Light Sensor Candidates for the Cherenkov Telescope Array

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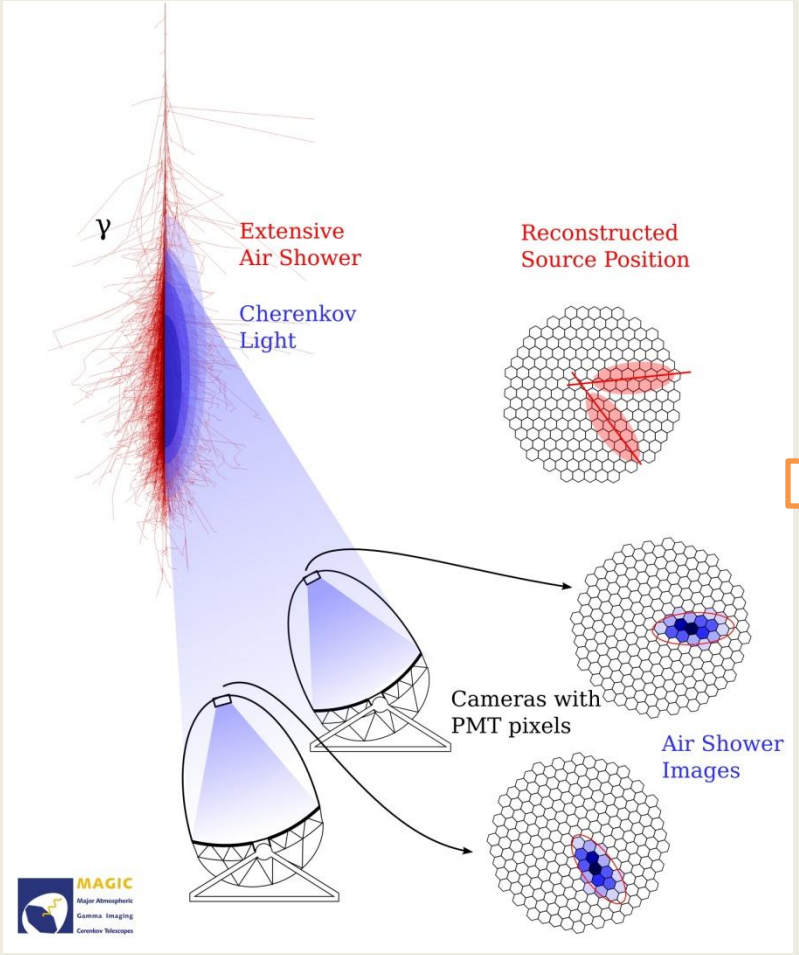
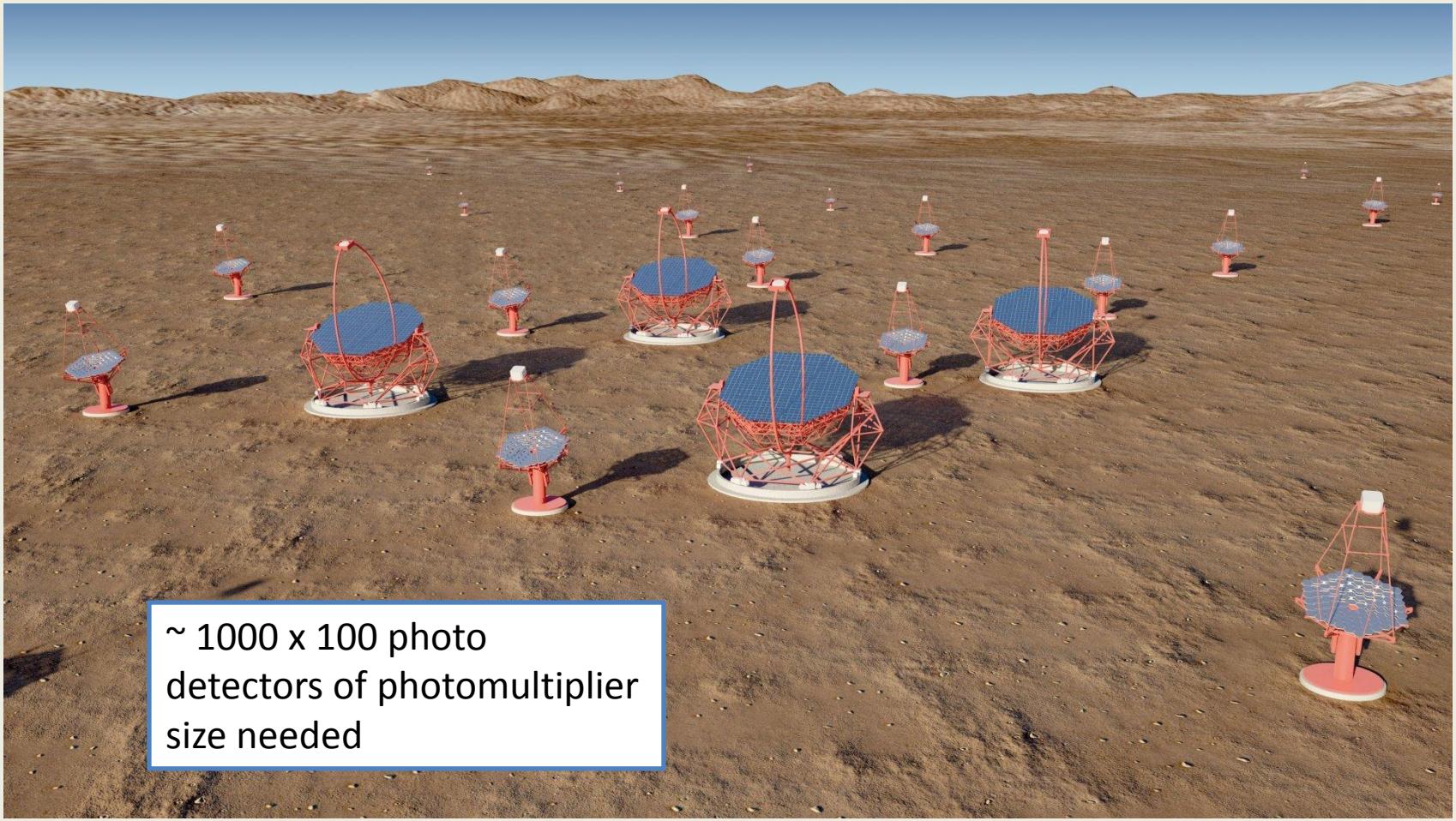
Ground-Based Gamma-Ray Astronomy

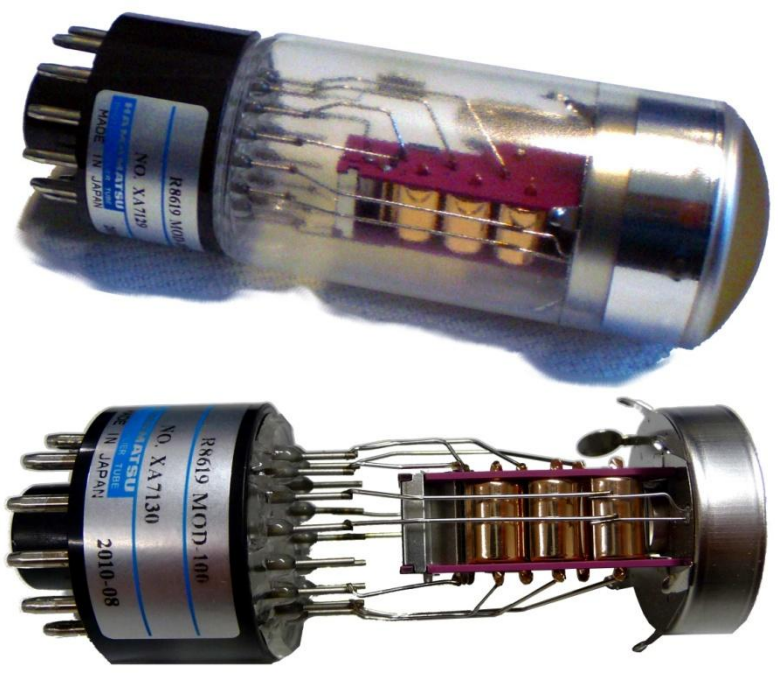


Fast, low-light-level detectors needed, crucial for sensitivity of the telescope

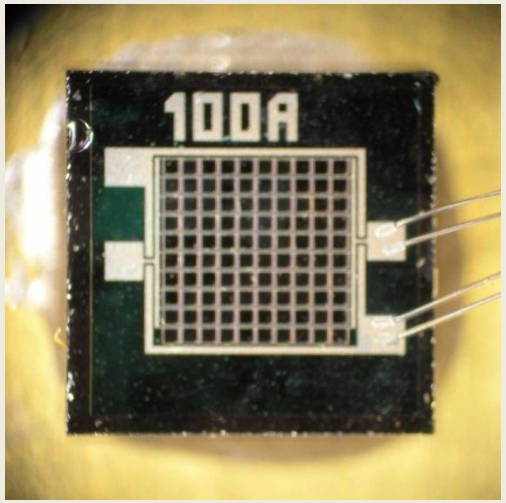
Cherenkov Telescope Array

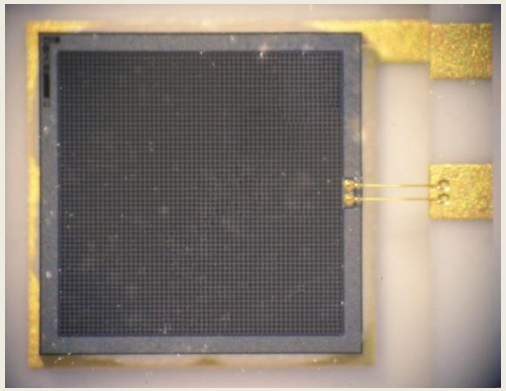


Development of Detectors



Photomultiplier
- established -

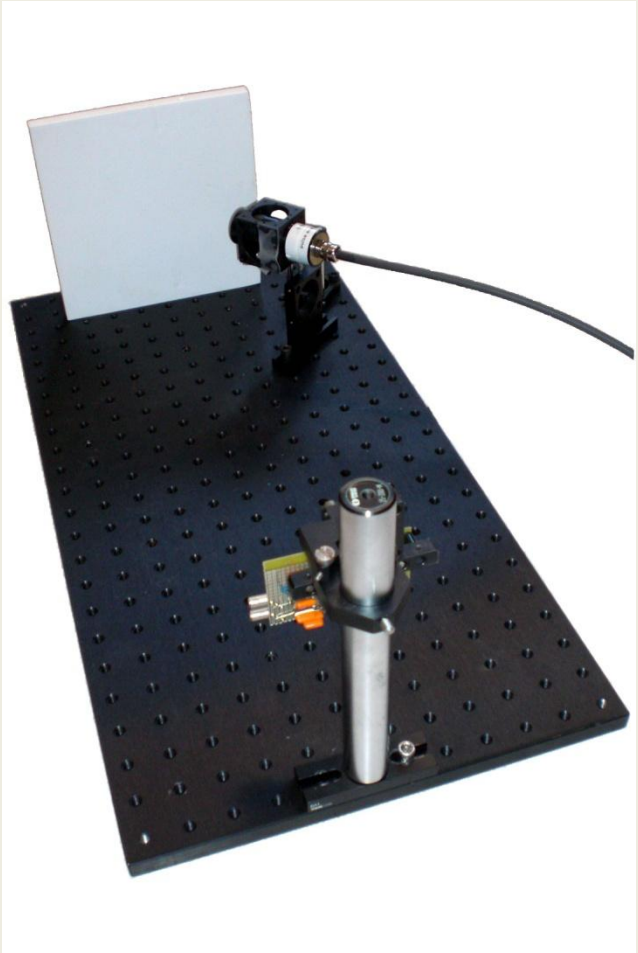




Silicon Photomultiplier
- new -

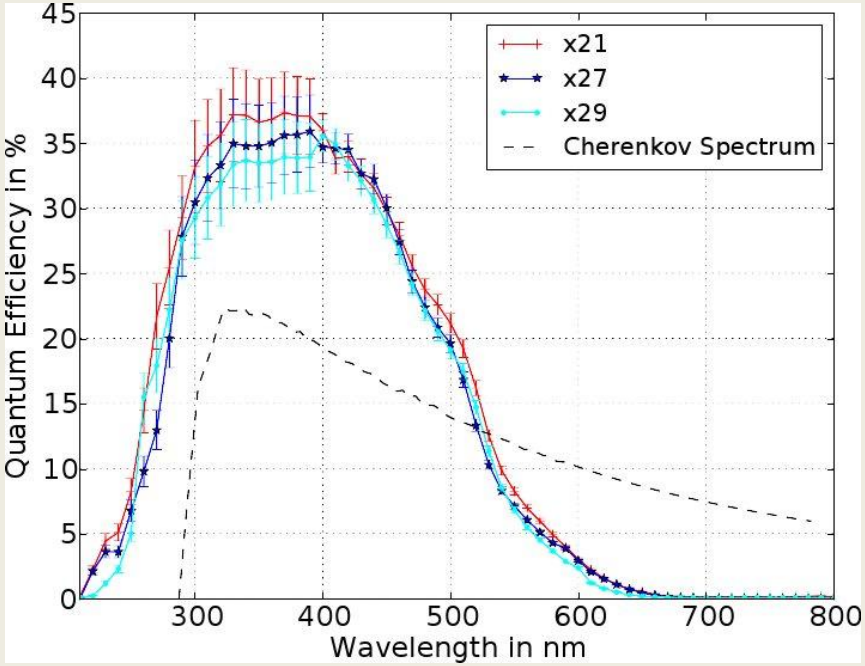
Evaluation of Detectors

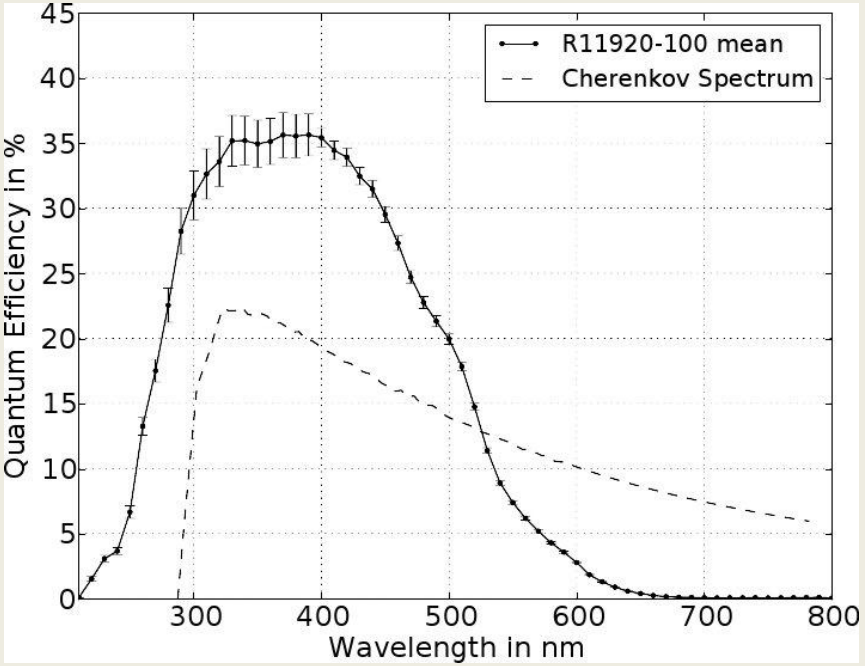
Quantum Efficiency Measurement Device
for PMTs



Photon Detection Efficiency set-up
for SiPM

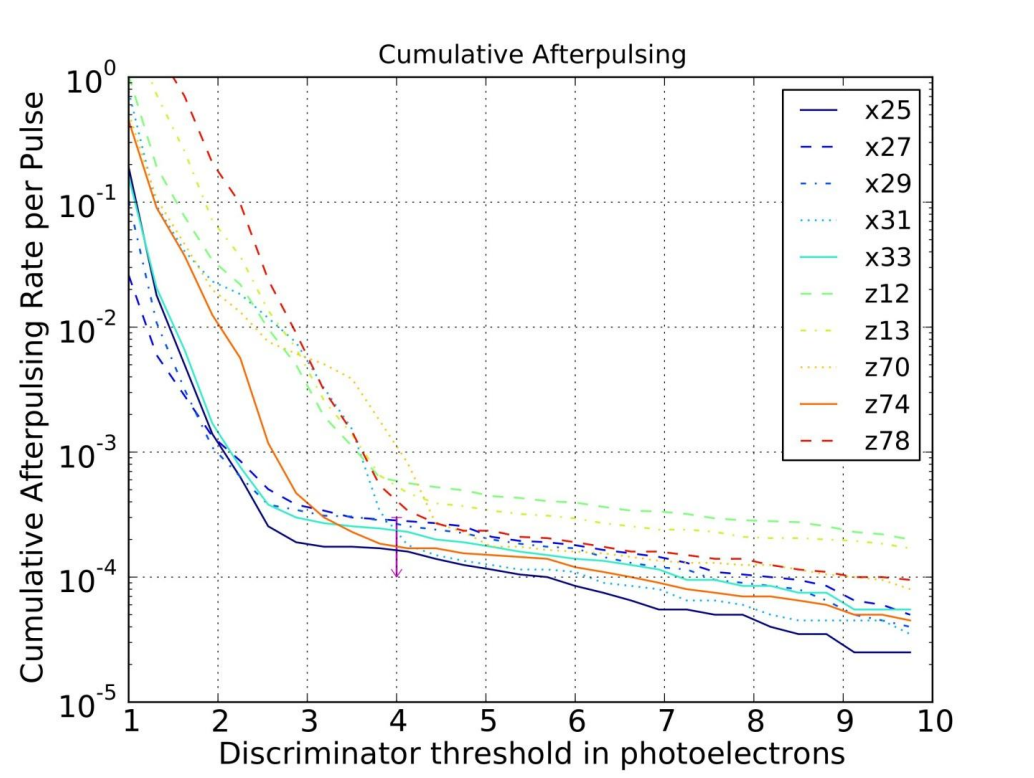
Photomultiplier Quantum Efficiency





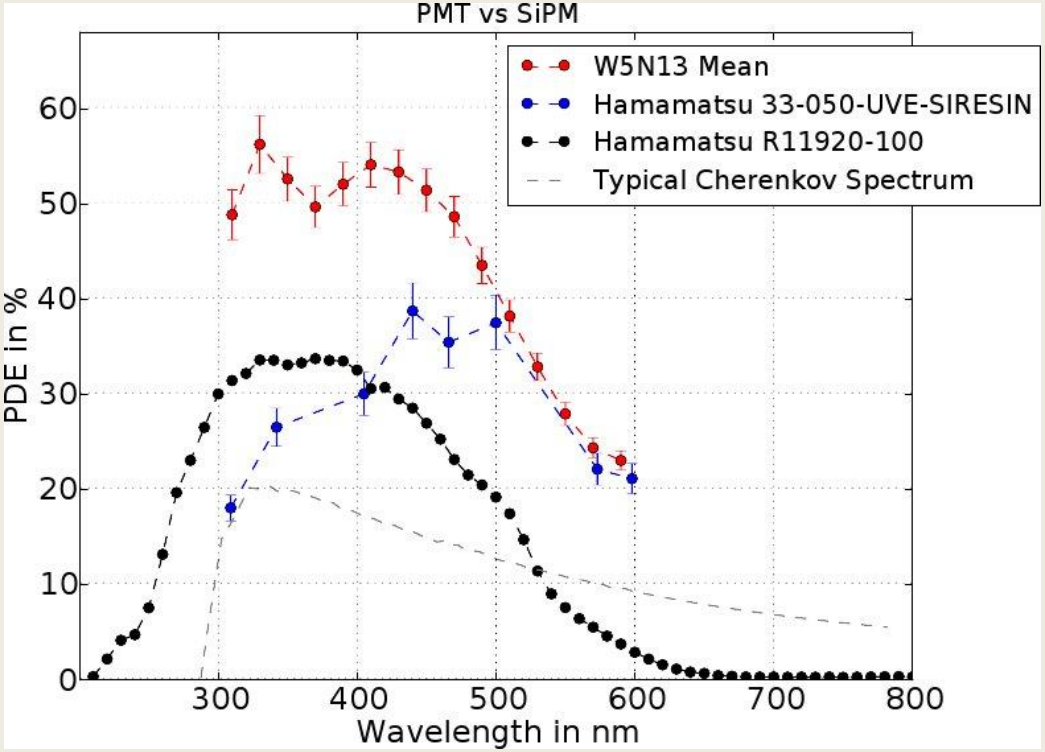
- Mean weighted quantum efficiency = (22.8 +- 1) %
- Light collection gain compared to current Cherenkov telescopes: (17 – 40) %

Cumulative Afterpulsing Probability



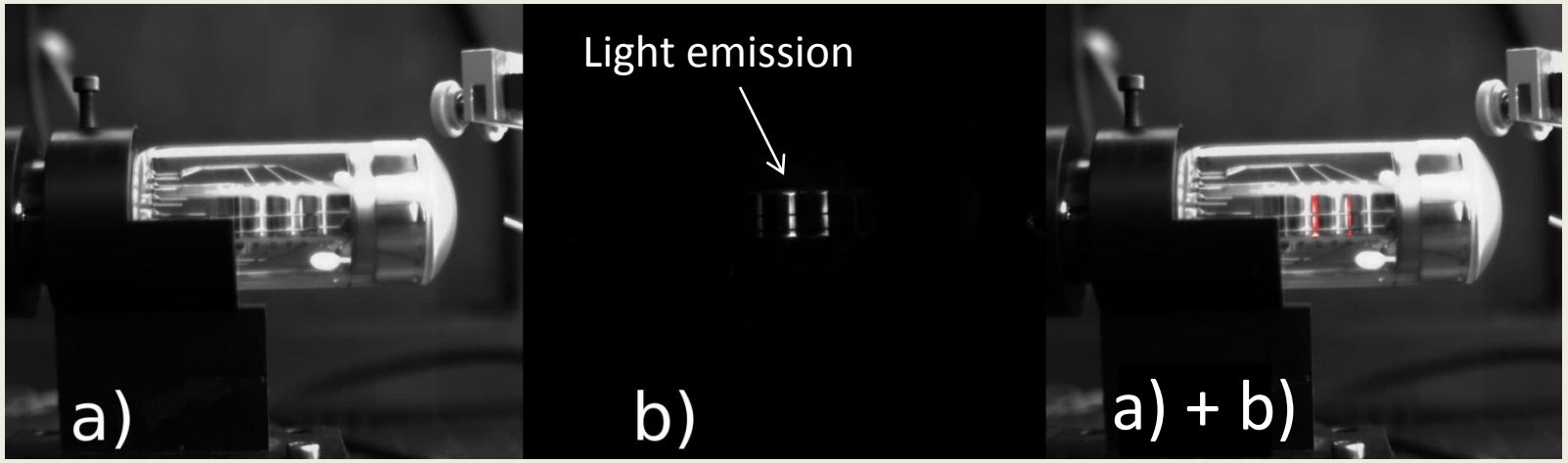
- 20 times less ion afterpulses, compared to current instrumentation:
  P(ap,4 photoelectrons) = 0.02%
- Less accidental trigger -> lower energy threshold, Trigger electronics simpler

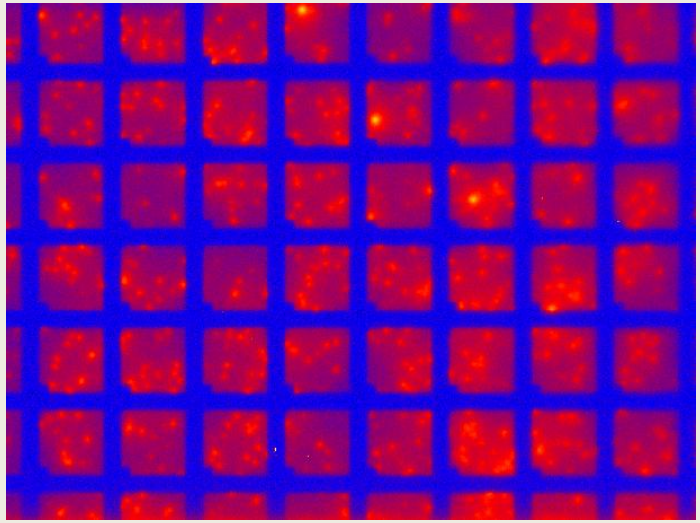
Silicon Photomultiplier Photon Detection Efficiency



- Light collection gain, compared to best photomultiplier available:
  market: +37%, prototypes: +119%
- Detector of the future

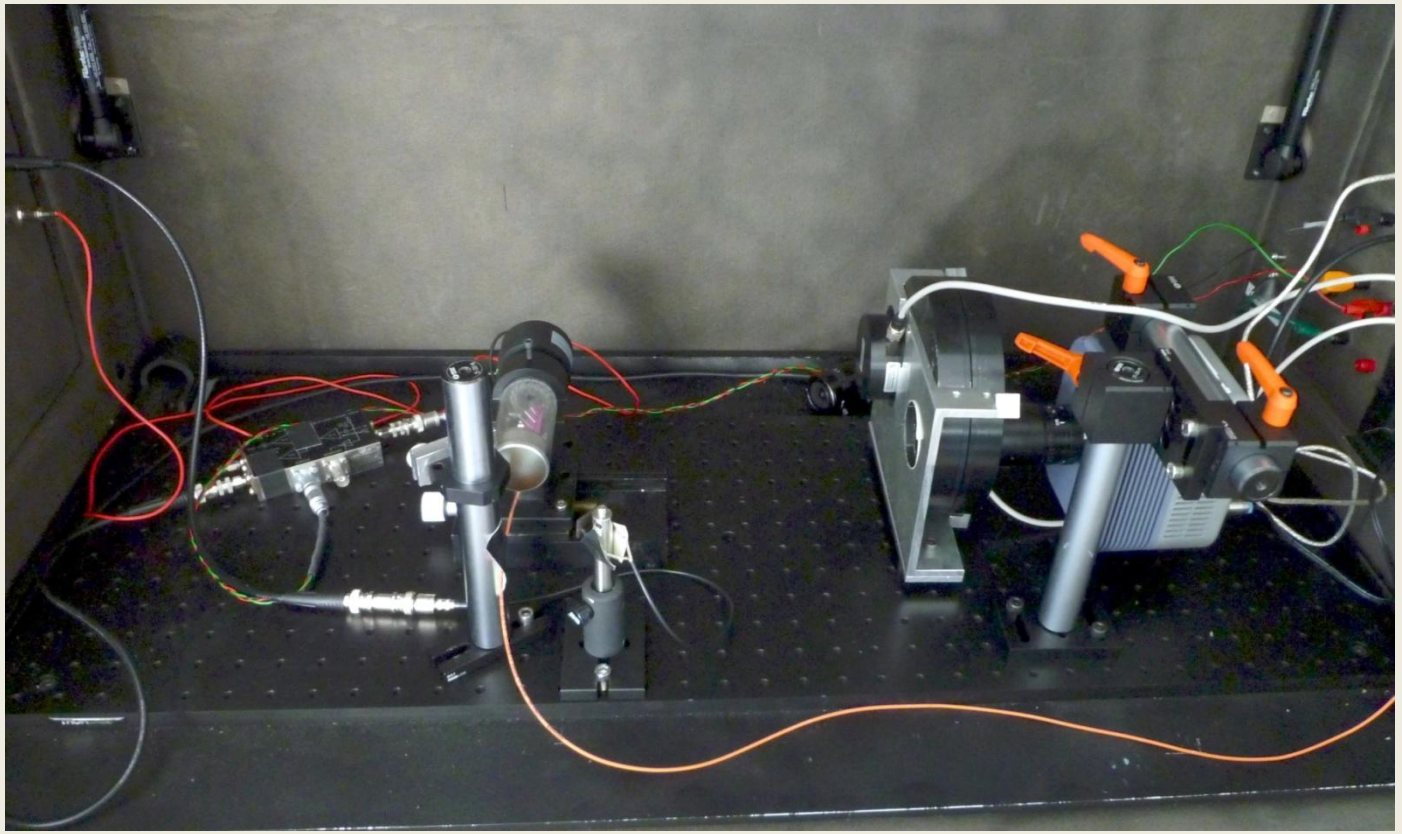
Light Emission Studies





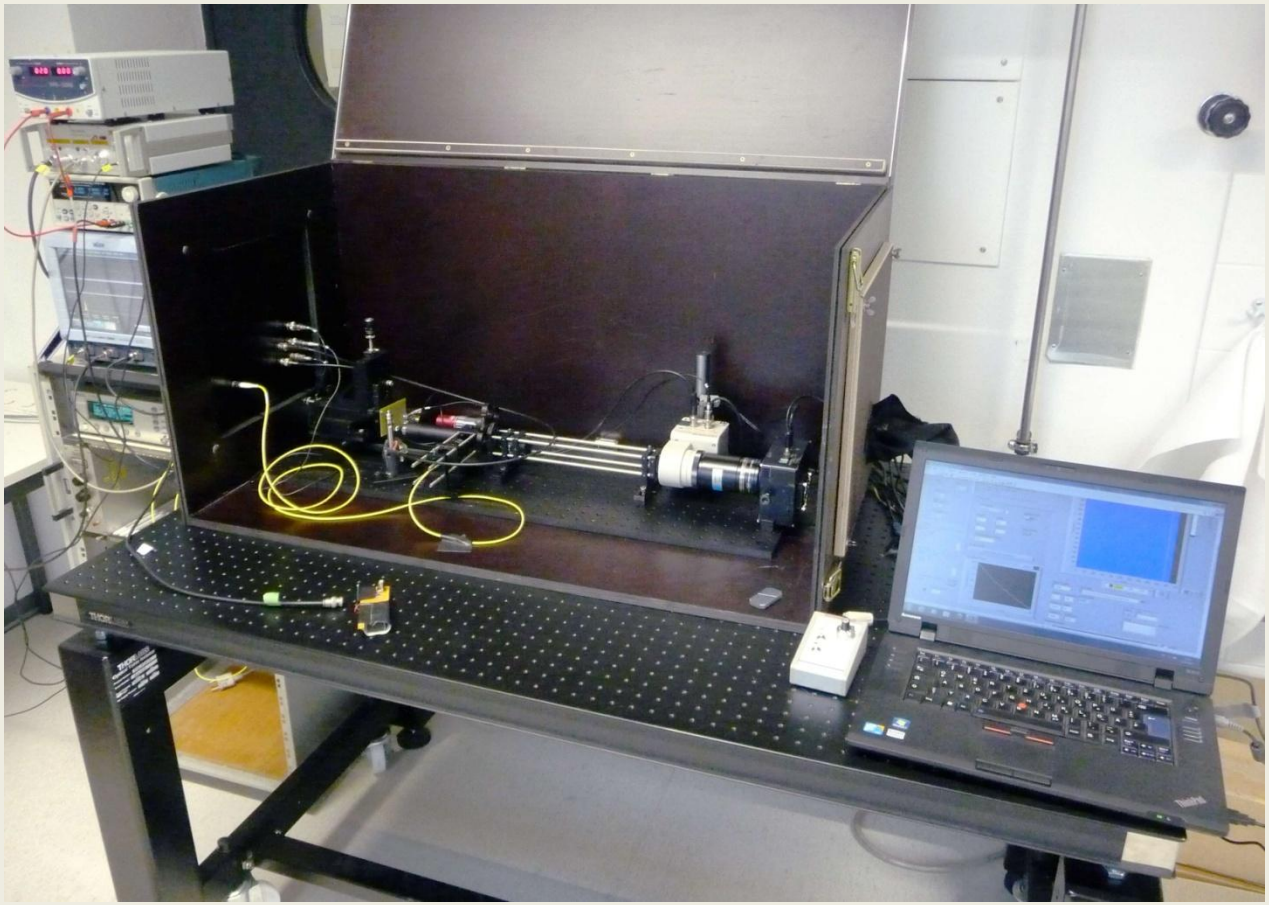
Light detectors emit light!

Light Emission Set-up



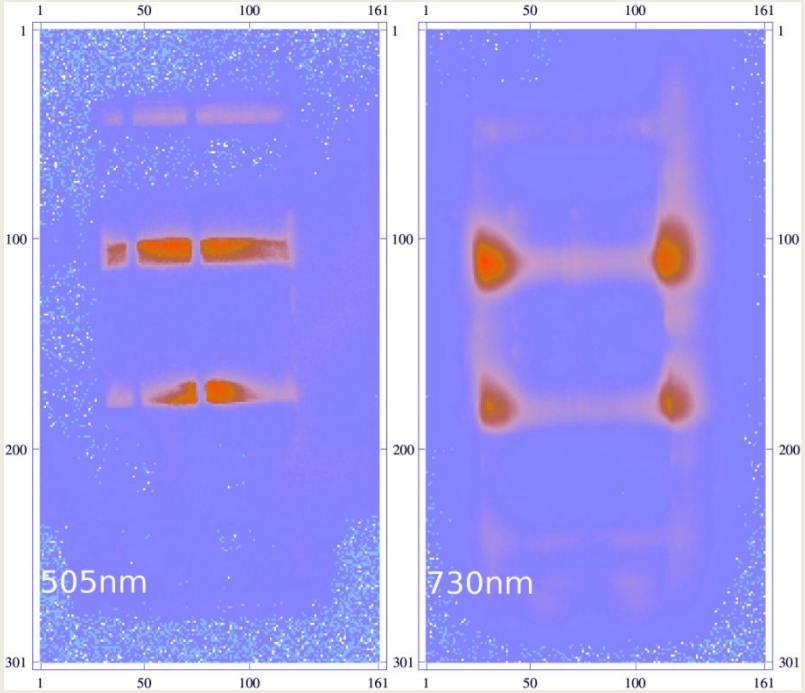
PMT set-up

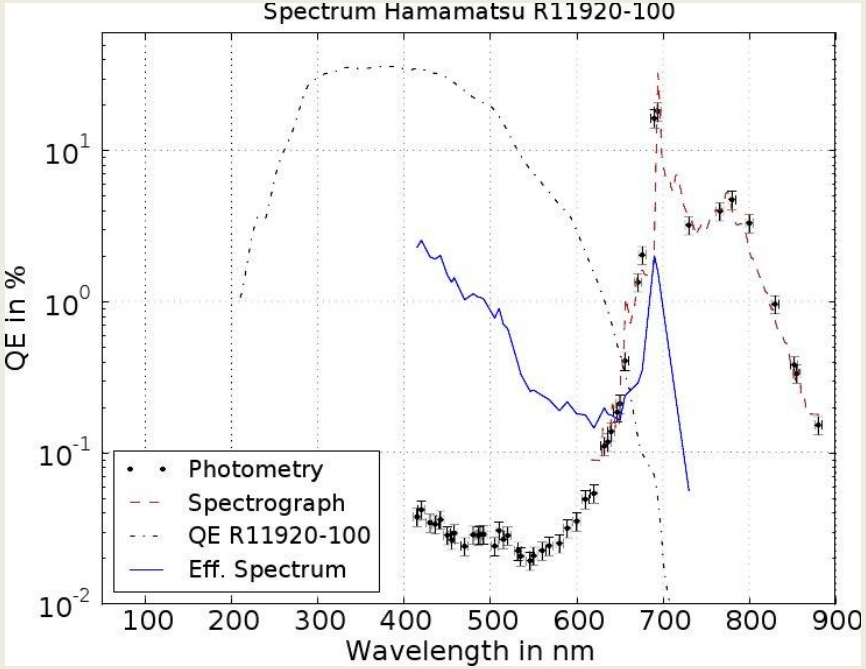
Light Emission Set-up



SiPM set-up

Photomultiplier Light Emission

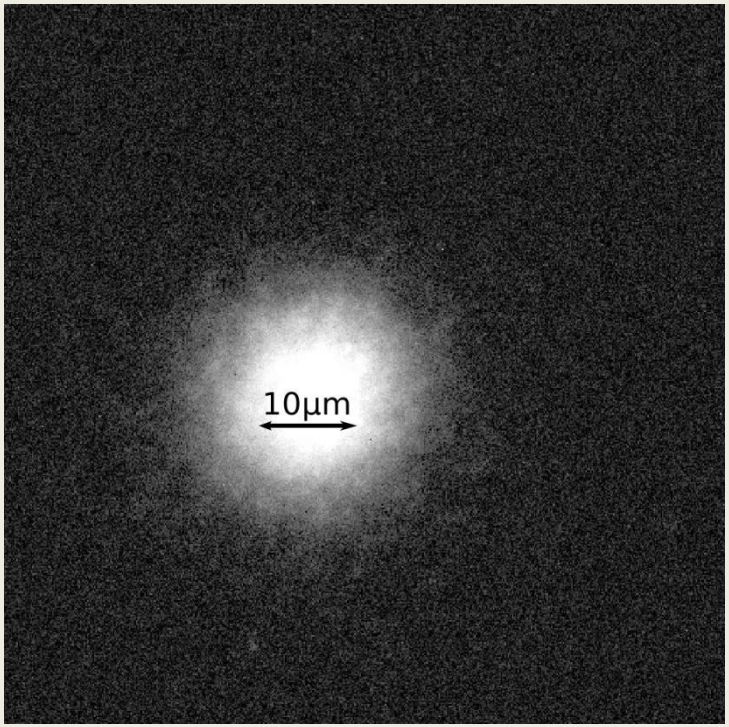


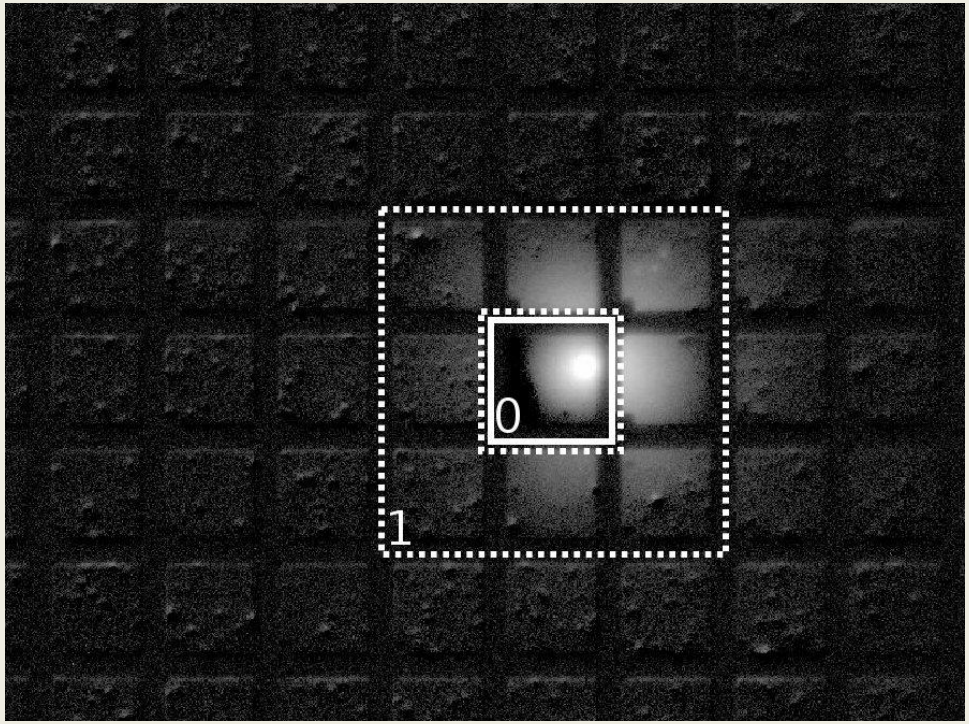


- Light emission from dynodes and support structure cause afterpulses

- Spectrum hints to fluorescence from corundum chromium -> possible quenching by introducing iron into recipe

Silicon Photomultiplier Light Emission





- Avalanches in silicon photomultipliers have a lateral size of ~ 10 micrometer
- Cross-talk morphology precisely measurable

Summary

Development of Detectors

- Photomultiplier Quantum Efficiency up to 35 % (peak)
- Ion afterpulses down by a factor of 20 to P(ap) ~ 0.02%
- Silicon photomultiplier photon detection efficiency up to 50% (peak)

Light Emission Studies

- Photomultiplier: fast afterpulses, possible to alter the recipe for the dynode support -> quench the light emission
- Silicon photomultiplier: analysis tool to measure avalanche size, cross-talk morphology

The development will result in lower energy threshold, and a simpler trigger

The studies led to design suggestions to the maufacturers for better detectors