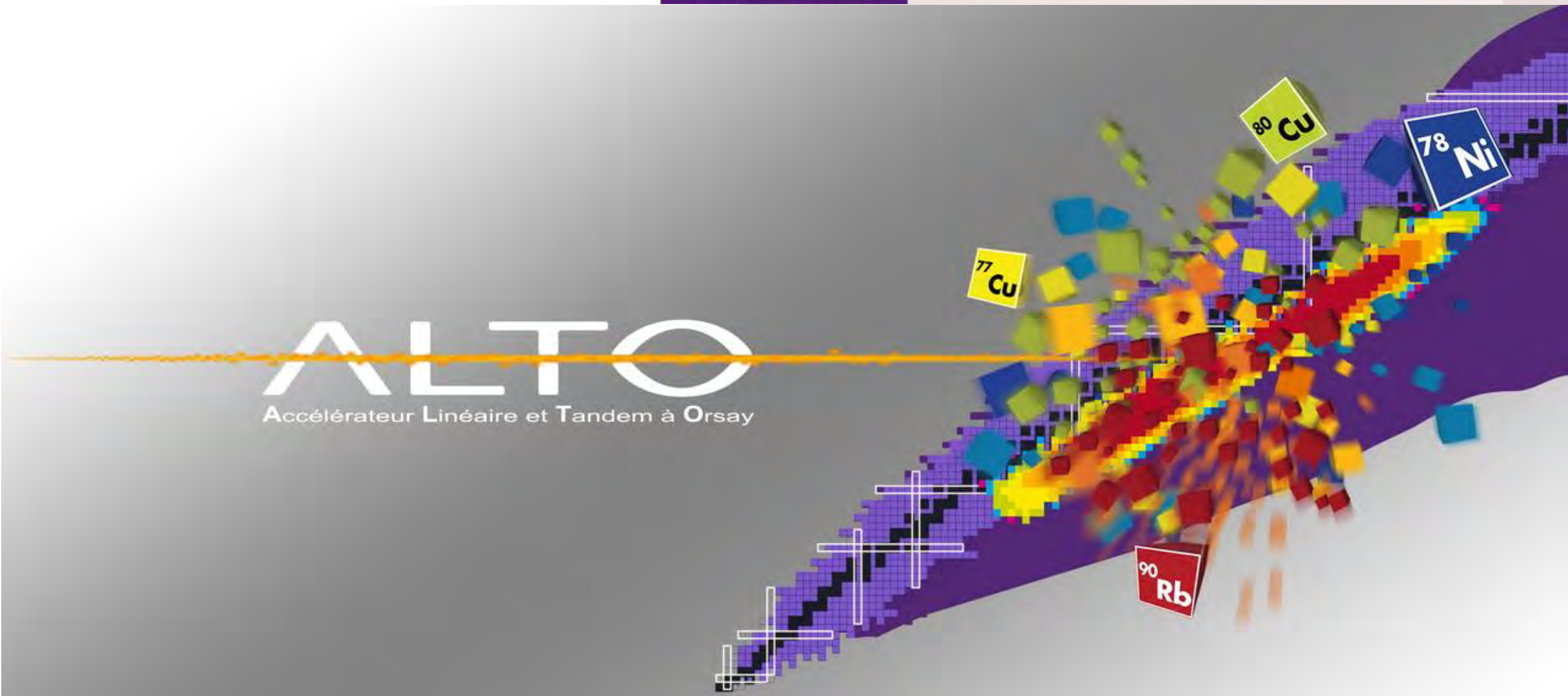
The ALTO facility

M. Lebois, on the behalf of the ALTO team

université PARIS-SACLAY

IJCLab Irène Joliot-Curie
Laboratoire de Physique des 2 Infinis

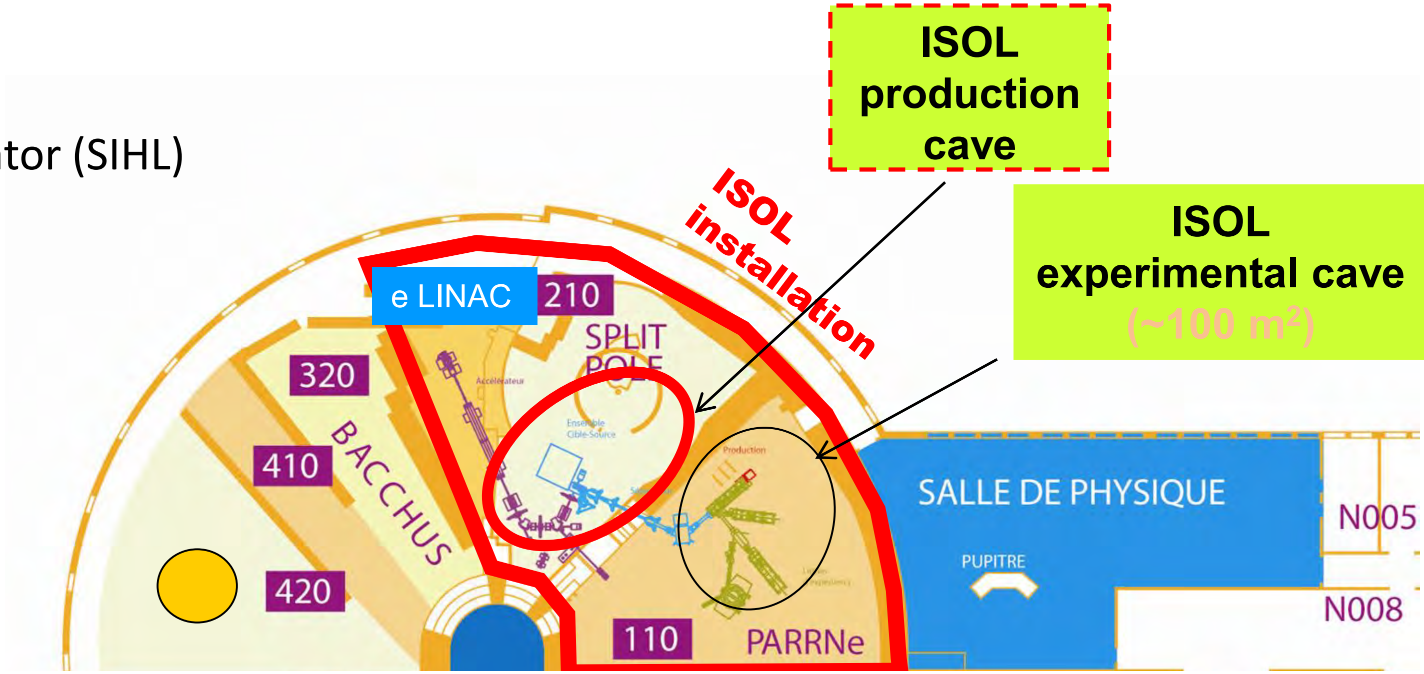
ALTO
Accélérateur Linéaire et Tandem à Orsay



CS IN2P3 Plateformes, 25&26 février 2020

The ALTO Facility: radioactive ions beams

+ Off-Line Separator (SIHL)
+ RIALTO

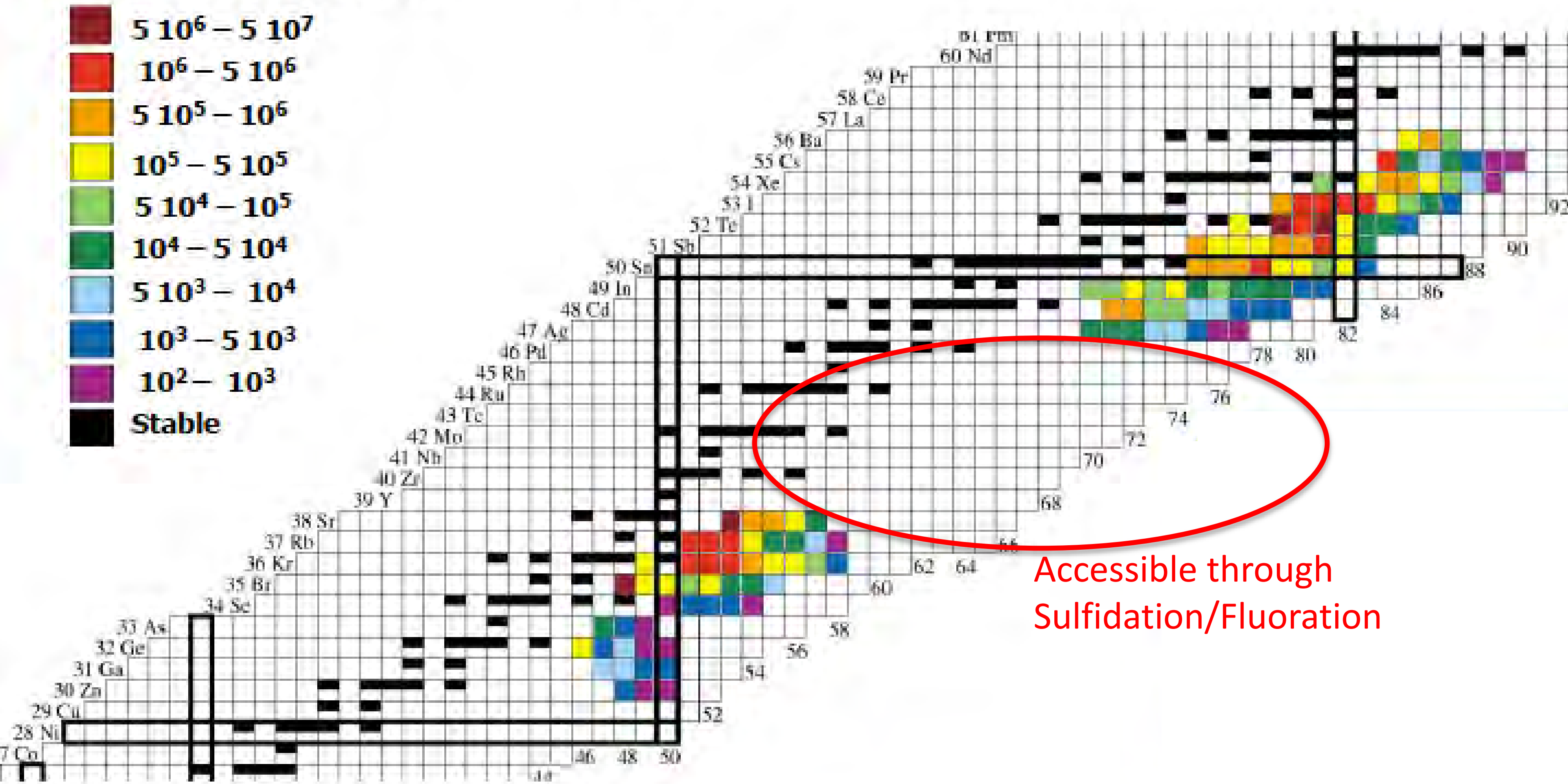


First photofission ISOL facility in the world (~10^{11} f/s)

- **50 MeV** & **10 µA** e^- beam
- UCx target (~70g, ~140 pellets)
- Z selection with : **Surface/LASER ion source**
- Mass Selection with PARRNe magnet -> mono-isotopic achievable

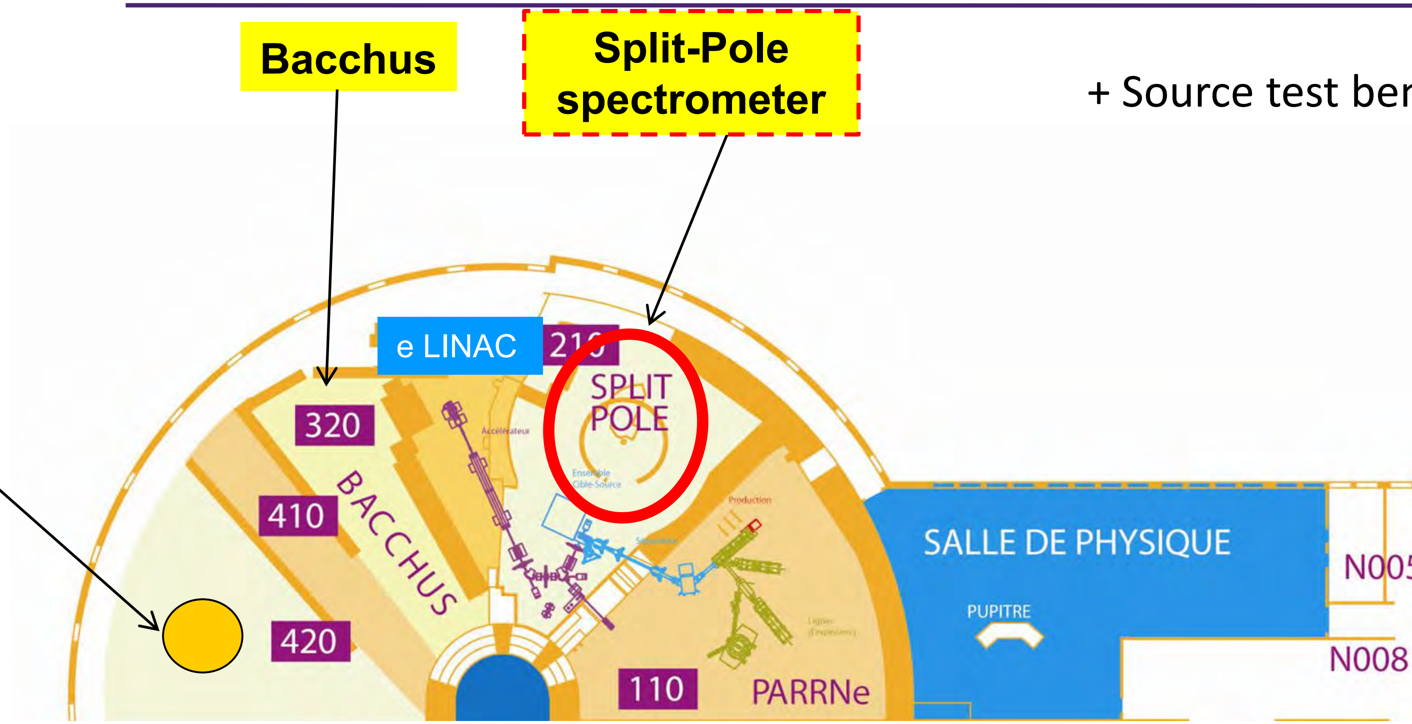
The ALTO Facility: radioactive ions beams

Production /s/100nA measured in june 2006



The ALTO Facility: stable beams

γ-spectroscopy

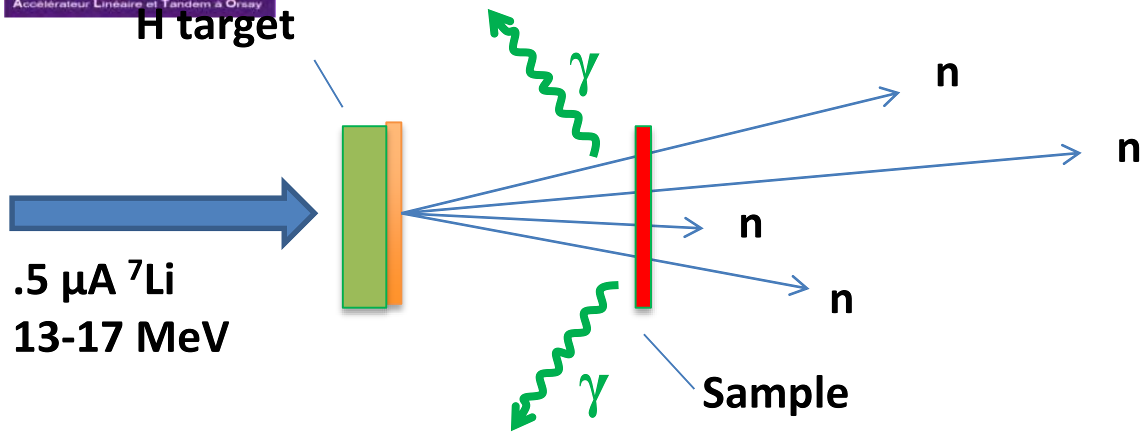


+ Source test bench

Standard Tandem beams

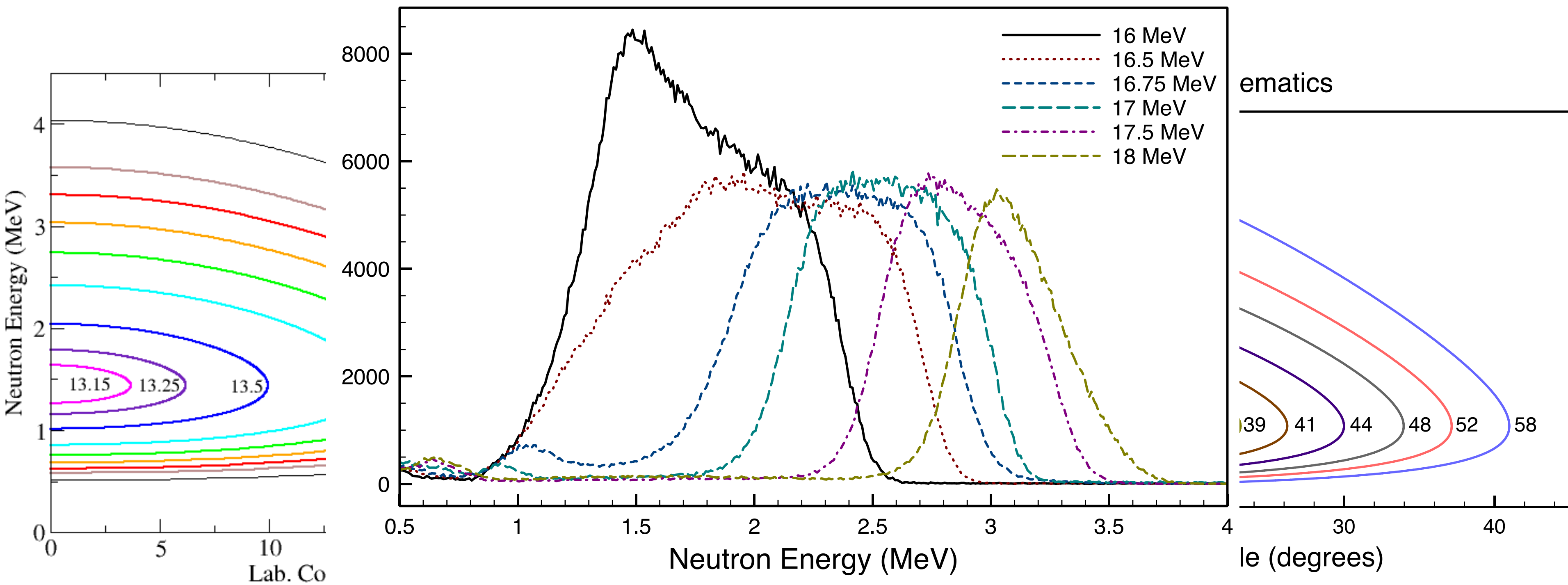
- from **H, ^{3}He, ^{4}He, ..., ^{14}C, ...** up to **^{127}I**
- terminal voltage: from **< 1 MV** up to **14.5 MV**
- beam pulsing: pulse width **1 – 2 ns**; repetition rate – **200 ns** or more
- **new ions source** purchased for higher intensity of difficult beams (Mg, Ca)

The ALTO Facility: neutron beam



Intensely focused monoenergetic neutron source:
10^7 n/s/steradian

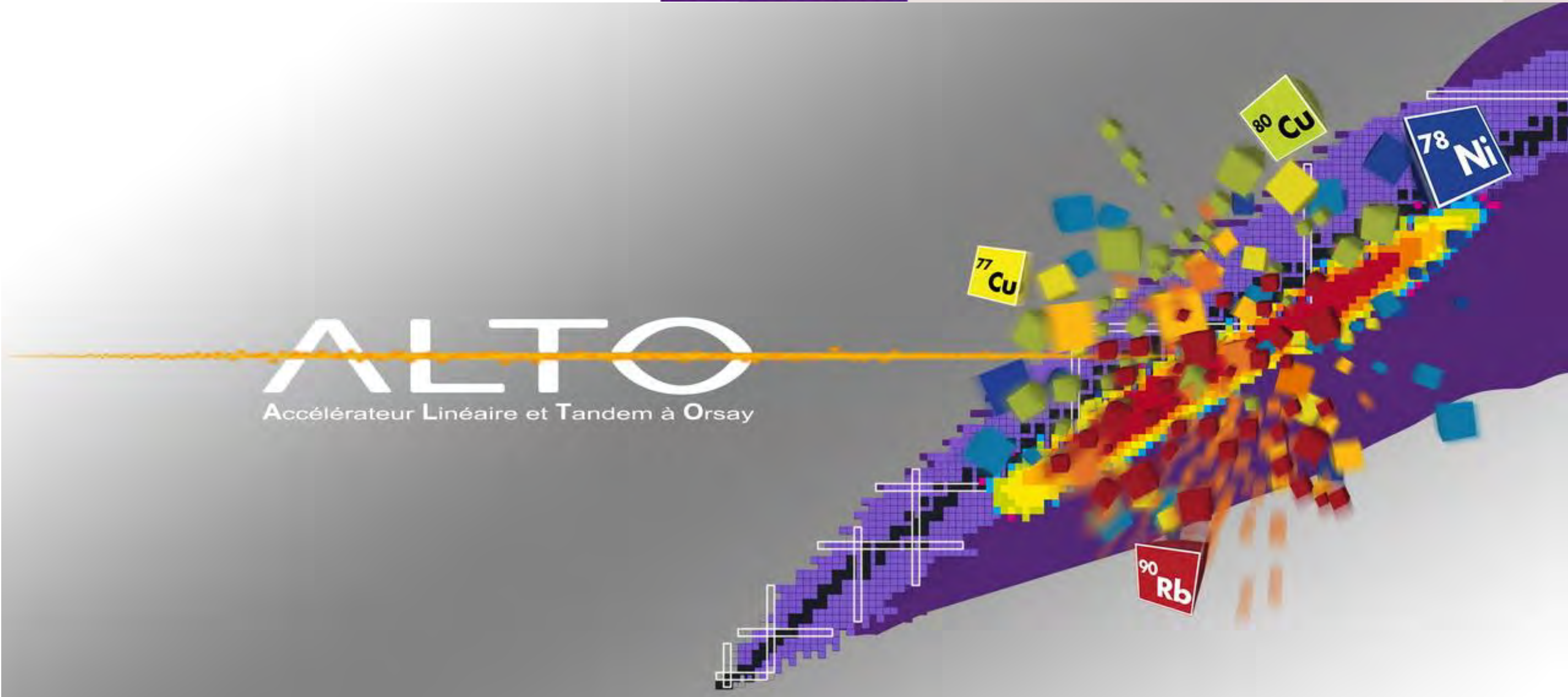
E_n=0.5 – 4 MeV



ALTO Activity (2016-20)

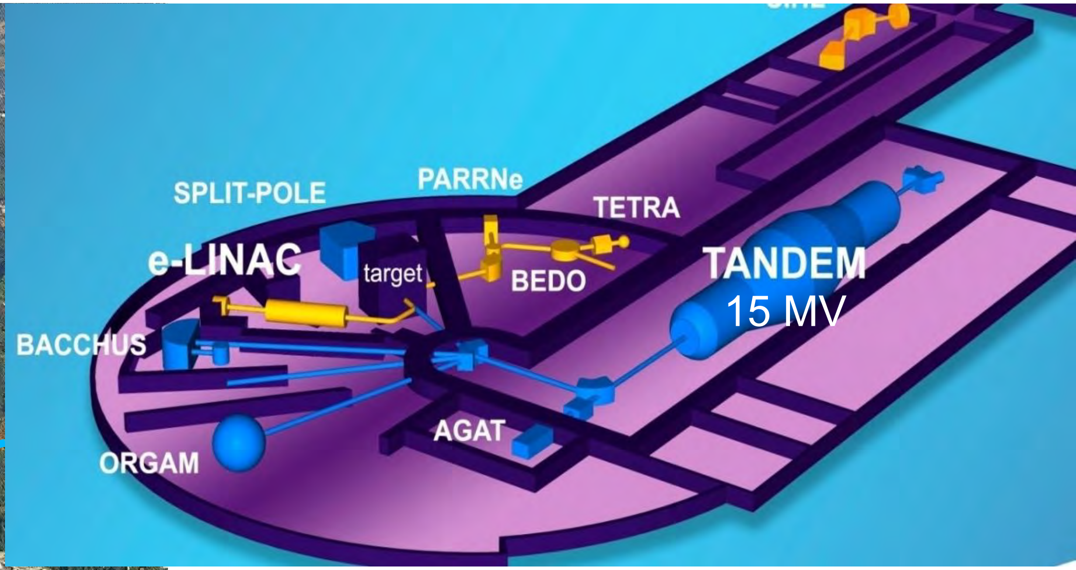
IJCLab Irène Joliot-Curie
Laboratoire de Physique des 2 Infinis

ALTO
Accélérateur Linéaire et Tandem à Orsay



CS IN2P3 Plateformes, 25&26 février 2020

The ALTO facility: WP20 in ENSAR2 H2020 European program

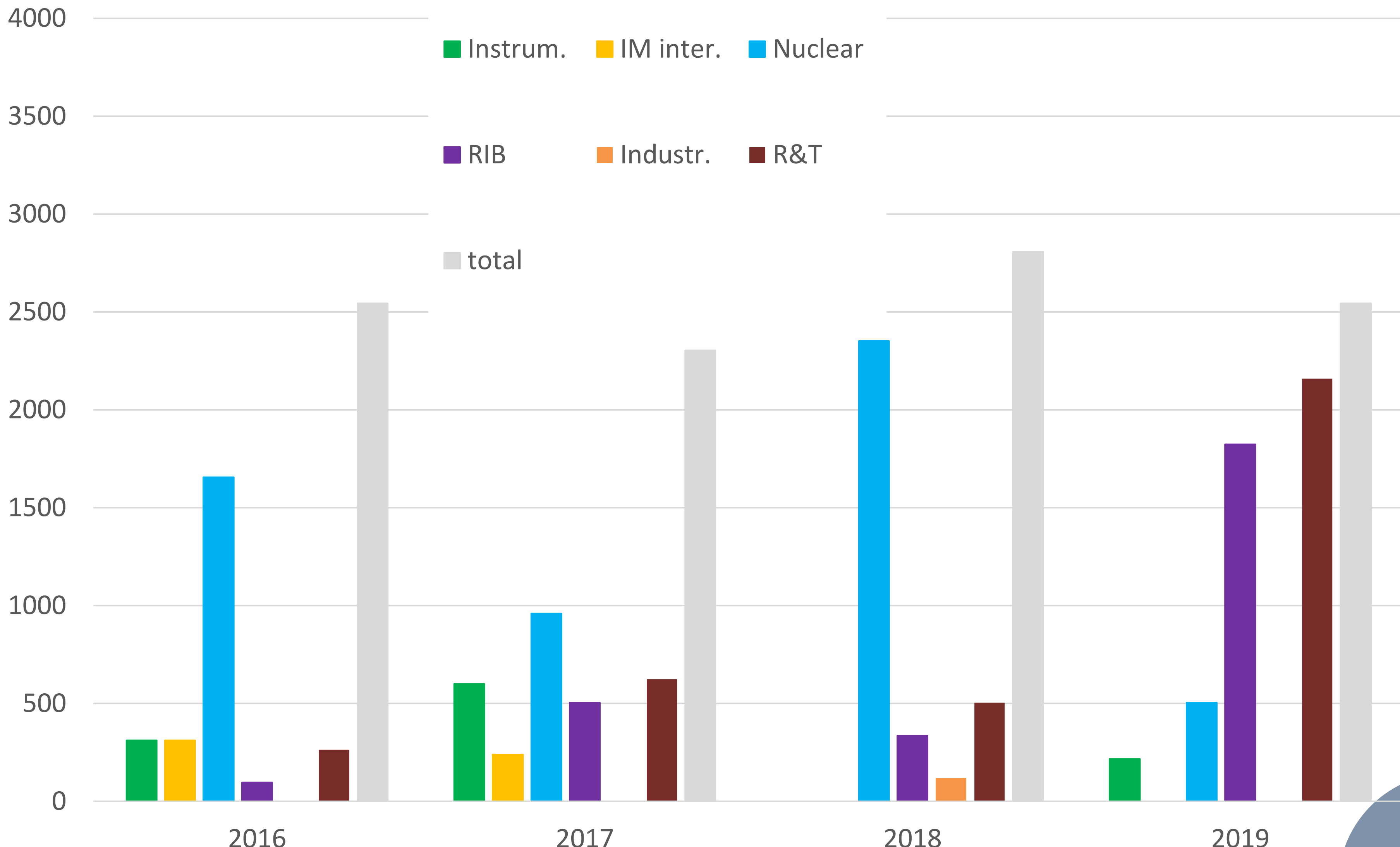


	2016	2017	2018	2019
Users	**200**	**113**	**165**	**60**
Beam-time	**2544h**	**2300h**	**3384h**	**2532h**
		1896h	1848h	1584h

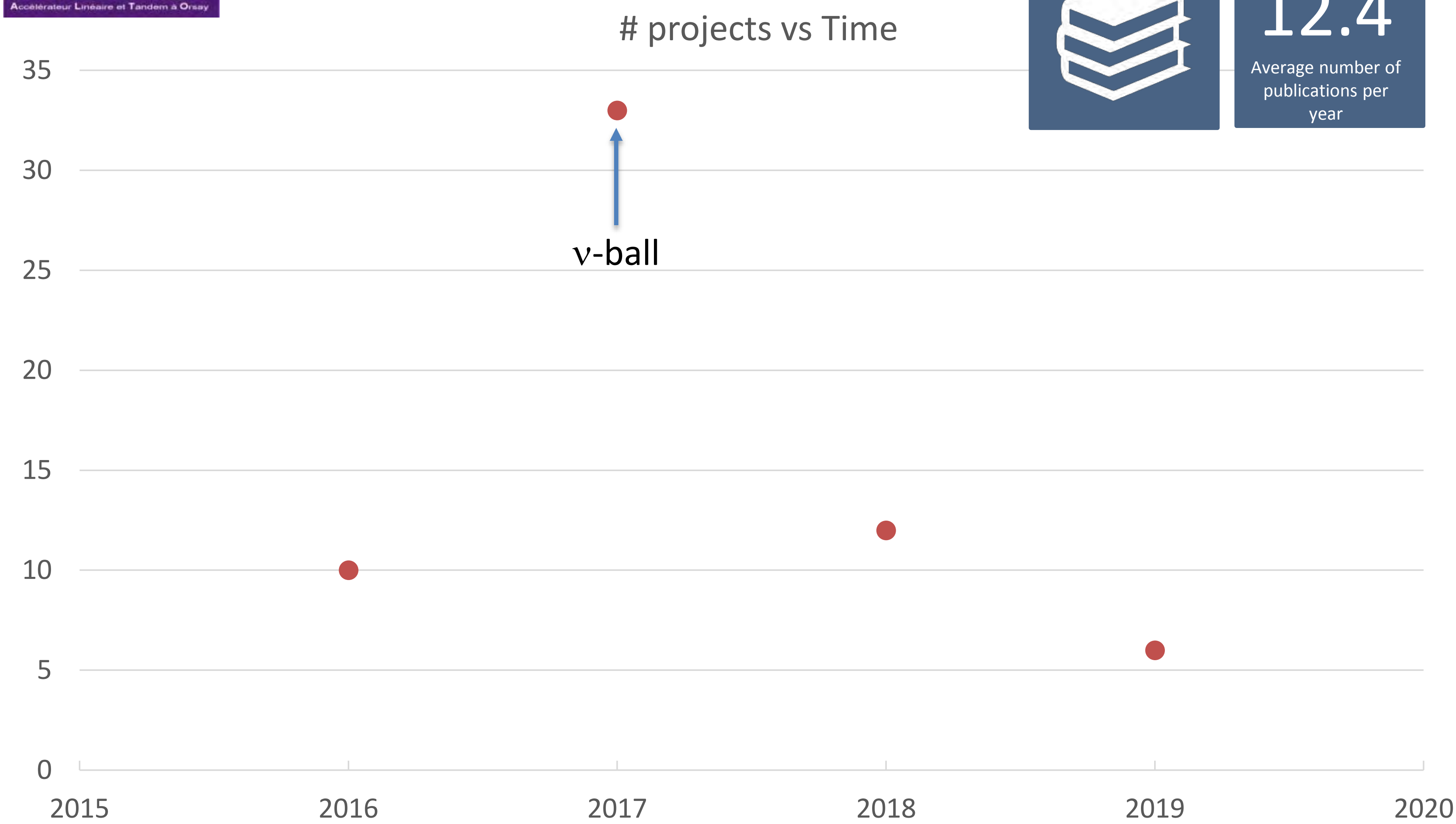
ENSAR2

DELIVERABLES: # Beam hours: 5088/2539, # Users : 99/108, # project: 18/30

ALTO Beam Time distribution (2016-2019)

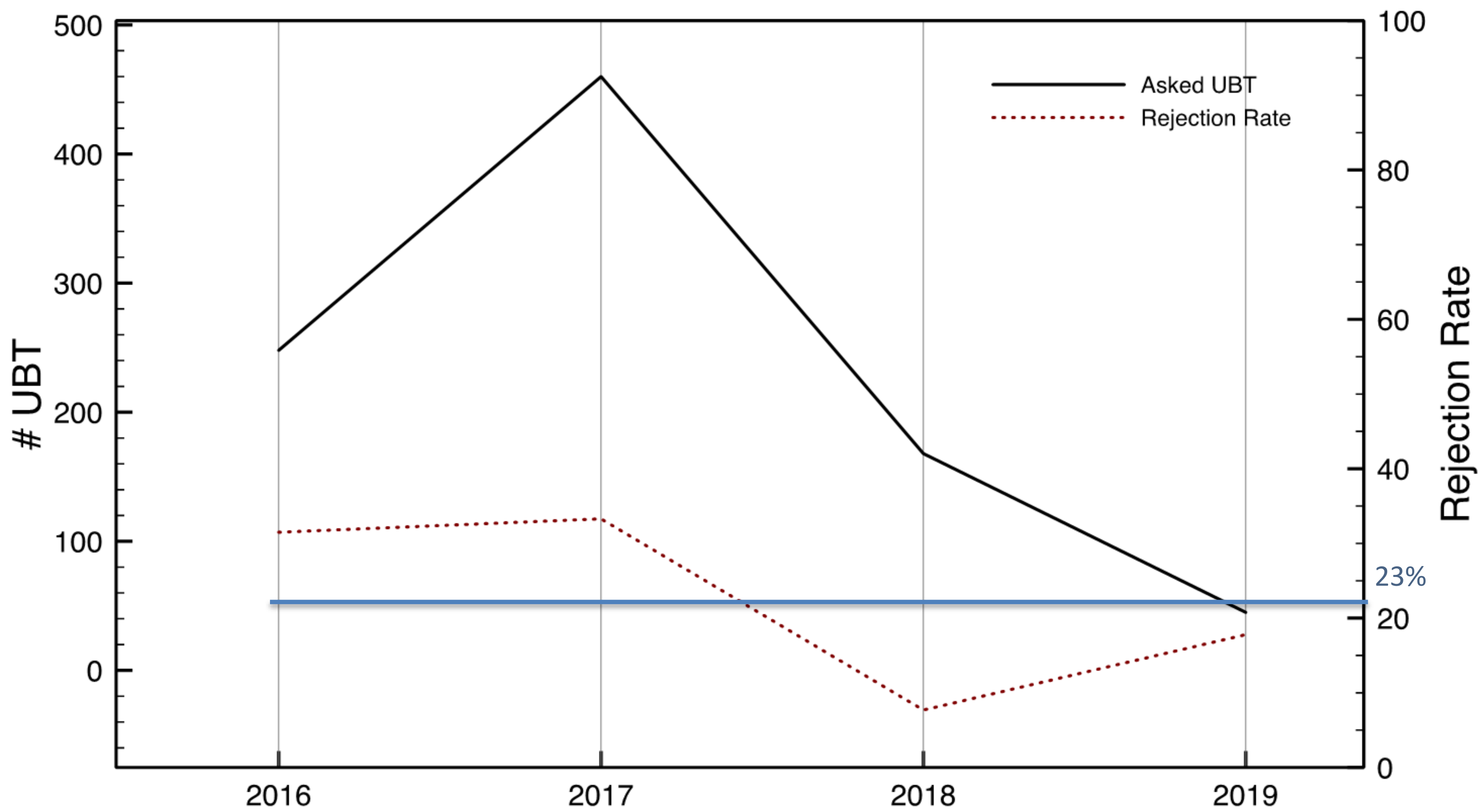


ALTO PAC #of projects



12.4
Average number of publications per year

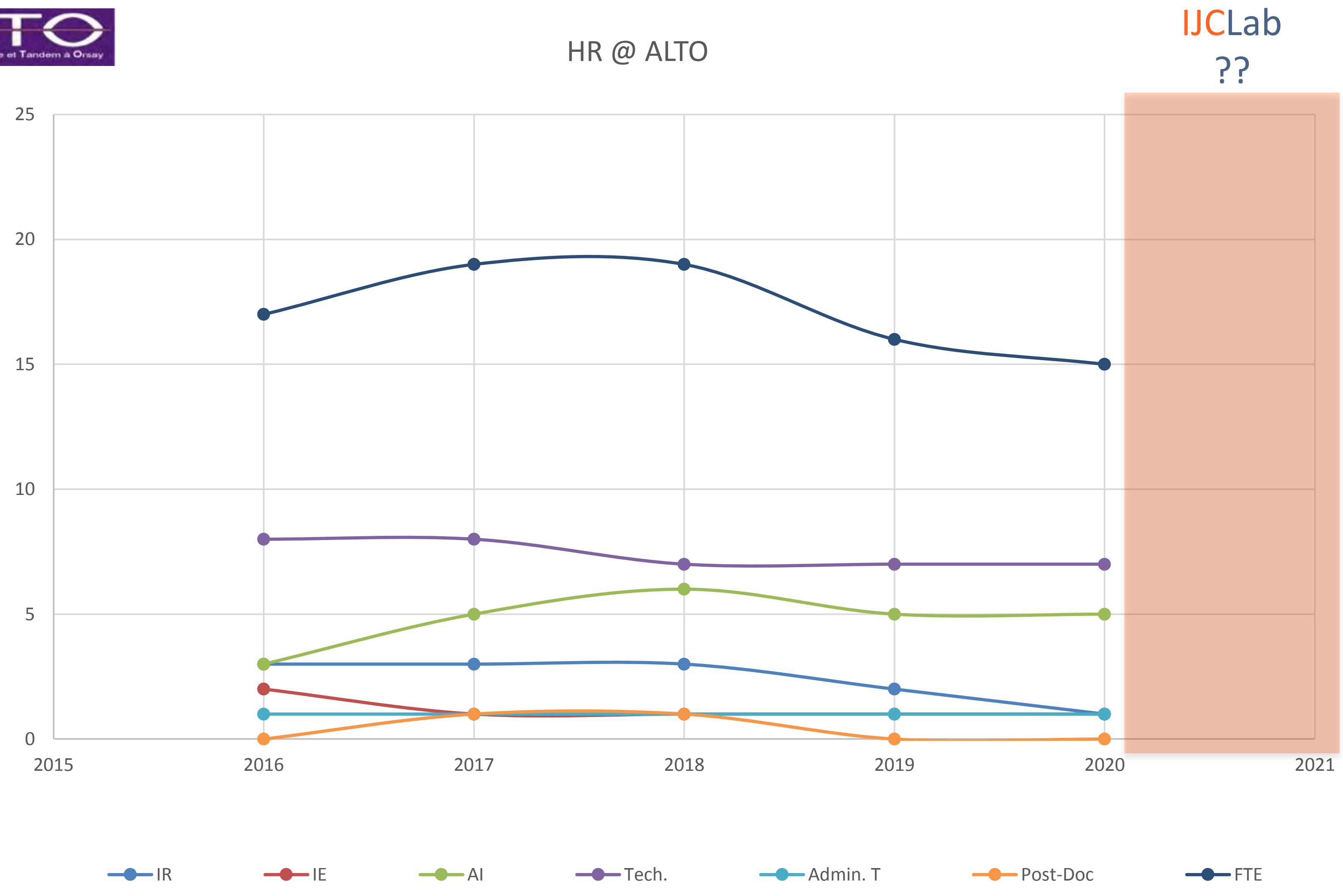
ALTO PAC # of UBT vs Beam Pressure



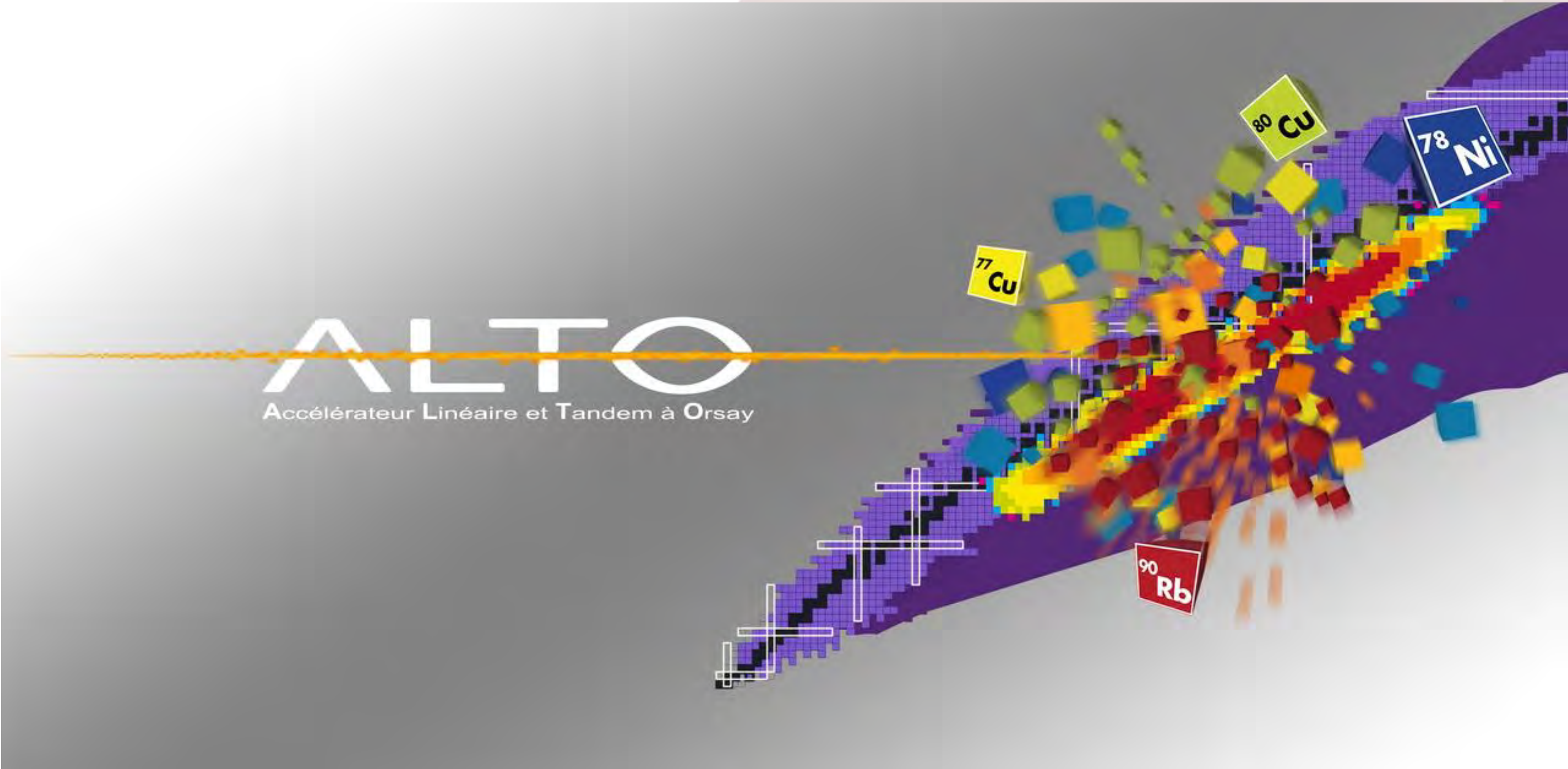
ALTO Budget 2016-2019 (k€)

	2016	2017	2018	2019	2020
Running Costs					
IN2P3 dotation (M&O)	202	175	160	205	145
RP					
IPNO (labo)	12	29	32	26	74
ALTO	20	18	37,5	8	
Europe (ENSAR2, CHANDA)	50	50	50	95	71
Running Costs Total:	284	272	279,5	334	290
IN2P3 Master Projects					TBA
ISOL	149,5	84	128,4	46	
Tandem	23,5	102	103,5	35	
Space-ALTO					40
T&S			15	30	
IN2P3 Master Projects Total:	173	186	246,9	111	40
Total IN2P3:	375	361	406,9	316	
Other Sources					
ISOL (Labex P2IO+ SESAME & UPSud in 2018)	43,75	43,75	649,95	43,75	
Tandem					
TOTAL:	500,75	501,75	1176,35	488,75	330

ALTO Human Ressources 2016-2019



ALTO: Scientific Highlights
Stable beams



Particle decay branching ratios for states of astrophysical importance in ^{19}Ne

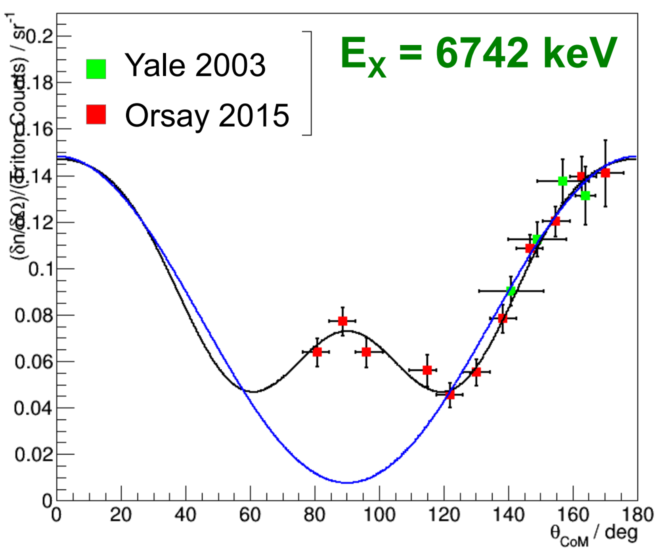
- States in ^{19}Ne above ^{15}O+α and ^{18}F+p thresholds play an important role in explosive H-burning.
- Energetics in X-ray bursts [^{15}O(α,γ)^{19}Ne] & γ-ray emission in classical novae [^{18}F(p,α)^{15}O].
- Reaction rate has a linear dependance to branching ratios (BR).

Split-Pole $\Delta E/E \sim 10^{-4}$

E(^{3}He) = 25 MeV
I(^{3}He) ~ 70 enA
CaF_2 ~ 200 μg/cm²
Θ_{SP} = 10°

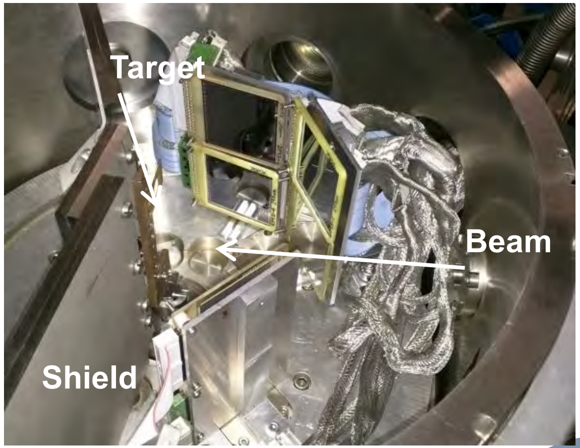
→ coincidence measurement of **^{19}F(^{3}He,t)^{19}Ne*(α|p)** with Split-Pole and a DSSSD array

t-α angular correlation



- Smaller binning (higher statistics)
- Better c.m. angular coverage toward 90°

→ **better BR determination**



J. Riley, A. M. Laird, N. de Séréville, A. Parikh et al.

Nuclear astrophysics studies with the Split-Pole magnetic spectrograph: near future

1 – PhD defense of A. Meyer jan. 2020

2 – Rejuvenation of detection (focal plane,…)

3 – Gas cell development for a new target to increase the range of possible transfer reaction with an astrophysical interest.

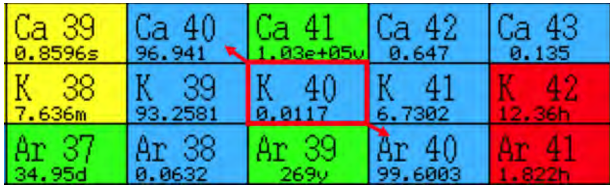
4 – Commissioning of the gas cell

5 – Needs to work on the articulation with RIB production (same experimental cave 210)

Determining the $^{39}K(n,p)^{39}Ar$ and $^{39}K(n,\alpha)^{36}Cl$ cross-sections with the LICORNE neutron source

Laboratoire de Physique des 2 Infinis

Potassium is a major element in many silicate minerals of the earth crust



decay

- Decay of ^{40}K -> ^{40}Ar ($T_{1/2}$ = 1.25 Ga)
- Mineral acting as closed system, accumulating ^{40}Ar

activation

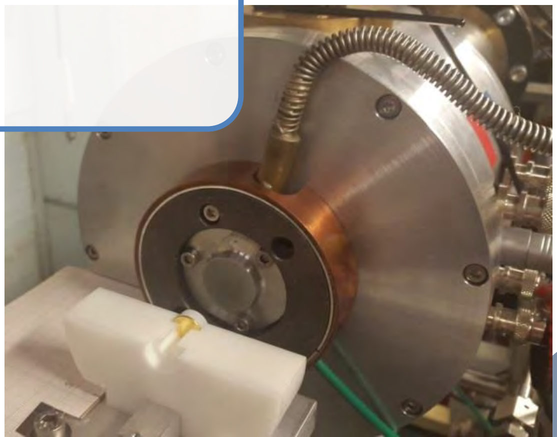
- Activation of $^{39}K(n,p)^{39}Ar$ in a fission reactor
- With a stable $^{39}K/^{40}K$ ratio, the ^{39}Ar represents K content

analysis

- Noble gas mass spectrometry: $^{40}Ar/^{39}Ar$

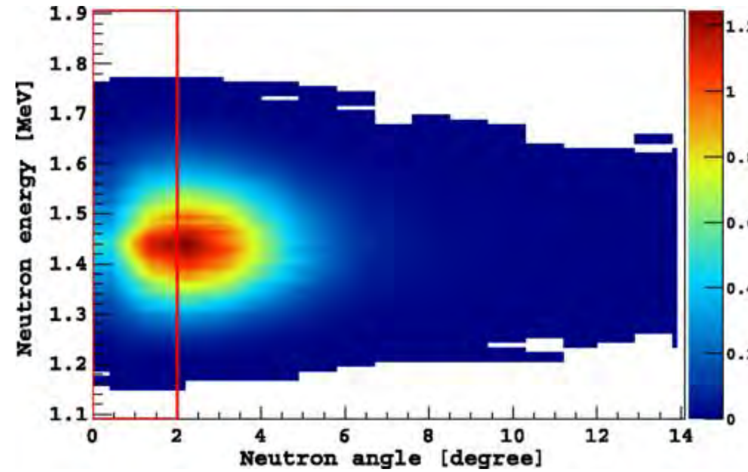
Age of the mineral

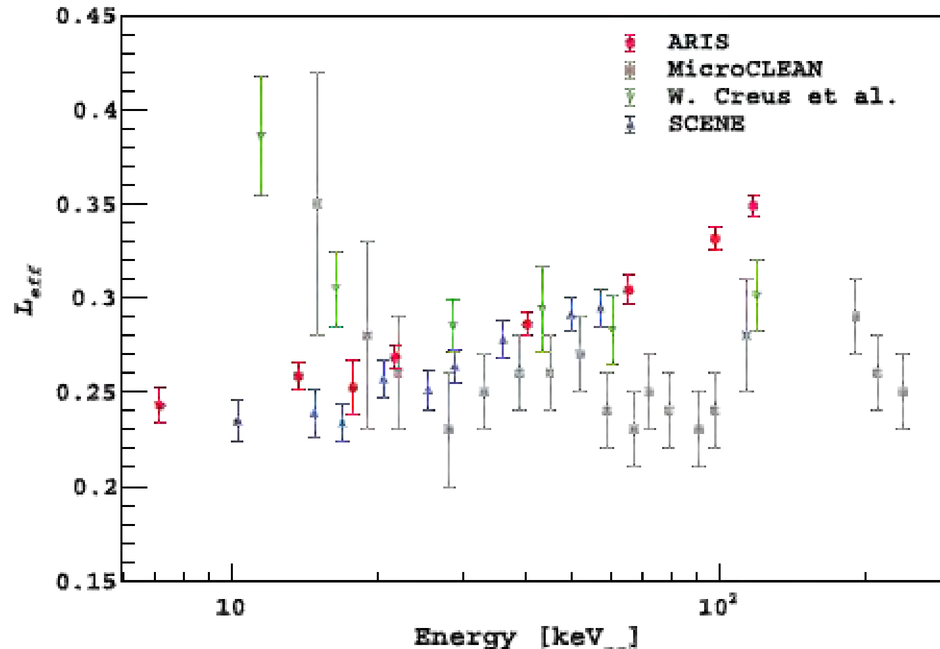
Rutte *et al.*, *Sci. Adv.* 2019;**5**:eaaw5526



Measurement of the liquid argon energy response to nuclear and electronic recoils

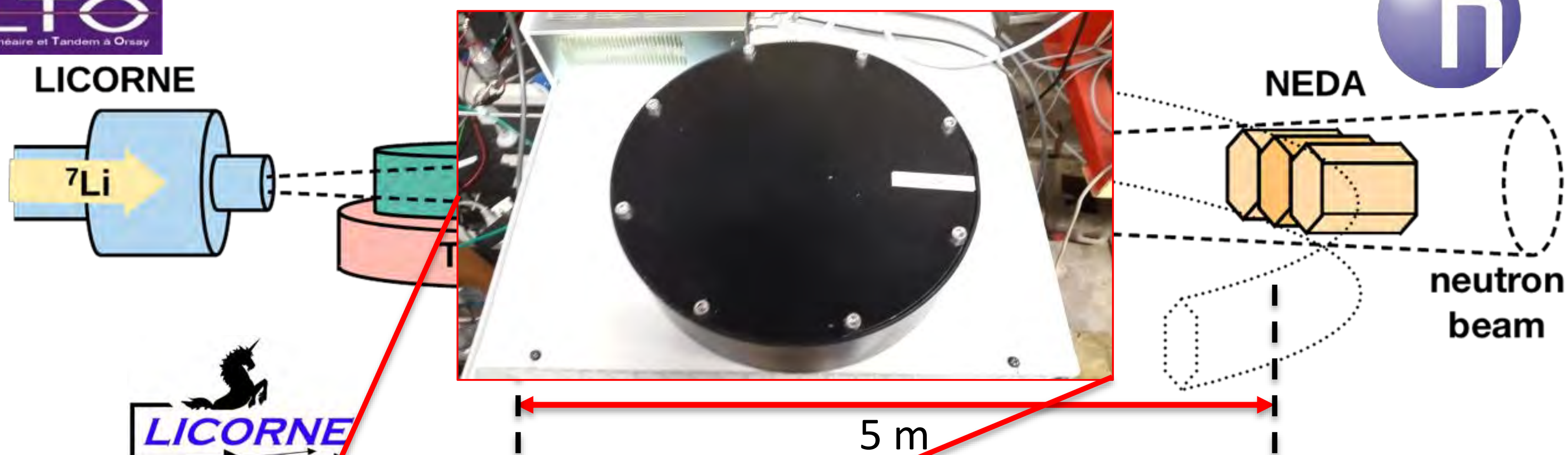
P. Agnes *et al.* (The ARIS Collaboration), Phys. Rev. D **97**, 112005 (2018)

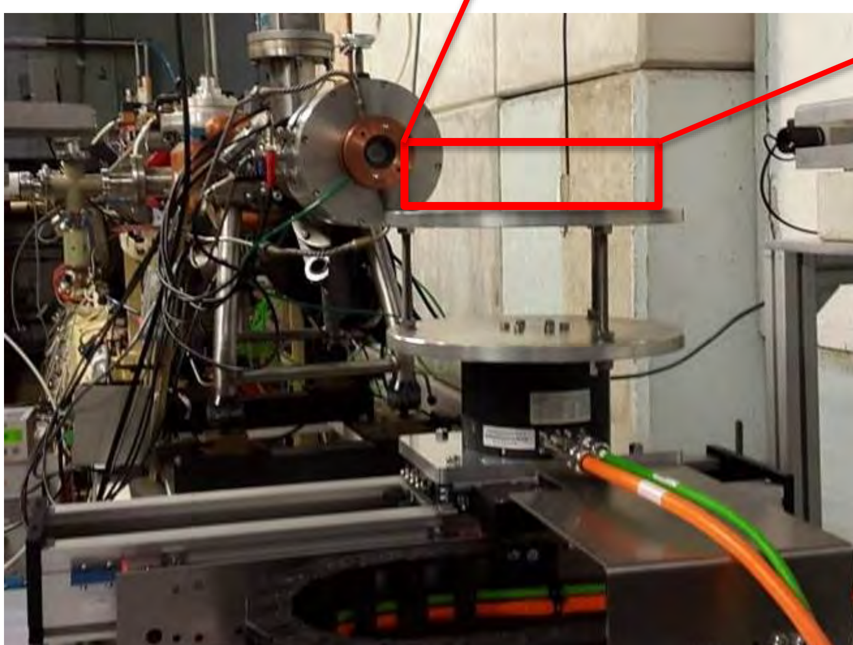




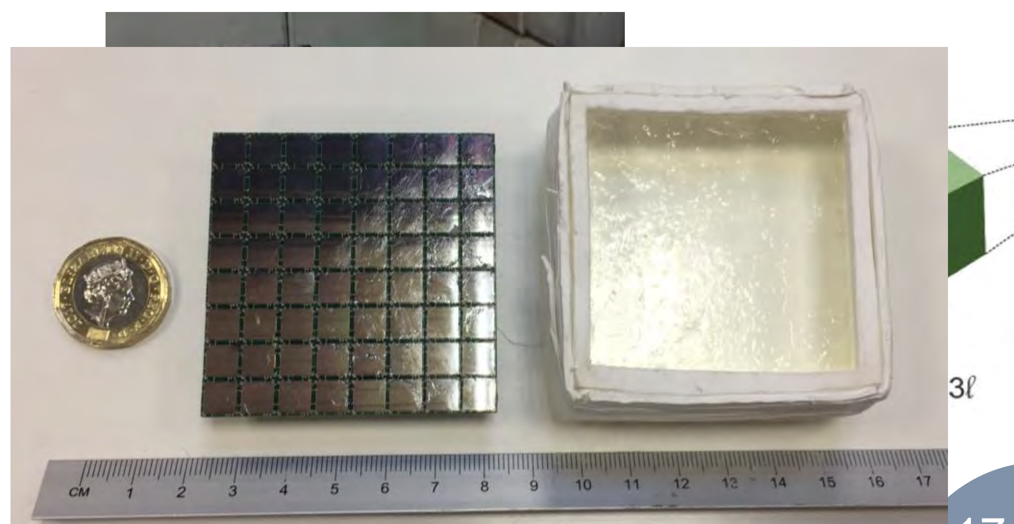
- Response to 1.5MeV Neutrons
- Mesure of very low energy recoil to test sensitivity

Fast Neutron Tomography with LICORNE and NEDA (dec. 2017/June 2019)



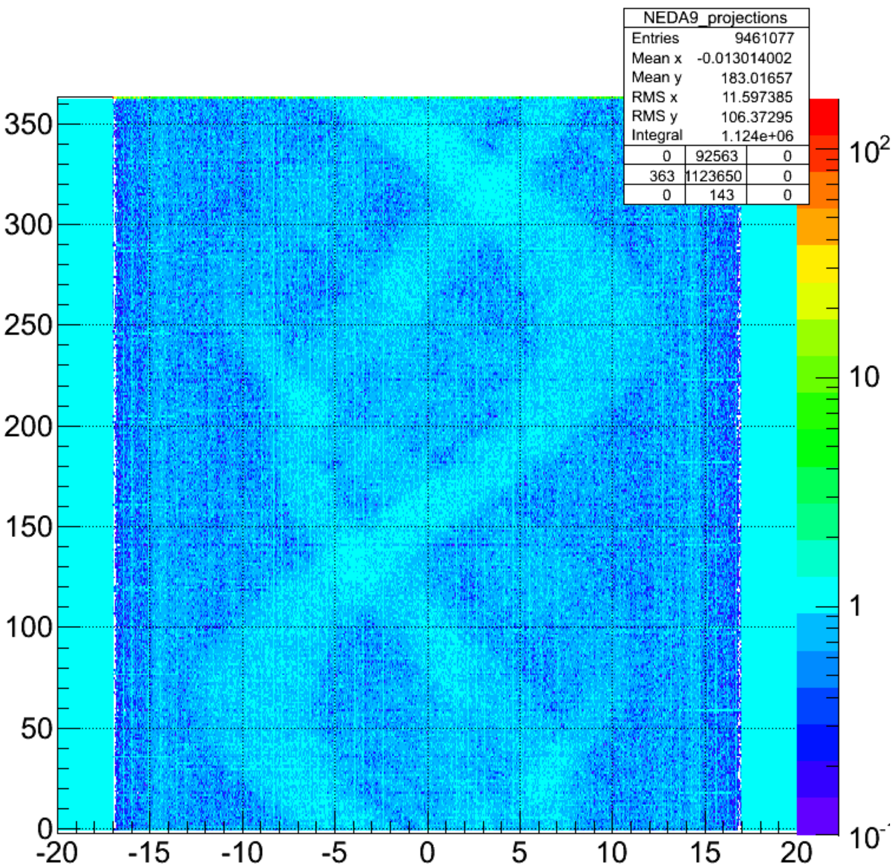


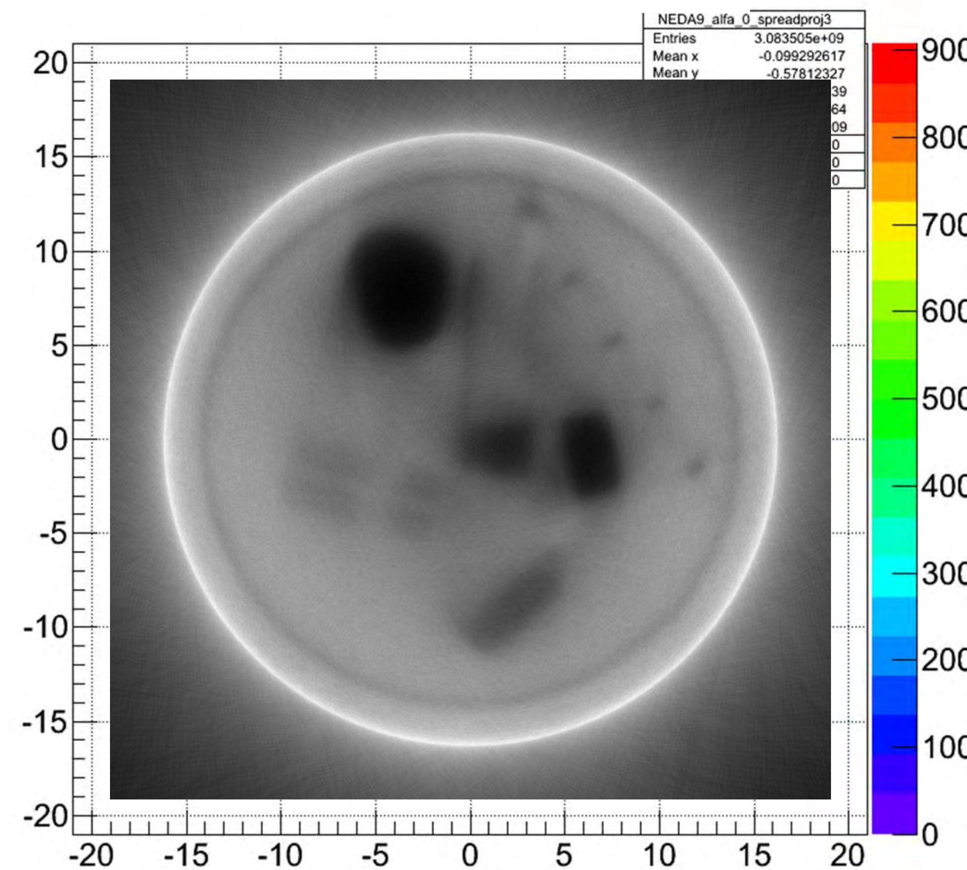
1st Use of **NEDA** with FASTER



Fast Neutron Tomography with LICORNE and NEDA (dec. 2016/June 2019)

Neutron Beam Attenuation measurement





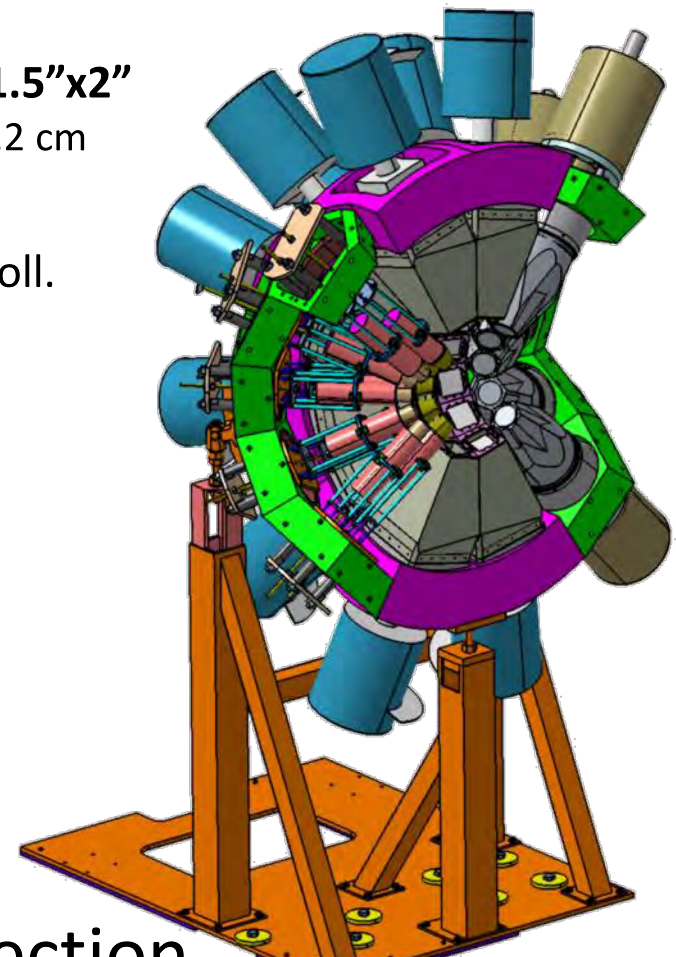
ν-ball: hybrid $LaBr_3$-Ge array for fast timing spectroscopic studies

M. Lebois et al., *Nucl. Inst. Meth. A, (2020), 10.1016/j.nima.2020.&63580*

24 Clovers around 90°
d_{center} = 20.88 cm
$\Delta\theta$ = 10.35°

10 PhaseI HPGe
d_{center} = 18 cm
$\Delta\theta$ = 20.1°
Loan Pool

20 $LaBr_3$ 1.5”x2”
d_{center} = 15.2 cm
$\Delta\theta$ = 14.3°
FATIMA Coll.
NPL Loan



- Hybrid spectrometer Ge/LaBr
- “FASTER” Digital DAQ
  - 184-200 *Independant* Channels (*Triggerless* mode)
  - 500 Ms/s, 12 effective bits QDC for LaBr3
  - 125 Ms/s, 14 effective bits ADC for HPGe and BGO
- Coupling with neutron source
- Coupling with
- Calorimetry for mechanism selection
- Pulsed beam (2 ns width 400 ns period)

nu – ball

The ν-ball campaign: the experiment list

Heavy Ion Reaction γ spectroscopy:

- Half-life measurement and isomer spectroscopy in the neutron rich deformed nucleus ^{166}Dy *(M. Rudigier et al., Phys. Lett. B, **801**, 135140; + 1 PRC accepted)*
- Electromagnetic transition rates in the nucleus ^{136}Ce
- Pinning down the structure of ^{66}Ni by 2n- and 2p-Heavy-Ion transfer reactions and g-factor measurement
- A study on the transition between seniority-type and collectivity excitations in the YRAST 4^+ state of ^{206}Po
- Measurement of the super-allowed branching ratio of ^{10}C *(release date June)*
- Feeding of low-energy structures of different deformations by the GDR decay: the nuBall array coupled to PARIS *(Analysis going on)*

PARIS

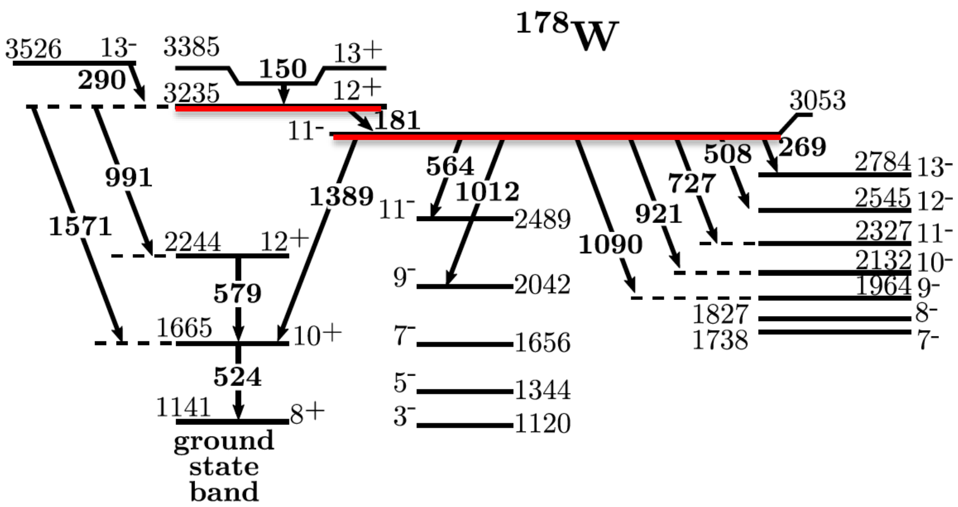
Neutron induced reaction γ spectroscopy:

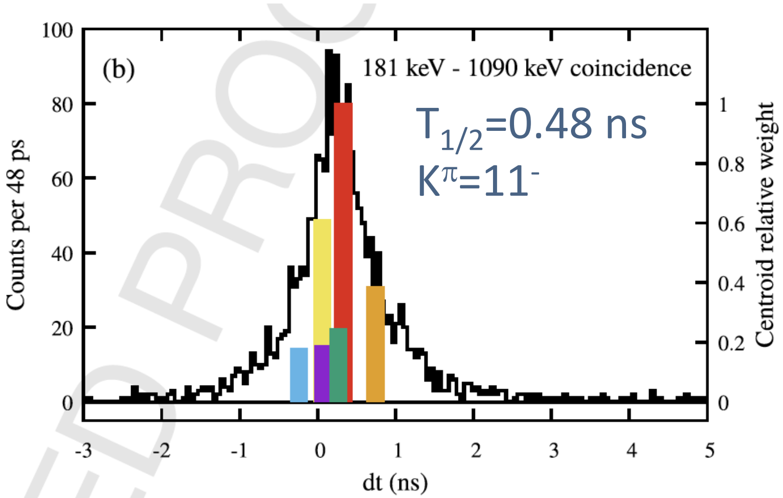
- Spectroscopy of the neutron-rich fission fragments produced in the ^{238}U(n,f) and ^{232}Th(n,f) reactions *(major results coming soon)*
- Spectroscopy above the shape isomer in ^{238}U

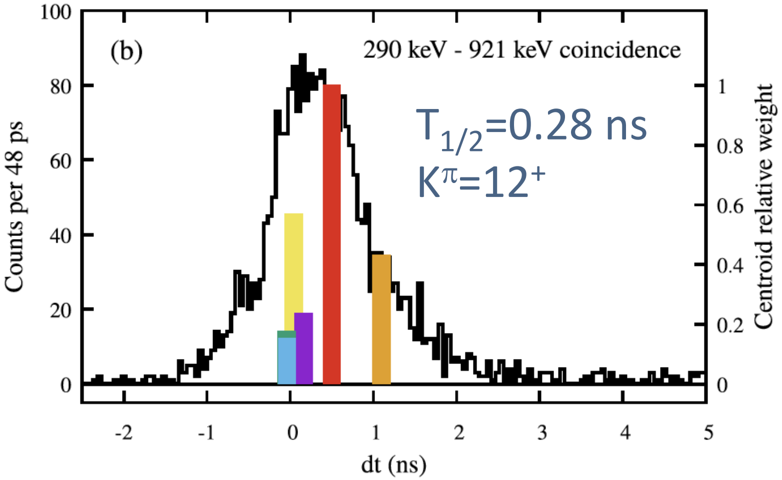
LICORNE

Muti-quasiparticle sub-nanosecond isomers in ^{178}W

*M. Rudigier et al., Phys. Lett. B, **801**, 135140*





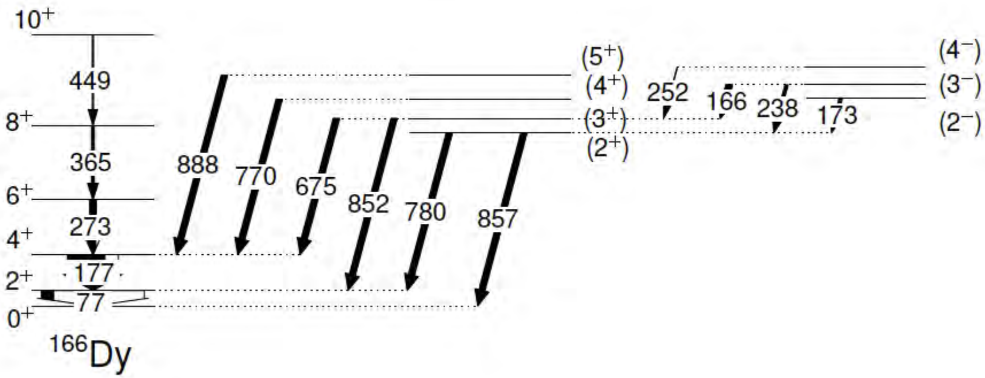


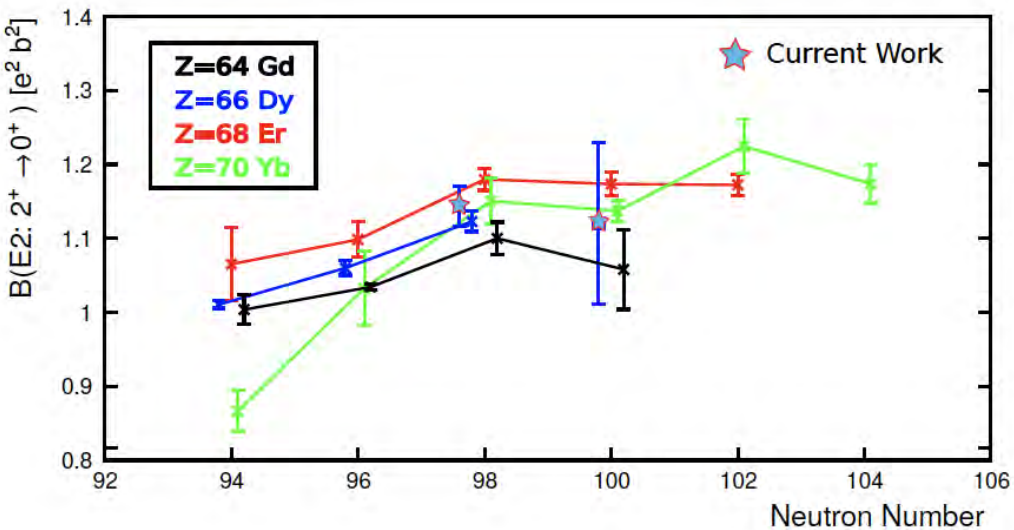
- 1st fast timing measurement with n-ball
- < ns measurement
- 4 qp isomers.

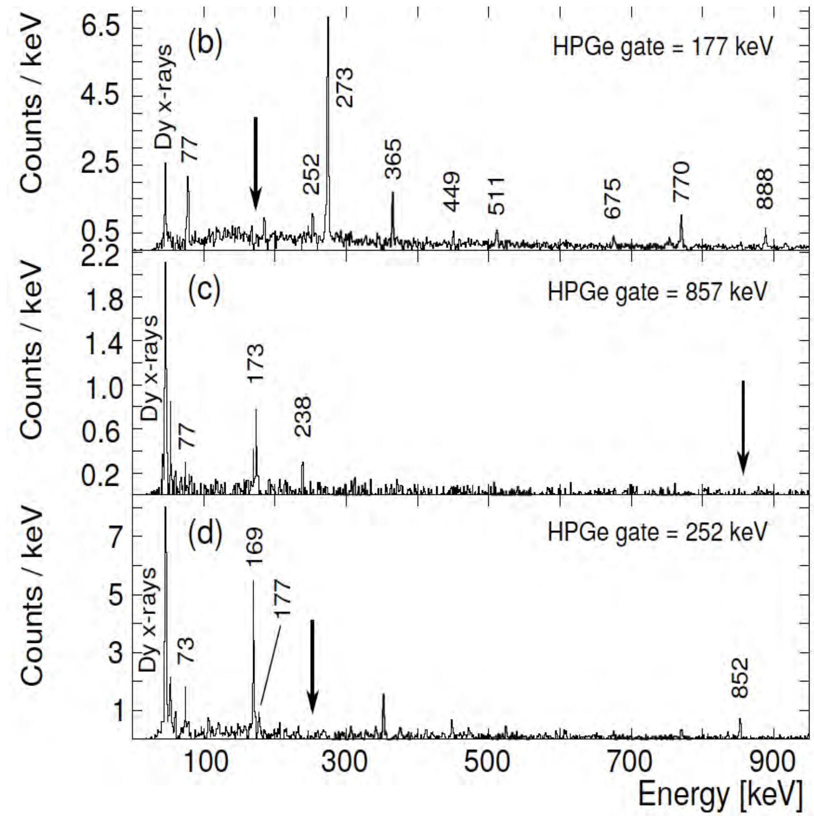
Half-life measurement and isomer spectroscopy in the neutron rich deformed nucleus ^{166}Dy

R. Canavan et al., Phys. Rev. C, accepted

Measure of 2_1^+ lifetime to get information on the deformation *via* ^{164}Dy(^{18}O,^{16}O)^{166}Dy reaction



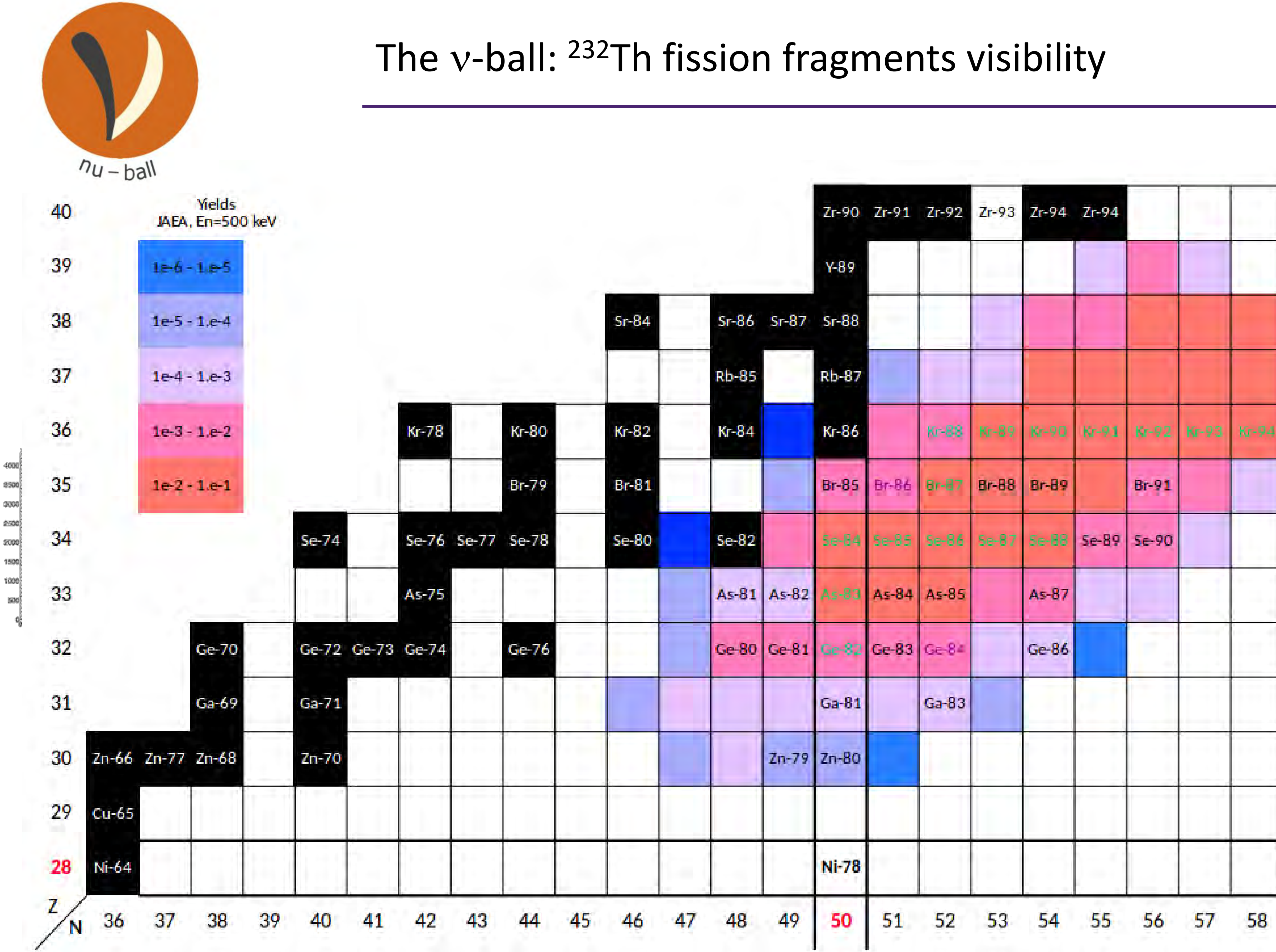




$T_{1/2}$ = 2.3(2) ns for 2_1^+

Q_0 = 7.58(9) eb quadrupole moment

The ν-ball: ^{232}Th fission fragments visibility



The ν-ball international collaboration

153 researchers from 16 different countries, 37 institutes, including ~80 thesis students

UK(29)
University of Surrey (13)
National Physical Laboratory (5)
University of Brighton (2)
University of West Scotland (4)
University of Manchester (3)
University of York (2)

Germany(16)
TU Darmstadt (7)
IFK- Koln (9)

Poland(14)
IFJ-PAN Krakow (8)
University of Warsaw (6)

South Africa(1)
iThemba (1)

Belgium(4)
JRC-Geel (3)
Leuven (1)

France(44)
IPN Orsay (16)
CSNSM Orsay (6)
CEA DAM/CEA Saclay (5)
Subatech, Nantes (3)
CENBG Bordeaux (6)
IPHC Strasbourg (3)
GANIL (2)
LPC Caen (2)
ILL (1)

Japan(1)
Riken(1)

Spain(6)
Madrid (4)
IFIC Valencia (2)

Serbia(2)
University of Novi Sad (1)
University of Belgrade (1)

nu – ball

Finland(2)
Jyvaskyla(2)

Norway(6)
University of Oslo (6)

Italy(8)
University of Milano(6)
University of Padova(1)
Legnaro(1)

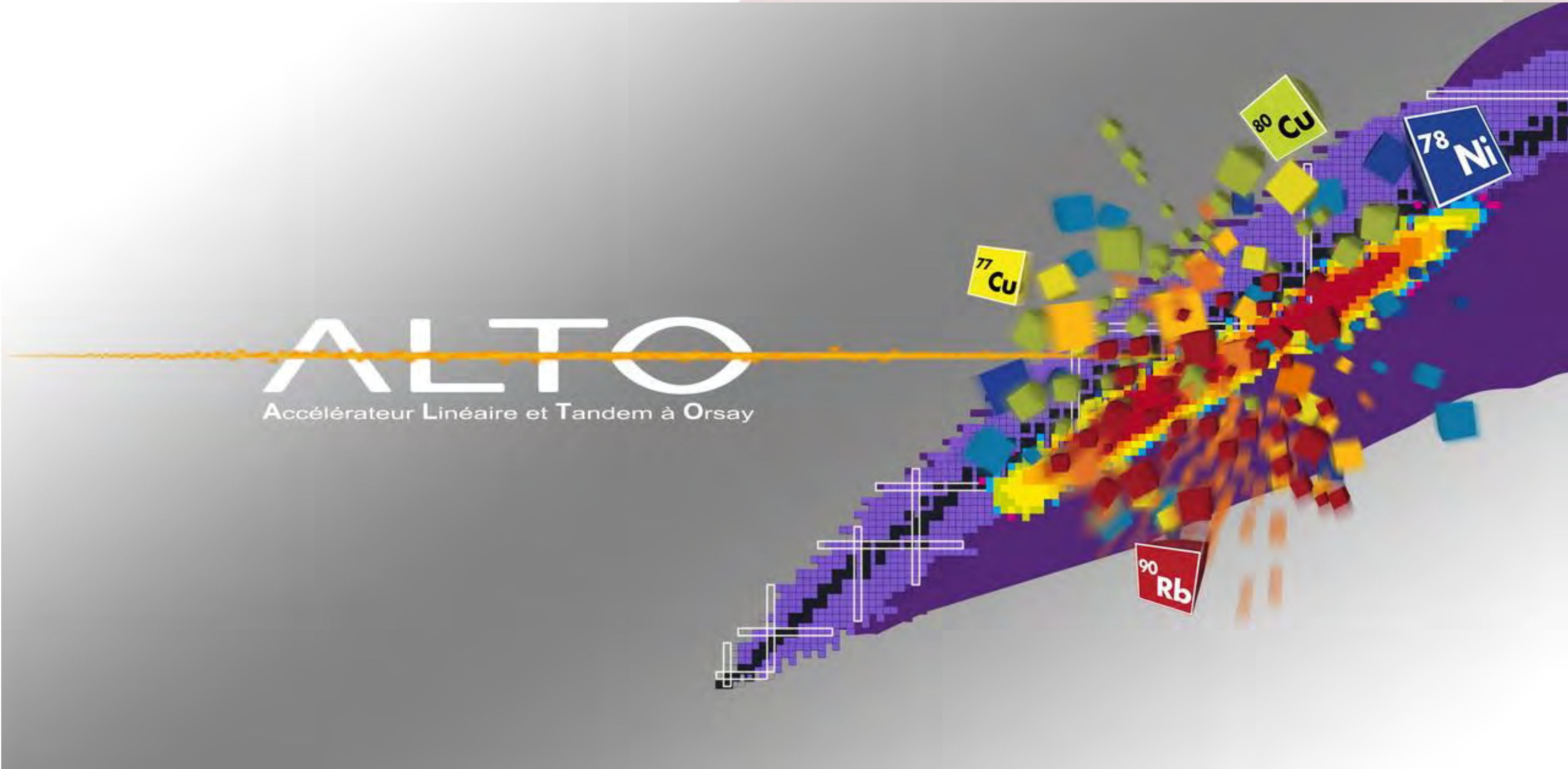
India(1)
Tata Institute (1)

Canada(4)
University of Guelph (4)

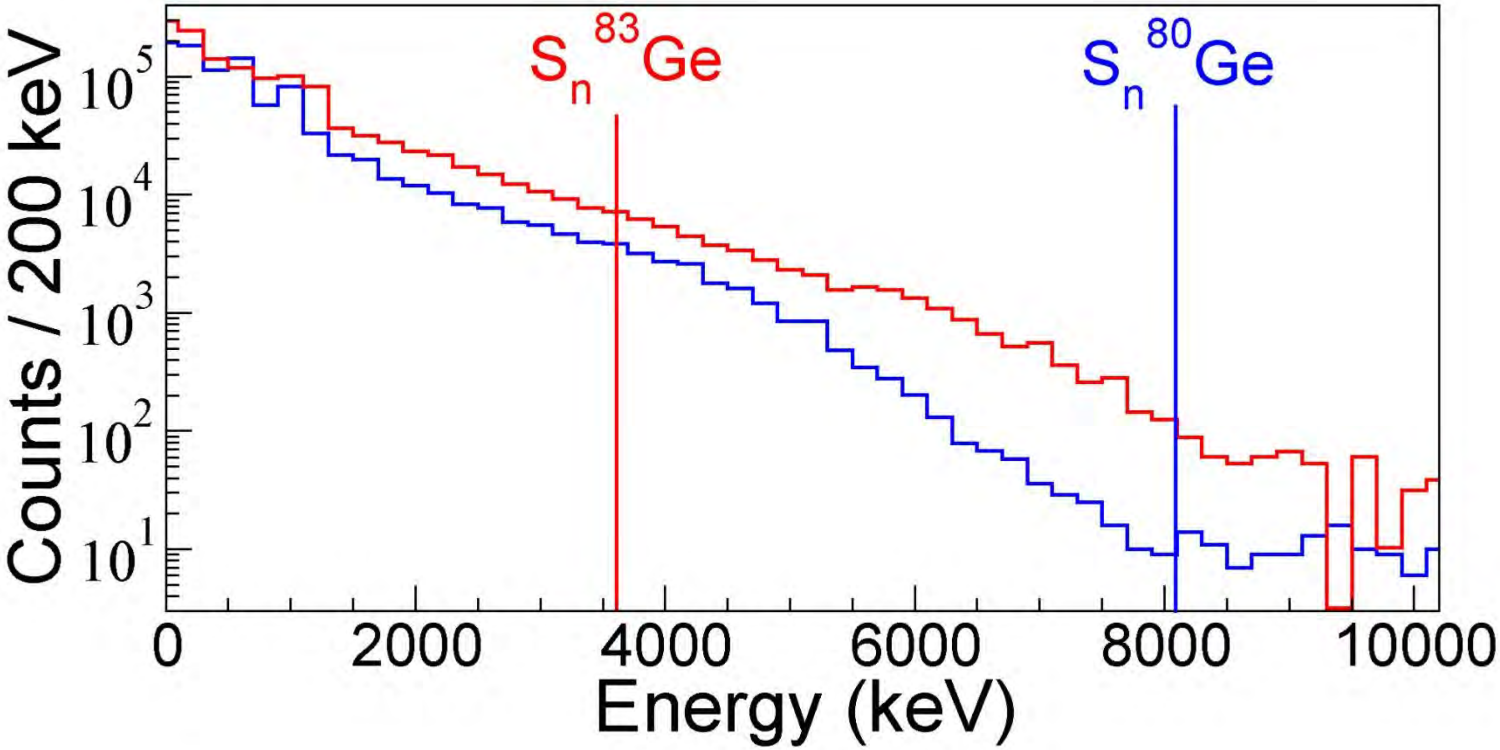
Romania(7)
IFIN-HH, Bucharest (1)
ELI-NP, Bucharest (6)

Bulgaria(8)
University of Sofia (8)

ALTO: Scientific Highlights
Radioactive beams



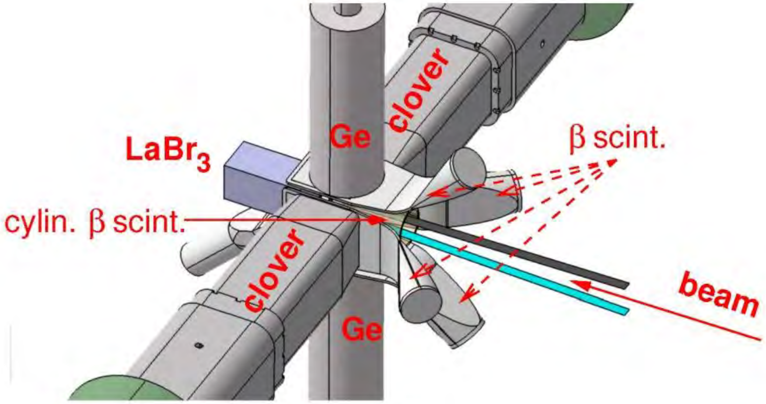
^{83}Ga - ^{80}Ga beta decay: the high energy emission



^{83}Ga → ^{83}Ge (15-40%), ^{82}Ge (85-60%)

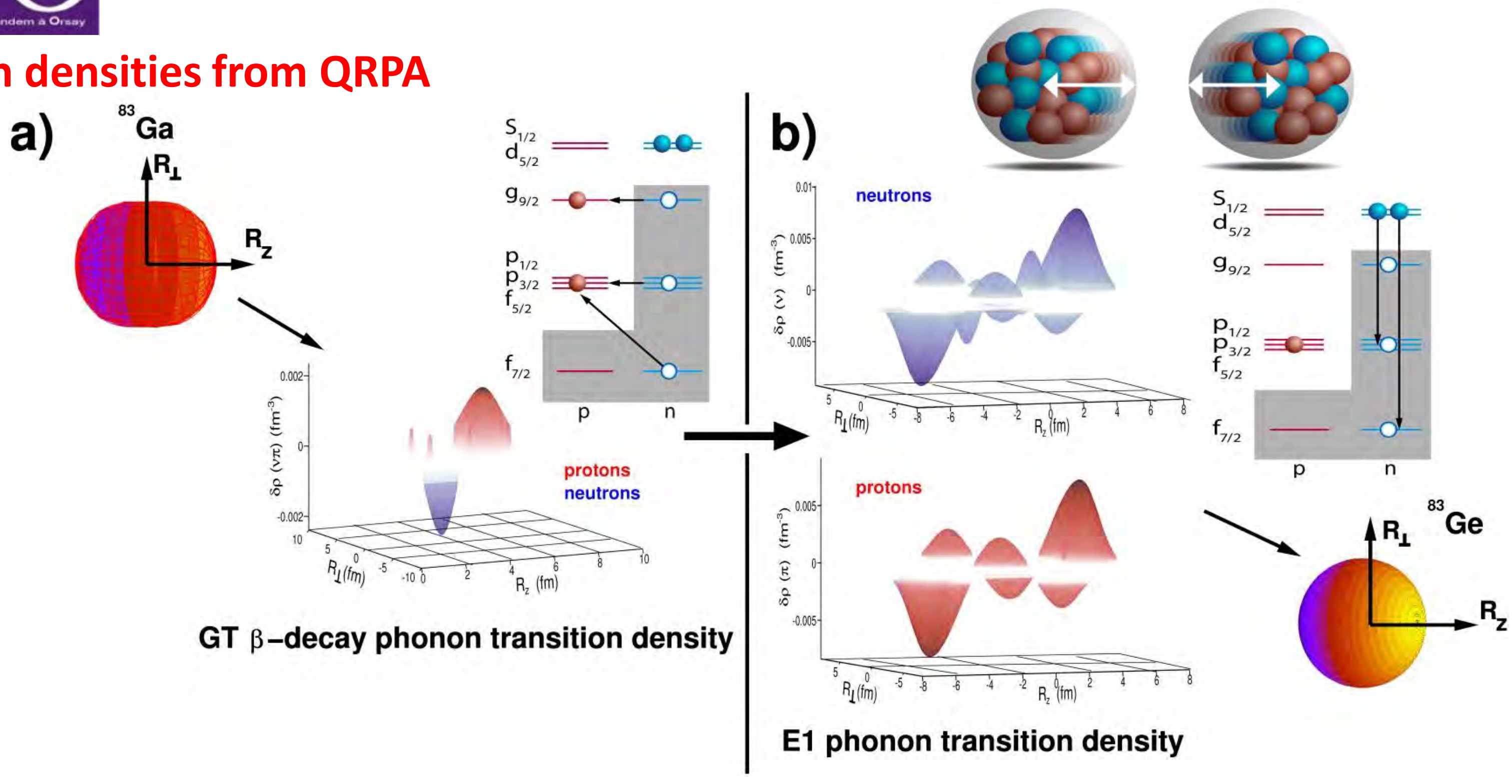
^{80}Ga → ^{80}Ge (98%), ^{79}Ge (2%)

BEDO setup with large $LaBr_3$



^{83}Ga: can GT trigger low-lying nuclear dipole oscillations ?

Transition densities from QRPA



a) GT decay create a depletion of neutron density in the core; adds a proton on the surface

b) The excited ^{83}Ge states can then decay via E1 γ emission with a «PDR-like» transition density

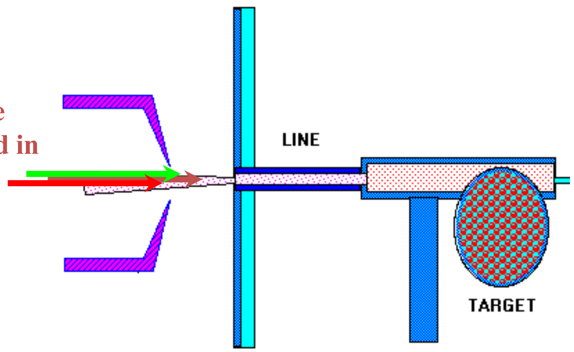
A. Gottardo, D. Verney et al., Phys. Lett. B 772C (2017) pp. 359-362

Radioactive In beam for P_n measurement in the ^{132}Sn region

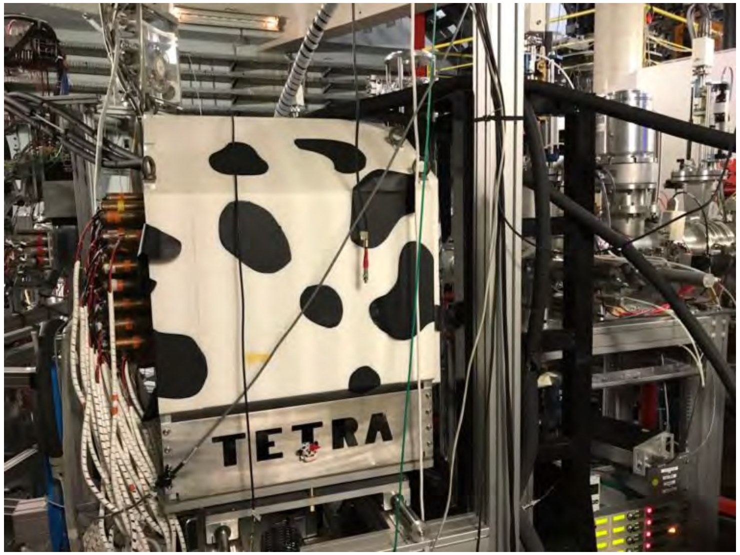
Uranium fission

Neutron rich radioactive nuclei beams well separated in mass A

LASER ION SOURCE



Beams of high purity and high selectivity



Nov. 2018

Study of the ^{132}Sn neighborhood:

^{132}In : ~10^3 pps

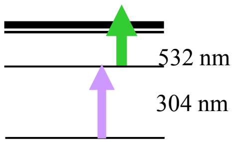
^{133}In : ~10^2 pps

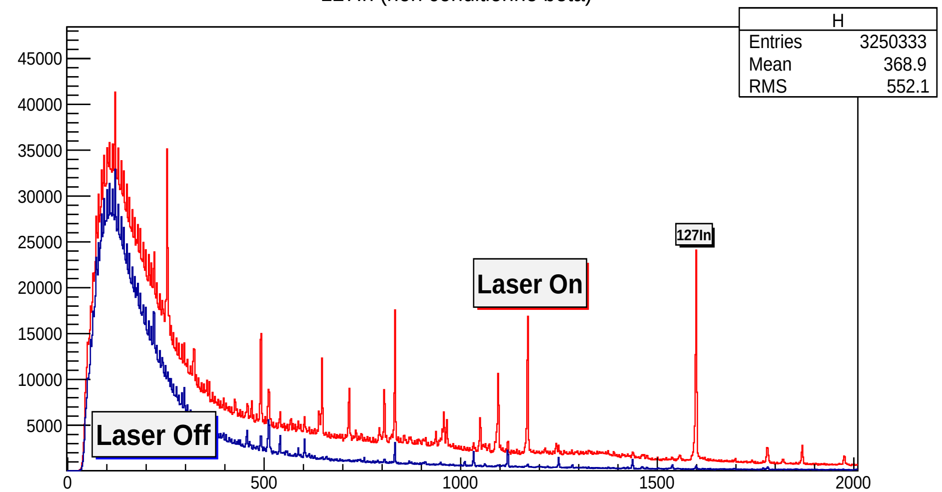
^{134}In : ~10^1 pps

Joint Institute for Nuclear Research

SCIENCE BRINGING NATIONS TOGETHER

In : 2 step- 2 colors





Efficiency : factor of **50**/surface ionisation

RIALTO source success

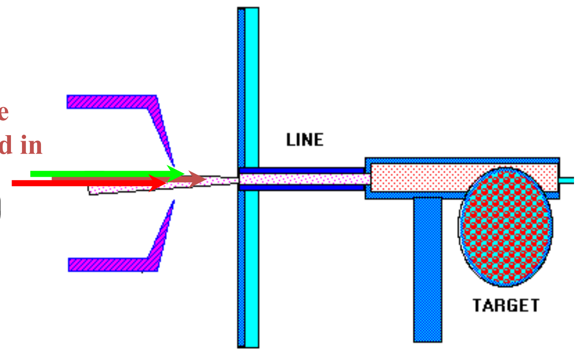
RIALTO Highlights

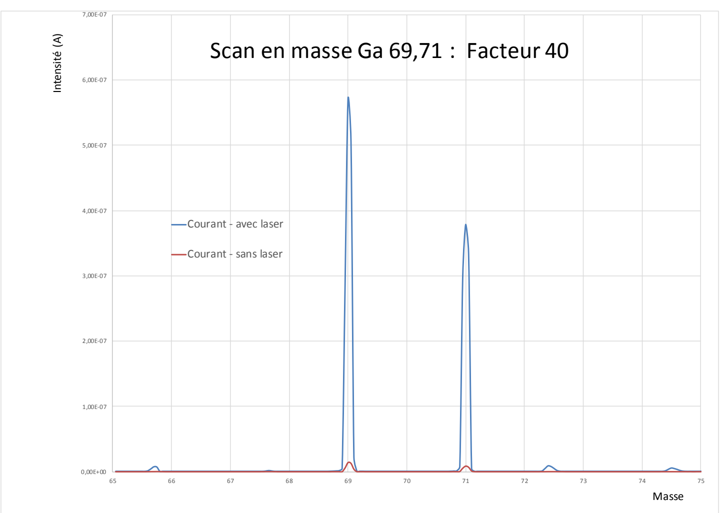
Uranium fission

Neutron rich radioactive nuclei beams well separated in mass A

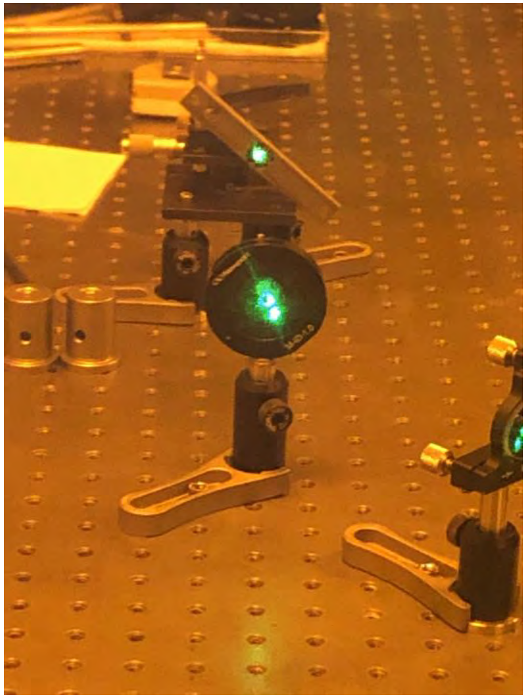
LASER ION SOURCE

Beams of high purity and high selectivity





Position Reliability

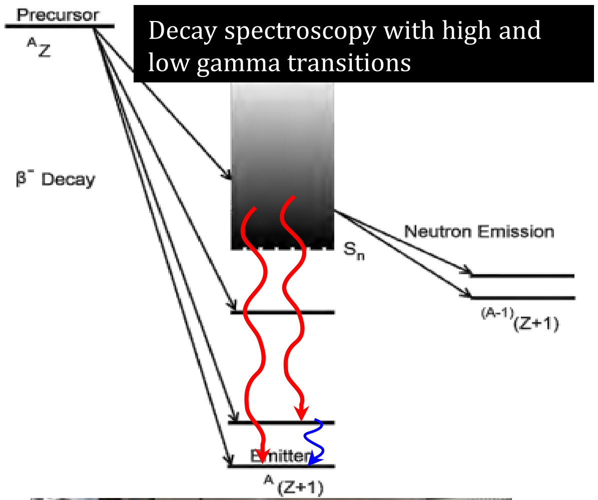


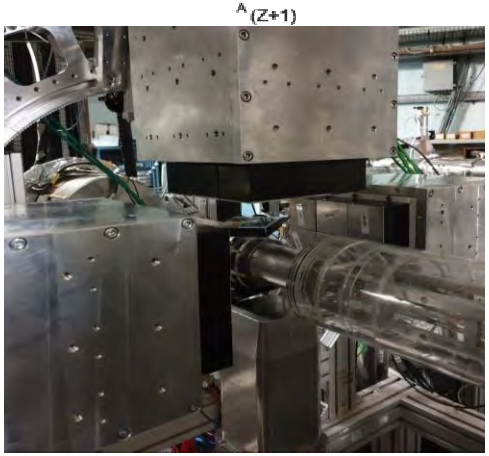
Juin 2019 : 15 days BT with a Ga Beam at ALTO

Efficiency : factor of **42**/surface ionisation

PDR studies in very neutron rich nuclei around N=50 shell closure through β decay

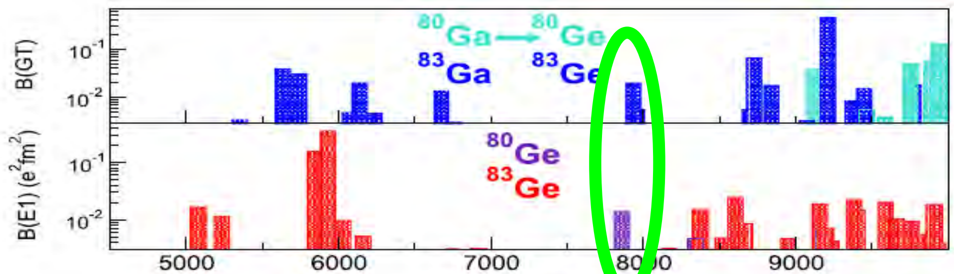
G. Benzoni (INFN)/ I. Matea (IPNO)



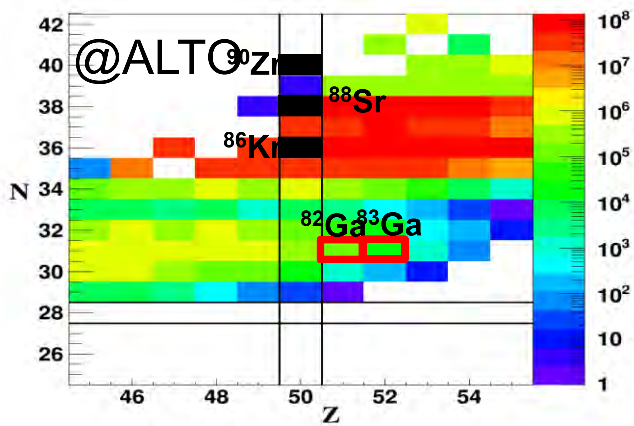


PDR along closed neutron shell isotonic chains
"Can pygmy GT be a doorway to pygmy DR ? ^{82,83}Ga case"

A.Gottardo et al., PLB772 (2017)



Energy matching between the two pygmy resonances (GT and Dipole)



Goal:
- study this phenomenon in neutron-rich nuclei along N=50 closed shell

- need to develop new RIB at ALTO

PhD Thesis of L. AL AYOUBI

Tulip Project (2019-2023)

The Project

Produce intense exotic ion beams through robust and innovative ISOL methods

The Method

Simultaneous optimization of all processes involved in ion production

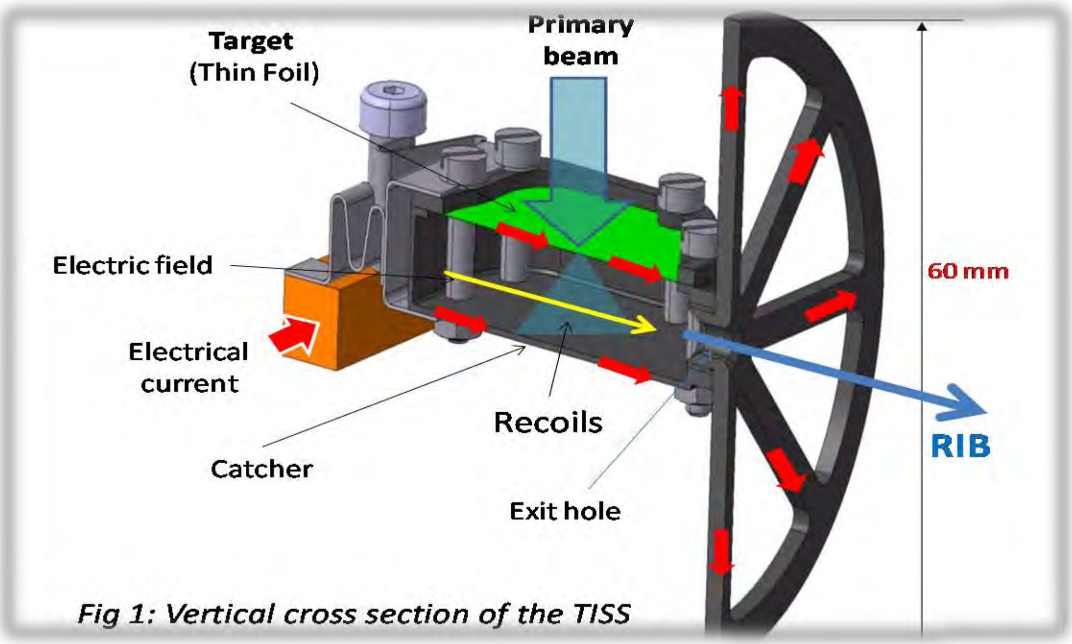


Fig 1: Vertical cross section of the TISS

June 2019

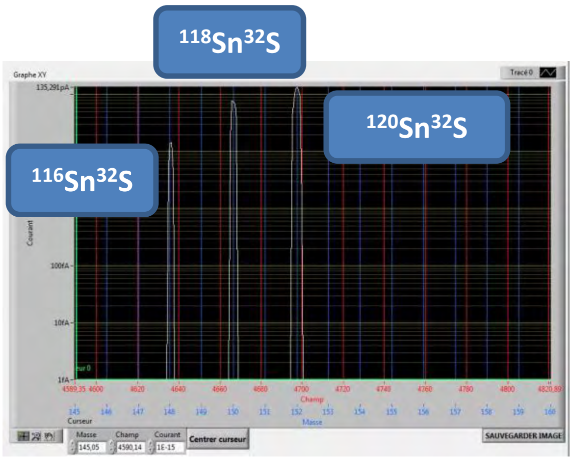
Tandem: First in-beam alkali production measurements

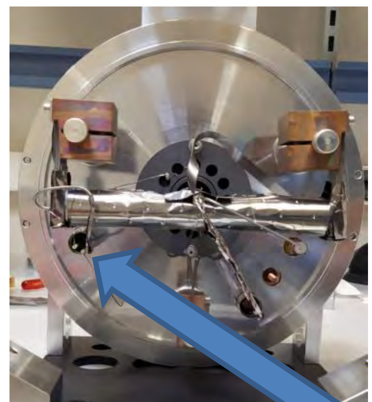
SnS RIB experiment @ ALTO

A. Andrighetto (LNL-INFN)/M. Cheikh Mahmed (IPNO)

Framework: ENSAR2/EURISOL JRA/BEAMLAB
Involved Laboratories: ISOLDE-CERN, IPNO-CNRS, LNL-INFN, GANIL, SCK.CEN

Offline tests @ ISOL-ALTO



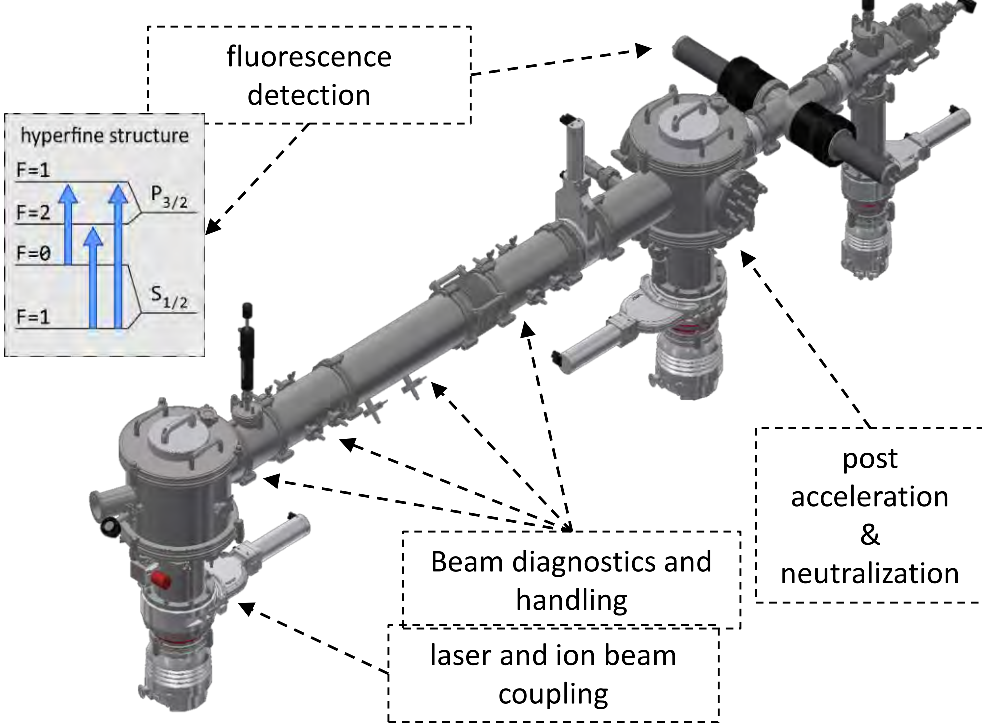


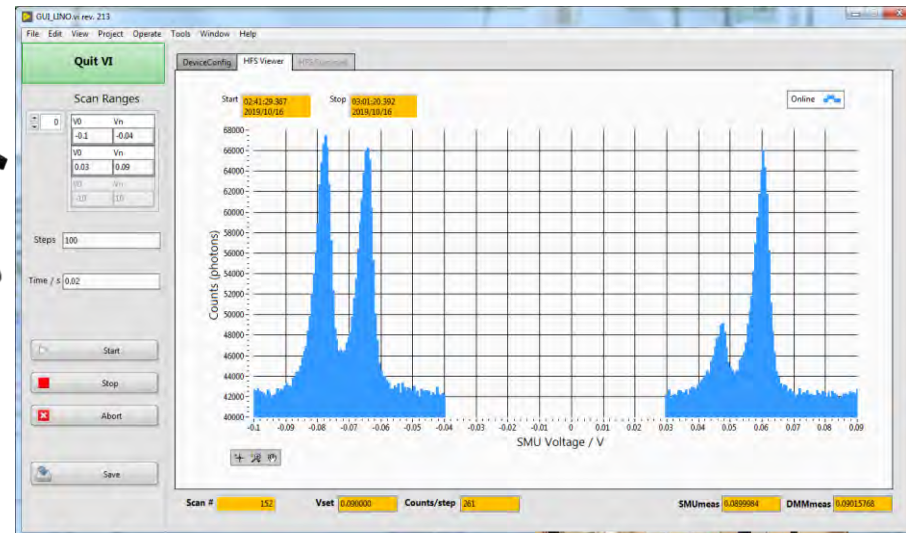
- SnS stable beams were produced by sulfurization of Sn
- Better control of S evaporation process is needed with the Online experiment conditions (target temperature ~ 2000 °C)
- Online experiment starts week 47

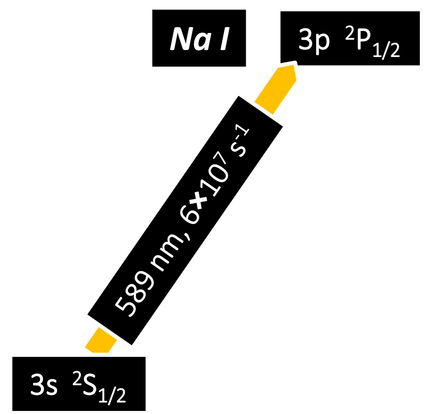
LINO @ ALTO

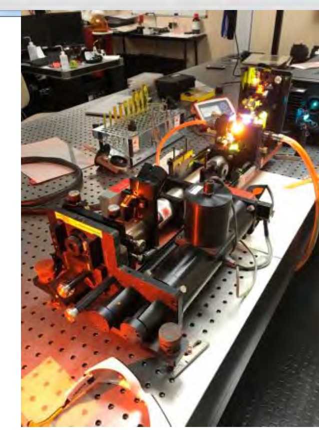
D. Balabanski (ELI-NP)/D. Yordanov (IPNO)

Colinear Laser Spectroscopy beam line









POLAREX @ ALTO Achivements: Publications & Conf.

Source : Implantation by fusion evaporation (d, ^{56}Fe) à ALTO (Tandem)

- Geometry and solid angle correction
  → S. Roccia, C. Gaulard, A. Etilé, R. Chakma
  NIMA 859 (2017) 18-22

- Nuclear magnetic moment of $^{57-58}Fe$ (Ph.D. A. Etilé)

- Multipole mixing ratio of $^{57-58}Fe$ (Ph.D. R. Thoer)
  → **PolarEx, a Future Facility for On-Line Nuclear Orientation at ALTO : Multipolarity Mixing Ratio Data Analysis,**
  Zakopane Conference on Nuclear Physics 2018,
  R. Thoer et al. , Acta Physica Polonica B, Vol. 50 N° 3

  → **+ 1-2 conference/y**

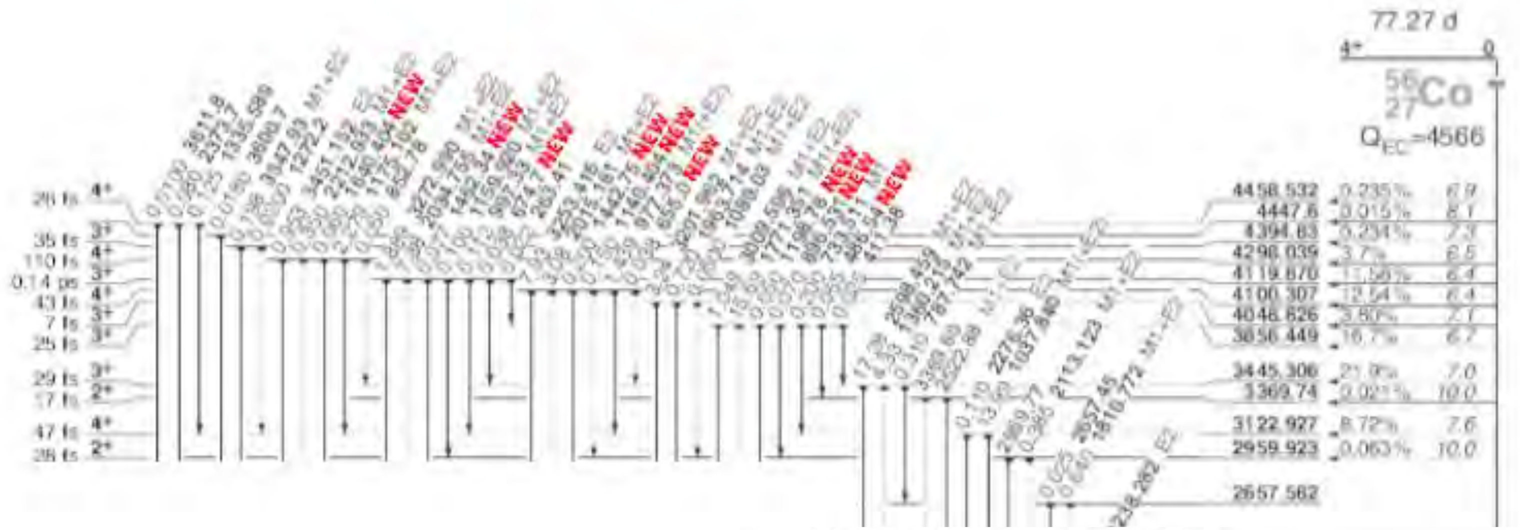
→ Publication to be submitted soon (draft ready) on the off-line commissioning

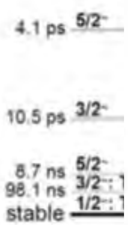
POLAREX @ ALTO Achivements: Off-line commissionning

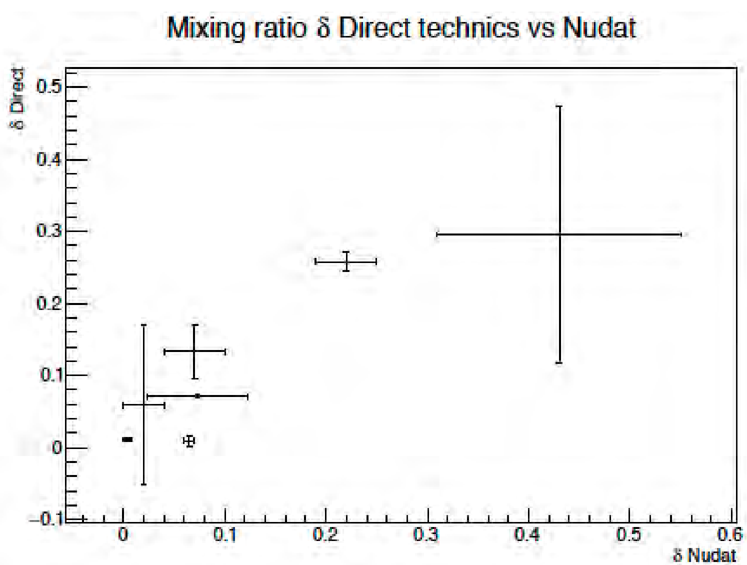
Case Study : ^{57}Fe

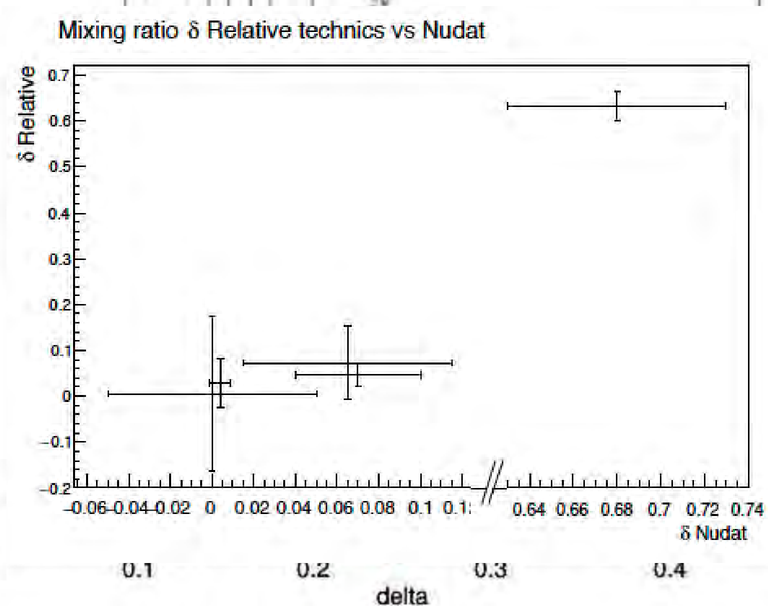
Preliminary

- ❑
- ❑









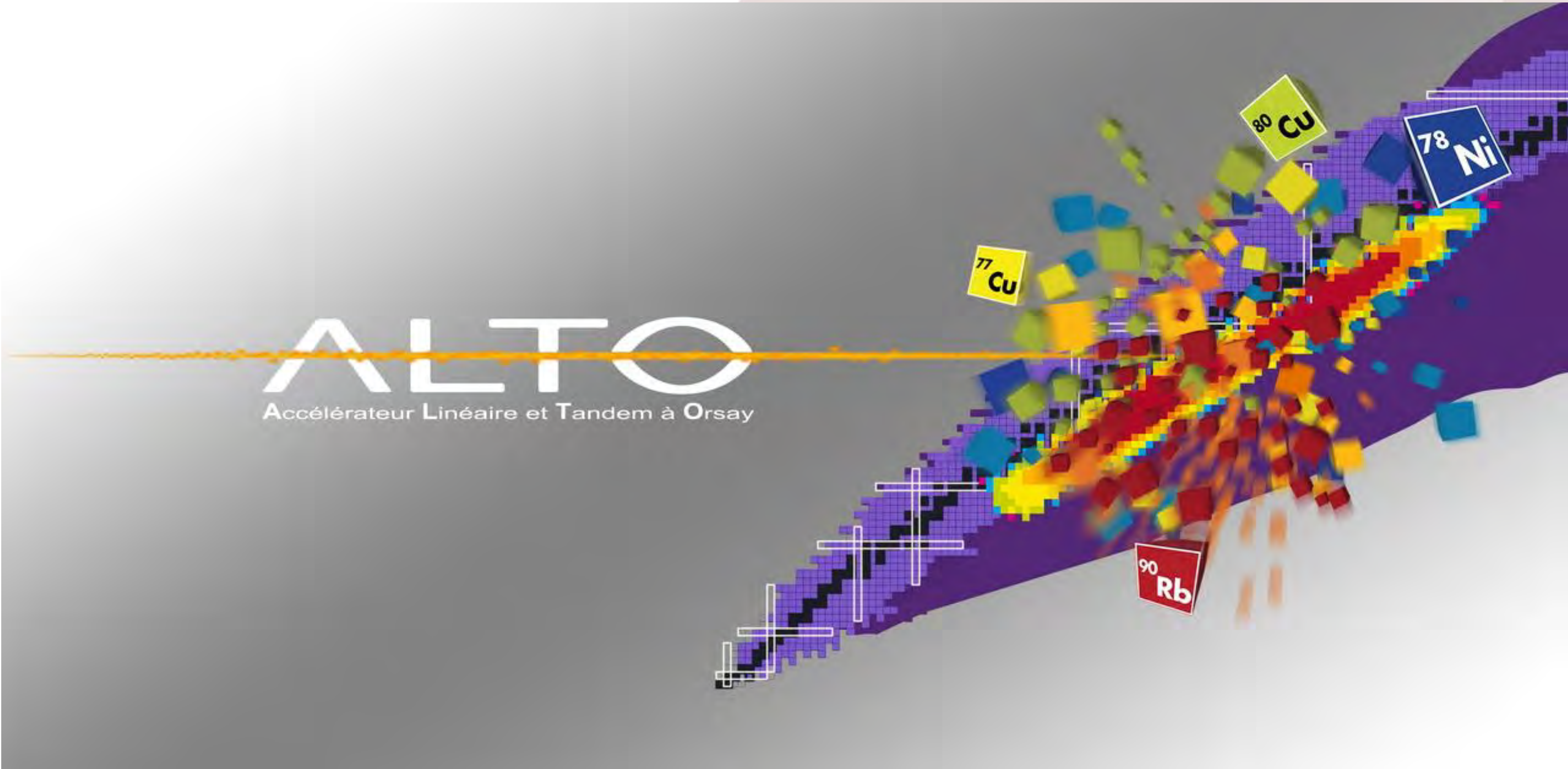
δ (F

δ (F

IJCLab
Irène Joliot-Curie
Laboratoire de Physique des 2 Infinis

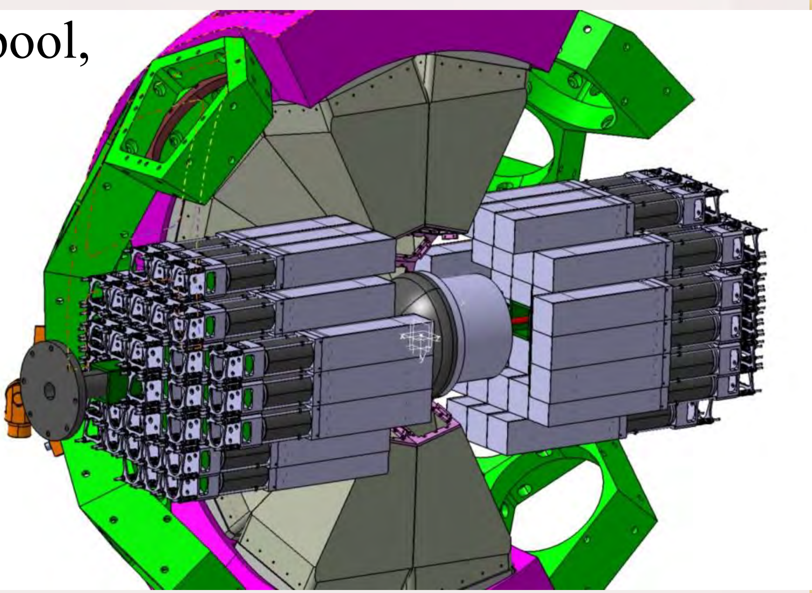
ALTO
Accélérateur Linéaire et Tandem à Orsay

ALTO: Beam perspectives



ν-ball2 campaign: October 2021 – December 2022

Result of negotiations with Gammapool, Jyvaskyla, PARIS collaboration

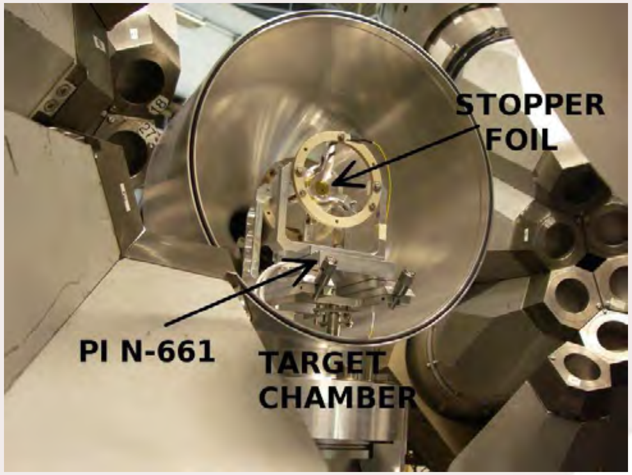


New Configurations

<u>ν-ball/PARIS</u>
GDR studies. High energy gamma detection for light nuclei (ALTO high intensity ^{6,7}Li, ^{14}C beams)

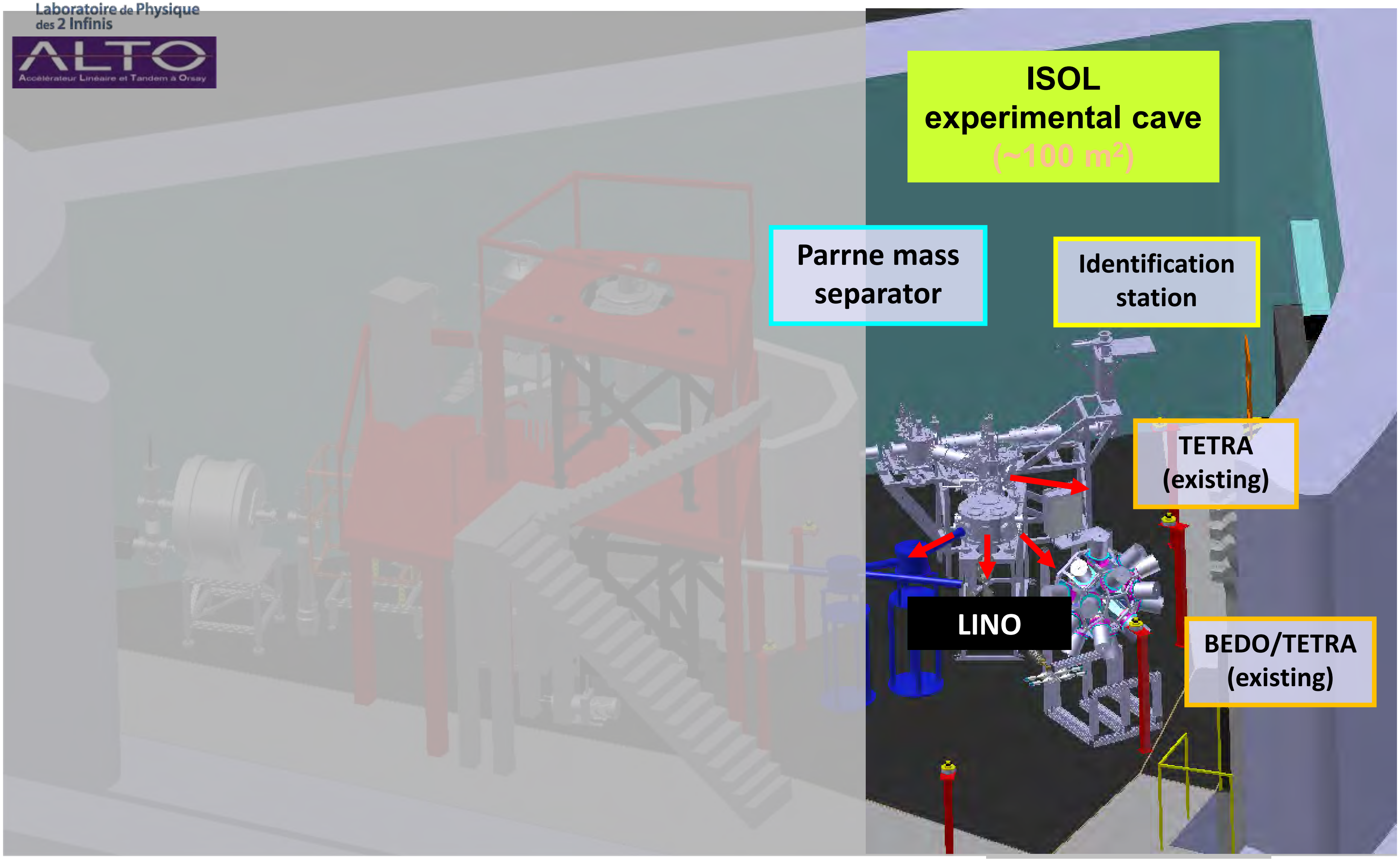
<u>ν-ball/OUPS plunger and/or charged particle detector</u>
RDM lifetimes

<u>ν-ball/Fast Timing</u>
24 clovers coupled with 40 FATIMA for best hybrid array performance. Lifetime measurements 10-ps 10ns range for weakly populated states



<u>ν-ball/LICORNE</u>
Improve fission technique: Reduce gamma backgrounds from the source and intrinsic target activity. More primary beam. Low density targets for DPM lifetime measurements. ^{252}Cf IC

The ALTO Facility: RIB line construction



The ALTO Facility: BEDO upgrade

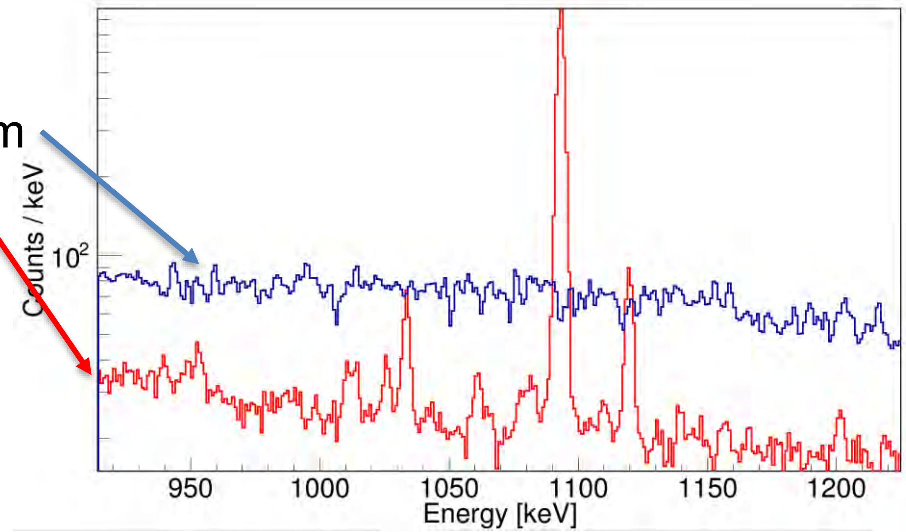
*A. Gottardo et al., Phys. Rev. Lett., **116**, 182502*

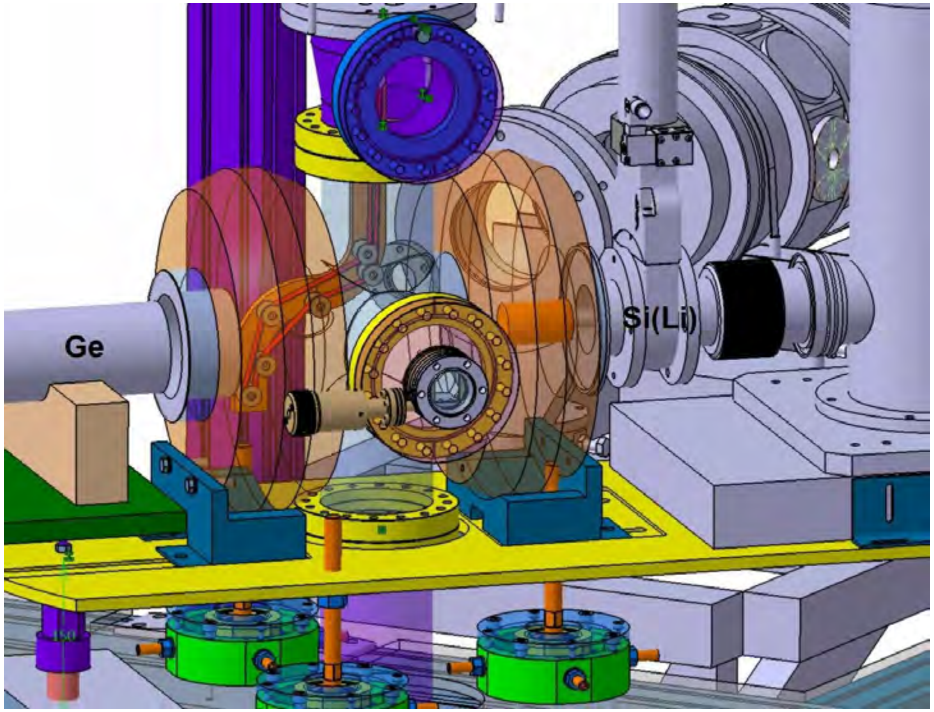
Transition from a low-lying 0^+ state to the 0^+ ground state

Main limitation with Si(Li) detector : huge Compton background !

Si(Li) spectrum

Ge spectrum





New design of the setup, adding a magnetic lens

G. Tocabens, PhD Thesis

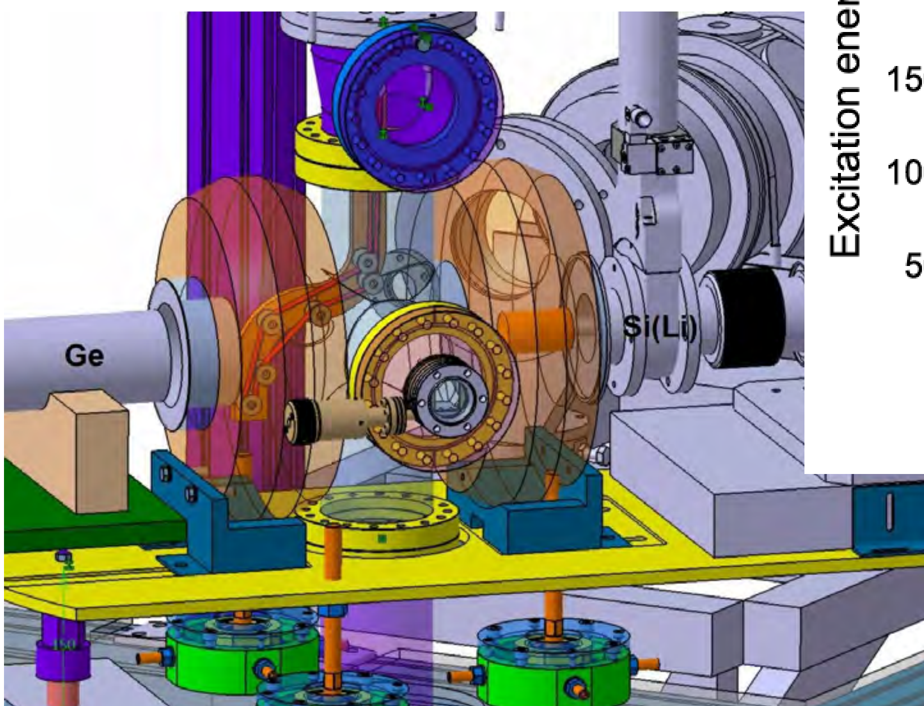
The ALTO Facility: BEDO upgrade

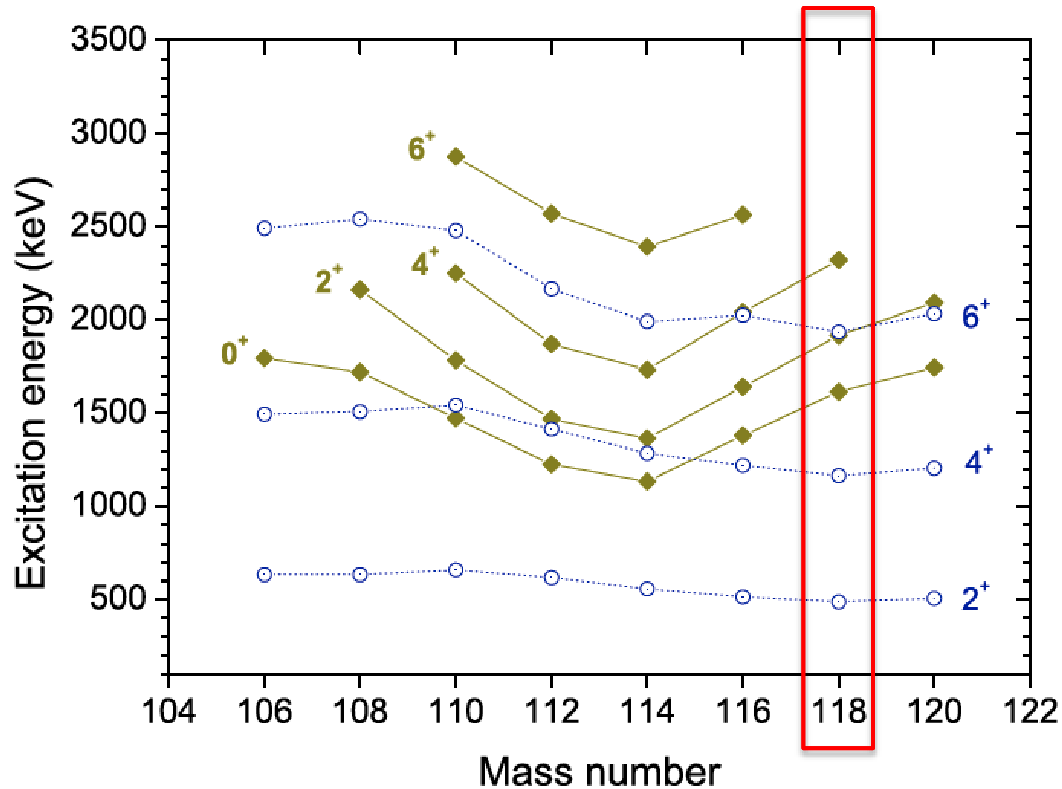
Probing Vibrational Modes and Shape Coexistence in 118Cd through Conversion Electron Measurements

N. Marchini, A. Nannini, M. Rocchini, INFN

$$^{118}Ag \xrightarrow{\beta^-} {}^{118}Cd$$

- Measurement of internal conversion
- Spin assignement of 2.223 & 2.182 MeV states
- $q^2(E0/E2)$ measurement
- Confirmation of quadrupole-octupole-coupled nature of states



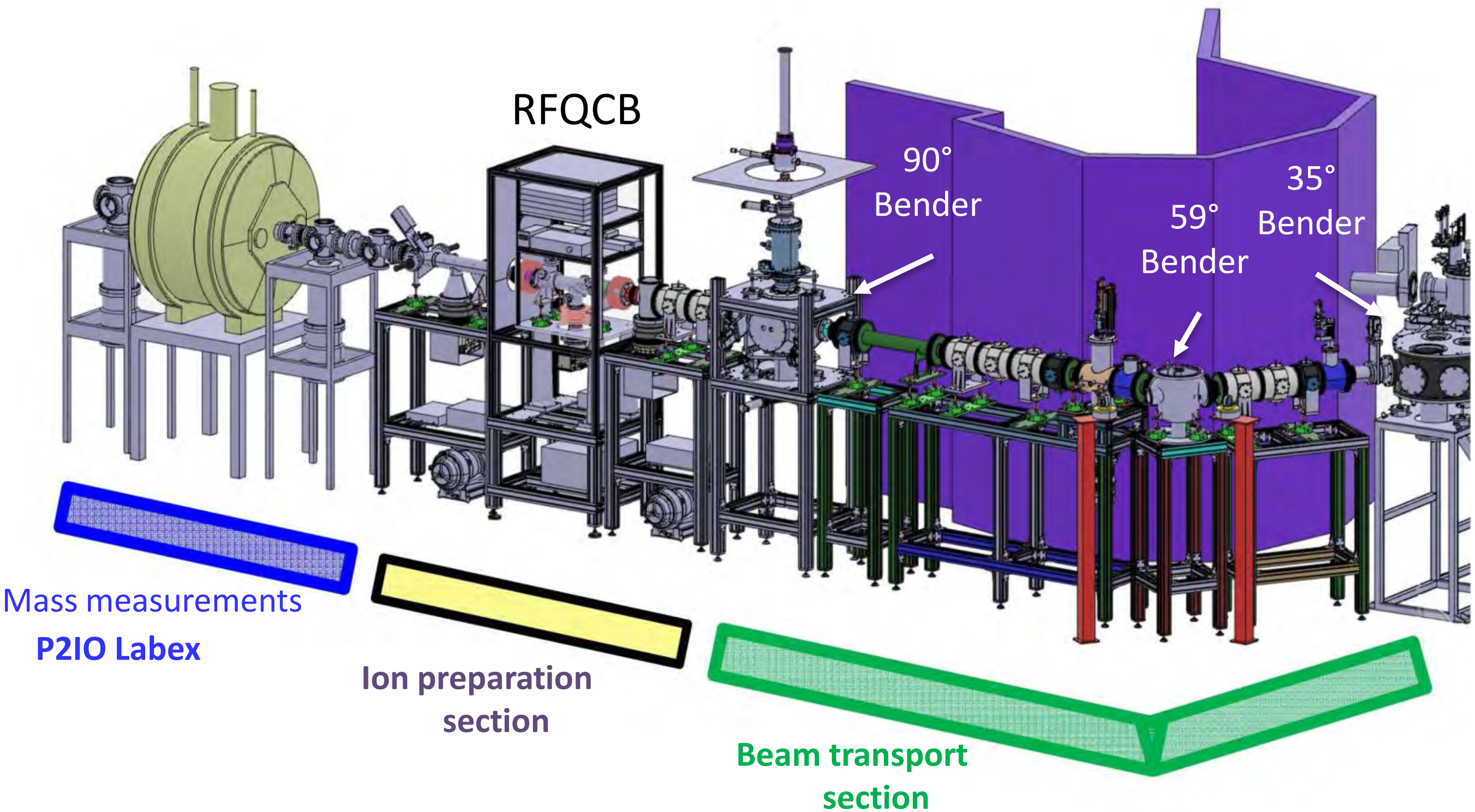


Reaching Terra Incognita of Exotic Nuclei (ReTIEN)

ReTIEN project: 0.58 M€ equipment

Action financé par la Région Ile de France

Financed end 2017
Started June 2018
Estimated end June 2021



February 2020 status

- On-track
- DR4 procurement ongoing process

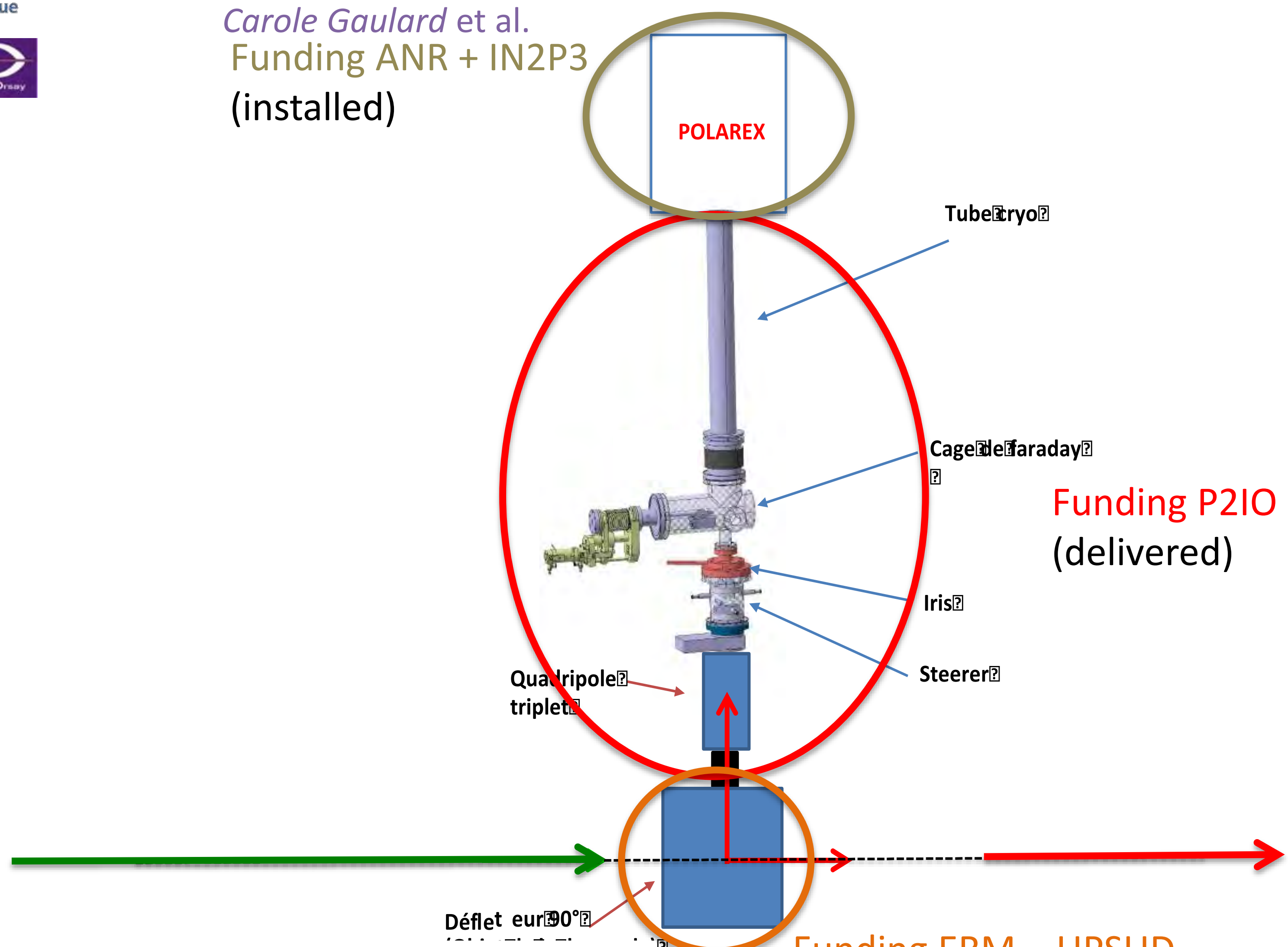
POLAREX @ ALTO

Carole Gaulard et al.

Funding ANR + IN2P3
(installed)

Funding P2IO
(delivered)

Funding ERM – UPSUD
(delivered)



POLAREX @ ALTO: Scientific Program

- Study of Pm isotopic chain (A=147, 149, 151)
  Measurement of H_{hf} of Pm in Fe
  Measurement of magnetic moments of Pm isotopes

- Study of magnetic moments of Sb *(A= $130^{g,m}$, $132^{g,m}$, $134^{g,m}$)*

- Collectivity development from N=40 to N=50 :
  the case of the $g_{9/2}$ mid-shell ^{77}Ge

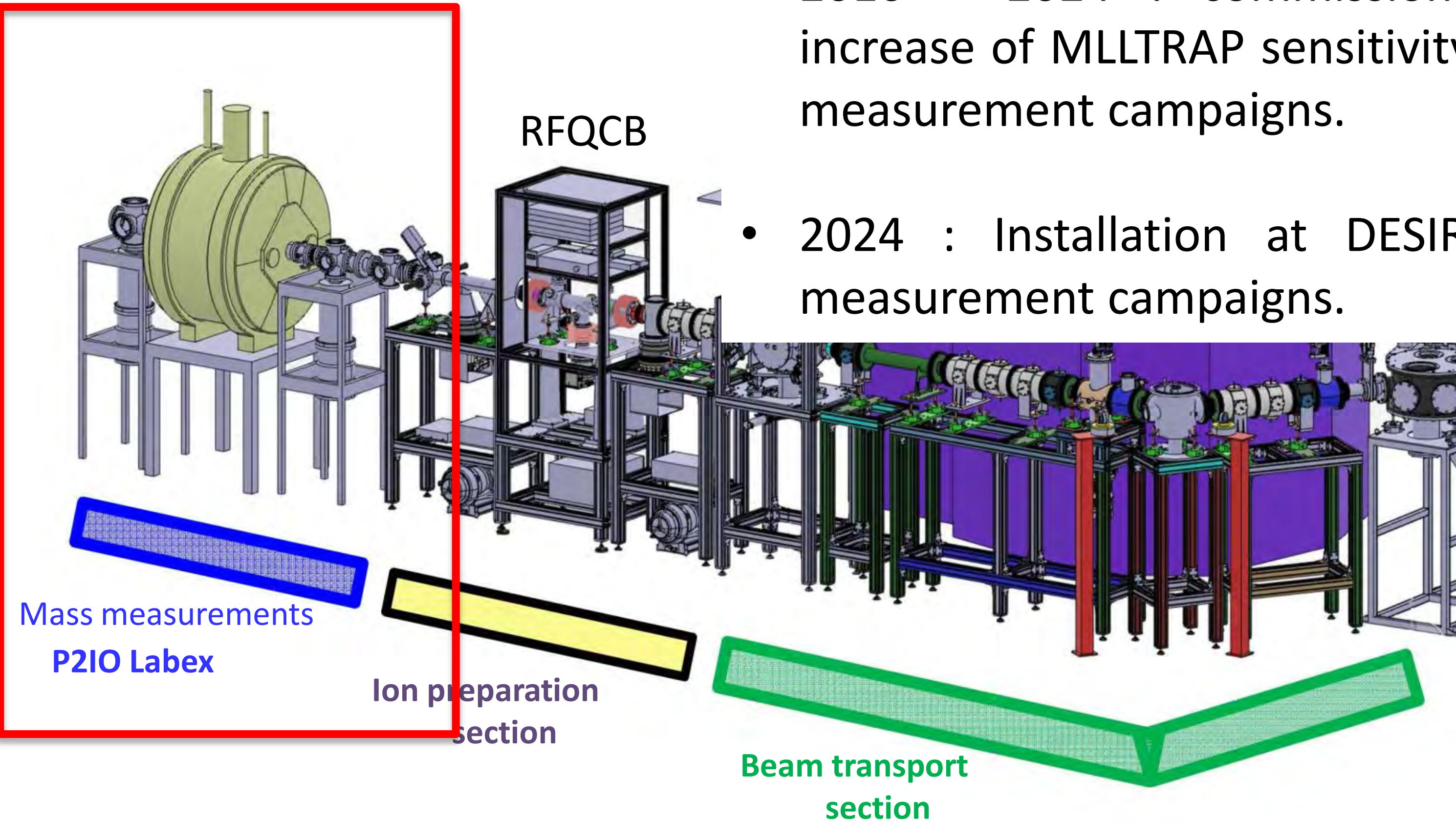
- Orientation of ^{137}I and decay of high level excite states of ^{137}Xe
  - *Magnetic dipole moment of ^{137}I*
  - *Parity admixture in excited states of ^{137}Xe*
  - *Beta delayed neutron emission from ^{137}Xe*

- *Magnetic moment measurements of Sb and I nuclei close to ^{132}Sn*

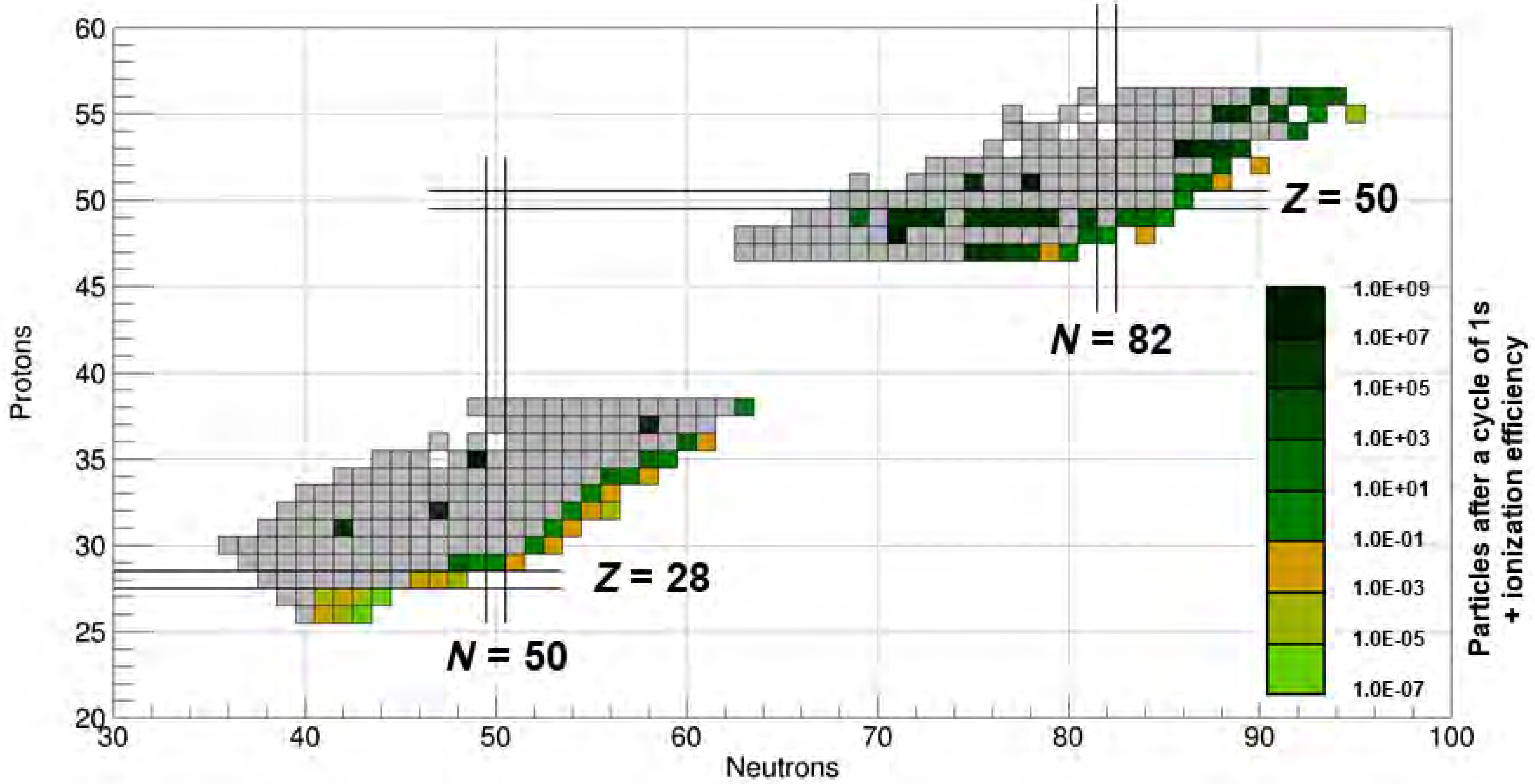
MLL-TRAP @ ALTO

Enrique Minaya Ramirez et al.

- Nuclear structure studies with high precision mass measurements.
- 2016 – 2024 : commissioning at ALTO, increase of MLLTRAP sensitivity (R&D), mass measurement campaigns.
- 2024 : Installation at DESIR, new mass measurement campaigns.



Mass measurement program @ ALTO (γ,f)



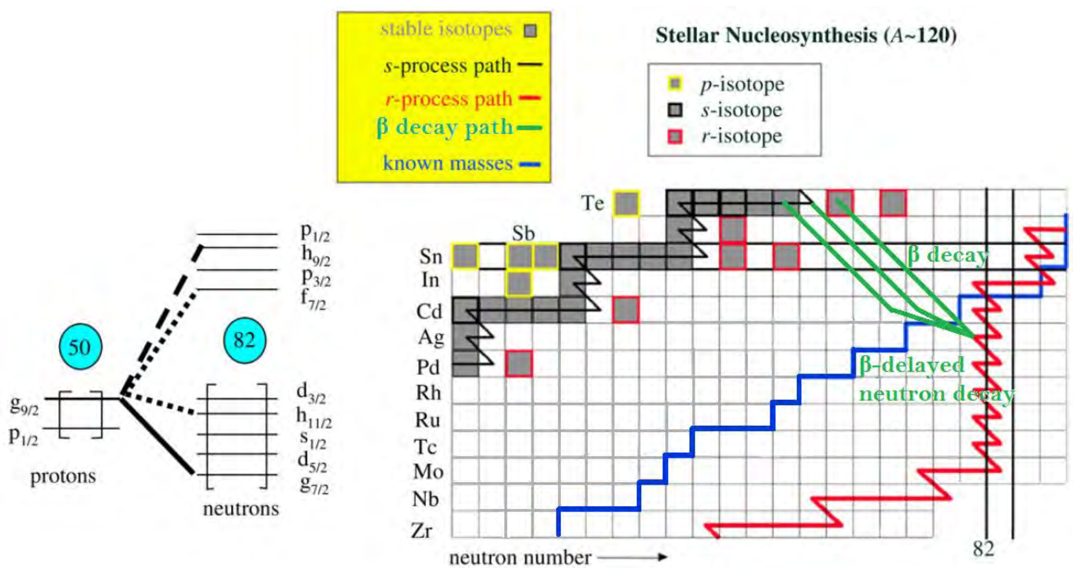
In color : Unknown masses or known masses with a low precision accessible with MLLTRAP.

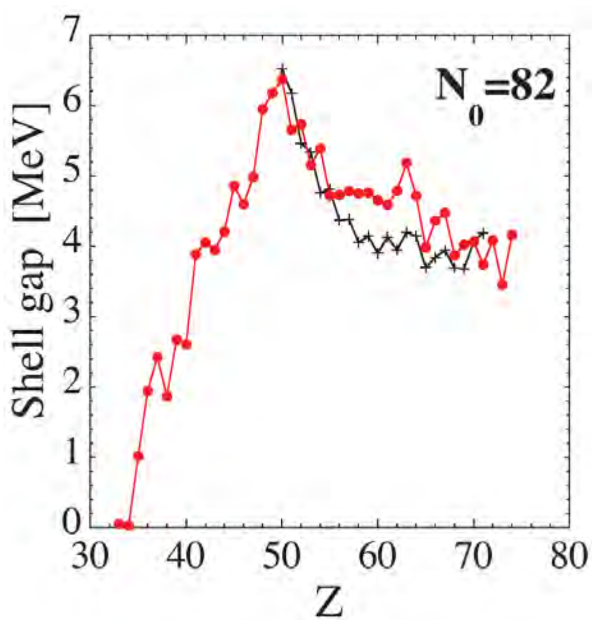
→ Neutron rich nuclei around the magic numbers N=50 and 82.

MLL-TRAP @ ALTO: Mass Measurement

Letter of Intent for Day 1 MLLTRAP experiments (approved in March 2017 by the ALTO scientific program advisory committee) :
"High-precision mass measurement of silver isotopes (A=113 – 129) towards the N=82 shell closure with MLLTRAP at ALTO"

The physics behind these masses will allow to explore nuclear structure modifications, with a possible weakening of the shell gap around Z < 50 and to calculate the impact on mass A = 130 r-process elemental abundances. This inaugural scientific program will create new opportunities for wider collaboration and show readiness for upcoming national projects

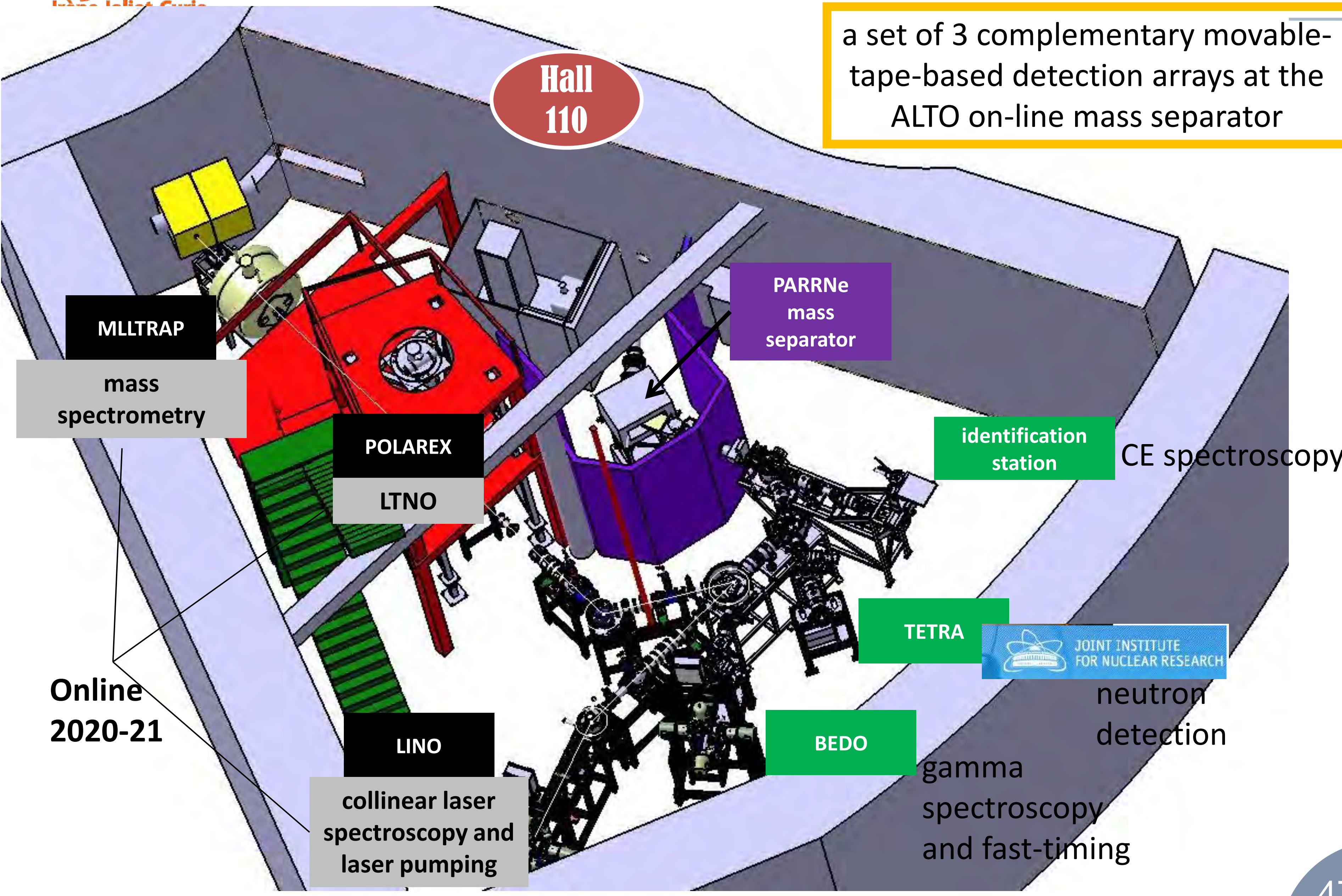




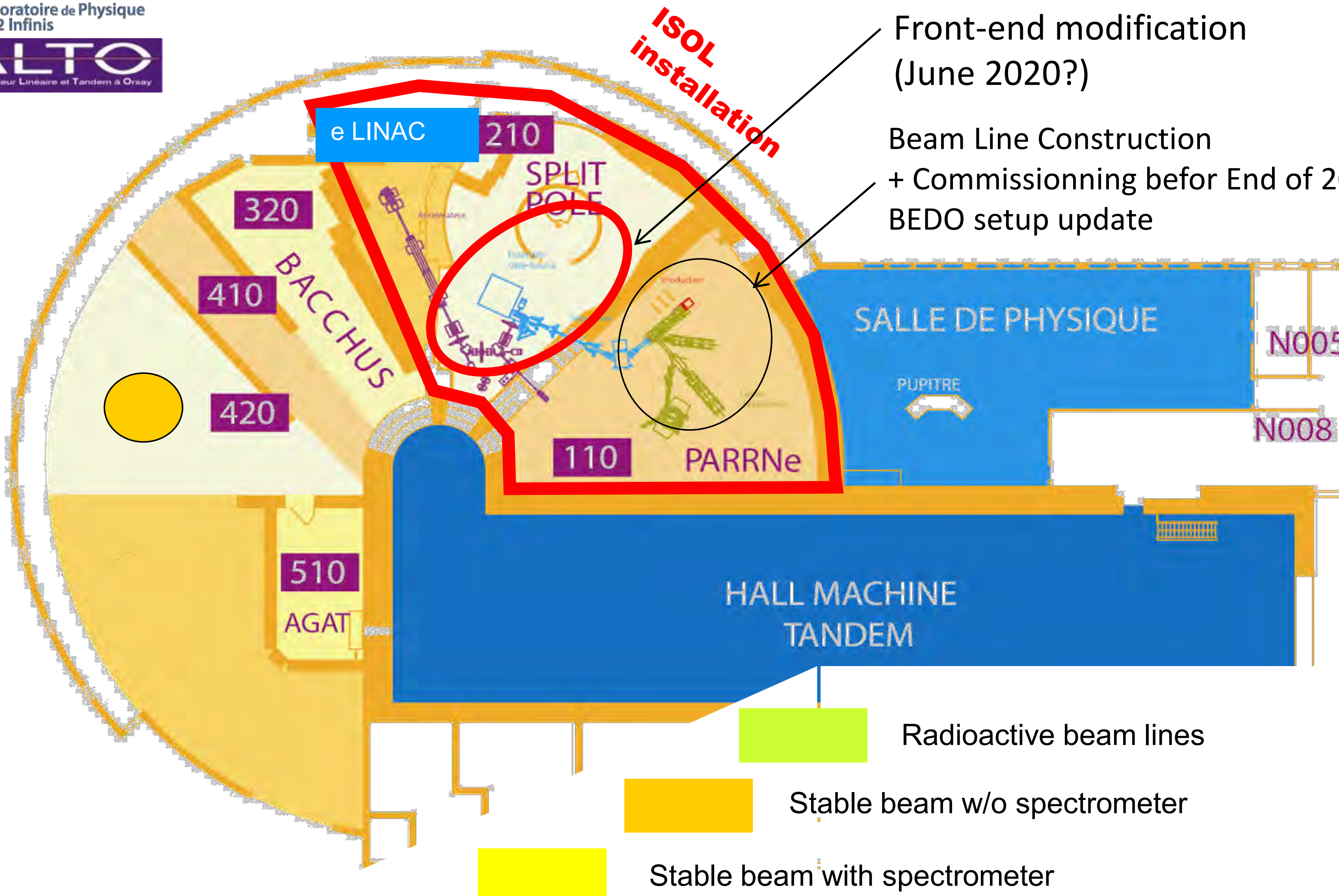
S. Goriely et al., PRC88(2013)

The ALTO Facility: RIB line construction

a set of 3 complementary movable-tape-based detection arrays at the ALTO on-line mass separator



The ALTO Facility: RIB line construction



Front-end modification (June 2020?)

Beam Line Construction
+ Commissionning befor End of 2020
BEDO setup update

Radioactive beam lines

Stable beam w/o spectrometer

Stable beam with spectrometer

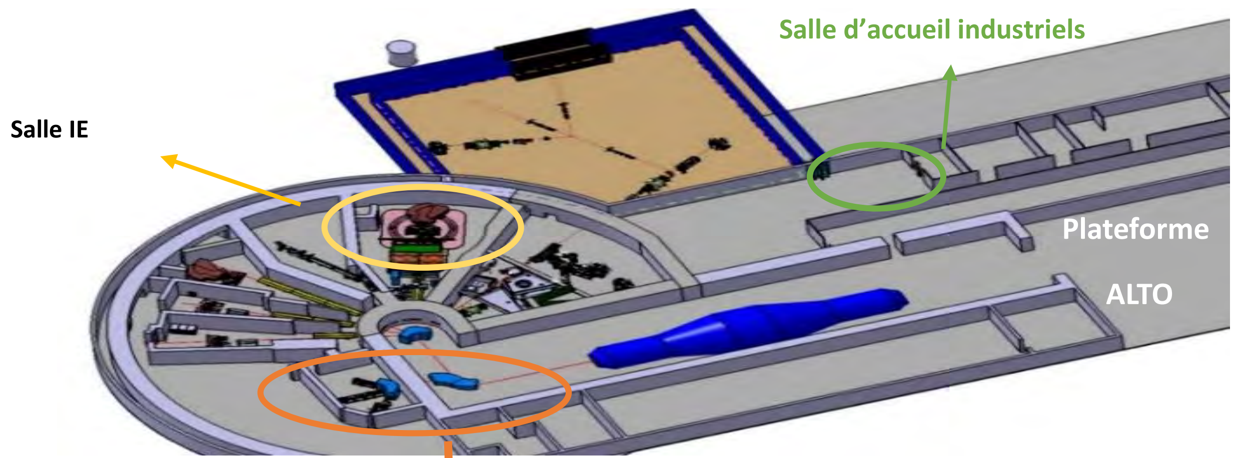
RIALTO: Ag beam development

Projet Space ALTO

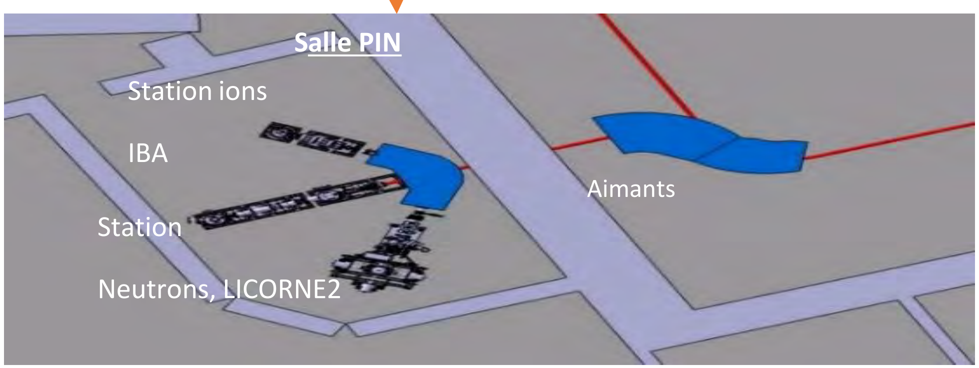
Station Pour l'irrAdiation des Composants et systèmEs à ALTO

SESAME PIA

The objective of the project :
- To meet the demands of industrials for electron, neutron and proton beams.
- Create within the ALTO platform, high-performance and functional experimental areas dedicated to irradiation.
- To have several automated and scalable stations to produce particle beams calibrated in energy, flux and dose.
- Offer irradiation possibilities to perfectly simulate the space radiative environment.



AIM for ISO9001 et ISO17025 labelisation



Faisceaux	Énergie	Flux
Neutrons	0.5 – 4 MeV	10^8 n/s/sr
Protons	20 keV – 30 MeV	10^{16} p/s
Electrons	Jusqu'à 50MeV	$5x10^{10}$ p/cm^2/s

Thank you

Atouts GANIL-ALTO : Variété des faisceaux primaires
Variété des cibles
Variété des installations

Actuellement et à moyen terme

In-flight SPIRAL2/S3 à moyen terme
p to U @ 0.75 MeV/n – 14,5 MeV/A → Cr to Cm cible mince

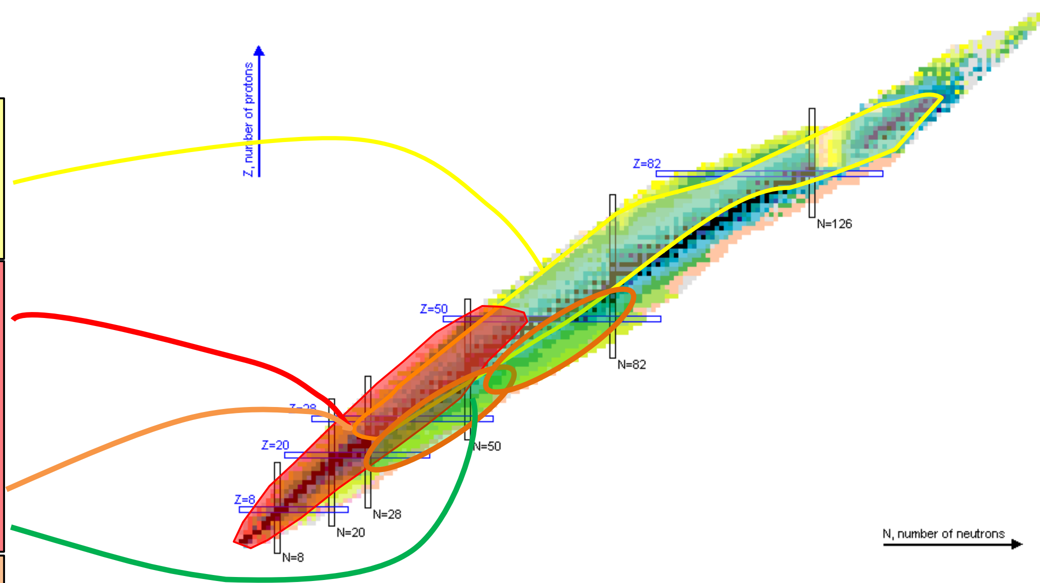
ISOL SPIRAL 1 existant

^{12}C à ^{238}U (up to 95 MeV/A) → cible épaisse de graphite

^{12}C à 2 .10^{13}pps (95 MeV/A) → cible épaisse, masse jusqu'au Nb

^{12}C à ^{238}U, low energy → cible mince, jusqu'à l'U

ISOL ALTO existant
Ions lourds H à I @ 15 MeV → cible
Electrons@ 50 MeV → UCx



Fragmentation cible
Transfert de nucléons
Fusion-évaporation
Fragmentation projectile
Fission induite

→ **Nombreuses possibilités d'optimisation des dispositifs de production ISOL**

Budget

Years	Funding	Dotation	
2006-2010	ANR JCJC	150 k€	Postdoc, moving from Canada, upgrade
2011-2018	IN2P3	Env. 90k€	30k€ structure at ALTO, 20k€ installation at ALTO, 5 à 8 k€/year
2016-2019	Projet Emblématique – Labex P2IO	175 k€	½ Ph.D. grant (R. Thoer), construction of vertical beam line
2018	ERM – Université Paris-Sud	26,2 k€	Construction of 90° deflector
2018	SESAME – Ile de France	580 k€	Construction of horizontal beam line

CSNSM, **Orsay, FR** C. Gaulard, J. Guillot, S. Roccia, R. Thoer
IPNO, Orsay, FR F. Ibrahim, F. Le Blanc, D. Verney
University of Maryland, **College Park,** ***USA*** J.R. Stone, W. B. Walters
ILL Grenoble, FR U. Köster
University of Surrey, Guildford, UK P. M. Walker
University of Tennessee , Knoxville, USA C.R.Bingham, R.Grzywacz, K. Kolos, M. Madurga, N.J. Stone
Niigata University, Niigata, JP T. Otsubo
University of Novi Sad, **Novi Sad, Serbia** M. Veskovic, J. Nikolov

Budget 2019 et demande 2020-22

Budget 2019 : 12 k€
R&D :
- Développement tripleur en fréquence pour faisceau Antimoine : 8 k€
- Fiabilisation position faisceau : 2 k€

Fonctionnement :
Consommables pour Ga (solvants, colorants, filtres) : 2 k€

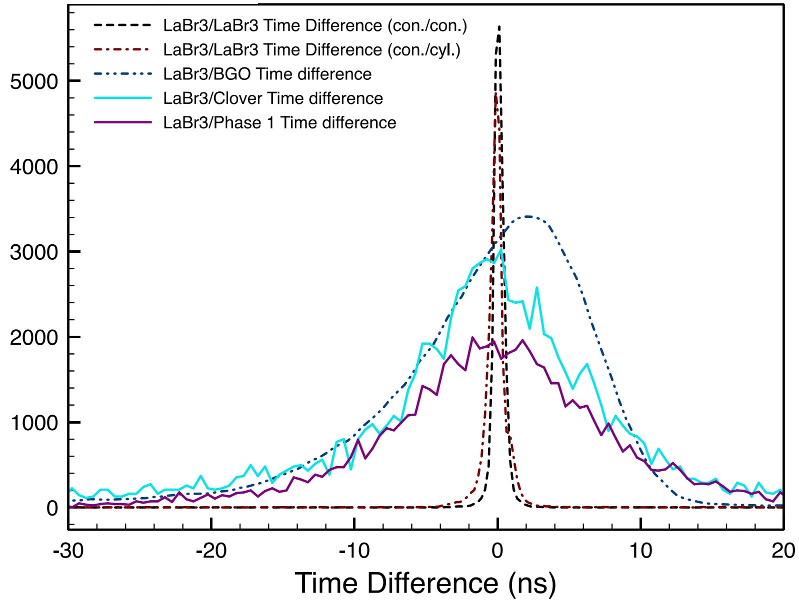
Demande 2021 : 20 k€
R&D prévue :
- Asservissement du 3ème faisceaux : 10 k€

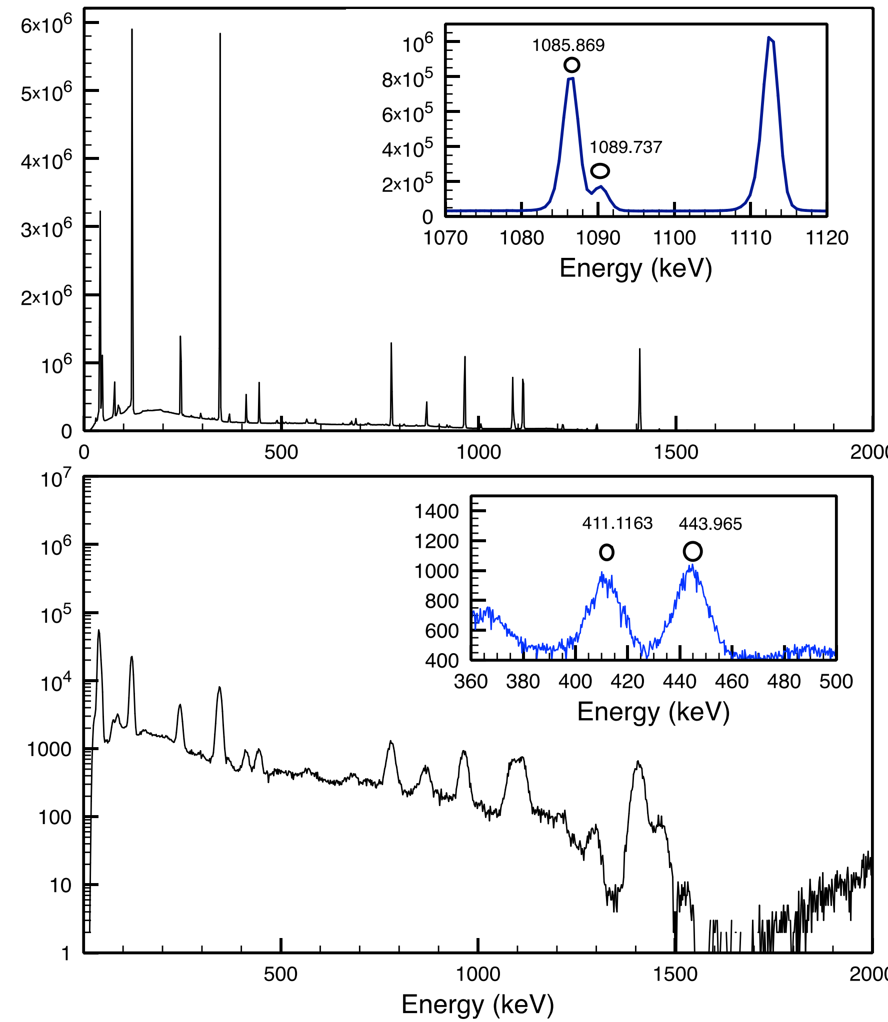
Fonctionnement :
- Maintenance YAG : 7 k€
- Consommables pour Zn : 3 k€

Demande 2020 : 25 k€
R&D prévue :
-Asservissement de la position par les retours des faisceaux : 20 k€ (2 faisceaux sur 3)
- Développement faisceau Sb et Ag (colorants, solvant, filtres, optique) : 5 k€

Demande 2022 : 12 k€
Fonctionnement :
- Optique : 7 k€
- Consommables : 5 k€

ν-ball: Measured Performances





20 $LaBr_3$ 1.5"x2" **90°**

d_{center} = 15.2 cm

$\Delta\theta$ = 14.3°

10 PhaseI HPGe

d_{center} = 18 cm

$\Delta\theta$ = 20.1°

Time Resolution: ~250ps

Energy Resolution (@662 keV): 2,6%

Photopeak efficiency (@1.33 MeV): .5%