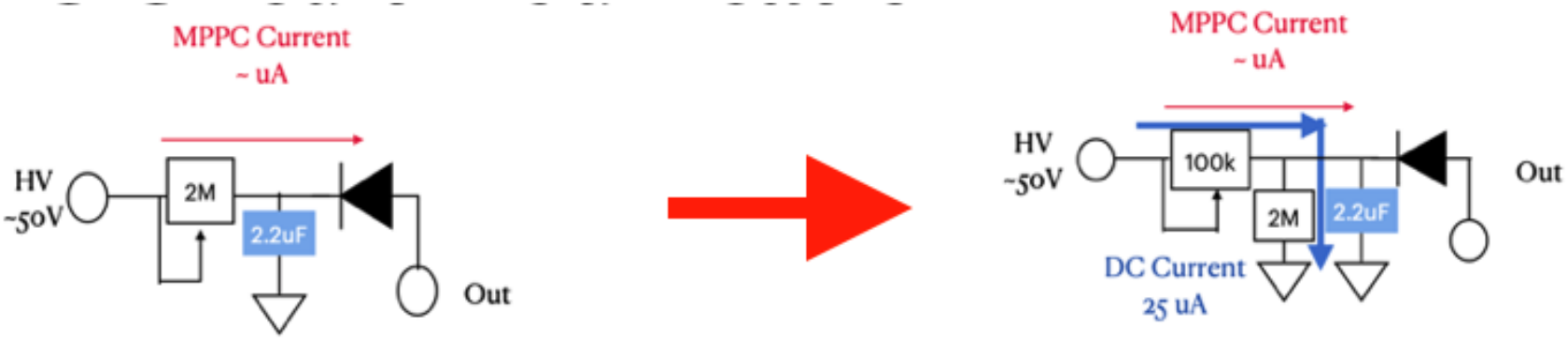
고려대학교
KOREA UNIVERSITY

Hadron & Nuclear Physics Lab

LAMPS ToF Progress

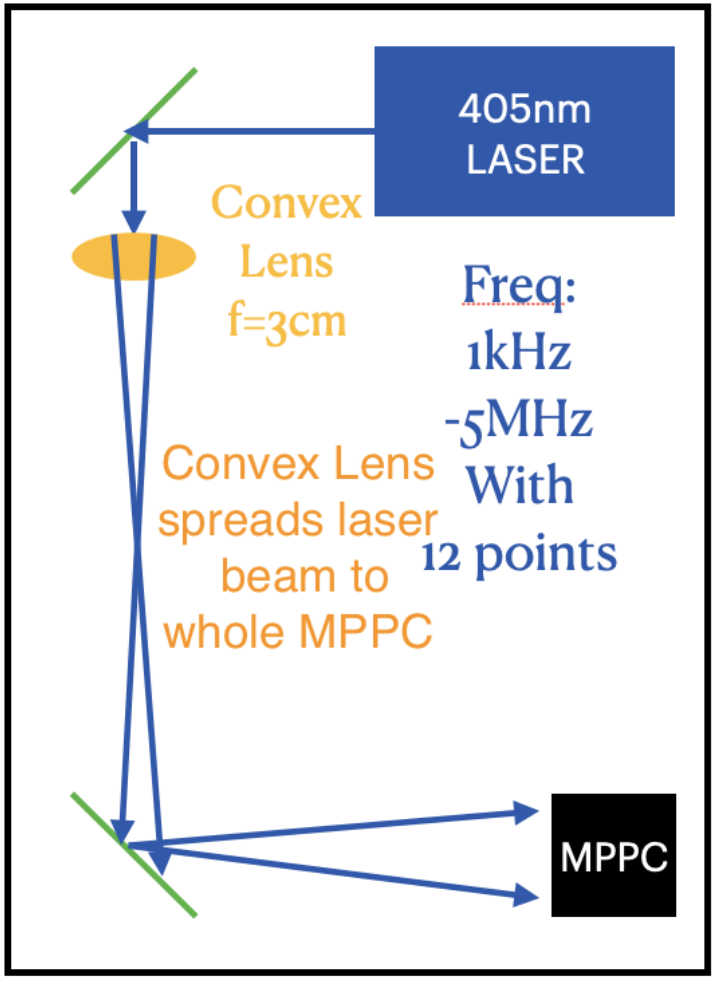
August 20, 2021

New ToF Circuit test



- Benefits from this modification: Gain-drop on signal frequency is reduced.
- Voltage-Control: $\sim$ 2 V
- Gain drop vs Frequency with new circuit were tested.
- Pulse shape seemed fine, gain-control was good.

Gaindrop-frequency test



Gain-Frequency relation

$$I = I_{base} + Gain \times freq \quad (1)$$

$$Gain = g(HV - R \times I) \quad (2)$$

$$Gain = g\frac{HV - R \times I_{base}}{1 + gR \times freq}$$

$$= g\frac{HV - R \times I_{base}}{1 + f/f_{HDF}} \quad (3)$$

- MPPC gain has liner dependence on applied voltage.
- This equaiton assumes flat photon distribution for all identical MPPCs.

Result

Half-Drop Frequency	BTOF	FTOFIn	FTOFOut
MIP	3MHz	10MHz	10MHz
Saturation	0.5MHz	0.9MHz	1.2MHz

- Saturation region is around MHz/Segment.
- BTOF/FTOFOut covers wide-region, so Photon distribution was not flat.(Only half of MPPCs were hit.)

MPPC Gain Check.

$$I_{MPPC} = I_{photon} * N_{photon}/N_{MPPC} \quad (4)$$

$$= V_{drop}/R_{trim} = 40\mu\mathrm{A} = 2.5 \times 10^{14} e/s. \quad (5)$$

Known parameters: $R_{trim} = 50\mathrm{k}$, $V_{drop} \simeq 2$ V at f_{HDR}, $N_{MPPC} \simeq 3$.

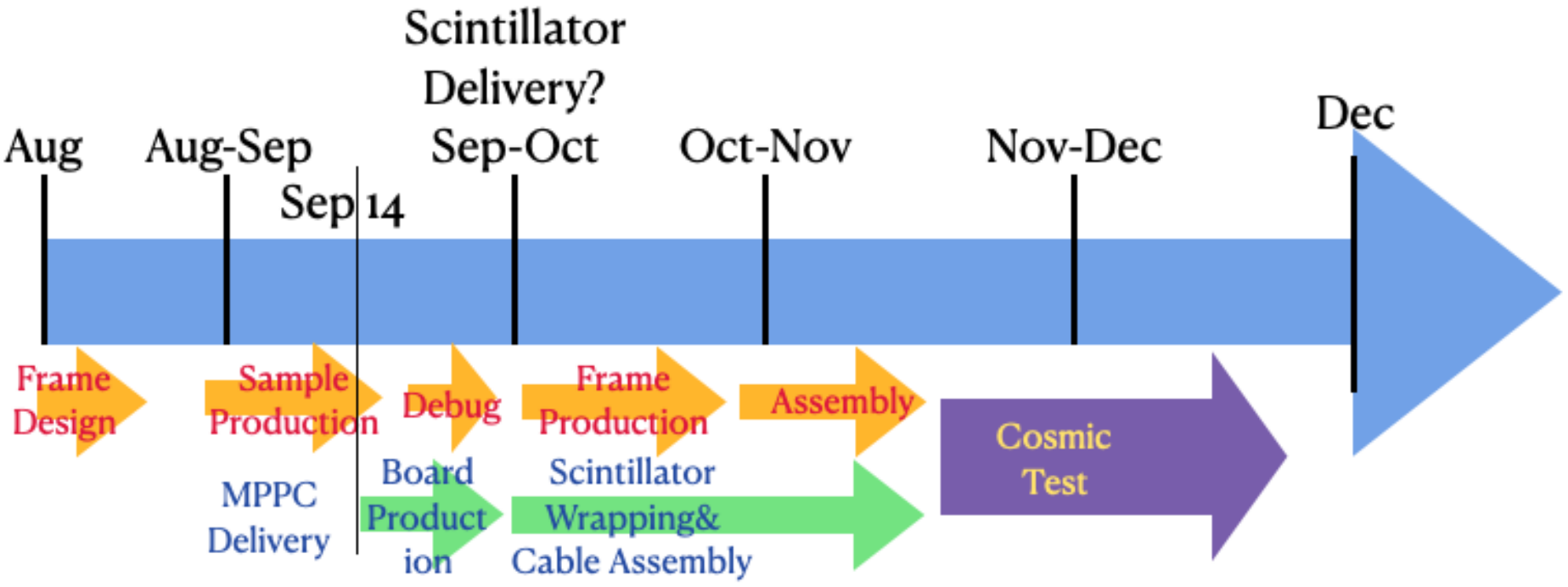
Photon Estimation

$$\frac{N_{Photon}}{N_{mppc}} = \frac{1}{N_{mppc}} \frac{G_{sig}}{G_{photon}}$$

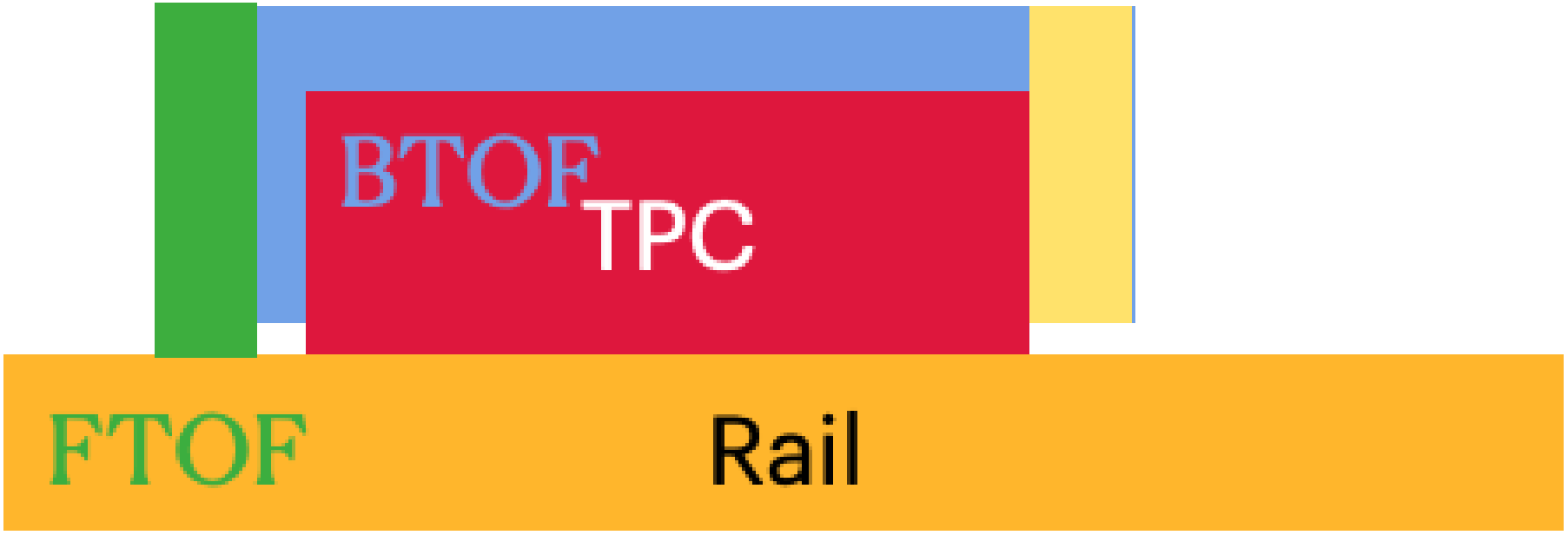
# Photons	BTOF	FTOF
MIP	30/MPPC	3/MPPC
Saturate	200/MPPC	100/MPPC
$f_{PhotonHDF}$	~100MHz	~100MHz
$Gain_{MPPC}$	$\frac{3.75\times10^{14}e/s}{100MHz}=2.5\times10^{6}$	

- $f_{PhotonHDF}$ is based on saturation data.

ToF Schedule

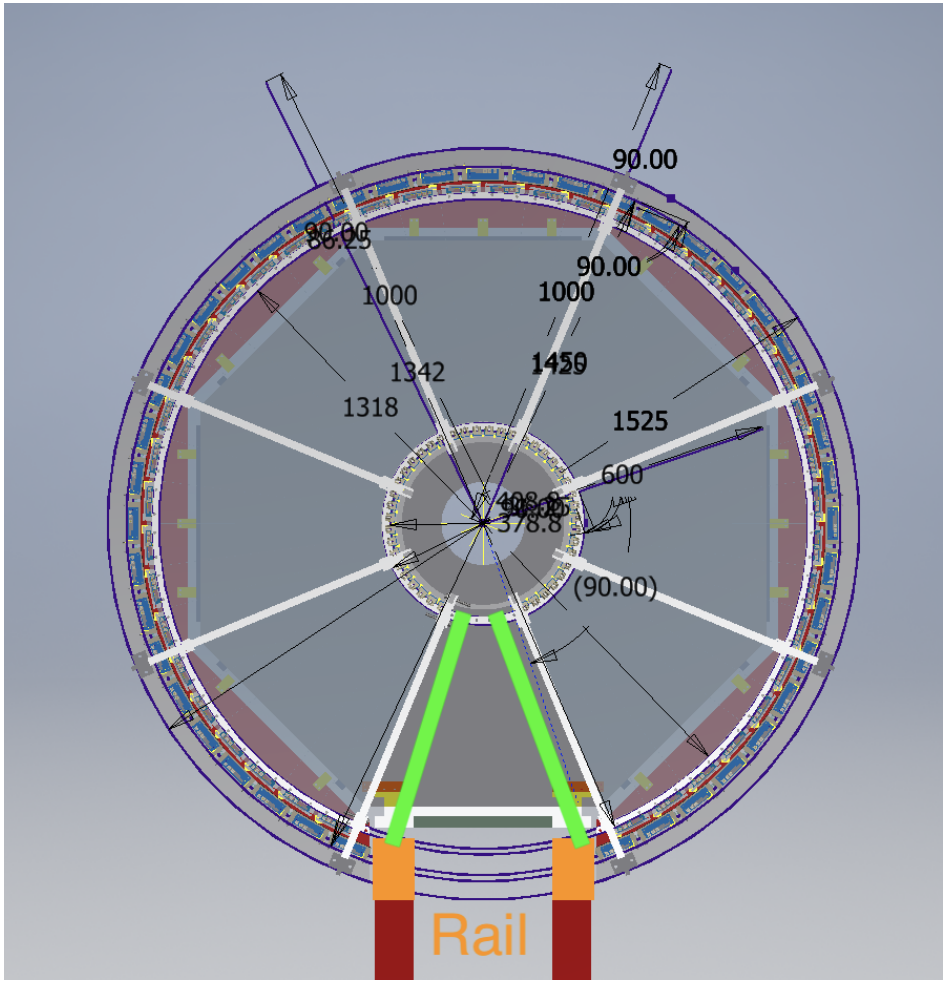


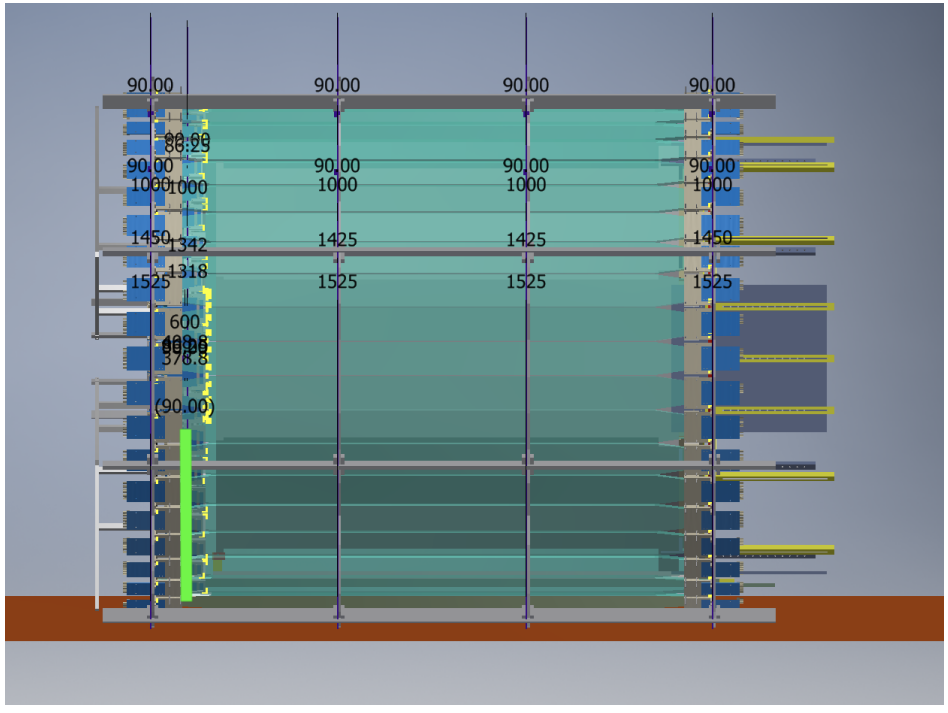
Frame Design Concept



- TPC and FTOF supports BTOF
- FTOF is supported by rail

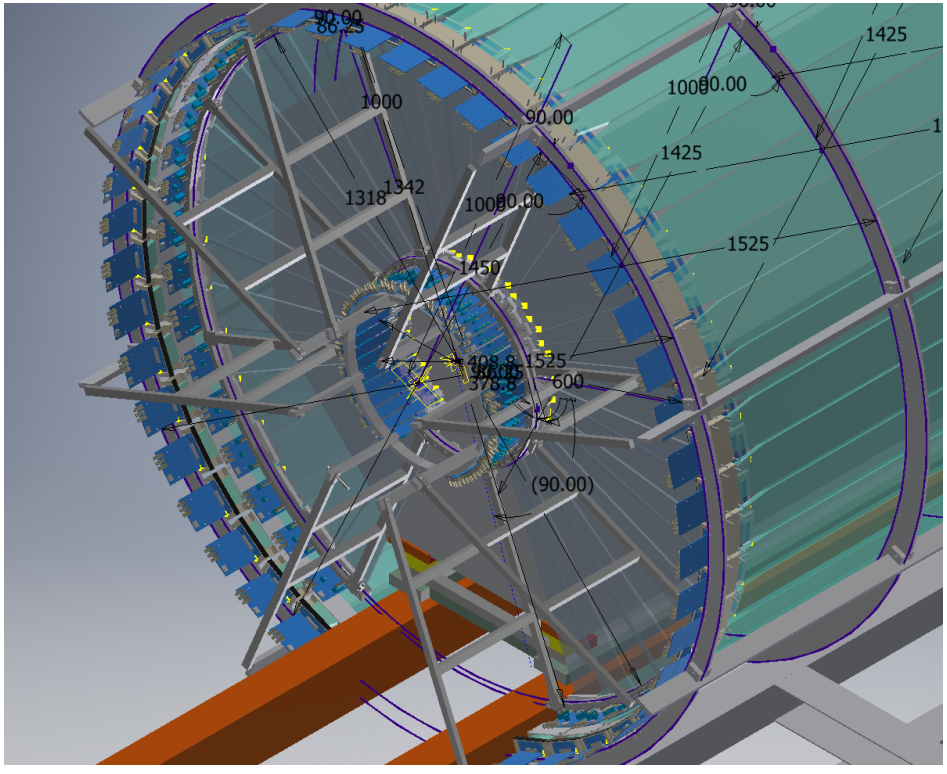
FTOF Support

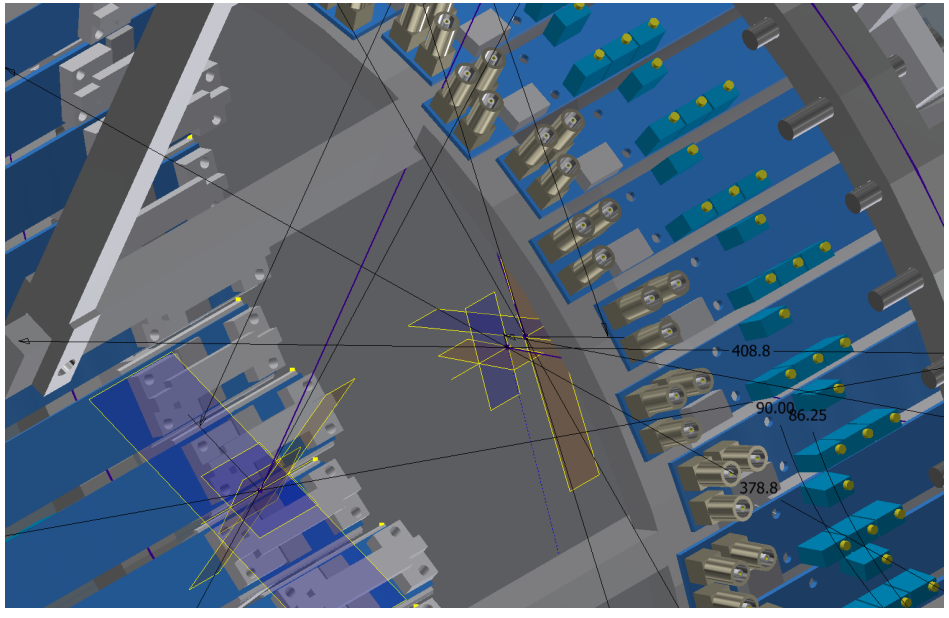




- FTOF is supported by two legs on the Rail.

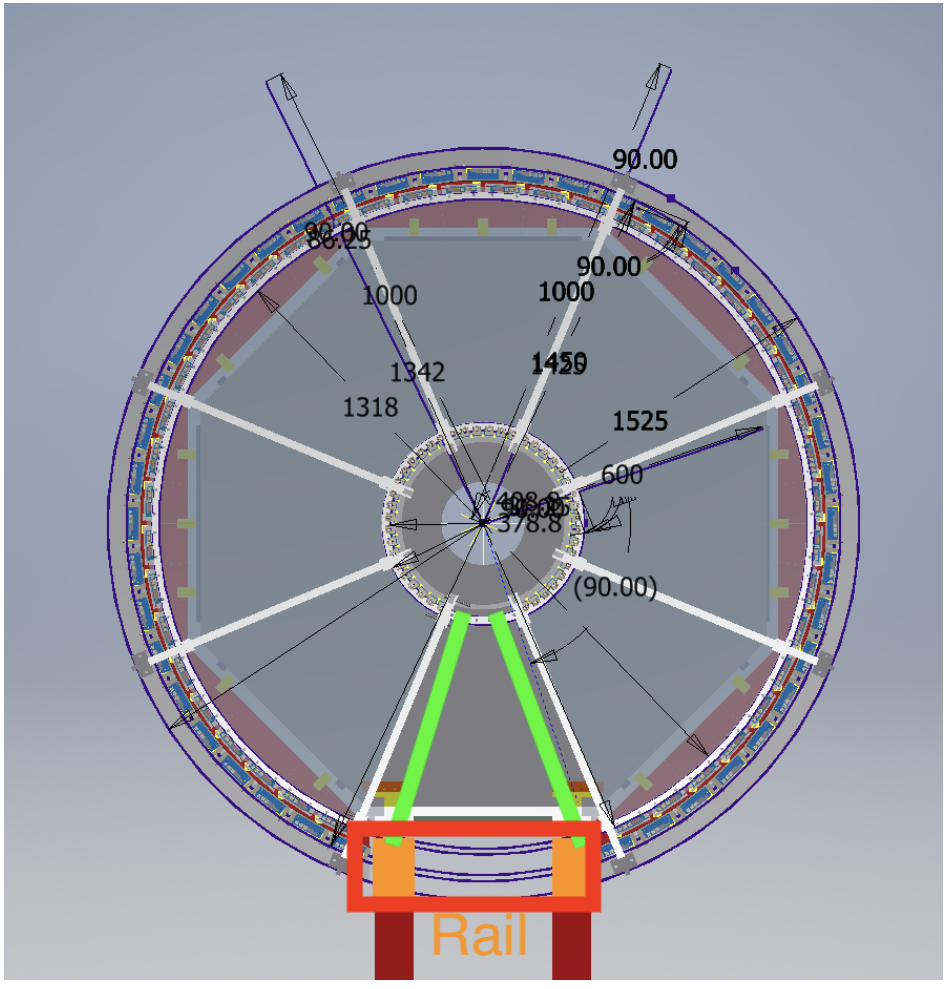
FTOF Board Protection





- Supporting structure prevents FTOF detatchment while inserting LEMO.

Loss-region



- Around 1/8 region cannot be covered by TOFs, due to support structure

BACKUP

MPPC Gain at Specsheet

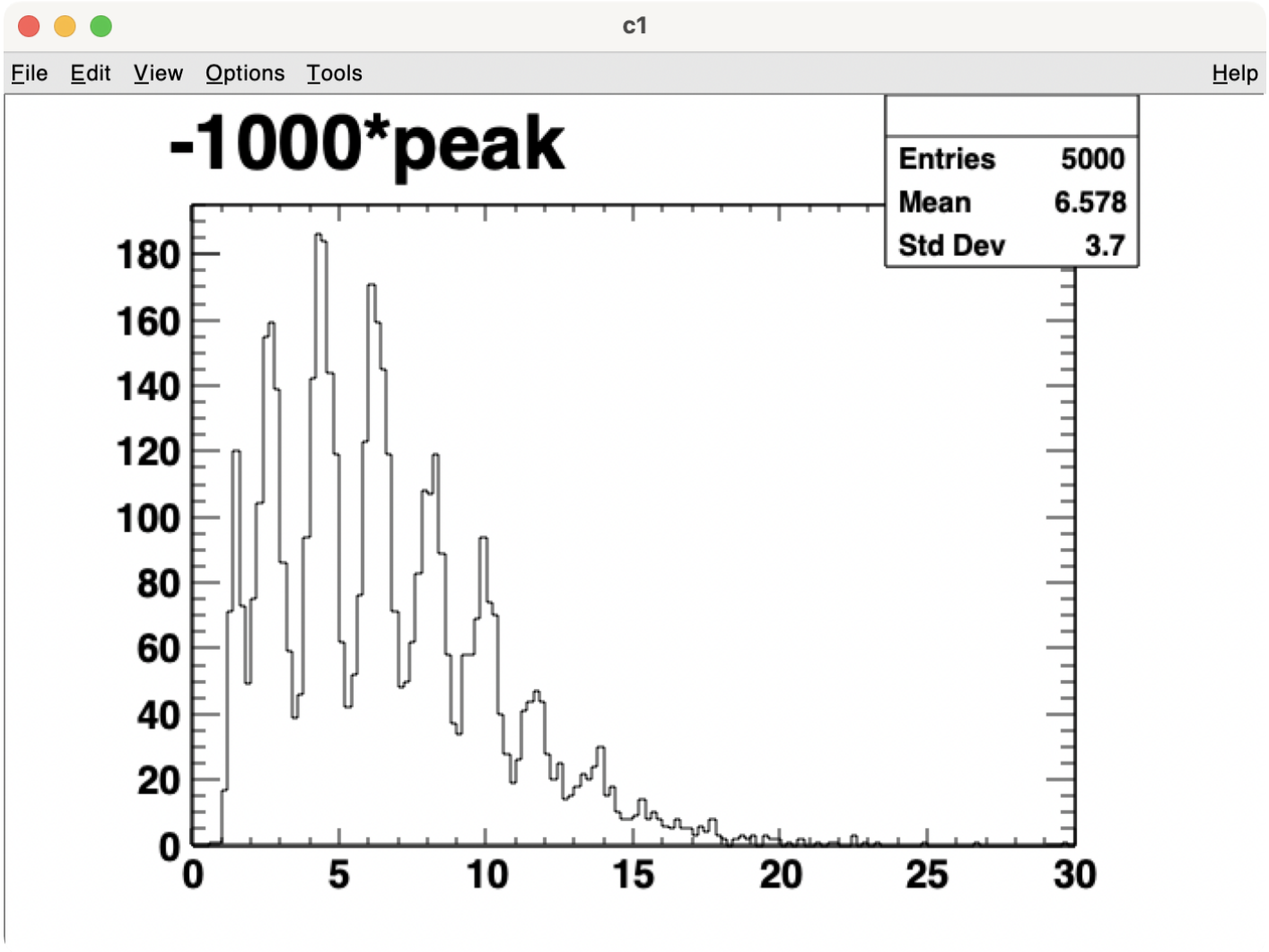
S13360-1350CS	Vover =3 V	270 to 900	450	40	90	270	60	1.7×10^6	53 ± 5
S13360-1350PE		320 to 900			500	1500	320		
S13360-3050CS		270 to 900			2000	6000	1280		
S13360-3050PE		320 to 900							
S13360-6050CS		270 to 900							
S13360-6050PE		320 to 900							

Electrical and optical characteristics (Typ. Ta=25 °C, Vover=2.7 V, unless otherwise noted)

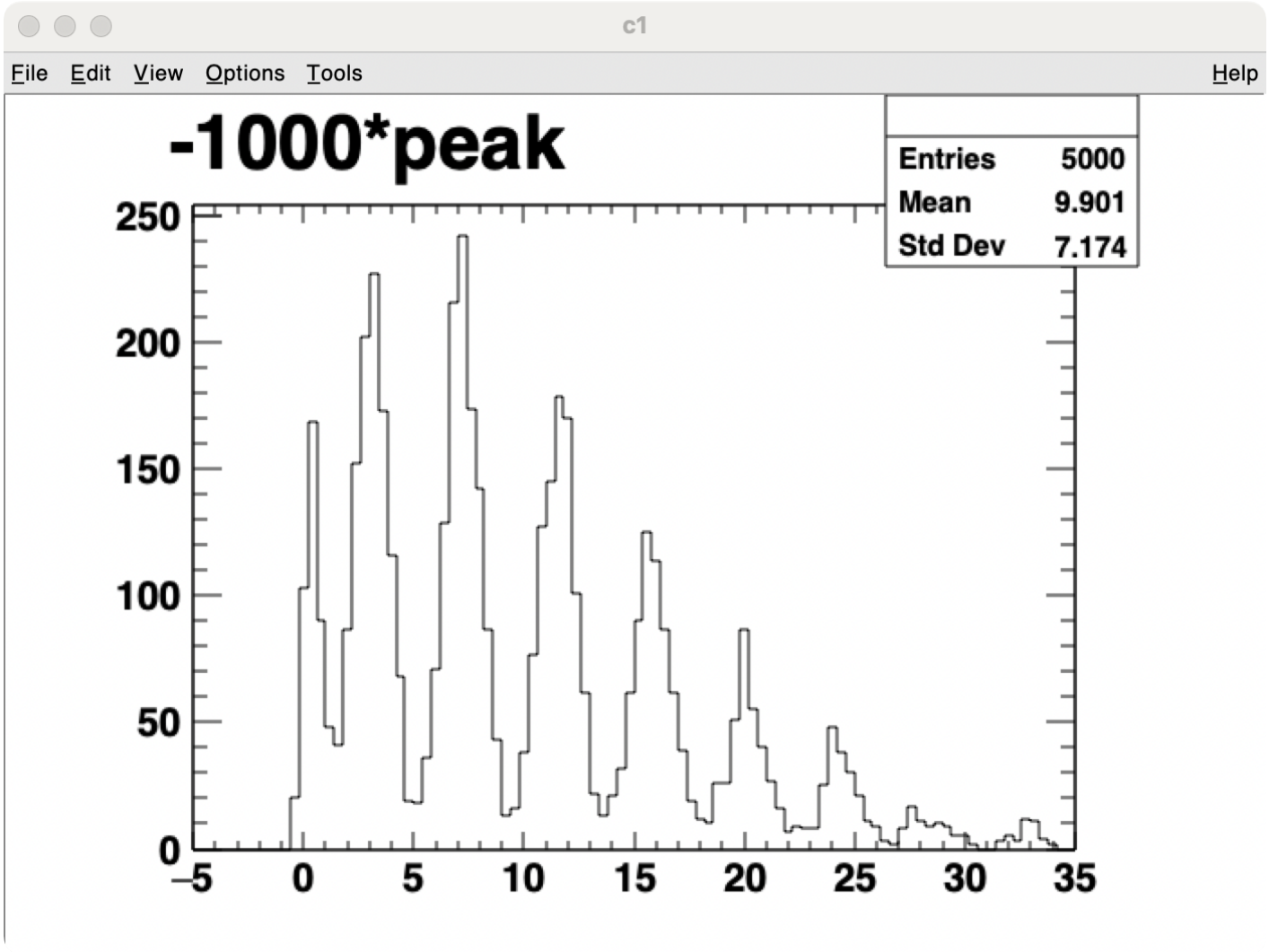
Parameter		Symbol	S14160/S14161 -3050HS-04, -08	S14160/S14161 -4050HS-06	S14160/S14161 -6050HS-04	unit
Spectral response range		λ	270 to 900			nm
Peak sensitivity wavelength		λp	450			nm
Photon detection efficiency at λp*3		PDE	50			%
Breakdown voltage		VBR	38			V
Recommended operating voltage*4		Vop	VBR + 2.7			V
Vop variation between channels in one product*5	Typ.	-	0.1			V
	Max.		0.2			
Dark current	Typ.	ID	0.6	1.1	2.5	μA
	Max.		1.8	3.3	7.5	
Crosstalk probability		-	7			%
Terminal capacitance		Ct	500	900	2000	pF
Gain		M	2.5×10^6			-
Temperature coefficient of recommended reverse voltage		ΔTVop	34			mV/°C

*3: Photon detection efficiency does not include crosstalk and afterpulses.
*4: Refer to the data attached for each product.
*5: The parameter is for the S14161 series (multichannel type)

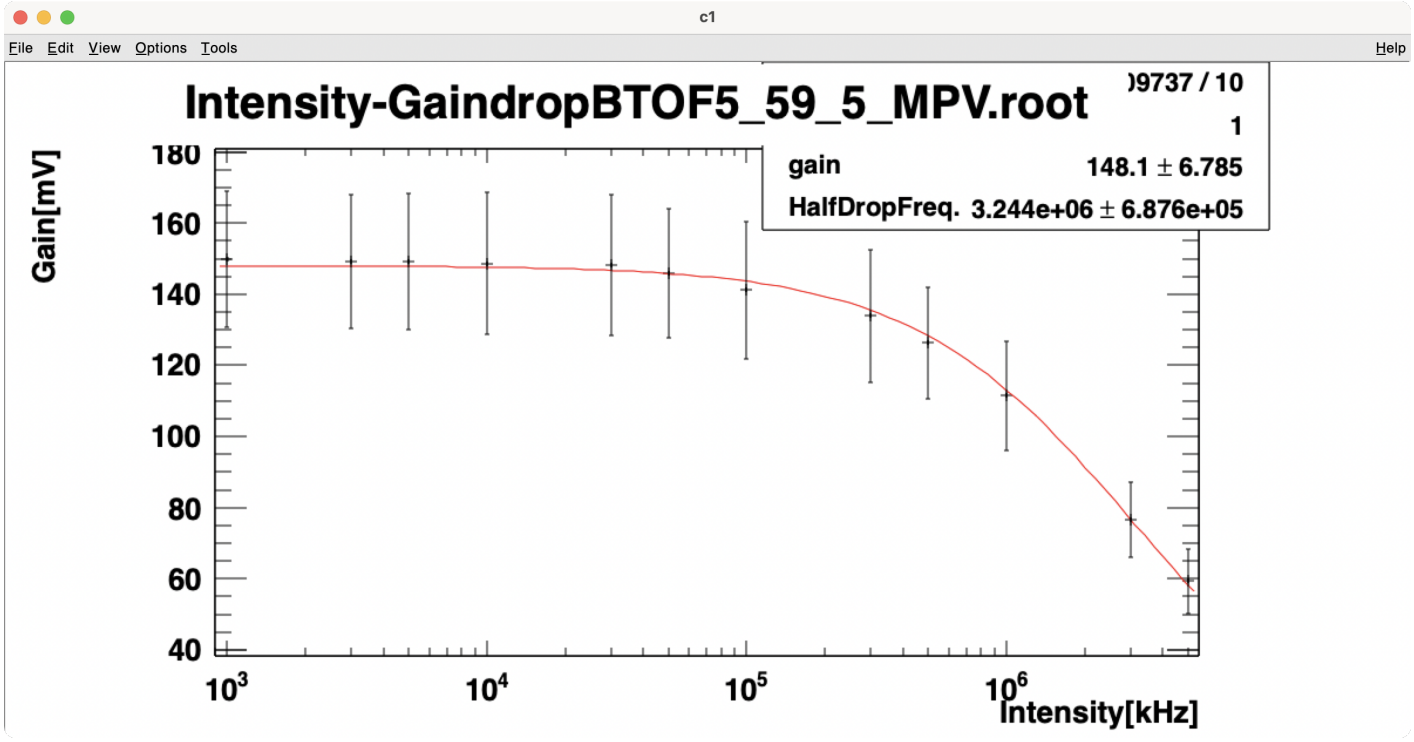
BTOFPhoton


c1
File Edit View Options Tools Help
-1000*peak
Entries 5000
Mean 6.578
Std Dev 3.7
180
160
140
120
100
80
60
40
20
0
0 5 10 15 20 25 30

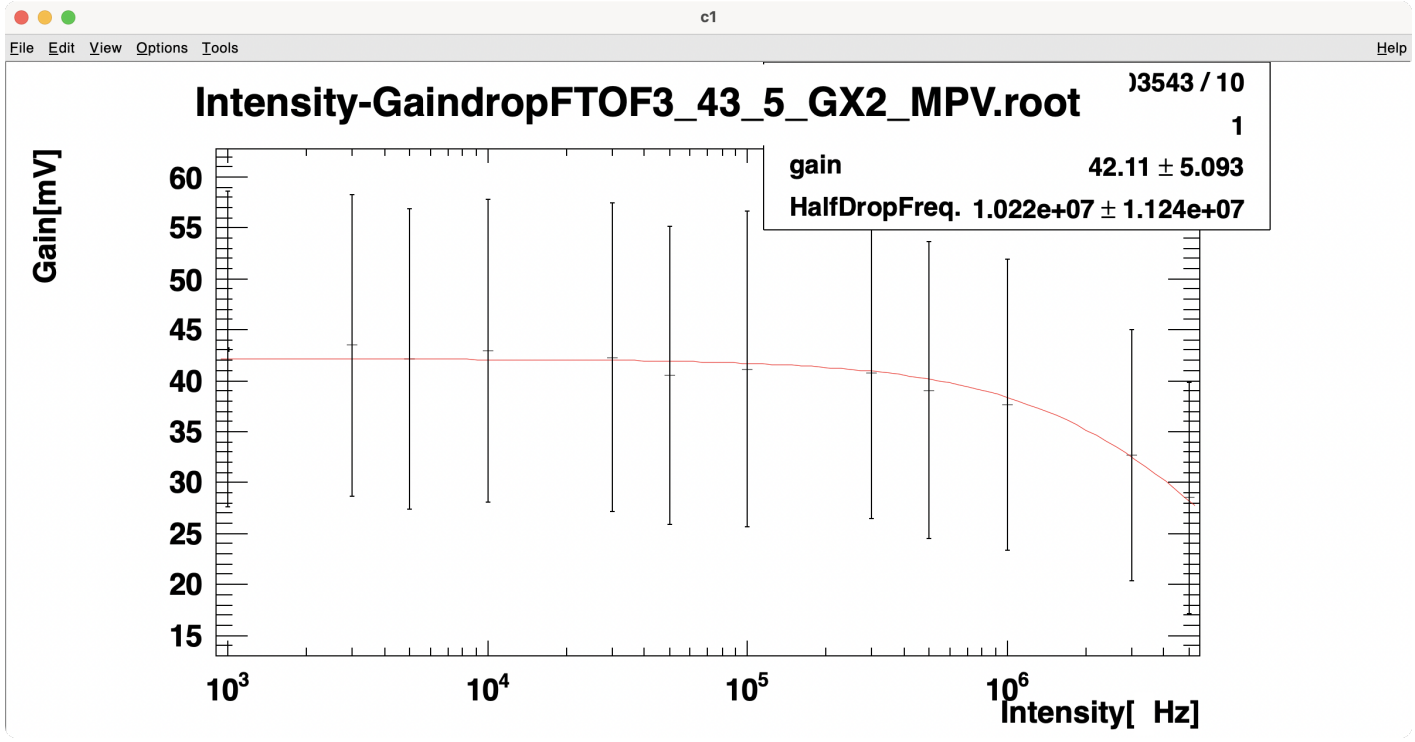
FTOFPhoton


c1
File Edit View Options Tools Help
-1000*peak
Entries 5000
Mean 9.901
Std Dev 7.174
250
200
150
100
50
0
−5
0
5
10
15
20
25
30
35

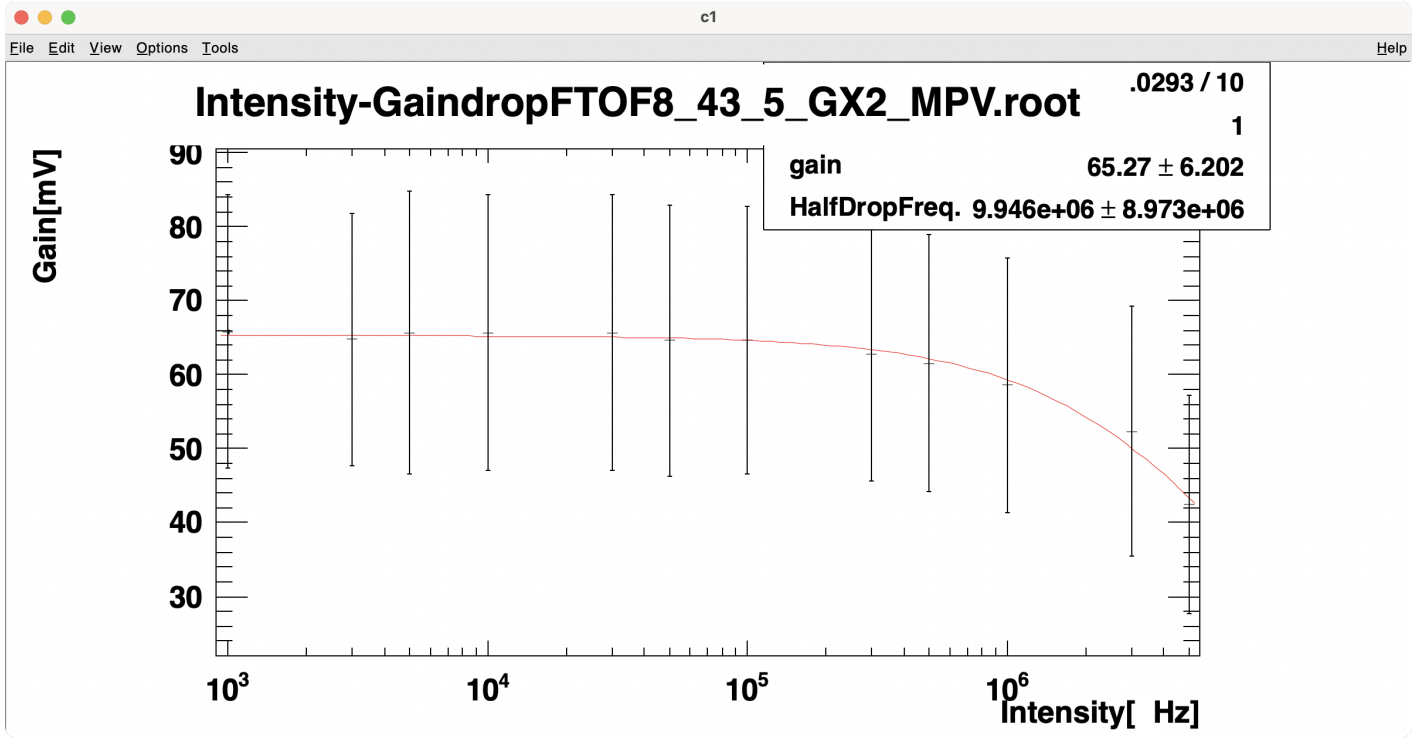
BTOFMIP


c1
File Edit View Options Tools
Help
Intensity-GaindropBTOF5_59_5_MPV.root
)9737 / 10
1
gain 148.1 ± 6.785
HalfDropFreq. 3.244e+06 ± 6.876e+05
Gain[mV]
180
160
140
120
100
80
60
40
10^3
10^4
10^5
10^6
Intensity[kHz]

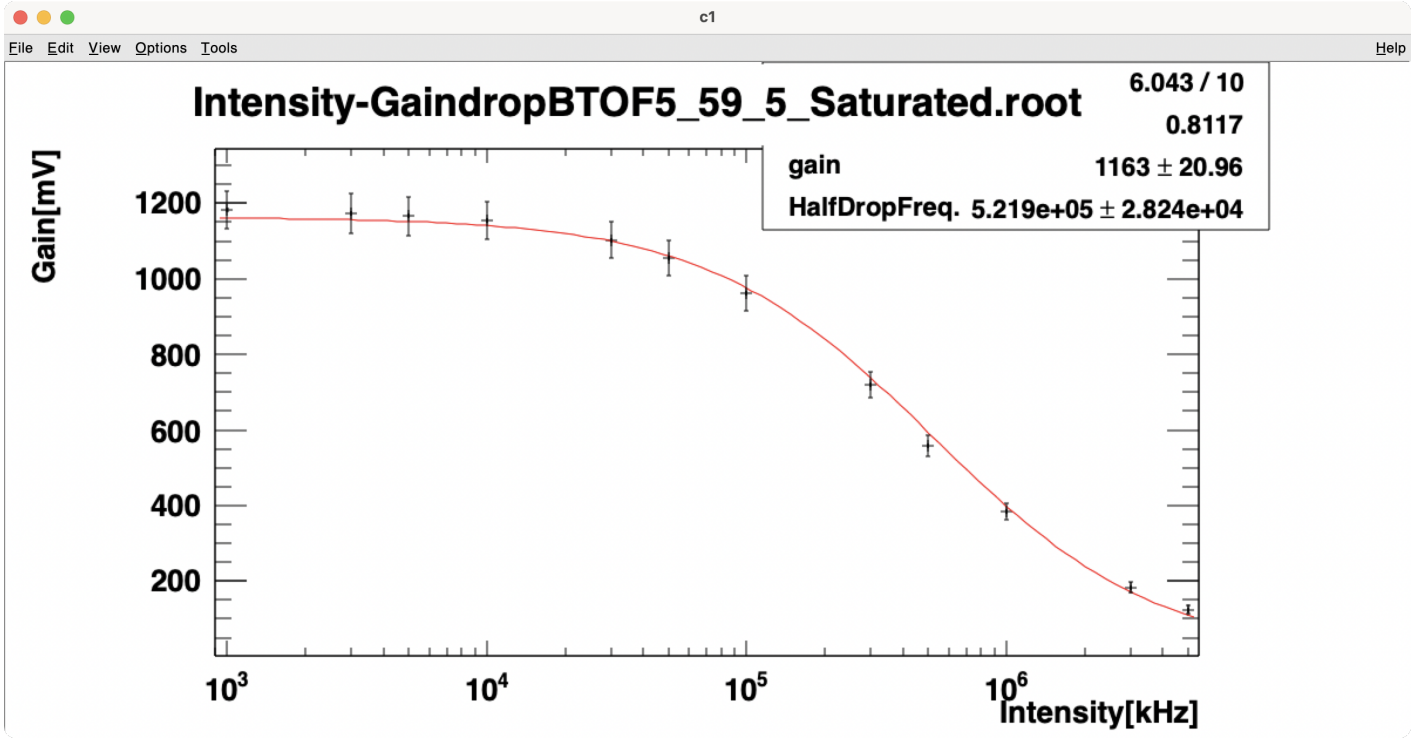
FTOFInMIP


c1
File Edit View Options Tools
Help
Intensity-GaindropFTOF3_43_5_GX2_MPV.root
)3543 / 10
1
gain 42.11 ± 5.093
HalfDropFreq. 1.022e+07 ± 1.124e+07
Gain[mV]
60
55
50
45
40
35
30
25
20
15
10^3
10^4
10^5
10^6
Intensity[Hz]

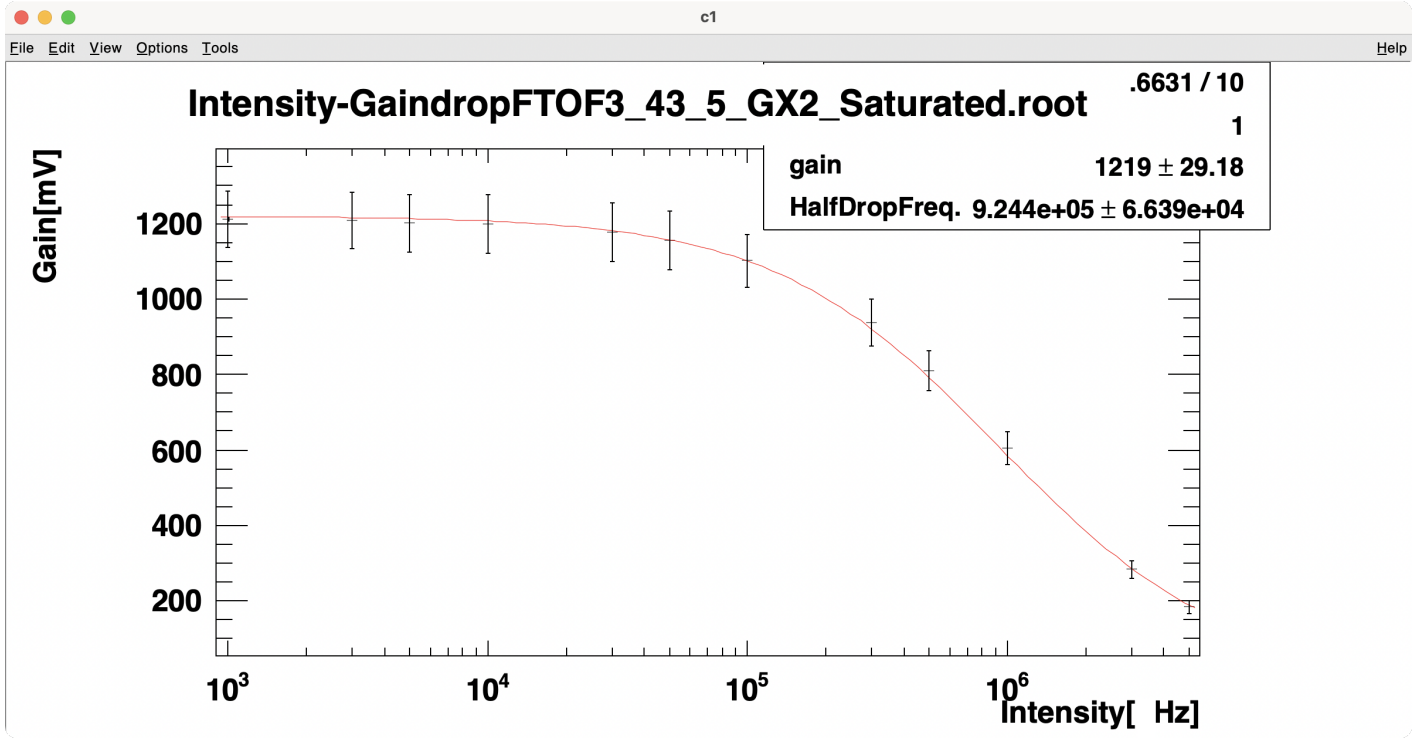
FTOFOutMIP


c1
File Edit View Options Tools
Help
Intensity-GaindropFTOF8_43_5_GX2_MPV.root
.0293 / 10
1
gain 65.27 ± 6.202
HalfDropFreq. 9.946e+06 ± 8.973e+06
Gain[mV]
90
80
70
60
50
40
30
10^3
10^4
10^5
10^6
Intensity[Hz]

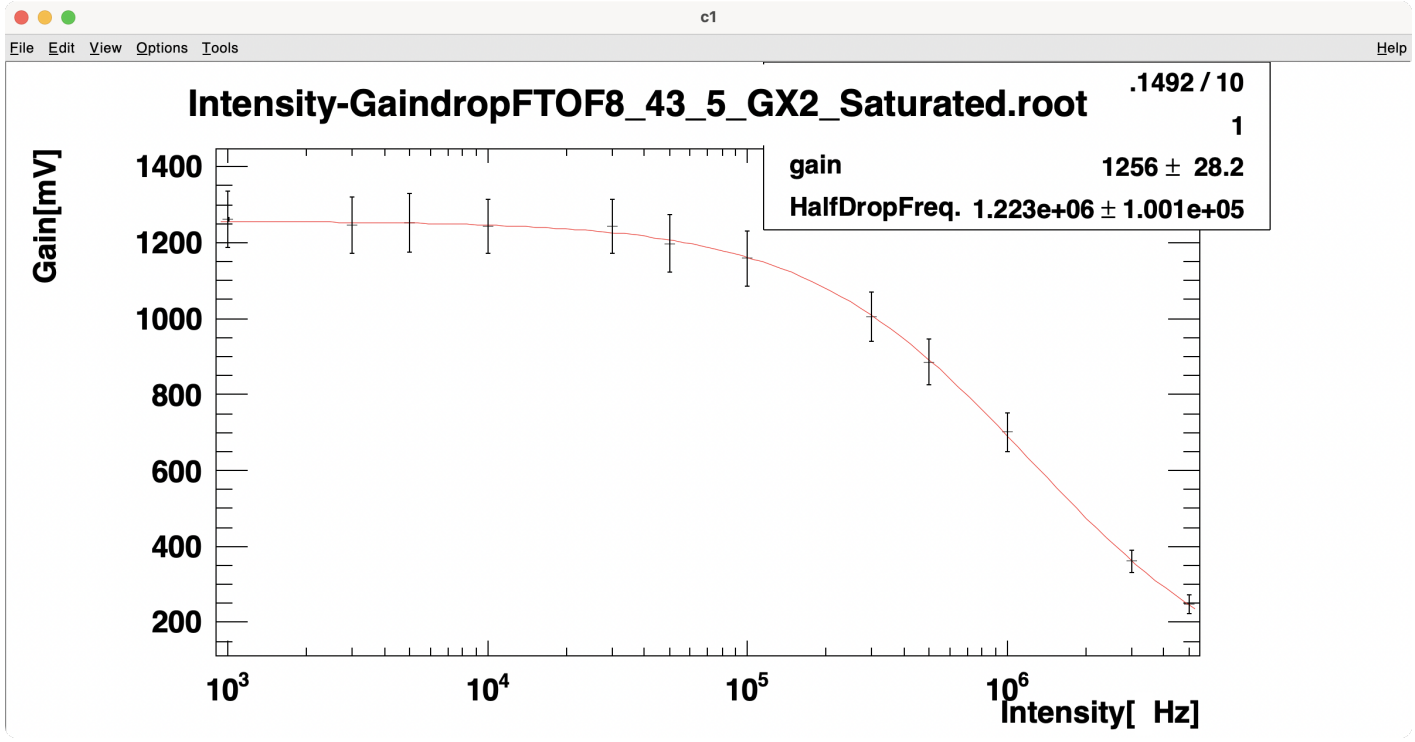
BTOFSat


c1
File Edit View Options Tools Help
Intensity-GaindropBTOF5_59_5_Saturated.root
6.043 / 10
0.8117
gain 1163 ± 20.96
HalfDropFreq. 5.219e+05 ± 2.824e+04
Gain[mV]
1200
1000
800
600
400
200
10^3
10^4
10^5
10^6
Intensity[kHz]

FTOFInSat


c1
File Edit View Options Tools
Help
Intensity-GaindropFTOF3_43_5_GX2_Saturated.root
.6631 / 10
1
gain 1219 ± 29.18
HalfDropFreq. 9.244e+05 ± 6.639e+04
Gain[mV]
1200
1000
800
600
400
200
10^3
10^4
10^5
10^6
Intensity[Hz]

FTOFOutSat



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