SiPM Roadmap

See the recent summaries:

SiMP Summary at the Collaboration Meeting (January 2024):
https://indico.bnl.gov/event/20473/contributions/84622/attachments/51960/88885/BIC%20SiPM%20Choice%20Intro.pdf

Follow up on the irradiated SiPMs (from INFN Bologna):
https://indico.bnl.gov/event/21335/contributions/85608/attachments/52127/89150/BIC%20DCR%20Simulation%201-16-24.pdf

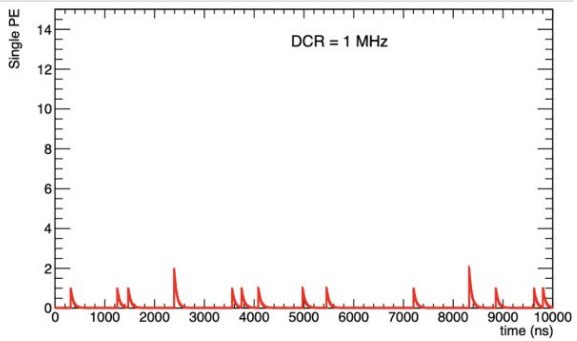
NOISE

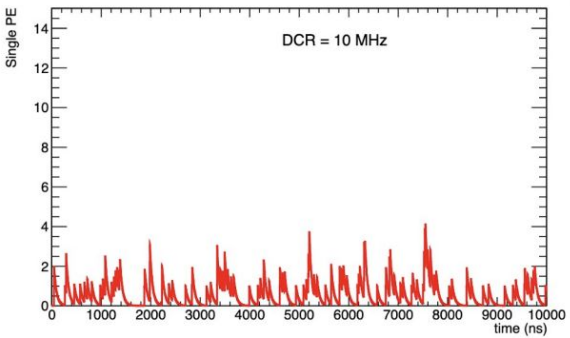
- Dark count rate (DCR) determines threshold
  - MIPs at midrapidity will generate 3-6 N_{pe} on average
    - Would be good to have threshold slightly below MIP
- DCR above a few 10s of MHz will endanger the MIP

Specification	S13360-3050 (3x3 mm)	S14160-3050 (3x3 mm)
DCR (Typ.)	500 kHz	1 MHz***
Crosstalk (%)	3	7

*** Estimated, differing values in literature

- Signal will gang 1.2 cm x 1.2 cm area (16 3x3 mm or 4 6x6 mm)
  - DCR for one BIC channel will be ~16x value in table
- Plan to test S14160 SiPMs at ANL & Regina





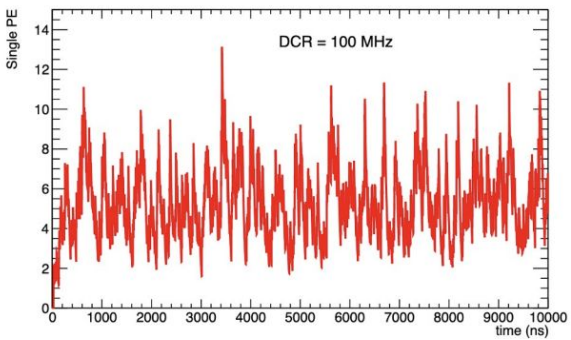
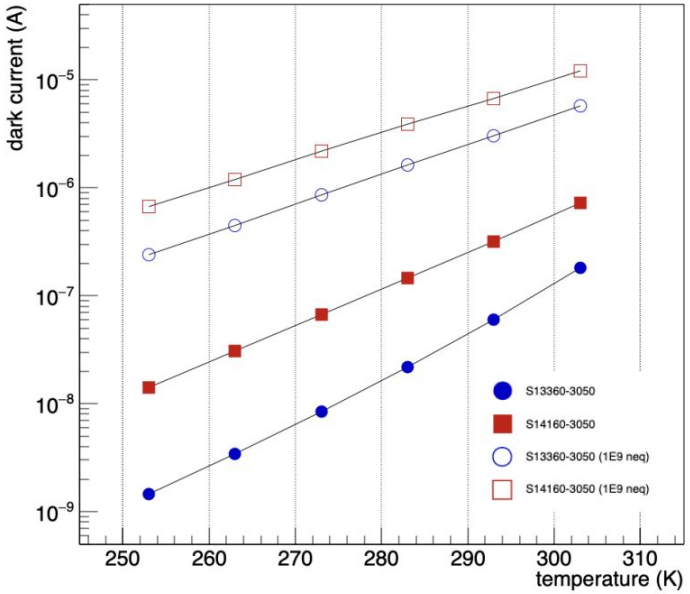


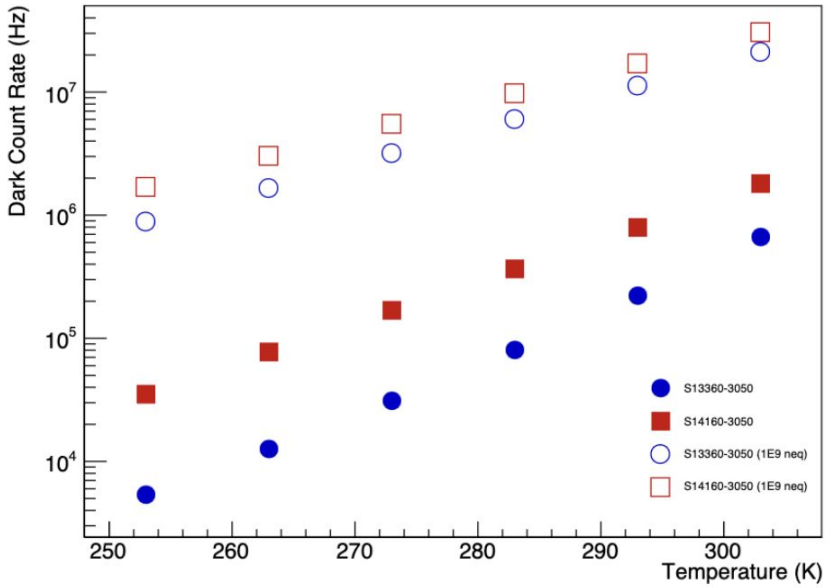
TABLE 1: Barrel Imaging Calorimeter SiPM Specs

Parameter	Specification	Notes	S13360	S14160
Active Area	3 mm x 3 mm (4 x 4 array)	Preassembled array covering 1.2cm x 1.2cm	✅	✅
Pixel Size	50 µm		✅	✅
Package Type	Surface Mount		✅	✅
Peak Sensitivity	450 nm		✅	✅
PDE	~ 50%		❌	✅
Gain	> ~ 2 x 10^6		~	✅
DCR	Typ.: ~ 500kHz / SiPM Max: < 1.5 MHz / SiPM	DCR applies to each SiPM in the 4 x 4 array	✅	❌?
Temperature coefficient of Vop	< 40mV/C		❌	✅
Direct crosstalk probability	< ~ 7%		✅	✅
Terminal capacity	~ 500pF / SiPM	Applies to each SiPM in the 4 x 4 array	✅	✅
Packing granularity				
Vop variation within a tray	< 200 mV		✅	✅
Recharge Time	< 100 ns		✅	✅
Fill Factor	> 70%		✅	✅
Protective Layer	Silicone (n ~ 1.5-1.6)		✅	✅

Dark Currents from INFN Measurements

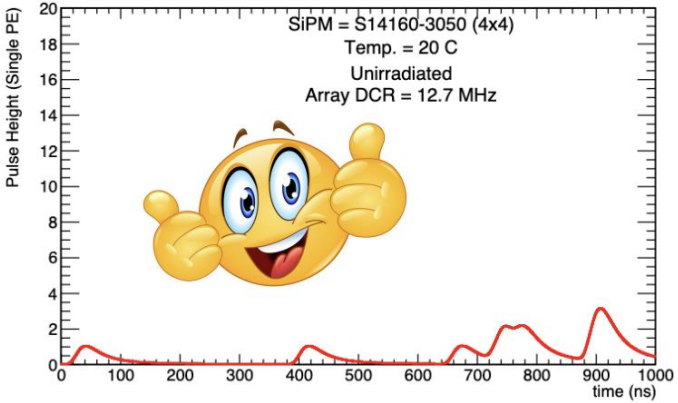
- Scale currents by gain & q_e to get a dark count rate
  - This is a bit naïve, but Roberto indicated it should be alright
- Order of magnitude increase after 1E9 1 MeV neq dose
  - Our conservative estimate of dose for lifetime of experiment was 3E10

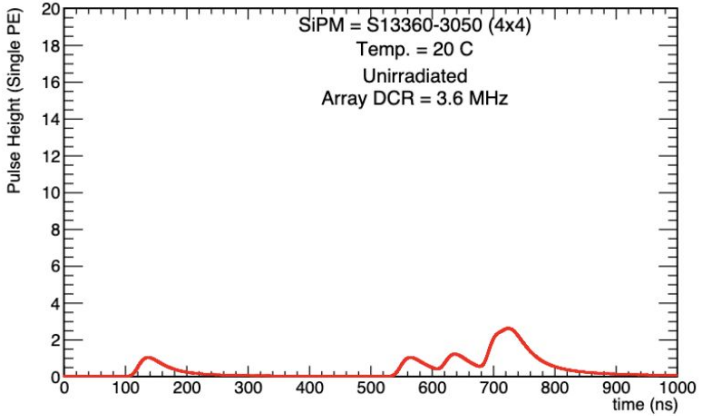


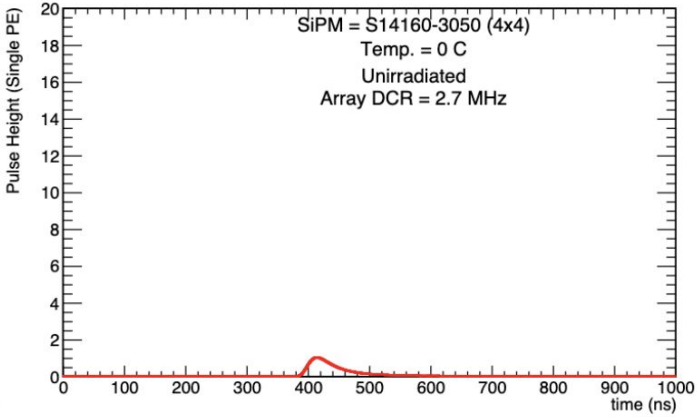


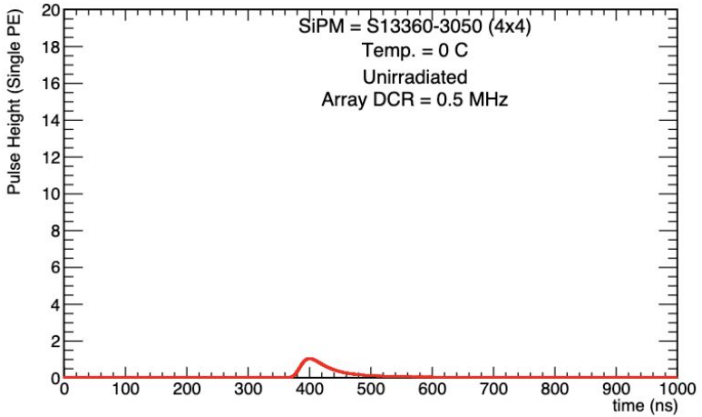
Temperature Dependence

Both sensors look reasonably good before irradiation, could easily set a threshold at 4 or 5 p.e.







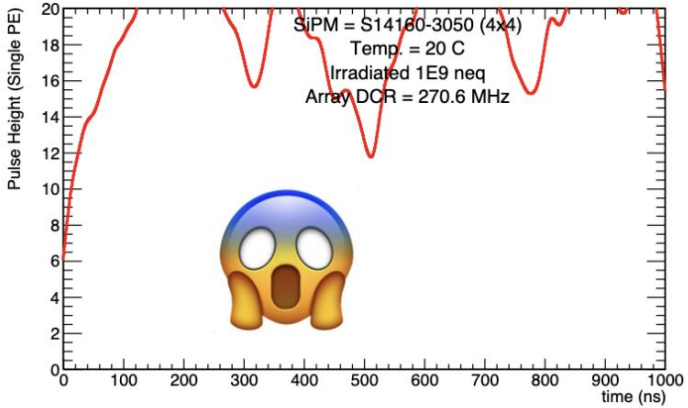


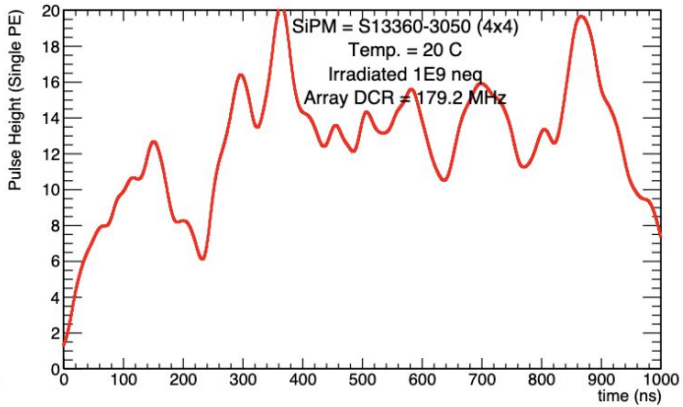
Radiation Damage

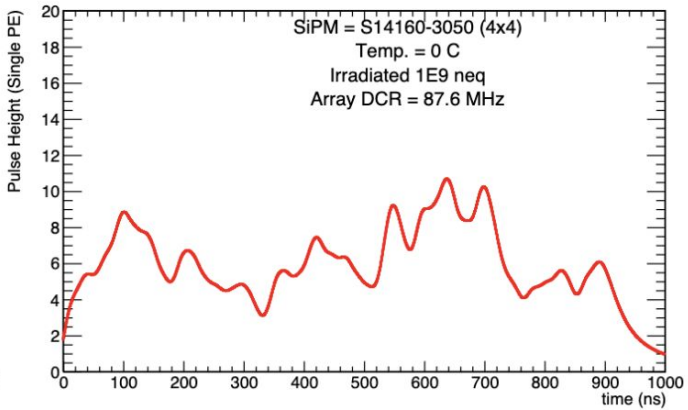
0 °C not cool enough to save the MIP for either SiPM after 1E9 1 MeV neq dose

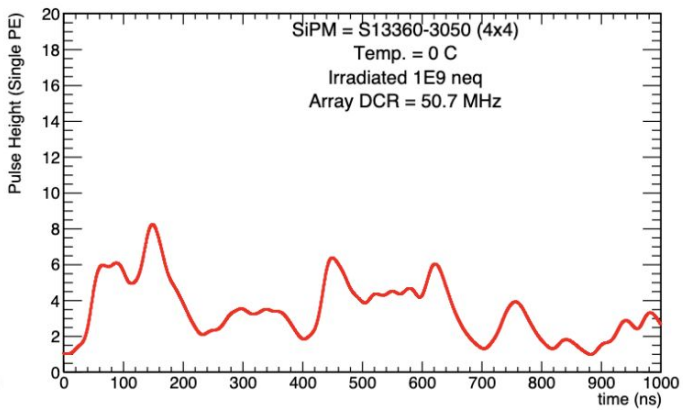
This assumes that the dark *current* produced by irradiation translates directly into dark *counts*, which is the **worst case** scenario

Keep in mind that this represents only ~1/30th of the 10-year expected dose









Roadmap

Question: Which SiMPs are we planning to stick to eventually.

1. SiMPs at hand: S14 (4 6x6 mm and 2 1.2x1.2cm) we can borrow some S13 (6x6 mm at hand)
2. We need to test them very quickly (overlap with ALERT)
3. Irradiation tests (APRIL)