Experimental Proposal: E073

- Title: “Electron Screening and Alpha-Decay”
- Spokeperson: A. Musumarra, University of Catania & INFN-LNS
- GSI Contact Person: C. Nociforo, GSI
- Year of Approval: June 2006
- Shifts: 41 approved (main)
  10 used (main, only FRS-S4)
  31 left (main)

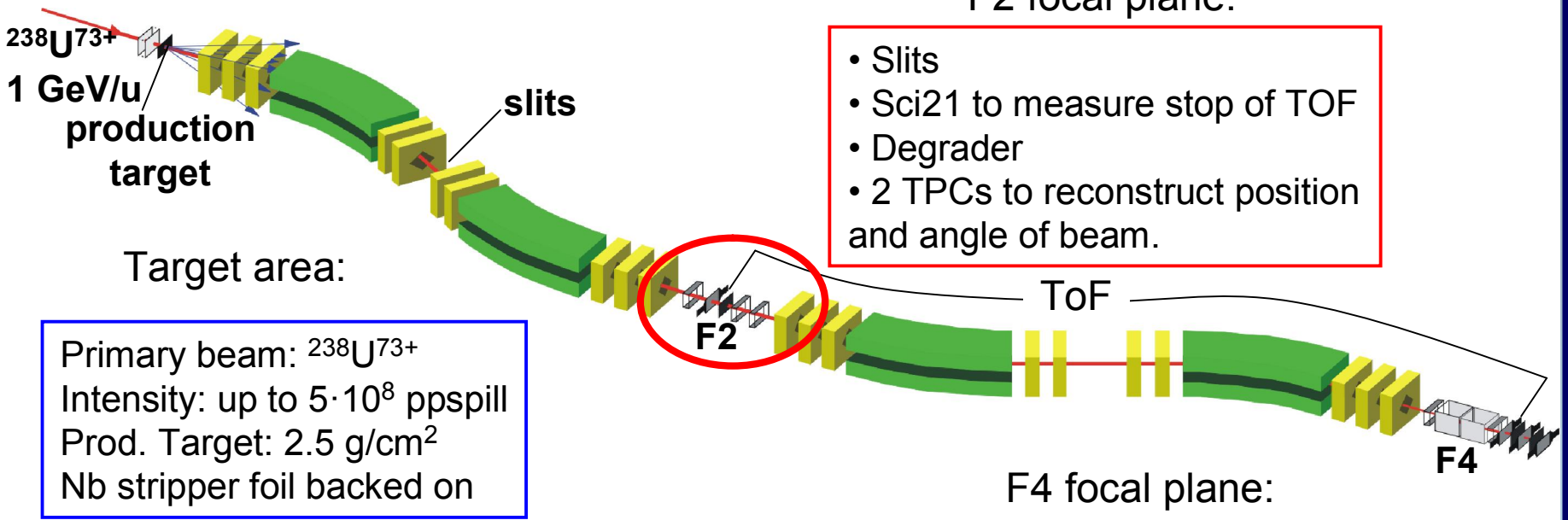
Physical Motivation

- Search for evidence of electron screening effect in alpha-decay by modification in lifetime and Q_α-values of fully stripped, H-like and neutral α-emitters.
- According to theory, $\Delta\lambda / \lambda \sim 0.5$ % → faced only theoretically!
  (Z. Patik *et al.*, Phys. Rev. C **78**, 2008)
- First step: measurement of neutral atom at FRS and at INFN-LNS, Italy
- Second step: measurement of bare, H-like, He-like nuclei at ESR.

Selected isotope

	$T_{1/2}$ (s)	α-branch	Q_α (MeV)
^{213}Fr	34.6 (3)	99.45 %	6.905

E073 beam time at FRS (April 2008)



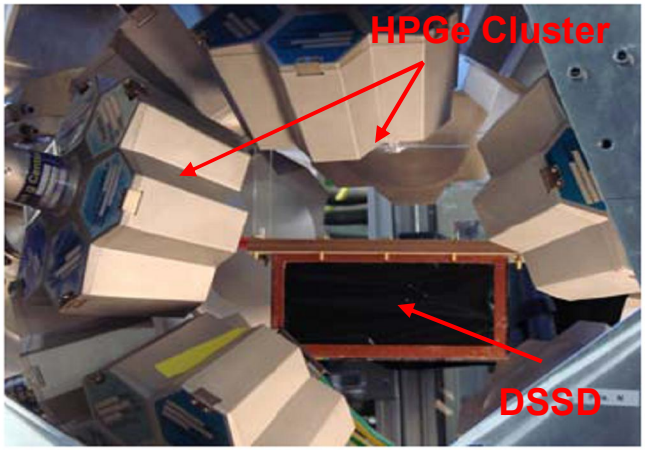
F2 focal plane:

- Slits
- Sci21 to measure stop of TOF
- Degrader
- 2 TPCs to reconstruct position and angle of beam.

Target area:

Primary beam: $^{238}U^{73+}$
Intensity: up to $5 \cdot 10^8$ ppspill
Prod. Target: 2.5 g/cm^2
Nb stripper foil backed on

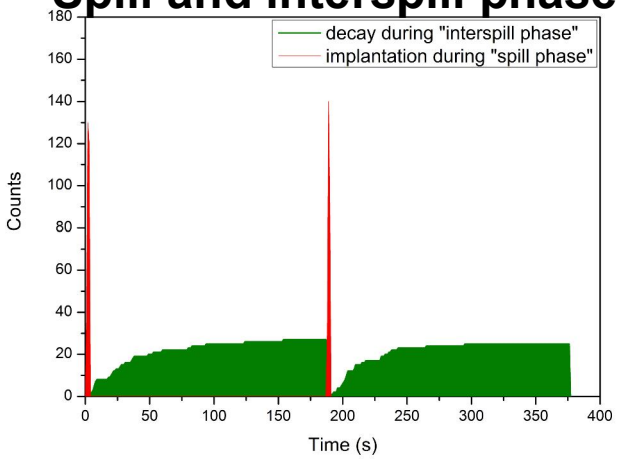
F4 focal plane:



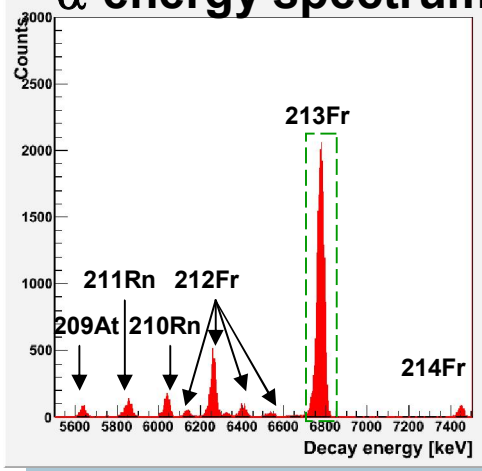
- 2 TPCs to reconstruct position and angle of beam
- 2 MUSICs with Nb stripper in between
- Sci41 provides start of TOF and Trigger
- Degrader to slow particles
- Sci42 to check implantation procedure
- DSSD is active stopper
- Sci43 is VETO detector
- RISING HPGe array around DSSD.

E073 beam time at FRS (2)

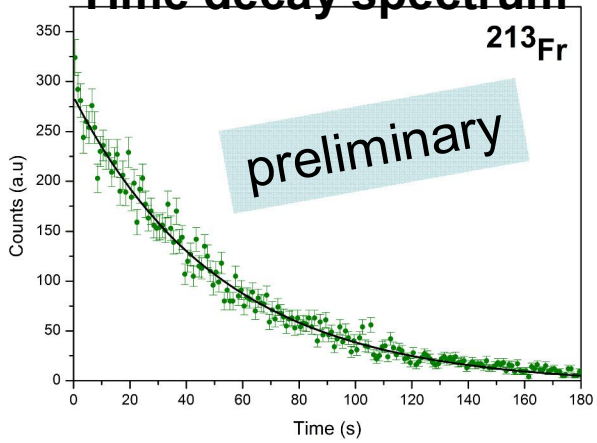
Spill and interspill phase



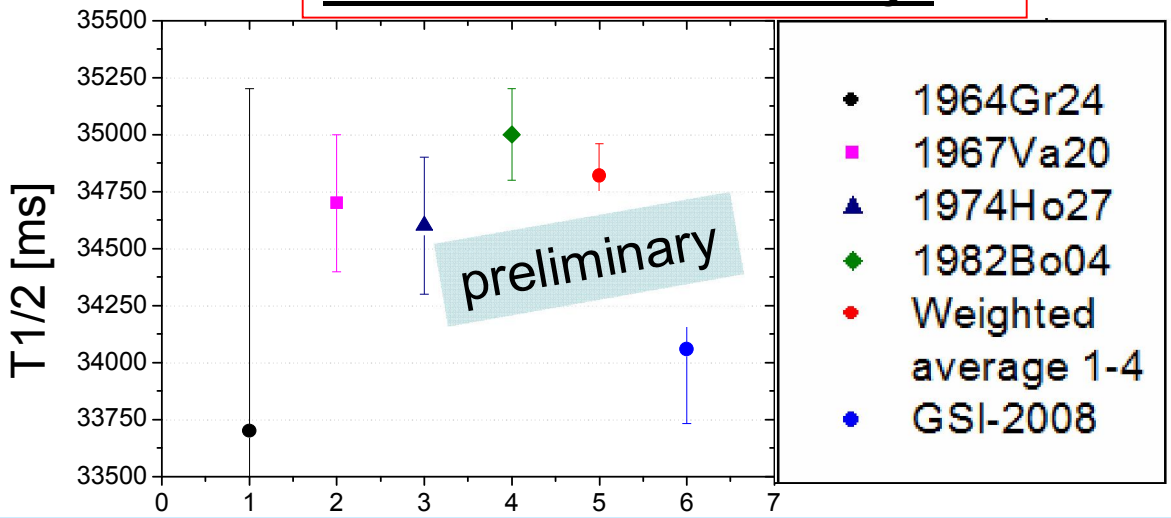
α-energy spectrum



Time decay spectrum



Statistics: ~ 2 x 10^4 decays



1: Fusion evaporation 205Tl + 12C at 86 MeV

2: Fusion evaporation 205Tl + 12C at 74-105 MeV

3: Proton Spallation at 600 MeV, ISOLDE (evidence for ~ 5% 213Ra)

4: Proton Spallation at 5 GeV, Bevatron

5: Weighted Average 1-4

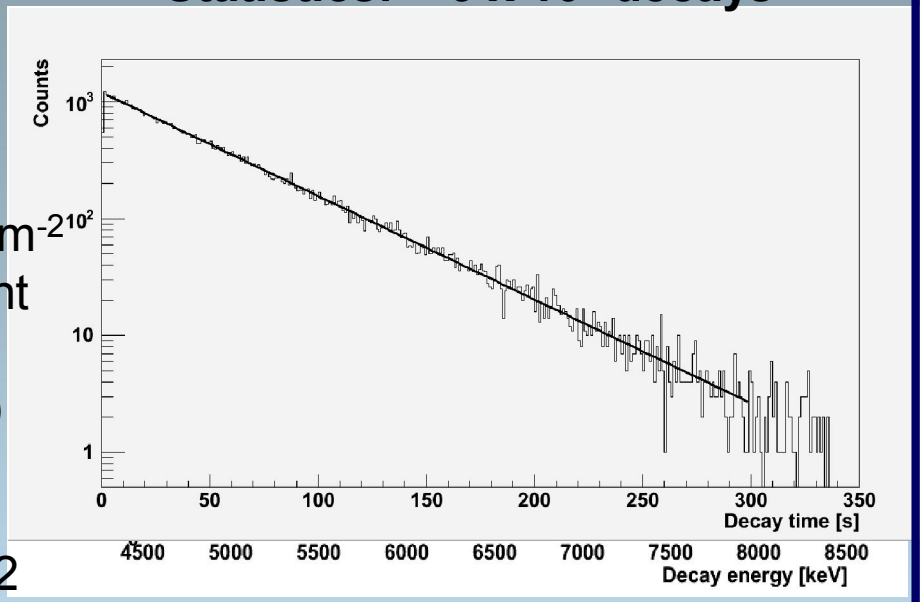
6: 238U fragmentation at 1 Gev/u

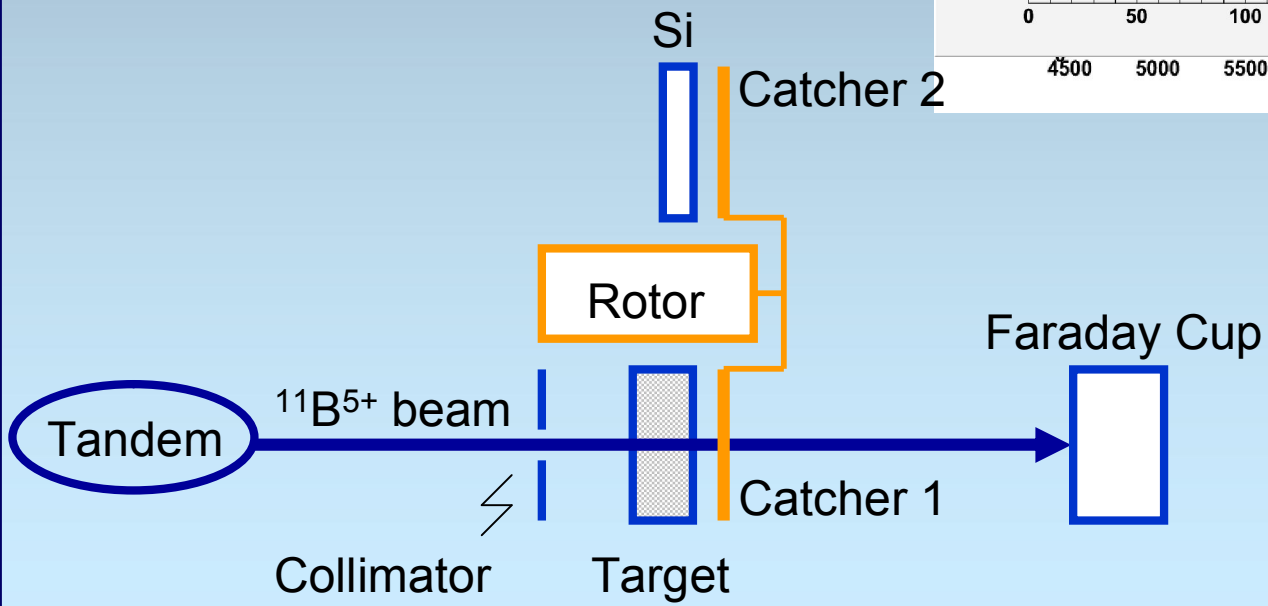
E073 beam time at LNS (May 2010)

Statistics: ~ 6 x 10^5 decays

Production reaction: Fusion-evaporation
Primary beam: $^{11}B^{5+}$ at 72 MeV (TKE)
5-10 nA ~ 6-12 x 10^9 pps
Target: ^{208}Pb 0.983 mg cm^{-2} + ^{12}C 26 µg cm^{-2}
Time: ~ 8 shifts + background measurement

Rotor interval: 20 – 460 s (180 ms rotation)
Collimator: diam. 3 mm

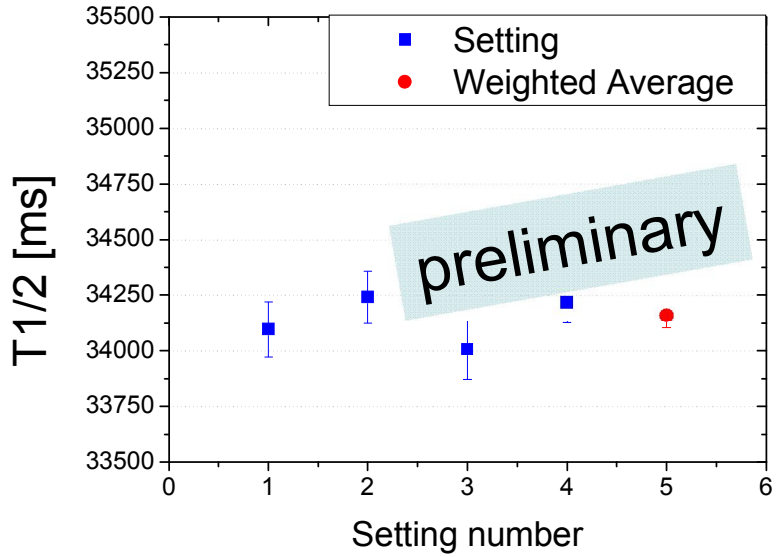


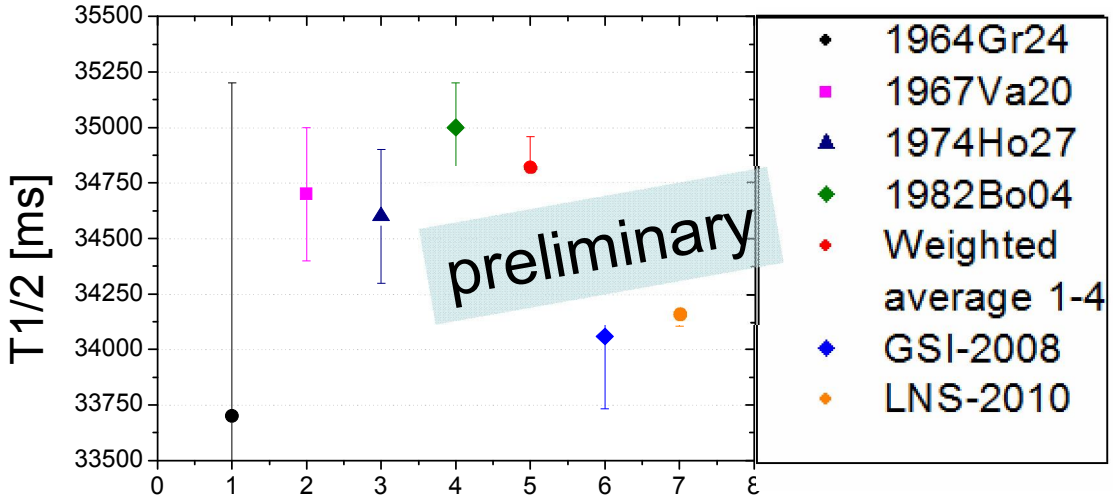


Electronic read-out:

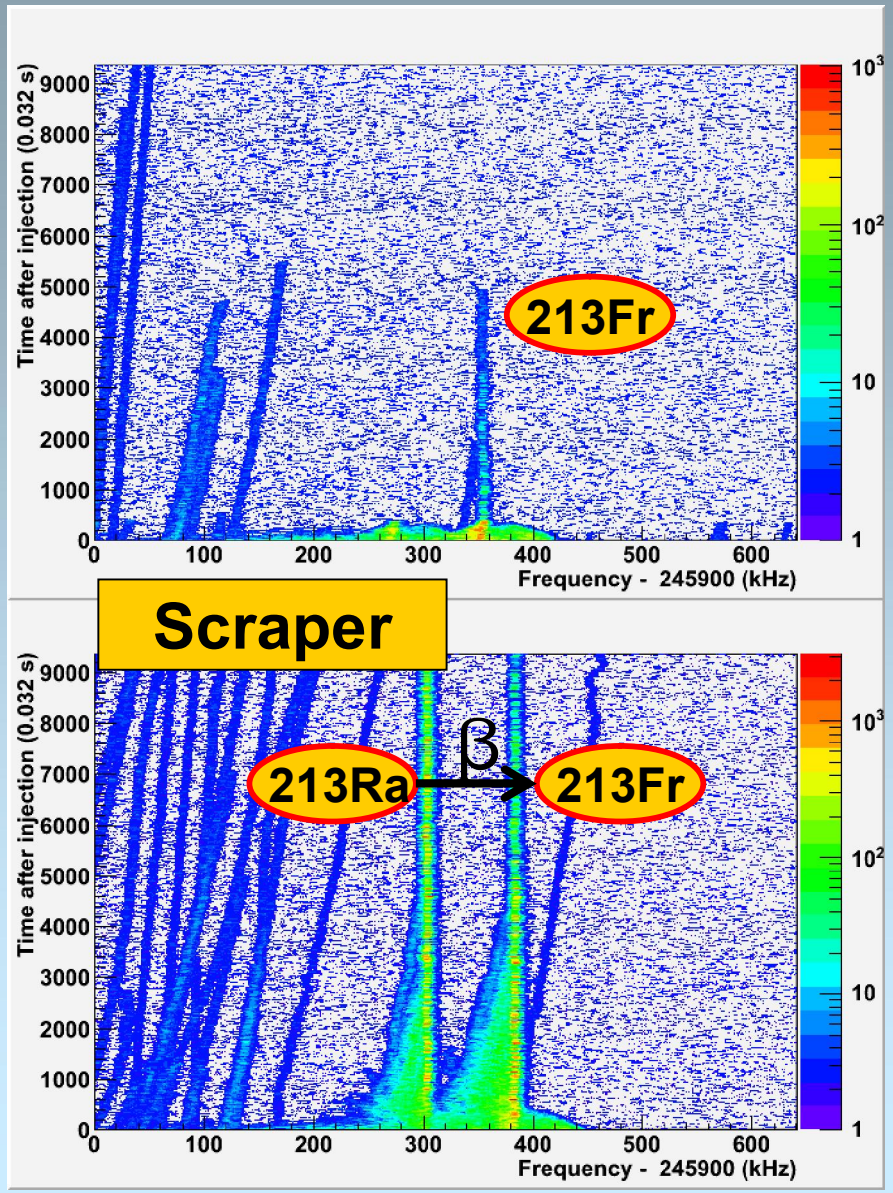
- energy signal from Si
- motor signal
- pulser for DT correction
- time from CPU-DAQ

Half-life measurements



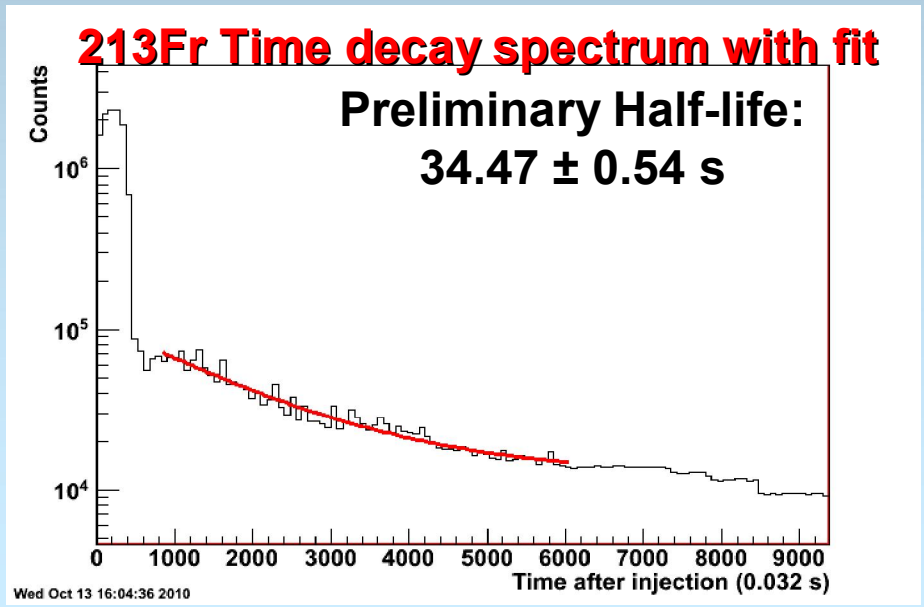


$^{213}Fr^{86+}$ alpha decay half-life at ESR (July 2010)



Primary beam: $^{238}U^{73+}$ at 450 MeV/u
5×10^8 pps
Target: Be 1022 mg cm^{-2}

$^{213}Fr^{86+}$ beam stored and cooled inside ESR



Comments

Summary E073

We have measured the half-life of neutral ^{213}Fr with the required precision to evidence any modification due to the electron screening effect.

We have preliminary but promising results from the test measurement at the ESR. Further analysis can provide useful information for the preparation of the experiment.

Beam time required in 2011:

18 shifts of ^{238}U at 400-600 MeV/u
intensity 10^9 pps

- *4 shifts*: FRS tuning for ^{213}Fr
- *14 shifts*: **Schottky** measurements in the ESR.