JENNIFER2 General Meeting

# Task 4.2
# Development of long-lived microchannel-plate photomultipliers

E. Torassa
(INFN Padova)

K. Inami
(Nagoya University)

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# Task description

## Description of Work and Role of Specific Beneficiaries / Partner Organisations

**Task 4.2: Development of long-lived MCP photomultipliers**
[INFN,KEK] Person Months allocated = 7

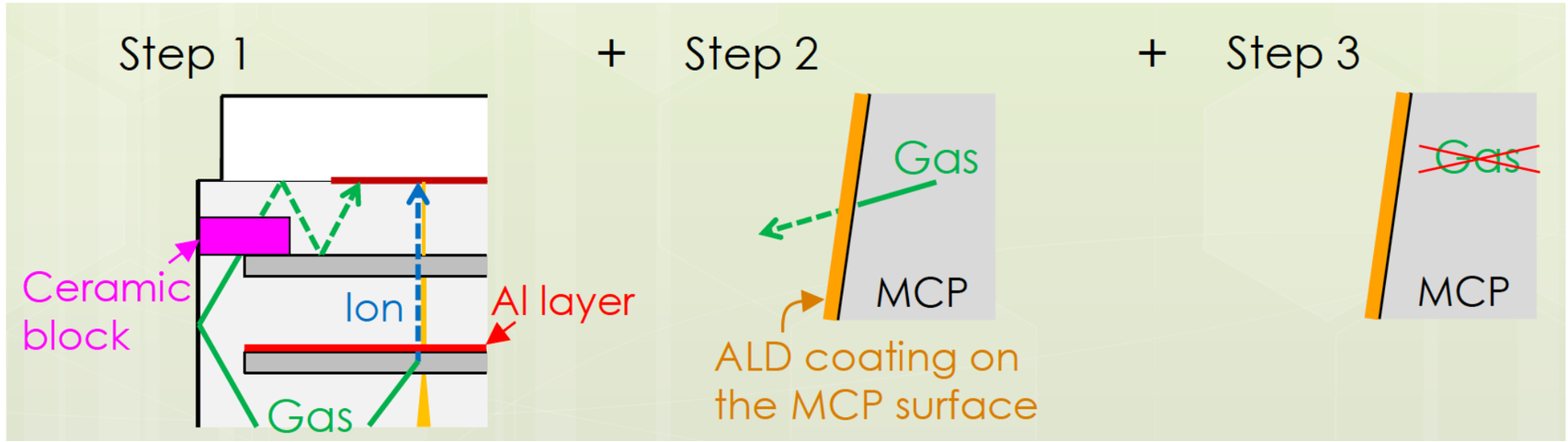
- The main objective is reduction of residual gas components, responsible for lifetime reduction in the MPC production procedure. Study of MCP-PMT samples: time and pulse height, photocathode lifetime analysis. Identification of ions responsible for lifetime reduction.
- Institutions' roles: INFN – leading partner, sample characterization,
  Hamamatsu Photonics – sample provider,
  KEK – integration of components.
- Key people: Ezio Torassa (INFN), senior researcher. Prof. Kenji Inami (KEK).

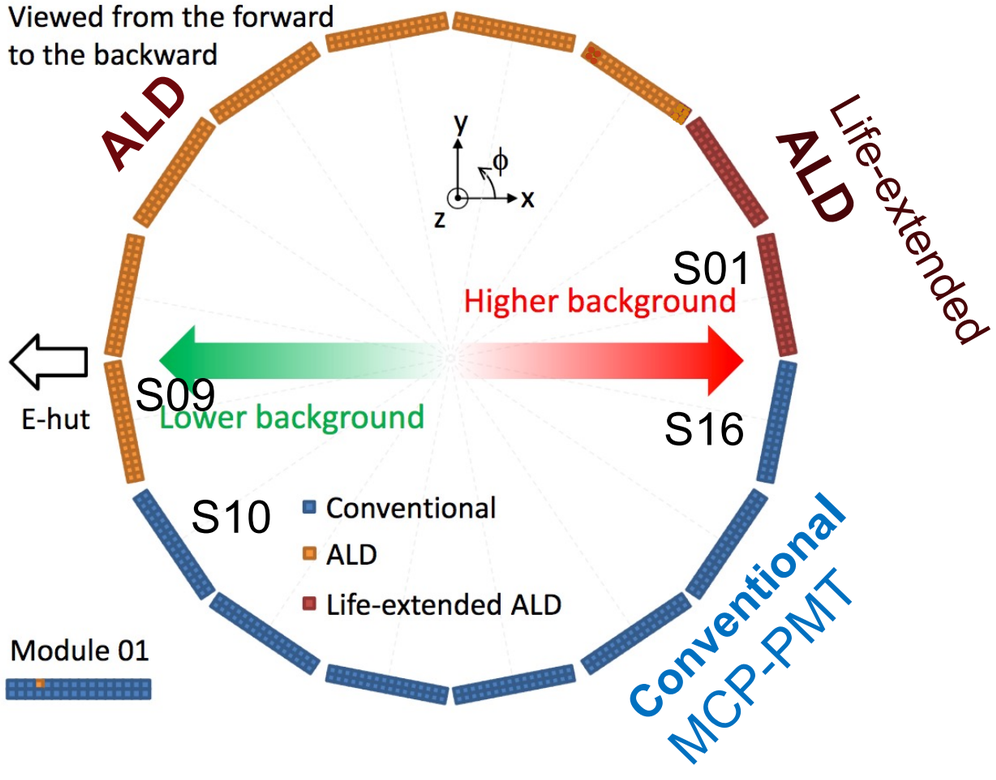
## Description of deliverables

**Task 4.2:**Report on the lifetime properties of the MCP PMTs (month 24)

# MCP-PMT developments

Conventional Atomic Layer Deposition extended lifetime ALD



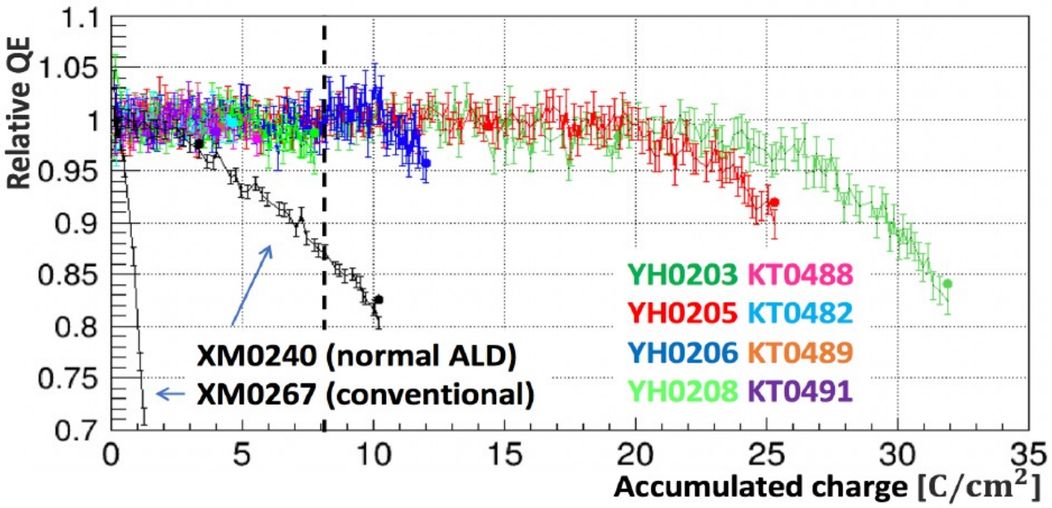

We measured the mean QE degradation for different MCP-PMT generations anyway there are not negligible fluctuations between different photodetectors.

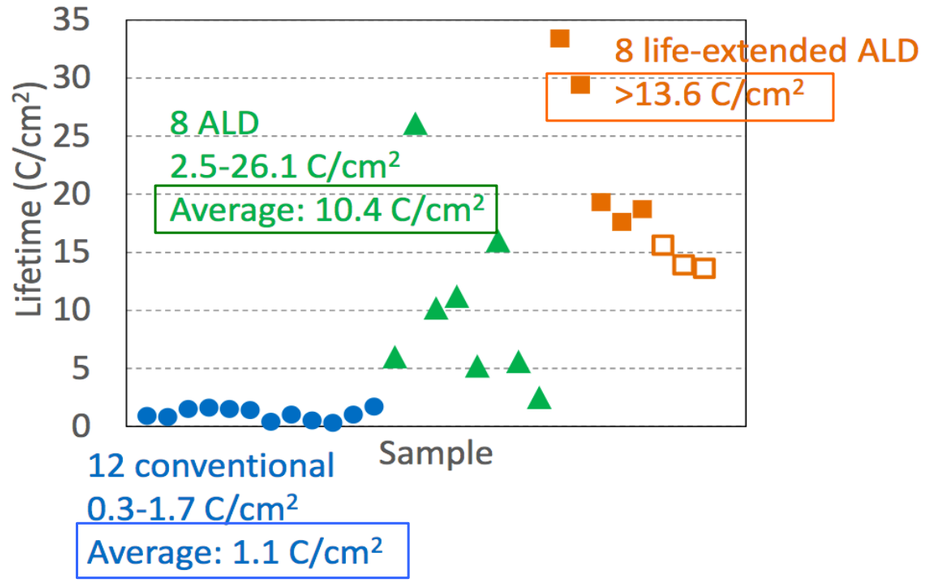
We need to monitor QE for each MCP-PMT and try to develop new generations with higher lifetimes.

# Lifetime measurement

Lifetime is the integrated charge / $cm^2$ reducing the quantum efficiency at 80%.
It can be measured:

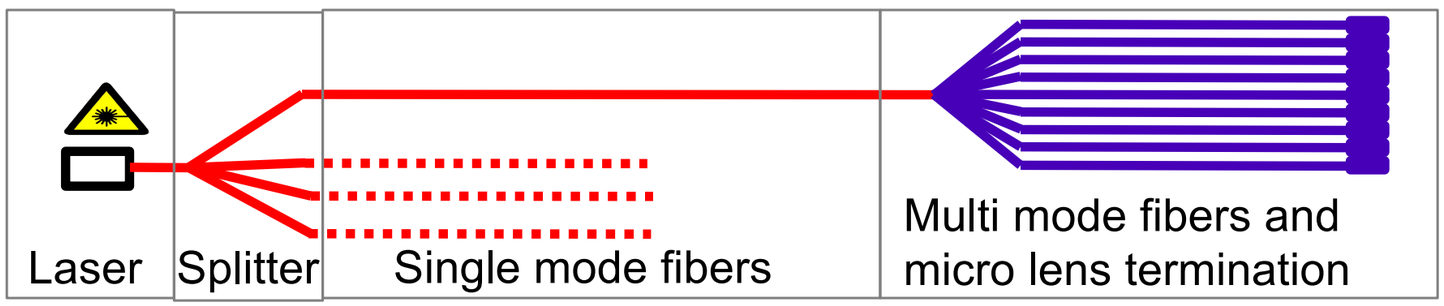
1) In the lab by loading charge with a led and measuring QE with laser pulse




2) In the lab after loading charge with the accelerator, dismounting MCP-PMTs and measuring QE with laser pulse (ongoing)

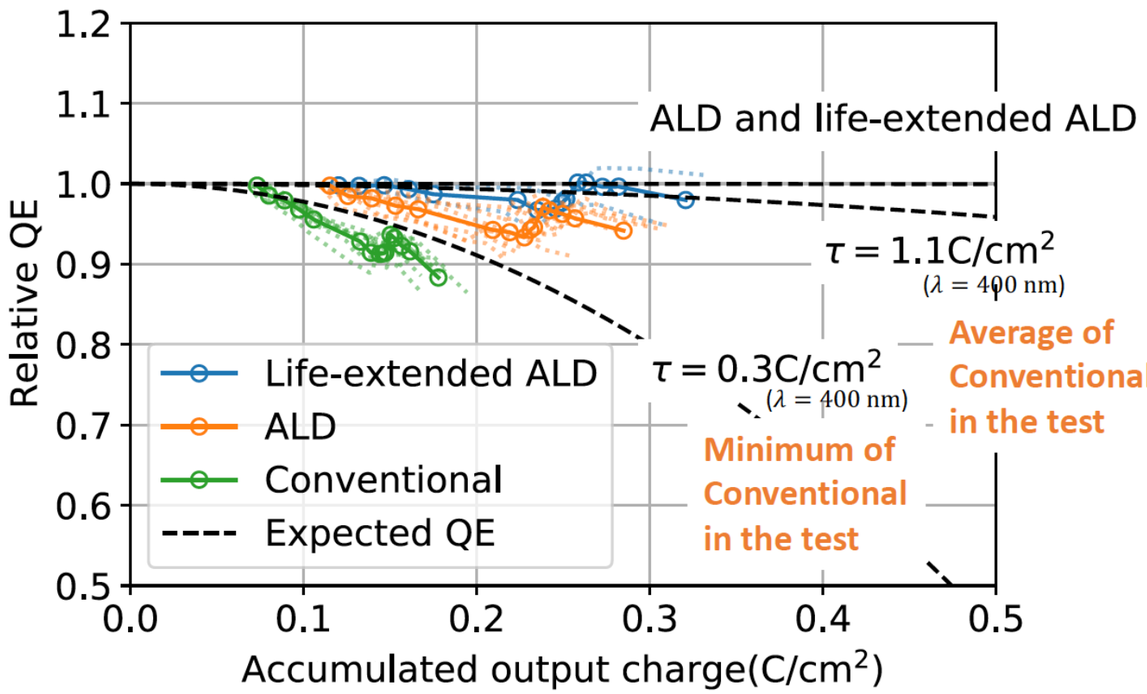
3) Inside the experiment by using the laser calibration system

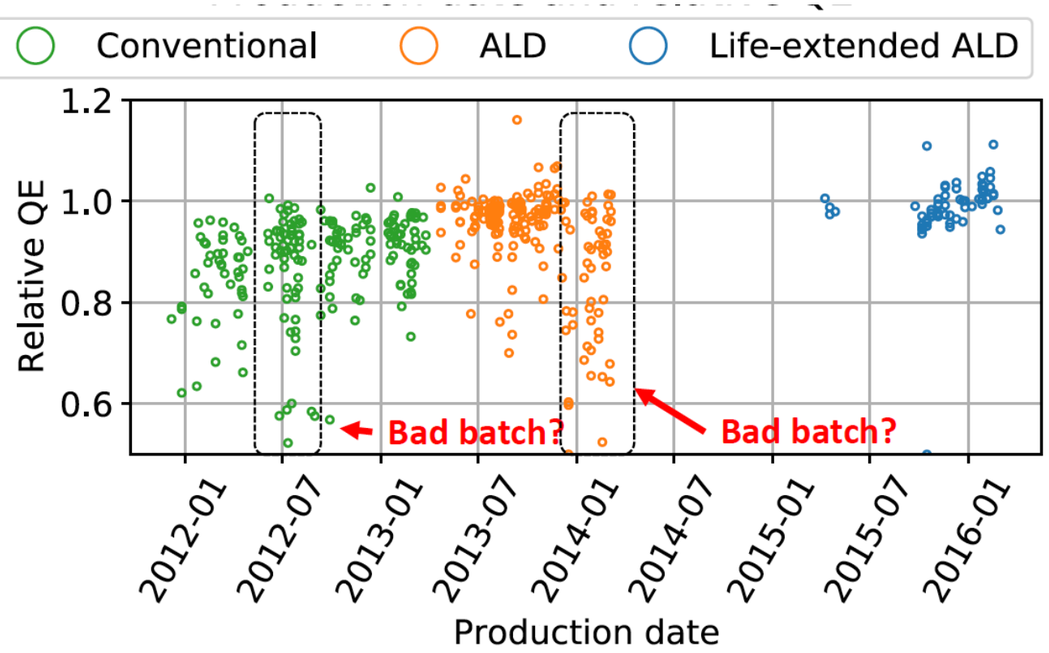


# Lifetime measurement

The laser calibration is a wide system with the laser in the electronic hut connected with photodetectors with 30 m long optical fibers. The main goal of this system is time calibration. The QE monitoring requires to have a constant number of photons arriving to the photodetectors for several years.

4) Inside the experiment by using Cherenkov photons from dimuons

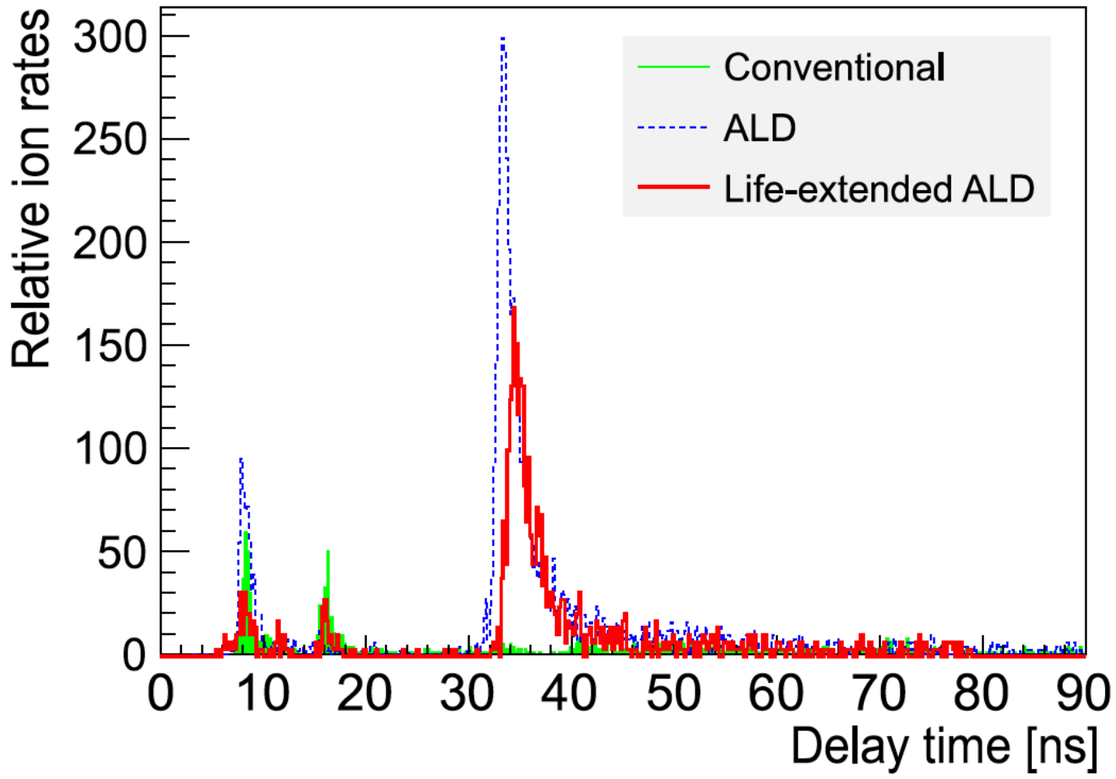



The accumulated charge up to now is only 0.2-0.4 C/cm²
From the preliminary results lifetimes look like lower than expected.
One possible explanation can be the presence of bad batches.

# MCP-PMT development

Feed-backed ions emitted from the MCP surface by electron multiplication process deteriorate the photocathode condition, these ions arrive with some delay at the photocathode and produce secondary electronic signals.  The delay time is related to the ion mass.




The peaks around 8 ns, 16 ns and 32 ns correspond to the ions $H^+$, $He^+$ and $H_2O^+$, respectively

# Conclusions

- **Deviations from the initial work plan**
  The goal was to have a new MCP-PMT generation with increased lifetime but a  better understanding of QE deterioration for the current MCP-PMTs is needed. The comparison between the relative QE measured in the lab after MCP-PMT dismounting and relative QE measured using dimuons will help to validate the measurement procedure.
- **Link between secondments, tasks and deliverables**
  Secondments scheduled for the next year will help to improve the laser calibration system and to check the QE measurement.
- **Scientific breakthrough and success achieved**
  Studies of secondary electronic signals made it possible to understand MCP-PMT lifetime can be improved if a new production procedure will be able to reduce the residual quantity of $H^+$, $He^+$ and $H_2O^+$ ions. There is currently no budget to start this new development.
- **Future implementation**
  The current backup solution for the MCP-PMT replacement is the upgrade of the TOP detector with SiPM.  Test of the latest generation of SiPM, their irradiation and new SiPM development are ongoing activities