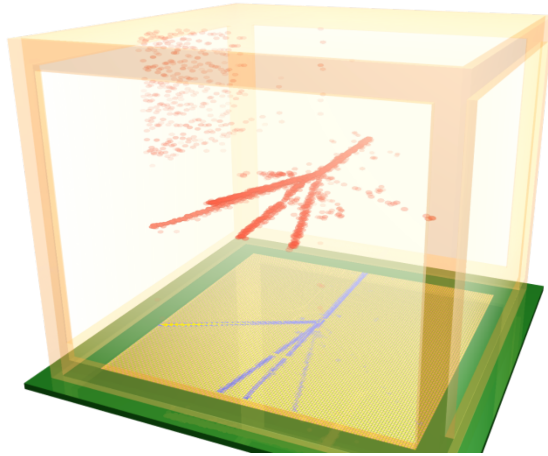
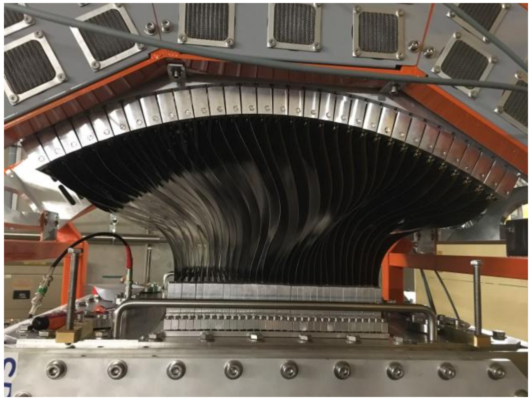
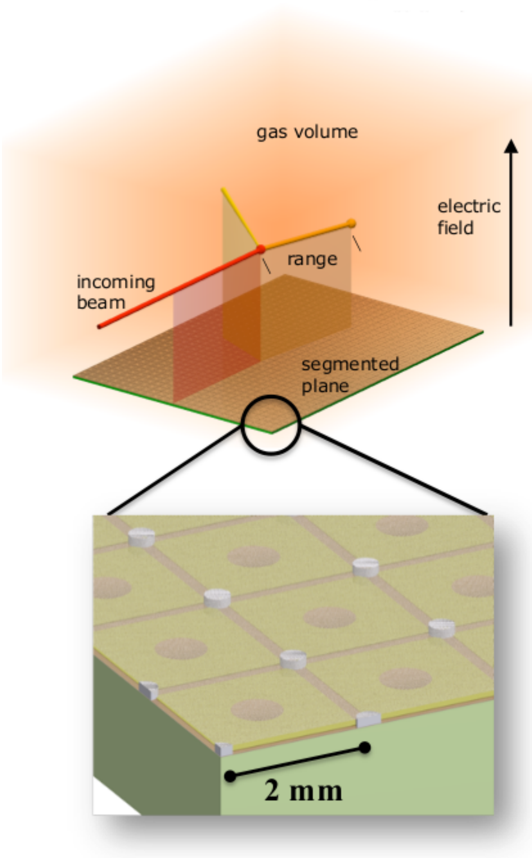
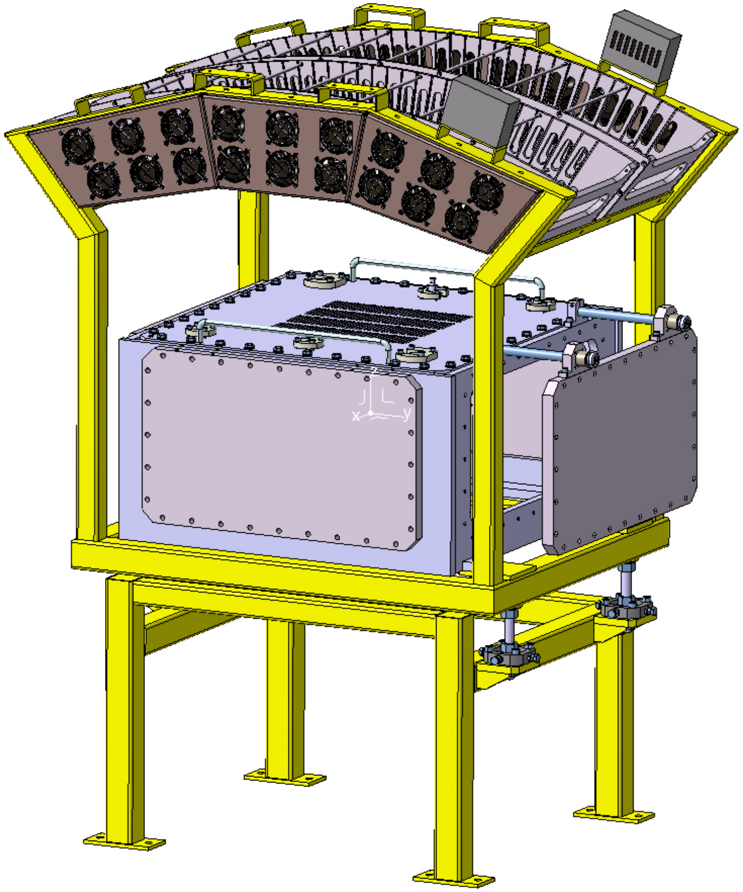
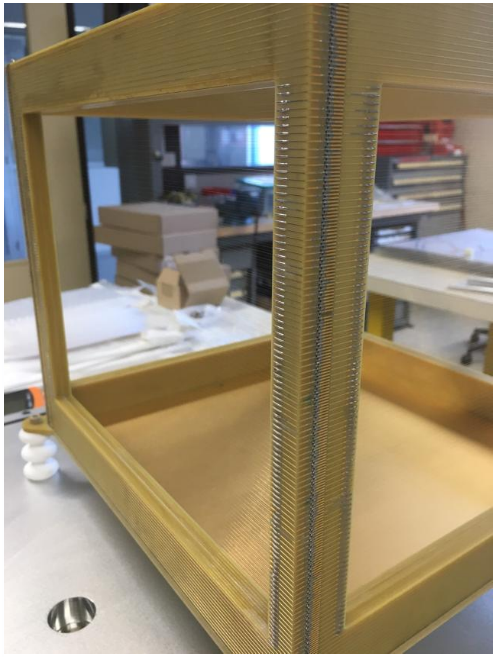
ACTAR TPC






gas volume
electric
field
range
incoming
beam
segmented
plane
2 mm





Active Target and Time Projection Chamber

✓ Gas-filled active target and time projection chamber

- Gas = detector AND target
- Vertexing = resolution similar to thin solid target
- High effective thickness = up to 10^3 higher

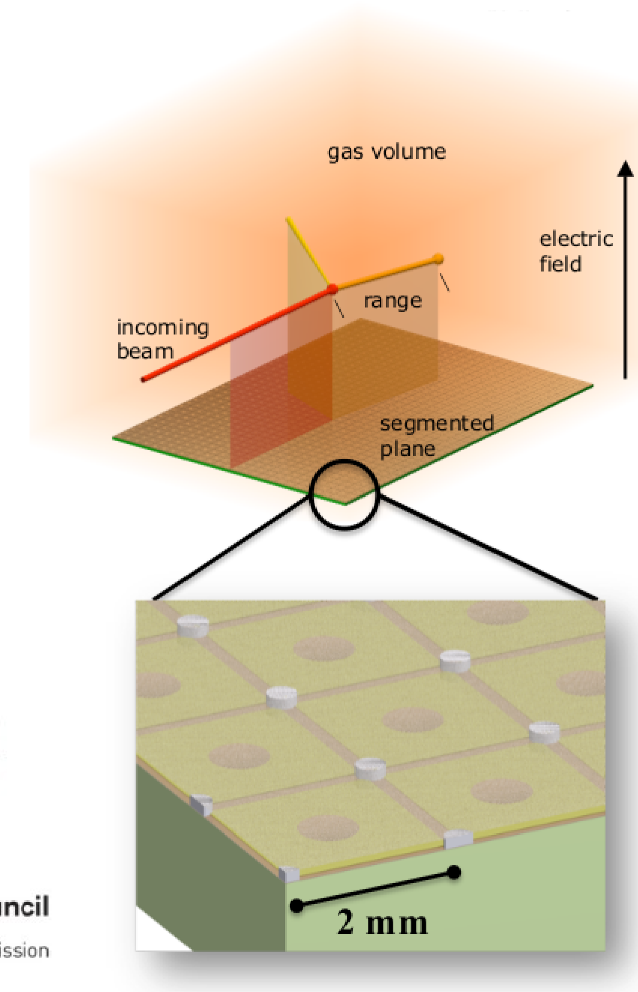
✓ Major advantages over conventional approaches

- Detection efficiency close to 4π
- Detection of low energy recoils (that stop inside the target)
- Event-by-event 3D reconstruction
- Compact, portable and versatile detector

✓ Physics programs

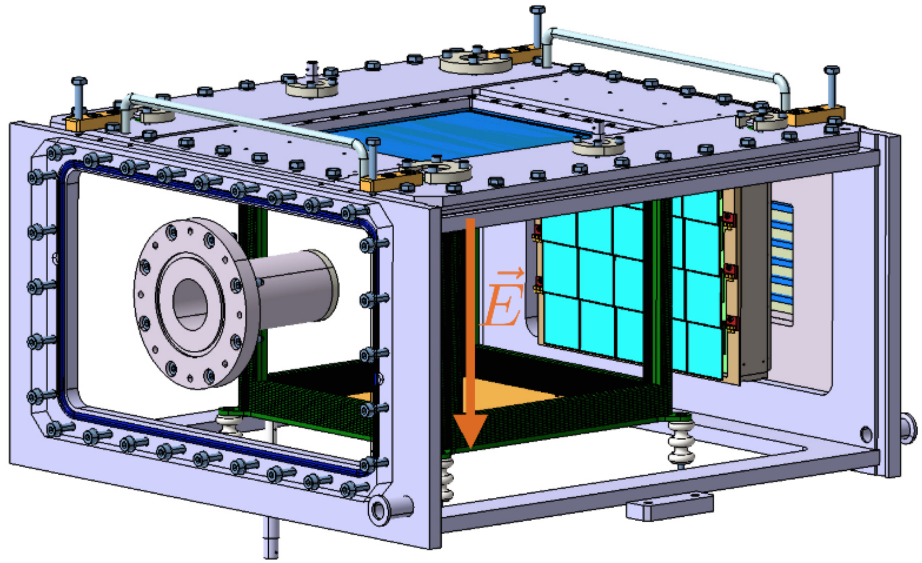
- Resonant scattering
- Inelastic scattering and giant resonances
- Transfer reactions
- Rare and exotic decays (2p, β2p, …)
- Transfer-induced fission, …

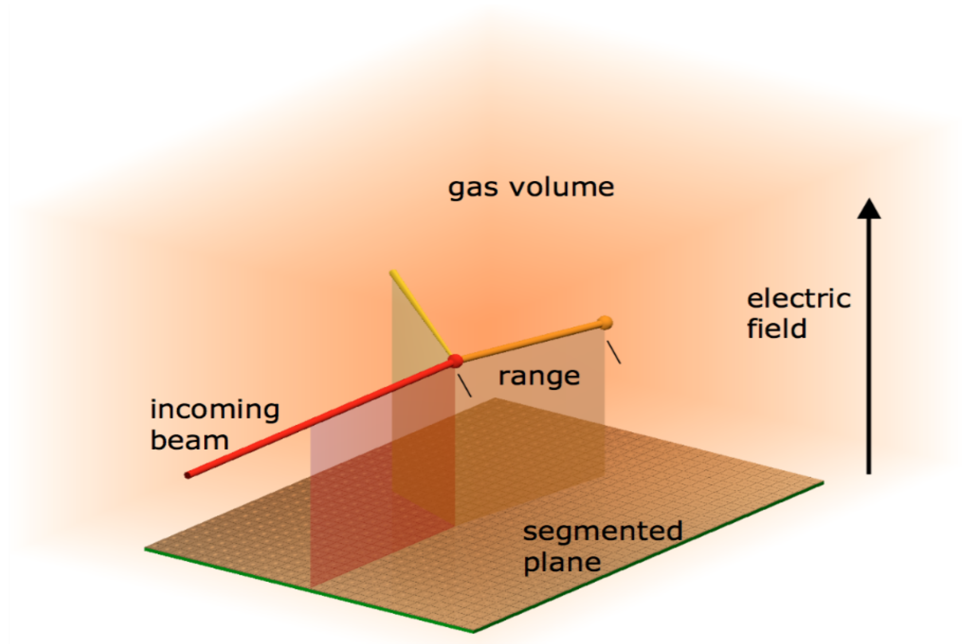
European Research Council
Established by the European Commission

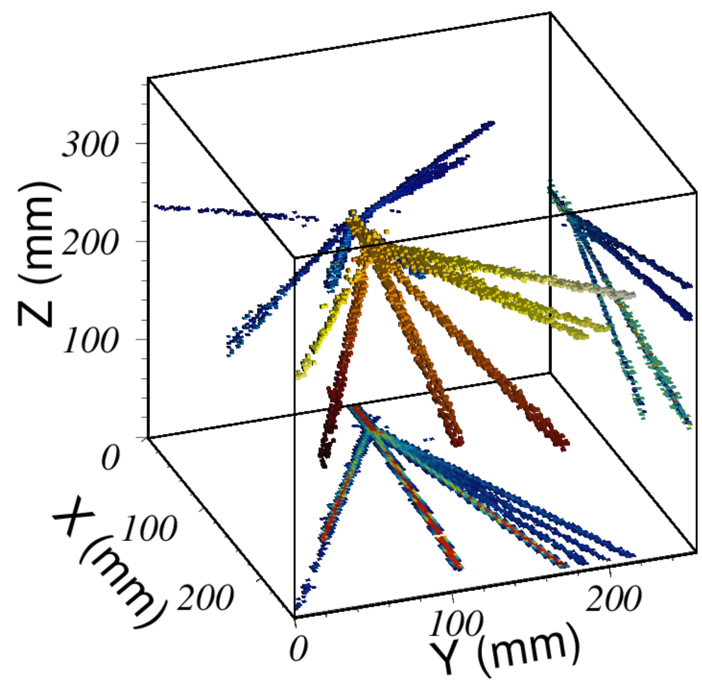


ACTAR TPC : Design

- ✓ Drift region
- ✓ Amplification region
- ✓ Segmented pad plane
- ✓ Electronics
- ✓ Auxiliary detectors







ACTAR TPC : Design

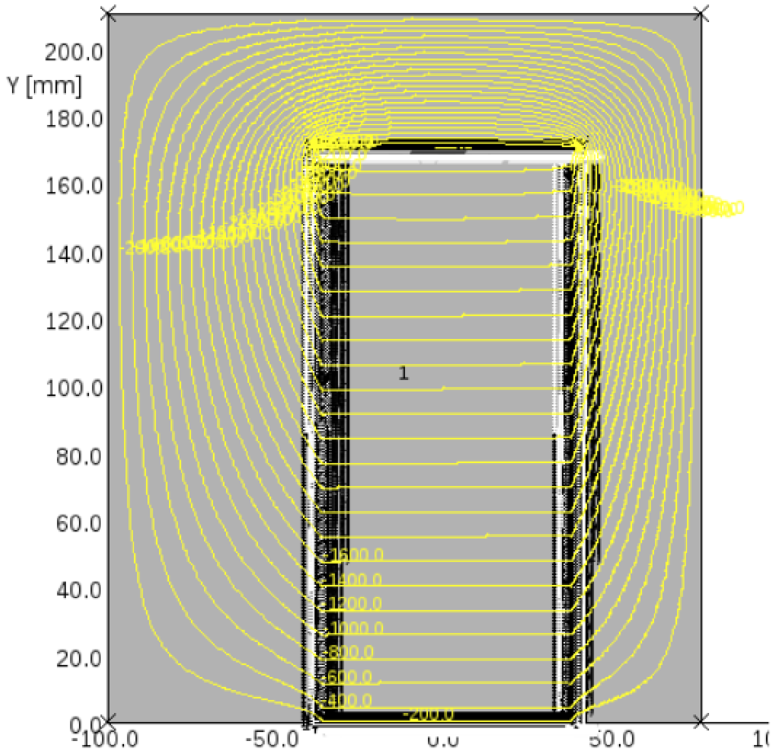
✓ Drift region: principle

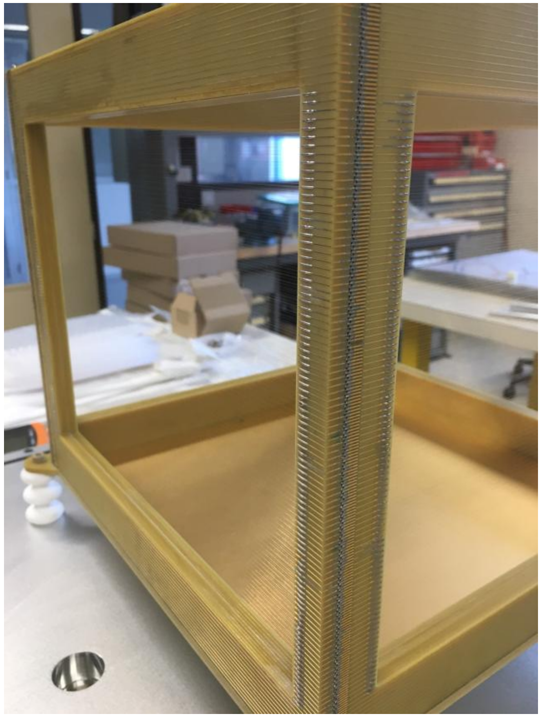
- Particles ionize the gas along their trajectories
- Ionization electrons drift to pad plane under a homogeneous electric field
- Transparent to particles on 4 sides

  → Wire field cage
- Homogeneous vertical drift electric field

  → Double wire field cage: 2 mm pitch (outside), 1 mm pitch (inside)

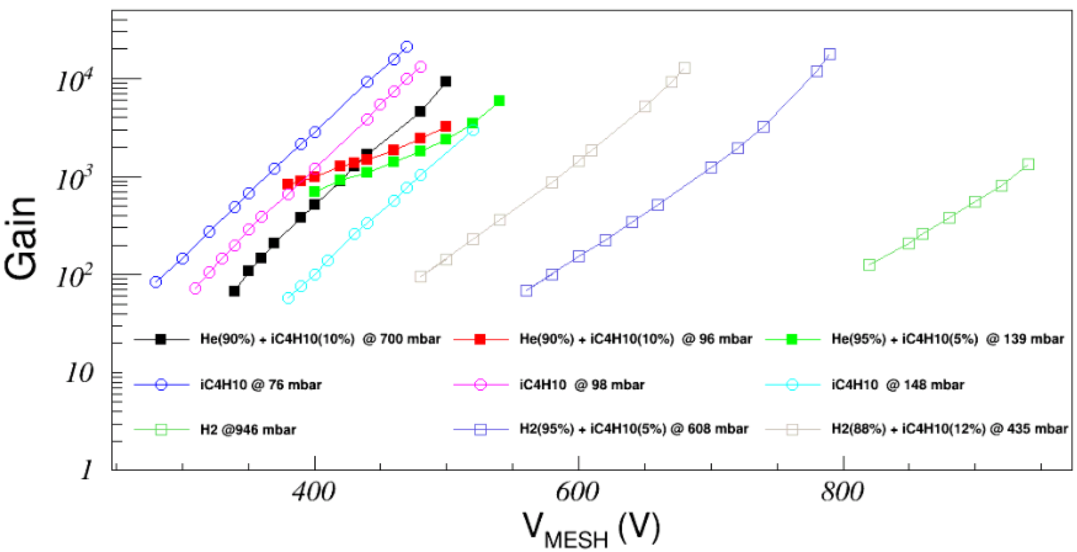
  → Optical transparency = 98 %

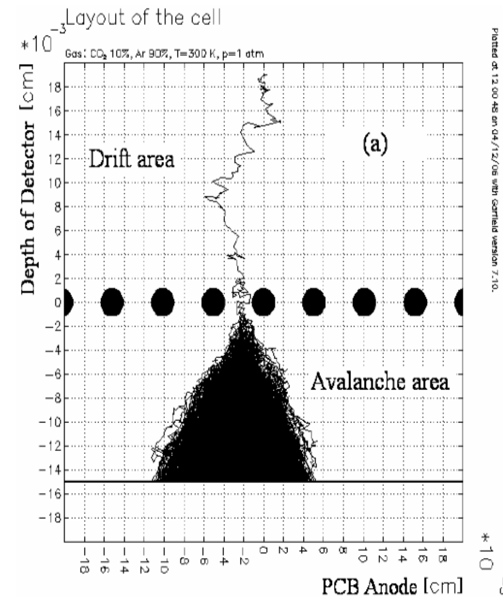


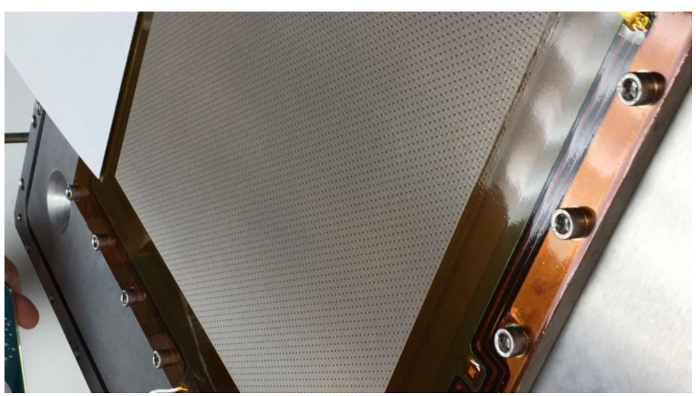


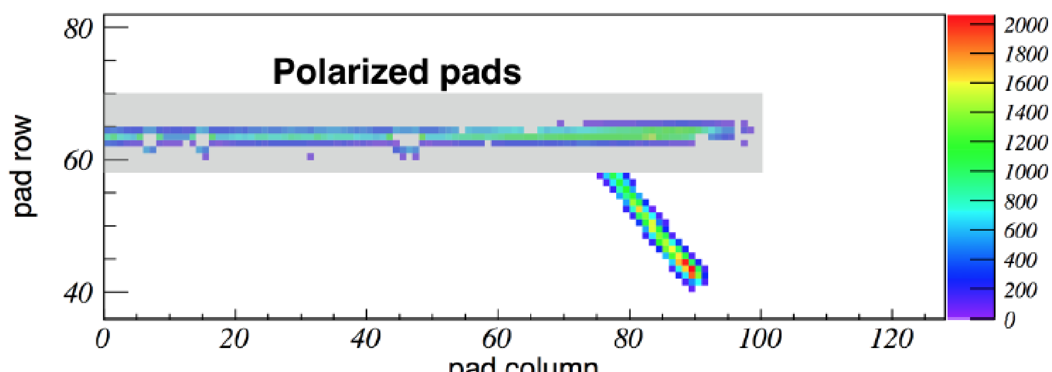
ACTAR TPC : Design

- ✓ Drift region
- ✓ Amplification region: principle
  - Micro Pattern Gaseous Detectors: micromegas, possible upgrade to GEMs
  - Operate at P = 75 mbar – 1 bar: gap = 220 μm
  - Local gain reduction via pad polarization



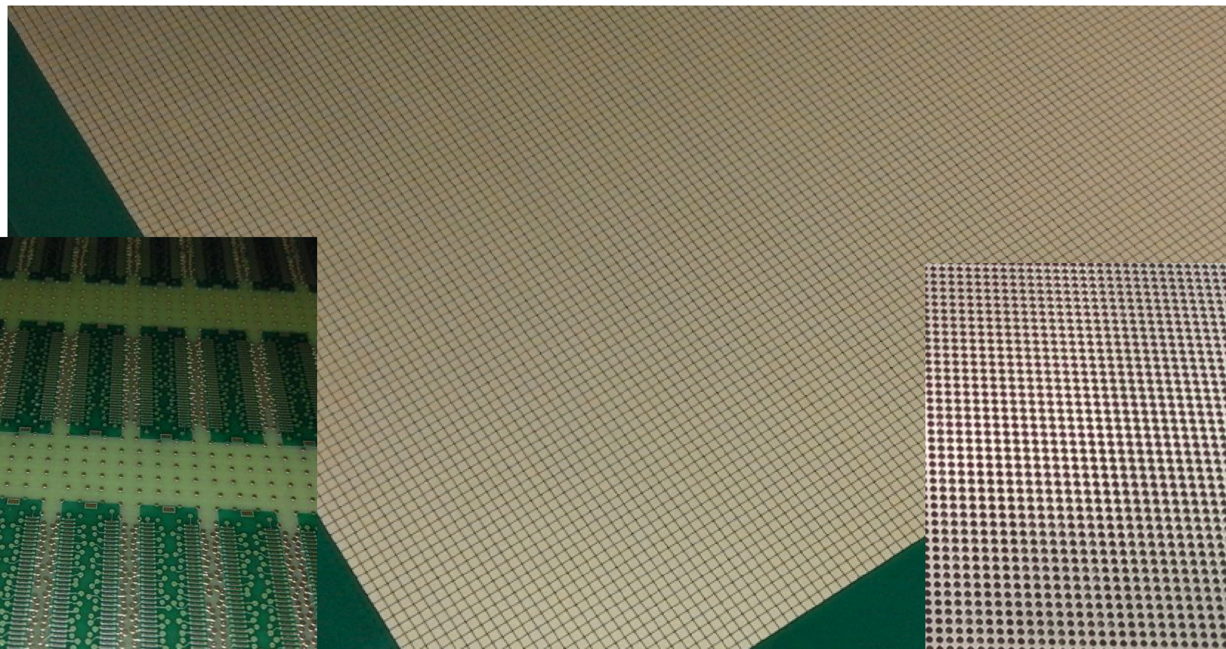


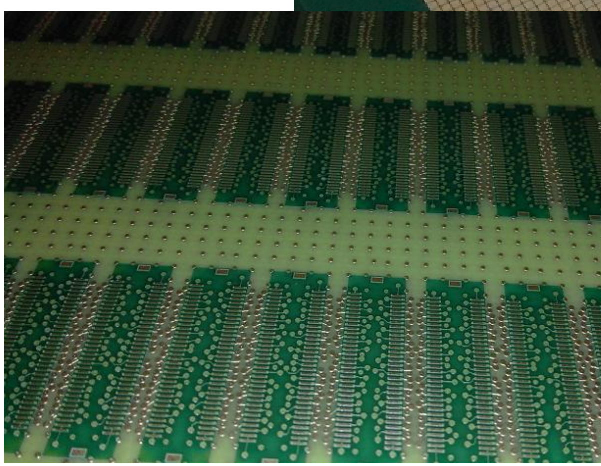




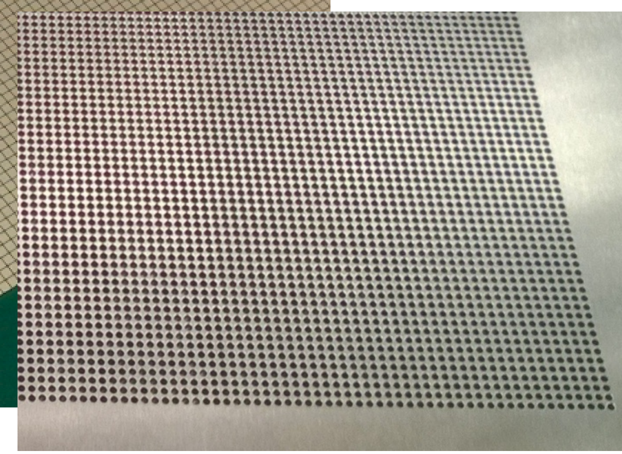
ACTAR TPC : Design

- ✓ Drift region
- ✓ Amplification region: principle
- ✓ Segmented pad plane
  - Micromegas → transverse multiplicity given by the electron straggling: 2x2 mm^2 pads
  - 16384 pads with very high density: connectics challenge!





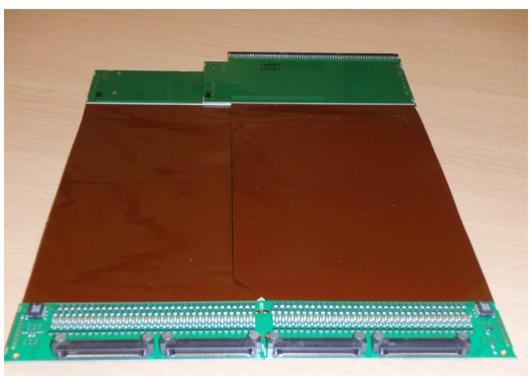
Multi-layer PCB routing solution :
P. Gangnant/M. Blaizot-GANIL
JST Connectors, 0.5 mm pitch

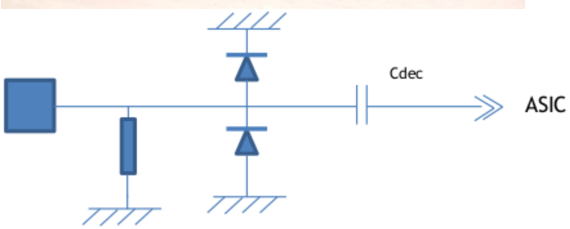


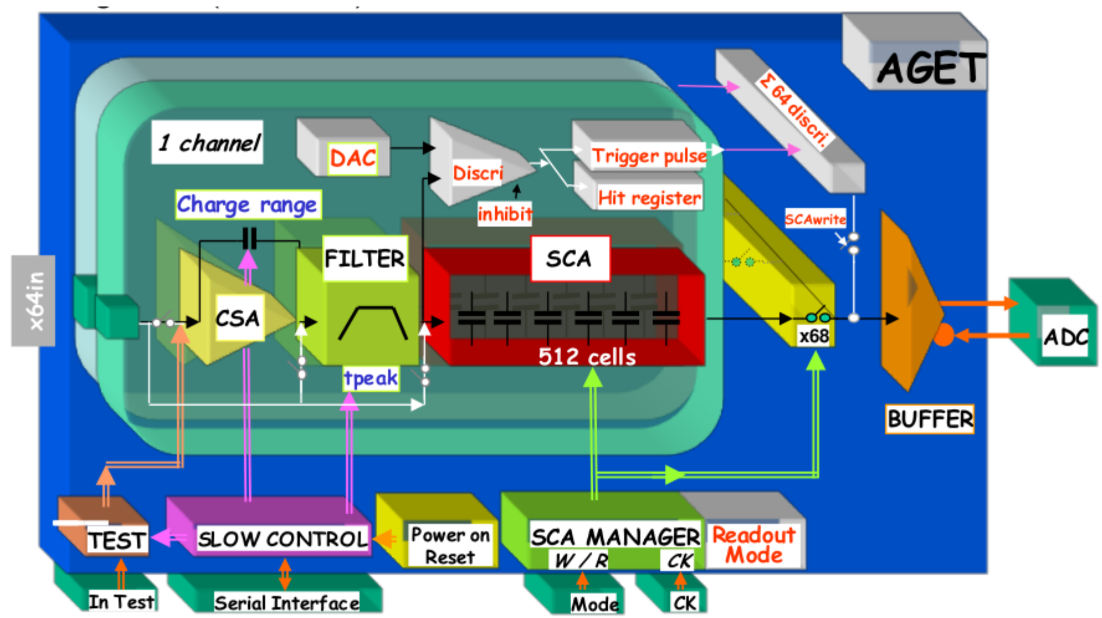
FAKIR solution : J. Pibernat-CENBG

ACTAR TPC : Design

- ✓ Drift region
- ✓ Amplification region: principle
- ✓ Segmented pad plane
- ✓ Electronics
  - Very front end sparking protection circuit: ZAP boards
  - Pads equipped with GET electronics:
    - → 512 samples ADC readout depth x 16384 pads = volume sampling in 8 Mega voxels
    - → adjustable gain, peaking time, individual trigger: pad per pad



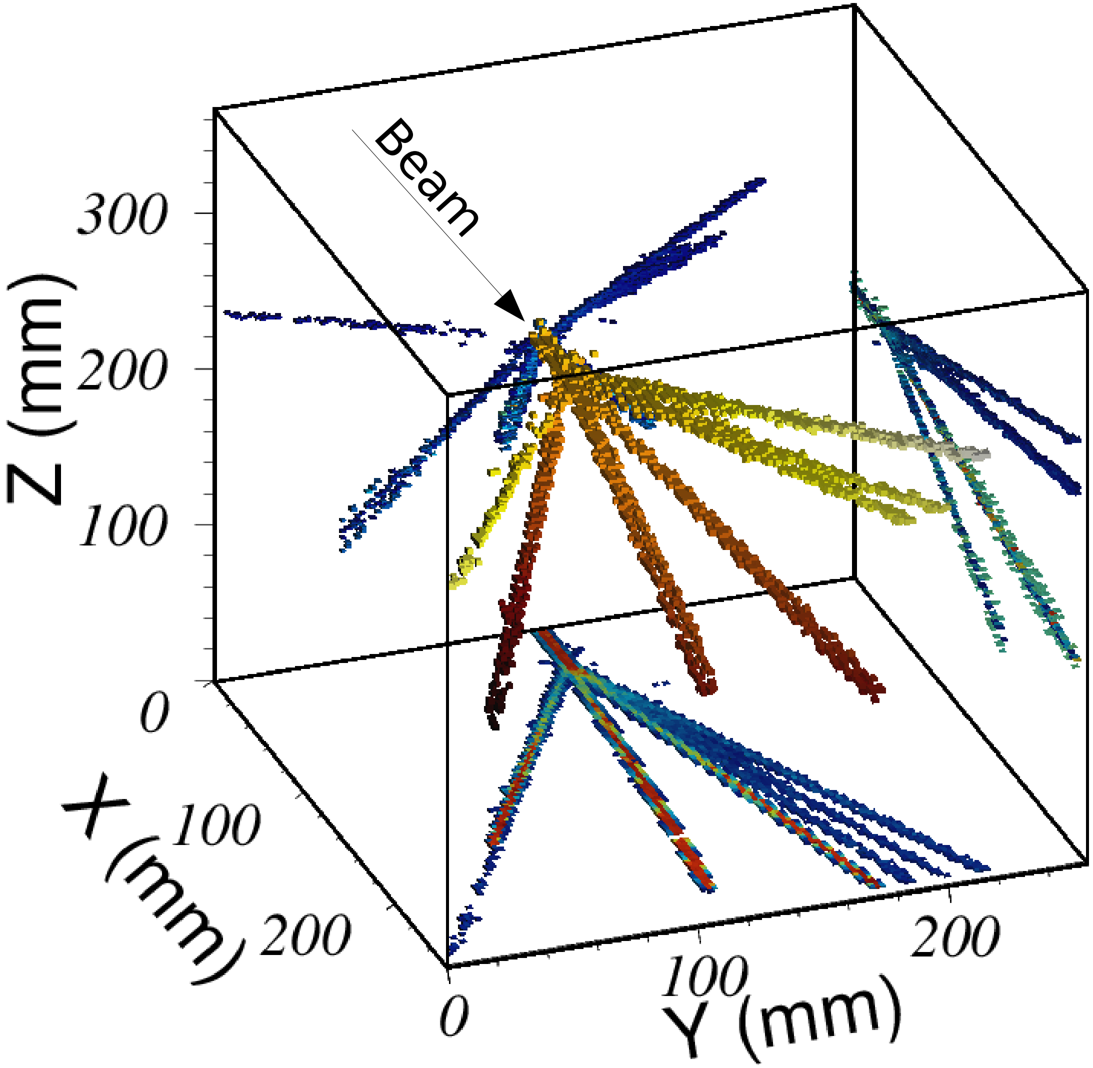




E.C. Pollacco et al., NIM A887, 81 (2018)

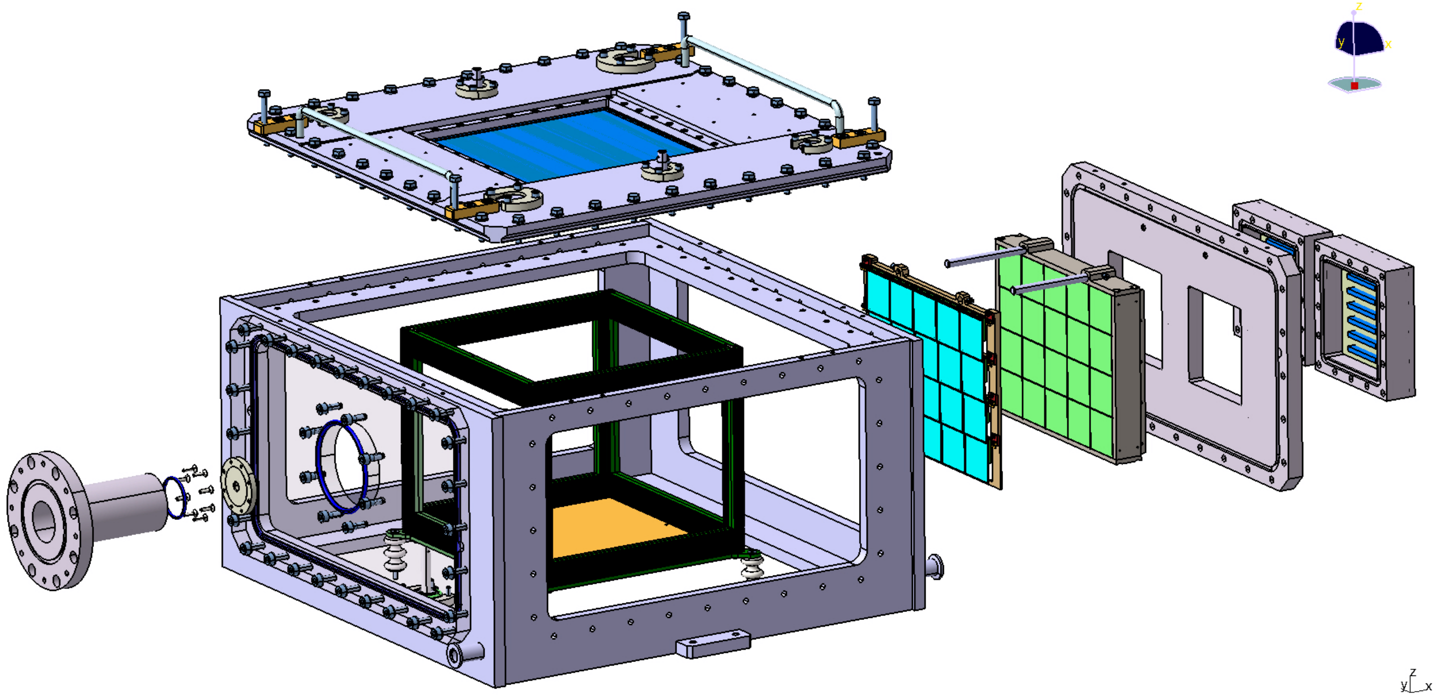
ACTAR TPC : Design

^{18}O (beam) + ^{12}C (iC_4H_{10} target gas)

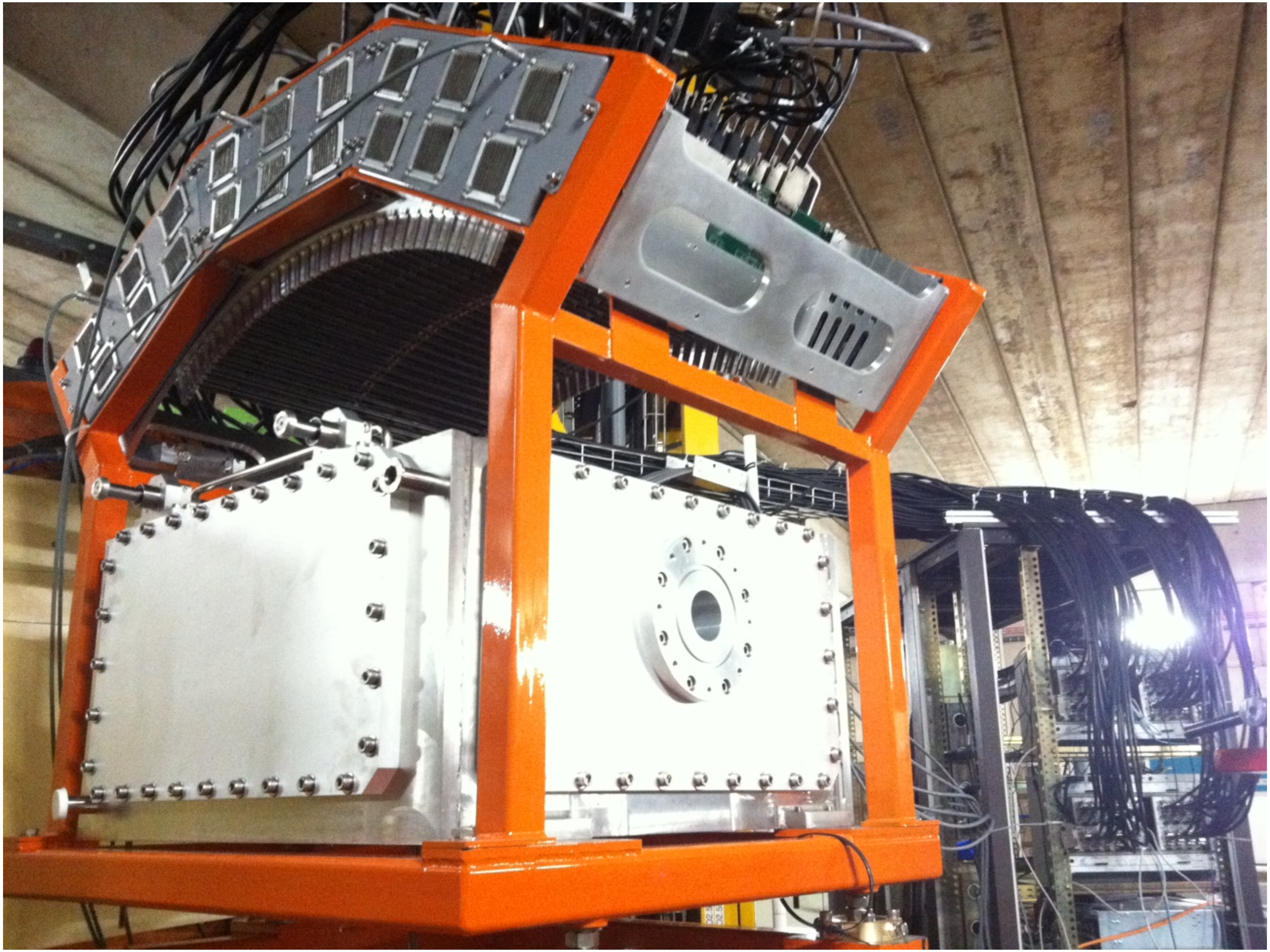


ACTAR TPC : Design

- ✓ Drift region
- ✓ Amplification region: principle
- ✓ Segmented pad plane
- ✓ Electronics
- ✓ Auxiliary detectors
  - Already equipped with Si/CsI telescopes on 1 side
  - Configurable flange design: can be adapted to many other detectors



ACTAR TPC : Design



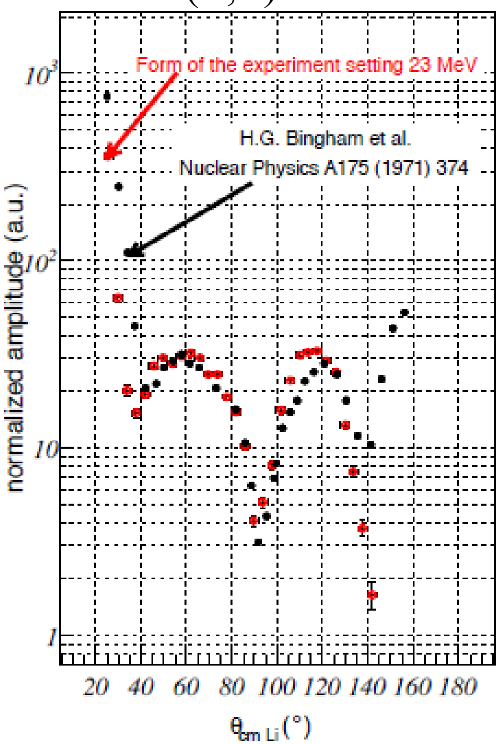
ACTAR TPC : Commissioning

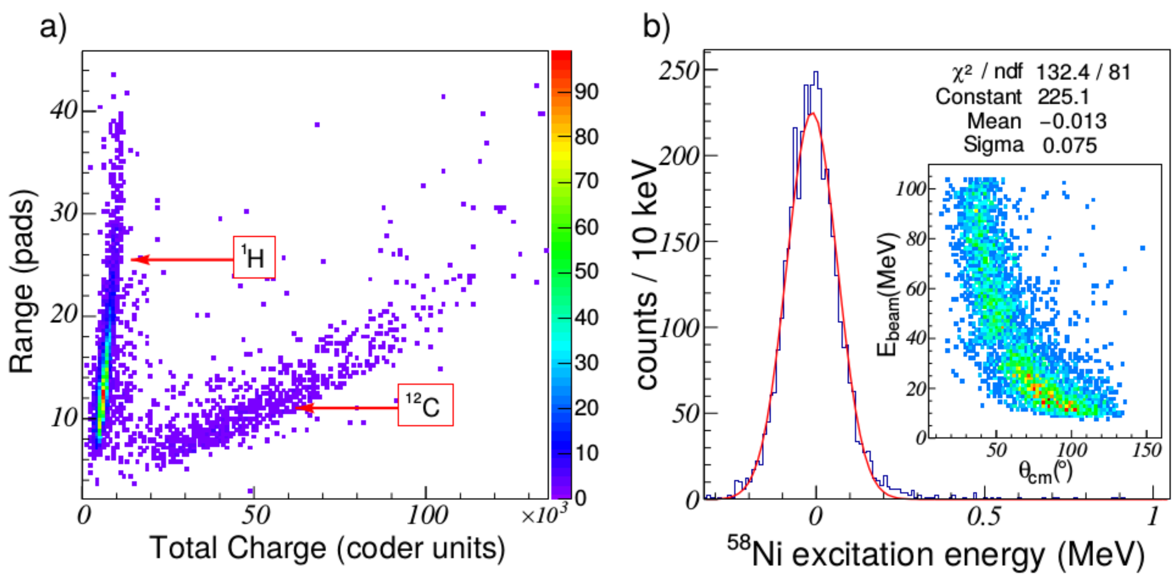
✓ First commissioning with a 32x64 pads Demonstrator

- $^{6}Li(\alpha,\alpha)$ and $^{12}C(p,p')$ at Tandem Orsay
  → angular distributions validated

- $^{58}Ni(p,p)$ at GANIL
  → 200 keV protons tracking, excitation energy resolution = 175 keV FWHM

$^{6}Li(\alpha,\alpha)$





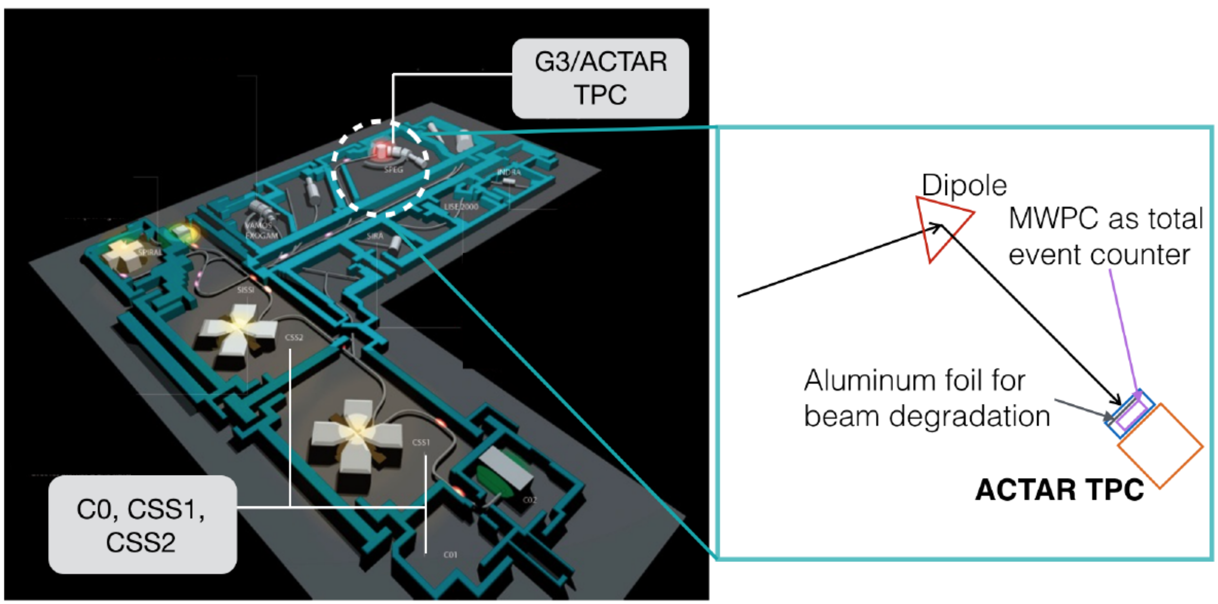
B. Mauss, PhD thesis (GANIL)

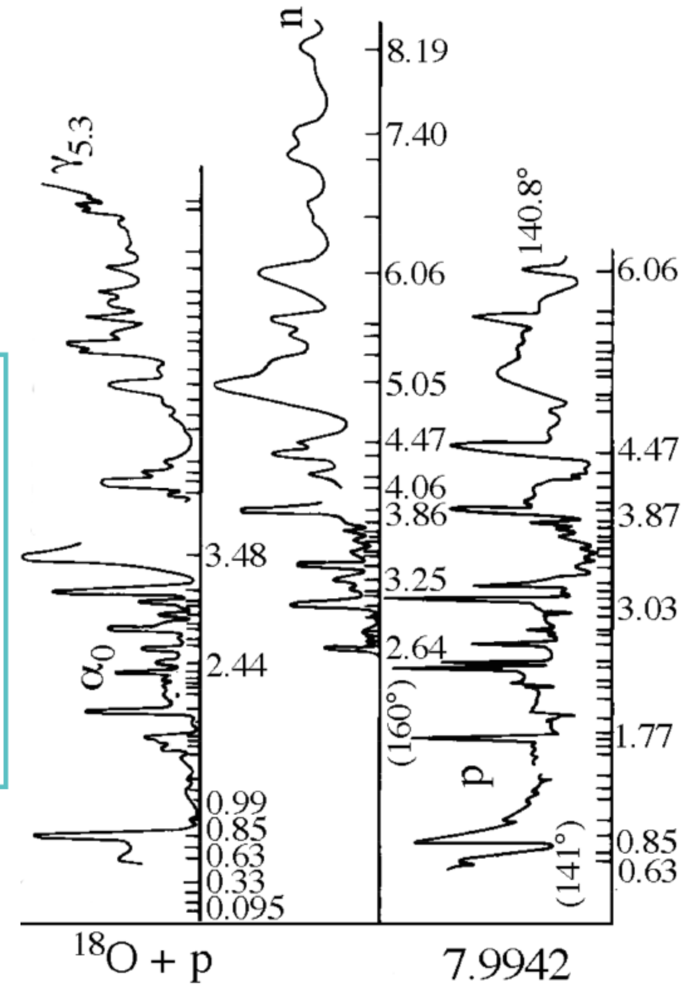
ACTAR TPC : Commissioning

✓ First commissioning with a 32x64 pads Demonstrator

✓ Commissioning of the 128x128 pad full detector

- ^{18}O(p,p) and ^{18}O(p,α) excitation functions
  → 3.2*A* MeV ^{18}O beam in 100 mbar iC_4H_{10}





ACTAR TPC : Commissioning

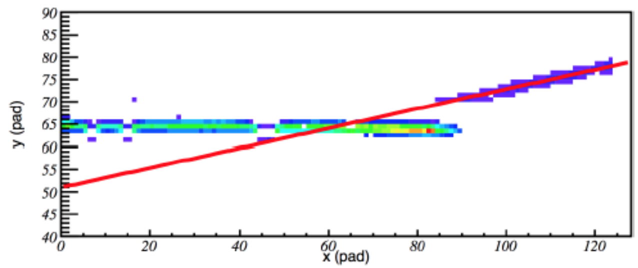
✓ First commissioning with a 32x64 pads Demonstrator

✓ Commissioning of the 128x128 pad full detector

- ^{18}O(p,p) and ^{18}O(p,α) excitation functions

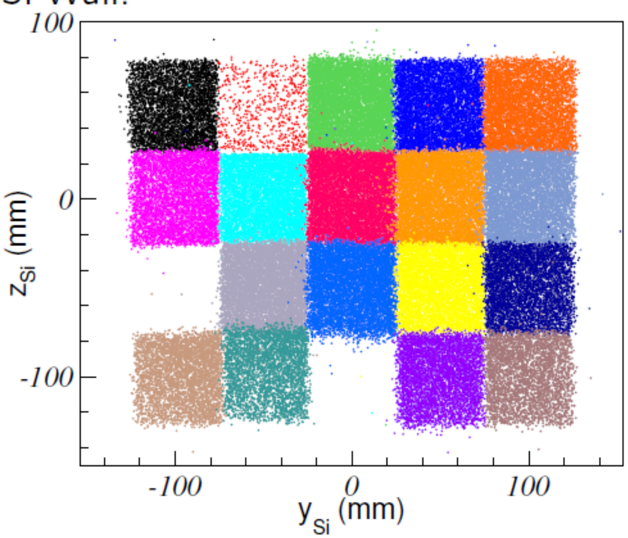
B. Mauss, PhD thesis (GANIL)

3D fit projected in 2D:

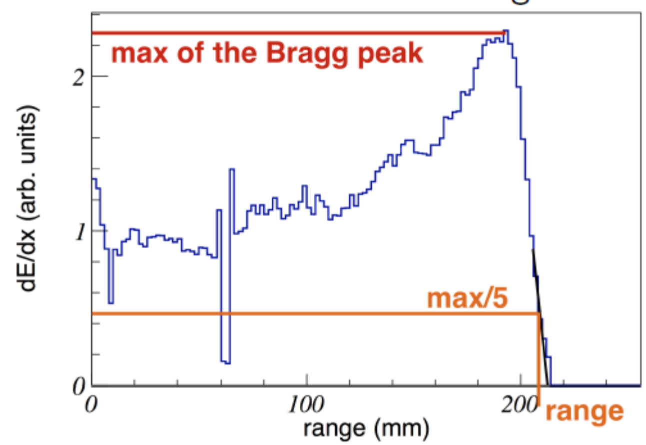


Track reconstruction article in preparation (P. Morfouace and B. Mauss)

Reconstruction of the impact on the Si Wall:



Determination of the range:



Angular resolution calculated with the shape of the Si sides

$\longrightarrow$ Resolution of $\sigma = 0.85^\circ \simeq$ LISE++ straggling calculations

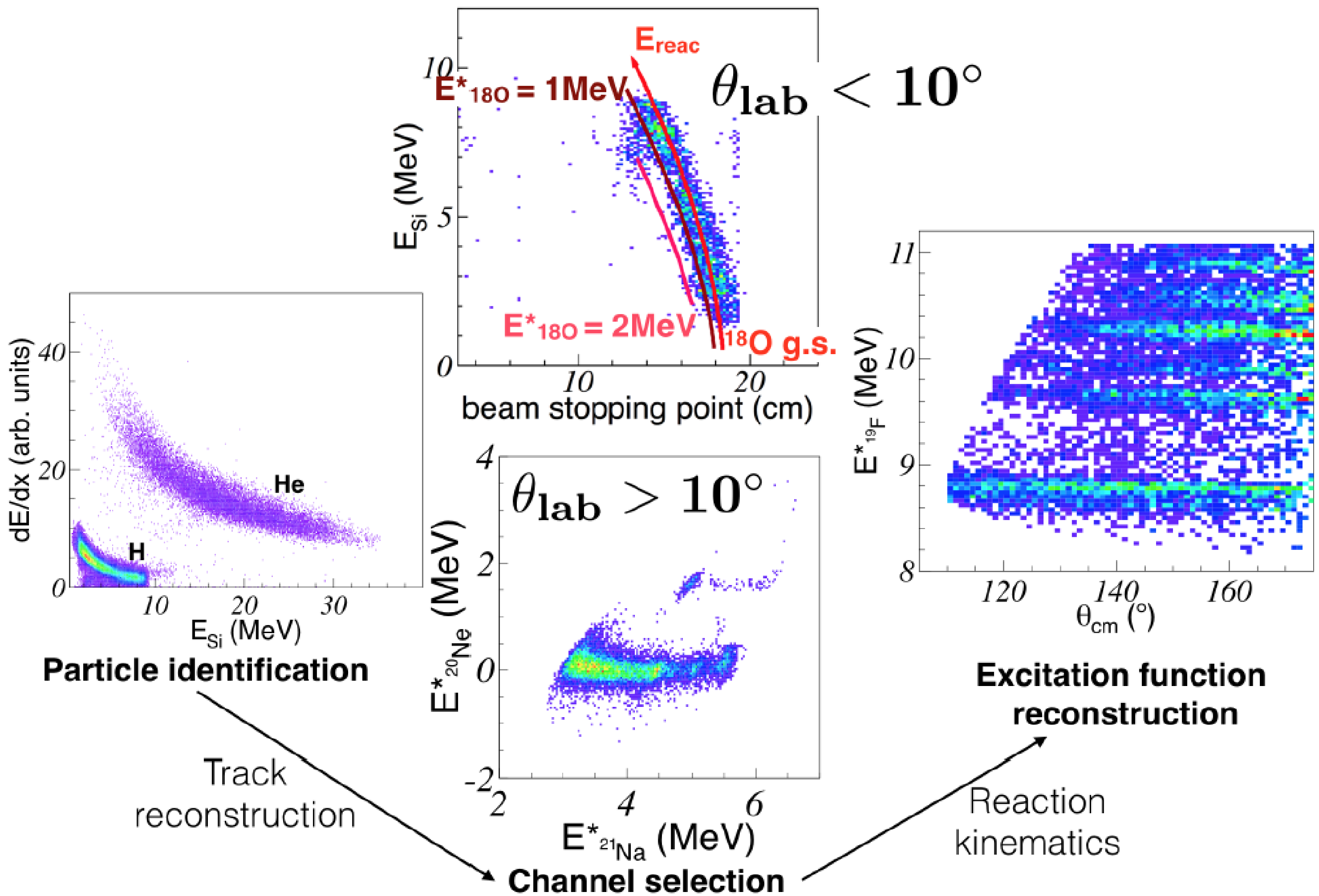
ACTAR TPC : Commissioning

✓ First commissioning with a 32x64 pads Demonstrator

✓ Commissioning of the 128x128 pad full detector

- ^{18}O(p,p) and ^{18}O(p,α) excitation functions

B. Mauss, PhD thesis (GANIL)



ACTAR TPC : Commissioning

✓ First commissioning with a 32x64 pads Demonstrator

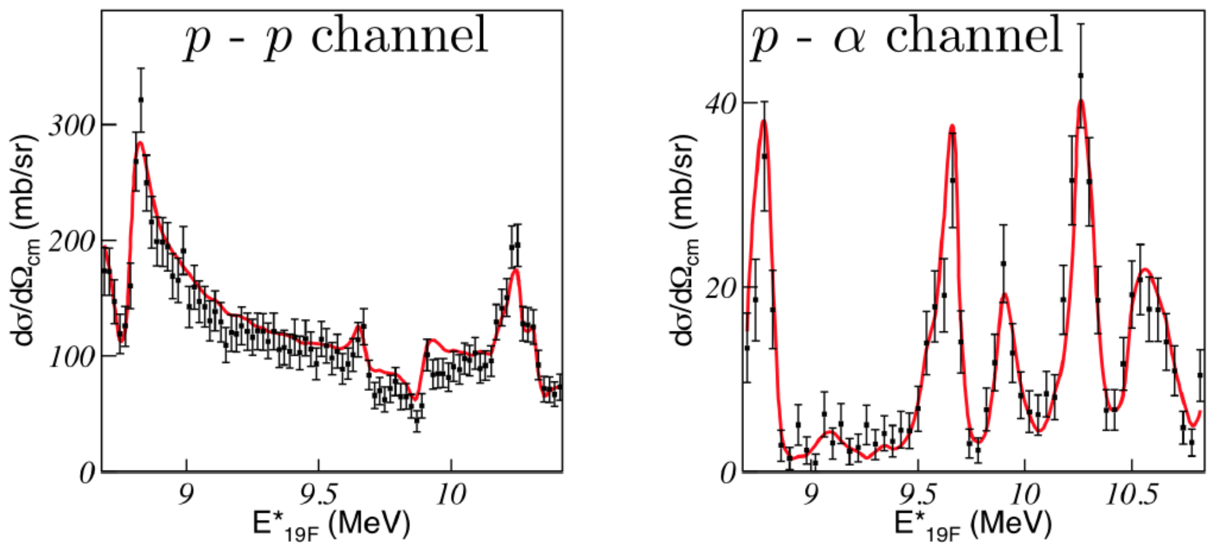
✓ Commissioning of the 128x128 pad full detector

- $^{18}O(p,p)$ and $^{18}O(p,\alpha)$ excitation functions

Results at $\theta_{cm} = (160 \pm 5)^\circ$ for the ^{18}O experiment:

Extraction of the absolute cross section

B. Mauss, PhD thesis (GANIL)



R-matrix calculation performed with the AZURE2 code.

Previous experimental data:
R. R. Carlson, C. C. Kim, J. A. Jacobs and A. C. L. Barnard in Physical Review 122, 607-616 (1961)

article on the commissioning in preparation

$\longrightarrow$ theoretical curves convoluted with a gaussian function of resolution (47 ± 42) keV FWHM for the (p,p) channel, and (61 ± 54) keV FWHM for the (p,α) channel at $\theta_{cm} = 160^\circ$

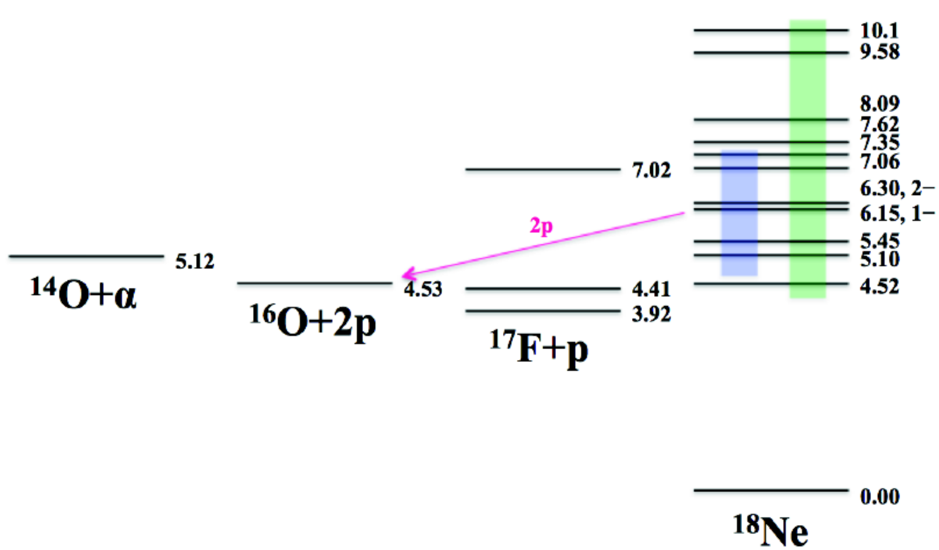
ACTAR TPC : Opportunities with EURISOL-DF

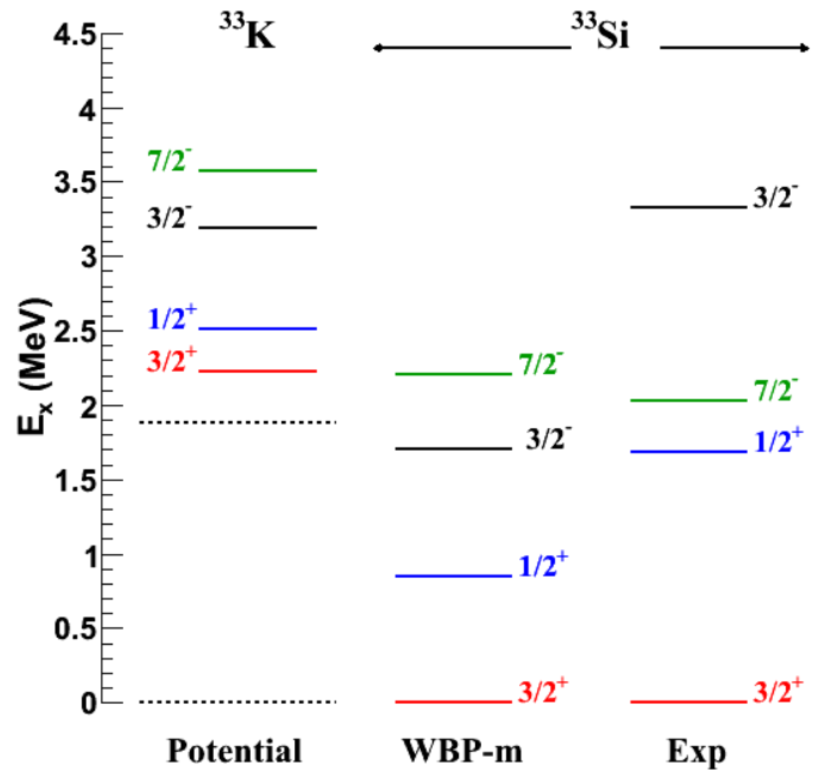
✓ GANIL - SPIRAL1

- 2 experiments accepted: resonant scattering
  - → ^{17}F(p,2p) and (p,α): G.F. Grinyer, T. Roger
  - → ^{32}Ar(p,p): B. Fernandez-Dominguez

- 1 new proposal for the next GANIL PAC

- Plans to extend to transfer reactions





ACTAR TPC : Opportunities with EURISOL-DF

✓GANIL - SPIRAL1

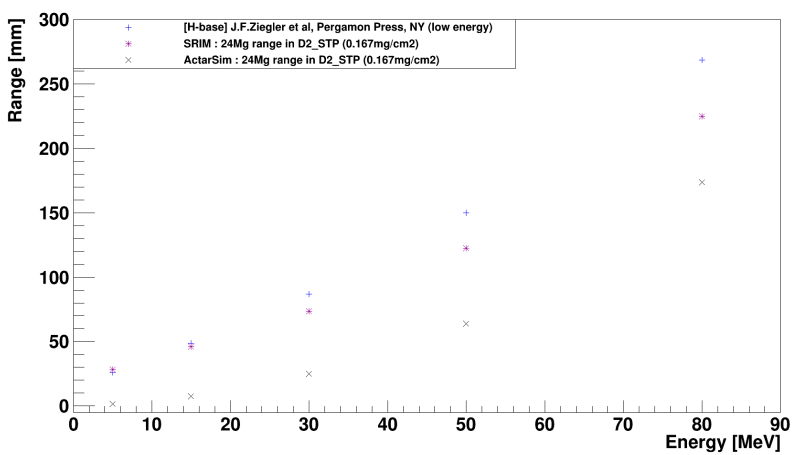
✓LNL - SPES

→ ACTAR TPC Demonstrator was sent to Legnaro (Coordinator: T. Marchi)

- 1st part: energy loss measurement
- 2nd part: transfer reaction on post-accelerated fission fragments

Table 1. List of the proposed projectile for the energy loss profile measurements. As an example, the pressure needed to stop the gas on the pad plane is given for the iC_4H_{10} case.

Ion	Beam Energy (MeV/u)	Gases to be measured	BTU requested	*iC4H10 pressure (mbar) typical case example*
^{7}Li	1.0 - 4.5	H_2, D_2, CH_4, iC_4H_{10}, CF_4, CO_2, He	4.5	*500*
^{9}Be	1.5 - 4.5		4.5	*500*
^{10}B	1.8 - 4.5		4.5	*500*
^{12}C	2.0 - 4.5		4.5	*250*
^{15}N	2.0 - 4.5		4.5	*250*
^{16}O	2.0 - 4.5		4.5	*250*
^{19}F	2.0 - 4.5		4.5	*250*
^{24}Mg	2.0 - 4.5		4.5	*250*
^{40}Ca	2.0 - 3.8		4.5	
^{120}Sn	1.5 - 1.7		4.5	
Total			45	



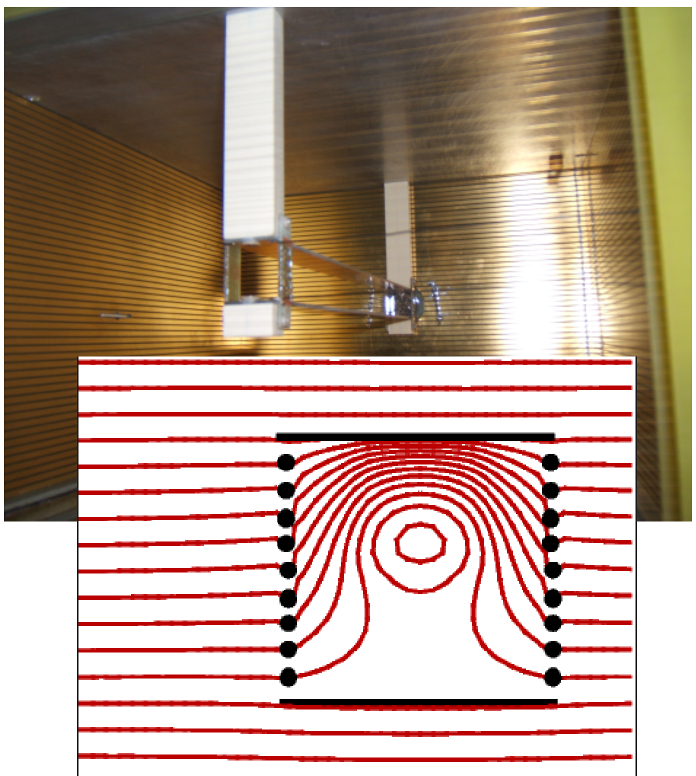
ACTAR TPC : Opportunities with EURISOL-DF

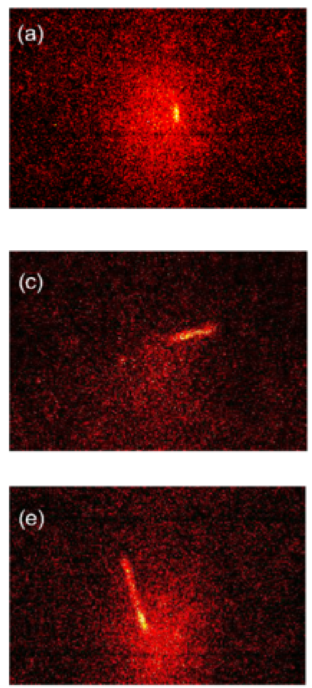
✓GANIL - SPIRAL1

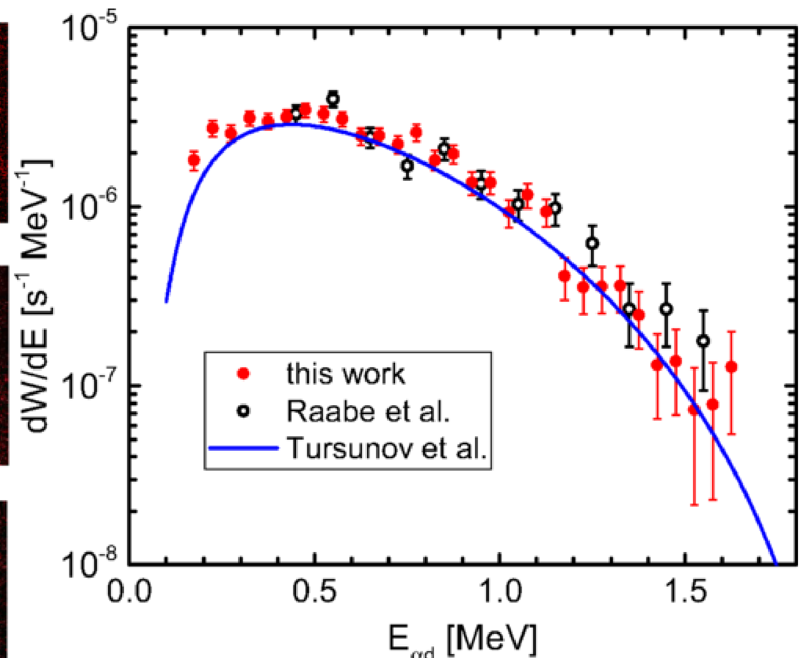
✓LNL - SPES

✓HIE-ISOLDE

- Beam time structure is not an advantage for an active target, unless a beam mask is used (high instantaneous energy deposit will saturate the preamps)
- However, it is a good advantage for a TPC!







M. Pfützner et al., PRC 92, 014316 (2015)

Collaboration

GANIL

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B. Duclos

G. Fremont

P. Gangnant

J. Goupil

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A.T. Laffoley[2]

L. Legeard

C. Maugeais

B. Mauss

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P. Morfouace

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T. Roger

C. Spitaels

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E.C. Pollacco

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European Research Council

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laboratoire commun CEA/DRF CNRS/IN2P3

actar TPC

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