CDEX-10 LAr detector

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2015.10

CJPL 中国锦屏地下实验室 China Jinping Underground Laboratory

Final Symposium of the Sino-German GDT Cooperation

Outline

1. **Introduction of the LAr test facility**
2. **Single photoelectron response of PMTs**
3. **Photoelectron yield of the LAr detector**
4. **Summary**

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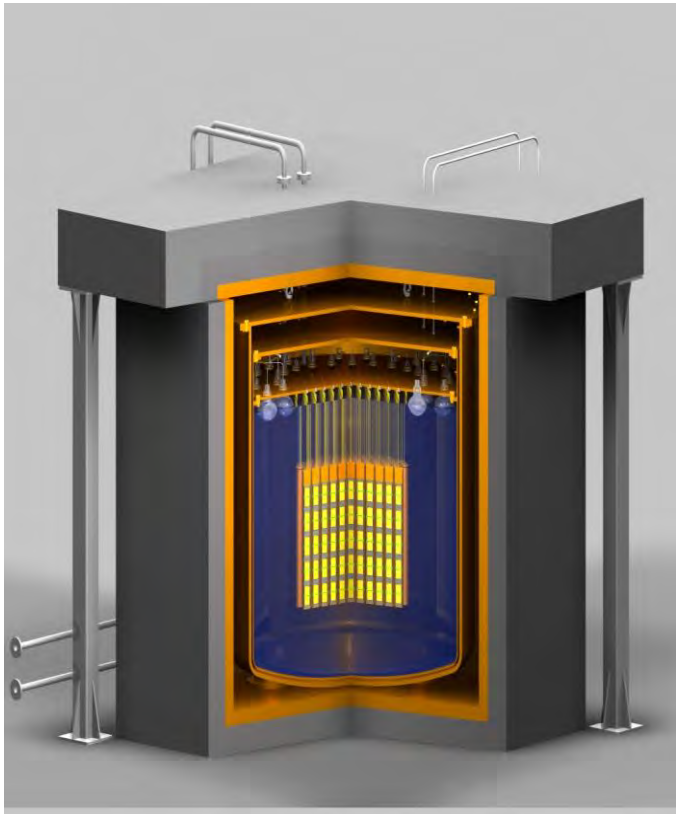
LAr Detector for CDEX-10



Why choose liquid argon?

- Good stopping power
- High scintillation yield (40000photons/MeV)
- Excellent particle identification capability
- transparent to their own scintillation light

CDEX (China Dark matter EXperiment)

- Keep Ge in a low temperature
- Anti-Compton
- Passive shielding

ton-scale LAr as anti-Compton detector of ULE HPGe array in WIMPs direct detection @ CJPL

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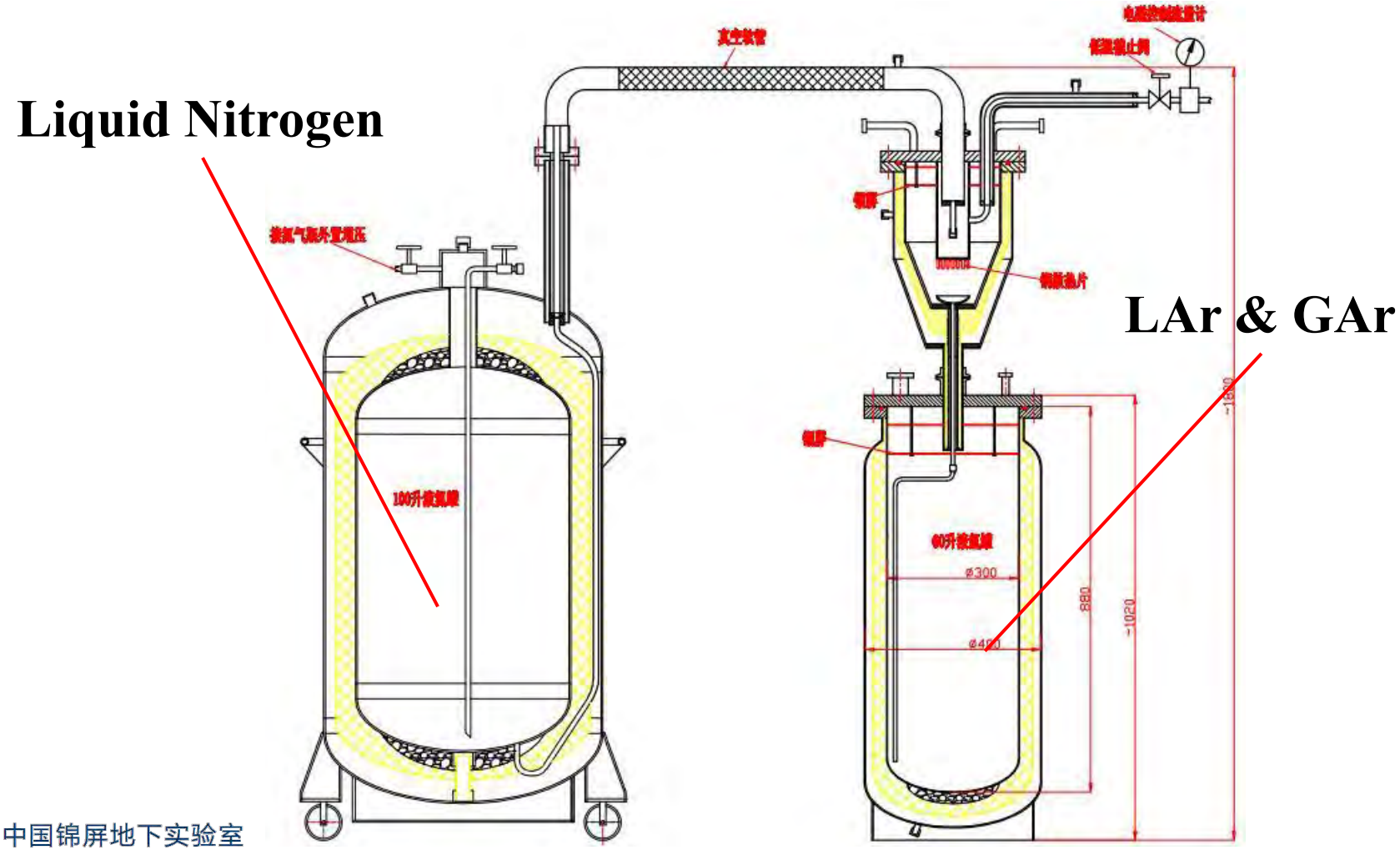
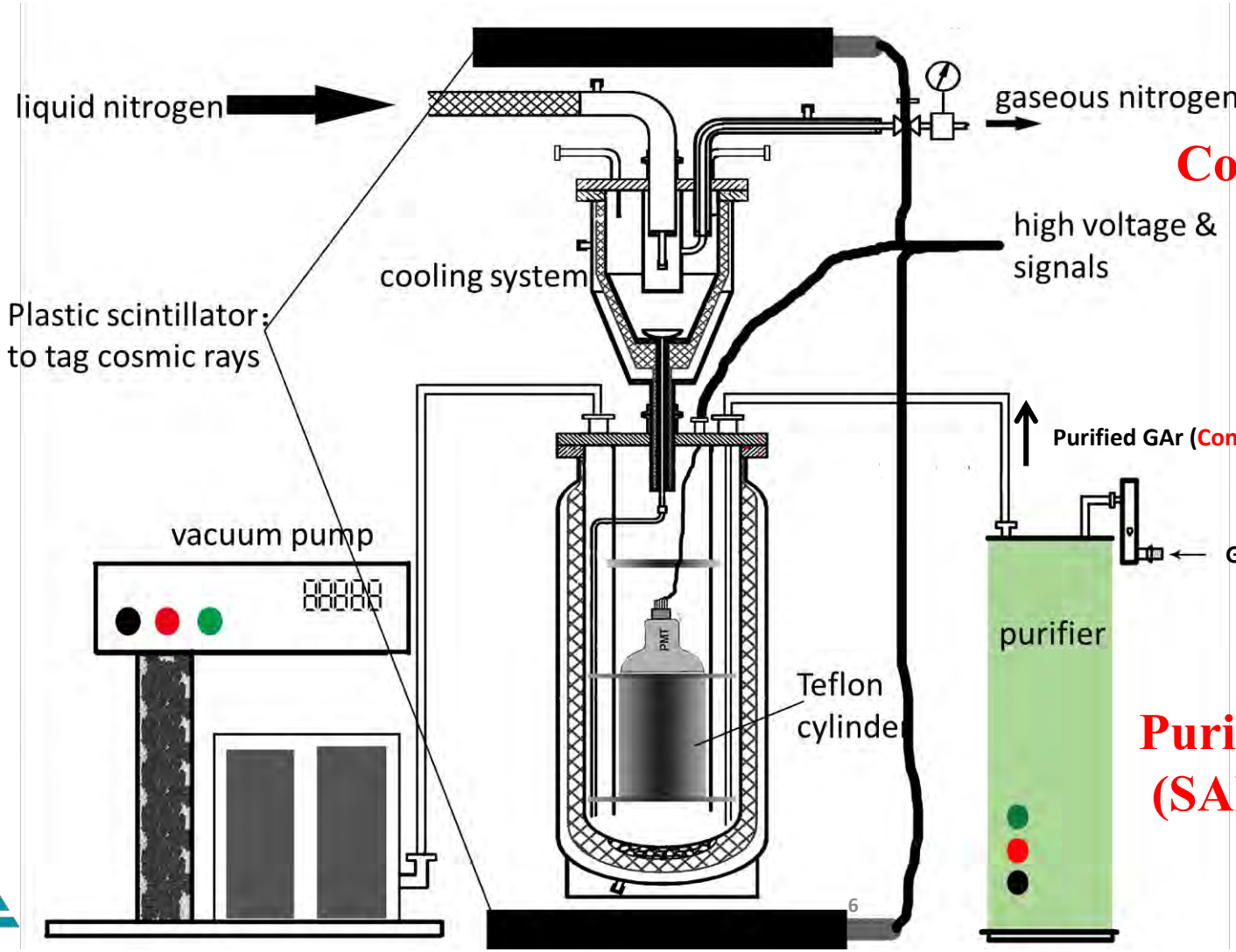
The Liquid Nitrogen Cooling System

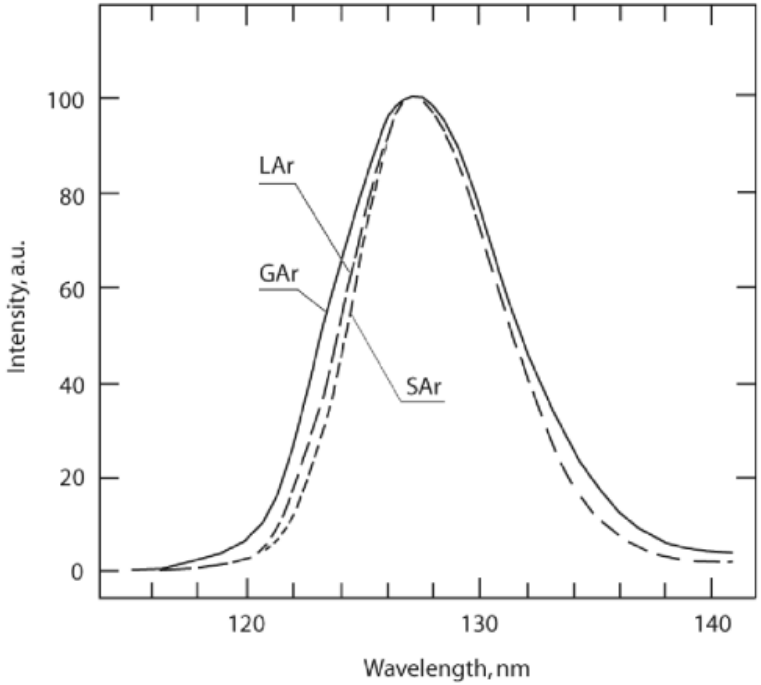


LAr System


liquid nitrogen
gaseous nitrogen
Cooling System
high voltage &
signals
cooling system
Plastic scintillator:
to tag cosmic rays
Purified GAr (Contamination < 1 ppb)
vacuum pump
Gar (Contamination ~ 10 ppm)
PMT
purifier
Teflon
cylinder
Purification System
(SAES getter)

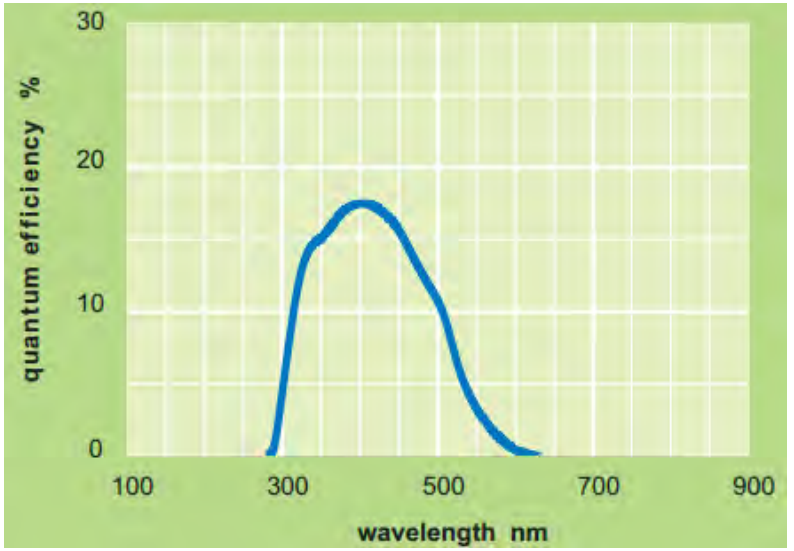
Wavelength shifter (WLS)

Emission spectra of argon



We need WLS!

Spectral response curve of PMT ETL 9357KB



- TPB (tetraphenyl butadiene) is selected to be the WLS.

TPB evaporation system

Conditions:

Temperature: ~200 ℃

Pressure: 10^{-3} Pa

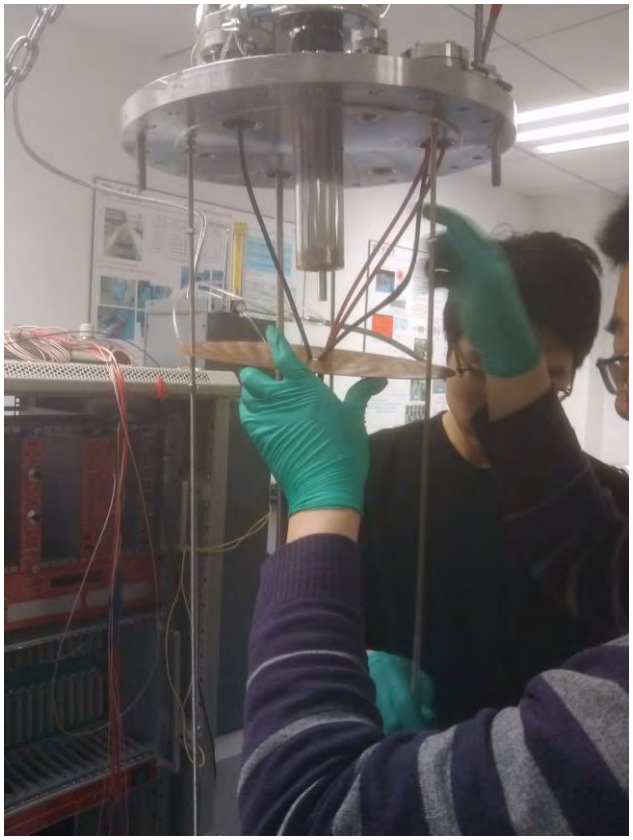
TPB thickness: ~0.3 mg/cm^2

Teflon cylinder

TPB

PMT

System Installation



PMT window: TPB deposited

Inner surface: TPB deposited

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System In Tsinghua University

System In Sichuan University

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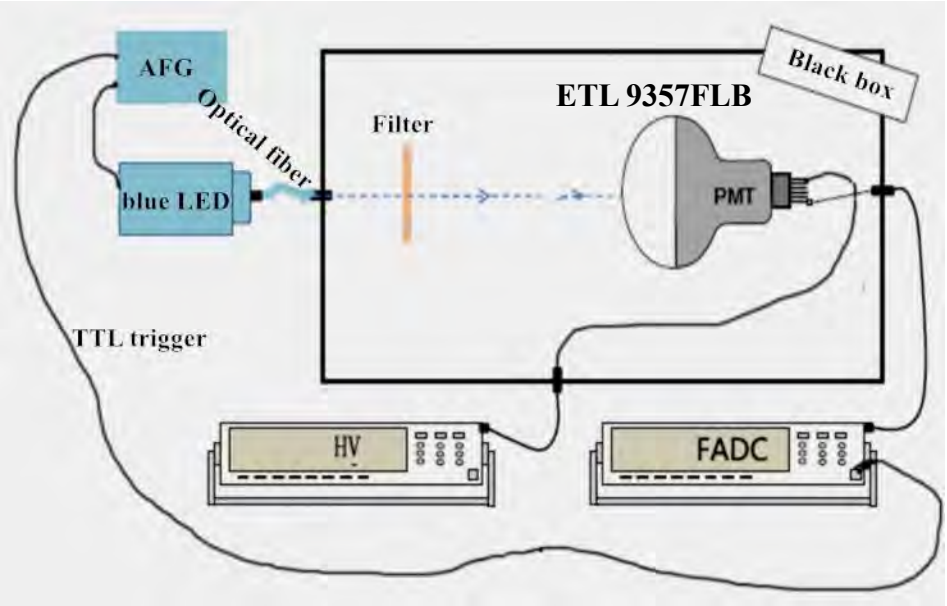
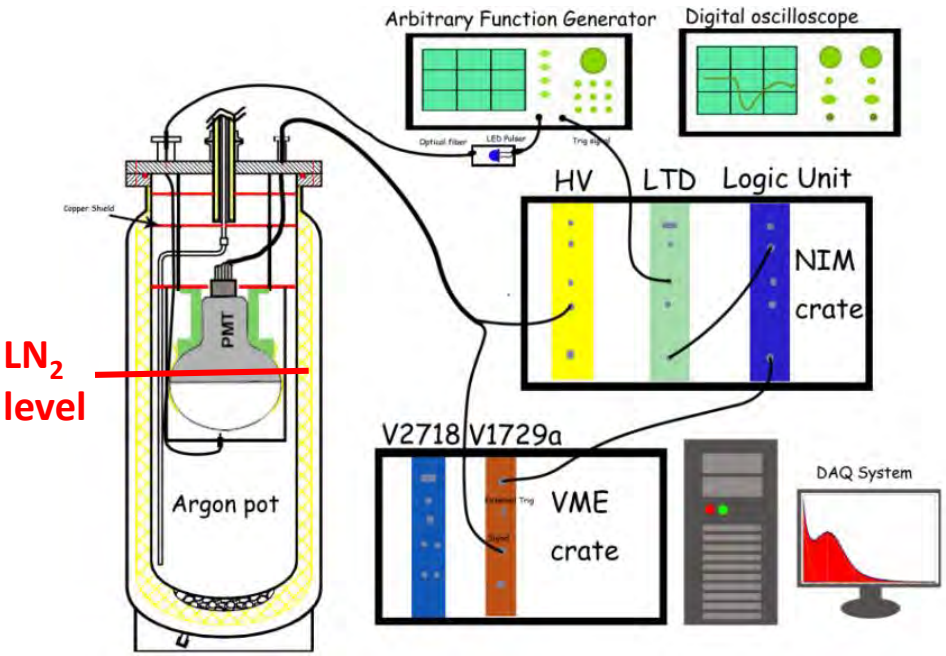
Single photoelectron response of PMTs



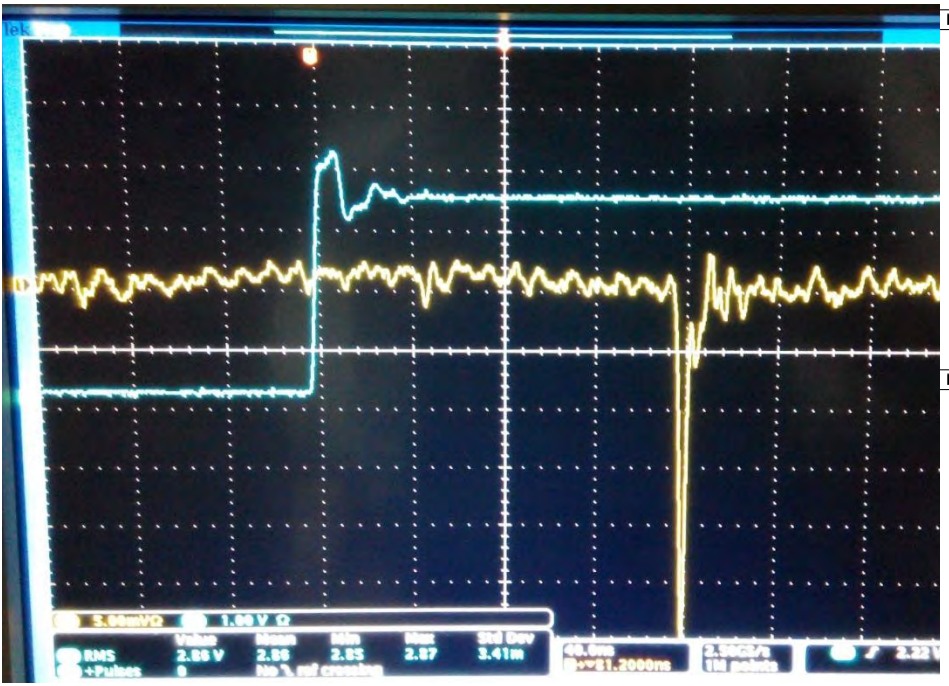
Room temperature

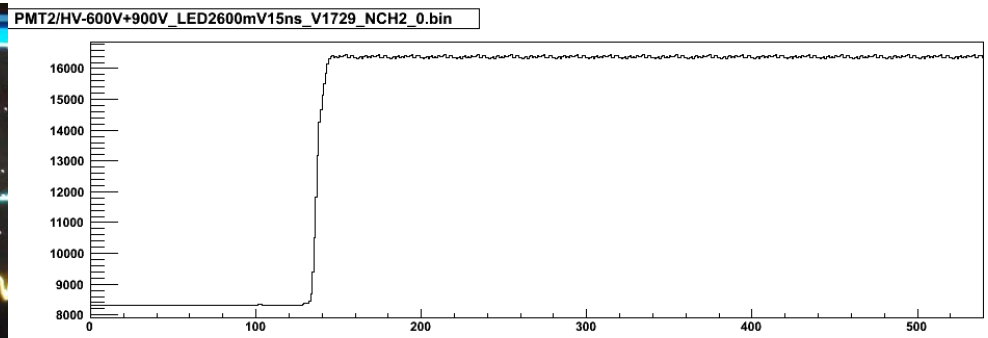


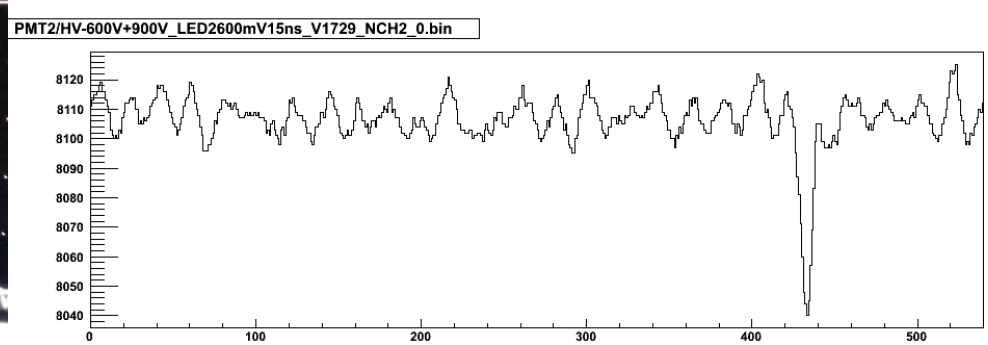
LN_2 temperature

- **Absolute gain, resolution and peak-to-valley ratio.**
- **Gain calibration of the PMT: the energy scale can now be expressed in units of 'average number of photo-electrons'**

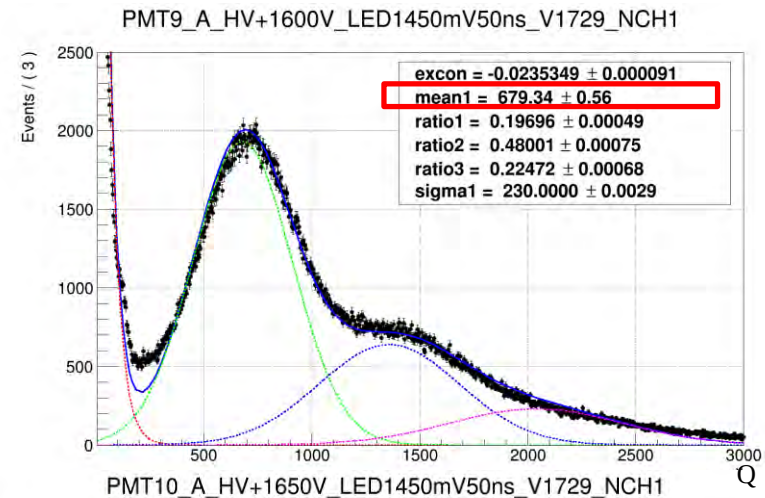
Trigger & PMT signal

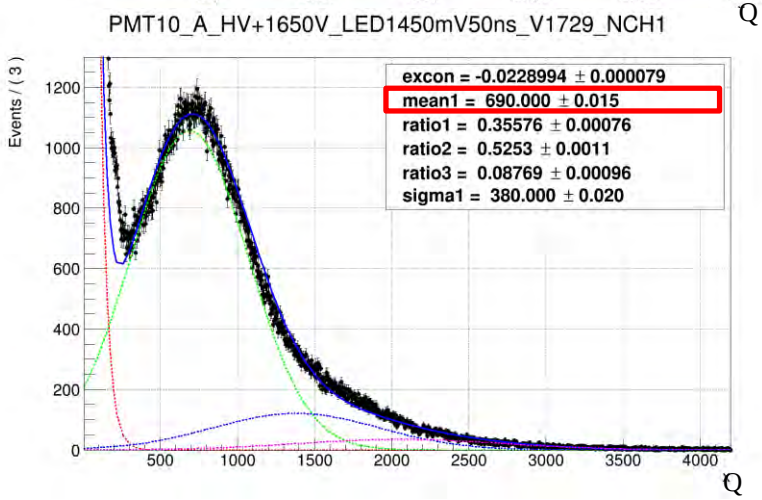


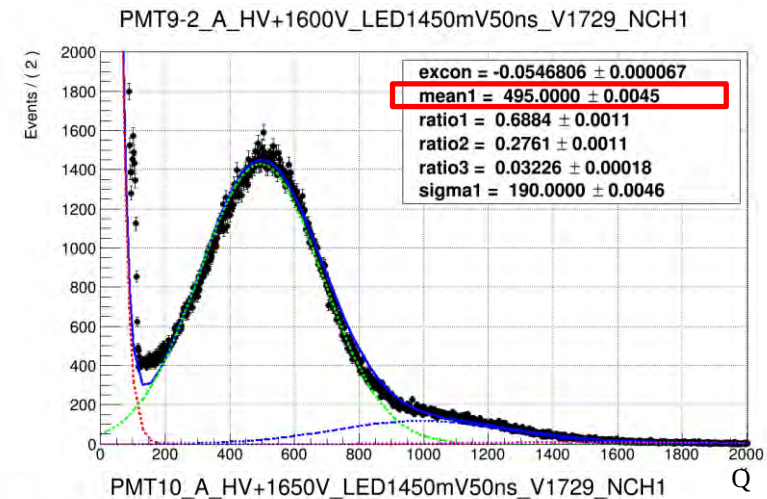


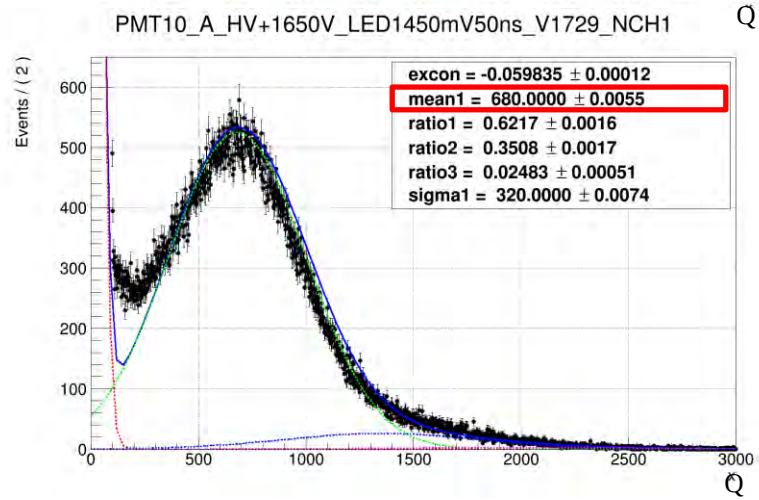


Single photoelectron spectrum









Room temperature

LN_2 temperature

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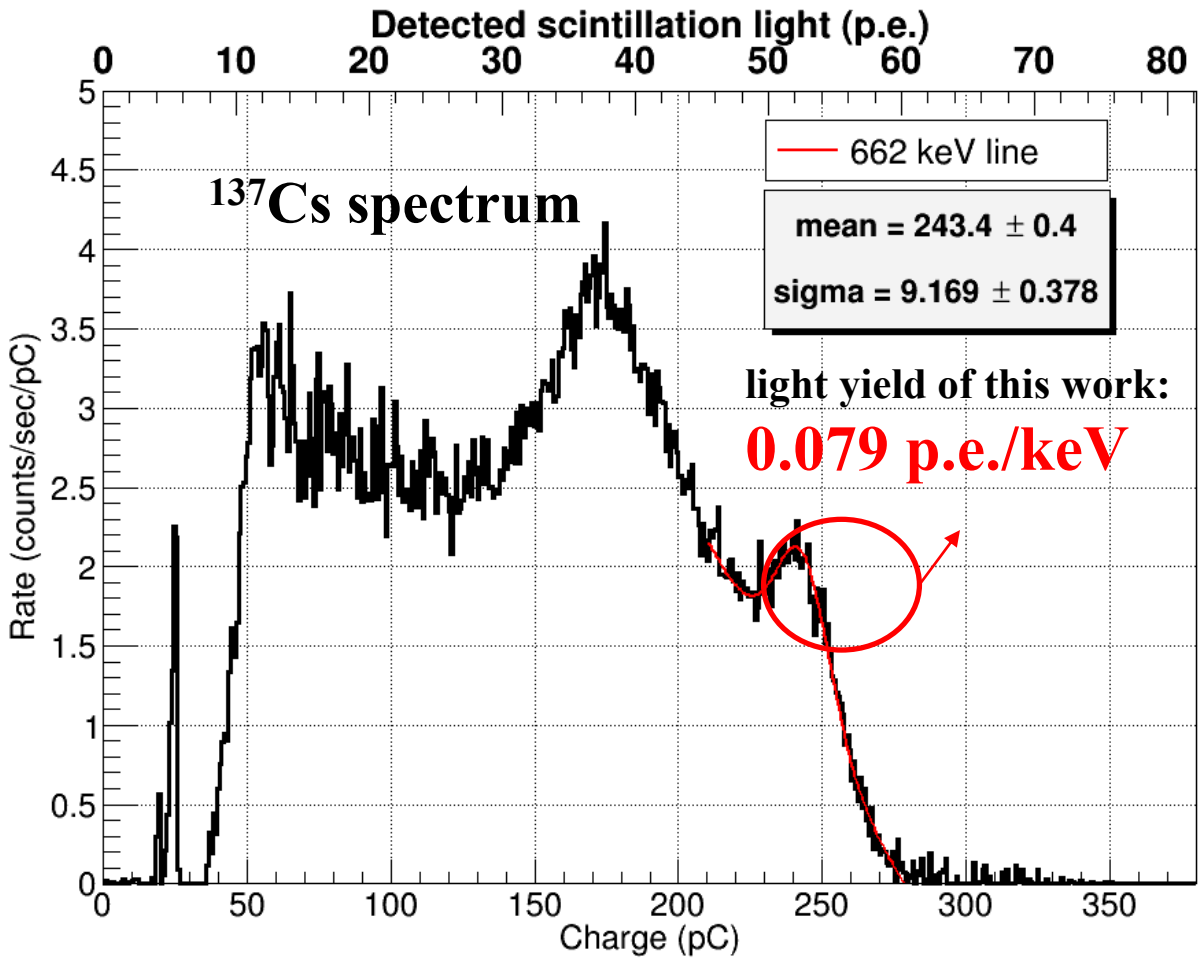
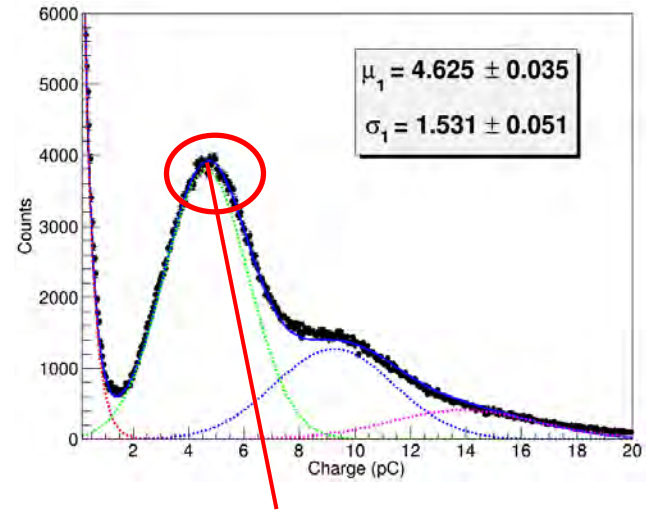
External ^{137}Cs source

50-mm-thick lead collimator with a 10 mm diameter hole

^{137}Cs source

Scintillation spectrum (PMT with TPB coating)

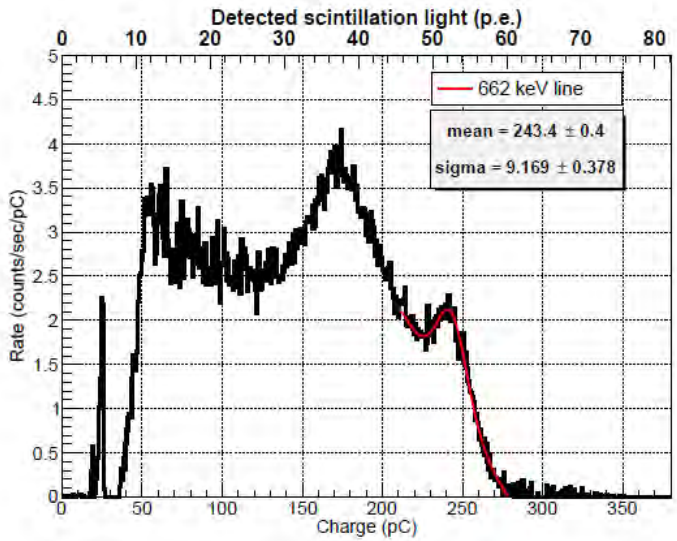




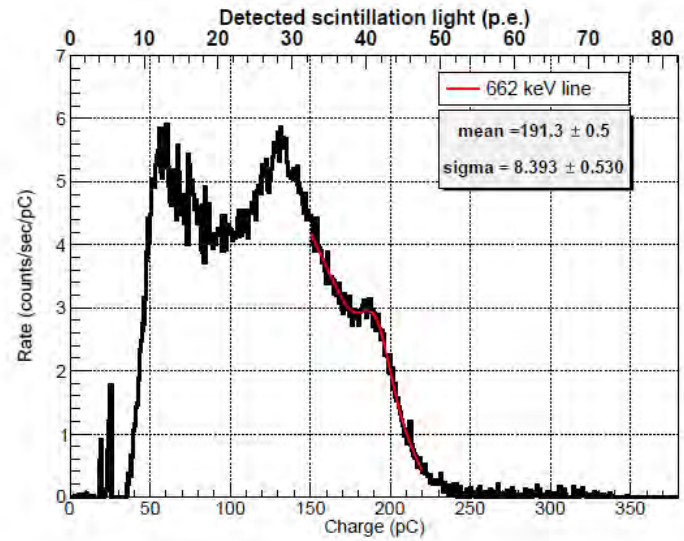
Gain: 4.625 pC/p.e. @LN

TPB coating on the PMT window (thickness ≈ 0.3 mg/cm^2)

Scintillation spectrum (PMT with TPB coating)



Top - 0.079 p.e./keV

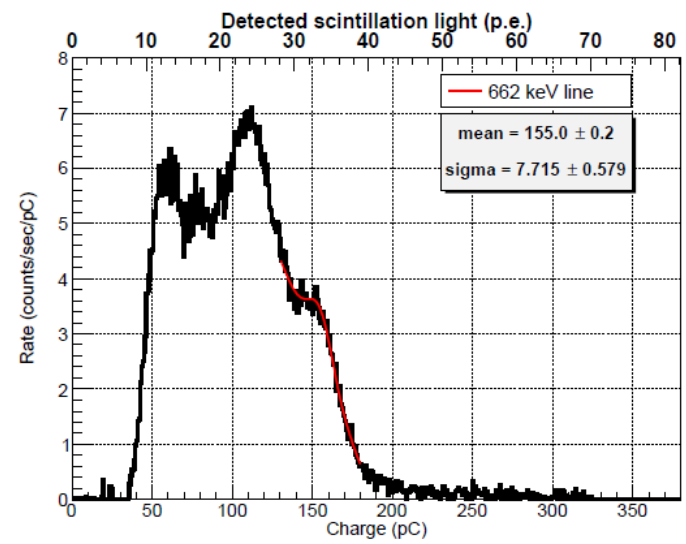


Middle(100mm) - 0.063 p.e./keV

For single photon, about
12.7 keV ~ 19.6 keV energy threshold
can be estimated.

0.05 p.e./keV @ GERDA Lar

1.24 p.e./keV @ GERDA MiniLAr

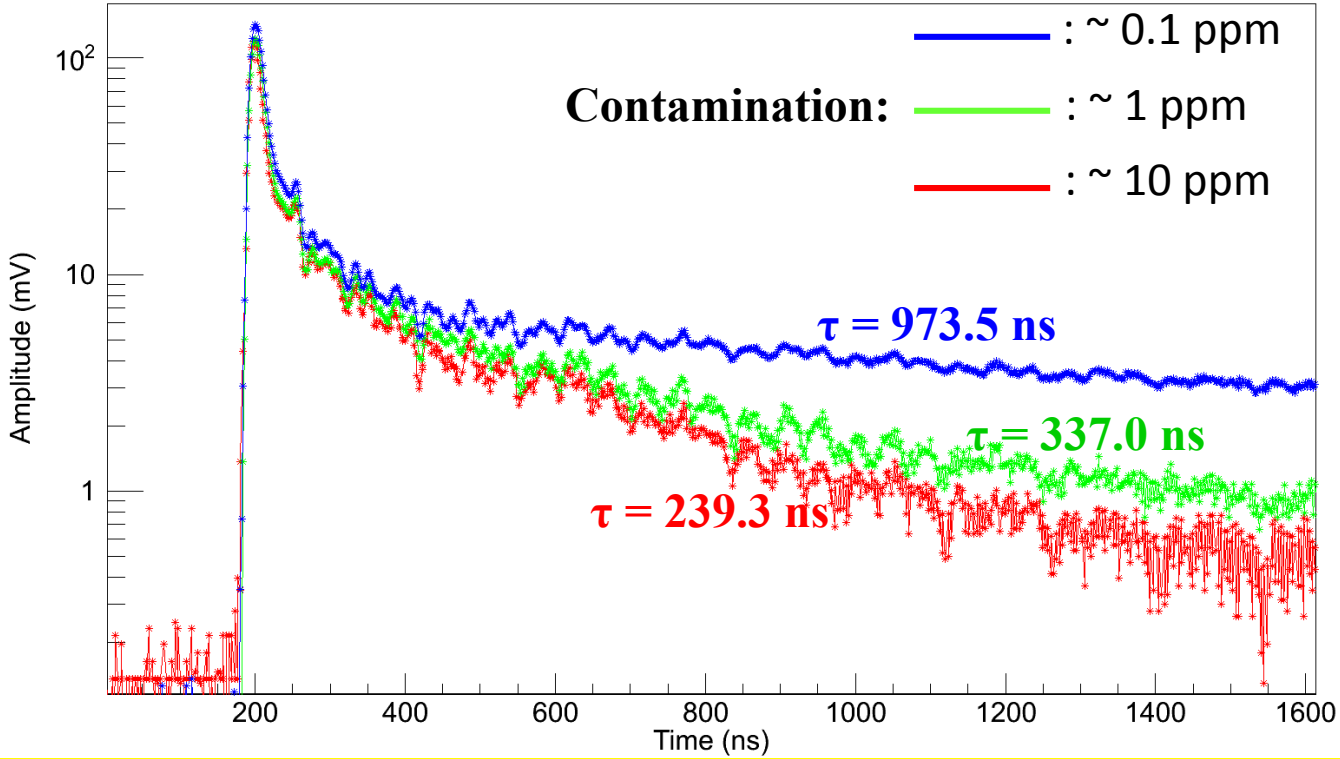


Bottom(200mm) - 0.051 p.e./keV

* Acciarri R et al. J. Instrum., 2010, 5: 6003
* Heisel, M. (2011). LArGe: A liquid argon scintillation veto for Gerda. PhD Thesis, Ruprecht-Karls-Universität, Heidelberg, Germany.

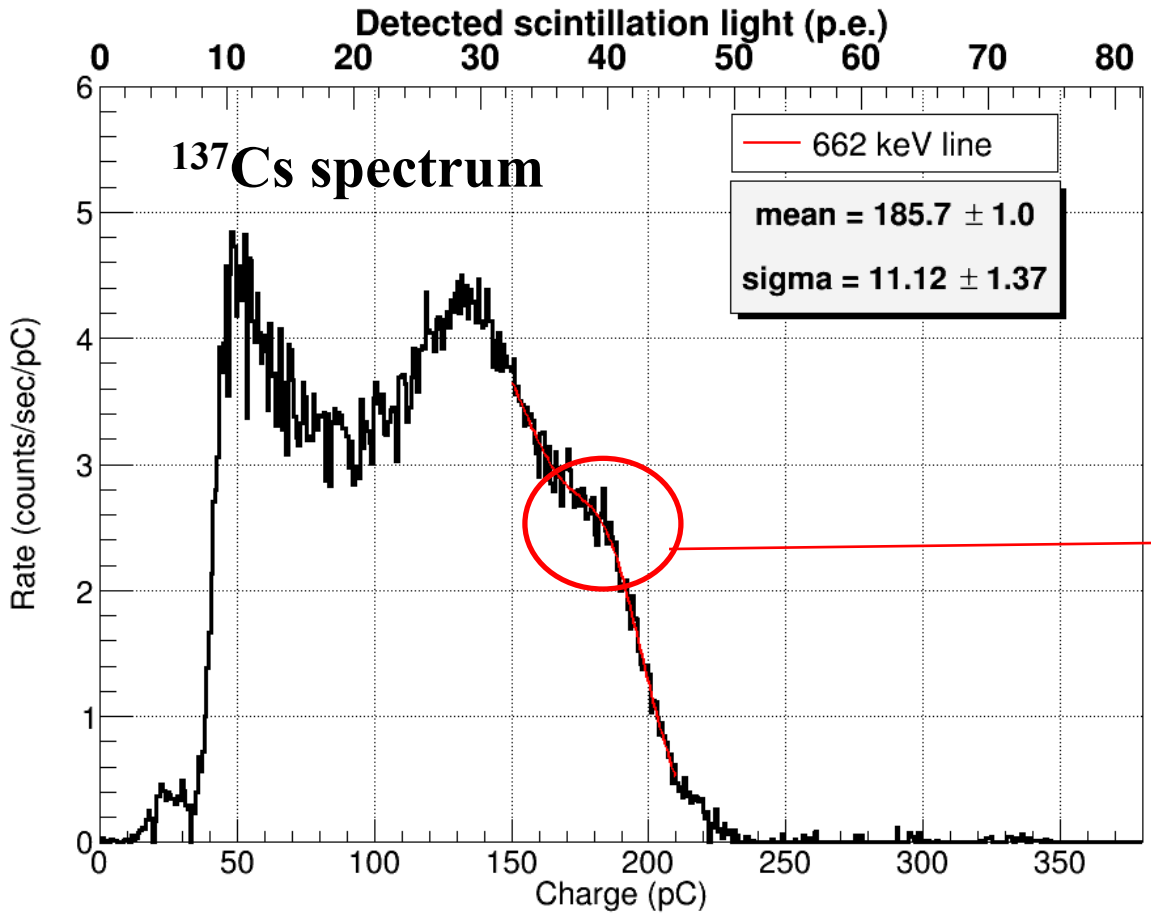
Scintillation Time Dependence in GAr with Different Purity

Averaged Waveform of GAr with different purities



- **Argon scintillation light is generated by cosmic rays.**
- **Different contamination levels lead to different signal shapes.**
- **Important way to PSD and monitor the Ar purity.**

Scintillation spectrum (PMT without coating)



light yield of this work:

0.061 p.e./keV

The same position with TPB

0.079 p.e./keV

increased by:

~30%

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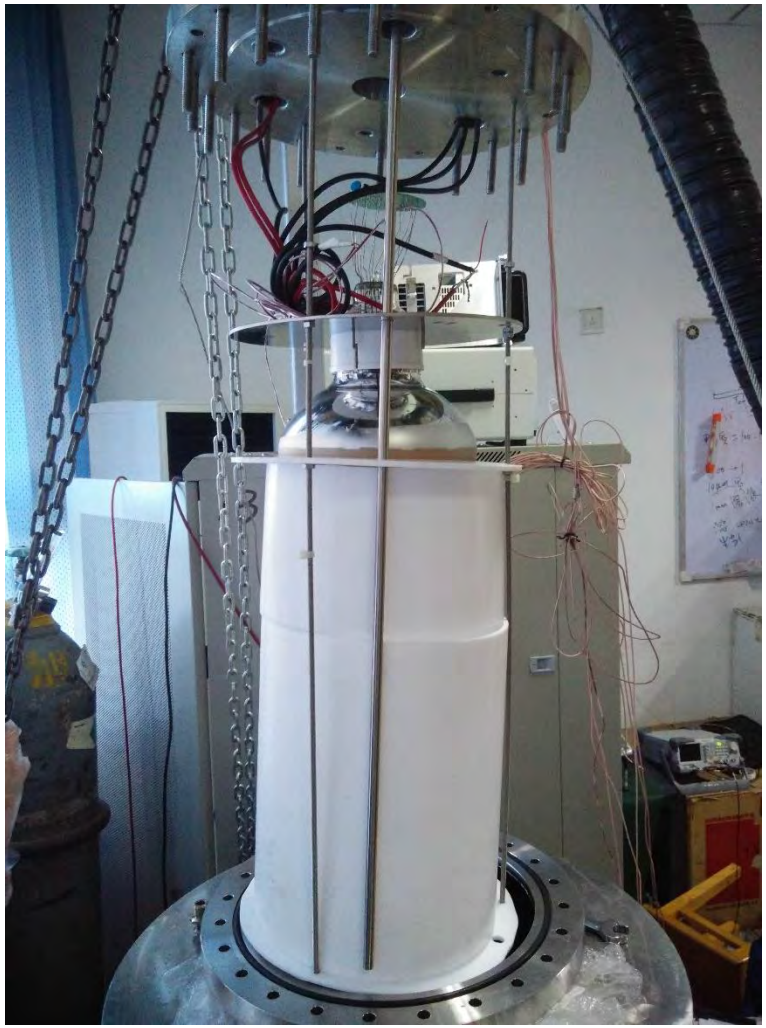
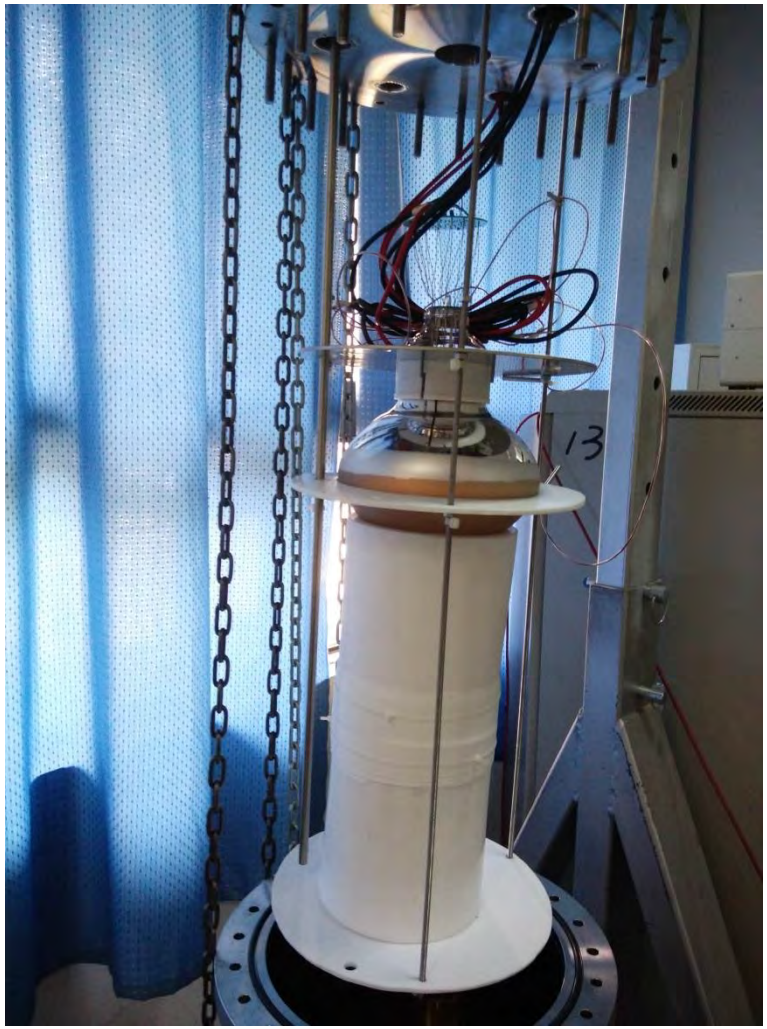
Boccone V et al. J. Instrum., 2009, 4: 6001

Compare the Teflon cylinder for the LAr



250mm diameter, 450mm height



150mm diameter, 400mm height

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Summary

- Gain calibration of the PMTs for the LAr have been done under room temperature and nitrogen temperature.
- The photoelectron yield of the detector for 662 keV line has been measured with a maximum value up to 0.051~0.079 p.e./keV as a preliminary result. (estimated about 12.7 keV ~ 19.6 keV energy threshold)
- It can be seen, that the PMT window coating improves the total light collection by about 30%.

- The purity of the LAr limits the photoelectron yield, need to be measured and studied quantitatively.
- The photon collection efficiency should be studied for larger volume (diameter/length of the Teflon cylinder).

Thanks for your attention!

On the way to the CDEX-10…

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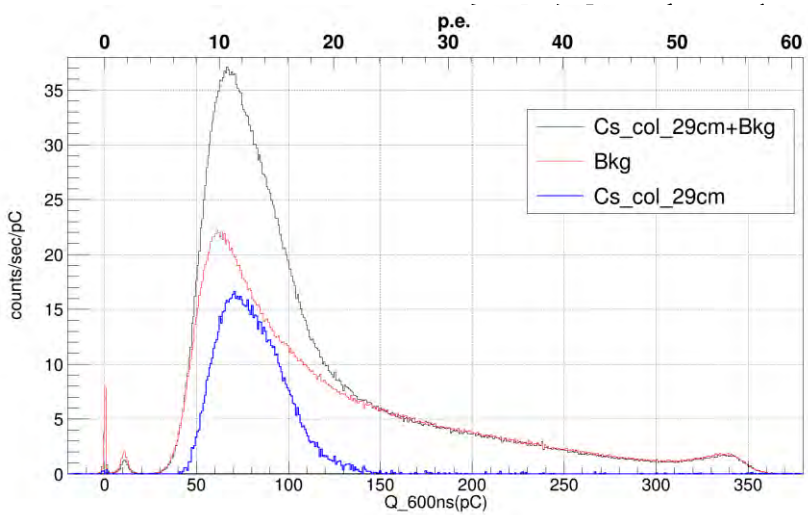
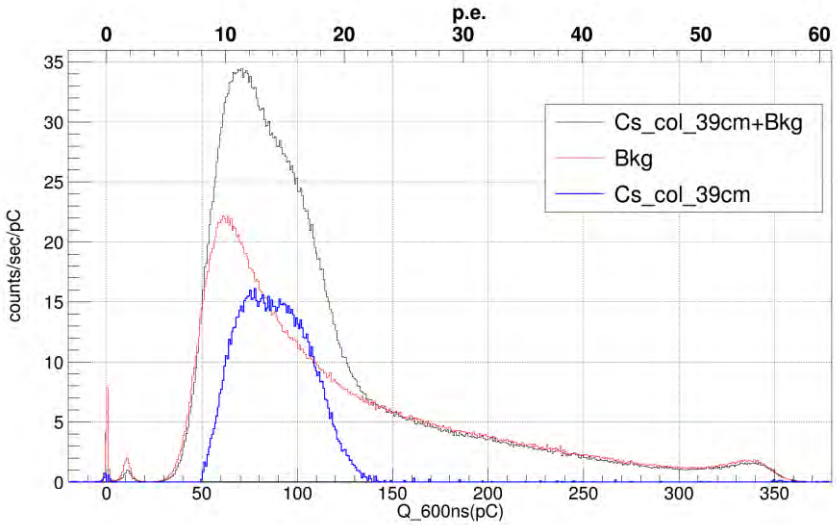
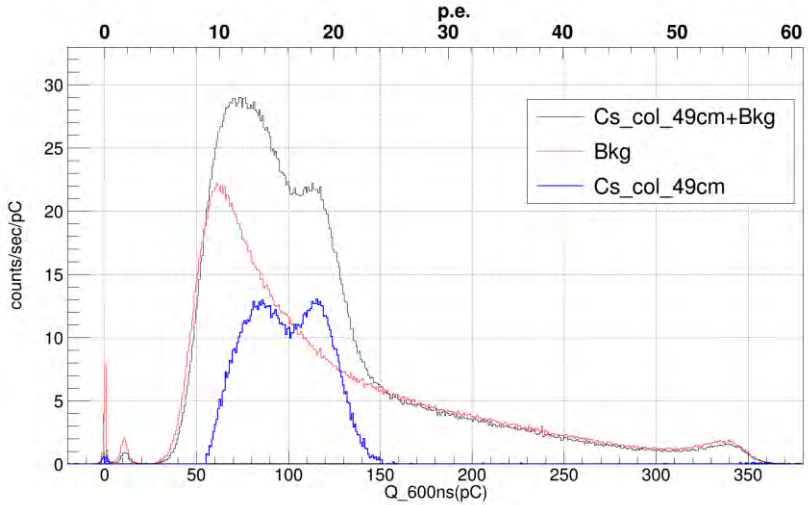
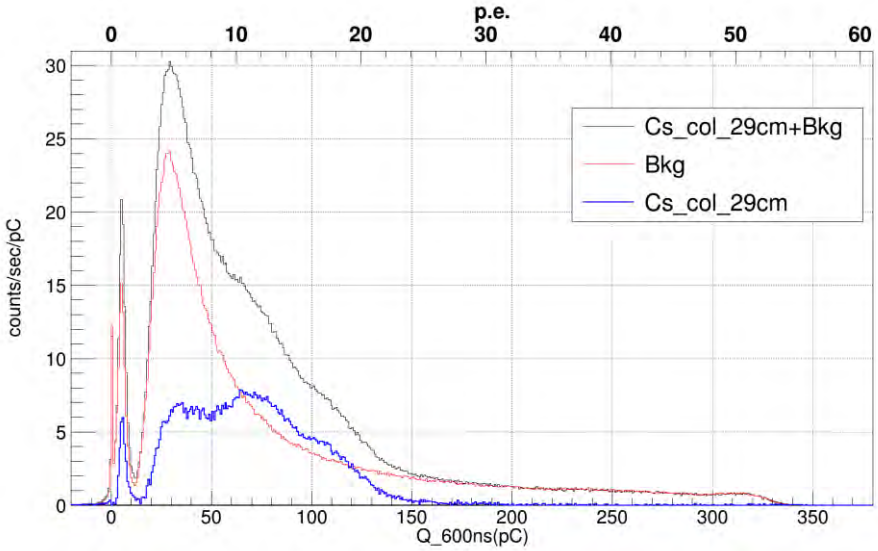
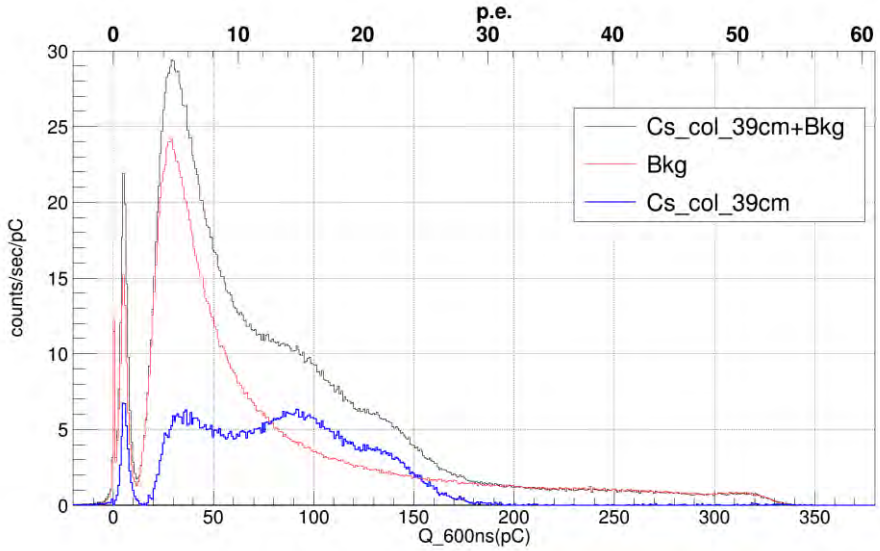

p.e.
0 10 20 30 40 50 60
counts/sec/pC
0 5 10 15 20 25 30 35
0 50 100 150 200 250 300 350
Q_600ns(pC)
Cs_col_29cm+Bkg
Bkg
Cs_col_29cm

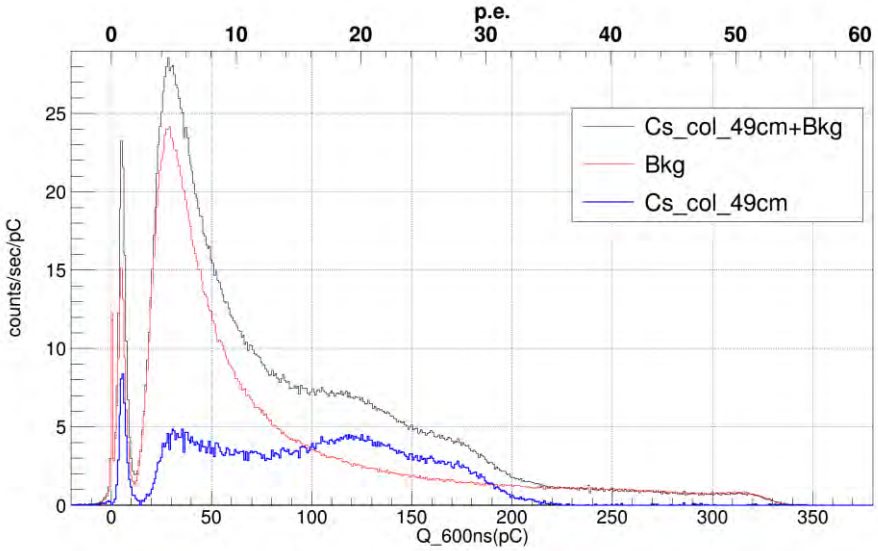

p.e.
0 10 20 30 40 50 60
counts/sec/pC
0 5 10 15 20 25 30 35
0 50 100 150 200 250 300 350
Q_600ns(pC)
Cs_col_39cm+Bkg
Bkg
Cs_col_39cm


p.e.
0 10 20 30 40 50 60
counts/sec/pC
0 5 10 15 20 25 30
0 50 100 150 200 250 300 350
Q_600ns(pC)
Cs_col_49cm+Bkg
Bkg
Cs_col_49cm

（原PMT不镀膜结果）Cs射线高度：29cm~49cm







（PMT镀TPB结果）Cs射线高度：29cm~49cm