Calibration Concepts

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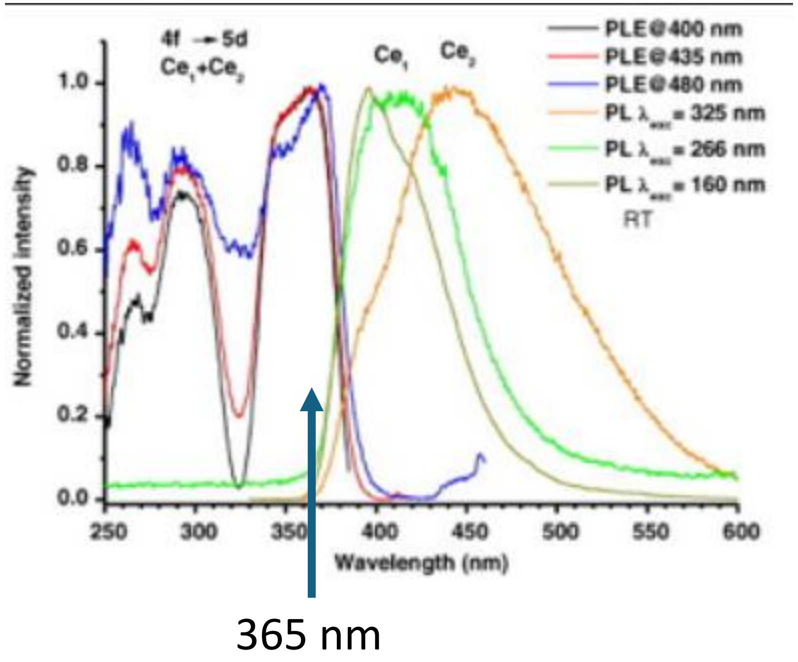
PIONEER collaboration meeting

Monitoring our 10 LYSO crystal array

- 2 UV LEDs excite light production
- Bundles of 7 fibers distribute UV
- Fibers couple to back of crystal by PMs
- Primarily monitors long term stability
  - Useful for setting up DAQ without beam
- Difficult to scale to full calorimeter
- Next look to successful muon g-2 experiment for inspiration
- A. Anastasi et al JINST 14 P1125



Crucial design elements of this laser system

- 1) The light source wavelength is in the range of calorimeter photo-detector sensitivity
- 2) The light distribution system has adequate intensity and homogeneity
- 3) The system needs to monitor the stability of the light delivered

Now an overview of the hardware

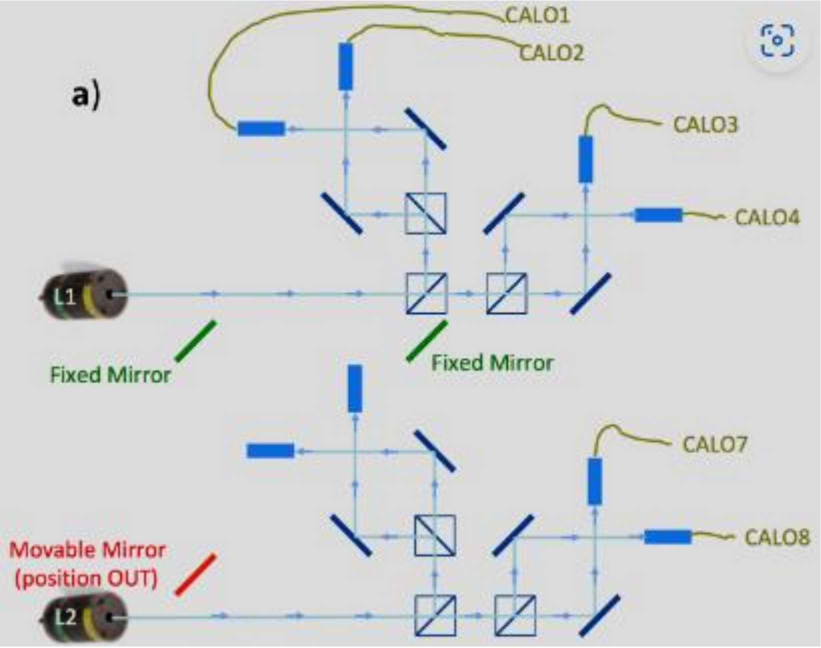
Muon g-2 laser-based gain monitoring system for the calorimeters

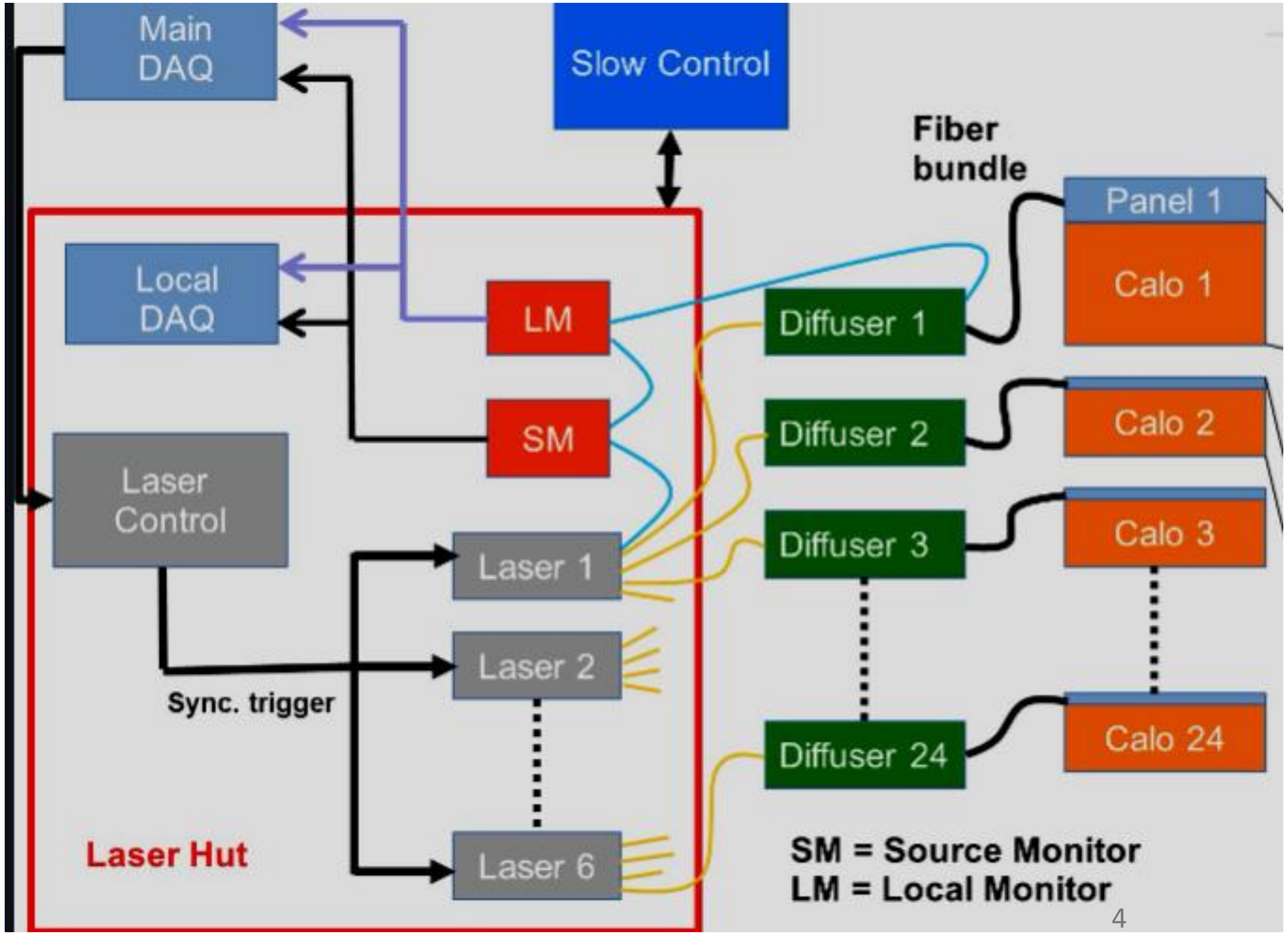
Muon g-2 has 24 Calorimeters – with a 6x9 array of PbF_2 crystals (54) in each viewed by SiPMs

6 Lasers Picoquant LDH-P-C-405M 600 ps duration launched into 25 meter silica fibers

Each laser illuminates diffusers for 4 calorimeters, about the number of crystals in our calorimeter

Diffusers distribute 405 nm light pulses to crystals





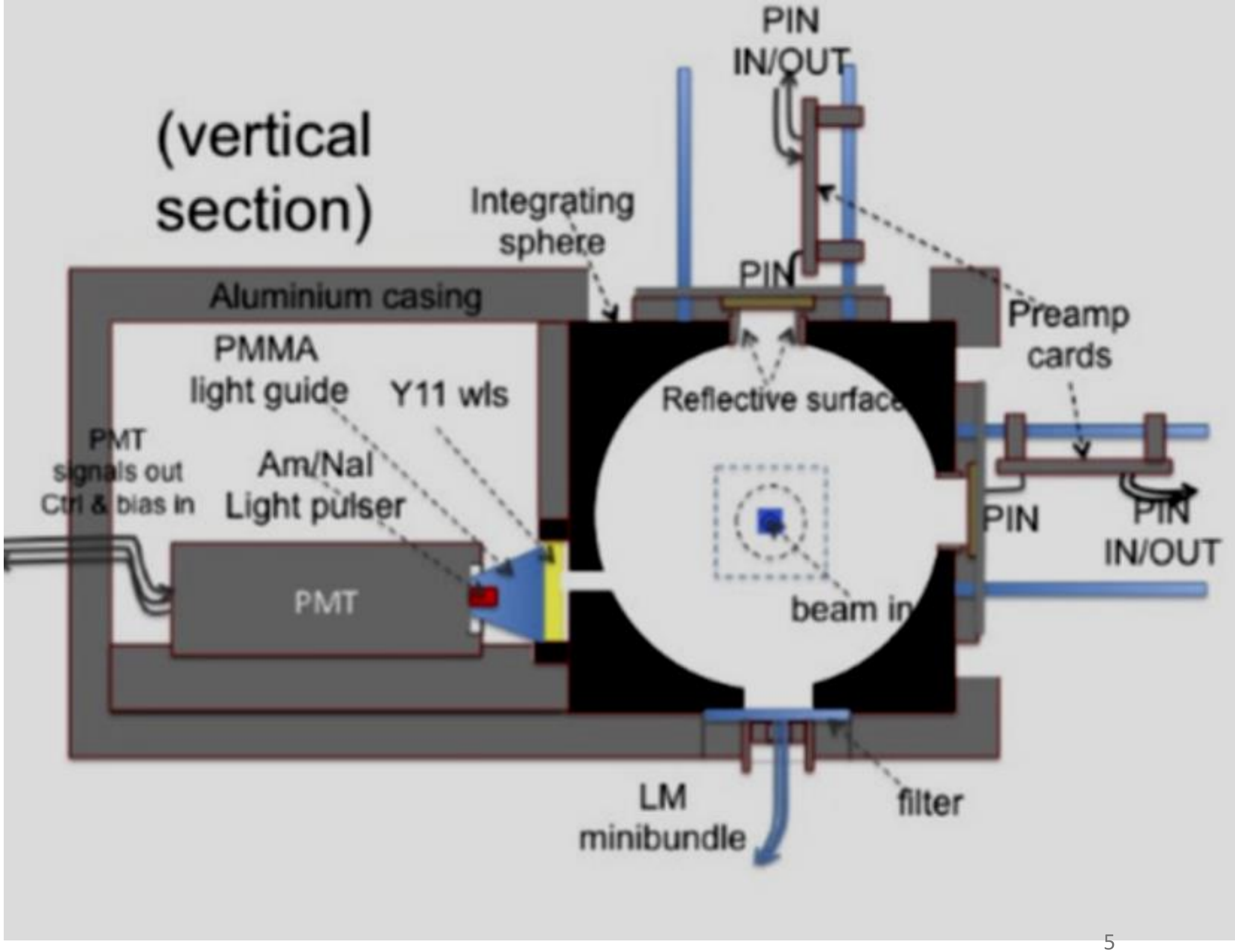
Light monitors
Each laser has one

Light split off from laser enters the integrating sphere at “beam in”

Light from each of 4 calorimeters enters at the bottom

Large area PIN diodes and PM receive the light

241Am / NaI provides 5 MeV reference alphas

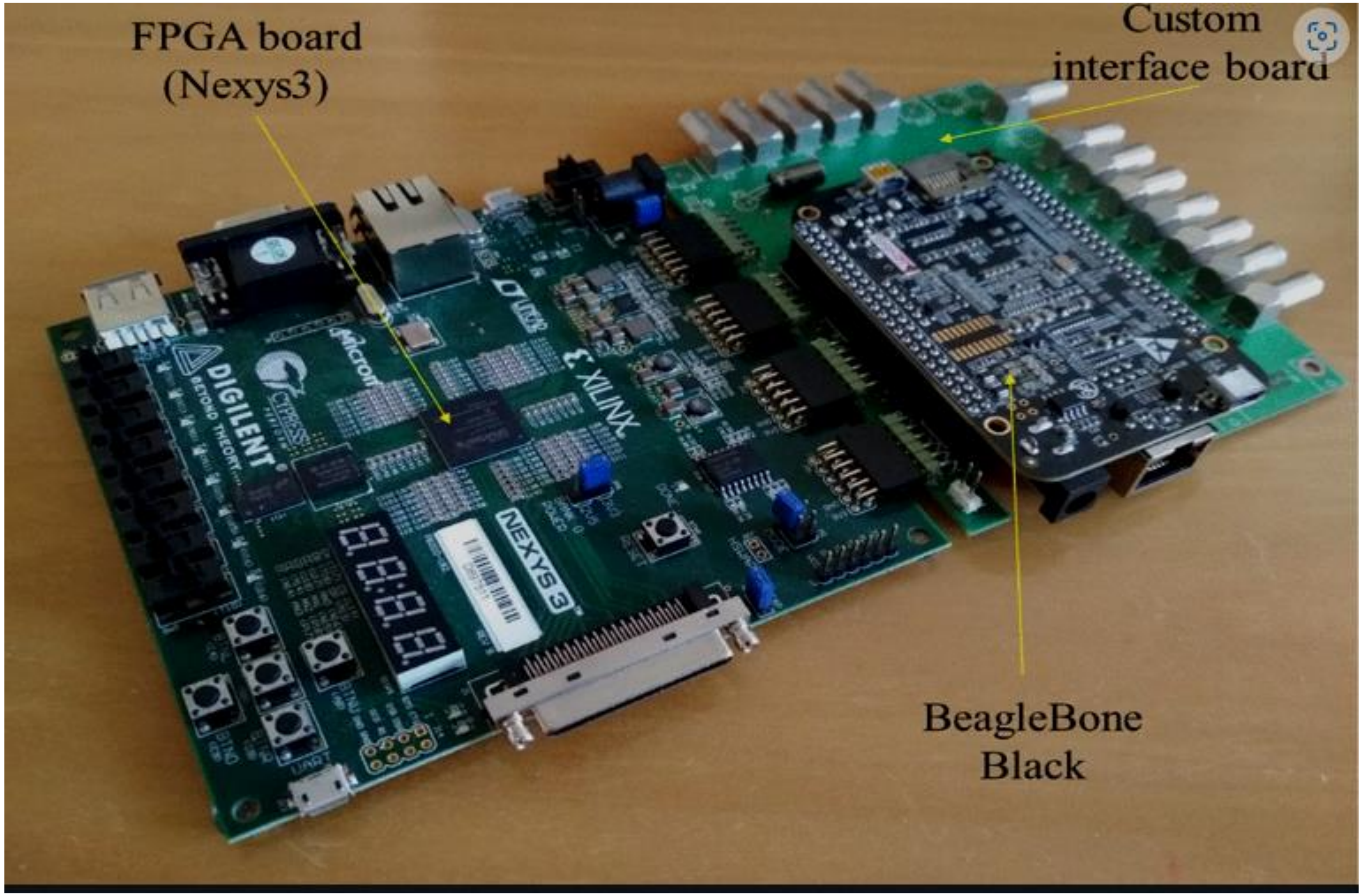


Laser pulse control board

Board contains a Spartan 6 FPGA and ARM CPU to program pulse sequences.

SIPM gains in g-2 calorimeters are rate dependent and different pulse sequences mapped this behavior

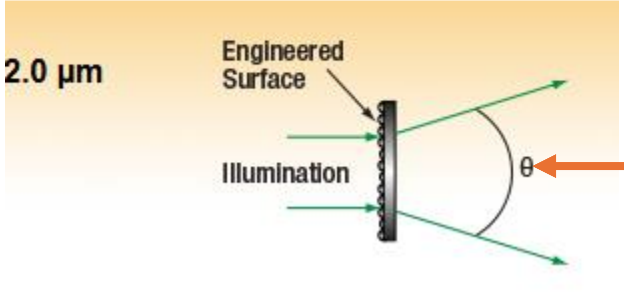
The board manages the light monitor system.



The Diffusing System

Light from launching fiber is transmitted through an engineered diffuser (Thorlabs EDI-S20)

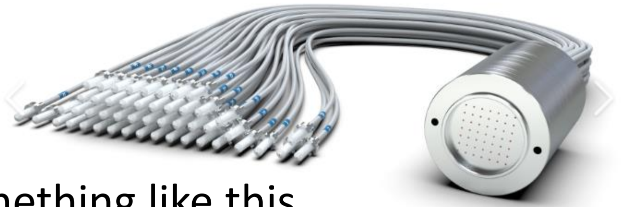
Structured microlens array transforms gaussian beam to flat top beam



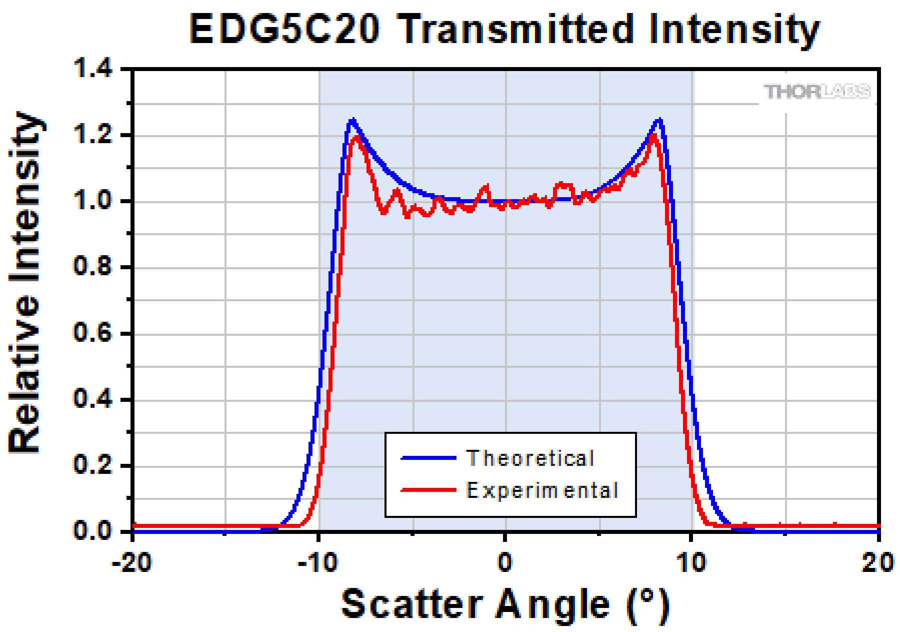
Fiber launcher

Fiber bundle

Each fiber terminates in a prism
On the front face of a crystal in
the array

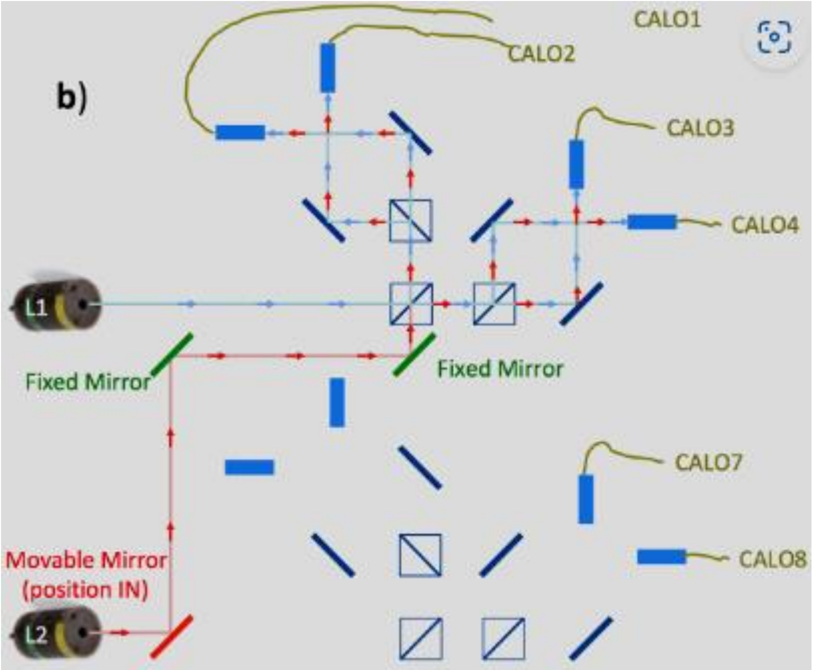


We would do something like this



Fiber bundle is positioned to intercept flat central part

Double pulsing with two independent lasers.



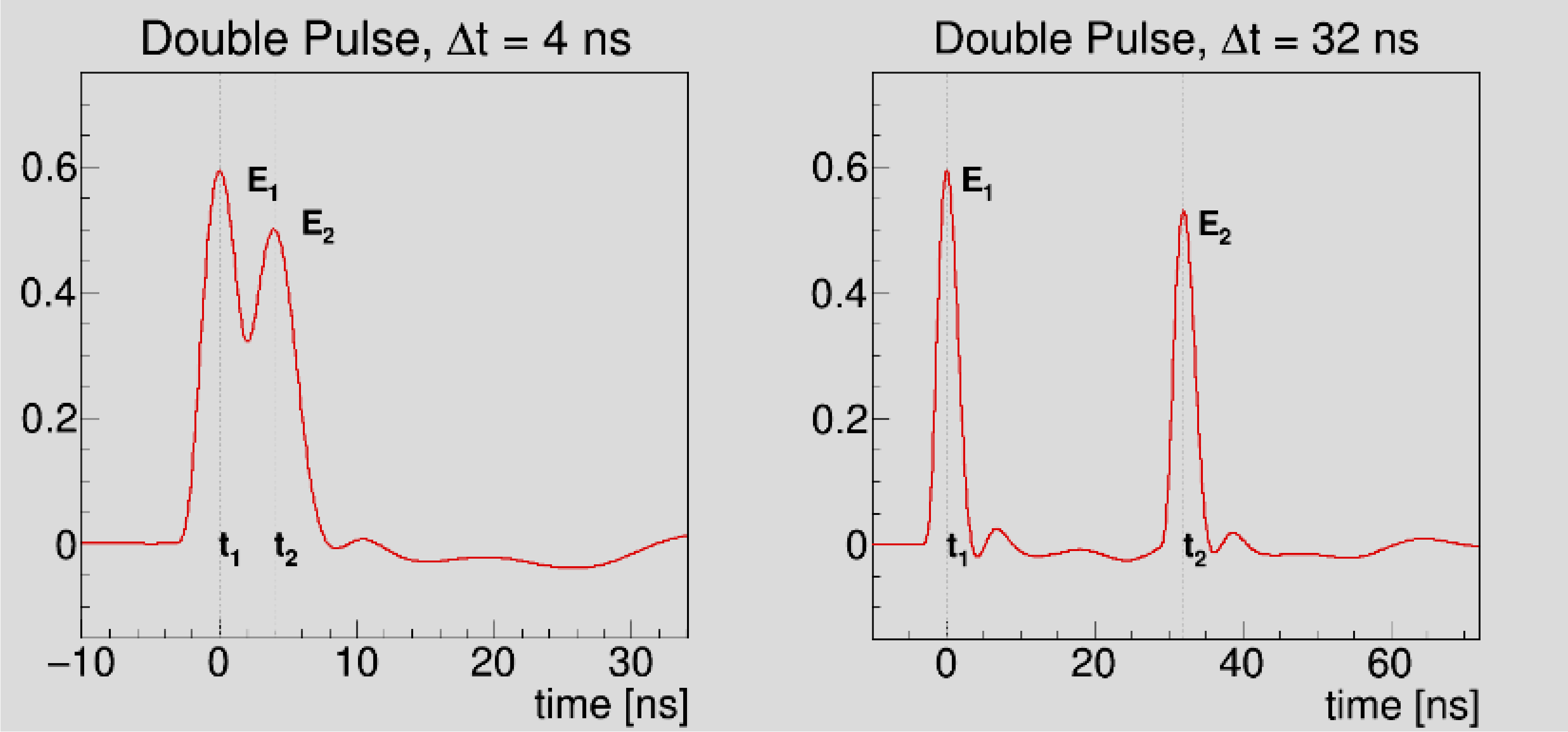
Amplitudes of pulses can be varied independently.

Consecutive pulses from same laser limited to 40 MHz rep rate.

Pulse statistics from independent lasers are uncorrelated.

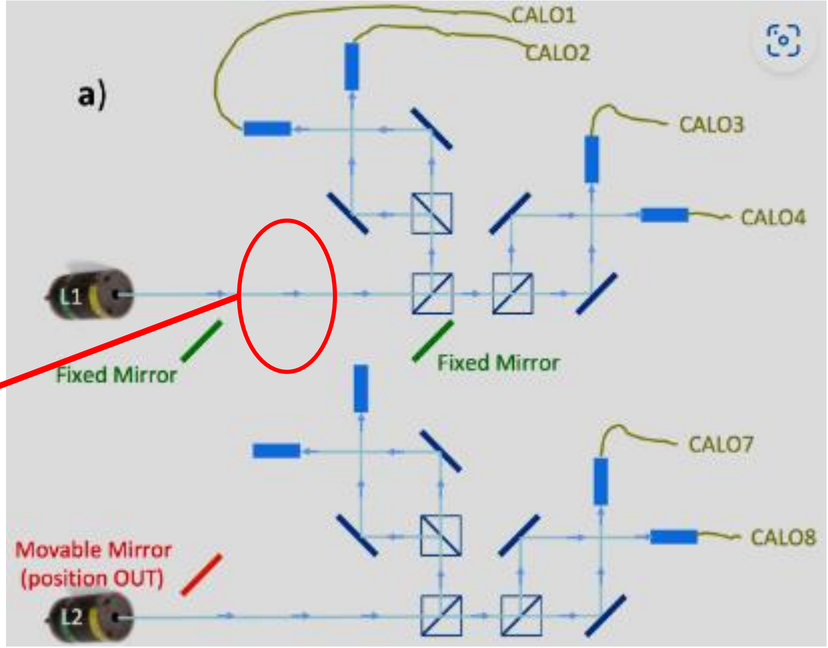
A movable mirror re-directs the laser's light along the same path as another laser.

Two pulses with different amplitudes and times are sent to the same calorimeter

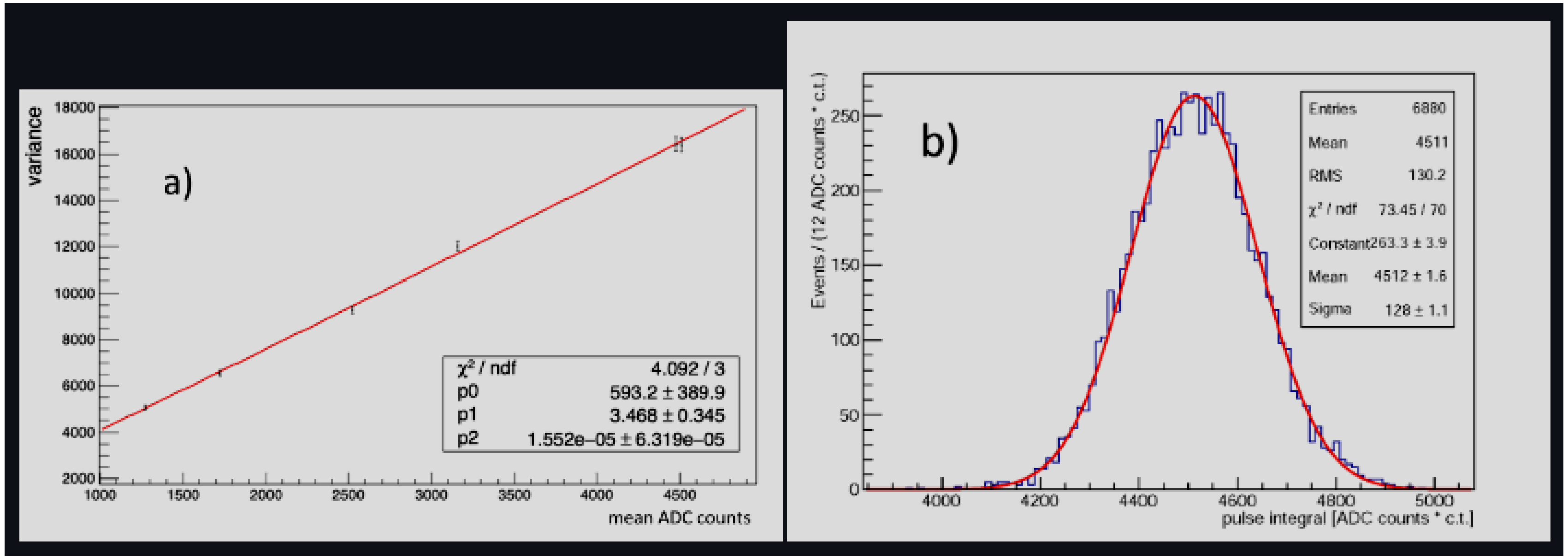


Vary the laser’s output with calibrated neutral density filters

Assume laser’s photon distribution is Poissonian
with measured mean proportional to photo-electrons



Variance is proportional to the mean.
The slope of the variance/mean plot is
the proportionality constant or gain of
the SIPM.



The LYSO version with a UV laser

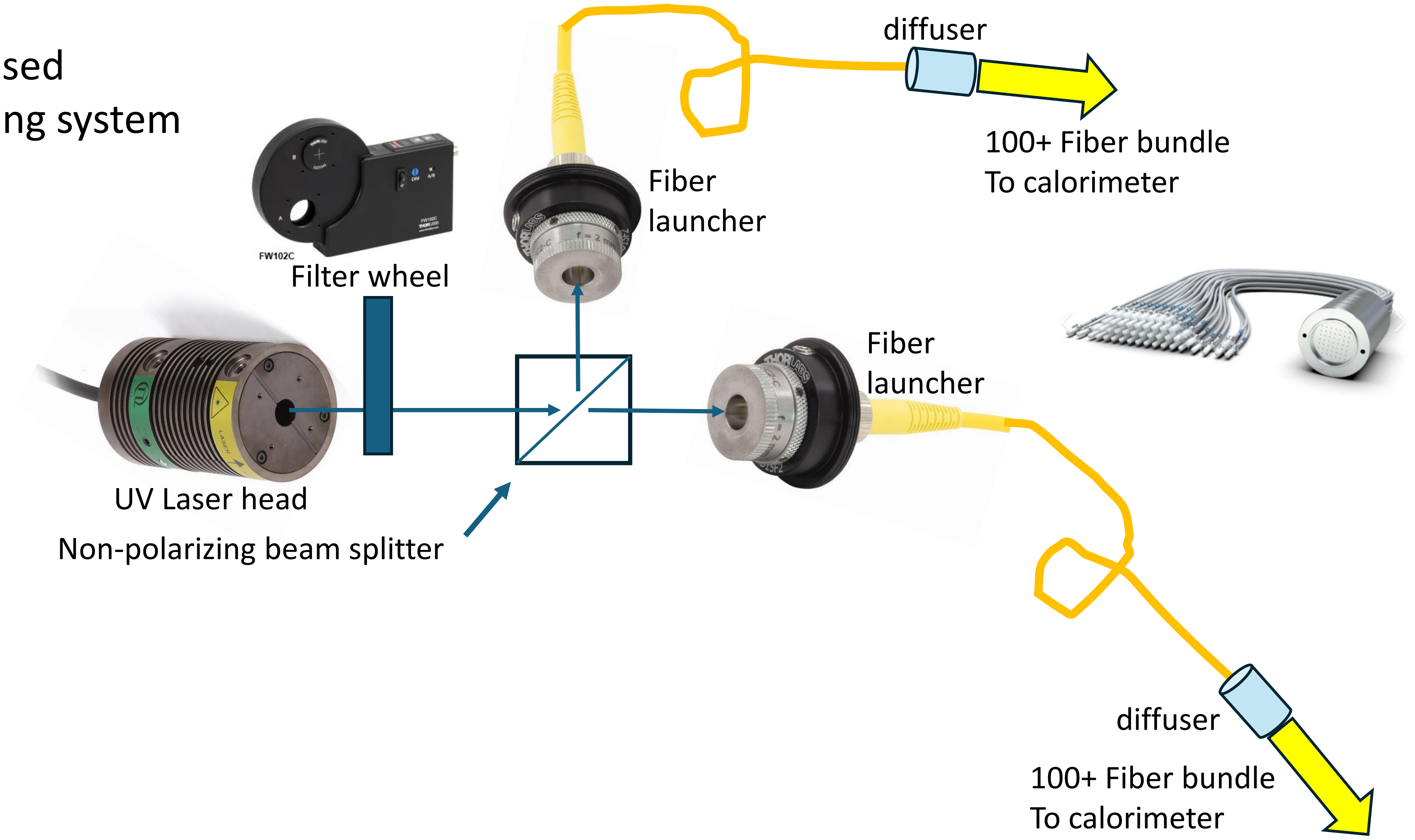
Laser:
Picoquant LDH-FA=355 ☑

UV Optics:
Engineered diffuser
Fiber, Launcher ☑

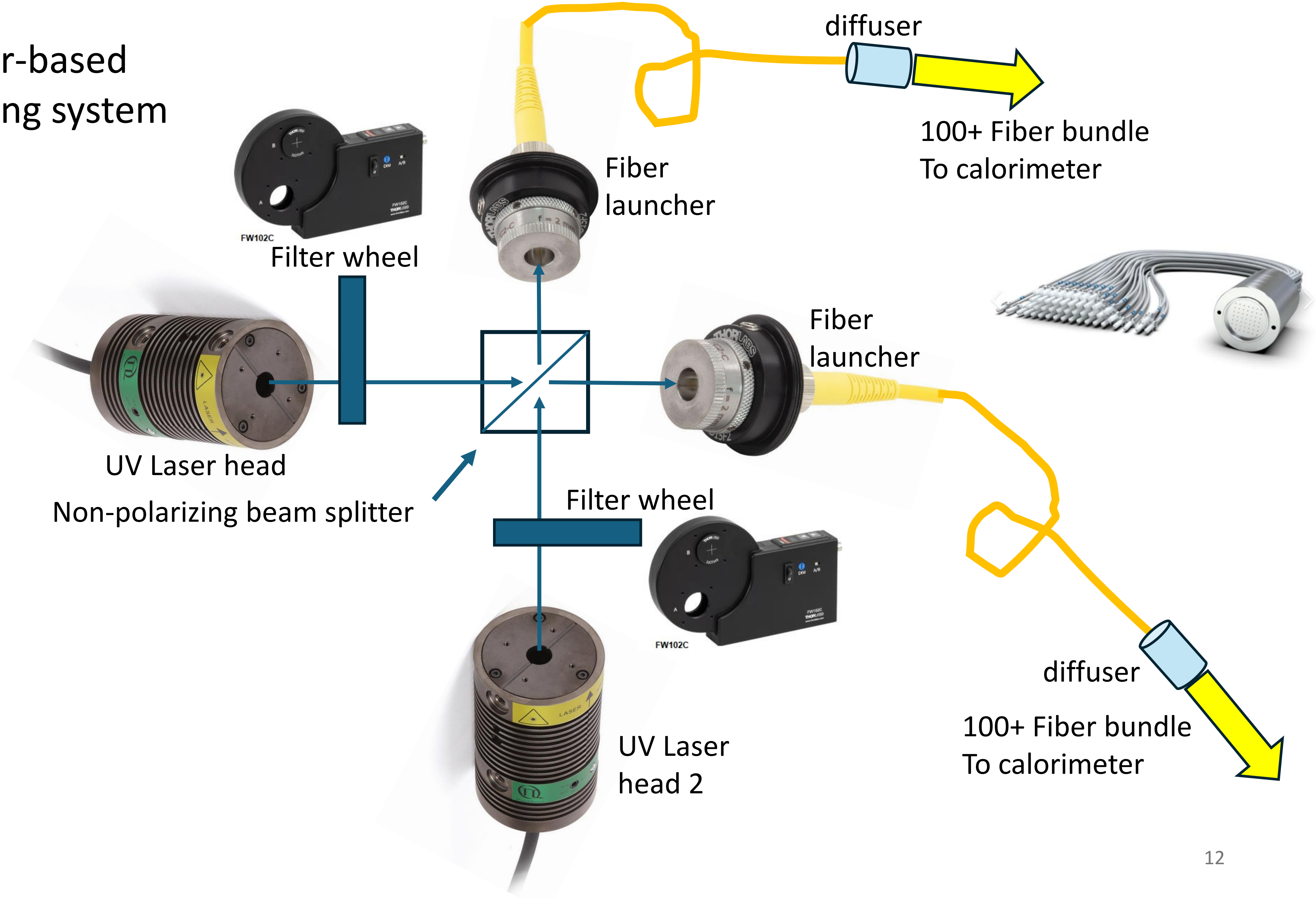
Laser control ☐

Laser Monitor ☐

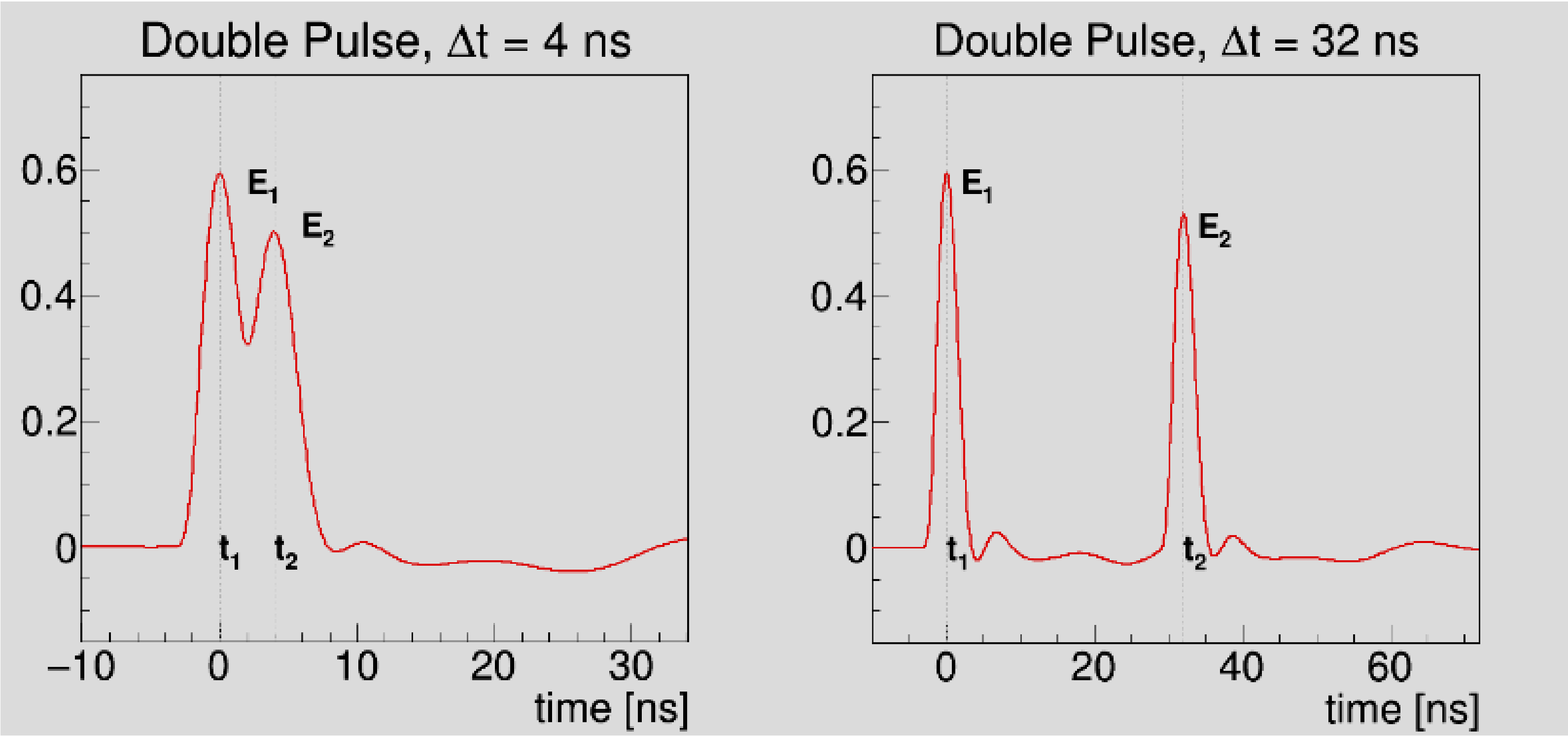
LYSO laser-based gain monitoring system

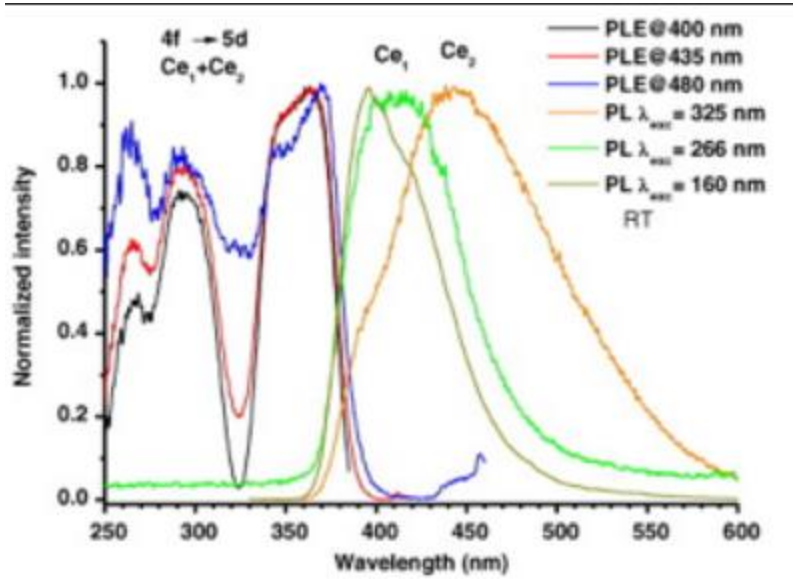


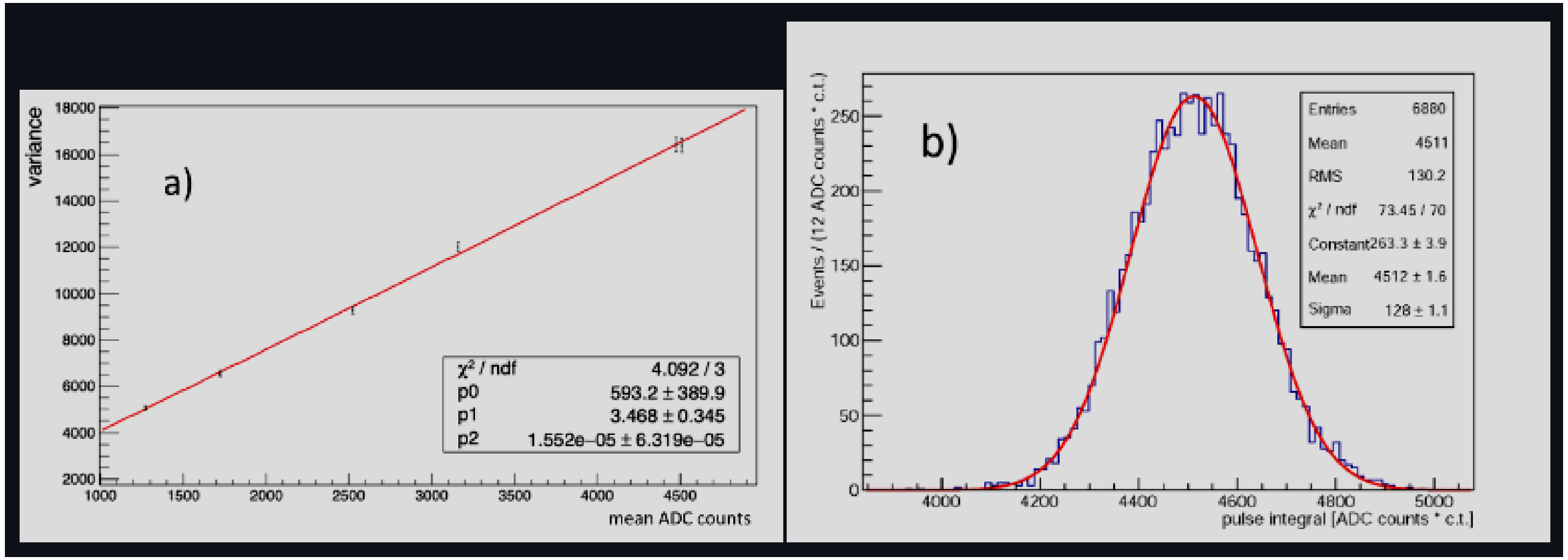
PIONEER laser-based gain monitoring system



With appropriate control of the lasers, we can have an equivalent laser calibration system that uses LYSO's own light.







That's All Folks