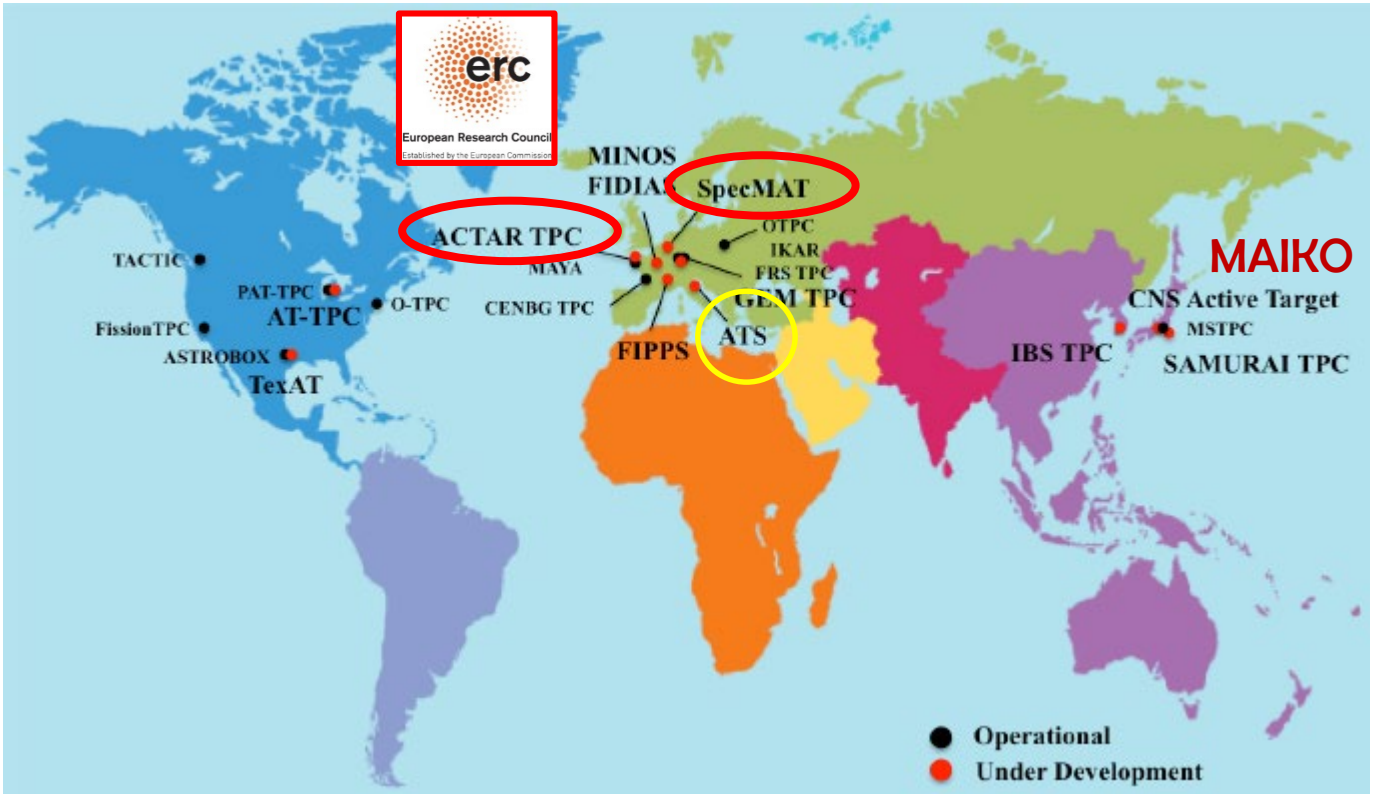
Actar Demonstrator test at LNS: an overview

"***Performance test and optimization of the ACTAR Demonstrator for heavy ion beams experiments.***"

GDS Workshop
on Rare gas target handling and recycling systems
Orsay, 23/01/2019

T. Marchi INFN – LNL

Active Targets around the World



G.F. Grinyer, J. Pancin, T. Roger, EURISOL meeting 2014

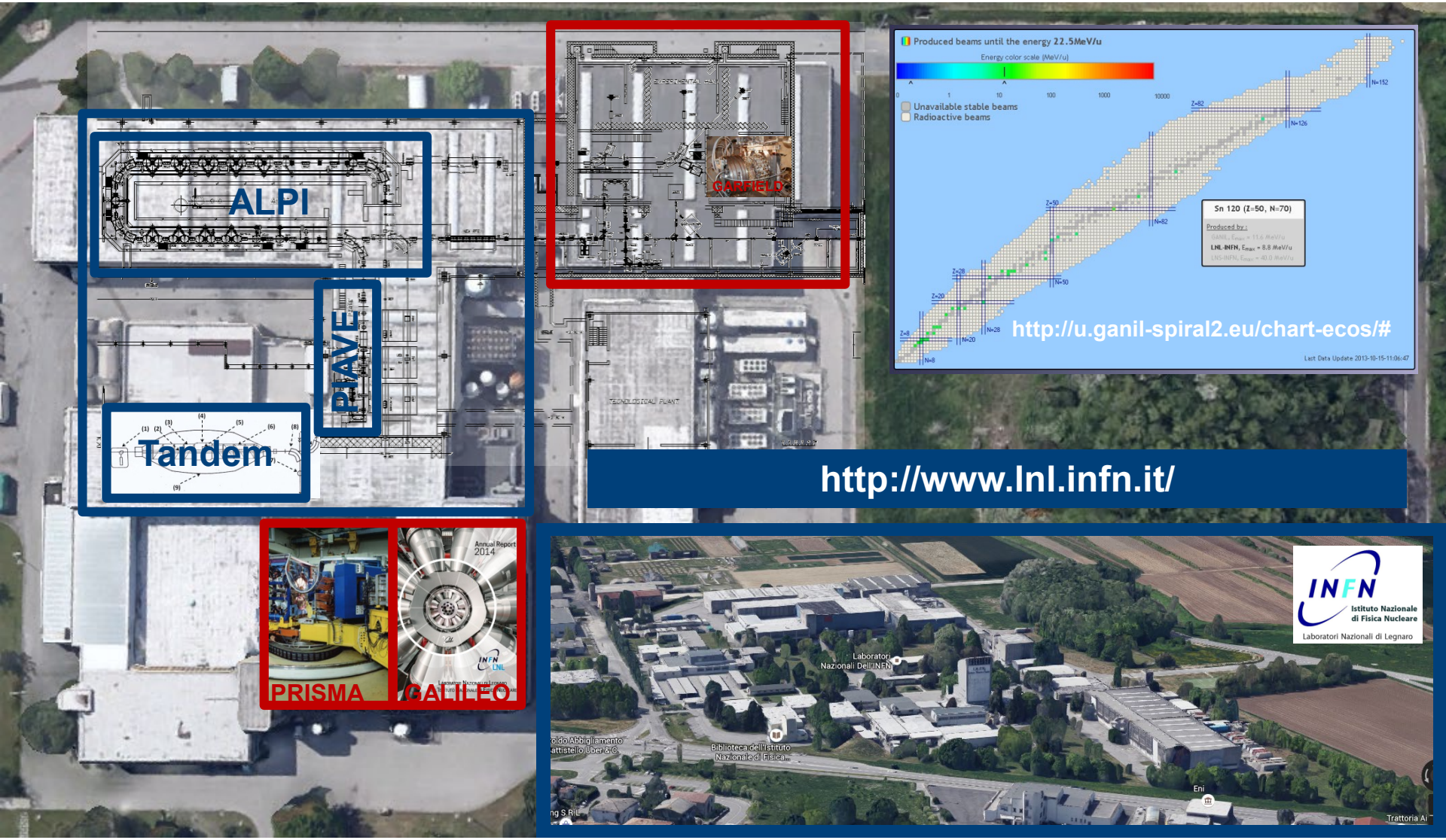
Review about Active Target detectors:

S. Beceiro-Novo, T.Ahn, D. Bazin, W. Mittig, Prog. in Part. & Nucl. Physics (2015) 124- 165,

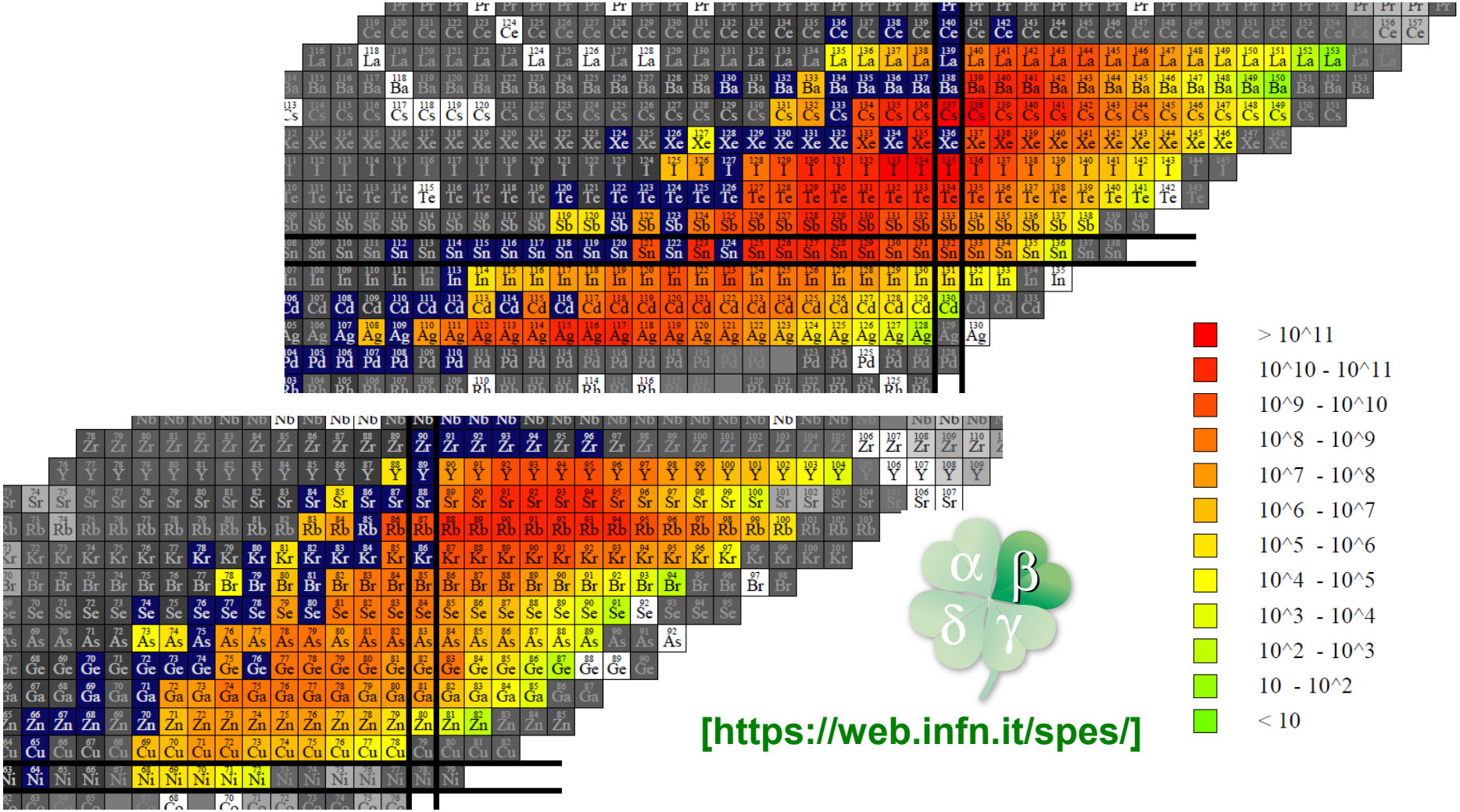
Outline

- An Active Target for SPES, exploiting the ACTAR TPC Demonstrator
- ACTAR-test campaign at LNS (December 2018 - February 2019)
- Next steps with the ACTAR Demonstrator

An Active Target for SPES-β



SPES beams



[https://web.infn.it/spes/]

Two letters of intent for SPES endorsed by the SAC:
B. Fernandez Dominguez et al, Direct Reactions with exotic nuclei in the r-process using an active target
R. Raabe, T. Marchi et al, Shell Structure in the vicinity of ^{132}Sn with an active target

$f_{7/2}$ vs $p_{3/2}$ neutron orbitals, in Sn like in Ca?

MagicTin*

Expected beam intensities @ 10 AMeV		
	SPES 1st day (5 μA p beam)	SPES full power (200 μA p beam)
^{132}Sn	7.8 10^5	3.1 10^7
^{133}Sn	7.0 10^4	2.8 10^6
^{134}Sn	1.2 10^4	4.9 10^5
^{135}Sn	1.6 10^2	6.2 10^3
^{136}Sn	-	0.9 10^2

[Adapted from O. Sorlin, M.-G. Porquet, Progr Part. Nucl Phys 61 (2008) 602]

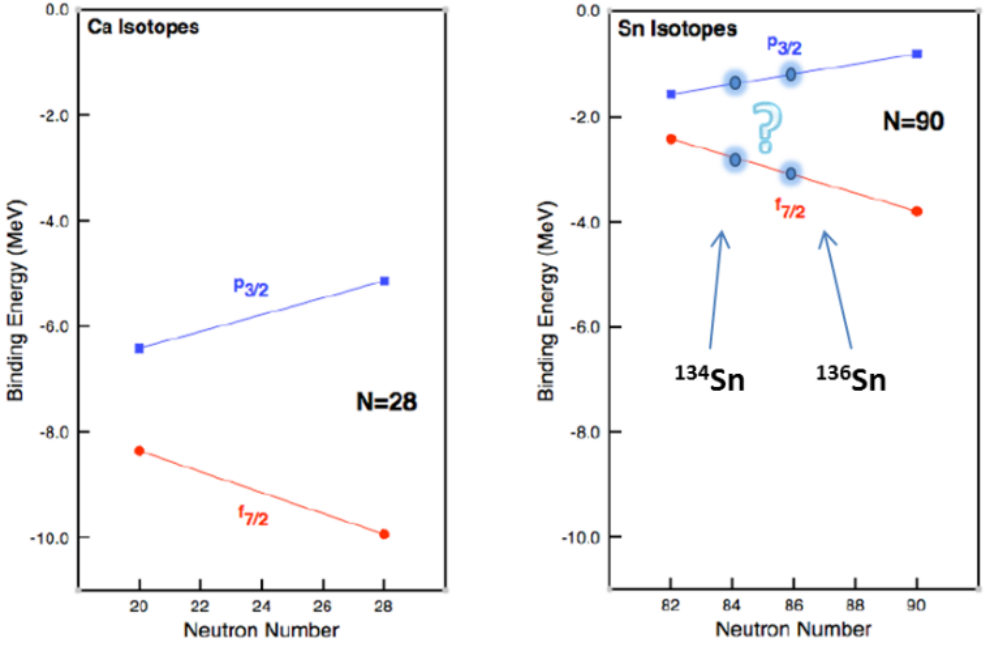


Fig.1 Analogy between f7/2 and p3/2 evolution of binding energies in the known Ca isotopes to what could be expected for the Sn isotopes approaching N=90. Figure adapted from[13].

LoI endorsed by SPES SAC

Beyond ^{132}Sn

Expected beam intensities @ 10 AMeV		
	SPES 1st day (5 μA p beam)	SPES full power (200 μA p beam)
^{132}Sn	7.8 10^5	3.1 10^7
^{133}Sn	7.0 10^4	2.8 10^6
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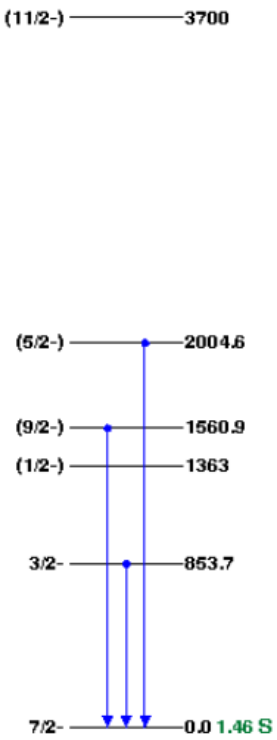
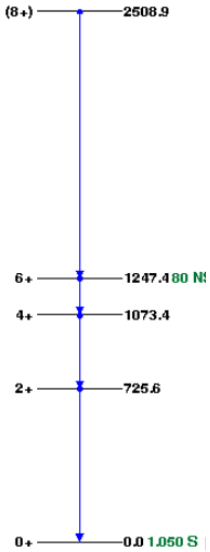


^{133}Sn

d(^{132}Sn,^{133}Sn)p
Q = 177 keV

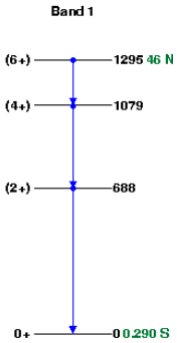


^{134}Sn

d(^{133}Sn,^{134}Sn)p
Q_{gs} = 1.4 MeV

^{135}Sn

d(^{134}Sn,^{135}Sn)p
Q = 47 keV

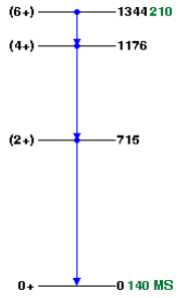


^{136}Sn

d(^{135}Sn,^{136}Sn)p
Q = 1.1 MeV

^{137}Sn

d(^{136}Sn,^{137}Sn)p
Q = -264 keV



^{138}Sn

d(^{137}Sn,^{138}Sn)p
Q = 0.9 MeV

[ENSDF 2016]

The ACTAR TPC Demonstrator

Active Volume: **6,4 x 12,8 x 17,0 cm^3**

Total Gas Volume: **about 10 l**

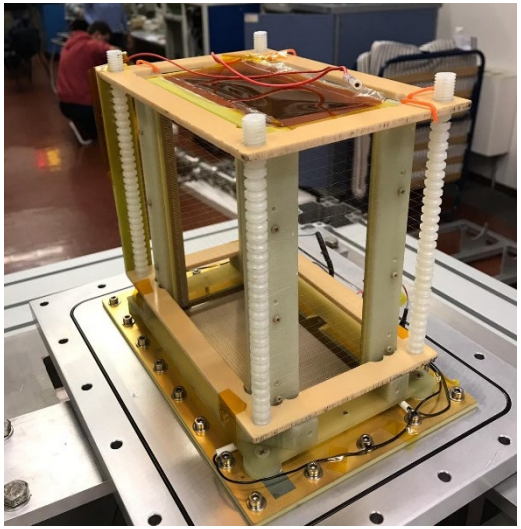
Operating pressure: **0-2 bar**

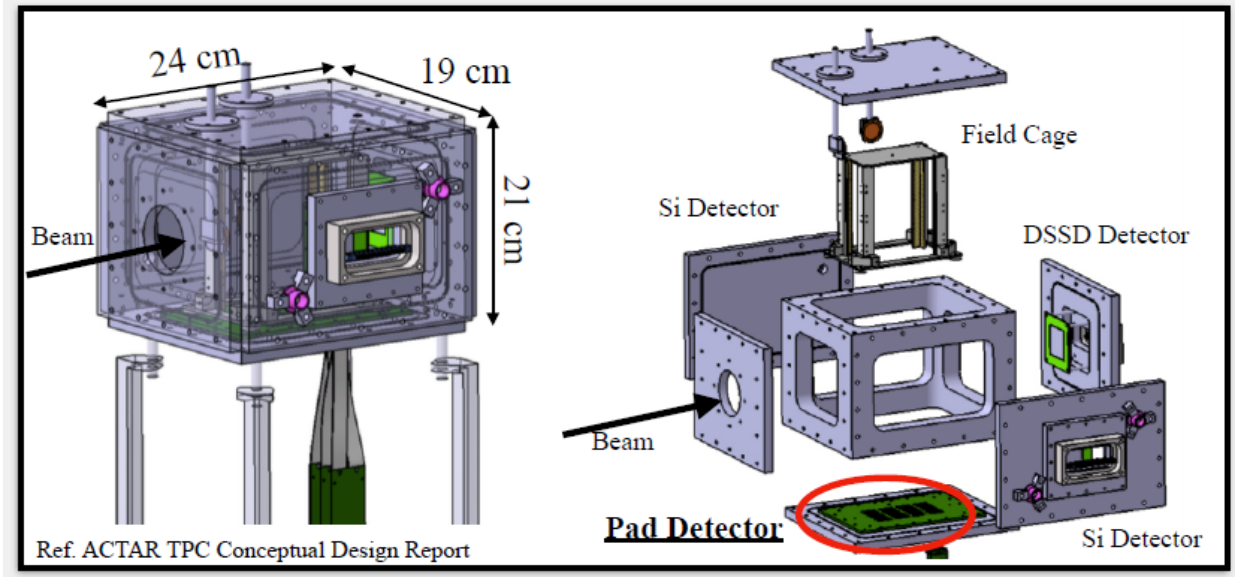
Maximum Cathode Voltage: **3kV**

MPGA: micromegas **(220 μm gap)**

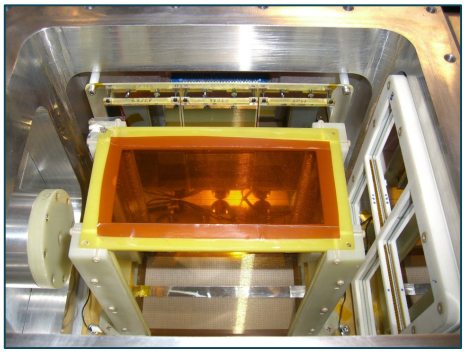
Charge collection: **2048 pads - 2x2 mm^2**

Beam interface: **6μm MYLAR window**





ACTAR TPC Demonstrator at IPNO 2015



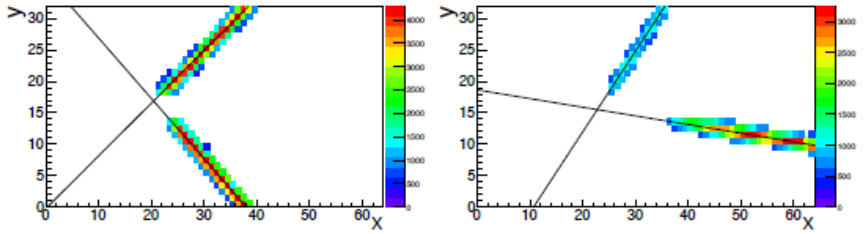
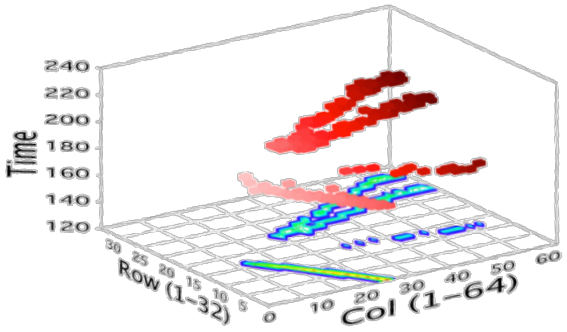
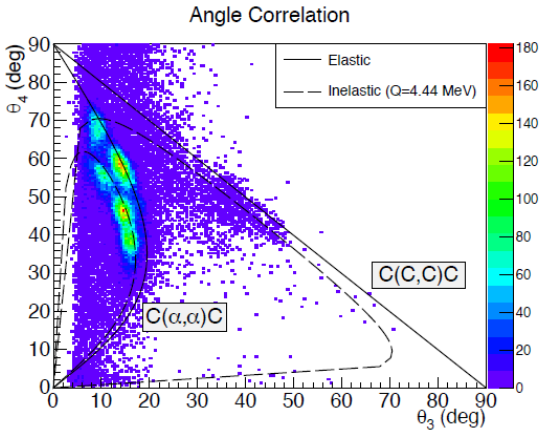
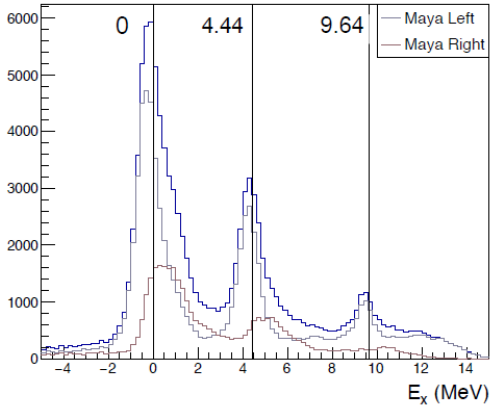


Figure 4.19: *Charge deposition on the pad plane of (a) a $^{12}C(^{12}C,^{12}C)^{12}C$ and (b) a $^{12}C(\alpha,\alpha)^{12}C$ scattering reaction.*



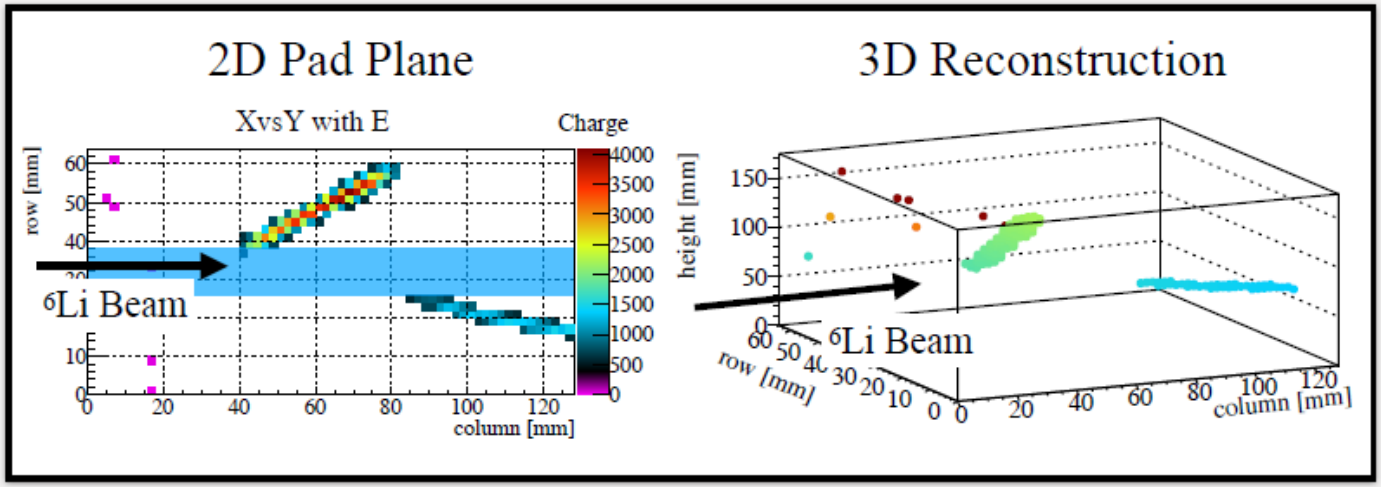


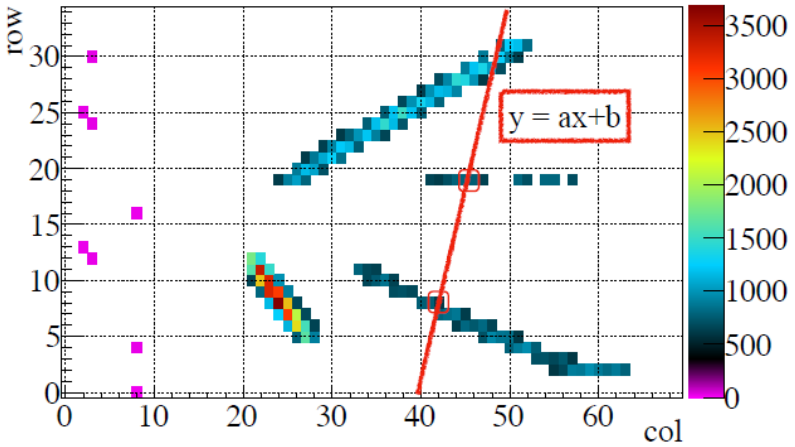


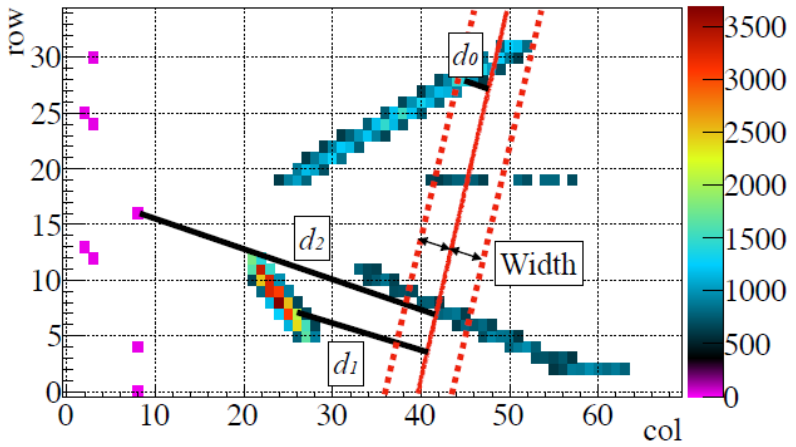
^{12}C @80 MeV on He:C_4H_{10} (90:10)
^{6}Li @11-20 MeV on He:CO_2 (90:10)

Main issues:
Non homogeneus electric field
Zero suppression thresholds
Gas composition

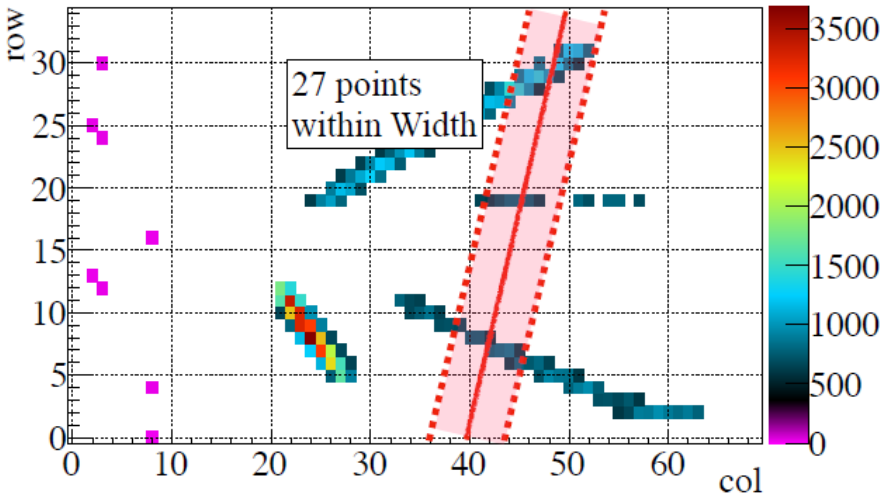
PID and Tracking







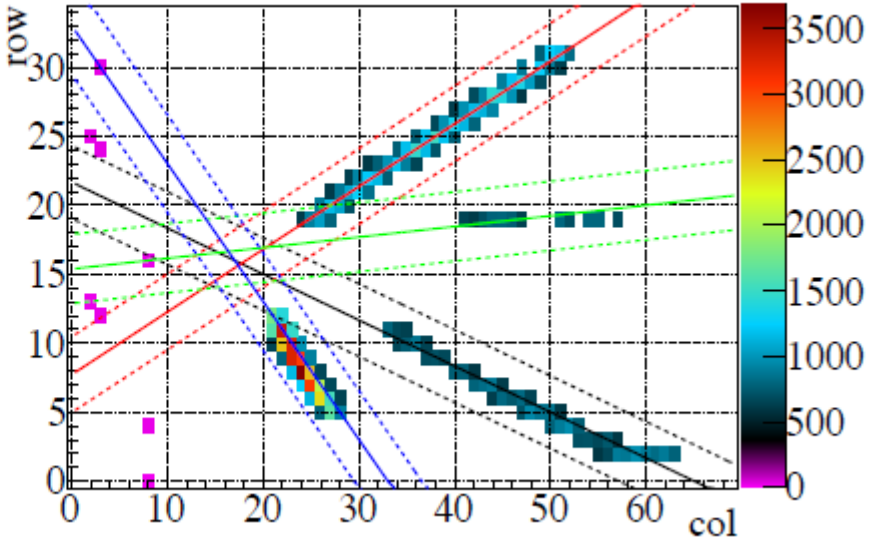
PID and Tracking



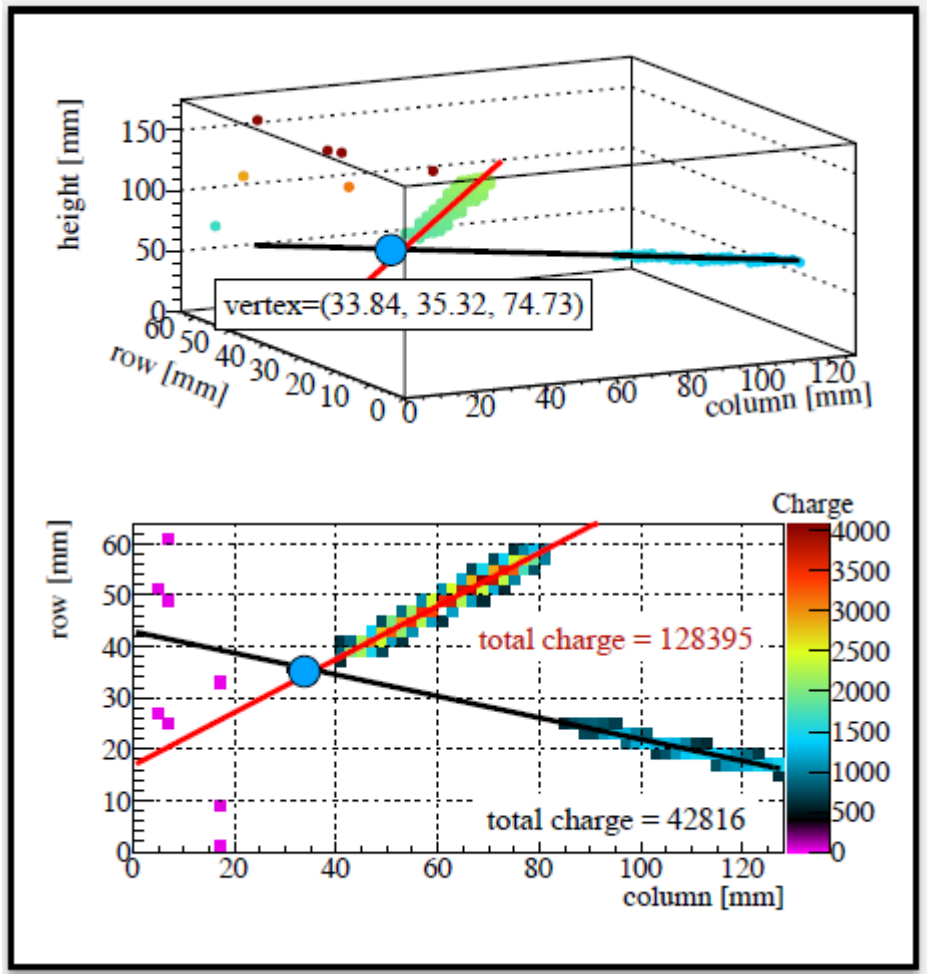
$$\text{Mean} = \frac{\sum d_i}{\text{number of elements}}$$

Minimize «Mean» to obatin the track «clusters», then fit linear trajectories

Run #205, event #5	
Max Loop	7500
Length	10
Width	2.5



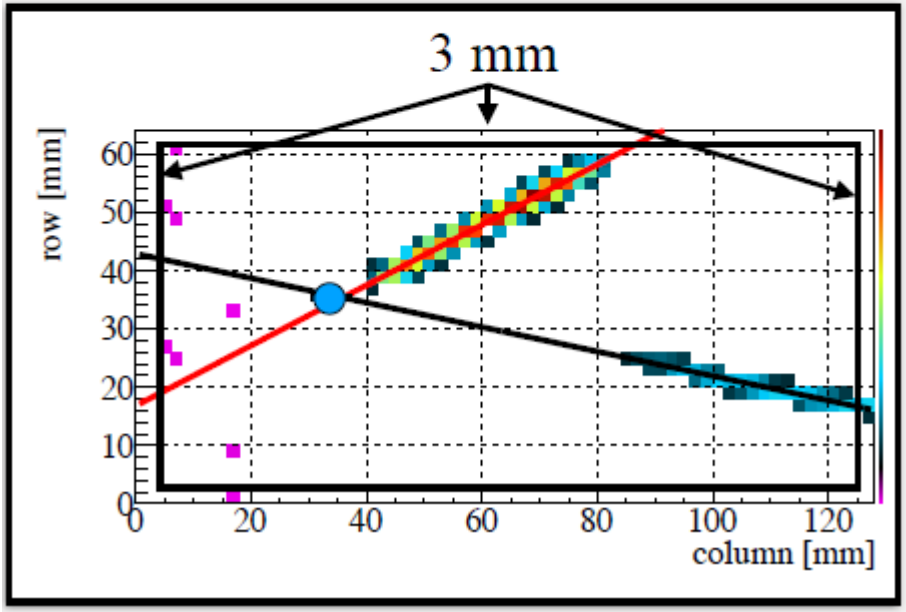
PID and Tracking

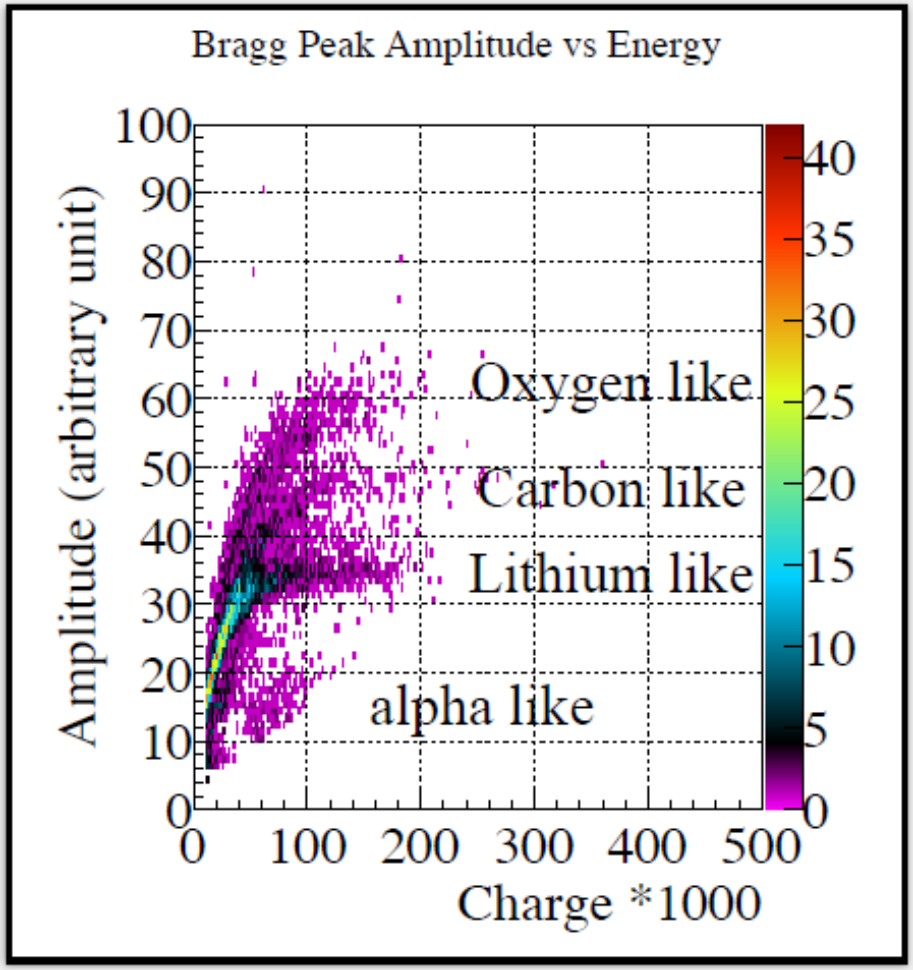


	Number of Event	Ratio (Track/Total Event)
1 Track	10580	16.9%
2 Tracks	39461	63.1%
3 Tracks	9487	15.2%
4 Tracks	478	0.8%

PID and Tracking

Event Selection		
Cut 1	Event has 2 tracks	Track Fitting
Cut 2	Vertex position is in beam region	Vertex Fitting
Cut 3	A particle stops inside the gas volume	Pad Information





Next steps

1. **The ‘new’ setup at LNL**
2. **Validation of the experimental techniques**
3. **Charachterization of the response to heavy ions**

The GAS system

Design constraints:

1- Hazards: explosive, flammable, toxic, polluting gases

2- Pressure gauge calibration can be gas dependent

3- Exhaust management

4- Easy to operate and to move

5- Remotely controllable (plus pressure value storing in the data stream)

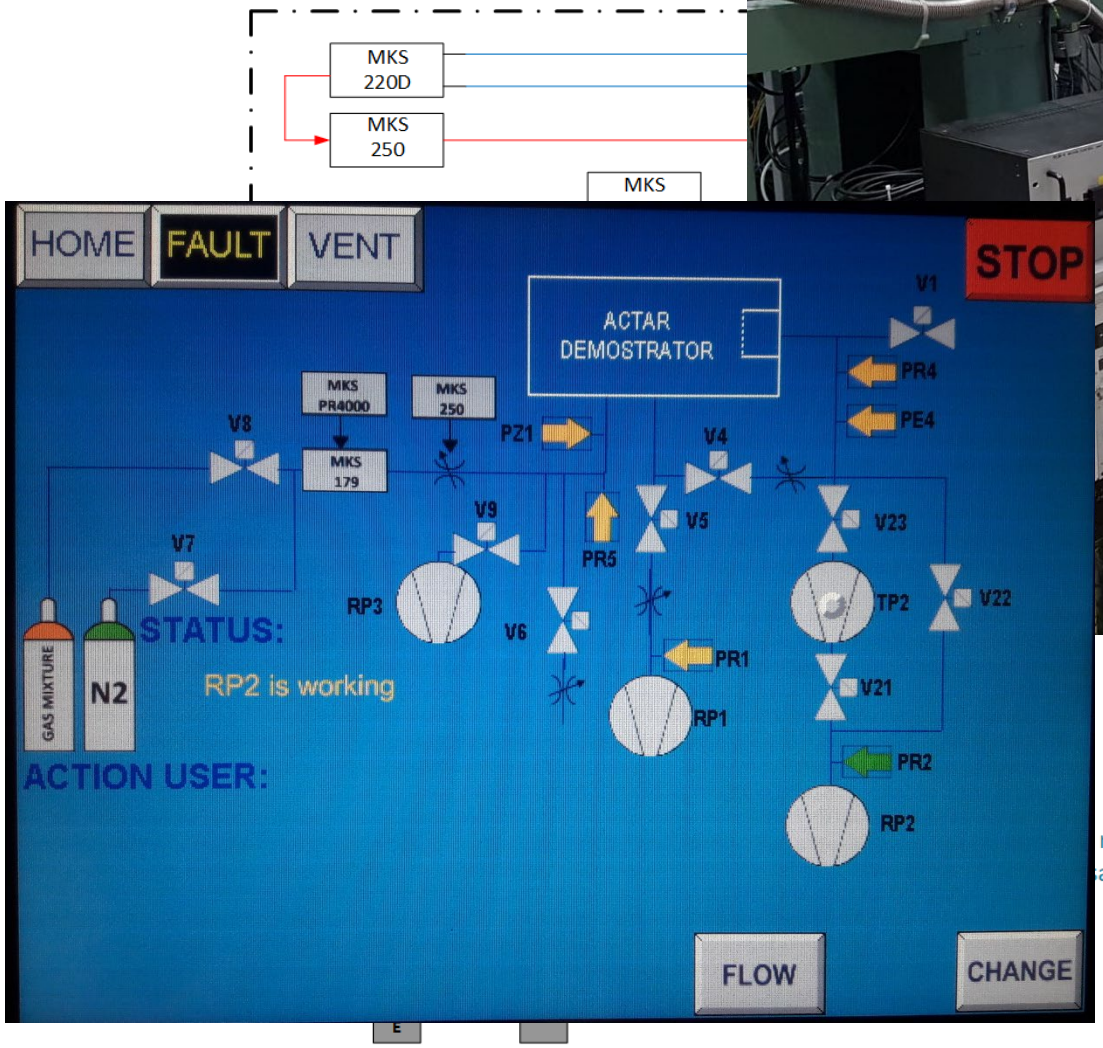
6- Stable and fast in pressure control

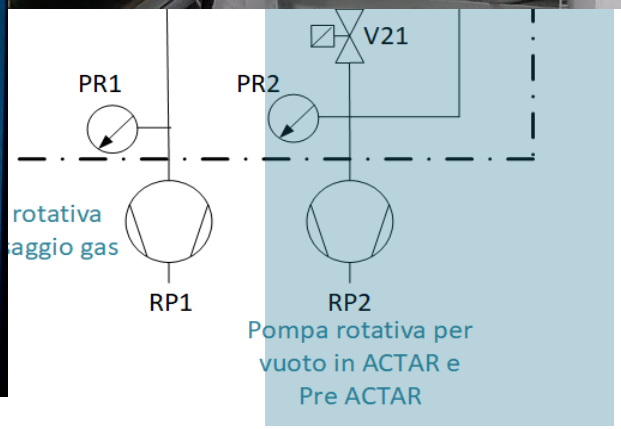
7- Ensure window safety

8- MIXING is not always simple, rather buy pre-mixed bottles

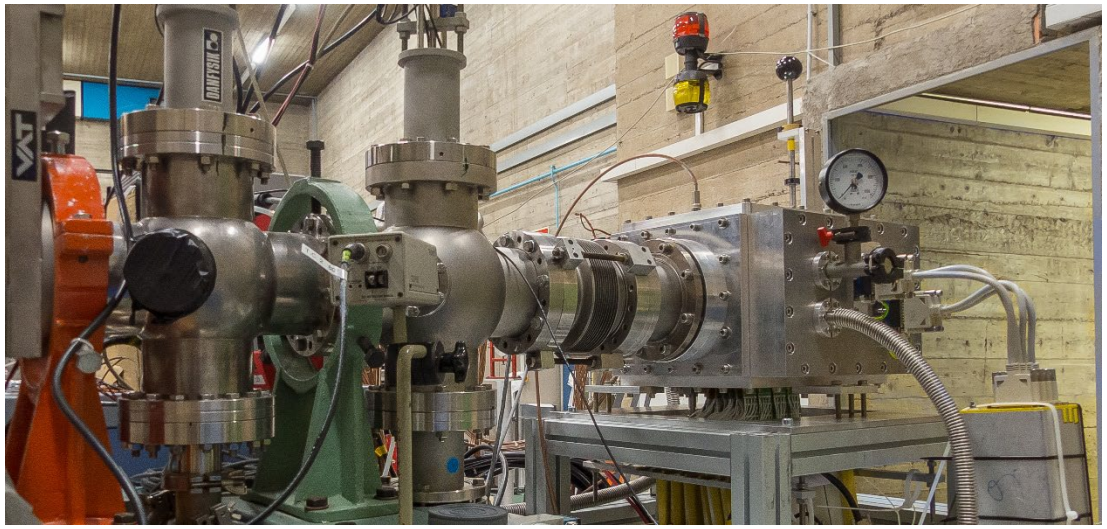
CERTIFICATION according to local regulation

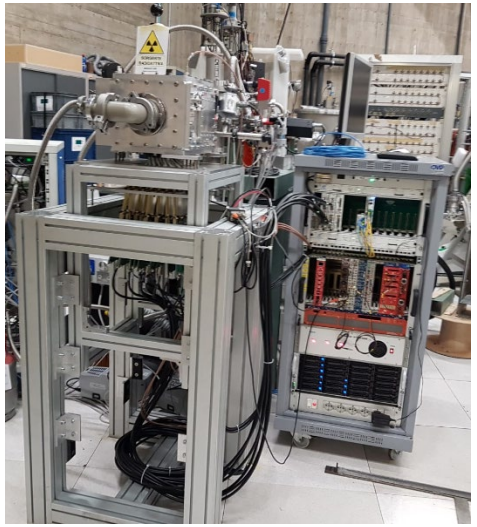
The GAS system



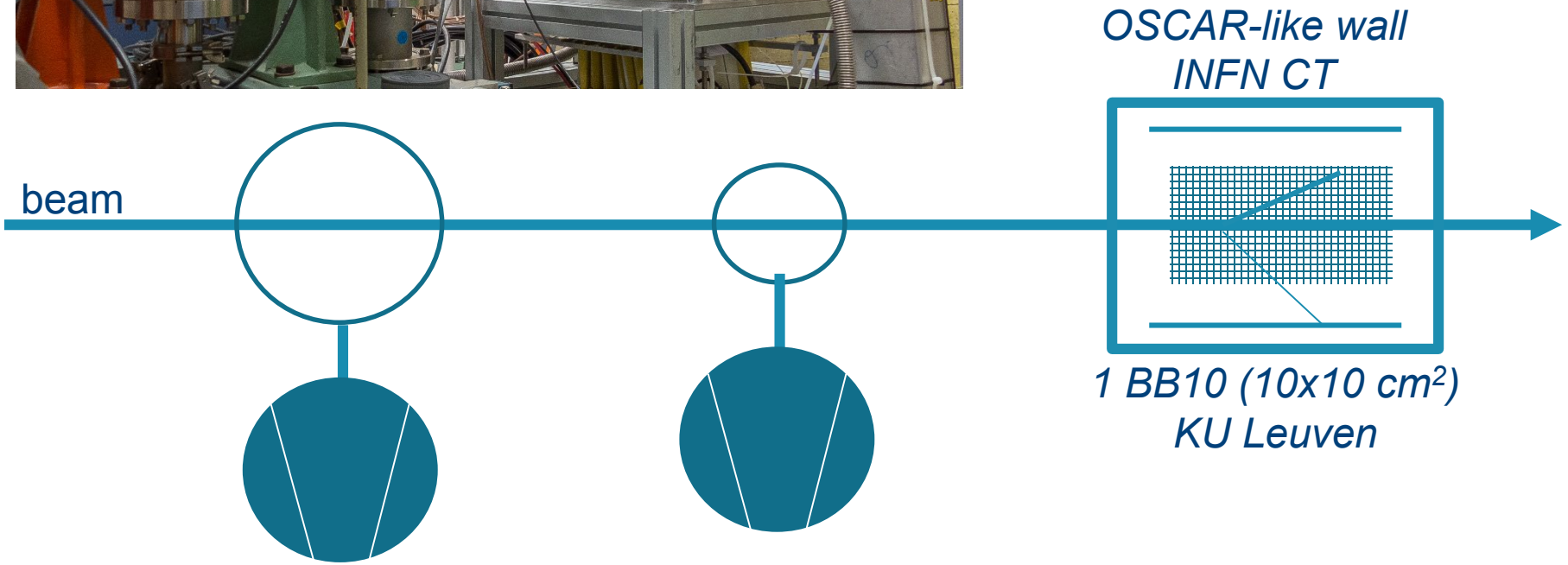


ACTARtest at LNS - setup





Using GET electronics

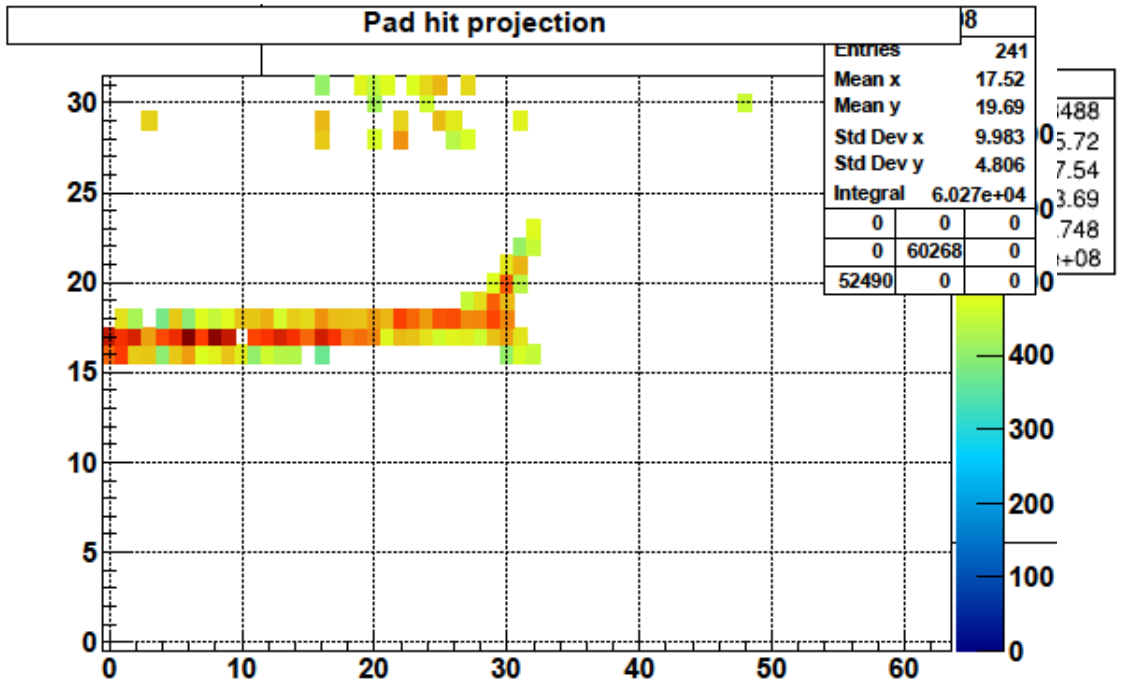


OSCAR: D. Dell'Aquila et al NIM A877 (2018) 227-237

ACTARtest at LNS – energy loss

beam	energy
p	3 MeV
^{6}Li ^{7}Li	7 – 9 MeV
^{10}B ^{11}B	30 - 33 MeV
^{12}C	36 MeV
^{14}N	42 MeV
^{16}O	45 MeV
^{27}Al	75 MeV
^{50}Ti	142 MeV
^{107}Ag	169 MeV

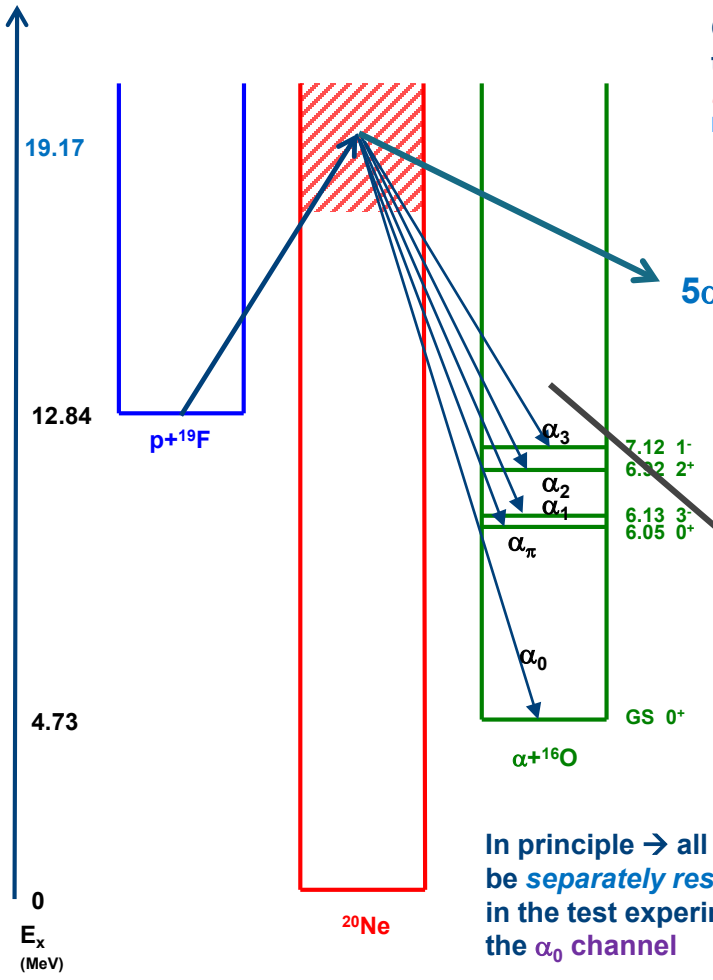
On different gases: CF4, iC4H10, CH4, P10, He:CO2



- 6 μm mylar window + dead layer
- ✓ Pressure tuned for full stopping
- ✓ External triggering using mesh signals
- ✓ Very low count rate to avoid pileup
- ✓ Multiple charge states measured for some cases (but still there is the window)

Actar test at Ins – reactions

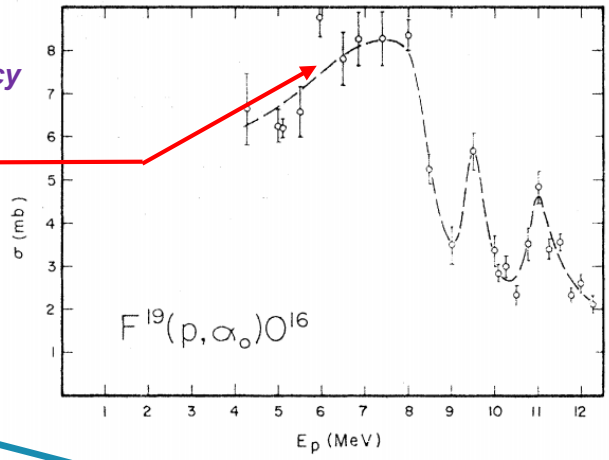
Test case 1: $^{19}F(p,a)$ reaction at E_p=5-7 MeV (TANDEM)



5α!

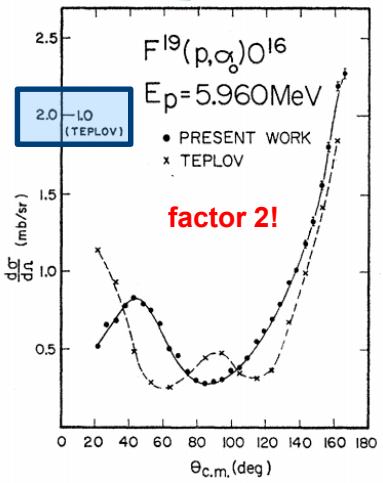
Opportunity to measure with *good accuracy* the angle-integrated *cross section* → large *uncertainties* at E_p=5-7 MeV (Warsh et al, Phys. Rev. 131 (1963) 1690)

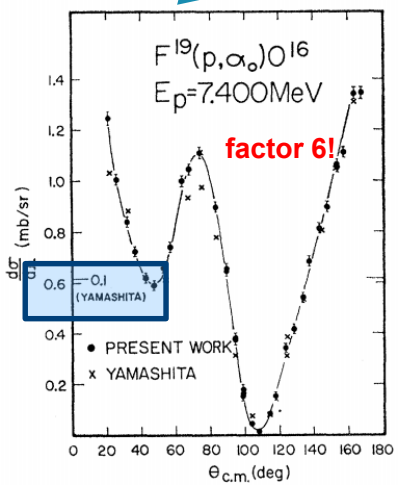
Ambiguities in *shapes* and in the absolute *x-section scale* of angular distributions (Warsh et al, Phys. Rev. 131 (1963) 1690)



α feeding:
Opportunity of studying *multi-track events* with *low background* and no ambiguities

In principle → all the α_i channels can be *separately resolved* (to be verified in the test experiment) → surely for the α_0 channel





Actar test at Ins – reactions

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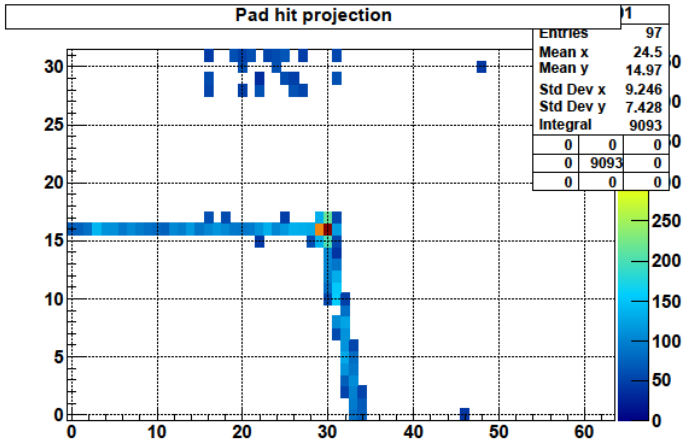
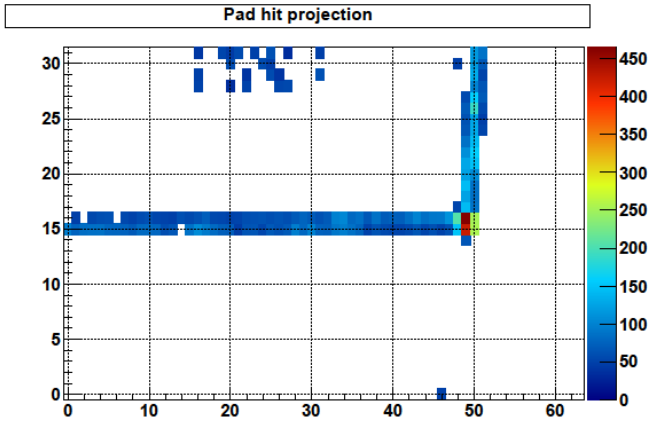
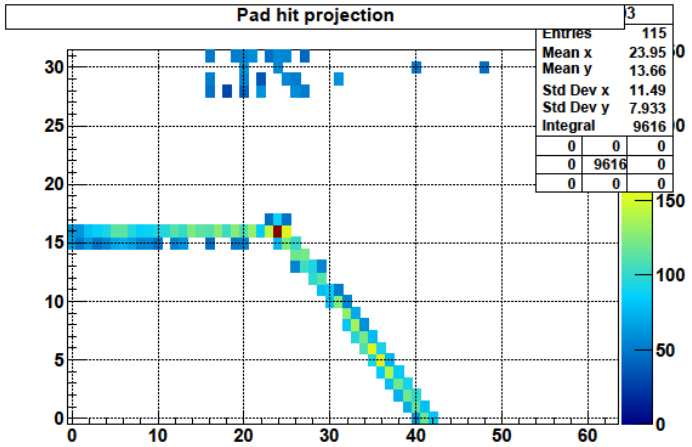
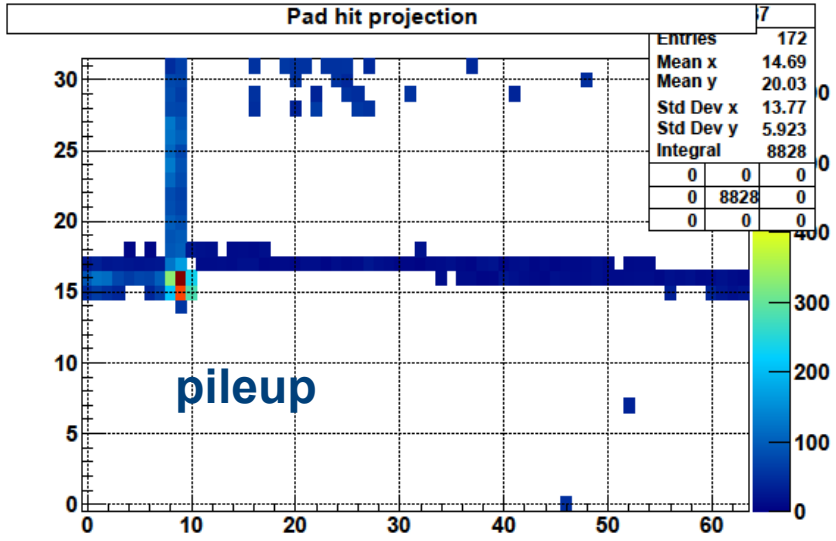
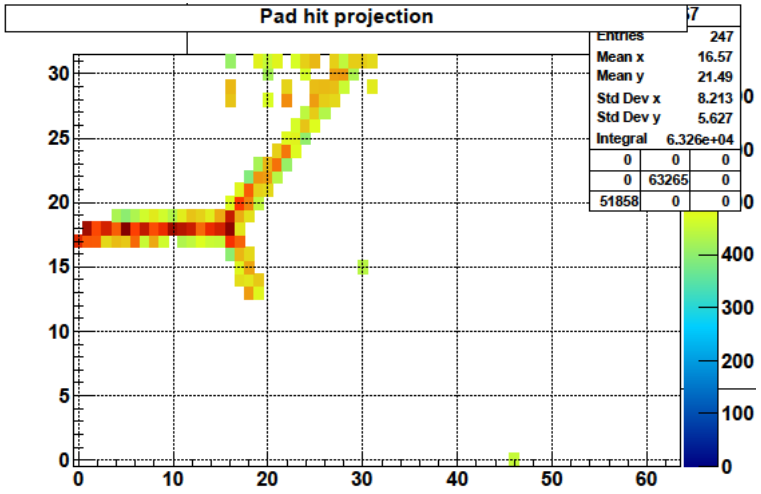


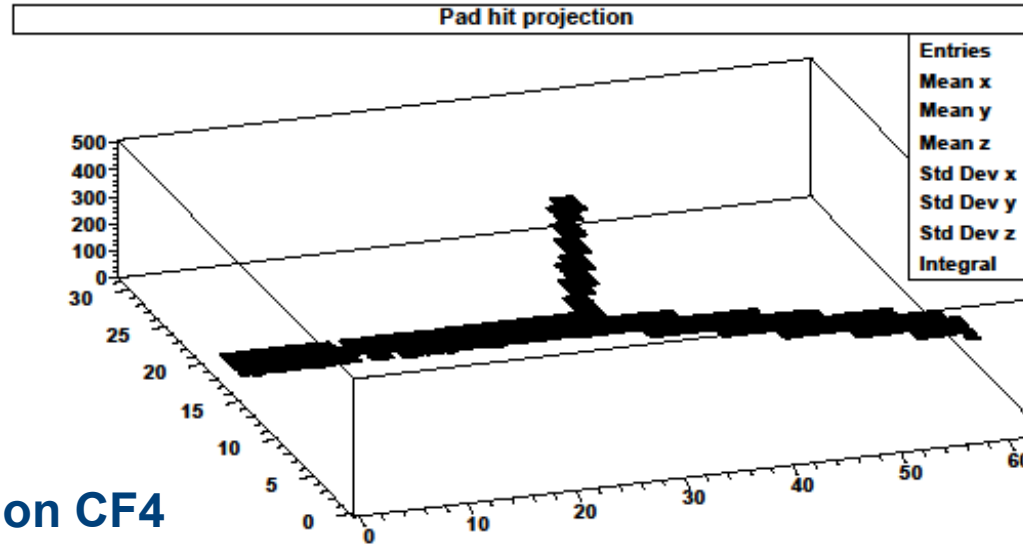




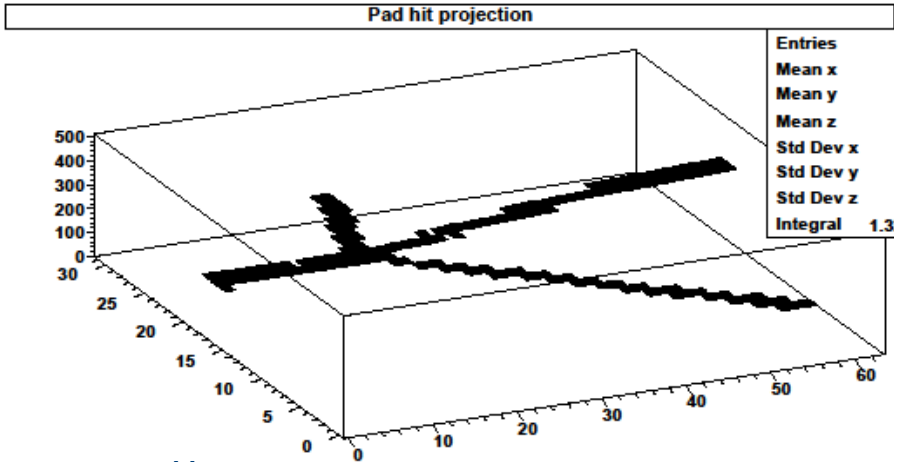


Actar test at Ins – reactions

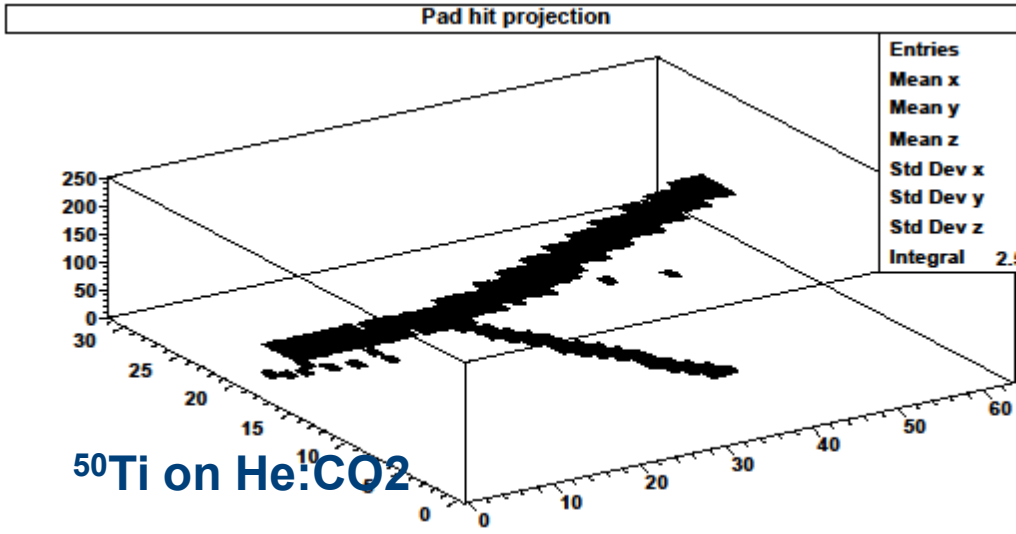




^{7}Li on CF4



^{11}B on iC4H10



^{50}Ti on He:CO2

NOTES for experiment's preparation

Projectile & Target

Energy of interest

Cross section/
Target Thickness

GAS

GAS
PRESSURE

Electric
fields

GAIN

Ejectile's
energy loss

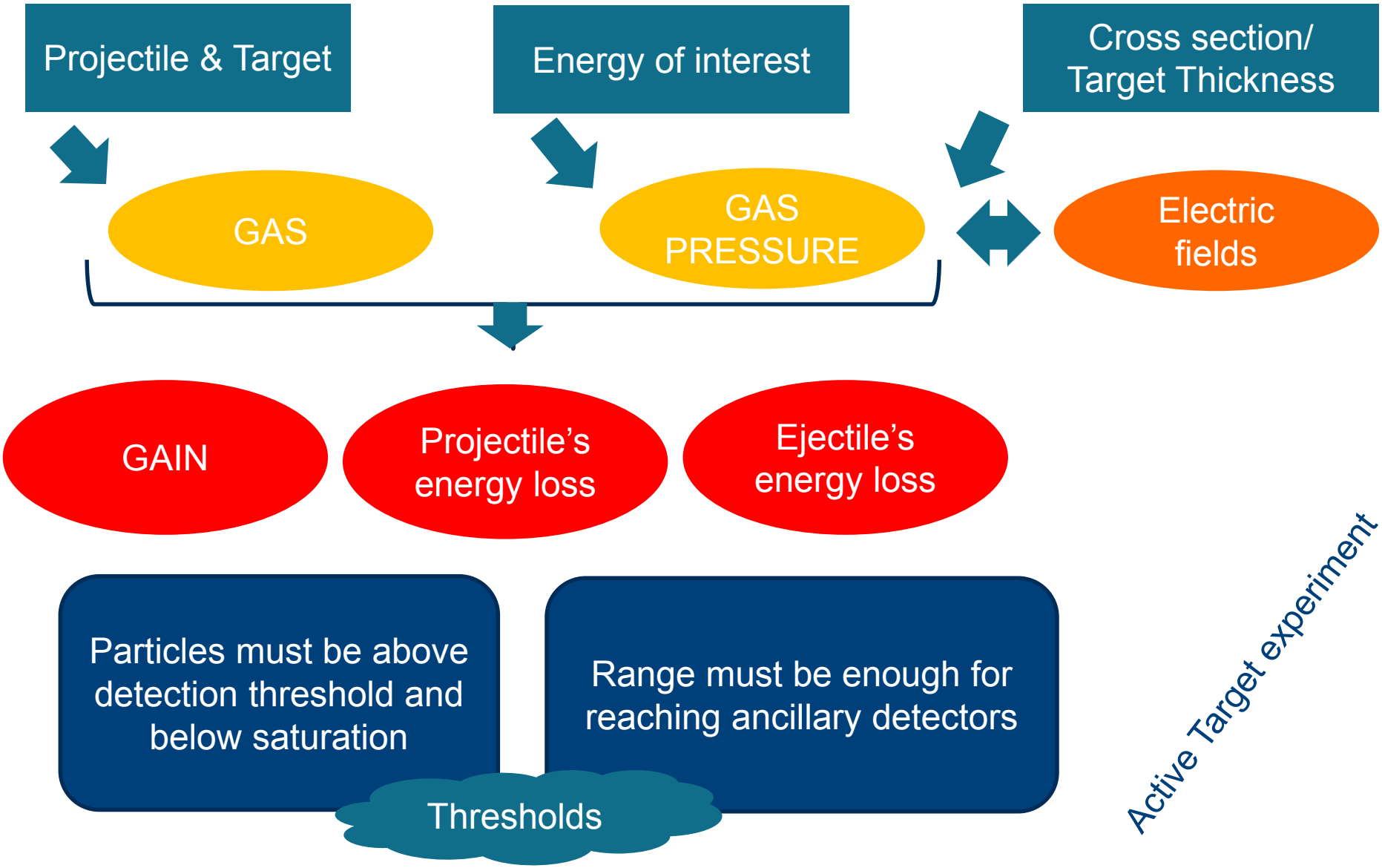
Particles must be above detection threshold and below saturation

Range must be enough for reaching ancillary detectors

Thresholds

Standard experiment

NOTES for experiment's preparation



Summary and outlook

- ACTAR TPC Demonstrator is being exploited for further R&D and for experiments with stable beams
- ACTAR-test campaign at LNS in progress (December 2018 - February 2019): energy loss measurements + direct reactions

- 3 approved experiments at LNS for 2019 (caveat: using pure D_2)
- A path is defined towards an Active Target at SPES

Takeaway message:
a wide spectrum of opportunities, but not everything is feasible

ACTAR TPC and NUCLEX collaborations

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