First Operation Of A Ton Scale Dual Phase Liquid Argon TPC

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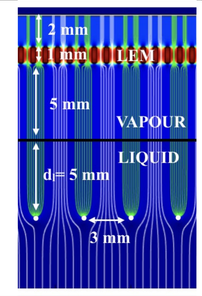
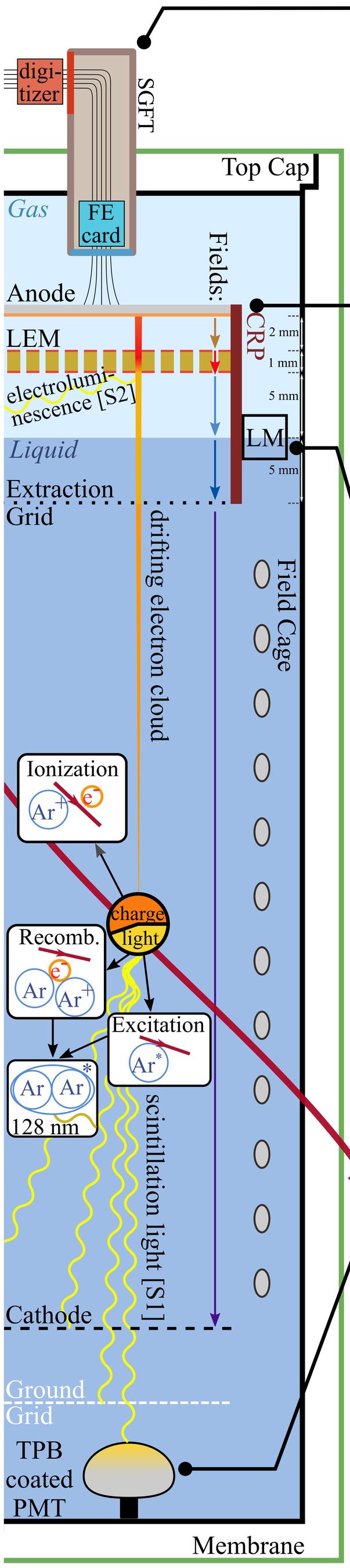
For the WA105 Collaboration - Neutrino 2018 conference

The Dual Phase Technology

3D imaging from electrons ***drifting*** [0.5 kV/cm] towards the anode, ***extracted*** [2 kV/cm] in the gas layer, ***amplified*** [33 kV/cm] in the LEMs and ***induced*** [5 kV/cm] to a 2D collection readout with equal charge sharing.

Advantages w.r.t to single phase design: accessible electronics, better granularity, very large S/N ratio, longer drift, fewer channels.
Challenges: stability of the LAr level, GAr thermodynamics, operation of a large area of amplification and readout plane.

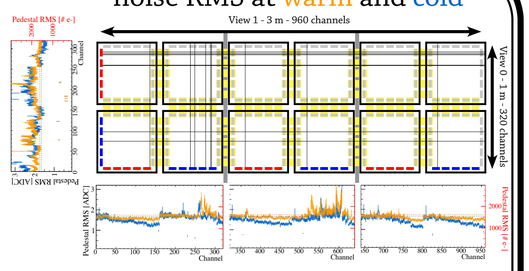




Paper
'***A 4 tonne demonstrator for large-scale dual-phase liquid argon time projection chambers***'
is in preparation

Electronics

noise RMS at warm and cold

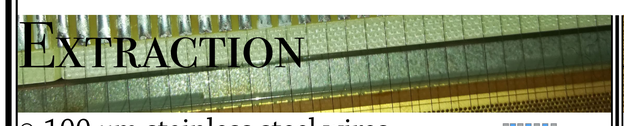


- FE cards plugged inside independant and sealed chimneys
- 17 problematic channels out of 1280
- Stable noise at the level of 1500 e^-

The 3×1×1 m³ Demonstrator

Charge Readout Plane

Extraction

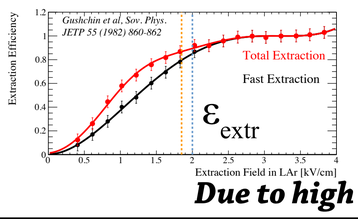


- 100 μm stainless steel wires
- 3.125 mm spacing

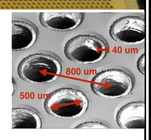
A field of 2 kV/cm is required to minimize the slow extraction component

The effective gain is:

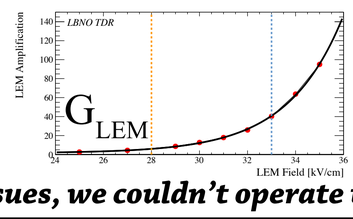
$G_{eff} = \varepsilon_{extr} \times G_{LEM} \times \varepsilon_{ind}$



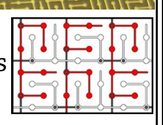
Amplification (LEM)



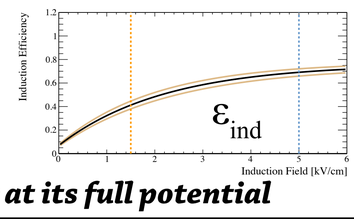
- 50×50 cm^2 manufactured panels
- Drilled PCB with 180 holes/cm^2
- 1 mm thick (10 μm precision)



Collection (Anode)



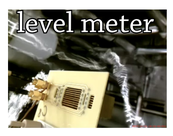
- 50×50 cm^2 manufactured panels
- 4-layer PCB with orthogonal strips
- 3.125 mm pitch, low capacitance
- Equal charge sharing between views



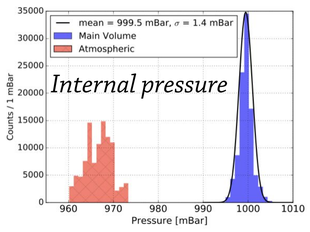
~20 [nominal]
~ 3 [best run]

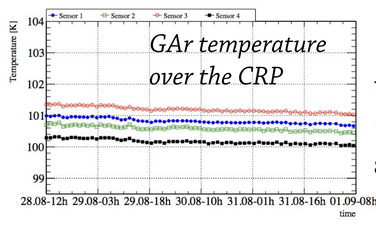
Due to high voltage issues, we couldn't operate the detector at its full potential

Cryogenics Stability

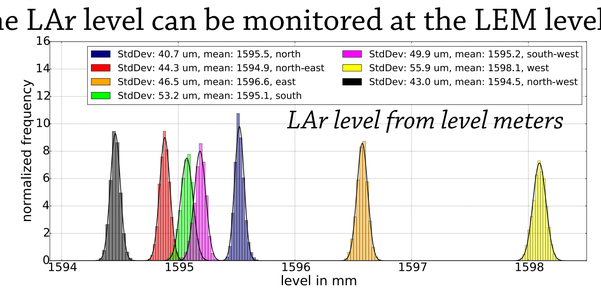


Cryo-cameras installed for visual feedback during filling and comissioning

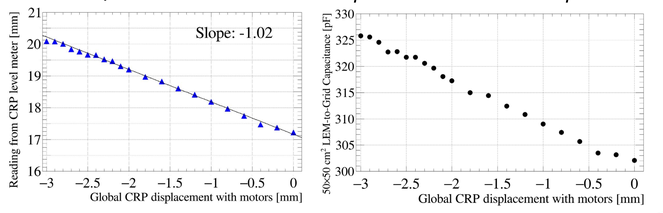




- GAr temperature and pressure constantly monitored and were very stable over time.
- In the vapour phase, a gradient of 2 K/cm is observed.
- Liquid argon level is measured by 8 level meters installed around the CRP.
- The position of the CRP can be adjusted to the liquid with 3 ropes.
- The LAr level can be monitored at the LEM level by measuring the LEM-Grid capacitance.



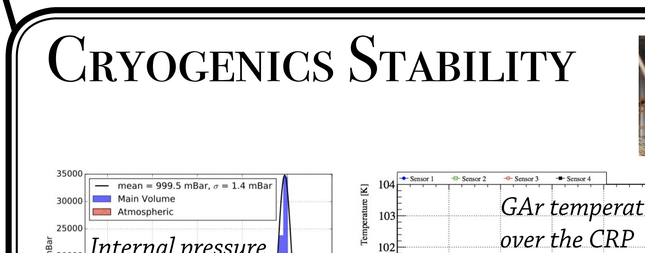
LAr level from level meters and capacitance vs CRP dispacement



Very HV

- Field cage made of 20 shaping rings of stainless steel.
- For a drift field of 0.5 kV/cm, a custom-made HV feedthrough polarizes the cathode at -56kV ; it was successfully tested at -300 kV.

Light Signal



PMT gain calibration performed at warm and in LAr with the study of the SPE vs HV

S1 signal provides the t_0 and can serve as internal trigger

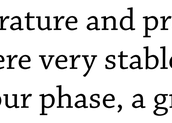
S2 signal depends on the HV settings

Data Collected

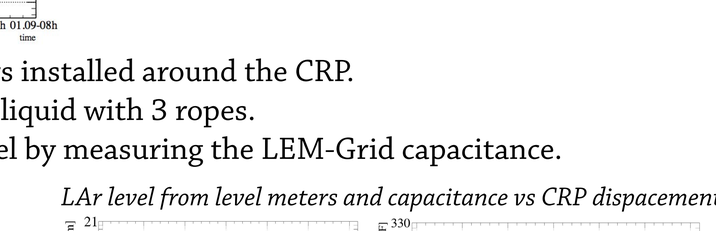
Cosmic runs with two trigger configurations (external scintillator planes, PMT)
Total of ~500 k events recorded in more than 100 different HV settings

1st evidence of e^- extraction into the gas phase from light signal:

Event displays:



Through going track crossing the entire drift volume:



Interactions and showers:

Corresponding waveforms of the through going track: