Neutron-Rich Nuclei:
Halos & Shell Closures

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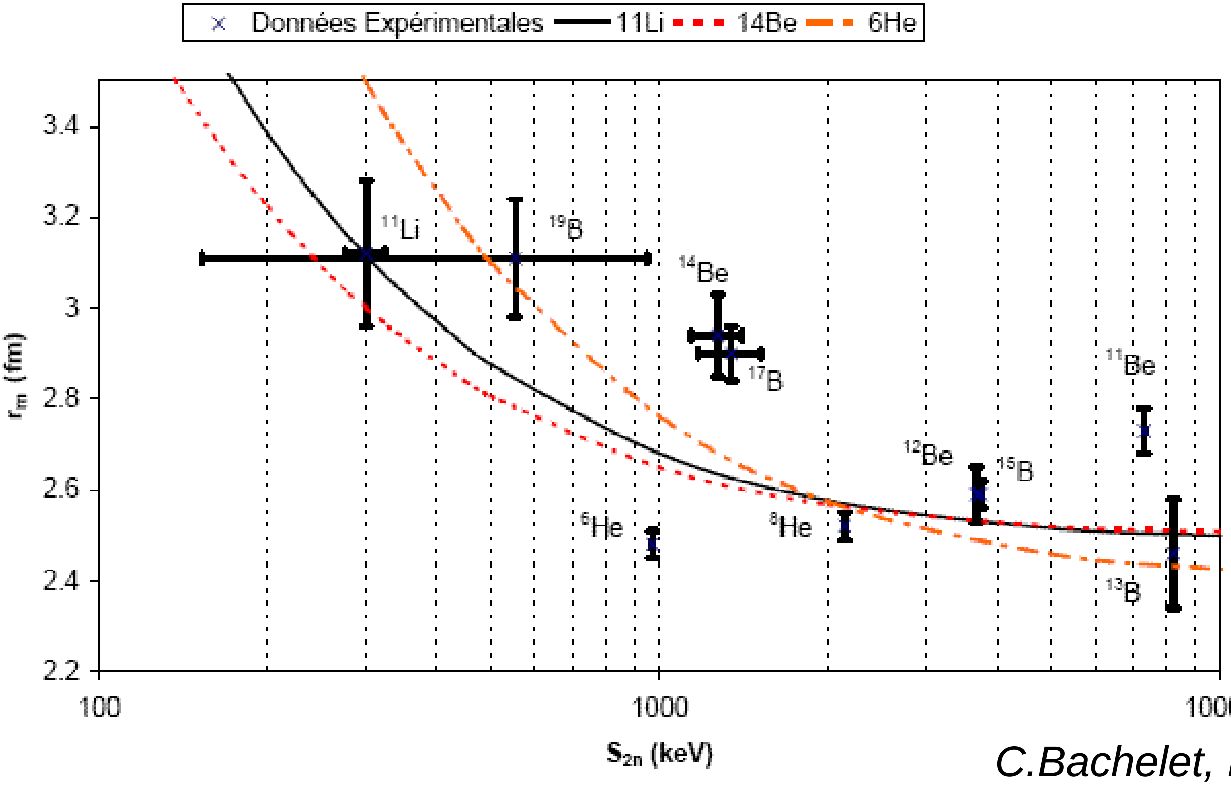
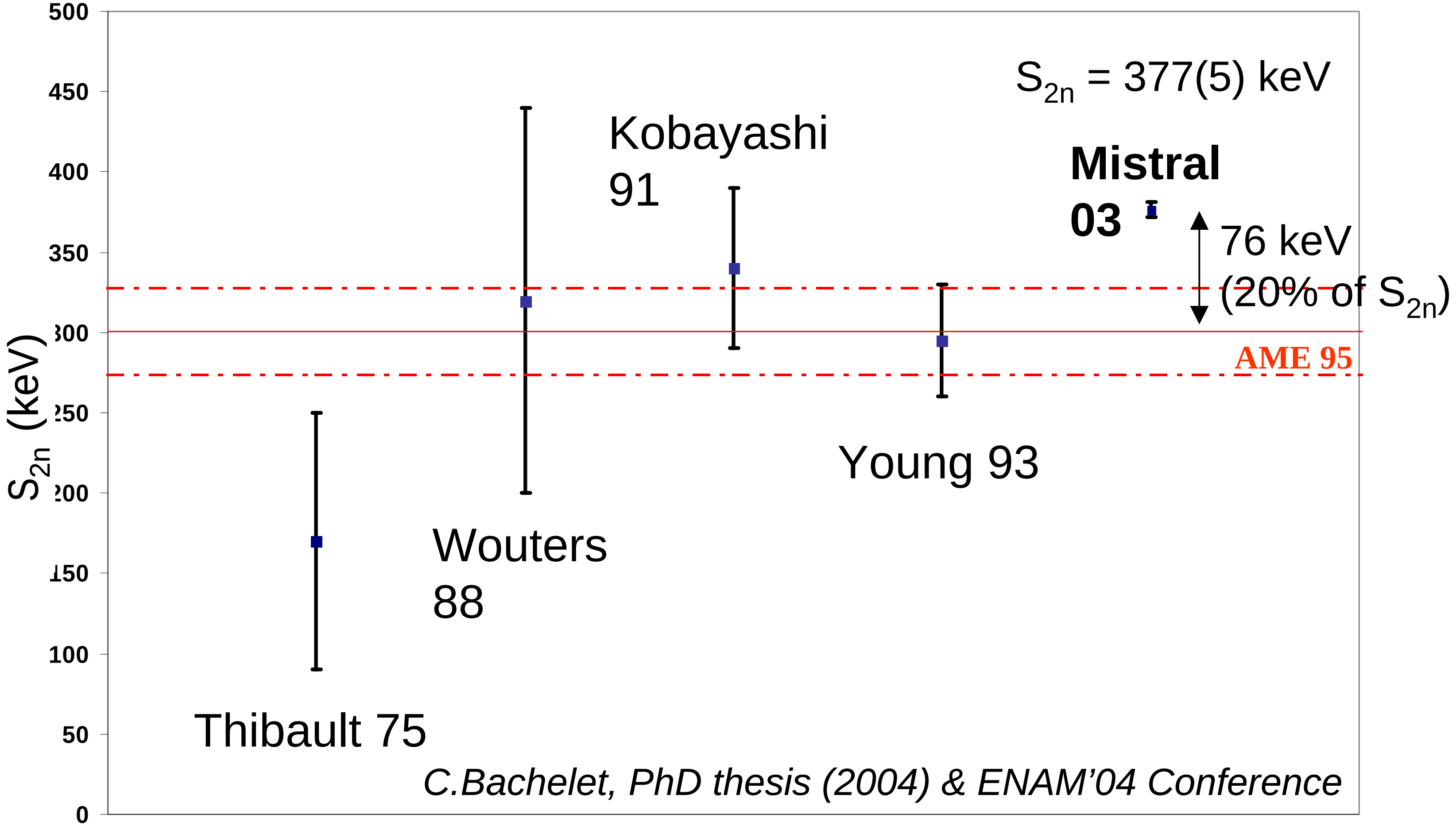
Halo nuclei & Masses

- Determine the binding energy of the halo neutron(s)
- Halo Nucleus = Core + (x)n
  - → Binding of the halo neutrons = $S_{(x)n}$
  - → $S_{x(n)}$ more sensitive than M
- Access to the matter radius – Model accuracy ?



C.Bachelet, PhD thesis (2004)

^{11}Li (and others…)



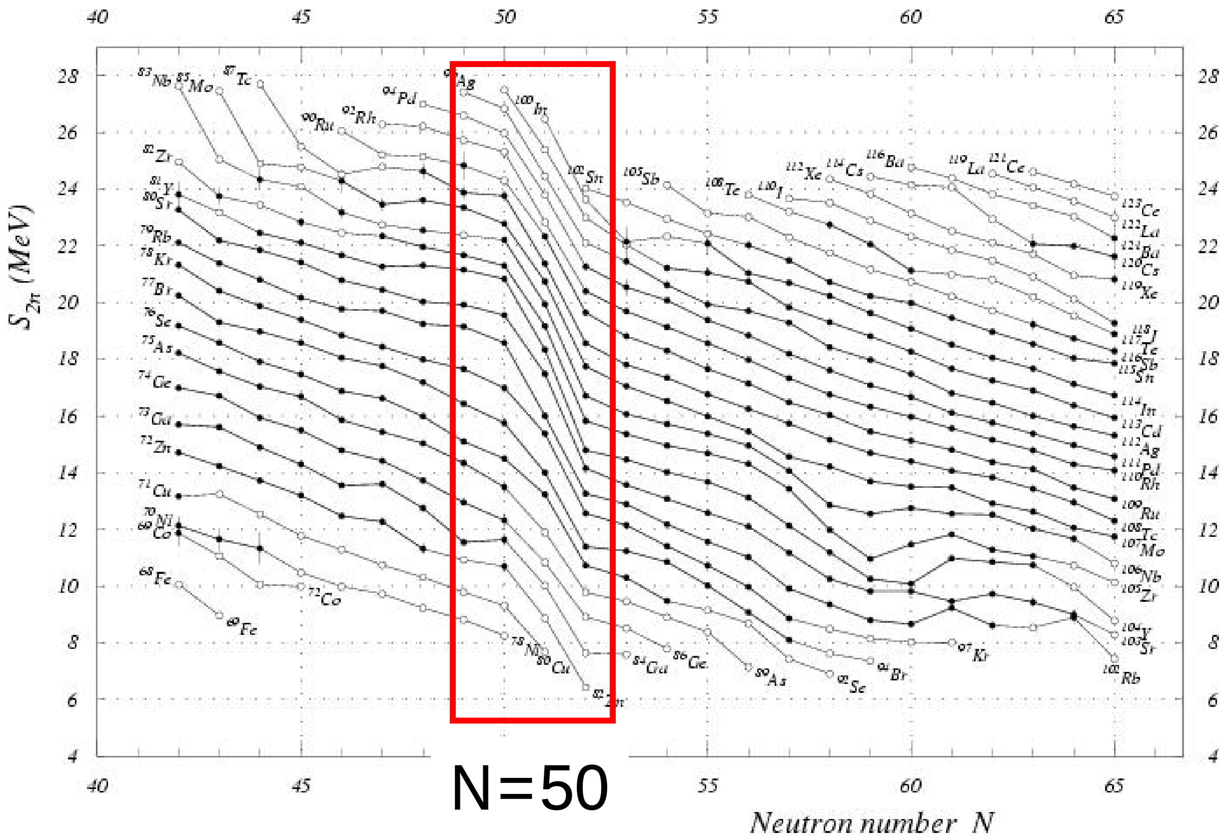
^{11}Li @ ISAC – Up to 44000 pps so far – $T_{1/2}$ = 8.5 ms

Other potential candidates: ^{8}He(119ms), ^{11}Be (13.8s), ^{19}C (48ms)…

No: ^{14}Be(4.3ms), ^{14}B(14ms), ^{17}B(5ms)…

Shell Closures…

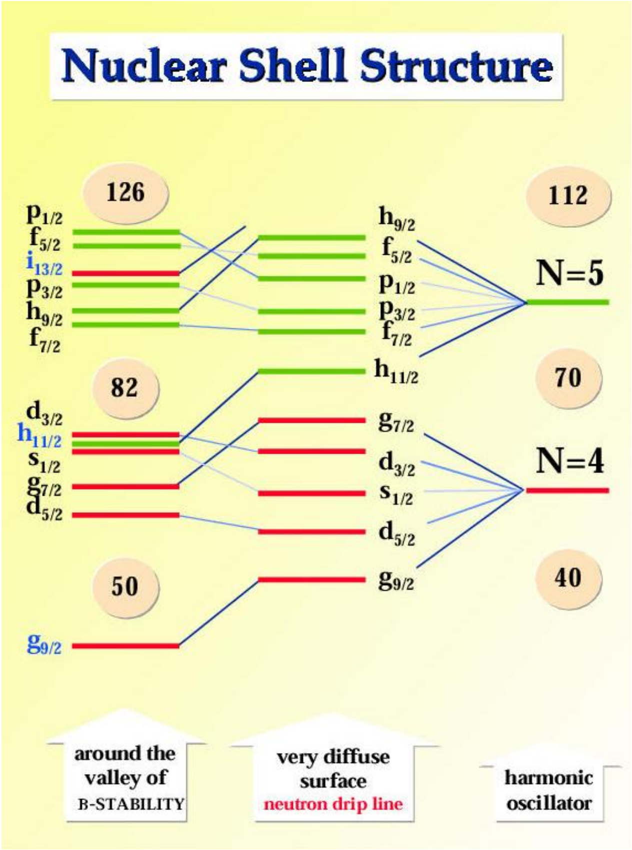
A “macroscopic” effect:

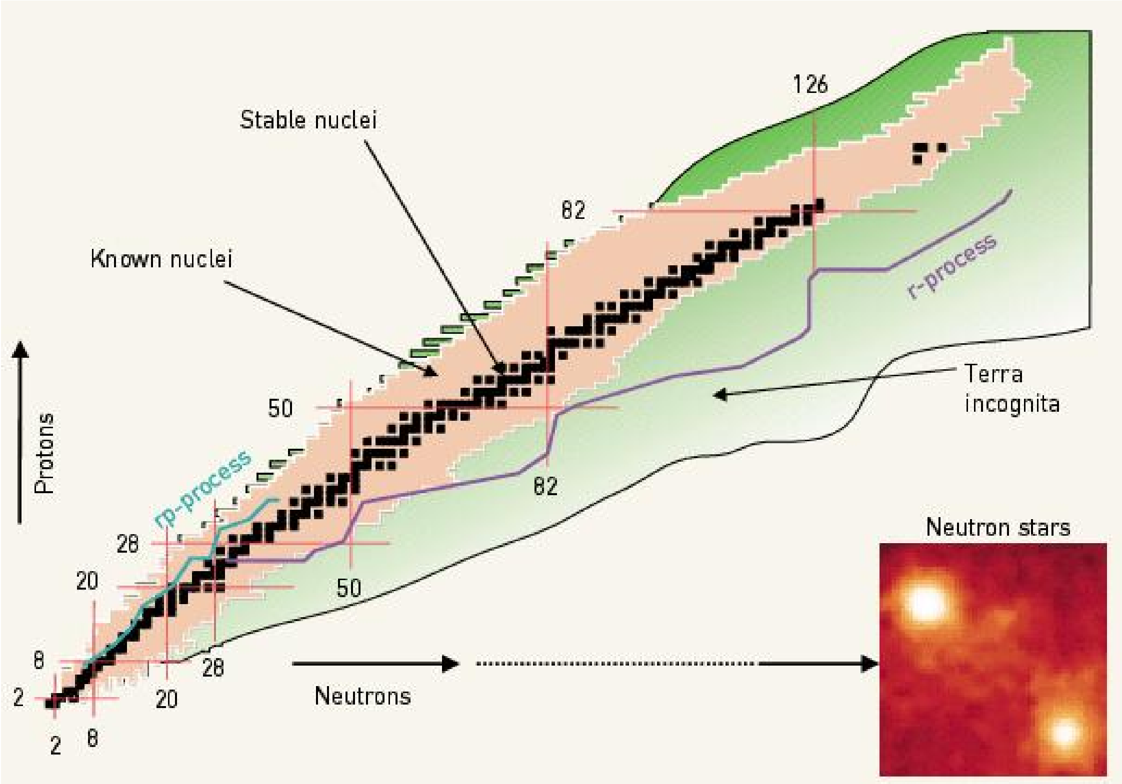


$$S_{2n}(A,Z) = (M(A-2,Z) – M(A,Z) + 2M_n) c^2$$

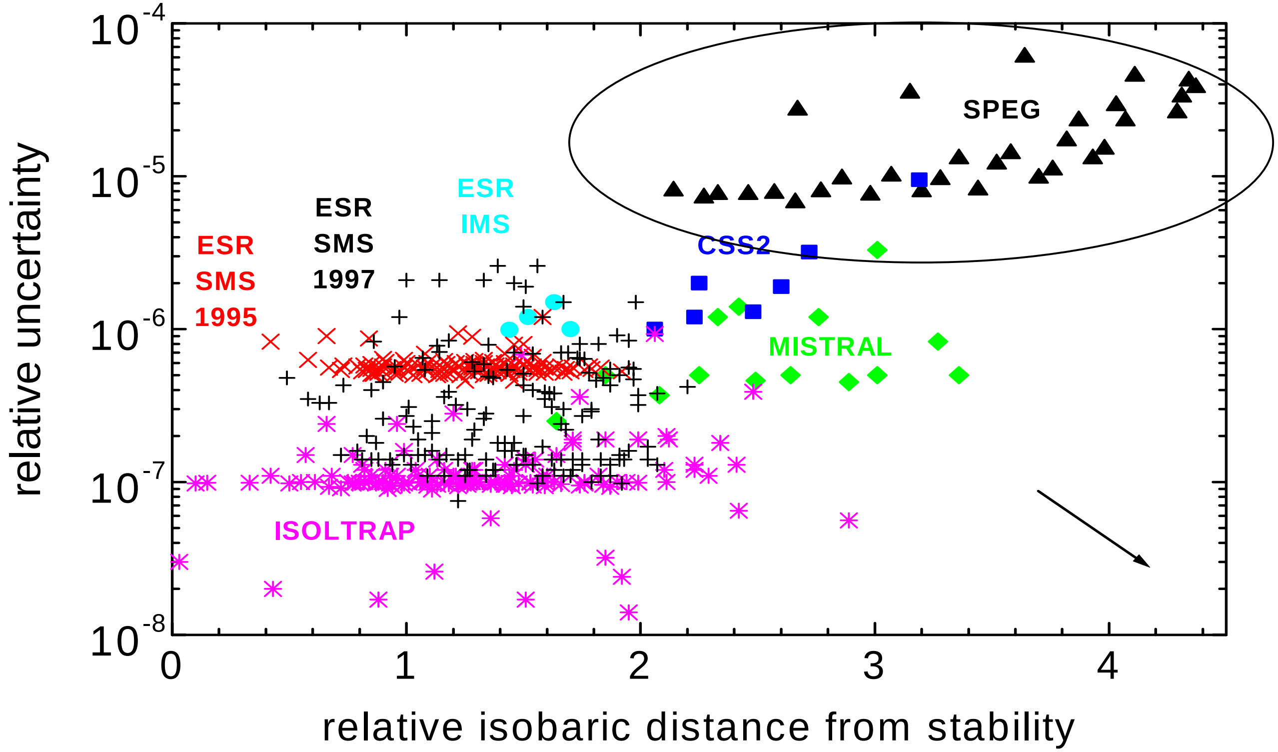
… Away From Stability.

Persistence of shell closures, shape coexistence, r-process…



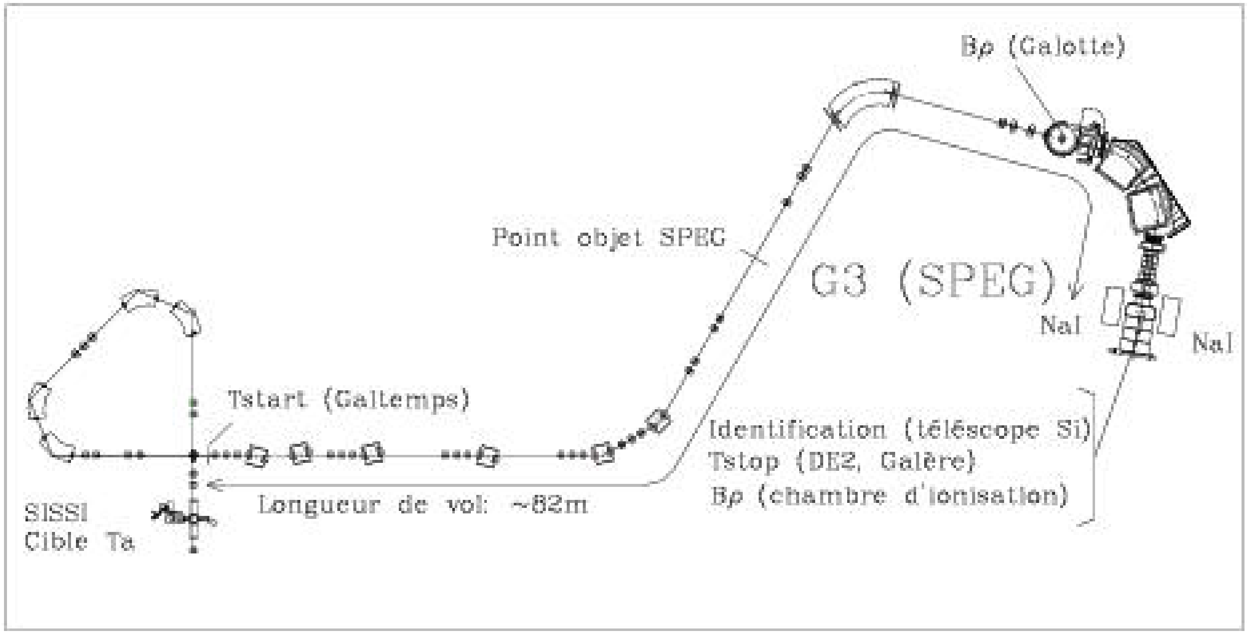


Mass Measurements of (very) neutron-rich nuclei



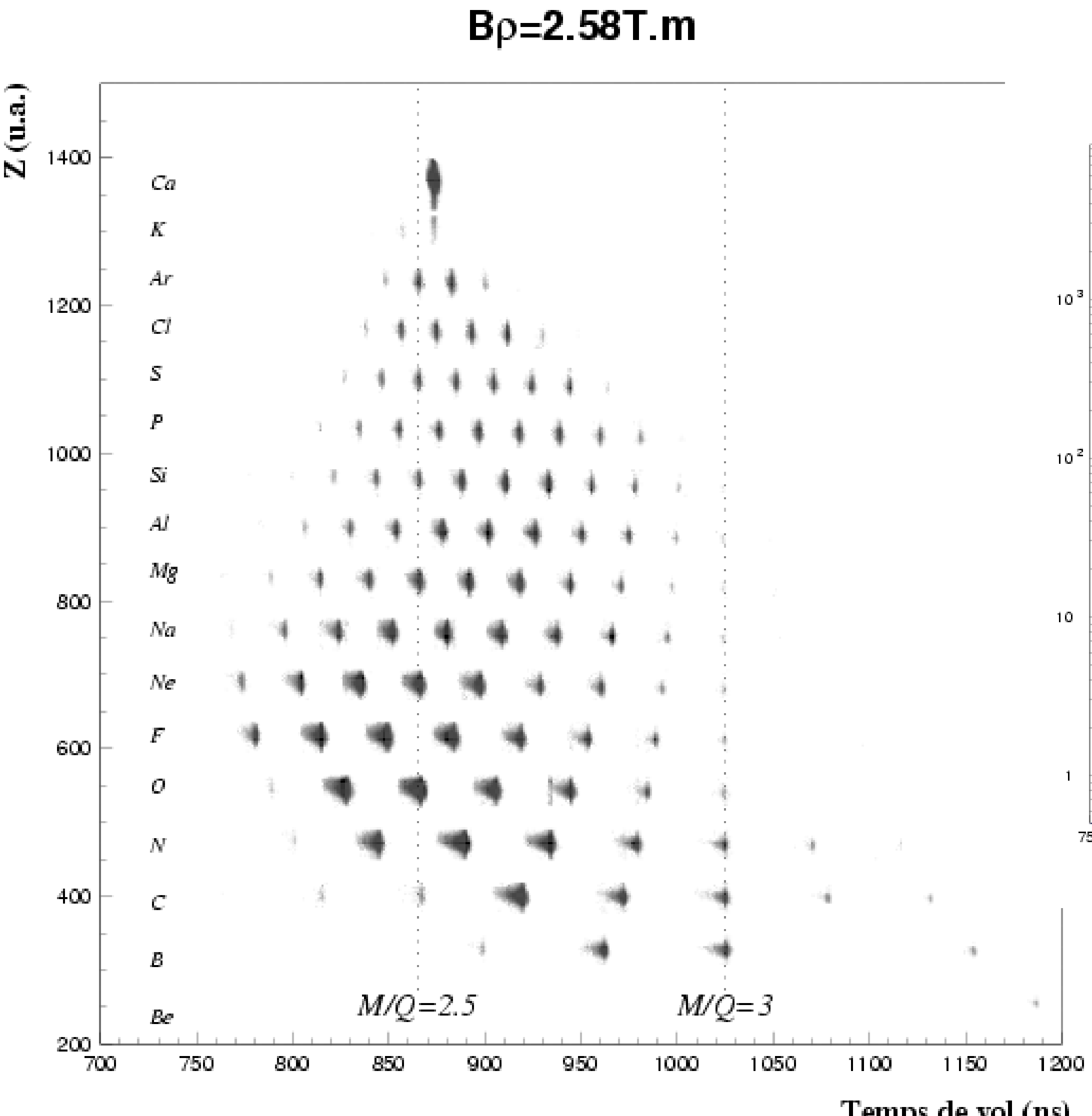
See: Lunney, Pearson & Thibault, Reviews of Modern Physics 75 (2003) 1021

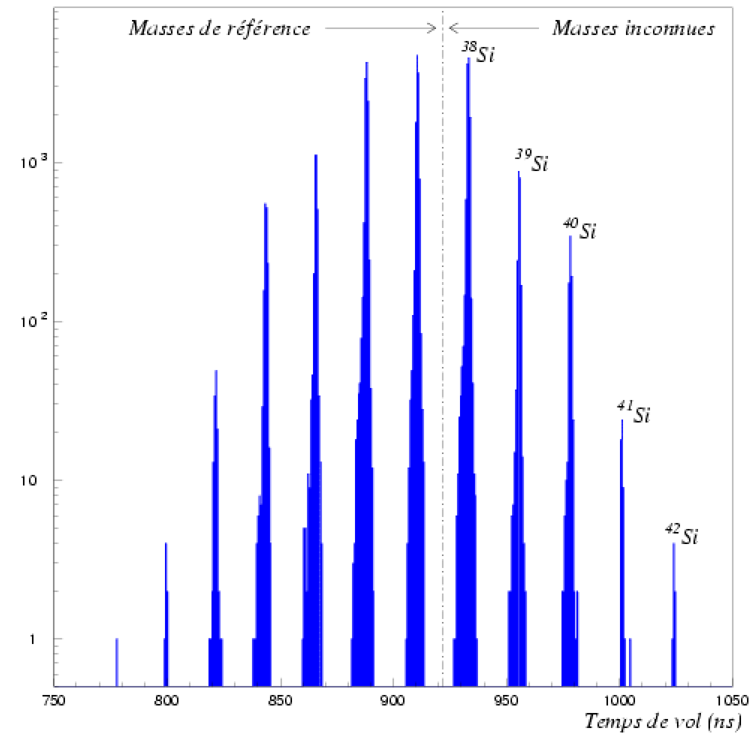
Time-Of-Flight Method



- $B\rho = Mv/Q$ with $v = D/TOF$
- Fragmentation – $T_{1/2} > 1\mu s$
- Measurements possible with ~ 100 ions
- $\Delta M > 100$ keV or so; 1MeV for most exotic

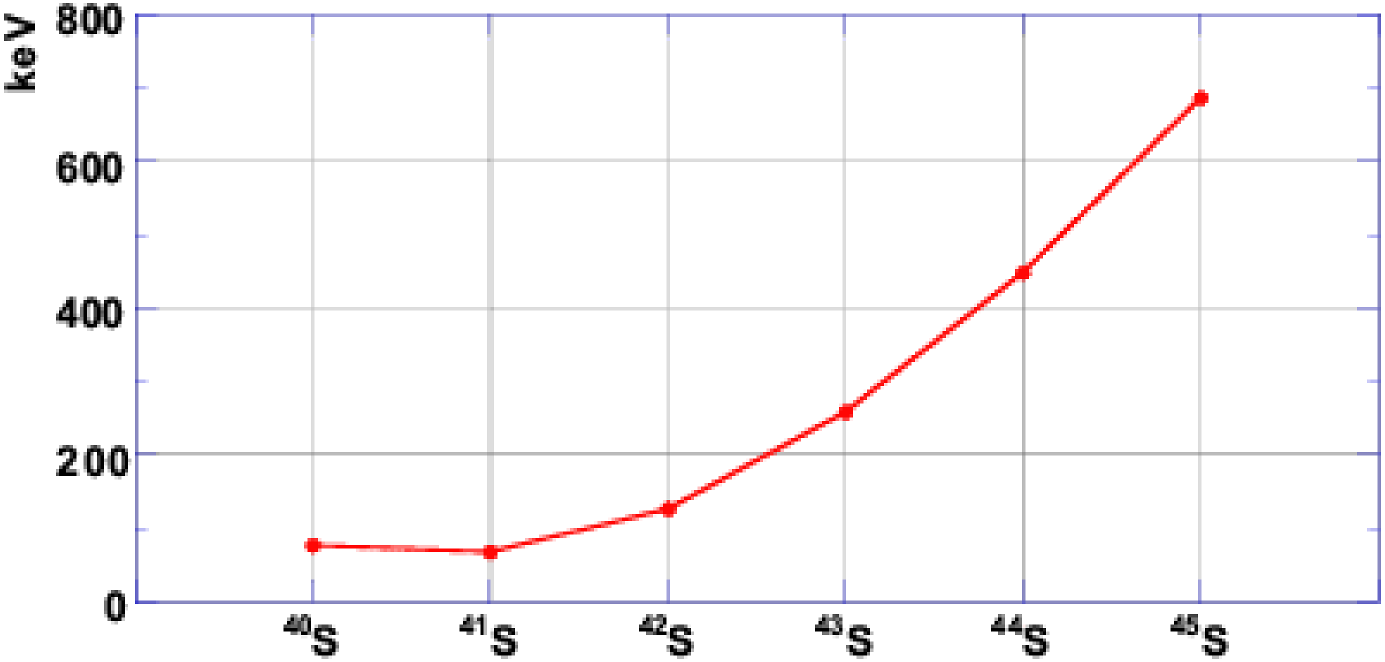
Reference Masses Needed





FS, PhD Thesis

Extrapolation Errors



Reference Masses = Anchor Points

FS, PhD Thesis

SPEG04

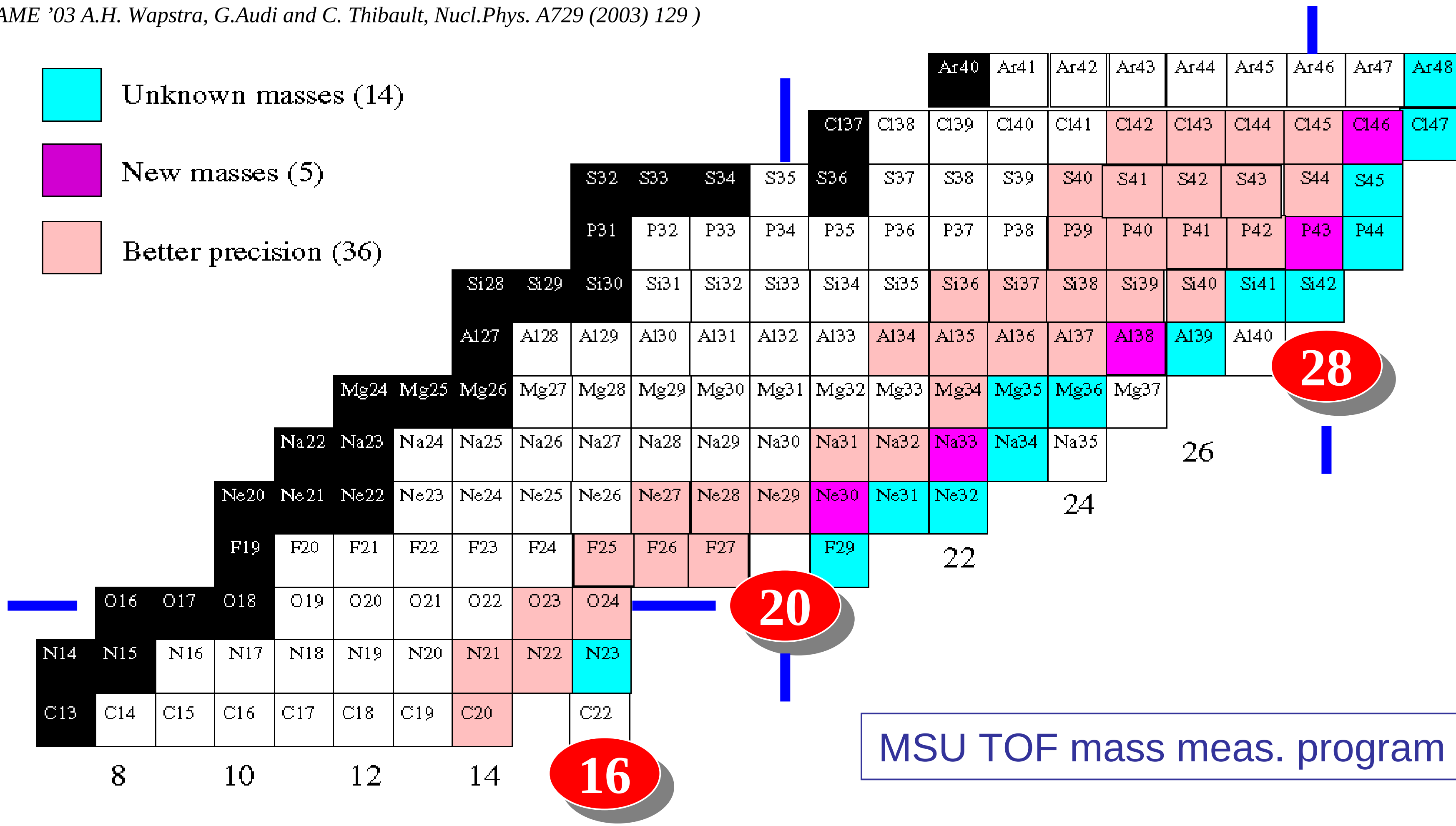
55 new neutron-rich mass measurements (14 for the first time)

(AME ’03 A.H. Wapstra, G.Audi and C. Thibault, Nucl.Phys. A729 (2003) 129)

^{48}Ca + ^{181}Ta (250-450-550 mg/cm^2)
60 A.MeV, beam intensity up to ~ 5 μAe

Two setting of the spectrometer :

- ✓ **Bρ = 2.5 Tm : reference set-up centered at ^{34}Mg**
- ✓ **Bρ = 2.75 Tm : exotic set-up centered at ^{36}Mg**



MSU TOF mass meas. program (?)

From H.Savajols, ENAM’04

One more (nice) thing…

- These data sets can be re-analyzed when new references masses are added:
  - Example:

    SPEG’91 (N.A.Orr et al.) re-analyzed with SPEG’99 (F.S. et al.)

- Can reduce the extrapolation errors dramatically