



B-TOF Hardware

-

Latest News

Sebastian Zimmermann
On behalf of the Panda SciTil group

Panda Meeting GSI, 07.03.2018

Overview

- Test of different temperature sensors
- Time resolution scans Erlangen
 - time resolution
 - Influence of scintillator thickness
- Railboard v2
- TOFPET v2

Temperature Sensors

Study done by BSc Student, B. Temper

The Detectors

- Maxim Integrated DS18B20
 - Connected in **parallel**
 - 3 lines (Power, Ground, Data)
 - **2 line** in parasitic mode
 - **64 bit** unique address
 - - 55 °C to 125 °C
 - **9 to 12 bit** resolution
 - 0.5 °C to 0.0625 °C
- Texas Instruments TMP107
 - Connected in **series**
 - 3 lines
 - **5 bit** address
 - - 55 °C to 125 °C
 - **14 bit** resolution
 - 0.015625 °C

Circuit diagrams

- DS18B20

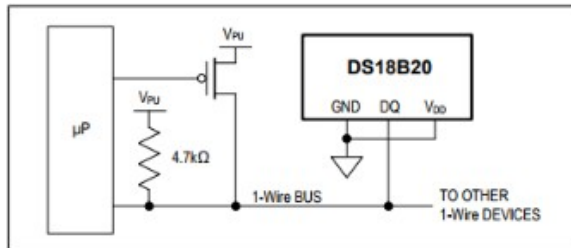


Figure 6. Supplying the Parasite-Powered DS18B20 During Temperature Conversions

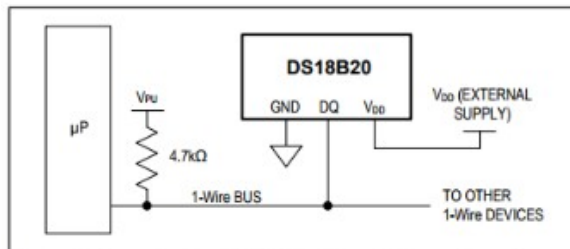
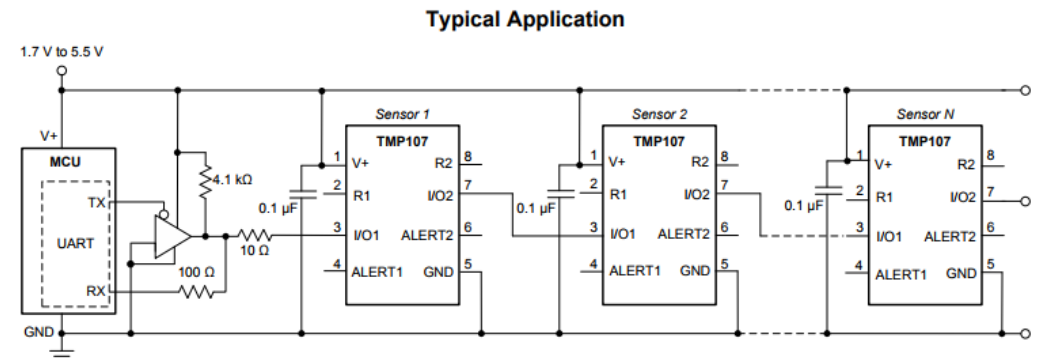


Figure 7. Powering the DS18B20 with an External Supply

- Connected in parallel
→ if sensor dies no further implications

- TMP107



All figures shown as TMP107 represent TMP107-Q1 as well.

- Connected in series
→ if sensor dies, all sensors behind it are cut off

Time to Read out

- Time per Sensor read:
~12 ms
- Time for conversion:
~153 ms
- Time per Sensor read: ~
0.37 ms

# Sensors	1	5	12	60
Time [ms]	610.6	677.4	771.5	1410
Time [ms] parasitic	764.9	818.7	912.6	1550

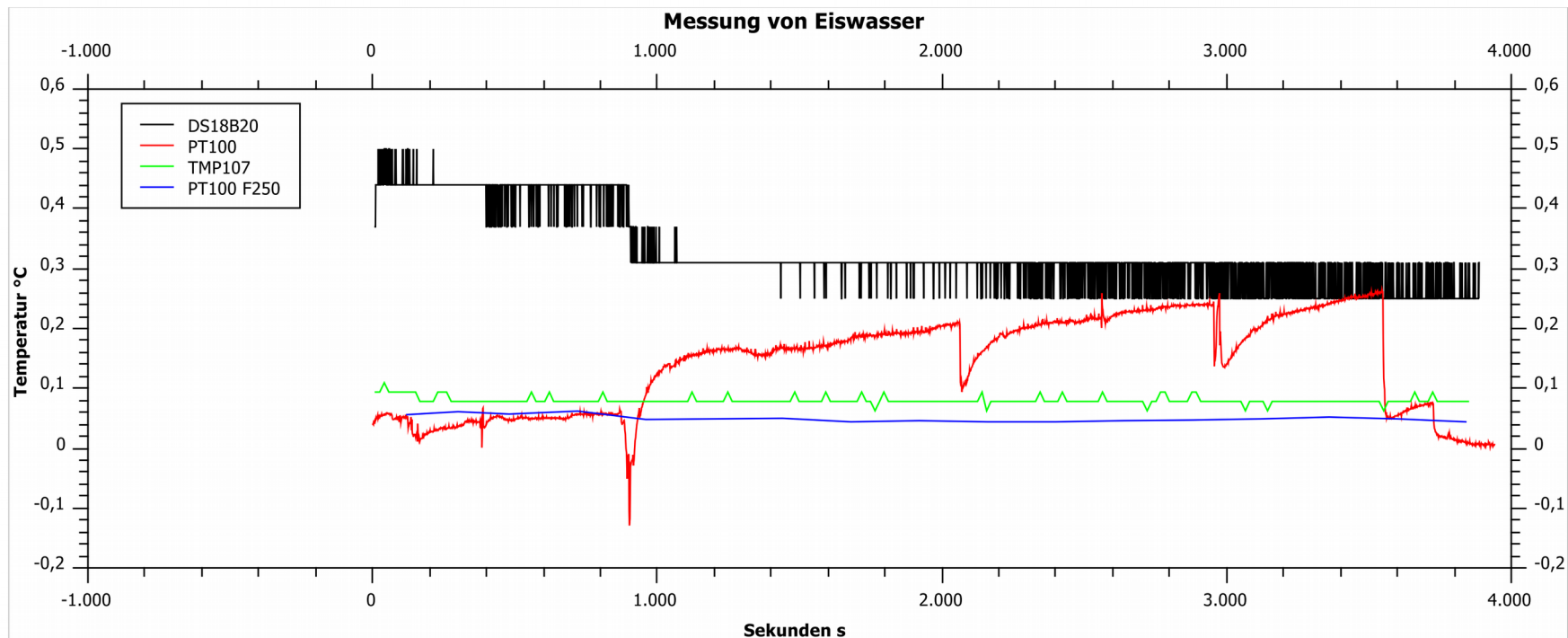
# Sensors	4	5	32
Time [ms]	130.5	146.4	156.4

No time difference between parasitic
with/without MOSFET

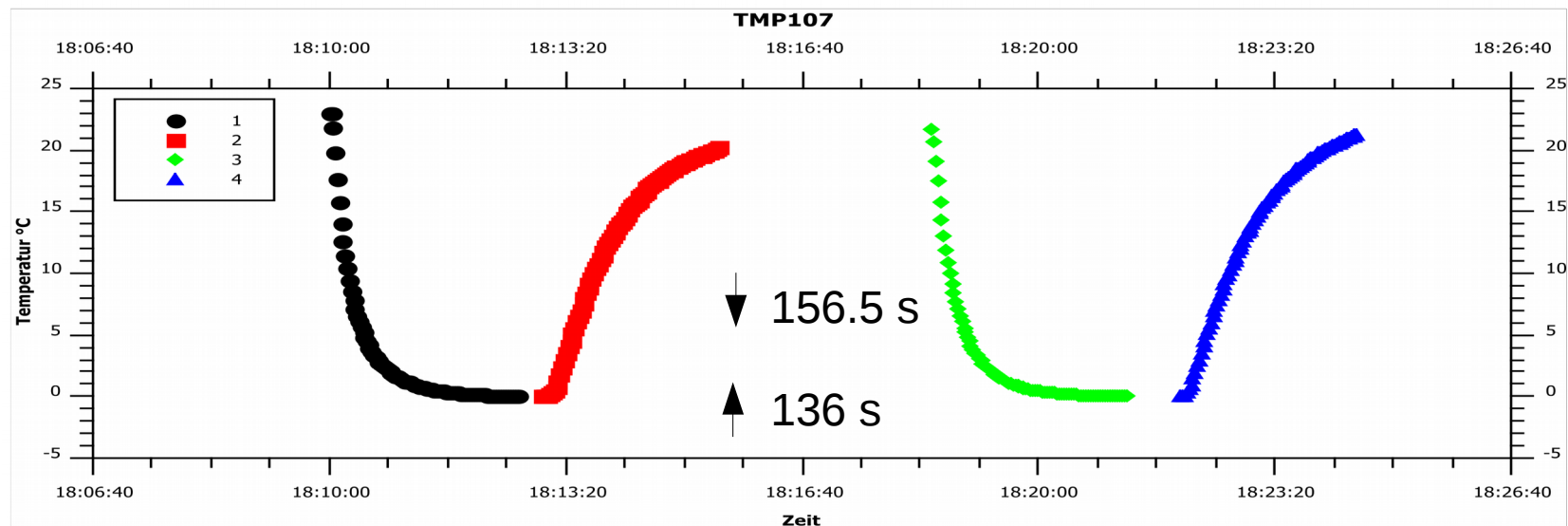
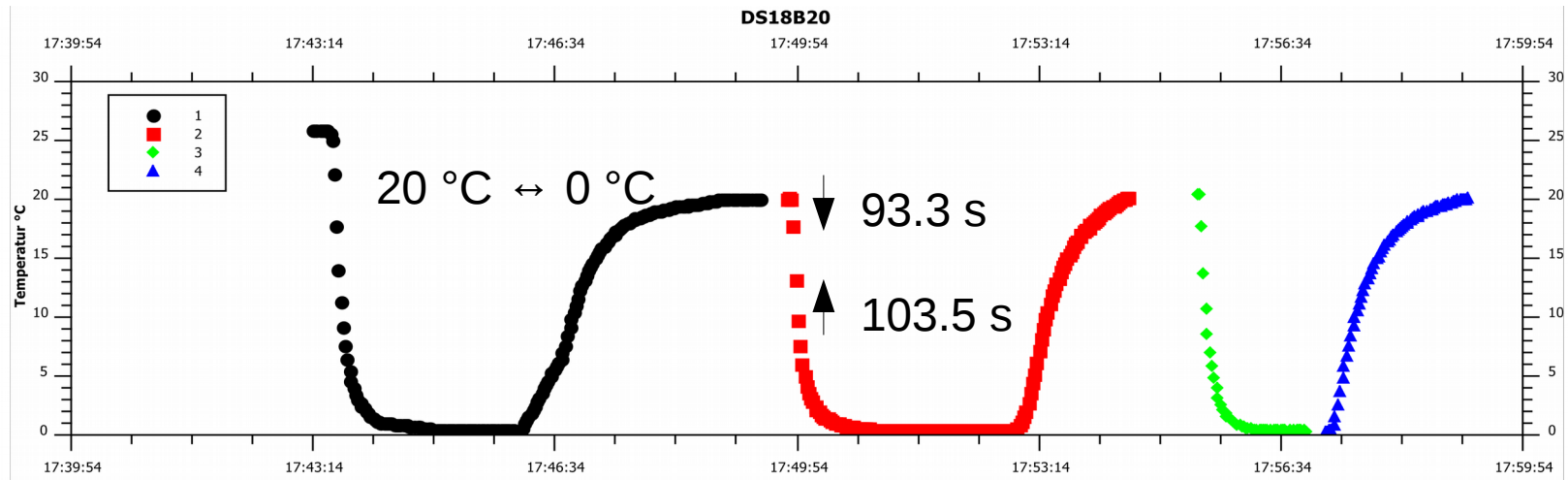
Values for 60 sensors are extrapolated

Fixed Point measurement

- DS18B20
 - Larger offset
 - coarse resolution
- TMP107
 - Greater stability
 - Finer resolution

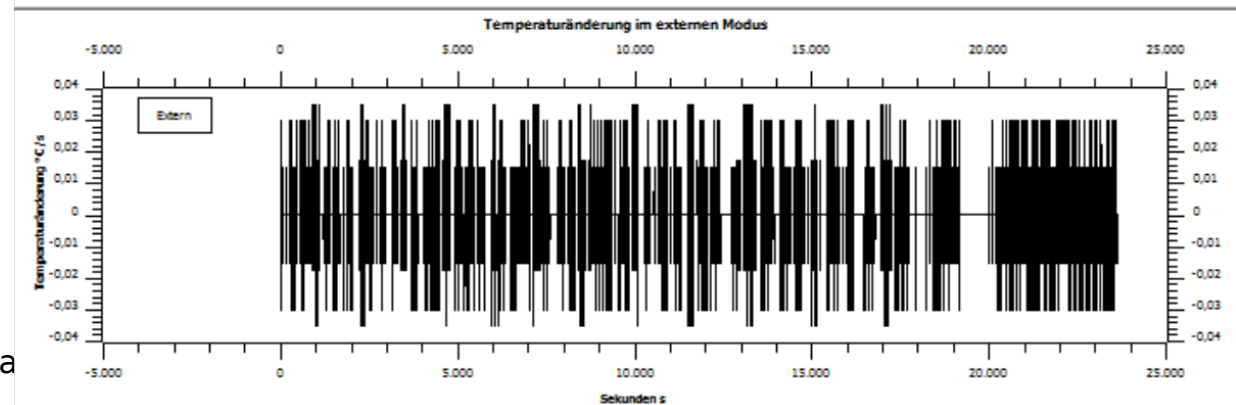
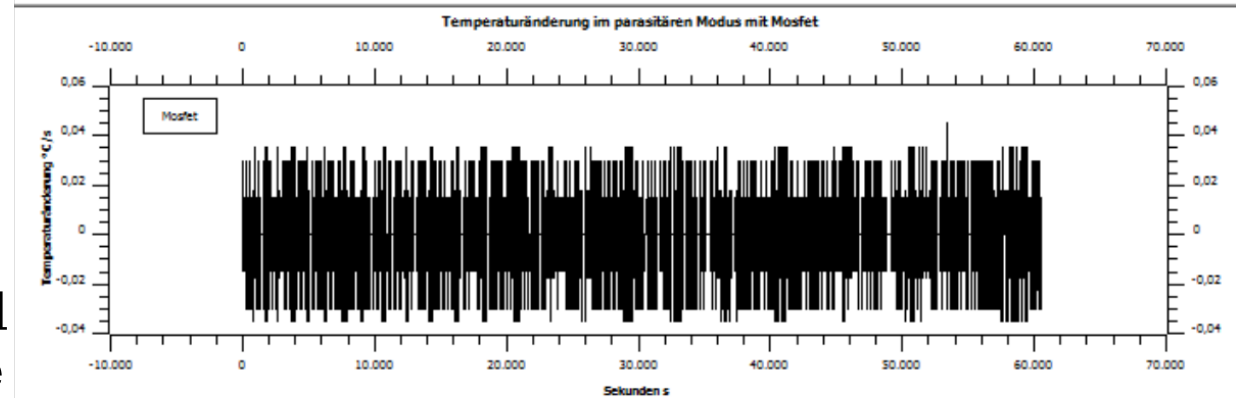
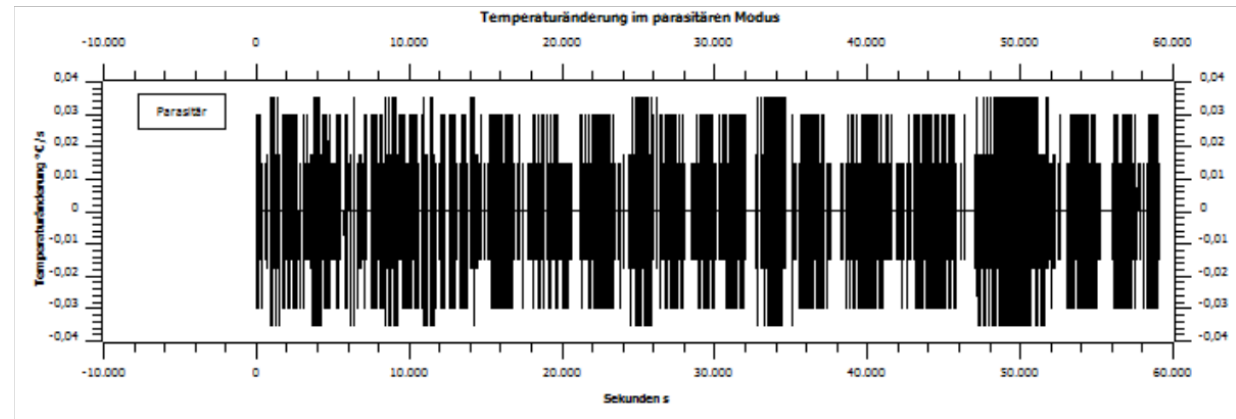


Reaction Time



Stability

- Measured only for DS18B20
- No measurement possible for the TMP107 due to limited software capabilities
 - Were not able to continuously write data to file but only fill buffer and write to file post measurement
- No connection drops or stutters

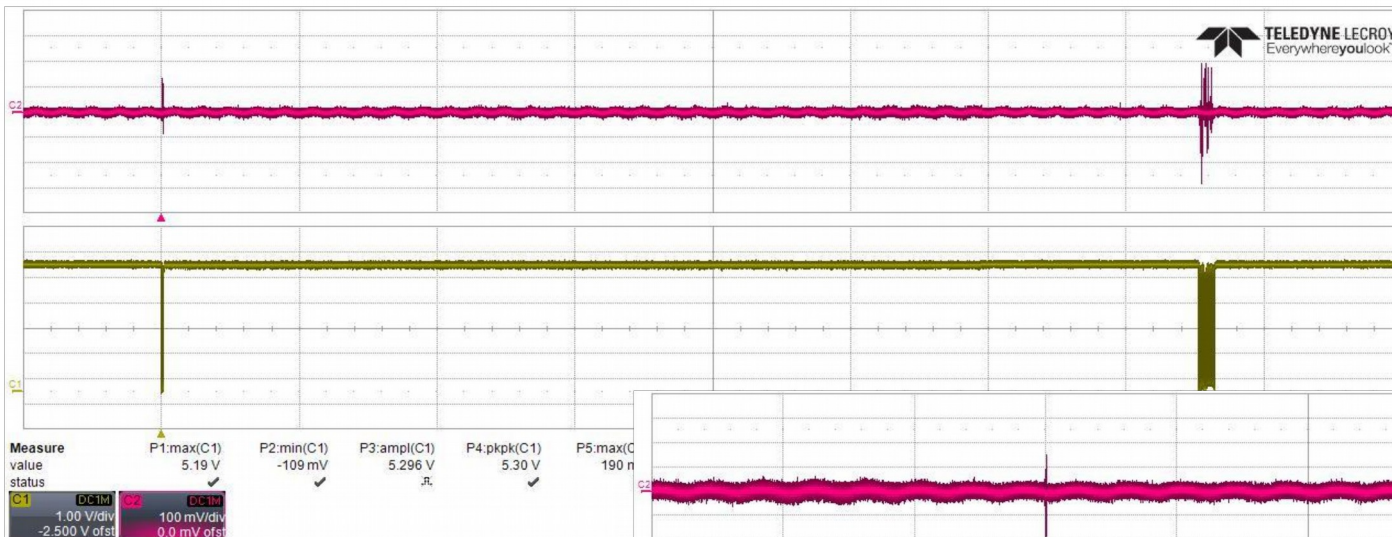


Crosstalk

Even signal ground for both devices shows large fluctuations. Crosstalk measured (with and) without taking this into account. Results similar.

- DS18B20

- TMP107

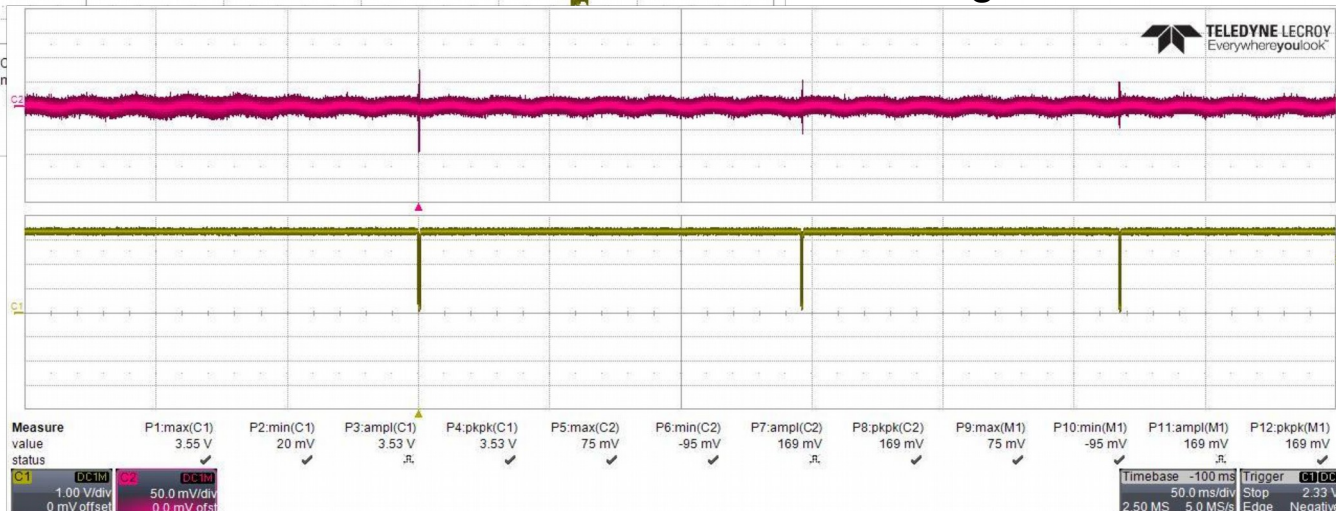


~420 mV with 5 V signals

Can go down to 3 V

~184 mV
with 3.3 V signals

Can go down to 1.7 V

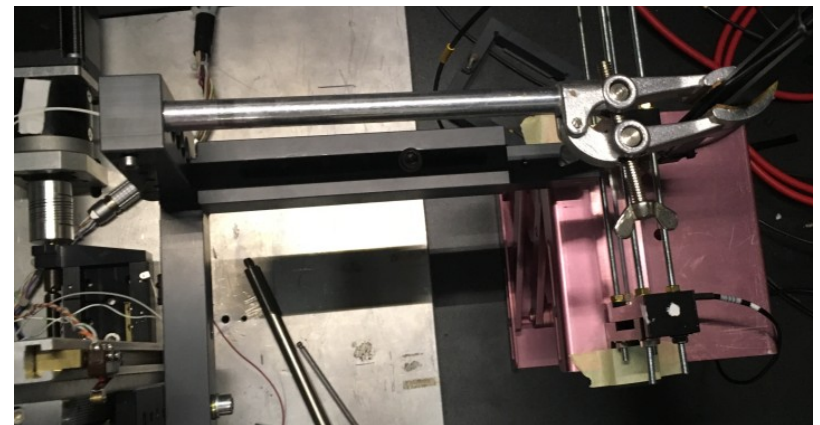


Advantage / Disadvantage

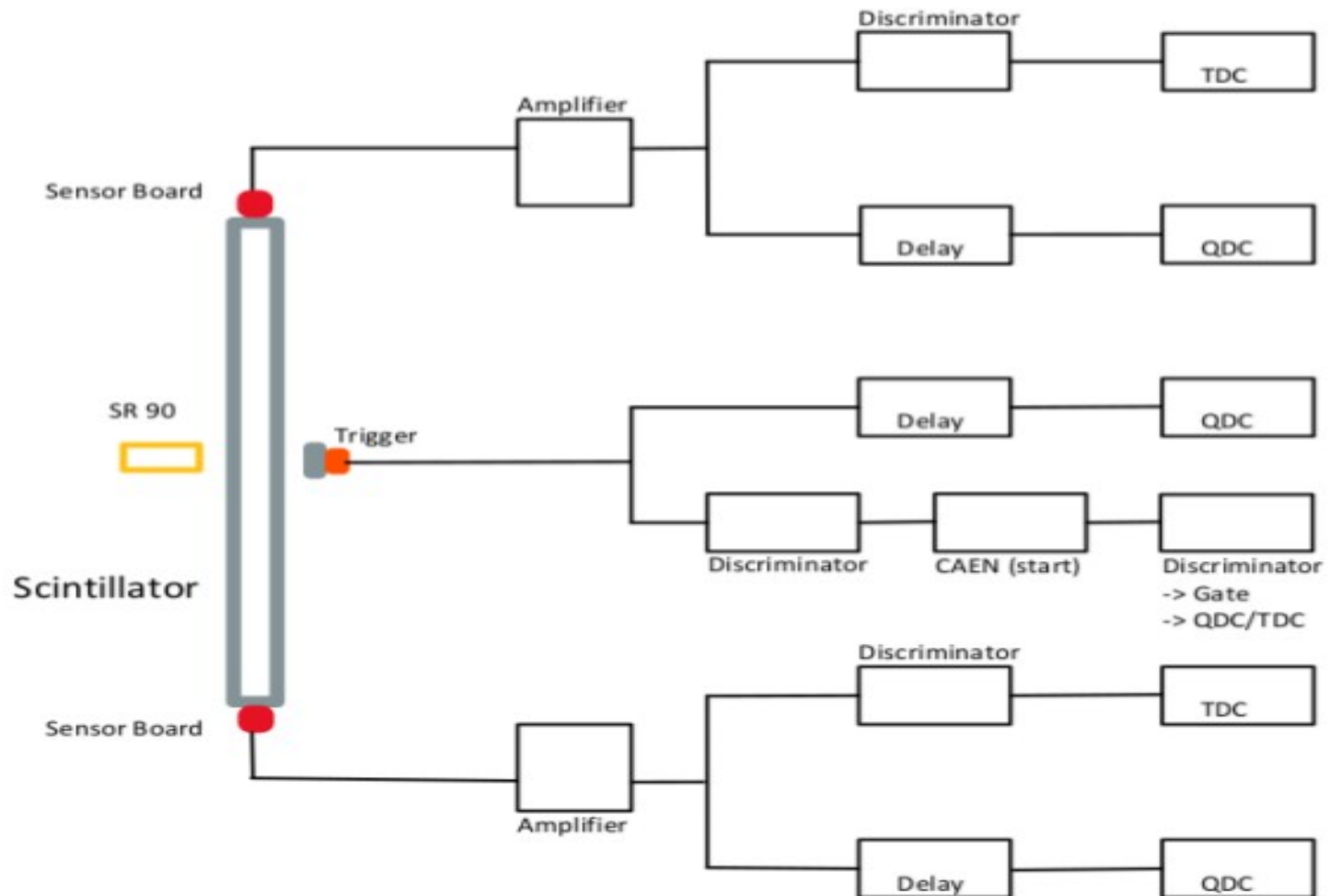
- DS18B20
 - 64 bit address
 - Arduino for read out
 - Slower read out (1550 ms a 60 sensors)
 - Coarser resolution
 - Faster temp adjustment (d: 93 s, u: 104 s)
 - Stable over long periods of time, no drops
 - Larger crosstalk (420 mV) due to larger signals (5 V to 3 V)
 - If sensor dies no further implications
 - Does not need to be re-initialized every time power is cut off
- TMP107
 - 5 bit address (32 sensors)
 - TI software for read out
 - Faster read out (156 ms a 32 sensors)
 - Finer resolution
 - Slower temp adjustment (d: 157 s, u: 136 s)
 - Could not do measurement due to software restrictions
 - Lower crosstalk (184 mV) due to smaller signals (3.3 V to 1.7 V)
 - If sensor dies, sensors behind are cut off

Scintillator Thickness Scans

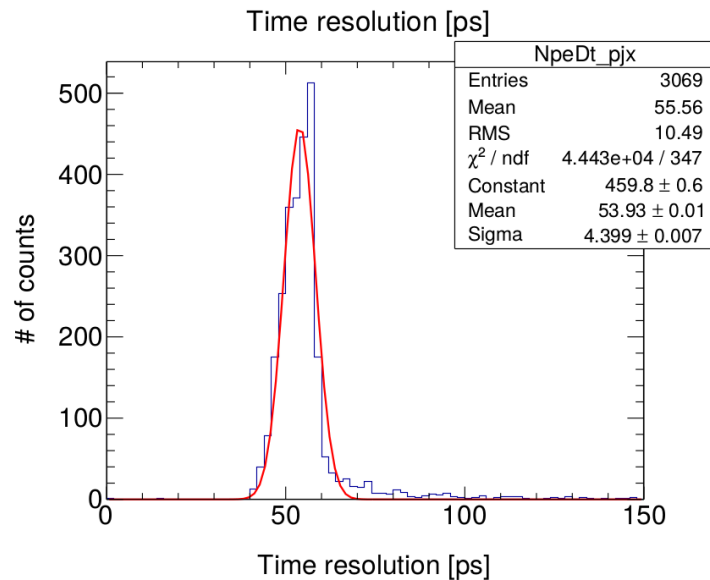
- Time Resolution measured for scintillators of different thicknesses
 - 3, 4, 5, 6 mm
- Measurements done in Erlangen
 - November 2017
- Done in low noise environment in copper cladded box
- Utilizing a ^{90}Sr source with a small trigger scintillator on x-y stepper motors
(5x5x5 mm³ BC 420 Hamamatsu SiPM)



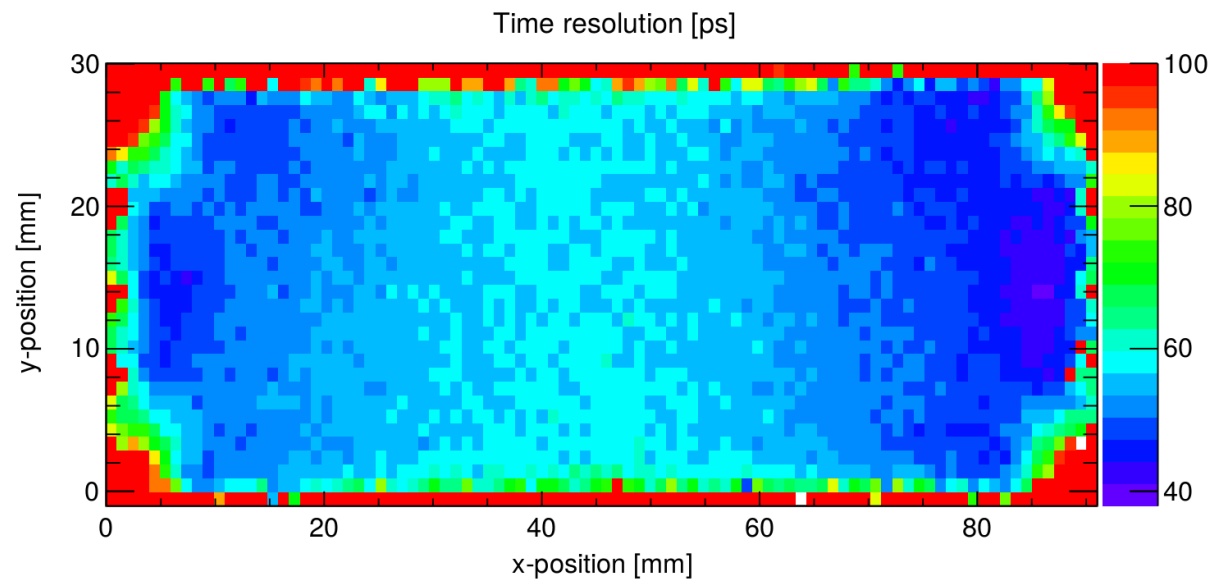
Electronics Setup



Previous Measurement Results



Measured with EJ-232
(90x30x5 mm³),
4 x HPK S13360-3050-PE



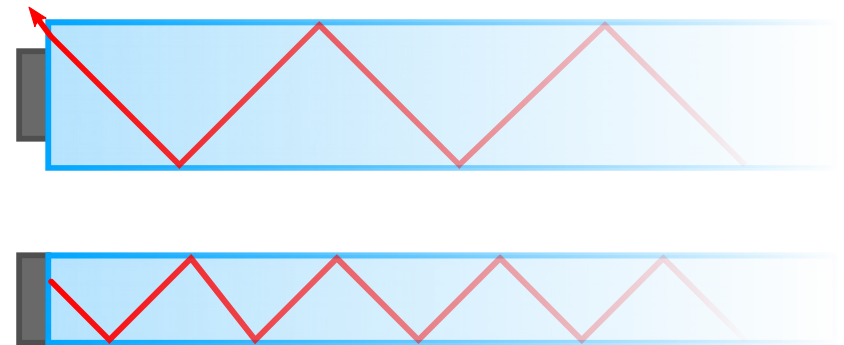
Measurement Results

- Wrapping material has impact on time resolution
 - More photons =! better time resolution
- Position resolution from timing differences
 - Sigma = 5.5 mm in x direction

	Wrapping material	Time resolution [ps]	Number of detected photons
EJ-232	No wrapping	55.0 ± 0.3	288 ± 2
	Aluminised Mylar foil	52.7 ± 0.3	355 ± 2
	Tyvek hardstructure 1057D	55.0 ± 0.3	394 ± 3
	Enhanced specular reflector (ESR)	55.2 ± 0.3	355 ± 3
	Teflon tape	59.4 ± 0.3	408 ± 4
	aluminium foil	54.2 ± 0.3	344 ± 3
EJ-228	Wrapping material	Time resolution [ps]	Number of detected photons
	No wrapping	61.3 ± 0.3	371 ± 2
	Aluminised Mylar foil	59.7 ± 0.3	445 ± 3

Motivation

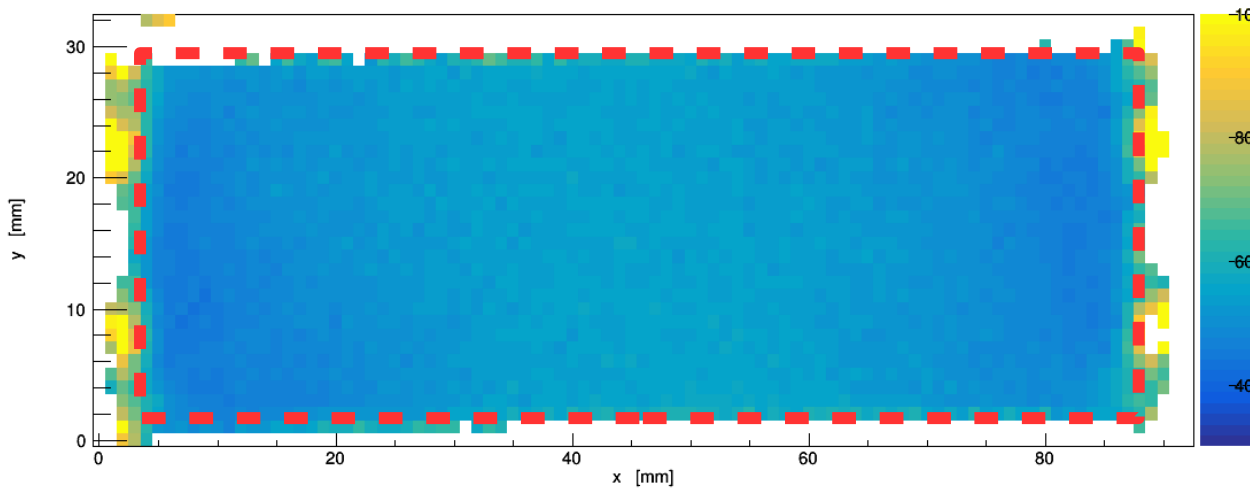
- Initial thickness (5 mm) chosen due to space constraints
- Loss of photons means loss of time resolution (25% sensitive)
- Balance between loss of photons and photon production
- Study influence of Scintillator thickness on the homogeneity of time resolution by closer matching the thickness of the scintillator to the width of the SiPMs (3mm)
- Reduce material along the particle path



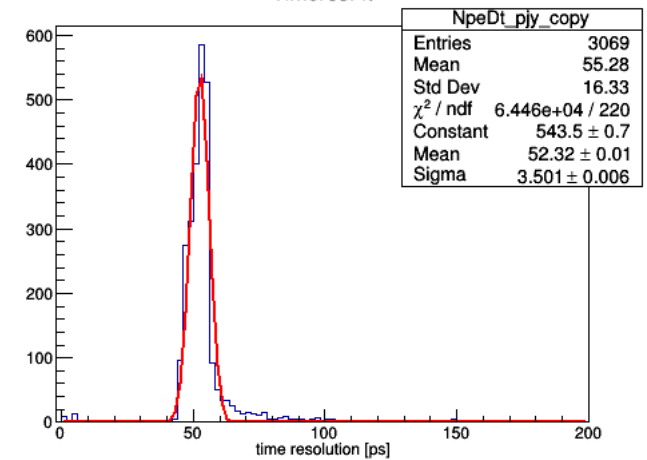
Run 51 / 5 mm

Preliminary

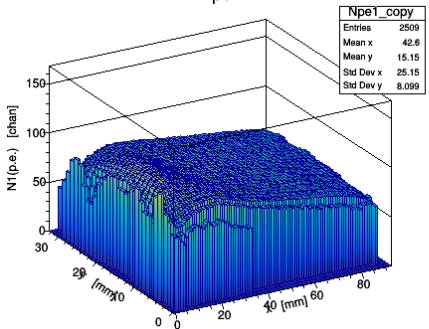
TDiff Resolution



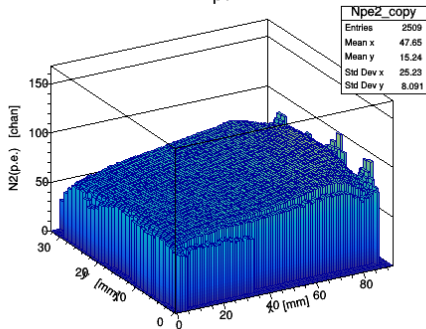
TimeresFit



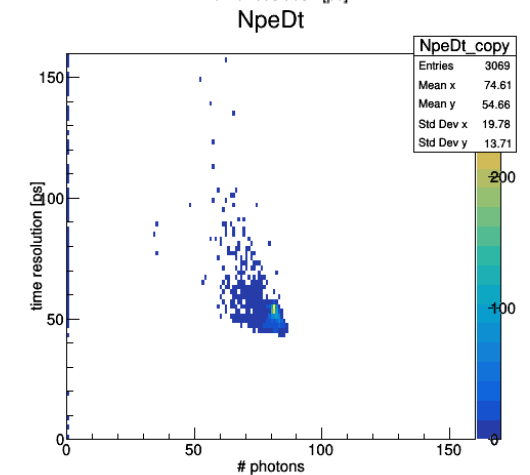
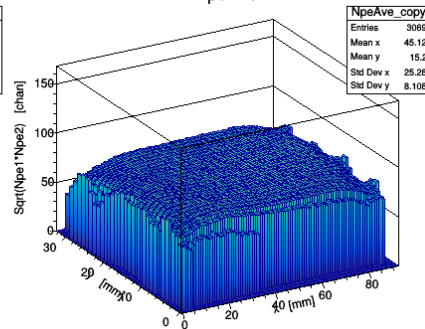
Npe1



Npe2

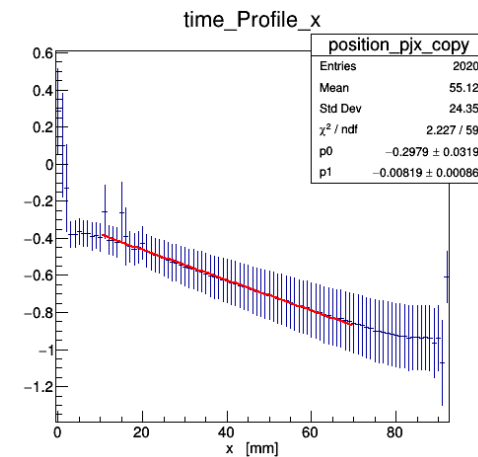
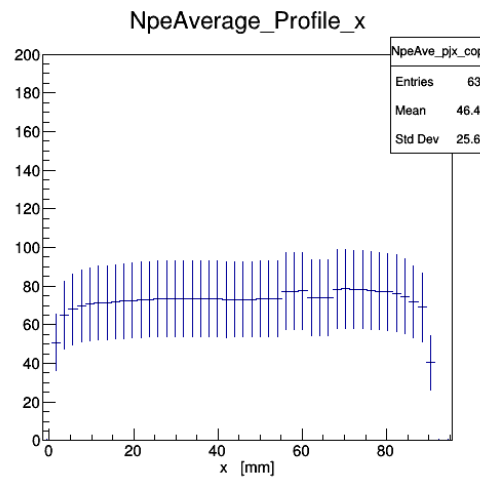
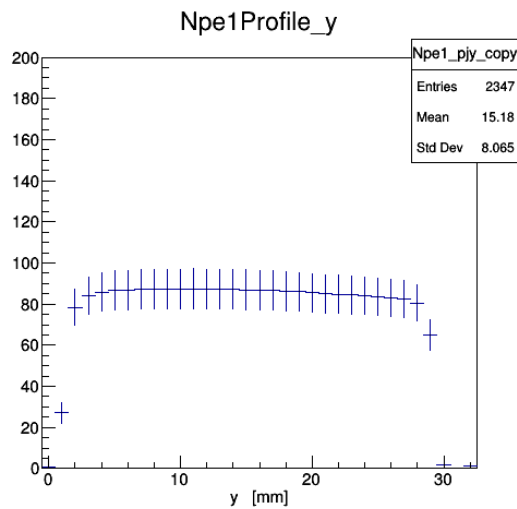
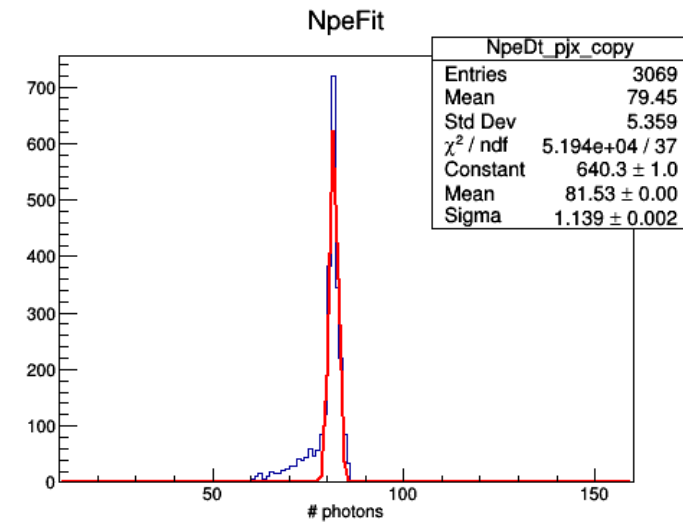
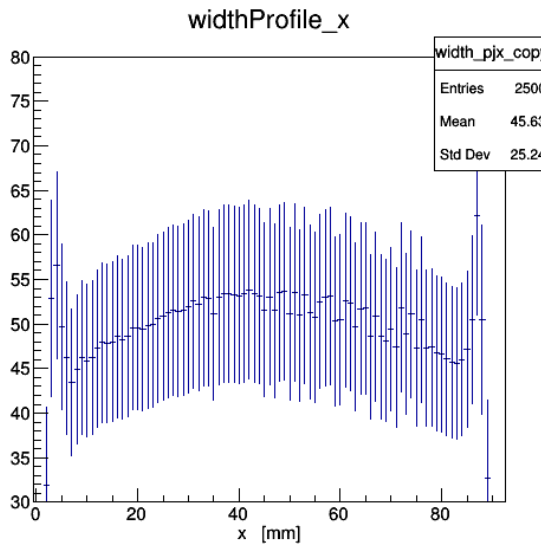
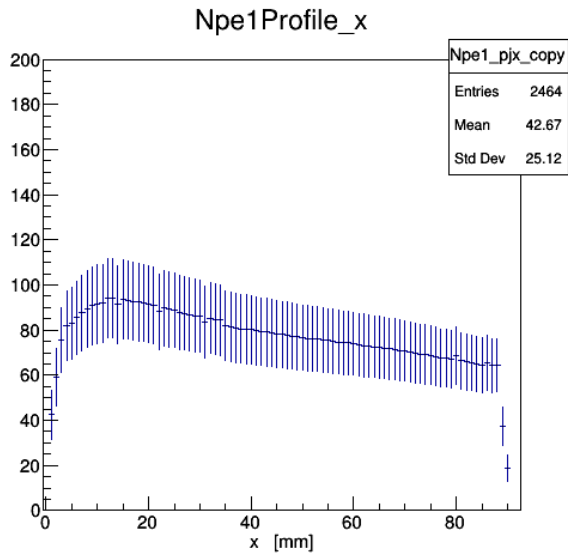


NpeAve



Run 51 / 5 mm

Preliminary

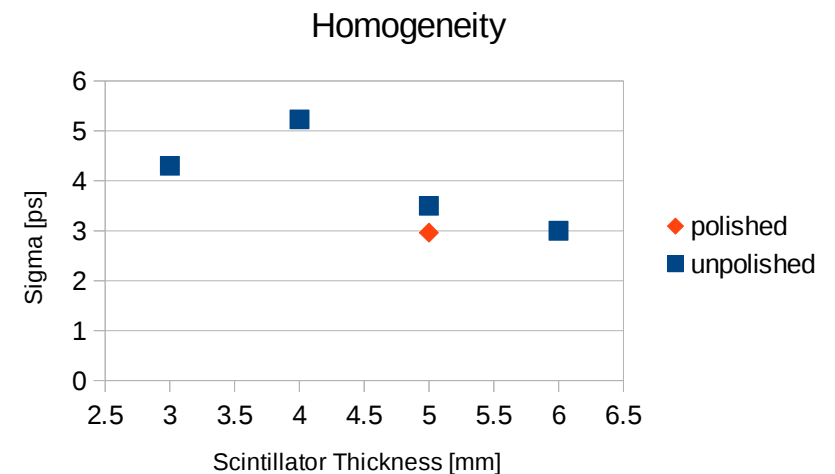
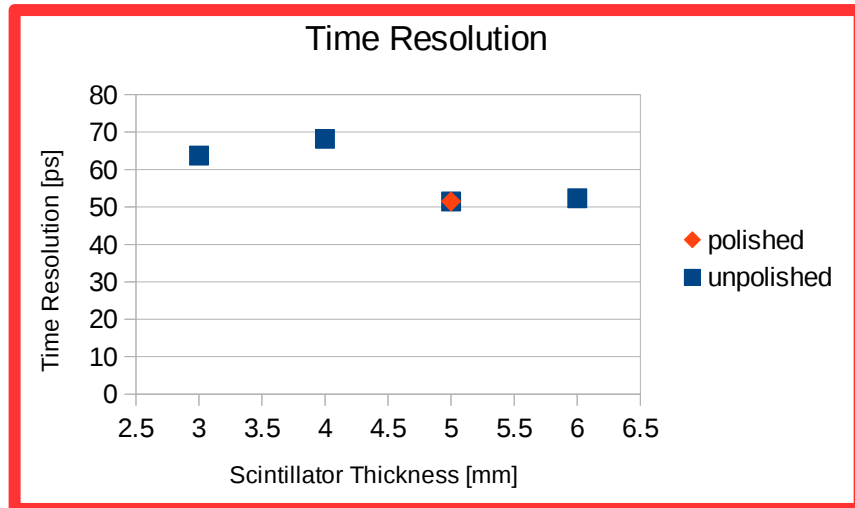


Quick Summary

Preliminary

	speed x [ps/mm]	+/-	tilt y [ps/mm]	+/-	Npe1	Npe2	NpeAve Fit	Time Res [ps]	Time Res sigma	norm. sigma	Std Dev
3 mm	9.6	0.8	2.3	3.6	59.8	56.31	55.39	63.74	4.3	0.0674615626	19.45
4 mm	7.4	1.6	1.8	7.9	83.17	70.67	73.59	68.18	5.23	0.0767087122	20.93
5 mm p	9.1	0.8	2.4	3.6	84.05	78.75	79.82	51.49	2.96	0.0574868907	15.53
5 mm	8.2	0.9	2.3	3.6	86.99	80.32	81.53	52.32	3.5	0.0668960245	16.33
6 mm	8.7	0.8	2.5	3.6	85.02	75.66	77.99	51.14	3	0.0586624951	14.73

Scintillator: EJ-232 quenched: EJ-232Q (0.5%)



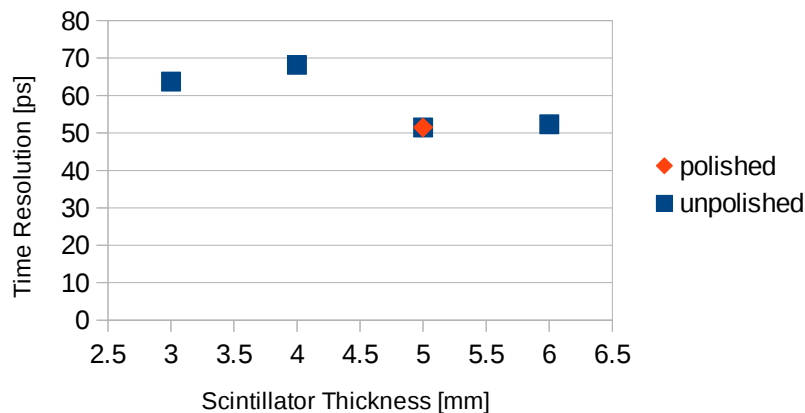
Quick Summary

Preliminary

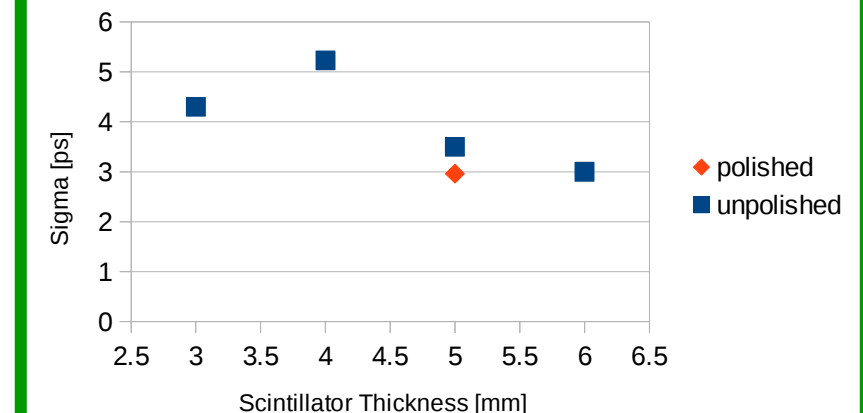
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Scintillator: EJ-232 quenched: EJ-232Q (0.5%)

Time Resolution



Homogeneity

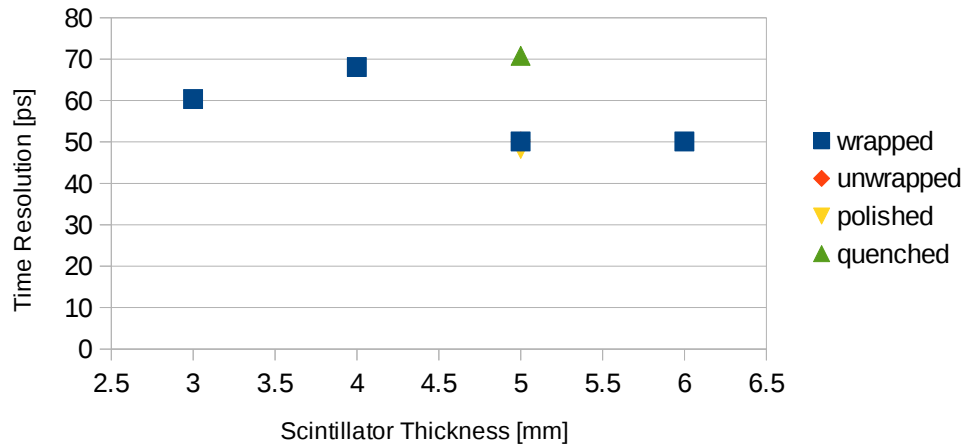


Quick summary first (shorter) run

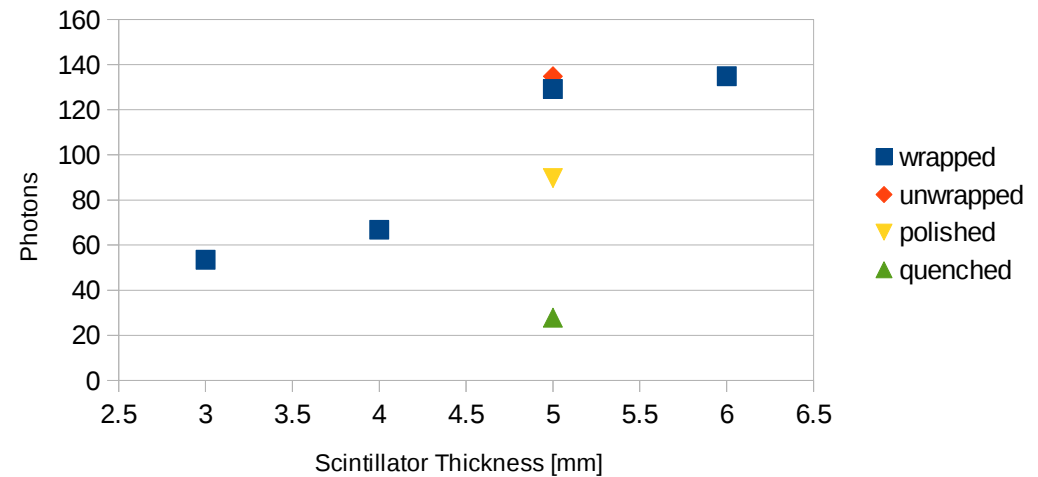
Preliminary

		speed x [ps/mm +/-	tilt y [ps/mm +/-	Npe1	Npe2	NpeAve	Fi	Time Res [ps	Time Res sigma	Std Dev
Run 38	3 mm wrapped	6,5 0,8	1,6 3,5	72,37	46,84	53,47		60,34	5,05	14,94
Run 44	4 mm wrapped	6,6 0,6	1,6 2	85,64	55,14	66,79		68,09	5,48	20,71
Run 17	5 mm unwrapped	6,7 1,4	1,6 5,3	136,73	142,01	134,8		50,12	3,44	22,67
Run 22	5 mm wrapped	6,6 1,1	1,5 4,1	139,94	128,69	129,2		50,14	3,85	21,06
Run 47	5 mm polished	7,8 1,2	2,2 4,4	111,87	78,1	89,66		48,29	3,51	22,08
Run 48	5 mm quenched	7,4 1,1	1,6 4,3	33,32	25,65	27,8		70,8	6,92	19,36
Run 46	6 mm wrapped	6,06 0,62	2,2 2	101,7	70,7	84,17		48,7	3,53	14,13

Time Resolution

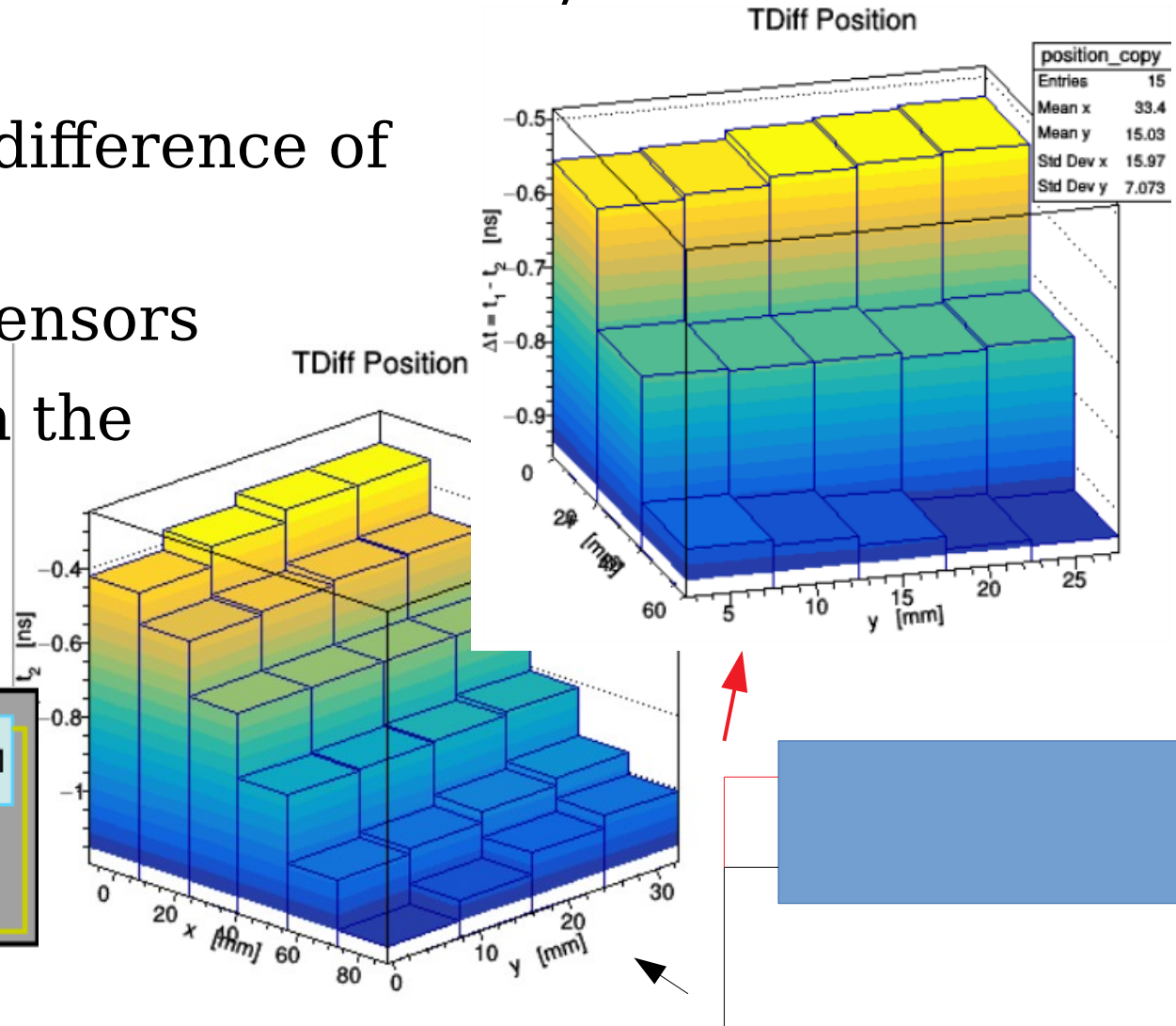
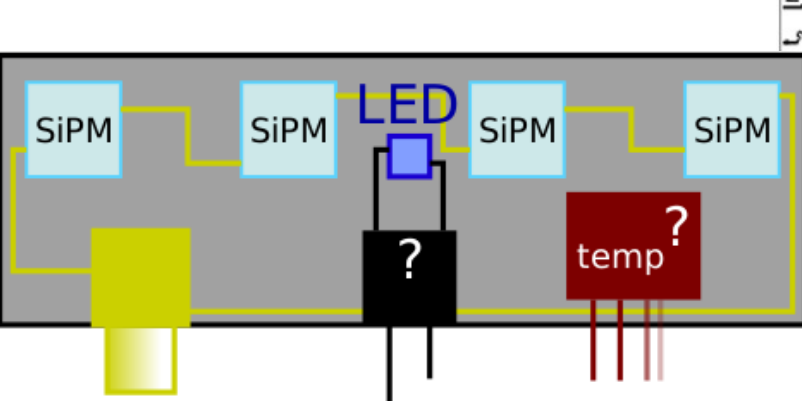


Average Amount of Photons



Readout Delay

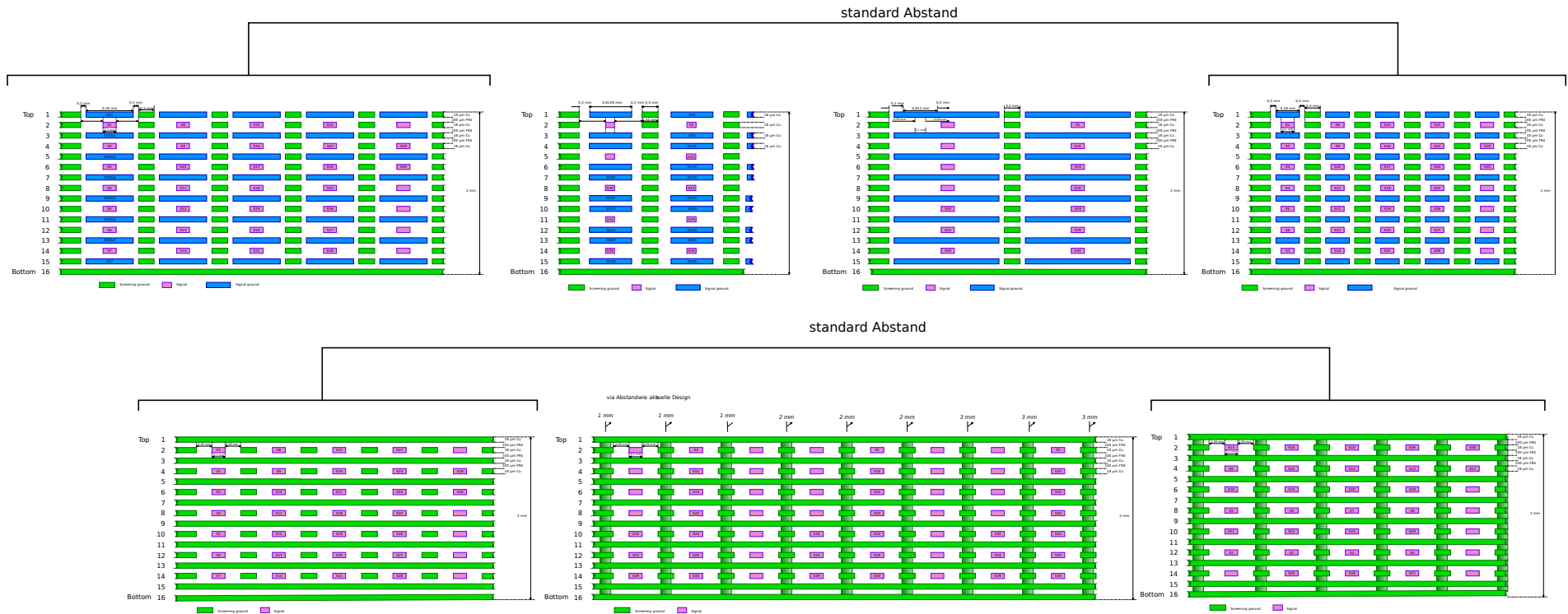
- Slanting in time difference of signal left/right
- Visible close to sensors
- Slant depends on the way the sensors are read out



Signal Transfer / Railboard v2.0

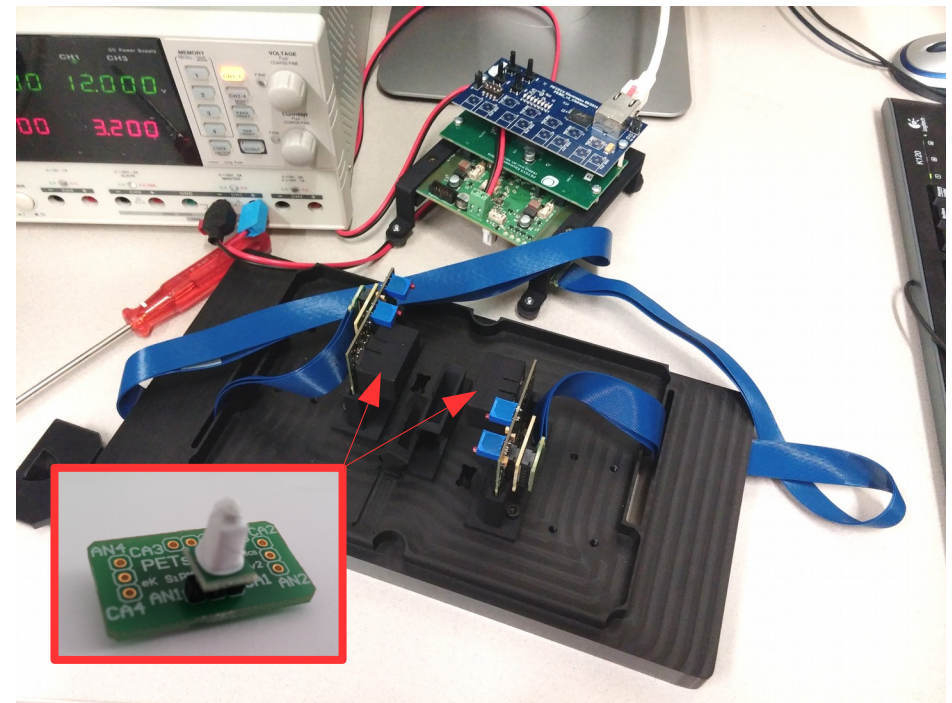
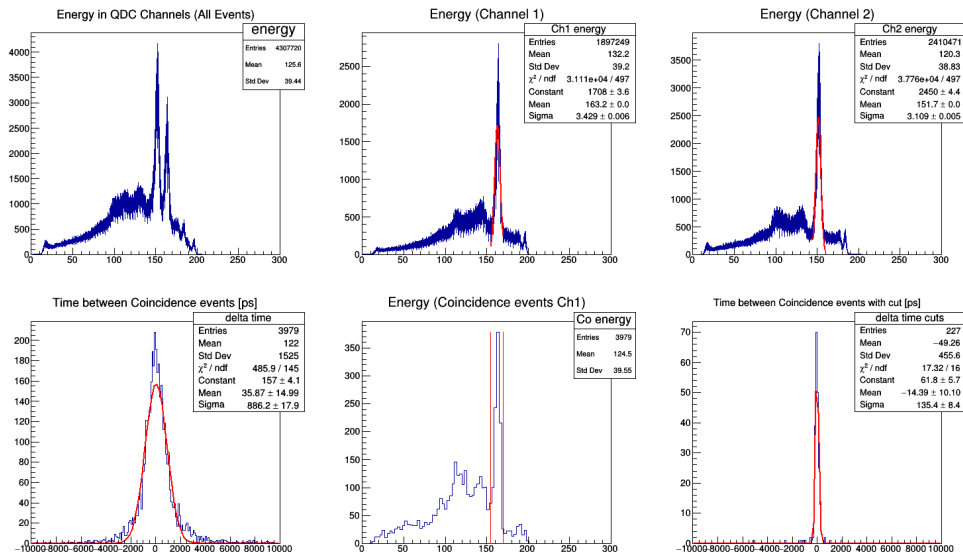
- Detector is designed to be cable less
- Space efficient
 - Signal transmission and mechanical support combined into PCB
- Crosstalk potentially an issue
- Testing of multiple new designs integrated into one half-length 16 layer PCB
- Includes designs with
 - Two separate ground layers
 - One ground layer
 - Shuffled lines

Railboard v 2.0

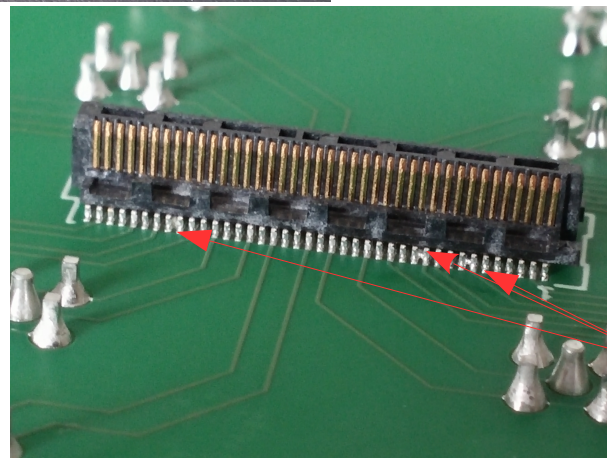
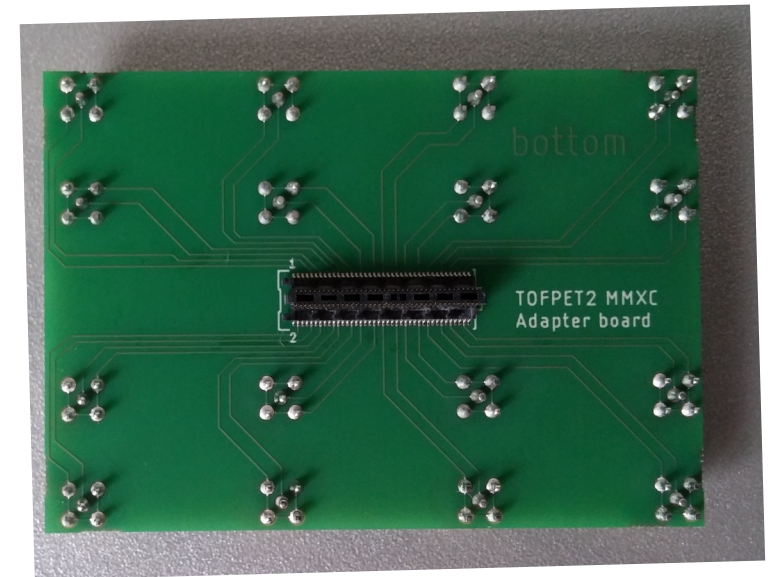
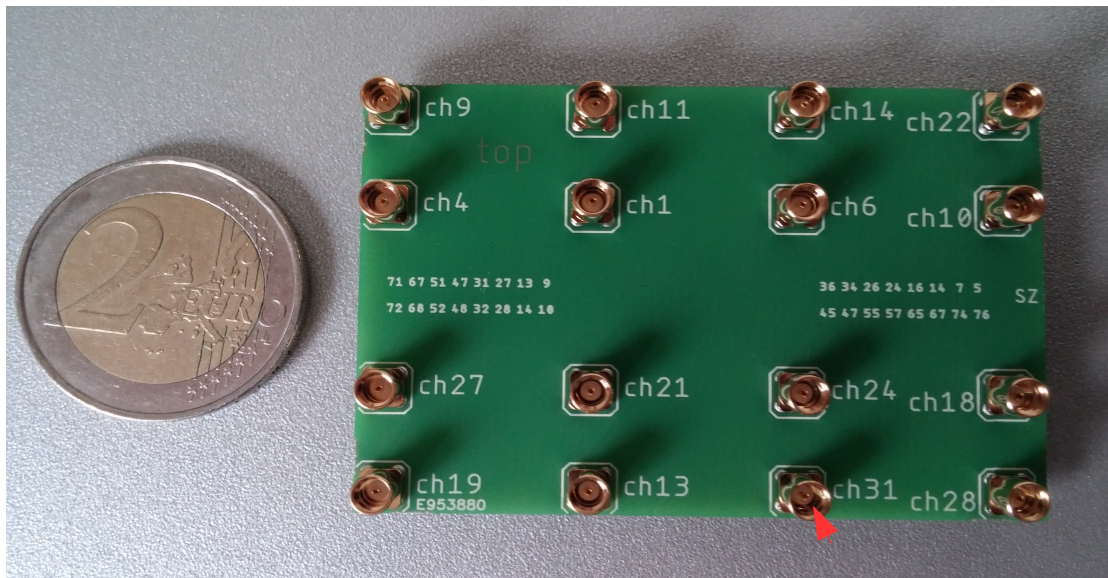


TOFPET2 Readout

- TOFPET2 by PETsys Electronics
 - Readout ASIC
- Time resolution of 135.4 ps reached in ^{22}Na coincidence measurement
- Will be tested with our dual module and the Railboard



TOFPET v2 Adapter Board



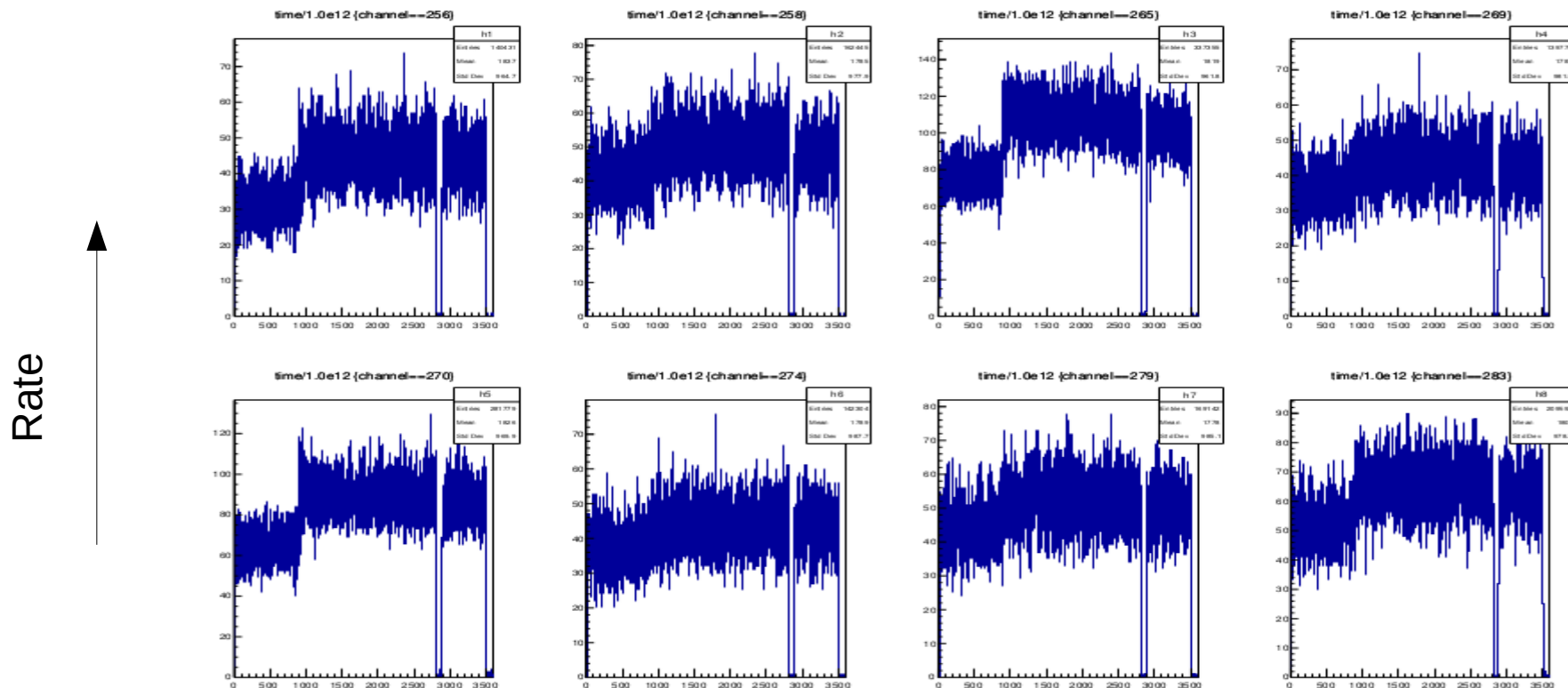
Unclean soldering
But most other boards
are fine

Tested the TOFPETv2 in Gießen

- Took the TOFPET v2 kit to Gießen
 - For them to test it
 - They are considering upgrading from v1
- Tested it with local setup (46 channels)
 - Worked with no problems except for connector issues
- Tested readout of PMTs and MCPs
 - Opposite polarity signals
 - Calibration procedure needed to be altered to accommodate external power supply
 - Took a lot of tweaking parameters and thresholds
- Had some rate stability issues (not stable)

Measurement unstable

- Cosmics on large scintillating plate read out by 8 PMTs



Summary

- 2 Temp sensors tested, decision pending
- Time Resolution of 52 ps achieved
- Thinner Scintillators (3 mm, 4mm) perform worse than 5 mm Scintillator
 - Worse time resolution
 - Less homogeneity
- The current design (5 mm) seems to be the best option
 - Polished scintillator seems to outperform the regular 5 mm plate
- New Railboard design will be tested
- TOFPET2 by PETsys performance with our hardware will be tested

Thank you for your attention!

Outlook

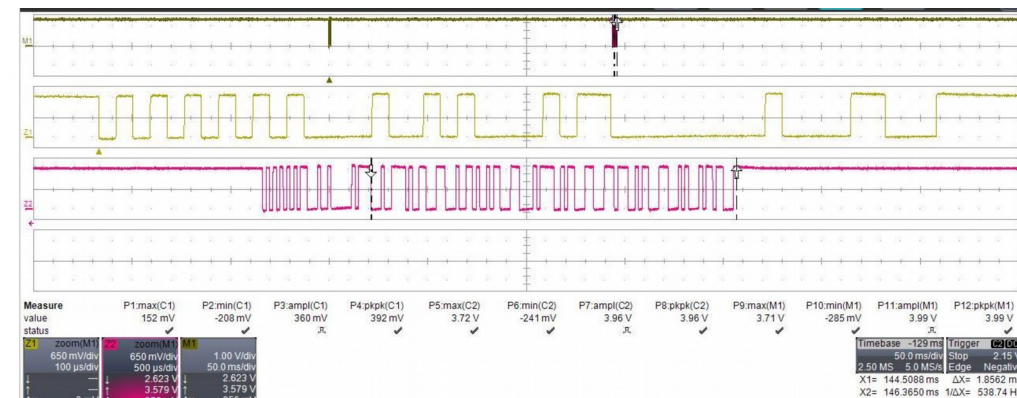
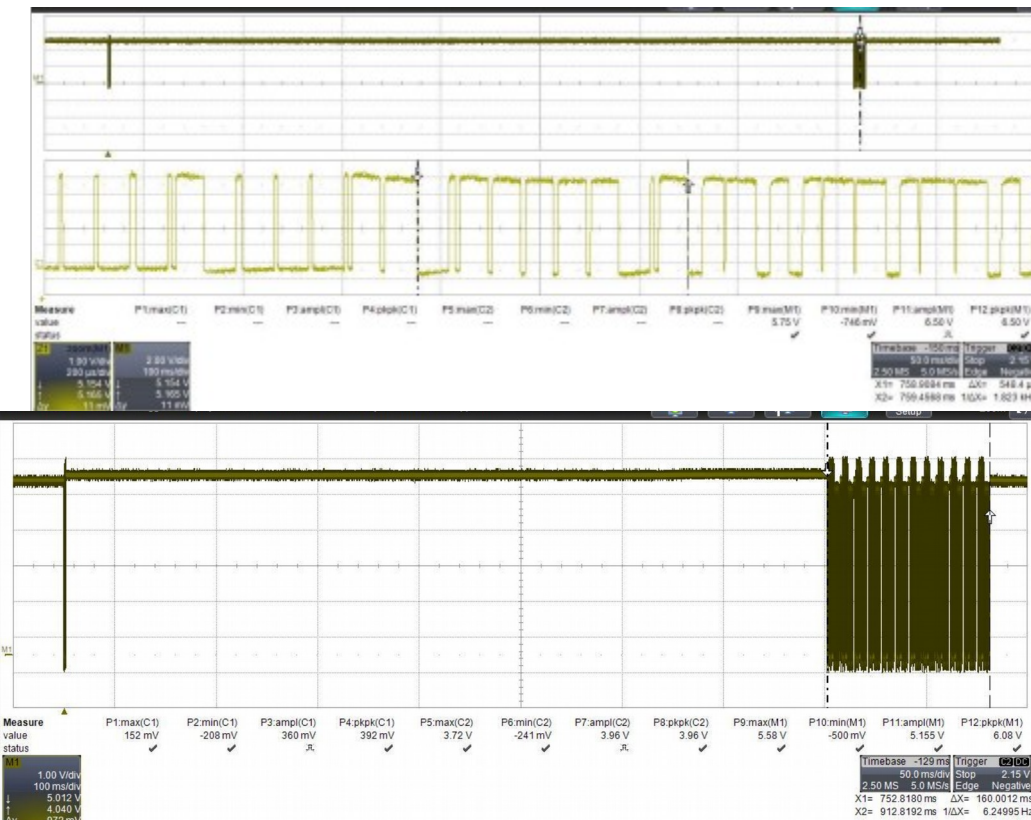
Thank you for your attention

Backup

Communication

- DS18B20

- TMP107



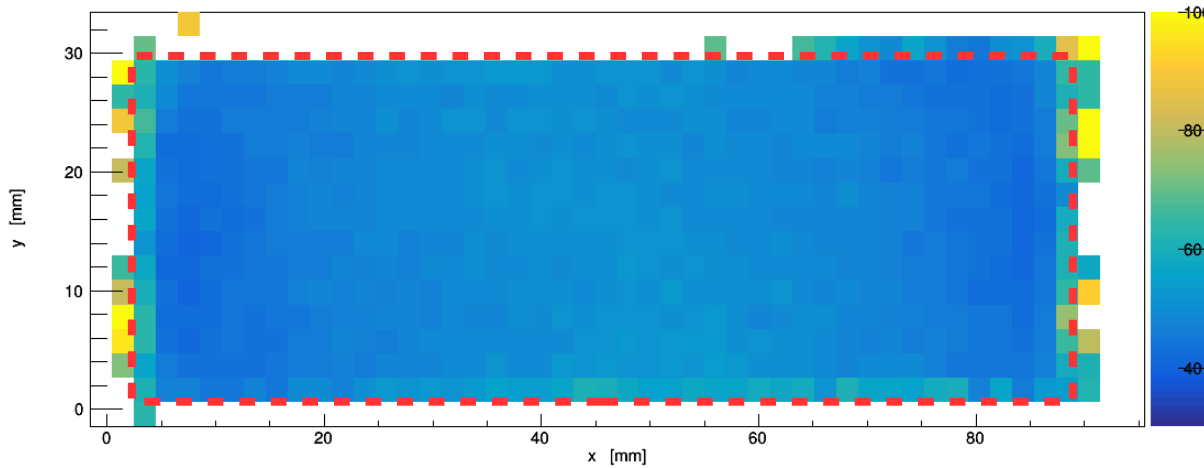
Communication is not affected by long transmission lengths. Tested up to 9 m

Script

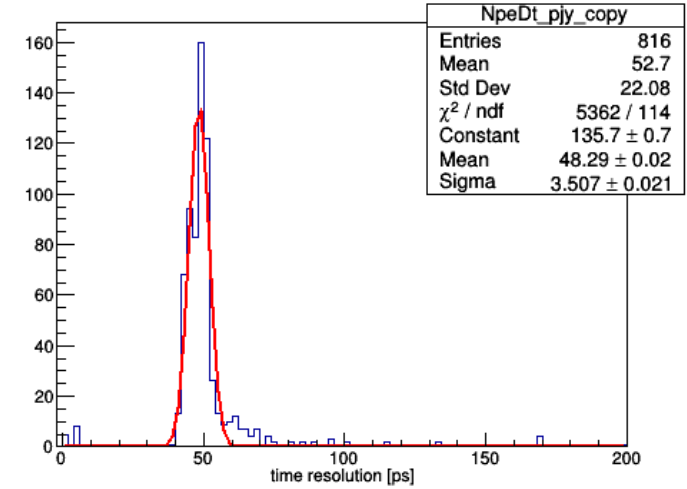
- Filtered out:
 - Points with less than 200 events
 - Non pedestal peak < 5
- Projections are summ of all bins in one direction scaled by the number of entered bins
 - Outer bins are skipped

Run 47 / 5 mm polished

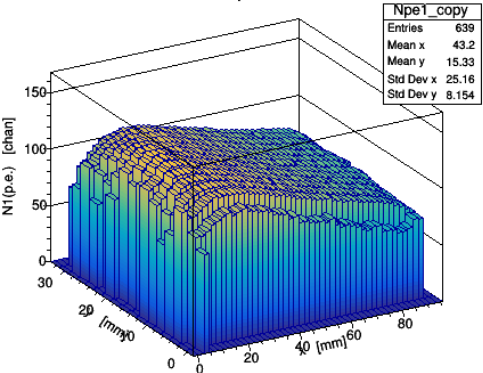
TDiff Resolution



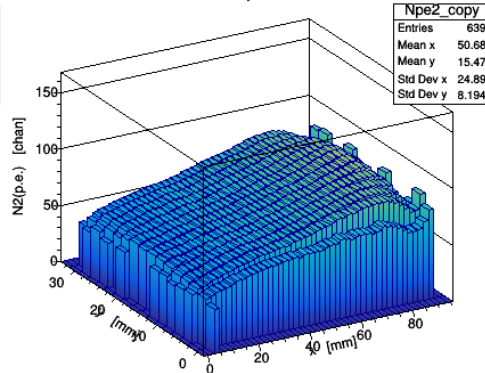
TimeresFit



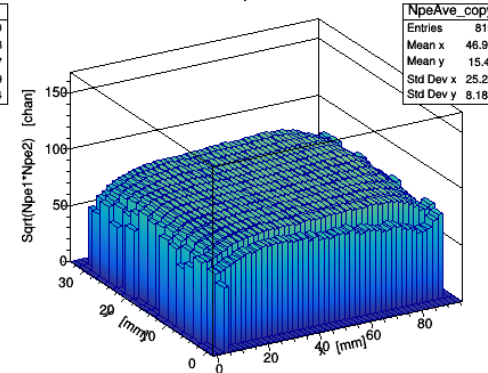
Npe1



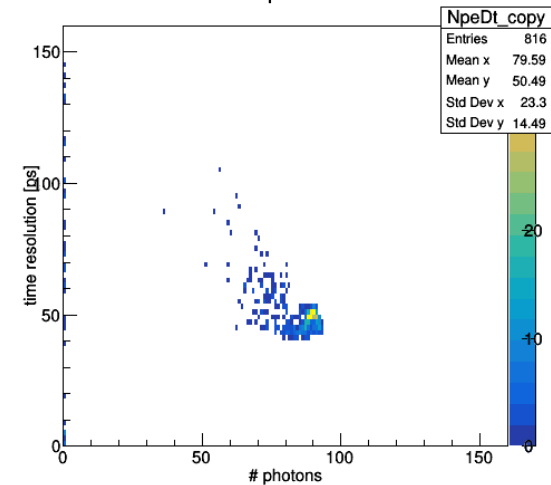
Npe2



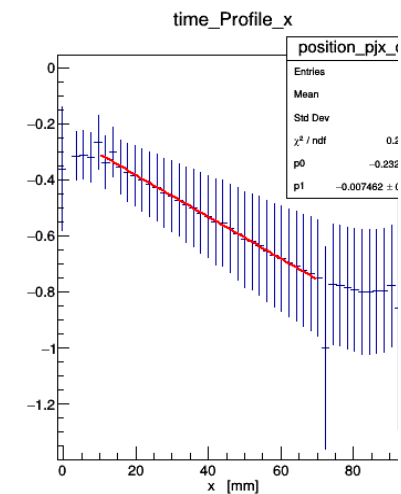
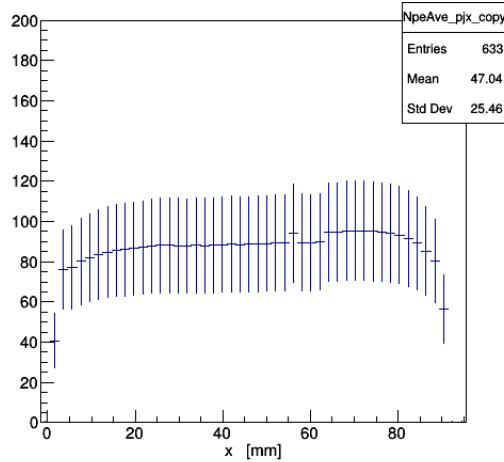
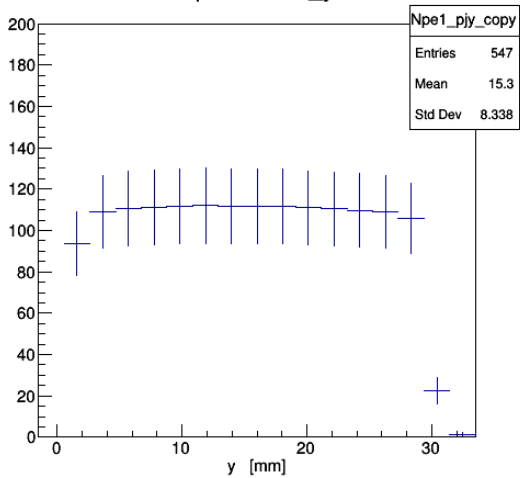
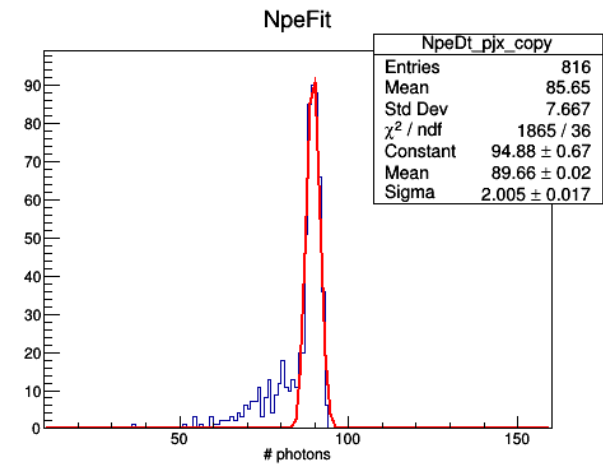
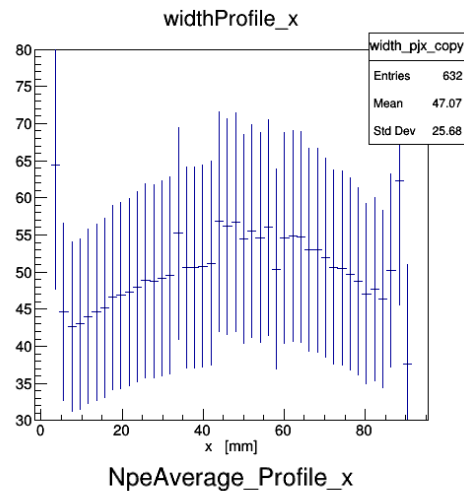
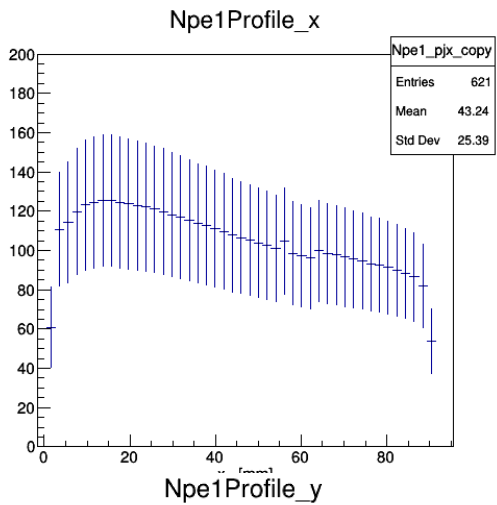
NpeAve



NpeDt

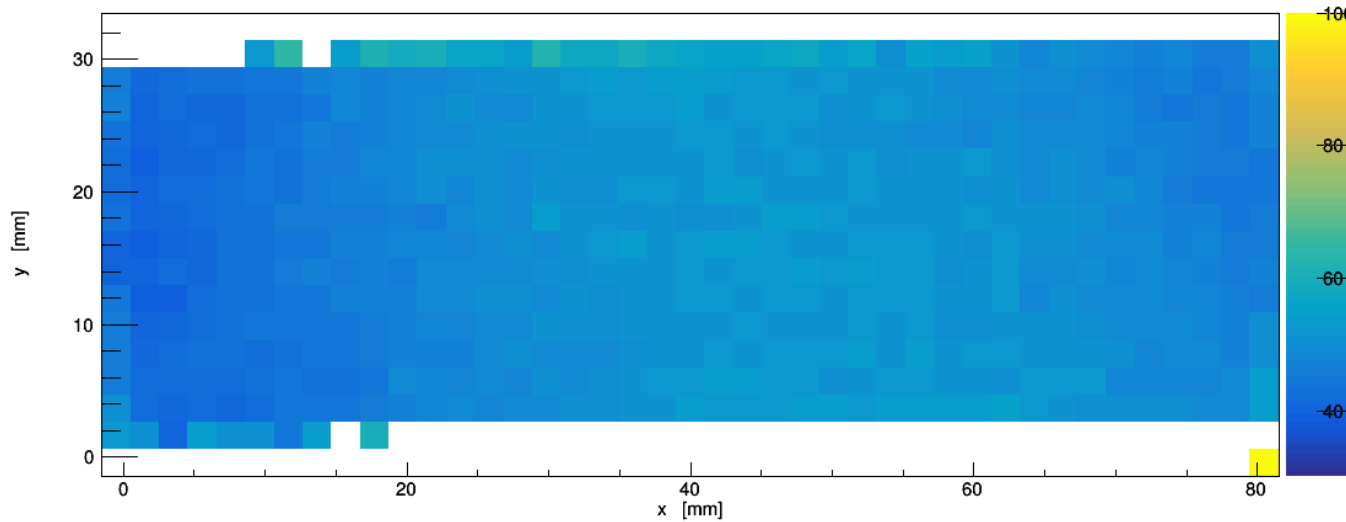


Run 47 / 5 mm polished

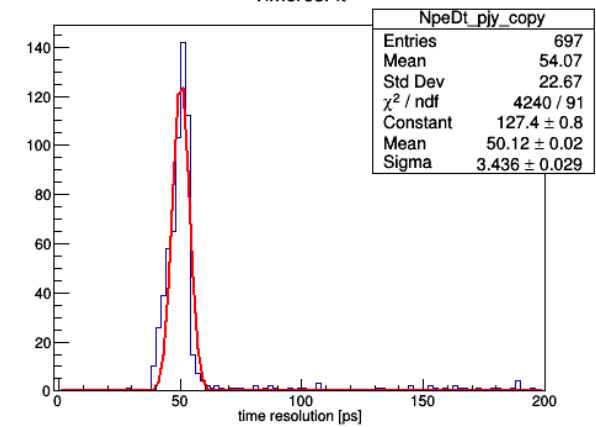


Run 17 / 5 mm unwrapped

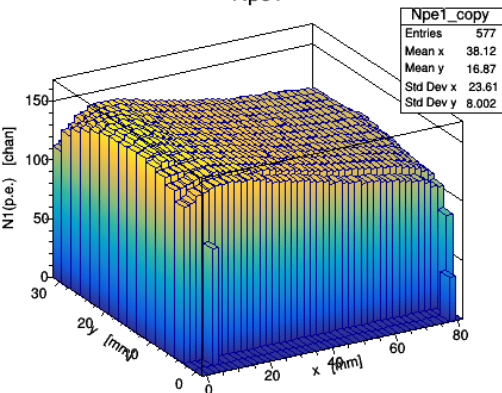
TDiff Resolution



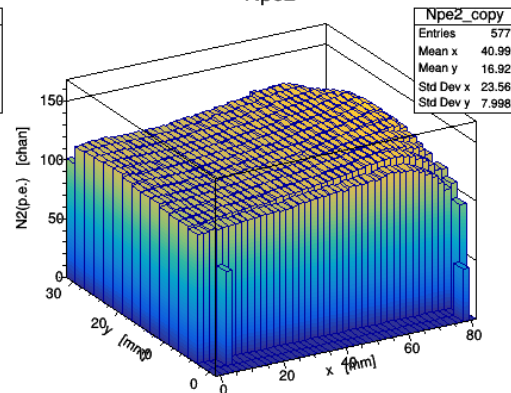
TimeresFit



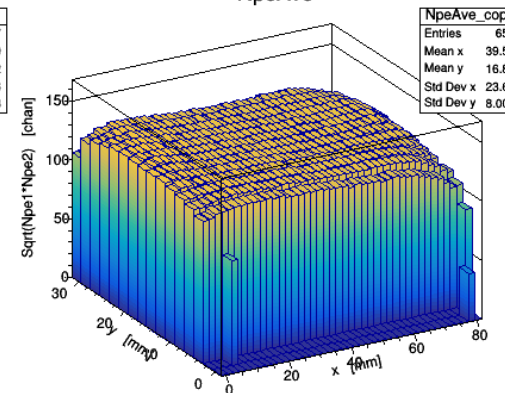
Npe1



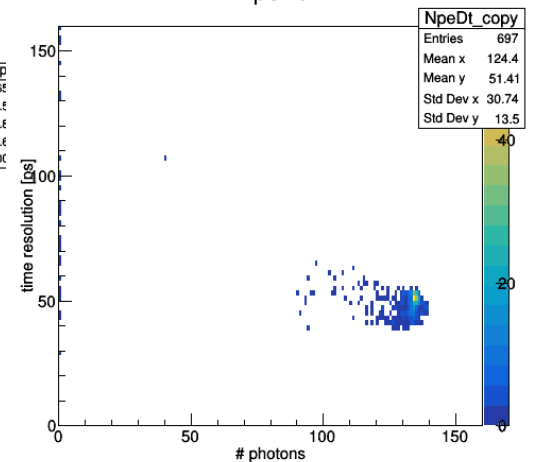
Npe2



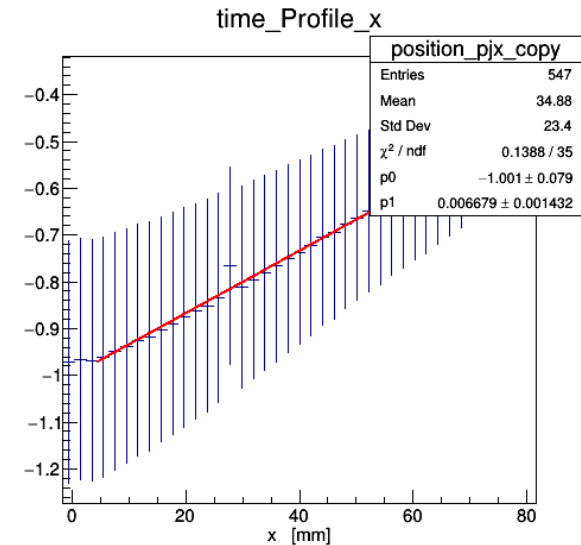
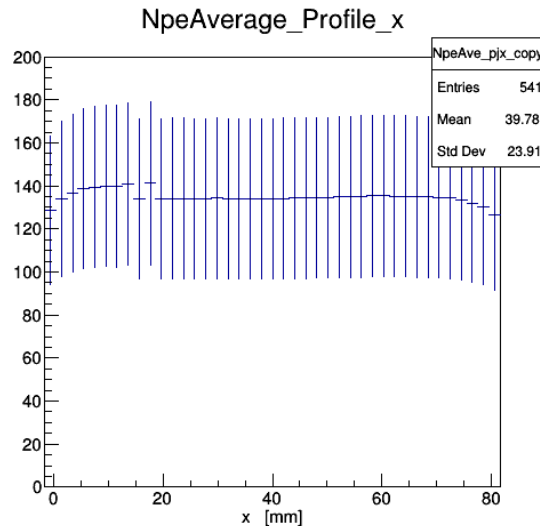
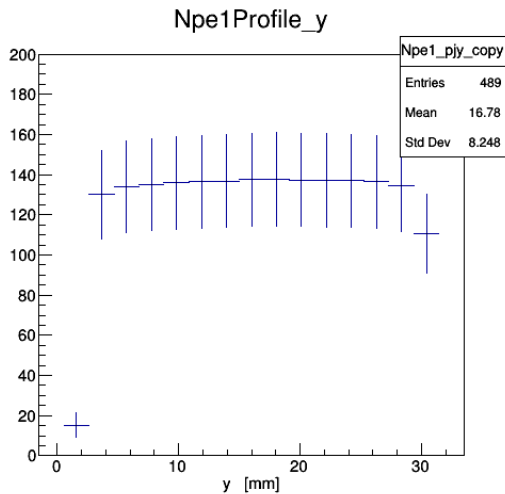
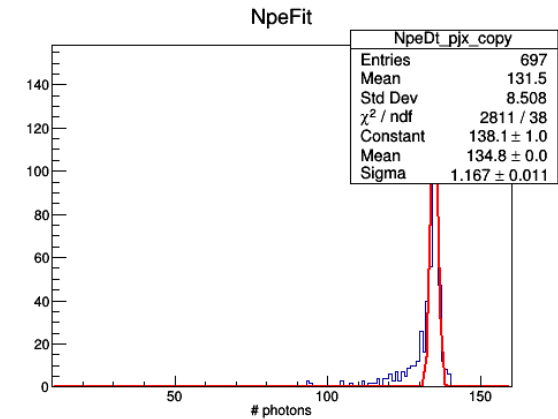
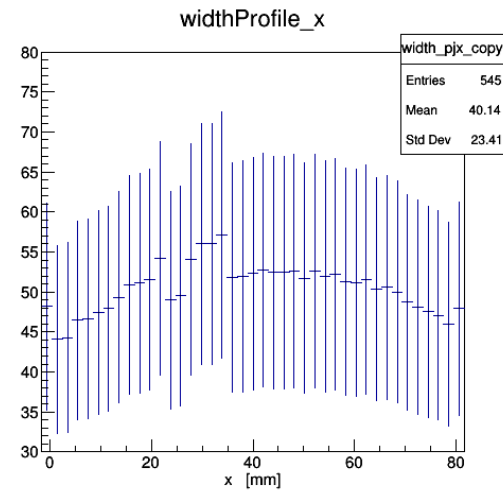
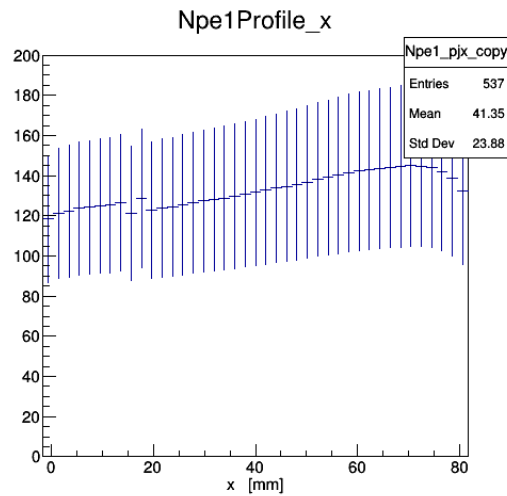
NpeAve



NpeDt

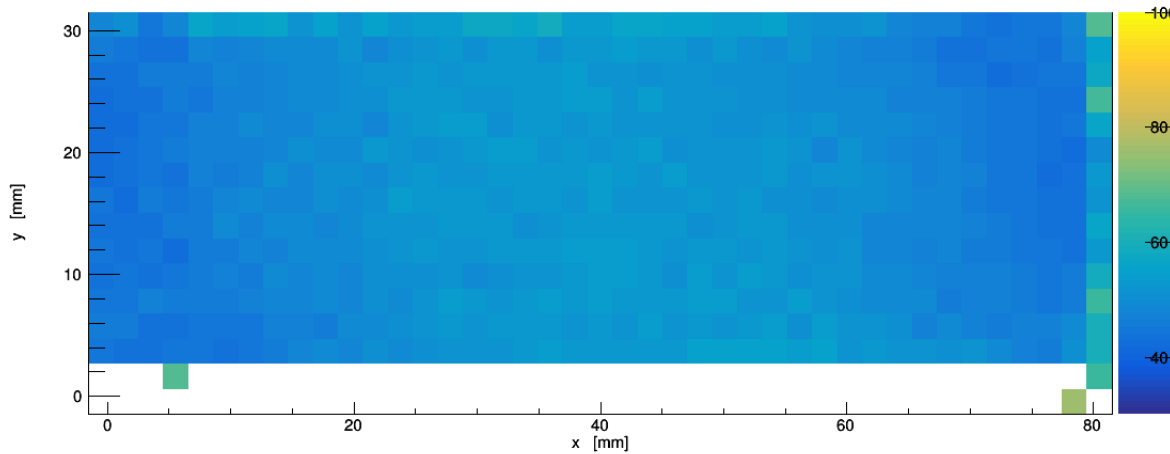


Run 17 / 5 mm unwrapped

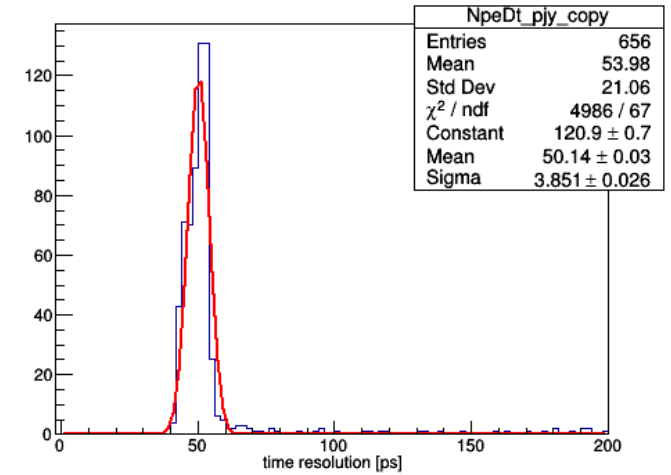


Run 22 / 5 mm wrapped

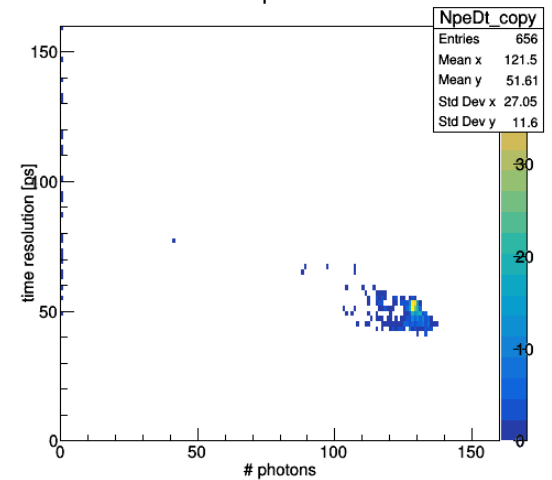
TDiff Resolution



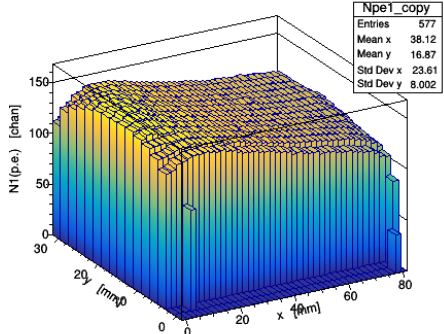
TimeresFit



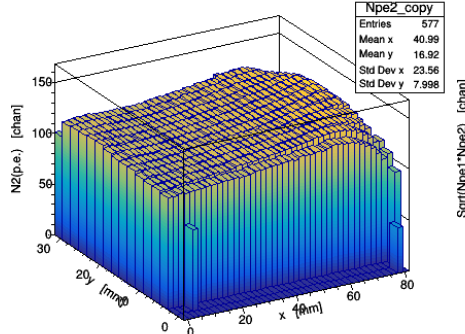
NpeDt



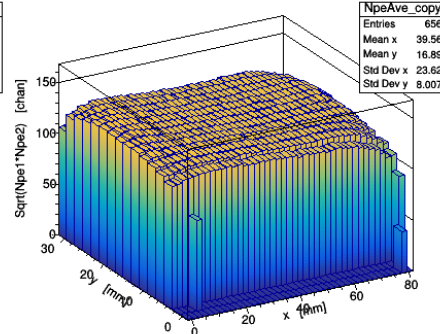
Npe1



Npe2

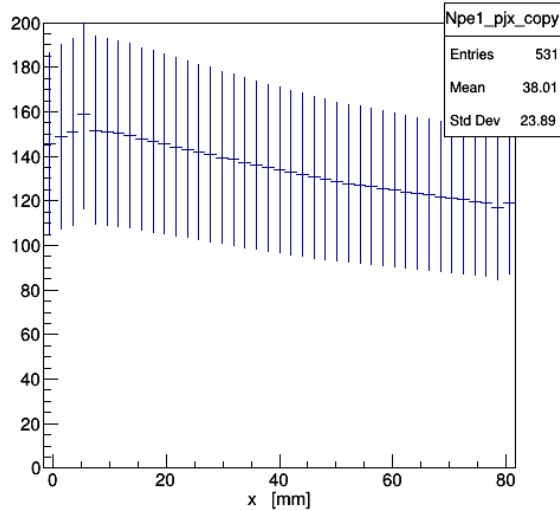


NpeAve

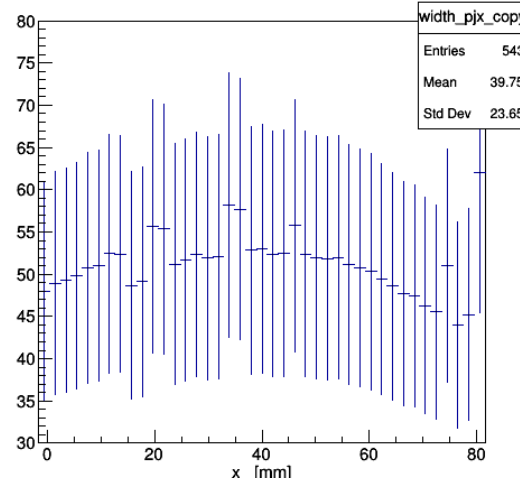


Run 22 / 5 mm wrapped

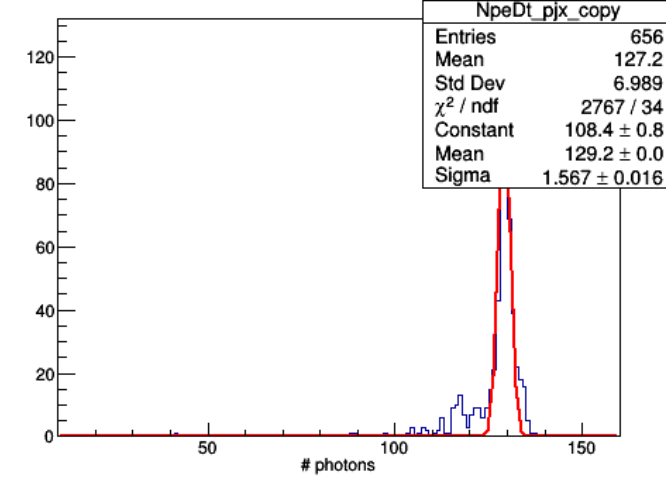
Npe1Profile_x



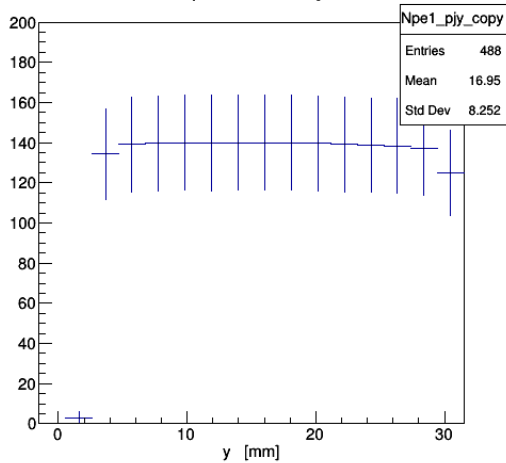
widthProfile_x



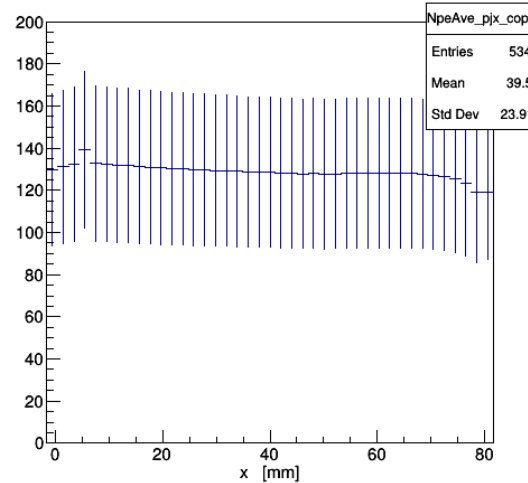
NpeFit



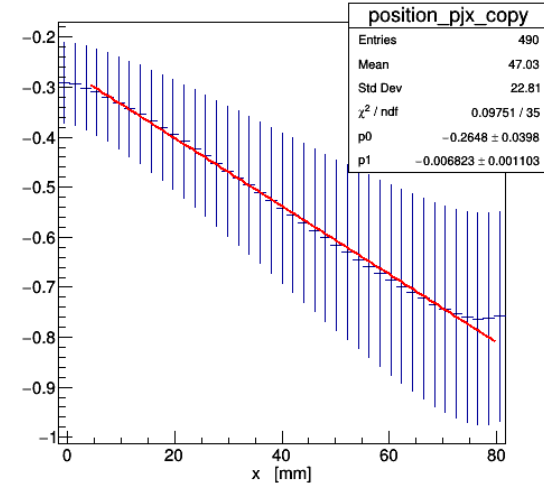
Npe1Profile_y



NpeAverage_Profile_x

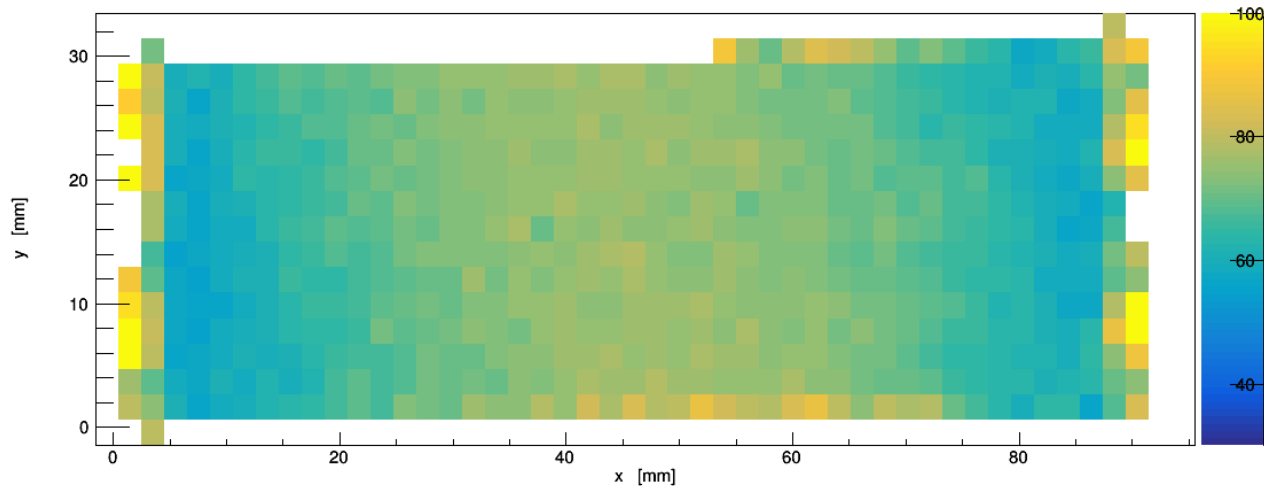


time_Profile_x

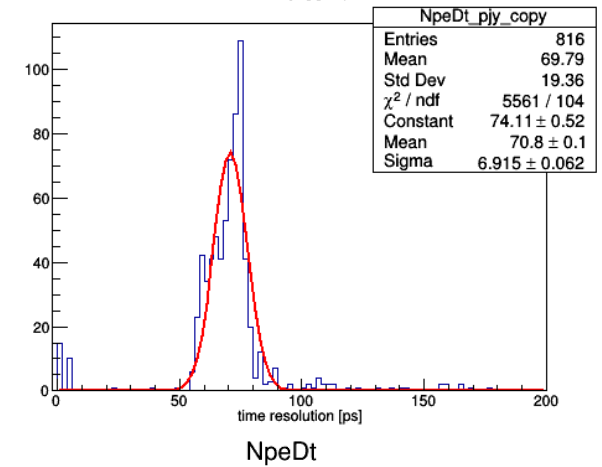


Run 48 / 5 mm quenched

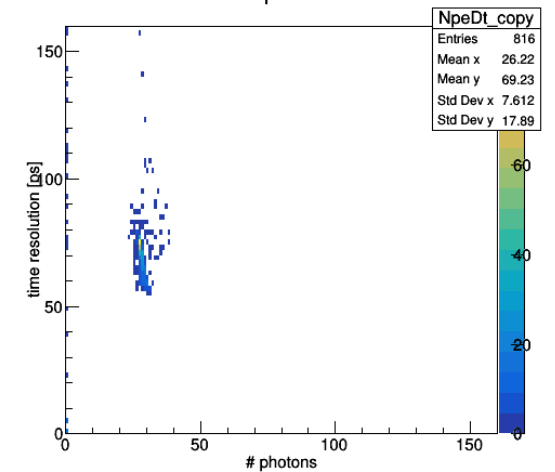
TDiff Resolution



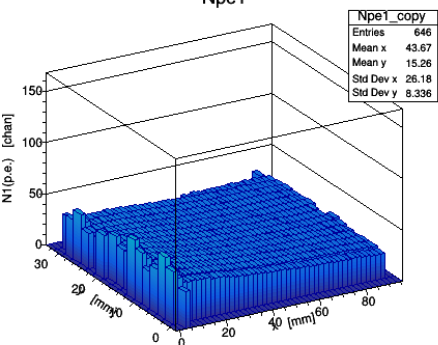
TimeresFit



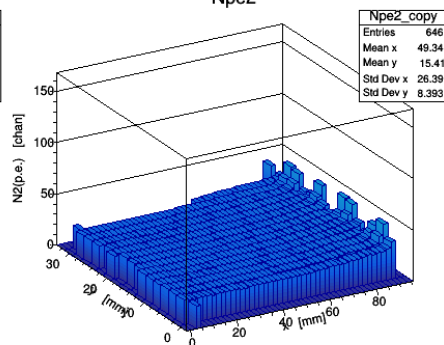
NpeDt



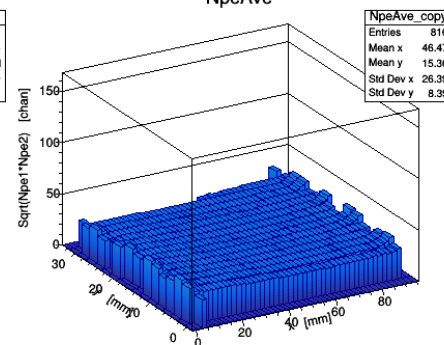
Npe1



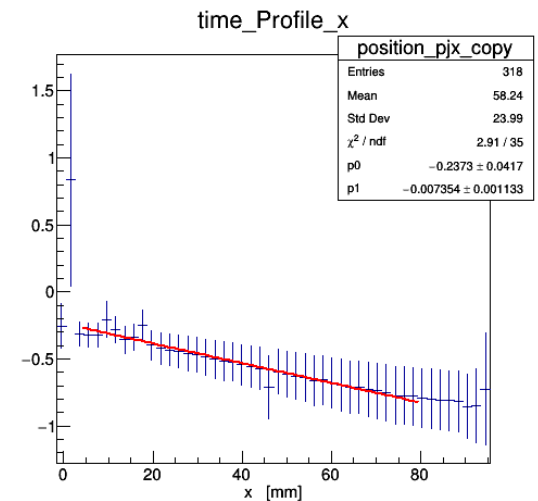
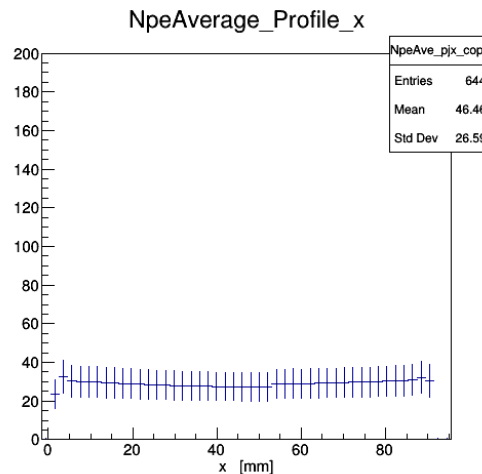
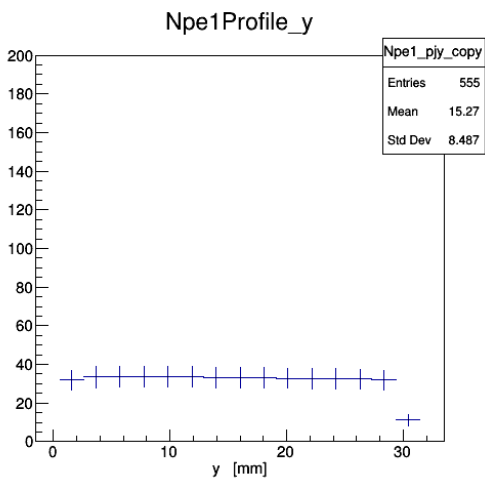
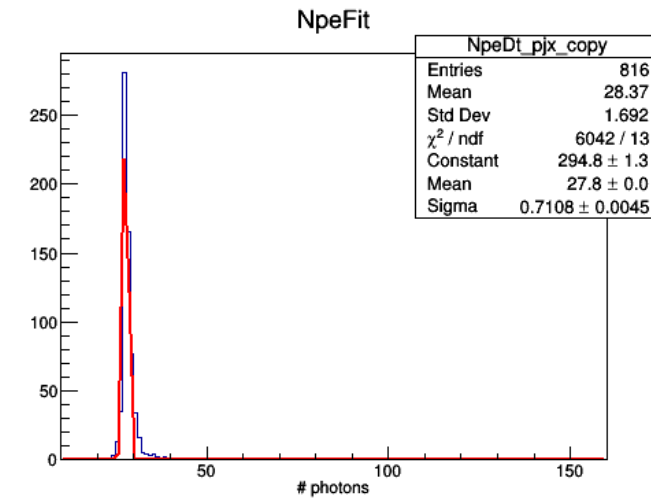
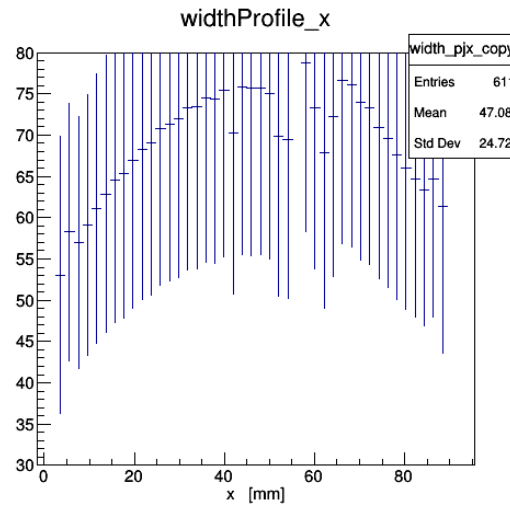
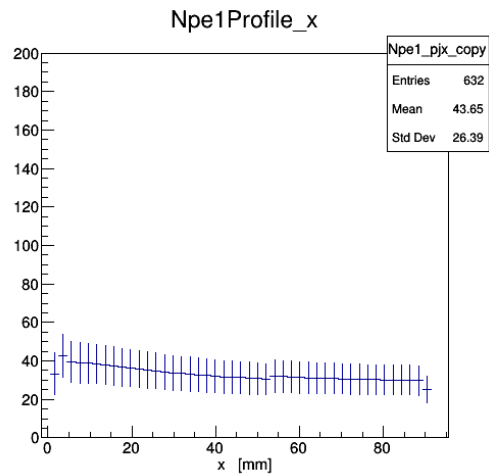
Npe2



NpeAve

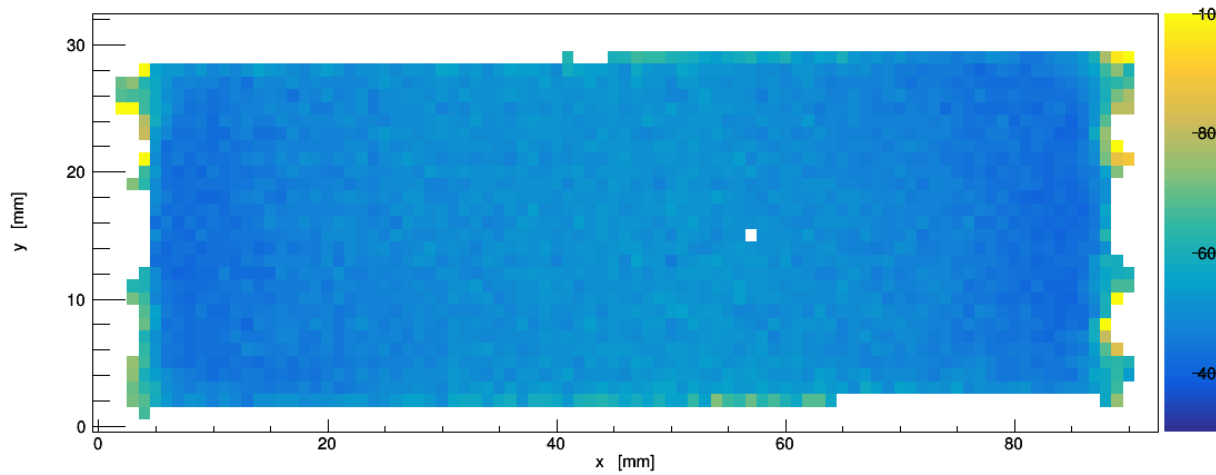


Run 48 / 5 mm quenched

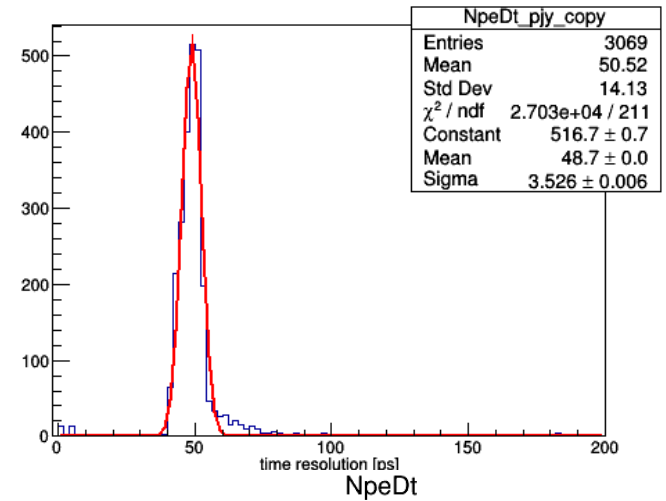


Run 46 / 6 mm

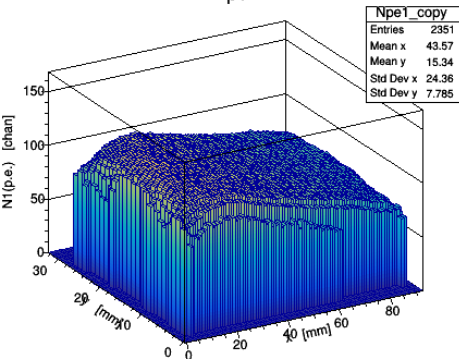
TDiff Resolution



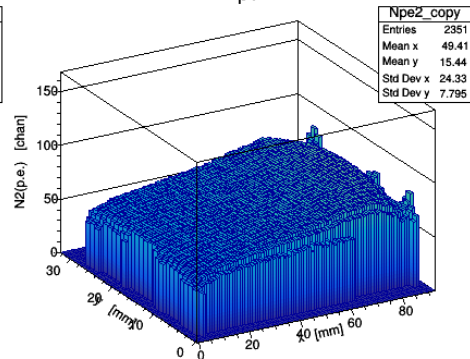
TimeresFit



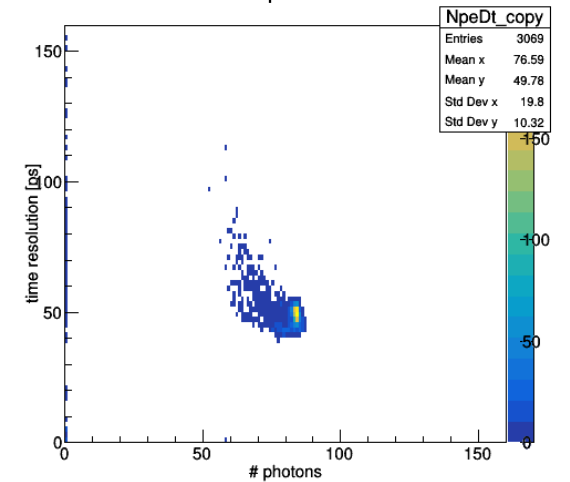
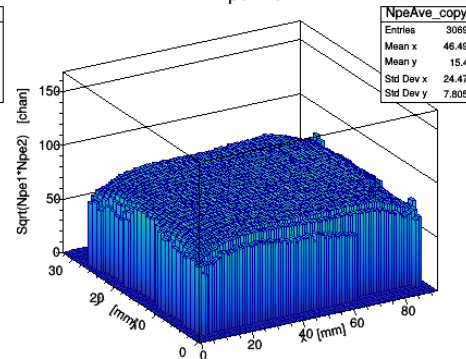
Npe1



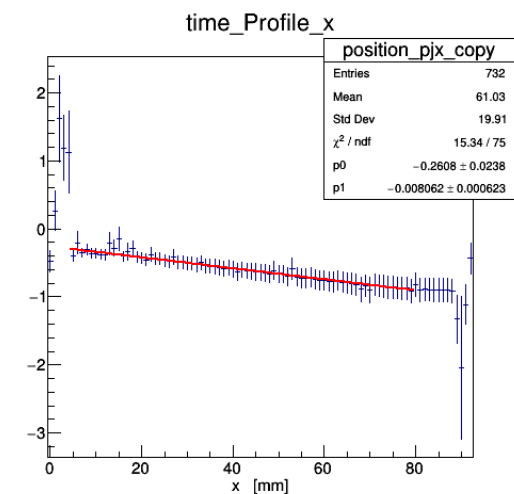
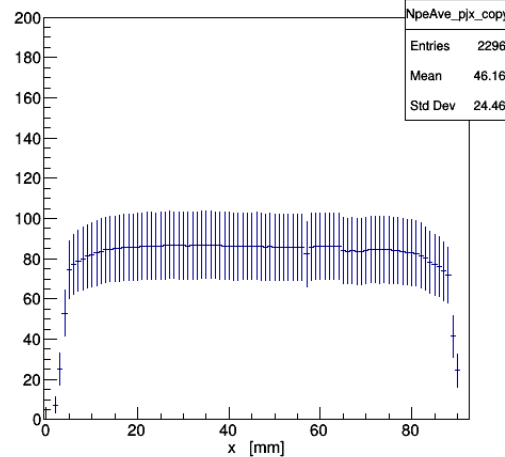
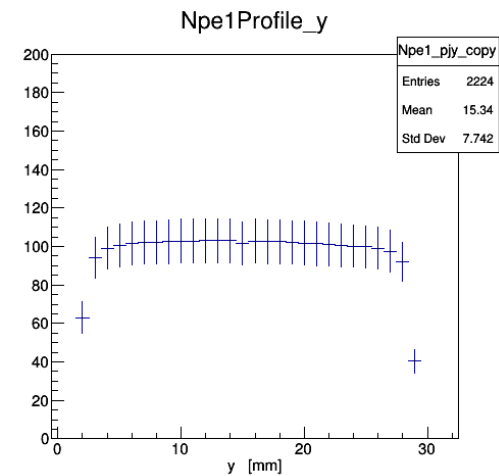
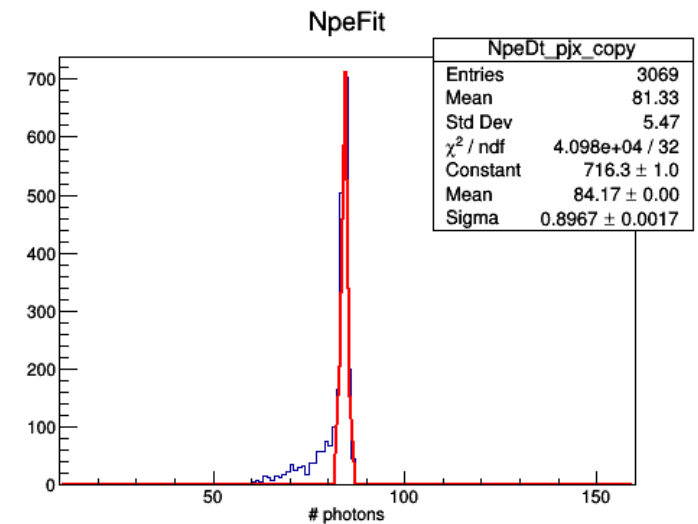
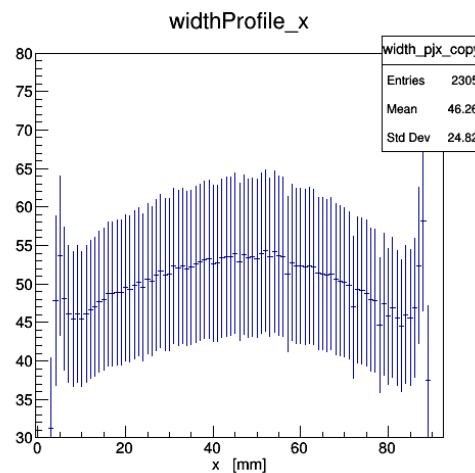
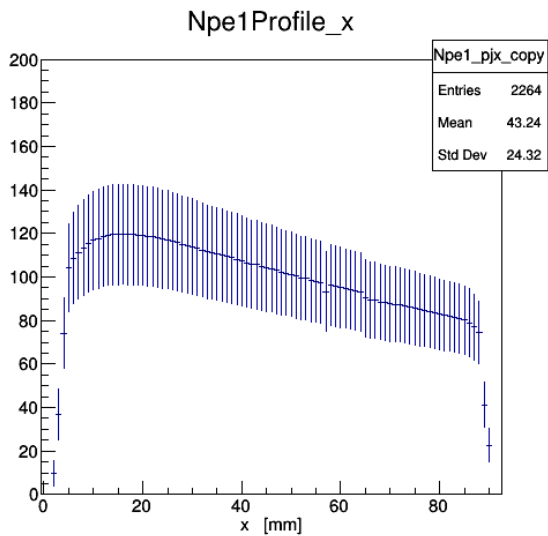
Npe2



NpeAve

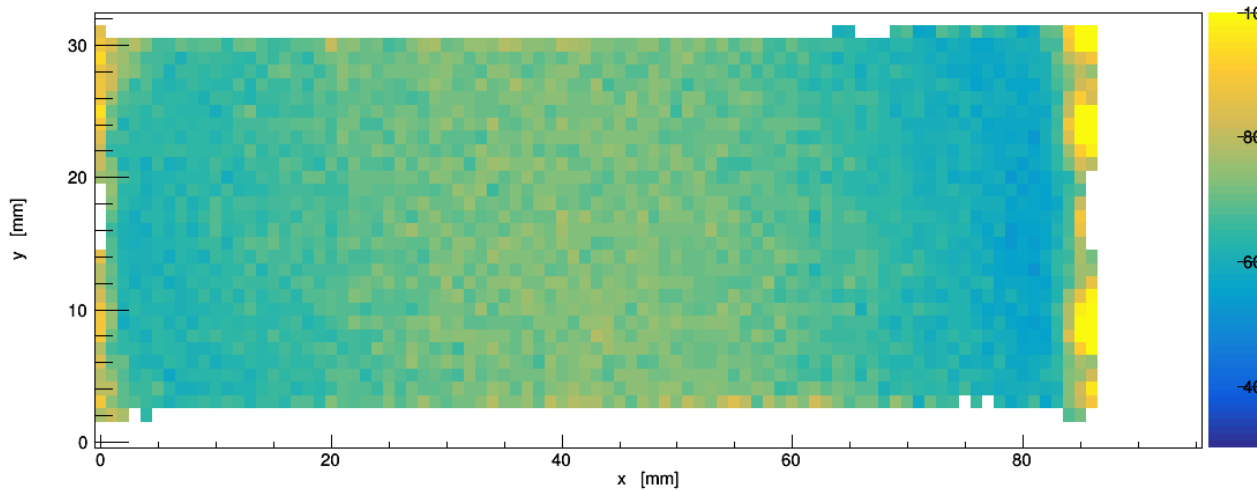


Run 46 / 6 mm

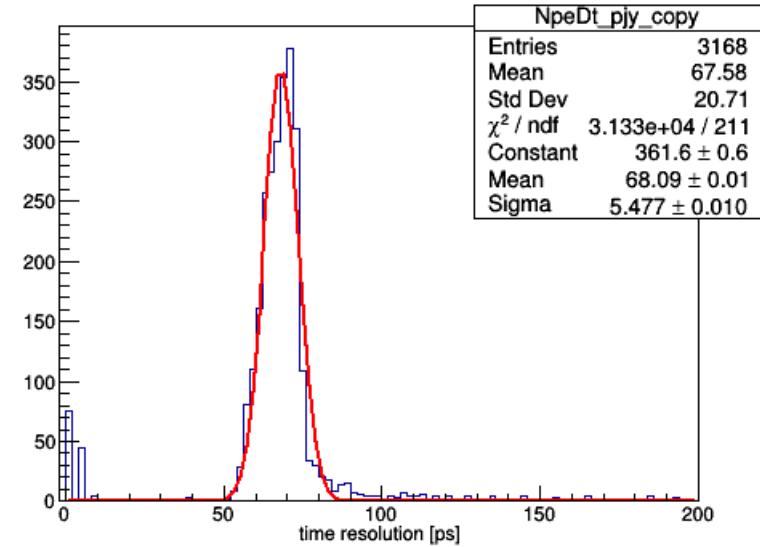


Run 44 / 4 mm

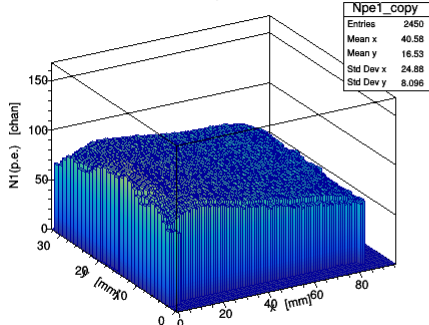
TDiff Resolution



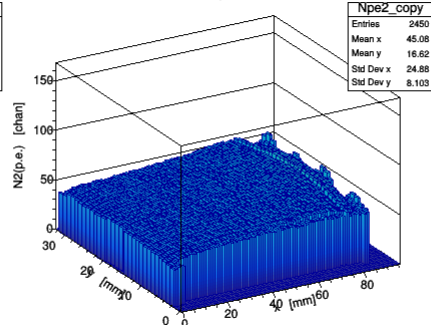
TimeresFit



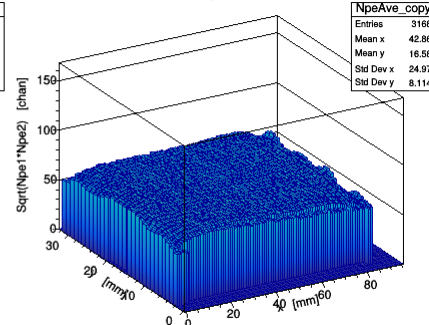
Npe1



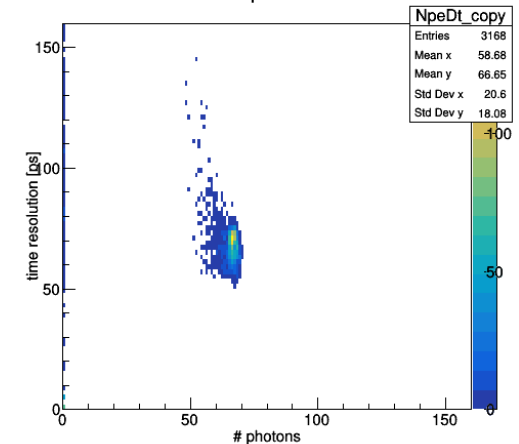
Npe2



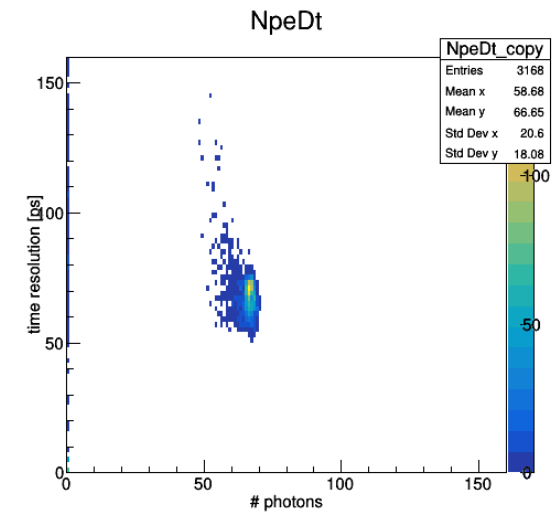
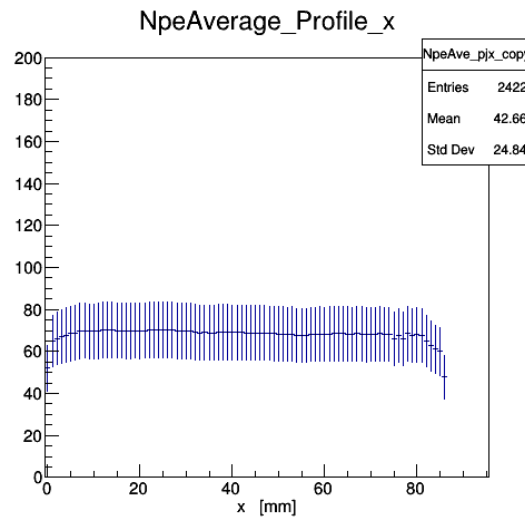
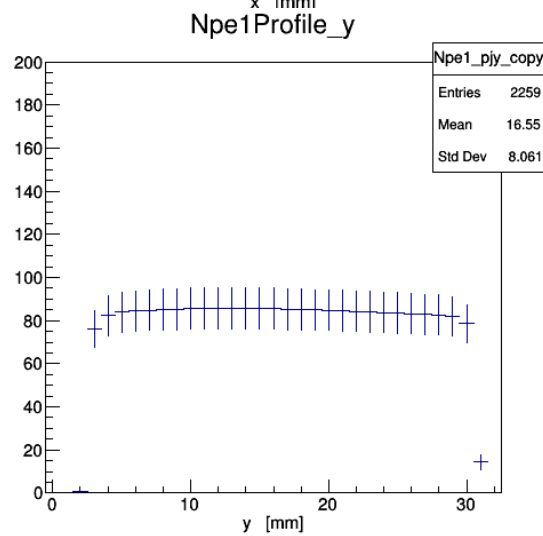
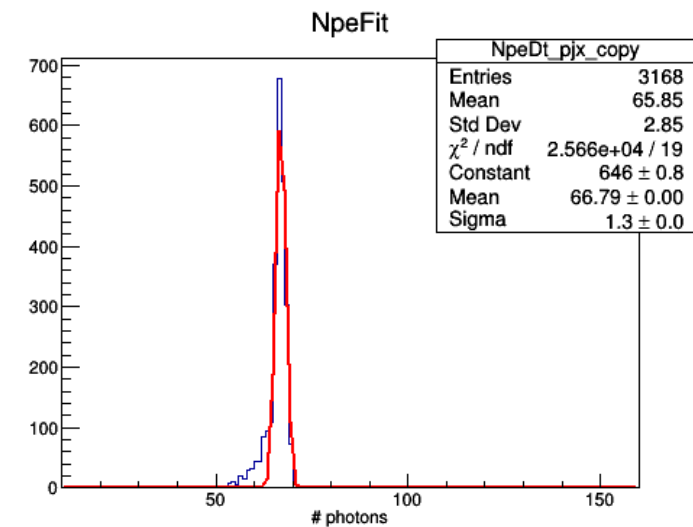
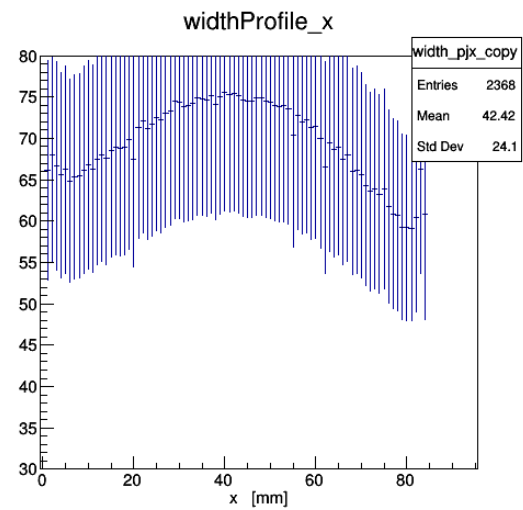
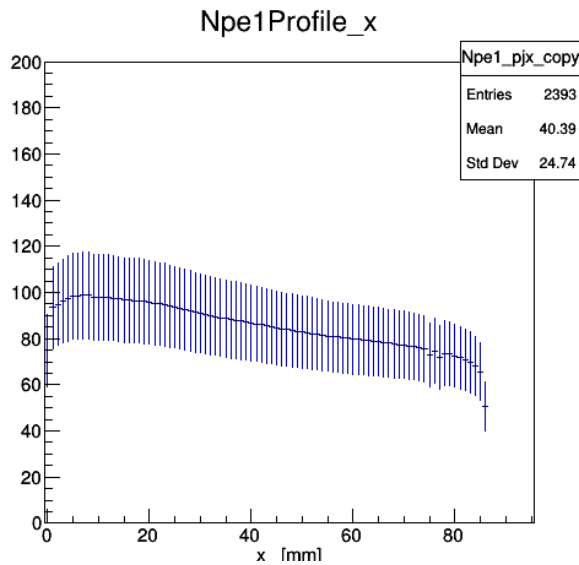
NpeAve



NpeDt

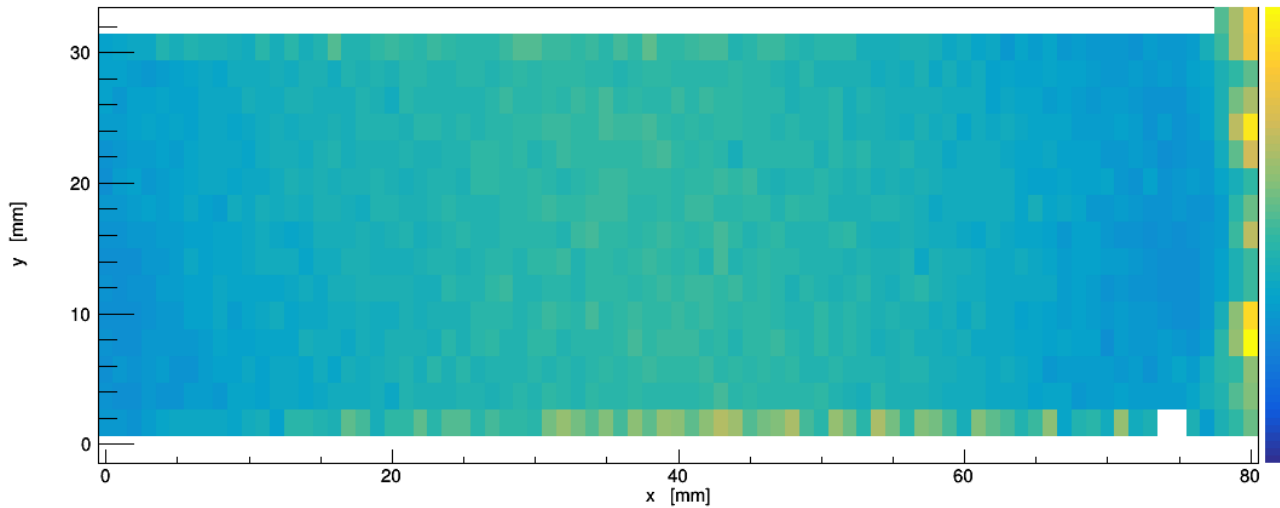


Run 44 / 4 mm

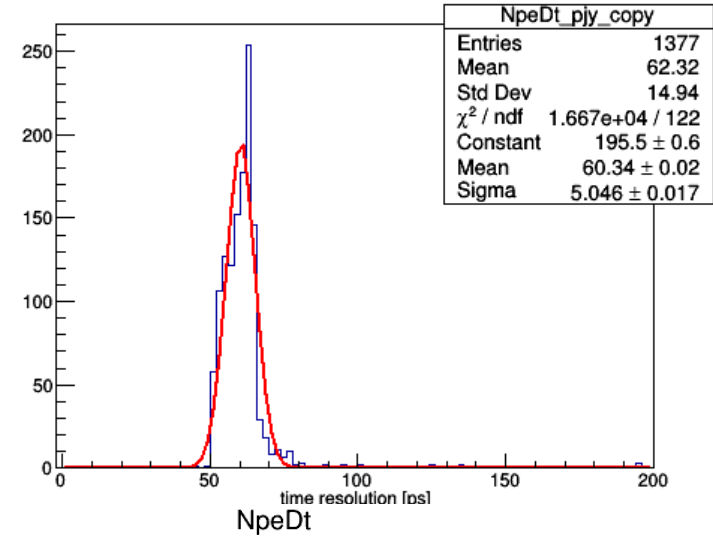


Run 38 / 3 mm

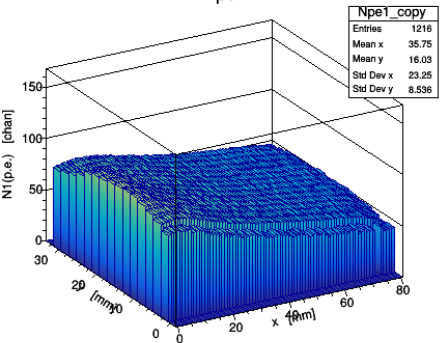
TDiff Resolution



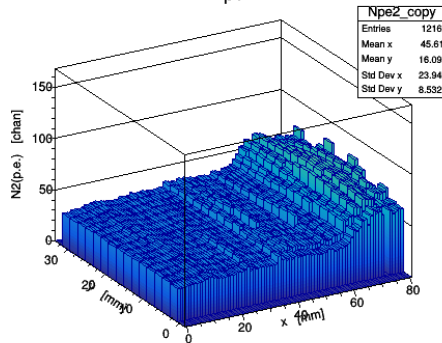
TimeresFit



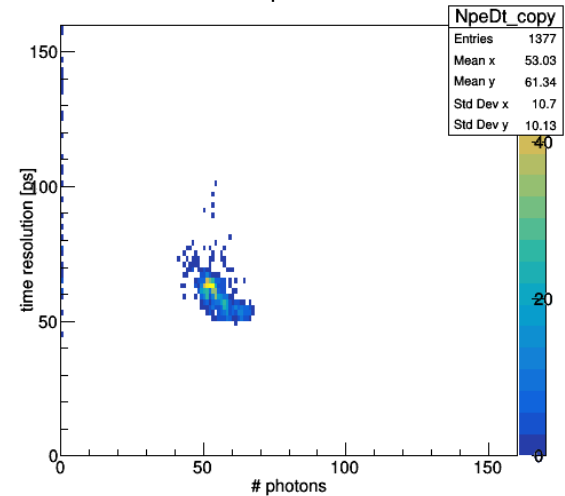
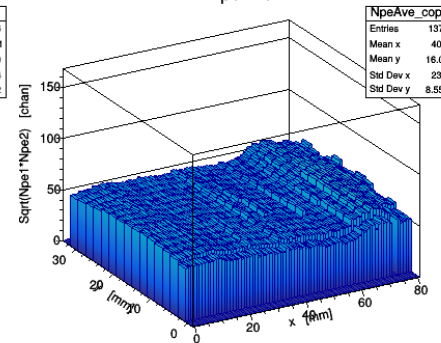
Npe1



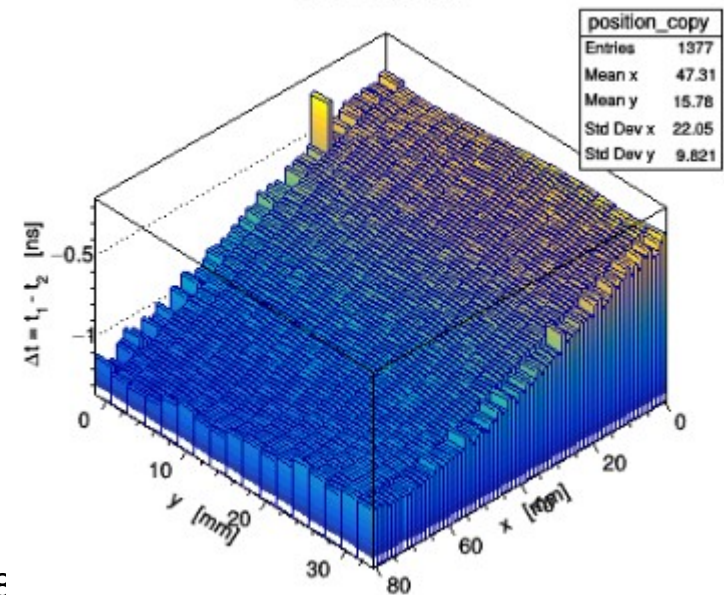
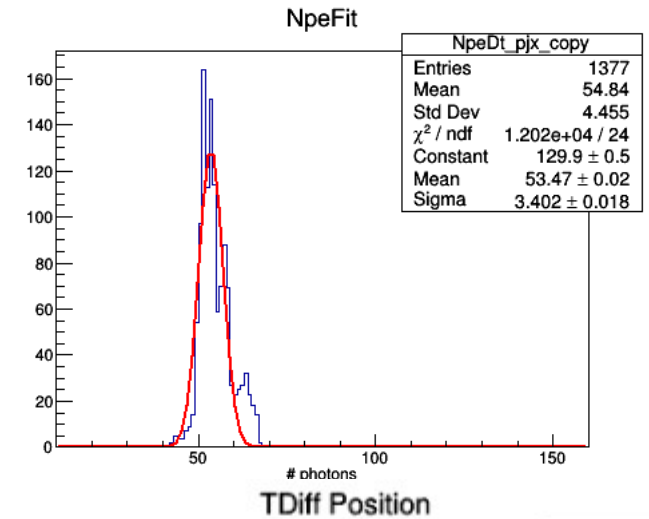
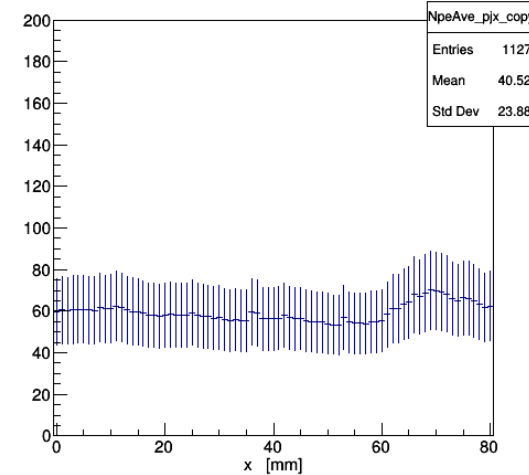
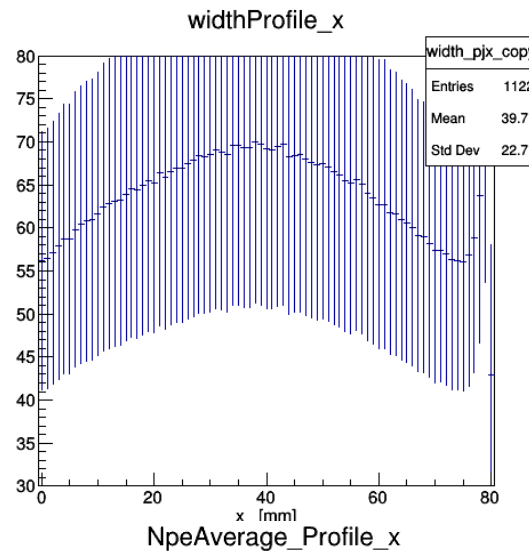
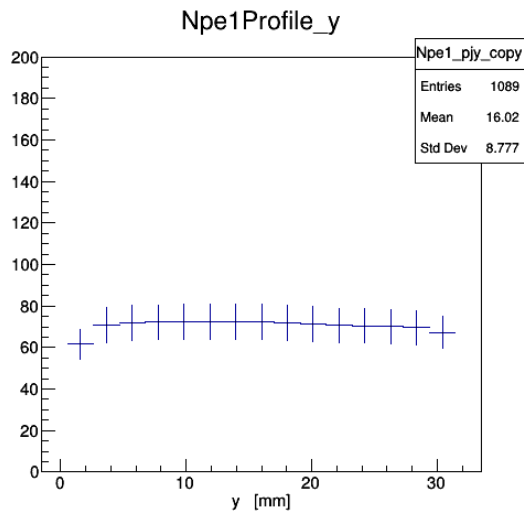
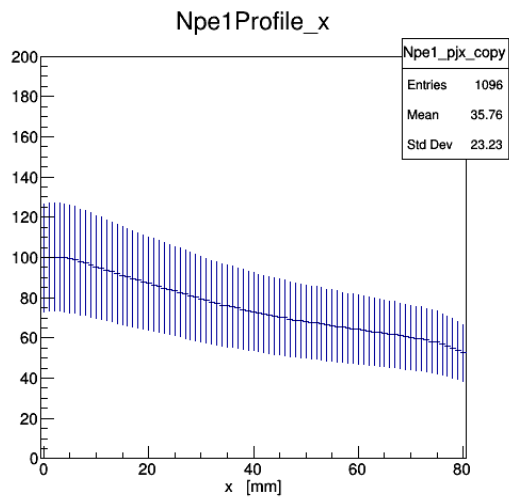
Npe2



NpeAve

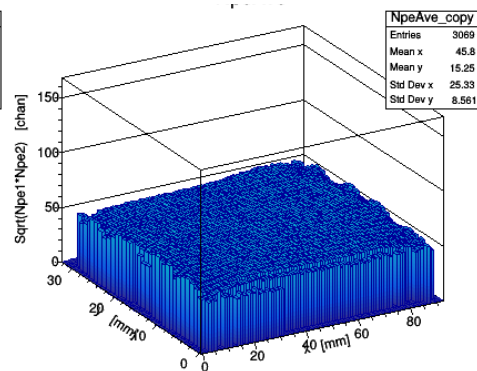
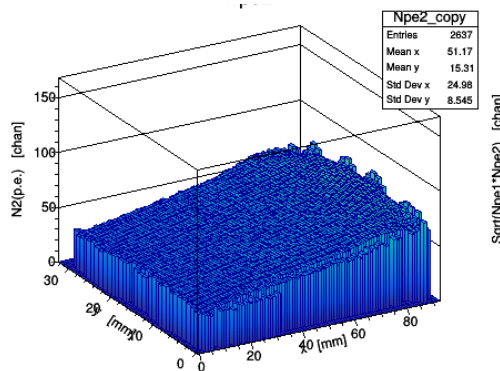
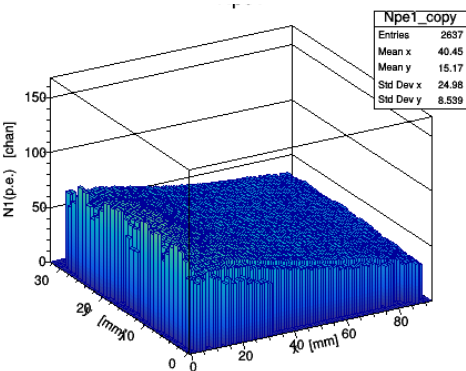
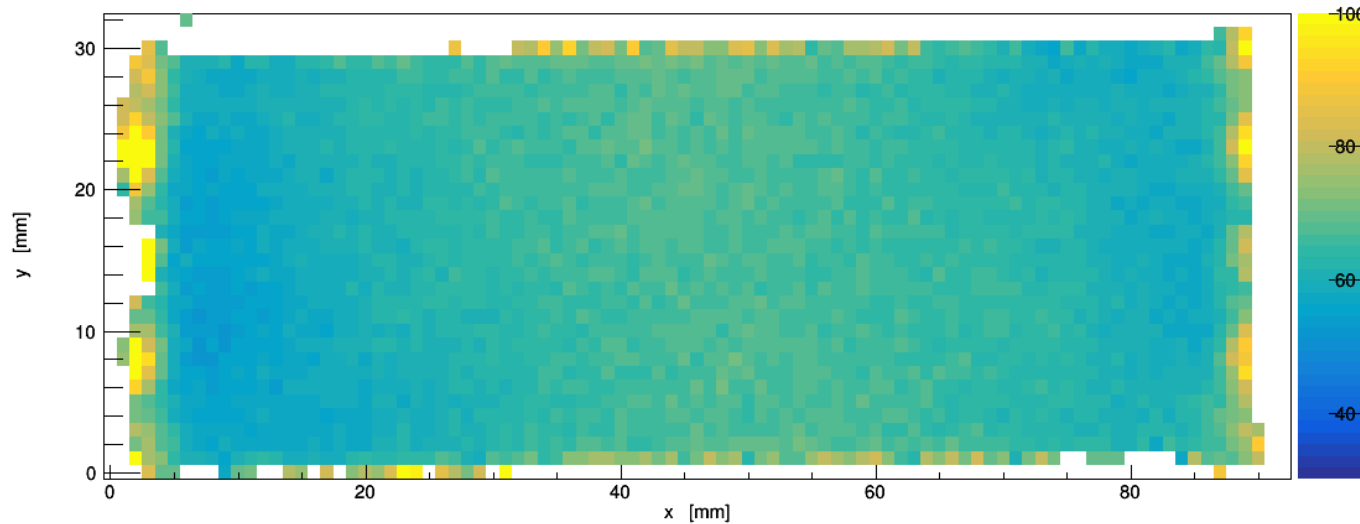


Run 38 / 3 mm

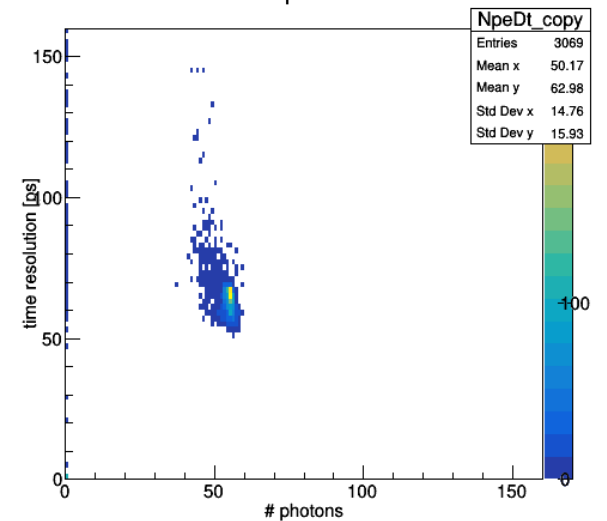


Run 49 / 3 mm

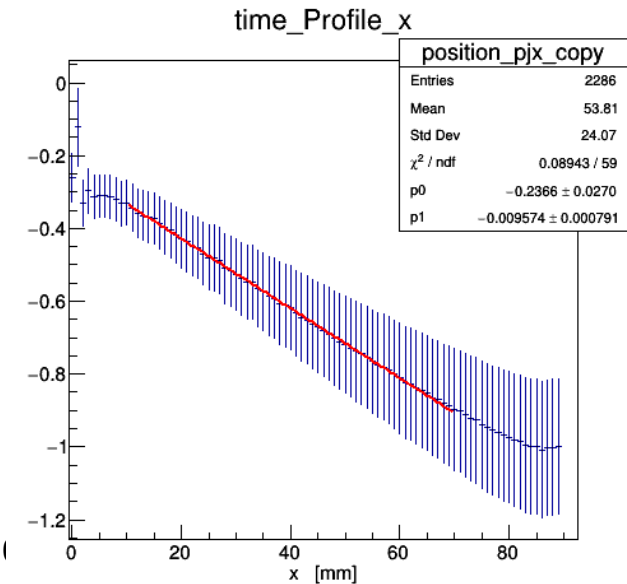
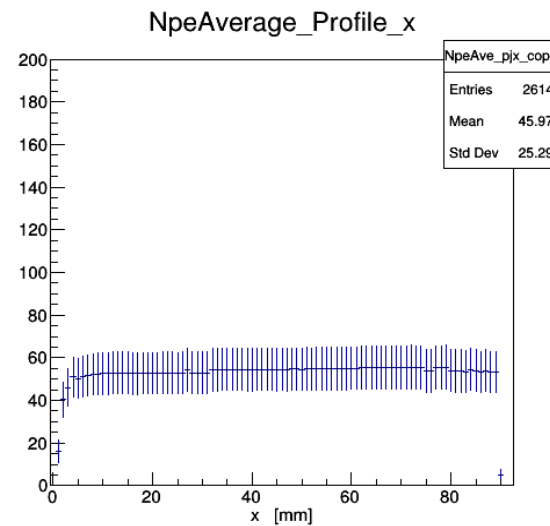
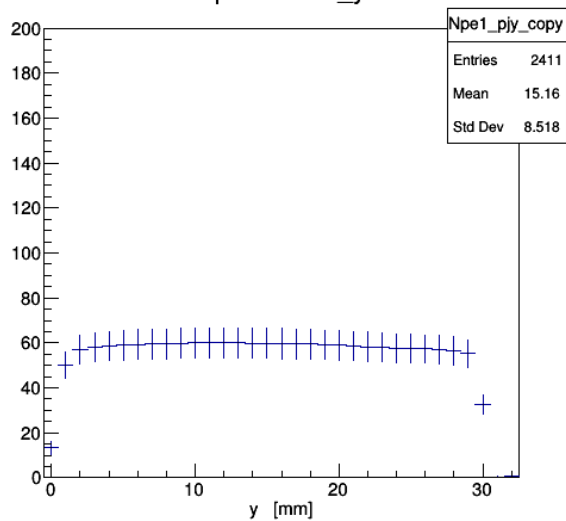
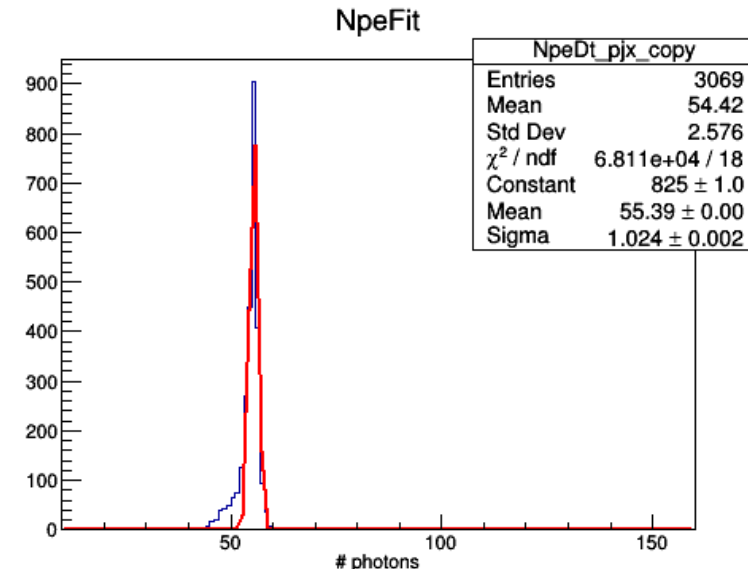
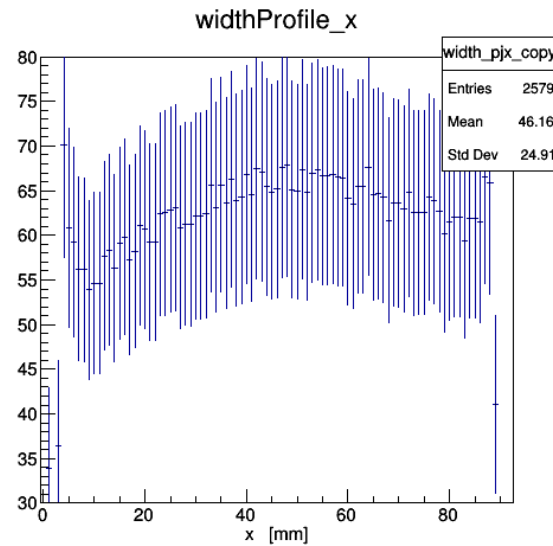
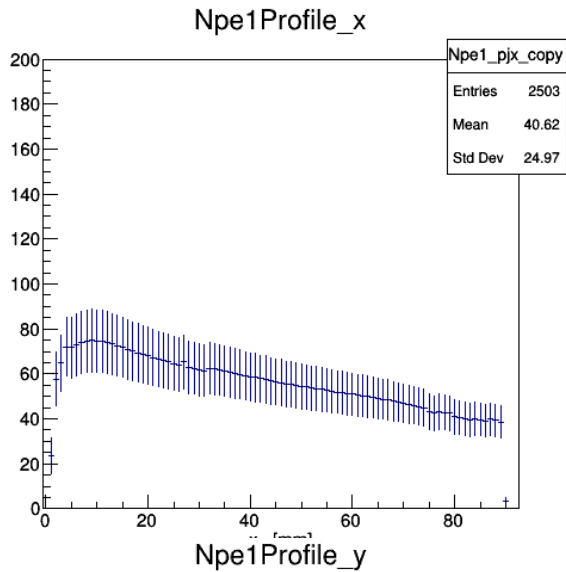
TDiff Resolution



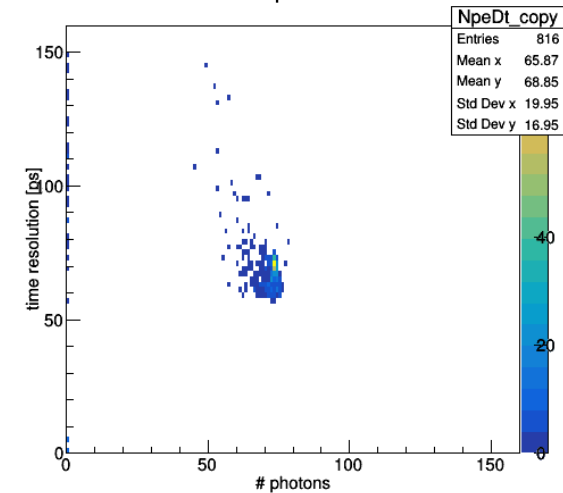
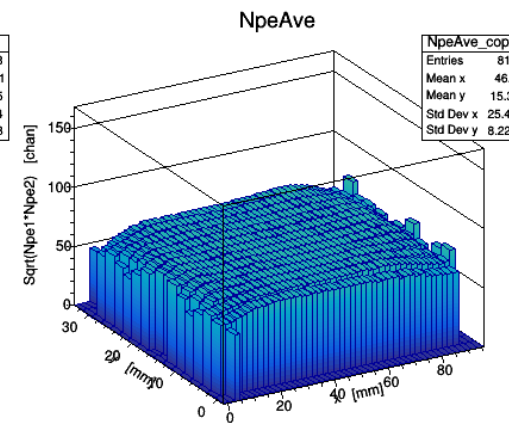
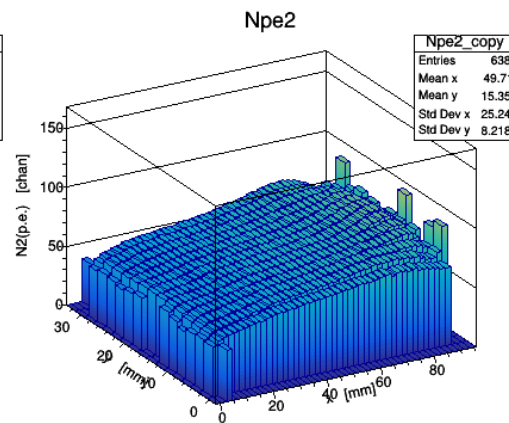
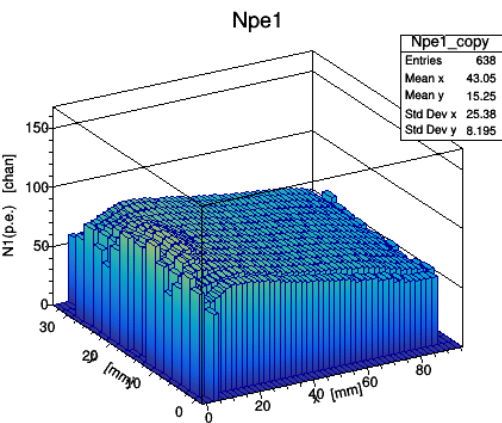
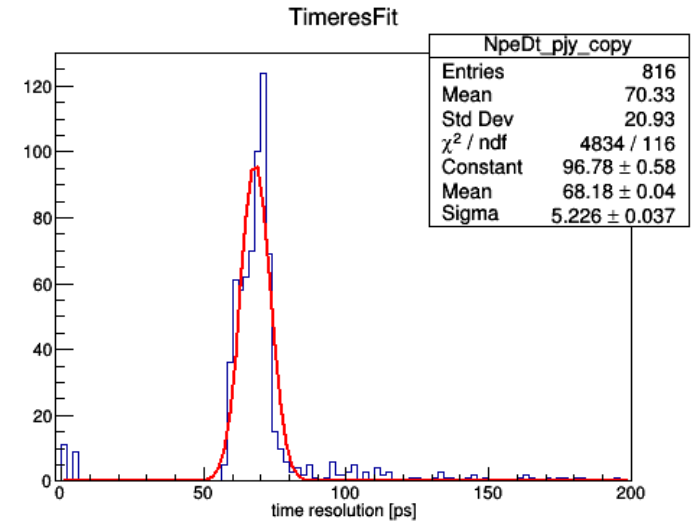
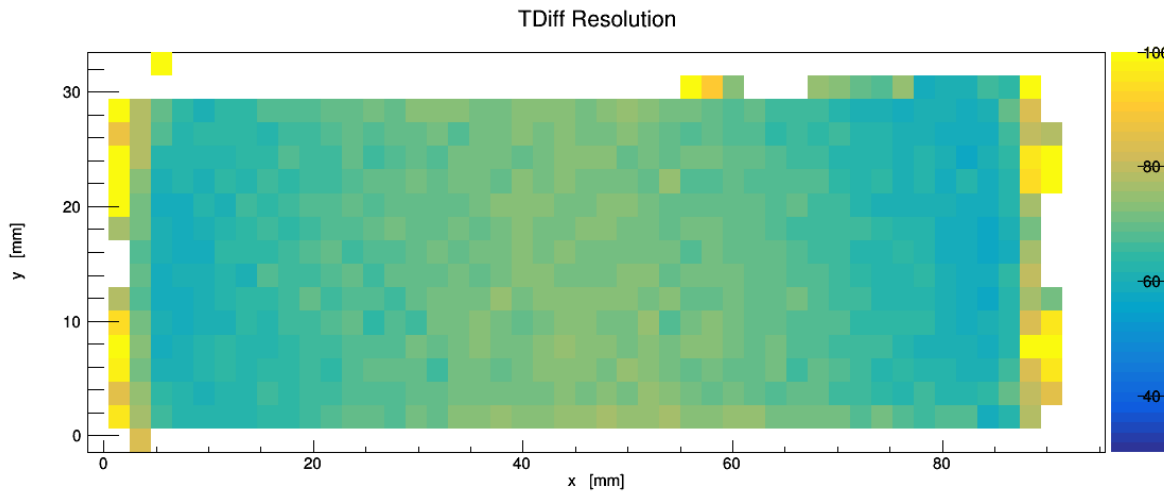
NpeDt



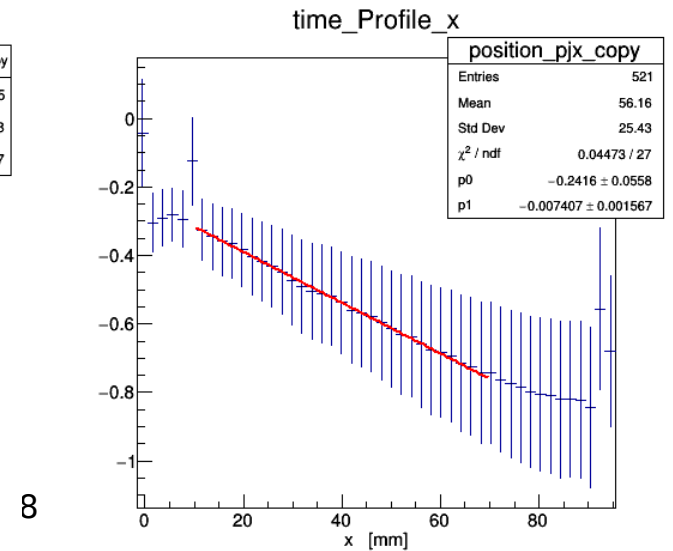
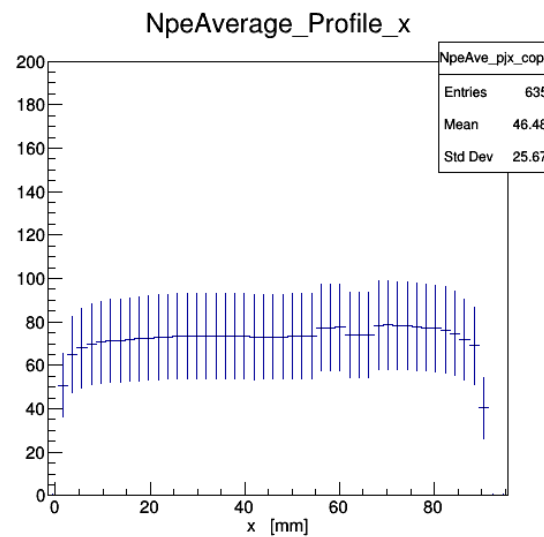
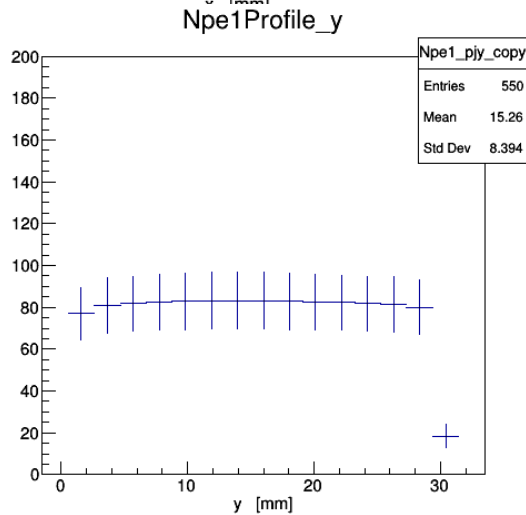
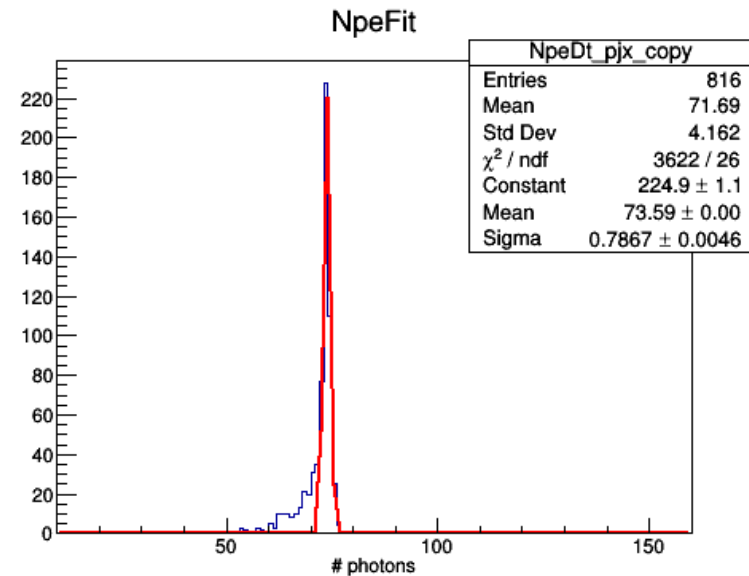
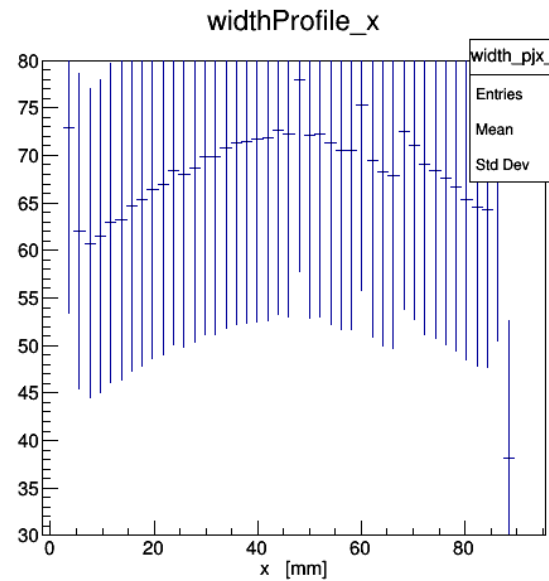
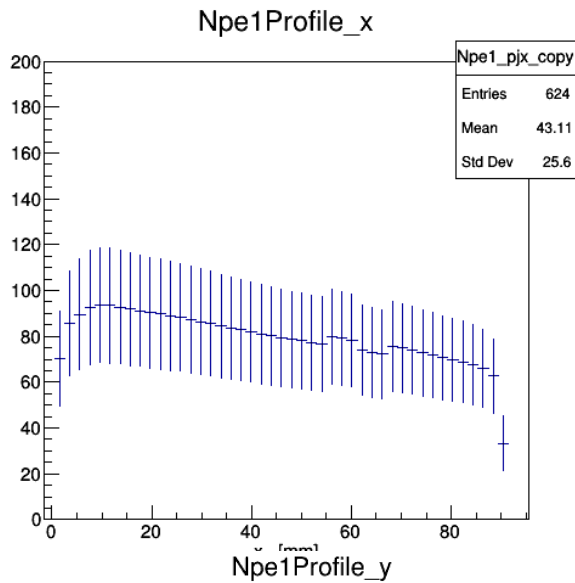
Run 49 / 3 mm



Run 50 / 4 mm

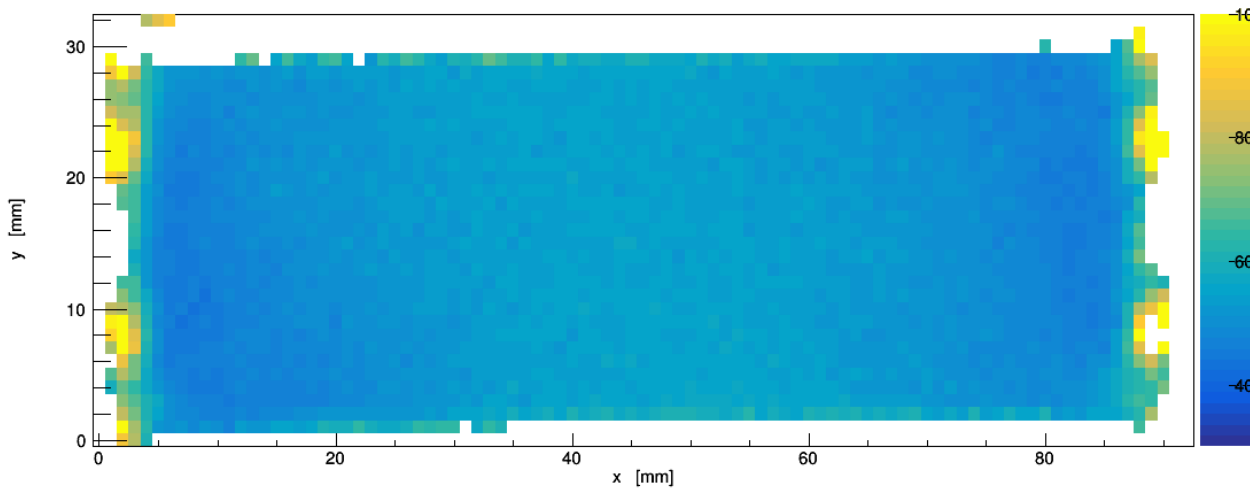


Run 50 / 4 mm

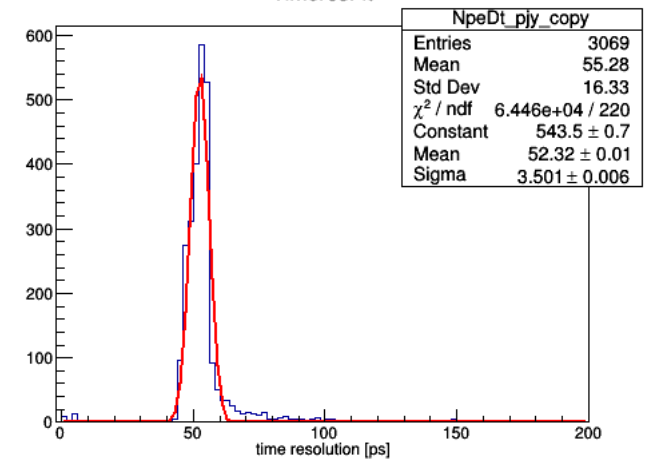


Run 51 / 5 mm

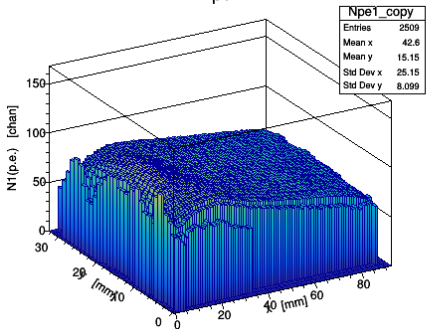
TDiff Resolution



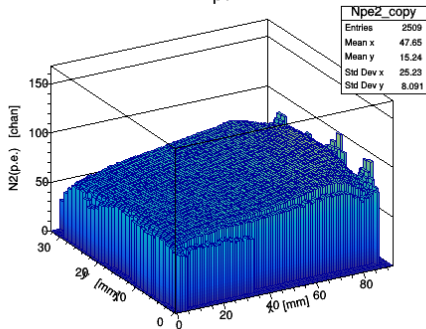
TimeresFit



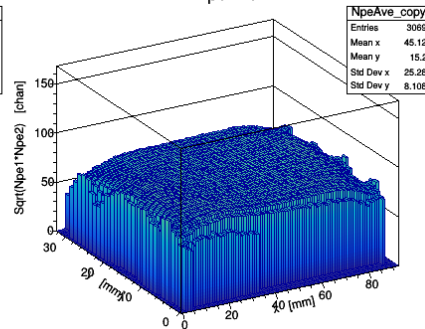
Npe1



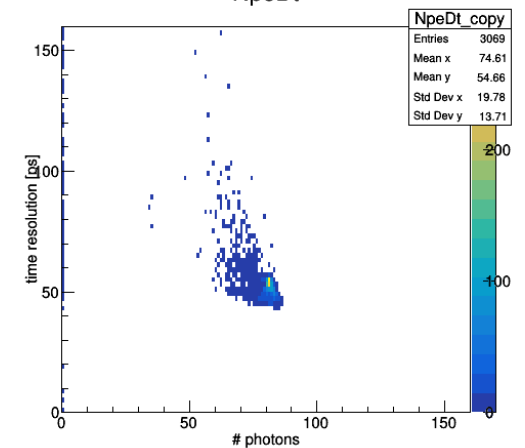
Npe2



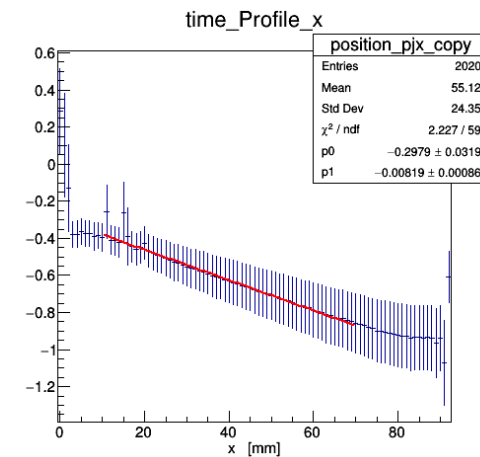
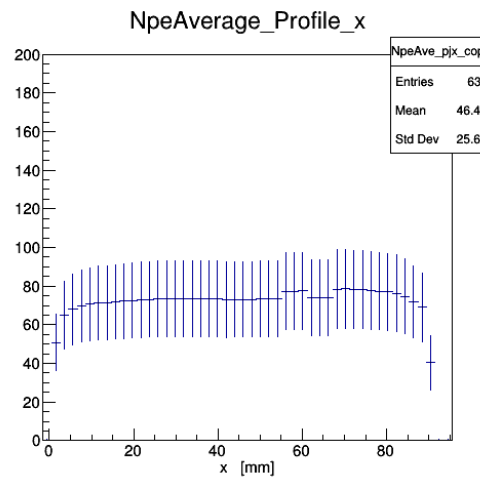
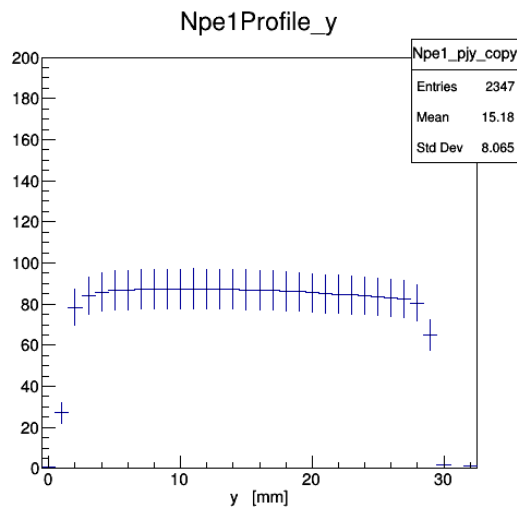
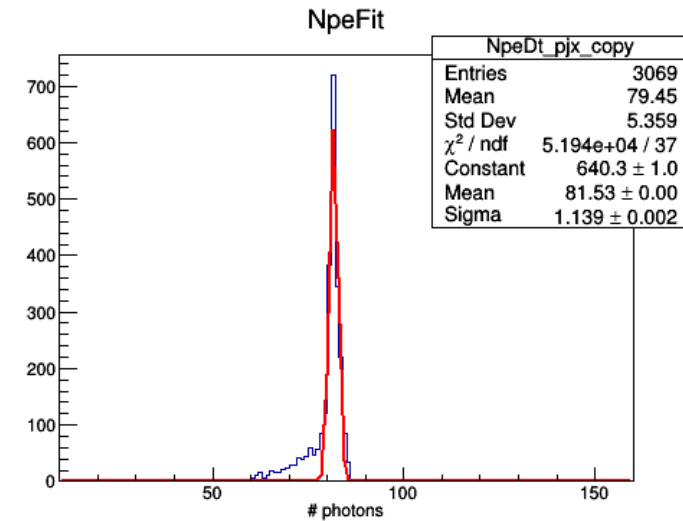
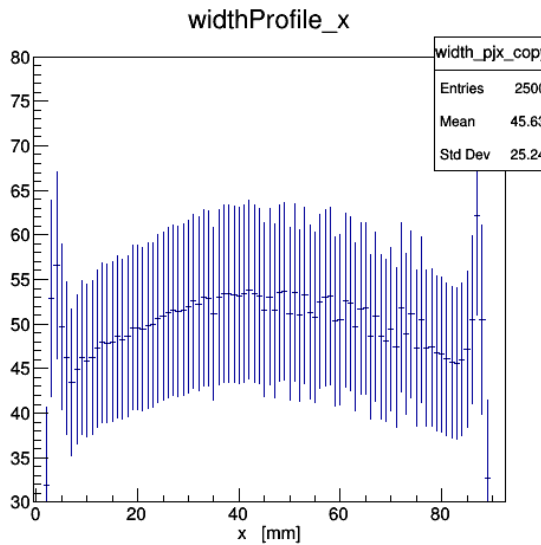
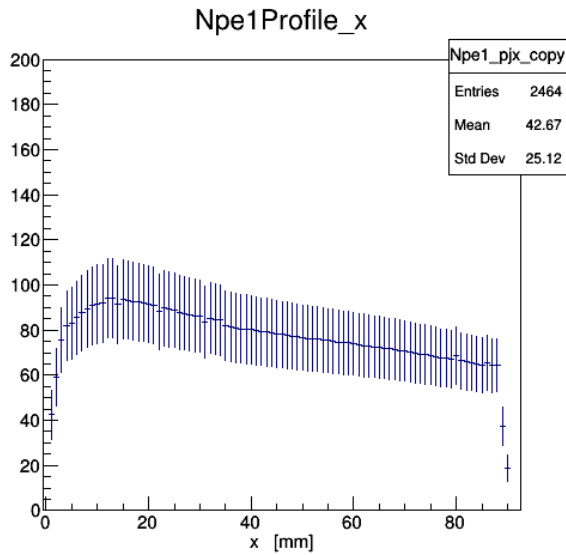
NpeAve



NpeDt

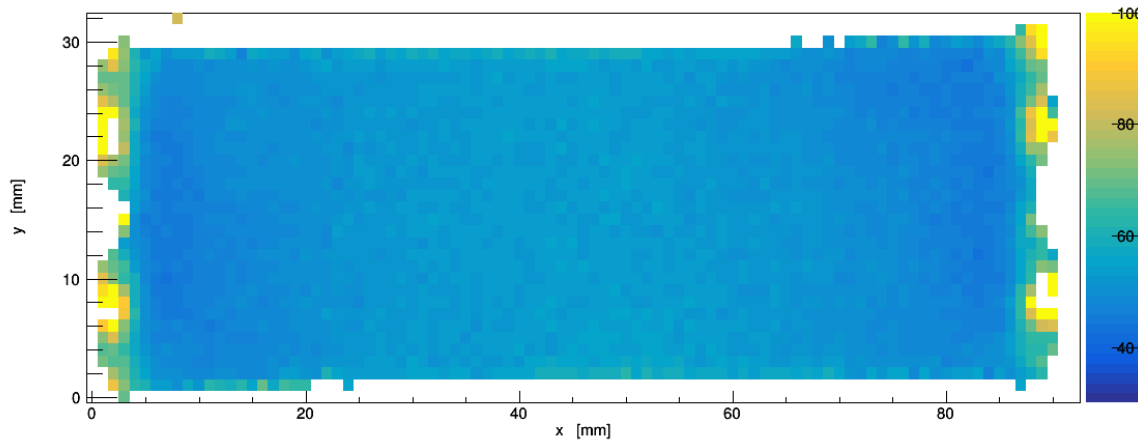


Run 51 / 5 mm

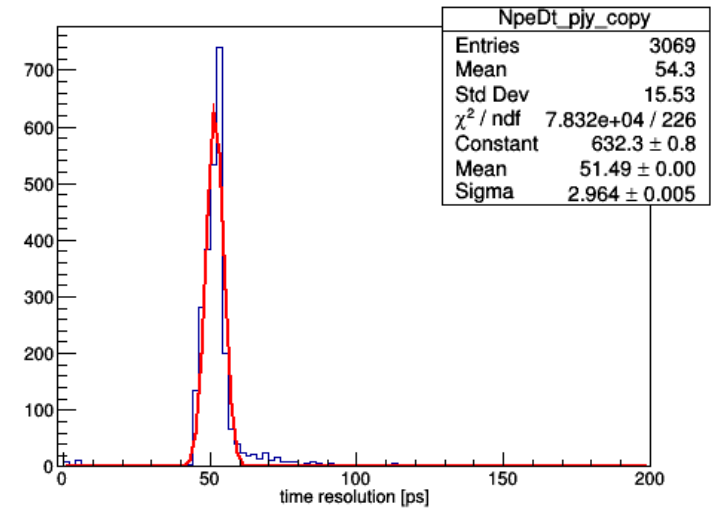


Run 53 / 5 mm polished

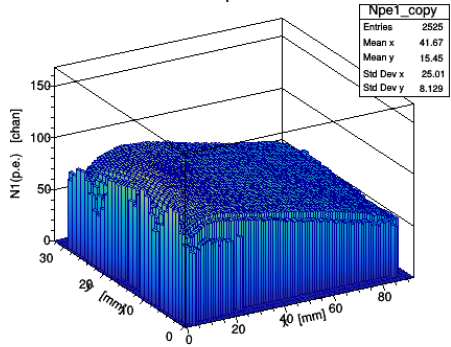
TDiff Resolution



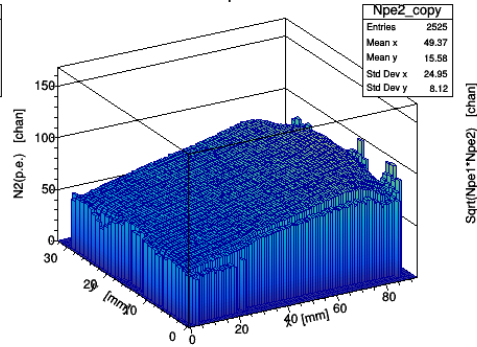
TimeresFit



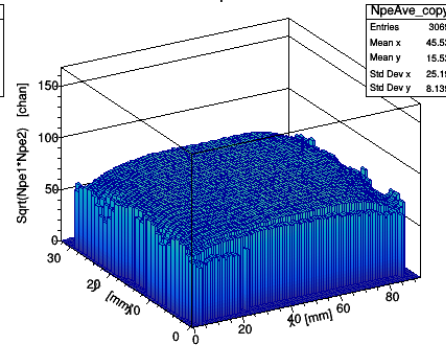
Npe1



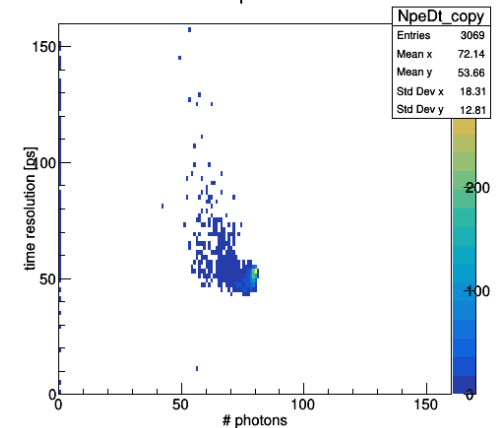
Npe2



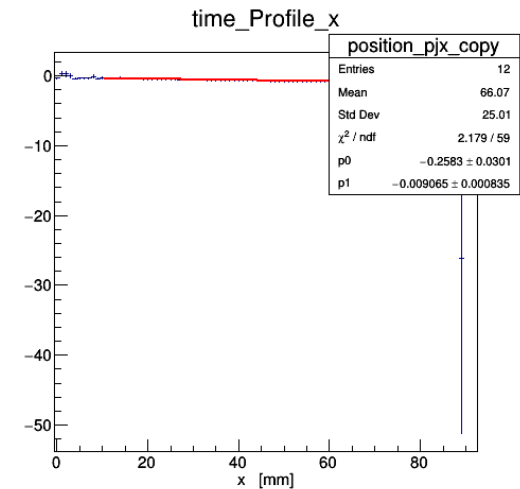
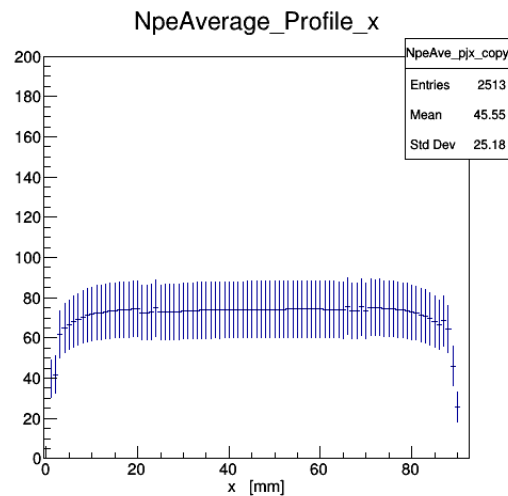
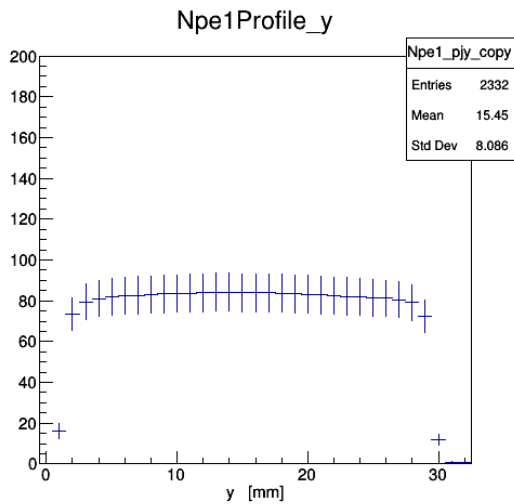
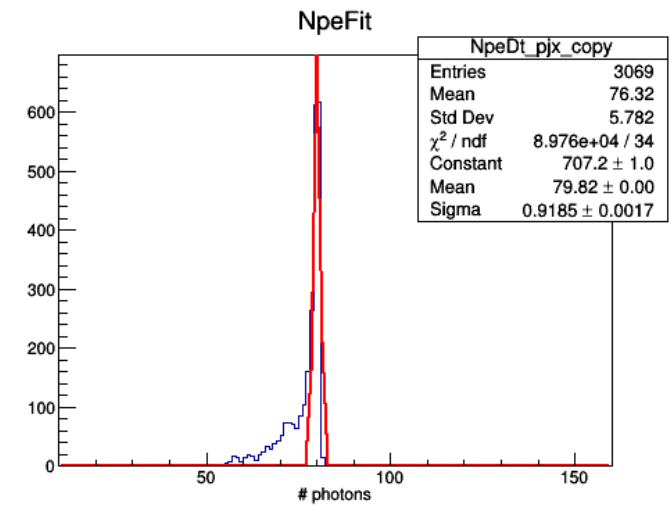
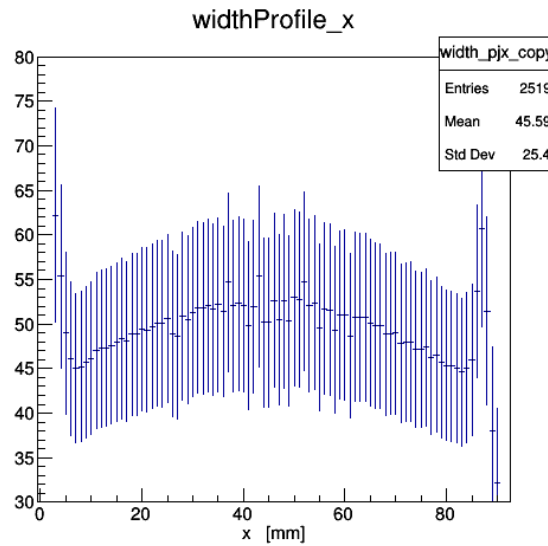
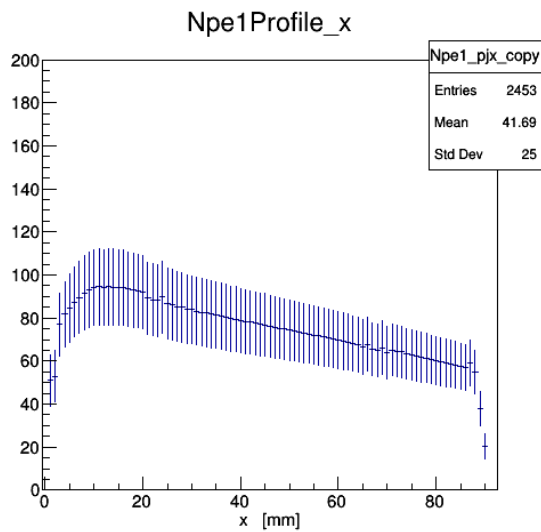
NpeAve



NpeDt

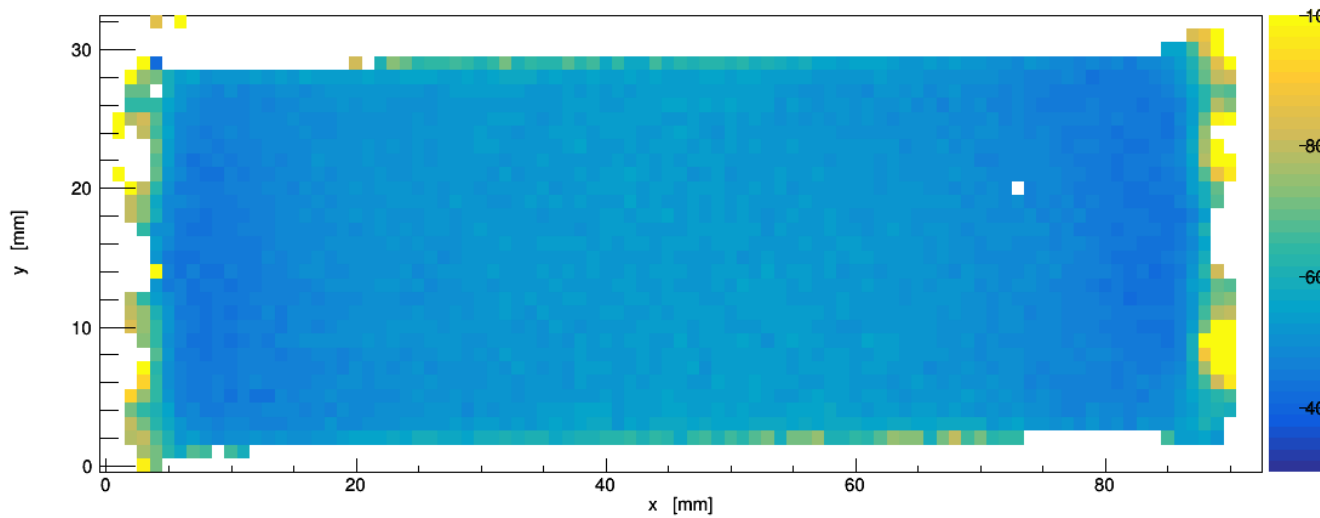


Run 53 / 5 mm polished

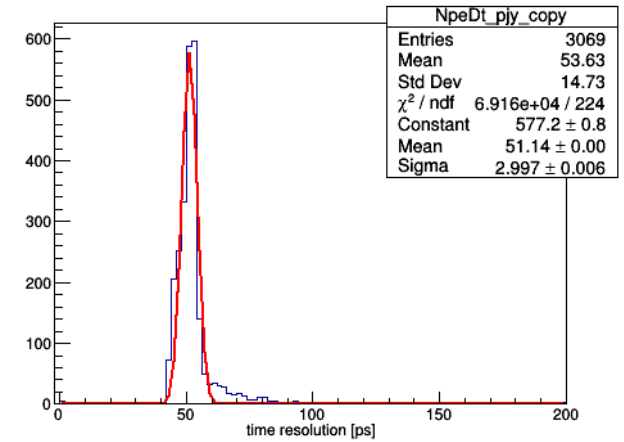


Run 52 / 6 mm

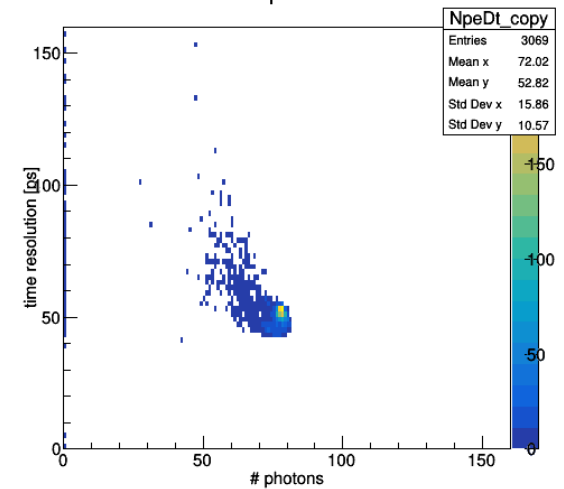
TDiff Resolution



TimeresFit



NpeDt



Npe1

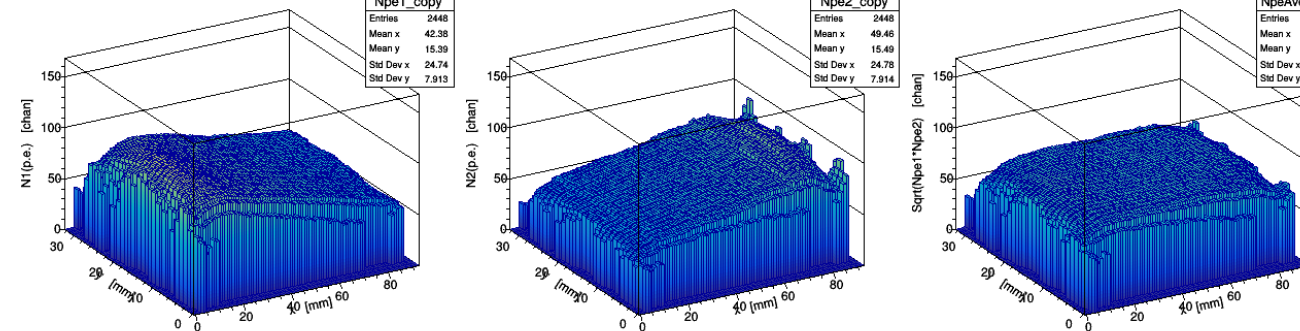
Npe1_copy	
Entries	2448
Mean x	42.38
Mean y	15.39
Std Dev x	24.74
Std Dev y	7.913

Npe2

Npe2_copy	
Entries	2448
Mean x	49.46
Mean y	15.49
Std Dev x	24.78
Std Dev y	7.914

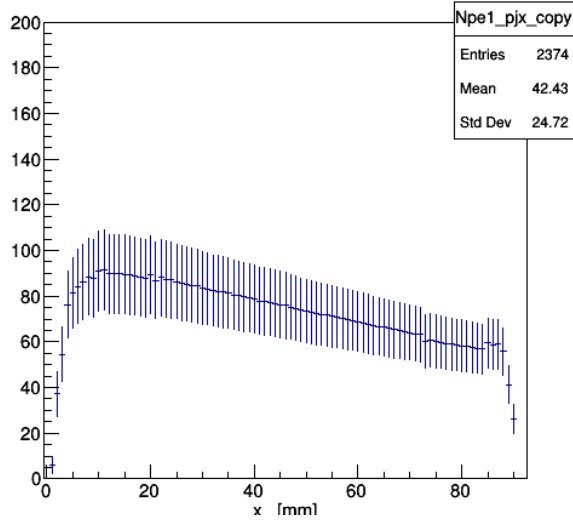
NpeAve

NpeAve_copy	
Entries	3069
Mean x	45.92
Mean y	15.45
Std Dev x	24.93
Std Dev y	7.929

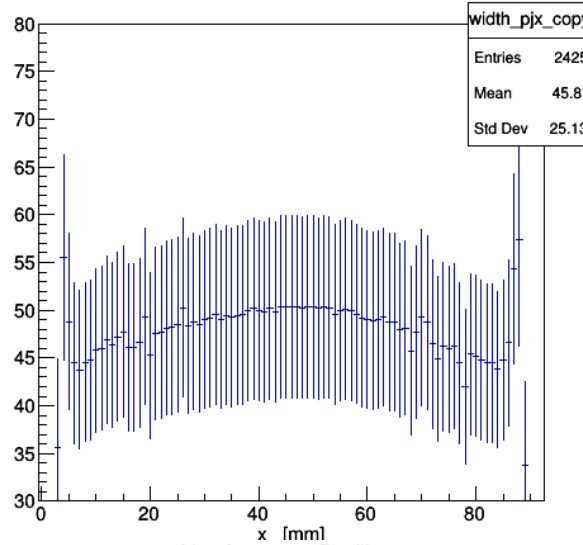


Run 52 / 6 mm

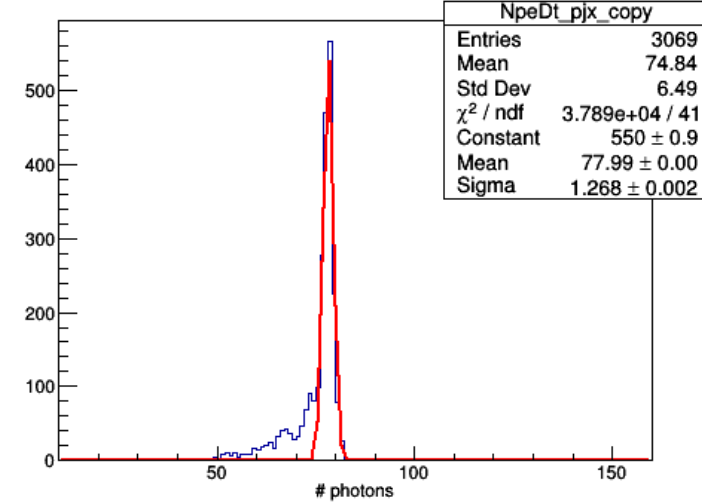
Npe1Profile_x



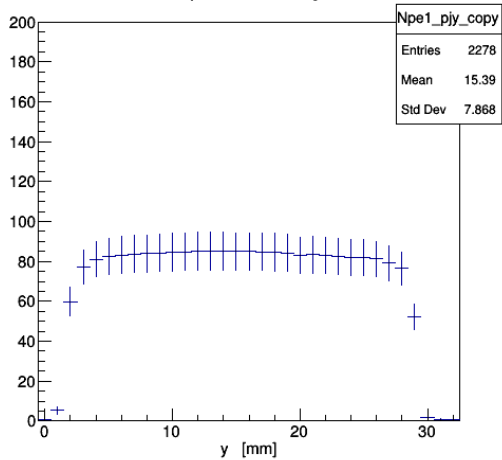
widthProfile_x



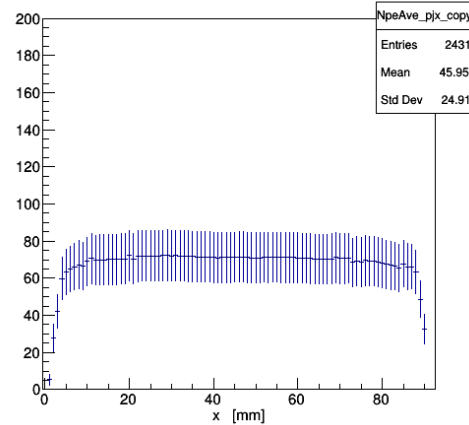
NpeFit



Npe1Profile_y



NpeAverage_Profile_x



time_Profile_x

