

Shell evolution in the newly explored neutron-rich region around $Z=82$ and far beyond $N=126$: experimental details



G.Benzoni and R.Nicolini
INFN sezione di Milano and
Universita' degli studi di Milano



Menu:

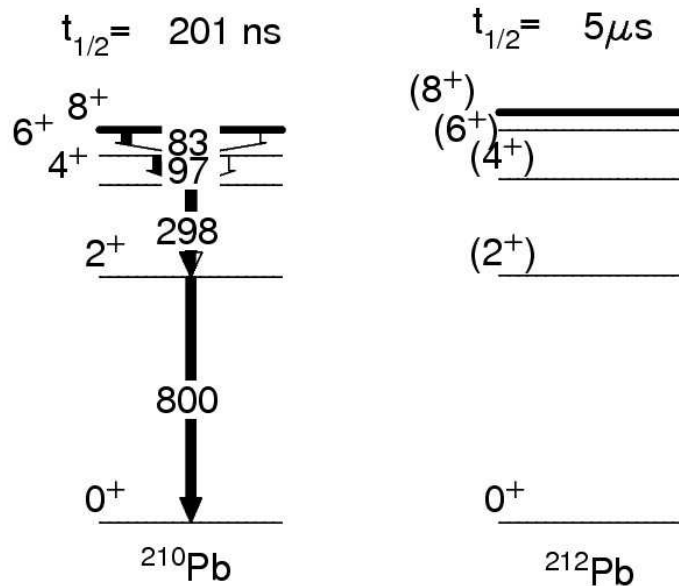
- aim of experiment
- experimental details
- digging useful information
- preliminary results on Pb isotopes

To be continued A.Gottardo:

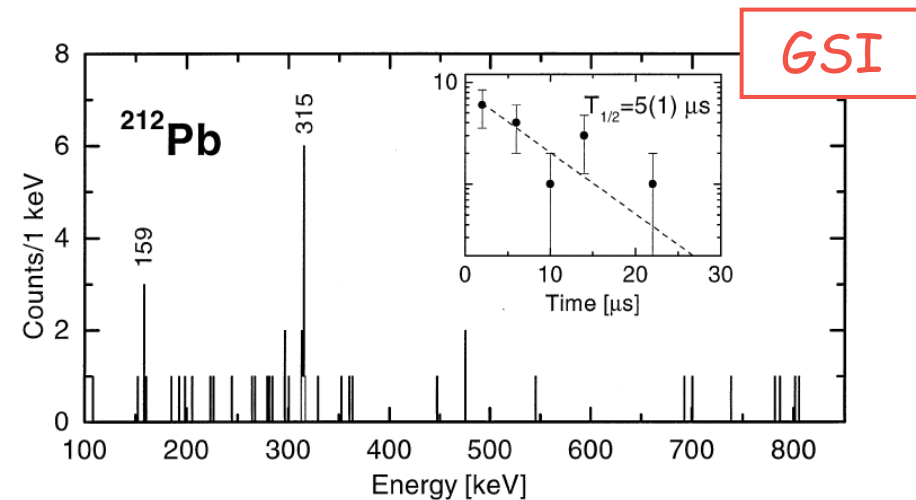
- results on Pb isotopes, gamma energies and lifetimes
- shell model calculations
- comparison

Search for exotic Pb isotopes "east of ^{208}Pb "

Need to test stability of shell structure in this region ($N=126$, $Z=82$)
 Indications of a weakening of $Z=82$ when approaching drip-line
 Drip-line is far away and not at all possible to approach



Neutron-rich lead
 isotopes known up to ^{212}Pb



- 5×10^6 pps
- 2 HPGe detectors ($\text{Eff}_\gamma = 1\%$)
- 350 ions implanted

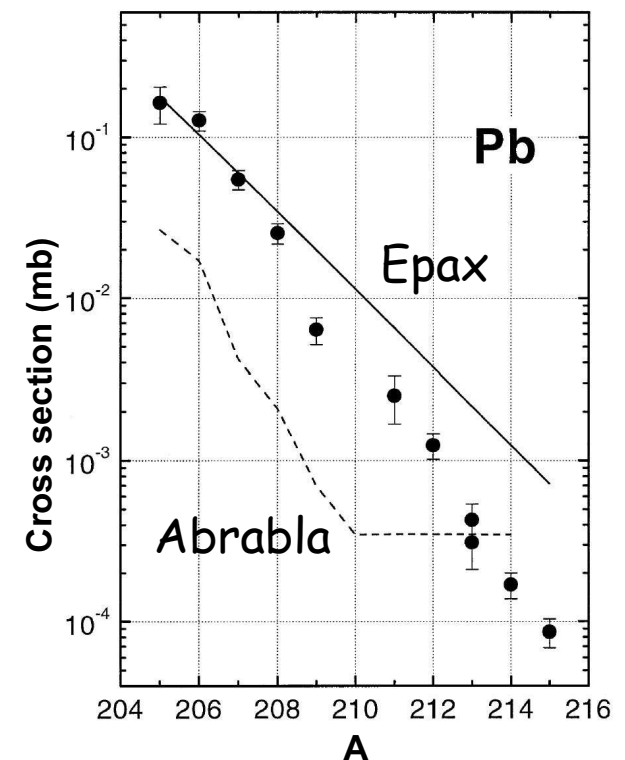
M. Pfutzner PLB444 (1998) 32.

Experimental approach:

^{238}U fragmentation at 1 GeV/u allows to reach heavy Pb isotopes with **reasonable cross section** (^{212}Pb up to ^{220}Pb).

	<i>COFRA</i> (mb)	Ions/hour
^{212}Pb	9.05×10^{-4}	41.60×10^3
^{214}Pb	1.84×10^{-4}	9.30×10^3
^{216}Pb	3.01×10^{-5}	1.30×10^3
^{218}Pb	3.69×10^{-6}	1.80×10^2
^{220}Pb	3.17×10^{-7}	15.0

The **GSI UNILAC-SIS** accelerator system combined with the **FRS and RISING setup** provide a UNIQUE worldwide facility to populate and study the neutron-rich lead isotopes.



Experimental details:

Experiment performed at the end of September 2009

5 days data taking

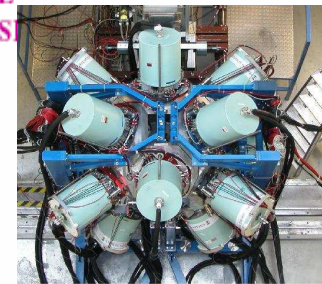
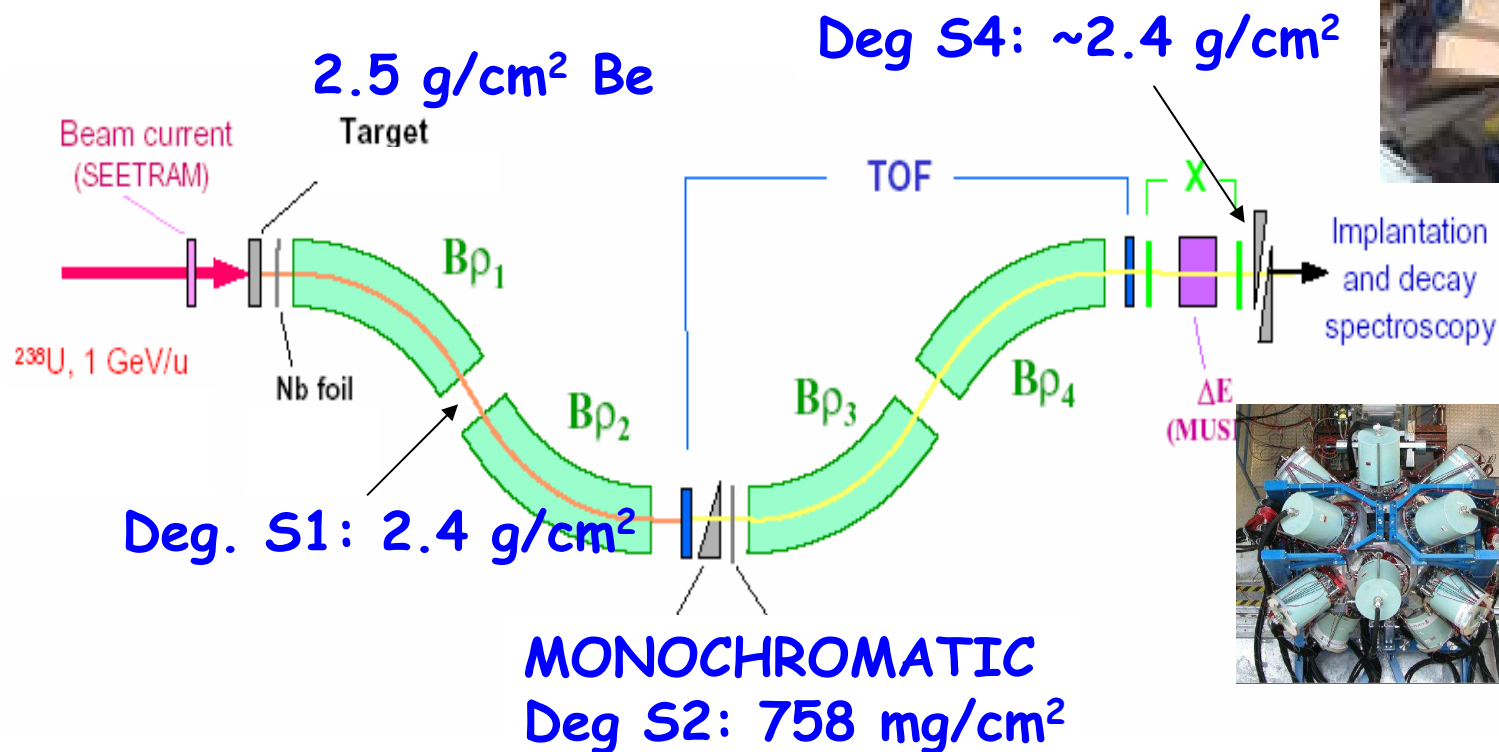
Beam current $1-2 \times 10^9$ pps

3 FRS settings:

^{205}Pb : ID confirmation

$^{215-217}\text{Pb}$: "production" settings:

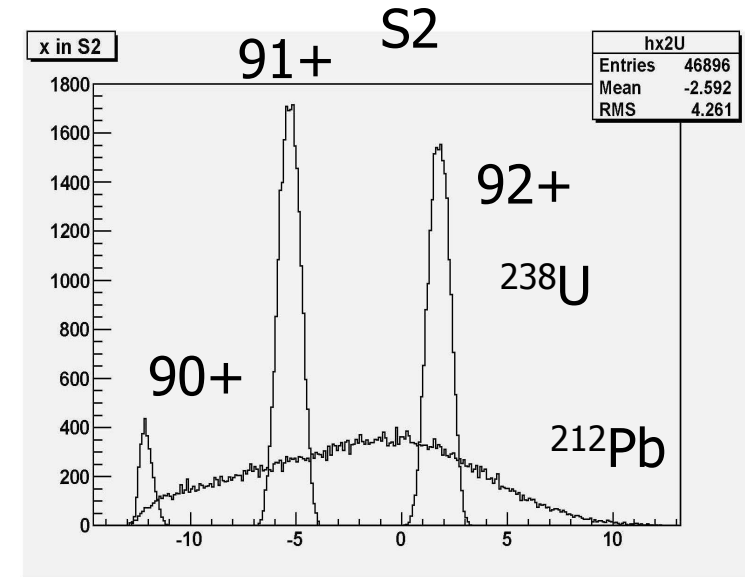
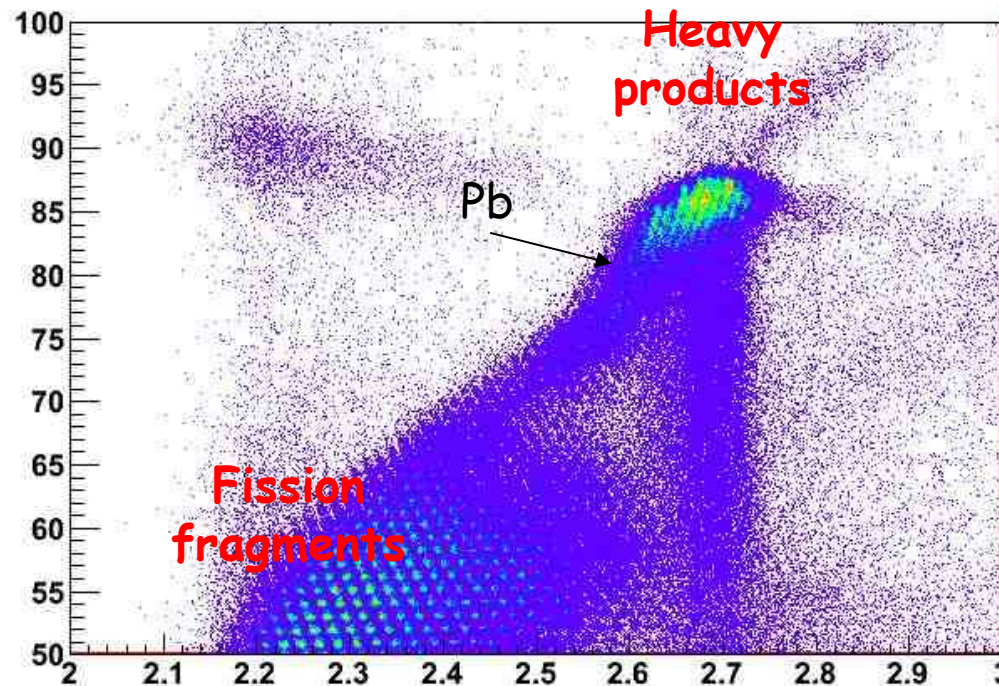
populated nuclei ranging from $^{212-218}\text{Pb}$



Experimental challenges:

Fission fragments+high Z products +
charge states of primary beam coming
through

$$(A/Q)^{212}\text{Pb} == (A/Q)^{238}\text{U} == 2.583$$

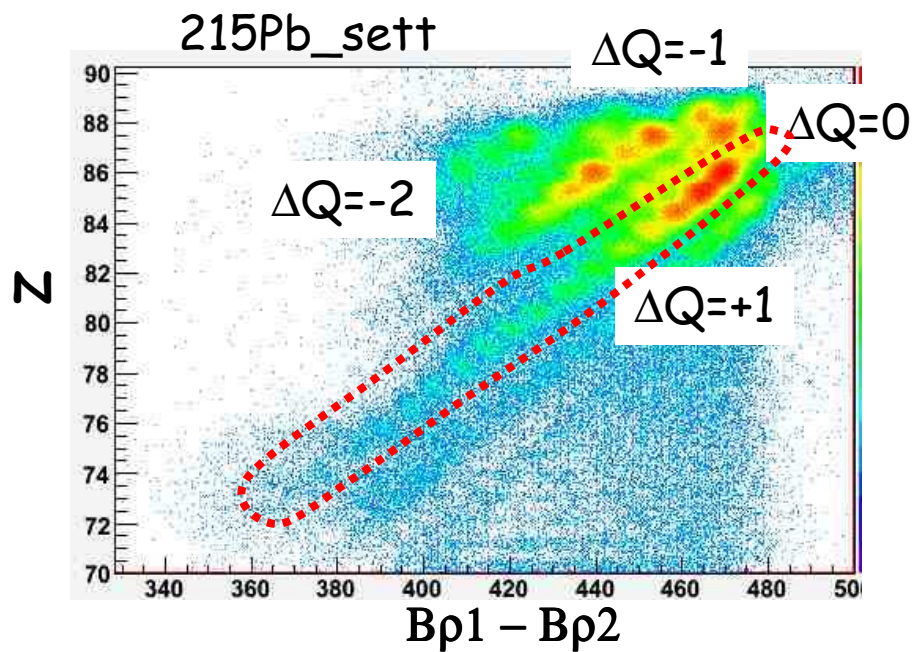


Formation of many charge states
owing to interactions with
materials

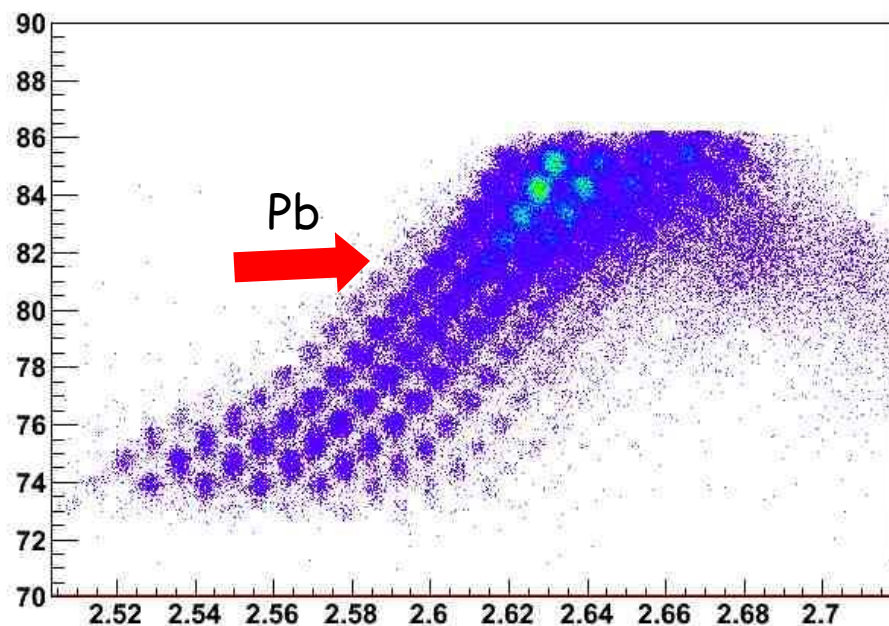
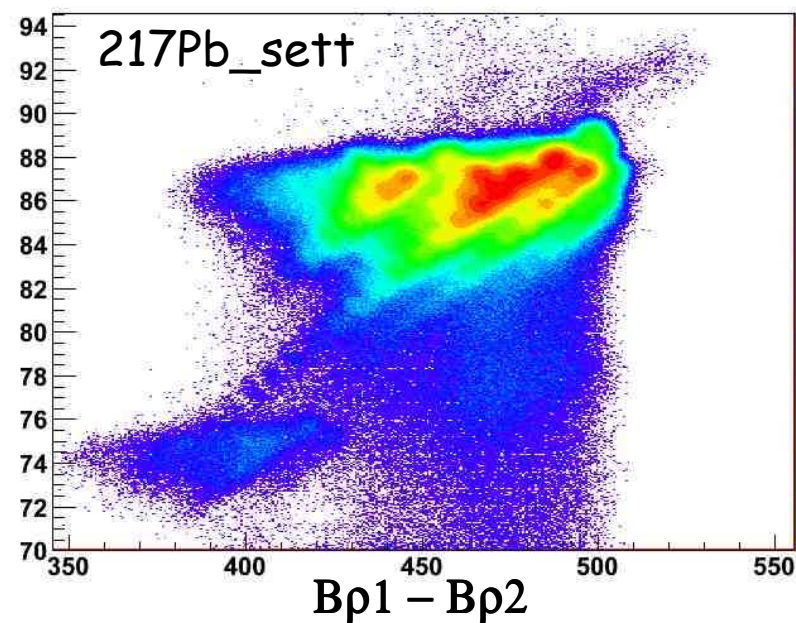
⌊ Isotope identification is
complicated

⌊ Need to disentangle nuclei
that change their charge state
after S2 deg.

$$(B\rho)_{\text{Ta-S2}} - (B\rho)_{\text{S2-S4}}$$

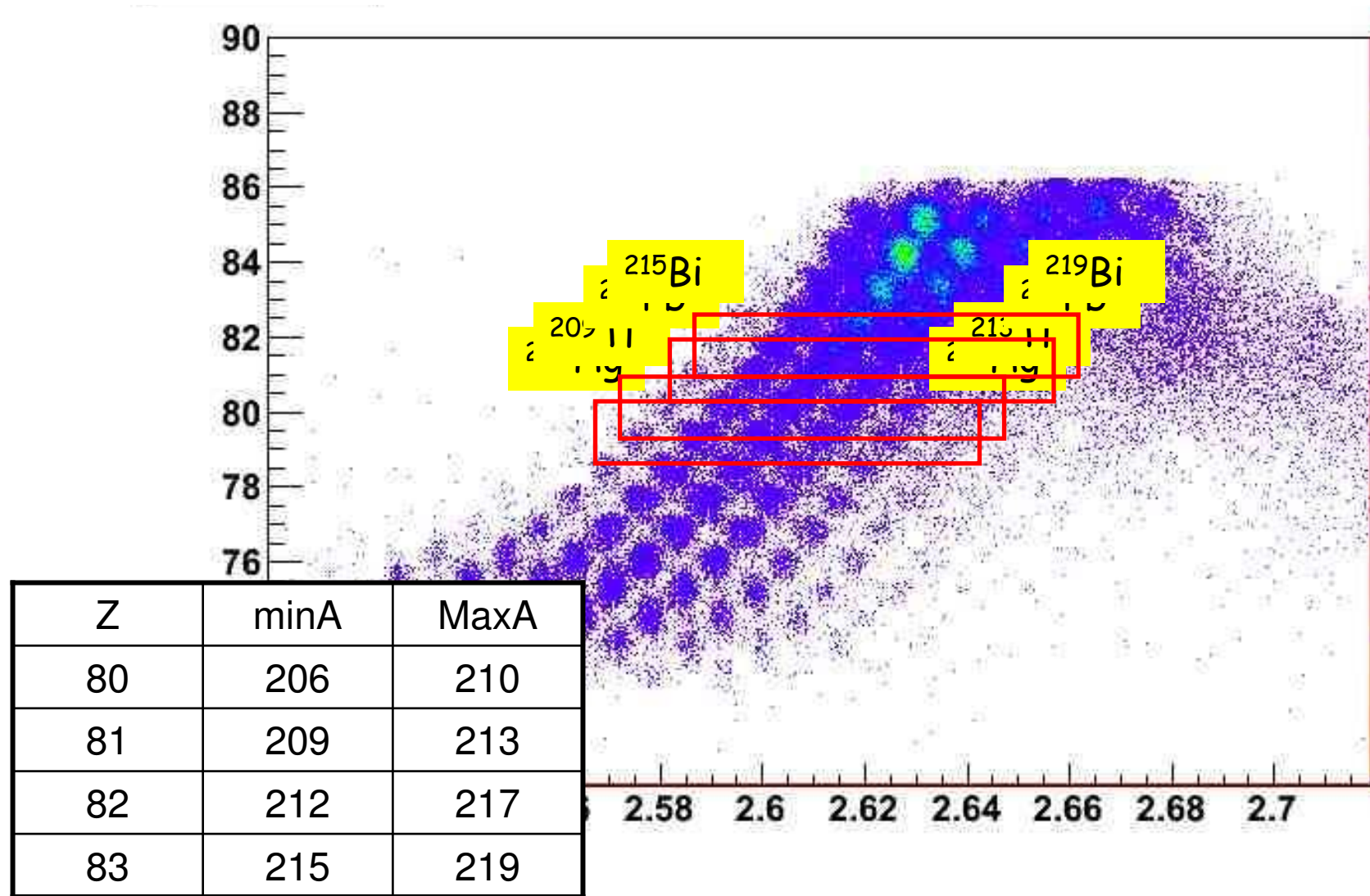


Application of charge
state selection



Clear ID plot, well resolved

Populated nuclei in ^{215}Pb setting with $\Delta Q=0$



^{212}Pb comparison btw us and M.Pfutzner...

narrower slits to cut primary beam and
heavier nuclei (increased beam intensity)
Higher γ efficiency ($\sim 12\%$)

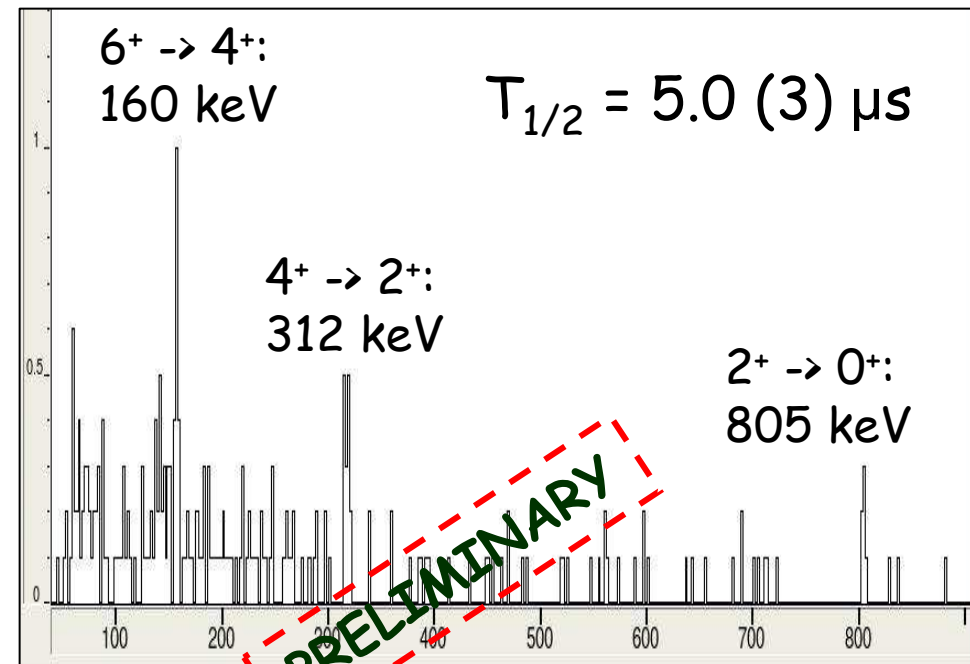
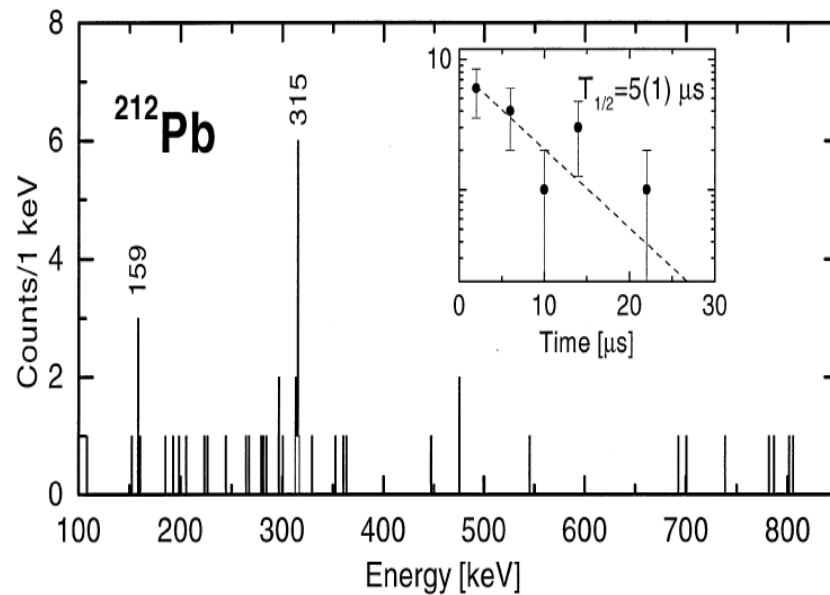
$t_{1/2} = 5\mu\text{s}$
 (8^+) _____
 (6^+) _____
 (4^+) _____

 (2^+) _____

Number of isotopes: 453

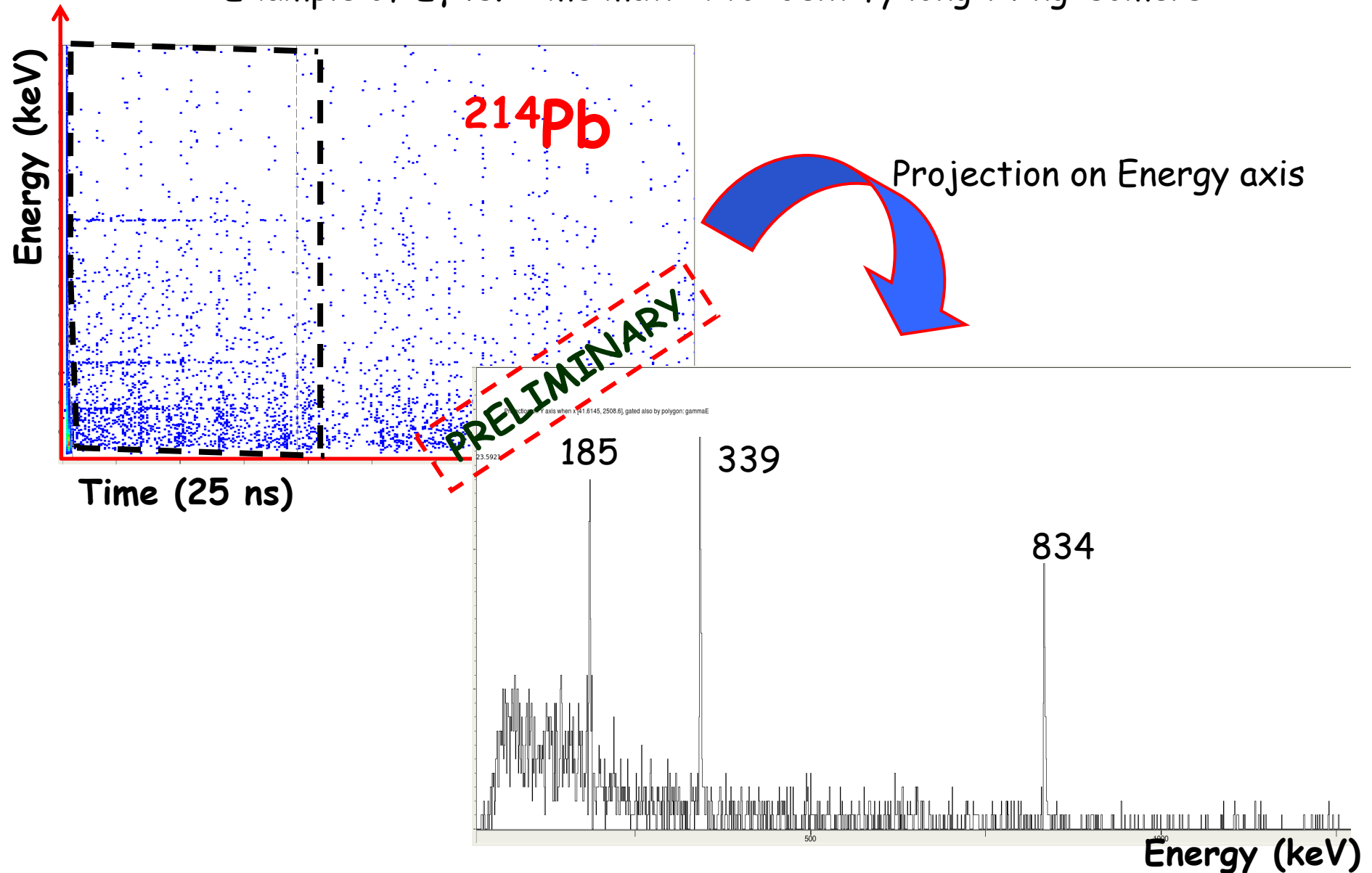
0^+ _____
 ^{212}Pb

Number of isotopes: 350



Isomers in μs range found in all measured Pb isotopes, $^{212-218}\text{Pb}$

Example of E_γ vs. Time matrix to identify long-living isomers



Still to do

- study other charge states
- study short/long living isomers with other TAC signals
- extract isomeric ratios
- study beta decay
- detailed study of isomers in species (Hg, Tl, Bi, Po)
- (suggestions ???)

Collaboration: ~70 people and 18 institutions

G. Benzoni, J.J. Valiente-Dobon, A. Gottardo, R. Nicolini.

A. Bracco, F.C.L. Crespi, F. Camera, A. Corsi, S. Leoni, B. Million, O. Wieland, G. de Angelis, D.R. Napoli, E. Sahin, S. Lunardi, R. Menegazzo, D. Mengoni, F. Recchia, P. Boutachkov, L. Cortes, C. Domingo-Prado, F. Farinon, H. Geissel, J. Gerl, N. Goel, M. Gorska, J. Grebosz, E. Gregor, T. Haberman, I. Kojouharov, N. Kurz, C. Nociforo, S. Pietri, A. Prochazka, W. Prokopowicz, H. Schaffner, A. Sharma, H. Weick, H.-J. Wollersheim, A.M. Bruce, A.M. Denis Bacelar, A. Algora, A. Gadea, M. Pfützner, Zs. Podolyak, N. Al-Dahan, N. Alkhomashi, M. Bowry, M. Bunce, A. Deo, G.F. Farrelly, M.W. Reed, P.H. Regan, T.P.D. Swan, P.M. Walker, K. Eppinger, S. Klupp, K. Steger, J. Alcantara Nunez, Y. Ayyad, J. Benlliure, E. Casarejos, R. Janik, B. Sitar, P. Strmen, I. Szarka, M. Doncel, S. Mandal, D. Siwal, F. Naqvi, T. Pissulla, D. Rudolph, R. Hoischen, P.R.P. Allegro, R.V. Ribas, Zs. Dombradi

- 1 Universita' degli Studi e INFN sezione di Milano, Milano, I;
- 2 INFN-LNL, Legnaro (Pd), I;
- 3 Universita' di Padova e INFN sezione di Padova, Padova, I;
- 4 University of the West of Scotland, Paisley, UK;
- 5 GSI, Darmstadt, D;
- 6 Univ. Of Brighton, Brighton, UK;
- 7 IFIC, Valencia, E;
- 8 University of Warsaw, Warsaw, Pl;
- 9 University of Surrey, Guildford, UK;
- 10 TU Munich, Munich, D;
- 11 University of Santiago de Compostela, Santiago de Compostela, E;
- 12 Comenius University, Bratislava, Sk;
- 13 Univ. Of Salamanca, Salamanca, E;
- 14 Univ. of Delhi, Delhi, IND;
- 15 IKP Koeln, Koeln, D;
- 16 Lund University, Lund, S;
- 17 Univ. Of Sao Paulo, Sao Paulo, Br;
- 18 ATOMKI, Debrecen, H.