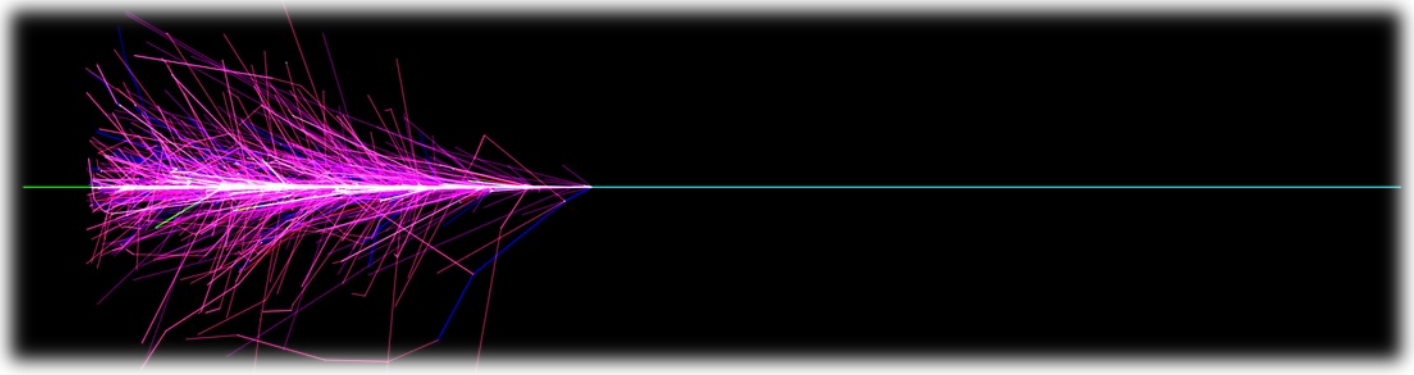
technische universität dortmund

SFB 876 Providing Information by Resource-Constrained Data Analysis

lehrstuhl physik e5



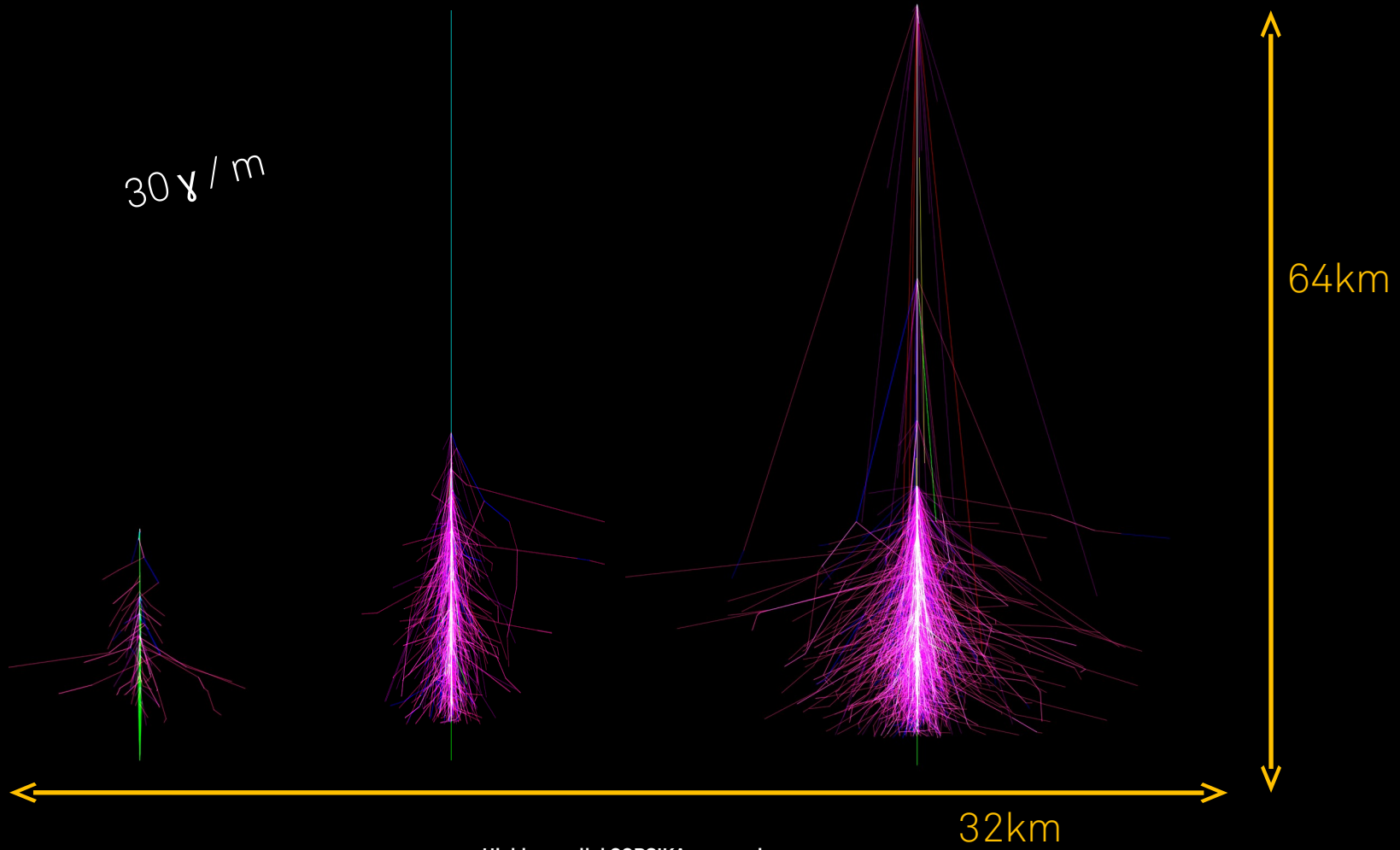
Highly parallel Cherenkov processing

Dominik Baack

Corsika Workshop

Online

24. 06. 2020



Highly parallel CORSIKA processing

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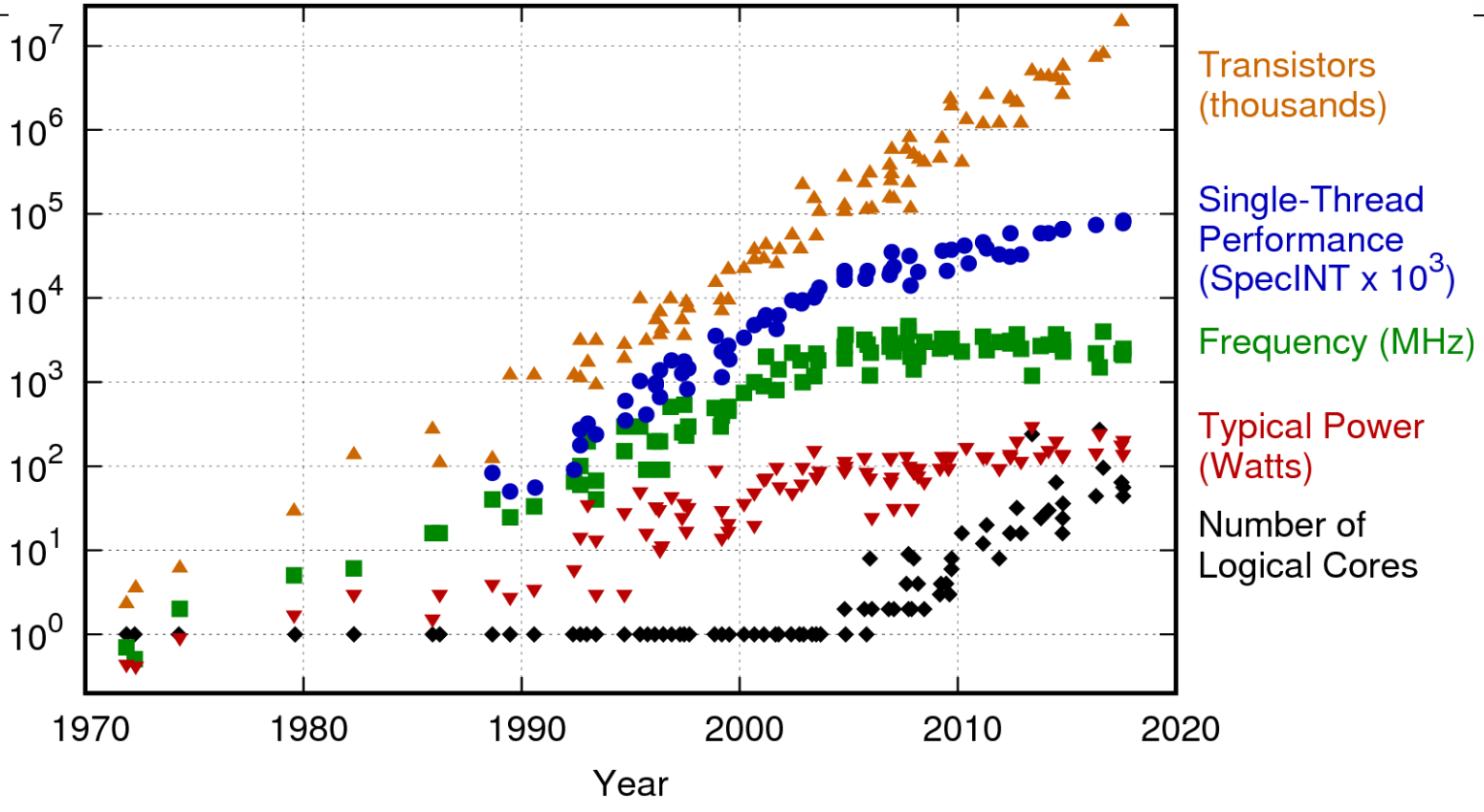
42 Years of Microprocessor Trend Data

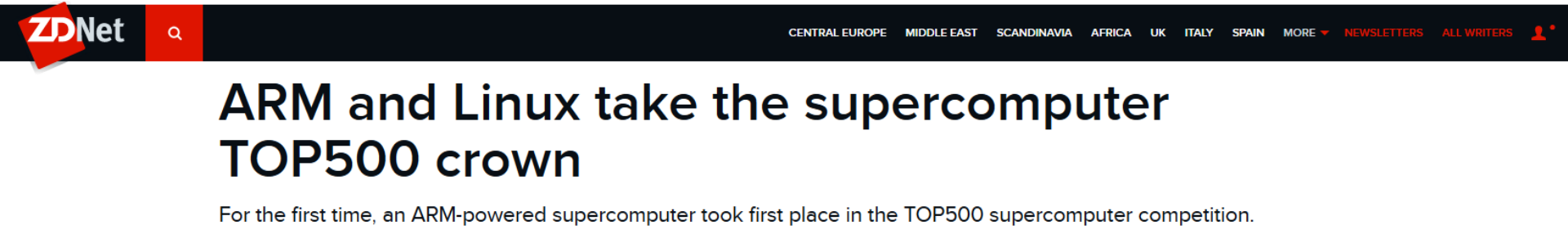


Original data up to the year 2010 collected and plotted by M. Horowitz, F. Labonte, O. Shacham, K. Olukotun, L. Hammond, and C. Batten
New plot and data collected for 2010-2017 by K. Rupp

https://www.karlrupp.net/2018/02/42-years-of-microprocessor-trend-data/

Multicore on CPU

- AMD Epyc, ARM Neovers, IBM Power9, Intel XE
  → Many core architecture



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%

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

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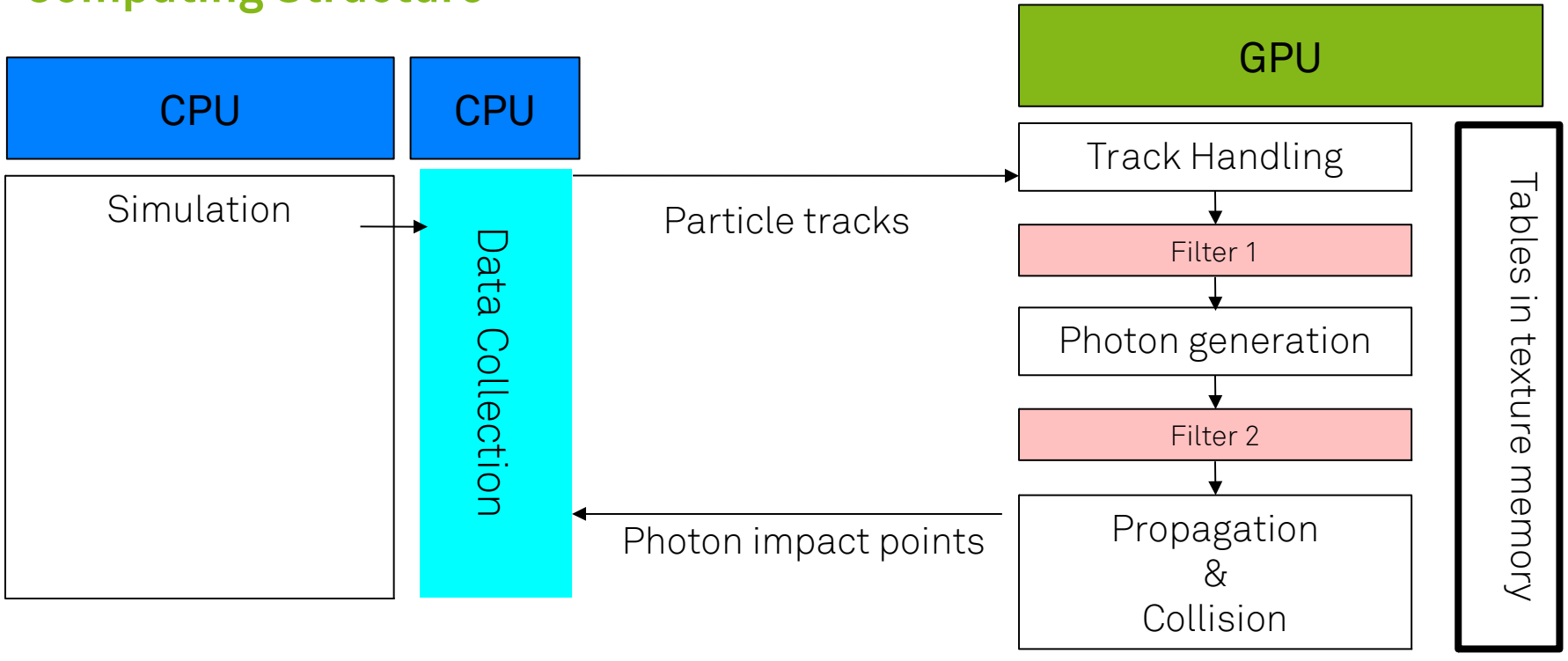
Corsika 7

High parallel Chernekov light

- Completely independent calculations for each photon
- “Simple” arithmetic no complex processes
- OpenCL allows platform independent vectorization & parallelization, first test shows good performance

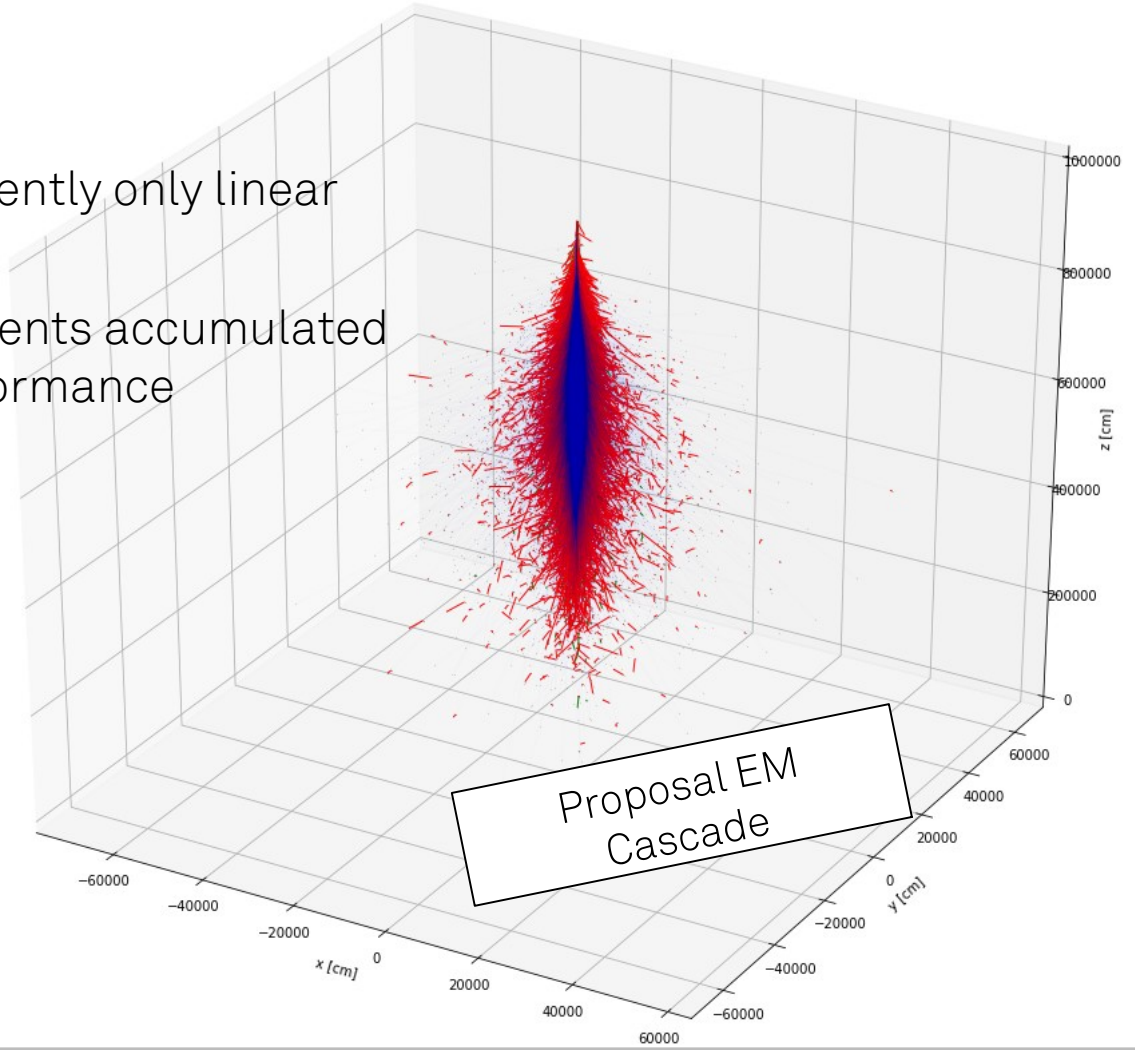
  … but …
- CUDA – Nvidia proprietary but higher performance possible

Computing Structure



Prerequisite

- Single track is currently only linear
- >>1024 track segments accumulated to reach good performance



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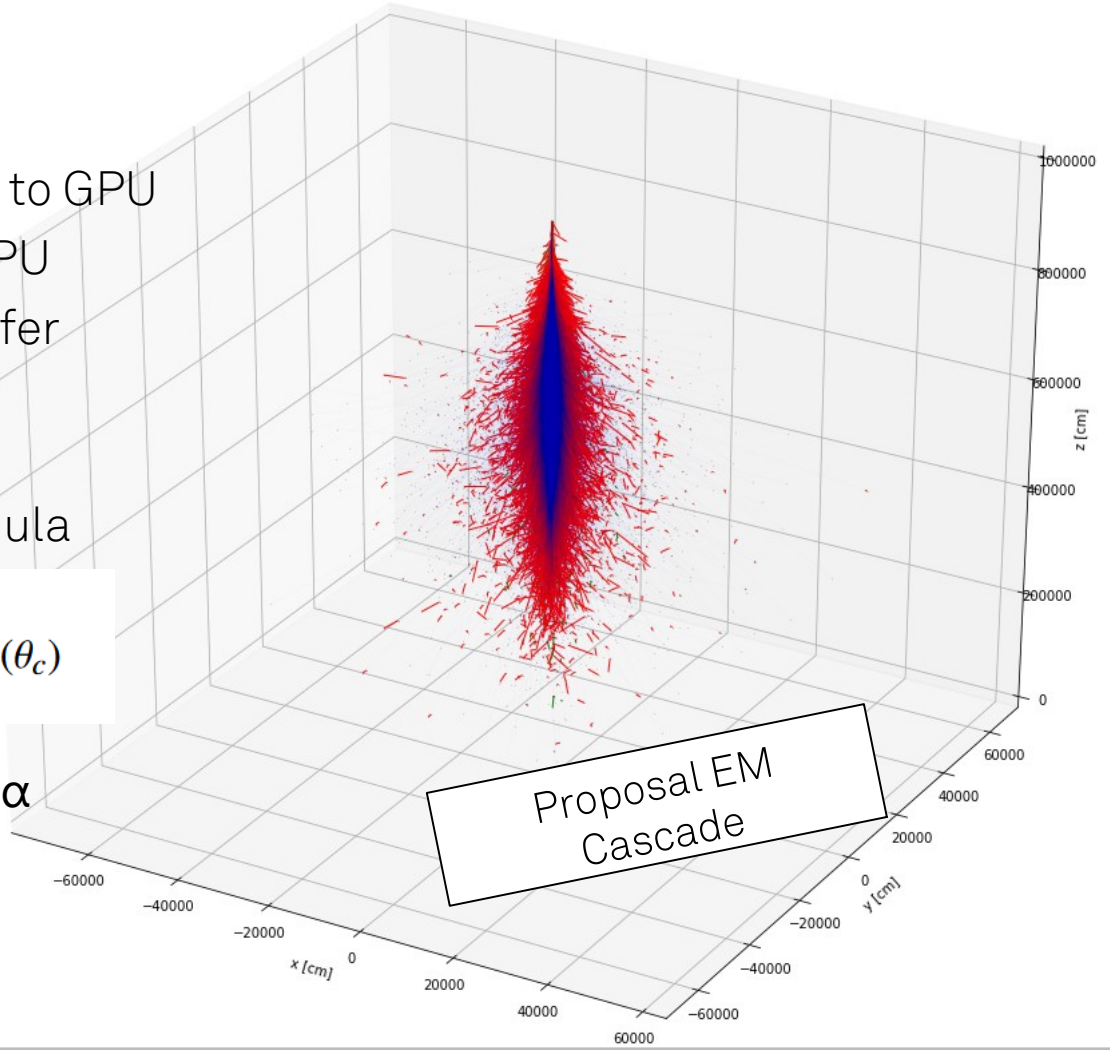
Track Handling

- Charged / All Tracks to GPU
  - More work to GPU
  - Less data transfer

- Use presolved Frank-Tamm Formula

$$\frac{d^2N}{dxd\lambda} = \frac{2\pi\alpha z^2}{\lambda^2} \cdot sin^2(\theta_c)$$

to calculate N and α



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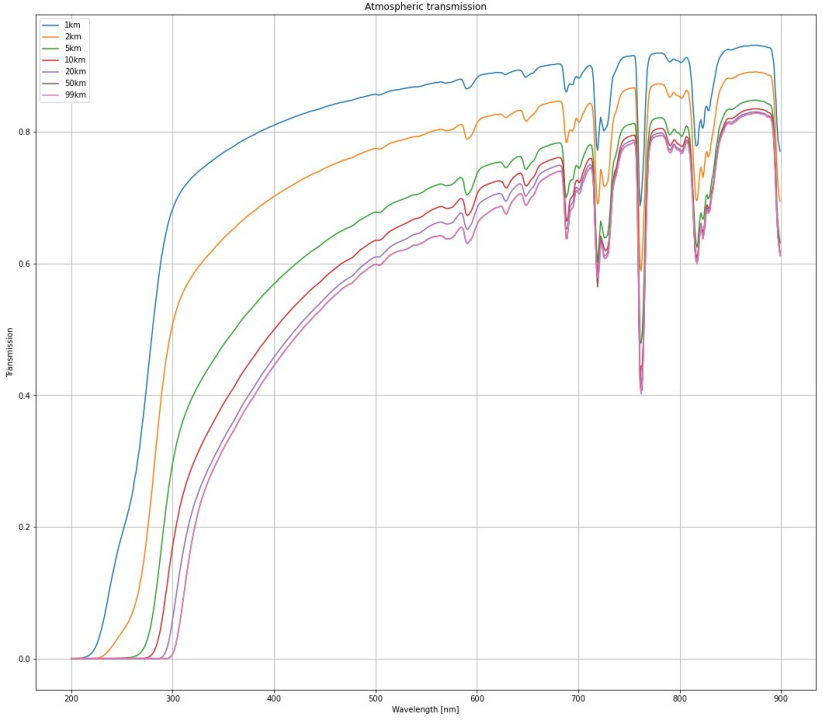
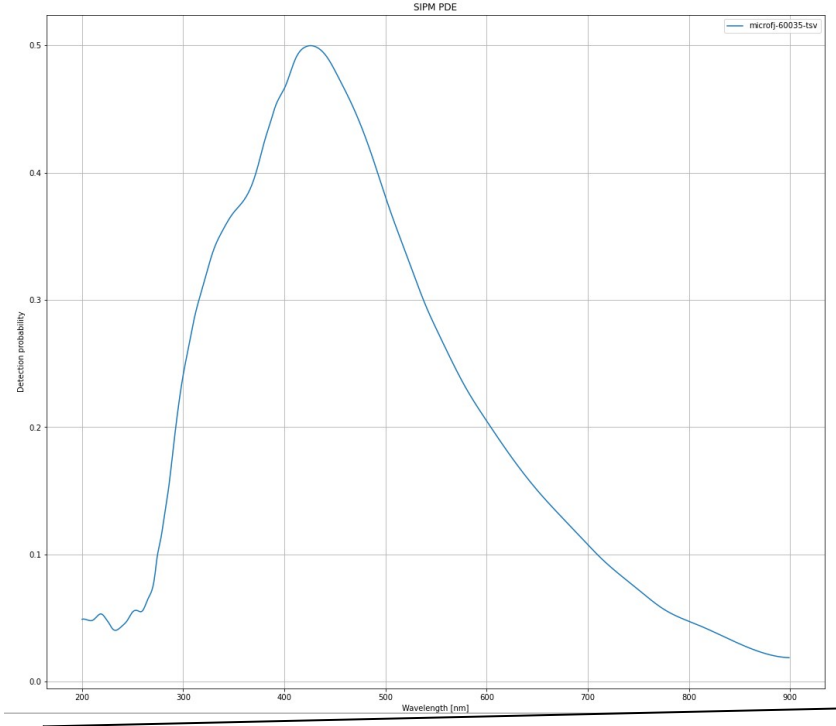
Frank-Tamm Handling





And many more possible:

- Mirror reflection
- Collimator absorption
- Filter ....

Highly parallel CORSIKA processing

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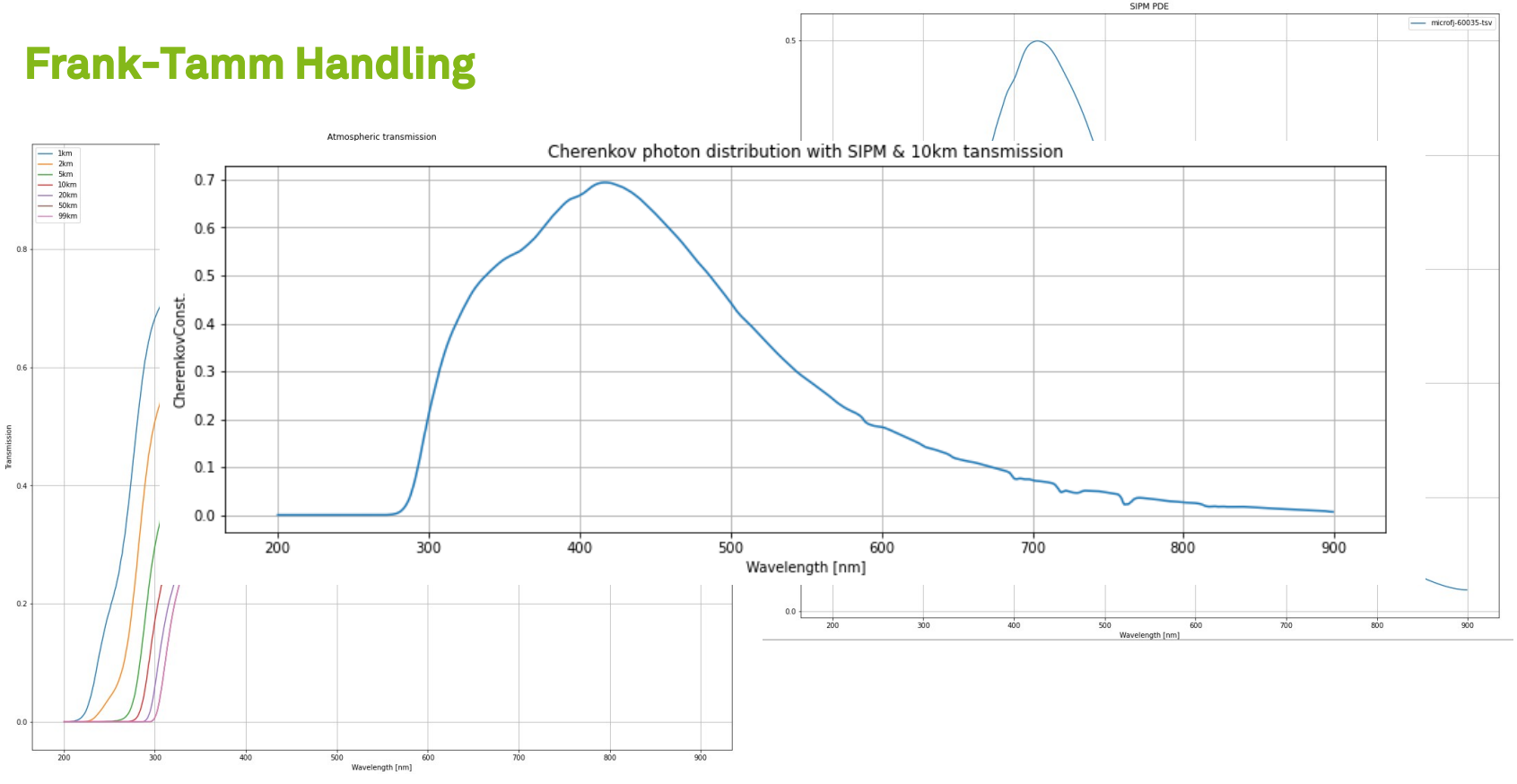
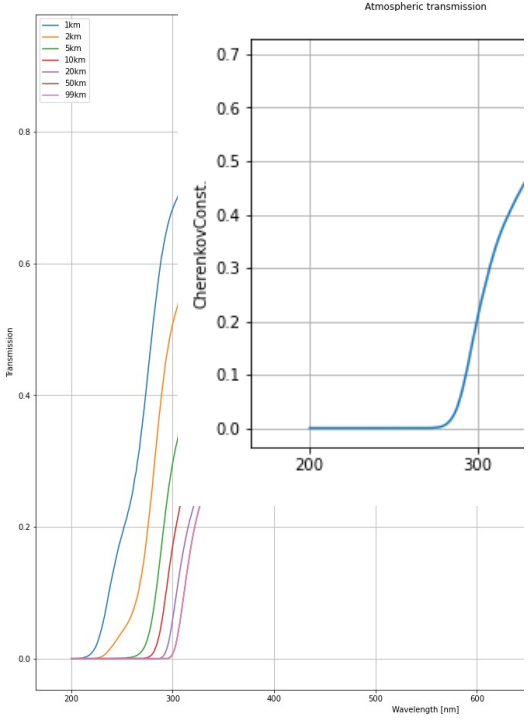
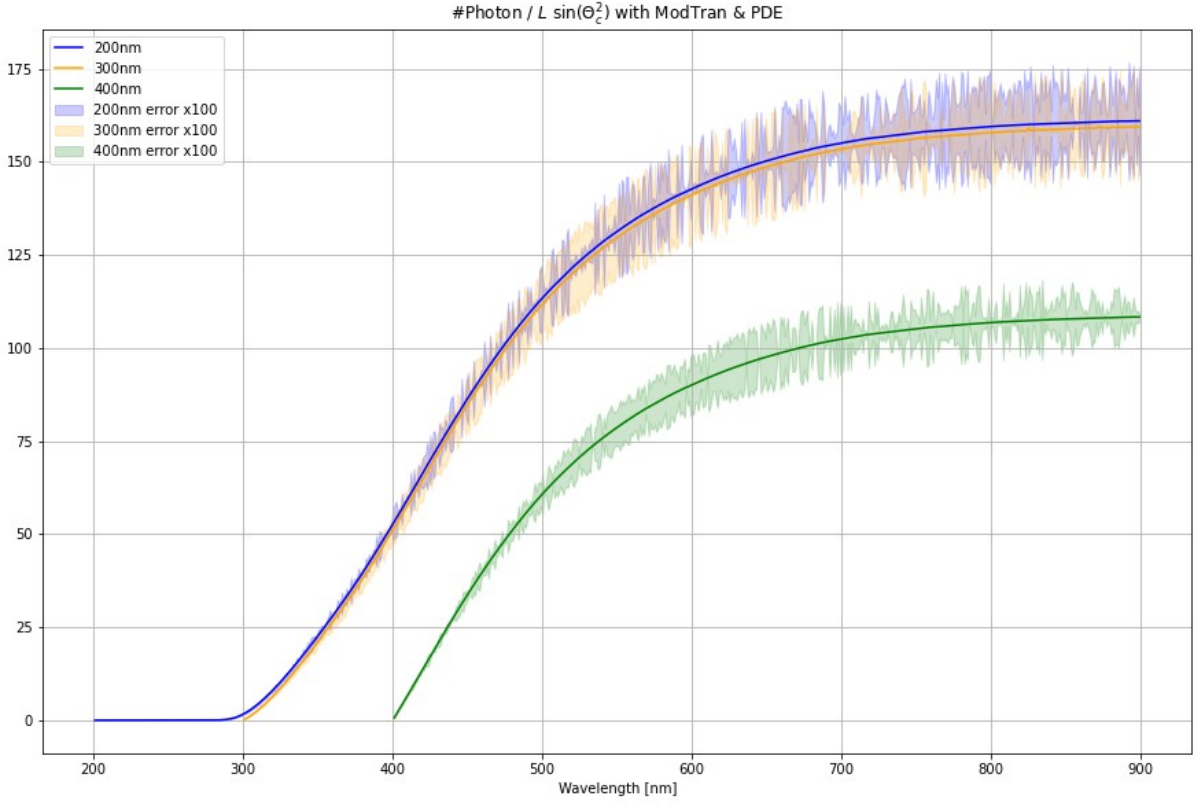
Frank-Tamm Handling



Frank-Tamm Handling





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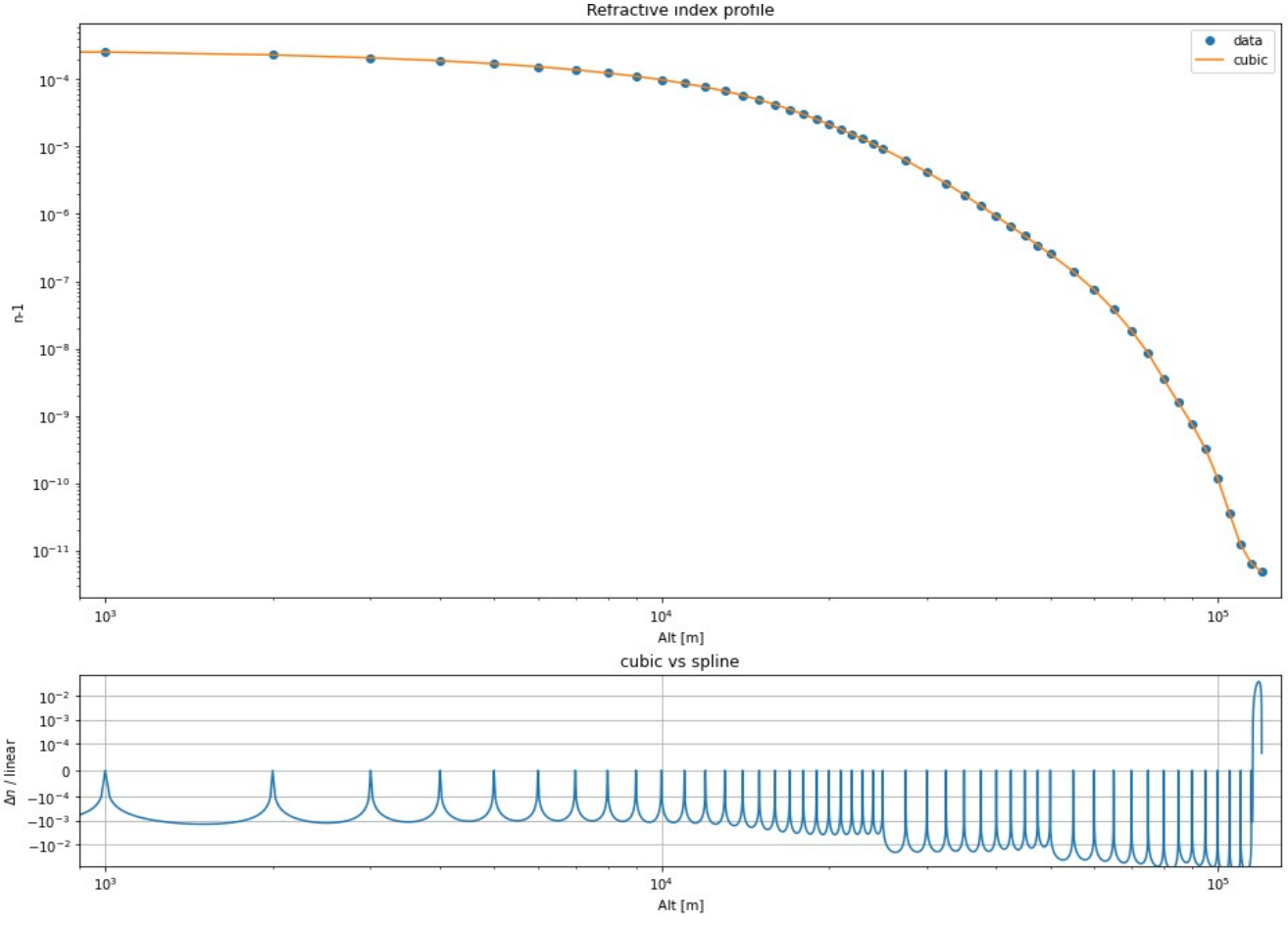
Track Handling



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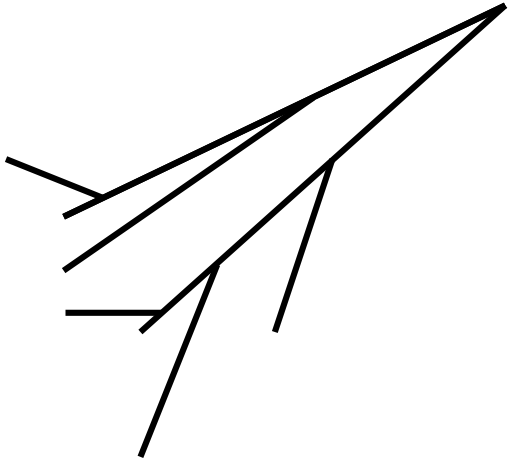
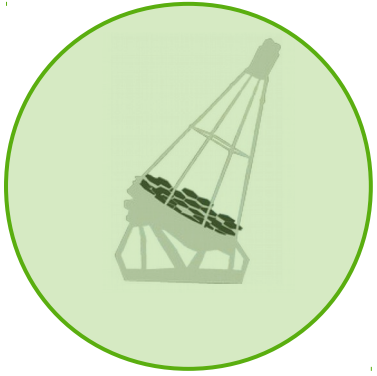
Fitler 1

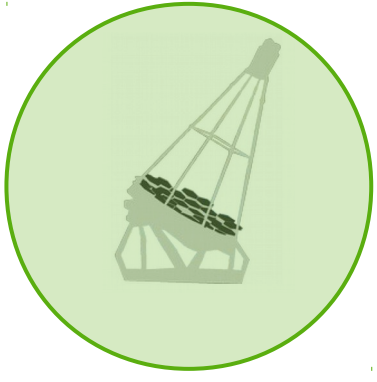
- Remove particle with angle cuts
  - p•v < cut
- Not possible with
  - diffuse Emission
  - Fluorescence





Photon generation

- Generate photons along the track
  - Single point
  - Equally spaced
  - Specific distribution
- Wavelength Information possible
  - Optical Dispersion currently slow
- Thinning possible



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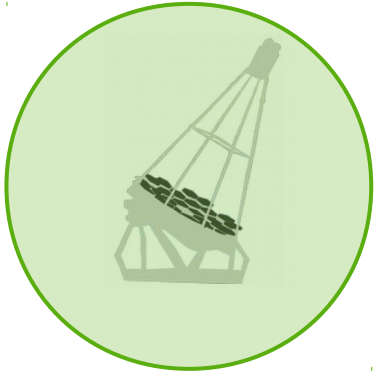
Filter 2

- Similar to filter 1 only for photons



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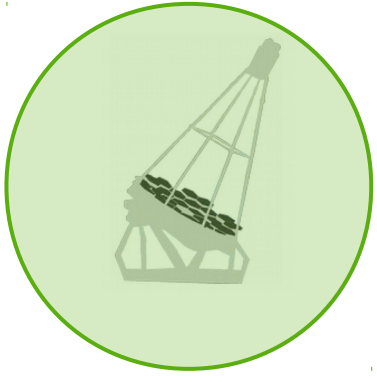
Propagation

- Propagate to observation level
  - Linear with tabulated correction factor
  - Step width with local curvature approximation

- Clip to visible area
  - Sphere around telescope



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High parallel Chernekov light

- Currently propagating ~1E6 raw photons per second easily achievable
- In Vito tests still necessary when EM-Model for Corsika8 is working
- Sorting approach to reduce “starvation” of threads in a warp currently tested