

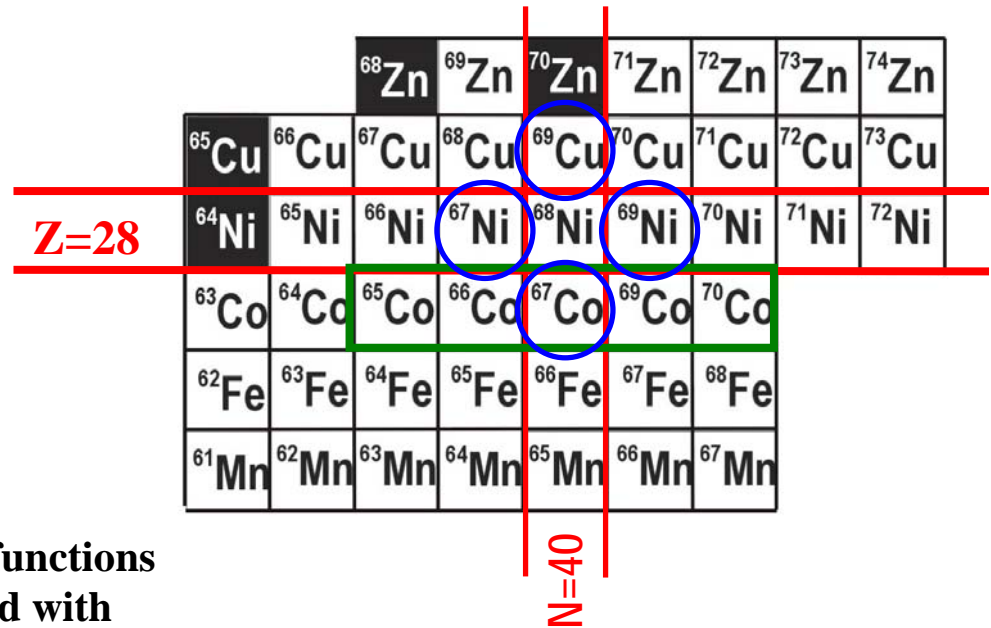
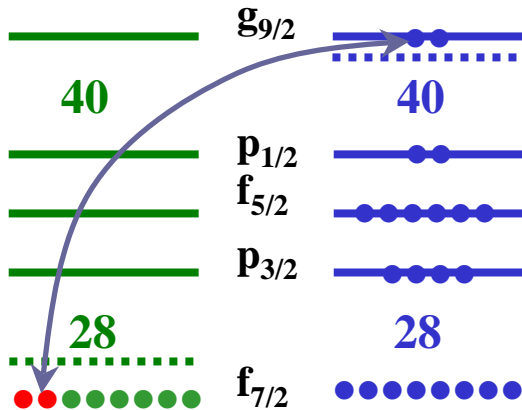
Beta-decay of the n-rich ^{67}Fe studied at the LISOL facility

**Irina Stefanescu, Dieter Pauwels,
O. Ivanov, M. Sawicka, T.E. Cocolios,
M. Huyse, P. Van Duppen,
Y. Kudryavtsev, J. Gentens, P. Van den Bergh**

*Instituut voor Kern- & Stralingsfysica,
Katholieke Universiteit Leuven, Belgium*



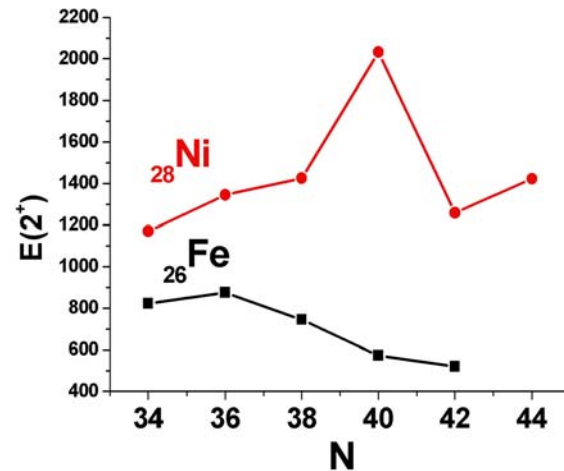
Nuclear structure around ^{68}Ni



➤ $^{67,69}\text{Ni}$ and ^{69}Cu from β -decay indicate wave functions characterizing the low-lying states weakly mixed with configurations implying 2p-2h excitations across $N=40$;

➤ low-energy 2^+ states in the even-even Fe isotopes indicated the presence of large prolate deformations below Ni;

➤ calculations predict $\beta \sim 0.26$ for ^{66}Fe (E. Caurier et al., Eur.Phys. J. A 15, 145(20002), M. Hannawald et al. PRL 82, 1391(1999)).



Production of n-rich Fe beams

| | | | | |
|------------------|------------------|------------------|------------------|------------------|
| Z=28 | ⁶⁷ Ni | ⁶⁸ Ni | ⁶⁹ Ni | |
| | 21 s | 29 s | 1.14 s | |
| ⁶⁵ Co | ⁶⁶ Co | ⁶⁷ Co | ⁶⁸ Co | |
| 1.14 s | 0.18 s | 425 ms | 1.6 s | |
| | ⁶⁵ Fe | ⁶⁶ Fe | ⁶⁷ Fe | ⁶⁸ Fe |
| | 0.45 s | 0.44 s | 0.47 s | 0.1 s |
| | | N=40 | | |

➤ production of n-rich Fe beams possible in the past only at fragmentation facilities

(GANIL: O. Sorlin et al., NPA 660, 3(1999))

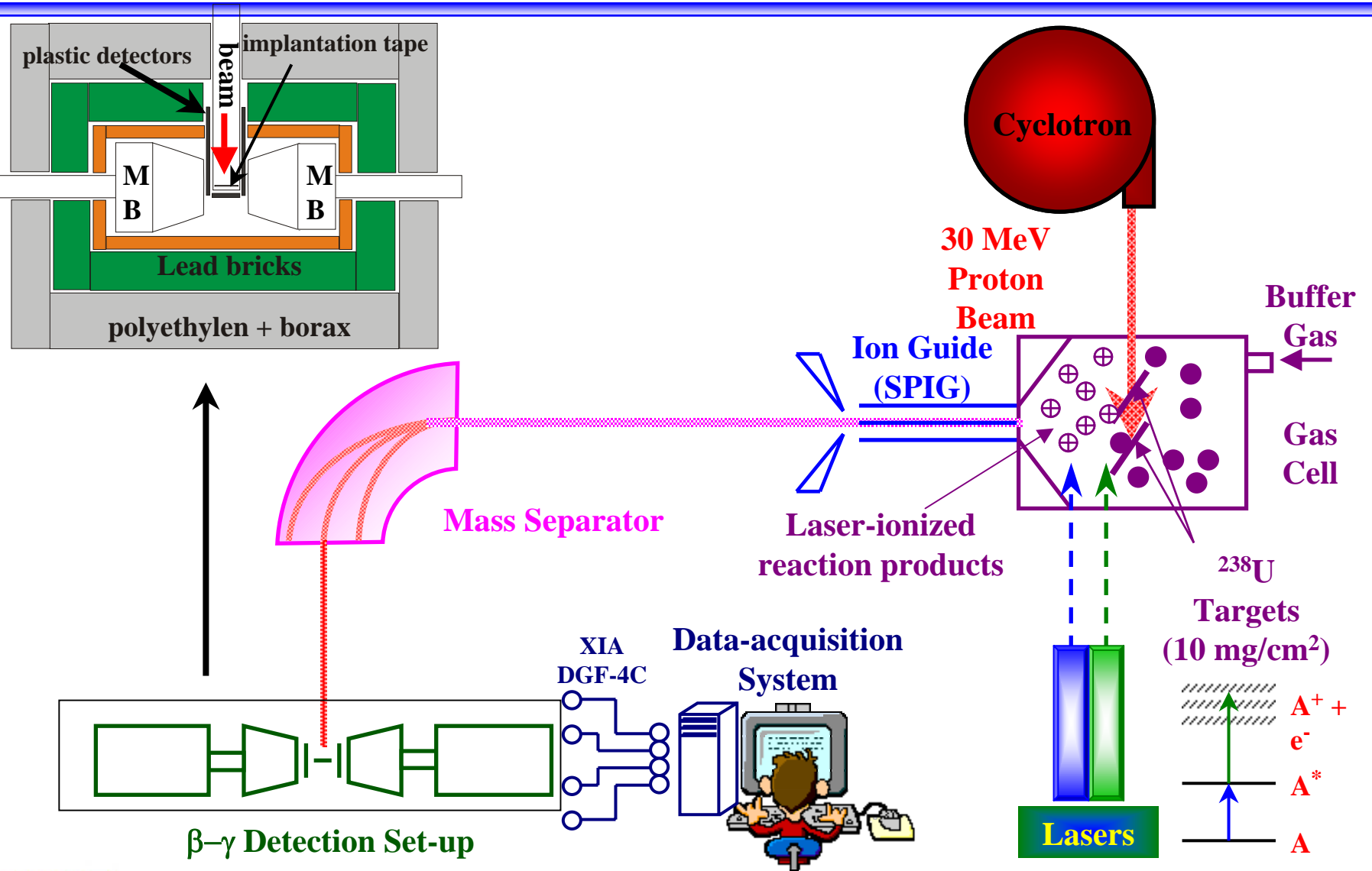
(GSI: F. Ameil et al., Eur. Phys. J. A1, 275(1998)).

➤ 2005: first ISOL-type ^{65,66,67}Fe beams produced at the LISOL facility, Louvain-la-Neuve (Belgium) by combining proton induced fission of ²³⁸U with resonant laser ionization;

➤ efficient and selective technique used in the past for the production of the n-rich Ni (S. Franchoo et al., PRC 65, 054308(2001)) and Co (W.F. Mueller et al., PRC 61, 054308(2000)) beams;

➤ 2006: beamtime for the investigation of the beta-decay of ⁶⁷Fe.

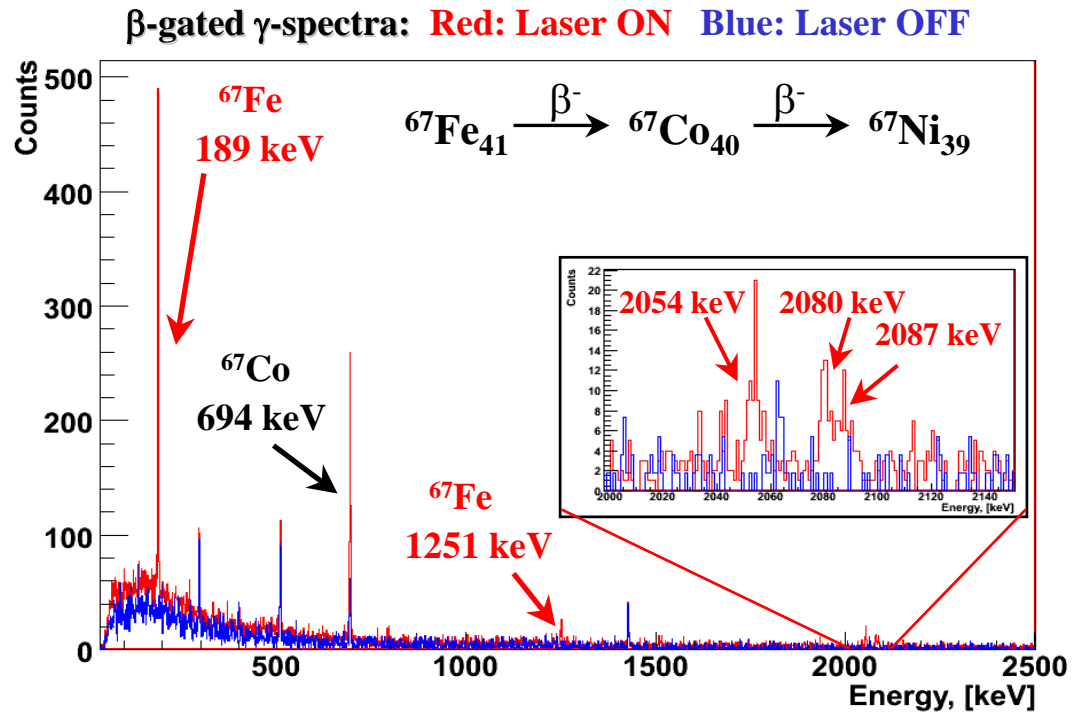
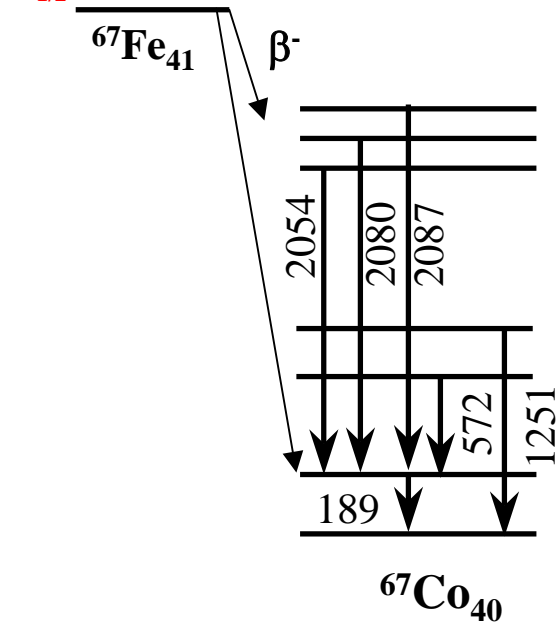
Leuven Isotope Separator On-Line (LISOL)



^{67}Fe : β -gated γ -spectra (2005)

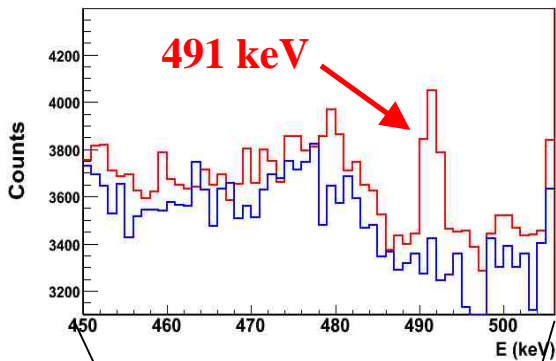
- measuring time ~16 h;
- beam on-beam off cycles: 1.5s/1.5s;
- laser on/off runs for the identification of the nonresonant γ -rays.

$T_{1/2} = 411(32)$ ms



- preliminary level-scheme of ^{67}Co constructed based on β - γ and γ - γ coincidences;
- half-life of ^{67}Fe fixed to 411(32) ms based on the time evolution of the γ -intensity of the 189 keV transition.

^{67}Fe : single γ -spectra



$T_{1/2}=411(32)$ ms

$^{67}\text{Fe}_{41}$

β^-

?

?

$T_{1/2}=425(20)$ ms

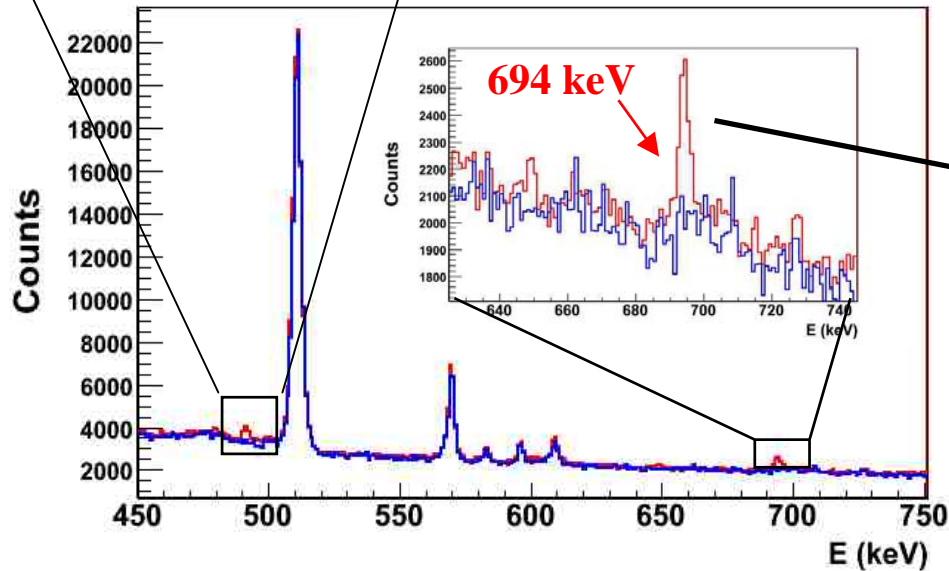
189 (7/2⁻)

$^{67}\text{Co}_{40}$

β^-

(5/2⁻)

Red: Laser ON Blue: Laser OFF



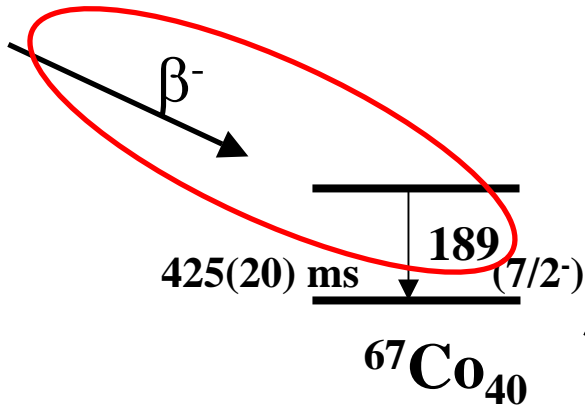
$T_{1/2}=21$ s

$^{67}\text{Ni}_{39}$

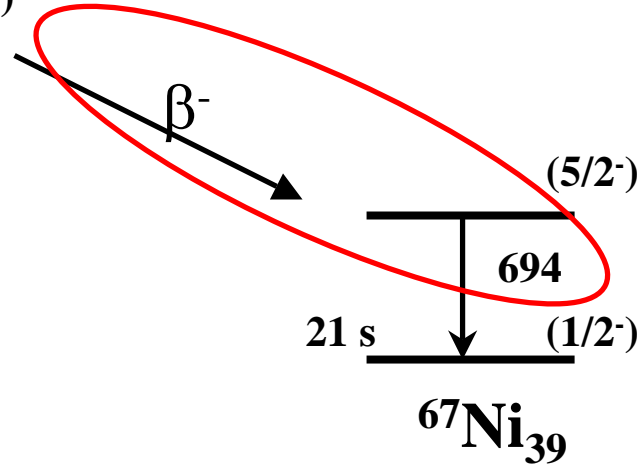
L. Weissman et al., PRC 59, 2004(1999).

^{67}Fe : β - γ - γ - time correlations

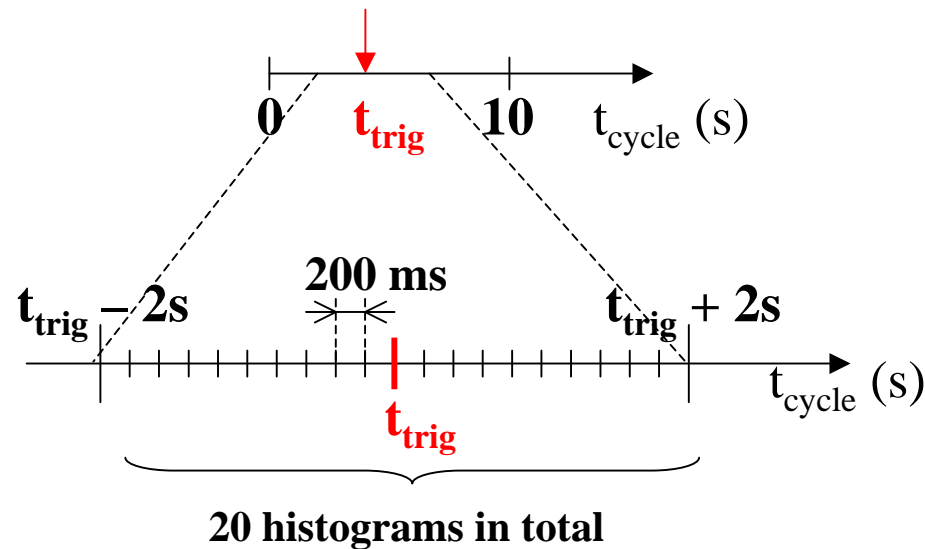
0.47(5) s
 $^{67}\text{Fe}_{41}$



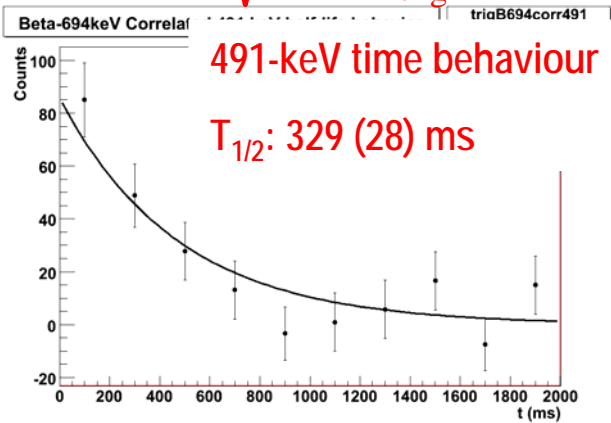
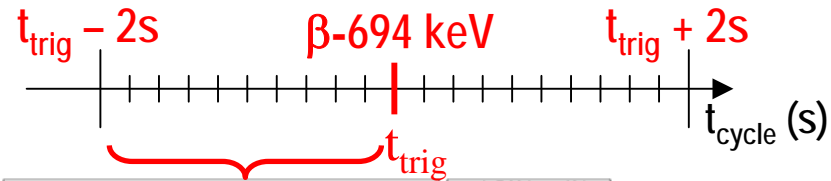
Step 1: Find a trigger event (β -189 keV or β -694 keV coincidence events, single- γ 491 keV, etc).



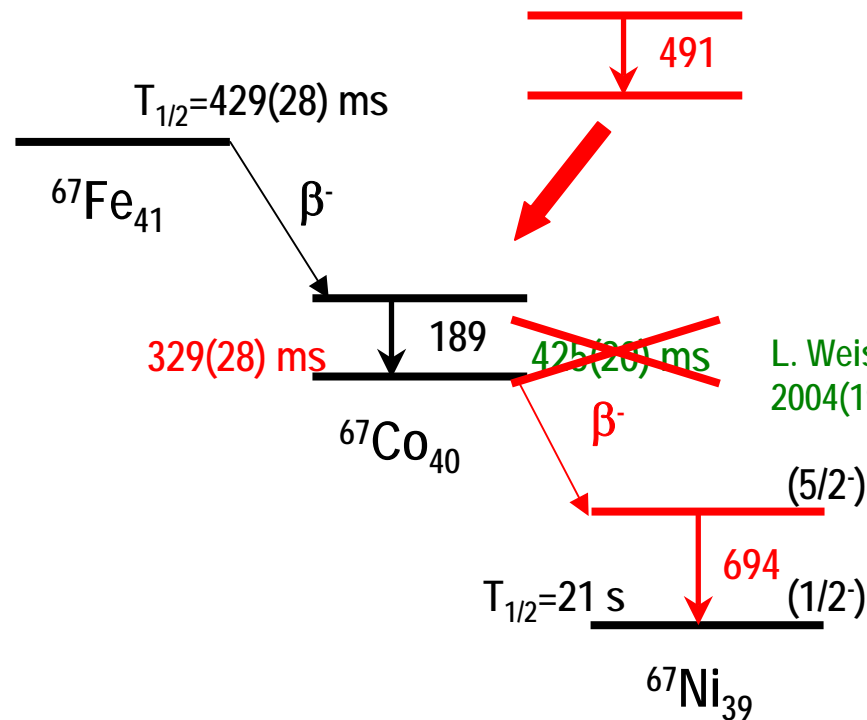
Step 2: Build histograms with the events coming before and after the trigger in 200 ms slices (single γ 's, β -gated γ 's, etc).



^{67}Fe : β - γ - γ - time correlations

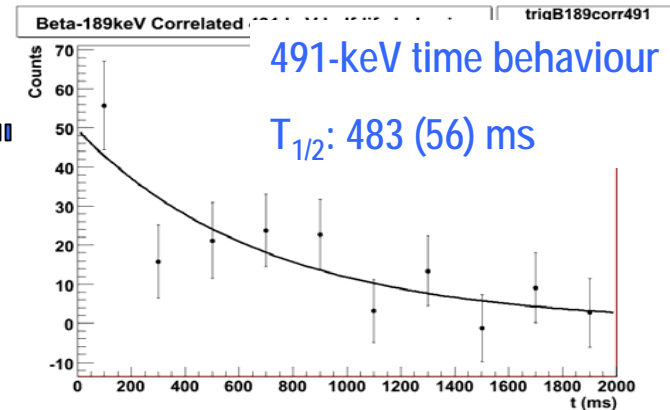
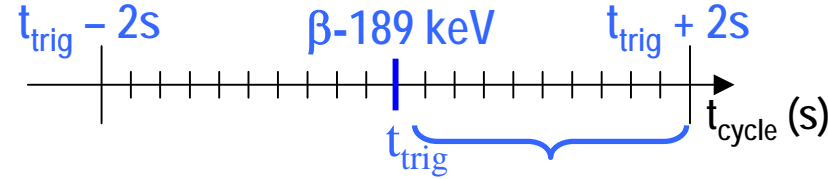
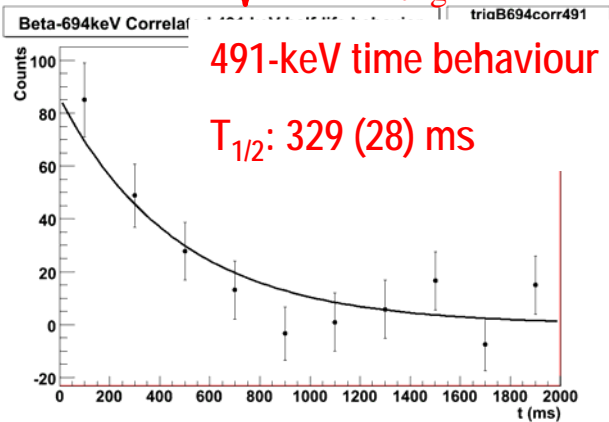
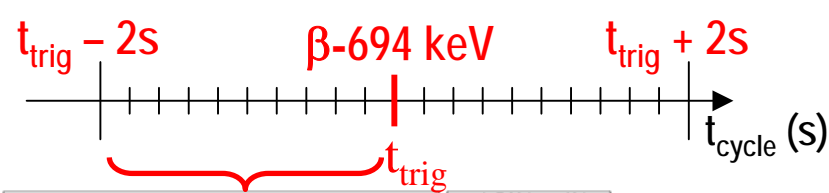


491 keV in ^{67}Co !

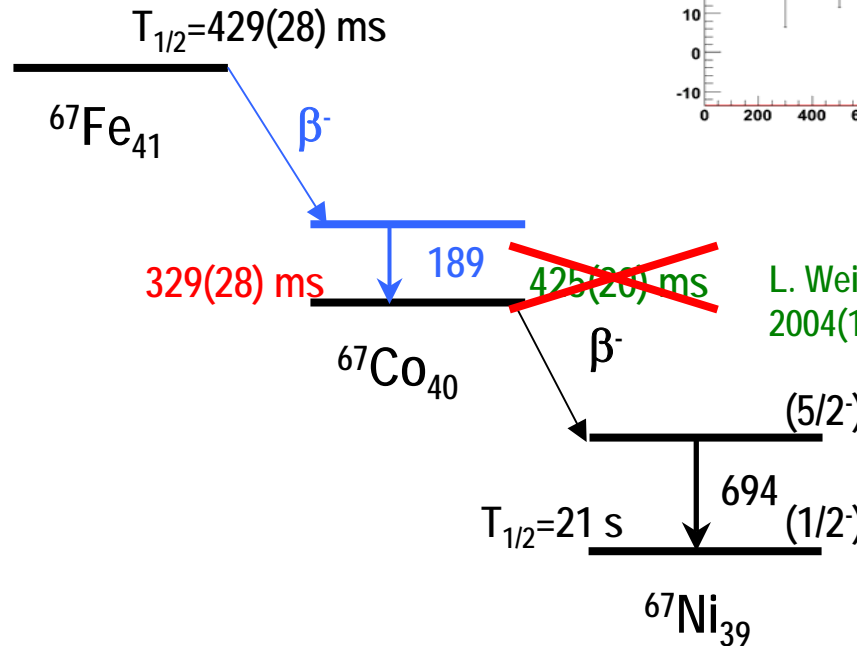


L. Weissman et al., PRC 59, 2004(1999).

^{67}Fe : β - γ - γ - time correlations



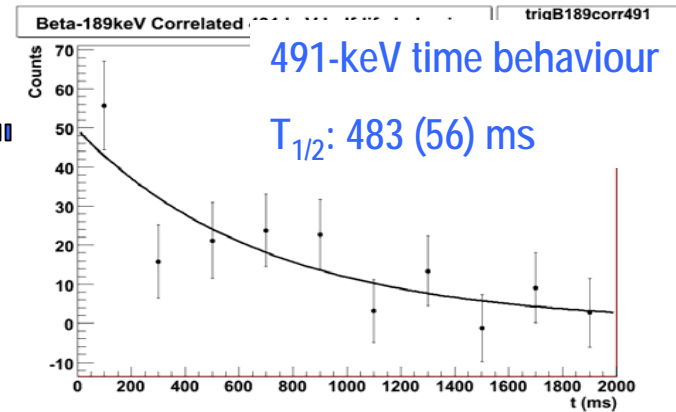
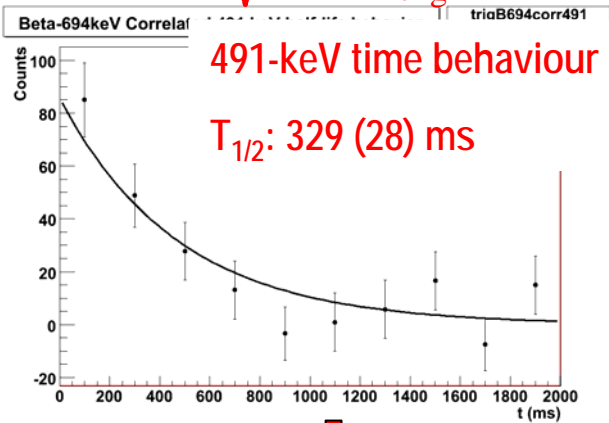
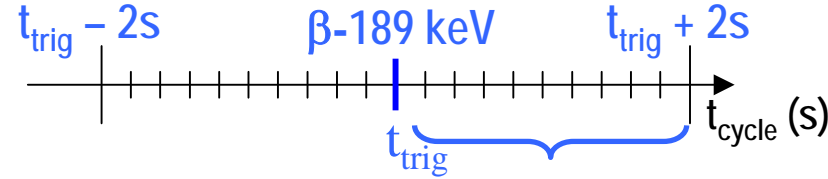
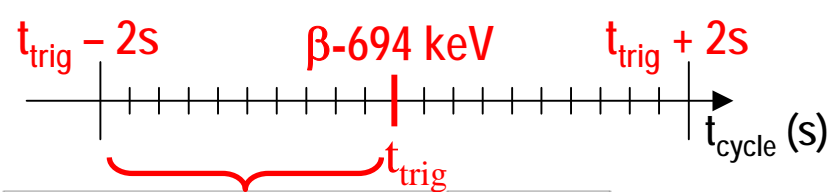
491 keV after β -189 keV ←



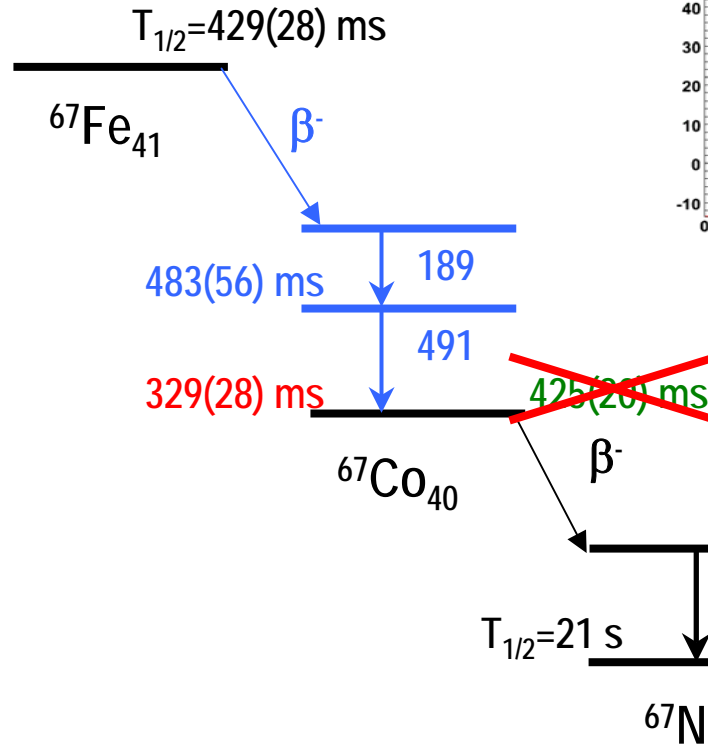
L. Weissman et al., PRC 59, 2004(1999).

↓
491 keV in ^{67}Co !

^{67}Fe : β - γ - γ - time correlations



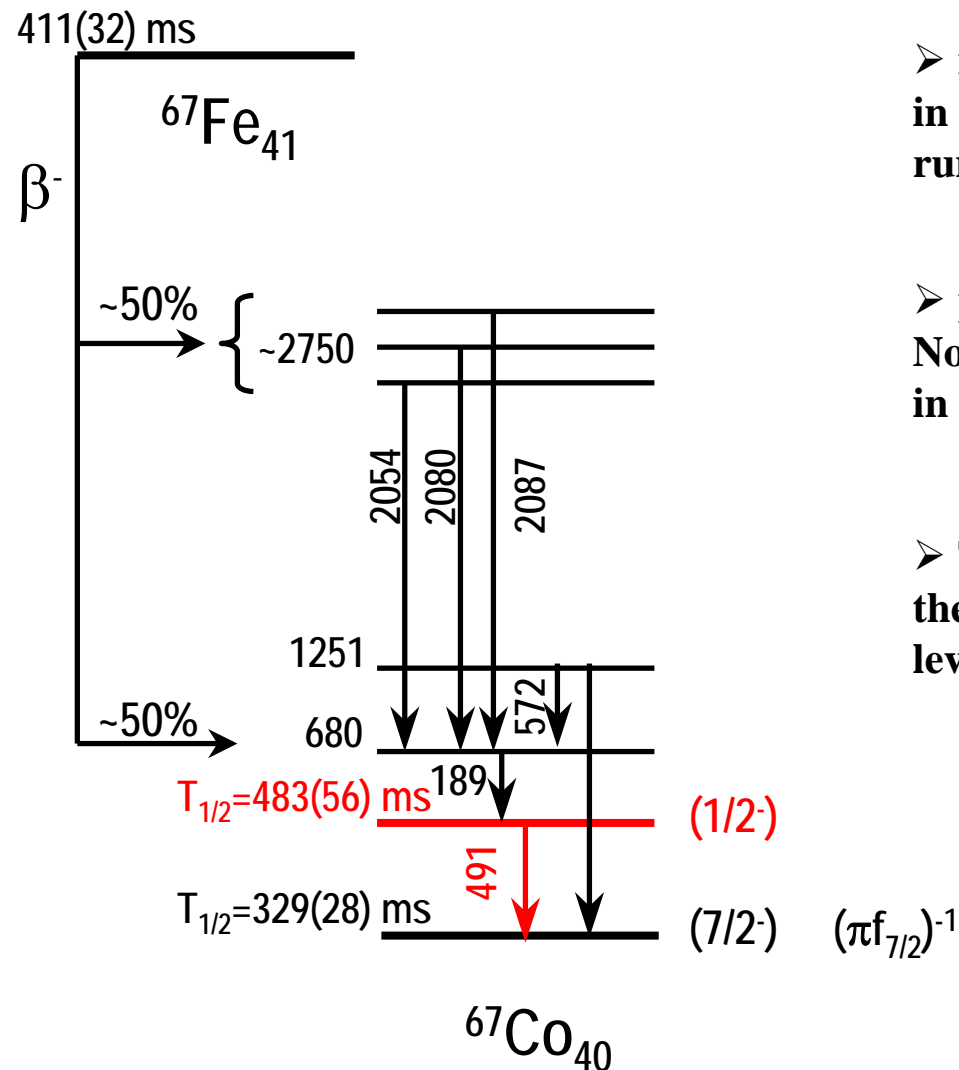
491 keV after β -189 keV



L. Weissman et al., PRC 59, 2004(1999).

↓
491 keV in ^{67}Co !

^{67}Co : preliminary level scheme and interpretation

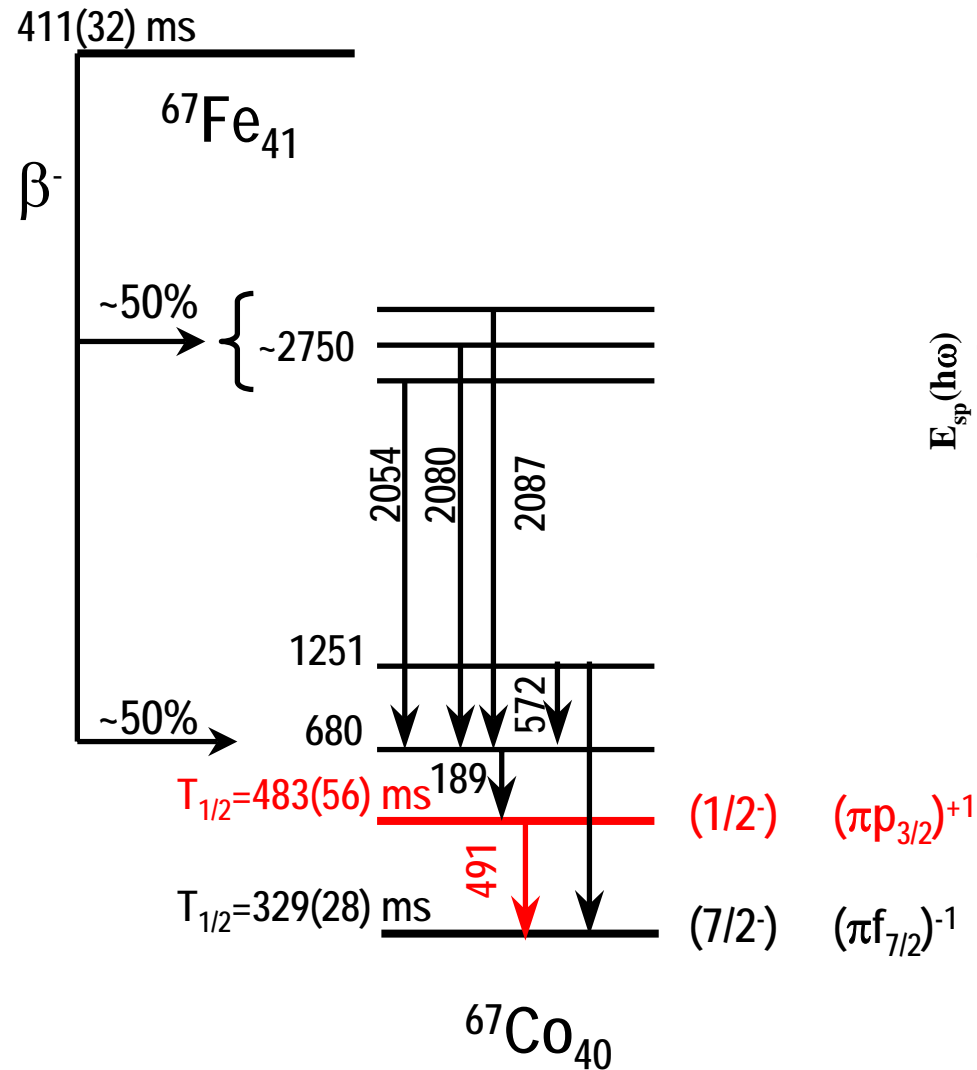


➤ no sign for a similar isomeric state was found in the preliminary level scheme of ^{65}Co (test run 2005).

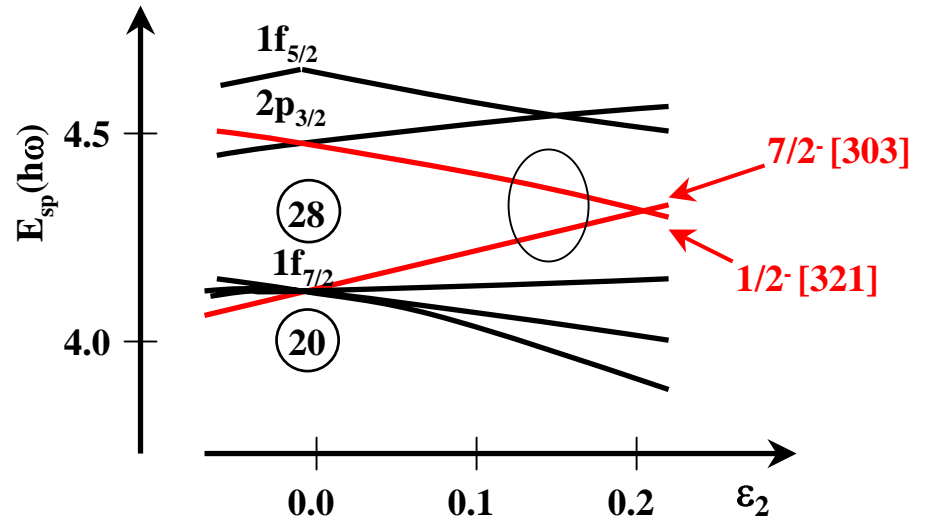
➤ preliminary shell-model calculations by Nowacki did not account for a low-lying isomer in ^{67}Co .

➤ $T_{1/2}^{\text{sp}} \sim 500$ ms suggests a M3/E4 character for the 491 keV transition $\rightarrow I^\pi = 1/2^-$ for the isomeric level.

^{67}Co : preliminary level scheme and interpretation



➤ presence of the low-energy isomer can only be explained by taking into account deformation ($\beta \sim 0.1 \div 0.2$)



➤ level scheme expected to combine *single-particle* and *collective* degrees of freedom.

Conclusions and outlook

- ✓ first ISOL-type n-rich $^{65,66,67}\text{Fe}$ beams were produced at the LISOL facility in Louvain-la-Neuve;
- ✓ beams used for nuclear structure investigations by beta-decay;
- ✓ 6 new γ -rays were identified and placed in the level scheme of ^{67}Co (N=40);
- ✓ results indicate the presence of a 491 keV isomeric level ($T_{1/2}=483(56)$ ms);
- ✓ half-life and position of the isomer in the level scheme of ^{67}Co based on a newly developed technique of β - γ correlations;
- ✓ presence of the isomer can be explained by invoking deformation;
- ✓ level-scheme expected to combine single-particle and collective degrees of freedom.
 - analysis of ^{67}Fe data set needs to be finalized (β -branchings, γ -crossover transitions);
 - July 2007: beamtime for $^{65,66}\text{Fe}$.