ANALYSIS TOOLS FOR THE LHC EXPERIMENTS

Dietrich Liko / CERN IT

Acknowledgements

- I would like to thank my colleagues from the four experiments for their helpful discussions
  - I have added references to relevant presentations at the conference

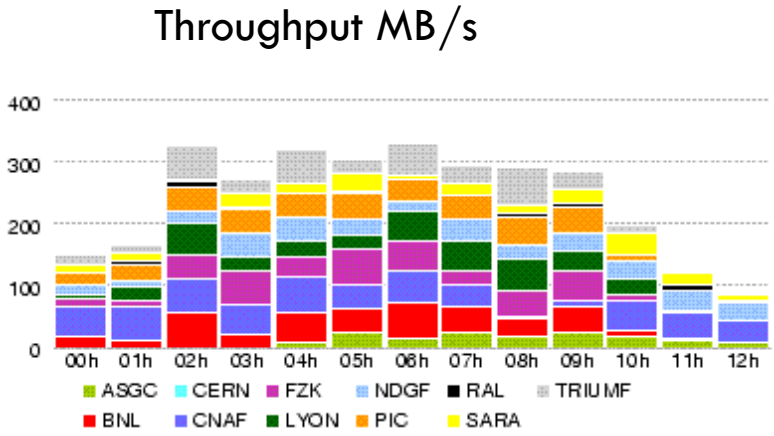
- I am trying to give an overview and I had to shorten some arguments
  - Possibly biased by my own opinions

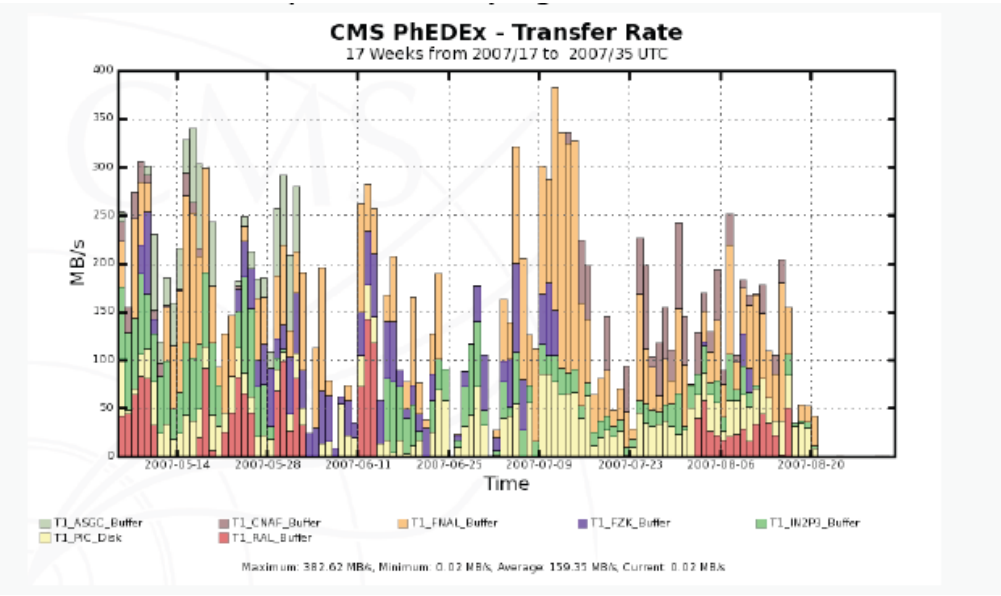
Introduction

- The experiments are planning their analysis according to their computing models
  - Data is being distributed to the Tier-1/Tier-2 centers for analysis
- The experiments have developed tools that allow the users to analyze the data using resources on the grid
  - I want to take a close look at these tools
  - Is the grid already a tool for everybody ?
- In addition there is also the need for more interactive analysis
  - Strong connection with the Analysis Framework and the Data Model chosen by the experiment

Transfer Tier-0 to Tier-1

M4 data taking by ATLAS





Data is available in distributed manner

Transfers to higher Tiers often still problematic

Reminder on Data Formats

- RAW
  - Have to be recorded on permanent storage
  - Only a small fraction can be analyzed directly
- Event Summary Data – ESD
  - Output of the reconstruction
  - Often large; difficult to analyze the full set
- Analysis Object Data – AOD
  - Quantities in particular relevant for physics analysis
  - Main input for analysis, distributed to many sites
- Analysis specific data
  - Sometimes called N-Tuples or DPD

CMS Analysis Environment

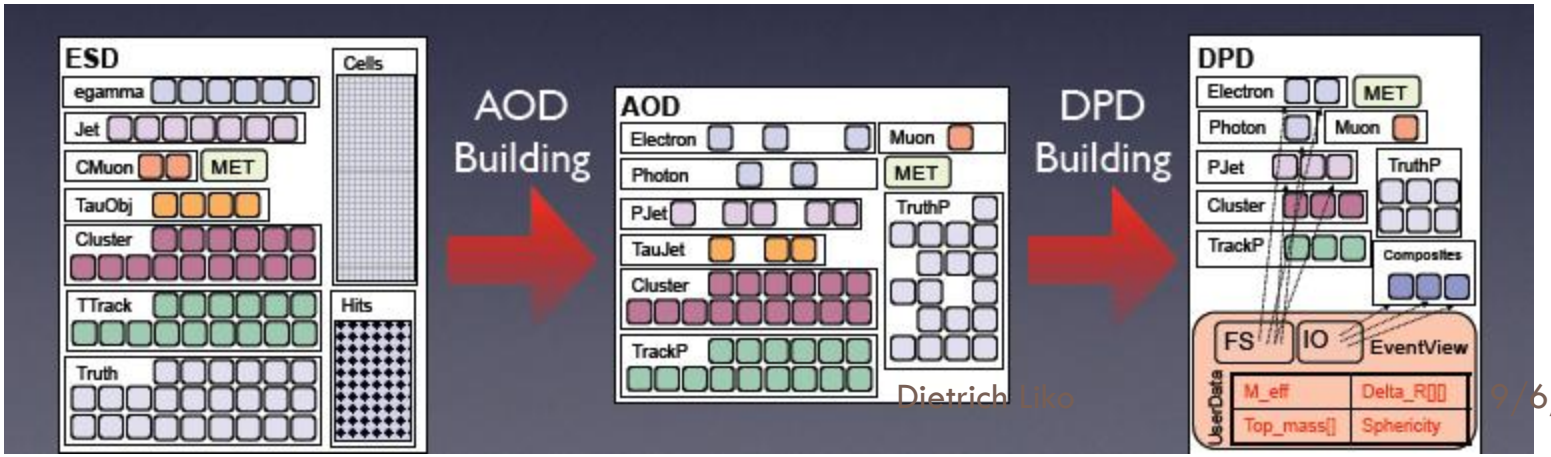
- Support multiple analysis strategies
  - Let their users choose
- Data Model needs to support direct ROOT access
  - No persistent/transient separation
- Strategies
  - Full Framework – grid and local
  - FWLite – ROOT
  - TFWLiteSelector – ROOT and PROOF
  - 'Bare' ROOT

ATLAS Analysis Model

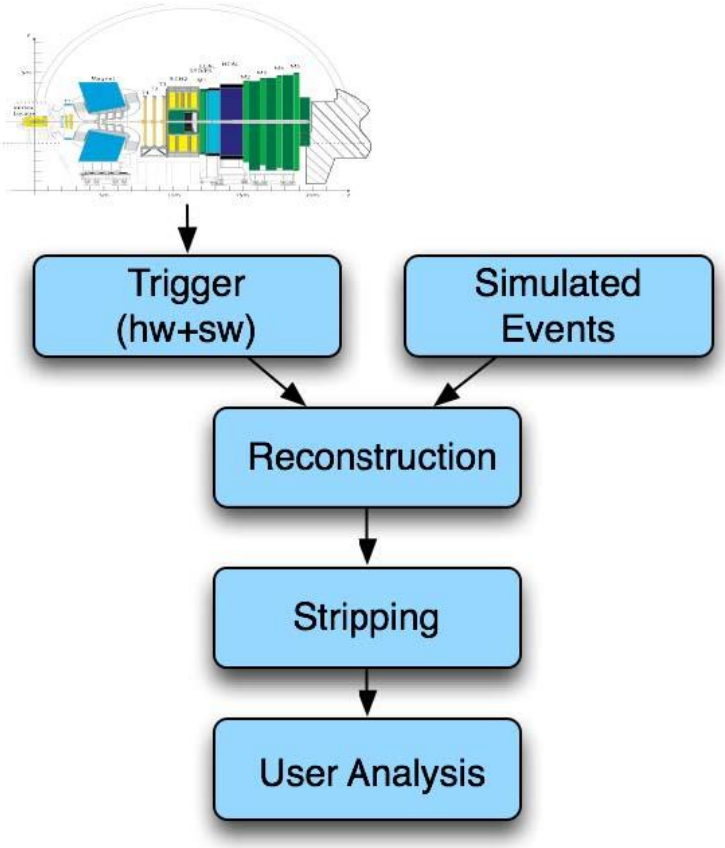
- Basic principle: Smaller data can be read faster
  - *Skimming* - *Keep interesting events*
  - *Thinning* - *Keep interesting objects in events*
  - *Slimming* - *Keep interesting info in objects*
  - *Reduction* -Build higher-level data

83

- Derived Physics Data
  - Share the schema with objects in the AOD/ESD
  - Can be analyzed interactively



LHCb Analysis Model



- Stripping is a centrally managed analysis run as a production
  - Reduces analysis datasets to a size of 10^6 to 10^7 events per year
- All stripped data will be disk resident and replicated to all Tier-1 sites
- LHCb distributed analysis jobs are run on the Grid

ALICE Analysis Model

- All data in ROOT format
- An emphasis is being put on being able to do the same analysis interactive and batch based
- Also scheduled analysis an important issue
  - Organized analysis based on a train model

Batch vs Interactive

- Need for batch type analysis tools and interactive analysis tools
  - Many groups the emphasis is having a solid batch type solution
  - Use the "traditional" grid infrastructures using their specific tools and applications
- Need for more interactive tools is recognized
  - ROOT/PROOF is here the main activity and its driven by ALICE effort
  - To profit from this development often an evolution of the event model is required
- Different groups put different emphasis on certain design criteria
  - For example transient/persistent separation

GRID Analysis Tools

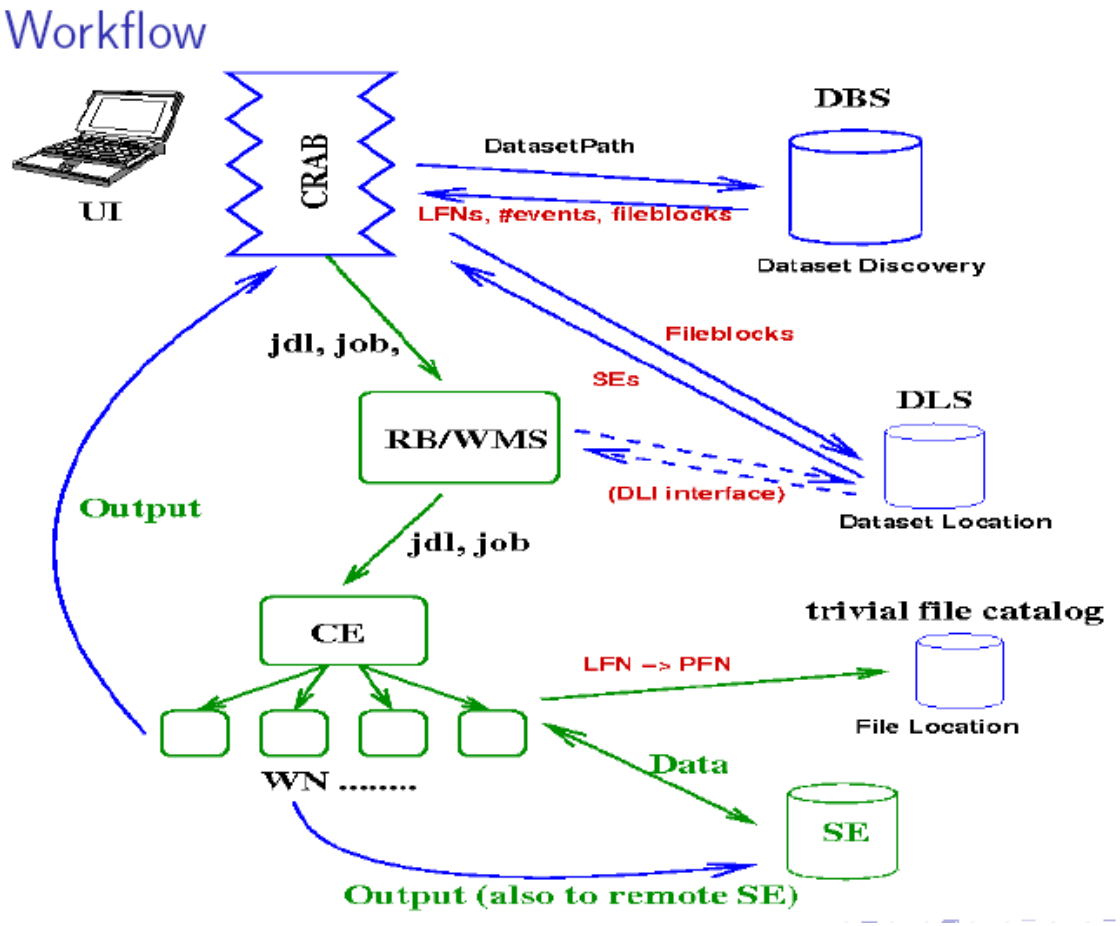
- CMS
  - CRAB together with gLite WMS and CondorG
- LHCb
  - GANGA together with DIRAC
- ATLAS
  - pathena/PANDA
  - GANGA together with the gLite WMS and ARC
- Alice
  - Alien2, PROOF

CRAB Features

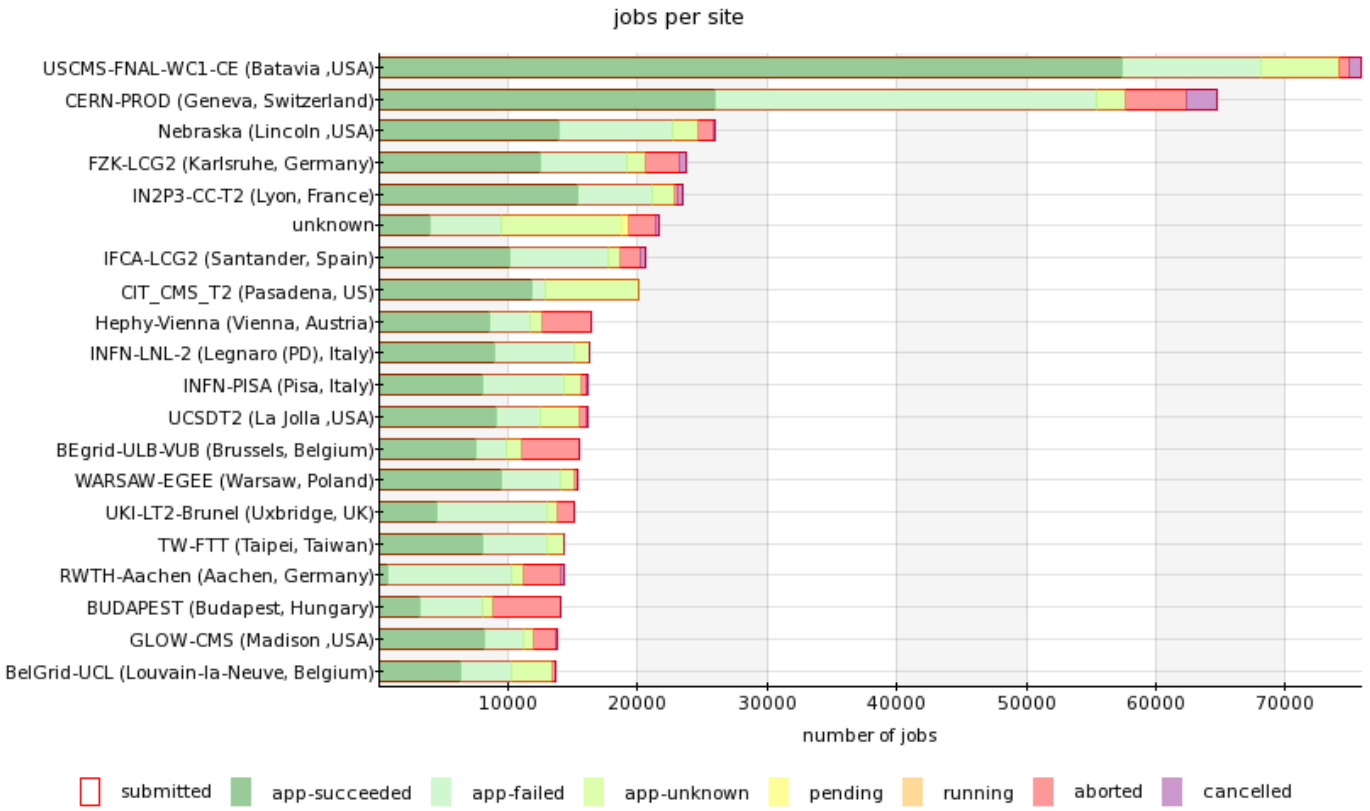
- CMS Remote Analysis Builder
  - User oriented tool for grid submission and handling of analysis jobs
- Support for WMS and CondorG
- Command line oriented tool
  - Allows to create and submit jobs, query status and retrieve output

176,314

CRAB Workflow



CRAB Usage from ARDA Dashboard



Mid-July → mid-August 2007 – 645K jobs (20K jobs/day) – 89% grid success rate

CRAB Future

- Evolution of the system to a client server architecture
  - Keeps the same interface
- Aims to provide a “service” for the user
  - Reduce load on human
  - Improve scalability and reliability

LHCb

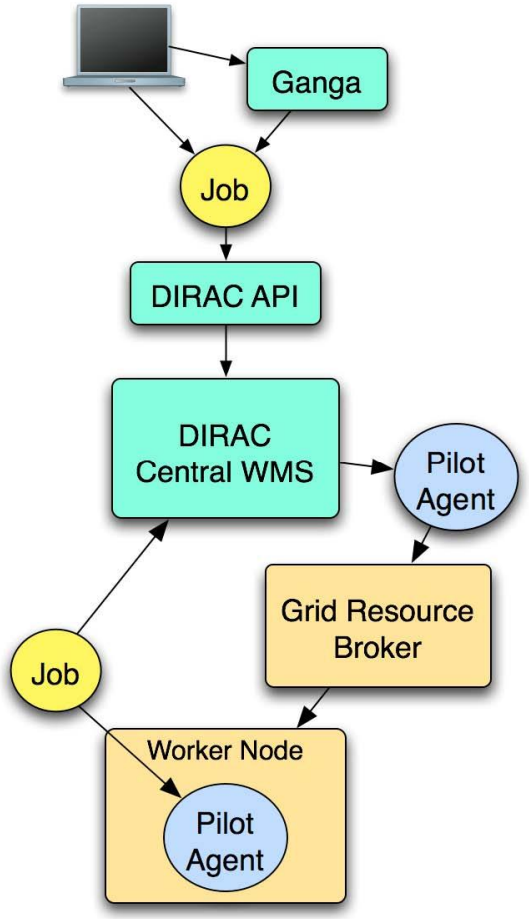
- Use GANGA for Job Preparation and Submission
  - Tool being developed together with ATLAS
  - Discussed in the following together with ATLAS

#146

- Use DIRAC as Workload Management system
  - Use Pull model
  - Puts a layer on top of the EGEE infrastructure
  - Accounting, prioritization, fairshare
  - VO policy can be applied at a central location

#176

DIRAC



- DIRAC API provides a transparent and secure way to submit jobs
- LCG jobs are the pilot jobs that pull jobs from a central task queue
- Workarounds for many problems on the grid
  - Blackholes
  - Downtimes
  - Incorrect configurations
  - Prestaging of data

ATLAS Strategy

- On the EGEE and the Nordugrid infrastructure ATLAS uses direct submission to the middleware using GANGA
  - EGEE: LCG RB and gLite WMS
  - Nordugrid: ARC middleware

#287

demo at exhibition

- On OSG PANDA system
  - Pilot based system
  - Also available at some EGEE sites

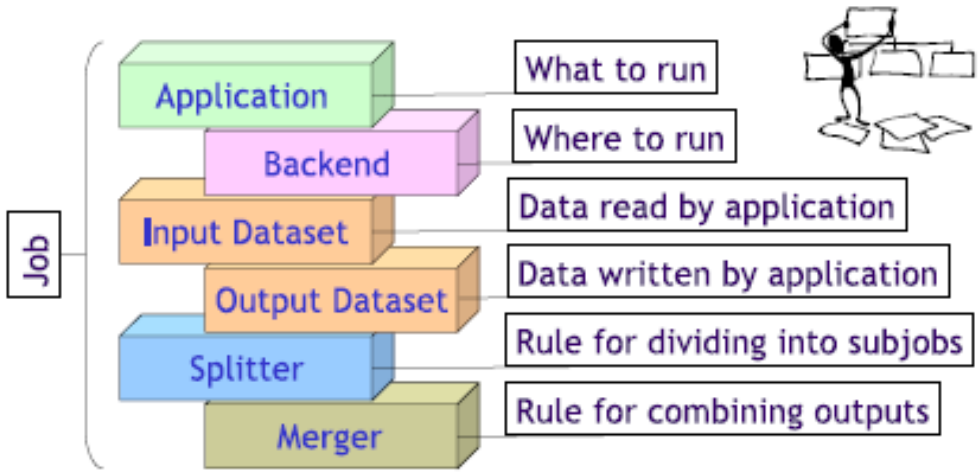
#167

GANGA Features

- User friendly job submission tools
  - Extensible due to plugin system
- Support for several applications
  - Athena, AthenaMC (ATLAS)
  - Gaudi, DaVinci (LHCb)
  - Others …
- Support for several backends
  - LSF, PBS, SGE etc
  - gLite WMS, Nordugrid, Condor
  - DIRAC, PANDA (under development)

GANGA cont.

- Building blocks of a GANGA job

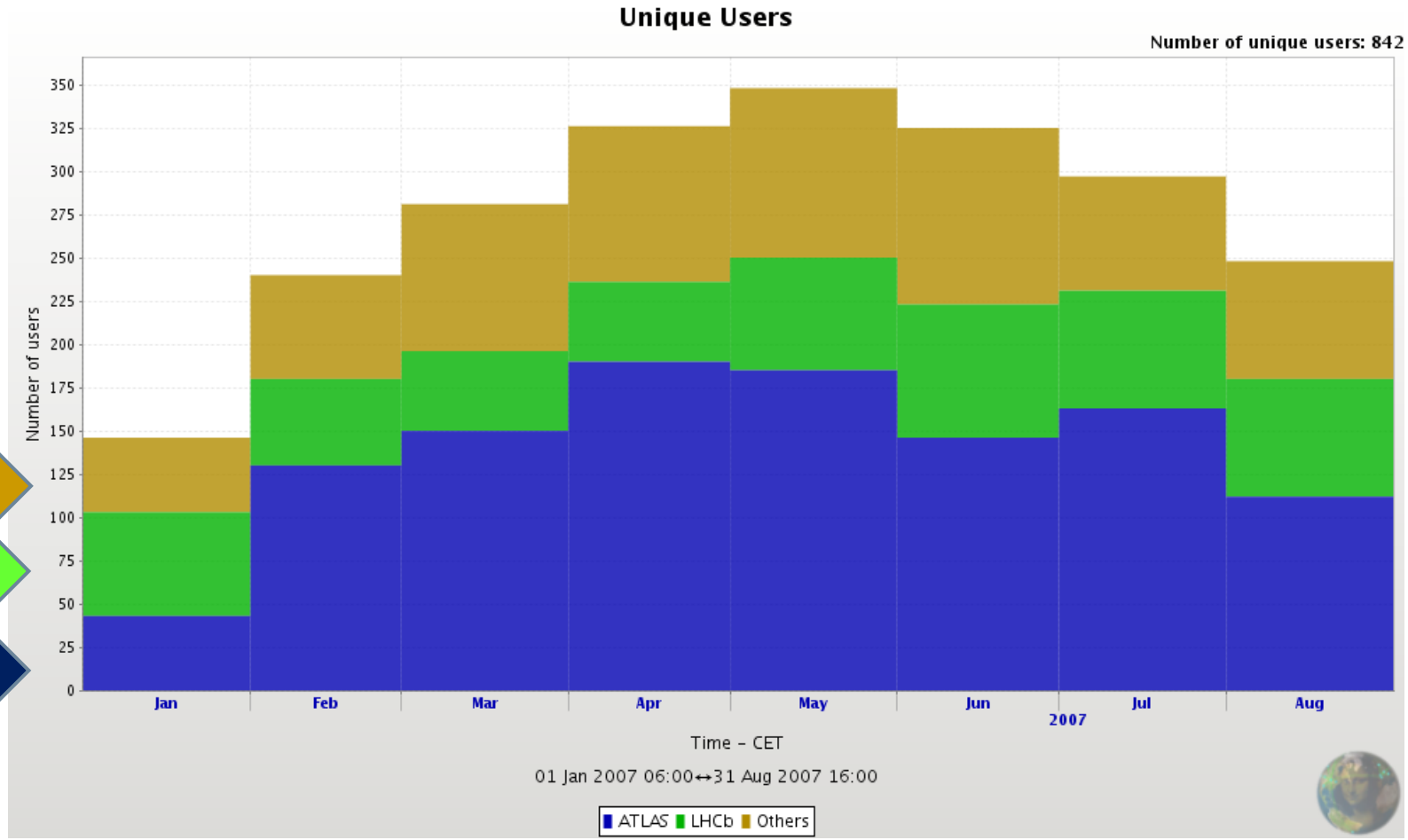


- Supports several modes of working
  - Command line
  - IPython prompt
  - GUI

For ATLAS

- Applications
  - Athena (Analysis)
  - AthenaMC (User production)
- Backends
  - Batch
  - LCG
  - Nordugrid
  - PANDA under development

GANGA Usage



Others

LHCb

ATLAS

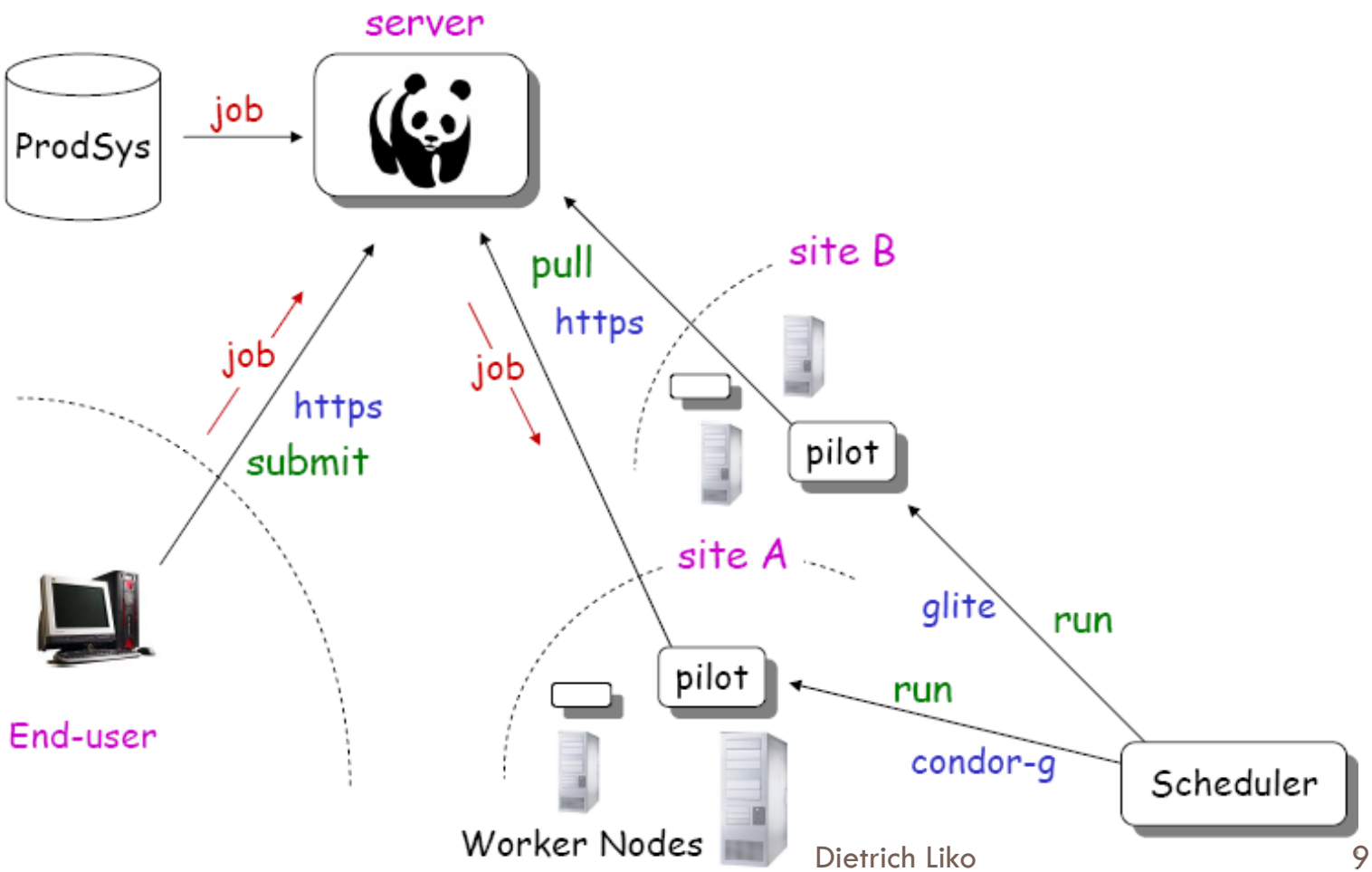
In total ~842 persons have tried GANGA this year (more then 500 in ATLAS)

Per week ~ 275 users (for ATLAS ~ 150)

PANDA Features

- PANDA is the ATLAS production and analysis system on OSG
  - Under evaluation also in some EGEE clouds
- For analysis pathena, a command line tool, is assembling the job
- Status of the job can be monitored using Web pages
- Large number of user sending many jobs

PANDA System



ATLAS future developments

- For our users interoperability is evidently important
- On the one hand
  - PANDA jobs on some EGEE sites
- On the other hand
  - PANDA as a additional backend for GANGA
- The positive aspect is that it gives ATLAS choices on how to evolve

Alice strategy

- Batch analysis
  - Alien provides single entry point in the system

443

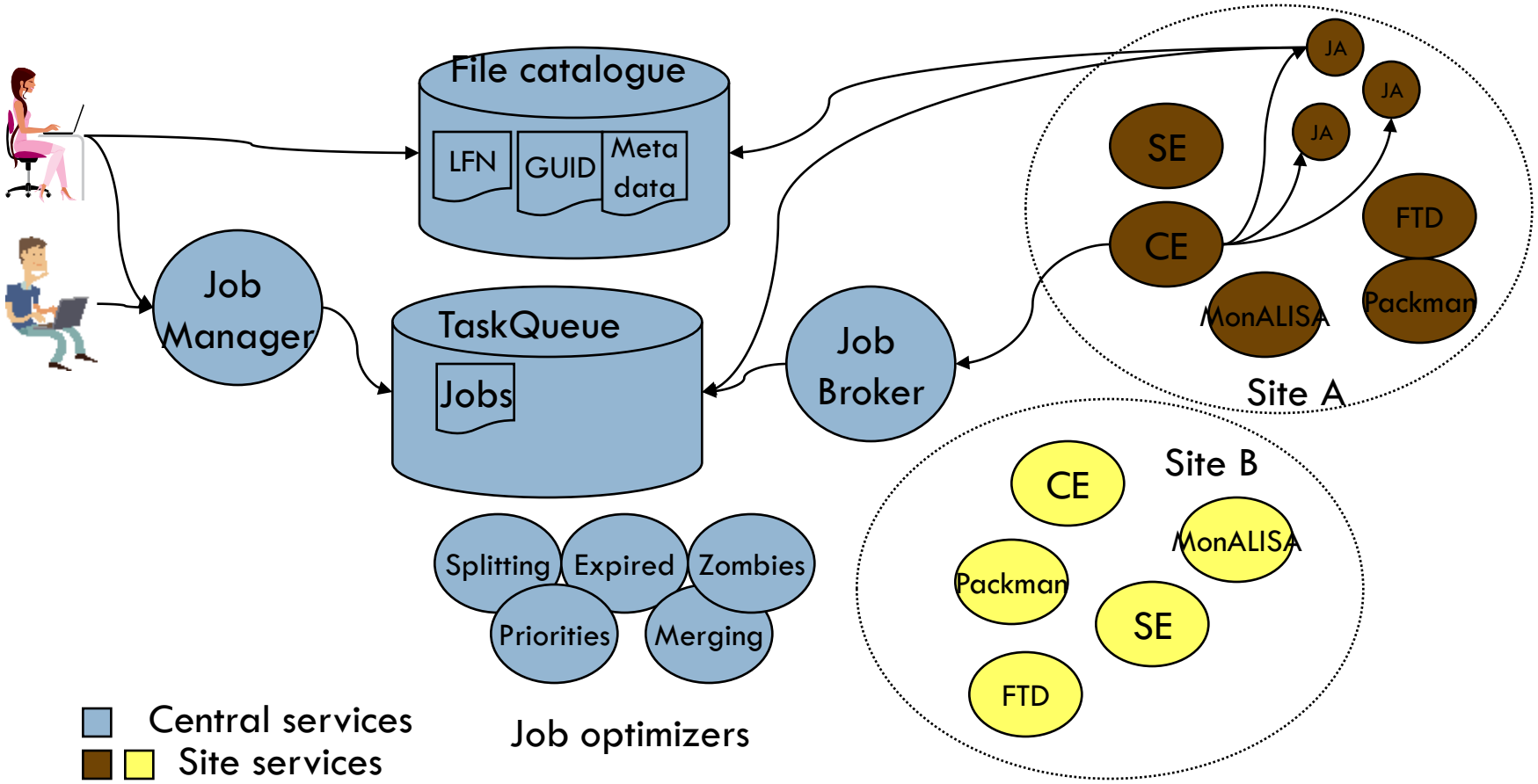
- Interactive analysis
  - PROOF
  - Used for Alice at the CAF

444,307

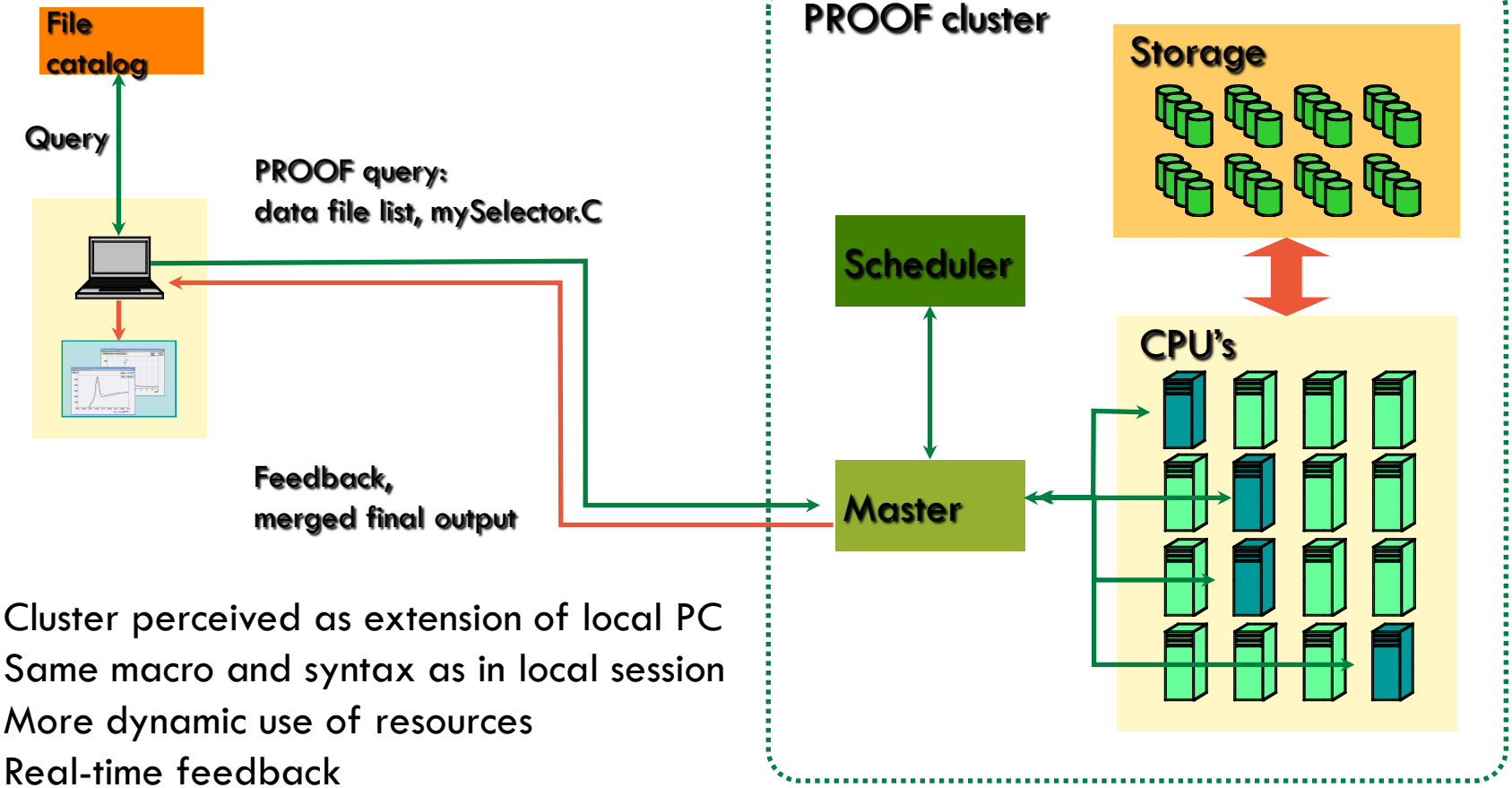
Alien2

- GRID middleware
  - Developed as single entry point to the GRID for ALICE
  - Used also by other Vos
- All the components necessary to build a GRID and interact with other GRIDs
  - File System with metadata
  - Authorization, authentication, job optimization and execution, storage management
  - Audit, quotas, monitoring
  - Interfaces to various GRID implementations
- User interface integrated in the shell and into ROOT
  - Filecatalog as virtual file system
  - Taskqueue as virtual batch system
- Used since:
  - 2002 for centrally managed productions
  - 2006 for user analysis

Alien2 – Job Execution Model



PROOF



- Cluster perceived as extension of local PC
- Same macro and syntax as in local session
- More dynamic use of resources
- Real-time feedback
- Automatic splitting and merging

PROOF at CAF

- Aims to provide prompt and pilot analysis, calibration/alignment, fast simulation and reconstruction
- Test setup in place since May 2006
  - 40 "standard" machines, 2 CPUs each, 250 GB disk
  - 2 Partitions: development (5 machines), production (35 machines)
- The cluster is a xrootd pool
  - Disk cache
  - 1 Machine: PROOF master and xrootd redirector
  - Other machines: PROOF workers and xrootd disk servers
    - Access to local disks → Advantage of processing local data

User Experiences on the Grid

- Many users have been exposed to the grid
  - Work is getting done
- Simple user interface is essential to simplify the usage
  - But experts required to understand the problem
- Sometimes user have the impression that they are debugging the grid

User Experiences

- Role of the sites
  - Not only running the middleware
  - Data availability, software configurations
  - Often significant investment required by the site
- User support
  - First line support by experts in the experiments
    - Provide fast feedback to users, debugging of problems
  - Identify application problems
    - Feedback to the developers inside the experiment
  - Identify grid problems
    - Feedback to GGUS

Conclusions

- We have seen an increasing number of physicist using the grid
  - Hundreds of users are using the various tools
  - Large number of jobs are being submitted
- Often the grid is still complex
  - Data distribution and storage is a very important issue
  - Strong user support is required to address the complications
- Rising interest in interactive analysis
  - Leads to evolutions of the Data Format
  - Slightly different strategies by the experiments