Workshop on

PHYSICS with SPIRAL II

Michel-Ange, May 28-29, 2001

Mass Measurements with a Penning Trap Spectrometer

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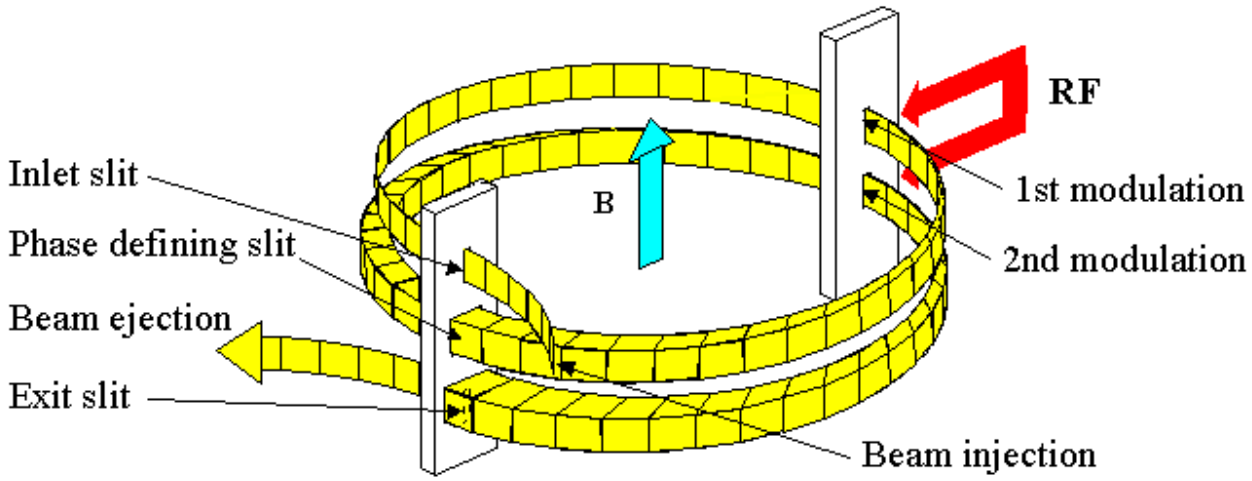
- experimental methods
- mass spectrometry
- Penning Trap
  - Lise + Gas Cell
  - Spiral-II
  - Eurisol
- Conclusion : it is still not too late!

EXPERIMENTAL DATA II

- REACTION ENERGIES
  - A(a,b)B $Q_r = \mathcal{M}_{\rm A} + \mathcal{M}_{\rm a} - \mathcal{M}_{\rm b} - \mathcal{M}_{\rm B}$
    - close to stability
    - (n,γ) and (p,γ) $\Rightarrow$ backbone
    - self-calibrated A(a,b)B v/s C(a,b)D
- DESINTEGRATION ENERGIES
  - A(β^-)B $Q_{\beta^-} = \mathcal{M}_{\rm A} - \mathcal{M}_{\rm B}$
  - A(α)B $Q_\alpha = \mathcal{M}_{\rm A} - \mathcal{M}_{\rm B} - \mathcal{M}_\alpha$
  - A(p)B $Q_p = \mathcal{M}_{\rm A} - \mathcal{M}_{\rm B} - \mathcal{M}_{\rm p}$
    - far from stability
- MASS SPECTROMETRY
  1. Classical Spectrometers
  2. Time-of-Flight Spectrometers
  3. Cyclotron Spectrometers
     a. Radio-Frequency Spectrometer
     b. Penning Trap Spectrometer
     c. Storage Ring Spectrometer

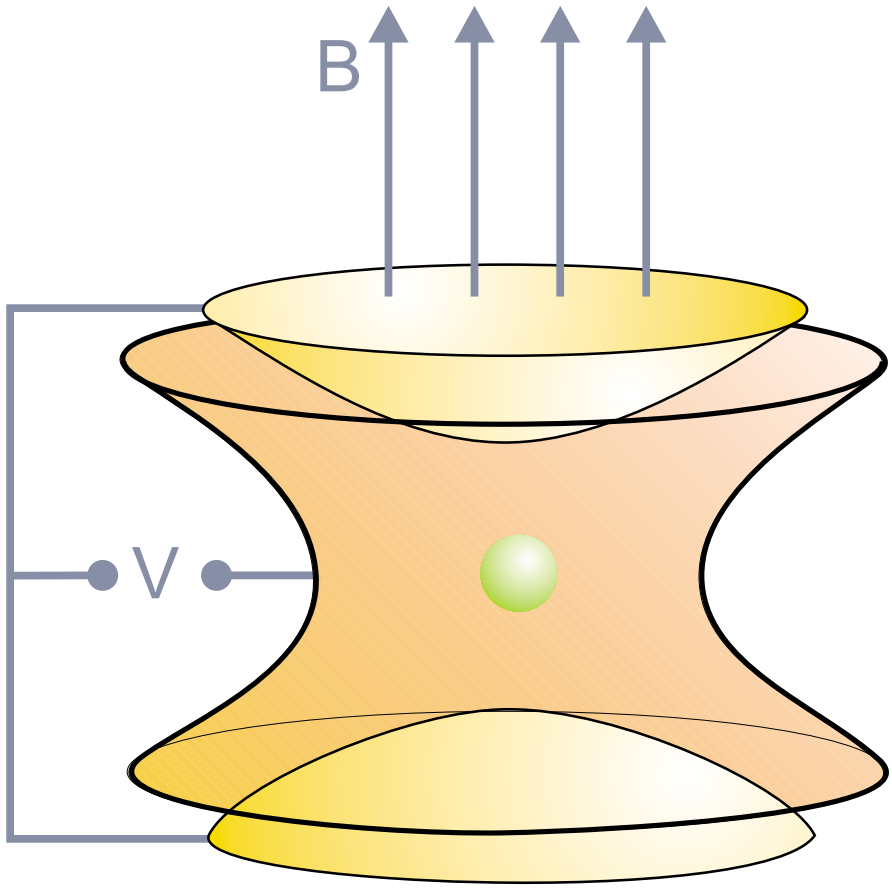
RADIO-FREQUENCY SPECTRO-METER PRINCIPLE



- 2 turns helix
- 2 RF excitations spaced 1 turn
- if 2 excitations in opposite phase

  $\Rightarrow$ cancel $\Rightarrow$ exit $\Rightarrow$ detection
- Φ : 0.5-1 metre

PENNING TRAP PRINCIPLE



- $\vec{B}$ $\Rightarrow$ cyclotron motion in horiz. plane
- V $\Rightarrow$ axial confinement
- r_0 : 1-2 cm

PENNING TRAPS PERFORM.

- STABLE
  - MIT-Trap 5×10^{-11}
- RADIOACTIVE (ISOLTRAP)

	Res. Power	$T_{1/2}$	Precision
• Typical	1.0 million	≥ 1 s	2×10^{-8}
• Isomers	3.7 millions	≥ 8 s	2×10^{-8}
• Short $T_{1/2}$	0.1 million	65 ms	3×10^{-7}
		(^{74}Rb	1000/s)

Sensitivity: 1000 ions $\Rightarrow$1 in detector

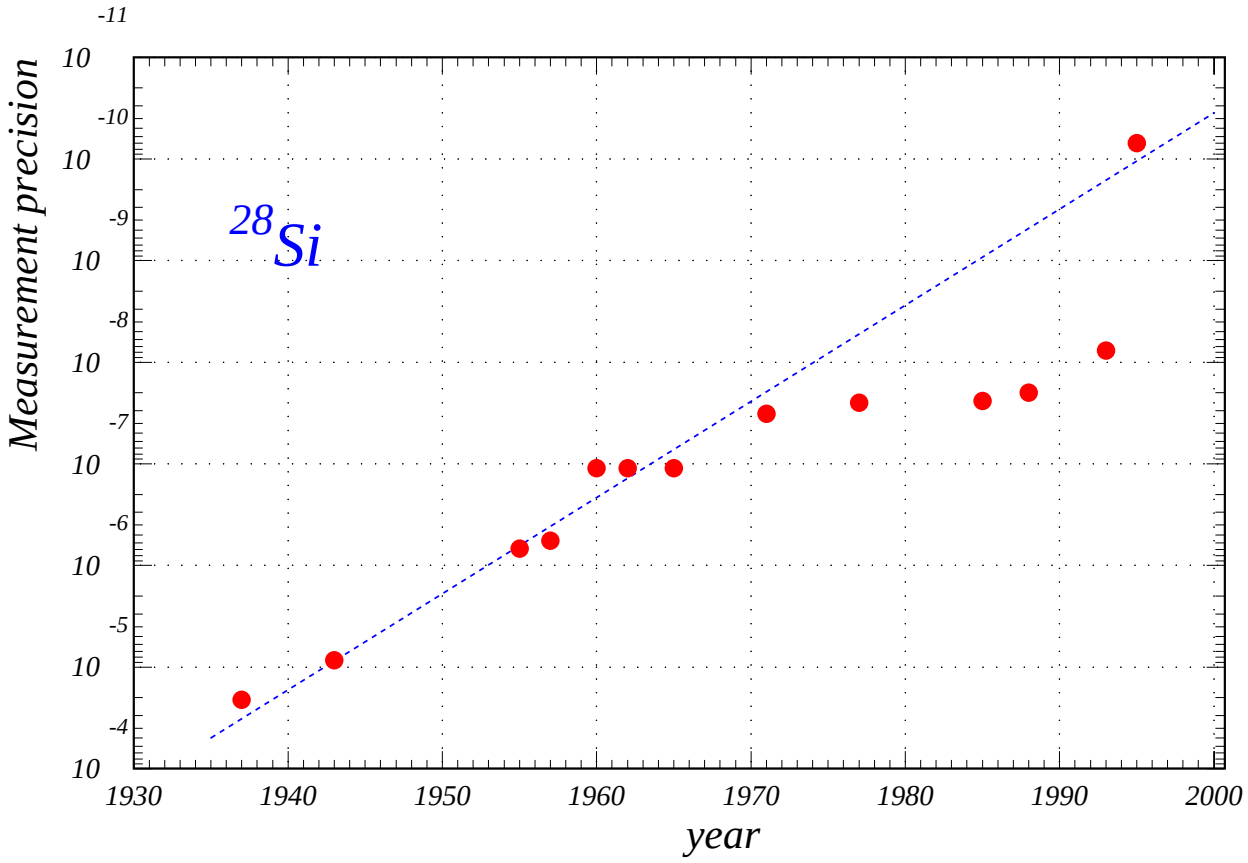
SRF

- MISTRAL 0.1 million 50 μs 3×10^{-7}

Sensitivity: 10 000 ions $\Rightarrow$1 in detector

cooling: 100 ions $\Rightarrow$1 in detector

PRECISION FOR ^{28}SI

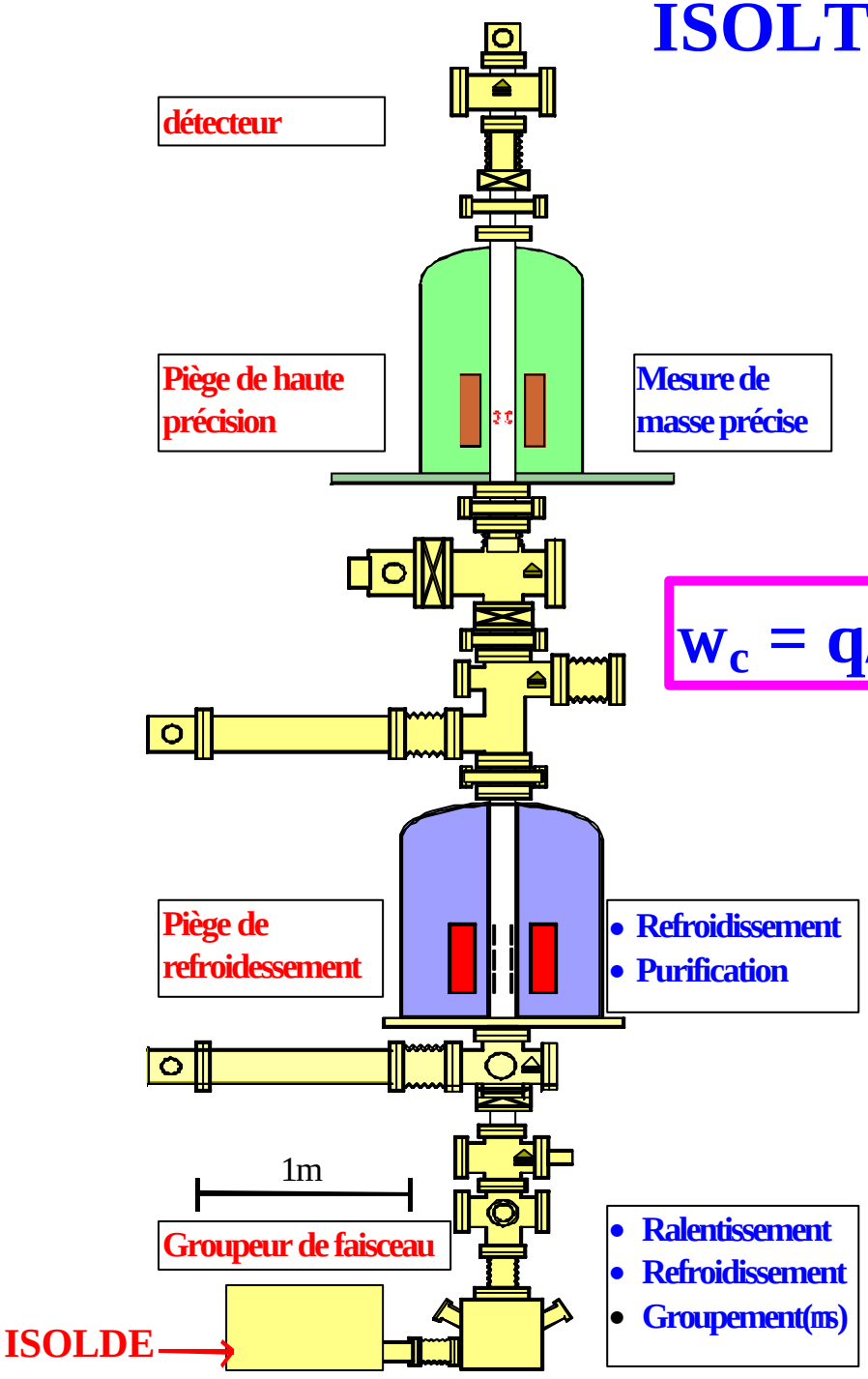


One order of magnitude every 10 years

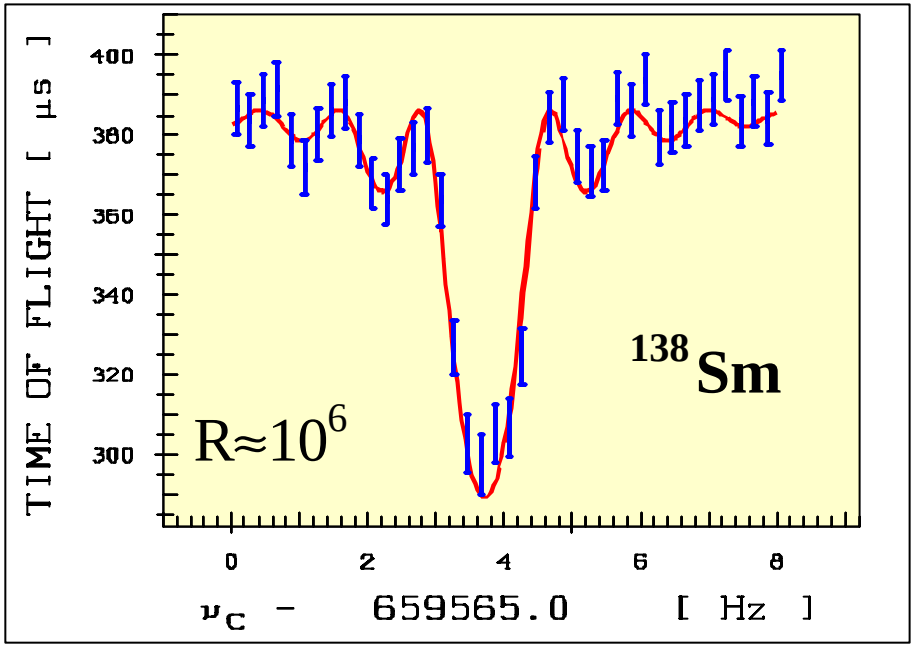
- 1937: 600 keV
- 1970-1990's "plateau" at 0.7 keV
- 1993: Stockholm-trap + (p,γ) +
  + Manitoba-Spectr + (p,α)
- 1995: pure MIT-trap 2 eV

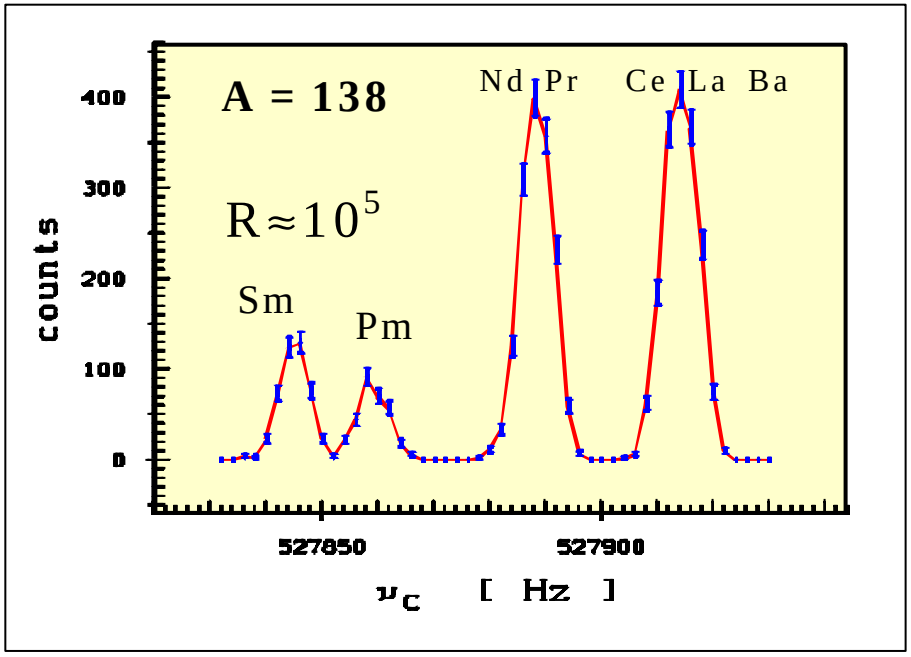
ISOLTRAP

D.Beck, April 2001



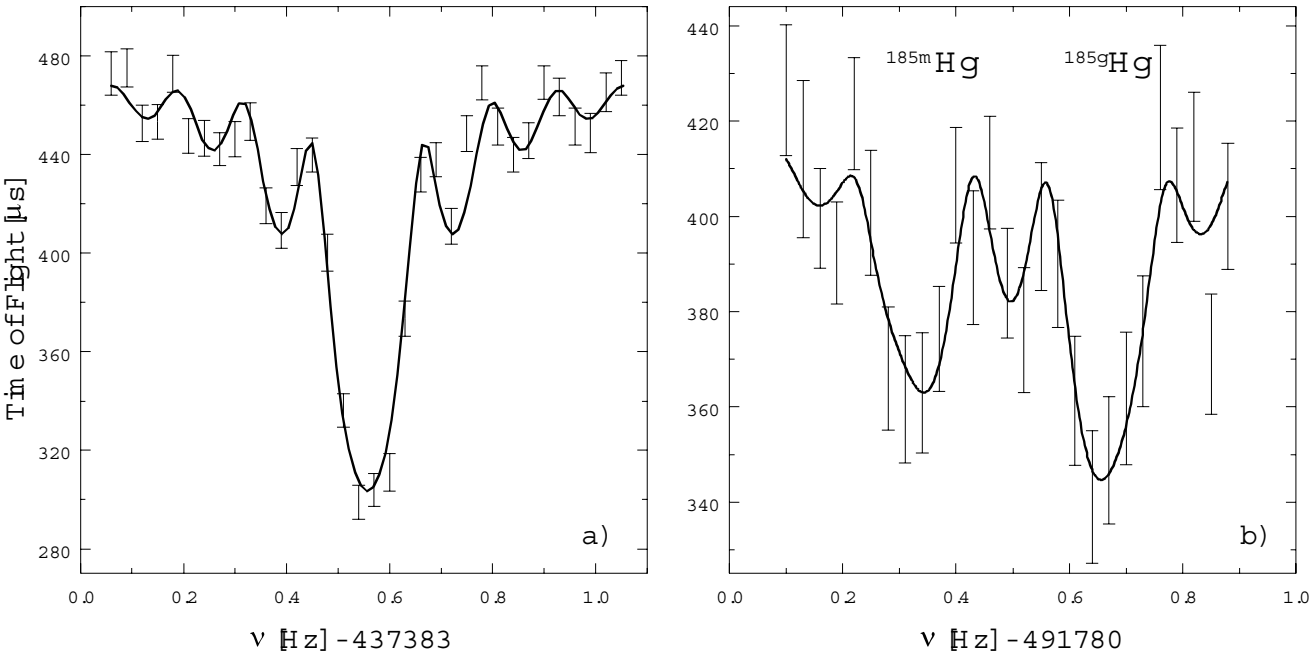
$$\omega_c = q/m \times B$$





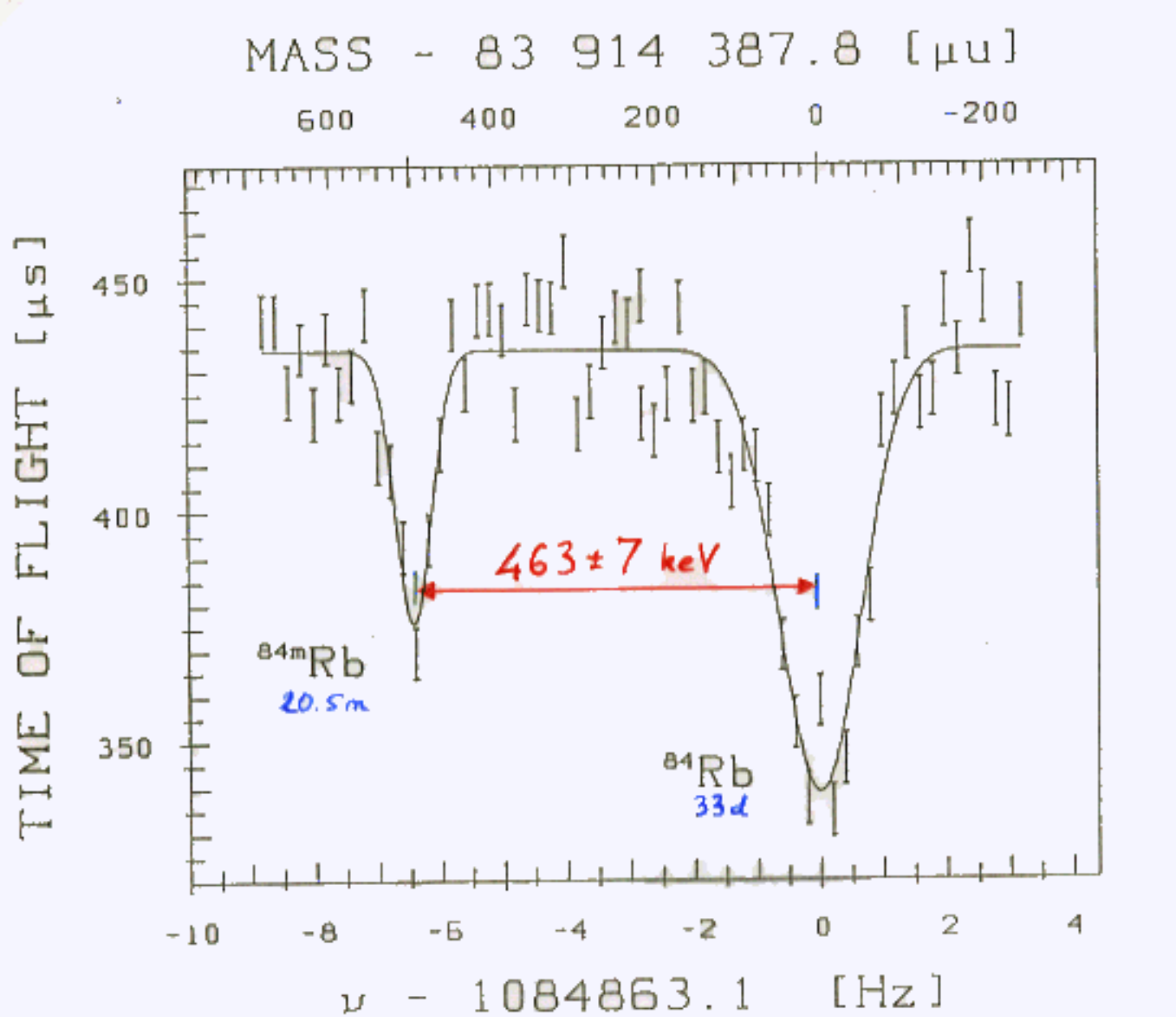
ISOMER SEPARATION

- ^{185}Hg - $^{185}Hg^{m}$



line width = 50 keV Isom. Exc. = 104 keV

Exc. time = 8 s Res. Power = 3.7 millions

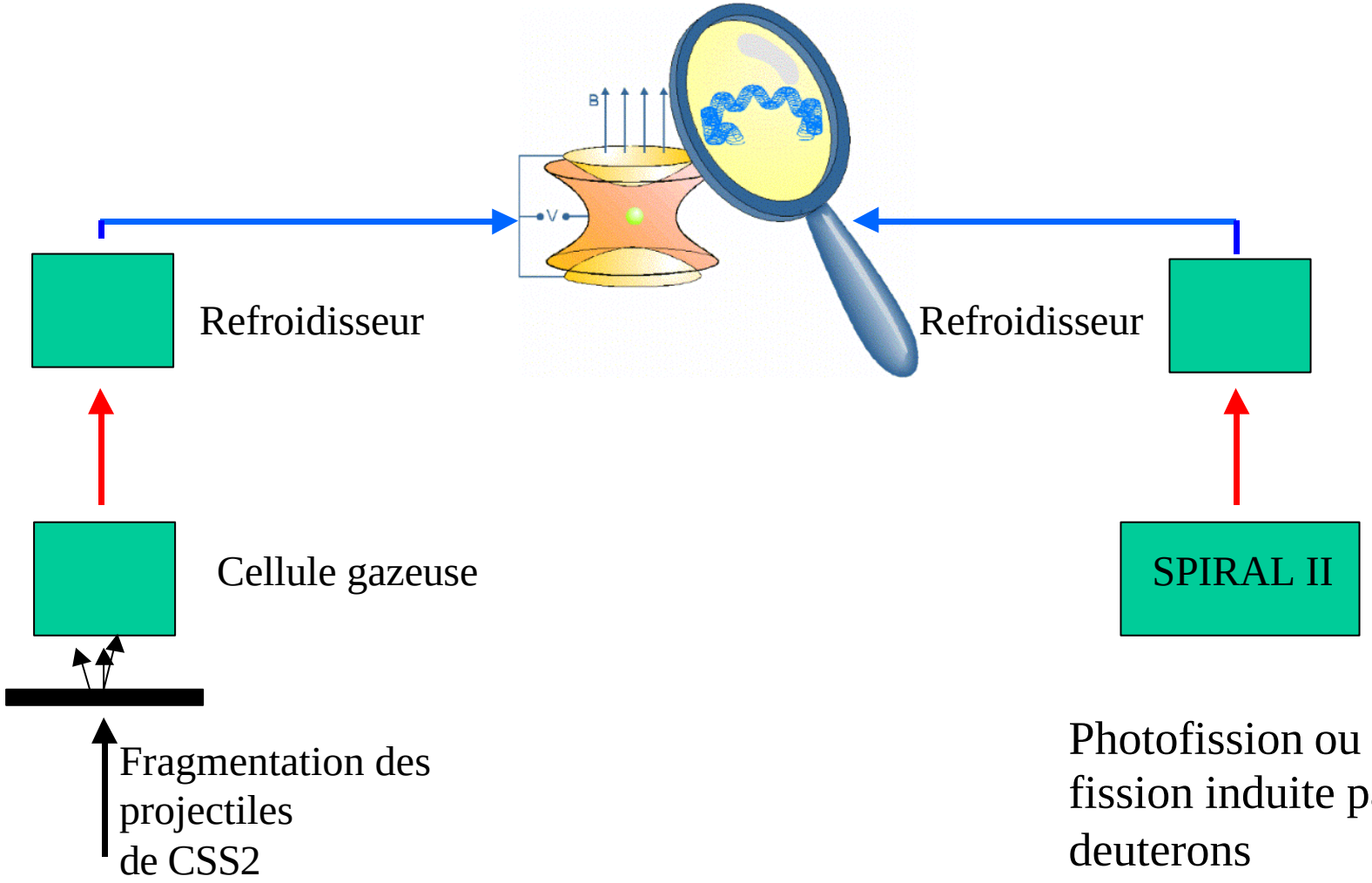


Penning Trap 463 ± 7 keV M. König 1991

Litterature 463.62 ± .09 keV NDS

Mesures de masses avec un piège de Penning à GANIL

D.Beck, April 2001



... et Eurisol !!