



Present and future of JURO-spectroscopy at JYFL



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University of Jyväskylä (JYFL)
Finland
on behalf of the JUROGAM collaboration



JURO history

1996 DORIS - 0.8 %
12 TESSA units

1997 JUROSPHERE - 1.7 %
15 EUROGAM Phase 1 + 10 TESSA units

2003 JUROGAM - 4.2 %
43 EUROGAM Phase 1 + GASP units

2008 JUROGAM II - 6.1 %
15 EUROGAM Phase 1 + 24 EUROBALL Clover units

combined with RITU

140 peer reviewed articles
-including 16 letters
- 60 since 2005

nature LETTERS

**Nuclear isomers in superheavy elements as
stepping stones towards the island of stability**

for JUROGAM II (since 2009)

- 46 annealing processes

- 24 FET changes

- 31 PA/HV repairs

- 4 (to be) sent to the factory

repair course given by

Ivan Hietter (Canberra)



NuPECC Long Range plan 2010

- 2000-3000 hours per year for JURO experiments
- large variety of stable-ion beams
- ENSAR - Access Laboratory
- Centre of Excellence in Finland → 2017
- UK investments in instrumentation



Accelerator laboratory JYFL,
University of Jyväskylä, Finland



Electron accelerator ELSA, University
of Bonn, Germany



European Centre for Theoretical
Studies in Nuclear Physics and
Related Areas, ECT*, Trento, Italy



Forschungszentrum Jülich, FZJ
(COSY and HPC), Jülich, Germany



Institut de Physique
Nucléaire, IPNO, Orsay, France



Grand Accélérateur National d'Ions
Lourds, GANIL (SPIRAL), Caen, France



Helmholtzzentrum für
Schwerionenforschung
GmbH, GSI, Darmstadt,
Germany



European Organisation for
Nuclear Research, CERN
(ALICE, AD, COMPASS
and ISOLDE),
Genève, Switzerland



Kernfysisch Versneller
Instituut, KVI, Groningen,
The Netherlands



Laboratori Nazionali
del Sud of INFN, LNS,
Catania, Italy



Laboratori Nazionali
di Frascati of INFN, LNF,
Frascati, Italy



Laboratori Nazionali
di Legnaro of INFN,
LNL, Legnaro (Padova), Italy



Mainzer Mikrotron, MAMI,
University of Mainz,
Germany

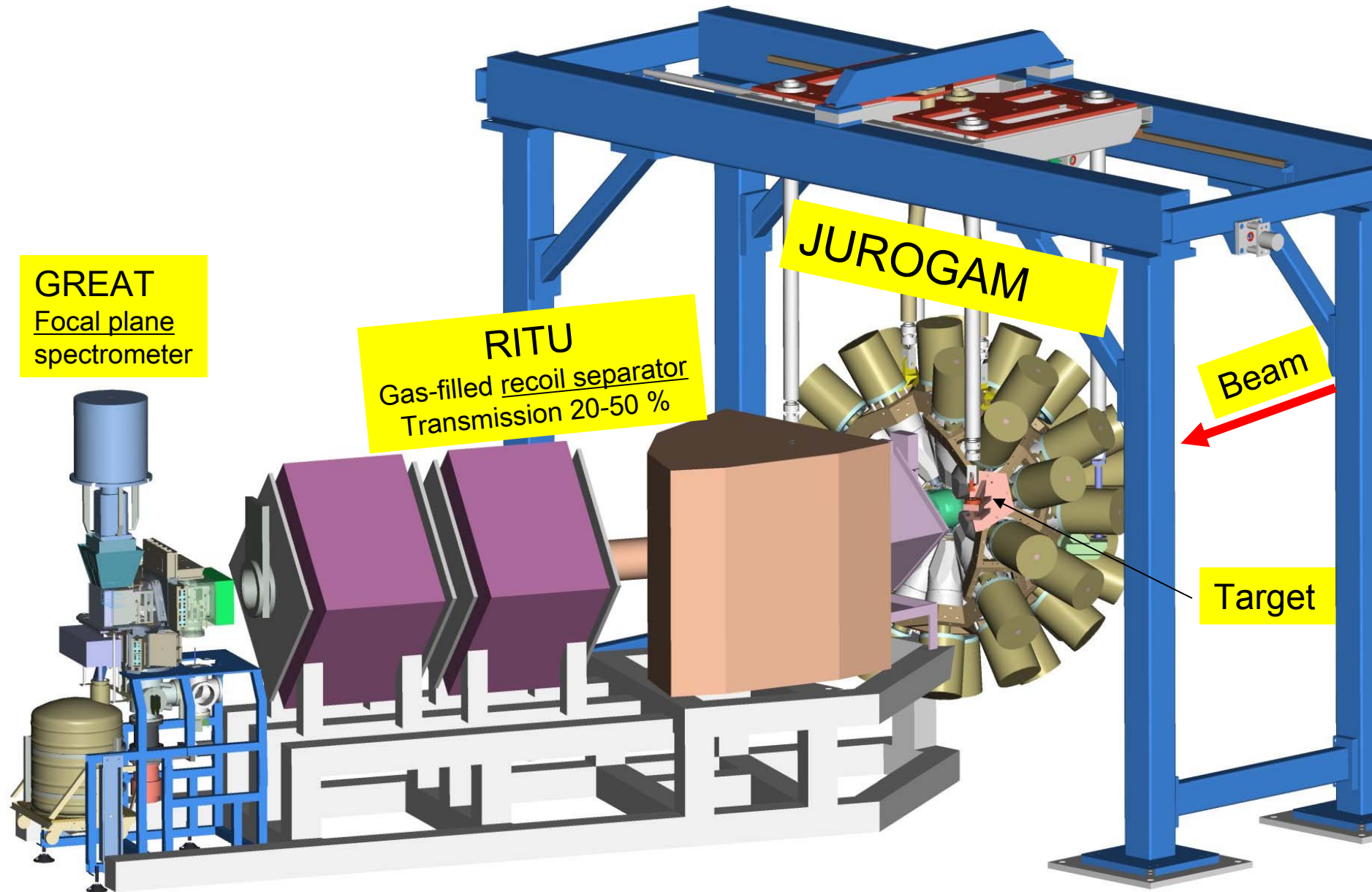
Max-lab, University of
Lund, Sweden

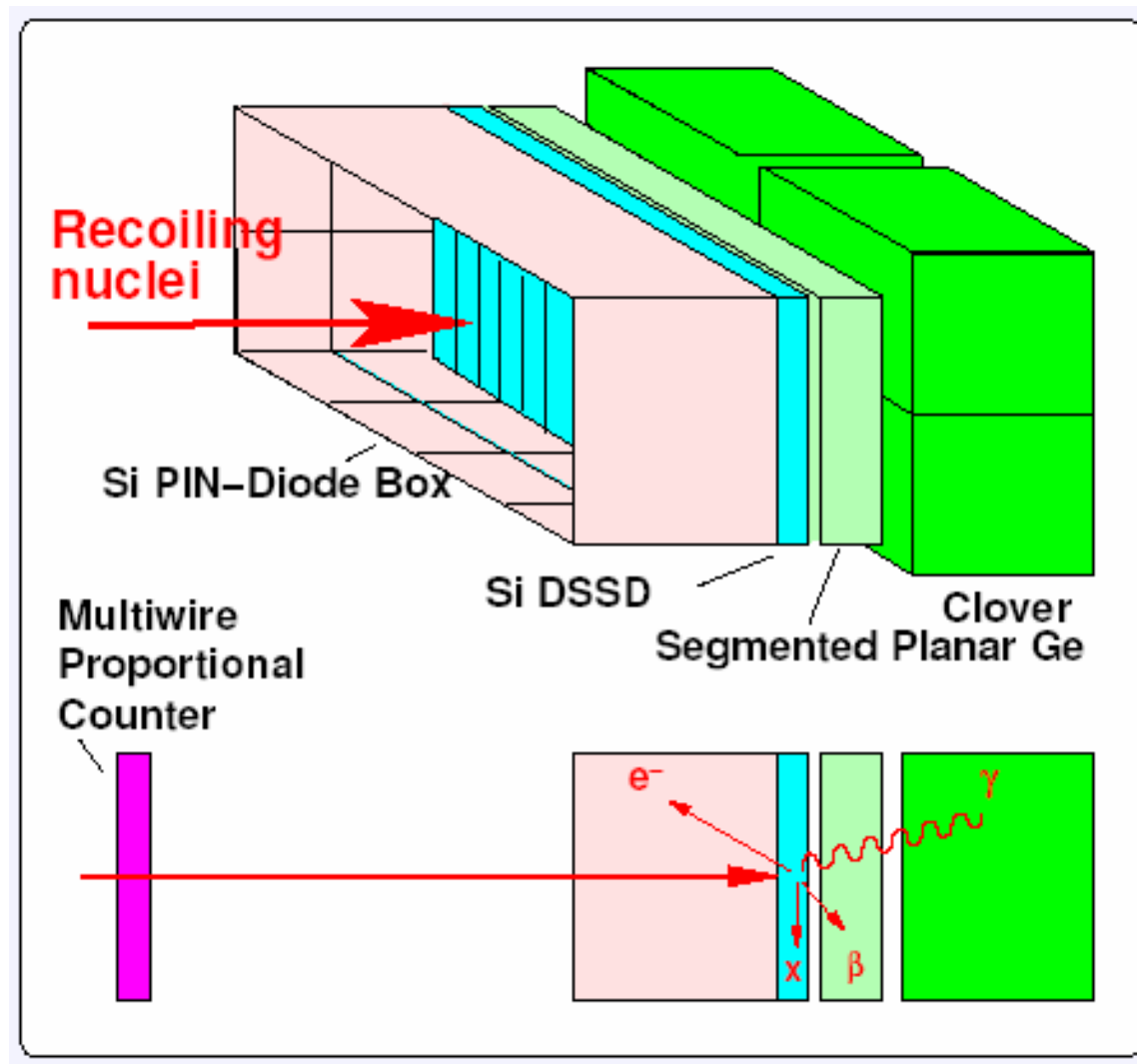
NuPECC member countries

FP7 facilities

Smaller-scale facilities

Recoil-Decay-Tagging (RDT) at JYFL





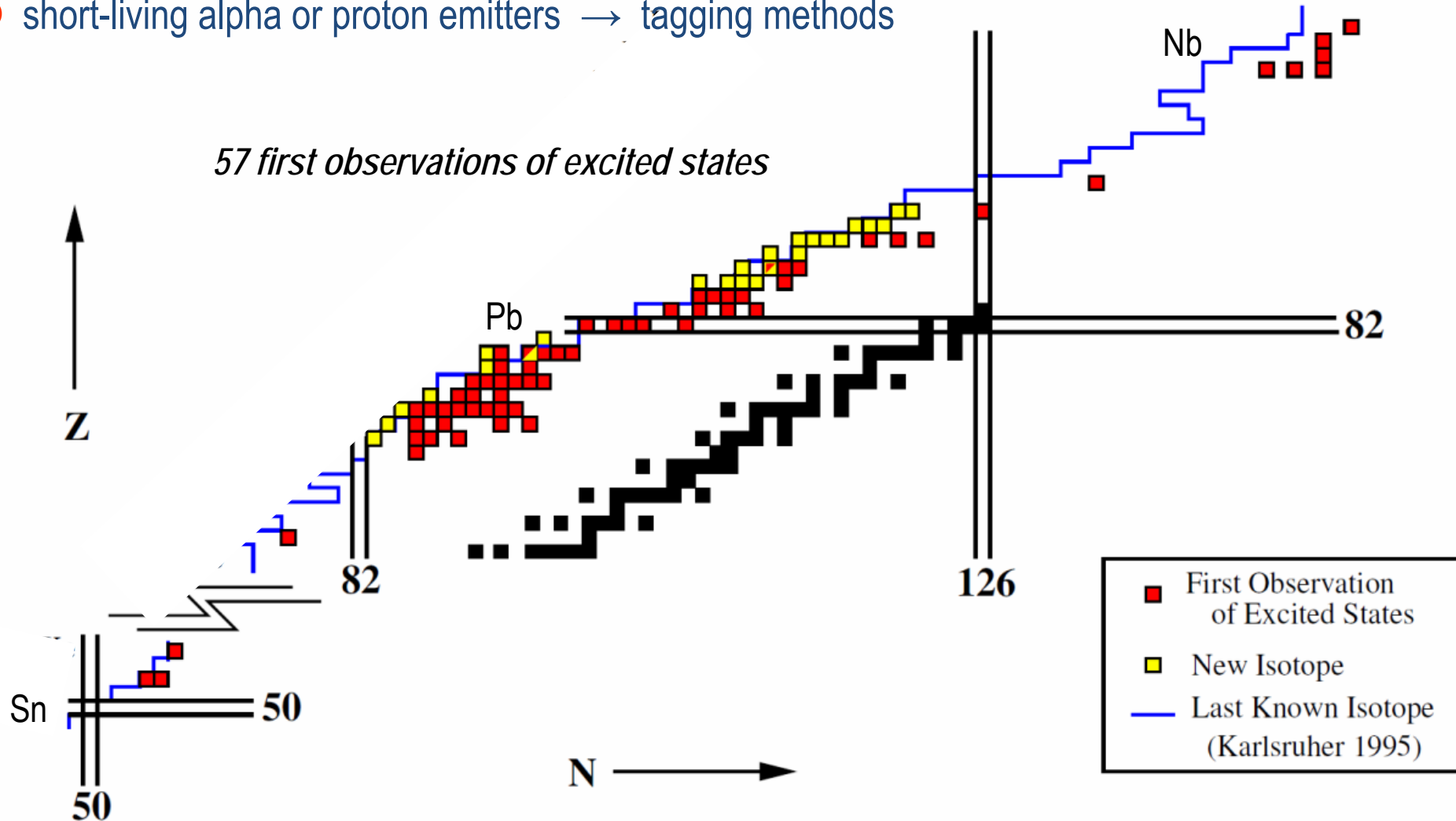
- 10 ns stamping with a 100 MHz clock
- 250 Lyrtech digital channels
- free running mode
- enables to correlate prompt and delayed events
- event reconstruction and analysis software package GRAIN



*UK – JYFL investment
Daresbury design*

very neutron deficient heavy and SHE nuclei

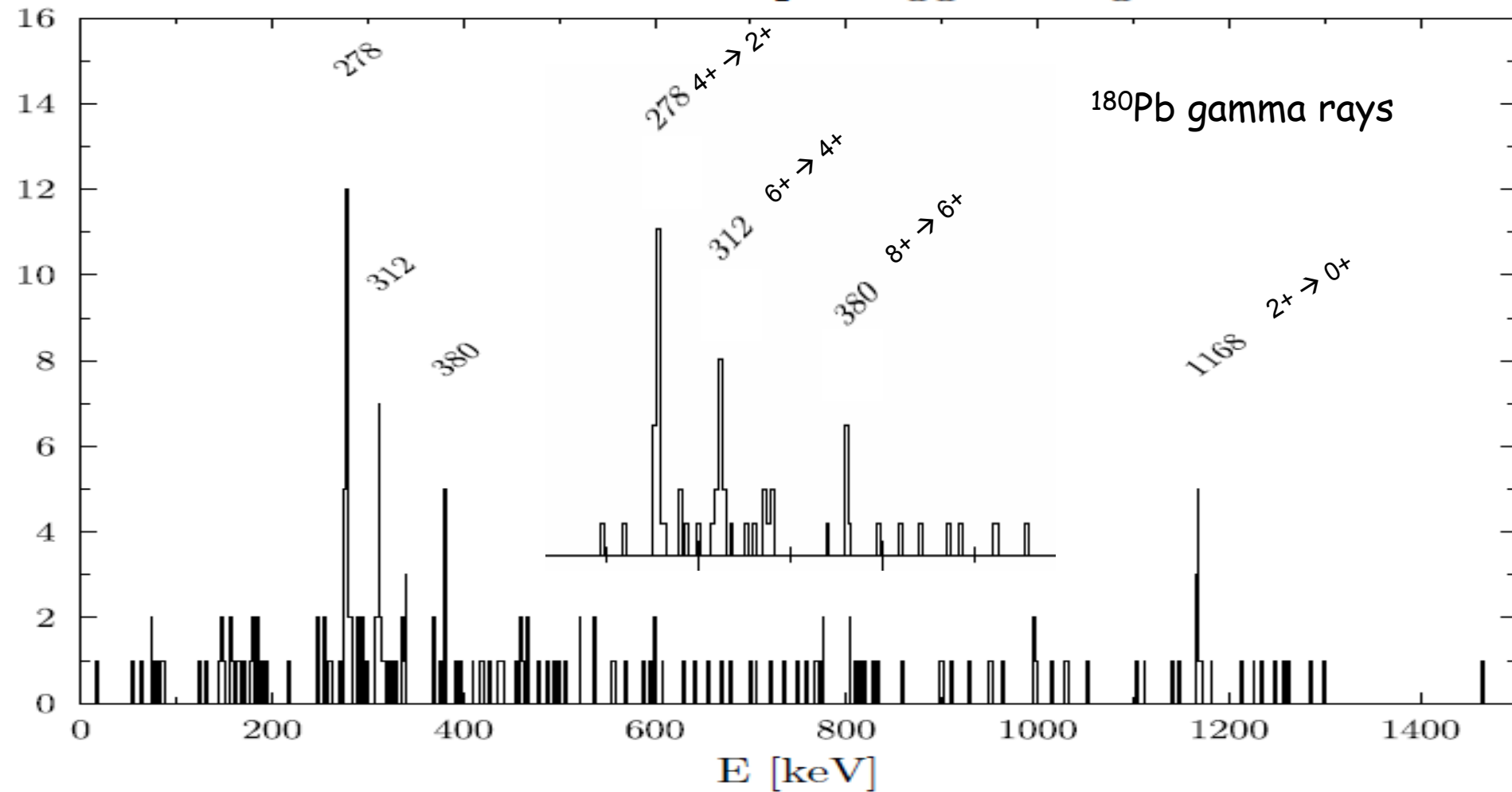
- ☺ can be produced via fusion evaporation with stable-ion beams and stable targets
- ☹ cross-sections down to 1 nb
- ☺ short-living alpha or proton emitters → tagging methods



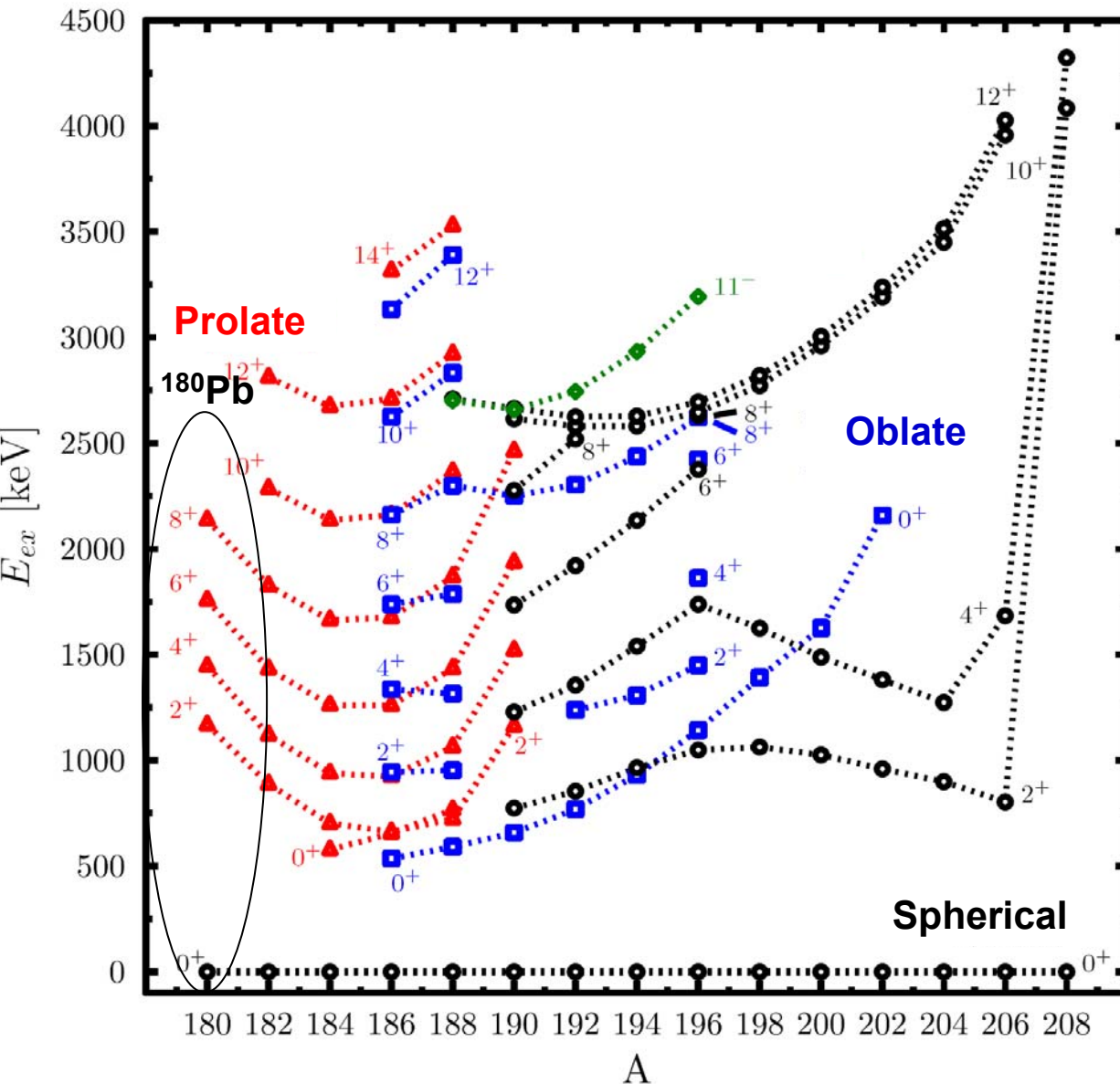
						83		Bi 208.98038 σ 0.034		Bi 184 13 ms \longleftrightarrow 6.6 ms α 7.194... γ 124; α 7.220; 7.445... γ 449		Bi 185 60 μ s ? p 1.598 α 8.030	
82		Pb 207.2 σ 0.172		Pb 180 4 ms α 7.22		Pb 181 45 ms α 7.065		Pb 182 55 ms α 6.921		Pb 183 415 ms 535 ms α 6.698; 6.860 γ (61...); e^- α 6.775; 6.570 γ 217 β^+ ?		Pb 184 0.55 s α 6.63	
TI 177 0.23 ms 18 ms p 1.958 α 7.487 $\alpha \rightarrow m$ α 6.907 $\alpha \rightarrow g$ p 1.156		TI 178 255 ms α 6.704; 6.785; 6.616... β^+ ?		TI 179 1.7 ms 0.27 s α 7.201 $\alpha \rightarrow m$ α 6.568 $\alpha \rightarrow g$		TI 180 1.5 s α 6.281; 6.362; 6.208...		TI 181 1.4 ms 3.2 s hy ? α 6.578 α 6.186		TI 182 3.1 s β^+ α 6.40 γ 351; 261; 333; 414...		TI 183 60 ms 6.9 s hy ? α 6.343...	
Hg 176 21 ms α 6.740 β^+ ?		Hg 177 0.17 s α 6.58		Hg 178 0.26 s α 6.43		Hg 179 1.09 s α 6.288 βp		Hg 180 2.56 s ϵ α 6.120; 5.689... γ 301; 381...		Hg 181 3.6 s ϵ α 6.005; 5.934... γ 148; 43; 1987... βp ; $\beta \alpha$		Hg 182 10.8 s ϵ α 5.865... γ 129; 217; 413...	

Recoil Decay Tagging with ^{180}Pb and ^{176}Hg alpha decays

 $^{92}\text{Mo}(^{90}\text{Zr}, 2n)^{180}\text{Pb}$ - 10 nanobarn - WR

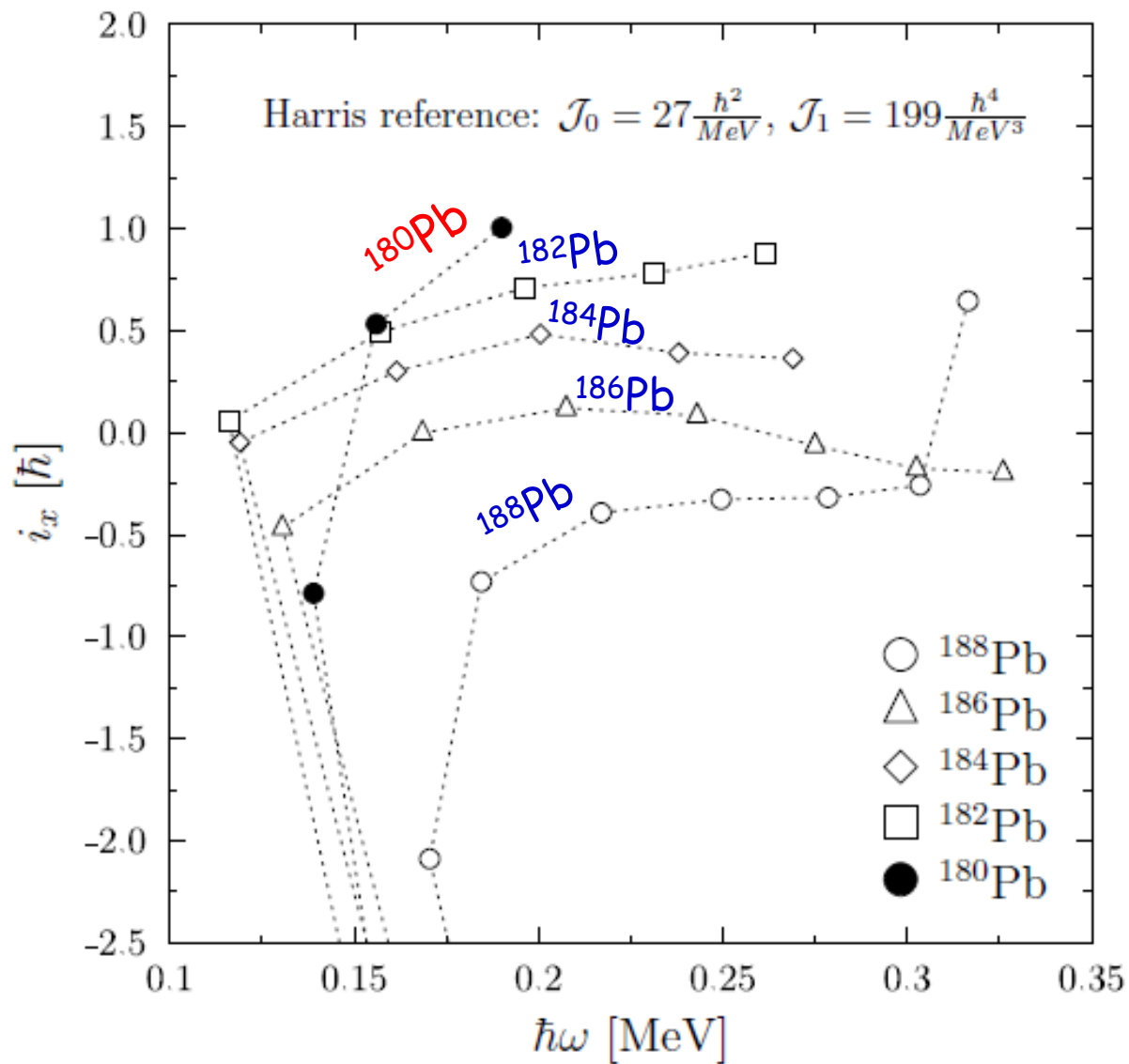
 ^{180}Pb $\alpha\alpha$ +escape-tagged singles


Level systematics of even-A Pb nuclei



in ^{180}Pb still
a prolate minimum
at about 1 MeV above
the spherical one

Obs !
 $S(p) = 930 (50) \text{ keV}$,
 $S(2p) = 200 (25) \text{ keV}$



Alignments:

^{180}Pb behaves
like ^{188}Pb

→

???

Reminder:

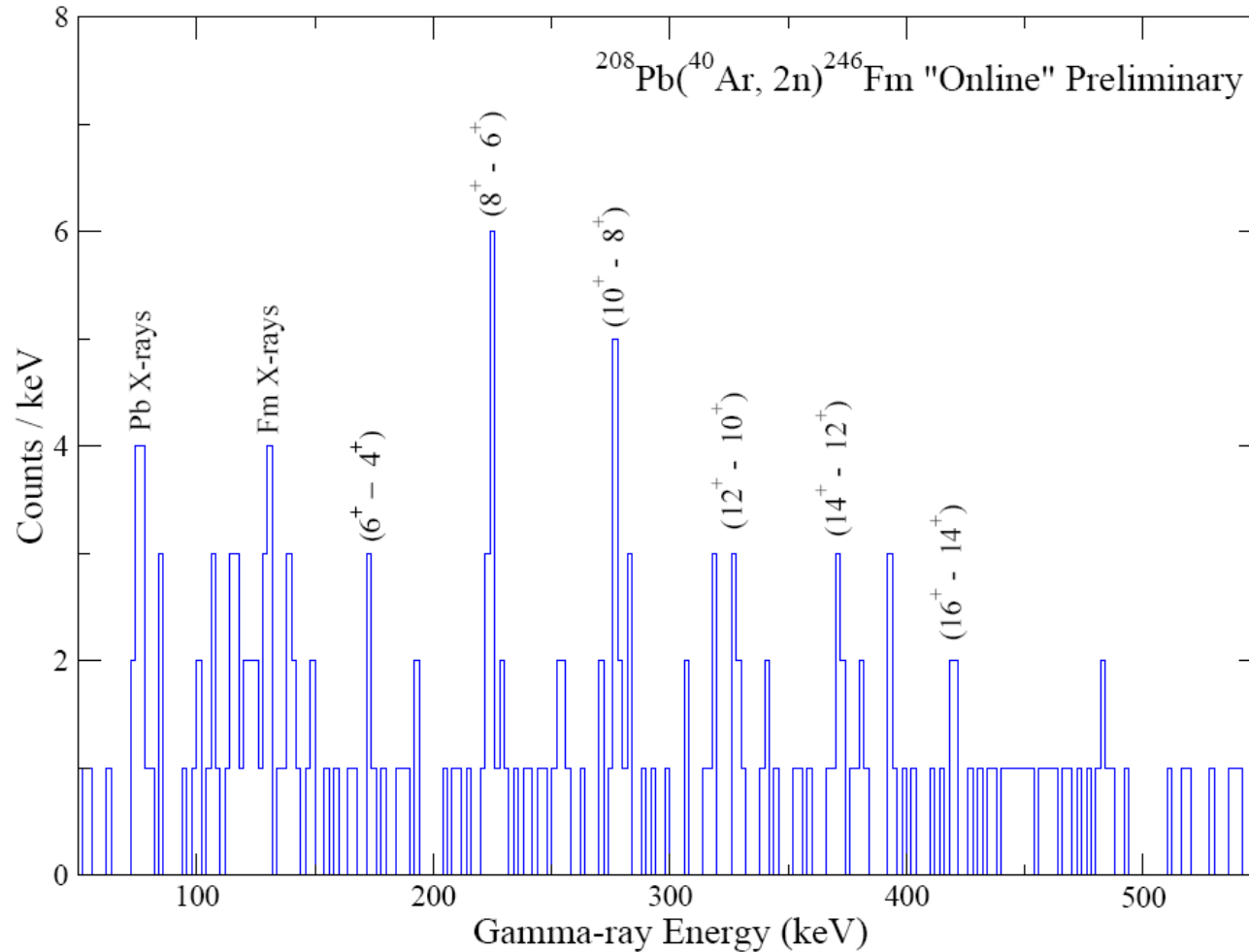
in-beam gamma-ray experiment

→ 10 pA on a 0,5 mg/cm² target

10 nanobarn

→ 1 reactions per hour !!

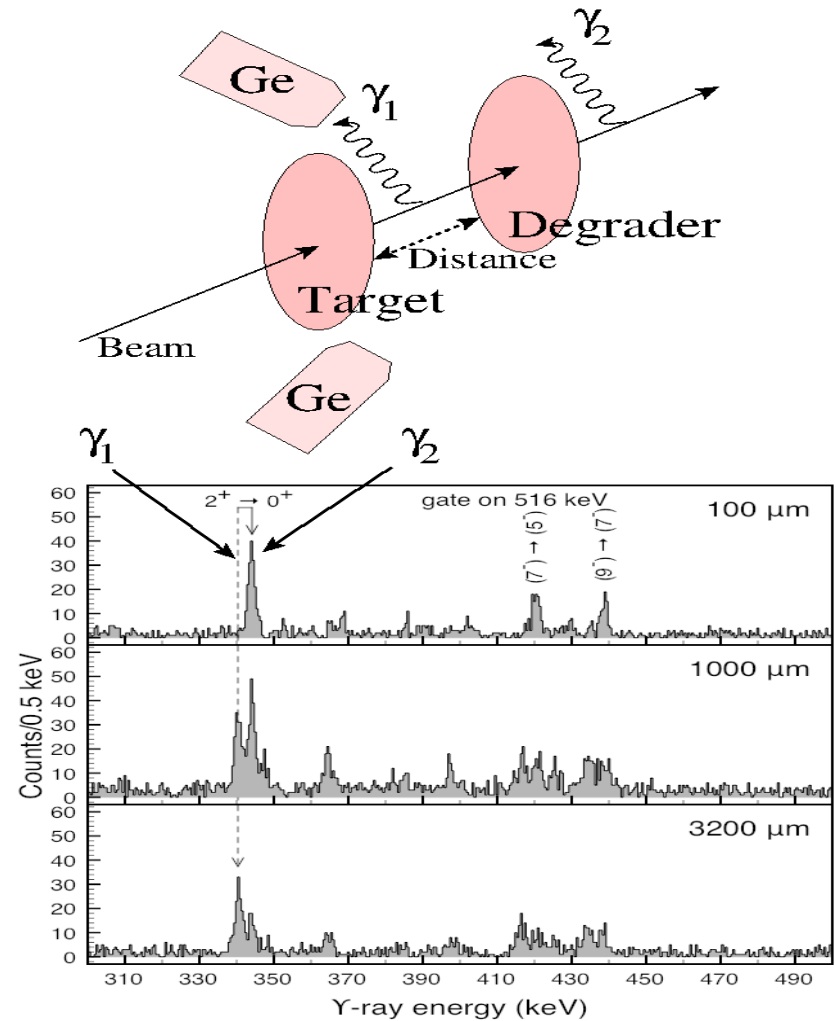
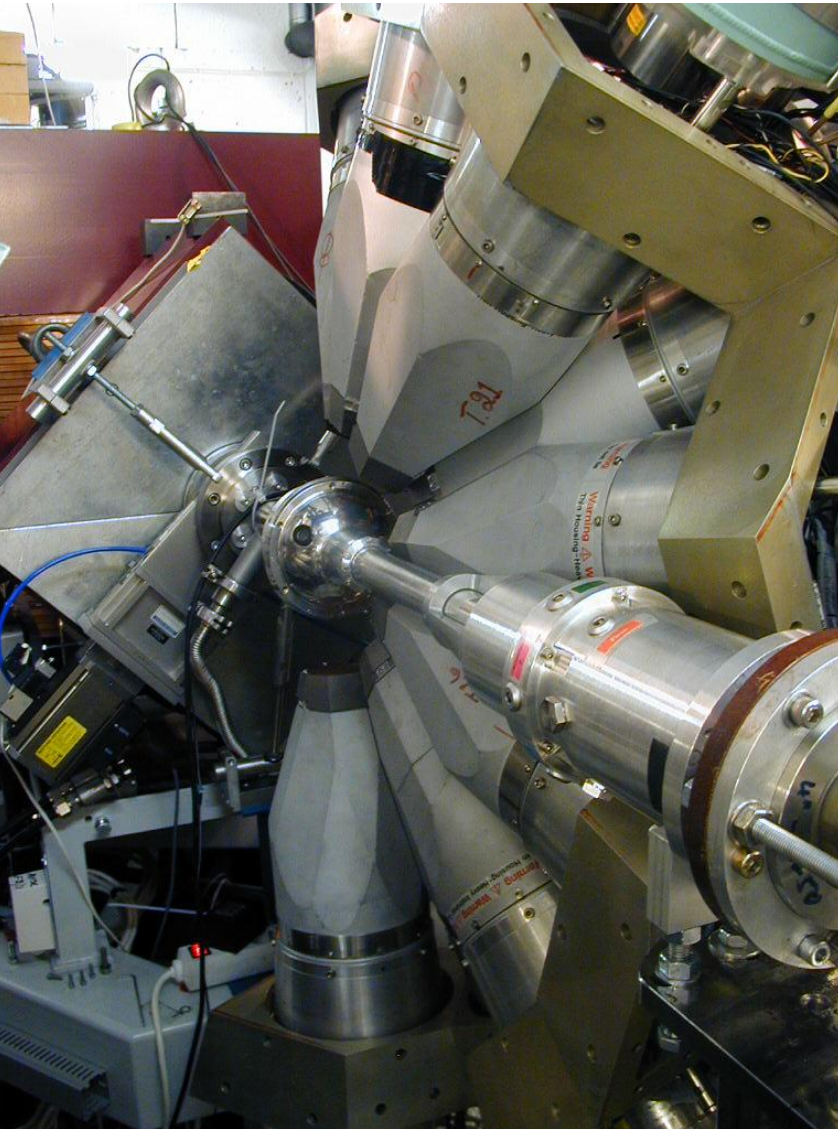
40 pA – 35 kHz per Ge detector – digital electronics
→ 15 nanobarn in SHE studies



more in Steffen Ketelhut's talk

RDT-Plunger-lifetime measurements

plunger inside JUROGAM at RITU



- RDT enables very clean spectra
- more in Tuomas Grahn's talk
- new plunger DPUNS (D. Cullen et al.)

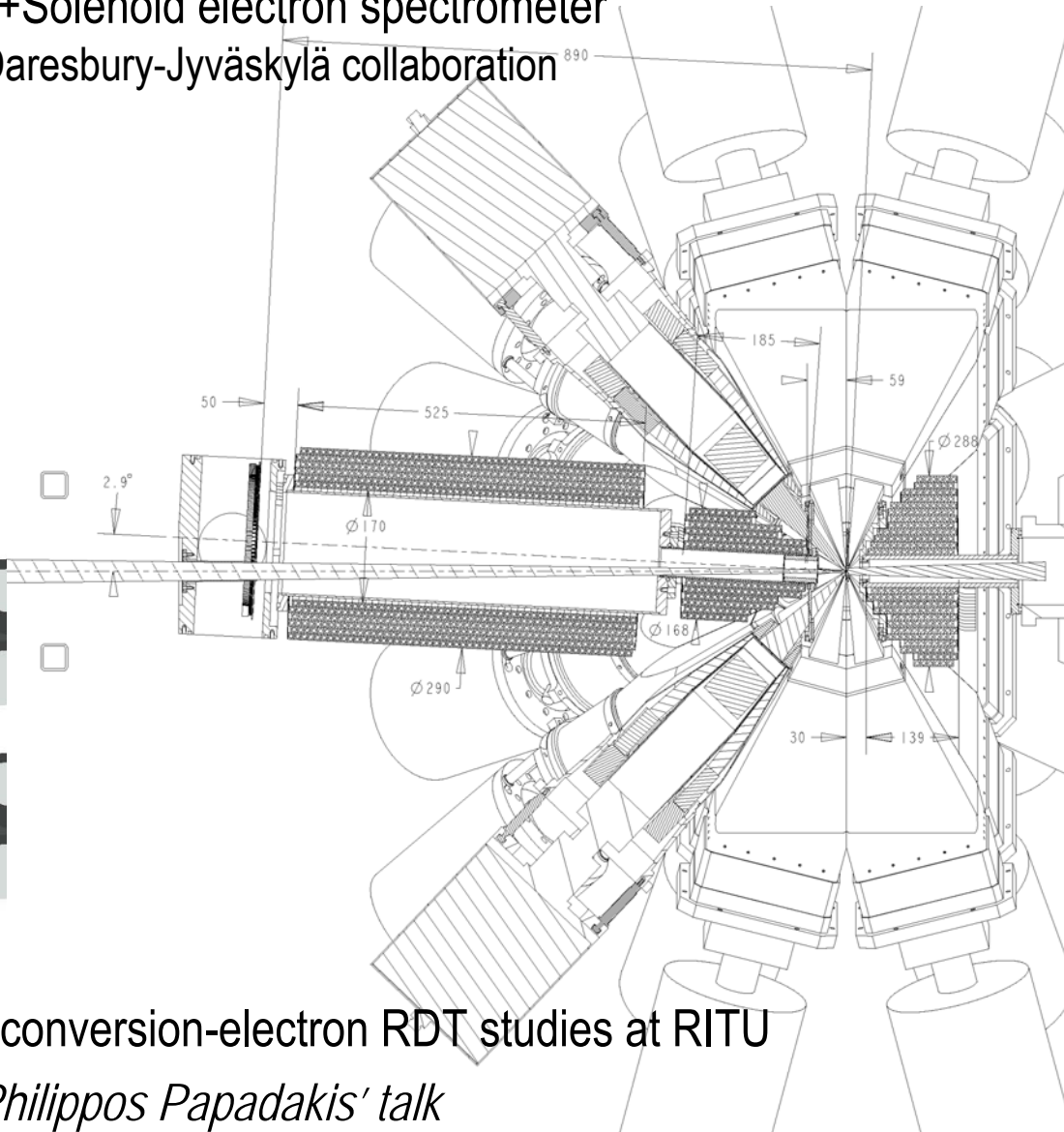
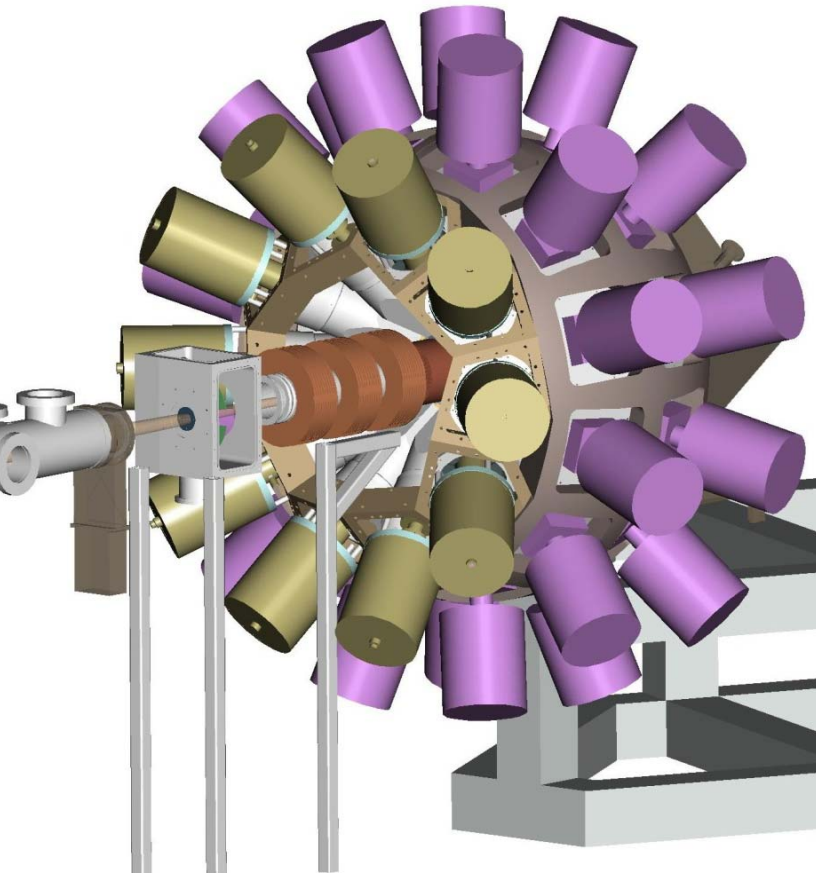
JURO proposals

24 pending JURO-proposals (230 days)

Expt. No	Title	Spokeperson(s)	Days Remaining (S) = Scheduled				
				JR112	Oblate-prolate shape competition and isomeric states in ^{185}Tl	P.Nieminen G.J.Lane	7
JR98	Decay study of ^{113}Ba	T. Bäck	14	R46	Alpha-decay study of the proton unbound $^{211-213}\text{Pa}$	J.Uusitalo	14
R45	Pushing nuclear structure studies to the extremes for the proton drip line around A=70	D. Jenkins	4 (S)	S08	Simultaneous conversion-electron and gamma-ray spectroscopy using SAGE; an in-beam study of ^{253}No	R.-D. Herzberg	10
JR103	Magnetic rotation and shape co-existence in ^{144}Dy	D. Cullen	7			M.Sandzelius	
JR104	Proof-of-principle of double-beta tagging	D. Jenkins A. Obertelli	7 (S3)	S09	Complete spectroscopy of the transfermium nucleus ^{255}Lr	K.Hauschild A.Lopez-Martens	4
JR106	Neutron single-particle orbitals and resultant shapes in neutron-deficient A=173 nuclei	D. O'Donnell C. Scholey	12 (S)	S10	Spectroscopy of the odd-proton $^{249,251}\text{Md}$	Ch.Theisen	11
JR107	Configurations and competing structures in $^{195,194}\text{Bi}$	P. Nieminen	8	L02	Using the (p,p'gamma) reaction to investigate low-spin states in ^{154}Gd	L. Bianco	5
JR108	In-beam gamma-ray spectroscopy of N=Z+3 ^{111}Xe	B. Hadinia	14				
L01	Decay spectroscopy of ^{159}Re using LISA and GREAT	R. Page	14	L03	Search for fast alpha decays in ^{218}Th and ^{216}Ra	T. Grahn D. O'Donnell	7
S06	Exploring nuclear shapes in the transitional region of N~90: Coulomb excitation of $^{152,154}\text{Sm}$ to study E0 transitions with SAGE	P. Davies	3	JR113	DPUNS Commissioning: Investigation into the low-energy yrast structure of ^{98}Ru via lifetime measurements	M. J. Taylor	5
S07	Probing E0 transitions in ^{188}Pb using the SAGE spectrometer	J. Pakarinen	7	JR114	DPUNS: Lifetime measurements of proton-unbound states in ^{151}Lu ; proton emission from a spherical or deformed system?	D. M. Cullen	14
JR109	Search for non-collective transitions in ^{166}Os	T.Grahn D.O'Donnell	10	JR115	Shape co-existence in odd-A isotopes: In-beam spectroscopy of $^{177,179}\text{Au}$	D. T. Joss M. Venhart	10
JR110	Prompt and delayed spectroscopy of ^{199}At and ^{201}At	U.Jakobsson J.Uusitalo	10	R47	Isomeric and decay spectroscopy of ^{179}Pb	C. Scholey P. Ruotsalainen	14
JR111	In-beam gamma-ray spectroscopy of heavy elements: ^{256}Rf	P.T.Greenlees B.Gall R.-D.Herzberg Ch.Theisen	21 (17S)				
						TOTAL	232 - (S) 36

SAGE

JUROGAM2+Solenoid electron spectrometer
Liverpool-Daresbury-Jyvaskylä collaboration



simultaneous gamma- and conversion-electron RDT studies at RITU

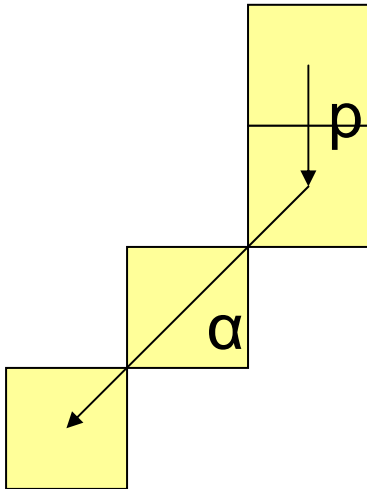
more in Philippos Papadakis' talk

LISA

detector array for detection
of prompt light ions at RITU and MARA

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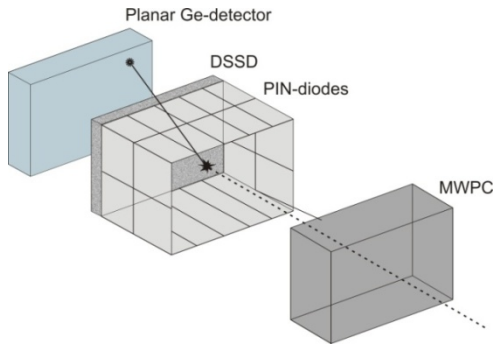
tagging of very fast proton emitters



Liverpool-Daresbury
investment

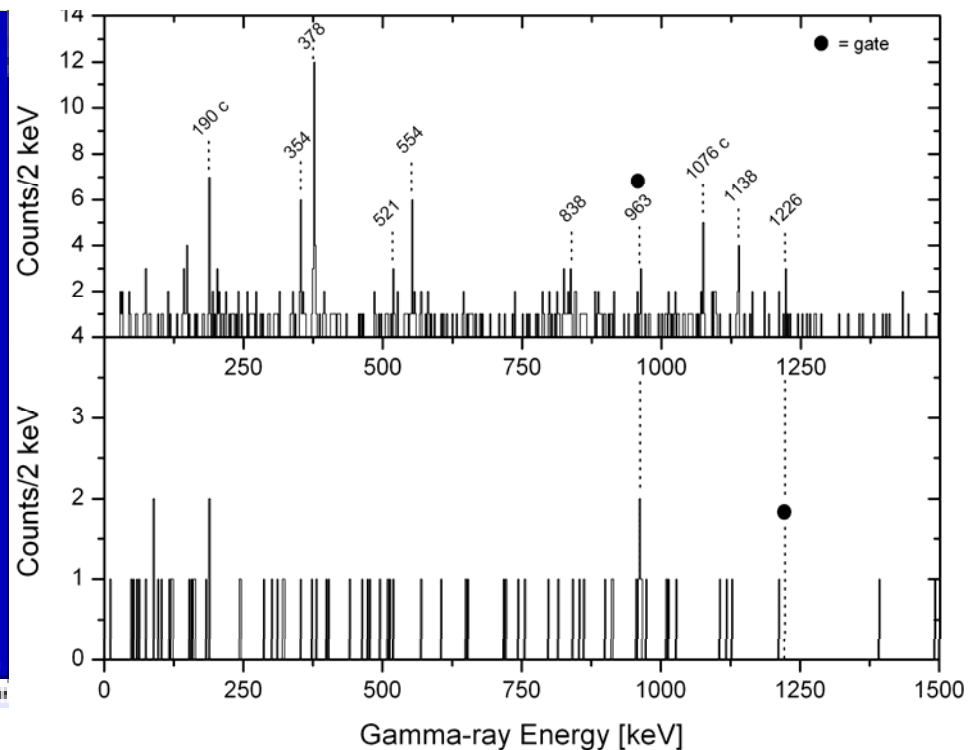
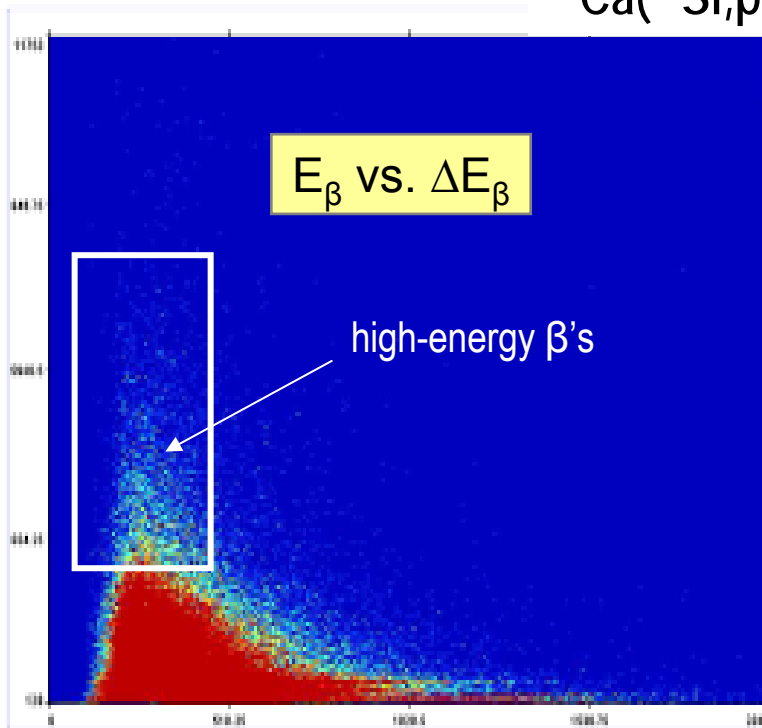
Recoil – β – Tagging for $N = Z$ nuclei

York contribution



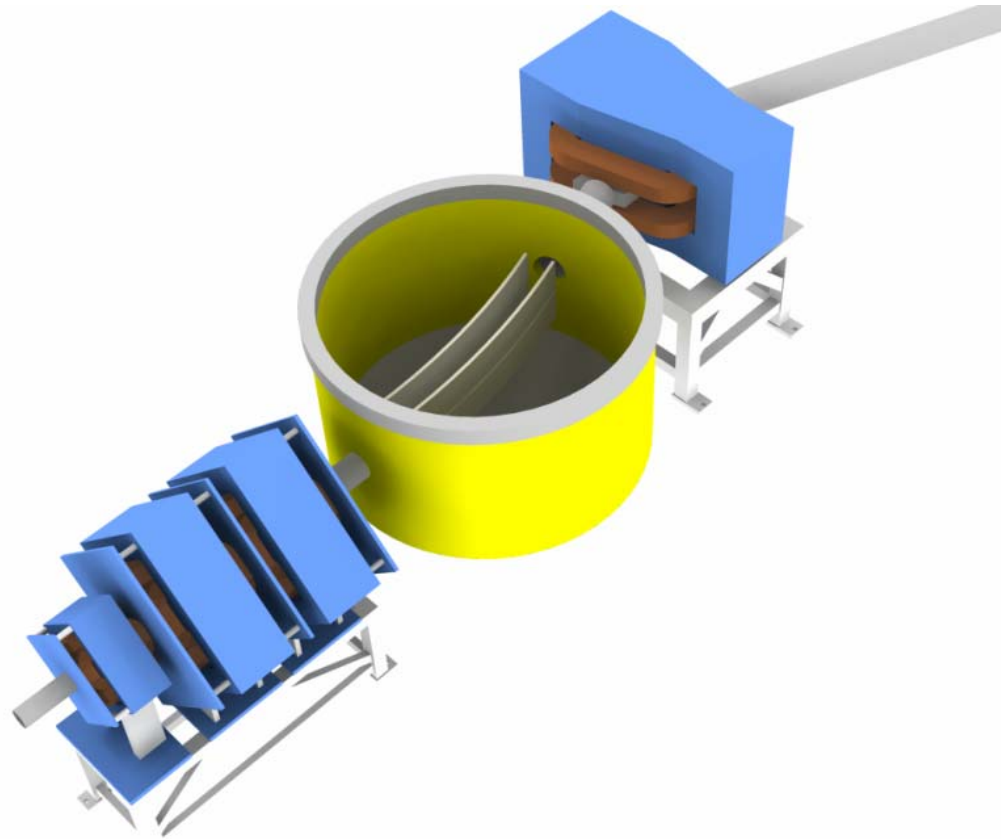
access to excited state structure of $N=Z$
superalloyed β –emitters
 $T = 1$ and $T = 0$ states

$^{40}\text{Ca}(^{28}\text{Si}, p n) ^{66}\text{As}$ $Z=N=33$



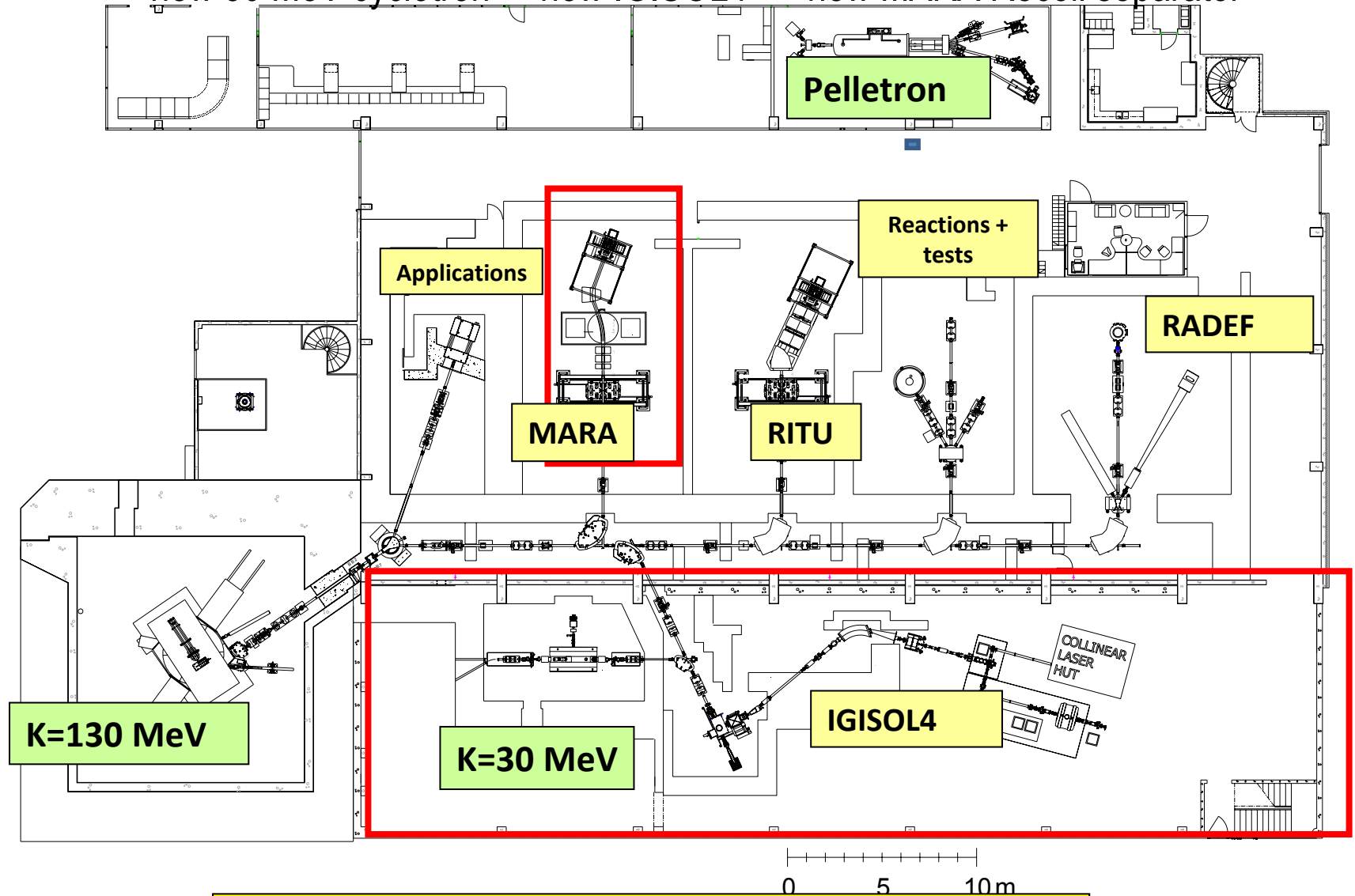
new instrumentation

MARA (vacuum) recoil separator from 2012
for extending tagging measurements towards
lighter neutron deficient nuclei



more beam time

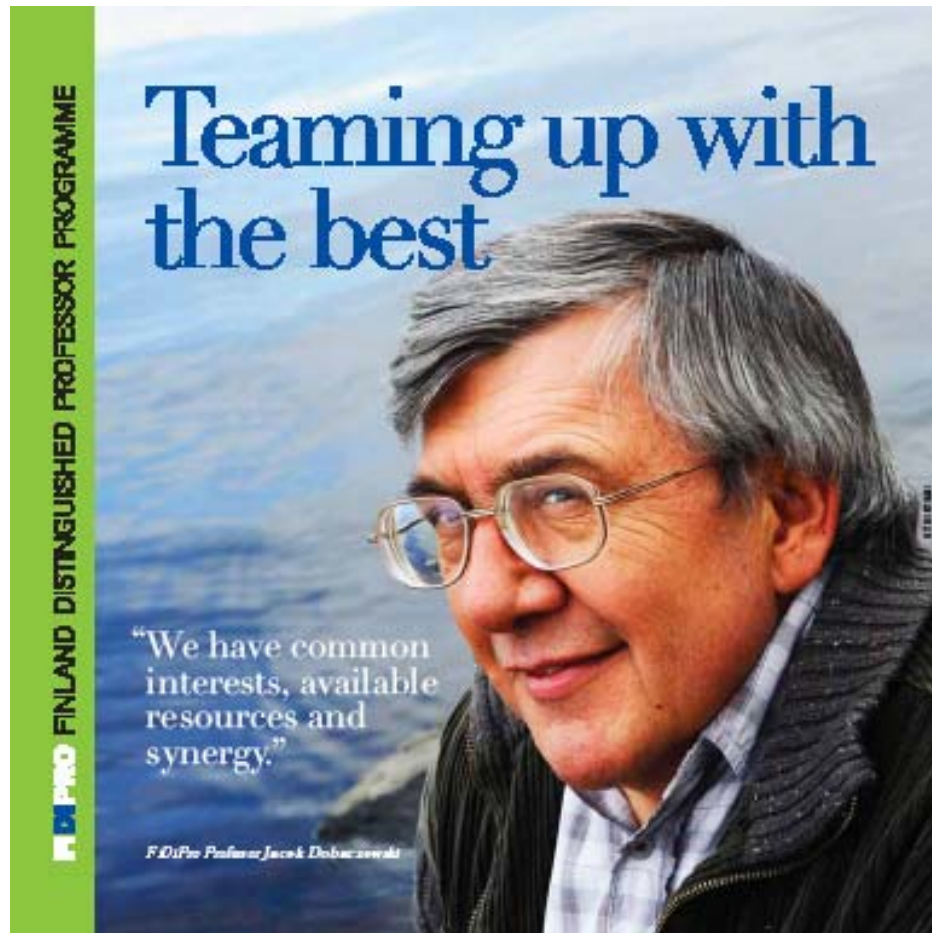
upgrade of the JYFL Accelerator Laboratory
new 30 MeV cyclotron - new IGISOL4 - new MARA Recoil separator



→ more beam time for difficult experiments and testing

FiDiPro team of Jacek Dobaczewski

EuTINP





Thank you!