HD Supercell efficiency measurements in Liquid Argon @ Milano-Bicocca: MC computed geometric acceptance

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28/02/2023

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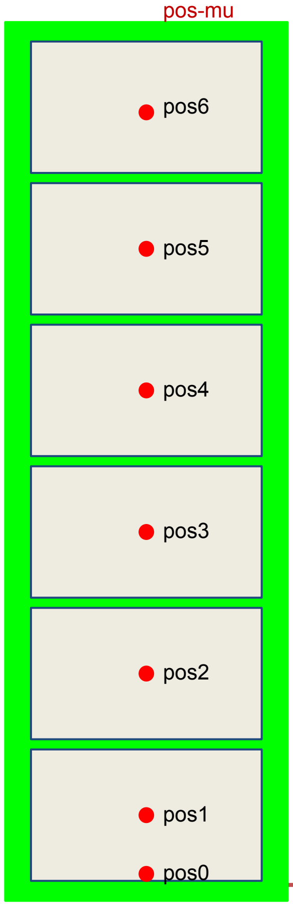
HD-XA Supercell PDE measurements & data analysis

- Available alpha-source scanning data of XA configurations :
  - HG, FE, FG (pDUNE nomenclature)
  - First PDE analysis: C. Massari master thesis.
  - Last PDE update: 25/10/2022

- **NEW** (done)
  - XA HD SC simulation (MiB PDE measurement setup)
  - **geometric acceptance** (this talk)
  - comparison between analytical and MC computation
- **NEW** (work in progress): Refinement of data analysis
  - signal calibration
    - peak finding algorithm
    - gain computation
    - wfm deconvolution by Gaus+Wiener for the muon analysis (LAr purity corrections)

Method & Data taking



z-scanning of the SC with the ^{241}Am α (5.480 MeV) source at the following positions:

1. **pos0**: (the lowest possible): ~2 cm above the flange.
2. **pos1, 2, 3, 4, 5, 6**: the center of each dichroic filter.
   Acquired: 10^4 x 4 wfms; 20 μs length; ~5 μs pretrigger.

3. Source at the topmost position (~49 cm from the flange) and ~ out of LAr:
   - one **μ run** (10^4 x 4 events; 20 μs, 5 μs pretrigger)
   - one **s.ph.e. run** (10^4 x 8 events; 20 μs length; 1.6 μs pretrigger)

Source-to-dichroic filter distance: (55 +/- 1) mm.

Noise Run: V_{bias} = V_{bd}-1V for FFT and filter shape&cutoff definition

Solid angle: analytical computation

Calculated analytically as the angle of the vertex of a pyramid with a rectangular base (the SC)

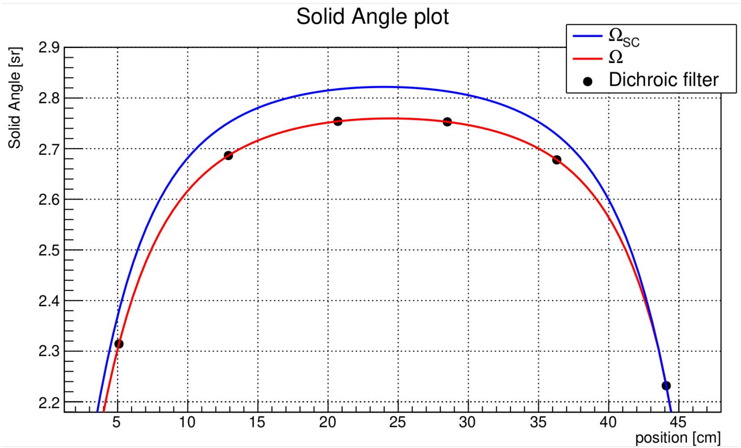
$$\Omega_{SC}(x) = 2\arctan\left(\frac{abh}{2R_1(x^2+h^2)+2R_2[x(x-b)+h^2]}\right) + 2\arctan\left(\frac{abh}{2R_1(x(x-b)+h^2)+2R_2[(x-b)^2+h^2]}\right)$$

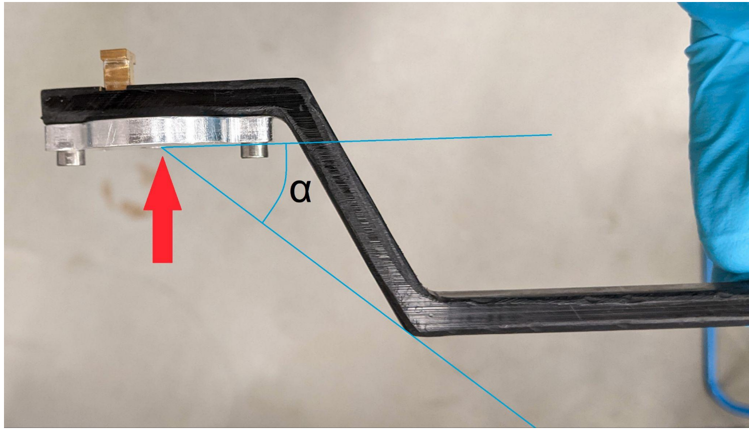
The source holder covers part of the solid angle

$$\Omega_s(x) = 2\arctan\left(\frac{wh(b-x-h\cot\alpha)}{2R_3[h\cot\alpha(b-x)+h^2]+2R_4[(h\cot\alpha)^2+h^2]}\right) + 2\arctan\left(\frac{wh(b-x-h\cot\alpha)}{2R_3[(b-x)^2+h^2]+2R_4[h\cot\alpha(b-x)+h^2]}\right)$$

The solid angle is thus:

$$\Omega(x) = \begin{cases} \Omega_{SC}(x) - \Omega_s(x) & \text{if } x < b - h\cot\alpha \\ \Omega_{SC}(x) & \text{if } x \geq b - h\cot\alpha \end{cases}$$

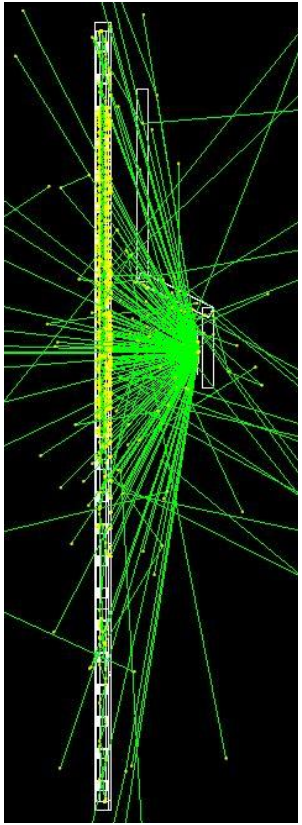




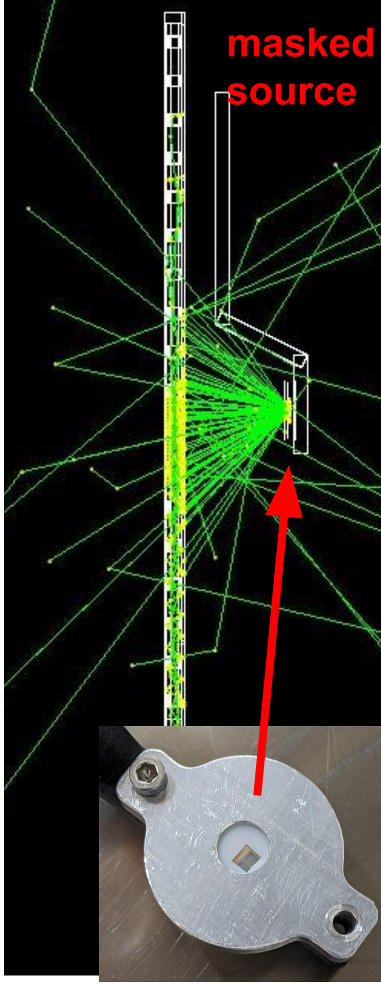
MC computed geometric acceptance

- computed via a geant4 simulation
  - geometry takes into account also the source holder and teflon mask (previously only the source holder arm was modeled)
  - solid angle obtained from the ratio of photons hitting the pTP deposit over the scintillation photons
    - $\Omega = (\gamma_{pTP}/\gamma_{scint})*4\pi$

unmasked source



masked source



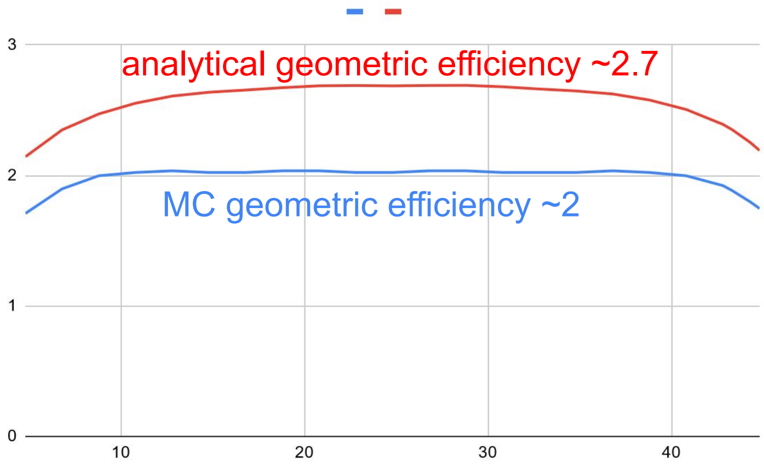
MC computed geometric acceptance

- the MC result is lower than the analytical computation with the same configuration (holder arm only)
    - possible difference in the geometry
    - effects from absorption and scattering in lAr

i.e.

position	MC sim	analytical
4th dichroic	**2.43**	**2.69**

- adding source geometry, holder and teflon mask, the geometric acceptance decreases from a peak of **2.7** steradiants to **2**



MC geometric acceptance correction

- preliminary: all data must be reanalyzed

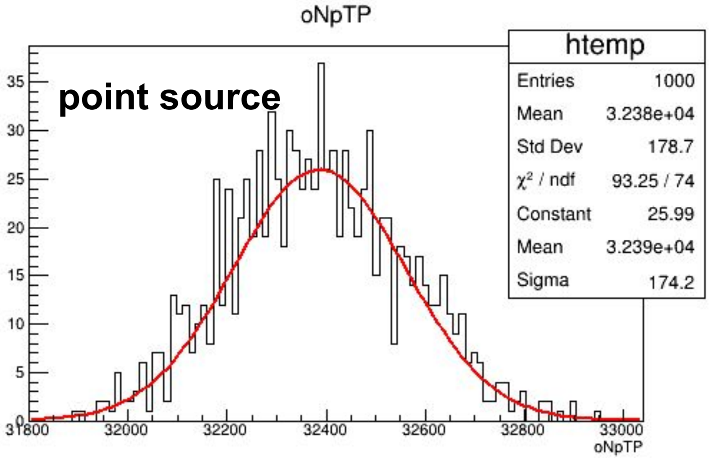
		OV	PDE	Uncorrected ε_{XA}	Measured Xtalk	P_{LAr}	Position systematic	Corrected $\varepsilon_{XA\ x\ talk\ only}$	Corrected $\varepsilon_{XA\ x\ talk\ and}$ P_LAr	**Corrected geometric acceptance (MC)**
this work	HPK** & G2P	3.0V	50%	1.94 (0.03)	6.62%	TBD	0.08	1.82 (0.08)		**2.5 (0.16)**
	FBK*** & G2P	4.5V	45%	1.72 (0.03)	15.7%	1.06	0.10	1.49 (0.10)	1.58 (0.10)	**2.1 (0.23)**
	FBK*** & Eljen	4.5V	45%	1.50 (0.02)	15.7%	TBD	0.06	1.29 (0.07)		**1.8 (0.18)**
JINST work	HPK commercial*	2.7V	45%	3.5 (0.1)	22%			2.9 (0.1)		

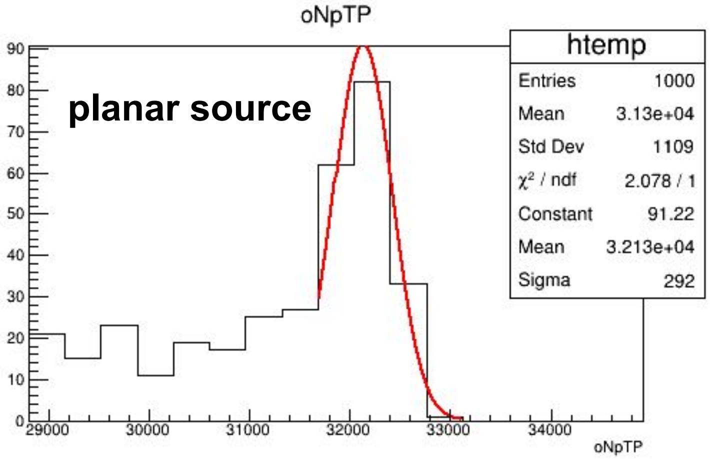
Point source vs Planar source

The geometric acceptance has been computed simulating:

- first a point-like source
  - faster to run
- then a planar source (~5mm diameter) → a low energy tail shows up and the peak mean is found ~4% lower
  - simulations can be re-run to take this effect into account

source	point-like	planar	planar/point
peak mean	3.238e+04	3.13e+4	96.6%





Point source vs Planar source

source	point-like	planar	planar/point
peak mean	417	397	95.2%

- the detected photons spectrum shape is similar to the one from measurements