

Structure of Very Heavy Elements: GABRIELA

Introduction and Motivations

Current experimental set-up

Milestones and (subset) results

Perspectives : short/long term

A. Lopez-Martens for the GABRIELA collaboration



CSNSM



GABRIELA

GABRIELA is a project dedicated to spectroscopic studies of heavy elements

The project takes place at the Flerov Laboratory for Nuclear Reactions, JINR, Dubna

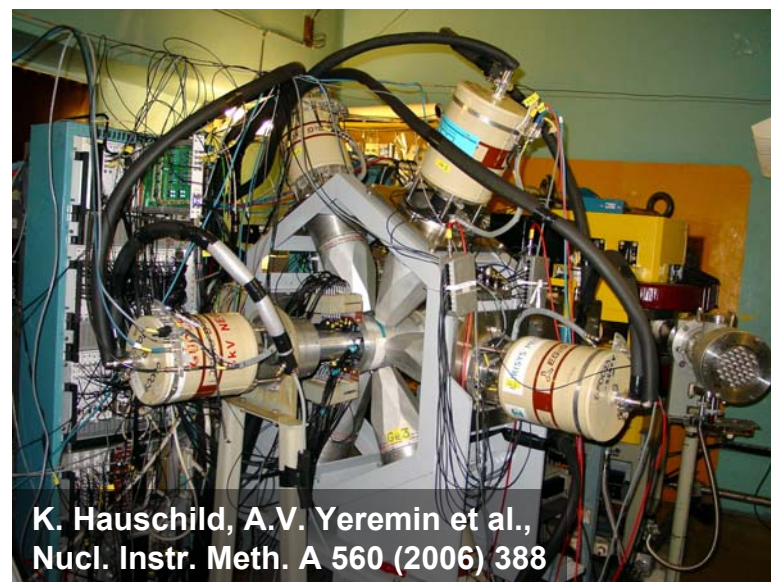
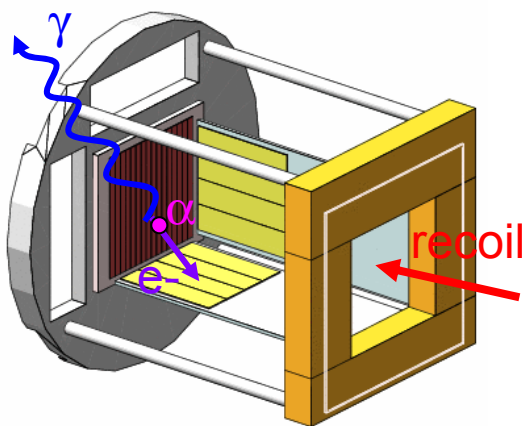
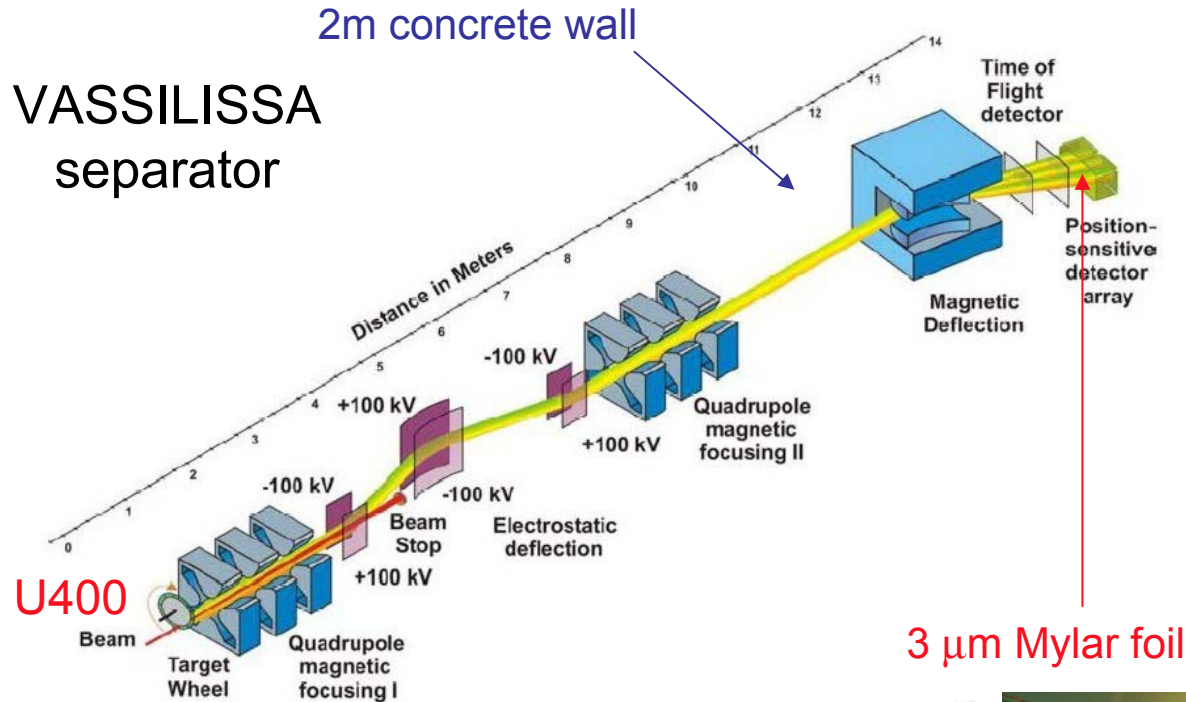
Advantages of Dubna:

- intense stable beams ($\sim 1 \text{ p}\mu\text{A}$)
- stable and radioactive targets ($^{233-236,238}\text{U}$, ^{237}Np , $^{239,240,242,244}\text{Pu}$, $^{241,243}\text{Am}$, $^{245-248}\text{Cm}$, ^{249}Bk , ^{249}Cf ,...)
- beam time

Goals of the project:

- study of single-particle states and nature of their couplings along isotopic and isotonic chains as $N=152 \rightarrow 162$
- study of isotopes for which very little spectroscopic information exists
- study of the stability of heavy nuclei produced in fusion-evaporation reactions

Gamma Alpha Beta Recoil Investigations with the Electromagnetic Analyser



Milestones

Dec 2003 and Jan 2004: project accepted by JINR and IN2P3 Scientific Council □s

May 2004: 1 day beam time

tests at the focal plane, 2 Ge + 1 BGO

^{48}Ca beam, ^{164}Dy and ^{174}Yb standing targets

June-July 2004: 6 days beam time

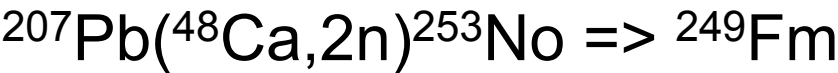
tests with new chamber, 2Ge, 1BGO and 1electron detector

^{40}Ar beam, ^{164}Dy , ^{174}Yb and ^{181}Ta rotating targets

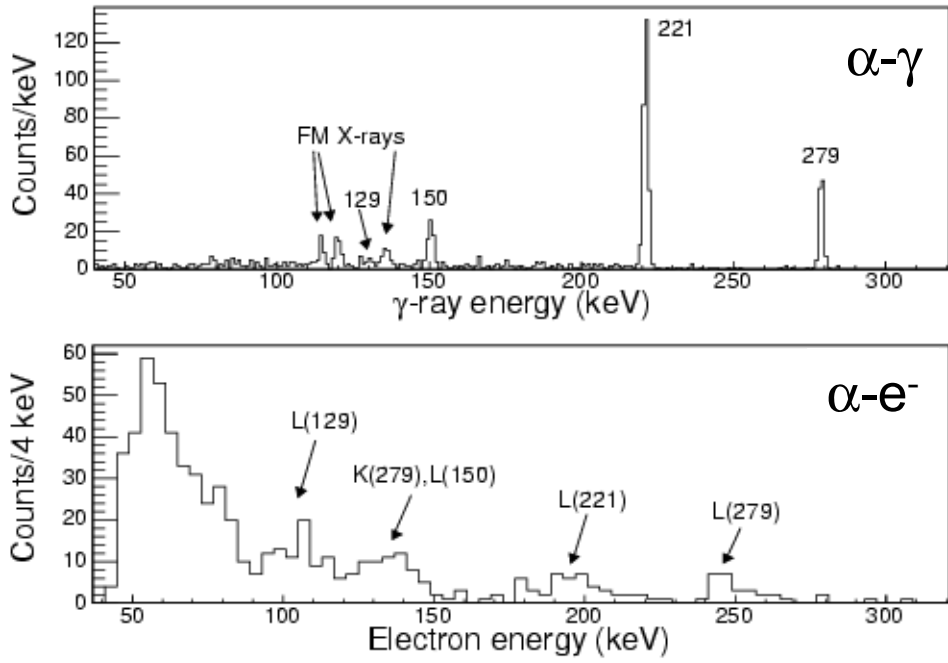
Sept-oct 2004: 1 month beam time

full setup

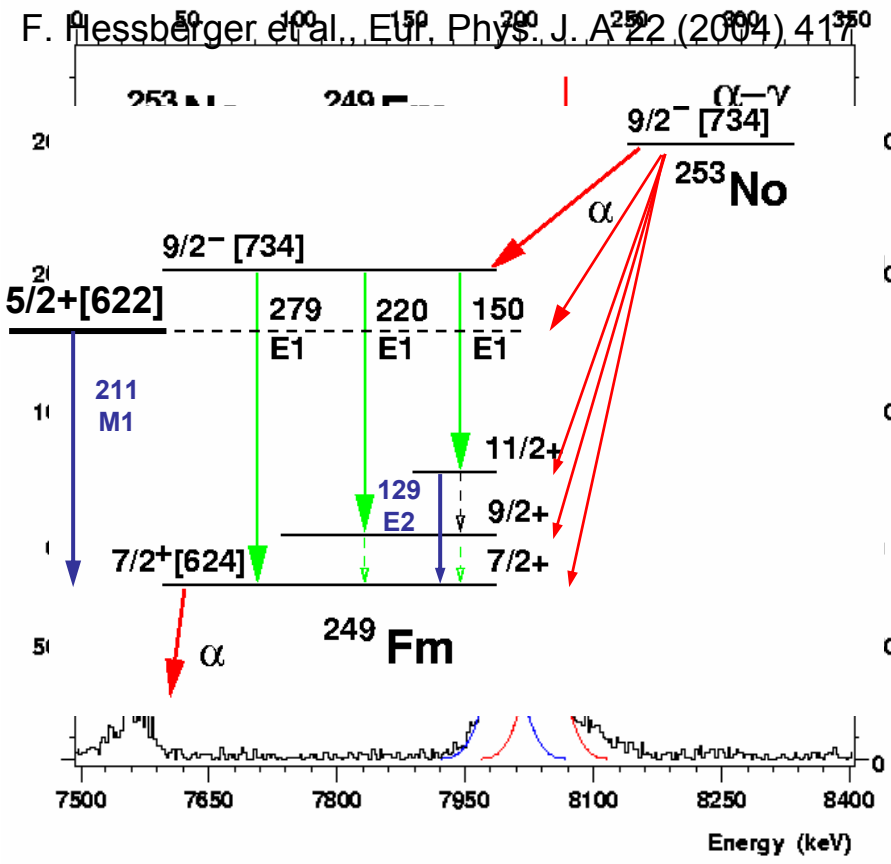
^{48}Ca beam, $^{207-208}\text{Pb}$ and ^{209}Bi rotating targets



Alpha Decay of ^{253}No – Gabriela Expt.
 A. Lopez-Martens et al., Submitted to Phys. Rev. C

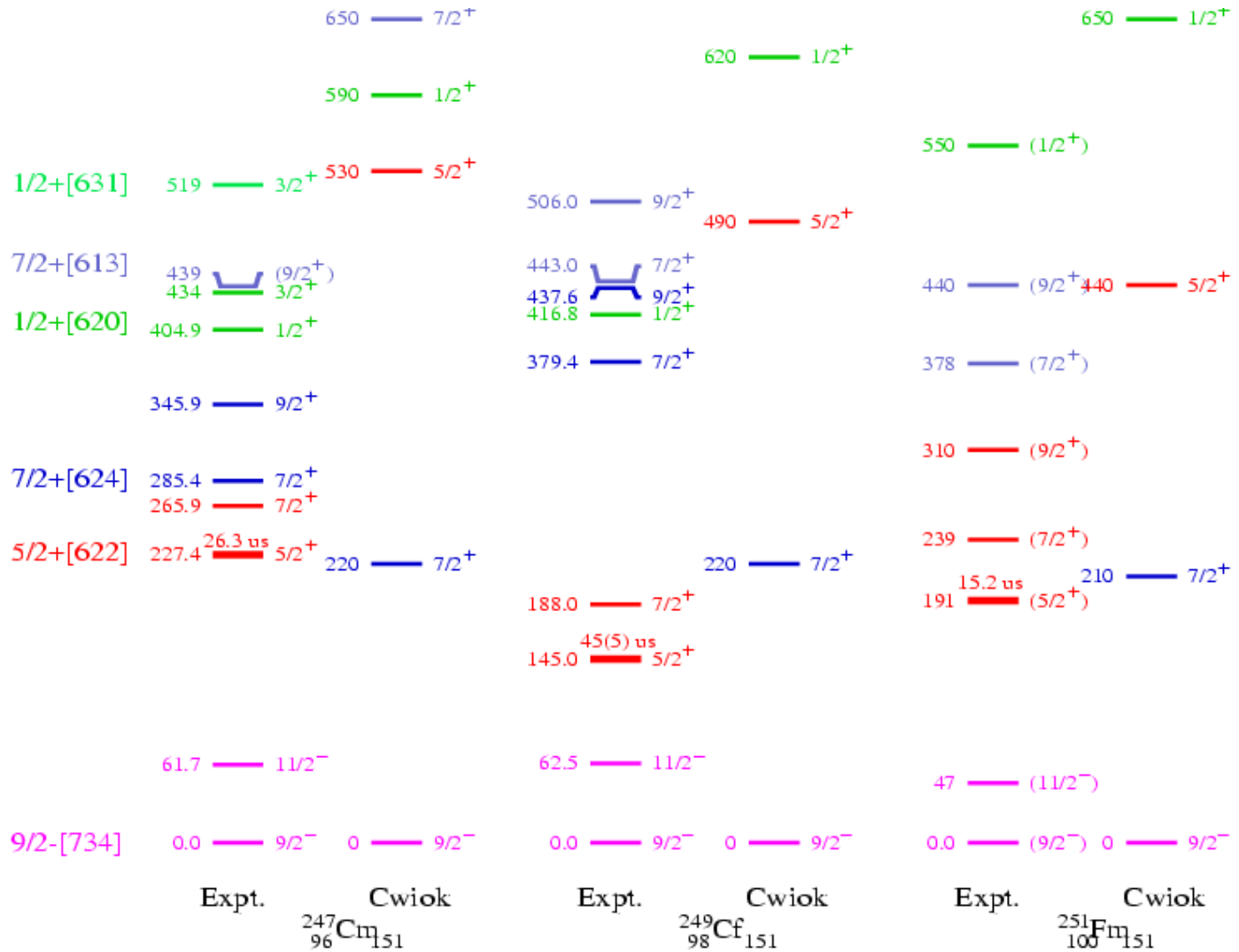


Alpha Decay of ^{253}No – JYFL Expt.,
 R.-D. Herzberg et al, J. Phys G30 (2004) R123



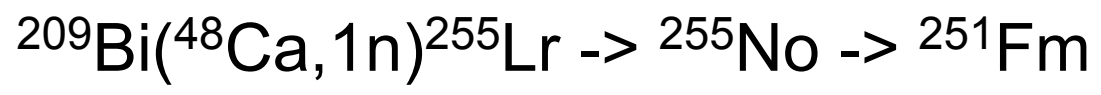
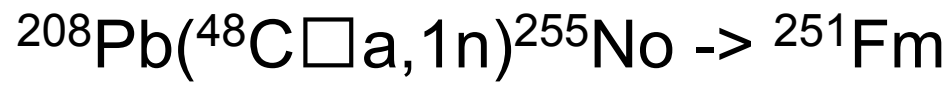
F. Hessberger et al., Eur. Phys. J. A 22 (2004) 417

N = 151 systematics : isomeric 5/2+

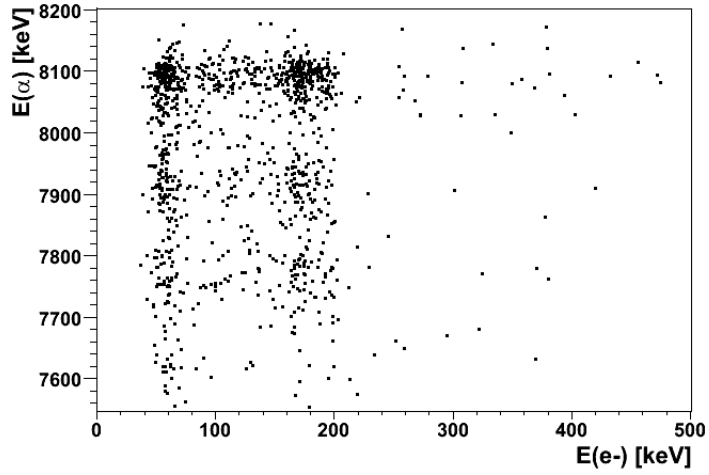
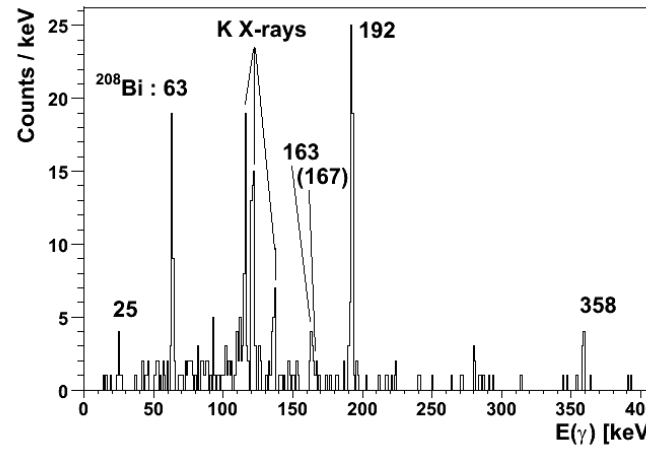
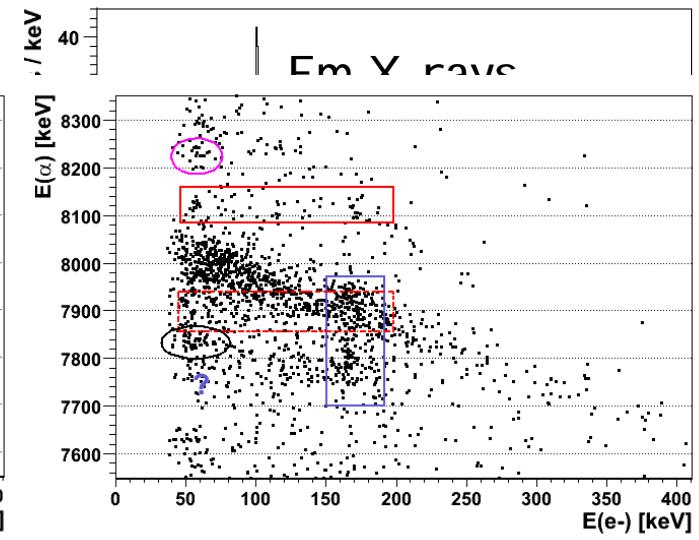
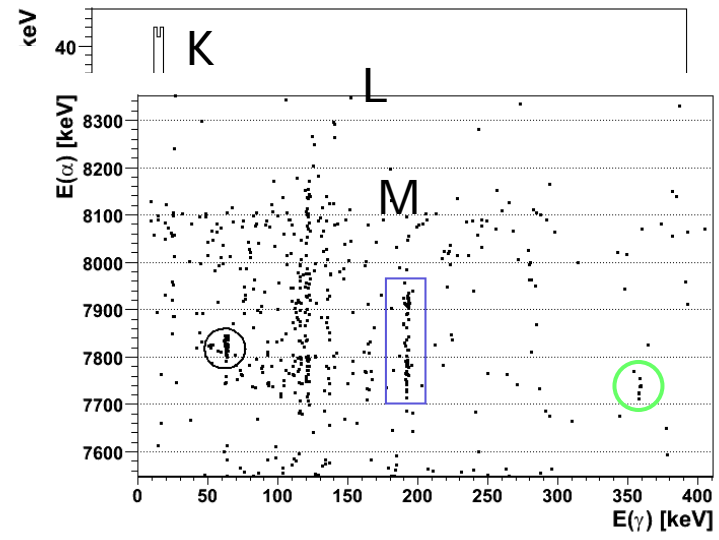
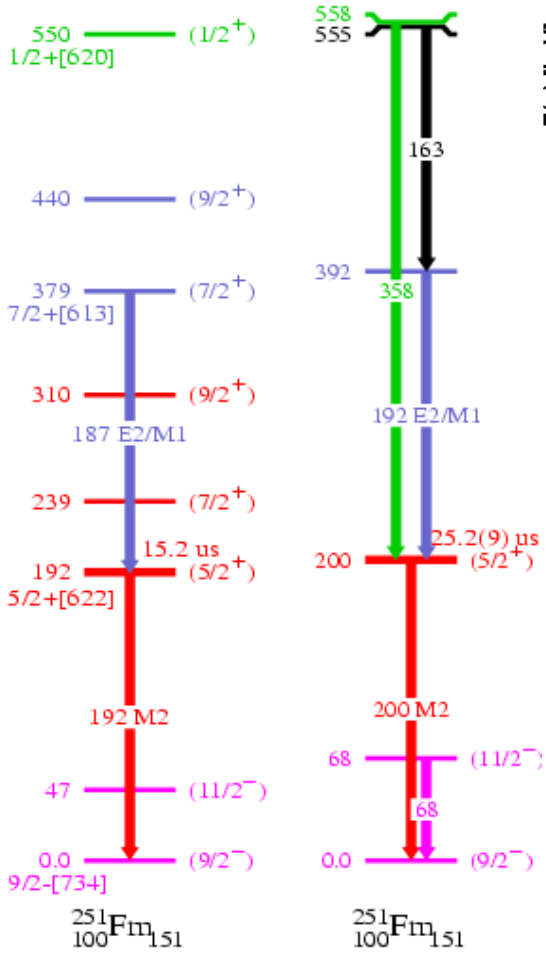


^{251}Fm : ORNL annual report : no peer reviewed publication

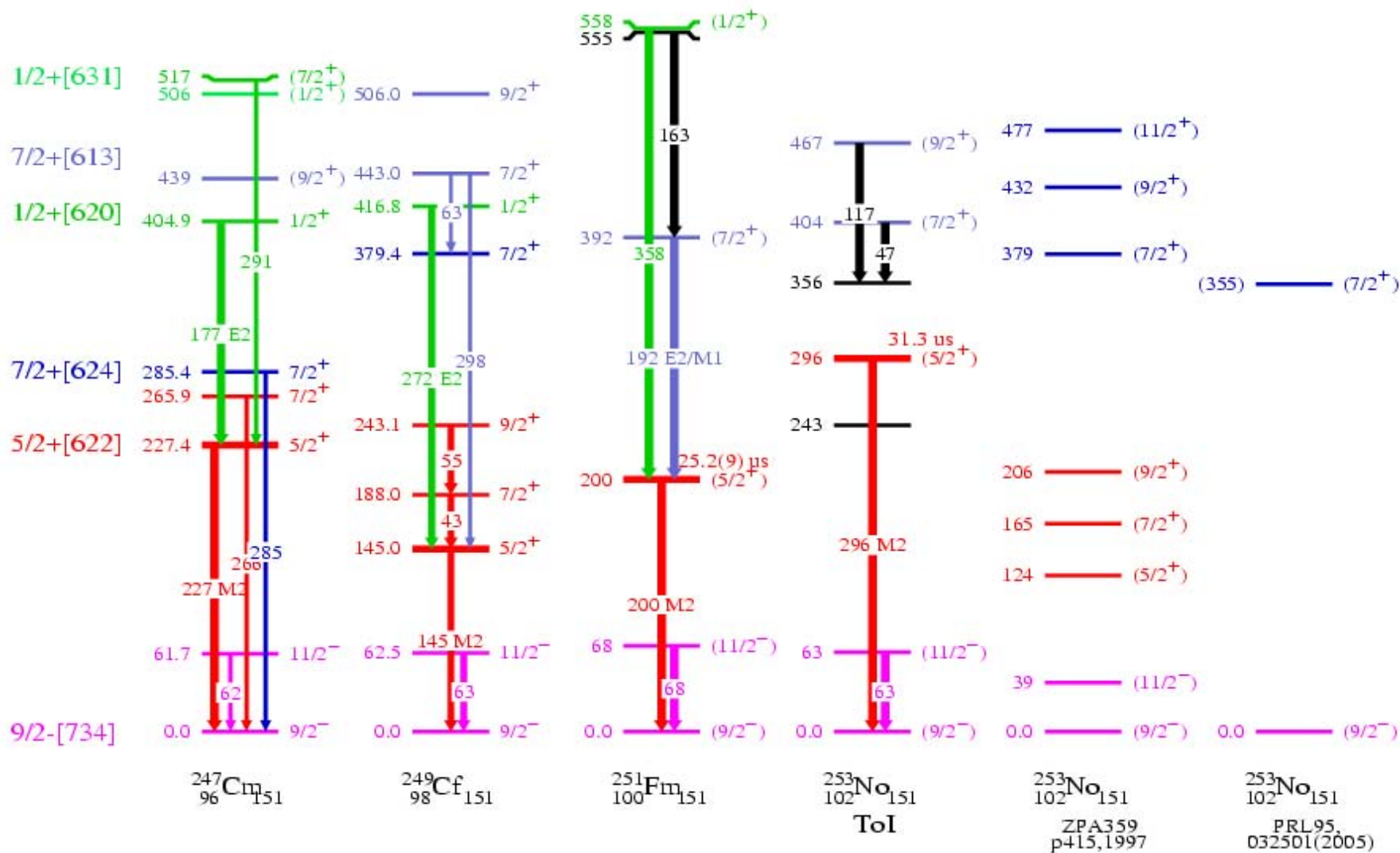
more recently: α - γ coincidences measured at SHIP



'Tol'



Extending the N = 151 systematics to ^{253}No



New measurement at SHIP and α -decay information from ^{257}Rf : $E(5/2^+) = 180(30)$ keV

GABRIELA: delayed e- and X-rays observed, substantial population of 5/2+ state in reaction

Milestones

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Sept-oct 2004: 1 month beam time

full setup

^{48}Ca beam, $^{207-208}\text{Pb}$ and ^{209}Bi rotating targets

July 2005: 10 days beam time

^{48}Ca and ^{22}Ne transmission test

Oct-Nov 2005: 1 month beam time

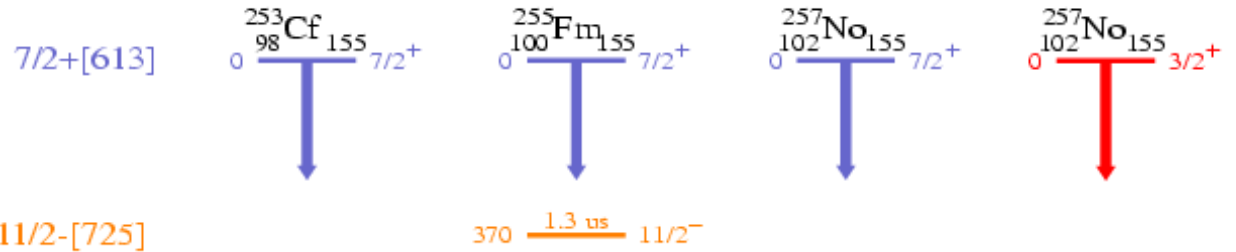
thinner chamber, new e- electronics, 6 Ge + 2 BGO + 4 passive shields

^{22}Ne beam, ^{238}U rotating target

^{48}Ca beam, ^{210}Pb class III rotating target

^{48}Ca beam, ^{208}Pb and ^{209}Bi rotating targets

N = 153 systematics

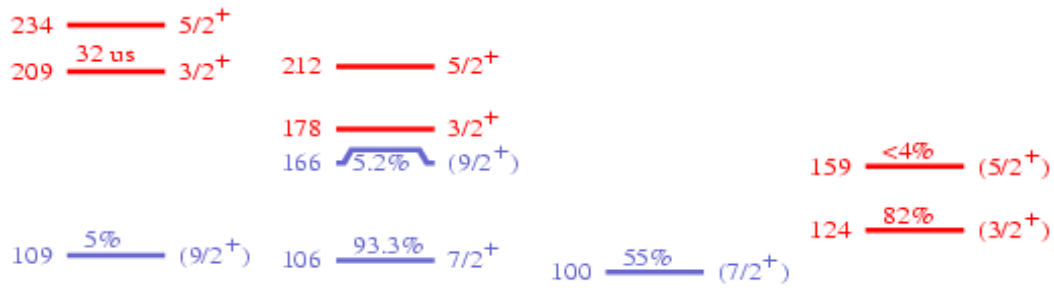


Abrupt change of alpha decay pattern

Change in ^{257}No ground state ?

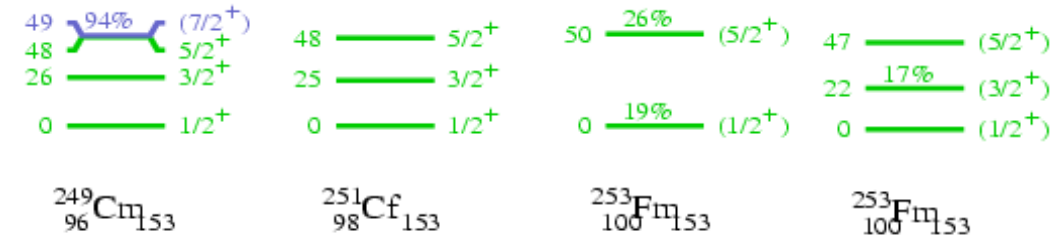
$11/2^-$ [725]

$3/2^+$ [622]



$7/2^+$ [613]

$1/2^+$ [620]



$^{208}\text{Pb}(48\text{Ca}, 1n)^{257}\text{No} \rightarrow ^{253}\text{Fm}$

Cross section ?

Asai et al PRL95(2005)

$^{248}\text{Cm}(^{13}\text{C}, 4n) \sigma = 1100 \text{ nb}$

Just as we were getting prepared ...

^{210}Pb target ready, radioprotection clearance.....

Unique opportunity to use ^{210}Pb target and look at γ -e- coincidences in ^{253}Fm .

3 bombarding energies

120 hours, beam dose of 8×10^{17}

=> no events

assuming 100 nb

=> target thickness limit $< 5 \mu\text{g}/\text{cm}^2$



To pursue this further : $^{244}\text{Pu}(^{18}\text{O}, 5n) \sigma > 100 \text{ nb}$

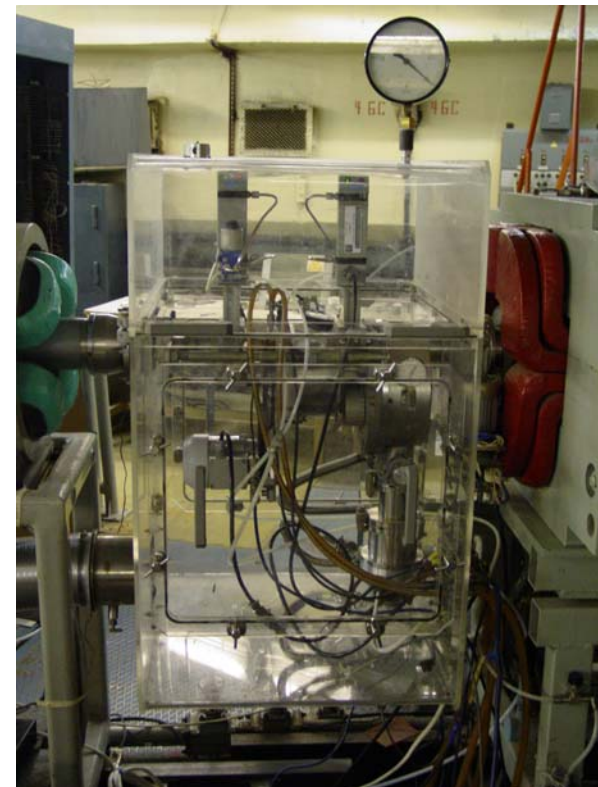
=> requires transmission tests with an ^{18}O beam

Is the $3/2+[622]$ swapped with $7/2+[613]$ in ^{259}Rf ?

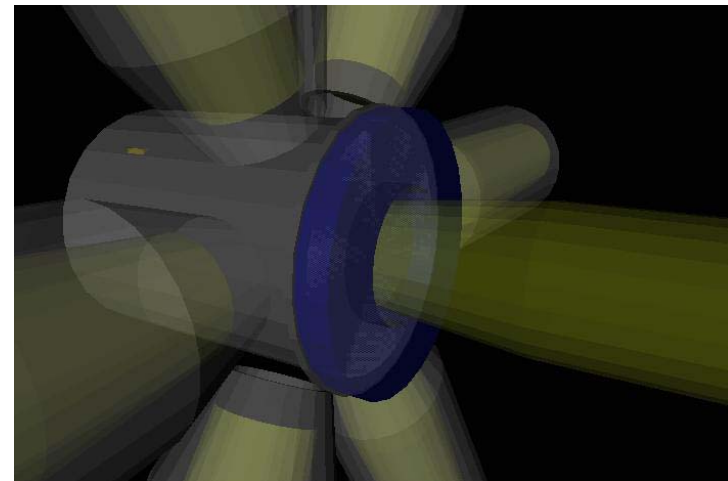
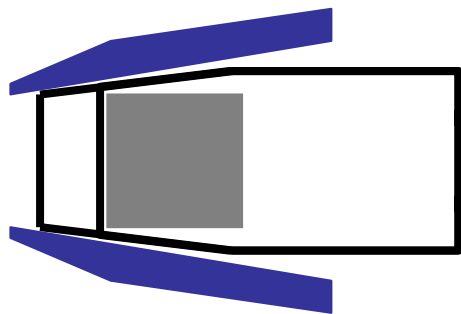
$^{242}\text{Pu}(^{22}\text{Ne}, 5n)^{259}\text{Rf} \rightarrow ^{255}\text{No}$

$\sigma \sim 5 \text{ nb}$, $I_B \sim 1 - 1.5 \mu\text{A}$

=> improvements to set-up



Improvements to experimental setup



1) Modified Ge detector

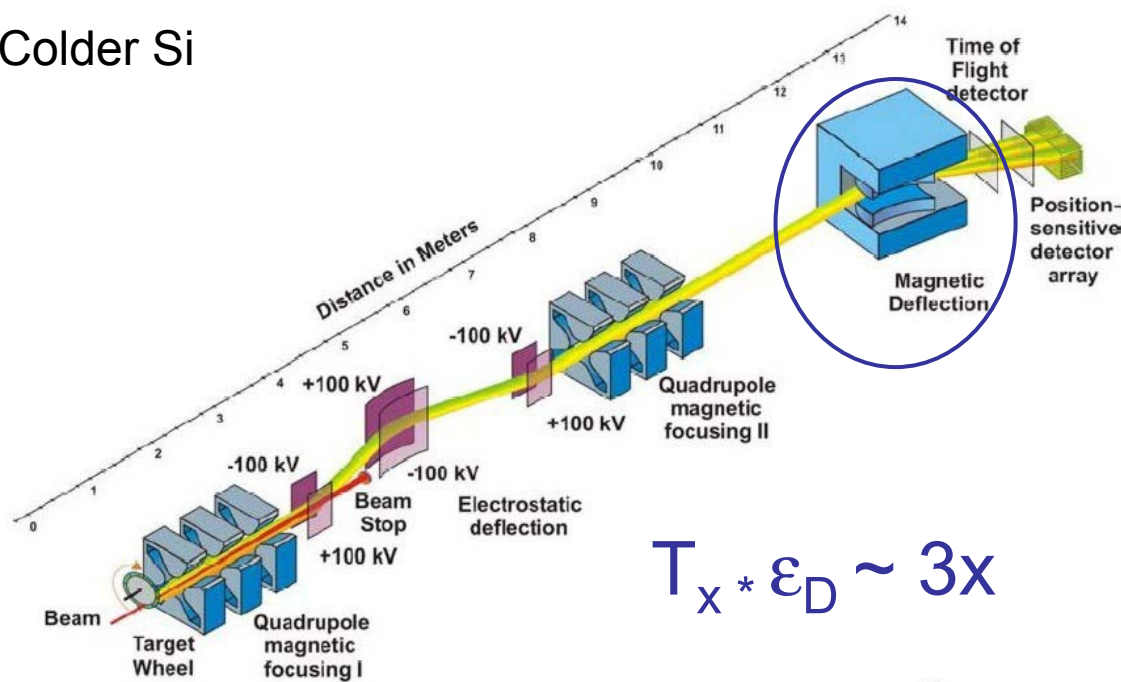
=> 2x array efficiency

2) New Si detectors : larger + more strips

3) New lower power preamplifier => Colder Si
=> better e- resolution

4) 37° magnet replaced by 8°
=> less dispersion

5) ToF : thinner foils
=> less straggling
shorter
=> less dispersion



$$T_x * \epsilon_D \sim 3x$$

These modifications should be tested before next campaign (oct-nov 2006)
=> tests in September 2006

Further into the future

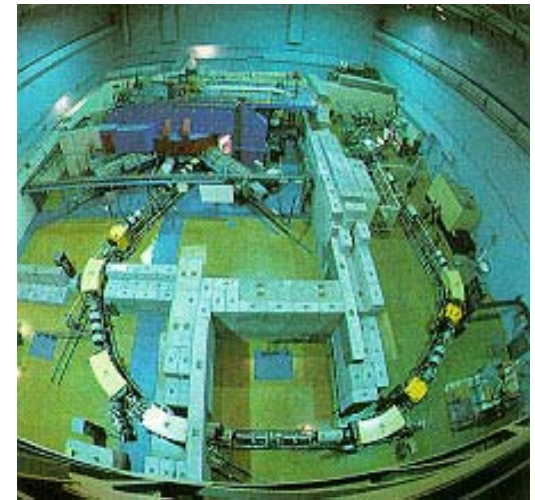
Limited beam time available at U400 (1-2 months/year)

Vassilissa is in the same experimental hall as the Gas Filled Separator

=> limited access time to target area

The cyclotron U400M will soon be upgraded to extract low energy beams (5 AMeV)

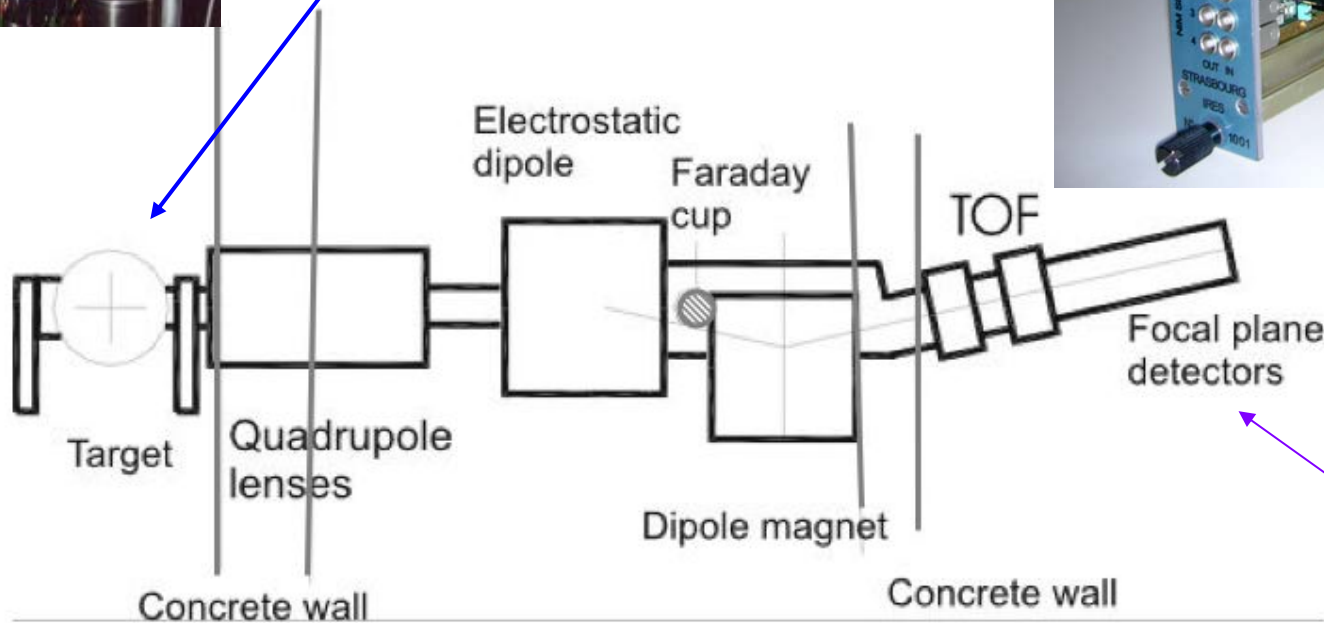
There is enough space for a dedicated experimental hall



= > The GABRIELA collaboration has applied for funds to build an upgraded separator (**S**eparator for **H**eavy **E**lement **S**tudies) at the U400M dedicated to prompt and focal plane gamma-ray spectroscopy



At the target position:
 Ge detectors equipped
 with TNT2-D cards
 and/or
 BaF2 array



Upgraded
 focal plane
 setup

If application is successful, 3 year funding should start sept 06
 => 1st test beams : sept 09

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