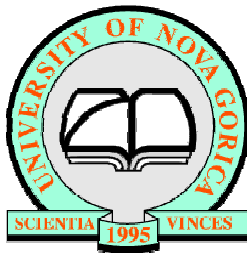




Pierre Auger Offline Software

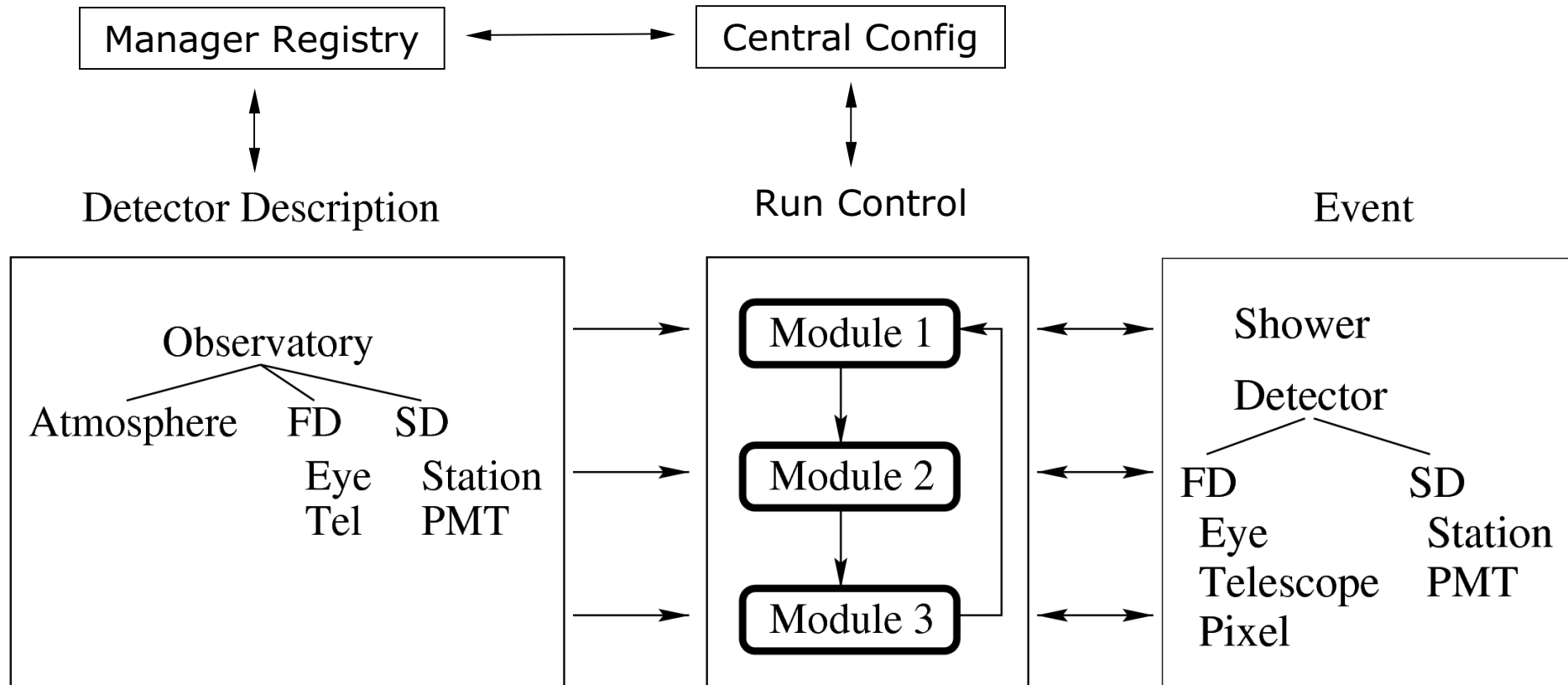


Darko Veberič
Laboratory for Astroparticle Physics
University of Nova Gorica, Slovenia



Overview

Offline



Nucl. Instr. and Meth. A **580** (2007) 1485.

Organization

Offline

- **Framework**

event, detector & atmosphere classes, central configuration, coordinate system registry, data-source managers

- **Event I/O**

object persistence, raw event & external simulation files

- **ADST**

alternative data summary, event, detector & reconstruction viewer

- **Modules**

reading/writing, calibration, physics, reconstruction, simulation

- **Validation**

of event structures, of some modules

- **Utilities**

misc. helpers, Geometry

- **Build system**

libtool → CMake; APE; Buildbot

SLOCCount

Offline

- **Framework** 48 k lines
- **Event I/O** 19 k lines
- **ADST** 36 k lines
- **Modules** 92 k lines
- **Validation** 3 k lines
- **Utilities** 28 k lines

- **Total** 235 k lines

most under GPL

physics code available
upon request

David A. Wheeler's SLOCCount

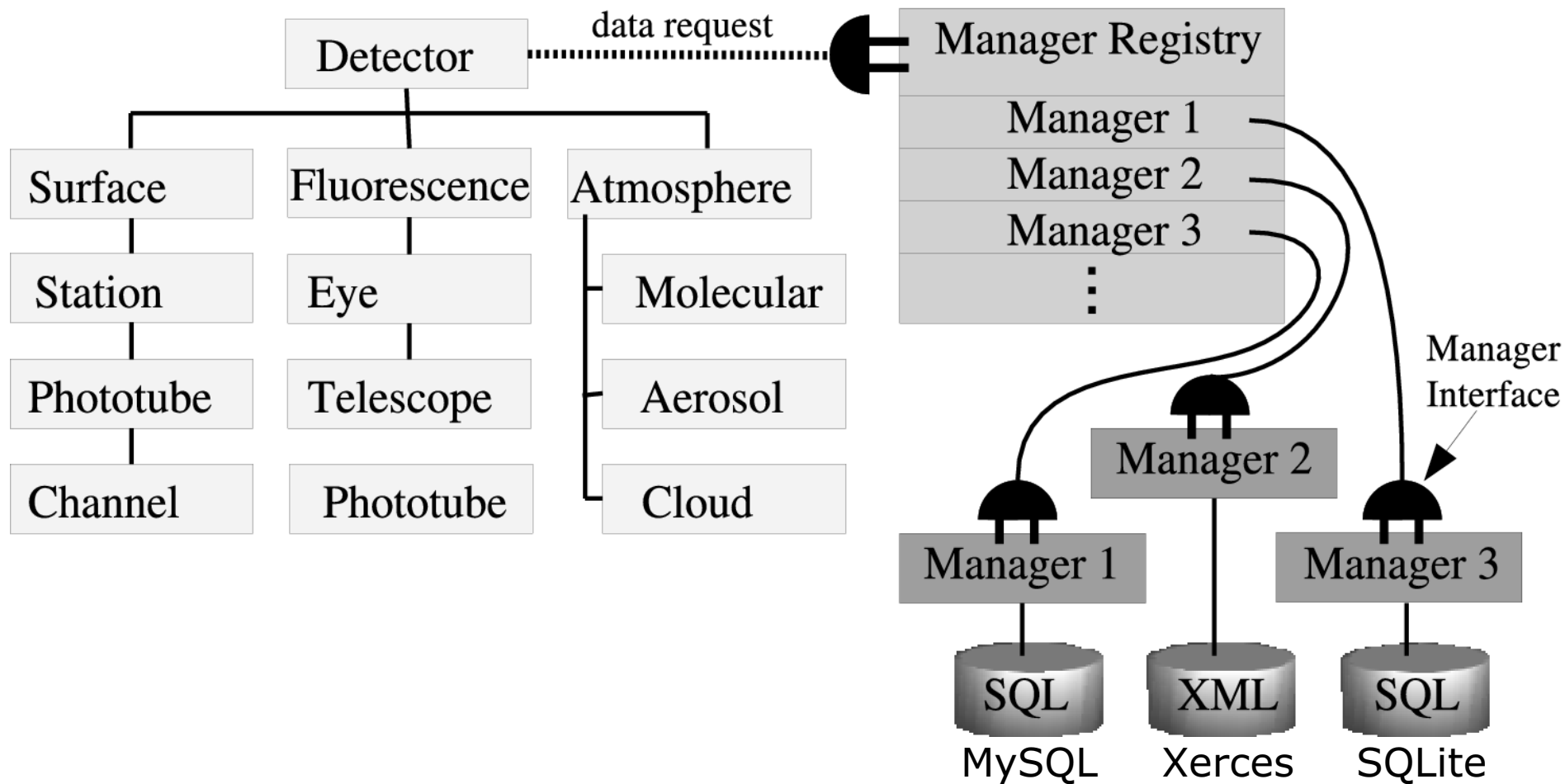
Framework

Offline

- Event structures
- Detector description
- singly-linked trees
initially with pointers, later with ShadowPtr (cleanup, propagation of constness, deep copy; compiler-generated ctor, dtor, copy-ctor, assign)
- strict separation of framework classes and (physics) code
- one class per header file
- non-deletable
processing only adds things, Has/Make/Get interfaces
- prevent accidental processing of a copy
private ctor/dtor
- data-source Managers
config defined queues of Managers; easy source replacement
wrappers for MySQL, SQLite, Xerces
- central configuration: Detector, Managers, Modules
- Registry of Random number streams, seeding conf

Framework: Managers

Offline



Framework: Config

Offline

- XML
- run-time XML Schema validation: XSD
- automatic conversion of physical quantities into internal units

```
<energy unit="GeV"> 137.23 </energy>  
<height unit="km"> 14.3 </height>
```

- default configuration checksummed, modifications reported in run logs
- full config saved in ADST

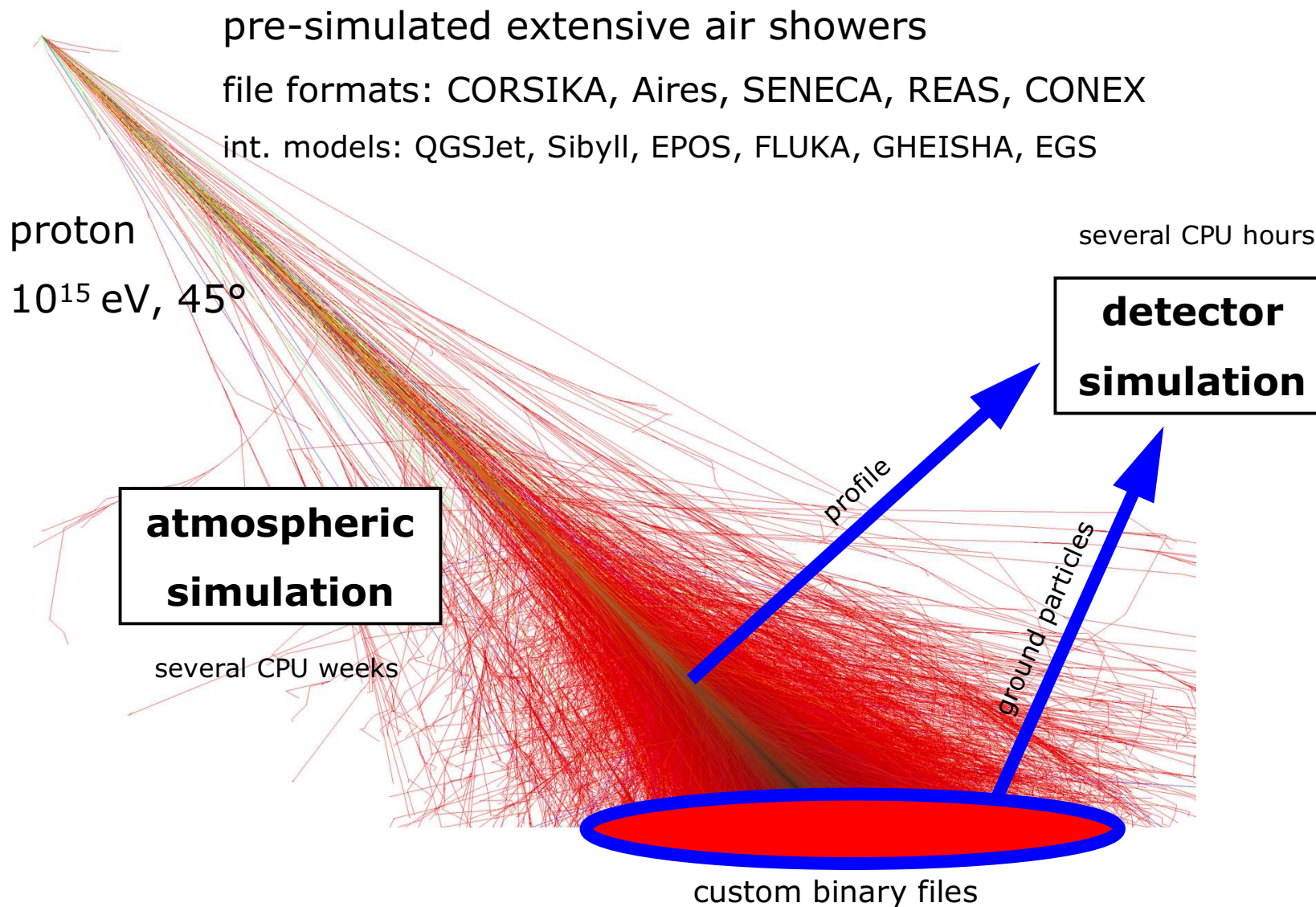
Event I/O

Offline

- all Event/Detector classes have a ROOT-streamable counterpart inherited from TObject
- for historical reasons (state of ROOT I/O in 2004) event kept apart from the particular I/O solution
- experimenting also with boost streaming
- high maintenance cost (2 copies of practically identical classes; even 3 if counting ADST)

Event I/O: Simulation

Offline



ADST

Offline

- summary files (ROOT)
- GUI
event/detector browser, run configuration inspector, simple selection tools
- micro/macro ADST
reconstruction results only; simulation intermediaries included
specialized analysis for sub-detectors
- produced on regular basis with production releases
reconstruction version history

see next talk

Modules

Offline

- Fluorescence Detector, Surface Detector, Radio Detector
- calibration, reconstruction, simulation (Geant4)
- readers/writers: native event/detector, ADST
- modules replaceable
implementing several alternative or competing approaches
- if needed, Modules communicate only through the Event structure
- considering super-Module concept
collection of Modules, easier sharing of data
- currently 116 Modules

Modules: Run Control

Offline

- rudimentary control-language implemented in XML

```
<sequenceFile>
  <enableTiming/>
  <moduleControl>
    <loop numTimes="unbounded" pushEventToStack="yes">
      <module> EventFileReaderOG </module>
      <module> EventCheckerOG </module>
      <module> SdQualityCutTaggerOG </module>
      <module> SdCalibratorOG </module>
      <module> SdSignalRecoveryKLT </module>
      <module> SdEventSelectorOG </module>
      <module> SdPlaneFitOG </module>
      <module> LDFFinderKG </module>
      <module> SdEventPosteriorSelectorOG </module>
      <module> SdRecPlotterOG </module>
      <module> RecDataWriterNG </module>
    </loop>
  </moduleControl>
</sequenceFile>
```

intermediate Event states
can be streamed at any
time by inserting Writers

Utilities

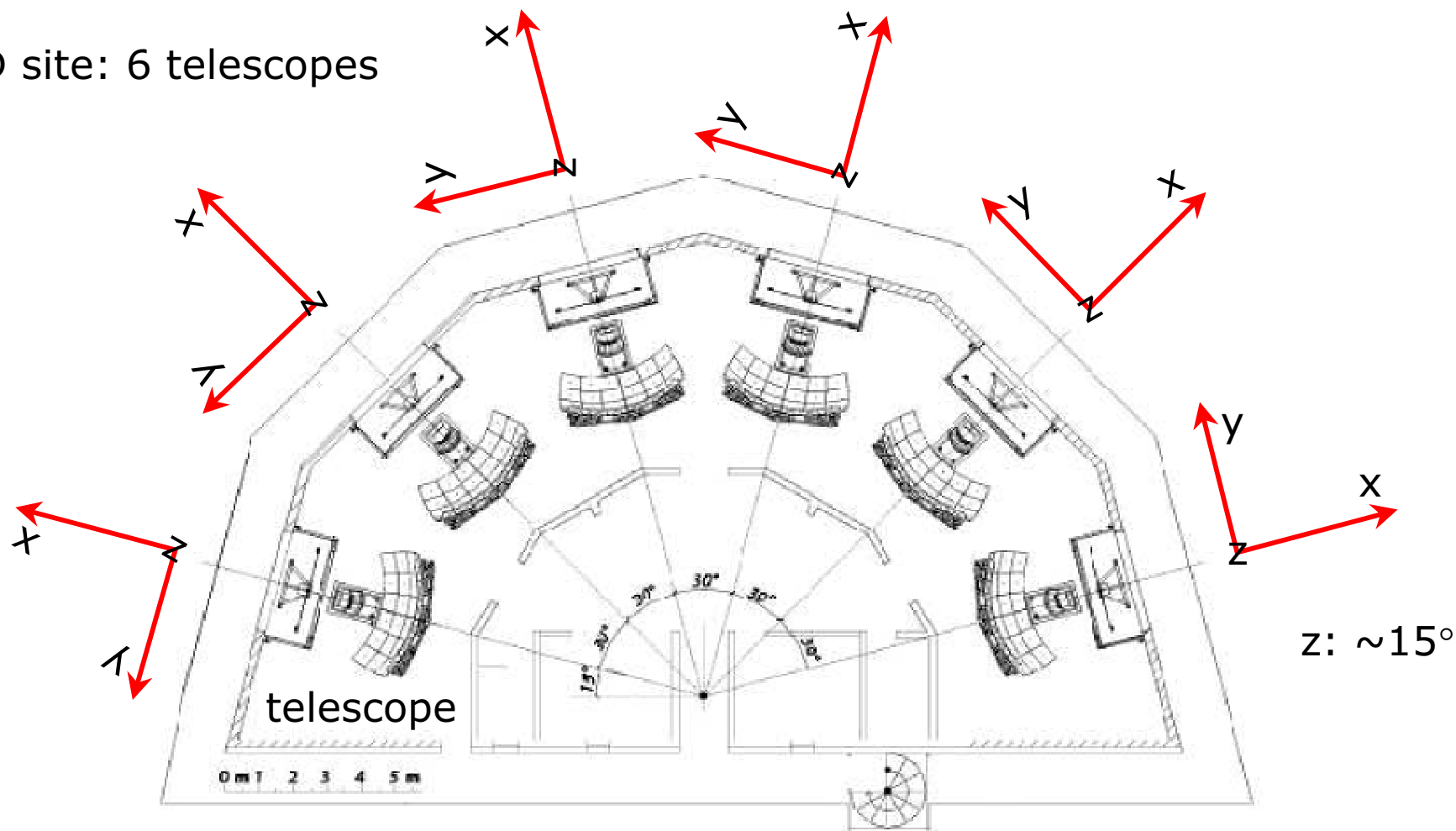
Offline

- XML Reader (Xerces wrapper)
- SI units, internal units definition
[at some point even considering compile-time unit checking]
- Mathematics, Statistics & Physics functions
- Traces, trace algorithms
- Linear Algebra, Geometry (next slide)
- Fourier Transform wrapper
- MD5 for configuration checksums
- custom exceptions
- logging
- special template library
specialized event & detector containers, shadow pointer, Meyers
singleton, counted objects, safe bool cast
- depreciation helpers

Utilities: Geometry

Offline

FD site: 6 telescopes

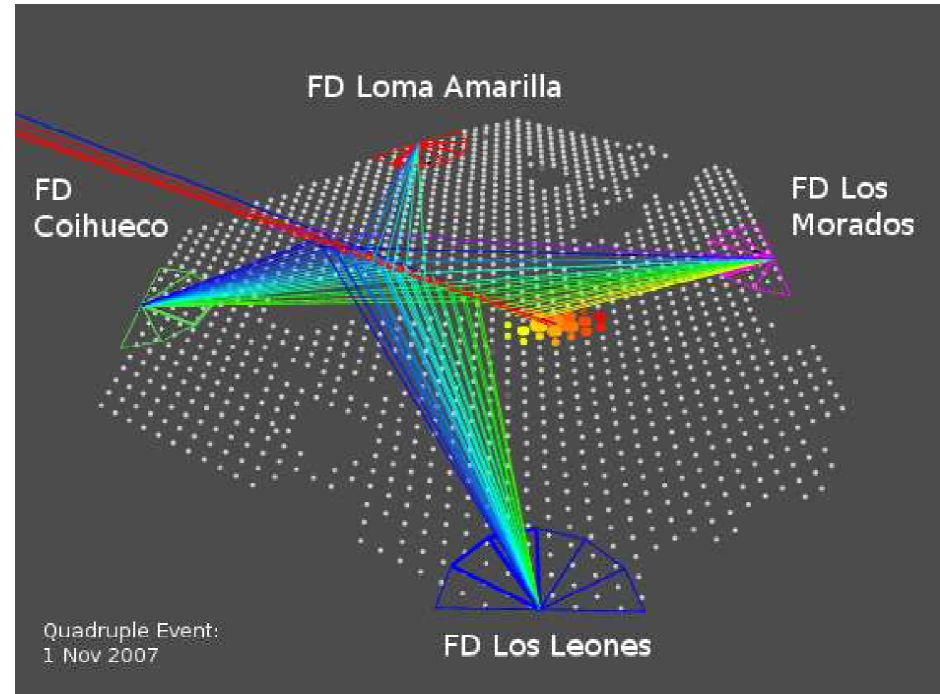
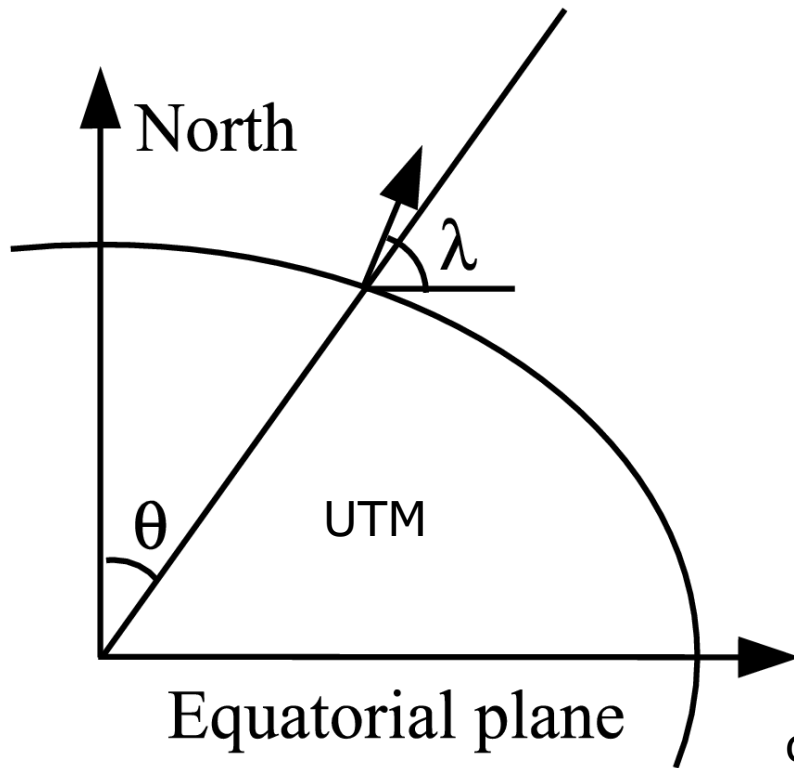


laser, star alignment → detector description

Utilities: Geometry

Offline

one preferred
coordinate system
impossible



70 km

curved, non-Cartesian coordinates

Geometry: Implementation

Offline

- affine geometry: Vectors, Points
- current backend CLHEP will be replaced with Eigen
- users should **avoid** explicit usage of **coordinate-system components**
- central registry of coordinate-systems in Framework
- functions/methods return abstract Vectors, Points
- reference to a coordinate system needed only at creation (or at explicit output of components)
- users do not handle to/from transformations
- all operations transparent (dot, cross, scaling)
- transformations happen in the background (if needed!)
- add transformation policies (caching of transformations, preference)

Build System

Offline

- initially **libtools**
high **M4** maintenance burden; bloat
- **SCons** considered
initial problems; many project reported upstream communication problems

-  **CMake**

seems to be preferred by for large projects, multiplatform

- **APE** for external dependencies and production releases
small dependency resolution engine; python



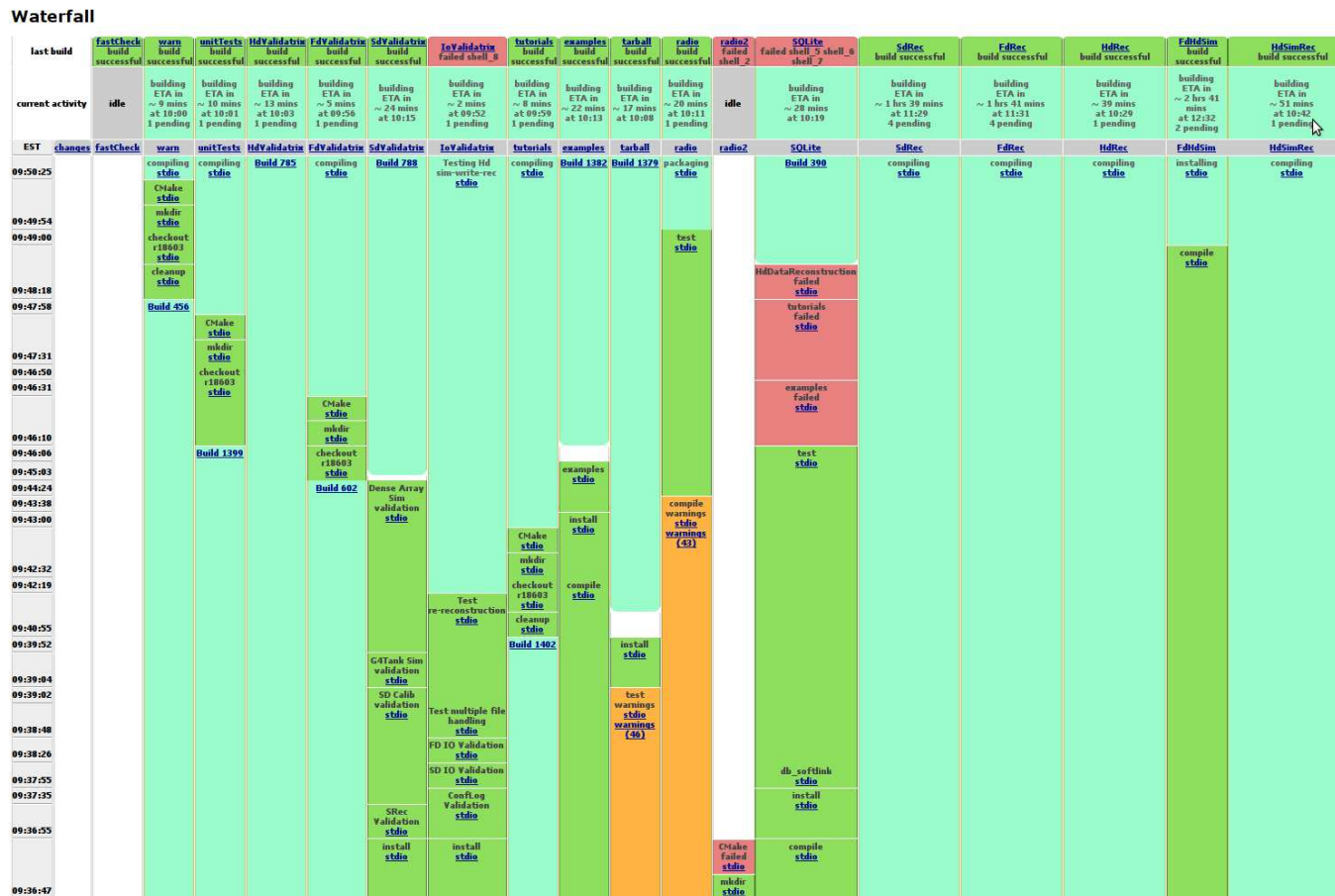
-  **Buildbot**

~50 CPU: automated compile, test, validation after each commit
several linux flavors & Mac OS X, email blame notifications

Validation

Offline

- Unit testing: CppUnit, (boost test library)
- I/O validation (test ROOT schema evolution)
- detect changes in reconstructed quantities on example datasets



Main Design Principles

Offline

- **Abstraction of external dependencies**

wrappers for geometry (CLHEP, Eigen), XML reader (Xerces), persistency (ROOT), FT (fftw), shower simulations (CORSIKA, Aires), sub-detector data formats (CDAS, FdEventLib); exceptions: STL, boost, Modules (authors responsible for compatibility with new versions)

- **const-correctness**

- **prefer static over dynamic polymorphism** (templates)

- **no code duplication**

- **modified Google+Taligent coding style**

CamelCase, naming, strict enforcement (everywhere except Modules)

- **doxygen** documentation

Lessons learned

Offline

- **Event I/O**

- should not be separate to Event/Detector → ROOT streaming
- ? some sort of DST always needed

- **Run Control**

- XML language deficiencies
- (+) revision with python as control language considered
- (+) python bindings for event/detector/module structures
- ? Modules sometimes need to exchange data

- **Centralized configuration facility**

- bulky (defaults: 3.7M of XML, but some act as simple DBs)

- **External dependency wrappers**

- + extremely valuable; localized maintenance; constant user interfaces
- + enables fast replacement for alternatives; needs assessment of importance for each component

- **User-friendly interfaces**

- + Geometry

End

Offline

