Status on time resolution

Suyu Xiao from IHEP

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Time resolution by macro Q_getReso.py

https://gitlab.cern.ch/atlas-hgtd/TestBeam/PyAna/blob/master/Macros/Q_getResoExample.py

- Two 3*3 matrix needed
  - One for sigma
  - Another for sigma error

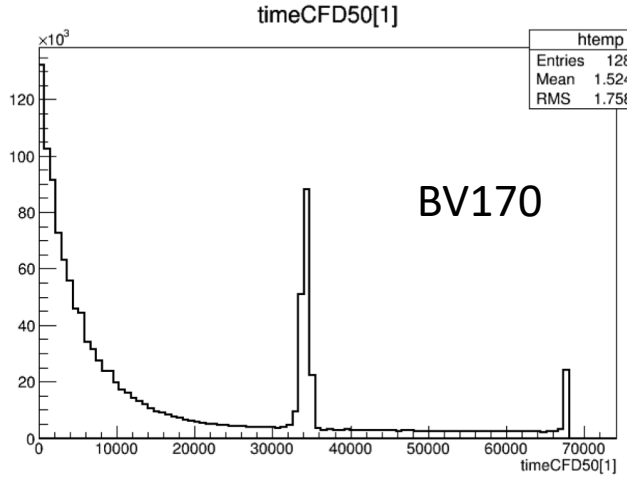
- For our case

Studied sensors | Reference sensor

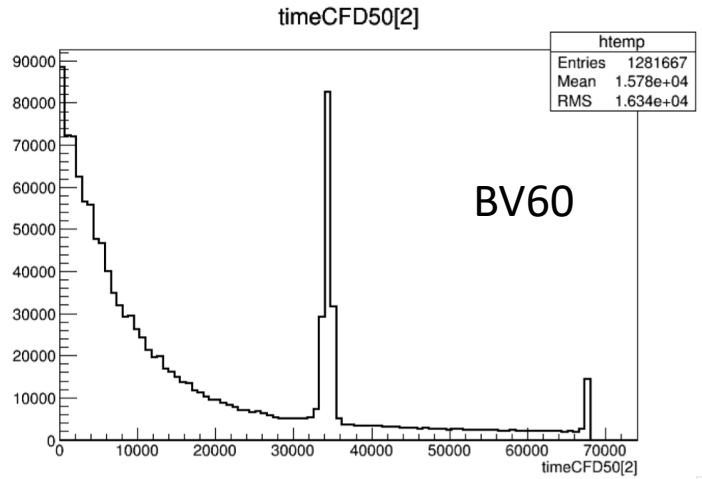
		0	1	2	3
Sensor		LGA35	BV170	BV60	SiPM3
Bias Voltage	101	190	50	50	26.5
	102		90	70	
	103		130	90	

  - Sigma of BV170-BV60, BV170-SiPM3, BV60-SiPM3 are needed

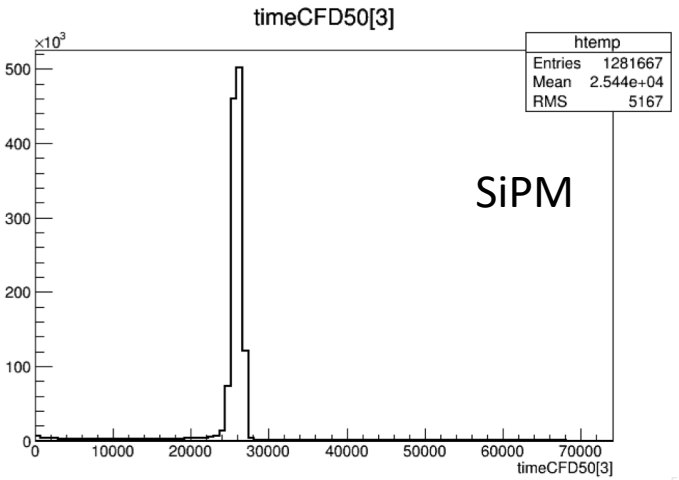
Distribution of delta_t batch 103



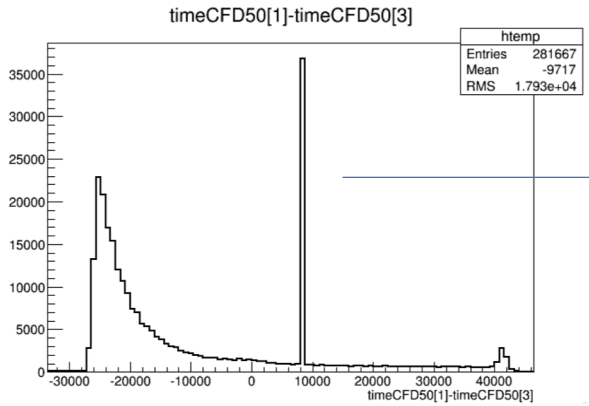
BV170

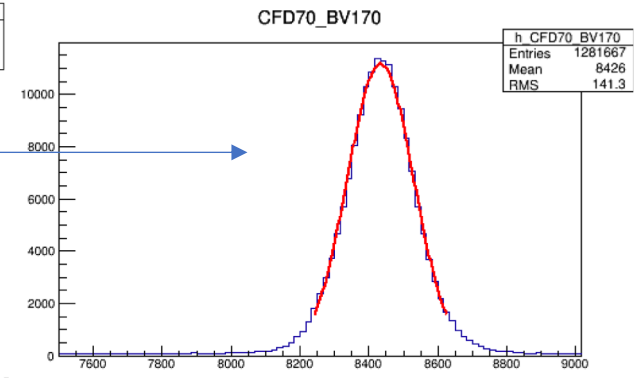


BV60

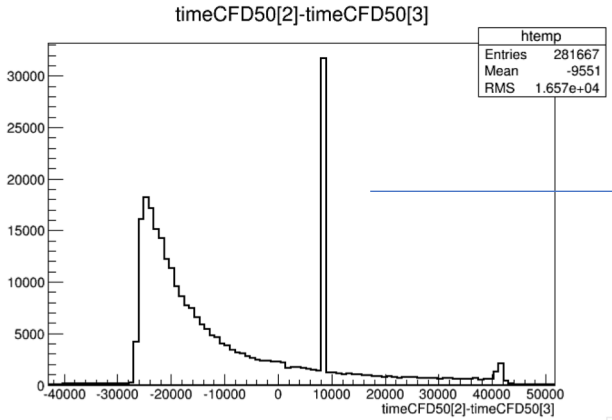


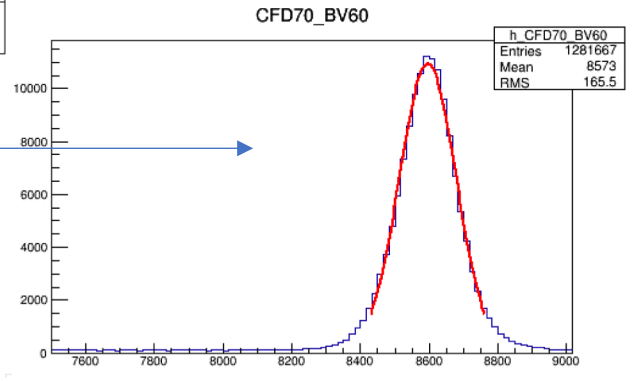
SiPM





BV170-SiPM3

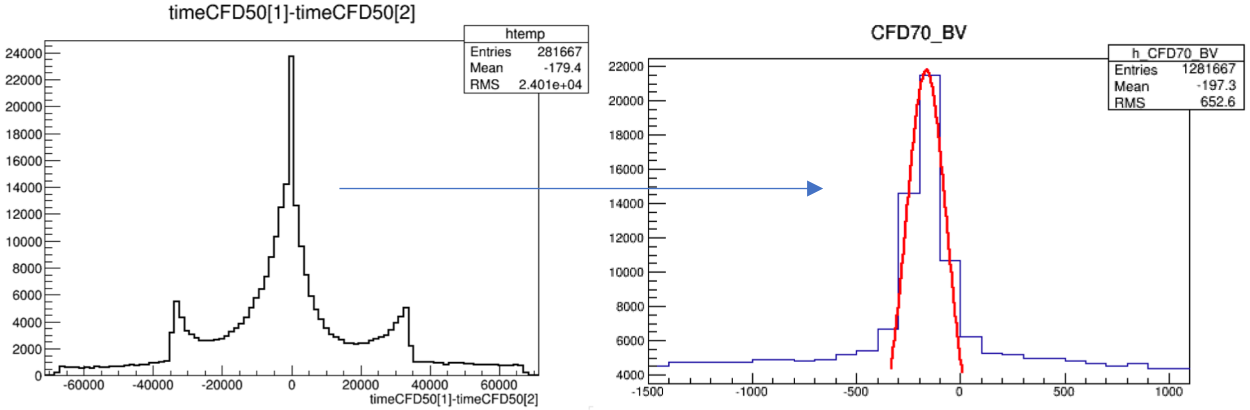




BV60-SiPM3

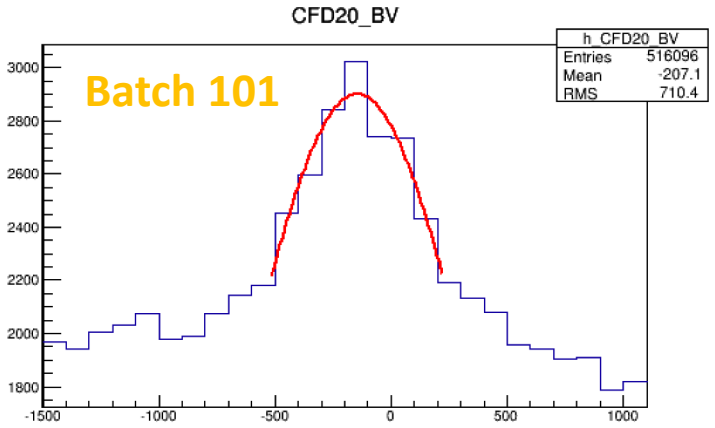
Distribution of delta_t batch 103

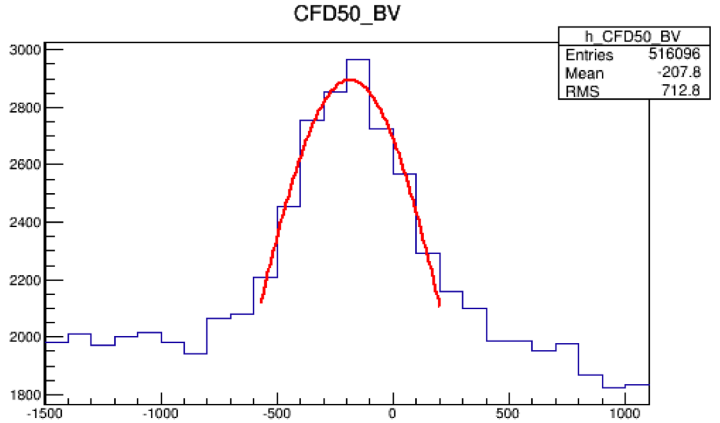
BV170-BV60

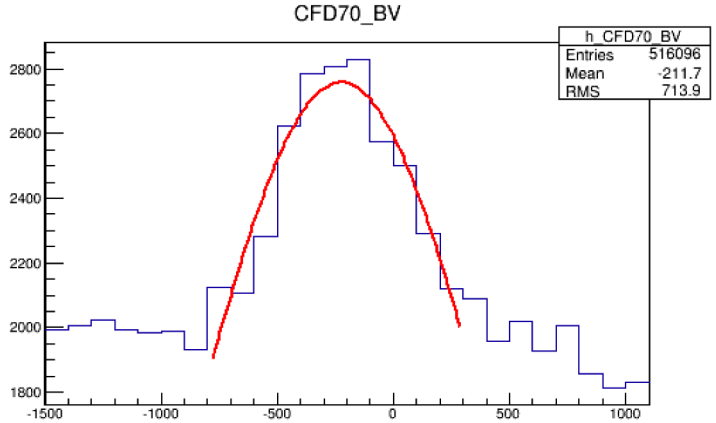



```
[[  0.          95.71651314  96.58138081]
 [ 95.71651314   0.          82.82710778]
 [ 96.58138081  82.82710778   0.        ]]
[[ 0.          0.81719462  0.26681542]
 [ 0.81719462  0.          0.26164118]
 [ 0.26681542  0.26164118  0.        ]]
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
[ 5814.64211181  3347.00877564  3513.32100828]
sigma_t 0 76.2538006384 +/- 0.558386188697
sigma_t 1 57.8533385004 +/- 0.735982921917
sigma_t 2 59.2732739797 +/- 0.718351902186
```

Distribution of delta_t batch 101 & 102







503.32 +- 27.50

485.73 +- 17.94

642.01 +- 19.34

```
[[   0.          205.1396479   130.79033849]
 [ 205.1396479     0.           95.19229135]
 [ 130.79033849   95.19229135    0.        ]]
[[ 0.          3.76676801  0.60722986]
 [ 3.76676801  0.          0.47103253]
 [ 0.60722986  0.47103253  0.        ]]
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
[ 25063.40772571  17018.86741684  -7957.29508411]
getReso.py:95: RuntimeWarning: invalid value encountered in sqrt
  output=np.sqrt(a)
getReso.py:96: RuntimeWarning: invalid value encountered in power
  outputEr=(1/2.)*np.power(a,-1/2.)*aer
sigma_t 0 158.314268863 +/- 2.45738173481
sigma_t 1 130.456381281 +/- 2.98213539916
sigma_t 2 0.0 +/- 0.0
```

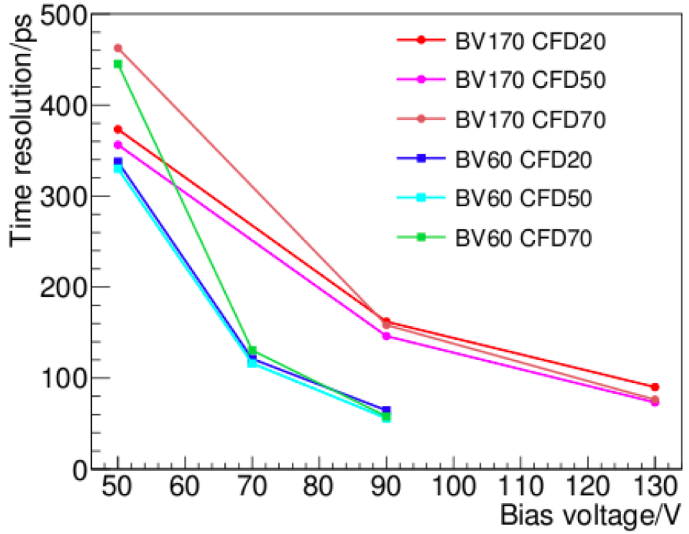
Batch 101

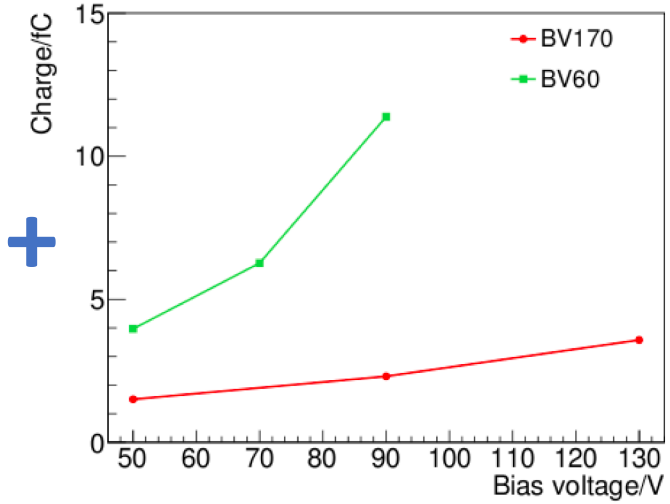
?

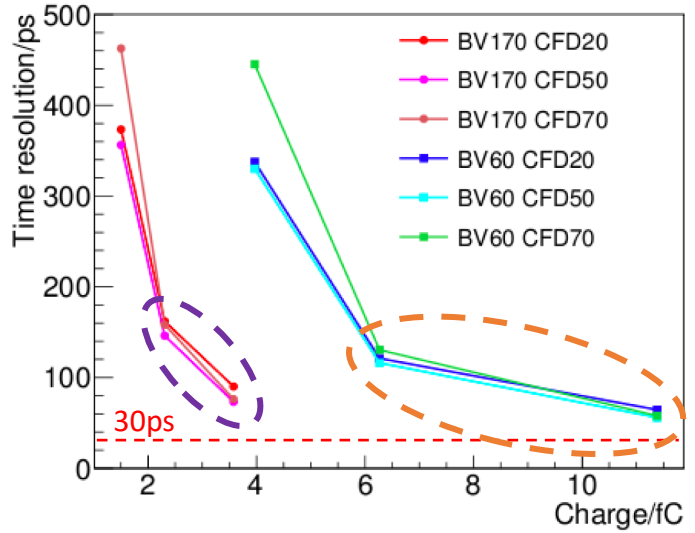
```
[[   0.          642.01139449  185.48117422]
 [ 642.01139449    0.          136.301164  ]
 [ 185.48117422  136.301164      0.        ]]
[[  0.          19.34374183   1.5457233 ]
 [ 19.34374183   0.           0.71000165]
 [  1.5457233    0.71000165   0.        ]]
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
[ 214001.94466738  198176.6859845  -179598.67867585]
getReso.py:95: RuntimeWarning: invalid value encountered in sqrt
  output=np.sqrt(a)
getReso.py:96: RuntimeWarning: invalid value encountered in power
  outputEr=(1/2.)*np.power(a,-1/2.)*aer
sigma_t 0 462.603442127 +/- 13.4268224683
sigma_t 1 445.170401065 +/- 13.9526219079
sigma_t 2 0.0 +/- 0.0
```

Batch 102

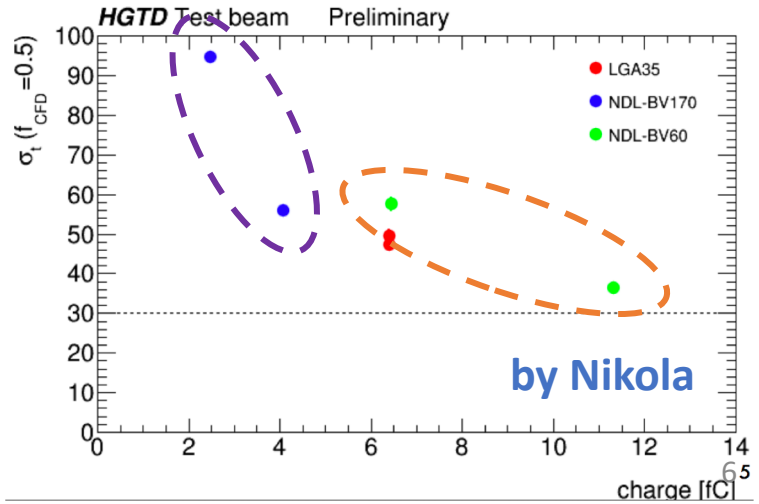
Preliminary time res by Q_getReso.py





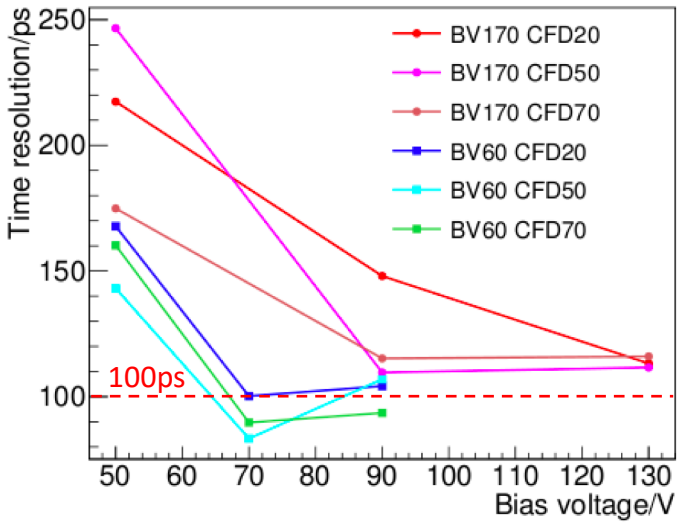


- Leaving the SiPM res=0 issue, here's preliminary time resolution distribution.
- There's still some difference from Nikola's result.



What's different with laser test

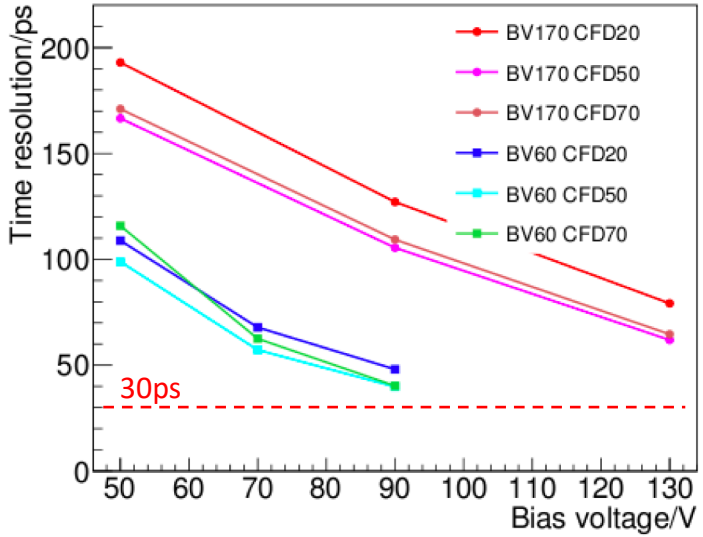
- SiPM resolution should be considered. While fluctuation for laser synchronous time t0 is too small to ignore.



$$\sigma_{sensor}{}^2 = \sigma^2 - \sigma_{SiPM}{}^2$$

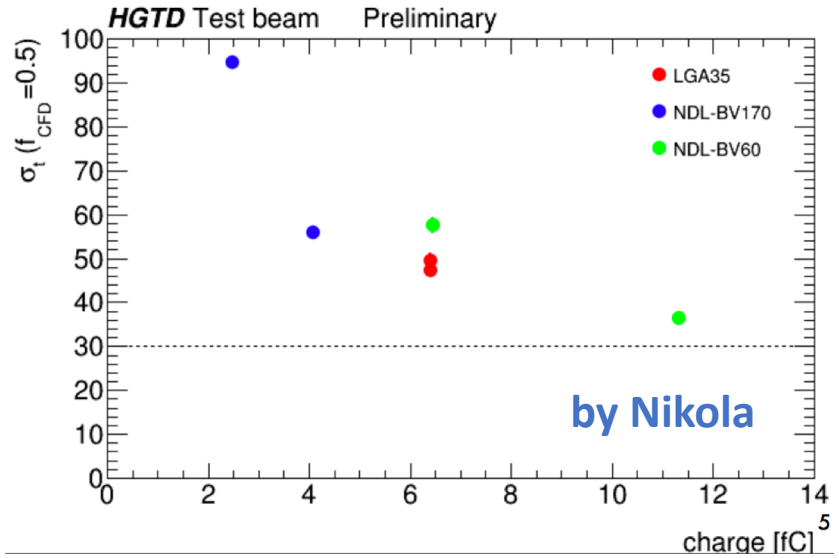
SiPM time resolution

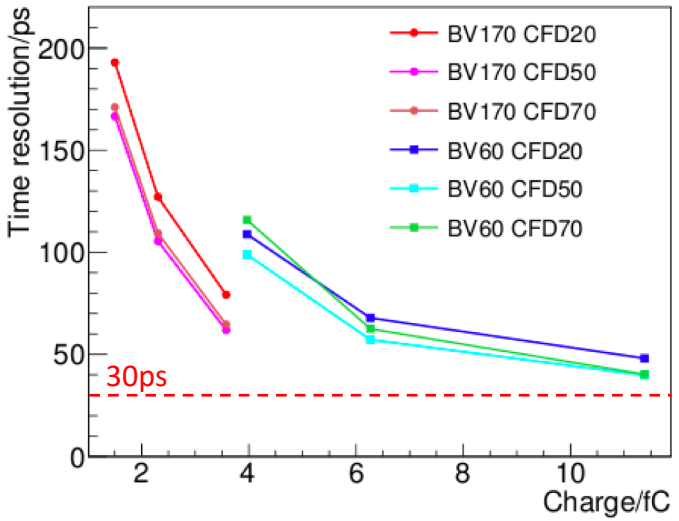
	Voltage [V]	σ(CFD 0.2) [ps]
March SiPM	27.8	39. ±2.2
May SiPM2	27.6	63.3±0.9
May SiPM3	27.6	71.8±1.3



https://indico.cern.ch/event/777891/contributions/3471578/attachments/1868113/3072730/2019_06_27_TB.pdf by Nikola

What's different with laser test





- Subtracting SiPM resolution, resolution seems more reasonable.
- But the problem is how to get SiPM resolution?
  - $\boldsymbol{\sigma_{sensor}}^2 = \boldsymbol{\sigma}^2 - \boldsymbol{\sigma_{SiPM}}^2$ will lead to sqrt(a minus value) problem.

Thanks!