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SPES LETTER OF INTENT

High spin γ-ray spectroscopy of heavy, octupole deformed Ac and Fr nuclei produced in fusion-evaporation reactions with the intense *A*~90 Rb radioactive beams at SPES

Collaboration

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Test of feasibility

- Fusion-evaporation
- The strongest available beam
- Efficient gamma and ancillary detector setup
- Interesting physics case…

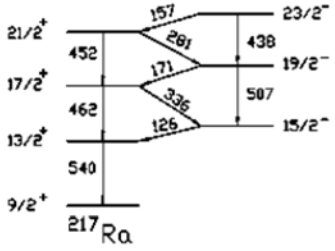
pps

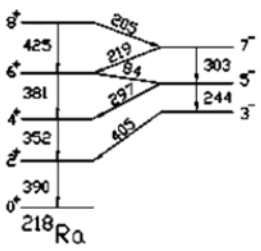
Rb	89	37	52	9.09E+02	4,75E+10	9,50E+08
Rb	90	37	53	1.58E+02	9,62E+10	1,92E+09
Rb	91	37	54	5.84E+01	9,62E+10	1,92E+09
Rb	92	37	55	4.49E+00	5,09E+10	1,02E+09
Rb	93	37	56	5.84E+00	3,38E+10	6,76E+08
Rb	94	37	57	2.70E+00	1,37E+10	2,74E+08

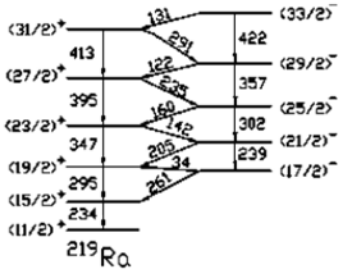
Estimated beam intensities with BEST Cyclotron@SPES
Protons on direct target: E_p=40MeV, Current on target 200 μA
UCx target; other targets shown in "Comments"

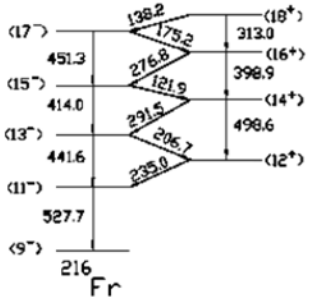
i~ 0.3 pnA

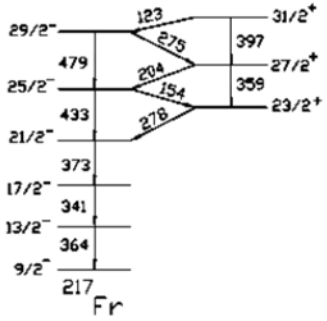
Onset of octupole deformed shapes in actinides at $N=130$, $Z=86$

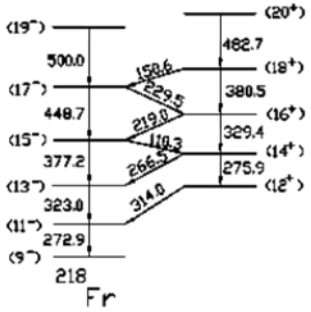


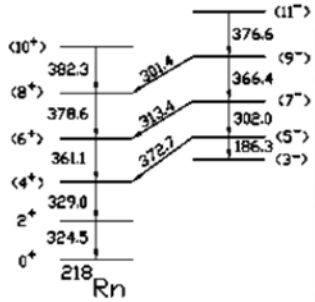






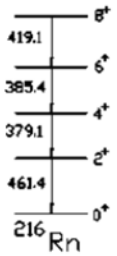




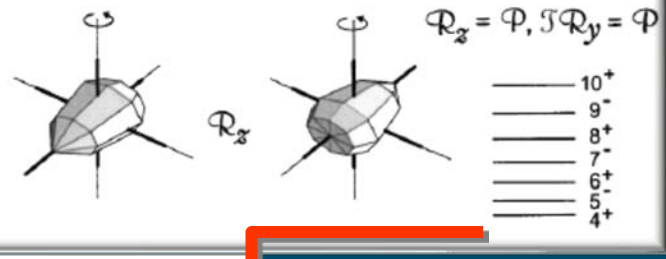


Alternative parity bands

Debray PRC 73(2006)



Reflection asymmetric shapes



Simplex symmetry:

Even A

$\sigma=+1$ $I^\pi = 0^+, 1^-, 2^+, 3^-, \ldots$

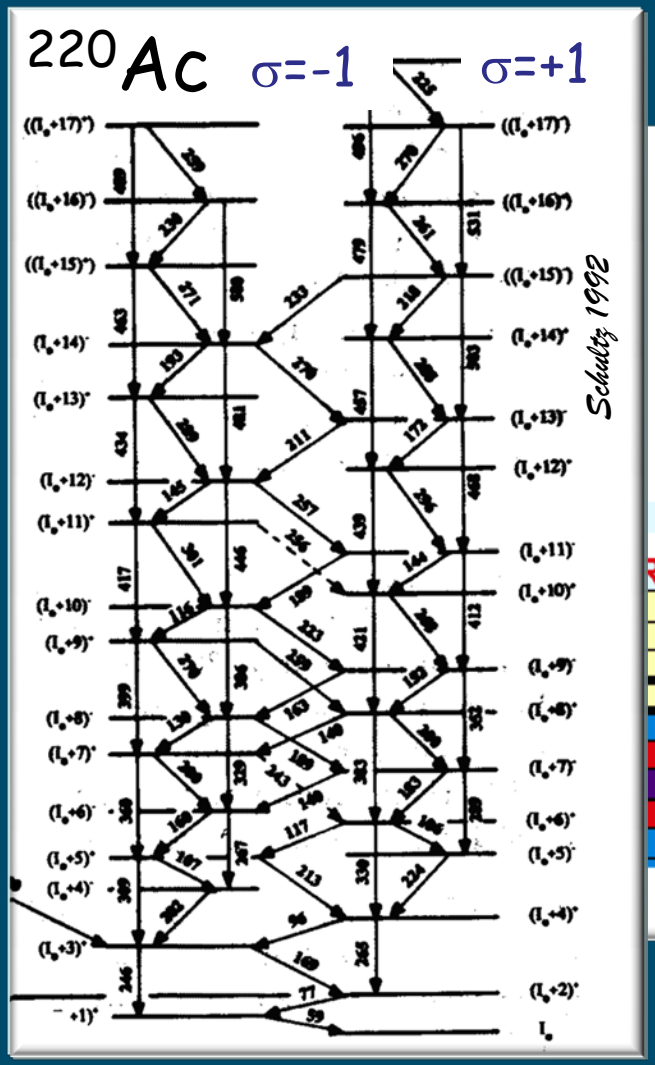
$\sigma=-1$ $I^\pi = 0^-, 1^+, 2^-, 3^+, \ldots$

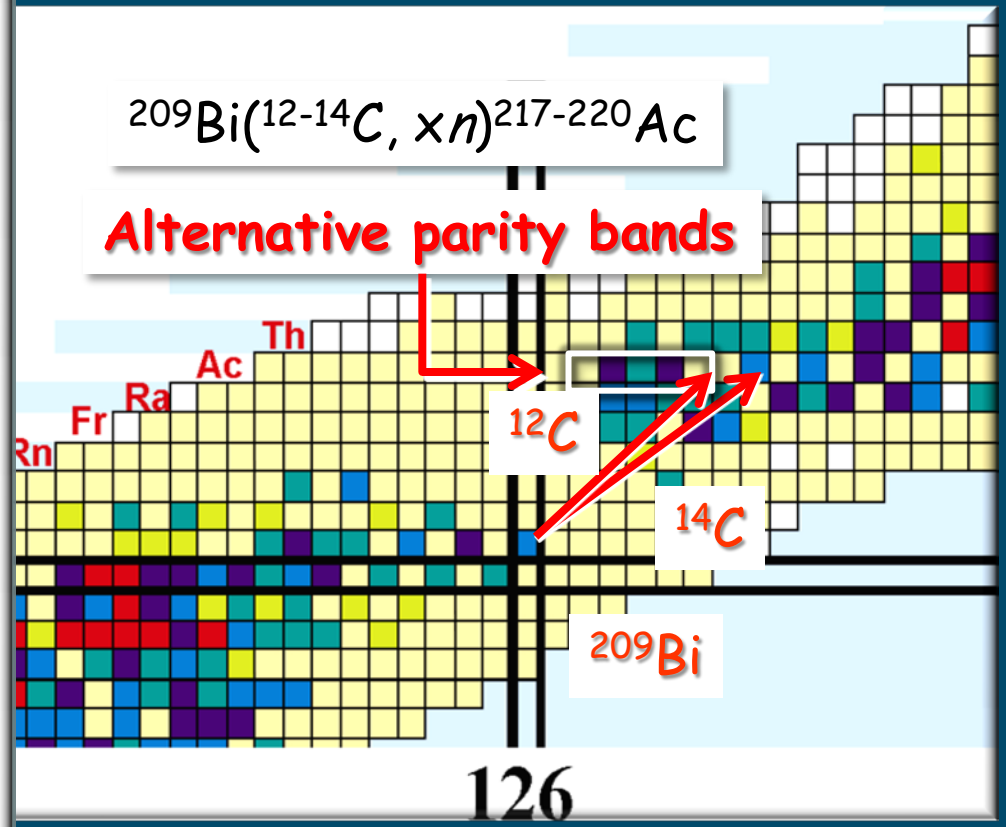
Odd A

$\sigma=+i$ $2I^\pi = 1^+, 3^-, 5^+, \ldots$

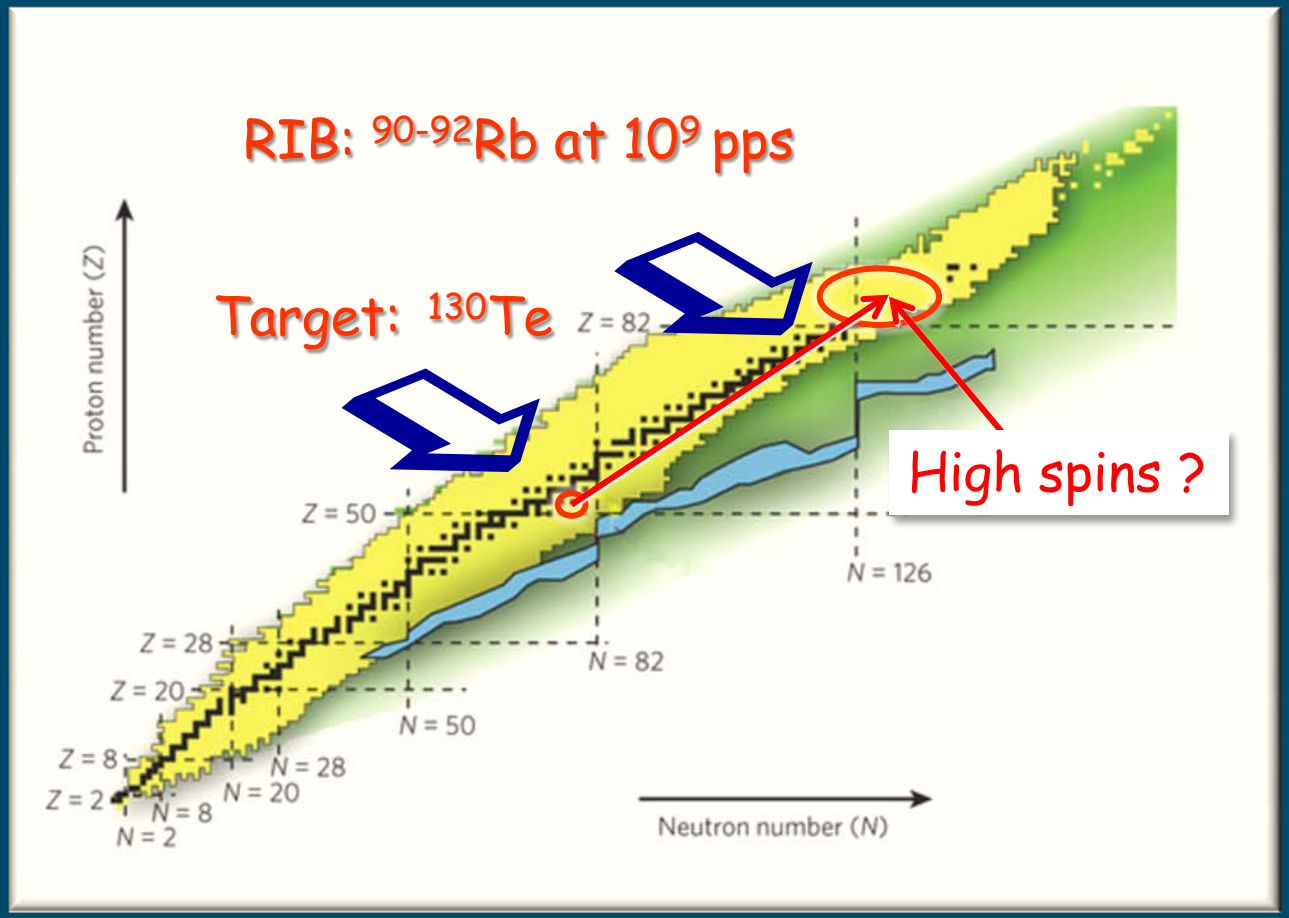
$\sigma=-1$ $2I^\pi = 1^-, 3^+, 5^-, \ldots$

Experimental investigation of alternative parity bands in actinides

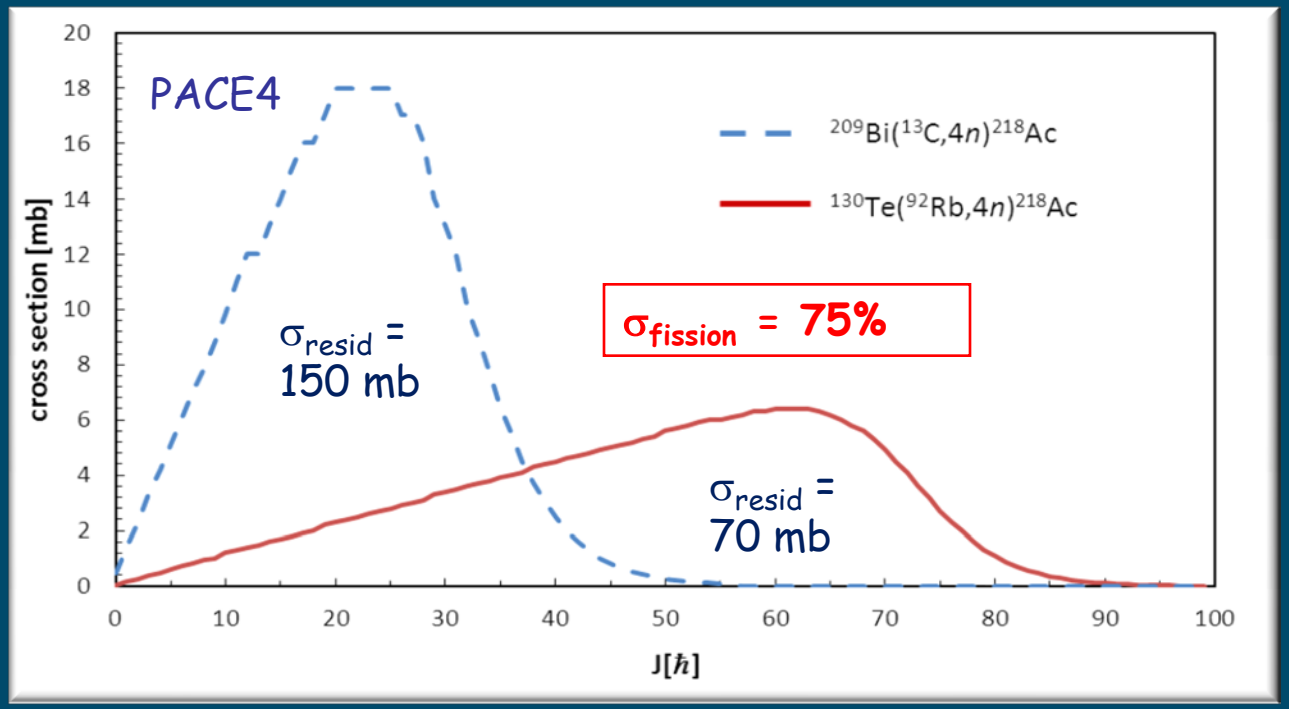




Alternative use of a symmetric reaction with a RIB



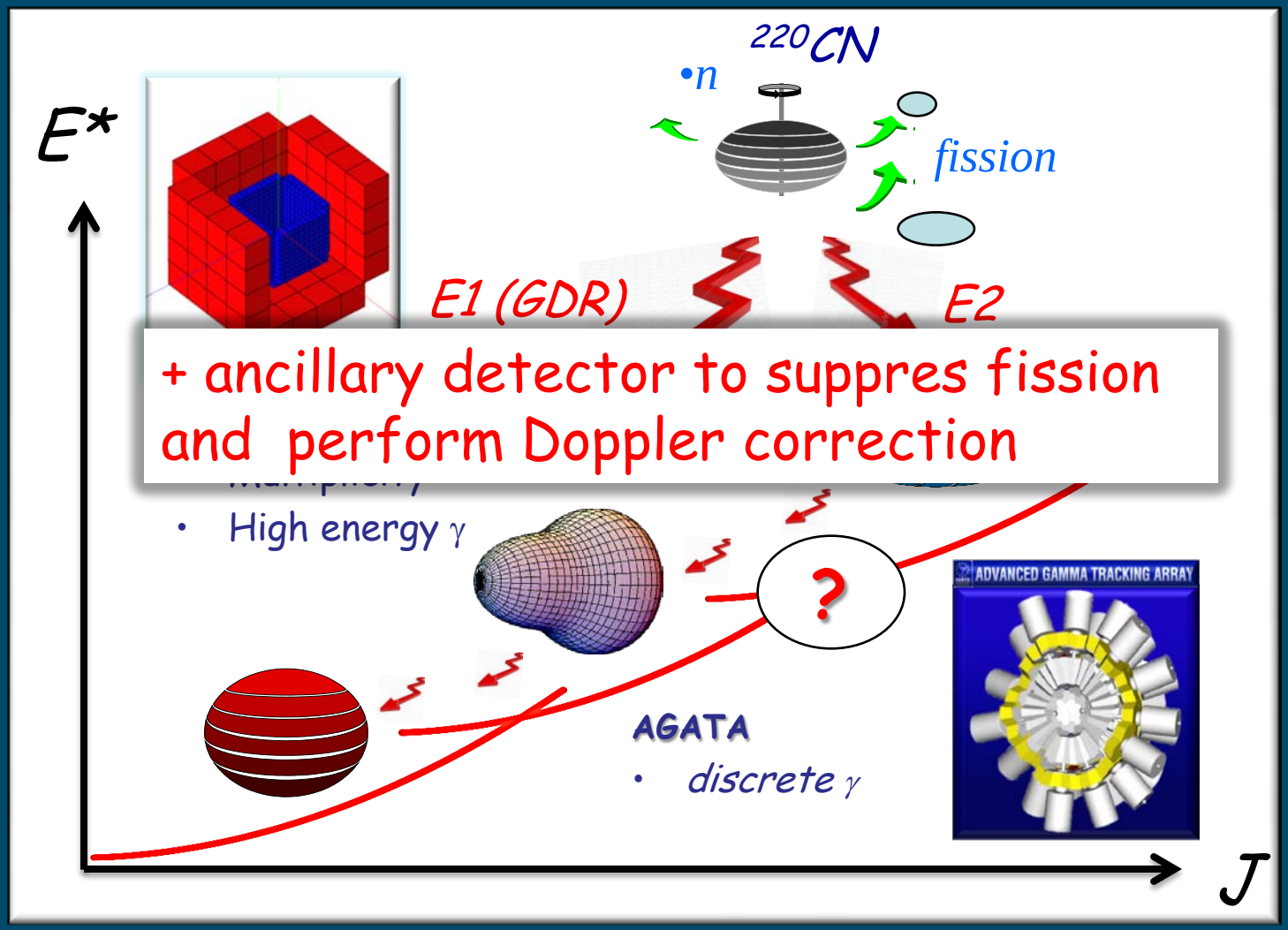
Increase of angular momentum



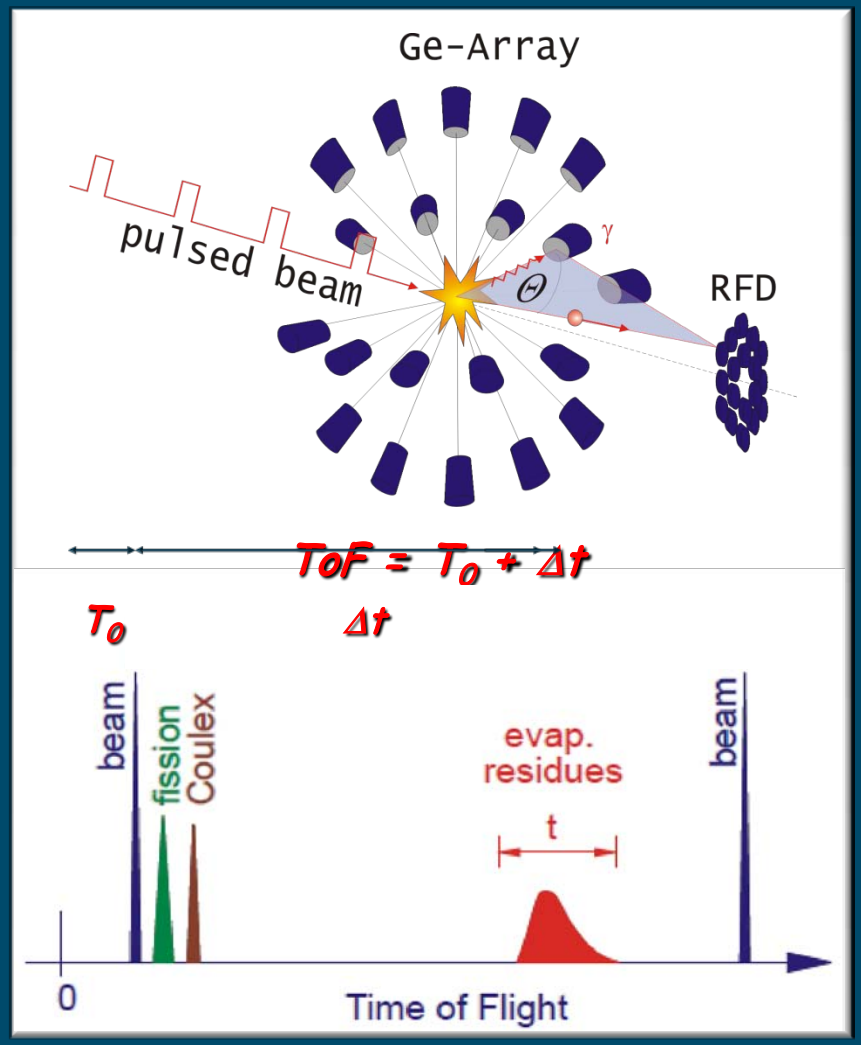
High spin states: ^{130}Te(^{92}Rb, 4n)^{220}Ac

E_b = 370MeV, v/c > 4%

γ-spectroscopy at high spin and temperture



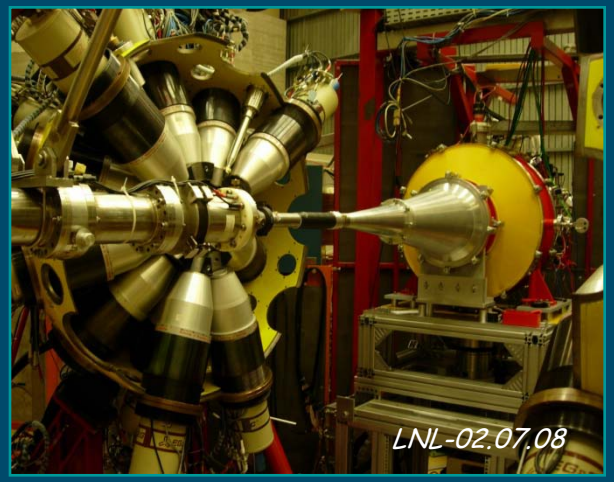
Recoil Filter Detector - Principle of Operation

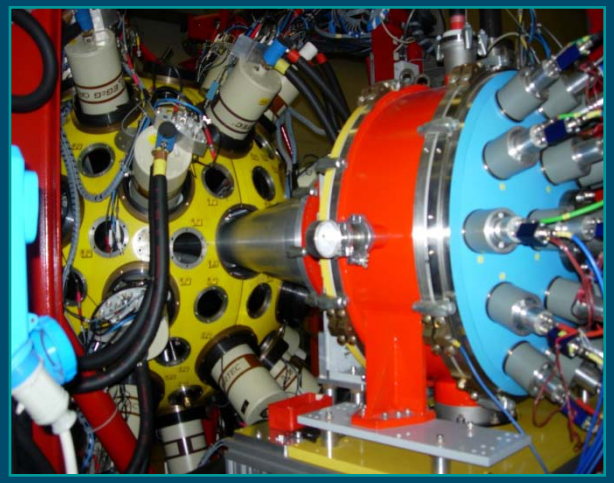


- RFD is a HI (ancillary) detector that measures evaporation residues in coincidence with γ-rays detected in a germanium array
- Time-of-Flight technique is applied to select the evaporation residues in an event-by-event mode

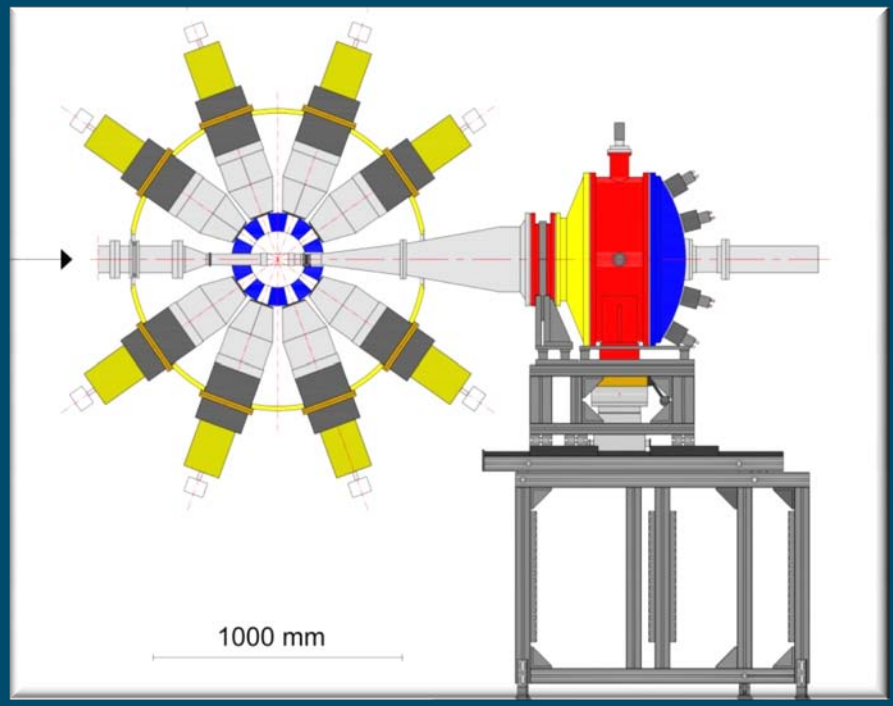
SPES exotic beams for science

RFD coupled with GASP

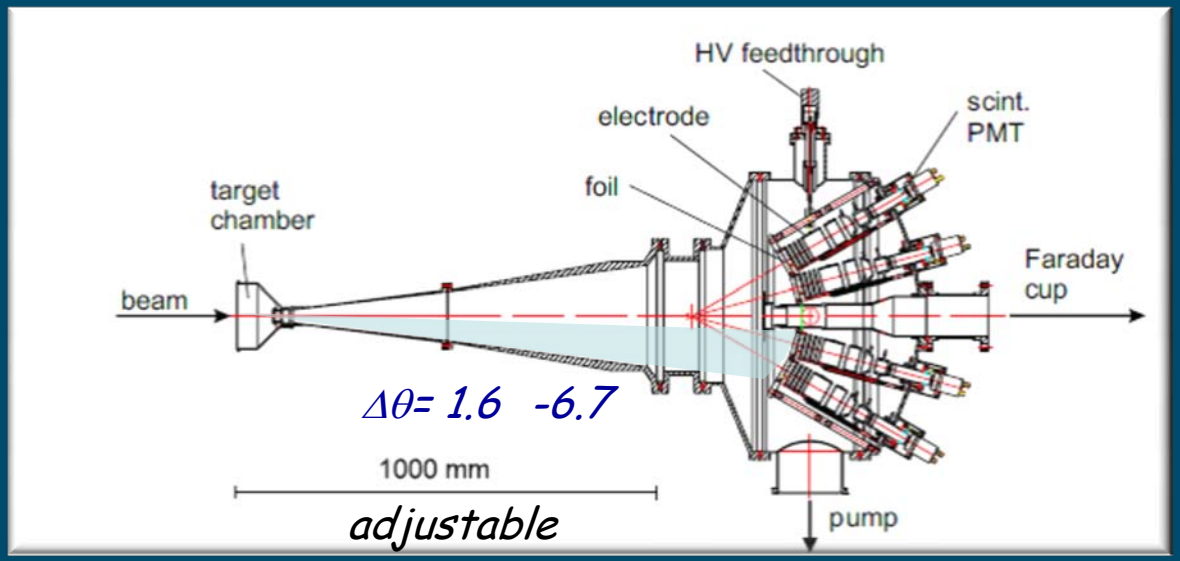




- Installation at GASP 2008
- Experiments 2009



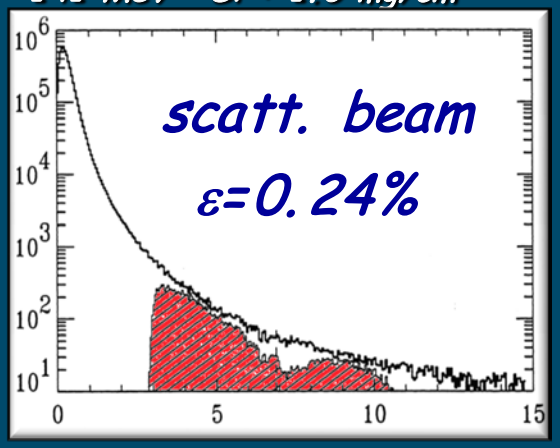
HI Detection Technique



- 18 individual detectors
- ToF = 50 –700 ns
  <β>= 0.5 –7%
- ε~50%

- Detectors don't 'see' directly the target position
- Scintillators are far from the beam line

141 MeV ^{28}Si + 1.0 mg/cm^2



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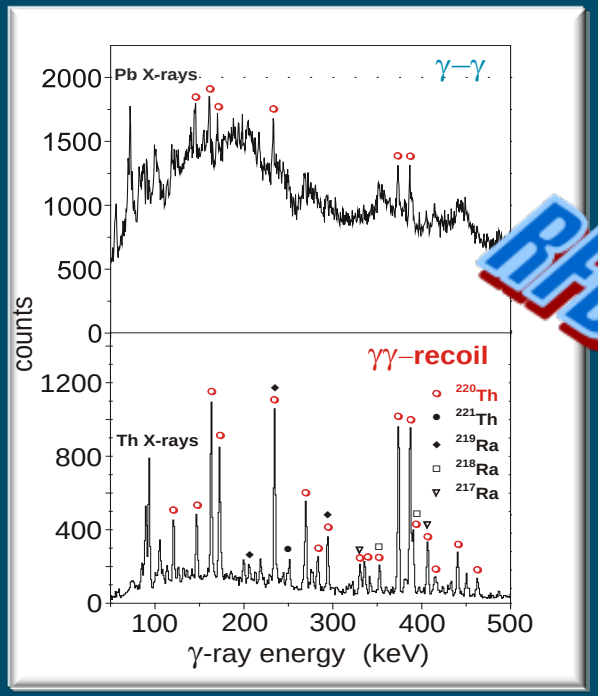
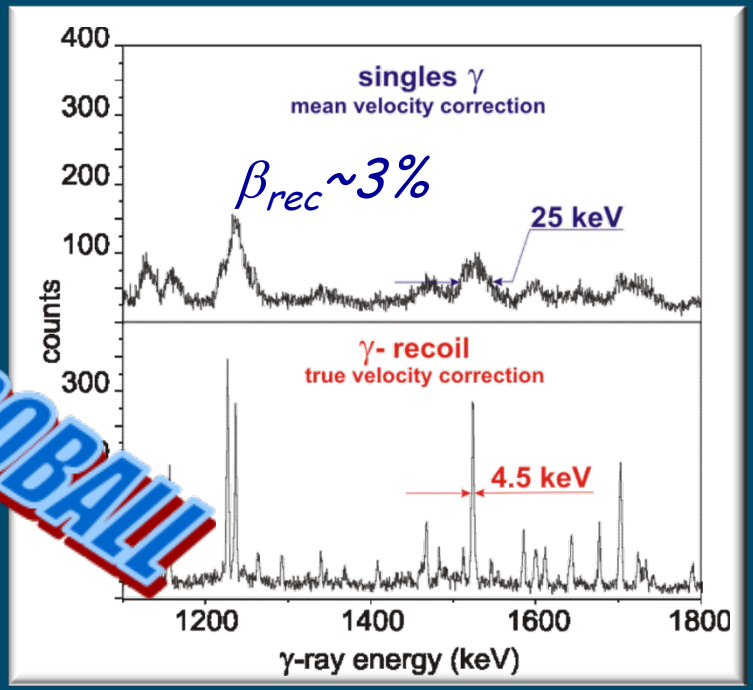
Improvement of γ-spectra by a coincident recoil detection (with RFD)

92 MeV ^{16}O + 0.4 mg/cm^2 ^{208}Pb



RFD+EUROBALL

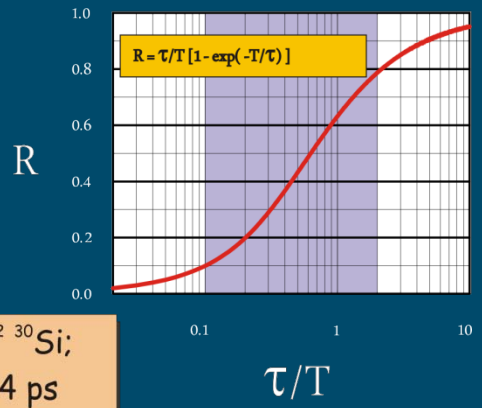
68 MeV ^{18}O + 0.8 mg/cm^2 ^{30}Si



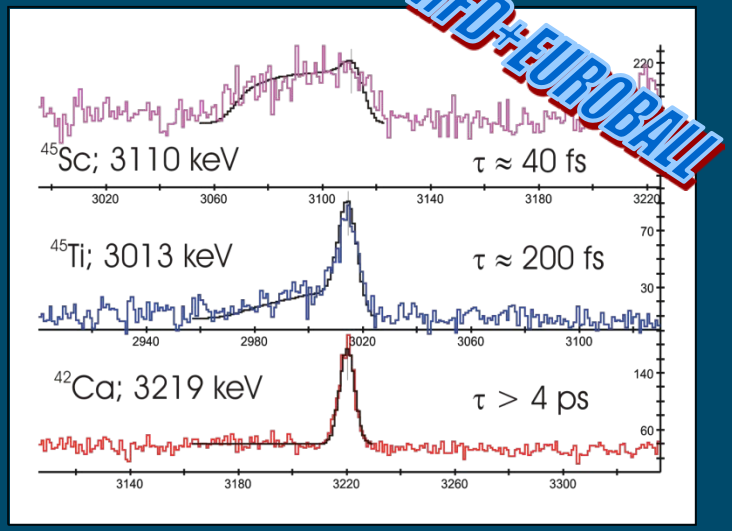
- *Heavy systems:*
  - ✓ *fission background reduction*
  - ✓ *low cross sections σ ~ 0.1 mbarn*
- *Large recoil velocity:*
  - ✓ *reduction of the Doppler broadening*

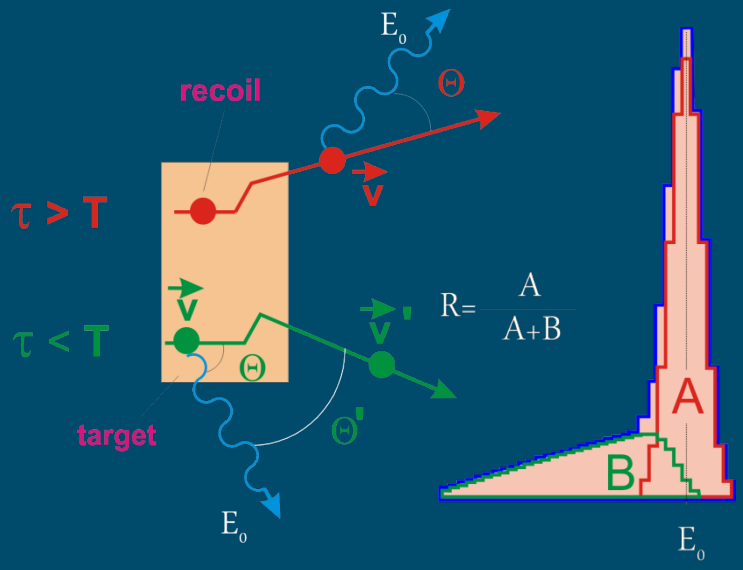
SPES exotic beams for science

Estimation of a short lifetime based on the recoil velocity measurement



68MeV ^{18}O + 0.8mg/cm^2 ^{30}Si;
Recoil transit time ≈ 0.4 ps





- Energy of a γ-ray emitted in a target (B) is not sufficiently Doppler corrected
- A level lifetime can be expressed by number of decays in vacuum (A) relative to a total γ-line intensity (A+B)

SPES exotic beams for science

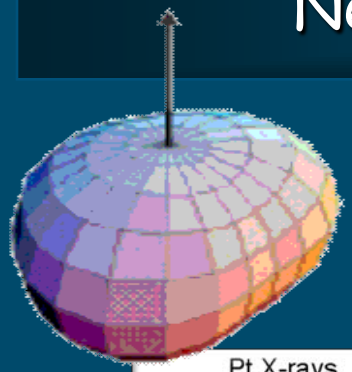
Perspectives at RIB

- **RFD at γ-ray detector arrays**
  - *GALILEO*
  - *AGATA*
  - *PARIS*

- ***RFD a good solution for measurements with radioactive bea***
  - ✓ high efficiency
  - ✓ projectiles do not irradiate the setup and can be transported to a FC distant from the experimental area.
  - ✓ detectors are not sensitive to any kind of radioactivity

- ***RFD upgrade***
  - ✓ replacement of scintillators by ultra fast diamond detectors
  - ✓ dedicated geometry (efficiency optimization)

New research prospects with Br-Y RIB

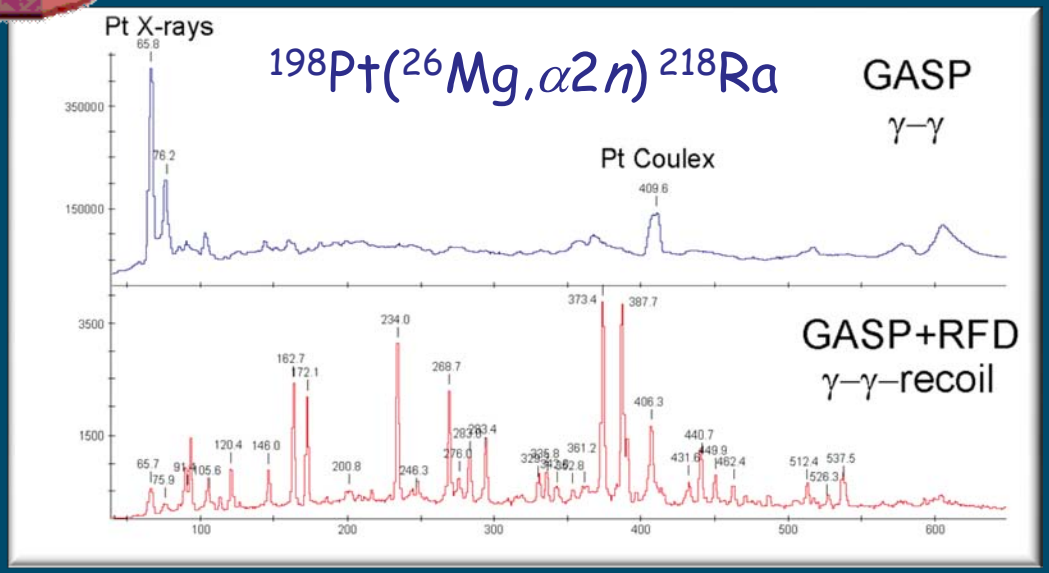


^{218}Ra: heart-shape nucleus:

quadrupole deformation + octupole phonon wave

Frauendorf PRC77(2008)

B(E1,E2)



CN= ^{224}Th

σ_{resid}(^{219,220}Th)~ 10mb

σ_{fiss}~ 250mb (90%)

i< 1pnA

^{130}Te(^{93}Kr,5n)^{218}Ra

Increased stability against fission

CN= ^{223}Ra

σ_{resid}~ 200mb

σ_{fiss} ~ 150mb (40%)

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