Corsika 8 - Cherenkov Module

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Thesis - Optimization of HPC code for Gamma Ray experiments

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Branch link : https://gitlab.ikp.kit.edu/AirShowerPhysics/corsika/-/tree/275-Cherenkov-module

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Context

My thesis - Objectives

- Reduce CPU time for corsika simulations
- Keep same physics results
- Consider the context : CTA (Cherenkov Telescope Array)

Context

My thesis - Workload

- First part : Optimize Corsika 7.6900 (speedup : 1.25 for the same results)
- Second part : Develop Cherenkov Module in Corsika 8
- Third part : Optimize Cherenkov Module in Corsika 8

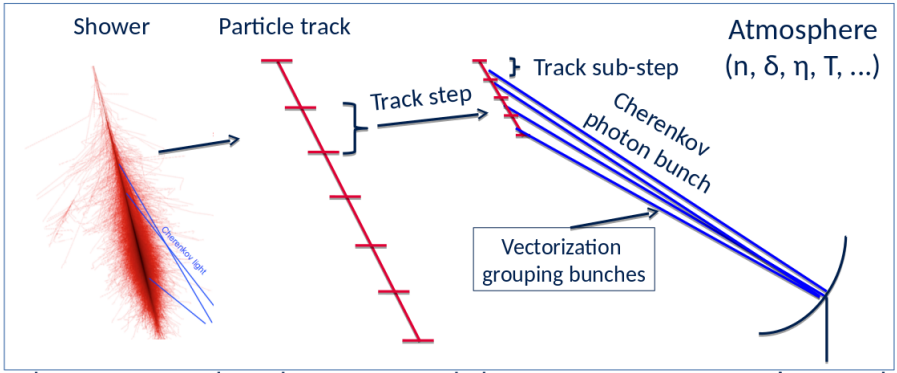
Context

Why Cherenkov Module ?

- Important for CTA experiments
- Represents >70% of time elapsed
- Good potential for vectorization

Reminders & Strategy

Simulation in Corsika 7



Reminders & Strategy

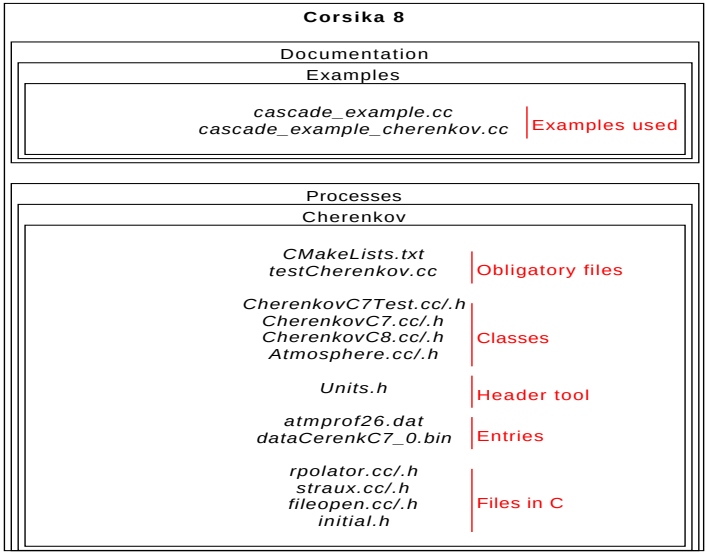
Work in progress

- One Process Cherenkov Module and 3 differents implementations (same Corsika 7 algorithm for CherenkovC7Test/C7)
- 2 atmospheres models :
  - Tabulated atmospheric model like IACT/atmo for Cherenkov Module (C7) and a future process (C8T)
  - Analytic model of Corsika 8 (C8)

Class	Process	Cerenk Entries Type	Atmosphere Type
CherenkovC7Test	Base	C7	C7
CherenkovC7	Continuous	C8	C7/C8
CherenkovC8	Continuous	C8	C8/C8T

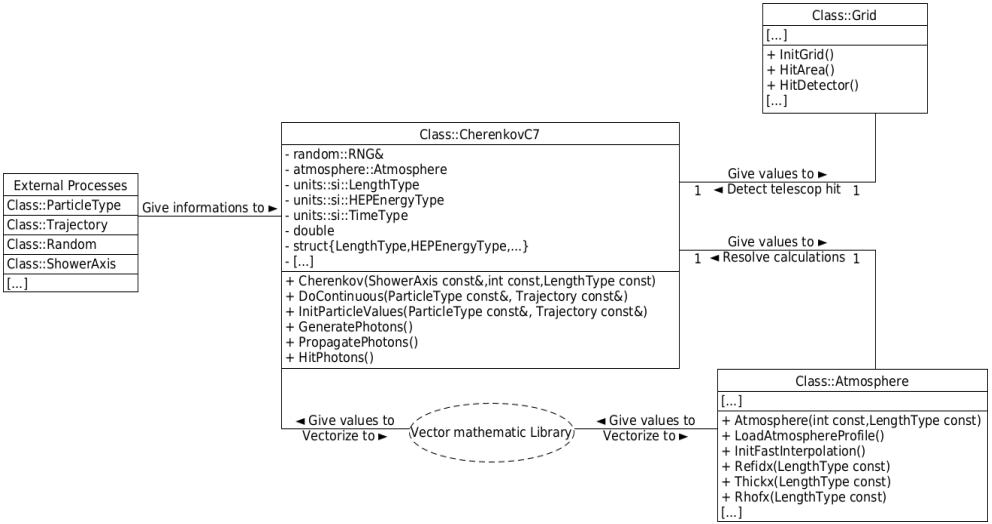
Reminders & Strategy

Cherenkov Module - Files



Reminders & Strategy

CherenkovC7 / CherenkovC7Test - Class Diagram



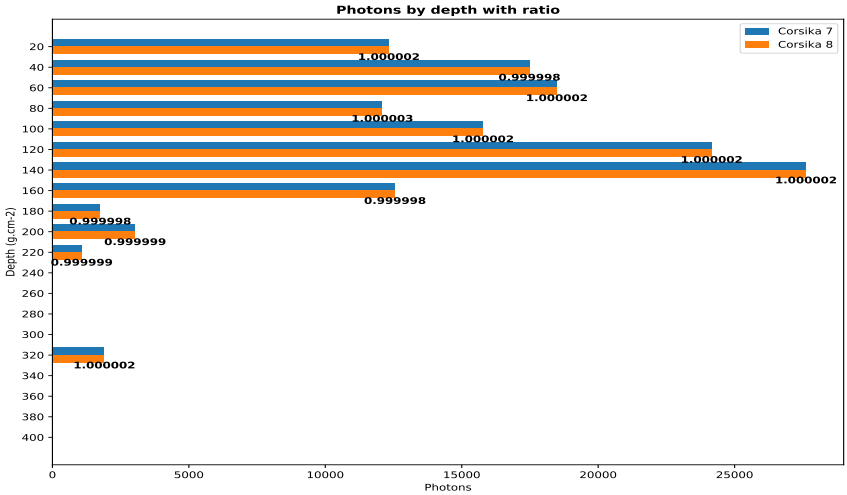
First results

Test Protocol

- Goal : Compare results of a Corsika 7 Cherenkov simulation in framework Corsika 8 (CherenkovC7Test) with a real Corsika 7 simulation
- Experiment : INPUTS_CTA_PROD3-Paranal-baseline-template-20deg-nopipe
  - 1 air shower
  - Atmosphere n°26 in Corsika 7 (tabulated atmospheric profile)
  - Incident particle : Proton
- Tools :
  - Corsika 7.7100 modified to export entries and values
  - CherenkovC7Test reads Corsika 7 entries and export values
  - A python script reads files and analyzes them (details information on photons)

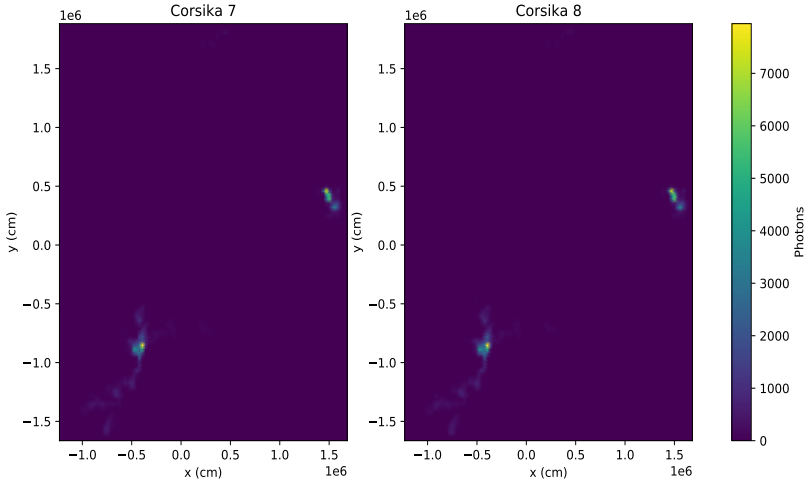
First results

Corsika7/CherenkovC7Test - Photons by depth



First results

Corsika7/CherenkovC7Test - Photon's position in CORSIKA detection plane



First results

Corsika7/CherenkovC7Test - Some numbers

```
### CORSIKA 7
## Telout
-------------------------------------------------------------------------------------------------------------------
#Value                        Sum                Average            Ecart_Type                  Min                  Max
-------------------------------------------------------------------------------------------------------------------
#Photons          148260.659425902          4.847495813          0.262473378          0.050897517          4.999553250
#PosX (cm)    6270363549.154823303       205014.338700501       942000.116876823    -1227570.906808319      1682505.188875718
#PosY (cm) -13826466916.713527679      -452066.925509679       711135.077469372    -1664262.043104748      1882506.498548123
#Uemis             -8889.634314276         -0.290653402          0.282007899          -0.646297248          0.220877322
#Vemis             -1485.255146541         -0.048561555          0.198425674          -0.387735857          0.571234063
#Cartim (ns)   13259555298.979465485       433531.315971210       8020.045922023       422503.948238014      459520.298424724
#Zemis (cm)    56621985671.517272949      1851299.188213741       458201.481430887       944505.171285555      3160498.840138351
Number values :  30585

### CORSIKA 8
## Telout
-------------------------------------------------------------------------------------------------------------------
#Value                        Sum                Average            Ecart_Type                  Min                  Max
-------------------------------------------------------------------------------------------------------------------
#Photons          148260.659397450          4.847495812          0.262473384          0.050897517          4.999553250
#PosX (cm)    6267892348.225929260       204933.540893442       941987.193866601    -1231971.472259758      1679408.759381398
#PosY (cm) -13828136178.390563965      -452121.503298694       711208.232609945    -1659496.303283561      1878975.414993426
#Uemis             -8890.781707839         -0.290690917          0.281987148          -0.646265381          0.218260287
#Vemis             -1486.149441237         -0.048590794          0.198467586          -0.386909183          0.571265390
#Cartim (ns)   13259596640.028072357       433532.667648458       8020.633336553       422504.245989671      459703.813963975
#Zemis (cm)    56621985671.517272949      1851299.188213741       458201.481430887       944505.171285555      3160498.840138351
Number values :  30585
```

Next Steps

- Need to optimize precision of results about Cherenkov Module opposite to Corsika 7
- Add a simple grid to save cleanly photons information
- Use atmosphere/environment in framework and add tabulated atmospheric model
- Compare results and performances between Corsika 7/8 (python scripts and perf counters)
- Rewrite module with better style (CherenkovC8):
  - Use QuantityVector class
  - Use more auto type
  - Reduce number of variables

Questions

- Must I consider Cherenkov photon like "particle" to use analytic atmosphere of Corsika 8 ?
- Where can I find particle energy at the beggining and ending of step ?
- If I want calculate in single precision, must I always convert my types in float or there is something else?
- Where can I find an example of atmosphere usage in framework ?

Thank you for your attention