DE LA RECHERCHE À L'INDUSTRIE

Update of SEASON project

Spectroscopy Electron Alpha in Silicon bOx couNter

Marine VANDEBROUCK

GCM2022 Workshop
October 2022

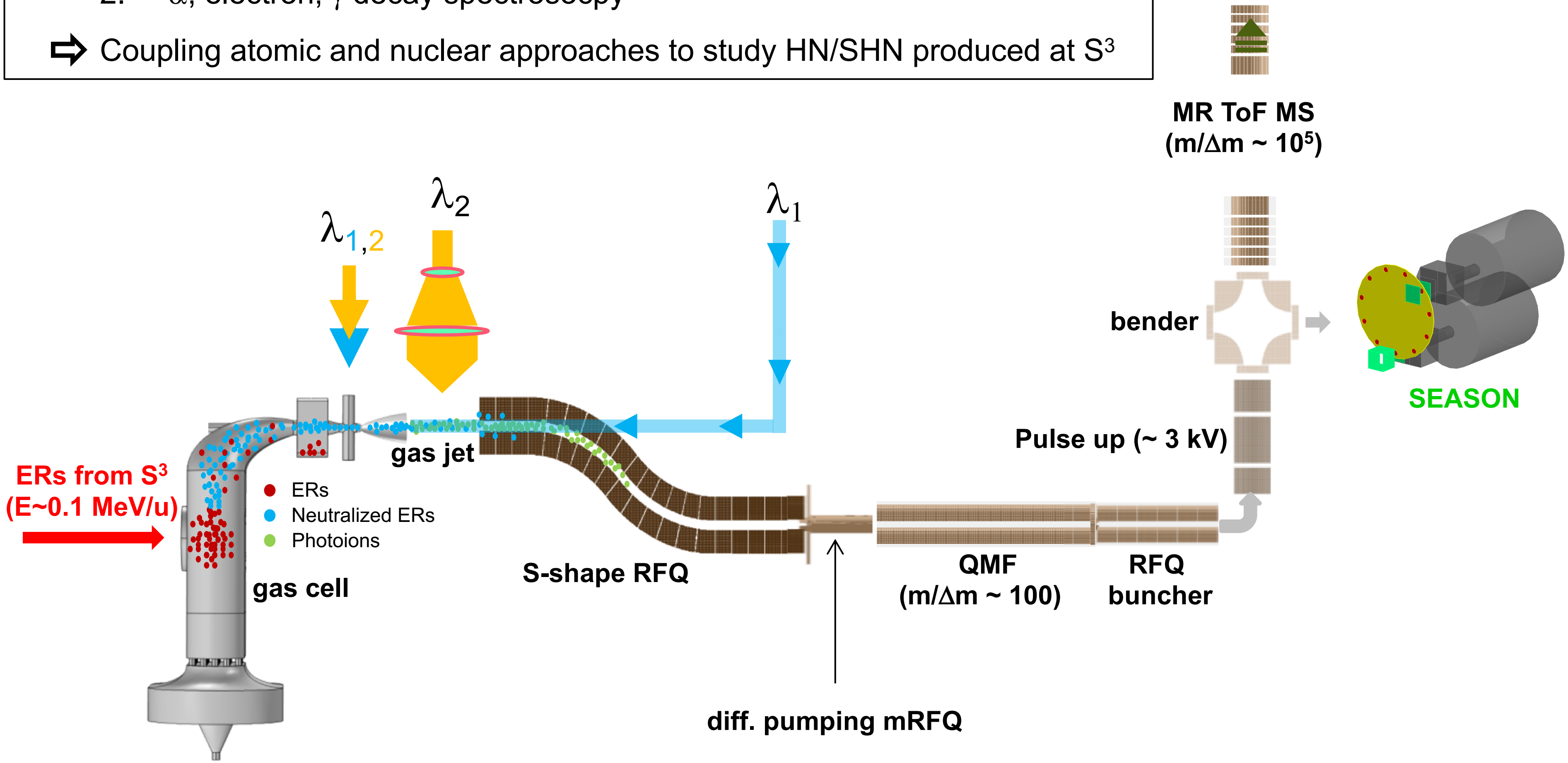
AGENCE NATIONALE DE LA RECHERCHE

SEASON at S^3-LEB

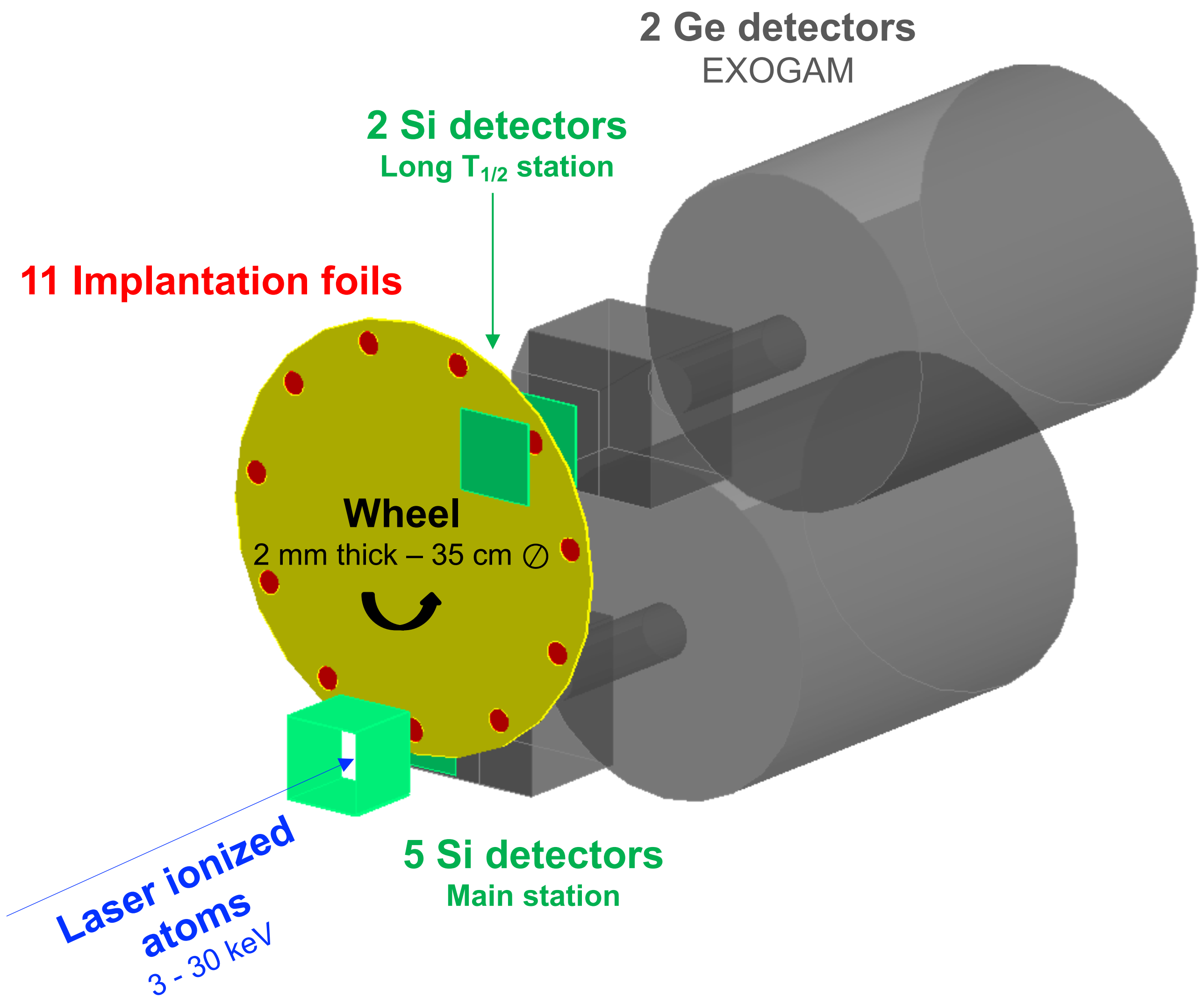
- **SEASON** will be mounted at the end of the S^3-LEB for the study of HN/SHN

- It will be dedicated to :
  1. Counting laser ionized at atoms (laser ionization spectroscopy)
  2. α, electron, γ decay spectrosocpy

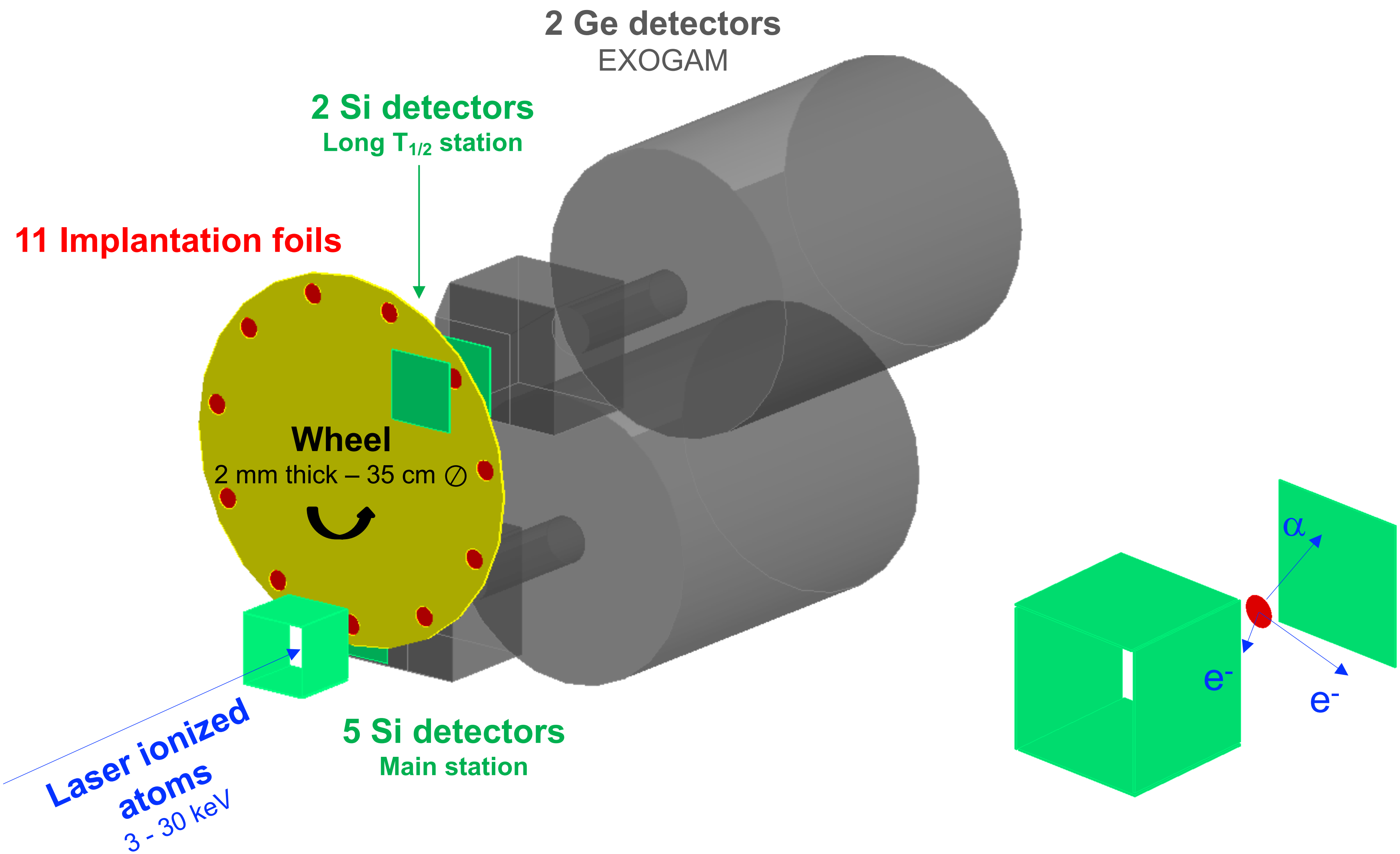
⇨ Coupling atomic and nuclear approaches to study HN/SHN produced at S^3



What is SEASON?

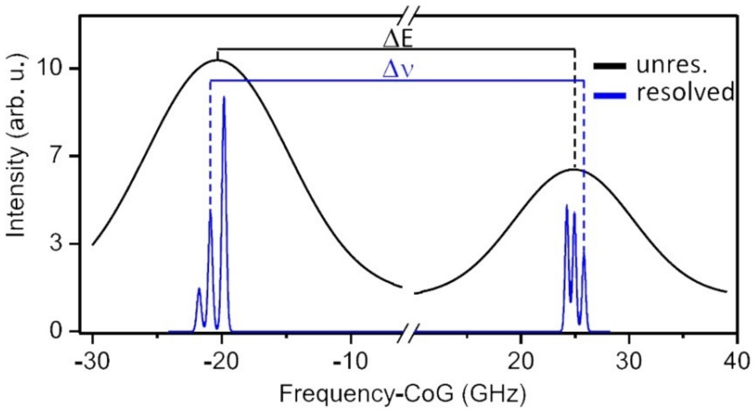


What is SEASON?



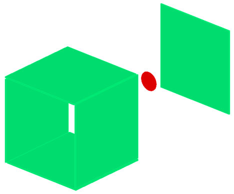
SEASON characteristics

Goal 1: counting the laser ionized atoms to perform laser ionization spectroscopy



R. Ferrer *et al.*, PLB 728(2014)

- Need good detection efficiency for α (5 – 12 MeV) and electrons (20 – 600 keV)



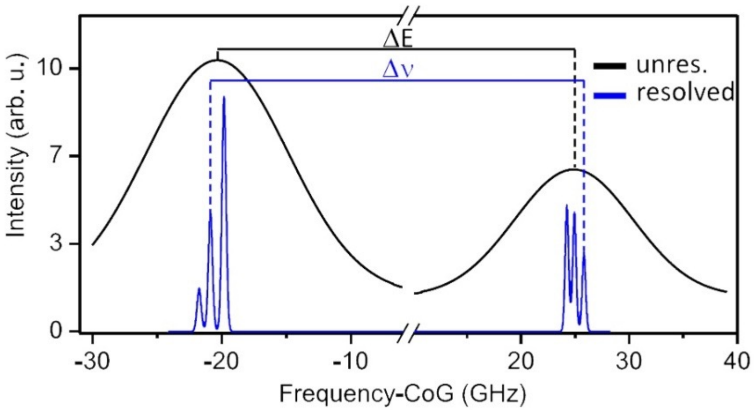
Tunnel configuration
Si detectors (BB7 from Micron)

- ✓ Thickness 1 mm
- ✓ Active area 64 x 64 mm^2

- Simulations (NPTOOL) in compact configuration:
- α detection efficiency 81%
- electron detection efficiency 51%

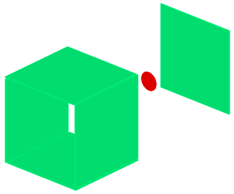
SEASON characteristics

Goal 1**:** counting the laser ionized atoms to perform laser ionization spectroscopy



R. Ferrer *et al.*, PLB 728(2014)

- Need good detection efficiency for α (5 – 12 MeV) and electrons (20 – 600 keV)



Tunnel configuration
Si detectors (BB7 from Micron)
- ✓ Thickness 1 mm
- ✓ Active area 64 x 64 mm^2

- Simulations (NPTOOL) in compact configuration:
- α detection efficiency 81%
- electron detection efficiency 51%

Goal 2**:** perform α, electron, γ decay spectroscopy

- Need good energy resolution and avoid summing effects

Energy resolution (FWHM)	15 keV (α from 5 MeV to 12 MeV) 7 keV (electron from 20 keV to 600 keV)
Energy threshold	20 keV
Time resolution (FWHM)	20 ns

Si detectors (BB7 from Micron)
- ✓ Thickness: 1 mm
- ✓ Active area: 64 x 64 mm^2
- ✓ Number of strips: 32 x 32
- ✓ Strip pitch: 2 mm
- ✓ Dead layer: 50 nm

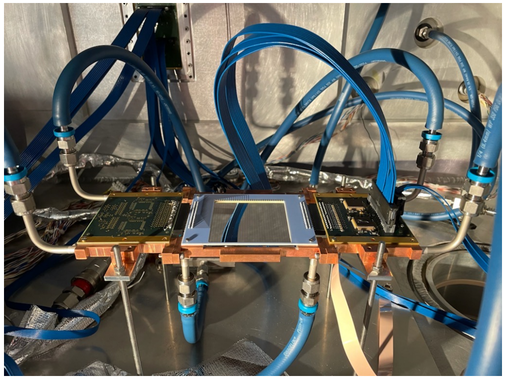
- Test of the SEASON DSSD prototype
Work of Damien THISSE (postdoc)

- Implantation foils

- Mechanics

Test of the SEASON DSSD prototype

Si detector



FRONT- END

FEANICS

Front-End Adaptive gaiN Integrated CircuitS
is a novel multi-channel ASIC in development at CEA/IRFU

2 gains (2 energy ranges) depending of the signal height

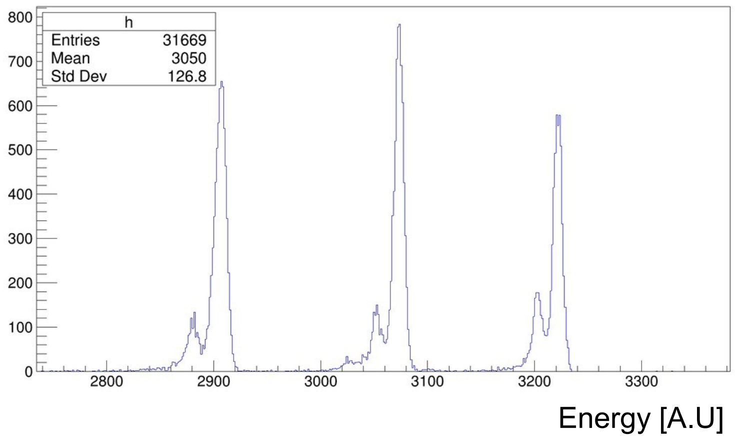
High gain 50 fF ⟷ electron
Low gain 550 fF ⟷ alpha

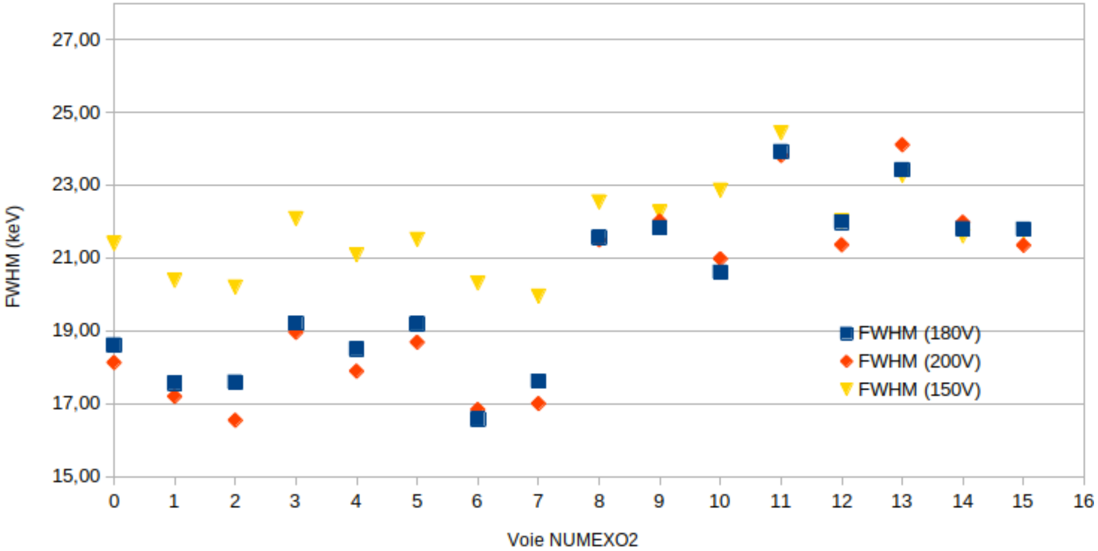
BACK- END

NUMEXO2

Test of the SEASON DSSD prototype

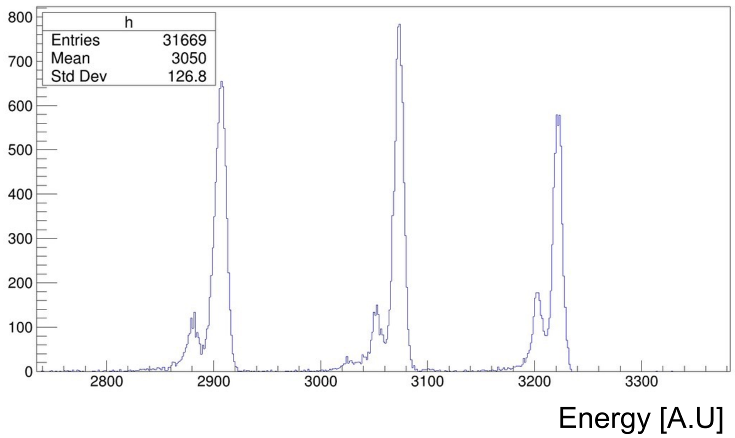
Source 3α – Fixed low gain 550 fF

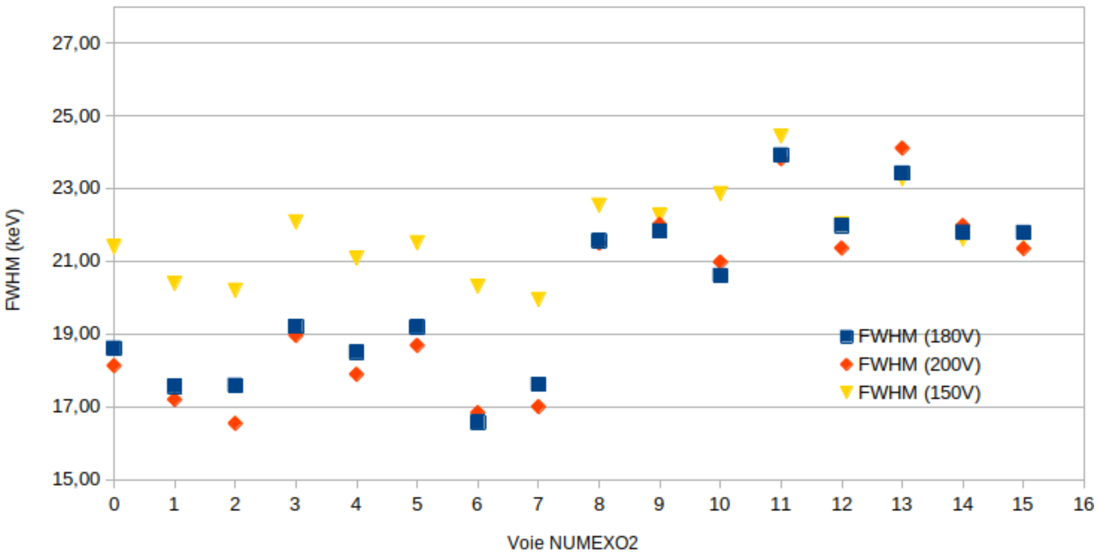




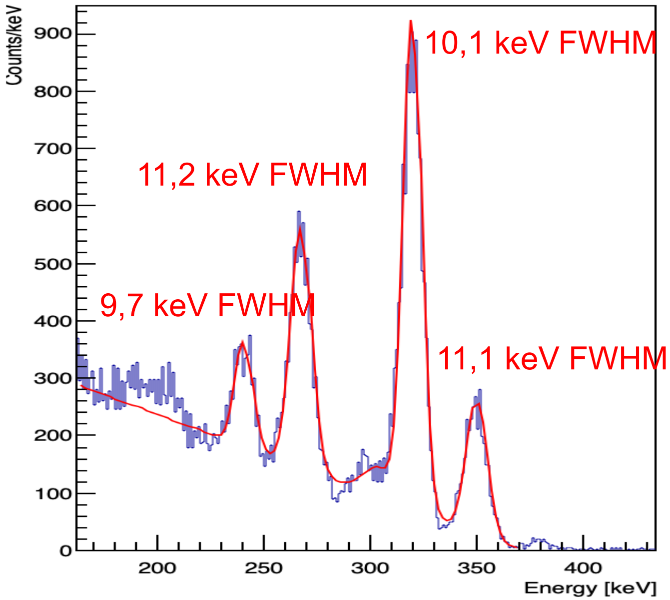
Test of the SEASON DSSD prototype

Source 3α – Fixed low gain 550 fF



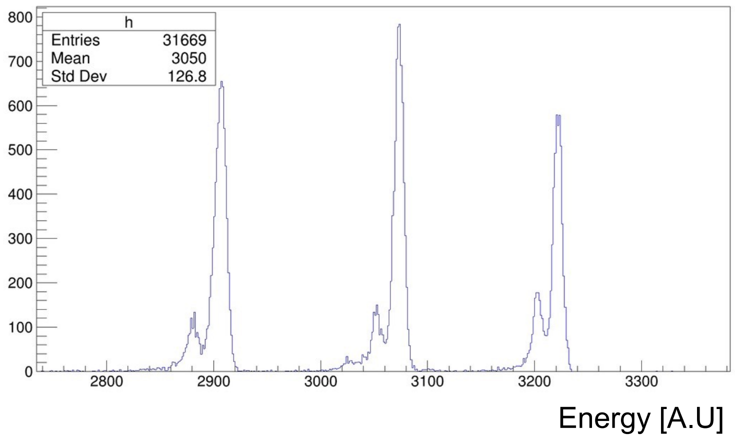


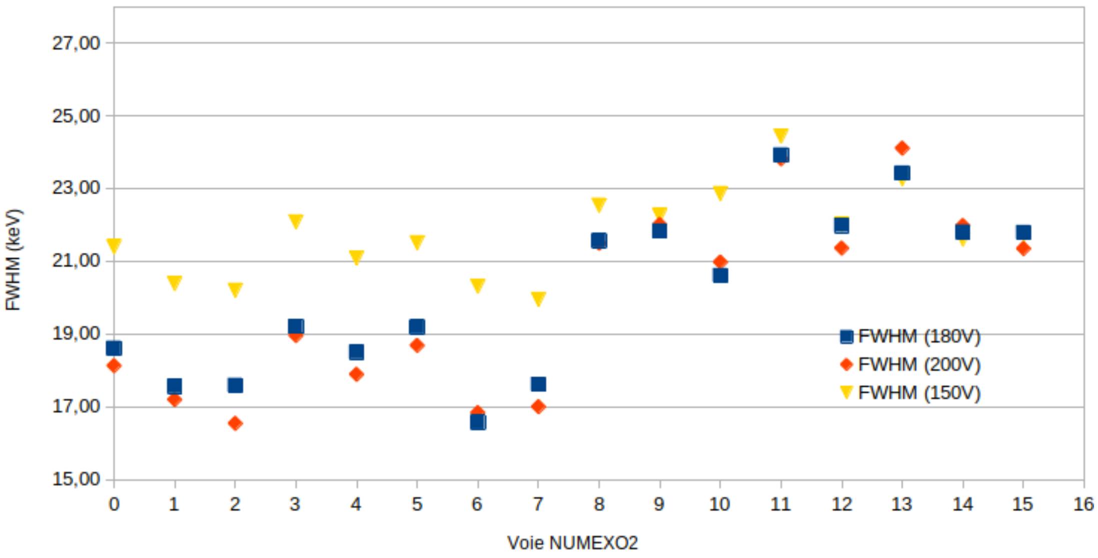
Source 133Ba – Fixed high gain 50 fF



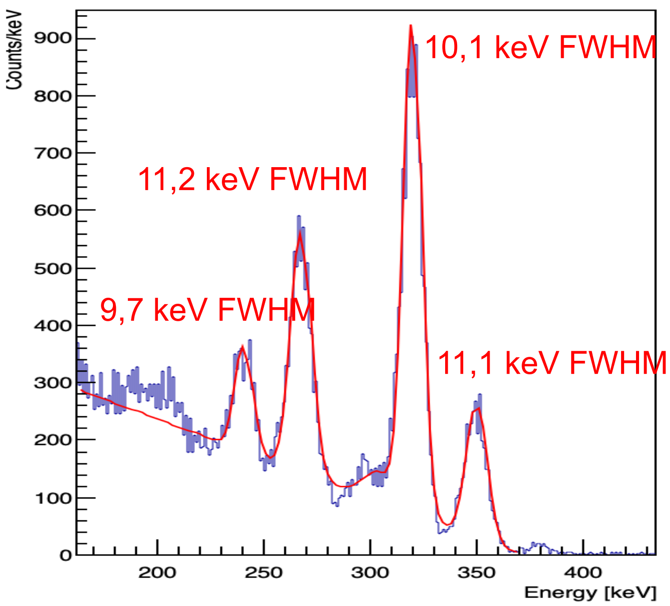
Test of the SEASON DSSD prototype

Source 3α – Fixed low gain 550 fF





Source 133Ba – Fixed high gain 50 fF



- Close to wanted performances with room for improvment (ex : dead layer)
- Ongoing tests with the adaptive gain

- Test of the SEASON DSSD prototype

- Implantation foils

Work of Emmanuel REY-HERME (PhD student)

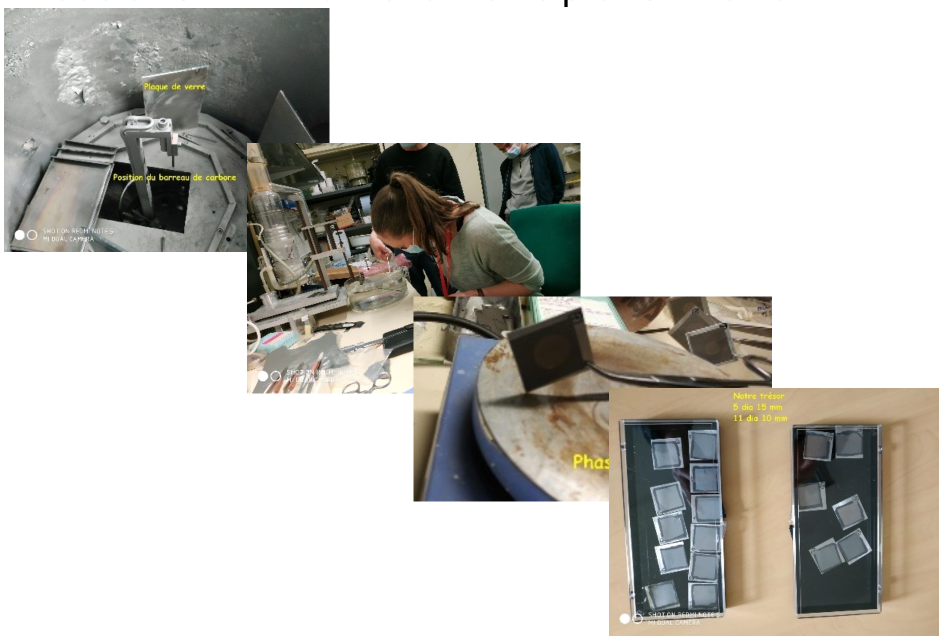
- Mechanics

Implantation foils

Option 1: Carbon foils ~ 20 $\mu g/cm^2$ (90 nm)

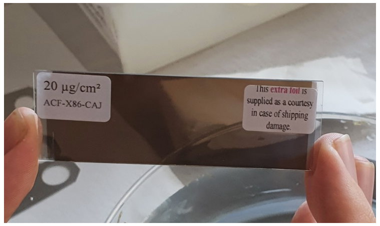
Option 1.1: homemade C foils

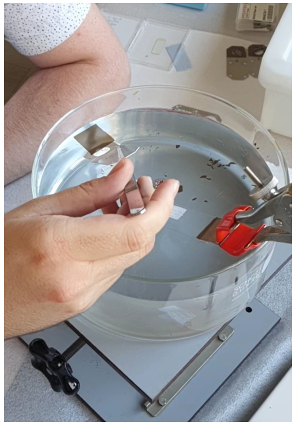
Made at GANIL thanks to the help of G. Fremont



Option 1.2: Purchased from ACF metals C foils

The carbon foils are received on their glass plate



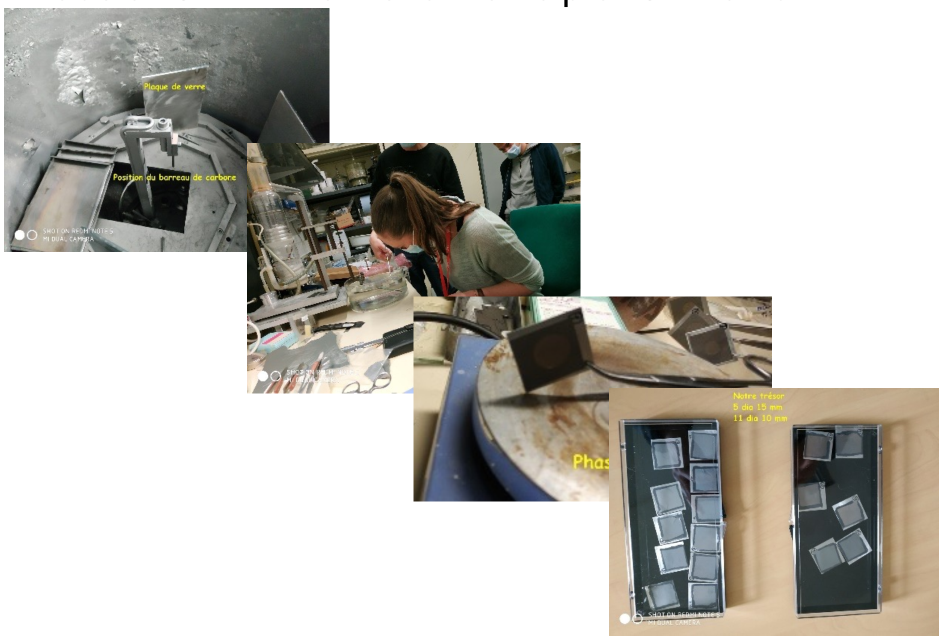


Implantation foils

Option 1: Carbon foils ~ 20 μg/cm^2 (90 nm)

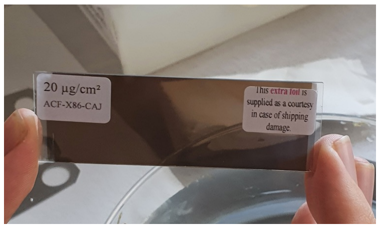
Option 1.1: homemade C foils

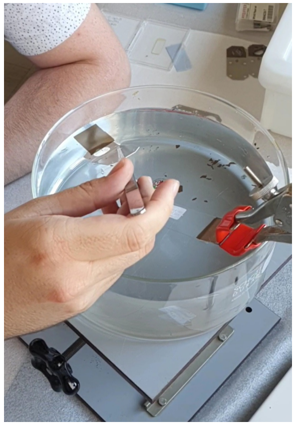
Made at GANIL thanks to the help of G. Fremont



Option 1.2: Purchased from ACF metals C foils

The carbon foils are received on their glass plate





Option 2: SiN foils ~ 15 μg/cm^2 (50 nm) or ~ 9 μg/cm^2 (30 nm)

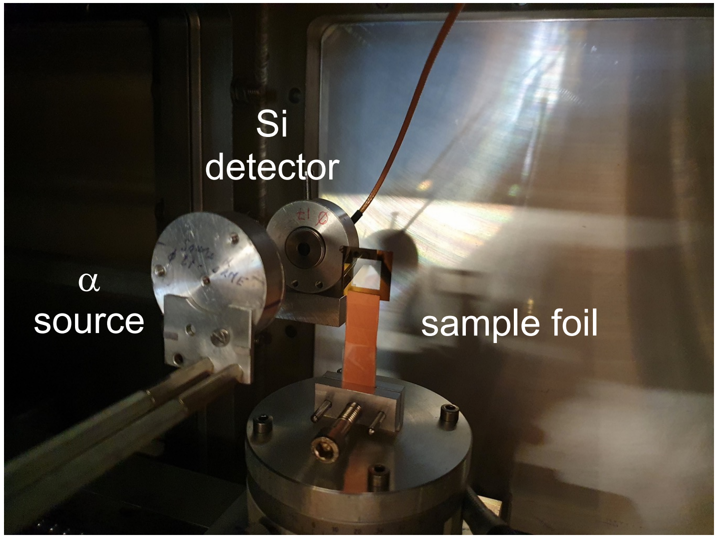
Purchased 4 foils from the SILSON company (2 X 30 nm and 2 X 50 nm)

Implantation foils

- Test bench at CEA Irfu/DEDIP (also used for FASLTAFF)

Foil	Nominal thickness (µg/cm²)	Measured thickness (µg/cm²)	Straggling (keV)
Carbon (GANIL)	~ 20	20 - 36	9 - 14
Carbon (ACF metal)	20(2)	19(1)	9
SiN (MICRON)	15(2)	12(1)	7

Deviation observed for SiN foils

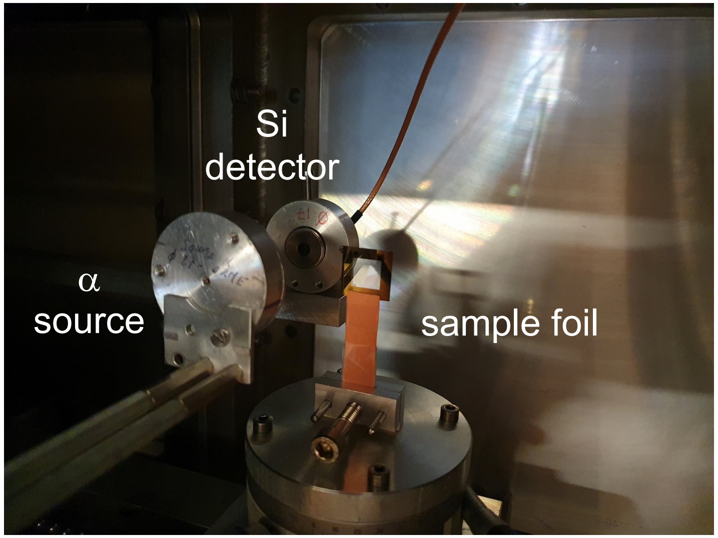


Implantation foils

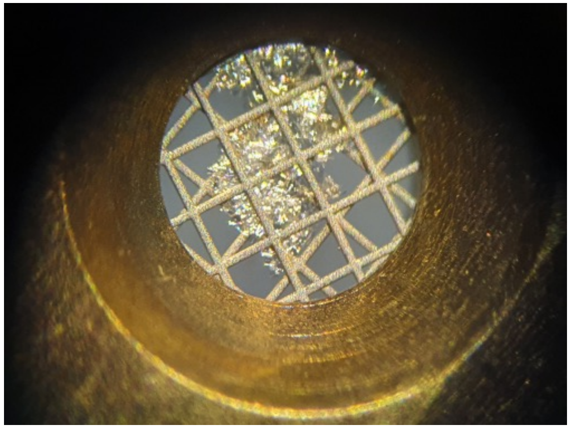
- Test bench at CEA Irfu/DEDIP (also used for FASLTAFF)

Foil	Nominal thickness (µg/cm²)	Measured thickness (µg/cm²)	Straggling (keV)
Carbon (GANIL)	~ 20	20 - 36	9 - 14
Carbon (ACF metal)	20(2)	19(1)	9
SiN (MICRON)	15(2)	12(1)	7

Deviation observed for SiN foils



- Transmission Electron Microscopy (TEM) @JANNuS facility at IJCLab



- ➢ Diffraction measurement ⇨ No crystalline structure/amorphous
- ➢ X-ray study ⇨ Silicon and Nitrogen with a stochiometry ~ 1/1

Element	Z	$p_m(\%)$	$p_A(\%)$
Nitrogen	7	34.08	50.40
Silicon	14	63.12	46.56
Oxygen	8	1.87	2.42
Aluminium	13	0.44	0.34
Chlorine	17	0.49	0.29

- ➢ Electron Energy Loss Spectroscopy ⇨ Measured thickness 13(1) µg/cm²

Implantation foils

Option 1: Carbon foils ~ 20 μg/cm² (90 nm)

<u>Option 1.1</u>: homemade C foils

- Easy to make, not expensive
- Problem of repeatability, fragile

<u>Option 1.2</u>: Purchased from ACF metals C foils

- Easy to make, not expensive (~ 15 €/foil)
- Fragile

Option 2: SiN foils ~ 15 μg/cm² (50 nm) or ~ 9 μg/cm² (30 nm)

- Robust
- Expensive (~ 200 €/foil), support is imposed

Implantation foils

Option 1: Carbon foils ~ 20 μg/cm^2 (90 nm)

Option 1.1: homemade C foils

- Easy to make, not expensive
- Problem of repeatability, fragile

Selected option for SEASON

Option 1.2: Purchased from ACF metals C foils

- Easy to make, not expensive (~ 15 €/foil)
- Fragile

Option 2: SiN foils ~ 15 μg/cm^2 (50 nm) or ~ 9 μg/cm^2 (30 nm)

- Robust
- Expensive (~ 200 €/foil), support is imposed

- Test of the SEASON DSSD prototype

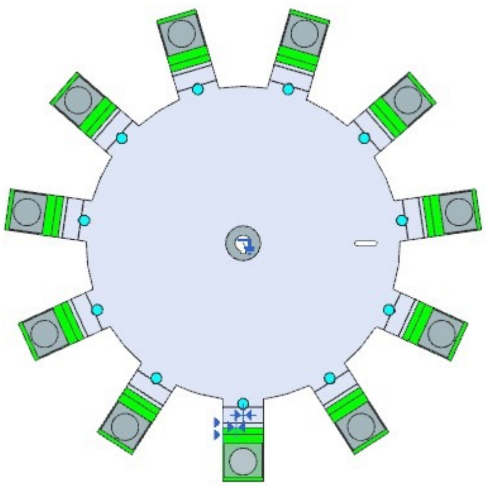
- Implantation foils

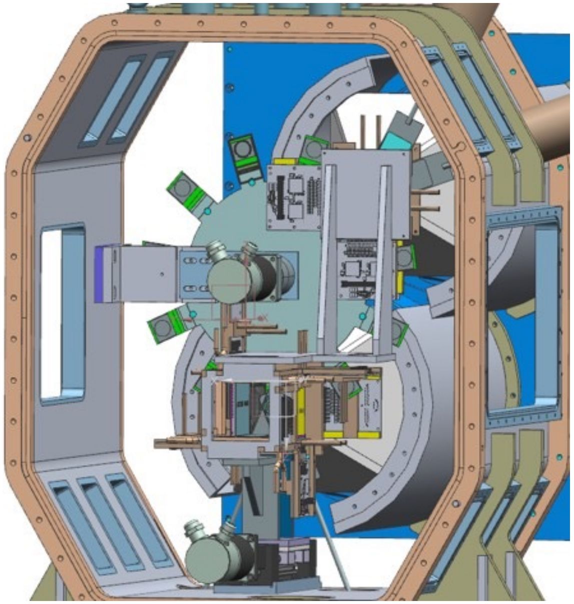
- Mechanics

Design at CEA Irfu/DIS

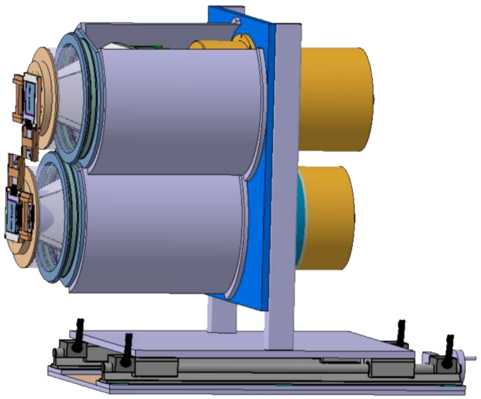
Mechanics

Wheel

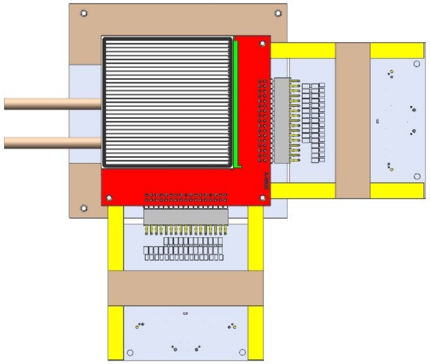


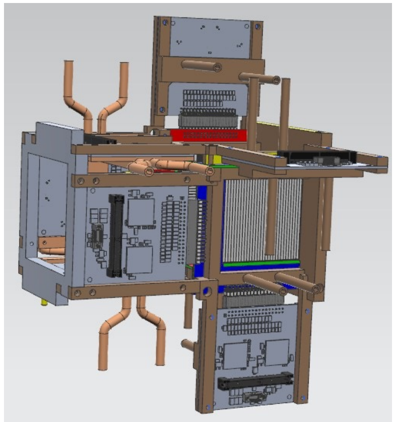


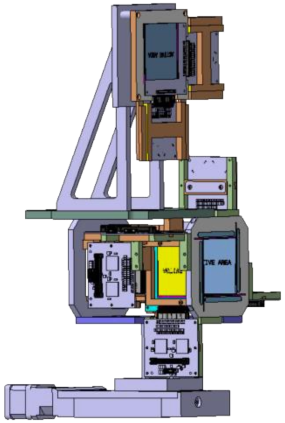
Downstream Si detectors (Main and long $T_{1/2}$ stations)



Upstream Si detectors (Main and long $T_{1/2}$ stations)





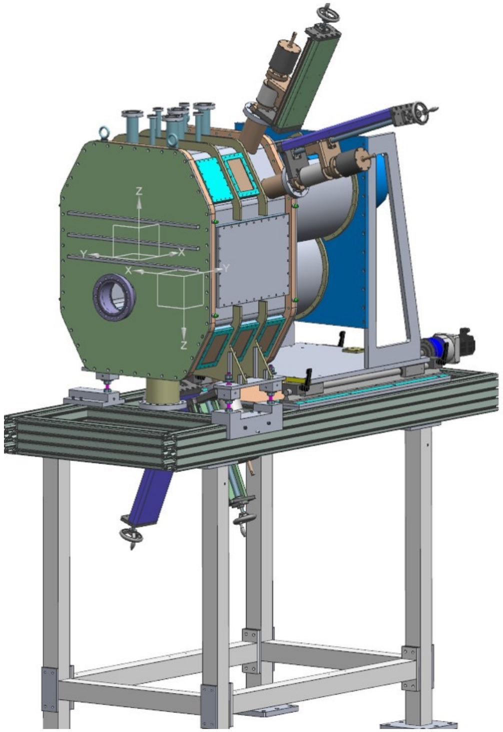


Conclusion

- Detector and electronics have been validated
- Study of the implantation foils allowed to choose the material
- Design is finished, several elements have already been ordered
- First SEASON detector has been ordered and should be received in few weeks

Collaboration

Florent Bouyjou, Sandrine Cazaux, Thomas Chaminade, Olivier Cloué, Philippe Daniel-Thomas, Antoine Drouart, Alexis Gaget, Olivier Gevin, Thomas Goigoux (postdoc), Jean-Christophe Guillard, Hervé Le Provost, Jorge Mendes-Ribeiro, Gilles Minier, Julien Noury, Yann Reinert, Johan Relland, Emmanuel Rey-Herme (PhD student), Arnaud Roger, Barbara Sulignano, Christophe Theisen, Damien Thisse, Marine Vandebrouck



Thank you !