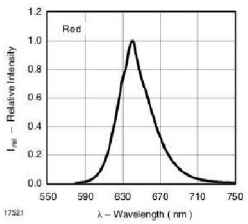
SiPM and Quartz tests at UVA

- Work by James Maxwell, Oscar Rondon
- Goals:
  - test output of quartz with UV sensitive small diameter CPM: Channel Photo-Multiplier
  - test response of SiPM: Silicon Photo-Multipliers to quartz light
- Purpose: contribute to design of SANE front quartz hodoscope to be built by NSU and JLab.

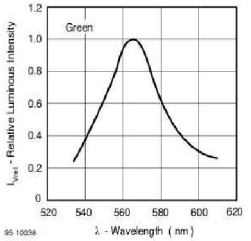
Response of SiPM's to LED light

- J.M. tested 1mm SiPM response to three colors of LED light, reported at 9/2/05 SANE meeting
- Test circuit too noisy for expected small quartz light pulses



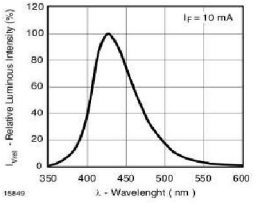
Red LED Spectrum

Figure 8. Relative Intensity vs. Wavelength



Green LED Spectrum

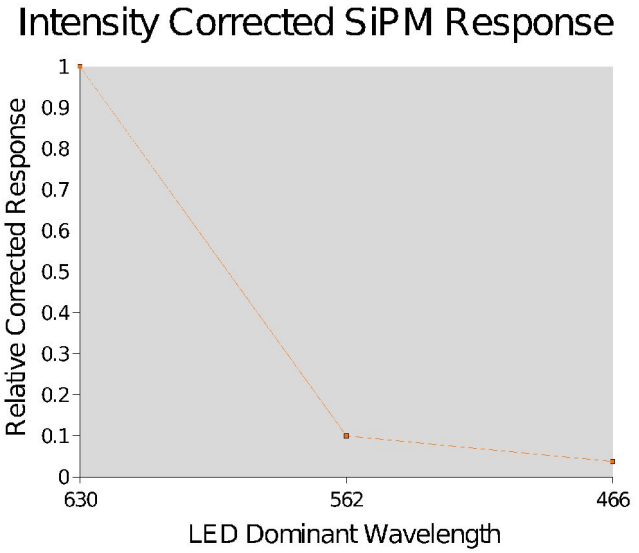
Figure 19. Relative Intensity vs. Wavelength



Blue LED Spectrum

Figure 7. Relative Intensity vs. Wavelength

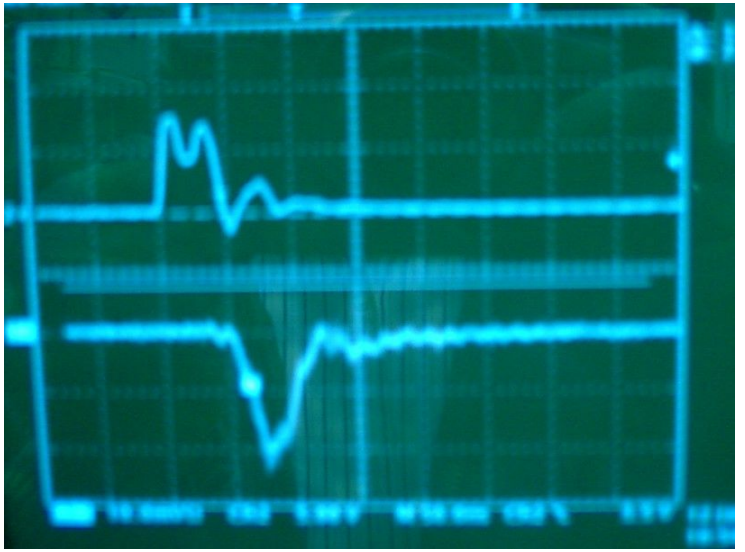
Corrected SiPM Response Data



Quartz Rod light signals too small to see, SiPM Setup is plagued with noise. A more efficient, shielded circuit should significantly reduce this noise.

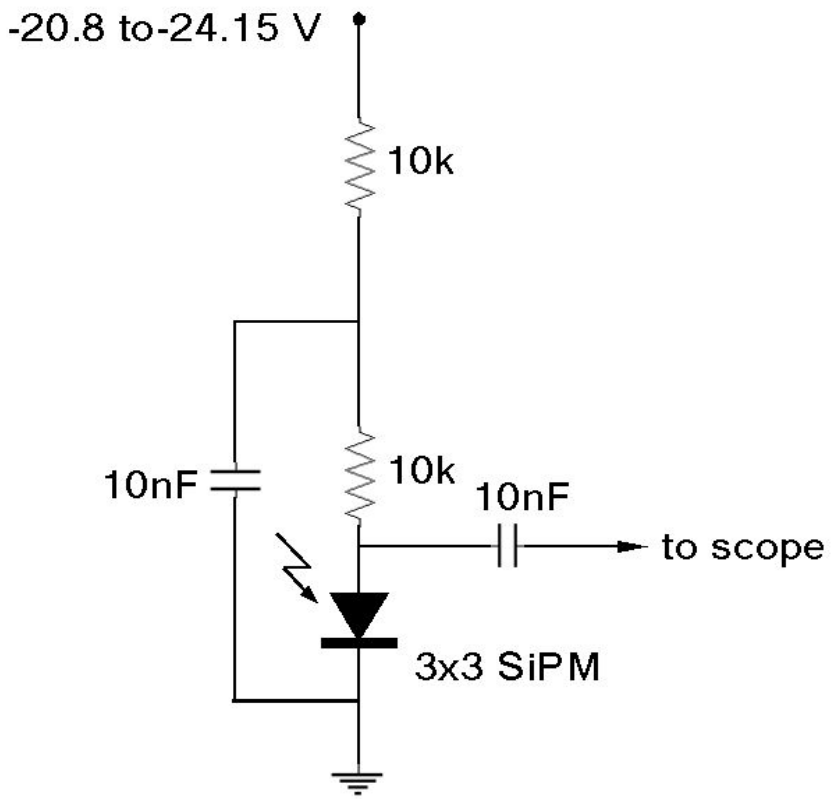
Pulse output of 1mm SiPM

- Test circuit was rebuilt for reduced noise
- Checked for shortest signal generator pulse producing an output
- Tens of mV output pulses for ~10 ns, ~7V pulse into blue LED
- No response below 10ns



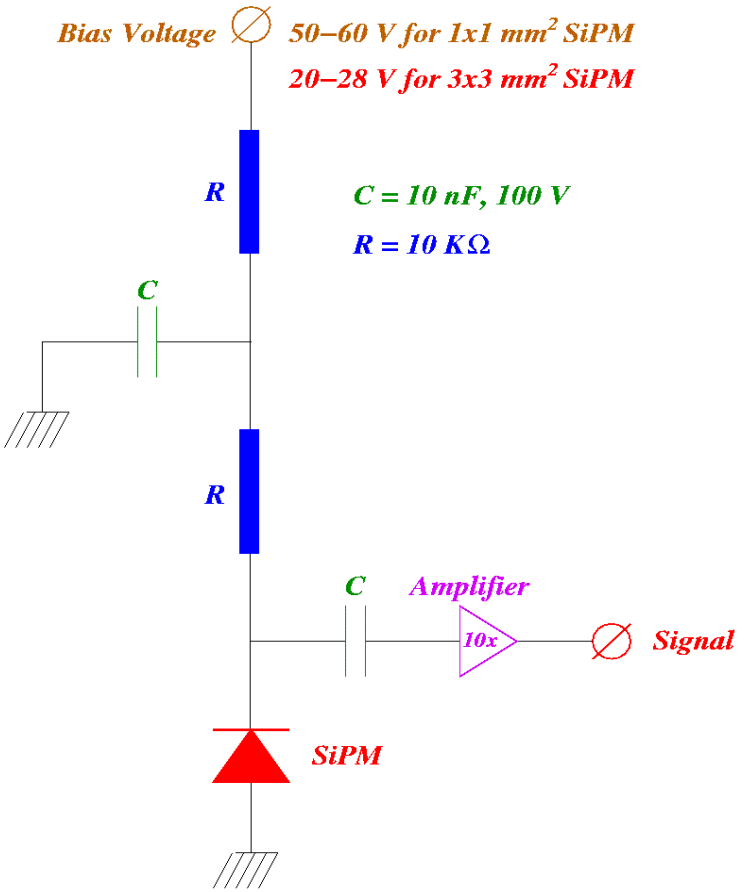
3×3 mm^2 SiPM

- P. Bosted loaned to UVA 5 3mm SiPM's purchased by Hall C
- 3 mm SiPM Geiger-mode (reverse bias) voltages range from ~ -19V to ~-22V
- Four devices had photovoltages ~400 mV; one was DOA



3×3 mm^2 SiPM

- P. Bosted loaned to UVA 5 3mm SiPM's purchased by Hall C
- 3 mm SiPM Geiger-mode (reverse bias) voltages range from ~ -19V to ~-22V
- Four devices have photovoltages ~400 mV; one was DOA



MEPhI Report on SiPM's

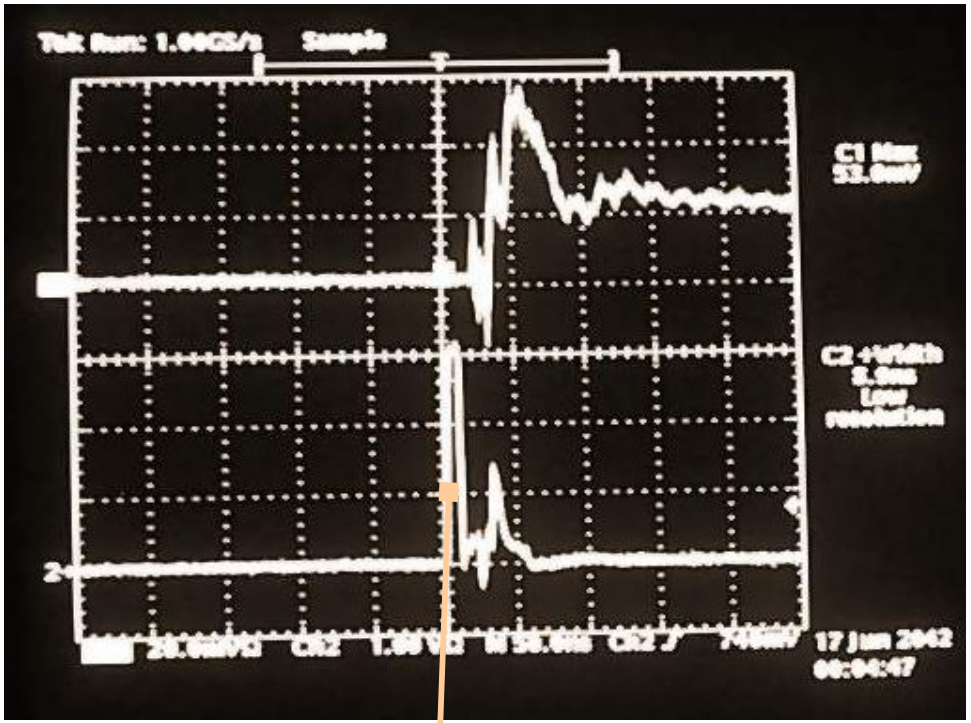
- 3x3 mm2 SiPM's,properties and performance -fig.
  - Main parameters:
    - sensitive area : 3x3 mm2
      # of pixels: 5625
    - Depletion region: appr. 1 mkm
      pixel size: 30 mkmx30 mkm
    - Working voltage: 20...28 V
      Gain: 1...2 x10**6
    - Dark rate.room temperature: 20 MHz
      SiPM noise equivalent(FWHM):

room temperature	5-10 electrons
-50 C	.4 electrons

    - Single pixel recovery time: 1mks
      Afterpulsing probability: appr.1%
    - Optical crosstalk: appr. 30%-50%
      ENF: appr. 1.5-2.0(overvoltage dependent)

3mm SiPM output

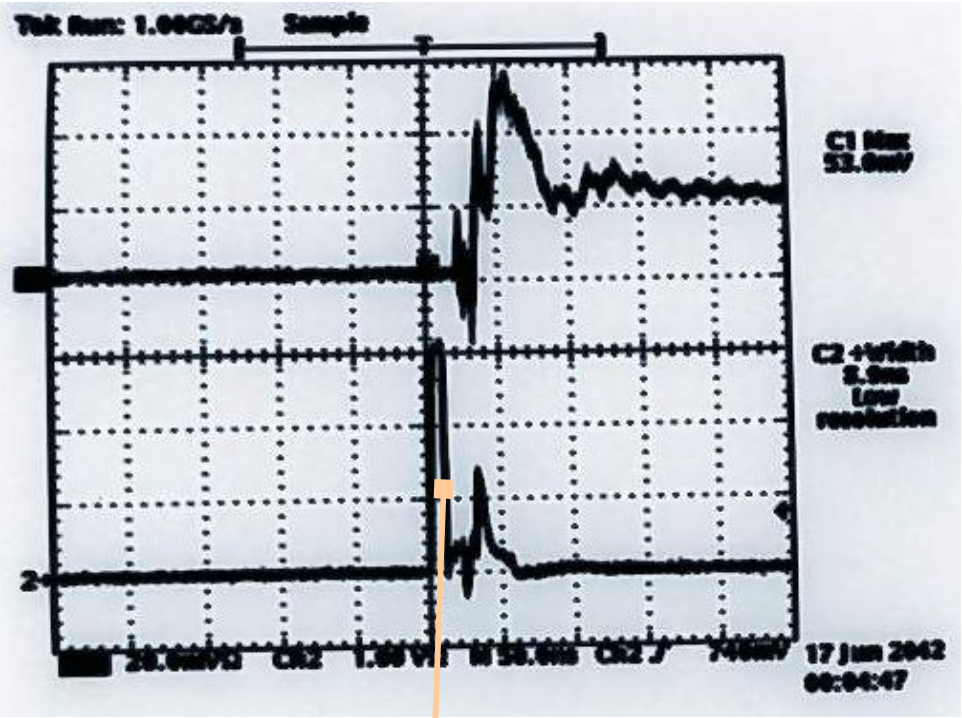
- Response to LED light
  - Device # 12 response to blue LED light
  - long tail after main peak
  - ~50 mV output for ~9 ns LED pulse
  - No response for shorter LED pulses



LED pulse 9 ns, 3V

3mm SiPM output

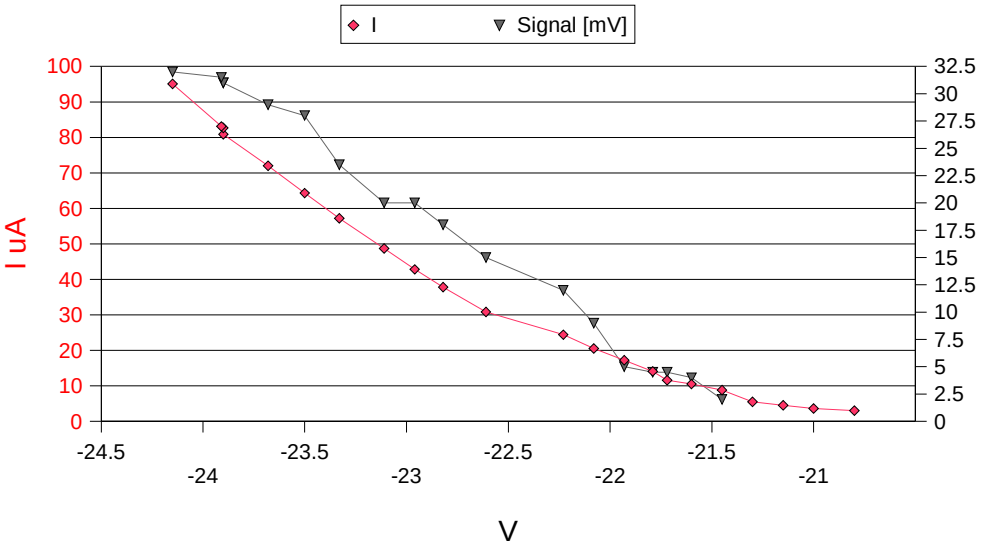
- Response to LED light
  - Device # 12 response to blue LED light
  - long tail after main peak
  - ~50 mV output for ~9 ns LED pulse
  - No response for shorter LED pulses

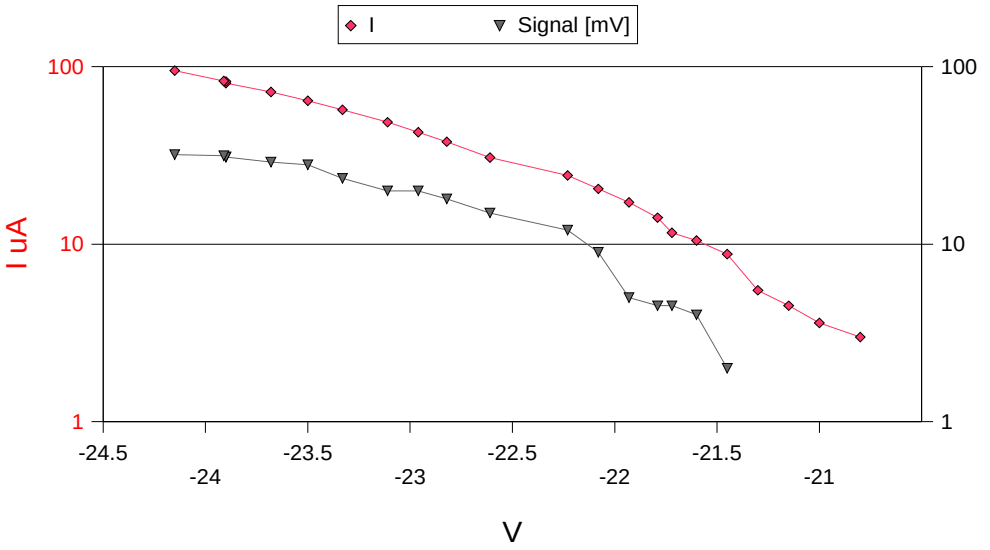


LED pulse 9 ns, 3V

I-V and V-A responses

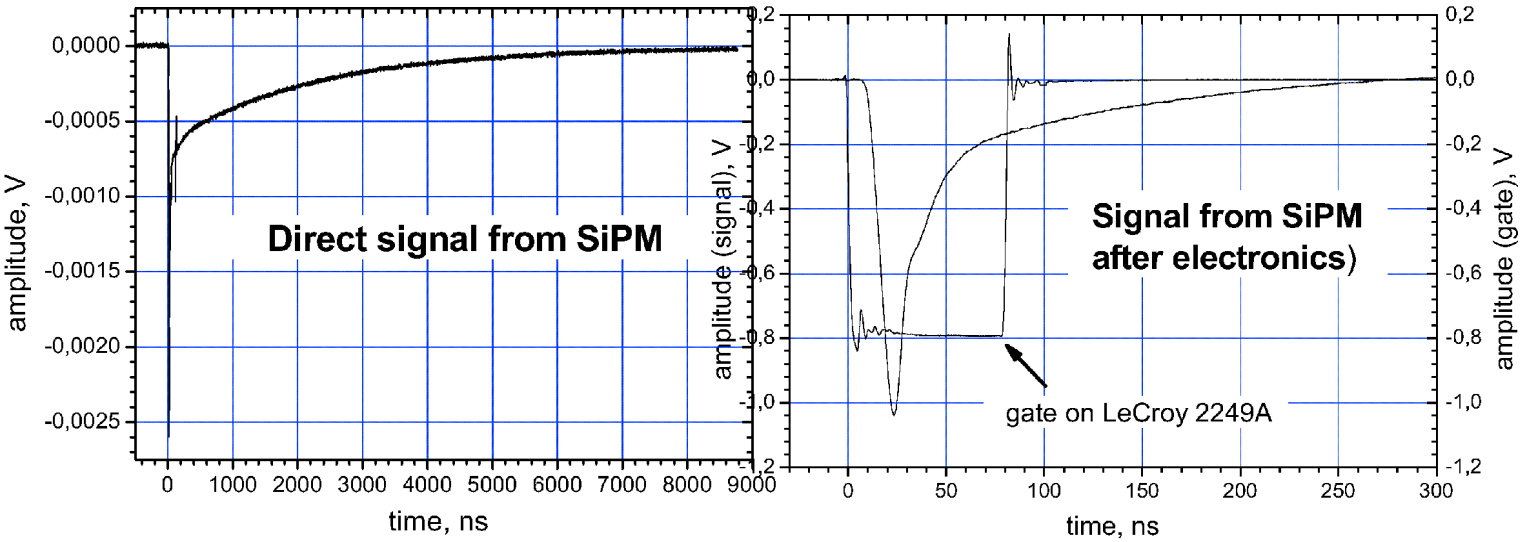
- 3x3 mm SiPM #12 Measured I and pulse amplitude A vs V_{bias} from Geiger threshold (-20.8 V)
- Log plot shows step features that may be related to discrete photon detection
- ADC spectrum should confirm this



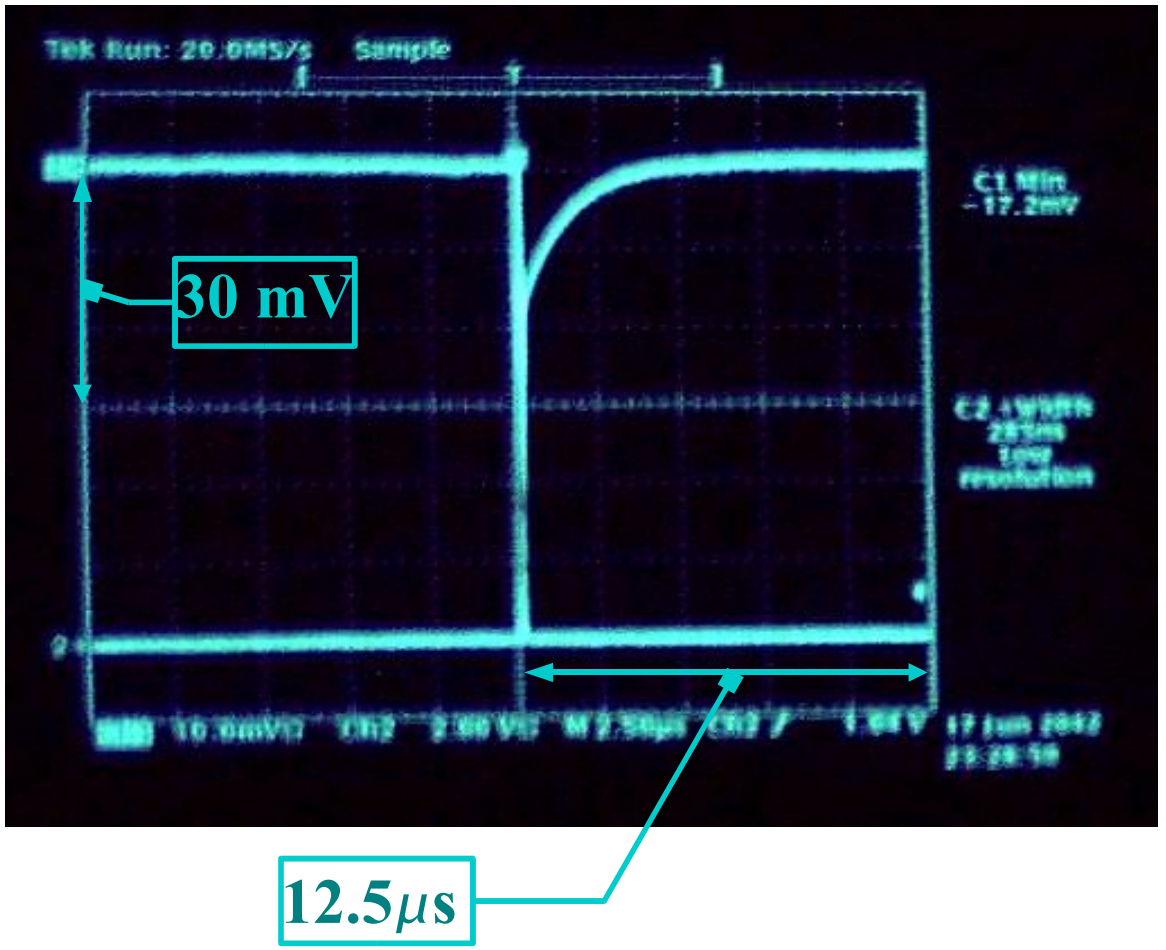


Expected and Observed Direct Signals

- SiPM with larger area (3x3 mm^2)



Expected and Observed Direct Signals



- Signal from SiPM # 13
  - (#12 died for no clear reason)
  - V_{bias} = 24.16 V (~ 3V above G-M breakdown)
  - tail ~ 4μs
  - signal ~ 50 mV at peak, not 2.5 mV

LED output

- Blue LED λ= 466 nm, E_ν = 2.66 eV
- Assume light concentrated in ± 30 deg. cone, ~0.84 sr
- LED output ~1.5 mcd(1 mA) = 30 uW/sr
- Geometry: SiPM touching LED, full cone of light incident on SiPM.
- LED photon output: 30e-6 W/sr * 0.84 sr * 6.24e18 (eV/s)/W * (1/2.66) photons/eV * 10e-9 s/pulse = 5e5 photons/pulse.
- Allowing for factors of 1/2 in LED output, solid angle, etc. LED output > 50-100e3 photons/pulse, or >10-20 photons/pixel, for 5625 pixels in 3x3SiPM.

Red

TLUR54..

Parameter	Test condition	Part	Symbol	Min	Typ.	Max	Unit
Luminous intensity [1]	I_F = 10 mA	TLUR5400	I_V	4	15		mcd
		TLUR5401	I_V	4	15	32	mcd
Dominant wavelength	I_F = 10 mA		λ_d		630		nm
Peak wavelength	I_F = 10 mA		λ_p		640		nm
Angle of half intensity	I_F = 10 mA		φ		± 30		deg

Blue

TLHB540.

Parameter	Test condition	Part	Symbol	Min	Typ.	Max	Unit
Luminous intensity [1]	I_F = 20 mA	TLHB5400	I_V	6.3	15		mcd
		TLHB5401	I_V	10		32	mcd
Dominant wavelength	I_F = 10 mA		λ_d		466		nm
Peak wavelength	I_F = 10 mA		λ_p		428		nm
Angle of half intensity	I_F = 10 mA		φ		± 30		deg
Forward voltage	I_F = 20 mA		V_F		3.9	4.5	V
Reverse voltage	I_R = 10 µA		V_R	5			V

[1] in one Packing Unit $I_{Vmin}/I_{Vmax} \leq 0.5$

Typical Characteristics (T_{amb} = 25 °C unless otherwise specified)

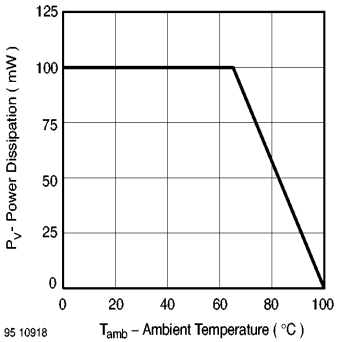


Figure 1. Power Dissipation vs. Ambient Temperature

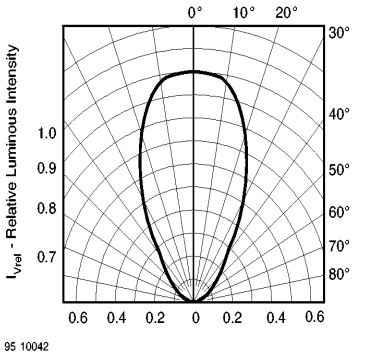


Figure 3. Rel. Luminous Intensity vs. Angular Displacement

Future plans

- Continue systematic studies of response to LED light
  - reduce circuit noise
  - measure blue LED output with CPM
- Look for quartz/scintillator light with SiPM
- Use wavelength shifter
- In parallel:
  - set up coincidence CPM with PMT to measure attenuation of quartz light in bars and rods with CPM with Sr-90 source
  - set up SiPM-CPM coincidence to measure SiPM efficiency

3×3 mm^2 SiPM

- P. Bosted loaned to UVA 5 3mm SiPM's purchased by Hall C
- 3 mm SiPM Geiger-mode (reverse bias) voltages range from ~ -19V to ~-22V
- Four devices have photovoltages ~400 mV; one was DOA

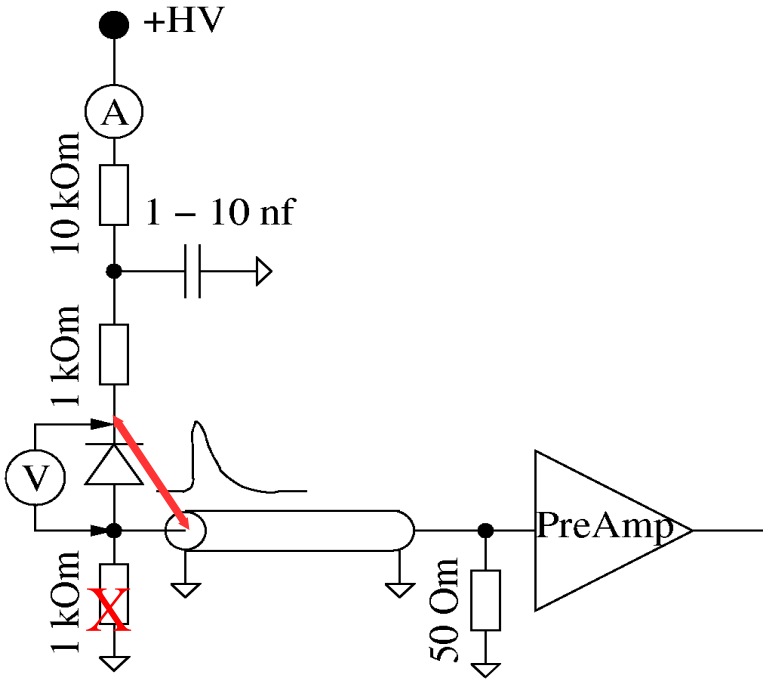


Fig. 1

3mm SiPM output

- Minimal tests of response to LED light
  - Device # 10 failed: no signal to V_{Geiger} + 2 V
  - Device # 12 responds to red (top) and blue LED light, good (~3V) voltage range.
  - long tail after main peak