2D Absolute Photo Detection Efficiency measurement Summary

Jun 17, 2021

Morii

2D scan data in this document

PMT	Mesh	PMT	Mesh
SQ0283	Full	SQ0797	Full
SQ0285	Half	SQ0817	Full
SQ0291	Full	SQ0846	Half
SQ0326	Half	SQ0866	Full
SQ0428	Full	SQ0953	Full
SQ0551	Full	SQ0967	Full
SQ0553	Half	SQ0975	Full
SQ0582	Half	SQ0987	Full
SQ0655	Half	SQ0991	Full
SQ0657	Full		
SQ0775	Full		

Mesh Full:
Azimuth : 72 (0~360 degree)
Zenith: 64 (0~60 degree)

Mesh Half : Reduce mesh due to time limitation
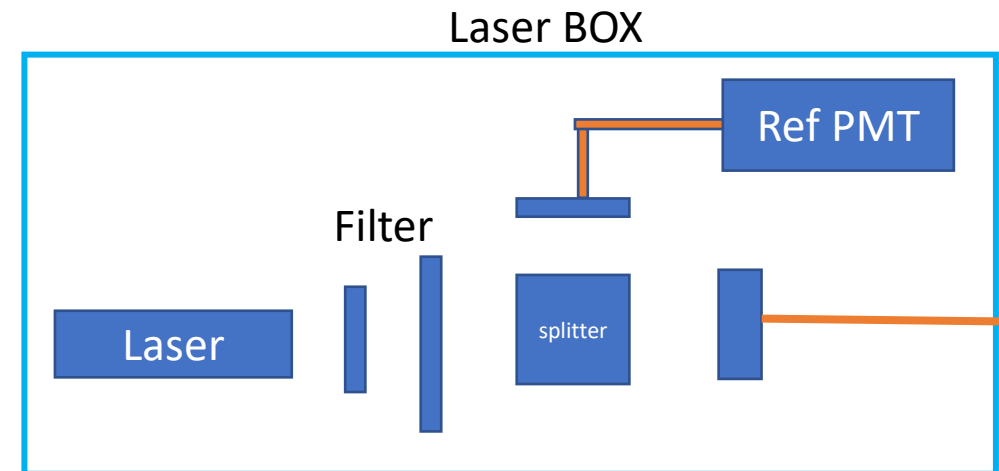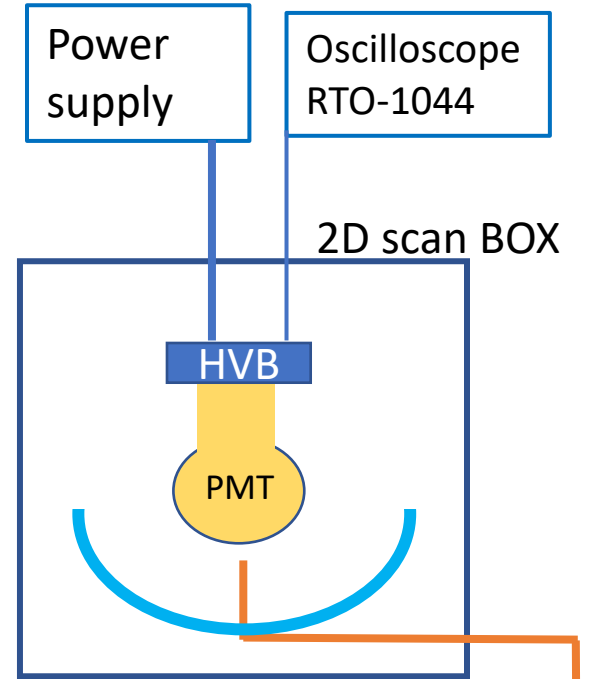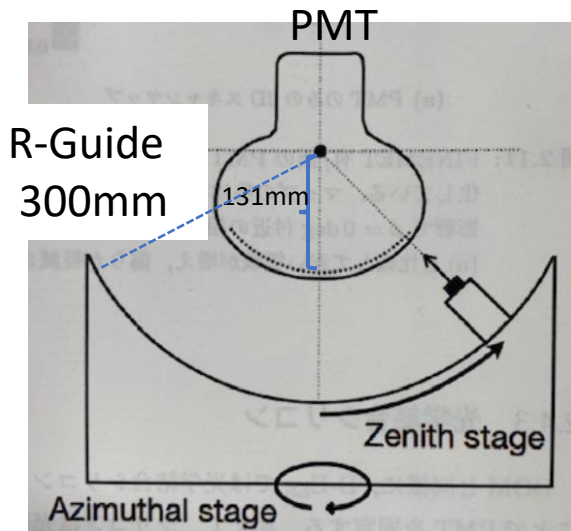Azimuth : 36 (0~360 degree)
Zenith: 32 (0~60 degree)

Not include the quick scan data in Sep – Oct 2021 because the profile is not accurate due to motor trouble.
Just confirm no issue after remove gel to reuse PMT

2D scan measurement setup

Laser: Hamamatsu
    c10196 + M10306
     400nm pulse width 60ps
Filter: fix 1% + rotation 1%
Reference PMT: R7056/UA8971

PMT & Rotation stage position

Measurement and analysis

Mesh 4608
   Azimuth : 72 (0~360 degree)
   Zenith: 64 (0~60 degree)
200 waveform / one mesh point
Intensity : ~20 pe
Measure : Target PMT & reference PMT
Data acquisition time: 44 hours

Calculation method

$$PDE_{DEgg}(\Phi, \Theta) = PDE_{ref} \cdot \frac{1}{f_{beamline}} \cdot \frac{\sum charges_{DEgg}(\Phi, \Theta)/gain_{DEgg}(\Phi, \Theta)}{\sum charges_{ref}/gain_{ref}}$$

Known parameter: PDE_{ref}=0.263 (Factory data), $Gain_{Degg}$, $Gain_{ref}$

$f_{beamline}$: Signal line/ reference line
          calibrated with same reference PMT

Based on the QE value of the reference PMT, calculate the ratio of
the total of 200 integrated values of the waveforms of each PMT.
The gain of the 8-inch PMT is 1×10^7 (fixed at the center value).

Example :2d map (sq0975)
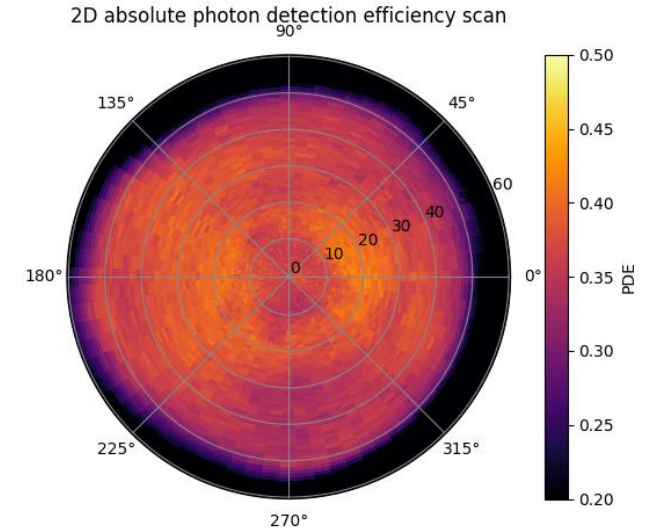
QE profile for zenith angle
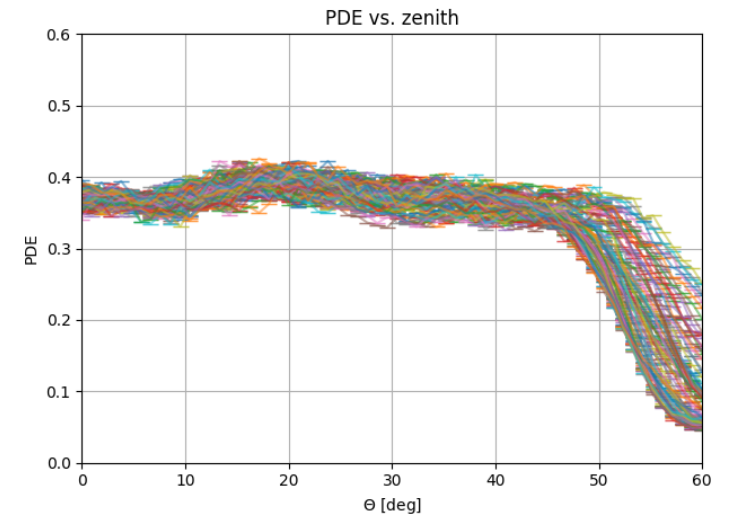
2D-Scan compare 1st batch with 2nd batch

- PMT that manufactured by end of 2018(sq0285~326) have the profile of decline for zenith
- PMT that manufactured after 2019 have flat profile for zenith

1st Batch (~sq0351)

Sq0285: Mesh (32 x36)(arrival:2018/12)
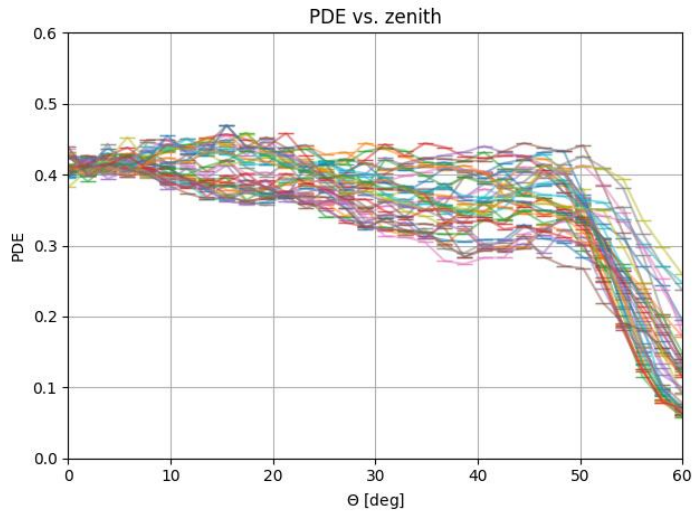
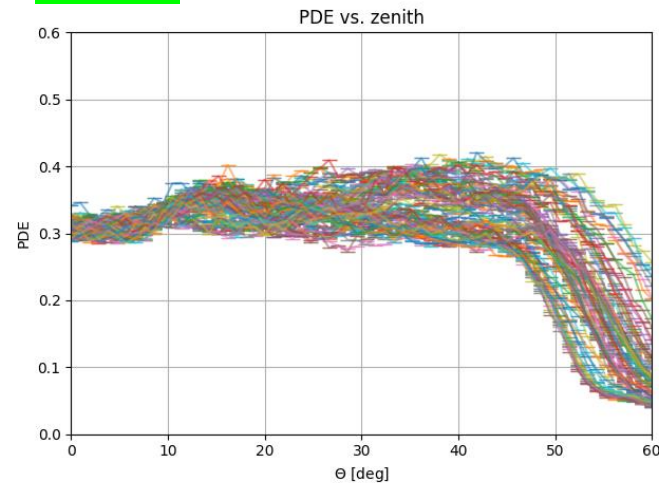### Sq0291: (64x72)(arrival 2018/12)
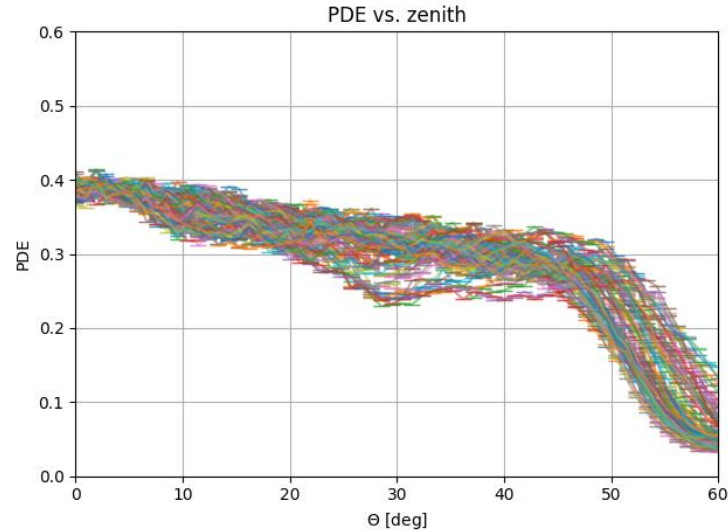
Sq0283:(64X72) (arrival 2018/12)
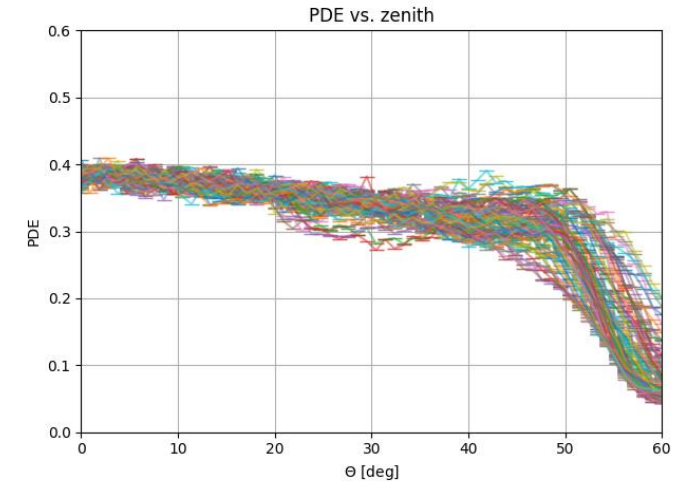
2nd Batch(sq0352~)

Sq0326: 32X36 (arrival 2018/12)
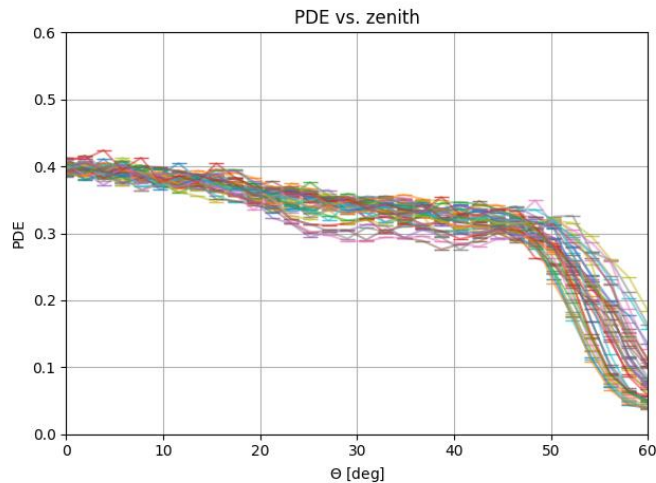
Sq0428(arrival 2019/1)

Sq0553 (Arrival 2019/3)

5
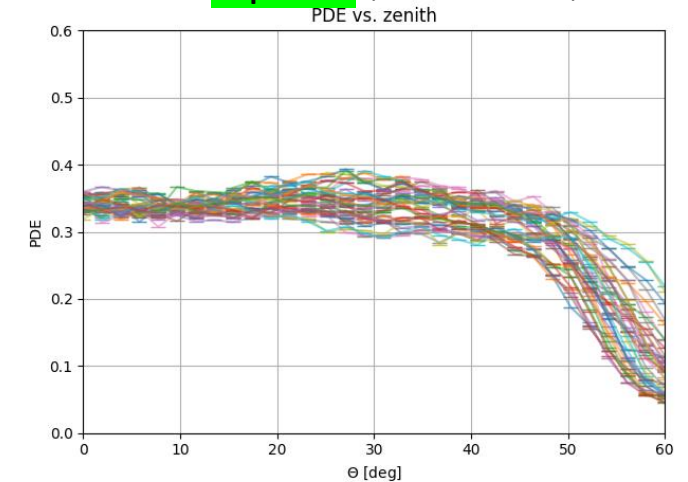
2D-Scan compare 1st batch with 2nd batch

Sq0655 (arrival 2019/3)
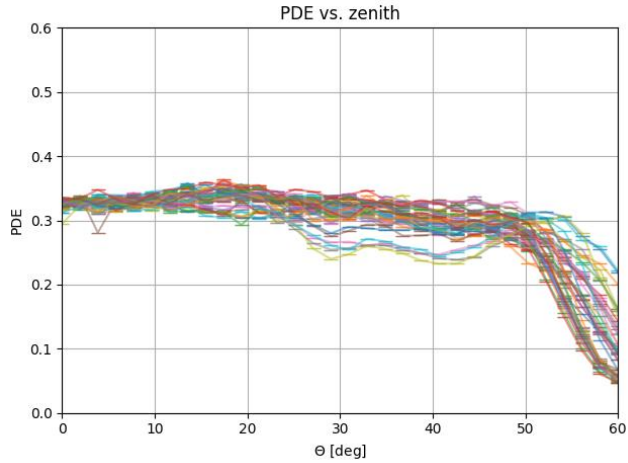
Sq0775 (arrival 2019/8)
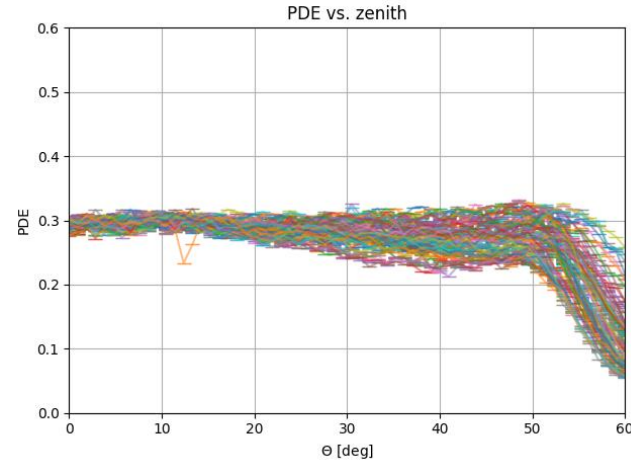
Sq0797 (arrival 2019/8)
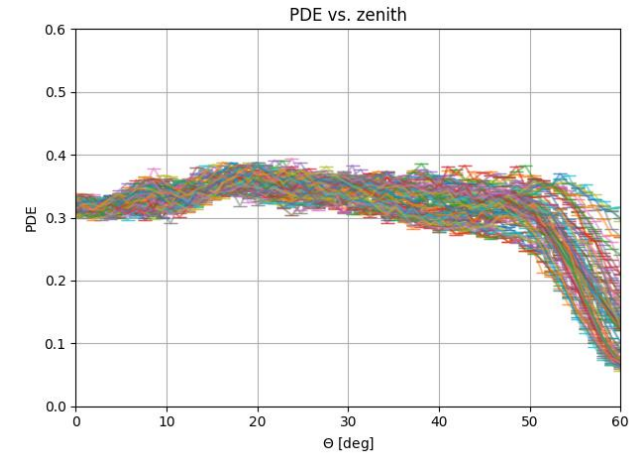
Sq0886 (arrival 2019/8)
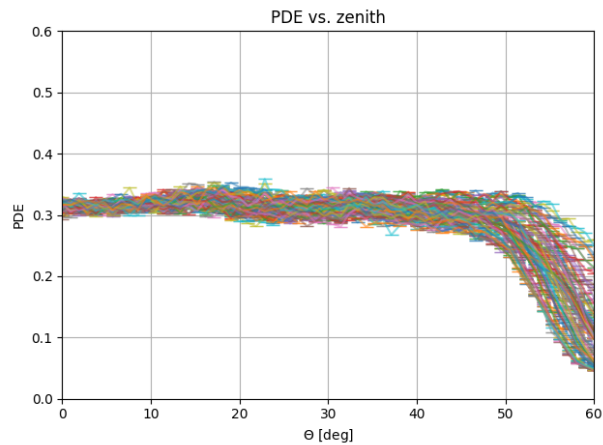
Sq0817 (arrival 2019/8)
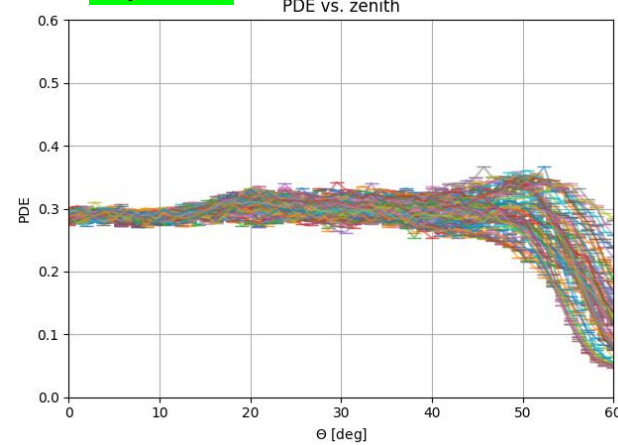
Sq0987 (arrival 2019/9)
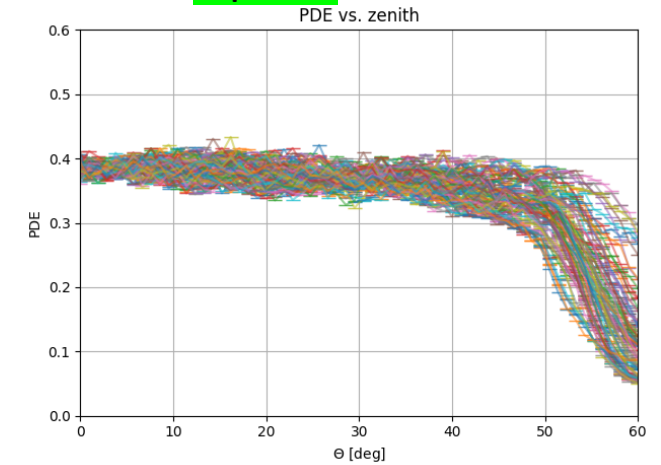
Note: new cathode contact shape was introduced after sq0814

Hollow Profile @Azimuth=270 degree : confirmation SQ0975
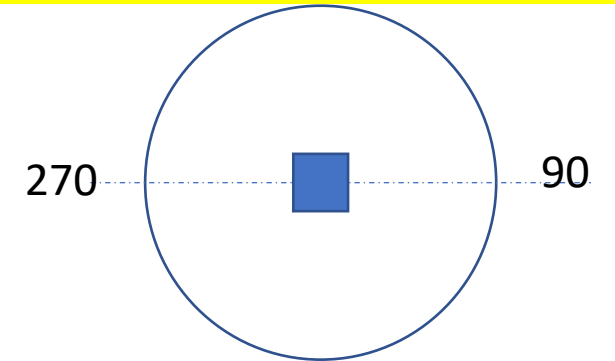
Apr 9 data

Normal position

2D absolute photon detection efficiency scan

PDE vs. zenith

No systematic error
This is due to first dynode structure

270 ⬝⬝⬝ 90

Jun 25 Data

Rotate Azimuth 180 degree

2D absolute photon detection efficiency scan

PDE vs. zenith

270 ⎯⎯ 90

My guess : Electrons due to light coming from an oblique direction at 270 degrees are difficult to hit due to the inclination of the first dynode.

Hollow Profile @Azimuth=270   (Another example）

Sq0655: gain 1×10^7 Vc=4.039
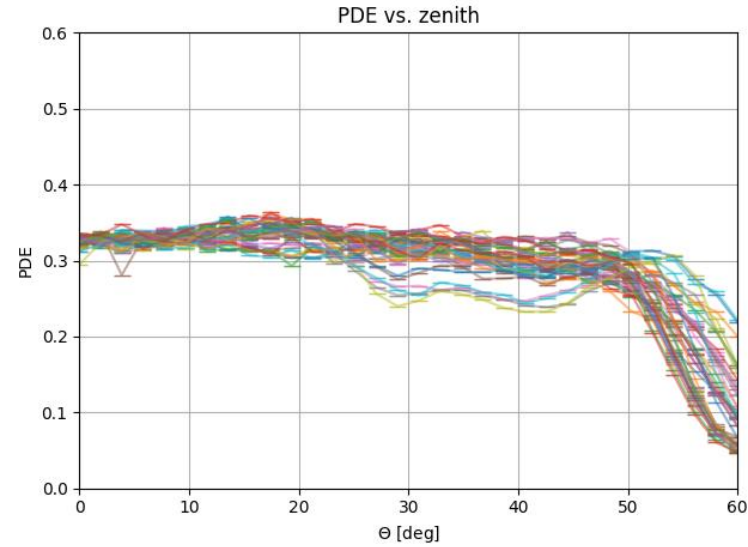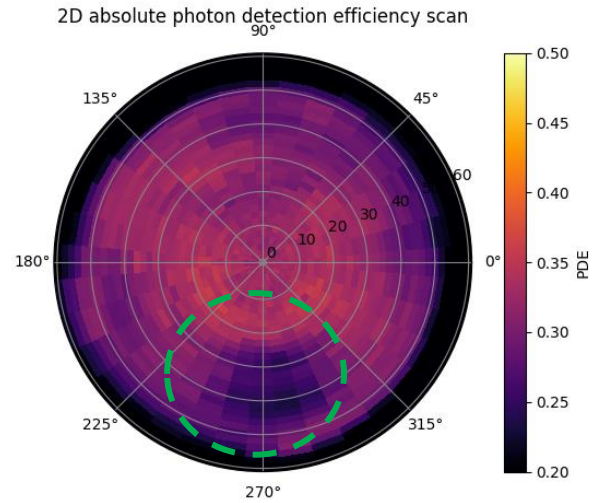
Sq0846: gain 1×10^7 Vc=3.751V
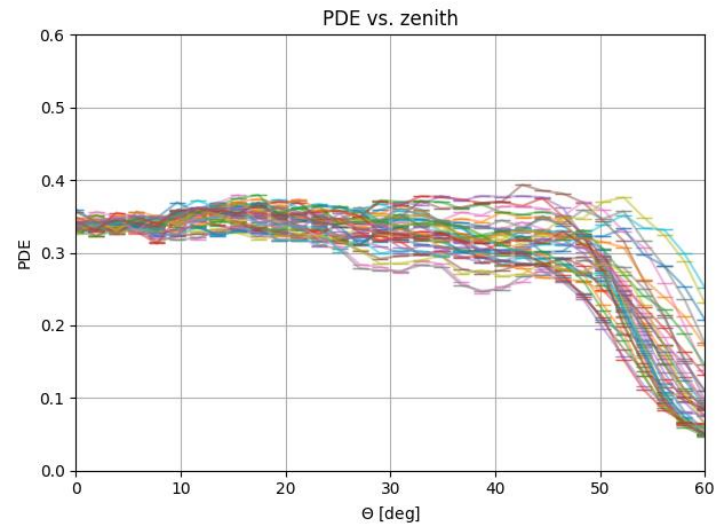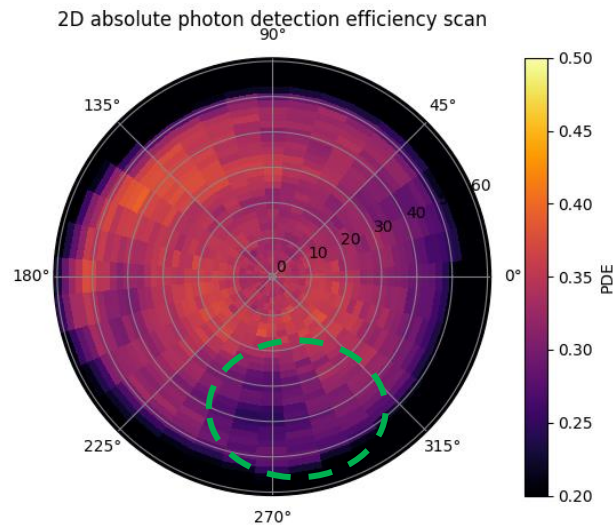
QE comparison : averaged for measurement vs Hamamatsu data

Hamamatsu measurement
Wide DC light source : Φ190 mm
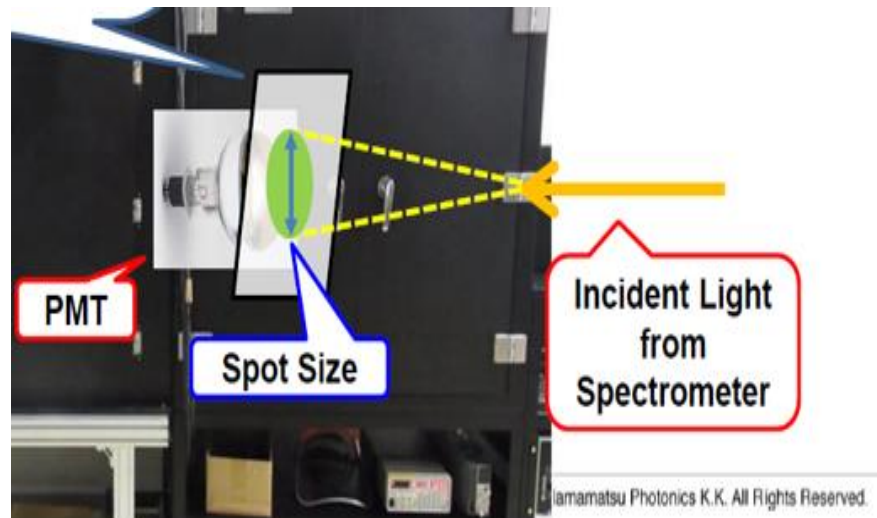
Chiba-U measurement
Pulse spotlight source : Φ several mm scan
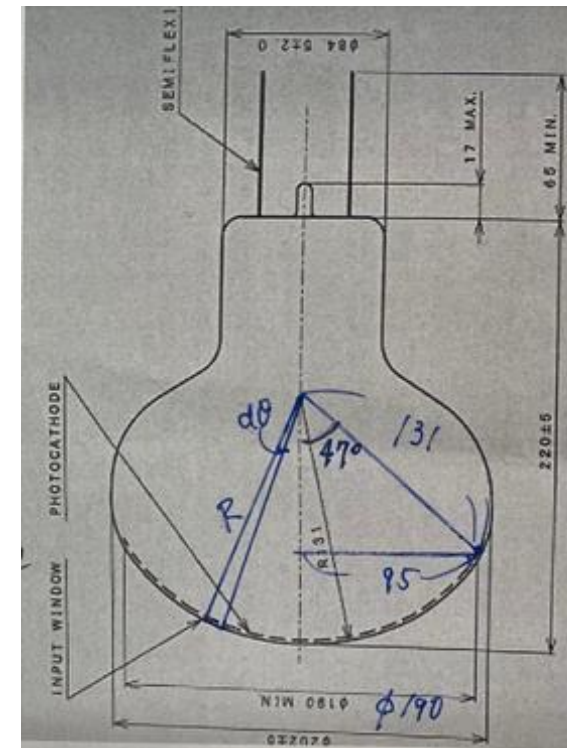
Averaging: zenith 0~47 degree (= φ190mm)
azimuth 0~360 degree

QE comparison : averaged for measurement vs Hamamatsu data
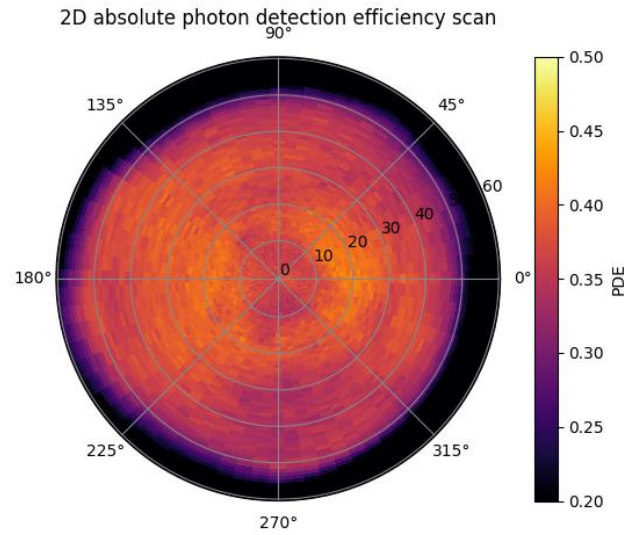
Our data is lower than Hamamatsu data by 2~4%
At the case of the previous GEN1, our measurement results tended to be lower than Hamamatsu data.
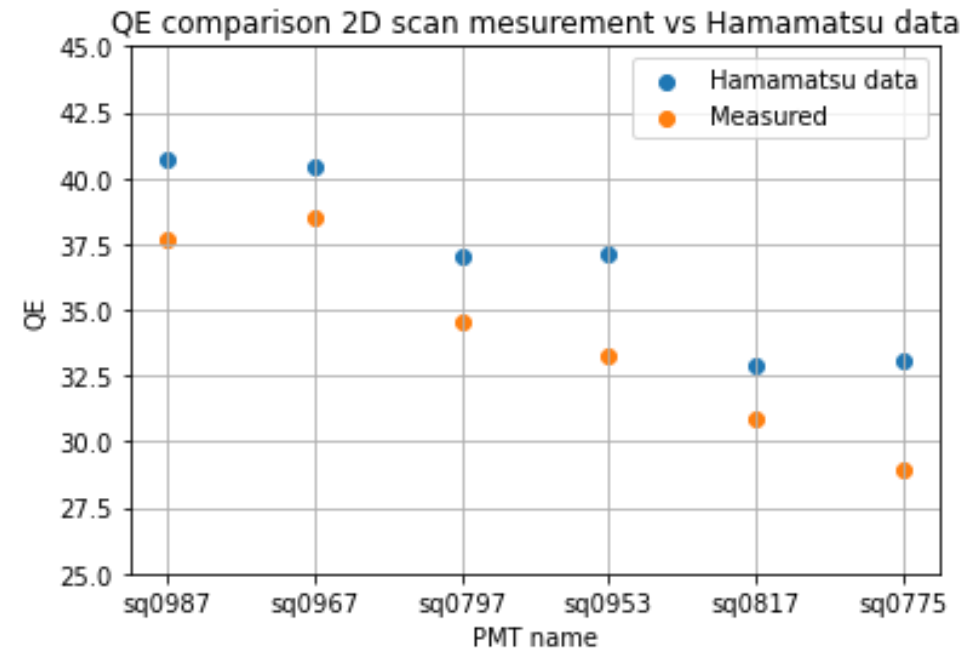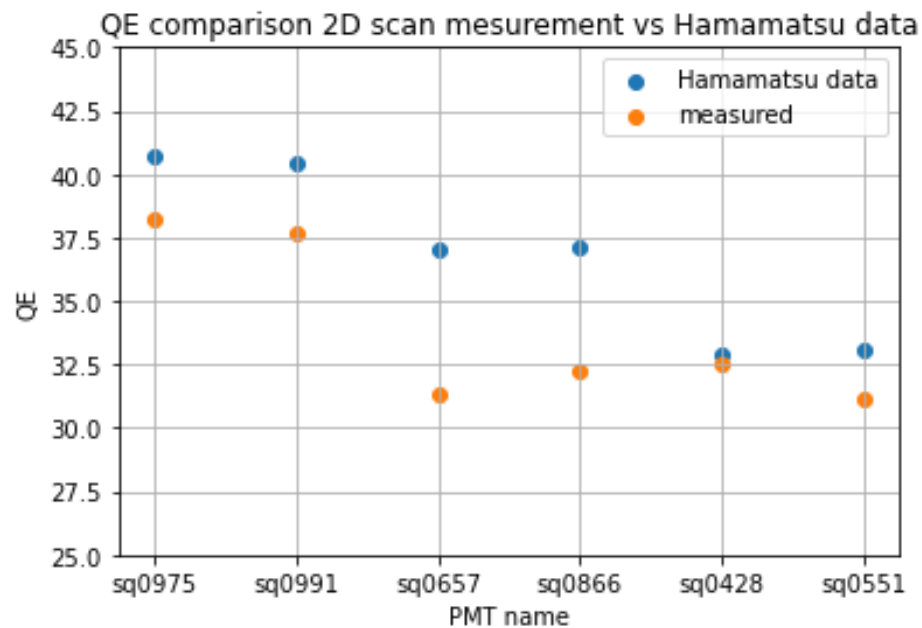
Back up

2D Photon Detection Efficiency scan(Golden 1ˢᵗ Gr :Best)

Sq0975(best QE)

Sq0991(best QE)

Hamamatsu data 40.67
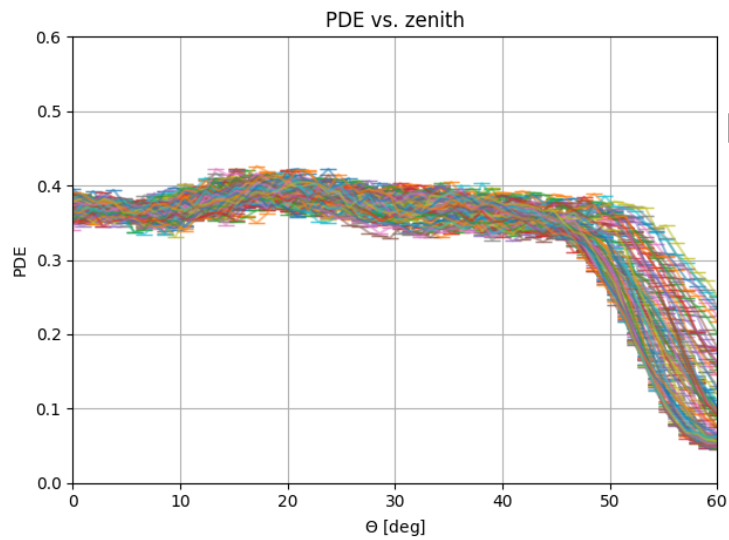
Hamamatsu data 40.36
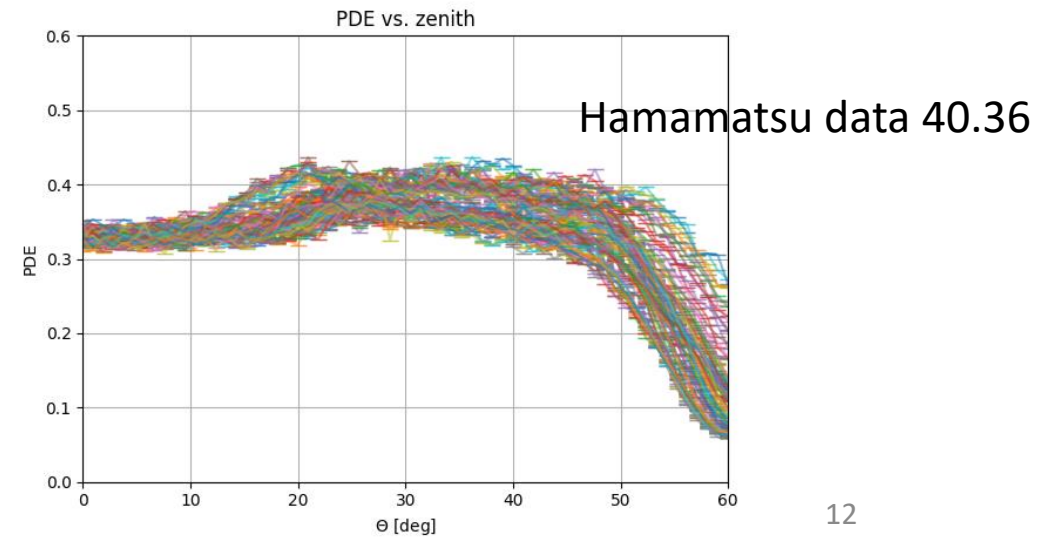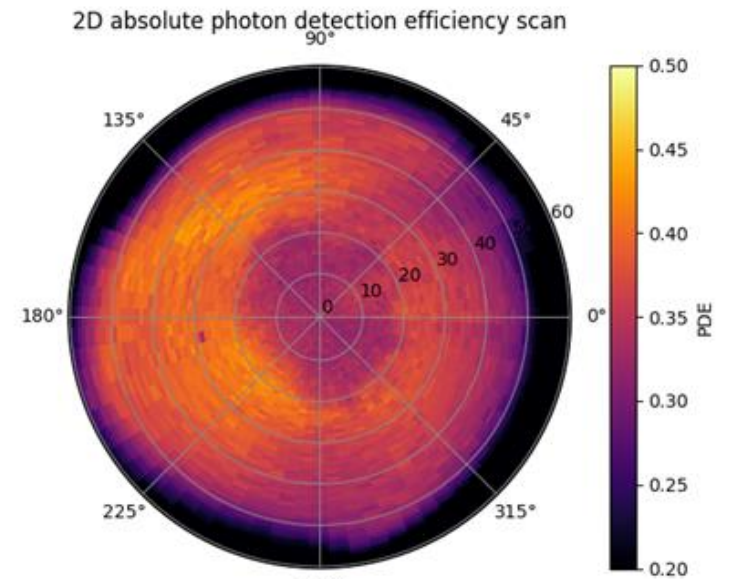
2D Photon Detection Efficiency scan(Golden 1ˢᵗ Gr: average)

Sq0657(averaged QE)

Sq0866(averaged QE)
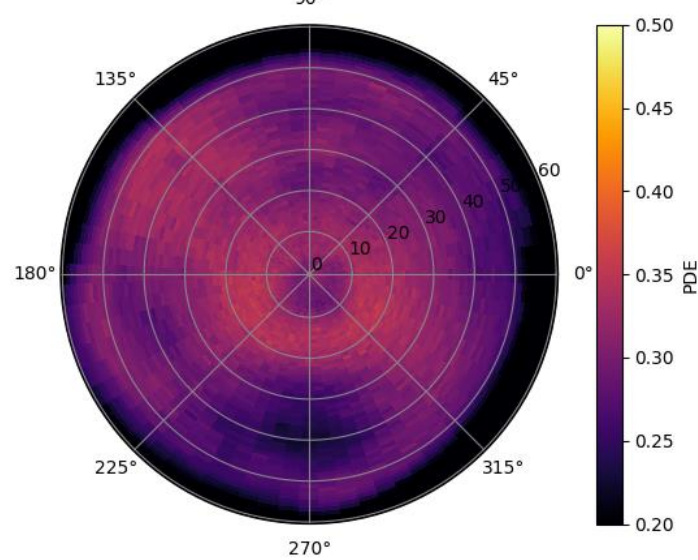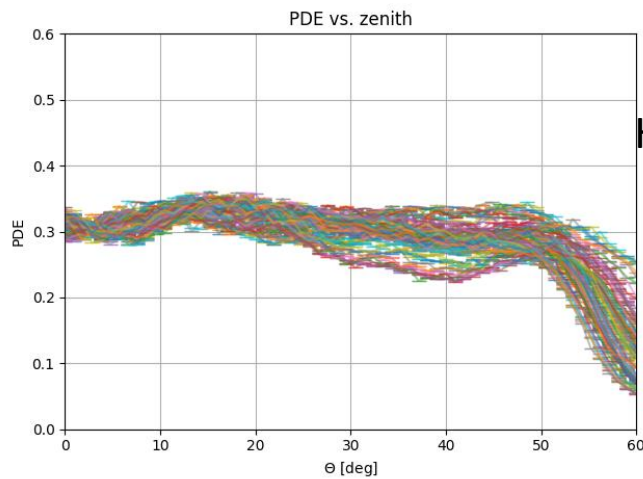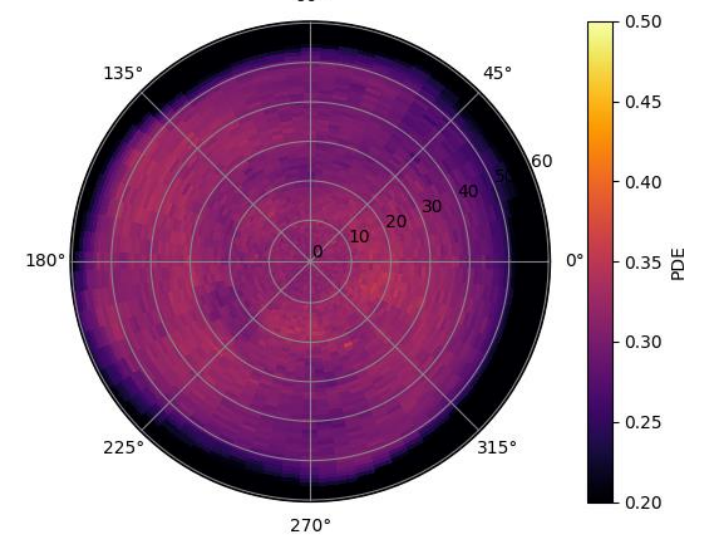
Hamamatsu data 37.03
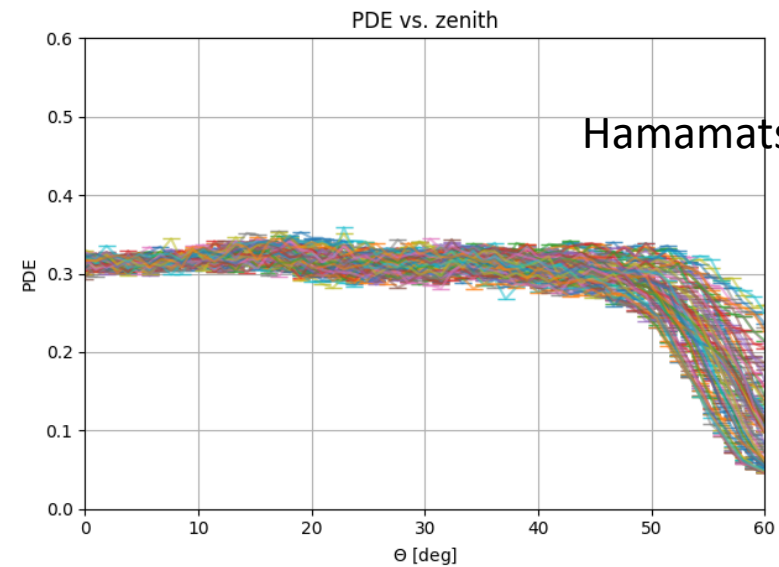
Hamamatsu data 37.1

2D Photon Detection Efficiency scan(Golden 1ˢᵗ Gr: worst)

Sq0551(worst QE)
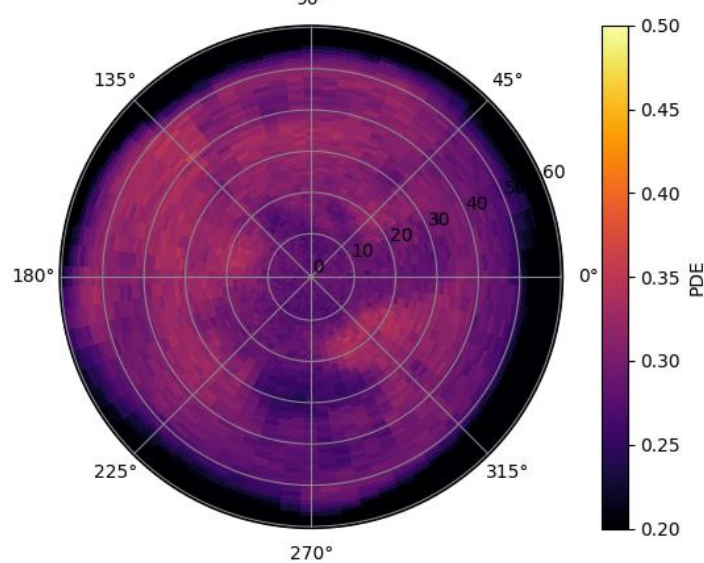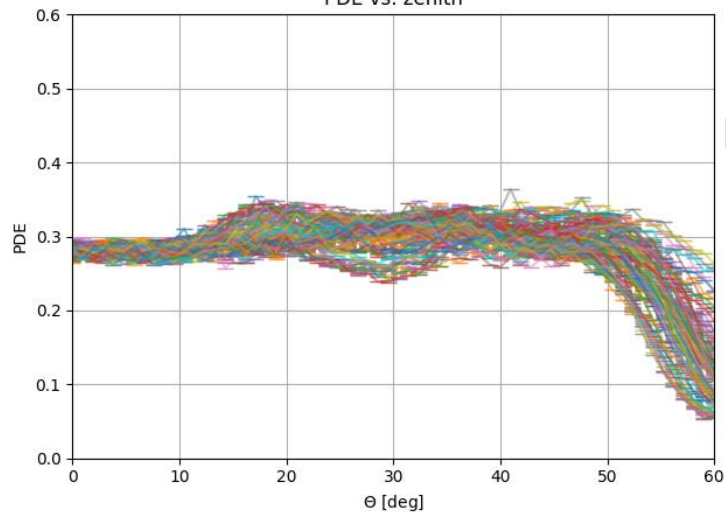
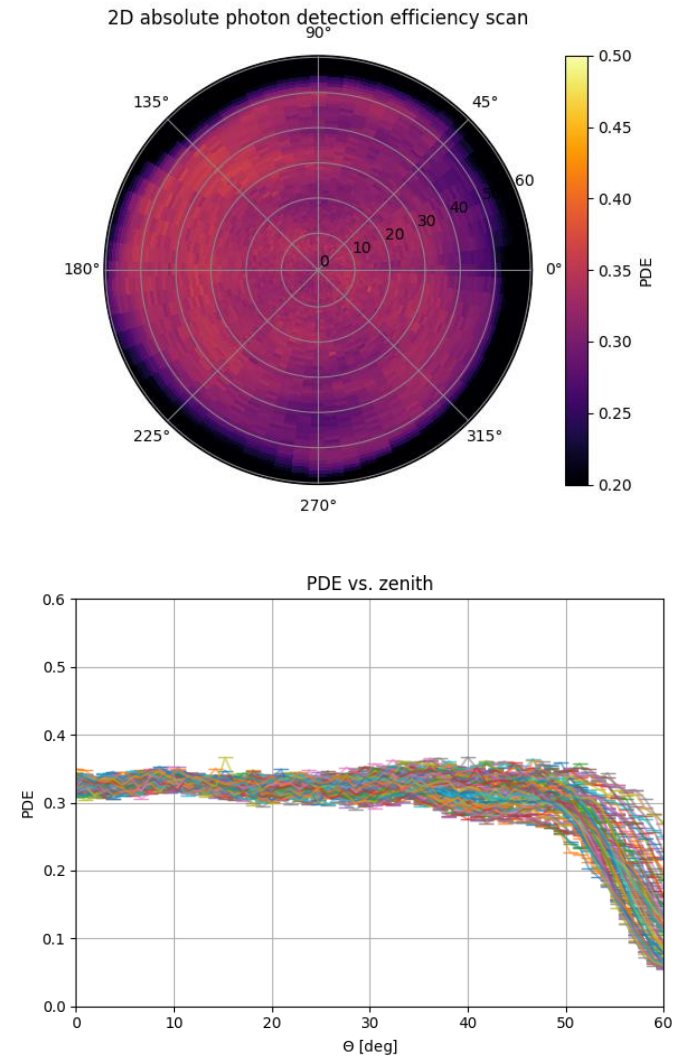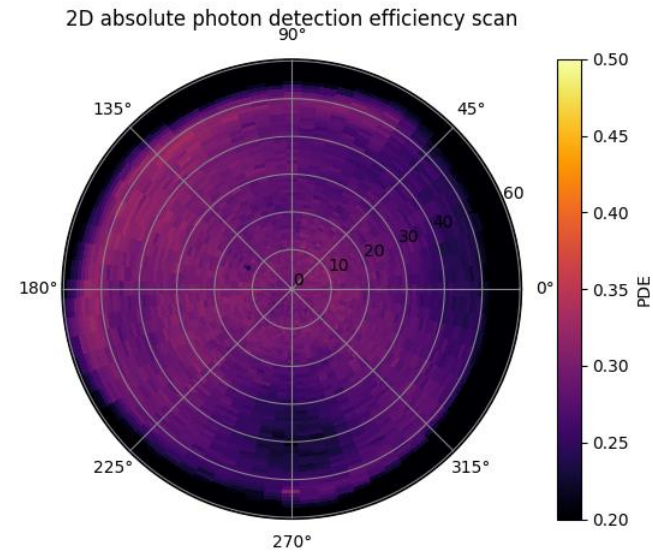Sq0428(worst QE)
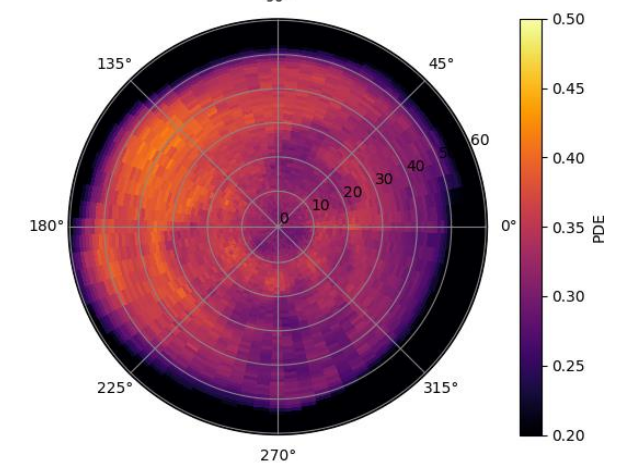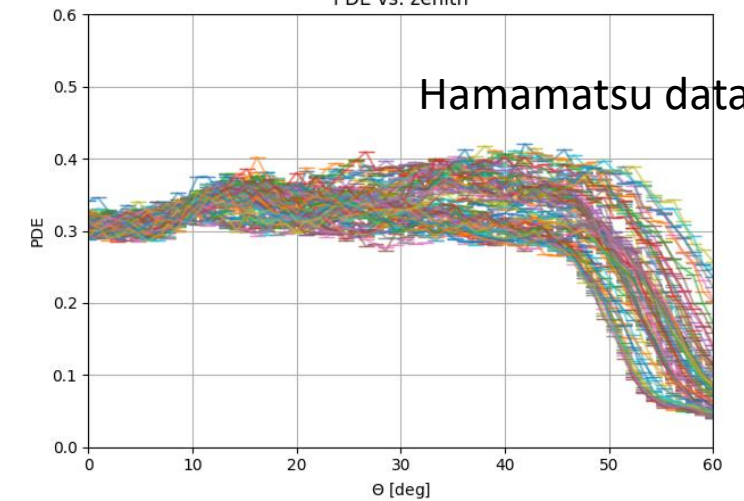
Hamamatsu data 32.9

Hamamatsu data 33.1

2D Photon Detection Efficiency scan(Golden 2ⁿᵈ Gr: Best)

Sq0987
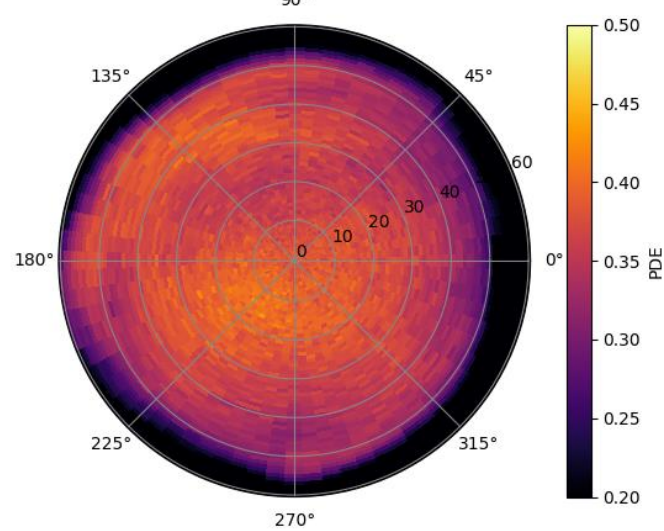
Sq0967
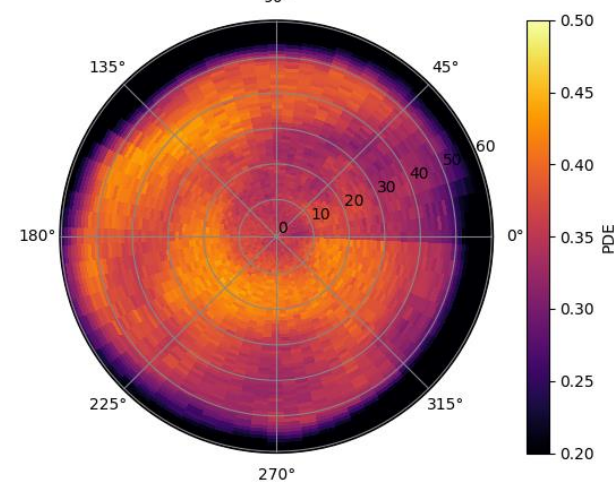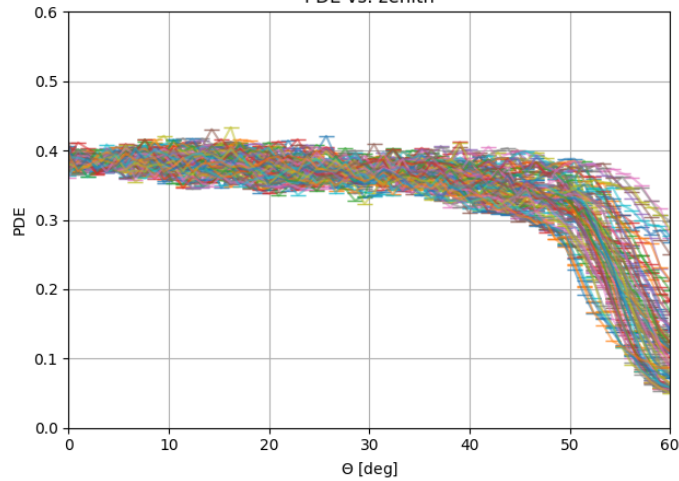
Hamamatsu data
QE:39.96
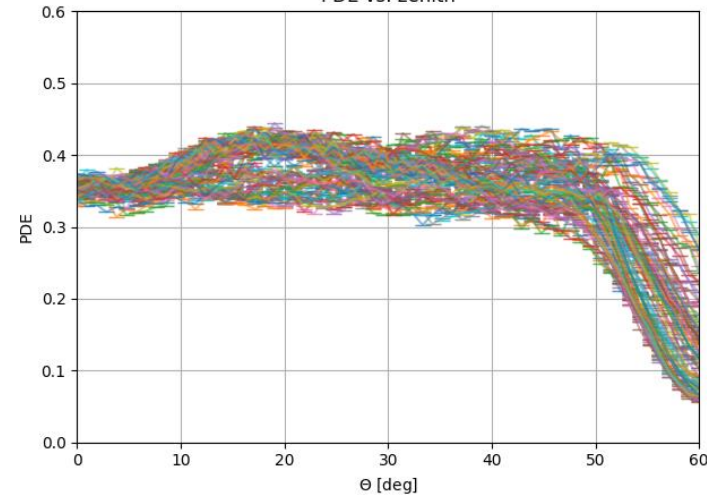
Hamamatsu data
QE:39.86

2D Photon Detection Efficiency scan(Golden 2nd Gr: average)

Sq0797
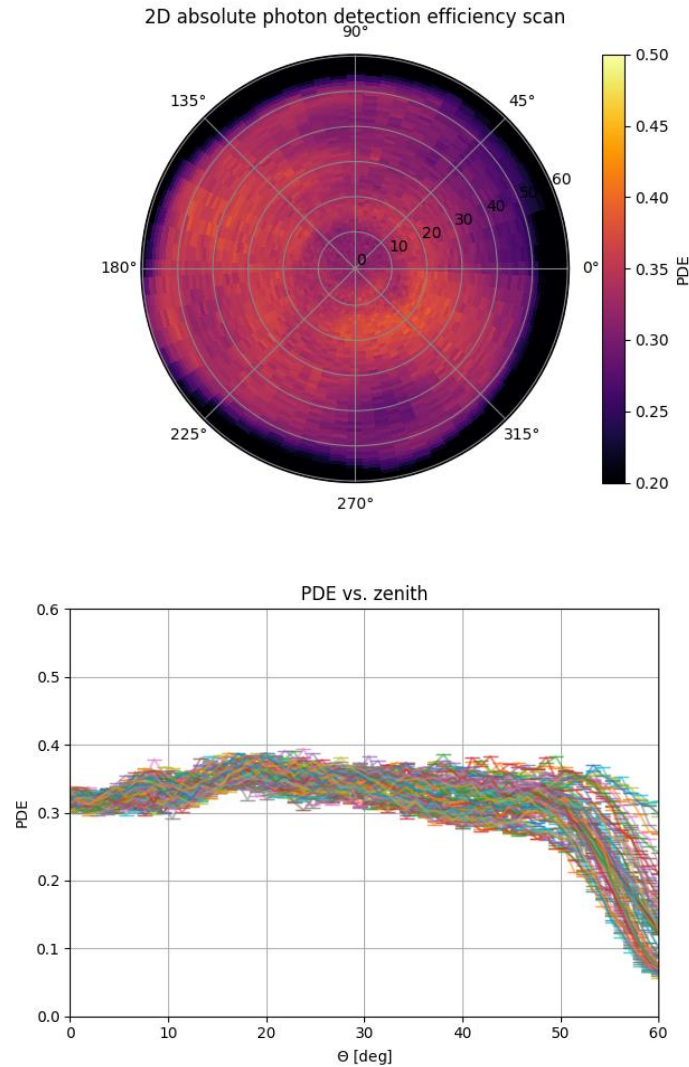
Sq0953
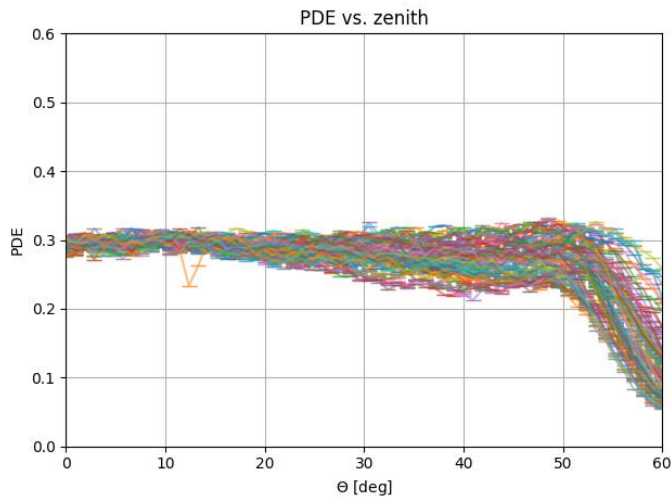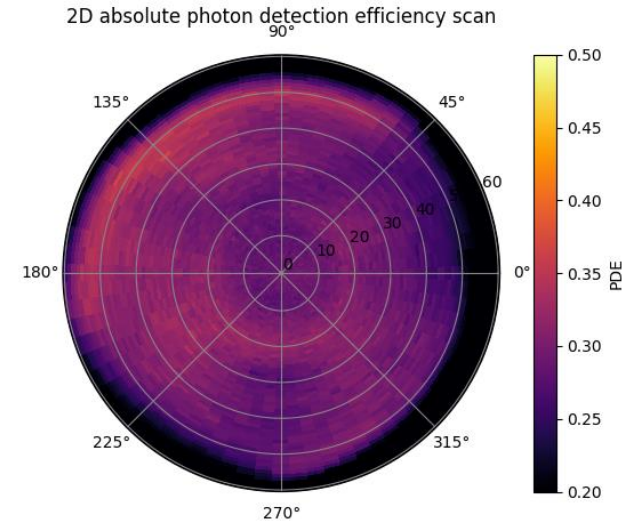

Hamamatsu data
QE:37.0

Hamamatsu data
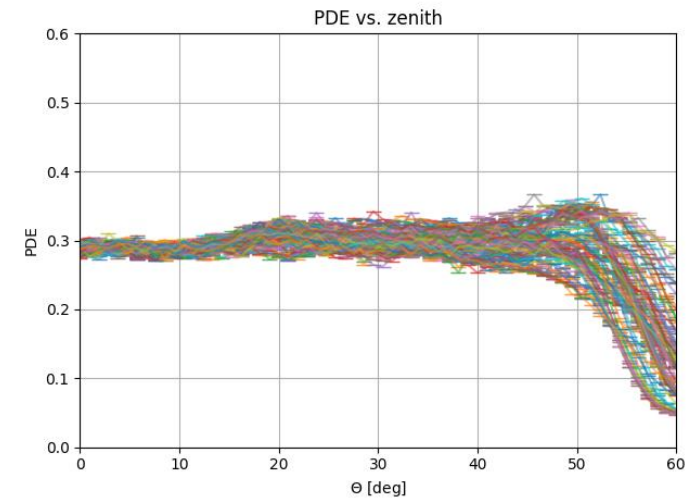QE:37.0

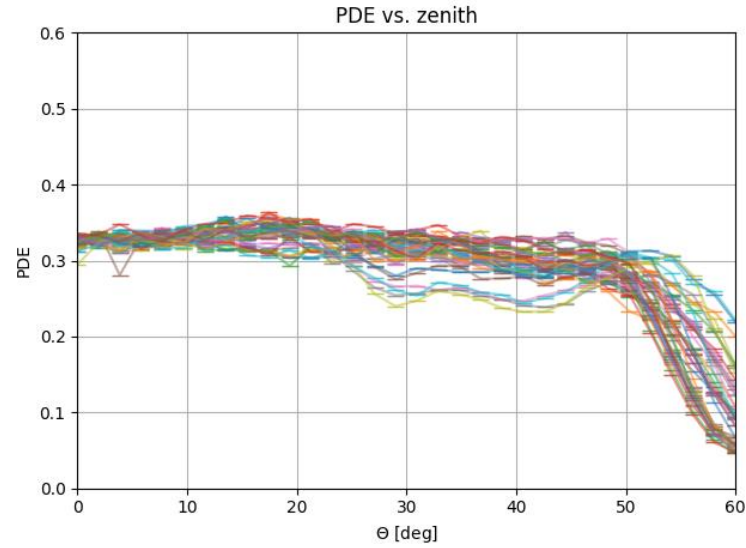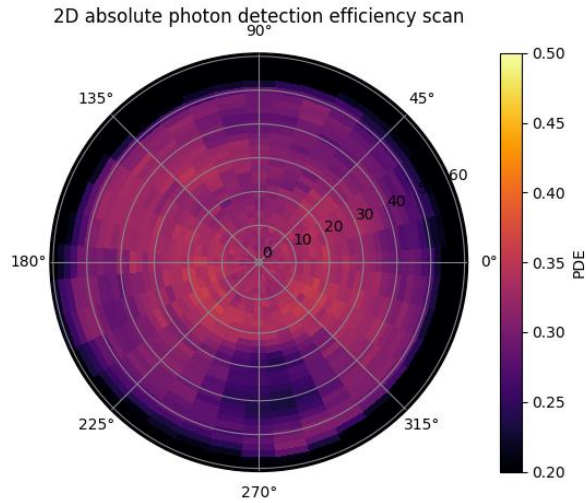# 2D Photon Detection Efficiency scan(Golden 2nd Gr: worst)

Sq0775

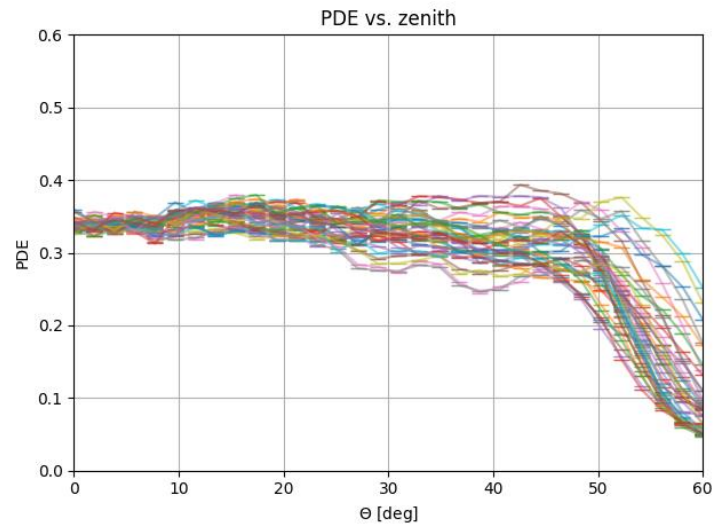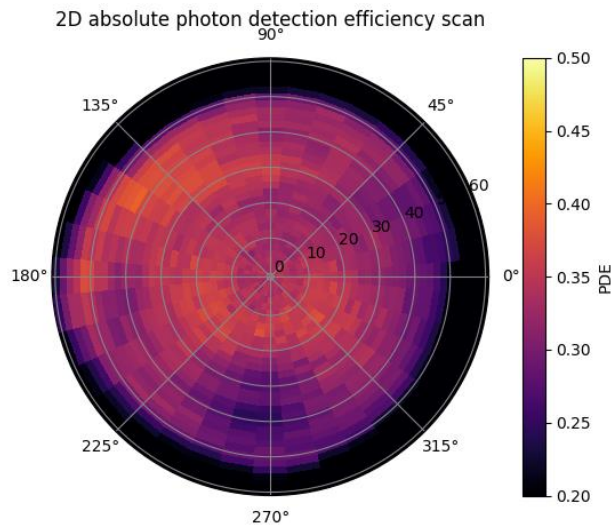Sq0817

Hamamatsu data
QE:33.8

Hamamatsu data
QE:33.6

2D-scan profile confirmation (Half mesh)

Sq0655: gain 1×10^7 Vc=4.039

Hamamatsu data QE:36.8
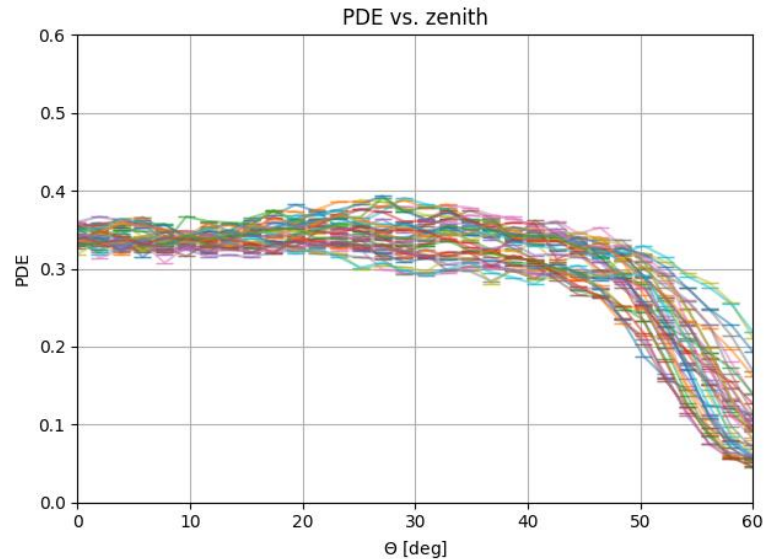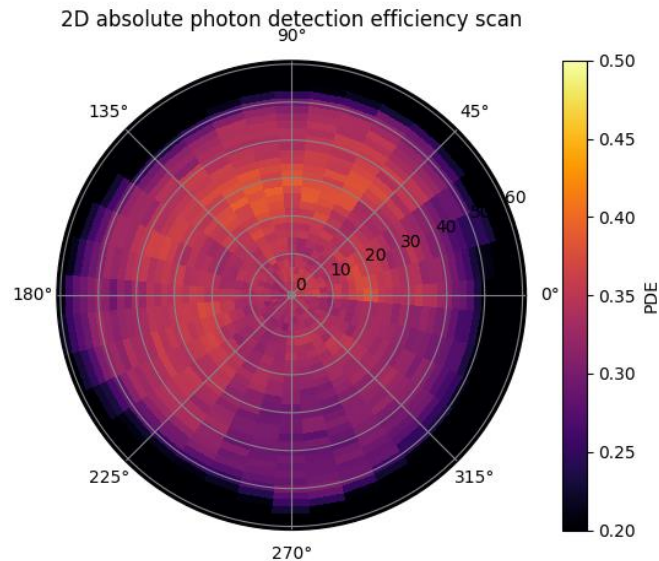
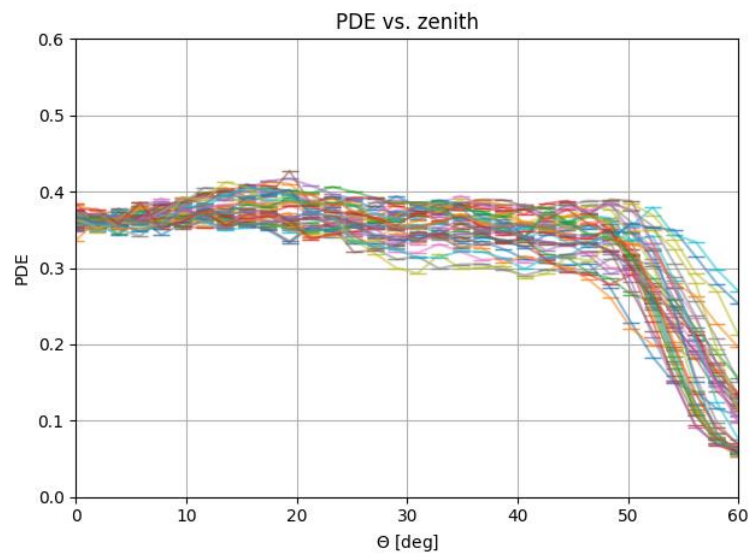Sq0846: gain 1×10^7 Vc=3.751V

Hamamatsu data QE:39.3
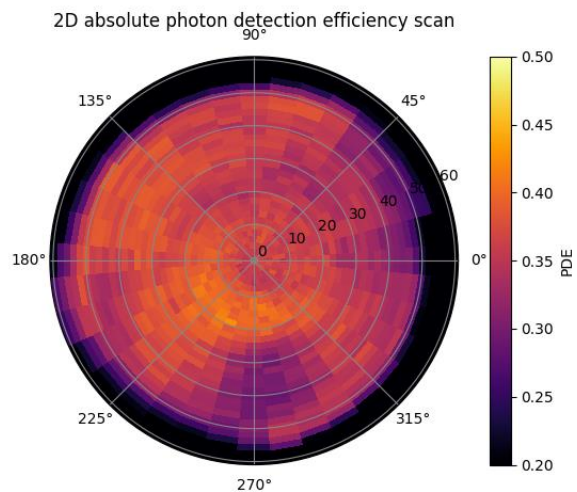
2D-scan profile confirmation (Half mesh)

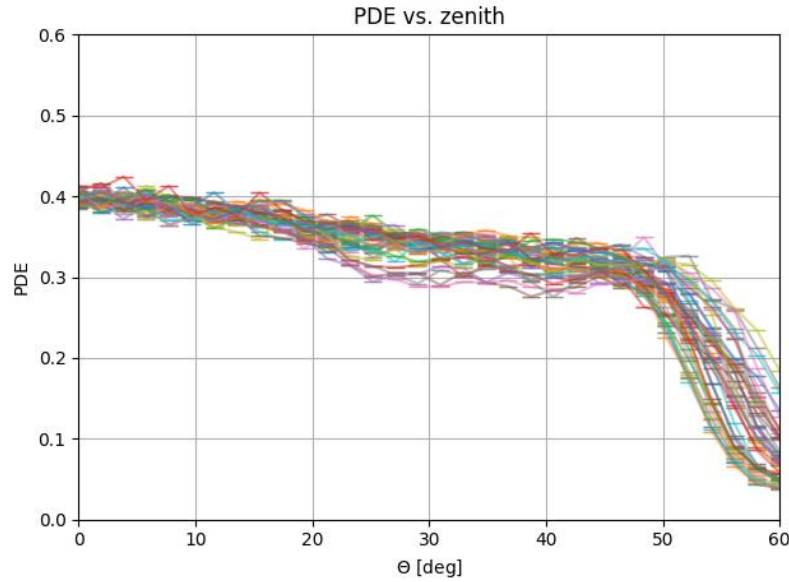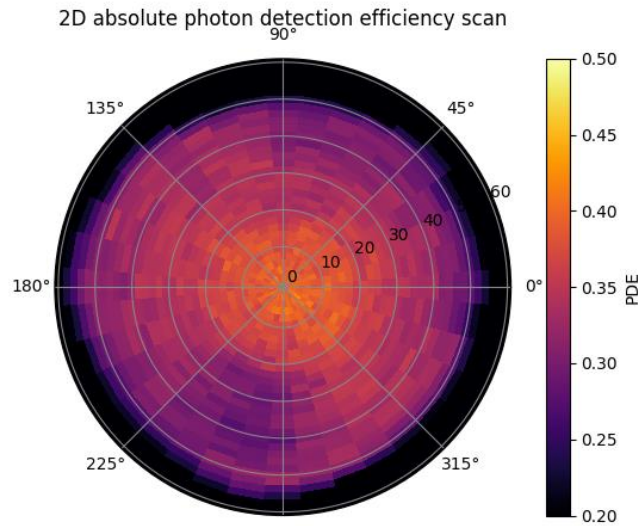Sq0553: gain 1×10^7 Vc=4.061

Hamamatsu data QE:35.9

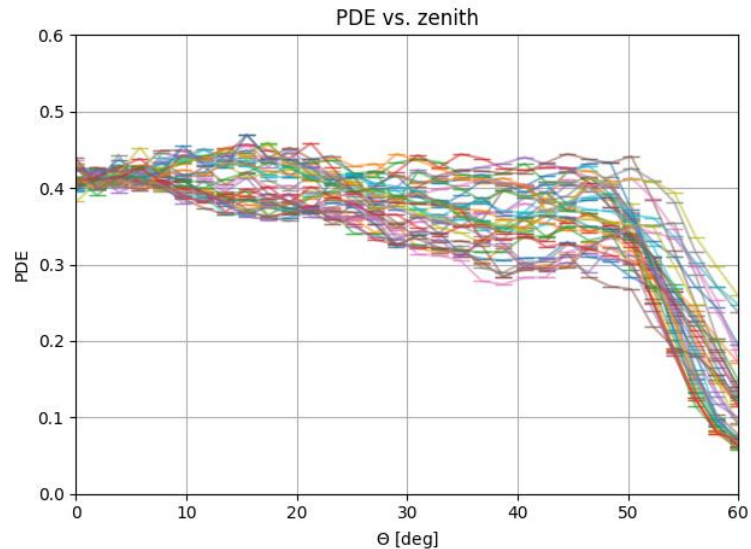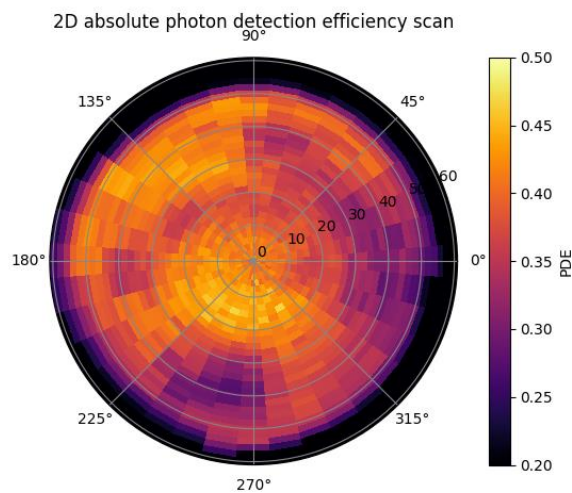Sq0582: gain 1×10^7 Vc=4.006V

Hamamatsu data QE:36.2

2D-scan profile confirmation (Half mesh)

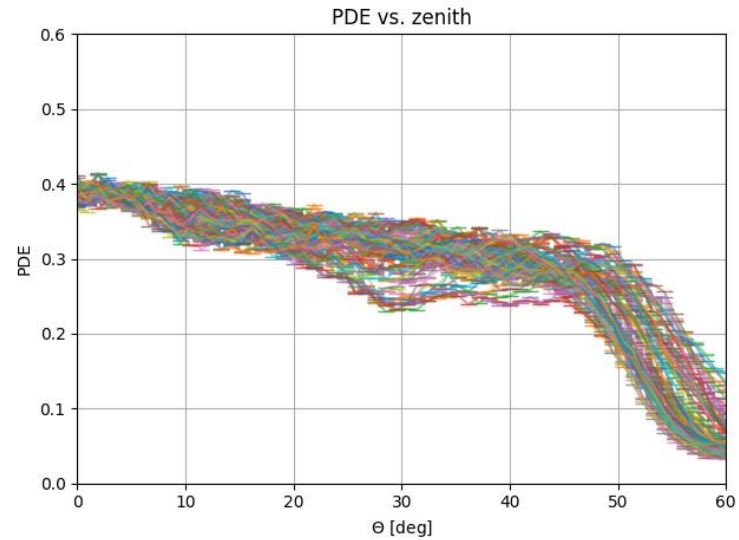SQ0326: gain 1×10^7 Vc=4.067V

Hamamatsu data QE:39.4

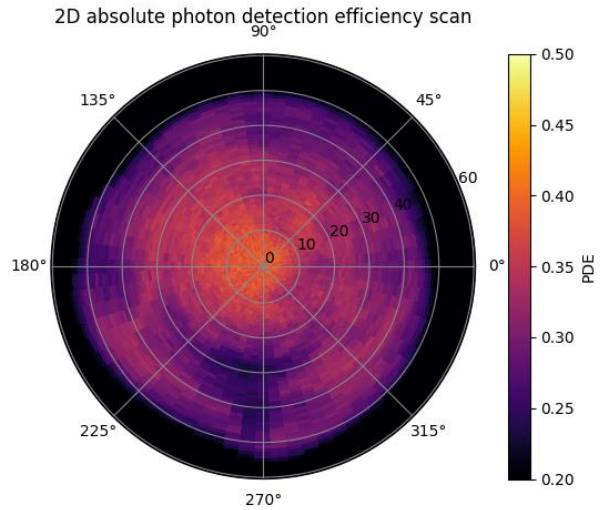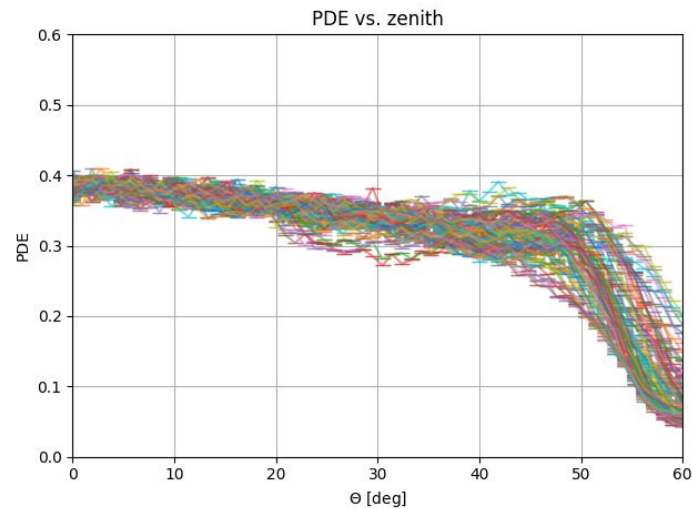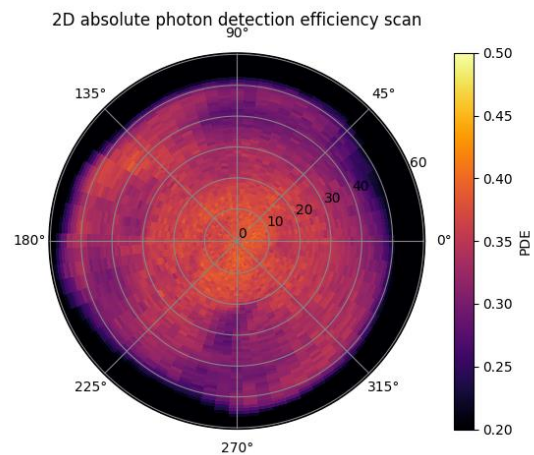SQ0285: gain 1×10^7 Vc=3.676V

Hamamatsu data QE:39.8

2D-scan profile confirmation

SQ0291: gain 1×10^7 Vc=3.935V

Hamamatsu data QE: 38.8%

SQ0283: gain 1×10^7 Vc=3.67V

Hamamatsu data QE: 40.3%