



# **“End station A setup” data analysis**

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Josef Uher

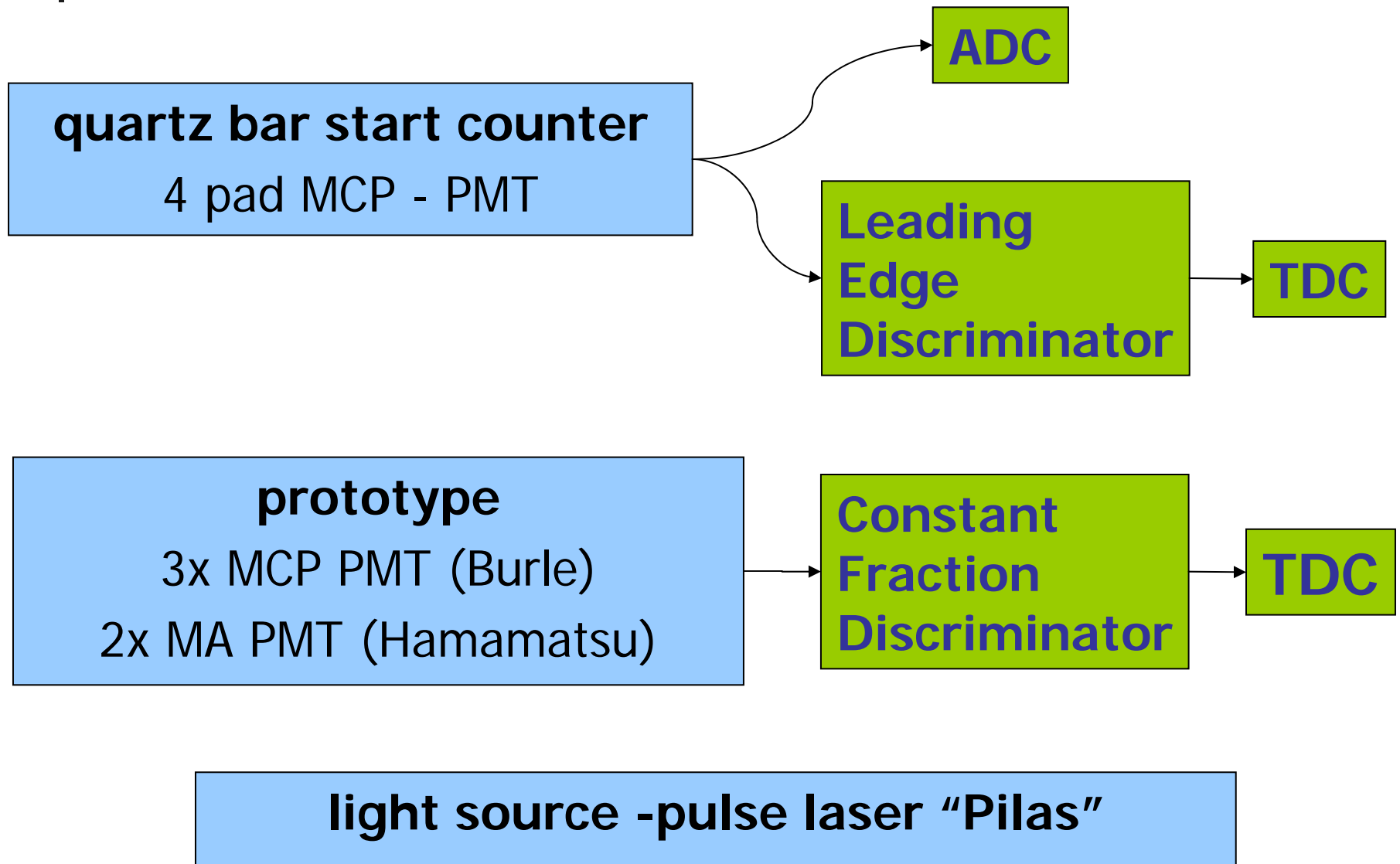


## Outline

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- Introduction to setup and analysis
- Quartz bar start counter
- MA and MCP PMT in the prototype

## What was analyzed





## Tasks for data analysis software

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- develop a timing strategies for start counters
- develop a calibration procedure for the prototype (determine time offsets for each of all modules, determine single electron timing resolutions)
- help to tune the setup and find errors

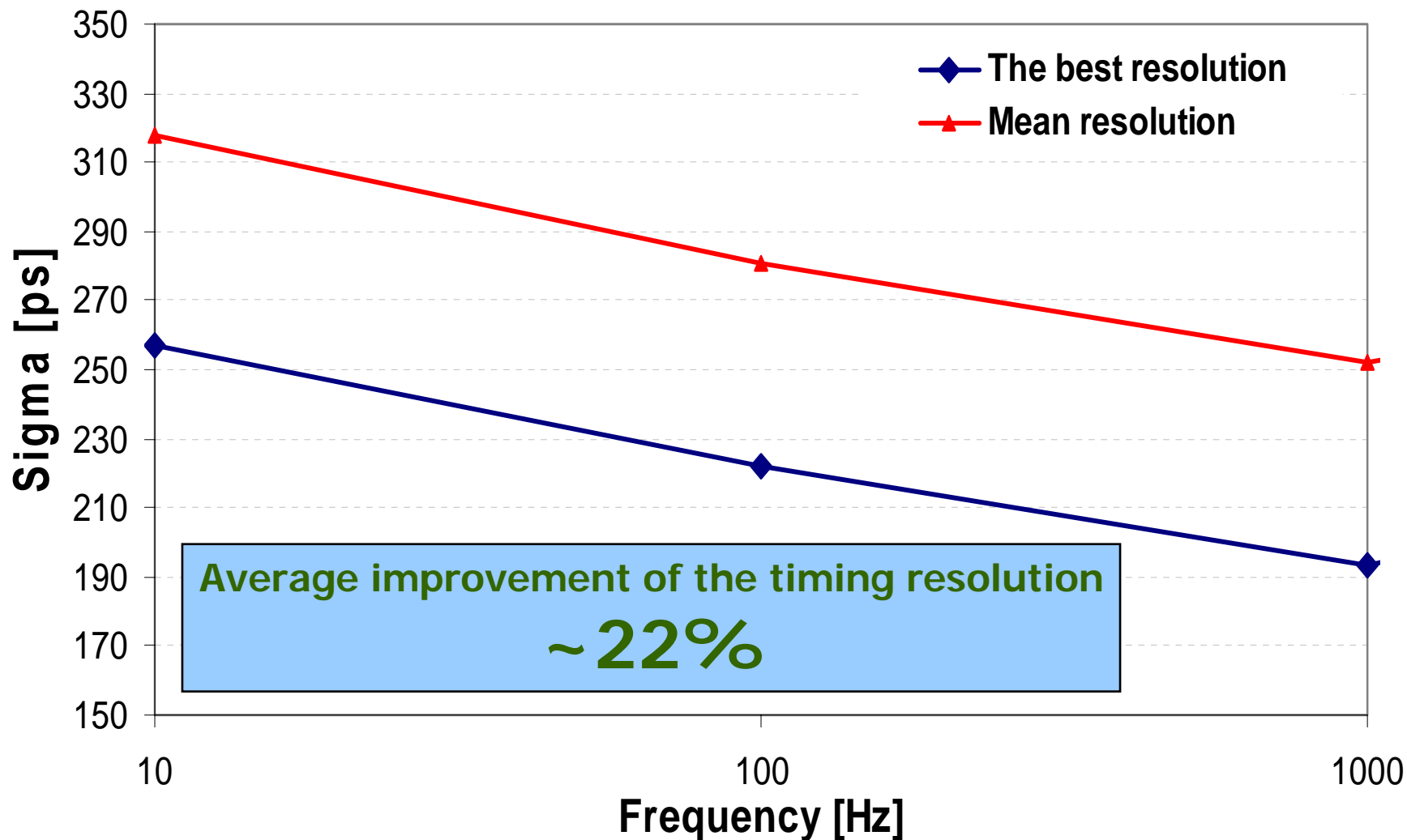


## What can affect timing resolution?

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- fluctuation of avalanche
- recoil of photoelectrons from MCP surface
- charge sharing
- cross talk
- electronics noise
- smear of pulse source (laser)
- ...

## Timing resolution vs. Pilas trigger frequency



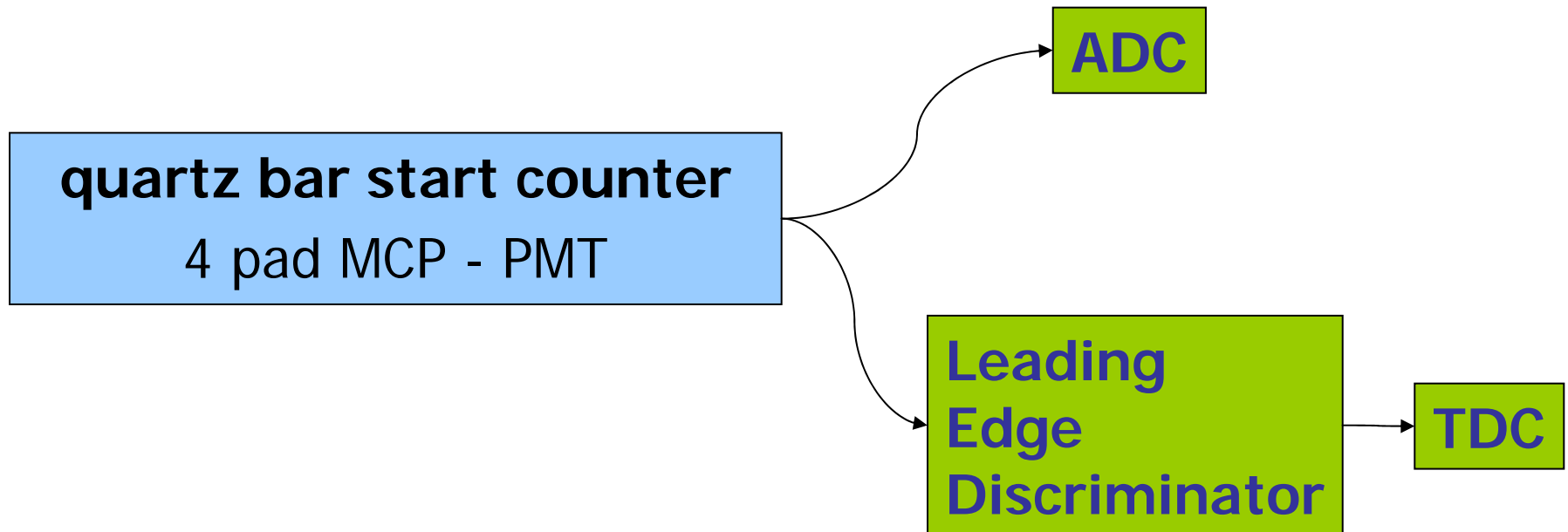
(measured with MA PMT Hamamatsu)



## Quartz bar start counter

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## Quartz bar start counter

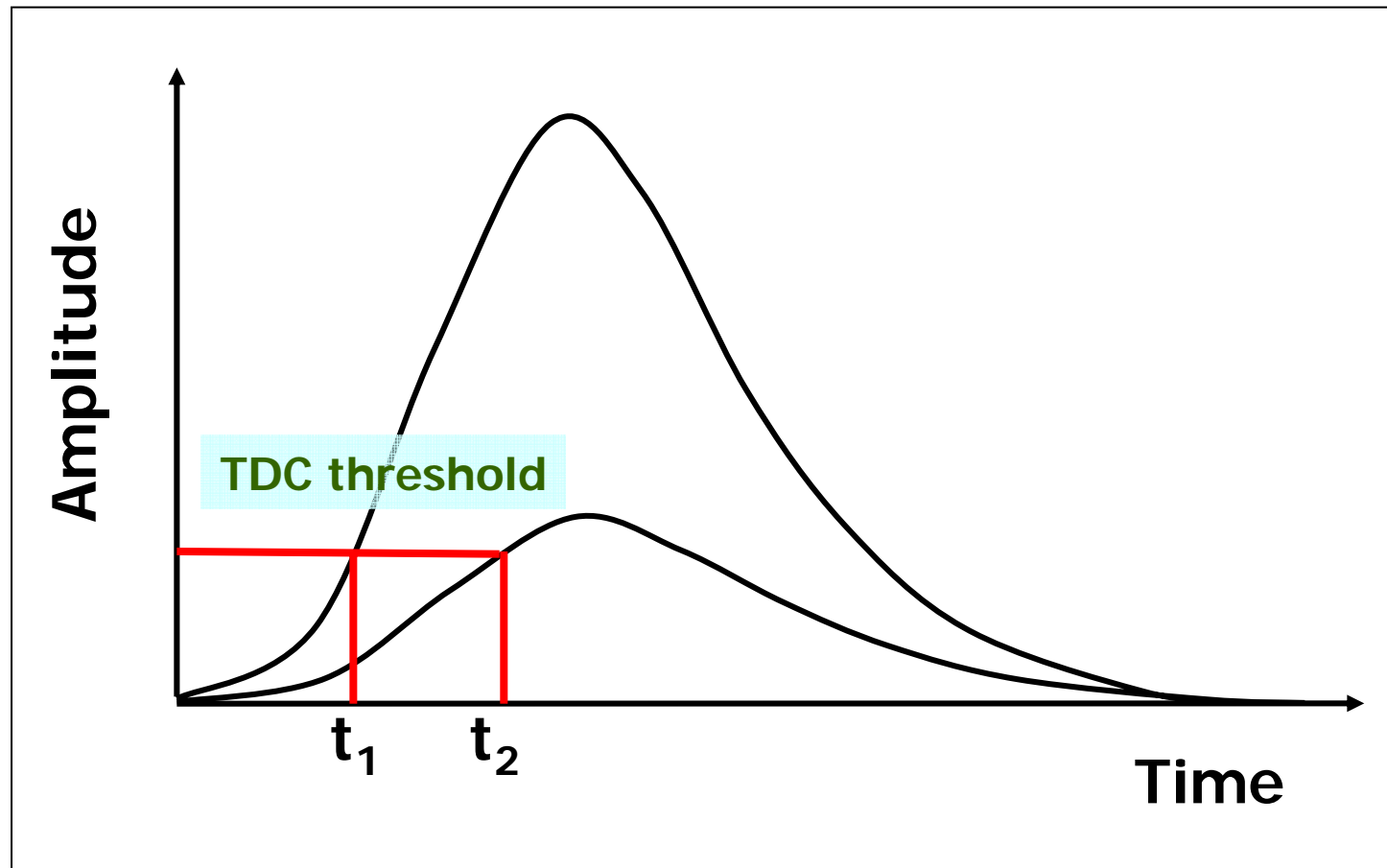


Configuration with ADC gives possibility to correct measured time on pulse height off-line.

= > better control than in case of CFD



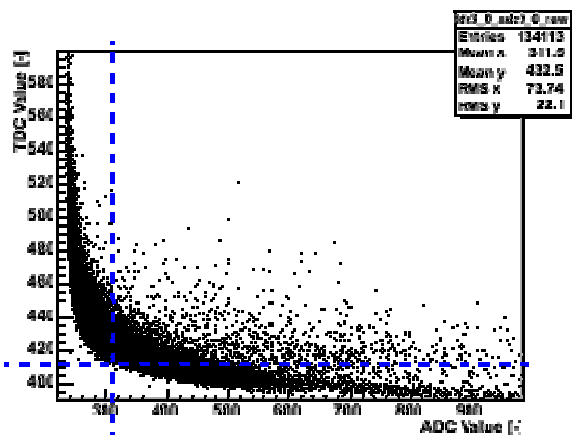
# ADC correction – how it works?



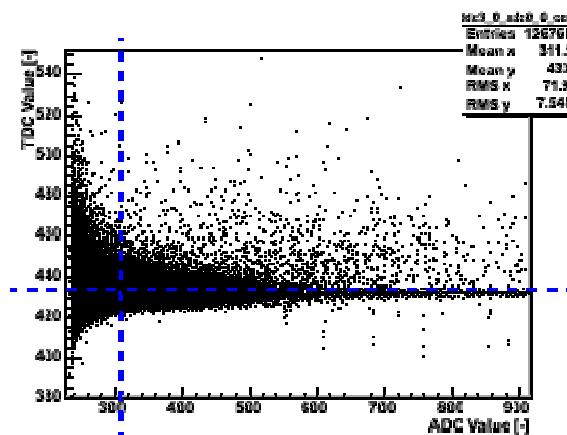
# ADC correction – how it works?

ADC vs. TDC

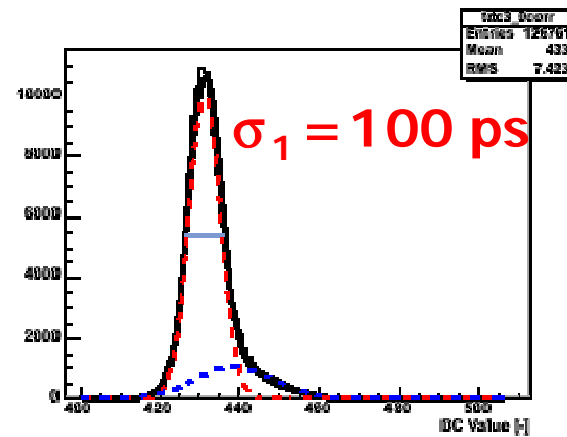
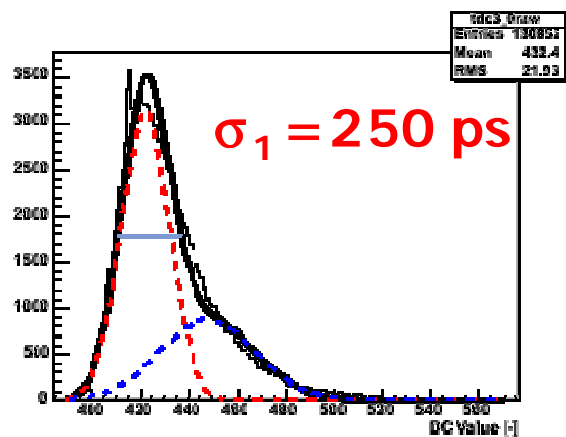
Before correction



After correction

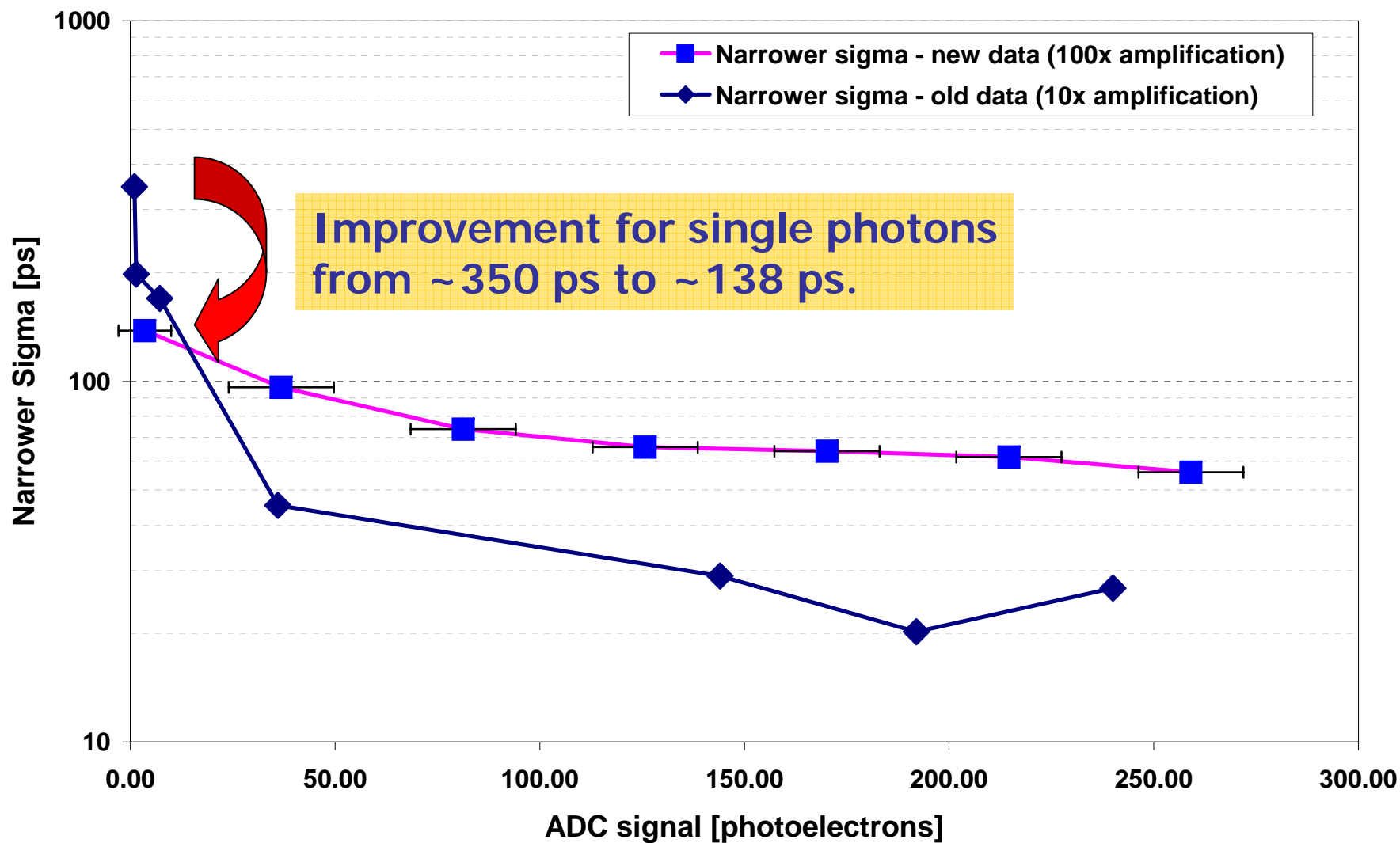


TDC spectra



# Quartz bar start counter timing resolution

Time resolution vs. number of electrons  
Quartz bar start counter

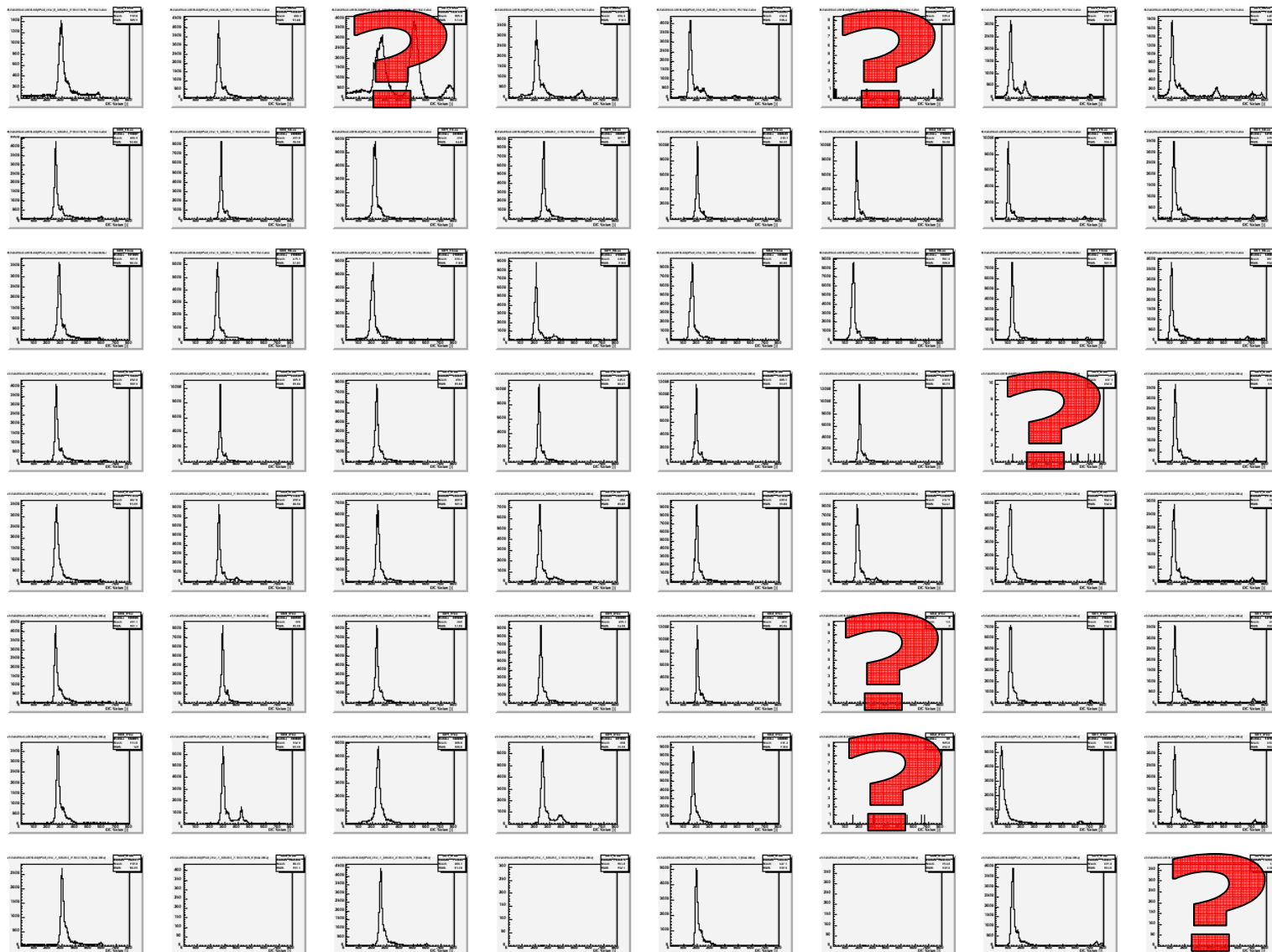




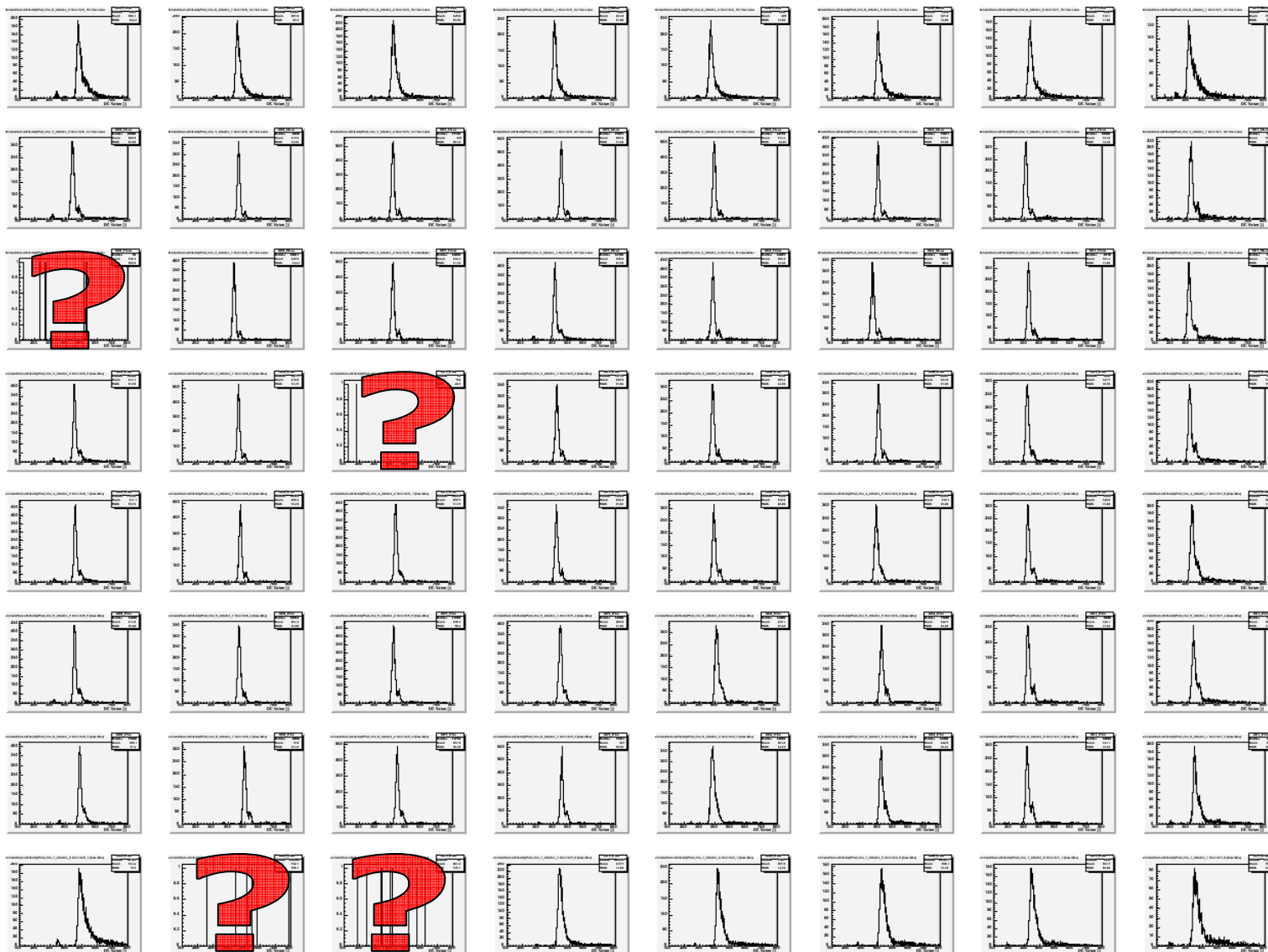
# Prototype



# Burle MCP-PMT, raw TDC spectra



# Hamamatsu MA-PMT, raw TDC spectra





# MCP and MA PMT timing resolution

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## MA PMT Hamamatsu

|               |                 |                       |
|---------------|-----------------|-----------------------|
| <i>SLOT 3</i> | Best resolution | Average resolution    |
| $\sigma$ [ps] | <b>194.25</b>   | <b>250.5</b> $\pm 43$ |

## MCP PMT Burle

|               |                 |                        |
|---------------|-----------------|------------------------|
| <i>SLOT 4</i> | Best resolution | Average resolution     |
| $\sigma$ [ps] | <b>156.5</b>    | <b>258.75</b> $\pm 58$ |

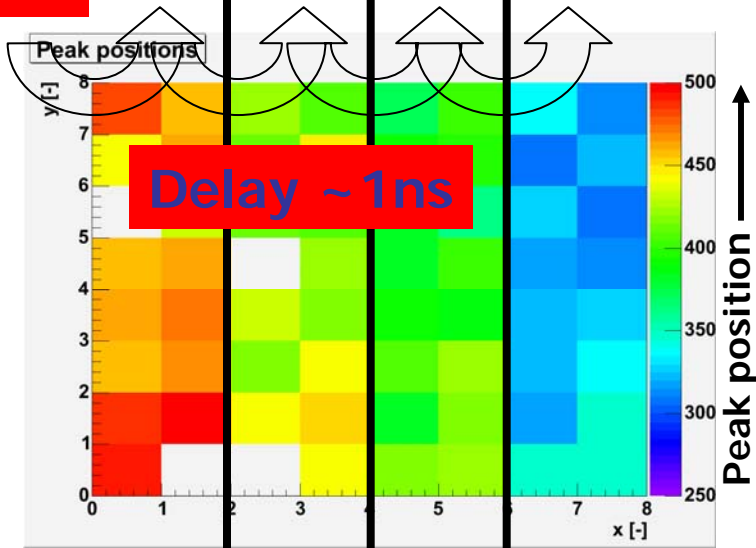
(raw data only, single photon mode, no corrections)

# Pad timing offset maps

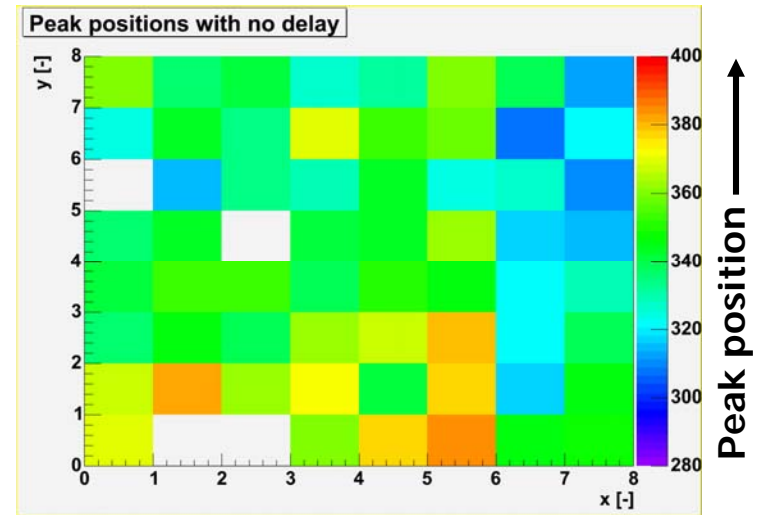
Start

TDC 1 TDC 2 TDC 3 TDC 4

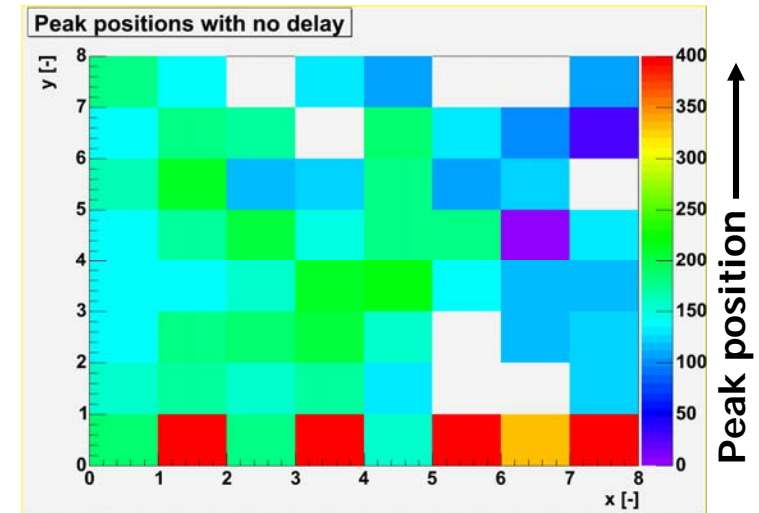
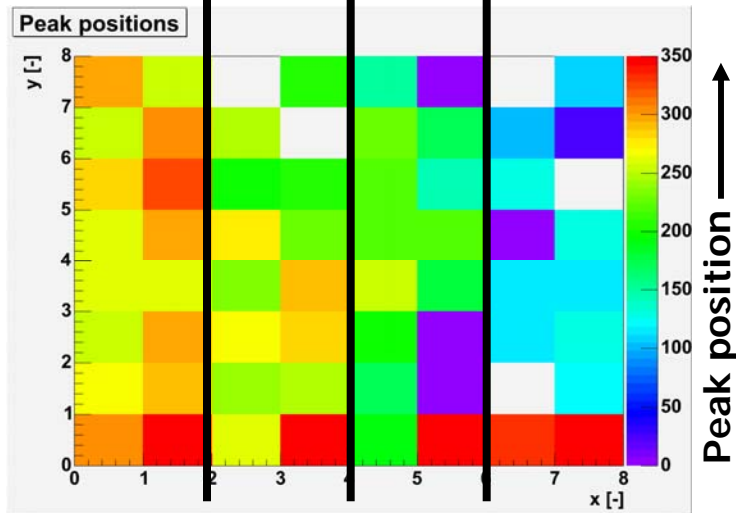
MA PMT Hamamatsu



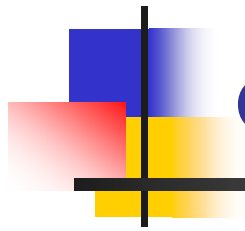
Without TDC link offset



MCP PMT Burle







# Cross talk





## Cross talk treatment

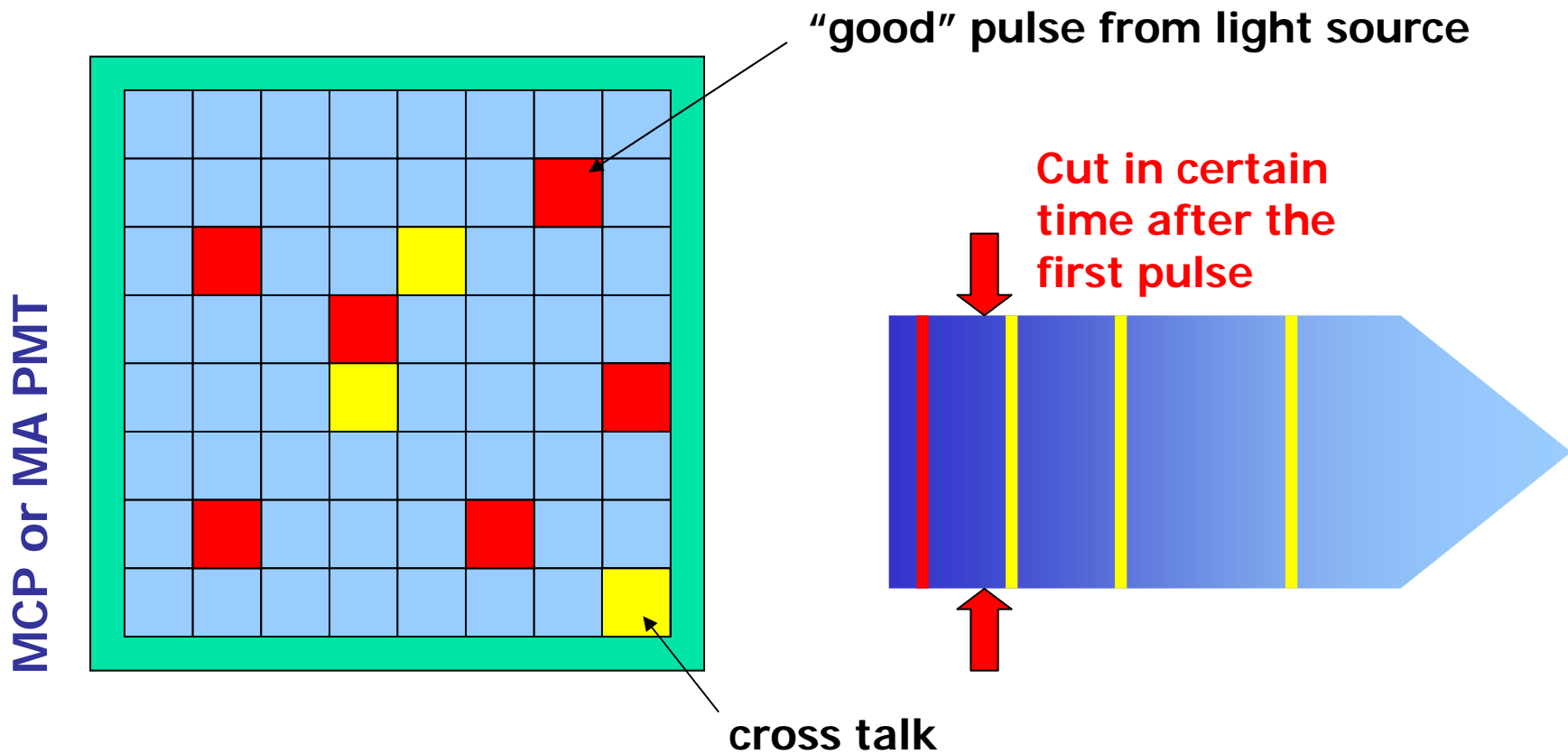
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### **Possible sources of “false pulses”:**

- charge sharing
- recoiled electrons
- internal PMT cross talk (wiring)
- cross talk in amplifiers
- cross talk in CFD
- photons bouncing in prototype box

# Cross talk treatment

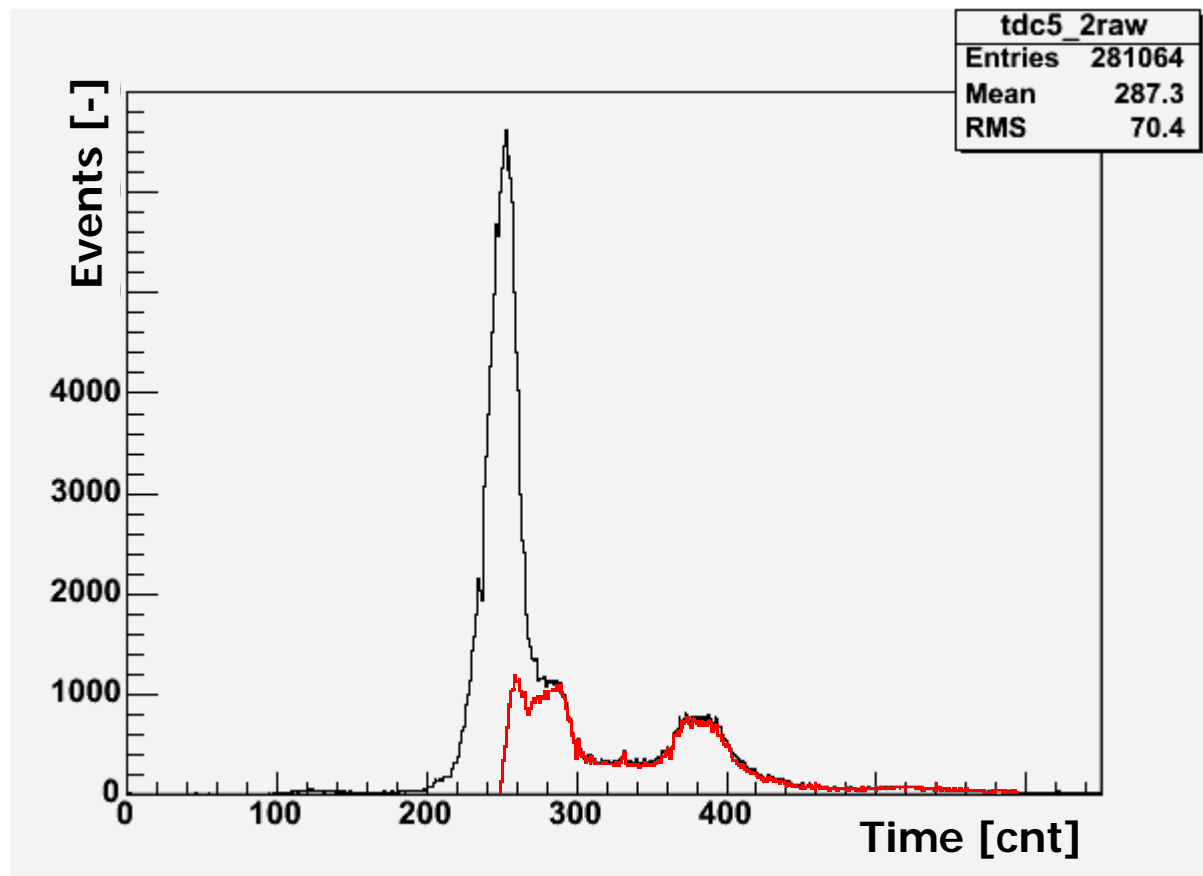
Cross talk can appear in any pad of MCP or MA PMT



# Cross talk treatment

Example of cross talk treatment with time window 15 counts.

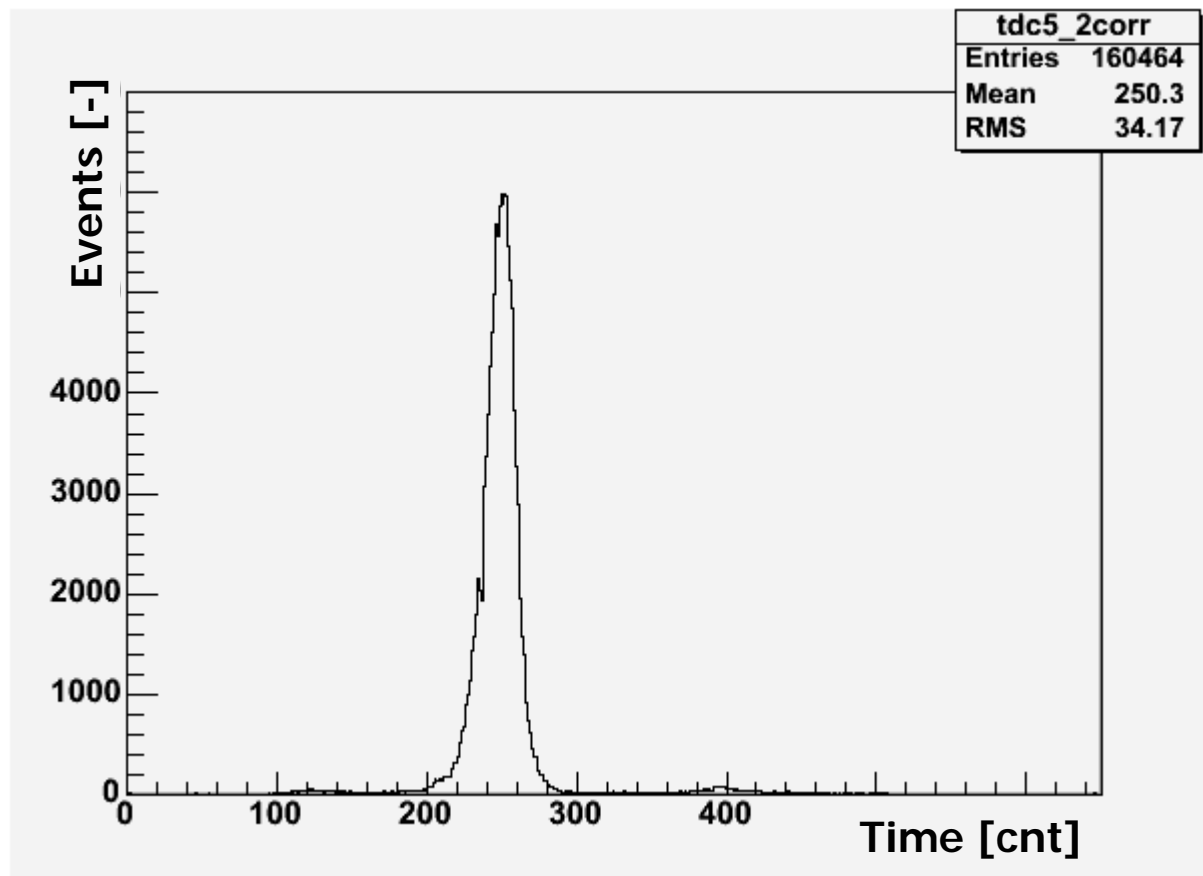
MCP PMT Burle



# Cross talk treatment

Example of cross talk treatment with time window 15 counts.

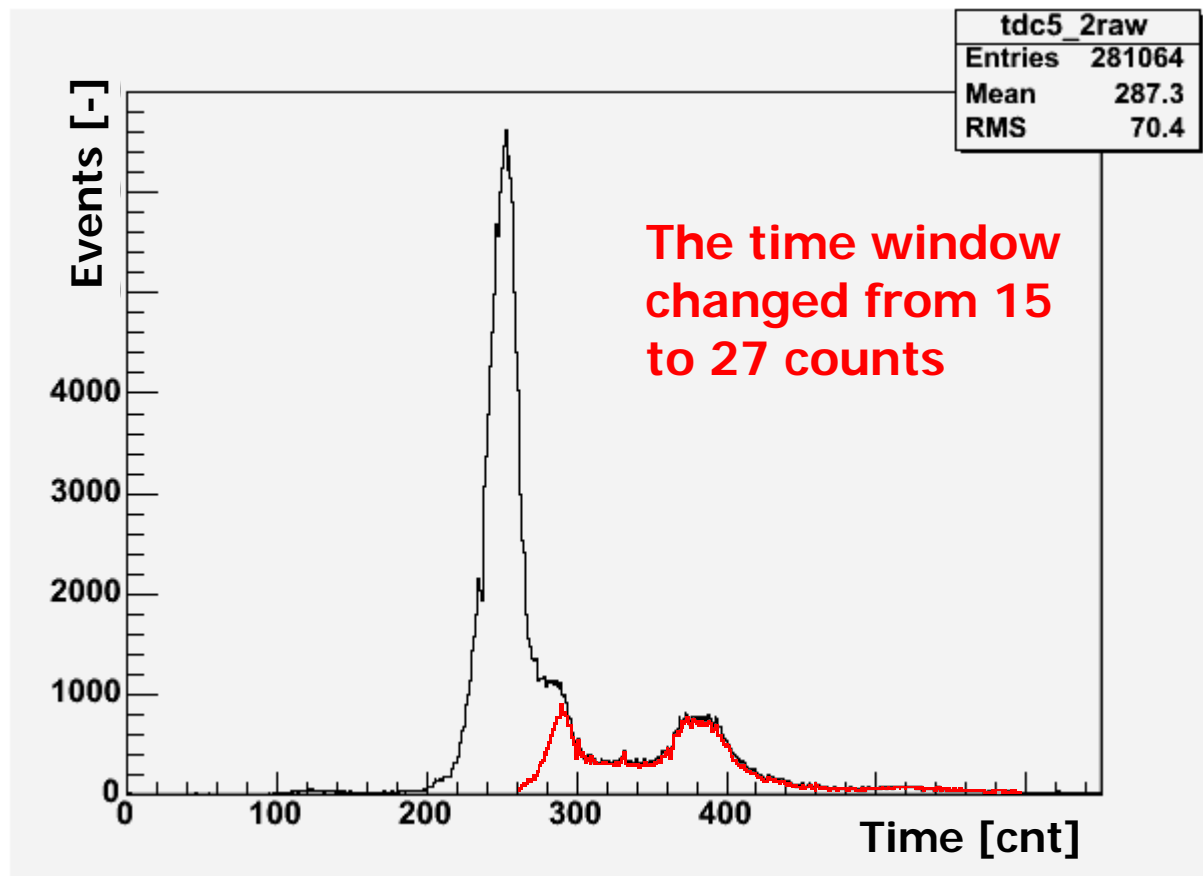
MCP PMT Burle



# Cross talk treatment

Example of cross talk treatment with time window 27 counts.

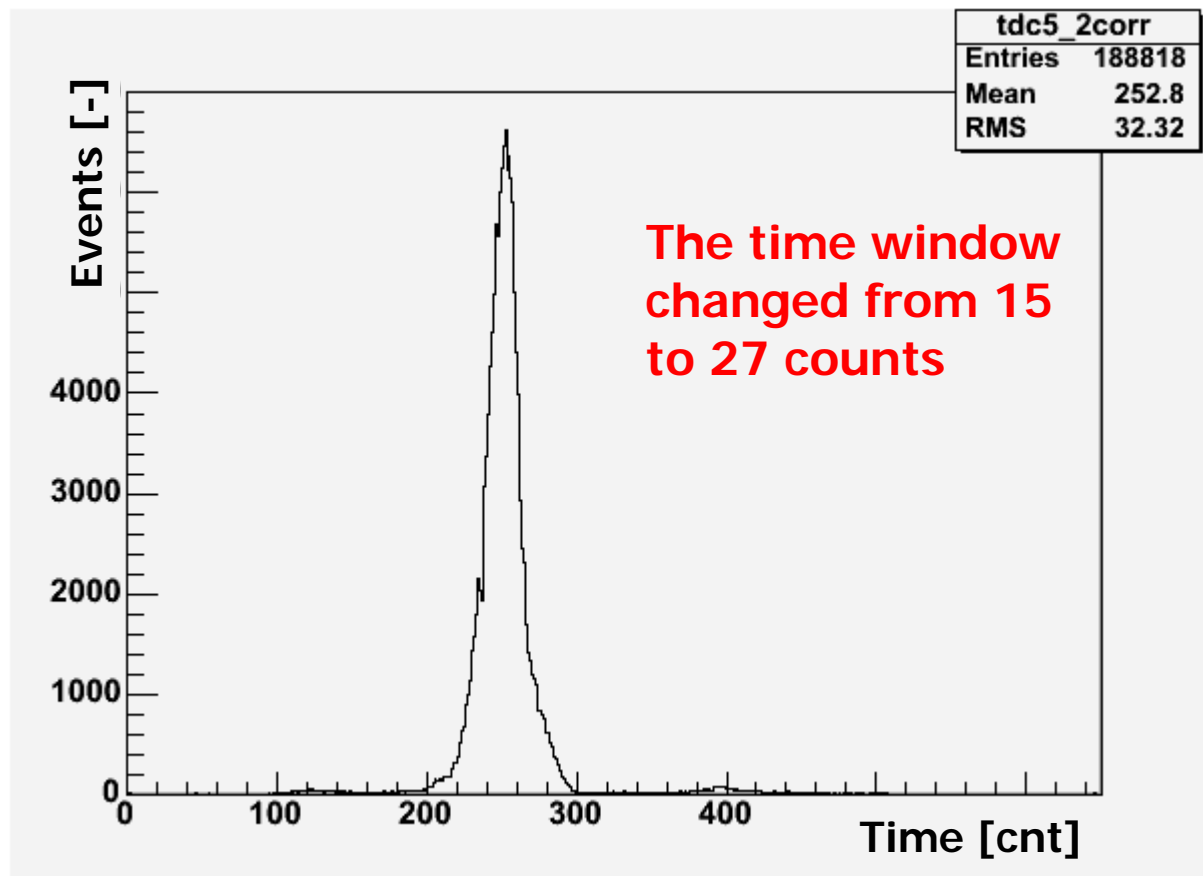
MCP PMT Burle



# Cross talk treatment

Example of cross talk treatment with time window 27 counts.

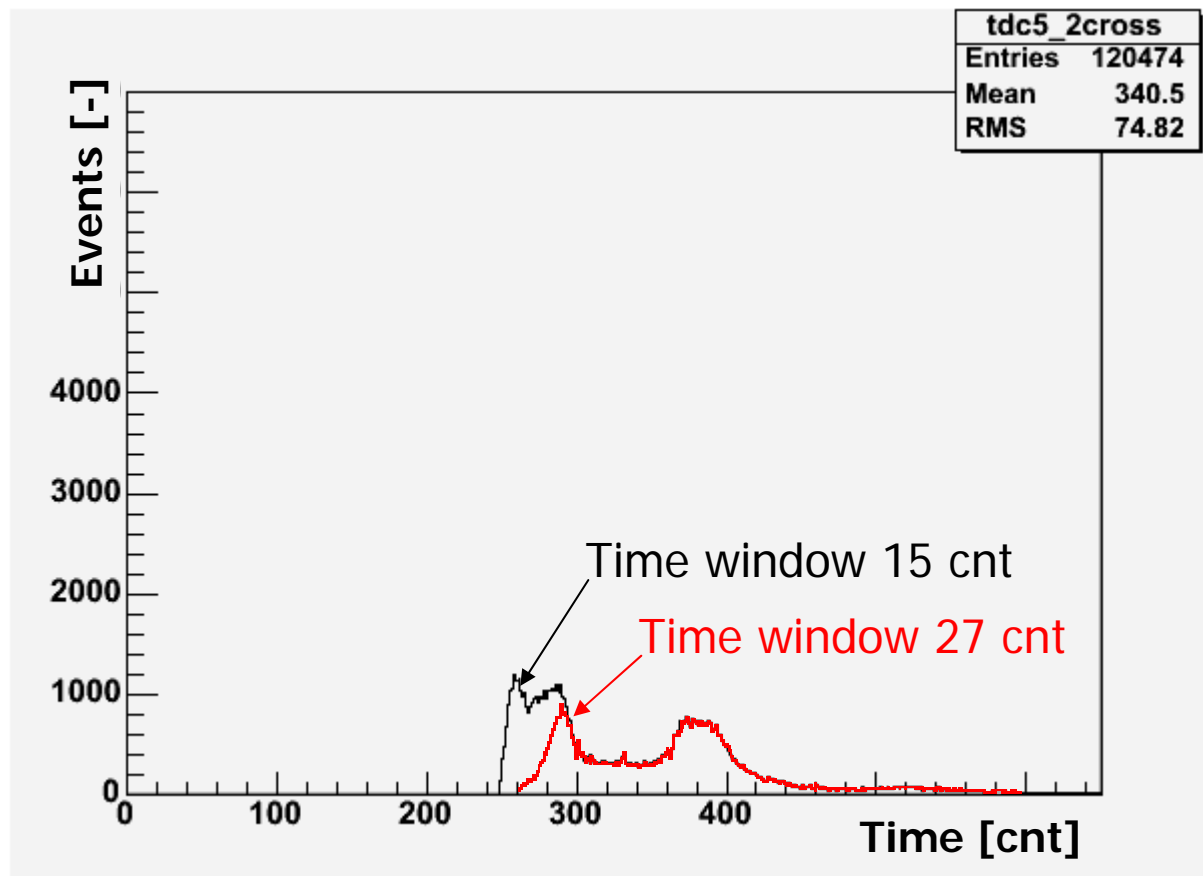
MCP PMT Burle



# Cross talk treatment

Cross talk spectra with time window 15 and 27 counts.

MCP PMT Burle



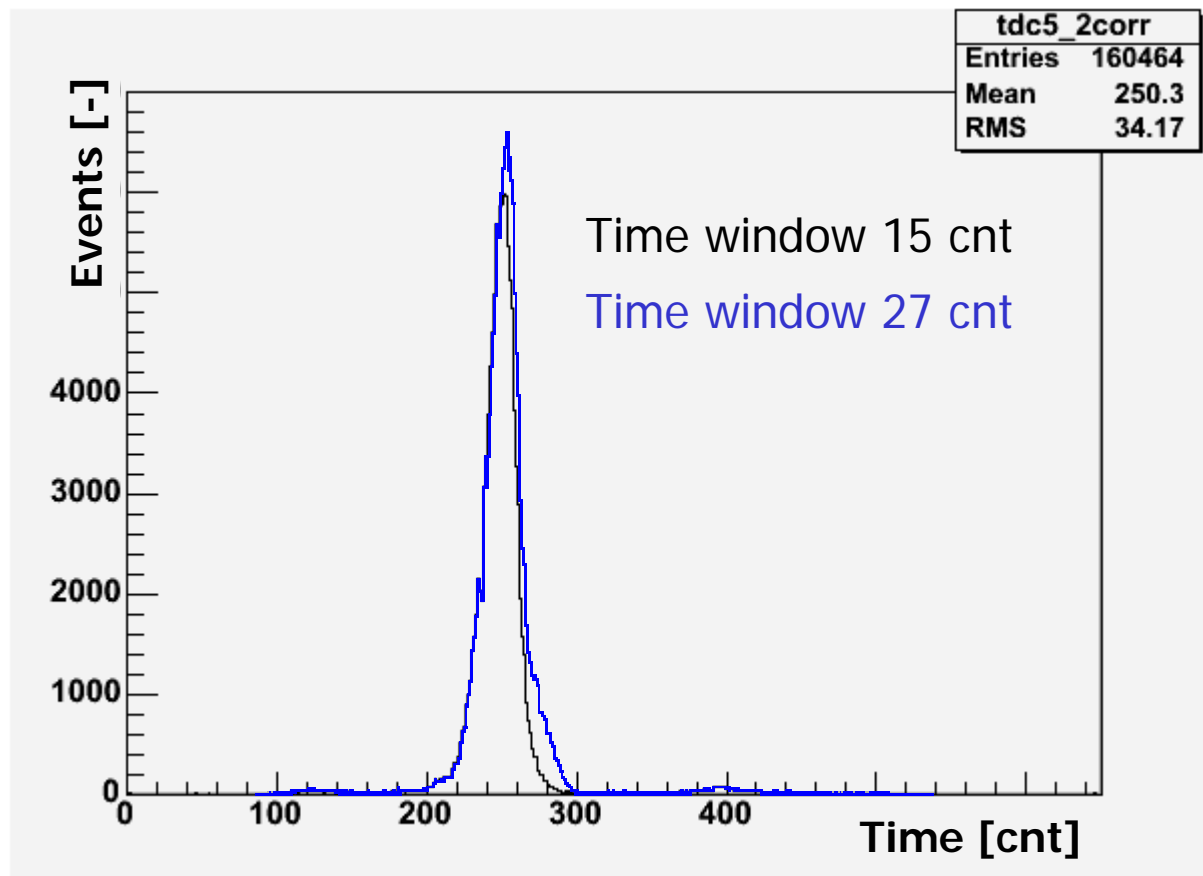
*Cross talk only*



# Cross talk treatment

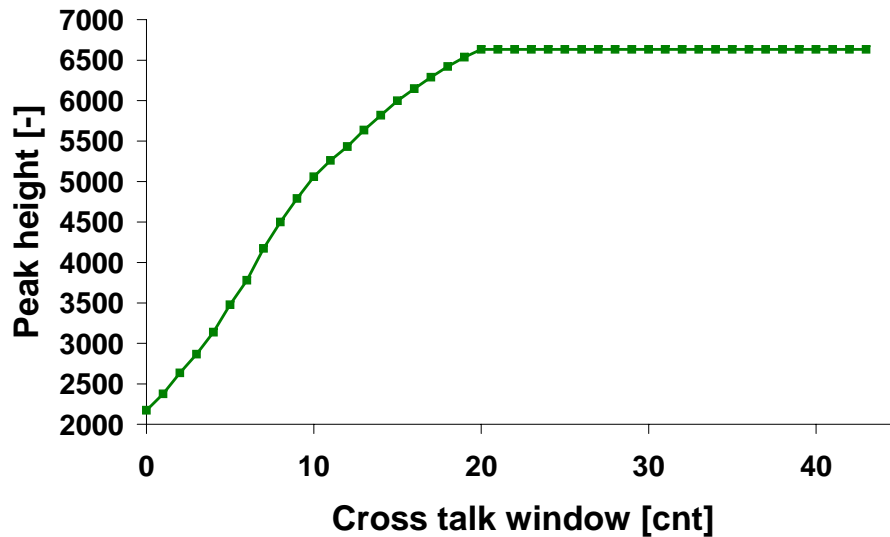
Corrected TDC spectra with time window 15 and 27 counts.

MCP PMT Burle

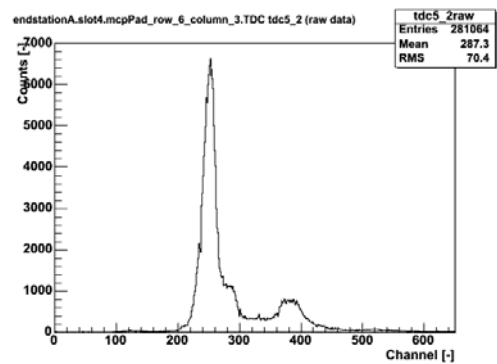
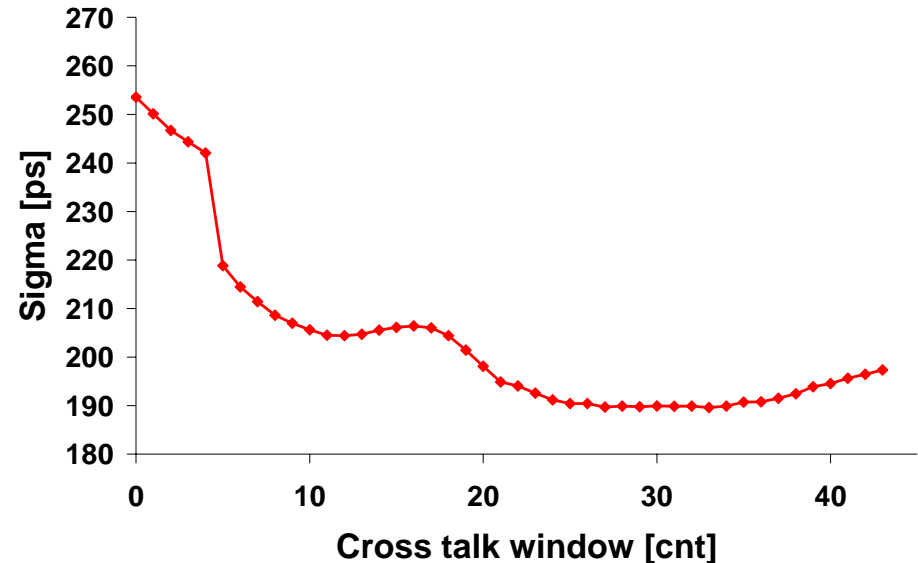


# Cross talk treatment

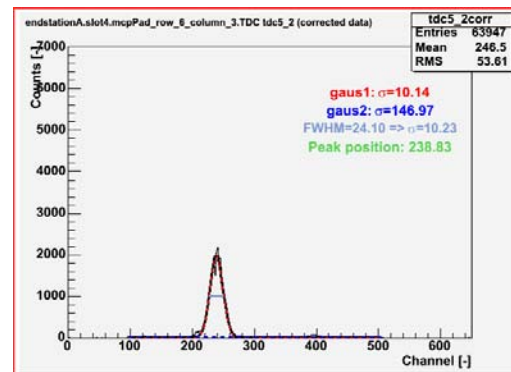
TDC peak height as a function of cross talk time window



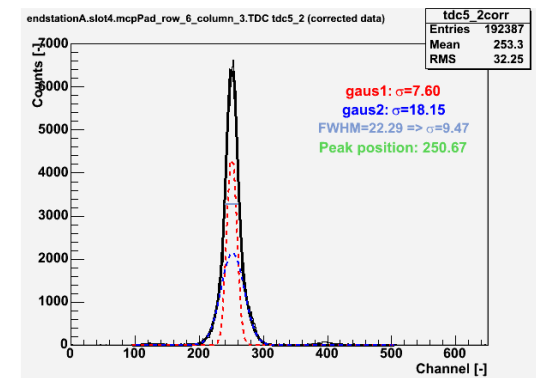
Timing resolution as a function of cross talk time window



Raw TDC spectrum

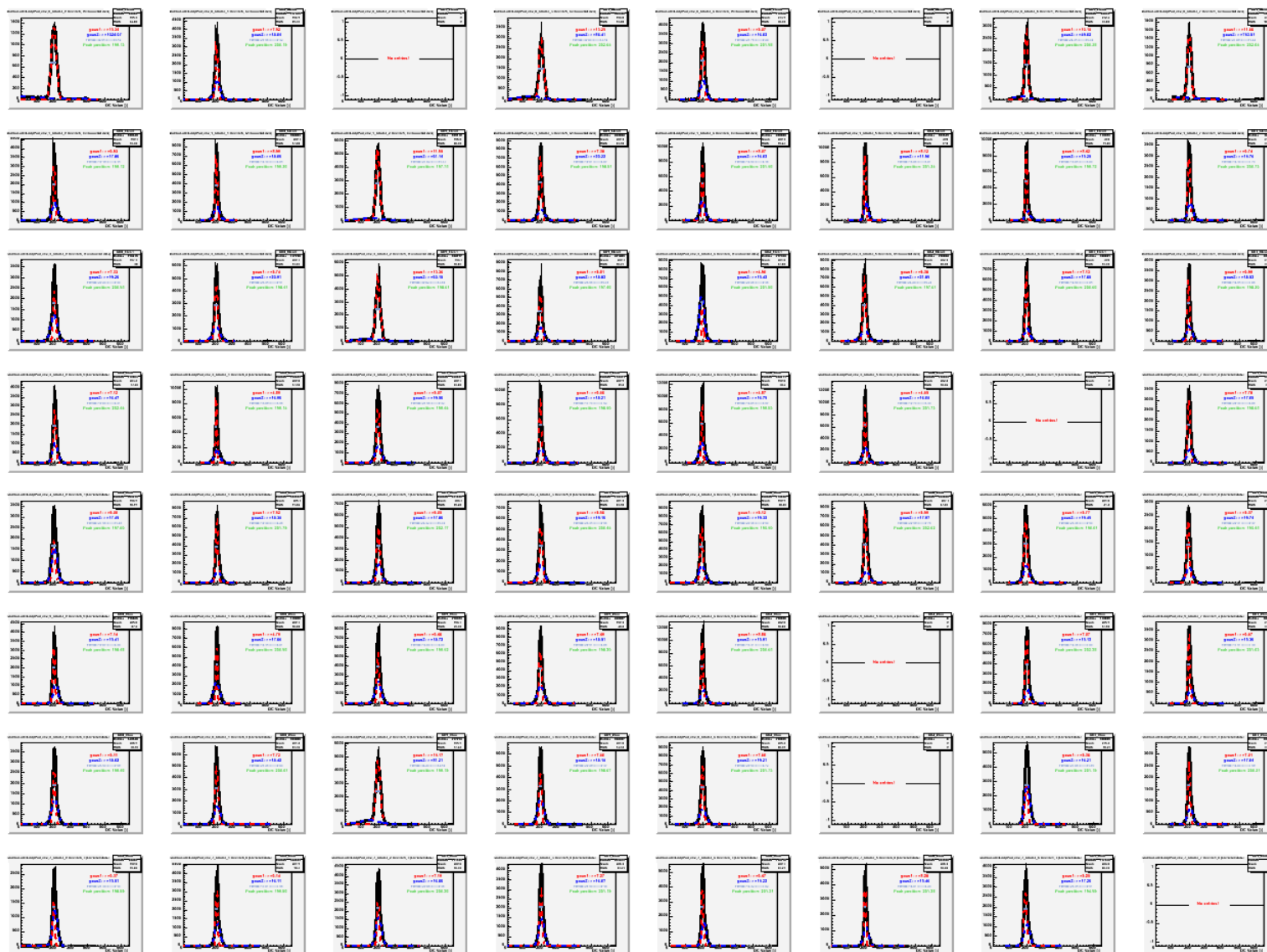


Time window 1

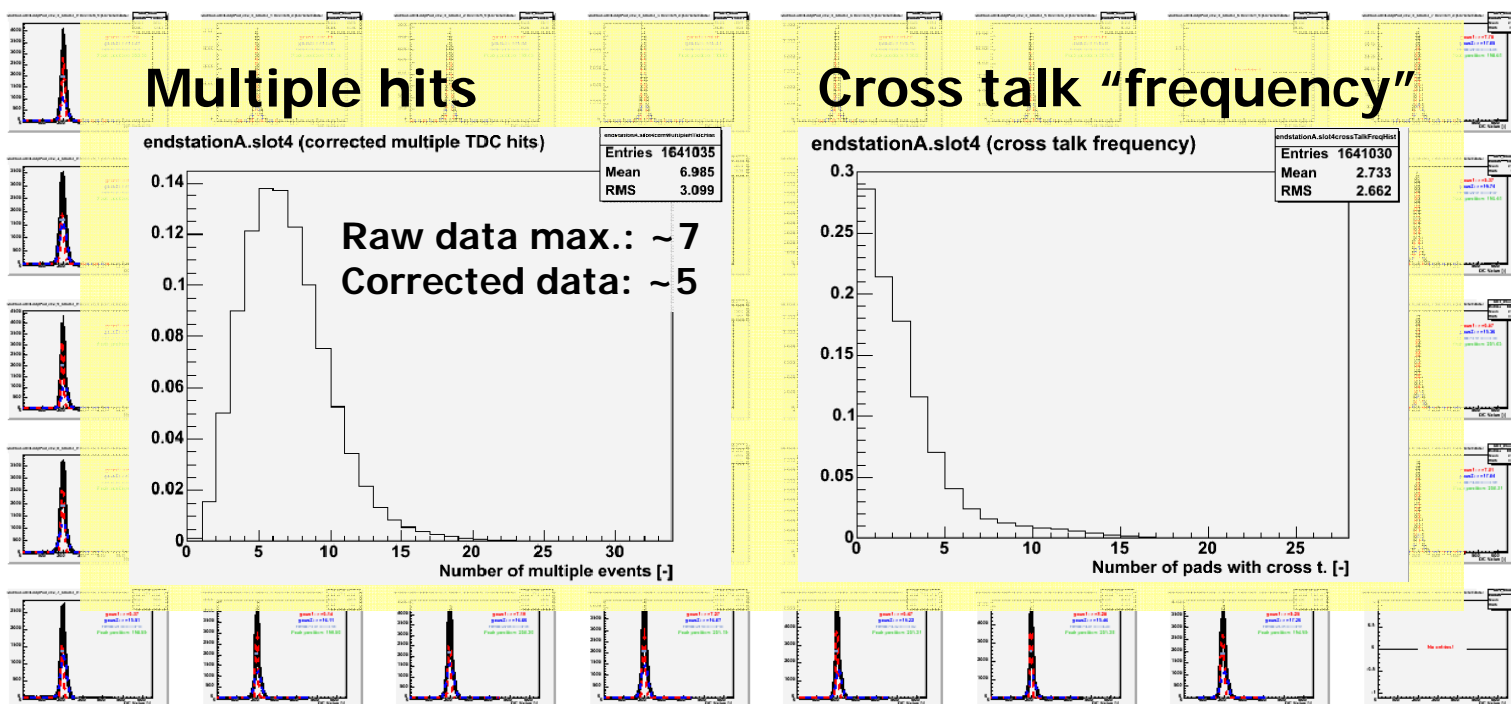


Time window 31

# MCP PMT Burle after cross talk correction



# MCP PMT Burle after cross talk correction





## Conclusion

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- **Influence of Pilas laser on timing resolution discovered. Higher Pilas trigger frequency needed – another Pilas laser will be tested.**
- **Repeated measurement of quartz bar start counter timing resolution – still needs more work**
- **All slots in the prototype will be tested in near future**
- **Effective cross talk treatment was implemented in data analysis code**