The XENON1T light calibration system

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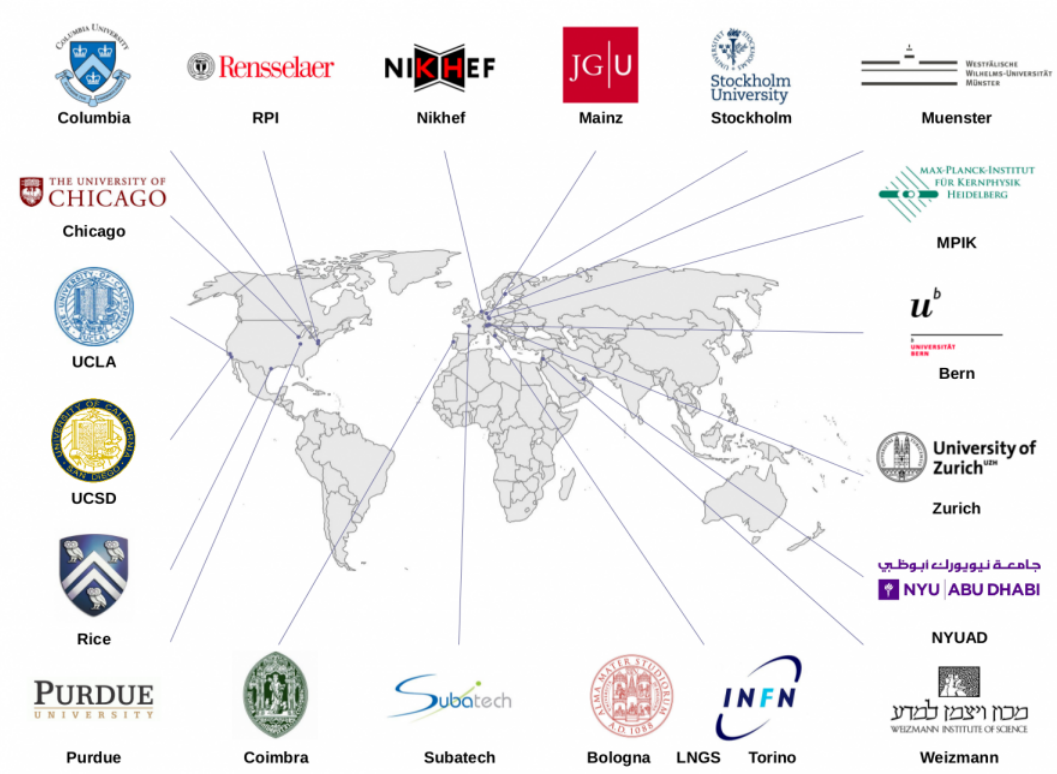
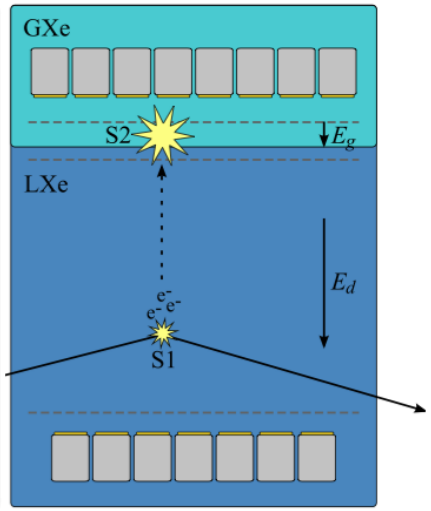
The XENON1T PMT calibration system

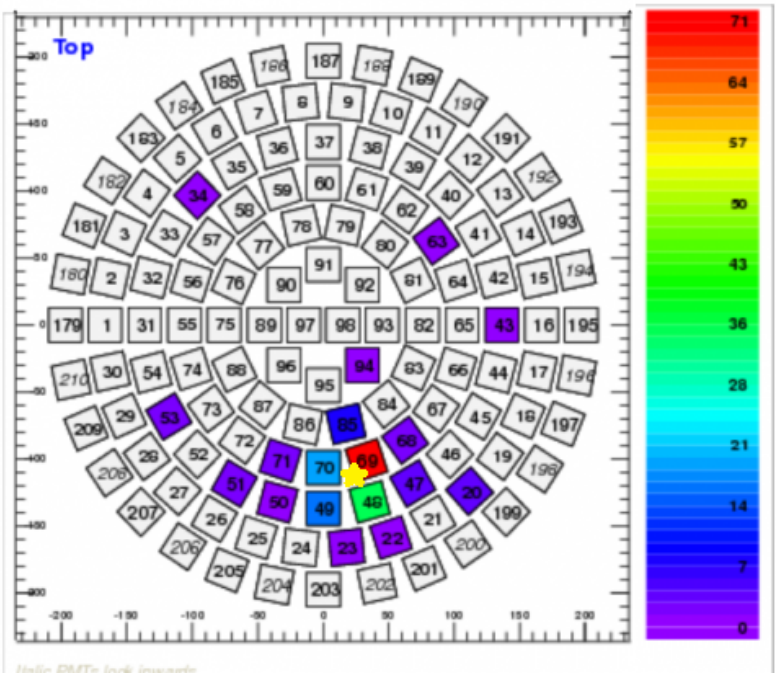
- Construction started 2013 at LNGS, Italy .
- Having completed : water tank, ReStox (storage and recovery), cryostat, cryogenic and purification systems.
- Currently commissioning with 500 kg of xenon.
- To do: TPC and PMT array installations, electronics and DAQ.

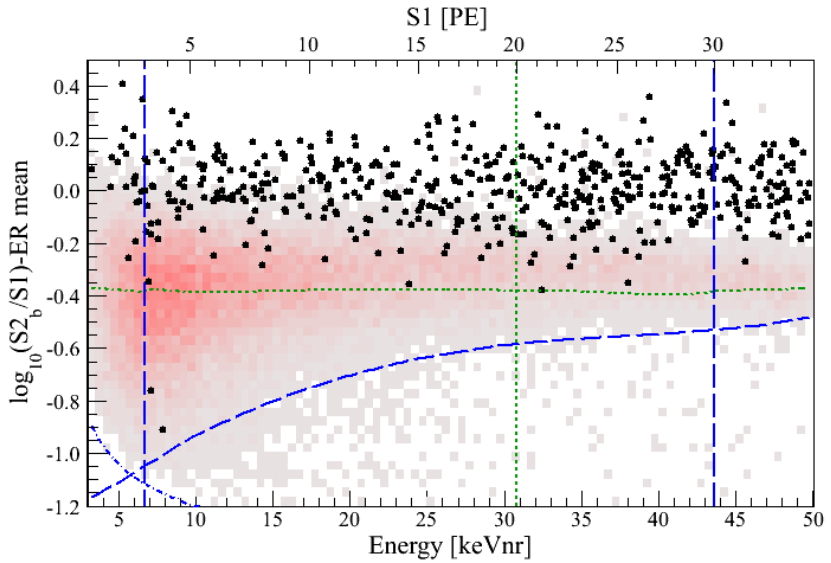


Dark matter detection with XENON1T

- Prompt scintillation (S1), λ =178 nm .
- Secondary scintillation (S2) by e^- drift drift from ionization and extraction in gas.
- Drift time (Z) and hit pattern(X,Y) allows position reconstruction (precision: 0.2 mm Z, 1.6 mm X,Y).
- S1/S2 ratio depends on dE/dX, allows nuclear/electronic recoil discrimination (>99% efficiency).

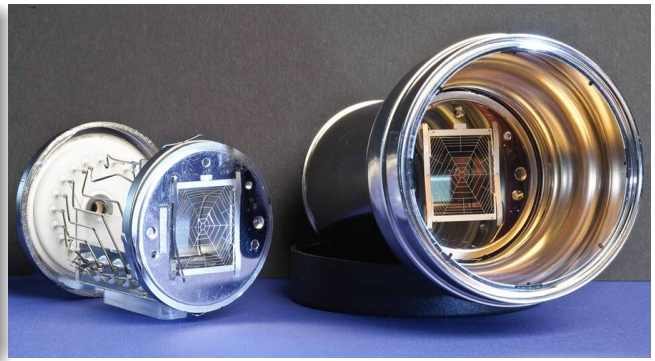


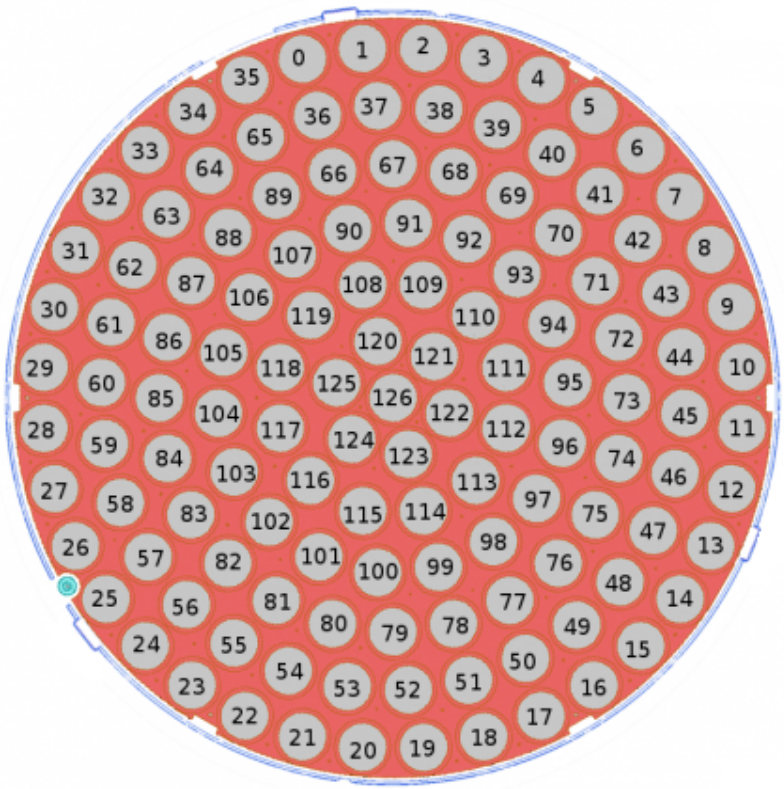




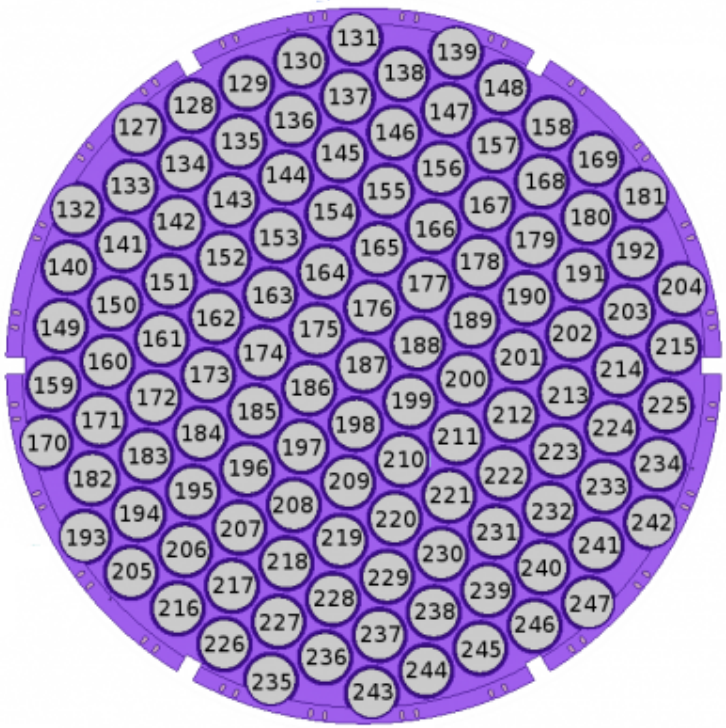
XENON1T photosensors

- 3" PMTs from Hamamatsu model R11410-21 on top (127) and bottom (121) arrays (average QE 36%).
- Reduced radioactivity in collaboration with company "arXiv:1503.07698 [astro-ph.IM]".





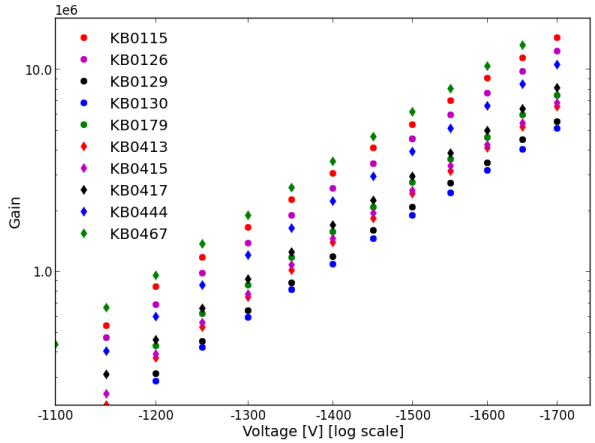
top



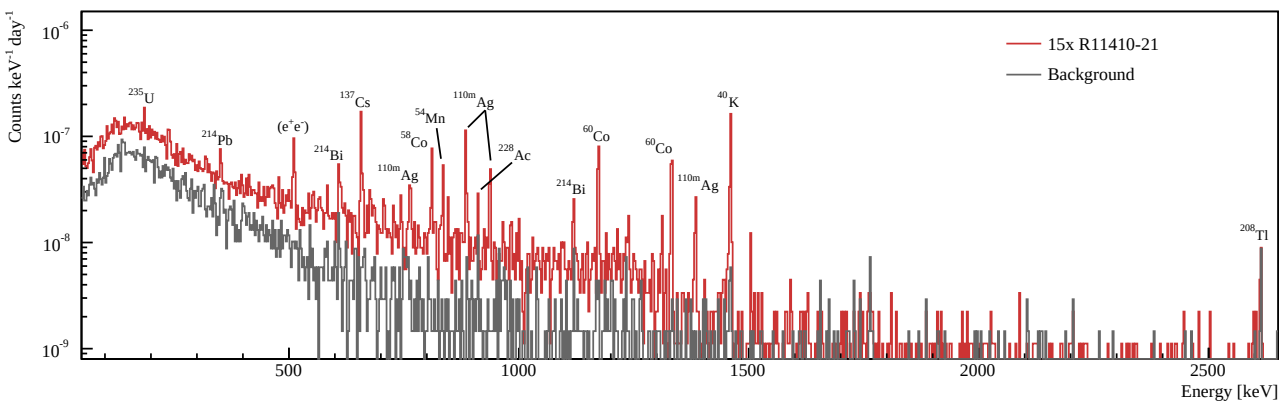
bottom

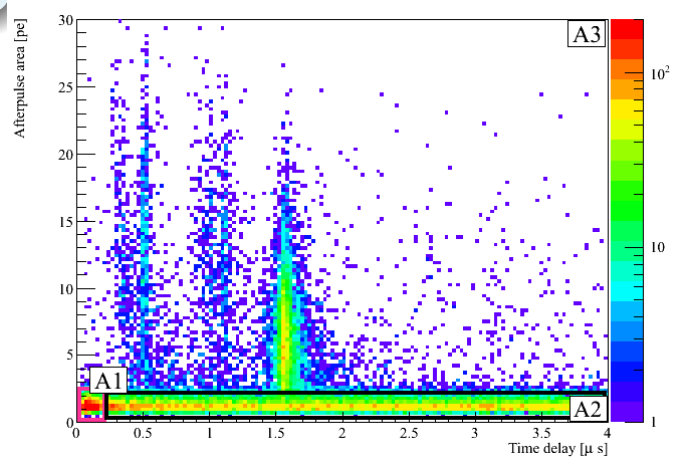
PMT tests before installation

- All PMTs screened by ultra-low background Ge detectors.
- All PMTs are tested at -100 °C (e.g. gain, DC rate, afterpulses, etc) to meet the essential requirements of the experiment.
- Regular calibration of the PMTs is required to monitor the gain, DC rate, resolution on SPE, noise level and afterpulses.



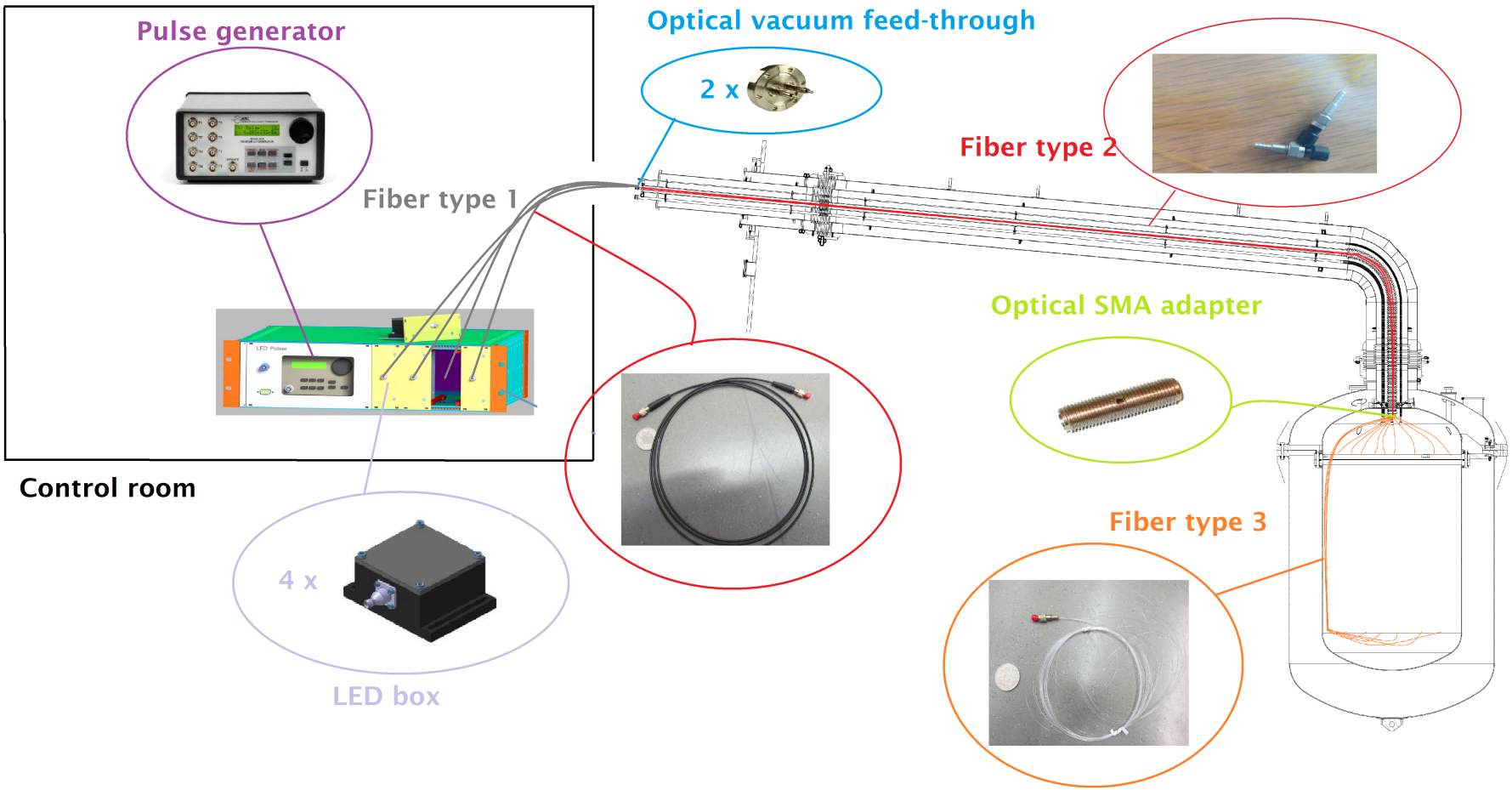
Gain versus HV





Afterpulses

PMT calibration setup, schematics

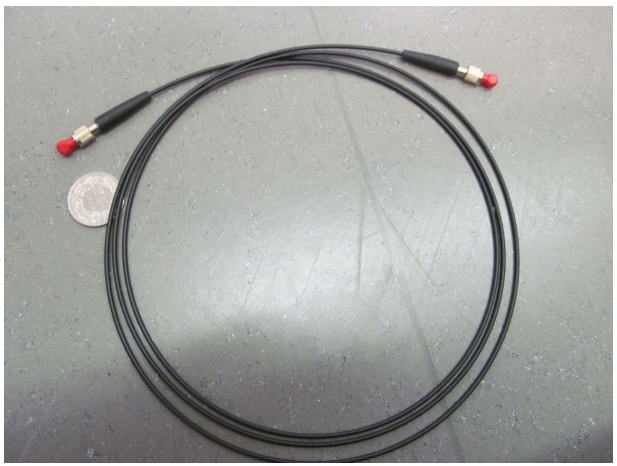


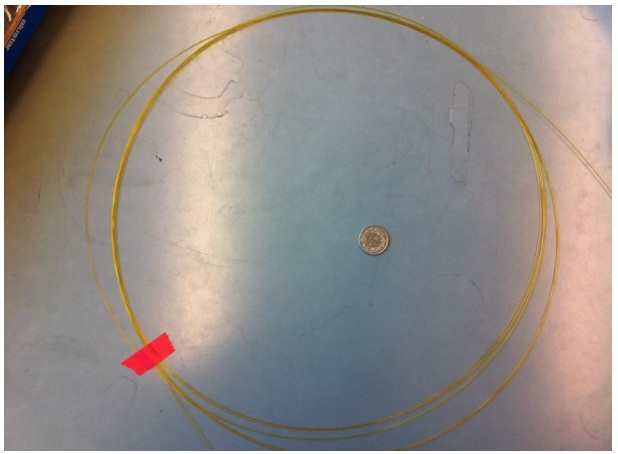
Optical fibers

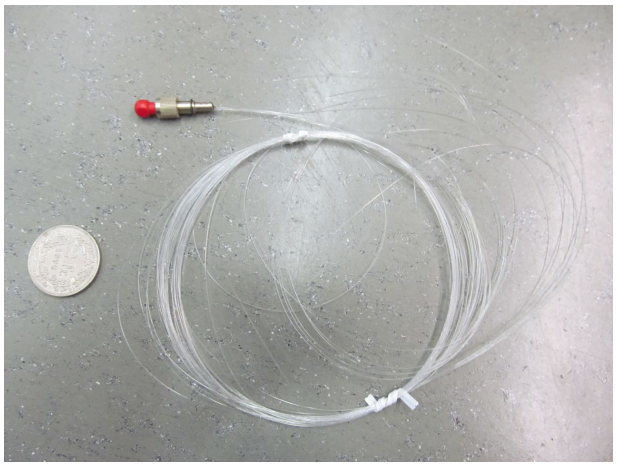
Fiber type 1: Guides the light from LED to the feed-through. Plastic fiber 980 μm core + 1.2 mm black jacket to prevent ambient light input.

Fiber type 2: Transfers the light from feed-through to the TPC. Quartz fiber 660 μm core + 110 μm Polyamide coating for thermal protection.

Fiber type 3: 1$\rightarrow$7 splitting fiber assembly to split the light into the top and bottom PMT array. Made of 250 μm PMMA (Polymethyl methacrylate) to optimize the flexibility.







Light sources

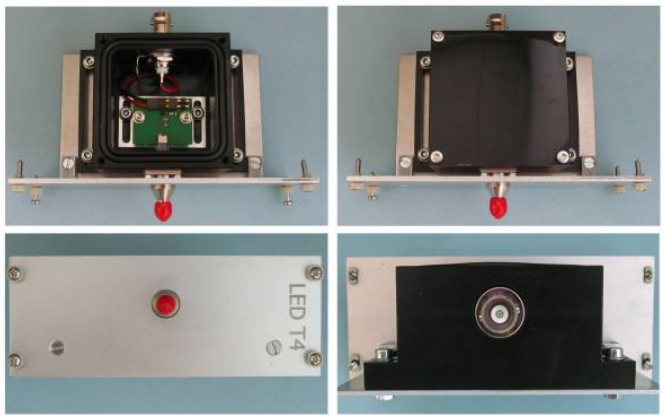
Pulse generator: BNC model 505, 4 channels. Remotely controllable via RS-232 port.

Digital clock (trigger generator): External timer module (from either SC or DAQ) should be used.

LED box: BNC input for TTL pulses from pulse generator. SMA optical output to guide the LED light (470 nm).

4 channel pulse generator

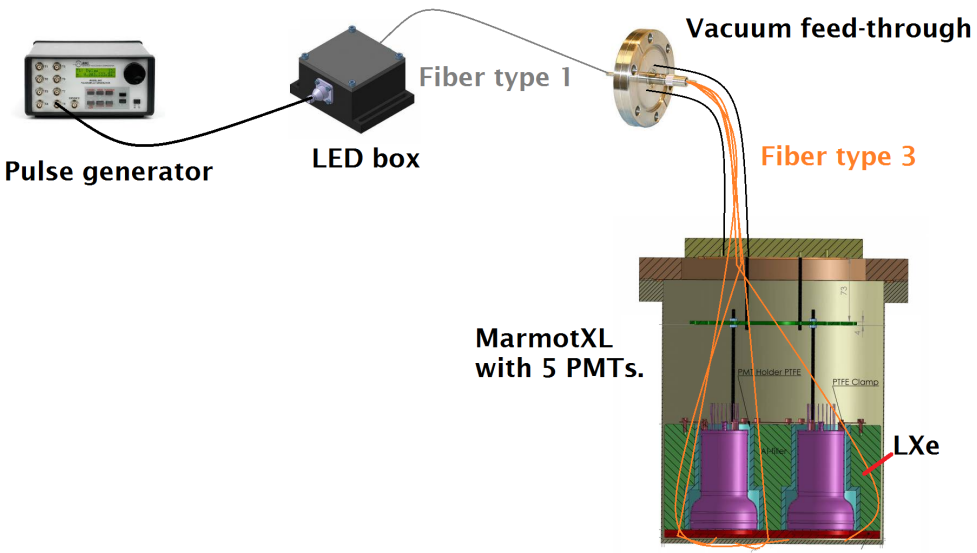
LED calibration frame



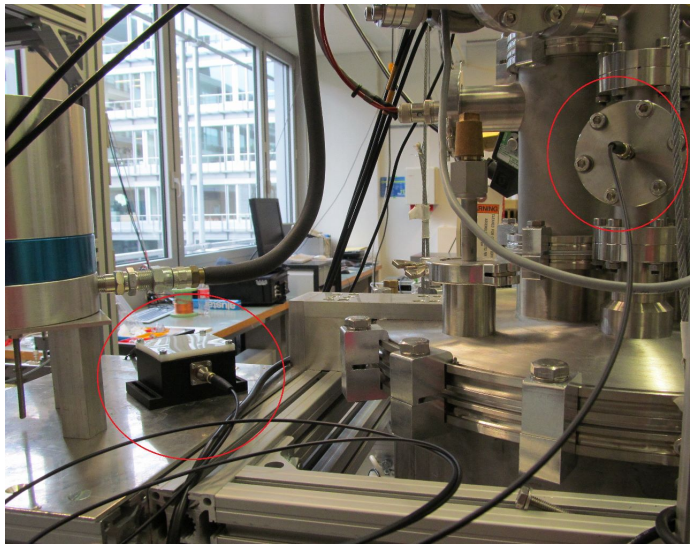
LED box

Test setup at UZH

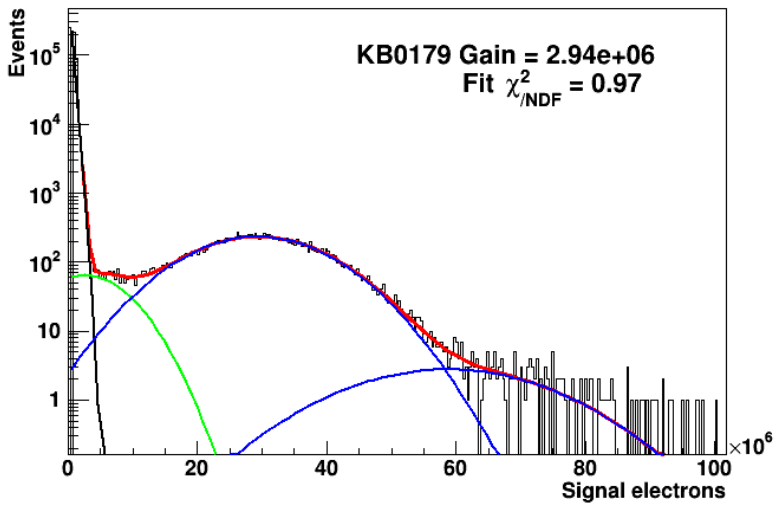
Test setup was successfully made using MarmotXL LXe facility at UZH. Single photo-electron spectrum from 5 PMTs inside LXe was observed using fiber-optic setup.



Schematics of the test setup using MarmotXL chamber



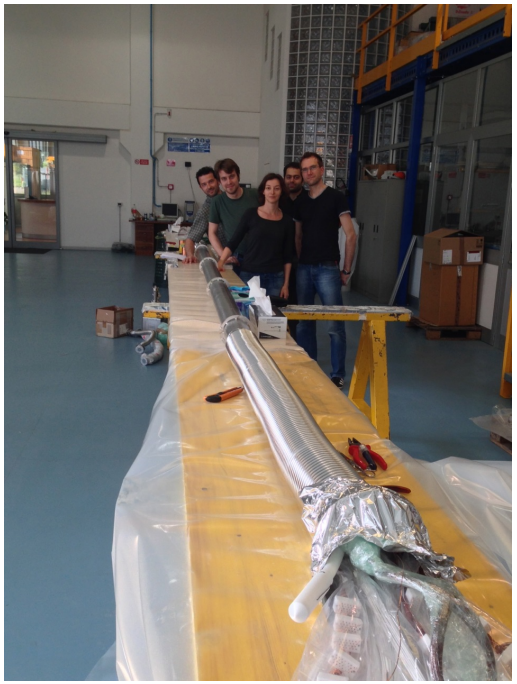
LED box and optical vacuum feed-through

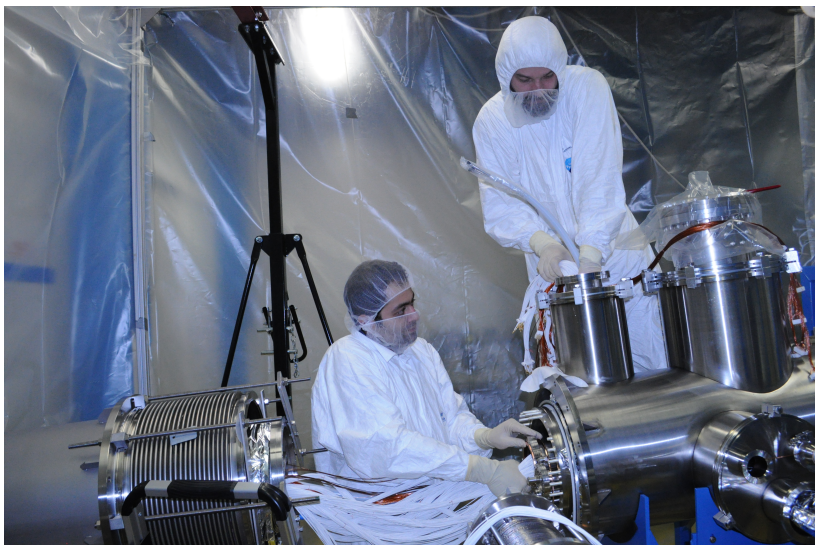


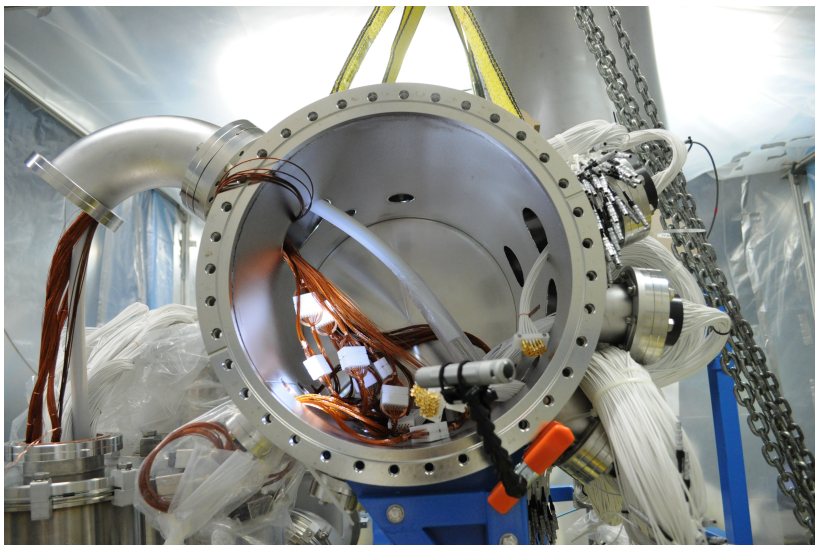
SPE spectrum from the test PMTs.

Installation

- Installation of the quartz fibers inside umbilical pipe (June 2014).
- Installation of the quartz fibers extension through the cryogenic line into the porcupine (January 2015).
- To do: Installation of PMMA fibers inside the TPC.
- To do: Installation of the plastic fibers and the LED frame inside DAQ room.

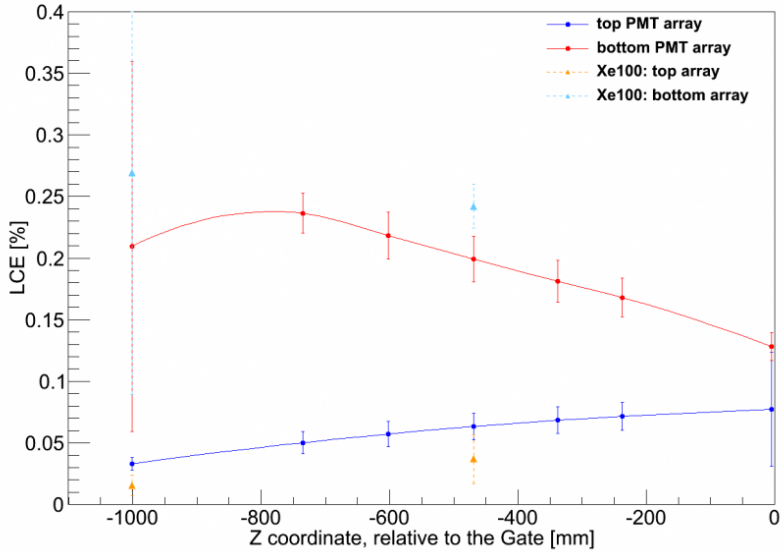


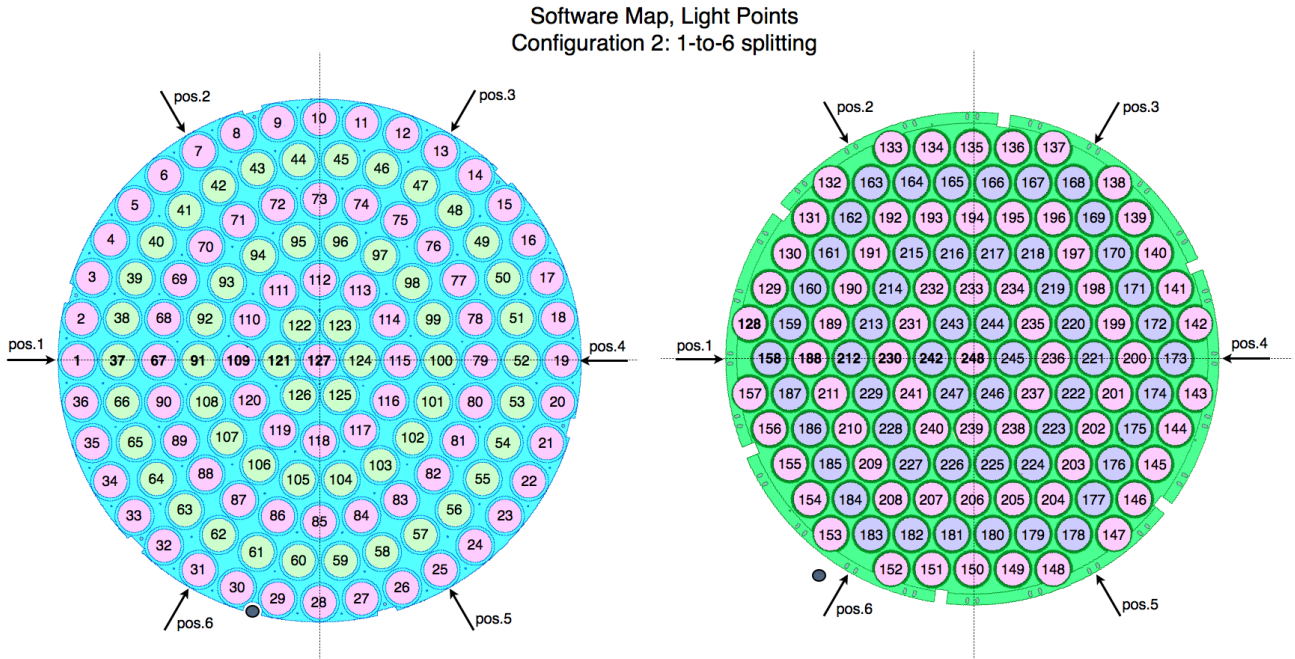




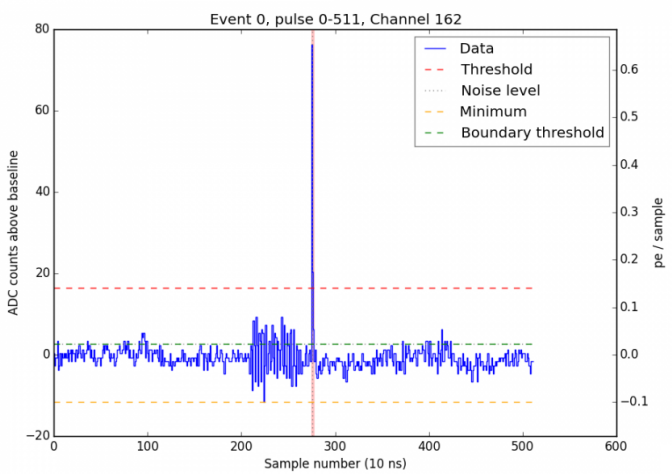
Light emission simulations [A. Kish]

- 4 x 6 light emitting fibers are distributed through the top and bottom PMT arrays.
- MC simulation with GEANT4 was used to estimate light collection efficiency on individual PMTs for different geometrical configuration of fiber placements.

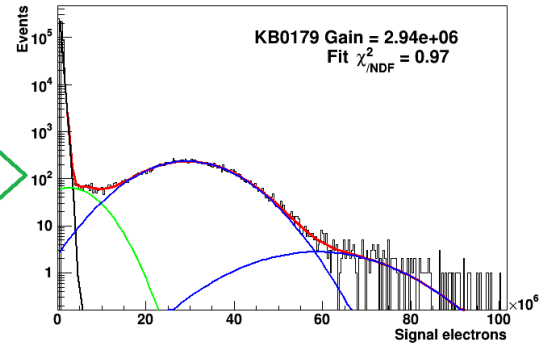




PMT calibration software : work in progress ...

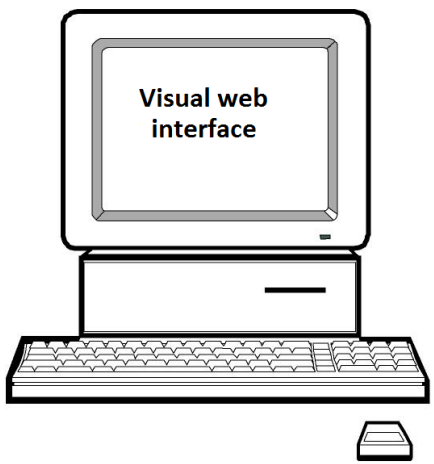


Raw data processing:
*Baseline subtraction
*pulse finding
*integration algorithm

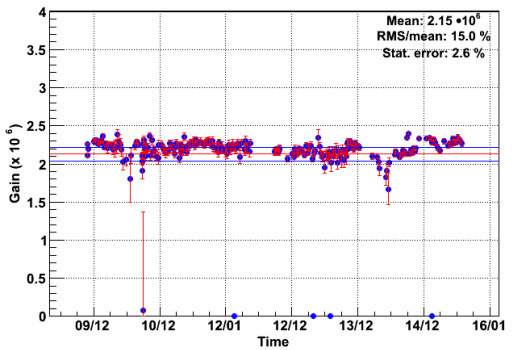


SPE spectrum and fitting

PMT calibration database



Monitoring plots :
Gains, noise rates, DC rates and ...



Summary and outlook

- Individual sections of the PMT calibration system of the XENON1T detector were developed, built and tested at UZH.
- A major part of the system, including quartz fibers inside the umbilical pipe and cryogenic line through the vacuum FTs, were installed at LNGS.
- Installation of the PMMA fibers inside the XENON1T TPC and the connections of the light sources to the vacuum FTs are to be performed by September-October 2015.
- Work in progress to develop the PMT calibration software of the XENON1T detector in order to precisely measure PMT gains and other characteristics and regularly monitor their stability.

Any Questions?