FADC scaler rate with MAROC sum Board
01/2021

Possible setting
MAROC sum board

LED (V)	Laser frequency (kHz)					
	20000	5000	2000	1000	500	100
LED OFF	Wh2p (1) Wh3p (2) Wh3 (3)	Wh2p (4) wh3p (5) Wh3 (6)	Wh2p (7) wh3p (8) wh3(9)	Wh2p(10) wh3p (11) wh3(12)	Wh2p(13) wh3p (14) wh3(15)	Wh2p(16) wh3p (17) wh3(18)
2.09	Wh2p(19) wh3p (20) wh3(21)	Wh2p(22) wh3p (23) wh3(24)	Wh2p(25) wh3p (26) wh3(27)	Wh2p(28) wh3p (29) wh3(30)	Wh2p(31) wh3p (32) wh3(33)	Wh2p(34) wh3p (35) wh3(36)
2.12	Wh2p(37) wh3p (38) wh3(39)	Wh2p(40) wh3p (41) wh3(42)	Wh2p(43) wh3p (44) wh3(45)	Wh2p(46) wh3p (47) wh3(48)	Wh2p(49) wh3p (50) wh3(51)	Wh2p(52) wh3p (53) wh3(54)
2.15	Wh2p(55) wh3p (56) wh3(57)	Wh2p(58) wh3p (59) wh3(60)	Wh2p(61) wh3p (62) wh3(63)	Wh2p(64) wh3p (65) wh3(66)	Wh2p(67) wh3p (68) wh3(69)	Wh2p(70) wh3p (71) wh3(72)
LASER OFF	LED 2.09 73	LED 2.12 **74**	LED 2.15 75			

DATA
- CODA (FADC sum signal + TDC pixel data)
- FADC scaler (sum signal)
- MAROC scaler (pixel signal)

Pixel occupancy for different laser setting
From Maroc sum data
2021 run period

Runs	Laser fr (MHz)	occupancy
Wheel 2 + paper ("strong light")		
	20	
1131	5	12.17
1117	2	10.44
1105	1	9.6
1106	0.5	9.18
1107	0.1	8.86
Wheel 3 ("medium light")		
1167	20	2.3
1163	5	2.5
1157	2	2.2
1142	1	2.07
1146	0.5	2.03
1150	0.1	1.99

Runs	Laser fr (MHz)	Occupancy
Wheel 3 +paper ("weak light")		
1186	20	1.07
1126	5	1.07
1121	2	1.07
1073	0.1	1.07
1074	0.5	1.05
1075	0.1	1.05

Need to debug the TDC decoder crash at 20 MHz strong light

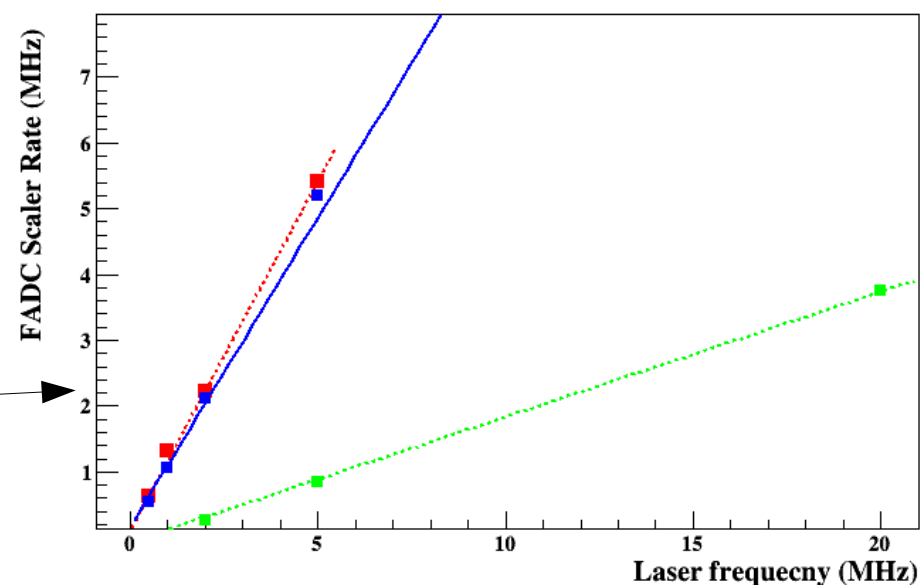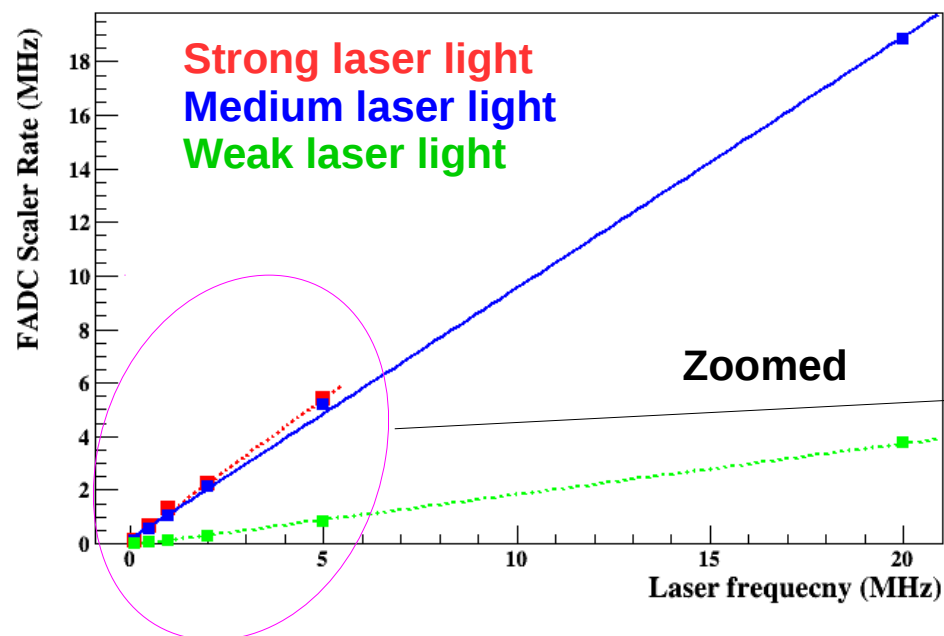# Avg. pixel rate vs fadc scaler rate
Laser OFF
MAROC sum board

LED (V)	Avg. pixel rate (kHz)	Expected sum rate (MHz) (A)	FADC scaler rate (MHz)	Deadtime (%)	Corrected rate (MHz) (B)	A/B
2.09	45	2.880	2.744	5.5	2.90	0.99
2.12	139	8.896	7.913	18	9.65	0.92
2.15	341	21.824	15.746	44	28.11	0.78

- Expected sum rate = Avg. pixel rate x 64
- Deadtime = 1 / [1/(rate x 20 ns)]
- 20 ns is FADC width for a LED pulse
- Corrected rate= FADC rate/ (1- deadtime)
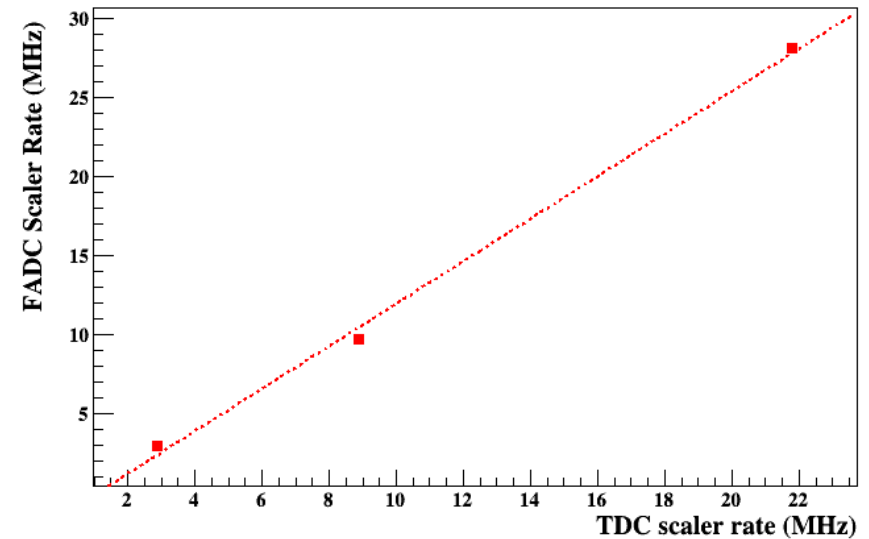
After deadtime correction, the ssp rate and fadc rate agrees within 20%.

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MAROC sum board
LED OFF
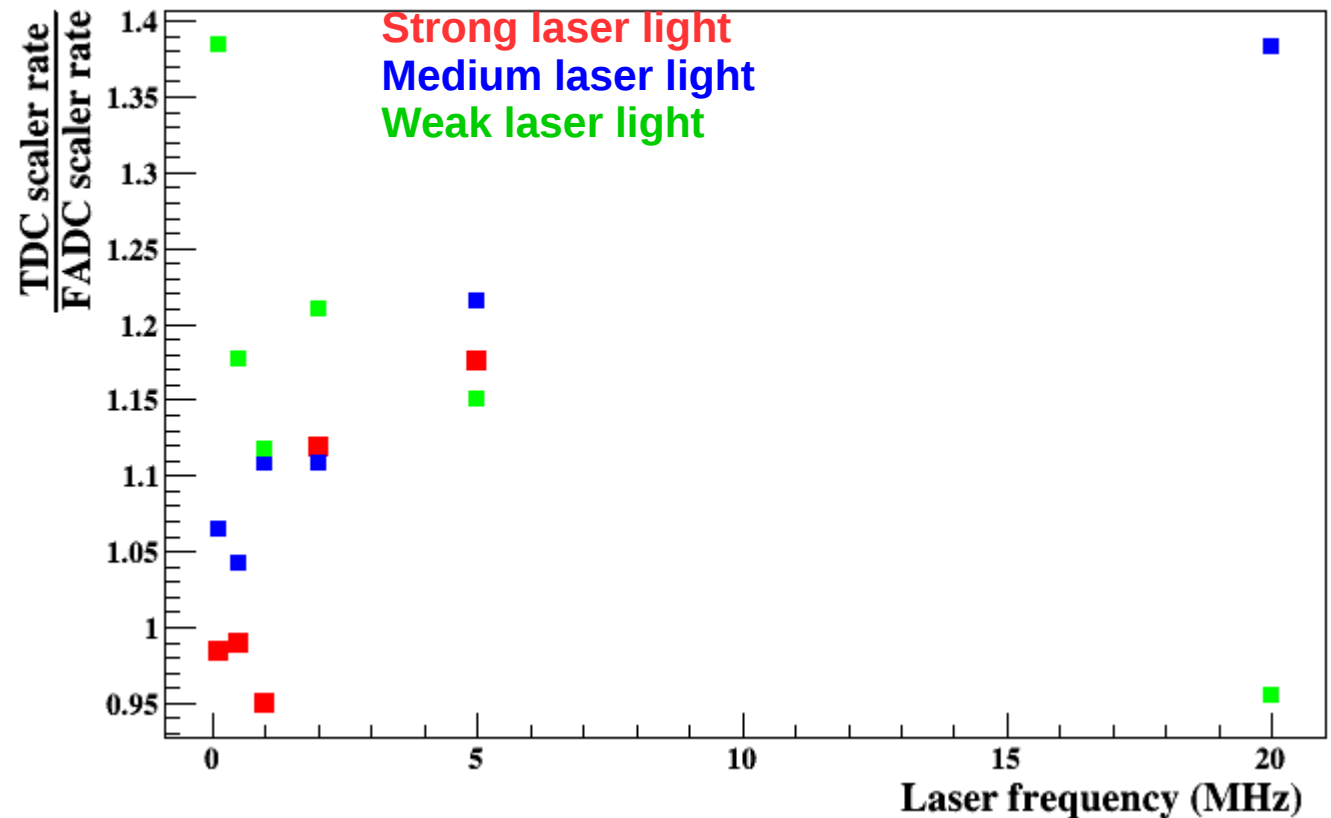**FADC scaler rate vs laser frequency**

FADC scaler rate increase linearly with laser frequencies for all light intensities

Pixel and sum scaler rates
LED OFF
MAROC sum board

Two scaler readout:
1) pixel rate (TDC)
2) sum signal rate (FADC)

- FADC scaler rate is measured from FADC scaler (sum signal rate)
- TDC scaler rate is from measured pixel scaler rate
- Agreement between two scaler rates is within 20%

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Laser wheel 2 + paper ("strong light")
LED OFF
MAROC sum board

Laser_fr (MHz)	Avg. pixel rate (kHz/pixel)	Expected FADC rate (MHz)	FADC rate (MHz)
5	1209	6.357	5.405
2	407	2.495	2.229
1	188	1.253	1.32
0.5	90	0.628	0.635
0.1	17.4	0.126	0.128

$$\text{Expected FADC rate} = \frac{\text{Avg. pixel rate} \times 64}{\text{Avg. pixel occupancy}}$$

LED OFF
MAROC sum board

Medium light

Laser_fr (MHz)	Avg. pixel rate (kHz/pixel)	Expected FADC rate (MHz)	FADC rate (MHz)
20	938	26.100	18.868
5	247	6.323	5.205
2	81	2.335	2.107
1	38	1.174	1.059
0.5	18	0.567	0.544
0.1	3.6	0.115	0.108
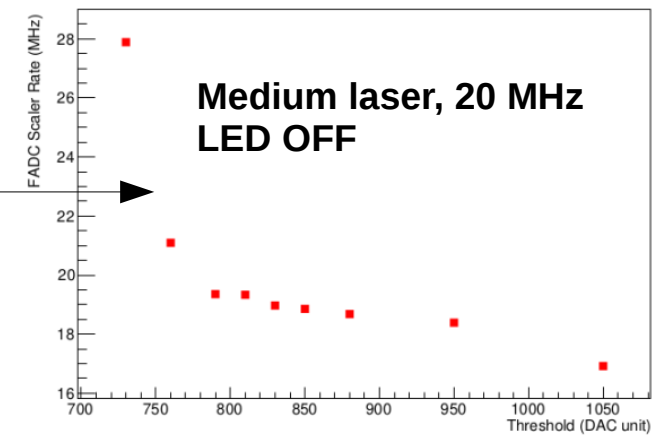
Weak light

Laser_fr (MHz)	Avg. pixel rate (kHz/pixel)	Expected FADC rate (MHz)	FADC rate (MHz)
20	60	3.588	3.756
5	16.2	0.968	0.841
2	5.4	0.322	0.266
1	2.4	0.143	0.128
0.5	1.2	0.073	0.062
0.1	0.3	0.018	0.013

Threshold scan

Medium laser, 20 MHz LED OFF

Threshold scan

weak laser, 0.1 MHz LED OFF

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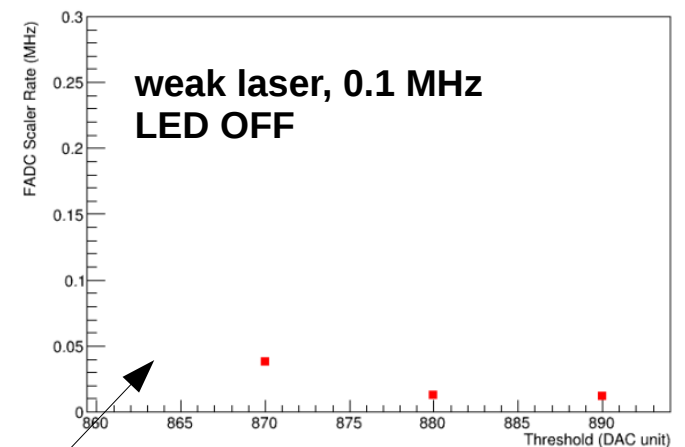
Laser wheel 3 ("medium light")
LED ON
MAROC sum board

Medium light (2.09 V)	
Laser_fr (MHz)	FADC rate MHz
0	2.744
0.1	2.832
0.5	2.934
1	3.431
2	4.692
5	7.474
20	20.400

Medium light (2.12 V)	
Laser_fr (MHz)	FADC rate MHz
0	7.913
0.1	8.004
0.5	8.297
1	8.756
2	9.434
5	11.469
20	22.912

Medium light (2.15 V)	
Laser_fr (MHz)	FADC rate MHz
0	15.746
0.1	15.845
0.5	16.466
1	16.634
2	17.014
5	18.533
20	26.234

Laser wheel 3 ("medium light") LED ON MAROC sum board
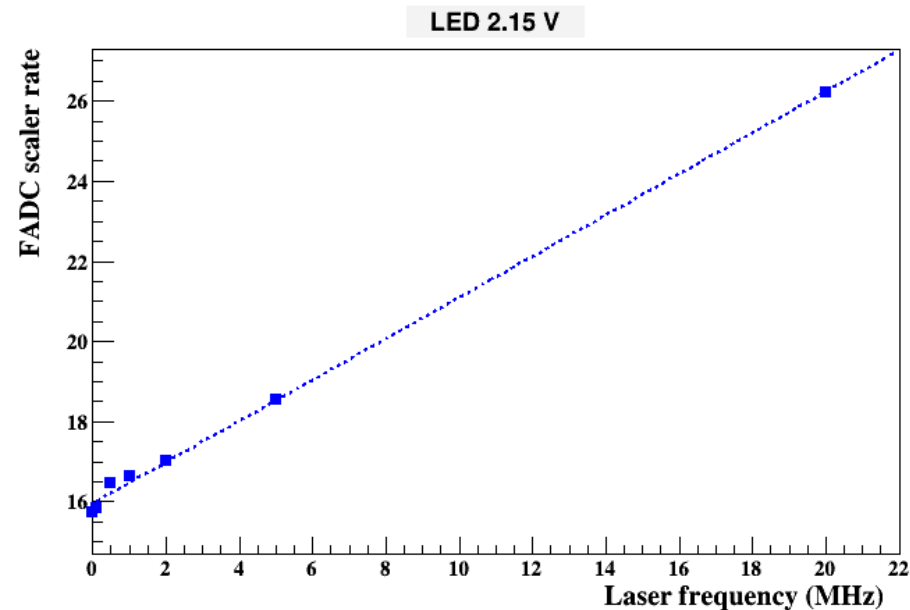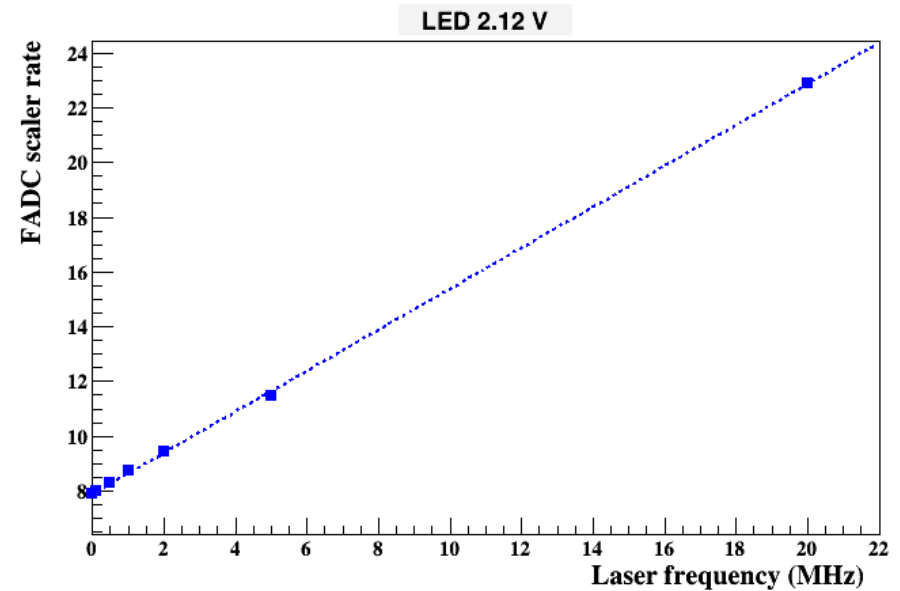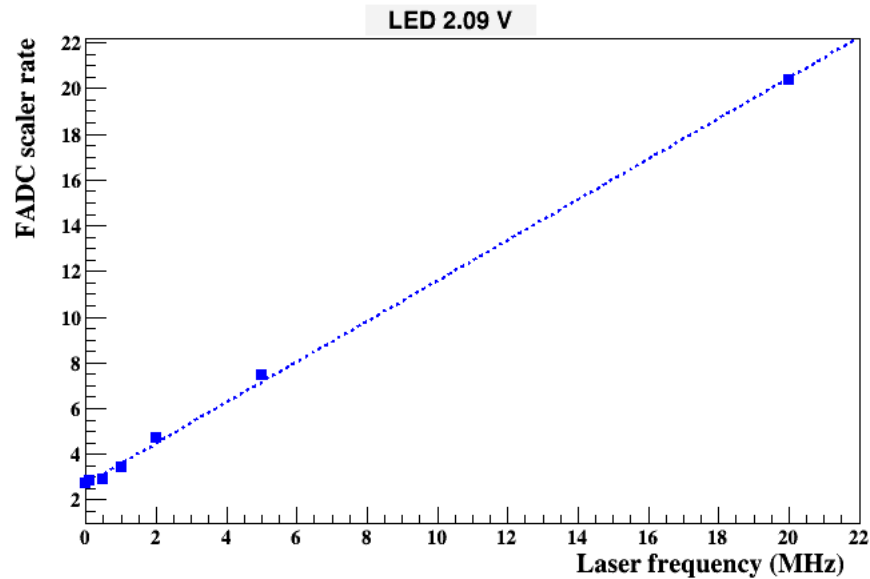
FADC scaler rate increase linearly with laser frequency

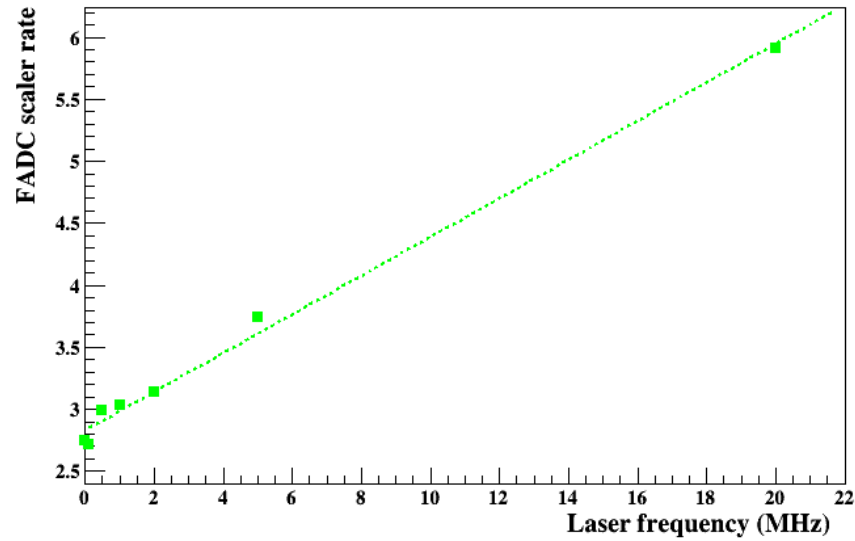# Laser wheel 3 + paper ("weak light")
LED ON
MAROC sum board

Weak light (LED 2.09 V)	
Laser_fr (MHz)	FADC rate MHz
0	2.744
0.1	2.718
0.5	2.993
1	3.037
2	3.136
5	3.738
20	5.916

Weak light (LED 2.12 V)	
Laser_fr (MHz)	FADC rate MHz
0	7.913
0.1	7.979
0.5	8.019
1	8.134
2	8.248
5	8.749
20	10.129

Weak light (LED 2.15 V)	
Laser_fr (MHz)	FADC rate MHz
0	15.746
0.1	15.777
0.5	15.846
1	15.915
2	16.081
5	16.197
20	17.811

**Laser wheel 3 + paper ("weak light")
LED ON
MAROC sum board**
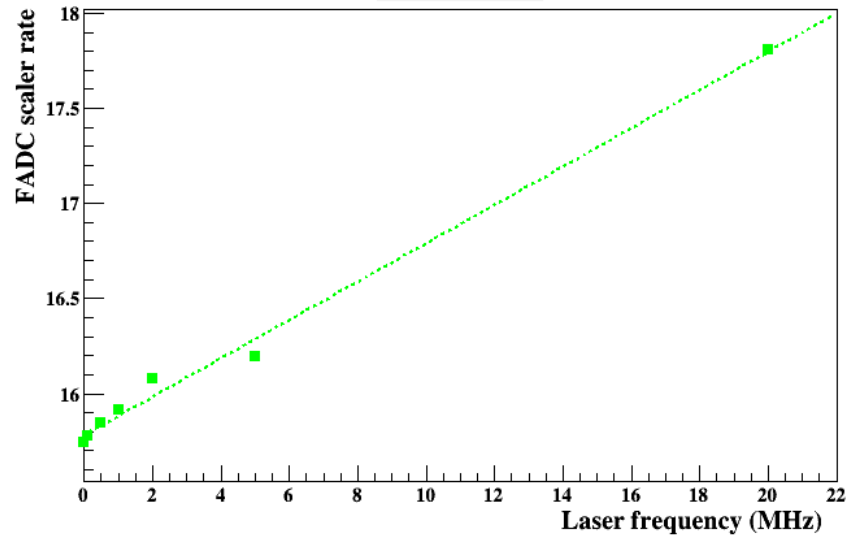
FADC scaler rate increase linearly with laser frequency

Laser wheel 2 + paper ("strong light")
LED ON
MAROC sum board

Strong light (2.09 V)	
Laser_fr (kHz)	FADC rate MHz
0	2.744
0.1	2.816
0.5	3.002
1	3.428
2	4.310
5	7.143

Strong light (2.12 V)	
Laser_fr (kHz)	FADC rate MHz
0	7.913
0.1	8.031
0.5	8.163
1	8.513
2	8.977
5	10.64

Strong light (2.15 V)	
Laser_fr (kHz)	FADC rate MHz
0	15.746
0.1	15.51
0.5	15.32
1	15.73
2	15.794
5	17.100

Laser wheel 2 + paper ("strong light")
LED ON
MAROC sum board

LED 2.09 V
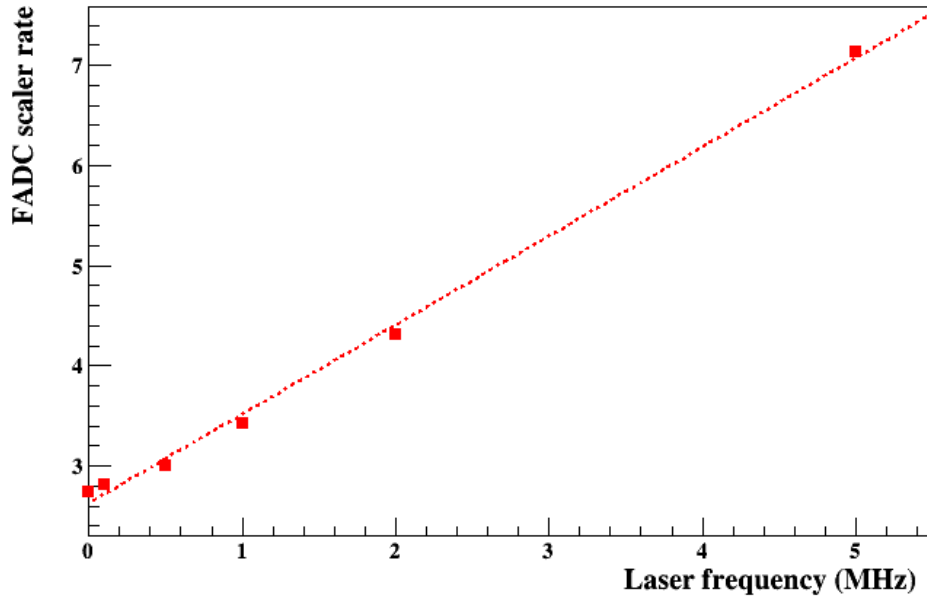
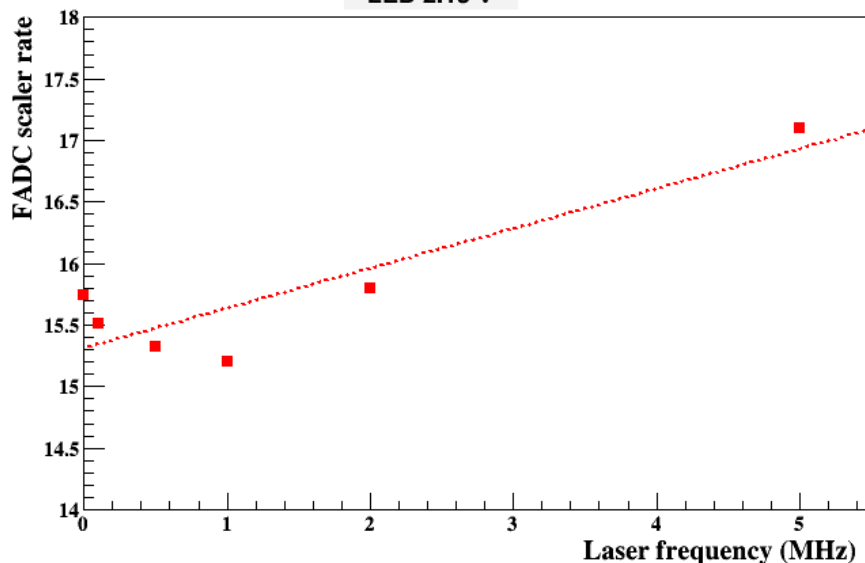**LED 2.12 V**
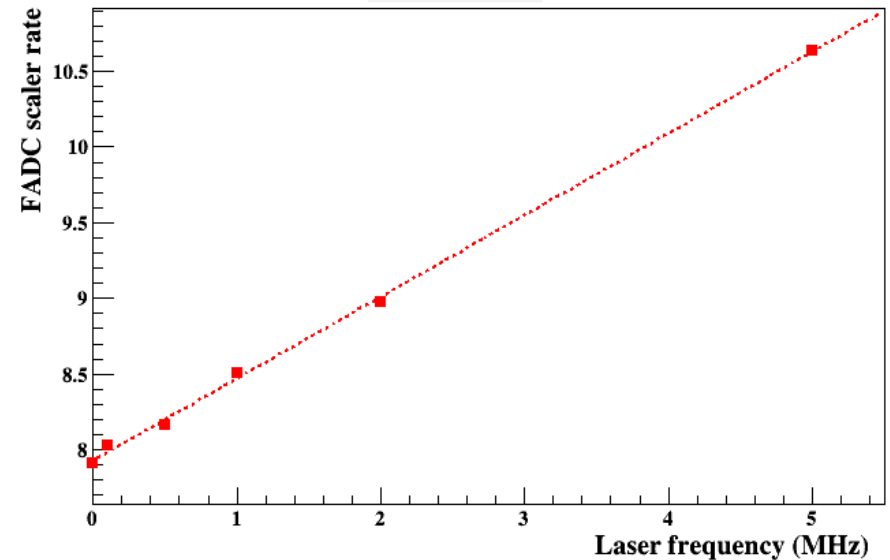
LED 2.15 V

- Laser signal arrives at fixed narrow FADC time window
- At LED 2.15 V, it more likely to have a photon from LED in the same time window where the laser signal arrives causing deadtime for laser signal

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Conclusion

- With one pixel fired, the sum rate and pixel rates can be related well
- Pedestal for FADC signal shifts (toward lower value) with increasing light
- Threshold scan (FADC rate vs threshold value) was performed to pick right threshold for FADC scaler rate
- For LED (Laser OFF), the deadtime correction for FADC scaler rate are significant
- Corrected FADC scaler rates can be related to pixel rate
- With pixel occupancy, the pixel rate and FADC sum rate agrees within 20 % for all laser condition (laser frequency and laser intensities)
- LED at 2.09 V and 2.12 V the effect on addition of laser can be understood. However at 2.15 V, the light from LED overwhelms the laser.
- For LED 2.15 V, we already have large number of photons in time window where the laser signal arrives causing deadtime to laser signal
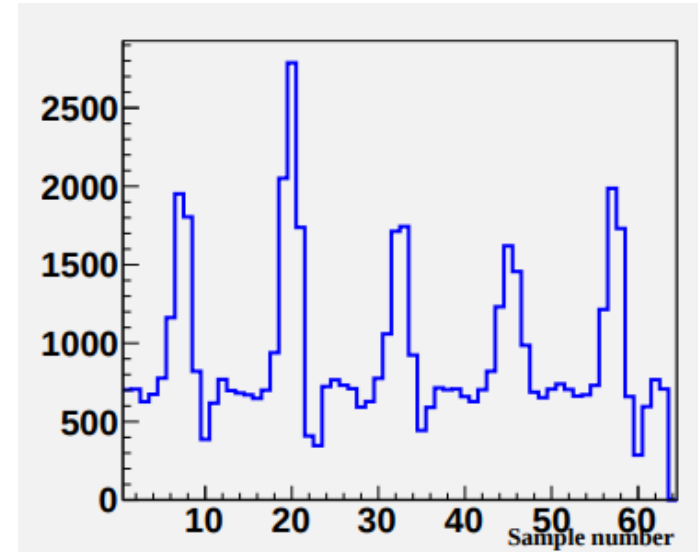
Back up slides

Rising edge time distribution

FADC waveform sum signal
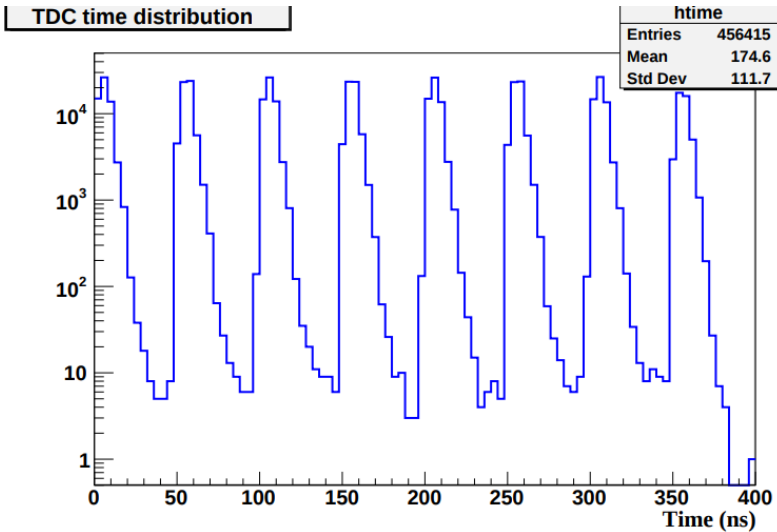
Multiple peaks at higher laser frequency is nornak

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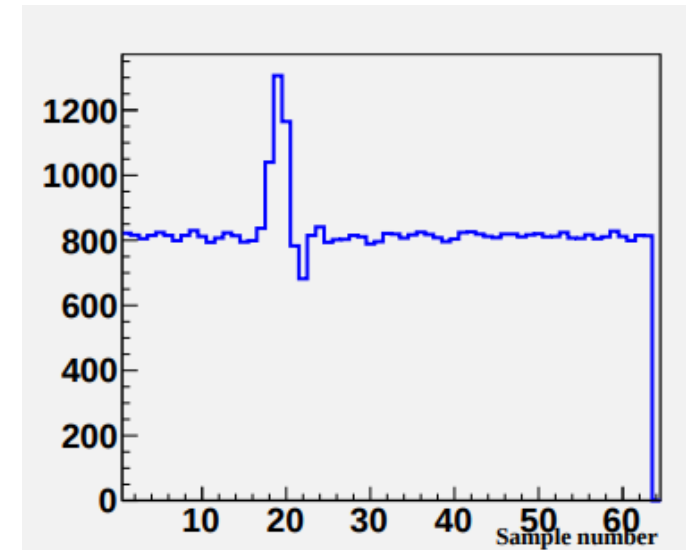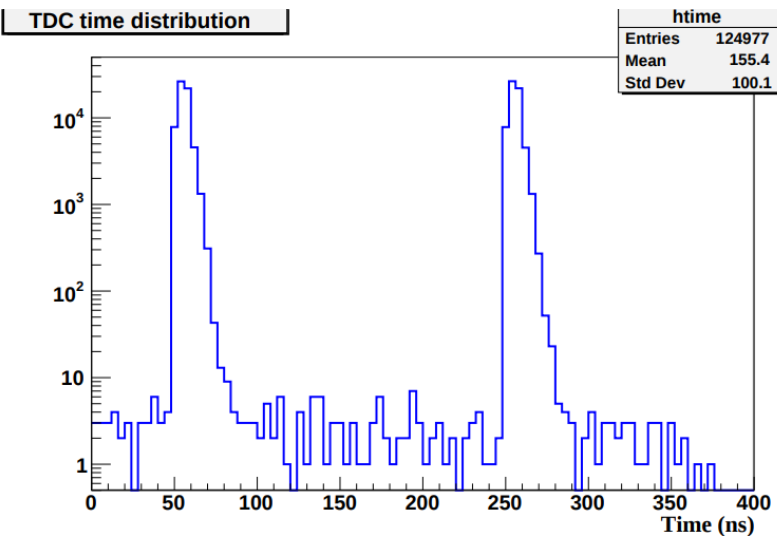
Pixel occupancy for different laser setting
From Maroc sum data
From 2020 run period

Laser frequency (MHz)	occupancy
Wheel 2 + paper ("strong light")	
1000	10.7
500	10.3
100	9.9
Wheel 3 ("medium light")	
1000	2.3
500	2.2
100	2.2
Wheel 3 +paper ("weak light")	
1000	1.1
500	1.1
100	1.1

Pixel occupancy is number of pixel hit for each triggered event