First tests of Micromegas in double phase liquid Argon

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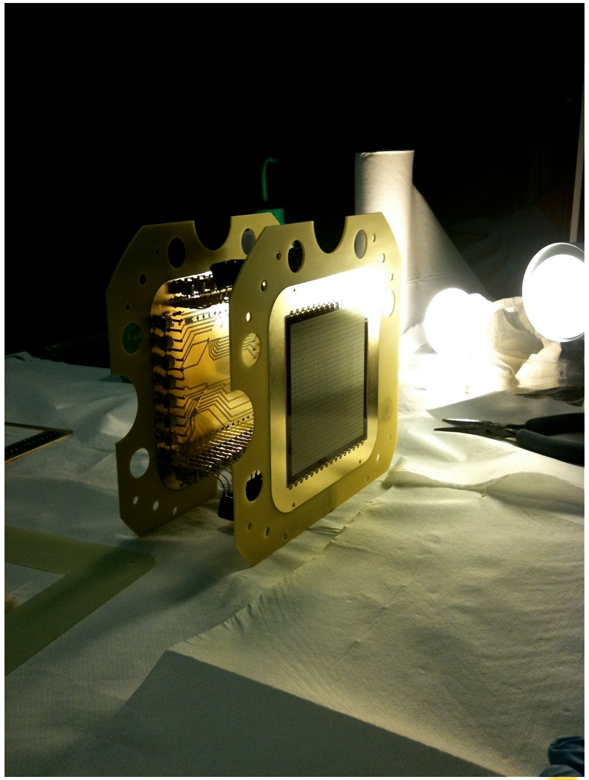


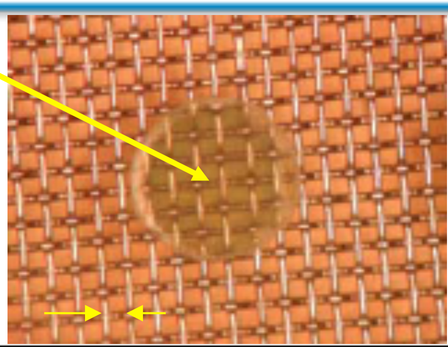
Outline

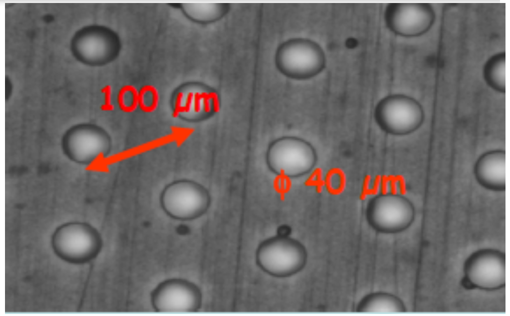
- Introduction : scope of this study and gain measurements in high pressure Argon at room temperature

- First operation of a 100 μm bulk-micromegas in double phase Liquid Argon
  - TPC Setup
  - The bulk-micromegas design and operation
  - Preliminary results : gallery of cosmic tracks and estimate of the achieved gain

- Conclusion

Comparison of bulk & micro-bulk technologies





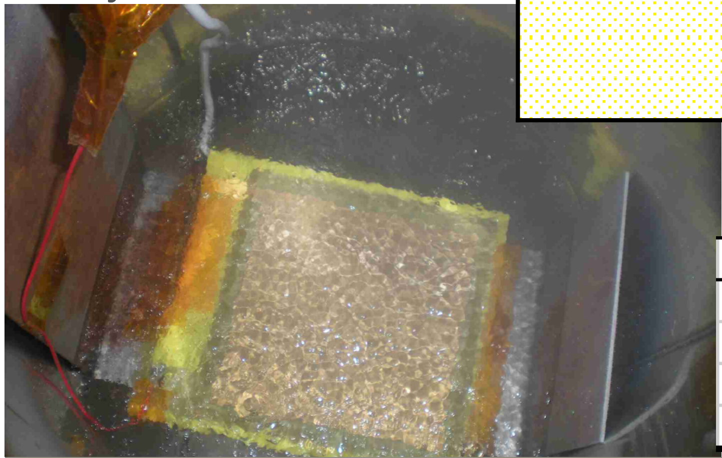
	bulk	micro-bulk
Standard amplification gap	128 μm	50 μm
Other possible amplification gaps	(64)-100-150-194 μm	(12.5)-25 μm
Standard Mesh pitch	63 μm	100 μm
Standard Mesh openings	45 μm	40 μm
Standard maximum size	40x40 cm^2	10x10 cm^2
R&D maximum size	500x1500 cm^2	30x30 cm^2
Best FWHM 5.9 keV resolution	8%	6%
Currently in use in experiments	T2K/TPC	Axion CAST experiment, nTOF
Current R&D programs	ILC/TPC, ILC/DHCAL, SLHC/Muon chambers upgrade, CLAS12 spectrometer, ...	NEXT, MIMAC, ...

- Large size
- Large scale production

- Low-budget material
- Excellent energy resolution
- < 50 μm amplification gap

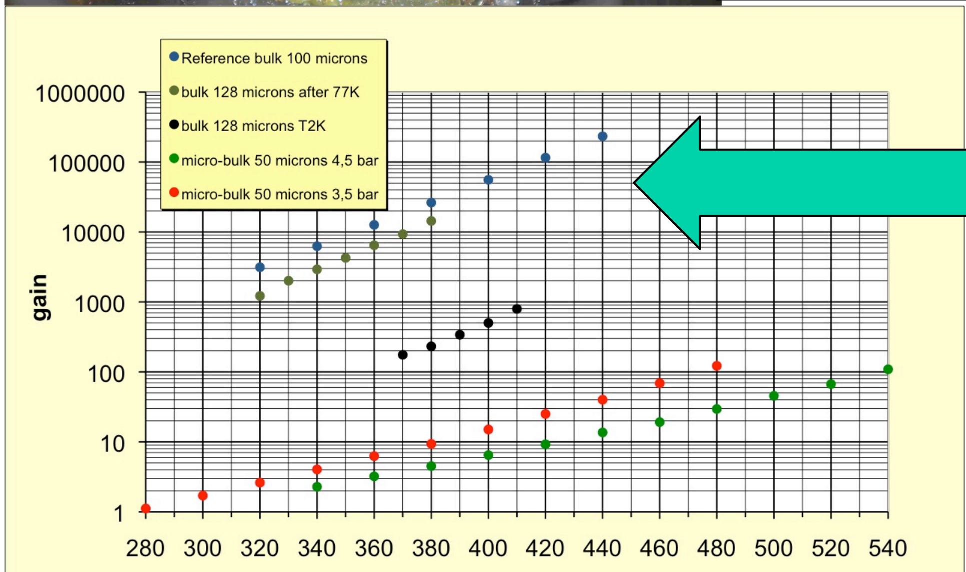
Robustness test of a bulk-micromegas @ 77K

Depth (mm)	T (°C)	Max Vmesh (V)	Max Eamp (kV/cm)
40	-47	670	52,3
25	-78	750	58,6
8	-119	850	66,4
0	-163	975	76,2
-10	-196	1300	101,6



Rough CTE @ 20°C

Material	CTE (ppm/°C)
FR4	14-16
copper	17-18
304L stainless steel	14-17
Pyralux PC1025	100-130



After drying of the detector @ 80°C for 1 night

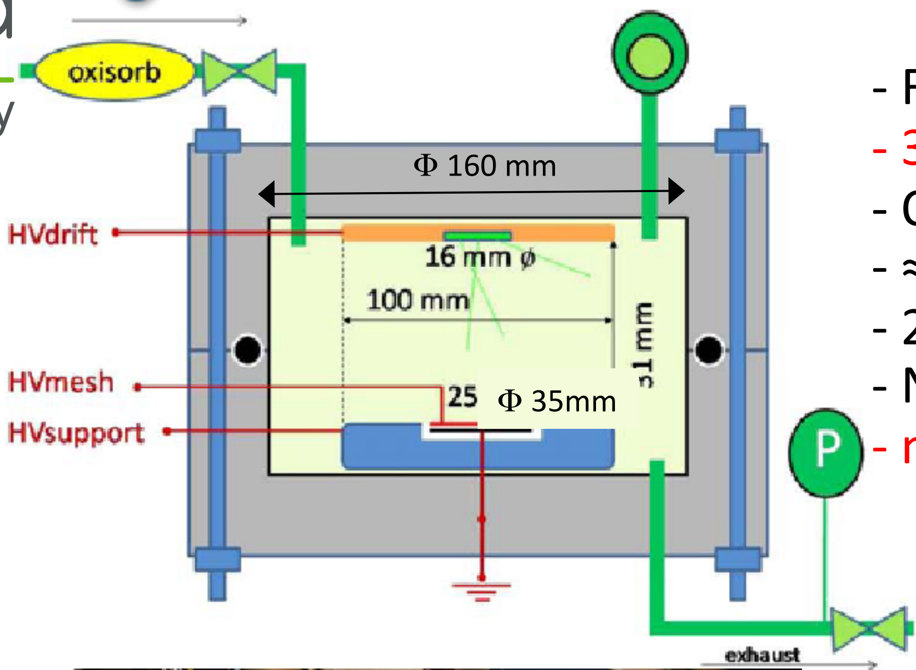
Gain was measured in Ar+5%iC_4H_{10} at 1 bar

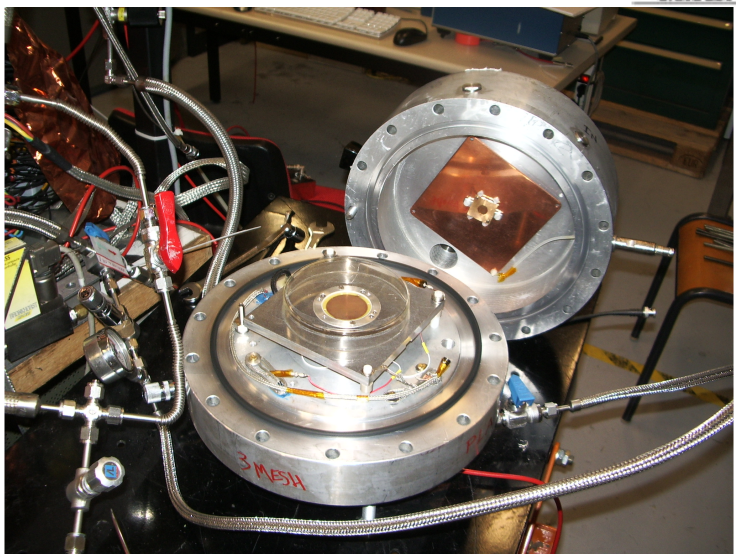
Bulk-micromegas seems to be robust enough to be operated at cryogenic temperatures

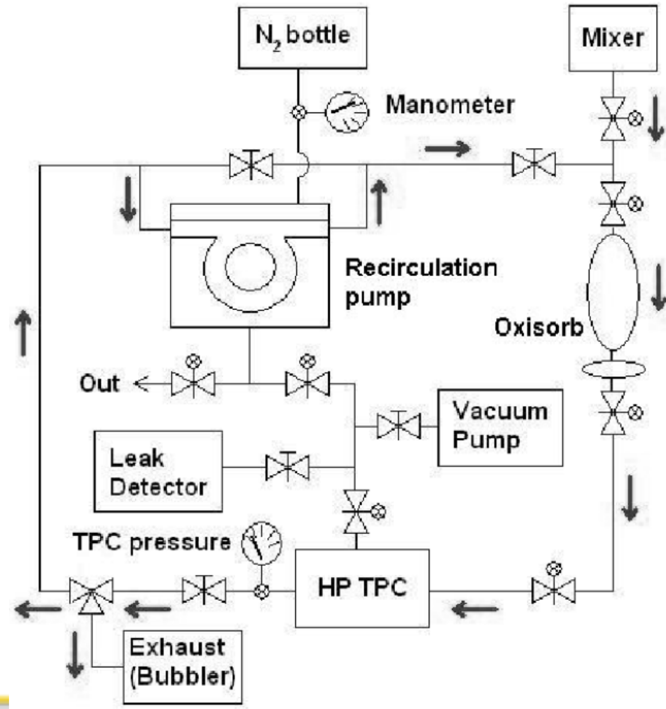
Ref: A. Delbart *et.al.*, GLA2010, proceedings of 1st International Workshop towards the Giant Liquid Argon Charge Imaging Experiment

High Pressure Argon Gain measurements

- Former Hellaz experiment chamber
- 35 mm diameter 25 & 50 μm micro-bulk
- Ortec 142C preamp
- ≈100 Bq ^{241}Am alpha source
- 200 Hz counting rate
- N_p=2 10^5 e-
- no particular purification (Ar-60)







T. Dafni et al. NIM A 608 259-266, 2009

Microbulk Gain in Argon @ room temperature

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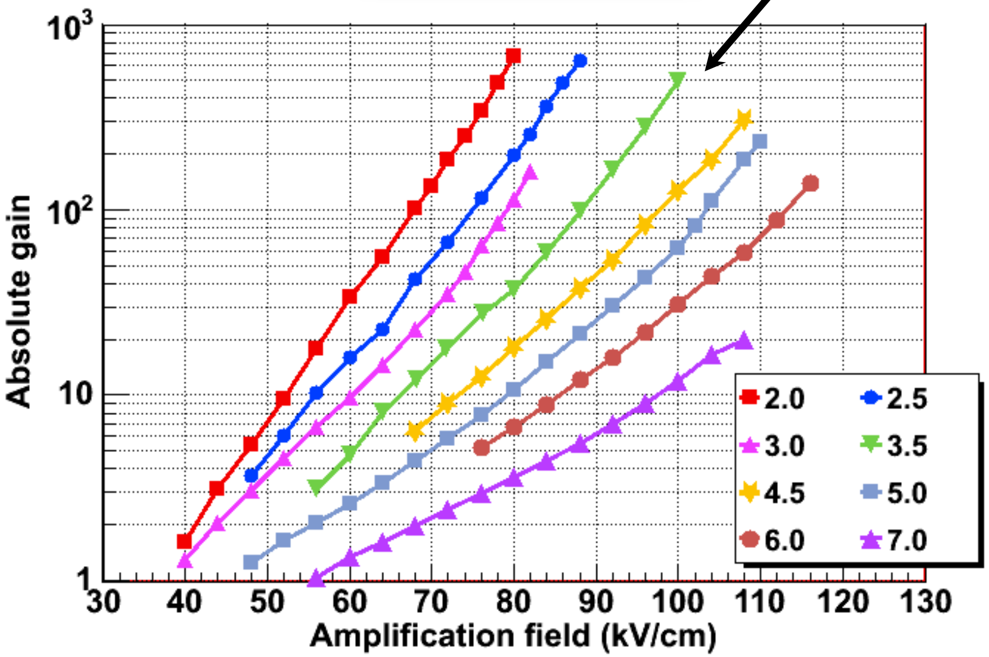
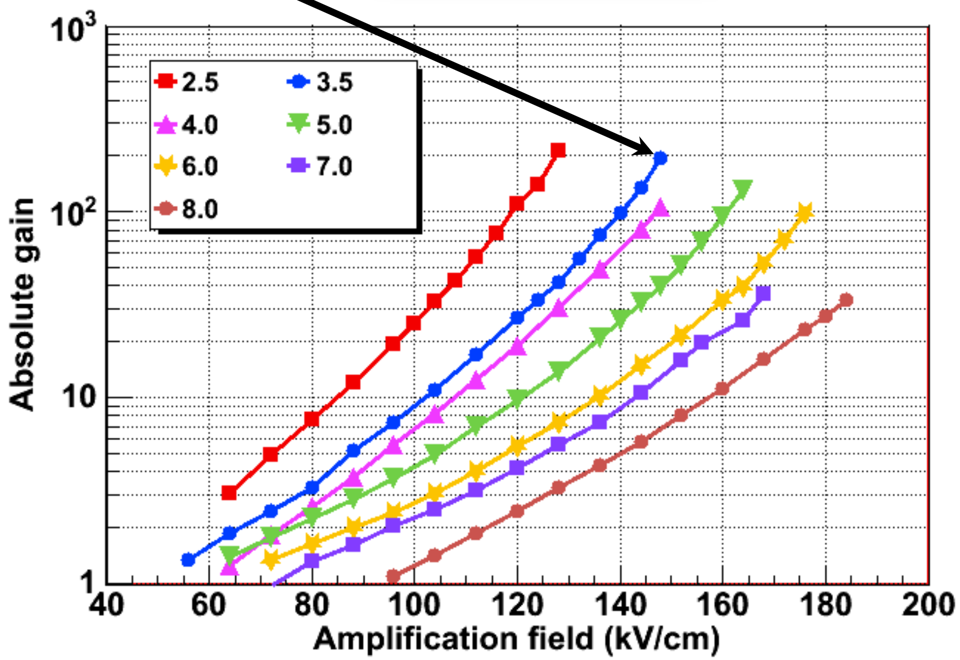
@ 3,5 bars at room temperature

50 µm microbulk



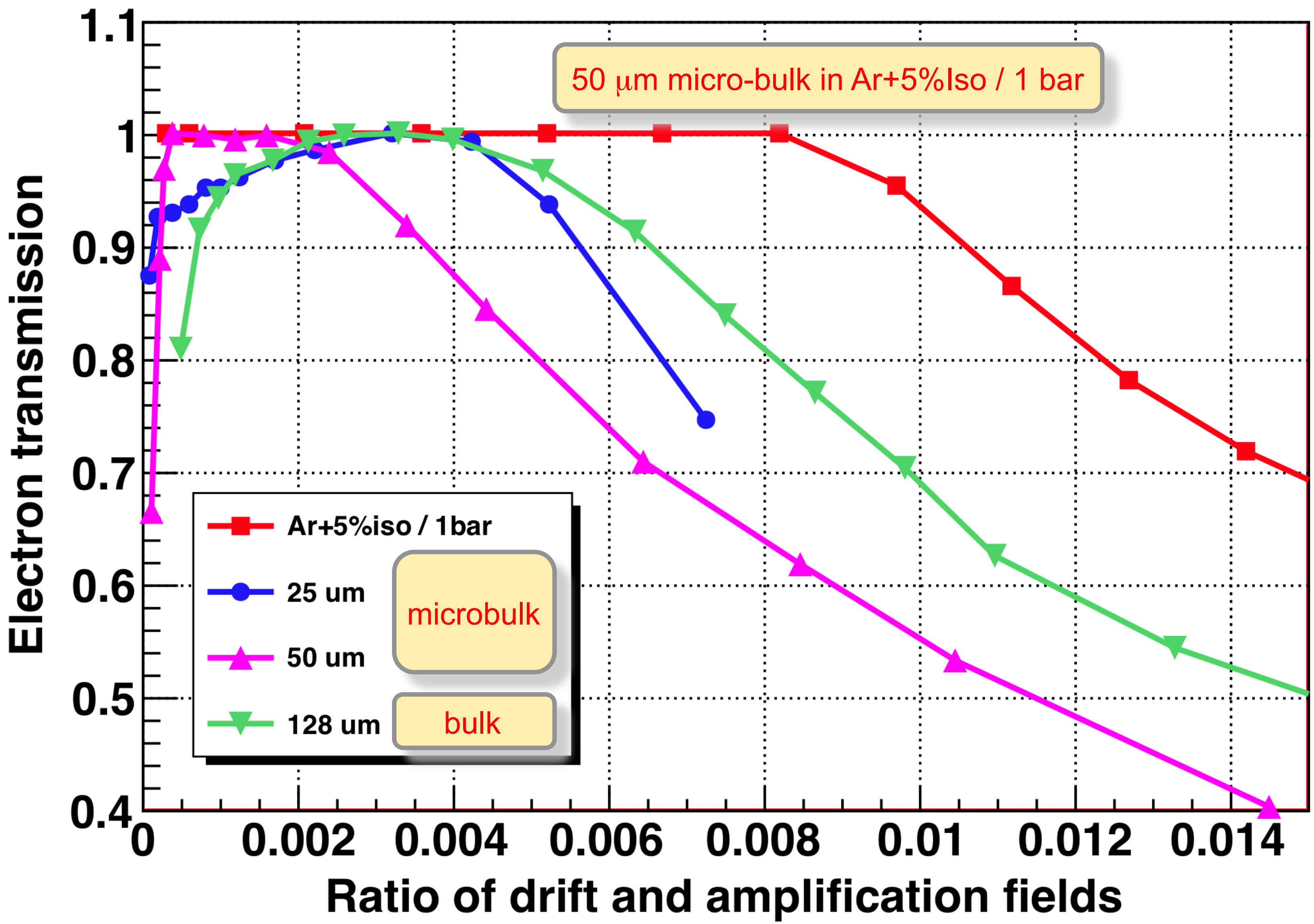
25 µm microbulk



Ref: F. J. Iguaz, New results of micromegas (microbulk) detectors, Freiburg RD51 collab. Meeting, may 25th 2010

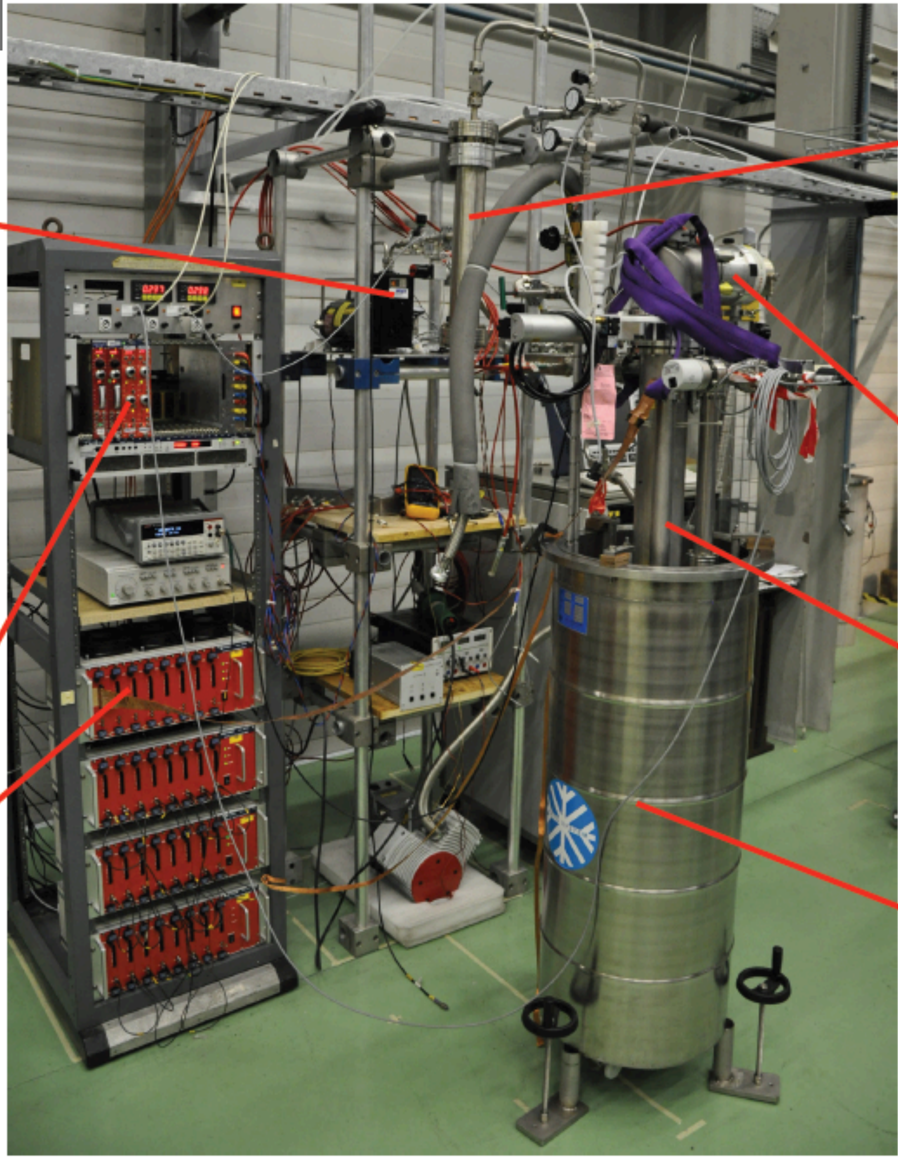
High gain achieved but how does this compare to double phase very pure argon conditions ?

Electron transmission of micro-bulk in Argon at 3,5 bars



The Liquid Argon 3 liters ETH setup

Ref: D. Lussi's talk



argon purification system

power supplies

charge DAQ system

input LAr purification cartridge

turbo pump

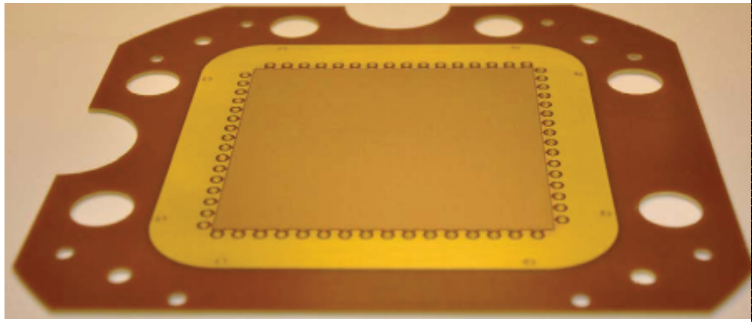
detector vessel

cryostat (LAr bath)

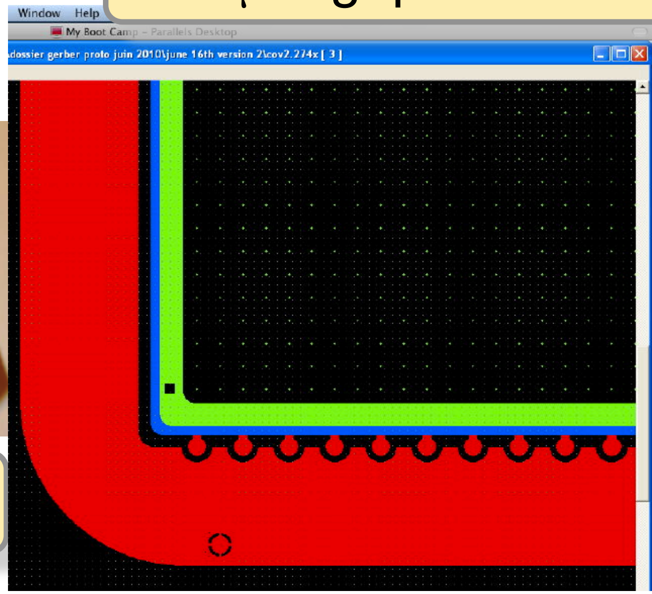
A bulk-micromegas for the ETH LAr TPC

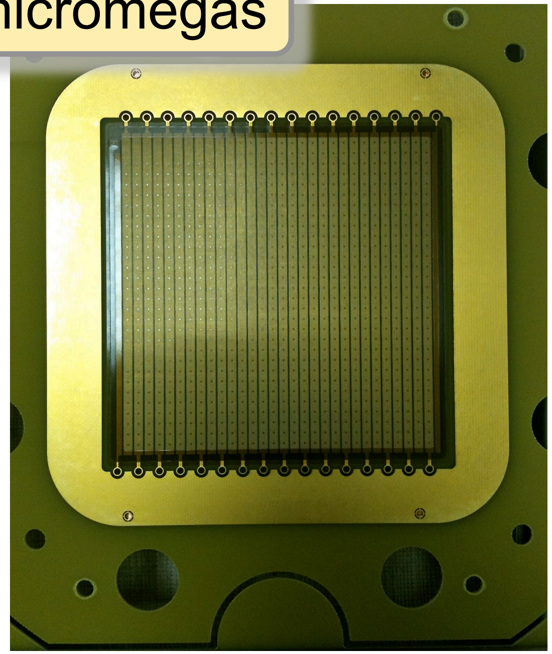
Ref: D. Lussi's talk

100 μm gap 1D bulk-micromegas



The double LEM 2D readout anode PCB





Goal : Operation & Gain measurements with a bulk-micromegas

In place of the double LEM 2D readout. Installation & tests during august 2010.

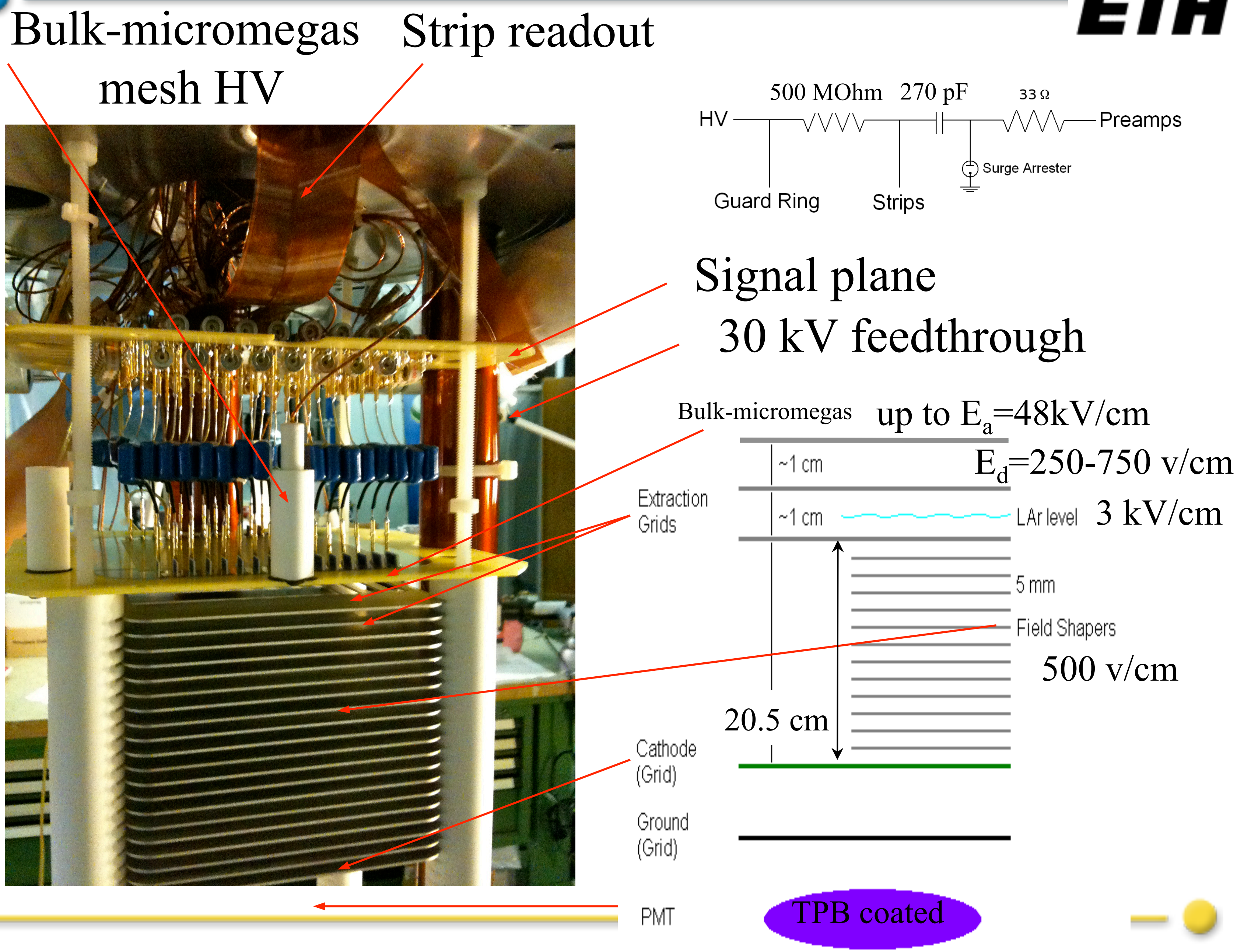
- Mechanical & electrical interfaces of the double LEM anode PCB are kept unchanged for direct integration in the 3l ETHZ Lar TPC
- Only 1D readout with 32 strips, 3.1 mm pitch (the 2D « GEM-COMPASS-like » readout is not suitable for charge collection in micromegas)
- a 5 mm border surrounding the active area is used for woven-micromesh termination
- 2 bulk-micromegas were done : 128 μm gap & 100 μm gap
- The modified PCB & the bulk-micromegas were manufactured by CERN/EN-ICE-DEM

The bulk-micromegas & TPC integration

The bulk-micromegas Is first assembled With the signal PCB	Assembly of the TPC field cage, cathode & micromegas PCB	Integration Of the TPC In the Cryostat

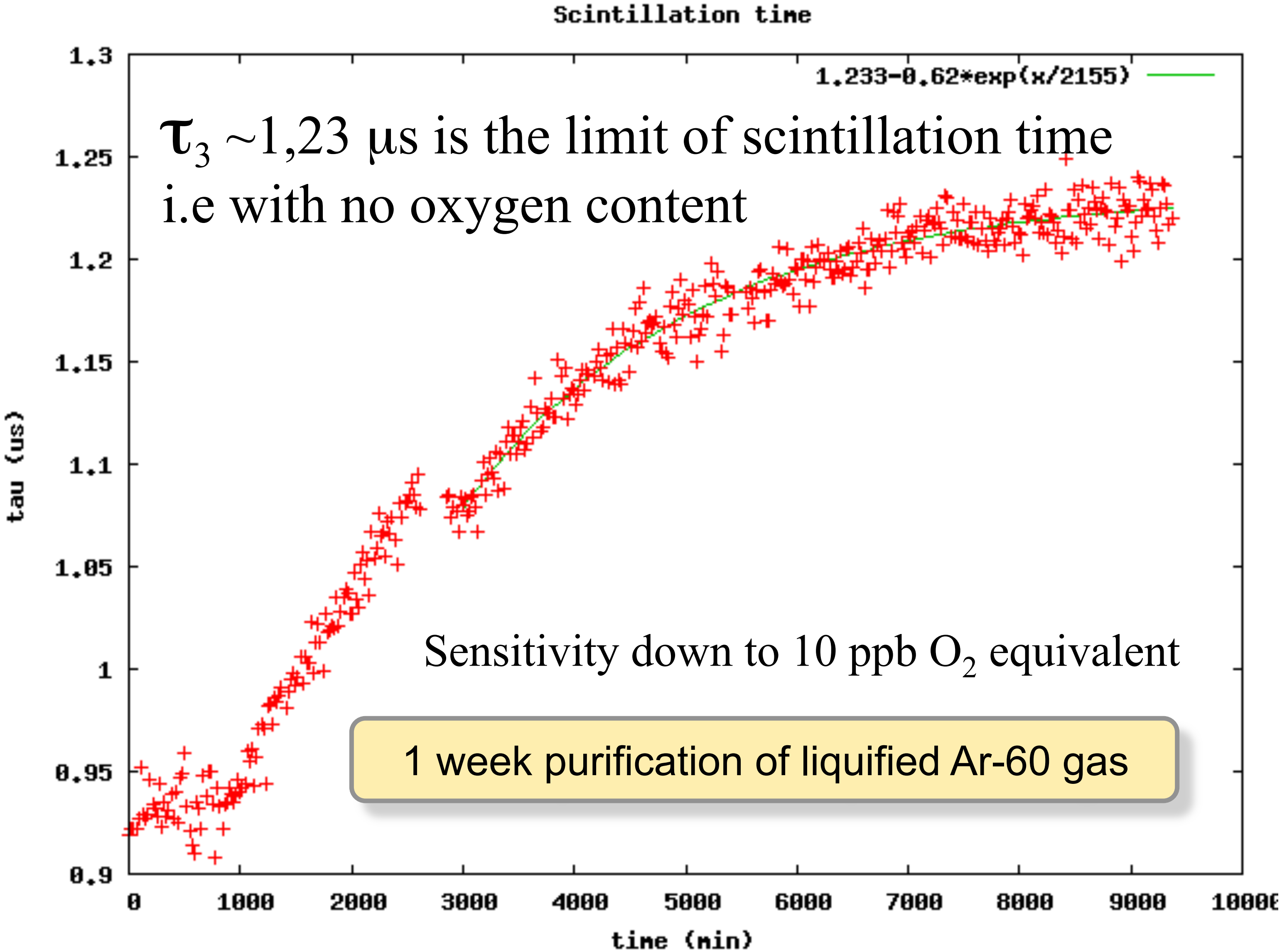


The TPC setup with bulk-micromegas



Liquid Argon purity evolution

Argon purity is monitored from the slow component scintillation time

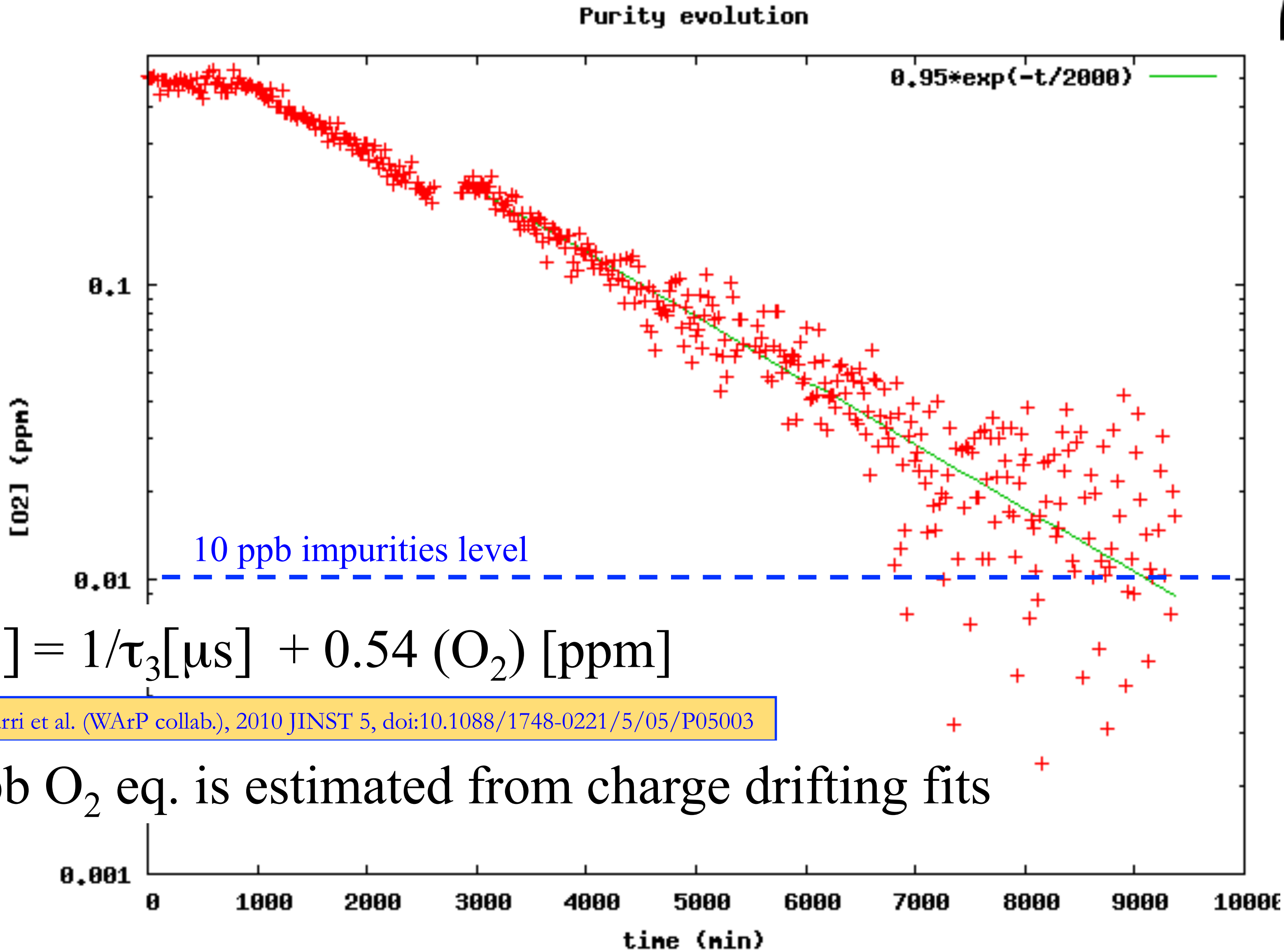


τ_3 ~1,23 μs is the limit of scintillation time i.e with no oxygen content

Sensitivity down to 10 ppb O_2 equivalent

1 week purification of liquified Ar-60 gas

Oxygen eq. content evolution (scintillation)

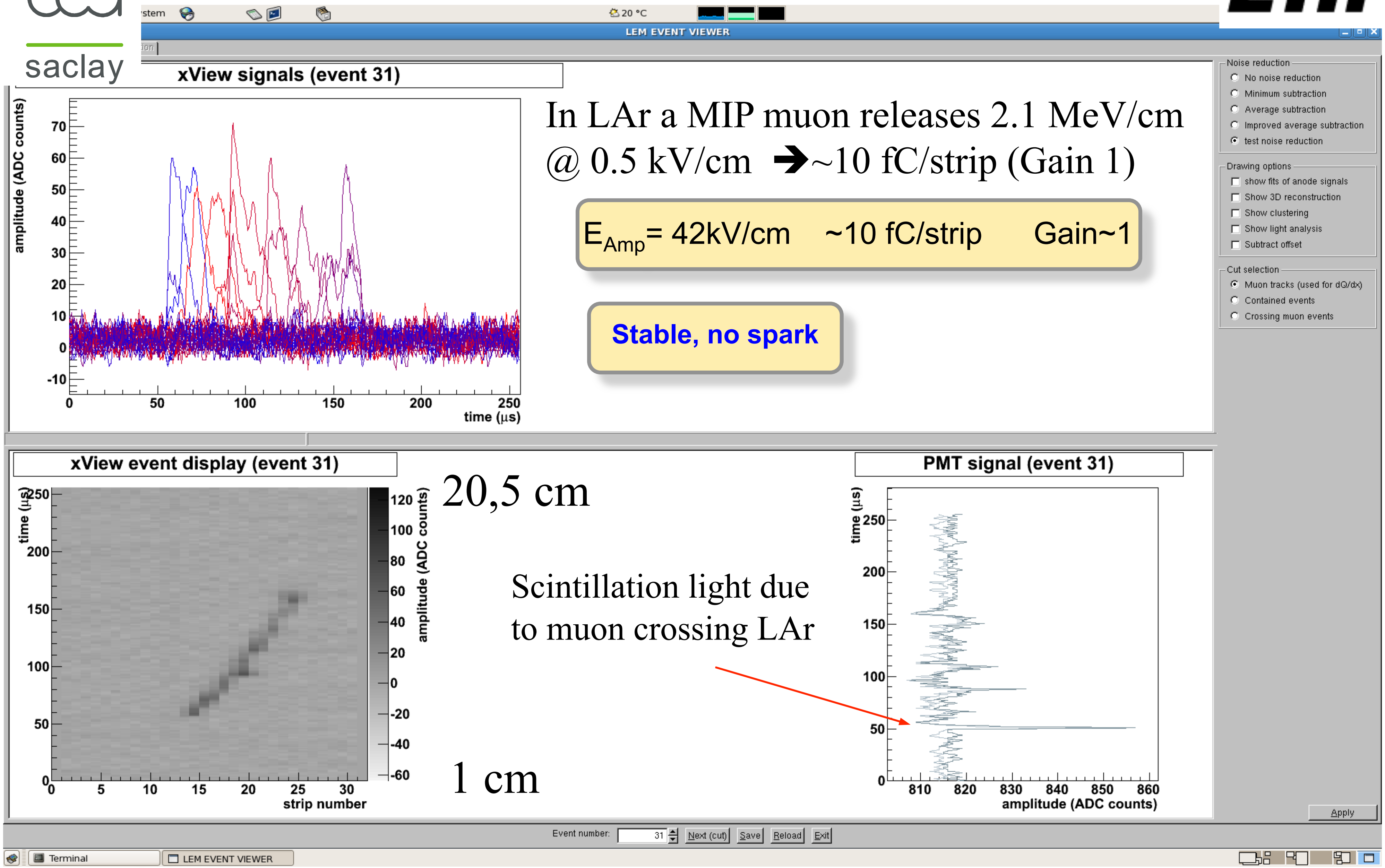


$$1/\tau[\mu s] = 1/\tau_3[\mu s] + 0.54\ (O_2)\ [ppm]$$

Ref: R. Acciarri et al. (WArP collab.), 2010 JINST 5, doi:10.1088/1748-0221/5/05/P05003

~2 ppb O_2 eq. is estimated from charge drifting fits

Typical track at low gain (close to 1)



In LAr a MIP muon releases 2.1 MeV/cm @ 0.5 kV/cm ➔~10 fC/strip (Gain 1)

E_{Amp}= 42kV/cm ~10 fC/strip Gain~1

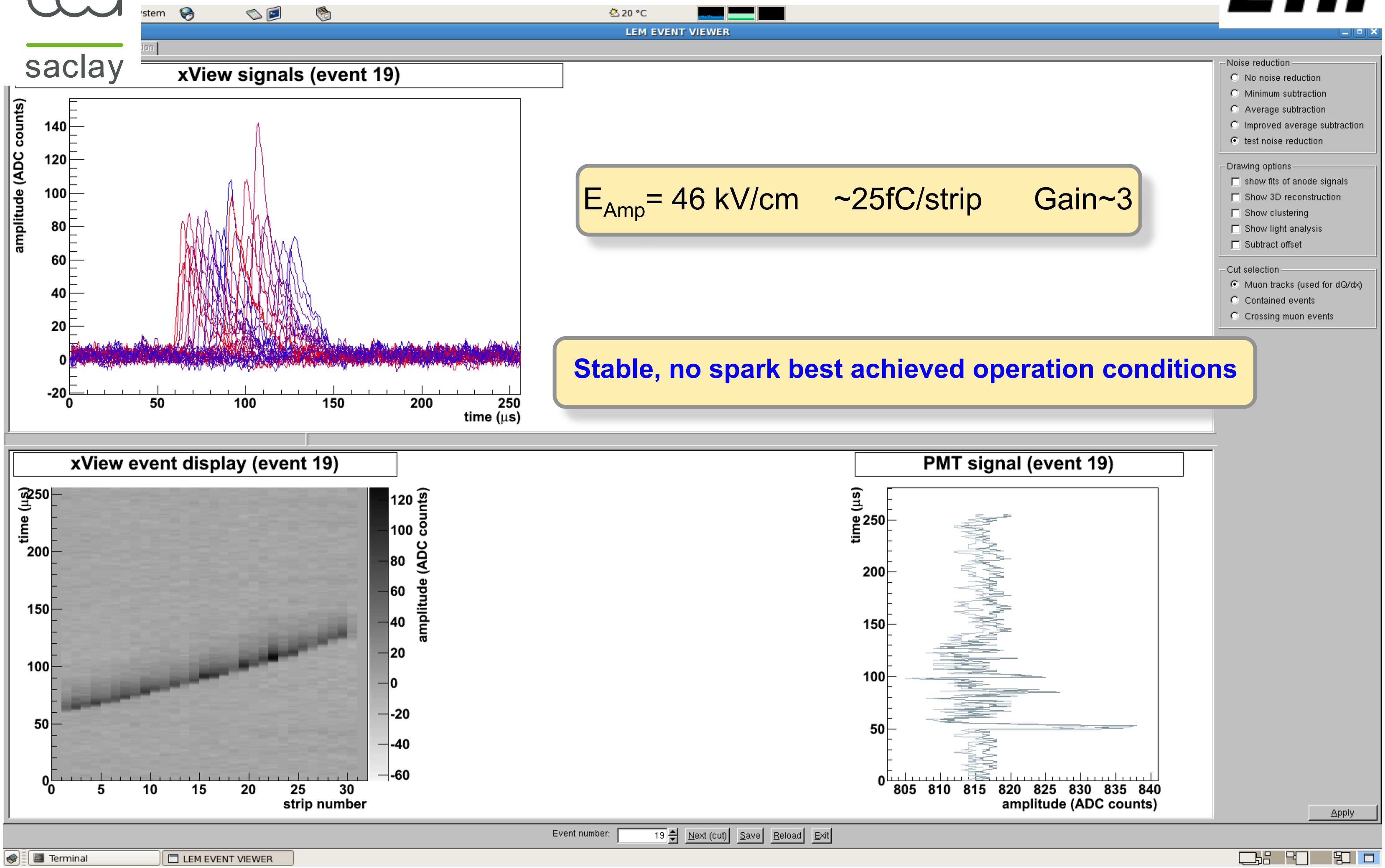
Stable, no spark

20,5 cm

1 cm

Scintillation light due to muon crossing LAr

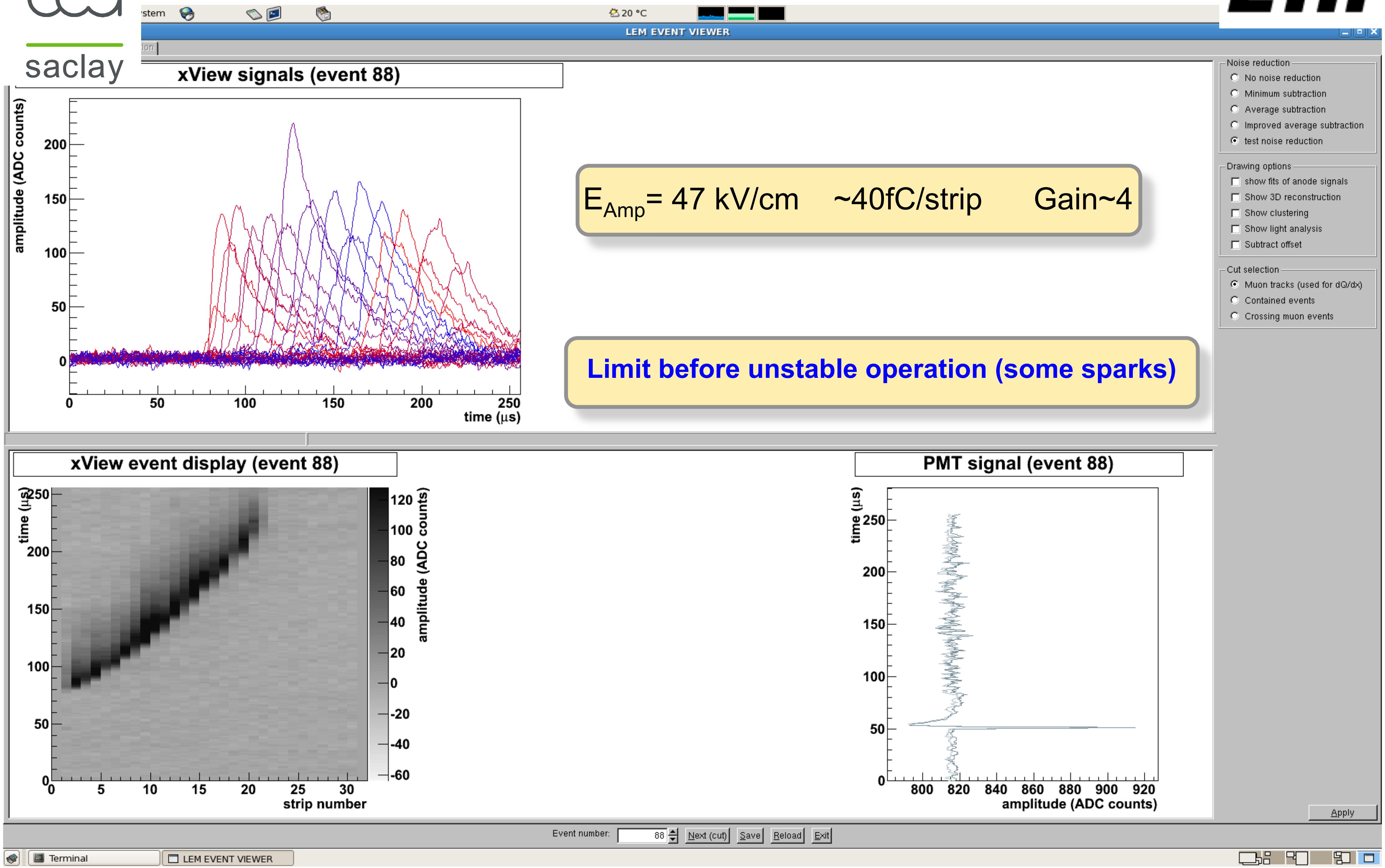
Typical track at middle gain (close to 3)



E_{Amp}= 46 kV/cm ~25fC/strip Gain~3

Stable, no spark best achieved operation conditions

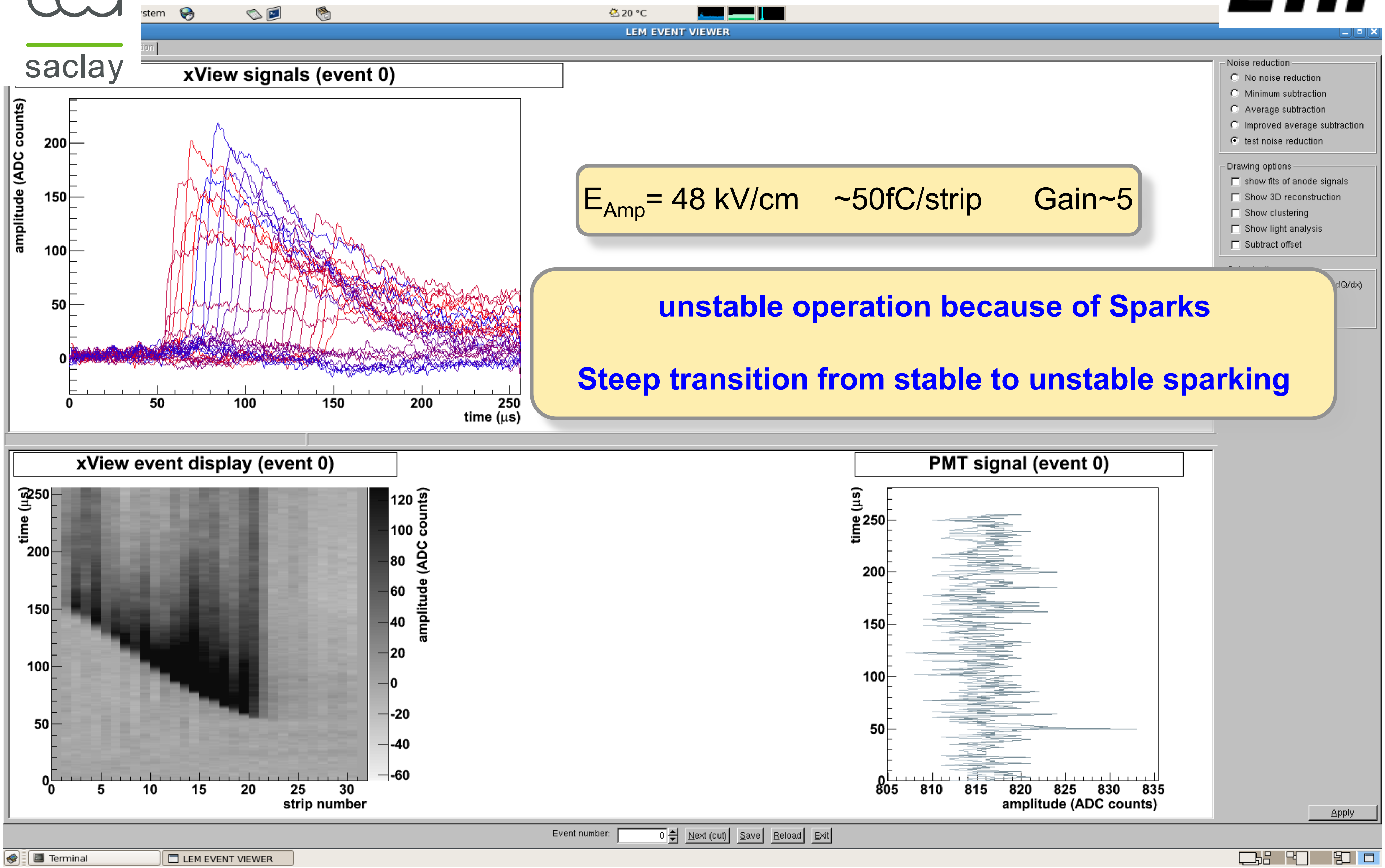
Typical track at higher gain (close to 4)



E_{Amp}= 47 kV/cm ~40fC/strip Gain~4

Limit before unstable operation (some sparks)

Typical track in unstable (close to 5)

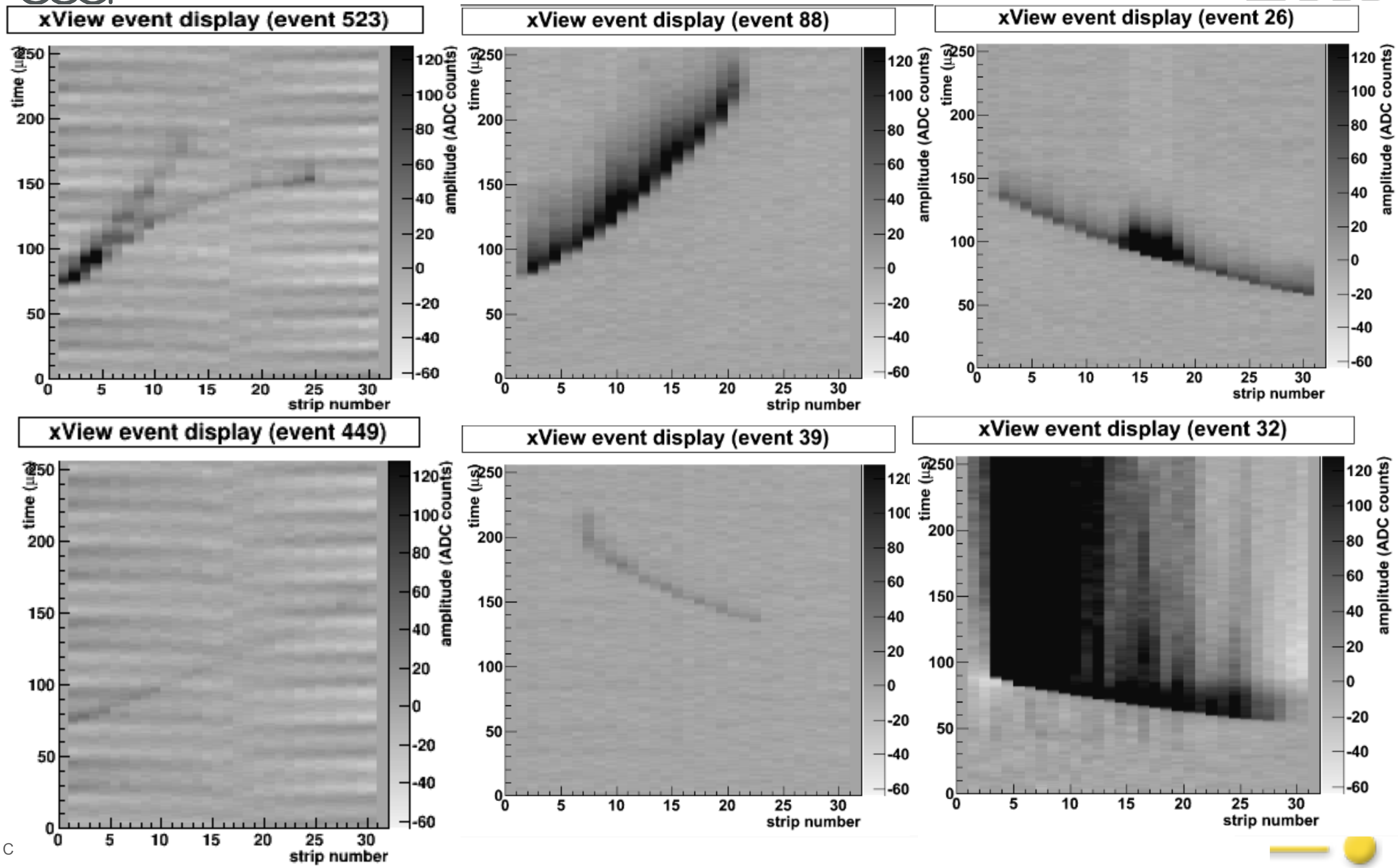


E_{Amp}= 48 kV/cm ~50fC/strip Gain~5

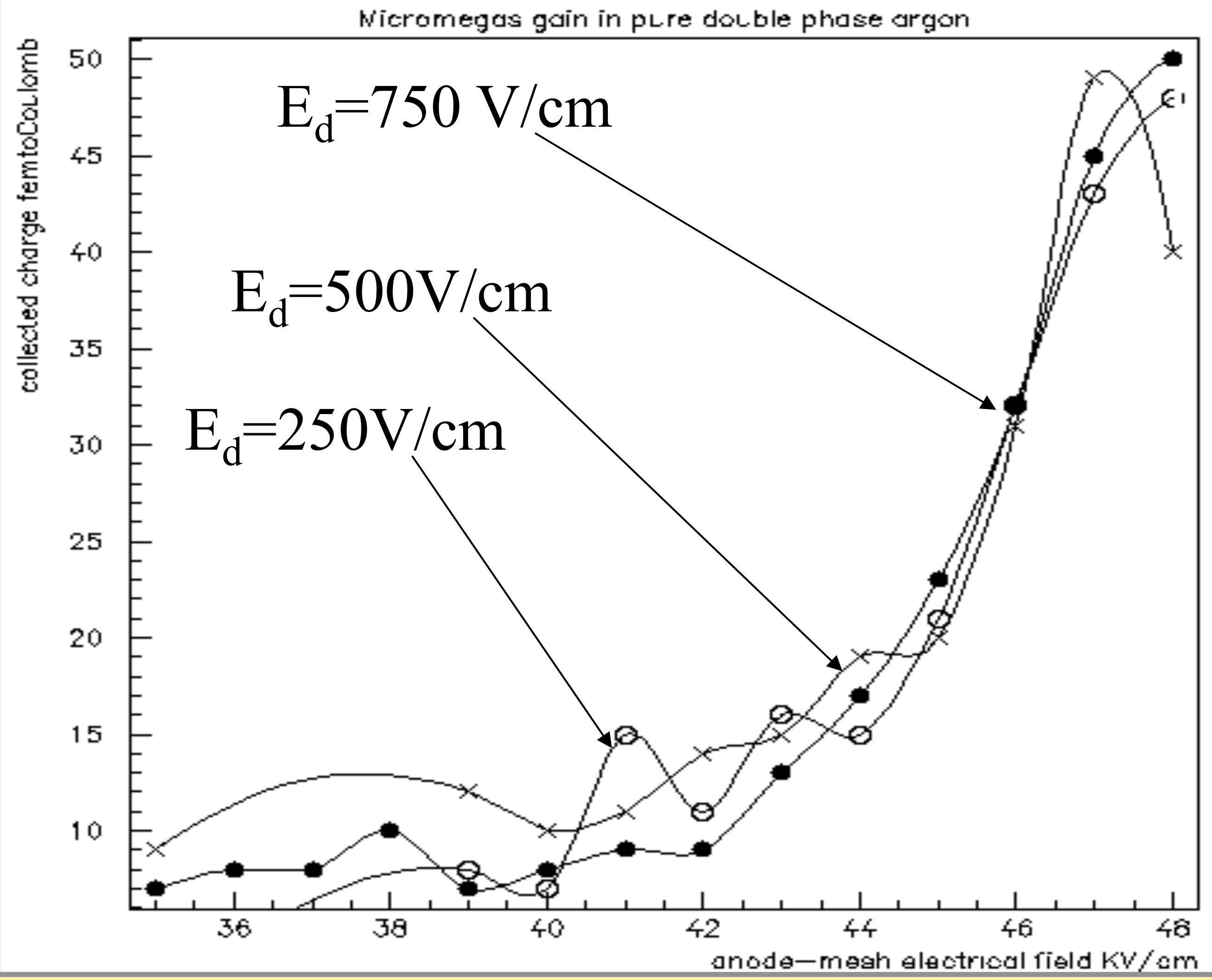
unstable operation because of Sparks

Steep transition from stable to unstable sparking

Tracks galery

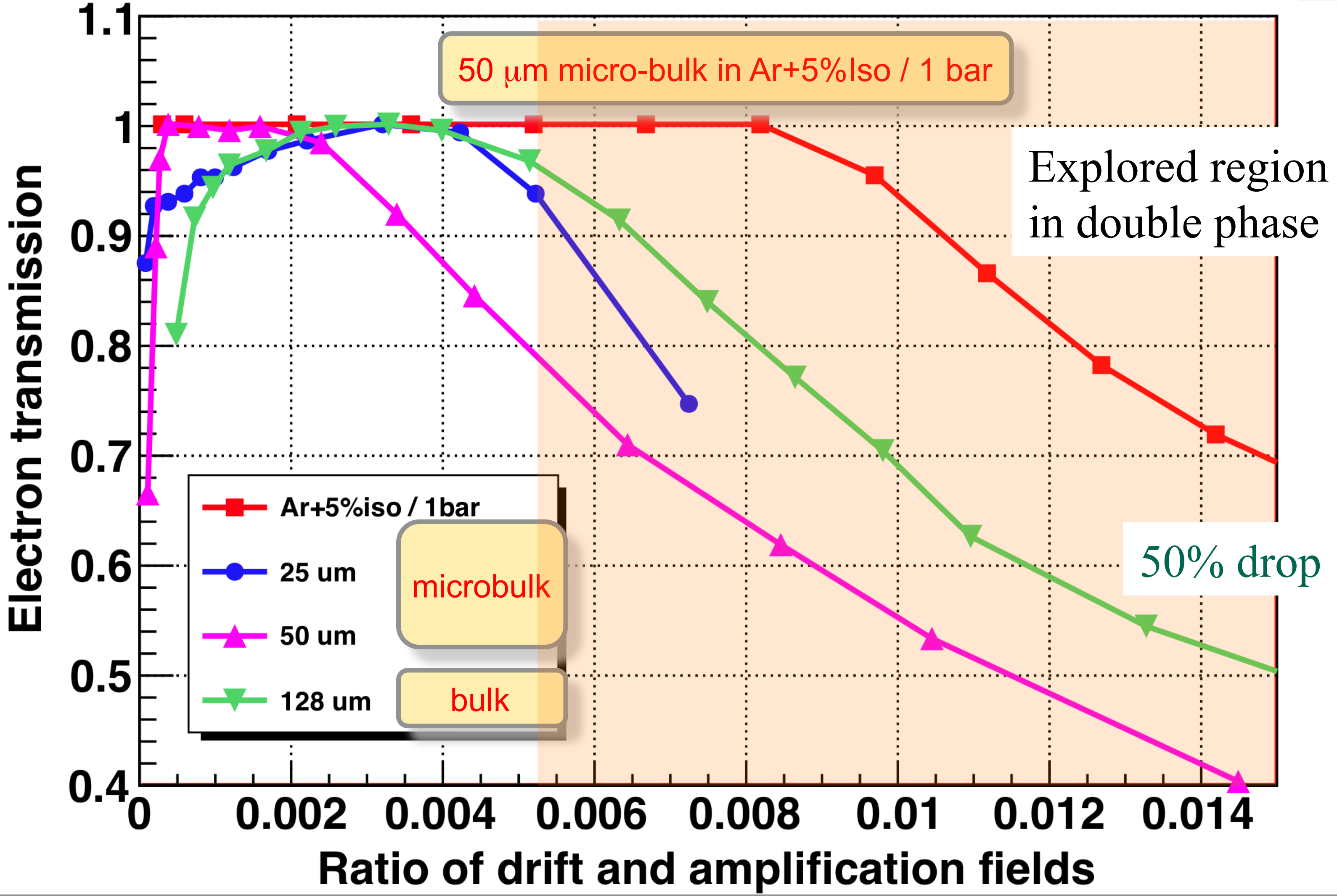


Collected charge Vs E_{drift}/E_{amp}



The collected charge does not seem to depend on the electric field ratio E_d/E_a

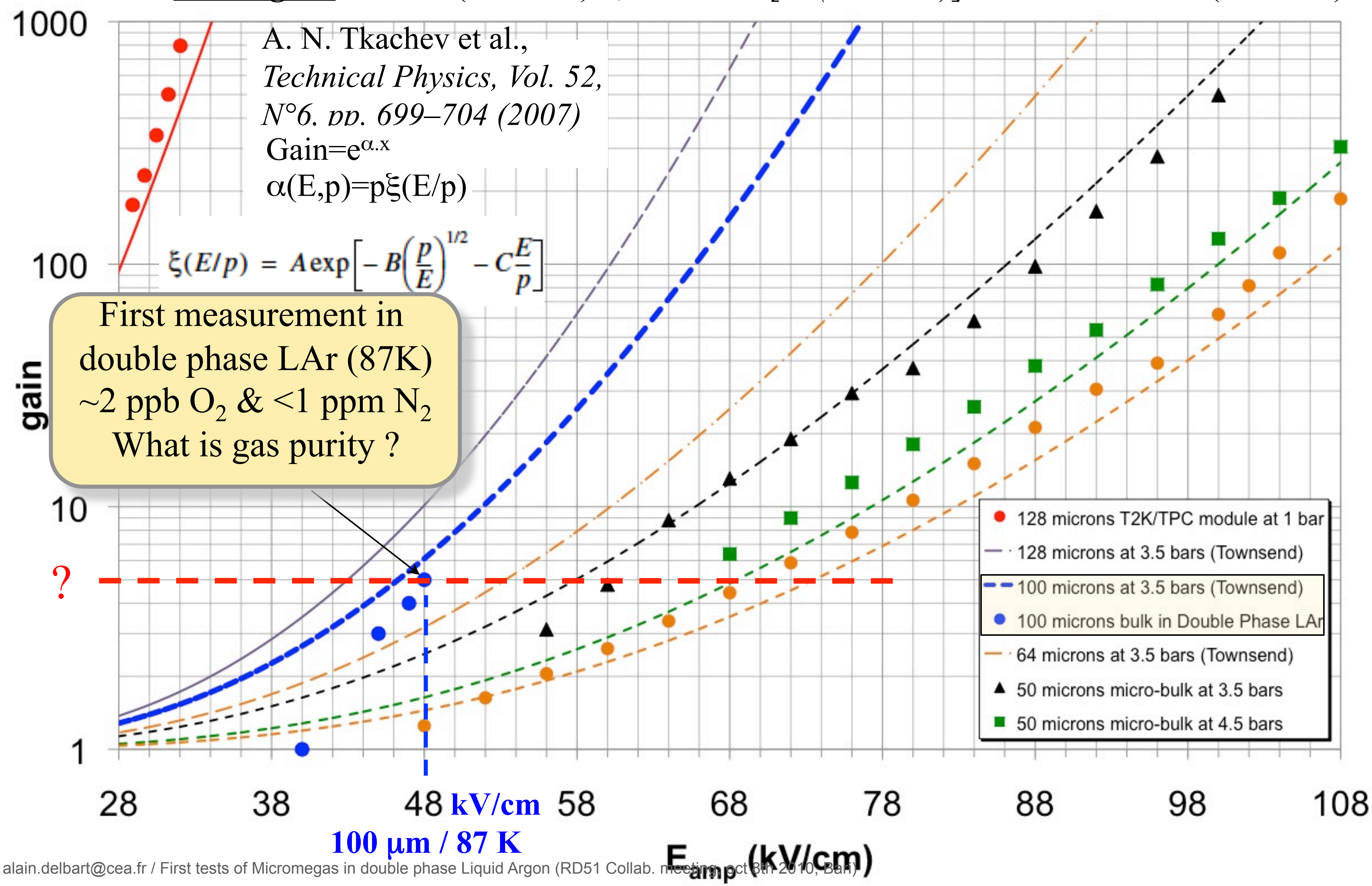
Electron transmission in 300K Argon at 3,5 bars (same gas density as 87K at 1 bar)



Why is this 50% loss of electrons not seen in cryogenic conditions (87K, 1 bar) ?

Summary of Gain measurements in Argon

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



Gain limits in pure Argon : a possible explanation ?

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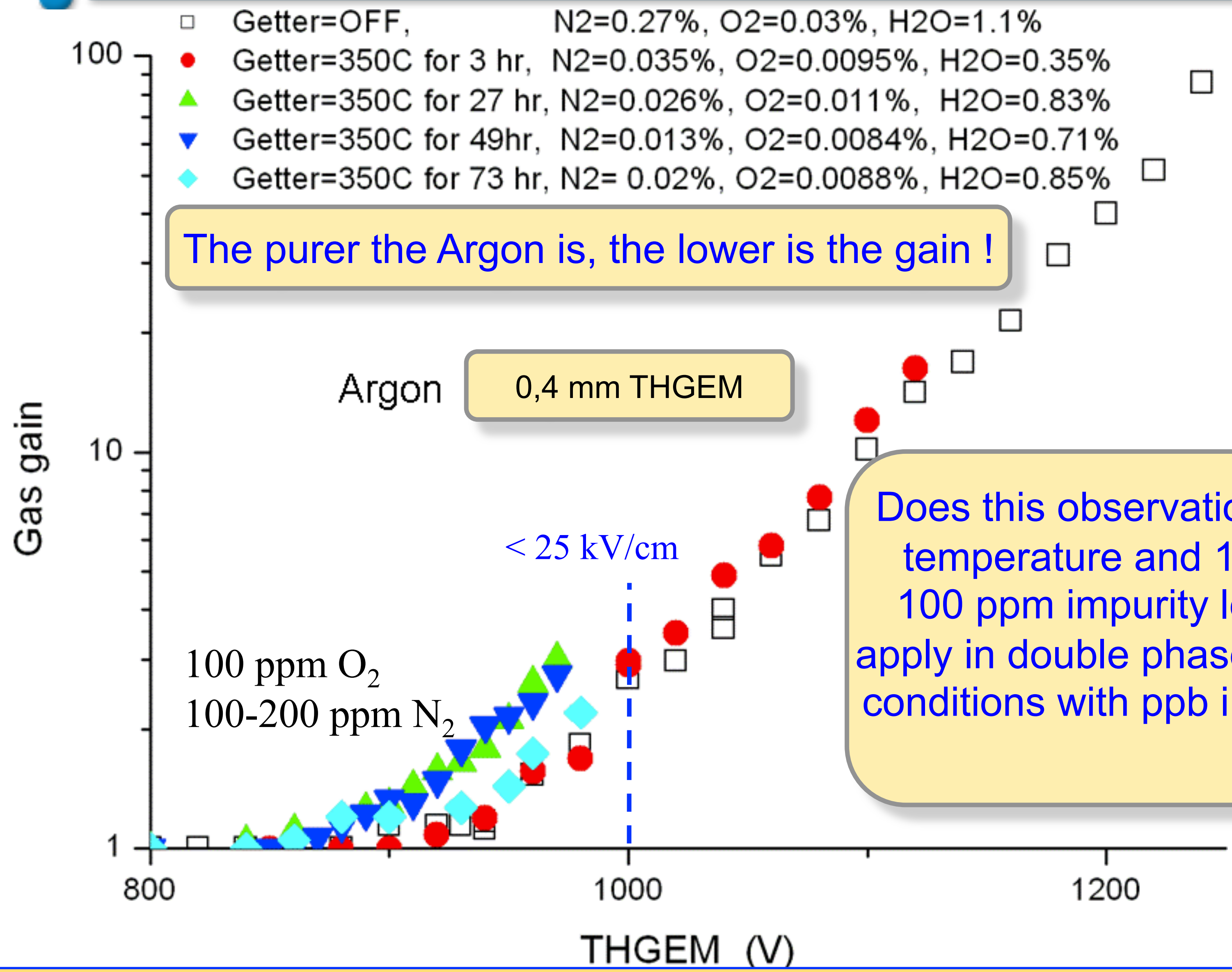


The purer the Argon is, the lower is the gain !

Does this observation at room temperature and 1 bar with 100 ppm impurity levels still apply in double phase cryogenic conditions with ppb impurities ?

Ref: J. Miyamoto, A. Breskin and V. Peskov, JINST 2010, doi:10.1088/1748-0221/5/05/P05008

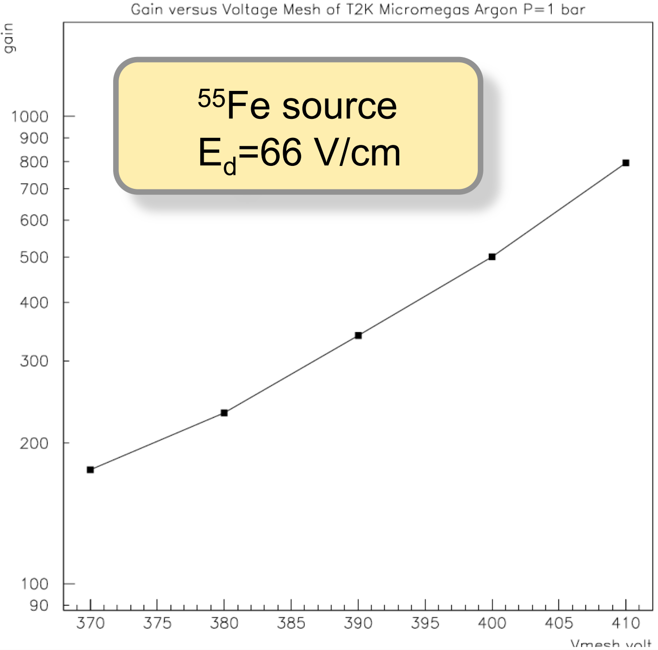
Conclusion

- A 100 μm gap bulk-micromegas was successfully operated in the 3l double phase Liquid Argon ETH-TPC
  - Stable operation in cryogenic environment at ~5 gain
  - ~2 ppb O_2 Liquid Argon purity achieved
  - First cosmic tracks observed
  - Maximum gain achieved of the order of ~5
  - A simple fit of the gain with a townsend law is consistent with the measured gain

- The maximum gain is low and may be due to the very high purity of Argon (which is demanded for charge drift in liquid)
- Such a low gain could be suitable for neutrino applications but higher gains (>100) are needed for dark matter search
- But these are the first tests and further improvements and studies are planned (thinner bulk gaps, micro-bulk, …)

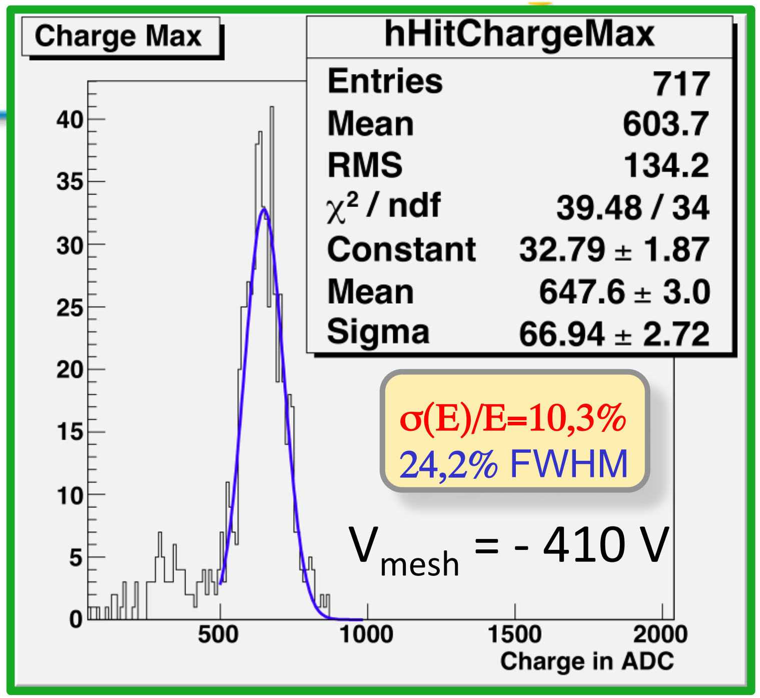
Backup slides

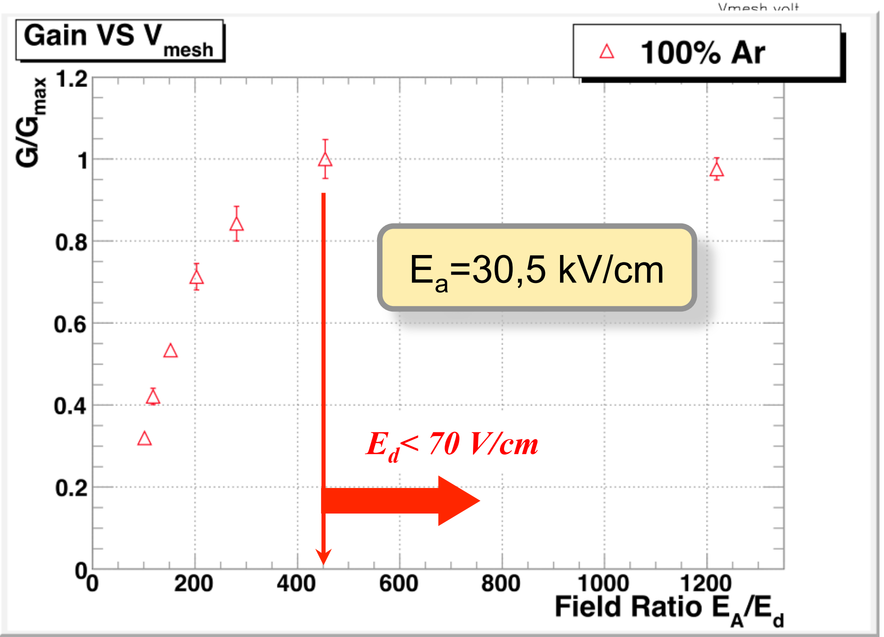
T2K/TPC module in Ar @ STP

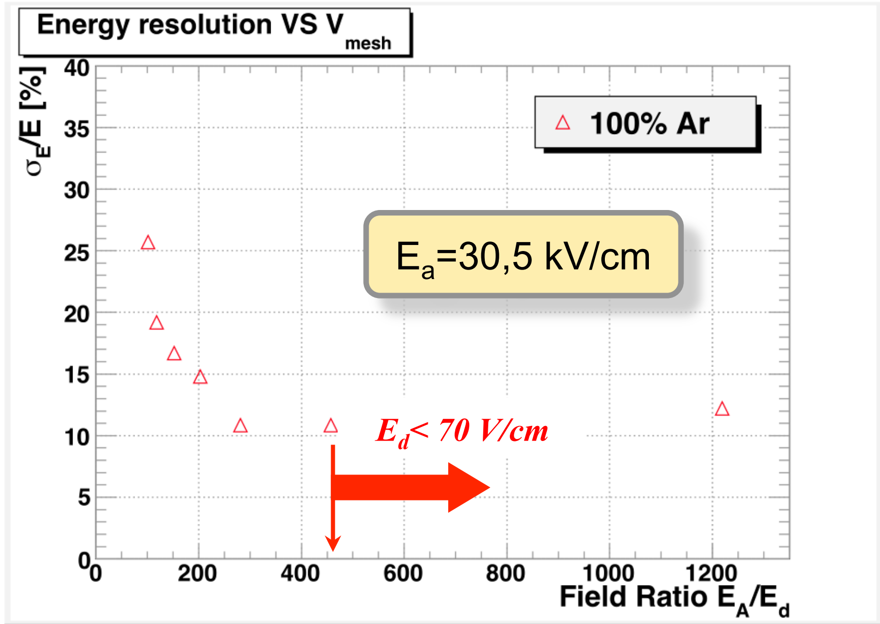


> 420 V

High sparking rate region
(almost continuously)







2D readout Micro-bulk manufacturing process

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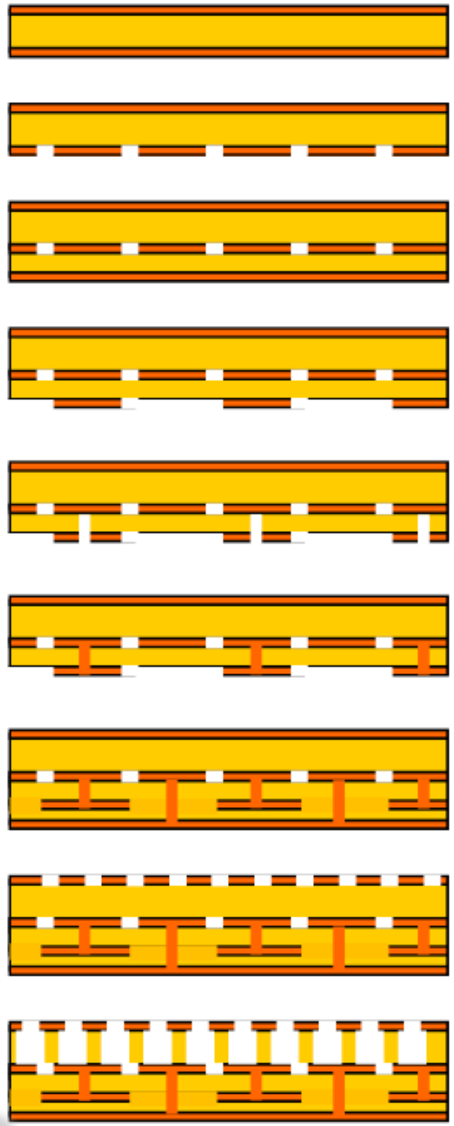
Building a Microbulk

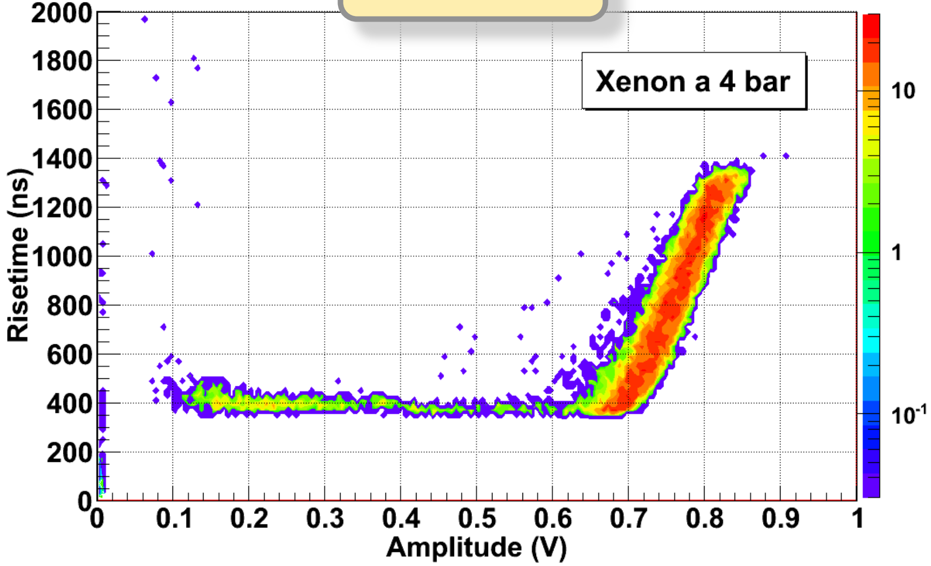
- Kapton foil (50 µm), both side Cu-coated (5 µm)
- Construction of readout strips/pads (photolithography)
- Attachment of a single-side Cu-coated kapton foil (25/5 µm)
- Construction of readout lines
- Etching of kapton
- Vias construction
- 2nd Layer of Cu-coated kapton
- Photochemical production of mesh holes
- Kapton etching
- Cleaning



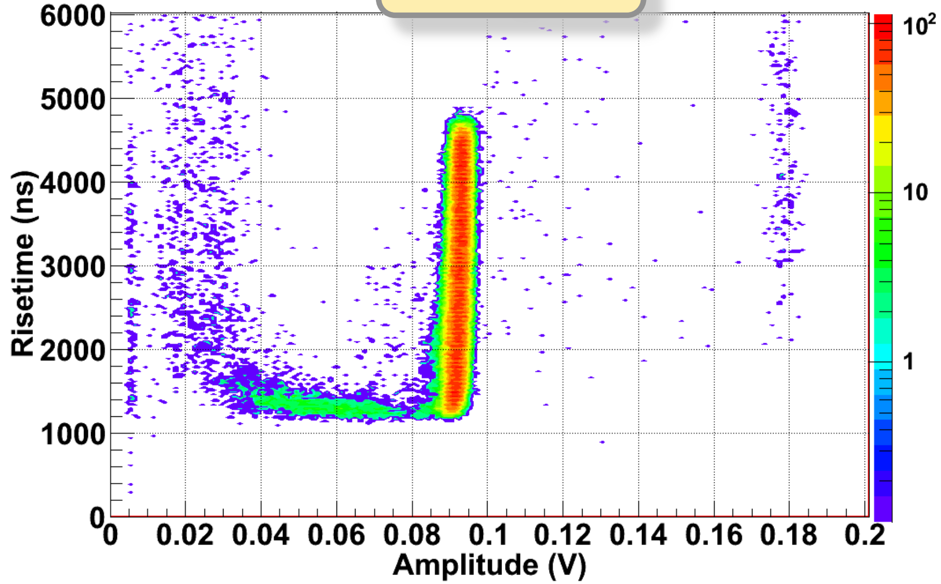
CERN/EN-ICE-DEM workshop (R. de Oliveira)

Rise time – Amplitude correlation in Hellaz setup

Xenon



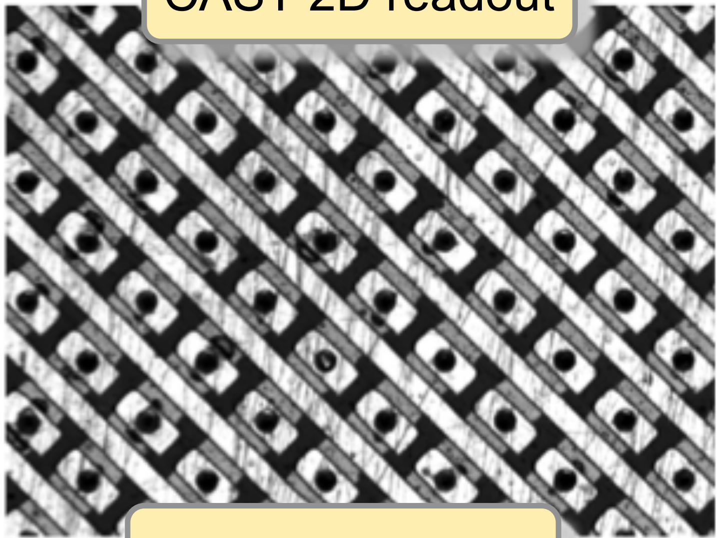
Argon



T. Dafni et al. NIM A 608 259-266, 2009

2D readout examples

CAST 2D readout



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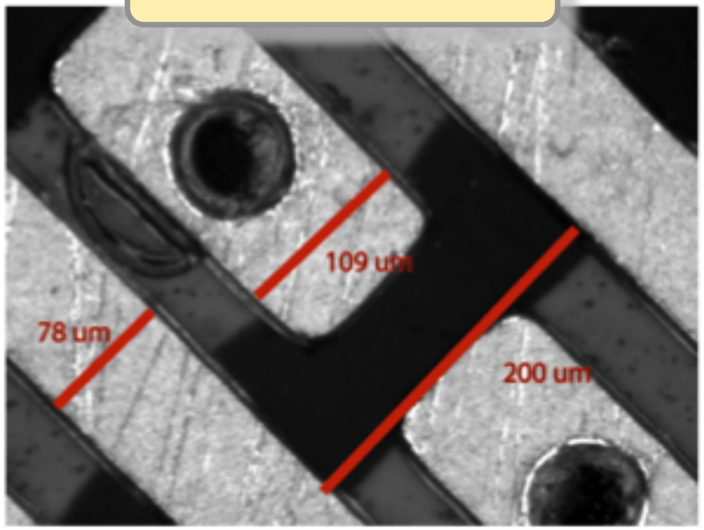
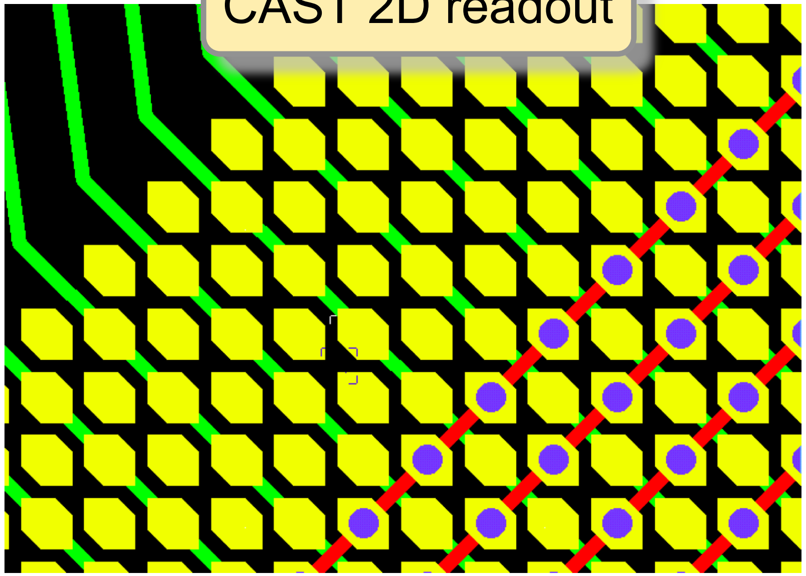
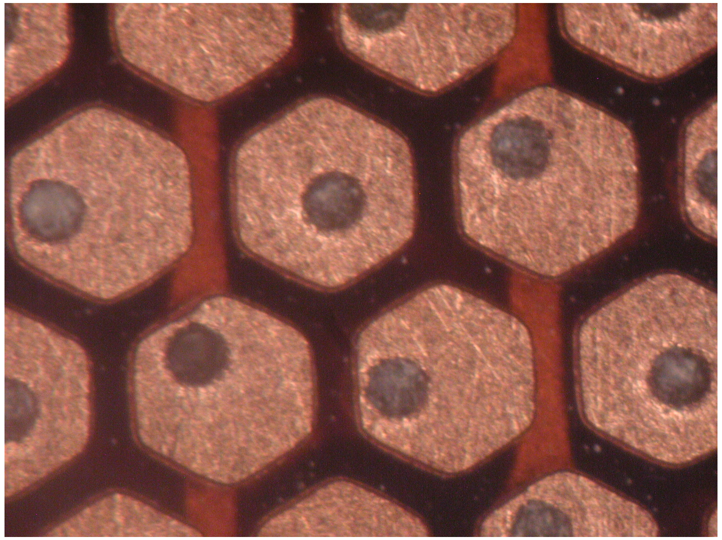


CAST 2D readout



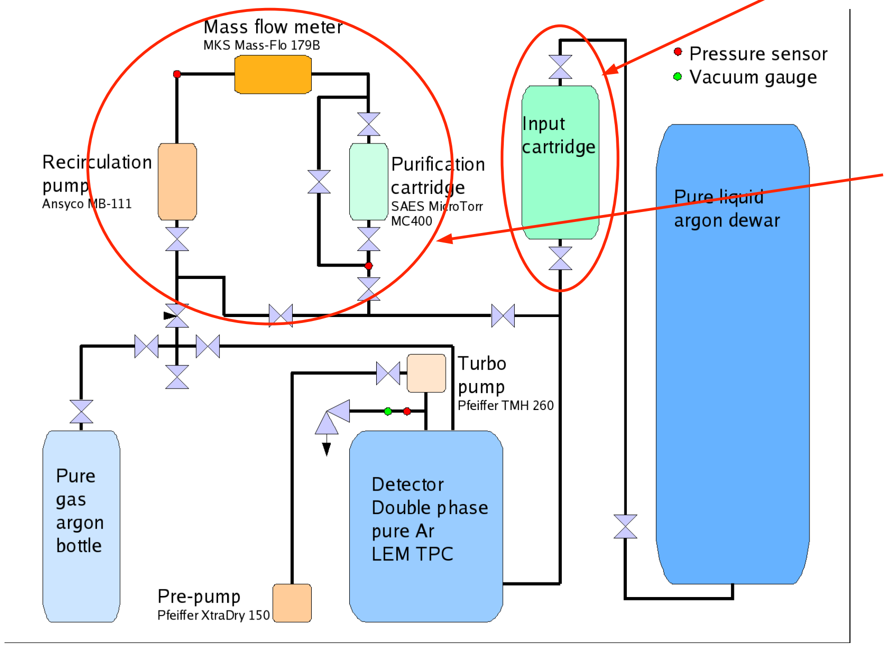


3 liters Liquid Argon Setup

For a 10 cm drift at 1 kV/cm, contaminations better than 10 ppb (O_2 equivalent) are needed.

To purify argon we use two purification stages:

2.10^{-6} mbar pumping before liquid filling



Input LAr purification:

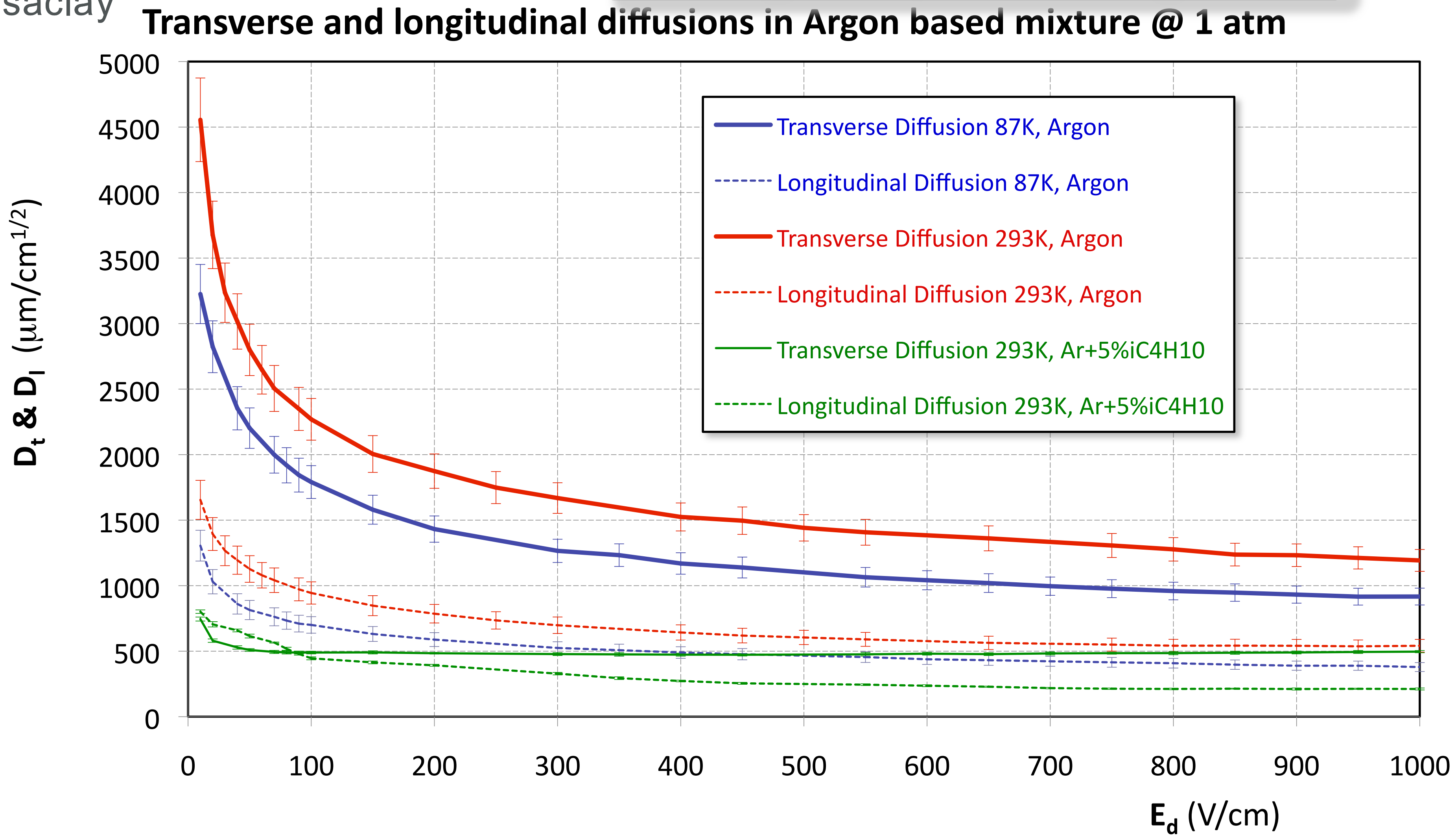
- Custom made cartridge for LAr purification at detector input.

GAr purification circuit:

- Heating resistors evaporate LAr in the detector.
- A metal bellow pump pushes GAr into a flow meter and SAES getter (~48h to recirculate 1 volume).
- Purified GAr condensates into the detector volume.

Transverse & longitudinal diffusion (Magboltz)

Diffusion @ 293K / 3,5 bar = Diffusion @ 87K / 1 bar



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