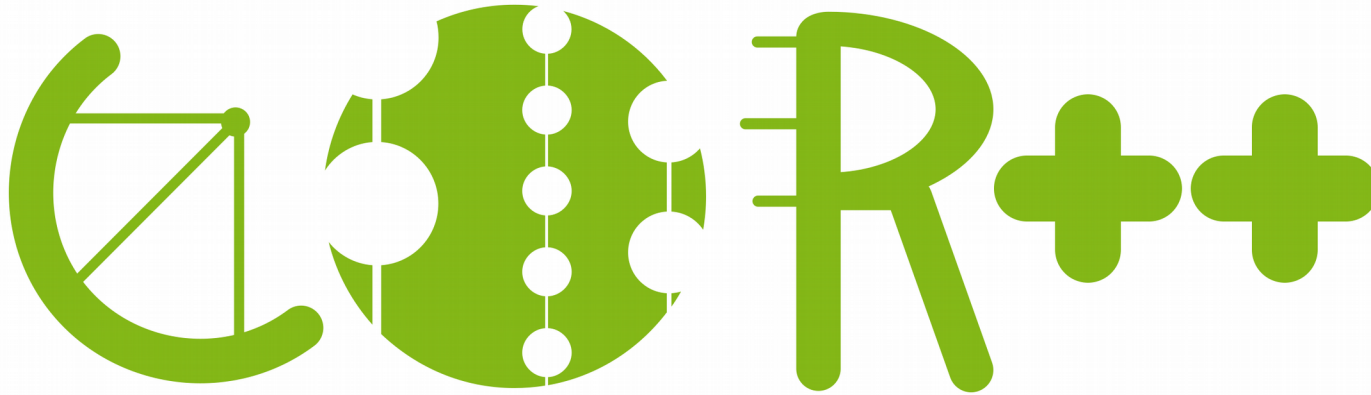




CORSIKA – GPU Computing

Dominik Baack

Next Gen Corsika Workshop

24.06.2018

Speed up Corsika

GPU Computing

- More performance than any CPU
- Performance benefit only for high parallel workload
- Performance degrades severely with branching



Pascal GP100 Block Diagram

Corsika on GPU – An economical approach

- Costs of Tesla GPU ~6000€
- Usage of OpenCL allows NVidia independent execution on multiple platforms (GPU, CPU, FPGA)
- Performance increase must outweigh additional computing node
- Computing node: 12 Cores, 64GB Ram

Corsika on GPU – An economical approach

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	44.9%
__ieee754_acos_sse2	358.305s	318.770s	89.0%
tofiip	336.495s	214.020s	63.6%
rmmard	250.622s	250.168s	100.0%
__cos_avx	192.107s	42.067s	21.9%
rhof	190.668s	21.047s	11.0%
updatc	187.214s	3.030s	1.6%
__GI__exp	180.922s	12.661s	7.0%
update	180.016s	4.380s	2.4%
__ieee754_exp_avx	166.768s	158.969s	95.3%
mutrac	165.054s	0.520s	0.3%
do_sincos_1	110.374s	55.137s	50.0%
__sin_avx	104.359s	29.603s	28.3%
telout_	55.212s	54.892s	99.4%
do_sincos_1	47.284s	25.782s	54.5%
__doasin	37.784s	1.0%	1.0%
do_cos	32.290s	1.2%	1.2%

Called several
100 Million times
2TeV

curved!

Callees	CPU Time: Total ▼	CPU Time: Self
▼ cerenk	2078.871s	533.937s
▶ distip	449.052s	203.941s
▶ tofiip	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_avx	1.280s	1.280s

Benchmark results over 2255sec

Corsika on GPU – An economical approach

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%
cere	533.937s	533.937s	93.8%
egs		0s	90.8%
en		0s	90.8%
s			90.8%
			90.7%

>80% Computing time in Cherenkov subroutine

	CPU Time: Total ▼	CPU Time: Self
tofig	2078.871s	533.937s
rmmard		203.941s
__cos_avx		214.020s
rhof		231.438s
updatc	187.214s	
__GI__exp	180.922s	
update	180.016s	4.380s
__ieee754_exp_avx	166.768s	158.969s
mutrac	165.054s	0.520s
do_sincos_1	110.374s	55.137s
__sin_avx	104.359s	29.603s
telout_	55.212s	54.892s
do_sincos_1	47.284s	
__doasin	37.784s	
do_cos	32.290s	
		1.0%
		1.2%

Benchmark results over 2255sec

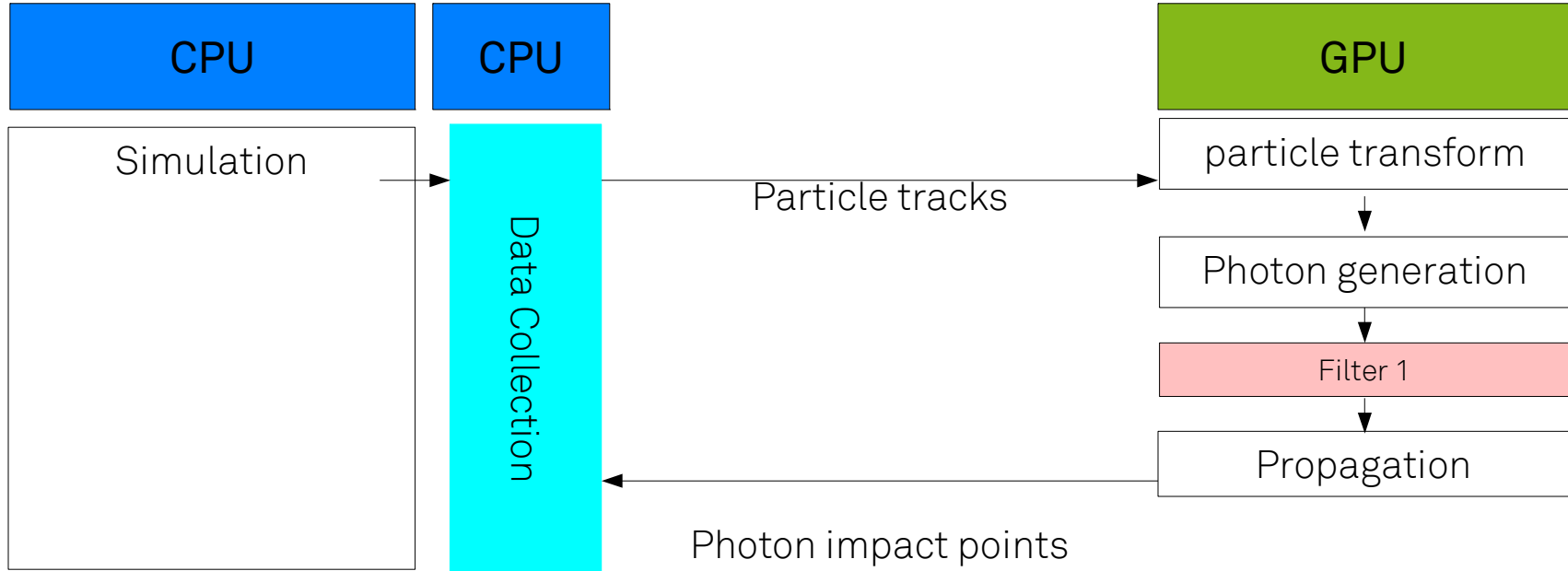
Corsika on GPU – An economical approach

- Optimization potential
- Performance needs to be at least 24x better to gain economical advantage (12 Cores)
- GPU's only for CORSIKA

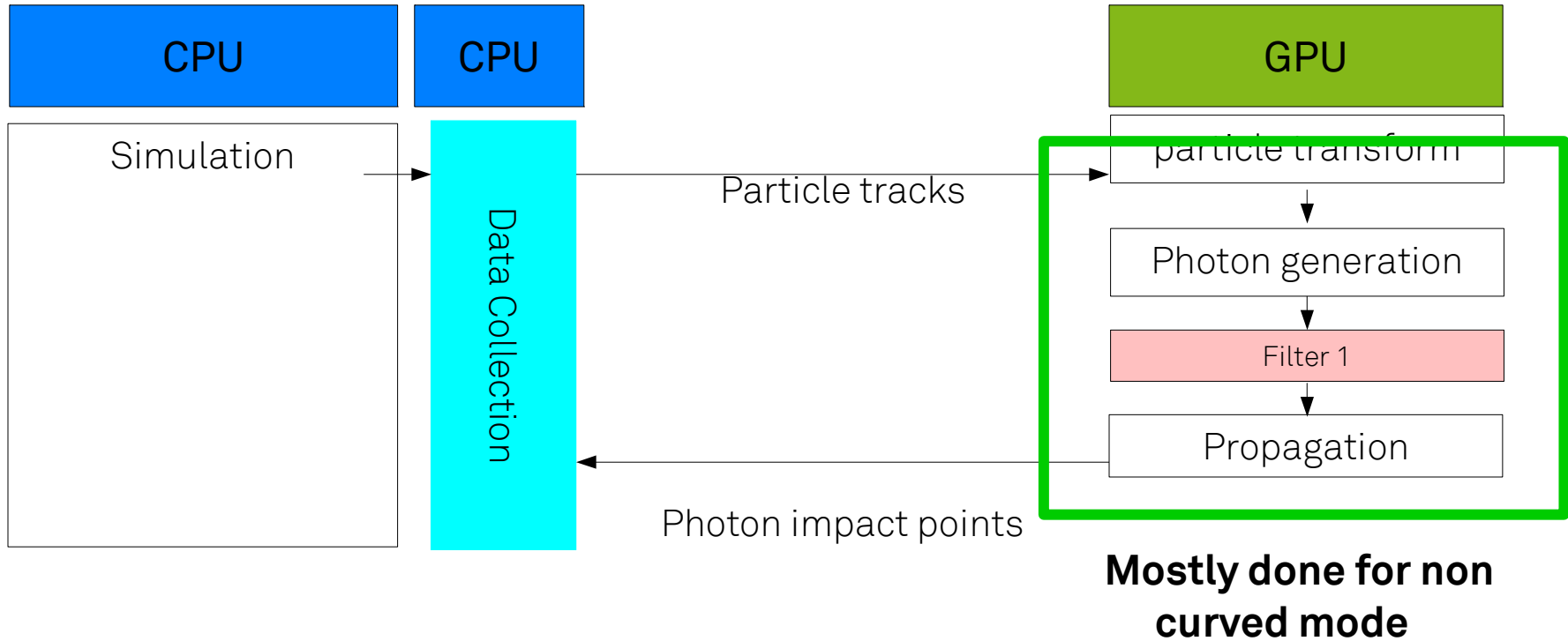
GPU Computing

- Optimize performance: Minimize IO between CPU – GPU
- Single transfer of telescope information (geometry, atmosphere ...)
- Transfer of particle tracks
- Receive photons to store

Computing Structure

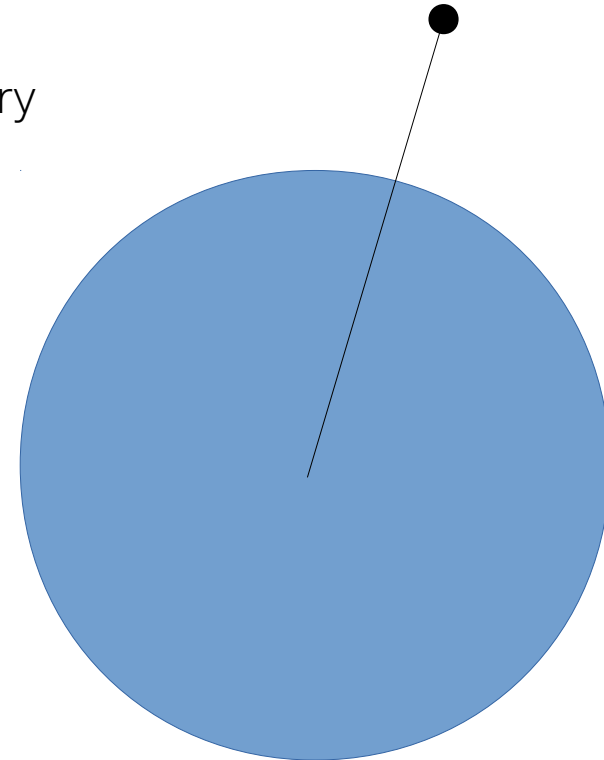


Computing Structure



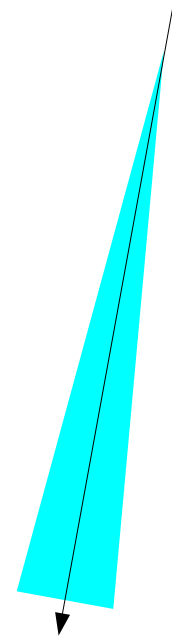
Curved

- Transform particle coordinates in cartesian system
- Currently some difficulties in understanding and optimization of the transformation and necessary calculations
- Interpolation with tables in curved :
DISTEF $\rightarrow 452 \times 360 \times 8 \sim 1.3\text{Megabyte}$
TOF $\rightarrow 452 \times 360 \times 8 \sim 1.3\text{Megabyte}$
- Atmosphere Table



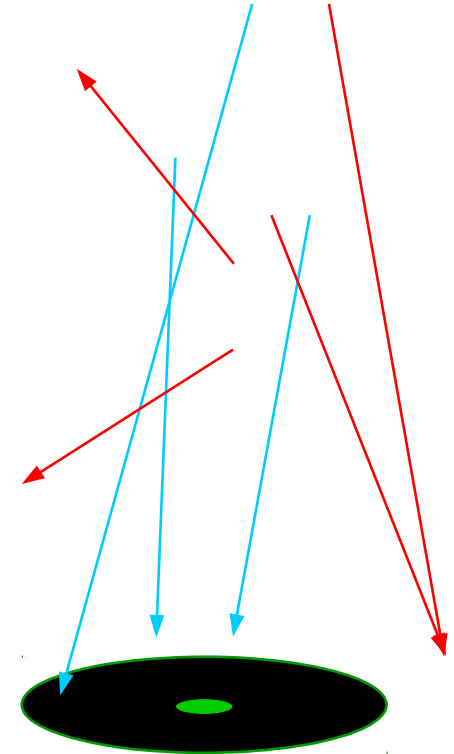
Photon generation

- Generate photons depending on local atmosphere
 - Atmosphere values used from fitted density
 - Difficult to describe complex atmospheres
 - Test to use texture memory
- Roll angle around track
- Roll position along track



Filter

- Fast hit check with straight trajectory
- Can reduce number of photon significant
- Upwards filter



Propagation & Collision

- Propagation of photons with refraction
- 1 Step per workitem
- Collision test with observation plane
- Possible to add experiment geometry
- Scattering currently ignored (e.g. calima)

