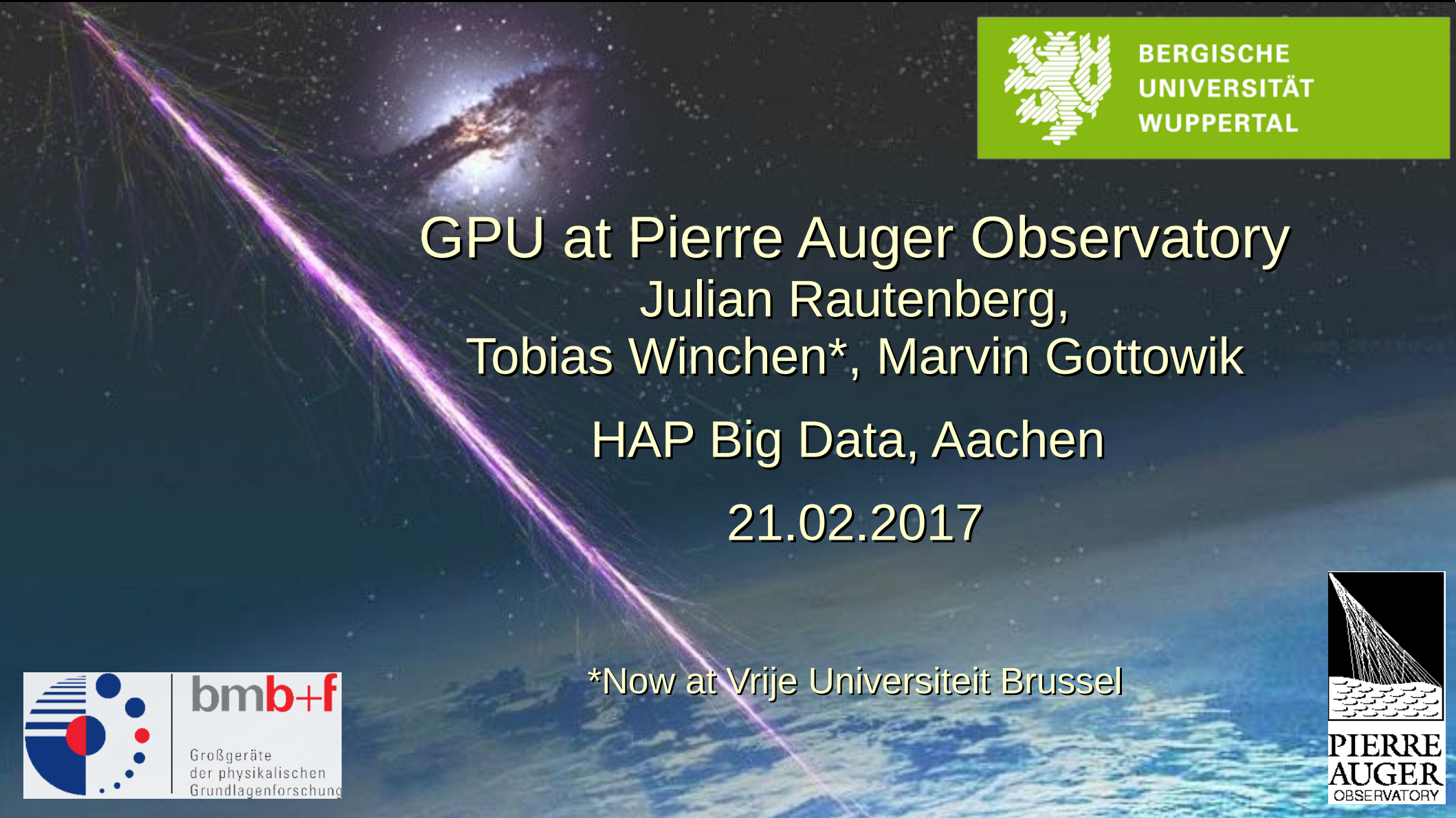


GPU at Pierre Auger Observatory

Julian Rautenberg,
Tobias Winchen*, Marvin Gottowik

HAP Big Data, Aachen

21.02.2017

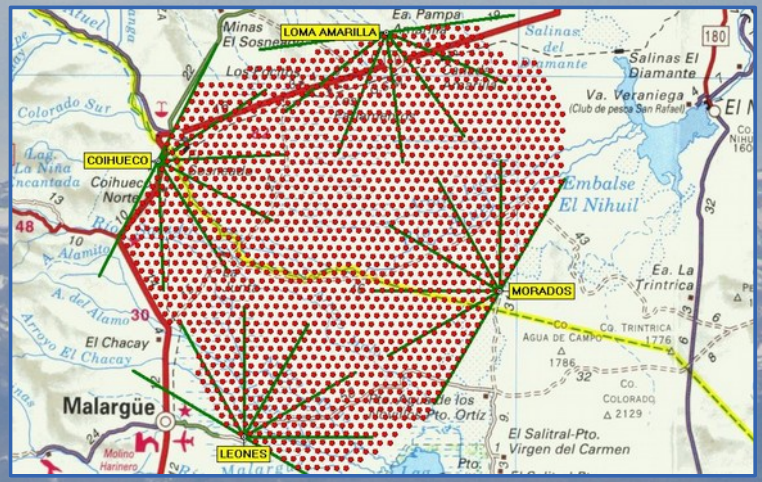
*Now at Vrije Universiteit Brussel

BERGISCHE UNIVERSITÄT WUPPERTAL

bmb+f
Großgeräte der physikalischen Grundlagenforschung

PIERRE AUGER OBSERVATORY

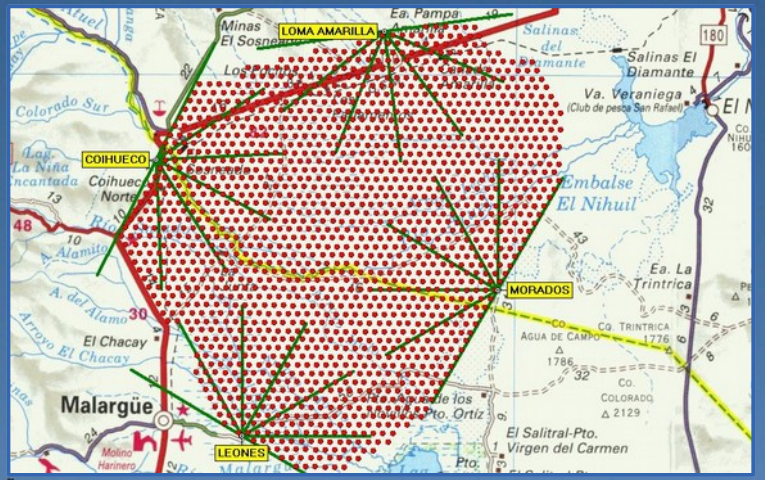
Surface Detector (SD)



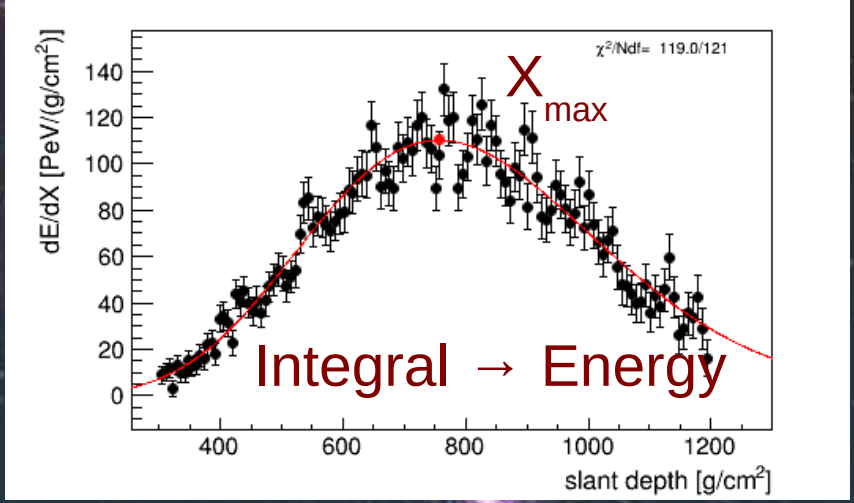
1660 Detectors
1.5 km spacing
Triangular grid
Continuous data-taking
Infill on half gridsize

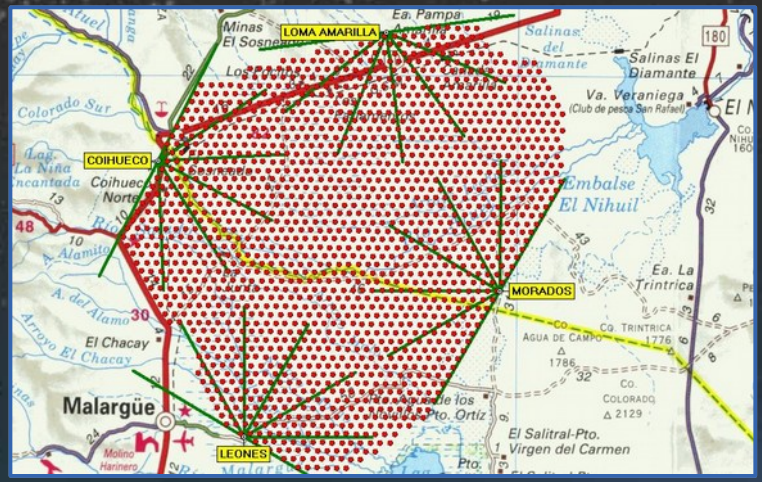
The Pierre Auger Cosmic Ray Observatory, NIM A 798 (2015) 172-213

Fluorescence Detector (FD)

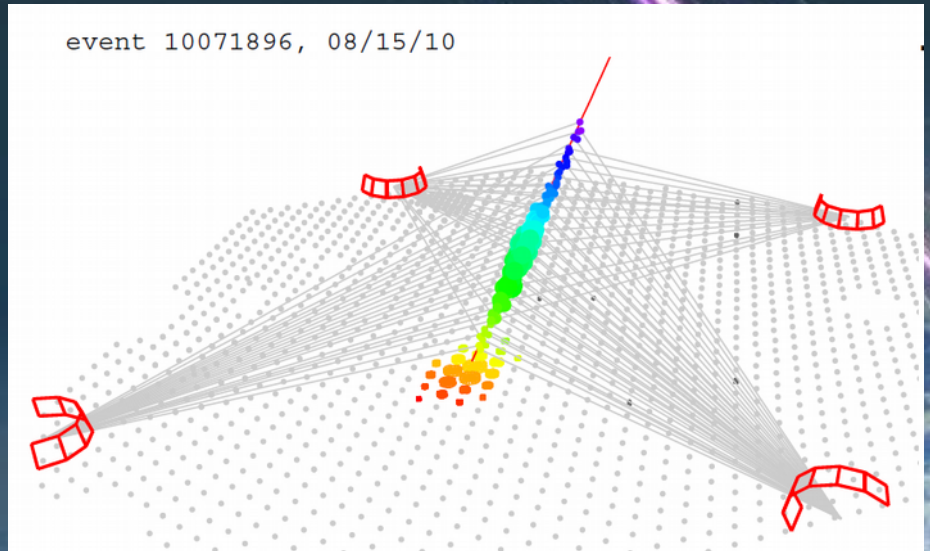


The Pierre Auger Cosmic Ray Observatory, NIM A 798 (2015) 172-213

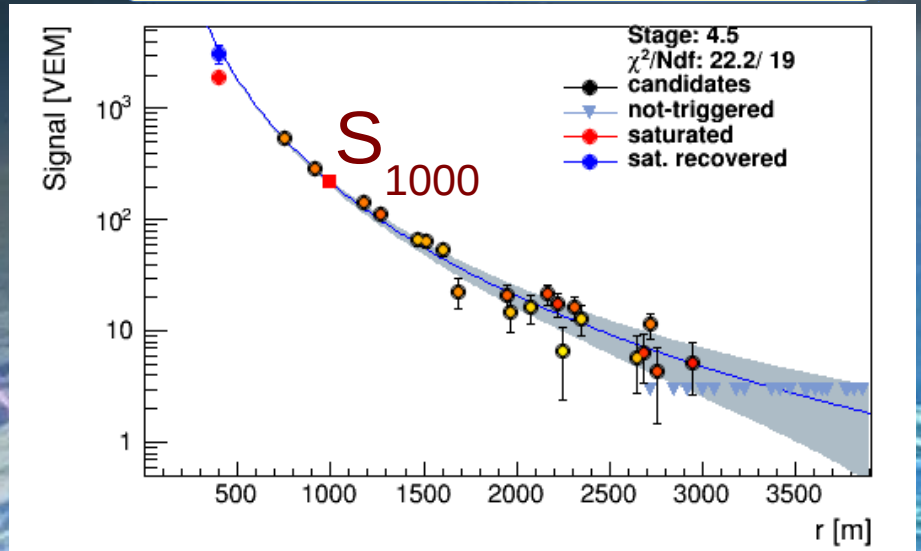




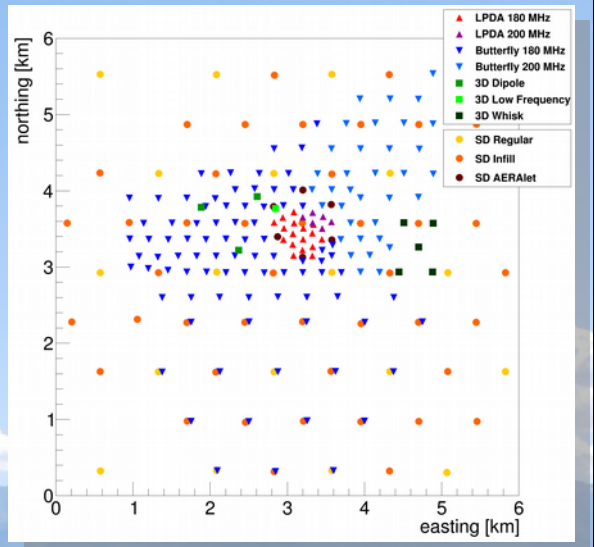
FD: longitudinal development



SD: lateral distribution



Radio Detector (RD)



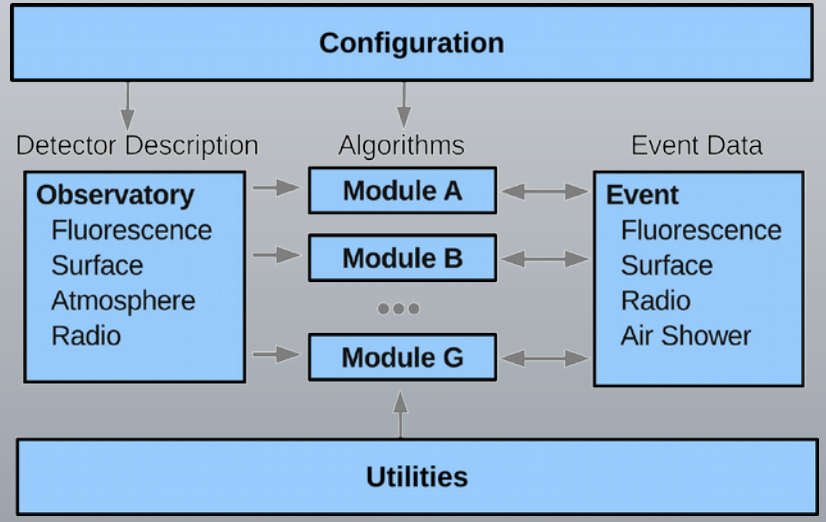
Deployed in three phases:
Phase I: 24 RDS in 09/2010
Phase II: +100 RDS in 05/2013
Phase III: +25 RDS in 02/2015

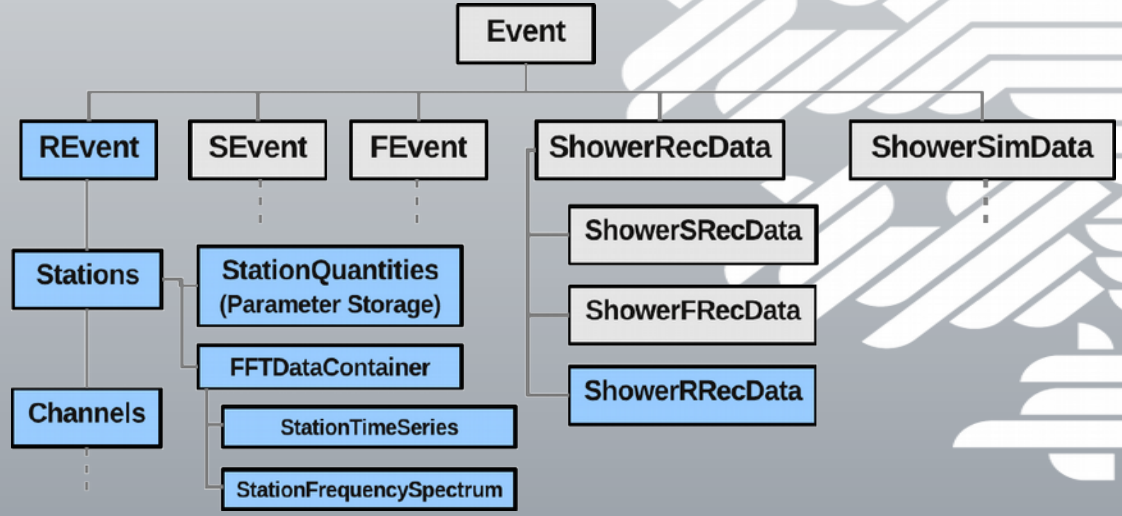
Four grid spacings:
150, 250, 375 / 750 m

Two antenna types

Reconstruction Framework

- Pierre Auger Framework **OffLine** – NIM A 580 (2007) 1485
- Modular setup with main components Detector- and Event-Class
- Extension for Radio Data and its Reconstruction – NIM A 635 (2011) 92





Reconstruction of Radio data

Front-End measures 2 Channels voltage traces

Analog components to be applied

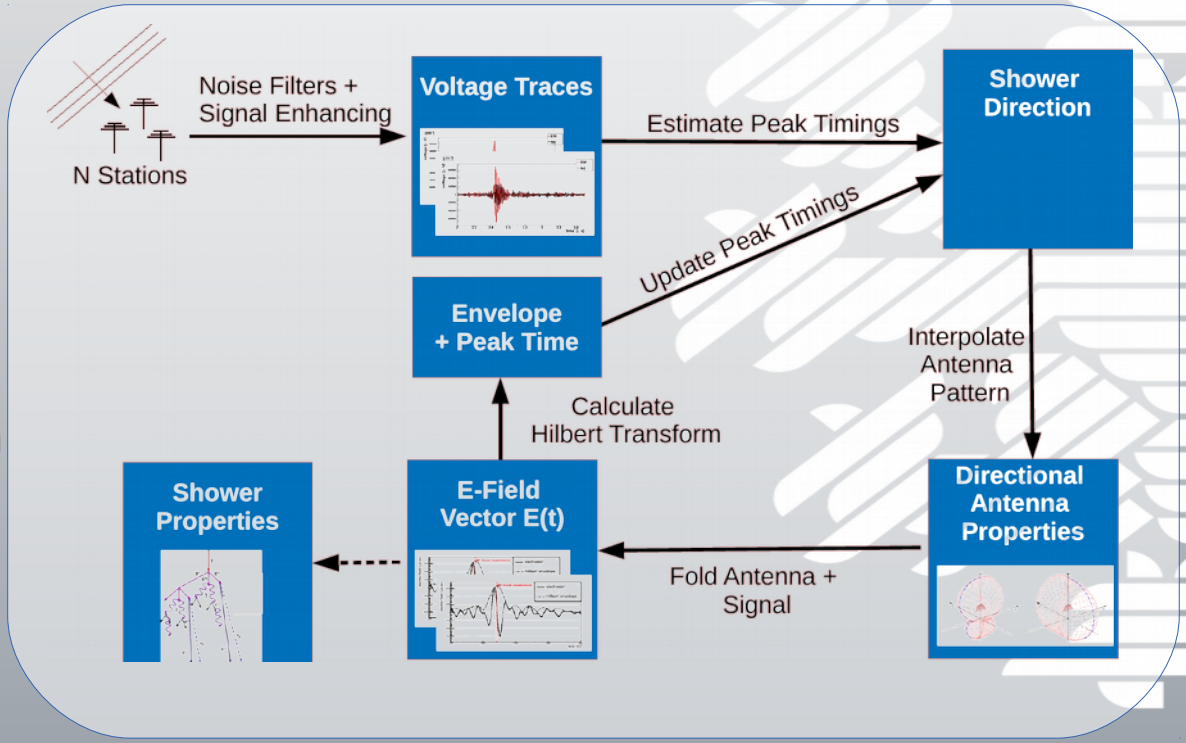
Corrections in frequency/time space

A lot of FFTs

Antenna properties are directional dependent

Iterative procedure for reconstruction of shower direction

At the moment: no iteration but use Surface Detector seed for direction



Profiling of Radio Reconstruction

Identification of bottlenecks

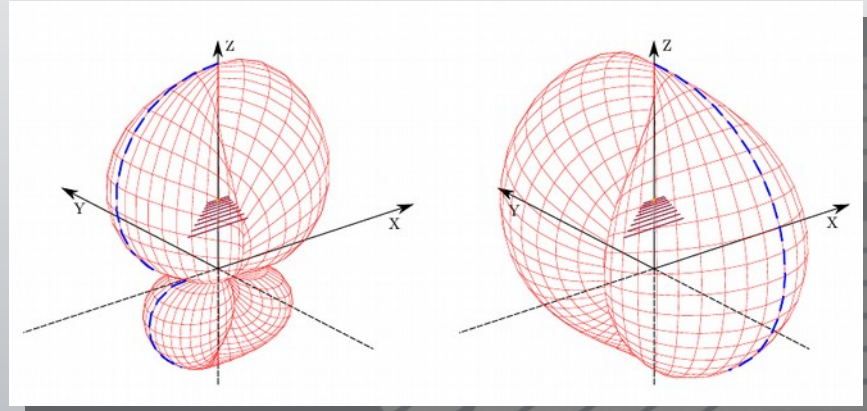
Differnt tools used:

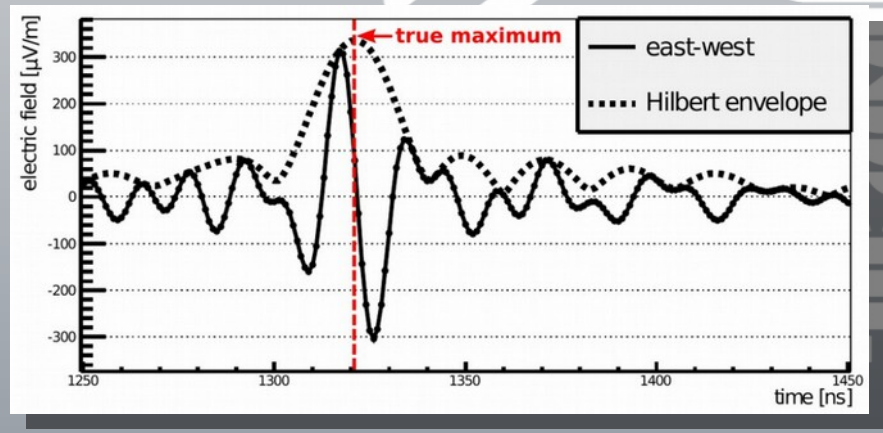
- Google-perftools + kCachegrind
- Valgrind + kCachegrind
- Intel VTune
- Linux kernel profiler (perf)

General conclusion:

25%	Interpolation of antenna pattern 25%
15%	FFT
<5%	Rest

Approach: only cpu-intensive parts to GPU
minimal invasive





GPU porting of Interpolation

Specific Task:

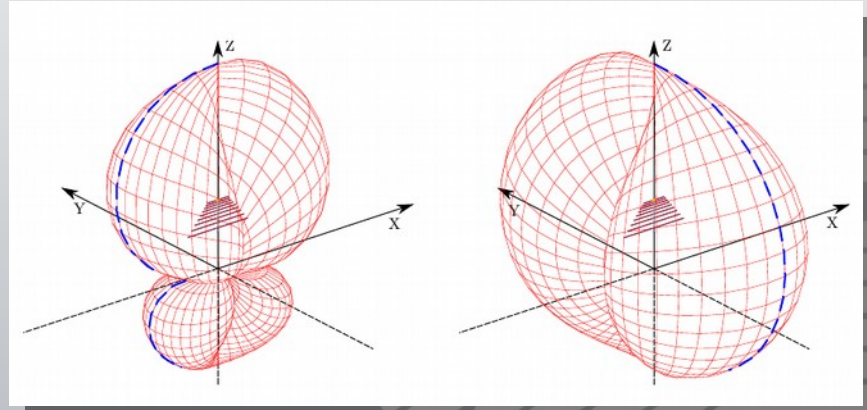
Few (~6) independent Patterns

2 Channels / Pattern

~ 80 frequencies, 180 x 90 angles

Theta / Phi Component Complex Numbers

Linear interpolation



Solution:

Bind Antenna Patterns as textures on GPU

Use texture interpolation

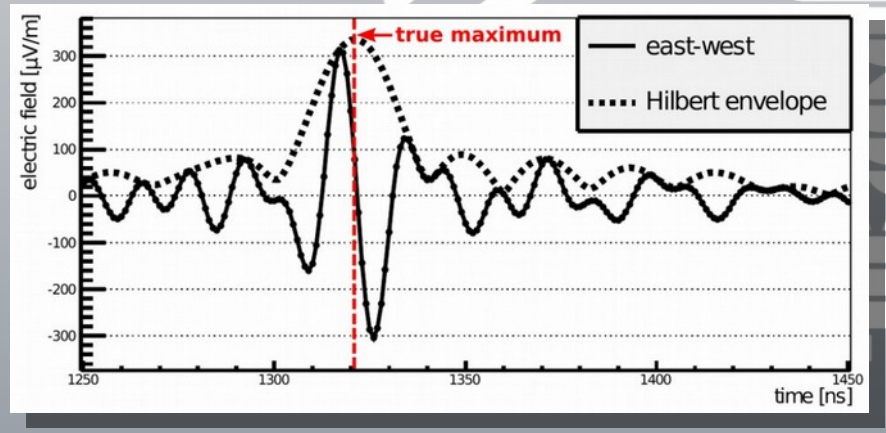
> 100x Speedup

GPU porting of FFT

OffLine uses data-container for FFT, that updates time/frequency only when requested

1D-FFT, 2D-FFT by wraper class to interface FFTW

Replaced by class to interface CuFFT



GPU porting of FFT

OffLine uses data-container for FFT, that updates time/frequency only when requested

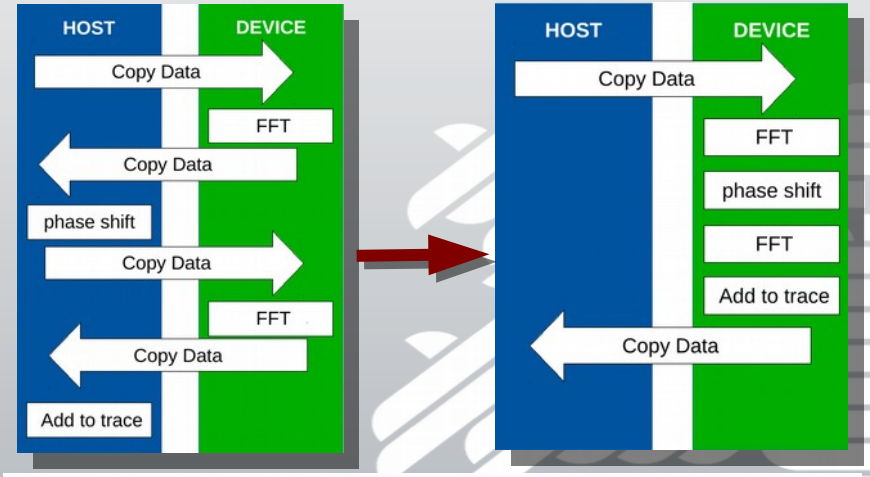
1D-FFT, 2D-FFT by wraper class to interface FFTW

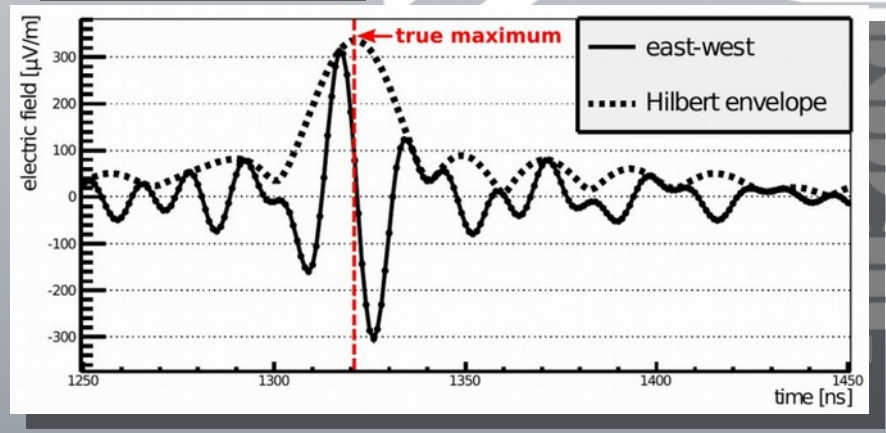
Replaced by class to interface CuFFT

For envelope use geom. sum with Hilbert transform (phase-shifted spectrum)

Avoid data copy to GPU:
also phase-shift and addition on GPU

Time used in Cuda negligible





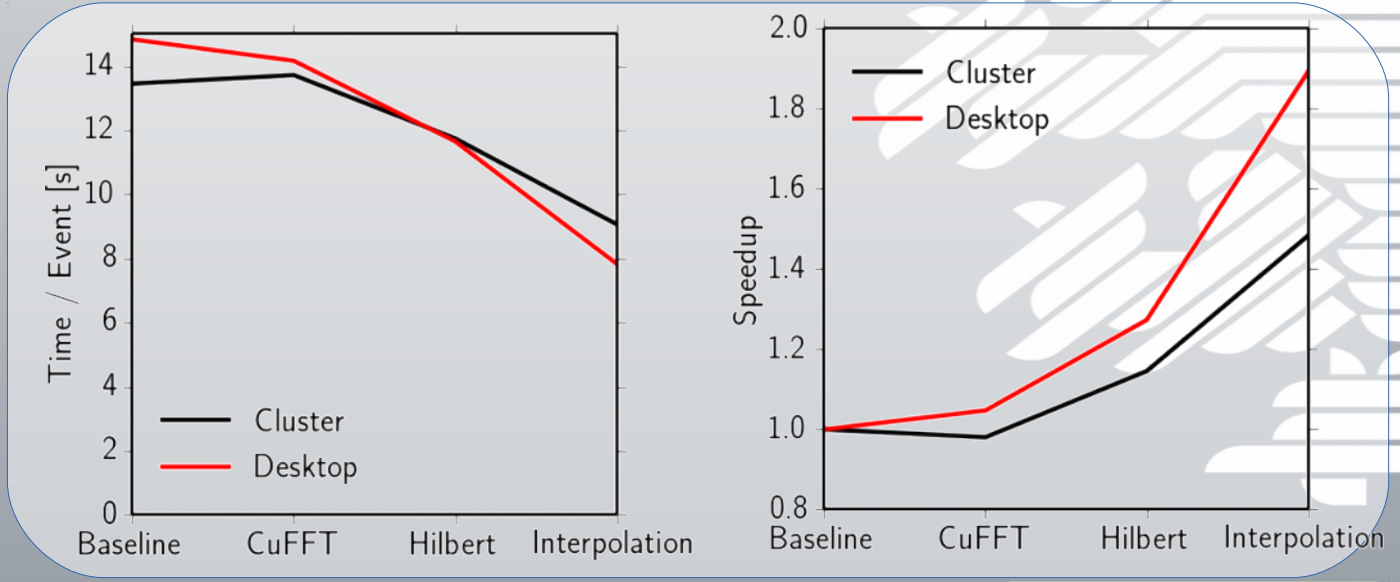
GPU porting Evaluation

GPU implementation tested on:

- Cluster with Intel Xeon X5650 @ 2.7 GHz / Tesla M2090
- Desktop with AMD A8-6600K / GeForce 750 Ti, Cuda 6.0

Total speedup x1.5 – x1.9

Lot of time spent with IO and structure.



GPU in Pierre Auger Framework: Status

Cuda support implemented in Framework OffLine

Implementation using pre-compiler flags fully transparent

CMake flag activated if Cuda available

At the moment no cluster used for Collaboration reconstruction,
only used by individual groups

For non-iterative reconstruction speedup x2
not enough for dedicated cluster maintenance

Benefit of general profiling of same scale

Major cpu-rescource used for GEANT4 simulation, not reconstruction