The SplitCal, a hybrid tracking calorimeter

EURIZON School for detector physics 2023

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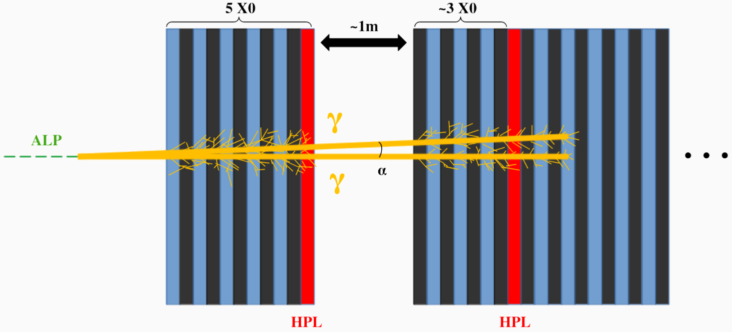
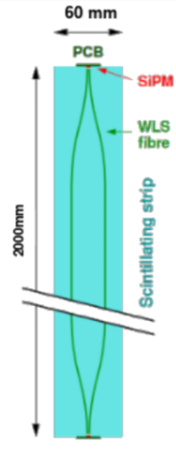
The SplitCal



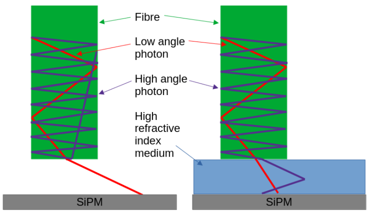
(a) SplitCal view with an ALP shower. $\gamma\gamma$ decays must be reconstructed and disentangled and MIPS must be identified $\rightarrow$ **Dynamic range**. Calorimeter is $6 \times 4\,\mathrm{m}^2$.



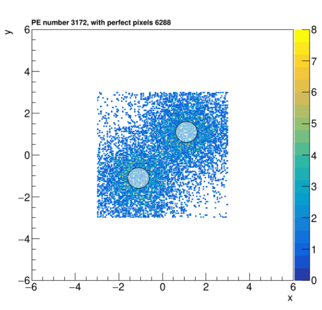
(b) Energy reconstruction layer base unit.

Contact surface optimization

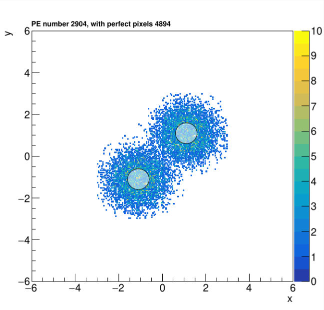
Putting no material between Fibre and SiPM means losing light to total reflection →



But putting material means saturating more pixels ←

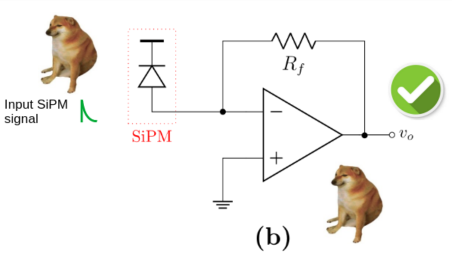


(a) 10k simulated γ at 2 cm on SiPM, n=1.0

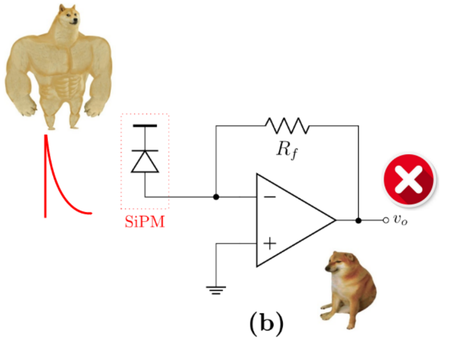


(b) 10k simulated γ at 2 cm on SiPM, n=1.5

The Quest for the right ASIC

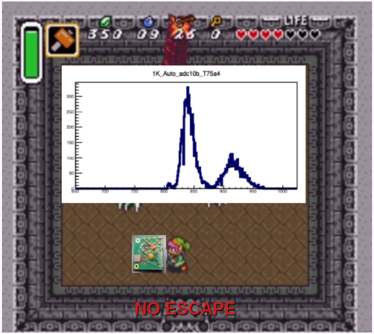


(a) Typical SiPM ASICs dealing with small (up to 3×3 mm^2)

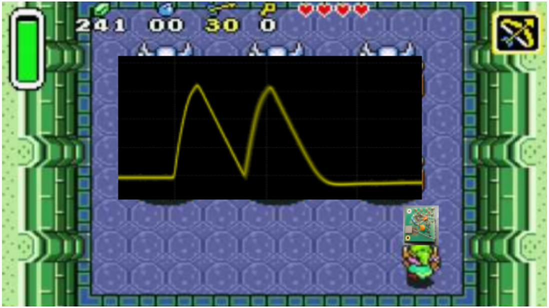


(b) Typical SiPM ASICs dealing with large (6×6 mm^2)

The Quest for the right ASIC



(a) PhD Student facing off against capacitive saturation [2022 recolored]. Any similarity to real or fictional characters is purely coincidental.

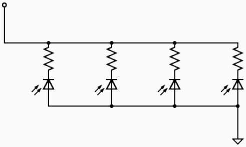


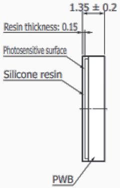
(b) PhD Student facing off against amplifier saturation [2022 recolored]. Any similarity to real or fictional characters is purely coincidental.

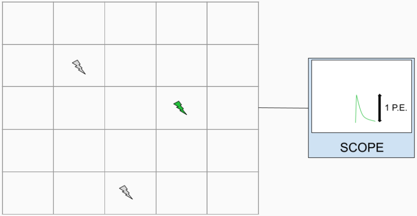
The Quest for the right ASIC

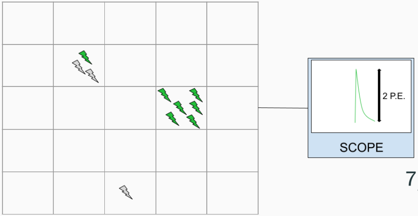
Backup: Contact surface optimization

- Best usage of SiPM pixels for dynamic range purposes is realized by spreading out photons onto SiPM surface
- Easiest way to realize this is by increasing the size of the air gap between Fibres and SiPM
  - Issue: loss of light from escaping higher angle photons
  - Answer: add reflective walls to redirect photons onto SiPM surface









Backup: Scintillator shaping

- Possibility of setup devoid of fibres has been investigated: much cheaper
- Scintillator strips have a potential downside however: corner effects
- This resuslts in loss of light, Liouville theorem prevents from *concentrating* light
- Solution: bounce photons from corner areas to the SiPM on the other side of the strip
- Testing with fibres remains to be done as that system might also benefit from this geometry.

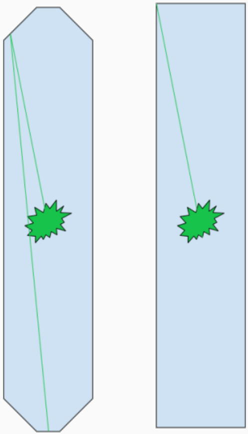
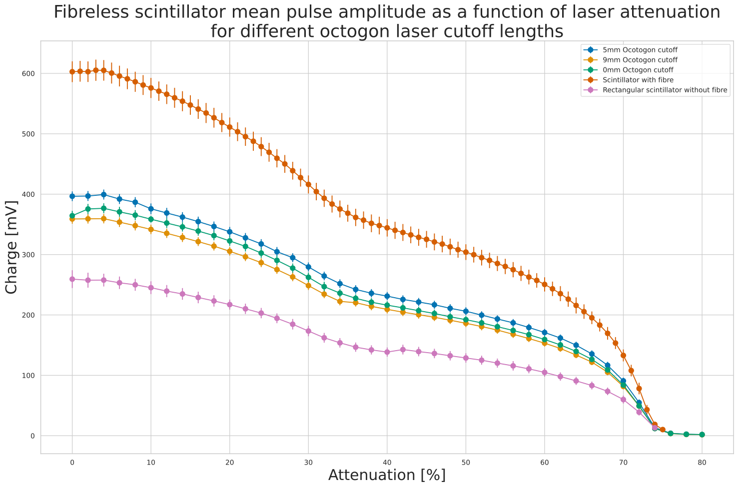


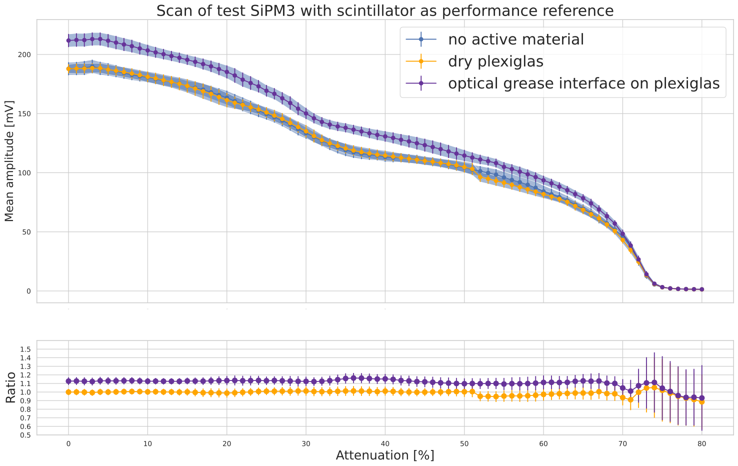
Figure 5: Working principle of Scintillator geometry optimization.

Backup: Scintillator shaping



→ Fibres outperform naked scintillator but notable improvement is observed, tests with active diffusion to be performed.

Contact surface optimization through measurements



Better performance of 3 mm plexiglas with optical grease indicates that, outside of external light losses, the advantage of active diffraction should widen for higher gaps.

Backup: Contact surface optimization

- Angular distribution of fibre photon output is known from litterature
- Remaining limitation: optical total reflection within the fibre, reduced with higher external optical index: can be estimated from simulating the fibre itself → ongoing
- Measurements can be used to estimate the gains in the meantime using plexiglas and optical grease
- Measurements are challenging to produce replicably.

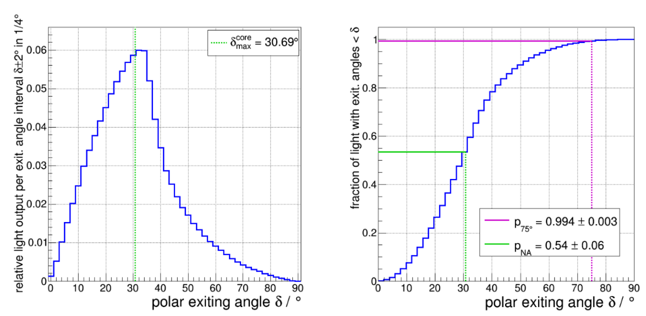


Figure 6: Double cladded WLS fibre angular output probability function (left) and cumulative distribution function (right). Nieswand, 2014

SplitCal directionality reconstruction

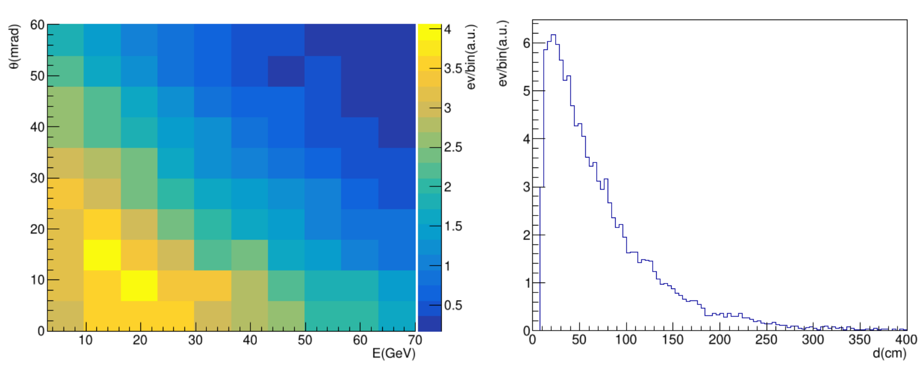


Figure 7: Left: angle of incidence θ [mrad] vs energy E [GeV] of photons; right: distance between the two photons at the SplitCal surface for 600 MeV ALP mass decaying to two photons in the ToyMC.