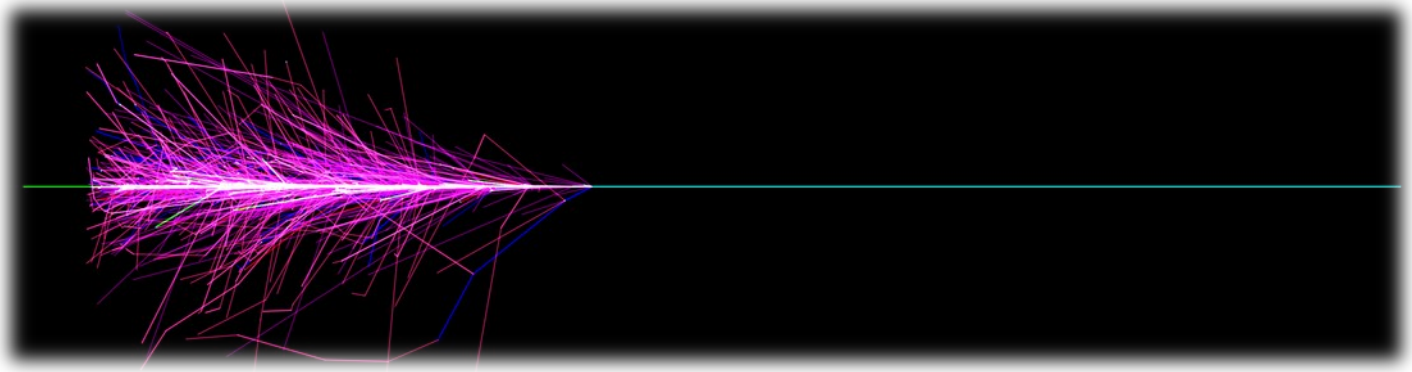

Optical Light Emission in CORSIKA8

Dominik Baack

01.12.2023

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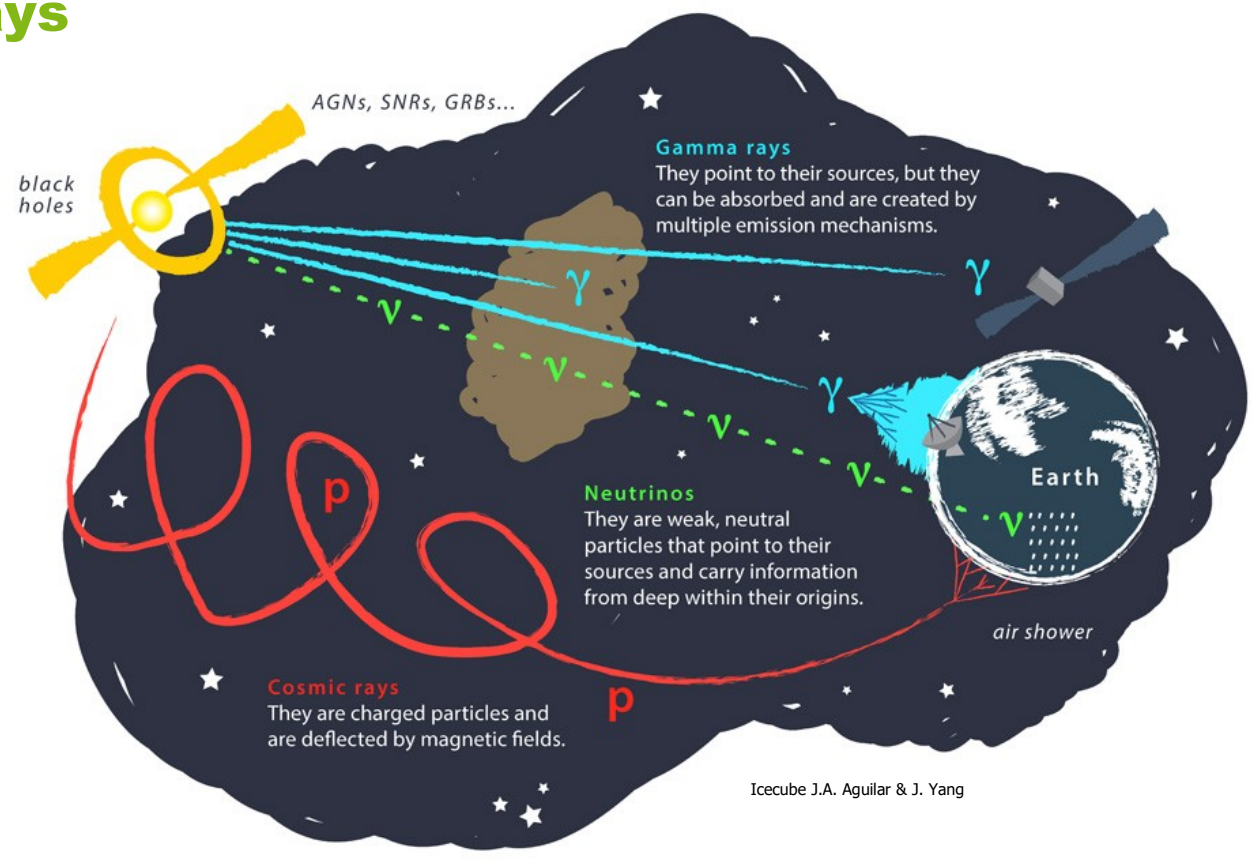
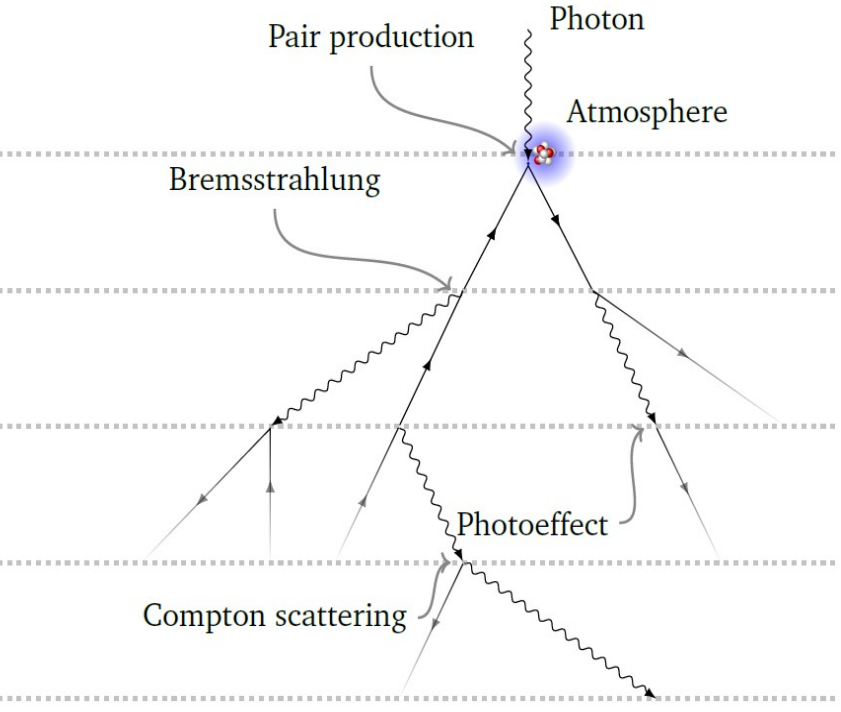
Cosmic Rays

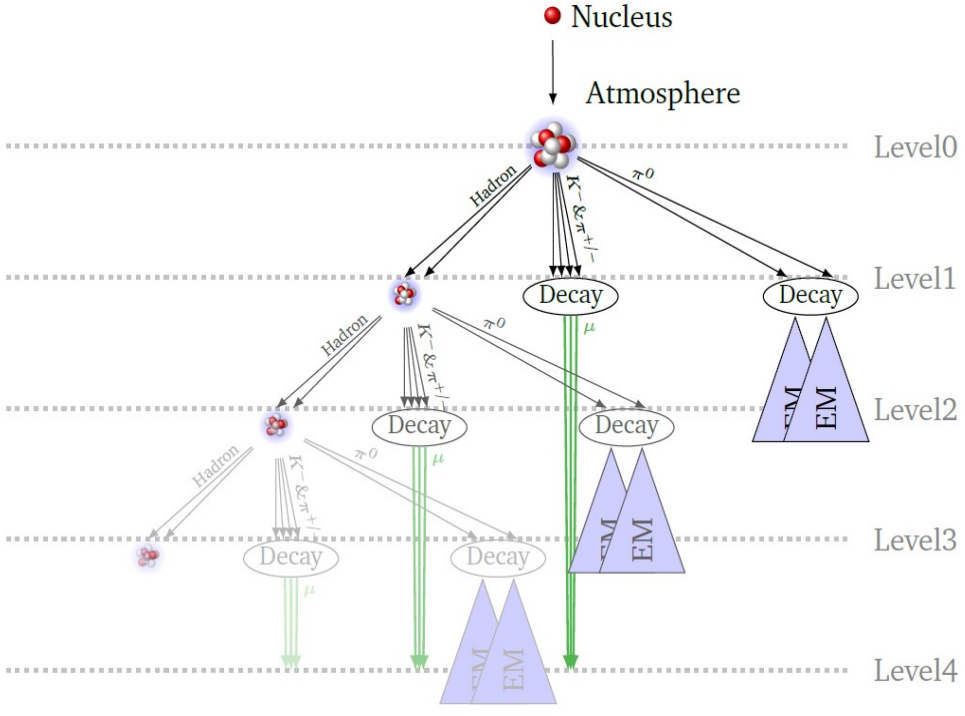


Icecube J.A. Aguilar & J. Yang

Cascades

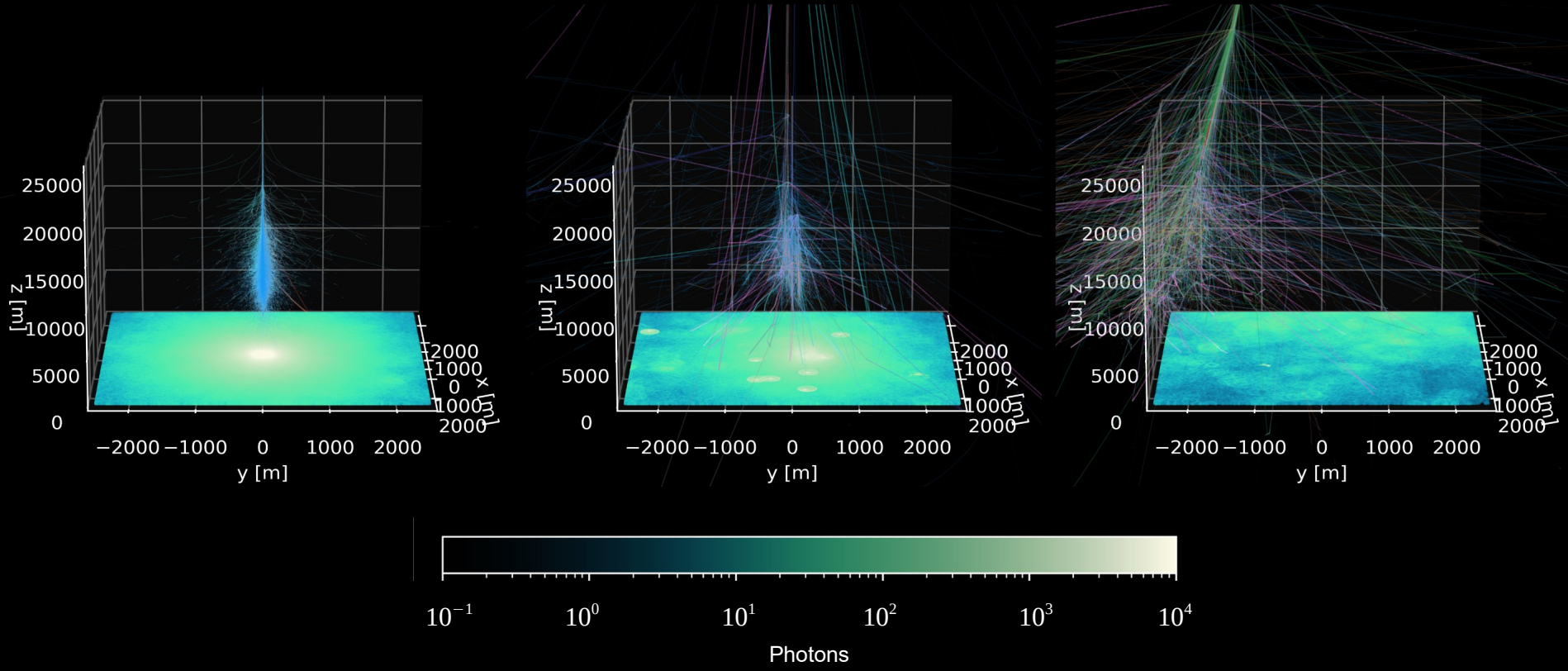


EM-Cascade

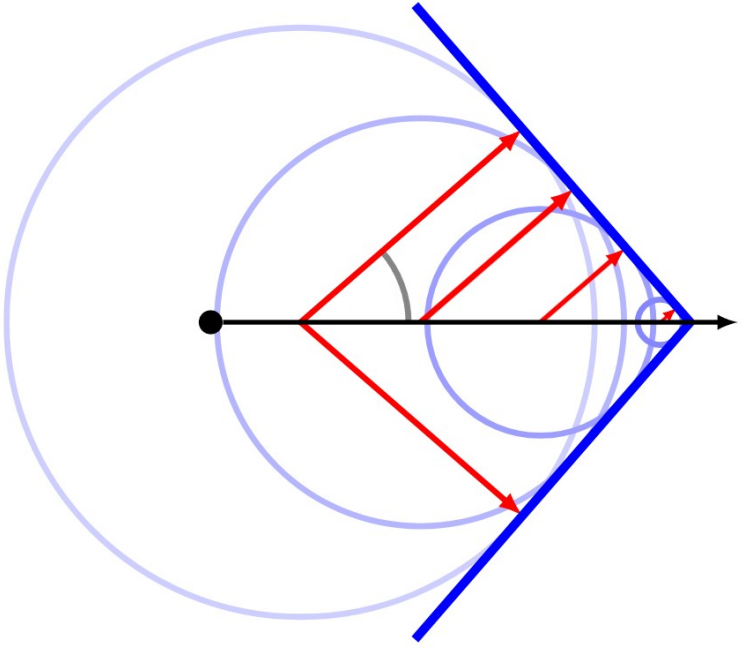


Hadronic Cascade

1TeV Cascades



Light Emissions



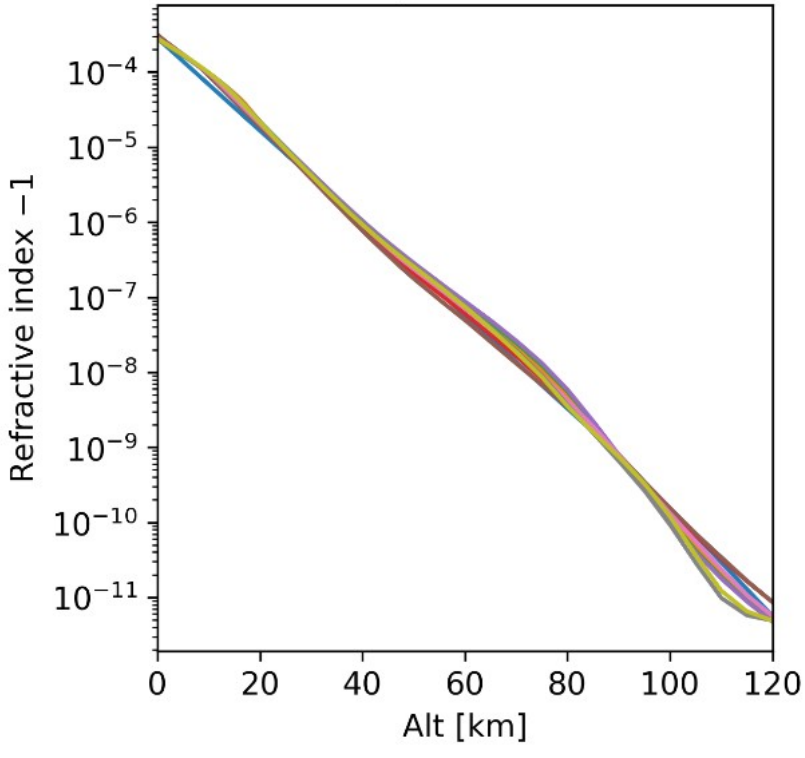
- Optical light emission from „faster-than-light“ particles → Cherenkov Light
- Charged particle excitation → Fluorescence

Photon Generation

$$N = \mu_r \pi z^2 \frac{e^2}{h\varepsilon_0 c_0} \int_{\lambda_1, \beta(l)>1/n(\lambda,l)}^{\lambda_2} \int_{l_1}^{l_2} \frac{1}{\lambda^2} \left(1 - \frac{1}{\beta^2 n^2(\lambda, l)}\right) \Theta\left(\beta(l) - 1/n(\lambda, l)\right) \mathrm{d}\lambda \, \mathrm{d}l$$

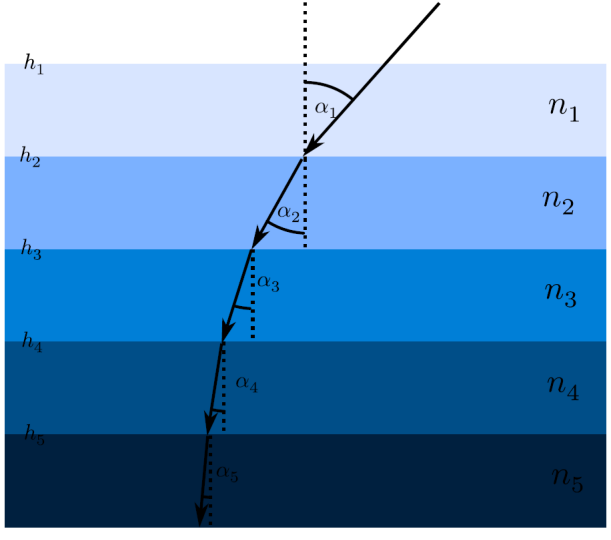
$$\vartheta = \arccos\left(\frac{1}{\beta(l)\, n(\lambda, l)}\right)$$

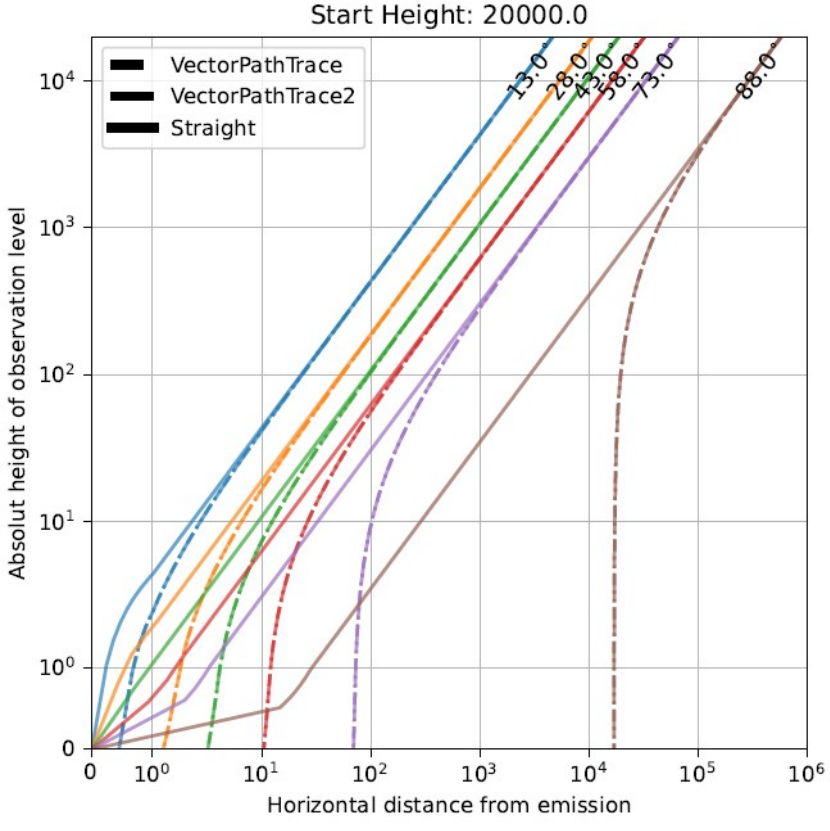
$$Y_\lambda = \varepsilon_\lambda(p, T, e) \cdot \frac{\lambda}{hc_0} \cdot \frac{\mathrm{d}E}{\mathrm{d}x} \cdot \rho_{\text{air}} \left[\frac{\text{photons}}{\text{m}}\right]$$



Photon Propagation

$$n_1 \cdot \sin(\alpha_1) = n_2 \cdot \sin(\alpha_2)$$





Optical Light Emissions

- >80% runtime

Function	CPU Time: Total ▼	CPU Time: Self	Instructions Retired: Total
aamain	2232.101s	0.020s	100.0%
__libc_start_main	2232.101s	0s	100.0%
main	2232.101s	0s	100.0%
_start	2232.101s	0s	100.0%
box3	2208.159s	0.020s	99.0%
cerenk	2078.871s	533.937s	93.8%
egs4	2026.466s	0s	90.8%
em	2026.466s	0s	90.8%
shower	2026.466s	0.070s	90.8%
electr	2023.865s	34.329s	90.7%
distip	449.052s	203.941s	16.8%
__ieee754_acos_sse2	358.305s	318.770s	21.0%
tofip	336.495s	214.020s	15.5%
rmmard	250.622s		
__cos_avx	192.107s		
rhof	190.668s		
updatc	187.214s		
__GI___exp	180.922s		
update	180.016s		
__ieee754_exp_avx	166.768s		
mutrac	165.054s		
do_sincos_1	110.374s		
__sin_avx	104.359s		
telout_	55.212s		
do_sincos_1	47.284s		
__doasin	37.784s		
do_cos	32.290s	32.240s	1.2%

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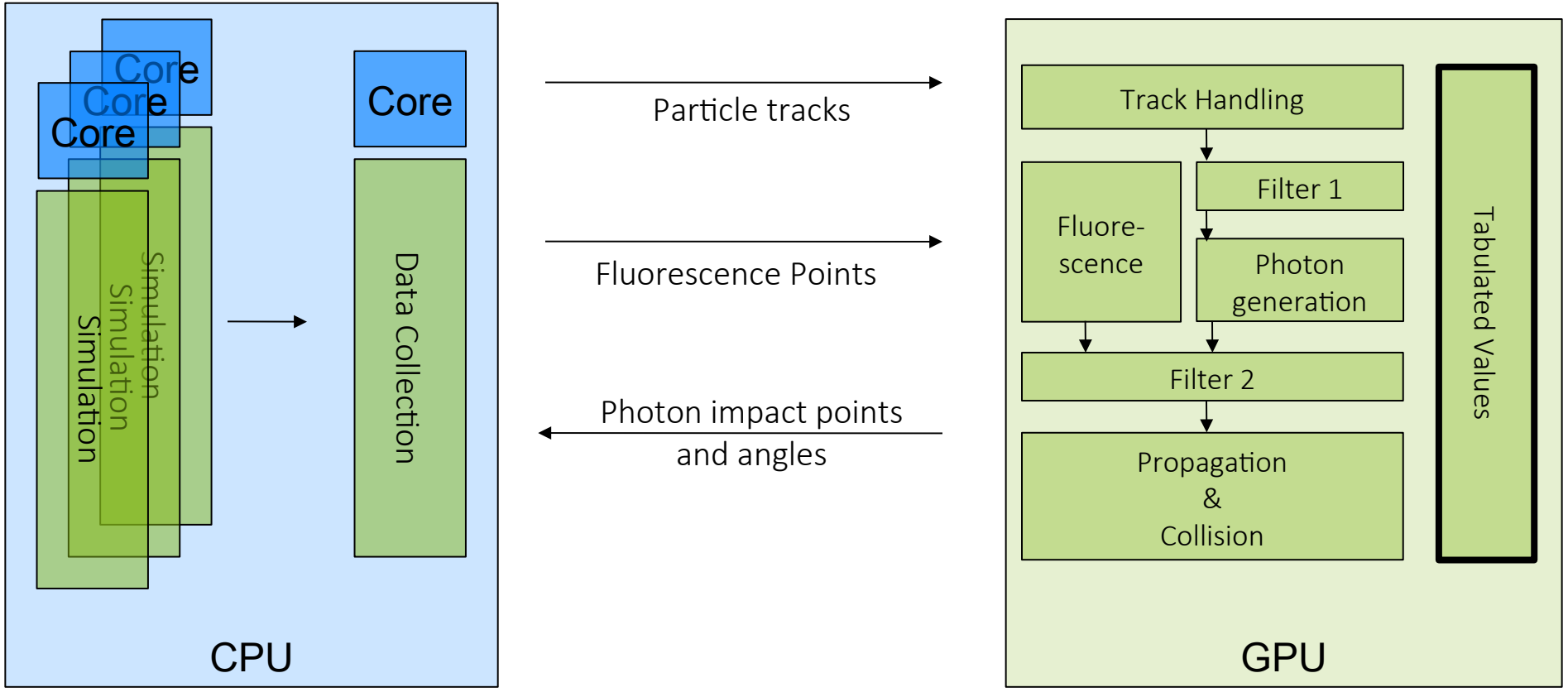
Corsika 7

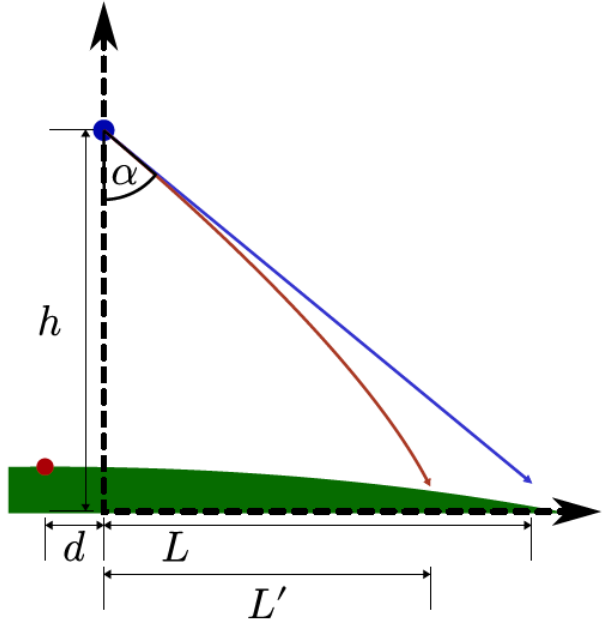
Callees	CPU Time: Total ▼	CPU Time: Self
▼ cerenk	2078.871s	533.937s
▶ distip	449.052s	203.941s
▶ tofip	336.495s	214.020s
▶ rmmard	231.852s	231.438s
▶ rhof	190.258s	20.957s
▶ __cos_avx	179.945s	38.086s
▶ __sin_avx	95.118s	25.432s
▶ telout_	55.212s	54.892s
▶ __tan_avx	2.140s	1.960s
▶ thick	1.880s	0.290s
▶ __ieee754_log_av	1.280s	1.280s

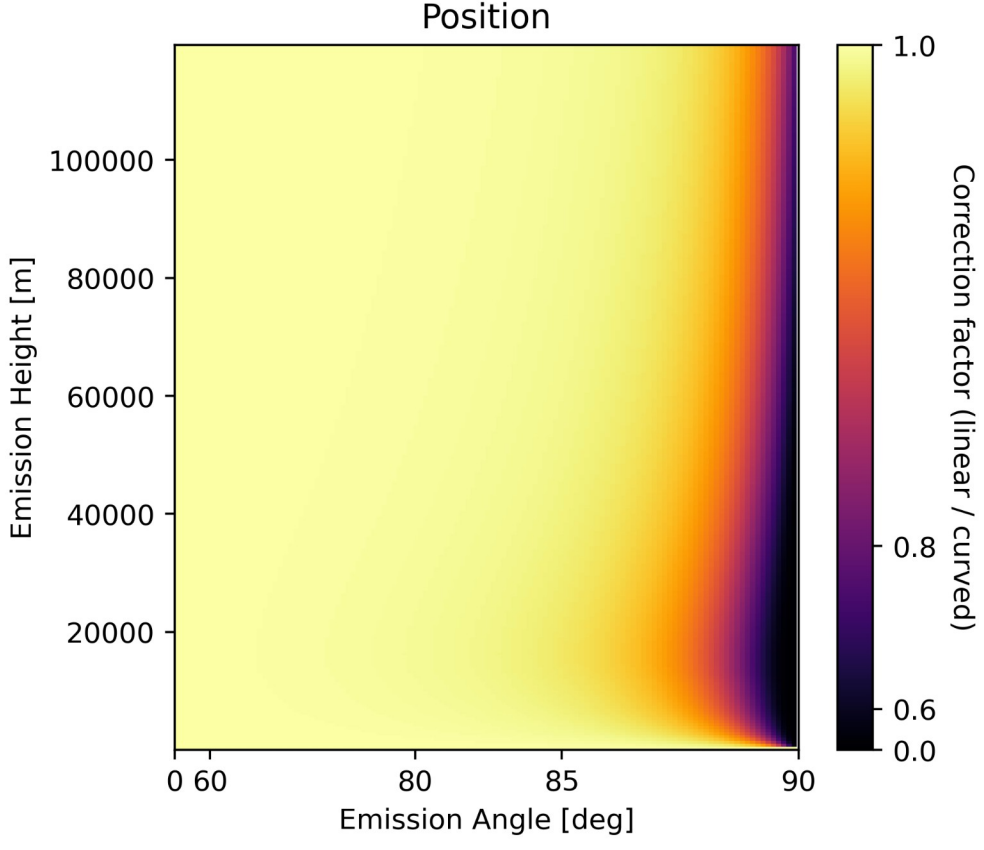
Going Parallel



Photon Propagation – Interpolation

- Straight line propagation with correction factor





Extension

- Numerical Raytracing