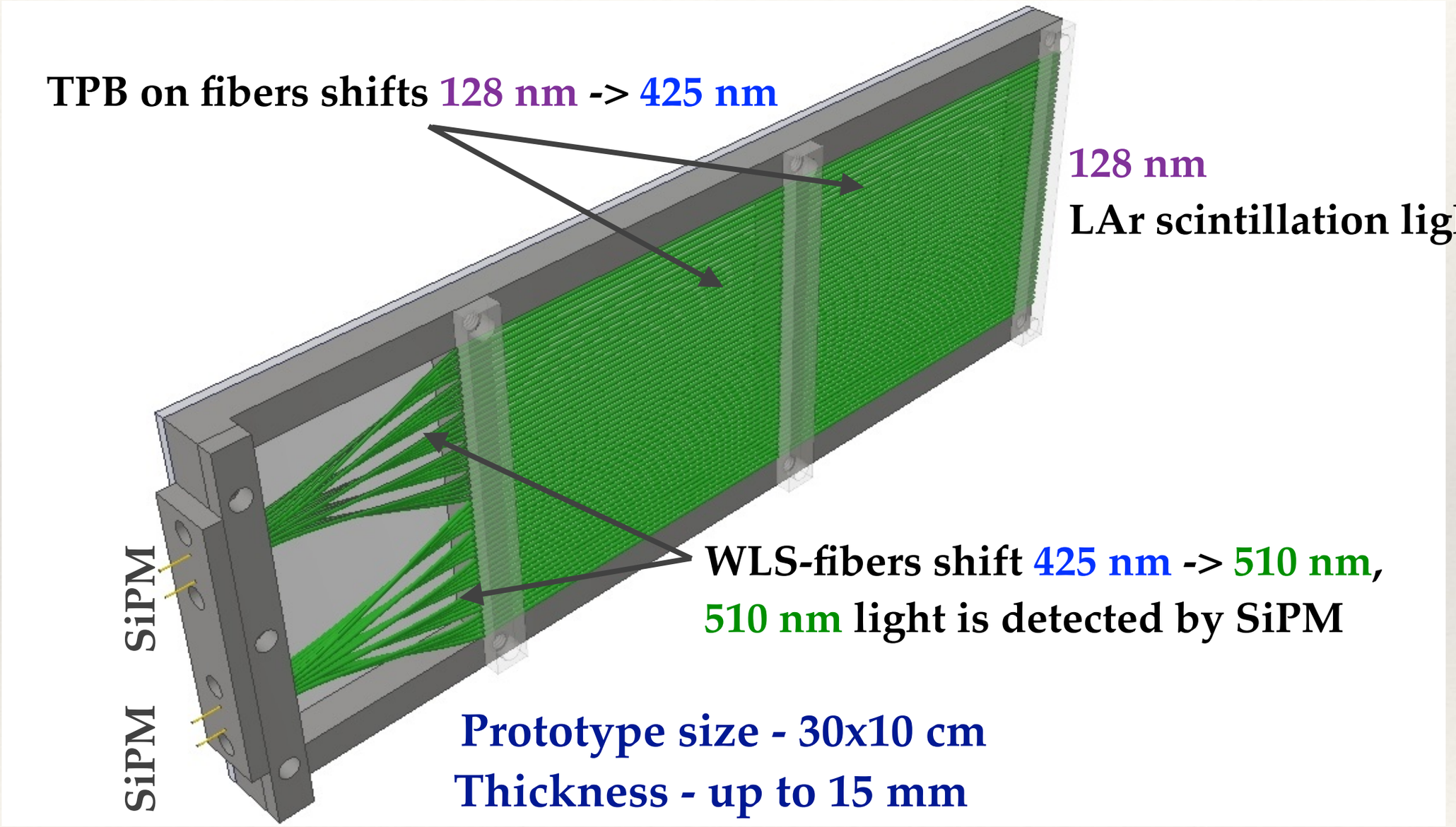
ArgonCube collaboration meeting, Bern, 12-13 June, 2018

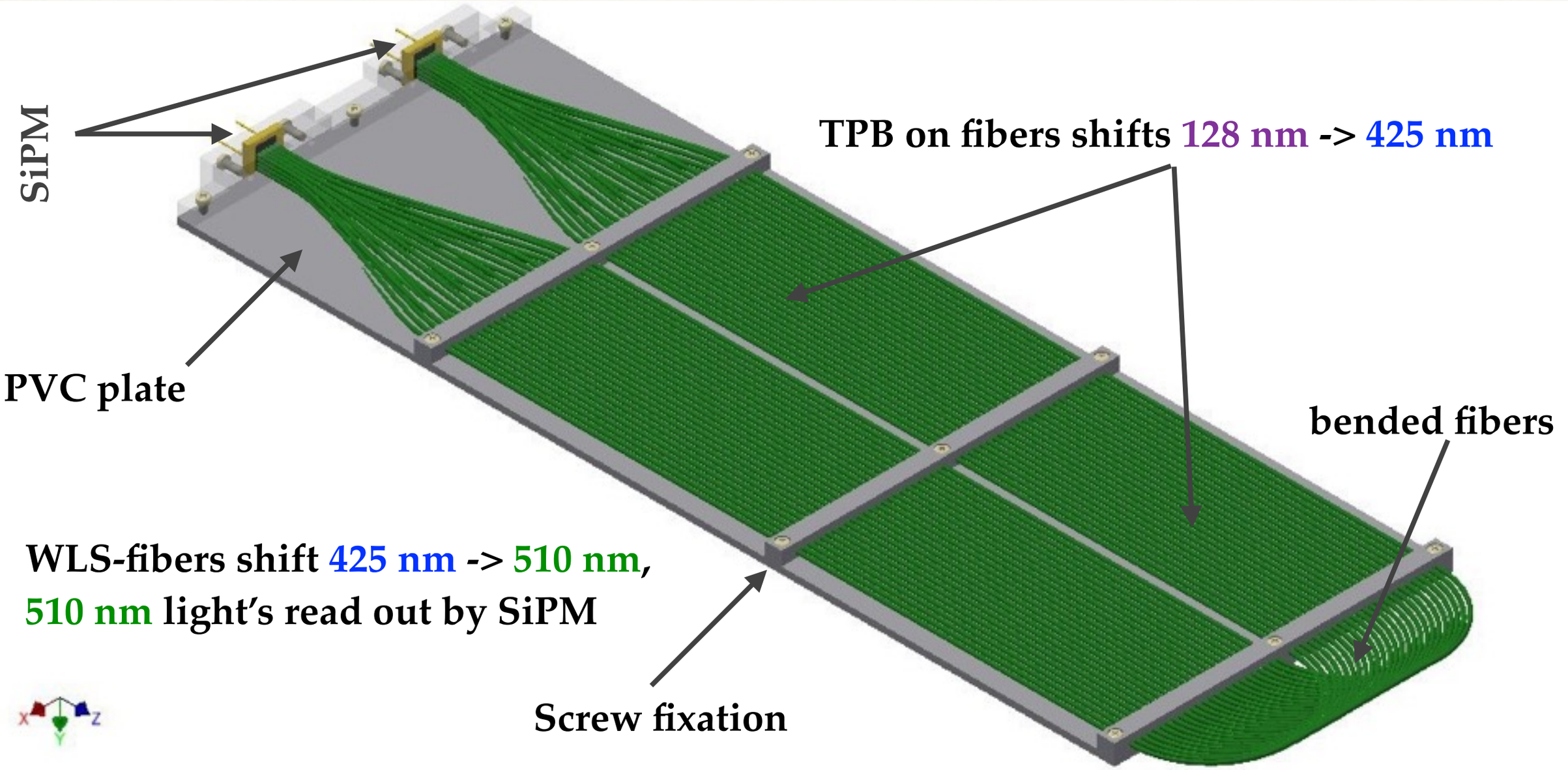
Results from Light Collection Module (LCM) tests

Alexandr Selyunin on behalf of JINR group

First design of Light Collection Module

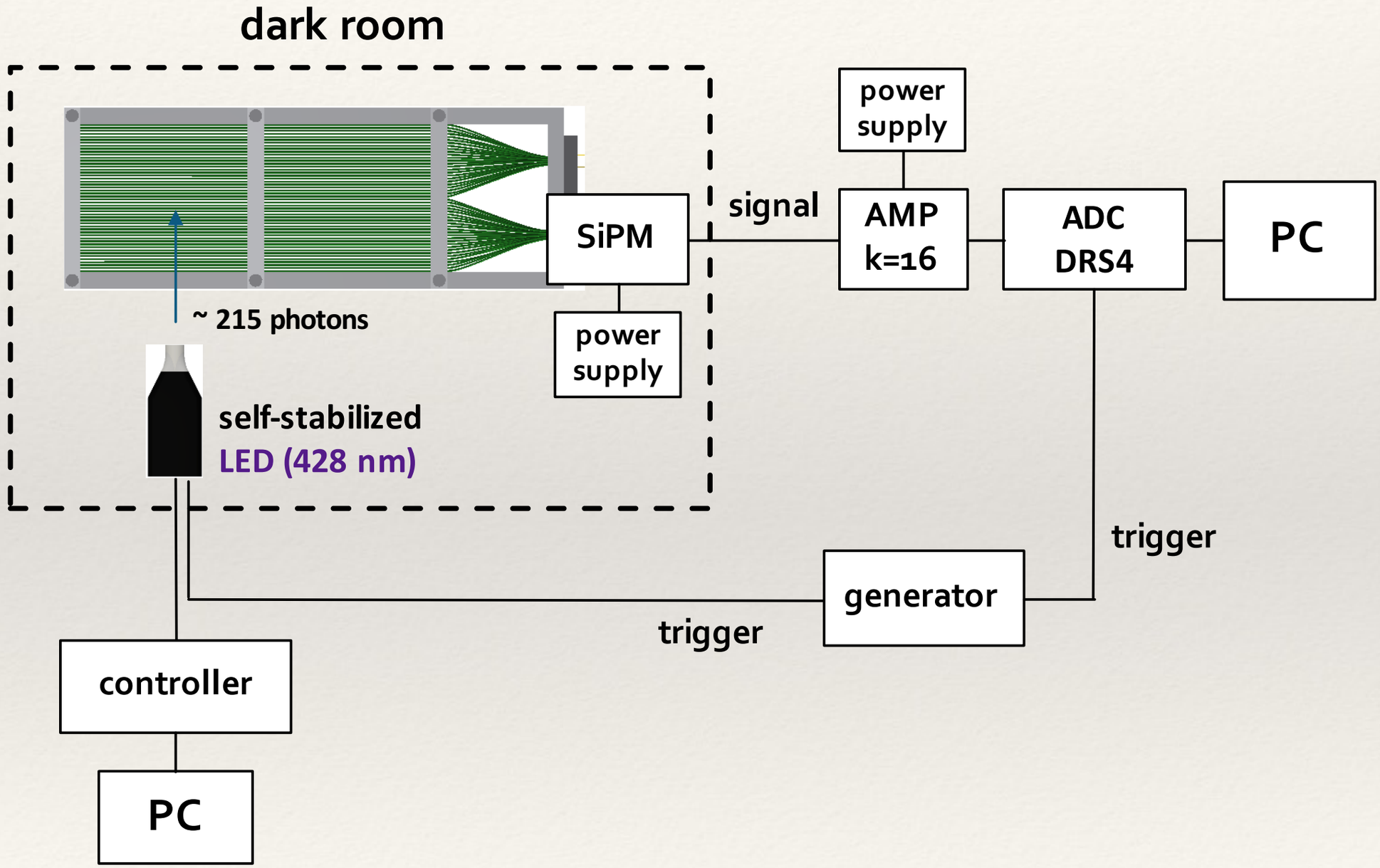


Slim design of Light Collection Module

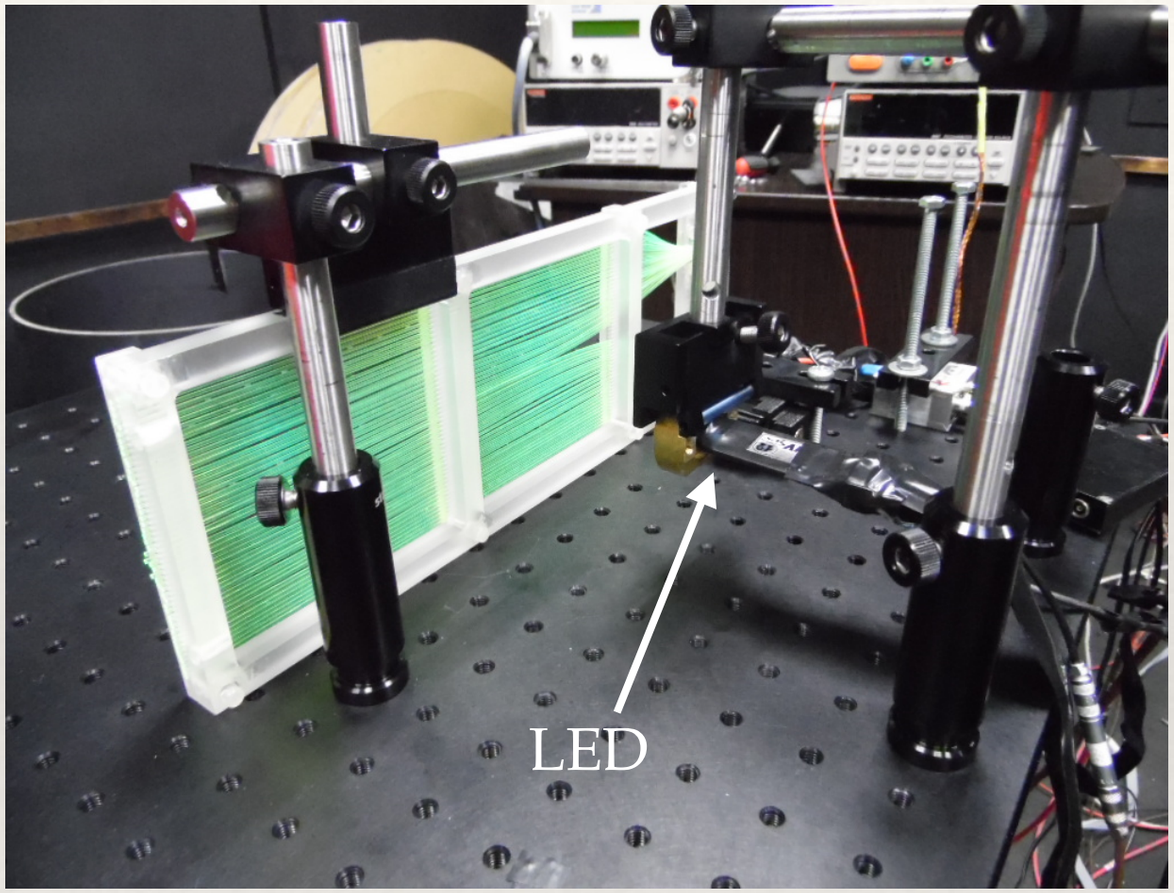


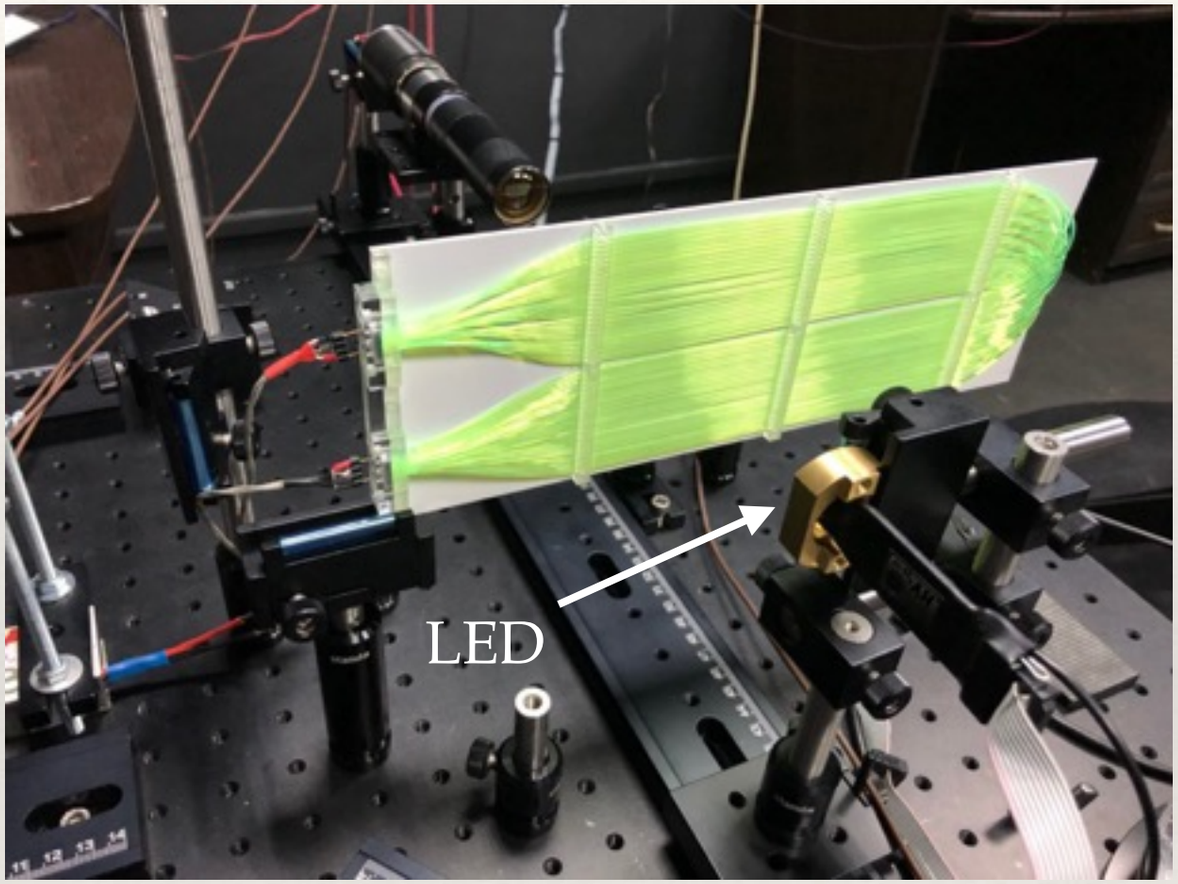
Same size as previous design - 30x10 cm
but thiner - 6-10 mm vs 15 mm

Test of LCMs with LED



Test of LCMs with LED

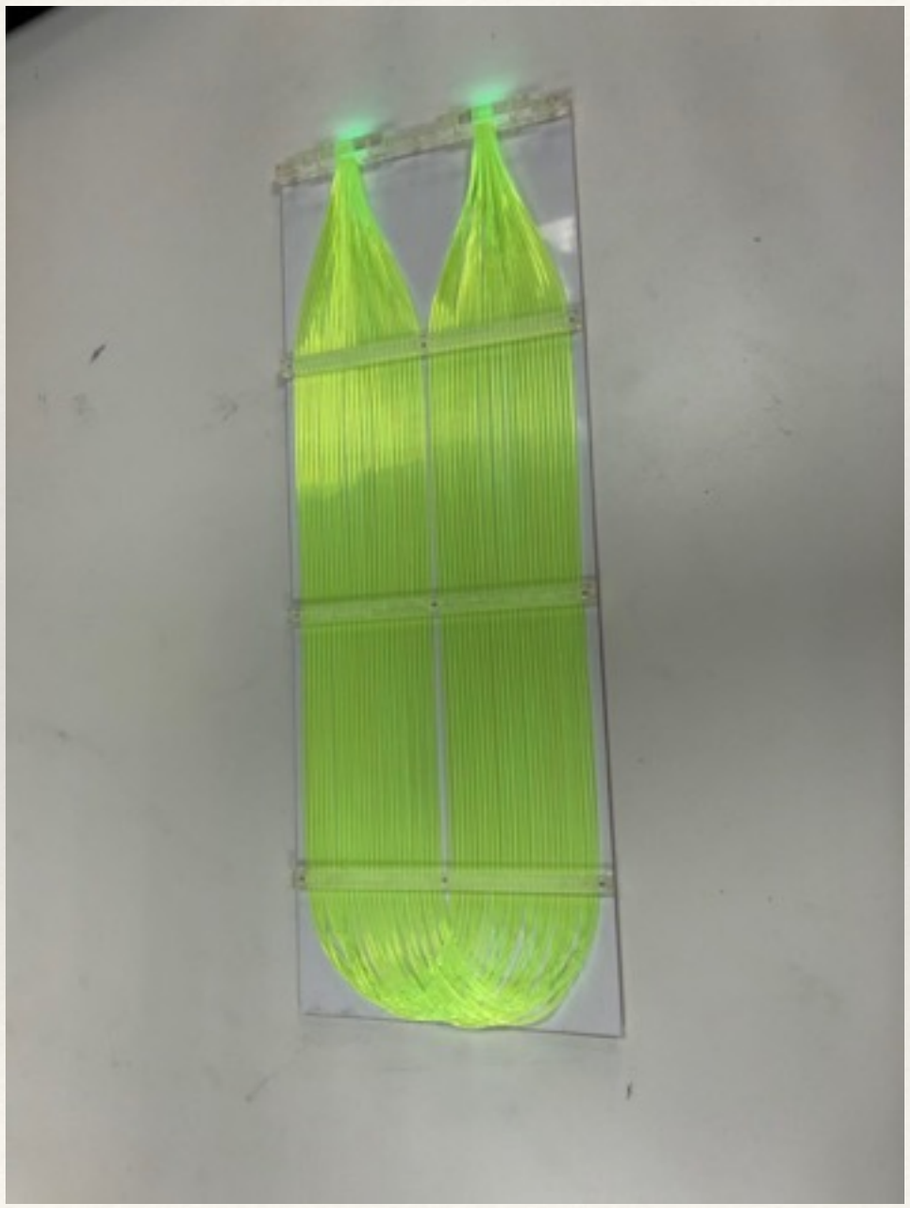




- **PDE for frame with PVC plate and mirrored faces is about 2 %**
- **Slim design PDE is about 3 %**
- **For both LCMs PDE_{SiPM} = 24 % (510 nm)**

Studies of slim LCM in LAr @ UniBe

Slim LCM was painted with TPB @ UniBe by means of airbrush



Before

After

Studies of slim LCM in LAr @ UniBe

Cryostat inner volume - cylinder 60x15 cm

SiPM calibration in LAr

integration gate = 120 ns

G_{pix} = **1.16** pC for both SiPMs,

G_{det} = Signal/mu,

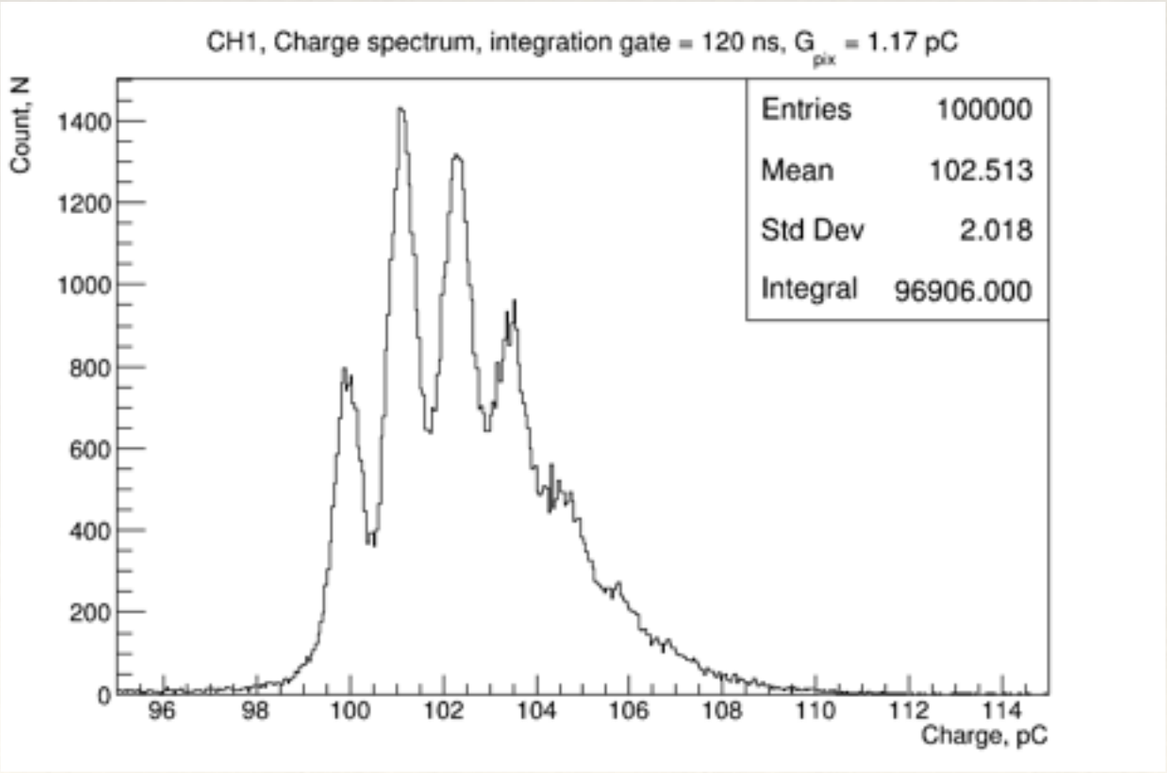
mu = - ln (P_0), from Poisson distribution of light,

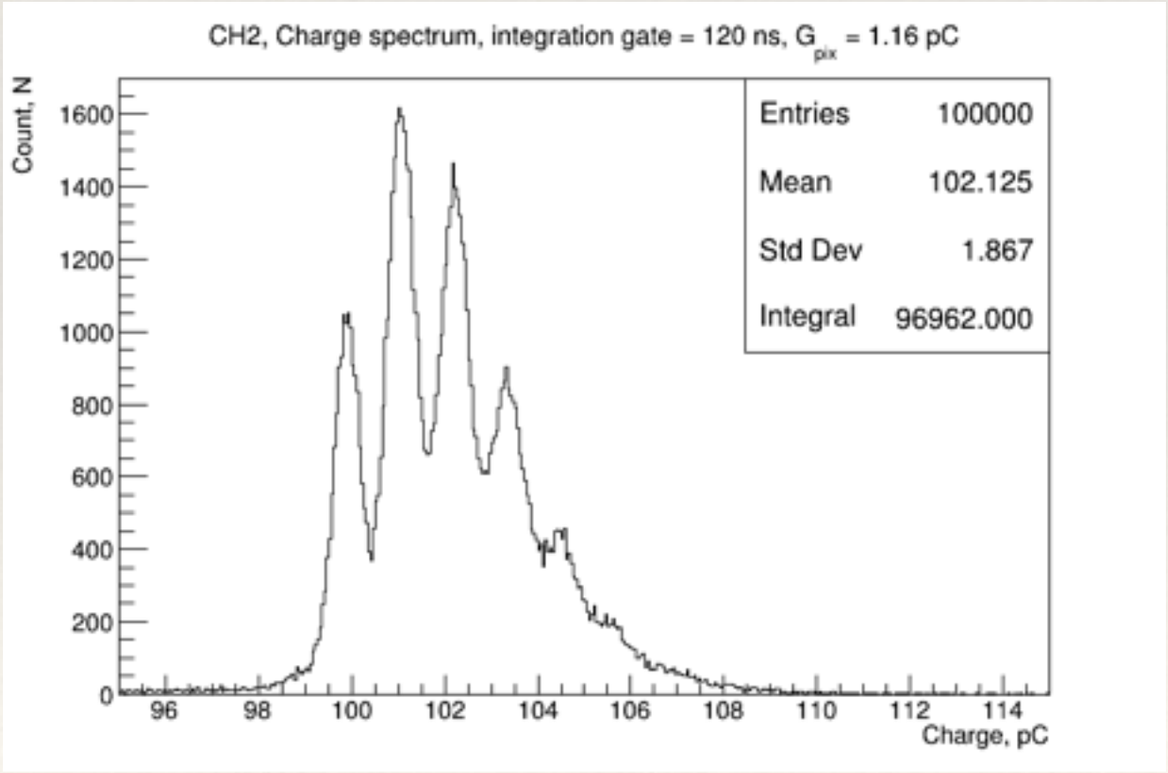
P_0 - probability of 0,

G_{det} = **1.45** pC

- U = 46 V, 11V less than@ room temp.
- LED as light source - 425 nm
- LAr conditions
- Amplifier for each channel - k = 16

$N_{cr} = G_{det}/G_{pix}$ = **1.25** - crosstalk factor





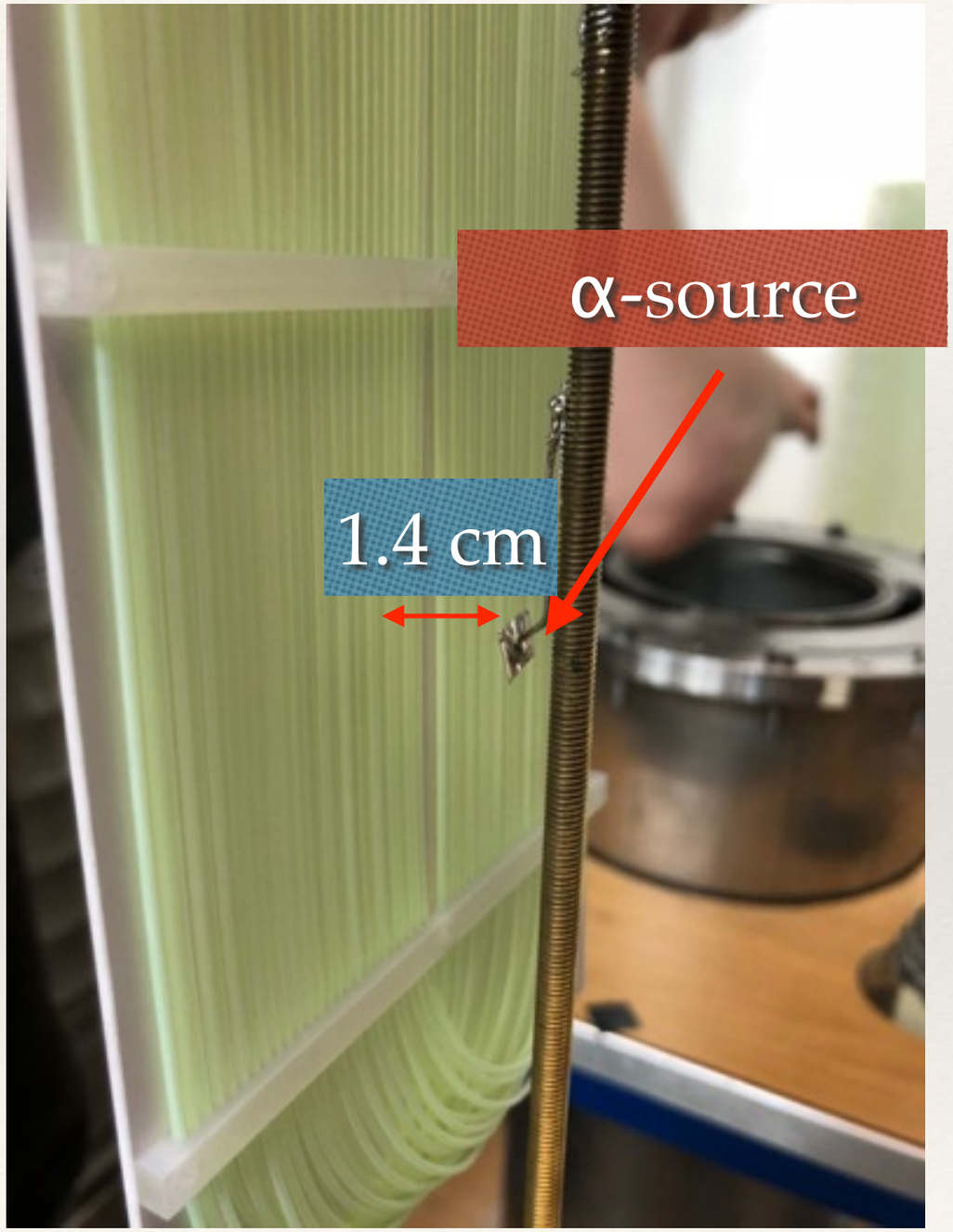
Quenching for α and e^-

Table 2
Reduction factors for α-particles and 1 MeV electrons, and photon yields for 1 MeV electrons

	Reduction factor		Photon yield for
	α-particles	1 MeV electrons	1 MeV electrons [ph/MeV]
Liquid Ar	0.71	0.78	4.0×10^4
Liquid Xe	0.75	0.62	4.2×10^4

Nuclear Instruments and Methods in Physics Research A291 (1990) 617-620

Studies of slim LCM with α–Am^{241}

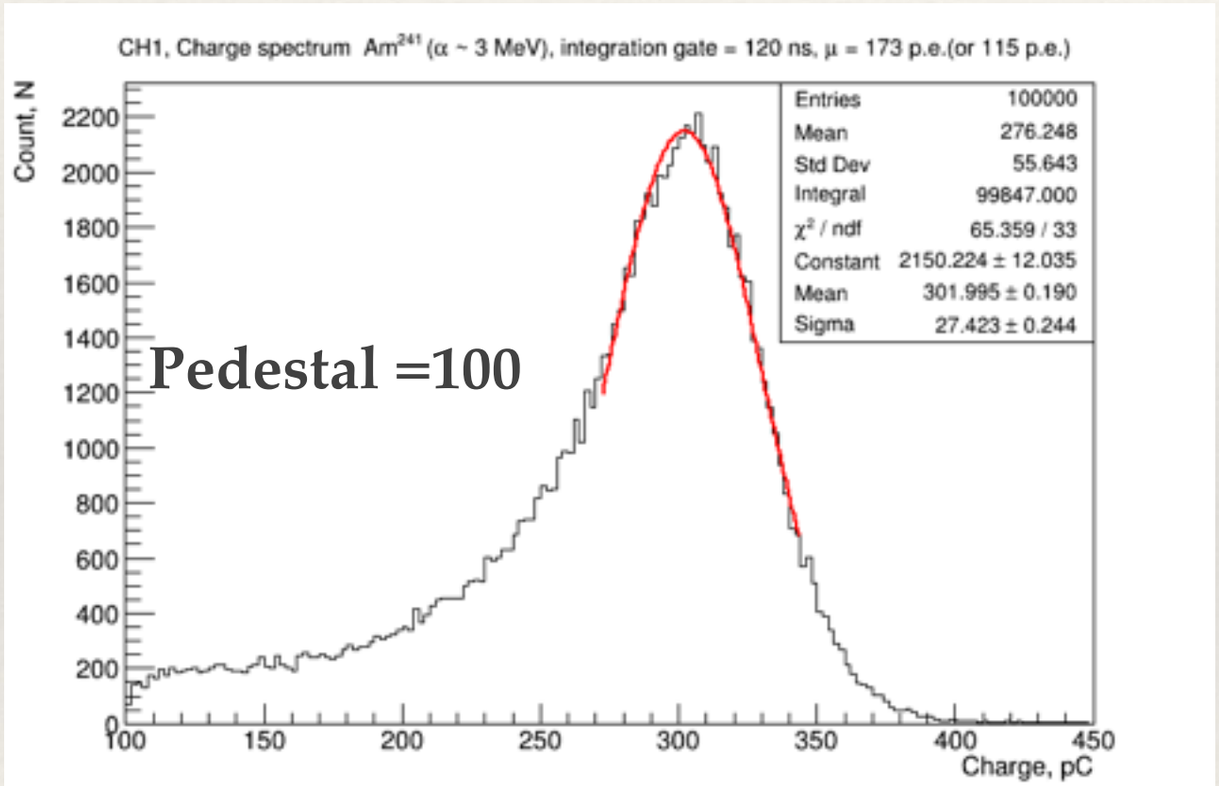


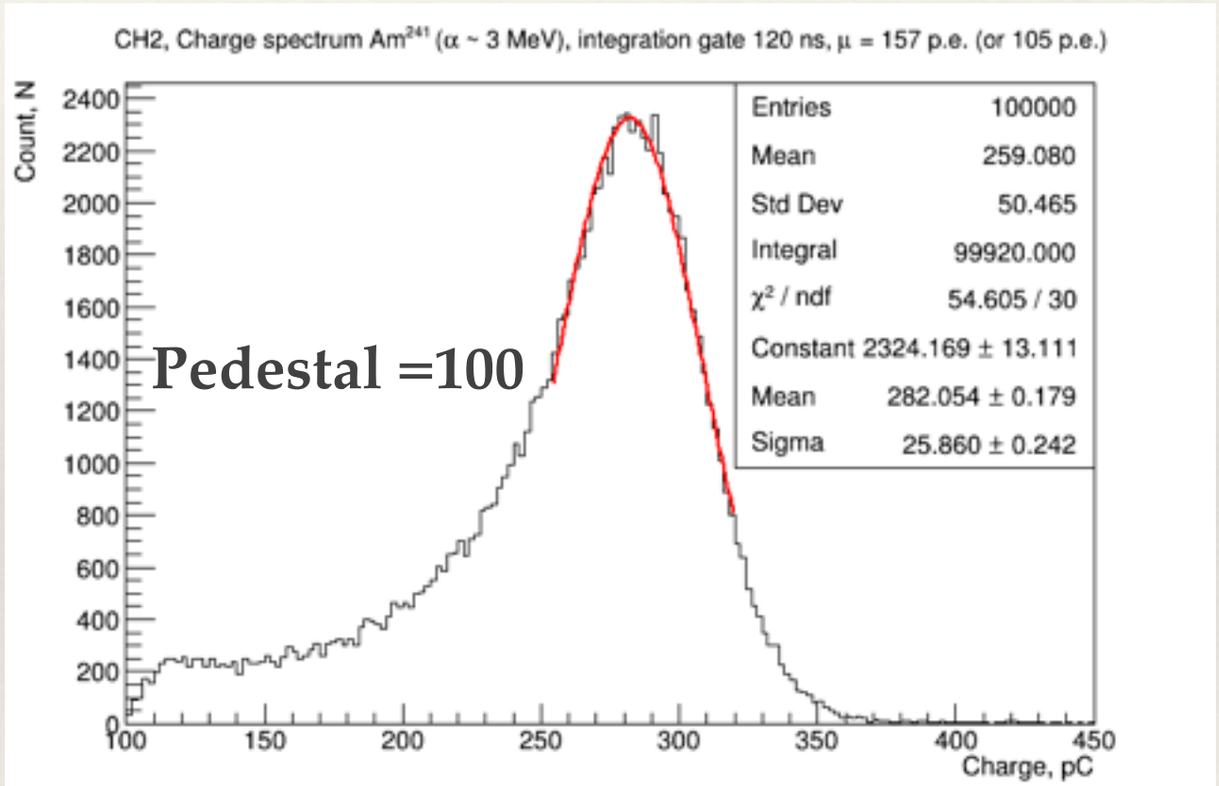
- α–source - rhodium film with Am^{241}
- Energy of α ~ 3 MeV because of film (covering?) (originally 5.4 MeV)
- LCM in LAr conditions
- 51300*0.71 = 36400 photons/MeV
- solid angle ~ 0.4 !!! Preliminary
- E_{tpb} = 1.3/2 = 0.65 - half of light goes to LCM
- if PDE_{LCM} = 3*0.65 = 2 %,

Expectation ~ 850 p.e. on LCM

Studies of slim LCM with α–Am^{241}

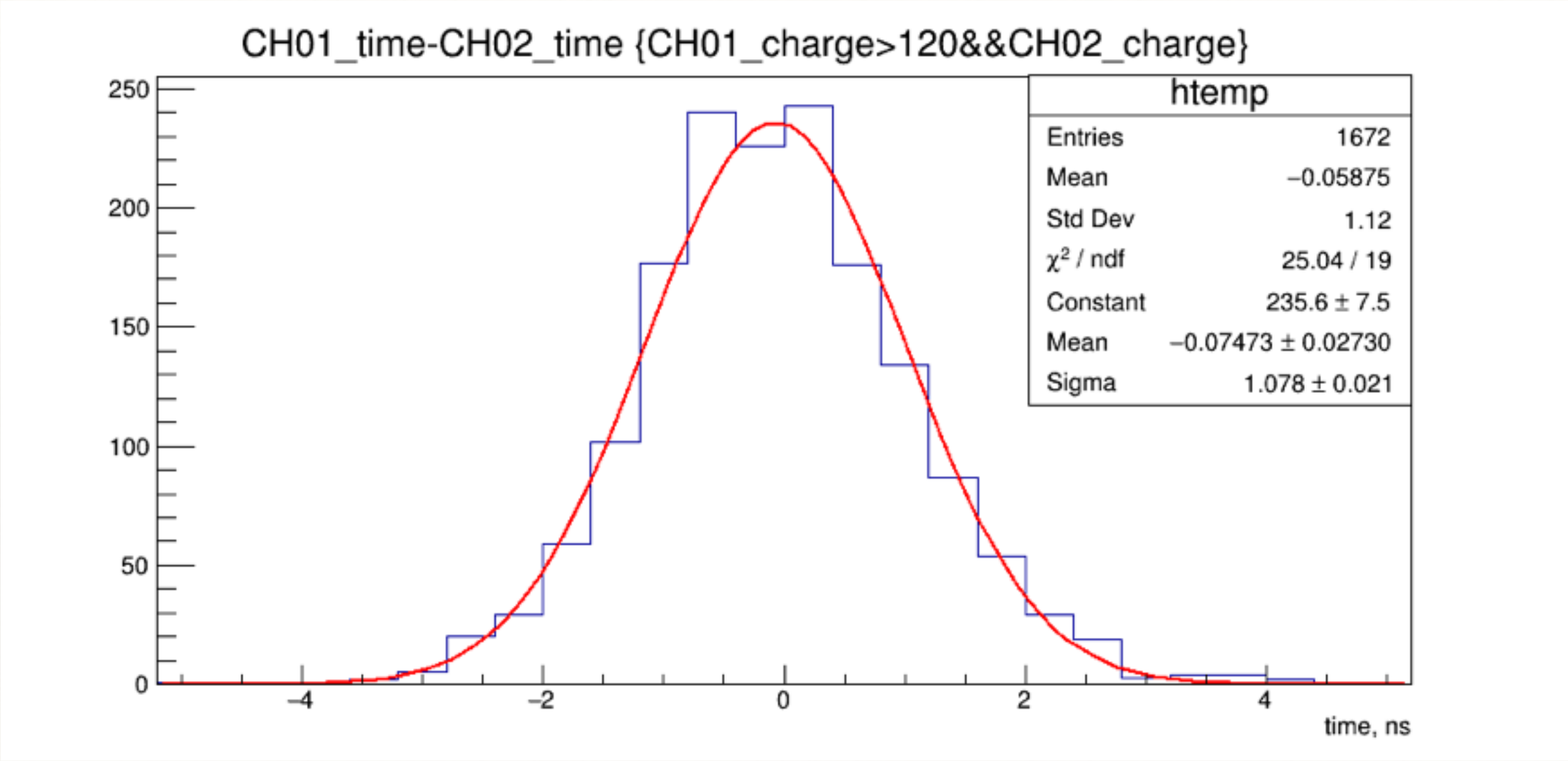
- **trigger - both channel in coincidence (threshold ~ 5 p.e. per ch)**
- **integration gate = 120 ns**
- **fast(~100ns)/total ratio = 0.7**





- **Total light collection - (201+182)/(1.45*0.7) = 380 p.e. ⟵??? expected ~ 850 p.e.**
- **Thus, PDE_{LCM} = 0.9 % ??? expected ~ 2 %**

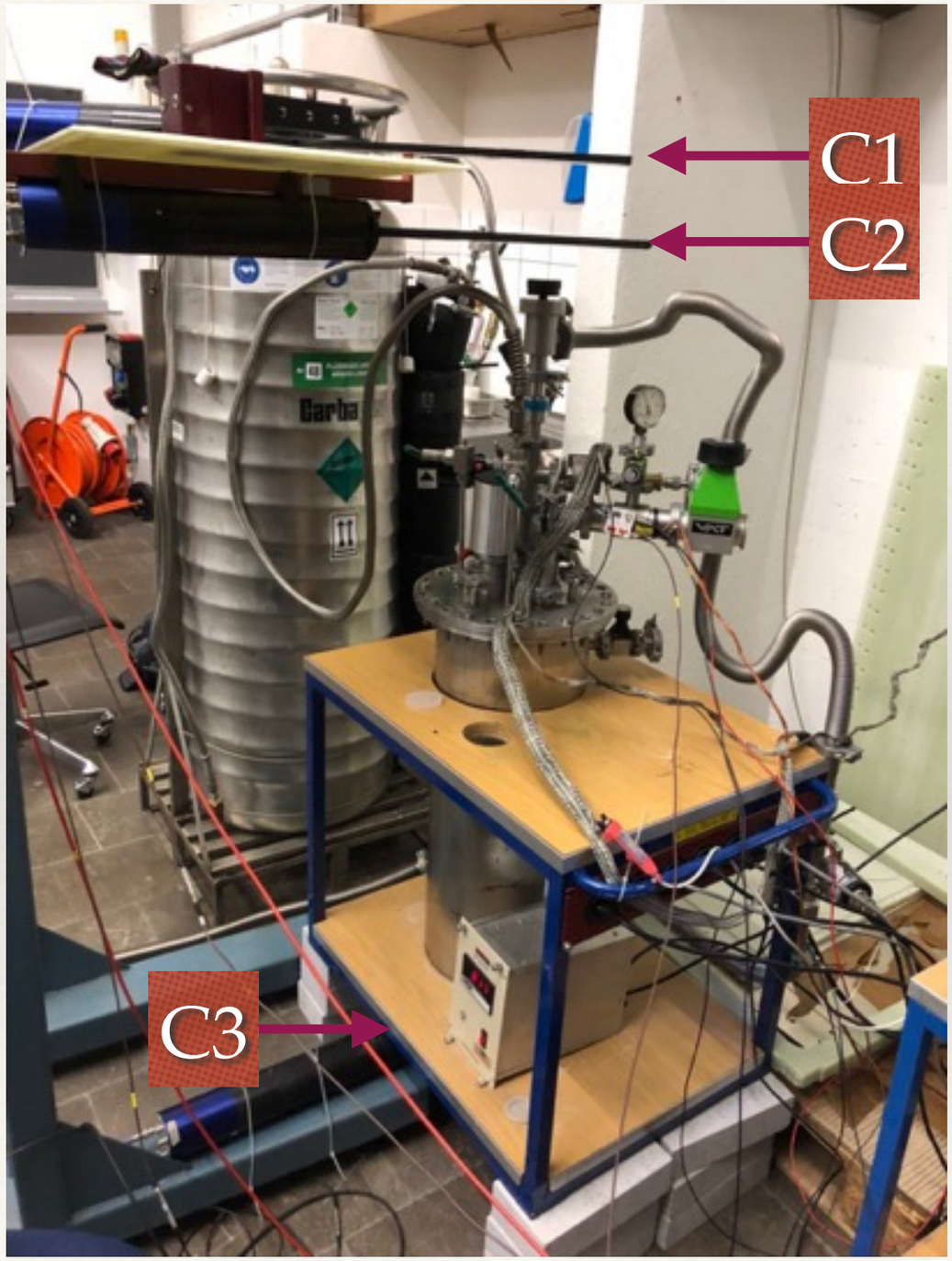
Studies of slim LCM with α–Am^{241}



time distribution with Am^{241} source between 2 SiPMs

Sigma is 1 ns

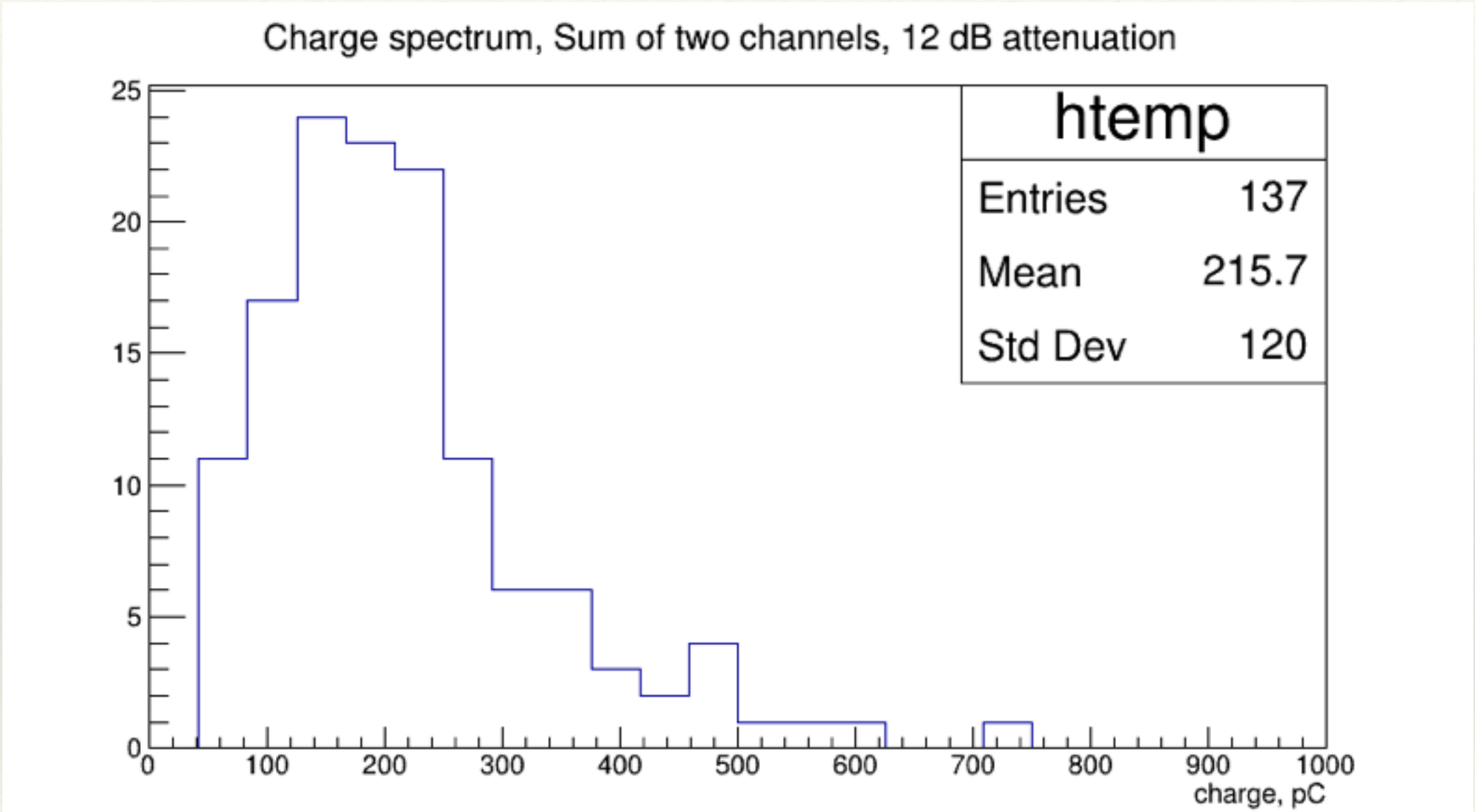
Studies of slim LCM with cosmic muons



- C1, C3 - counters 30x10 cm
- C2 - counter 40x10 cm
- trigger - all 3 in coincidence
- muon path in LAr ~ 40 cm
- 51300*0.78 = 40000 photons/MeV
- 2MeV/cm -> 80 MeV deposition in LAr
- E_{tpb} = 0.65, thus, PDE_{LCM} = 3*0.65 = 2 %,
- fast(~100ns)/total ratio - 0.3
- Solid angle = 1/10 !!! **Very Preliminary**
- Geometrical factor = 0.75
- Expectation ~ **1450 p.e.** on LCM

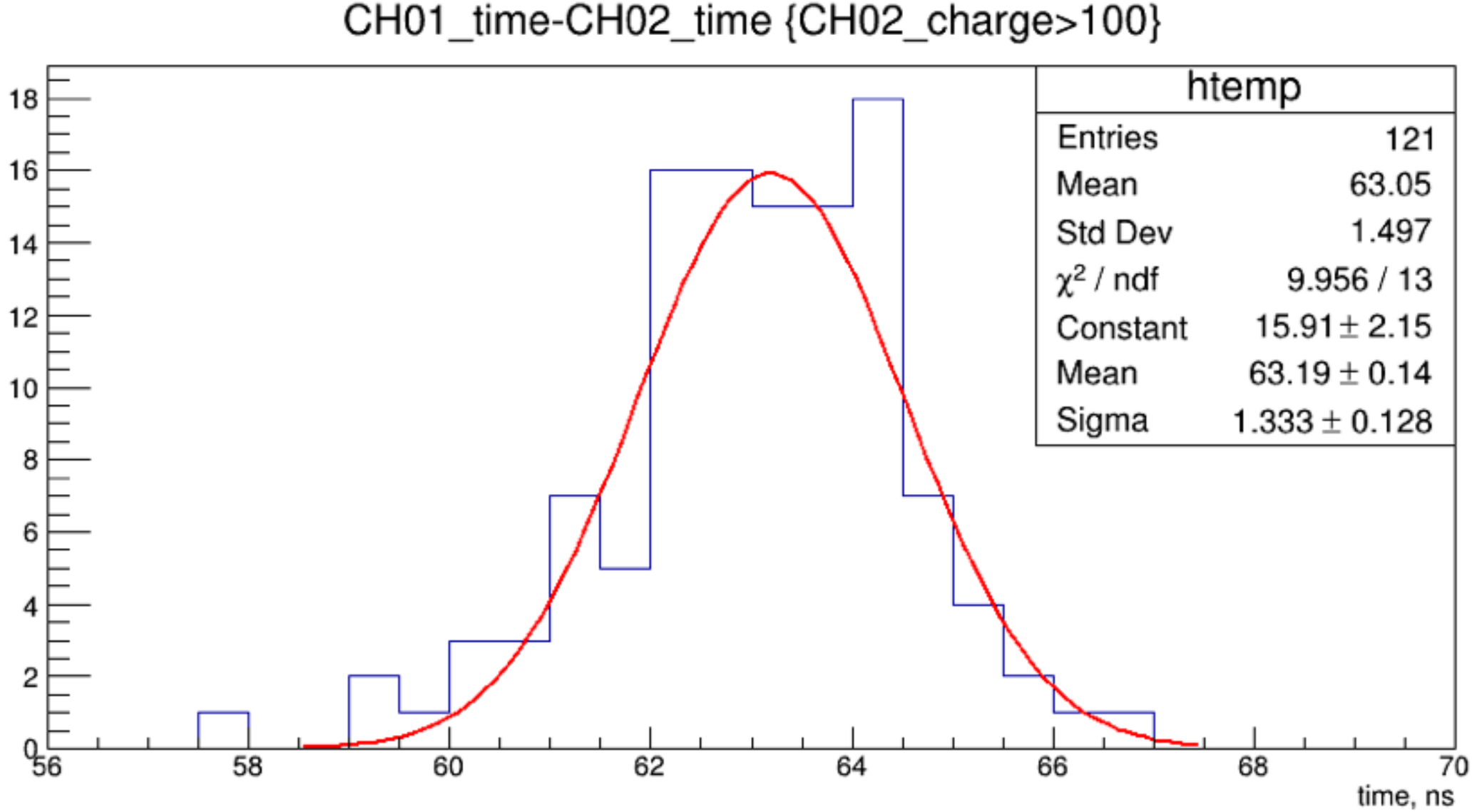
Studies of slim LCM with cosmic muons

- integration gate = 120 ns
- Signal from 2 SiPMs was summed with linear FAN IN



- Total light collection - 215/1.45 = 590 p.e. ??? expected ~ 1450 p.e.
- Thus, PDE_{LCM} = 0.8 % ??? expected ~ 2 % but close to result with α (0.9 %)

Studies of slim LCM with cosmic muons

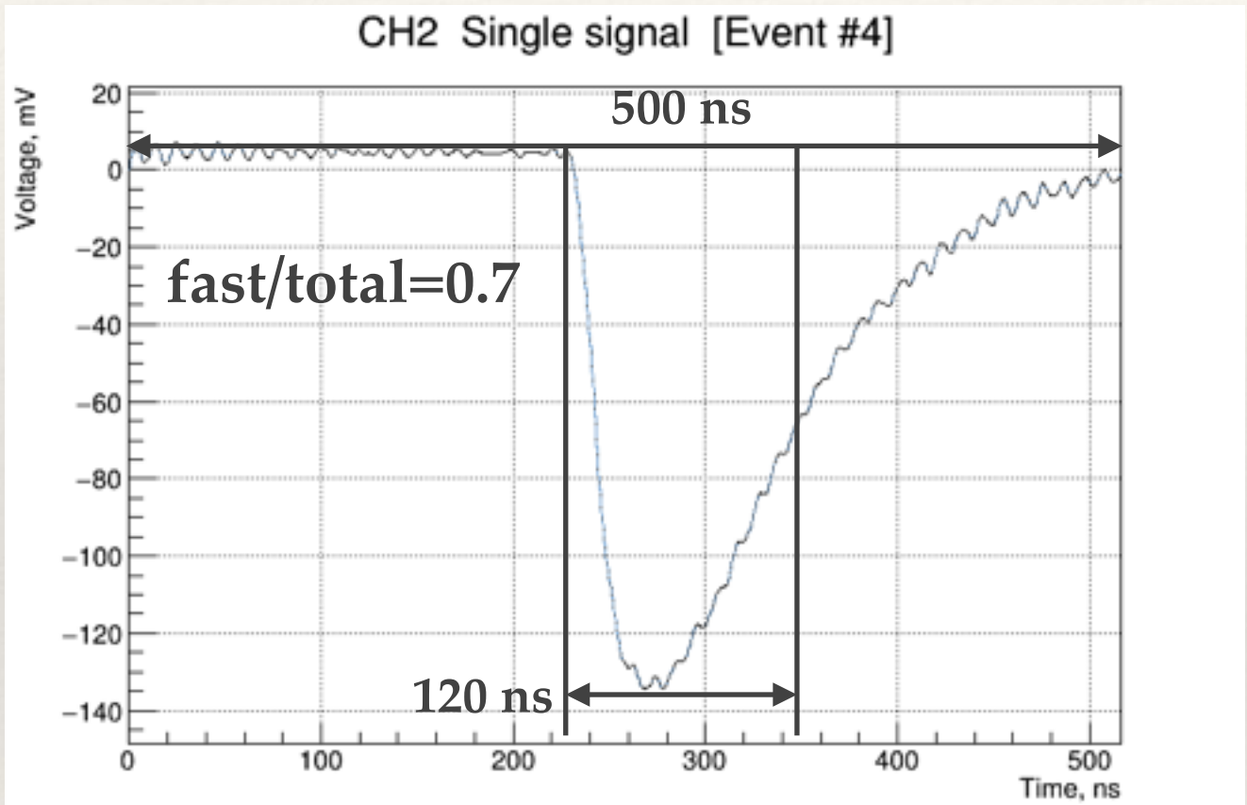


time distribution with muons between trigger and sum of 2 SiPM signal

Sigma is 1.3 - 1.5 ns (Jitter of Trigger is unknown!)

Signal shape

typical signal with α

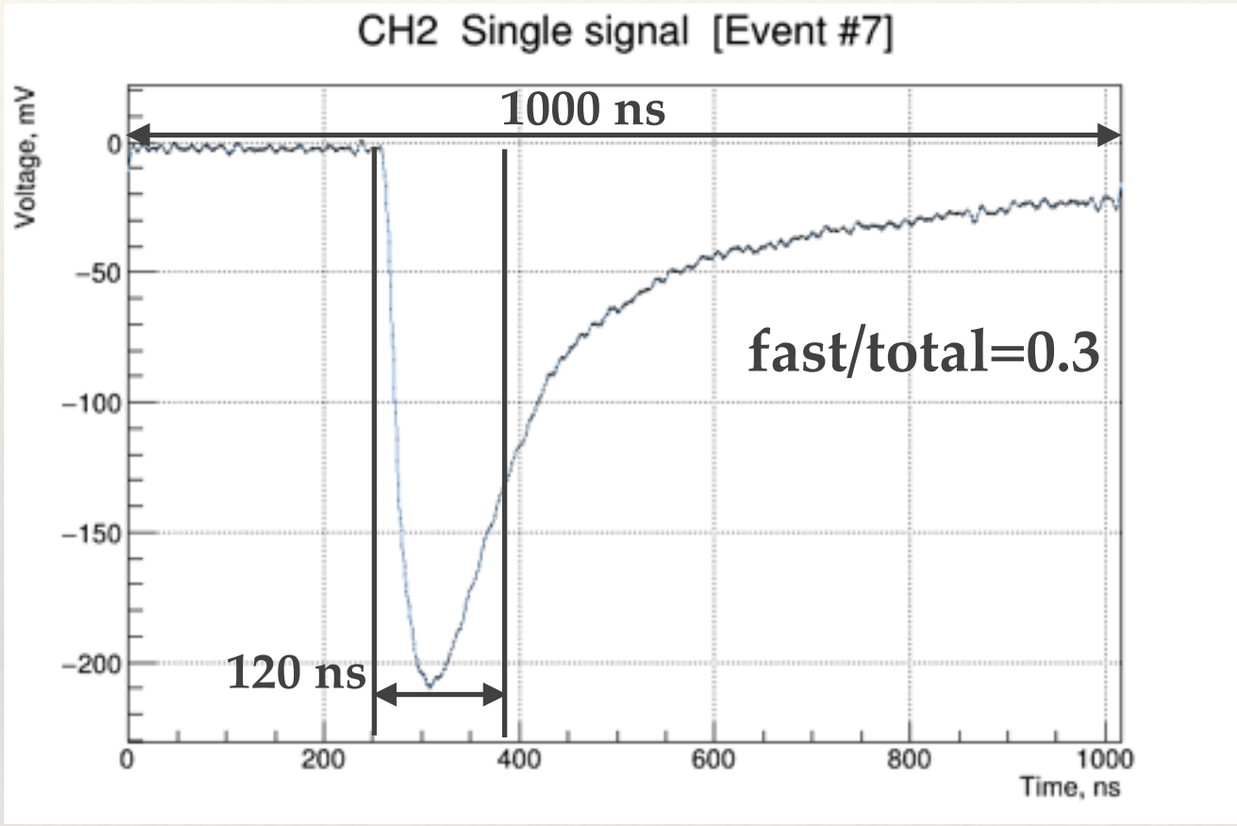


Rise time ~ 22 ns (0.1-0.9 level)

Fall time ~ 190 ns (0.9-0.1 level)

Width ~ 260 ns (0.1-0.1 level)

typical signal with muons

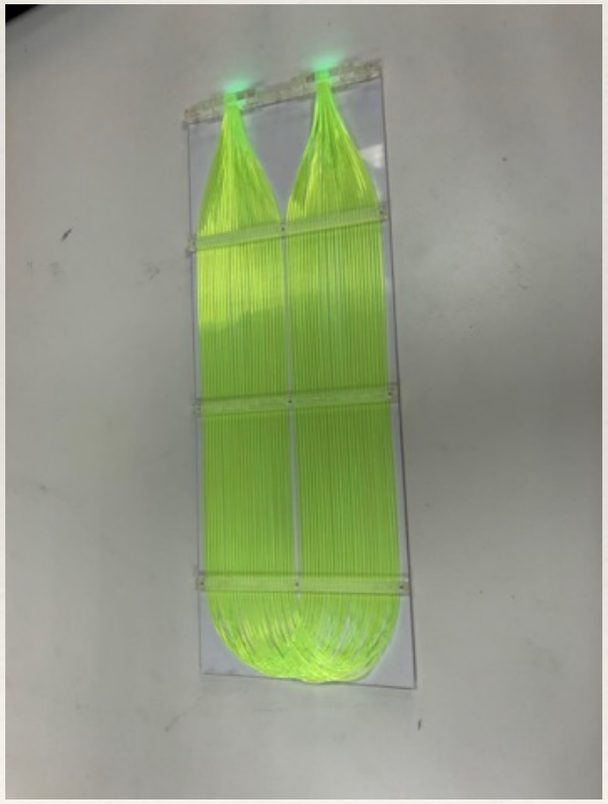


Rise time ~ 25 ns (0.1-0.9 level)

Very long tail

Possible reasons of low PDE_{LCM}

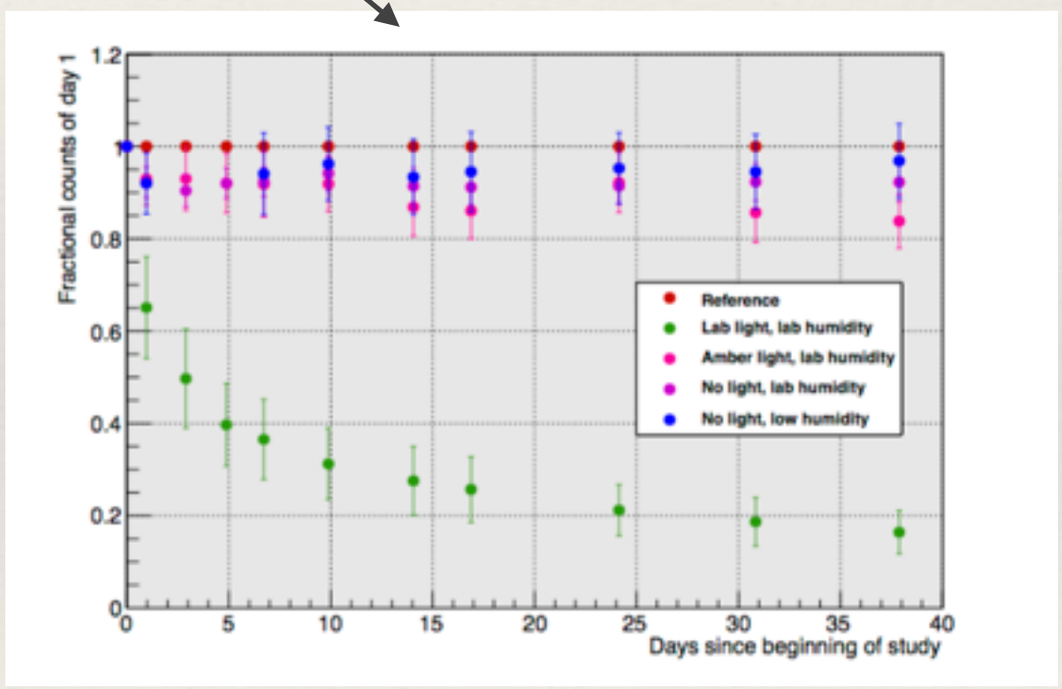
- **Diffusive light reflection by TPB layer on WLS-fibers**
- **TPB degradation due to exposure by ambient light in the Lab**
- **Low light yield in LAr (lowly likely)**



Before

After

first day ~ 40% drop!!!



LCM was exposed by Lab light about 1.5 - 2 days !!!!!

https://arxiv.org/pdf/1204.5762.pdf

Conclusion and plans

- **First result in LAr was obtained (last week of May)**
- **Obtained preliminary results twice less than expected PDE_{LCM} 0.9 instead of 2 %**
- **MC simulation needed for precise evaluation and confirmation of obtained results (precise, but not significant)**
- **We are planning to repeat LED tests of slim LCM with TPB in our Lab to verify assumption of light reflection in TPB layer**
- **Set up UV-tests @ Dubna: Mercury or Deuterium lamp with monochromator (200 - 250 nm), UV PMT, correction of TPB efficiency.**
- **We will try to measure the light output dependence from TPB layer thickness with UV light**

Many thanks to UniBe for providing LAr tests

Thank you for attention!

Questions?