MaPMT with MAROC sum readout in high-rate bench tests

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SoLID Collaboration meeting Jan 8, 2021





Motivation and goals

Motivation:

- In SoLID, Cherenkov detector rate is estimated to be as high as 200 kHz/pixel, 4 MHz/PMT for sum readout
- MaPMT with MAROC sum readout can be a potential option to handle such a high rate
- CLAS12 RICH detector has used MAROC electronics and validated its performance up to 2 kHz/pixel with some hot pixel up to 16 kHz
- Due to lack of beam time, MaPMT with MAROC sum readout is being tested on the bench mimicking the high rate environment, similar to SoLID by using LED and laser

Goals:

- To check and confirm the expected performance of MaPMT readout at high rate (200 kHz/pixel, 4 MHz/PMT)
- Understand the background subtraction at high rate similar to SoLID

Schematic layout of bench test

Setting

- Used 1 SN-HA0037 MaPMT (5 x 5 cm)
 - > total 64 pixels (6 x 6 mm)
- Laser and LED are used to create high rate environment as expected in SoLID
- Laser used as signal and LED operating under DC voltage as background
- Triggered by clock
- Data:
 - CODA (FADC sum signals and TDC pixel signals)
 - MAROC scaler (scaler for pixel)
 - FADC scaler (scaler for sum signal)

Schematic layout of bench test setup



Readout by MAROC sum board

- TDC signal from 64 pixels
- FADC sum signal (4 quads & total sum)

Readout by simple sum board

• FADC sum signal (4 quads & total sum)

MAROC scaler pixel readout

Rate (kHz)	LED off			LED 2.09 V			LED 2.12 V			LED 2.15 V		
Laser off				45			146			368		
Laser 10	0.2	0.7	2	45	45	47	144	146	146	362	369	365
Laser 100	5	4	21	45	48	65	144	149	164	363	370	382
Laser 200	7	8	42	45	52	86	144	153	184	363	375	402
Laser 500	15	20	106	46	62	150	145	164	248	363	386	465
Laser 1000	28	42	220	48	80	266	146	182	361	364	404	574

Laser and LED (2.15 V)



Laser filter:

- Strong laser light
- medium laser light
- weak laser light
- Pulsed laser and LED operating at DC voltage can provide the desired pixel rates
- Pixel rate is linear with laser + LED

FADC sum signals

Laser 1MHz (medium light) and LED 2.09 V

- MAROC sum board also gives FADC sum signals in addition to TDC information from pixel
- FADC sum signal:
 - > 4 quad sums (each quad sum 16 pixels)
 - Total sum (sum all 64 pixels)



The offline sum of 4 quads is equal to sum signal demonstrates the FADC sum signal performing we₿ at high rate up to 570 kHz/pixel

Correlation between pixel and sum Laser frequency 1MHz (strong light), LED 2.15 V



- This running condition is equivalent to 574 kHz/pixel (laser + LED)
- Linear correlation between pixel signal readout and sum signal readout by FADC is established
- Demonstrates that summing electronics work as expected to collect the charge from pixel $^{-6}$

Background subtraction

Laser 1MHz medium light (signal) and LED 2.09 V (background)



- Laser signal arrives in a fixed time window
- LED signals are random in time
- Applying the timing cut FADC signal can discriminate the signal from background

Background subtraction Pedestal subtracted quad and sum signal Signal from laser 1MHz (medium light) Background LED at 2.09 V



- Laser + LED run => extract signal based on fadc timing cut = > Laser signal => compare FADC spectrum with laser run only
- Based on the FADC timing information, background can be subtracted fairly well for rate ~250 kHz/pixel

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• Still working for higher rate case using TDC pixel information

Conclusion

- Due to limited access of beam, MaPMT MAROC sum readout is being tested on the bench using LED and laser
- With laser and LED in DC mode, the rate of 574 kHz/pixel (laser + LED) was achieved
- Yet to understand the sum signal rate and its relation with pixel signal rate
- Linear correlation between the TDC and FADC signal was established well above the pixel rates expected in SoLID
- Results presented are preliminary, work in progress
- Preparing for cosmic ray test using Lucite as radiator to produce the real Cherenkov signals
- Utilize high rate data from laser and LED along with cosmic data to study MaPMT MAROC sum readout

Acknowledgement: The SoLID collaboration

Especially Zhiwen Zhao, Benjamin Raydo, Andrew Smith, Alexandre Camsonne, Stephen Wood, Marco Contalbringo, Jack McKission, Roberto Malaguti, Jeff Wilson, and Haiyan Gao

Background slides

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MAROC sum board

Readout by MAROC sum board

- TDC signal from 64 pixels
- FADC sum signal (4 quads & total sum)

Readout by simple sum board

• FADC sum signal (4 quads & total sum)



- Laser + LED run => extract signal based on fadc timing cut = > Laser signal => compare FADC spectrum with laser run only
- Based on the FADC timing information, background can be subtracted fairly well

Background subtraction Pedestal subtracted quad and sum signal Signal from laser 1MHz (wheel 3, medium light) Background LED at 2.15 V



- Laser + LED run => extract signal based on fadc timing cut = > Laser signal => compare FADC spectrum with laser run only
- At higher background rate, FADCc timing information in not sufficient enough for background subtraction

FADC scaler vs ssp scaler rates



- For each filter, 3 points correspond to LED at 2.09, 2.12, and 2.15 V
- · Fadc and ssp scaler rate are linear