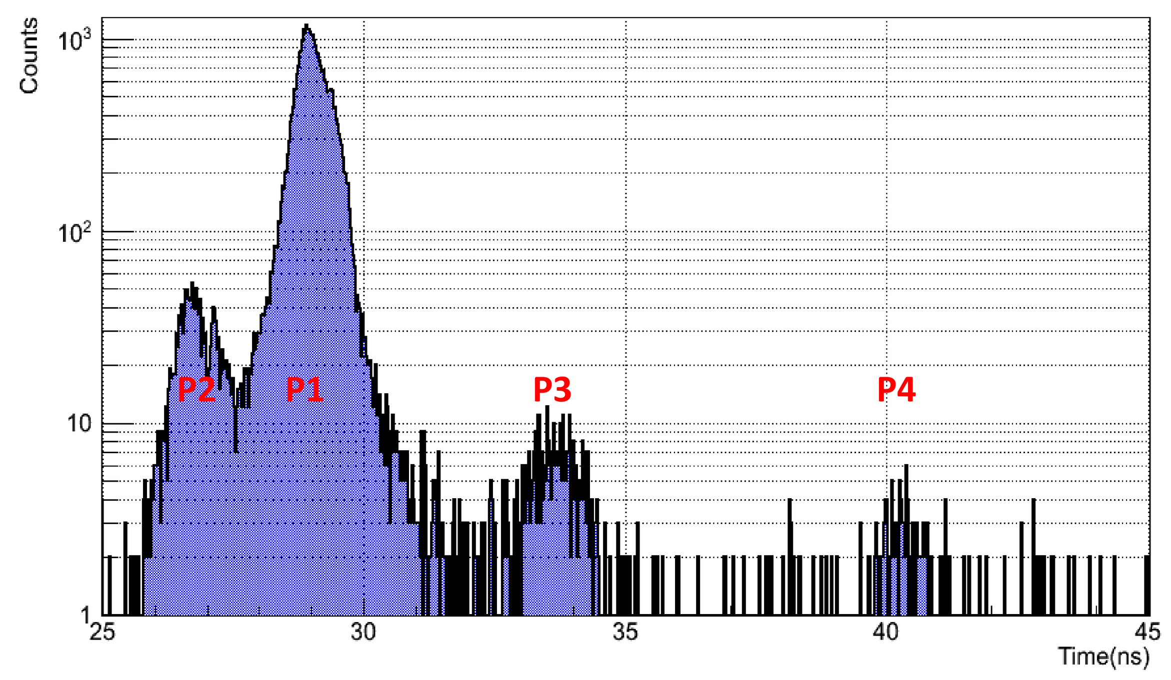
Study of H-8500 MaPMT for the FDIRC detector at SuperB

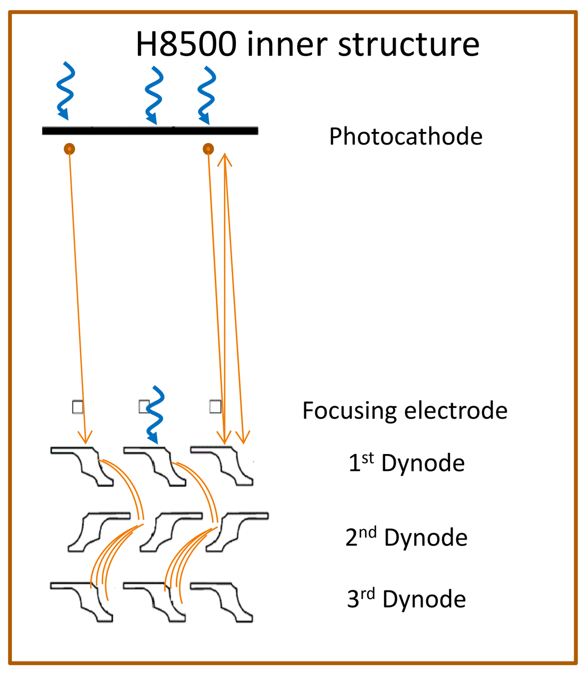
An overview of studies on the Hamamatsu H-8500 Multi-Anode Photomultiplier (MaPMT) is presented. The device will be used for the FDIRC Particle Identification detector of the SuperB experiment [1]. The H-8500 MaPMT has been chosen for its excellent single photon timing capabilities and its highly pixilated design. Results on timing studies, gain uniformity, single photoelectron detection efficiency uniformity and cross-talk are presented.

F. Gargano on behalf of SuperB PID Group
INFN-Bari
fabio.gargano@ba.infn.it

Tests of the H-8500 MaPMT [2] were performed in several test stands that were optimized for the different kinds of measurements.
A PILAS picosecond laser [3] with a narrow beam (50μm) @ 405nm was used as light source. Several front-end and readout electronics were employed for the different measurements.

A custom front-end electronics was used for detailed timing studies [4]. It provides an highly amplified analog signal and a digital signal by means of a commercial ECL comparator.
The laser intensity is set to a very low level in order to be sure to work at single photo-electron (p.e.) level. Corrections for the time walk effect are applied to data by a software algorithm.





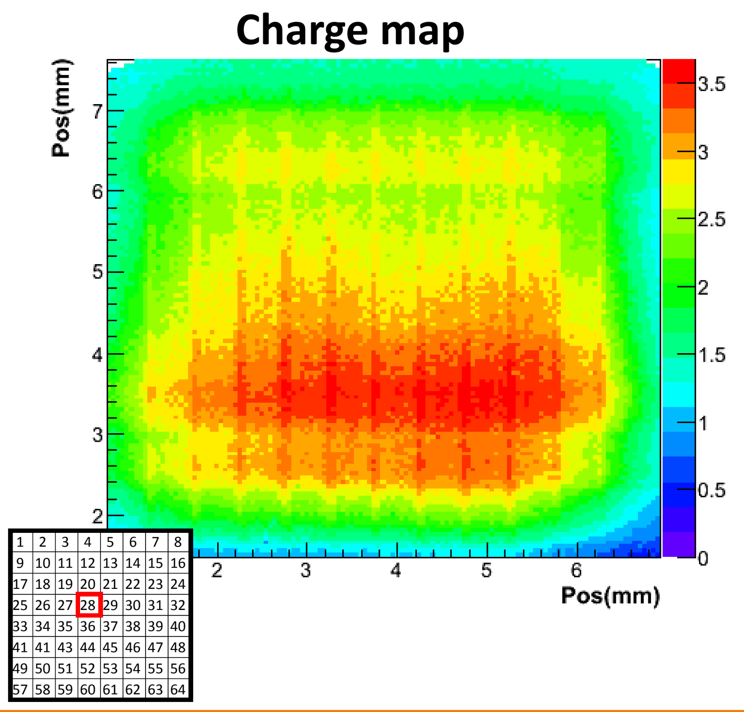
The time distribution is obtained by measuring the time between the laser pulse and the MaPMT detected signal.
The different peaks can be explained as follows:

- **P1**: Photons convert at the photocathode and p.e. are multiplied across all the 12 dynodes.
- **P2**: Photons convert at the 1st dynode and p.e. are multiplied across 11 dynodes. These p.e. are characterized by a shorter Transit Time (TT) (-2.4ns) and a lower gain.
- **P3** and **P4**: Photons convert at the photocathode but the p.e. is back scattered at the 1st dynode and then it moves again towards the 1st dynode. These p.e. are characterized by a longer TT (+4.6ns and +11.6ns).

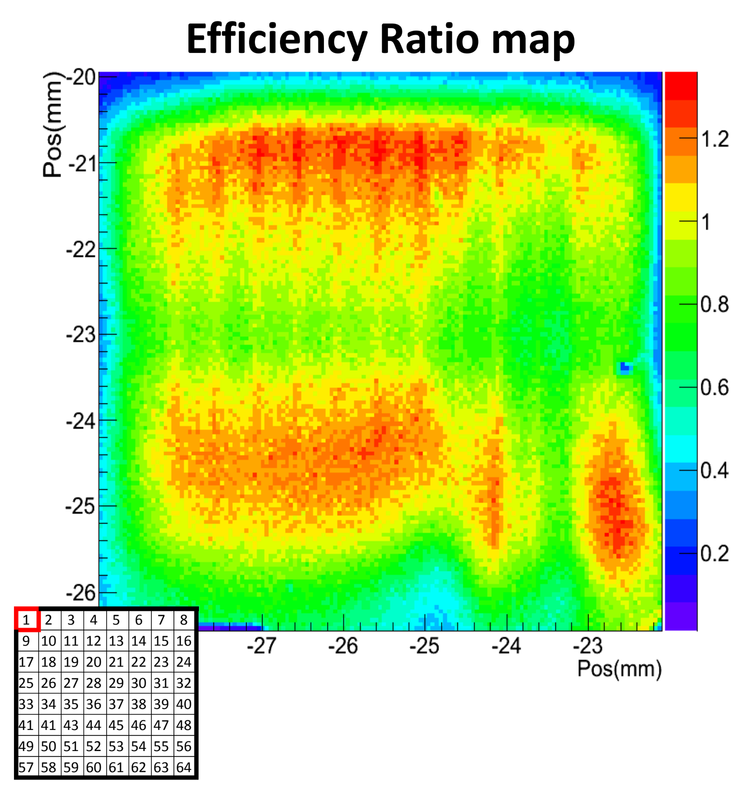
To estimate the Transit Time Spread (TTS) of H-8500 we have fitted P1 with a double Gaussian functions taking into account the intrinsic jitter of the readout electronics. The measured TTS depends on the laser beam position on the photocathode and its mean value is measured to be **160-200ps**. Further studies on the effect on timing of the inner structure of the MaPMT (i.e. focusing electrode) are still ongoing.

References:
1. J.Va'vra *"Progress on development the new FDIRC PID detector"* - This meeting – PID and Photo detectors session
2. http://sales.hamamatsu.com/assets/pdf/parts_H/H8500C_H8500D_TPMH1308E01.pdf
3. http://www.alsgmbh.com/pilas.htm
4. F.Giordano *"A front-end electronics board for single photo-electron timing and charge from MaPMT"* - This meeting – Session P4

The H-8500 gain uniformity within a single pixel was tested by increasing the laser intensity up to 20 p.e.



The signal was read out directly from the photomultiplier without any amplification stage.
The measured gain variation is around 50%.
The vertical lines in the map correspond to a gain increase of 5% around the focusing electrodes.

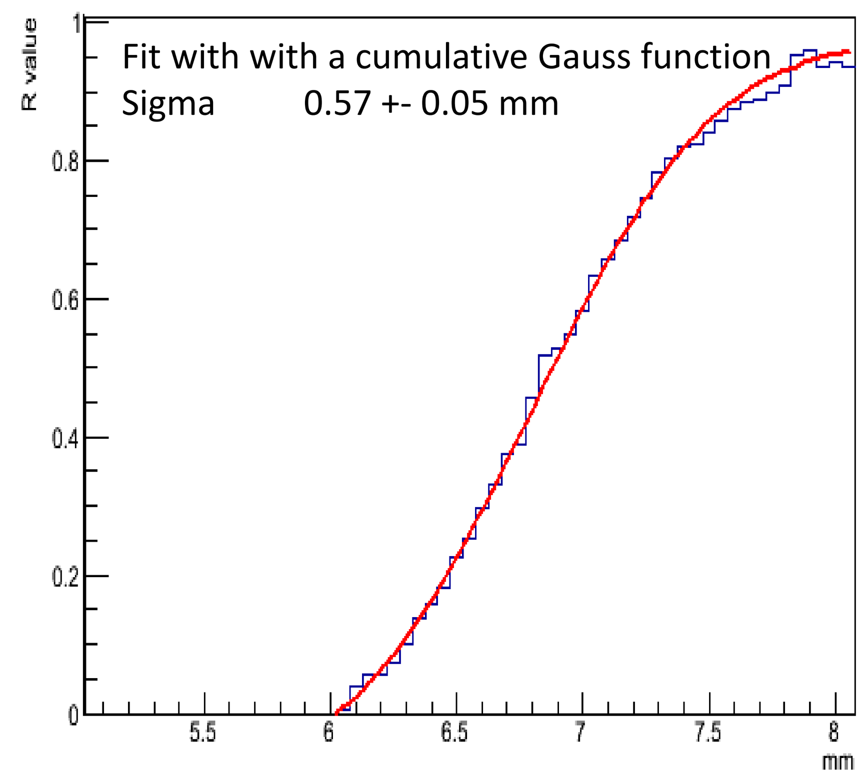


The study of the detection efficiency was performed setting the laser beam intensity at 1 p.e. and using the custom readout electronics described in [4]. The map shows the ratio between H-8500 and Photonis XP2020 (reference) detection efficiency: the variation inside the pixel is roughly 50%. The increase in efficiency is also evident near the focusing electrodes.

Pixel to pixel cross talk and charge sharing induce a correlation between two neighbor pixels. The former is related to the capacitive coupling between pixels, the latter is due to the avalanche sharing between two pixels. The measured cross talk at single p.e. level is almost 3%, but it depends on the position within the pixel. The charge sharing has been measured without any amplification stage at the light level of 20 p.e.

The R function is defined as:

$$R = \frac{Charge(1^{st}Pixel)}{Charge(1^{st}Pixel) + Charge(2^{nd}Pixel)}$$



From the fit a charge sharing region of 600μm has been measured.
The charge sharing effect disappears when decreasing the light intensity at 1 p.e. level because the focusing electrodes are more efficient in sweeping electrons far from pixel boundaries.

These measurements will be used to optimize the development of the final SuperB FDIRC readout electronics chain.
Work is ongoing to study the effect of the inner structure of the H-8500 on its timing performances, gain and efficiency. The observed characteristics and the future results will allow one to understand in detail the overall performances of the SuperB FDIRC PID.