OAK RIDGE National Laboratory

Calorimeter ASIC discussion

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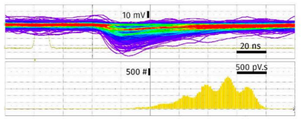
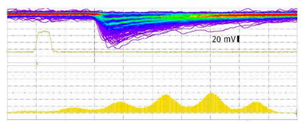
Overview of Calorimeters – SiPM

	Insert Calorimeter	Forward HCal	Forward ECal	Barrel HCal	Barrel ECal	Backward ECal	Backward HCal
SiPM Size	1.3x1.3 mm Or 3x3 mm	1.3x1.3 mm And 3x3 mm	6x6 mm2	3x3 mm		6x6 mm2	1.3x1.3 mm Or 3x3 mm
Voltage	38-45 V	50-53 V	33-47 V	38 V		40-46 V	50-53 V
Array of SiPM (summing)	-	5 or 10	2x2 Parallel	-		2x2	5 or 10
Capacitance/ channel	320pF or 1280 pF	1.6-3.2 nF And 6.4-12.8 nF	10 nF	320 pF		2.5 nF	1.6-3.2 nF Or 6.4-12.8 nF
Pixel/channel	7.3k Or 38k	13k-26k And 72k-144k	638k	40k		160-360k	13k-26k Or 72k-144k
Dynamic range	TBD	TBD	0.29pC-5.8 nC	TBD		10-10,000pC	0.1pC-320 pC

SiPM stability

	Insert Calorimeter	Forward HCal	Forward ECal	Barrel HCal	Barrel ECal	Backward ECal	Backward HCal
Overvoltage	+2 V	+3-4 V	+2 V	+2 V		+5 V	+3-4 V
Stability required [mV]	TBD	TBD	10 mV	100mV		TBD	TBD
Bias voltage accuracy	TBD	< 1% gain	0.05%	0.04%		TBD	TBD
Bias voltage current	1mA	1mA	1 mA	TBD		TBD	TBD
Temperature compensation	TBD	Yes	Yes, temperature compensated bias	TBD	SiPM Cooled	Bias voltage temperature compensation would be preferred	TBD

Feedback to ASICs

	Insert Calorimeter	Forward HCal	Forward ECal	Barrel HCal	Barrel ECal	Backward ECal	Backward HCal
SiPM analog waveform	TBD	TBD	TBD	TBD	TBD	Hamamatsu 14160-3010  (a) 10 μm Hamamatsu 14160-3015  (b) 15 μm	TBD

Pre-amp requirements

	Insert Calorimeter	Forward HCal	Forward ECal	Barrel HCal	Barrel ECal	Backward ECal	Backward HCal
Linearity	< 1 %	< 1 %	1-2 %	< 1 %	< 1 %	< 0.5 %	< 1 %
Gain stability	< 1 %	< 1 %	< 0.5 %	< 1 %	< 1 %	< 0.5 %	< 1 %
Peak time	10 ns	10 ns	< 200 ns	10 ns		20 ns	10 ns
Charge resolution	TBD	15-16 bit	14 bit	15-16 bit		14-bit	15-16 bit
Time-hit resolution	(TBD) 100 ps	(TBD)100 ps	1 ns	(TBD) 100 ps		(TBD) 5 ns	(TBD) 100 ps
Double pulse resolving	**TBD**	TBD	**Few hundred ns**	**50-100 ns**		**10 ns(?)**	TBD

FEB, RDO questions

	Insert Calorimeter	Forward HCal	Forward ECal	Barrel HCal	Barrel ECal	Backward ECal	Backward HCal
SiPM bias monitoring	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Temperature monitoring	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FEB on detector	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FEB accessibility	Between runs	Anytime	Between runs	Anytime	Between runs	Between runs	Anytime?
FEB-RDO distance	5m	5m	6-25m	5m	5m	3-5m	5m
RDO on detector	No	No	No	No	No	No	No
RDO location	Same as FHCal	On the side of the detector	Racks	5 m away	Same as Barrel HCal? 5 m	TBD	Side of detector

Time line – detector hardware, bench tests

	Insert Calorimeter	Forward HCal	Forward ECal	Barrel HCal	Barrel ECal	Backward ECal	Backward HCal
2023 Q3		First testbeam					
2023 Q4							
2024 Q1		First prototype					
2024 Q2							
2024 Q3							
2024 Q4							
2025 Q1							
2025 Q2							
2025 Q3							
2025 Q4							

HGCROC time line, critical steps (ORNL, OMEGA laboratory, Debrecen lead)

Testbench setup (already working):

- **July - Internal injection:**
  - **Test different gains, calibration, TOA/TOT threshold calibrations, etc**
- **Aug - External injection tests:**
  - **Test different gains, calibration, TOA/TOT threshold calibrations, etc**
- **Sept:**
  - **First prototype readout unit compatible with CAEN 5253 input**
- **Sept - Dec:**
  - **Feedback to the Omega group about the different technologies**
    1. **Analog waveforms from all detectors, capacitance per channel**
    2. **Hit frequency from full detector simulations**
    3. **First test benches with the existing HGCROC prototype**
    4. **Dynamic range requirements, resolution requirement**
- **2024:**
  - **Need all the prototype dates available**
  - **pfRICH requires first readout prototype in March (not calorimeter related, but ASIC related)**
  - **Starting to design new ASIC (month?)**

Still need more information

IJCLab, CNRS/IN2P3?
Ecole Polytechnique?
Others?

Other ASIC considerations (not full list)

Salsa:

- **ORNL contacted the developers, we will have one of the first test boards when available (no ETA yet)**

Pacific MicroCHIP:

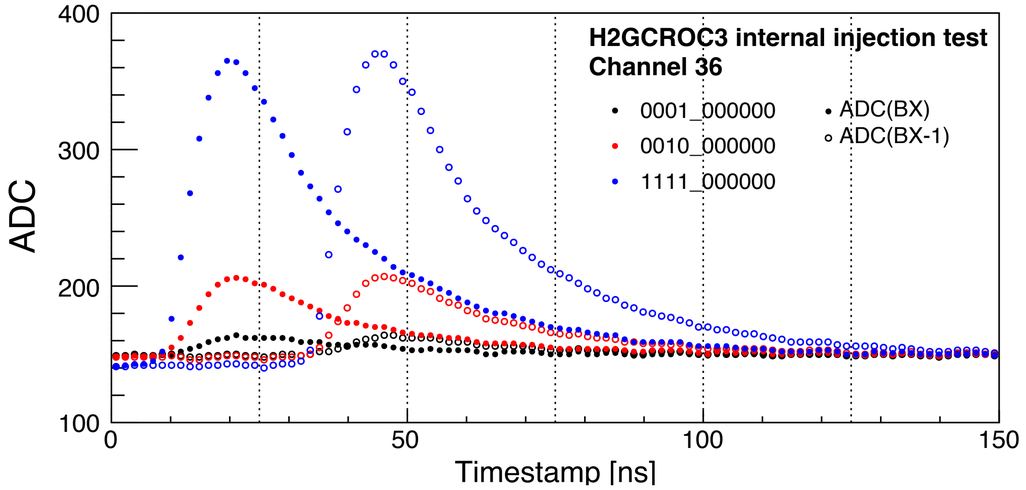
- **Gerard (Indiana) will have one and test it**

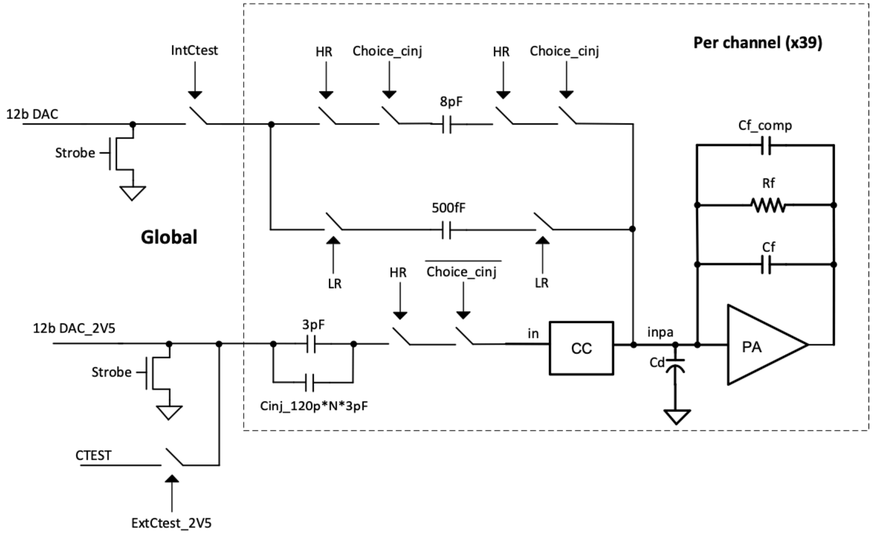
There might be others, collecting information

Detailed test of the HGCROC

Using internal injection test:

- **3 internal injection possibilities (each 11-bit input):**
  - 0.5 pF (0-2000 range)
  - 8 pF (0-2000 range)
  - 2.5 V injection through the C.C. (0-2000 range)
- **ADC calibration**
  - Synchronize all ADC pedestals at same level
  - Maximize the dynamic range by moving the pedestals to lowest possib
- **Reconstruct the full shape of the signal (all 150 ns long)**
  - ADC Calibration has to be repeated
  - 240 preamplifier simple gain settings (2600 total gain settings)
- **TOA Calibrations:**
  - Fix the global thresholds
  - Tune the local ch-by-ch thresholds
  - Tune the global thresholds
  - Repeat for several preamplifier settings
- **TOT Calibrations:**
  - Fix the global parameters
  - Tune the local ch-by-ch parameters
  - Tune the global parameters
  - Repeat for several preamplifier settings





With external injection tests:

- Clock and injection will be from the same external device
- Scan the whole dynamic range