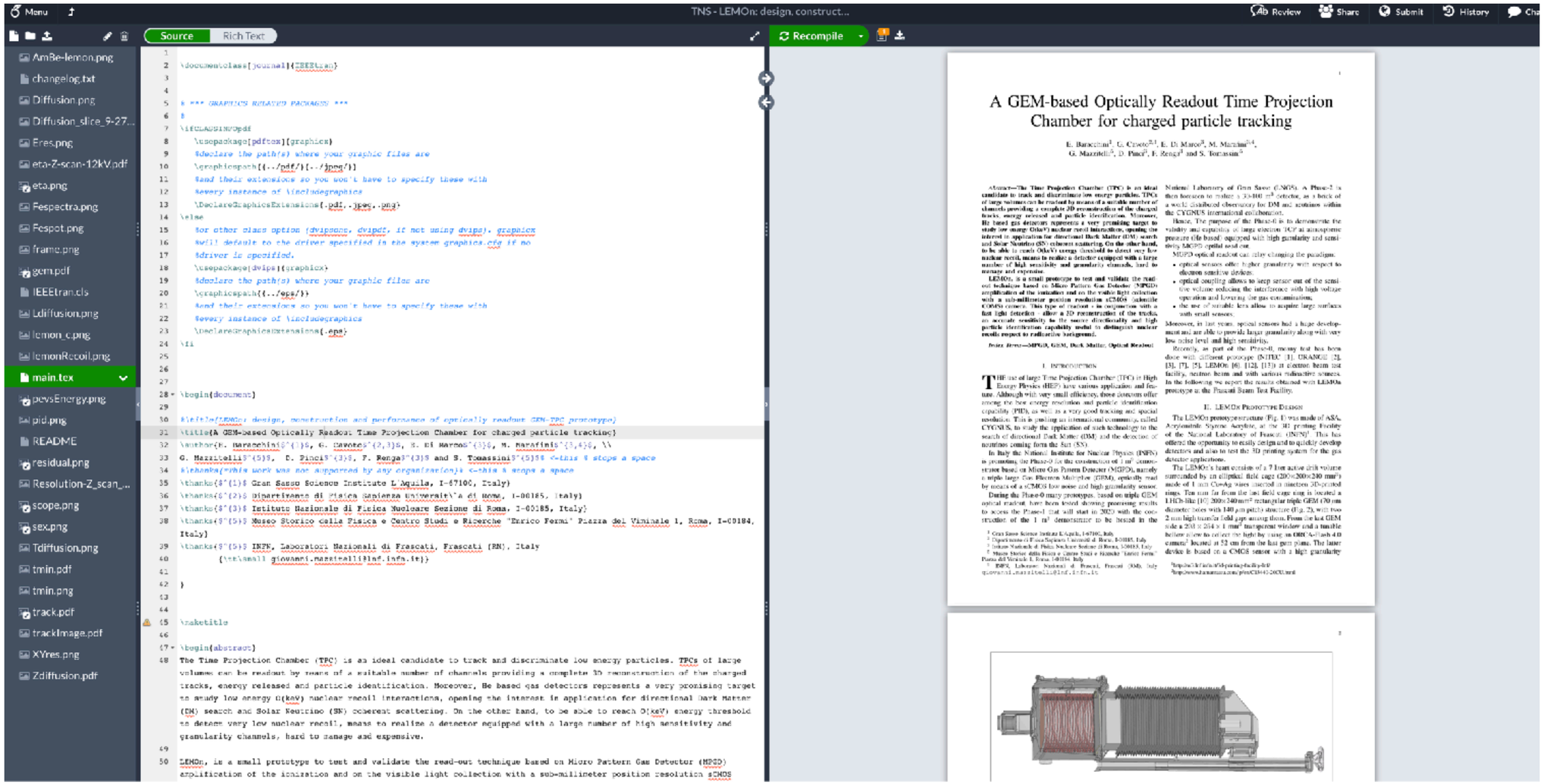
19/7/2019 update

- Editorial board (Di Marco, Baracchini, Bianco)
- engineering meeting
- Sistema gas
- DAQ
- Analisi
- contratto LNF art 15, ottobre 2019…

engineering meeting 17/7/2019

- evaluate vacuum vessel (feasibility and costs)
- evaluate cilinder vs cubic structure
- cons —> endcup
- FC DRIFT/Darkside, test up to 60kV
- FT DRIFT, limited to 30kV due to DRIFT vessel, up to 60kV if no ground vessel
- —> no electromagnetic shielding
- the radioactive shielding between vessel and water tank will be added as soon as defined, water tank and polietilene floor can be design
- ref https://docs.google.com/document/d/1rJY_7U6kgmUA-lKnsDCBJKKjK4b2mhqrt3yOy81z7J0/edit
- deadline preliminary design 1/9/2019
- deadline preliminary executive design 1/10/2019

BTF paper


Menu
TNS - LEMOn: design, construct...
Review
Share
Submit
History
Source
Rich Text
Recompile
Am8e-lemon.png
changelog.txt
Diffusion.png
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Zdiffusion.pdf
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\graphicspath{{../pdf/}{../jpeg/}}
%and their extensions so you won't have to specify these with
%every instance of \includegraphics
\DeclareGraphicsExtensions{.pdf,.jpeg,.png}
\else
%or other class option (dvipsone, dvipdf, if not using dvips). graphicx
%will default to the driver specified in the system graphics.cfg if no
%driver is specified.
\usepackage{dvips}{graphicx}
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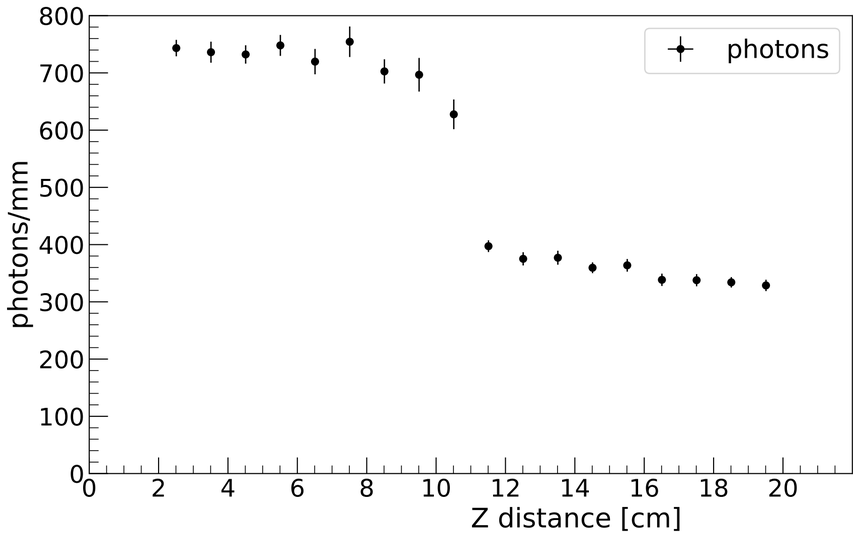
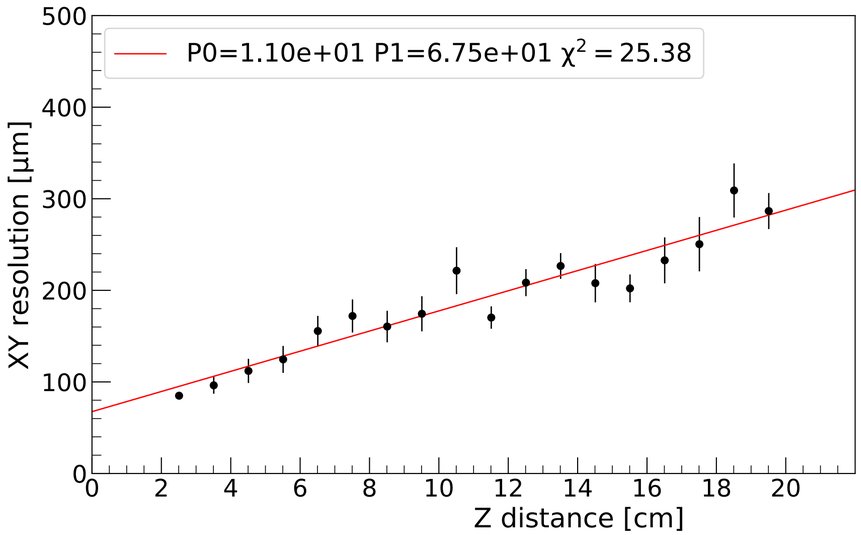
%and their extensions so you won't have to specify these with
%every instance of \includegraphics
\DeclareGraphicsExtensions{.eps}
\fi
\begin{document}
%\title{LEMOn: design, construction and performance of optically readout GEM-TPC prototype}
\title{A GEM-based Optically Readout Time Projection Chamber for charged particle tracking}
\author{E. Baracchini$^{(1)}$, G. Cavoto$^{(2,3)}$, E. Di Marco$^{(3)}$, M. Marafini$^{(3,4)}$, \\
G. Mazzitelli$^{(5)}$, D. Pinci$^{(3)}$, F. Renga$^{(3)}$ and S. Tomassini$^{(5)}$ <-this % stops a space
%\thanks{(This work was not supported by any organization)} <-this % stops a space
\thanks{$^{(1)}$ Gran Sasso Science Institute L'Aquila, I-67100, Italy}
\thanks{$^{(2)}$ Dipartimento di Fisica Sapienza Universit\'a di Roma, I-00185, Italy}
\thanks{$^{(3)}$ Istituto Nazionale di Fisica Nucleare Sezione di Roma, I-00185, Italy}
\thanks{$^{(5)}$ Museo Storico della Fisica e Centro Studi e Ricerche "Enrico Fermi" Piazza del Viminale 1, Roma, I-00184, Italy}
\thanks{$^{(5)}$ INFN, Laboratori Nazionali di Frascati, Frascati (RN), Italy
{\rm\small giovanni.mazzitelli@lnf.infn.it}}
}
\maketitle
\begin{abstract}
The Time Projection Chamber (TPC) is an ideal candidate to track and discriminate low energy particles. TPCs of large volumes can be readout by means of a suitable number of channels providing a complete 3D reconstruction of the charged tracks, energy released and particle identification. Moreover, He based gas detectors represents a very promising target to study low energy O(keV) nuclear recoil interactions, opening the interest in application for directional Dark Matter (DM) search and Solar Neutrino (SN) coherent scattering. On the other hand, to be able to reach O(keV) energy threshold to detect very low nuclear recoil, means to realize a detector equipped with a large number of high sensitivity and granularity channels, hard to manage and expensive.
LEMOn, is a small prototype to test and validate the read-out technique based on Micro Pattern Gas Detector (MPGD) amplification of the ionization and on the visible light collection with a sub-millimeter position resolution sCMOS
A GEM-based Optically Readout Time Projection Chamber for charged particle tracking
E. Baracchini[1], G. Cavoto[2,3], E. Di Marco[3], M. Marafini[3,4], G. Mazzitelli[5], D. Pinci[3], F. Renga[3] and S. Tomassini[5]
Abstract—The Time Projection Chamber (TPC) is an ideal candidate to track and discriminate low energy particles. TPCs of large volumes can be readout by means of a suitable number of channels providing a complete 3D reconstruction of the charged tracks, energy released and particle identification. Moreover, He based gas detectors represents a very promising target to study low energy O(keV) nuclear recoil interactions, opening the interest in application for directional Dark Matter (DM) search and Solar Neutrino (SN) coherent scattering. On the other hand, to be able to reach O(keV) energy threshold to detect very low nuclear recoil, means to realize a detector equipped with a large number of high sensitivity and granularity channels, hard to manage and expensive.
LEMOn, is a small prototype to test and validate the read-out technique based on Micro Pattern Gas Detector (MPGD) amplification of the ionization and on the visible light collection with a sub-millimeter position resolution sCMOS (scientific CMOS) camera. This type of readout - in conjunction with a fast light detection - allow a 3D reconstruction of the tracks, an accurate sensitivity to the source directionality and high particle identification capability useful to distinguish nuclear recoils respect to radiogenic background.
Index Terms—MPGD, GEM, Dark Matter, Optical Readout
I. Introduction
THE use of large Time Projection Chamber (TPC) in High Energy Physics (HEP) have various applications and features. Although with very small efficiency, these detectors offer among the best energy resolution and particle identification capability (PID), as well as a very good tracking and spatial resolution. This is pushing an international community, called CYGNUS, to study the application of such technology to the search of directional Dark Matter (DM) and the detection of neutrinos coming form the Sun (SN).
In Italy the National Institute for Nuclear Physics (INFN) is promoting the Phase-0 for the construction of 1 m^3 demonstrator based on Micro Gas Pattern Detector (MGPD), namely a triple large Gas Electron Multiplier (GEM), optically read by means of a sCMOS low noise and high granularity sensor.
During the Phase-0 many prototypes, based on triple GEM optical readout, have been tested showing promising results to access the Phase-1 that will start in 2023 with the construction of the 1 m^3 demonstrator to be hosted in the National Laboratory of Gran Sasso (LNGS). A Phase-2 is then foreseen to reach a 30-100 m^3 detector, as a brick of a world distributed observatory for DM and neutrinos within the CYGNUS international collaboration.
Hence, The purpose of the Phase-0 is to demonstrate the validity and expandibility of large electron TPC at atmospheric pressure (He based) equipped with high granularity and sensitivity MGPD optical readout.
MGPD optical readout can relay changing the paradigm:
• optical sensors offer higher granularity with respect to electron sensitive devices.
• optical coupling allows to keep sensor out of the sensitive volume reducing the interference with high voltage operation and lowering the gas contamination;
• the use of suitable lens allow to acquire large surfaces with small sensors.
Moreover, in last years, optical sensors had a huge development and are able to provide large granularity along with very low noise level and high sensitivity.
Recently, as part of the Phase-0, many test has been done with different prototype (NITEX [1], ORANGE [2], [3], [7], [5], LEMOn [6], [12], [13]) at cosmic beam test facility, neutron beam and with various radioactive sources. In the following we report the results obtained with LEMOn prototype at the Frascati Beam Test Facility.
II. LEMOn Prototype Design
The LEMOn prototype structure (Fig. 1) was made of ASA, Acrylonitrile Styrene Acrylate, at the 3D printing Facility of the National Laboratory of Frascati (INFN)[1]. This has offered the opportunity to easily design and to quickly develop detectors and also to test the 3D printing system for the gas detector applications.
The LEMOn's heart consists of a 7 liter active drift volume surrounded by an elliptical field cage (200×200×240 mm^3) made of 1 mm Cu-clad wires inserted in custom 3D-printed rings. Ten mm far from the last field cage ring is located a LHCb-like [10] 200×240 mm^2 rectangular triple GEM (70 mm diameter holes with 140 μm pitch) structure (Fig. 2), with two 2 mm high transfer field gaps among them. From the last GEM side a 204 × 204 × 1 mm^3 transparent window and a tunnel hollow pipe to collect the light by using an OSM (Coelbah 4.0 camera[2] located at 52 cm from the last gem plane. The latter device is based on a CMOS sensor with a high granularity
[1] Gran Sasso Science Institute L'Aquila, I-67100, Italy
[2] Dipartimento di Fisica Sapienza Universit\'a di Roma, I-00185, Italy
[3] Istituto Nazionale di Fisica Nucleare Sezione di Roma, I-00185, Italy
[4] Museo Storico della Fisica e Centro Studi e Ricerche "Enrico Fermi" Piazza del Viminale 1, Roma, I-00184, Italy
[5] INFN, Laboratori Nazionali di Frascati, Frascati (RM), Italy
giovanni.mazzitelli@lnf.infn.it
[1] http://www.lnf.infn.it/sl/3d-printing-facility-lnf/
[2] http://www.kamamura.com/pdfs/CH440-20CU.html

0.6kV/cm


photons
photons/mm
Z distance [cm]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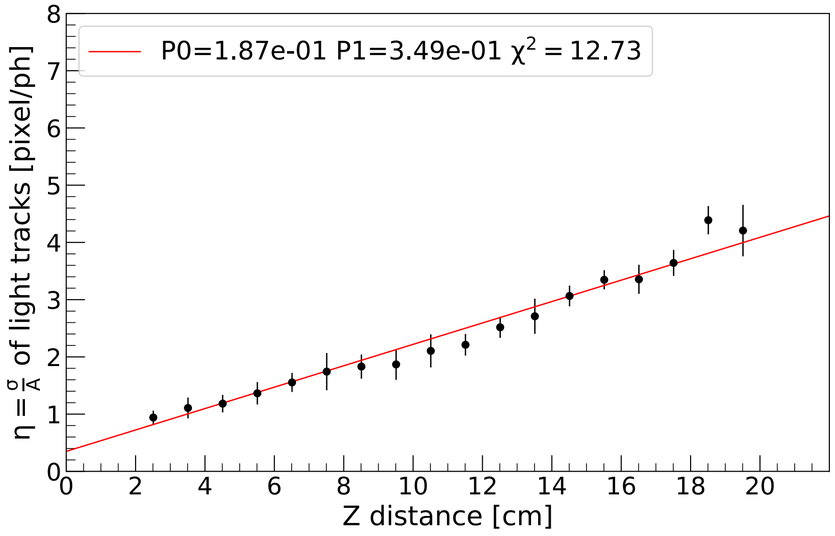
XY resolution [μm]
Z distance [cm]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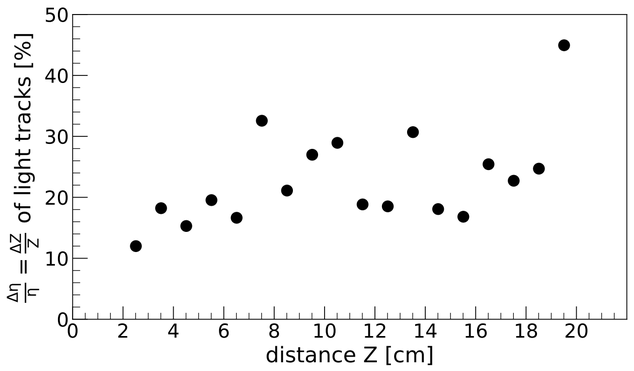
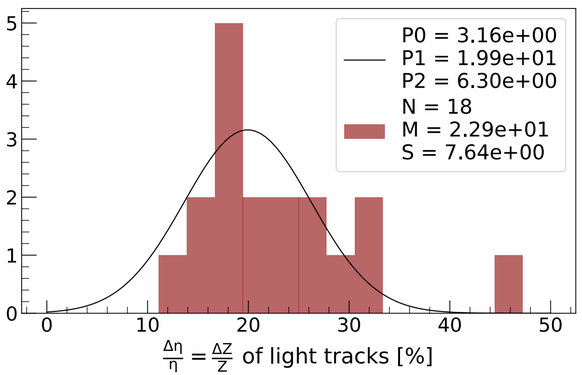
Z distance [cm]


$\frac{\Delta\eta}{\eta} = \frac{\Delta Z}{Z}$ of light tracks [%]
distance Z [cm]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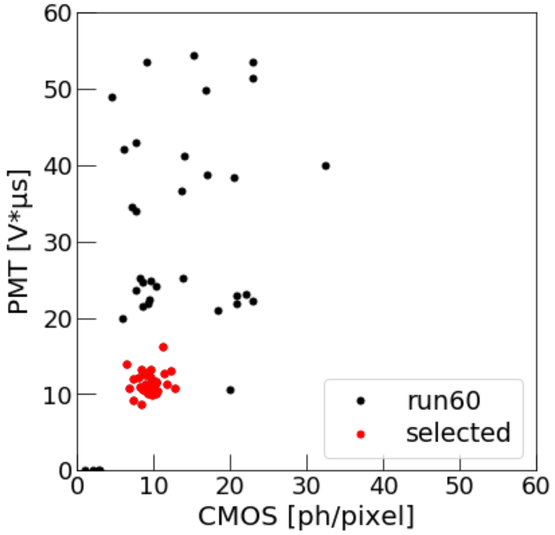
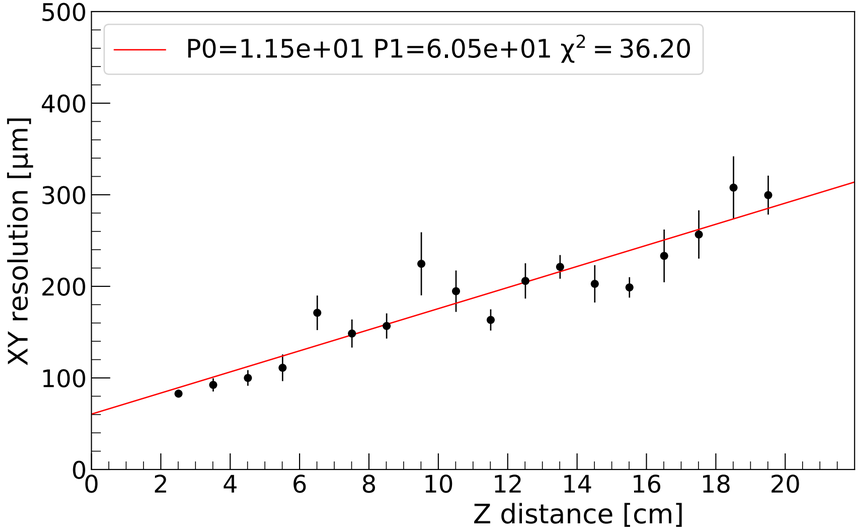
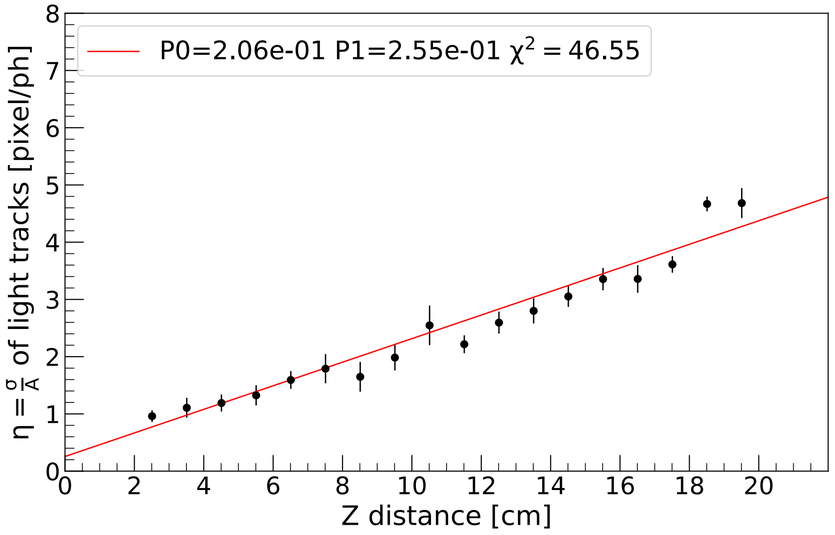
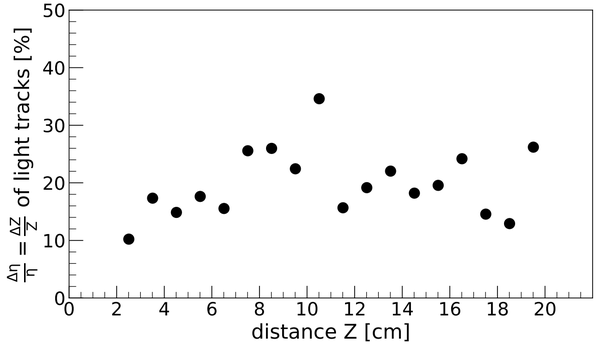
P1 = 1.99e+01
P2 = 6.30e+00
N = 18
M = 2.29e+01
S = 7.64e+00
$\frac{\Delta\eta}{\eta} = \frac{\Delta Z}{Z}$ of light tracks [%]

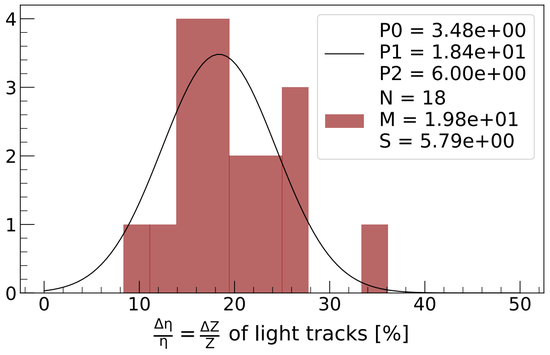
0.6kV/cm (strong cuts)



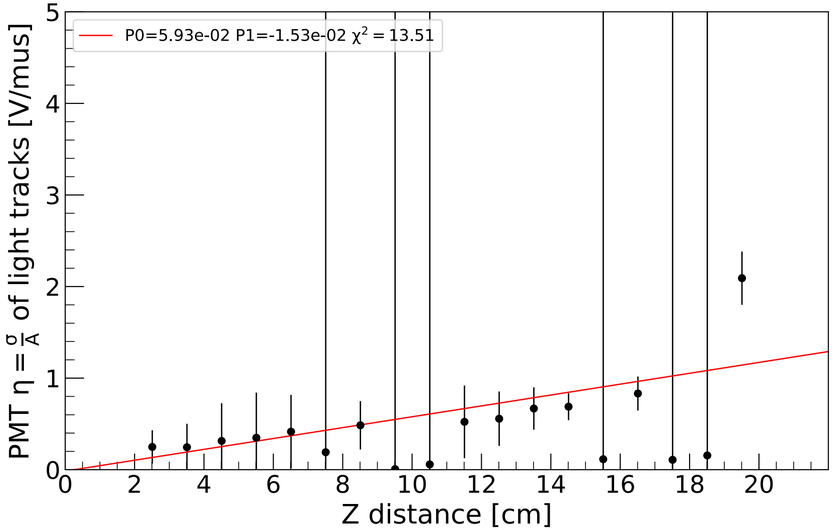


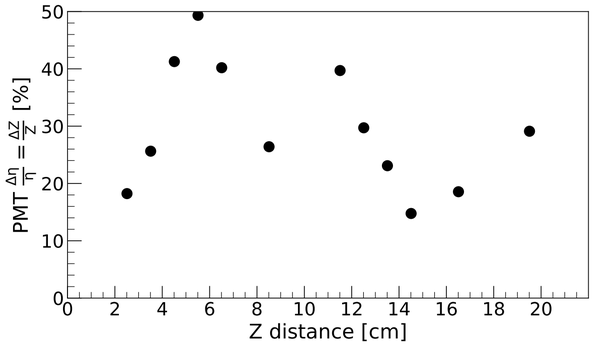


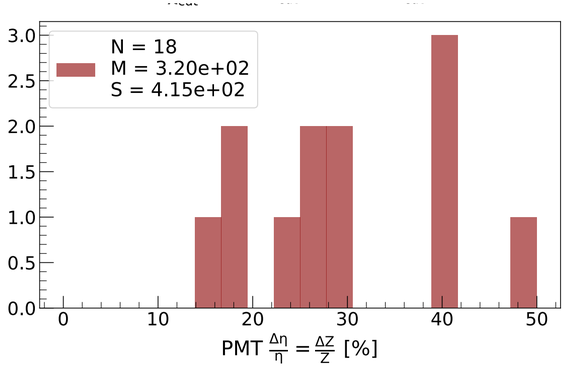


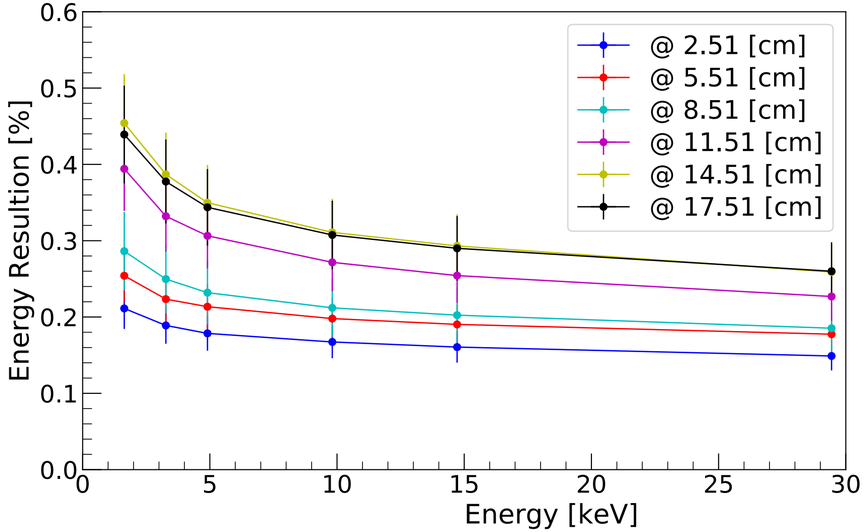


0.6kV/cm

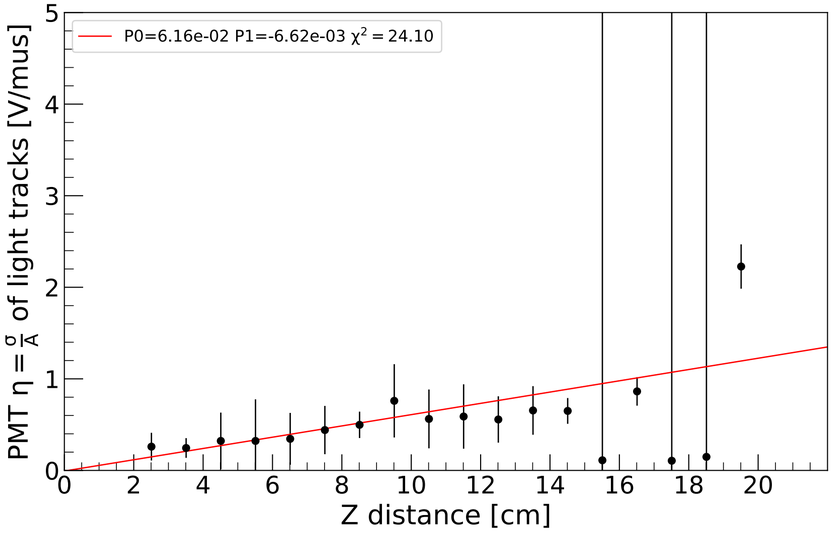

P0=5.93e-02 P1=-1.53e-02 $\chi^2 = 13.51$
PMT $\eta = \frac{\sigma}{A}$ of light tracks [V/mus]
Z distance [cm]

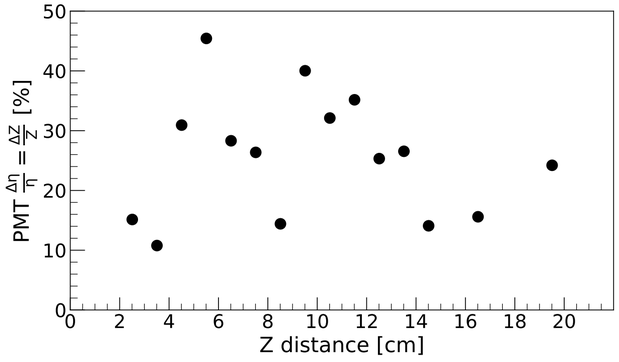

PMT $\frac{\Delta\eta}{\eta} = \frac{\Delta Z}{Z}$ [%]
Z distance [cm]

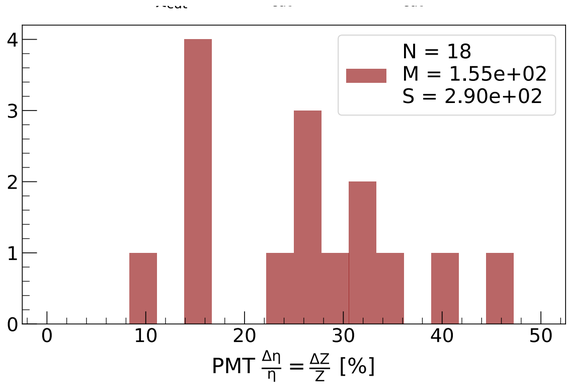

N = 18
M = 3.20e+02
S = 4.15e+02
PMT $\frac{\Delta\eta}{\eta} = \frac{\Delta Z}{Z}$ [%]

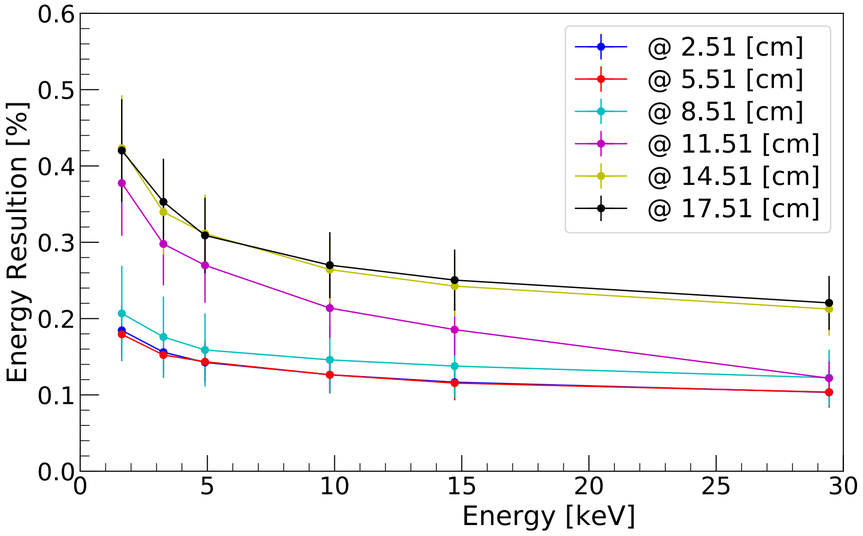

@ 2.51 [cm]
@ 5.51 [cm]
@ 8.51 [cm]
@ 11.51 [cm]
@ 14.51 [cm]
@ 17.51 [cm]
Energy Resultion [%]
Energy [keV]

0.6kV/cm (strong cuts)

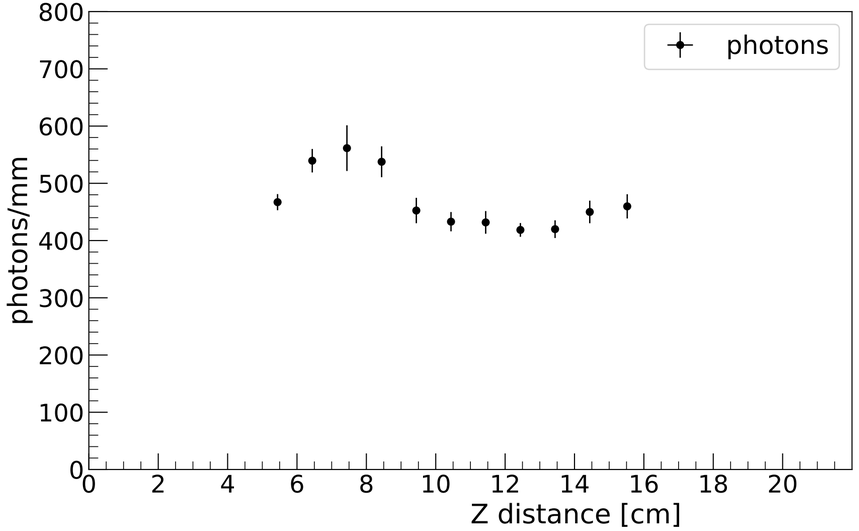


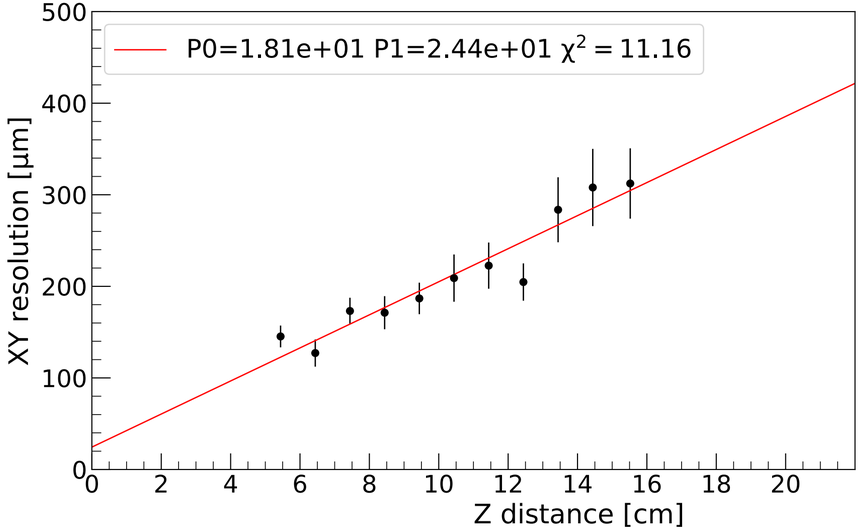


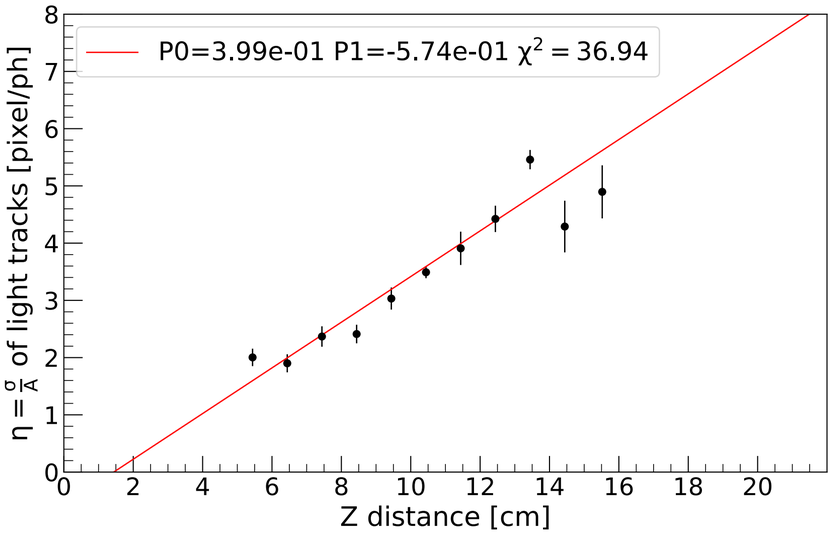




0.45kV/cm


photons
photons/mm
Z distance [cm]


P0=1.81e+01 P1=2.44e+01 $\chi^2 = 11.16$
XY resolution [μm]
Z distance [cm]


P0=3.99e-01 P1=-5.74e-01 $\chi^2 = 36.94$
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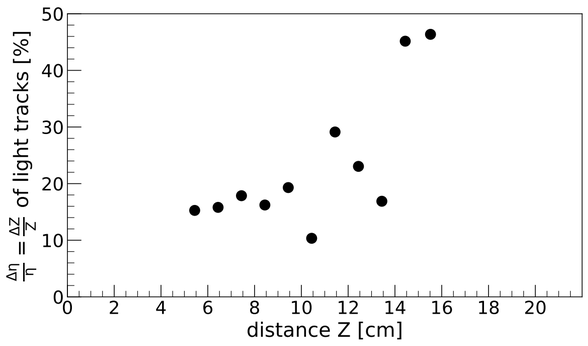
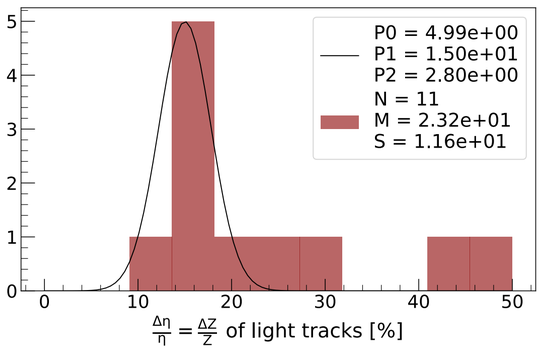
Z distance [cm]


$\frac{\Delta\eta}{\eta} = \frac{\Delta Z}{Z}$ of light tracks [%]
distance Z [cm]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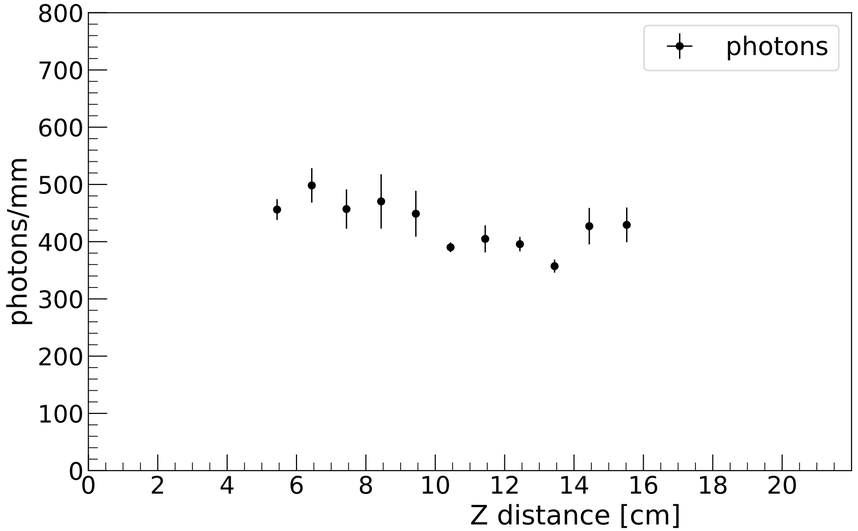
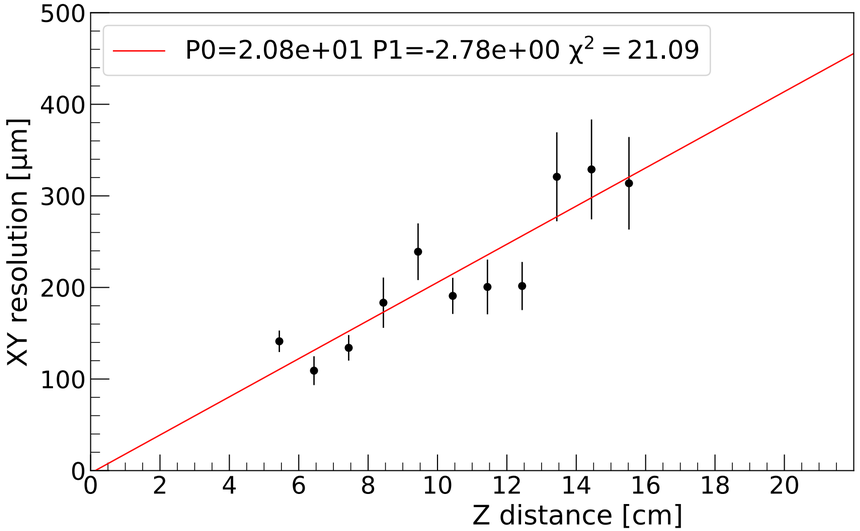
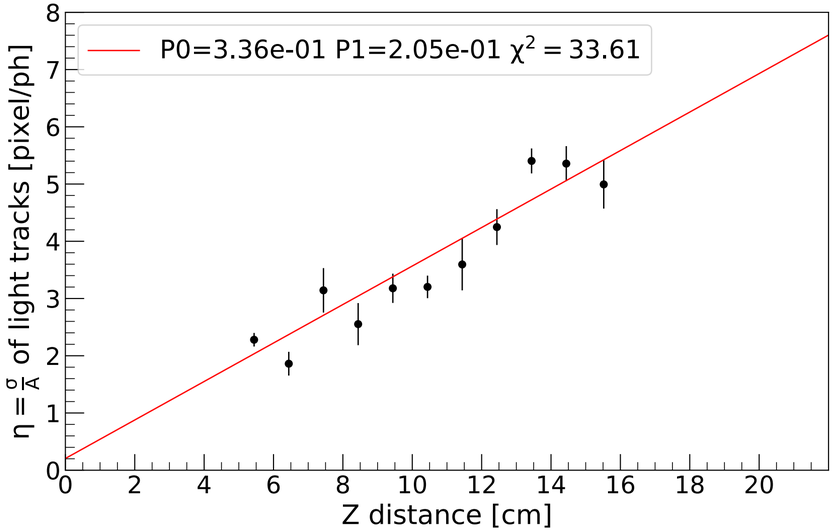
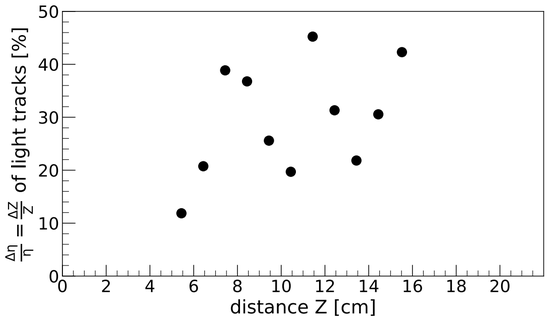
P1 = 1.50e+01
P2 = 2.80e+00
N = 11
M = 2.32e+01
S = 1.16e+01
$\frac{\Delta\eta}{\eta} = \frac{\Delta Z}{Z}$ of light tracks [%]

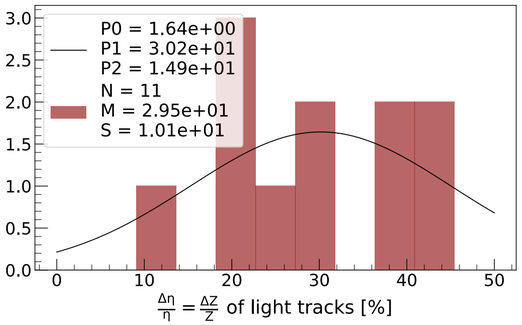
0.45kV/cm (strong cuts)



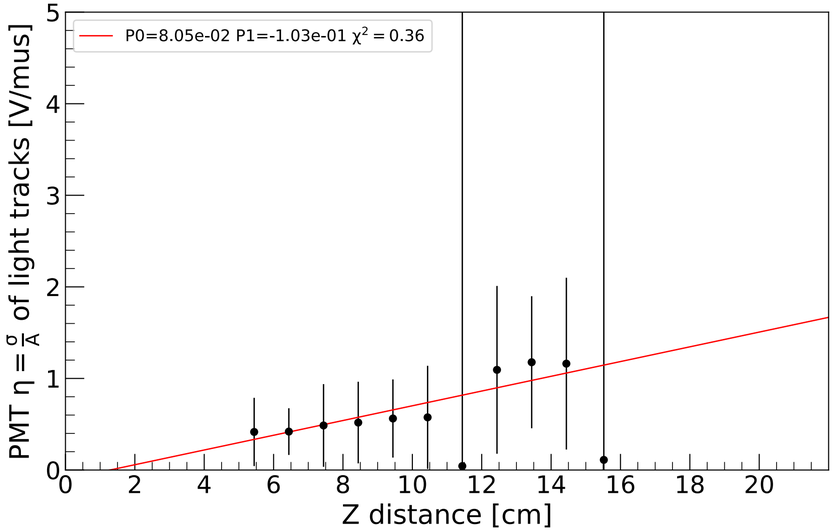


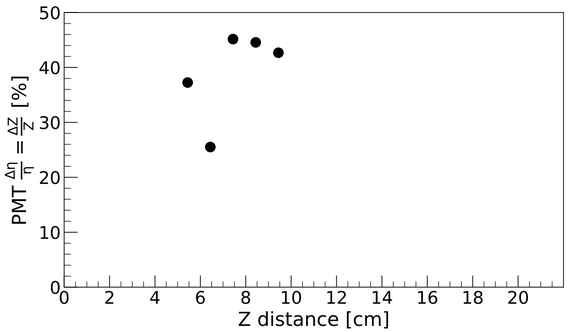


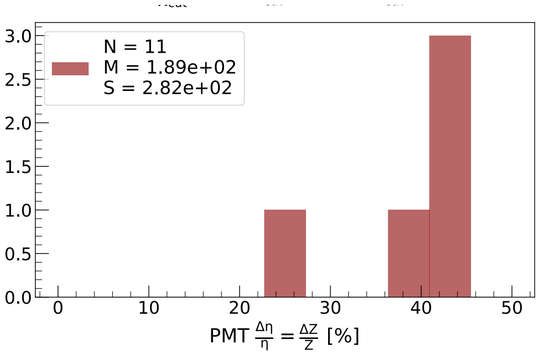


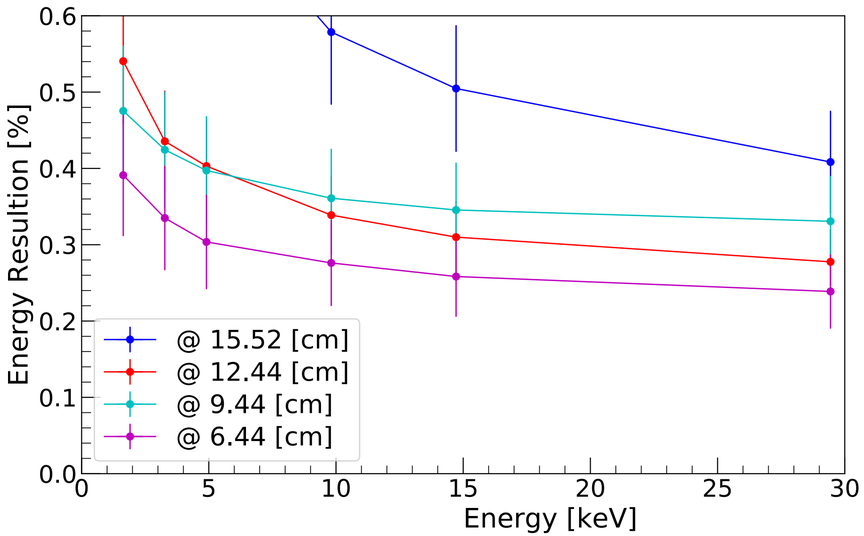


0.45kV/cm

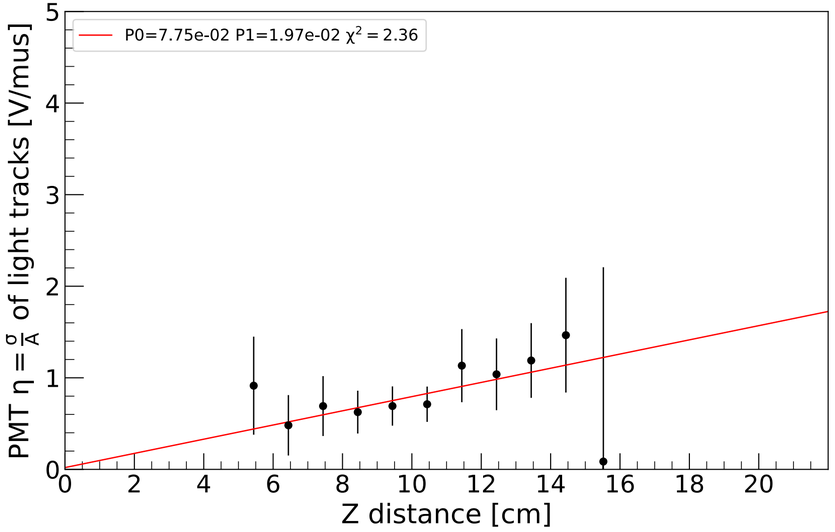

P0=8.05e-02 P1=-1.03e-01 $\chi^2 = 0.36$
PMT $\eta = \frac{\sigma}{A}$ of light tracks [V/mus]
Z distance [cm]

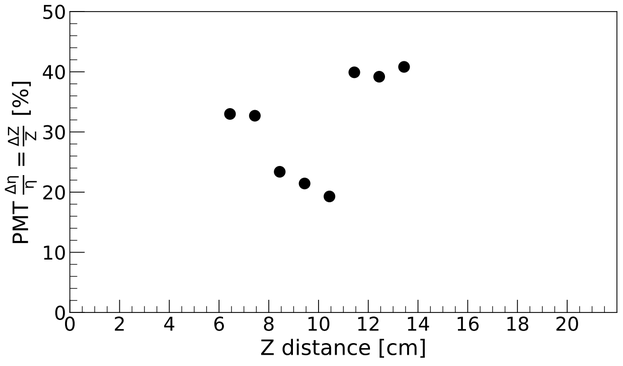

PMT $\frac{\Delta\eta}{\eta} = \frac{\Delta Z}{Z}$ [%]
Z distance [cm]

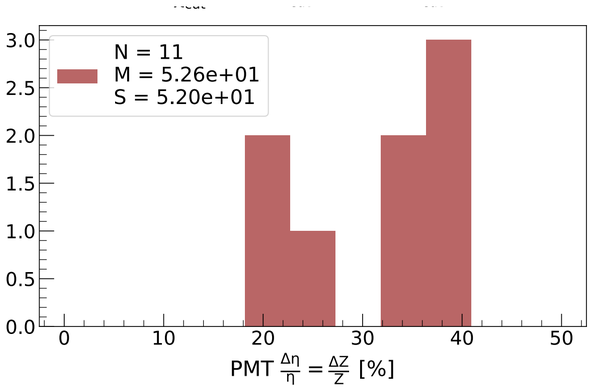

N = 11
M = 1.89e+02
S = 2.82e+02
PMT $\frac{\Delta\eta}{\eta} = \frac{\Delta Z}{Z}$ [%]

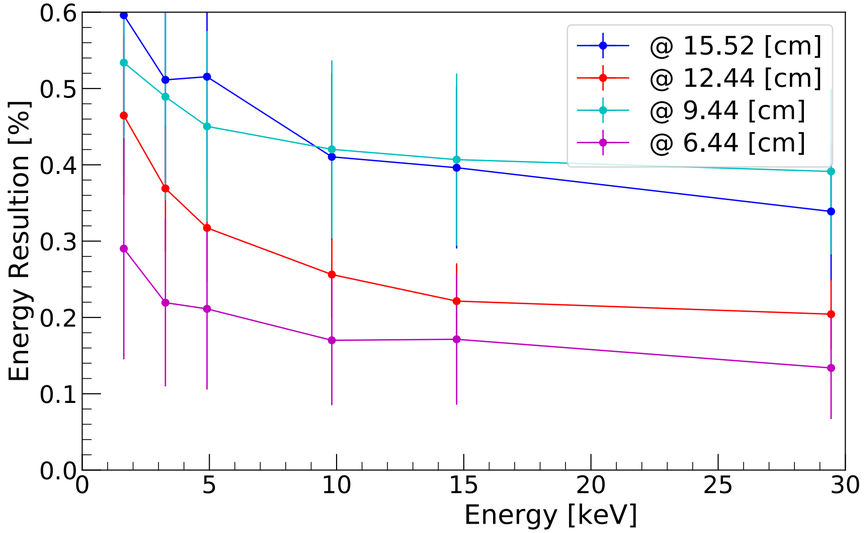

@ 15.52 [cm]
@ 12.44 [cm]
@ 9.44 [cm]
@ 6.44 [cm]
Energy Resultion [%]
Energy [keV]

0.45kV/cm (strong cuts)

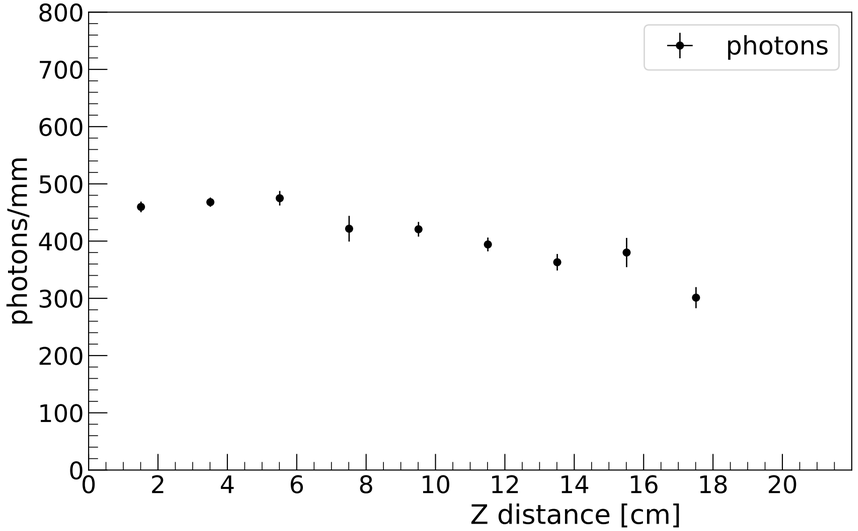


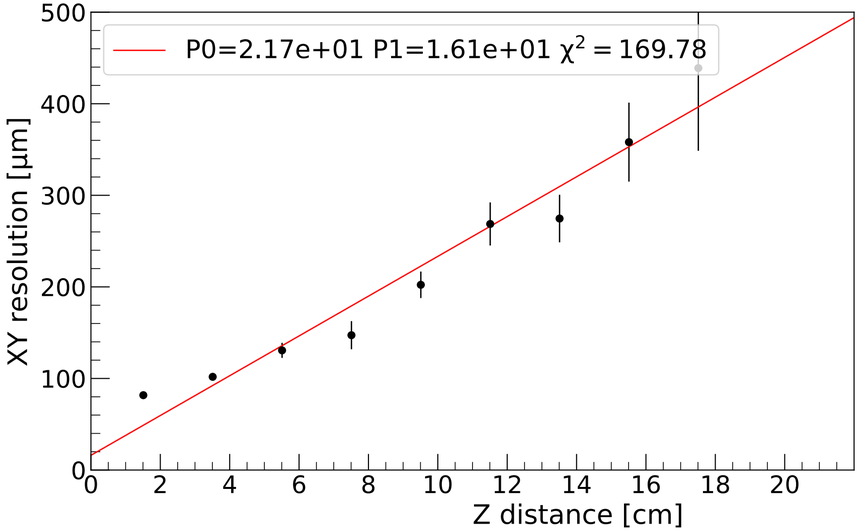


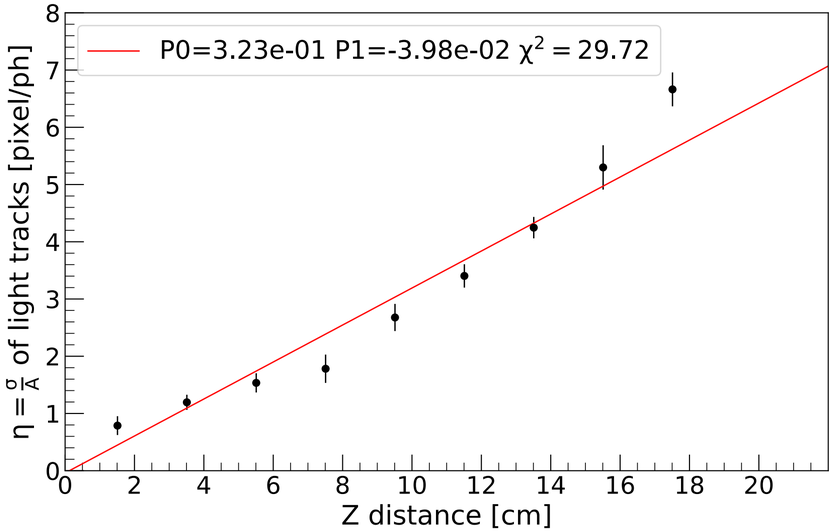


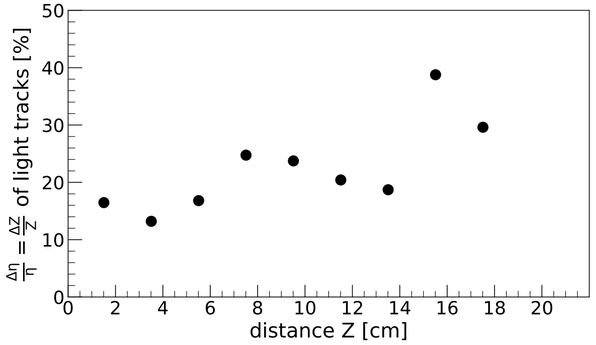


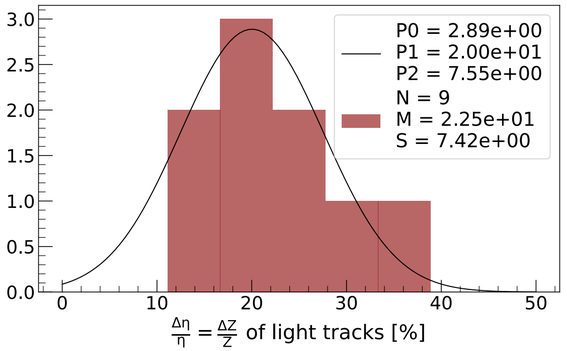
0.3kV/cm


photons
photons/mm
Z distance [cm]

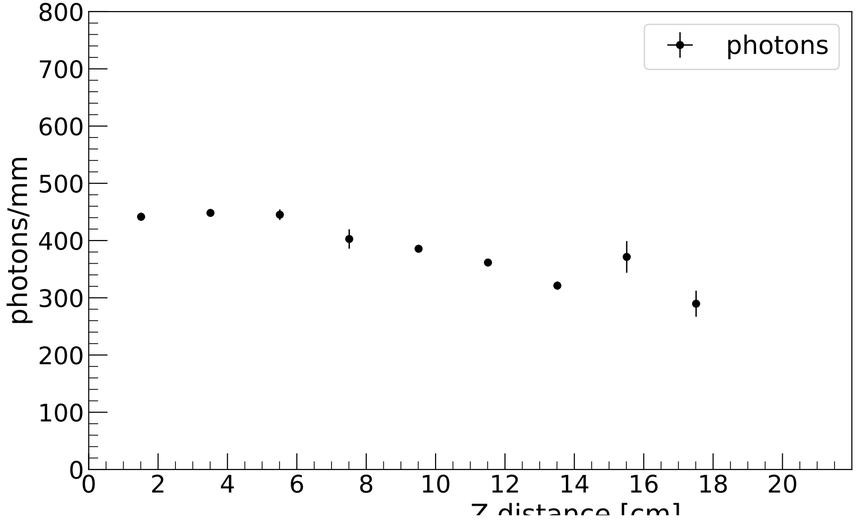

P0=2.17e+01 P1=1.61e+01 $\chi^2 = 169.78$
XY resolution [μm]
Z distance [cm]

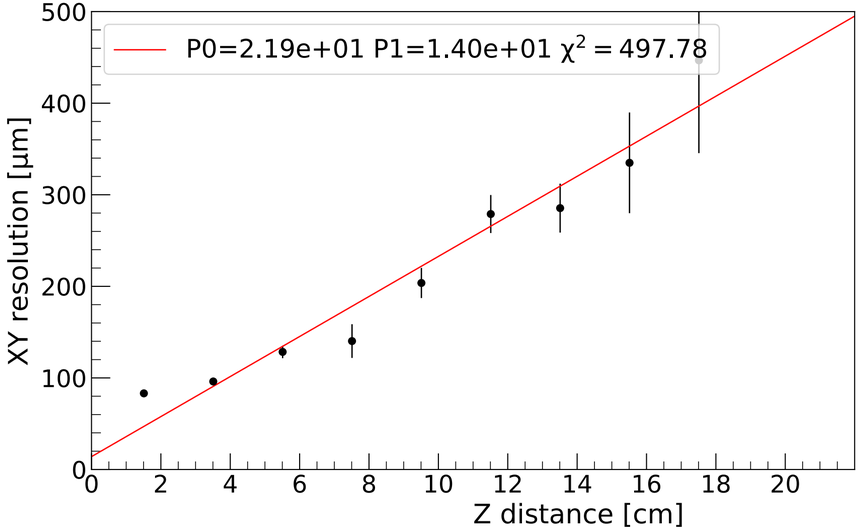

P0=3.23e-01 P1=-3.98e-02 $\chi^2 = 29.72$
$\eta = \frac{\sigma}{A}$ of light tracks [pixel/ph]
Z distance [cm]

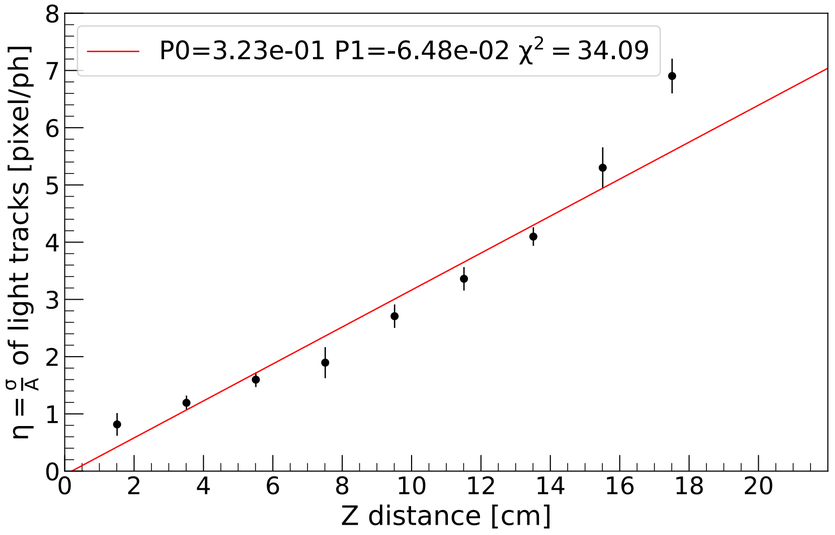

$\frac{\Delta\eta}{\eta} = \frac{\Delta Z}{Z}$ of light tracks [%]
distance Z [cm]

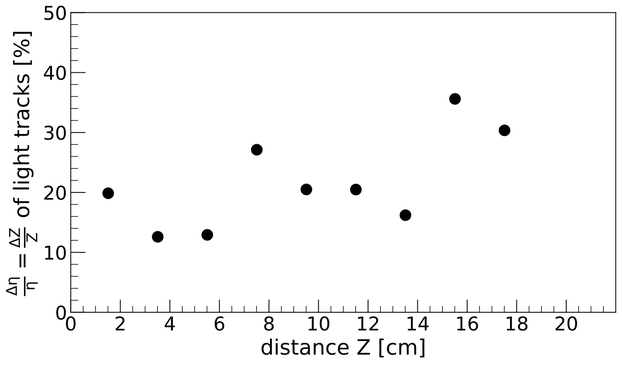

P0 = 2.89e+00
P1 = 2.00e+01
P2 = 7.55e+00
N = 9
M = 2.25e+01
S = 7.42e+00
$\frac{\Delta\eta}{\eta} = \frac{\Delta Z}{Z}$ of light tracks [%]

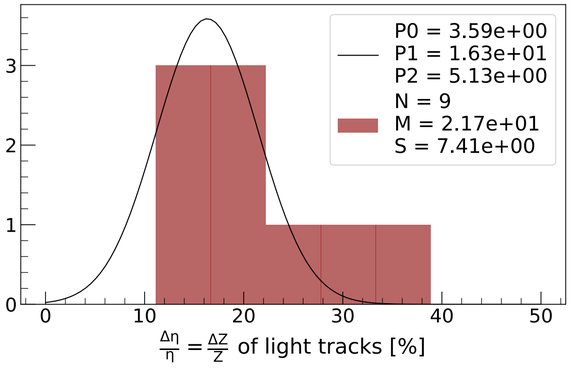
0.3kV/cm (strong cuts)



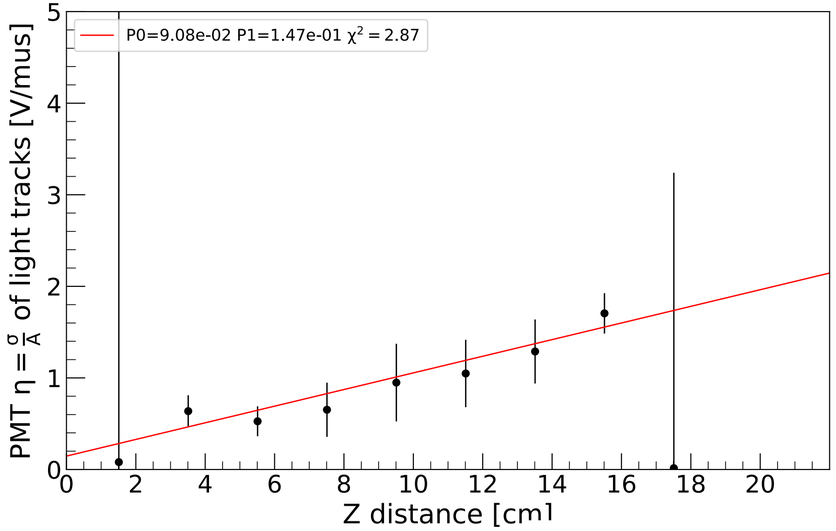


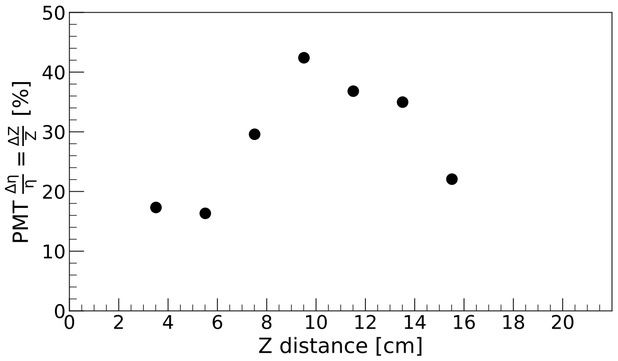


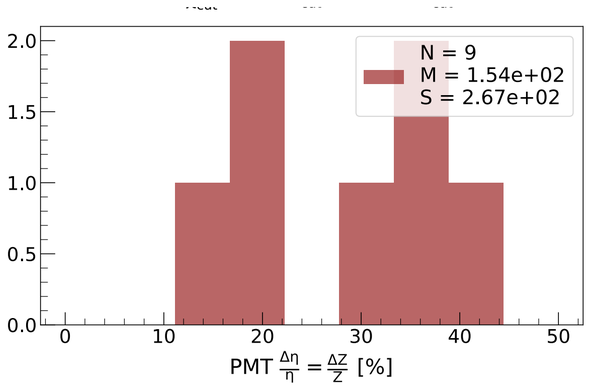


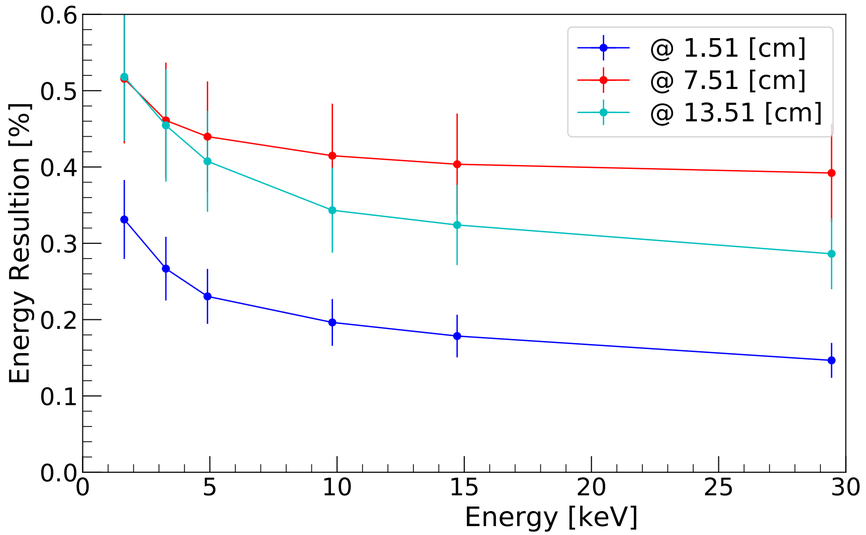


0.3kV/cm

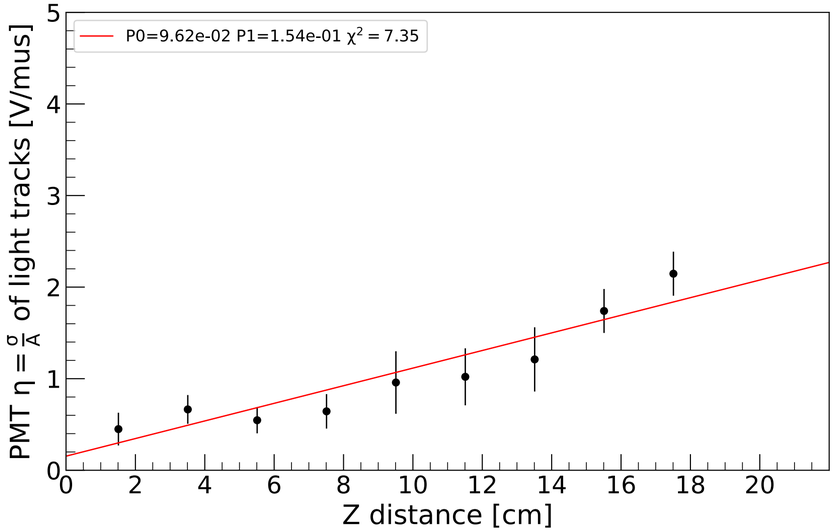

P0=9.08e-02 P1=1.47e-01 $\chi^2 = 2.87$
PMT $\eta = \frac{\sigma}{A}$ of light tracks [V/mus]
Z distance [cm]

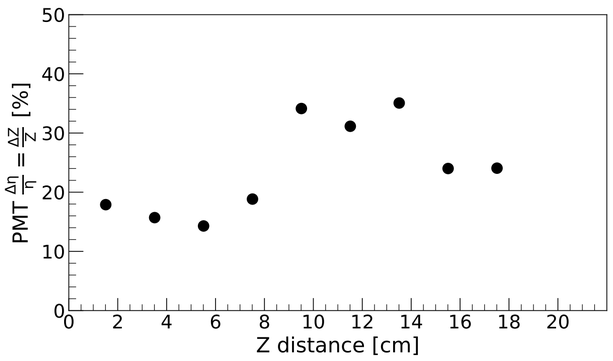

PMT $\frac{\Delta\eta}{\eta} = \frac{\Delta Z}{Z}$ [%]
Z distance [cm]

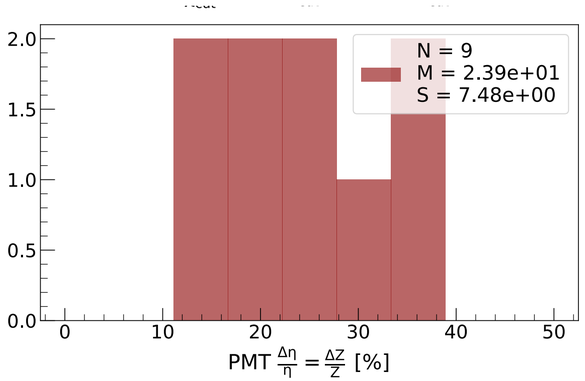

N = 9
M = 1.54e+02
S = 2.67e+02
PMT $\frac{\Delta\eta}{\eta} = \frac{\Delta Z}{Z}$ [%]

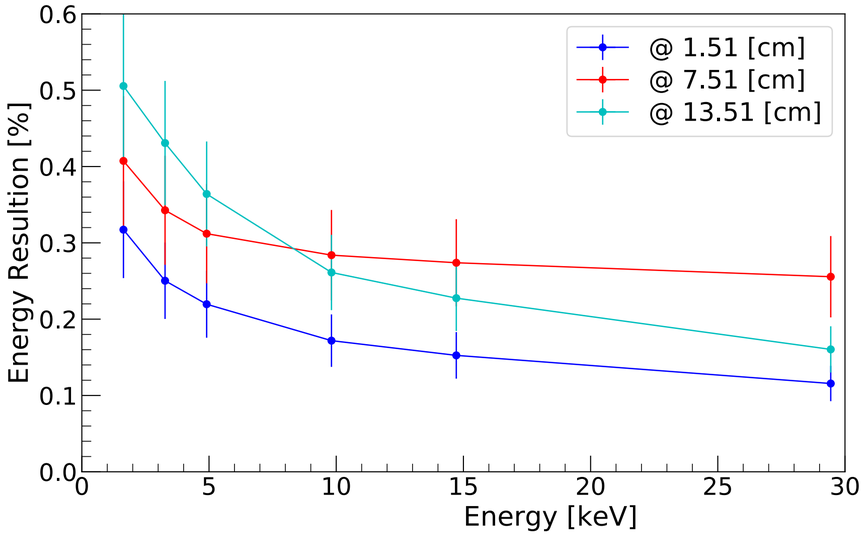

@ 1.51 [cm]
@ 7.51 [cm]
@ 13.51 [cm]
Energy Resultion [%]
Energy [keV]

0.3kV/cm (strong cuts)

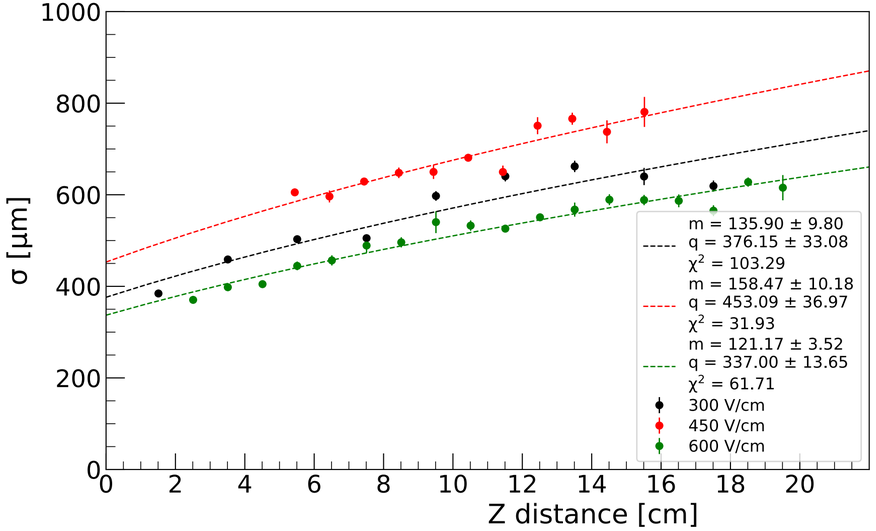


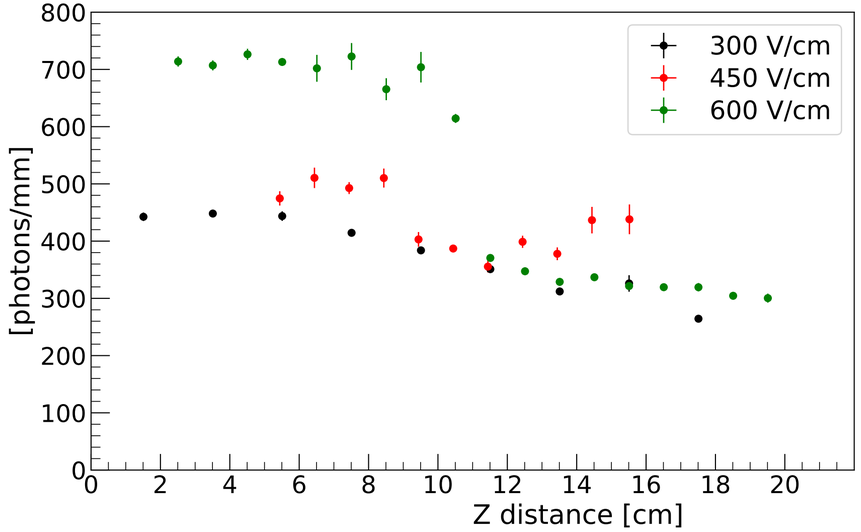


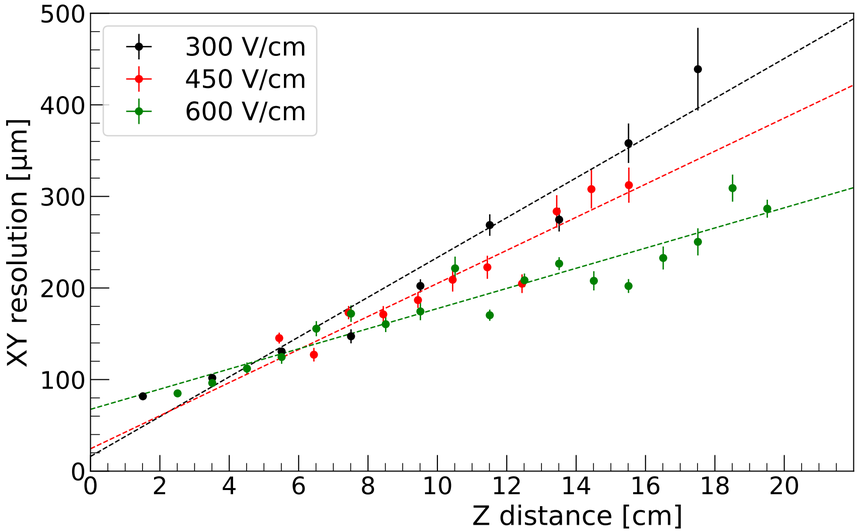




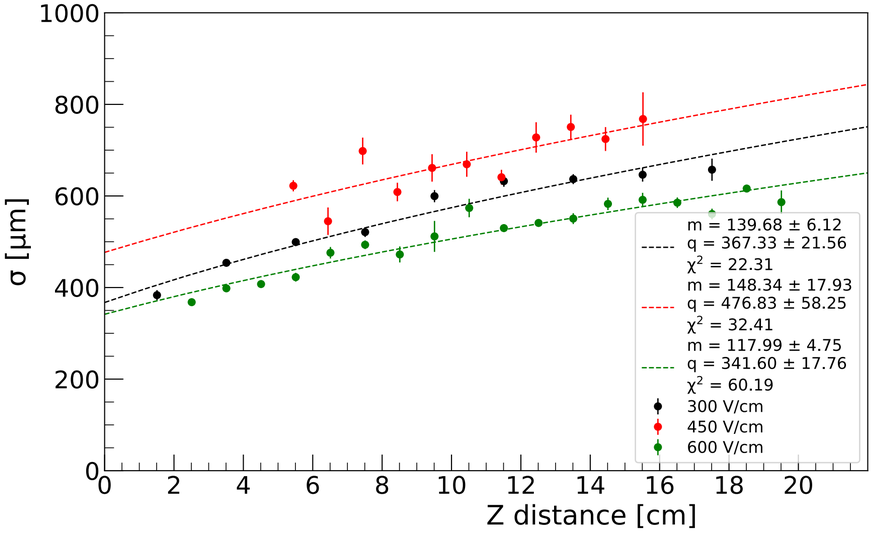
summary plots

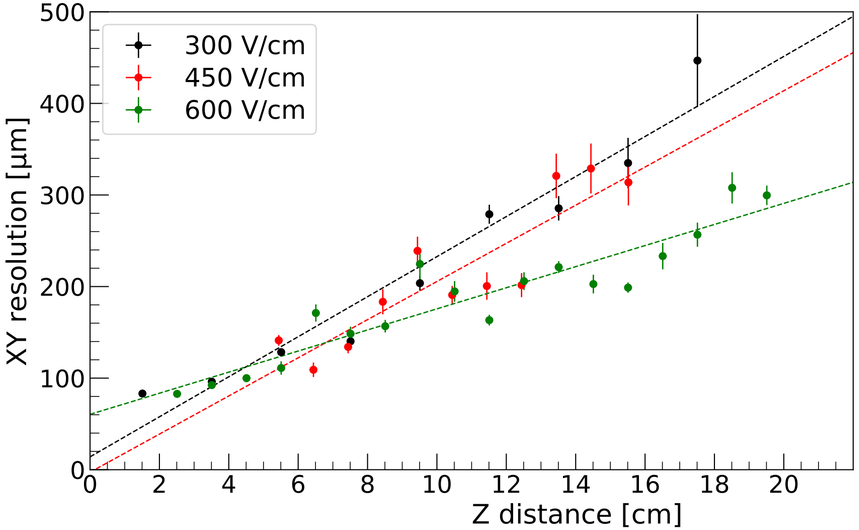


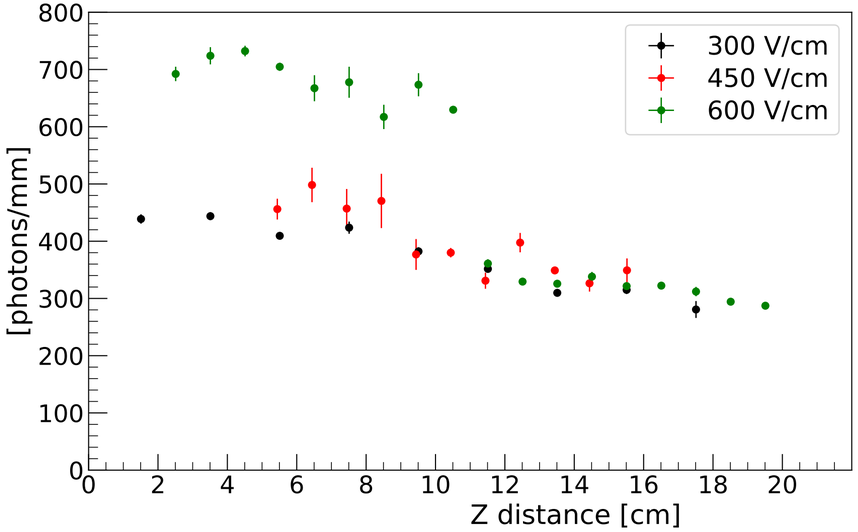




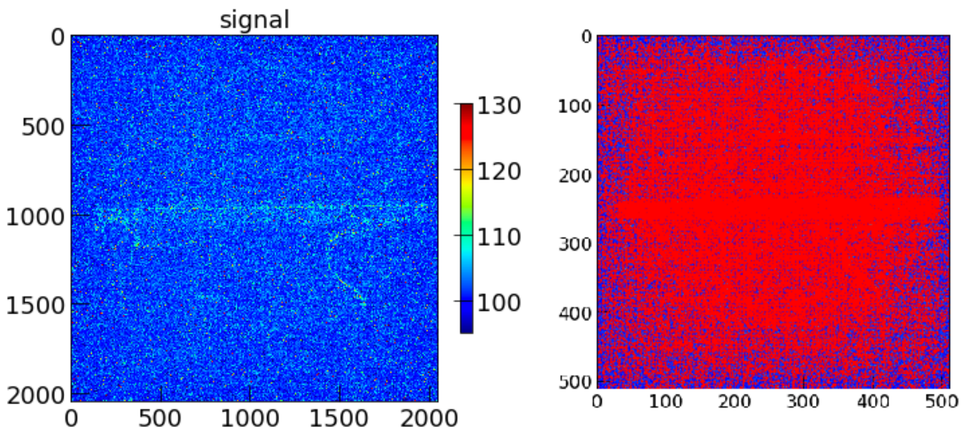
summary plots (strong cuts)



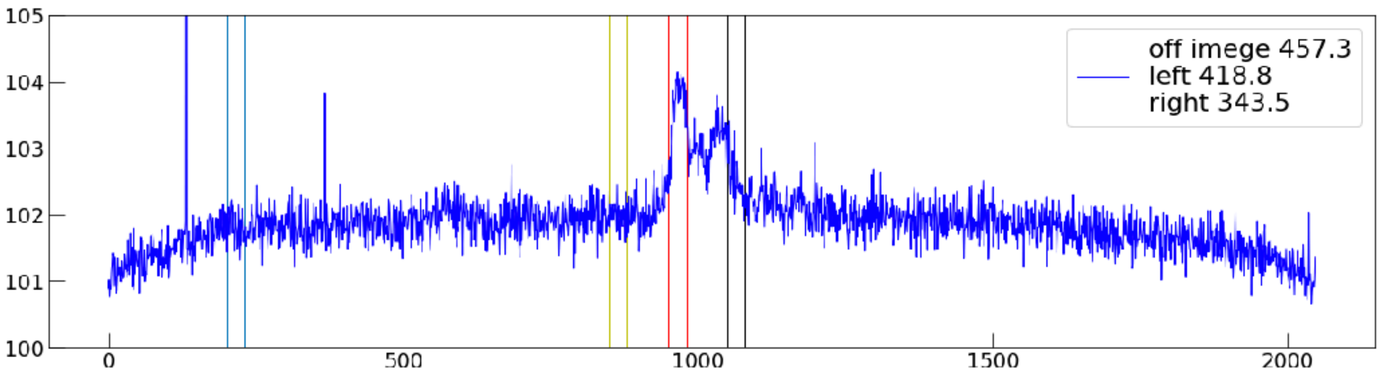


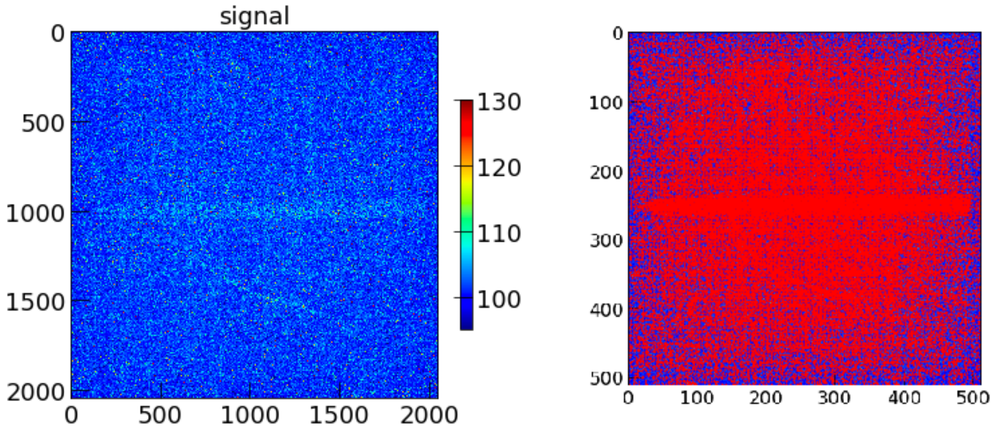


beam noise

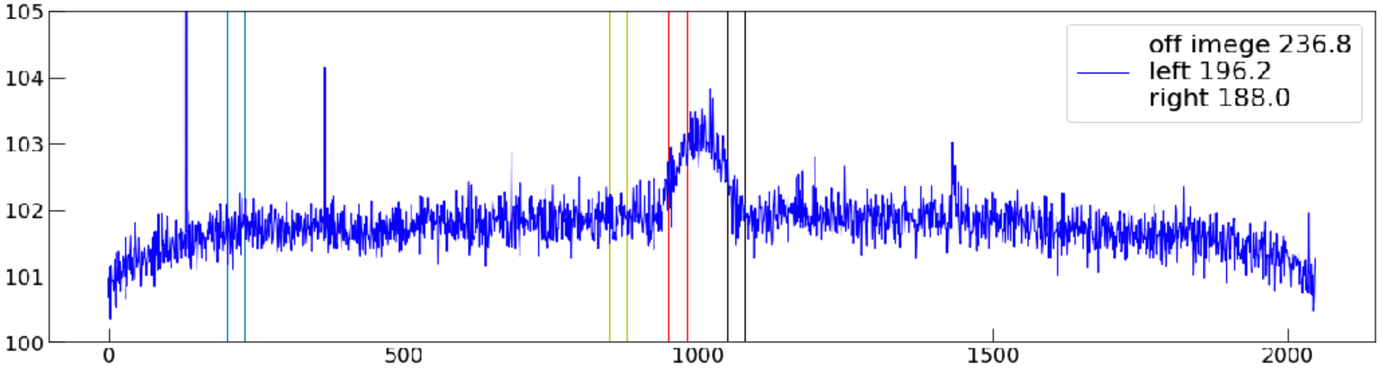


e-

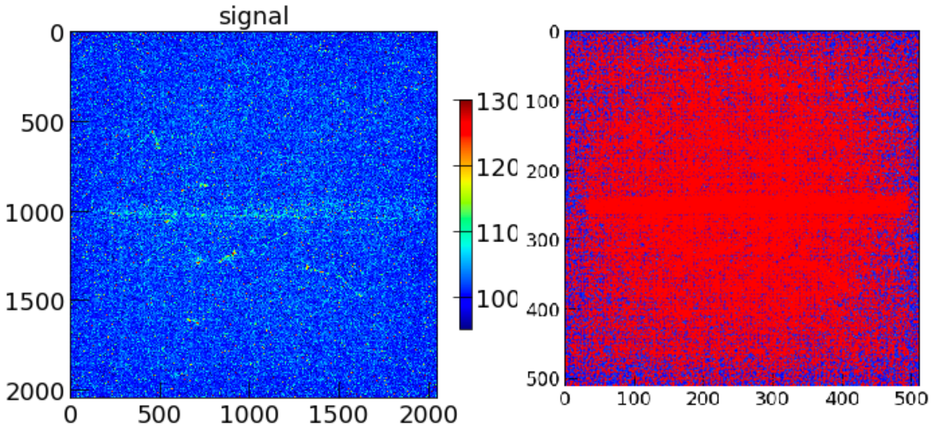


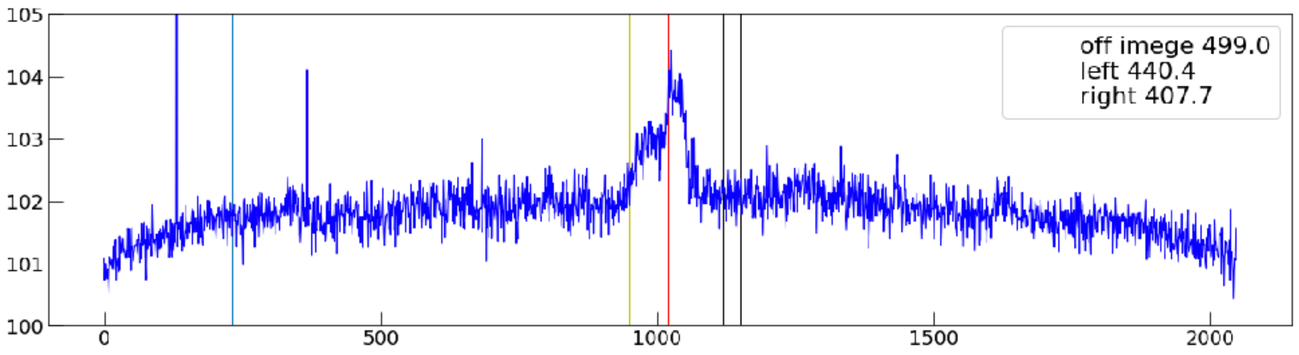


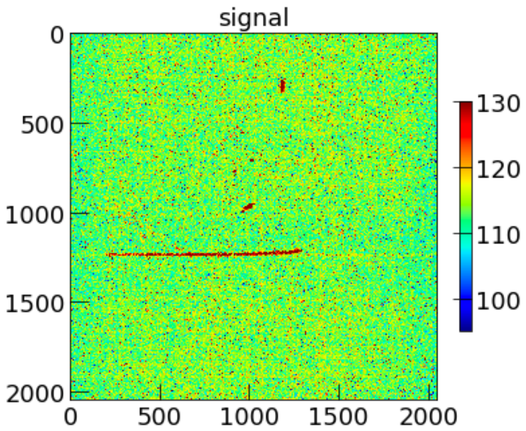
no e-



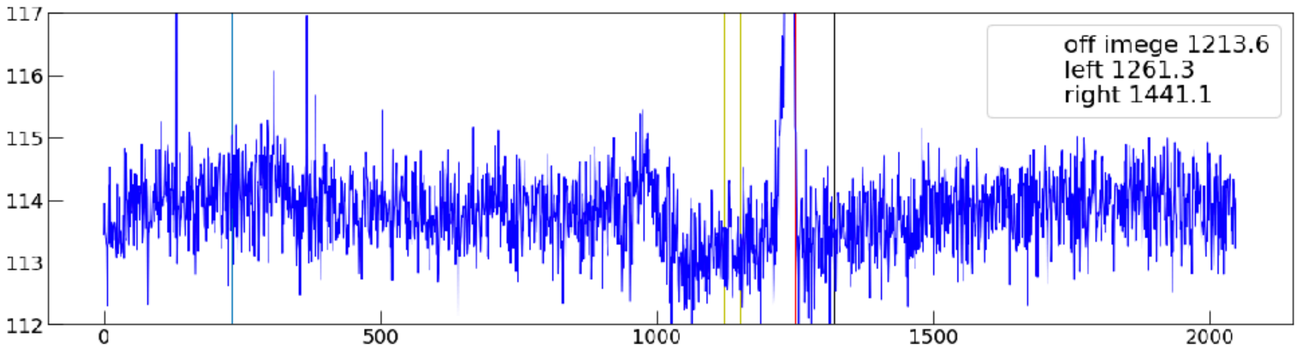
beam noise



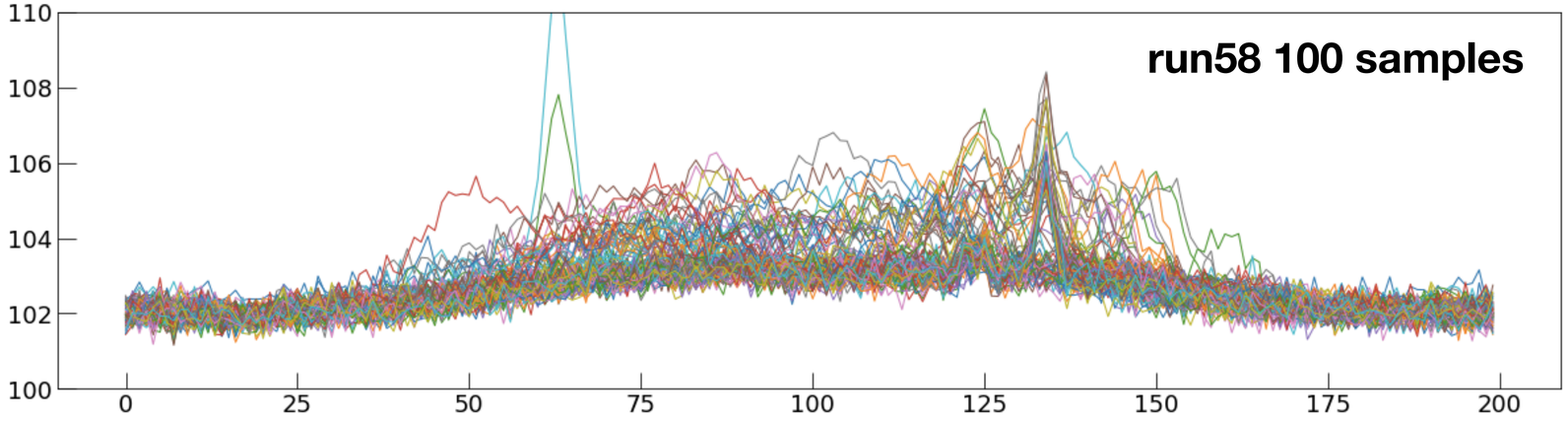


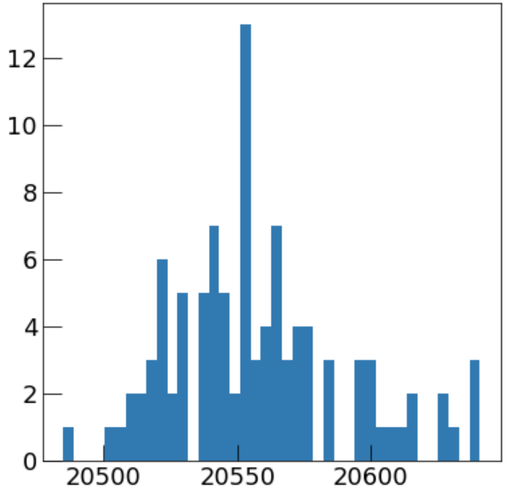


AmBe example



beam noise


run58 100 samples
110
108
106
104
102
100
0
25
50
75
100
125
150
175
200


12
10
8
6
4
2
0
20500
20550
20600