- 3 shifts characterizing the change in beam composition with different trapping/charge breeding times

4 shifts :

- ^{62}Mn
- Coulomb excitation on Ag target to obtain a relevant physics result