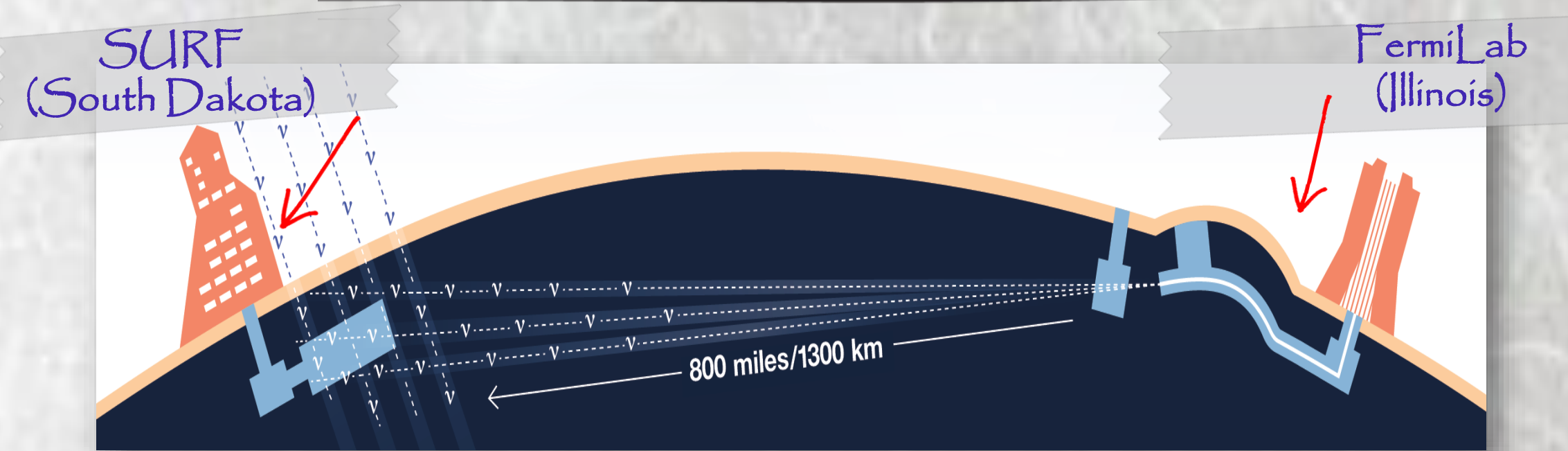


# The light detection system in ProtoDUNE Dual Phase

Chiara Lastoria on behalf of the DUNE Collaboration

## DUNE

40 kton underground LAr TPC



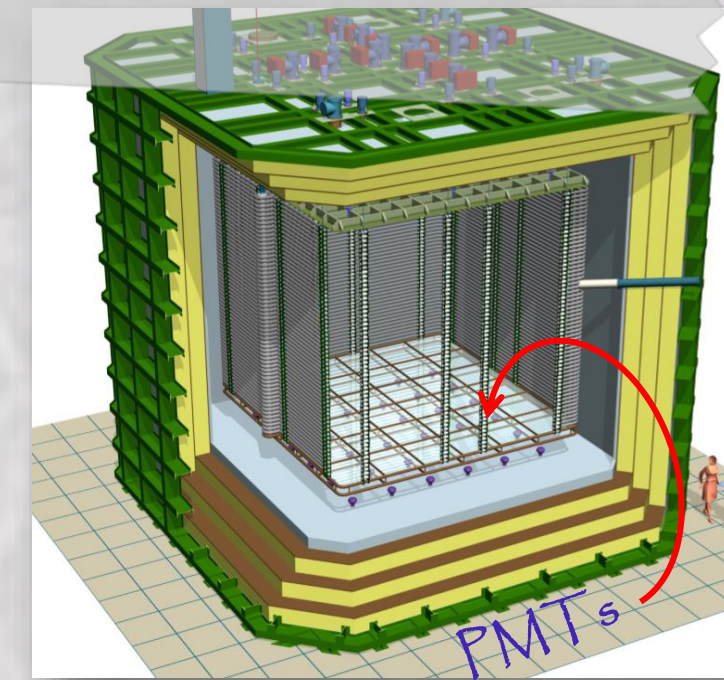
- GOALS**
- long-baseline  $\nu$  oscillation (CP violation)
  - $\nu$  for astrophysics
  - nucleon decays

## ProtoDUNE-DP\*

- \* 10 kton DPLAr TPC module, option for DUNE

- 6x6x6 m<sup>3</sup>, 300 ton
- electrons extracted, amplified, detected in GAR
- light detected by PMTs in LAr, under the cathode

Neutrino Platform (CERN)



## DP LAr technology

**ADVANTAGES**

- amplification of ionization charges in ultra-pure cold argon vapor
- low-energy detection threshold with high signal-to-noise ratio over long drift distances

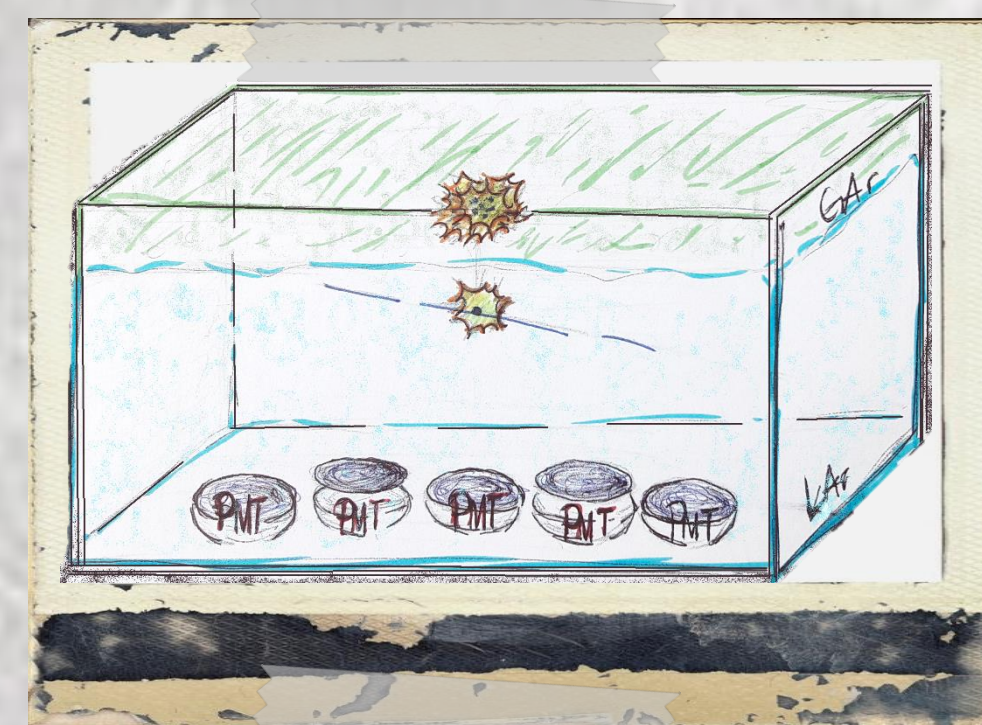
## Light detection system



- x36 • Hamamatsu 8" diameter borosilicate window
- 14 dynode stages ~ quantum eff. = 18%
- wavelength shifter for deep UV photons @ ~127 nm (TPB)

M H  
U A  
S V  
T E

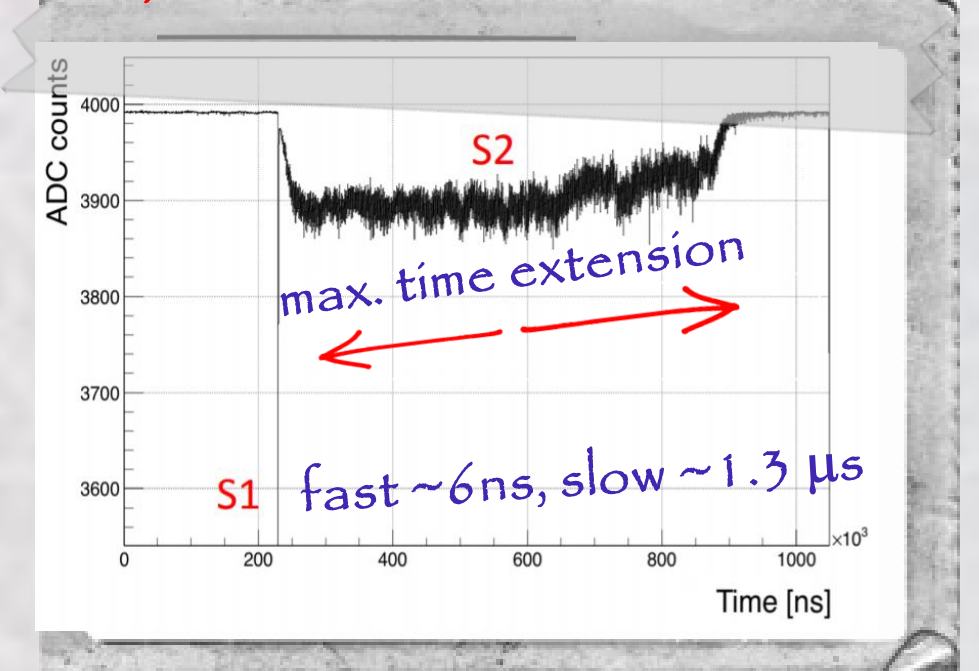
- be able to operate @ cryogenic temp. (CT) operation
- precision timing capabilities (few ns)
- wide dynamic range



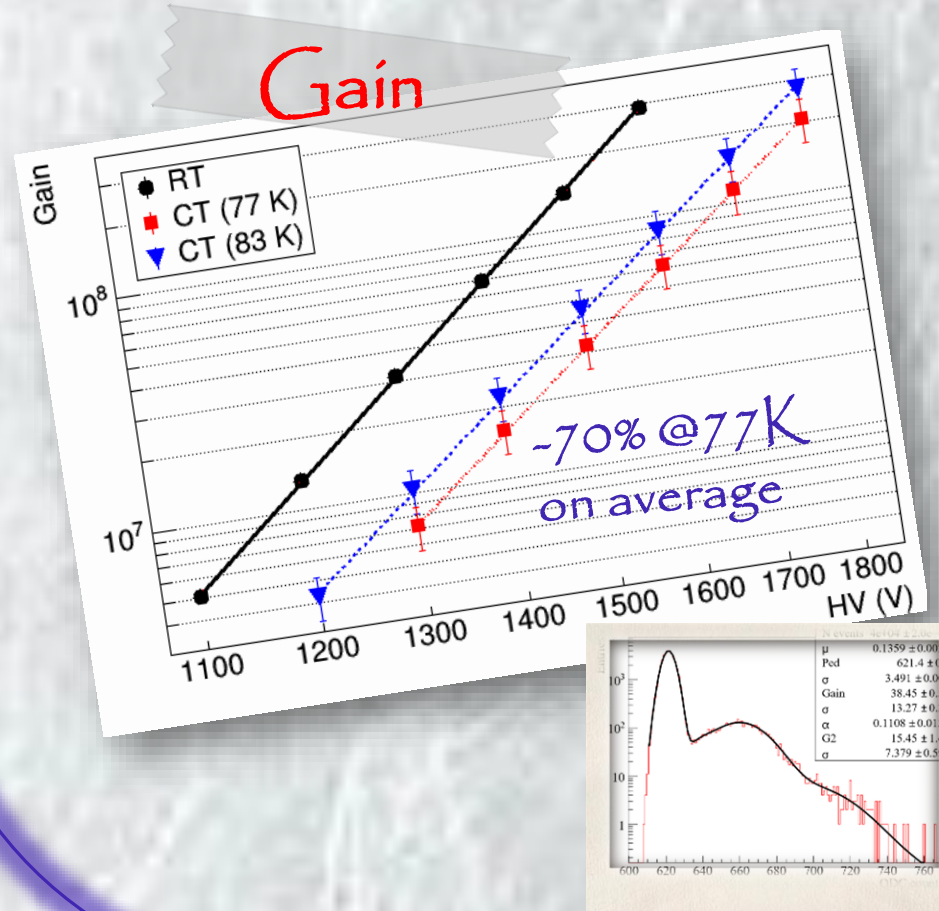
charged particle crossing LAr volume determines the observation of:

- primary scintillation light (S1)
- electro-luminescence light (S2), maximum time extension <-> maximum electron drift time

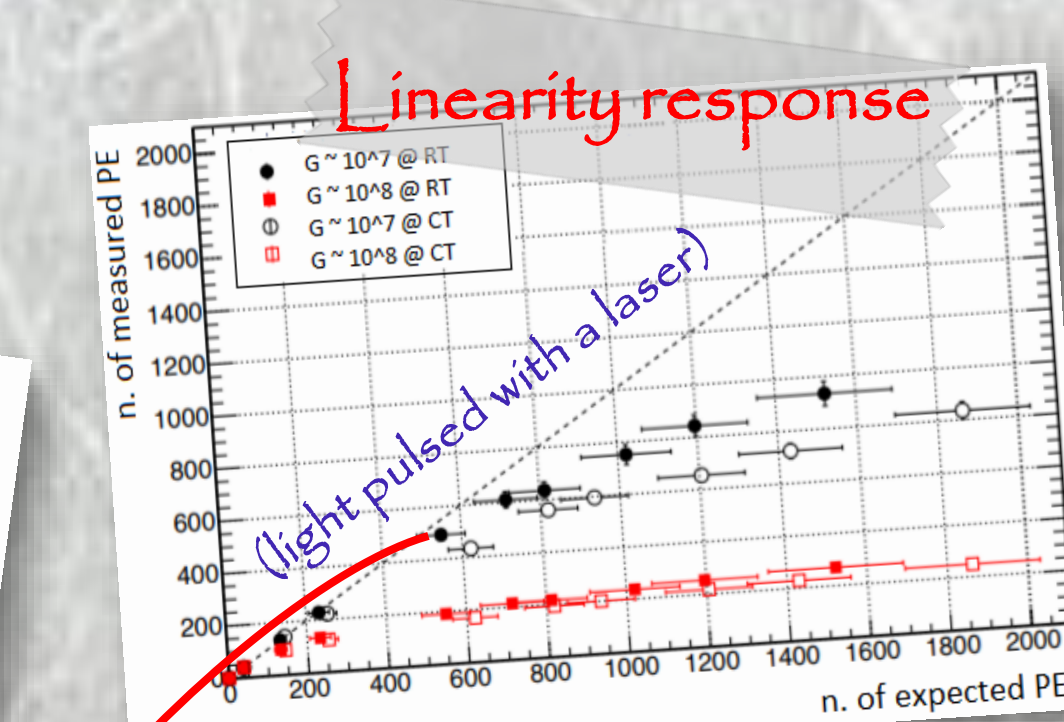
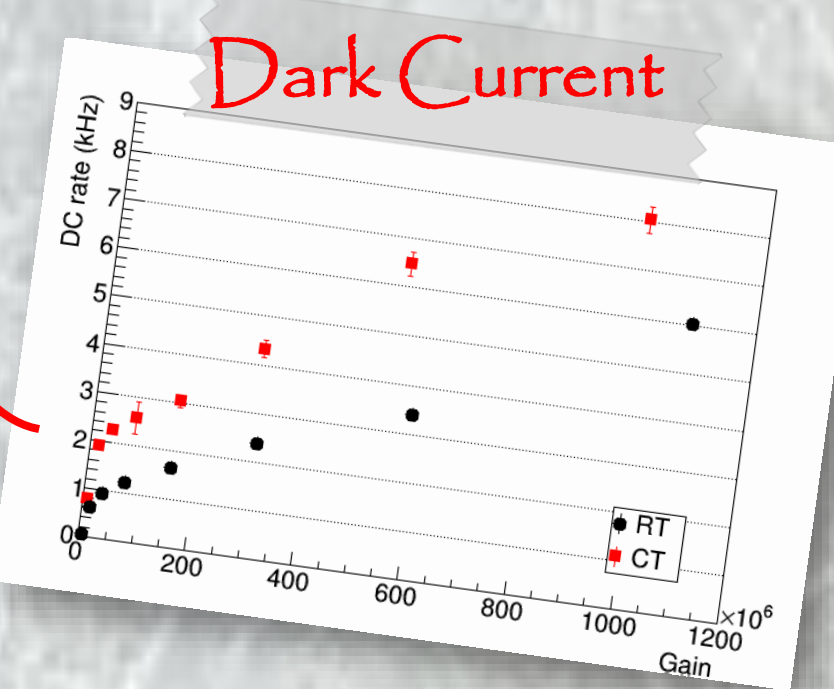
Typical light signal (3x1x1 m<sup>3</sup> data)



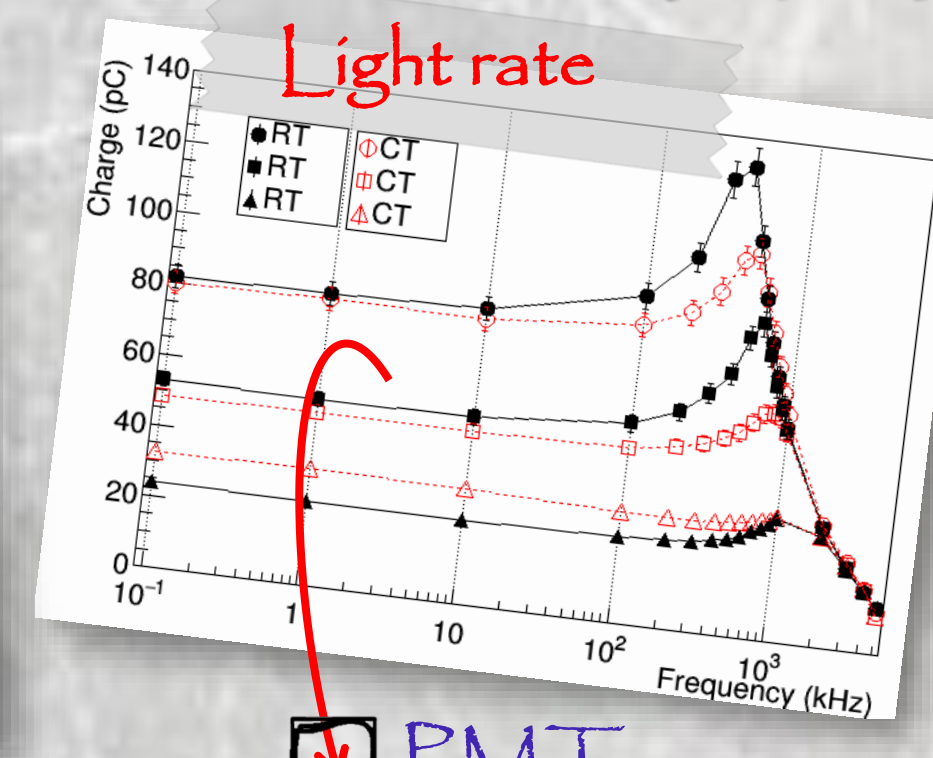
## PMT's characterization



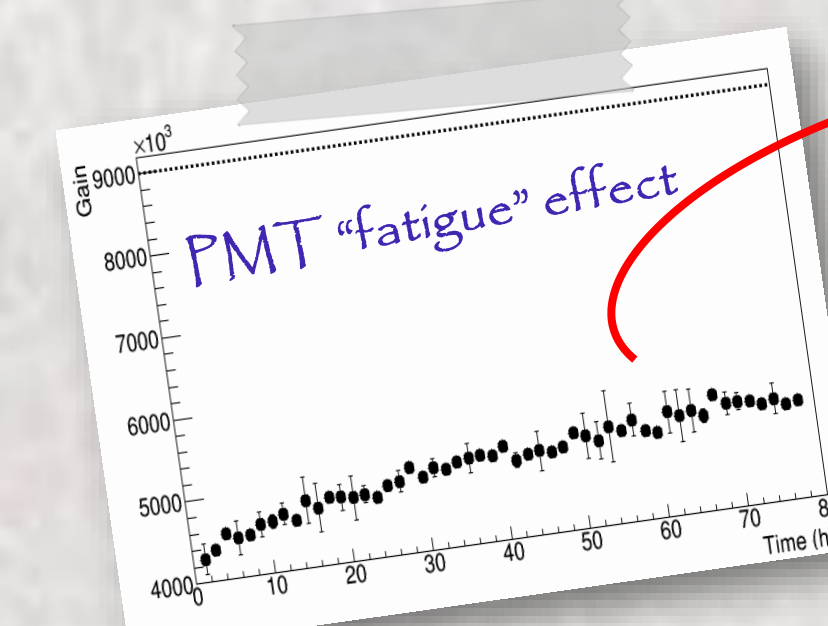
DC higher at CT (non thermionic effect)



PMT linearity slightly lower @ CT



PMT response stable up to ~10 kHz



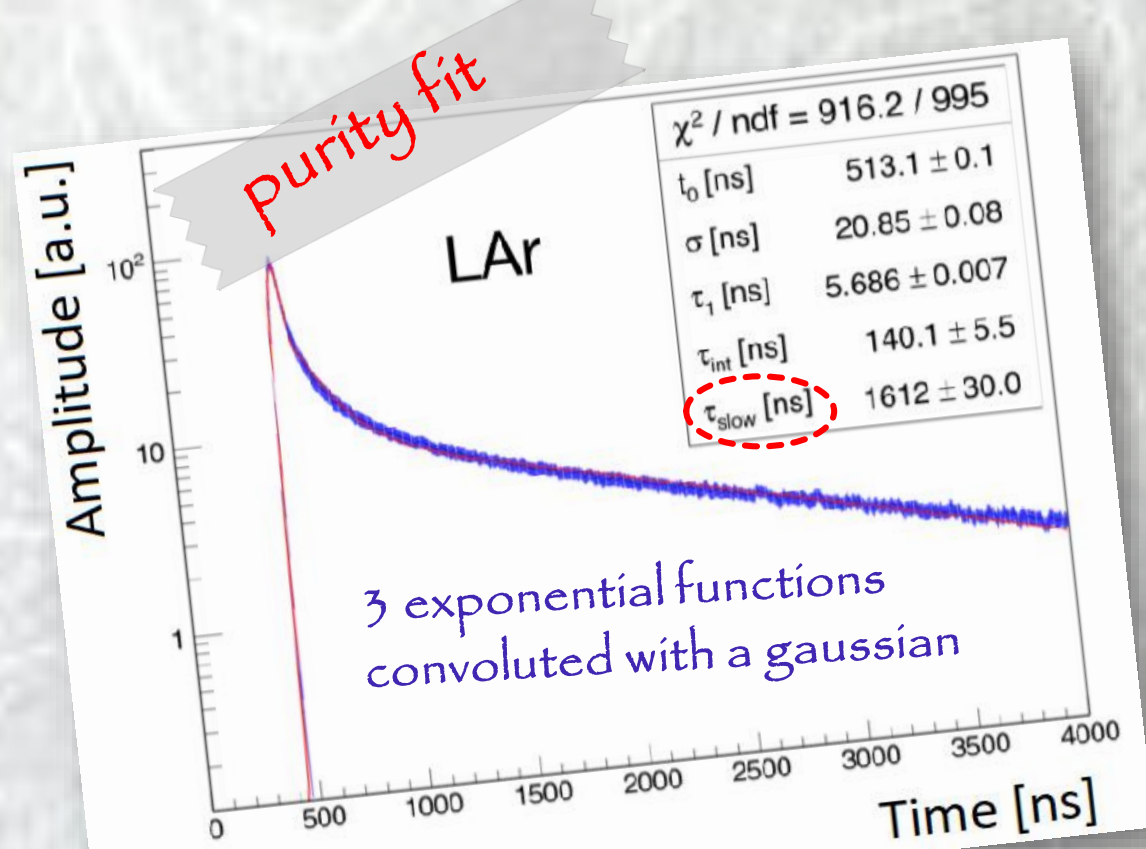
PMT gain decreases after receiving high output charge, nominal gain value recovered after long time (hours or even days)

\* "Cryogenic R5921-02 Mod Photomultiplier Tubes Characterization for the ProtoDUNE Dual Phase Experiment" to be submitted to JINST

## Light system performance in the 3x1x1 m<sup>3</sup> LAr-DP TPC

- 5 PMTs
- 2 TPB coating (direct or plate)
- 2 base configurations (positive ⊕ or negative ⊖ polarization)

Fields OFF



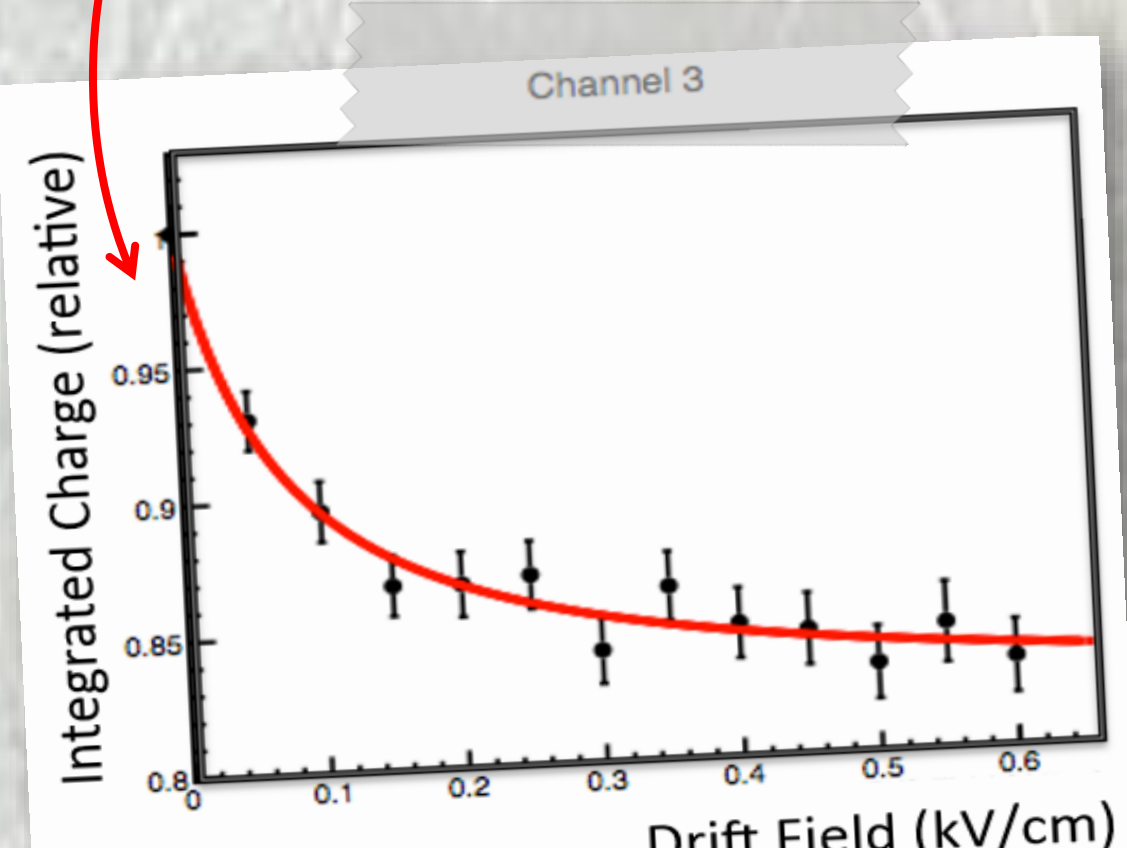
□ purity of LAr verified studying S1 properties

□ O<sub>2</sub> impurities better than ~1 ppm

\* "A 4 tonne demonstrator for large-scale dual-phase liquid argon time projection chambers" to be submitted to JINST

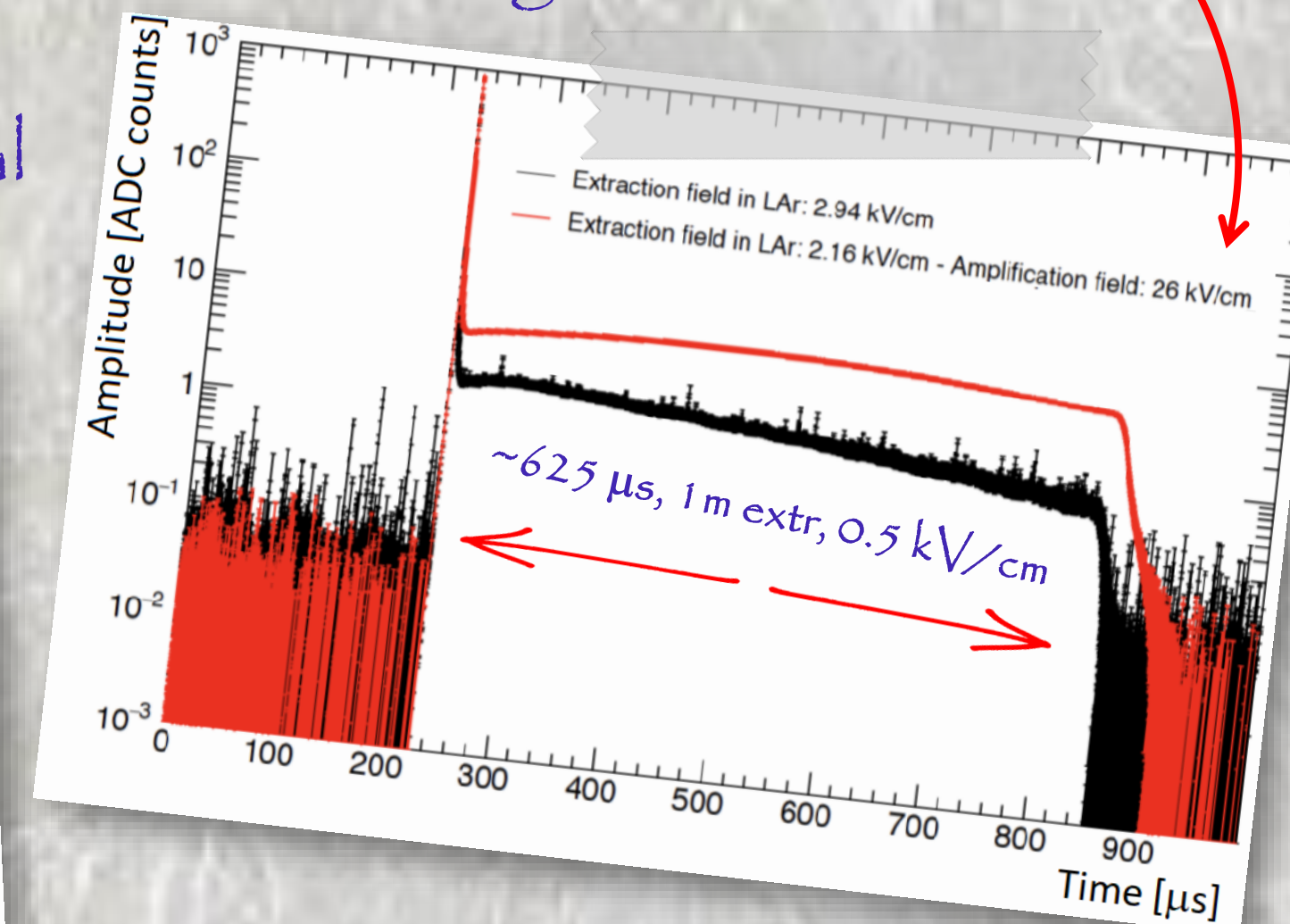
Fields ON

drift field, effect over the S1 signal

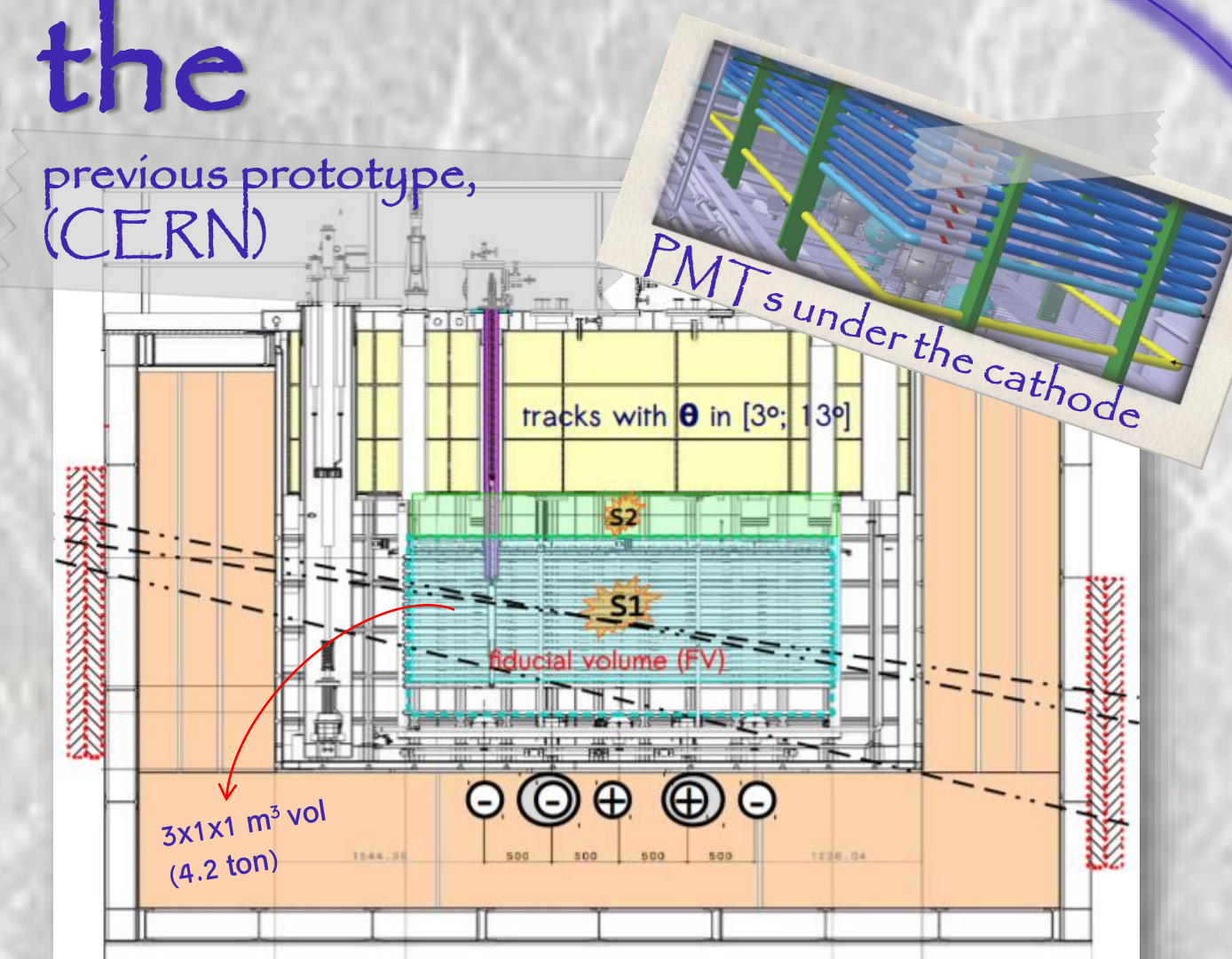


□ decreasing of S1 ampl., when the drift field increase

amplification and extraction field, effect over the S2 signal



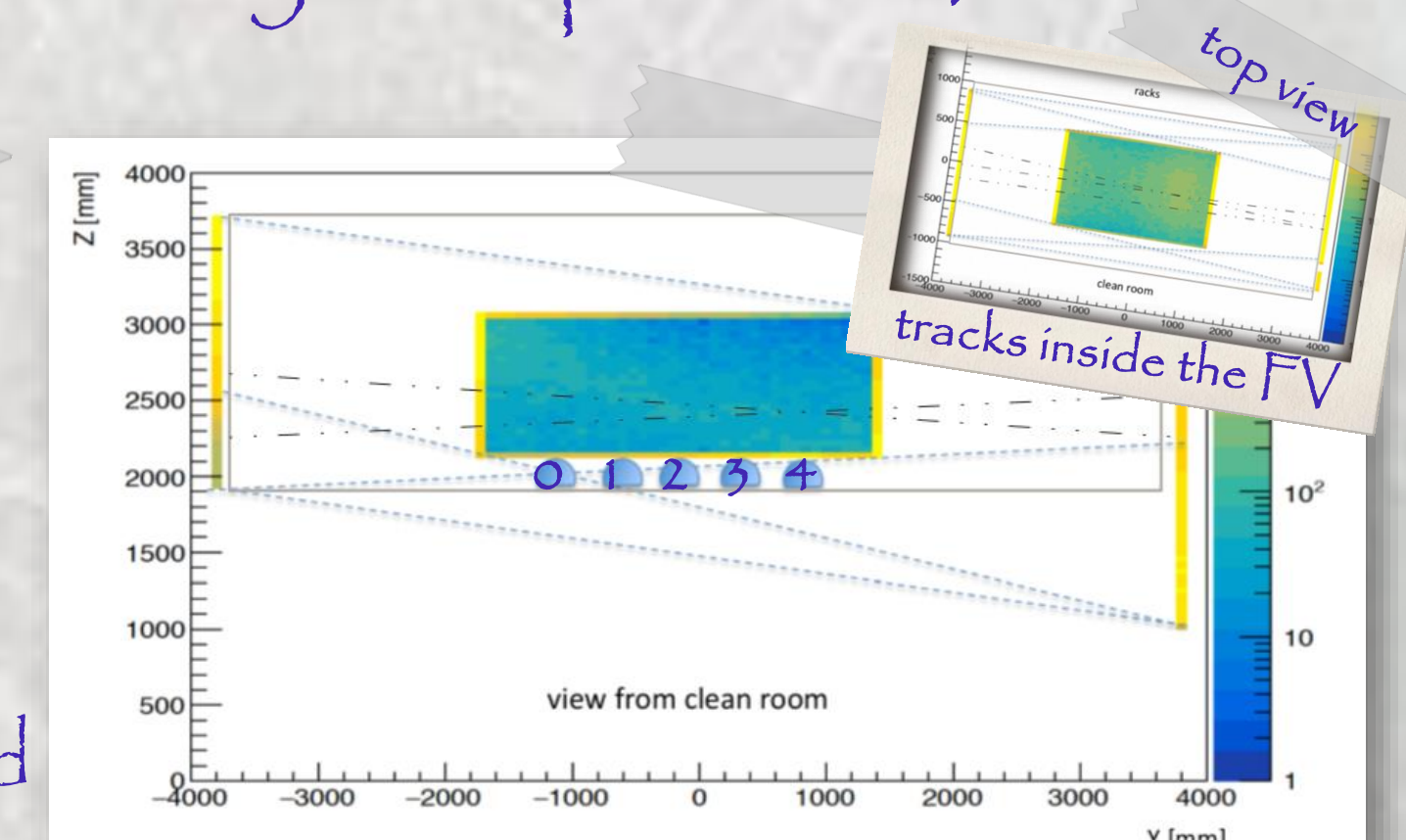
□ increasing the amplification field, increases the quantity of S2



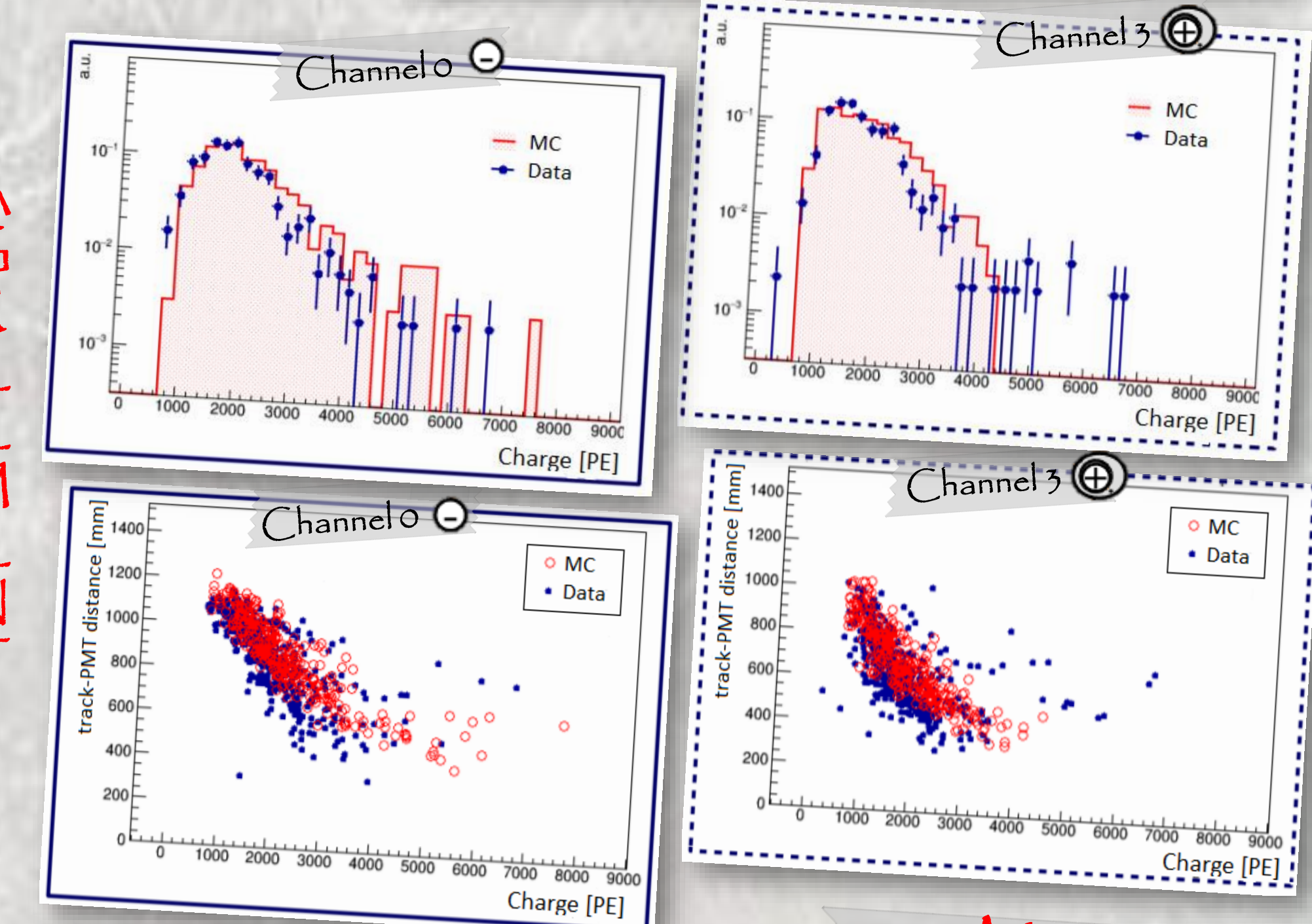
## 3x1x1 m<sup>3</sup>: data and MC (preliminary comparison)

DATA

only top-bottom diagonal tracks completely inside the FV are selected



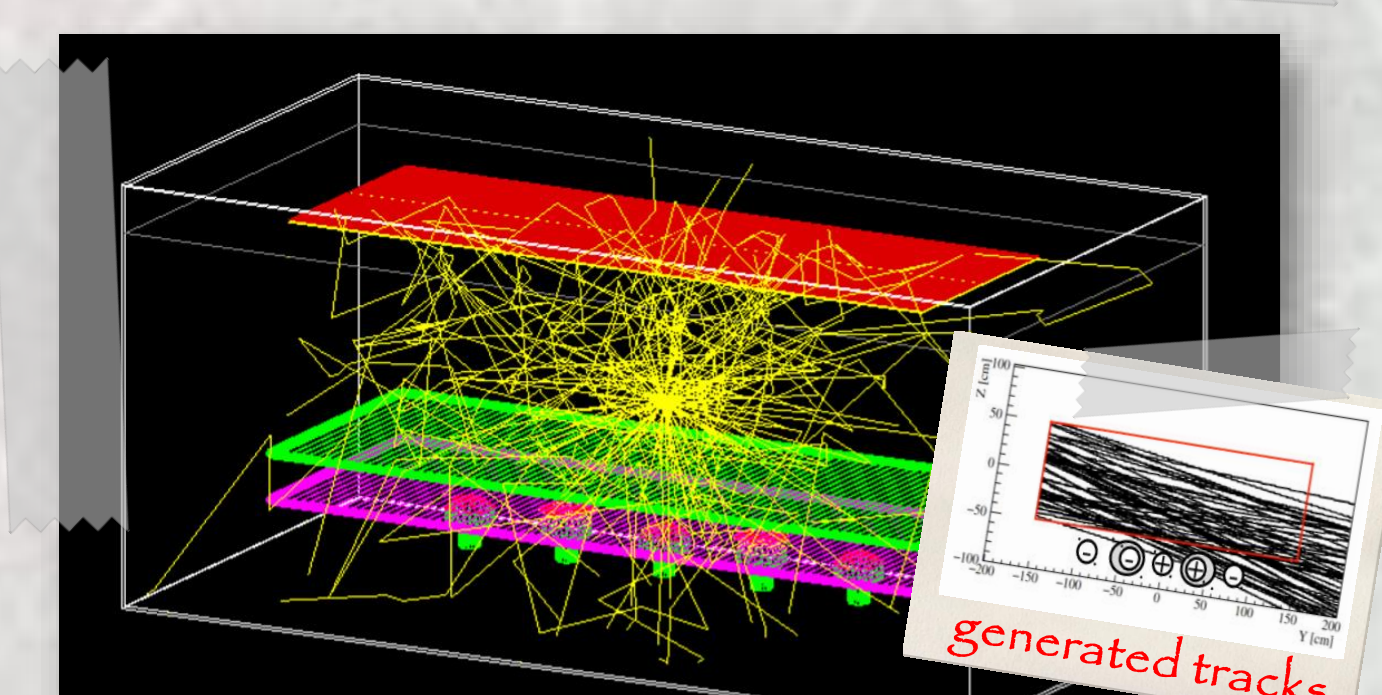
AGREEMENT



light maps simulated with LighSim

- travel time distr: double exp param
- LAr absorption:  $\lambda_{abs} = 30$  cm, exp. param
- rayleigh scattering:  $\lambda_{Ray} = 35$  cm
- abs. on stainless-steel and Cu
- TPB simulation
- quantum eff. = 20%
- ideal PMT response simulated

□ studies of some parameters impact (rayleigh scattering length, absorption...) are ongoing



## Conclusions

The light detection system:

- good performance in ProtoDUNE-DP ensured by 3x1x1 m<sup>3</sup> results

□ worked well in the 3x1x1 m<sup>3</sup> LAr TPC

- used as a trigger

□ PMTs already tested in lab ..ready to be installed!