

# DarkSide-50

Alessandro Razeto

LNGS 26/3/14

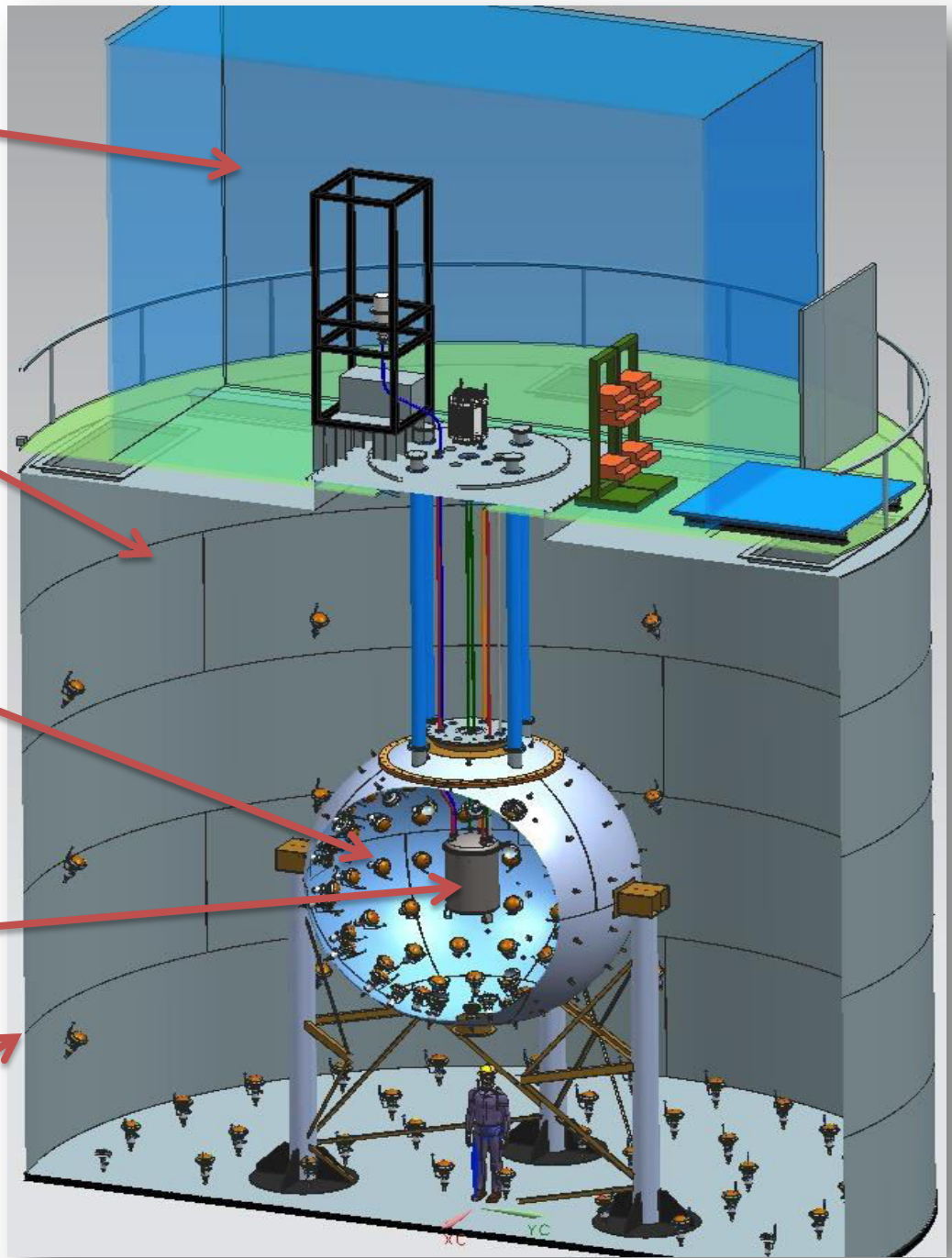
CRH  
Radon-free clean assembly room  
 $\leq 5 \text{ mBq/m}^3$  in  $>100 \text{ m}^3$

$\mu$  veto and n passive shield  
1000 ton water Cherenkov

neutron veto  
30 ton borated liquid scintillator

TPC  
150 kg of Ar

CTF blue tank  
Hall-C



# Zero background strategy

- Screen and select all detector materials for minimum radioactivity
- Identify muons to reject cosmogenic neutrons
  - Water Cherenkov detector
- Identify neutrons with high efficiency in a compact volume
  - Liquid scintillator detector
- TPC
  - Pulse shape discrimination
  - S2/S1
  - 3D reconstruction
  - Underground Ar
    - $^{39}\text{Ar}$  suppressed by a factor  $> 150$

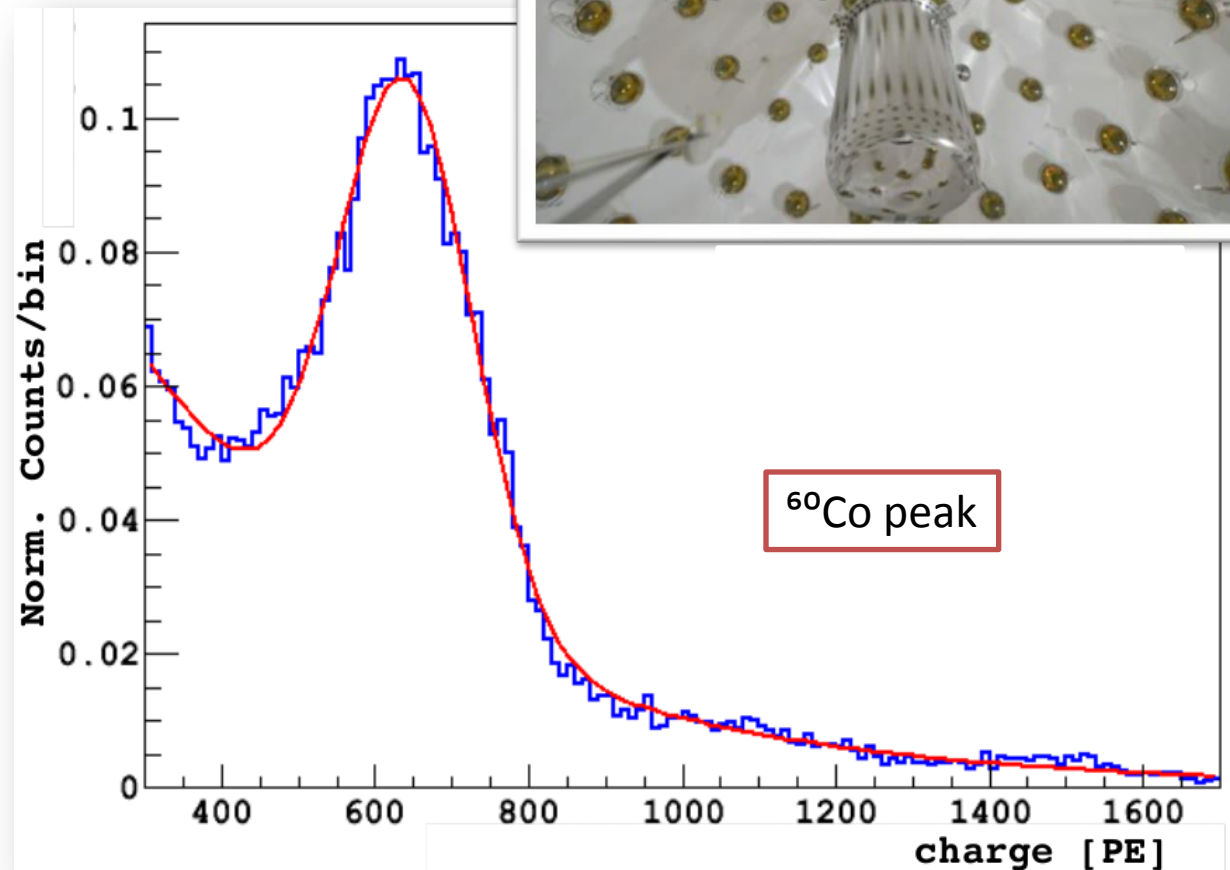
# Water Cherenkov detector

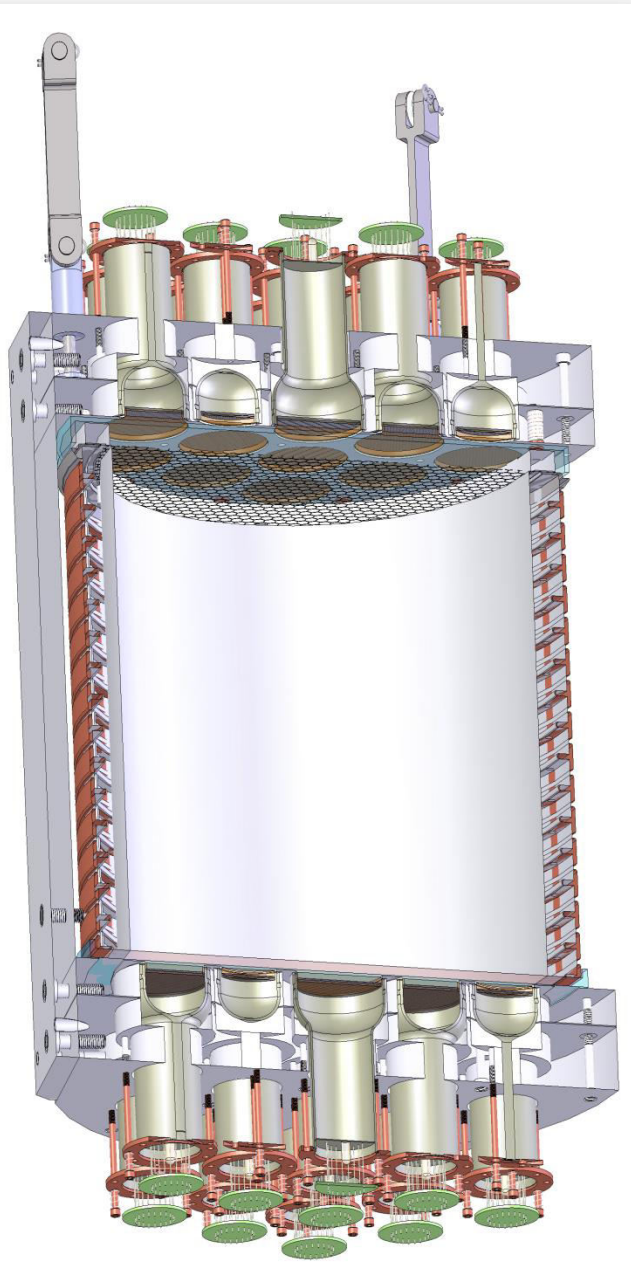
- 1000 ton of water
  - N &  $\gamma$  passive shield
- 80 8" PMTs
  - from CTF
- 1.2 GS/s National Instrument digitizers
  - DAQ from S. Davini and L. Pagani



# The Liquid Scintillator Neutron Veto

- 30 ton of borated scintillator
  - 50% PC + 50% TMB
  - 3 g/liter PPO
- 110 8" PMTs
- 1.2 GS/s ADC
  - Same as WC
- LY 0.5 pe/keV<sub>ee</sub>
- <sup>14</sup>C excess
  - TMB from biogenic metanol
  - Replace the TMB





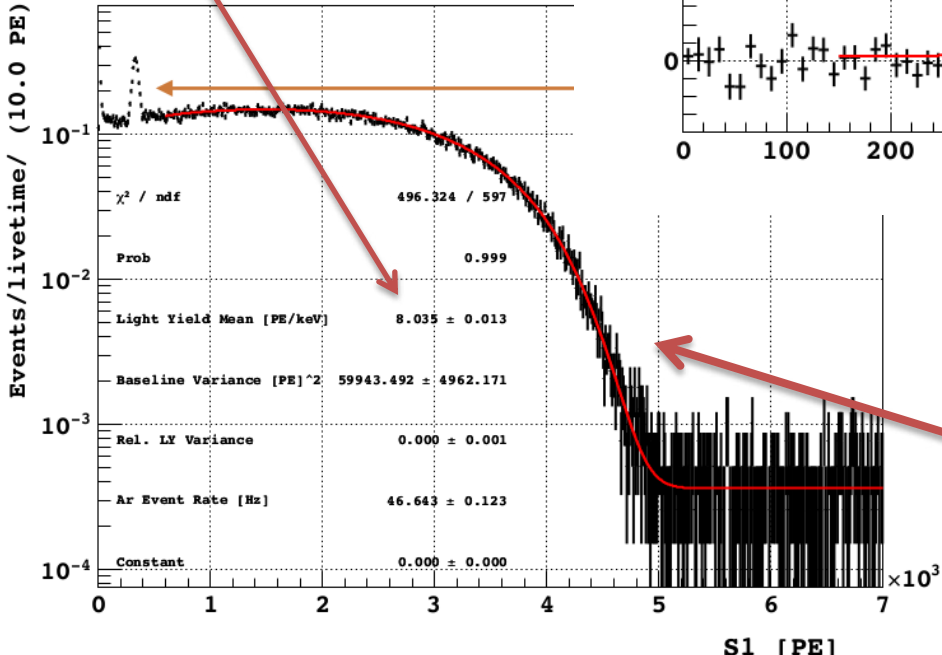
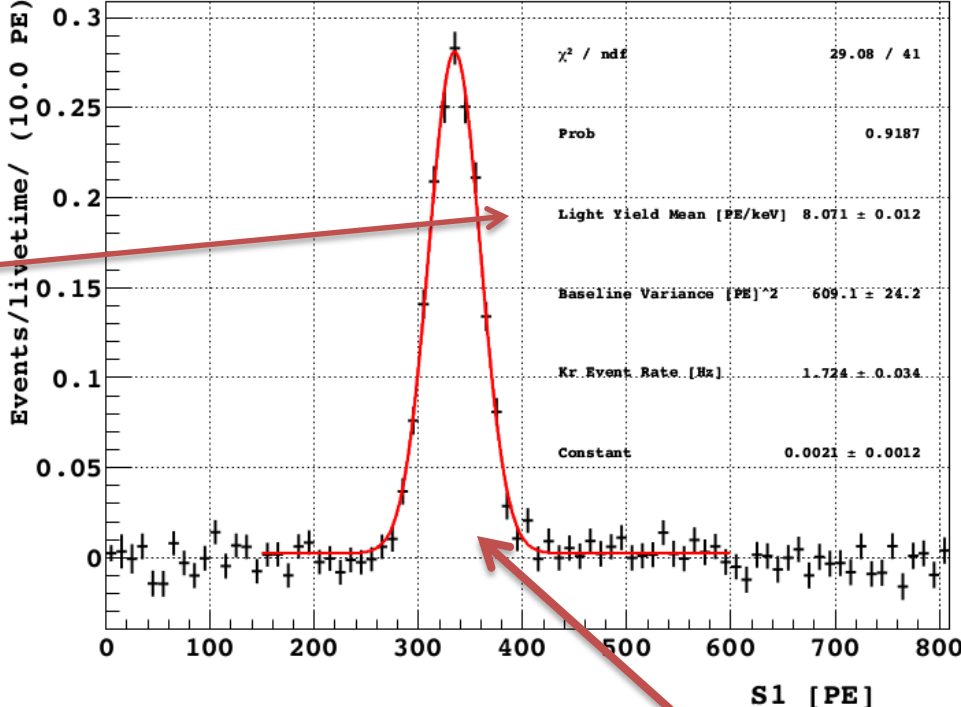
# TPC

- Detector operative since Oct 2013
- 38 R11065 PMTs
  - Working steadily
  - Gain stable at 1-2 % level
  - Light yield  $\sim 8$  pe/keV<sub>ee</sub>
- e<sup>-</sup> lifetime better than 5 ms
  - To be compared to a max drift time of  $\sim 400$   $\mu$ s
- HHV operating at nominal value
  - $E_d = 200$  V/cm,  $E_{\text{ext}} = 2.8$  kV/cm

# Light yield

The light yield of the TPC is  $\sim 8$  pe/keV<sub>ee</sub> at null field

Preliminary

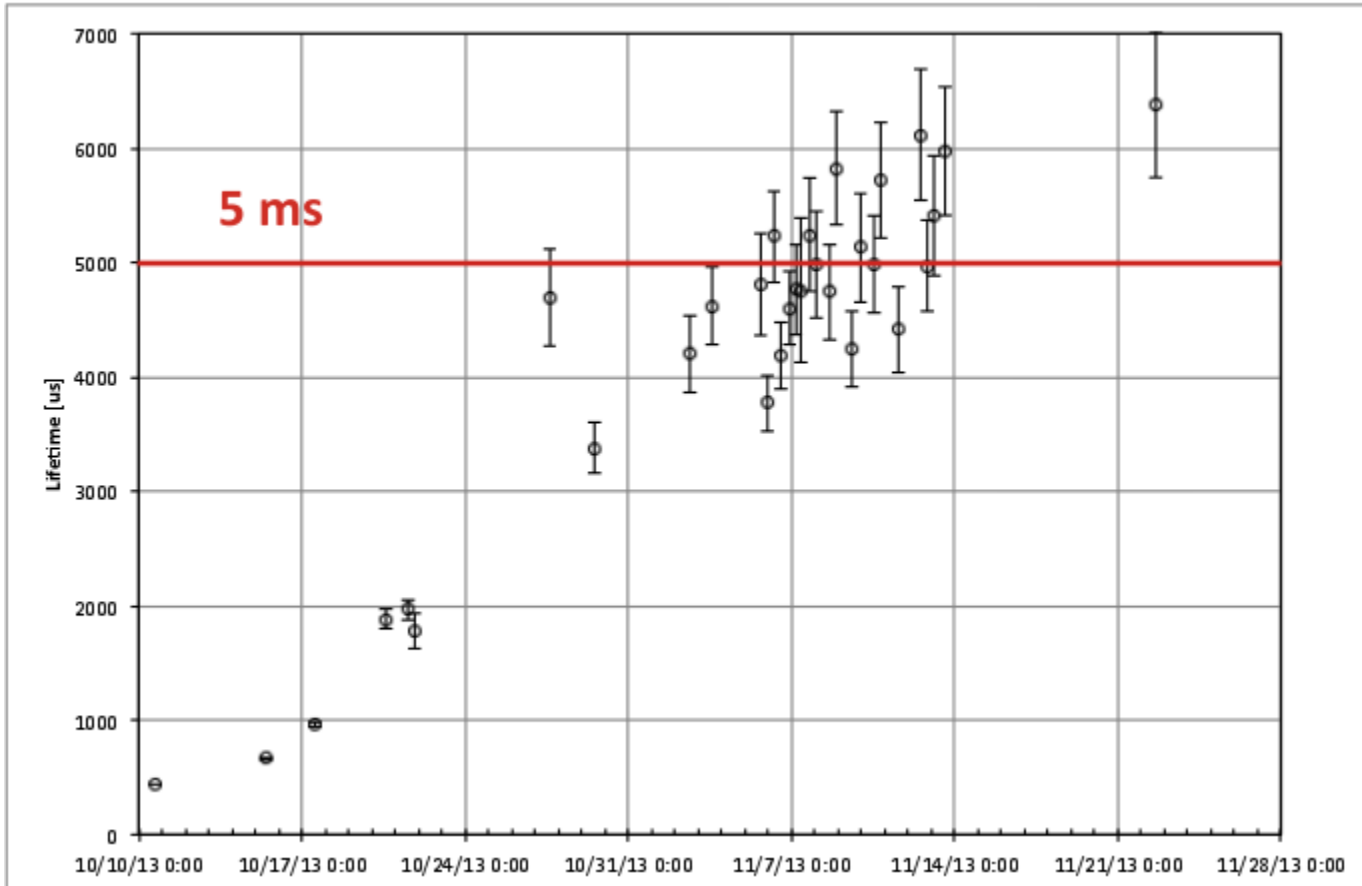


$^{83m}\text{Kr}$  peak  
41.5 keV

$^{39}\text{Ar}$  spectrum  
565 keV

Preliminary

# e<sup>-</sup> life time

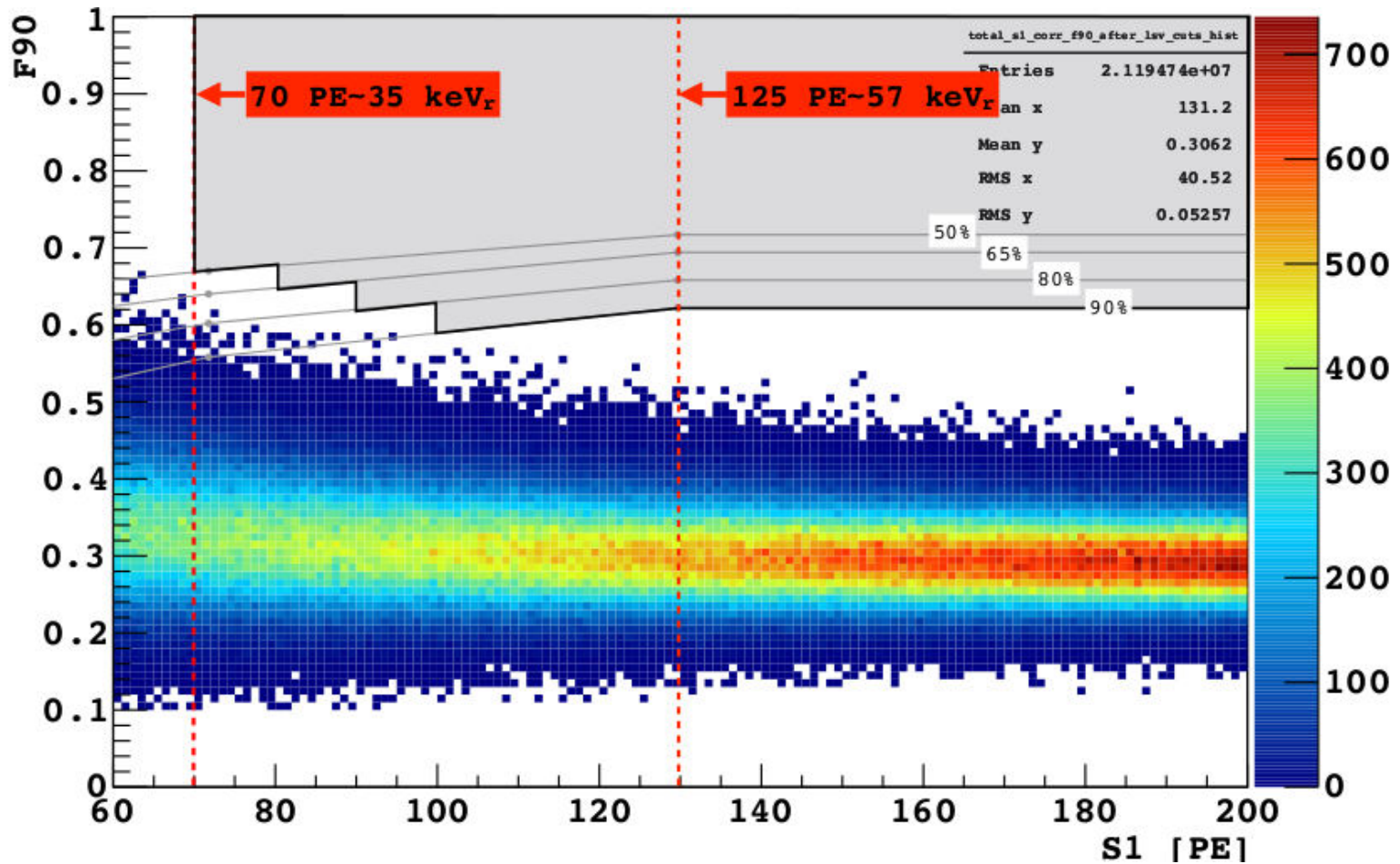




# Status

- Physics run started at the end of October 2013 with atmospheric argon
  - Data taking was paused in Nov 2013 - Jan 2014 for DAQ & electronics improvements
  - Current exposure  $\sim 1600$  kg day
- Results presented at DM2014
  - Analyzed data set correspond to 6.5 live days of atmospheric Ar
  - Analysis still under development: S2/S1 cut and x-y position reconstruction cut require calibrations
  - No background events found in  $2 \cdot 10^7$  events of  $^{39}\text{Ar}$   $\leftrightarrow$  280 kg day
    - Equivalent to  $\sim 3$  years of underground argon in DS-50
    - Even without the foreseen S1/S2 and x-y cuts

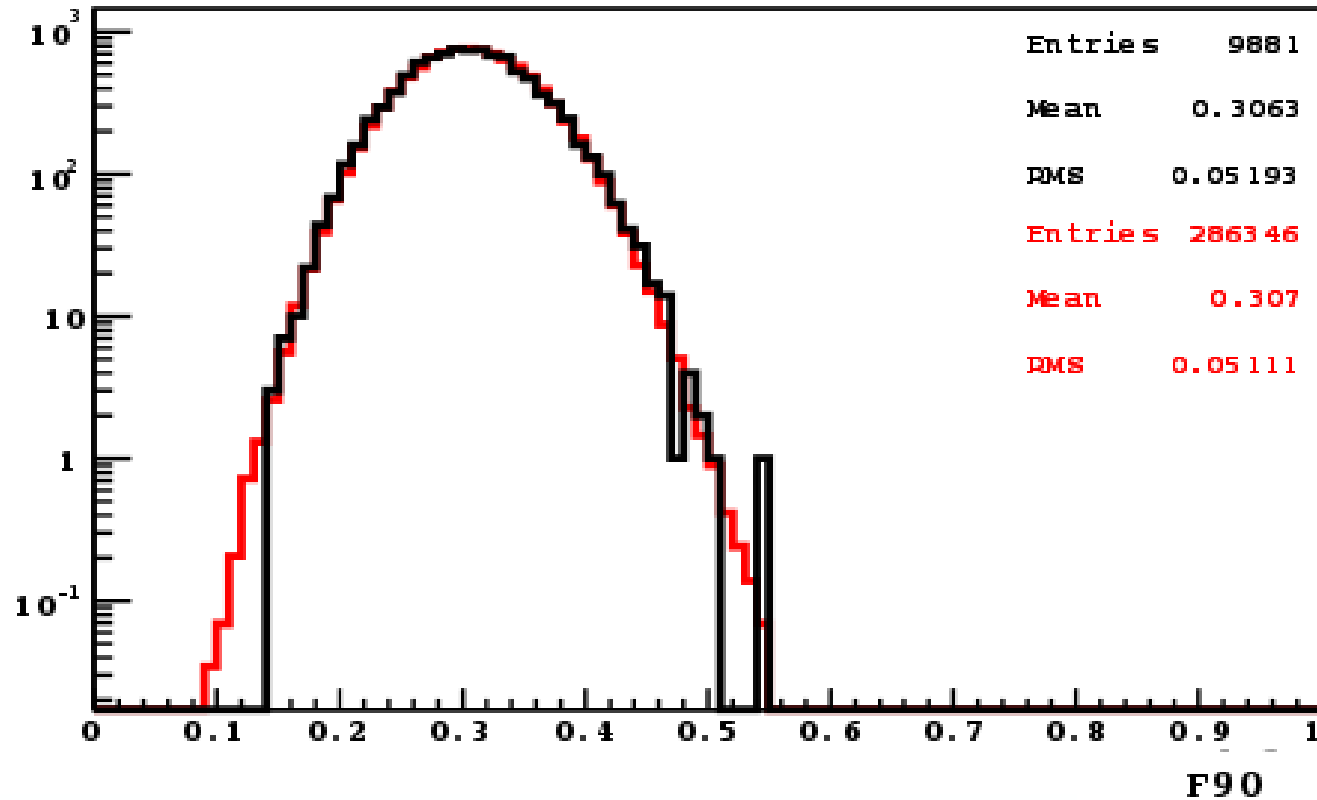
# Pulse shape discrimination



F90 acceptance from SCENE

# PSD simulation

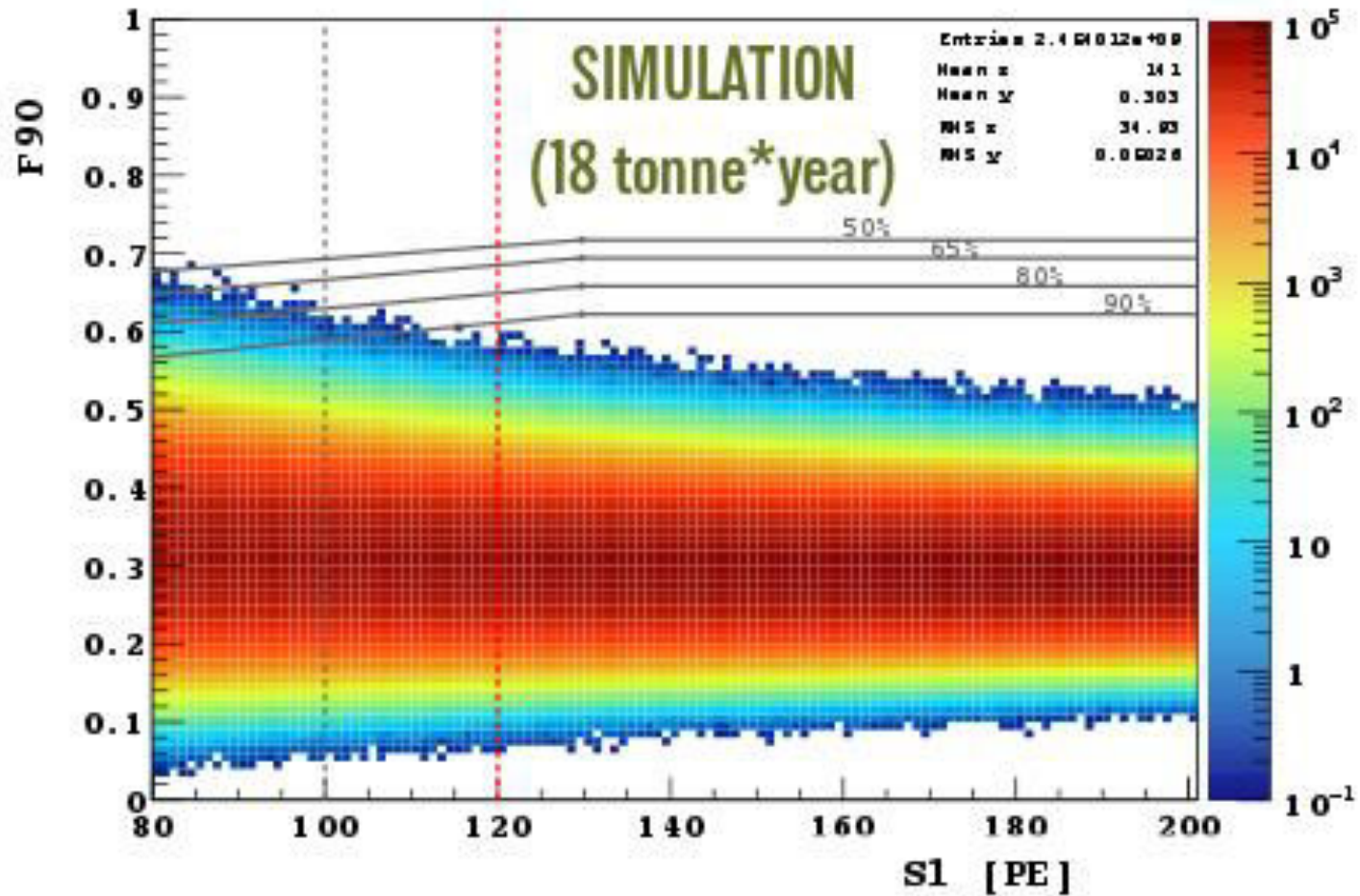
110 PE < S1 < 115 PE



F90 distribution modeled using the macroscopic effect of Ar, the detector layout and the electronic noise

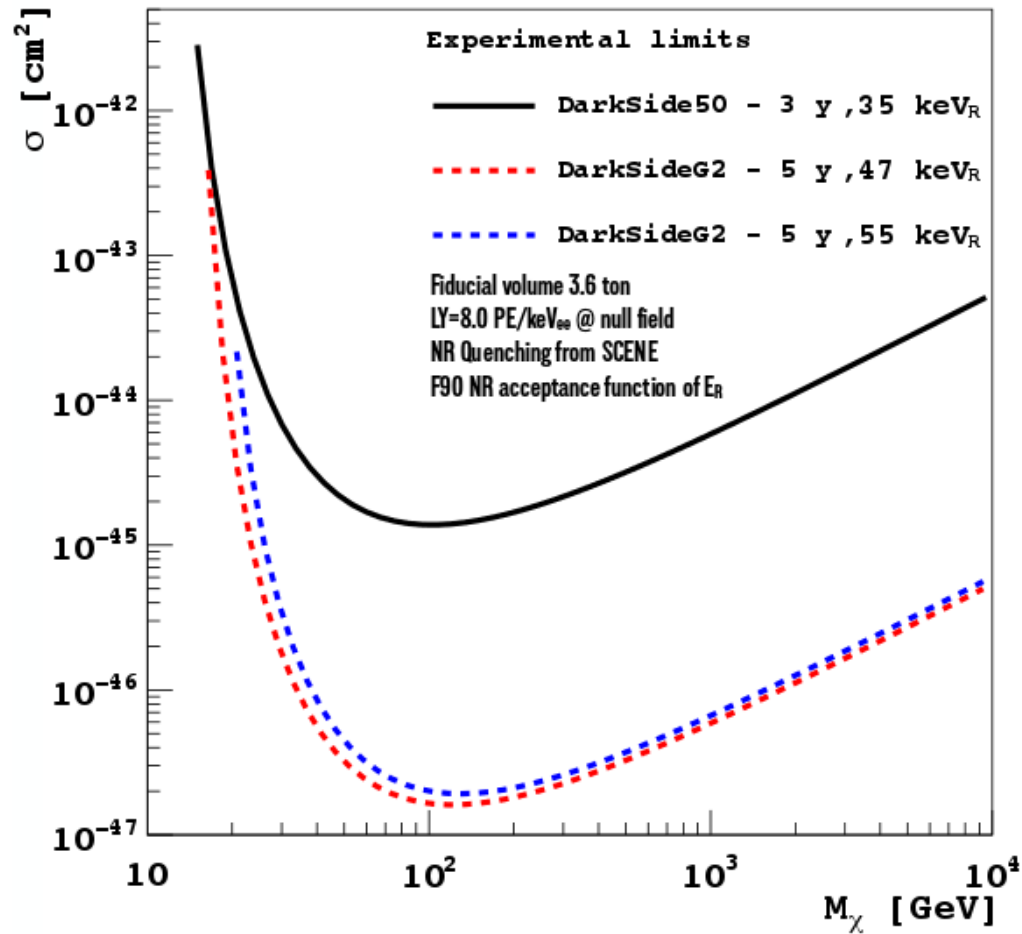
**Excellent agreement**

# G2 simulation

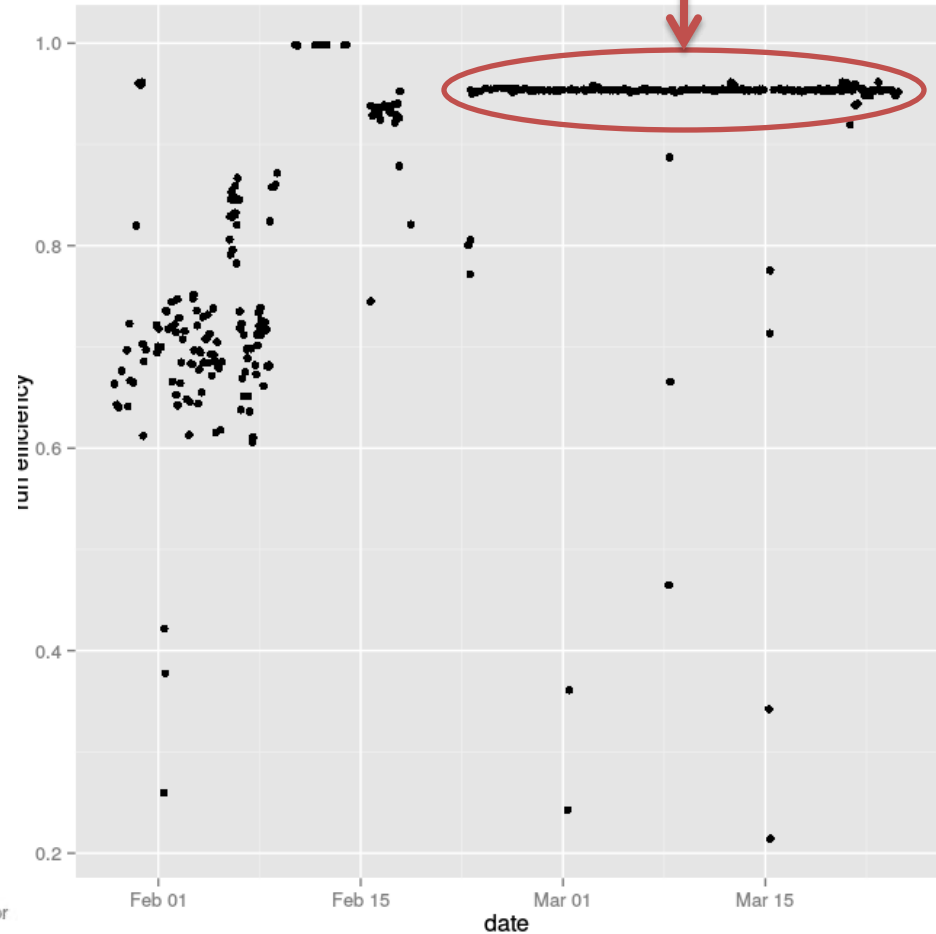
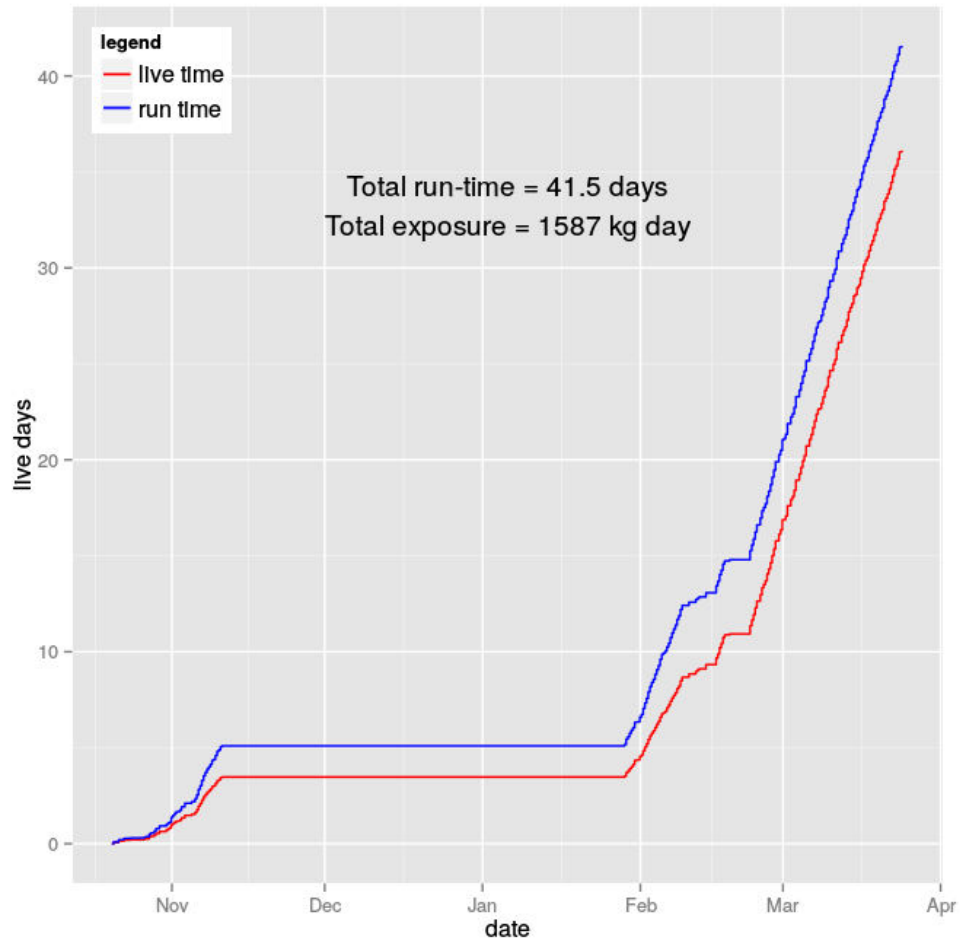


Considering same LY as DS50, same F90, NR from scene

# Projected sensitivity for DS-50 and G2



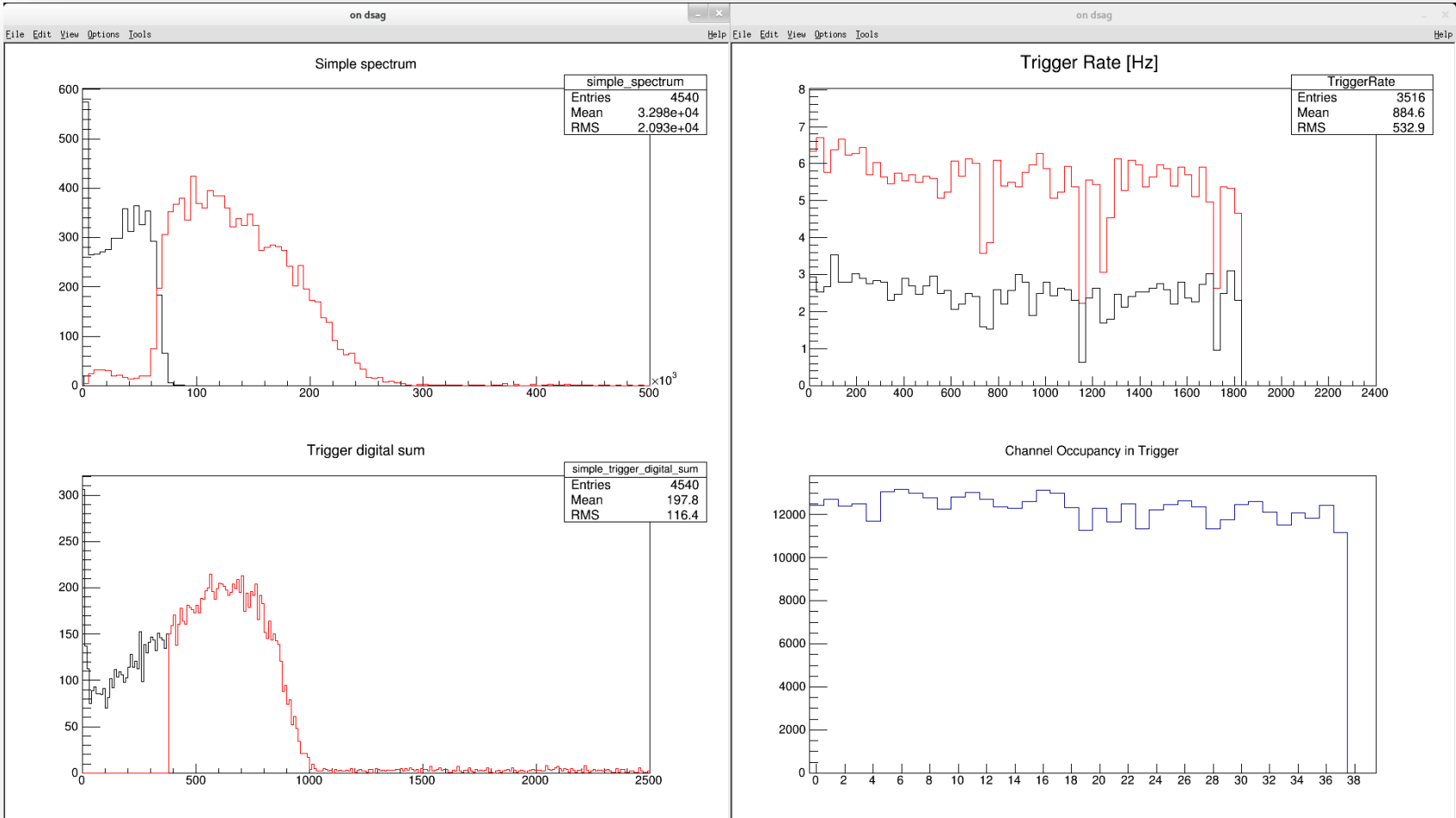
# Live time



Fiducial volume -> 44 kg

- We accumulated  $\sim 1600$  kg day as of March 23
- We are accumulating  $\sim 40$  kg day / day

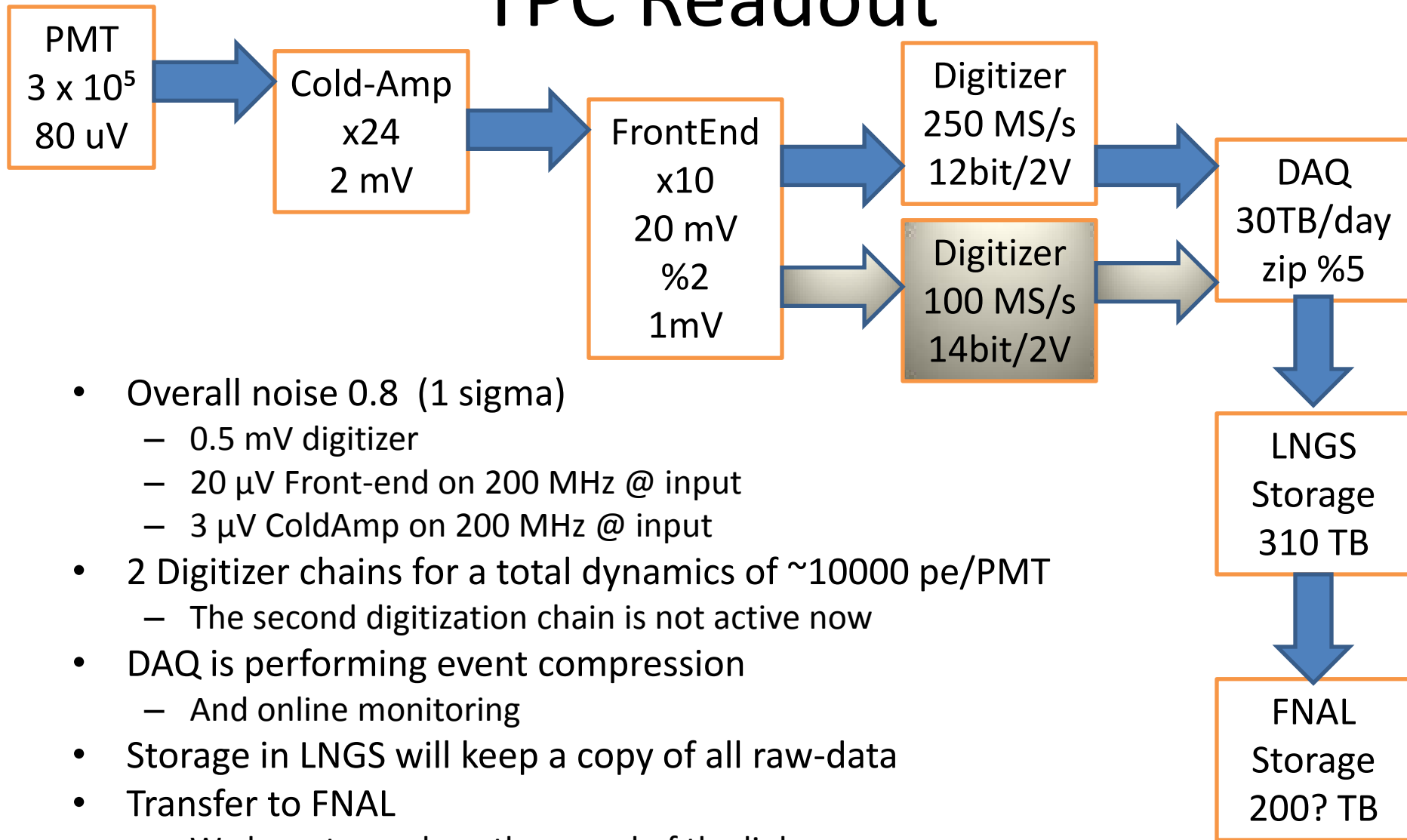
# G2 trigger



TPC read-out @ LNGS



# TPC Readout



- Overall noise 0.8 (1 sigma)
  - 0.5 mV digitizer
  - 20  $\mu$ V Front-end on 200 MHz @ input
  - 3  $\mu$ V ColdAmp on 200 MHz @ input
- 2 Digitizer chains for a total dynamics of  $\sim 10000$  pe/PMT
  - The second digitization chain is not active now
- DAQ is performing event compression
  - And online monitoring
- Storage in LNGS will keep a copy of all raw-data
- Transfer to FNAL
  - We have to work on the speed of the link

# Cold-Amp

- A signal amplifier realized with discrete components (FET & MOSFET)
  - Bandwidth  $\sim 200$  MHz
    - DC-Like behavior
  - Power  $\sim 100$  mW
    - We have now a version doing much less
  - Dynamics  $\sim 3000 - 10000$  pe
    - i.e. 3.2 V
  - Clean components

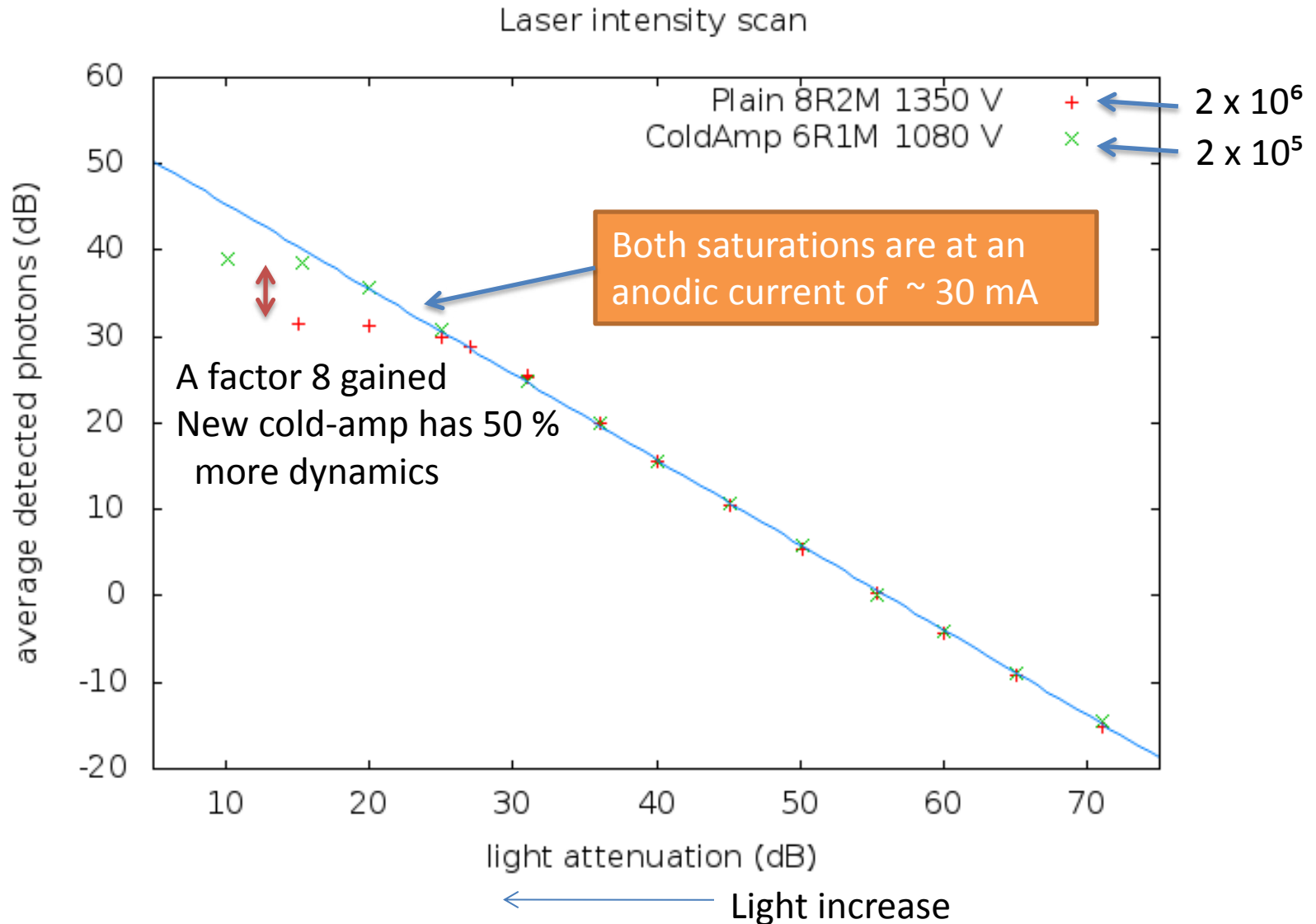
# PMTs + Cold-Amps



# Why are CA needed?

- **At  $4 \times 10^6$  gain our PMTs do not work in LAr**
- In DS-10 few PMTs x week was going in streaming mode
- In the test commissioning we had 4 batches
  - R11065-20 all flashing at 900 V at LAr temperature
  - R11065-10 1 working & 1 with streaming mode
  - R11065-0 working but with streaming mode
  - **R11065-0 + CA working flawless**
- Cold-Amplifiers allow to run the PMT at a lower gain
  - Lower dynodic/anodic current
  - Higher dynamics

# PMT Dynamics – Pulsed light

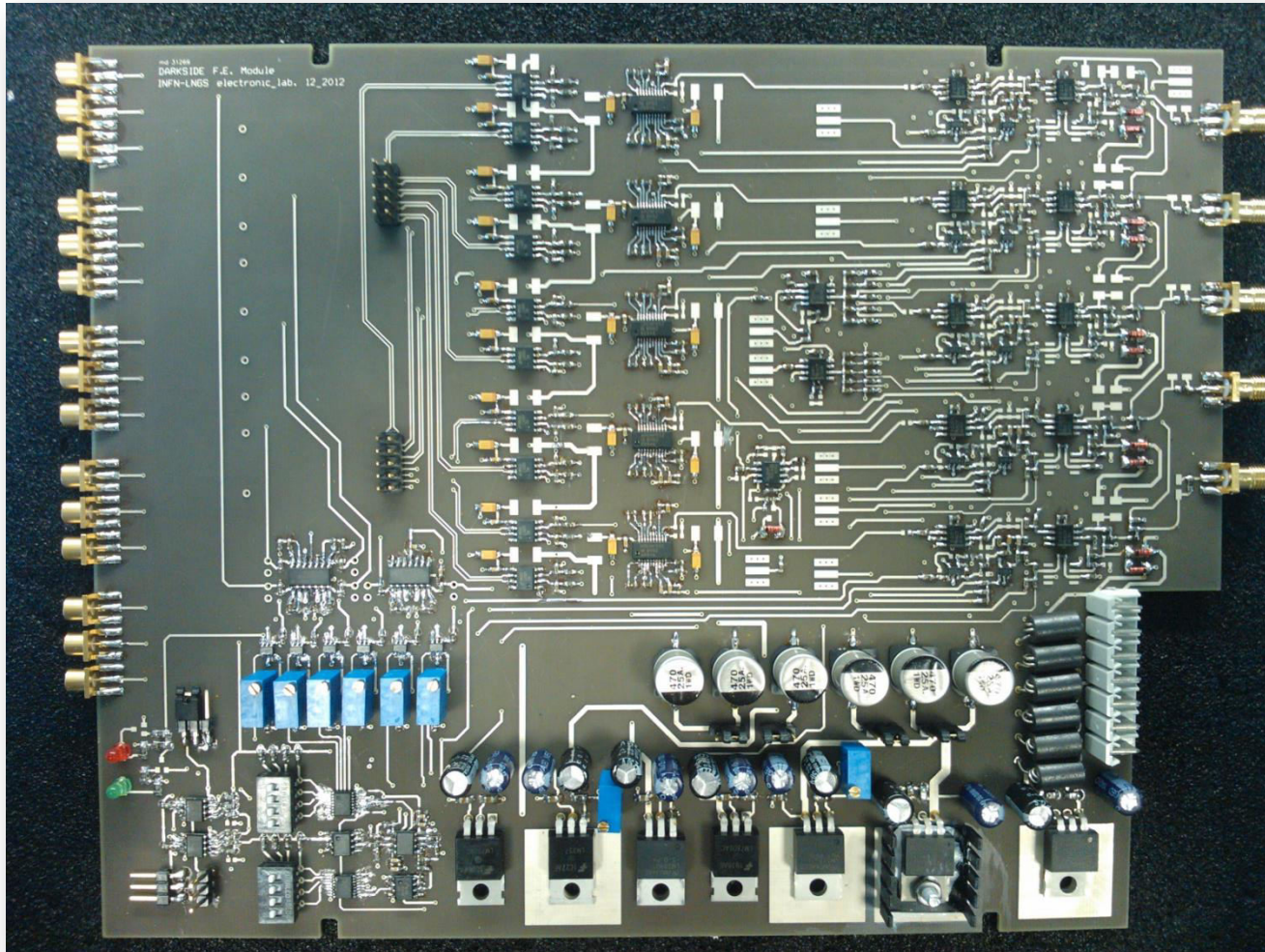


# TPC Front-end

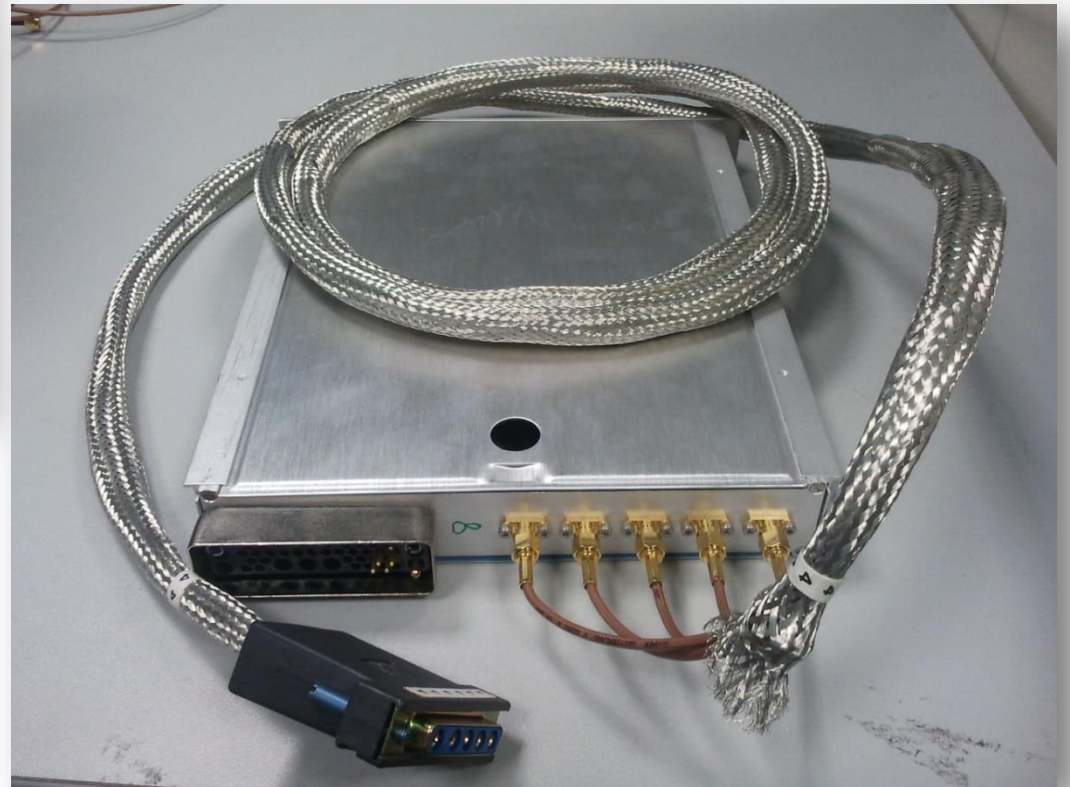
- NIM Board
  - 5 channel x board
- Many outputs
  - 2 @ 10x
    - 1 with 100 MHz shaping
  - 1 @ 1x
    - with 40 MHz shaping
  - 2 @ Discriminated
    - Each channels has an independent threshold
      - Programmable



# TPC Front-End (1<sup>st</sup> prototype)

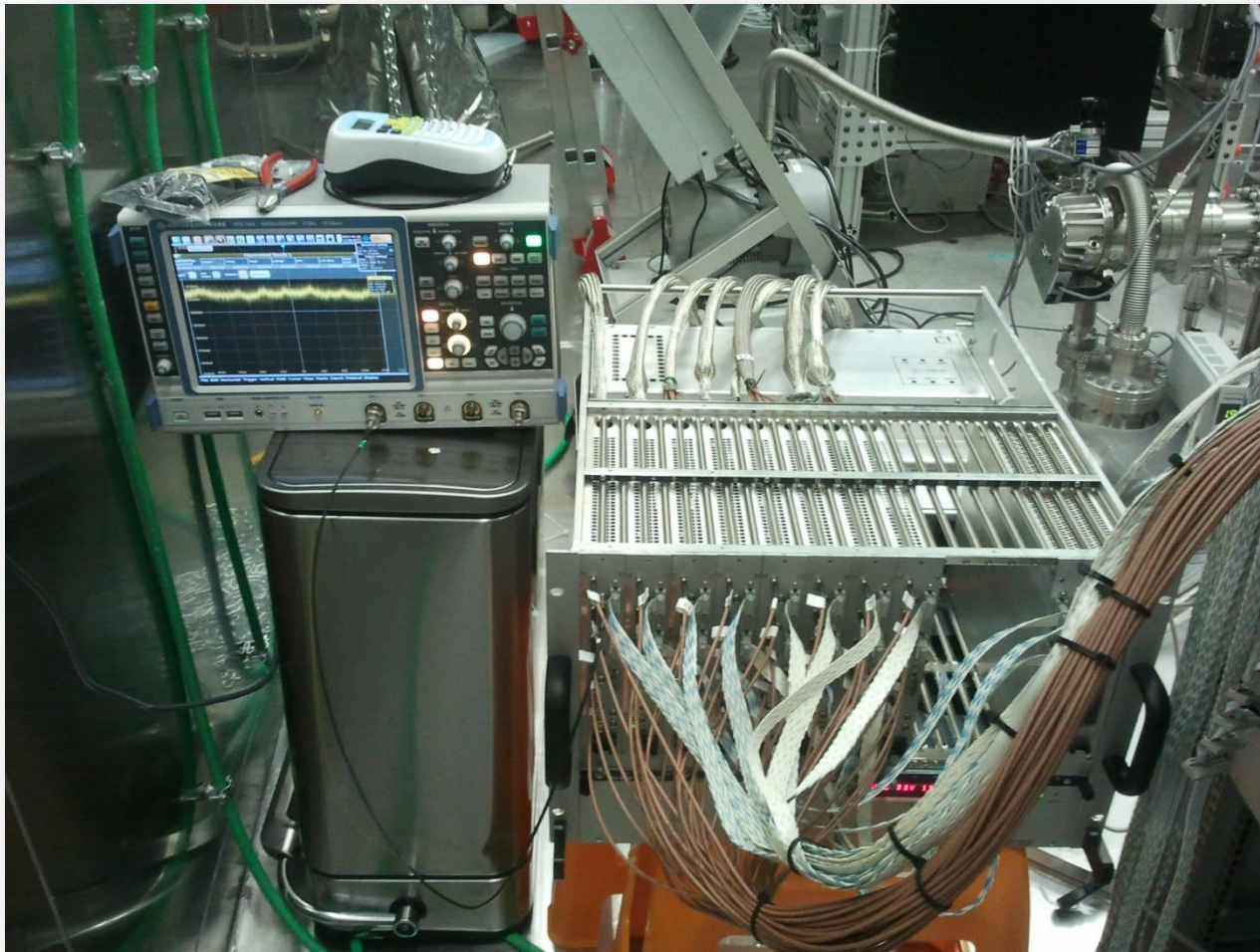


# TPC Front-End





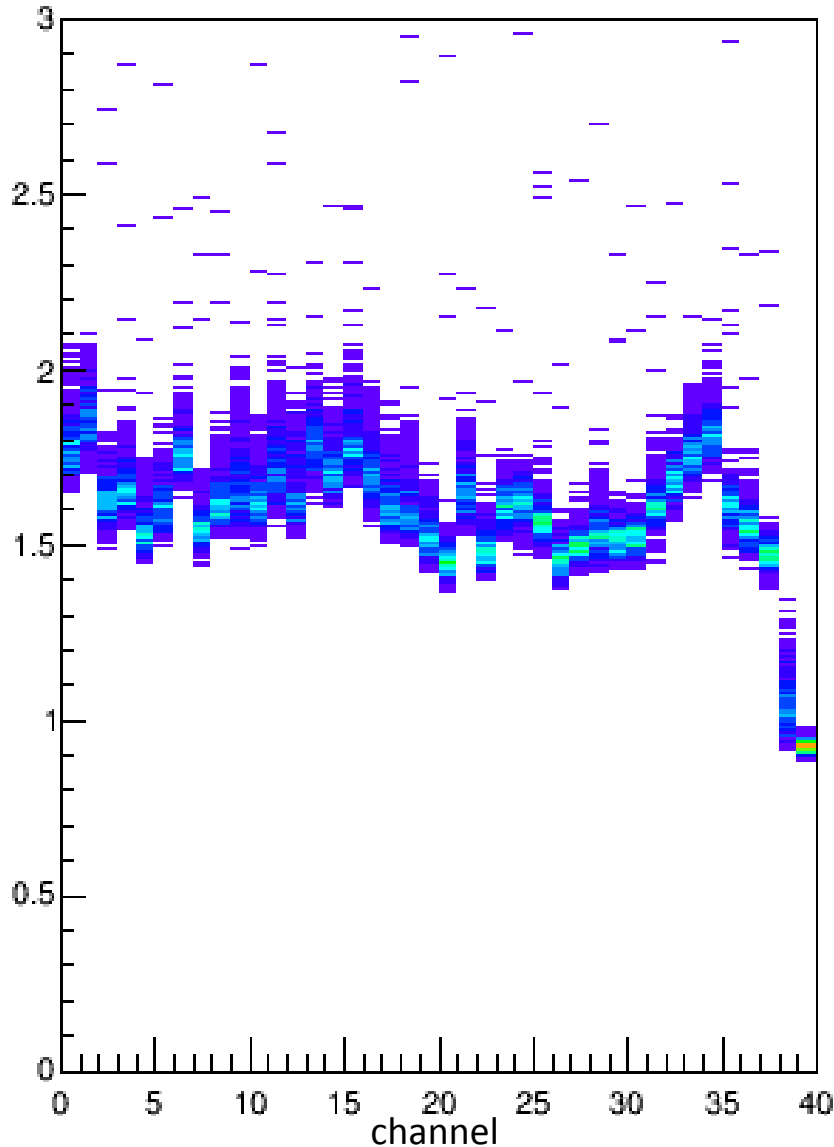
# TPC Front-End Setup in CRH



# TPC Digitizers setup



# TPC Noise analysis

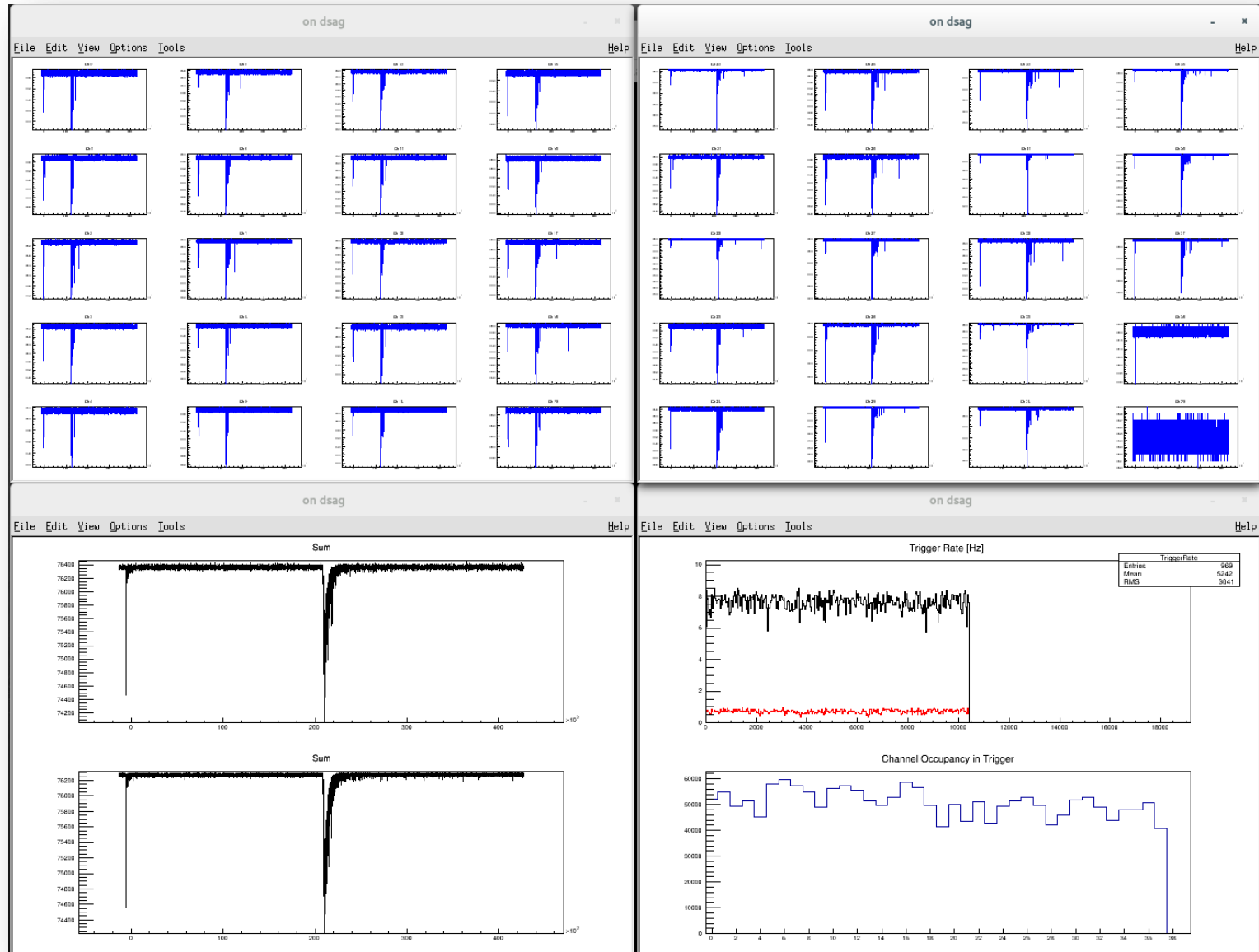


- This plot is from the online monitor
- The last 2 channels have no cold-amp
- 1 unit in vertical is 0.5 mV
- The digitizer has 0.45 mV
- We move the noise from 0.5 to 0.8 mV a factor around  $\sqrt{2}$ 
  - The amplification of 240 V/V provides the same order of noise of the digitizer

# Online monitor and data quality

- Online monitor up & running since Oct
- Online monitor embedded in the DAQ
- Many modules were developed
  - Waveform display
  - Laser SER display and fit
  - Noise monitor
  - Trigger monitor
  - S1 energy spectrum
  - Live time & run metadata

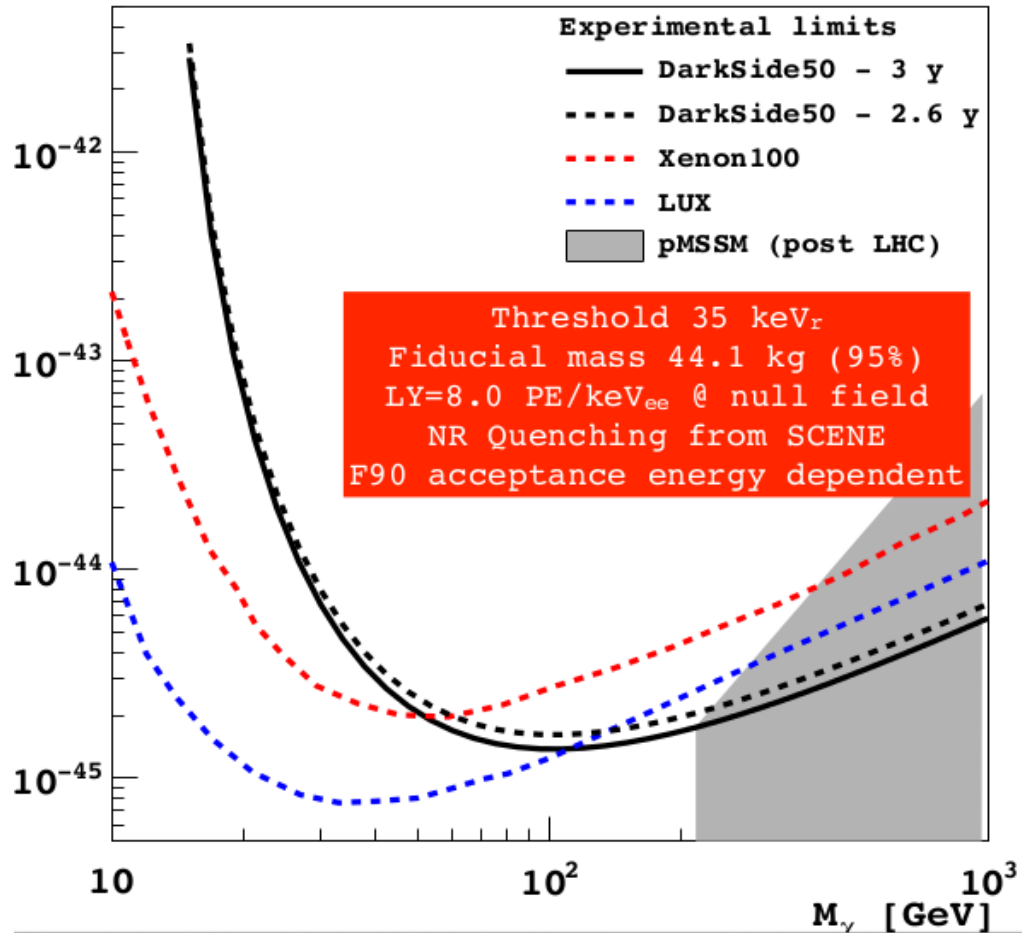
# Online monitor plots



# Conclusion

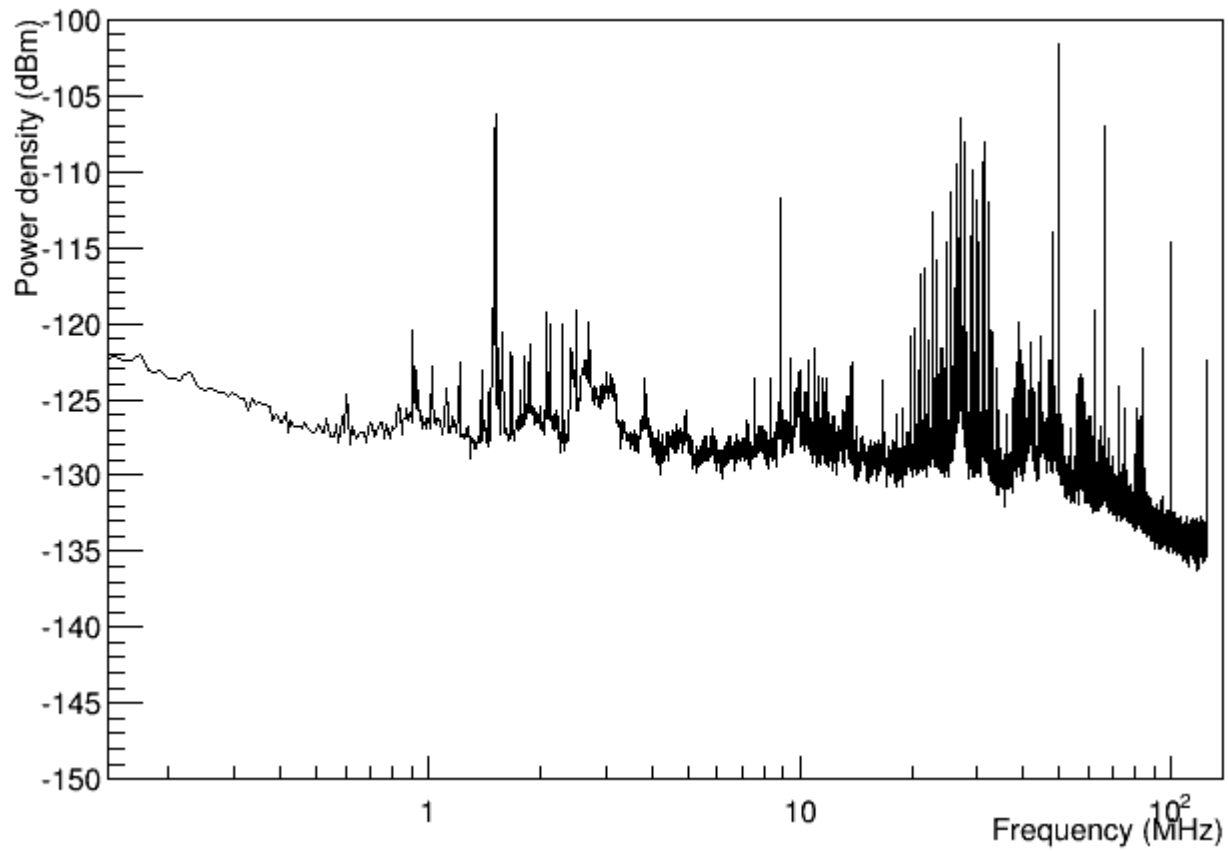
- Darkside-50 is taking data
- LNGS group gave important contributions
- In June we will perform calibrations
  - Including a  $^{39}\text{Ar}$  spike
- Underground Ar will arrive in July

# Backup slides



# FFT

Graph





# Scene

