In order to obtain the light intensity ($\Delta Q$) from an extensive air shower from the detected signal ($\Delta S$), intervening factors should be known as precise as possible.

**What should be calibrated?**

- **Preflight calibration**
  - PMT calibration
    - Whole the photomultiplier 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.
    - Calibrated monitor photo-diode
    - LEDs (3 wavelengths in 330-450nm range) + 5 photon counting electronics prepared by the Palermo group.

- **PDM (Photo Detector Module) calibration**
  - LED light is diffused by an integrating sphere to illuminate 10 MAPMTs with same intensity.
  - 2 units will be prepared.
  - LEDs (3 wavelengths in 330-450nm range) + 5 photon counting electronics prepared by the Palermo group.

- **In-flight calibration**
  - Onboard calibration
    - LED light source will be used to calibrate the detectors by F1 illumination (left fig.) and the detectors/arrays by lens illumination from F8 (right fig.).
  - GEM-EMUSO
    - 4 Xenon flash lamps (Hamamatsu L6604 transmittance $\exp(-T/\Delta T)$)
    - LEDS (3 wavelengths in 330-450nm range) + 5 photon counting electronics prepared by the Palermo group.

- **From-ground calibration**
  - Ground Light Source (GLS)
    - Light source with an integrating sphere
    - Integrating sphere with 3 wavelength LEDs

**Fluorescence efficiency measurement**

- Fluorescence efficiency is very important to determine the cosmic ray energy in JEM-EUSO.
- The LED array will be used as an extensive air shower fluorescence simulator.
- The light is reflected by a parabolic mirror and collected by the JEM-EUSO instrument.
- Performance will be checked for various intensity and direction.

**Sample of characteristics of 36ch UBA MAPMT**

- Pulse height
- Gain vs. HV
- X, Y, Z, φ, θ m in a black box

**Detection efficiency measurement with a prototype apparatus works!**

- Reduction ratio
- PD1: PD2: 0.97:10:1
- GLS UBA MAPMT
  - Detection efficiency
  - 0.96
  - 0.95

**End-to-end calibration**

- Parabolic mirror
- 30.5% Fluorescence efficiency measurement

**Expected signal from a GLS**

- Expected number of photoelectrons per flash (by GEM-EMUSO)
- Expected number of photoelectrons per flash (by GEM-EMUSO)
- Expected number of photoelectrons per flash (by GEM-EMUSO)