Tracking of low energy heavy ions

Two applications in nuclear physics

- Upstream beam tracking at medium energy (>10MeV/u)
- Downstream reaction product tracking at low energy (<1MeV/u)
- Event by event detection

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Application : Upstream Tracking

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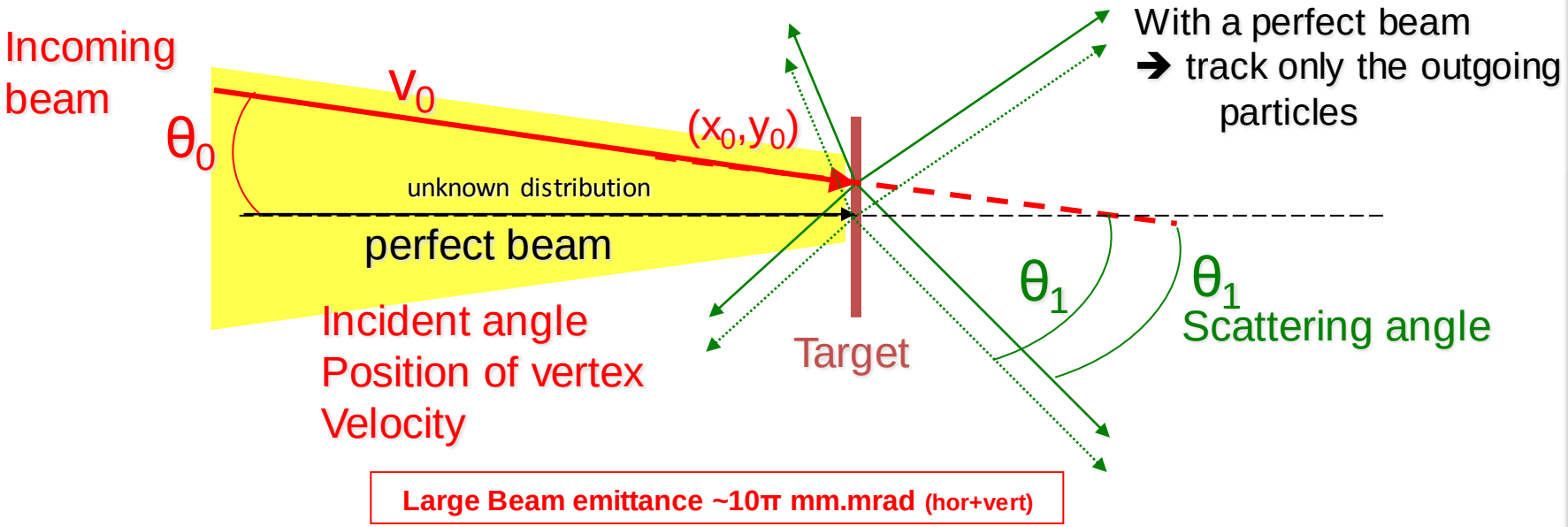
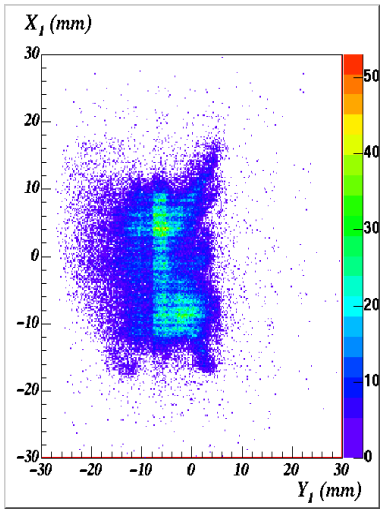
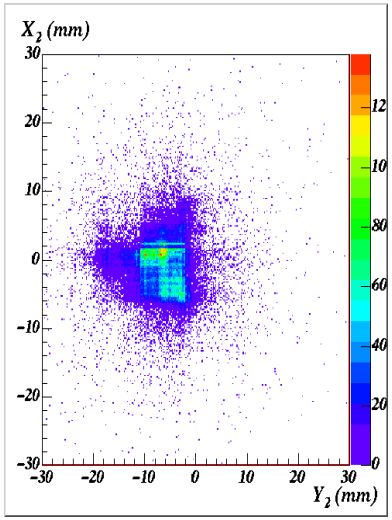


Large Beam emittance ~10π mm.mrad (hor+vert)

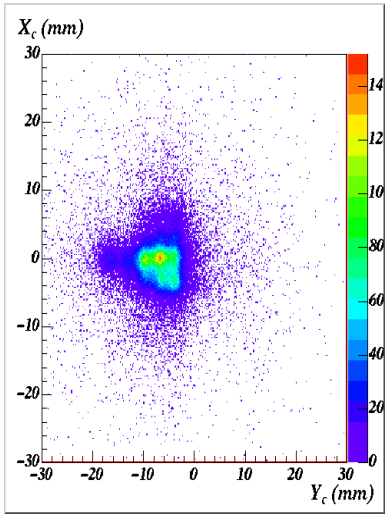
1.5m upstream



0.5m upstream



On target



Effects on kinematics reconstruction

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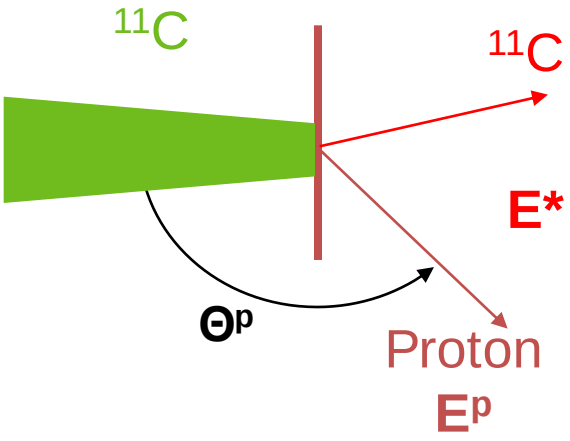
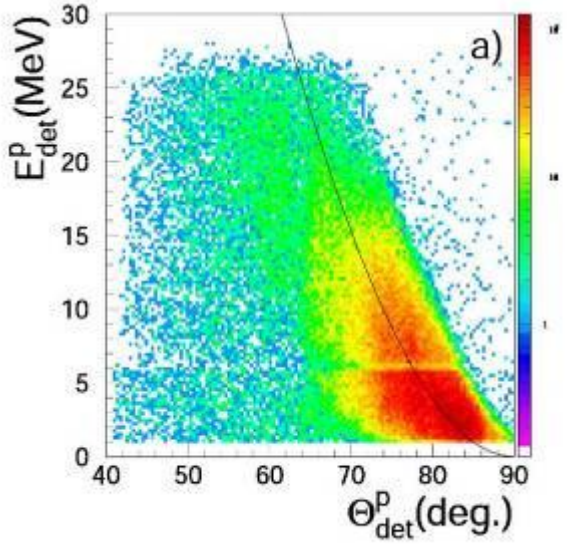
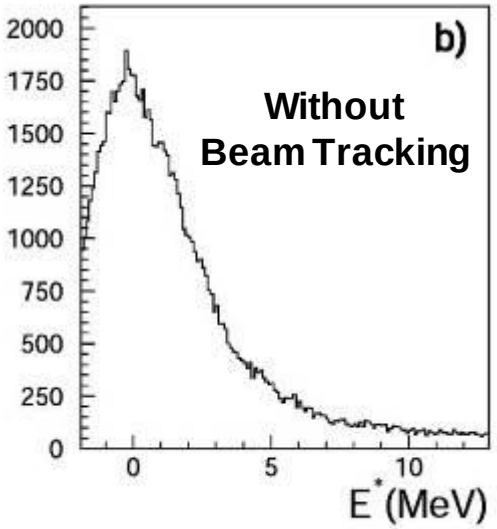
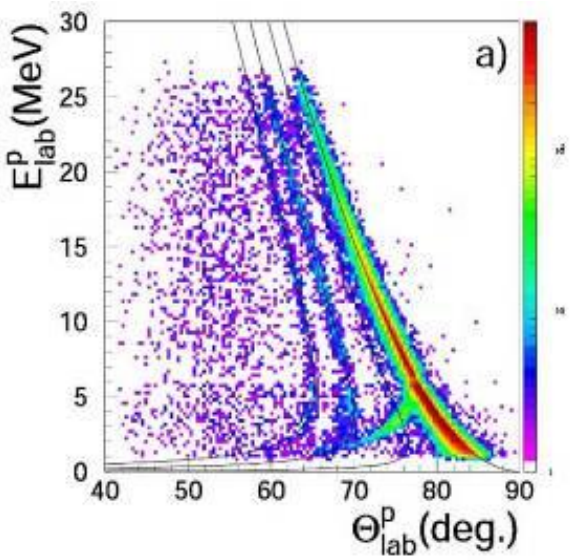
$^{11}C+p \rightarrow {}^{11}C+p'$ 40.6 MeV/u

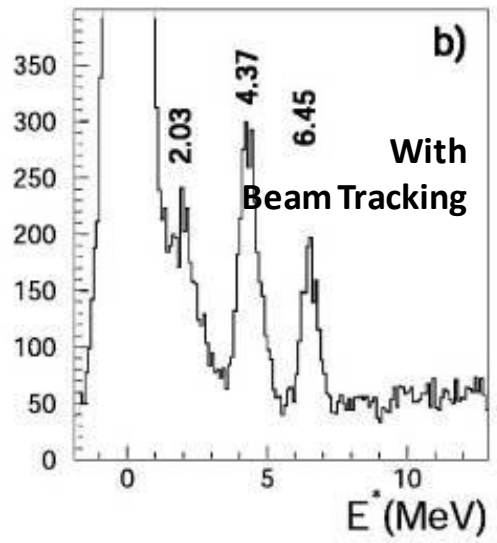
C. JOUANNE (SPHN) PHD 2002











Experimental set-up: CATS + MUST2

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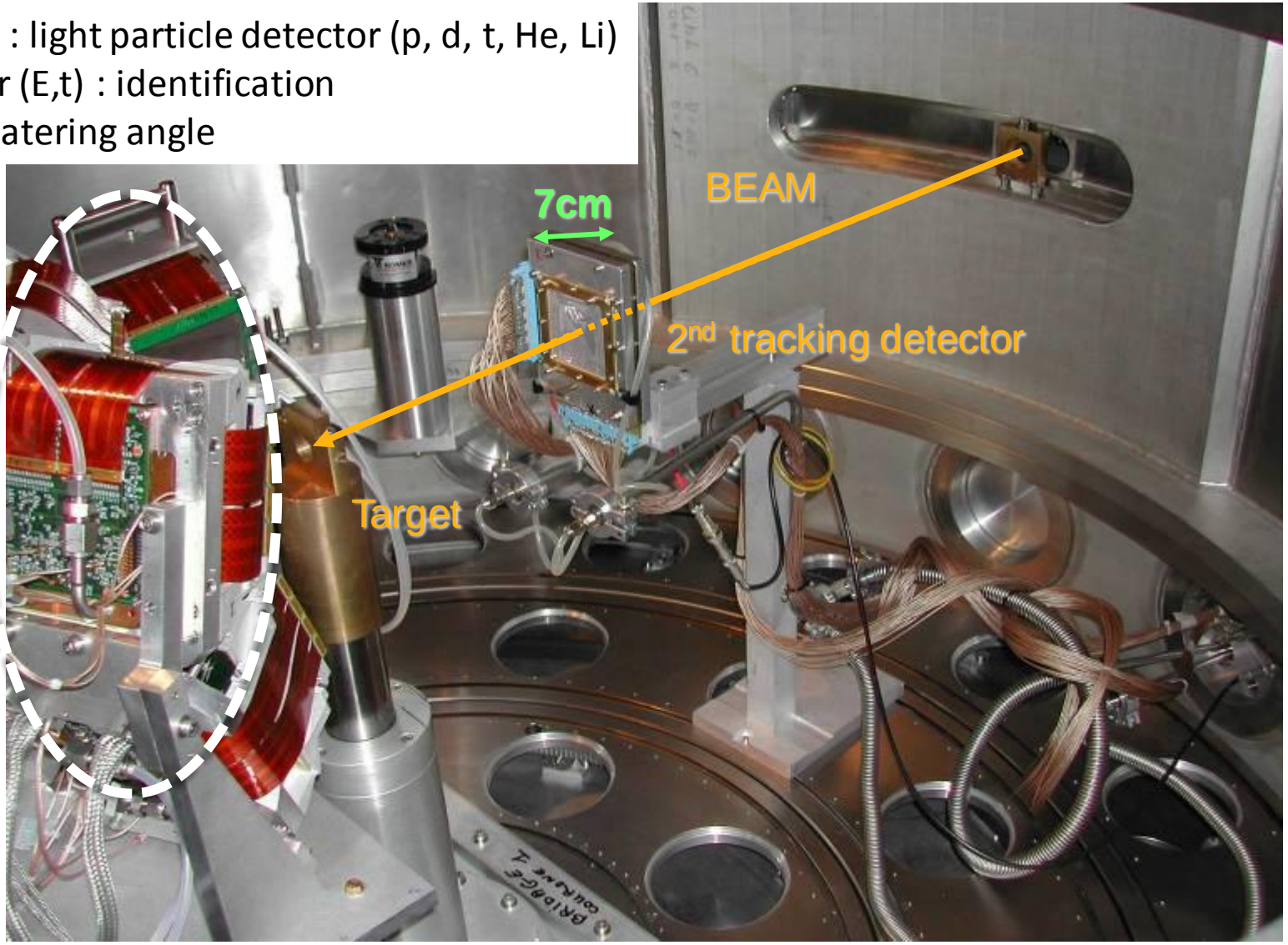
MUST 2 : light particle detector (p, d, t, He, Li)
(ΔE,E) or (E,t) : identification
(x,y) : scatering angle



The CATS Beam Tracking Detectors

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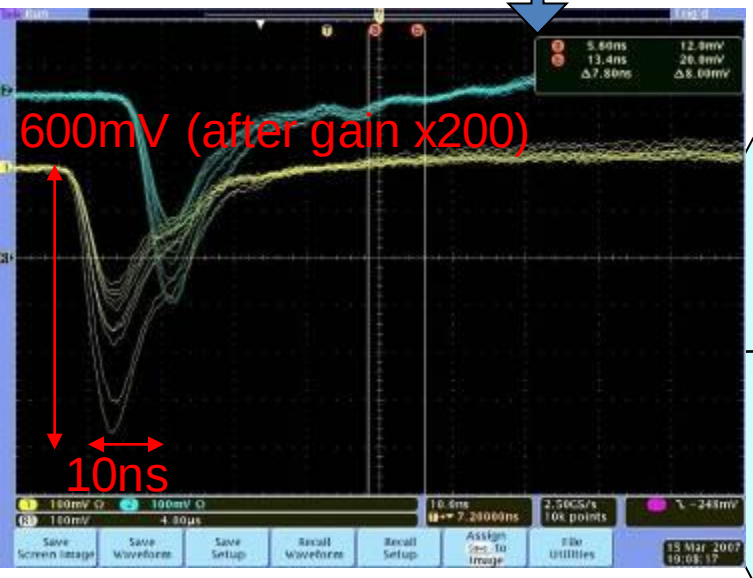
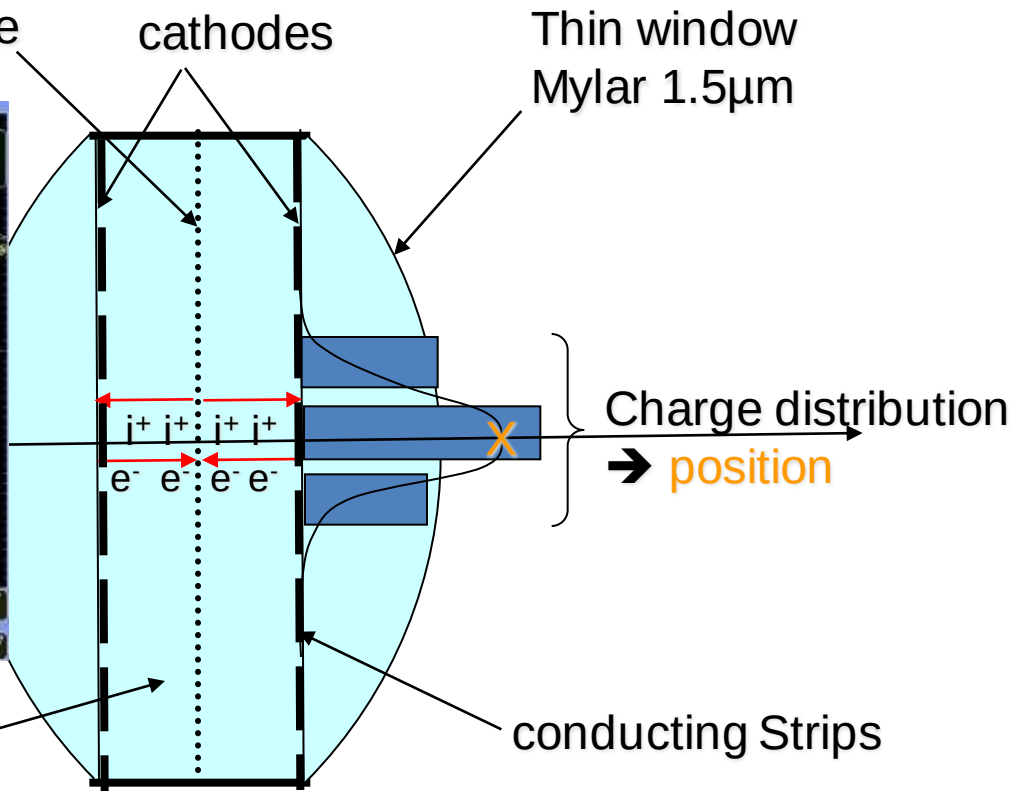
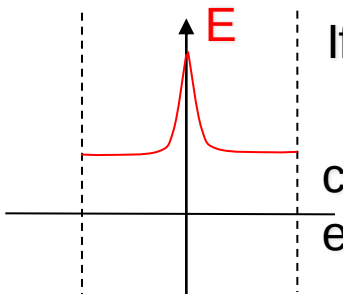
Low Pressure gas detector





Low pressure (P=4-10 Torr)
gas: CF_4, C_3F_8, iC_4H_{10}



If E/P high enough ➔ avalanche
(>100V/cm/Torr) ➔ amplification

charge movement ➔ induced signal
electrons are rapid ➔ fast signal

Basic CATS/BTD mechanics

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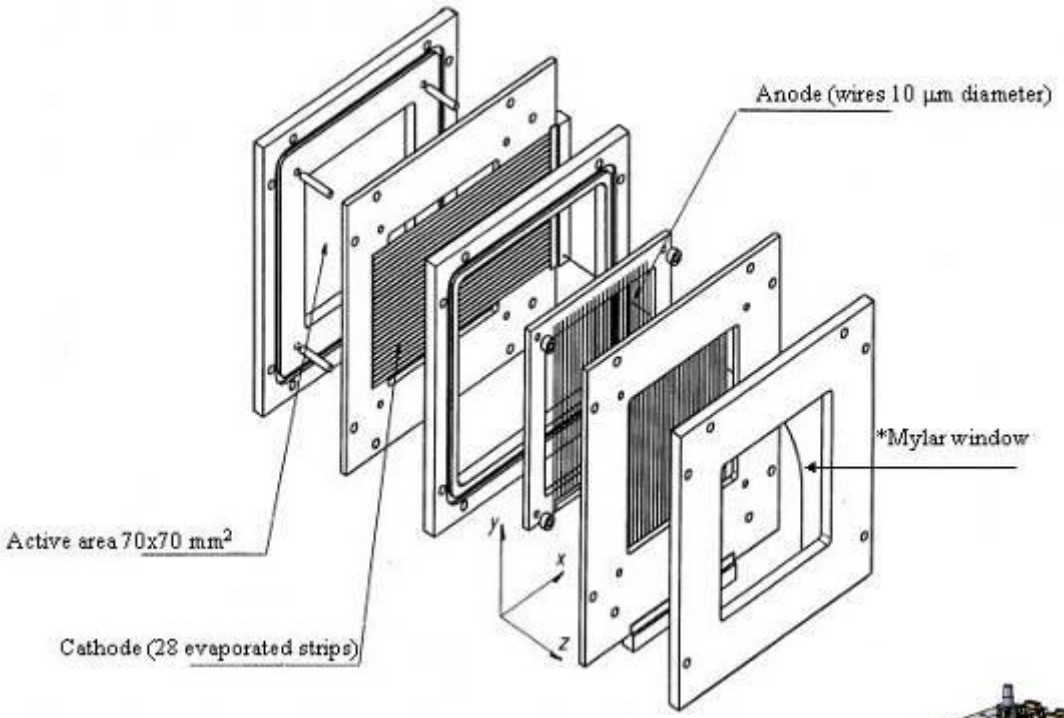

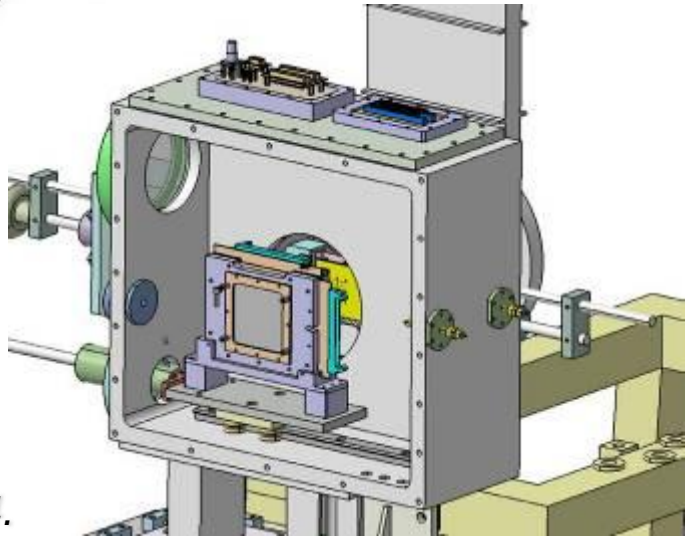

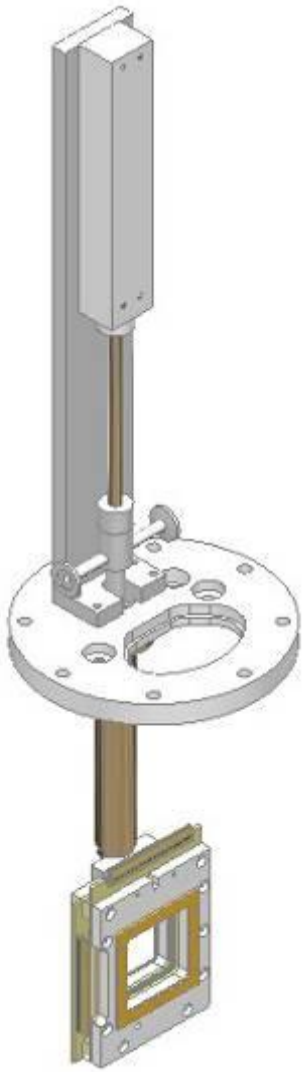

Active area: 7x7cm²
iC_4H_{10} @ 6Torr
2x28 strips on cathodes
1 fast anode signal

Ottini & al., NIM A, 431(1999) p. 476-484.

Virtues & Flaws of Low pressure detectors

☺

- fast signal ➔ good time resolution σ = 100ps
- good position resolution σ = 100µm
- high detection efficiency (~100%)
- large size available (>100cm^2)
- cheap and can be repaired
- Thin : ~5µm of Mylar (from windows and cathodes)

☹

- vulnerable to discharge : rate < 10^6pps
- 1.5µm windows required ➔ E_{ion} > 10MeV/u
- fragile and delicate to use

Application : Downstream Tracking

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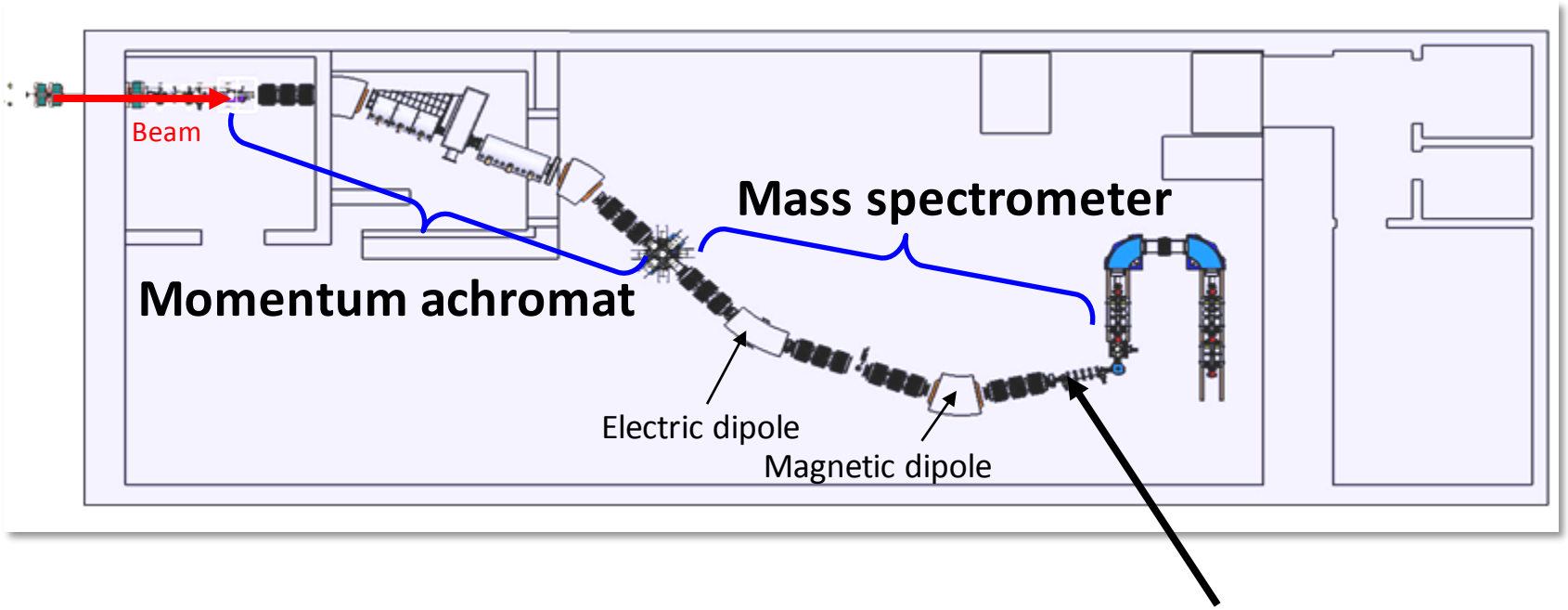
The Super Separator Spectrometer S^3

- Selection and transmission of low energy fusion-evaporation residues

➔ In flight mass measurement



Very low Energy regime <1MeV/u

Mass Dispersive Focal plane

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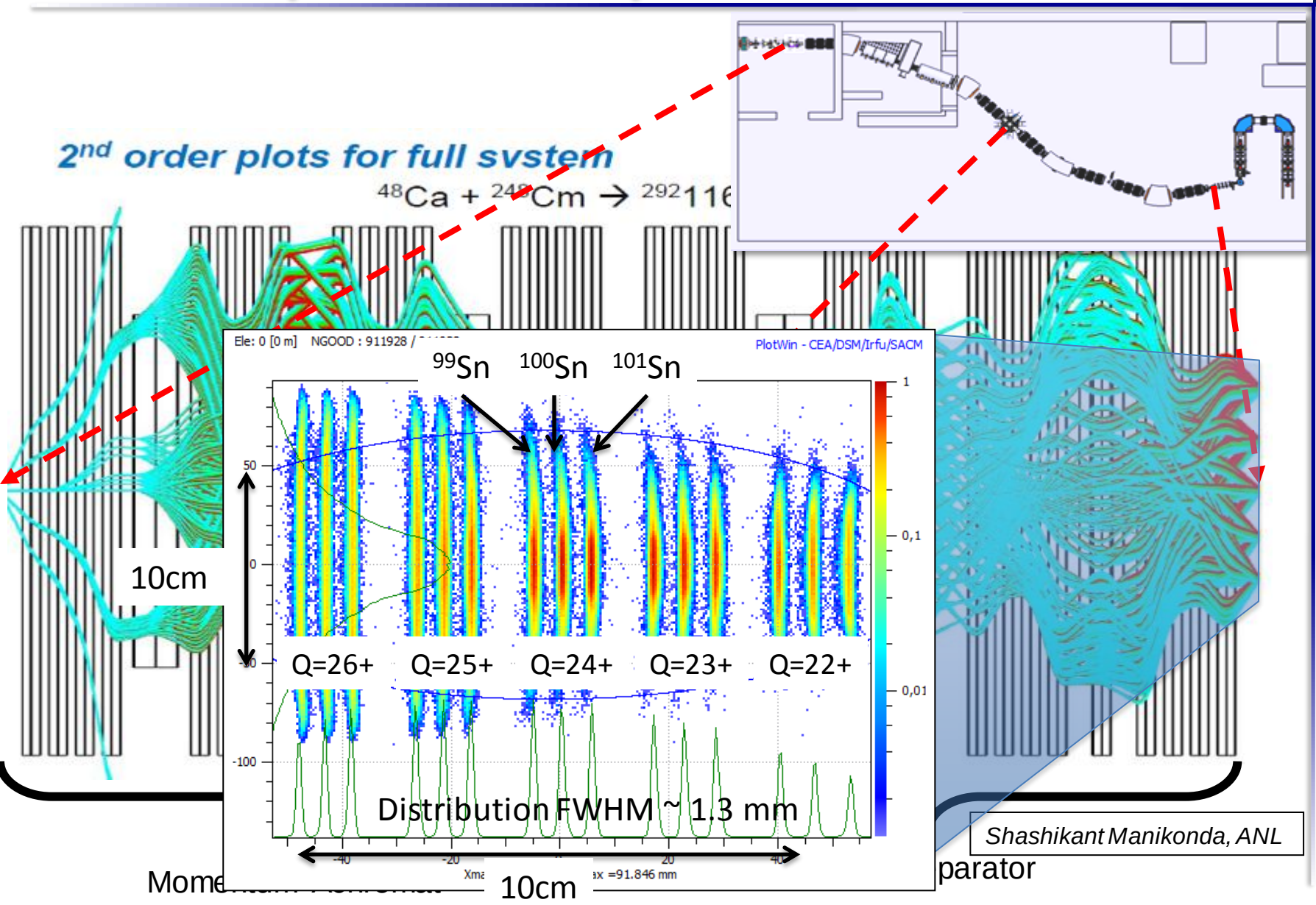
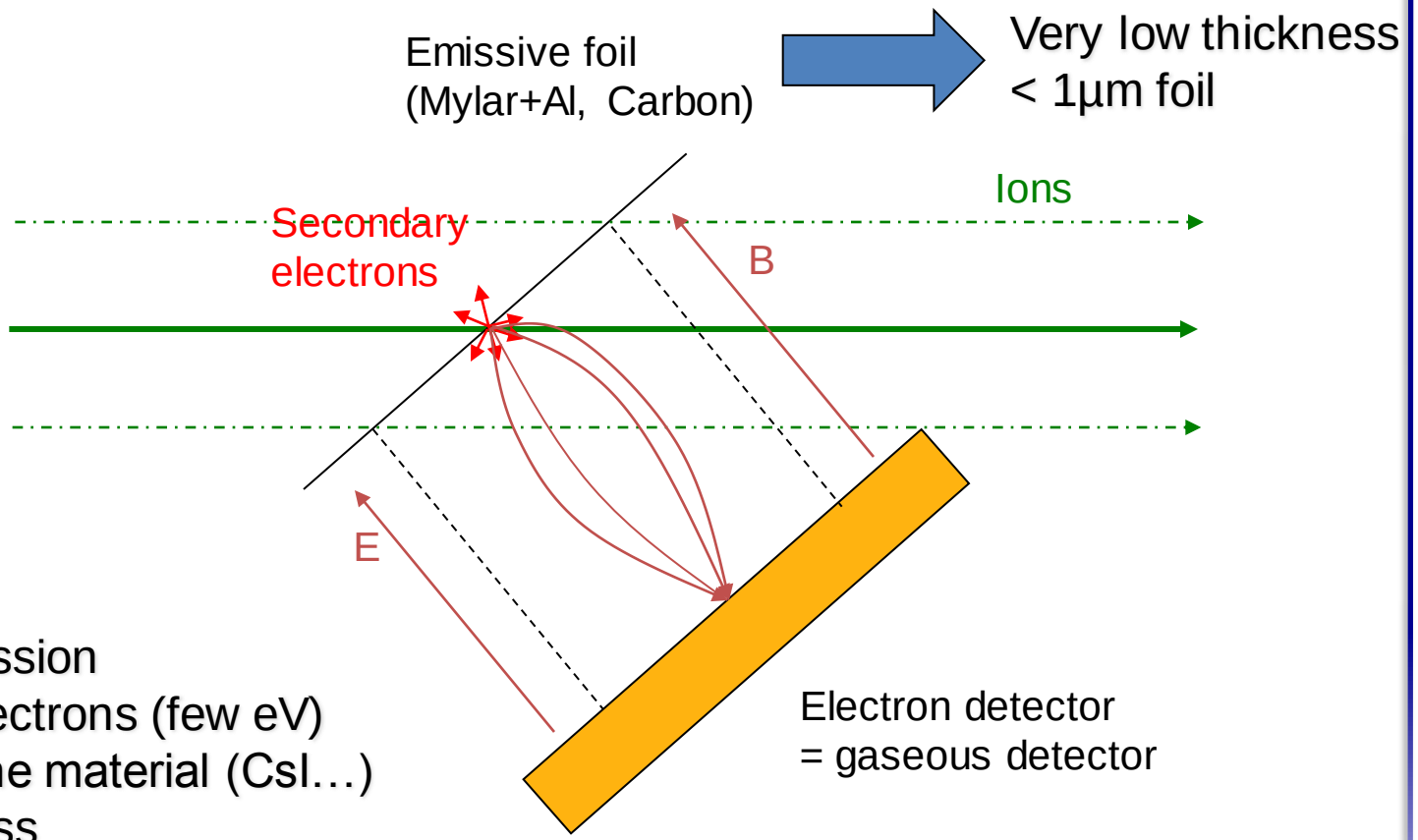
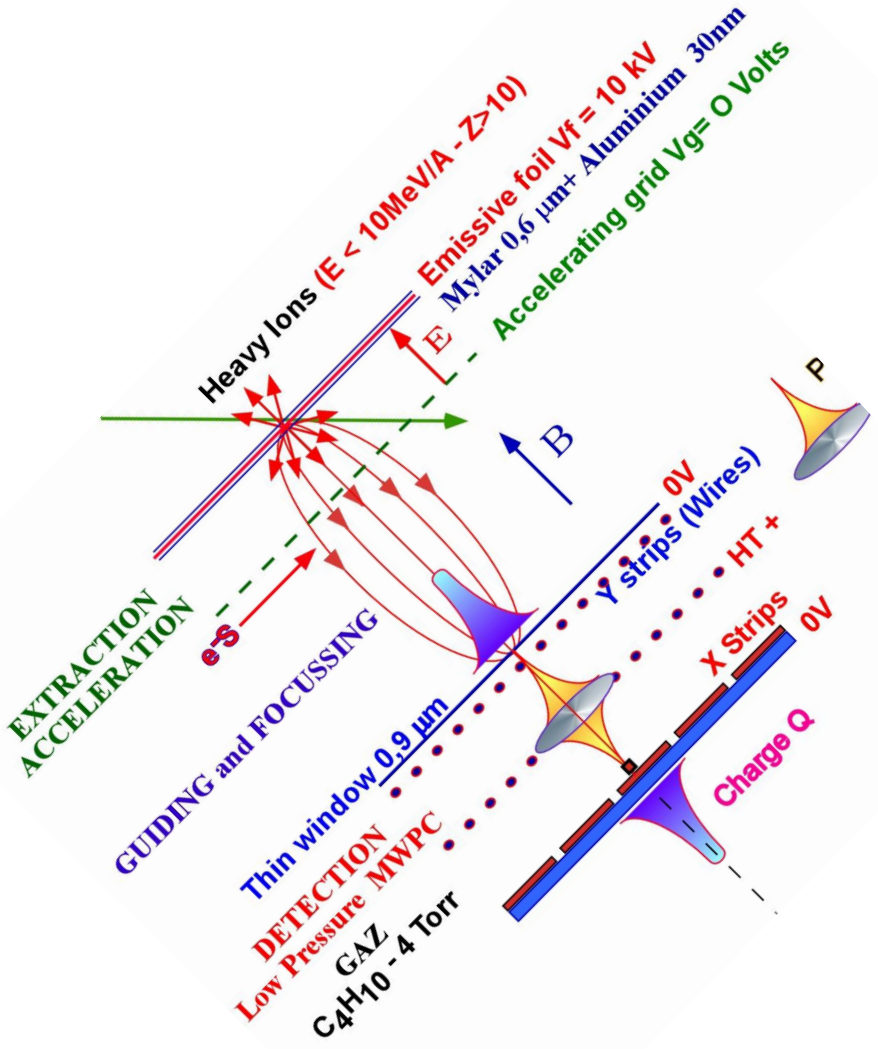


Emissive foil detector



Secondary emission
- low energy electrons (few eV)
- depends on the material (CsI…)
- surface process
- proportional to dE/dx

The Se-D : Secondary electron Detector



The Se-D : Secondary electron Detector

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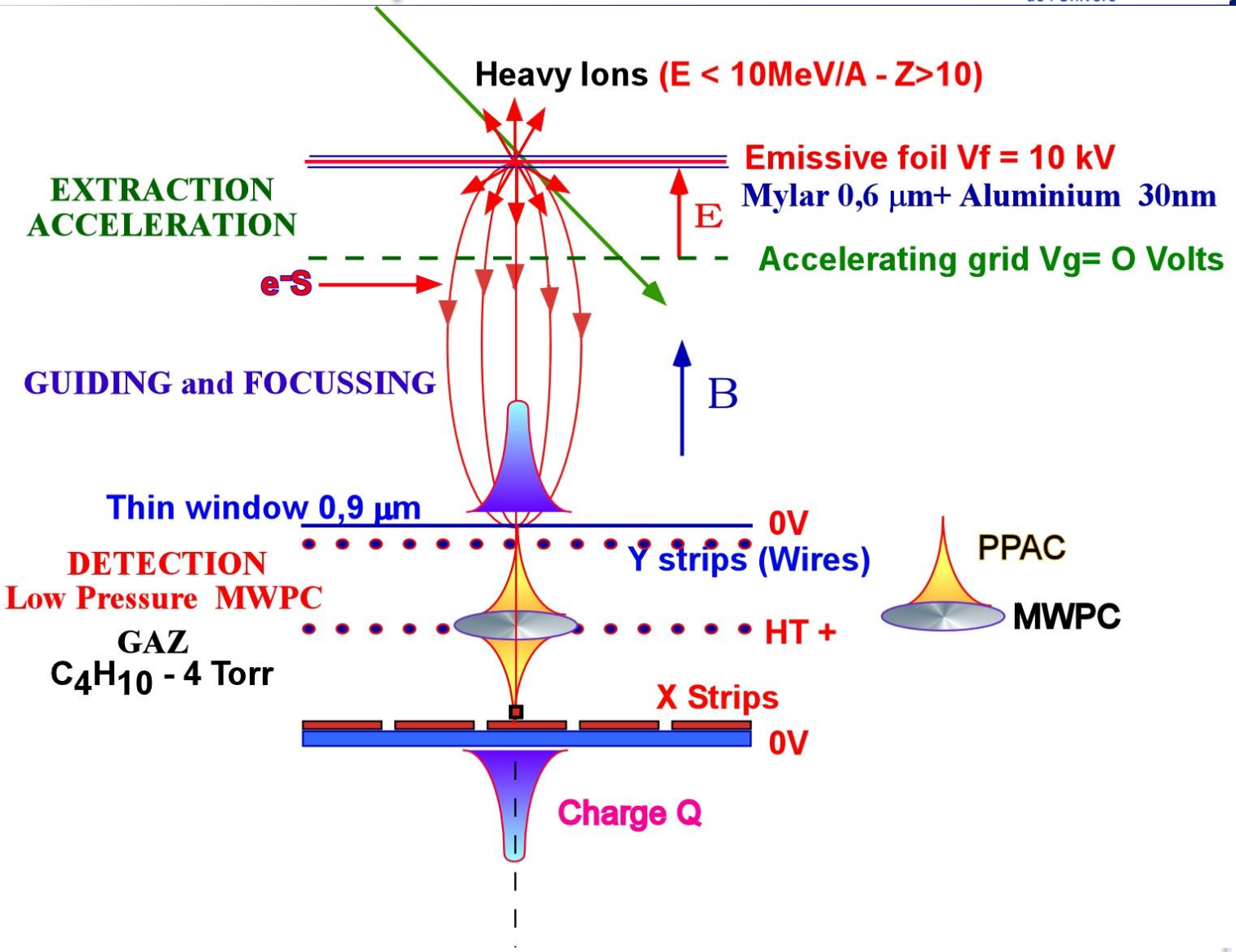
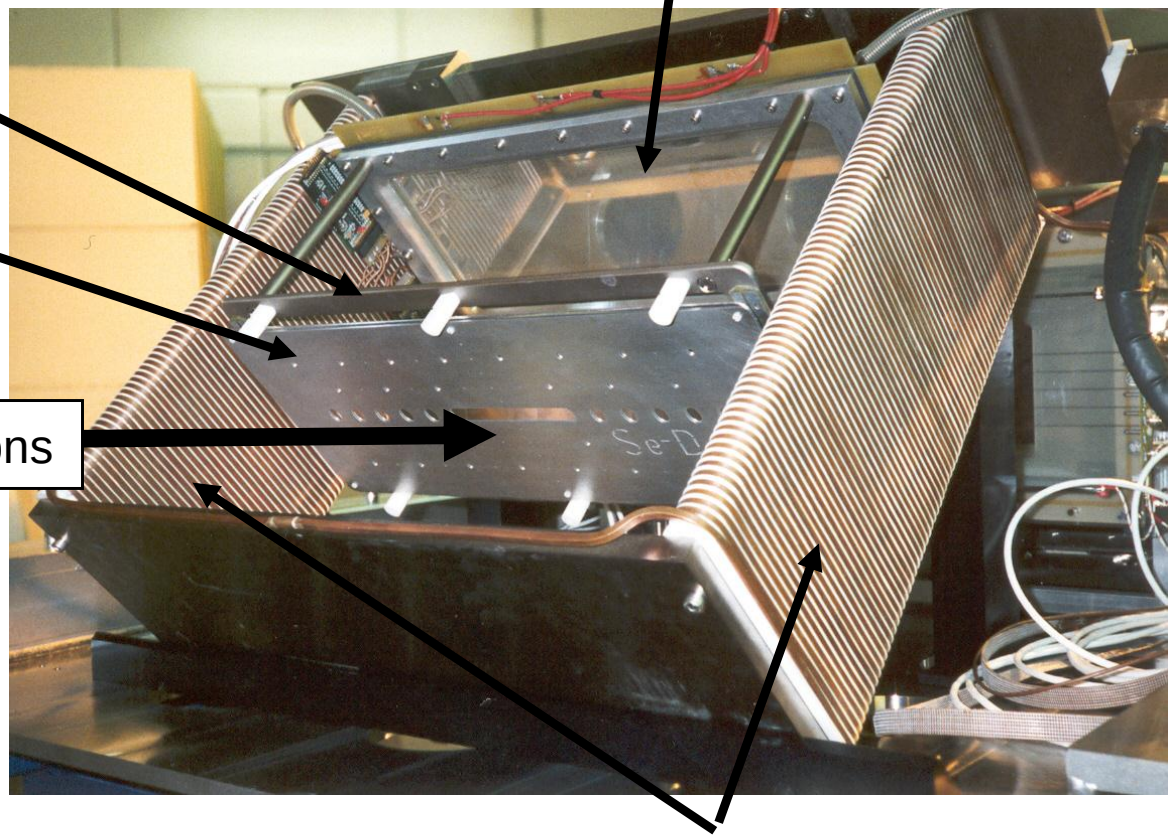


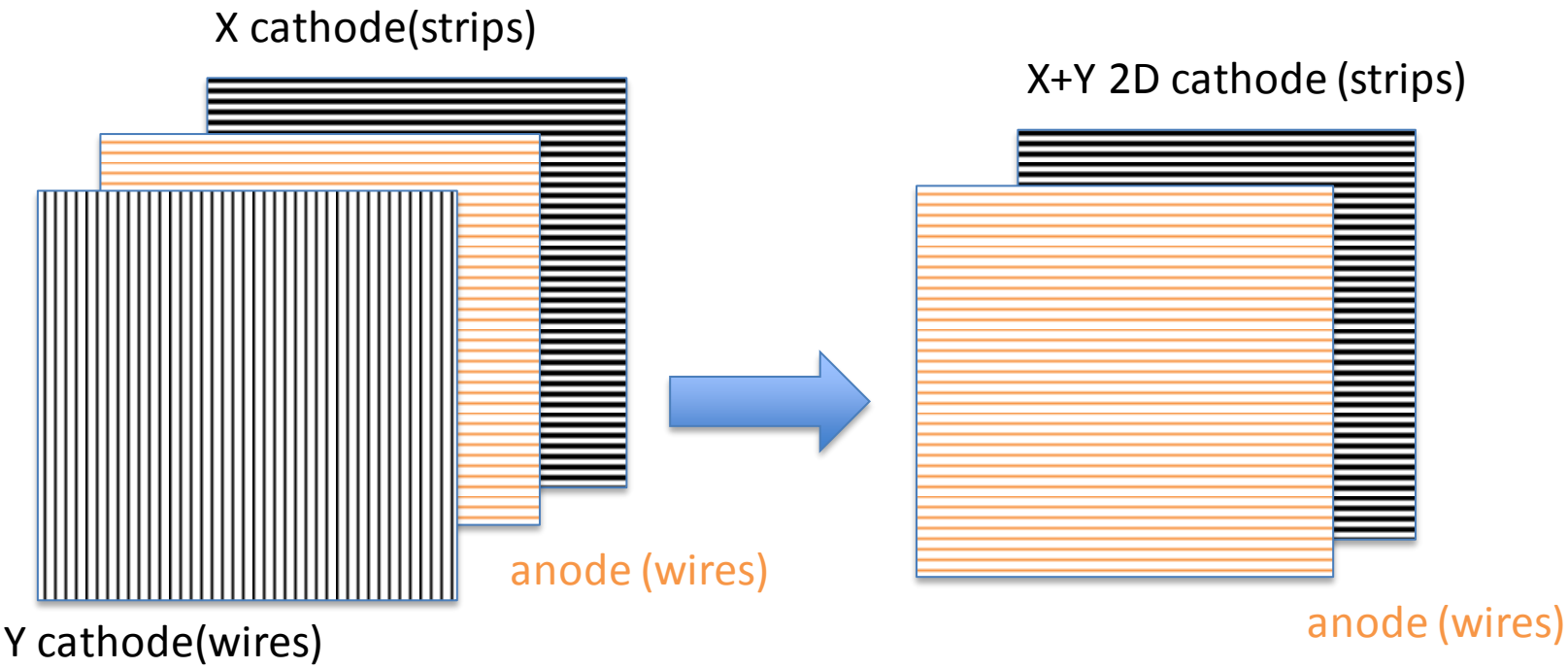
Existing Se-D Detector



- <1µm of Mylar
- σ_{time} ~ 100ps
- σ_{space} ~ 600µm

VAMOS Spectometer Focal plane size : 10 x 40 cm^2

Se-D with one 2D cathode



- similar time resolution σ_{time} ~ 100ps
- more robust
- higher counting rate : up to 2.10^6pps

New Prototype for S^3

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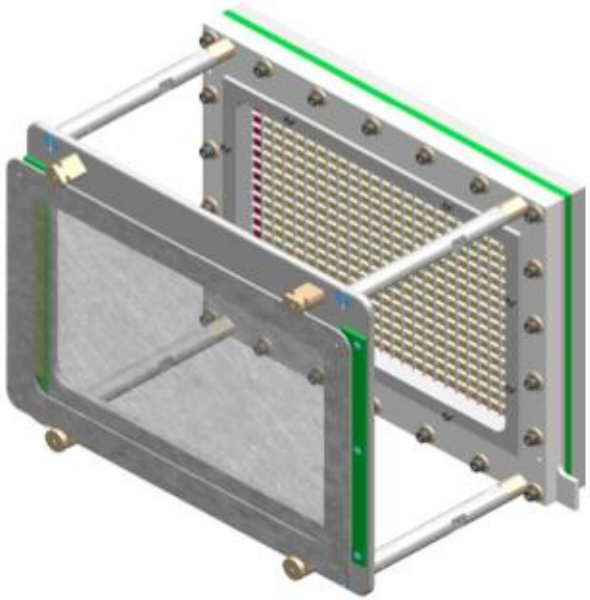

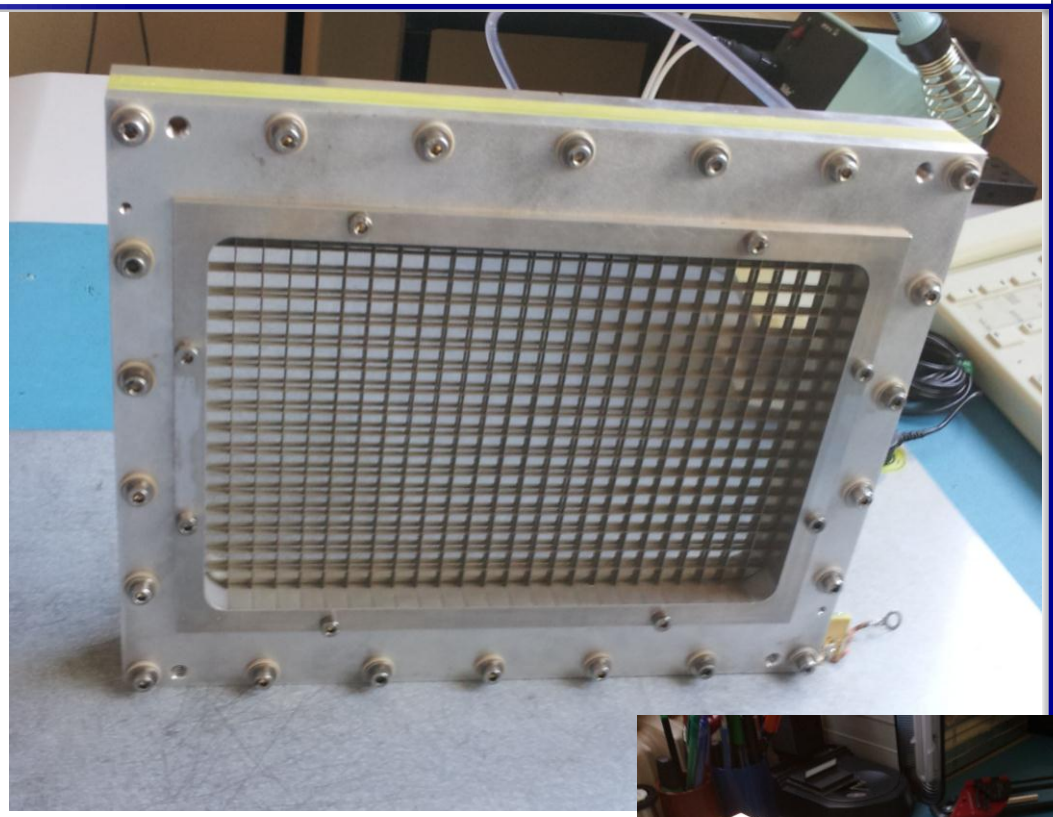

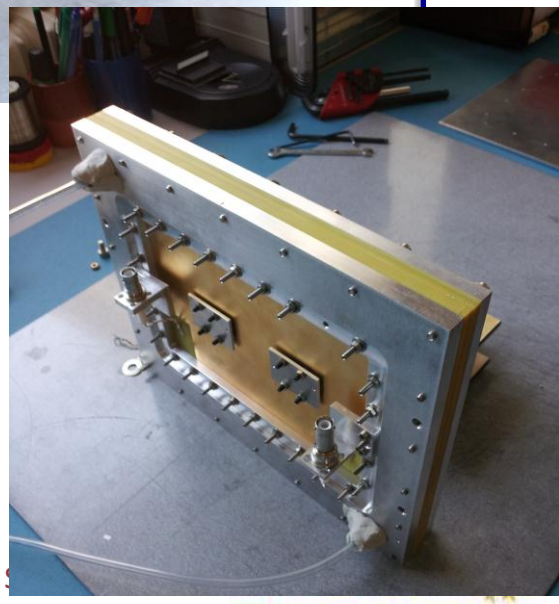

SED2D sym. chamber of 201x138 mm2 or 68x47 1D strips

- Mounted since sept 2011, time resolution on-going
- AFTER-SED ASIC to connect
- Spatial resolution to be done

Conclusions & Perspectives

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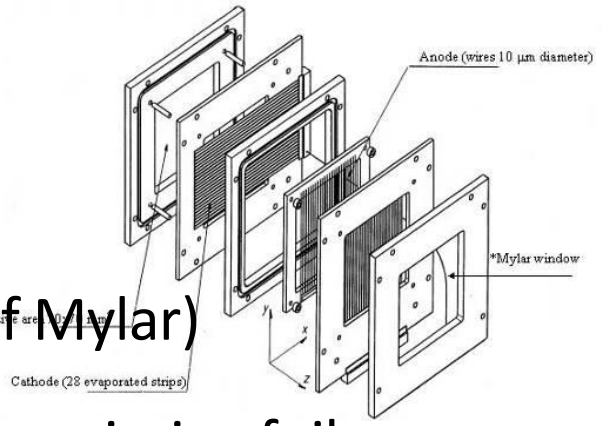
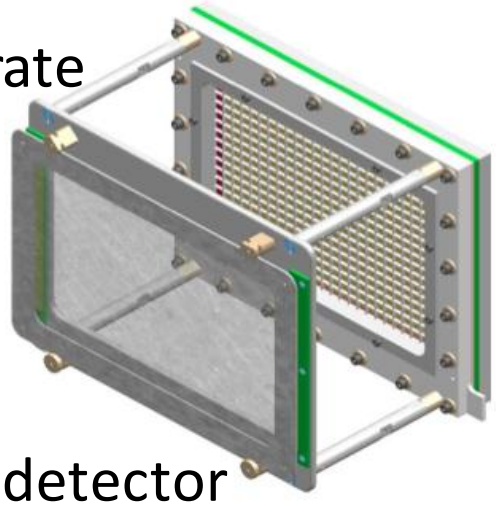
Upstream Beam Detectors: MWPC
good time and position resolution
BUT
Limited counting rate + not so thin (5µm of Mylar)



Downstream reaction product detectors: emissive foil
MWPC as 1st generation ➔ 2D cathode place
good time resolution, very thin, high couting rate
BUT
poor position resolution σ_{space} ~ 600µm



To come
- improve position resolution of emissive foil detector
- test of other secondary electron detector : Micromegas

➔ use emissive foil detectors for upstream applications

Collaboration

People involved at CNA, GANIL and CEA/IRFU

Technical support & Engineering: T. Chaminade, F. Druillole, E. Monmarthe (IRFU) M. Kebbiri (IRFU), S. Damoy (GANIL), M. Riallot (IRFU), G. Fremont (GANIL)

Scientific coordinator : M. Alvarez (CNA), H. Savajols, E. Clement, F. Farget (GANIL), A. Drouart, D. Doré, T. Materna (IRFU)

Technical coordinator and analysis : B. Fernandez (CNA) , J. Pancin (GANIL), T. Papaevangleou (IRFU)

And the others

Thank you for your Attention