

# Afterpulses measurements for the ANTARES PMT

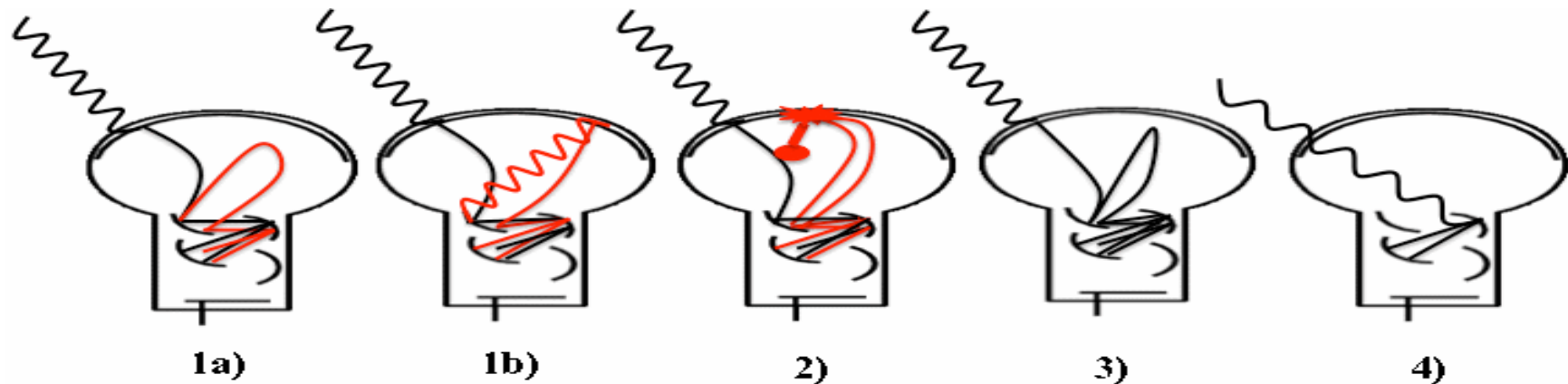


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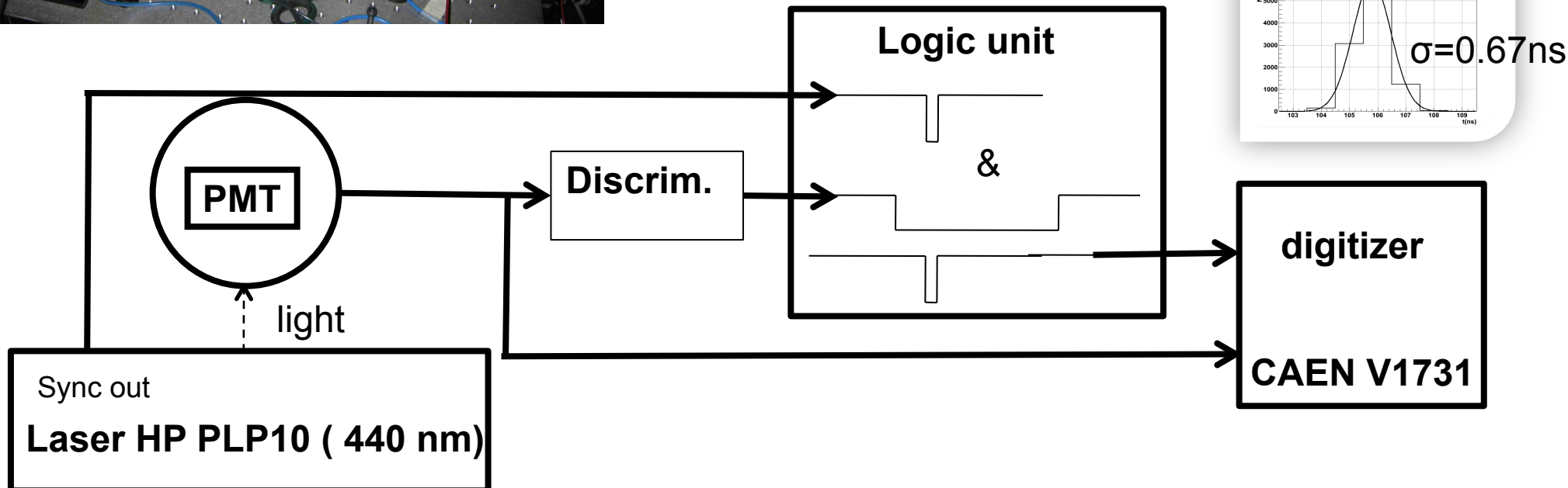
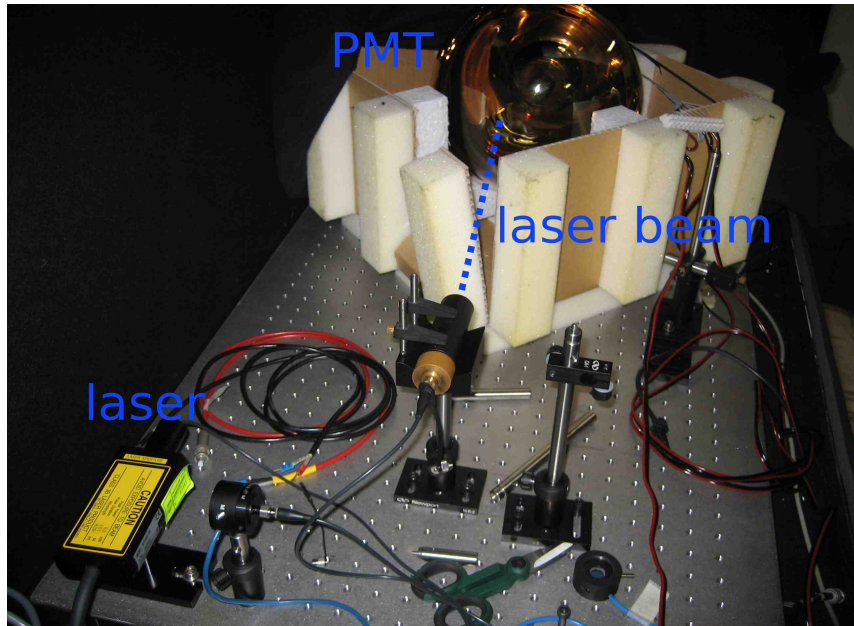
# Spurious pulses



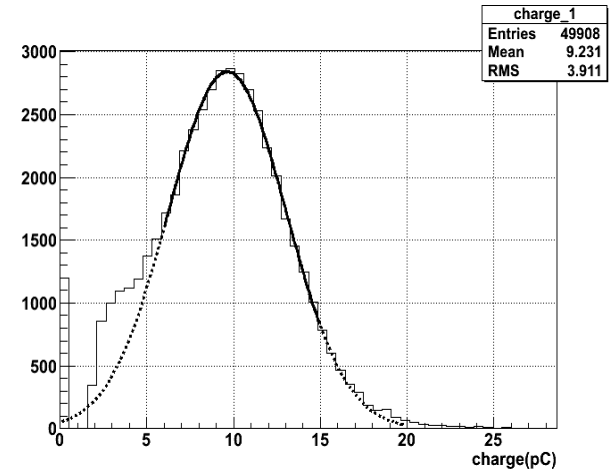
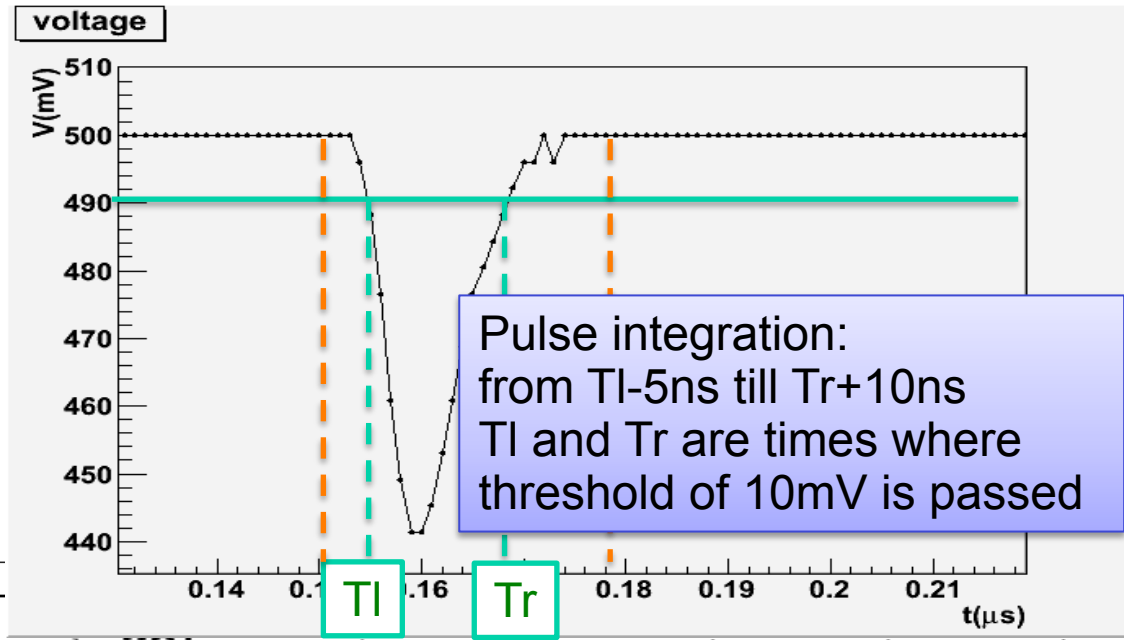
- Afterpulses type 1.
  - 1a due to escaped  $e^-$
  - 1b due to escaped  $\gamma$
- 2) afterpulse type 2. Due to ionization.
- 3) late pulse, due to  $e^-$  reflection
- 4) pre-pulse, photo-effect on the dynode

# Setup

- Laser length - 439nm
- SPE mode (1hit/100)
- Laser and PMT pulses in coincidence
- 1GHz digitizer
- 16 $\mu$ s after laser sync out
- Trigger to the channel0, because external trigger has 70MHz

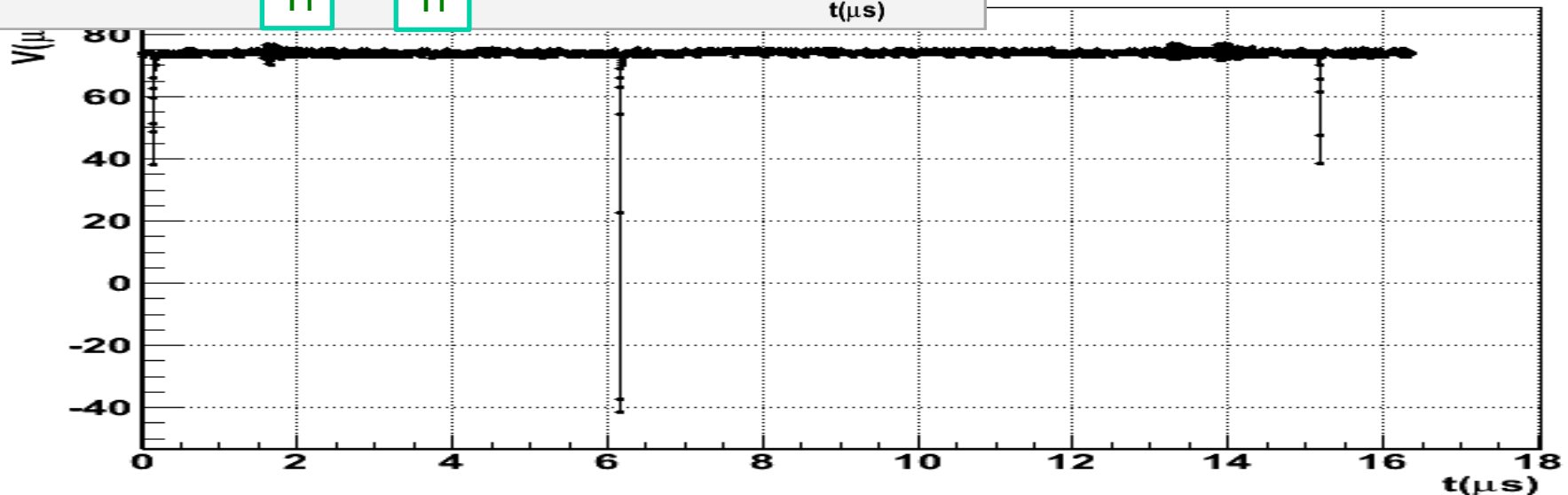


# Signal



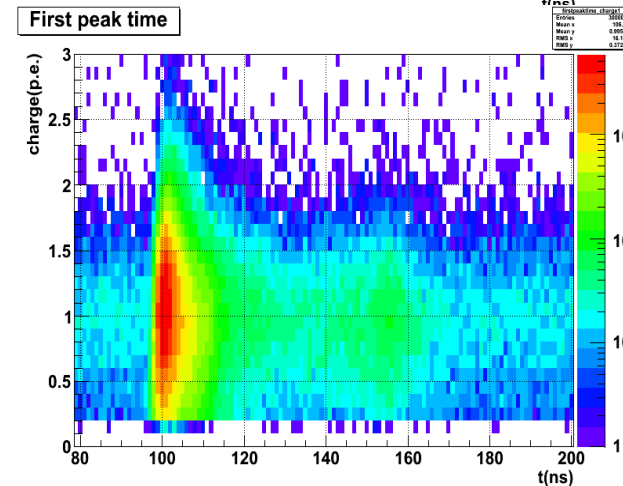
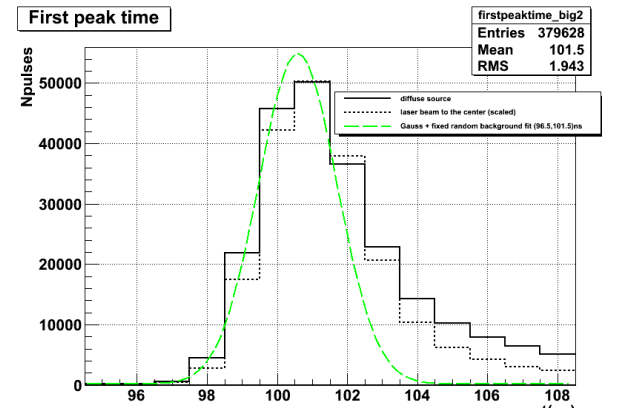
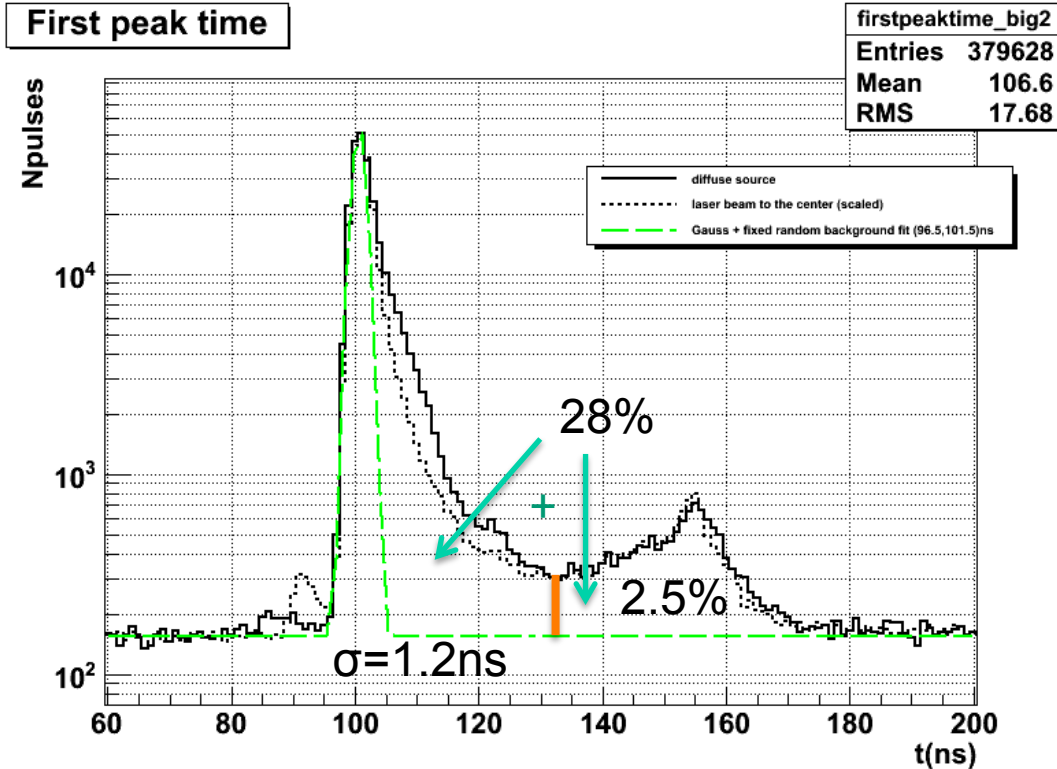
2p.e. contribution is negligible.

Left distortion due to integration systematic error for the small hits? Or low charge of the prepulses?



# Pre-pulses & late pulses.

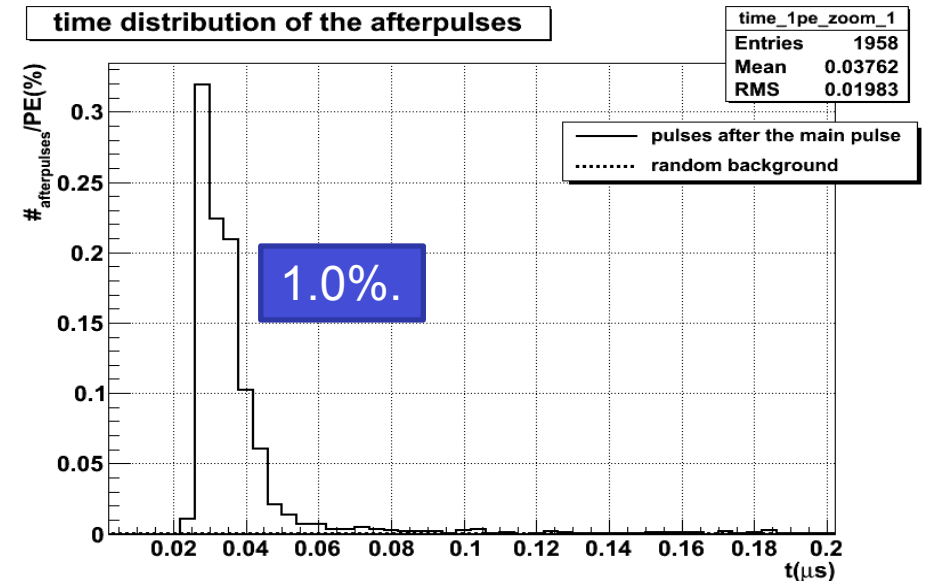
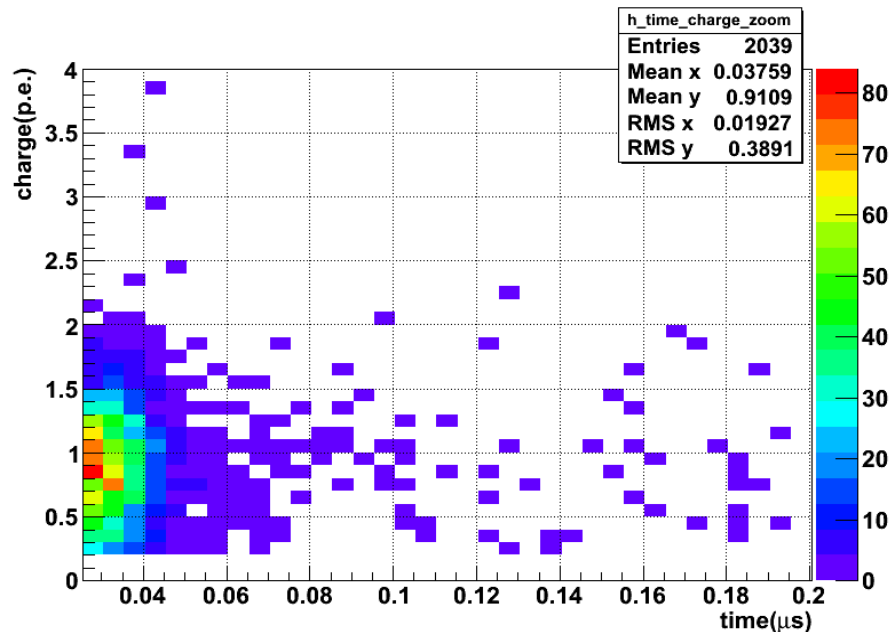
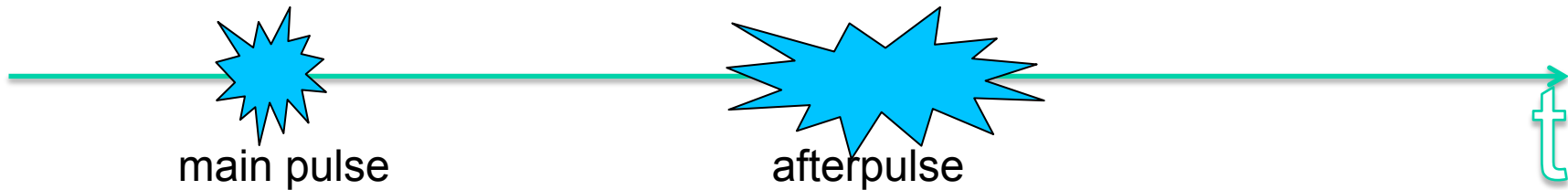
Hit time since beginning of the frame



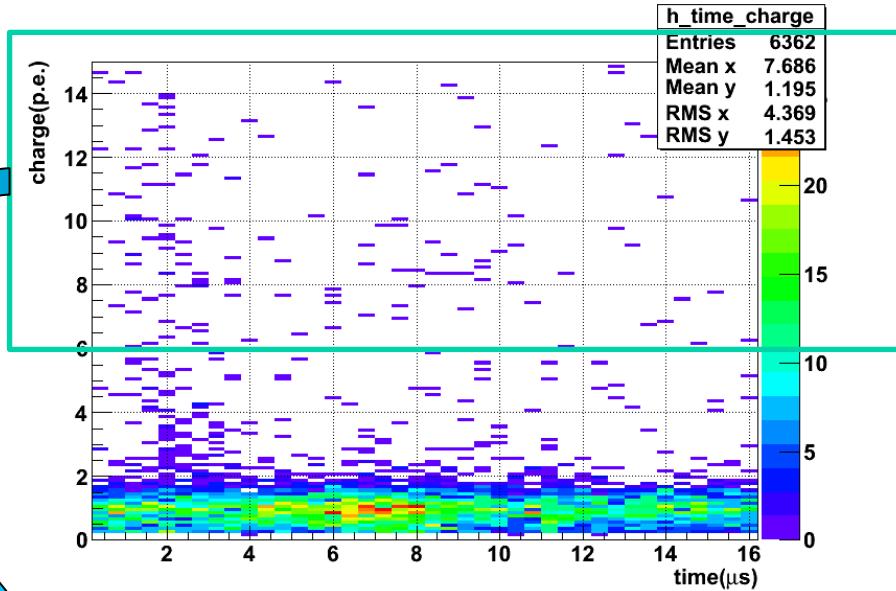
- Random noise plateau
- Two estimations of the delayed pulses

# Afterpulses type 1

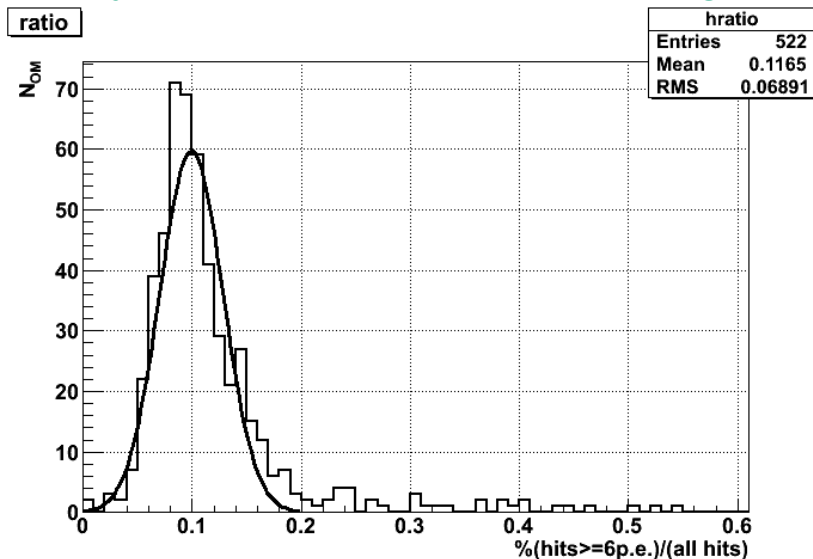
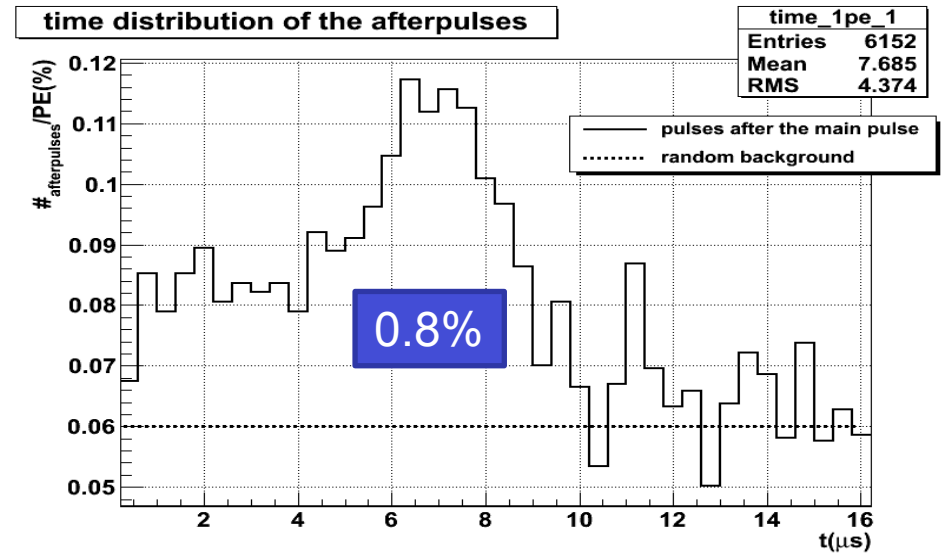
NB: afterpulse has always a main pulse before (main pulse + afterpulse).  
Prepulse and delayed pulse – are the “main” pulses (one pulse only).



# Afterpulse type 2



0.1% type 2 after-pulses with charge  $\geq 6$

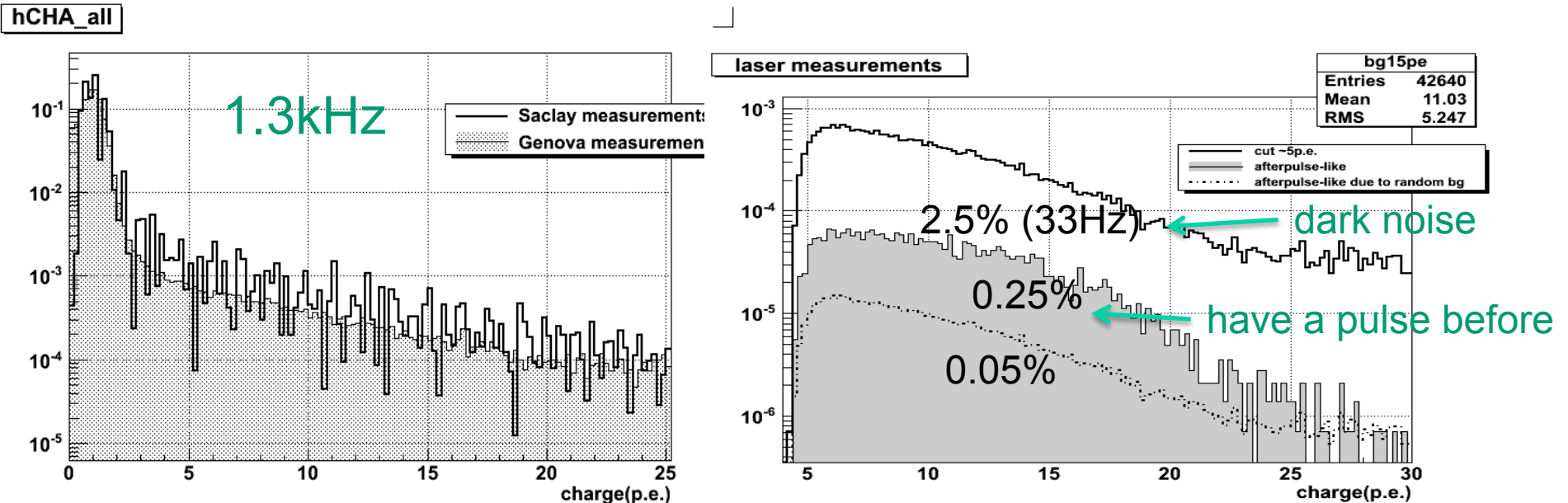


GRB files analysis of pulses with charge  $\geq 6$ .  
0.1% of them have charge  $\geq 6$

It is in consistency with the assumption:  
“high charge pulses are mostly due to the afterpulses”.

# Dark current spectrum (no laser)

- Comparison to the Saclay measurements with the bare PMT
- 1/3 p.e. threshold for the discriminator
- 25ns charge integration
- 10ns dead time for the token to another ARS





# Conclusions

|                |           |
|----------------|-----------|
| Pre-pulses     | <<1%      |
| Delayed pulses | 2.5%(28%) |
| Afterpulses t1 | 1.0%      |
| Afterpulses t2 | 0.8%      |

- Setup was improved (better time sampling, problem of the first hit time jitter solved).
- Measurements with a  $\mu$ -metal cage could decrease number of delayed pulses...
- Successful comparison with a Saclay measurements on the dark current.
- Afterpulses give an explanation for the hits with an high charge observed in ANTARES.
- Paper with description in the CDS: [ANTARES-OPMO-2011-002](#).
- Crosscheck with another laboratory is WELCOME!
- Include TTF from slide 5 to MC – see Aart's talk tomorrow.



**THANK YOU!**

