Fast timing meeting

Brighton 11 Jan 2011

Agenda

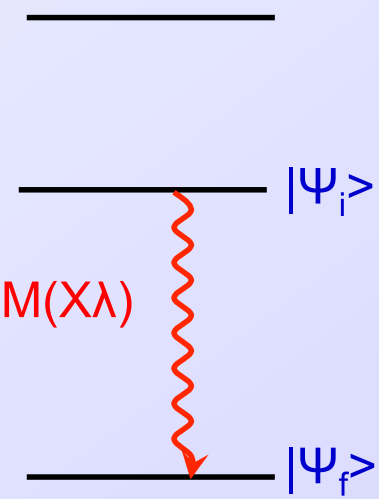
- Intro - Fast timing measurements
- Status NUSTAR and DESPEC
- Beta detectors
- Timing detectors and photosensors
- DAQ – Electronics
- Calibration, software, analysis
- DESPEC array
- Planning

Transition matrix elements

✓ Absolute transition matrix elements

$$B\left(X\lambda; I_i \rightarrow I_f\right) = \left(2I_i + 1\right)^{-1} \left| \left\langle \psi_f \left\| M(X\lambda) \right\| \psi_i \right\rangle \right|^2$$

$$B\left(X\lambda; I_i \rightarrow I_f\right) = \frac{L[(2L+1)!!]^2 \hbar}{8\pi(L+1)} \left(\frac{\hbar c}{E_\gamma} \right)^{2L+1} P_\gamma\left(X\lambda; I_i \rightarrow I_f\right)$$



→ Single particle estimates

- Shell evolution
- Mirror symmetries

→ B(E2) values

- Deformation of even-even nuclei
- Collective modes (spin dependence), shape coexistence…

→ Systematics

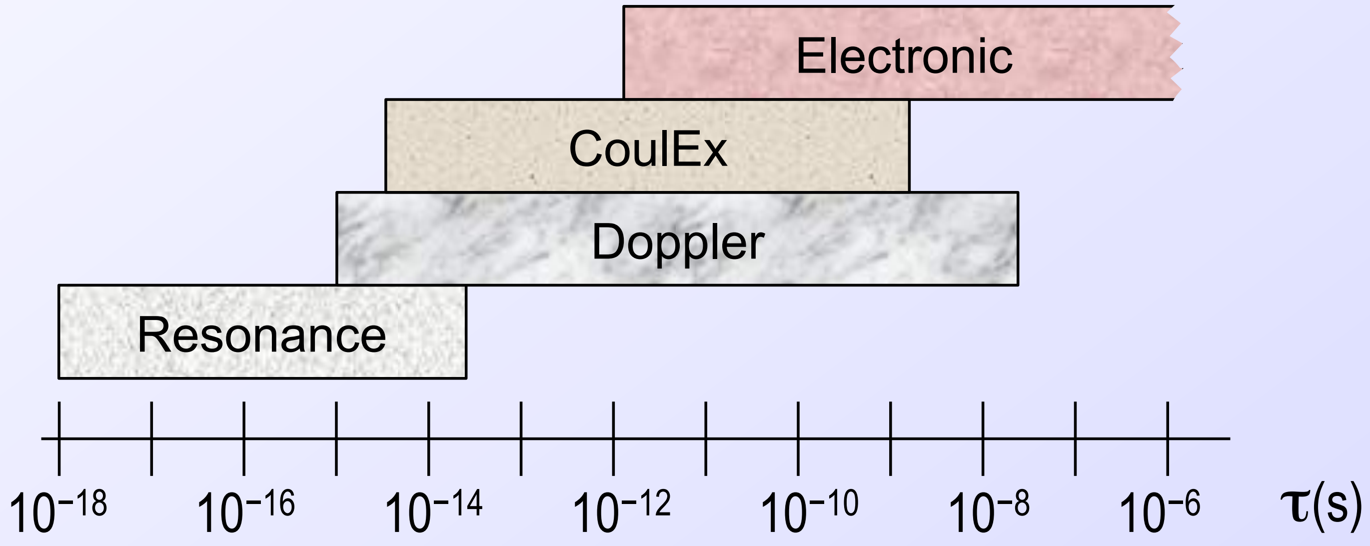
Nuclear half lives

→ Coulomb excitation

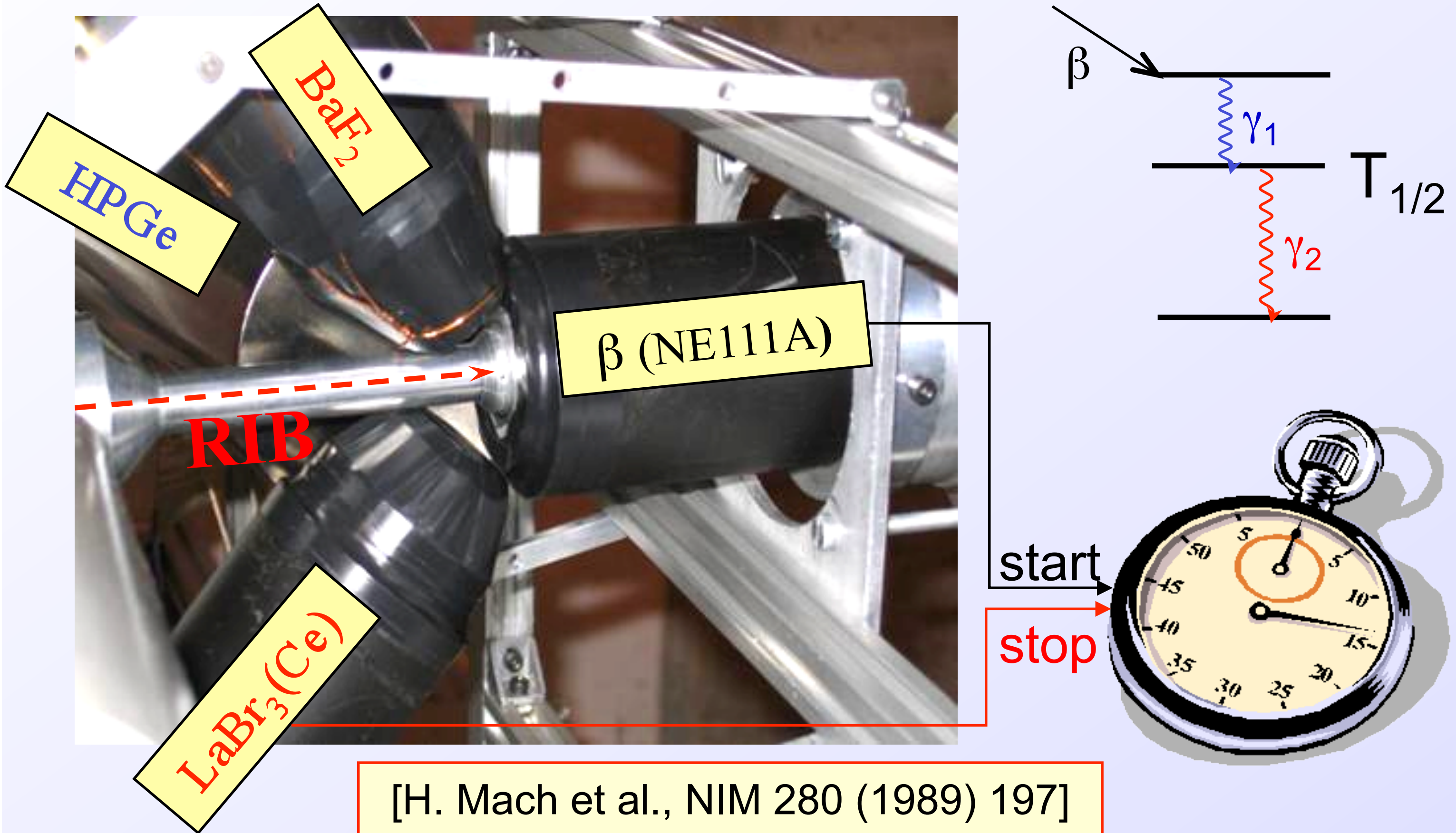
- Requires extra information / assumptions

→ Moments

Lifetimes



The Advanced Time Delayed $\beta\gamma\gamma(t)$ method



[H. Mach et al., NIM 280 (1989) 197]
[H. Mach et al., NPA 523 (1991) 45]

HPGe: BRANCH SELECTION
High energy resolution
Poor time response

Plastic β scintillator: TIMING
Fast response
Efficient start detector

$LaBr_3(Ce)/BaF_2$: TIMING
Fast response γ-detectors
Poor energy resolution
Stop detectors

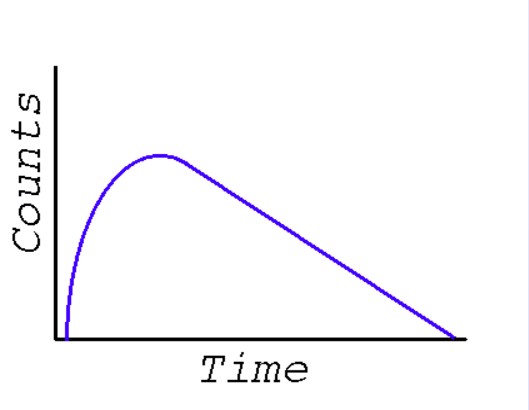
The Advanced Time Delayed $\beta\gamma\gamma(t)$ method

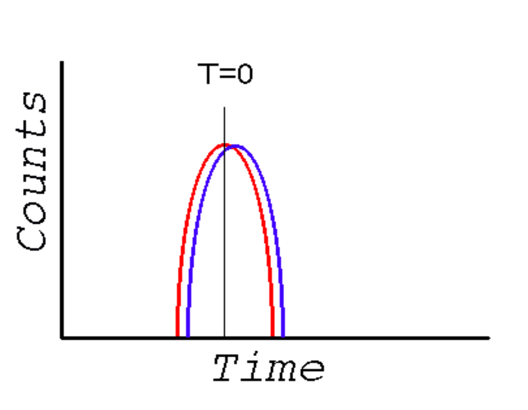
β–BaF_2–HPGe / β–$LaBr_3$–HPGe: lifetime measurements

TAC

De-convolution of slope

- Slope = $T_{1/2}$
- Range: 30 ps to 30 ns (or longer)





Centroid shift

- Shift in centroid position = τ
- Range: down to ~5-10 ps

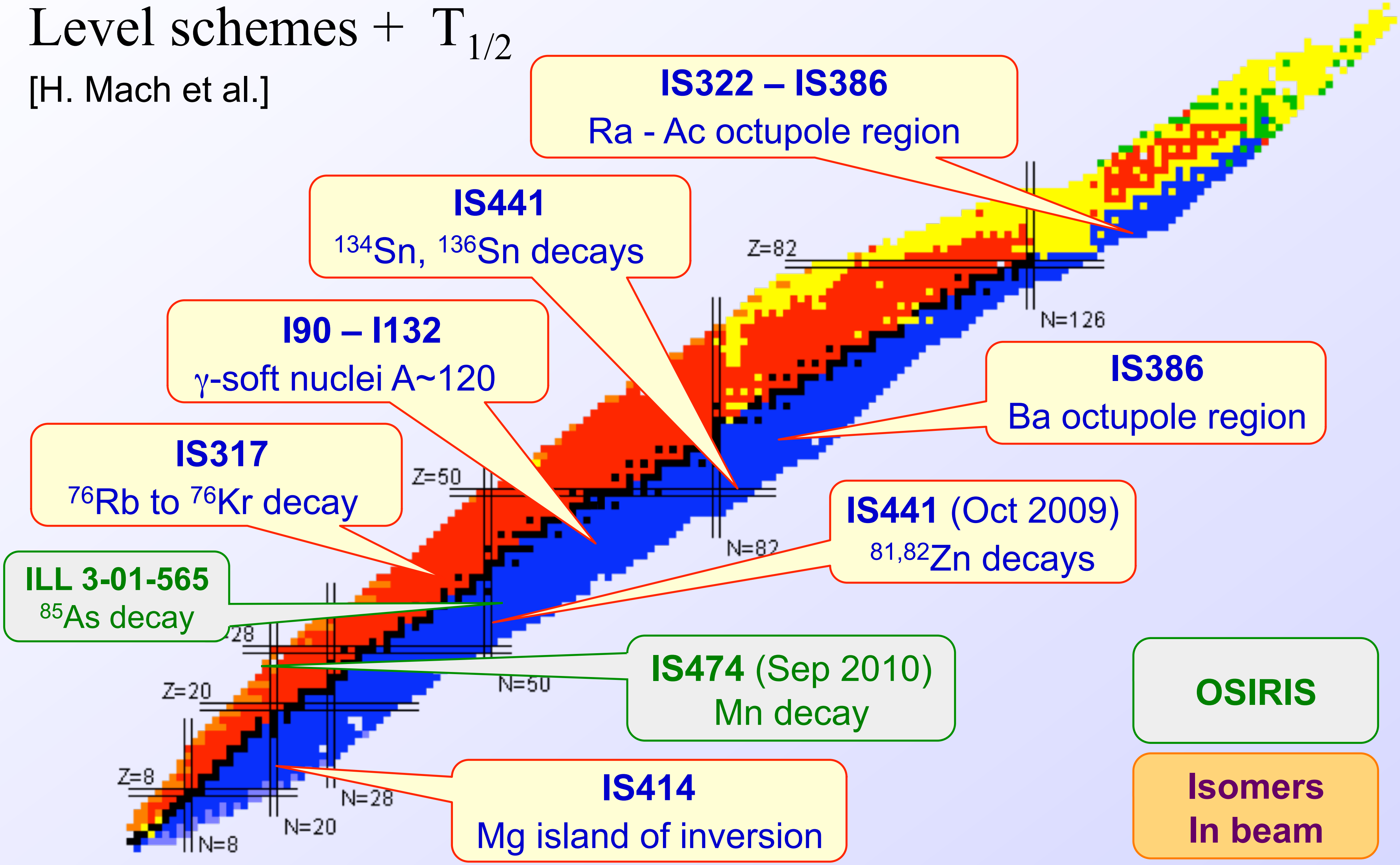
Precise Time calibrations

β–HPGe–HPGe: coincidences, level scheme

ATD βγγ(t) studies

Level schemes + $T_{1/2}$

[H. Mach et al.]

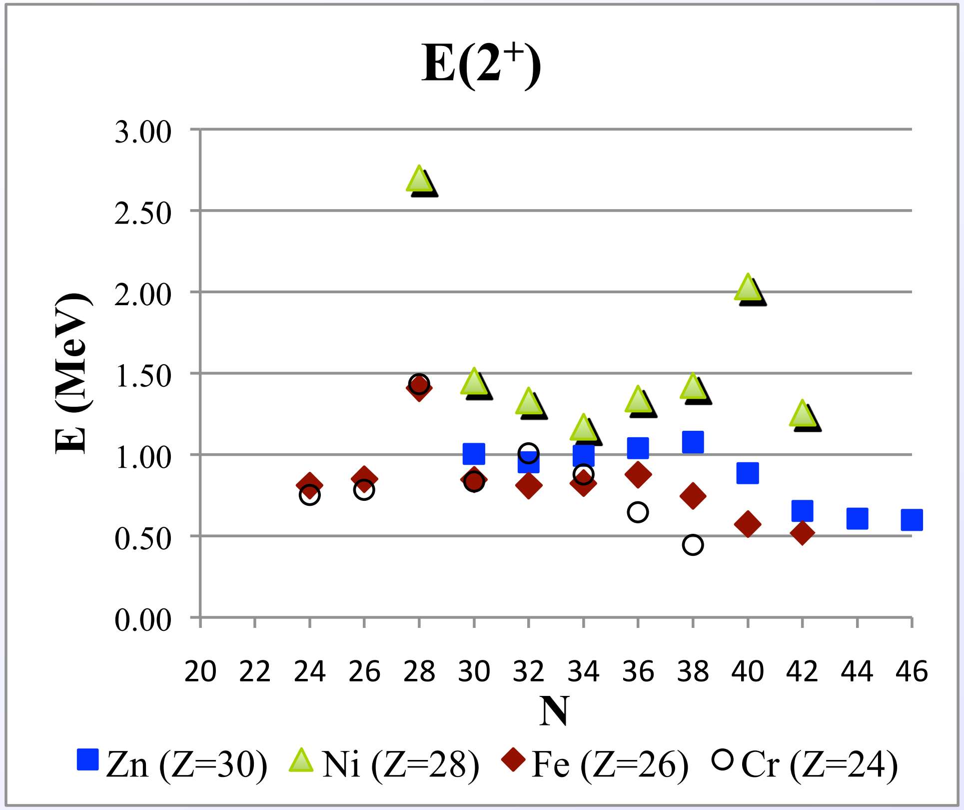


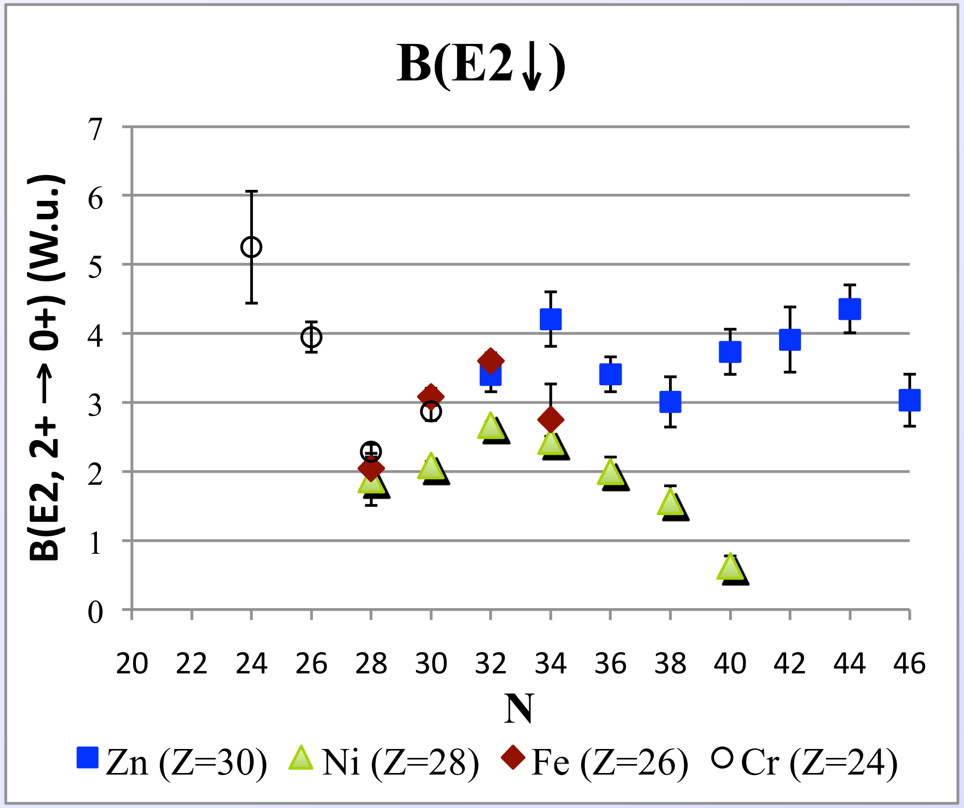
OSIRIS

Isomers
In beam

Example - Nuclear chart below ^{68}Ni

Prospects: nuclei below ^{68}Ni



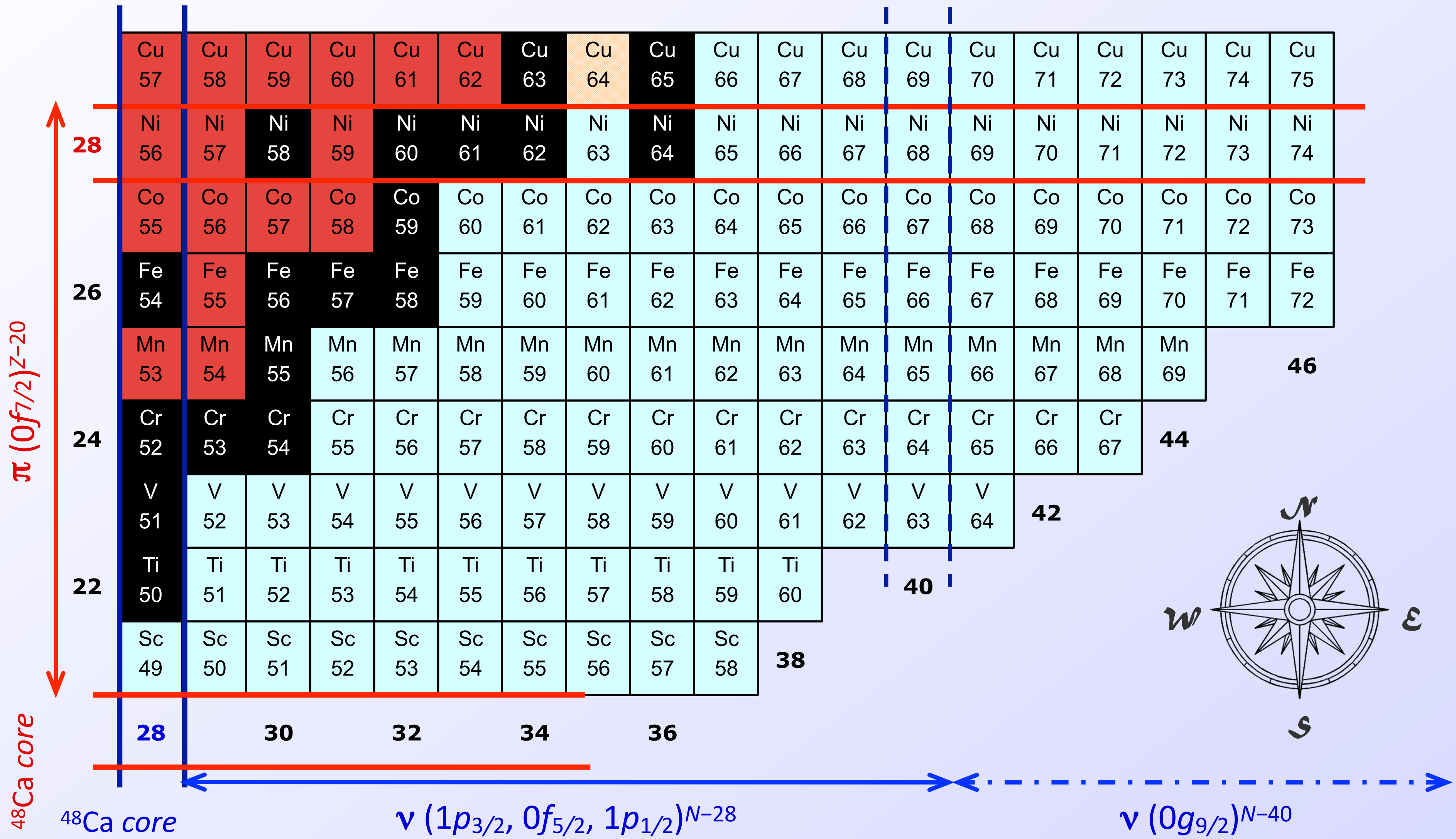


^{64,66}Fe, 2^{+} states (most intense transitions), M. Hannawald et al., PRL 82, 1391 (1999)

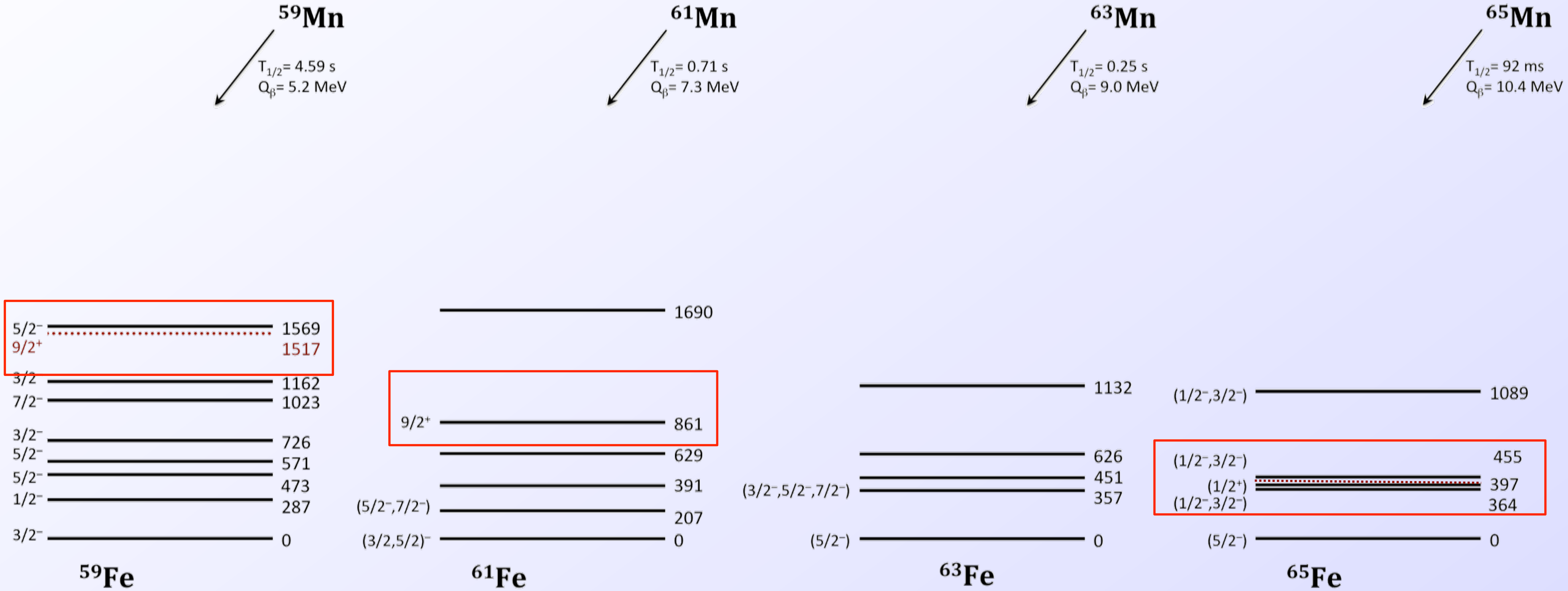
S. Lunardi et al., PRC 76, 034303 (2007)

^{68}Fe E(2^{+}) = 522 keV, J.M. Daugas et al., FINUSTAR, AIP Conf Proc 831, 427 (2006)

Prospects: Nuclear chart below ^{68}Ni



Odd-A Fe isotopes

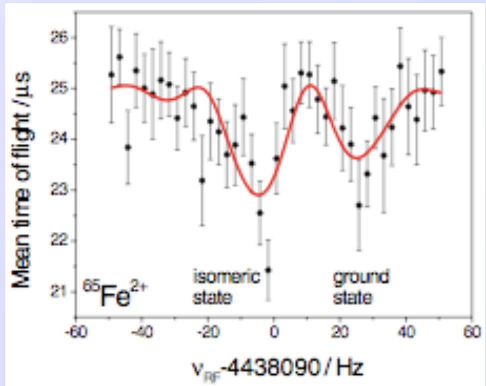


^{57}Fe E(9/2$^+$) = 2455 keV, A. Deacon et al., PRC 76, 054303 (2007)

^{65}Fe E(9/2$^+$) = 402(5) keV, $T_{1/2} \geq 150$ ms

M. Block et al., PRL 100, 132501 (2008)

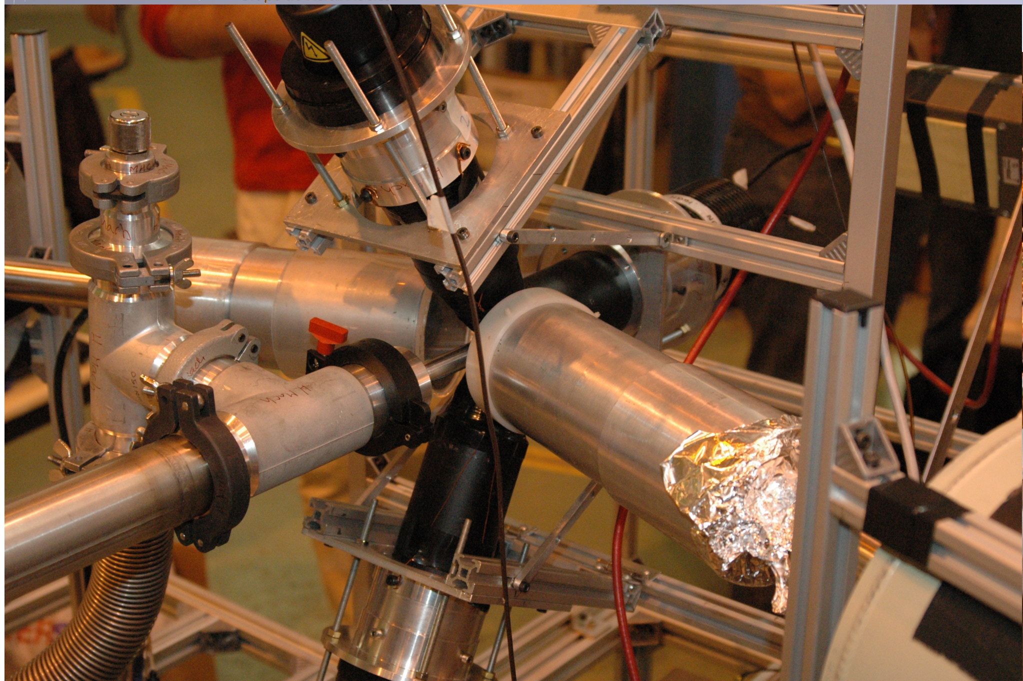
^{67}Fe $T_{1/2} \sim 75$ μs, J.M. Daugas et al. AIP Conf Proc 831, 427 (2006)

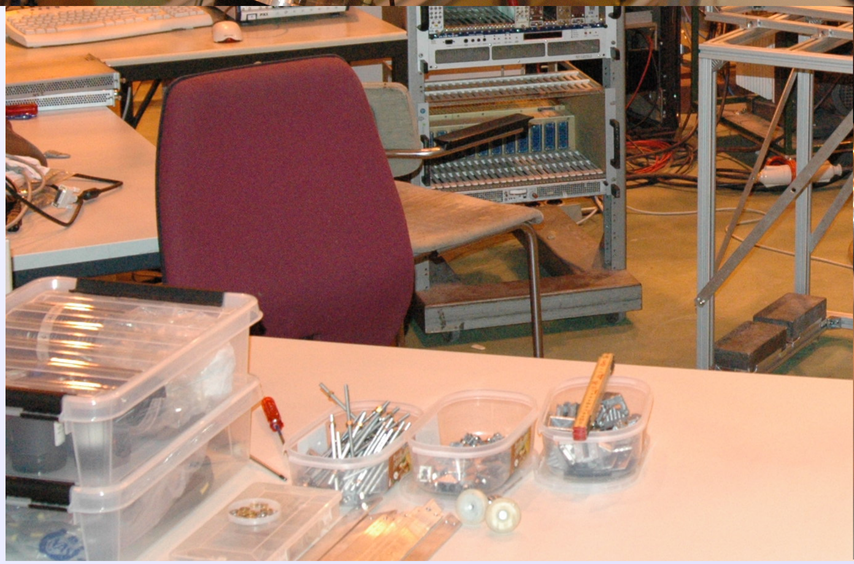


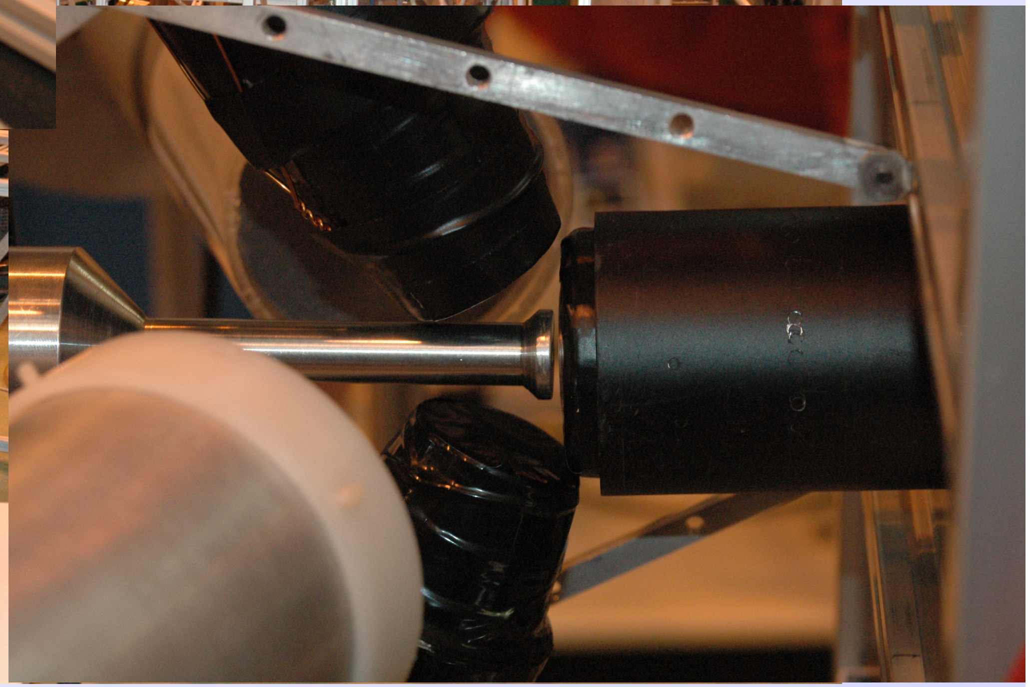
Nuclei below ^{68}Ni

- ✓ Nuclear structure just below Z=28 shell closure
  - → $\pi\ (f_{7/2})^{Z-20}$
- ✓ Filling $\nu\ (p_{3/2}, f_{5/2}, p_{1/2})$ and $\nu\ (g_{9/2})$ orbitals
  - → Understanding the effect of increased N/Z ratio
  - → N=40 subshell ?
  - → Evolution of collectivity: deformation
  - → Isomers
- ✓ Transition rates
  - → Better constraint to shell model calculations
  - → Probe residual interaction
- ✓ Systematics

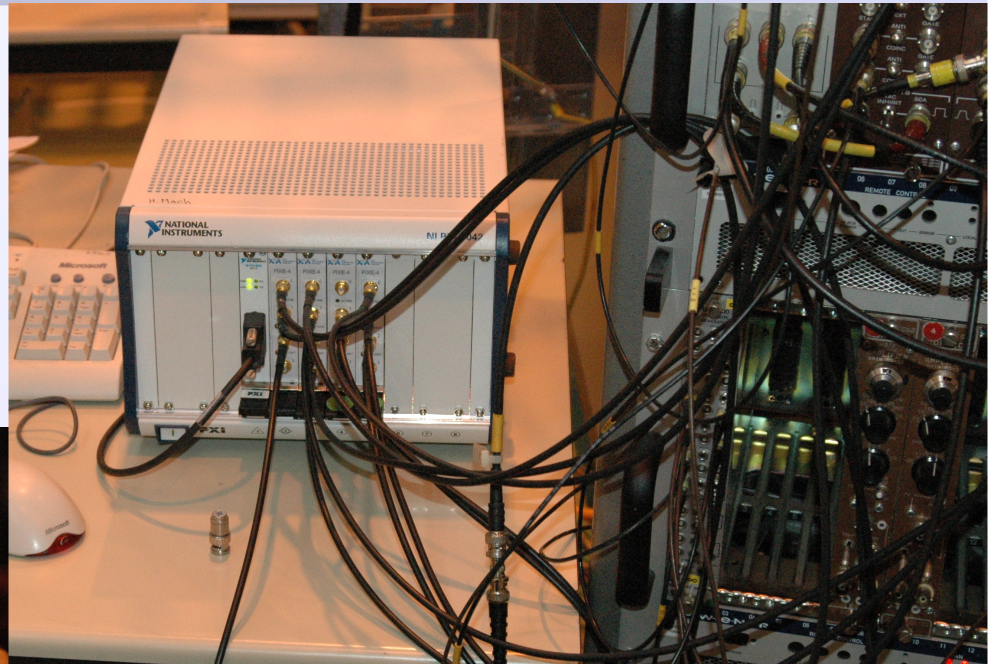
Experiment IS474 ISOLDE

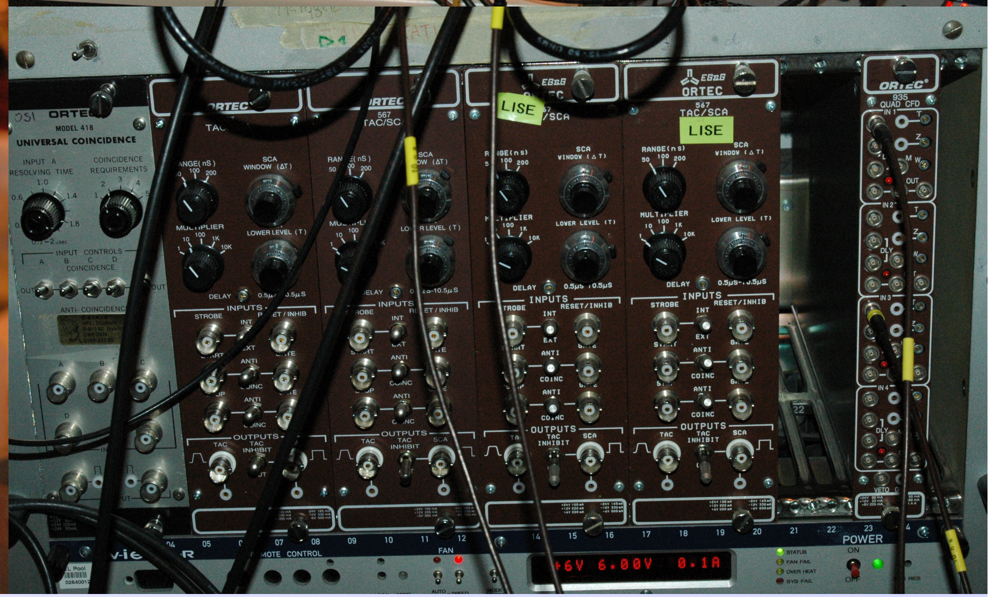




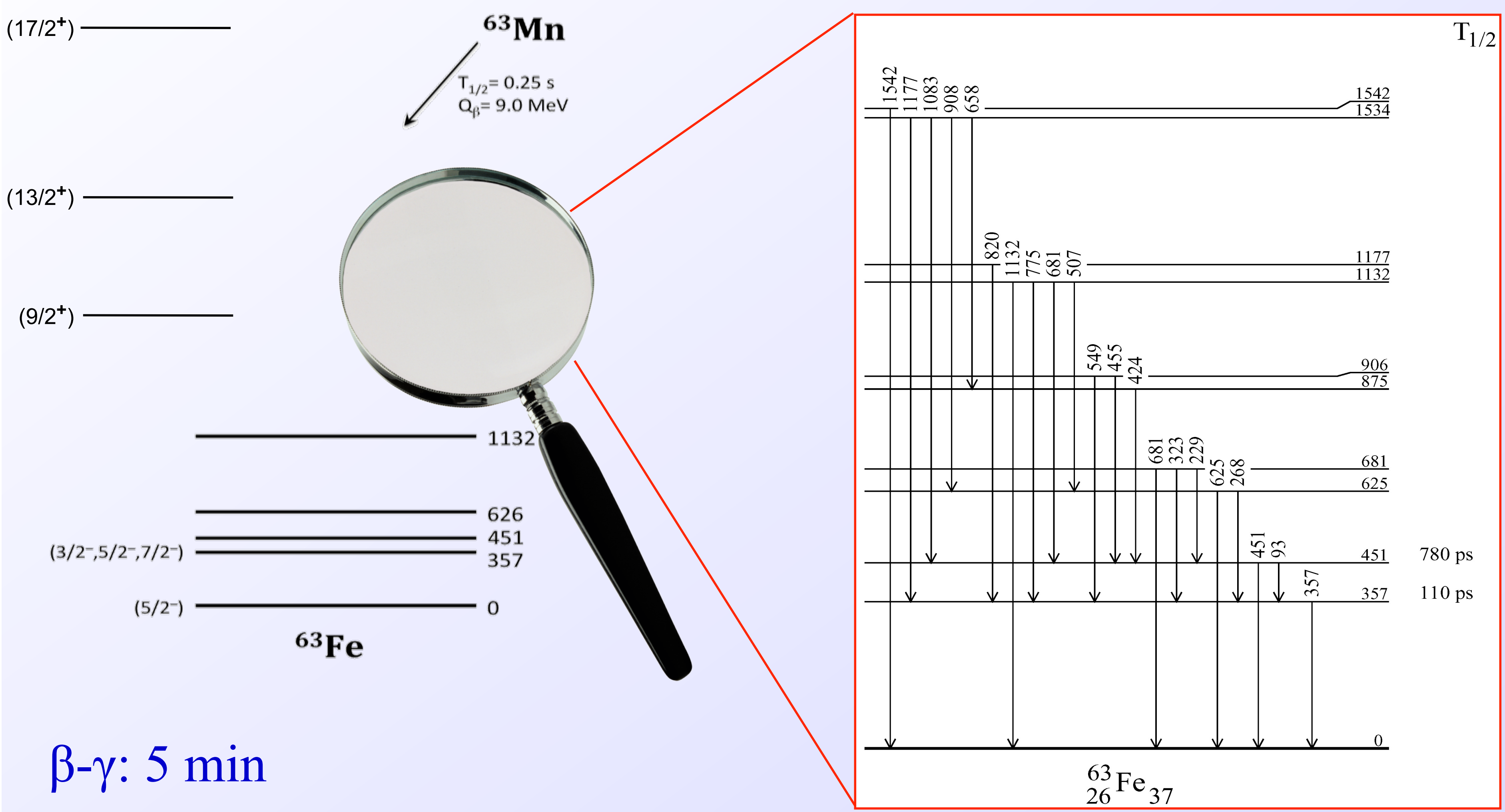


IS474 Aug 2010





Pre-analysis ^{63}Mn decay [before Sep run]



β-γ: 5 min

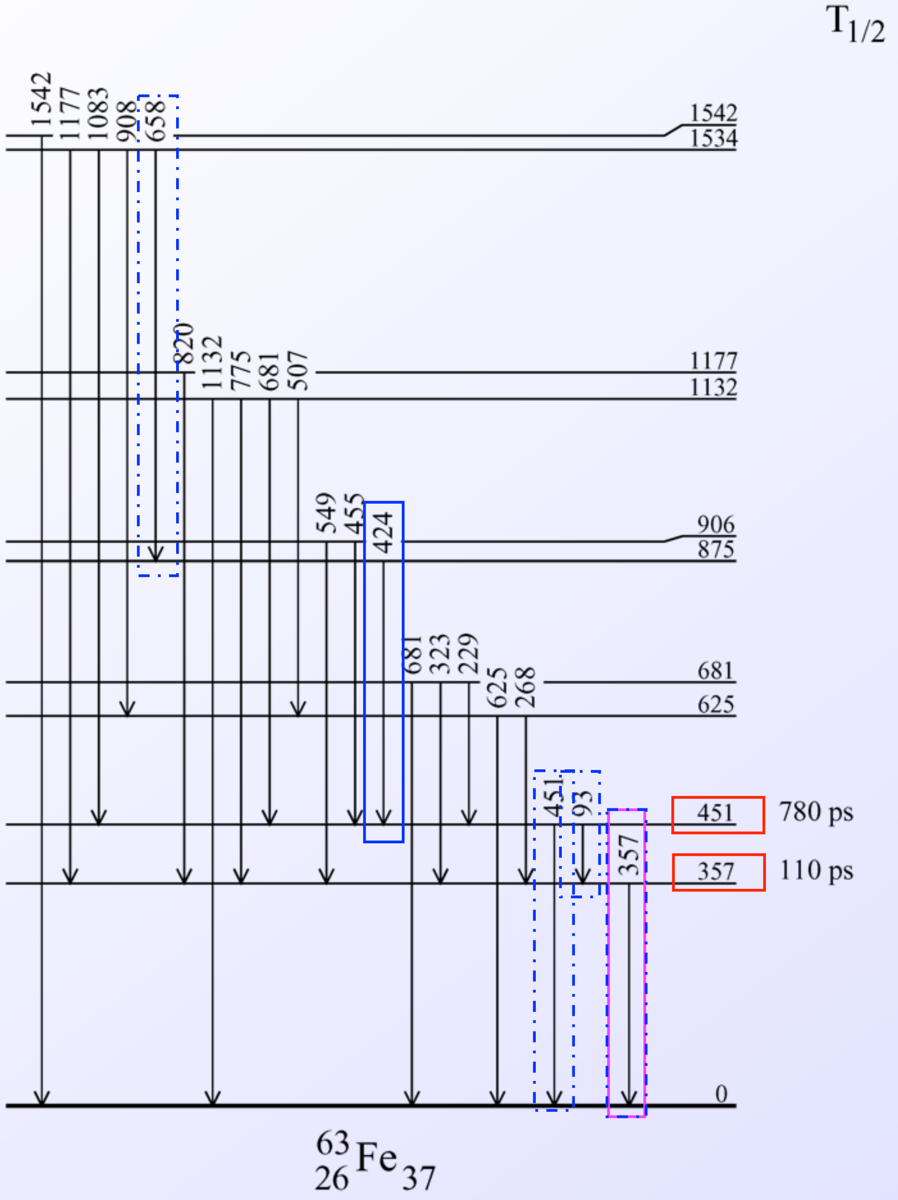
β-γ-γ: 17 min

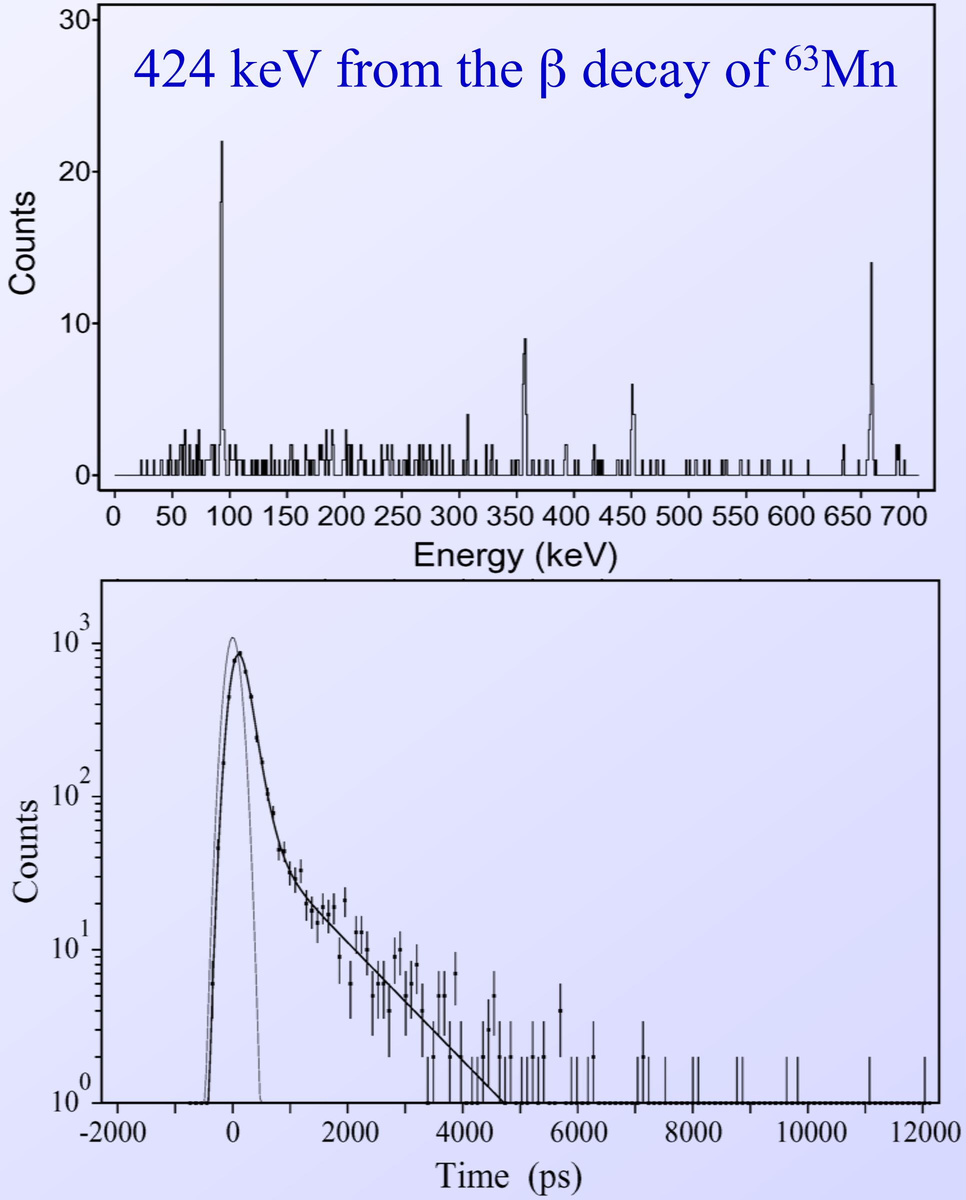
(in saturation)

[H. Mach]

Strong beta-feeding to 357, 451 and 1132 keV states, very weak g.s. feeding

Pre-analysis ^{63}Mn decay





Transitions in ^{63}Fe

✓ 357 keV level, $T_{1/2}$ = 110 ps

→ 357 keV transition (neglecting conversion coefficient)

- E1 not expected: $1/2^-$, $3/2^-$, $5/2^-$ states or $9/2^+$ (long lifetime)
- B(E2)~60 W.u. (too high)
- B(M1)=0.0079 μ_N^2

✓ 451 keV level, $T_{1/2}$ = 780 ps

→ 93 keV transition

- Similar for E1 and E2
- B(M1)=0.028 μ_N^2

→ 451 keV transition

- B(E1)=3.2x10^{-6} e^2fm^2 (low)
- B(M1)=2.9x10^{-4} μ_N^2 (low)
- B(E2)=1.4 W.u. (nicely fits systematics)

Low-lying levels in ^{63}Fe

- ✓ Two dipole M1 and one E2 transition
  - → Either $1/2^-$, $3/2^-$, $5/2^-$
  - → or $5/2^-$, $3/2^-$, $1/2^-$
- ✓ Beta feeding from $5/2^-$
  - → 357 and 451 keV
  - → not to ground state
- ✓ Similar to ^{57}Fe

$1/2^-$ is the ground state
$3/2^-$ is the 357 keV state
$5/2^-$ is the 451 keV state

Need more statistics to elucidate structure at higher E
Similar situation expected in odd-A Fe isotopes
Role of the $9/2^+$ orbital

New data from $^{59-66}Mn$ decay from Aug-Sep 2010