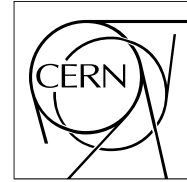




The Compact Muon Solenoid Experiment
CMS Performance Note



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Barrel Timing Layer crystals quality control plots

CMS Collaboration

Abstract

The note presents the latest results on the LYSO crystal quality controls, as uniformity of the light output and decay time, and planarity of the crystal arrays, towards the production of the Barrel Timing Layer sensors.

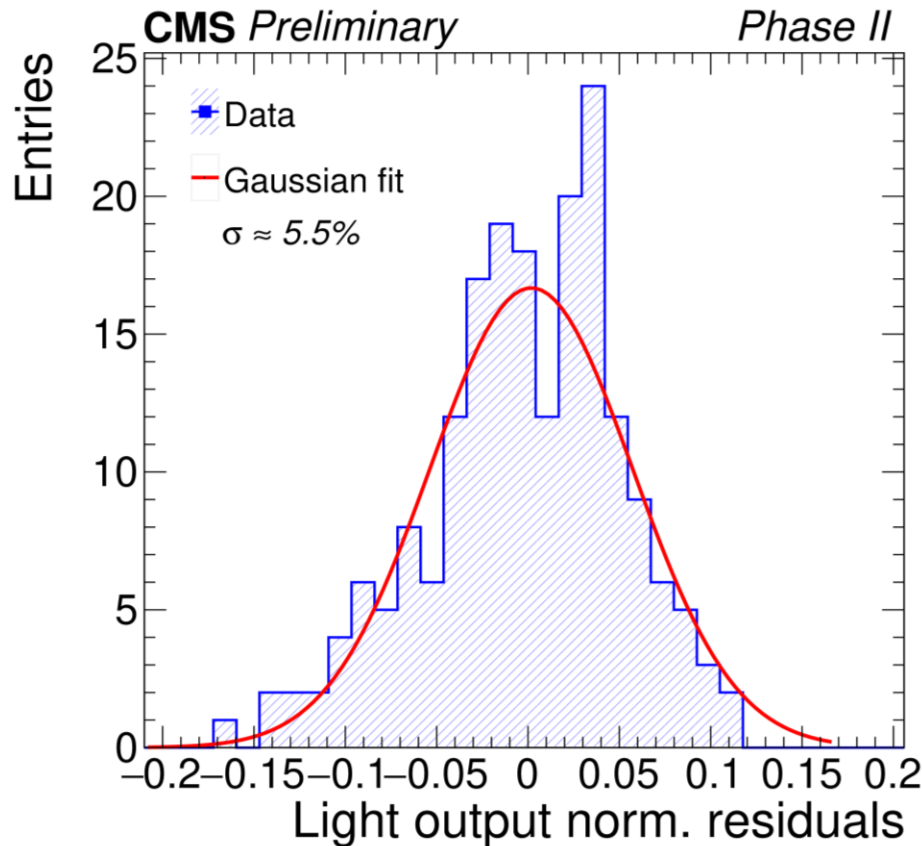
Barrel Timing Layer crystals quality control plots

CMS Collaboration

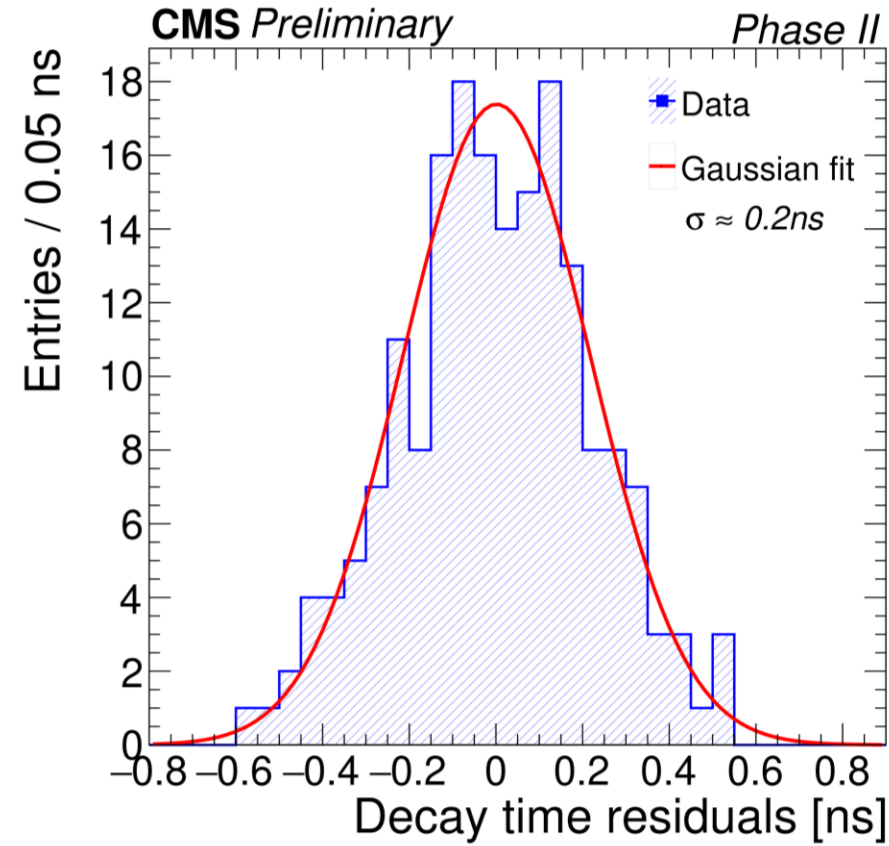
cms-dpg-conveners-mtd@cern.ch

Ingot quality measurements reproducibility

- 4 crystals are used as reference and measured at the begin and end of each measurement session
- Residuals with respect to the average measurement of each reference crystal are shown for the absolute light output measurement and the decay time
- Reproducibility of 5.5% and 0.22ns are established from gaussian fits to the distributions

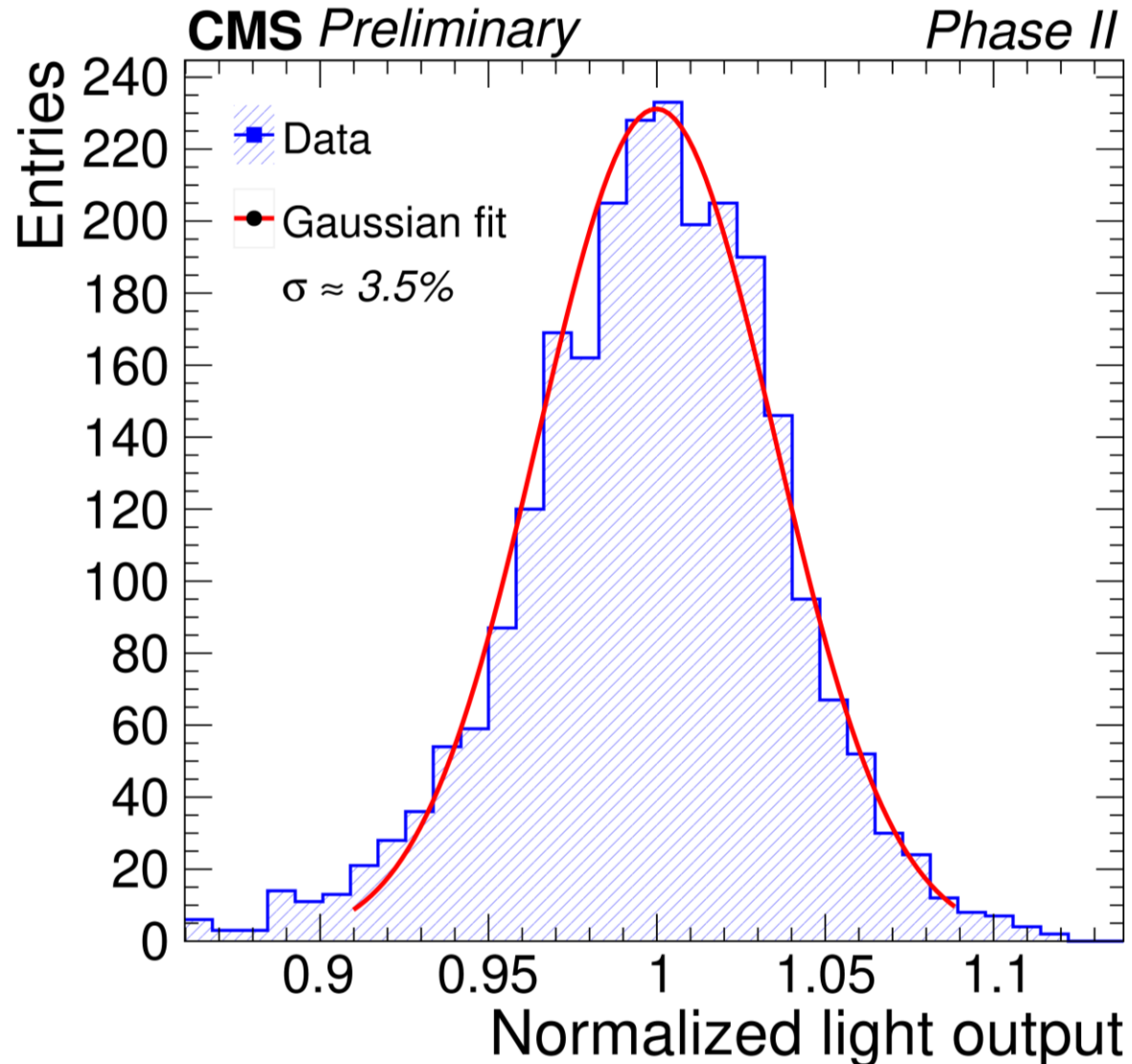


Light output normalized residuals of 4 reference crystals with respect to crystal-averaged values.



Decay time residuals of 4 reference crystals with respect to crystal-averaged values.

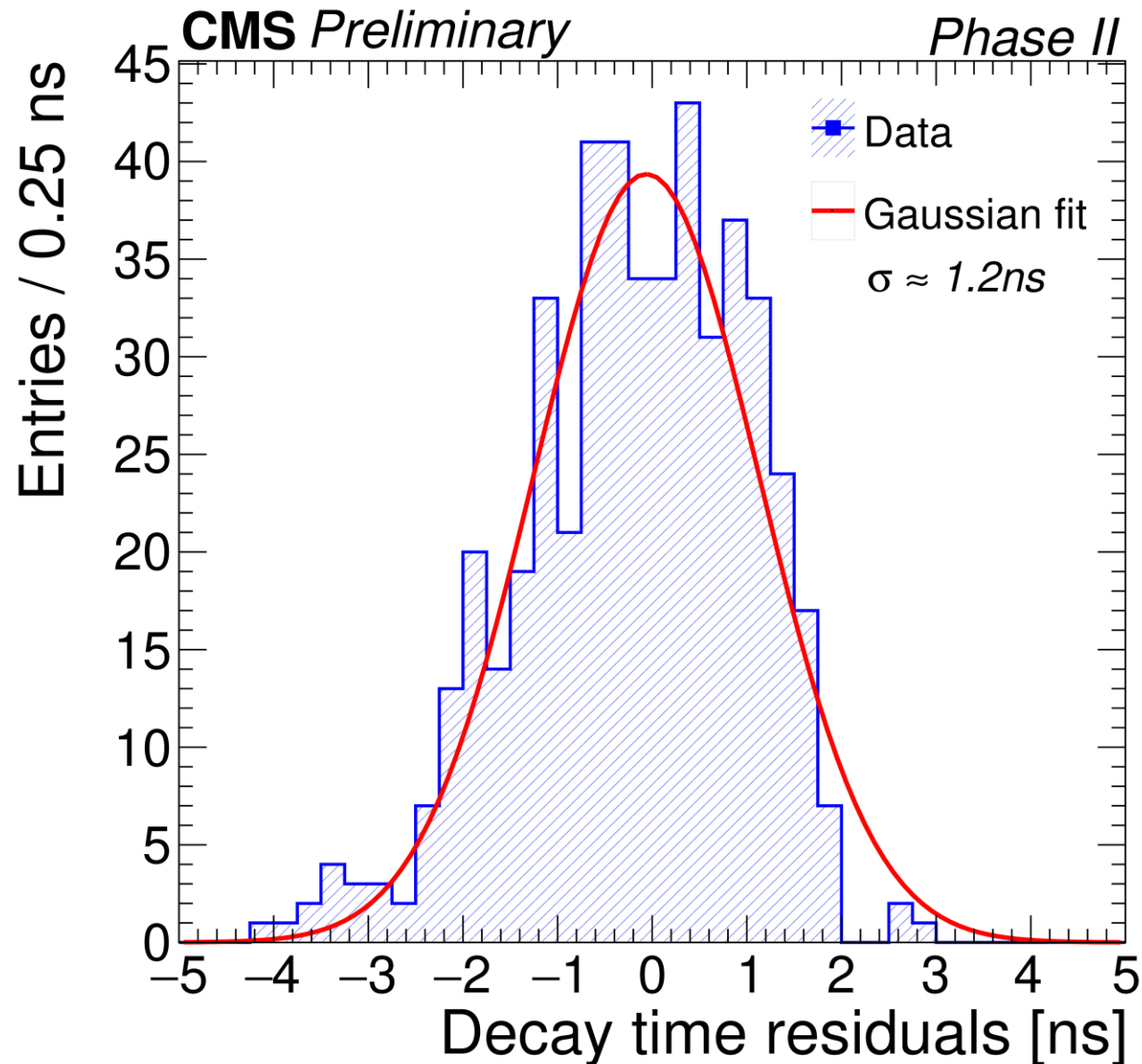
LYSO Production uniformity



- About 1/3 of the total production has been delivered and measured so far (total production is divided in 9 monthly batches)
- The normalized distributions of light output for all crystals inside arrays is shown
- Standard deviation of 3.5% is found after gaussian fit to the distribution

Normalized light output of
crystals inside arrays

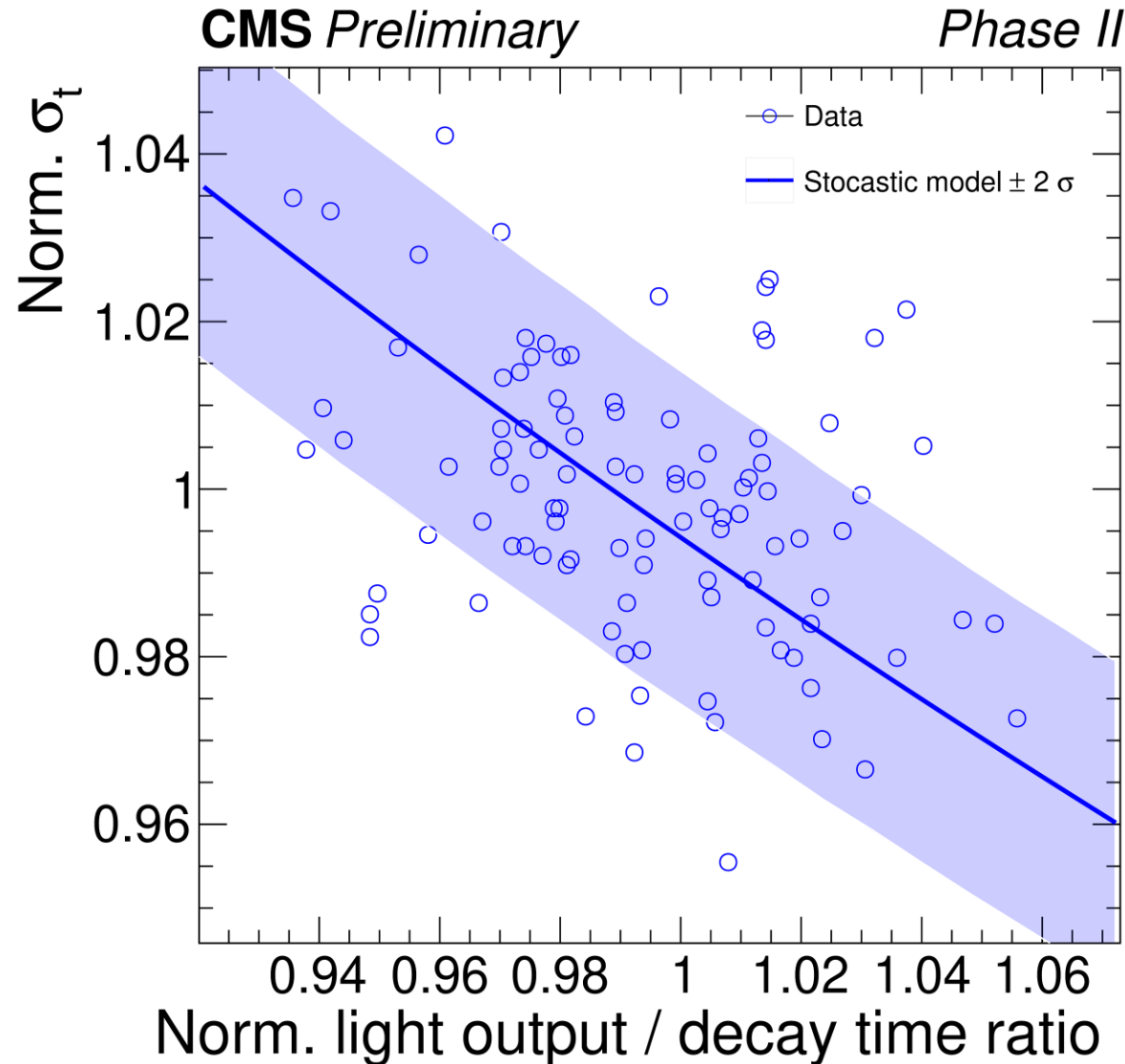
Decay time uniformity



- About 1/3 of the total production has been delivered and measured so far (total production is divided in 9 monthly batches)
- A standard deviation of 1.2 ns on the decay distribution is found after a gaussian fit

Decay time distribution of about 1/3 of the crystals produced so far and tested for quality control

Time resolution correlation with the light output/decay time figure of merit

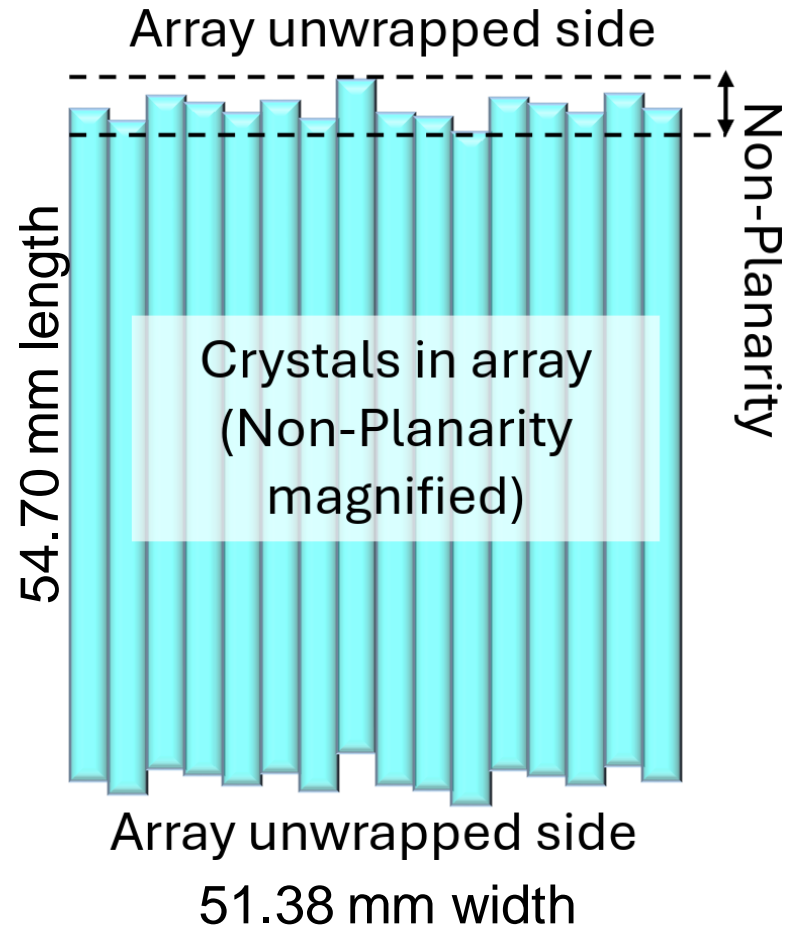
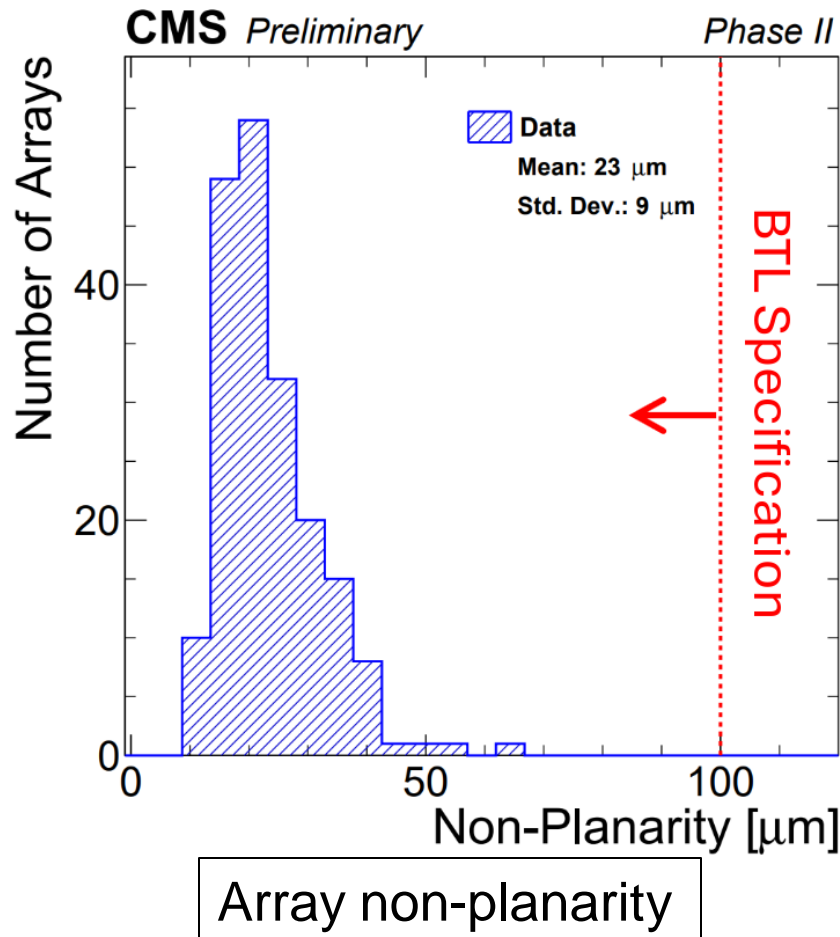


- The plot represents the correlation between the normalised LYSO figure of merit (light output/decay time) and the normalised time resolution
- Each point is averaged over the measurements performed on each ingot: light output and time resolution is extracted from each bar inside the LYSO arrays, decay time is obtained from the sample crystals measured on each ingot
- A line is super-imposed, corresponding to the expected dependence as a photostatistics model (inverse square root). The confidence intervals are at 2 sigmas, considering the measurements reproducibility as error.

Normalized time resolution vs. normalized light output / decay time ratio, averaged per each ingot

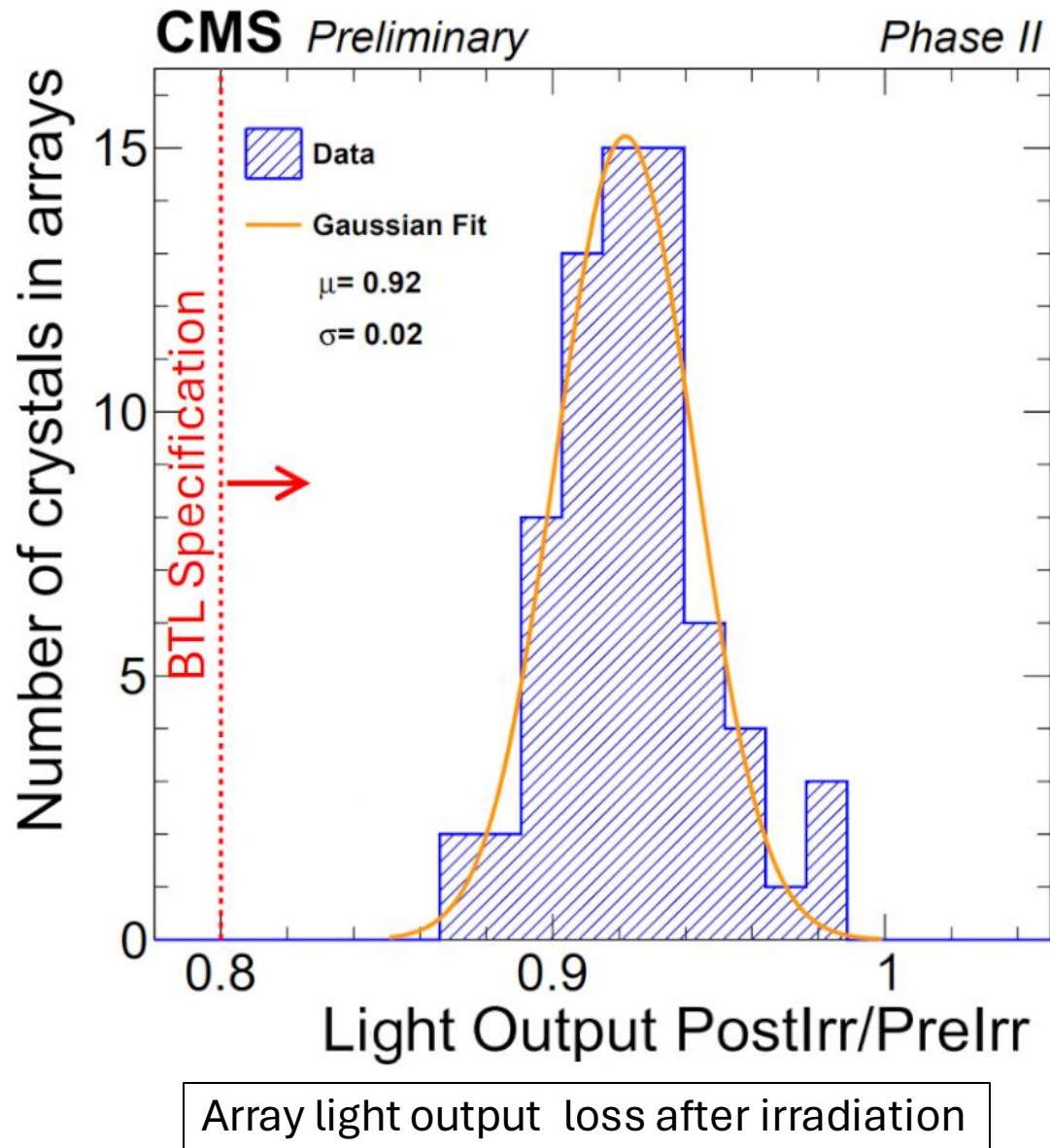
Array planarity checks

- The position of the face of each crystal on the unwrapped side of the array is measured with a Coordinate Measuring Machine with a precision of few μm . The difference between the position of the crystal that protrudes the most and the one that protrudes the least is taken as the measurement of the Non-Planarity of the array



- LYSO Array planarity is crucial to ensure a good coupling with the strip of photosensors (SiPM) that is attached to both unwrapped sides of the array. Non-Planarity is well below the expected thickness of the layer of glue that will couple LYSO crystals with SiPMs, which is about 100 μm .

Array light output loss after irradiation



- The Light Output (LO) of LYSO crystals inside array is measured using photons from an Na22 radioactive source, coupling LYSO crystals with SiPMs, as in final BTL design.
- The measurement of LO has been done before (PreIrr) and after (PostIrr) irradiating the crystals with 50 kGy of photons from a Co60 source.
- A gaussian fit (orange line) shows a reduction of 8% on average, caused by the crystal transparency loss, with $\sigma = 2\%$
- The LO PostIrr is above the tender specification for BTL (vertical red line), which is set at 80% of LO PreIrr.