

EEEMCal siPM and Readout Meeting

Justin Frantz (Ohio U),
ePIC EEEMCal FEE Mtg

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Agenda

- Finalized plans for the UCDavis Irradiation tests next week.
 - Attending are myself (Justin) and Gerard
- Quick check on Funding sources?
- Discussions about which siPM's for initial purchase
- Discussion about FEB plans to

Plan for October Beam Test at GSI – siPM's

- Two main goals:
 - 1) [Primary to me] get data with siPM readout demonstrating expected resolution
 - 2) Explore the two FEB Readout options HGCroc vs Discrete (full waveform sampling COTS solutions) - inform decision even if not able to finalize
- Carlos/ JCJLab/Orsay : 5x5 crystal prototype ~fully designed – need siPM's for these
 - Need ordered now. 4 months expected delivery – I have asked Ardavan for updated quotes – they will not probably include expected delivery date
- Project funds available through process involving Sasha Bazilevsky ~4 months

siPM's Irradiation Plan: Ingredients

- Also after carefully looking at [https://wiki.bnl.gov/EPIC/index.php?title=Radiation Doses](https://wiki.bnl.gov/EPIC/index.php?title=Radiation_Doses) Carlos and I arrived at 8×10^9 n/cm² for the inner most channels per standard year.
- 8×10^{10} for 10 years
- In first year, expect half design lumi : 4×10^9

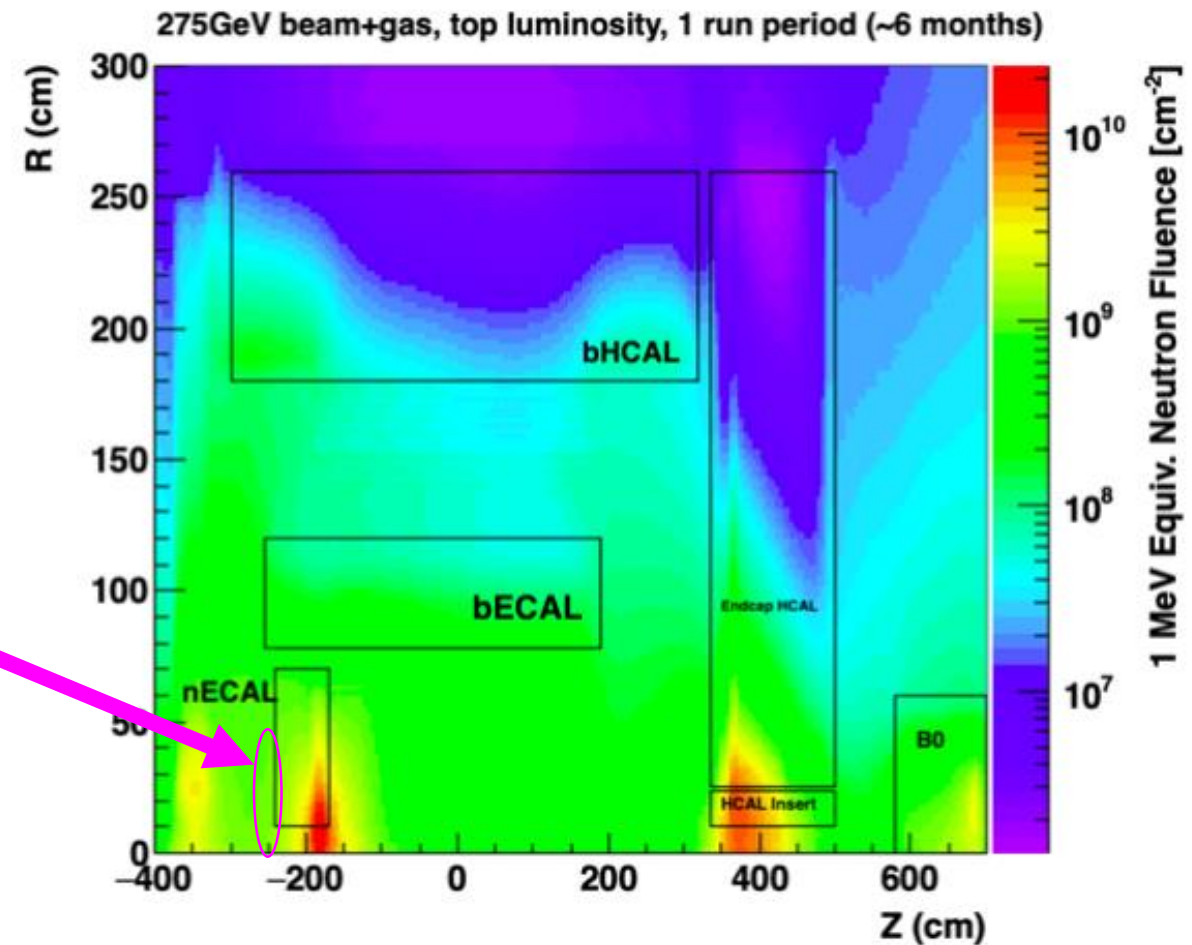


Figure 17: 1 MeV equivalent neutron fluence for 275 GeV hadron beam+gas events

siPM's Irradiation Plan: Ingredients

- First one point, UC Davis (Proton) Beam Energy 60 MeV
- Can provide in different fluxes (see next slide)
- Using this plot Gerard sent for conversion to MeV Equiv Neutron flux

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A. Akkerman et al. / Radiation Physics and Chemistry 62 (2000)

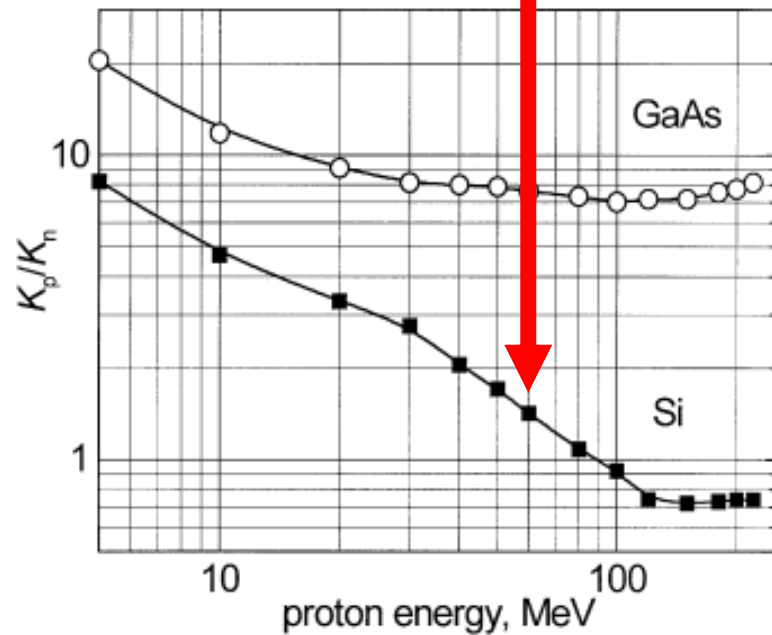


Fig. 6. The relative damage, K_p/K_n , as a function of proton energy where K_n is taken for 1 MeV neutrons.

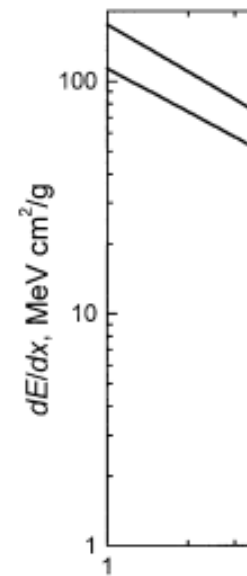


Fig. 7. The stopping power for GaAs as a function of proton energy (2000).

Assume 1.5 MeV/p as 60 MeV proton to MeV Neutron flux conversion factor

Rough idea of fwdCalo's plans

- We won't test as many because they are already testing many of the same models

Test 1 – Bare SiPMs (forward calorimeter groups)

Beam Flux (cm ⁻² s ⁻¹)	Time (seconds)	Total Fluence (cm ⁻²)	Number of SiPMs
10 ⁷	10	10 ⁸	4 S14160-1315PS (1.3mm, 15um pitch) 4 S14160-3015PS (3mm, 15um pitch)
10 ⁷	100	10 ⁹	4 S14160-1315PS (1.3mm, 15um pitch) 4 S14160-3015PS (3mm, 15um pitch) 1 S14160-6015 (6mm, 15um pitch)
10 ⁸	100	10 ¹⁰	4 S14160-1315PS (1.3mm, 15um pitch) 4 S14160-3015PS (3mm, 15um pitch) 2 S14160-6015 (6mm, 15um pitch)
10 ⁹	100	10 ¹¹	4 S14160-1315PS (1.3mm, 15um pitch) 4 S14160-3015PS (3mm, 15um pitch) 2 S14160-6015 (6mm, 15um pitch)
10 ¹⁰	100	10 ¹²	4 S14160-1315PS (1.3mm, 15um pitch) 4 S14160-3015PS (3mm, 15um pitch) 2 S14160-6015 (6mm, 15um pitch)
10 ¹⁰	1000	10 ¹³	4 S14160-1315PS (1.3mm, 15um pitch) 4 S14160-3015PS (3mm, 15um pitch) 1 S14160-6015 (6mm, 15um pitch)

siPM's Irradiation Plan - Proposal

Beam Flux (cm ⁻² s ⁻¹)	Time (seconds)	Total Fluence (cm ⁻²)	MeV n equiv fluence	Number of SiPMs/board
1.00E+08	540	5.40E+10	8.10E+10	Whole board of 20-3015 sipms
1.00E+08	540	5.40E+10	8.10E+10	3 S14160-3010PS (3mm, 10um pitch)
1.00E+08	540	5.40E+10	8.10E+10	2 S14160-3015PS (3mm, 15um pitch)
1.00E+08	540	5.40E+10	8.10E+10	2 S14160-6015 (6mm, 15um pitch)
1.00E+07	540	5.40E+09	8.10E+09	3 S14160-3010PS (3mm, 10um pitch)
1.00E+07	540	5.40E+09	8.10E+09	2 S14160-3015PS (3mm, 15um pitch)
1.00E+07	540	5.40E+09	8.10E+09	2 S14160-6015 (6mm, 15um pitch)
1.00E+07	35	3.50E+08	5.25E+08	2 S14160-3010PS (3mm, 10um pitch)
1.00E+07	35	3.50E+08	5.25E+08	2 S14160-3015PS (3mm, 15um pitch)
1.00E+07	35	3.50E+08	5.25E+08	2 S14160-6015 (6mm, 15um pitch)
as carlos suggests if we can retest this last bunch, and then re-irradiate, then shoot for longer on these to make 4e ⁹ ?				

“Initial Guess” Decision for Impending siPM Purchase

- Carlos (soft) voted for 3015
- Funds may limit : 3mm models 1.6-2 times more expensive
 - They are ~1.65 times more expensive for same surface area
 - They are ~2 x times more expensive since we can/want to include 4 more siPMs on top of 16 equivalent, 25% more
- Any further ideas on how to make this decision – irradiation testing should tell us something?

Ultimate Decision for siPM choices

- What goes into this decision:
 - Linearity (not really as much a concern? all should be linear enough after correction)
 - Noise characteristics around 5 MeV threshold most important
- Can we get information from NPS on expected light yield, etc...?
- Test benches being set up at Ohio, Lehigh, already at ACU –
 - Can test with sources, cosmics, LED crystals no crystals

FEB Decision

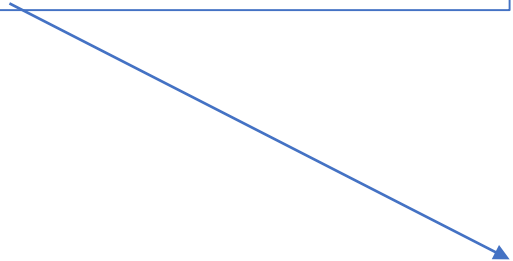
- Status Carlos/HGCroc – should be ready by October beam test time
- Gerard not sure, but probably can't have everything ready: can other engineering help get more in time?
- Can generic Flash ADC tell us enough info anyway, work on getting that set up over summer?
 - Carlo's can provide board for this, but would want help developing the solution.
 - Work needs to be done by other group (ie in US probably)

Backup

List of Needed Performance Parameters

- **Energy Resolution** (cluster) $2.5\%/\sqrt{E} + 1\%$
 - **Earlier 2023** $1\% + 2.5\%/\sqrt{E} [+ 1\%/E ?]$
- **Spatial resolution:** $1 + 3\%/\sqrt{E}$
- **Linearity** : correctable to 0.5%
- **Threshold (single tower)** : ~ 5 MeV [[Bazilevsky studies](#)]
- **Dynamic Range:** Tower level 2-5 MeV to ~ 15 GeV (x 7500-3000) (Cluster level -20-100 MeV – 20 GeV)
 - (assume $\geq 1-3$ ADCU per 5 MeV – which is threshold target.)
 - In pC : ~ 10 pC to 30-75 nC [?]- per channel : (min 10 pC from summer epic calo questionnaire document answer of “10-10000 pC”)
 - ADC : 14bit [?]
- **Rate Capability** : 20-100 kHz (highest [eta?] channels): Dominated by beam backgrounds, to be confirmed by further studies

This 20 is an old number?
YR: 50 MeV, later studies 100 MeV OK



List of Needed Performance Parameters

- **Waveform/timing:** All three of the below TBD
- *Timing resolution* : identify bunch crossing ~ 10 ns -- [can assume ≥ 2 tower measurements if needed $\rightarrow 14$ ns?]
- *Peak Time, N_samples* : $\geq 3-5$ in Peak + 2 pre-pedestal?
- *Sampling rate* : determined by above 40-80 MSPS
-
- **Noise Requirements** TBD by timing/resolution requirements: Pre-raddamage : DCR $\leq 3-10$ MHz Dark Current: ≤ 1.4 microAmps [Gerard's fEcal siPM presentation] Post-rad-damage

List of Needed Performance Parameters

- **Temperature/ Heating :**
- ***Temperature Sensitivity of siPM's*** - (Confirmation) tests of this would be good w/ w/o rad damage etc... look for opportunity
- ***Temperature Stability Requirement*** - tied to previous, later studies?

- ***Power consumption / Heating*** Pre-amp location [on adapter or preferably on IU adc board w/ 60 cm cable] - will be tested by Gerard IU.
 - TBTested with Dark current increase from Irradiation tests

Adapter Boards

- **Designs :**
- Larry: Updated (finished?) designs for 4x4 6010 and 6010 independent readout[details on ind] [also 6015?] adapter boards]
- We currently don't have board designs for 3mmx3mm models? Can we again start with the 3x3 = 9 siPM boards (made for previous prototype testings)
- For sooner tests if siPM's delayed can we make a customized board for say four 3mm sipm - usefl?
- **Production of Testing Adapter Boards:**
- How much? Can Gerard/someone make cheap test boards?

Gerard recent studies for fEcal w/ 6015 siPM's

- Gerard presented study for fEcal Readout [last week at Calo mtg](#):
 - Parts can be applied almost directly or done similarly for us to us?
- LED testing for 4 6015 siPM's on test adapter board - different pre-amp expectation than for us?
- Different dynamic range need (15 MeV threshold – 100 GeV) different light yield conversions
- Showed behavior of near threshold (for fEcal 15 MeV- ~20 pixel) and higher pulse and digitization characteristics
 - 13.5 pixel RMS 4.5 w/ simulated 100 μ A dark current rad damage RMS @ 13 is **18**
 - Timing resolution: assuming 14bit ADC digi-noise 39MSPS sampling need 5 ADCI pulses to achieve bunch crossing 10 ns resolution

Testing Proposals (who does them next slide?)

- Repeat Gerard's last tests on all (other) siPM's models
 - mostly same stuff done , but for other siPM models (too much work?) x 3
 - Independent readout of 6015 board? + 1 or x2
 - do we need to better characterize the LED for PDE do we want cosmics/crystals?
 - Need calibrated comparison (e.g. PMT) setup – at least for cosmics?
- Not covered so far but to be added
 - same tests : sim rad damage → real rad damage – repeat same tests?
 - Timing resolution is a pure sim study, can be done by anyone – To be improved by real pulse shape [pulse shape can be adjusted by design of adapter board,etc.]

Who does testing?

- Gerard IU?
- Backup: Ohio U?

Backup



https://wiki.jlab.org/cuawiki/index.php/OVERVIEW_OF_SPECIFICATIONS