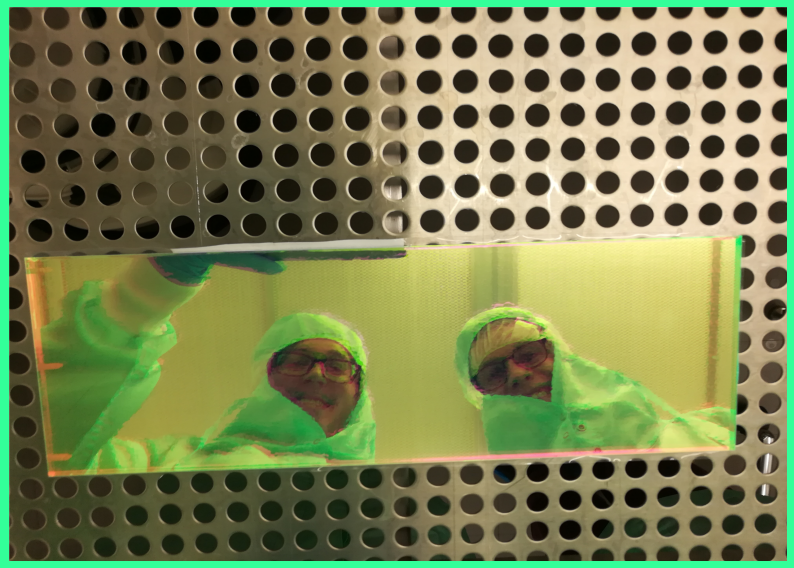
ArgonCube

ArCLight

Large area photon detector for LAR TPC



Collaboration meeting
Bern, 13.06.18

Igor Kreslo
AEC/LHEP University of Bern

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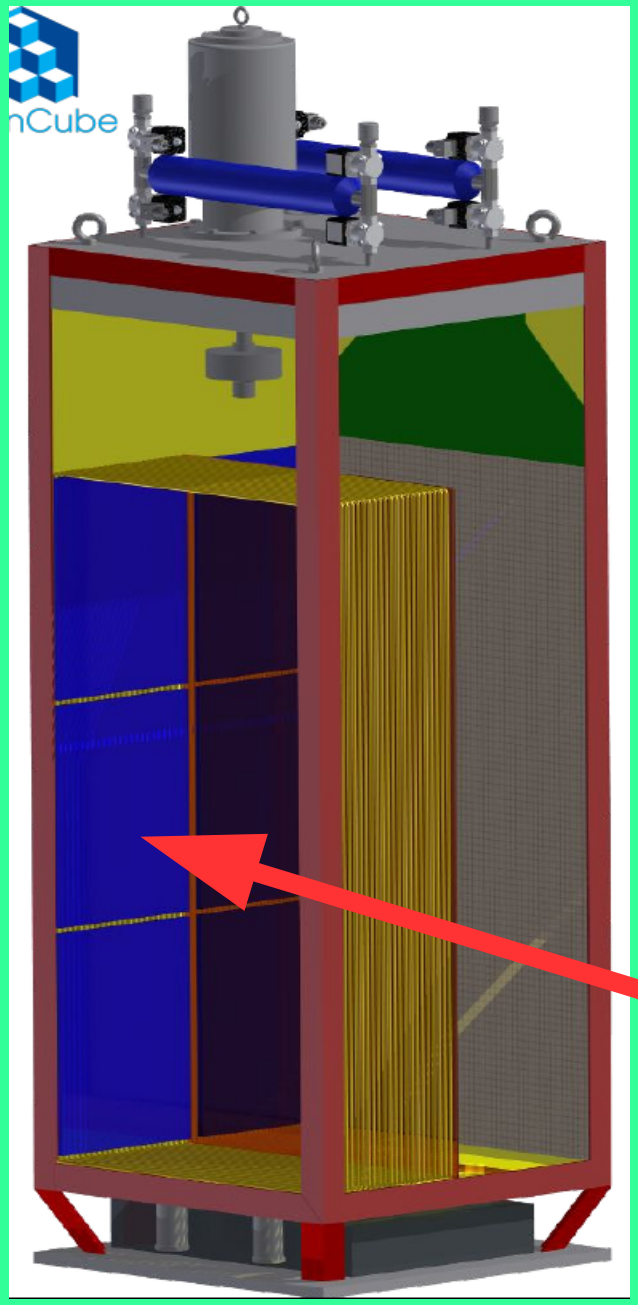
UNIVERSITÄT BERN

AEC
ALBERT EINSTEIN CENTER
FOR FUNDAMENTAL PHYSICS

ARGONCUBE module



Module: an independent TPC

- LAr purification: recirculation through Oxygen-traps
- Temperature: individual cryo-cooler unit
(removes heat input from electronics and heat leaks)

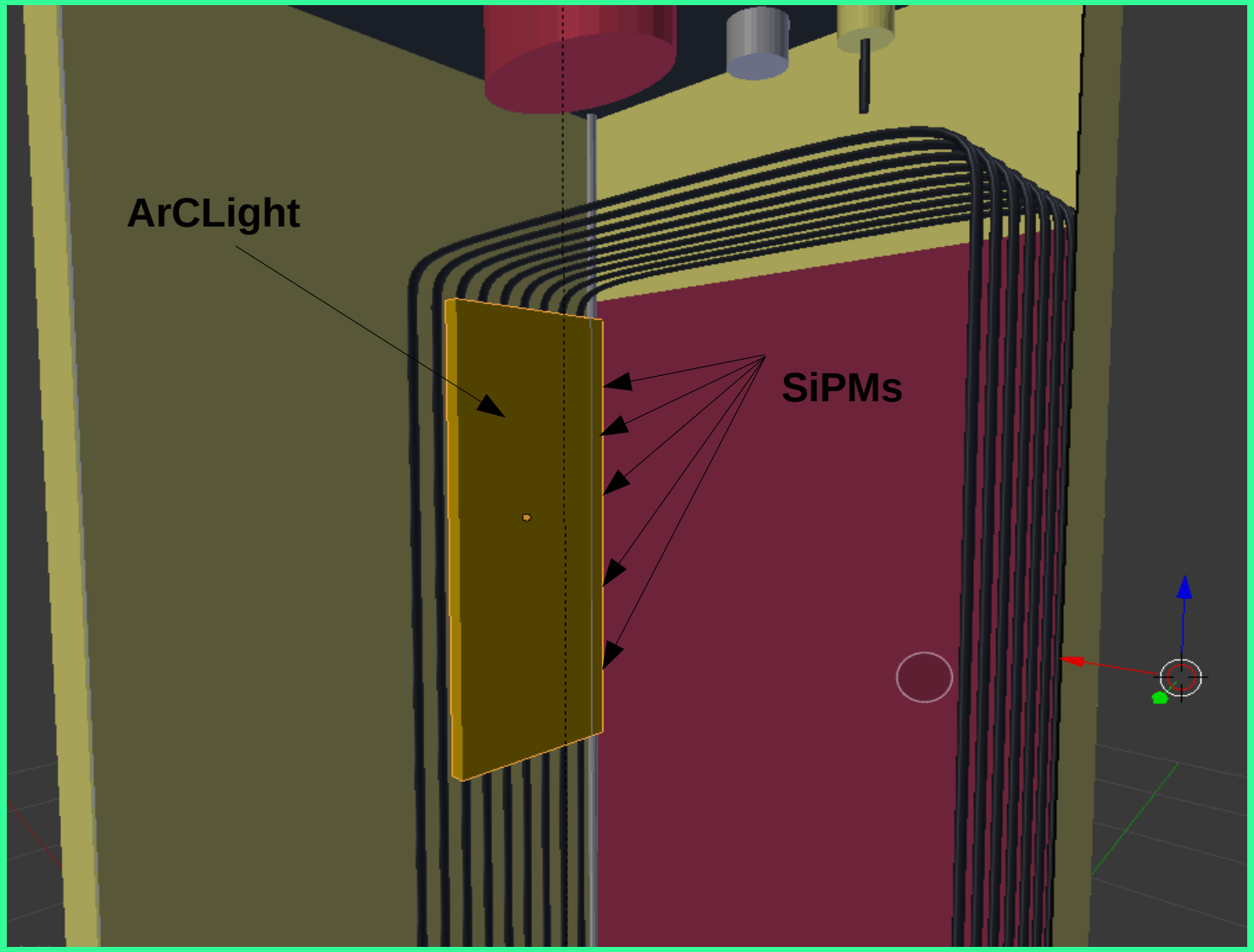
- Cathode bias (-100 kV) supplied via HV feed-through
- Resistive divider for field shaper
- Relatively low voltage => breakdown-free setup
- Electrically transparent container => low dead volume

- PCB-technology for R/O plane manufacturing
- Pad arrays for charge readout, *e.g.* 4x4 mm^2 pads
- 8x8 pads ROI served by one R/O ASIC at the PCB back
- Mechanically robust production technology
- Low failure cost

- Light collection via WLS light guides
- Light readout with SiPMs in coincidence

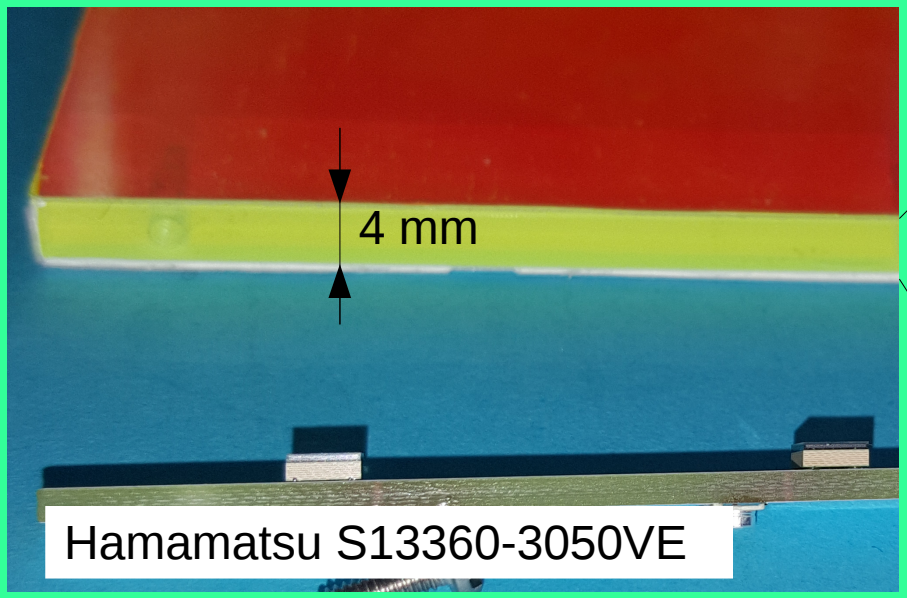
Reliable/repairable self-contained unit

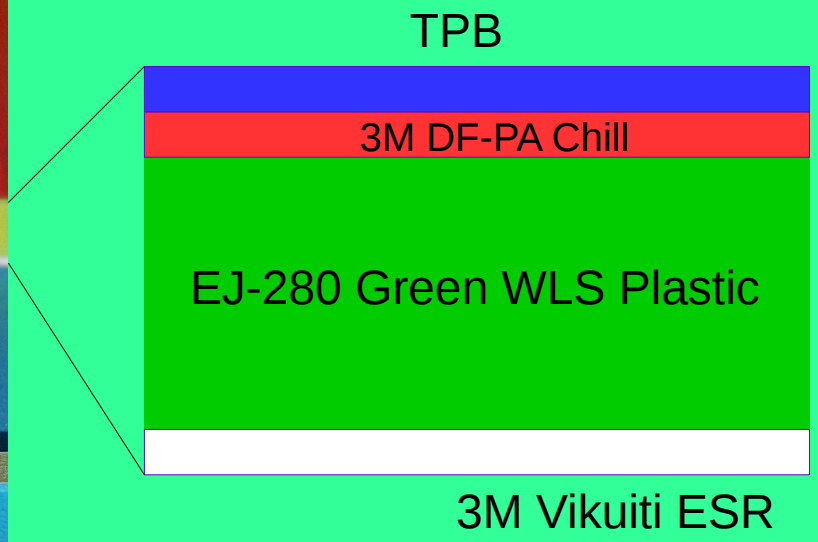
ArCLight in ArgonCUBE

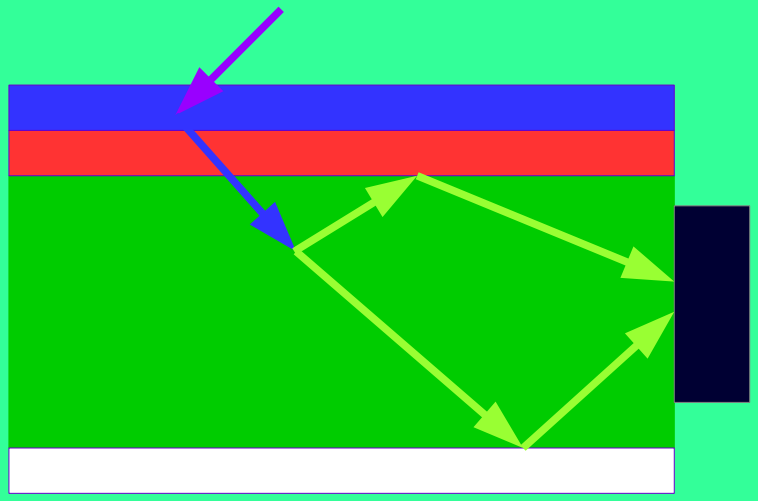


ArCLight - large area photon sensor

Inspired by Arapuca design







Self-supporting

SiPM can be placed at one edge only

No frame — no deformations in cold

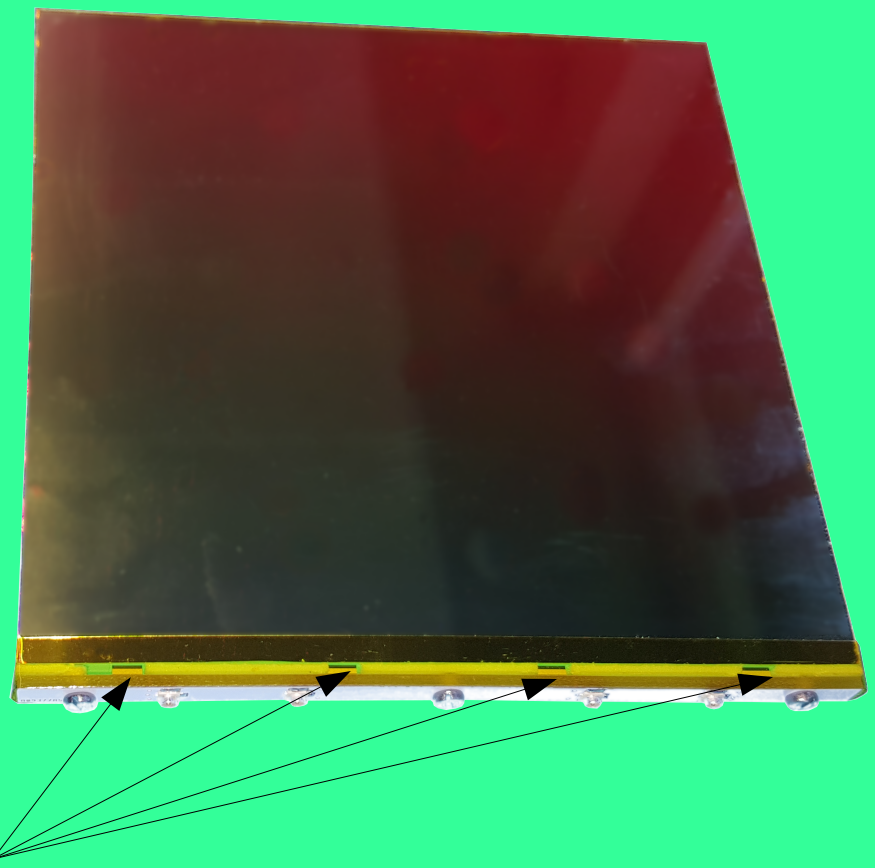
Can be placed in high field region

(parallel to the the drift)

Instruments 2018, 2(1), 3; doi:10.3390/instruments2010003
http://arxiv.org/abs/1711.11409

ArCLight 10x10 cm prototype

No TPB yet

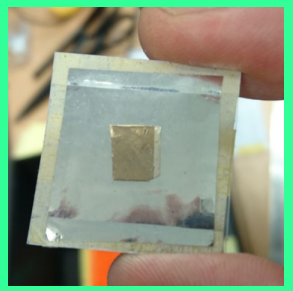


Light Sources:

1. Calibrated blue LED (430 nm)

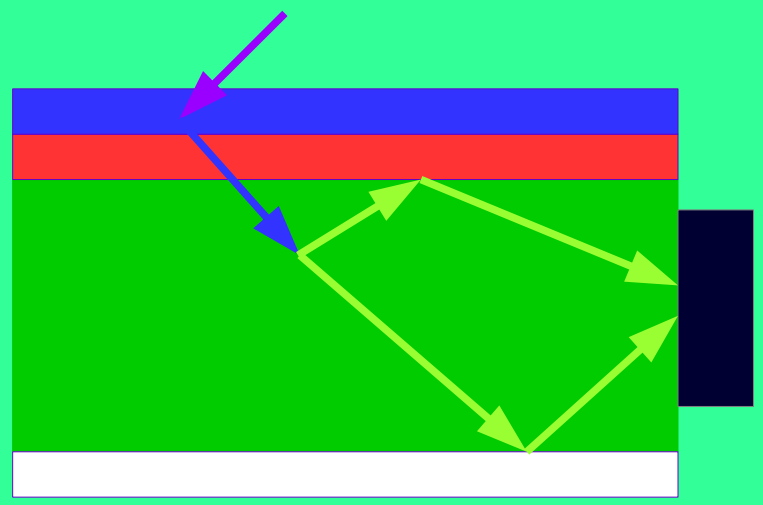
2. ^{241}Am+NE102 (425 nm)

Intensity O(1000) photons/pulse



SiPMs
R/O electronics: Bern FEB (32-ch SiPM signal processor)

Photon Detection Efficiency



E. Segreto 2012 JINST 7 P05008 :

$$\epsilon_{coll} = \frac{f}{1-\langle R_{490}\rangle(1-f)} = 0.077$$

TPB conv. efficiency ε_{tpb} = 1.2

Dichroic transparency for blue T_{430} = 0.87

EJ-280 conv. efficiency ε_{WLS} = 0.86

Dichroic reflectance for green R_{490} = 0.98

ESR reflectance for green R_{490} = 0.98

Total surface area S_{tot} = 216 cm^2

SiPM covered S_{det} =0.36 cm^2

$f = S_{det} / S_{tot}$ = 0.0017

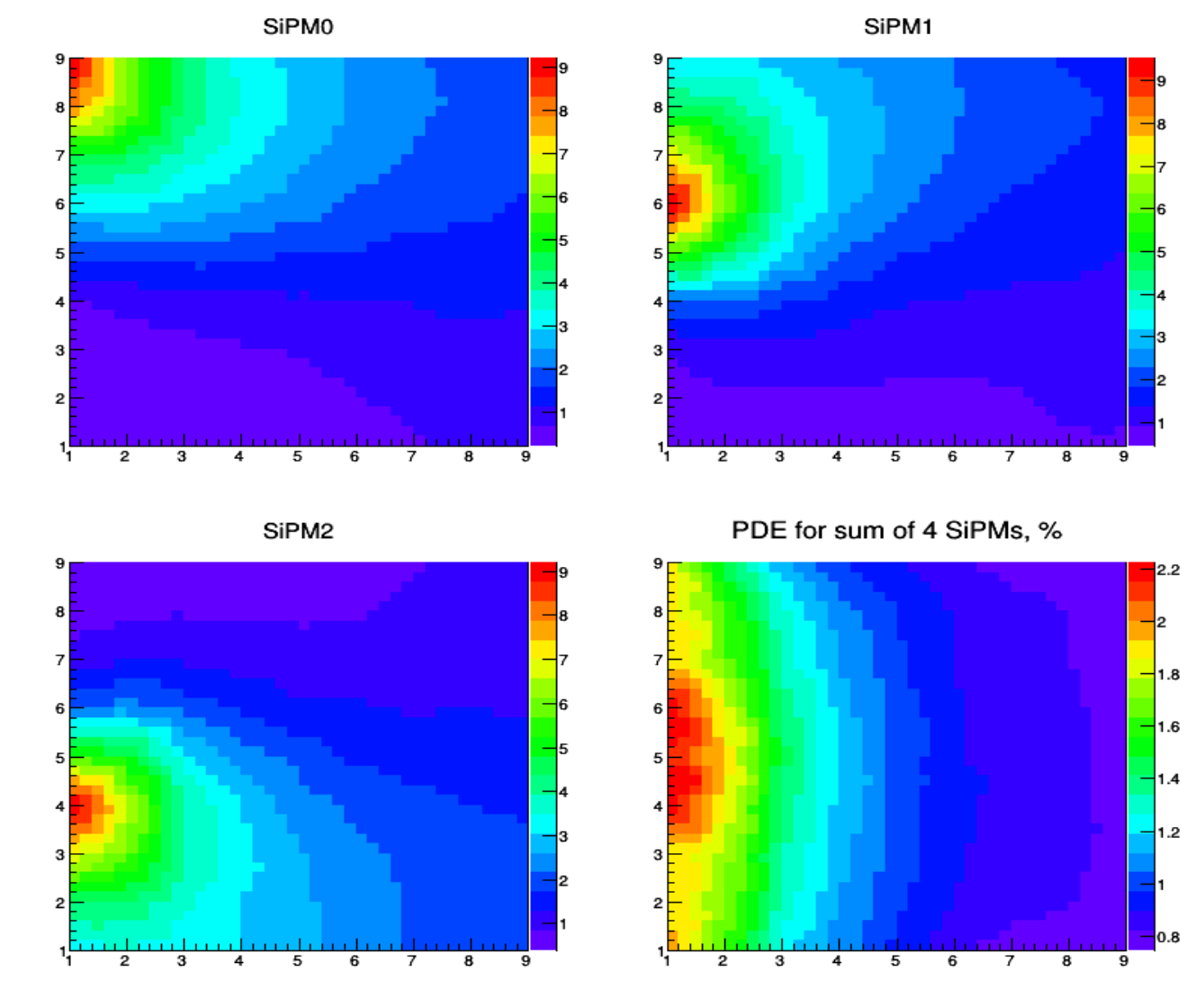
Absorbsion is neglected! (λ ~ meters)

Putting it all together:

$$PDE = \epsilon_{tpb} \cdot 1/2 \cdot T_{430} \cdot \epsilon_{WLS} \cdot \epsilon_{SA} \cdot \epsilon_{SiPM} = 0.01$$

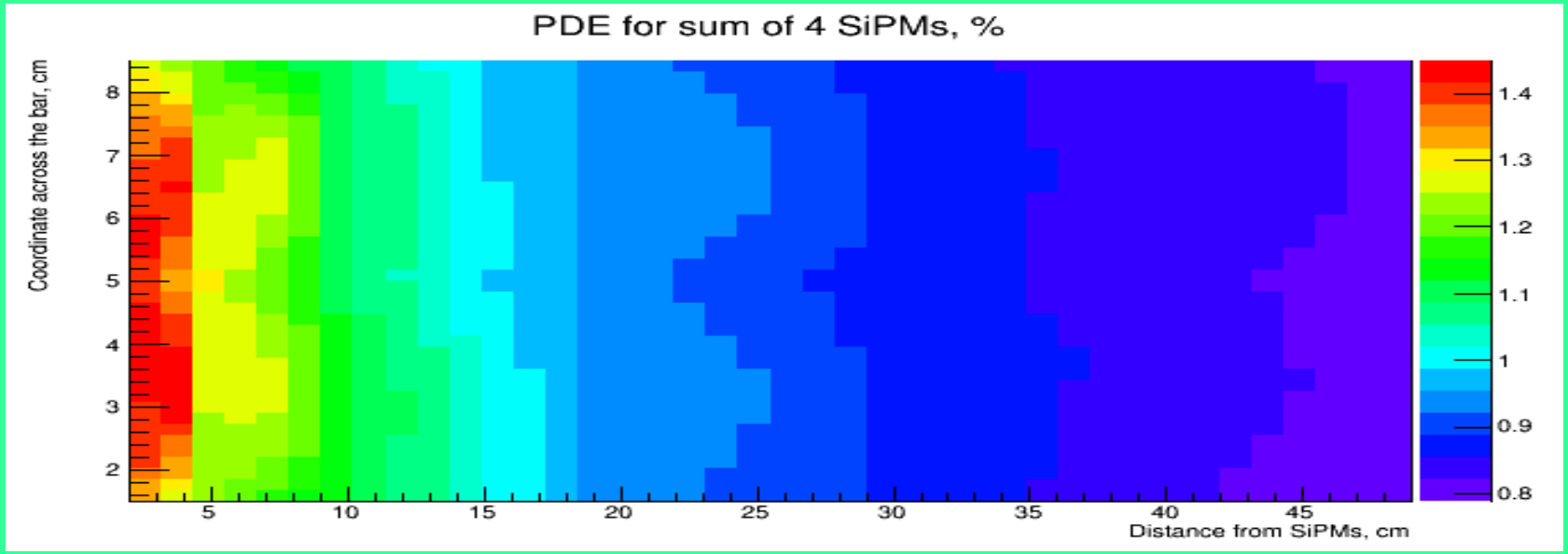
ArCLight 10x10 cm prototype

No TPB yet, expected PDE=1%

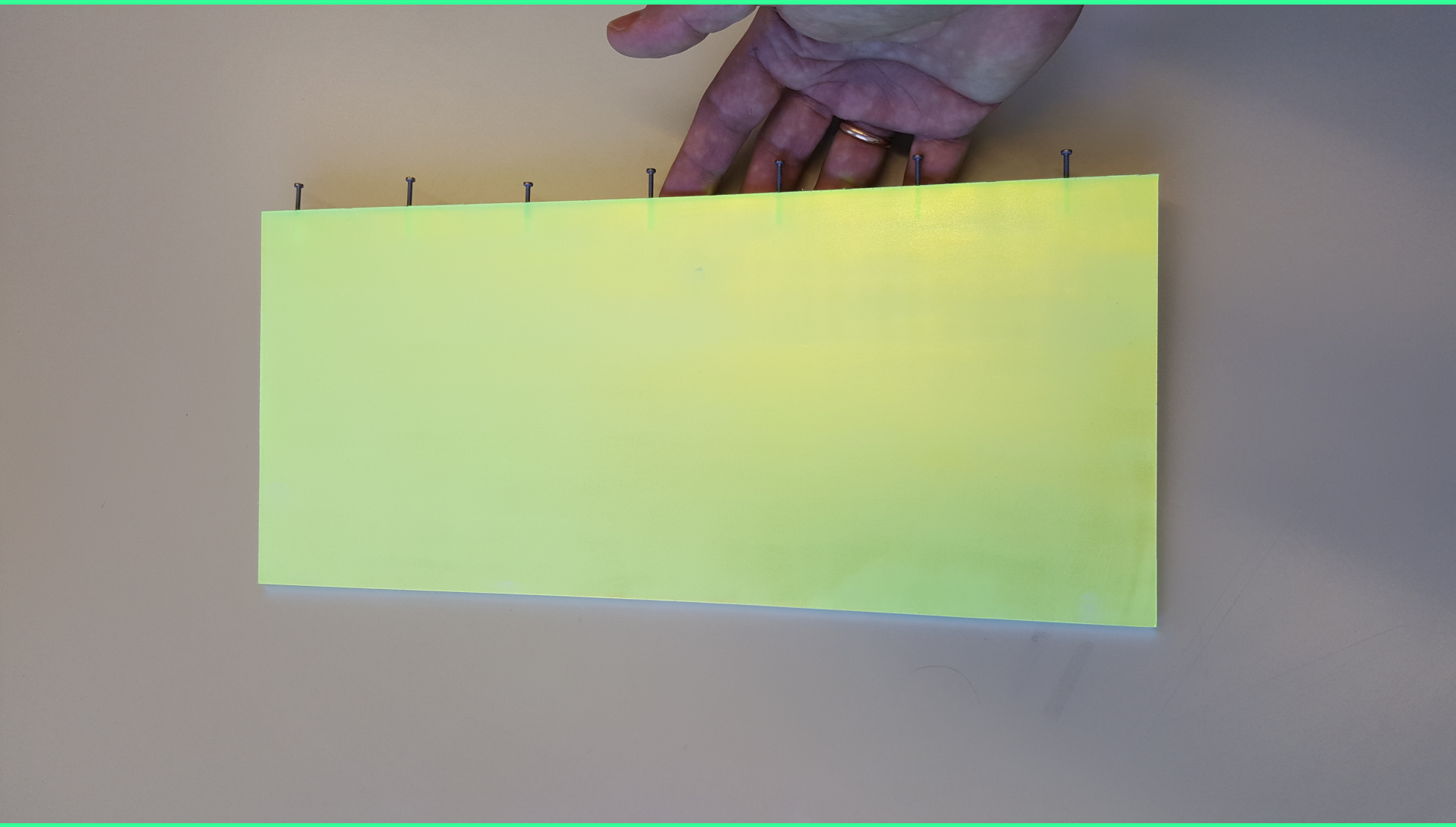


ArCLight 50 cm x 10 cm

No TPB yet

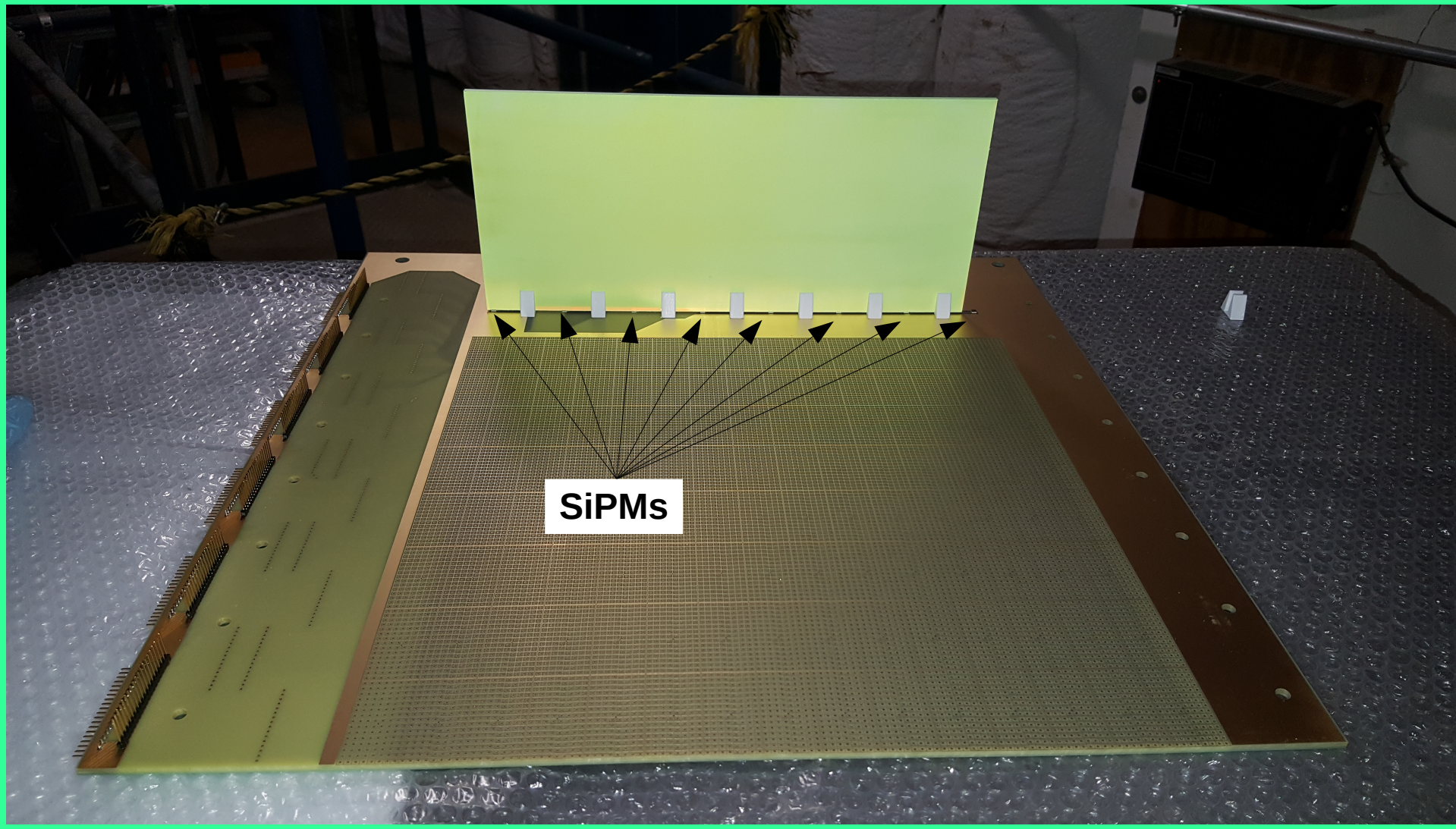


ArCLight 43x15 cm with TPB coating

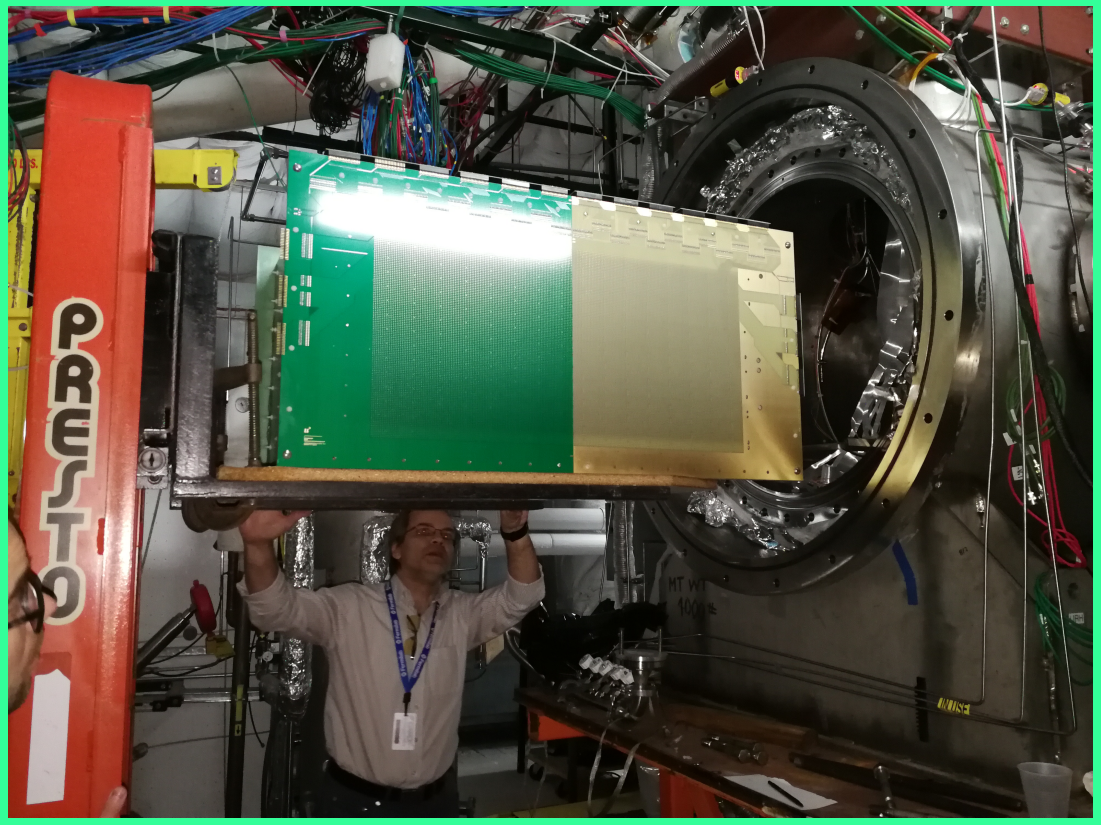


Scintillation light

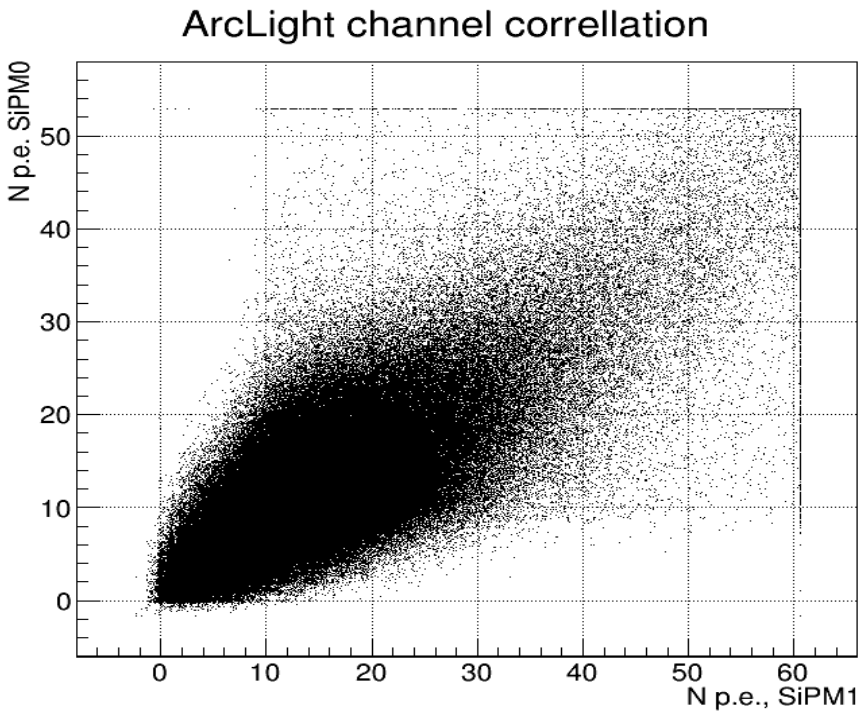
Vacuum UV @128 nm

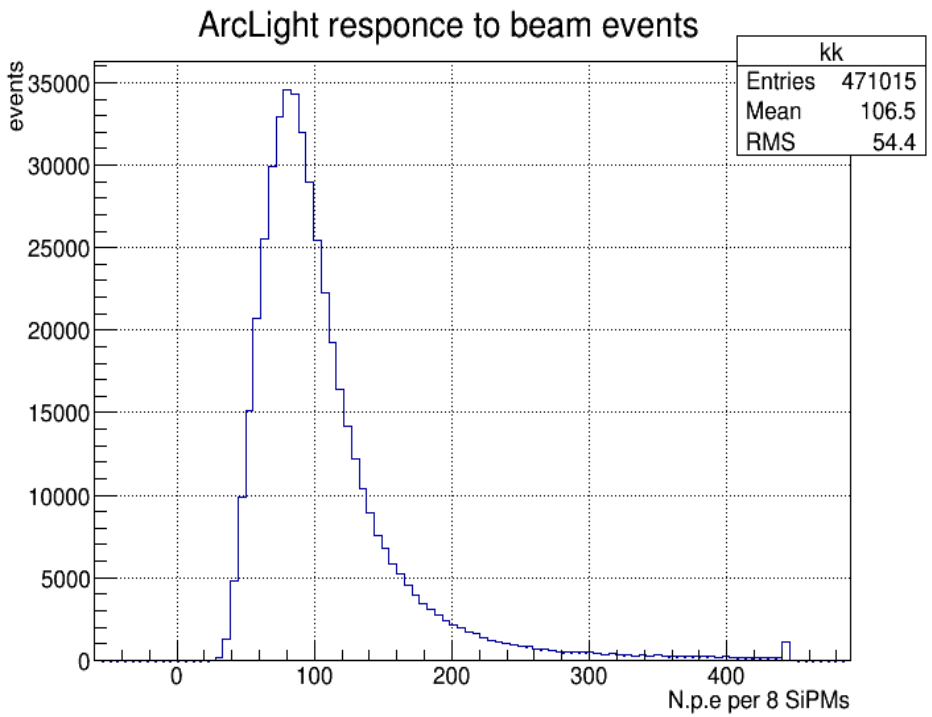


ArCLight installed at LArIAT (end of 2017)



Light yield from beam events





Expected calculated PDE 0.34%,

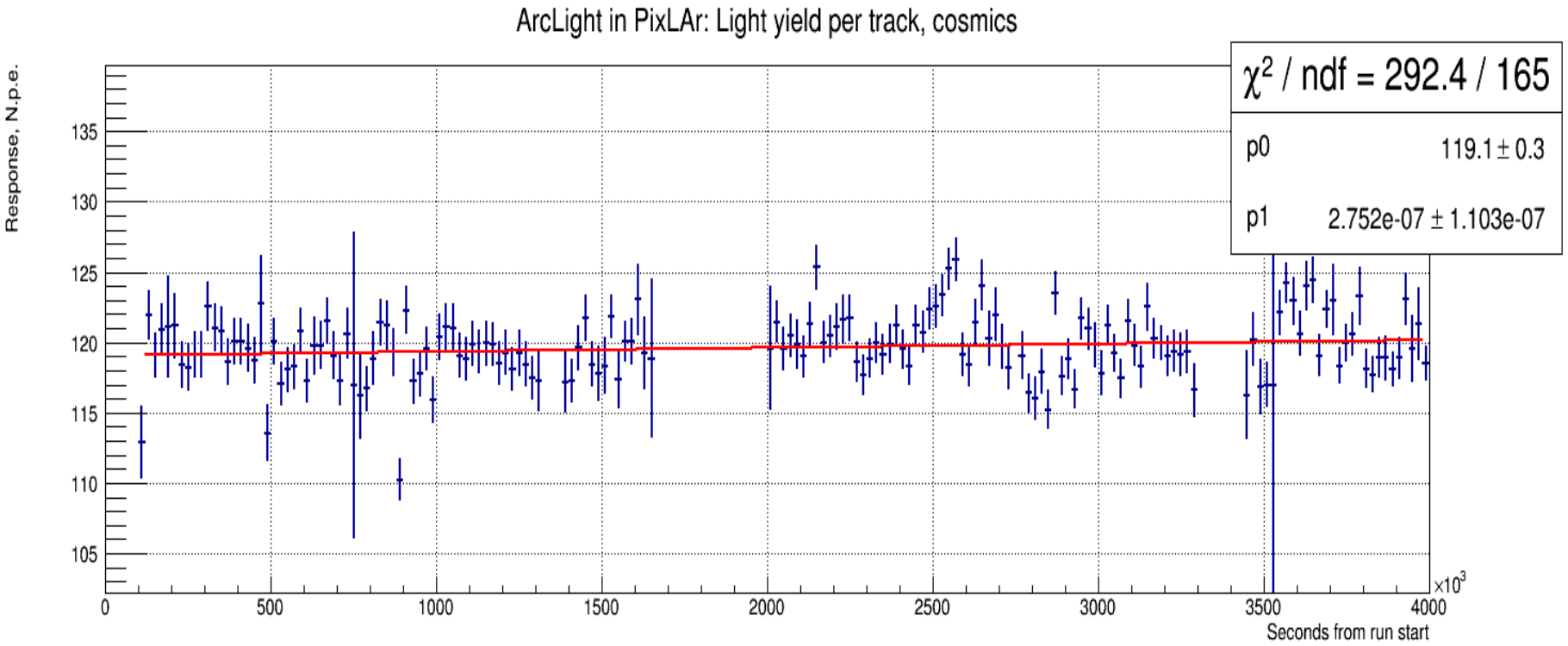
At no field MIP in LAr produces about 40000*0.3 photons/MeV in a fast part [1]
at 0.5 kV/cm LY is approx 40000 * 0.3 * 0.35 = 4200 photons/MeV,
For average 90-cm long MIP track we get 0.8e6 photons
Average solid angle ~0.26 sr (1.8%), Nphotons on ArcLight ~14400

Estimated measured PDE 0.7% - because of TPB at field cage walls !

[1] arXiv:1710.11233v2 [physics.ins-det] 13 Nov 2017

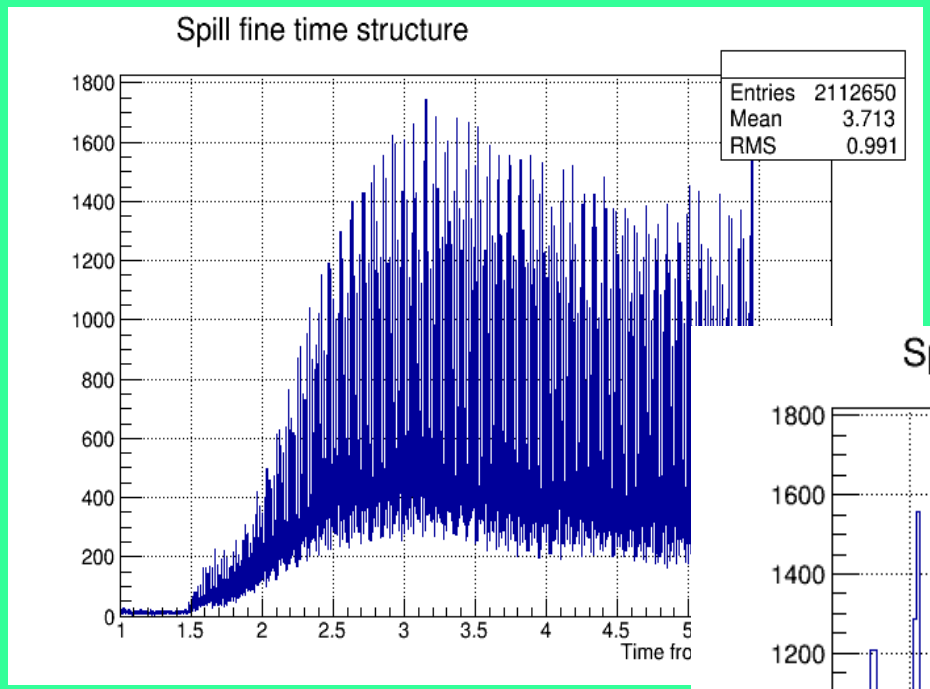
Light yield stability

Cosmic events

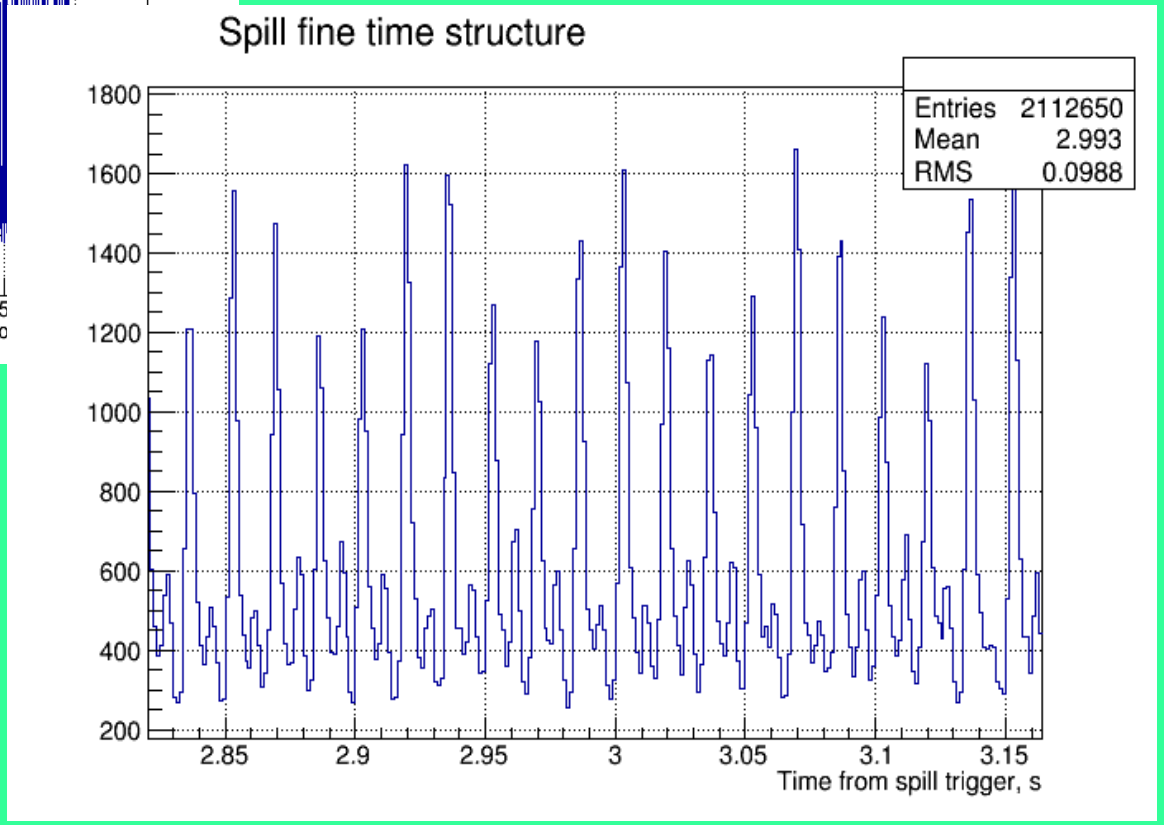


No decline, slight increase instead, although statistically not significant.

Timing w.r.t spill start is implemented!
Fine structure visible



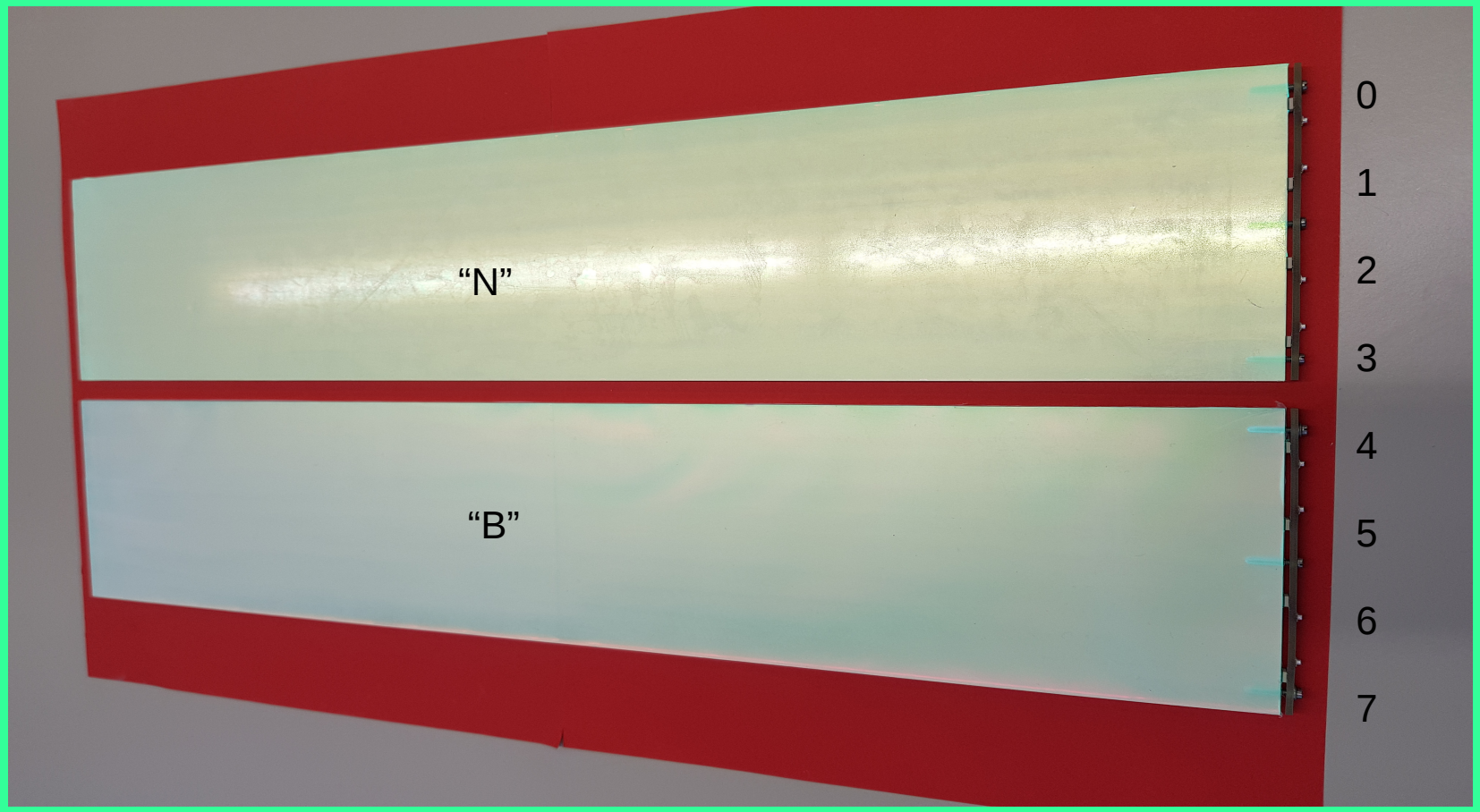
Not a demo of ultimate resolution!
Beam sync was far from the best...



ArcLight sensors in TallBo -ultimate efficiency test

Two assembly technologies:

“B” - encapsulated in polyolefine bag
“N” - naked



ArCLight in 2x2 ArgonCUBE option 1 (budget)

Tile 30x40cm: total surface area S_{tot} = 2456 cm^2

8 SiPMs/ tyle => SiPM covered S_{det}=0.72 cm^2

$f = S_{det} / S_{tot}$ = 0.0003 PDE=0.2%

From mean 0.5 m away: solid angle Ω=
0.48 sr (3.8%) / tyle , ~ 20% total acceptance

MIP: LAr scintillation produces ~40000 * 0.3 * 0.3=3600 photons/MeV @1kV/cm
(fast component only, ~100ns)

On detectors: 720 photons/MeV → ~ 1.5 pe/MeV detected

Threshold can be as low as 0.5 p.e. in cold (0.33 MeV)

ArCLight in 2x2 ArgonCUBE option 2 (performance)

Tile 30x40cm: total surface area S_{tot} = 2456 cm^2

40 SiPMs/ tyle => PDE = 1%

From mean 0.5 m away: solid angle Ω=
0.48 sr (3.8%) / tyle , ~ 20% total acceptance

MIP: LAr scintillation produces ~40000 * 0.3 * 0.35=4200 photons/MeV @0.5kV/cm
(fast component only, ~100ns)

On detectors: 840 photons/MeV → ~ 8.4 pe/MeV detected

Threshold can be as low as 0.5 p.e. in cold (0.06 MeV)

ArCLight timing capabilities

Contributions:

- LAr fast decay constant 5 ns

- UV propagation spread - negl.

- TPB decay constant 60% 1-10ns, 30% 50ns , take 20ns as an average
(https://arxiv.org/pdf/1411.4524.pdf)

- WLS decay constant 9.2 ns

- Propagation spread in WLS ~ 1 ns RMS

- SiPM+Electronics < 1ns

For marginally low signals (1pe) $5 \oplus 20 \oplus 9 \oplus 1 = 22$ ns

For high signals O(MeV) < 1ns can be reached (needs MC simulation)

Thank you!