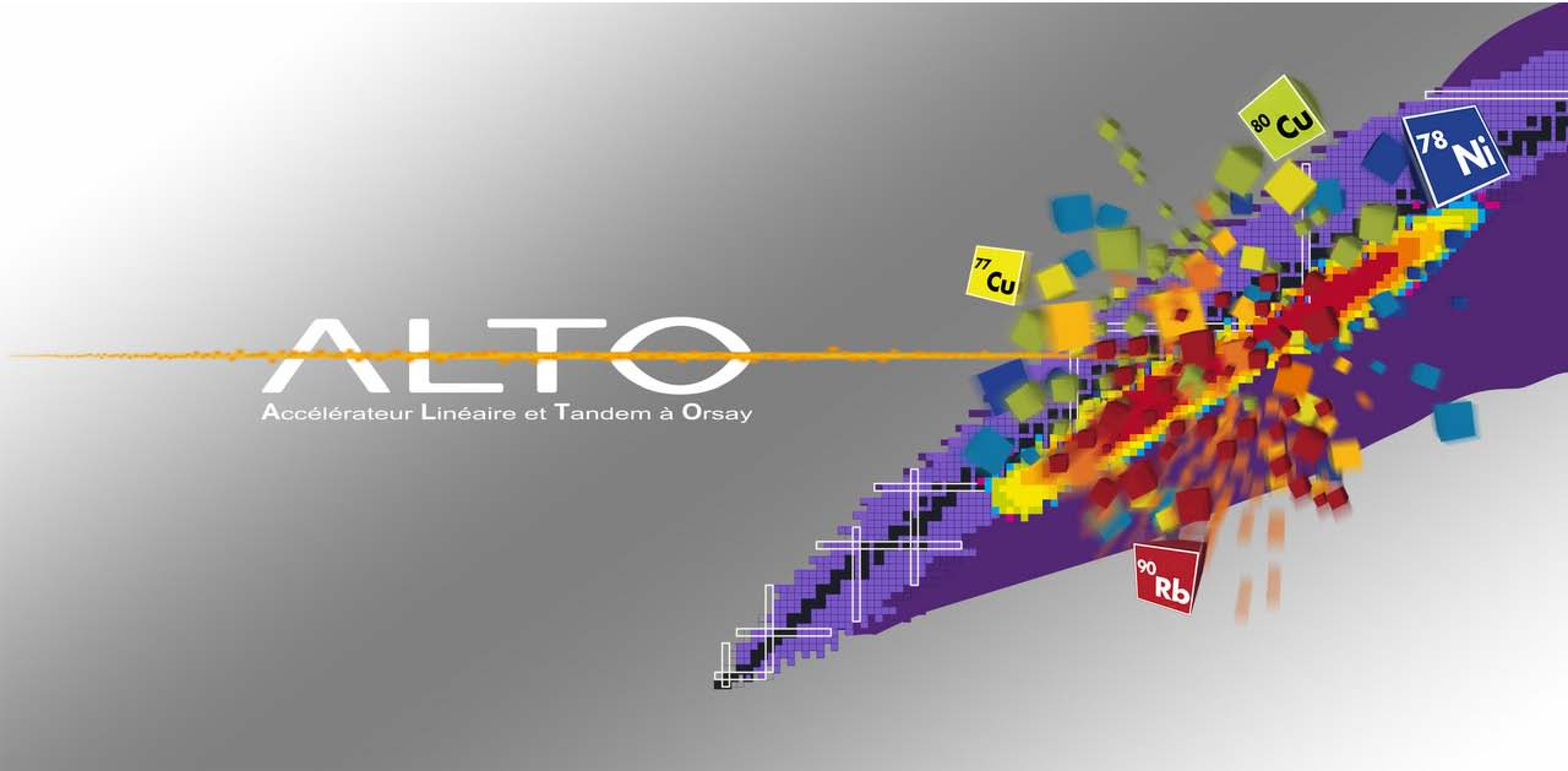
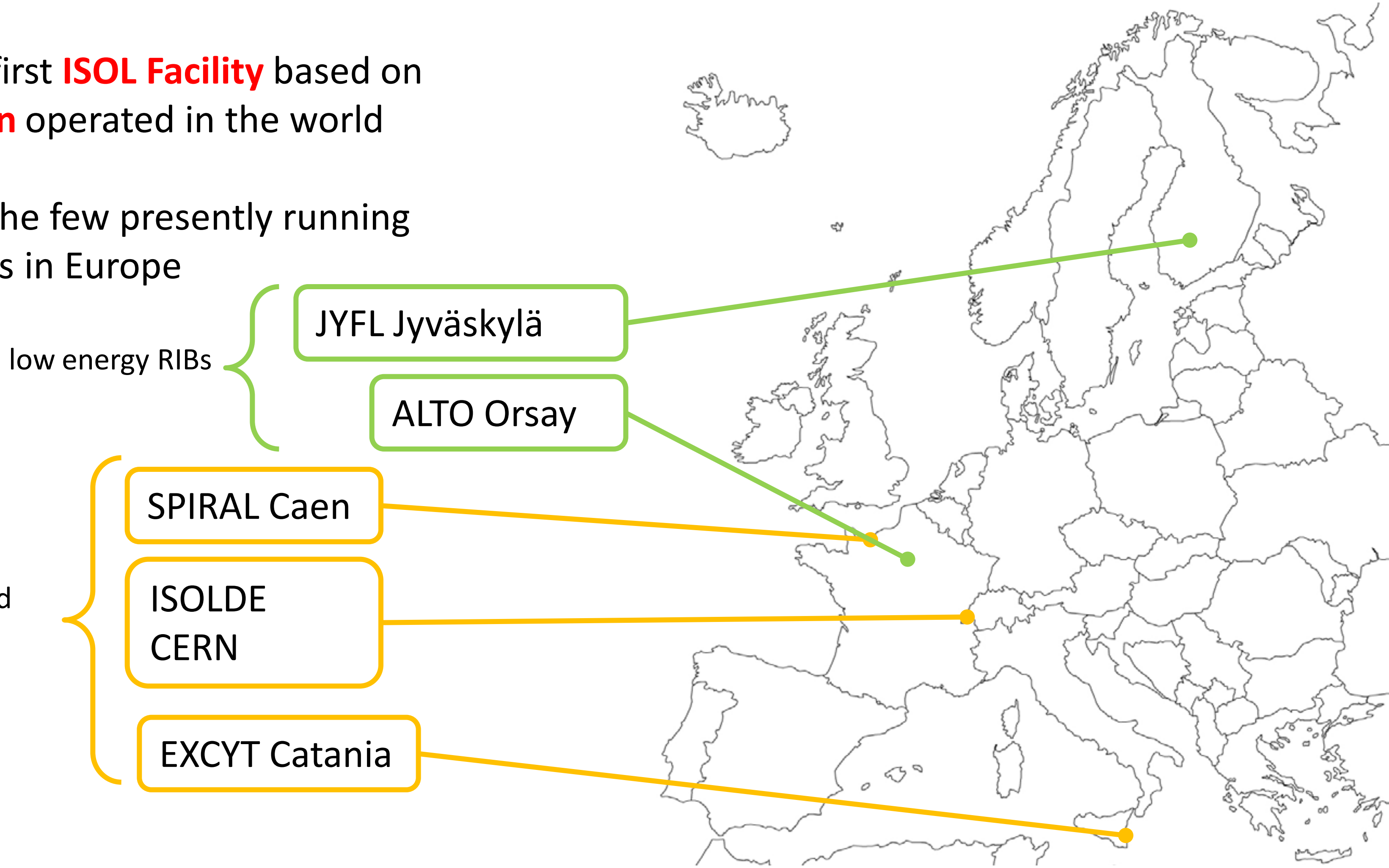
The ALTO facility

F. AZAIEZ



ALTO is the first **ISOL Facility** based on **photo fission** operated in the world

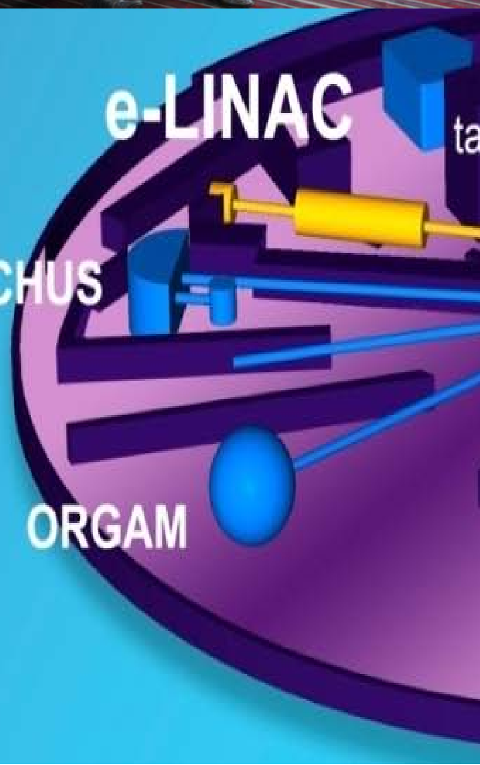
and one of the few presently running ISOL facilities in Europe

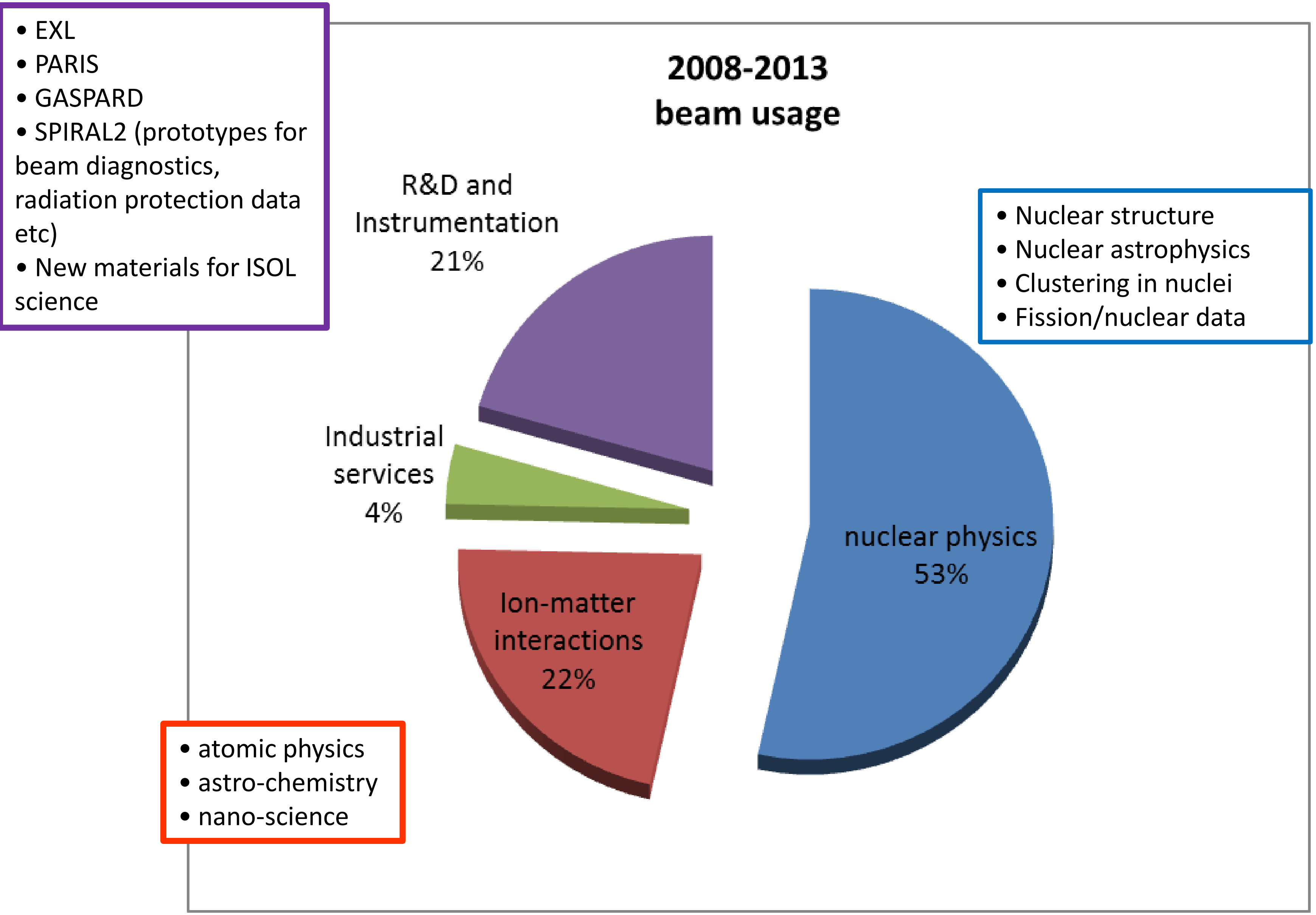


March 2012

green light from French nuclear safety authorities

May 13th 2013 – Formal inauguration

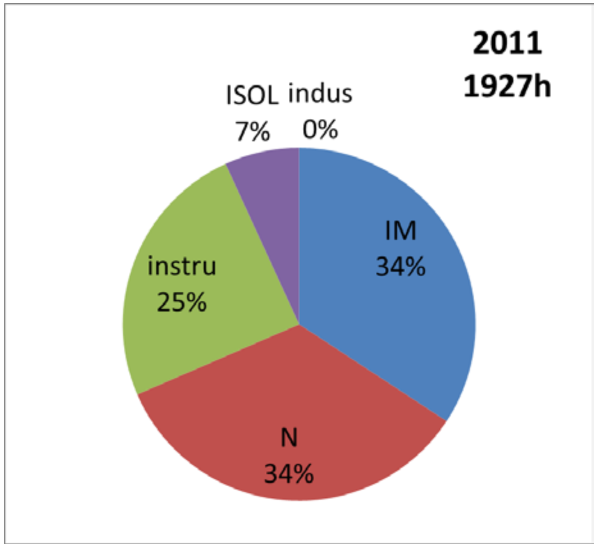



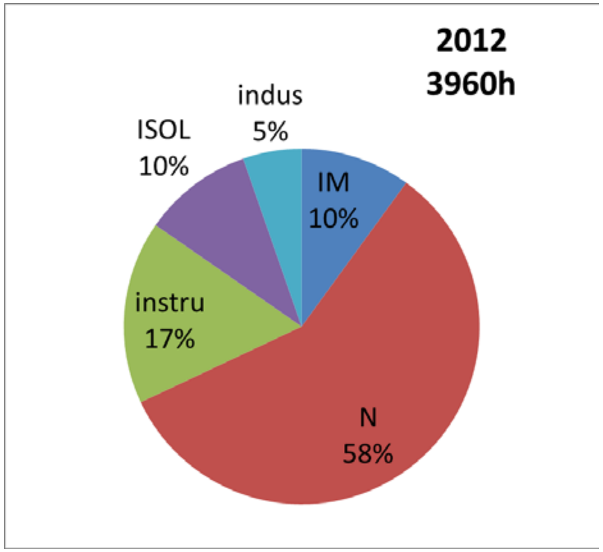


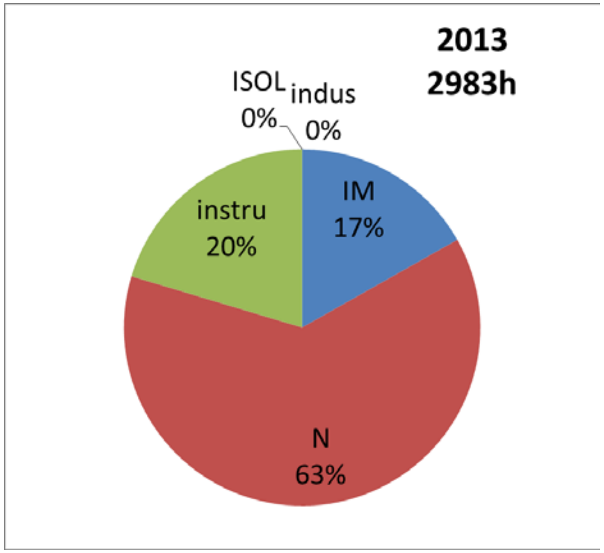
2008-2013
beam usage
• EXL
• PARIS
• GASPARD
• SPIRAL2 (prototypes for beam diagnostics, radiation protection data etc)
• New materials for ISOL science
R&D and Instrumentation 21%
Industrial services 4%
Ion-matter interactions 22%
nuclear physics 53%
• Nuclear structure
• Nuclear astrophysics
• Clustering in nuclei
• Fission/nuclear data
• atomic physics
• astro-chemistry
• nano-science

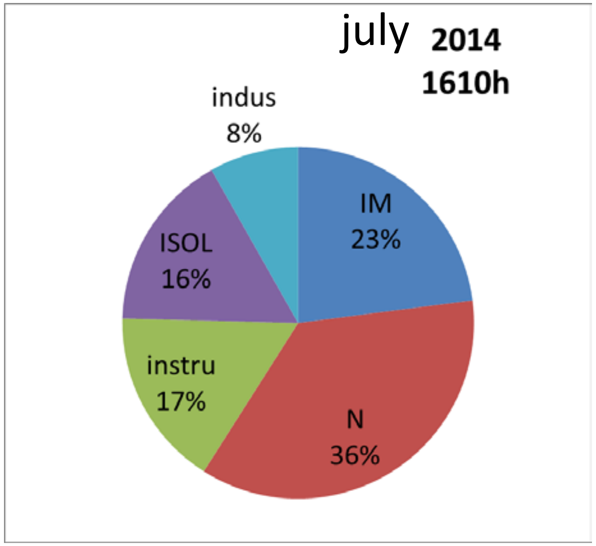
beam on target

IM: ion-matter int., irradiations
N : nuclear structure and astrophysics
Instru : instrumentation et R&D
indus : industrial services
ISOL : RIB









PAC: One/year

- R. F. CASTEN , Chair (Yale University)
- E. BALANZAT (CIMAP – Caen)
- D. BALABANSKI (ELI-Bucharest)
- S. GREVY (CENBG)
- E. KHAN (IPNO)
- P. REGAN (Univ. Surrey, UK)
- B. RUBIO (IFIC Valencia)
- C. TRAUTMANN (GSI)
- A. TUMINO (LNS -Catania)
- J. C. THOMAS (GANIL)
- P. REITER (Univ Köln)

Possibility to run ISOL and Tandem simultaneously (has been proven this summer)!

300 outside users (30 countries)/year

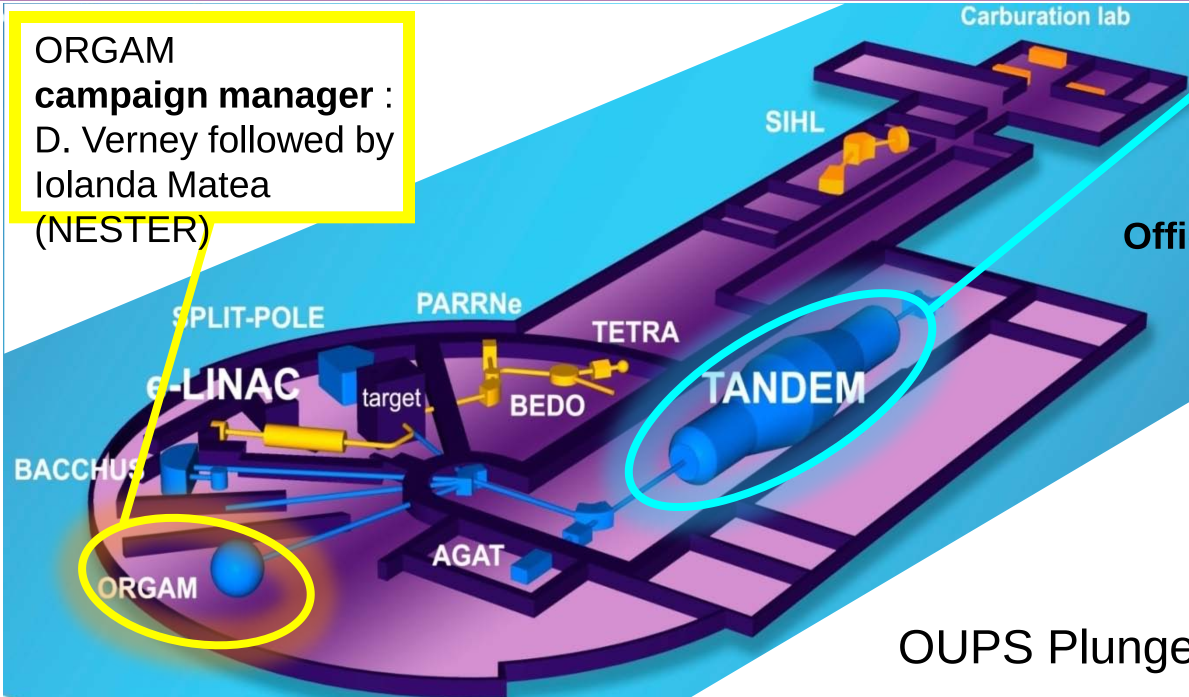
TNA	Number of beam hours promised - full contract	Number of beam hours 01/09/2010 - 31/10/2014	Estimated number of Users - full contract	Number of Users 01/09/2010 - 31/10/2014	Estimated number of days - full contract	Number of days 01/09/2010 - 31/10/2014	Estimated number of projects - full contract	Number of projects 01/09/2010 - 31/10/2014	Total amount for T&S - full contract	Amount for T&S 01/09/2010 - 31/10/2014	Amount for other direct costs - full contract (AGATA)	Amount for other direct costs (AGATA) 01/09/2010 - 31/10/2014	Access costs - full contract	Access costs 01/09/2010 - 31/10/2014
ALTO	1470	3840	116	119	556	875	19	28	73 720€	93 124€	0€	0€	151 998€	397056

in 2014 ALTO-SIB and ALTO-RIB ran in parallel !

ALTO:
a stable beam facility

The Orsay Gamma Array : ORGAM

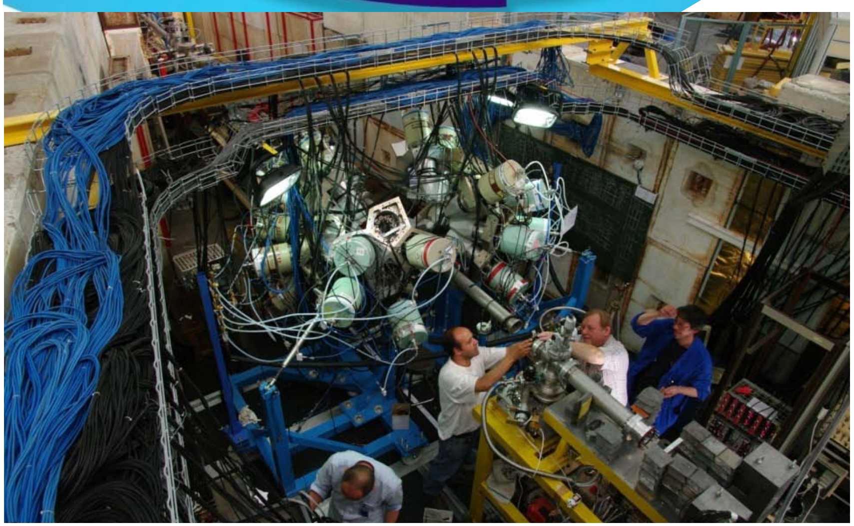
ORGAM **campaign manager** : D. Verney followed by Iolanda Matea (NESTER)



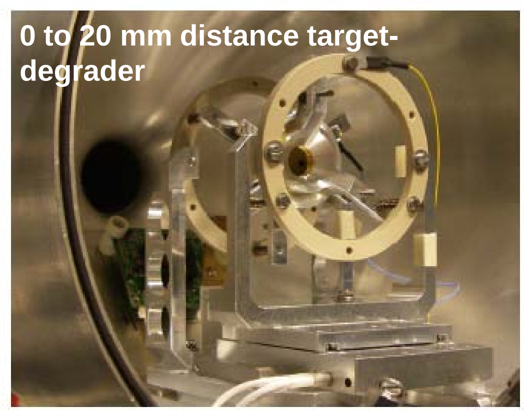
15 MV MP Tandem

Official request to:
- **loan-pool**
- **gamma-pool**

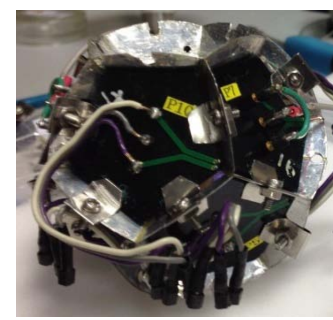
- construction finished mid-2009
- progressive use of ancillary devices: plunger, Si-ball, scintillators



OUPS Plunger



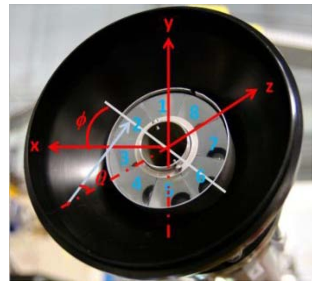
RCNP Osaka Si-bal



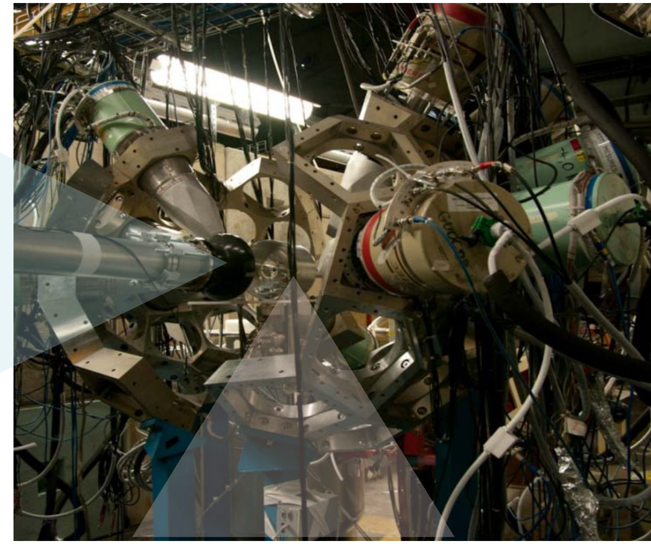
TDRIV on H-like ions: ^{24}Mg - revisited

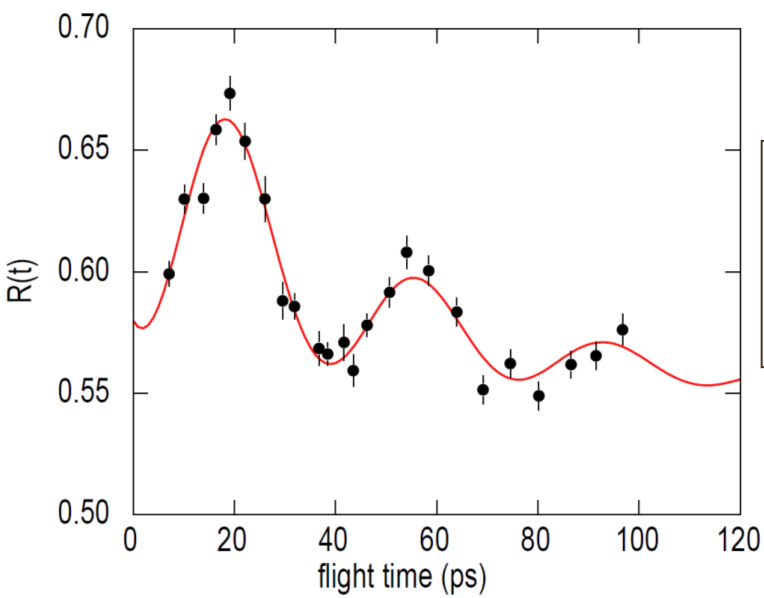
G. Georgiev (CSNSM), A.E. Stuchbery (ANU), Dec. 2012

- *Experiment:* High accuracy (< 2%) model independent (*B from first principles*) g-factor value for short-lived (ps) excited states
- *Theory:* g-factors of the 2$^+$ states in N=Z nuclei should be slightly higher than 0.5



8-fold segmented annular detector

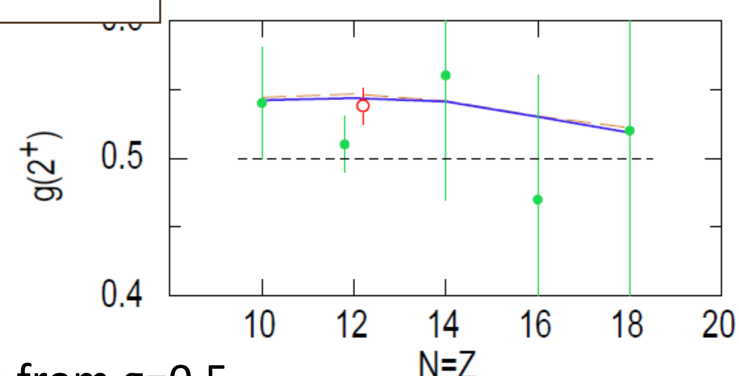




A. Kusoglu, A. Stuchbery, G. Georgiev *et al.*

^{24}Mg 2$^+$ state
USD shell model:
g(2$^+$)=0.5465

OUPS
(Orsay Universal Plunger System)



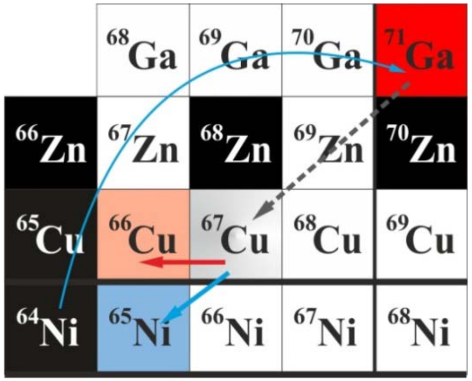
Our result: first experimental evidence of deviation from g=0.5

→ stringent test of the nuclear theories

Nuclear spin orientation in incomplete fusion reactions

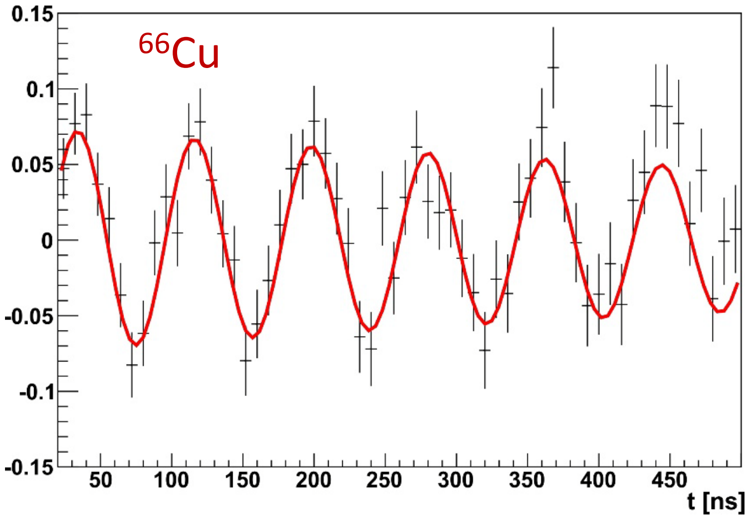
Pulsed 7Li beam 16 MeV on 64Ni target

G. Georgiev (CSNSM) Dec. 2013



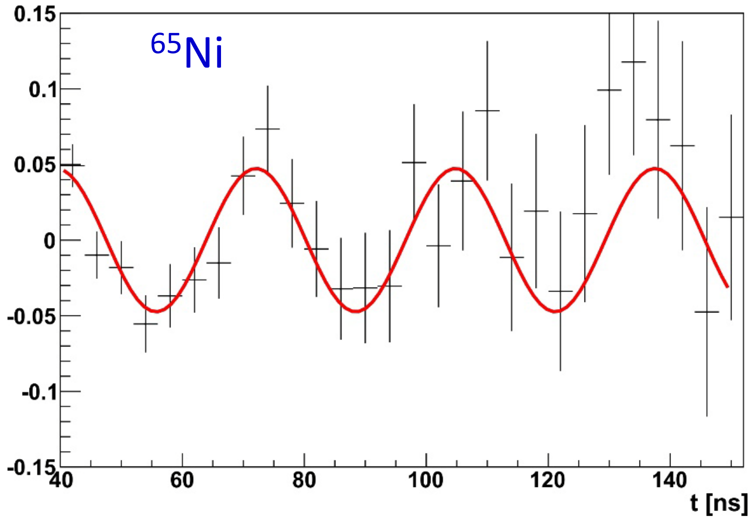
Nuclear spin orientation – a must for nuclear moments studies

- Fusion-evaporation reactions – **25 % - 75 %** alignment
- Projectile-fragmentation - **8 % - 13 %**
- Direct reactions (single-nucleon transfer) **~ 13 %**
- **Incomplete fusion** (multi-nucleon transfer?) – ???



Amplitude = 8 (1) %

Spin alignment = 23 (3) %



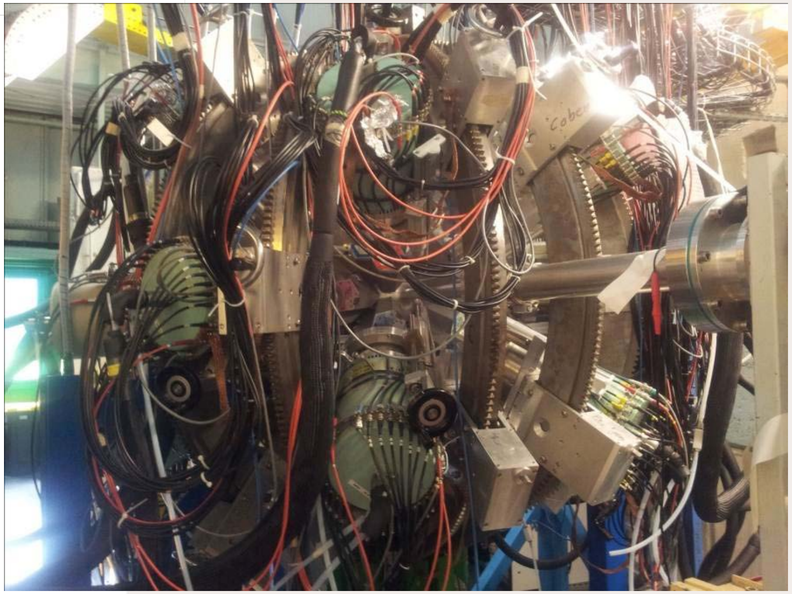
Amplitude = 4.8 (8) %

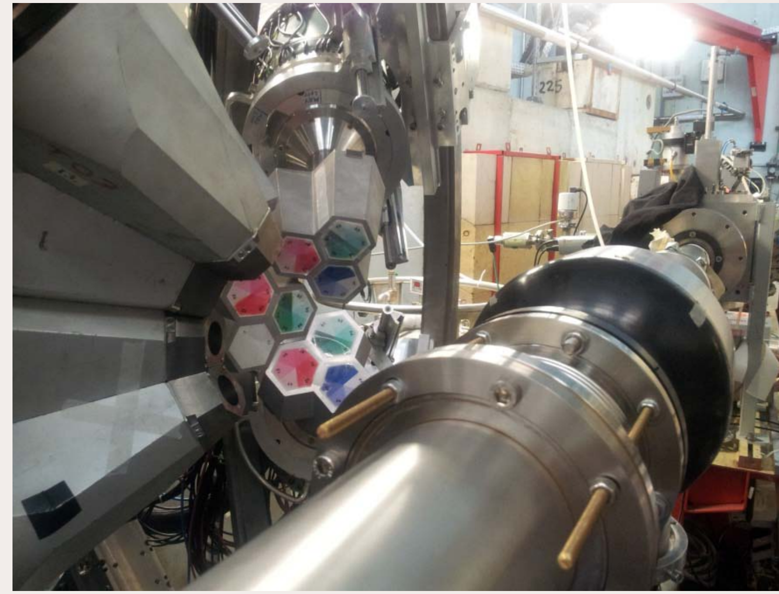
Spin alignment = 12.5 (20) %

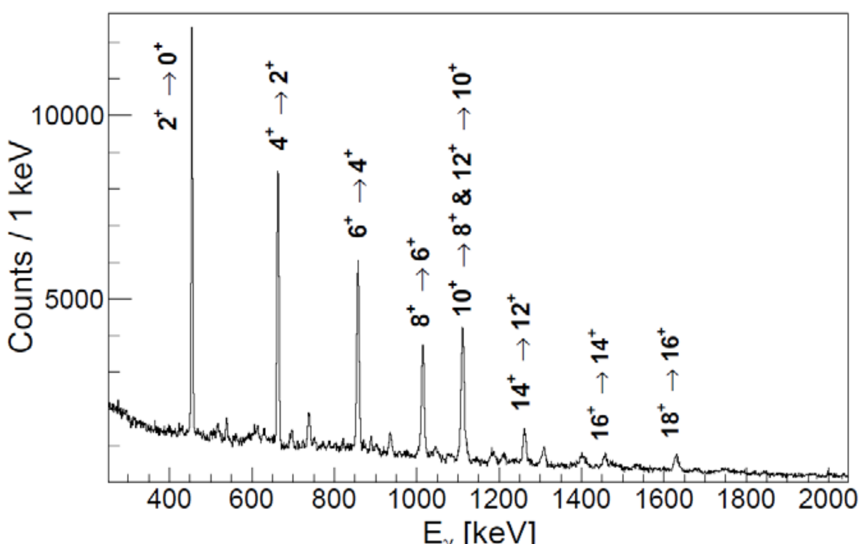
Results:

- considerable spin alignment in ^{7}Li induced reactions;
- dependence on the number of transferred nucleons?

MINORCA Campaign







12 ORGAM *AC* HPGe x 0.1%

8 Miniball triple cluster at ~14 cm from target
7.3% efficiency @ 1.33 MeV

MINORCA Accepted Proposals

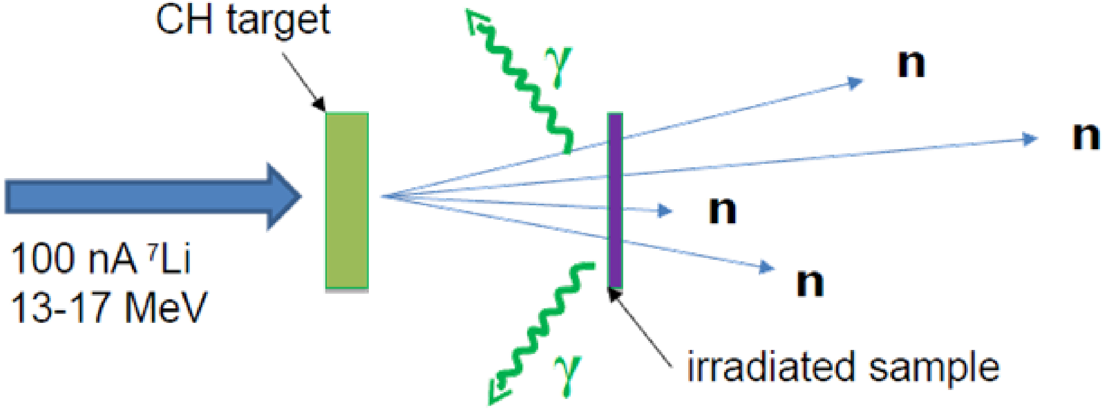
Total number of MINORCA requested UTs: **232** (about 80 days)

1. Single-particle structure in the second minimum. Search for high-K bands above fission isomers. (G. Georgiev – CSNSM) → **45 UTs**
2. g factor measurements of short-lived states in the Mg isotopes towards the Island of Inversion: 26Mg and 28Mg (G. Georgiev – CSNSM) → **18 UTs**
3. Shape coexistence in 74Se studied through complete low-spin spectroscopy after Coulomb excitation (M. ZIELINSKA – SPhN) → **21 UTs**
4. Measurement of octupole collectivity in Nd, Sm and Gd nuclei using Coulomb excitation (P.A. Butler – Univ. of Liverpool) → **21 UTs**
5. Spectroscopy of the neutron-rich fission fragments produced in the 238U(n,f) reaction (J. Wilson – IPN) → **45 UTs**
6. Evaluation of the Angular Momentum Dependence of the 96Mo γ Strength Function (B. Goldblum – Univ of California) → **22 UTs**
7. Search for X(5) symmetry in 78Sr nucleus (K. Gladnishki – Univ of Sofia) – **21 UTs**
8. Lifetime Measurement of 100Ru: A possible candidate for the E(5) critical point symmetry (T. Konstantinopoulos – CSNSM) – **18 UTs**
9. Lifetime measurements in 113Te: Determining Optimal effective charges approaching the N=Z=50 doubly-magic shell closure. (D.M. Cullen – Univ of Manchester) – **21 UTs**

The Tandem driven monochromatic neutron source

Lithium Inverse Cinematiques ORsay Neutron source

Campaign Managers: M. Lebois, J. Wilson

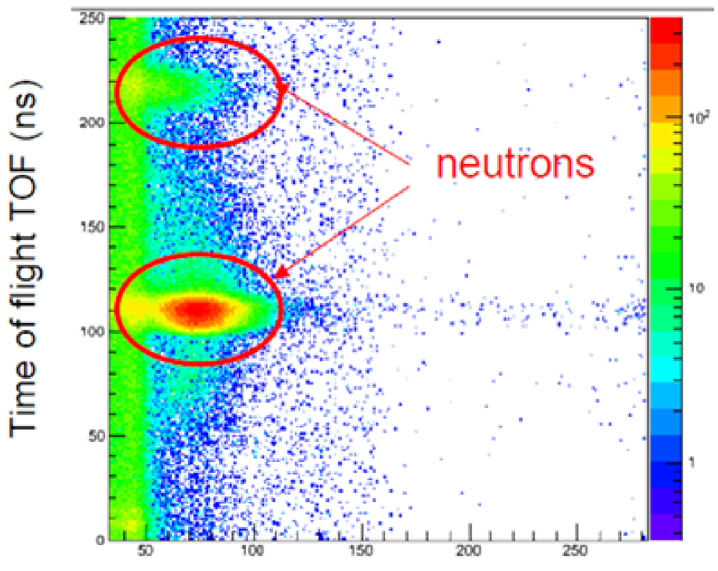


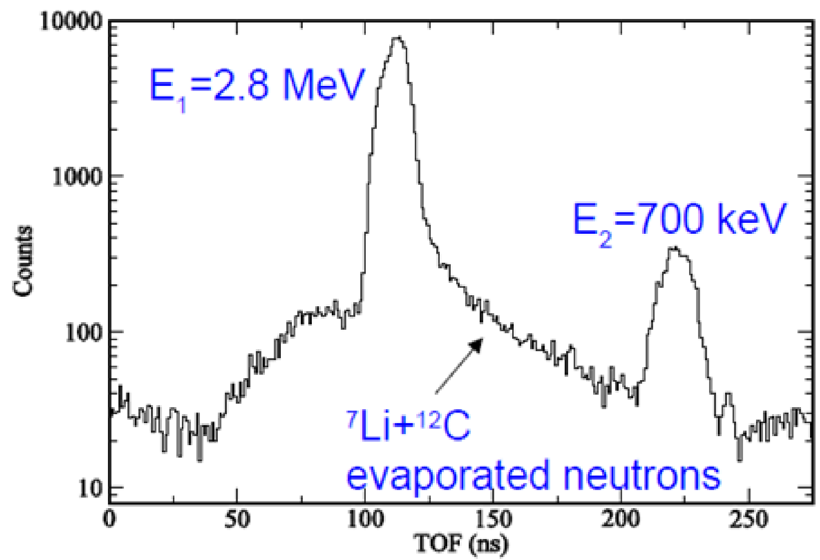
Focused intense mono-energetic neutron source:

10^7 n/s/sr

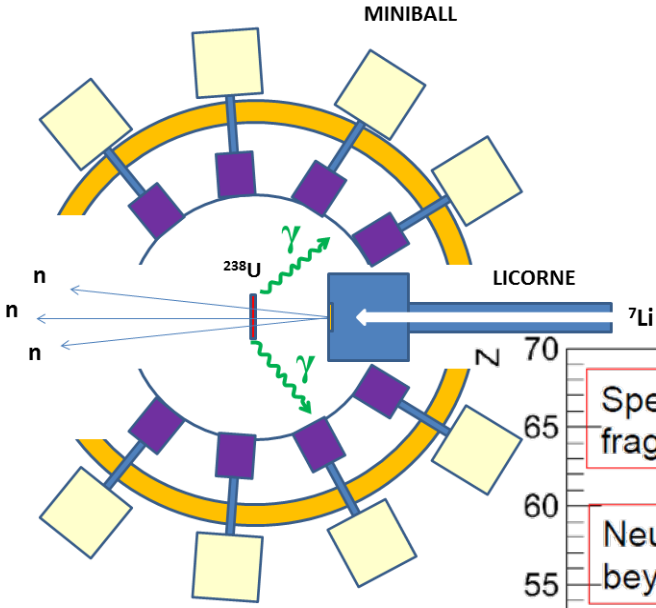
$0.5 < E_n < 4$ MeV

LICORNE

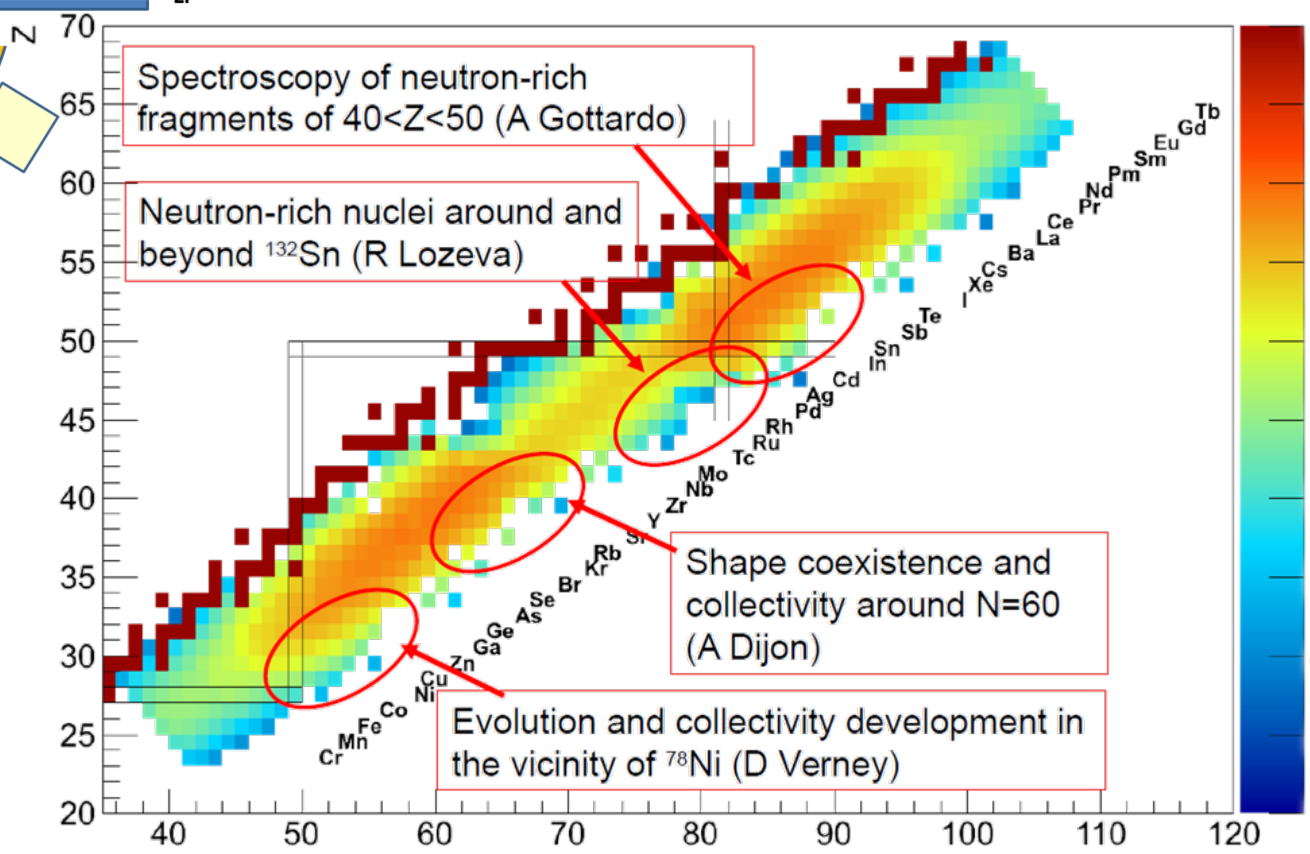




MINORCA+LICORNE

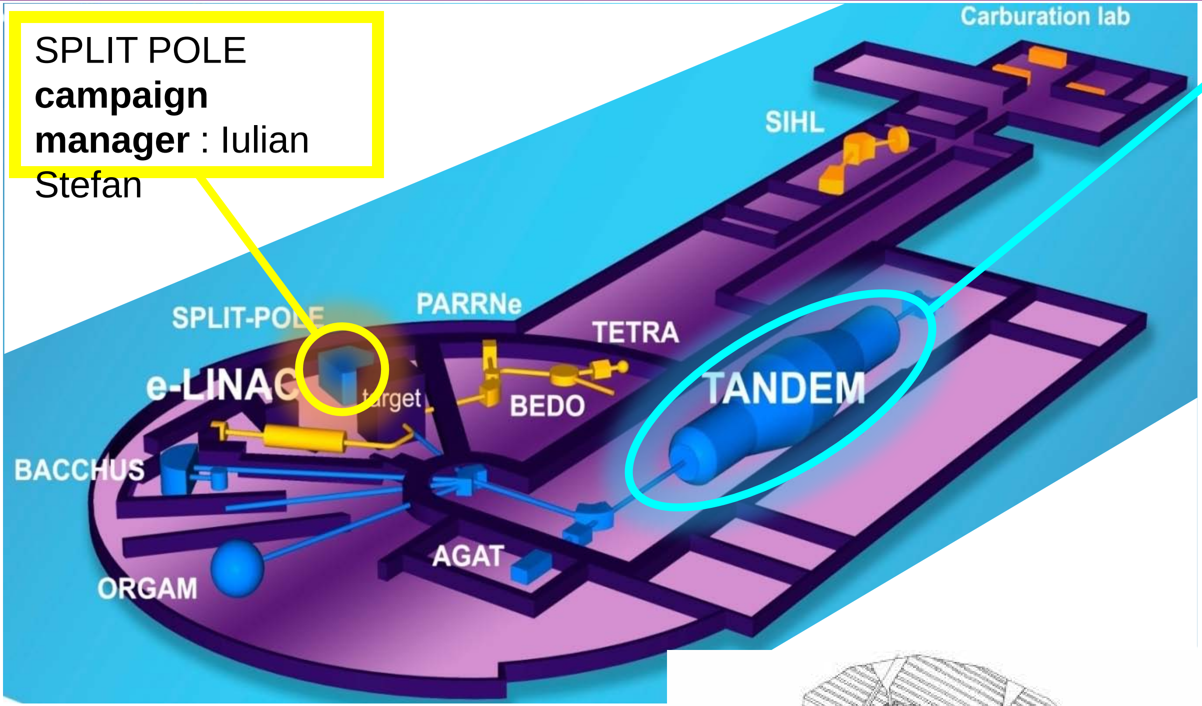


more in Matthieu's talk this morning



The Split Pole spectrometer and nuclear astrophysics

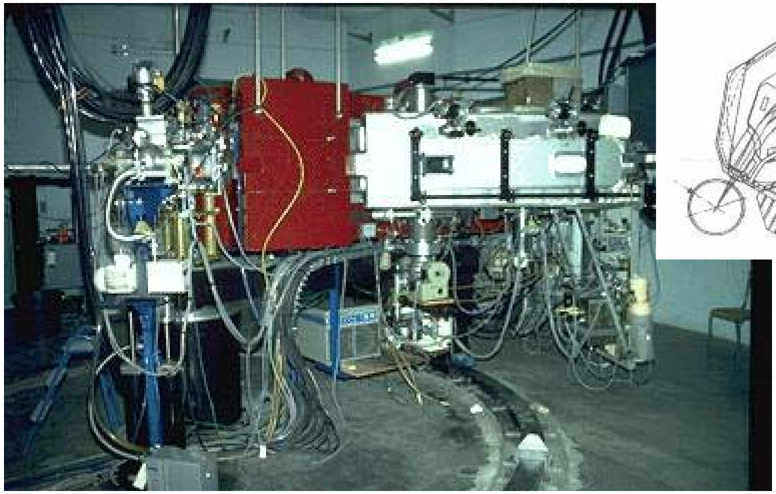
SPLIT POLE **campaign manager** : Iulian Stefan

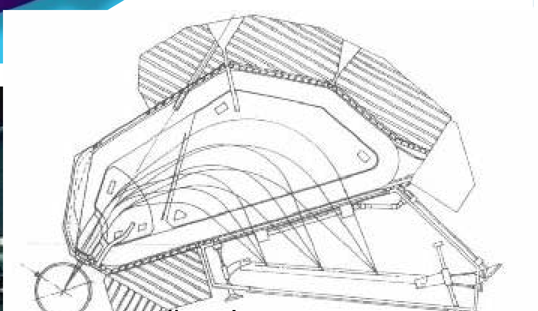


15 MV MP Tandem

- 2010-2011 rejuvenation
- 2012, 5 experiments
- 2013, 6 experiments

⇨ nuclear structure (20%)
⇨ ***nuclear astrophysics (80%)***





split-pole spectrometer

maximum magnetic rigidity : 1.65 Tm
maximum solid Angle : 4 msr
energy resolution E/ΔE~2000

focal plane detectors :
proportional counter : energy loss ΔE + localization
plastic : residual energy E

^{26}Al(n,p)^{26}Mg and ^{26}Al(n,α)^{23}Na in massive stars

S. Benamara, N. de Sereville

Phys.Rev. C 89, 065805 (2014)

^{26}Al nucleosynthesis in massive stars

- Core H burning
- Ne/C convective shell burning
- Explosive Ne burning

Limongi et al., Iliadis et al.

^{26}Al yield depends crucially on ^{26}Al(n,p) and ^{26}Al(n,α) reactions

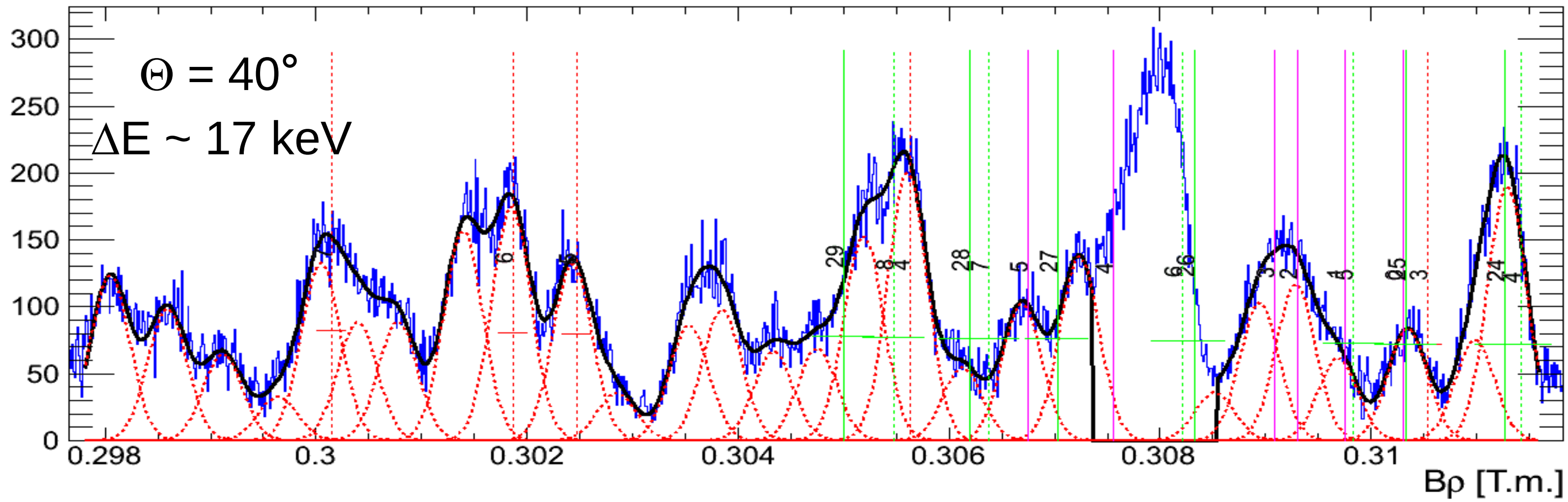
Rates x2 → ^{26}Al yield /2

Lack of spectroscopic information in ^{27}Al

Reaction: ^{27}Al(p,p')^{27}Al @ 18 MeV

- Targets: ^{27}Al, ^{12}C & mylar ~ 80 μg/cm^2
- SPLITPOLE : high-resolution measurement → θ = 10°, 25°, 40° & 45°

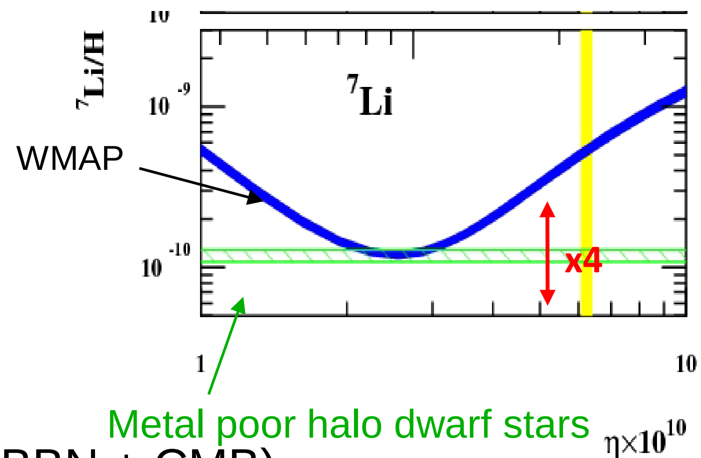
- ^{27}Al levels: kinematics displacement between Θ = 40° and 45°
- Many new states above (and below) neutron threshold
- Good agreement with known resonances



Big-bang & ^{7}Li cosmological problem

F. Hammache, N. de Sereville, I. Stefan

Primordial nucleosynthesis (BBN) is one of the three evidences for the Big-Bang model



When T < 10^9 K → BBN starts

- Production of D, ^{3}He, ^{4}He, ^{7}Li
- Abundances depend on baryonic density

D, ^{3}He, ^{4}He, observations agree with predictions (BBN + CMB)

^{7}Li problem: $(^7\text{Li/H})_{BBN}$ / $(^7\text{Li/H})_{obs}$ = 4

Possible explanations:

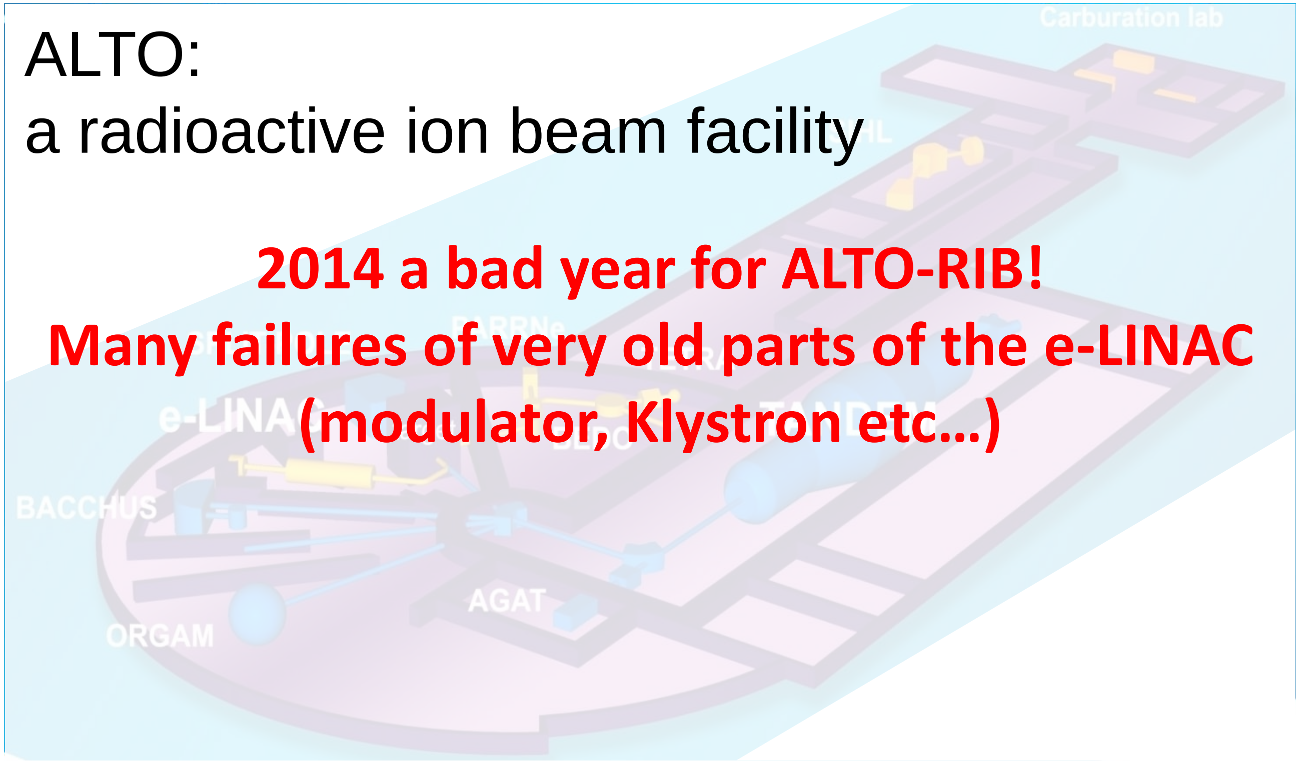
- Physics beyond standard model: super-symmetry, constant variation, ….
- Observations: can ^{7}Li be uniformly destroyed in the Splite plateau region?
- Nuclear physics: ^{7}Li produced by ^{7}Be EC & ^{3}He(^{4}He,g)^{7}Be known better than 15%

Last proposed solution studied with SPLITPOLE @ IPN Orsay

- ^{7}Be + ^{3}He → ^{10}C* hypothetical state at ~ 15 MeV (1-, 2-)
- ^{10}C studied - ^{10}B(^{3}He,t)^{10}C* @ 35 MeV
- Conclusion -> probably no solution from nuclear physics

Phys.Rev. C 88, 062802 (2013)

ALTO:
a radioactive ion beam facility



2014 a bad year for ALTO-RIB!

Many failures of very old parts of the e-LINAC (modulator, Klystron etc…)

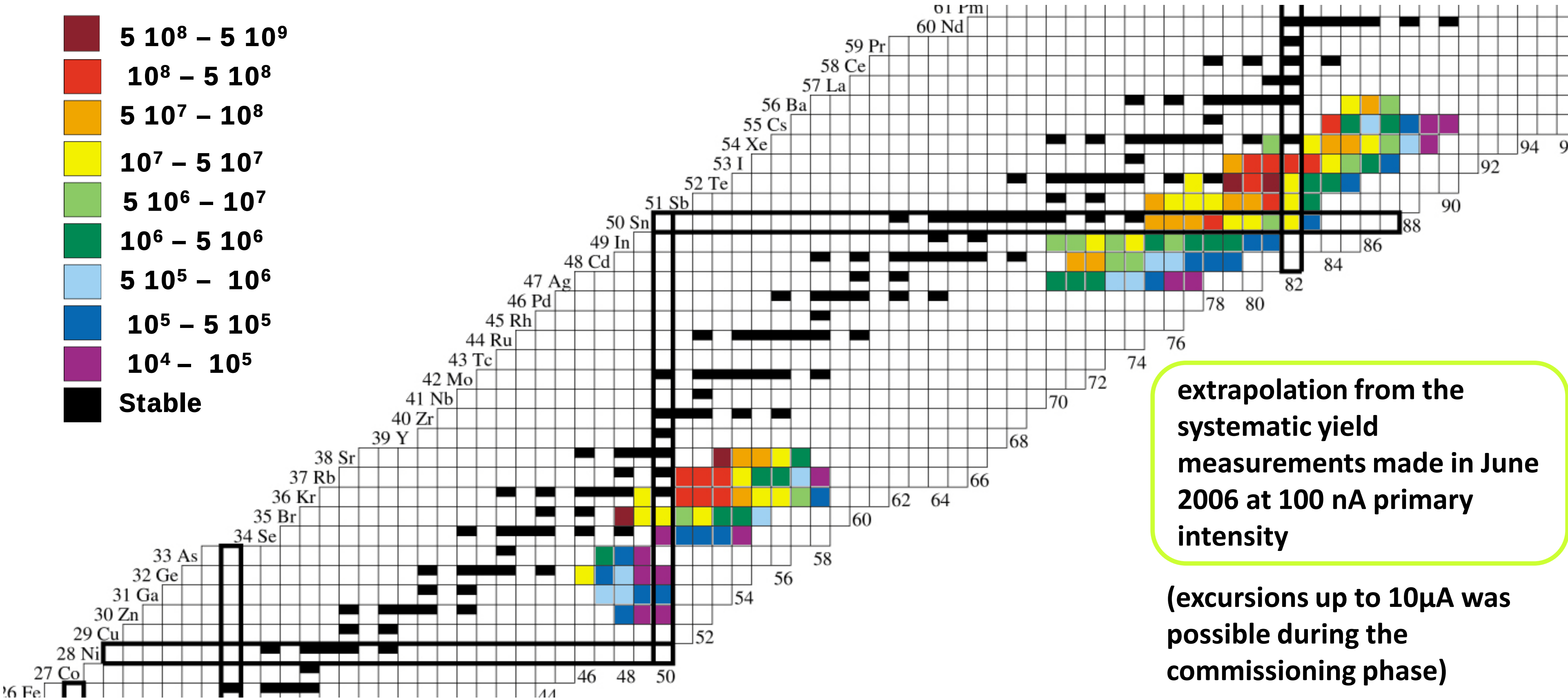
Beams “natively” available at ALTO

Measured productions yields at the detection point
on line with the PARRNe mass separator
electrons -> gamma induced fission

nominal intensity:
10 μA ⇒~ 10^{11} fissions/s

Production pps / 10 μA e-

- $5\ 10^8 - 5\ 10^9$
- $10^8 - 5\ 10^8$
- $5\ 10^7 - 10^8$
- $10^7 - 5\ 10^7$
- $5\ 10^6 - 10^7$
- $10^6 - 5\ 10^6$
- $5\ 10^5 - 10^6$
- $10^5 - 5\ 10^5$
- $10^4 - 10^5$
- Stable



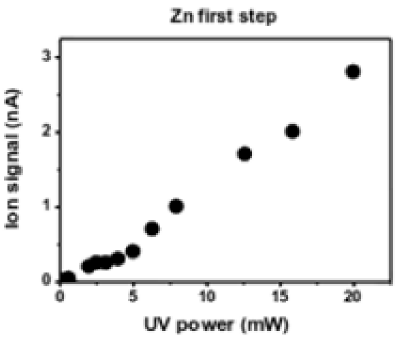
extrapolation from the systematic yield measurements made in June 2006 at 100 nA primary intensity

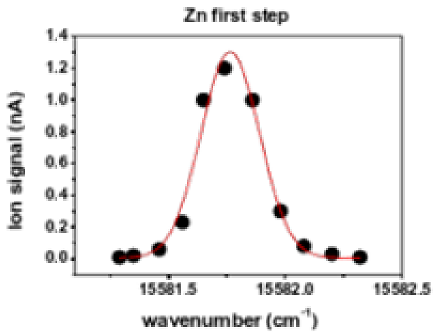
(excursions up to 10μA was possible during the commissioning phase)

Laser ionized RIBs at ALTO

The ALTO laser ion source **RIALTO** (Resonant Ionization at ALTO)- S. Franchoo et al.

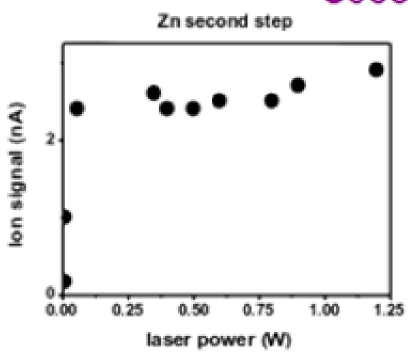
First step

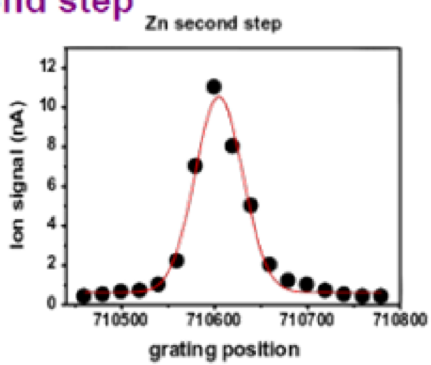


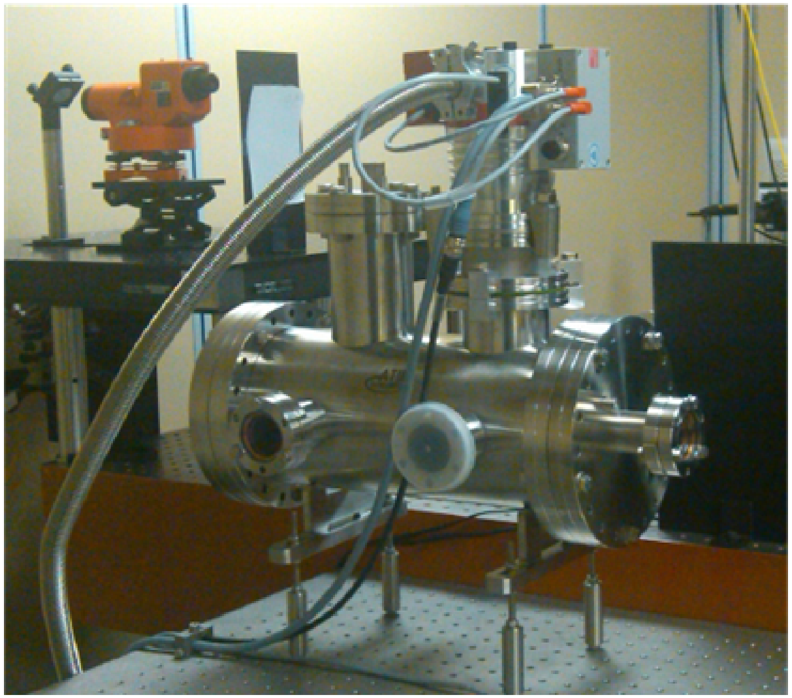


2011, 2012: Gallium with two ionisation schemes
2013: Zinc with frequency tripling
2014: Off-line chamber for development of laser schemes

Second step







R. Li, D. Yordanov, IPN Orsay
V. Fedosseev, T. Day Goodacre, B. Marsh, Isolde
K. Flanagan, University of Manchester
T. Kron, K. Wendt, University of Mainz

The ALTO laser ion source **RIALTO** (Resonant Ionization at ALTO)

Installation supervised by S. Franchoo
R. Li and C. Lau **IPN Orsay**
with the collaboration of
ISOLDE:
V. Fedosseev, B. Marsh, T. Goodacre
Univ. Manchester:
K. Flanagan

PHYSICAL REVIEW C **88**, 047301 (2013)

Probing nuclear structures in the vicinity of ^{78}Ni with β- and βn-decay spectroscopy of ^{84}Ga

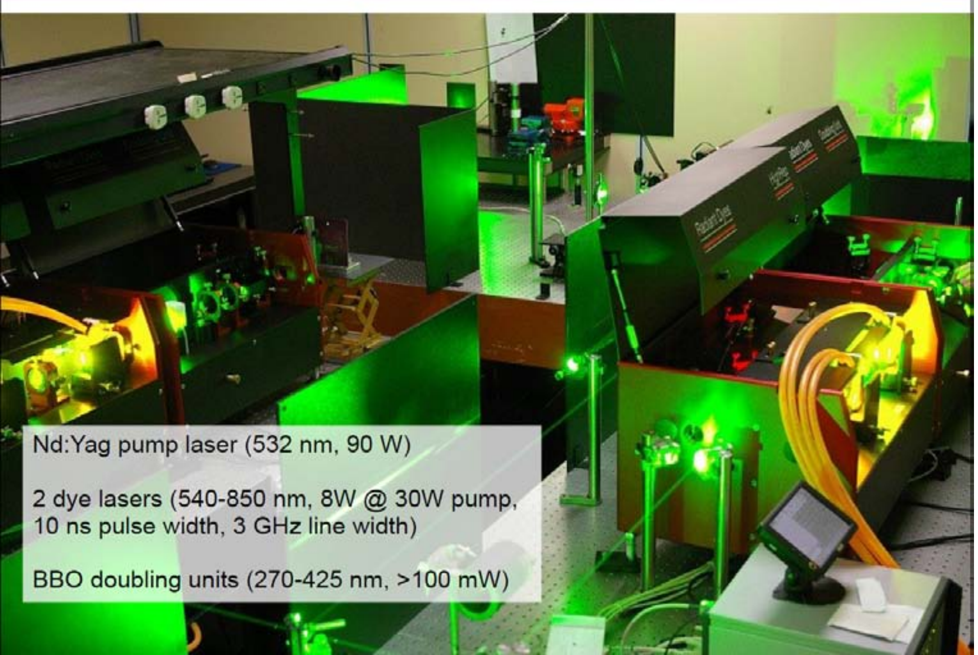
K. Kolos,[1,2,*] D. Verney,[1] F. Ibrahim,[1] F. Le Blanc,[1,3] S. Franchoo,[1] K. Sieja,[3] F. Nowacki,[3] C. Bonnin,[1] M. Cheikh Mhamed,[1] P. V. Cuong,[4] F. Didierjean,[3] G. Duchêne,[3] S. Essabaa,[1] G. Germogli,[1] L. H. Khiem,[4] C. Lau,[1] I. Matea,[1,5] M. Niikura,[1,5] B. Roussière,[1] I. Stefan,[1] D. Testov,[1,6] and J.-C. Thomas[7]
[1]*Institut de Physique Nucléaire, CNRS/IN2P3 and Université Paris Sud, Orsay, France*
[2]*University of Tennessee, Knoxville, Tennessee 37996, USA*
[3]*Institut Pluridisciplinaire Hubert Curien, CNRS/IN2P3 and Université de Strasbourg, Strasbourg, France*
[4]*Center of Nuclear Physics, Institute of Physics, Vietnam Academy of Science and Technology, Hanoi, Vietnam*
[5]*Department of Physics, University of Tokyo, Hongo, Bunkyo-ku, Tokyo, Japan*
[6]*Flerov Laboratory of Nuclear Reactions, Joint Institute of Nuclear Research, Dubna, Russia*
[7]*Grand Accélérateur National d'Ions Lourds (GANIL), CEA/DSM-CNRS/IN2P3, Caen, France*
(Received 4 August 2013; revised manuscript received 2 September 2013; published 14 October 2013)

The decay of ^{84}Ga has been reinvestigated at the PARRNe online mass separator of the electron-driven installation ALTO at IPN Orsay. The nominal primary electron beam of 10 μA (50 MeV) on a ^{238}UC$_x$ target in combination with resonant laser ionization were used for the first time at ALTO. Improved level schemes of the neutron-rich ^{83,84}Ge (Z = 32) isotopes were obtained. The experimental results are compared with the state-of-the-art shell model calculations and discussed in terms of collectivity development in the natural valence space outside the ^{78}Ni core.

DOI: 10.1103/PhysRevC.88.047301 PACS number(s): 23.20.Lv, 23.40.−s, 29.30.Kv, 21.60.Cs

installation ALTO at IPN Orsay. The nominal primary electron beam of 10 μA (50 MeV) on a ^{238}UC$_x$ target in combination with resonant laser ionization were used for the first time at ALTO. Improved level schemes

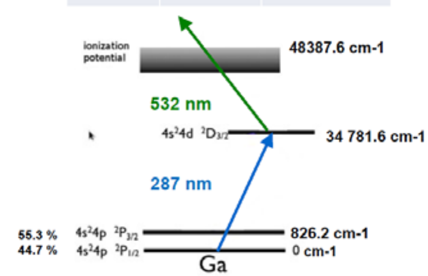
Laser ion source upgrade in 2012



Gallium on and off-line in 2012

Stable gallium

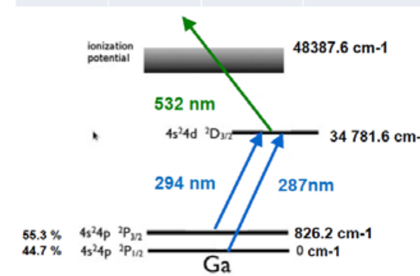
287nm (300mW)	532nm (~10W)	Ions (nA)
off	off	1.3
√	off	1.3
off	√	1.3
√	√	22



two new dye lasers (Radiant Dye)
enhancement x18

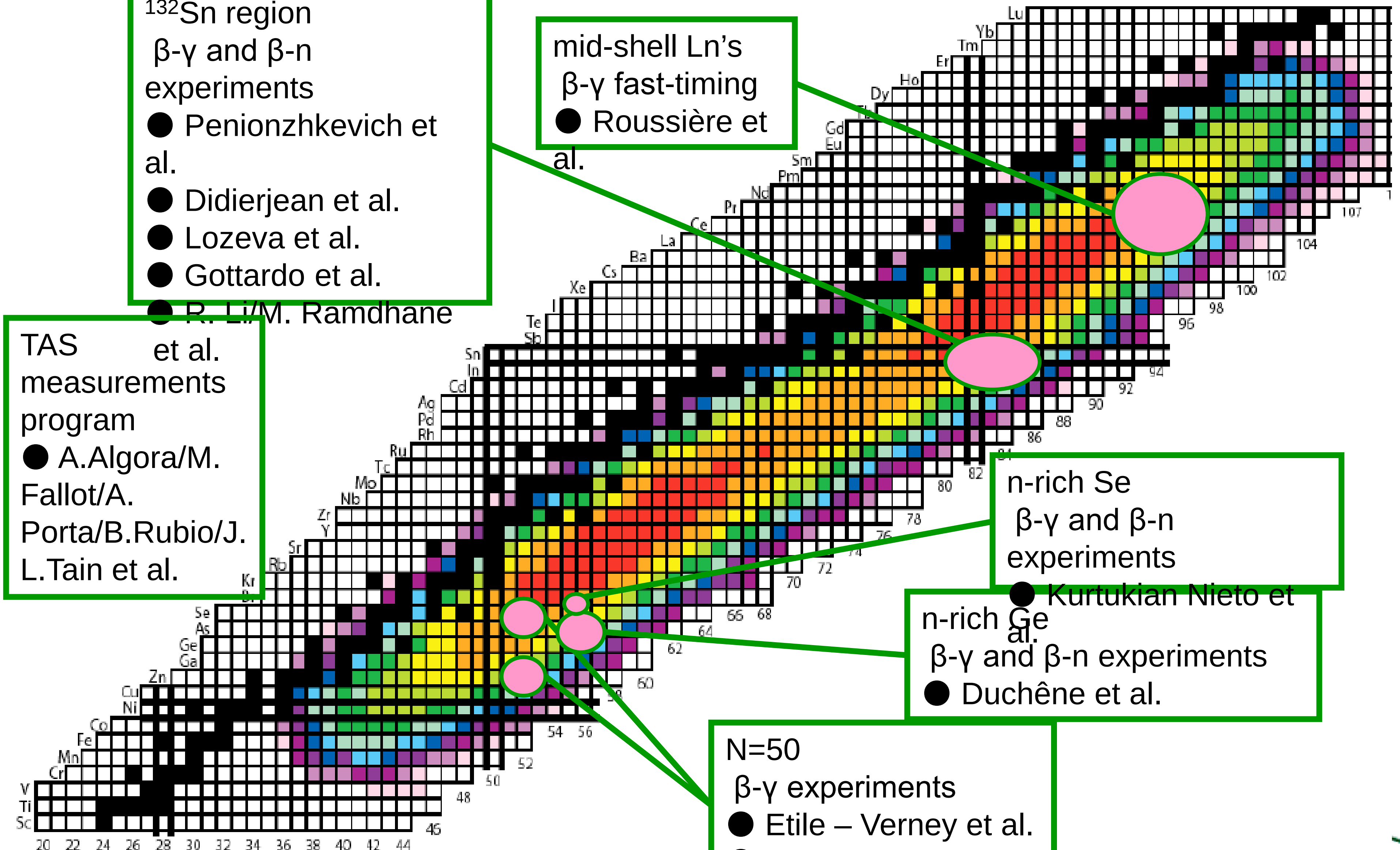
Radioactive ^{69}Ga

287nm (250mW)	294nm (130mW)	532nm (~10W)	Ions (pA)
off	off	off	66
√	off	√	150
off	√	√	220
√	√	√	305



both ground and metastable state
short-lived pyrromethene dye
enhancement x3 x2

Approved experiments to be scheduled



^{132}Sn region
β-γ and β-n experiments
- Penionzhkevich et al.
- Didierjean et al.
- Lozeva et al.
- Gottardo et al.
- R. Li/M. Ramdhane et al.

mid-shell Ln's
β-γ fast-timing
- Roussière et al.

TAS measurements program
- A.Algora/M. Fallot/A. Porta/B.Rubio/J. L.Tain et al.

n-rich Se
β-γ and β-n experiments
- Kurtukian Nieto et al.

n-rich Ge
β-γ and β-n experiments
- Duchêne et al.

N=50
β-γ experiments
- Etile – Verney et al.
- Astier et al

The variety of the physics program at ALTO
strongly depends on available LERIB lines and their instrumentation

PARRNe mass separator room (formerly line 110 of the Tandem)
Max number of measurement positions : 6