X-ARAPUCA simulation efficiency comparison for dimples, roughness and Vikuiti on the WLS.

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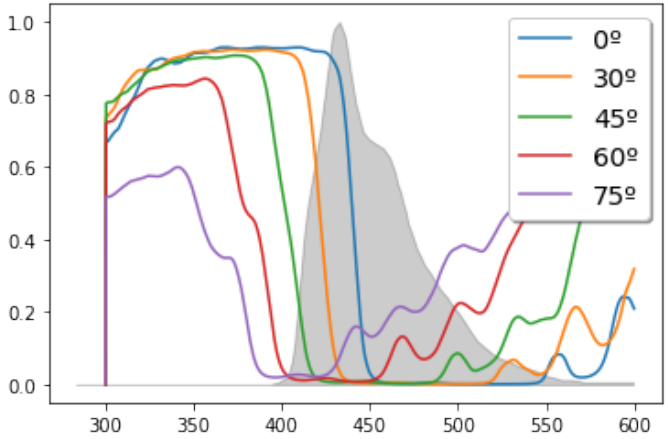
Updates of the group

- Update LAr and WLS refraction indexes.
- Added new features.
  - Vikuiti on the lateral of the WLS (can be turned on and off);
  - Square dimples;
  - Round (elliptical) dimples;
  - Roughness on dimple surfaces (parameters are uncertain).

Simulation details - Single Sided

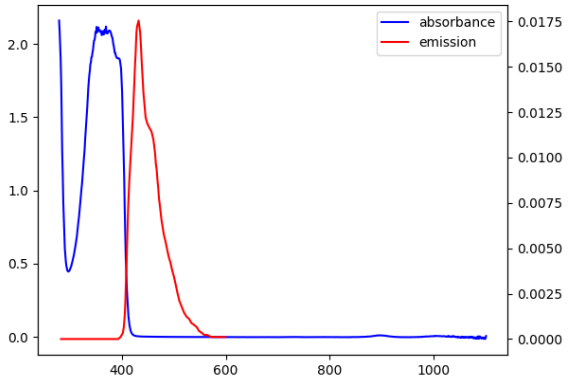
- The pTP layer absorbs and re-emits (by emission spectra) 47.5% of the photons in the direction of the dichroic filters.
- Dichroic filter transmittance of NEW ZAOT filters - experimental data (fitted).
- WSL absorbance and emission spectra by experimental data.
- Refraction index L. Ar. 1.3; WLS 1.55; critical angle - 57º.
- WSL non ideality included as 1% chance that the photon "tunnels" through.
- Inner X-ARAPUCA walls 98% reflectivity (do not change wavelength).
- SiPM detection efficiency spectrum by Hamamatsu data sheet.
- Supercell 6x1 (97mm x 97mm).
- Small distance WLS - SiPM: 0.1 mm (for flat dimple).
- No interactions with L. Ar. inside the X-Arapuca.

NEW experimental data on the ZAOT Dichroic Filters transmittance for incidence angles 0º, 30º, 45º, 60º, 75º(CARLA CATTADORI)



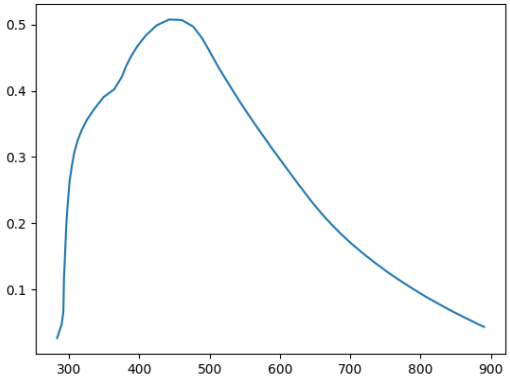
The gray area shows WLS emission (rescaled).

Emission / Zeroed WSL absorbance



We determined $\epsilon c = A_0/l_0$ using the experimental data A_0 (assuming $l_0 = 4\text{mm}$) an reconstructed for any distance using Beer-Lambert Law $T = 10^{-A} = 10^{-\epsilon c l}$.

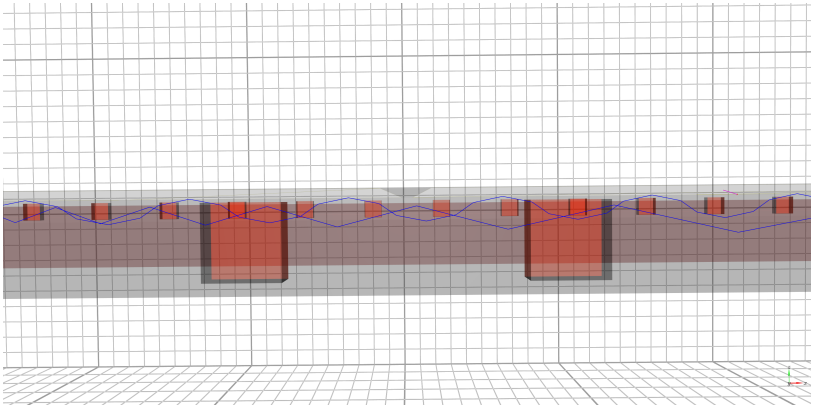
SiPM detection efficiency



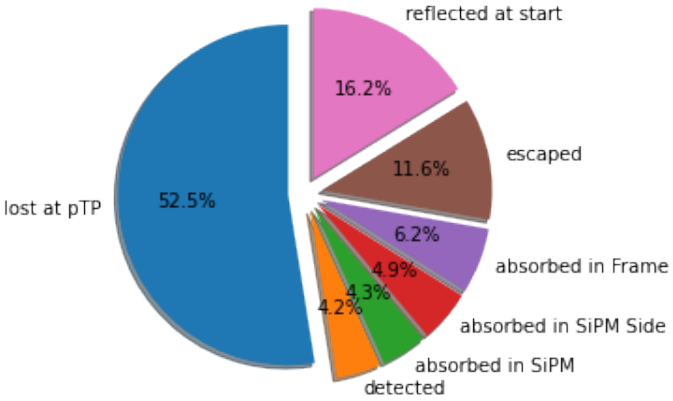
Data from Hamamatsu S13360 (Data sheet).

(X-ARAPUCA control case (no roughness, no dimple, no Vikuiti on the WLS, 48 SiPMs).

Click the image to see the model

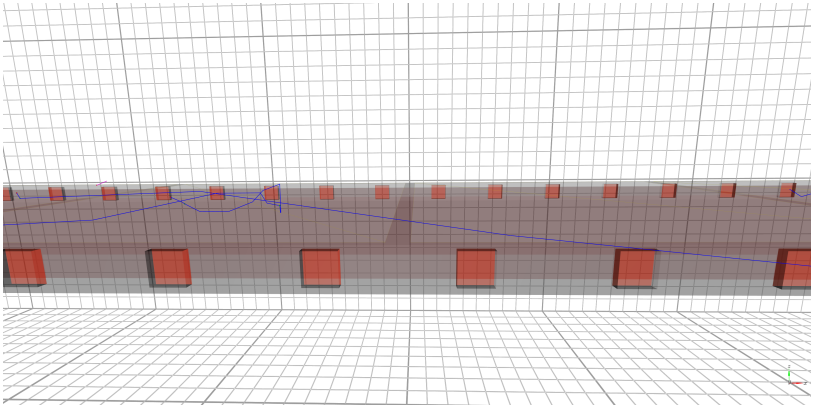


X-ARAPUCA control case (no roughness, no dimple, no Vikuiti on the WLS, 48 SiPMs). Pie chart

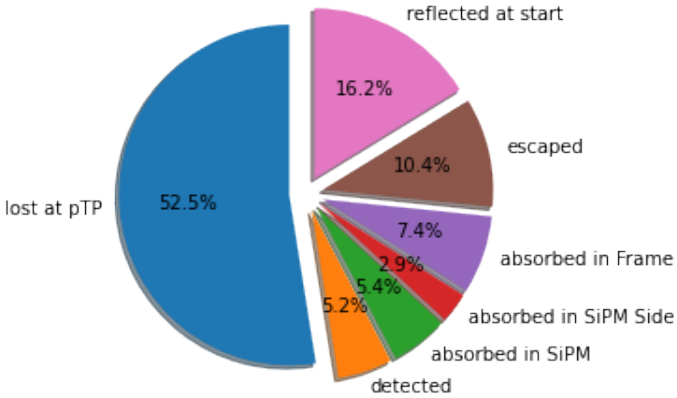


X-ARAPUCA (no roughness, no dimple, with Vikuiti on the WLS, 48 SiPMs).

Click the image to see the model

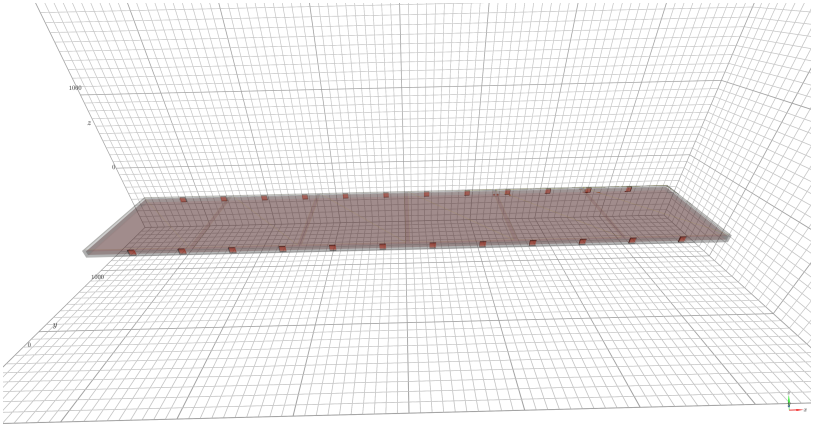


X-ARAPUCA (no roughness, no dimple, with Vikuiti on the WLS, 48 SiPMs). Pie chart

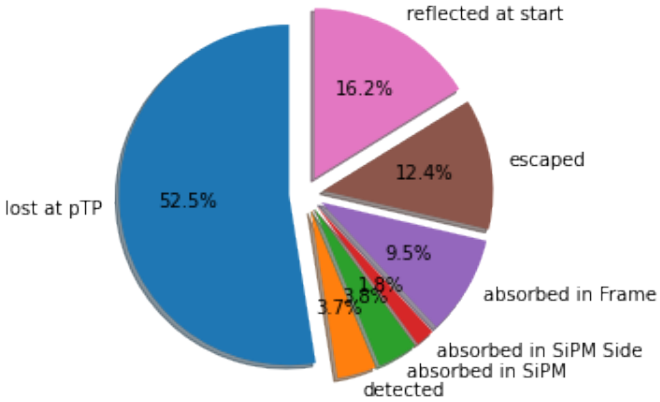


24 SiPMs X-ARAPUCA (no roughness, no dimple, with Vikuiti on the WLS).

Click the image to see the model

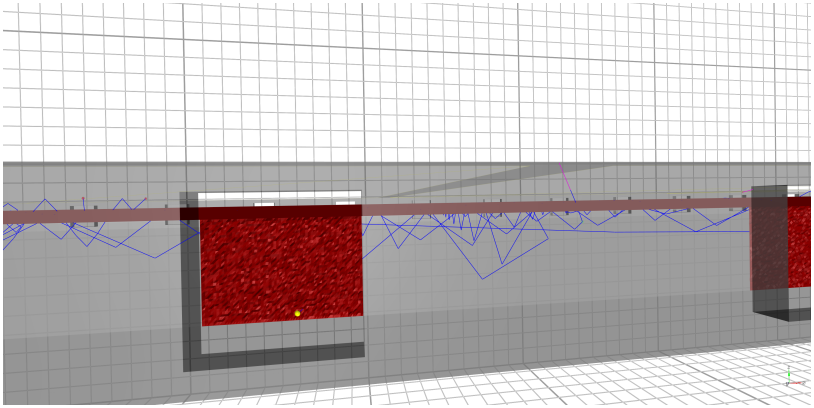


24 SiPMs X-ARAPUCA (no roughness, no dimple, with Vikuiti on the WLS). Pie chart

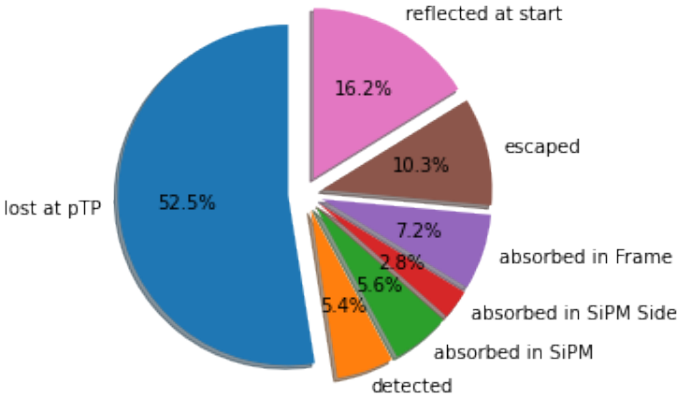


X-ARAPUCA (with roughness 0,1x0,1x0,1, no dimple, with Vikuiti on the WLS, 48 SiPMs).

Click the image to see the model



X-ARAPUCA (with roughness 0,1x0,1x0,1, no dimple, with Vikuiti on the WLS, 48 SiPMs). Pie chart



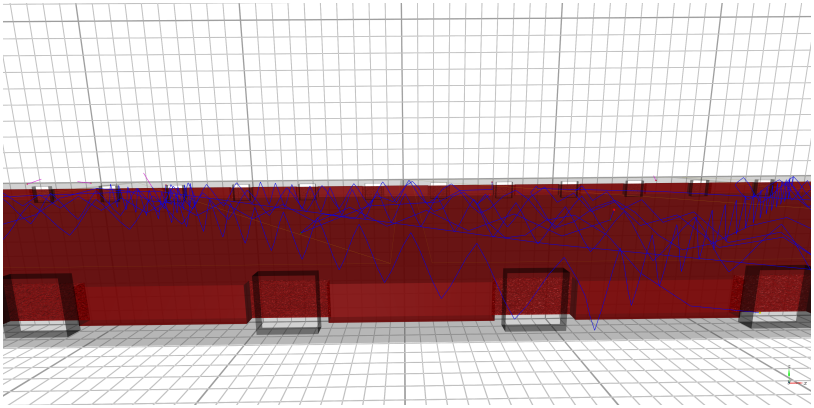
Vikuiti on WLS laterals and roughness effects

- (Control case) No roughness, no dimple, no Vikuiti on the WLS - 4.2% efficiency.
- No roughness, no dimple, with Vikuiti on the WLS - 5.2% efficiency.
- **24 SiPMs** no roughness, no dimple, with Vikuiti on the WLS - 3.7% efficiency.
- With roughness, no dimple, with Vikuiti on the WLS - 5.4% efficiency.

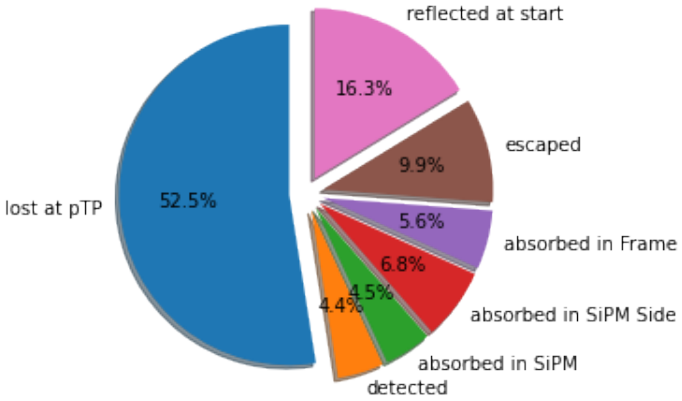
Vikuiti on WLS would increase in about 24% the efficiency (number of photons detected). Adding roughness would further increase in about 4%.

X-ARAPUCA (Square dimple 8mm width, 1.2mm depth, no Vikuiti on WLS, with roughness 0,1x0,1x0,1, 48 SiPMs, SiPM inside).

Click the image to see the model

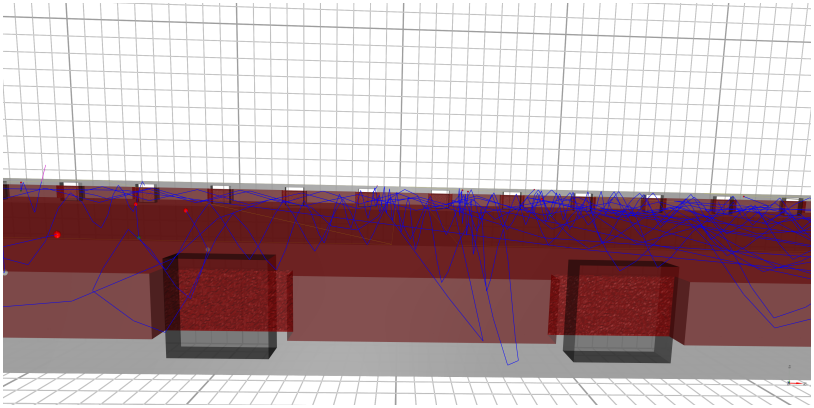


X-ARAPUCA (Square dimple 8mm width, 1.2mm depth, no Vikuiti on WLS, with roughness 0,1x0,1x0,1, 48 SiPMs, SiPM inside). Pie chart

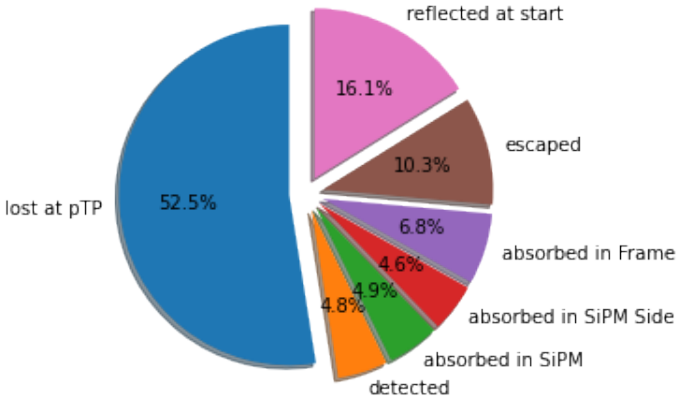


X-ARAPUCA (Square dimple 8mm width, 1.2mm depth, with Vikuiti on WLS, with roughness 0,1x0,1x0,1, 48 SiPMs, SiPM inside).

Click the image to see the model



X-ARAPUCA (Square dimple 8mm width, 1.2mm depth, with Vikuiti on WLS, with roughness 0,1x0,1x0,1, 48 SiPMs, SiPM inside). Pie chart



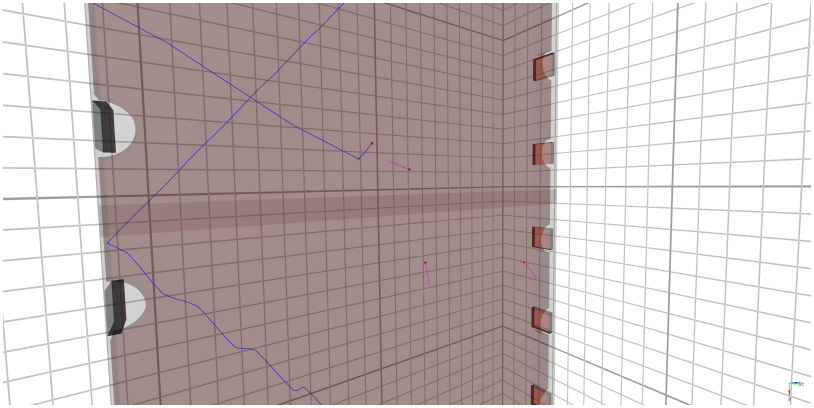
Vikuiti on WLS laterals for square dimples with roughness

- (Control case) No roughness, no dimple, no Vikuiti on the WLS - 4.2% efficiency.
- Square dimple 8mm width, no Vikuiti on WLS, with roughness 0,1x0,1x0,1, 48 SiPMs, SiPM inside - 4.4% efficiency.
- Square dimple 8mm width, with Vikuiti on WLS, with roughness 0,1x0,1x0,1, 48 SiPMs, SiPM inside - 4.8% efficiency.
- With roughness 0,1x0,1x0,1, no dimple, with Vikuiti on the WLS - 5.4% efficiency.

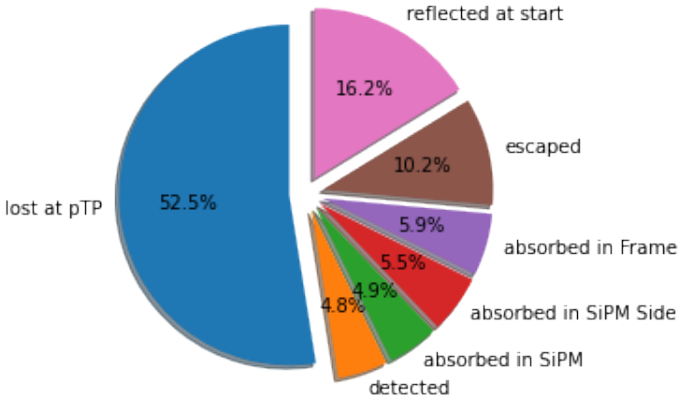
Rectangular dimples on WLS would increase the efficiency (number of photons detected) marginally, but less than simply adding Vikuiti to the WLS laterals.

X-ARAPUCA (Elliptical dimple (8mm width, 4mm depth), no Vikuiti on WLS, without roughness, 48 SiPMs, SiPM inside).

Click the image to see the model

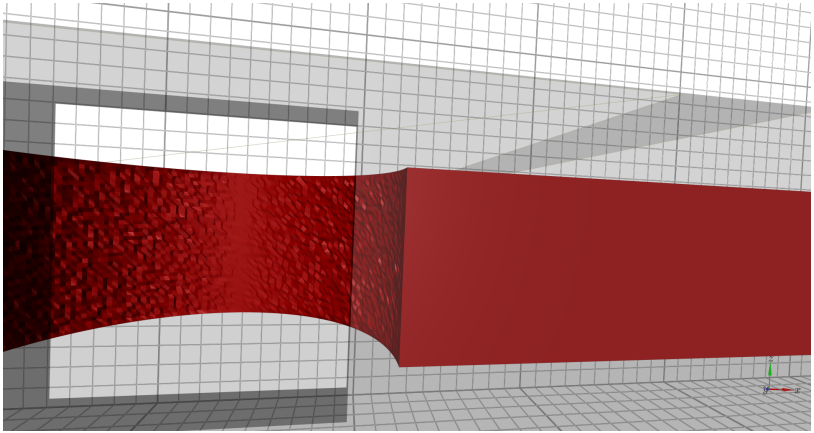


X-ARAPUCA (Elliptical dimple (8mm width, 4mm depth), no vikuiti on WLS, without roughness, 48 SiPMs, SiPM inside). Pie chart

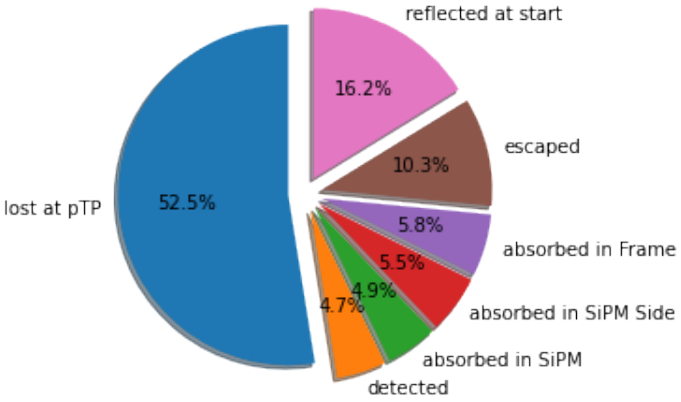


X-ARAPUCA (Elliptical dimple (8mm width, 4mm depth), no Vikuiti on WLS, with roughness, 48 SiPMs, SiPM inside).

Click the image to see the model

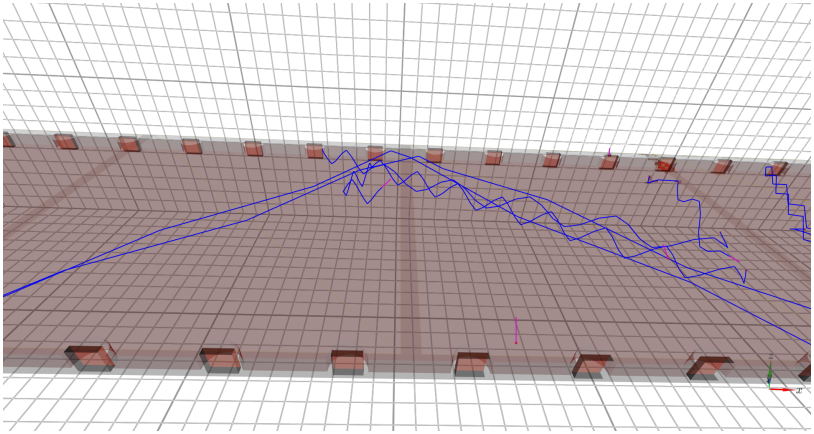


X-ARAPUCA (Elliptical dimple (8mm width, 4mm depth), no Vikuiti on WLS, with roughness, 48 SiPMs, SiPM inside). Pie chart

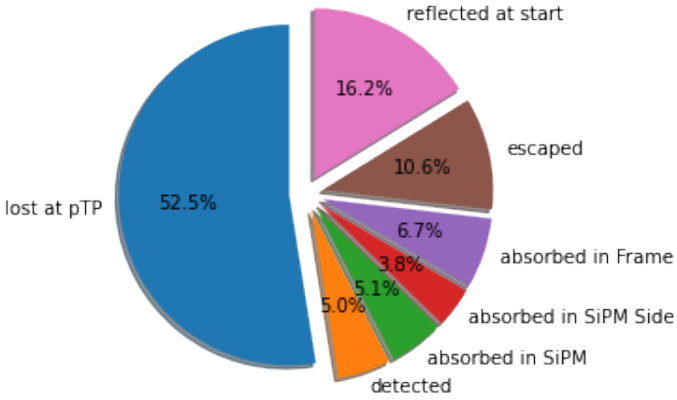


X-ARAPUCA (Elliptical dimple (8mm width, 4mm depth), with Vikuiti on WLS, with roughness, 48 SiPMs, SiPM inside).

Click the image to see the model



X-ARAPUCA (Elliptical dimple (8mm width, 4mm depth), with Vikuiti on WLS, with roughness, 48 SiPMs, SiPM inside). Pie chart



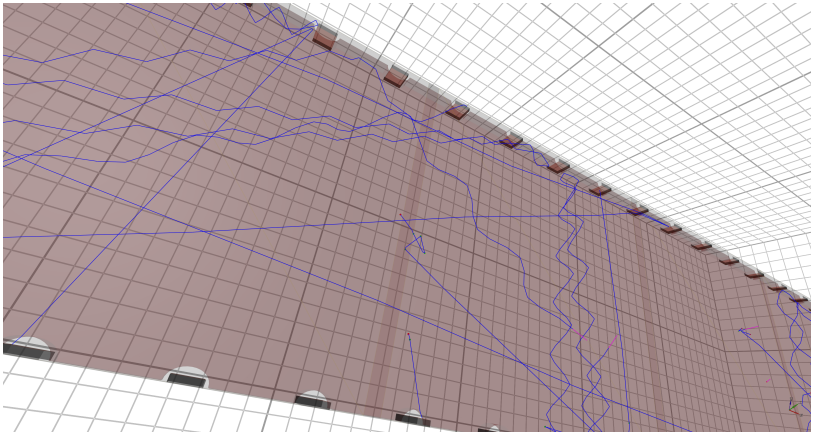
Vikuiti on WLS side and roughness effects for elliptical dimples

- (Control case) No roughness, no dimple, no Vikuiti on the WLS - 4.2% efficiency.
- Elliptical dimple (8mm width, 4mm depth), without Vikuiti on WLS, without roughness, 48 SiPMs, SiPM inside - 4.8% efficiency.
- Elliptical dimple (8mm width, 4mm depth), without Vikuiti on WLS, with roughness, 48 SiPMs, SiPM inside - 4.7% efficiency.
- Elliptical dimple (8mm width, 4mm depth), with Vikuiti on WLS, with roughness, 48 SiPMs, SiPM inside - 5.0% efficiency.
- With roughness 0,1x0,1x0,1, no dimple, with Vikuiti on the WLS - 5.4% efficiency.

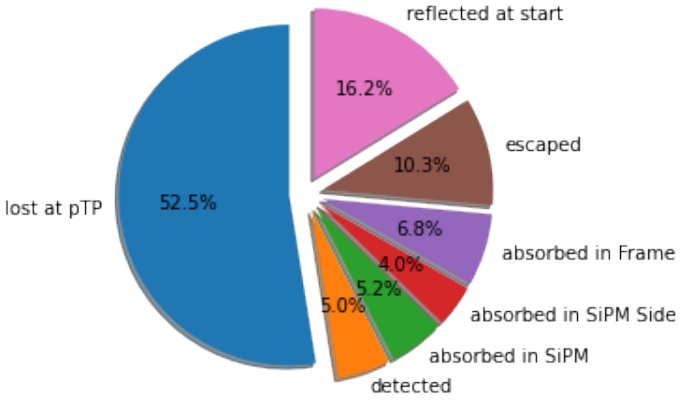
Semi-circular dimples on WLS would increase the efficiency (number of photons detected) a bit, but less than simply adding Vikuiti to the WLS laterals.

X-ARAPUCA (Elliptical dimple (8mm width, 3mm depth), with Vikuiti on WLS, no roughness, 48 SiPMs, SiPM inside).

Click the image to see the model

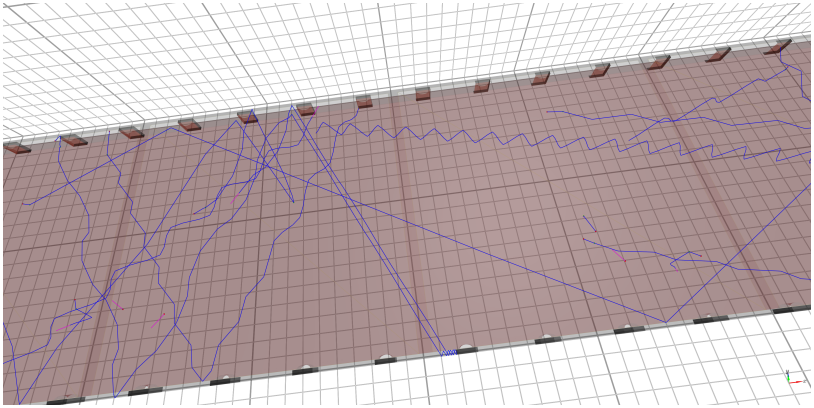


X-ARAPUCA (Elliptical dimple (8mm width, 3mm depth), with Vikuiti on WLS, no roughness, 48 SiPMs, SiPM inside). Pie chart

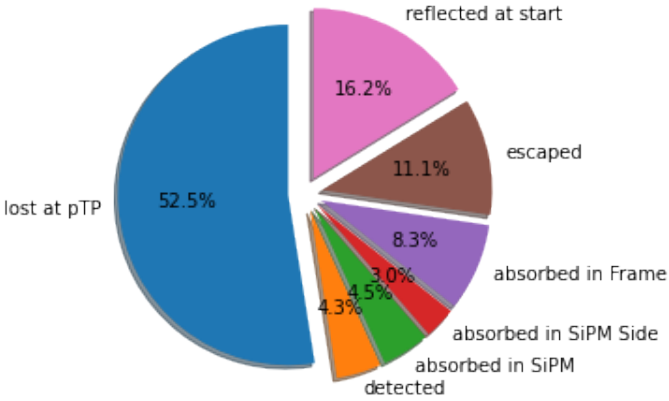


X-ARAPUCA (Elliptical dimple (4mm width, 1mm depth), with Vikuiti on WLS, no roughness, 48 SiPMs, SiPM outside).

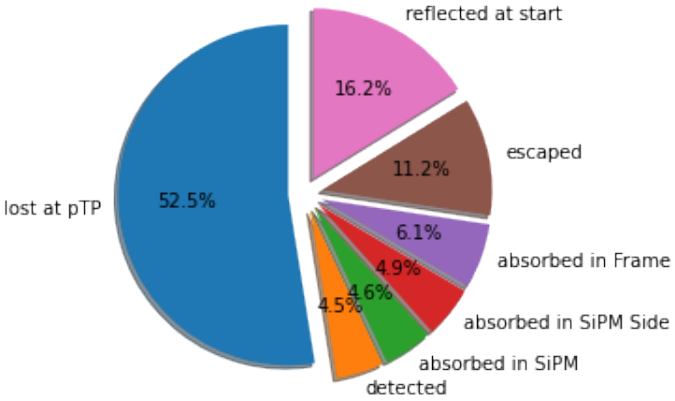
Click the image to see the model



X-ARAPUCA (Elliptical dimple (4mm width, 1mm depth), with Vikuiti on WLS, no roughness, 48 SiPMs, SiPM outside). Pie chart

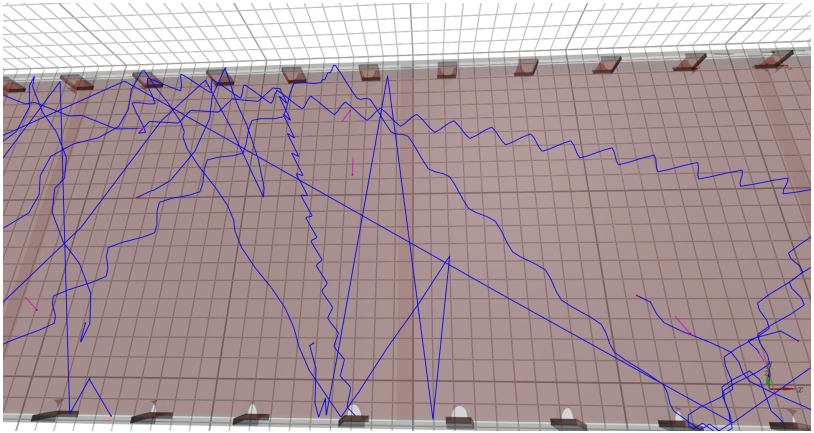


X-ARAPUCA (Elliptical dimple (4mm width, 1mm depth), without Vikuiti on WLS, no roughness, 48 SiPMs, SiPM outside). Pie chart

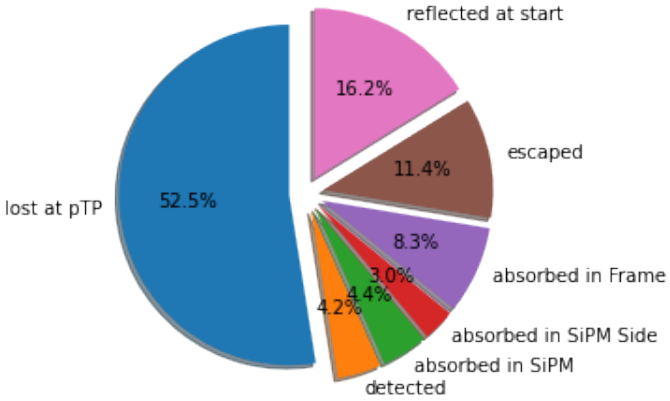


X-ARAPUCA (Elliptical dimple (4mm width, 3mm depth), with Vikuiti on WLS, no roughness, 48 SiPMs, SiPM outside).

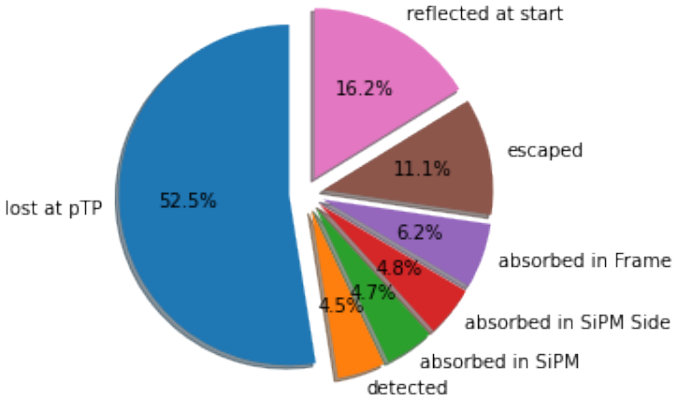
Click the image to see the model



X-ARAPUCA (Elliptical dimple (4mm width, 3mm depth), with Vikuiti on WLS, no roughness, 48 SiPMs, SiPM outside). Pie chart

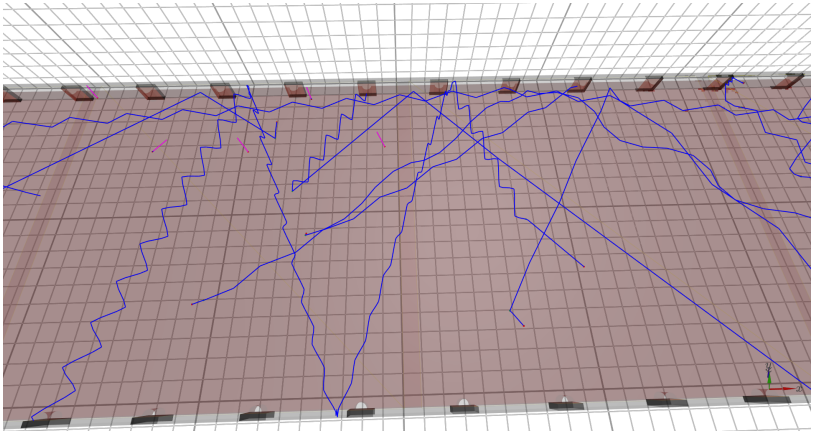


X-ARAPUCA (Elliptical dimple (8mm width, 3mm depth), without Vikuiti on WLS, no roughness, 48 SiPMs, SiPM inside). Pie chart

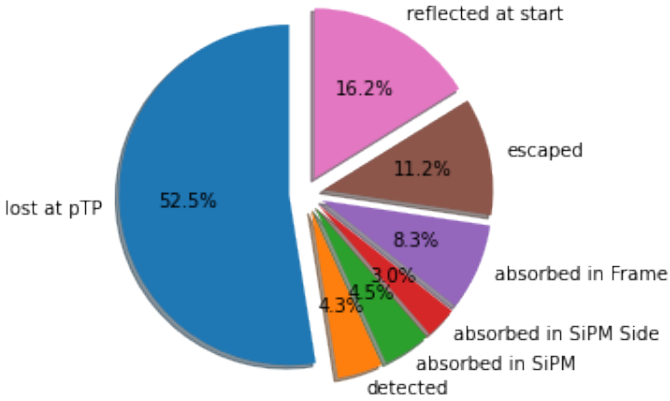


X-ARAPUCA (Elliptical dimple (3mm width, 1.5mm depth), with Vikuiti on WLS, no roughness, 48 SiPMs, SiPM outside).

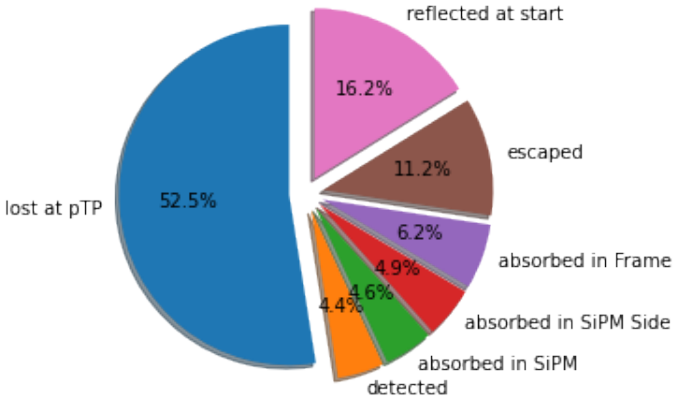
Click the image to see the model



X-ARAPUCA (Elliptical dimple (3mm width, 1.5mm depth), with Vikuiti on WLS, no roughness, 48 SiPMs, SiPM outside). Pie chart



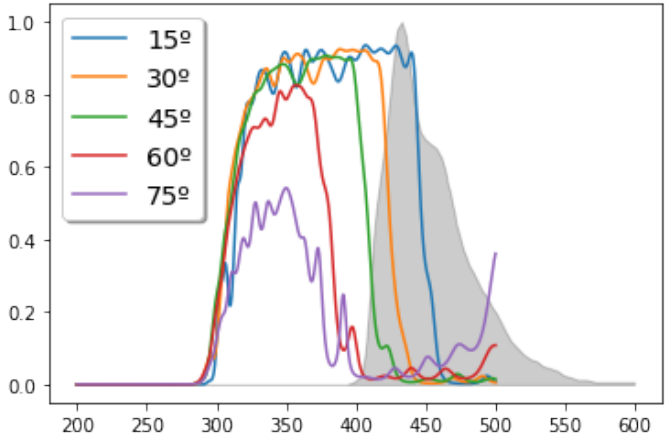
X-ARAPUCA (Elliptical dimple (3mm width, 1.5mm depth), without Vikuiti on WLS, no roughness, 48 SiPMs, SiPM outside). Pie chart



Different sizes for elliptical dimples dimples

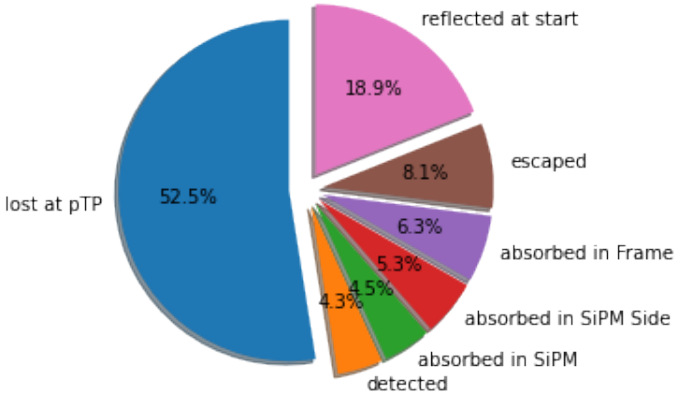
- (Control case) No roughness, no dimple, no Vikuiti on the WLS - 4.2% efficiency.
- Elliptical dimple (8mm width, 3mm depth), with Vikuiti on WLS, without roughness, 48 SiPMs, SiPM inside - 5% efficiency.
- Elliptical dimple (4mm width, 1mm depth), without roughness, 48 SiPMs, SiPM outside - with Vikuiti 4.3%, without Vikuiti 4.5% efficiency.
- Elliptical dimple (4mm width, 3mm depth), without roughness, 48 SiPMs, SiPM outside - with Vikuiti 4.2%, without Vikuiti 4.5%
- Elliptical dimple (3mm width, 1.5mm depth), without roughness, 48 SiPMs, SiPM outside - with Vikuiti 4.3%, without Vikuiti 4.4%
- With roughness 0,1x0,1x0,1, no dimple, with Vikuiti on the WLS - 5.4% efficiency.

Experimental data on the OPTO Dichroic Filters transmittance for incidence angles 15º, 30º, 45º, 60º, 75º



The gray area shows WLS emission (rescaled).

X-ARAPUCA OPTO Dichroics - control case (no roughness, no dimple, no Vikuiti on the WLS, 48 SiPMs). Pie chart



Histograms of escaped photons by angle for the new ZAOT and for OPTO dichroic filters.