Short overview of LIP-Coimbra activity in view of

1 - RPCs for time-tagged tracking

and

2 - GEMs for high sensitivity L-Xe experiments

1 – RPCs: Commitments within RD51

WG2 - COMMON CHARACTERIZATION AND PHYSICS ISSUES

1) **Generic aging and material radiation-hardness studies**

WG3 - APPLICATIONS + **WG4** – SIMULATIONS S/W TOOLS

1) **MPGD based RPCs for tracking and ToF**
2) **Medical applications**

1 - RPCs for time-tagged tracking

... Long list of authors (see next slide)

Early work (ALICE TOF, 1999)

1.1 – Timing RPC (tRPC)

Developments

1.2 – Larger and still fast

1.3 – High count-rate (CBM)

1.4 – HADES ToF wall

1.5 – Localization capability

1.6 – Small animal PET

Goal within RD51

1.7 – Pixelized RPC TOF tracker (the concept)

RPC work teams

HADES-RPC group

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RPC-PET team

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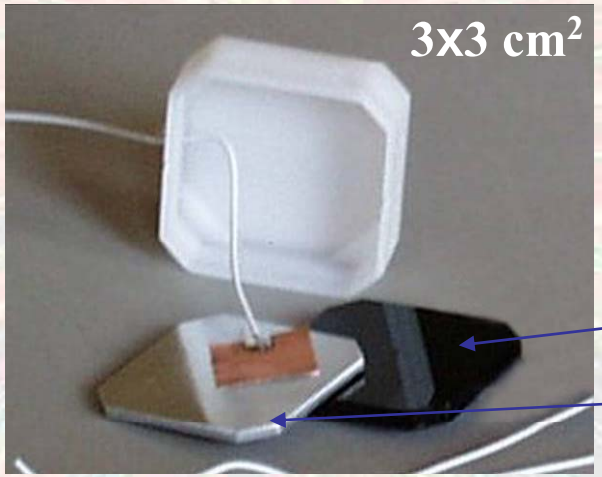
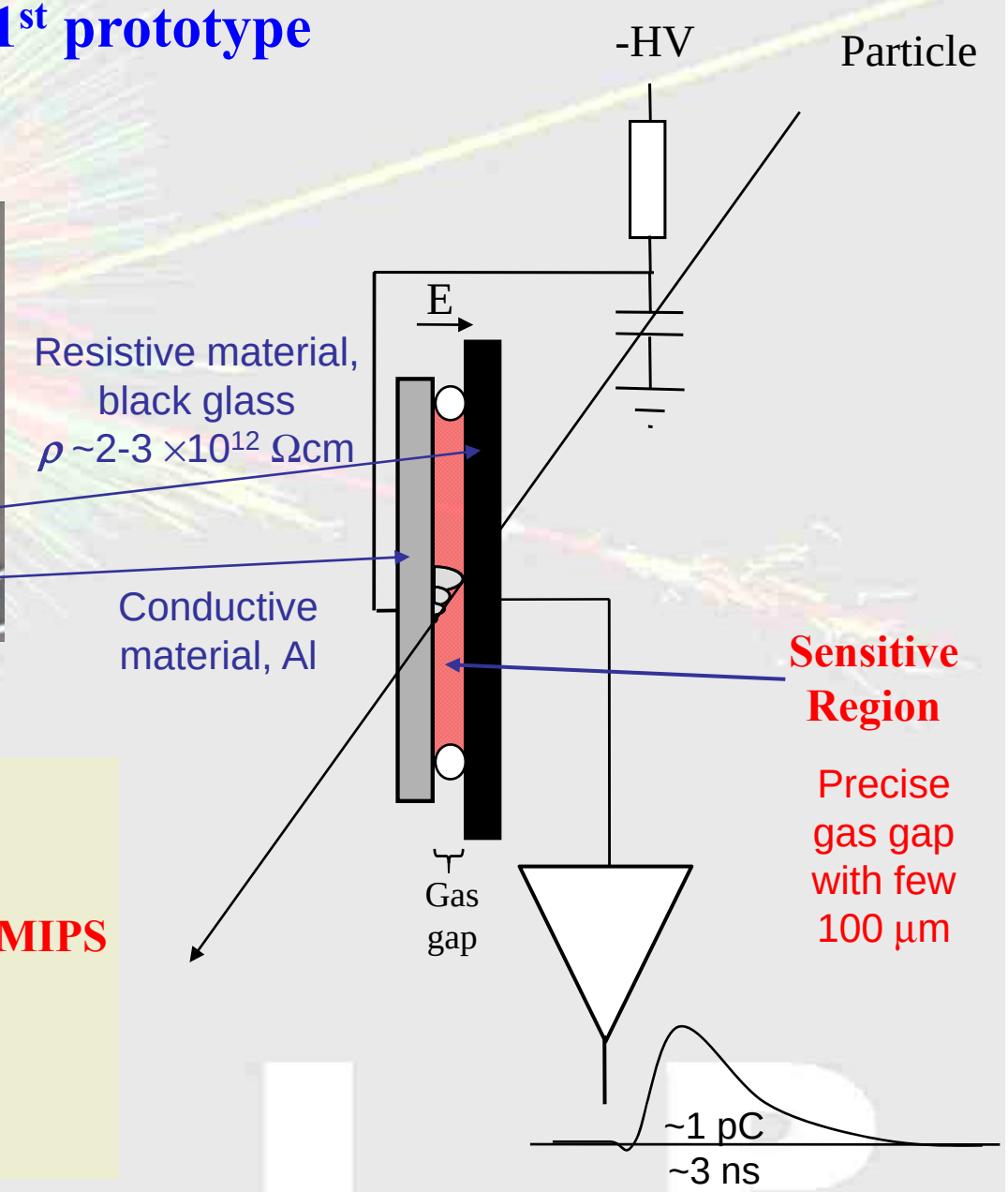
1.1 Timing RPC (tRPC) – the 1st prototype





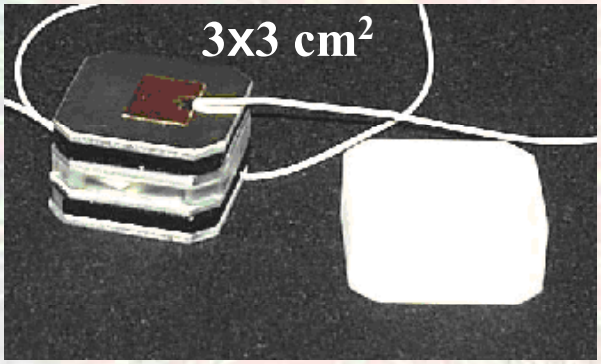
Main features

- **Timing resolution ~ 50 ps σ.**
- **Efficiency 75% for a 300 µm gap**

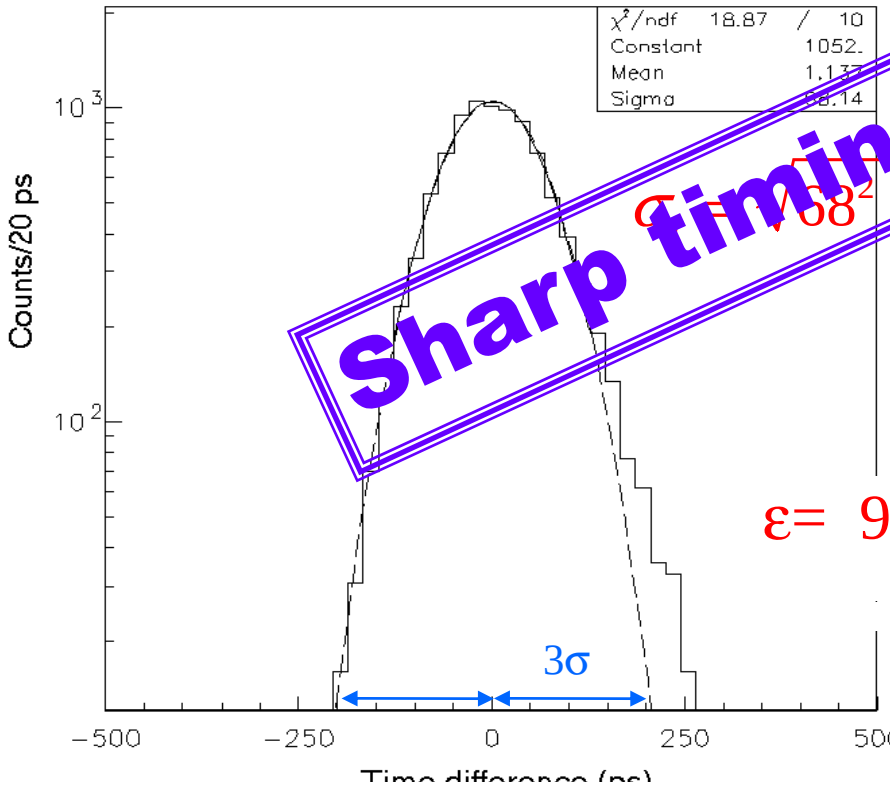
} **MIPS**

- No energy resolution.
- Possibility to measure the position.

1.1 Timing RPC (tRPC) – the 1st prototype



[Fonte 2000]

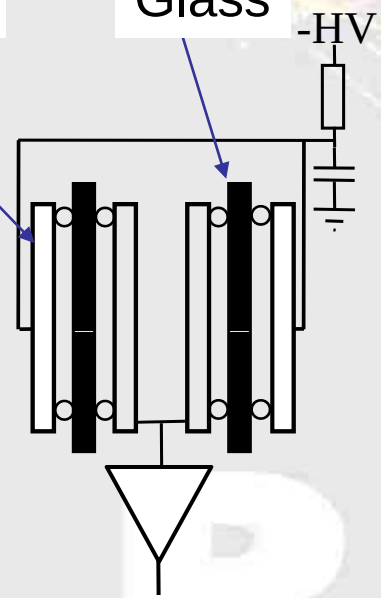


Sharp timing but small

$\sigma = \sqrt{68^2 - 49^2} = 47\ ps$

Resolution of the reference counter

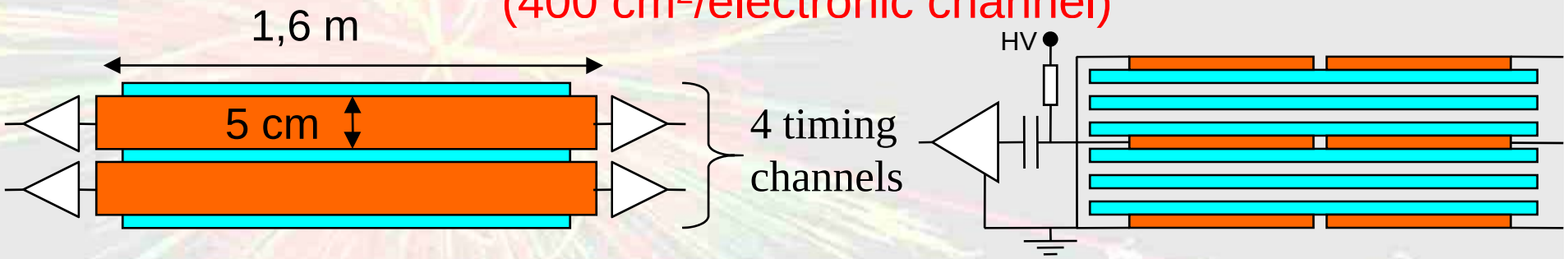
ε= 99.5 % for MIPs (75%/gap)



(optimum operating point ⇒ 1% of discharges)

1.2 - 2nd prototype: a large counter

Active area = 10 cm×160 cm = 0.16 m²
(400 cm²/electronic channel)



Top view

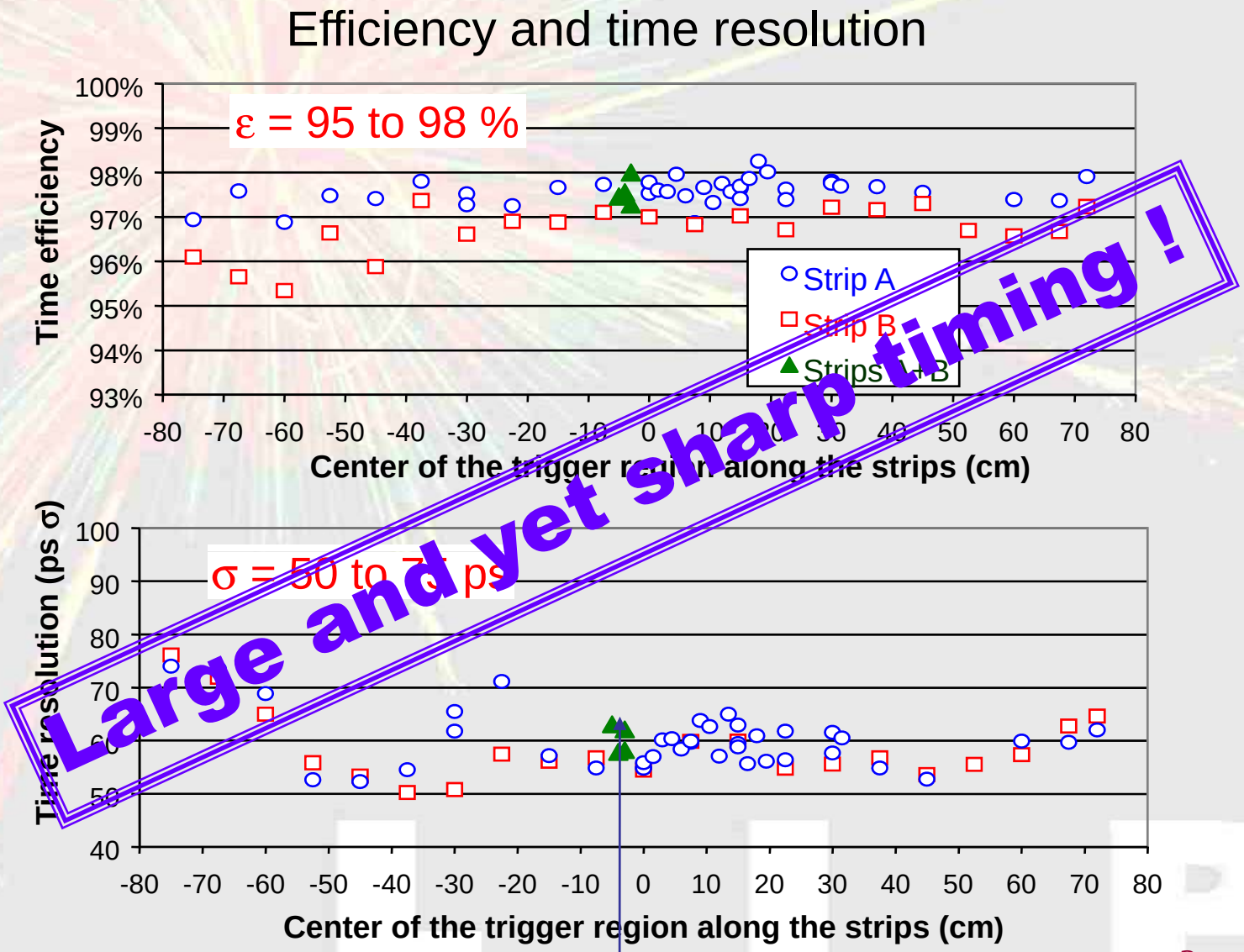
Cross section

Ordinary 3 mm
"window glass"
ρ ~8×10^{12} Ωcm

Copperstrips

[Blanco 2001]

1.2 - 2nd prototype: a large counter

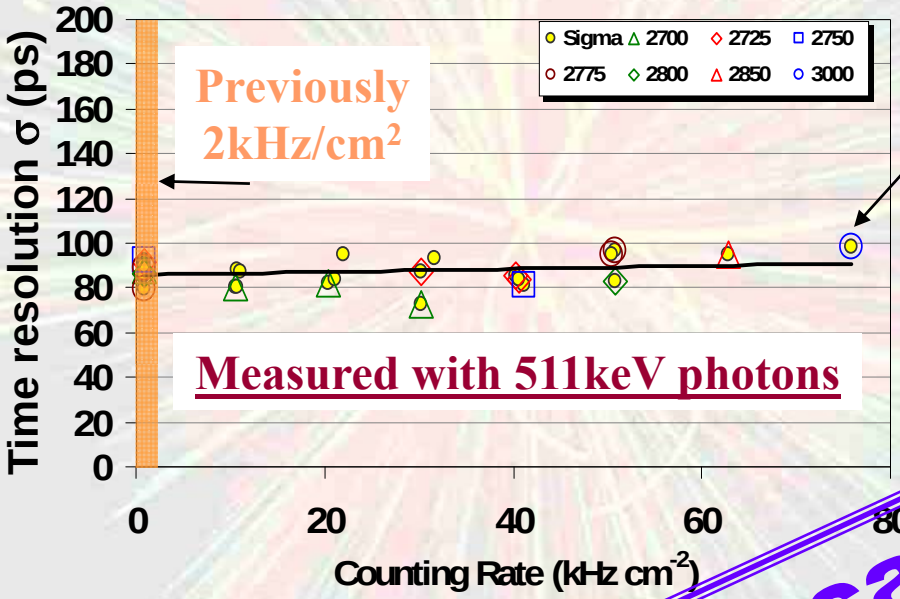


Large and yet sharp timing !

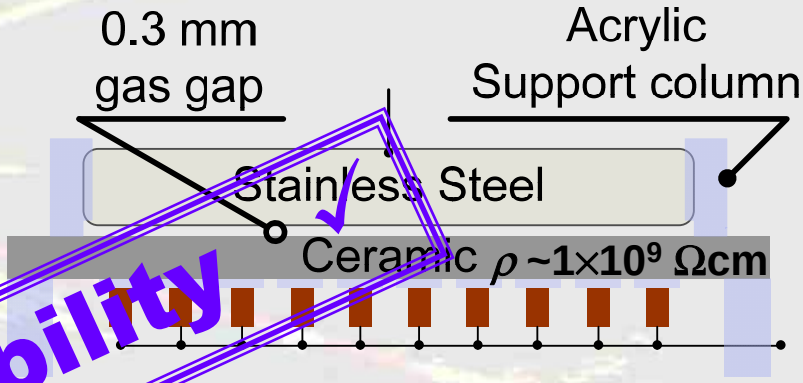
[Blanco 2001]

No degradation when the area/channel was doubled (800 cm^2/channel)

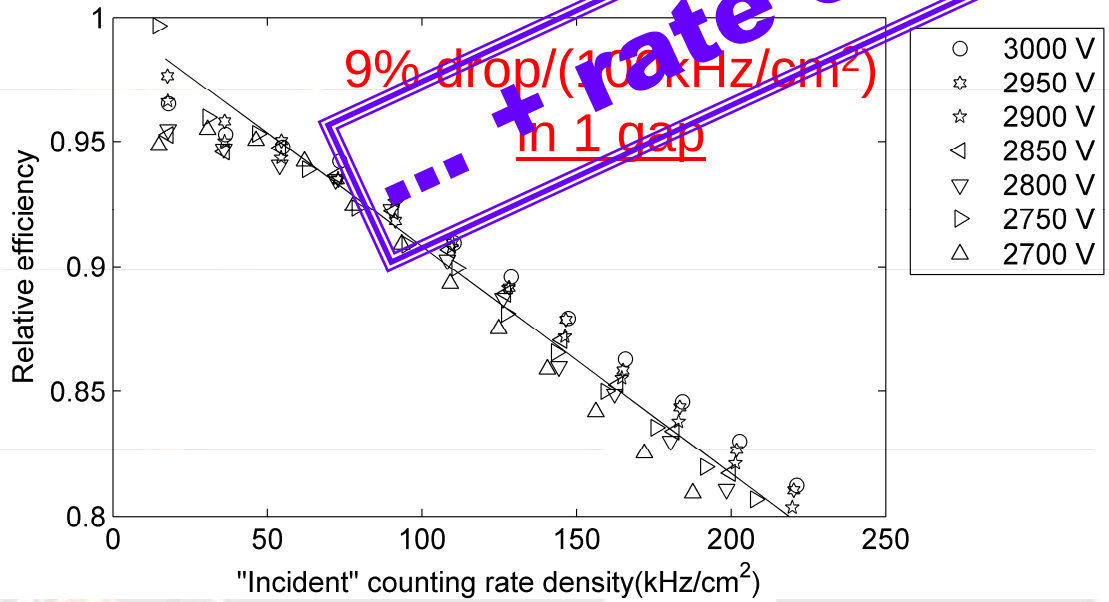
1.3 Another step: "high-rate" ceramic timing RPCs for CBM@GSI

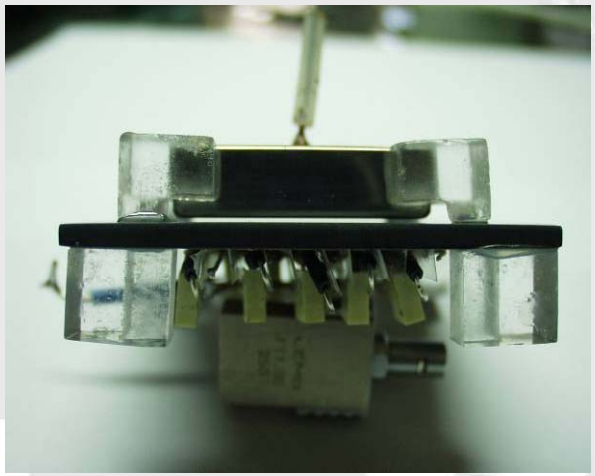


75kHz/cm²



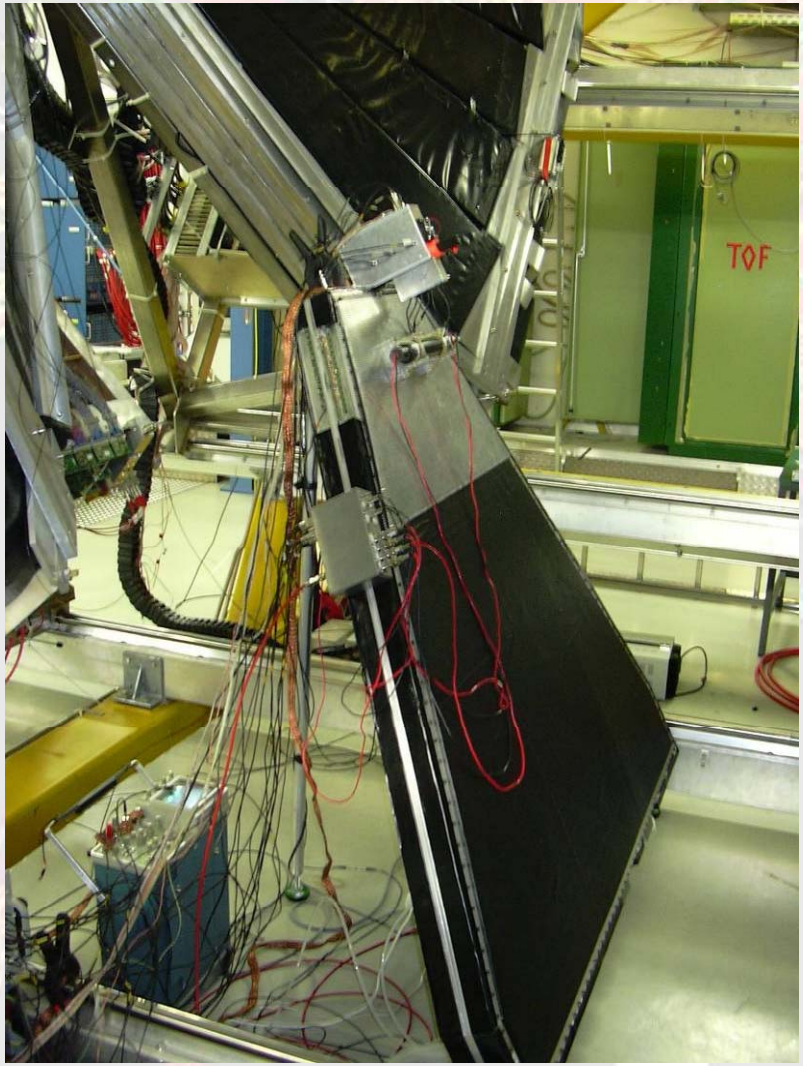
... + rate capability

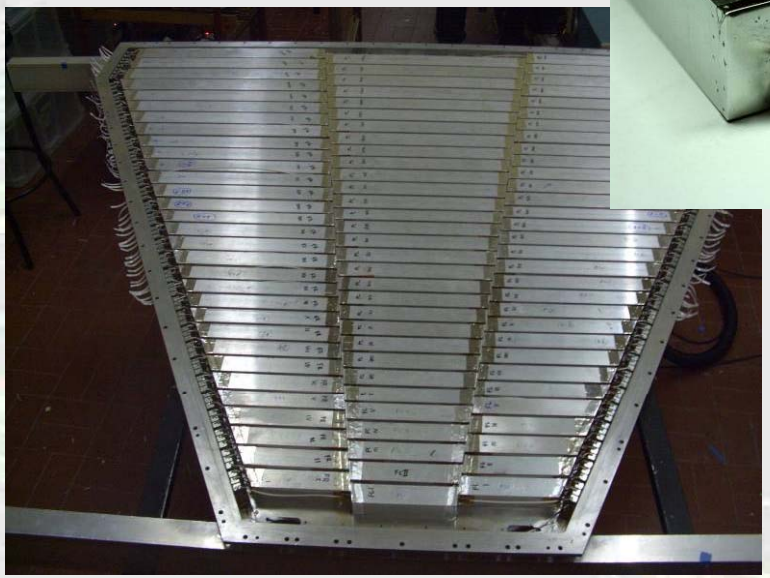


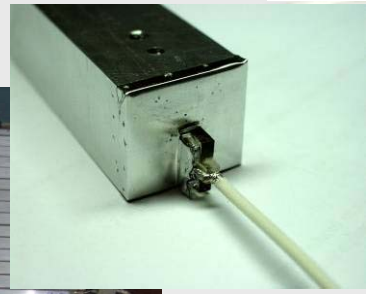


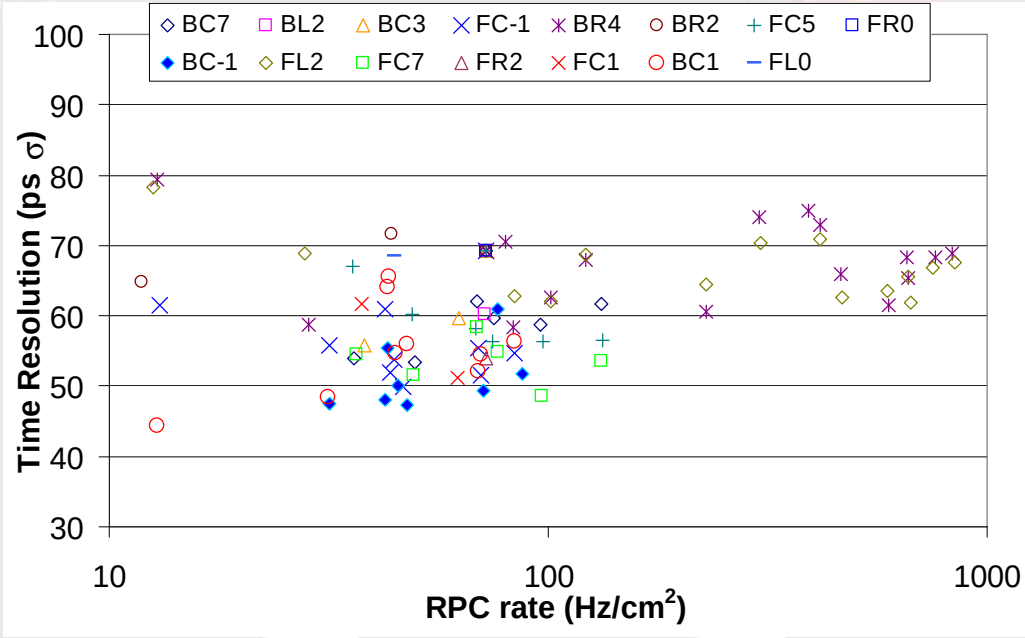
[Lopes 2006]

1.4 - 1st application: shielded tRPCs for HADES@GSI









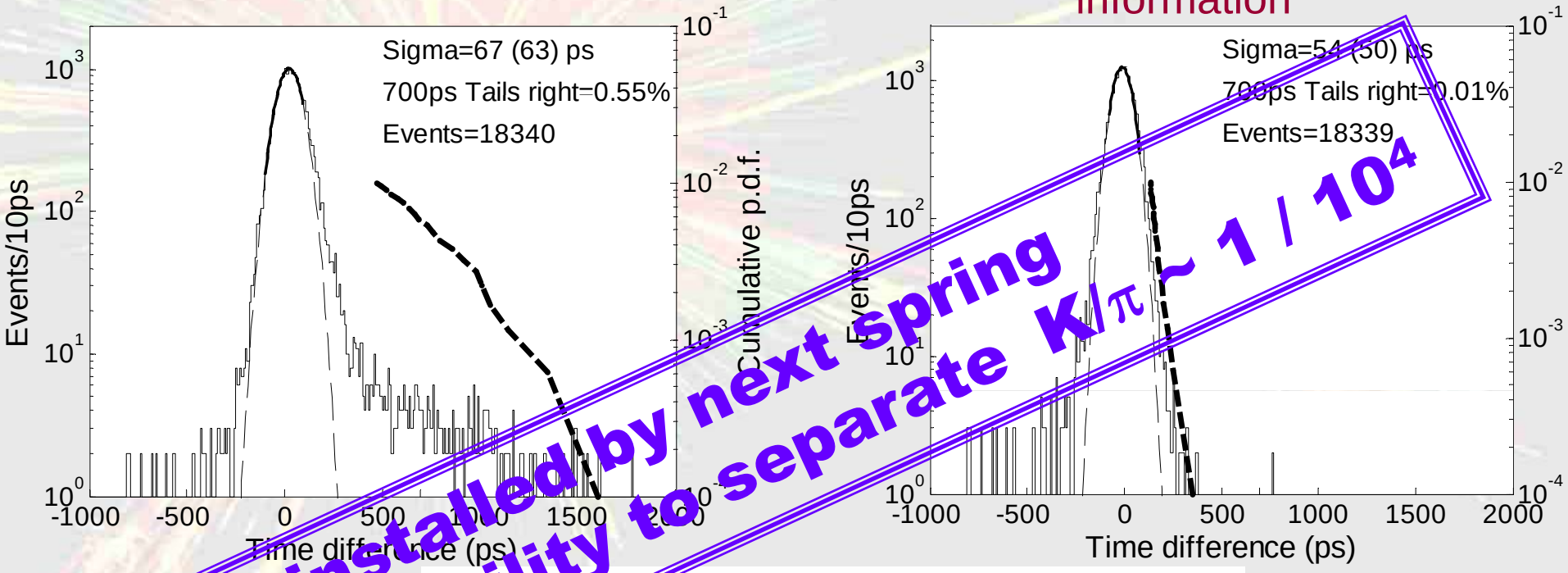
Shielded - No cross-talk (>GHz b.w.)
- Robust multihit performance

Redundant - Pure gaussian response

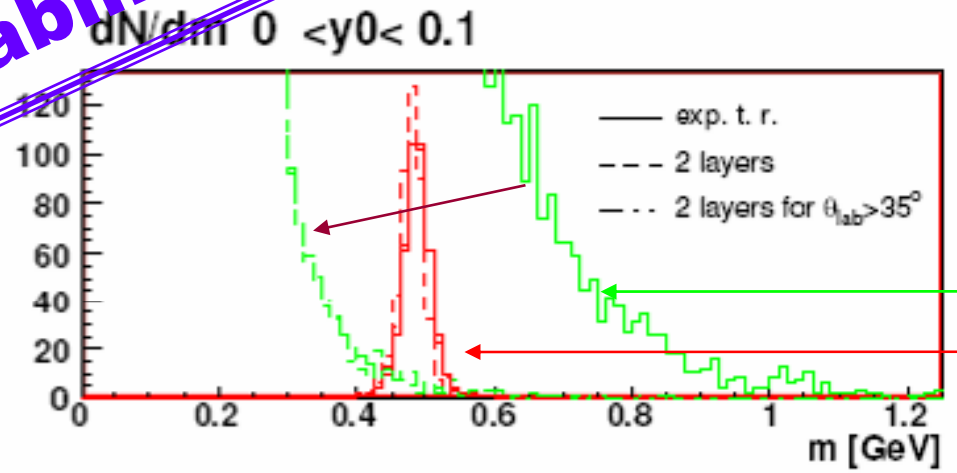
1.4 - 1st application: shielded tRPCs for HADES@GSI

Tails: 0.55% above 700 ps

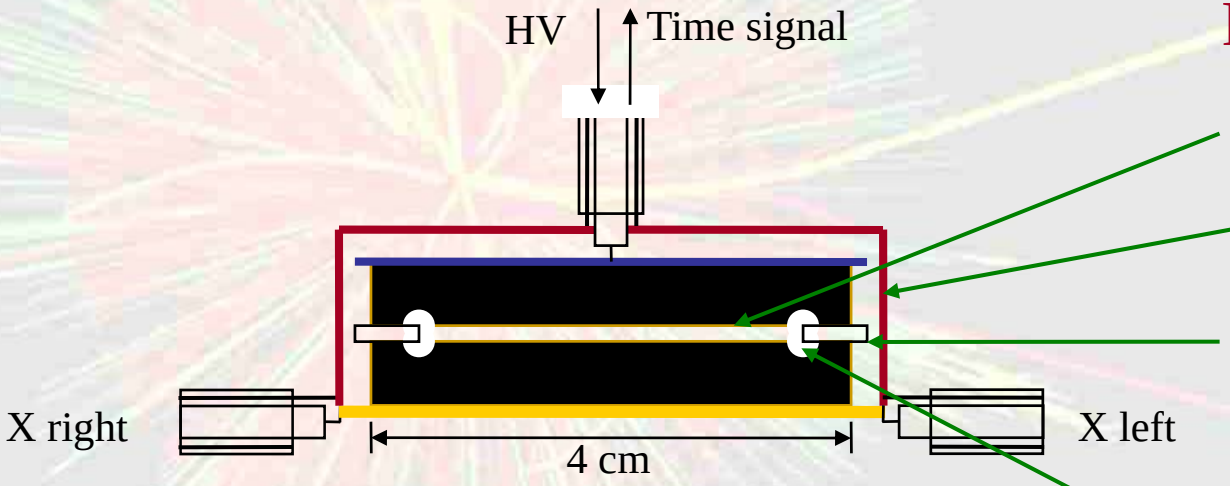
Tail cancellation using redundant information



- 6 m² installed by next spring
- PID capability to separate K/π ~ 1 / 10⁴



1.5 - 2D position sensitive readout



Precise construction

2 mm thick black glass lapped to ~1µm flatness

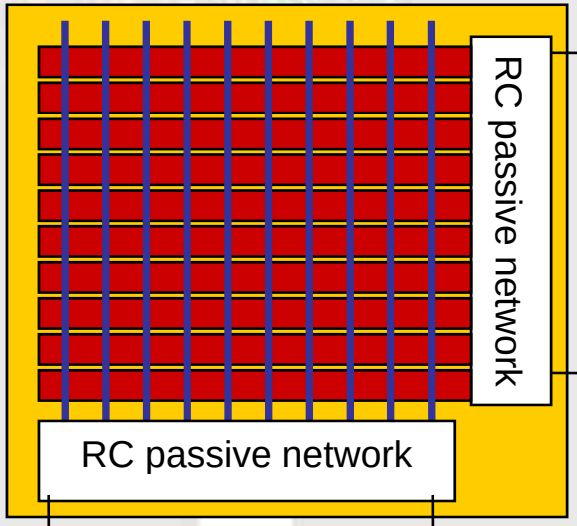
metal box (no crosstalk)

300 µm thick high ρ glass disk (corners)

Well carved into the glass (avoid dark currents from the spacer)

[Blanco 2002]

XY readout plane



out left

out right

10 strips for each coordinate at 4 mm pitch

Y-strips (on PCB)

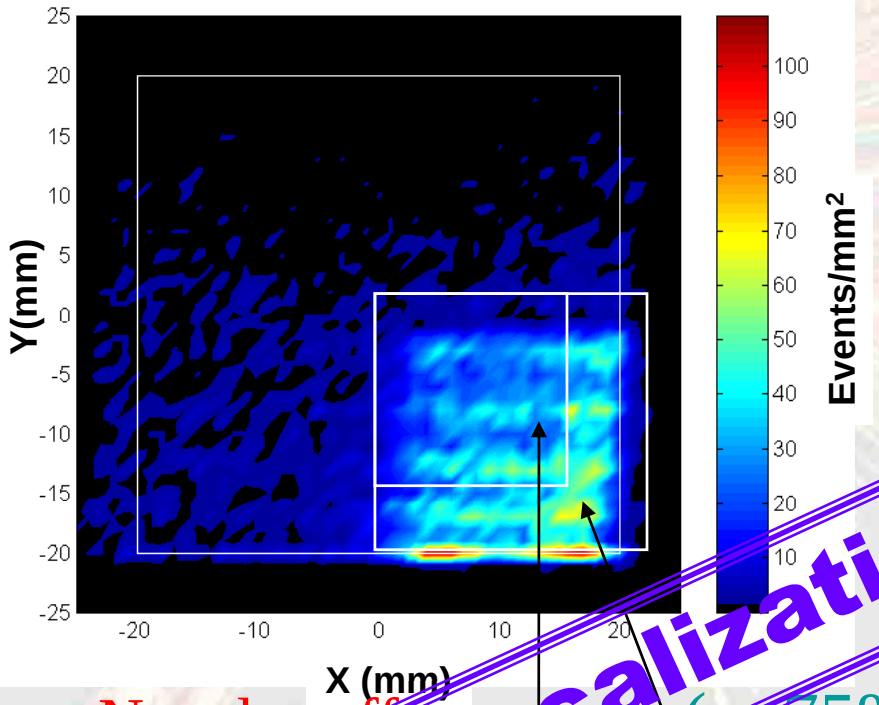
X-strips (deposited on glass)

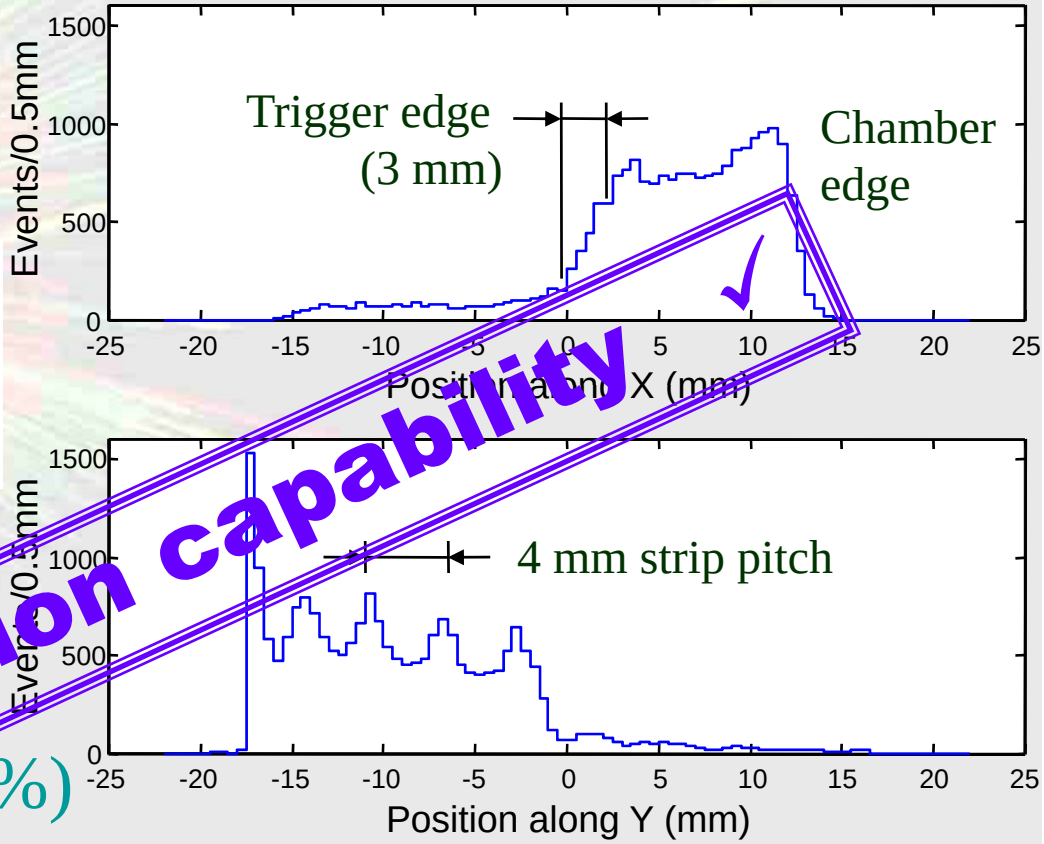
Resistive division

(for small and accurate TOF systems)

1.5 - 2D position sensitive readout

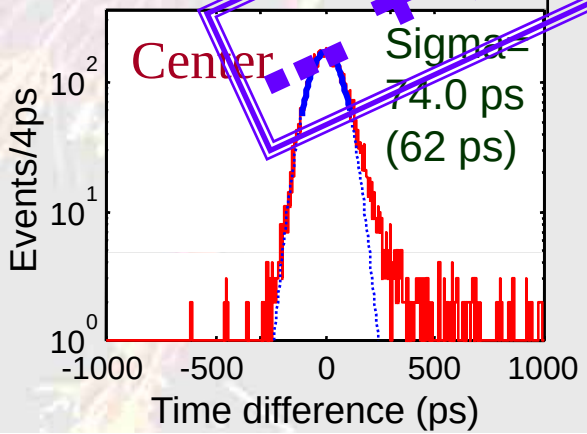
Position resolution

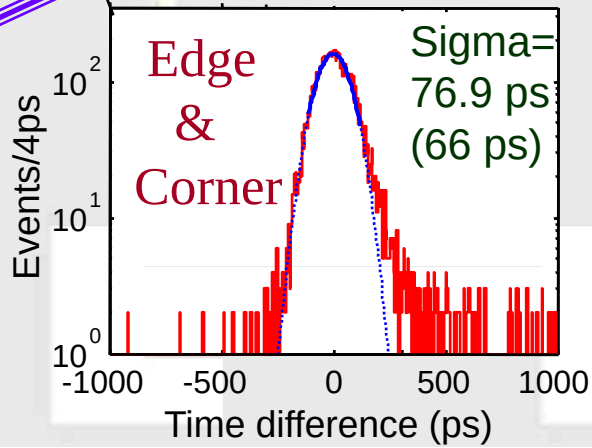




No edge effects (ε=75%)

+ localization capability





edges ≤ 3 mm

⇓

resolution ≤ 3 mm FWHM

(strips=4mm)

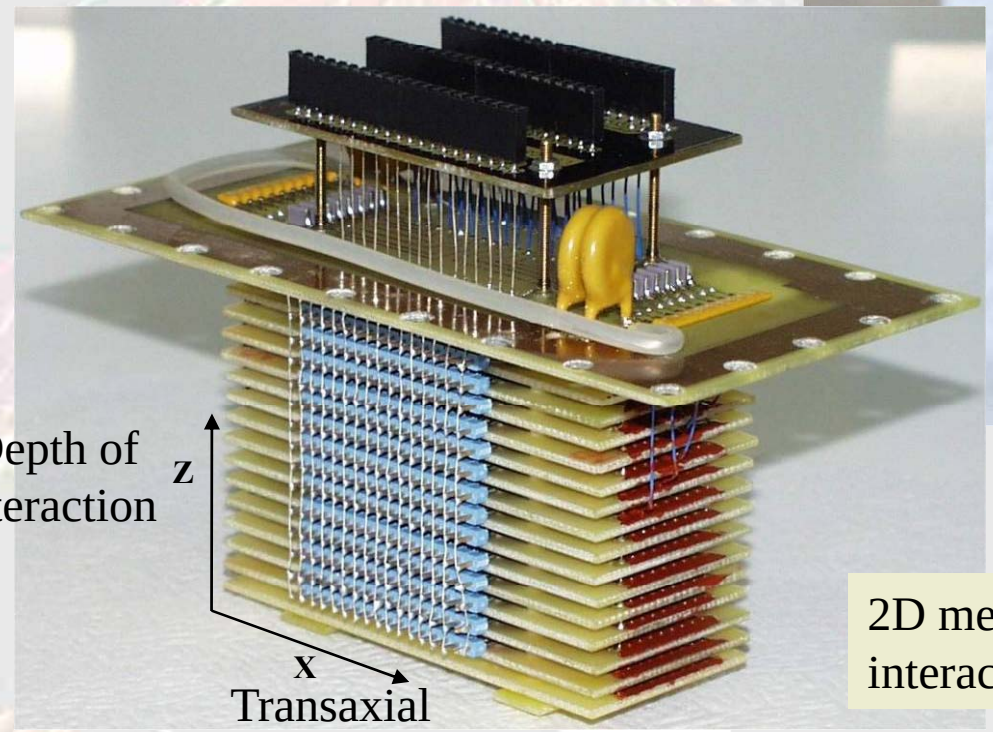
[Blanco 2002]

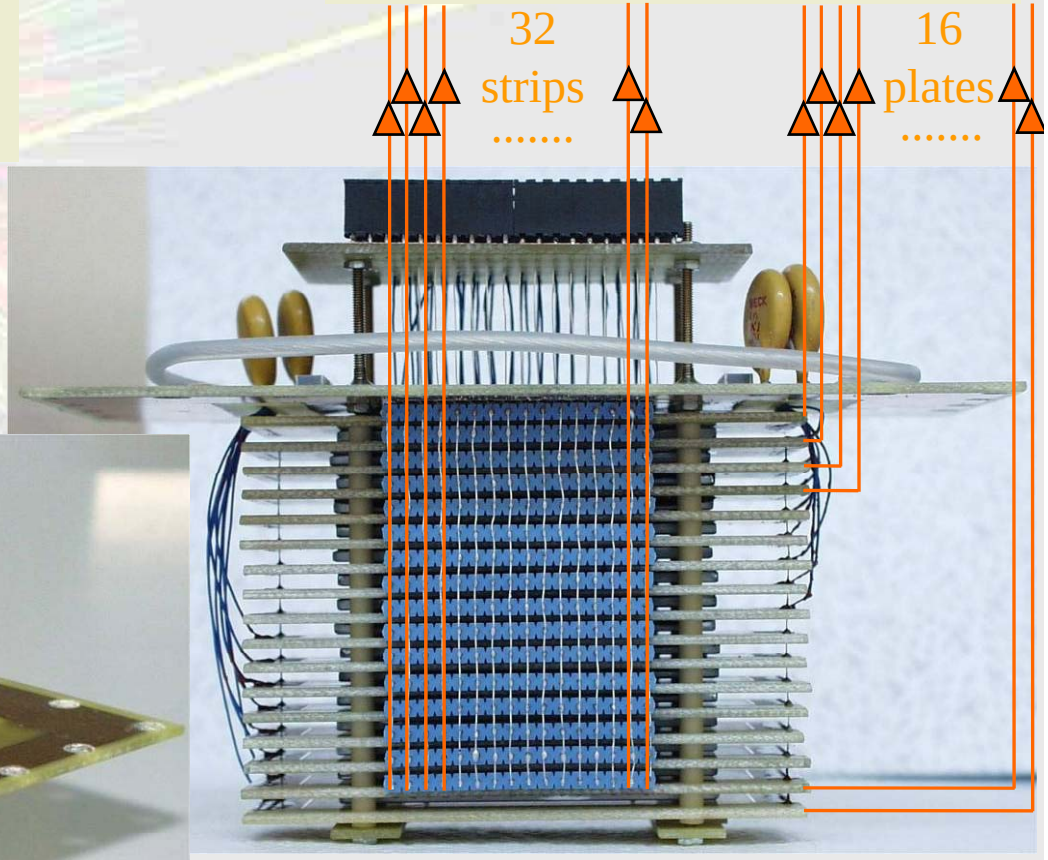
1.6 Small animal PET - a first prototype

Aimed at **verifying** the concept and show the **viability** of a **sub-millimetric spatial resolution**.

Charge-sensitive electronics allowing interstrip position interpolation

16 stacked RPCs



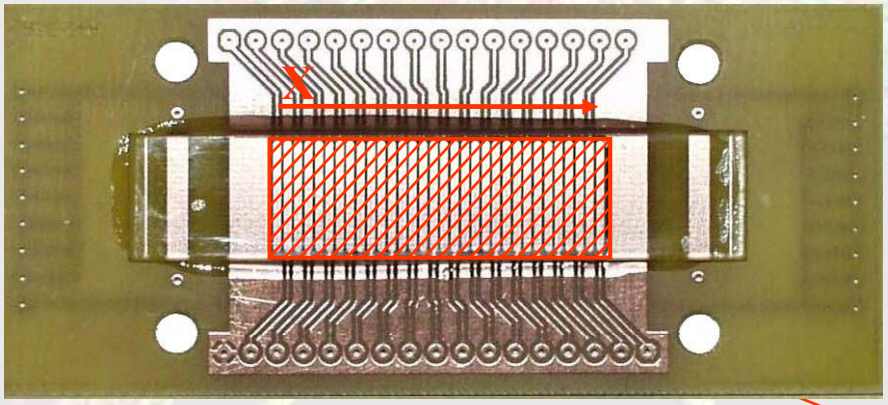


2D measurement of the photon interaction point (X,Z)

1.6 Small animal PET - a first prototype

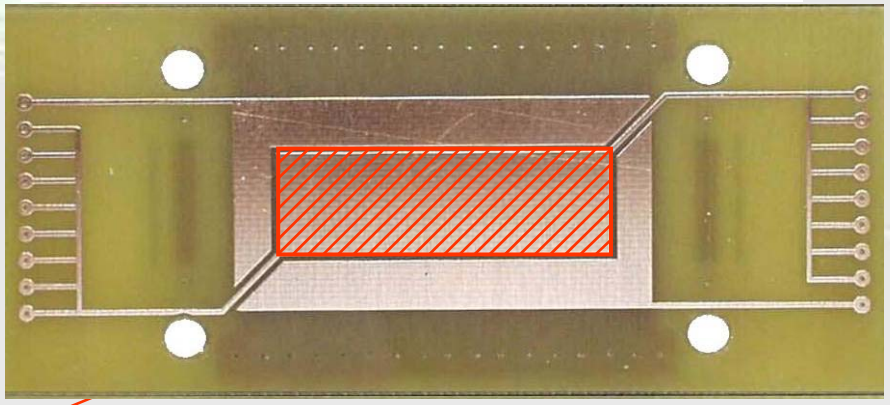
- **Copper** (on a PCB) and **glass electrodes**.
- 32 1-mm wide X pickup strips.
- 0.3 mm gas gap.
- Not optimized for high efficiency (2 mm glass)

ANODE: glass electrode glued on PCB



Transaxial coordinate

CATHODE: PCB copper layer



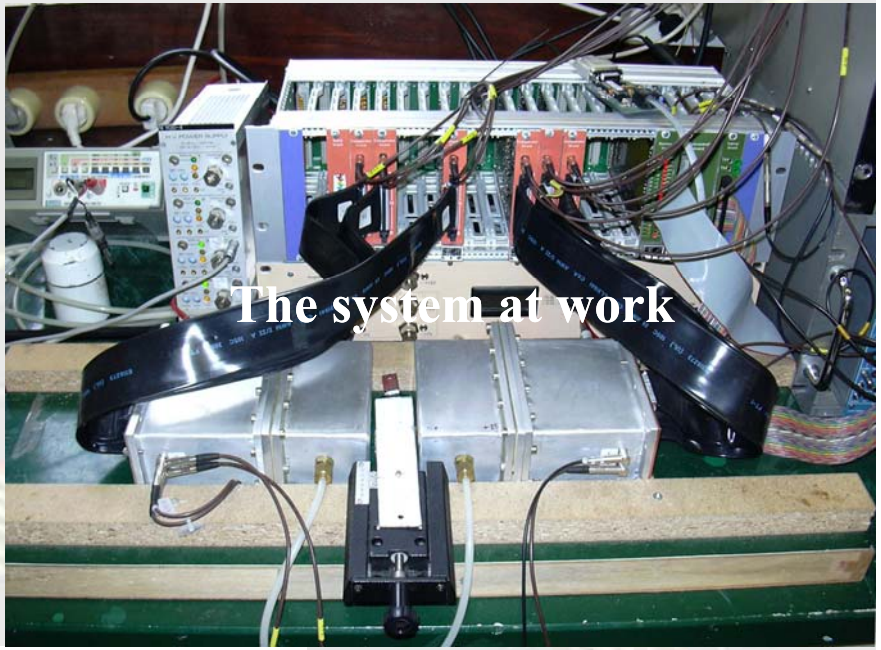
Depth of interaction

Active area 32 x 10 mm^2

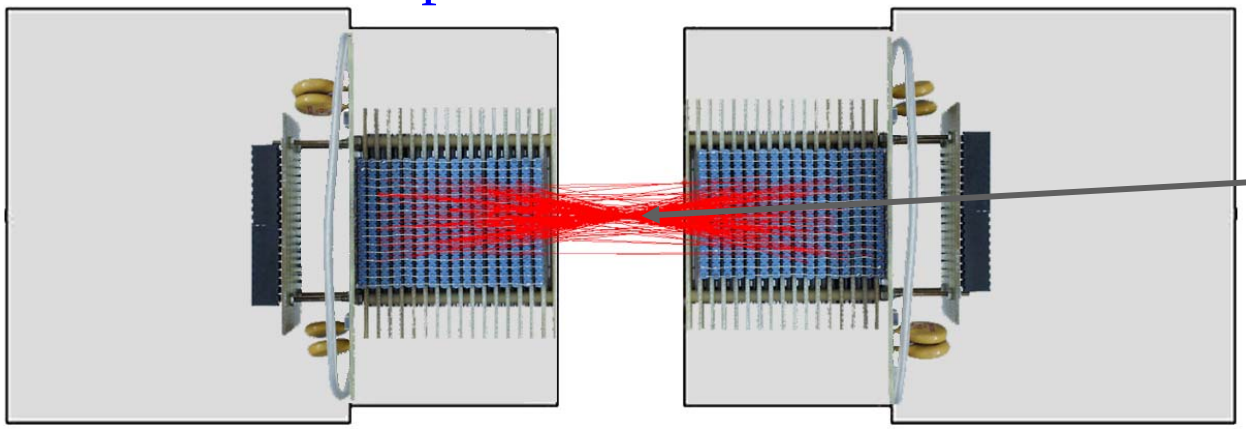
0.3 mm spacers

1.6 Small animal PET - a first prototype

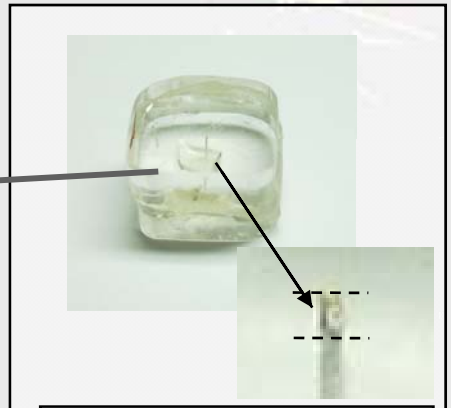
LOR = Line of Response, connects the two photon interaction points.



Intrinsic spatial resolution



Red lines correspond to real data (LORs) acquired with the ^{22}Na source



Custom-made ^{22}Na source

0.22 Ø x 0.5 mm

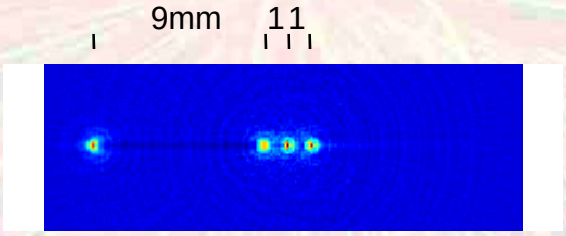
D = Distance between each LOR and the center of the system

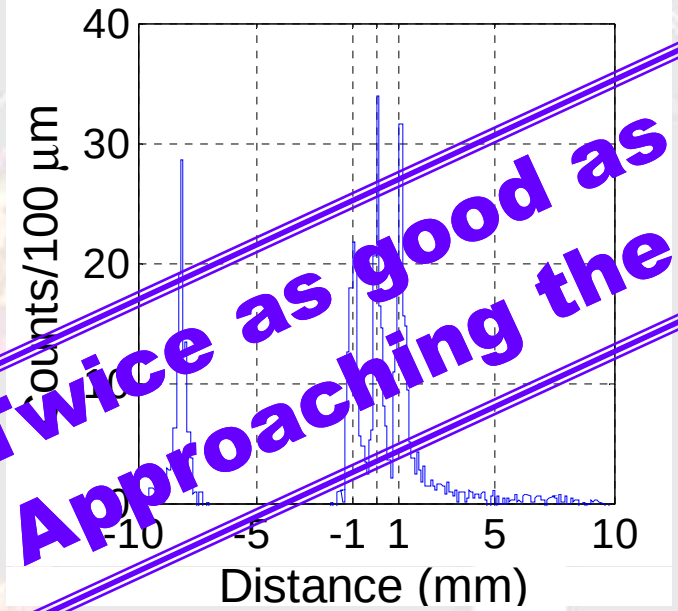
1.6 Small animal PET - a first prototype

Image spatial resolution (gaussian fitting)

Filtered Back Projection FBP

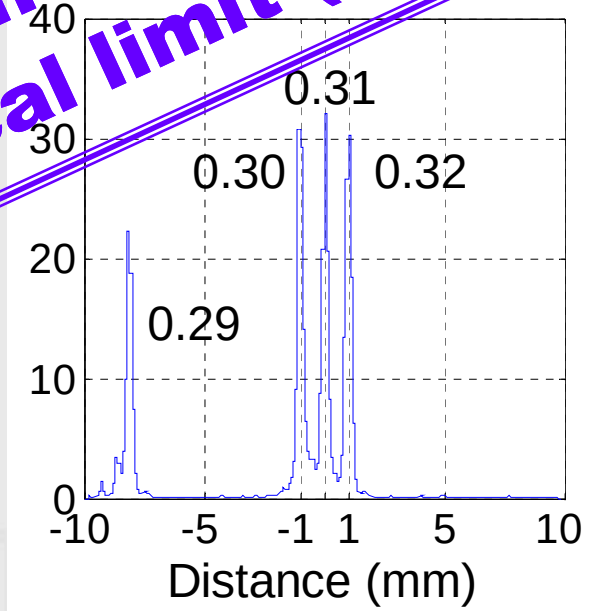
510 µm FWHM 1050 µm FWTM





Maximum likelihood-expectation maximization with resolution modeling (ML-EM)

~310 µm FWHM 810 µm FWTM



- **Twice as good as any other PET system**
- **Approaching the physical limit (~350 µm)**

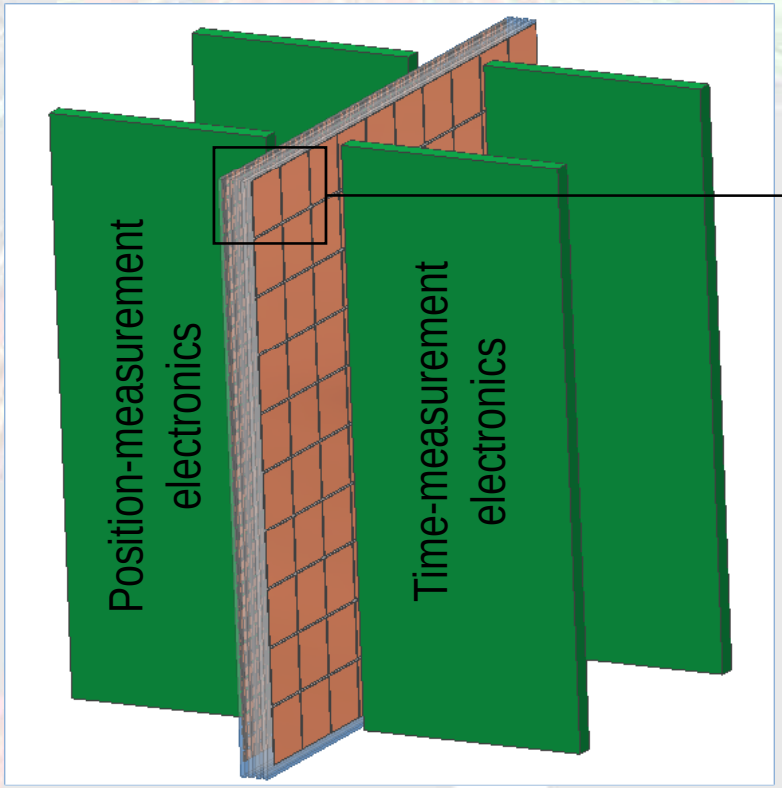
[Blanco, IEEE MIC 2004]

Proceeding IEEE MIC (2004) M2-177

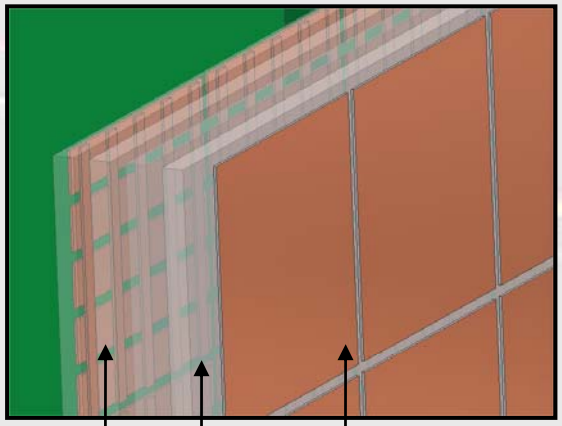
1.7 Near future (RD51)

The pixelized RPC TOF tracker

- High granularity: just depending on the pads size
- Sub-millimetric position resolution: 0.5 mm or better
- State-of-the art time resolution: 50 ps



General look of a demonstration module



Position measured with patterned electrode

Time measured on opposing pads

Resistive plates

2 – GEMs: Commitments within RD51

WG3 Cryogenic detectors + **WG4** Simulatios & s/w tools

MPGDs in double phase xenon detectors for rare low energy events

LIP-Coimbra + *U.Coimbra/U.Aveiro*

1) GEM tests at reduced vapour pressure
2) MHSP tests in 2-phase xenon

WG3 Medical applications + **WG7** Common Test Facilities

Study of MPGDs for gamma-ray imaging

LIP-Coimbra

1) GEM/mini-strip readout in double phase xenon
2) Small prototype of liquid xenon gamma-ray imager

2 - GEMs for high sensitivity experiments

Filipa Balau, Isabel Lopes, Vitaly Chepel*RD51 and Vladimir Solovov,

*he **ZEPLIN Dark Matter programme***

2.1 – High sensitivity experiments

2.2 – Double phase Xe detectors

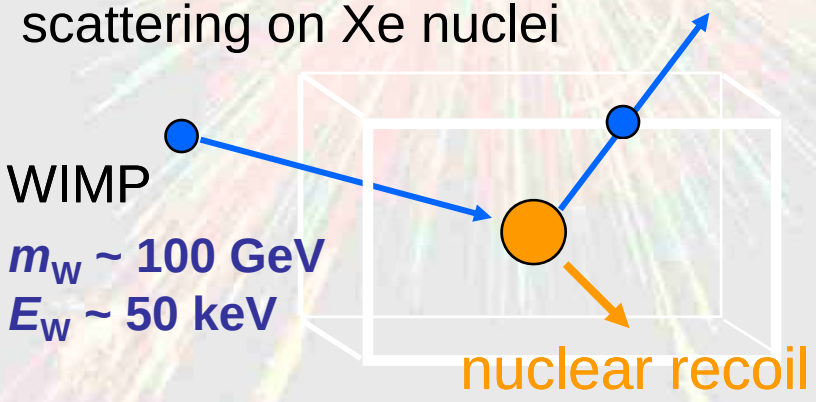
2.3 – Our measurements with a GEM

2.4 – Results

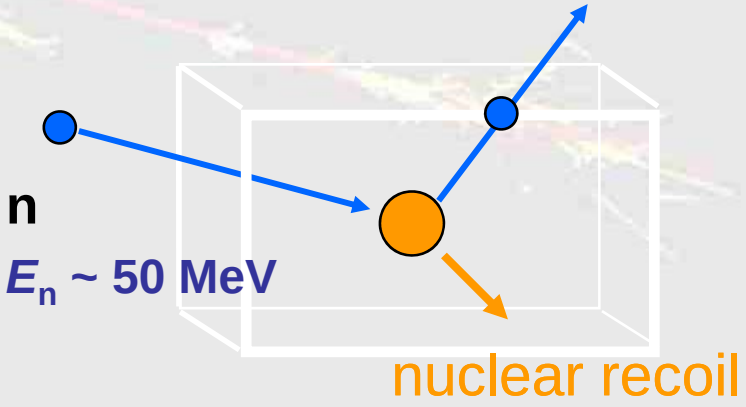
2.1 High sensitivity experiments

GOAL: Detection of a few electrons signal (ideally a single e^-) in gaseous phase of a LXe double phase detector

Ex.1: Direct search for Dark Matter in the form of WIMPs through elastic scattering on Xe nuclei



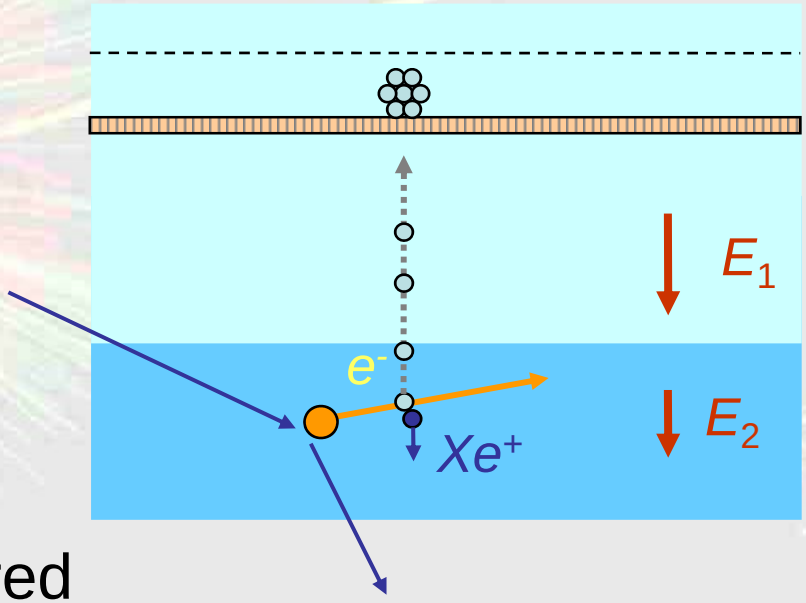
Ex.2: Coherent neutrino scattering on a nucleus



Energy of nuclear recoil: 0 to ~50 keV

2.2 Double phase Xe detectors

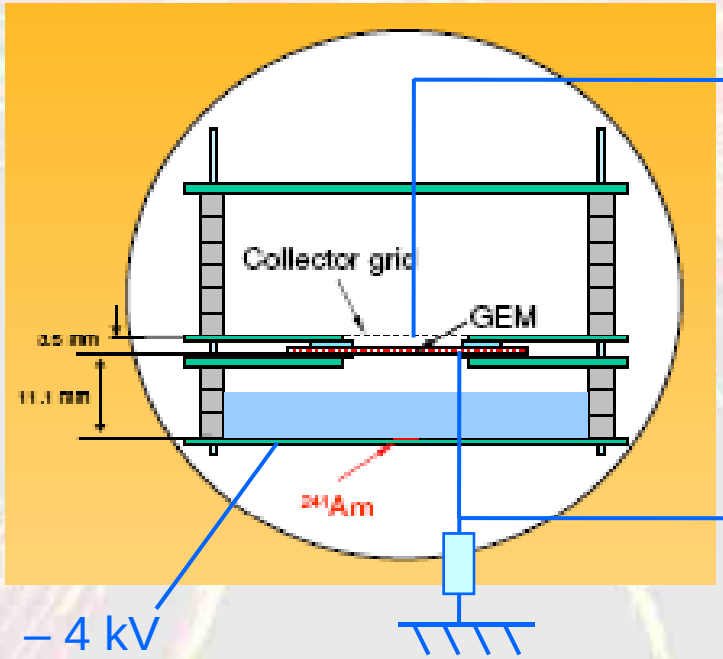
Measuringt ionisation from recoil tracks



- Total gain of ~10^4 required
- Stability of GEM operation in saturated gas (high density, low T, dependence on T fluctuations) ?
- Condensation of the liquid on the GEM ?
- Operation in ultrapure environment ?

2.2 Double phase Xe detectors

Our measurements with a single GEM



Q_{ext}

Q_{ext} – charge reaching collector grid

Gain = Q_{ext} / Q_0

Q_0

Q_0 – charge collected at lower GEM face (same potential applied to both sides)

The GEM

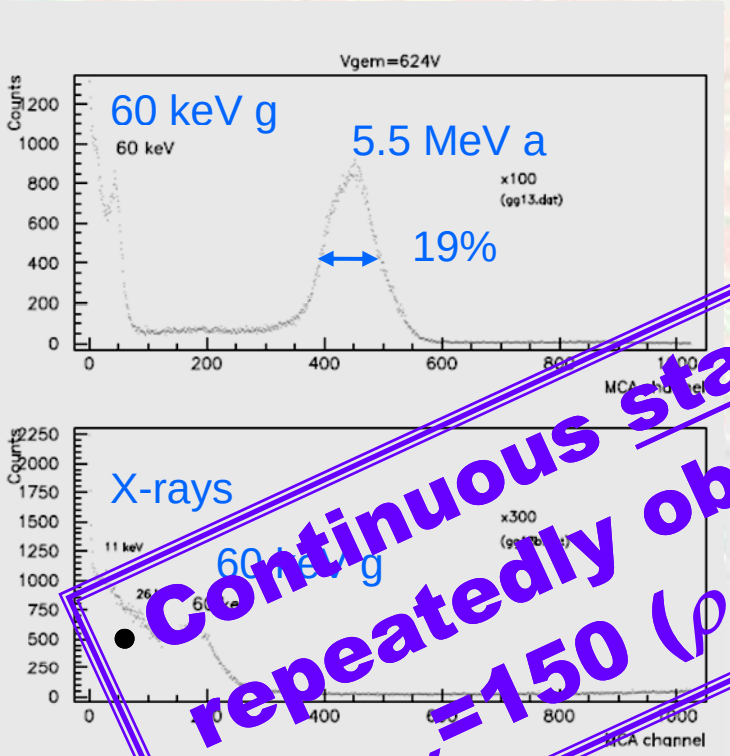
- **Thickness:** 60 µm
- **Hole diameter:** 70 µm
- **Hole spacing:** 140 µm
- **Manufacturer:** 3M

Mind ...

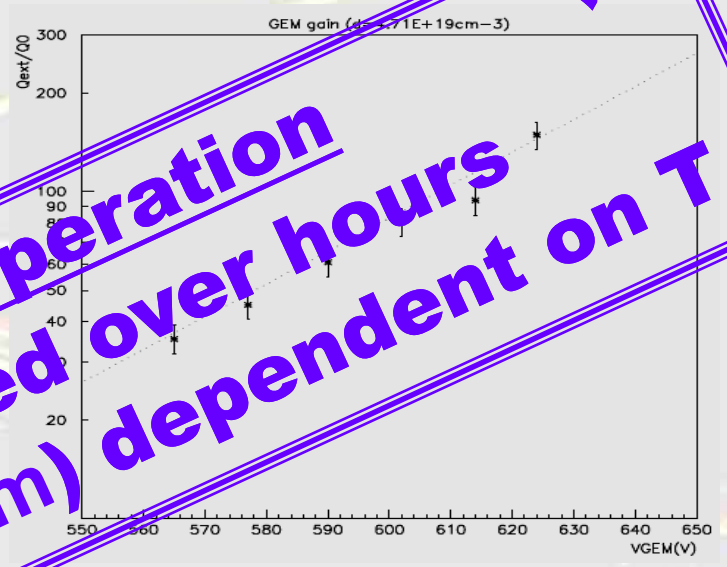
- Ultrapure xenon
- Only clean materials used
- Good temperature stabilization

2.2 Results

^{241}Am spectra



Gain as a function of V_{GEM}



$T\,(^{\circ}C)$	$P\,(bar)$	$Density\,(cm^{-3})$	Q_{ext}/Q_0	$V_{GEM}\,(V)$
-102	1.40	6.10×10^{19}	25	650
-108	1.04	4.71×10^{19}	150	624

Max gain

T ↓ ⇨ G_{max} ↑

- **Continuous stable operation**
- **repeatedly observed over hours**
- **G_{max}=150 (ρ ~ 2 atm) dependent on T**

[Balau et al.,NIM; in press]

Near future plans:

- Lower T (... approaching tripple point, -111 C)
- MHSP