

Studies on afterpulses and saturation of SiPM with fast UV light pulses



Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)

Marco Szalay

Tungsten Timing



28/02/2012

Table Of Contents

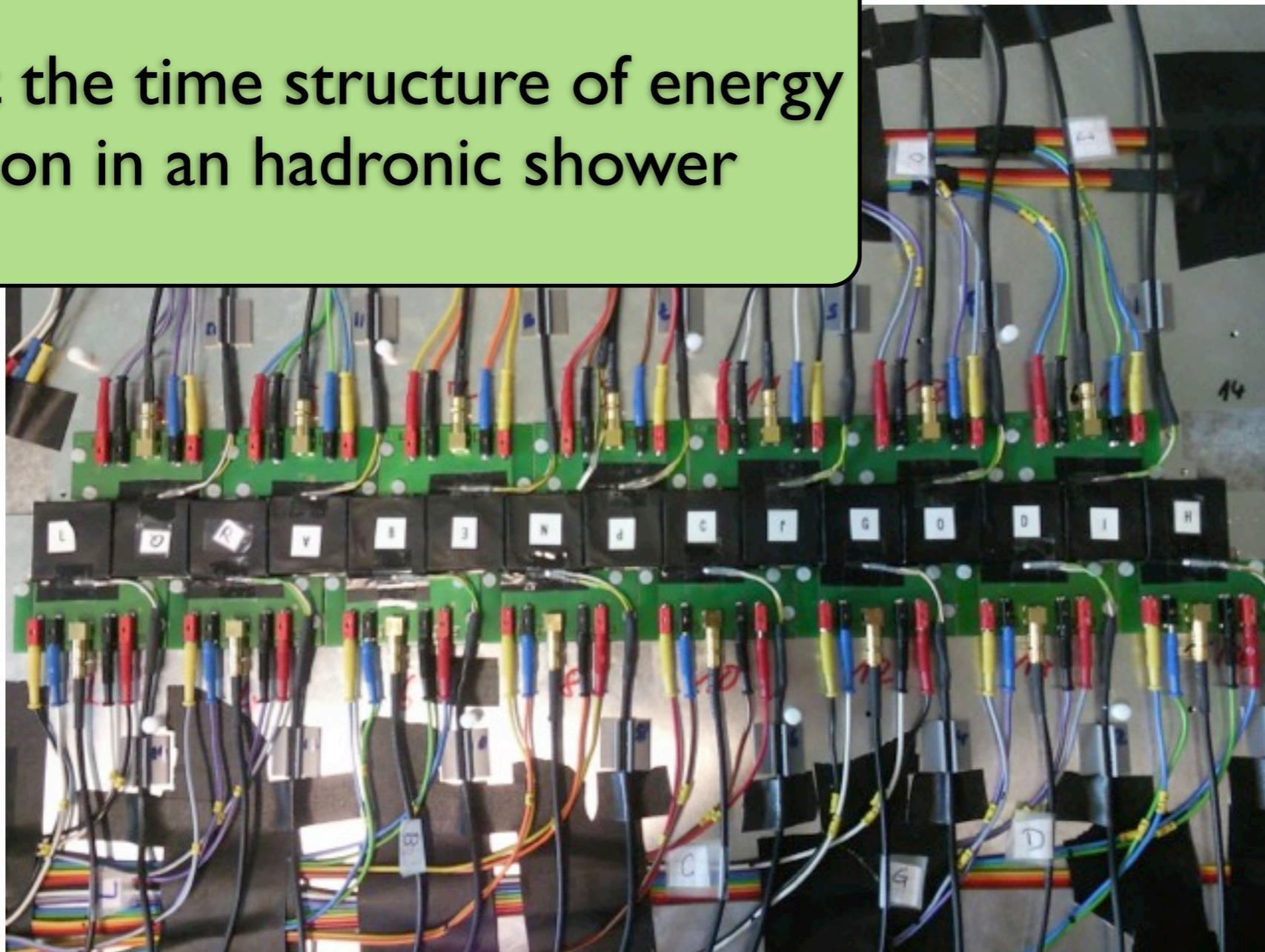
- Motivations
- The T3B experiment
- The WaveForm Decomposition algorithm
- The UV Led setup for Saturation and afterpulses measurements
- First results
 - SiPM Saturation Curve
 - Time Distribution of SiPM signals
- Future plans

Motivation

- Understand the saturation behavior of a SiPM (MPPC-50P Hamamatsu)
- Investigate the time structure of the SiPM signal on the test bench to
 - understand the time behavior of detector systems
 - disentangle afterpulses from signal

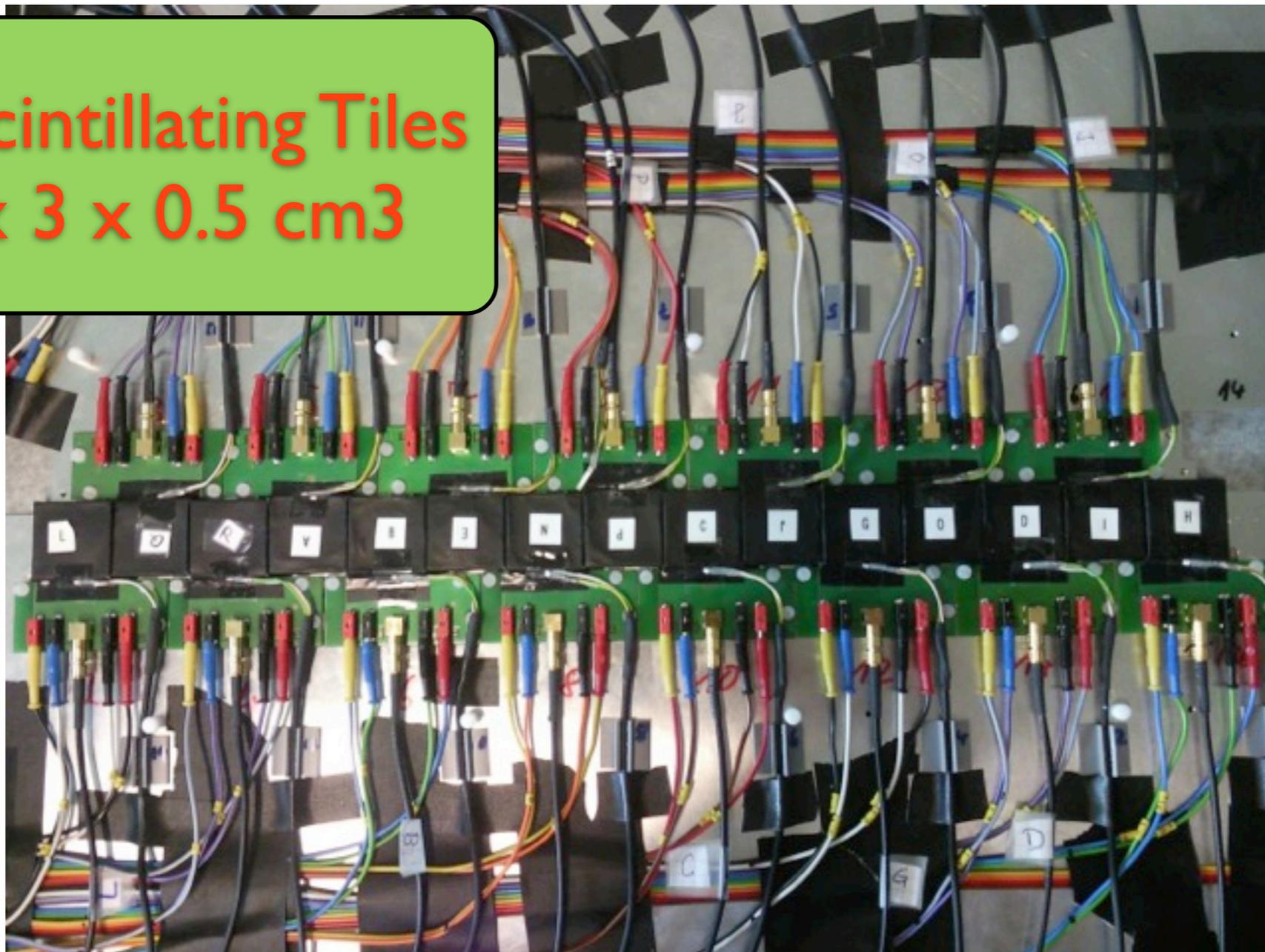
Tungsten Timing Test Beam - T3B

reconstruct the time structure of energy deposition in an hadronic shower



Tungsten Timing Test Beam - T3B

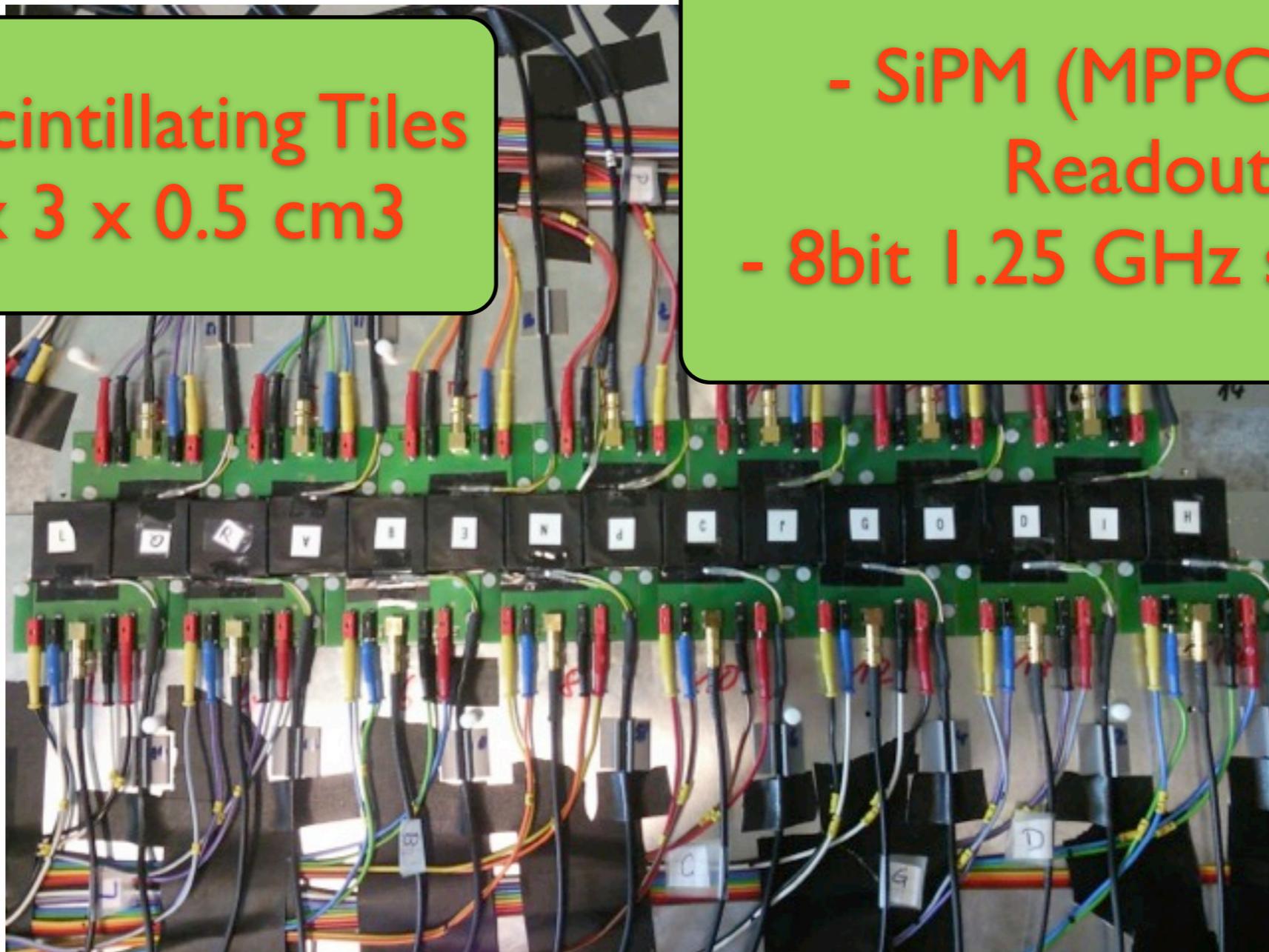
- 15 Scintillating Tiles
- 3 x 3 x 0.5 cm³



Tungsten Timing Test Beam - T3B

- 15 Scintillating Tiles
- 3 x 3 x 0.5 cm³

- SiPM (MPPC-50P)
Readout
- 8bit 1.25 GHz sampling

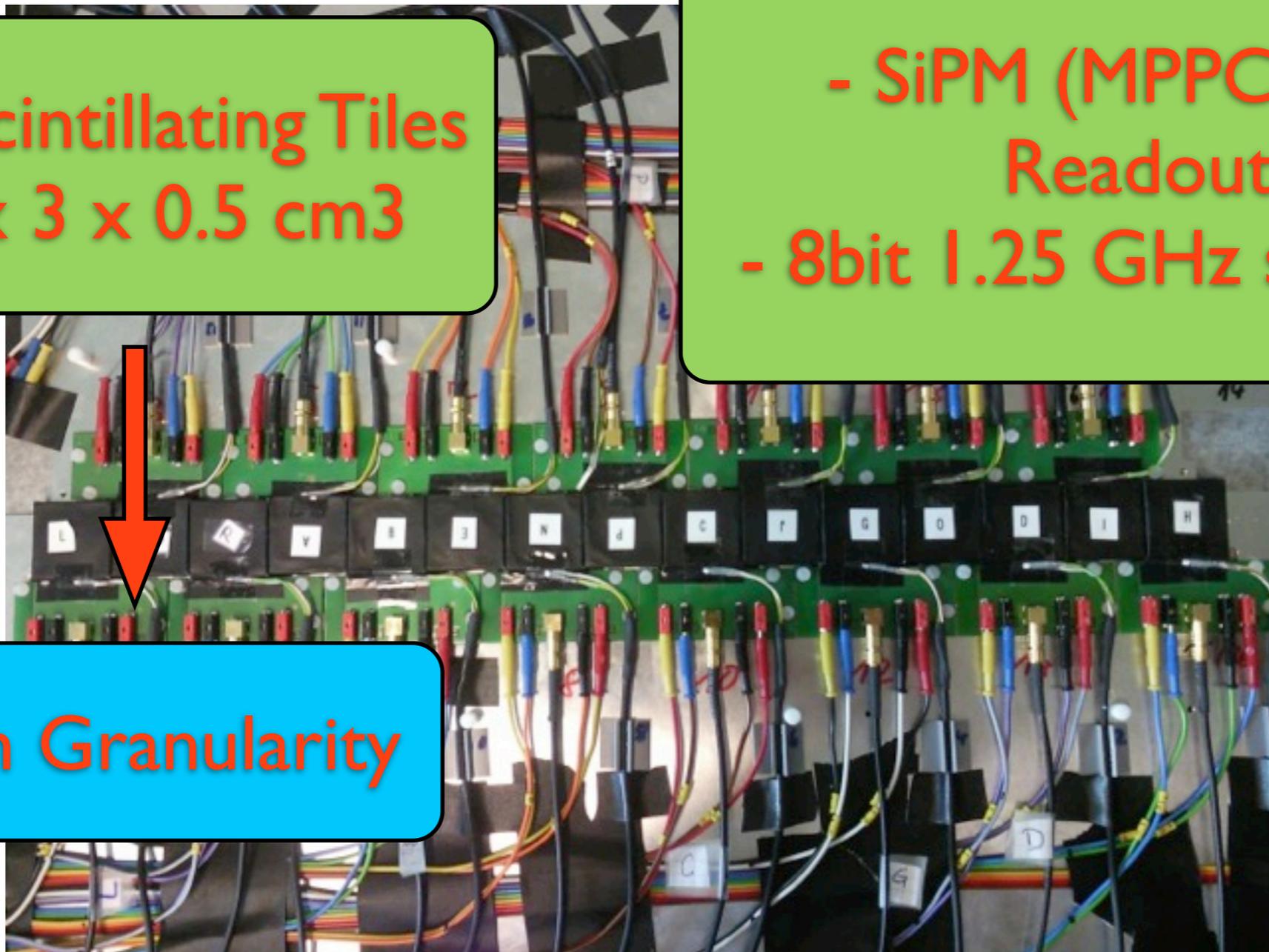


Tungsten Timing Test Beam - T3B

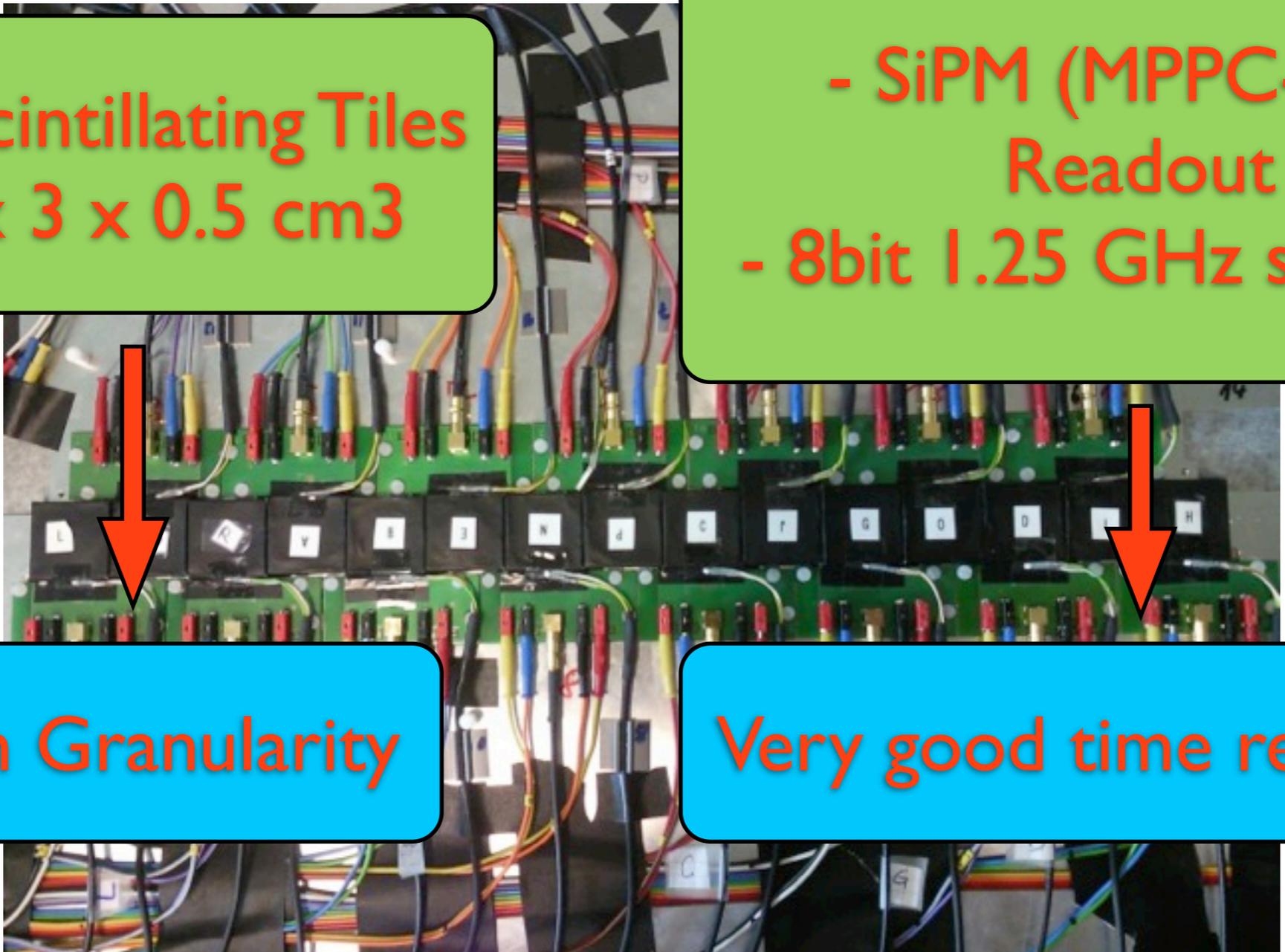
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High Granularity



Tungsten Timing Test Beam - T3B



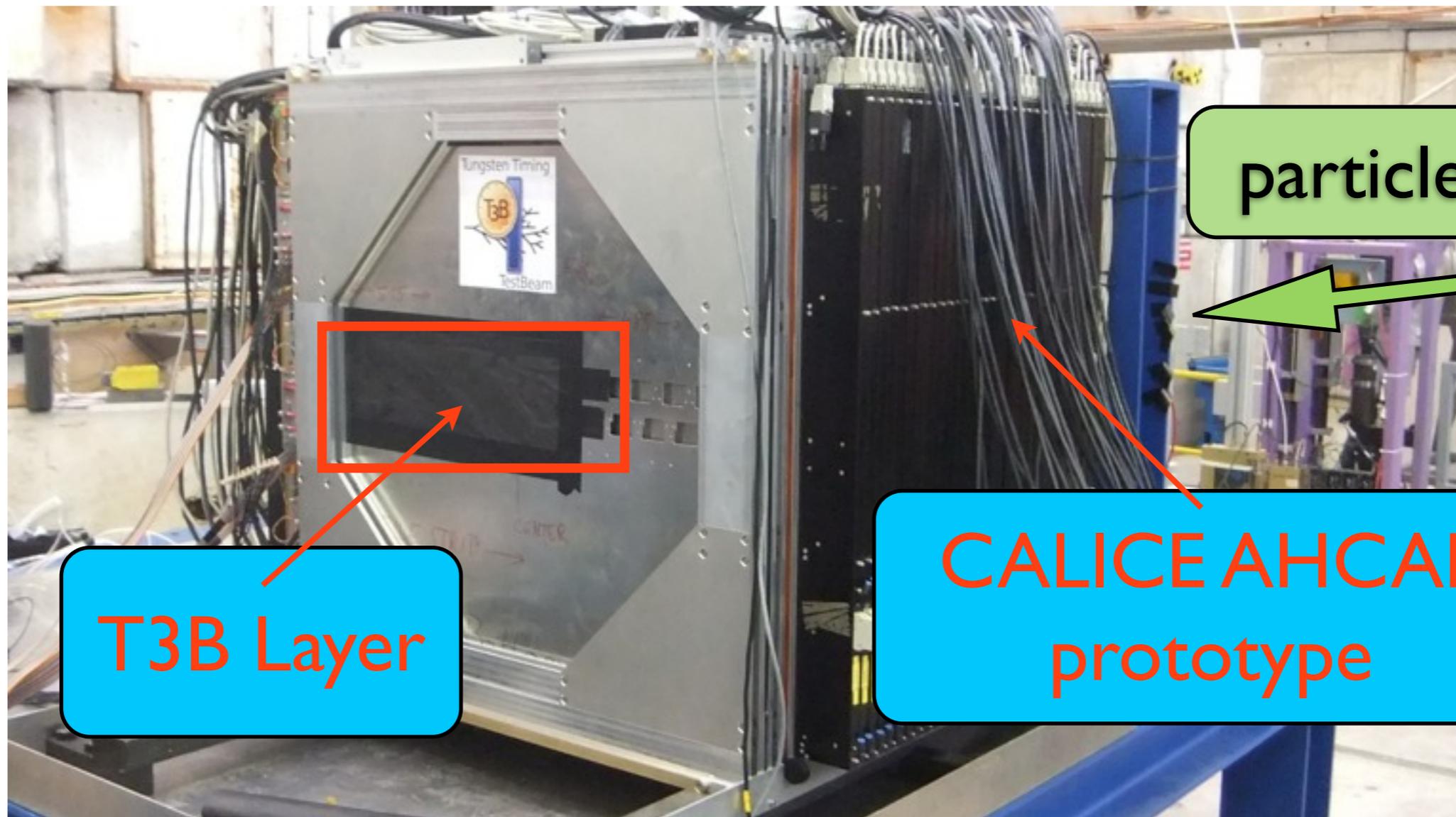
- 15 Scintillating Tiles
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High Granularity

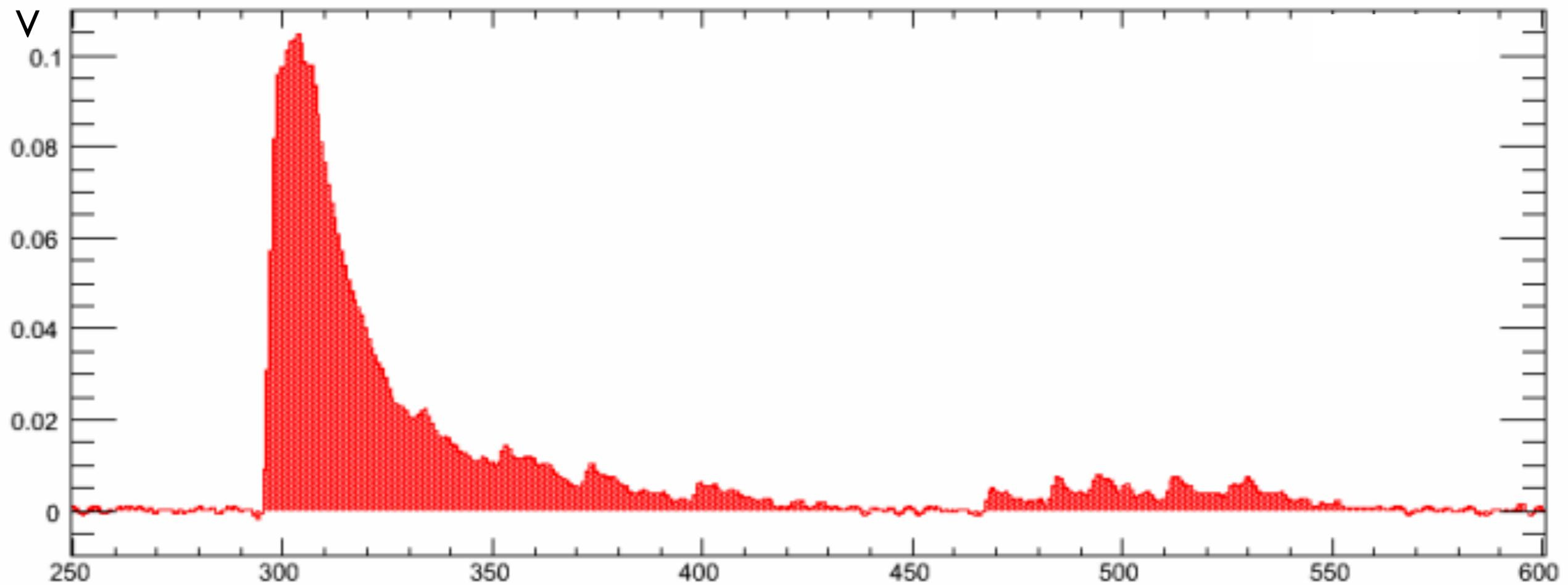
Very good time resolution

Tungsten Timing Test Beam - T3B



WaveForm Decomposition Algorithm

Event1212 Tile Position0 - Step1

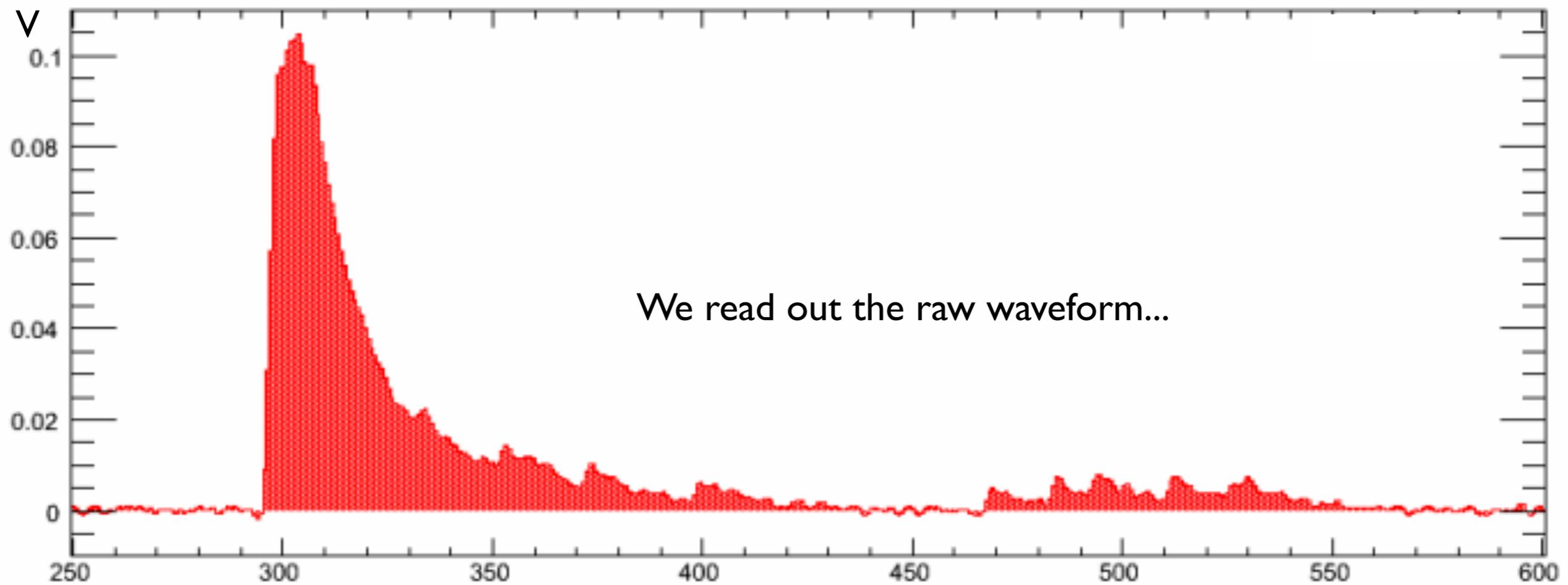


[http://www.mpp.mpg.de/~soldner/
WaveformDecomposition.gif](http://www.mpp.mpg.de/~soldner/WaveformDecomposition.gif)

source: Christian Soldner - IEEE 2011^{nS}

WaveForm Decomposition Algorithm

Event1212 Tile Position0 - Step1

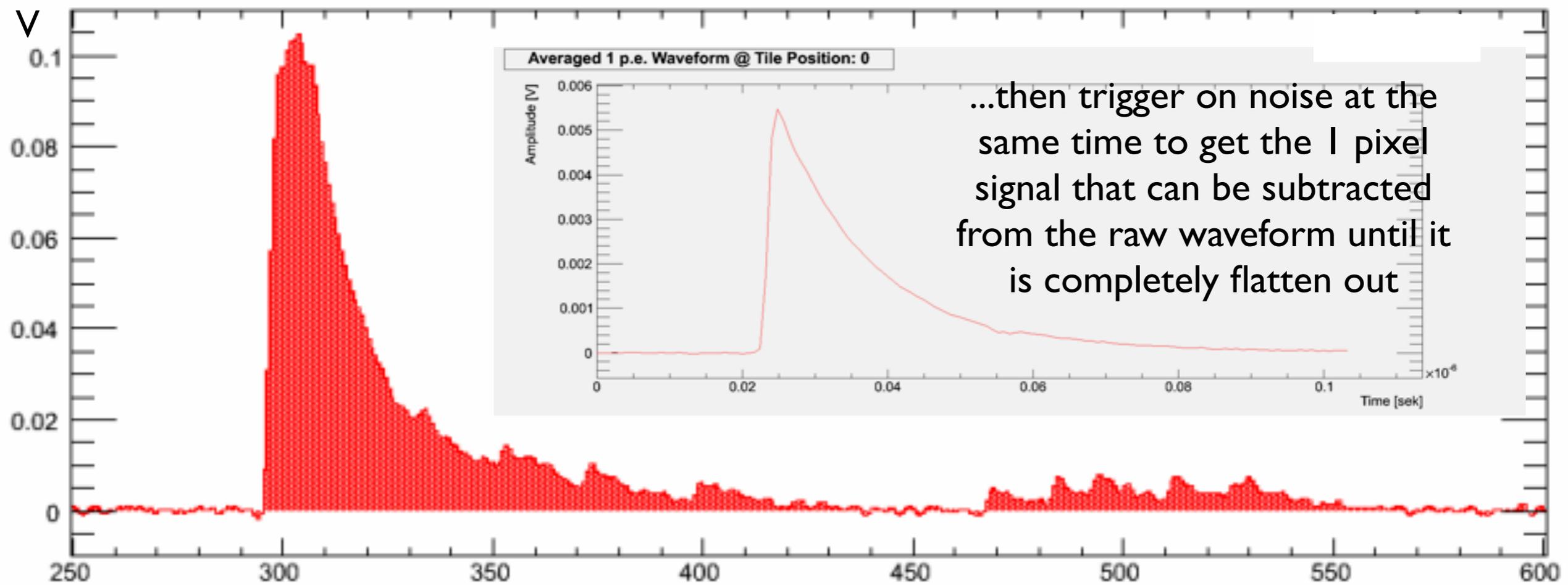


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WaveForm Decomposition Algorithm

Event1212 Tile Position0 - Step1

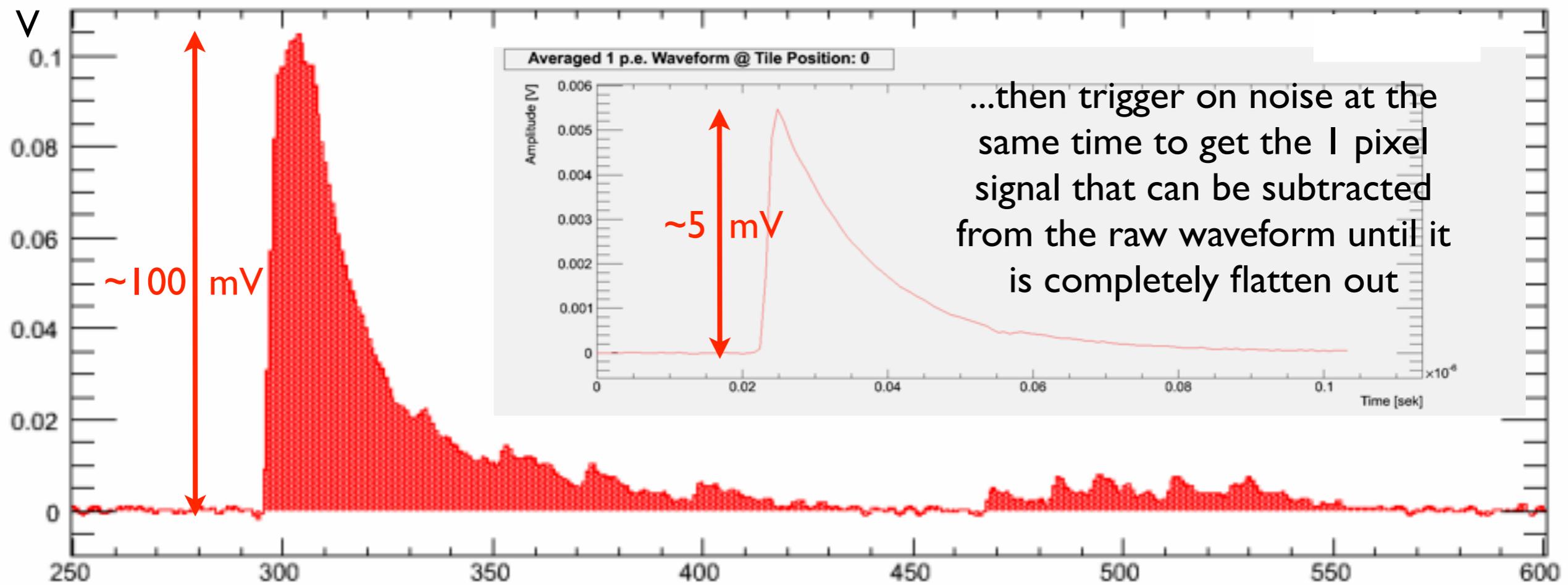


<http://www.mpp.mpg.de/~soldner/WaveformDecomposition.gif>

source: Christian Soldner - IEEE 2011

WaveForm Decomposition Algorithm

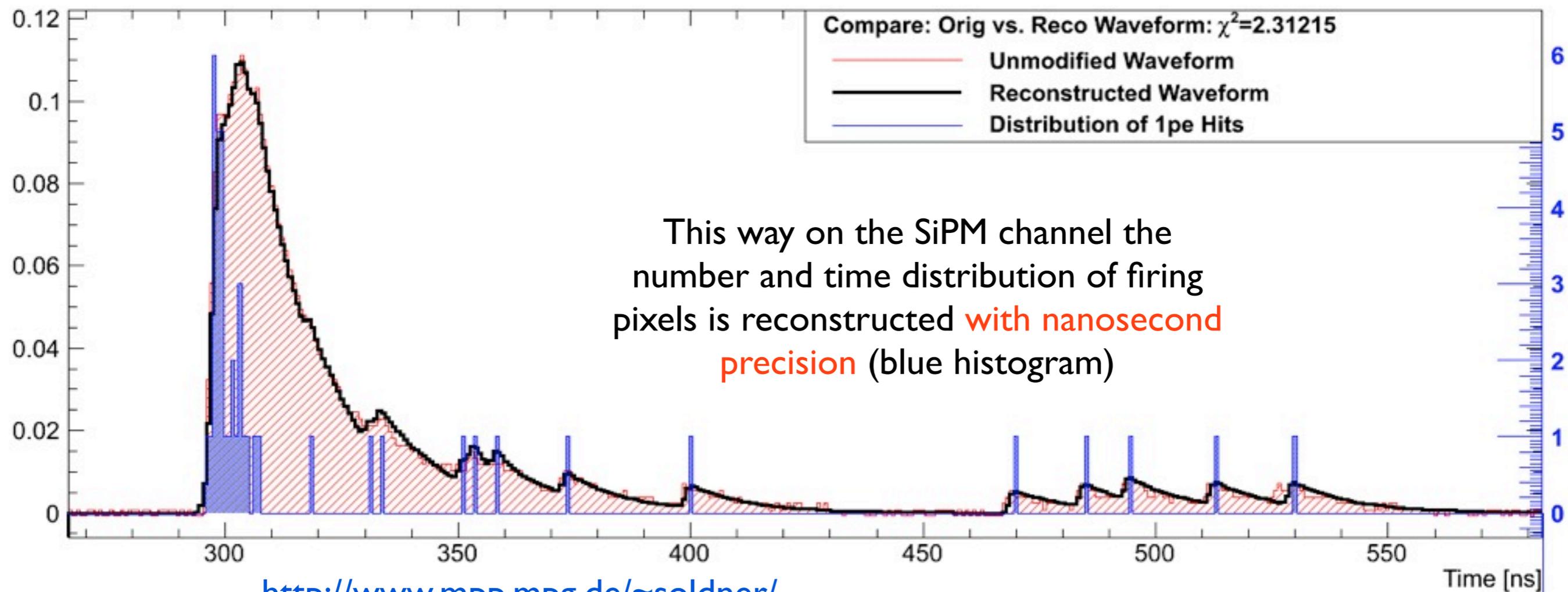
Event1212 Tile Position0 - Step1



<http://www.mpp.mpg.de/~soldner/WaveformDecomposition.gif>

source: Christian Soldner - IEEE 2011

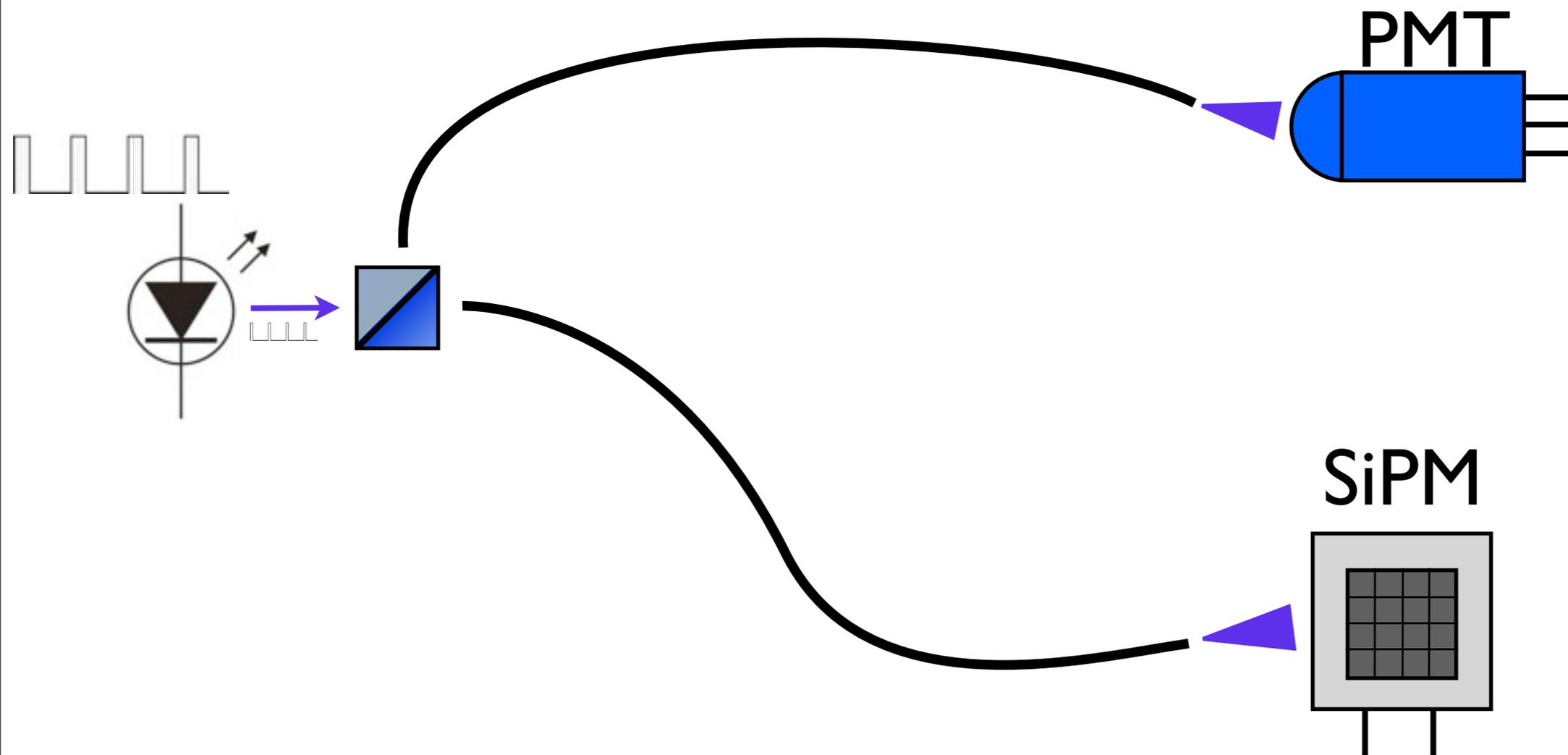
WaveForm Decomposition Algorithm



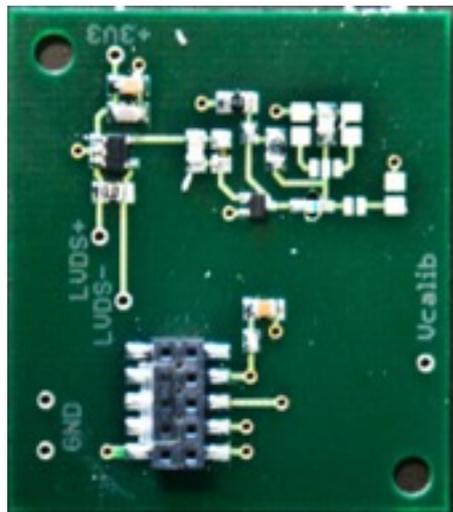
<http://www.mpp.mpg.de/~soldner/WaveformDecomposition.gif>

source: Christian Soldner - IEEE 2011

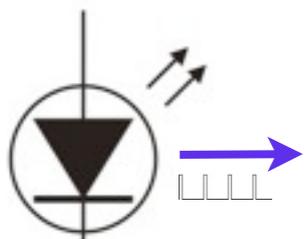
The UV Led Setup



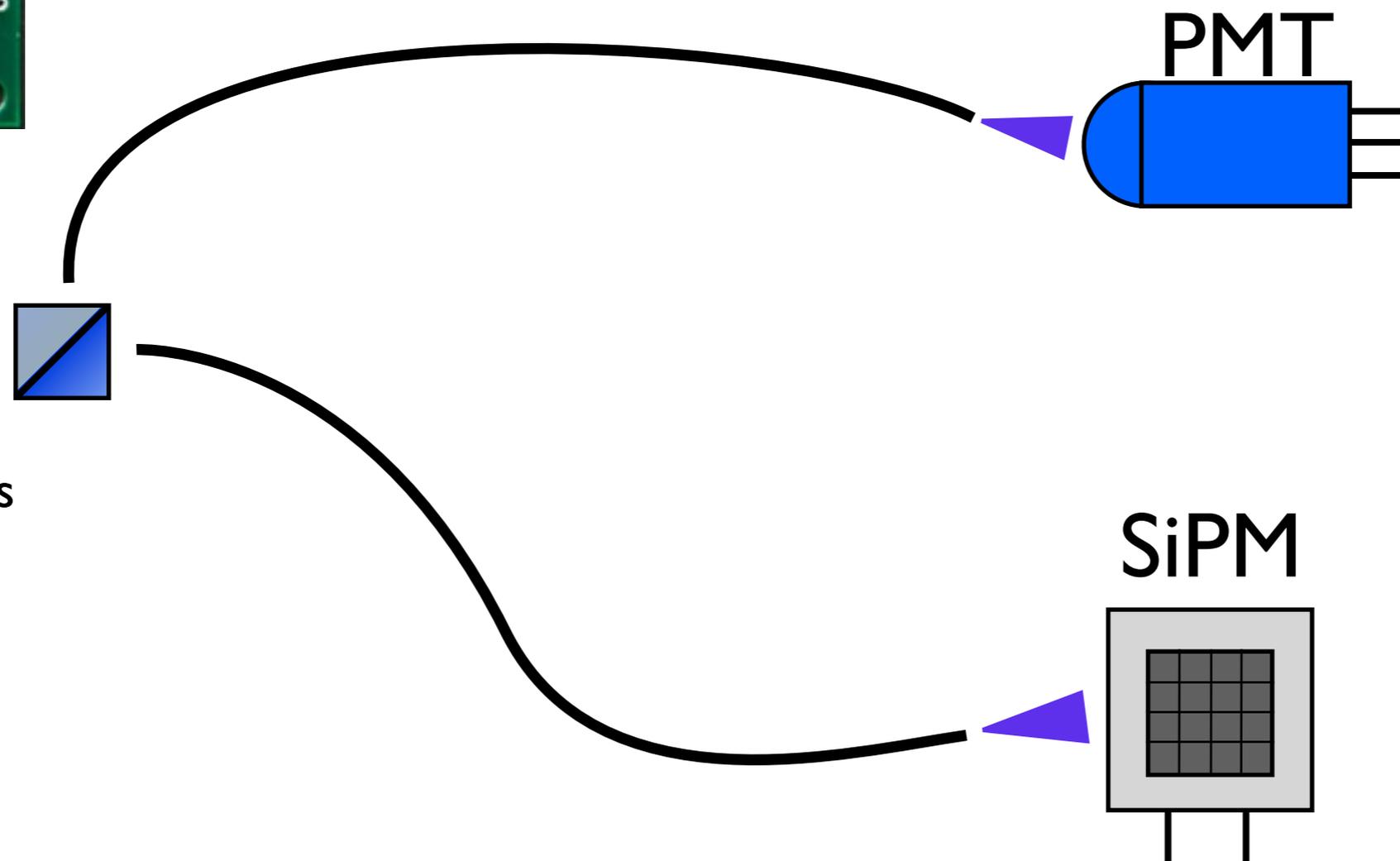
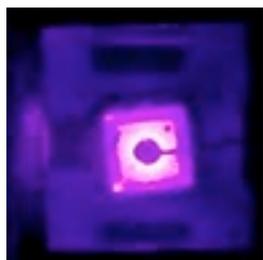
The UV Led Setup



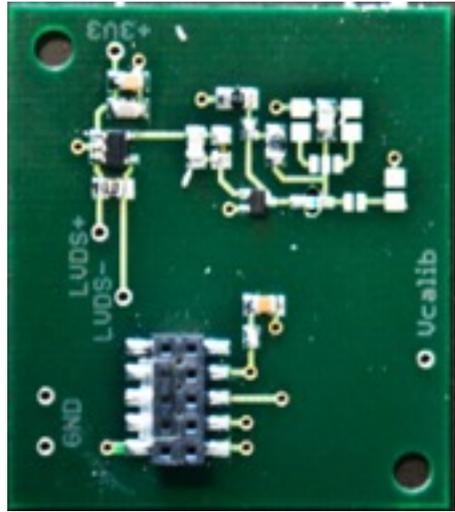
UV led board from the Wuppertal University CALICE group designed to deliver very short light pulses ($\sim 3\text{ns}$)



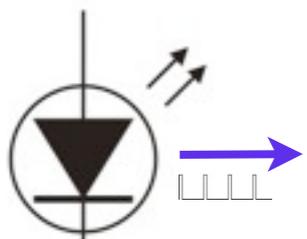
few ns light pulses
@1 KHz rate...



The UV Led Setup



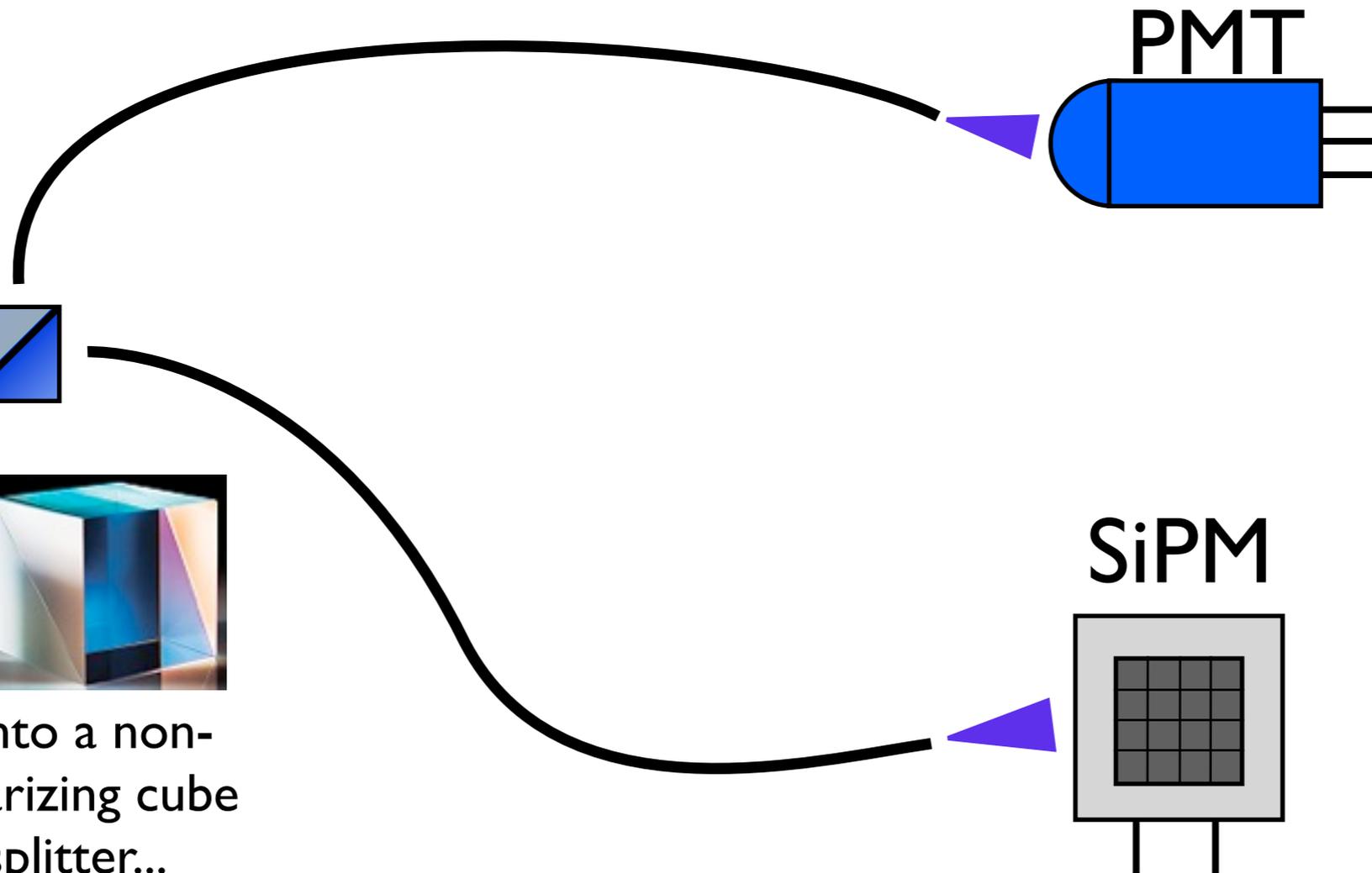
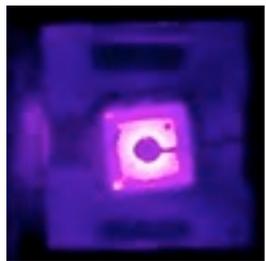
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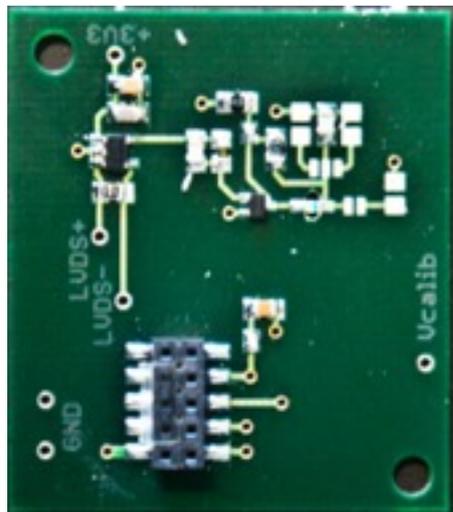
few ns light pulses
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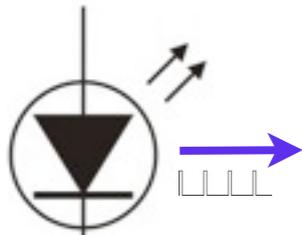
...into a non-polarizing cube splitter...



The UV Led Setup



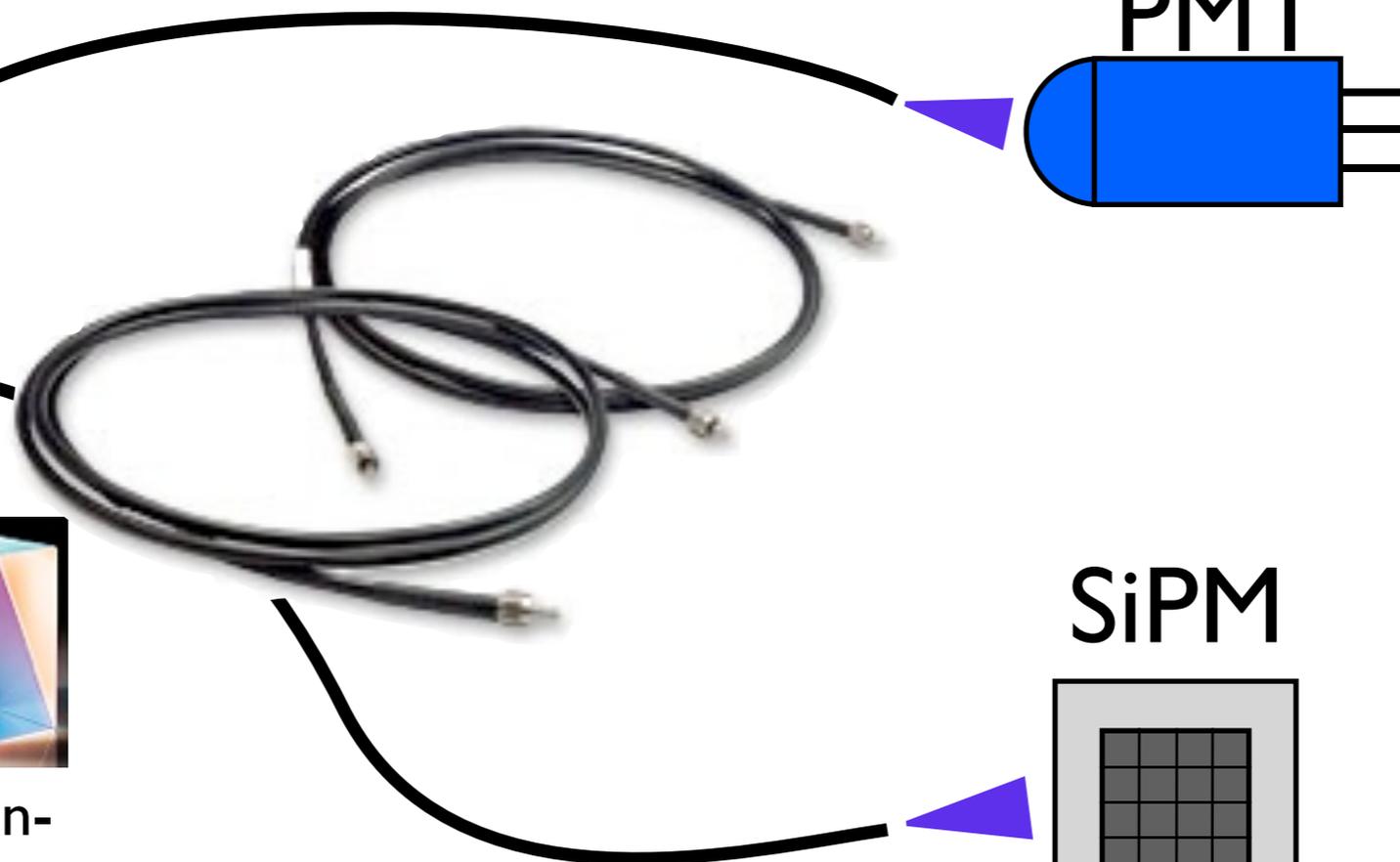
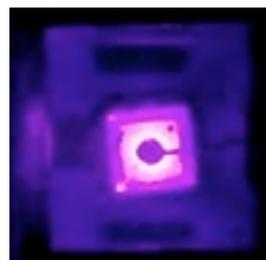
UV led board from the Wuppertal University CALICE group designed to deliver very short light pulses ($\sim 3\text{ns}$)



few ns light pulses @ 1 KHz rate...



...into a non-polarizing cube splitter...

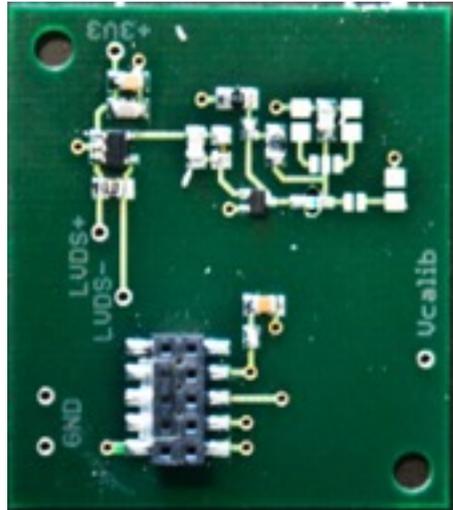


...coupled into UV transparent fiber optics...

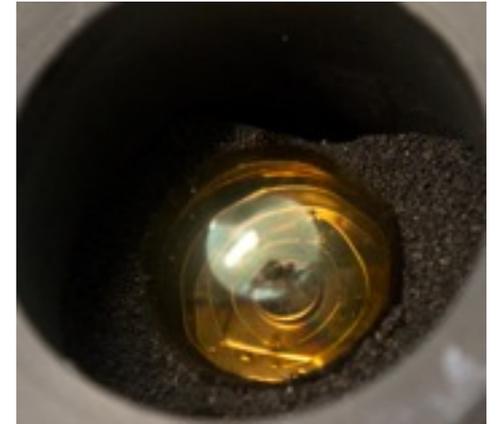
PMT

SiPM

The UV Led Setup



UV led board from the Wuppertal University CALICE group designed to deliver very short light pulses ($\sim 3\text{ns}$)



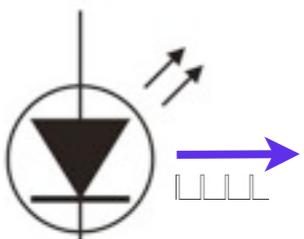
PMT

...shines on a PMT from the MAGIC group...

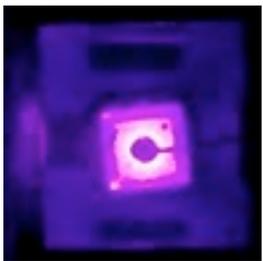
SiPM

...coupled into UV transparent fiber optics...

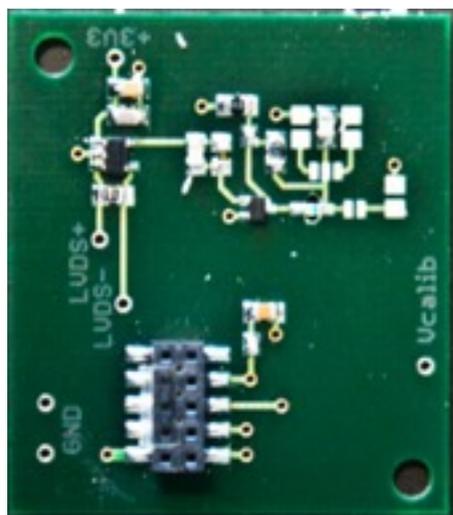
...into a non-polarizing cube splitter...



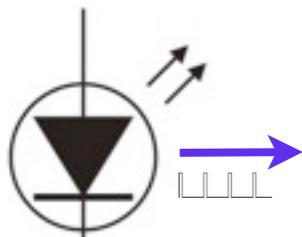
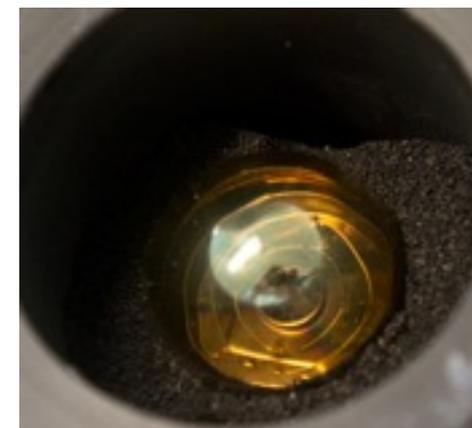
few ns light pulses @ 1 KHz rate...



The UV Led Setup



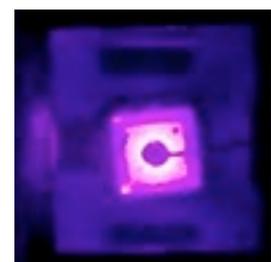
UV led board from the Wuppertal University CALICE group designed to deliver very short light pulses ($\sim 3\text{ns}$)



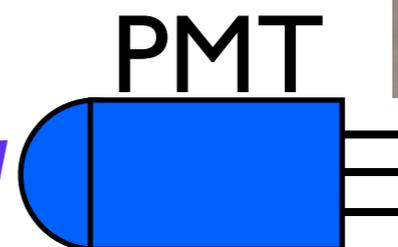
few ns light pulses @ 1 KHz rate...



...into a non-polarizing cube splitter...

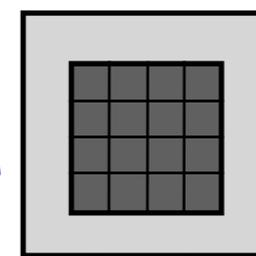


...coupled into UV transparent fiber optics...

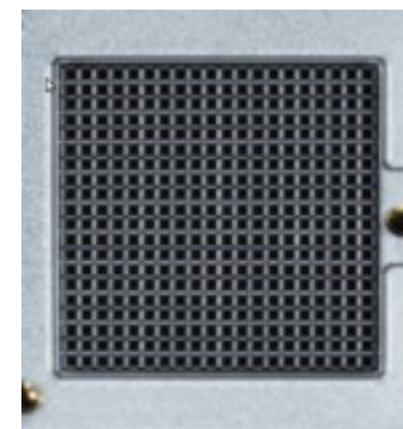


...shines on a PMT from the MAGIC group...

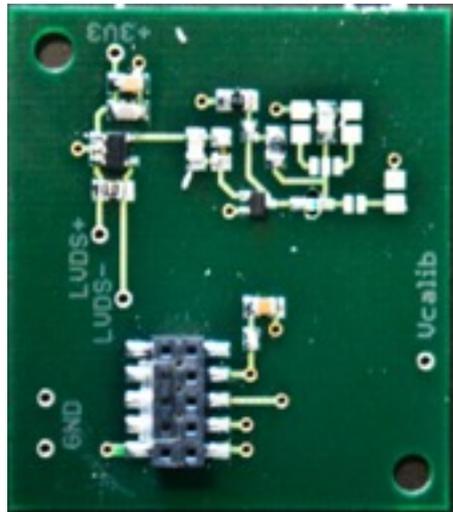
SiPM



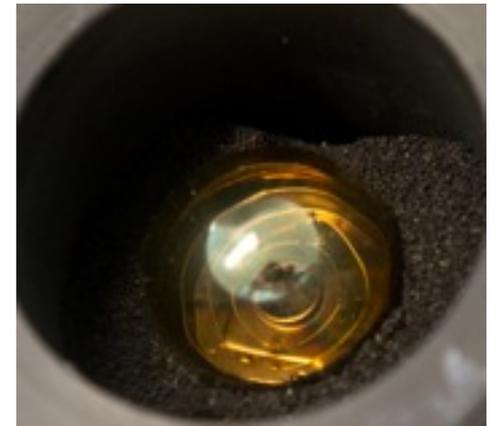
...and an Hamamatsu SiPM



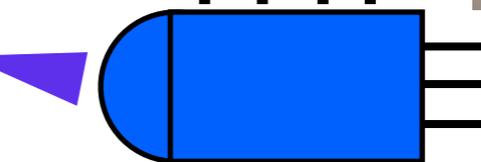
The UV Led Setup



UV led board from the Wuppertal University CALICE group designed to deliver very short light pulses ($\sim 3\text{ns}$)



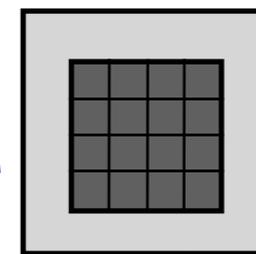
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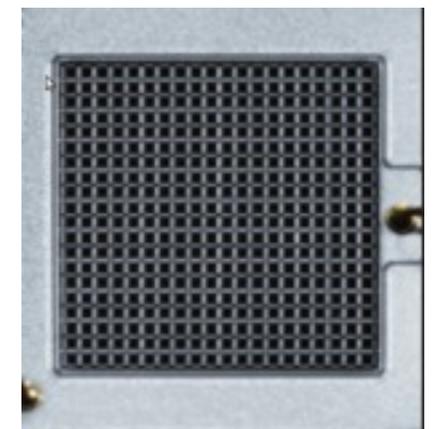
...shines on a PMT from the MAGIC group...

Read out with Picoscope 6000 digital oscilloscopes (8 bit - 1.25GHz) and custom software

SiPM



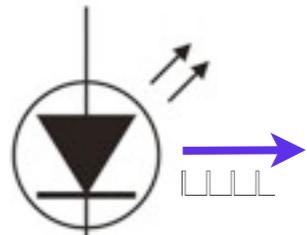
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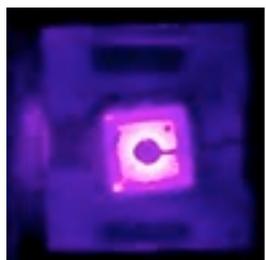
...coupled into UV transparent fiber optics...



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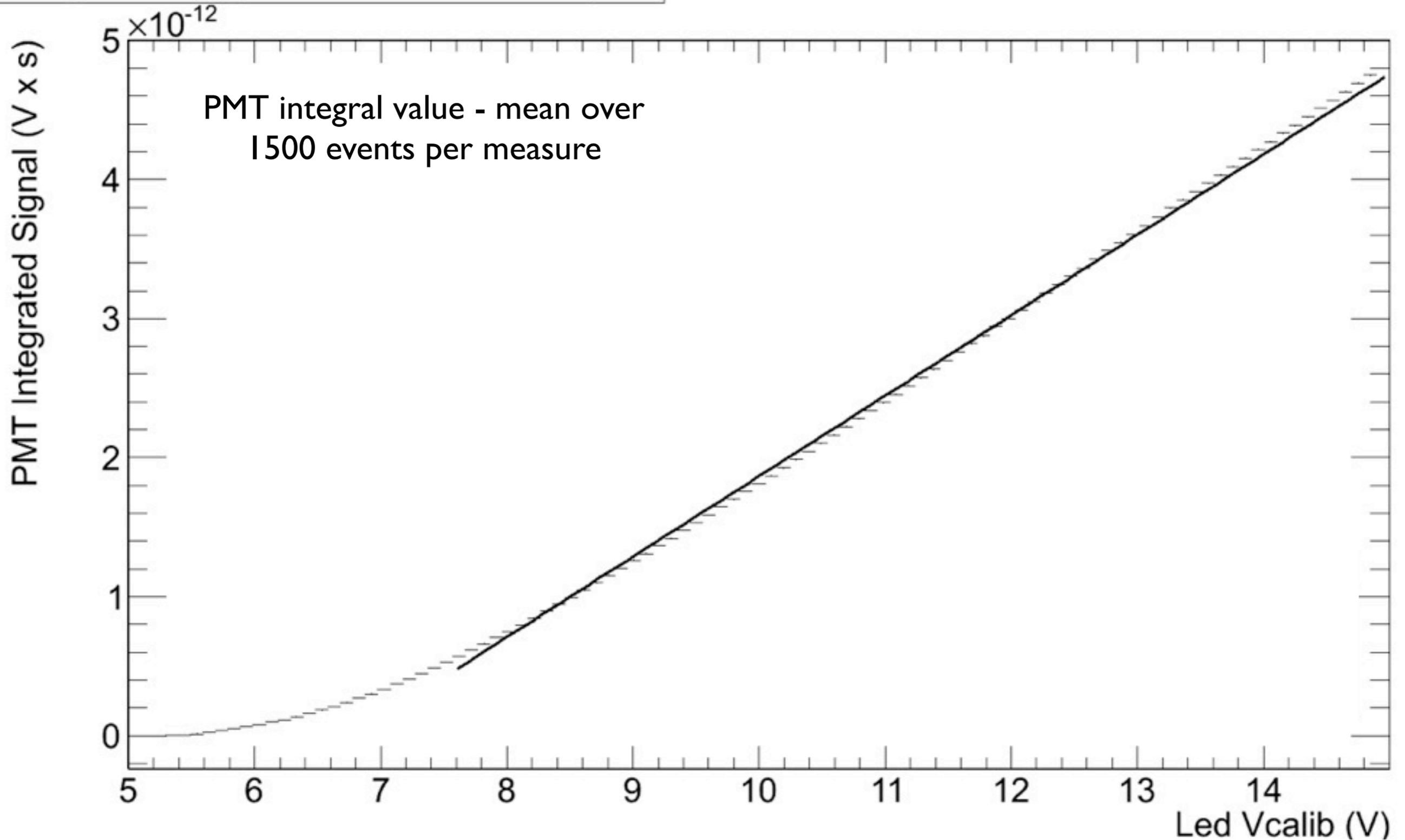


few ns light pulses @ 1 KHz rate...



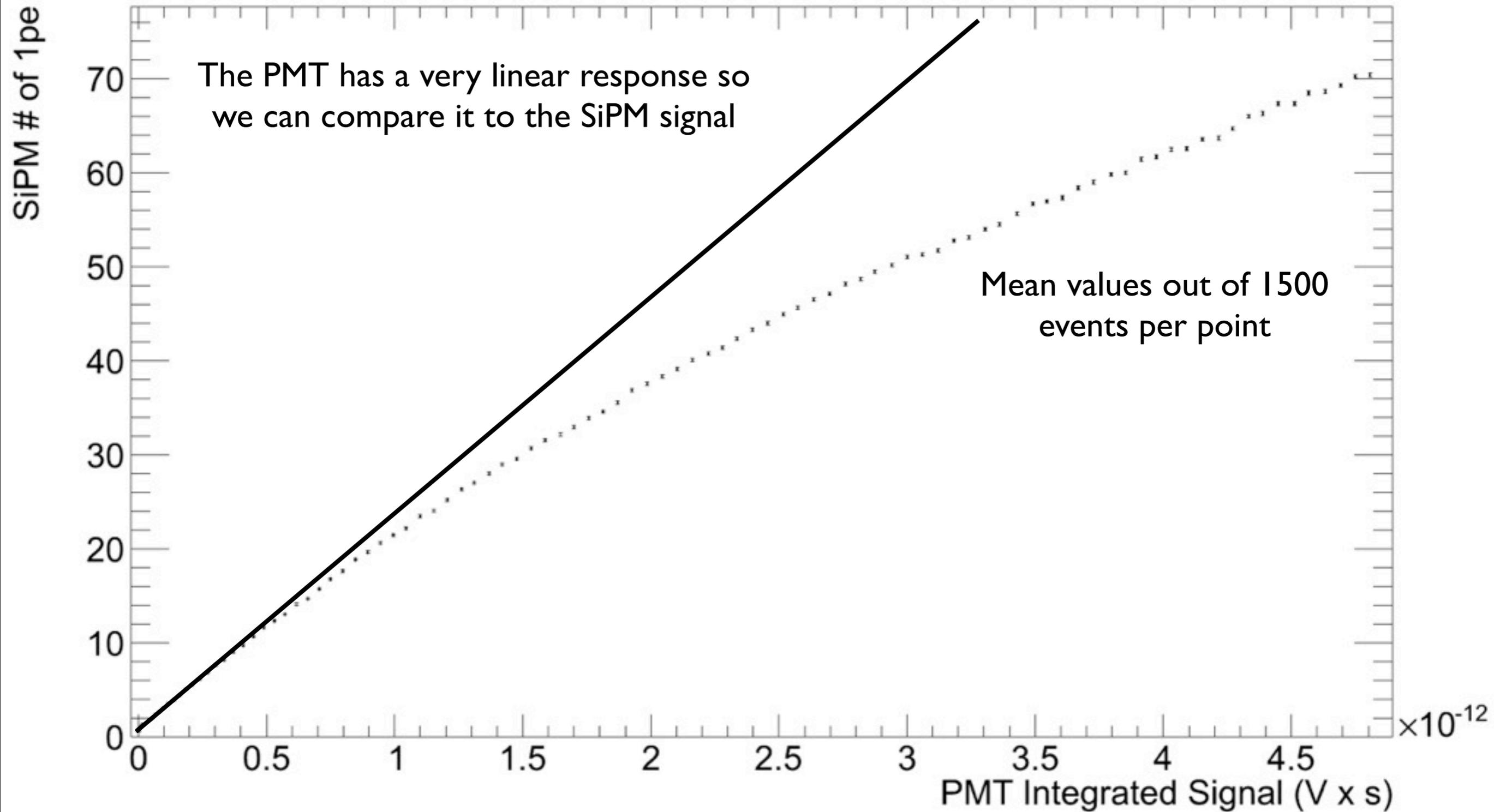
Led Emission Linearity

Signal Integral vs Led Intensity-



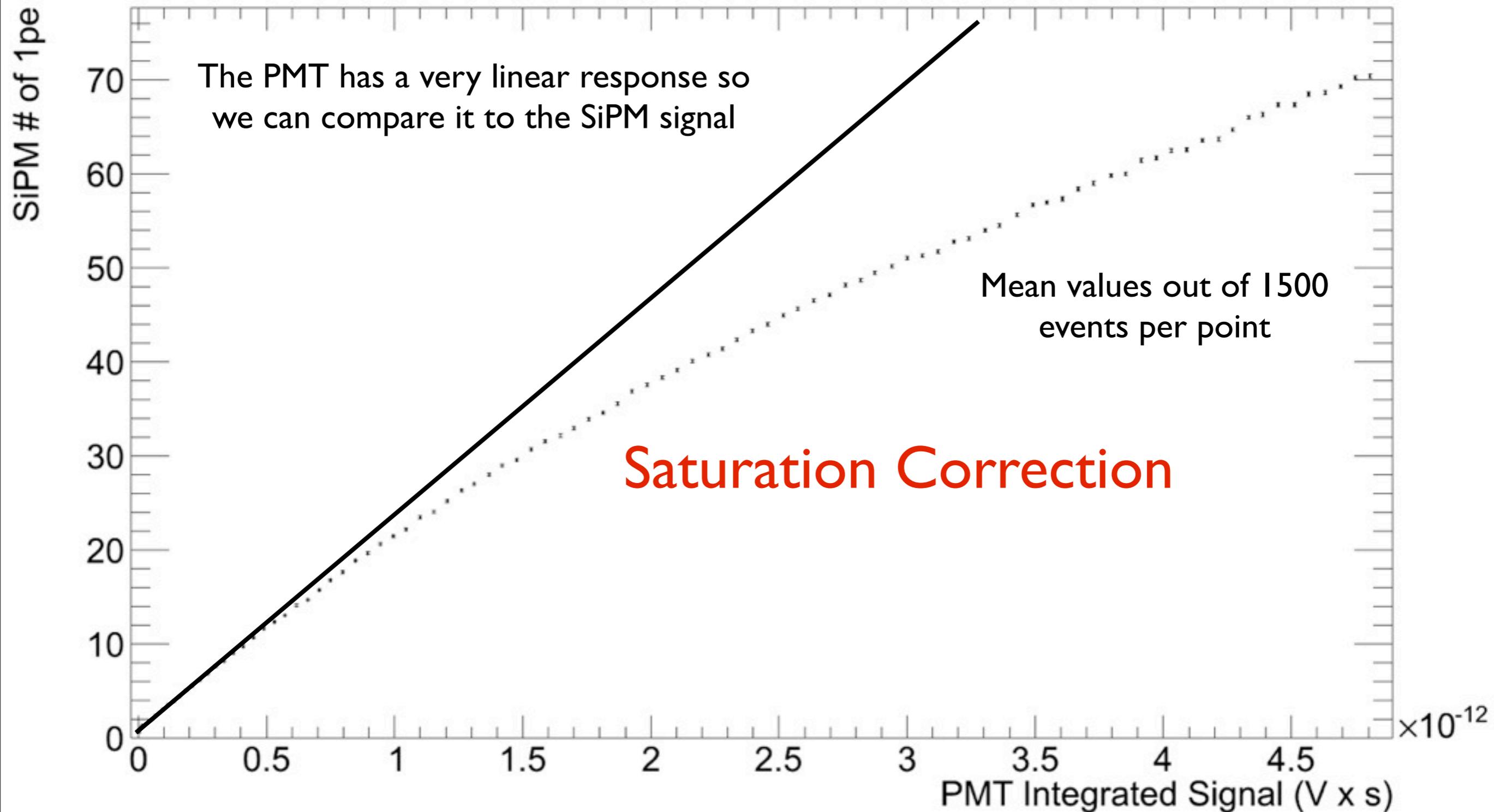
Saturation

Pmt vs SiPM



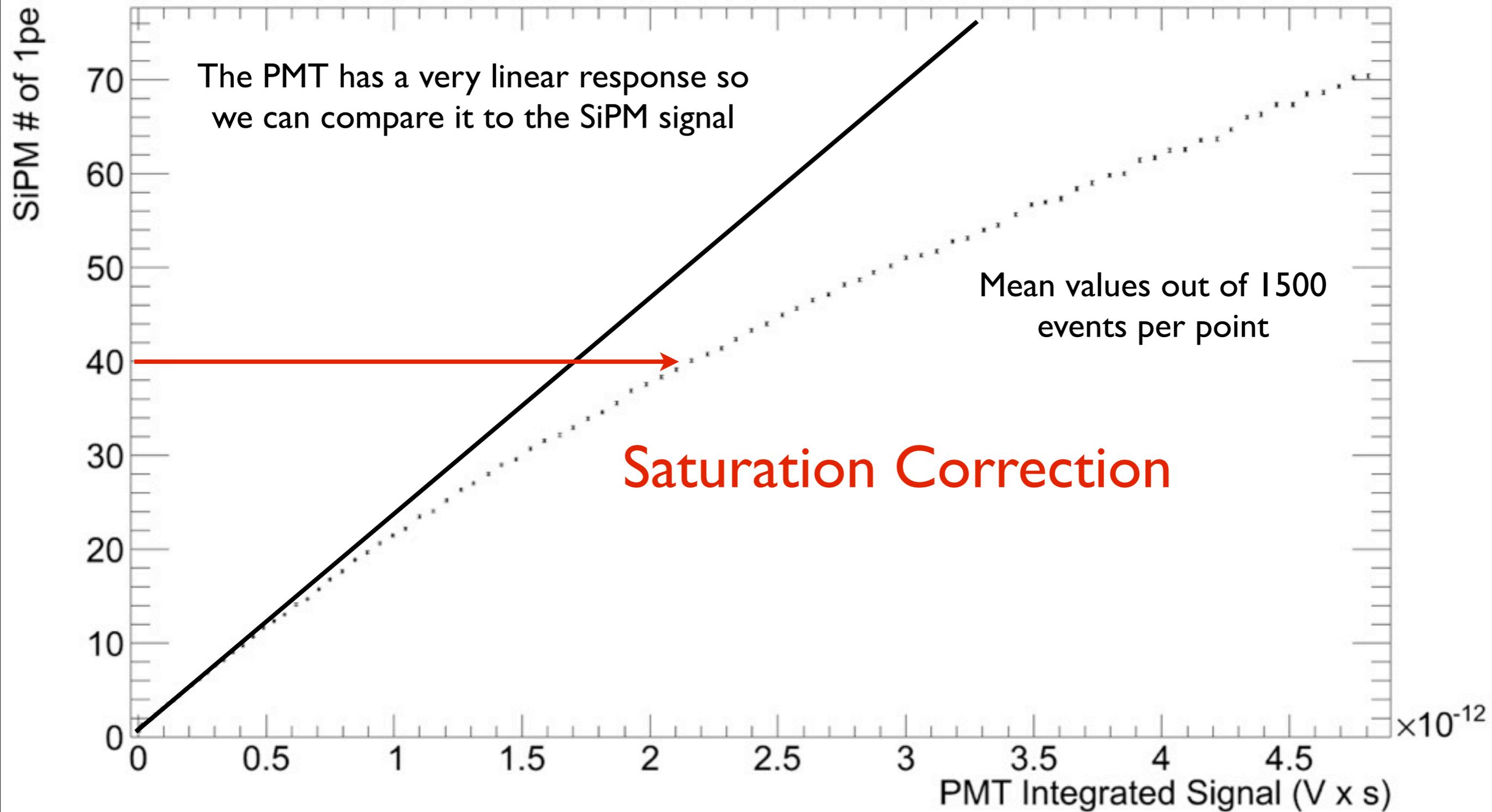
Saturation

Pmt vs SiPM



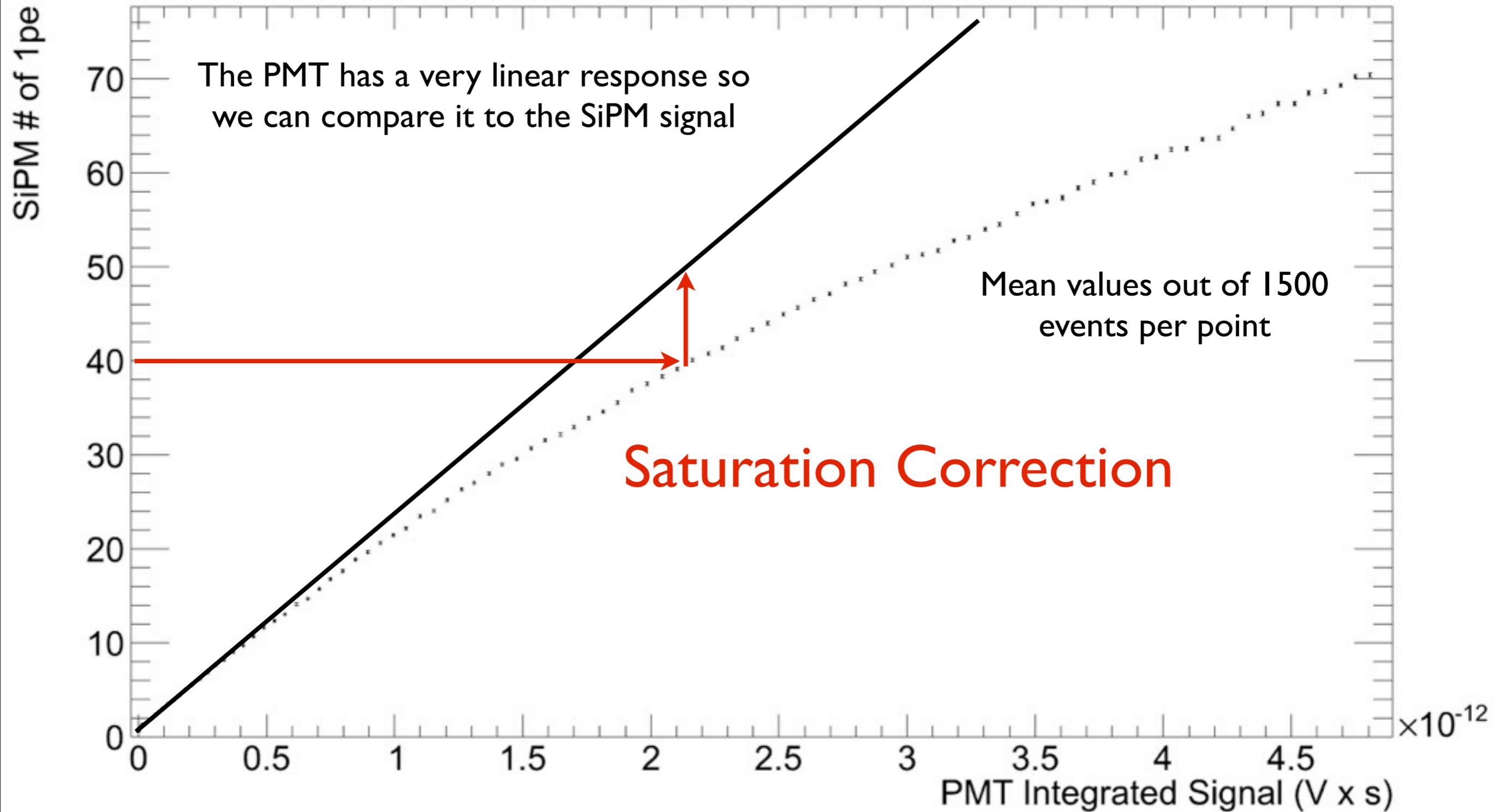
Saturation

Pmt vs SiPM



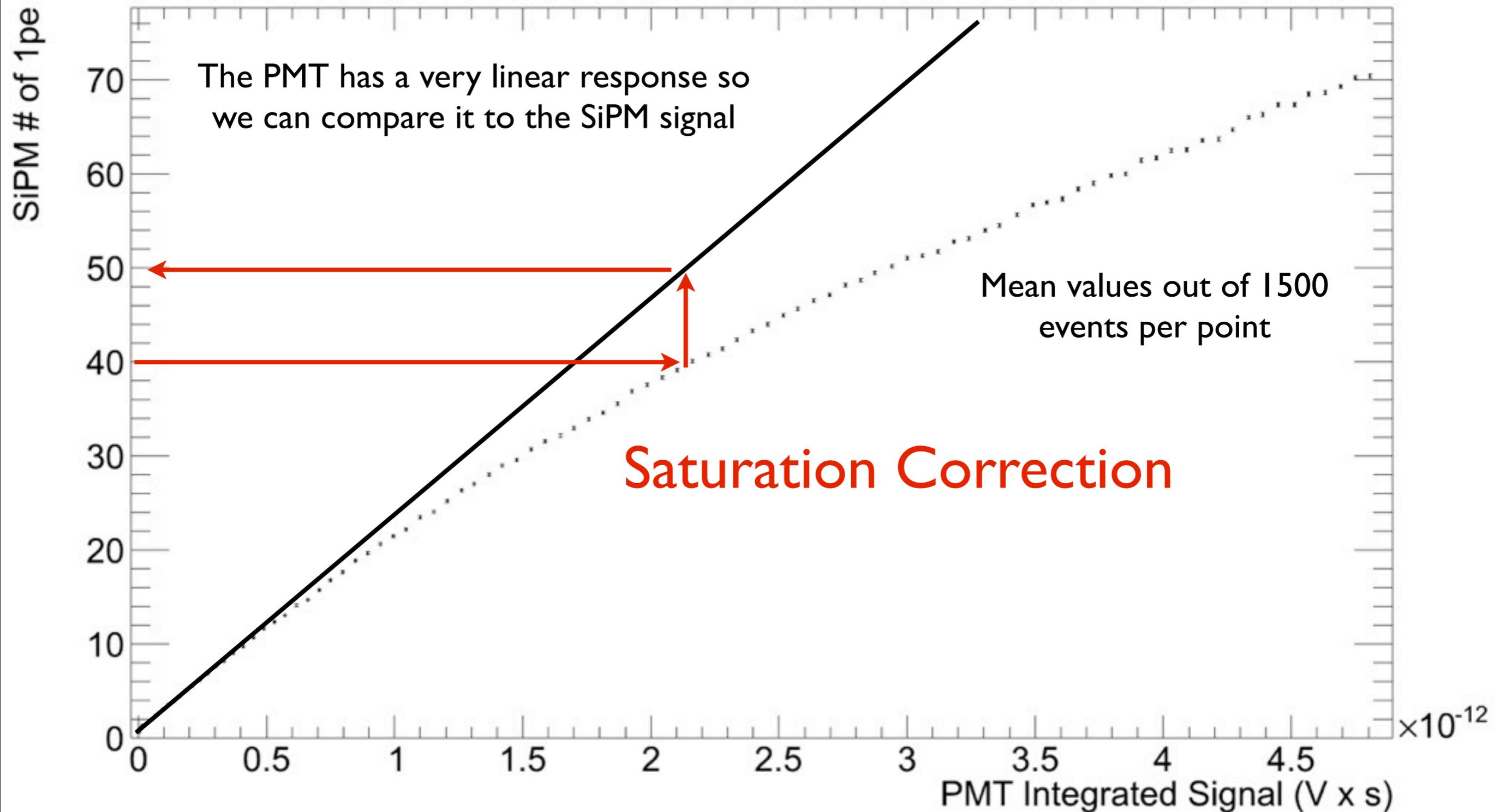
Saturation

Pmt vs SiPM



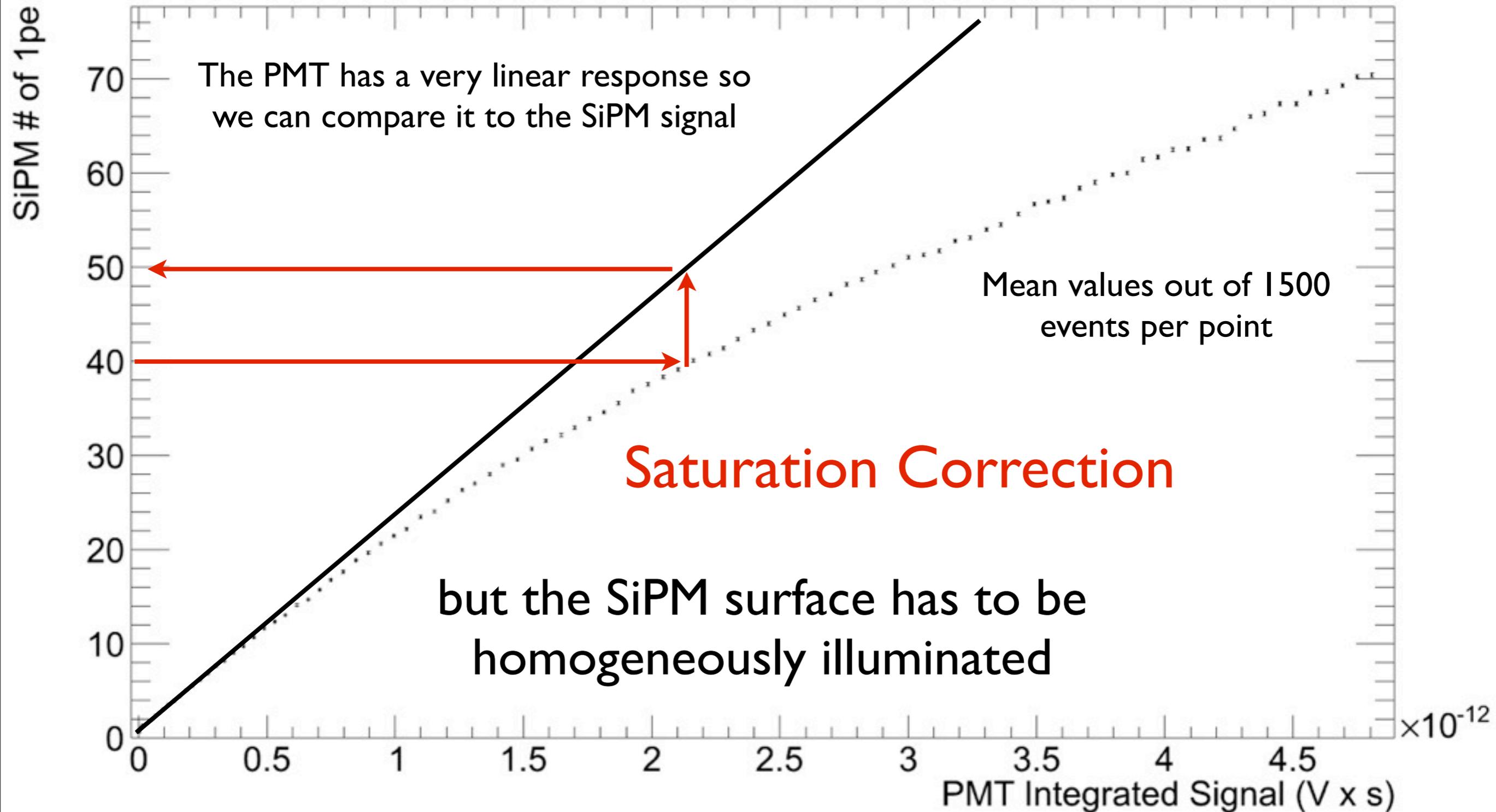
Saturation

Pmt vs SiPM

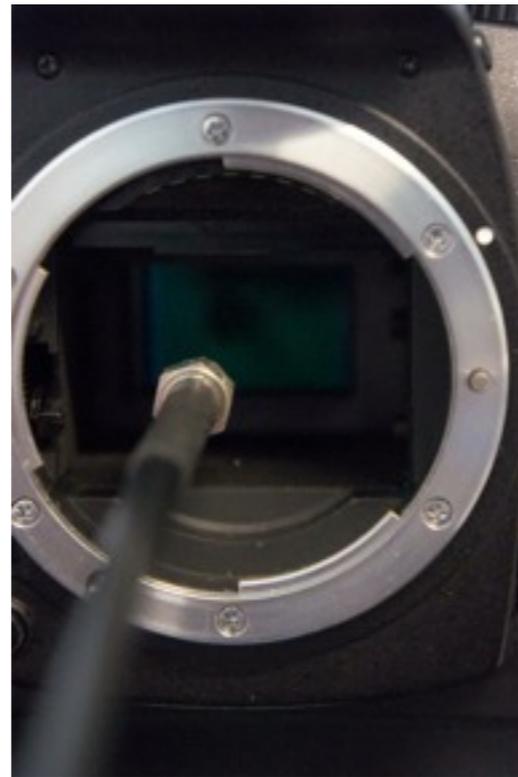


Saturation

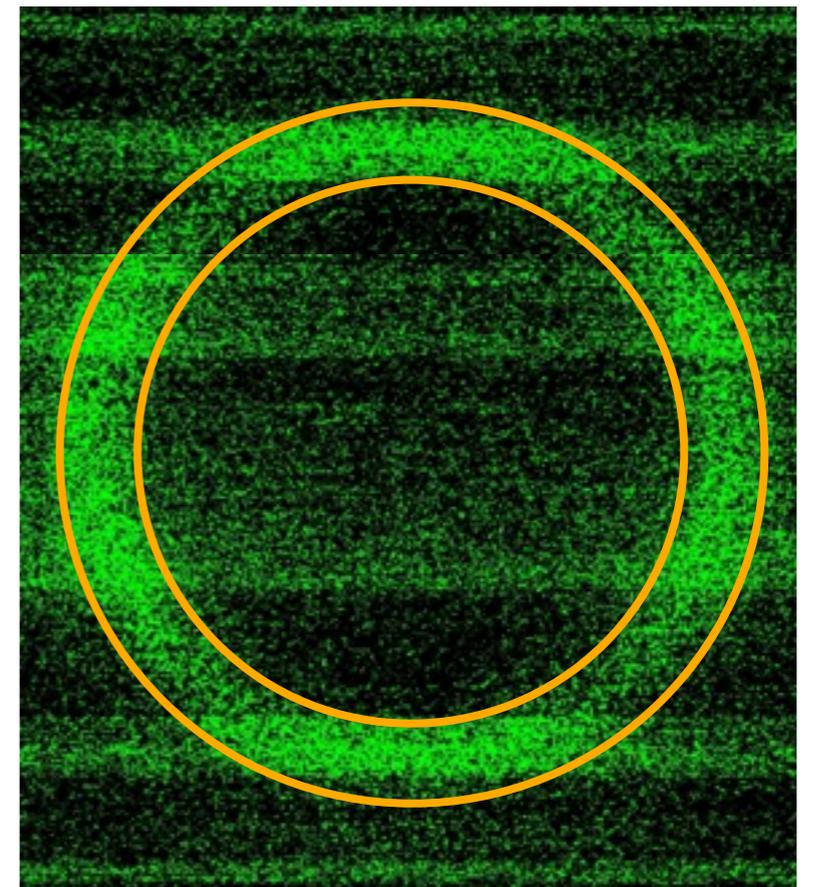
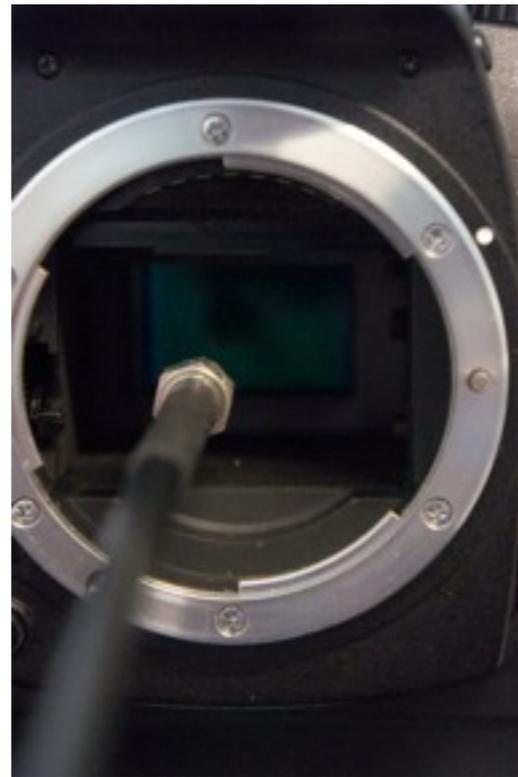
Pmt vs SiPM



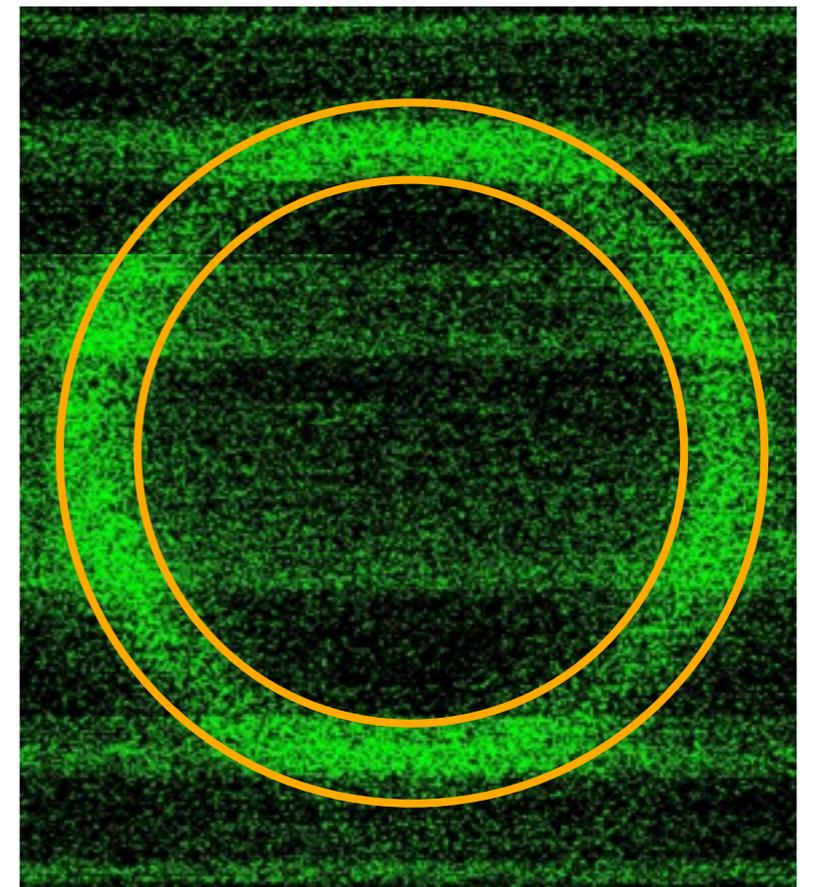
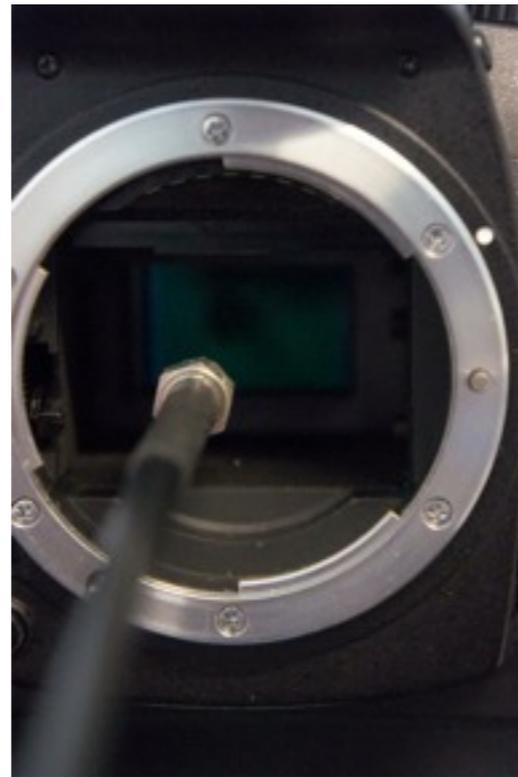
Light Homogeneity



Light Homogeneity

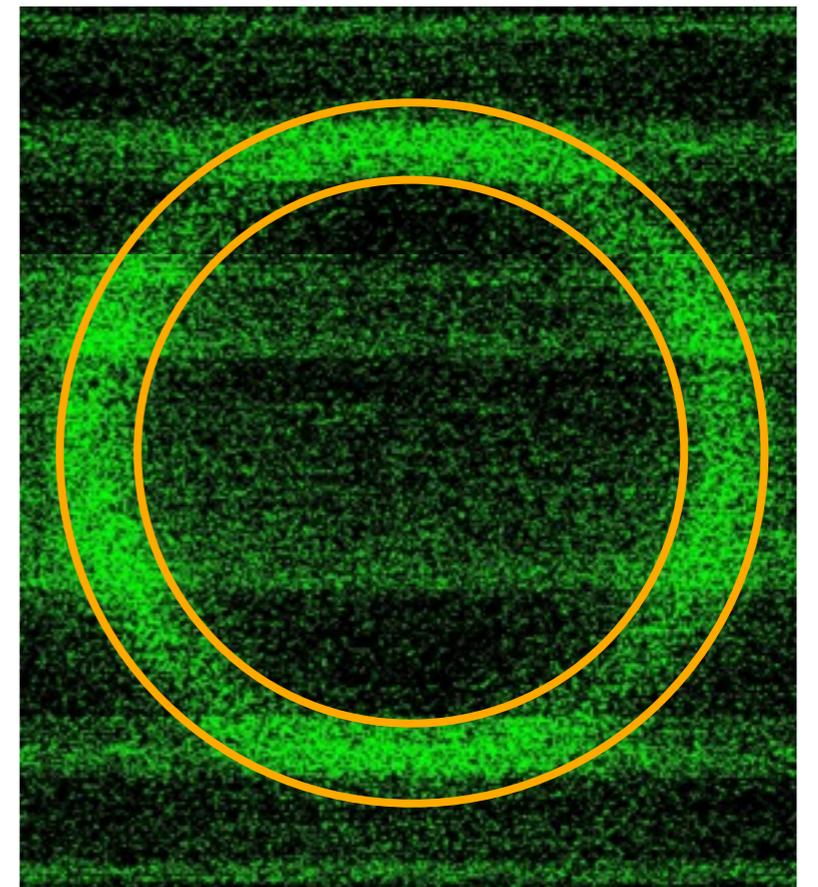
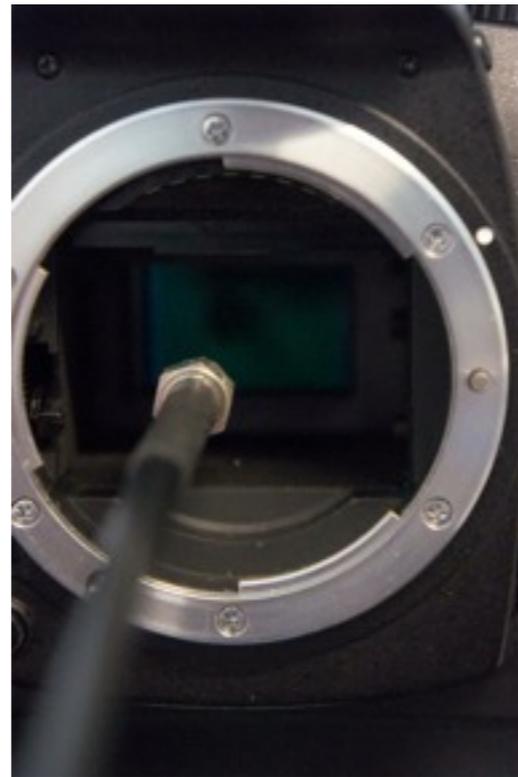
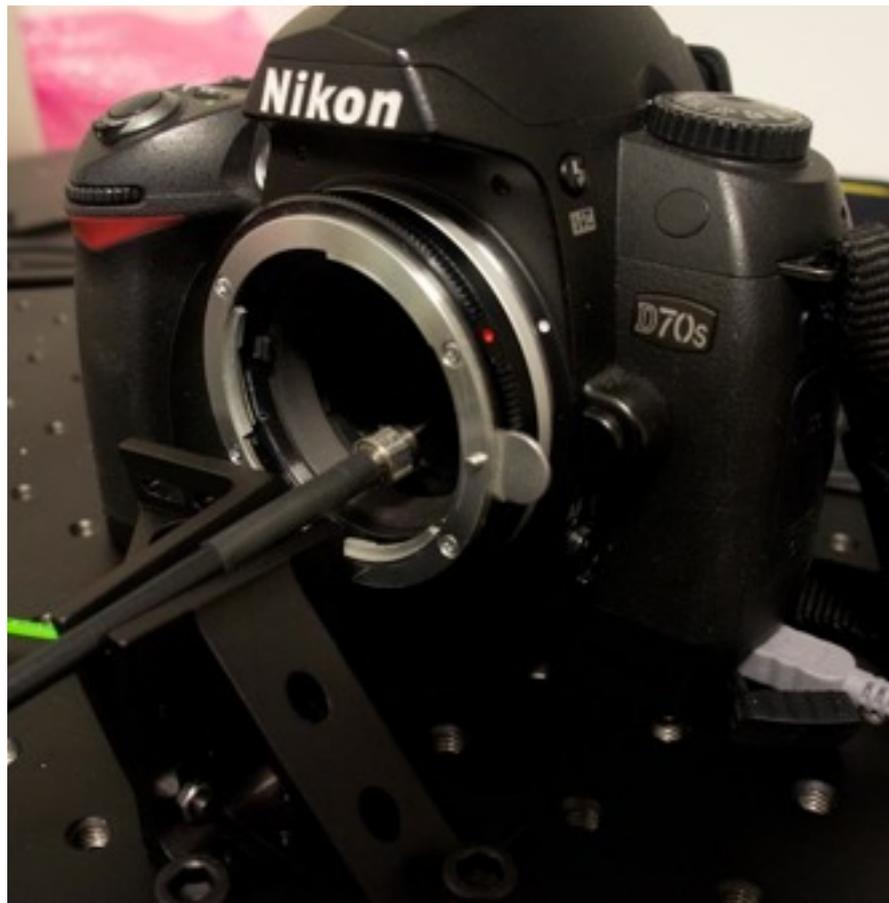


Light Homogeneity



The light emitted from the fibers is not homogeneous!

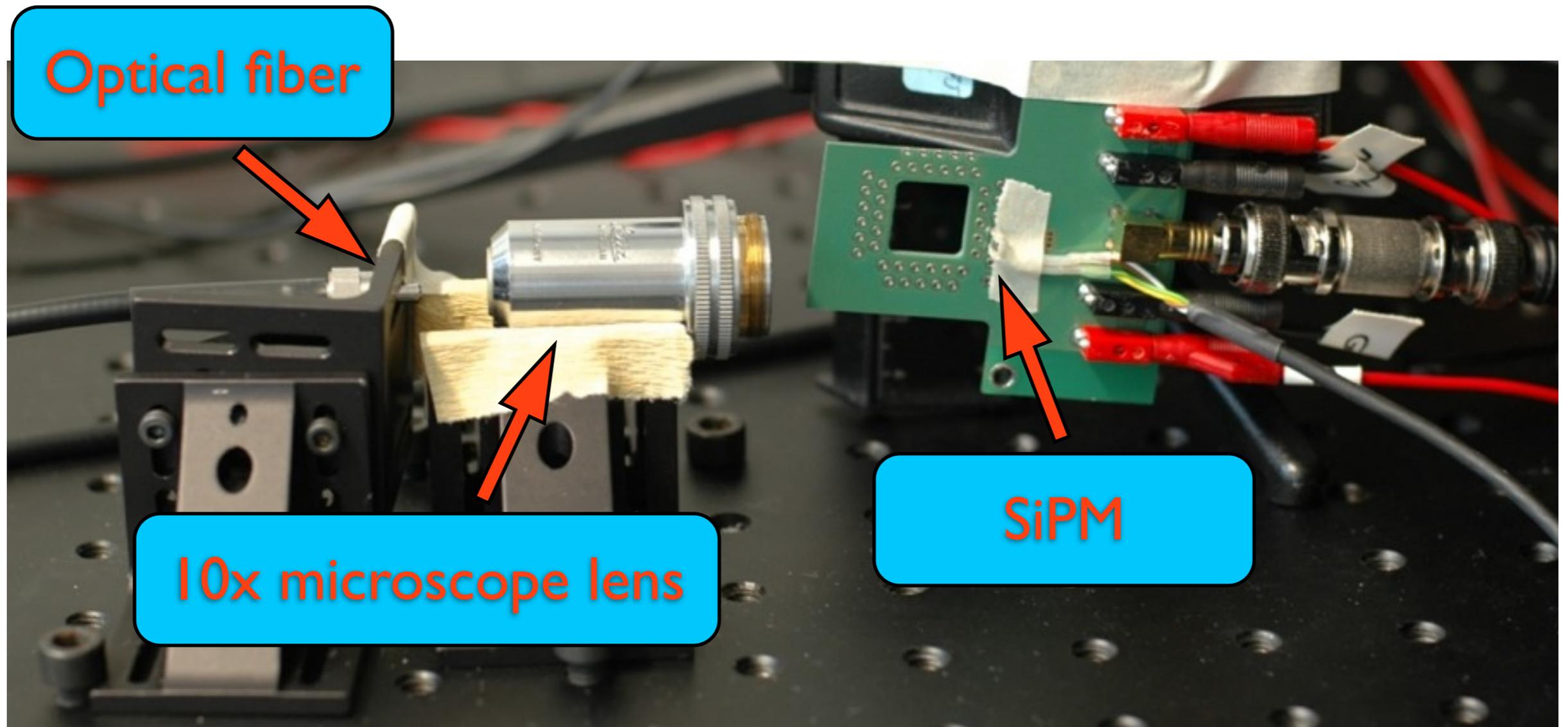
Light Homogeneity



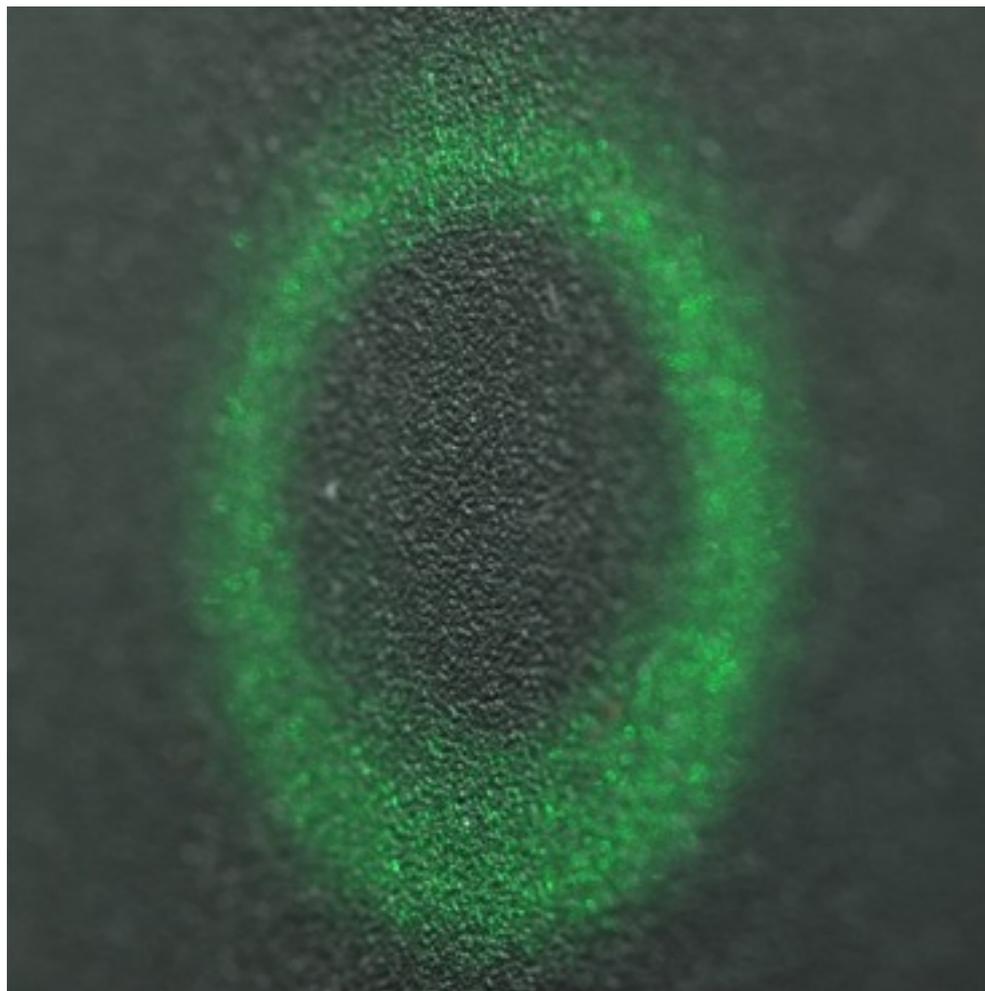
The light emitted from the fibers is not homogeneous!

We need a way to cancel out the ring pattern and get an homogeneous light distribution.

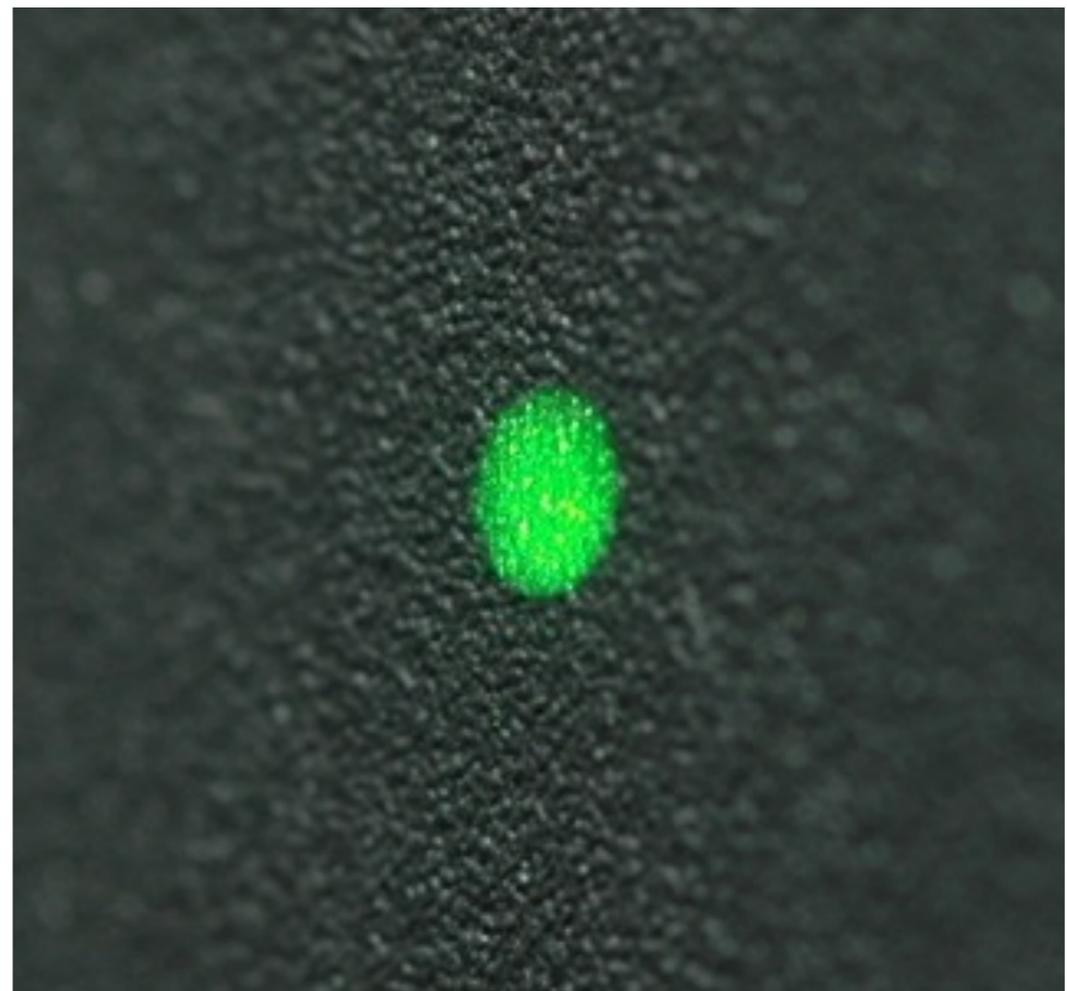
Light Homogeneity 2



Light Homogeneity 3

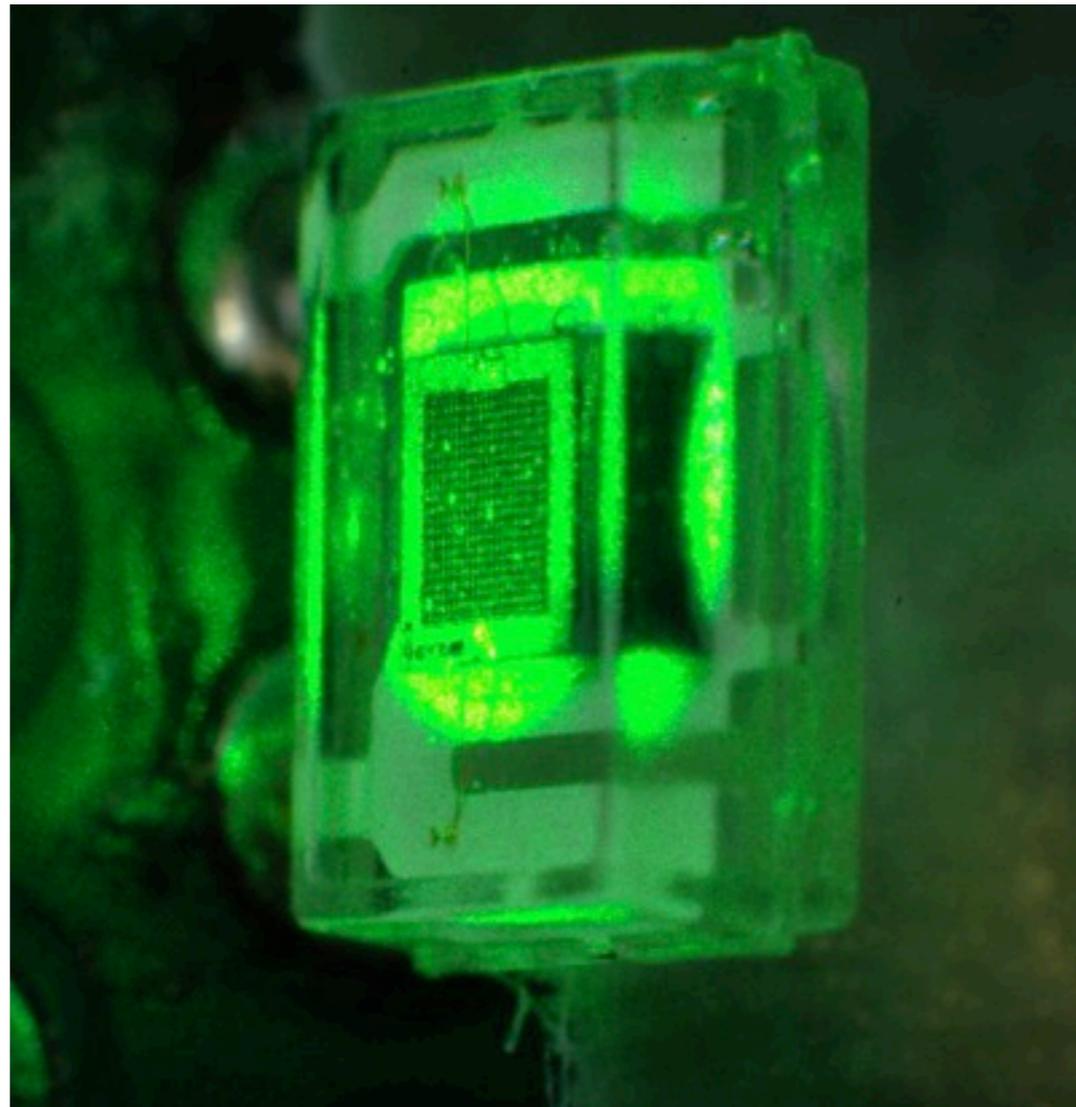


Without Lens

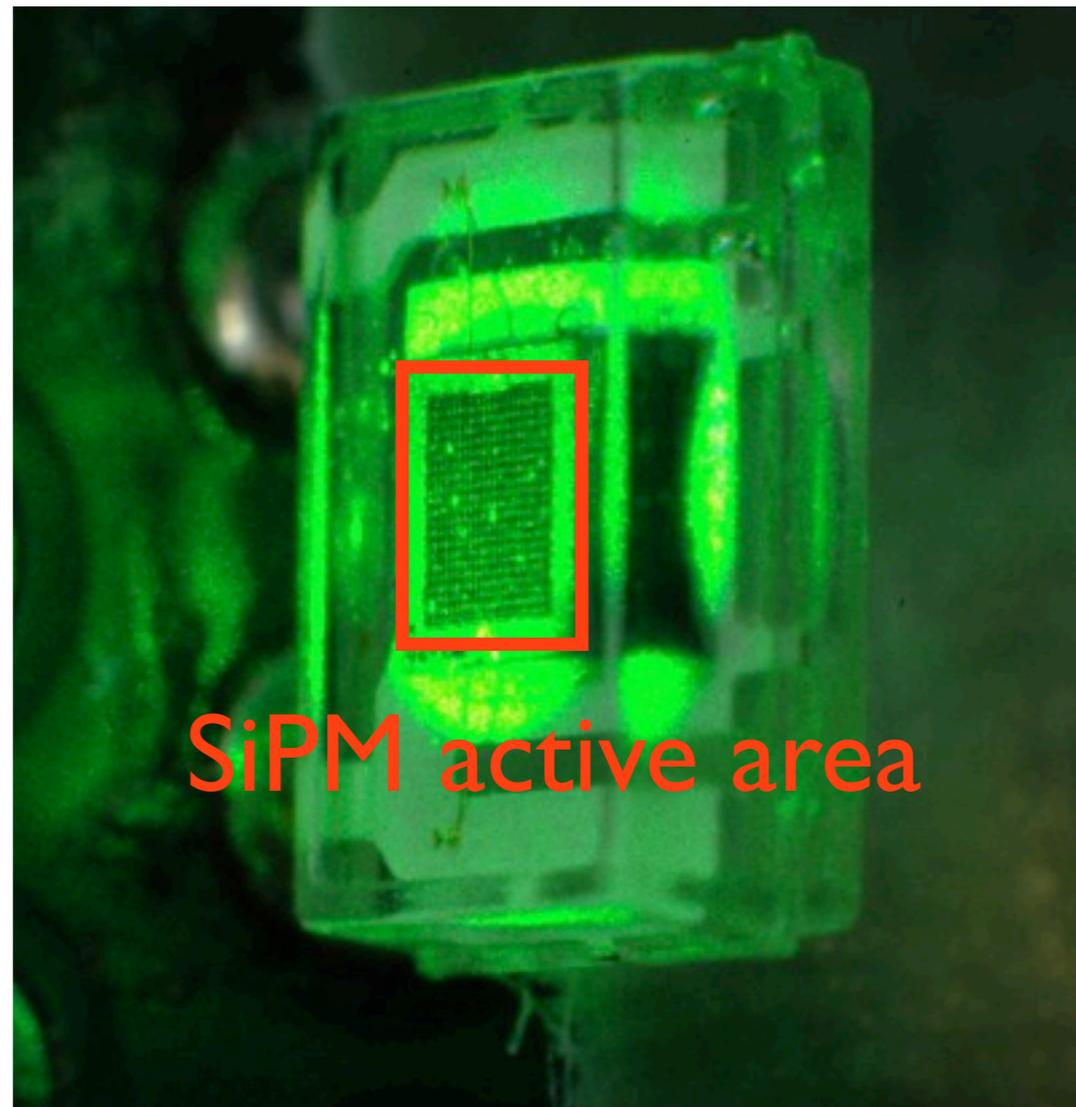


With Lens

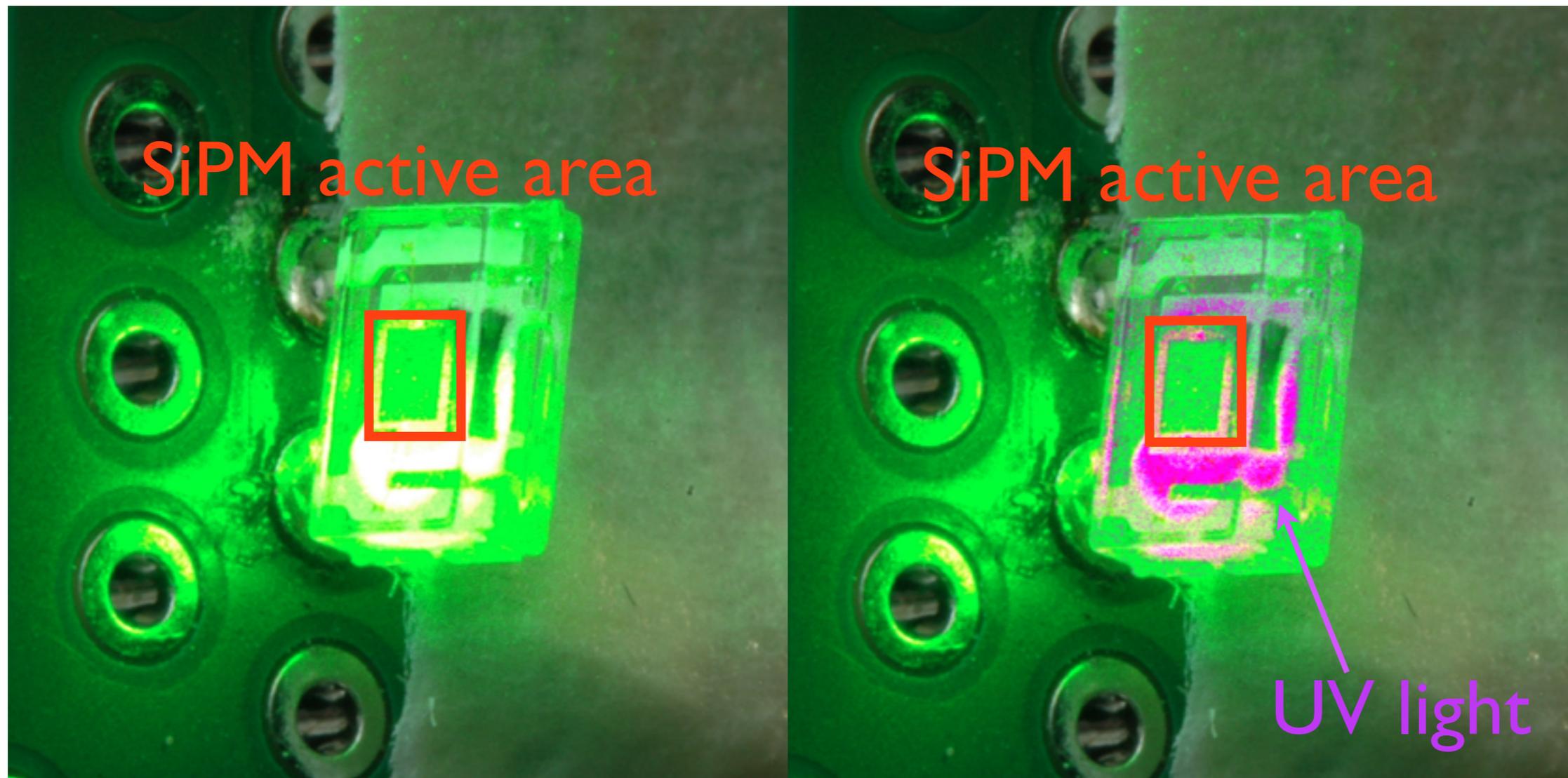
Light Homogeneity 4



Light Homogeneity 4

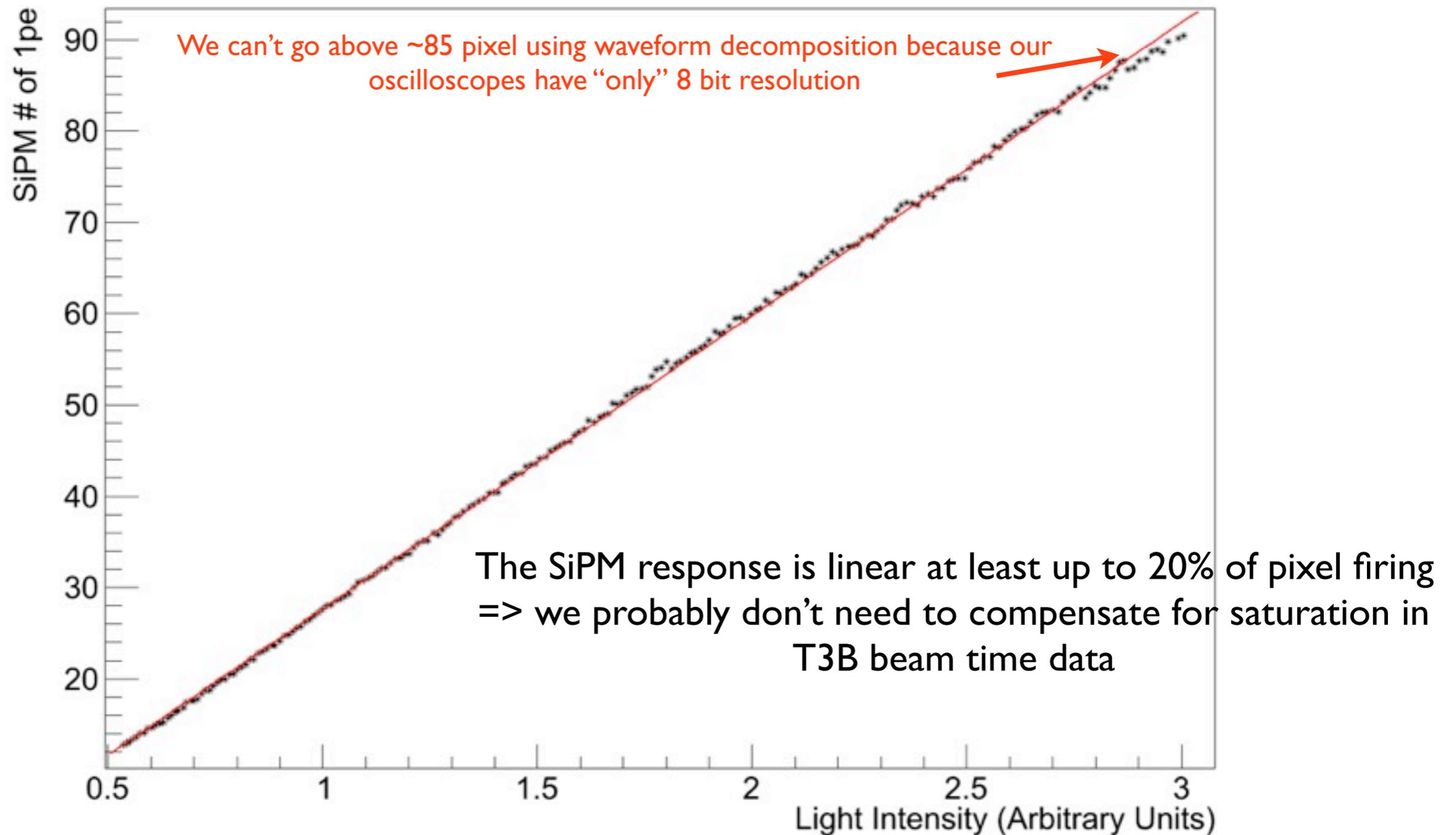


Light Homogeneity 4

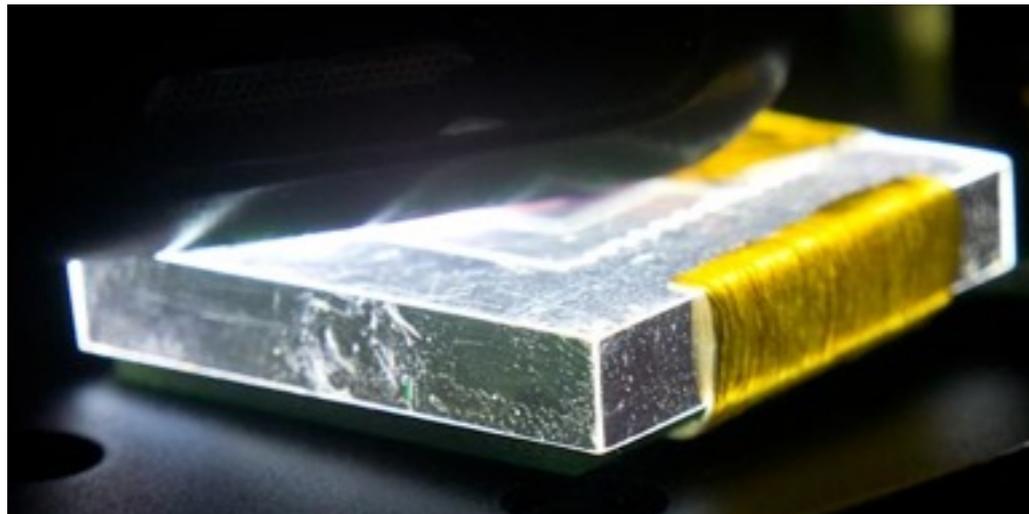


Saturation 2

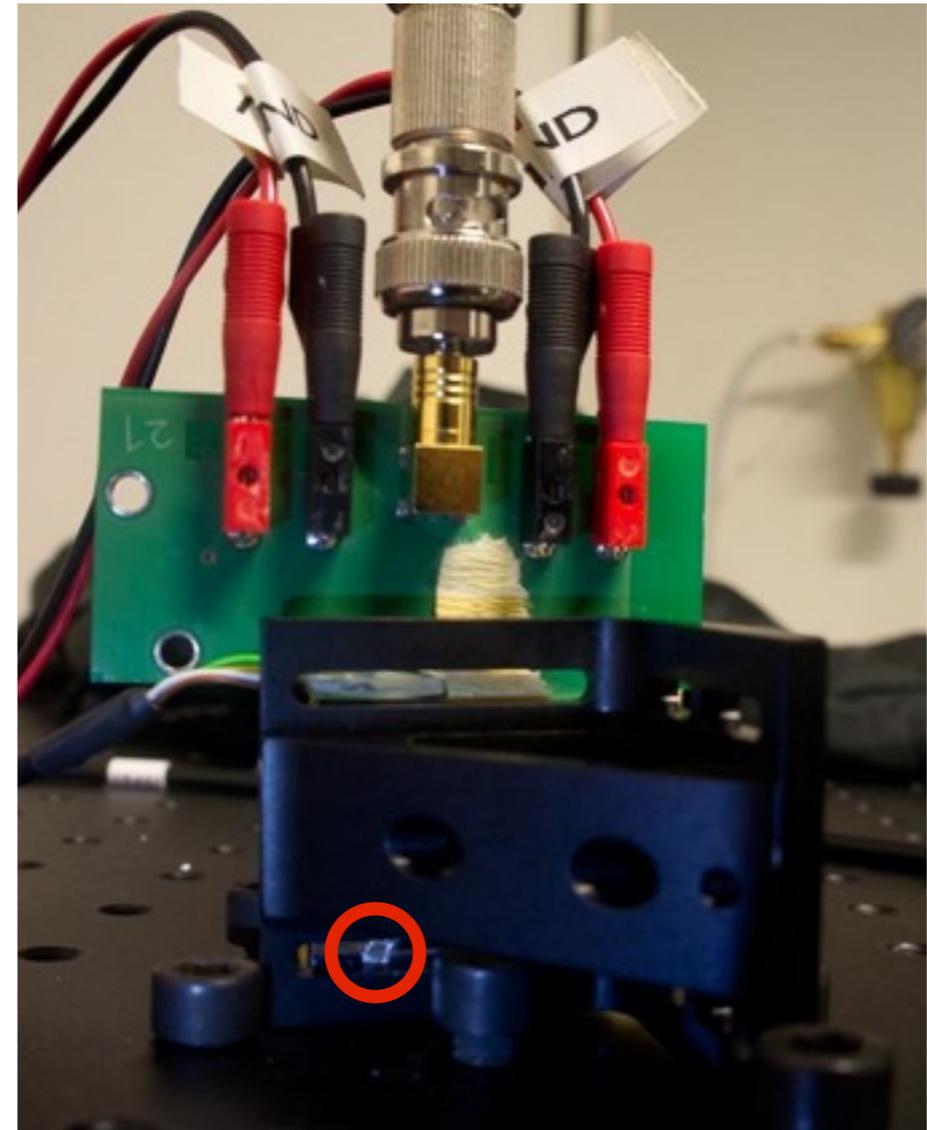
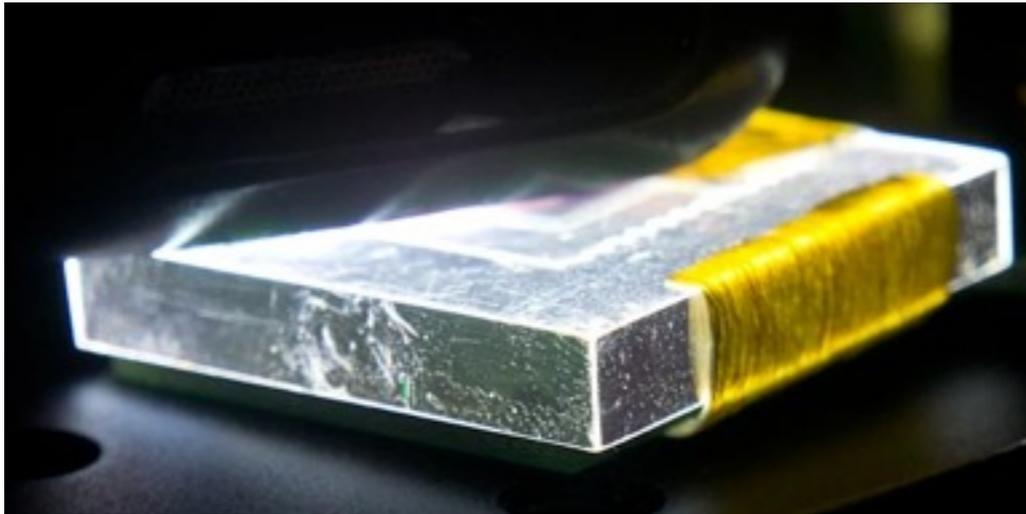
SiPM vs Light Intensity



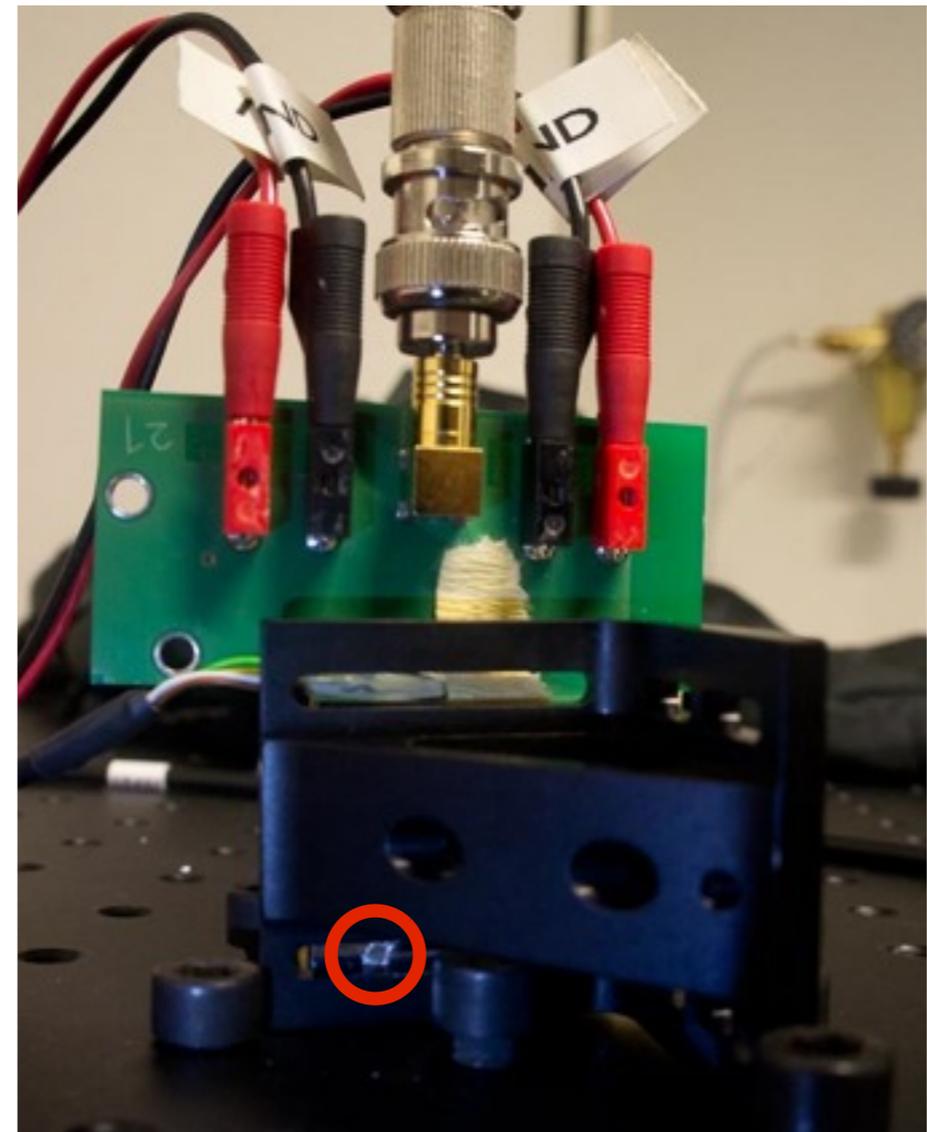
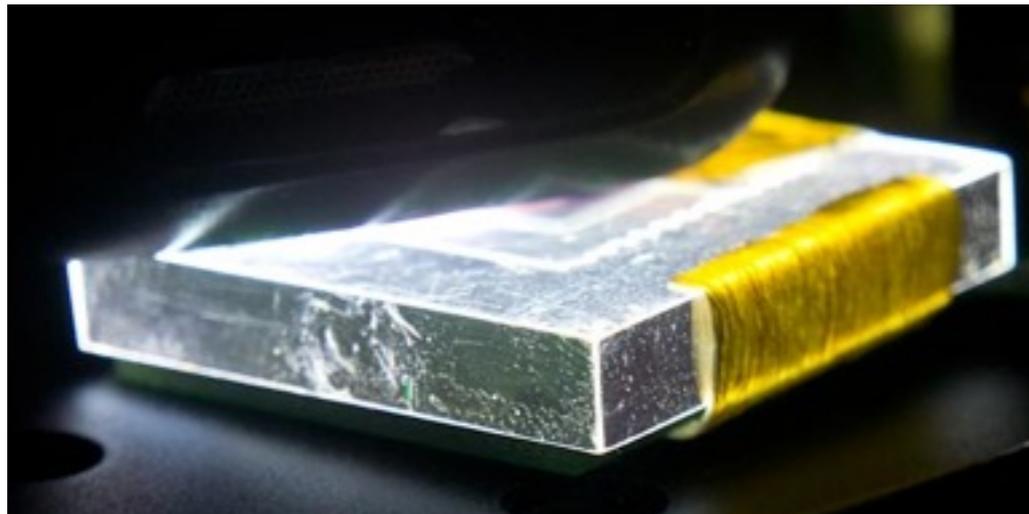
Coupling a T3B Tile



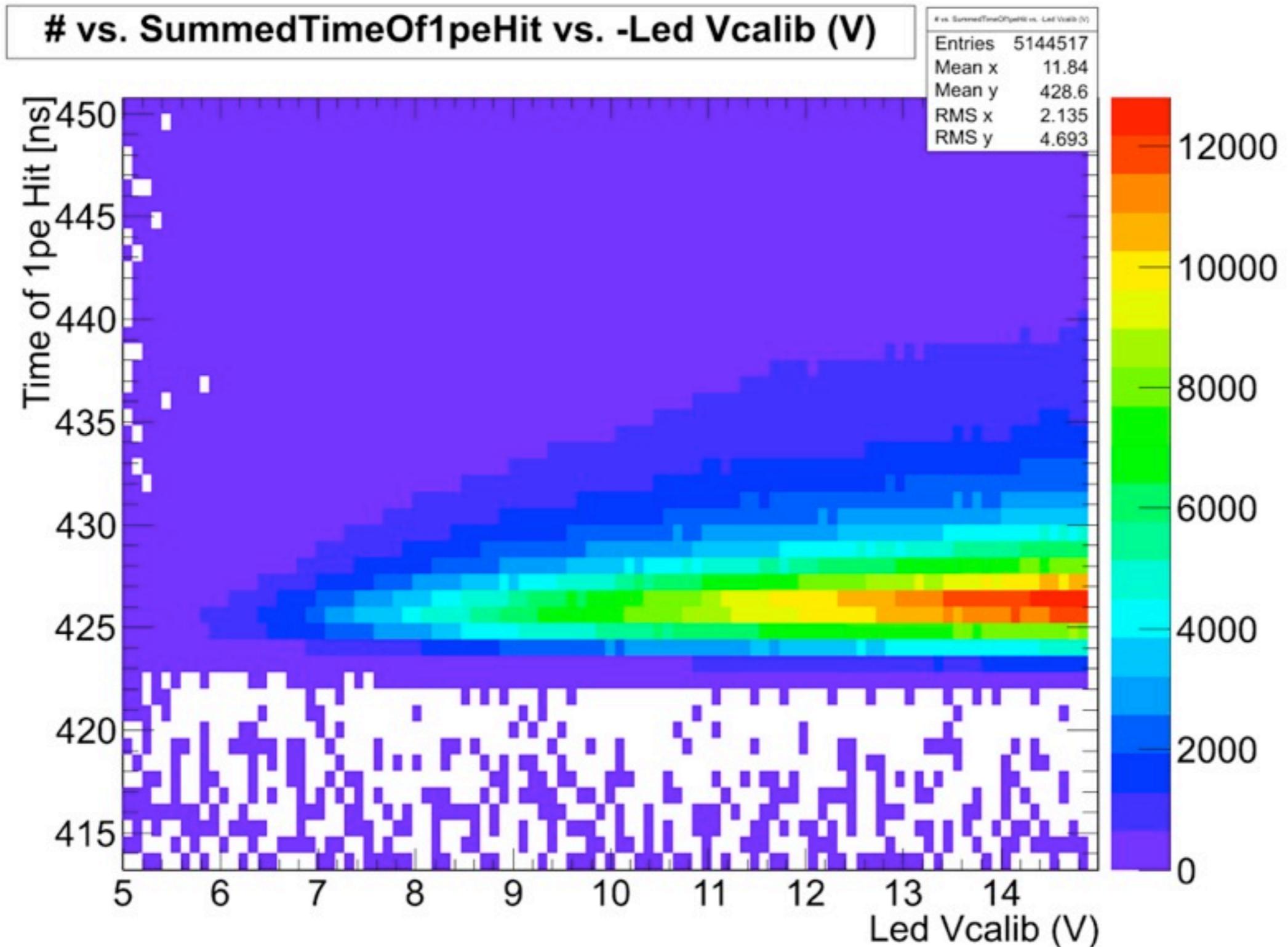
Coupling a T3B Tile



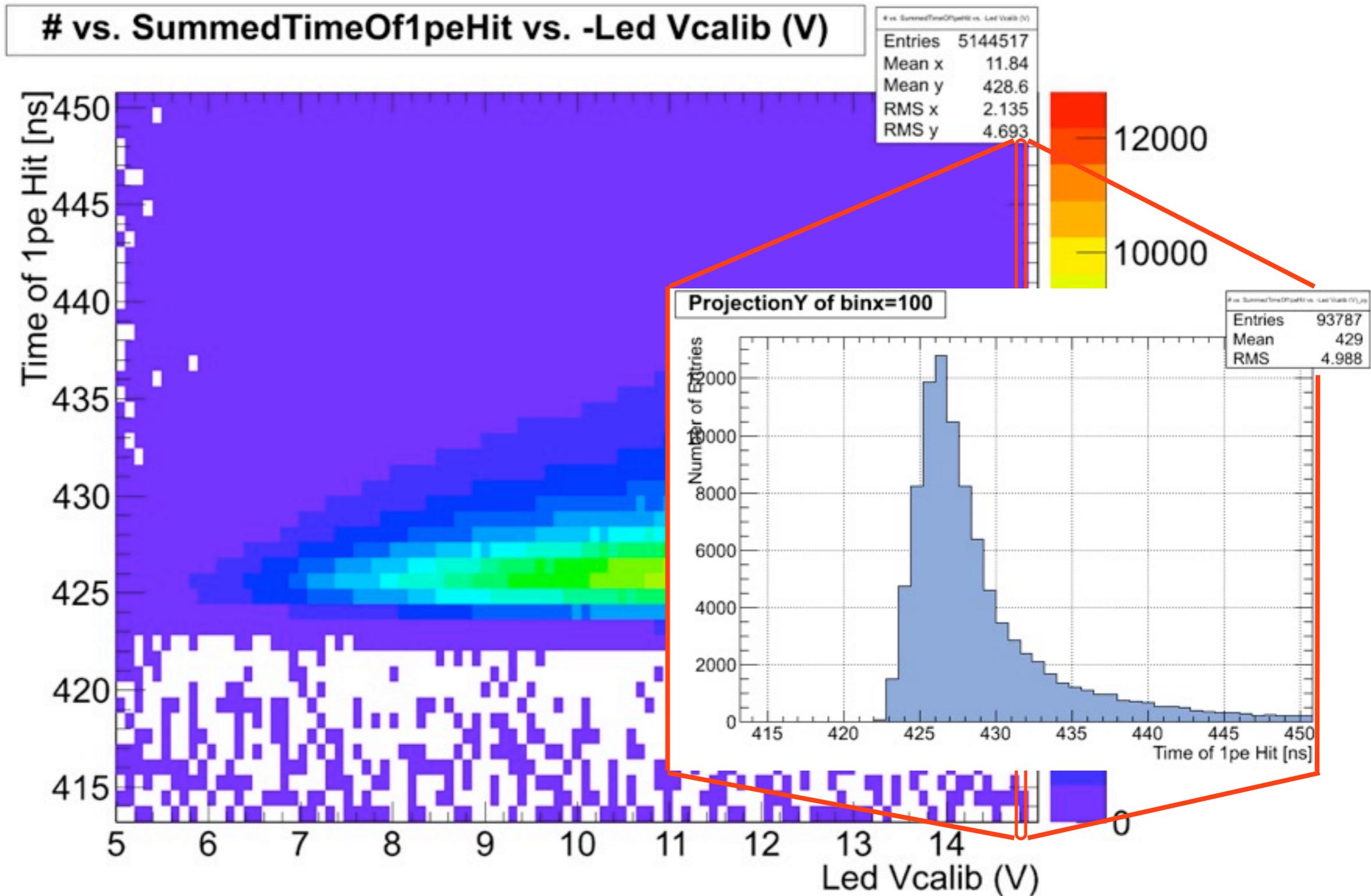
Coupling a T3B Tile



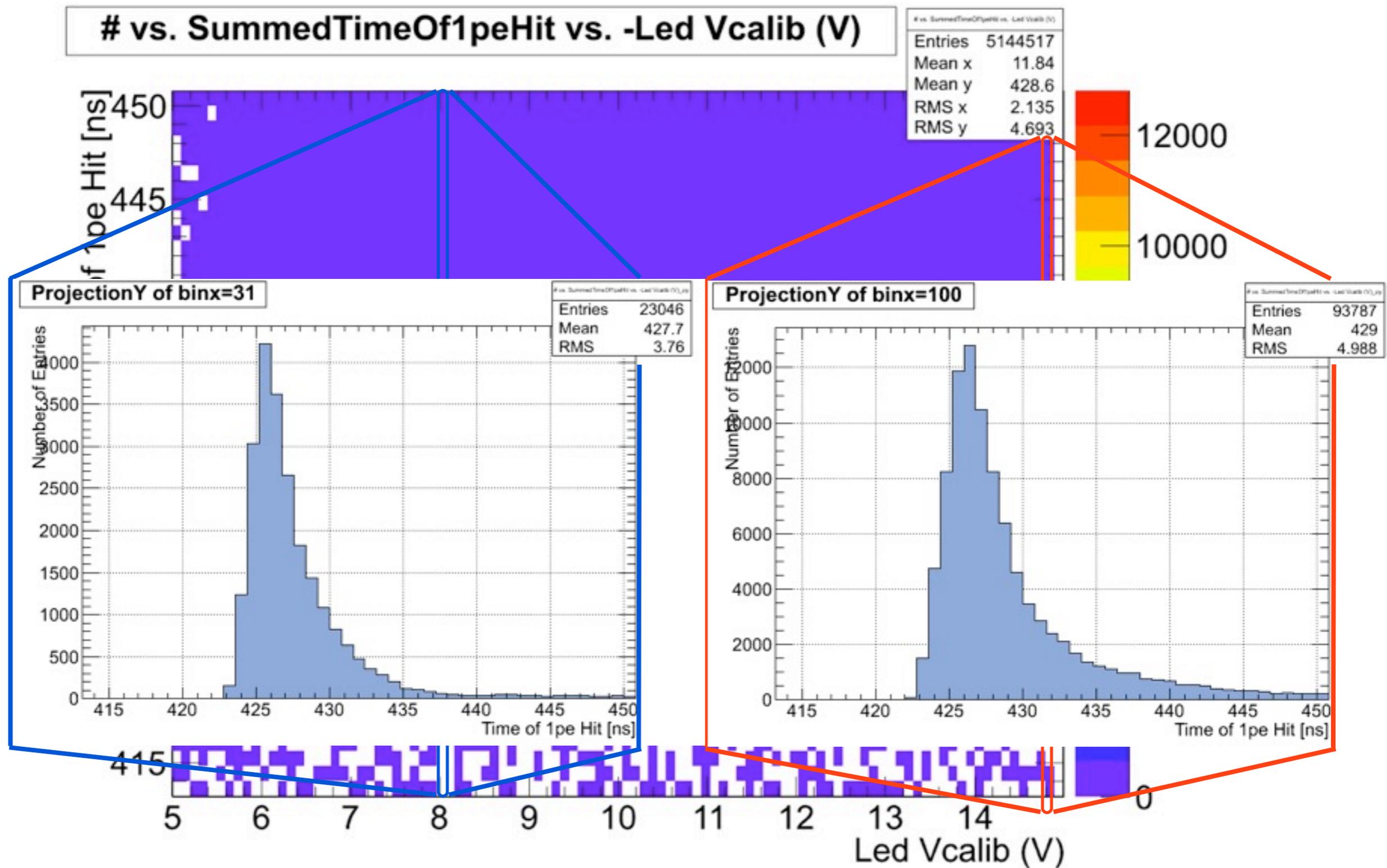
Time Distribution - No Tile



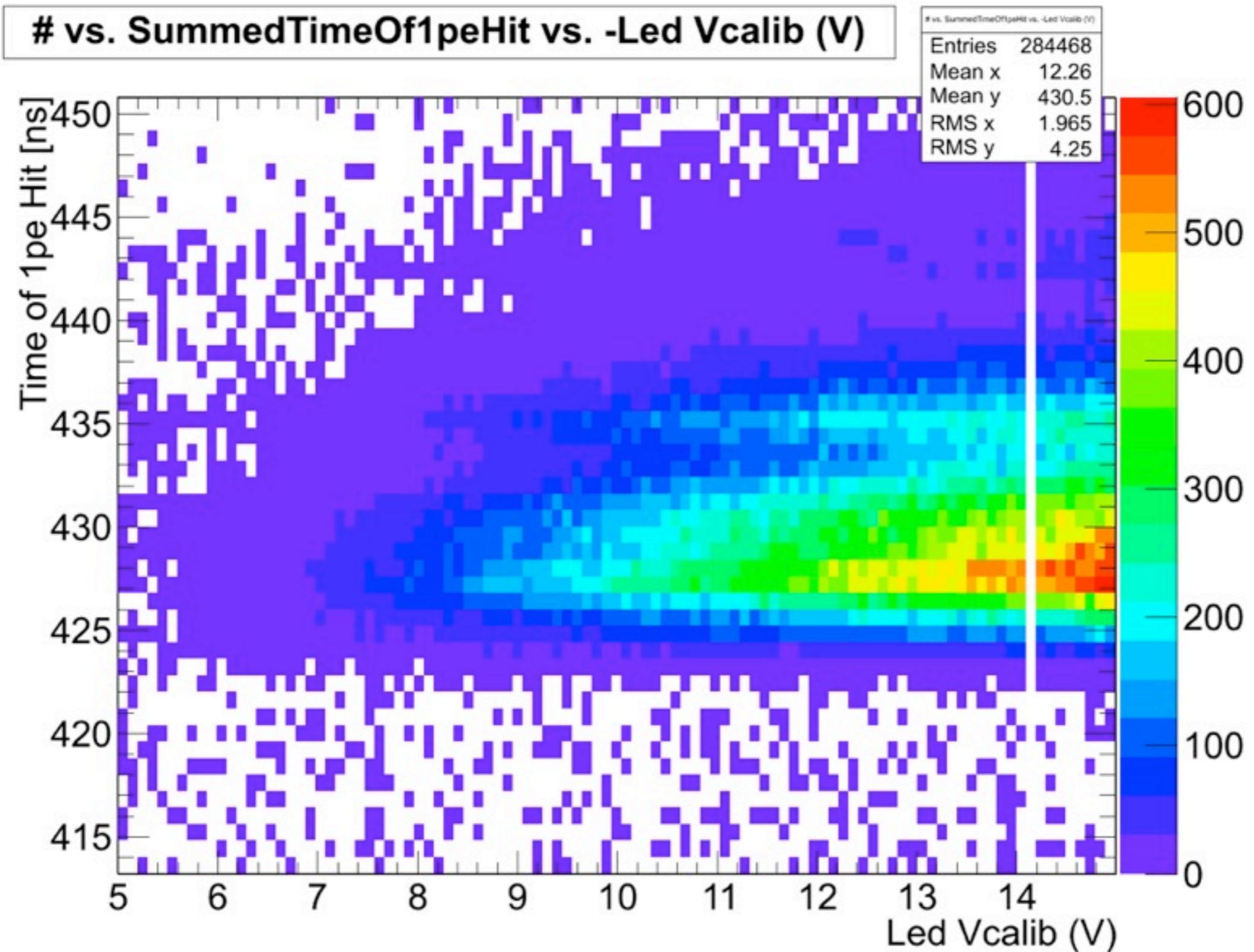
Time Distribution - No Tile



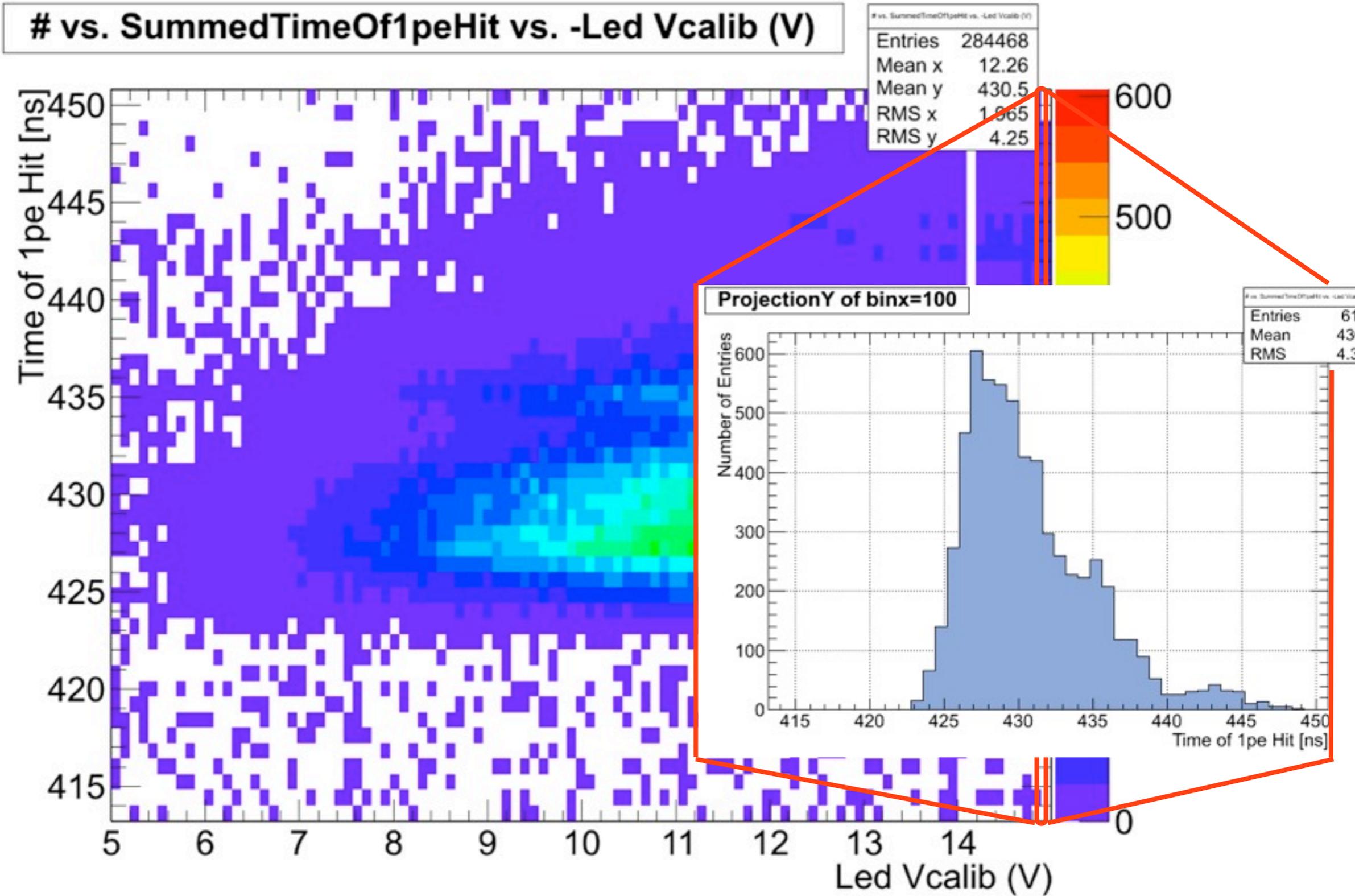
Time Distribution - No Tile



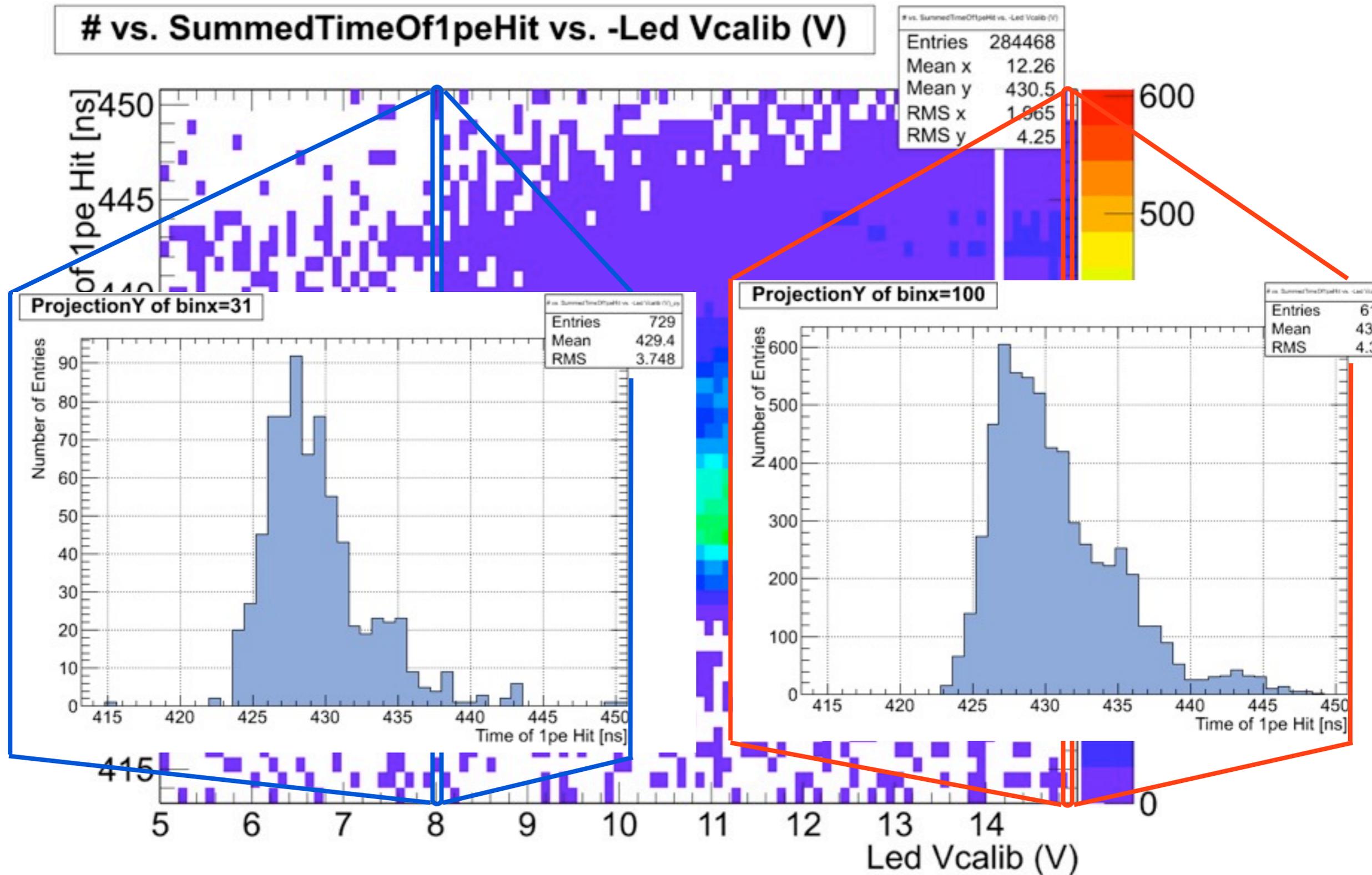
Time Distribution - With Tile



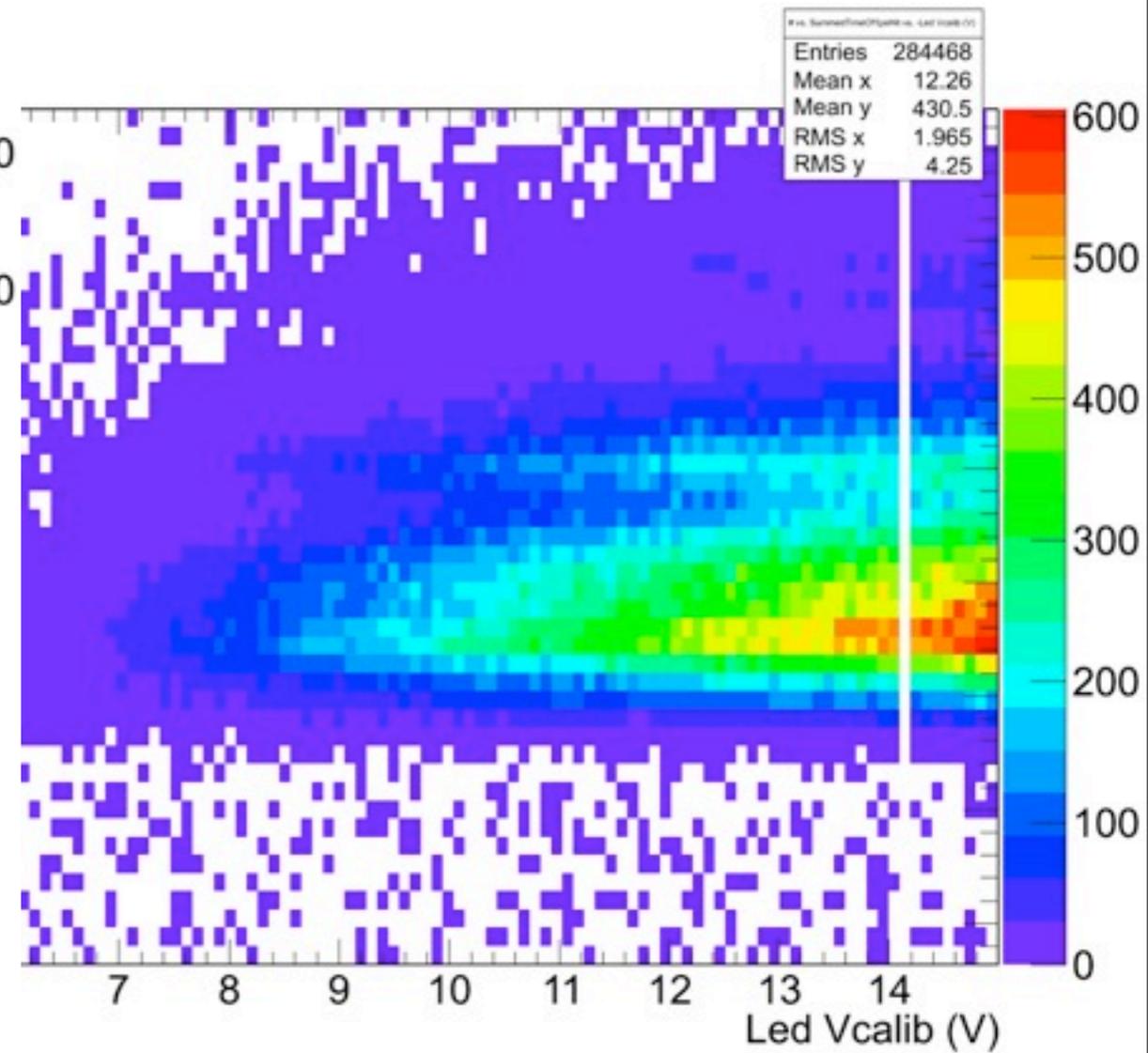
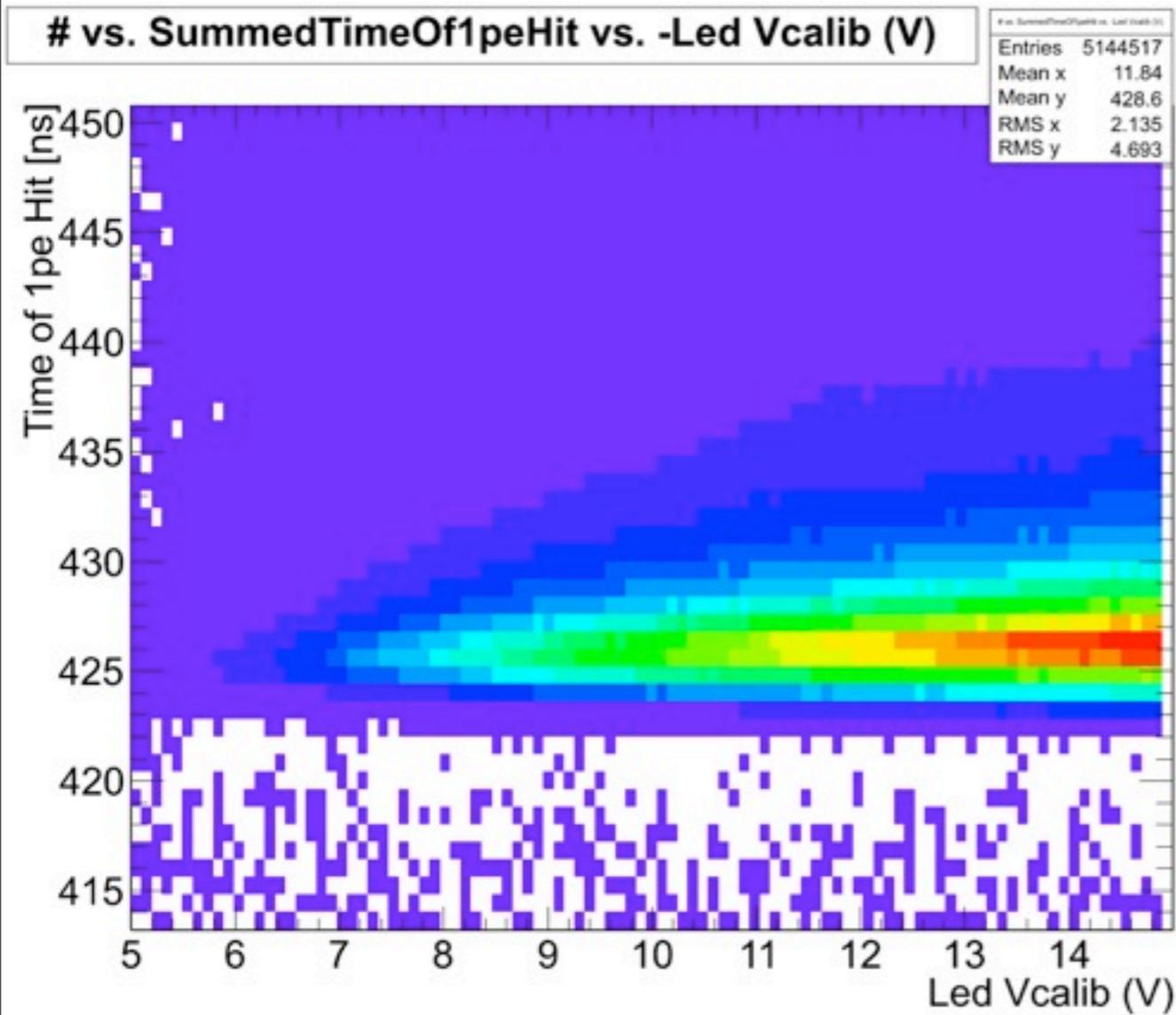
Time Distribution - With Tile



Time Distribution - With Tile



Comparison



Without Tile

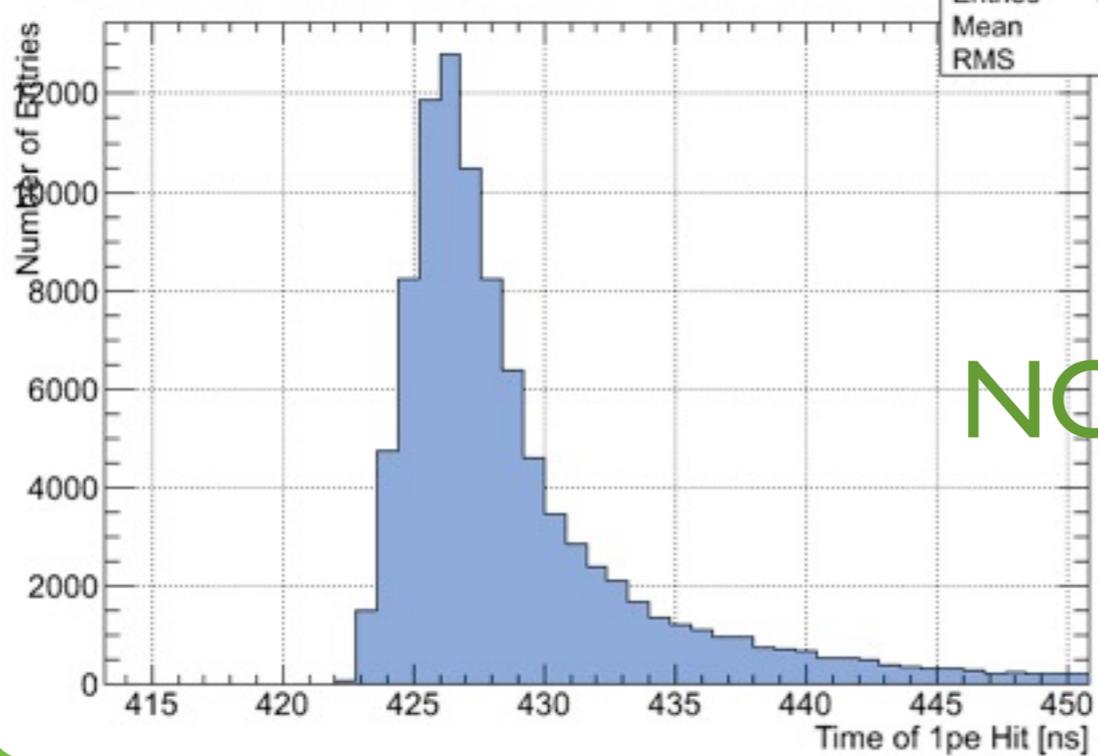
With Tile

na

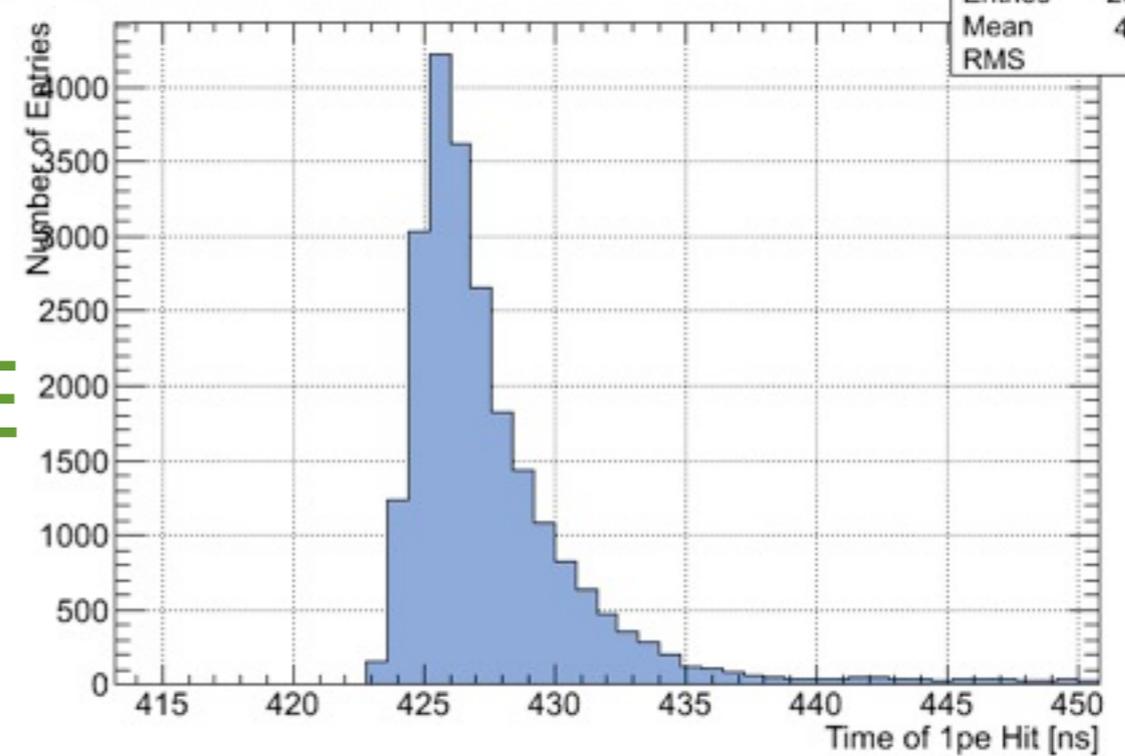
NO TILE

WITH TILE

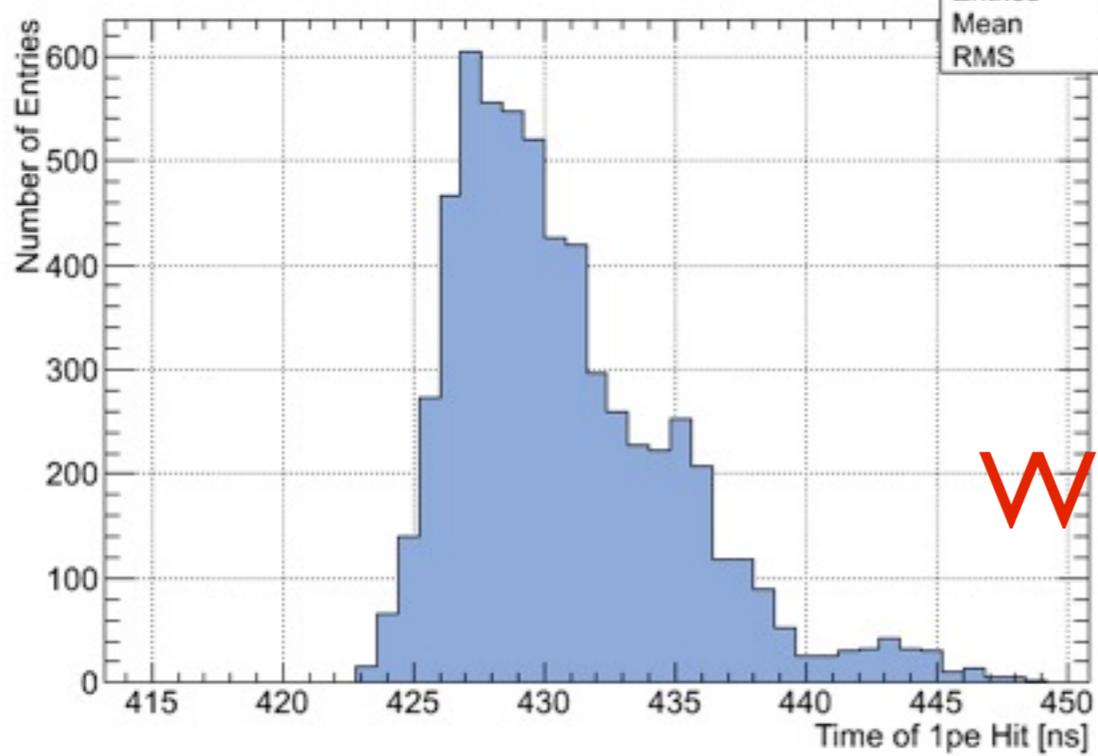
ProjectionY of binx=100



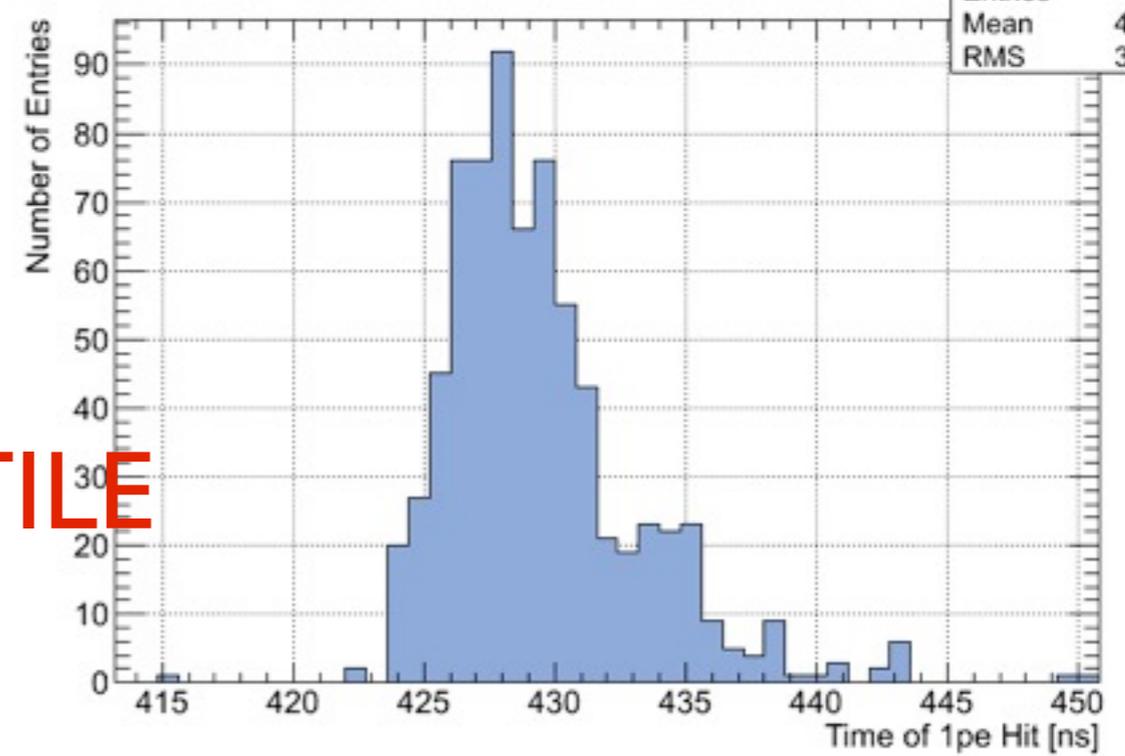
ProjectionY of binx=31



ProjectionY of binx=101



ProjectionY of binx=31



High Light Intensity

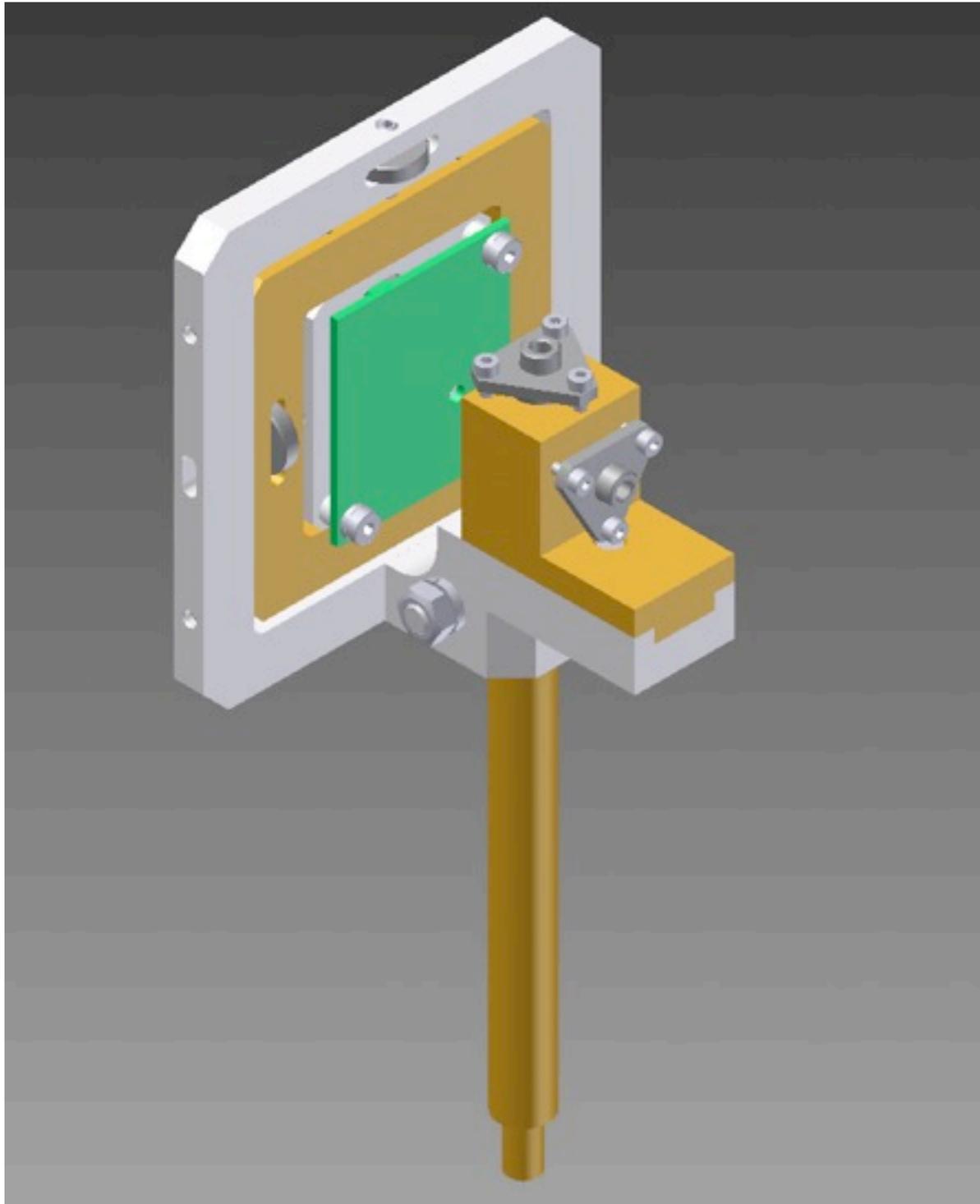
Low Light Intensity

Steps for the Future

- Improve the saturation curves to an higher number of pixel firing (probably using the integral of the raw waveform as a complement to the waveform decomposition algorithm)
- Investigate in depth late components like e.g. afterpulses, normalizing the SiPM signal with the PMT signal
- Compare the LED results with the muon data taken from T3B during beam time

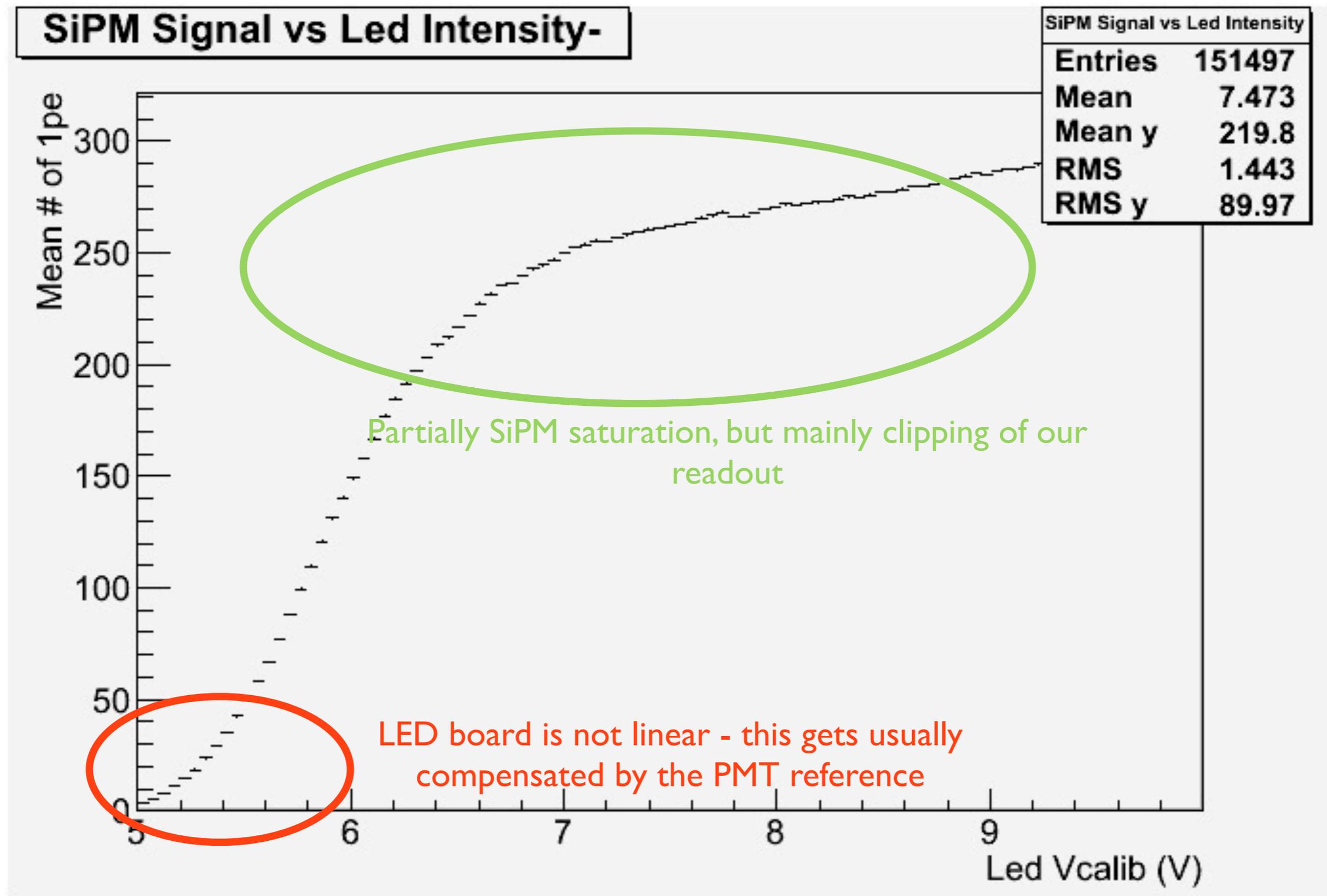
Backup

Light Splitter



- Precise alignment
- Tilting capability to get rid of some strange reflections in the fibers
- Easier reproducibility of the runs
- ETA: early march

Clipping



Clipping 2

