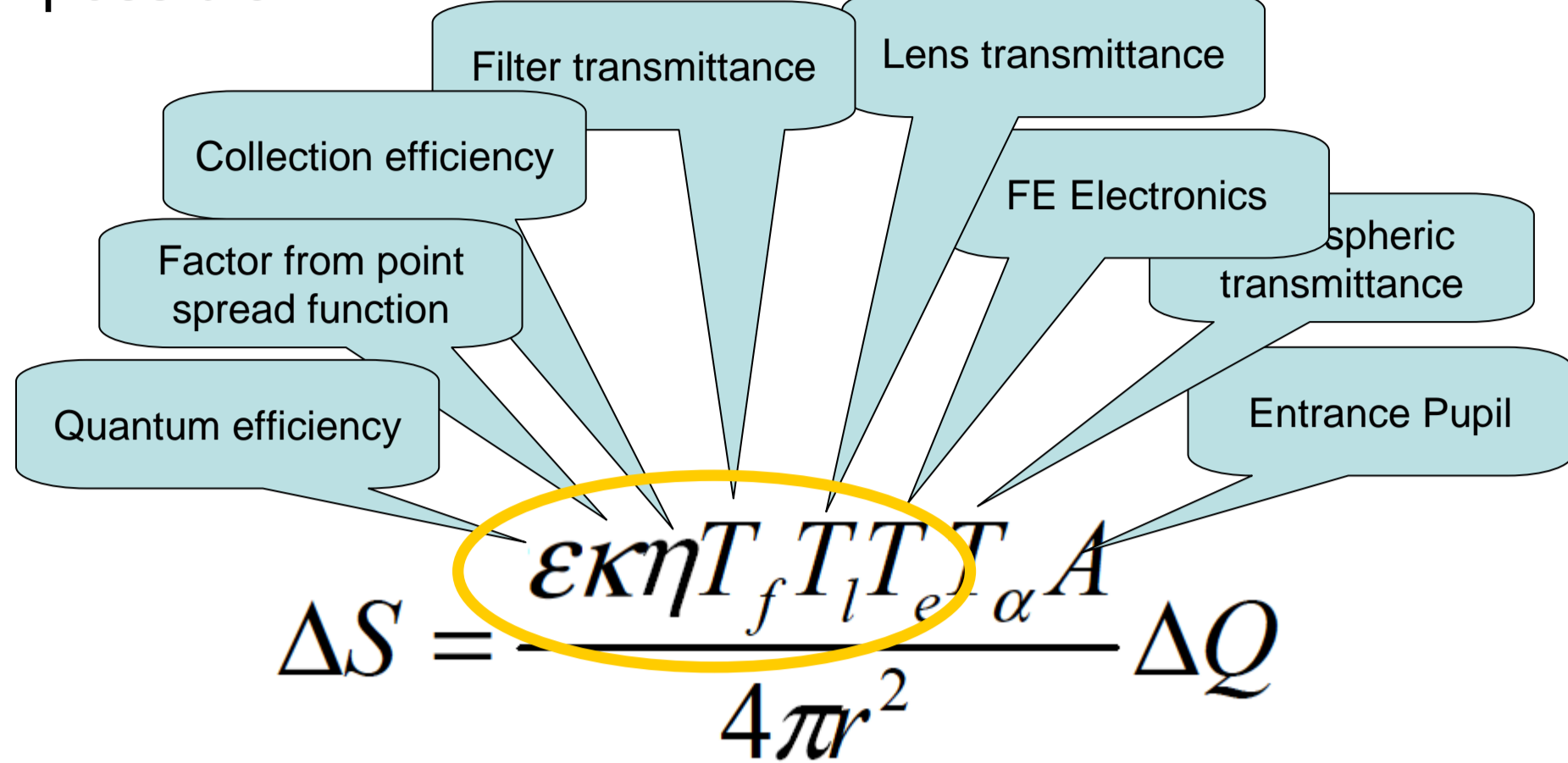


JEM-EUSO キャリブレーションシステム

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What should be calibrated?

In order to obtain the light intensity (ΔQ) from an extensive air shower from the detected signal (ΔS), intervening factors should be known as precise as possible.



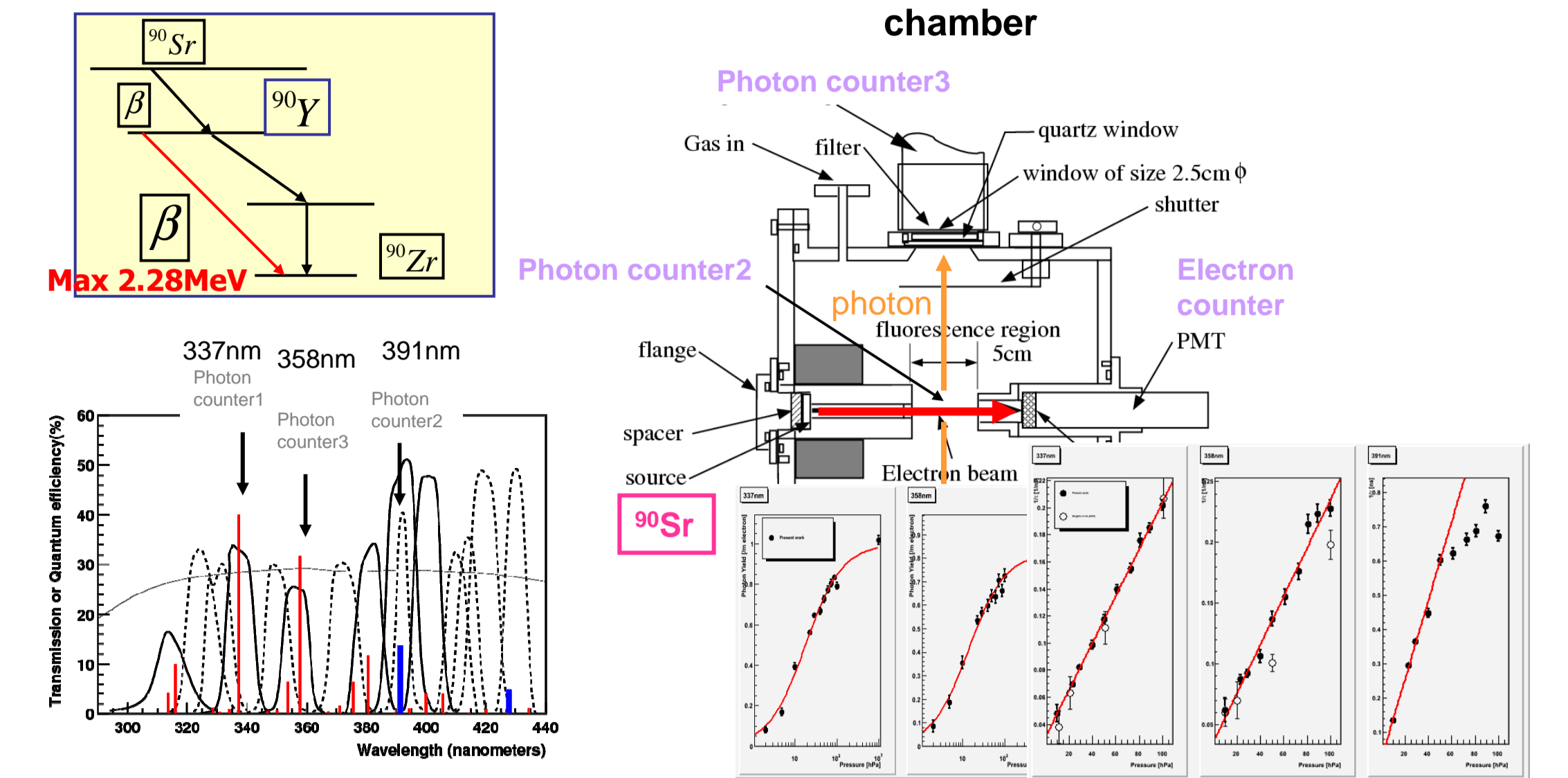
Category

Single photo-electron level measurement

- **Preflight calibration (Characterization)** (PMT, PDM, the JEM-EUSO instrument)
- **In-flight calibration**
 - Onboard calibration of the instrument (LED light source)
 - Atmospheric monitor
 - From-ground calibration (Ground Light Source (GLS), Ground LIDAR)

Fluorescence efficiency measurement

Fluorescence efficiency is very important to determine the cosmic ray energy in JEM-EUSO.



Preflight calibration

PMT calibration

Whole the photocathode is illuminated to take pulse height distribution of each pixel to determine optimal high voltage to meet the specified gain.

2 units will be prepared.

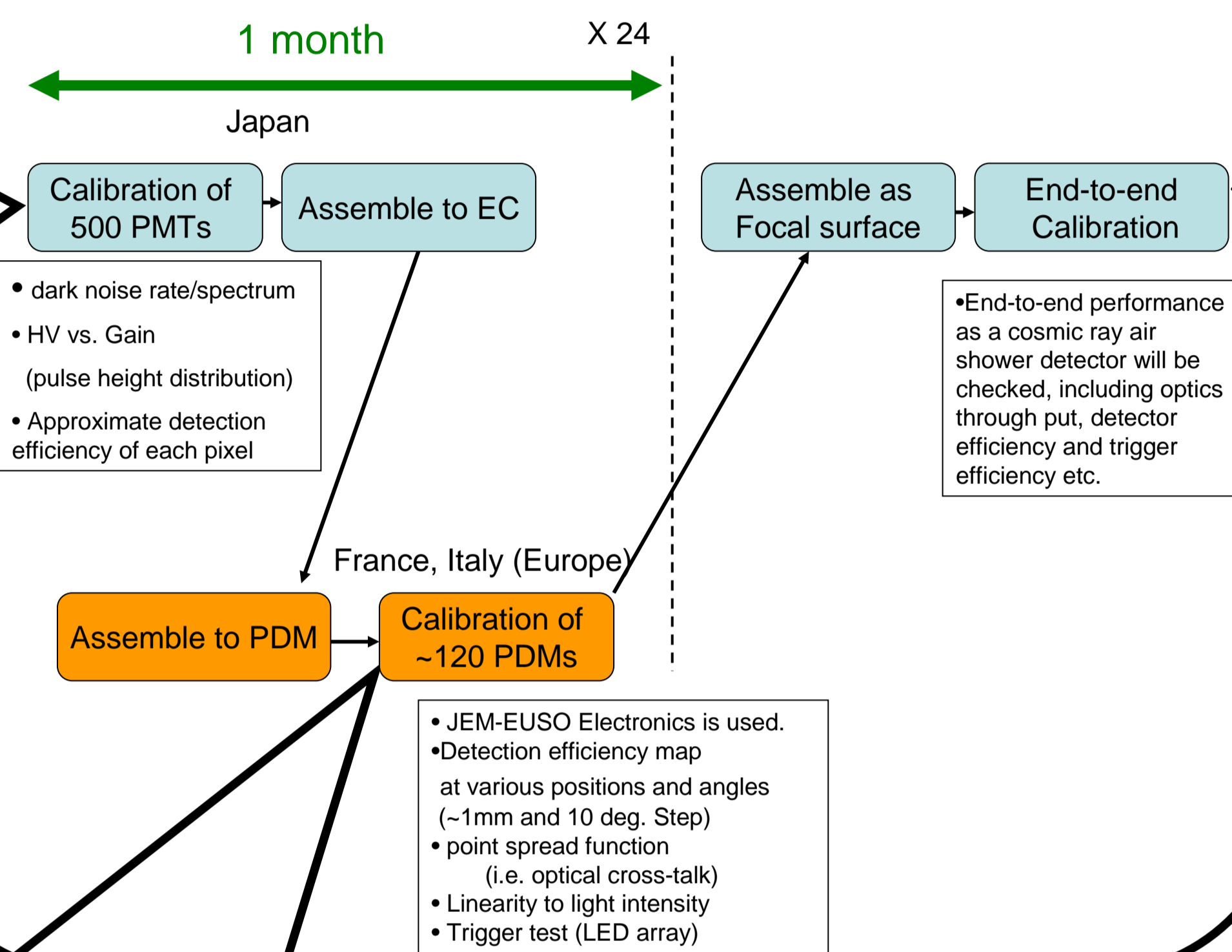
LED light is diffused by an integrating sphere to illuminate 10 MAPMTs with same intensity.

Calibrated monitor photo-diode

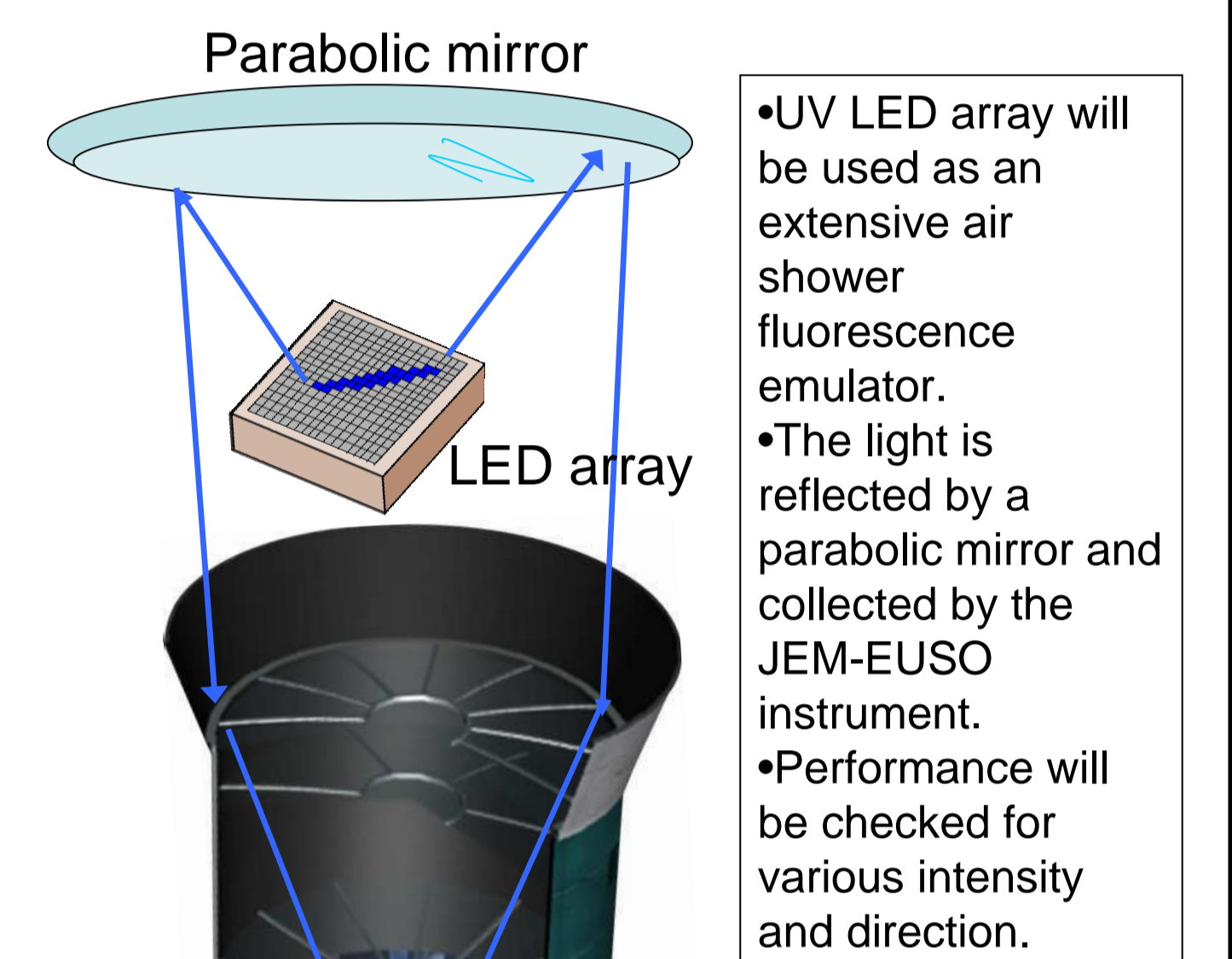
- LEDs (3 wavelengths in 330-430nm range)
- 5 photon counting electronics prepared by the Palermo group.

The box enclosing UVM and the HV power supply

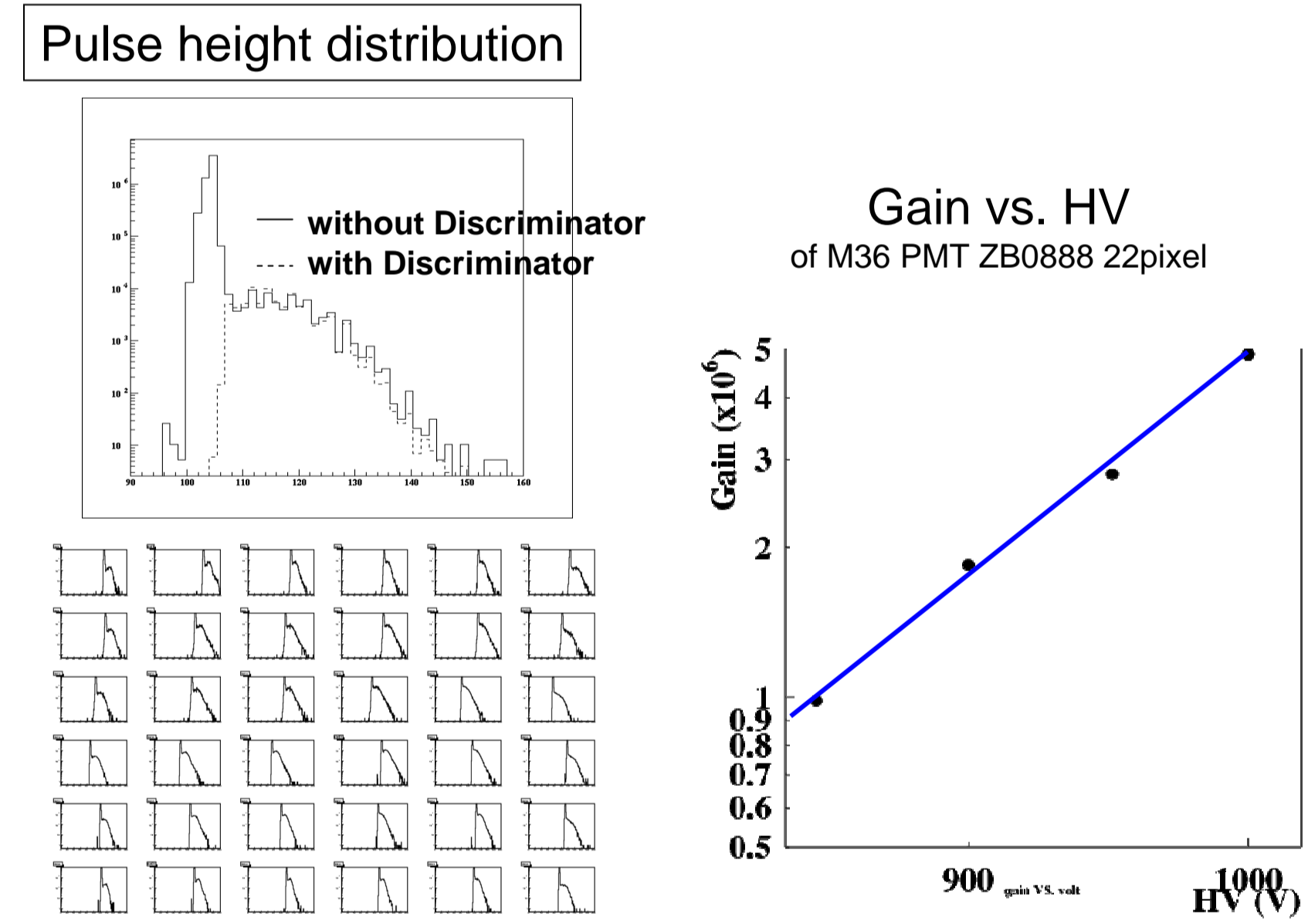
Calibration scheme



End-to-end calibration



Sample of characteristics of 36ch UBA MAPMT



PDM (Photo Detector Module) calibration

X, Y, Z, θ , ϕ mvt in a black box

2 units will be prepared.

The light source:

- integrating sphere
- collimator
- LEDs (3 wavelengths in 330-430nm range)

Detection efficiency measurement with a prototype apparatus works!

73 LEDs (395nm)

Reduction ratio PD1 : PD2 = $0.97 \times 10^6 : 1$

The reduction rate was measured with intense light and two calibrated photo-diodes. One of them was replaced by a MAPMT and the efficiency was measured with faint light (photon counting).

36ch UBA MAPMT	Detection efficiency
Pixel21	27.5%
pixel22	30.5%

In-flight calibration

- **Onboard calibration**
 - LED light source system to monitor detectors and detectors+optics
 - Monitor of BG counts to check hot/dead pixels
 - Possible absolute calibration with Moon in full-moon period.
- **From-ground calibration**
 - Ground Light Source (GLS)
 - check the focus of the optics, atmospheric condition, cross-check of the detector efficiency
 - (Ground) LIDAR
 - check the accuracy of air shower reconstruction experimentally (Energy & direction) and atmospheric condition

Onboard calibration

LED light source will be used to calibrate the detectors by FS illumination (left fig.) and the detectors+lenses by lens illumination from FS (right fig.).

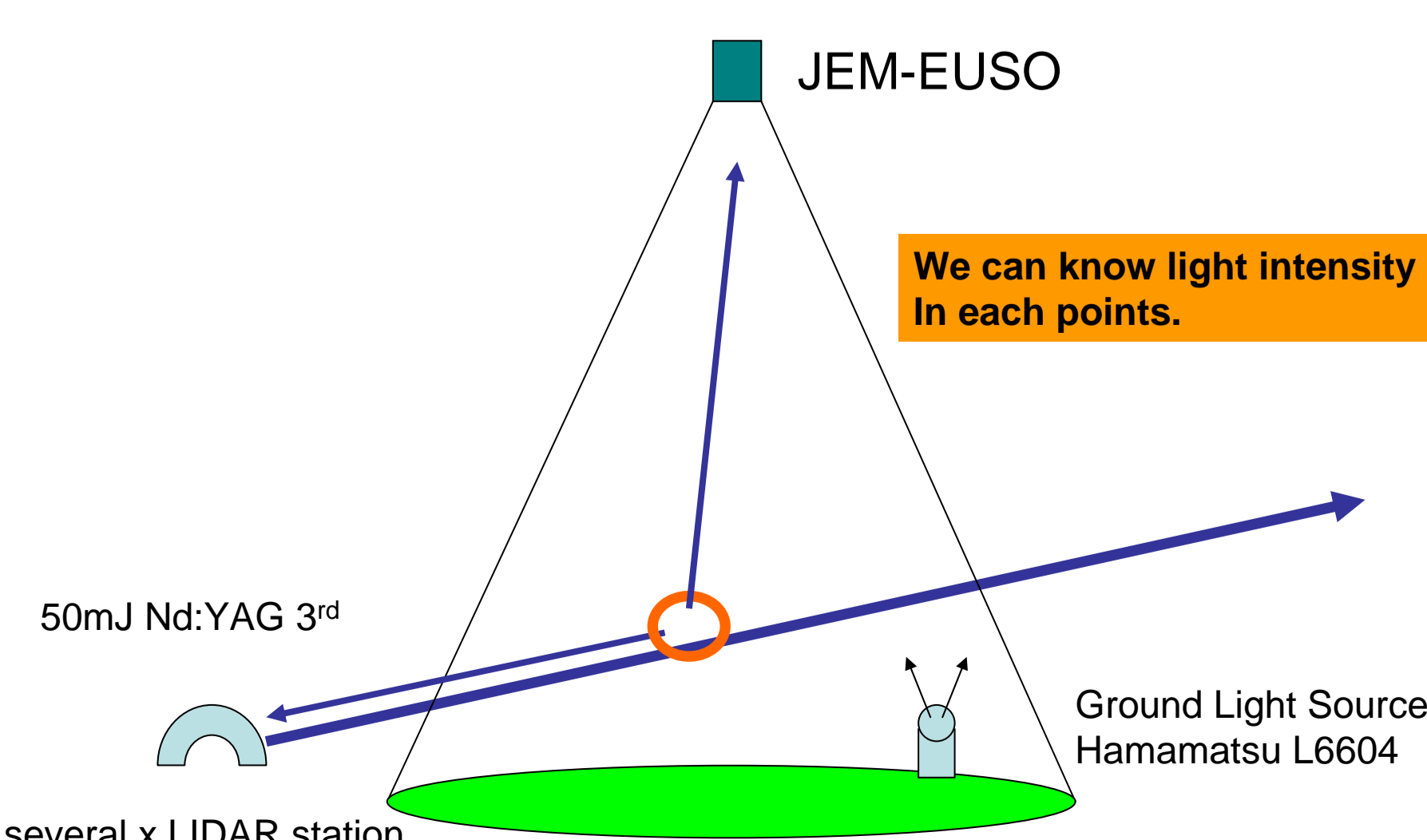
Detector calibration: Eg. 6 light sources on the rear of the 3rd lens

Optics (+detector) calibration: FS, Lenses, Lid

LED light source with an integrating sphere

Space qualified diffuse reflector on the lid

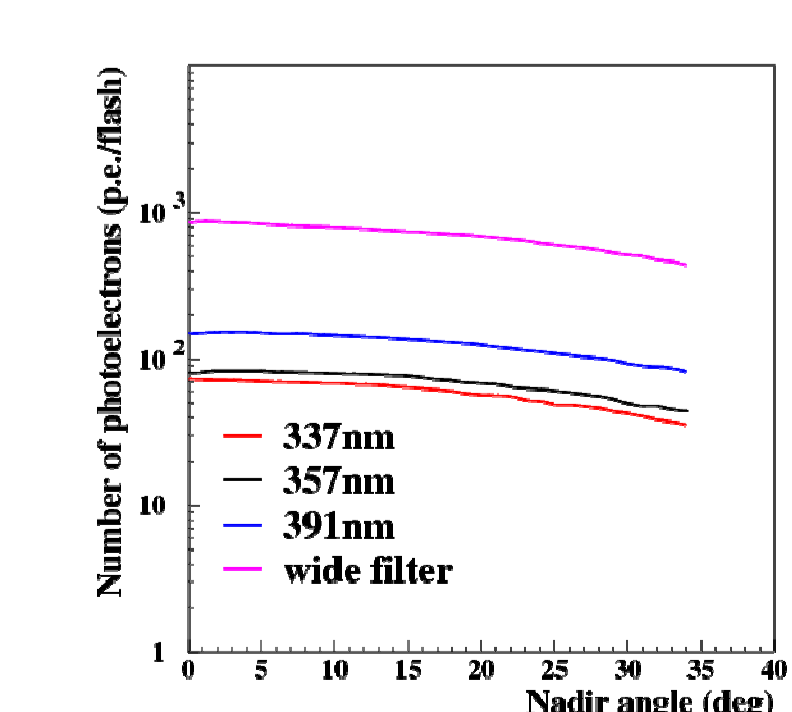
From-ground calibration



Ground Light Source (GLS)

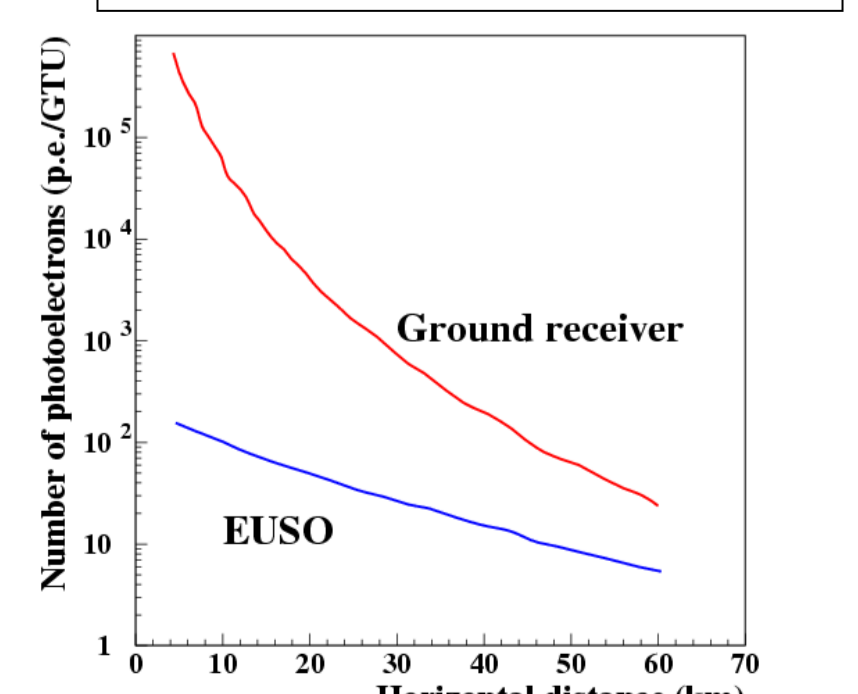
- GLS Breadboard Model:
 - 4 Xenon flash lamps (Hamamatsu L6604)
 - Optical filters: 1-broadband (300-400nm) and 3-line filters (337, 355, 391 nm ± 10 nm)
- Two versions:
 - Ground-based: 20 primary units all over the world and 10 spares (EUSO will see GLS once a day)
 - Air-borne: same components; mounted in P-3A Orion aircraft, monthly deployment at altitudes 2-6 km

Expected signal from a GLS



Expected number of photoelectrons per flash detected by EUSO. Pulse duration is short enough to fit in one GTU (2.5 μ s). The GLS's will be deployed on high mountains to reduce the effect of atmospheric condition.

Expected signal from a 50mJ ground LIDAR



Expected number of photoelectrons per GTU (2.5 μ s) detected by EUSO and a ground receiver (1m diameter) from a ground LIDAR (50mJ/shot, 355nm NdYAG third harmonic) shooting with elevation angle of 20 deg.