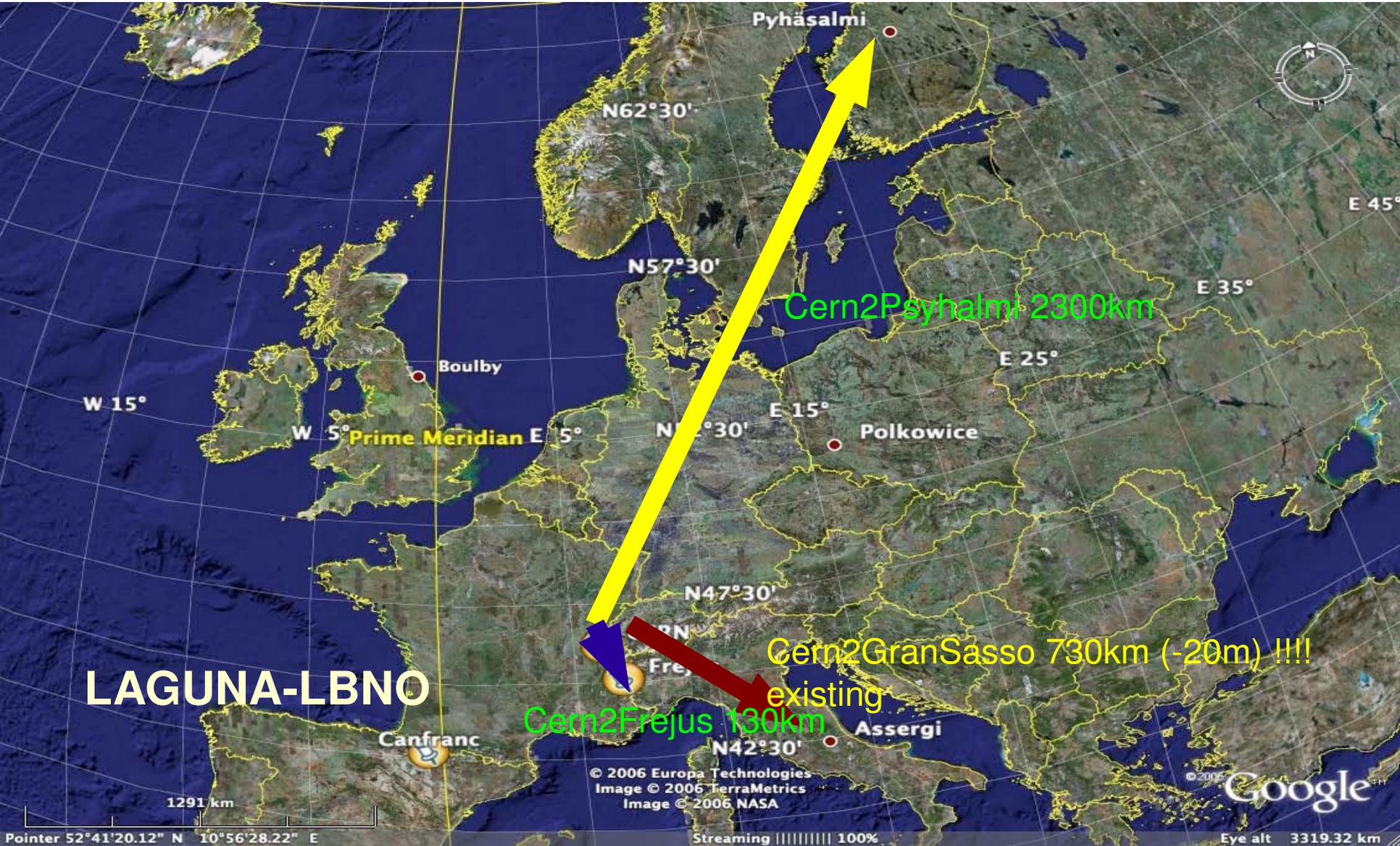


Liquid Argon TPC micromegas readout

Olivier Besida (CEA IRFU/SPP)

O. Besida, A. Curioni, A. Delbart, A. Giganon, F. Iguaz Gutierrez,
D. Lussi, E. Mazzucato, F. Resnatti, A. Rubbia, G. Vasseur, M. Zito

In collaboration with ETH Zurich
Rubbia's group



LAGUNA-LBNO

R&D in the perspective of a Giant Liquid Argon TPC (GLACIER) as (100 kton) a detector for neutrino oscillation on a long baseline 2300km CERN to Pyhäsalmi (Finland)

Energy 1st Osc. Max. : 4.65 [GeV]

Envisaged depth : up to 4000 m.w.e.

Looking for CP δ phase $\nu_{\mu} \longrightarrow \nu_{e}$ versus $\bar{\nu}_{\mu} \longrightarrow \bar{\nu}_{e}$

CPT violation $\nu_{\mu} \longrightarrow \nu_{e}$ versus $\nu_{e} \longrightarrow \nu_{\mu}$

Mass hierarchy thanks to matter effect

Measure neutrino speed : rule of thumb=190ns advance on light

If OPERA's result is right

Atmospheric & solar neutrino

Supernova neutrino detection (minimal lifetime ~30 years)

Life time of the proton

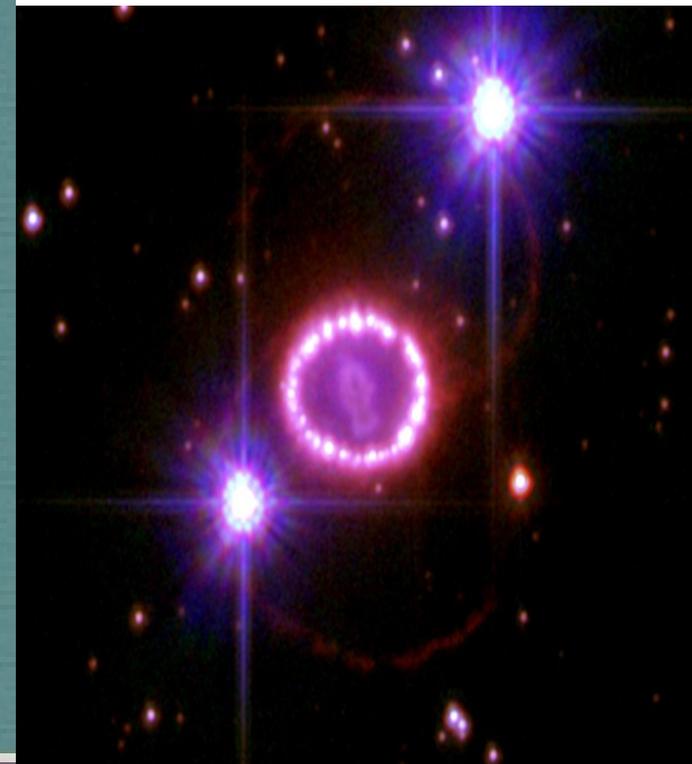
100 kton LAr TPC, $d = 10$ kpc

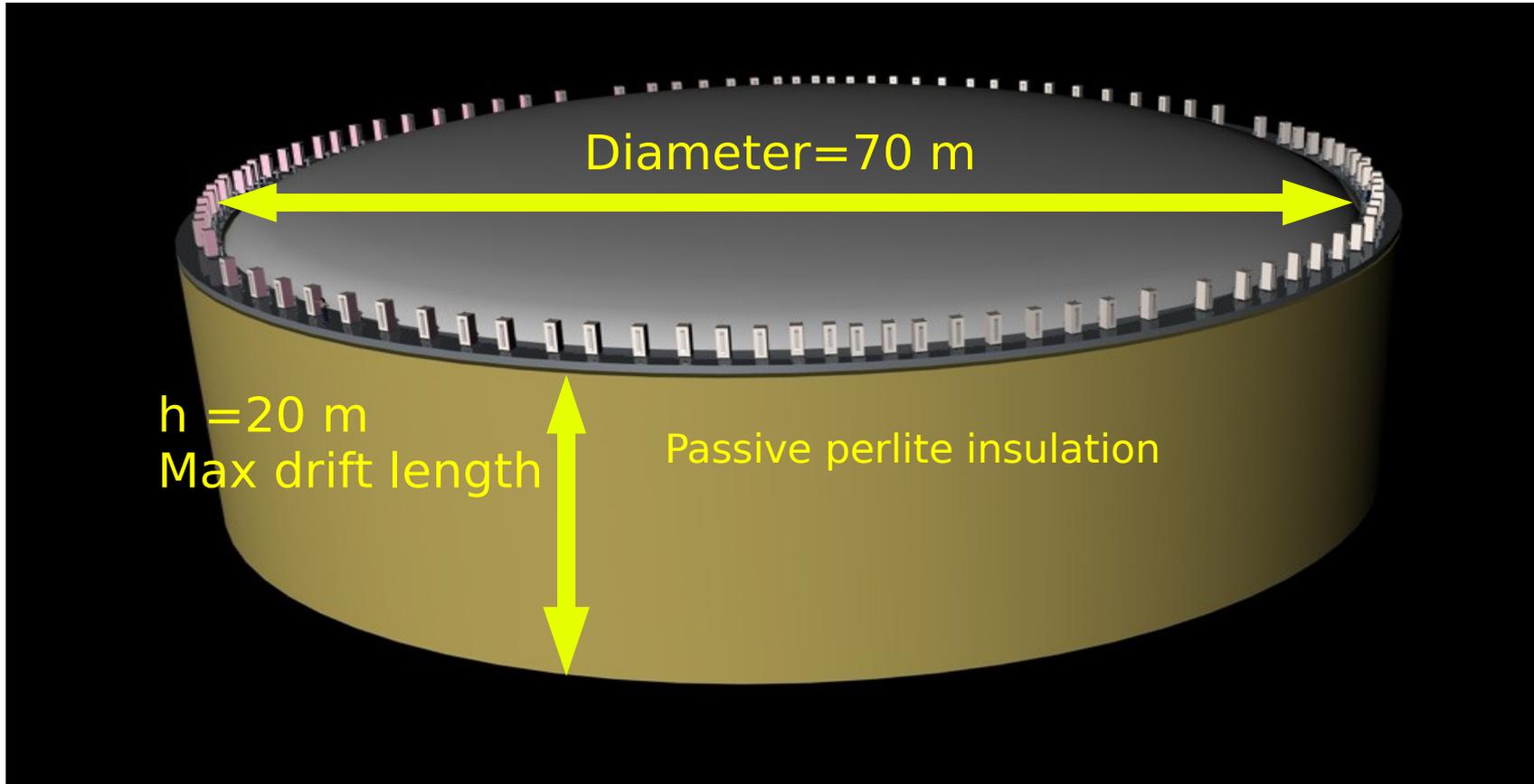
Scenario I: expected events in 100 kton detector

$$\langle E_{\nu_e} \rangle = 11 \text{ MeV}, \langle E_{\bar{\nu}_e} \rangle = 16 \text{ MeV}, \langle E_{\nu_x} \rangle = \langle E_{\bar{\nu}_x} \rangle = 25 \text{ MeV}$$

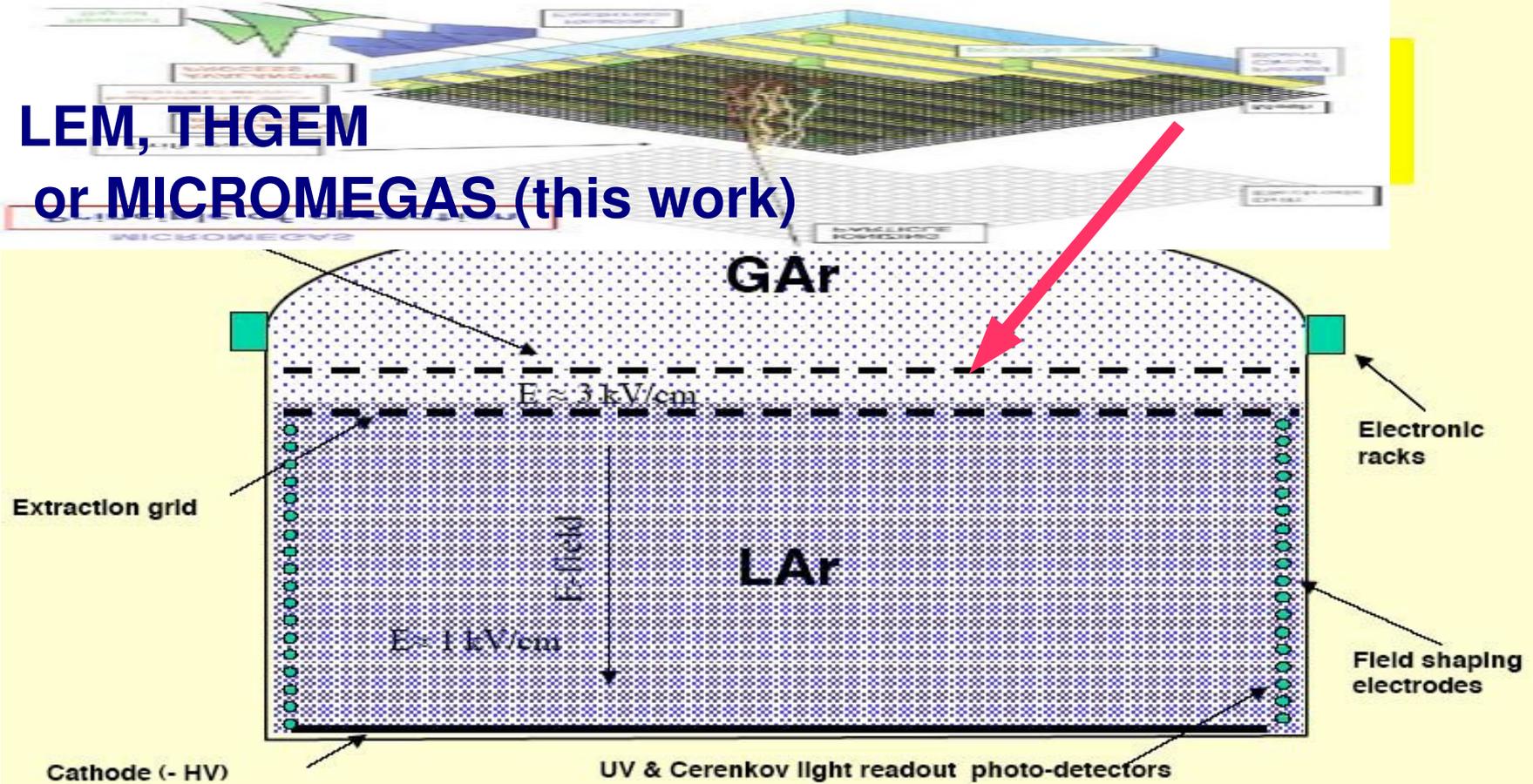
and luminosity equipartition

Reaction	Without oscillation	Oscillation (n.h.)		Oscillation (i.h.)	
		Large θ_{13}	Small θ_{13}	Large θ_{13}	Small θ_{13}
ELAS	1330	1330	1330	1330	1330
ν_e CC	6240	31320	23820	23820	23820
$\bar{\nu}_e$ CC	540	1110	1110	2420	1110
NC	30440	30440	30440	30440	30440
TOTAL	38550	64200	56700	58010	56700





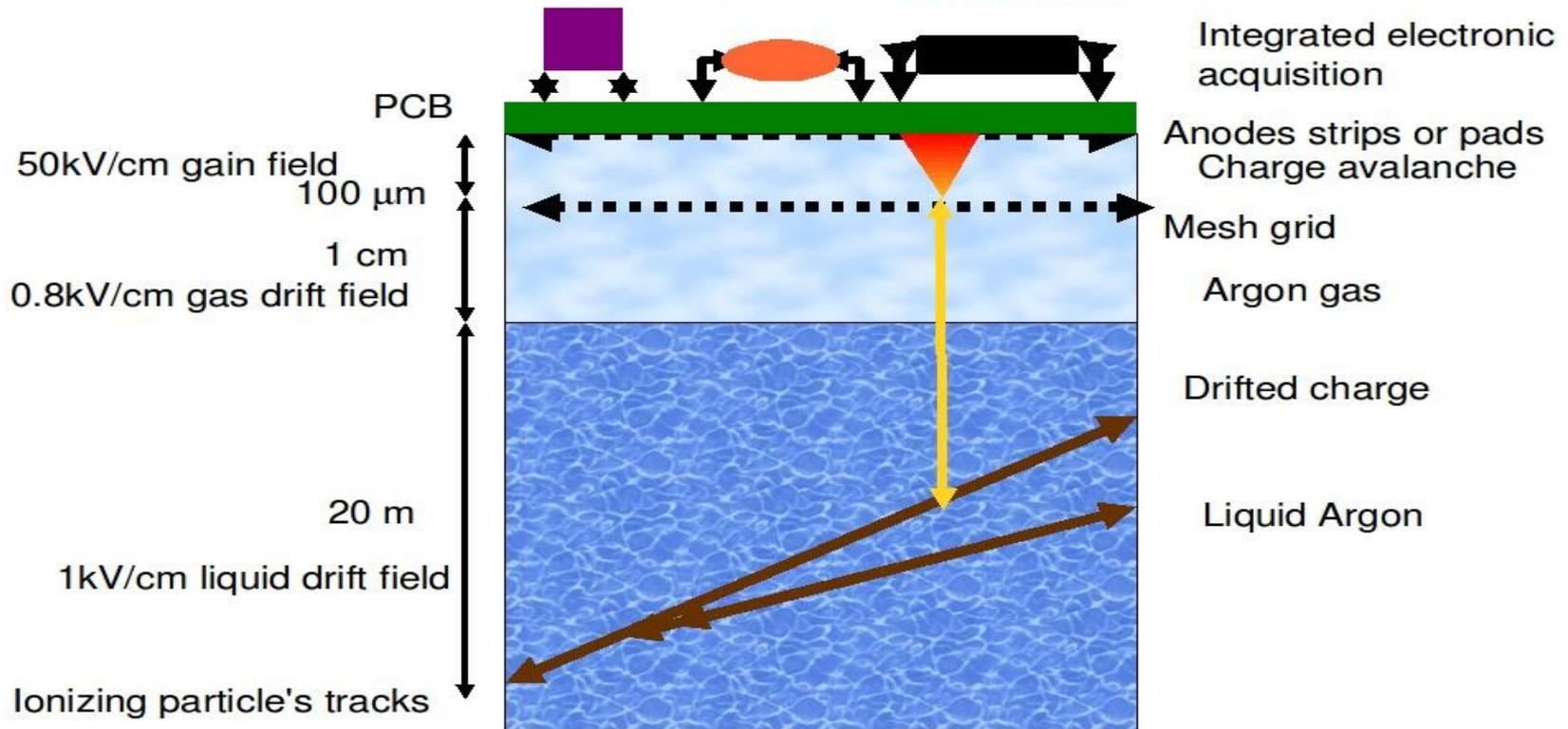
**LEM, THGEM
or MICROME GAS (this work)**



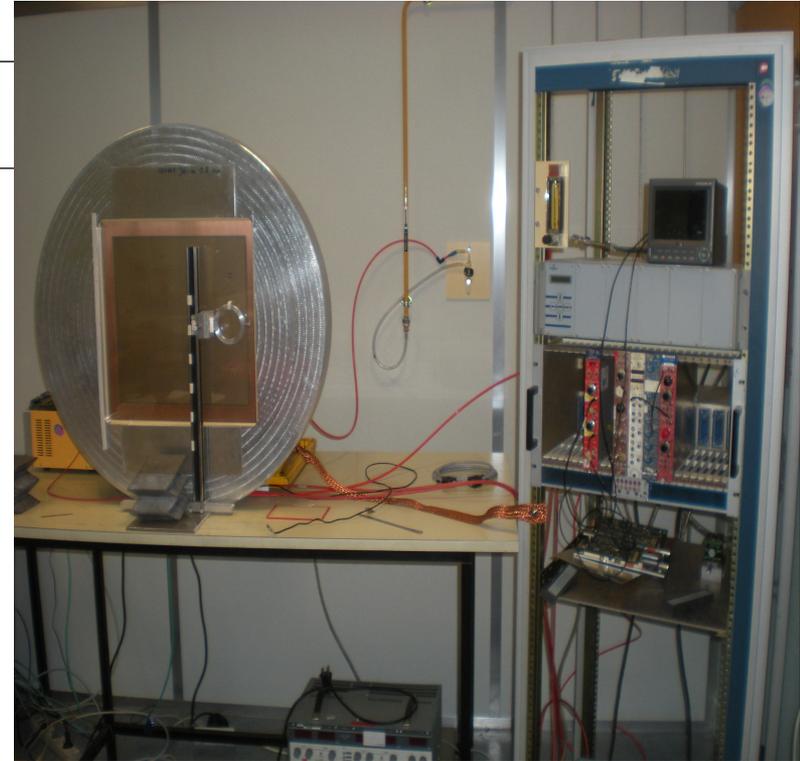
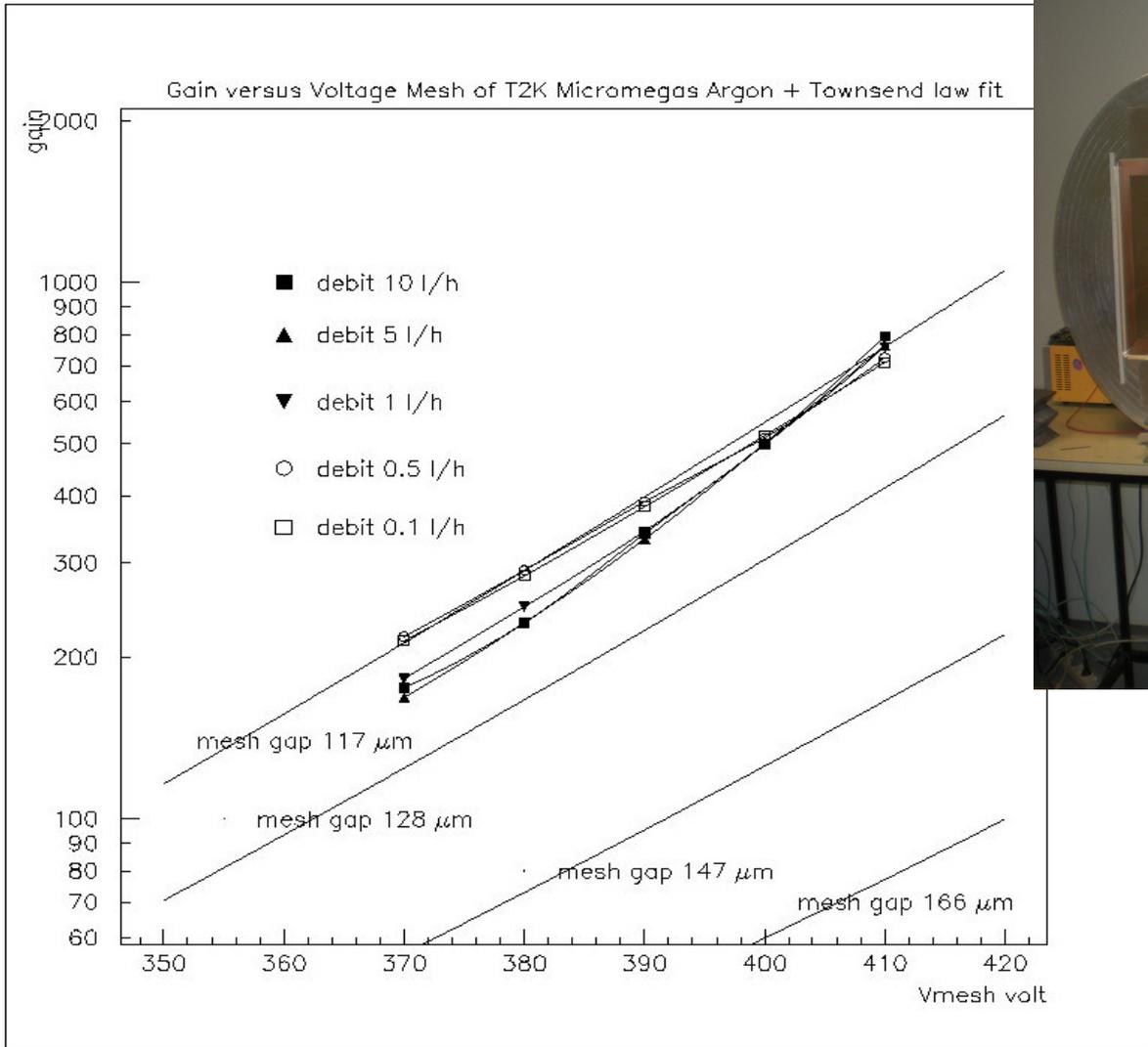
4000 m² of pixelised detector for particle tracking with a giant time projection chamber in the gaseous phase !

**To compensate a loss of electron by a factor ~ 150 along the 20m drift
In the liquid phase, requirement for a gain > 150 !**

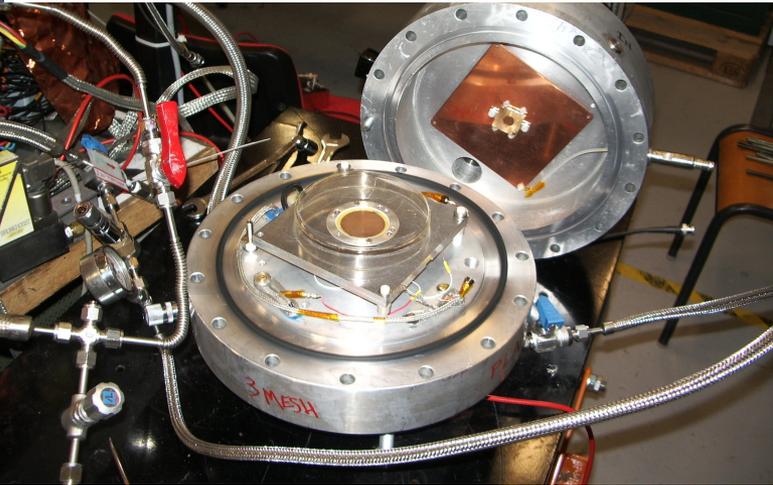
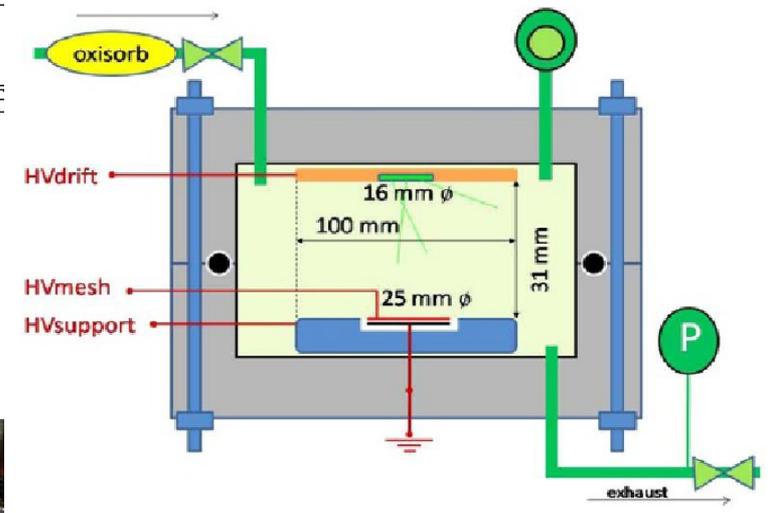
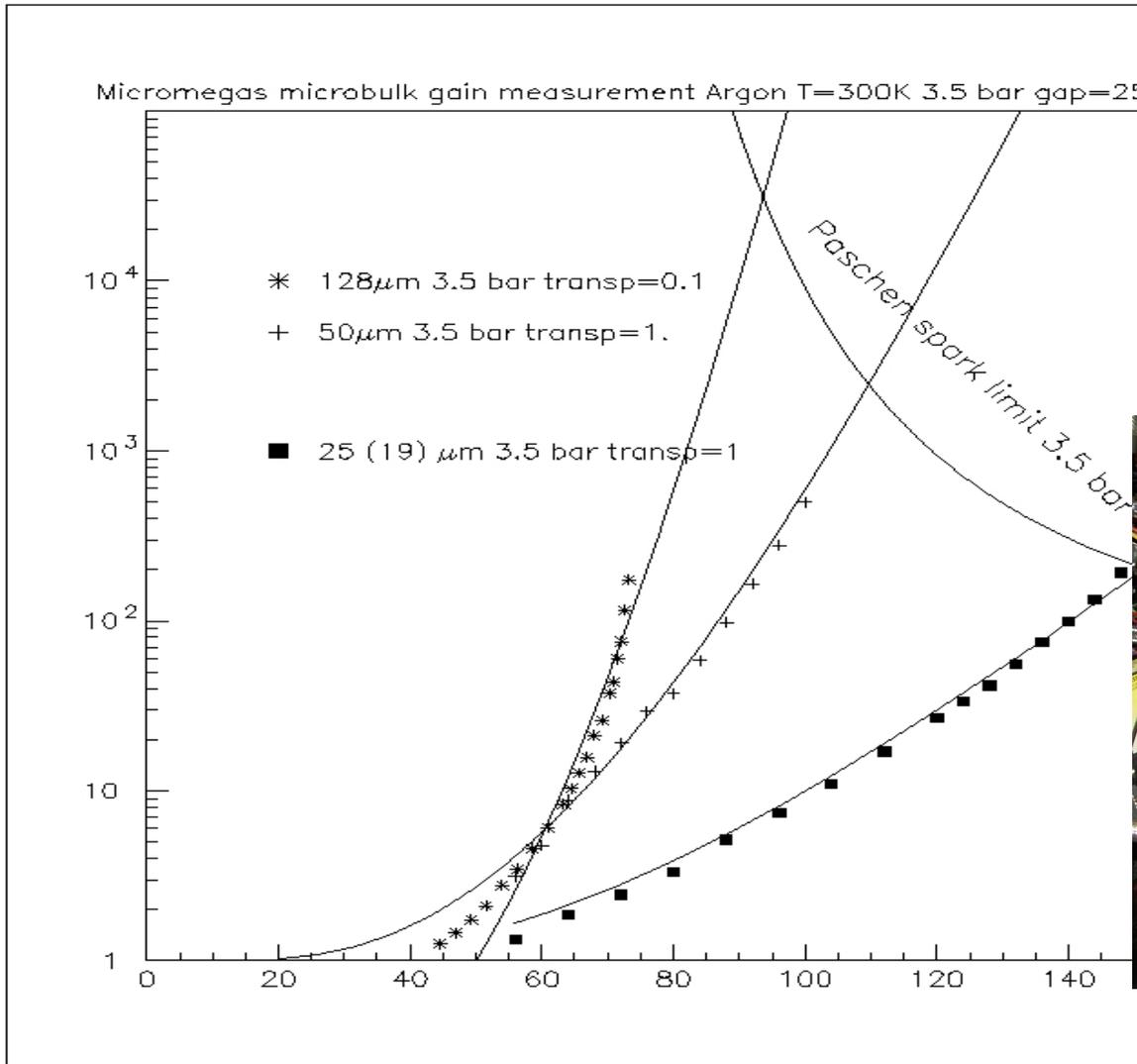
Double Phase Argon Cryogenic Micromegas TPC



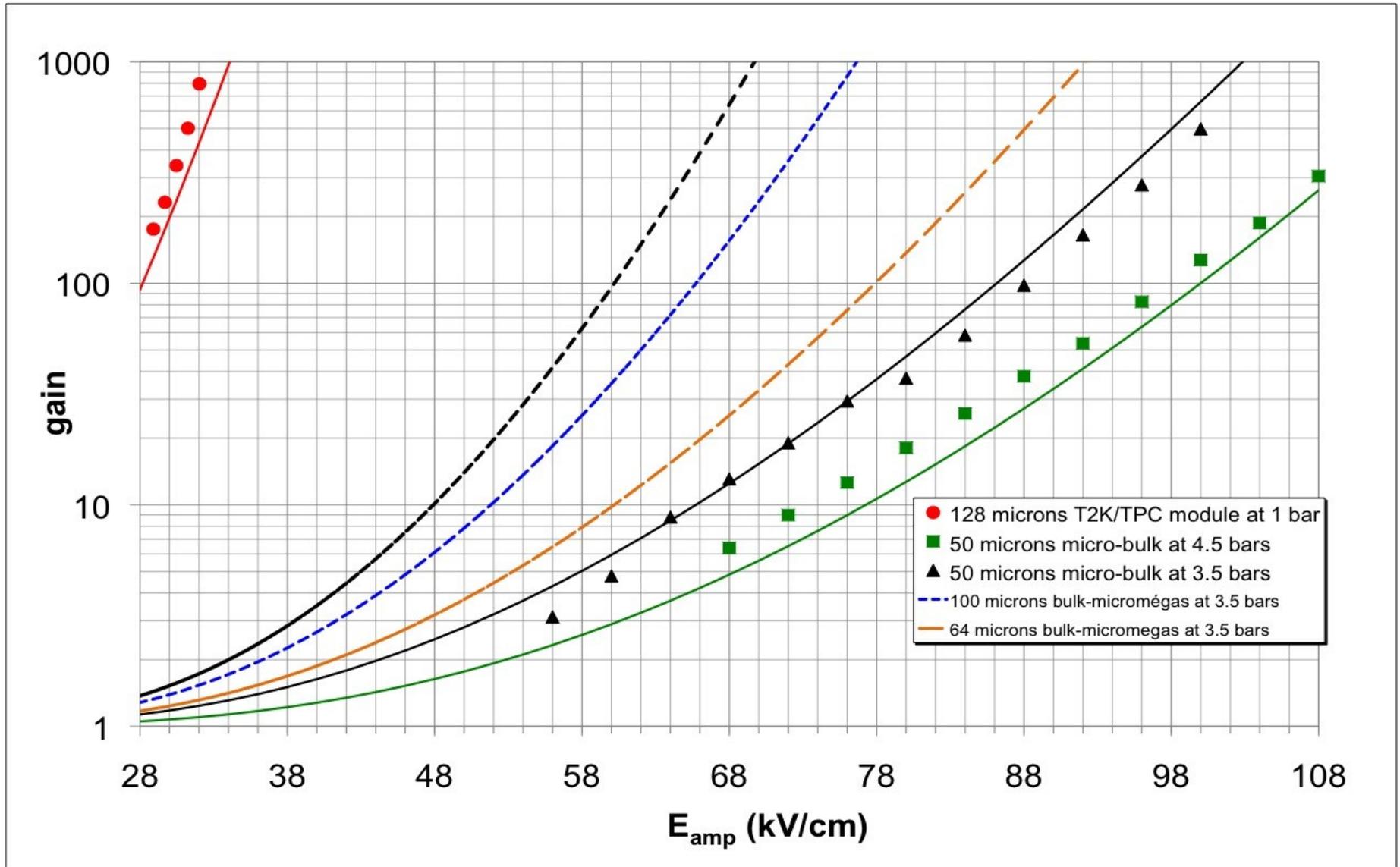
Schema of operation of a double phase Liquid TPC with gaseous amplification
In a bulk micromegas with integrated cold electronic acquisition

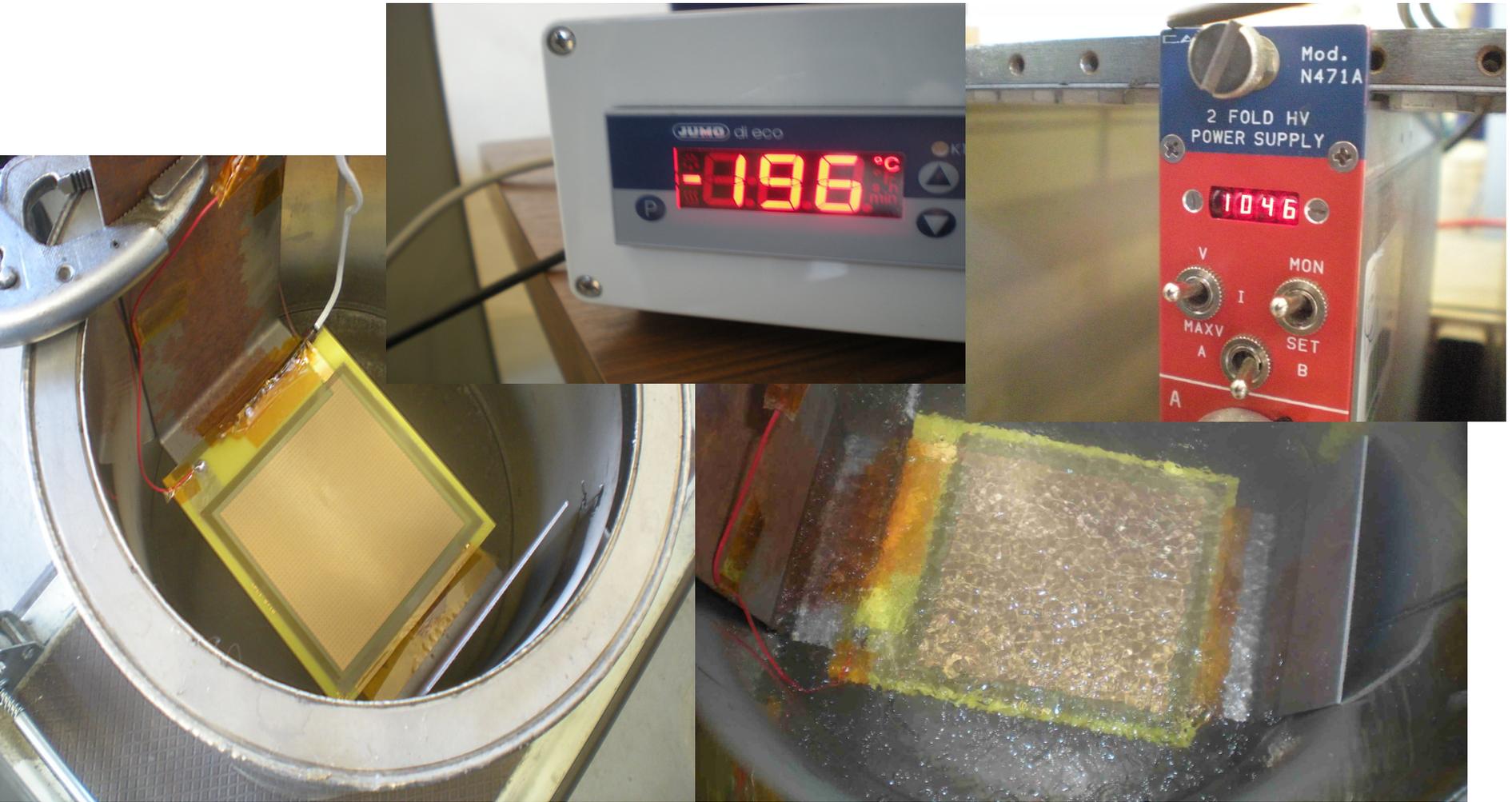


J.Beucher



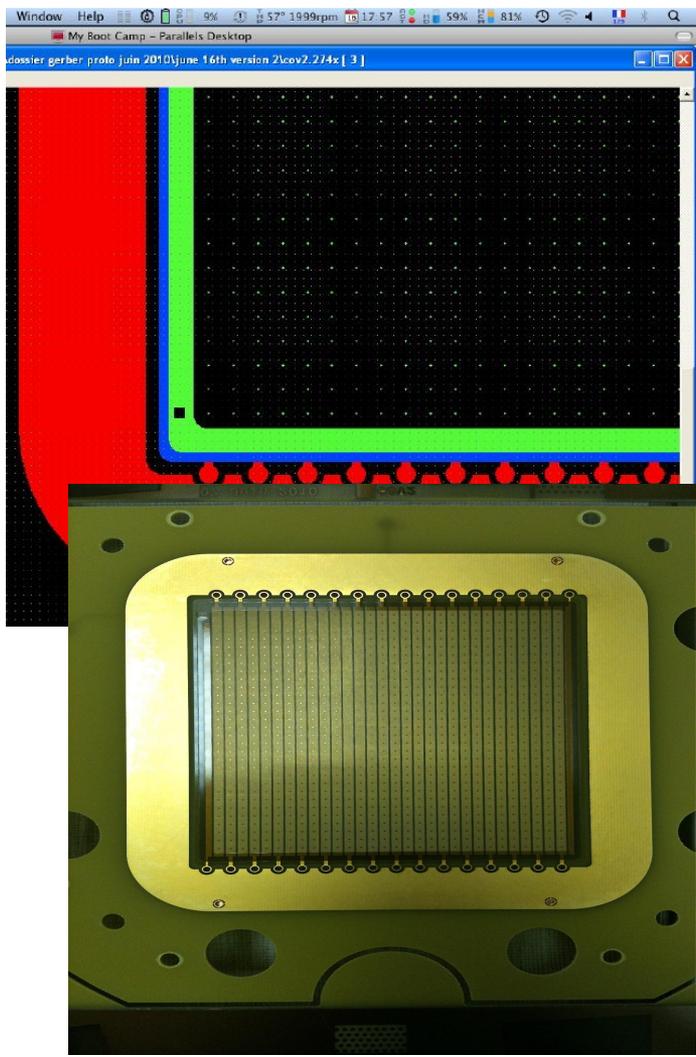
Paco Iguaz Gutierrez



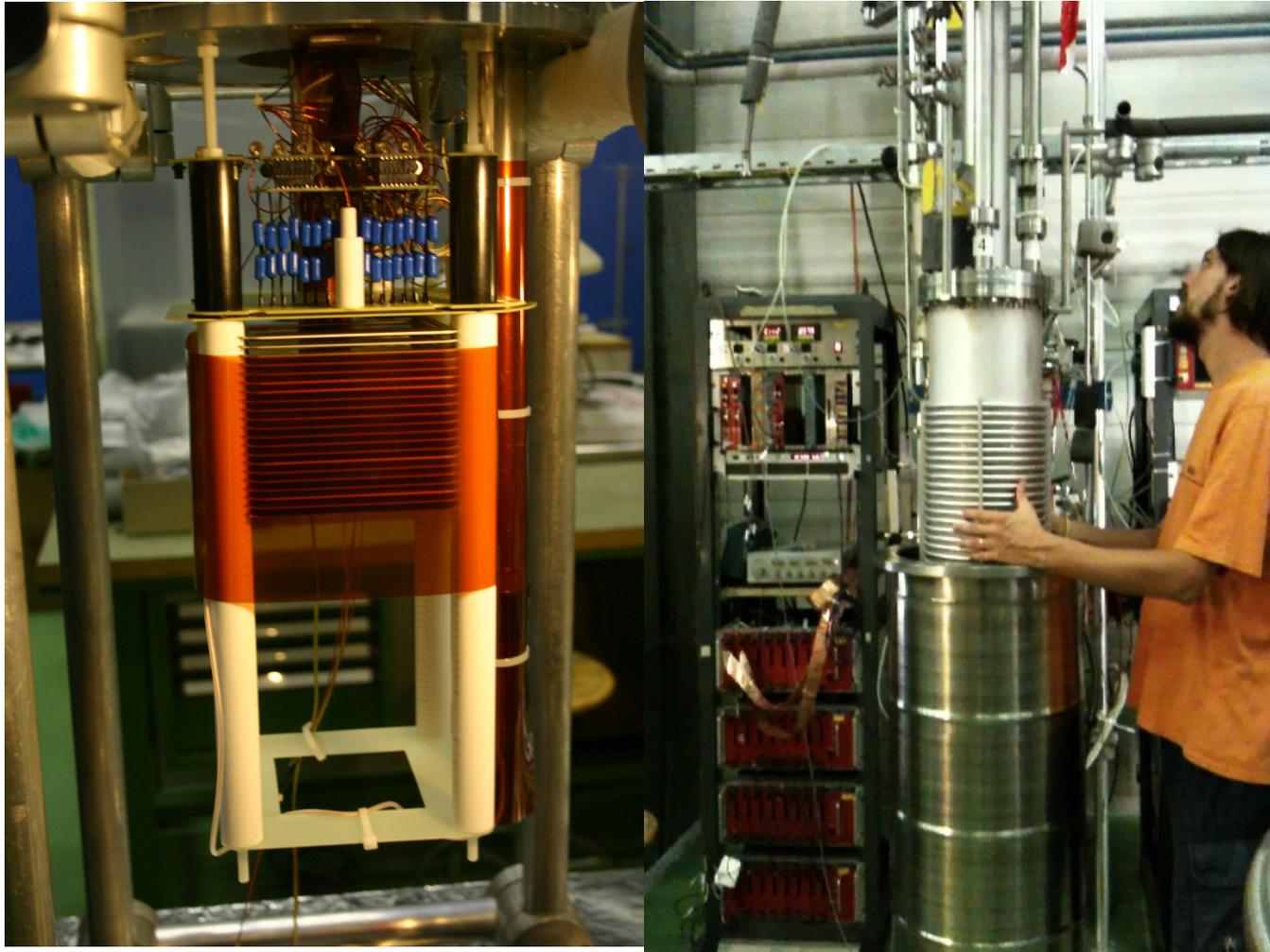


In cold nitrogen vapor

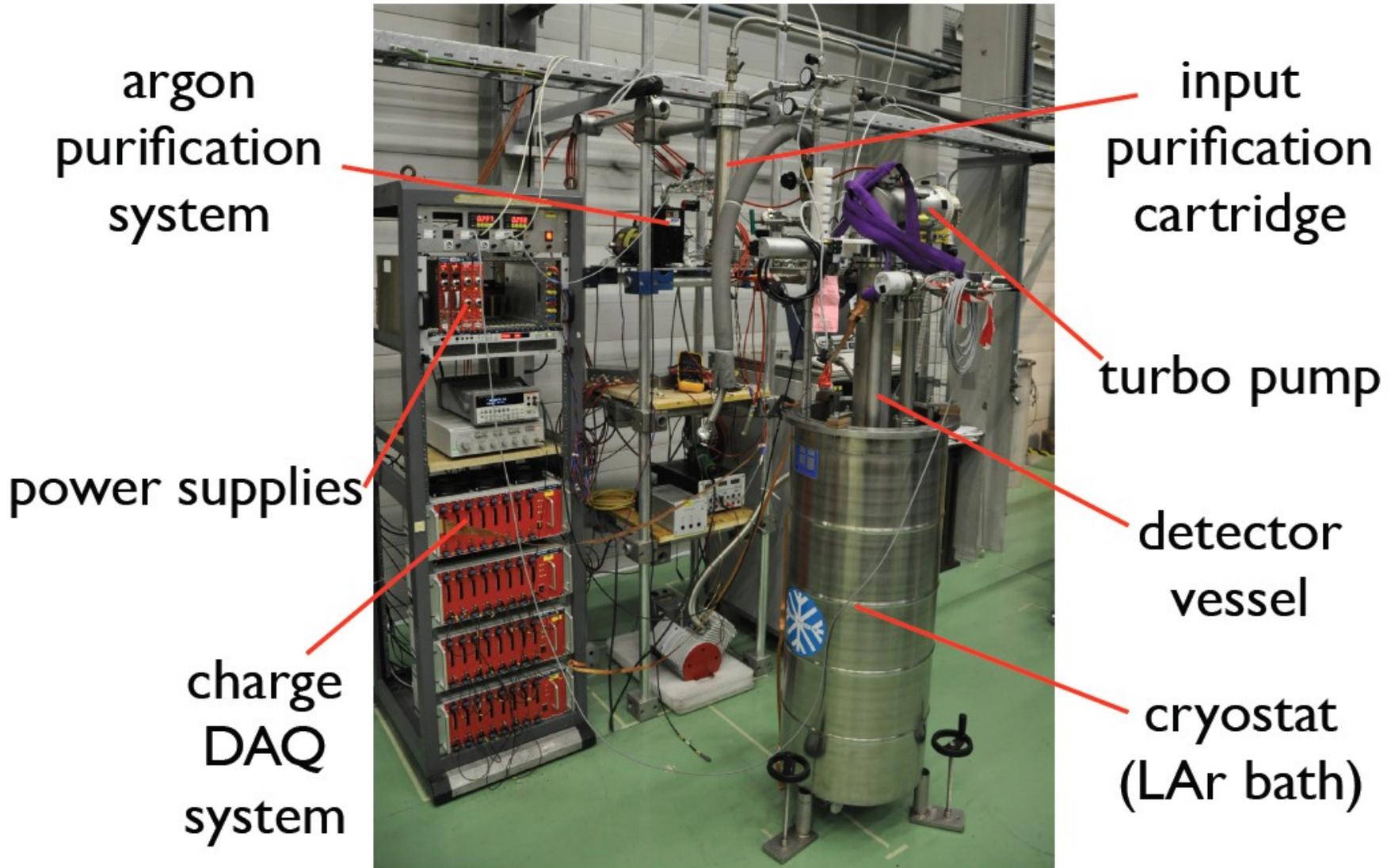
Into the liquid nitrogen bath with high voltage!
Breakdown à 1.3 kV

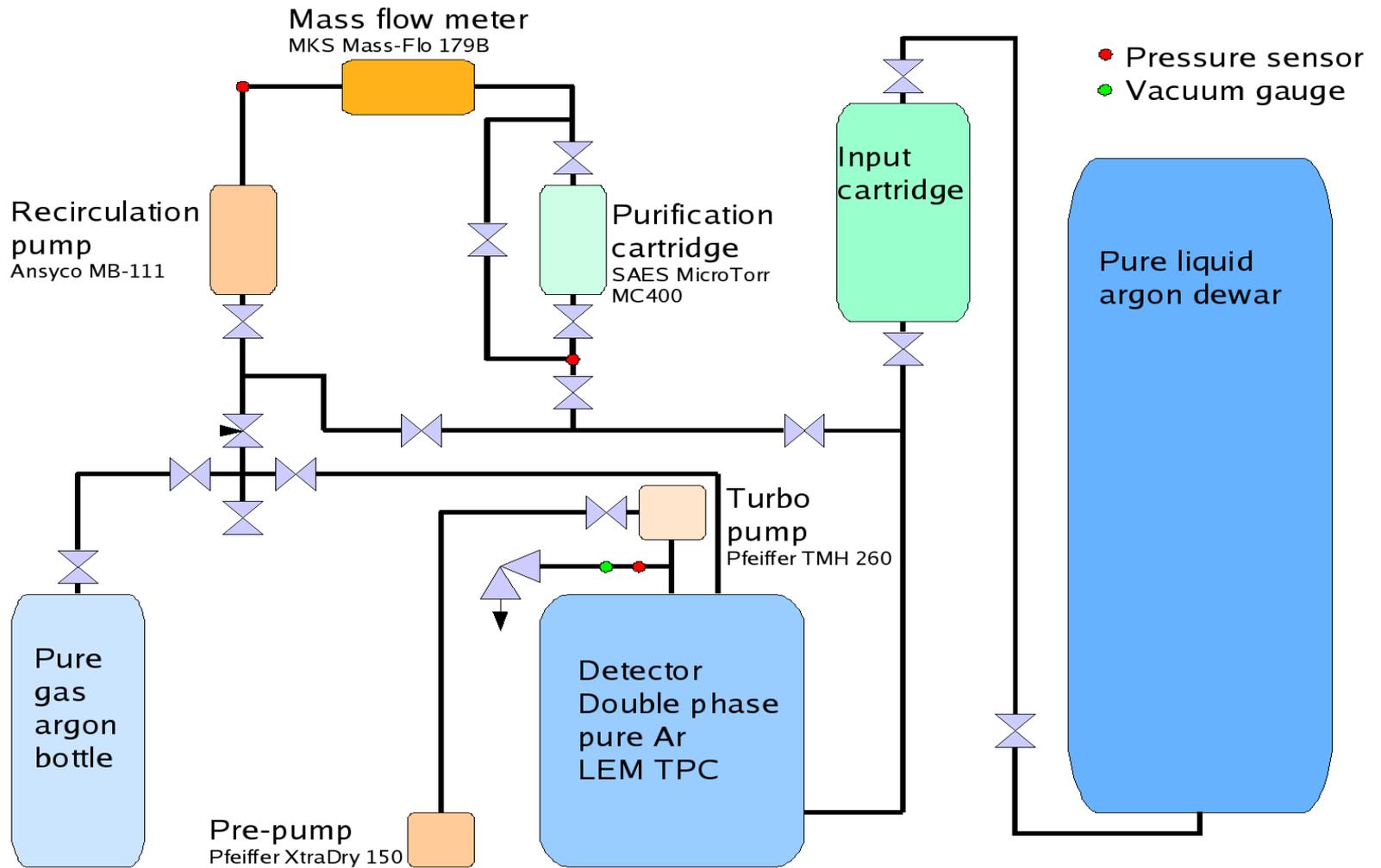


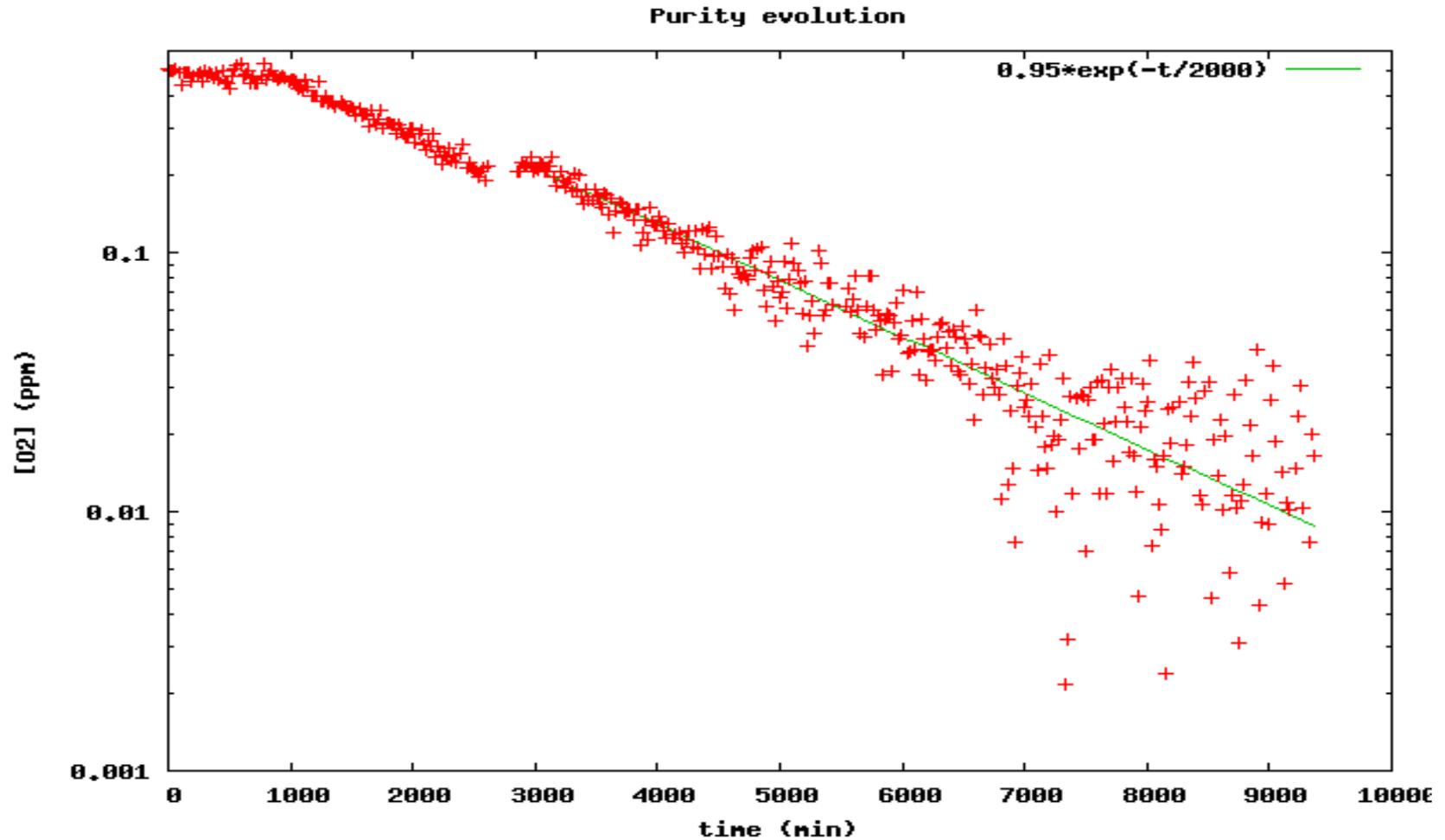
**Gap 100um 10cm x 10 cm 32 strips of 3mm width
Made by R. de Oliveira at Cern**



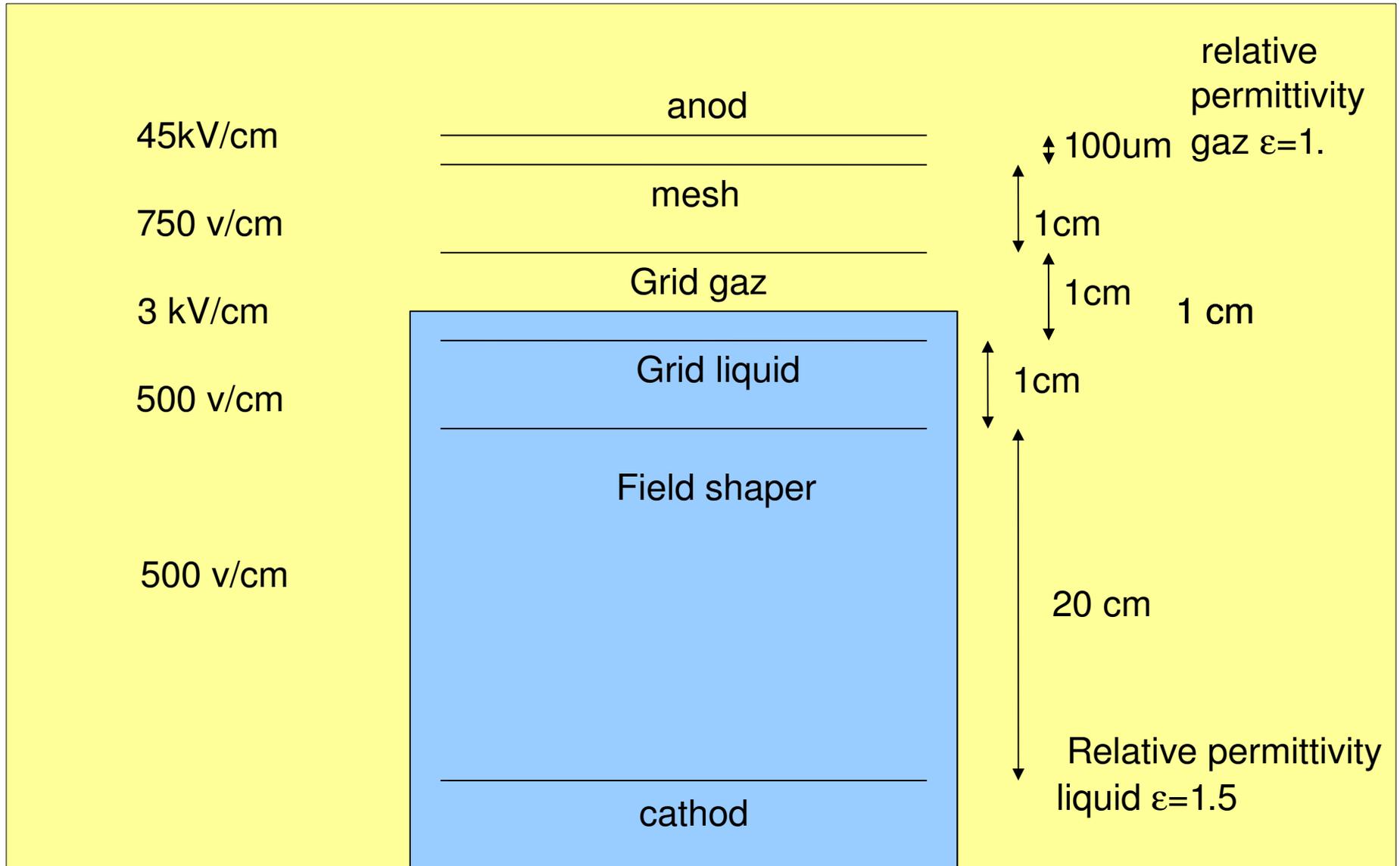
E. Mazzucato, M. Zito, A. Delbart, A. Rubbia, F. Resnati, D. Lussi, A. Curioni

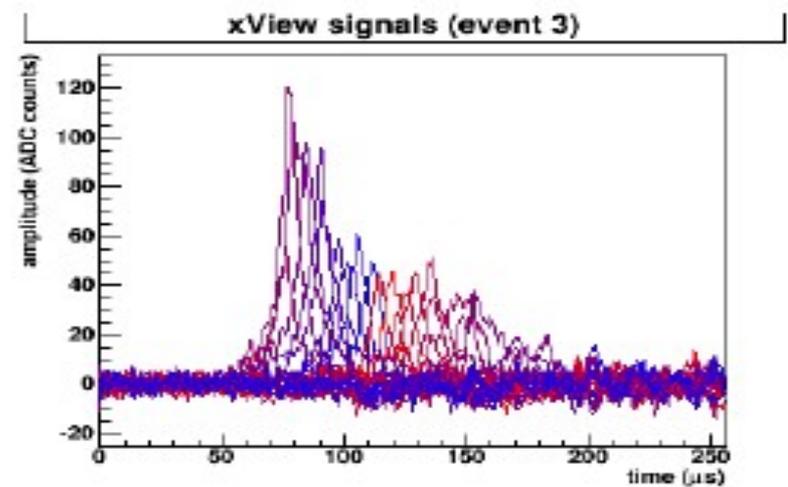
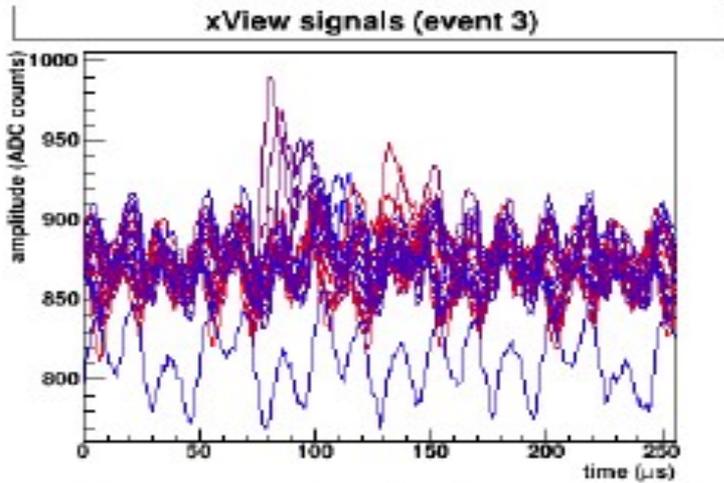




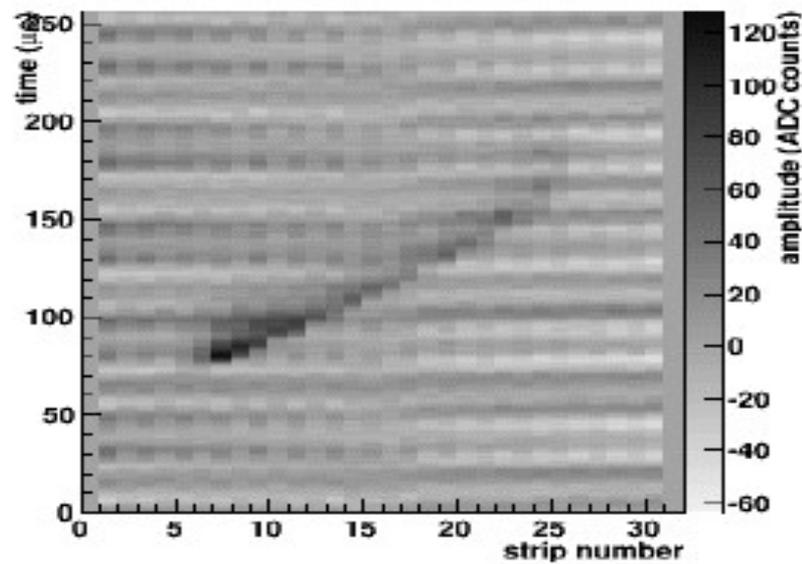


2ppb O₂ content in liquid Argon after 1 week of purification
 $\tau_3 = 1.23 \mu\text{s}$

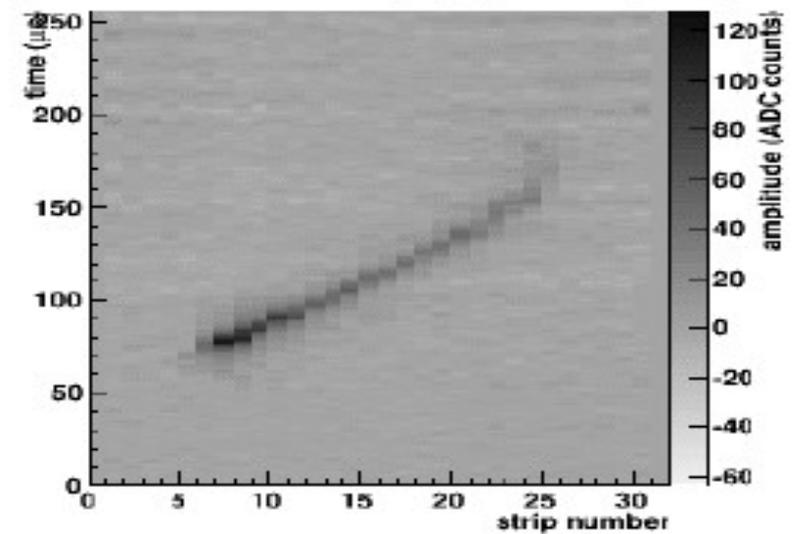




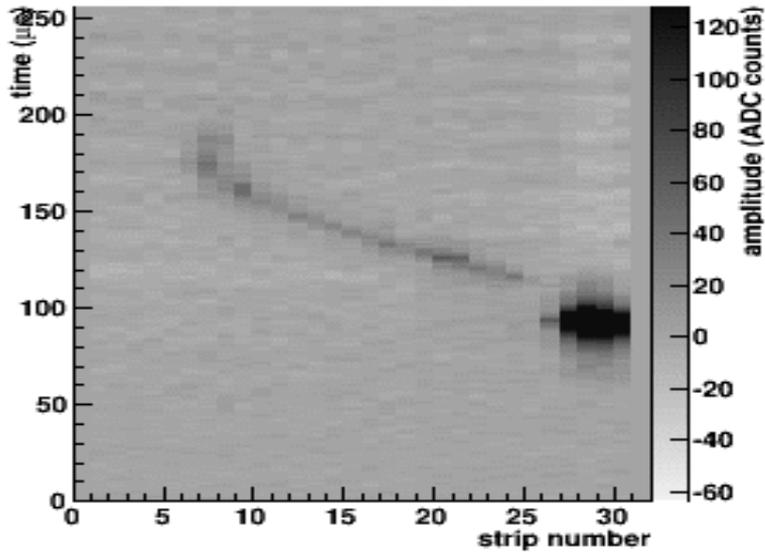
xView event display (event 3)



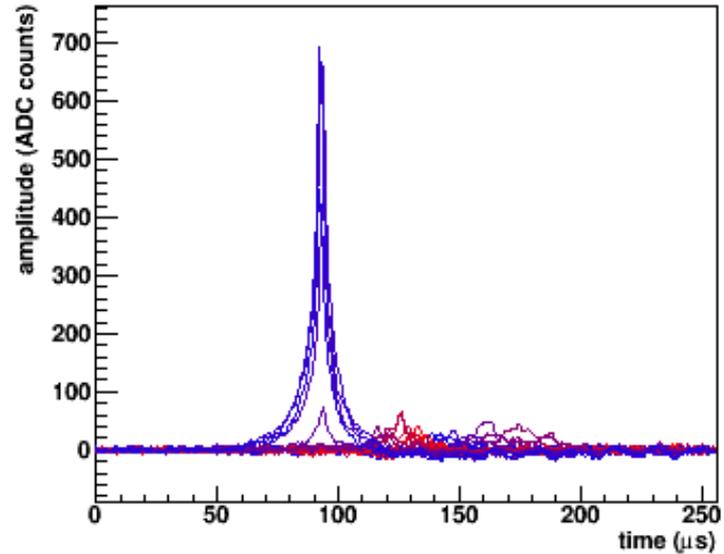
xView event display (event 3)



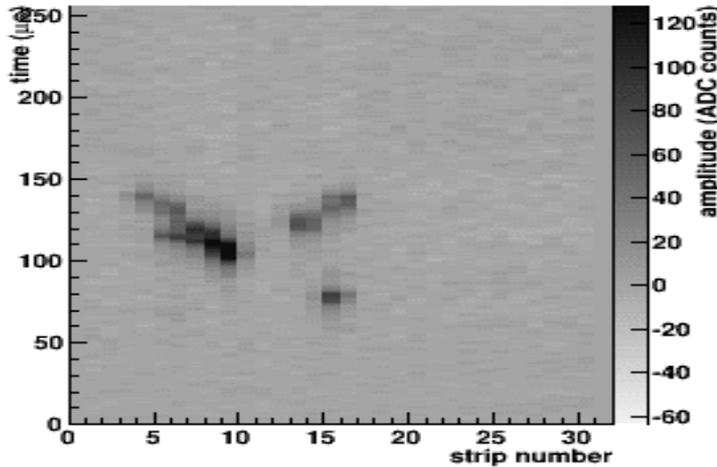
xView event display (event 1)



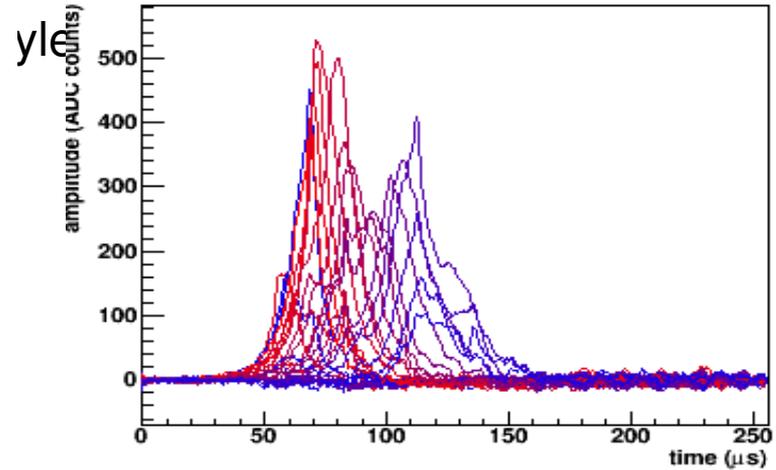
xView signals (event 1)



xView event display (event 29)

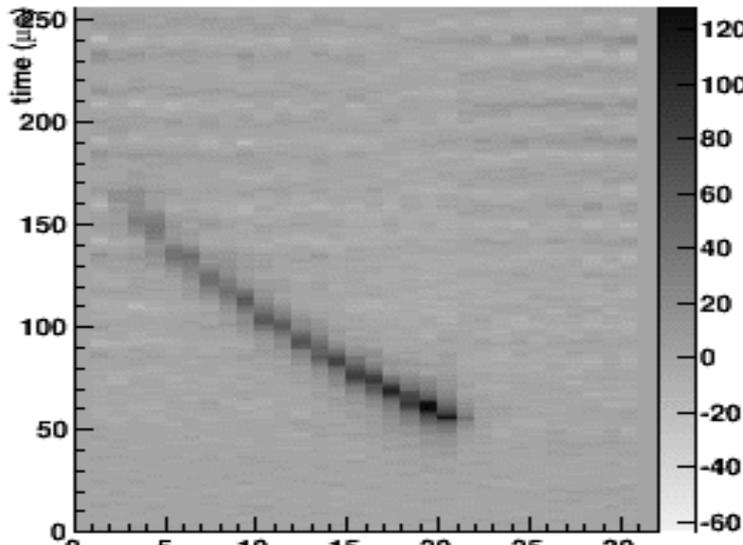


xView signals (event 36)

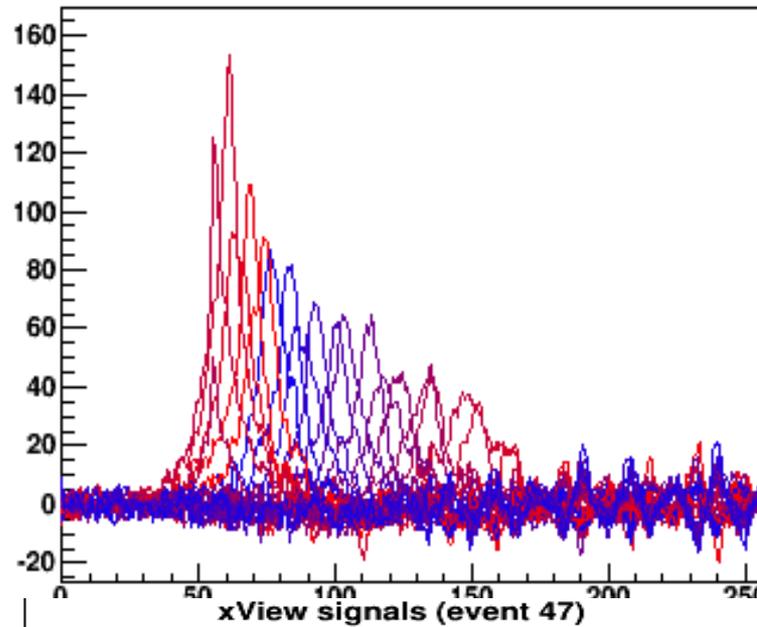


Typical cosmic tracks

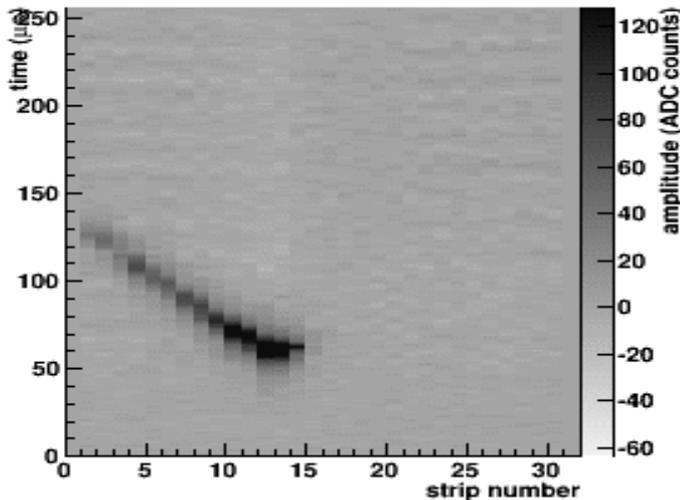
xView event display (event 37)



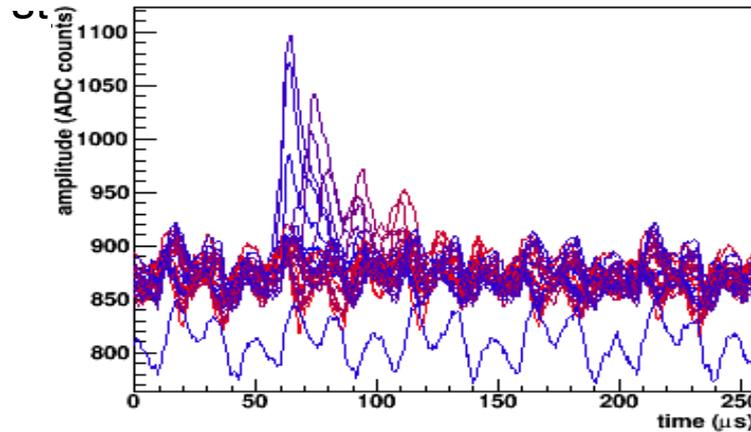
xView signals (event 37)



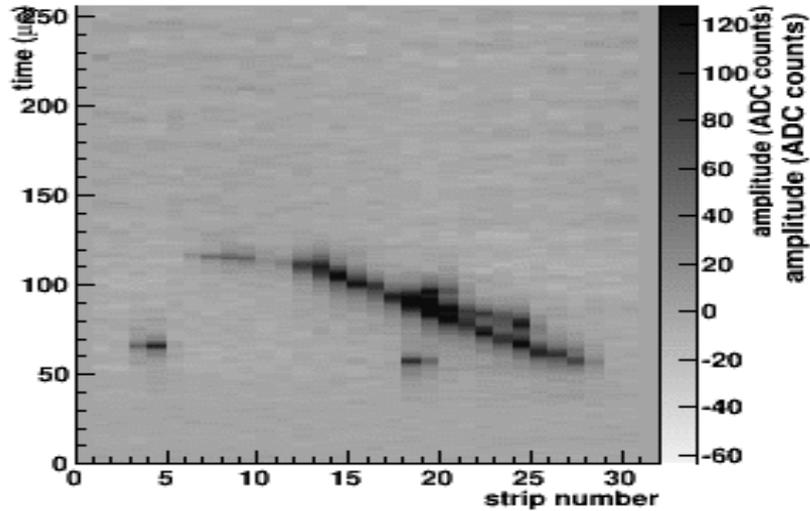
xView event display (event 47)



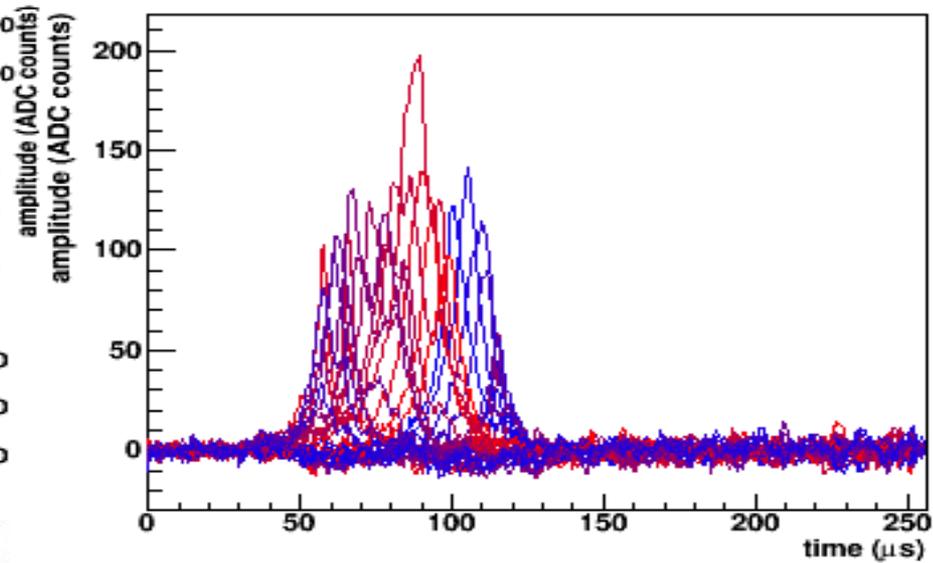
xView signals (event 47)



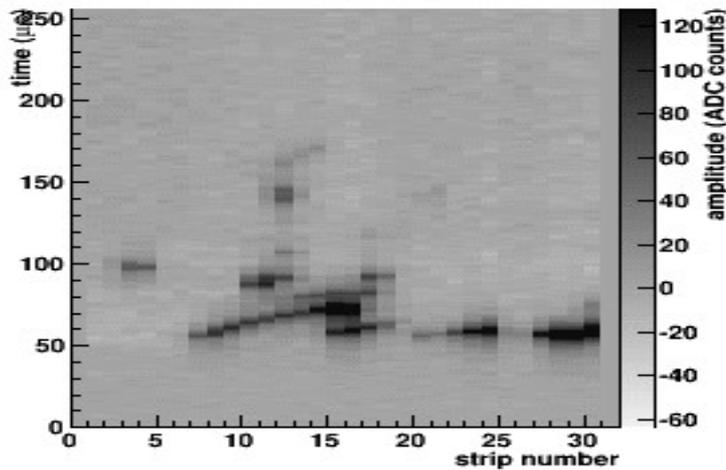
xView event display (event 49)



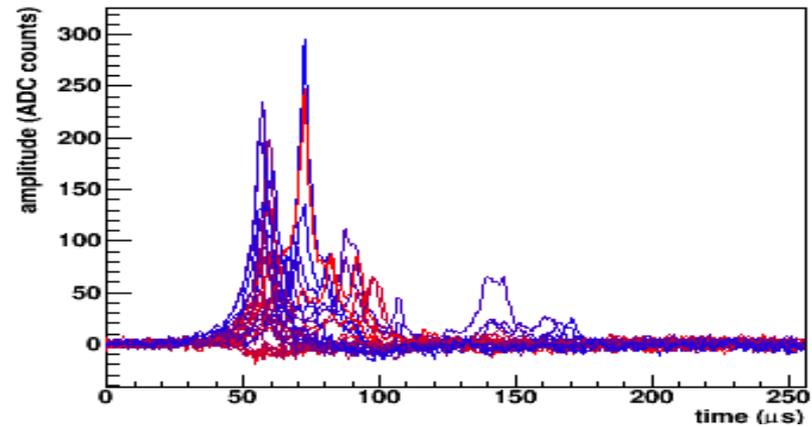
xView signals (event 49)



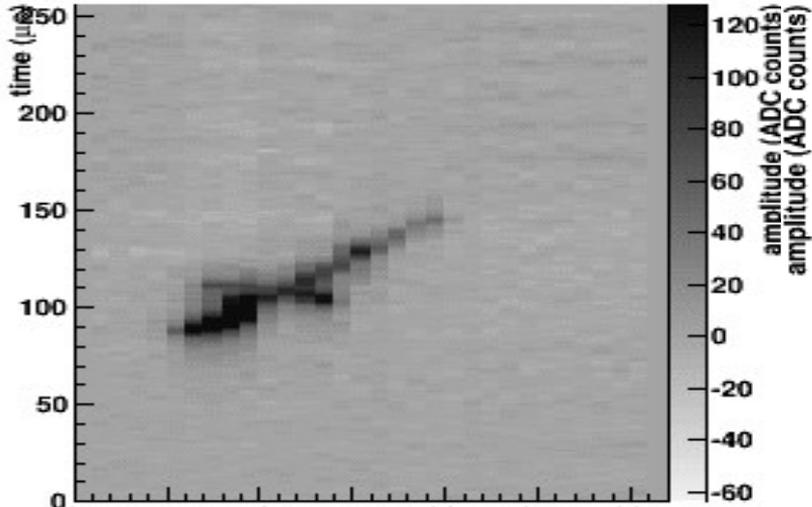
xView event display (event 50)



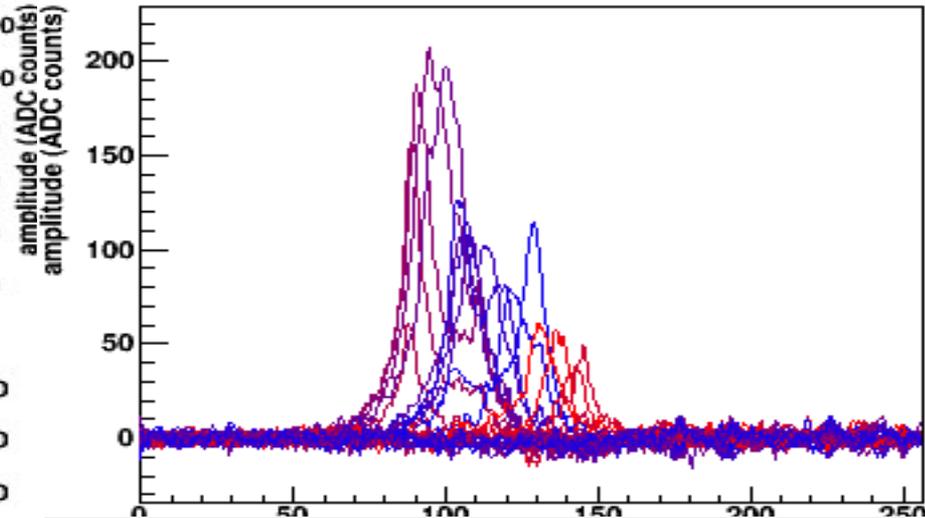
xView signals (event 50)



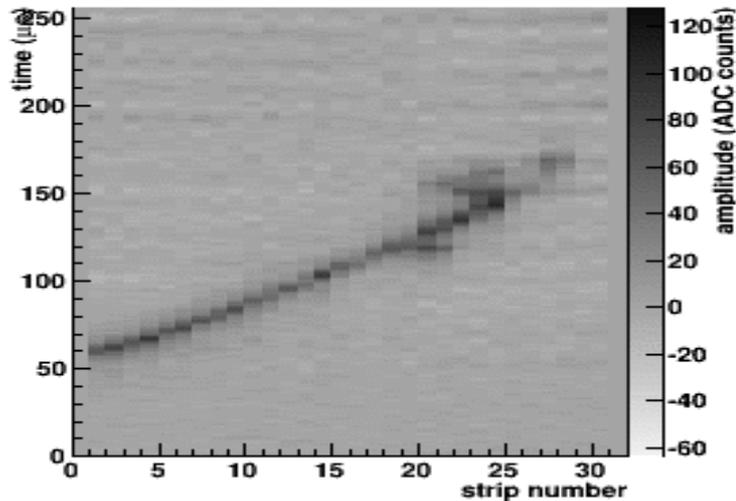
xView event display (event 54)



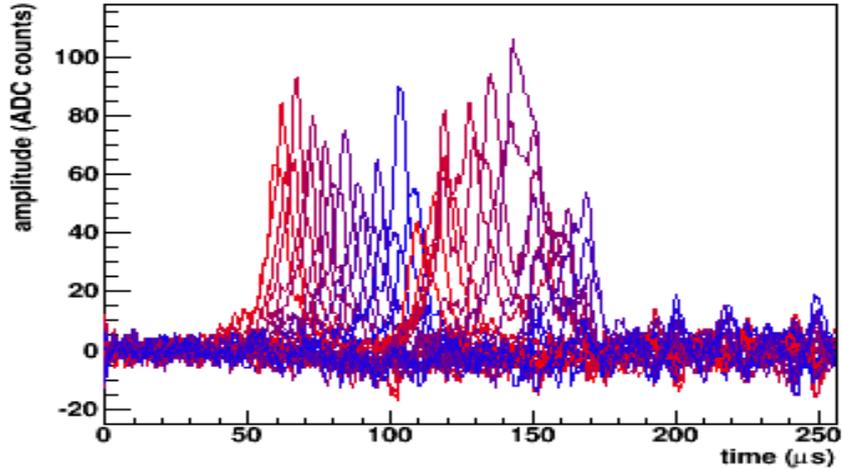
xView signals (event 54)



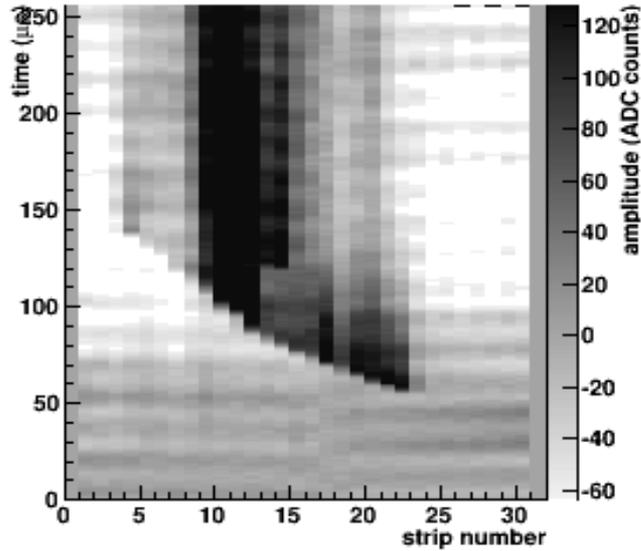
xView event display (event 78)



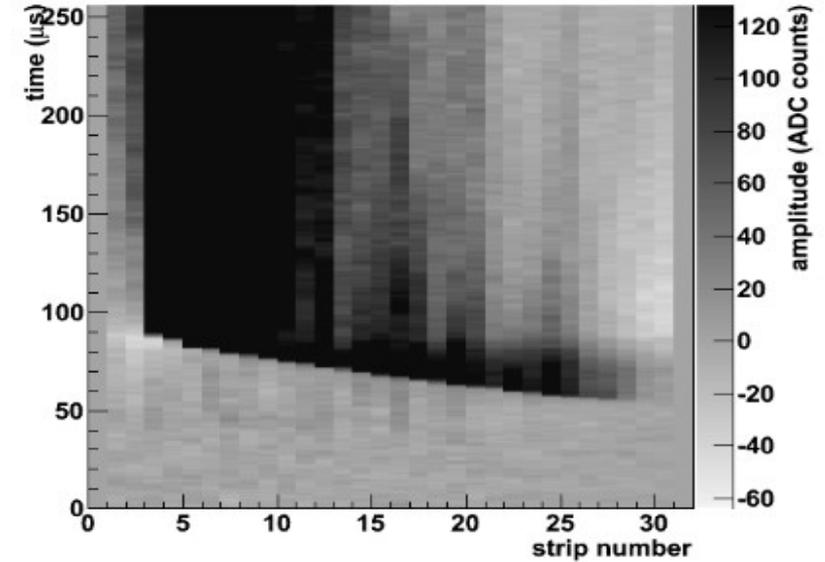
xView signals (event 78)



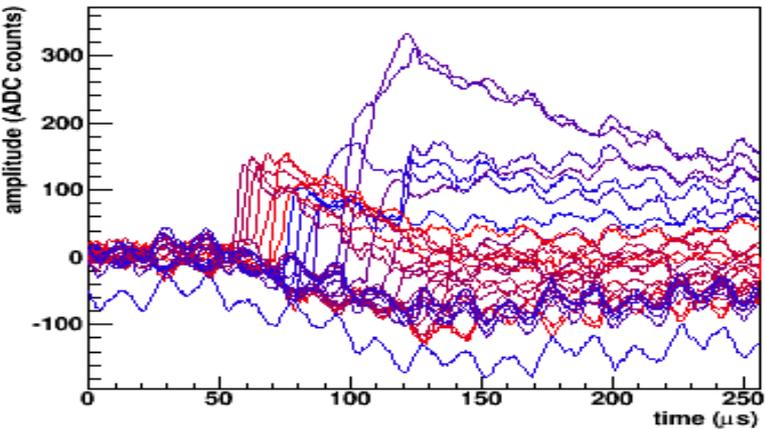
xView event display (event 11)



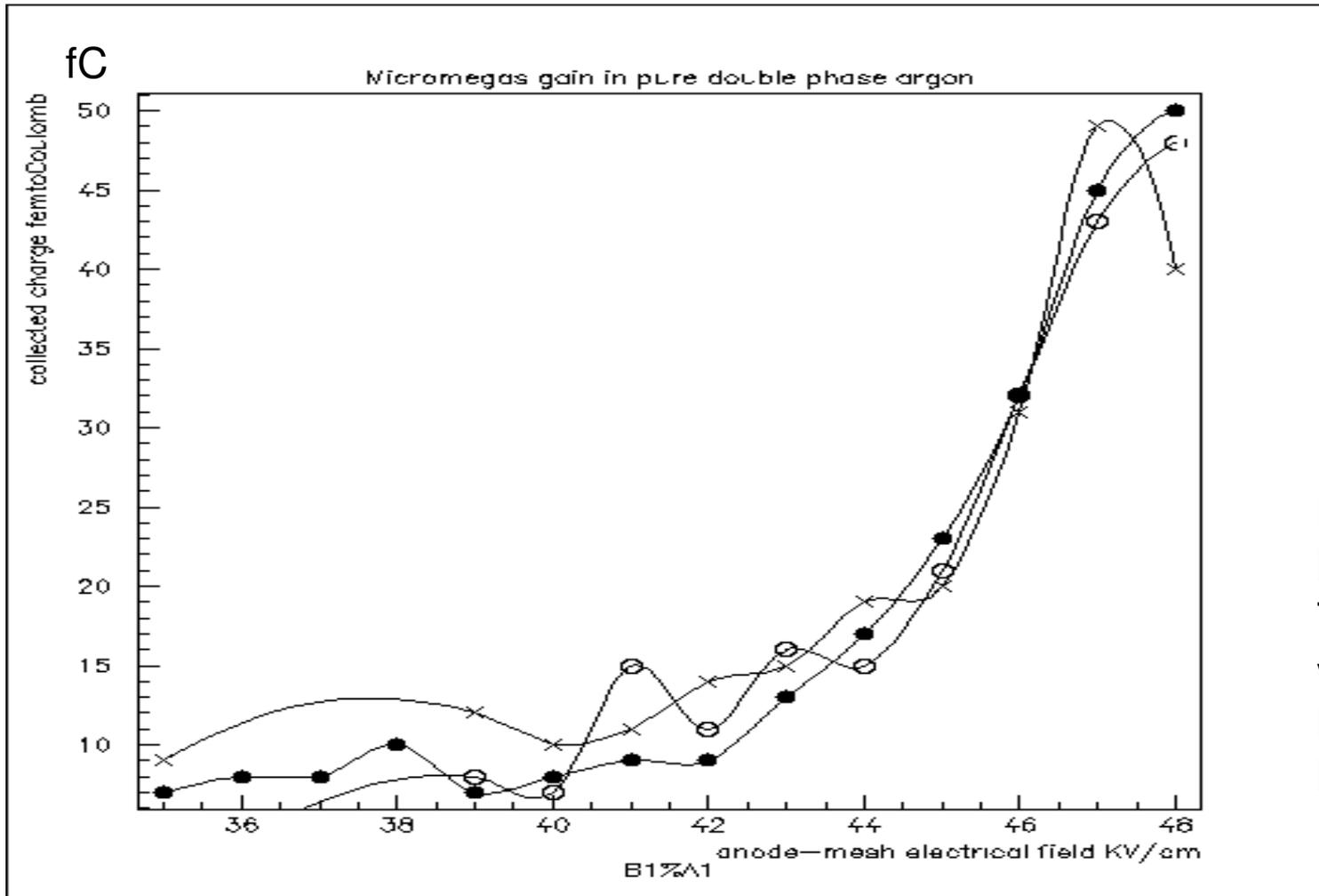
xView event display (event 32)



xView signals (event 11)



Emesh= 48KV/cm (gain~5)
 50femtoCb/strip
 Tau~300us?

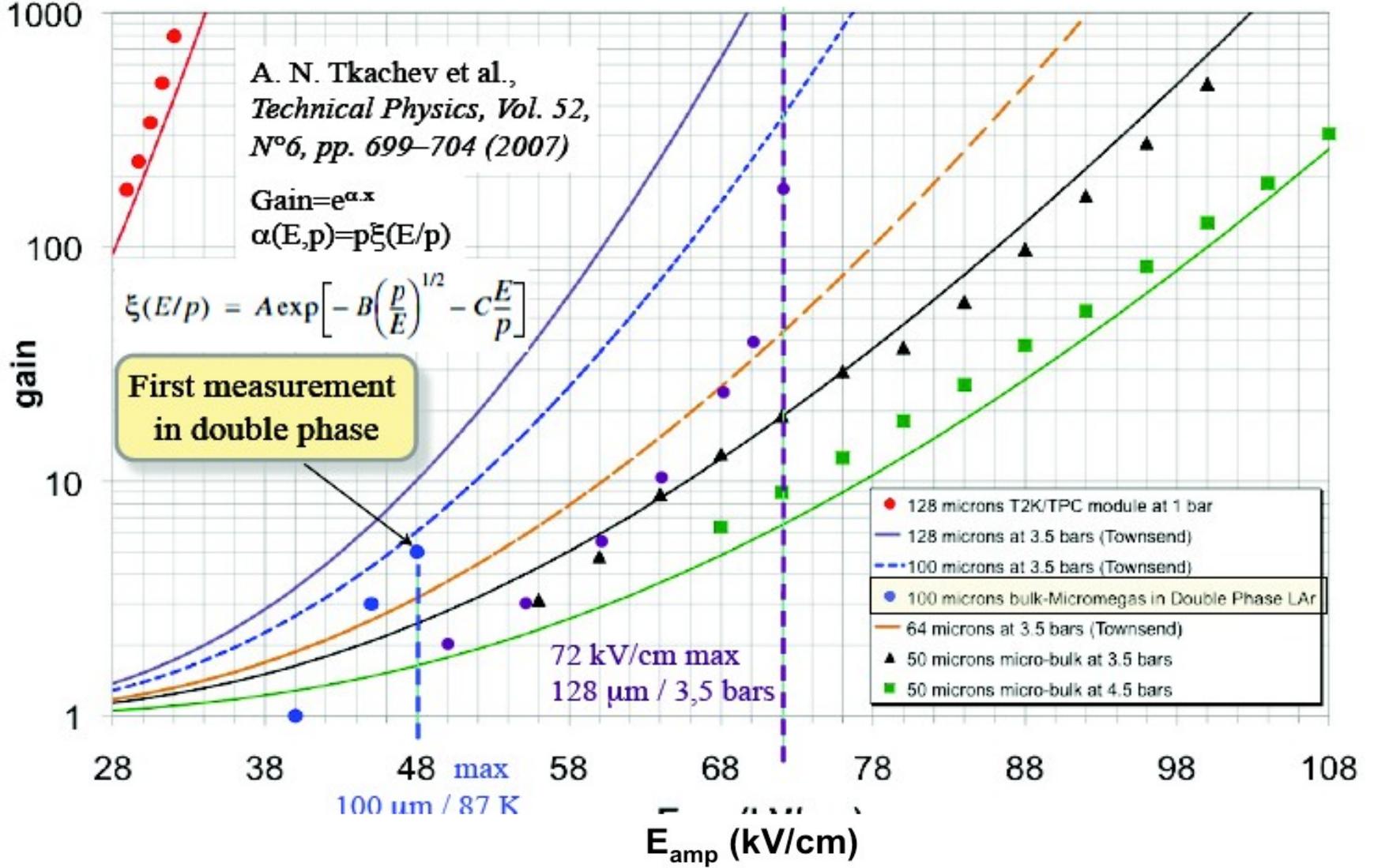


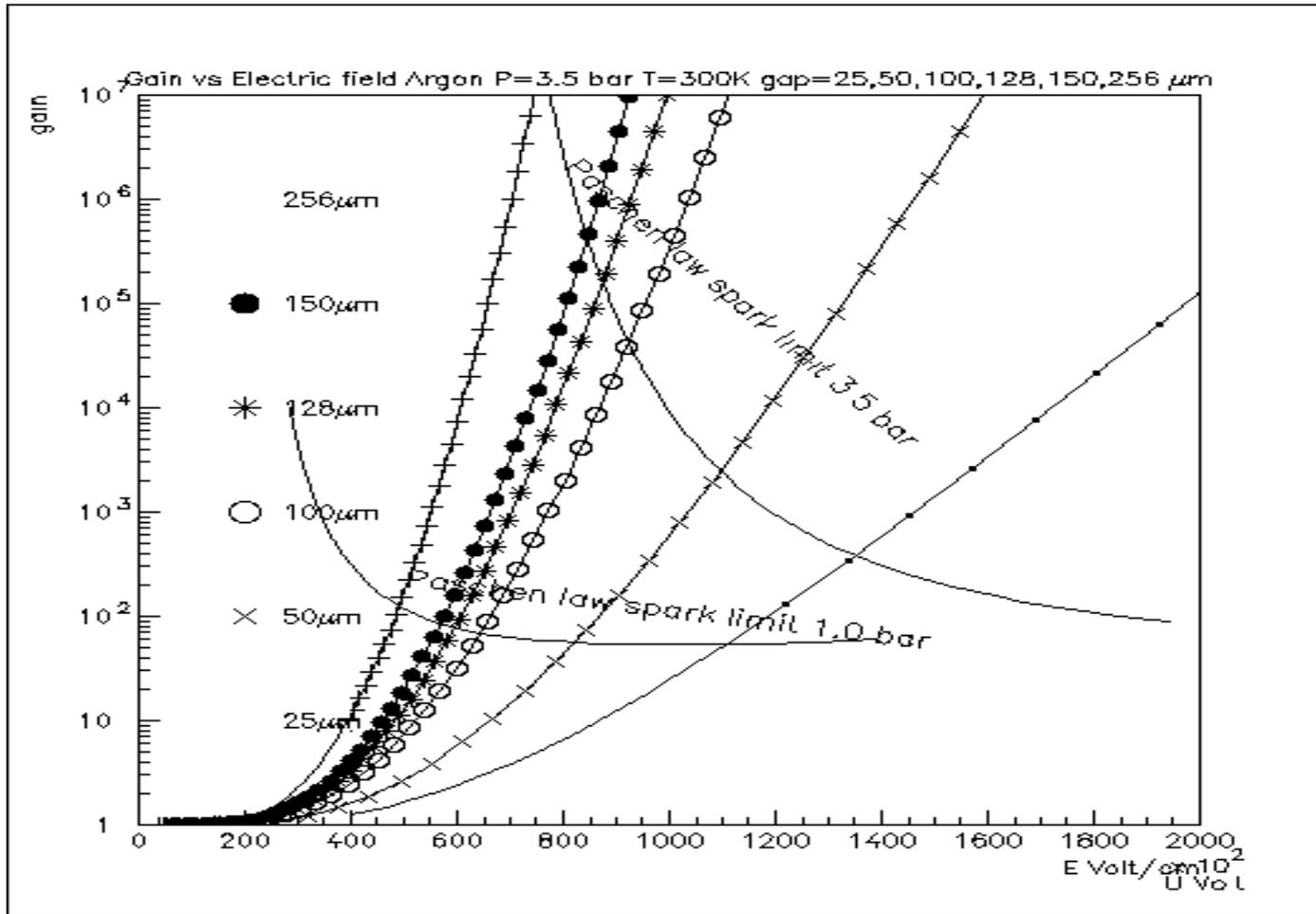
Gain of 5
limited by
charge
Breakdown
@48kV/cm

No observable
Effect on electron
Transmission
versus
Drift voltage
Either in gas or in
Liquid phase!

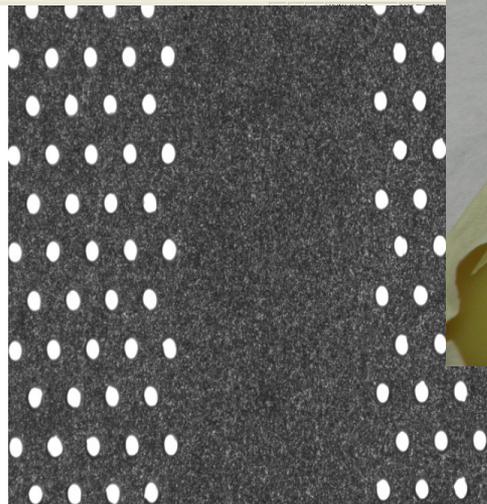
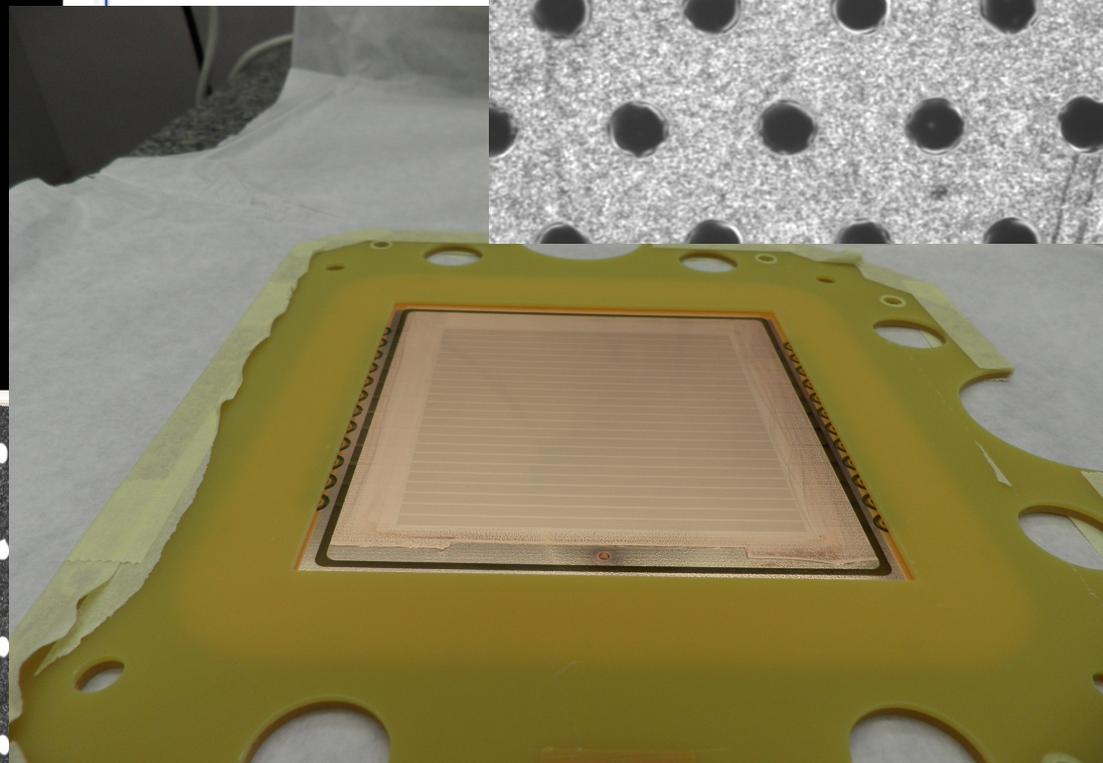
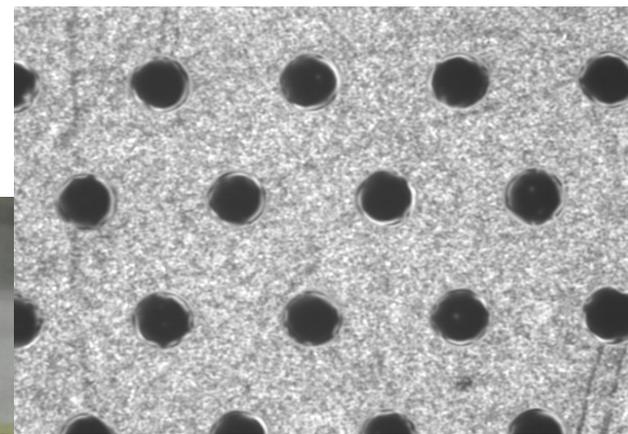
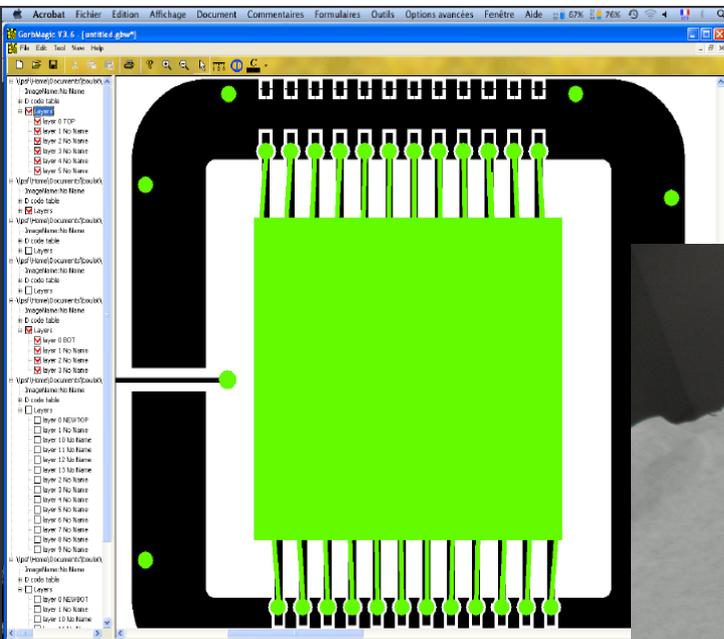
Bulk Micromegas gap=100microns

For Argon: $A = 43 \text{ (cm Torr)}^{-1}$, $B = 27.5 \text{ [V/(cm Torr)]}^{1/2}$, $C = 2.5 \cdot 10^{-4} \text{ (cm Torr)/V}$

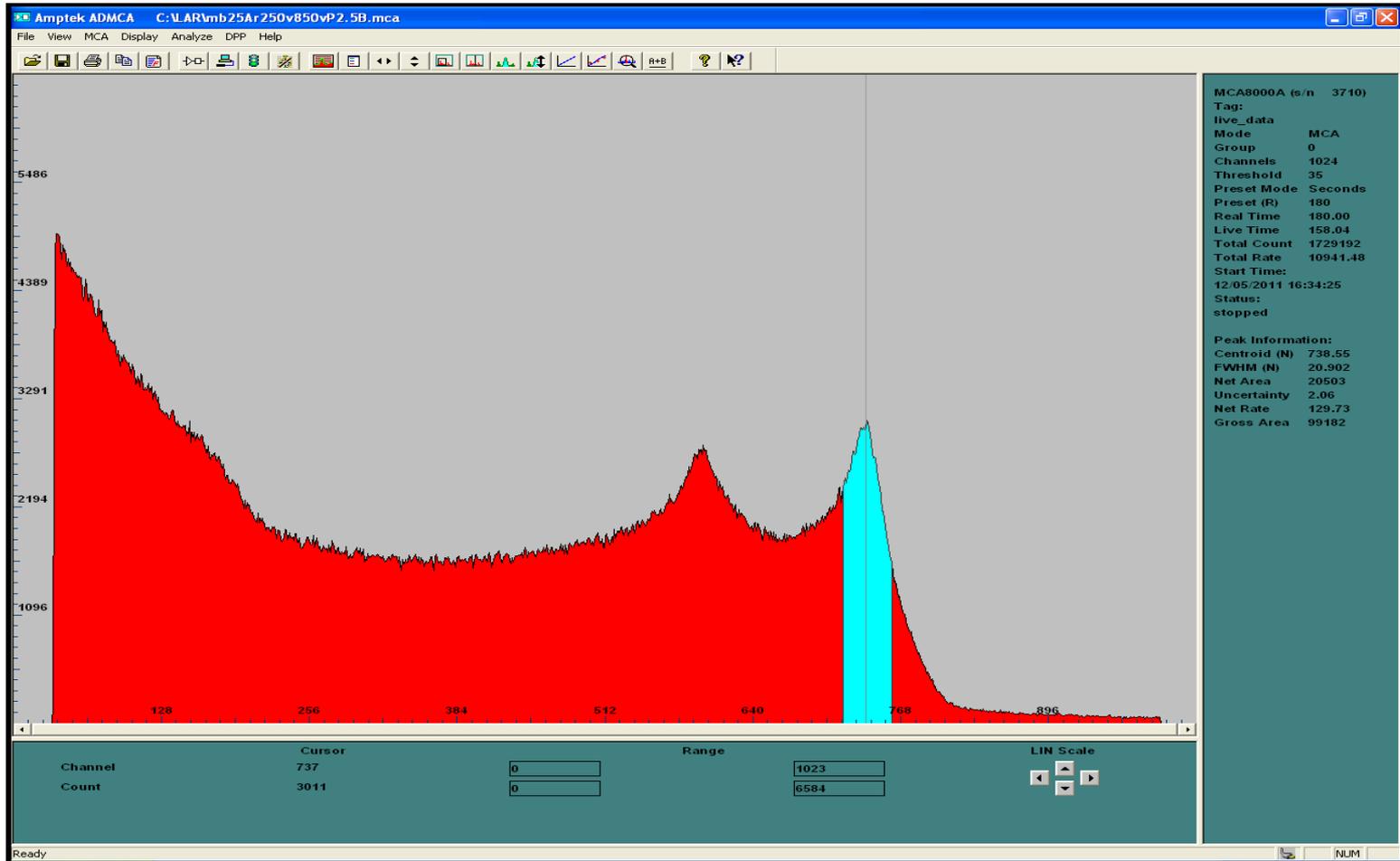




Unexplained sparking limit at 48kV/cm @ 87K for 100um gap
 Sparking should occur at 95kV/cm =>gain >1.E+04



**10cm x 10cm 24 strips of 3mm width gap 25 microns
Made by R. de Oliveira at cern**



A.Giganon

Am241 source

Pure argon tests (no quencher)

-encouraging tests with pure Argon @ 1 bar $T=300K$ 128 μm gap T2K like
Bulk micromegas gain~1000

-encouraging tests with pure Argon @ 3.5 bar $T=300K$ 50 μm gap
micobulk micromegas gain~300

-first tests with a bulk micromegas 100micron in cryogenic condition 87K
with pure argon gas of a double phase liquid/gasTPC

-Thanks to density of argon (1.4g/cm³) minimum ionizing tracks are easy to detect

-debugging phase: limit gain ~5 due to unexplained early charge breakdown

-no quencher

-surprise: no effect of the drift field in gaseous phase on the transmission of
electrons

-go to less stiff gain slope using smaller gaps with microbulk micromegas 25 microns
Exploring the phase space of the behaviour of micromegas in cryogenic condition
with pure Argon

Collaboration extended to IPN Lyon and Liverpool University