Aerogel RICH Readout HdSoC ASIC interface (7/11/2022)

- Readout concept
- Plans



Readout board Concept



Sensor parameters

- 35um micro-pixels (75% fill-factor)
- PDE good (Fig. 2 below) 38-50% (2.5 6V overV)
- Dark rate ~ 0.5 1.5 MHz (2.5 6V overV)
- Fast out 40pF (4ns RC for 100Ω termination)
- Gain ~3e6 @ 2.5Vover



Figure 2. PDE vs. Overvoltage



Figure 1. Photon Detection Efficiency (PDE)

Sensor Details

Sensor Details

- 4x smaller than had thought!
- Carrier board with SiPM biasing, amplification (next page)
- Both Fast/Slow outputs (need only one) → use Fast for signal, bias slow





Amplifier circuit

3e6 gain is 320uA over 1.5ns [FWHM]



Simulation Results

- TINA simulation (TI part)
- ~150mV for single p.e.
- Good risetime, no need for PZ cancellation



Sensor mapping (confusing) Orientation with bottom view





• J2-80 maps to J1-1

Concept to reality

• 64 channels on only 4" x 5" board!



8

Readout mating

- ASIC (final) spec is 64 channels, but 32 for now.
- Can read out full SiPM with 2x of these



Picosecond laser

- Would be nice to run at current intensity
 - > ~10ps jitter
 - Negligible for multi-channel timing
 - Check scaling of timing with Nphoton & multi-channel averaging
 - > Possibility of cooling (tests currently being done in dark box)



Next gen readout development: HDSoC Aerogel Ring Imaging Cherenkov (ARICH)

- mRICH using ARICH technique
 - Proximity focus
 - Can measure ring image to determine muon momentum







 Have purchased 2x aerogel samples, 64-pixel SiPM array







- Start with 1 and perhaps go to 4?
- What kind of resolution?

HMB v3 ARICH

Simulation assumptions

- Constrain to innermost pixels (muon will provide reference)
- If we can measure the index, use effectively as a "threshold device"

Aerogel Radiator

6

8

10

Note that vendor did not provide this information

18 16

14

12

10

8

6

4

2

0

0

2

4

Muon momentum [GeV/c]

Emission angle (degrees)

ARRAYJ-300XX-64P-PCB Board Drawing



HMB v3 ARICH

Simulation items

- Optimize Aerogel to sensor plane distance
- Probably wants its own lightbox?
- Assuming want to keep widest angle at n = 1.05 and central 4 pixels (17 deg, w= 9.2 mm)







HMB v3 compact Ring Imaging Cherenkov (cRICH)

• ARICH technique

- Works well at high p, but many atmospheric muons at lower momentum
- > Can make compact if use dense, thin material





Plans

- Still need to do a "fit check" of 1:1 board print out
- Received Hirose high-density connectors this morning and confirmed they seem fine (2mm called out – unobtainium – 3mm seems to mate just fine – 1 mm taller of no imporantance)
- We have digilent board in hand, and Mudit has been involved in using it to evaluate the HdSoC electrical properties
- Gearing up to do real physics measurements

An interesting measurement?

- If measure Time Of Flight scintillator with a 64 element device
- And can get the HdSoC contribution to 64ps
- Each Si-PM element scales as ~100ps/sqrt(Nphotons)
- Can measure scintillator (or Cherkov radiator) time in the limit of HdSoC dominated timing limit to 64ps/sqrt(64) ~ 8ps
- Sub-10ps timing would be impressive for a real detector not using micro-channel plates and only sampling at 1GSPS

Tabular

 Hirose connector has a very bizarre pin numbering convention (pin 1 is in upper right)

PIN SIGNAL PIN SIGNAL PIN SIGNAL PIN SIGNAL PIN SIGNAL 1 S9 2 S1 1 S41 2 S33 3 FP 4 F1 3 F41 4 F33 5 OM 6 S10 5 OM 6 S42 7 S2 8 F10 7 S34 8 F42 9 F2 10 CM 9 F34 10 CM 11 S11 12 S3 11 S43 12 S35 13 F11 14 F3 13 F45 CM 16 S44 19 F4 20 CM 19 F36 20 CM 21 S13 22 S5 21 S45 22 S37 23 F13 24 F5 23 F46 24 F37<		J	1			J2			
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55 S30 56 CM 55 S62 56 CM 57 F21 58 F29 57 F53 58 F61 59 S21 60 S29 59 S53 60 S61 61 CM 62 F20 61 CM 62 F52 63 F28 64 S20 63 F60 64 S52 65 S28 66 CM 65 S60 66 CM 67 F19 68 F27 67 F51 68 F59 69 S19 70 S27 69 S51 70 S59 71 CM 72 F18 71 CM 72 F50 73 F26 74 S18 73 F58 74 S50 75 S26 76 CM 75 S58 76 CM 77	53	F30	54	S22	53	F62	54	S54	
57 F21 58 F29 57 F53 58 F61 59 S21 60 S29 59 S53 60 S61 61 CM 62 F20 61 CM 62 F52 63 F28 64 S20 63 F60 64 S52 65 S28 66 CM 65 S60 66 CM 67 F19 68 F27 67 F51 68 F59 69 S19 70 S27 69 S51 70 S59 71 CM 72 F18 71 CM 72 F50 73 F26 74 S18 73 F58 74 S50 75 S26 76 CM 75 S58 76 CM 77 F17 78 F25 77 F49 78 F57 70 <t< td=""><td>55</td><td>S30</td><td>56</td><td>CM</td><td>55</td><td>S62</td><td>56</td><td>CM</td></t<>	55	S30	56	CM	55	S62	56	CM	
59 S21 60 S29 59 S53 60 S61 61 CM 62 F20 61 CM 62 F52 63 F28 64 S20 63 F60 64 S52 65 S28 66 CM 65 S60 66 CM 67 F19 68 F27 67 F51 68 F59 69 S19 70 S27 69 S51 70 S59 71 CM 72 F18 71 CM 72 F50 73 F26 74 S18 73 F58 74 S50 75 S26 76 CM 75 S58 76 CM 77 F17 78 F25 77 F49 78 F57 70 S47 90 S26 70 S40 90 S57	57	F21	58	F29	57	F53	58	F61	
61 CM 62 F20 61 CM 62 F52 63 F28 64 S20 63 F60 64 S52 65 S28 66 CM 65 S60 66 CM 67 F19 68 F27 67 F51 68 F59 69 S19 70 S27 69 S51 70 S59 71 CM 72 F18 71 CM 72 F50 73 F26 74 S18 73 F58 74 S50 75 S26 76 CM 75 S58 76 CM 77 F17 78 F25 77 F49 78 F57 70 S26 76 CM 75 S58 76 CM 77 F17 78 F25 77 F49 78 F57 70	59	S21	60	S29	59	S53	60	S61	
63 F28 64 S20 63 F60 64 S52 65 S28 66 CM 65 S60 66 CM 67 F19 68 F27 67 F51 68 F59 69 S19 70 S27 69 S51 70 S59 71 CM 72 F18 71 CM 72 F50 73 F26 74 S18 73 F58 74 S50 75 S26 76 CM 75 S58 76 CM 77 F17 78 F25 77 F49 78 F57 70 S47 90 S26 70 S40 90 S57	61	CM	62	F20	61	CM	62	F52	
65 S28 66 CM 65 S60 66 CM 67 F19 68 F27 67 F51 68 F59 69 S19 70 S27 69 S51 70 S59 71 CM 72 F18 71 CM 72 F50 73 F26 74 S18 73 F58 74 S50 75 S26 76 CM 75 S58 76 CM 77 F17 78 F25 77 F49 78 F57 70 S17 90 S26 70 S40 90 S57	63	F28	64	S20	63	F60	64	S52	
67 F19 68 F27 67 F51 68 F59 69 S19 70 S27 69 S51 70 S59 71 CM 72 F18 71 CM 72 F50 73 F26 74 S18 73 F58 74 S50 75 S26 76 CM 75 S58 76 CM 77 F17 78 F25 77 F49 78 F57 79 S47 90 S26 70 S40 90 S57	65	S28	66	CM	65	S60	66	CM	
69 S19 70 S27 69 S51 70 S59 71 CM 72 F18 71 CM 72 F50 73 F26 74 S18 73 F58 74 S50 75 S26 76 CM 75 S58 76 CM 77 F17 78 F25 77 F49 78 F57 70 S17 90 S25 70 S40 90 S57	67	F19	68	F27	67	F51	68	F59	
71 CM 72 F18 71 CM 72 F50 73 F26 74 S18 73 F58 74 S50 75 S26 76 CM 75 S58 76 CM 77 F17 78 F25 77 F49 78 F57 70 S17 90 S25 70 S40 90 S57	69	S19	70	S27	69	S51	70	S59	
73 F26 74 S18 73 F58 74 S50 75 S26 76 CM 75 S58 76 CM 77 F17 78 F25 77 F49 78 F57 70 S17 S17 S26 70 S40 S0 S57	71	CM	72	F18	71	CM	72	F50	
75 S26 76 CM 75 S58 76 CM 77 F17 78 F25 77 F49 78 F57 70 S17 90 S25 70 S40 90 S57	73	F26	74	S18	73	F58	74	S50	
77 F17 78 F25 77 F49 78 F57 70 S17 90 S25 70 S40 90 S57	75	S26	76	CM	75	S58	76	CM	
70 917 90 925 70 940 90 957	77	F17	78	F25	77	F49	78	F57	
19 01 00 020 19 049 80 001	79	S17	80	S25	79	S49	80	S57	

CM	Common I/O			
Sn	Standard I/O of pixel n			
Fn	Fast output of pixel n			