Update on H8500 test in Bari

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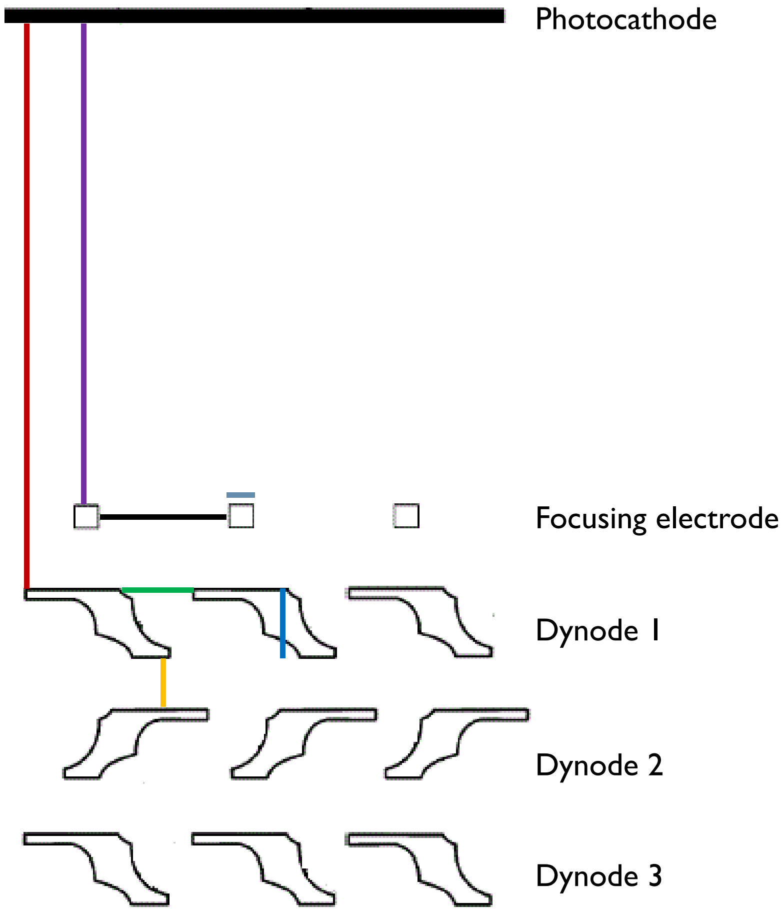
Outline

- H8500 structure
- Recap
- Calibration of Bari amplification chain
- High statistic analysis in different positions
- Effect of High Voltage on Transit Time Spread
- Next steps

H8500 Structure

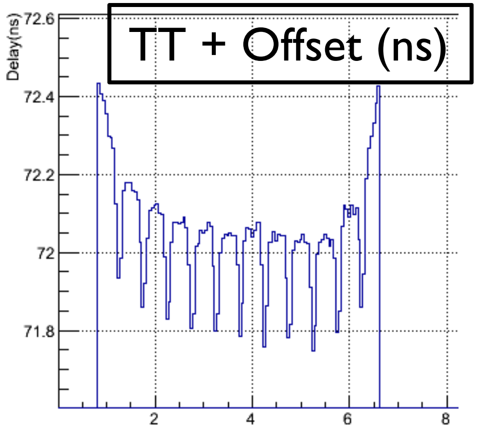
1) **red** line (distance between photocathode and first dynode): **3 mm**
2) **black** line (distance between two adjacent focusing electrode): **0.5 mm**
3) **green** line (distance between two adjacent dynodes): **0.2 mm**
4) **blue** line (dynode thickness): **0.2 mm**
5) **orange** line (distance between first dynode and second dynode): **0.2 mm**
6) **purple** line (distance between photocathode and focusing electrode): **2.75 mm**
7) **light blue** line (focusing electrode thickness): **0.05 mm**

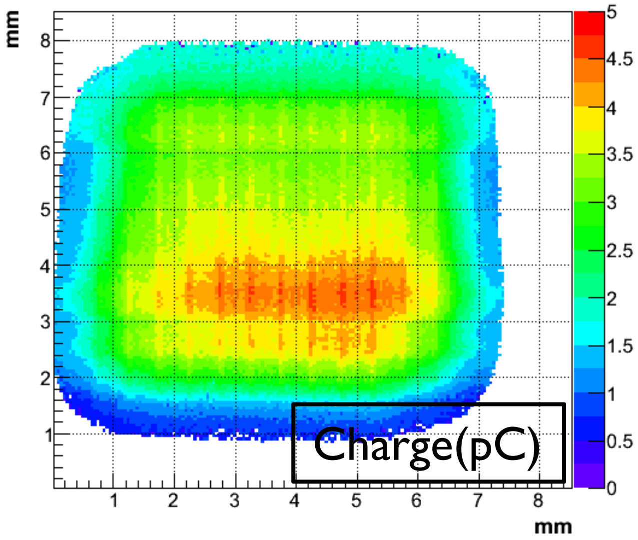
Data from Hamamatsu engineers



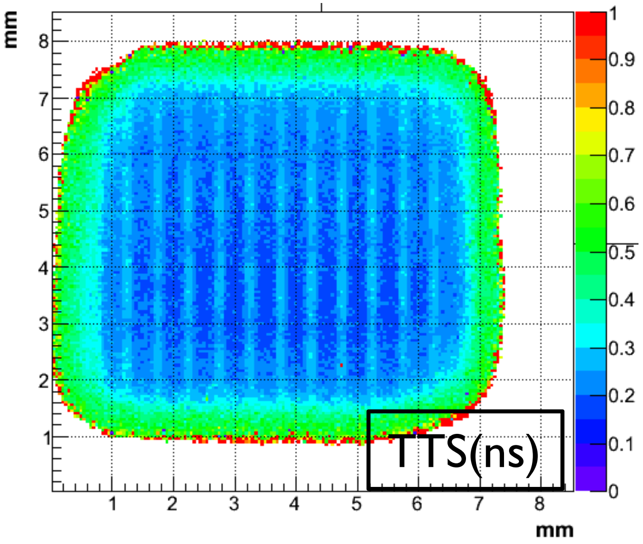
Recap

- Map of pixel 28 (50 μm step in X and Y)
  - Charge (i.e. Gain)
  - Transit Time Spread (TTS)
- 20-25 p.e. level
  - No amplification – Direct signals from MaPMT
- Narrow laser beam (Φ=50 μm)



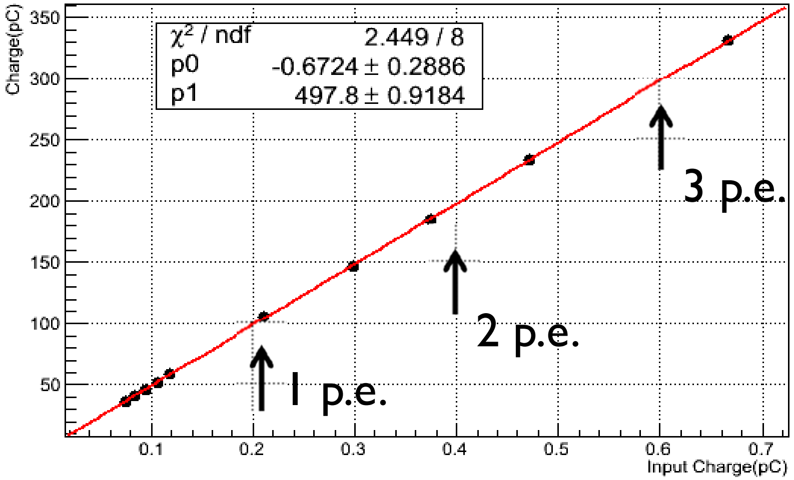


- Effect visible near the focusing electrodes both in Gain and TT
- To study in detail these effects we have set the laser beam intensity at 1p.e. and used our readout electronics.

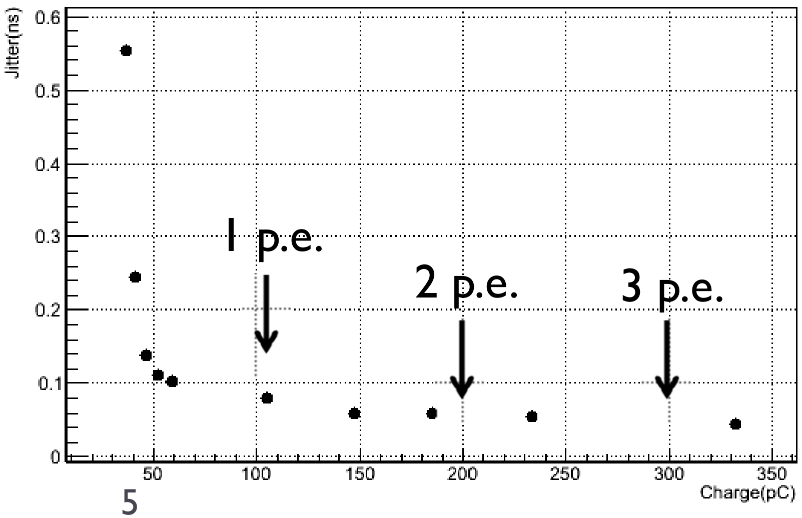


Calibration of read out Bari electronics

Poster at 12th Pisa Meeting on Advanced Detectors by F. Giordano
"A Front-End Electronics Board for MaPMT Single Photoelectron Signals"



- The overall charge gain of our electronics is almost 500
- The lower threshold we could set at the moment is 0.2 p.e.



- $\sigma_{meas} = \sigma_{start} \oplus \sigma_{ele}$
- σ_{start} = 25ps due to the generation of the start signal (standard NIM electronics)
- σ_{ele} due to our electronics

- σ_{meas}@1 p.e. = 90ps → σ_{ele}@1 p.e. = 85ps
- σ_{meas}@3 p.e. = 60ps → σ_{ele}@3 p.e. = 55ps

Detailed studies

- To study in detail the behavior near the focusing electrodes we have investigated two fixed position (high statistics run)

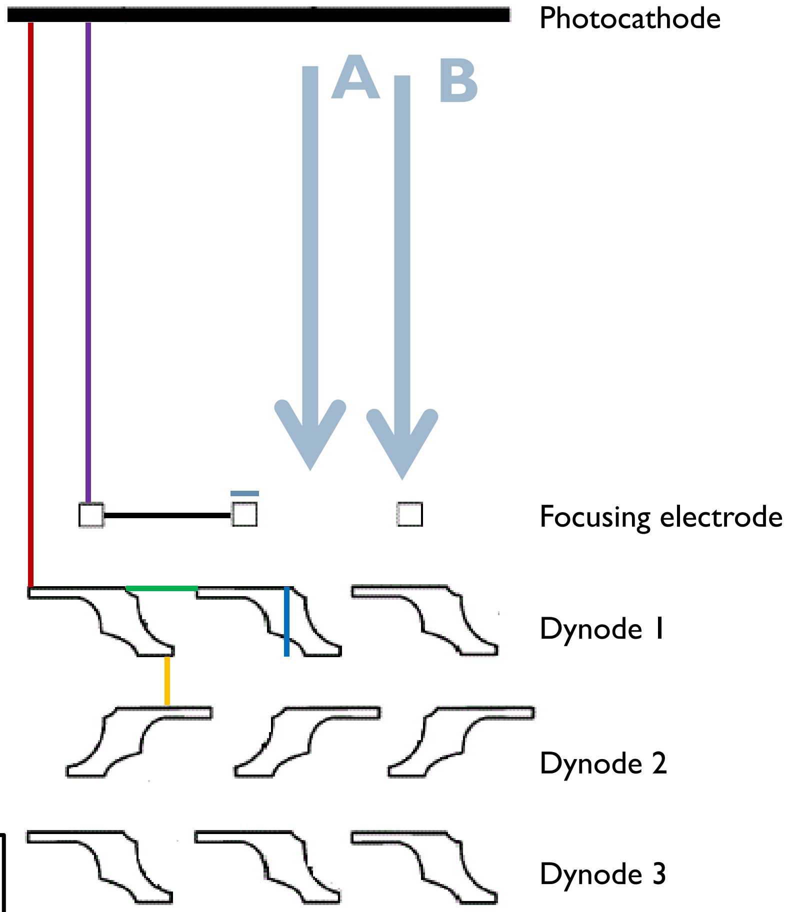
- Position A: between two focusing electrodes
- Position B: on the focusing electrode

σ of the Gaussian laser beam: 12μm

Beam size (4 σ): 50μm

Beam intensity: 1p.e.

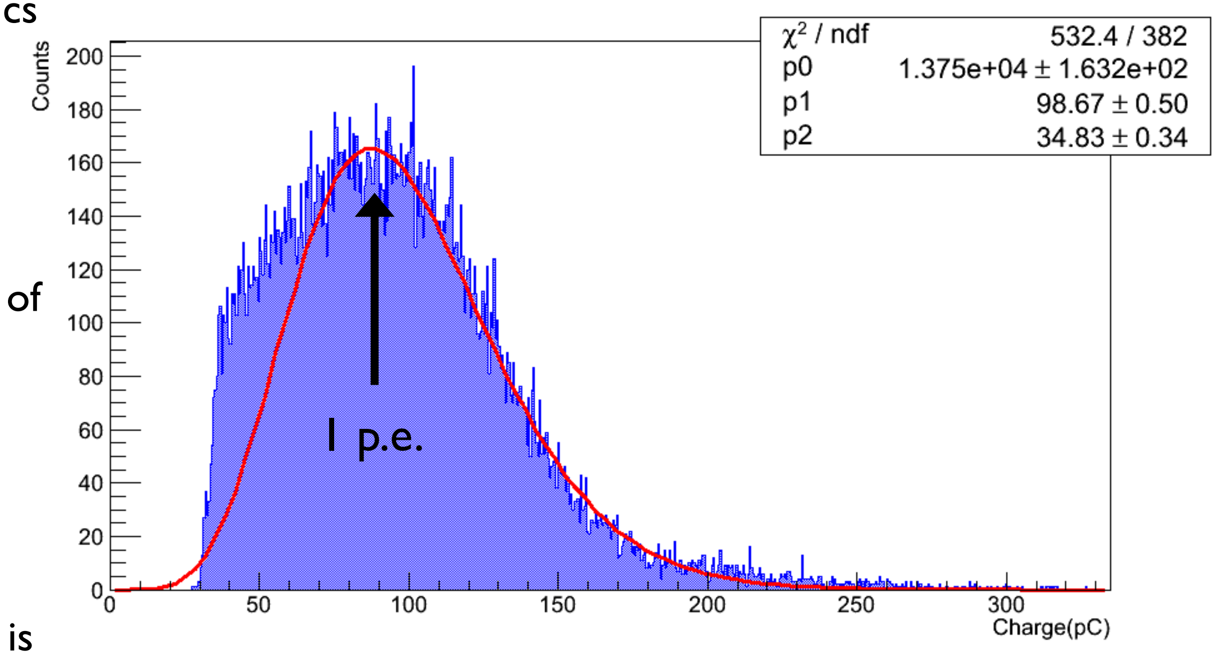
Almost at center of pixel 1



Poster at 12th Pisa Meeting on Advanced Detectors
“Study of H-8500 MaPMT for the FDIRC detector at SuperB”

Position A – Charge Distribution

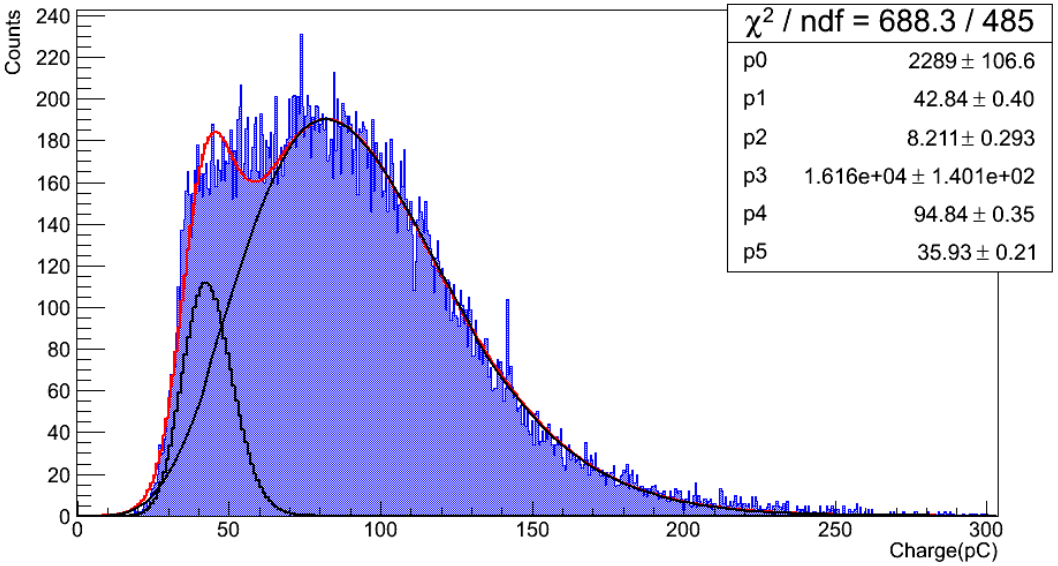
- The charge gain of our electronics is 500 and this allow to detect even small feature of the signal
- The threshold is set at 0.2 p.e.
- The detection efficiency is 14% and the expected mean number of photoelectrons (according to Poisson statistic is 1.1)
- The most probable value of the 1p.e. charge is 98.6 pC obtained by a fit with Polya distribution
- The lower part of the spectrum is due to photons (very few) that convert on the 1st dynode (I don't manage to have a good Polya+Polya fit in this case)



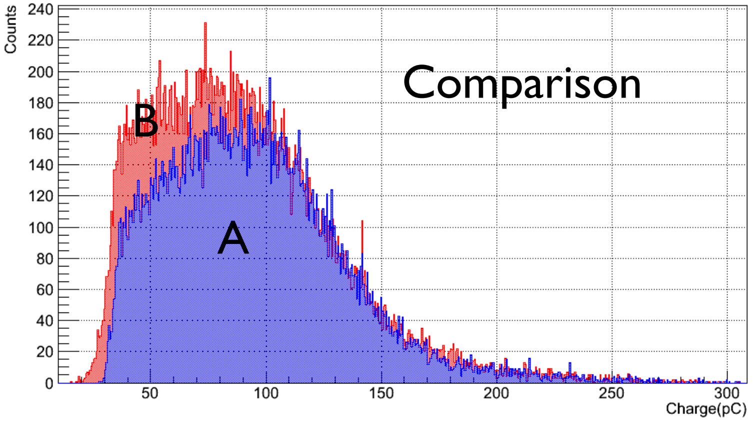
Charge pedestal subtracted

Position B – Charge Distribution

- The threshold is set at 0.2 p.e.
- The detection efficiency is 16% and the expected mean number of photoelectrons (according to Poisson statistic is 1.1)
- The most probable value of the 1p.e. charge is 95pC obtained by a fit with Polya distribution
- The lower part of the spectrum is due to photons that convert on the 1st dynode
- I have tried to fit also this low charge peak with a Polya distribution and I got a mean value of the charge of 43pC



Charge pedestal subtracted

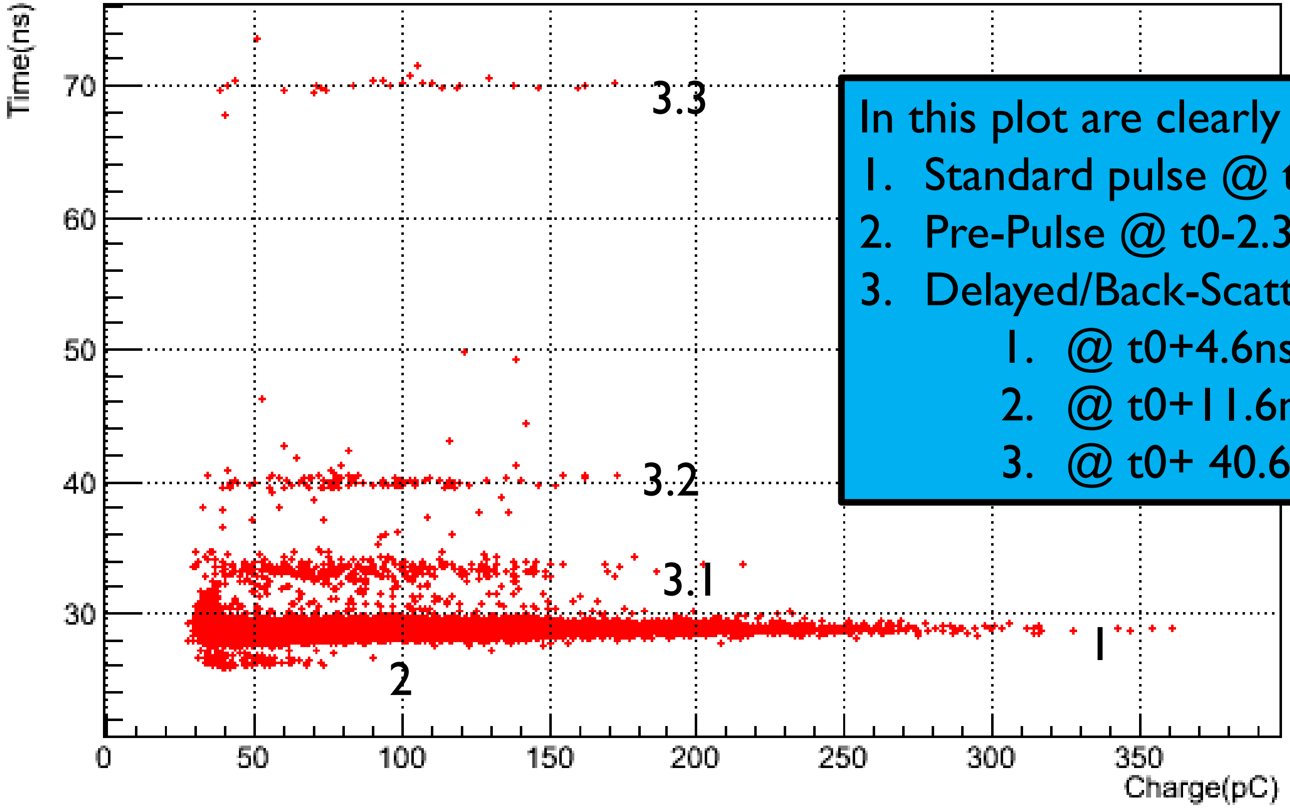


Position A – Charge-TT relation

In order to correct for the time walk effect I have fitted the raw data with the following function:

$$[0] + \left([1] + \frac{[4]}{x}\right) \times e^{-\frac{x^{[2]}}{[3]}}$$

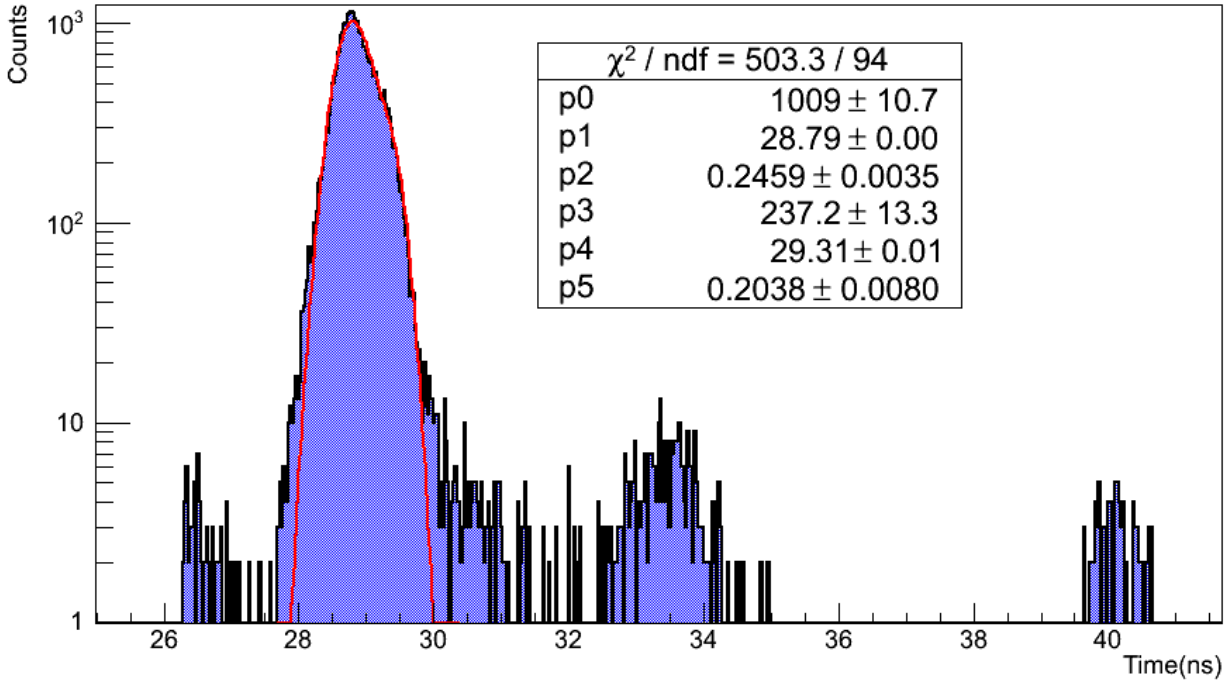
The correction is pretty good even if not perfect (especially for charge <40pC)



In this plot are clearly visible 5 kind of events:

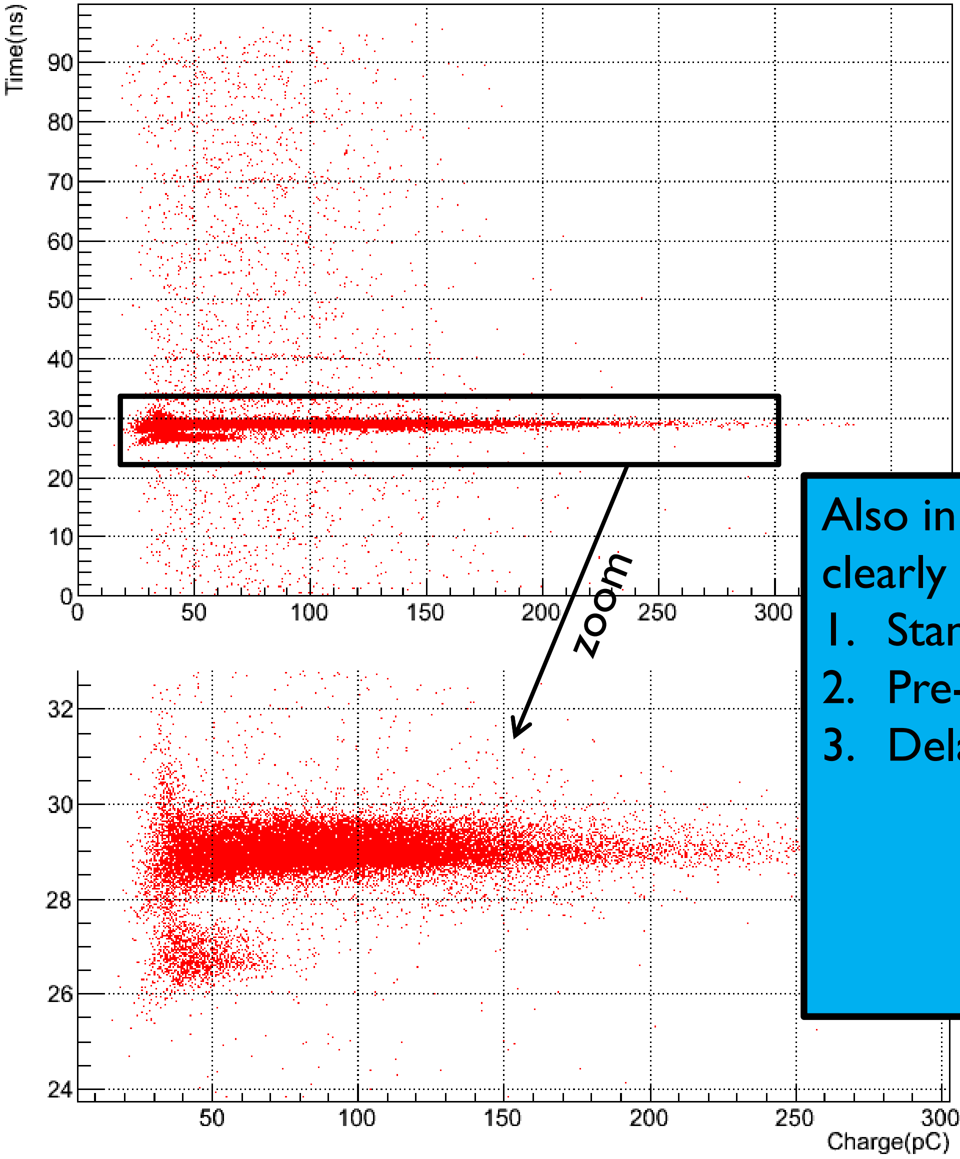
1. Standard pulse @ t0 (98%)
2. Pre-Pulse @ t0-2.3ns (0.3%)
3. Delayed/Back-Scattered pulse (1.7%)
    1. @ t0+4.6ns
    2. @ t0+11.6ns
    3. @ t0+ 40.6ns

Position A –Transit Time distribution



- I have fitted the main peak with a G+G function since the shape is not perfectly Gaussian.
- The 1st G peak has σ=245ps
- The 2nd G is slightly narrow (σ= 200ps)
- The shift between the two G is 500ps
- The FWHM is 600ps (σ=255ps)

Position B – Charge-TT relation

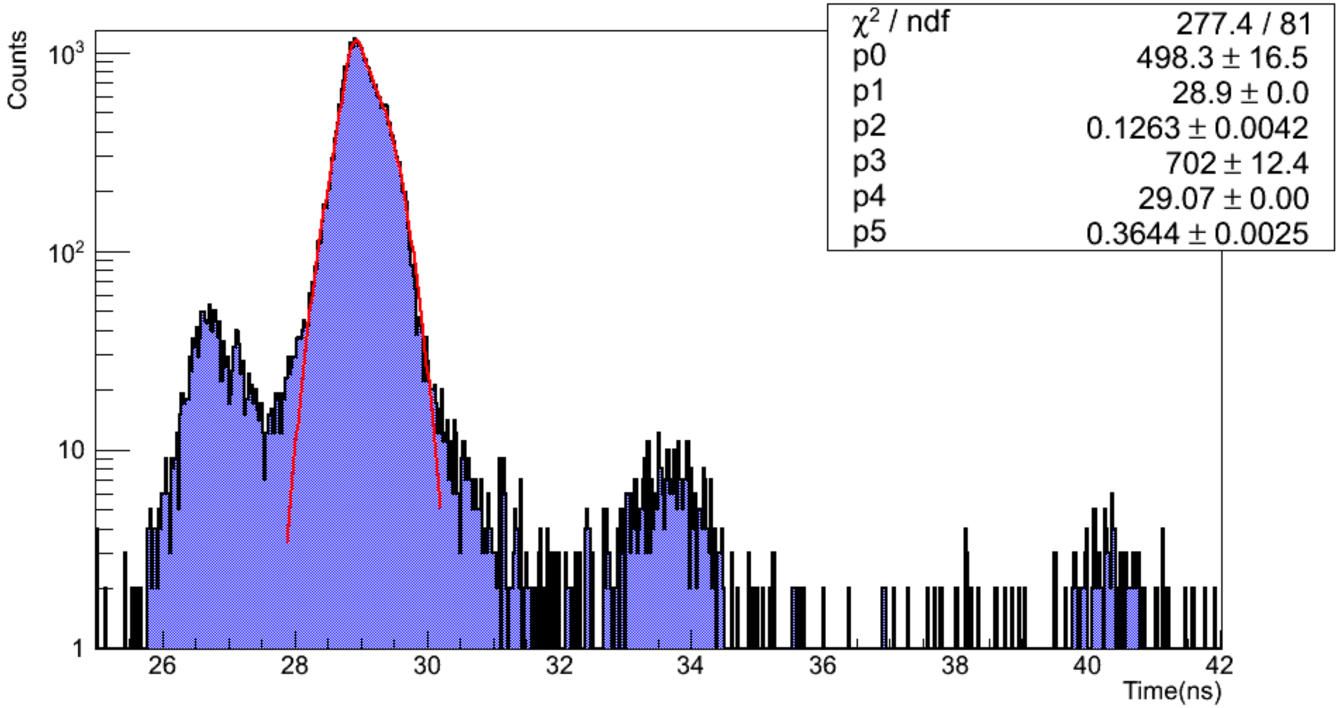


- During this measure the environment noise level is higher (1.2% of detected photons are due to noise)

Also in this plot there are 5 kind of events (not clearly visible due to the noise):

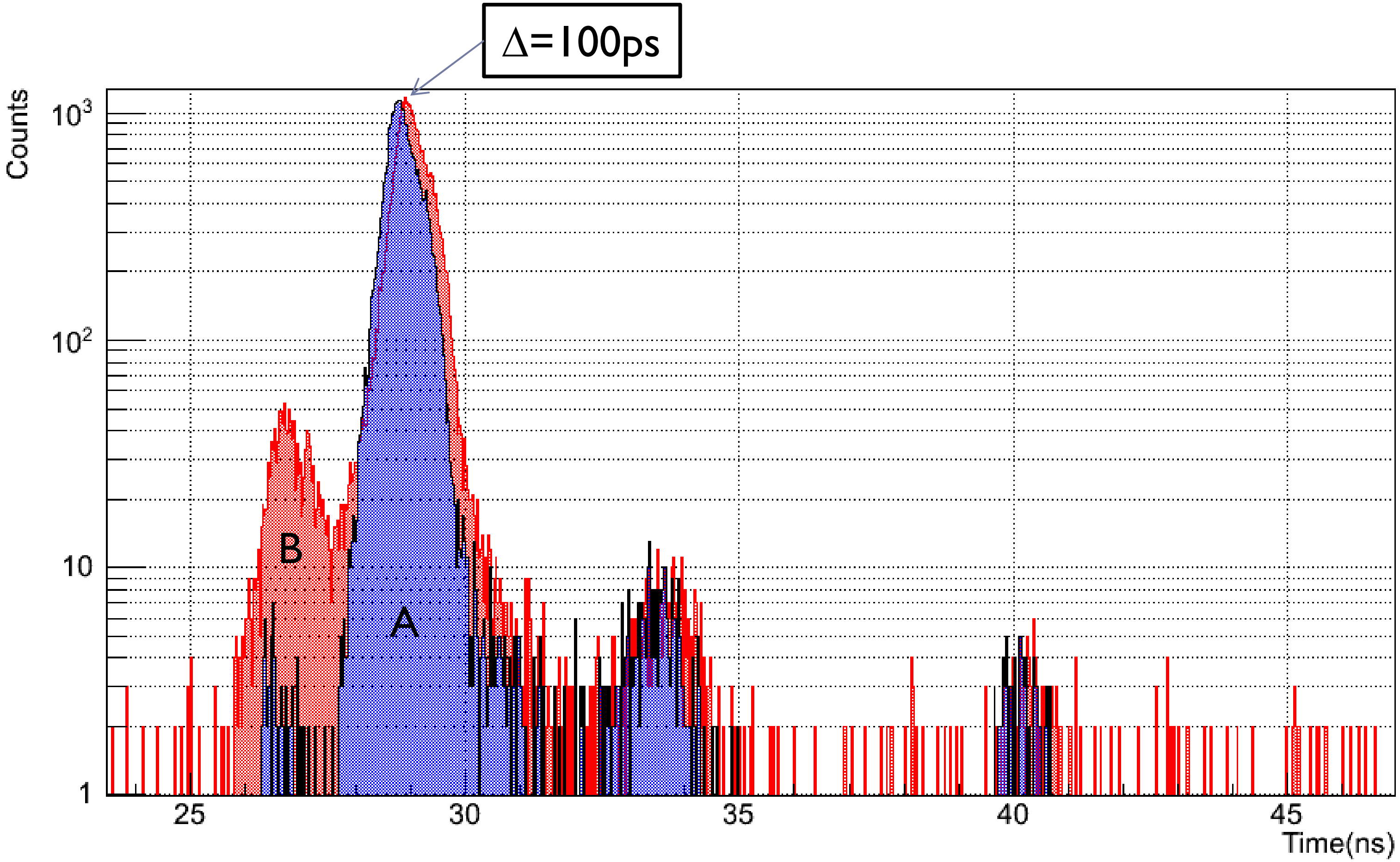
1. Standard pulse @ t0 (94.5%)
2. Pre-Pulse @ t0-2.3ns (5.0%)
3. Delayed/Back-Scattered pulse (0.5%)
    1. @ t0+4.6ns
    2. @ t0+11.6ns
    3. @ t0+ 40.6ns

Position B –Transit Time distribution



- I have fitted the main peak with a G+G function since the shape is not perfectly Gaussian.
- The 1st G peak has σ=126ps
- The 2nd G peak has σ=364ps
- The shift between the two is 170ps
- The FWHM is 580ps (σ=246ps)

Comparison Pos A and Pos B



Comparison between PosA and PosB

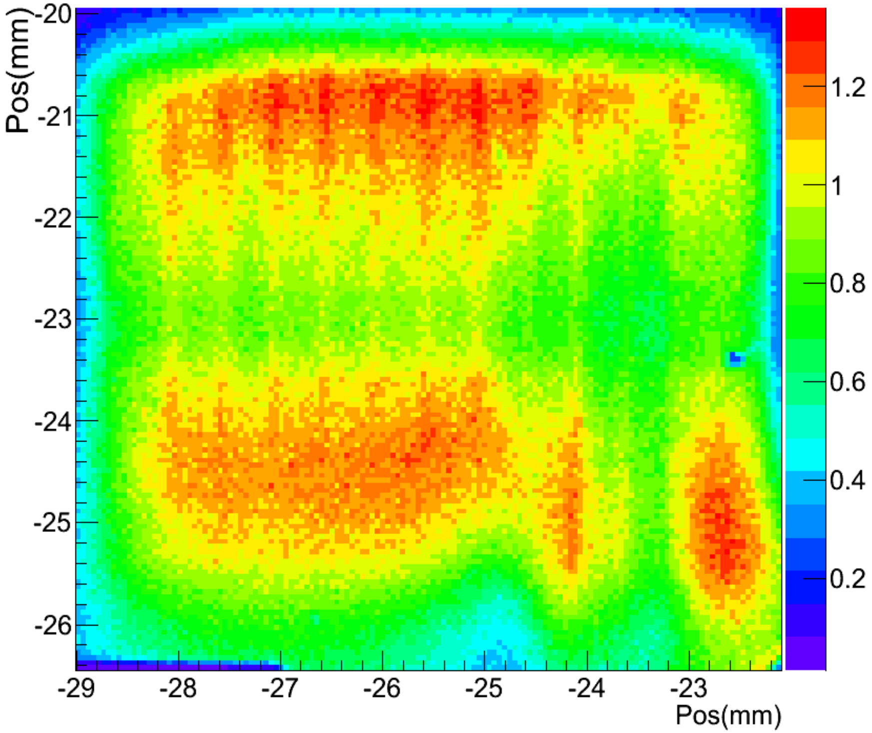
- Position A
- Charge Distribution
  - No clear evidence of the low charge events (conversion on the 1st dynode)
- Time Distribution
  - Only few pre pulses i.e. only few detected events that have converted on the 1st dynode

- Position B
- Charge Distribution
  - Clear peak of low charge events (conversion on the 1st dynode) with a charge of almost 1/3 p.e.
- Time Distribution
  - 5% of pre pulses

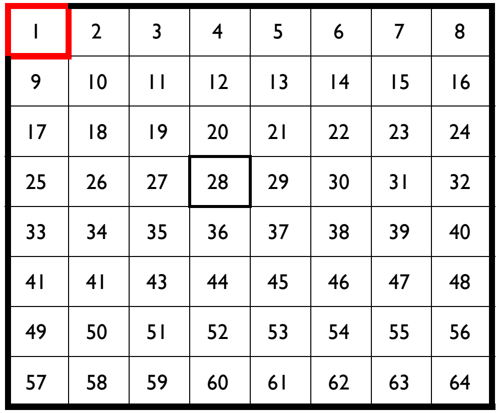
- The main difference between the two positions is due to events that miss the conversion on the photocathode
- In position A they go straight inside one channel and do not convert (or convert too late to give a detectable signal) and are lost
- In position B they hit the focusing electrode or the top of the dynode and simply miss one multiplication stage but are still detected as pre-pulse in time and low charge events.

Detection Efficiency at 1 p.e. level

Efficiency Ratio map



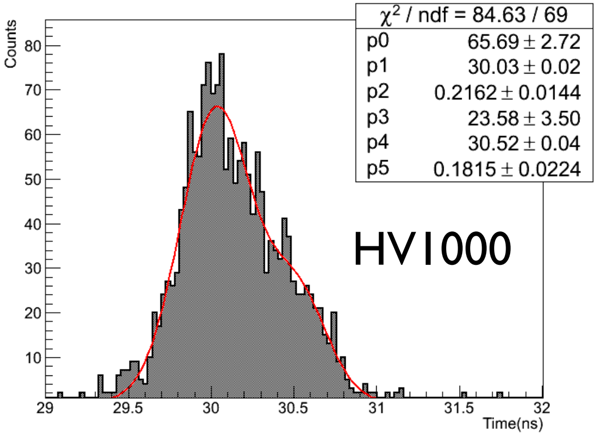
The map shows the ratio between H-8500 and Photonis XP2020 (reference) detection efficiency: the variation inside the pixel is roughly 50%. The increase in efficiency is also evident near the focusing electrodes. Threshold set at 0.2 p.e.

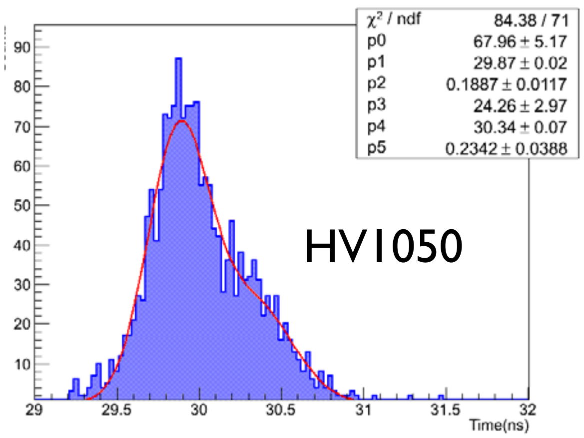


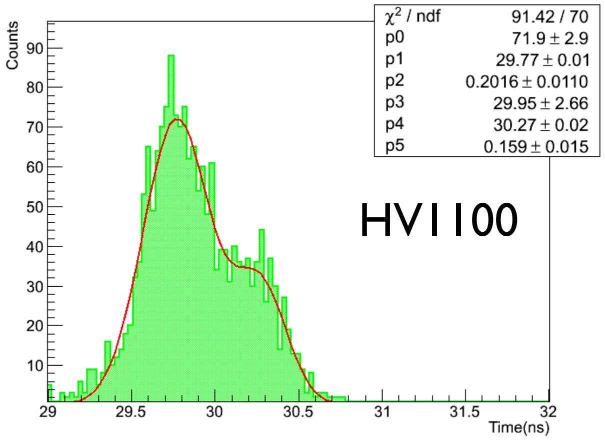
1	2	3	4	5	6	7	8
9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32
33	34	35	36	37	38	39	40
41	41	43	44	45	46	47	48
49	50	51	52	53	54	55	56
57	58	59	60	61	62	63	64

Non Gaussian shape of the main peak in TT

- Both in pos A and pos B we have noticed that the main peak is not a perfect Gaussian.
- It seems that inside one channel there are two paths of multiplication that give raise to two Gaussian with different width and slightly shifted. We are in contact with Hamamatsu engineers to understand this feature that reduce the timing performance of the H8500
- I have tried to see the effect of HV on the main peak shape







- At higher voltage as expected the TT decrease (-160ps @ 1050V & -260ps @ 1100V)
- At higher voltage seems that the two Gaussians are more clearly separated because the Gaussian distribution become narrower

Next Steps in Bari

- Produce a new version of our electronics
- Continue the detailed studies of the inner structure of H8500 (??)
- Tests over all the pixels
  - Wider beam to illuminate one pixel
  - Even wider to illuminate all the MaPMT
    - Select the proper diffuser
- Start testing H8500 in magnetic field (http://agenda.infn.it/getFile.py/access?contribId=80&sessionId=4&resId=0&materialId=slides&confId=4107)
- Test high Q.E. "selected" H8500
- Test other devices (H-R11265-M64, SiPM(??)) with the same test stand
- Start developing DAQ with cPCI for LAL electronics integration in CRT