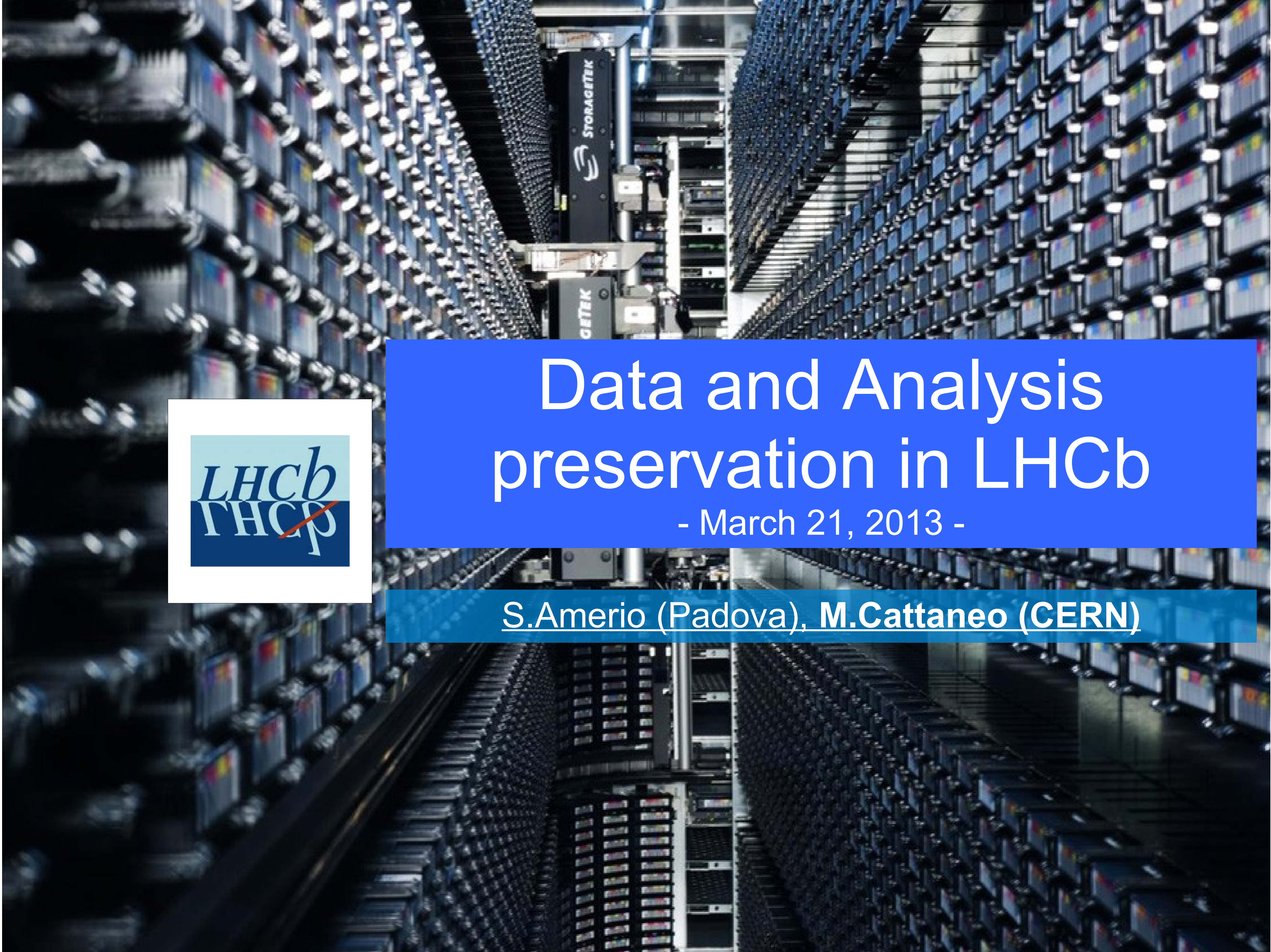

Data and Analysis preservation in LHCb

- March 21, 2013 -

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Outline

Overview of LHCb computing model in view of long term preservation

- Data types and software tools
- Data lifecycle and organization
- Data storage
- Software organization

Status of long term data preservation at LHCb

- Motivation and use cases
- Open access policy

LHCb Data types

RAW data
- *Format*: sequential files of integers and doubles
- *Size*: 60 kB/event, 3 GB/file, ~ 250 files /run

FULL.DST (Data Summary Tape Reconstruction Output)
-*Format*: ROOT-based file containing all reconstructed objects for each event plus a copy of the raw data
- *Size*: 130 kB/event on average, 3 GB

DST streams
-*Format*: ROOT-based file containing all of the event's information
- *Size*: 120 – 150 kB/event, 5 GB

MDST (MicroDST streams)
-*Format*:as DST; it contains only the part of the event contributing to the decay that triggered the stripping line
- *Size*: 10-15 kB/event, 3 GB

Approximately 1.2 millions of files, 3.3 millions including replicas

Software tools (I)

Data Processing

- AIDA
- Boost
- CLHEP
- COOL
- CORAL
- CppUnit
- Frontier_Client
- GCCXML
- GSL
- HepMC
- HepPDT
- Python
- QMtest
- Qt
- RELAX
- ROOT
- Reflex
- XercesC
- cernlib
- fastjet
- fftw
- graphviz
- libunwind
- neurobayes_expert
- oracle
- pyanalysis
- pygraphics
- pytools
- sqlite
- tcmalloc
- uuid
- xqilla
- xrootd
- gfal

Simulation : GEANT 4

- alpgen
- herwig++
- hijing
- lhapdf
- photos++
- pythia6
- pythia8
- rivet
- tauola++
- thepeg

Only proprietary tools:
- Oracle client
- neurobayes_expert

Processing of data done on **Intel X86** machines (x86_64, with older software running on 32 bits)

All of the software runs on Scientific CERN Linux operating system. Currently **SLC5** but migration to SLC6 is nearly complete.

Software tools (II)

Data Processing

AIDA
Boost
CLHEP
COOL
CORAL
CppUnit
Frontier_Client
GCCXML
GSL
HepMC
HepPDT
Python
QMtest
Qt
RELAX
ROOT
Reflex
XercesC
cernlib
fastjet
fftw
graphviz
libunwind
neurobayes_expert
oracle
pyanalysis
pygraphics
pytools
sqlite
tcmalloc
uuid
xqilla
xrootd
gfal

Simulation : GEANT 4

alpgen
herwig++
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tauola++
thepeg

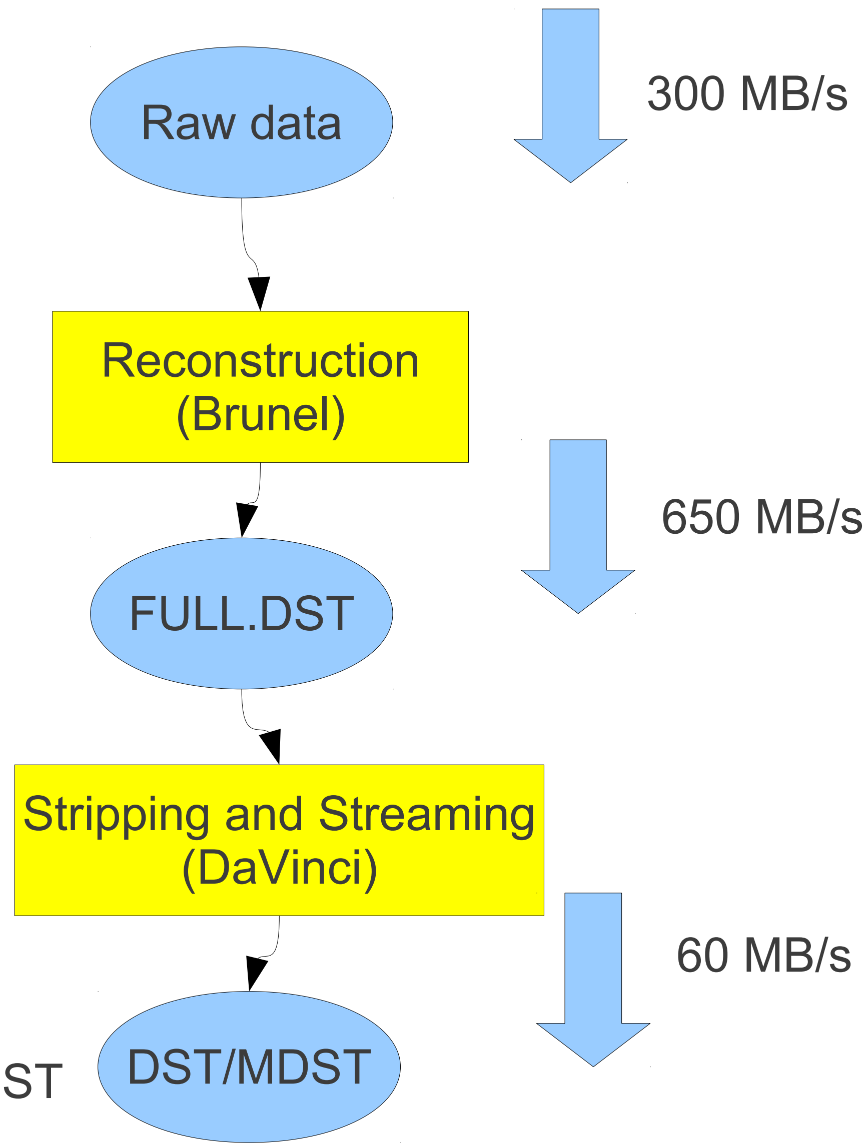
On top of these tools, a number of applications are developed for LHCb for simulation, data reconstruction, analysis...

Gaudi
Online
LHCb
Lbcom
Boole
Rec
Brunel
Phy
Hlt
Analysis
Stripping
DaVinci
Panoramix
Bender
Moore

The production system relies on the **DIRAC Grid Engine** (customized into LHCbDirac)

The same software is used for data analysis.
Jobs are sent to the grid using the **Ganga grid frontend.**

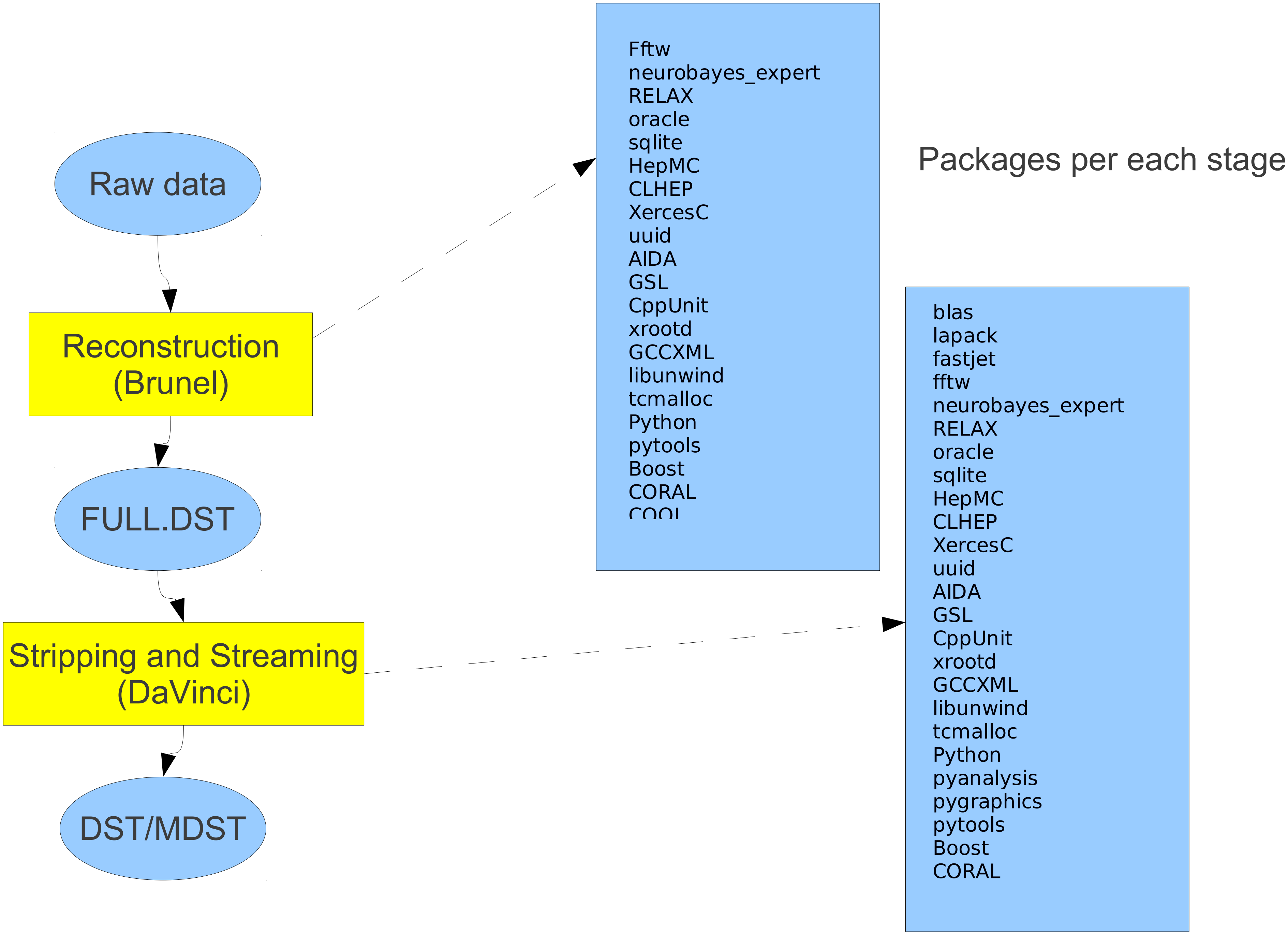
Data rate(per second of stable beam)



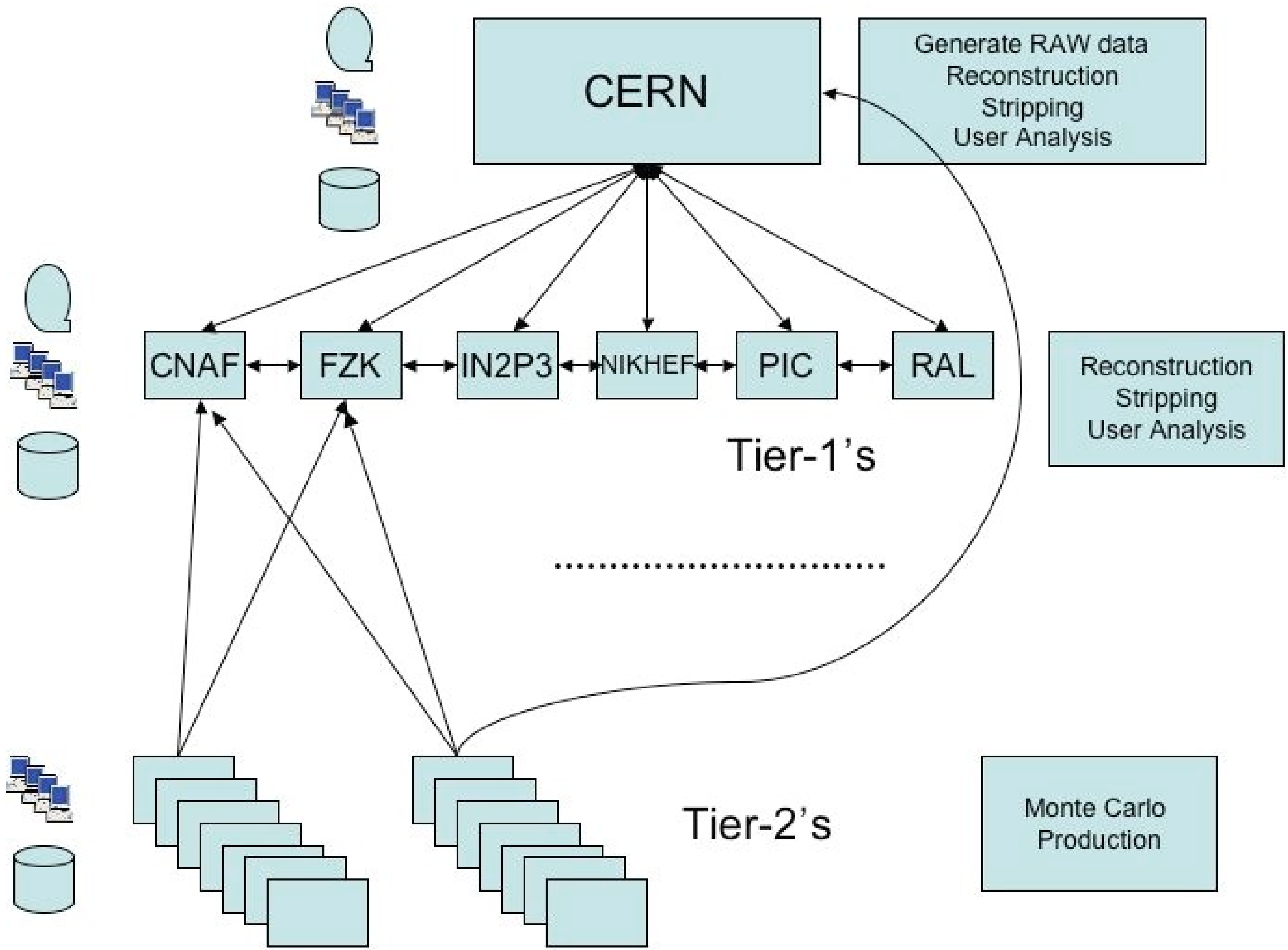
Size: 200%
of raw data
files

Size:
- 10% of FULL.DST
- 20% of Raw

Data lifecycle (II)



Computing and storage resources



Storage
Data are stored on tape and disk at T0 and T1 sites.

Backup copies:
- ***Raw data***: 2 copies on tape: 1 at T0, 1 in one of the T1s
- ***FULL.DST***: 1 copy on tape, for the most recent reprocessing
- ***DST/MDST***:
  - 4 copies on disk for the latest reprocessing N (3 on T0D1 storage at selected T1s + 1 at T0)
  - 2 copies for the (N-1) reprocessing
  - 1 archive replica on T1D0 either at T0 or at one T1.

Safety measures
Standard protections provided by mass storage systems via ACLs

Recovery mechanisms
- **Raw data:** two copies in geographically distinct locations → known losses can be recovered but no systematic checks on tape integrity
- **FULL.DST**: can be recovered rerunning the reconstruction
- **DST**
  - for live data, mechanims in place to recover a lost disk copy from other disk copies
  - for archived data we rely on single tape copy, no distaster recovery (but DST files can be regenerated)

Data organization and description

The Data Management system is based on two catalogues:

- A **replica catalogue** contains the whole information on individual files and their replicas. It is used for data manipulation and job brokering.
- A **book-keeping catalogue** contains information on the provenance of the files; it is used by physicists to select the files they want to analyse. Users can access this catalogue using a standalone GUI or using the LHCbDirac web portal.

All data other that raw is in **ROOT format**, but with LHCb specific data description.
Simulation uses **HepMC for interface to generators**.

Decoding is handled by the LHCb software framework, and data is described in header files and twiki.

Software organization (I)

Software is organized in the context of **CMT *packages* and *projects:***

Package: set of functions with a well defined functionality; basic unit of software development; C++/Python

Project: set of packages grouped together according to some functionalities, eg:

- Three projects for the framework (Gaudi, LHCb, Phys)
- Several component projects for algorithms (e.g Rec, Hlt, Analysis,...)
- One project per application containing the project application configuration (e.g. Brunel, DaVinci,..)

All software is versioned in **SVN repositories**
User level scripts and macros are often maintained in private areas).

Software organization (II)

Book-keeping knows which version of an application was used to produce each dataset.

CMT versioning machinery contains list of every SVN tag used to build a given version of the application.

We maintain an informal list of application version consistent with a given version of the data.

The software production chain (simulation/trigger/reconstruction/stripping) is guaranteed to be self-consistent only for a limited set of versions (one major version plus patches).

Latest analysis software can in principle process all existing versions of the data.

Latest version of the reconstruction can process all Raw data.

Long term data preservation

Goal
LHCb data and complete analysis capabilities should be preserved in the long term future.

Motivation
LHCb data will maintain a high physics potential in the future.
As an example, consider 2010 data: these samples are unique in terms of data taking conditions:

- Almost unbiased data, no pile-up due to low luminosity
- Three different center-of-mass energy: 0.9, 2.76 and 7 TeV

Physicists inside and outside the collaboration may be interested in revisiting LHCb data
- To perform new analysis (new theories, new analysis methods...)
- To cross-check their results

Data to be preserved
- FULL.DSTs, as they **contain raw data** and are the starting point to produce **user level analysis files (DST/MDST)**
- most recent DST/MDST, for new analysis on existing stripping lines

Software to be preserved
We are considering different options, see next slide.

Long term data preservation: use cases

1) *Read old DSTs* (e.g. to make new ntuples with different variables): the latest analysis software (DaVinci) version can be used.

2) *New stripping selection on a DST dataset:*
We need the DaVinci-stripping code corresponding to the latest stripping, so that the new selection can use existing stripping lines for the backgrounds.

3) *New MC* (due to new theory, decay mode, …)
We need the trigger emulation corresponding to a given data taking period + latest reconstruction and stripping code.

4) *Exactly reproduce an old analysis:* all original DSTs and analysis software (DaVinci) version are required; user-level scripts and macros are also needed.

NB: we are already performing software preservation for a specific application: **trigger swimming**, where old trigger code has to run on more recent DST.

LHCb open access policy (I)

LHCb open access policy approved last February

Key points:

Level-1 data: **Published results**
All scientific results are public. Data associated with the results will also be made available; format and repositories will be decided by the Editorial Board

Level-2 data: **Outreach and education**
LHCb already involved in outreach and education activities. Event displays and simple analysis level ntuples are already available and will continue to be provided to the public. The data are for educational purpose only, not suitable for publication

LHCb open access policy (II)

Level-3 data: **Reconstructed data**
LHCb will make reconstructed data (DST) available to open public; 50% 5 years after data is taken, 100% after 10 years.

Associated software will be available as open source, together with existing documentation.

Any publication that results from data analysis by non-members of the collaboration will require a suitable aknowledgement (“*data was collected by LHCb*”) and disclaimer (“*no responsibility is taken by the collaboration for the results*”).

Level 4 data: **Raw data**
Due to the complexity of the raw data processing stage, the extensive computing resources required and enormous access to tape resources, direct access to raw data is not permitted to individuals within the collaboration. Raw data processing is performed centrally. Due to this, the collaboration is currently not planning to allow open access to raw data.

Conclusions

We are analysing our computing model in view of long term preservation of data and analysis capabilities.

First goal is to guarantee that *all LHCb data* can be accessed and analysed *by the collaboration* in the long term future; we are identifying the necessary requirements (e.g. new reconstruction and analysis software versions able to run on all data taking periods; preservation of trigger emulations for all data taking periods).

In parallel, work on the *open access* is already ongoing:
• *Outreach activities* on subset of LHCb data (see Bolek's talk this morning)
• *Open access policy* official since February 2013.