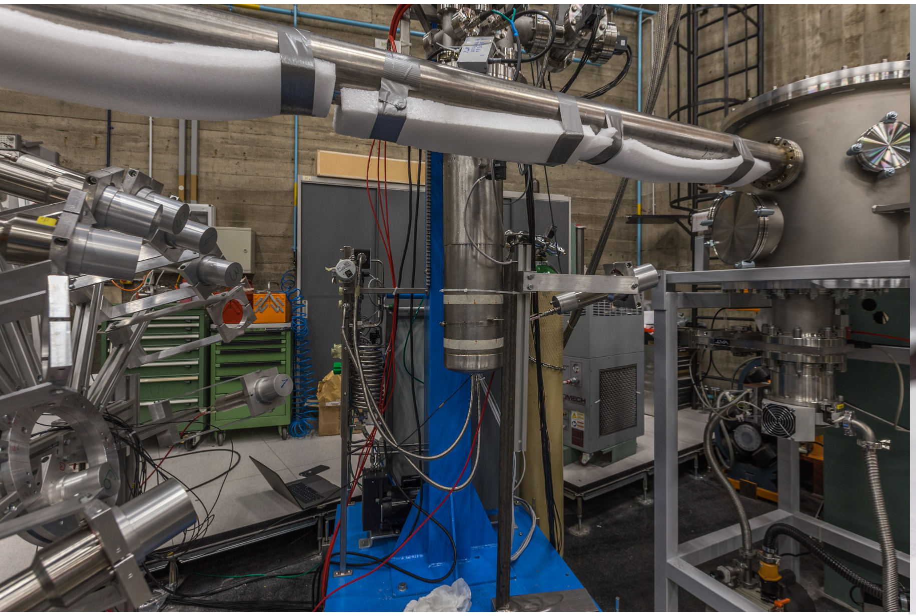
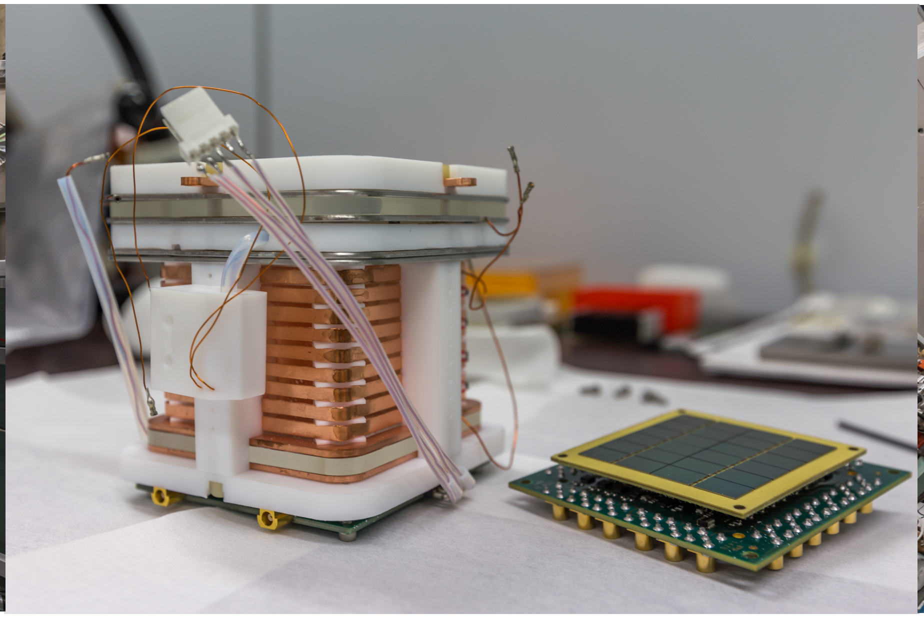
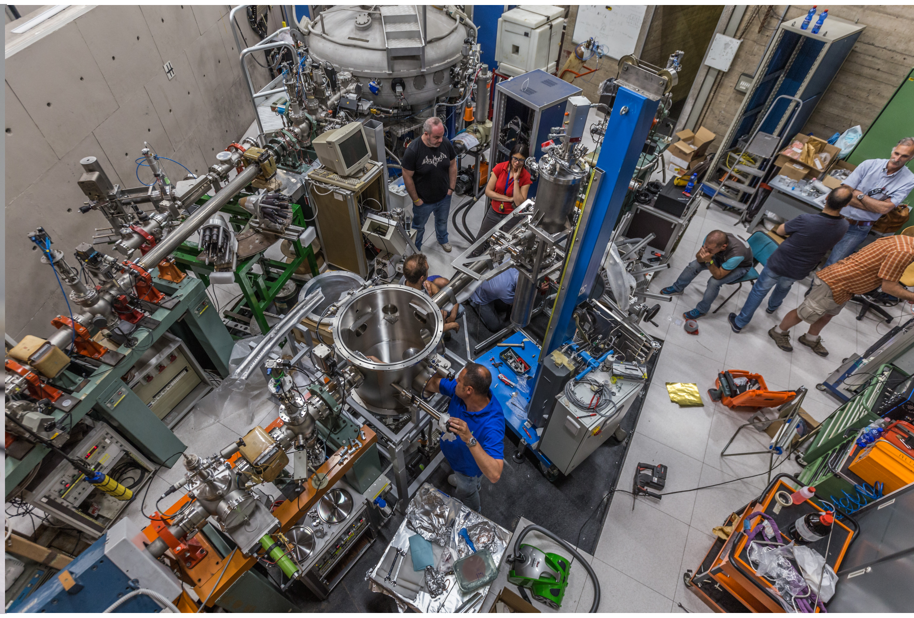
# ReD experiment
# Current Status

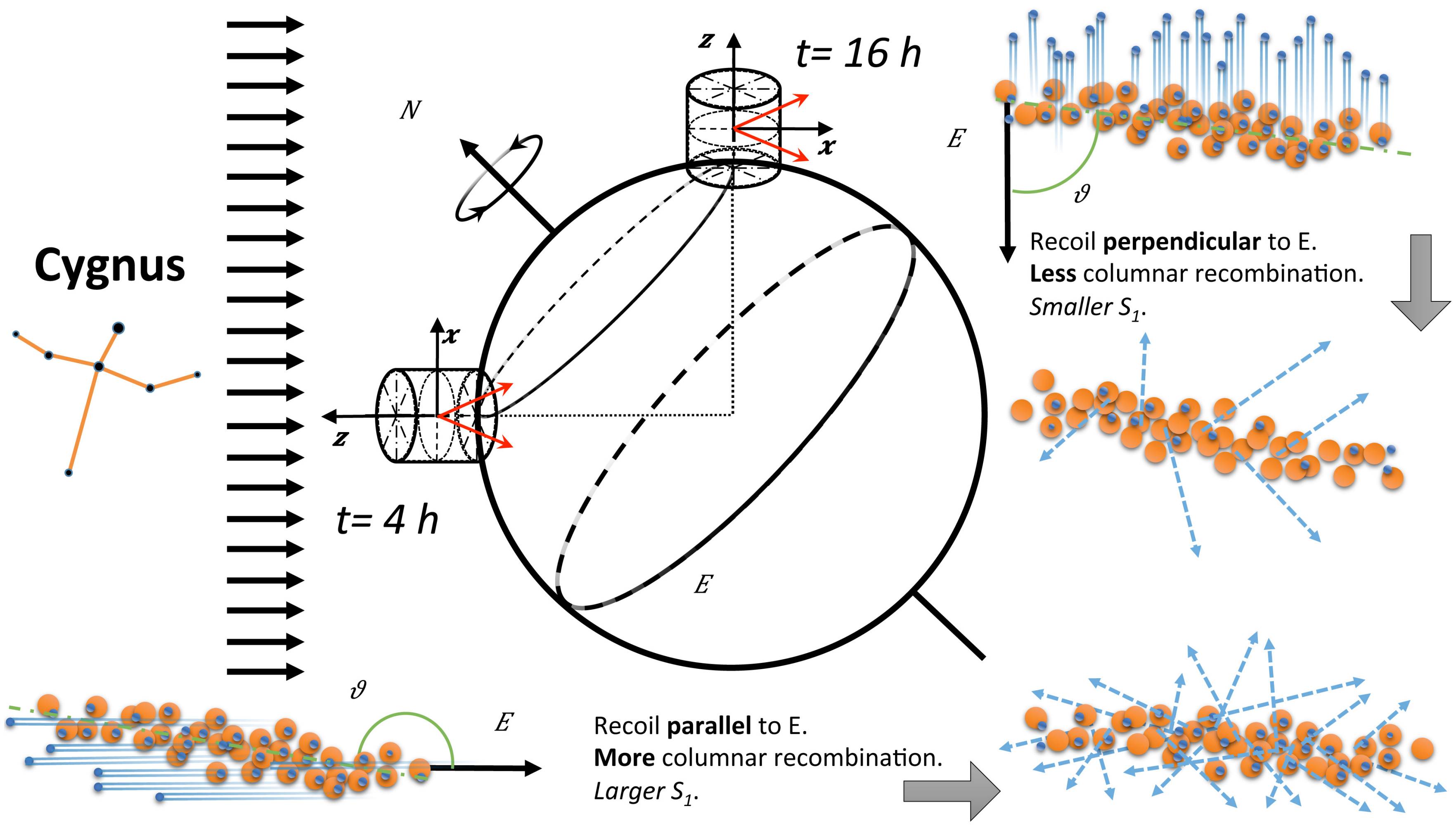




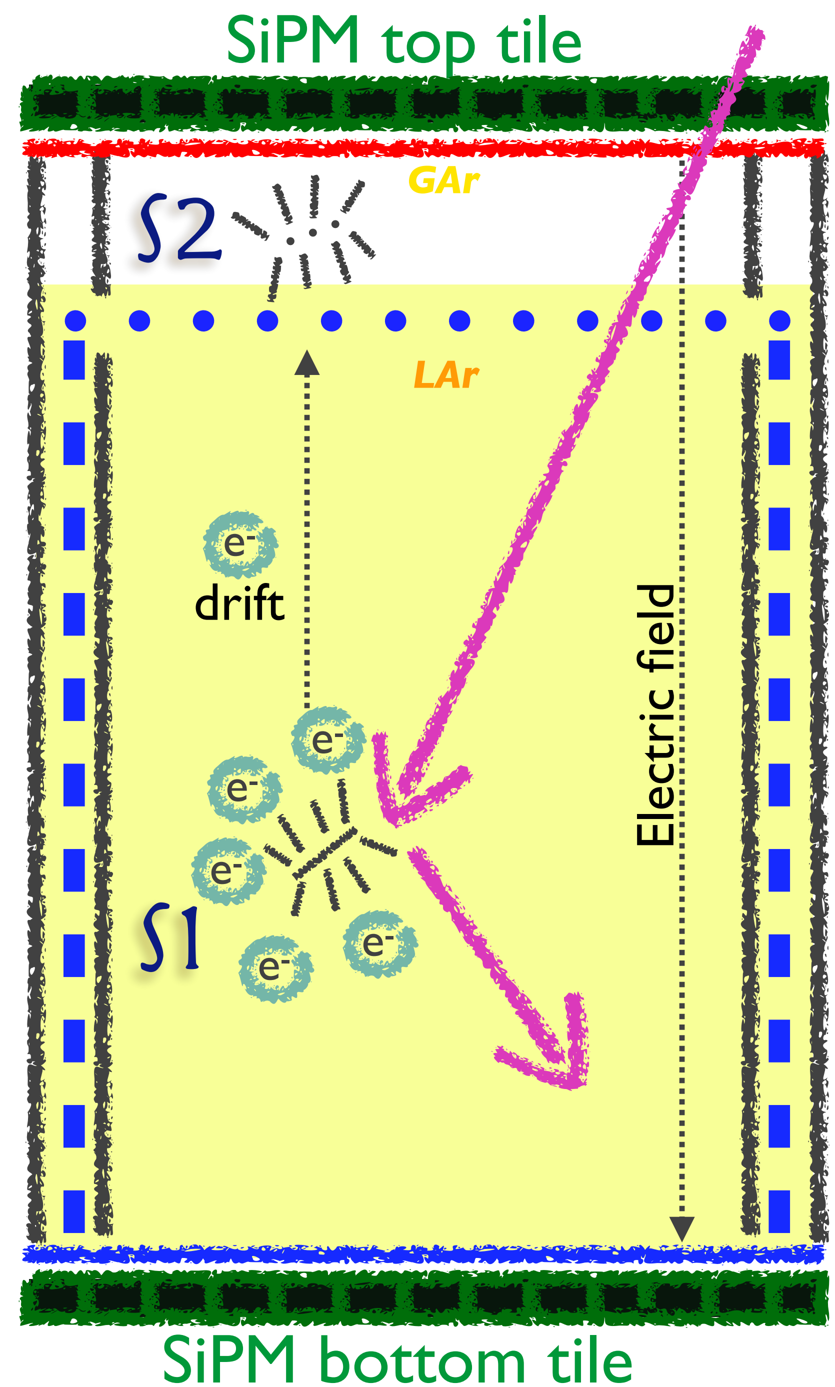
Yury Suvorov,
Physics Department of University of Naples Federico II
on behalf of DarkSide & ReD collaboration

October 25th, ICPPA Moscow

# Directionality concept

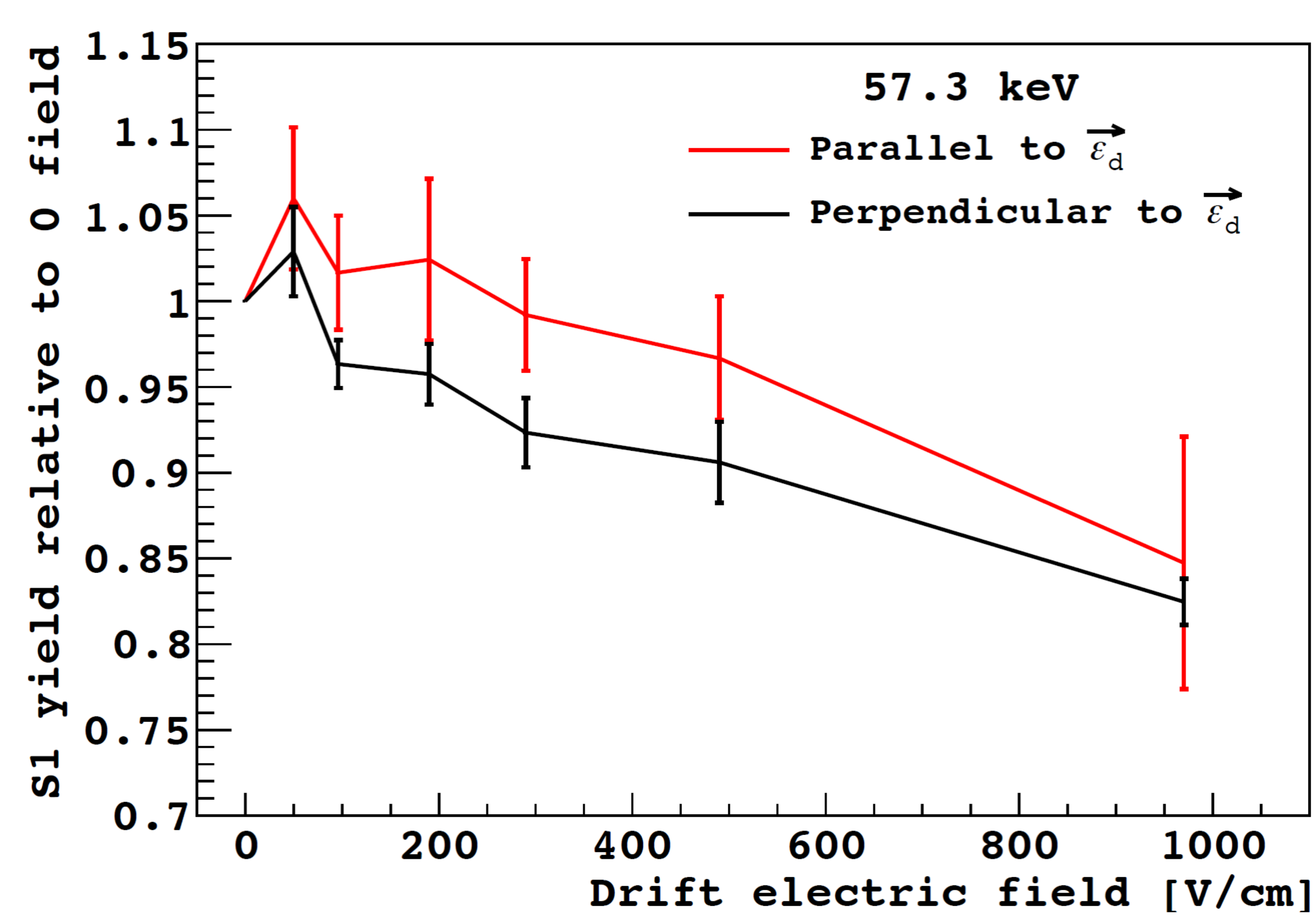
- Sidereal variation of WIMP wind from Cygnus, results in a substantial anisotropy in nuclear recoils;
- Ratio of horizontal WIMP induced Ar recoils to vertical ones, varies of a factor 10 over the day;
- Hard for the background to mimic the directional signal.



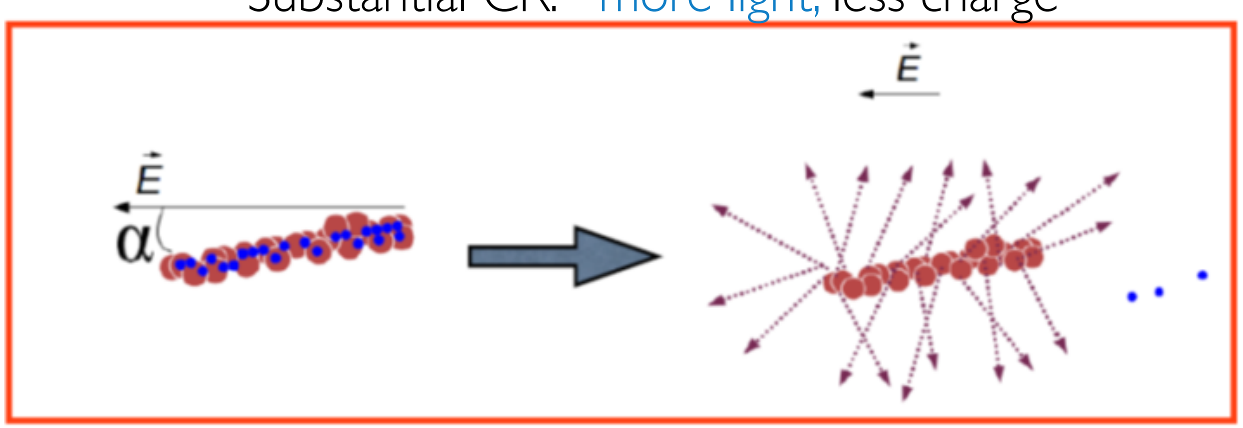




Columnar Recombination:
When a nuclear recoil is parallel to the electric field, there will be more electron-ion recombination since the electron passes more ions as it drifts through the core of the track.

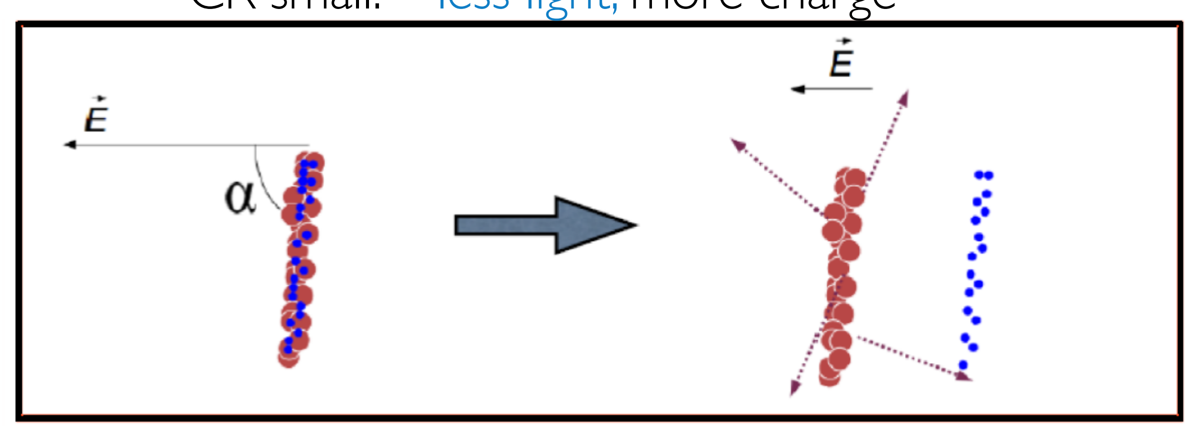
# Columnar Recombination, SCENE case




Substantial CR: more light, less charge




CR small: less light, more charge




Hint for anisotropy at 57.2 keV nuclear recoils



H. Cao et al., Phys. Rev. D 91 (2015) 092007

# LNS Tandem. The 80° beam-line

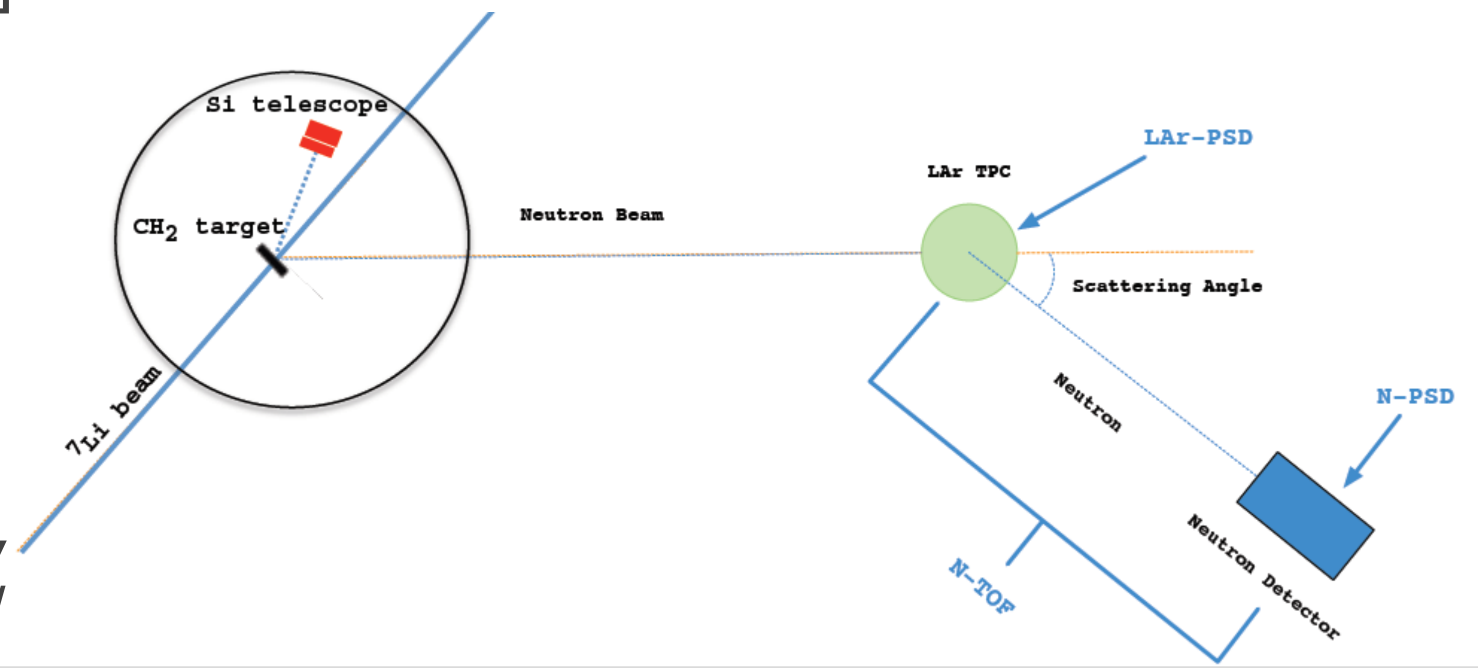
## Laboratori Nazionali del Sud (LNS), INFN Catania, Italy

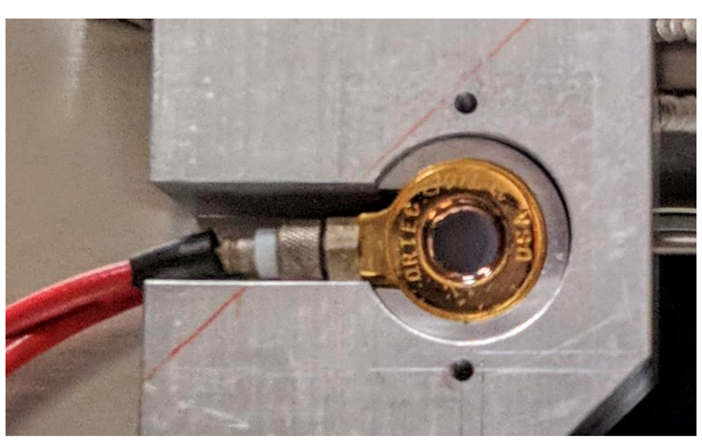
The 80° beam line, refurbished and equipped for ReD with new, custom made scattering chamber.

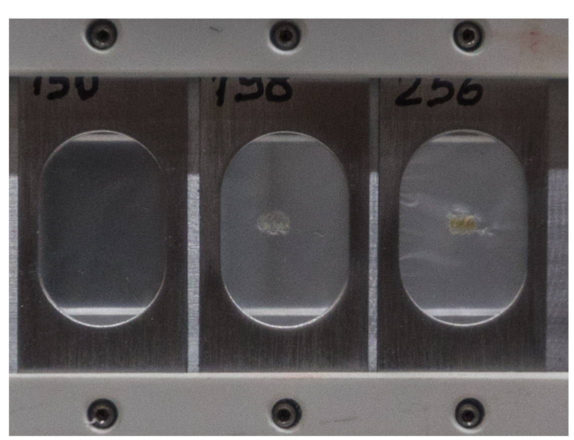
Continuous beam of $^{7}Li$ ions (range 17-60 MeV), intensity 0.2-7 nA given by the 15 MV TANDEM machine. Recoil energies from ~(1-100) $keV_{NR}$.

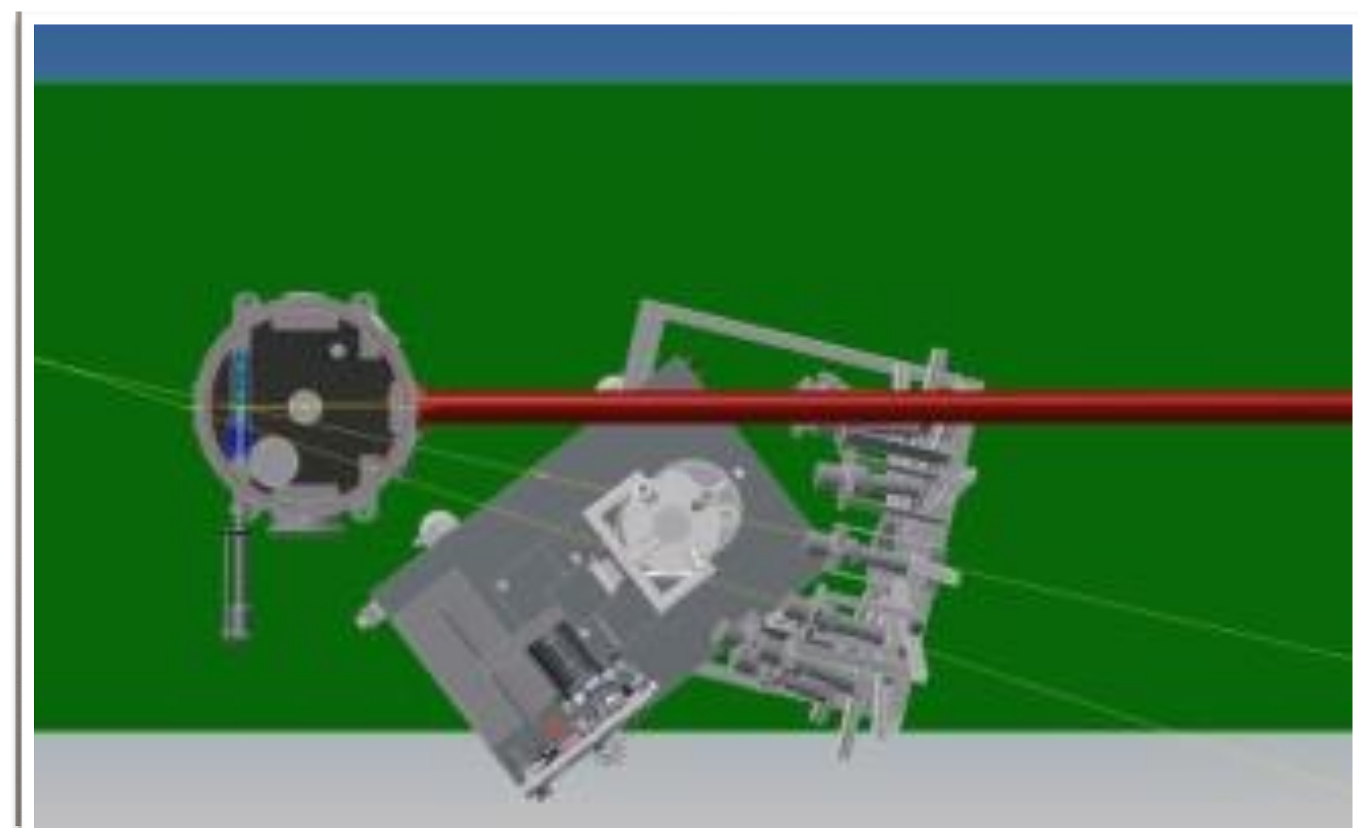
Reaction p($^{7}Li$,$^{7}Be$)n to produce neutrons by the $^{7}Li$ ions on the $CH_2$ targets (150-250 ug/cm$^2$). $^{7}Li$ of 28 MeV — neutron of ~7 MeV — recoil in the TPC of ~70 $keV_{NR}$.

$^{7}Be$ detection by the dE-E telescope made of Si detectors (20 and 1000 um) gives the start time and point at neutron in the TPC.



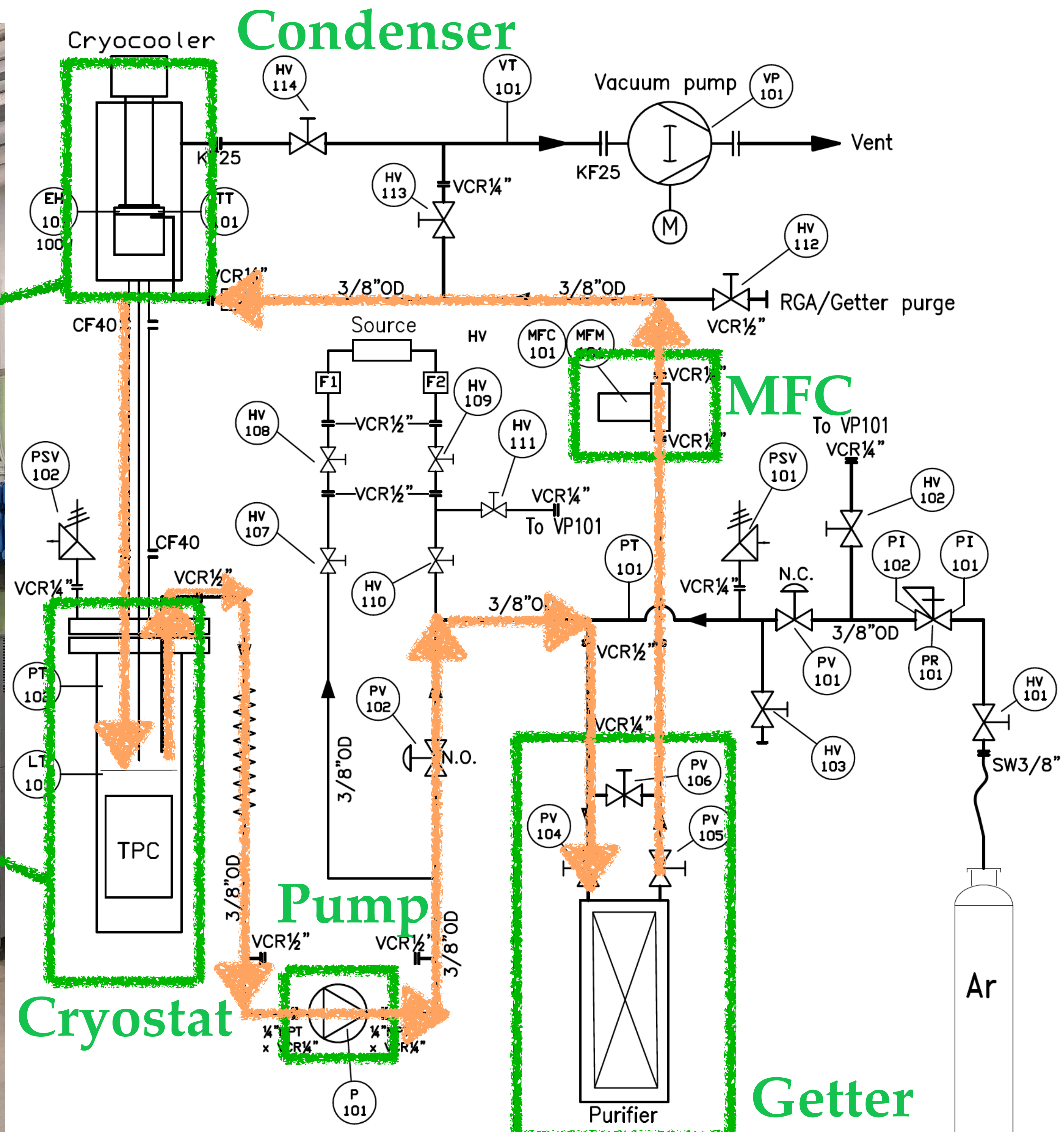




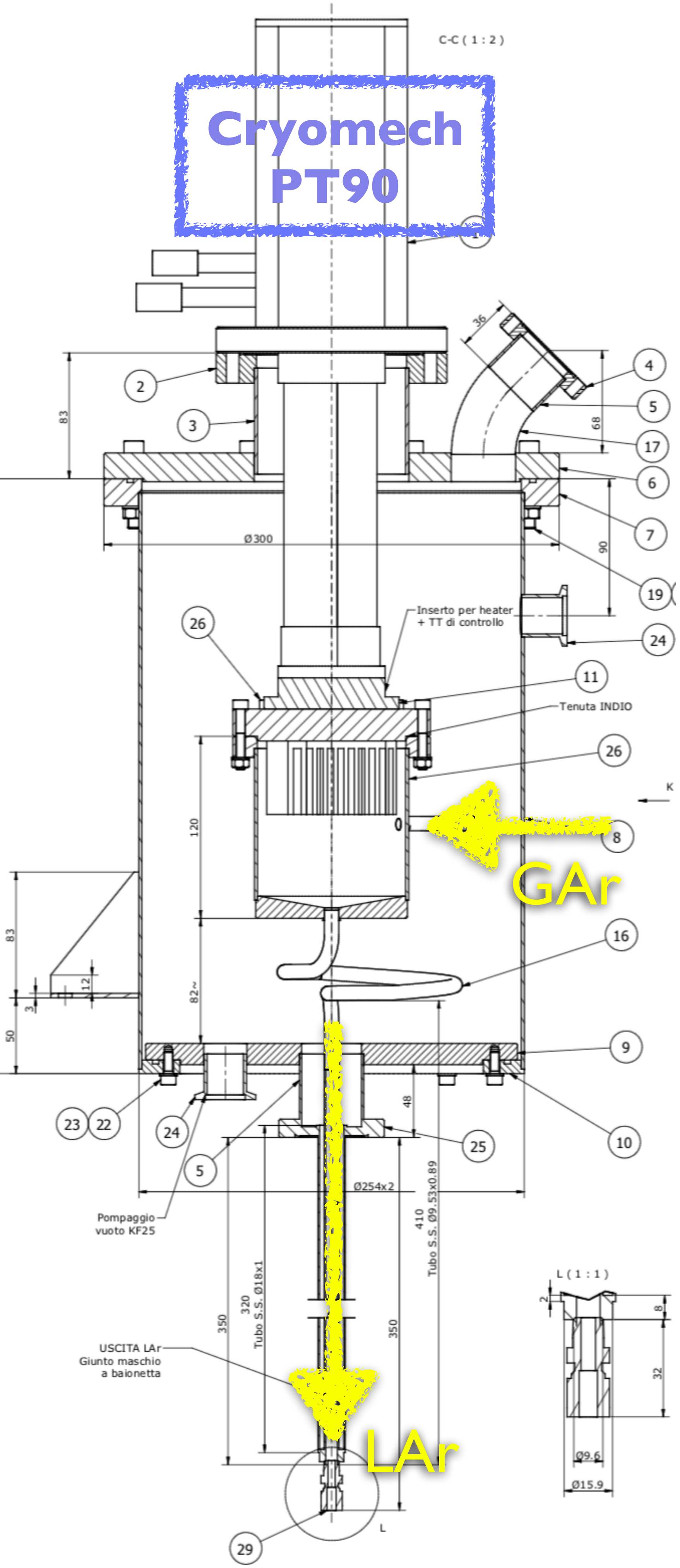
# ReD. Overview

- The nine 3" LScint detectors (neutron detectors),
- The TPC with its cryogenic system and NI based slow control,
- The Scattering Chamber with dE-E telescope @5deg and E @23 deg.

# ReD. The cryo system concept



# ReD. Condenser



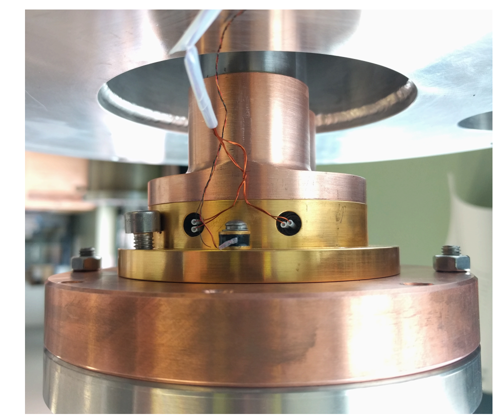

Custom made Ar Condenser (on our design).

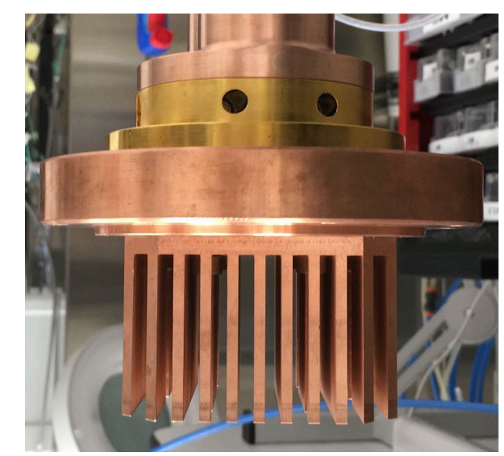
Cooling power provided by the Cryomech cold head PT90 (90W), coupled with air-cooled compressor CP2800.

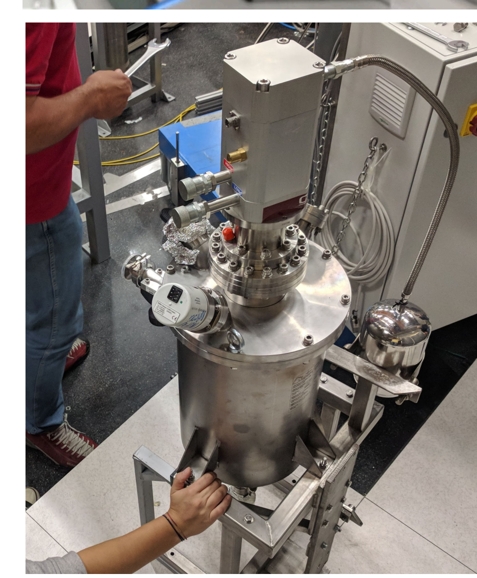
The cryomech cold head temperature is controlled by the heater.

Super insulation layers on the inner chamber. Indium foil for the proper copper parts coupling.

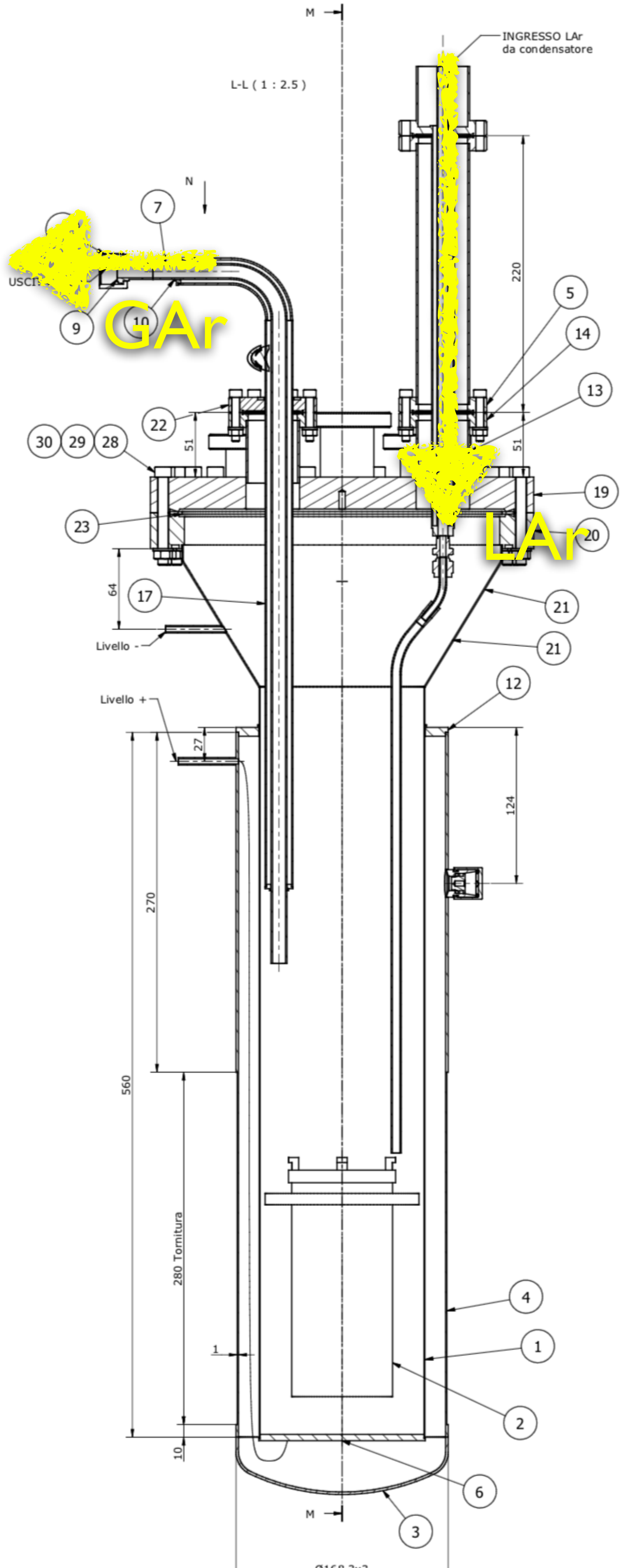
Cool down time: down to 87K in 1h.
Filling speed: 5 LAr in ~10h.







# ReD. Cryostat

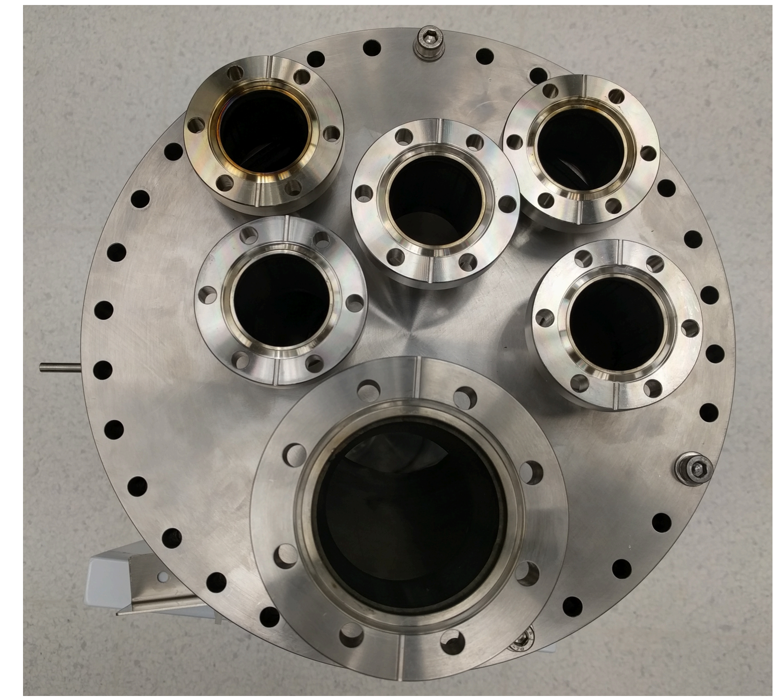



Double wall cryostat. 13 cm inner diameter, ~ 7.5 L. CF 250 top flange (copper seal).

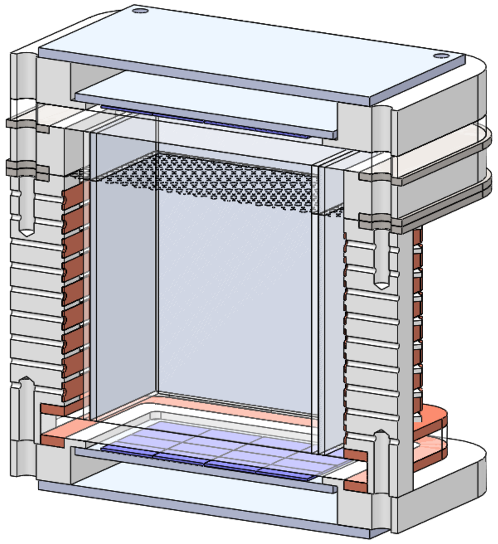
5 CF40+1 CF63 service flanges.

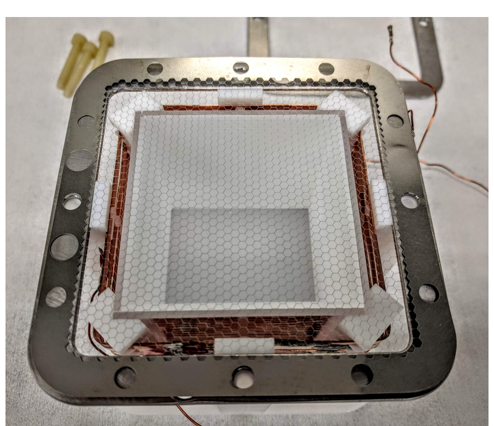
Integrated level measuring system (basted on dP).

Double wall LAr inlet line and outlet line for GAr.



# ReD. Time Projection Chamber





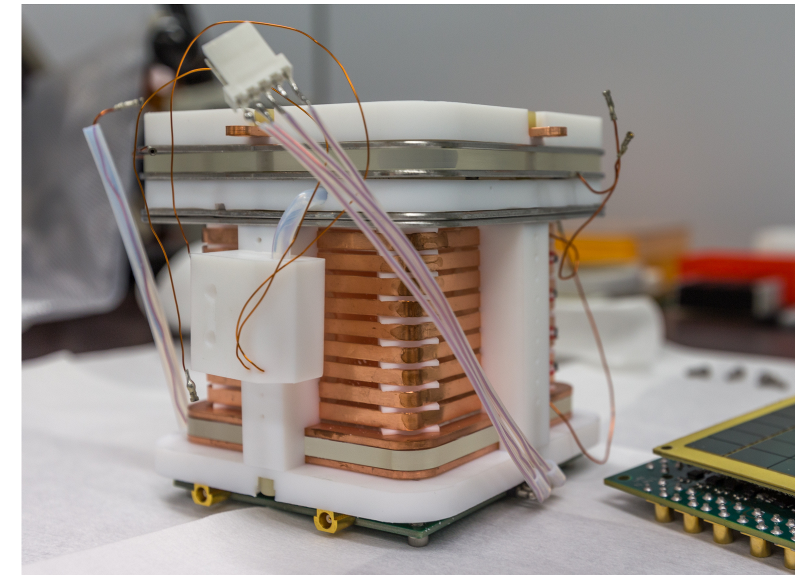
- The 10x10x10 $cm^3$ external (5x5x6x$m^3$ LAr volume) double phase LAr TPC designed & constructed @ UCLA (Yi Wang and Hanguo Wang).

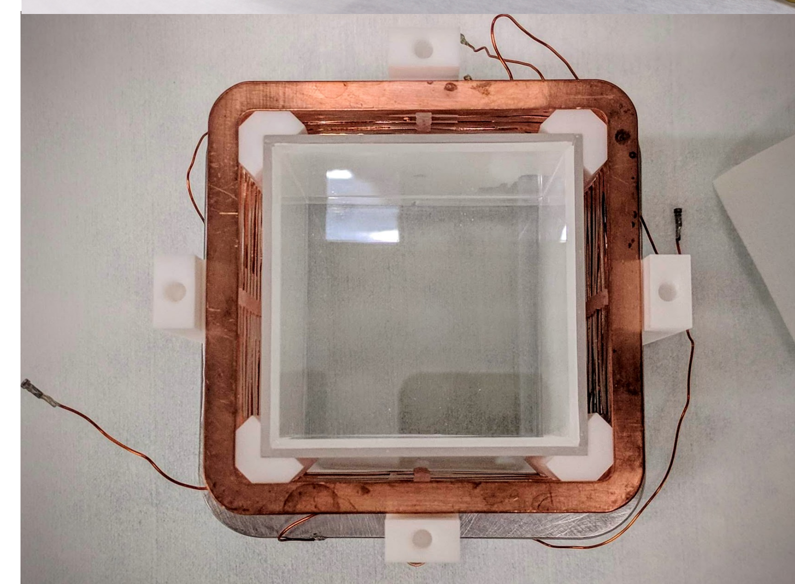
- Teflon pillars structure. Four internal (at the corners) and four external to hold the copper drift field shaping rings and the inner cube.

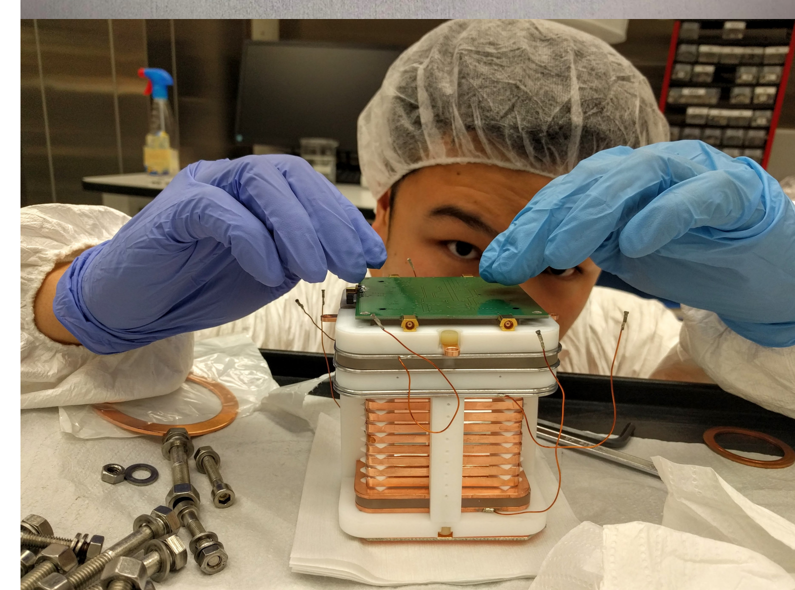
- Acrylic-ESR 3M sandwich reflective panels as walls to delimit the LAr volume on four sides.

- Acrylic Anode (10x10x0.45 $cm^3$) and Cathode (7.6x7.6x0.45 $cm^3$) coated with ITO (both side) and TPB (one side),

- Hexagonal stainless steel mash for the greed,
- Teflon holders for the top and bottom SiPM sensors.
- Teflon bubblier with pt1000 to boil off the LAr and diving bell (1 cm high, gas pocket of 0.7cm).







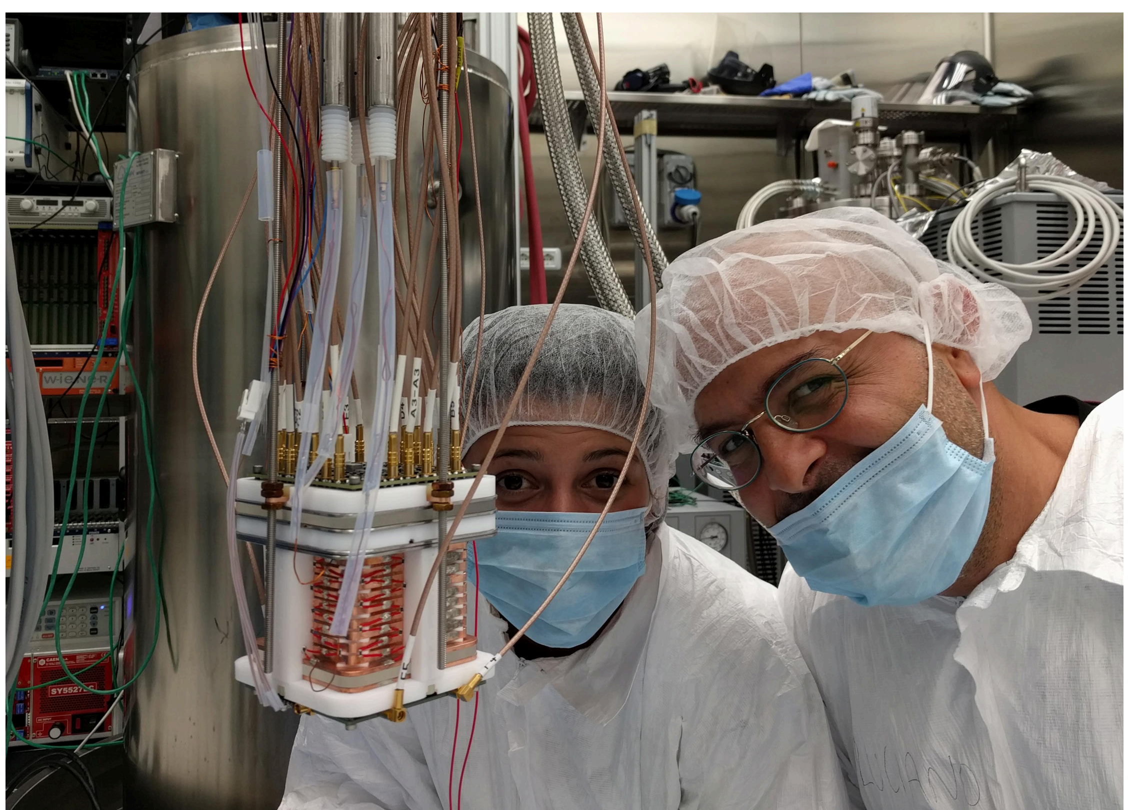
# ReD. High Voltage

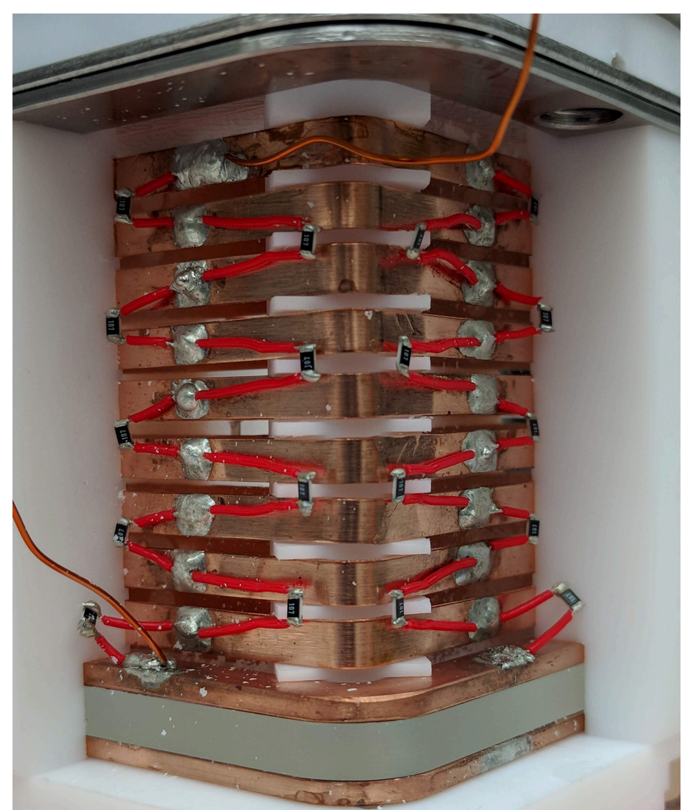
Custom made three rails HHV feedthrough (UCLA), SS + teflon, cryo-fit, CF40 flange for connection.

All rails can deliver up to 5 kV.
Three SHV20 connectors on warm side.

Cathode (-814V), Anode (+3.8kV), 1$^{st}$ ring (+85V).

200V/cm drift and 4.2kV/cm extraction filed.
HHV values simulated and tuned by the Comsol.

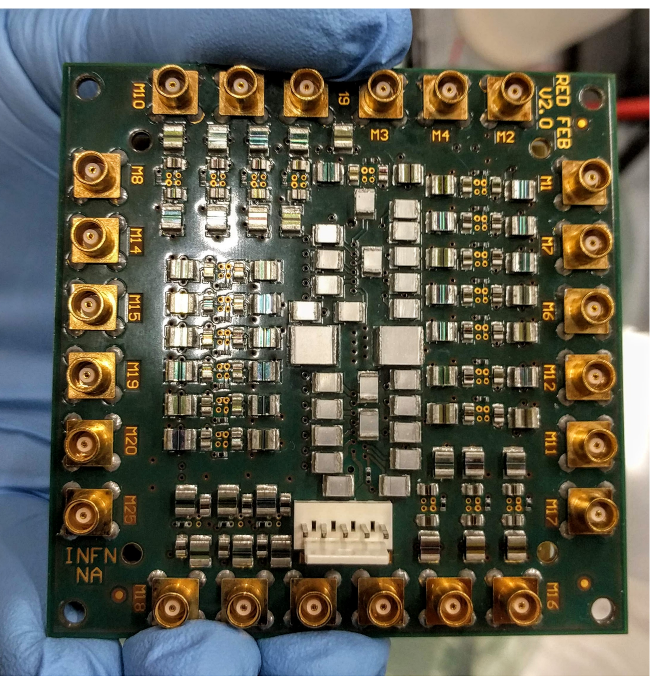


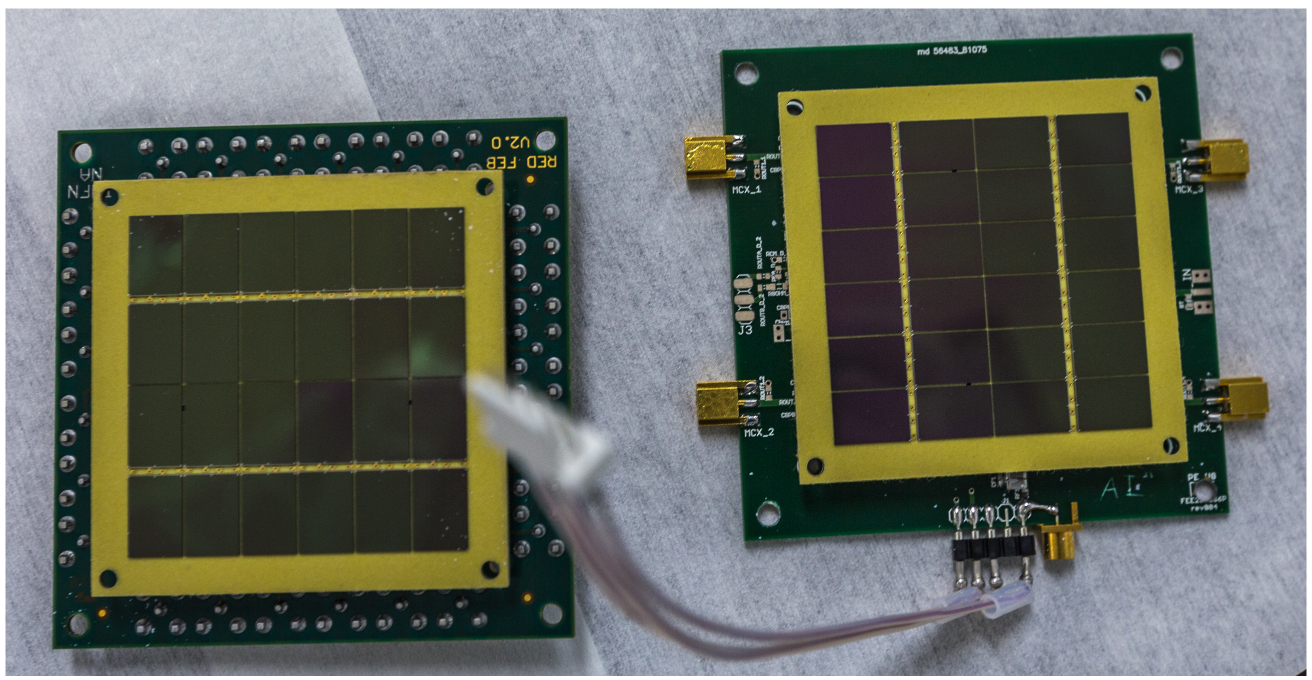


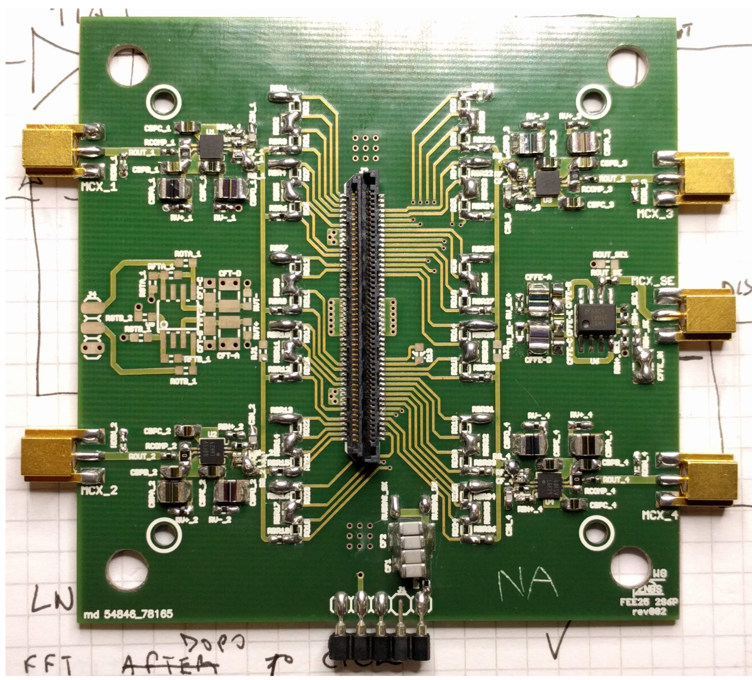
# ReD. Light and electronics readout

**Light readout:**
The Silicon Photo Multipliers developed in collaboration with Fondazione Bruno Kessler (FBK), Two 5x5 $cm^2$ tiles with 24 individual rectangular SiPMs of 12x8 $mm^2$. The 10 MΩ quenching resistance, 25x25 $\mu m^2$ cell, Arlon substrate.

Front end board electronics designed by INFN-Napoli + INFN-Bologna + LNGS.
On the Top: FBK Tile coupled with 24 channel readout FEB (to improve x-y).
On the Bottom: FBK Tile coupled with 4 channel readout FEB.





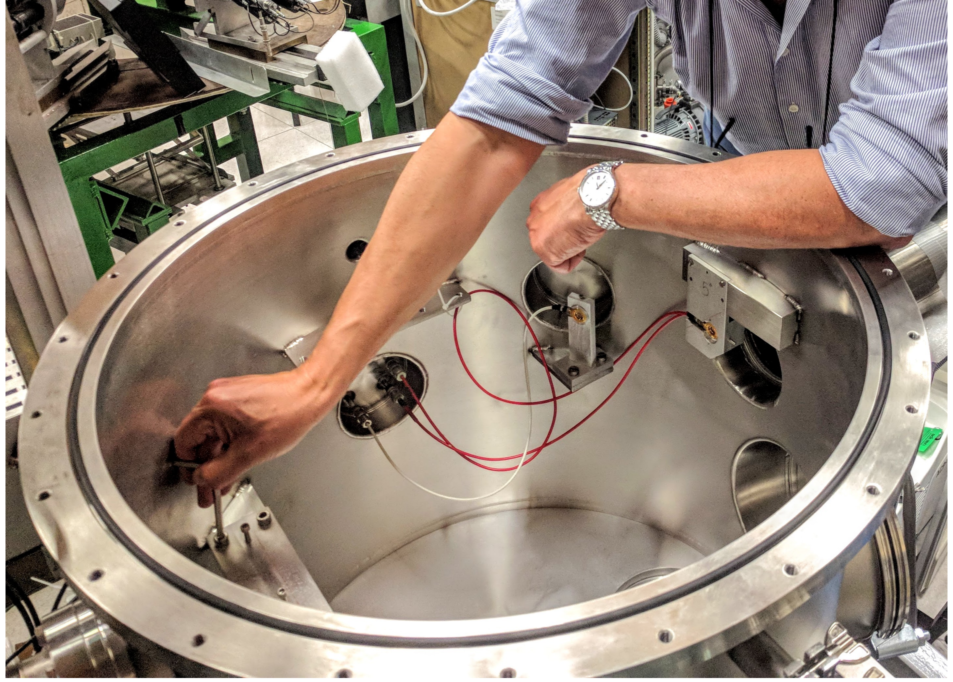


**Electronic readout:**
CAEN FADC boards V1730, 500 MHz sampling rate (data rate of 40MB/s).

Power supply for the pre-amplifiers +-2.5V and for the Vbias of 34 V.

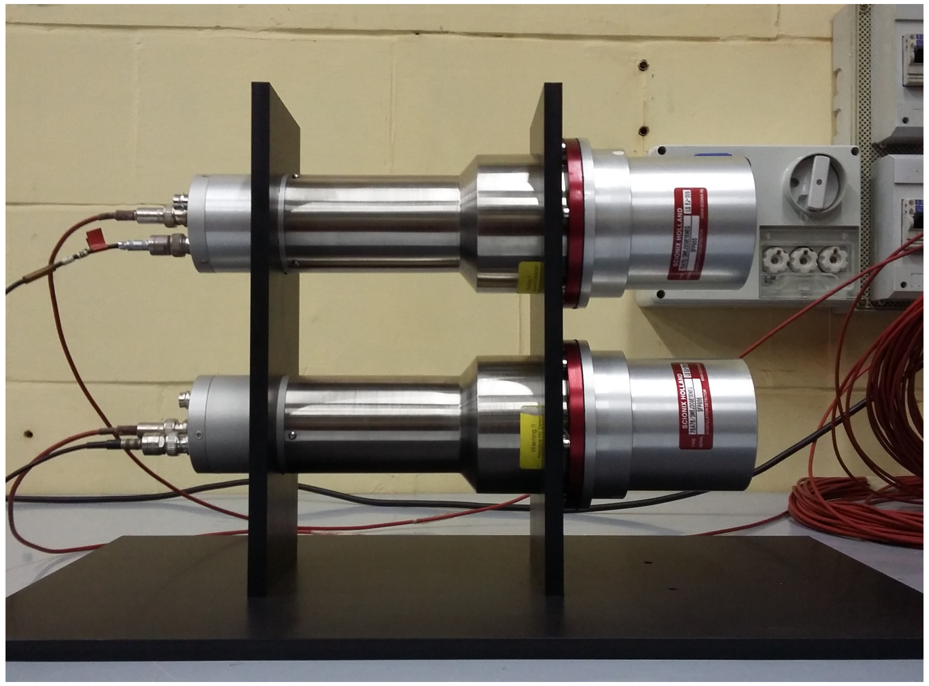
Both arrays works fine at LAr temperature (87K). DR ~1Hz/$cm^2$.

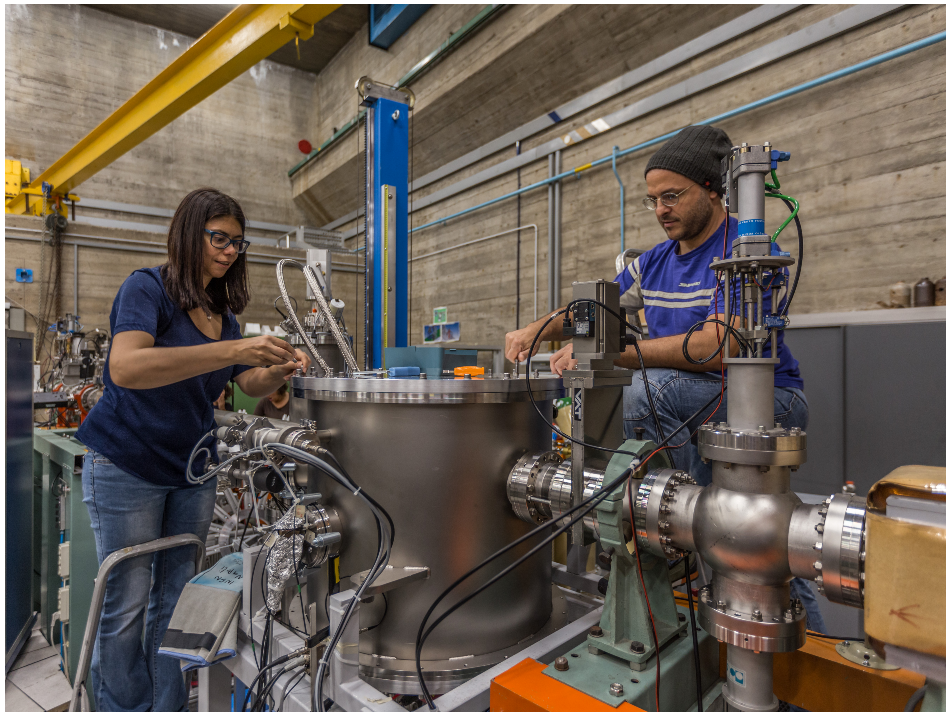
# Scattering chamber & n detectors



The $CH_2$ targets to produce neutrons & Au target for calibration purposes;
Volume: 60 cm in diameter, 60 cm in hight;
Vacuum of 10-5 mbar;
The Si dE-E telescope made of 1000um E + 20um dE );
Additional Si E defector for beam monitoring;
Neutron production yield: $10^5$ pps.

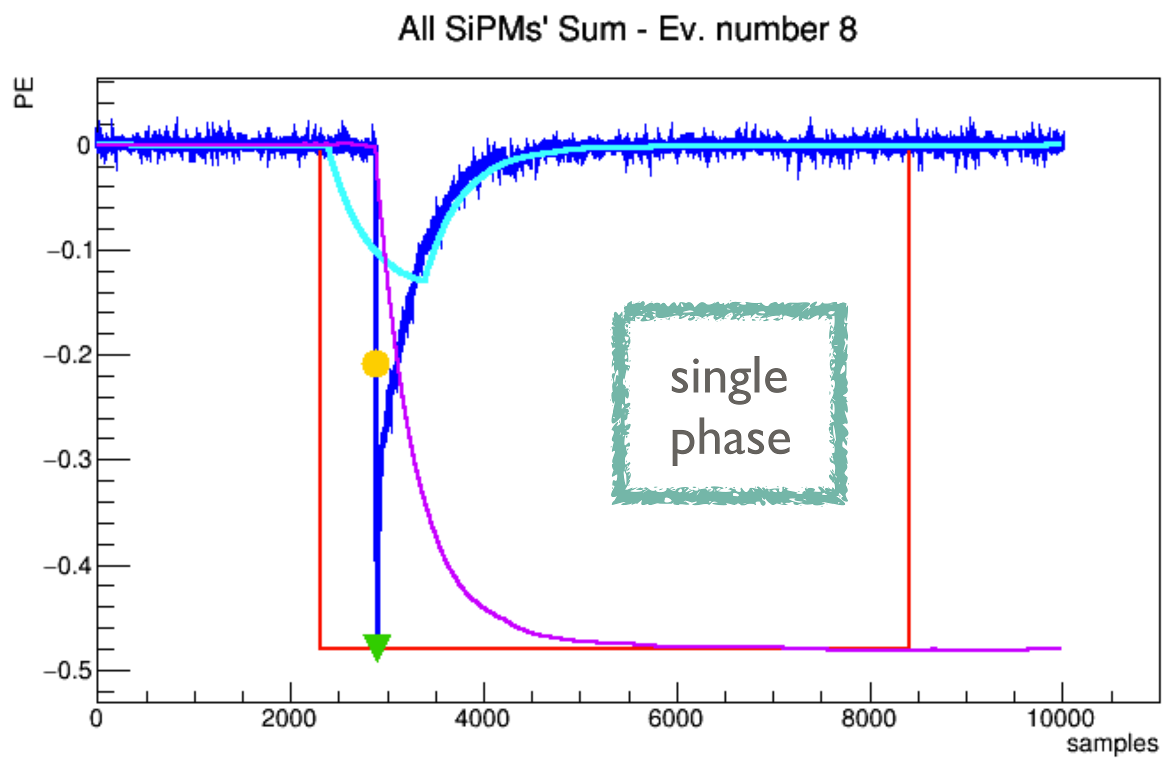
The 9 neutron Scionix detectors (high efficiency liquid scintillator EJ-309 coupled with 3" PMT).

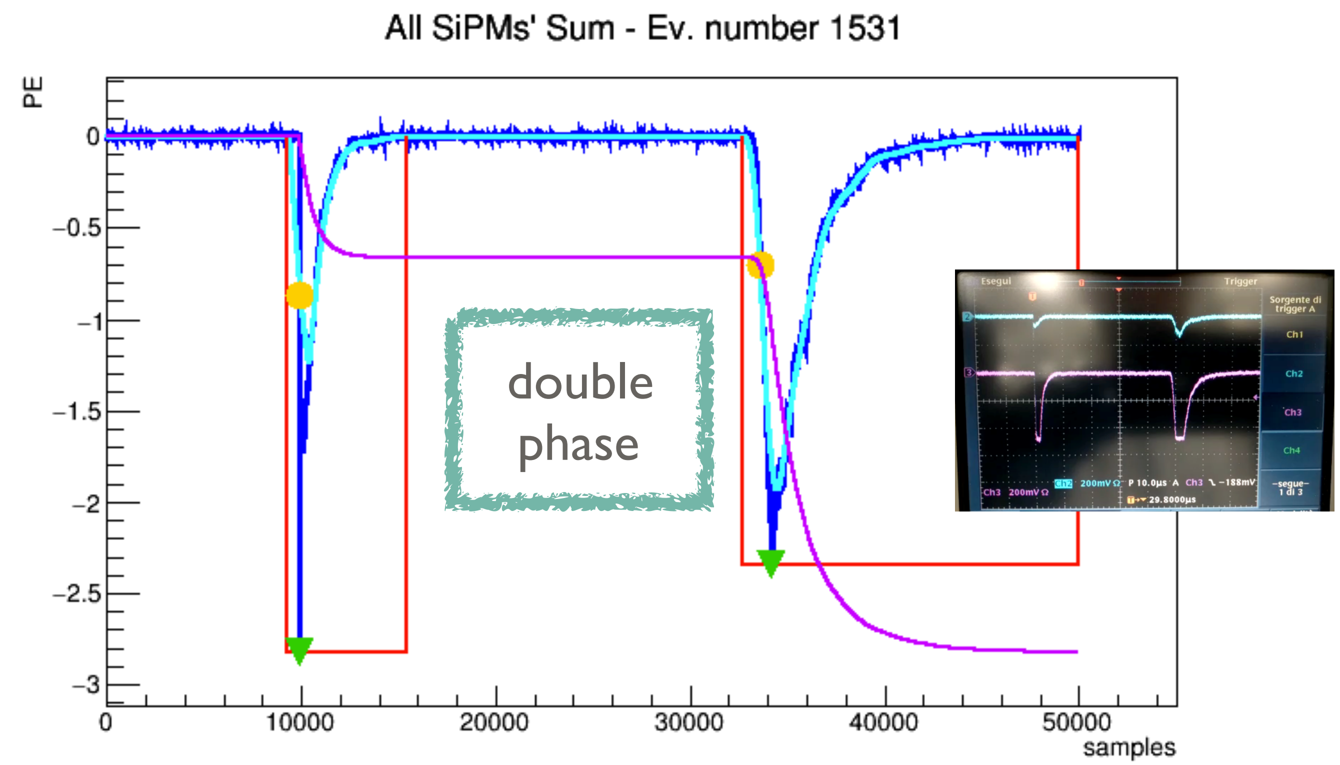


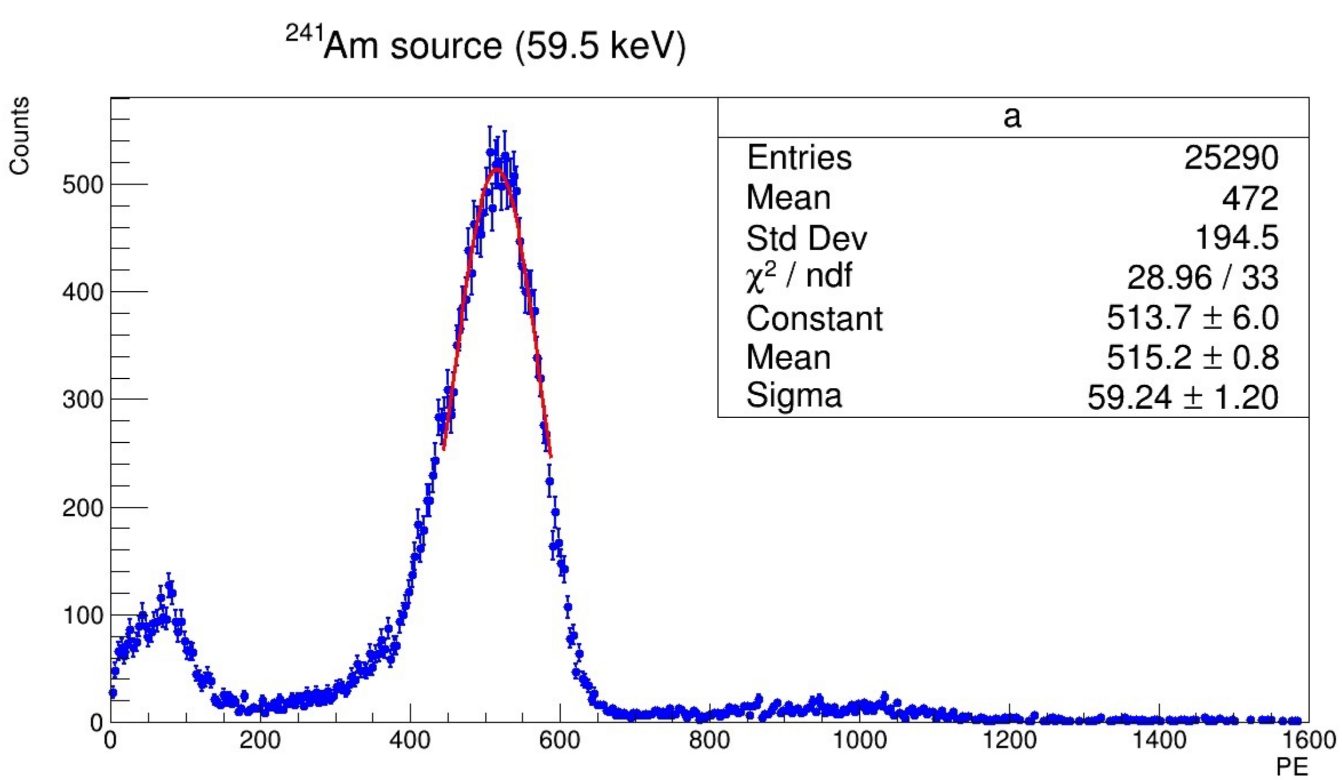


# First results

LAr scintillation light seen by the FBK SiPMs.



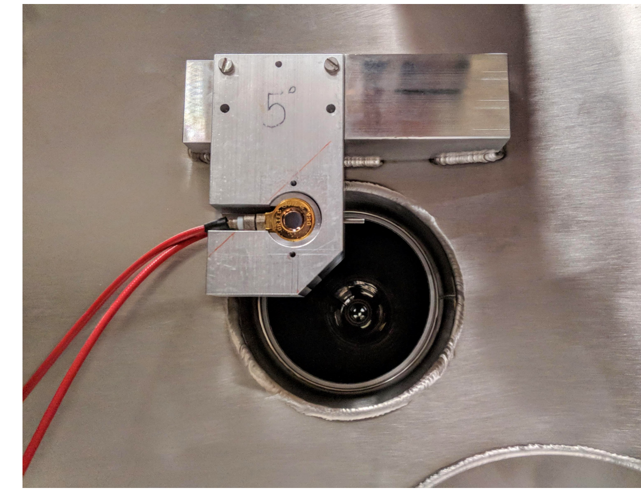



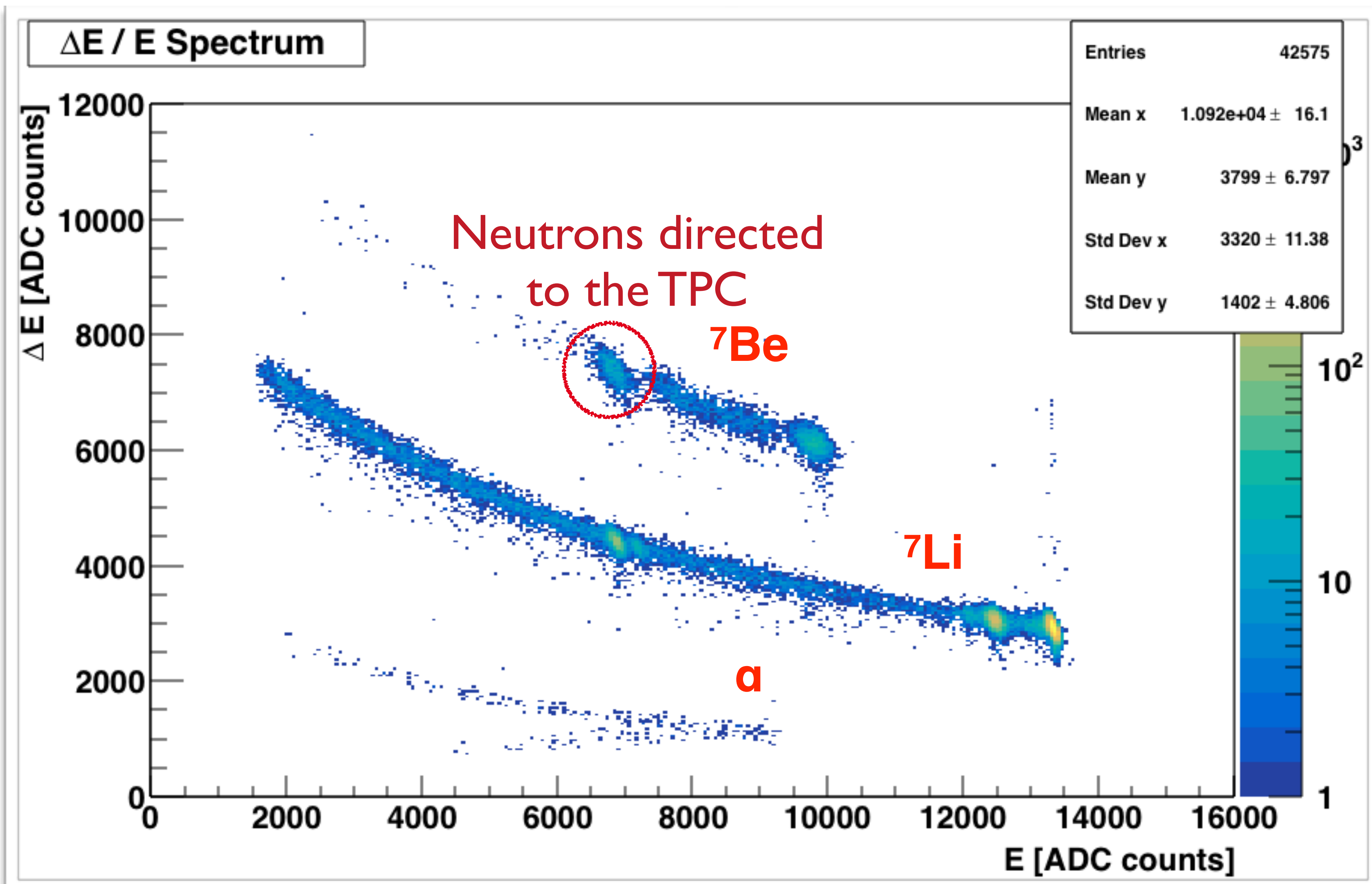

**ReD Light Yield**

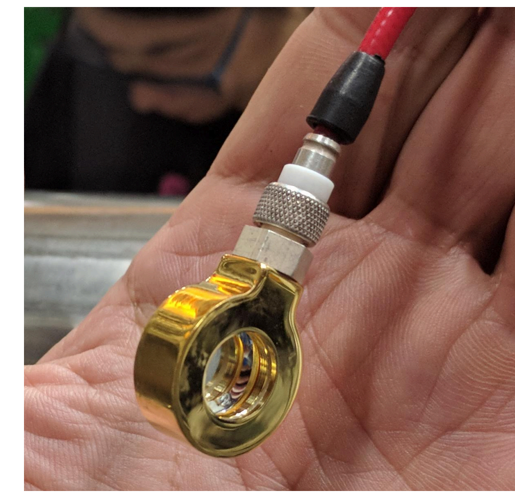
The 241Am source, single phase, null field, top+bottom tiles ~10 phe/keVee (8 phe/keVee in DS50).

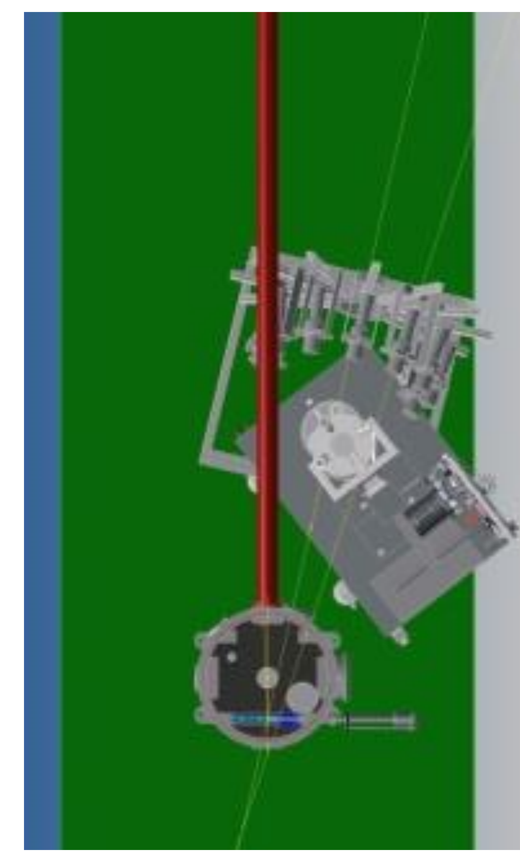
# Neutrons Selection

Select the neutrons with dE-E telescope by looking on the Be7.
Adjust the threshold to exclude the Li7 from scattering.
Look at the coincidence with LSint and check the TPC signal.



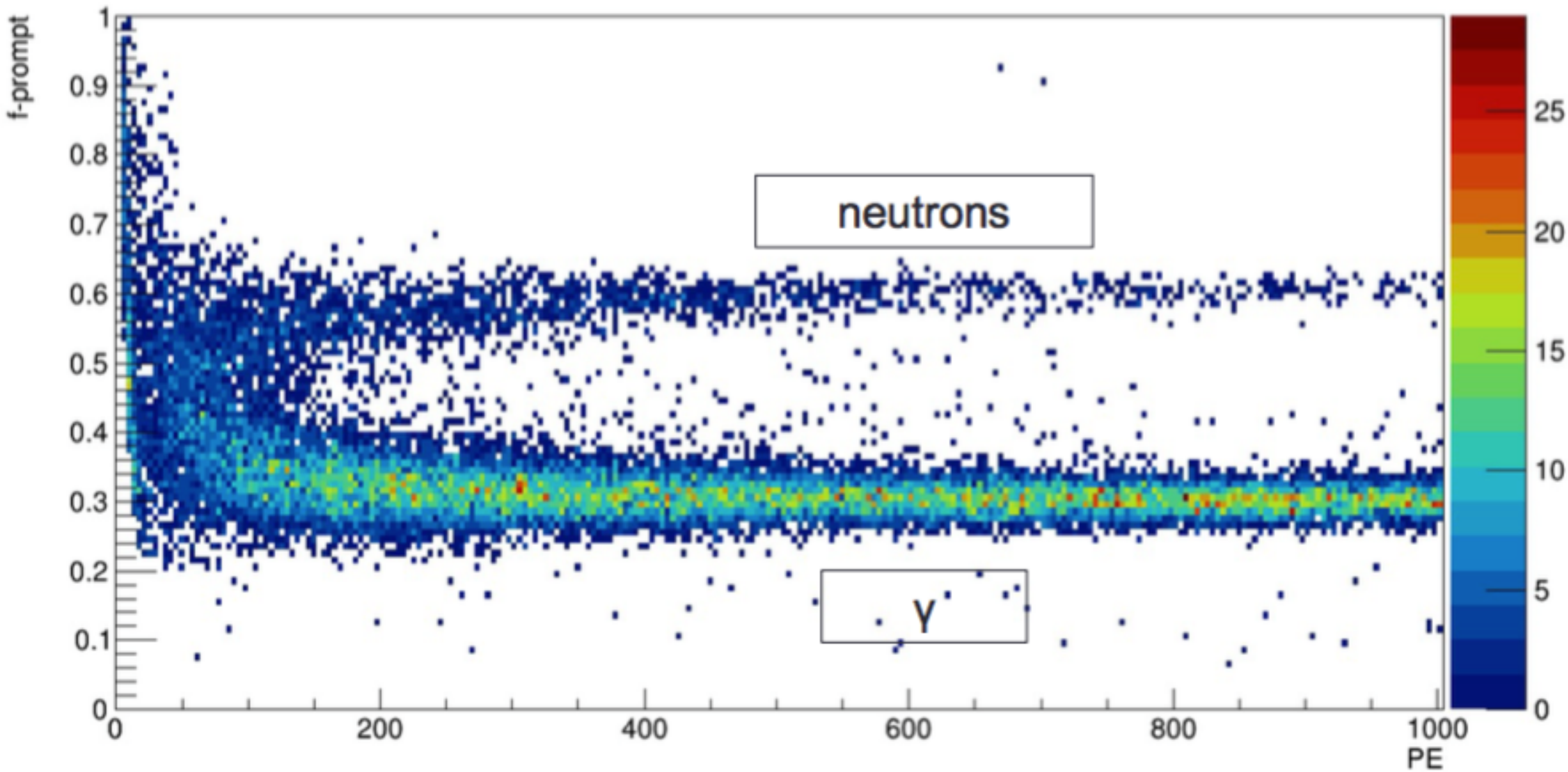




# PSD in LAr with SiPMs

**The Pulse Shape Discrimination (PSD) in LAr done with SiPMs and the 252Cf neutrons.**



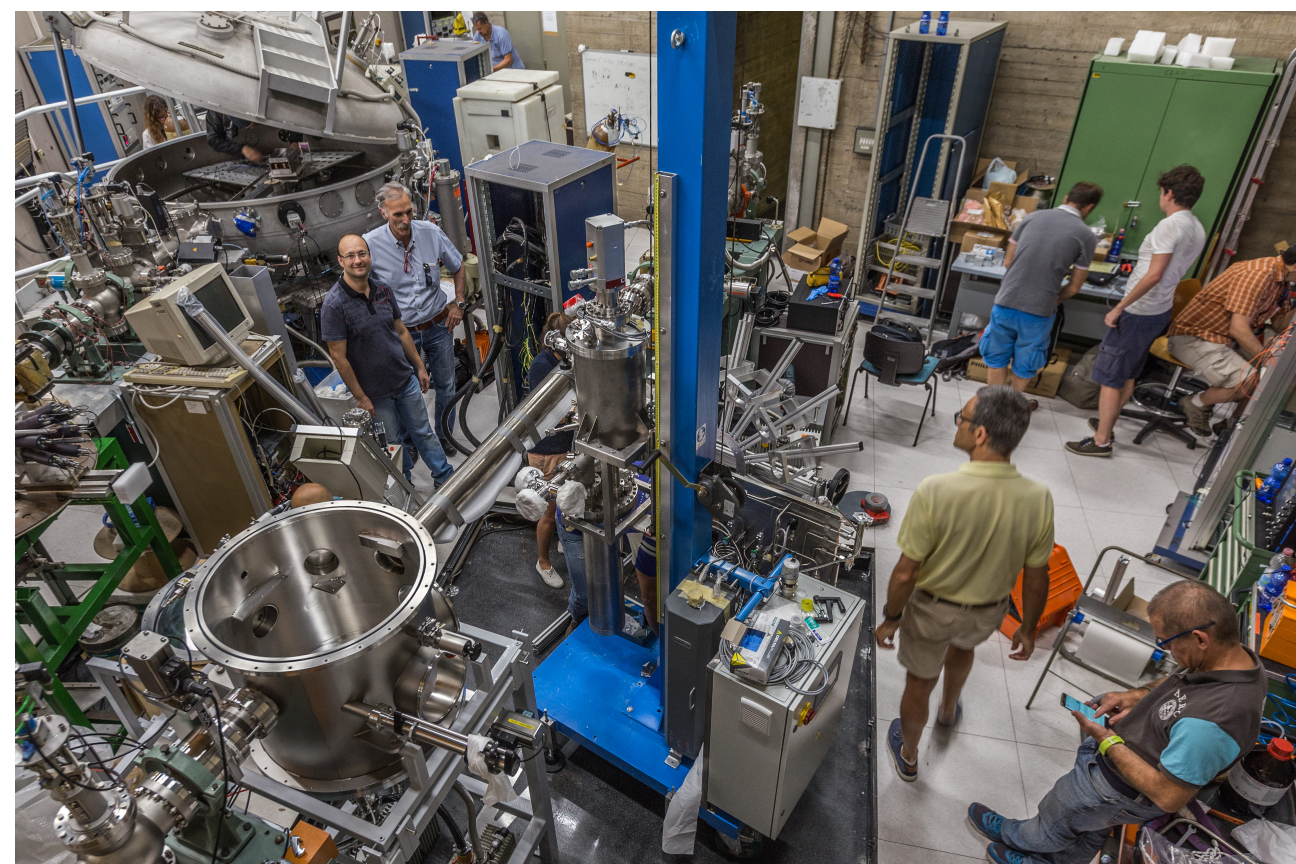
# What next?

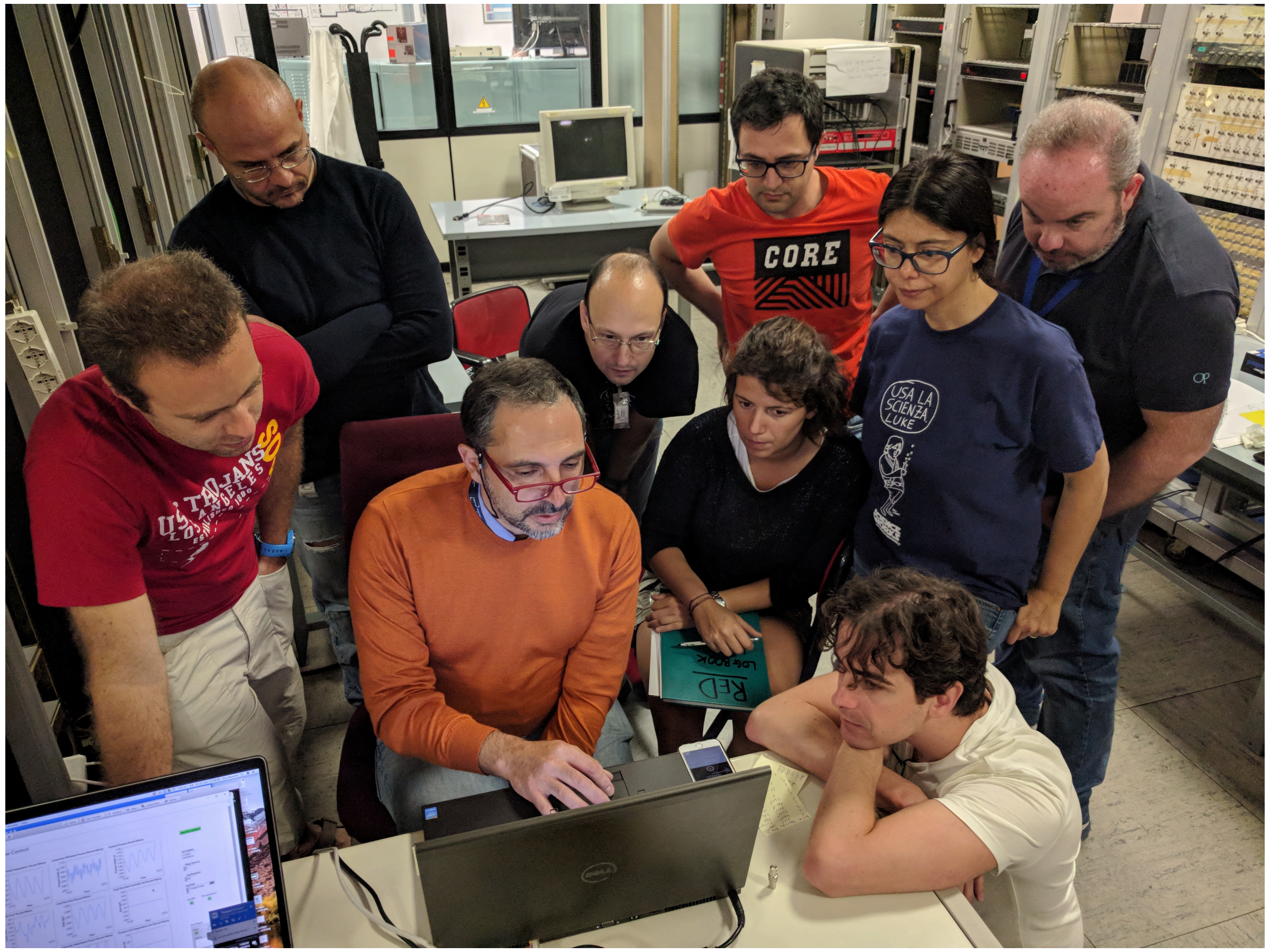
Detailed characterisation of the SiPM signals at different field configurations.

Study of the S2 signal and the S2/S1 ratio as a function of the extraction and drift fields.

Additional test on DAQ and trigger system running with TPC and LScint detectors.

Be ready for the next year, back on the beam at LNS.

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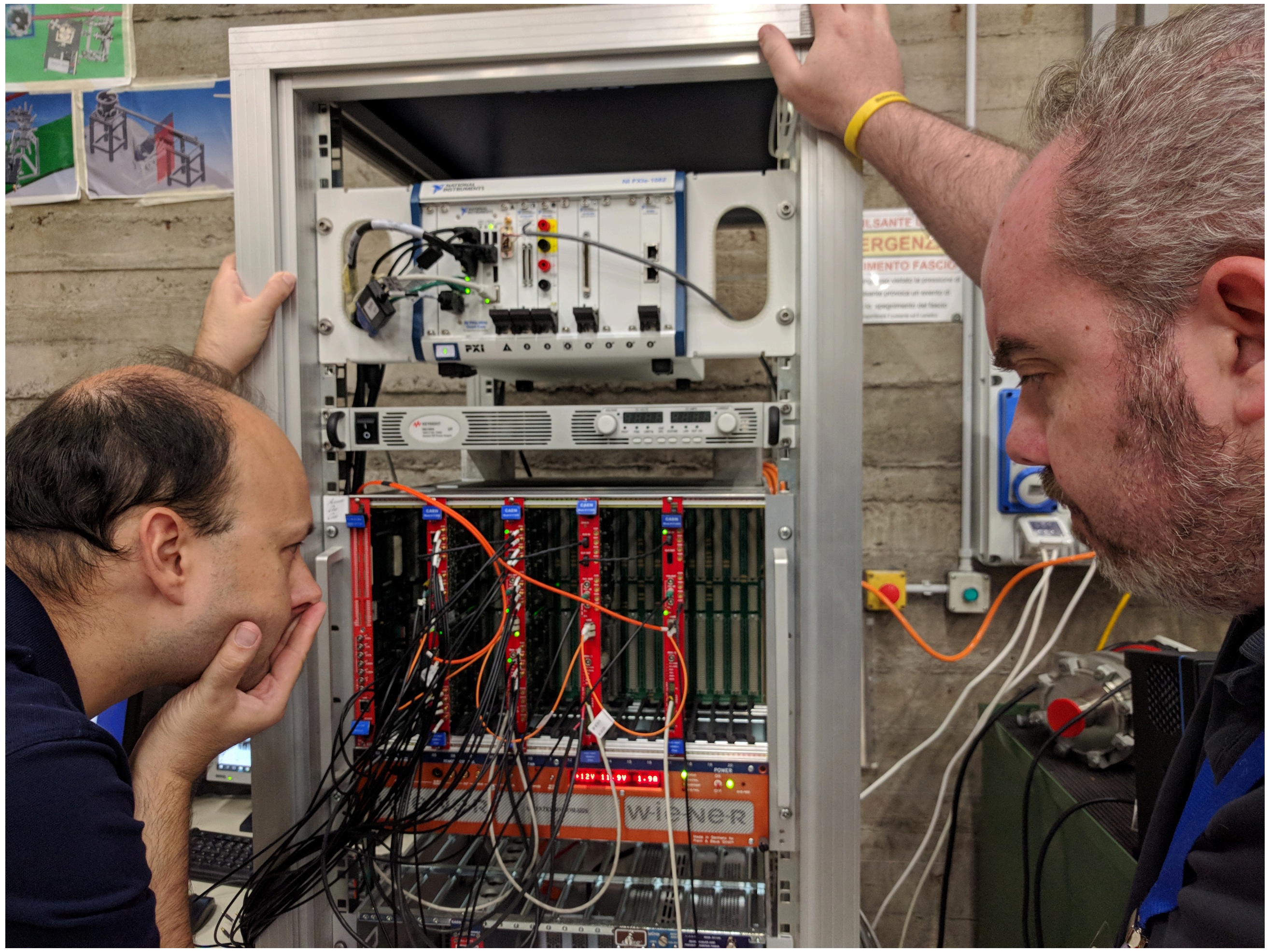


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