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Centro de Investigaciones
Energéticas, Medioambientales
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Light Simulation Studies

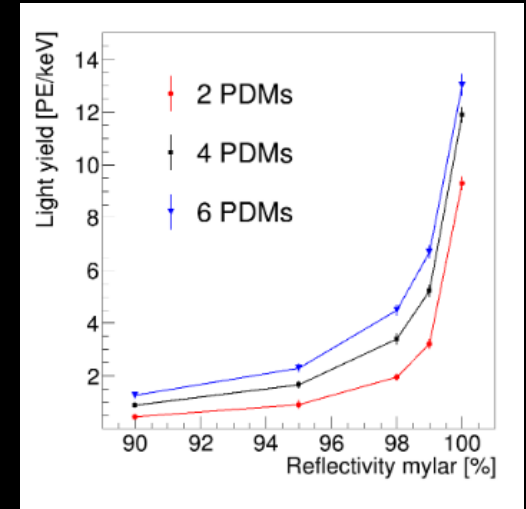
Antonio Giménez Alcázar
(CIEMAT)

DArT Collaboration Meeting
20-04-2022

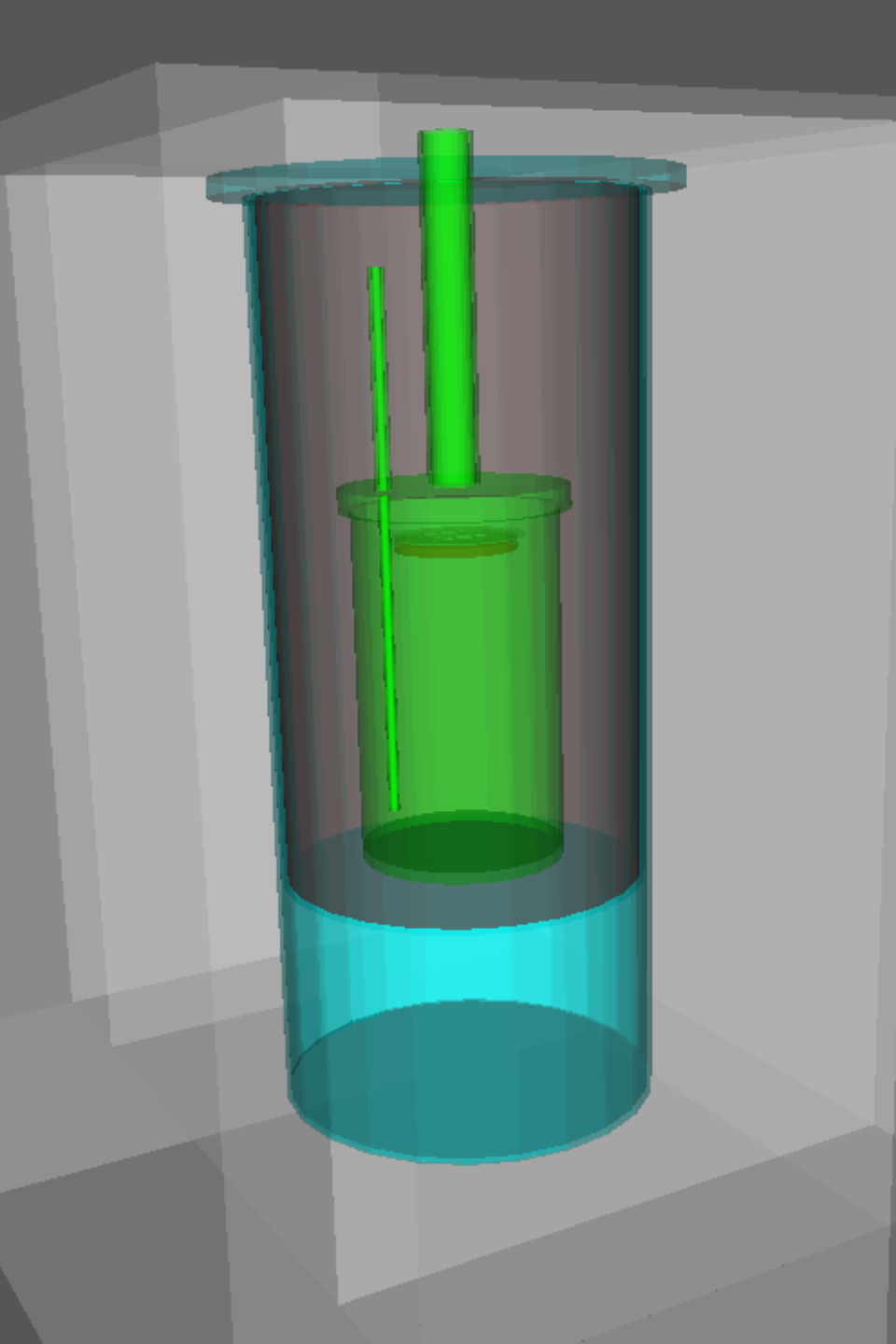
Context

- The energy deposits in the LAr of DArT produce vacuum ultraviolet photons (VUV) that are converted to visible photons by TPB and detected by SiPMs.
- Detected photons are converted to PE with an efficiency of 40%.
- The propagation of photons is simulated with G4DS (Geant4). It considers the optical properties of the detector materials and interfaces.

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- The propagation of photons is simulated with G4DS (Geant4). It considers the optical properties of the detector materials and interfaces.
- The goal of this study is to understand the effect of optical parameters on detector efficiency. In concrete, reflectivity (R) has a huge impact on it.

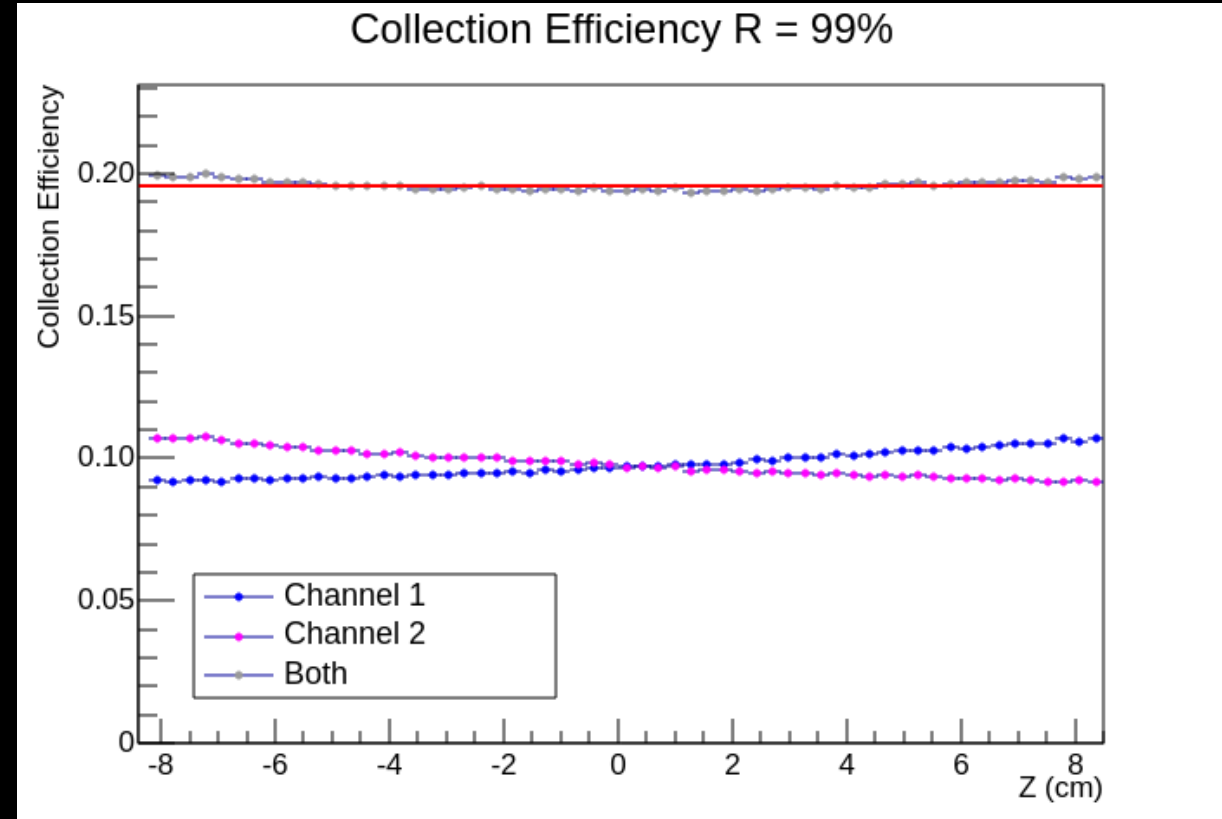


Simulations

- 10000 α particles
- Energy of 100 KeV
- Randomly simulated over the entire volume of LAr
- Different reflectivities for the Acrylic/Reflector interface:
 - 99 %
 - 97 %
 - 95 %
 - 93 %

Reviewing previous simulations

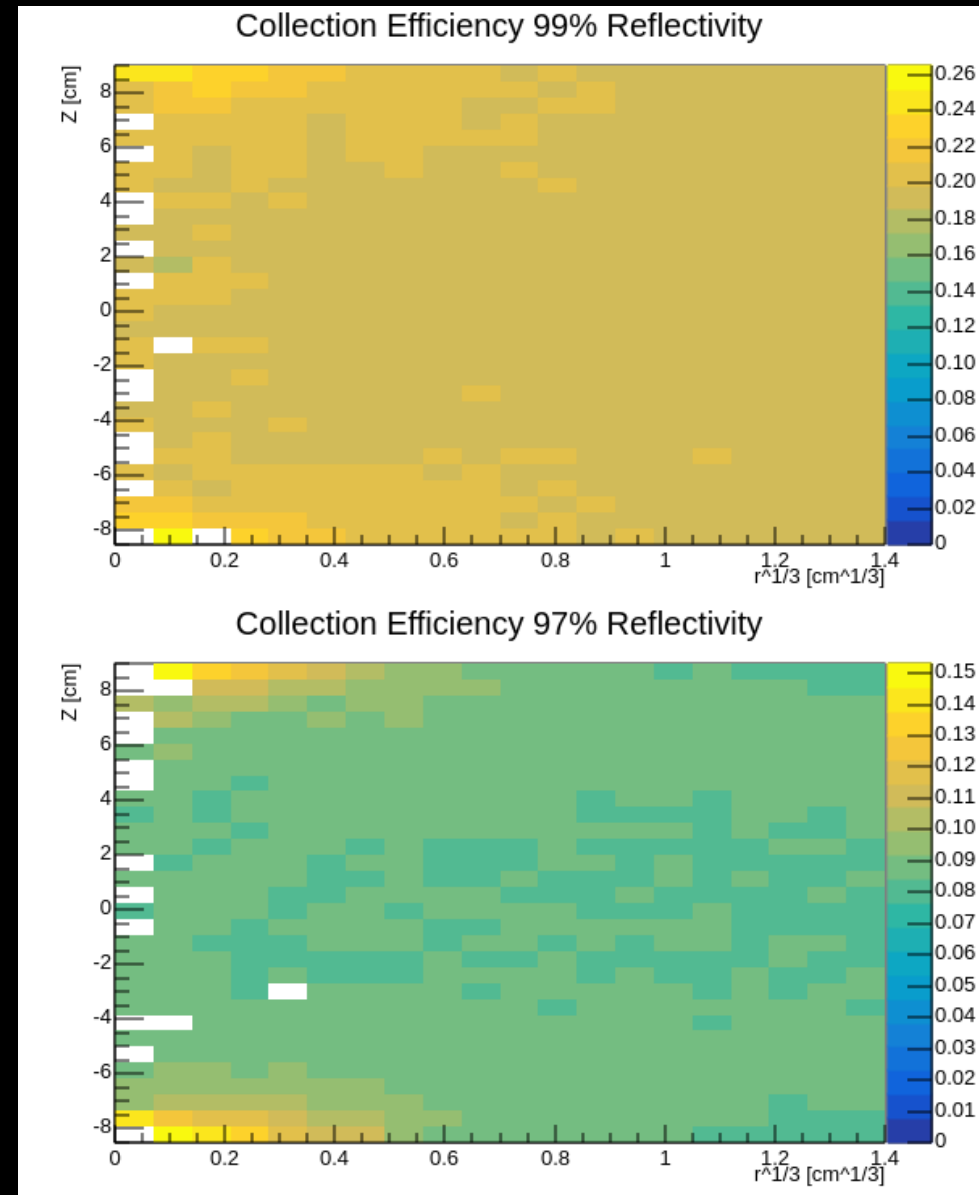
- Standard DArT geometry with 2 SiPMs.
- Low Collection Efficiency, ~20% of photons are detected by SiPMs.
- What happens if we add 2 SiPMs more?



$$C.\text{eff} = 0.1956 \pm 0.0001$$

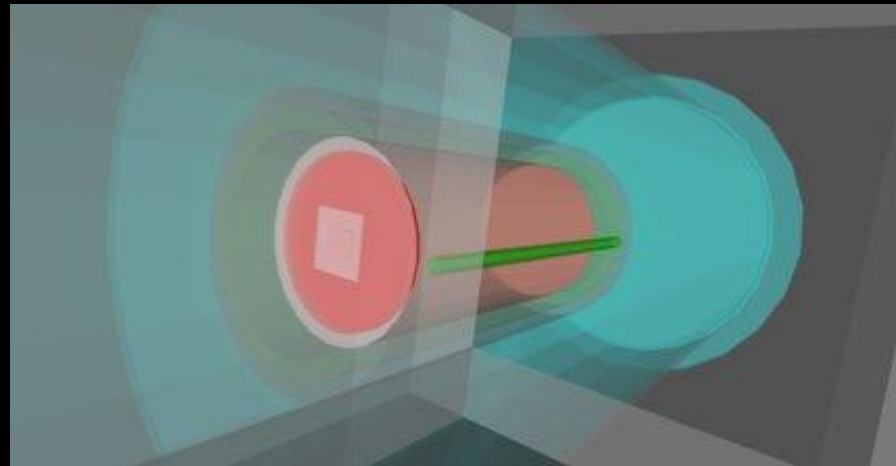
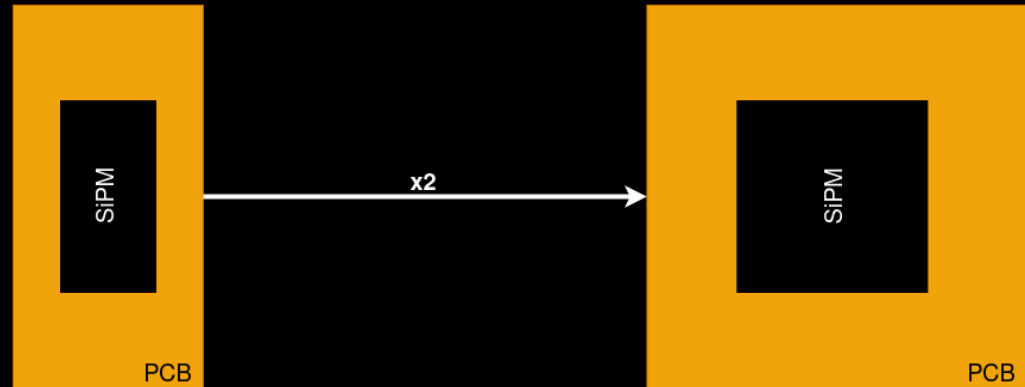
Reviewing previous simulations

- Standard DArT geometry with 2 SiPMs.
- Low Collection Efficiency, ~20% of photons are detected by SiPMs.
- What happens if we add 2 SiPMs more?
- Light collection in the detector is not uniform.
- Higher Efficiency close to SiPMs.



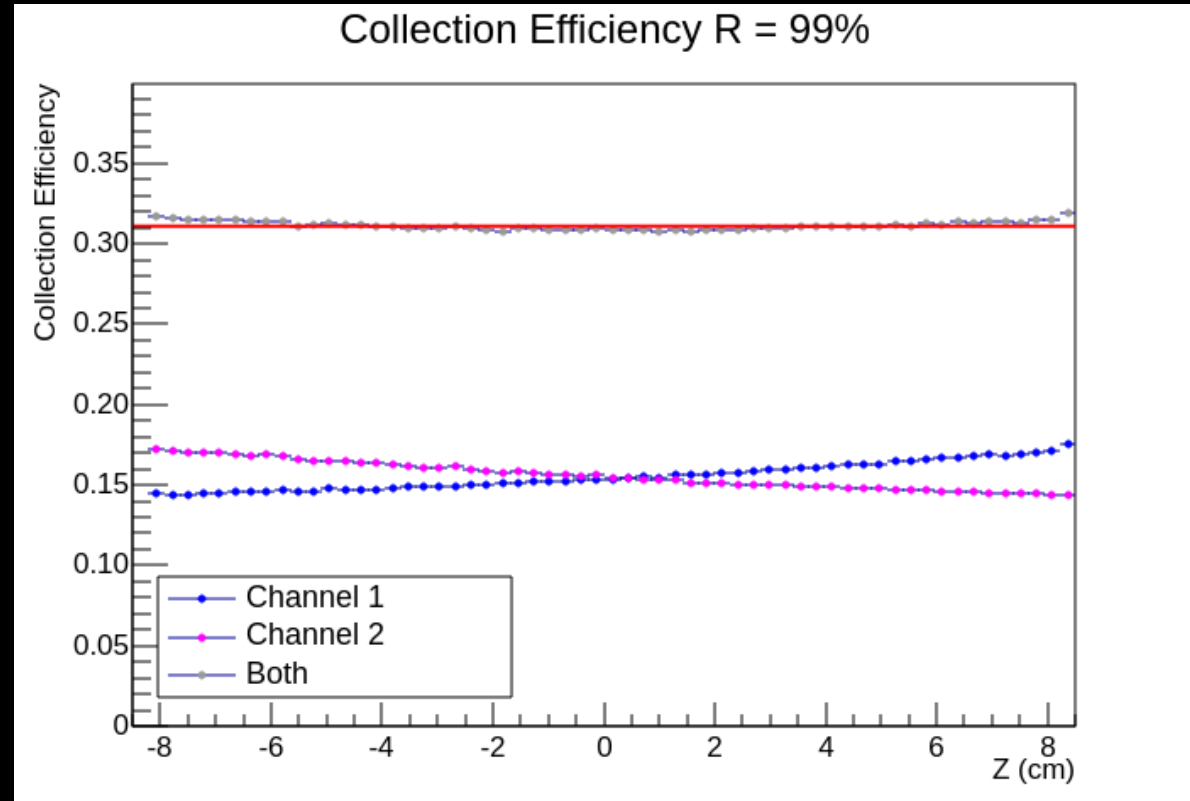
4 SiPMs

- In first approach, the collection area of SiPMs is doubled.
- Instead of adding one SiPM at the bottom and one on top of DArT, I have opted to duplicate the collection area making SiPMs bigger.
- Simulations with 4 SiPMs will be developed later.



Latest results

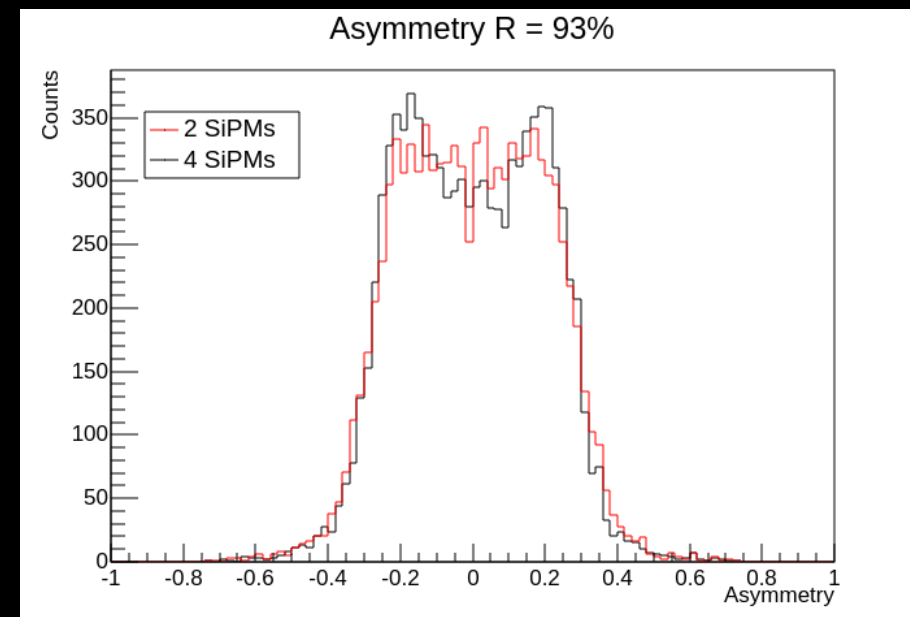
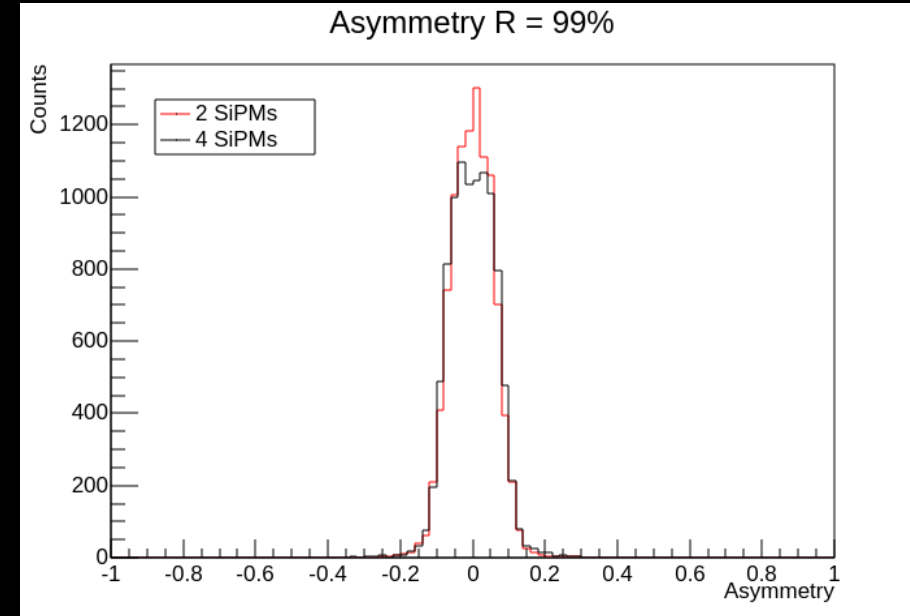
- Efficiency increases from **20% to 31%** for **R = 99%** (factor 1.6) and from **4% to 7%** for **R = 93%** (factor 1.8).



$$C.\text{eff} = 0.3107 \pm 0.0009$$

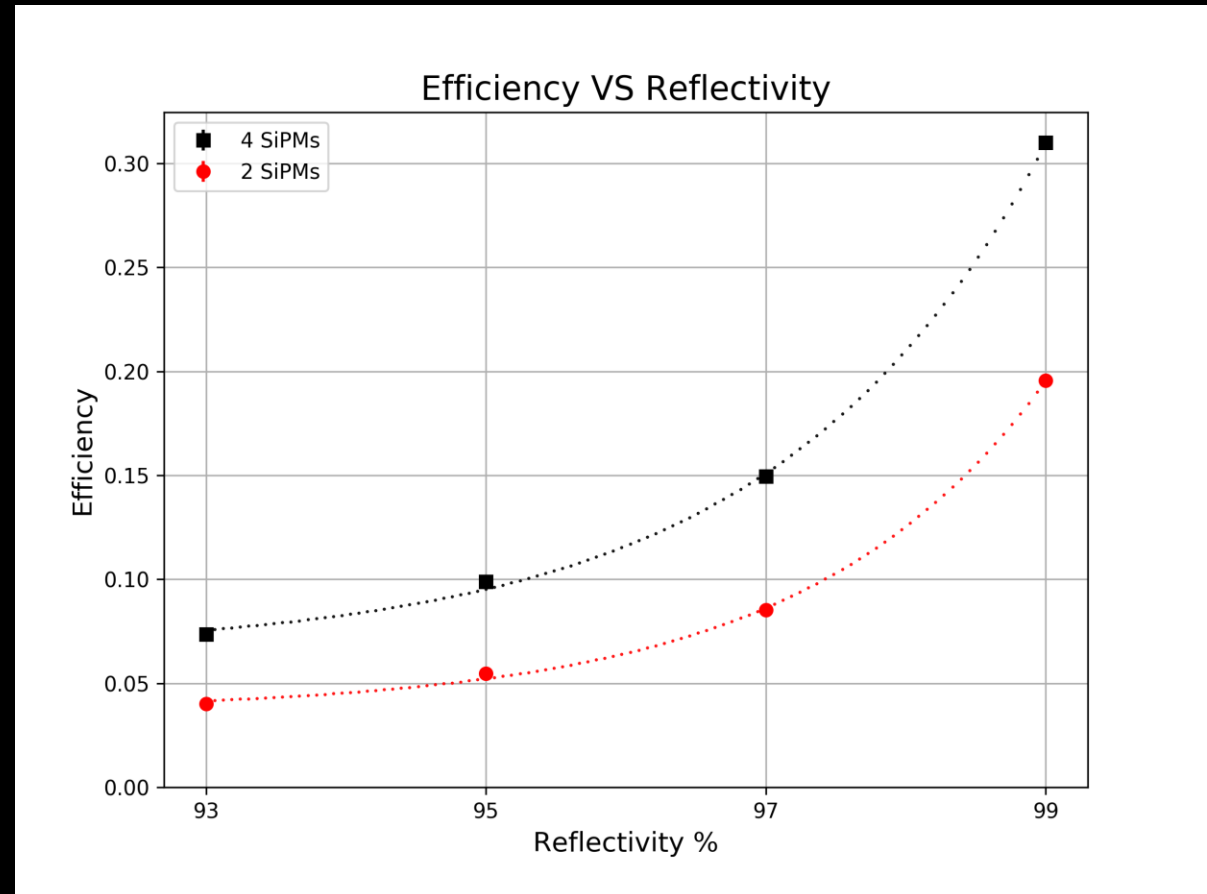
Latest results

- Efficiency increases from **20% to 31%** for **R = 99%** (factor 1.6) and from **4% to 7%** for **R = 93%** (factor 1.8).
- No asymmetry at 99% reflectivity.
- At lower reflectivity, the asymmetry distribution is different with 2 and 4 SiPMs.



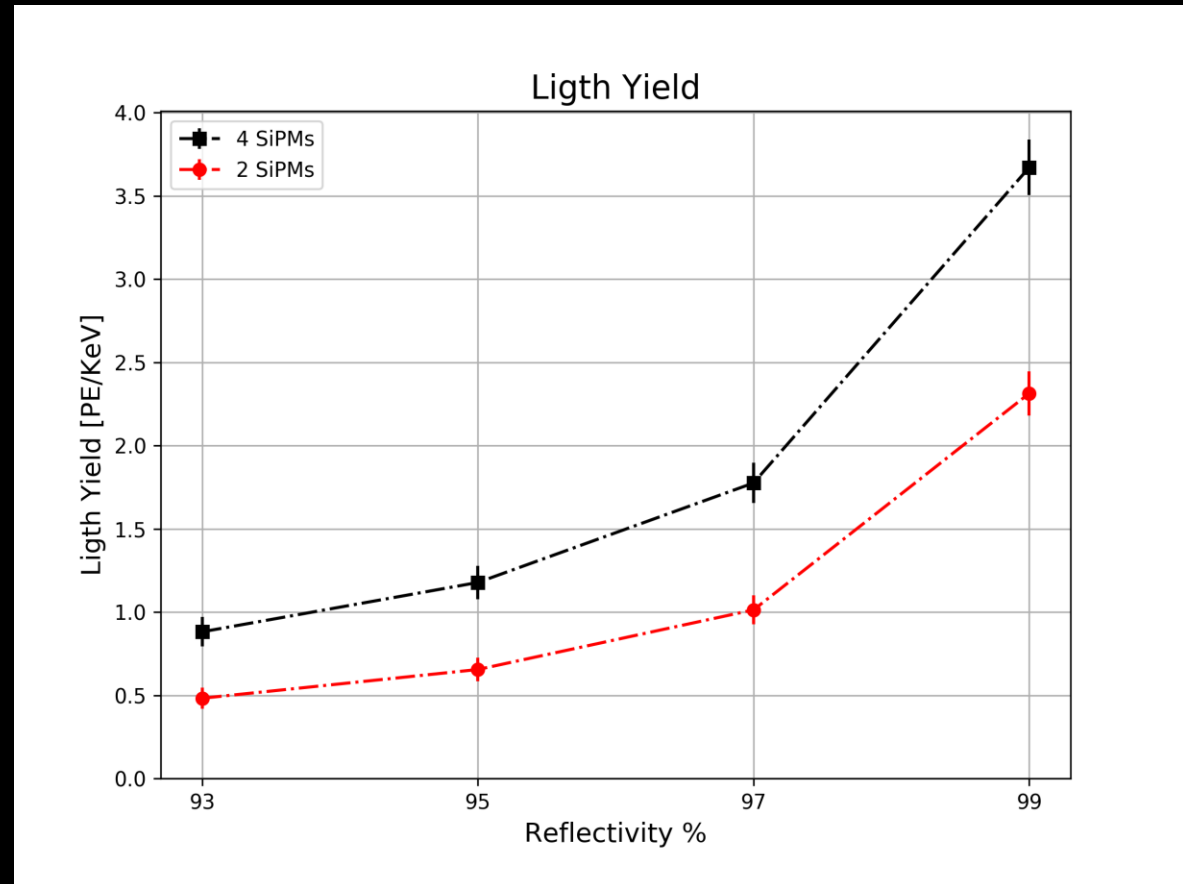
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- The efficiency increases exponentially with reflectivity.
- For R = 97%, the LY goes from **1.01 ± 0.09 PE/keV** (2 SiPMs) to **1.77 ± 0.12 PE/keV** (4 SiPMs).



Assuming a quenching factor of 0.72

Latest results

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- $LY = 0.96 \pm 0.02$ is obtained from data at CIEMAT with the different α peaks of the ^{222}Rn chain. [1]
- This value is compatible with simulations with R = 97%.

[1] E. Sánchez García, P.h.D Thesis, Underground argon radio-purity studies for DarkSide-20k and R&D on noble gas detectors for rare-events investigations

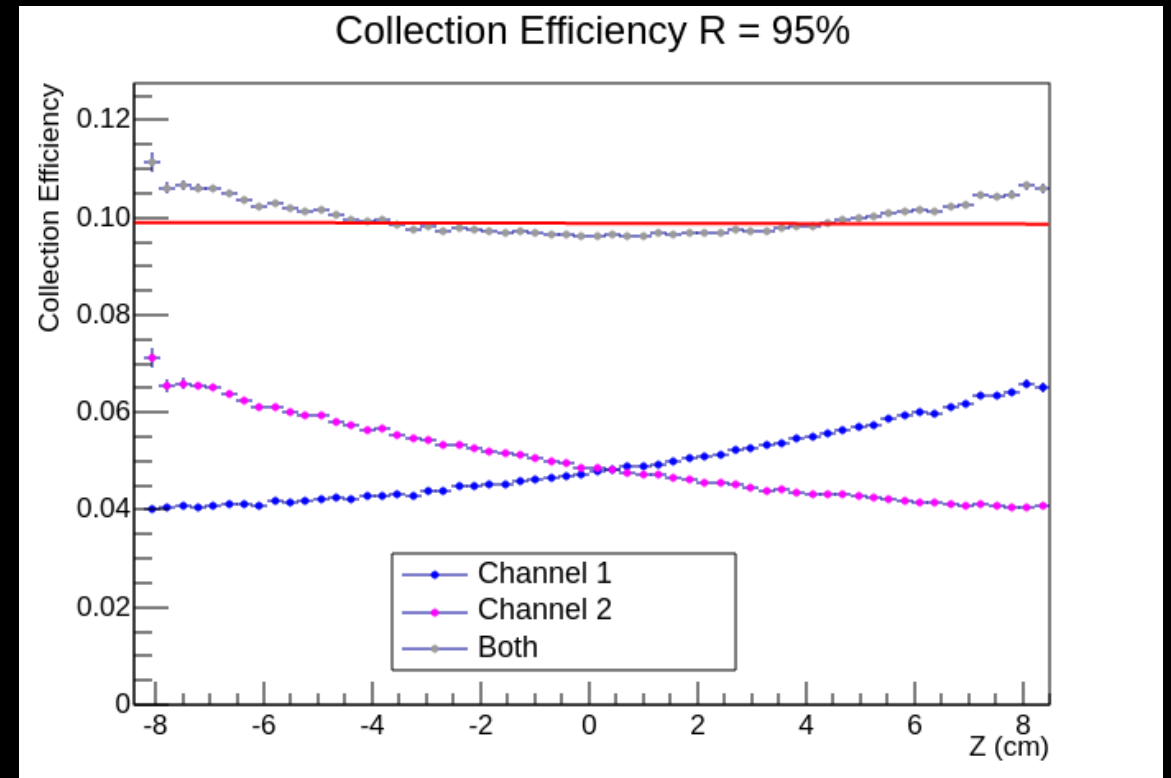
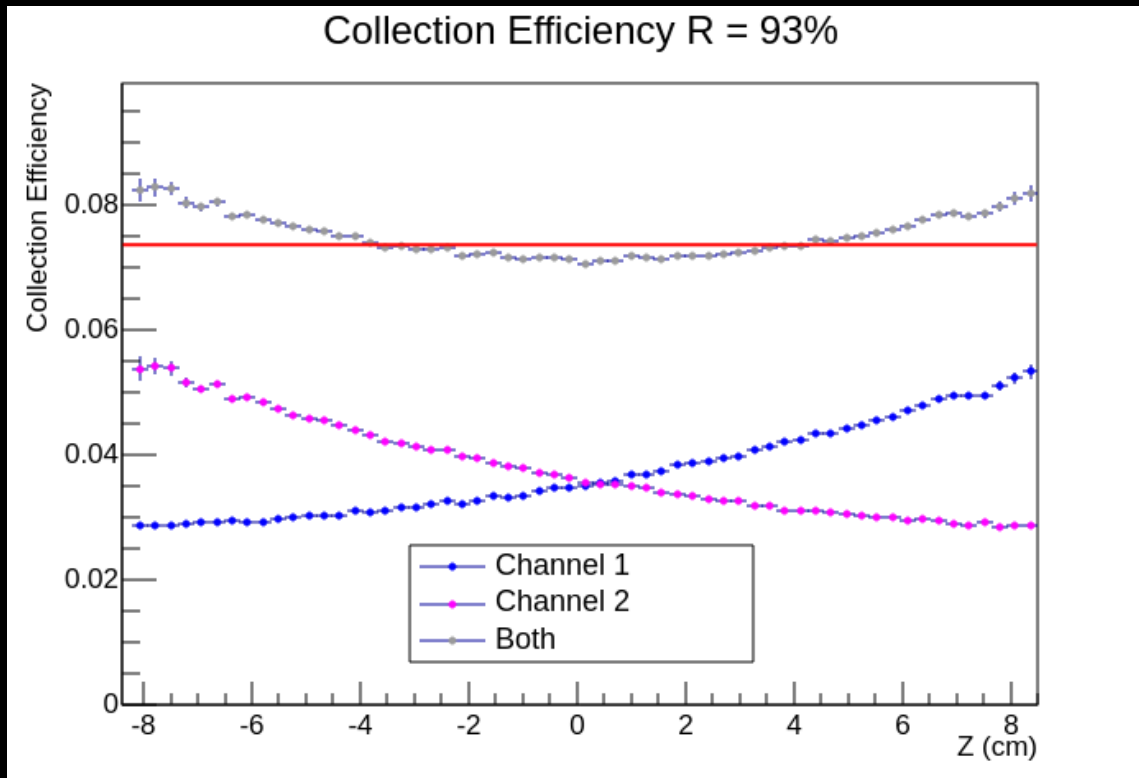
Conclusions

- By doubling the light collection area, efficiencies increase by a factor from 1.6 to 1.8 for reflectivities from 99% to 93%.
- The LY obtained in the simulations with a reflectivity of 97% is compatible with data collected at CIEMAT (on surface).
- With 4 SiPMs and reflectivity 97%, we get $LY = 1.77 \pm 0.12$ PE/keV.



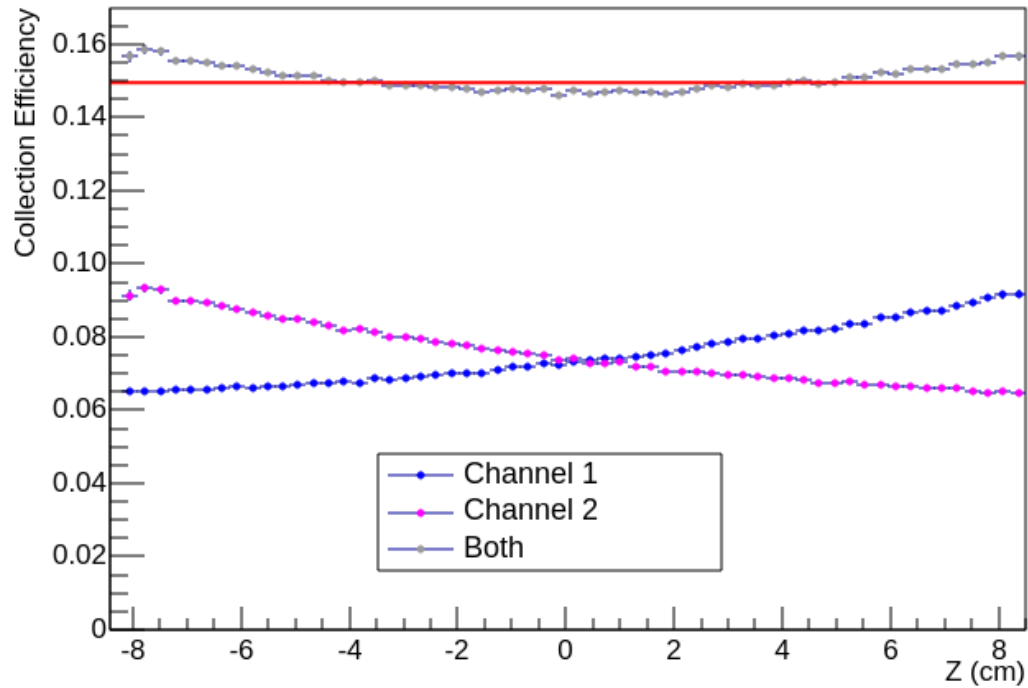
Thanks!

Backup Slides

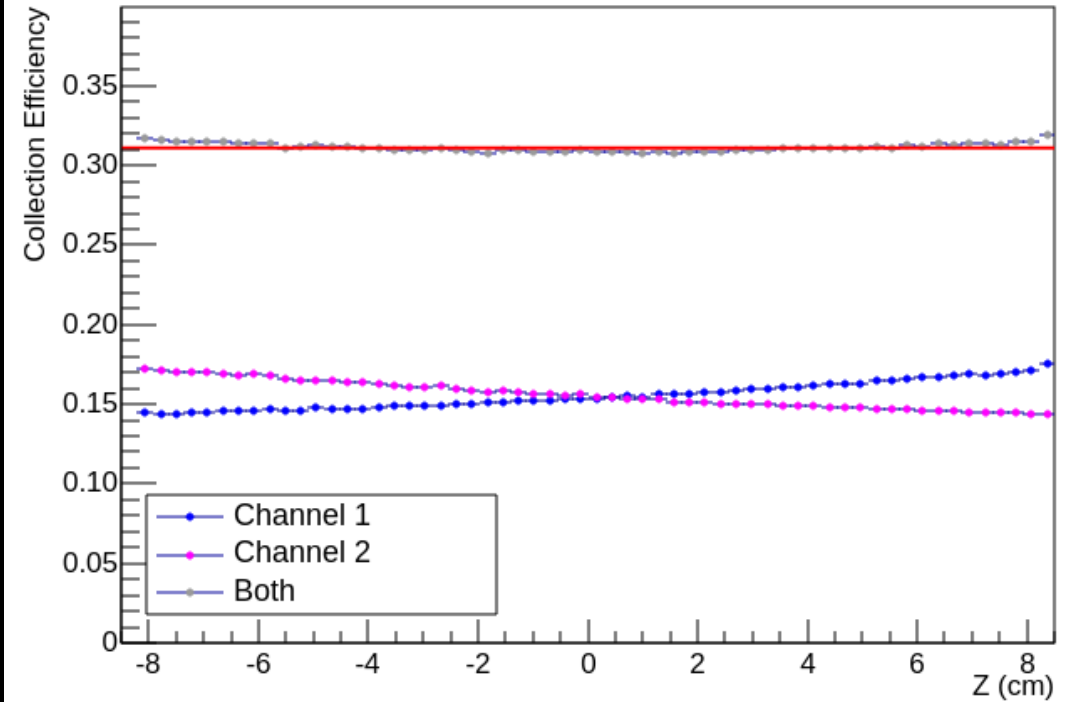


Backup Slides

Collection Efficiency R = 97%



Collection Efficiency R = 99%



Backup Slides

