# SEASON commissioning
## in Jyväskylä

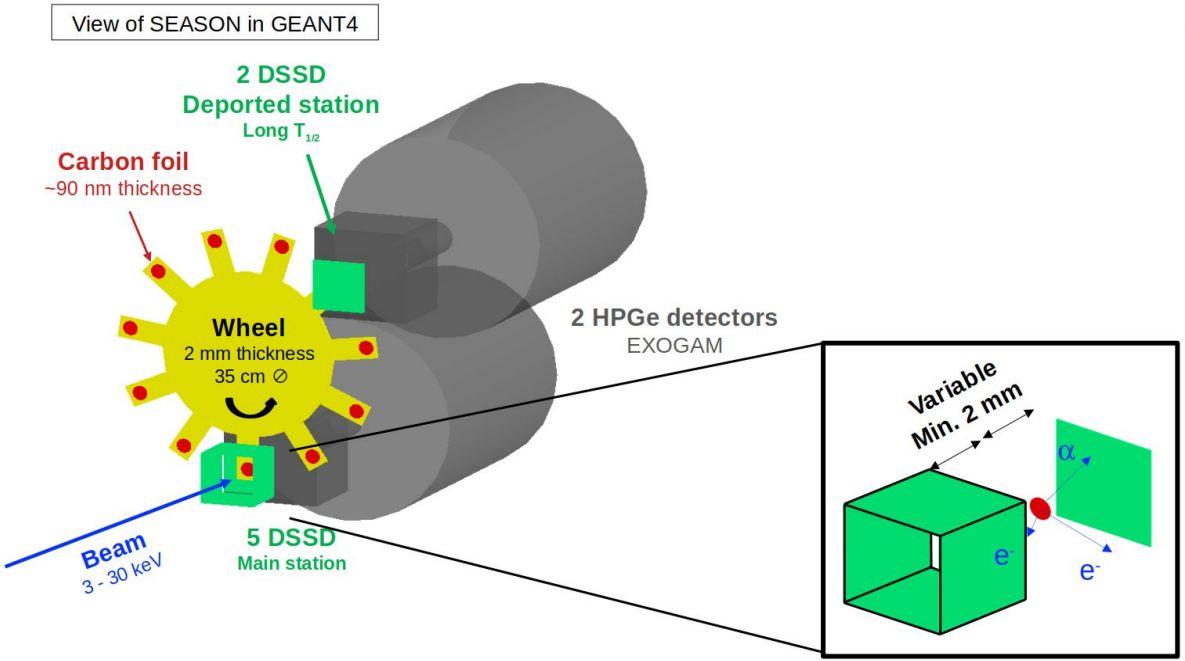
Mathilde Ragot

Supervisors : Damien Thisse
Marine Vandebrouck
Iain Moore

ISOL-France workshop - 17/03/2026

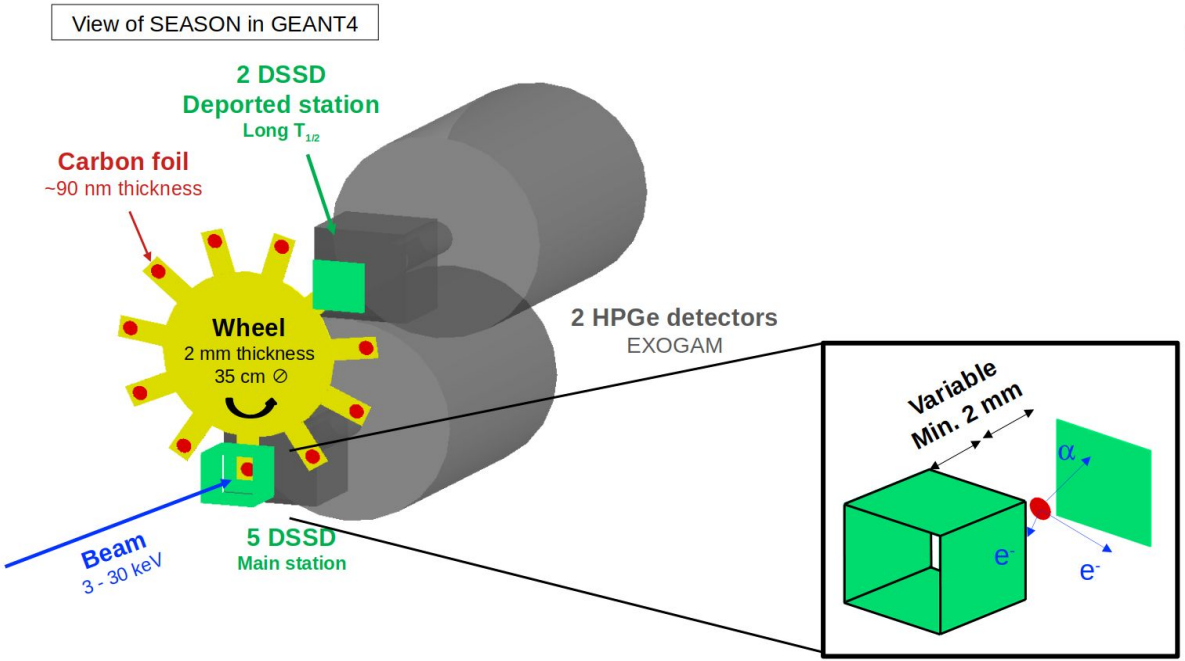
# 1 . SEASON introduction

# SEASON scheme



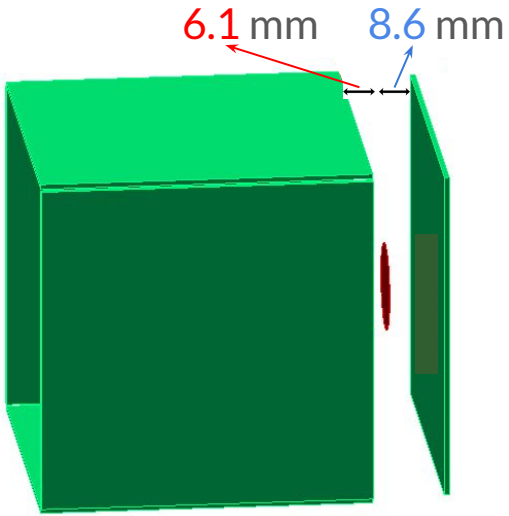

simulation done by Emmanuel Rey-herme

# SEASON scheme

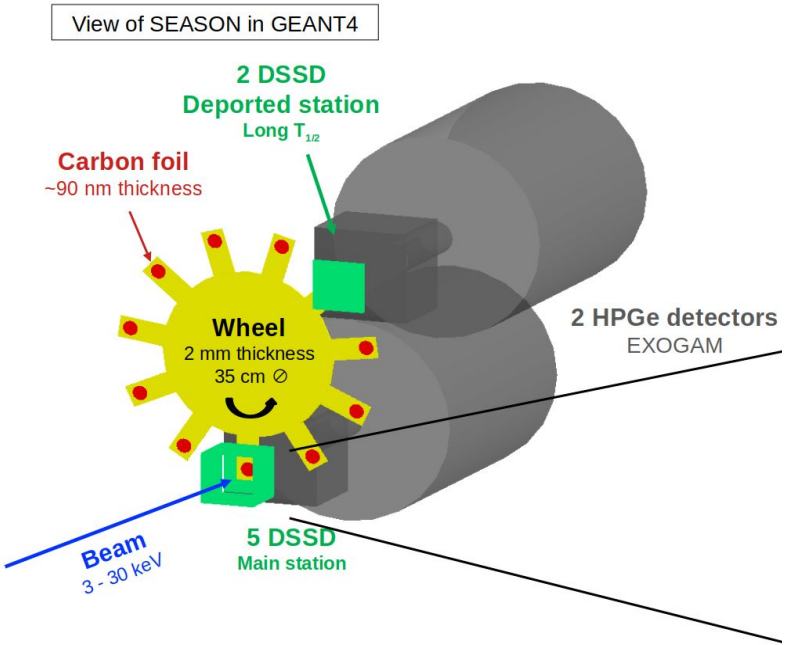


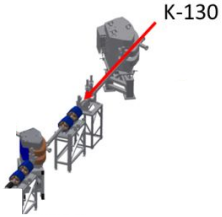

simulation done by Emmanuel Rey-herme

For now minimum distances reached :



# SEASON at Jyväskylä

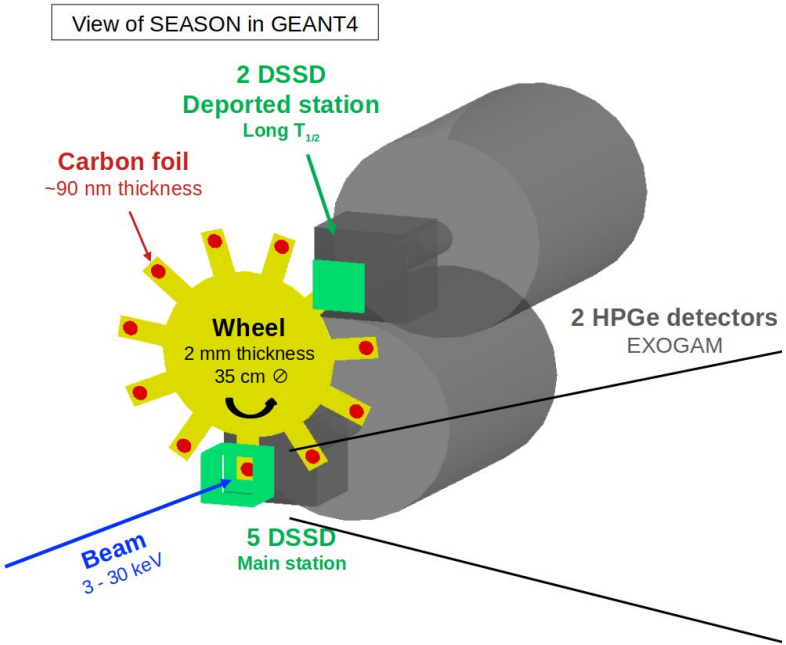


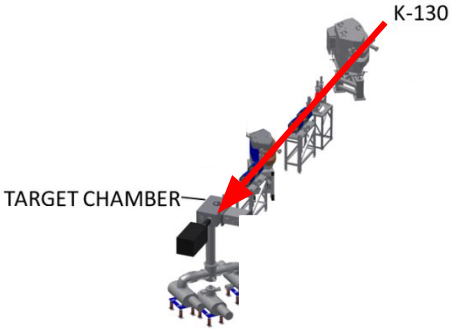

Layout of the IGISOL facility in Jyväskylä, Finland

simulation done by Emmanuel Rey-herme

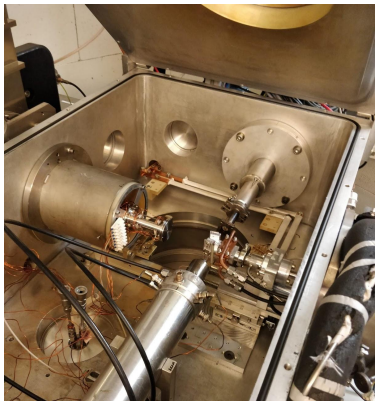
# SEASON at Jyväskylä




simulation done by Emmanuel Rey-herme

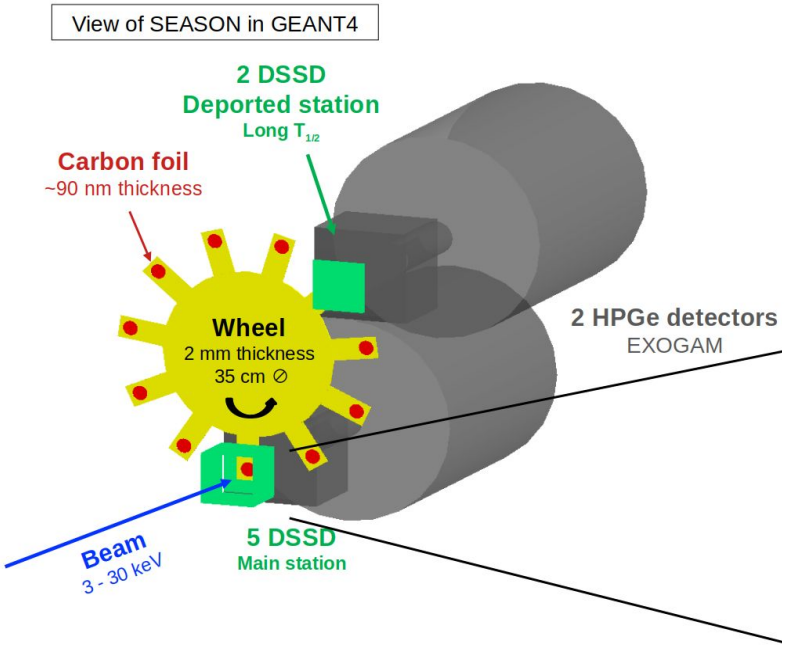


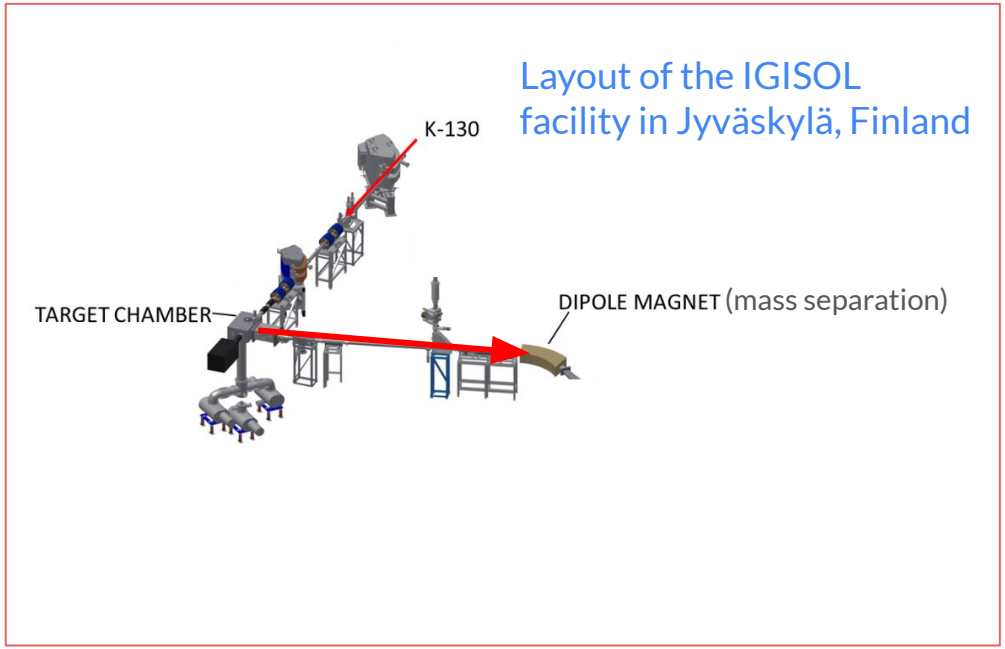

Layout of the IGISOL facility in Jyväskylä, Finland



target chamber

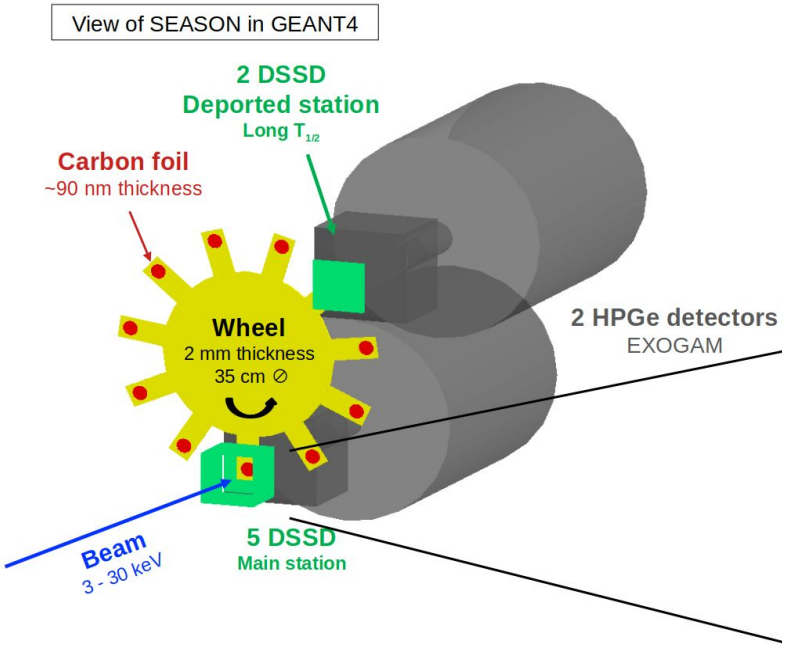
# SEASON at Jyväskylä

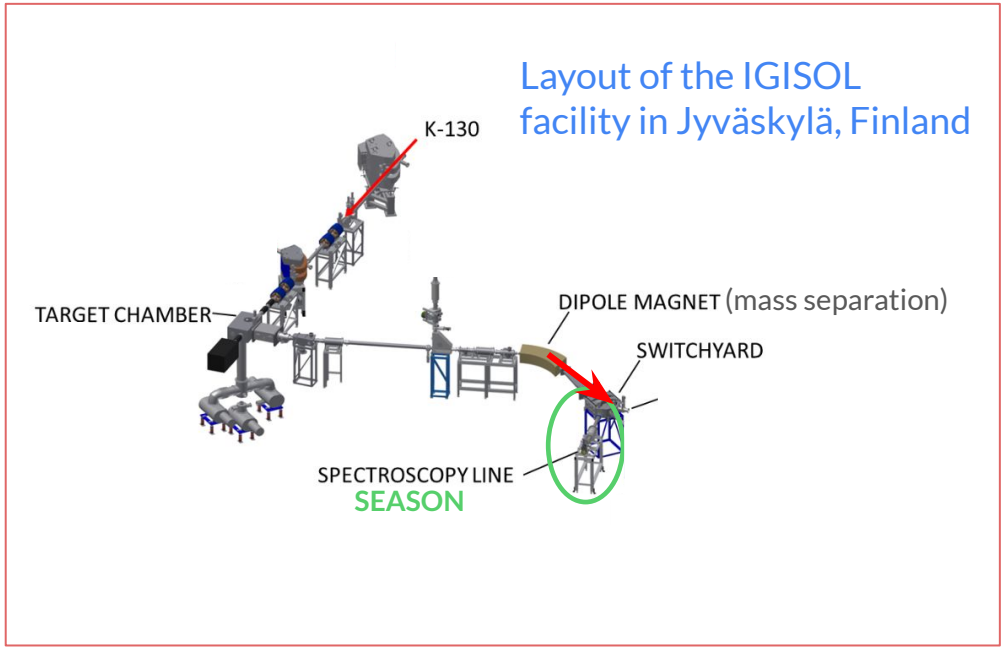



simulation done by Emmanuel Rey-herme

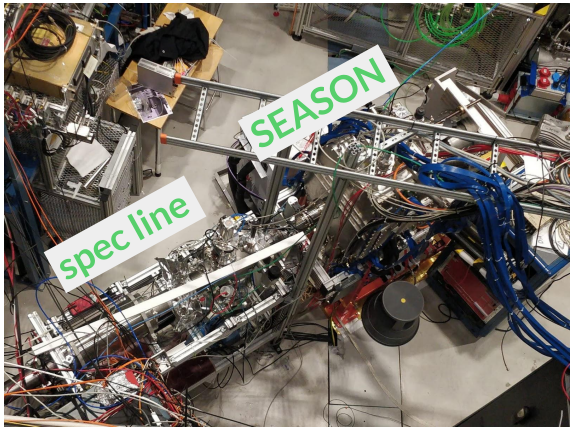
# SEASON at Jyväskylä

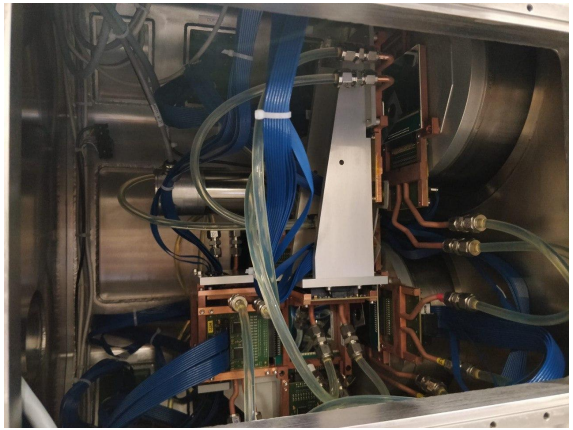


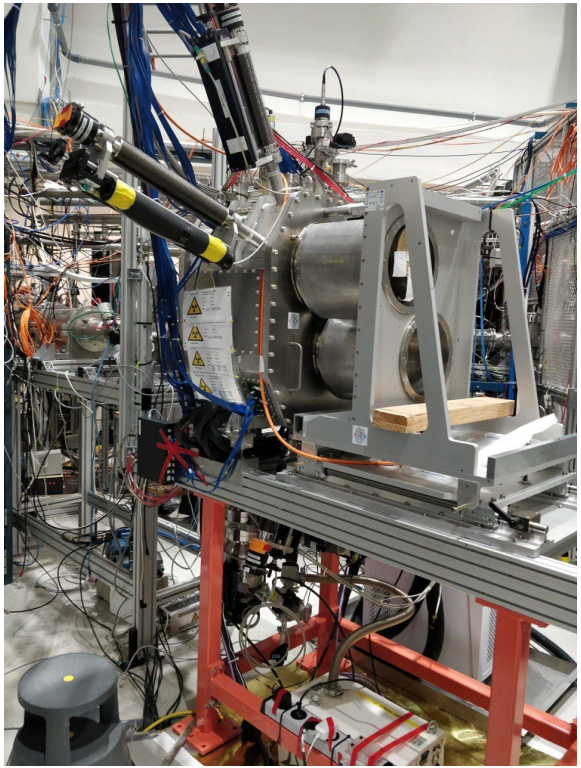




simulation done by Emmanuel Rey-herme

# Mounting in Jyväskylä





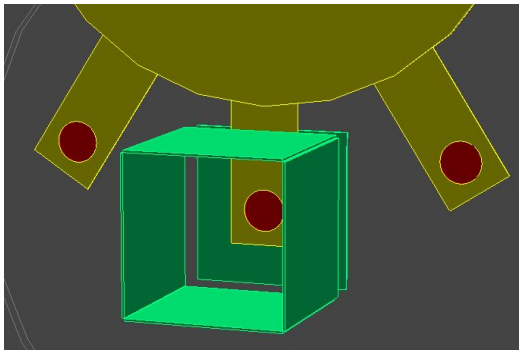
# 2. Commissioning in Jyväskylä

→ february 20th – february 27th

# SEASON's commissioning experiment

Test of two FEANICS modes :

All detectors : automatic gain switch between $\alpha$ and $e^-$



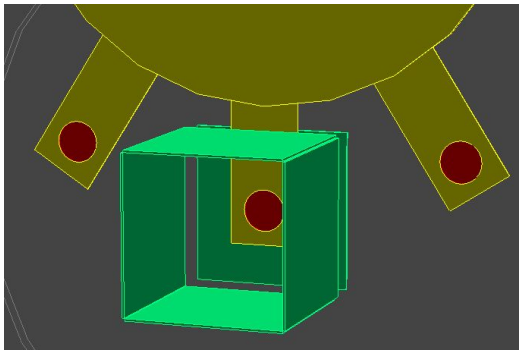
+ high efficiency

− noise level higher → resolution slightly degraded → higher energy threshold

# SEASON's commissioning experiment

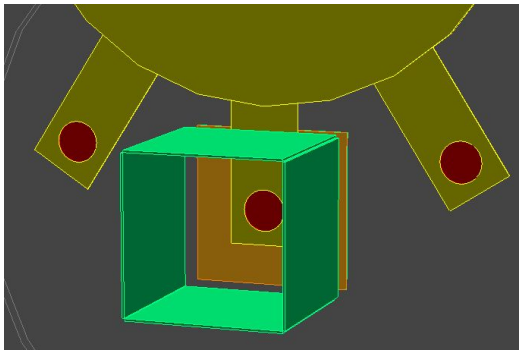
Test of two FEANICS modes :

All detectors : automatic gain switch between $\alpha$ and $e^-$



- ✚ high efficiency
- ▬ noise level higher → resolution slightly degraded → higher energy threshold

Fixed gain :
Main detector in a high gain mode,
Tunnel detectors in a low gain mode



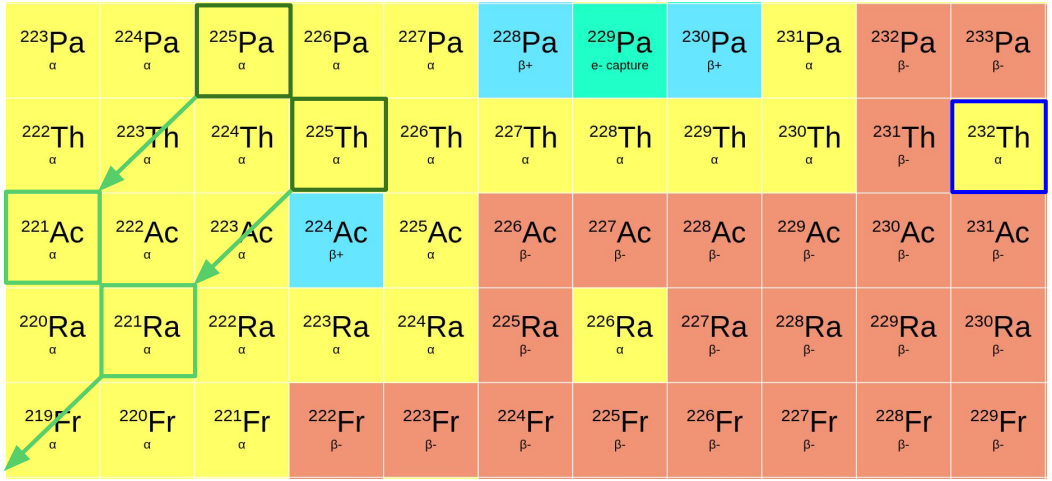
- ✚ less noisy → better resolution → lower energy threshold
- ▬ lower efficiency

# SEASON's commissioning experiment

Reaction used : $^{232}Th(p,xn)^{233-x}Pa$

Beam time use :

- mass 225 : 40 hours

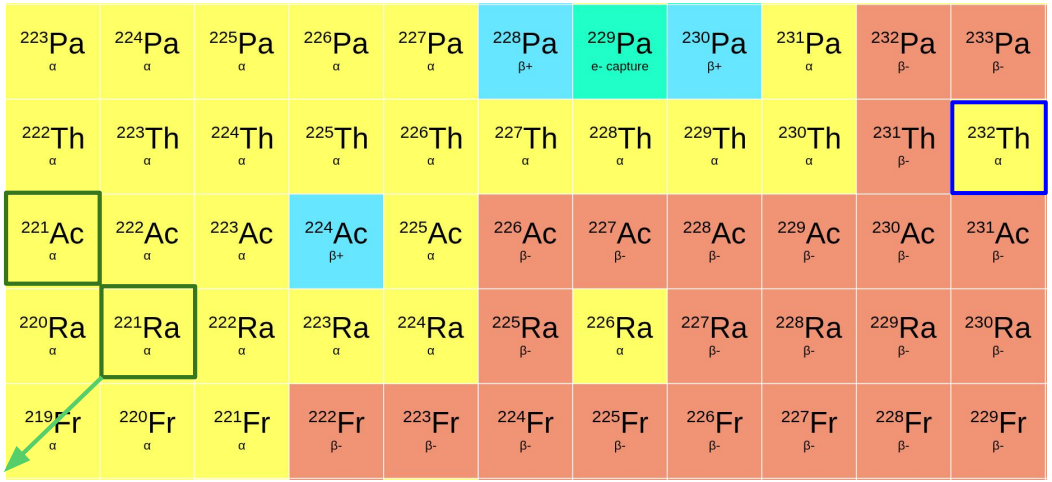


# SEASON's commissioning experiment

Reaction used : $^{232}Th(p,xn)^{233-x}Pa$

Beam time use :

- mass 225 : 40 hours
- mass 221 : 32 hours

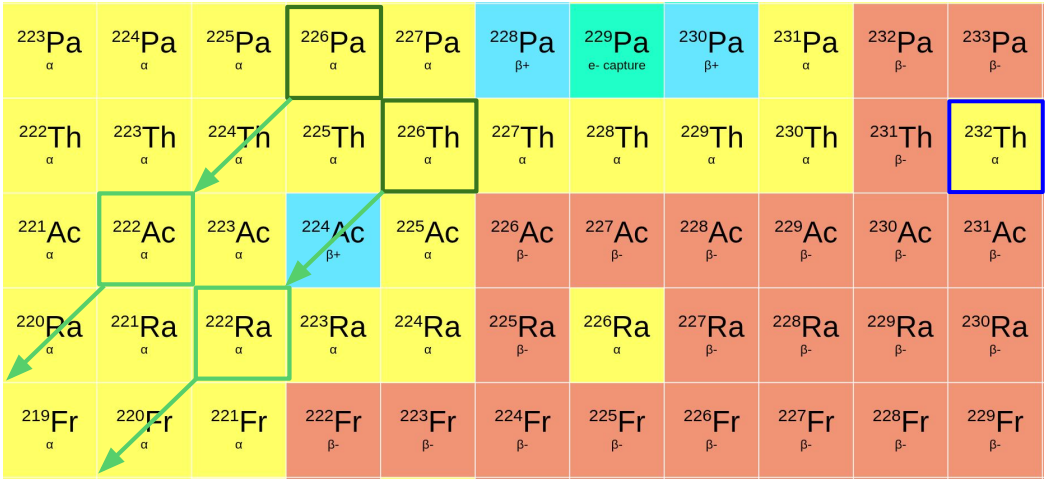


# SEASON's commissioning experiment

Reaction used : $^{232}Th(p,xn)^{233-x}Pa$

Beam time use :

- mass 225 : 40 hours
- mass 221 : 32 hours
- mass 226 : 29 hours

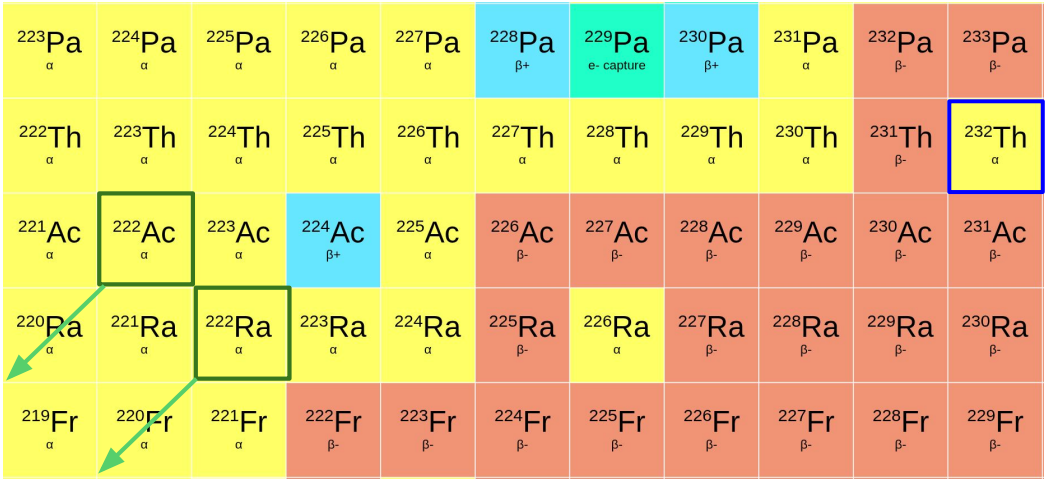


# SEASON's commissioning experiment

Reaction used : $^{232}Th(p,xn)^{233-x}Pa$

Beam time use :

- mass 225 : 40 hours
- mass 221 : 32 hours
- mass 226 : 29 hours
- mass 222 : 12 hours

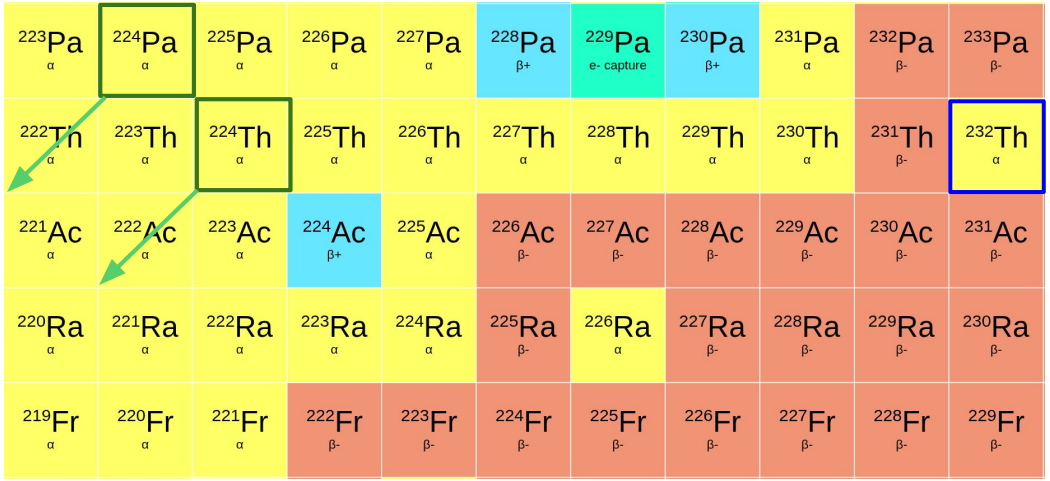


# SEASON's commissioning experiment

Reaction used : $^{232}Th(p,xn)^{233-x}Pa$

Beam time use :

- mass 225 : 40 hours
- mass 221 : 32 hours
- mass 226 : 29 hours
- mass 222 : 12 hours
- mass 224 : 4.5 hours



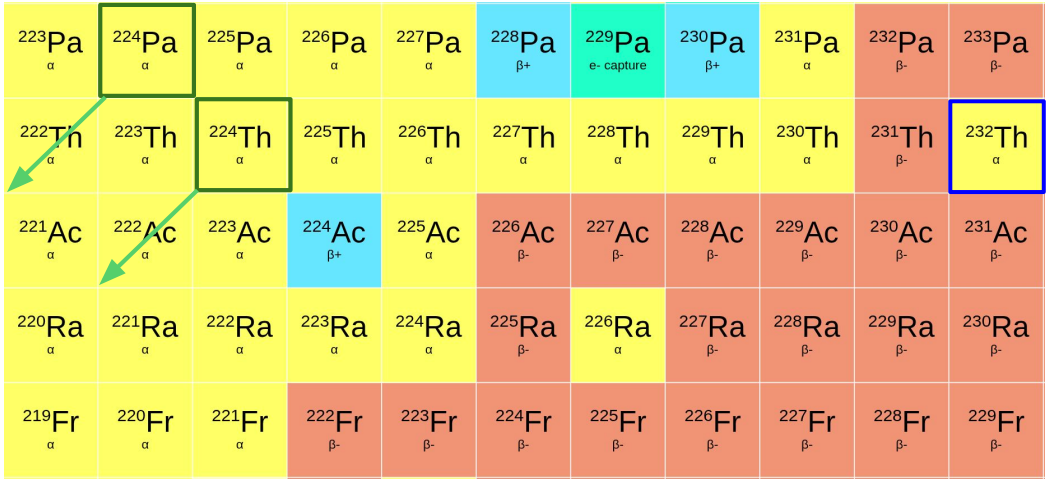
# SEASON's commissioning experiment

Reaction used : $^{232}Th(p,xn)^{233-x}Pa$

Beam time use :

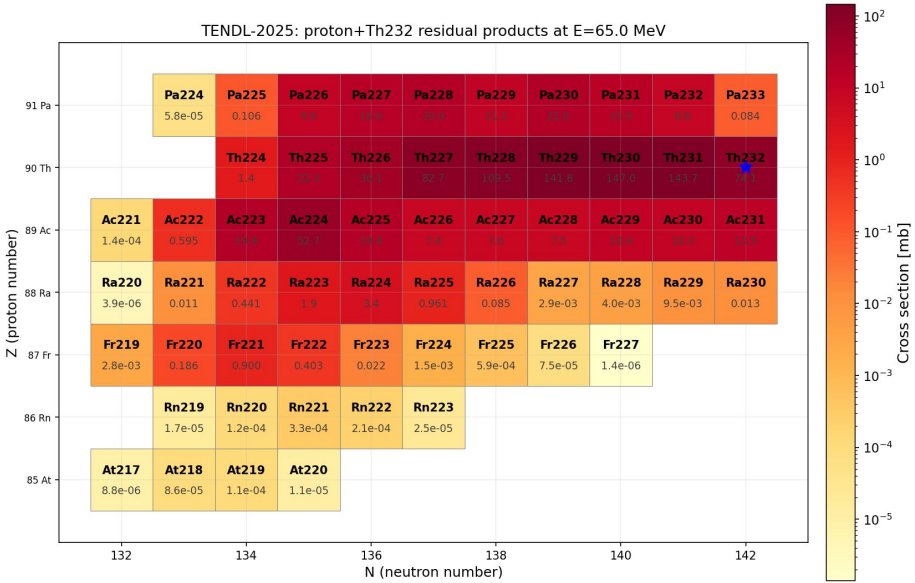
- mass 225 : 40 hours
- mass 221 : 32 hours
- mass 226 : 29 hours
- mass 222 : 12 hours
- mass 224 : 4.5 hours

Also tried $^{4}He$ beam



# Test of the $^4$He beam

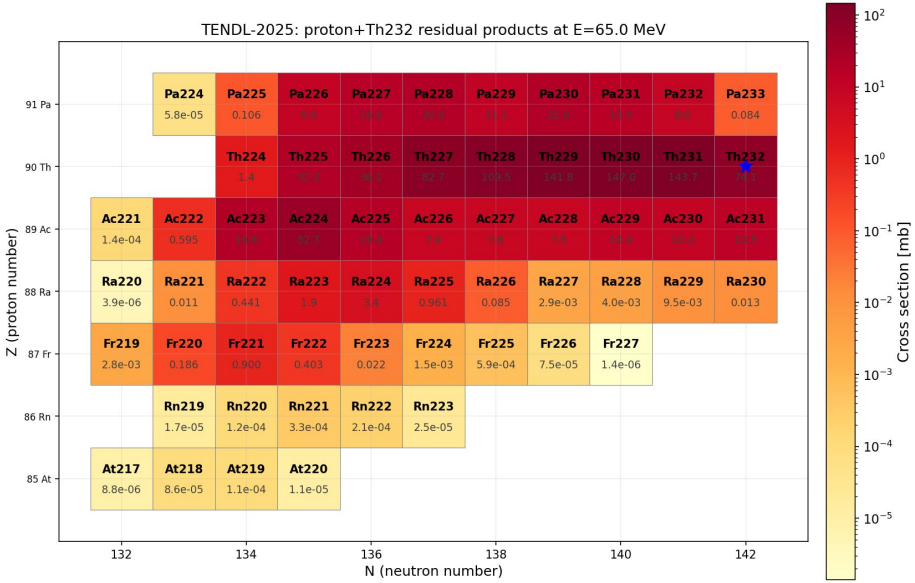
In principle :

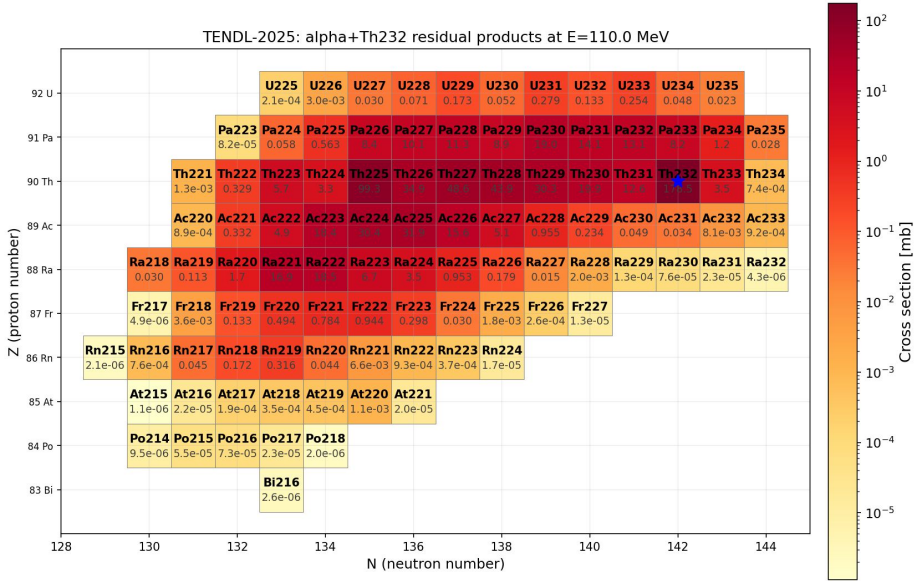



Figures by Emmanuel Rey-herme

# Test of the $^4$He beam

In principle :



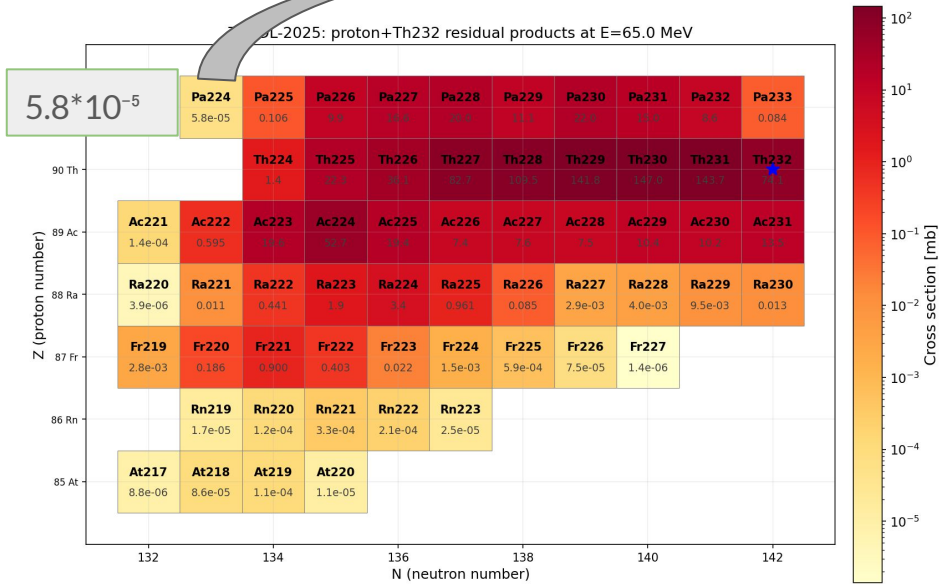



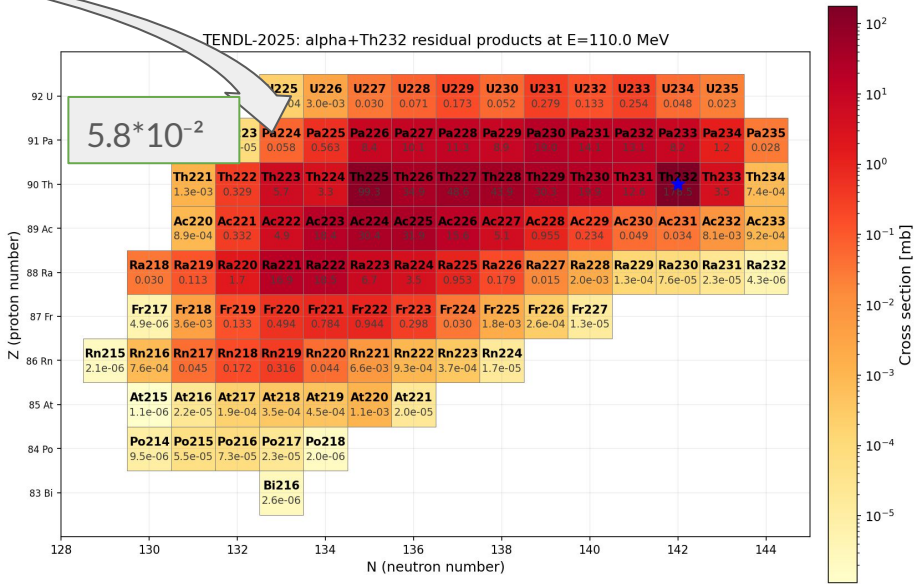

Figures by Emmanuel Rey-herme

# Test of the $^4$He beam

In principle :

x10$^3$



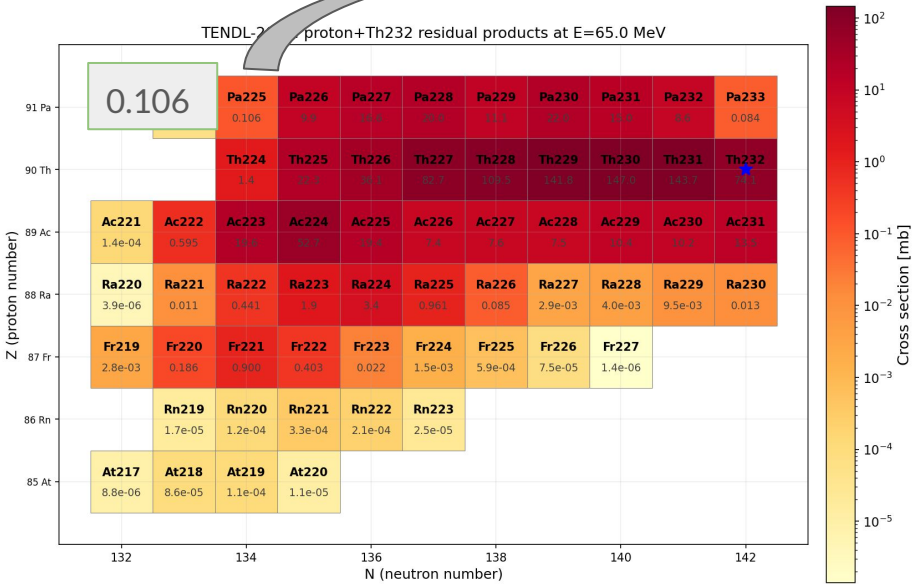



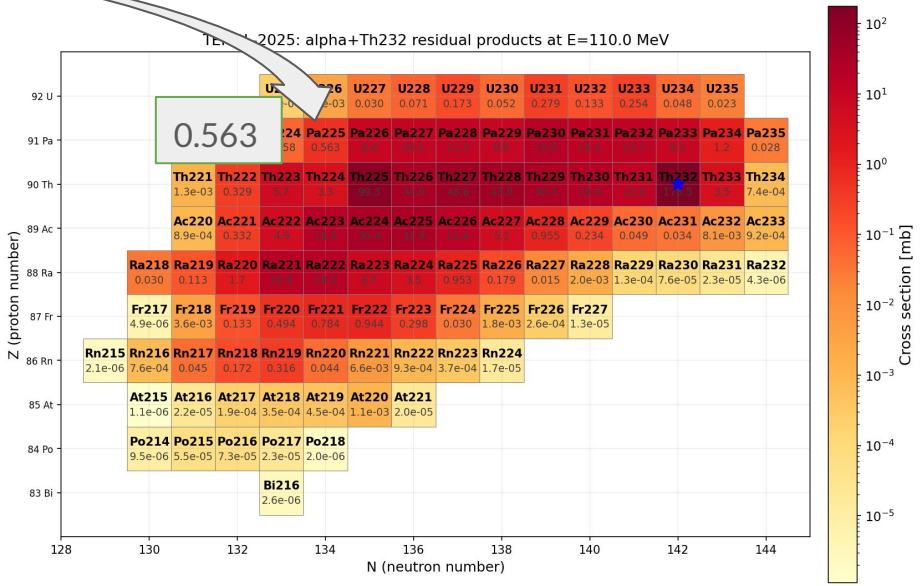

Figures by Emmanuel Rey-herme

# Test of the $^4$He beam

In principle :

x5




Figures by Emmanuel Rey-herme

# 3 Preliminary results of the online commissioning

# Technical SEASON properties

In automatic gain switch mode :

In conditions of the online commissioning experiment

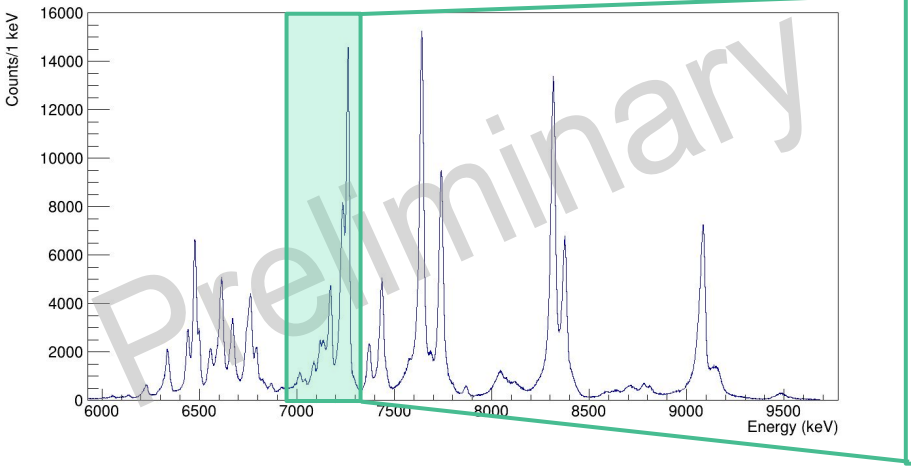
| | Energy resolution in main | Energy resolution in tunnels | Efficiency on Main | Efficiency in tunnels | Total efficiency |
|---|---|---|---|---|---|
| $\alpha$-particle | ~20 keV | **~18 keV** | ~36% | ~20% | **~56%** |
| electron | ~14 keV | ~14 keV | ~23% | ~18% | **~41%** |



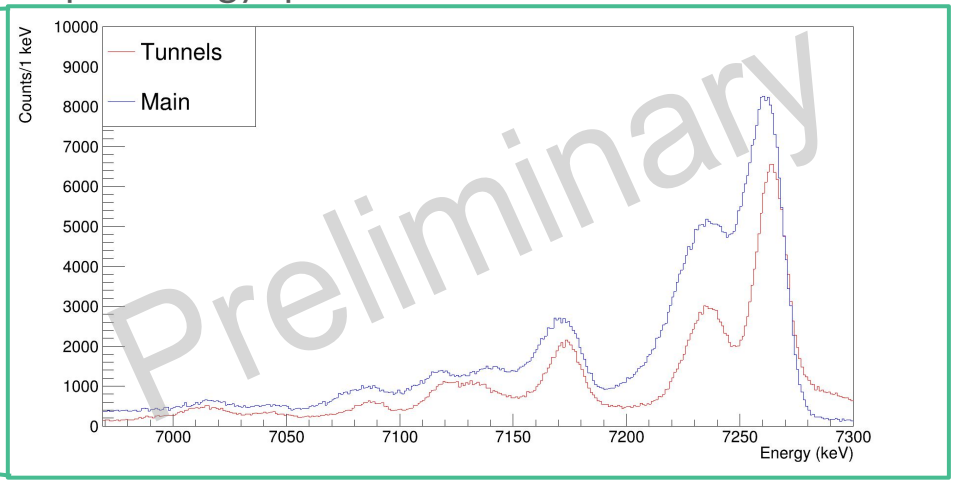
→ from mass 225 energy spectrum
→ from 3 $\alpha$ source measurements
→ from 133 Ba source measurements

# Mass 225

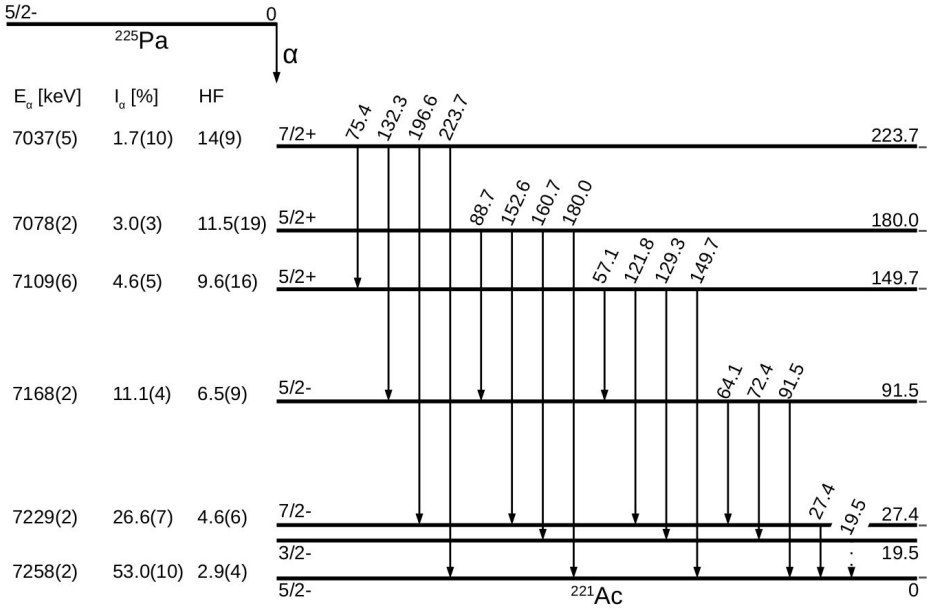
Alpha energy spectrum

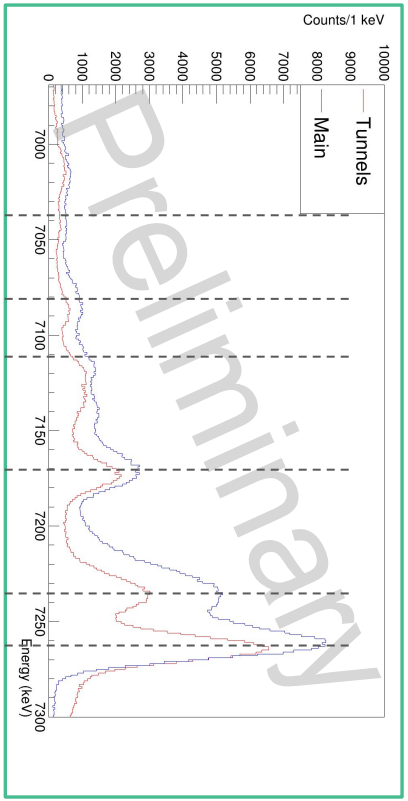



Alpha energy spectrum



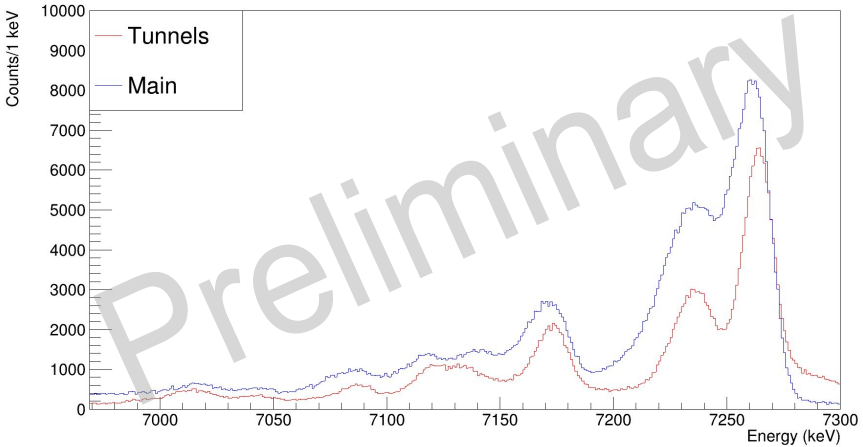
# Mass 225


5/2-
0
225Pa
α
Eα [keV]
Iα [%]
HF
7037(5)
1.7(10)
14(9)
7078(2)
3.0(3)
11.5(19)
7109(6)
4.6(5)
9.6(16)
7168(2)
11.1(4)
6.5(9)
7229(2)
26.6(7)
4.6(6)
7258(2)
53.0(10)
2.9(4)
7/2+
5/2+
5/2+
5/2-
7/2-
3/2-
5/2-
221Ac
223.7
180.0
149.7
91.5
27.4
19.5
0
75.4
132.3
196.6
223.7
88.7
152.6
160.7
180.0
57.1
121.8
129.3
149.7
64.1
72.4
91.5
27.4
19.5


Counts/1 keV
Main
Tunnels
Energy (keV)
Preliminary

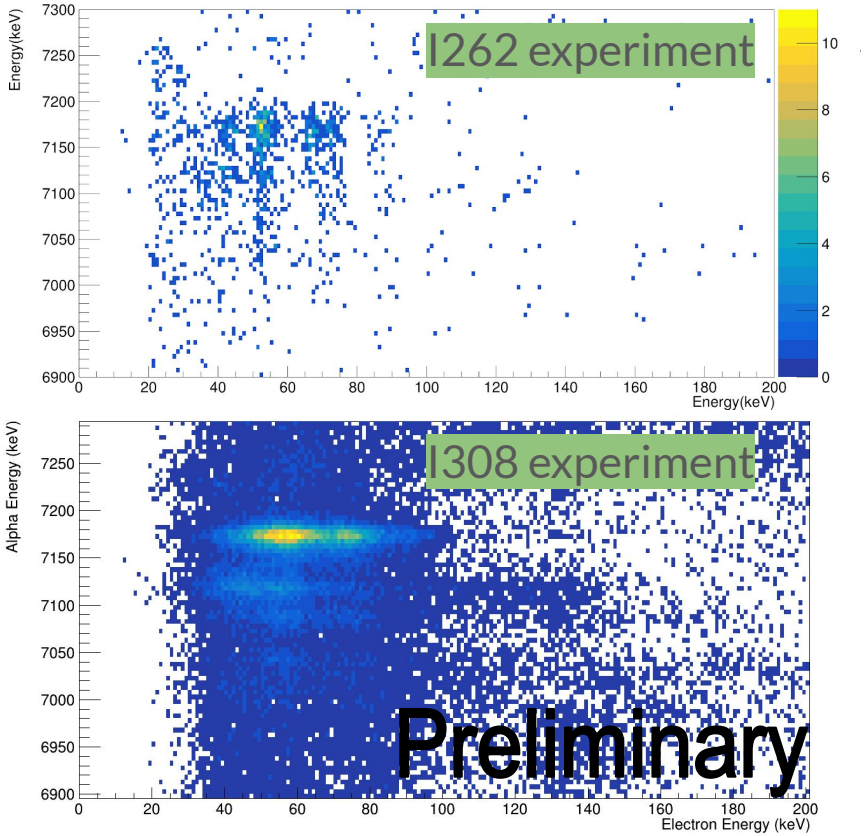
# Mass 225 : study of $^{225}$Pa

## Alpha energy spectrum



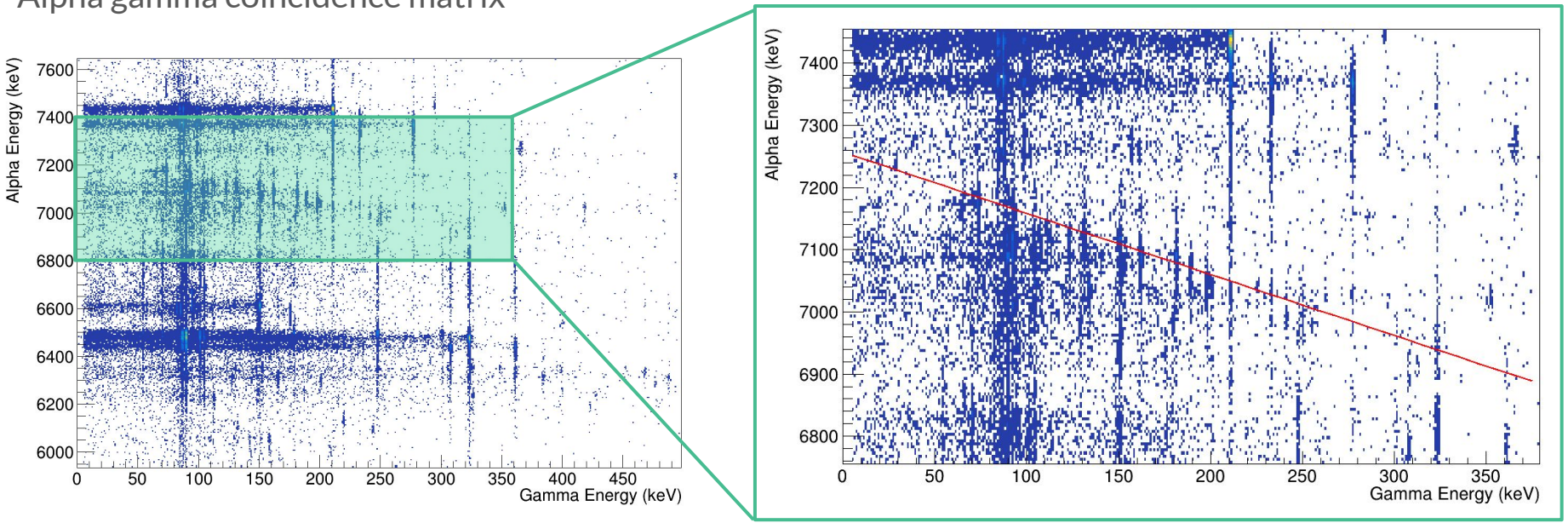

-> few issues of time alignment and energy resolution to be solved

## Alpha electron coincidence matrix



# Mass 225 : study of $^{225}$Pa

Alpha gamma coincidence matrix




$$Q_\alpha + E_\gamma = Q_\alpha(gs\ to\ gs)$$

# SEASON's schedule in 2026 - 2027

- 2 proposals have been submitted to the PAC of March at Jyväskylä :

Decay spectroscopy of Neptunium isotopes produced through the fusion-evaporation reaction $^{233}$U(p, $x$n)$^{234-x}$Np with SEASON

D. Thisse[1], E. Rey-herme[1], M. Vandebrouck[1], M. Ragot[1], N. Abrassart[1], B. Sulignano[1], I. Moore[2], J. Sarèn[2], T. Eronen[2], A. Kankainen[2], A. Raggio[3], S. Pineda[4], D. Renisch[5,6], C. Düllmann[5,6,7], S. Lecanuet[8], the IGISOL group[2], and the SEASON collaboration[1]

Decay spectroscopy of $^{223}$Pa produced through the fusion-evaporation reaction $^{230}$Th(p, $x$n)$^{231-x}$Pa with SEASON

E. Rey-herme[1], D. Thisse[1], M. Vandebrouck[1], M. Ragot[1], N. Abrassart[1], I. Moore[2], Ch. E. Düllmann[3,4,5], T. Eronen[2], A. Kankainen[2], S. Lecanuet[6], S. Pineda[7], A. Raggio[8], D. Renisch[3,4], J. Sarén[2], B. Sulignano[1], et al.[0], the IGISOL group[2], and the SEASON collaboration[1]

- From september : **SEASON will be available for anybody to propose an experiment at the PAC**

# Thank you !

**Jyväskylä**
Natalia Ambrosio, Theodore Davids, Tommi Eronen, Zhuang Ge, Anu Kankainen, Brian Koote, Iain Moore, Prince Parvez, Simon Rausch, Mikael Reponen, Alexandre Roger, Jan Saren

**GSI**
Sebastian Raeder

**IJCLab**
Matthieu Lebois

**LP2iB**
Samuel Lecanuet

**LPC Caen**
Skyy Pineda

**GANIL**
Margarida Paulino

**KU Leuven**
Andrea Raggio

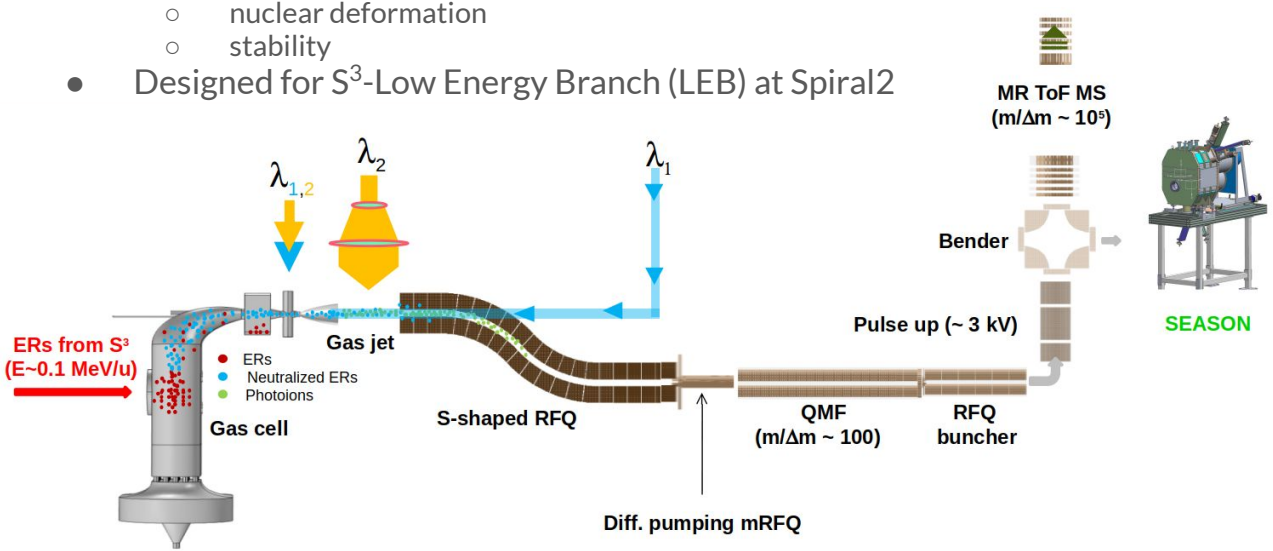
**CEA**
Damien Thisse, Léonard Jost, Emmanuel Rey-herme, Kilian Ronxin, Barbara Sulignano, Marine Vandebrouck


**SEASON development team :**
**Project Managers :**
O. Cloué (technic)
D. Thisse (scientific)
**Mechanical conception :**
S. Cazaux, P. Daniel-Thomas
**Detection/Acquisition :**
F. Bouyjou, T. Chaminade, Jules Dartois
**Control & Command :**
A. Gaget, J. Relland, A. Roger, S. Tzvetkov, T. Joannem
**Electrical engineering :**
J. Noury, Y. Reinert, J. Mendes Ribeiro

# Back-up

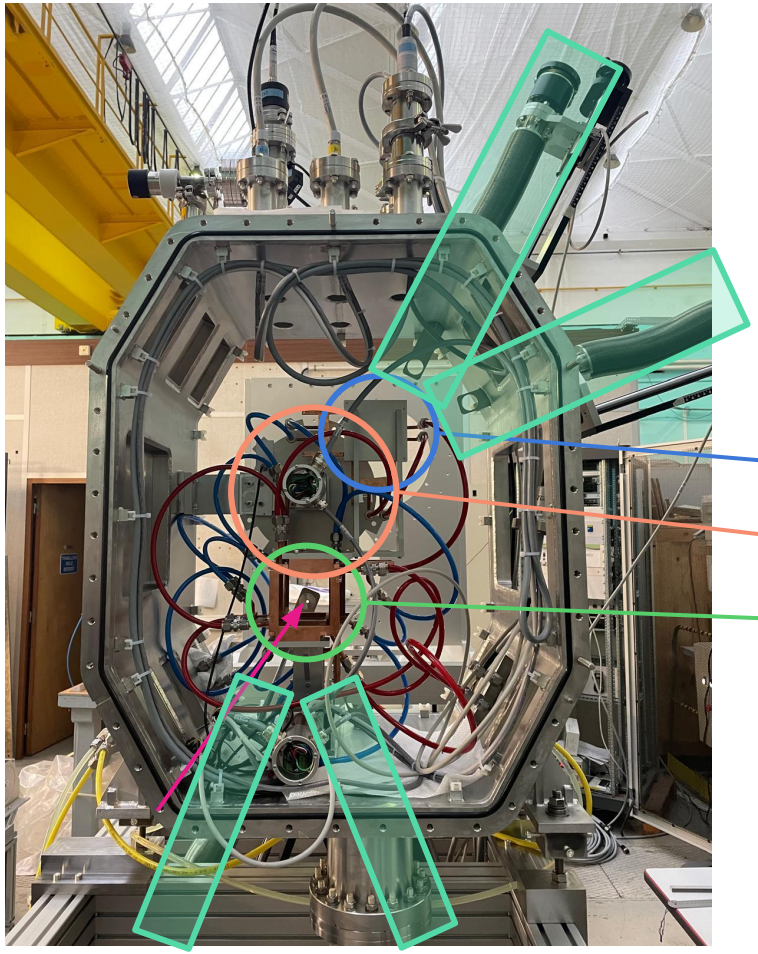
# SEASON's at GANIL

- Study of heavy and super heavy nuclei
  - single particle structure
  - nuclear deformation
  - stability
- Designed for $S^3$-Low Energy Branch (LEB) at Spiral2




- Counter for laser spectroscopy
- Detailed α, e-, γ decay spectroscopy

Coupling of atomic and nuclear approaches



beam direction

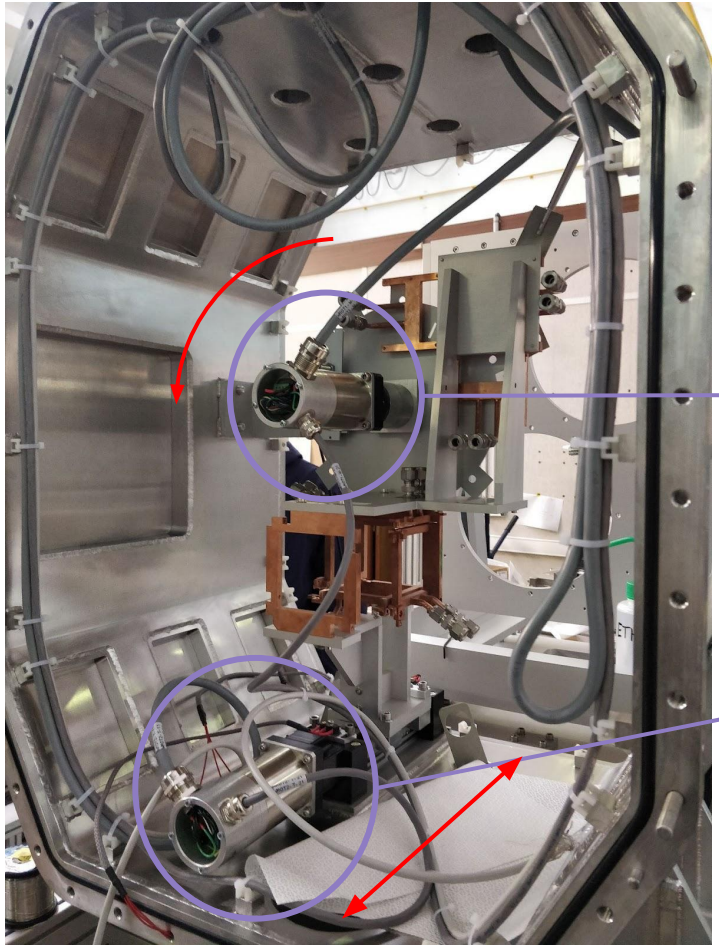
deported station

wheel

main station

calibration arms and its HMI that manages:
- the control of the sources storage
- the different calibration step

& provides safety features to avoid detector damage.

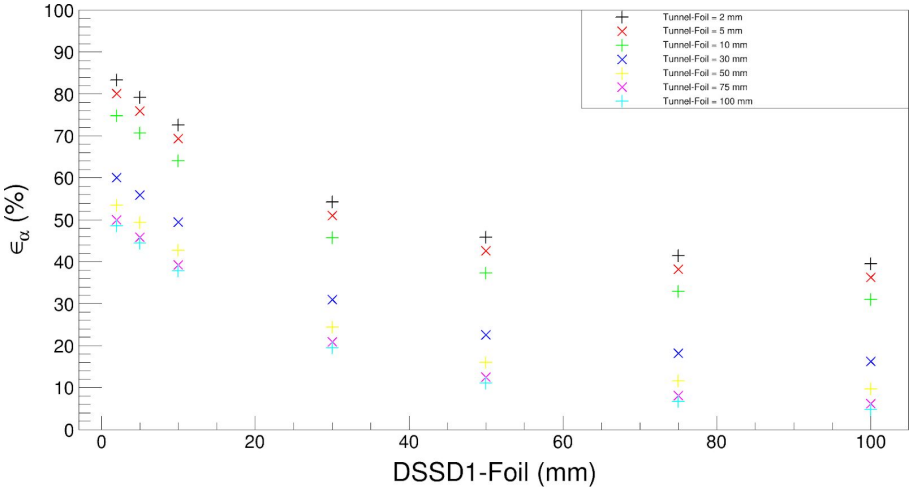


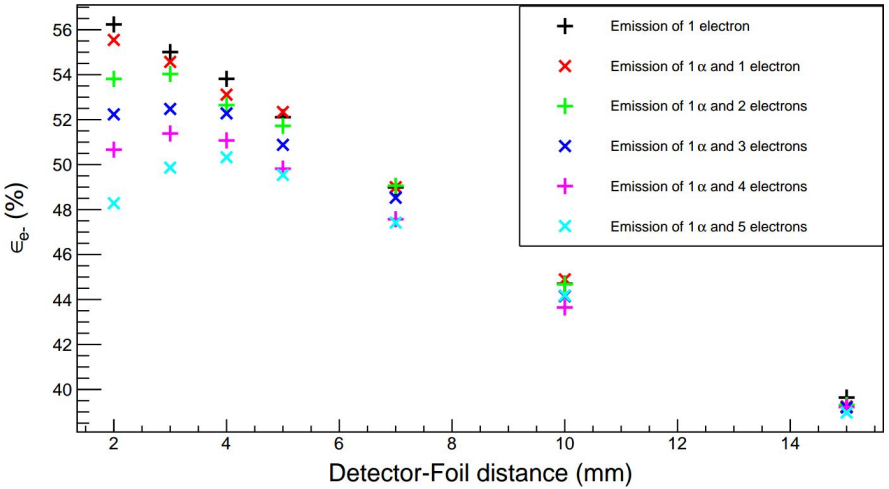
motor to rotate the wheel

Upstream system: motorised to slide the tunnel part of the main station and one of the two detectors in the deported station

# High efficiency for both electron and α-particle

E. Rey-herme, PhD thesis (2023)



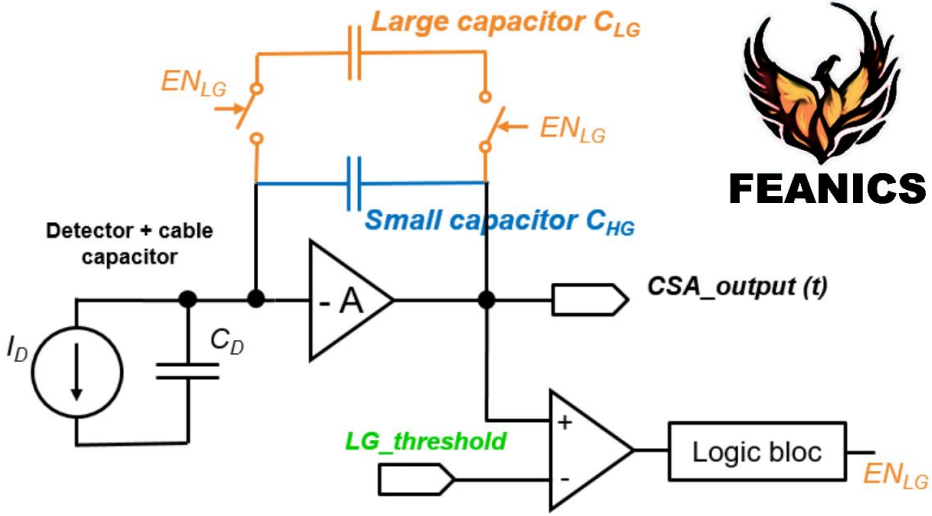




Most compact configuration:

Alpha efficiency = 84 %

Electron efficiency = 56 %

# FEANICS




FEANICS

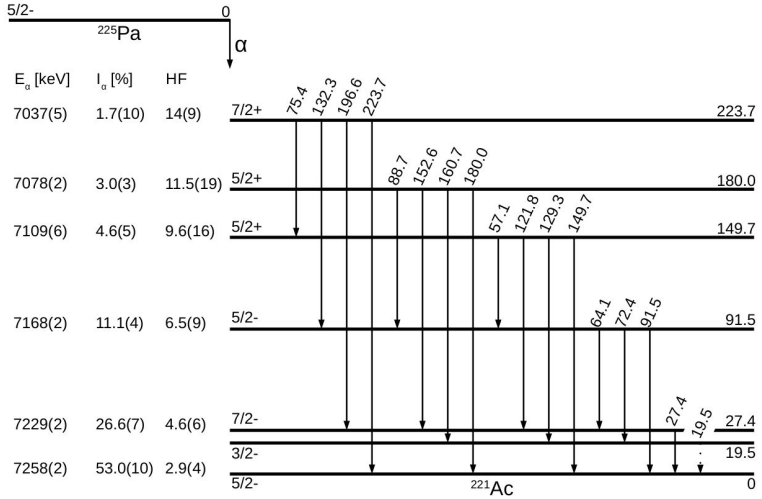
**F**ront **E**nd **A**daptive gai**N** **I**ntegrated **C**ircuit**S**:

- double gain preamplifier with automatic gain switch
- CSA floor noise (no detector): ~2.3 keV variable threshold for gain switch
- can also be set to fixed gain

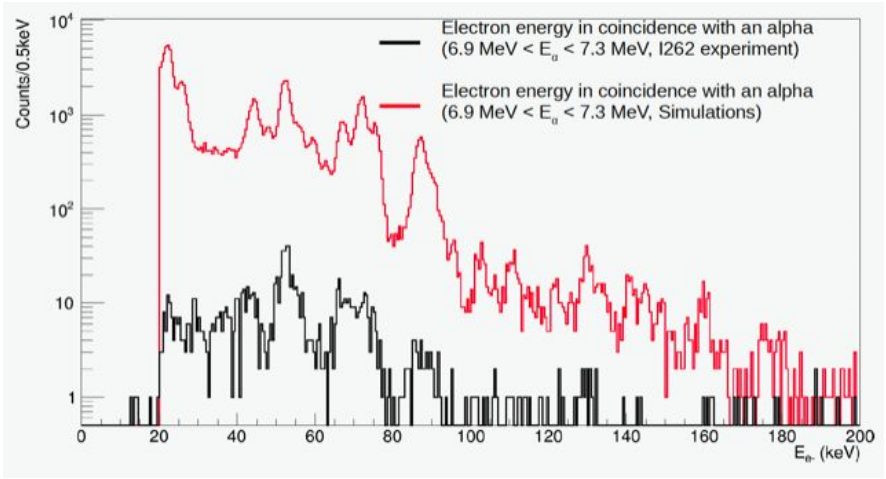
➔ Directly connected to the detector to limit the noise

➔ Outputs a differential signal to be sent to the digitizer

# Why this reaction ? $^{232}Th(p,xn)^{233-x}Pa$




E. Rey-herme, PhD thesis (2023)




- Use previous experimental results as a benchmark to characterize SEASON
- Improved efficiency => look for new transitions that were not visible before