Fission program at FRS / R3B

status

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CENBG, CEA Saclay, GANIL, Univ Chalmers

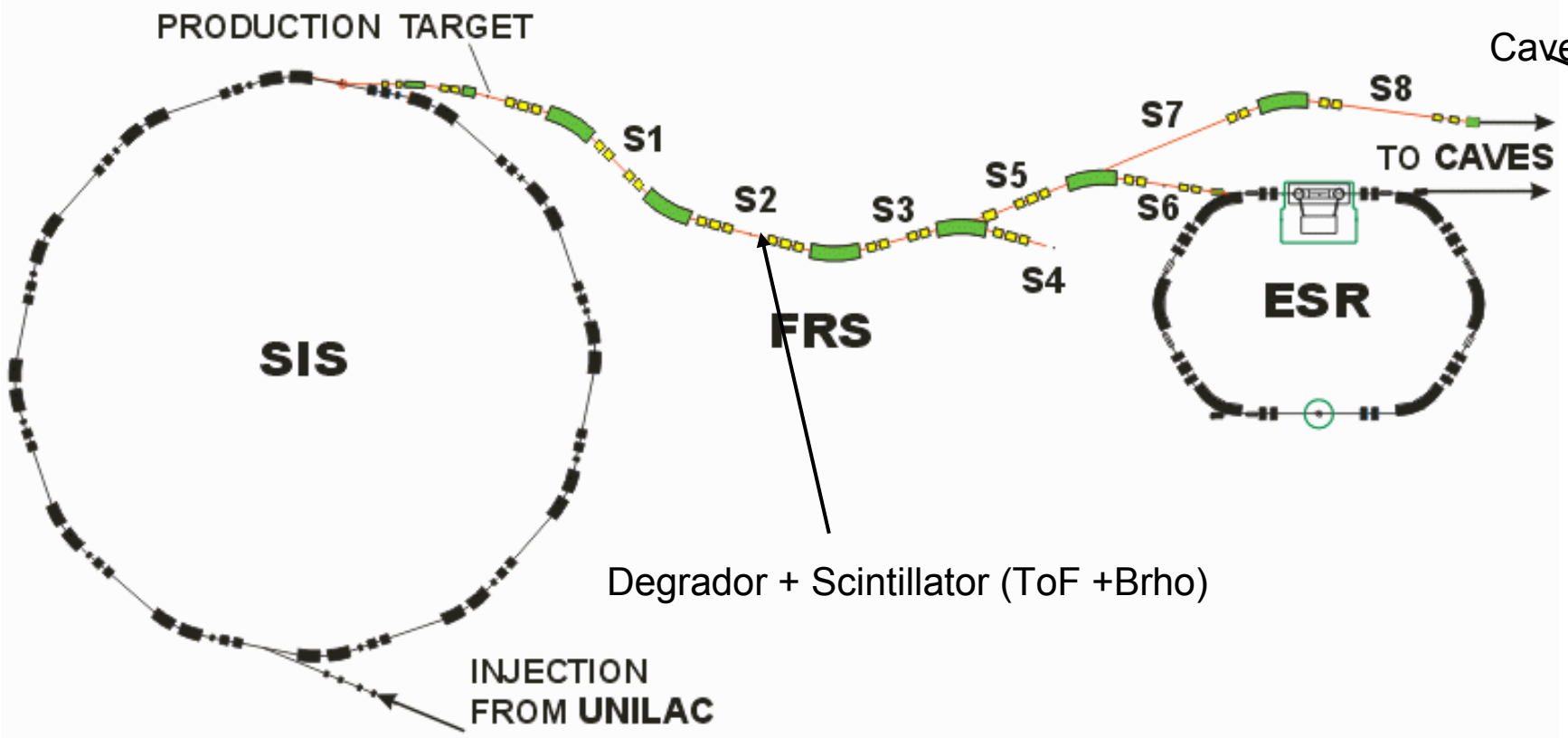
The experiment

- Comprehensive study of the fission process at medium and high excitation energy
  - Electromagnetic-induced fission of ^{238}U and lighter short-lived actinides
  - Spallation-fission of ^{208}Pb on ^{1}H (ANDES)
- The reverse kinematics at relativistic energies helps a lot
  - GSI is the only place worldwide where this is feasible

The experiment

- Pb+p system : study the fission dynamics at high excitation energy
- Actinides + Pb : survey the structure effects at low E*
- For both systems, we need to measure the same quantities:
  - (Z,A, Ekin) and count all fission fragments and neutrons in coincidence
- Beam-Time approved, 27 remaining shifts
- Experiment scheduled in summer 2012

2ndary beam ID



2ndary actinide beam ID

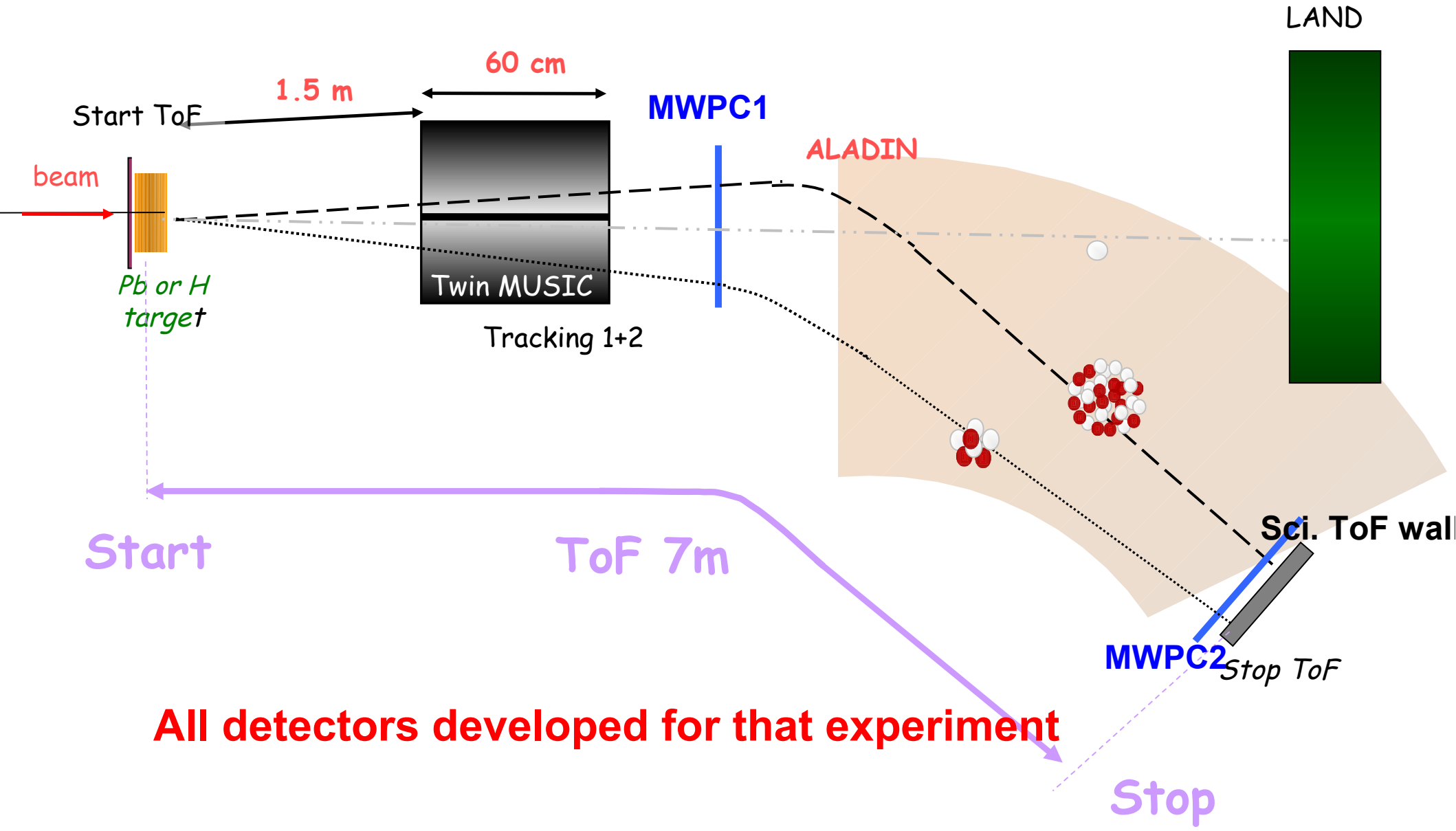
- 1st FRS/ Cave C experiment with actinides
- Selection of ^{238}U fragmentation products at S0
  - U, Np, Th, ^{180}Hg
- 1st magnetic selection S0-S2 (rate 10^5/s)
  - ToF + degrador
- 2nd magnetic selection, S2-Cave C
  - ToF, 2x tracking + 2x MUSIC (TUM)

Fission Fragment ID, Experimental technique

- COULEX-induced fission in an active Pb target
- Identification of all fission fragments
    - Measurement of Z, A and recoil energy
    - Can not be done anywhere else
- Classical Bρ, ToF, ΔE method
    - Using a large acceptance magnet
- Neutron multiplicity

The cave C is the place where to proceed

The fission set up



All detectors developed for that experiment

The main difficulty : get the A

ALADIN is not strong :

- Low angular deflection
- Difficult to get the proper Brho resolution (1/300)

The angular straggling induces uncertainty

- Reduce the amount of material in beam
- Only gazeous detector (low Z gaz)
- flight-path totally in vacuum or Helium

Mass resolution, constraints

- Brho resolution : proper position resol.

  - 0.2mm FWHM on the 3 tracking meas.

- To get the A resolved : proper ToF resolution

  - 40 ps FWHM on 7m flightpath !!

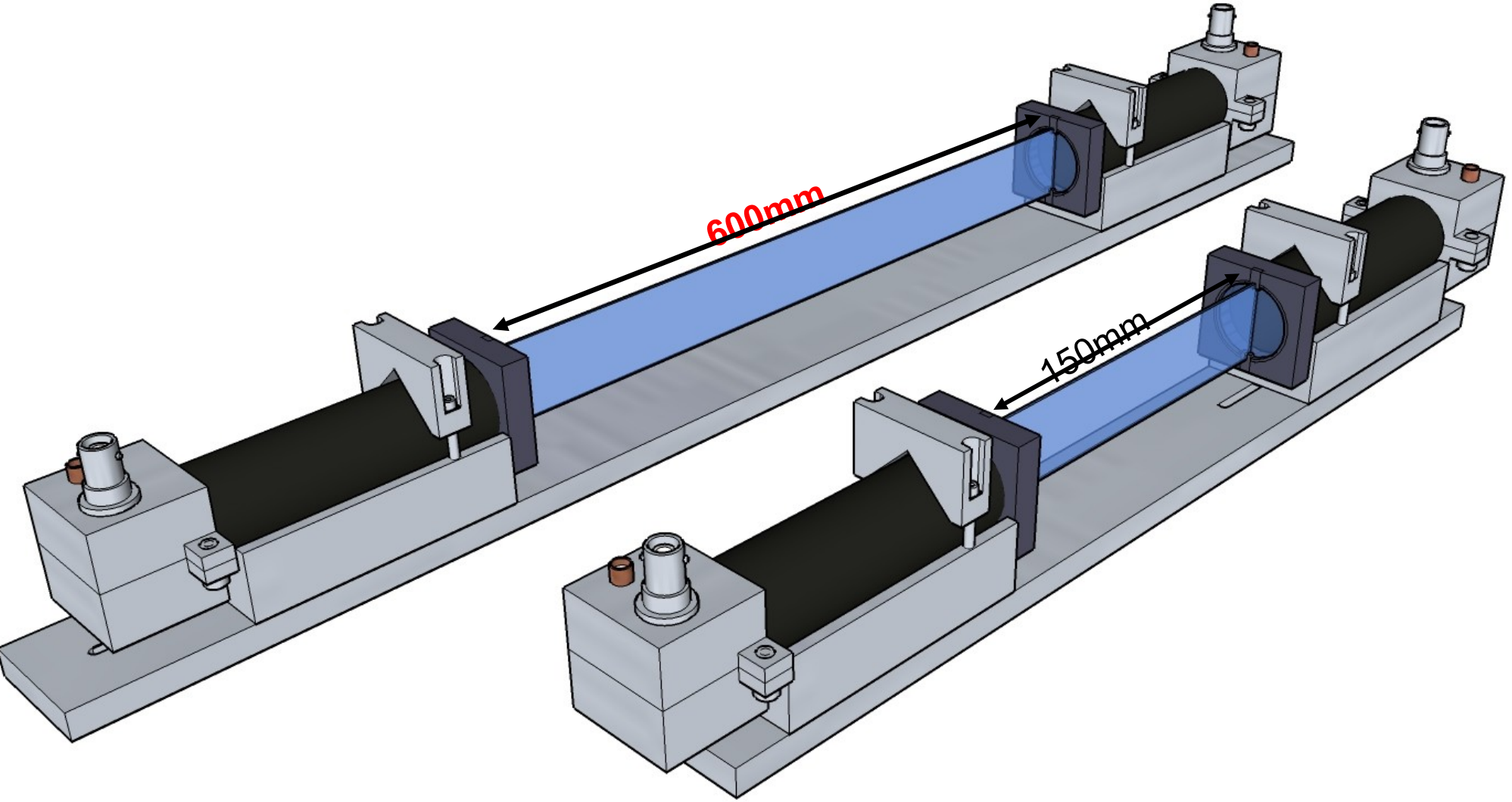
If we meet those requirements, we should get the A resolved up to A=150

Detector technical choices : ToF

- Plastic-based ToF set-up (CEA Bruyeres)
  - Tough ToF reso. requested (40 ps FWHM)
  - Large ToF wall at the end of the set up
- Development started 3 ½ years ago
  - 6 test runs at our electron linac
  - 2 test runs at FRS in 2009/2010
  - 2 test run at cave C, june/september 2011
- Feasibility demonstrated on a prototype

ToF measurement for SOFIA

ToF prototype 2, U beam

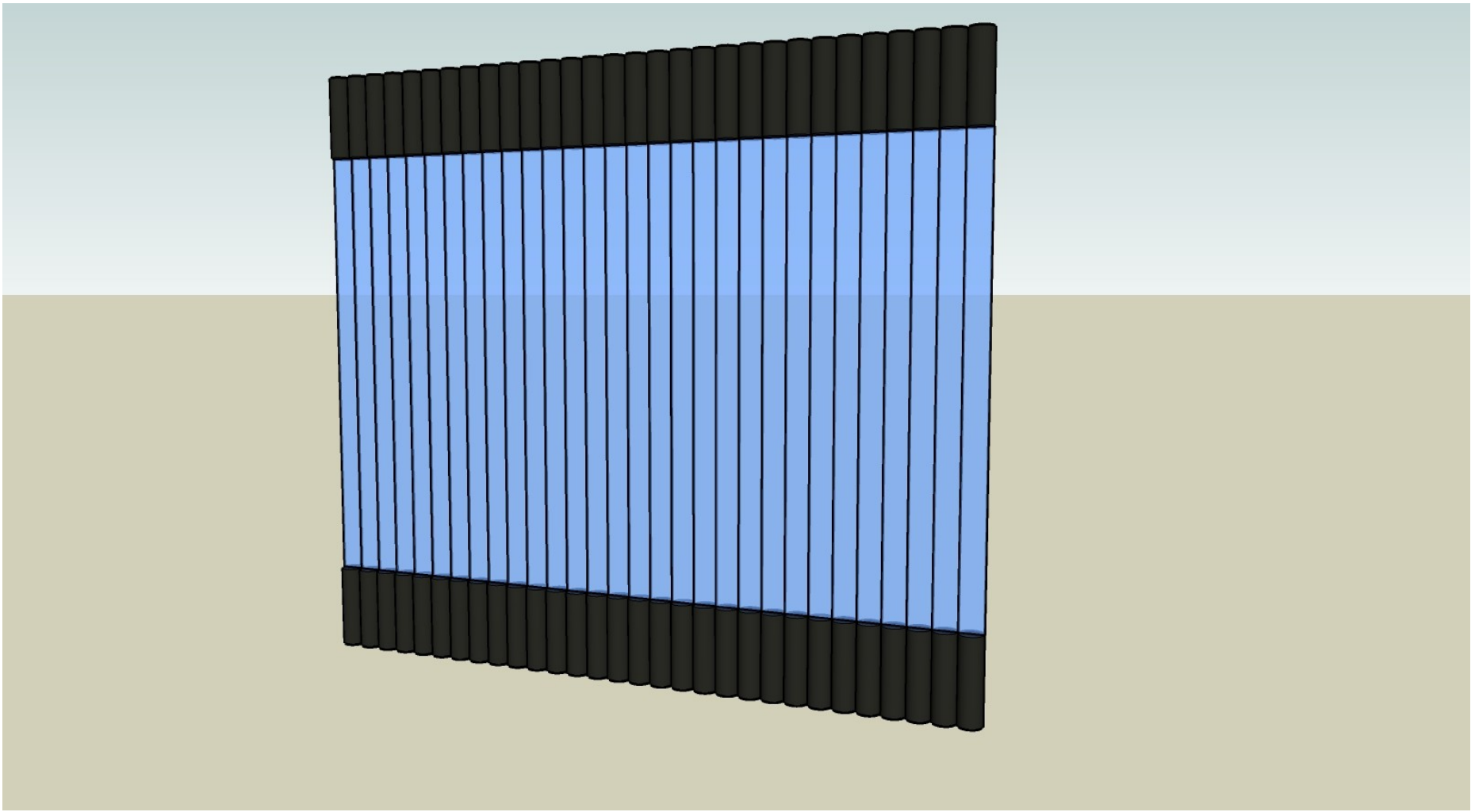


ToF resolution : 17 ps FWHM

I- ToF measurement for SOFIA

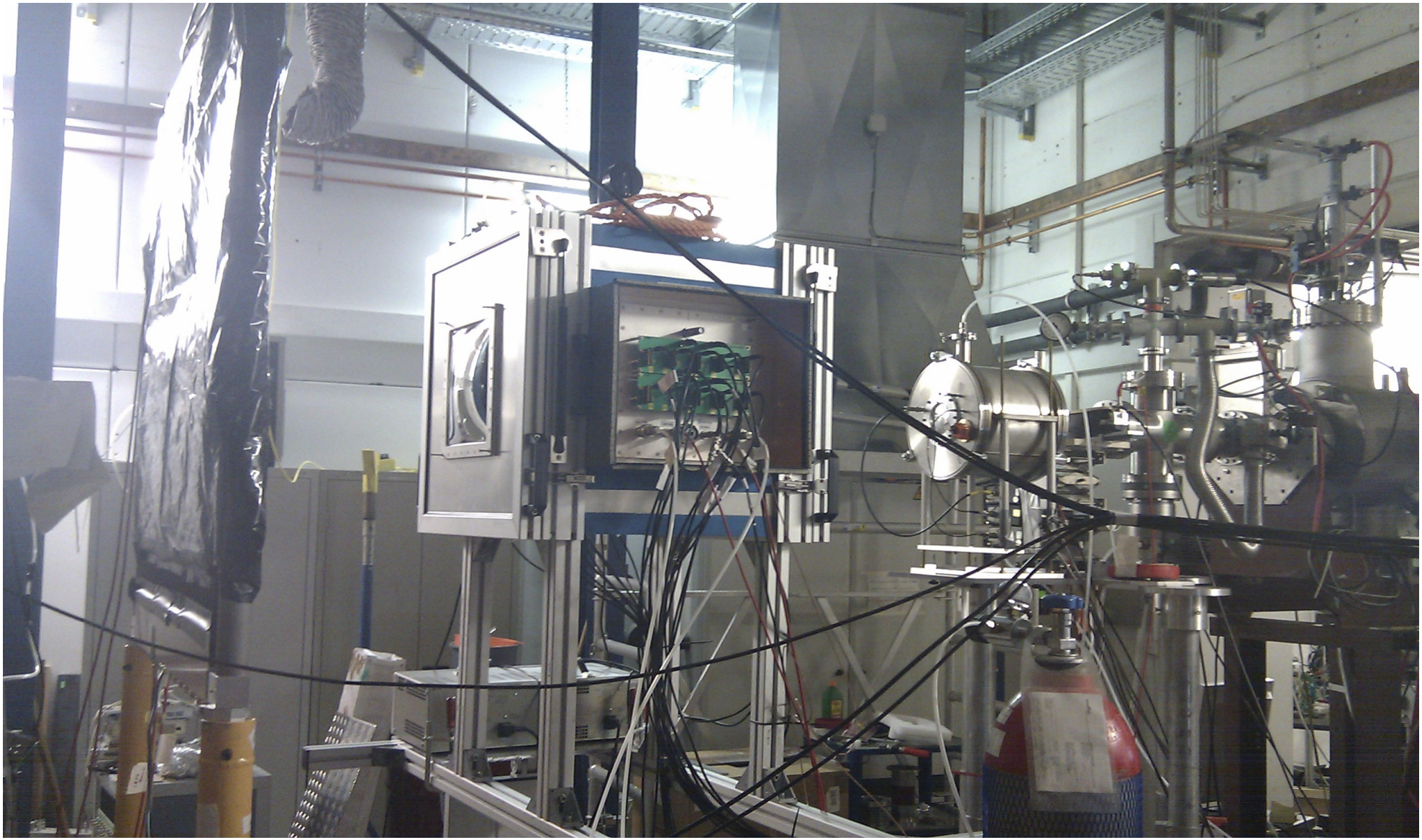
What we need :

LAND



ToF measurement for SOFIA

Actual ToF system, ^{124}Sn beam, june 2011



ToF resolution : 35 ps FWHM

ToF system

- Very high resolution ToF system defined
  - 35 ps resolution measured for heavy FF
  - In-line with our request
- Full tof wall assembled in may
- Tested in june and september

ToF electronics

- high resolution ToF $\Rightarrow$ high resolution electronics needed
  - No TDC available on the market
- FPGA programmer hired to implement the wave union algorithm in a GSI VME module
- Perfect collaboration with EE department
  - TDC delivered in september
  - 8 ps RMS resolution measurement
  - Outstanding results

MWPC

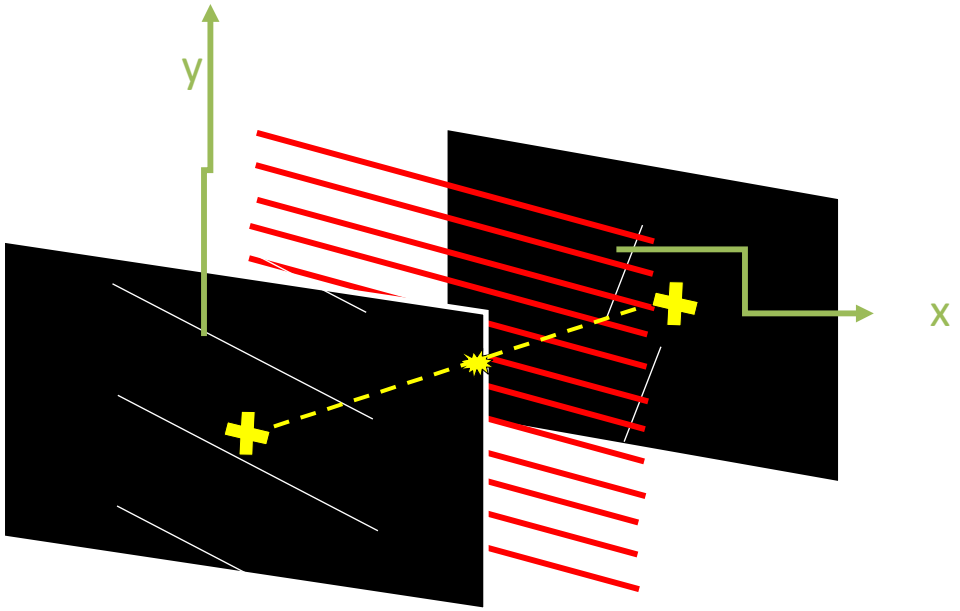
2 detectors developed and built by IPN Orsay

- 200 x 200 mm2 upstream ALADIN : delivered
- 900 x 600 mm2 at final plane : expected in feb.

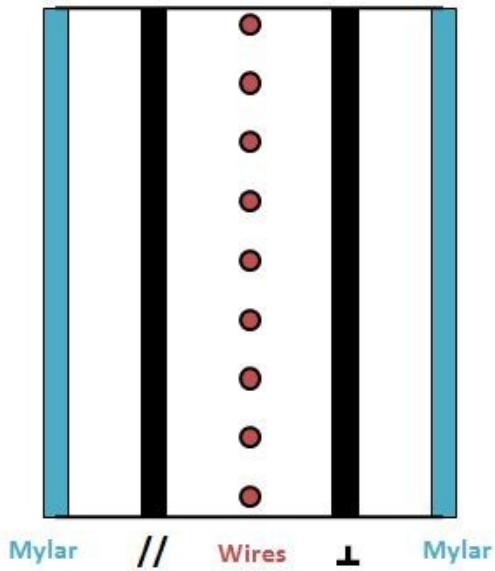
Based on the Alice MWPCs

- good tracking properties expected (200 um FWHM)
- low material budget (angular straggling constraint)

General design



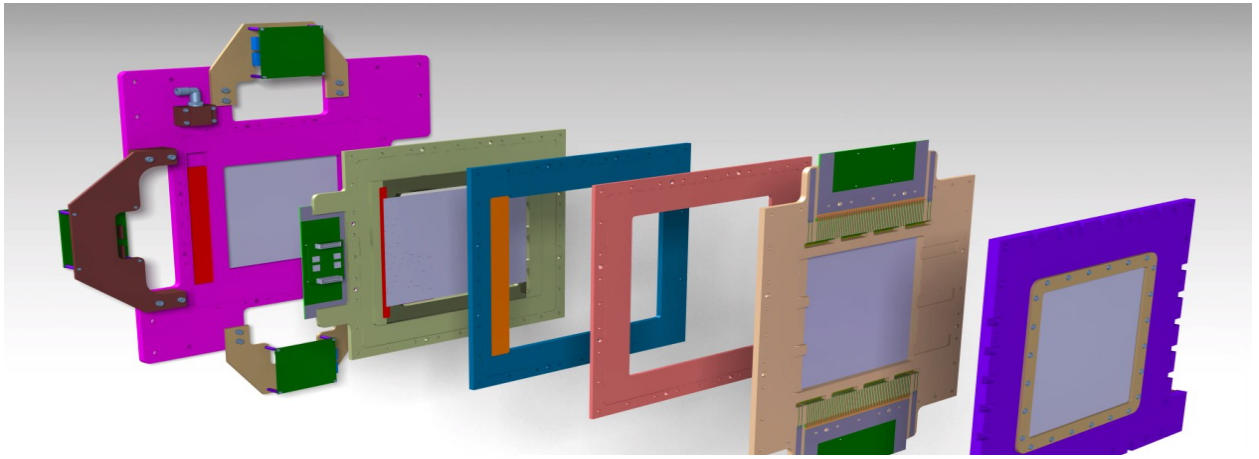
Concept for the two chambers

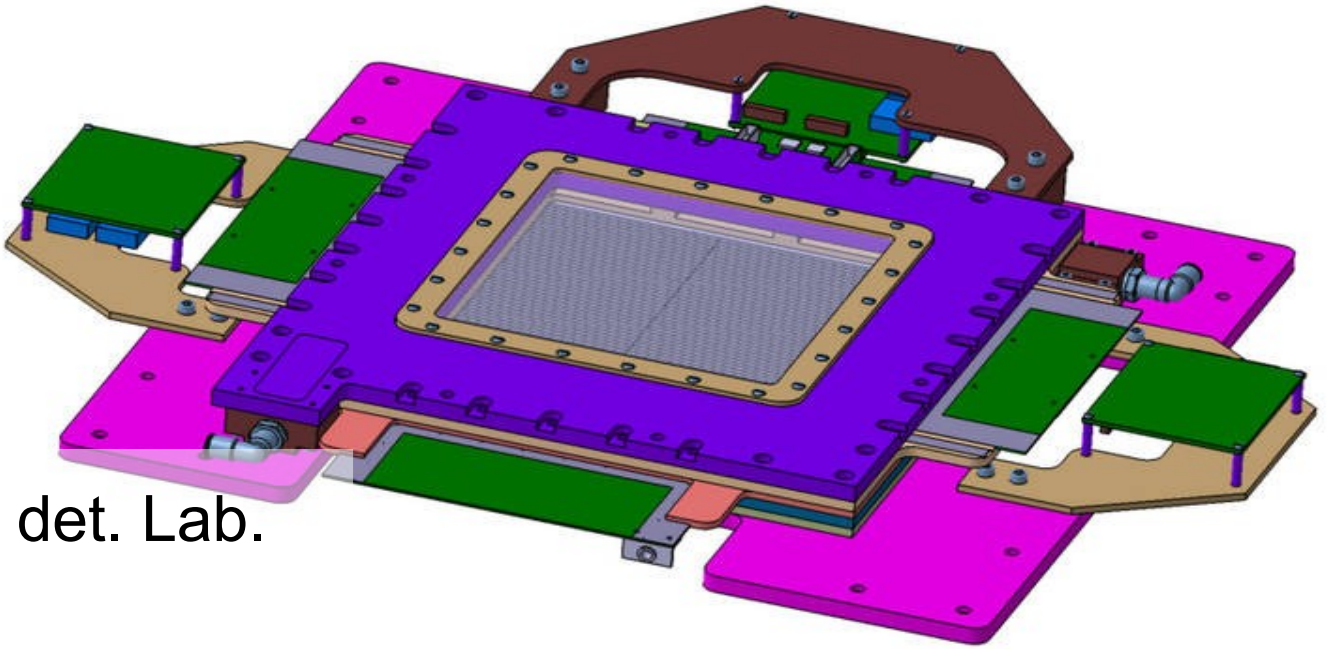


Resolution	vertical	2 mm
	horizontal	0,2 mm
Environment	pressure	atmospheric
Aluminum max	thickness	0,1 mm
Count rate	frequency	10^5/s
Chamber 1	Active surface	200*200 mm2
Chamber 2	Active surface	900*600 mm2

POSITION IS GIVEN BY THE TWO STRIPS PLANES (x and y)

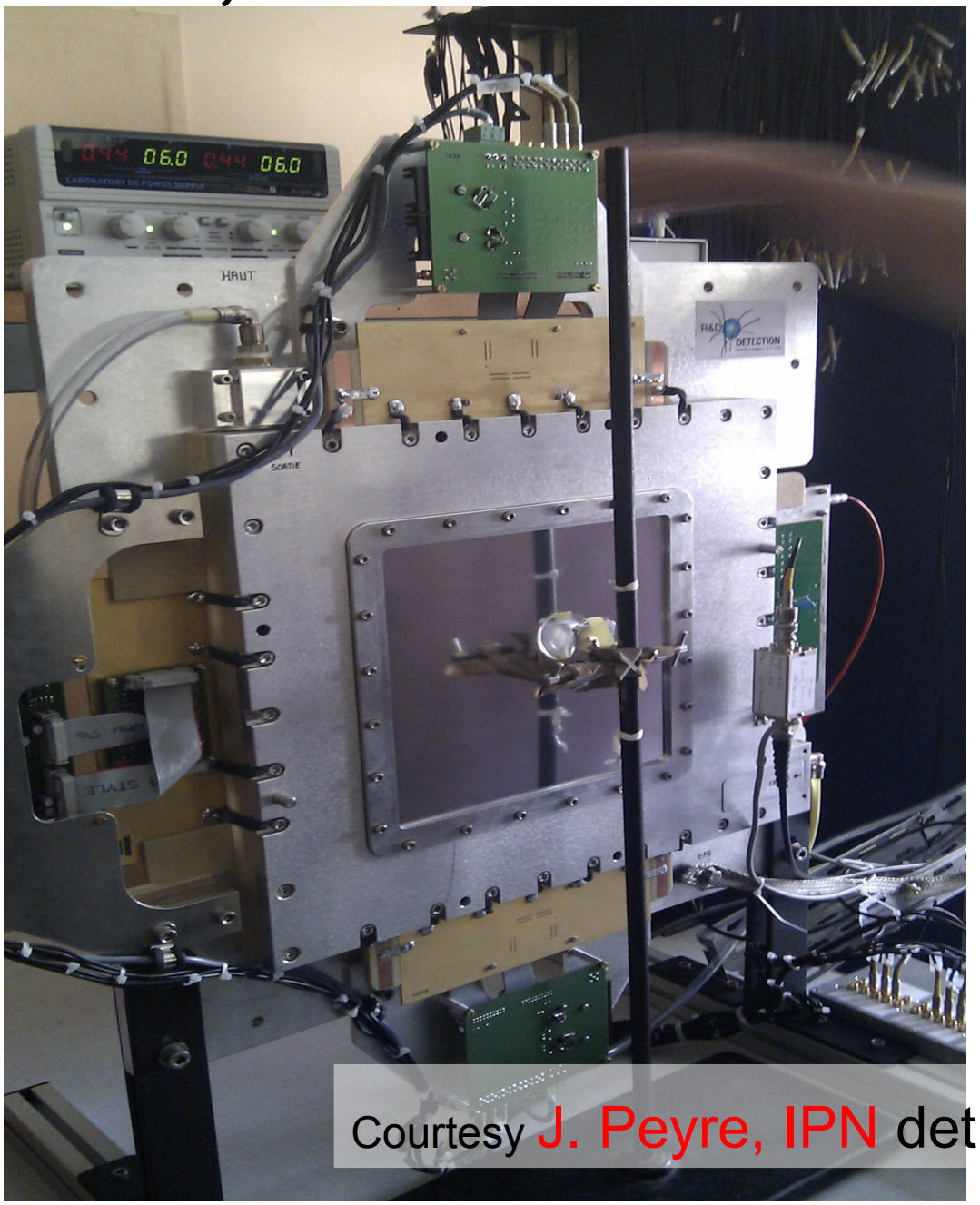
Courtesy J. Peyre, IPN det. Lab.





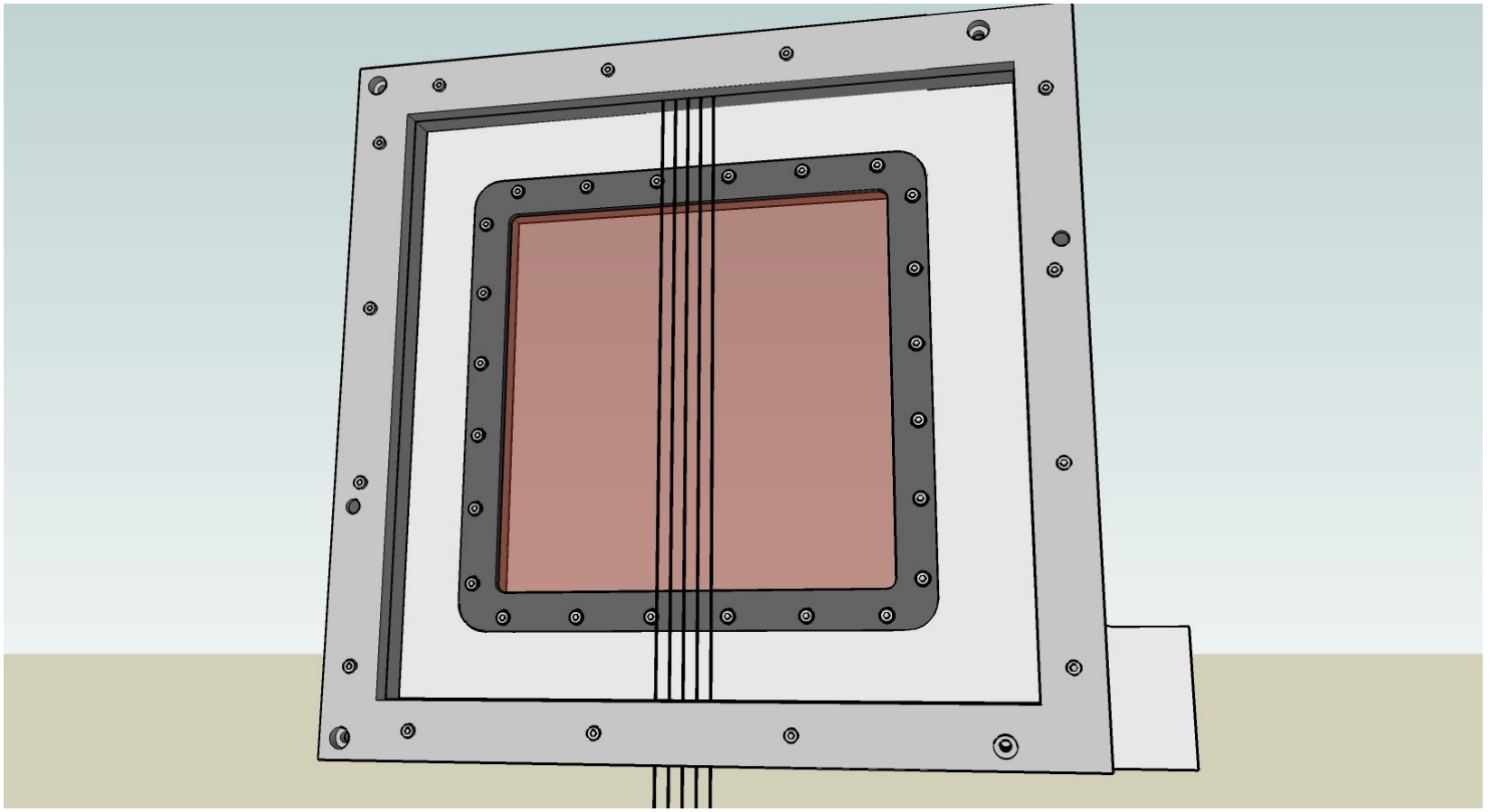
Courtesy J. Peyre, IPN det. Lab.

MWPC 1, out of the box

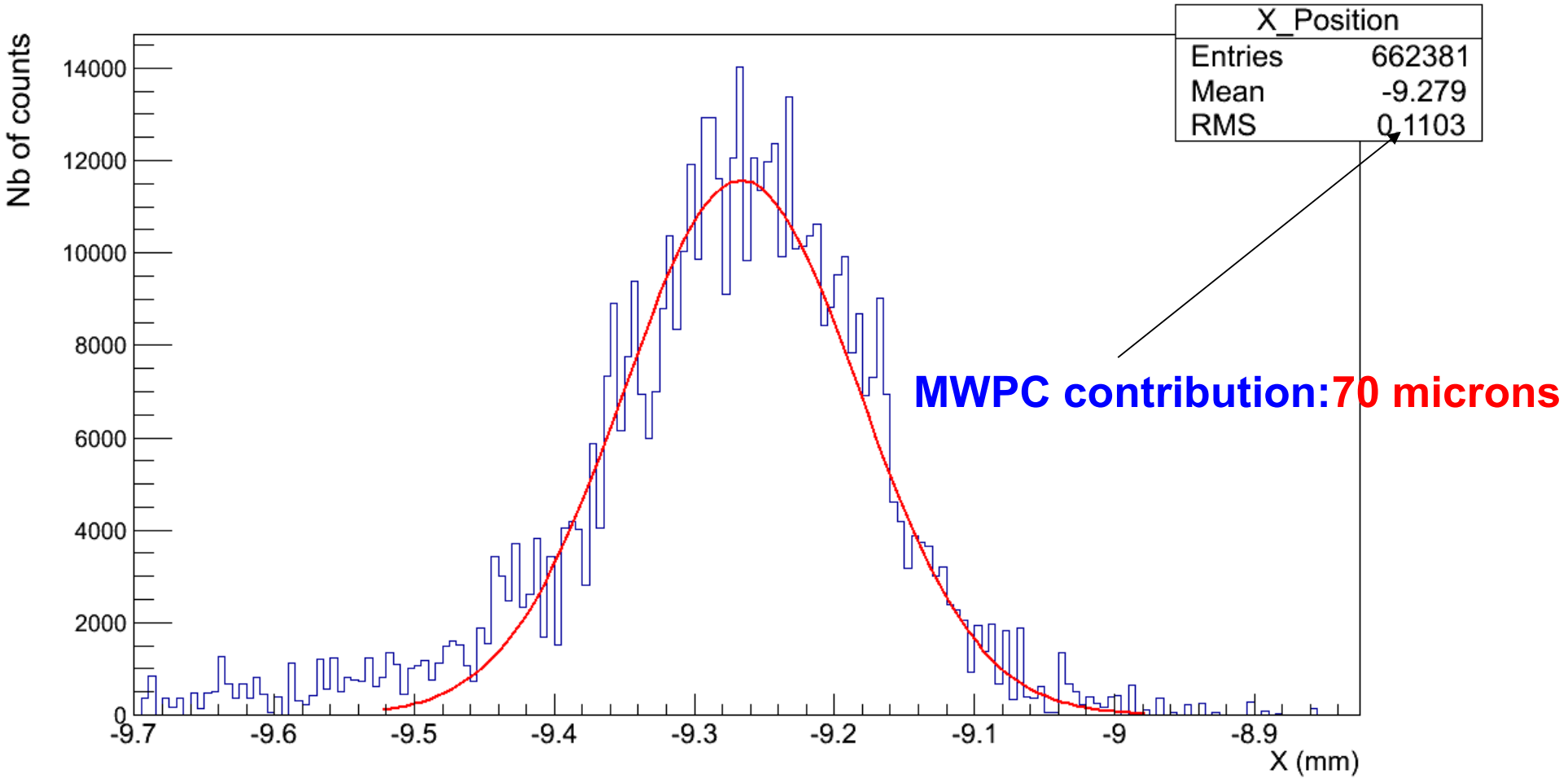


Courtesy J. Peyre, IPN det. Lab.

MWPC1 resolution measurement



MWPC tracking resolution : september run



MWPC conclusion

- MWPC concept validated
- Resolution of 140 microns FWHM measured
- Bigger detectors expected in feb
  - Need to be tested in a last test experiment
  - No big surprise expected

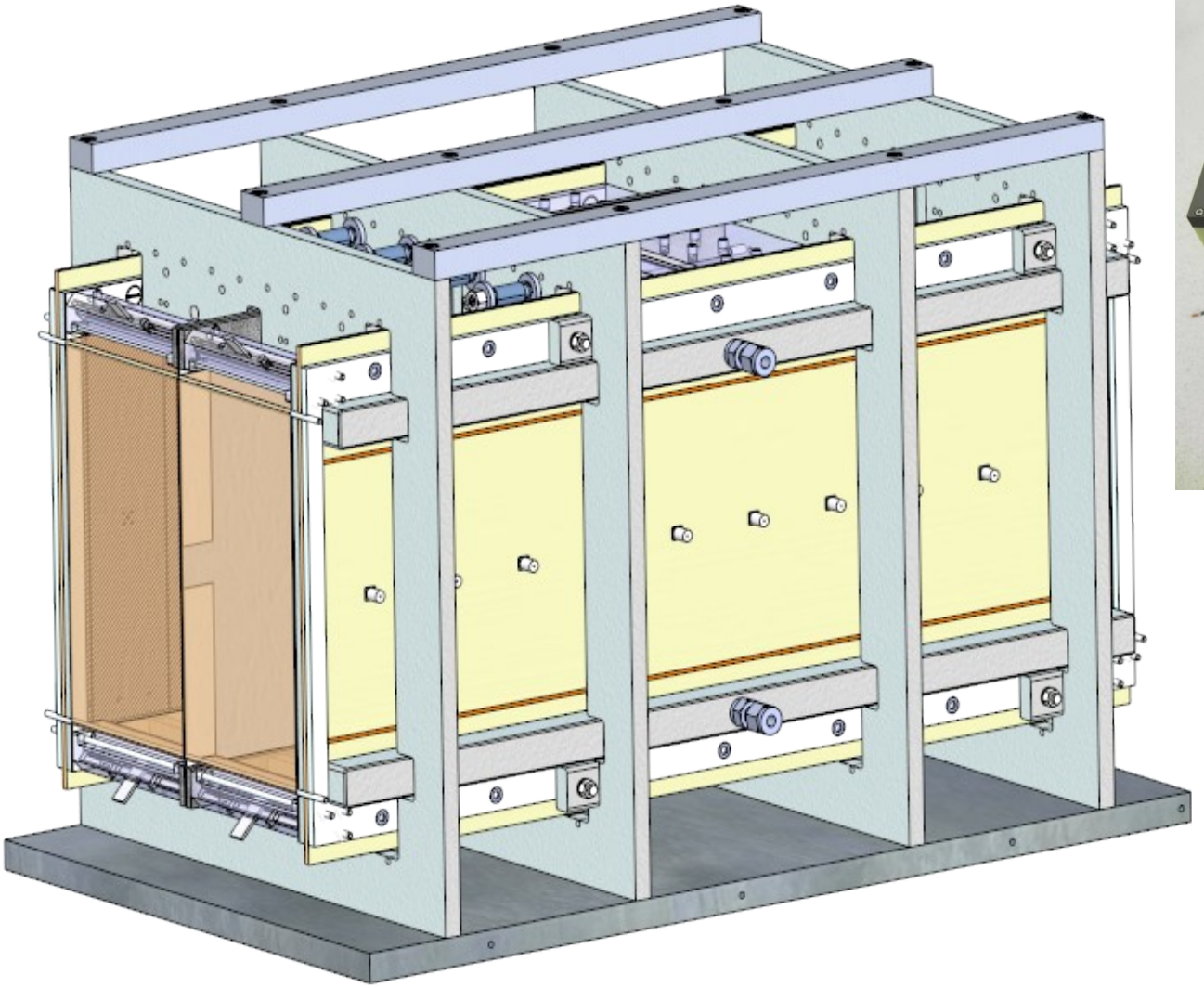
Detector technical : MUSIC

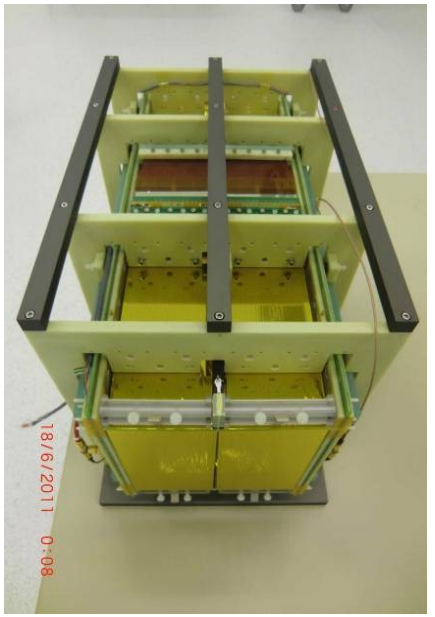
- Twin MUSIC chamber
  - Used to get the Z
  - Used as a high resolution tracker (drift time)
  - Dedicated gas Ne-CO2-CH4 to limit the ang. Str.
- Realised by GSI det. lab.
  - Completed in june 2011

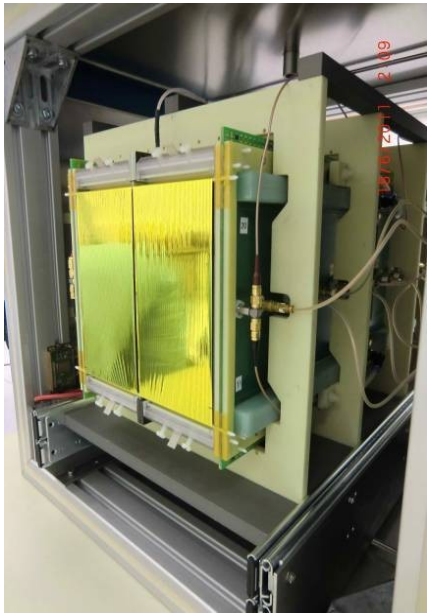
Detector Assembly

Courtesy B. Voss, GSI det. Lab.

Twin MUSIC, inner parts







Courtesy B. Voss, GSI det. Lab.

Twin MUSIC

- Tested in june and september
- Resolution of 3.5%FWHM /anode measured
- BUT Some sparks observed
  - Problem identified and solved in october
- Last test needed for final commisioning of the detector

Active target

Stack of ICs concept

Prototype design and built by CENBG may 2011

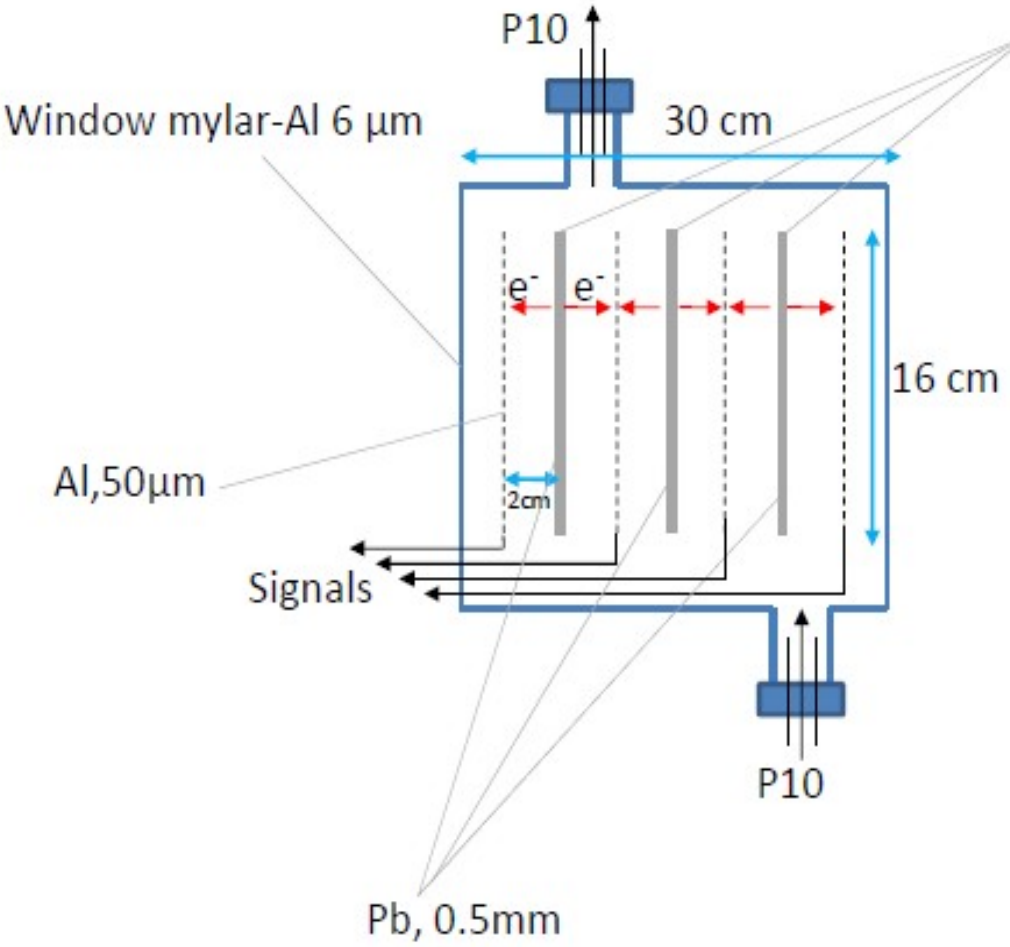
- Only 1 lead foil

Prototype tested in june

- good performance : energy resolution of 8% FWHM

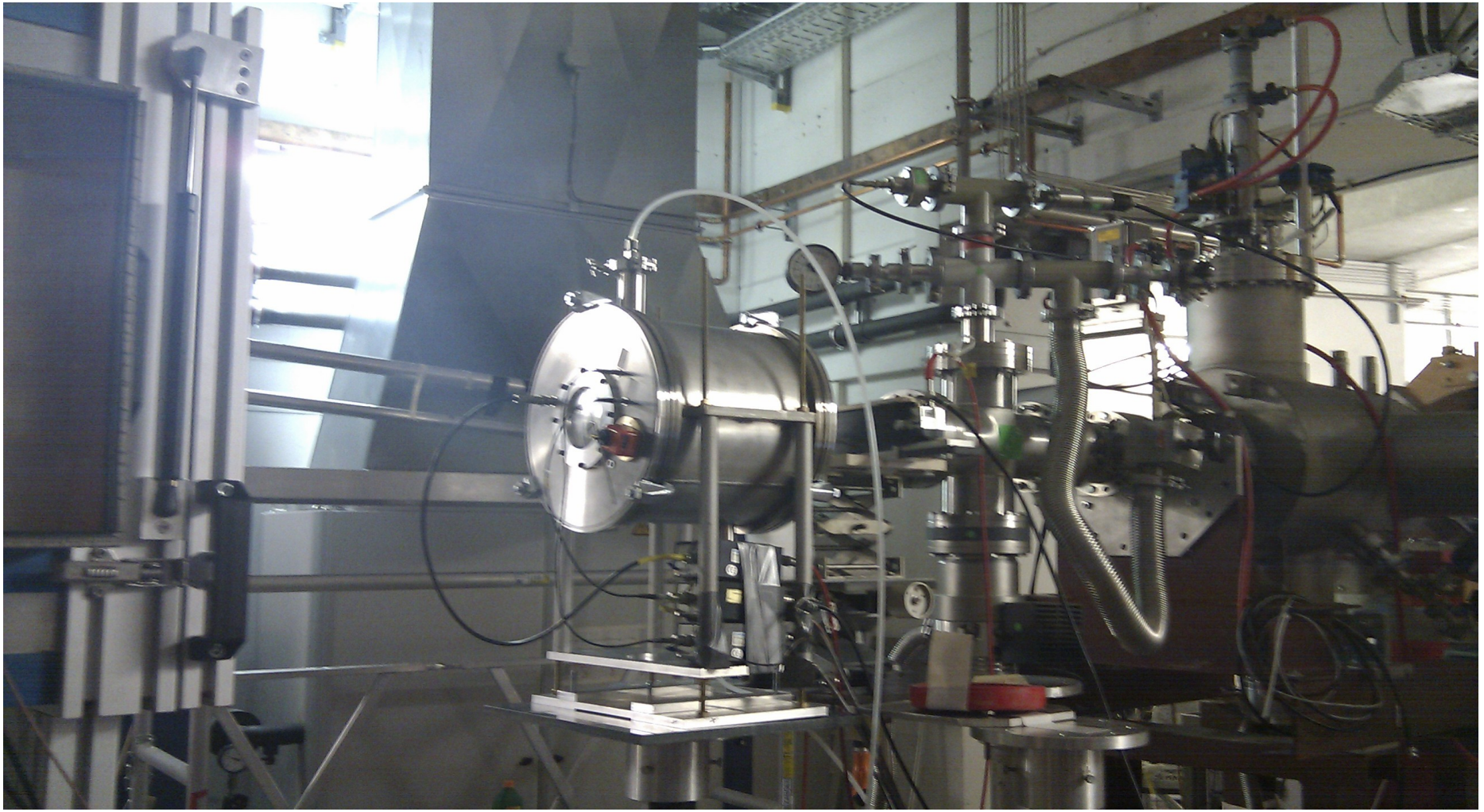
Final multi Pb foil active target built in august

Active target

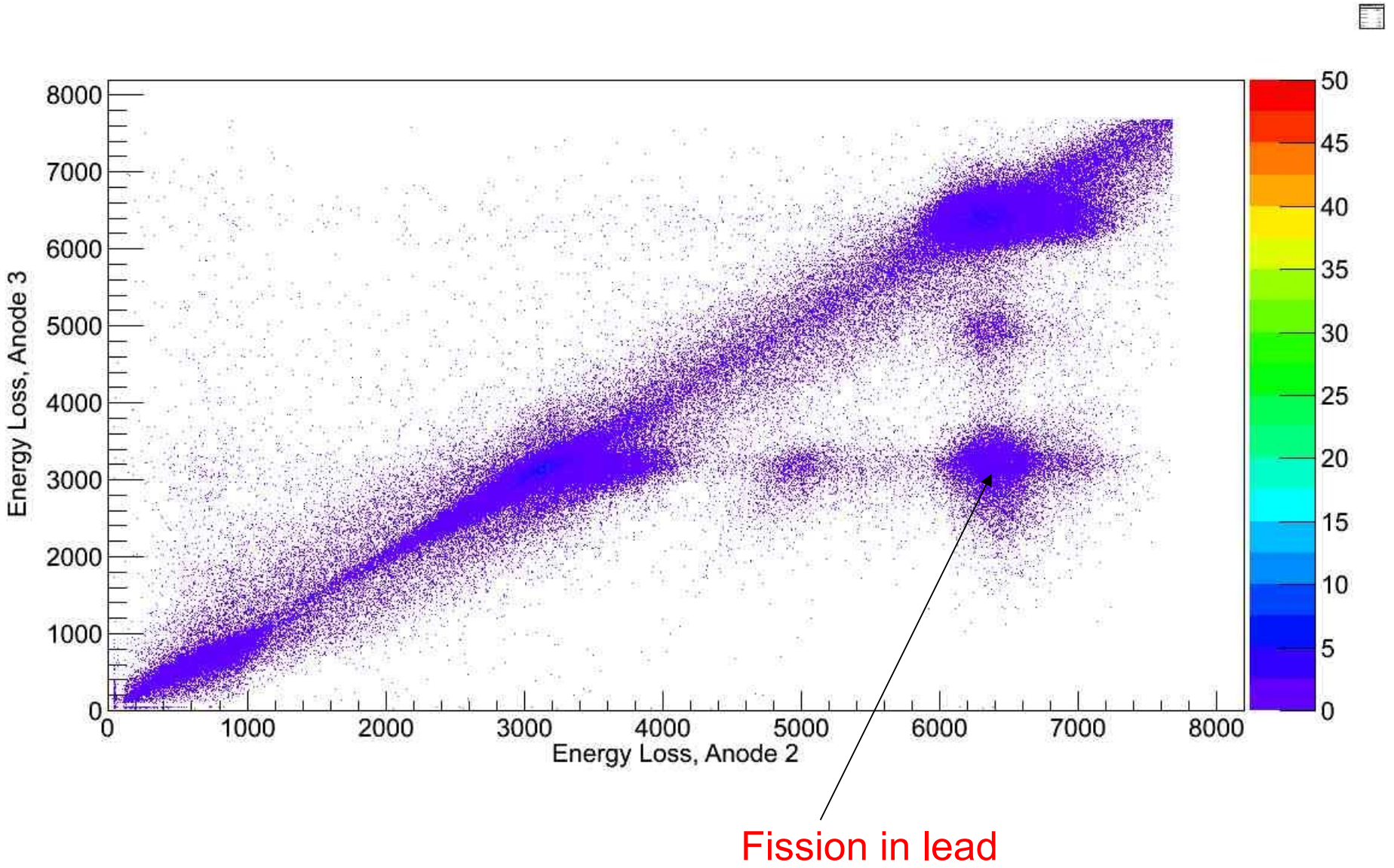


Courtesy B. Jurado, CENBG

Active target prototype



Active target



Active target conclusion

- Detectors fully commissioned
- Ready to operate

Summary

- SOFIA is on good tracks
- Most detectors are ready
- Some needs a final validation
- We will be ready to run once a last test run will be completed