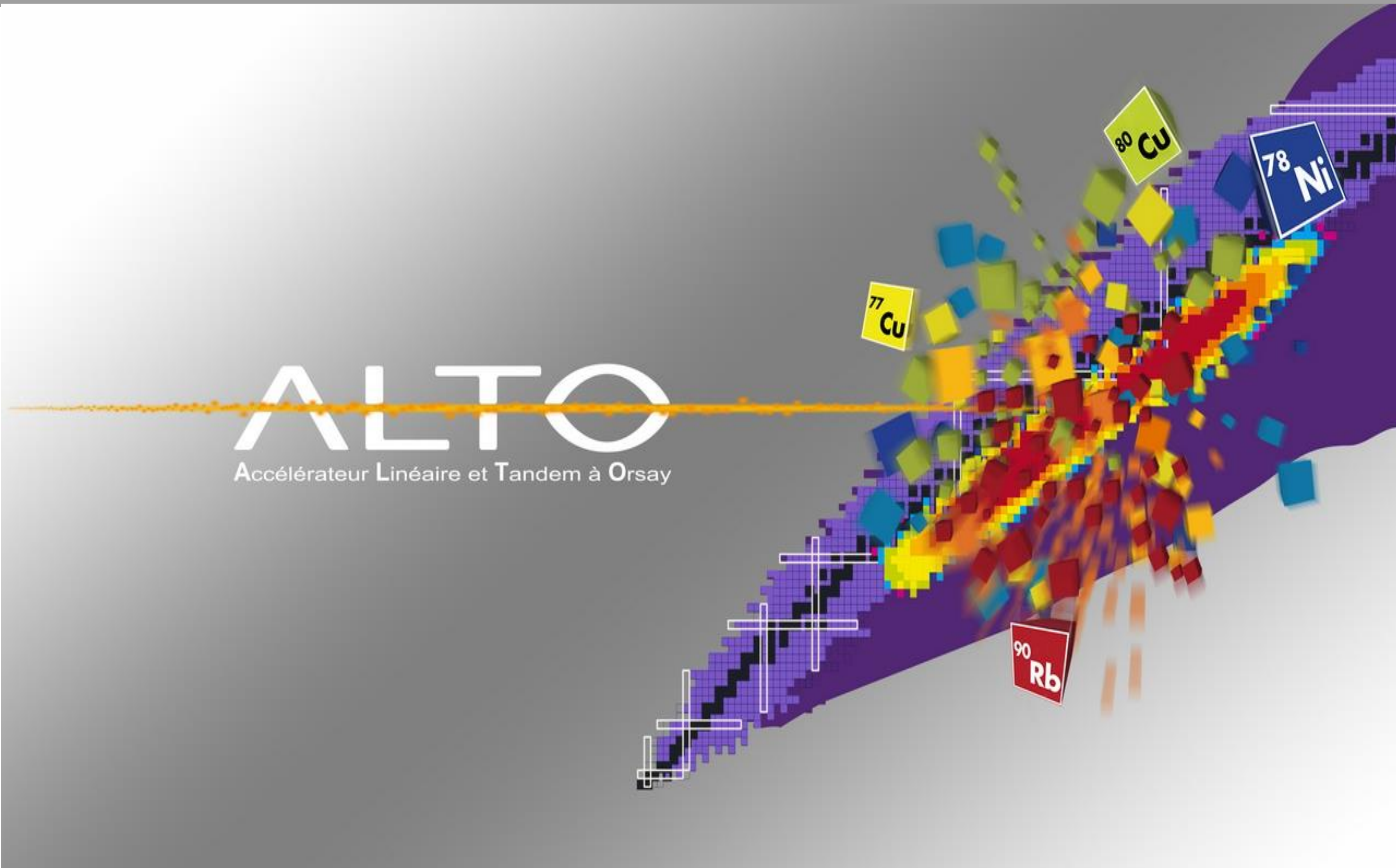
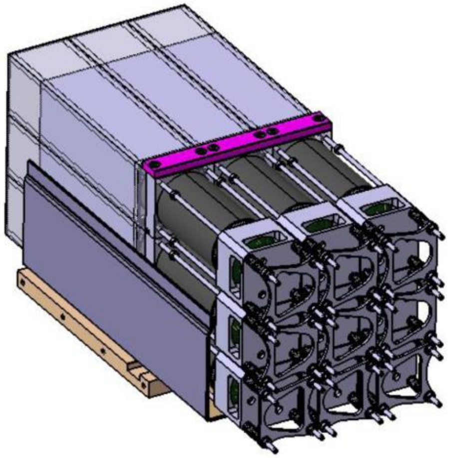
Tandem-ALTO IPN Orsay



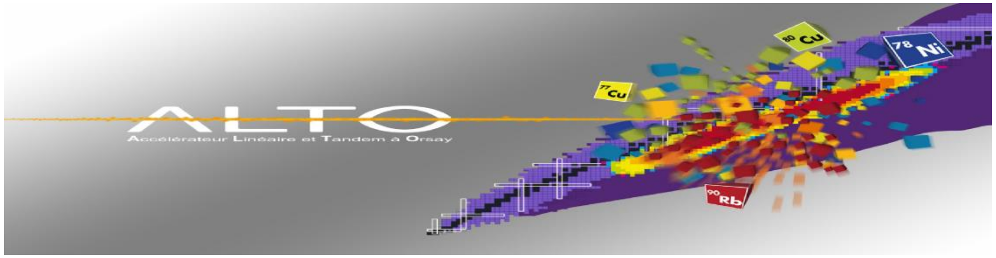
Outline

- ALTO facility: stable and radioactive beam



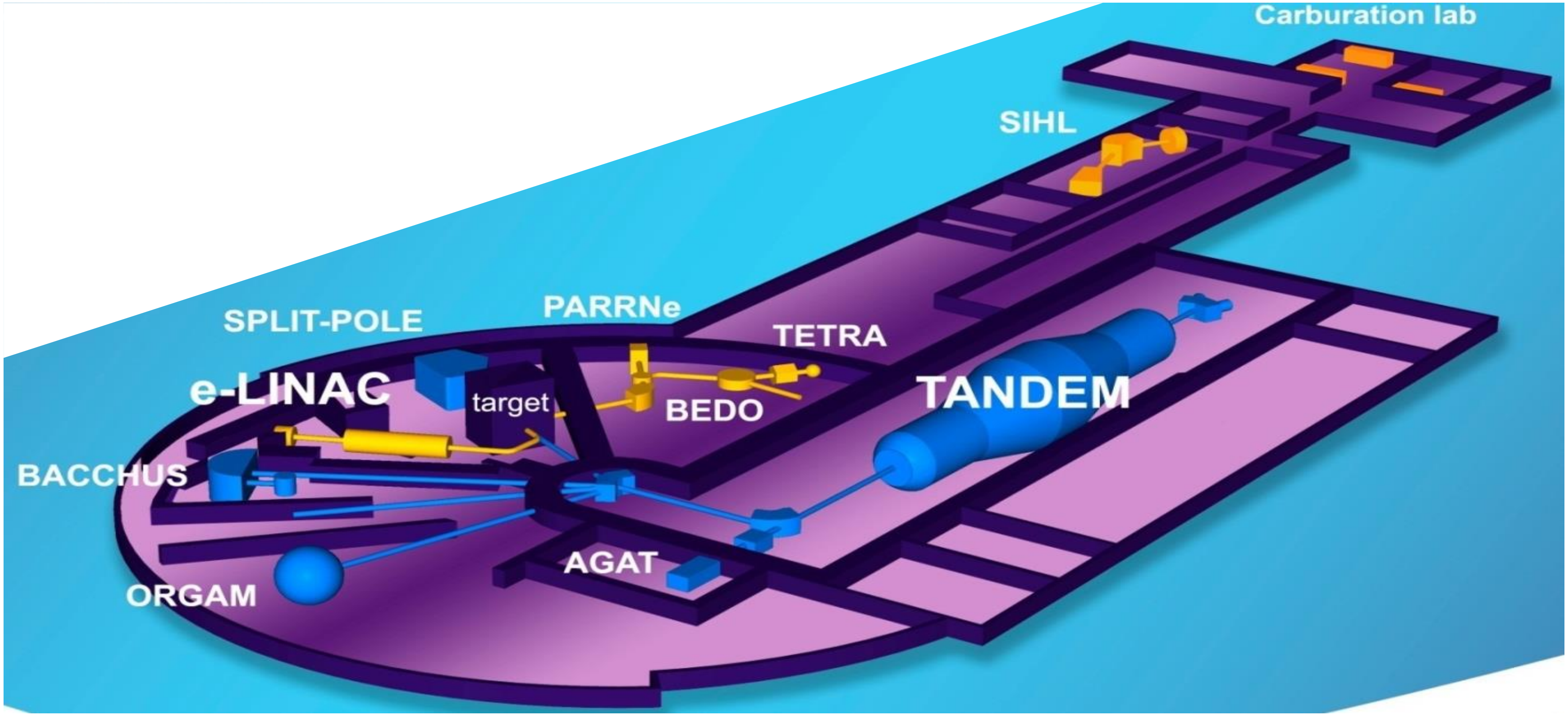
- BEDO setup and projects

- Beta-delayed neutron spectroscopy (+ gammas)



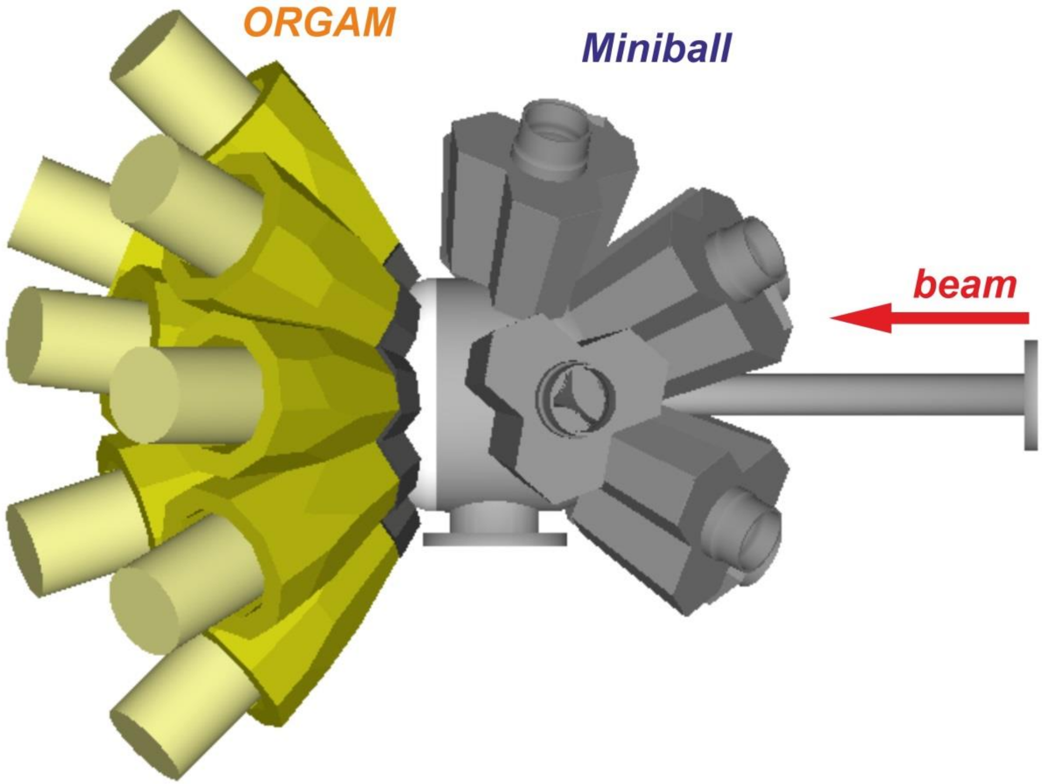
- ISOLDE experiment

Stable and radioactive beams !



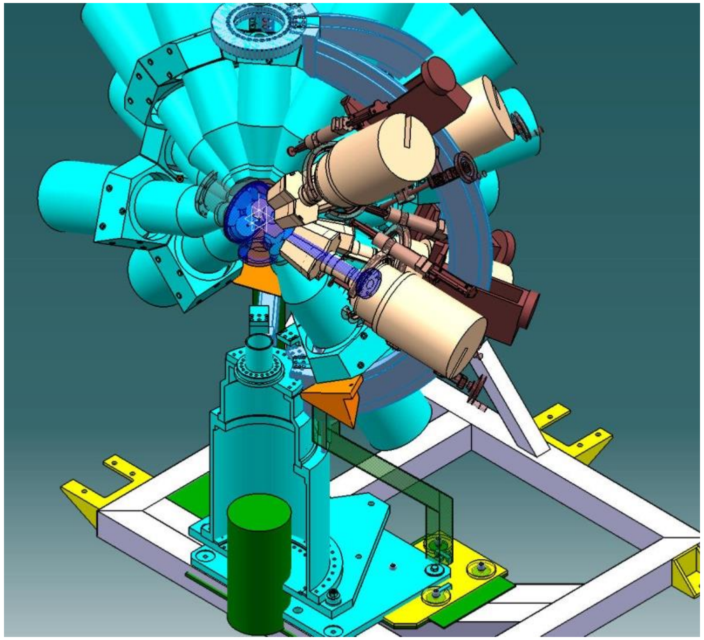
MINIBALL at Orsay coupled with ORGAM

Campaign Managers: Iolanda Matea & Georgi Georgiev



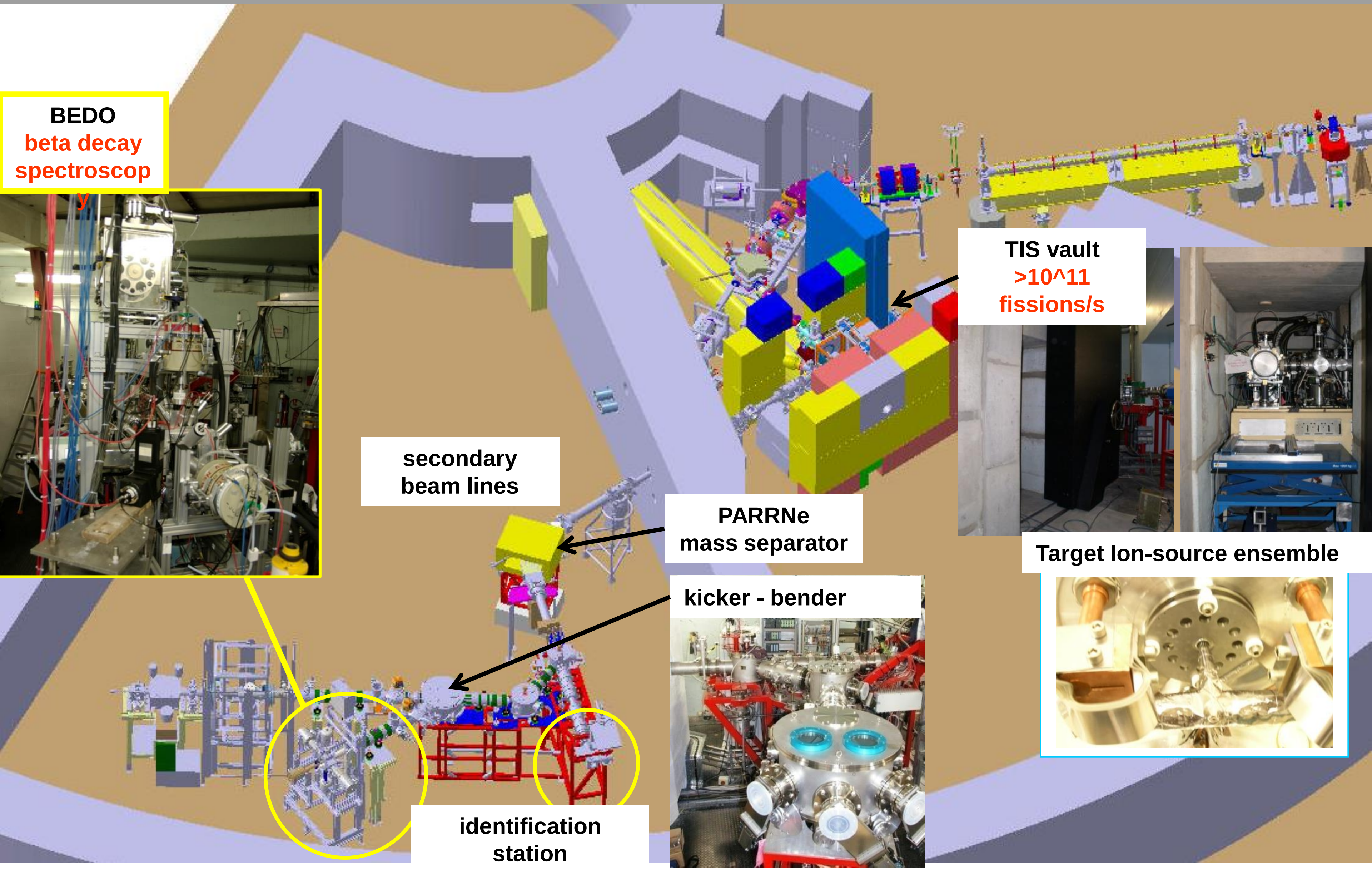
12 ORGAM ***anti-Compton shielded***
Ge detectors x 0.1%

8 Miniball triple cluster detectors
at @ 14 cm from target ***with addback***
without Compton shield



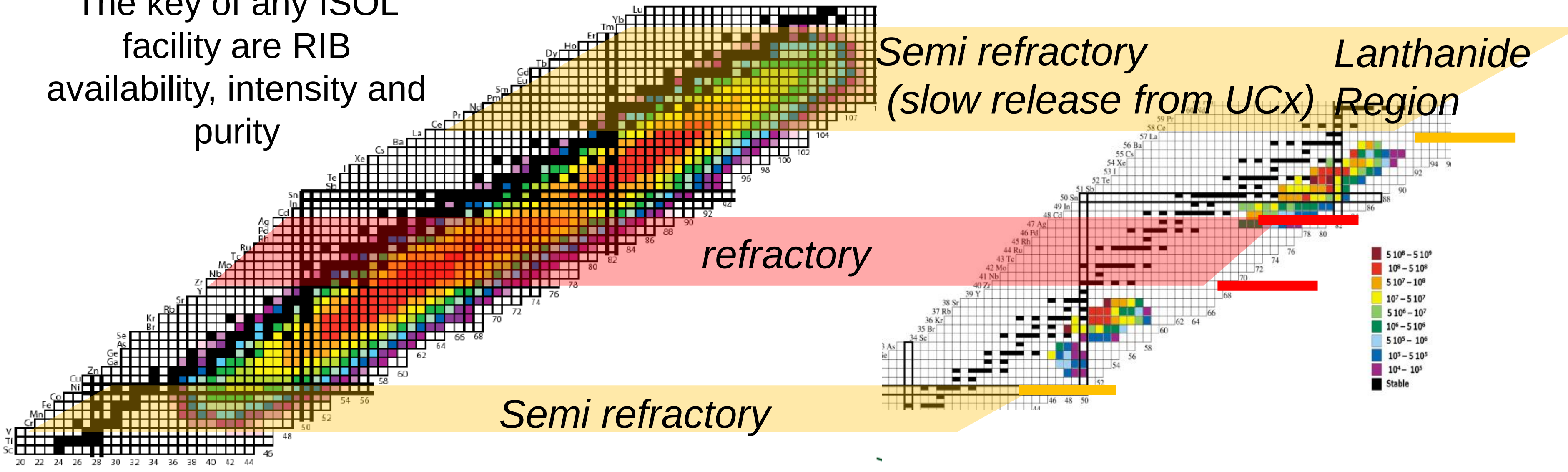
call for proposal launched in september 2013
-> 242 UBT requested
~4 month of beam time

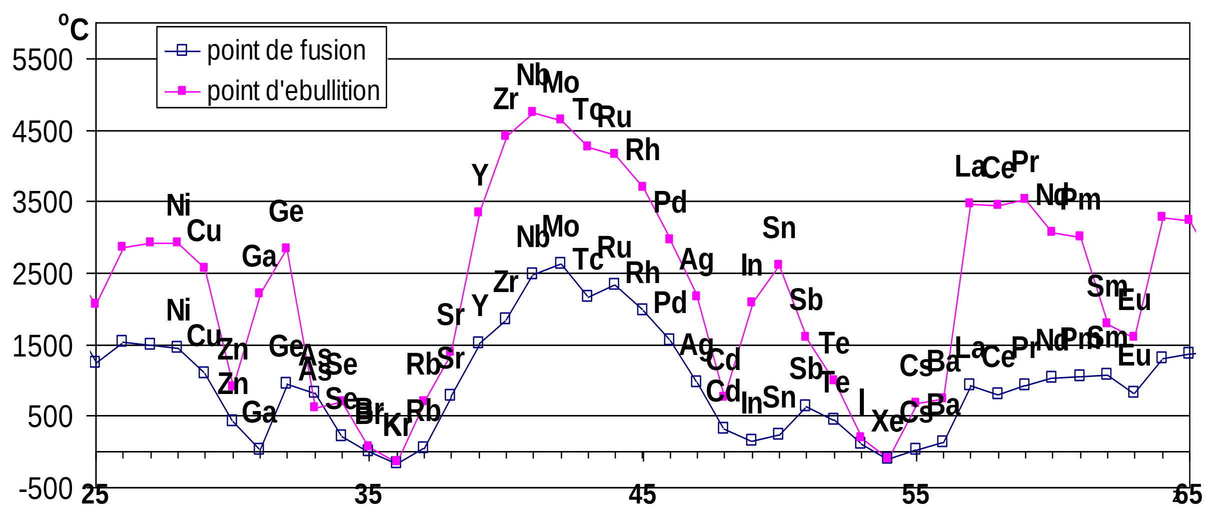
The ISOL facility



What beams can we produce ?

The key of any ISOL facility are RIB availability, intensity and purity



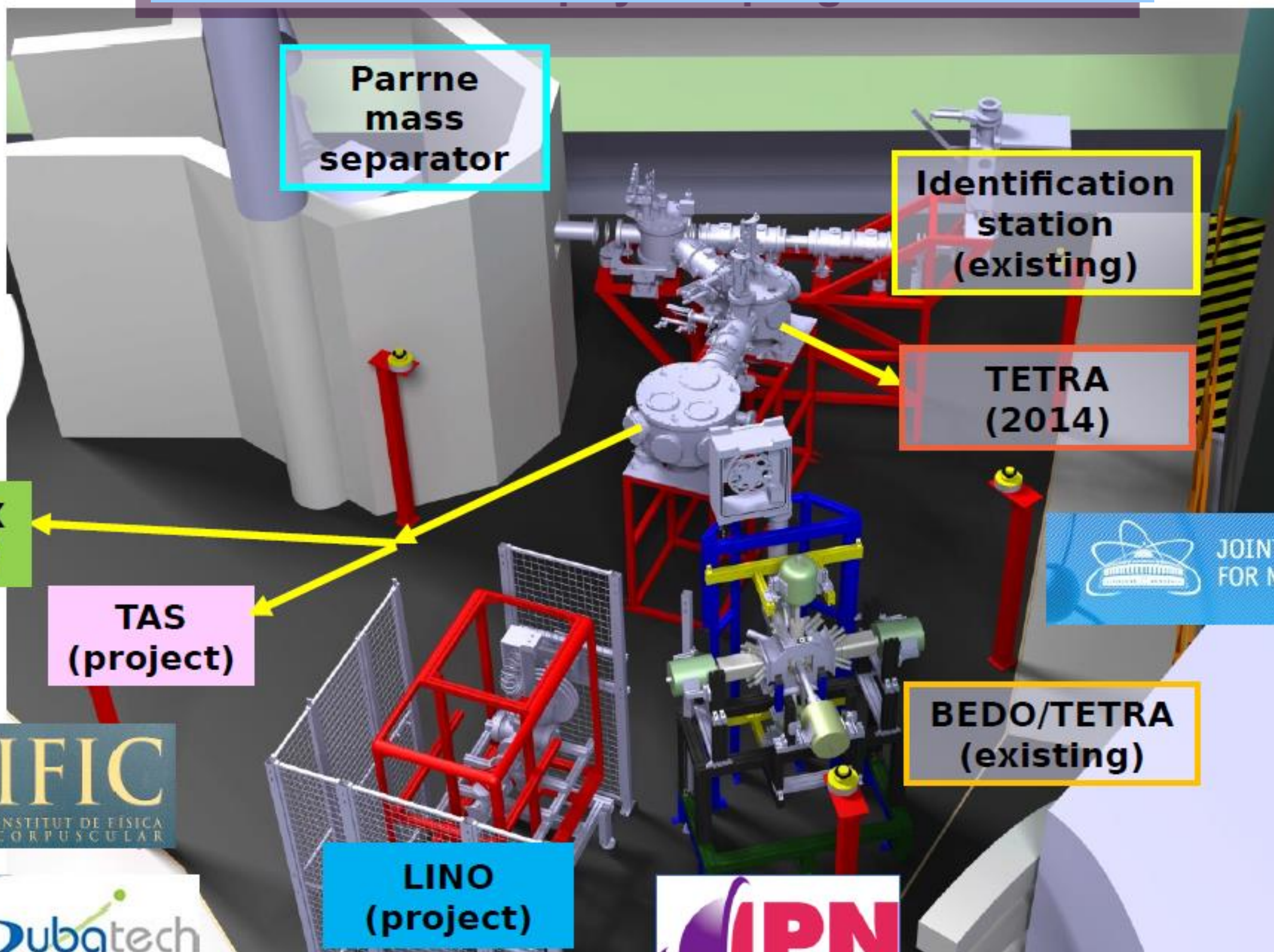


Scientific program at ALTO —toward SPIRAL2 — : ambitious R&D program for RIB developments

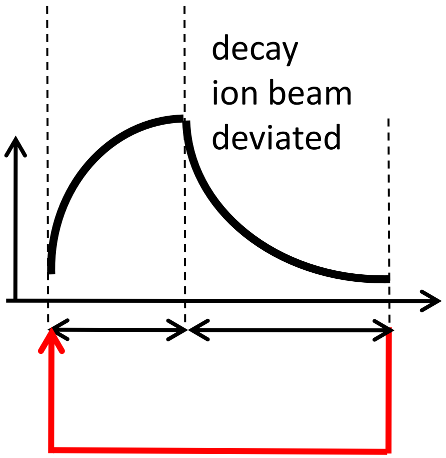
— in an European SPIRAL2-SPES-ISOLDE context—

Different beam lines

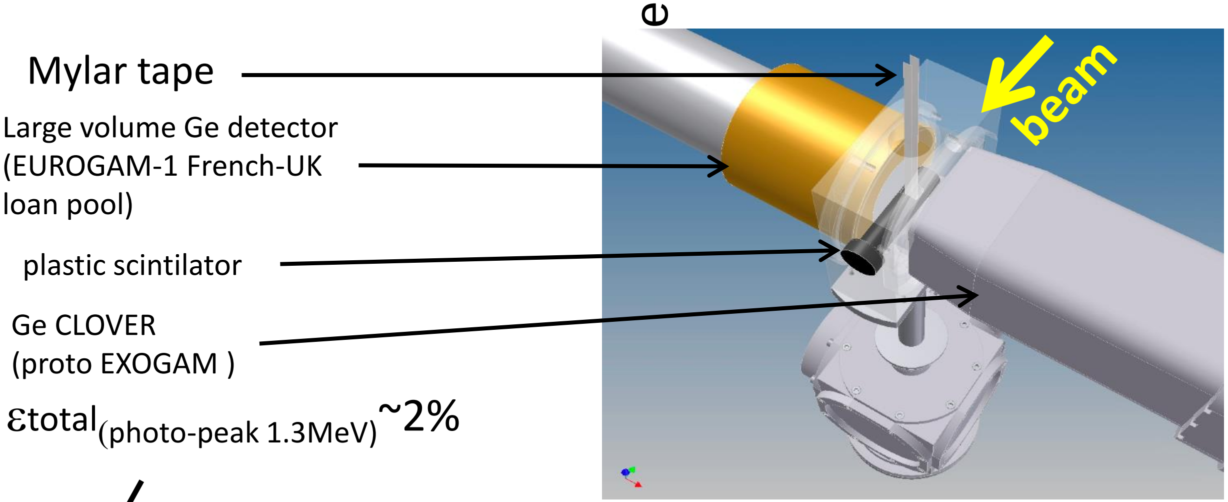
Ambitious physics program !



Tape station BEDO at ALTO

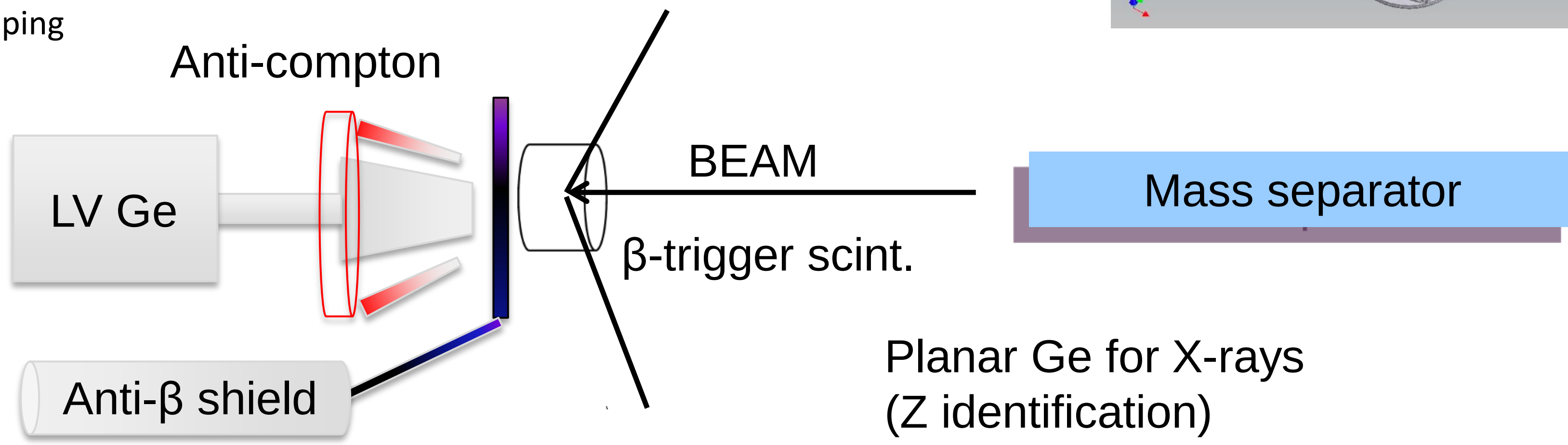


After the break-down of the electron source we should be able to restart in June 2015

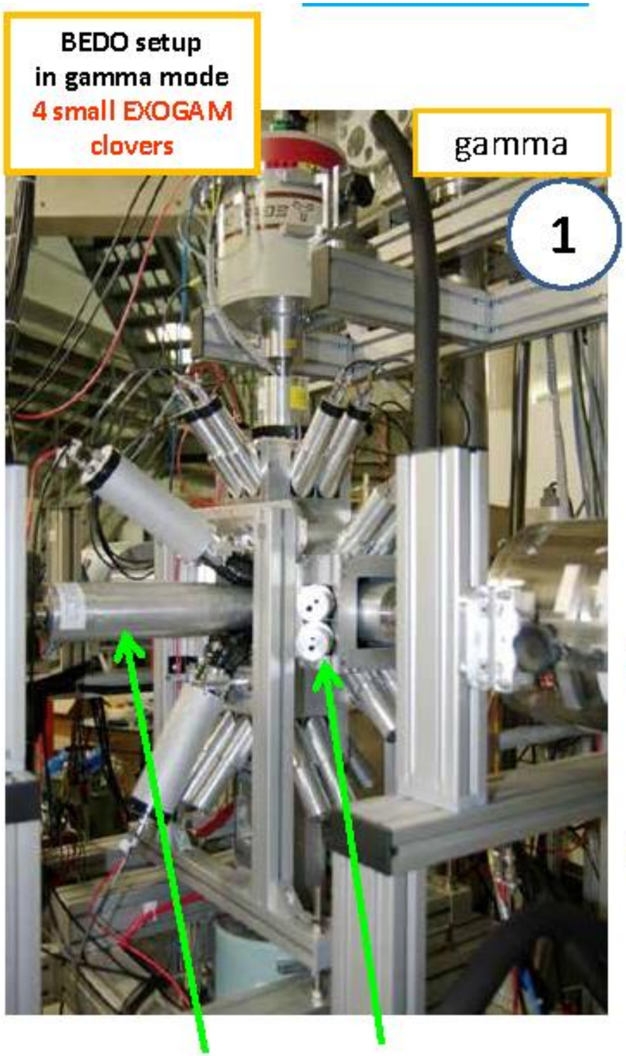


εtotal$_{\text{(photo-peak 1.3MeV)}}$~2%

T1/2 measurement: tape motion cycling
Triggerless DAQ 400ps resolution time stamping



Short-term experiments at ALTO (1)



Fast timing ^{134}Sn

Fast timing with $LaBr_3$

^{134}In (4^- ?): 200 pps with Laser ion source

- 1 % $LaBr_3$ efficiency
- 7% beta efficiency (start for the timing)
- 17% neutron-emission probability
- 70 ps lifetime in 2^+ of ^{134}Sn, larger in 4^+

5 days (1 beam prep.) for fast timing

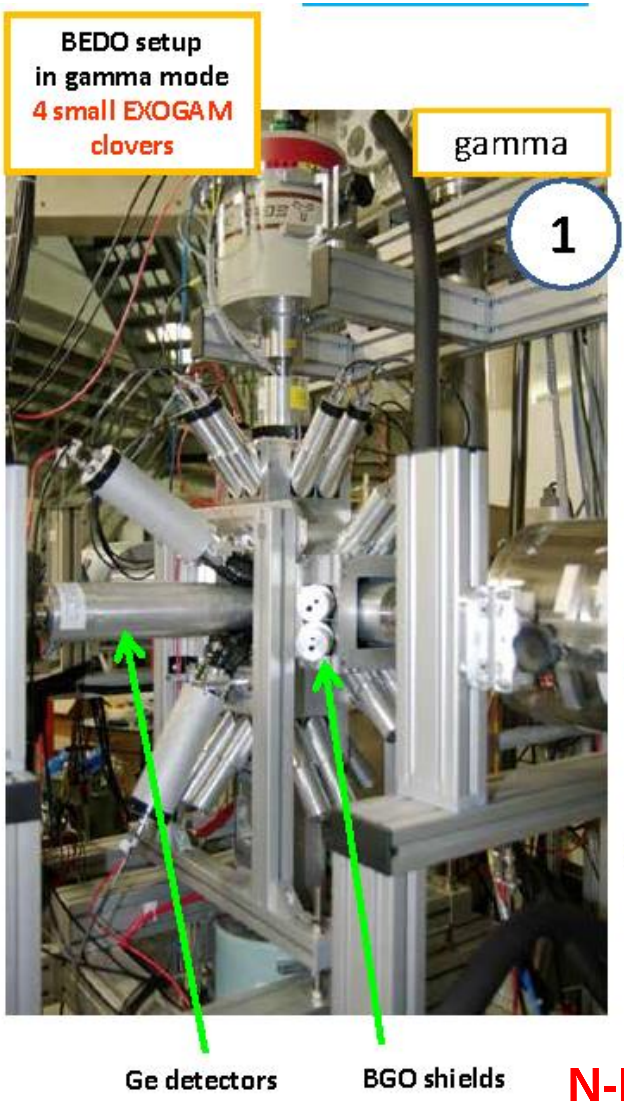
Short-term experiments at ALTO (2)

Decay spectroscopy: ^{135}Sn

^{135}In ($9/2^{+}$?): 50 pps with Laser ion source:

- Gamma efficiency 4%: need of gamma-gamma coincidences
- 50% estimated neutron emission after beta decay

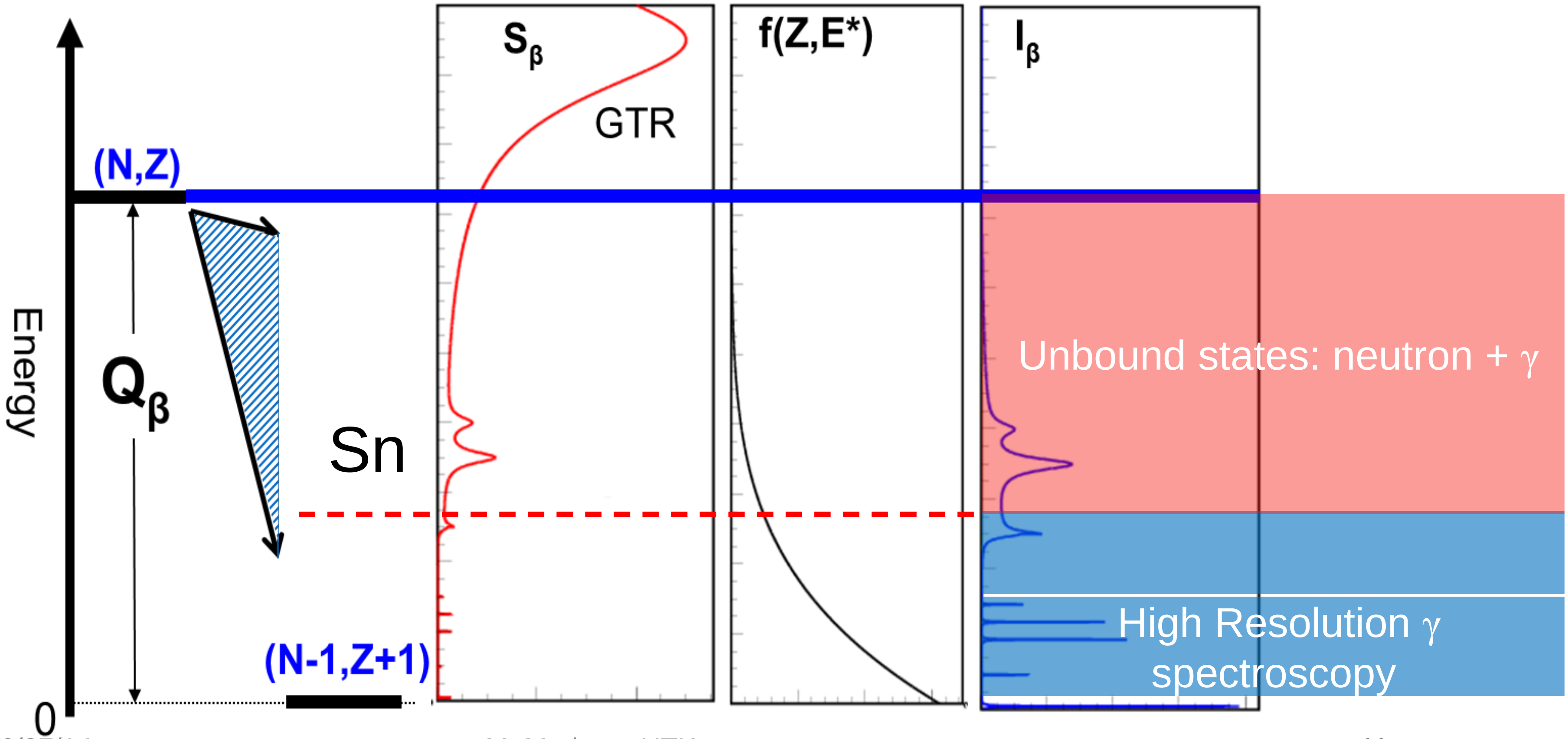
4 days (1 beam prep.) for Beta-gamma spectroscopy



N-RI-5

Mid-term experiments at ALTO: Bound and unbound states in β decay

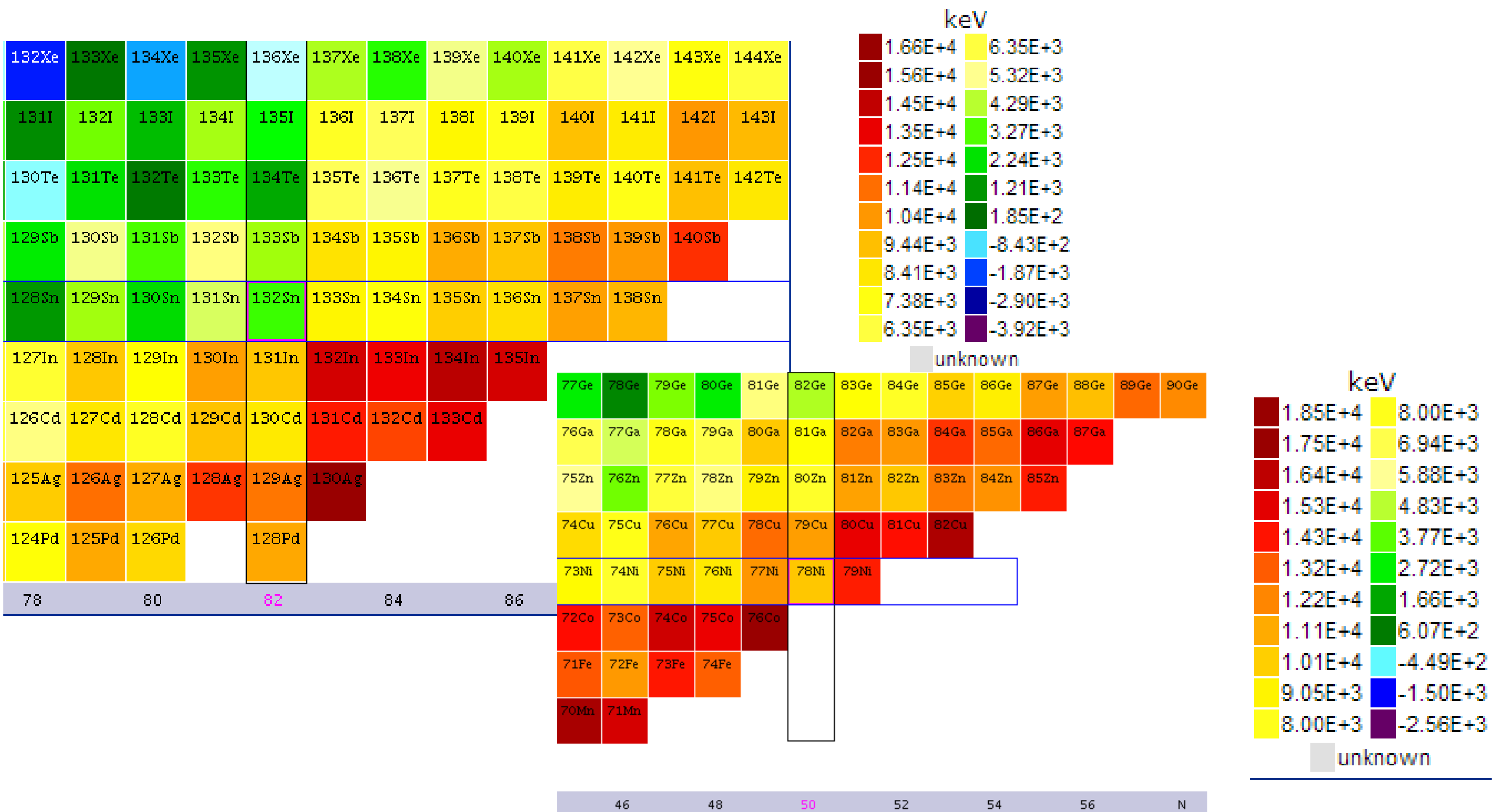
High Q-value beta decays



Courtesy of M. Madurga, CERN

Why β-delayed neutron spectroscopy?

In neutron-rich nuclei the beta-decay Q value increases to values well above 10 MeV

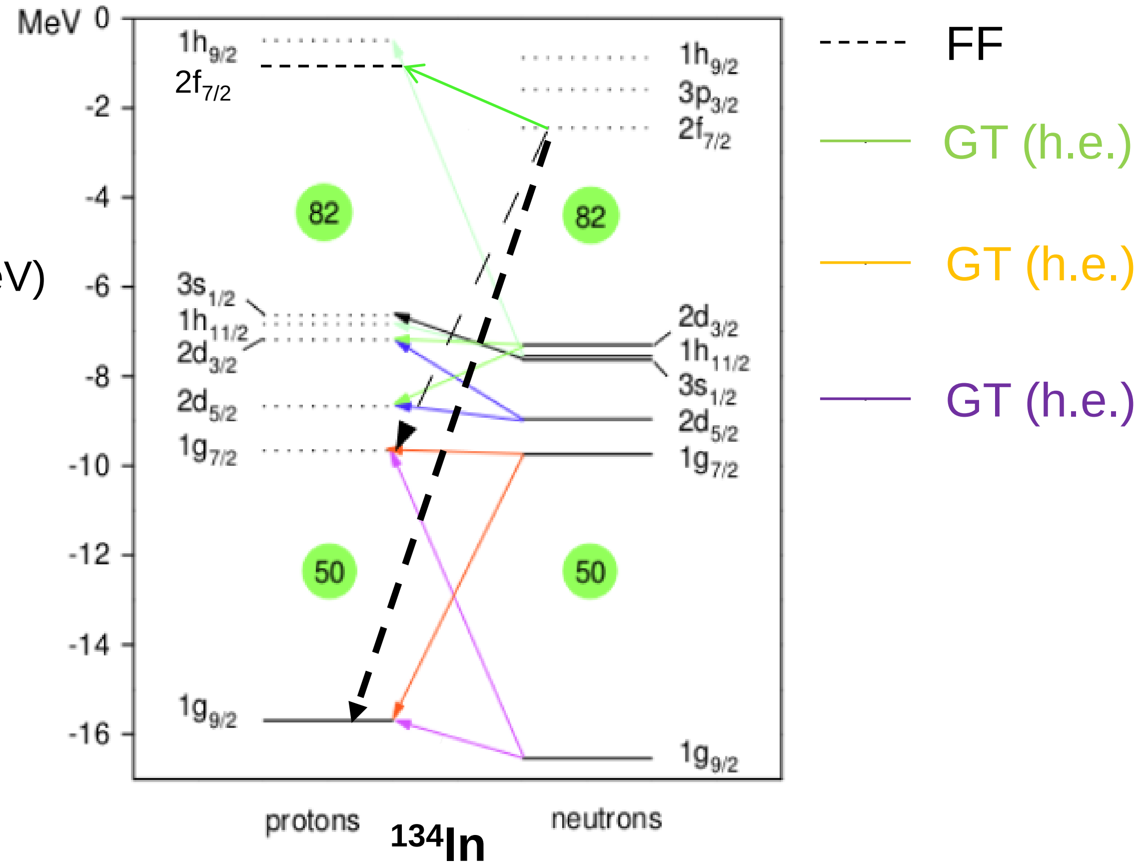


Mid-term experiments at ALTO: collective states via β-decay

The large Q_{β}-value window (> 12 MeV) allows populating at least the PDR

Example: ^{134}In -> ^{134}Sn (Q_{β}= 14.7 MeV)
$\nu f_{7/2}$ -> $\pi g_{9/2}$

β decay: $\nu 2f_{7/2}$ -> $\pi 2f_{7/2}$, $\pi 2f_{5/2}$;



Courtesy of M. Madurga, CERN

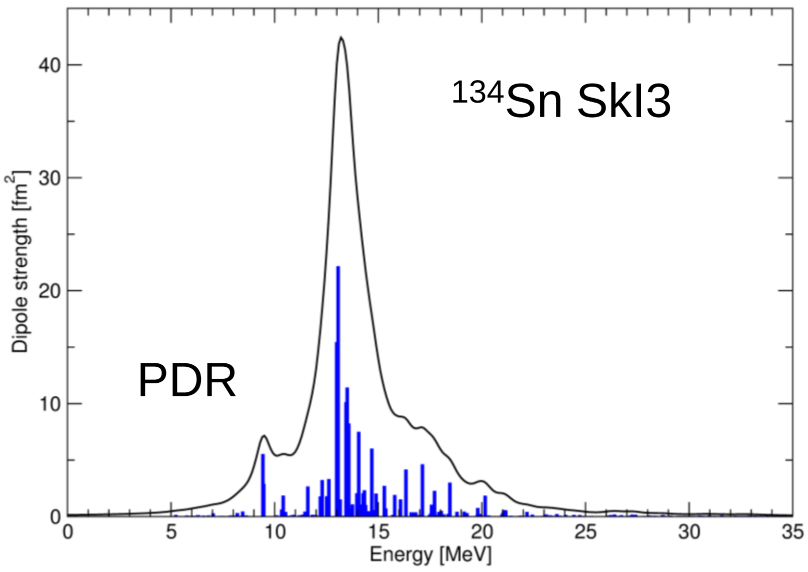
^{133,134}In rates @ ALTO: 1000 pps ; 50 pps

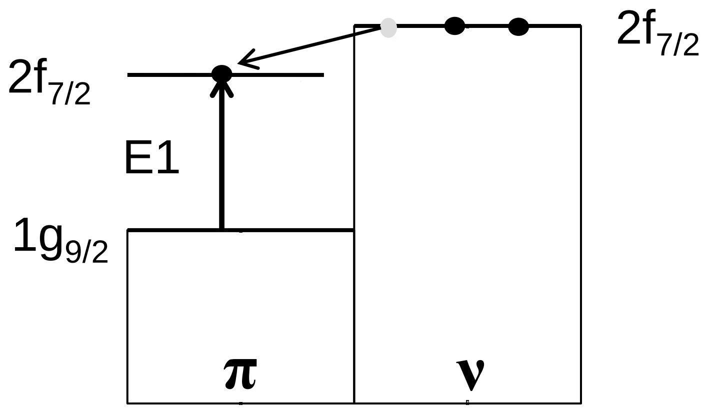
Mid-term experiments at ALTO: collective states via β-decay (2)

The β decay could populate states which are the PDR on the IAS(R) of the mother nucleus

Example: $^{134}In \rightarrow {}^{134}Sn$ (Q_β= 14.7 MeV)
$\nu f_{7/2} \rightarrow \pi g_{9/2}$

β decay: $\nu 2f_{7/2} \rightarrow \pi 2f_{7/2}, \pi 2f_{5/2}$;





QRPA calculations with the SkI3 interaction: PDR at 10 MeV

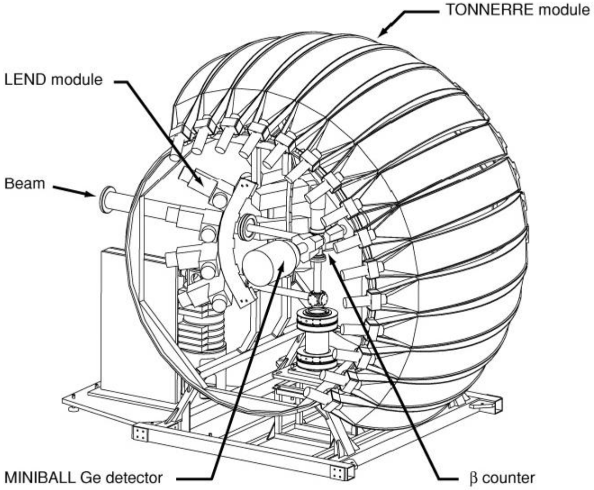
^{133,134}In rates @ ALTO: 1000 pps ; 50 pps

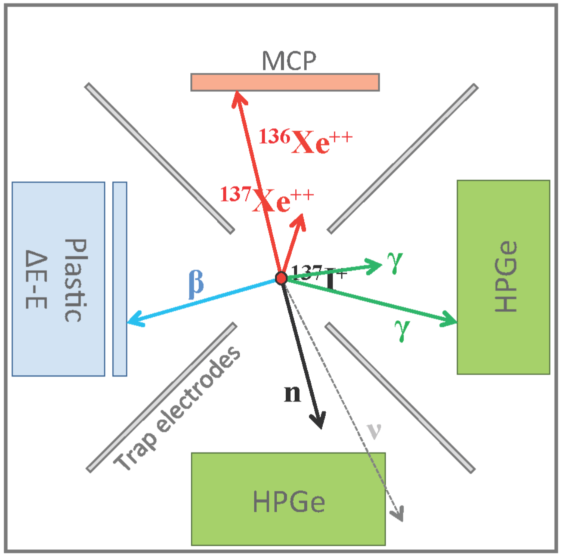
^{133}In (9/2$^+$), ^{134}In (4$^-$), ^{100}Rb (3$^-$), ^{84}Ga (0$^-$): all possible cases at ALTO. Both population of PDR via GT and the PDR on the IAS (if energetically allowed) possible

Experimental setup (1)

Tonnere, VANDLE neutron arrays

ε: 12 %; σ: 120 keV (1 MeV)





Ion trap for neutron spectroscopy?

ε: > 60 %; σ: 30 keV (1 MeV)

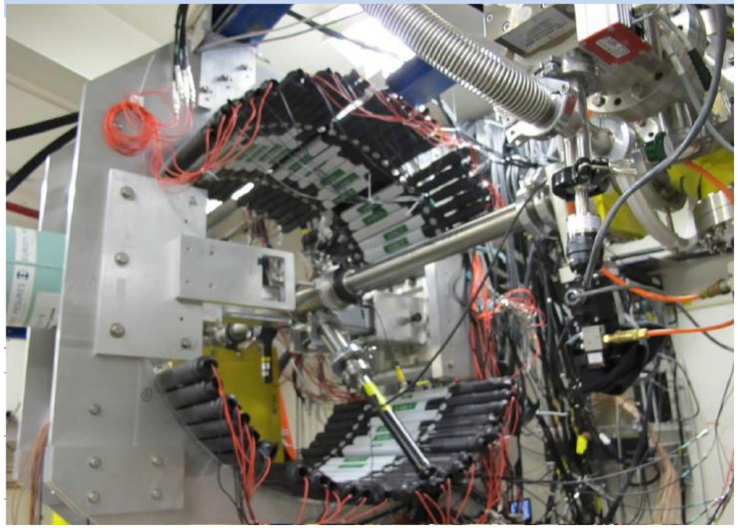
R.M. Yee et al., Phys. Rev. Lett.110 (2013) 092501

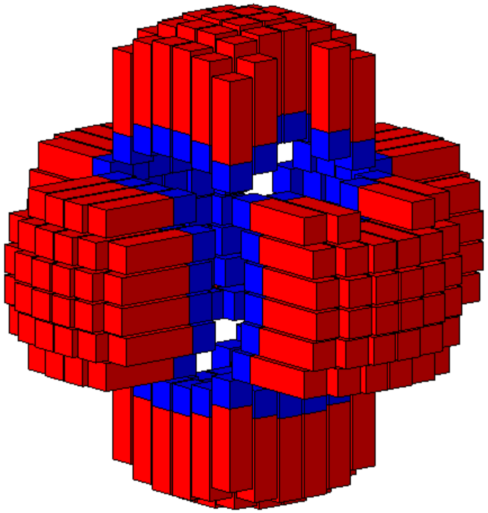
Polarized radioactive beams: spin of states via the neutron angular distribution

Available (?) experimental setups

Neutron arrays (VANDLE at Oak Ridge, MONSTER...)

ε: 12 %; σ: 100 keV (1 MeV)





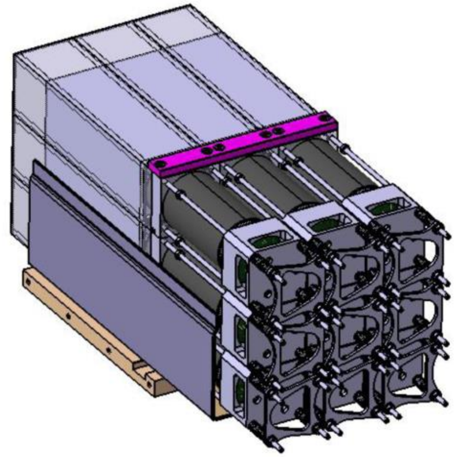
Complementarity of high-energy (6-12 MeV) γ-ray spectroscopy:

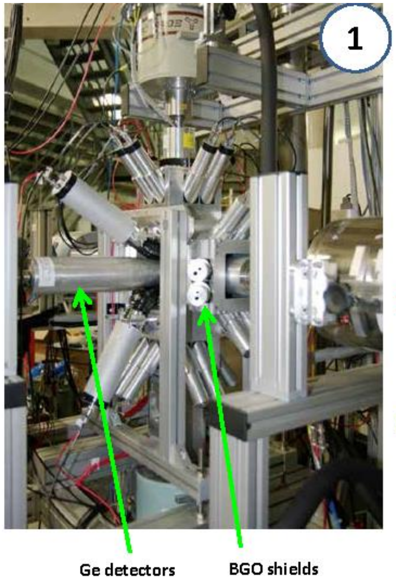
- Energy resolution for the states (important for comparison with shell model)
- Indications on the multipolarity of the states

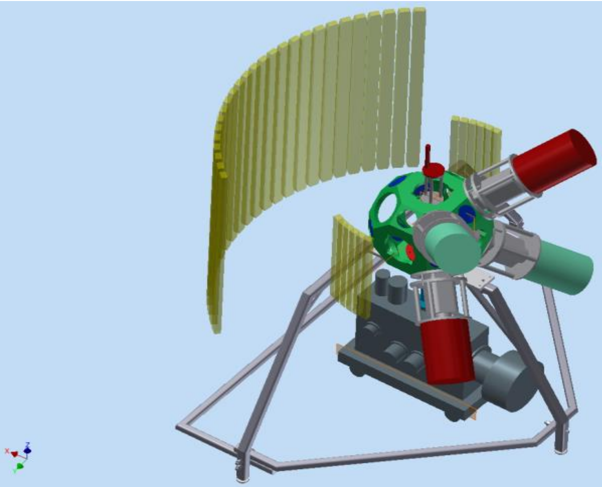
Possible experiment at ALTO

BEDO:

- Tape station
- Two large-volume Ge crystals
- Two Paris clusters
- Neutron detector







ISOLDE IDS-VANDLE setup

Which neutron detectors ?

- Tonnere (kaput ?)
- Detectors from Strasbourg ?
- Monster

Counting rate and open problems

Counting rate estimate:

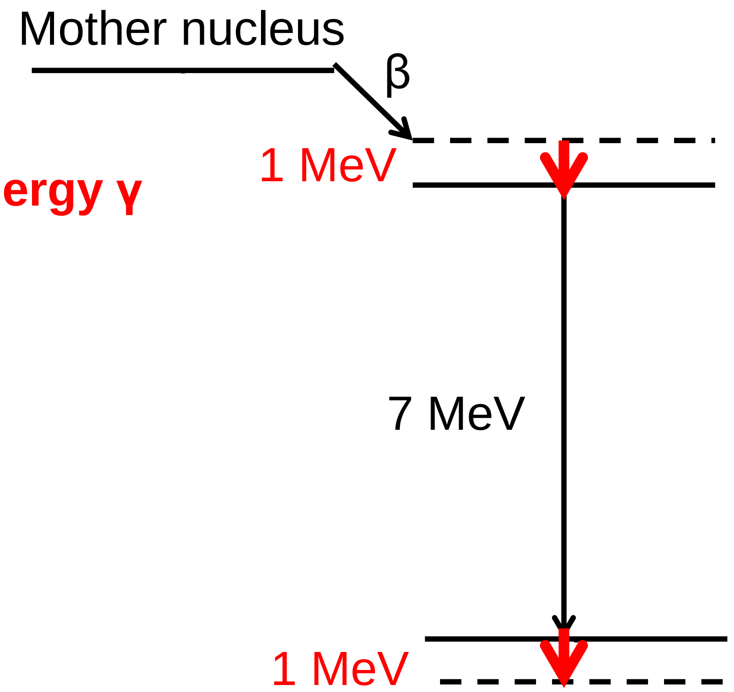
^{134}In: 50 pps

2 Ge crystal efficiency (2%), 2 Paris cluster efficiency (3%)

3 % γ branching ratio from 6-10 MeV states

170 high-energy γ/h from PARIS

4 high-energy γ/h in coincidence with low-energy γ



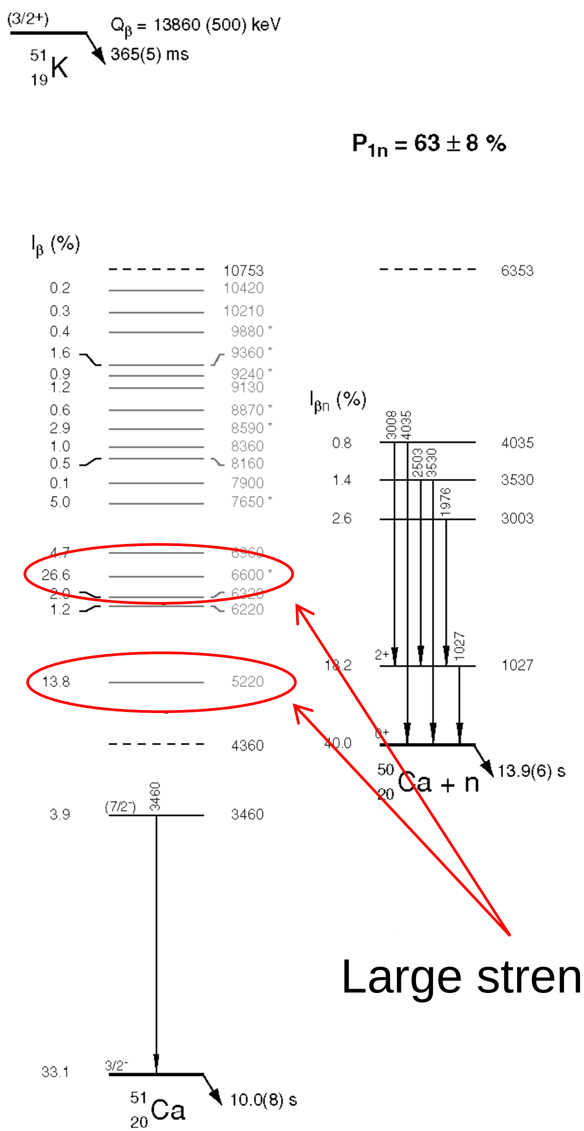
Open problems:

- γ branching ratio, but it could also be an indication on the nature of the state
- Feeding of the high-lying states or decay to excited states: measure the β energy ?

Proposal (approuved): Beta-delayed neutron spectroscopy of $^{51-54}Ca$

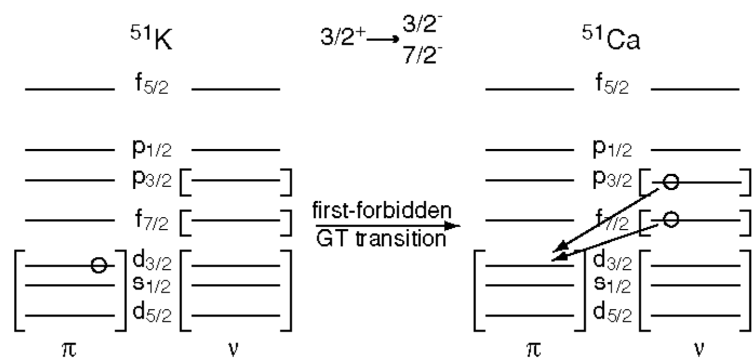
Past ^{51}Ca measurement

^{51}Ca : many intersting states above the neutron separation threshold



Large strength: ?

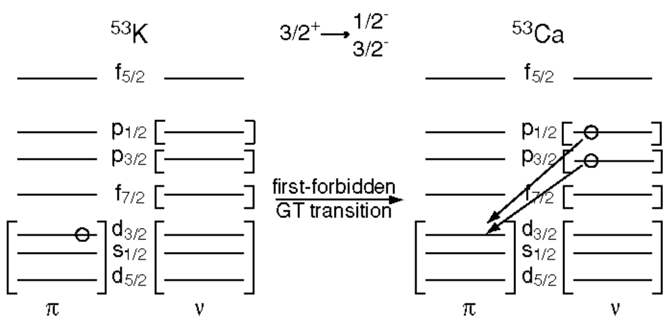
F. Perrot et al., Phys. Rev. C 74, 014313 (2006)



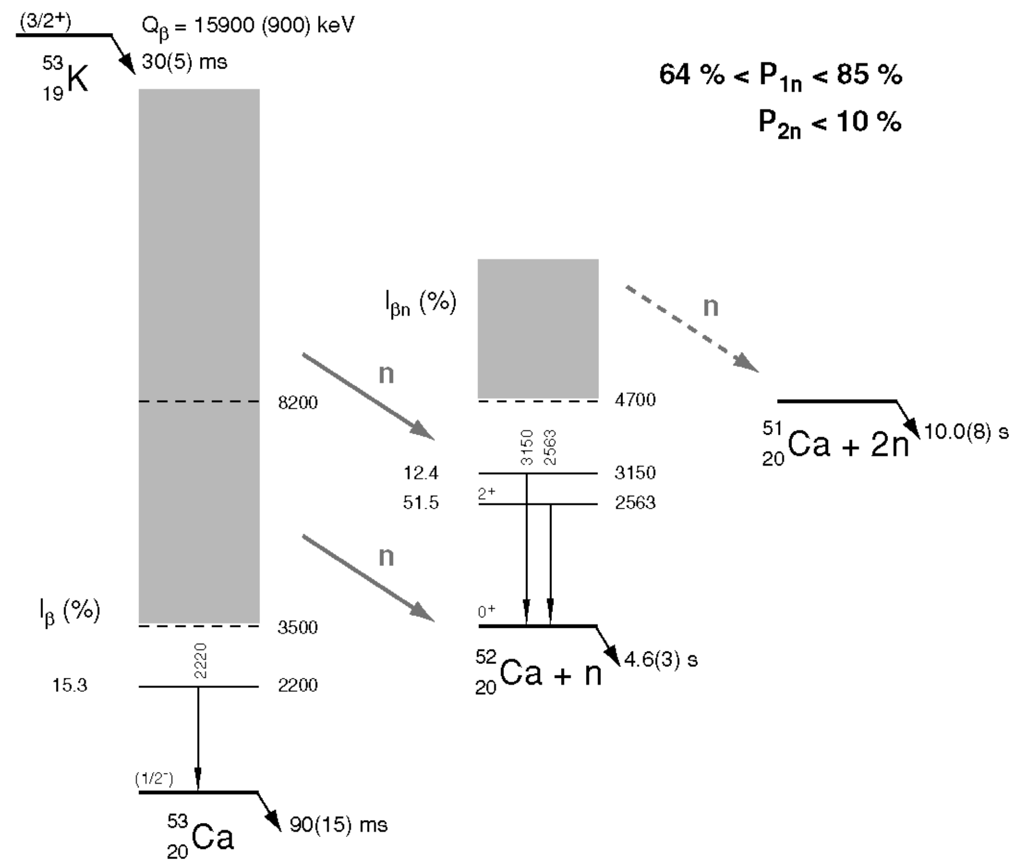
The 7/2$^-$ state is an hole in the $\nu f_{7/2}$ shell (FF transition);

GT : $\nu f_{7/2}$ -> $\pi f_{7/2}$ (high energy!)

Past ^{53}Ca measurement



- The GT decay should populate the $\pi f_{7/2}$ shell -> we expect $\nu f_{7/2}^{-1}$ $\pi f_{7/2}^{1}$ states at 8-10 MeV: 2n emission
- FF could also lead to $\nu p_{1/2}^{-1}$ $\nu p_{3/2}^{-1}$ $\nu f_{7/2}^{-1}$ states (closed Z=20)



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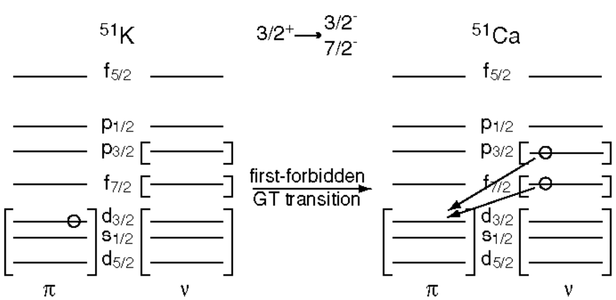
Not enough statistics to reconstruct the level scheme

What we want to measure

^{51}Ca



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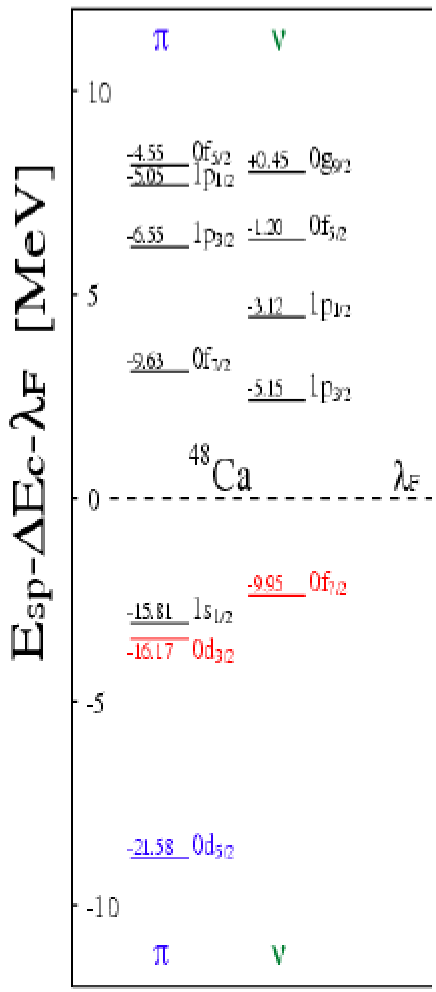
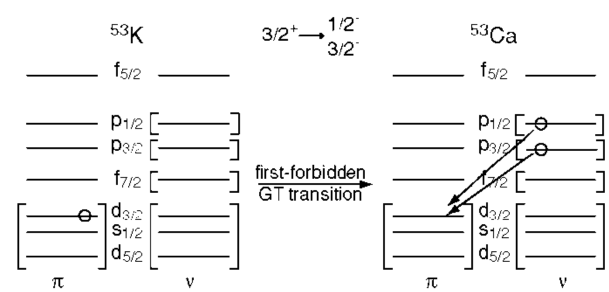


^{53}Ca



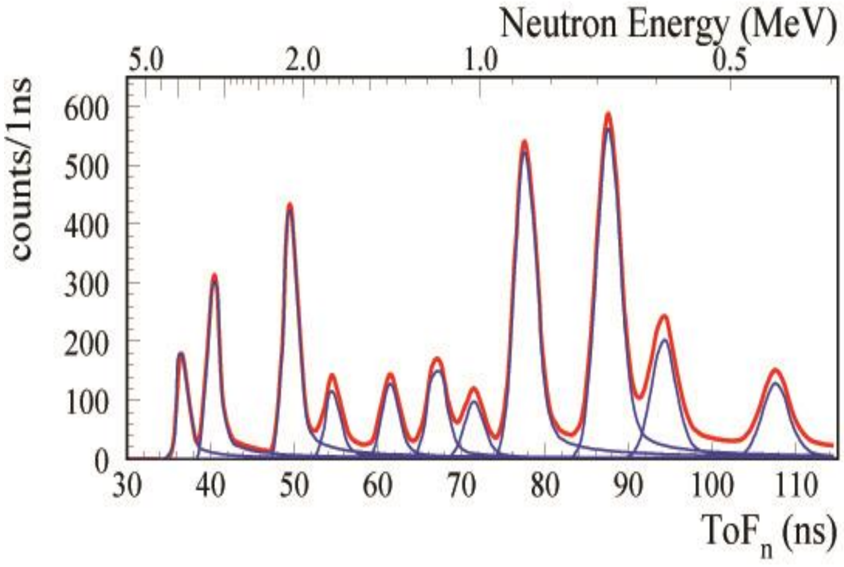
- The GT decay should populate the $\pi f_{7/2}$ shell -> we expect $\nu f_{7/2}^{-1}\ \pi f_{7/2}^{1}$ states at and above 10 MeV: 2n emission
- FF could also lead to $\nu p_{1/2}^{-1}\ \nu p_{3/2}^{-1}\ \nu f_{7/2}^{-1}$ states (closed Z=20)

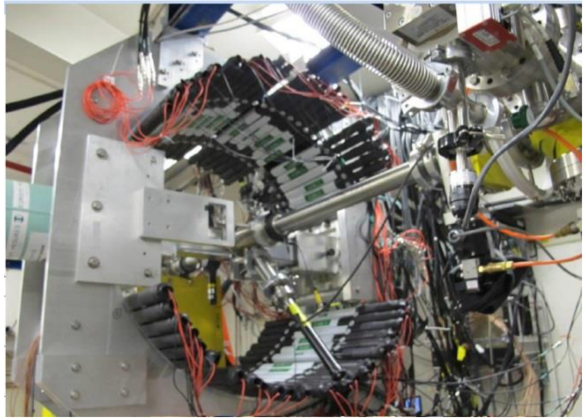
^{51,52,53}Ca: GT (and FF) strength distribution

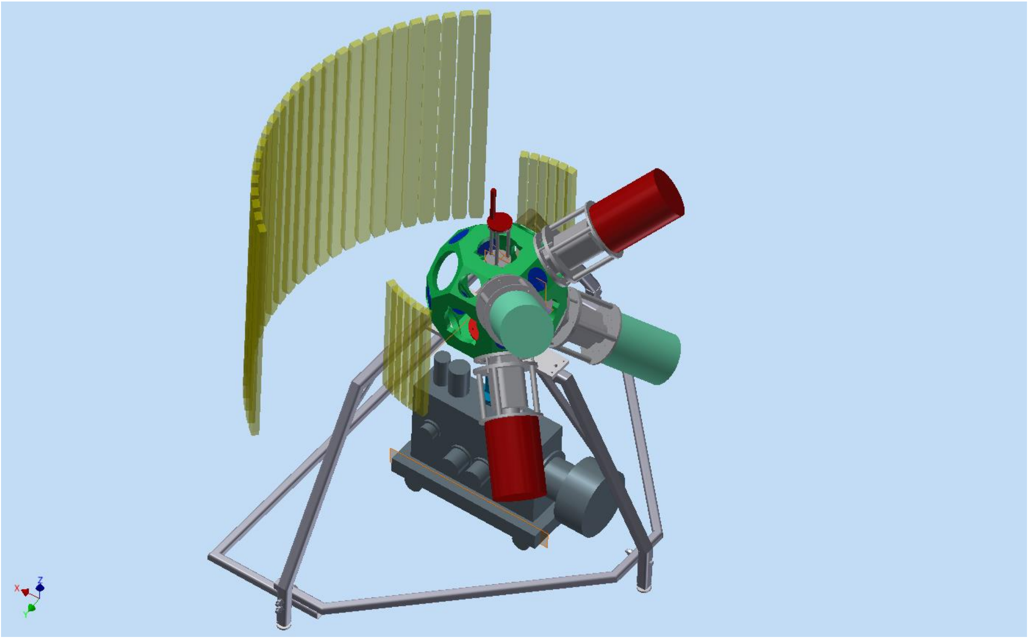
Experimental setup: VANDLE + IDS

VANDLE neutron array

ε: 10 %; σ: 80 keV (1 MeV)







Experimental setup: rates

1n efficiency	2n efficiency	γ efficiency
10 %	~ 0.1 %	~ 2 %

	^{51}K	^{52}K	^{53}K
Production rates	32000 pps	3000 pps	50 pps
Counts (1n)	$5.67\cdot10^{7}$	$1.35\cdot10^{7}$	$5\cdot10^{5}$
Counts (2n)	?	$3.2\cdot10^{4}$	$7\cdot10^{3}$

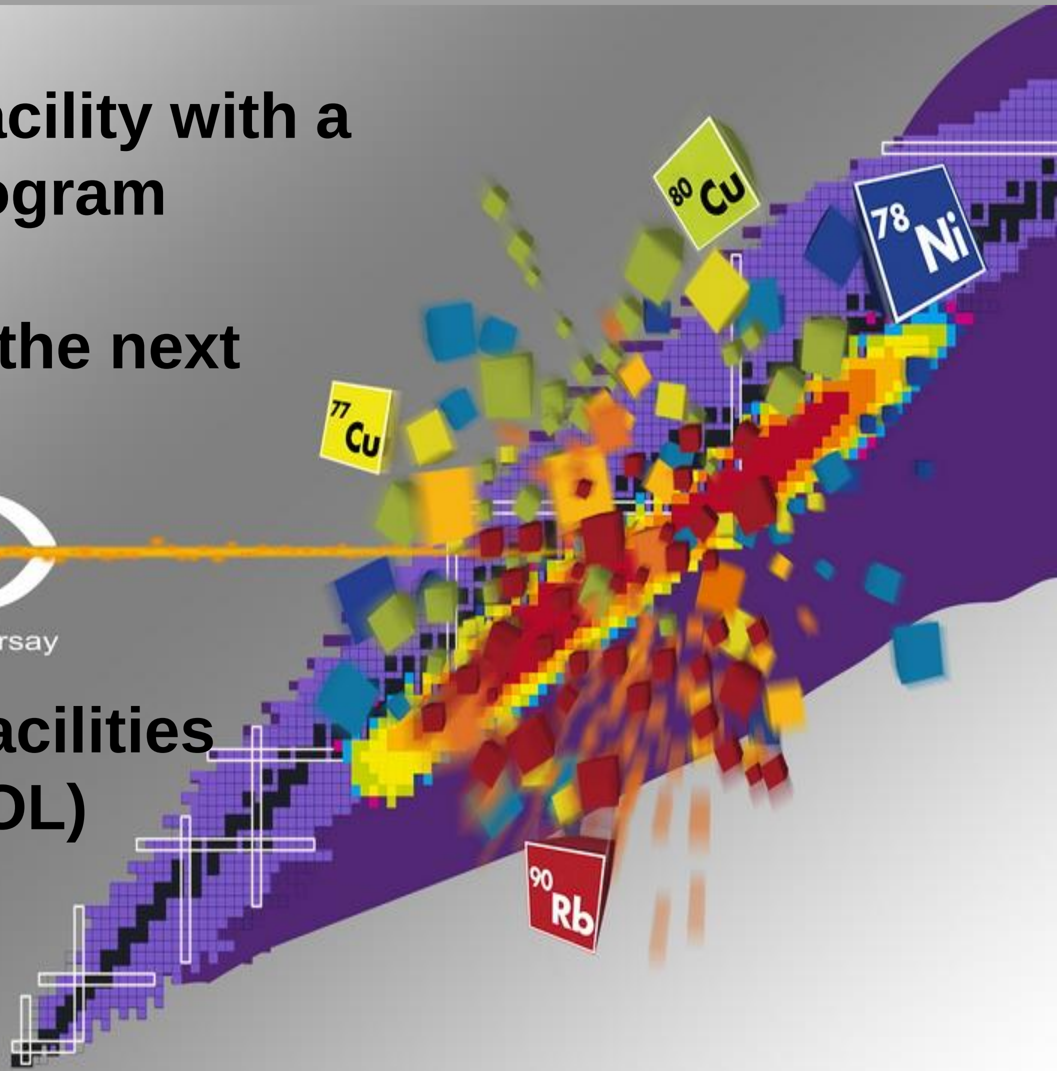
Conclusions

- **Small radioactive beam facility with a very diverse scientific program**

- **New detectors coming in the next moths/years**

ALTO
Accélérateur Linéaire et Tandem à Orsay

- **Good training for future facilities (SPES, SPIRAL2, EURISOL)**




Thank you
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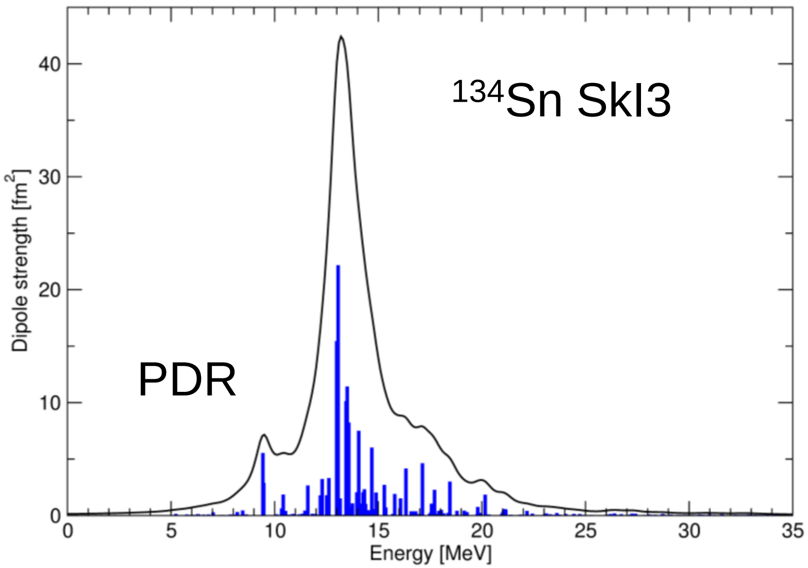

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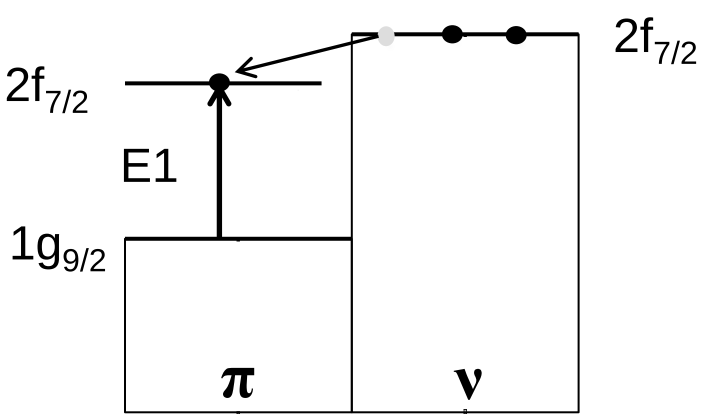

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