DEVELOPMENT OF WLS+SIPM PHOTO DETECTION SYSTEM FOR READOUT OF THGEM IN NOBLE GAS FILLED DETECTORS

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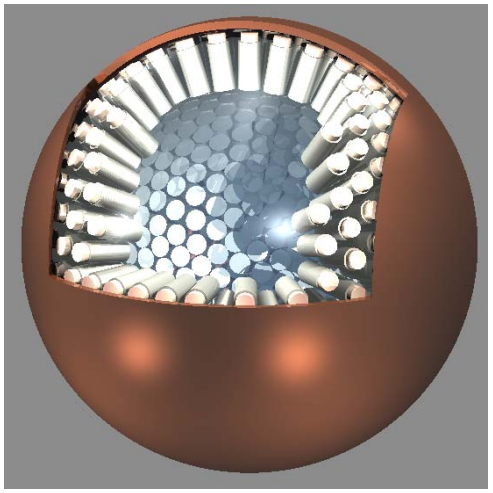
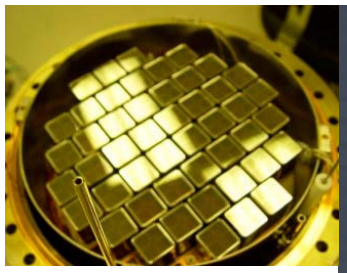
OUTLOOK

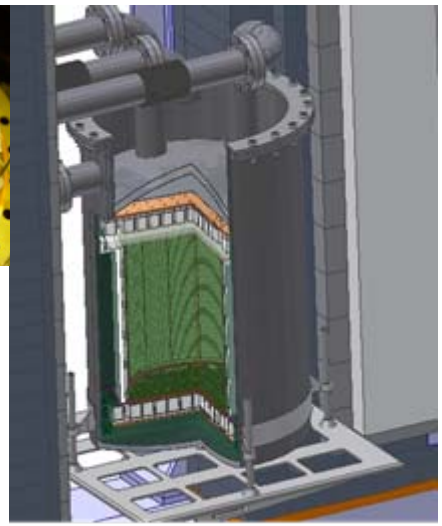
- Motivation (Dark Matter and neutrino coherent scattering off atomic nuclei experiments)
- First tests with MRS APD in LXe
- WLS for Xe emission and PDE measurements
- Experimental setup
- First test run (single GEM, Dec10)
- Second test run (double GEM, June11)
- Conclusion
- Future steps

EXPERIMENTS

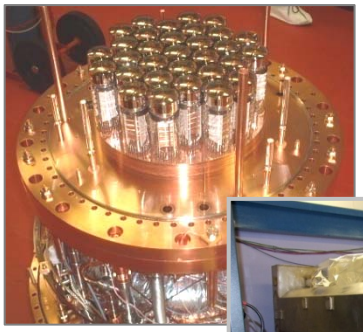


XMASS at Kamioka

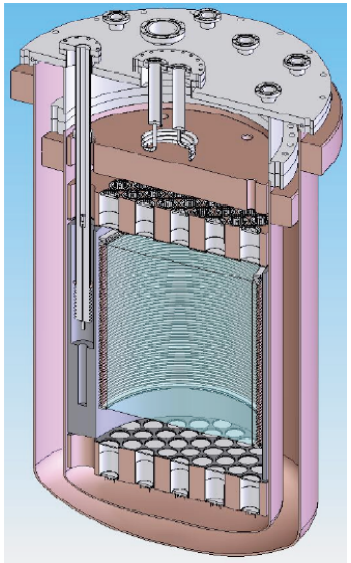




Xenon10,100
at Gran Sasso



ZEPLIN III at
Boulby mine



LUX at SUSEL

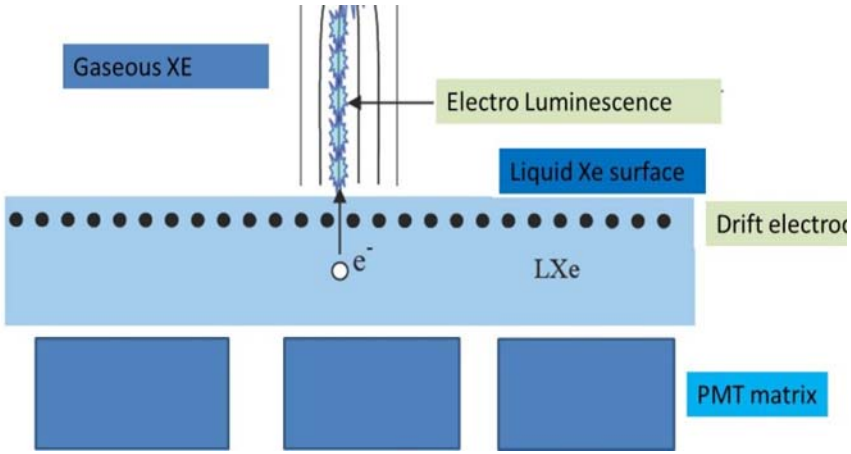
All detectors utilizes PMTs for detection of the LXe VUV light.

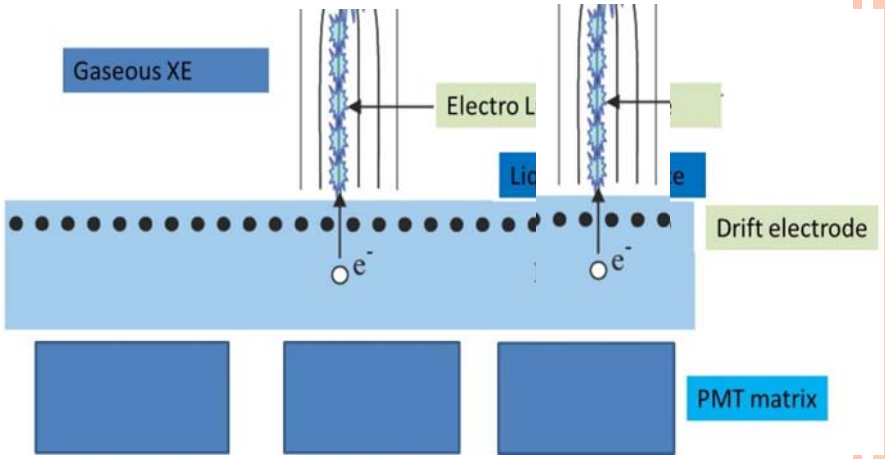
At present, PMTs (even low-background) are the most radioactive elements of detector.

Search for a replacement of PMTs for the future detectors is actual.

NEUTRINO COHERENT SCATTERING OFF ATONIC NUCLEI

- Very small signals - a few electrons
- Main problem of two phase Xe detectors – background of spontaneous electrons
- To eliminate this background position sensitive detector can be used. Signal localization determination can separate one cluster of a few electrons from real event or a few electrons from background.

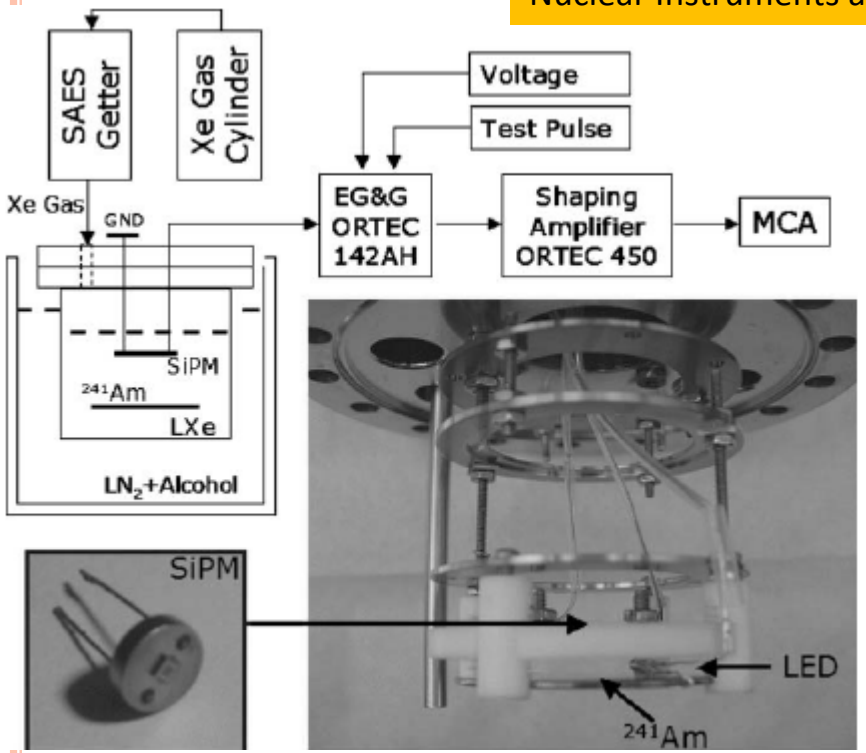


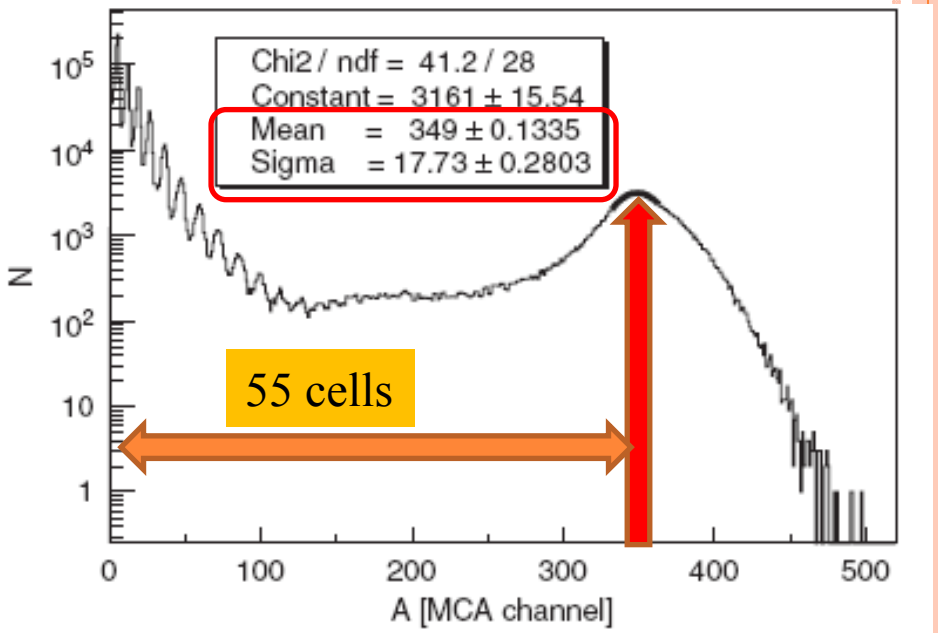


FIRST SURPRISING RESULTS WITH SIPM IN LIQUID XE(1)

E. Aprile, P. Cushman, K. Ni, P. Shagin

Nuclear Instruments and Methods in Physics Research A 556 (2006) 215–218



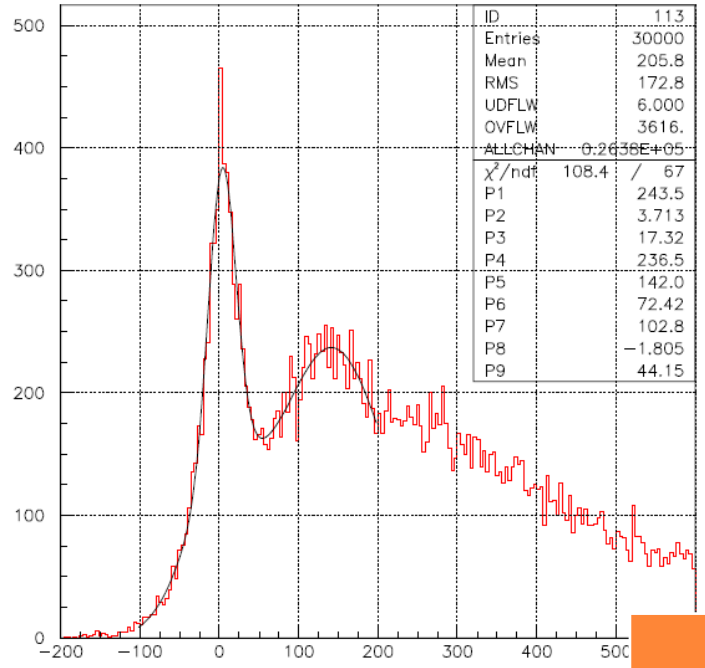


Ncells=55ph.e.=1006ph.=5,5%.

Q.E. SiPM was estimated to be 22% (5.5% is the PDE) at the Xe wavelength of 178 nm

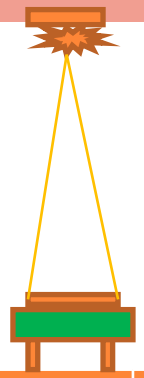
? N^{σ} ph.e.$=(A-Aped)^2/\sigma^2=(349/17.7)^2=389$?

RESULTS FOR LIQUID XE (2)



Typical spectrum for CPTA "blue" diode

In liquid Xe we can suppose light flash localization as a point. PDE was calculated as: **N ph.e./ Nph.(in corresponding solid angle)**



Diode	N ph.e.	PDE
SiPM (3x3 mm^2)	2.11	~0.3%
MRS APD "green" with glass (2x2 mm^2)	0.132	0
MRS APD "blue" (2x2 mm^2)	1.61	~0.7%

Our results indicates about order of magnitude low PDE for "green" and "blue" diodes than it was measured by Aprile's group .

Most likely breakdown signal was measured as signal from α-particle.

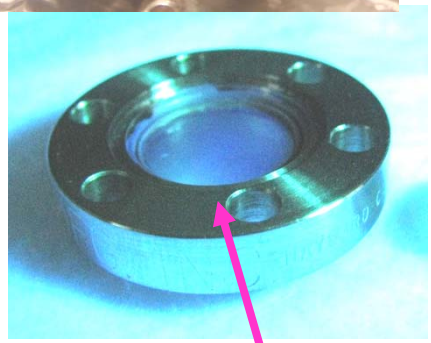
No any significant visible or IR component was found.

RESULTS FOR WL SHIFTER IN LIQUID XE (1)

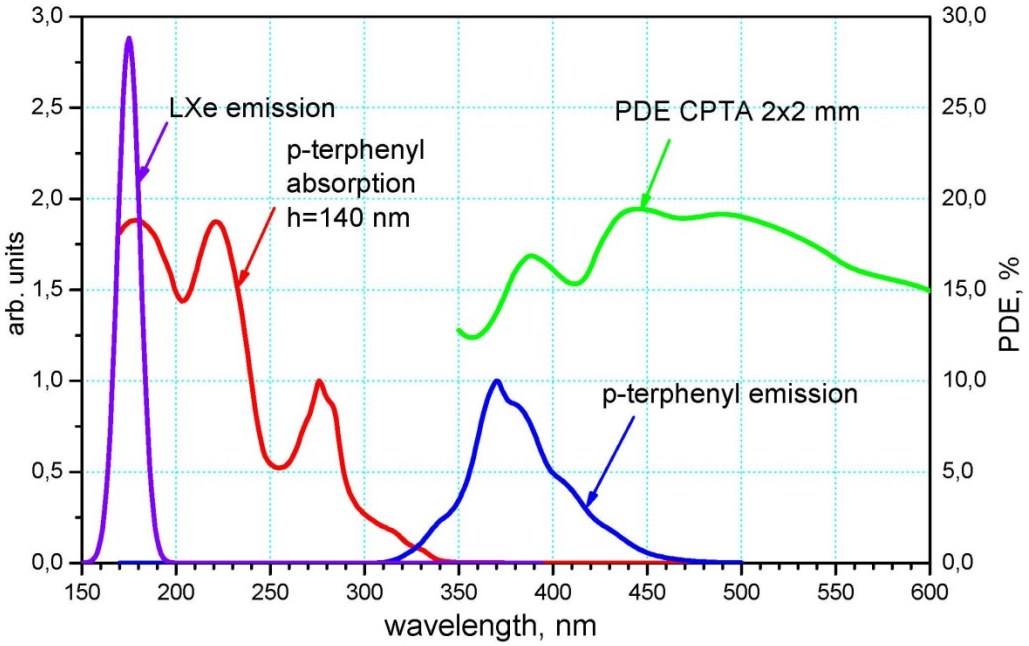
Two Sapphire viewports from CABURN VACUUM SCIENCE

MRS APD (CPTA) 2x2 mm^2 mounted inside special package

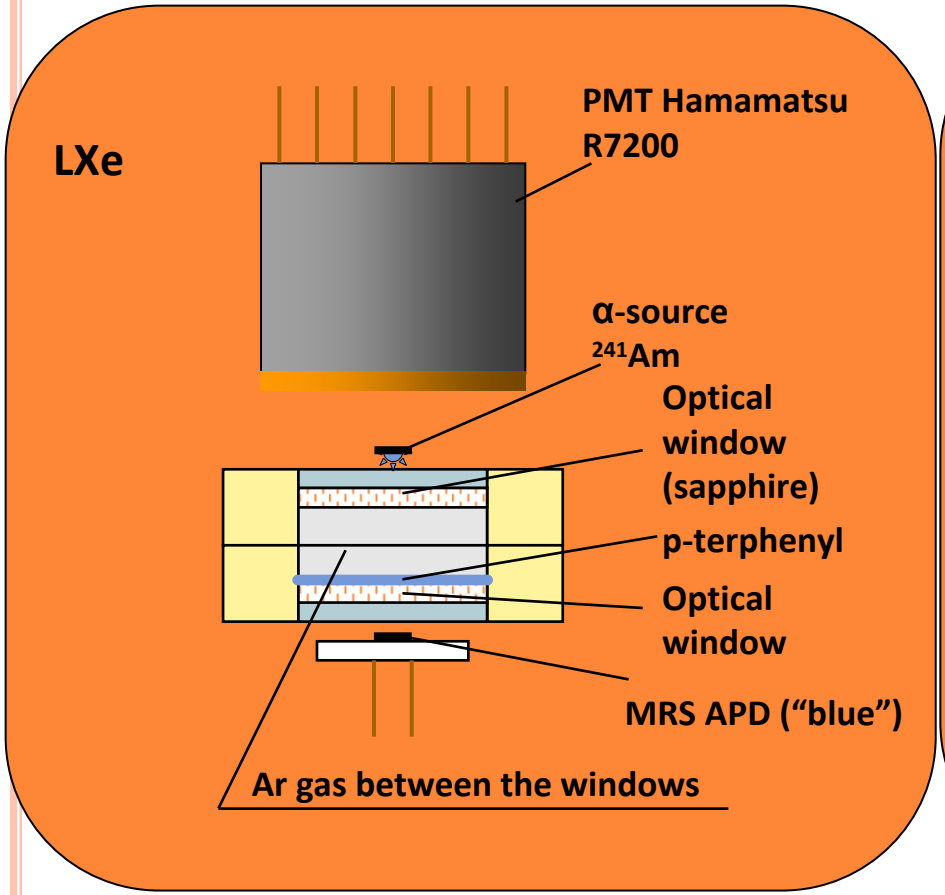
2 x 2 mm, 1584 pixels

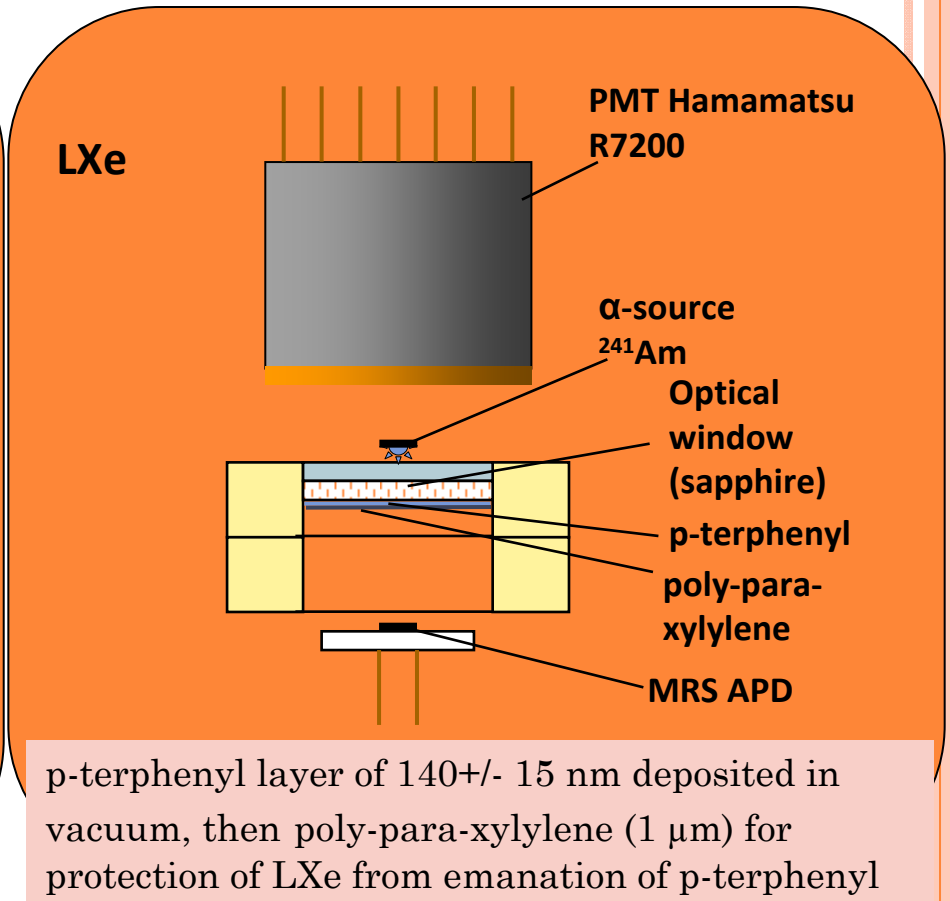


The p-terphenyl evaporated layer is clearly visible when irradiated by a UV lamp



RESULTS FOR WL SHIFTER IN LIQUID XE (2)



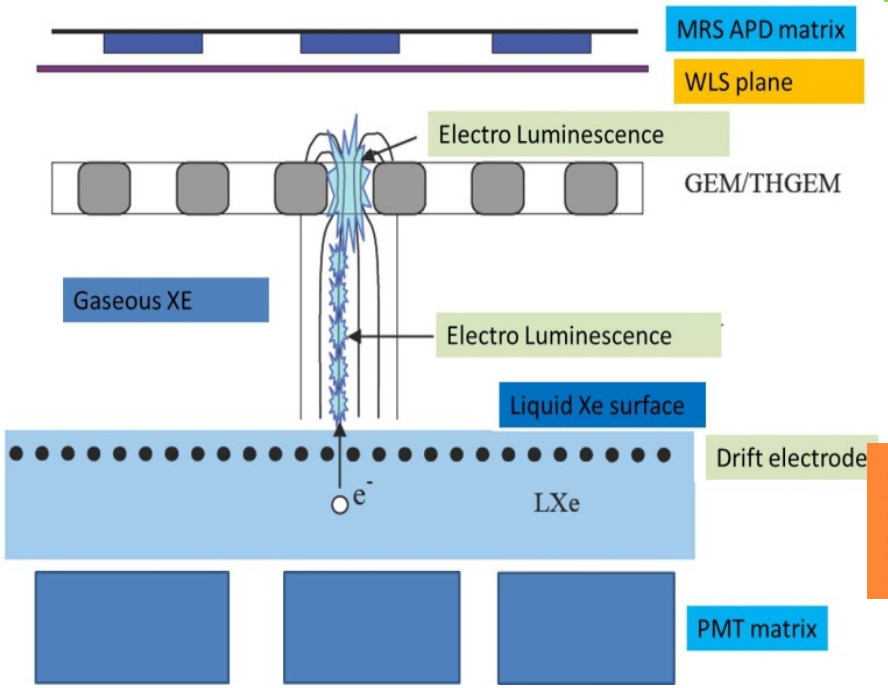


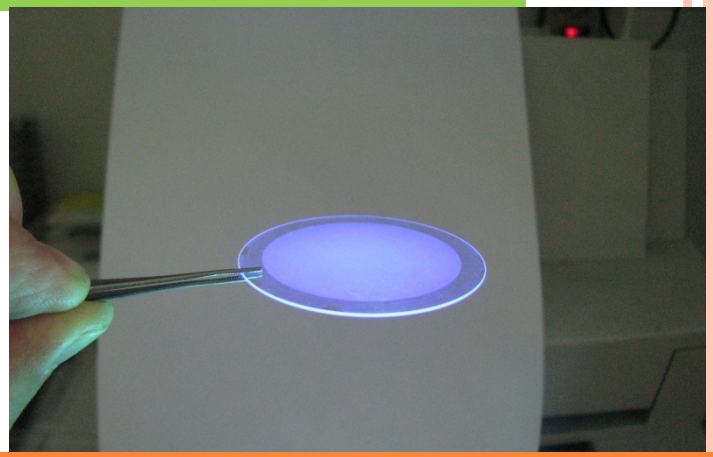
p-terphenyl layer of 140+/- 15 nm deposited in vacuum, then poly-para-xylylene (1 μm) for protection of LXe from emanation of p-terphenyl

Type of construction WLS	PDE, %
p-terphenyl is sealed between two optical windows	9.7±1.2
p-terphenyl is coated by a poly-para-xylylene film.	8.4±1.1

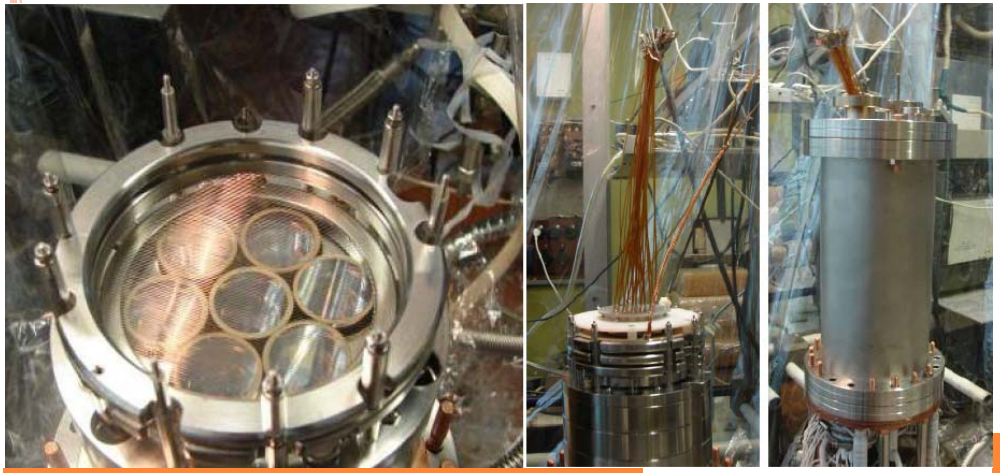
!!!N.B.!!!
MRS APD PDE (15-22)%
For p-terphynyl emission spectrum. Perfect result – ~50% lost just due to simple geometry of reemission.

EXPERIMENTAL SETUP(1)

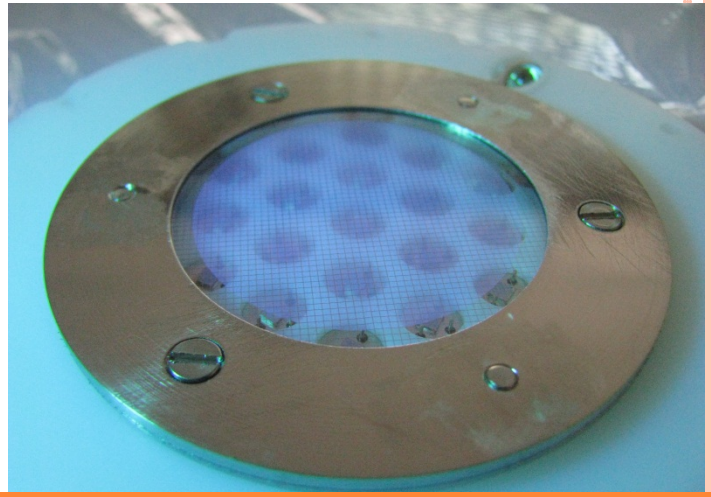




p-terphenyl layer deposited in vacuum on sapphire plate + poly-para-xylylene (1 μm) for protection of LXe from emanation of p-terphenyl

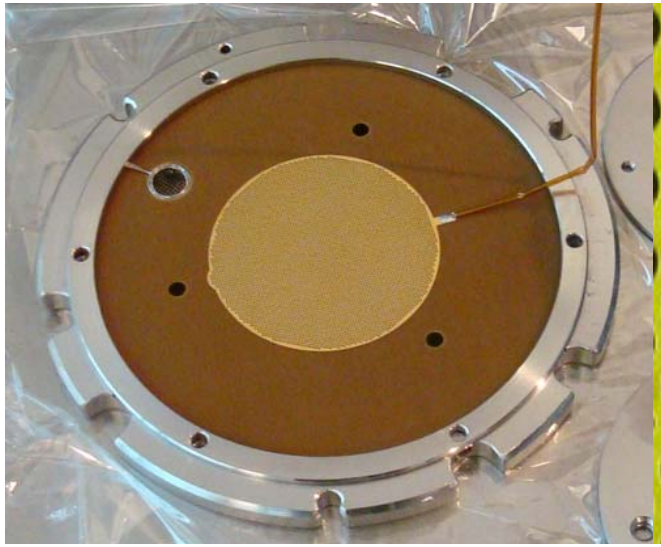


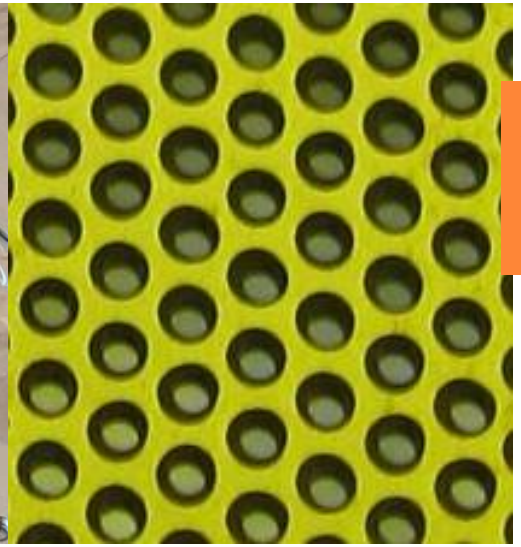
PMT array and vacuum chamber



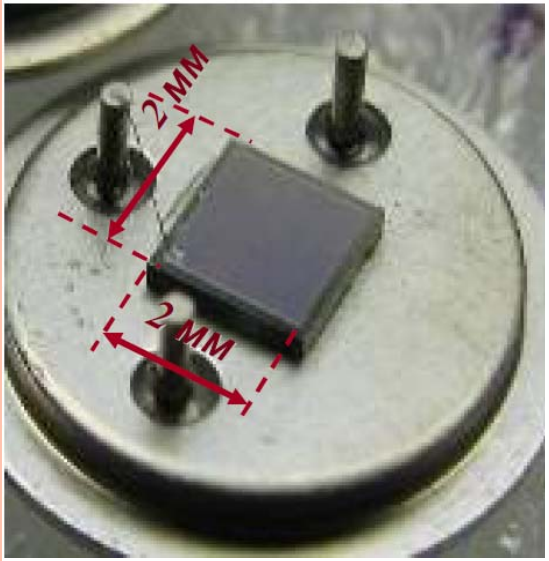
Array of 19 MRS APD covered by plate with WLS (2x2 mm^2 diodes placed with 13 mm step -about 6% fill factor)

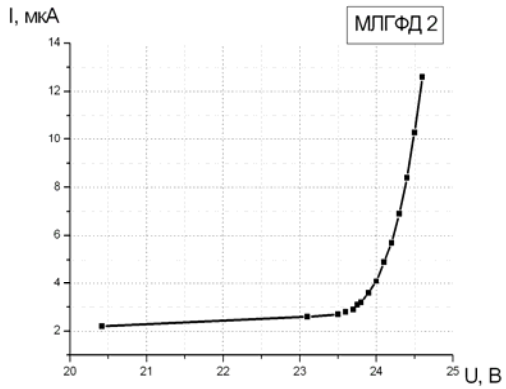
EXPERIMENTAL SETUP(2)





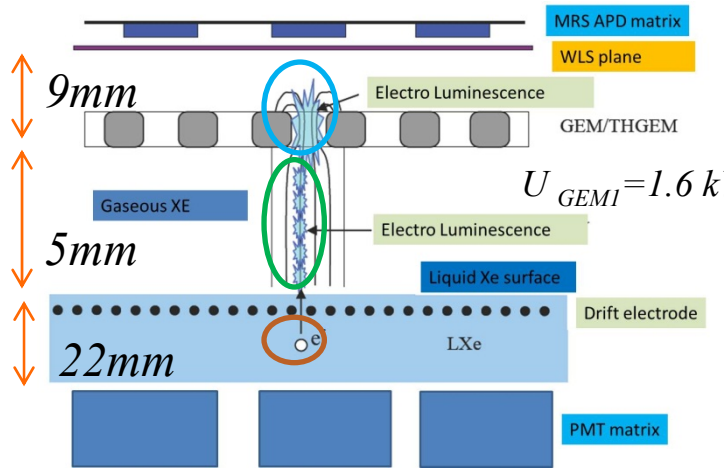
250 μm thick kapton, 35 μm copper
0.4 mm hole 0.7 mm spacing
0.1mm etching at the edge of hole

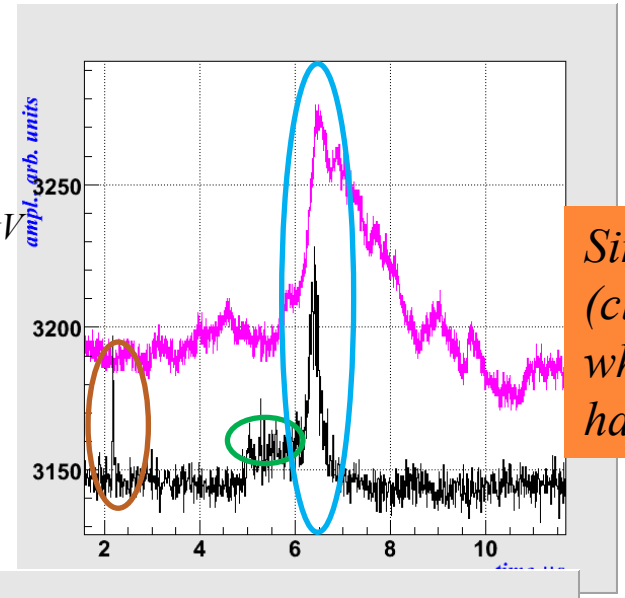




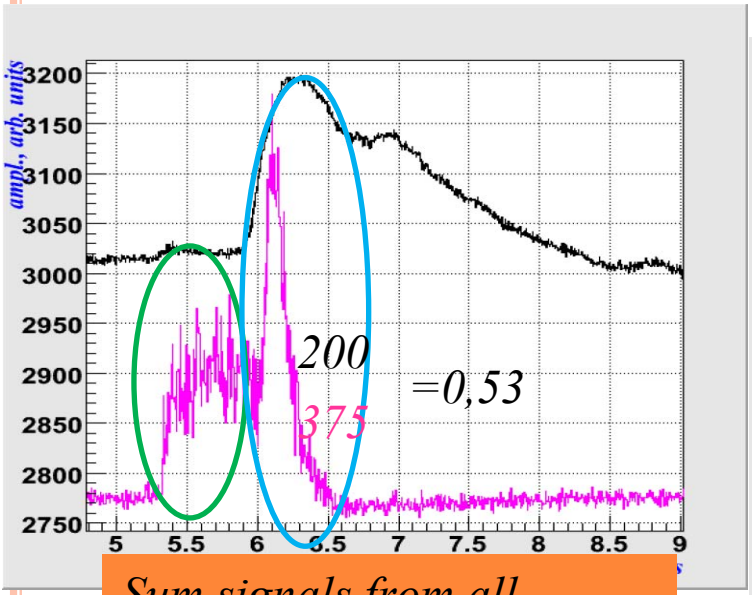
19 MRS APD on metal package
Breakdown voltage 23-25 V
For measurements we set bias 1V overvoltage to have 5 mV single electron peak after amplifier (to set "minimal sensitivity", about (3-4)% PDE for MRS APD+WLS)

FIRST TEST RUN (SINGLE GEM)

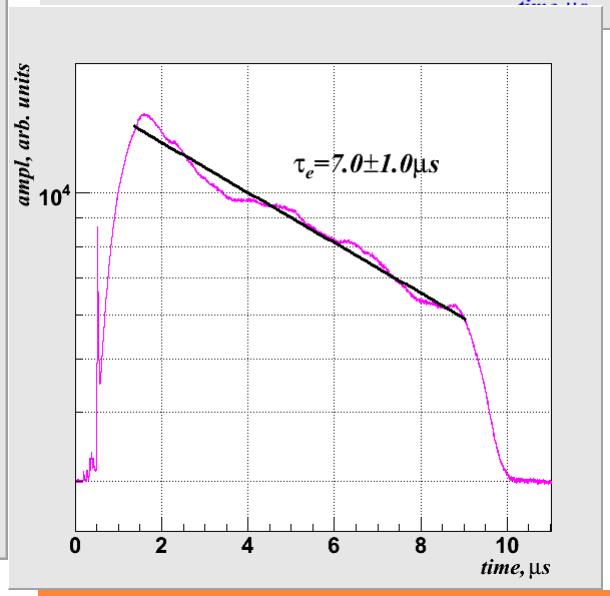




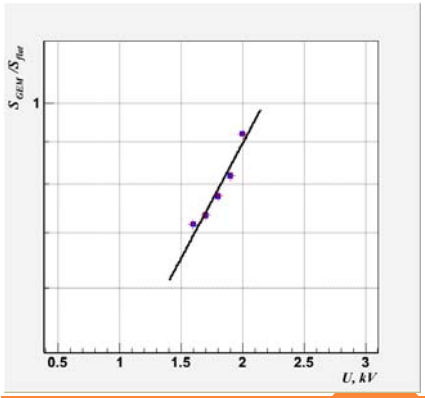
Single MRS APD signal (closest to the THGEM hole, where electro luminescence happened)



Sum signals from all MRS APDs ~ 40 ph.e.

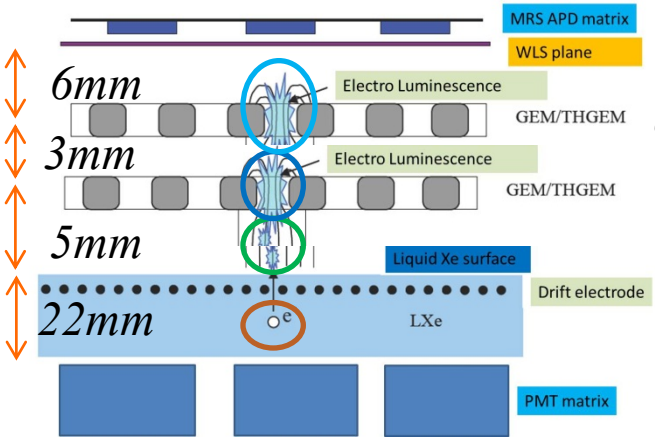


Electron life time in Xe (for muons)



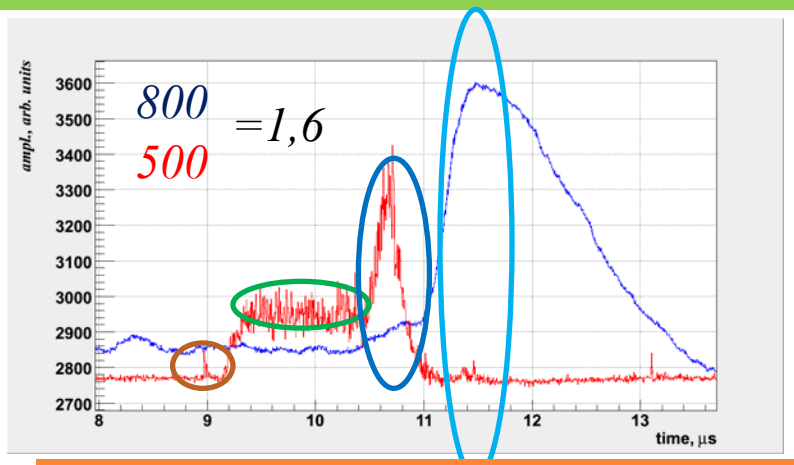
Electroluminescence from THGEM

SECOND TEST RUN (DOUBLE GEM)

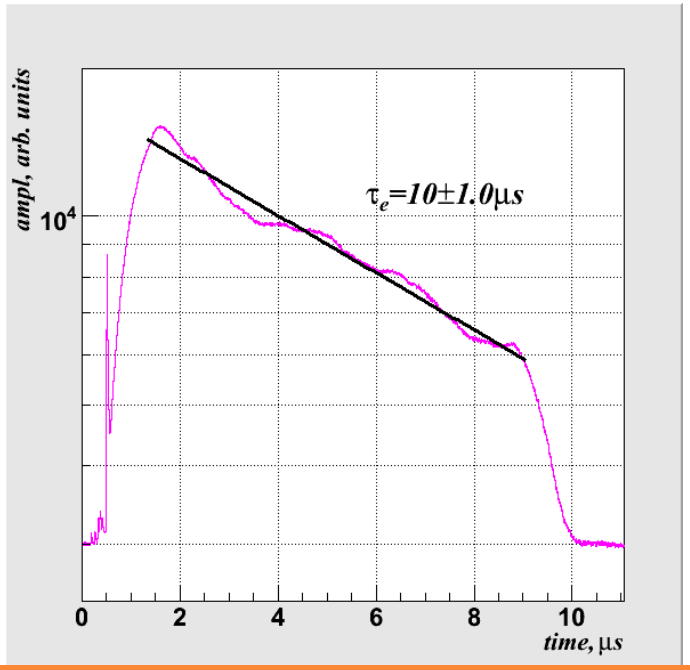


$U_{GEM1}=1.6\ kV$

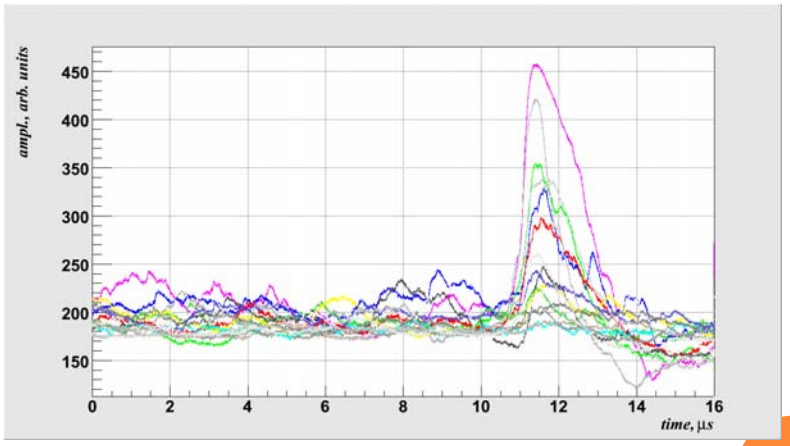
$U_{GEM2}=1.6\ kV$



Sum of matrix signals(3 times more signal respect to single THGEM)

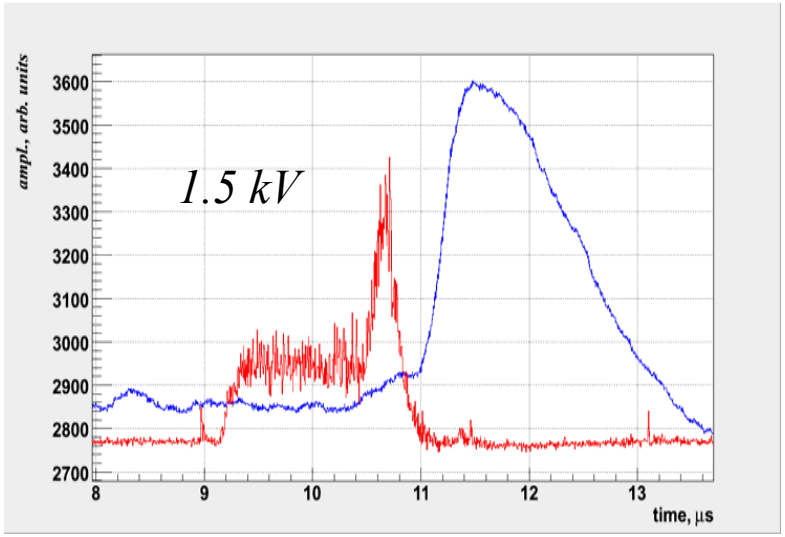


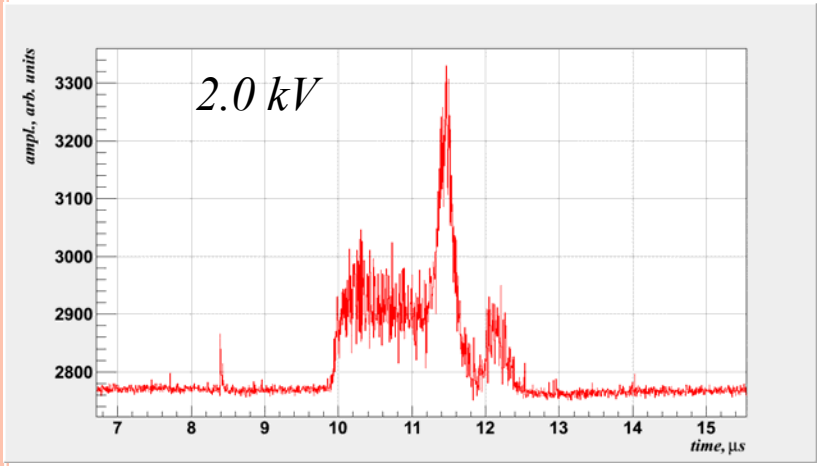
Electron life time in Xe
(improved by 30% with respect to first run)



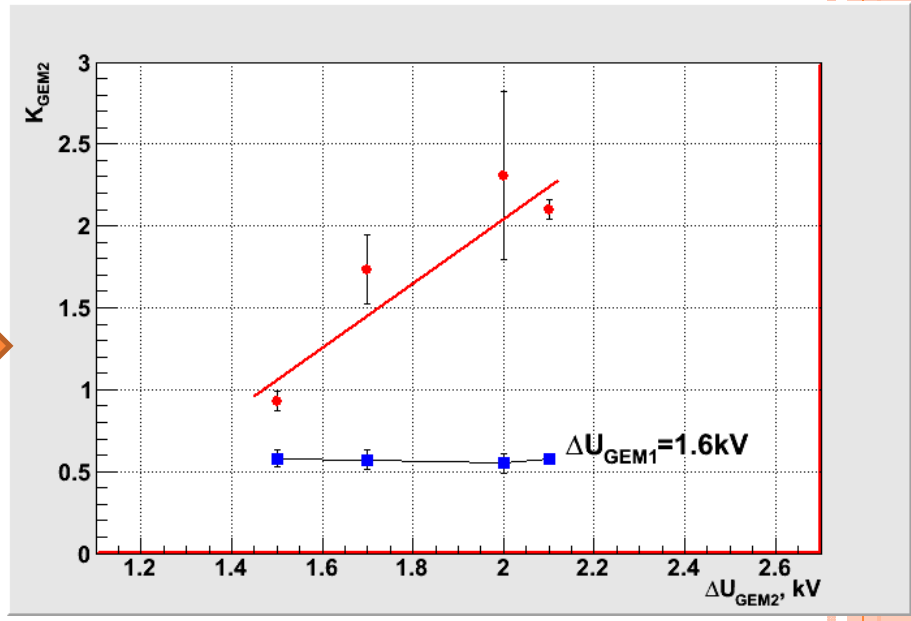
Individual MRS APD signals

SECOND THGEM AMPLIFICATION

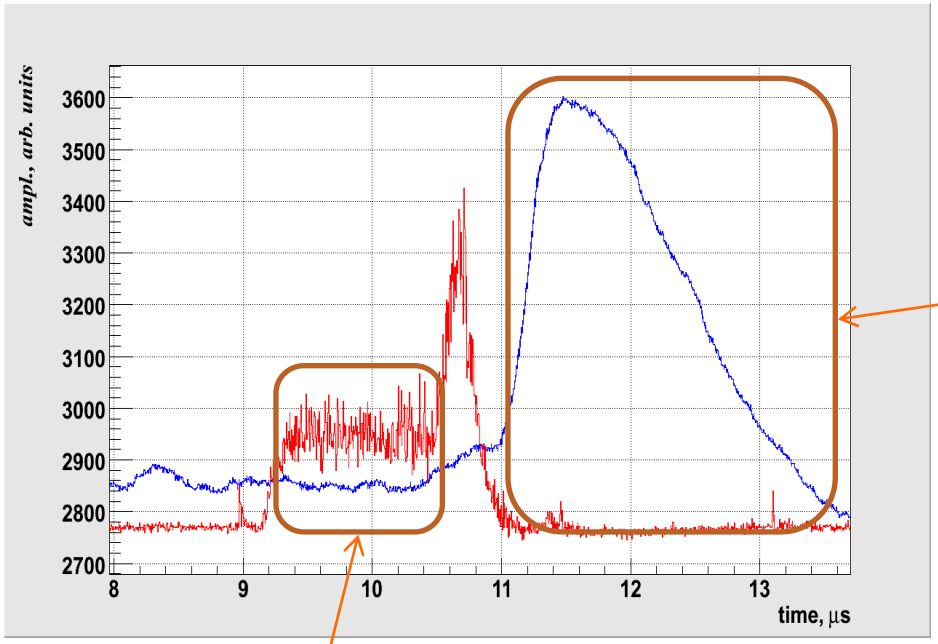




The same light yield v.s. U was found as for THGEM1 during first test



ESTIMATION OF FIRED CELL NUMBER PER SINGLE IONIZATION ELECTRON EXTRACTED FROM LIQUID



For THGEM2 U=1.6 kV
MRS APD array signal ~150 cells

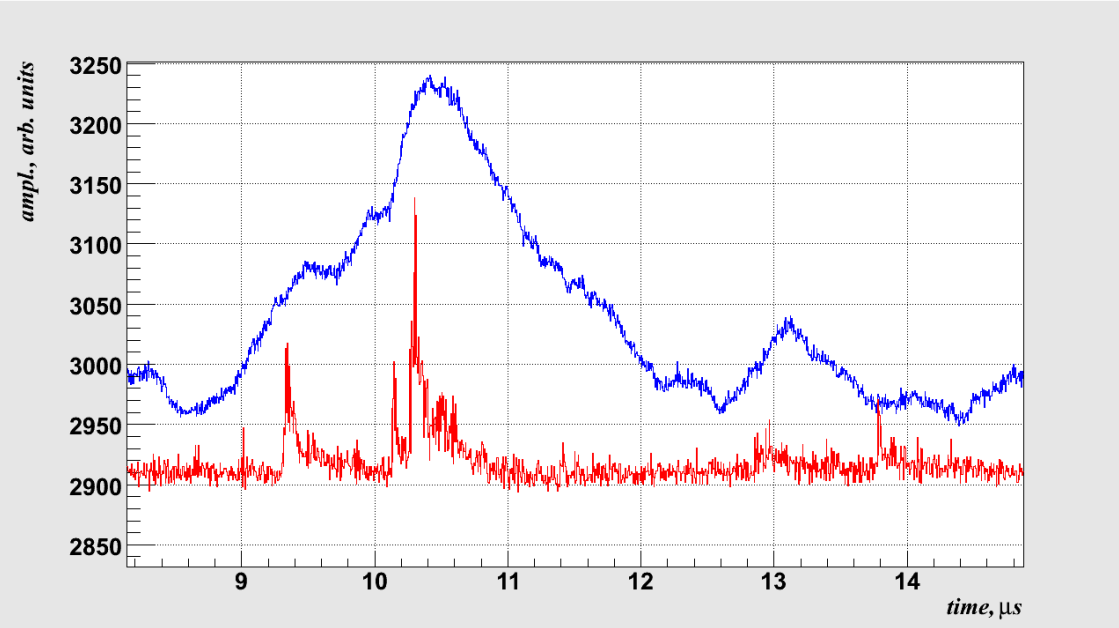
~300 for THGEM2 U=2.1 kV
For 1V overvoltage ->3% PDE (MRS APD +WLS)
Fill factor for array ~6% -> 50%
So, it can be increased by a factor of 60, i.e. ~9000 cells

For field in liquid 2.5 kV/cm and in gas 4.90 kV/cm
Area corresponds to 5950 ph.e. and 850 e (7 ph.e./e.)

~ 10 cells/e
Can be achieved.

PROBLEMS WE FACED DURING TWO RUNS

Not very stable THGEM operation at highest voltage (a lot noise and breakdown pulses appeared from time to time)
Quality of THGEMs to be improved (1-mm CIRLEX is under consideration as material for THGEM)



CONCLUSION AND FUTURE STEPS

Results

1.Large-size WLS plate with protection layer was tested successfully in Xe (electron life time seems O'k)

2. THGEMS were tested in pure Xe (in proportional scintillation mode)

3.The estimated single electron signal is ~10 cells for 50 % fill of array and full PDE .

Future steps

1.We plan to use THGEMs from different materials, because we had some problems with the current type of THGEMs (1-mm CIRLEX foils were ordered)

2.New WLS materials (see Dmitry Akimov's poster) for "blue-green" region of reemission is successfully tested.

(we can use n-p structures; for p-n we broke unreasonable percent of diodes during package mounting, wire bonding, cleaning and ect., since surface in not protected)