

Physics with the MLL trap at Alto and S³



First Physics with the Super Separator Spectrometer S³

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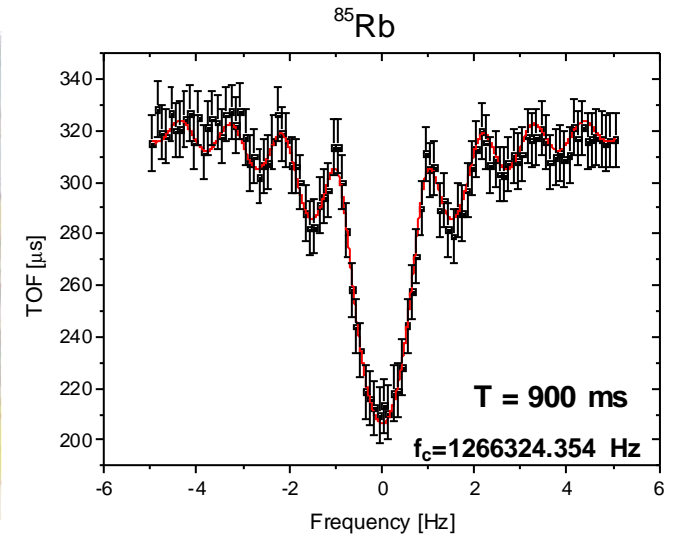
Outline

- I. MLLTRAP project
- II. MLLTRAP@ALTO
- III. Mass measurements above fermium

MLLTRAP project in Germany



Peter G. Thirolf , Christine Weber



2009 → Off-line commissioning of the double Penning trap system MLLTRAP

V.S. Kolhinen, et al., Nucl. Instrum. Methods Phys. Res., Sect. A 600 (2009) 391

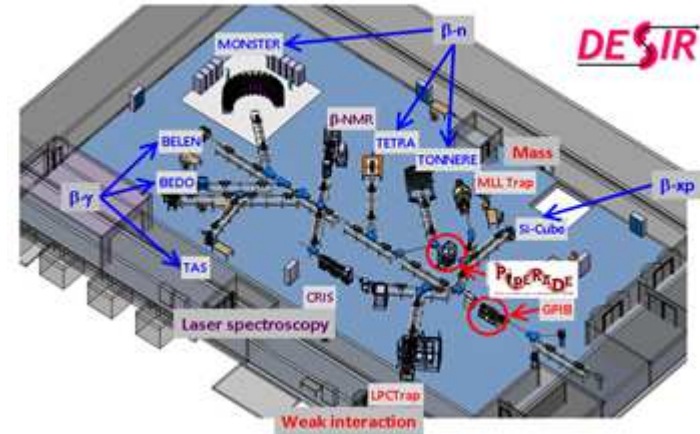
MLLTRAP → Penning trap mass spectrometer → High-precision mass measurements

MLLTRAP project in France

The DESIR facility at GANIL-SPIRAL2 :

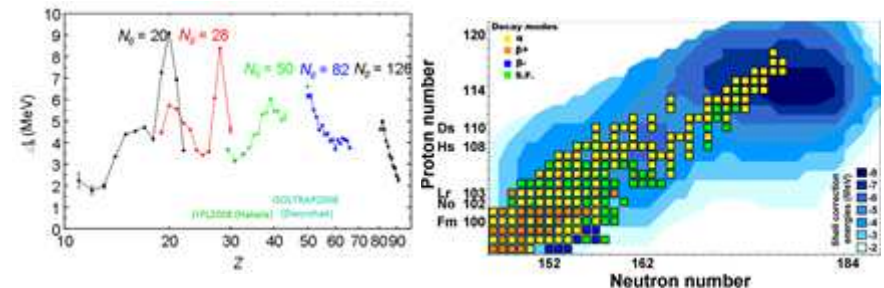


- β decay spectroscopy
- Laser Spectroscopy
- High-precision mass measurements



Mass measurements

- Nuclei with $Z \geq 104$
- $N=Z$ nuclides up to ^{100}Sn
- Quantum phase transitions around $A = 100$ ($N=60$)



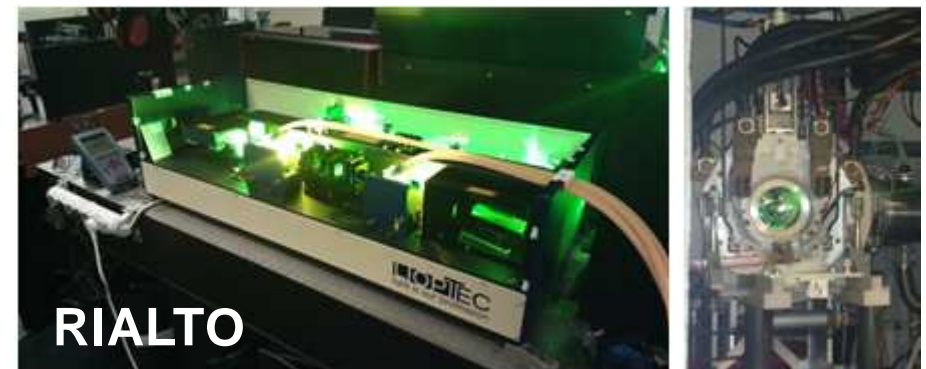
MLLTRAP project in France

The ALTO facility at Orsay



First operational RIB facility based on photo-fission → populating the GDR of ^{238}U

- ❑ 30-kV platform
- ❑ mass separator ($A/\Delta A = 1500$)
- ❑ 10 μA , 50 MeV e- beam
- ❑ $10^{11} - 4 \times 10^{11}$ fissions/s

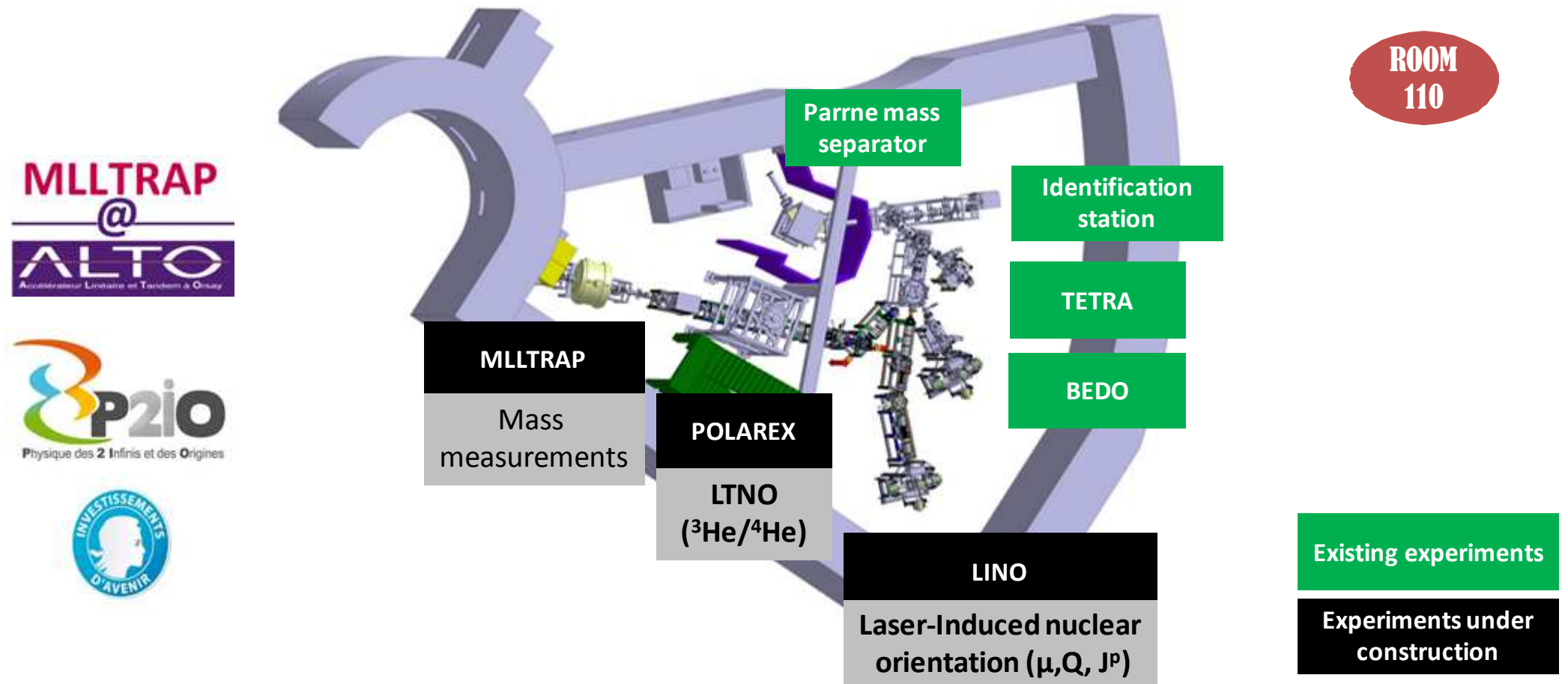


Status of MLLTRAP@ALTO

March 2016 : “Charting Terra Incognita of Exotic Nuclei”



The MoU between MLL and IPNO was signed in May 2016



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Move of MLLTRAP from MLL to Alto

February – April 2016



July 2016



July 2016

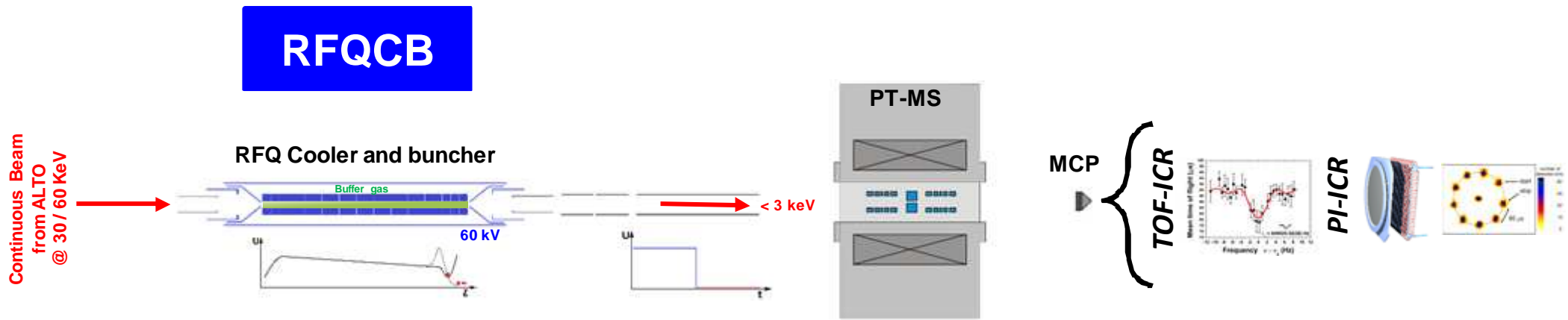


The truck left MLL the 14th of July 2016



*Free area for MLLTRAP
December 2016*

MLLTRAP setup at Alto



RFQ Design → COLETTE

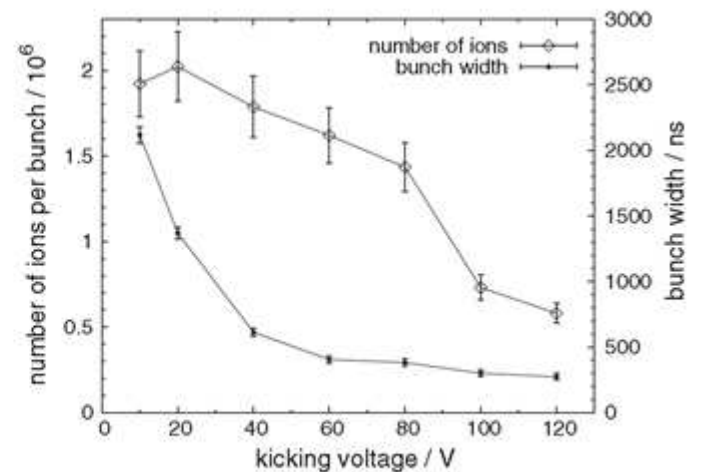
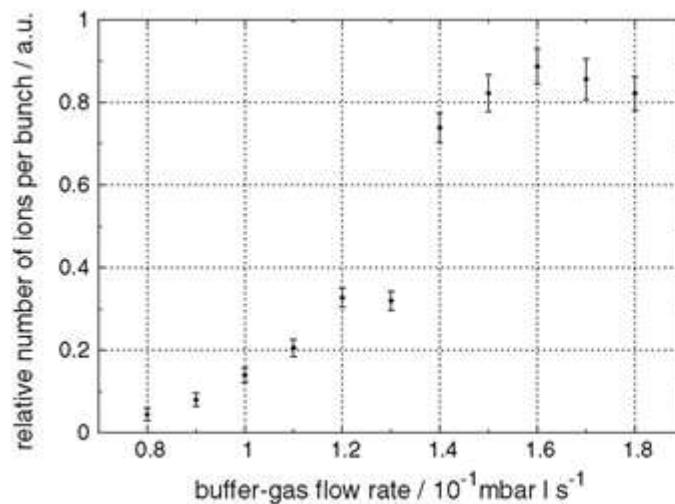
$2r_0 = 14 \text{ mm}$, 15 segments



$^{39}\text{K}^+$ @ 30 keV,
 $V_{\text{RF}} = 85V_{\text{pp}}$ $F_{\text{RF}} = 1 \text{ MHz}$
 Bunching efficiency = 54%

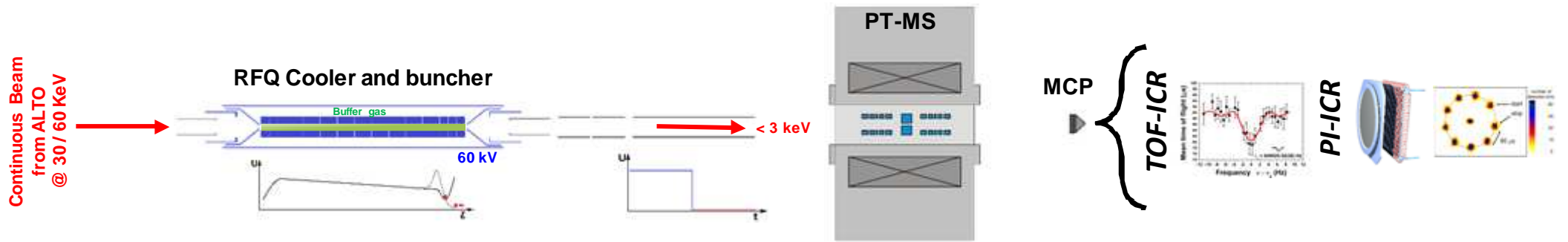
COLETTE@TRIGA

T. Beyer et al., Appl. Phys. B 114 (2014) 129



MLLTRAP setup at ALTO

Penning trap



High-precision mass measurements

In-trap decay spectroscopy



Purification Trap

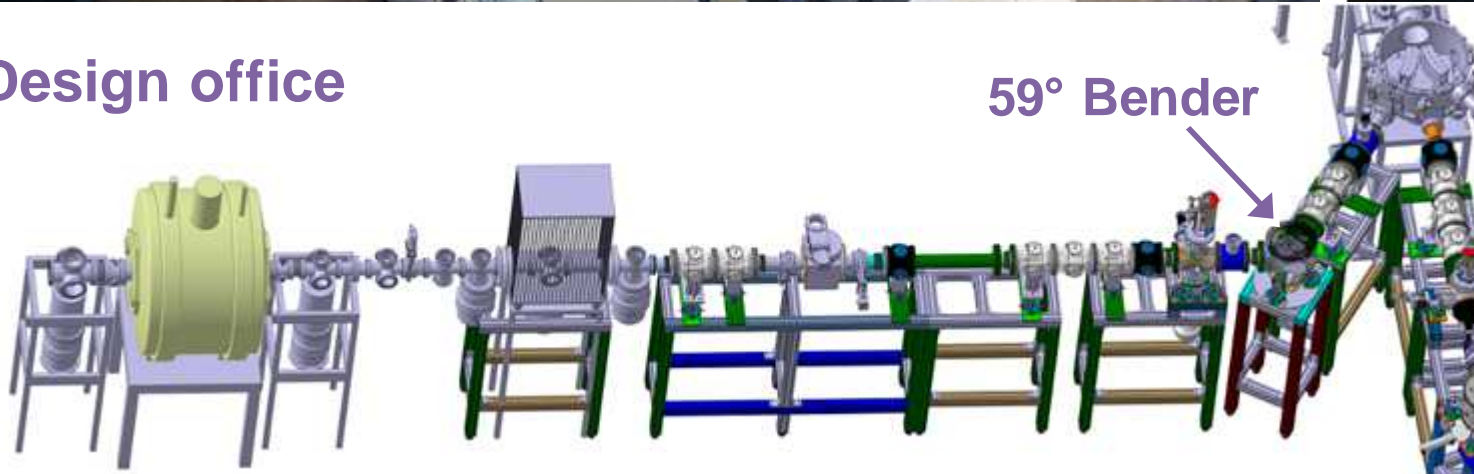
Measurement Trap

Detector Trap

Status of MLLTRAP@ALTO

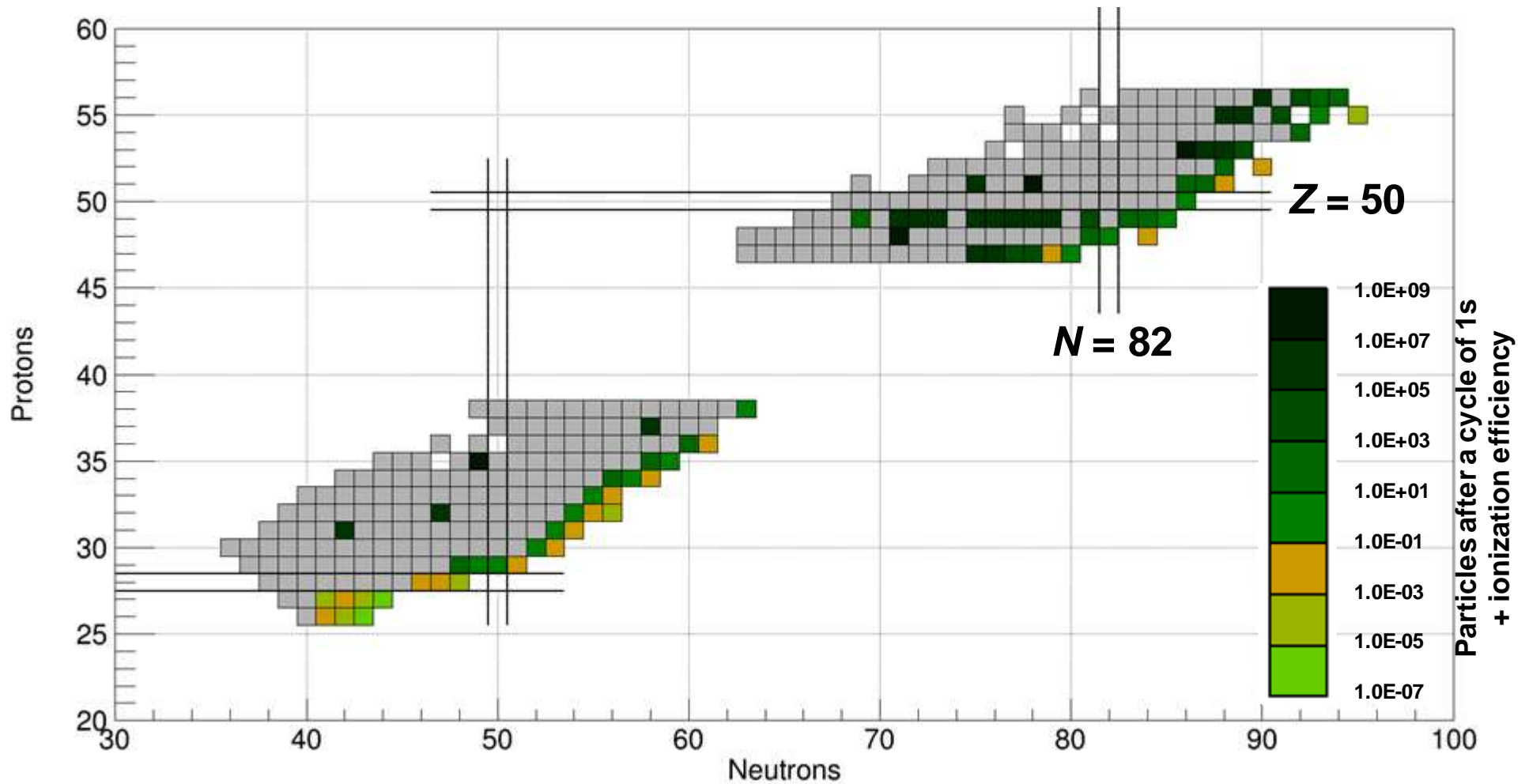


IPNO Design office



High-precision mass measurements at ALTO

Isotopes produced at ALTO by photo-fission



High-precision mass measurements at ALTO

ALTO

**Letter of Intent for Day 1
MLLTRAP experiments**

PAC session :	EXP # (Do not fill in):
March 2017	

Title: High-precision mass measurement of silver isotopes ($A=113 - 129$) towards the $N=82$ shell closure with MLLTRAP at ALTO

Is it a follow up experiment? [Yes/No]: **No** If yes, experiment number:

Spokespersons (if several, please use capital letters to indicate the name of the contact person):

Enrique Minaya Ramirez

Address of the contact person:

Institut de Physique Nucléaire 15 rue Georges Clémenceau 91406 Orsay

Other Participants or Organisations:

P. Ascher¹, B. Blank¹, P. Chauveau², P. Delahaye³, S. Franchoo⁴, M. Gerbaux¹, S. Grévy¹, J. Ljungvall², A. Lopez-Martens², D. Lunney², M. MacCormick⁴, A. De Roubin⁵, P. Thirolf⁶, J.-C. Thomas³, D. T. Yordanov⁴

¹*Centre d'Etudes Nucléaires de Bordeaux-Gradignan, France*

²*Centre de Sciences Nucléaires et de Sciences de la Matière, Orsay, France*

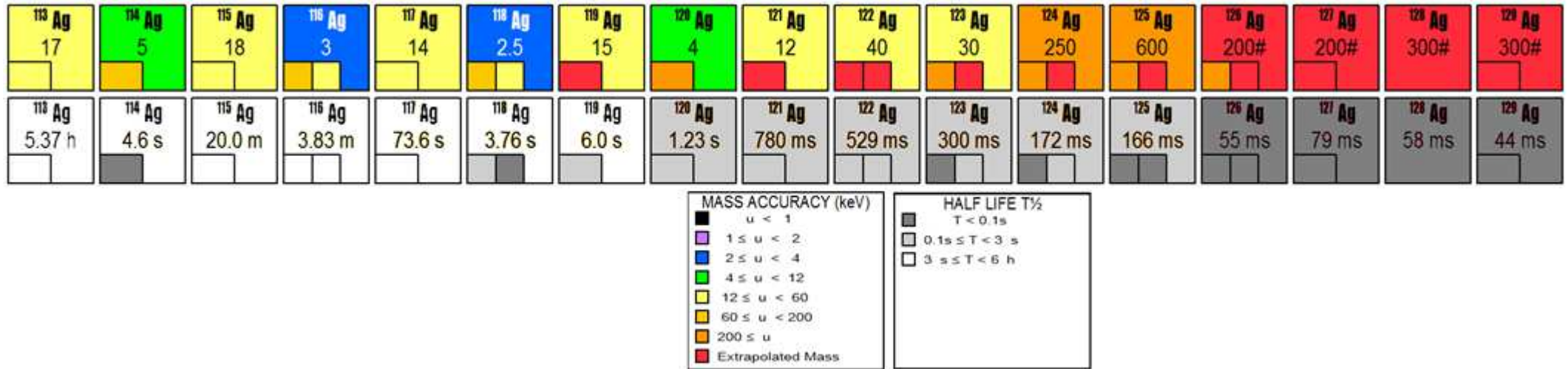
³*Grand Accélérateur National d'Ions Lourds, Caen, France*

⁴*Institut de Physique Nucléaire d'Orsay, France*

⁵*University of Jyväskylä, Department of Physics, Finland*

⁶*Ludwig-Maximilians-Universität München, Garching, Germany*

High precision mass measurements of silver isotopes

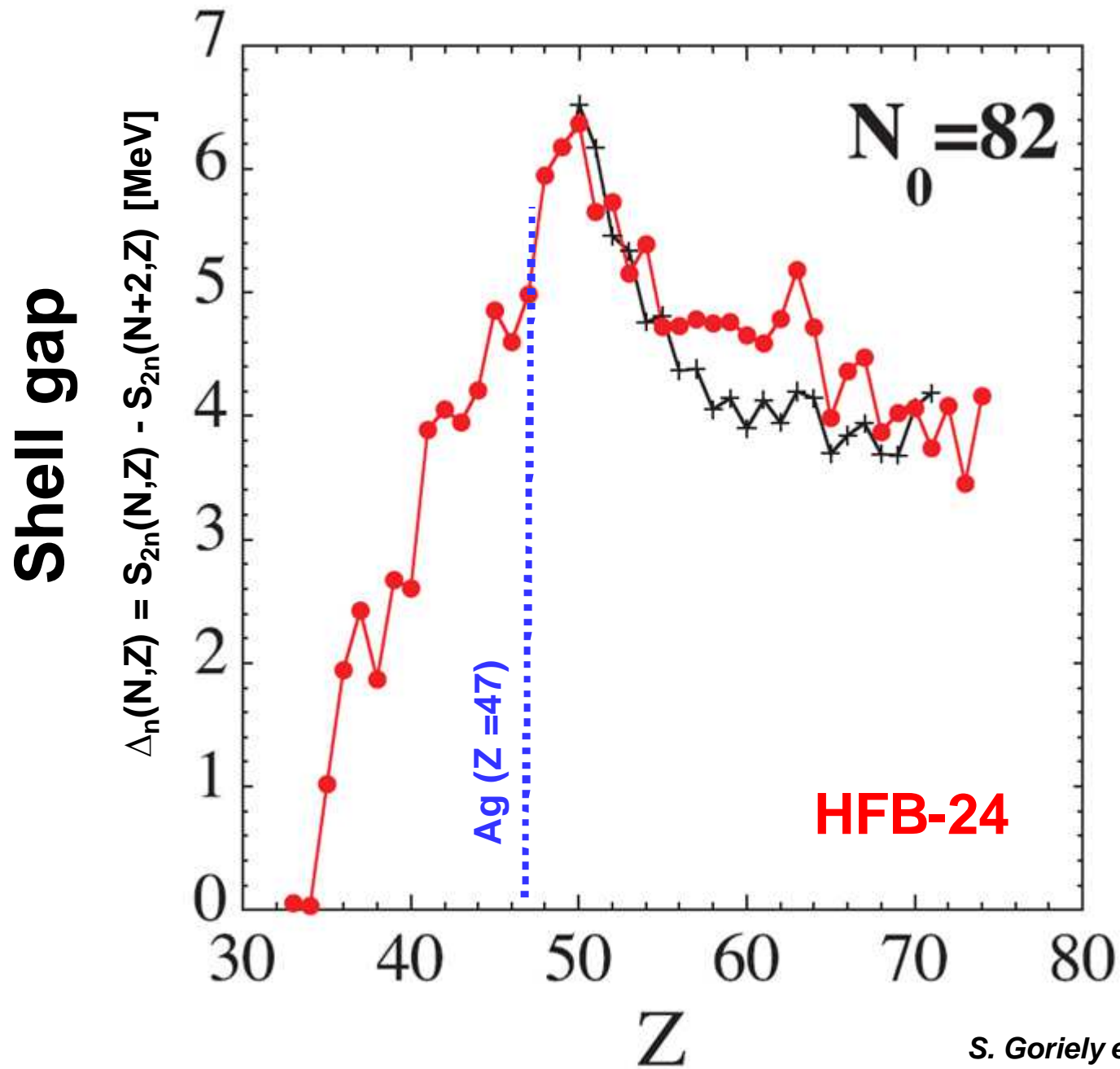


^{113,115,118}Ag : Characterize the performance of the full detection system

¹²³⁻¹²⁵Ag : Sensitivity of MLLTRAP to ions with short half-lives and low statistics

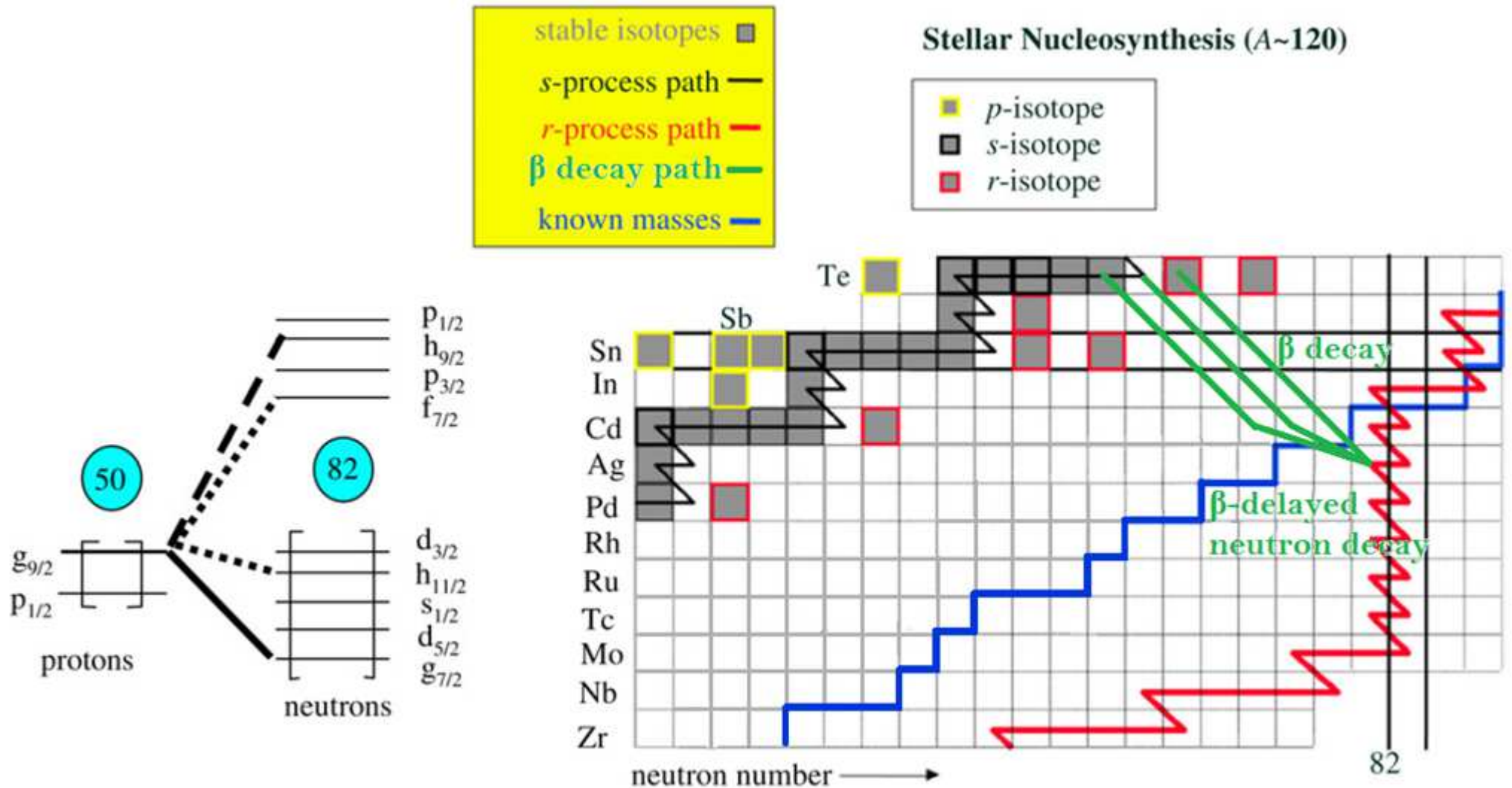
¹²⁶Ag and above : evolution of the shell gap at N= 82 (PI-ICR)

Nuclear structure around $N = 82$



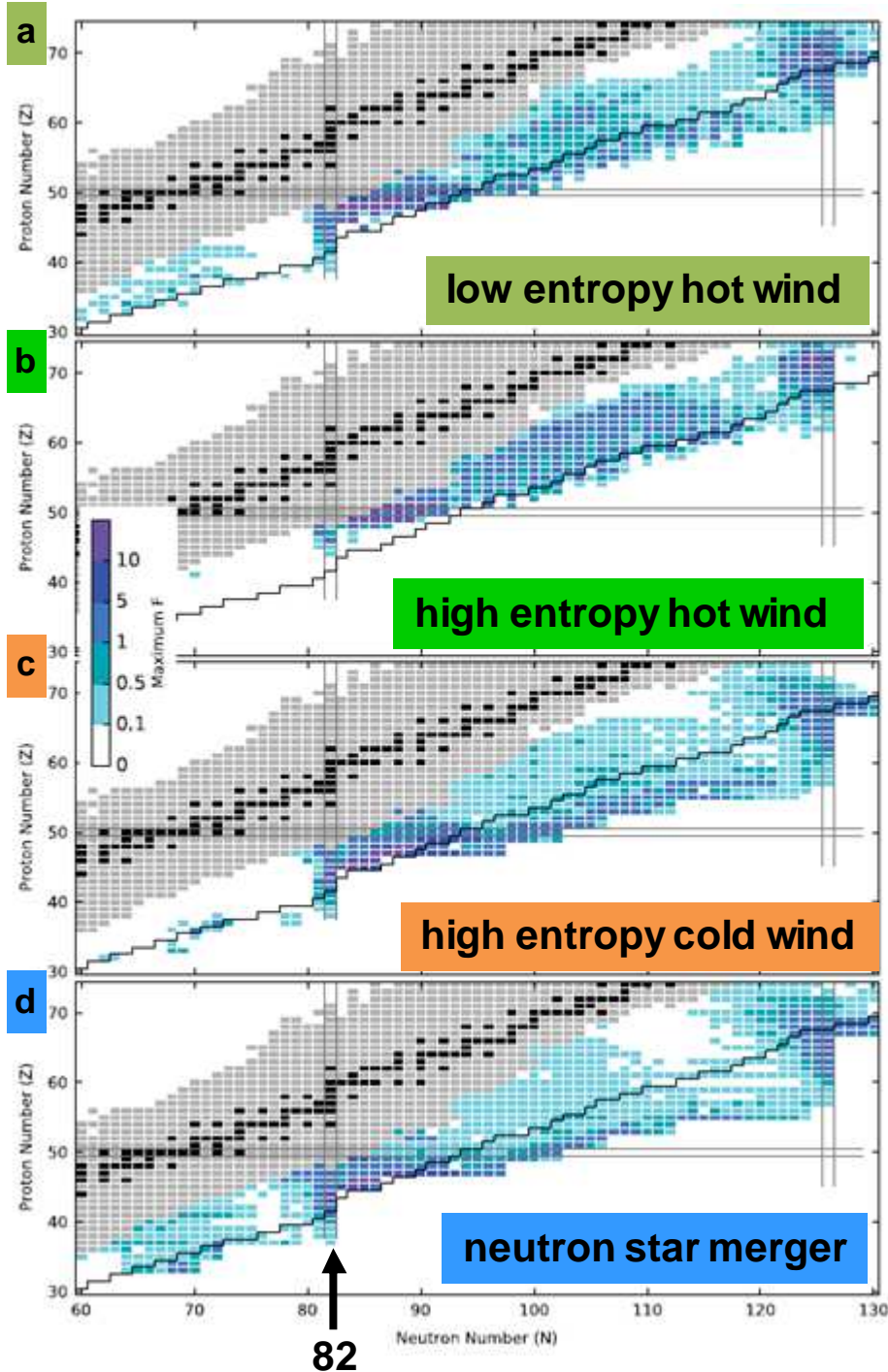
S. Goriely et al., PRC88(2013)

Masses for nuclear astrophysics studies



Masses for nuclear astrophysics studies

Important nuclei from sensitivity studies



Nuclear mass (silver isotopes)

mass	a	b	c	d
126	0.05	*	0.15	1.28
127	0.11	0.02	0.22	1.68
128	2.22	3.51	1.23	2.89
129	1.92	0.71	1.18	2.90
130	12.54	0.04	0.68	3.03

Status of MLLTRAP@ALTO

2016

Warm-up of the superconducting magnet at Munich, shipment and cooling and shimming of the superconducting magnet at IPN

Move of all associated equipment to IPN

Design of an RFQ cooler and buncher

Construction of the RFQ cooler and buncher

Installation, Alignment of the vacuum tube and traps

Vacuum tests, electronics tests, off-line ion source

Trapping, buffer gas cooling, first resonance

Mass cross check

Preparation of the temperature stabilization device

Installation of the MCP delay line detector

Off-line test of the RFQ and MLLTrap

On-line test of the RFQ and MLLTrap

High-precision mass-measurement campaign

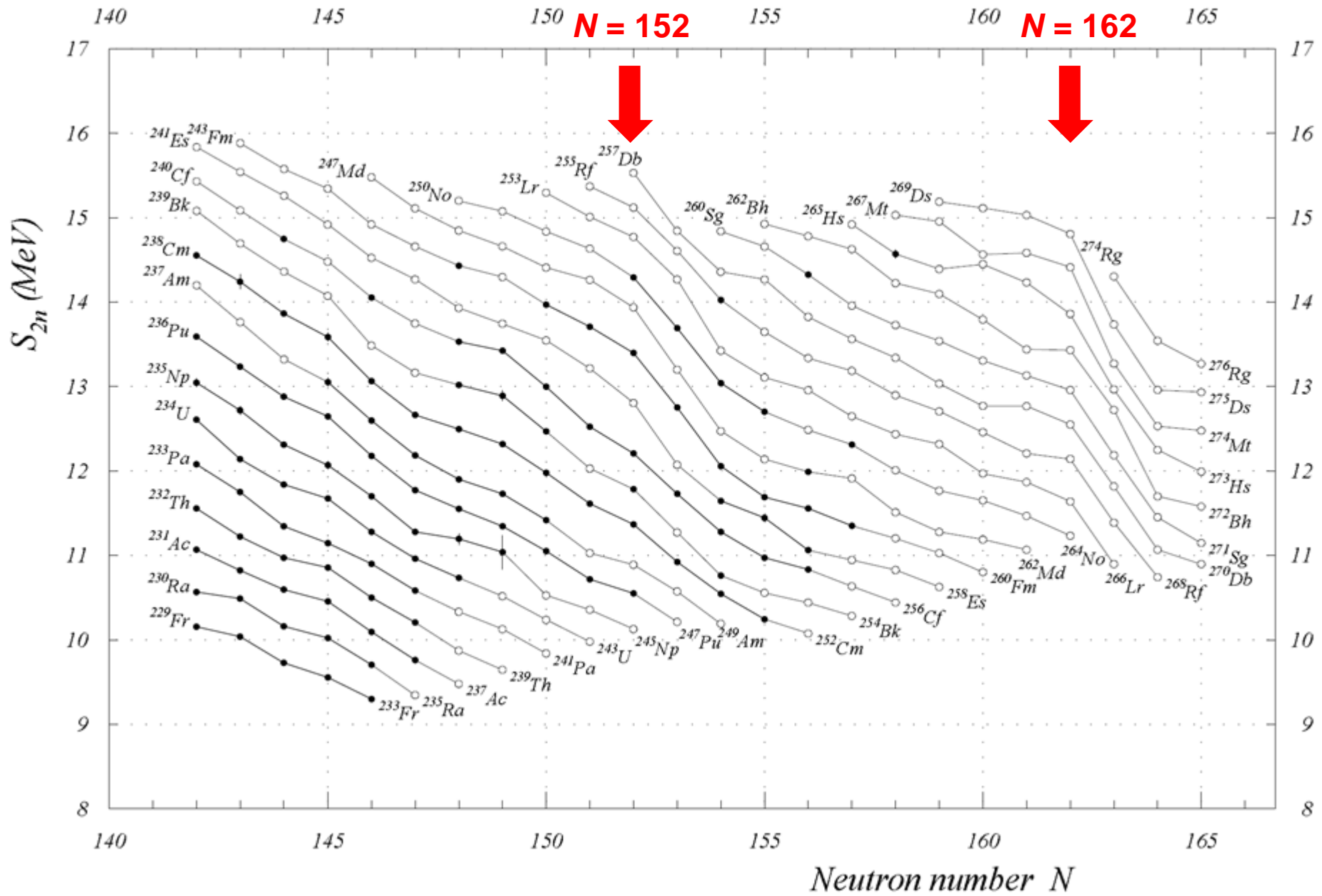
2020

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High-precision mass measurements above fermium

Fig. 8. Two-neutron separation energies $N = 142$ to 165



High-precision mass measurements above fermium

Day 1 SPIRAL2 Phase 2

(RIB in DESIR & GANIL Experimental Area)

Version 10/12/2010

Title: Precision mass measurements of nuclei with $Z \sim 104$ from S^3 with MLLTRAP at DESIR

Spokespersons (if several, please use capital letters to indicate the name of the contact person):

P.G. Thirolf

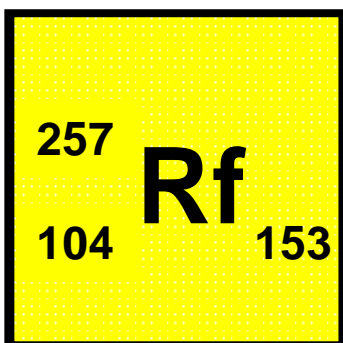
Address of the contact person: Faculty of Physics, LMU Munich, Am Coulombwall 1, 85748 Garching/Germany

Phone: 0049-89-28914064

Fax: 0049-89-28914072

E-mail: Peter.Thirolf@lmu.de

Other Participants or Organisations: H. Savajols (GANIL), C. Weber (LMU), B. Blank (CENBG), M. Gerbaux (CENBG), J. Giovinazzo (CENBG), S. Grevy (CENBG), D. Lunney (CSNSM), E. Minaya Ramirez (GSI)



$T_{1/2}$ (g.s.)	σ (nb)
4.7 s	~40

Anchor point for
 ^{269}Ds ($Z=110$, $N=159$)

High-precision mass measurements above fermium

Chart of Nuclides interface showing filters for facilities and production status. The interface includes a search bar, a selected element (Cf, Z=98, A=256), and various filter options.

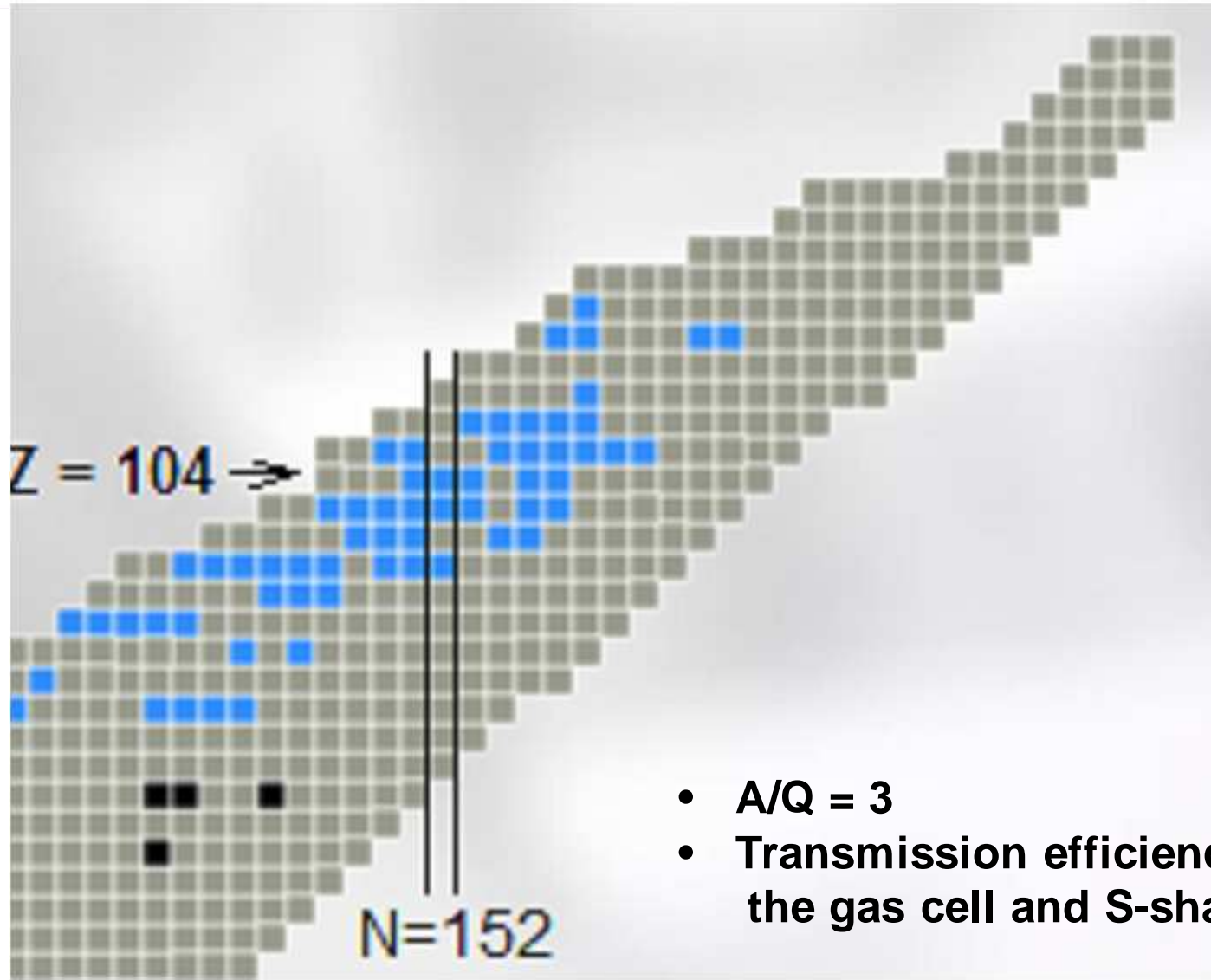
Facilities:

- All facilities
- Stable ions facilities
- Cyclotrons
- LINAC
- Radioactive ions facilities
- SPIRAL1
- S3
- SPIRAL2-Phase2-50kW

Production Status:

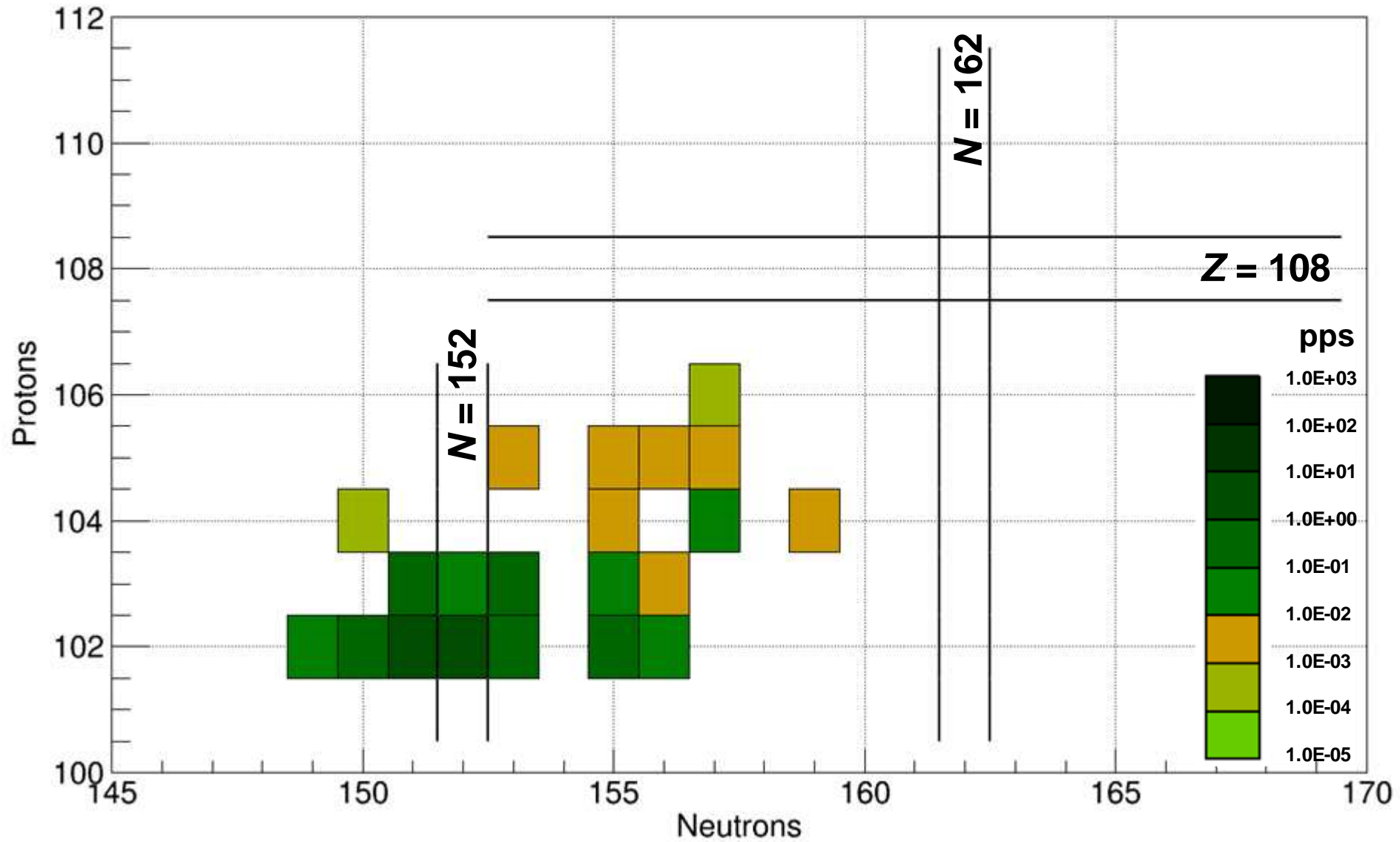
	Stable	Radioactive
Produced	Green	Blue
To Be Produced	Light Green	Light Blue
Not Produced (yet)	Black	Grey

Version 1.1 - 2016-05-23
Data update : 2017-01-31

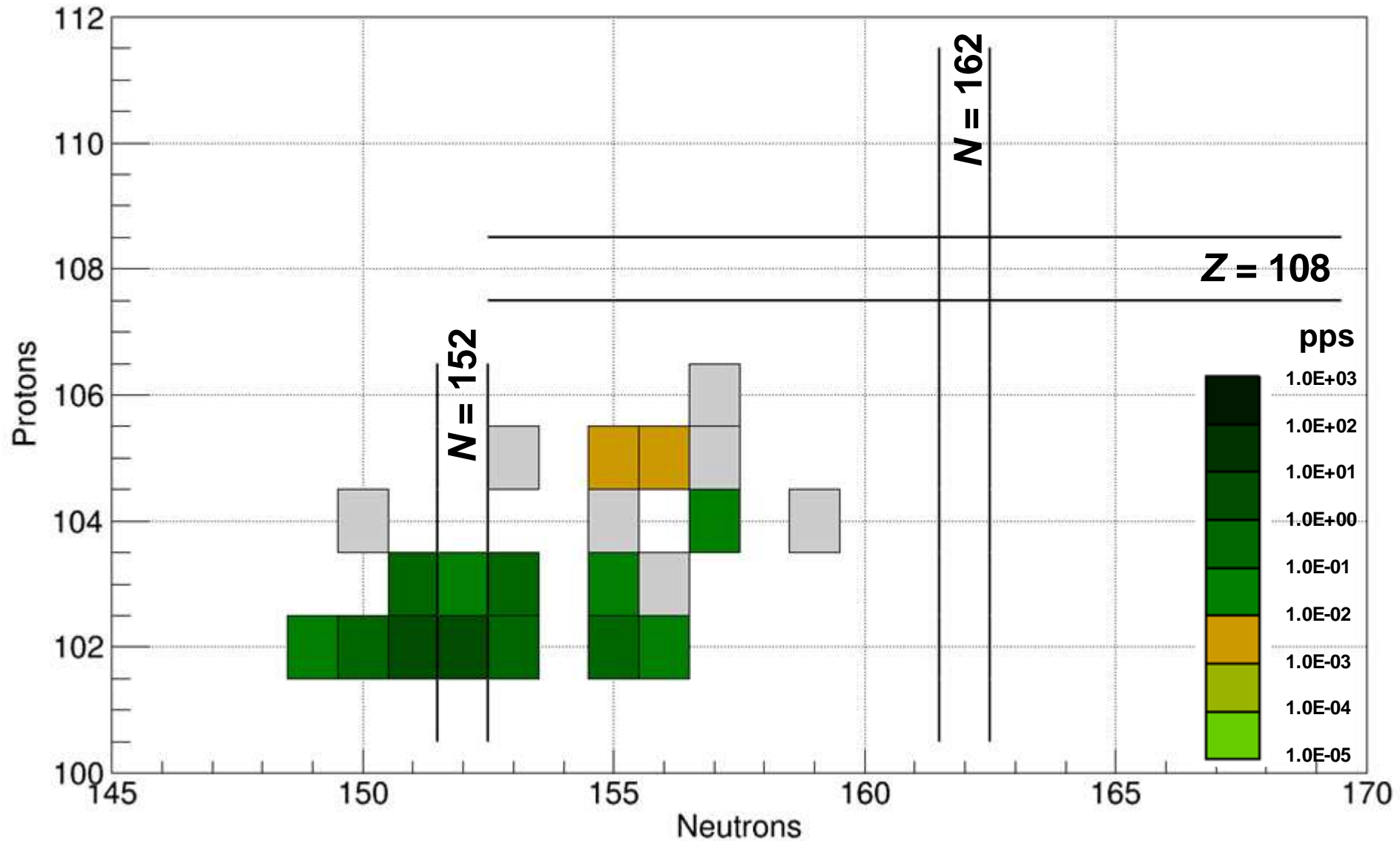


- $A/Q = 3$
- Transmission efficiency of the gas cell and S-shaped RFQ

High-precision mass measurements above fermium



High-precision mass measurements above fermium



Thank you for your attention!

