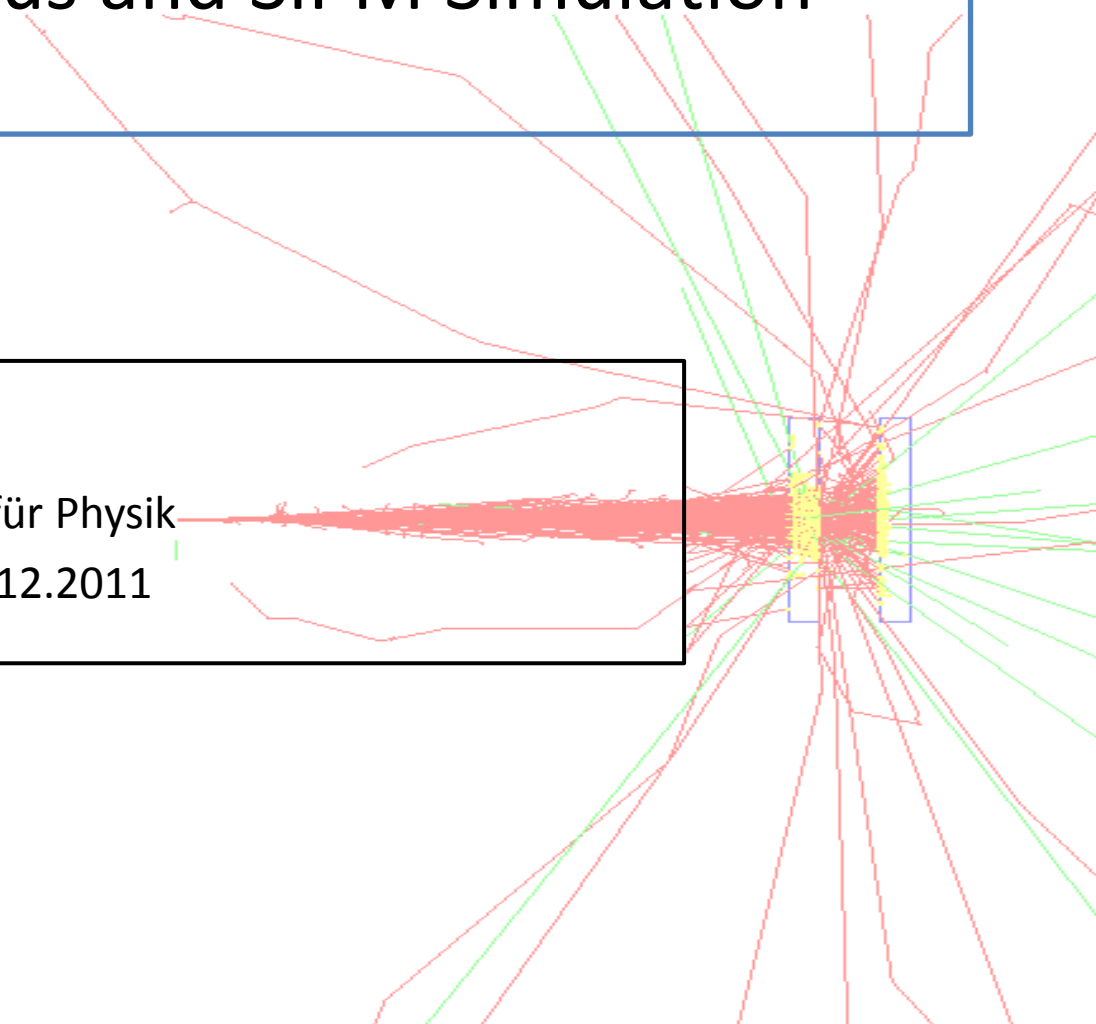


Tile Tester Status and SiPM Simulation

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Kirchhoff-Institut für Physik
HCAL Meeting 13.12.2011



Outline

- Tile Test-System
 - Status
 - Plans
- SiPM Simulation
 - Validation
 - Photon-counting Resolution
 - Outlook
- Summary

Tile Test-System

Tile Test-System

•Motivation:

- Characterization & QA of 8 Mio. scintillator tiles for the final detector

•Challenge:

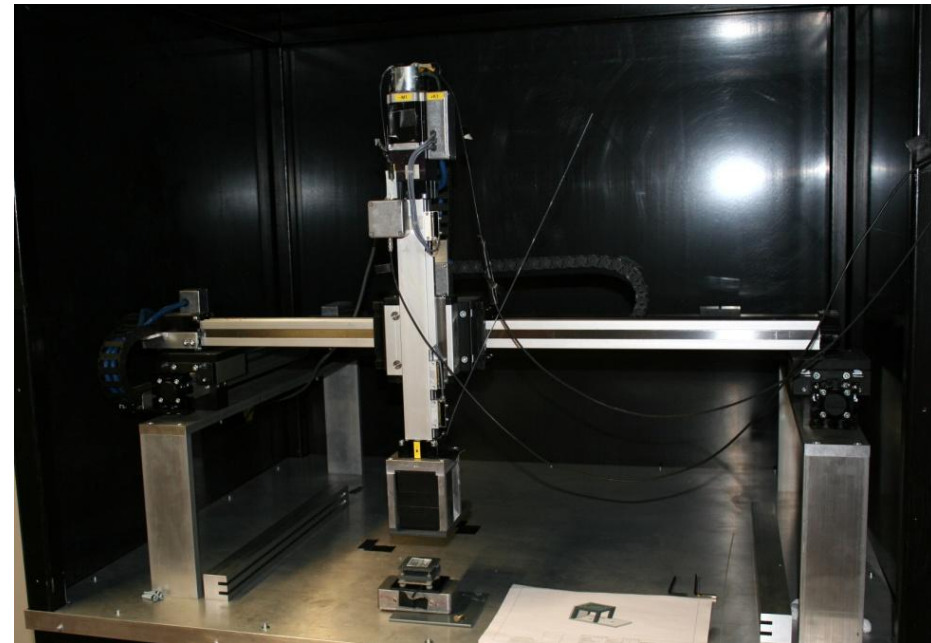
- Measurement time per tile ca. $1s \cdot n$ (n = number of parallel measurements)
⇒ Development of a prototype large-scale tile test system

•Tile Tester:

- Array of ca. 144 tiles
- Positioning stage + measurement head with 12-24 light sources

•Measurements:

- Dark-rate spectrum
- SPS vs. $V_{\text{bias}} \Rightarrow V_{\text{break}}$, gain, corr. noise
- Saturation curve
- MIP Response



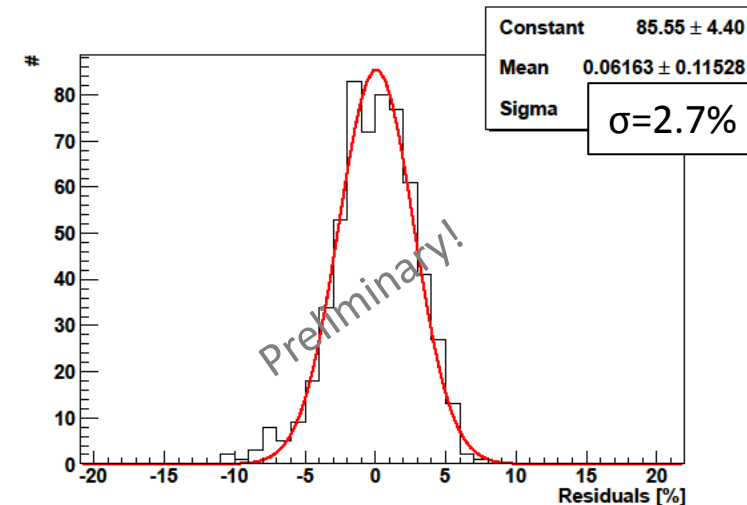
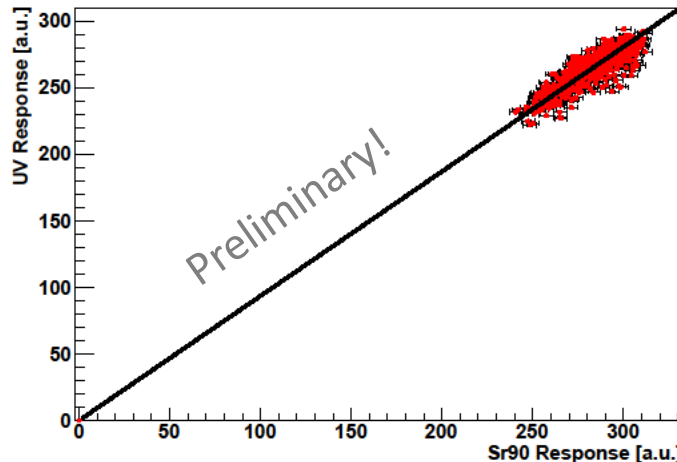
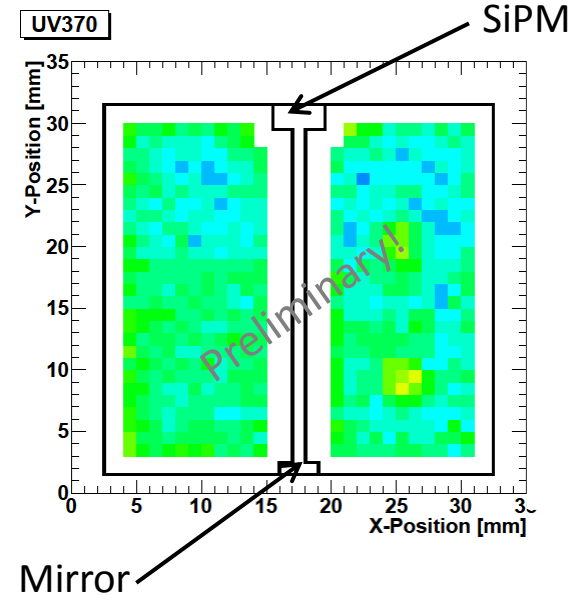
MIP Response: UV-Laser vs. Sr90

- MIP response measurement with Sr90 is too slow for large scale testing

⇒ Can we use a UV-laser?

- First test: tilescan with UV & Sr90
- Clear correlation between UV & Sr90 response
- UV reproduces Sr90 within $\pm 2.7\%$
- Tests with more tiles will follow...

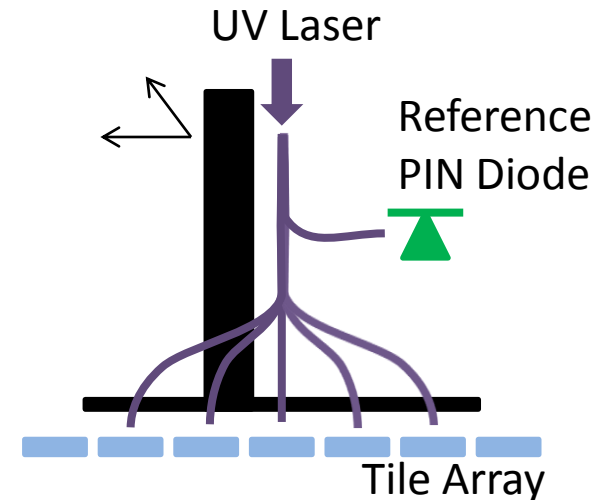
Ratio Sr90/UV response:



Currently working on...

UV-Laser system:

- UV-light is distributed to 12 – 24 tiles via optical fibers
- Reference PIN diode
- Temperature monitoring

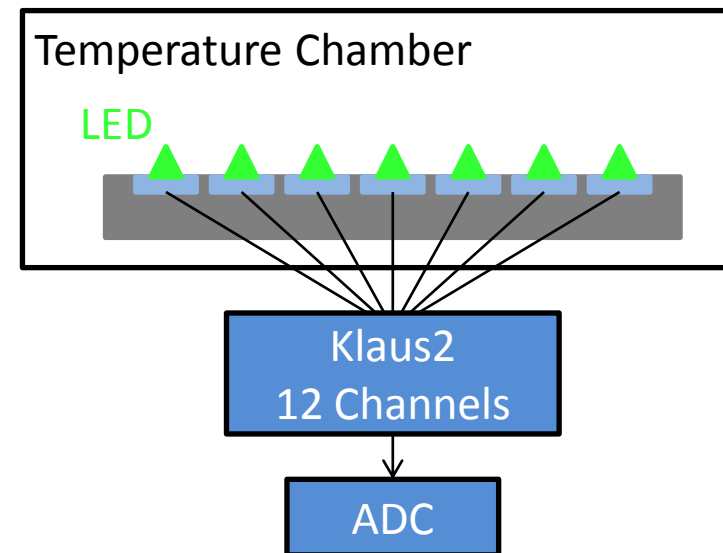


Temperature measurement:

- Temperature dependence of parameters cannot be measured for all 8mio tiles

⇒ Measure distribution of temp. koeffizient for 144 tile

⇒ We plan to have results in February



SiPM Simulation

SiPM Simulation

•SiPM Simulation:

- Better understanding of SiPM response (e.g. saturation, resolution, timing)
- Optimization studies

•Simulation framework:

- Shared libraries for integration into external software (e.g. Geant4)
- or standalone GUI

•Input:

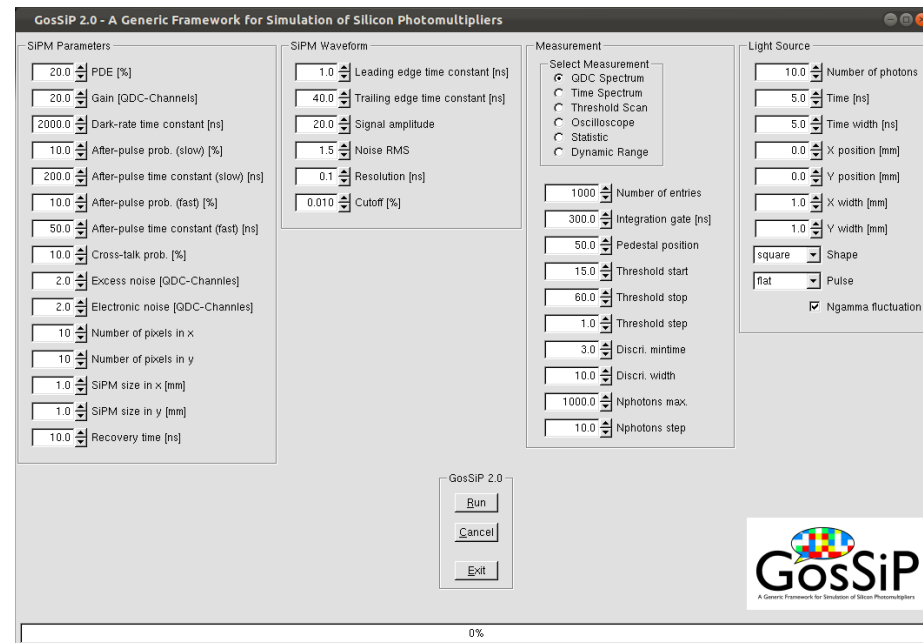
basic SiPM parameters:

PDE, gain, cross-talk probability, ...

& light source properties

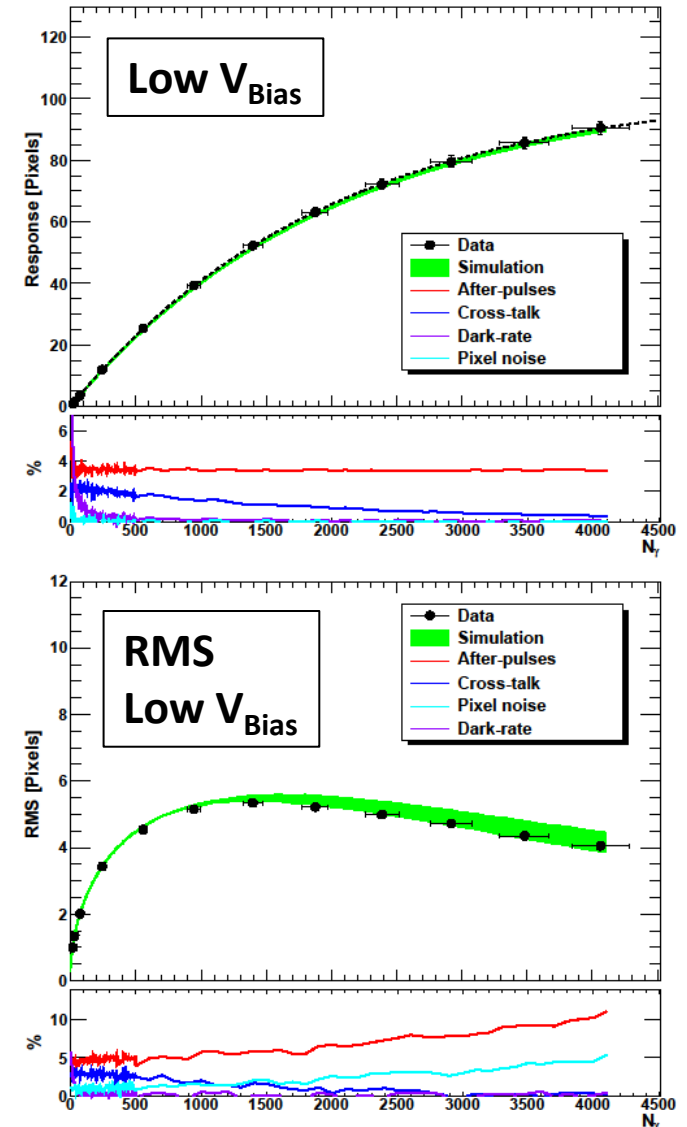
•Output:

Signal waveform and charge



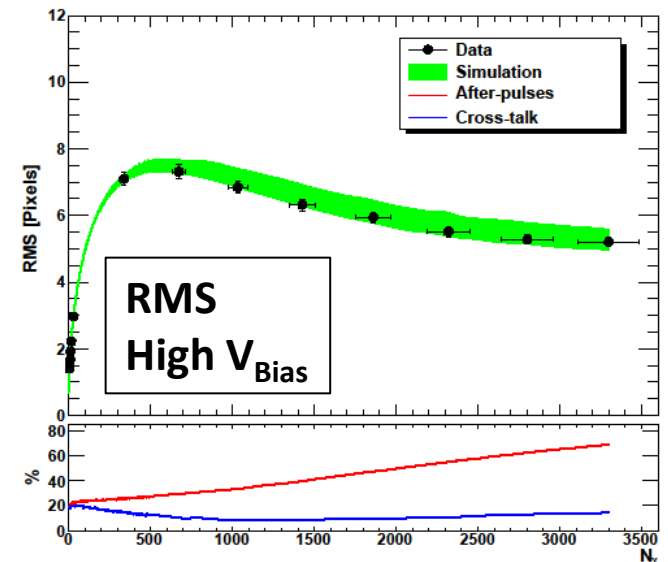
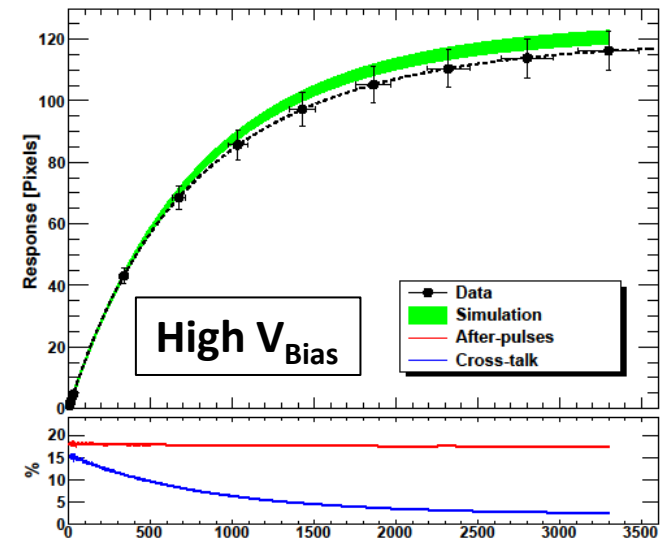
Simulation Validation – Low V_{Bias}

- Saturation curve influenced by all SiPM parameters
- Input parameters determined from independent measurements
- Simulation tested for 100 pixel MPPC for low & high operating voltage (noise):
 - Simulation reproduces data with <5% accuracy!
 - Similar results expected for other sensors
 - Noise dominated by after-pulses
 - Cross-talk negligible for high intensities



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Photon-counting Resolution

- Photon-counting resolution is determined by saturation curve & RMS

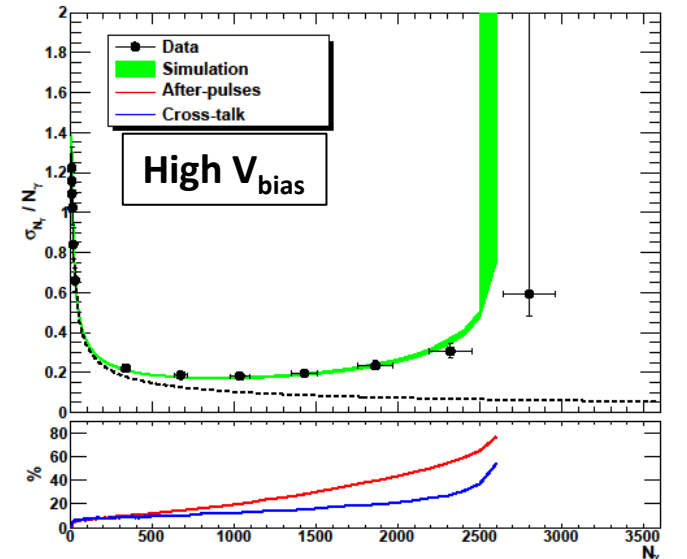
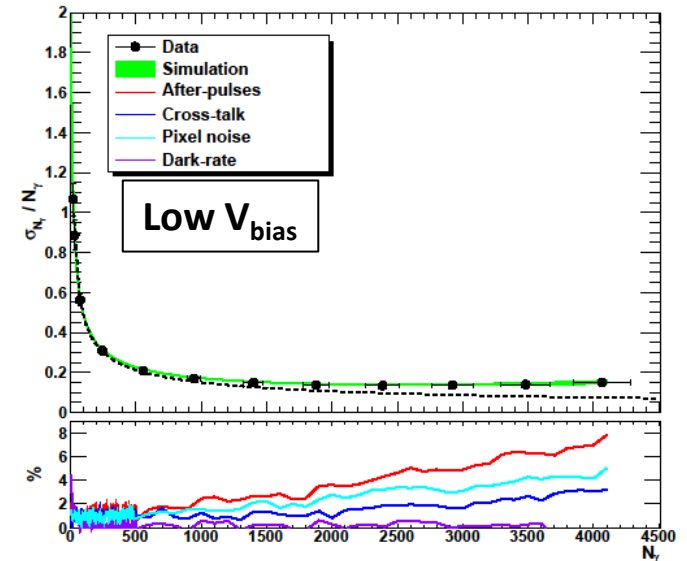
- Linear range:

$$\frac{\Delta N_\gamma}{N_\gamma} \approx \frac{\overset{\text{DR}}{a}}{N_\gamma} \oplus \frac{b}{\sqrt{N_\gamma}} \quad \text{PDE, CT, AP}$$

- In a wide range dominated by PDE

- For high intensities CT & AP significantly contribute by reducing the dynamic range

- Good resolution up to 80 firing pixels (out of 100)



Plans

- Characterisation of CPTA SiPMs

⇒ Provide simulation model

depending only on operating voltage and temperature

- Simulation will soon be available under:

www.kip.uni-heidelberg.de/ilc/GosSiP

Summary

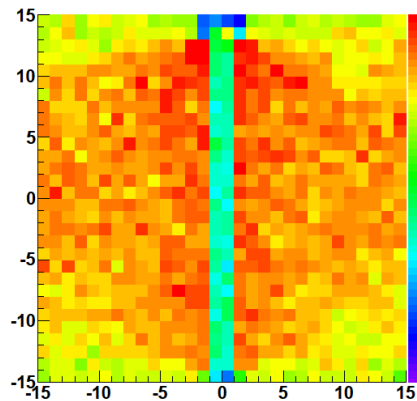
- Construction of large-scale tile tester ongoing
- Temperature measurements for 144 tiles in the near future
- Detailed SiPM simulation available
 - Excellent description of SiPM response in the full dynamic range
 - Used for first studies of saturation & photon-counting resolution
 - Implementation of CPTA SiPMs in the near future

Tile Simulation - Outlook

SiPM simulation works fine → next Step: simulation of tile-SiPM System

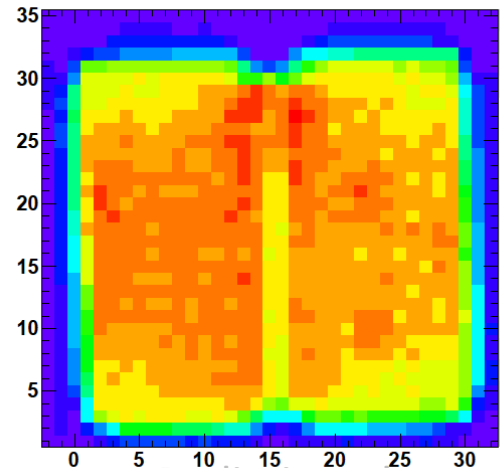
- Tile Simulation with Geant4, combined with SiPM Simulation:
 - Link photon hit position & time from Geant4 to SiPM simulation
- First test (MIP response scan) looks promising

Muon Response Simulation

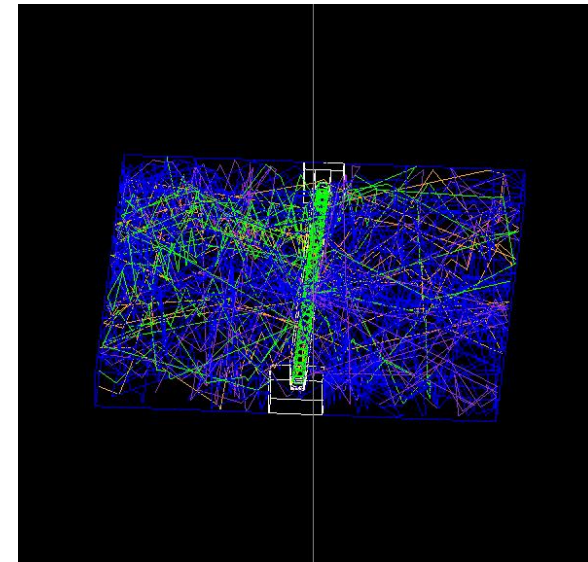


Preliminary!

Sr90 Response Measurement

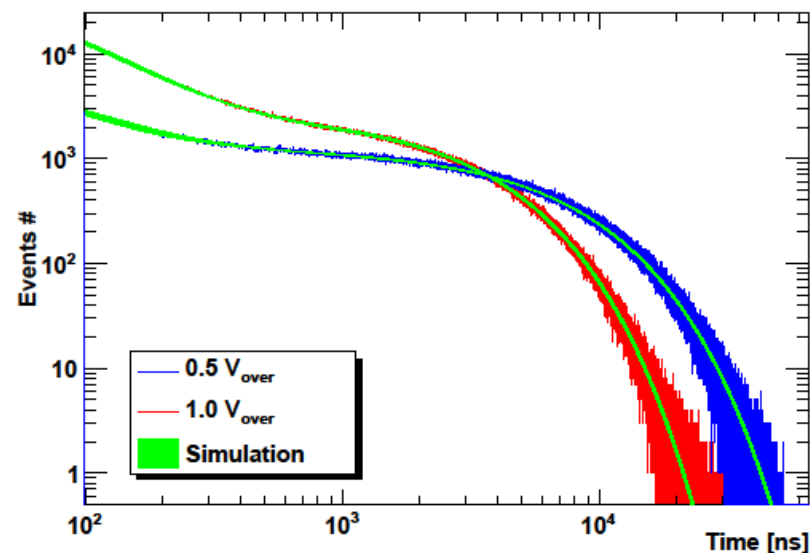
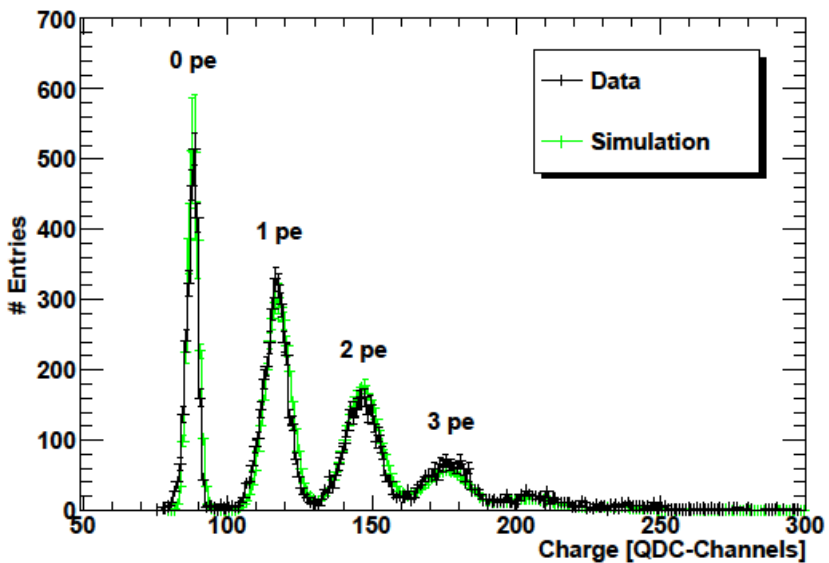
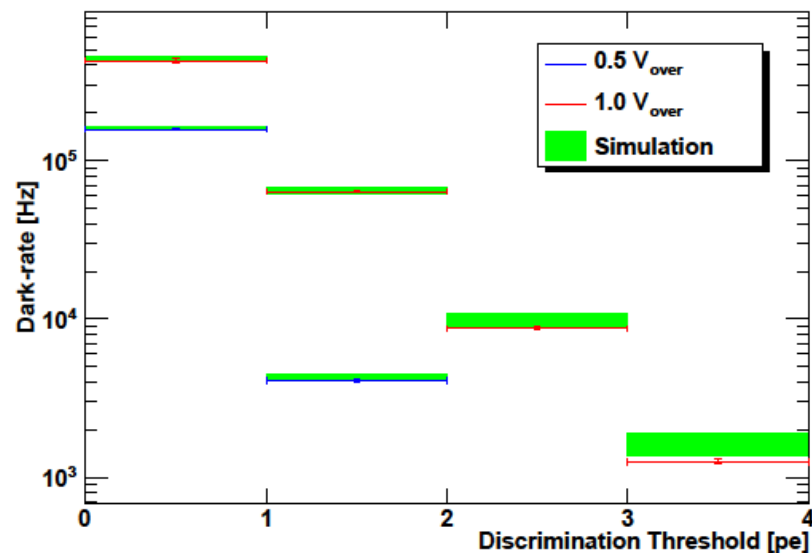
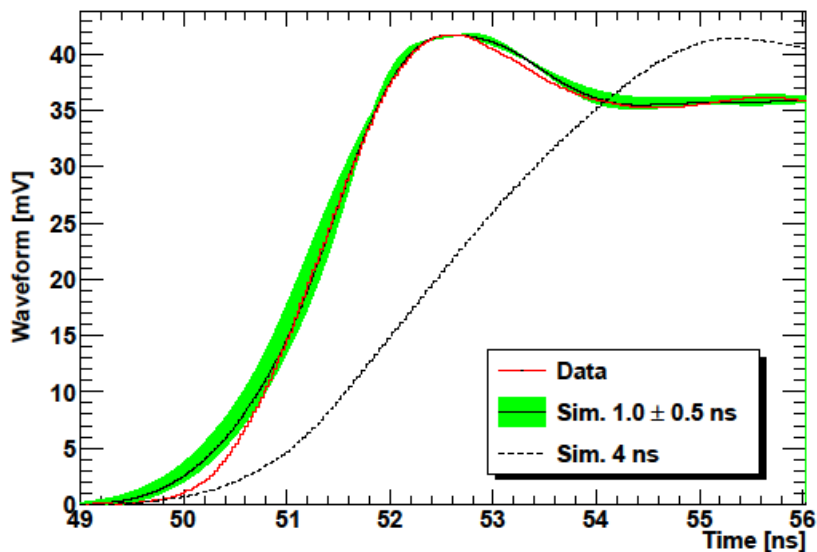


Preliminary!



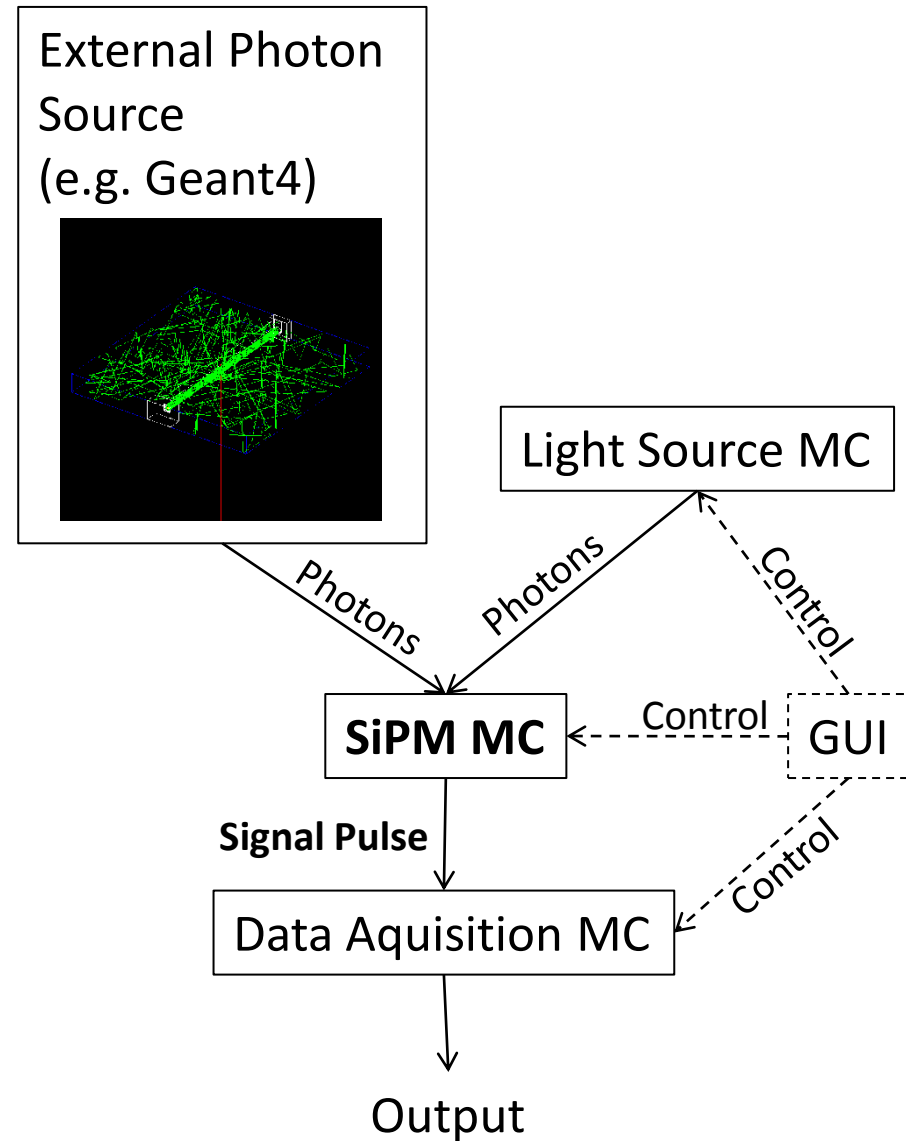
Backup

Backup



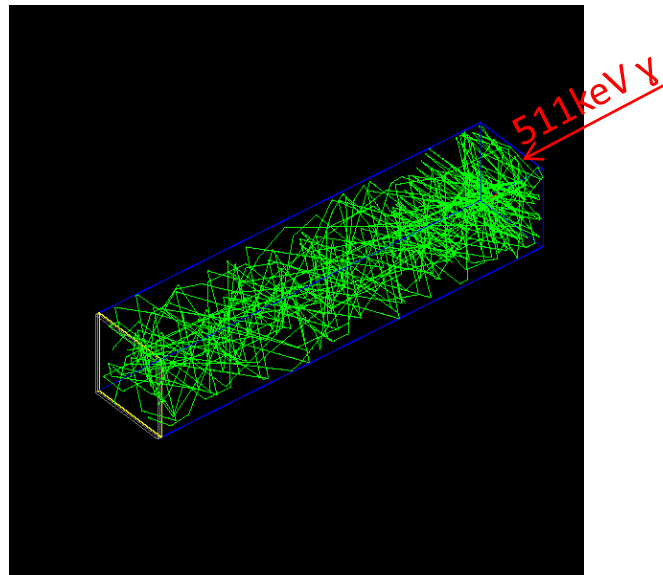
Simulation Principle

- Time & spatial distribution of incident photons from light source class or from external simulation
- **SiPM simulation generates output signal waveform**
- Simple DAQ MC to simulate typical characterization measurements
- Graphical User Interface implemented



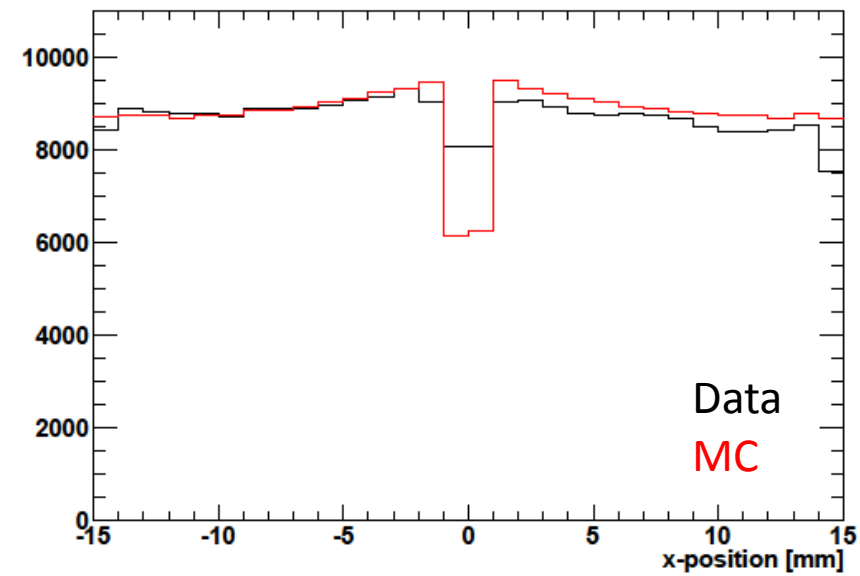
Spin-off Studies

- Other studies with Geant4 + SiPM simulation:
 - Study of timing and light propagation in scintillation crystals for PET
 - Study & development of SiPM - microlense system improving PDE



Backup

X Projection



Y Projection

