

The logo for ACTAR TPC features the word "actar" in a bold, lowercase sans-serif font, with "TPC" in a smaller, uppercase font to its right. A stylized black line above the text splits into two branches, resembling a particle detector or a beam path. The logo is set against a white square background that is part of a larger grey gradient.

actar TPC

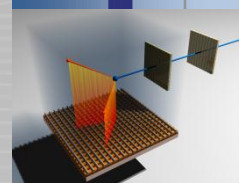
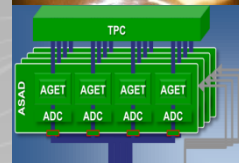
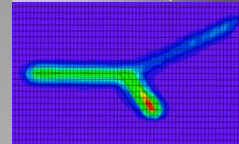
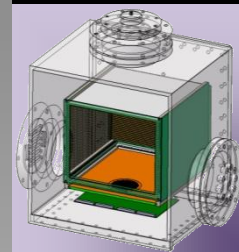
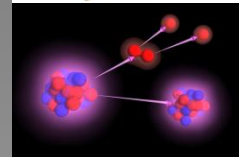
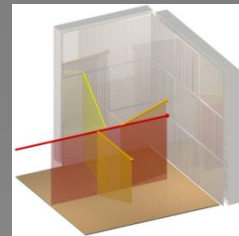
ACTAR TPC: a new time projection chamber for radioactive beam experiments

D. Suzuki

Institut de Physique Nucléaire d'Orsay

On behalf of the ACTAR TPC collaboration

suzuki@ipno.in2p3.fr



Outline

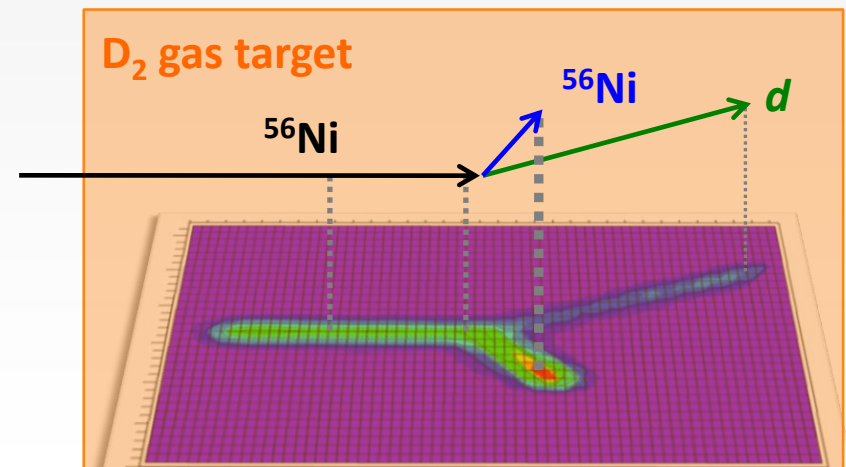
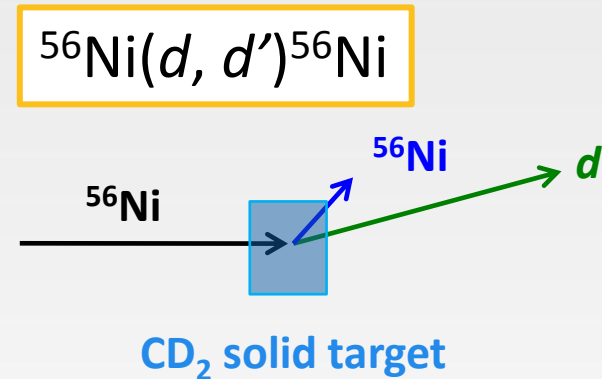


- **Physics motivation**
- **Basic concept: “Active-target” TPC**
- **ACTAR TPC project scope**
- **Micromegas prototype test**
- **ACTAR TPC demonstrator**

Challenges of RI beam reactions



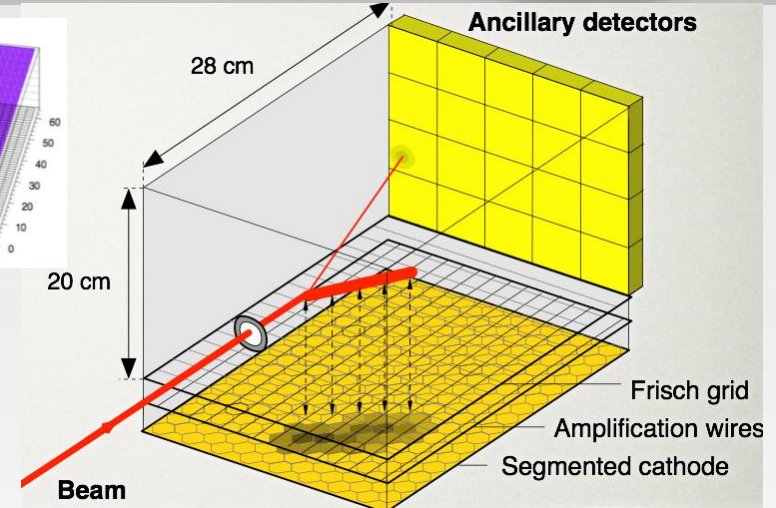
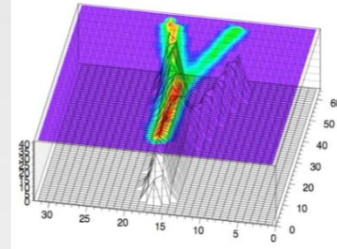
- Light ion ($p, d, {}^3\text{He}, {}^4\text{He}\dots$) as hadronic probe
- RI beams (heavy) + target (light)
- “Asymmetric” collision
 - Swiftly moving CM frame
 - Low-energy probe ion in LAB frame
 - Energy loss in target deteriorates the resolution
- Idea of “Active-target” TPC
 - Track ions “inside” the target



MAYA @GANIL

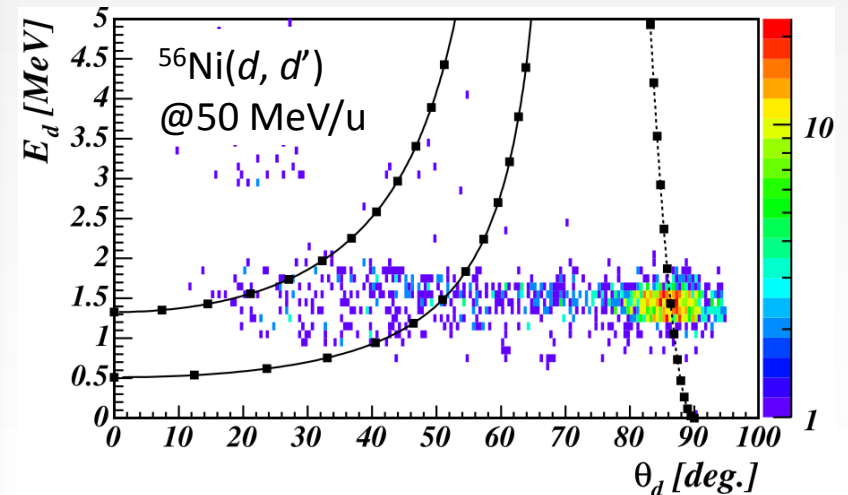


- Operational since 2003
 - Low beam energy (~ 3 MeV/u)
 - Low transferred energy



Beam/Energy [MeV/u]	Date	Reaction	Gas	Mixture [%]	Pressure [mbar]
^8He @ 3.9	2003	$^8\text{He}(p,p')$	C_4H_{10}	100	1000
^8He @ 3.5	2003	$^8\text{He}(p,d)^7\text{He}$	C_4H_{10}	100	525
$^{25,26}\text{F}$ @ 50.0	2004	$^{25}\text{F}(d,^3\text{He})^{24}\text{O}$	D_2	100	2200
^{56}Ni @ 50.0	2005	$^{56}\text{Ni}(d,d')$	D_2	100	1050
^8He @ 15.4	2005	$^8\text{He}(^{12}\text{C}, ^{13}\text{N})^7\text{H}$	C_4H_{10}	100	30
^{11}Li @ 3.6	2006	$^{11}\text{Li}(p,d)^{10}\text{Li}$	C_4H_{10}	100	150
		$^{11}\text{Li}(p,t)^9\text{Li}$	C_4H_{10}	100	664
^6He @ 3.5	2007	$^6\text{He}(p,n)^6\text{Li}$	C_4H_{10}	100	107
^{68}Ni @ 50.0	2010	$^{68}\text{Ni}(d,d')$	D_2	100	1040
		$^{68}\text{Ni}(\alpha,\alpha')$	$\text{He} + \text{CF}_4$	98/2	500
^{56}Ni @ 50.0	2011	$^{56}\text{Ni}(\alpha,\alpha')$	$\text{He} + \text{CF}_4$	98/2	1200
^8He @ 15.4	2011	$^8\text{He}(^{19}\text{F}, ^{20}\text{Ne})^7\text{H}$	$\text{He} + \text{CF}_4$	10/90	175
^{12}Be @ 3.0	2012	$^{12}\text{Be}(p,p')$	C_4H_{10}	100	100

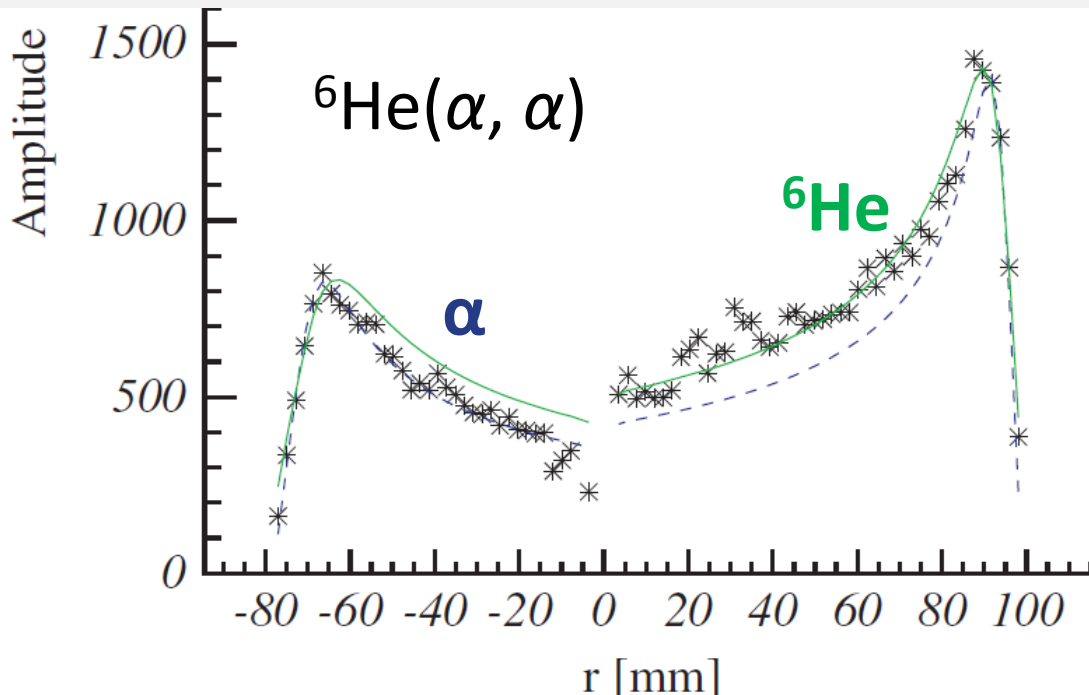
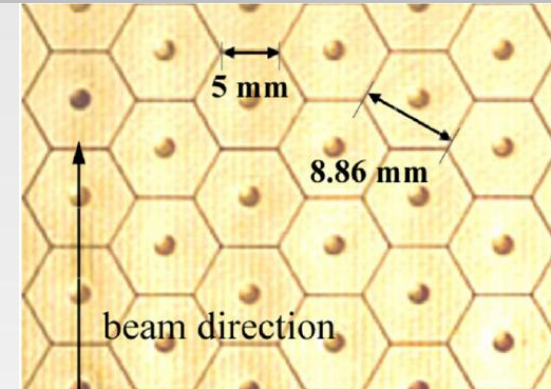
C.E. Démonchy et al., Nucl. Instrum. and Meth. A 583 (2007) 341



C. Monrozeau et al., Phys. Rev. Lett. 100 (2008) 042501

Beyond MAYA

- Precise particle identification of stopped particles
 - Discriminating (p , d , t) or (${}^3\text{He}$, ${}^4\text{He}$, ${}^6\text{He}$) is difficult with MAYA
 - Using energy deposit profile
 - MAYA is using wire technology with hexagonal pads ~ 1 cm
 - MPGD with smaller pixels 2×2 mm²



Taken with
Micromegas 2 mm-wide strips

D. Suzuki et al.,
Nucl. Instr. and Meth. A 691 (2012) 39.

Next Generation: ACTAR TPC

- **Specifications**

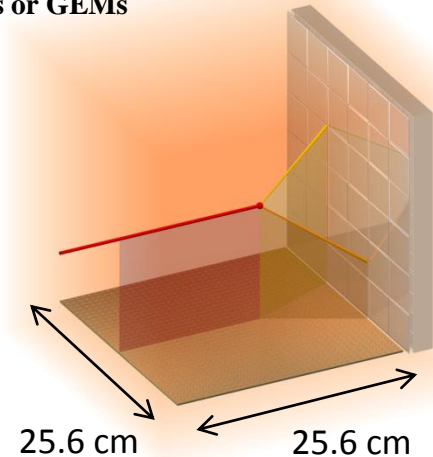
- Microegas/ GEM ($\sim 650 \text{ cm}^2$, pad size $2 \times 2 \text{ mm}^2$)
- 16,384 channel
- GET (General Electronics for TPC's):
 - Wave-digitizer using 511 analogue memory cells @ 100 MHz max
 - Internal trigger/ zero suppression for reducing data traffic
 - ANR Funded Project (Nov. 2009 – Oct. 2013)
 - IRFU/CEA-Saclay, CENBG, GANIL, MSU
- Different physical geometries: Reaction and decay

- **2012 - 2013 Research and Development**

- Tests of prototype detector (Micromegas & GEM)
- Building of demonstrator
- Physics simulations (ACTARsim)
- Chamber design (geometry, mechanics)
- GET electronics development

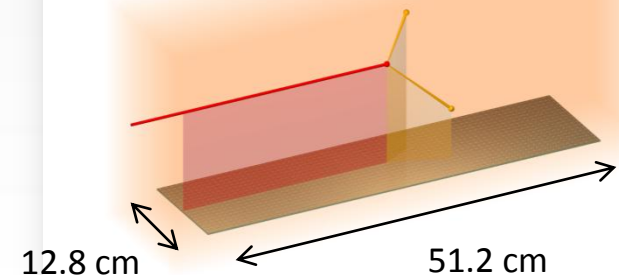
Reactions

MMs or GEMs



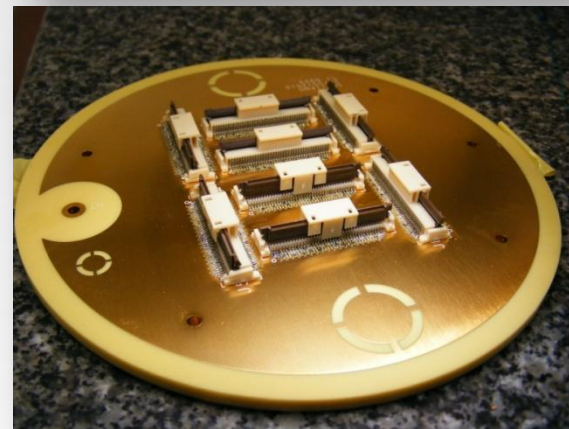
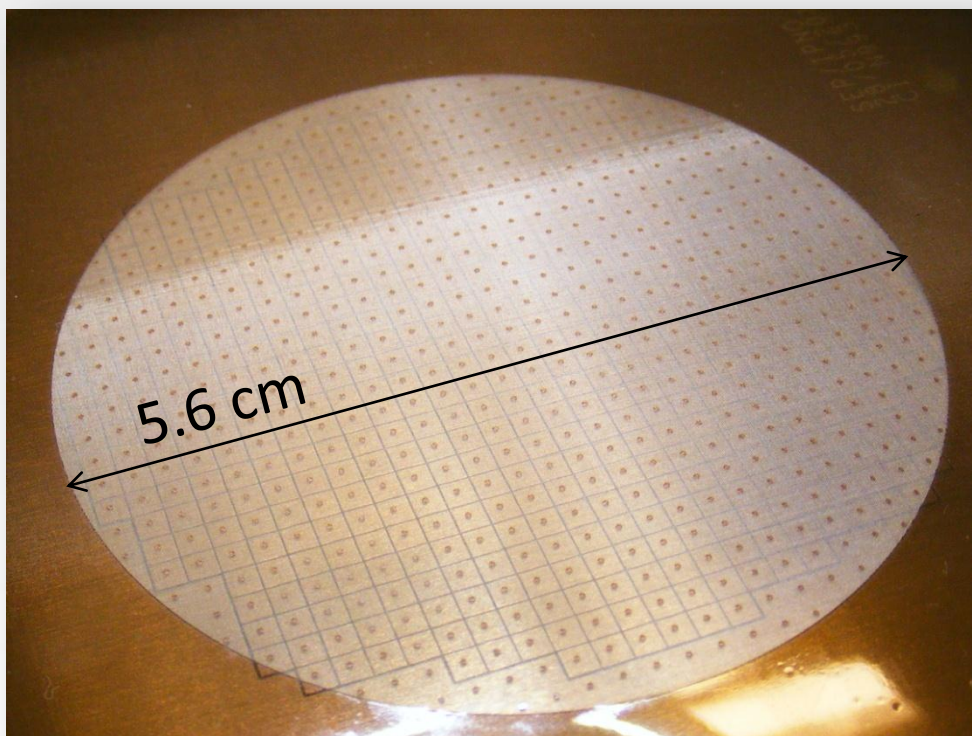
Decay

MMs + GEMs



Micromegas Prototype

- $\phi 5.6$ cm, 2×2 mm² 576 channel prototypes
 - Design @ IPN Orsay
 - Bulk micromegas @ CEA Saclay (IRFU-SEDI)
 - Amplification gaps (128 and 256 μ m)

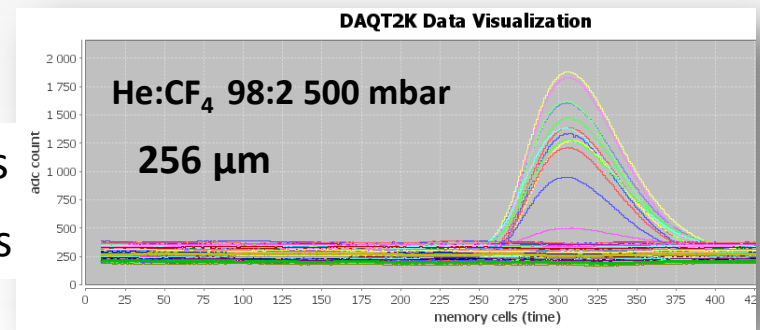
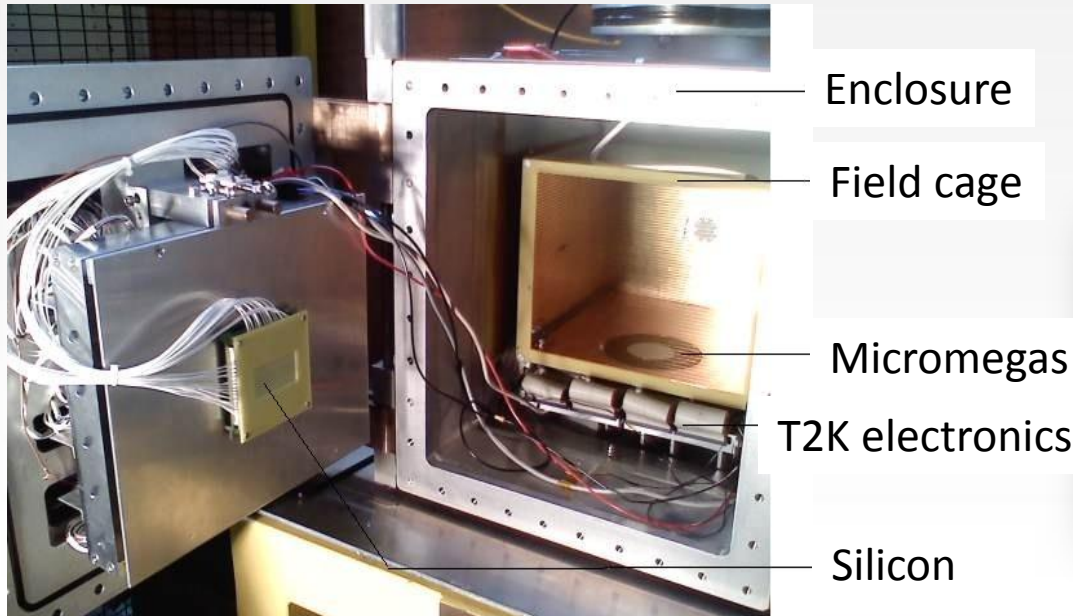
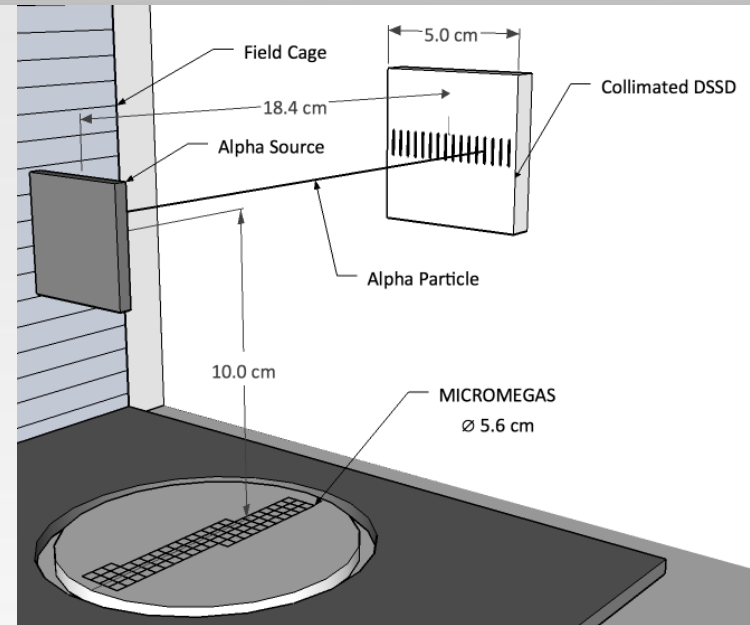


72-channel connector

Detector tests inside Maya @ GANIL

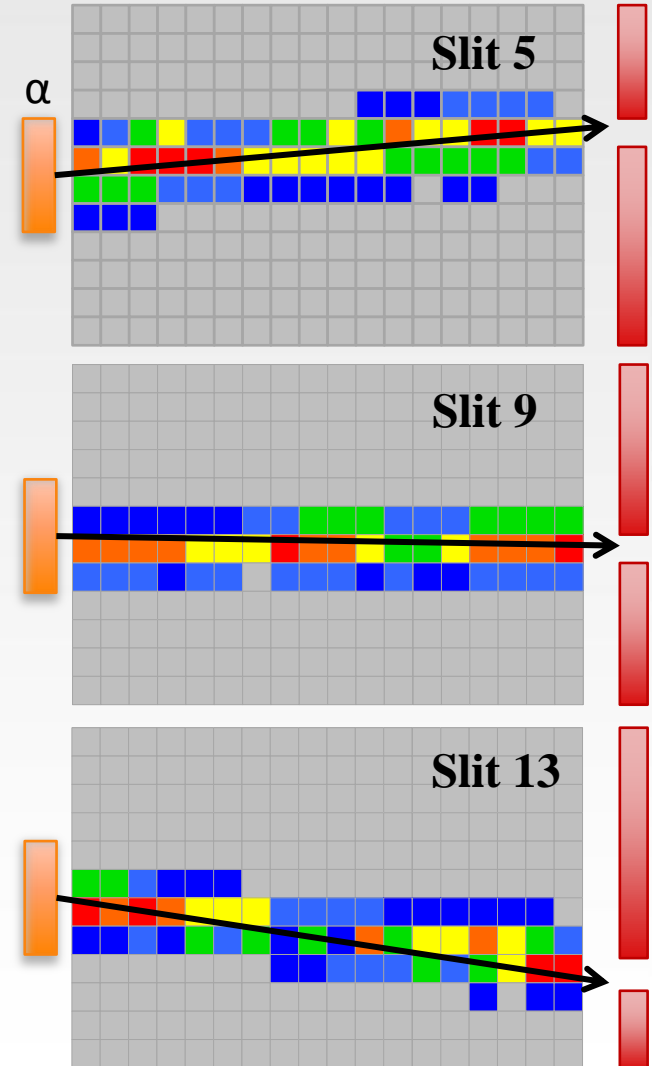
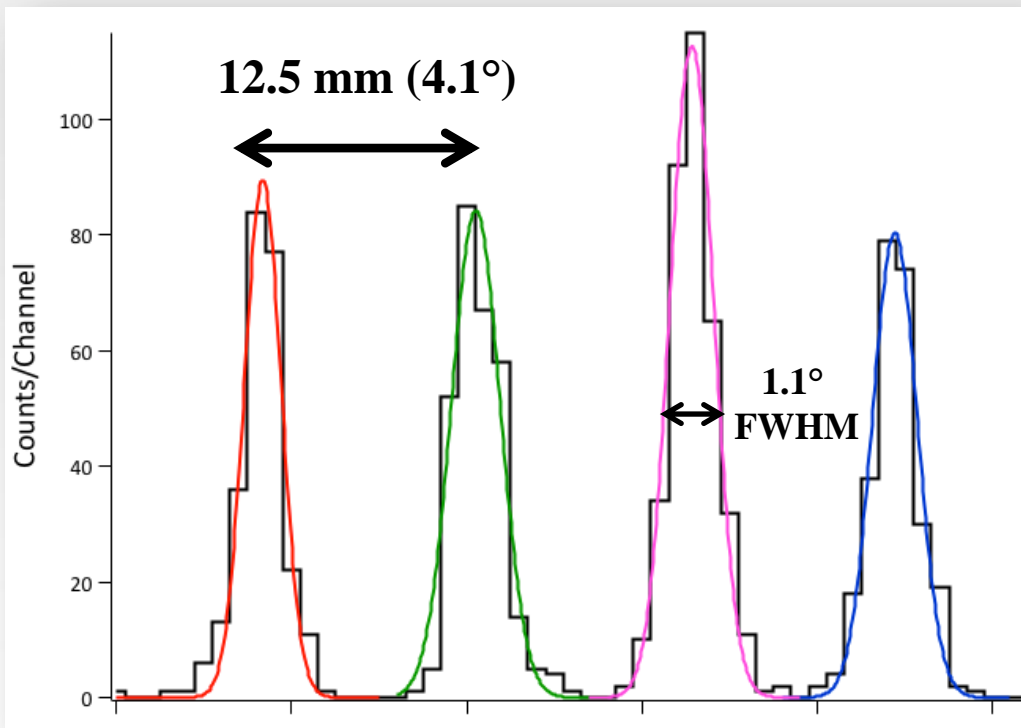
- Determine angular and energy resolution
- Gases: C_4H_{10} , He:CF₄ 98:2, Ar:CF₄ 98:2
- Pressures: 25 – 1100 mbar
- ²³⁹Pu/ ²⁴¹Am/ ²⁴⁴Cm source
- T2K electronics (511 analogue circular memory cells)

T. Lux for the T2K TPC groups, J. Phys: Conf. Ser. 65 (2007) 012018



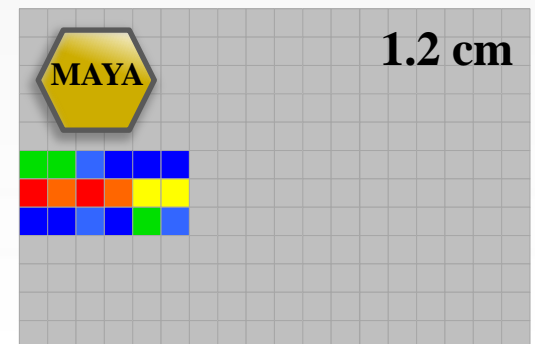
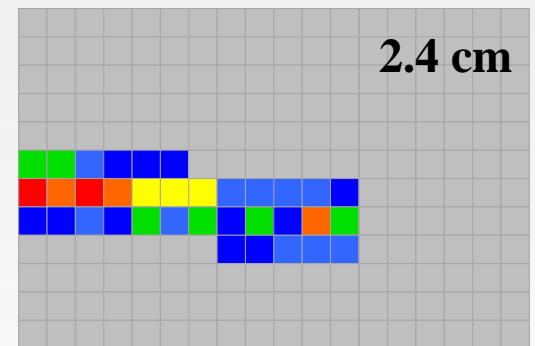
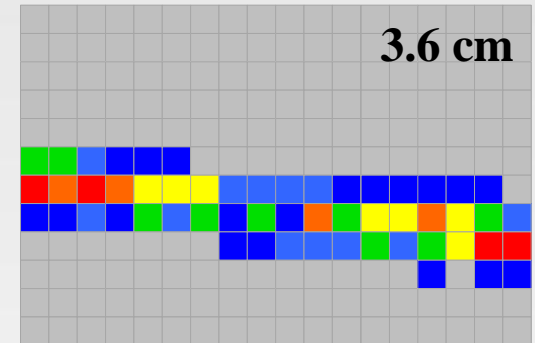
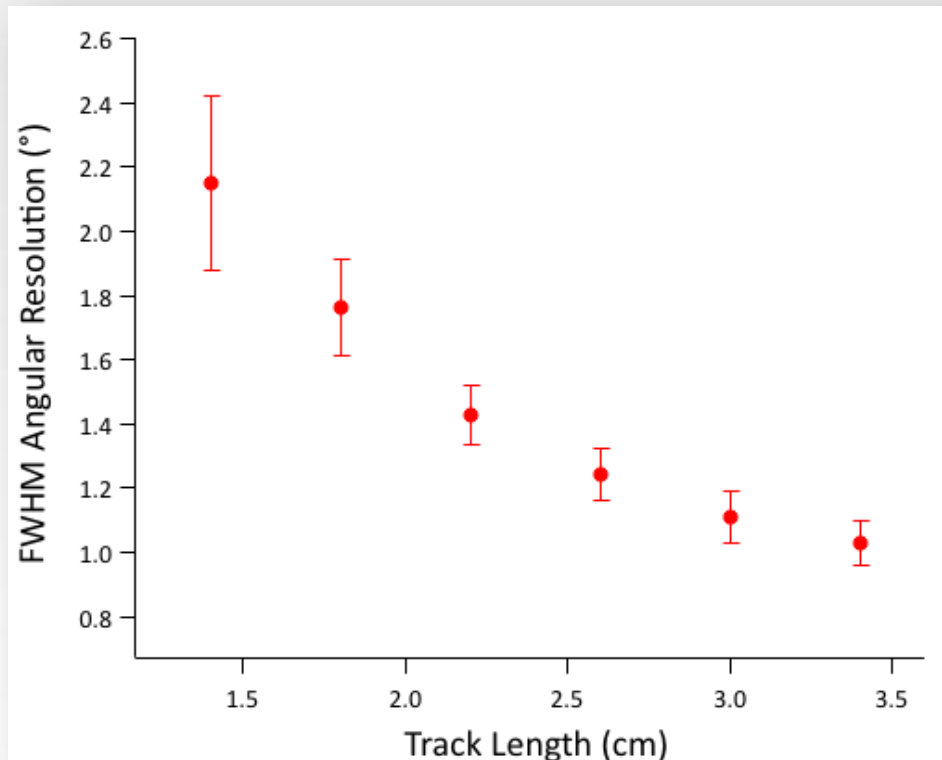
Horizontal Angular Resolution

- Slit position reconstruction: He:CF₄ 98:2
 - Extrapolation of 4 cm traces on pad plane
 - Varied pressure, drift and amplification voltages
 - Angular resolution < 1.3° (FWHM)



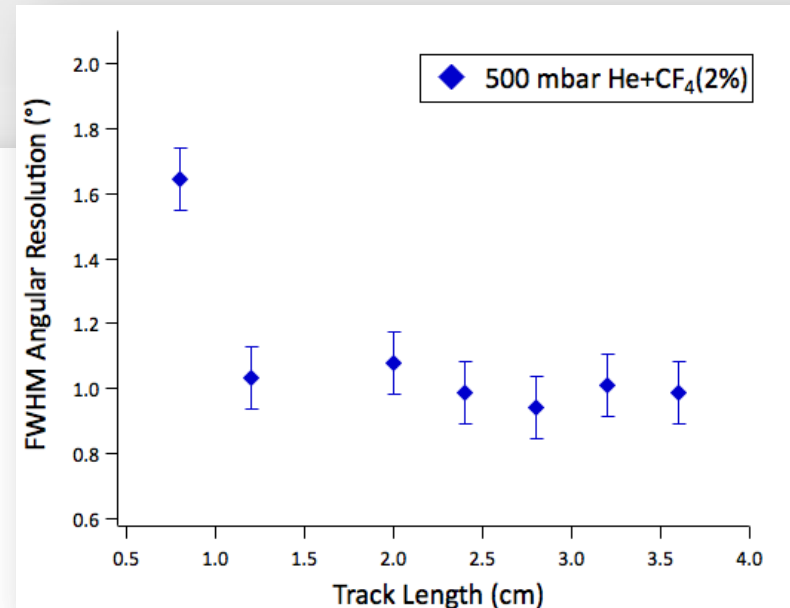
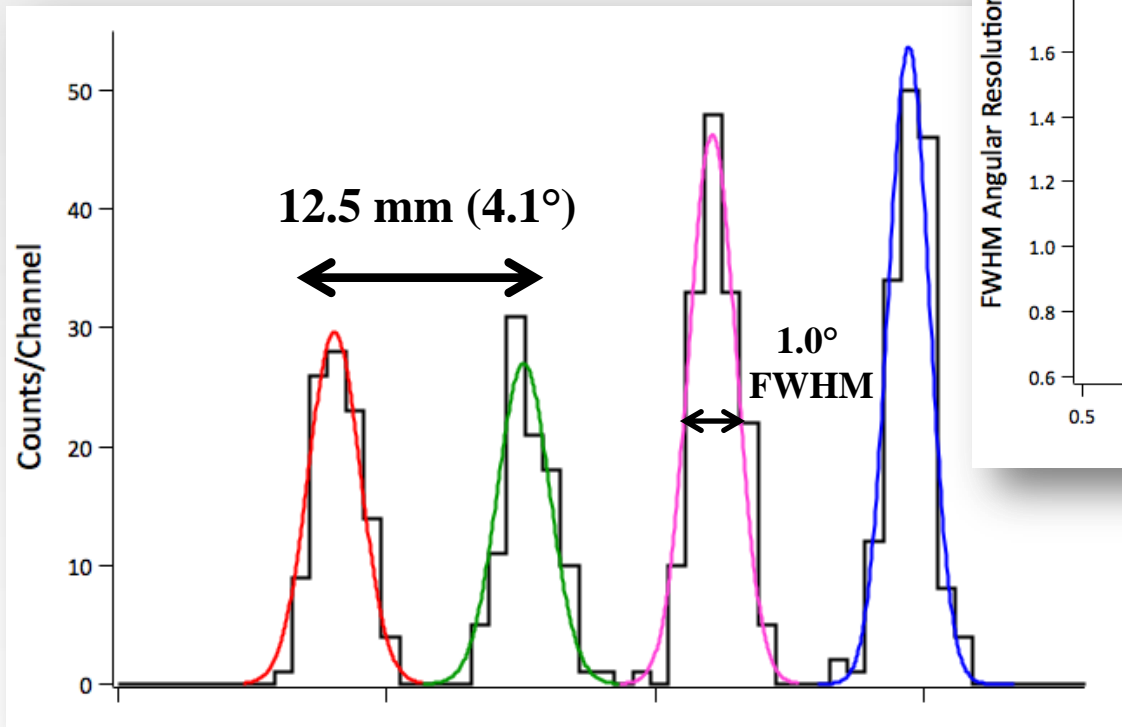
Horizontal Angular Resolution

- How does resolution evolve with short traces?
 - Important for low-energy reaction and decay products
 - MAYA reconstruction not possible below ~ 5 cm



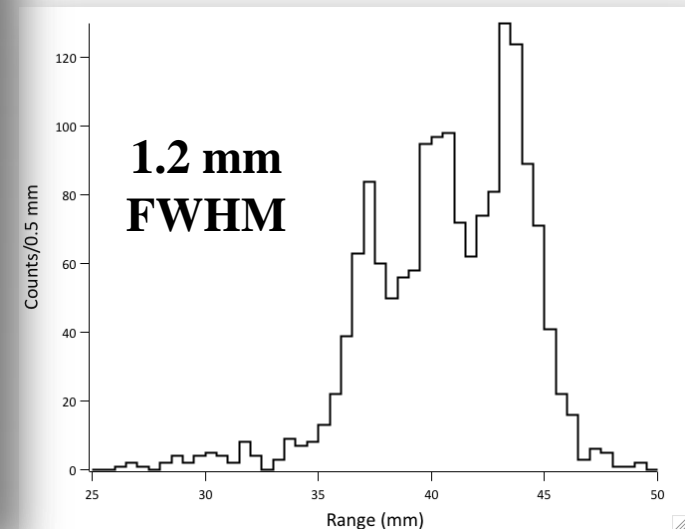
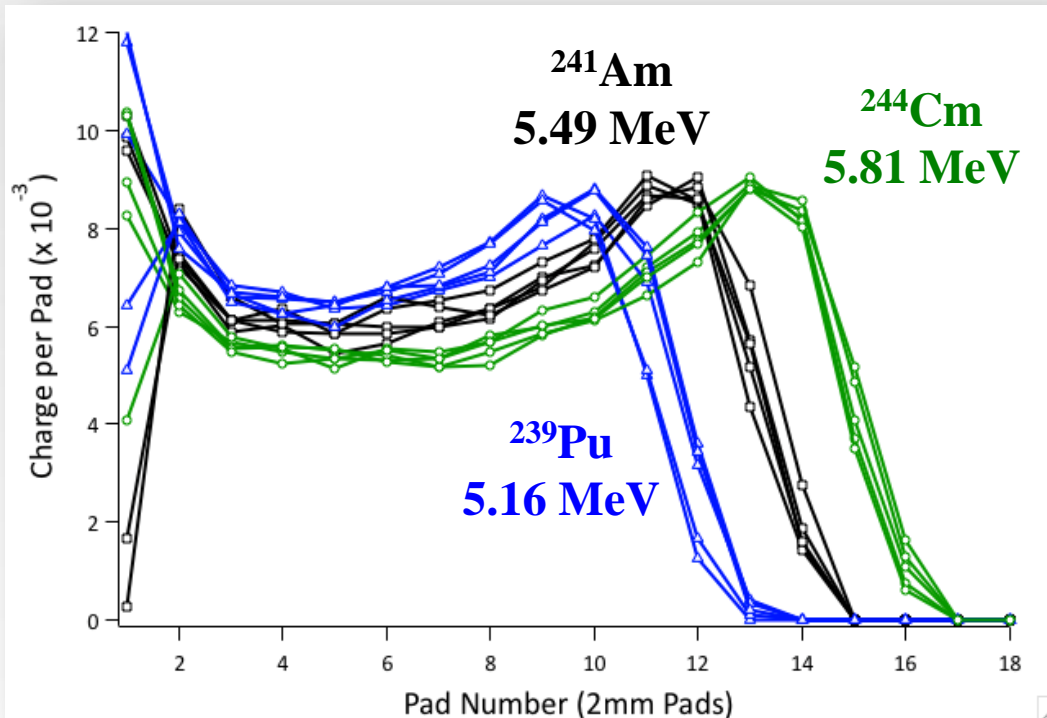
Vertical Angular Resolution

- Vertical angles determined from the calibrated drift times
 - Less sensitive to trace length (gas and pressure dependent)
 - Angular resolution $< 1.2^\circ$ (FWHM)
 - Equivalent to the horizontal resolution



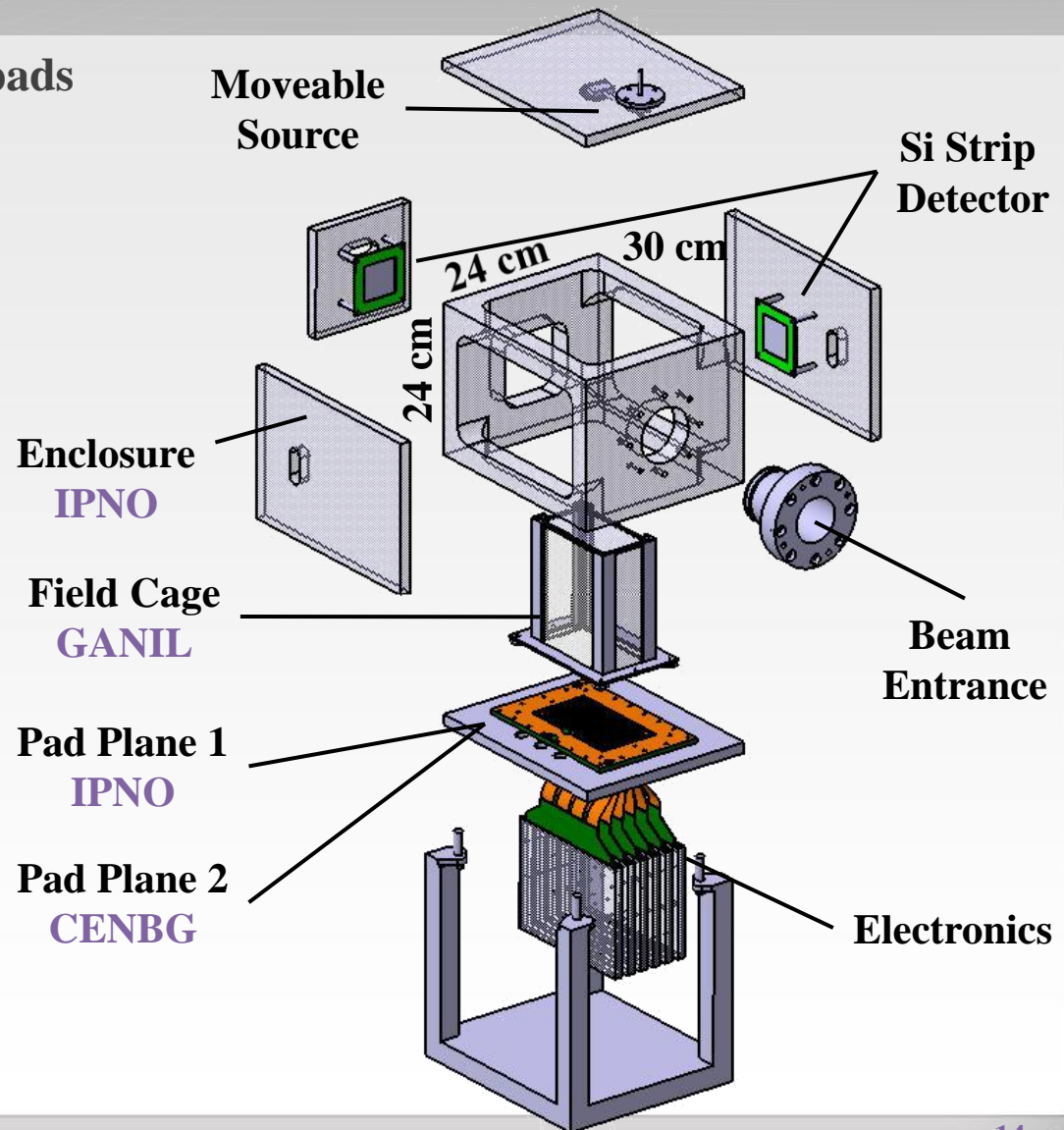
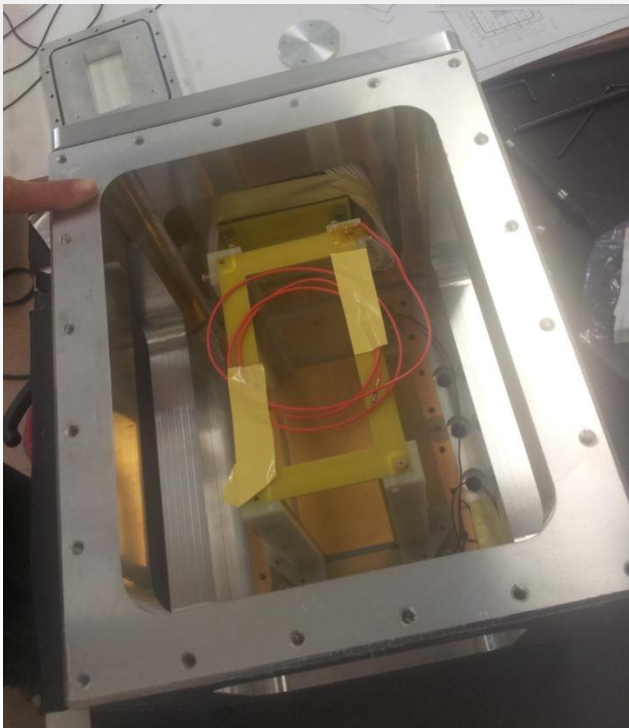
Energy (Range) Resolution

- Range of α 's in Ar:CF₄ 98:2 @ 1100 mbar
 - Range resolution > 0.8 mm (FWHM)
 - Energy resolution > 80 keV (FWHM)



ACTAR TPC Demonstrator

- $12 \times 6 \text{ cm}^2$; $2 \times 2 \text{ mm}^2 \times 2,048$ pads
- Test high-density connection
 - High-density connector (IPNO)
 - Direct insertion to Micromegas
- Test GET electronics
- Assembled on Sep. 24, 2012



Summary

- **ACTAR-TPC, a new time projection chamber for radioactive beam experiments, is under development in France.**
- **A high-granularity Micromegas was tested with C_4H_{10} , He:CF₄, and Ar:CF₄**
 - **Angular resolution ~ 1° FWHM**
 - **Energy resolution ~ 80 keV FWHM**
 - **Met or exceeded collaboration requirements**
- **ACTAR TPC Demonstrator has been assembled**
 - **Test starts from October 2012**
 - **Test a complete GET system**
 - **Define the final detector design**
 - **Budget request for the full detector: Fall 2012**

ACTAR TPC Collaboration



- **CENBG**

- B.Blank, J.Giovinazzo, J.L.Pedroza, J.Pibernat

- **GANIL**

- S.Damoy, G.F.Grinyer, J.Pancin, D.Perez-Loureiro, F.Saillant, B.Raine, T.Roger, G.Wittwer

- **IPNO**

- V.Chambert, E.Khan, A.Lermitage, G.Noël, J.Peyre, J.Pouthas, P.Rosier, D.Suzuki, M.Vandebrouck, L.Vatrinet, T.Zerguerras

- **IRFU Saclay**

- F.Druillole, A.Gillibert, E.C.Pollacco

- **K.U. Leuven**

- R.Raabe, S.Sambi

- **U de Santiago de Compostela**

- H.Alvarez-Pol, J.Benlliure, M.Caamaño, D.Cortina-Gil, B.Fernandez-Dominguez

- **Funding partners:**

