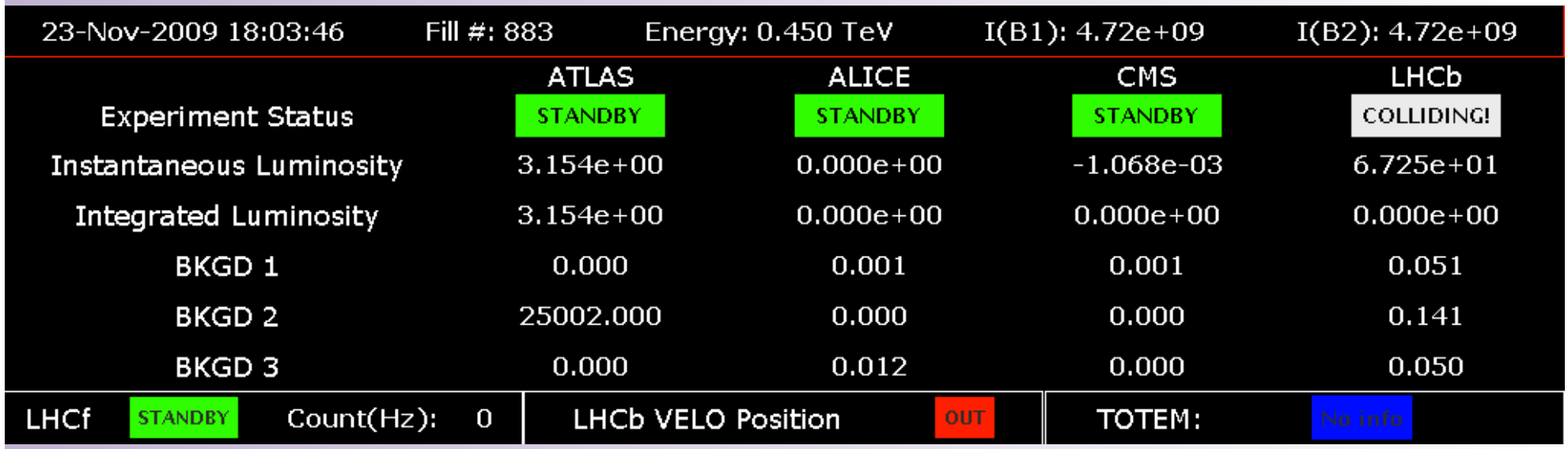
CSCS workshop
Paul Szczypka
Yasmine Amhis
EPFL

29.04.2010



23-Nov-2009 18:03:46	Fill #: 883	Energy: 0.450 TeV	I(B1): 4.72e+09	I(B2): 4.72e+09
	ATLAS	ALICE	CMS	LHCb
Experiment Status	STANDBY	STANDBY	STANDBY	COLLIDING!
Instantaneous Luminosity	3.154e+00	0.000e+00	-1.068e-03	6.725e+01
Integrated Luminosity	3.154e+00	0.000e+00	0.000e+00	0.000e+00
BKGD 1	0.000	0.001	0.001	0.051
BKGD 2	25002.000	0.000	0.000	0.141
BKGD 3	0.000	0.012	0.000	0.050

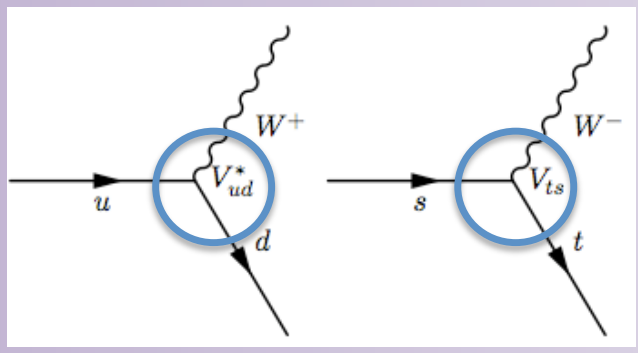
Data Analysis at LHCb

One question ?

One of the main questions LHCb attempts to answer (amongst others) is:

"Why is there so much matter in the Universe?"

CKM Matrix



Weak Interaction

Cabibbo

Nobel Prize 2008

Maskawa

Kobayashi

$$\begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} \cong \begin{pmatrix} 1-\lambda^2/2 & \lambda & A\lambda^3(\rho - i\eta) \\ -\lambda & 1-\lambda^2/2 & A\lambda^2 \\ A\lambda^3(1-\rho-i\eta) & -A\lambda^2 & 1 \end{pmatrix} + \delta V$$

Wolfenstein parameterisation

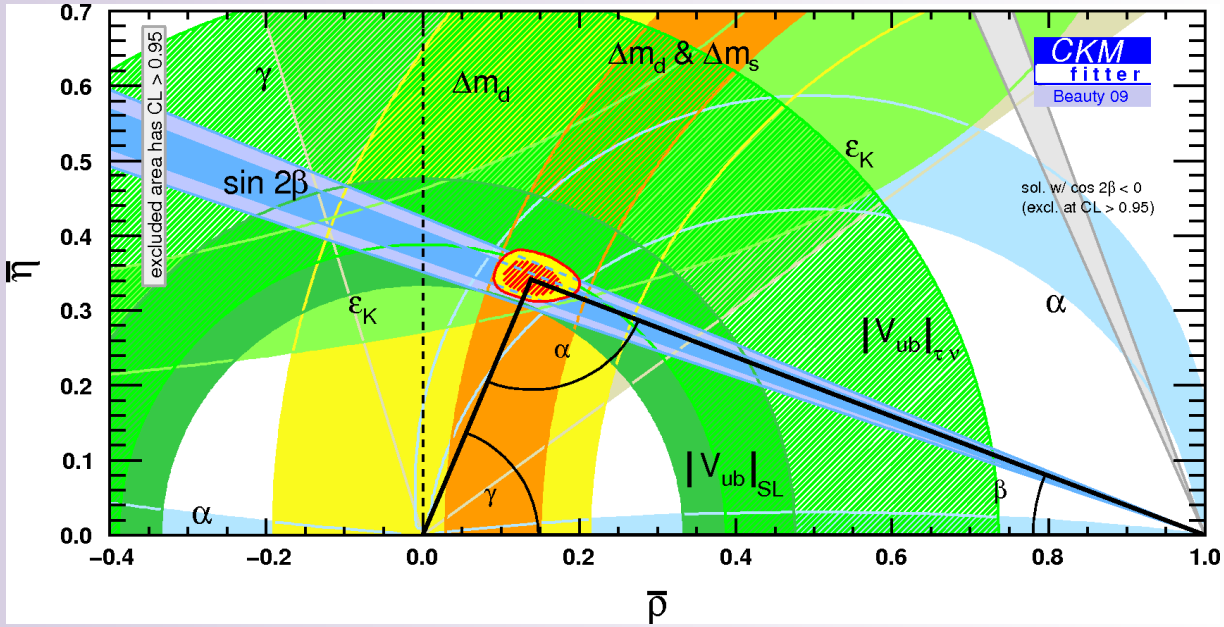
CKM Triangle(s)

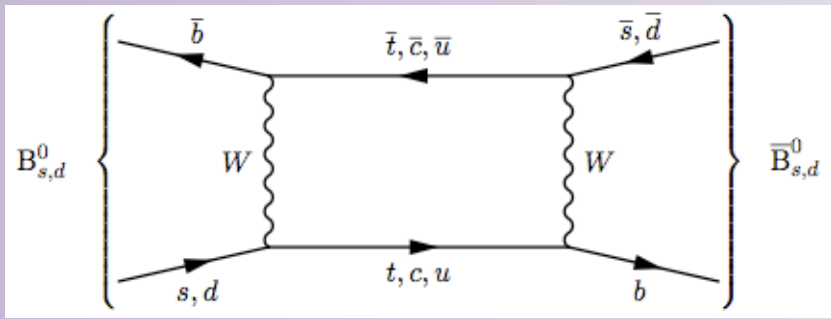
The CKM matrix must be unitary to preserve probability: $V^{H}V = 1$

This gives us 9 constraints:

- 6 sums to 0 for the off-diagonal elements
- 3 sums to 1 for the diagonal elements.

It turns out that only two of the 0-sum constraints produce "open" triangles. Both of which are the same to order λ^3





The ratio of the mixing frequencies, Δm_s & Δm_d is proportional to $|V_{ts}/V_{td}|^2$

Direct search

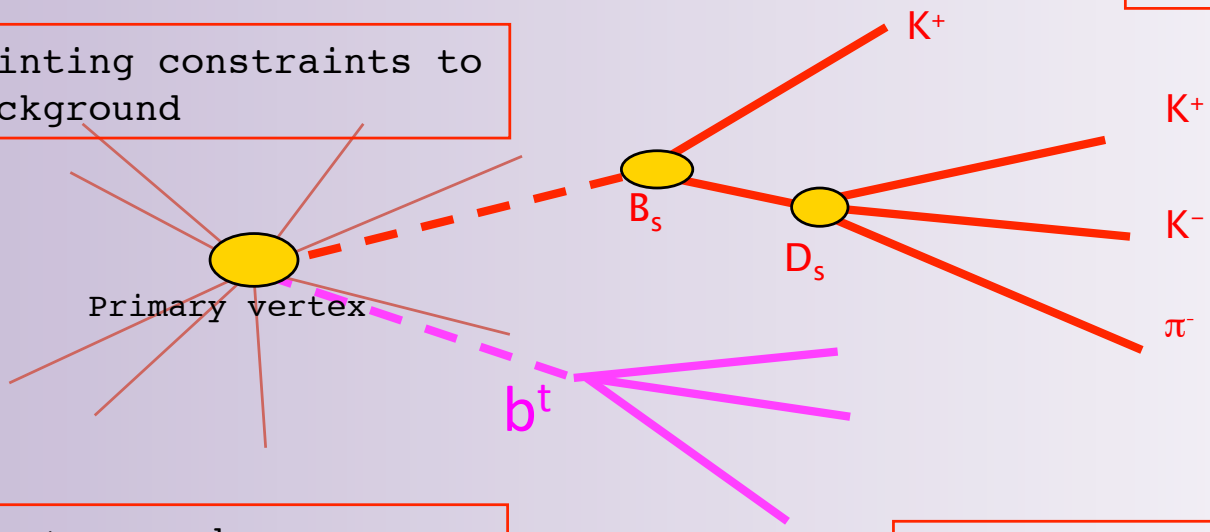
Indirect search

Detector Requirements

- Key features:
  - Highly efficient trigger for both hadronic and leptonic final states to enable high statistics data collection
  - Vertexing for secondary vertex identification
  - Mass resolution to reduce background
  - Particle identification

Example: $B_s \rightarrow D_s K$

Mass + pointing constraints to reduce background

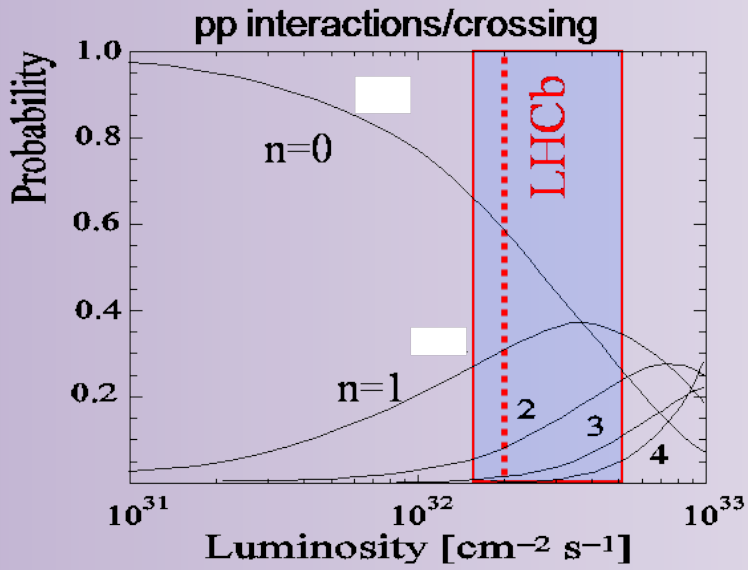


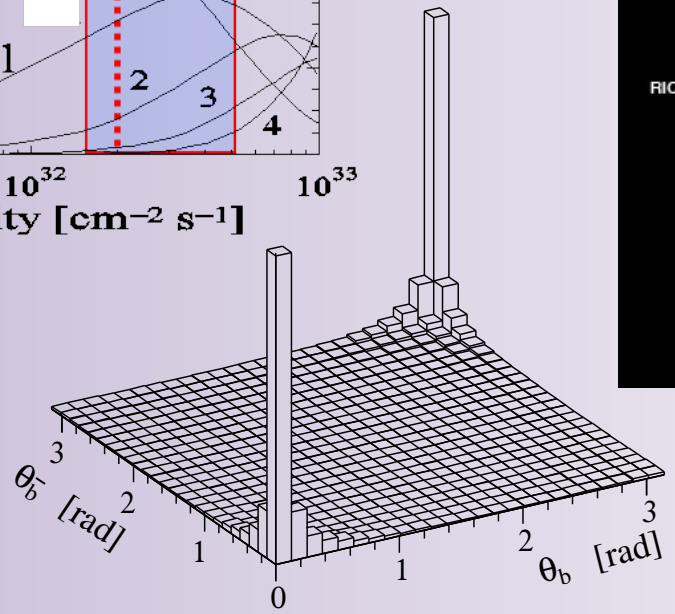
Good K/π separation

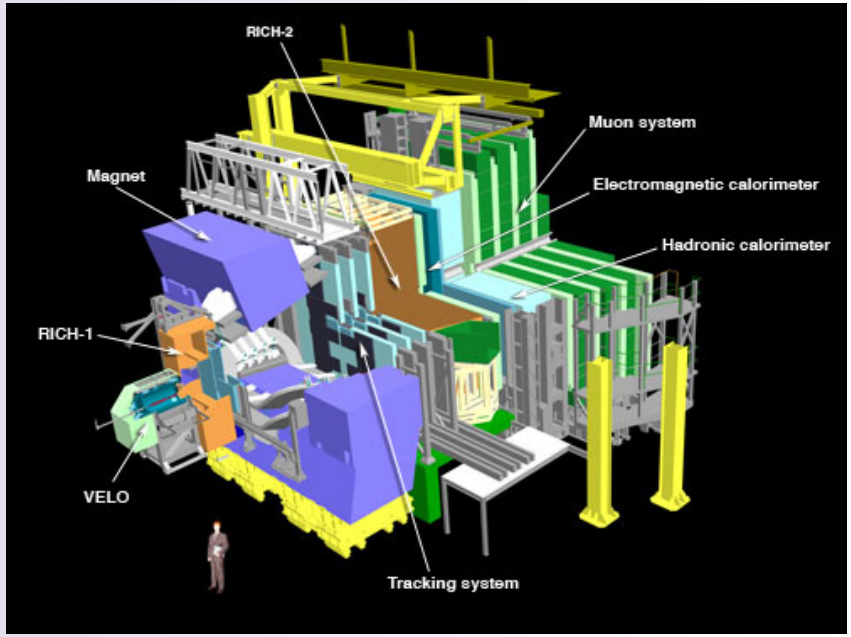
Good primary + secondary vertexing to measure proper time

Flavour Tagging

The LHCb Experiment







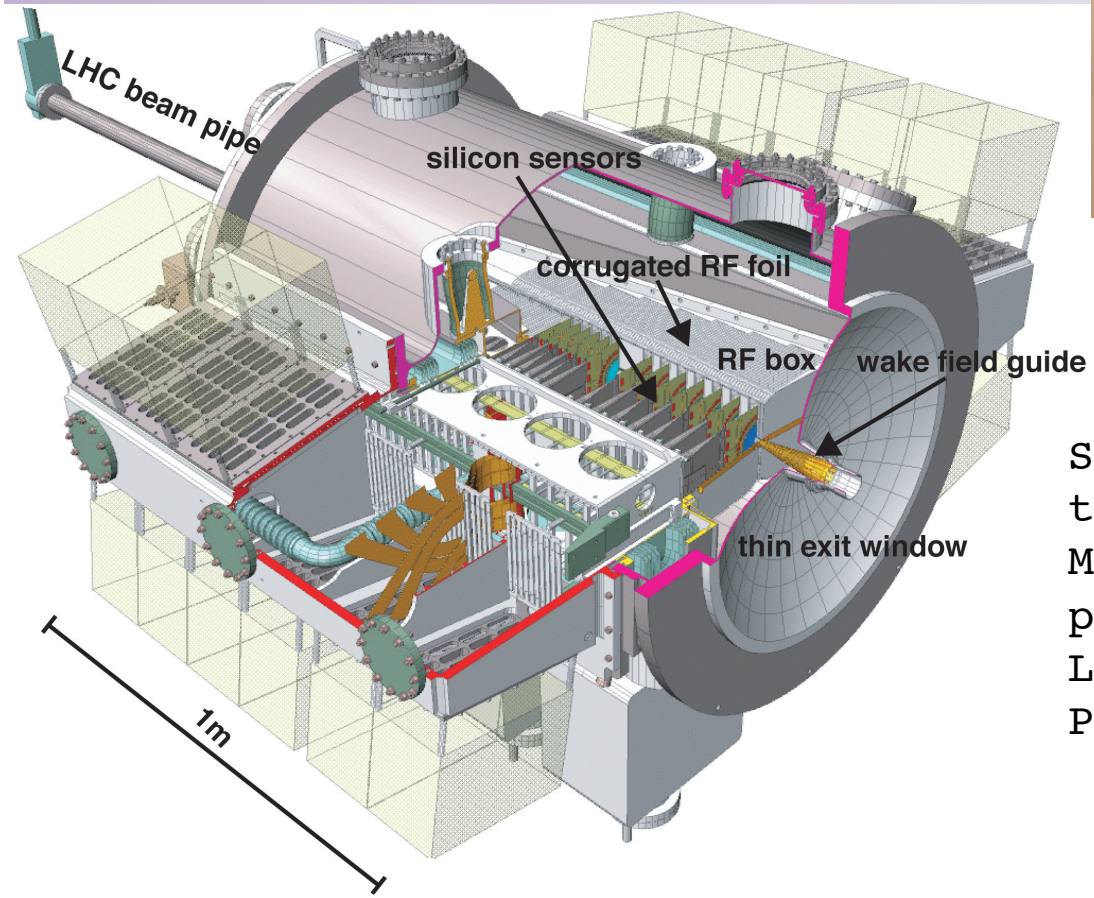
Relatively "small" detector:
Length: 20m
Weight: 4.5×10^6kg

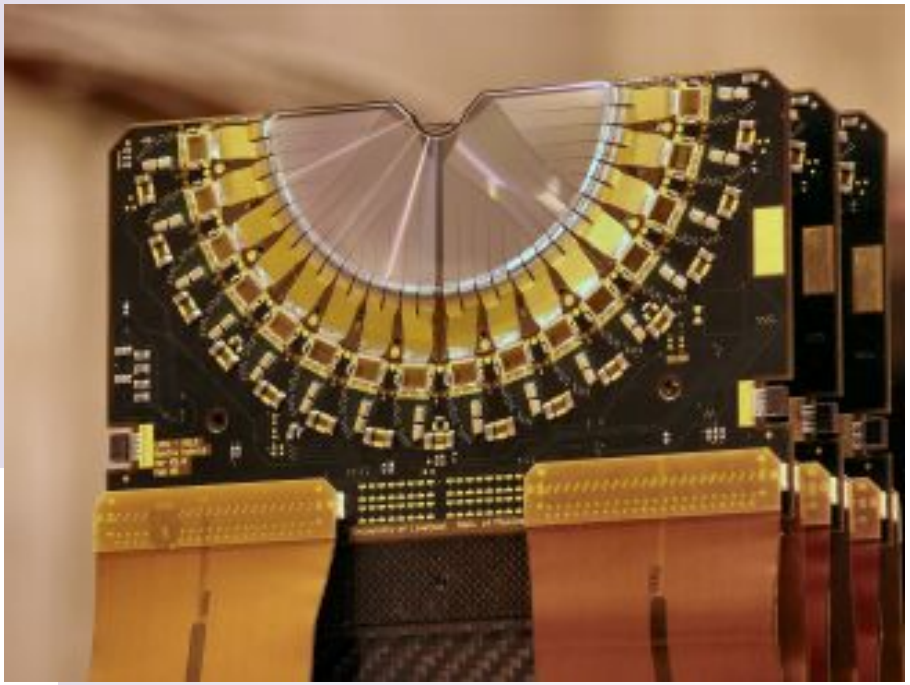
- High *b*-particle rate.
- Good Vertexing and lifetime measurement.
- Excellent PID.

VeLo & Tracking

The Velo (Vertex Locator) provides precise measurements of track coordinates close to the interaction region.

Tracks are identified using 220 μm Si strip sensors.
Radial and Azimuthal sensors mounted in a Module.



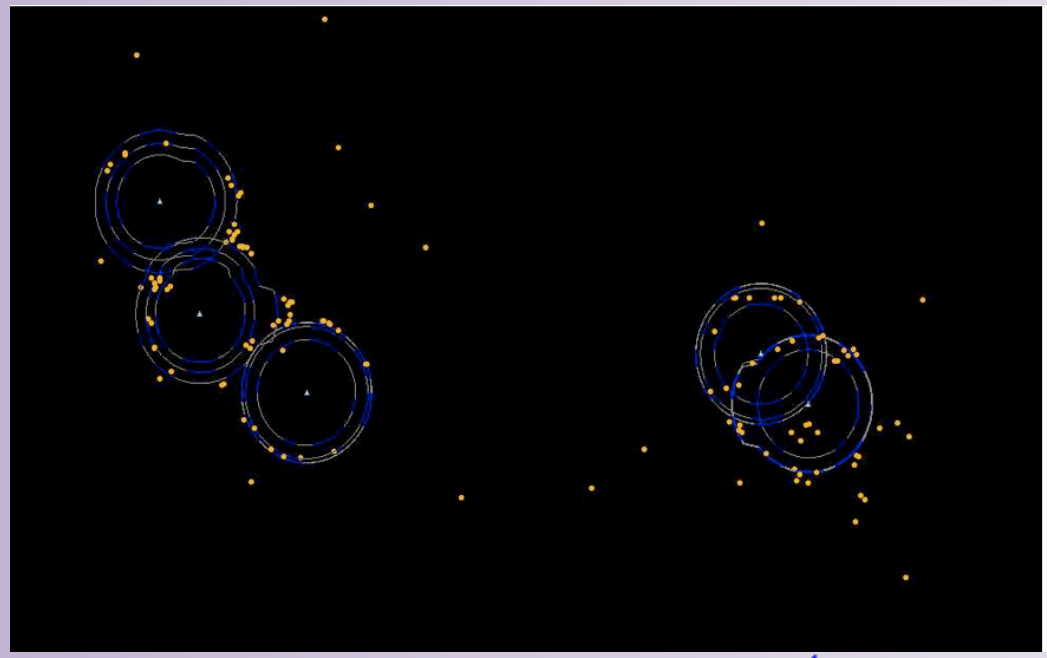


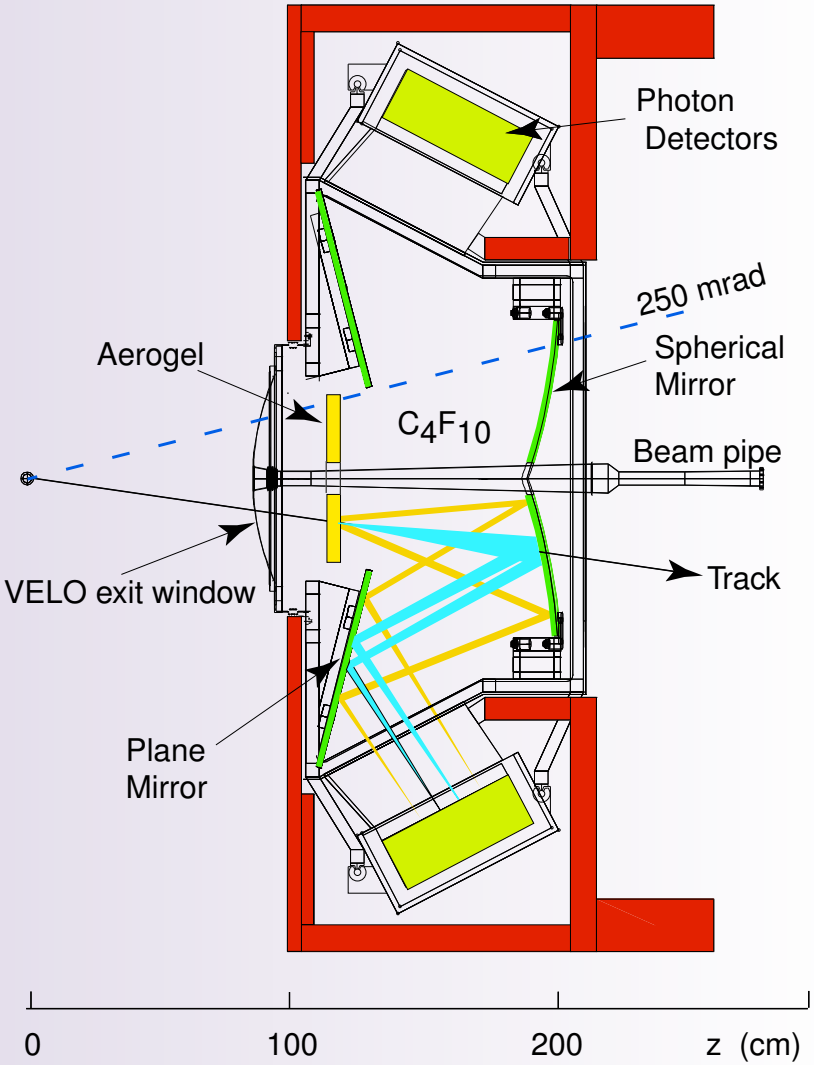
A Velo Module, 4096 channels/ module.

Sensors cover ~182°, overlap used to align VeLo halves.
Modules mounted on retractable platform to reduce damage during LHC fill.
Platform accurate to 10 μm at 21°C

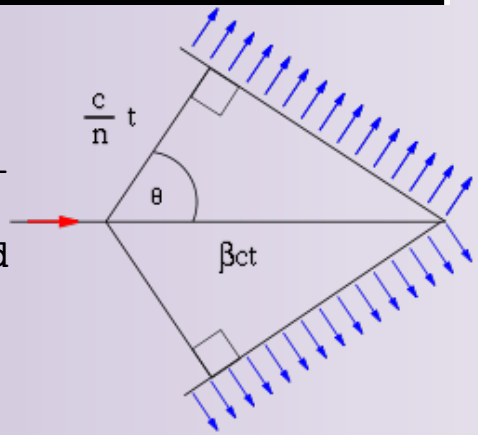
Particle Identification

PID mainly achieved through the two RICHes
Using track as seeds, rings centered on the tracks are found and a particle likelihood is assigned for each track hypothesis.



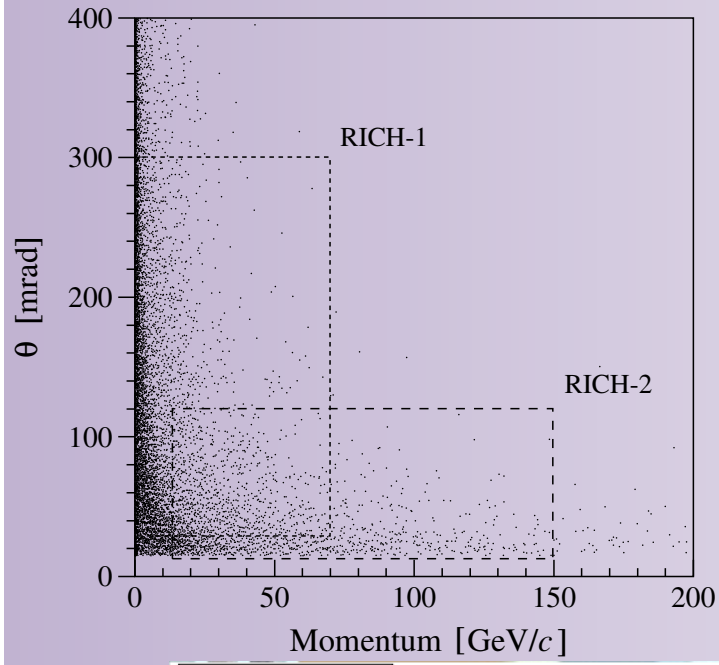


Cone formed by superluminal particles in the radiator. Rings formed when projected onto the detector plane.



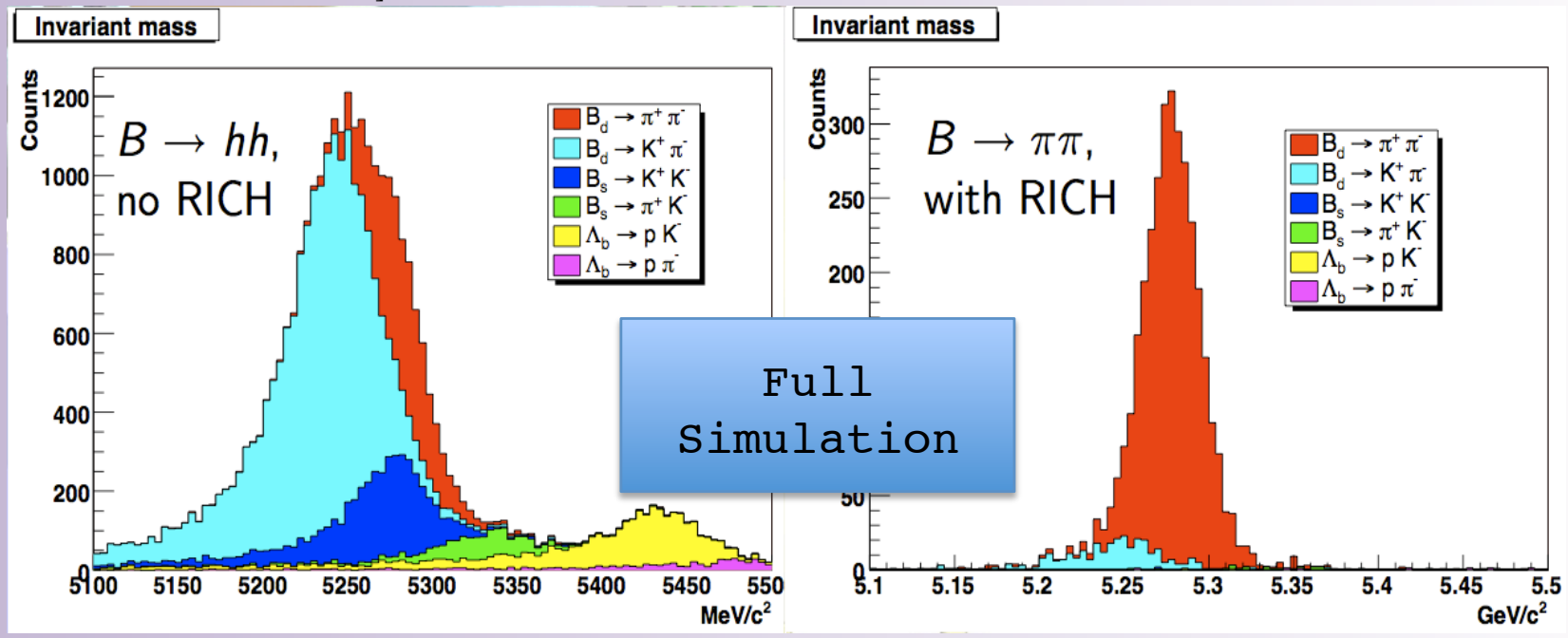
In other words, we can calculate the speed of a particle once we've measured the diameter of the ring.

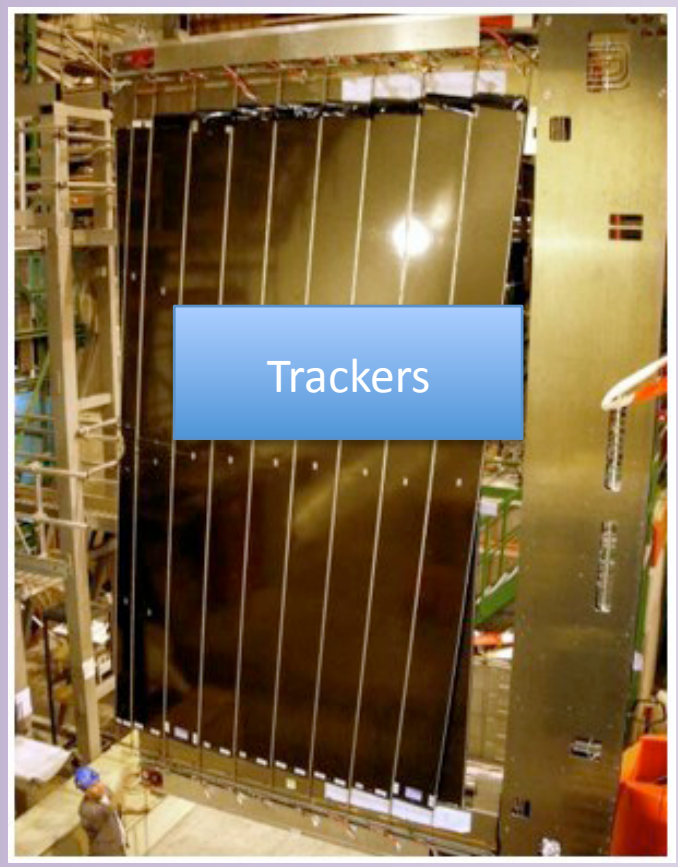
RICHes

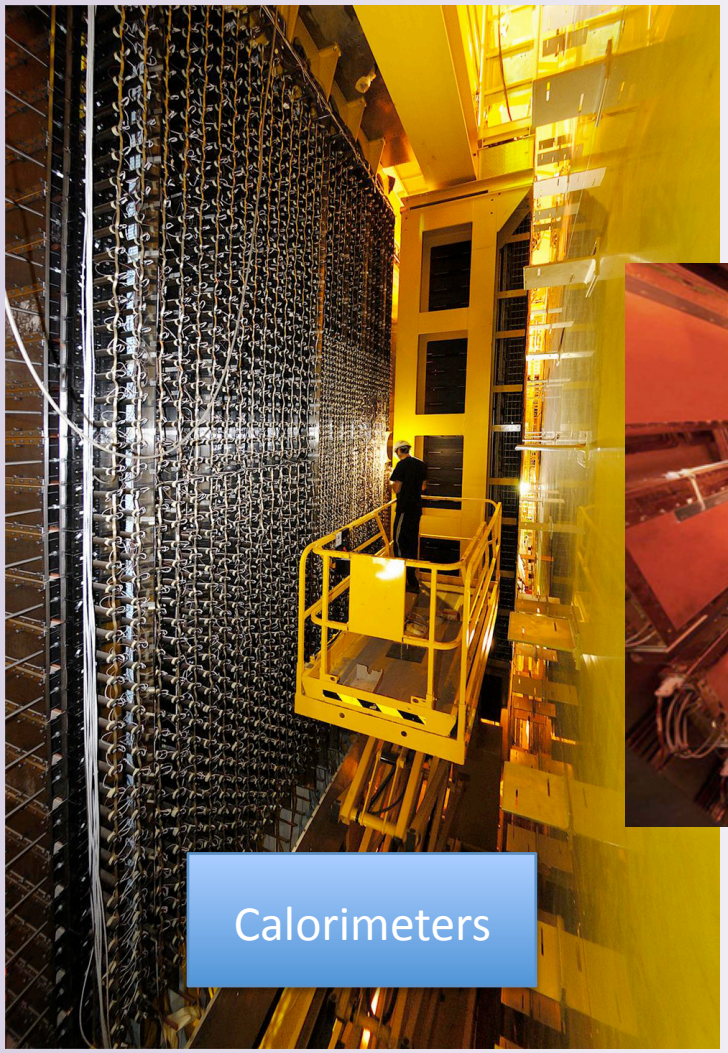


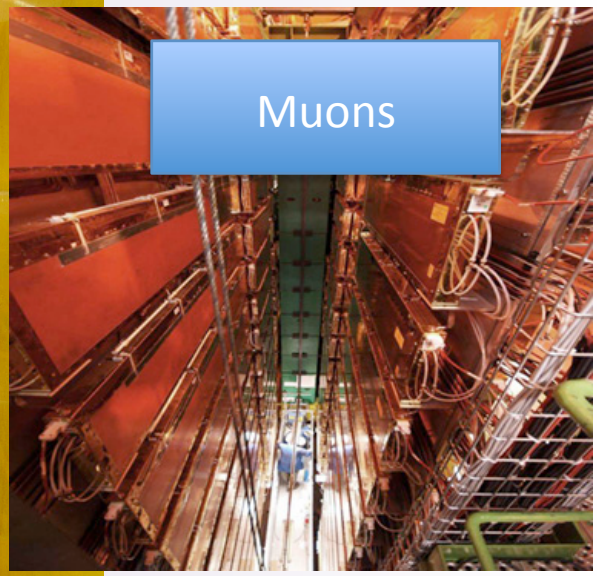
- Two RICHes cover most of the expected phase space
- RICH 1 covers low-momentum particles
- RICH 2 covers high-momentum particles
- Using both RICHes LHCb can achieve excellent Particle Identification.

B->hh selection, showing effect of RICH to ID Pions.




Trackers

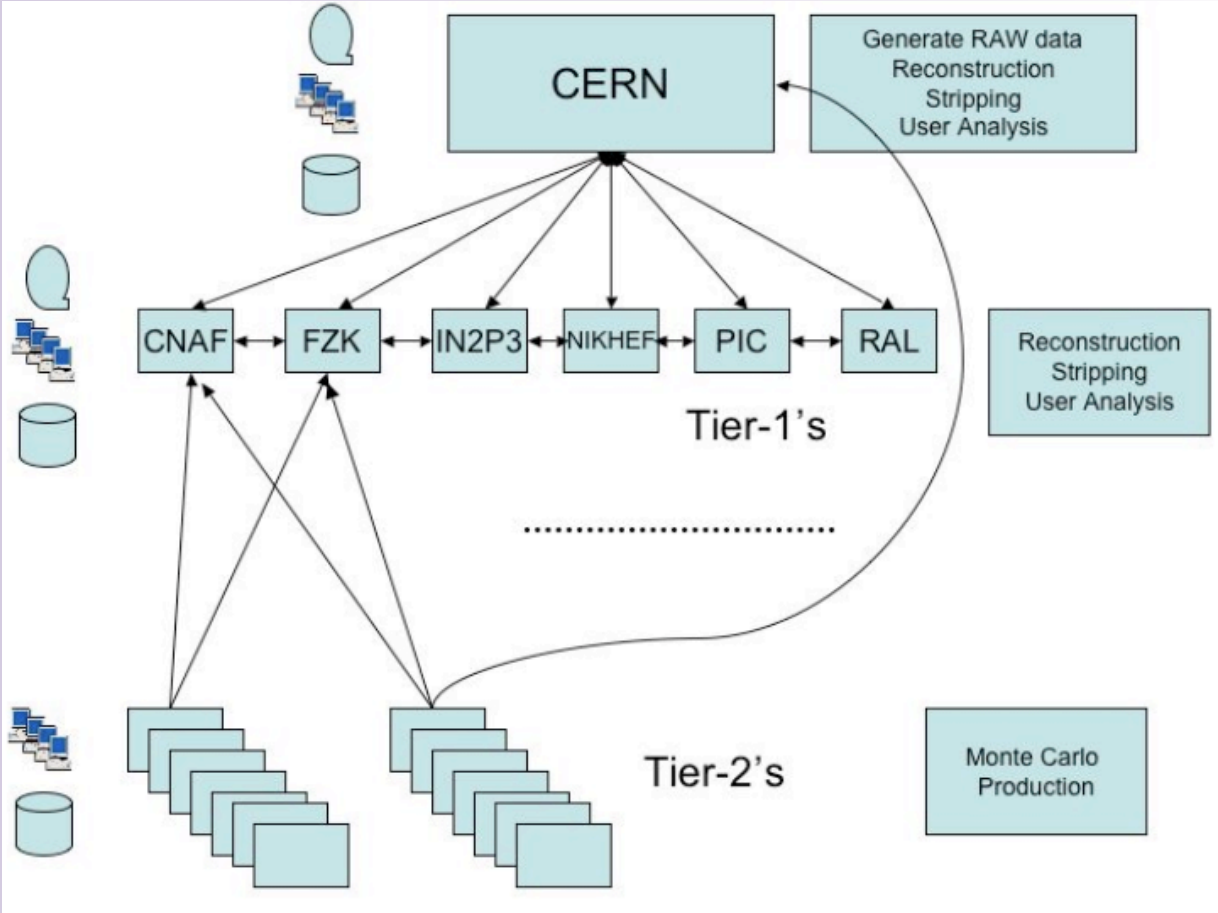

Calorimeters


Muons

LHCb Computing Model

Tier1 sites perform:
- Reconstruction
- Stripping
- User-Analysis

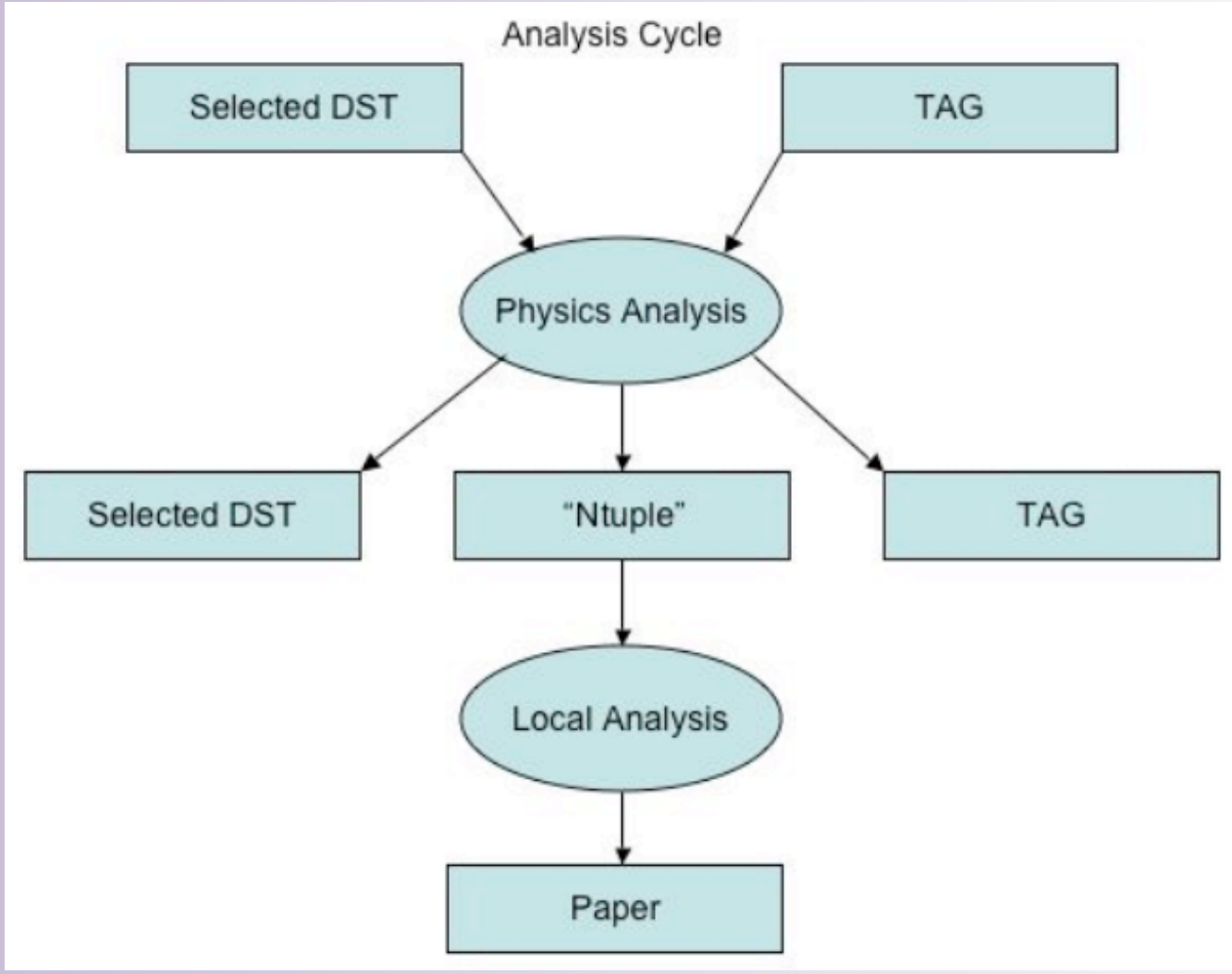
Tier 2 sites, such as CSCS are used for:
- MC Production
- Some User-Analysis



Don't worry, MC data will be required throughout the lifetime of the experiment. ;)

LHCb requires 23 Tb spread across all Tier2 sites for stripped DST storage.
This may change if many users wish to use Tier2 sites for analysis.

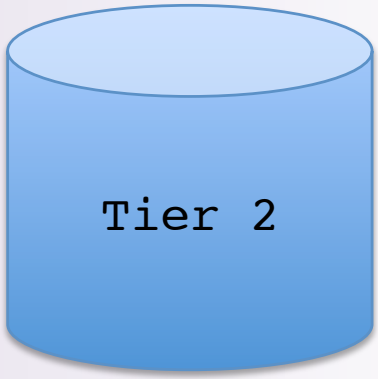
LHCb Physicist Analysis Cycle



Flags used in the talk

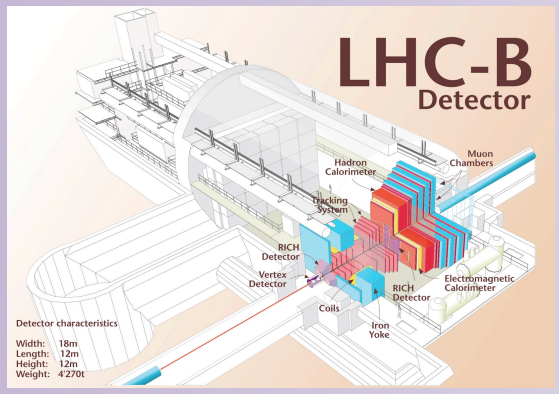
CERN.ch

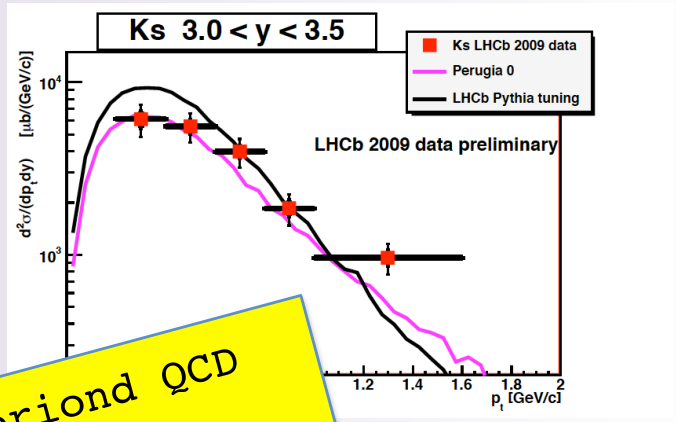
CNAF.it
CERN.ch
GridKa.de
Nikhef.nl
RAL.uk
in2p3.fr



CSCS.ch ;-)

From submiting jobs to getting a publication

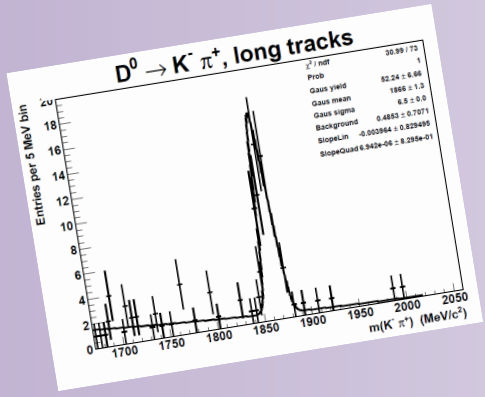


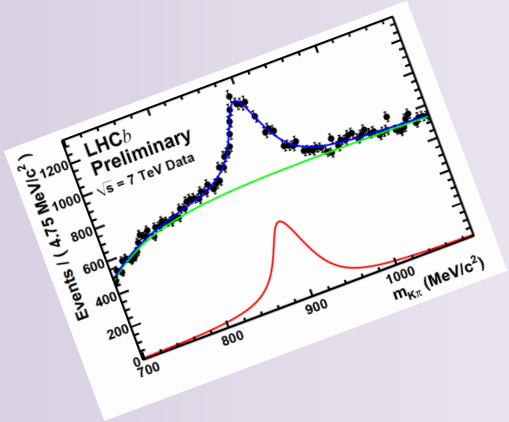


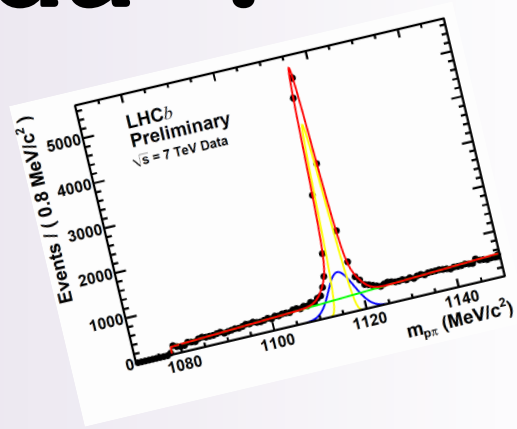
Moriond QCD 2010

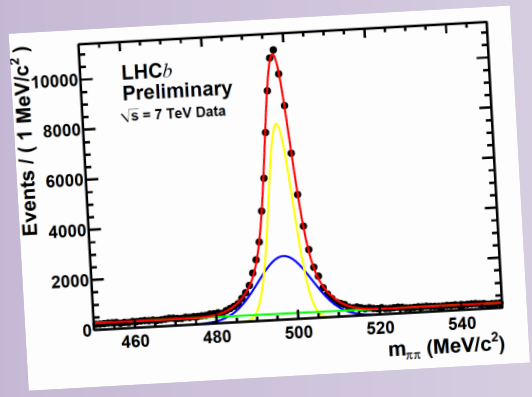
Ks cross section measurement at 900 GeV

LHCb propaganda !

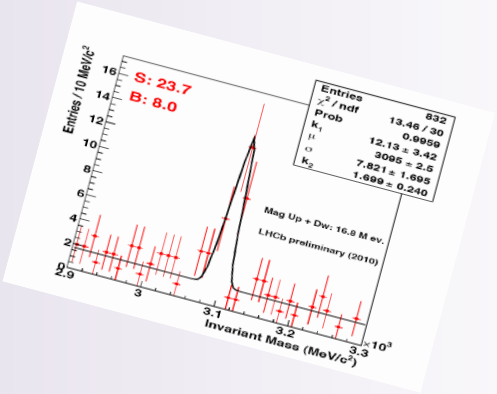


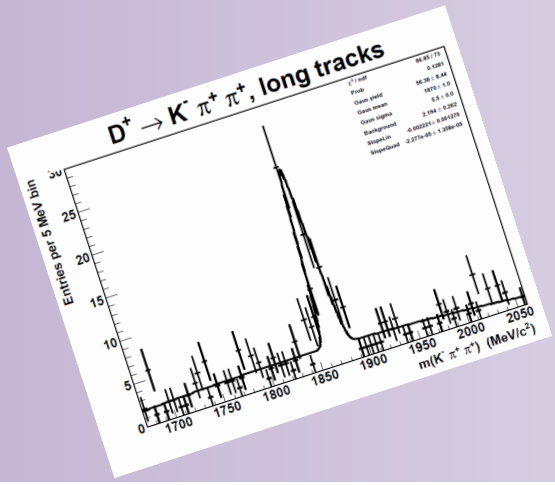


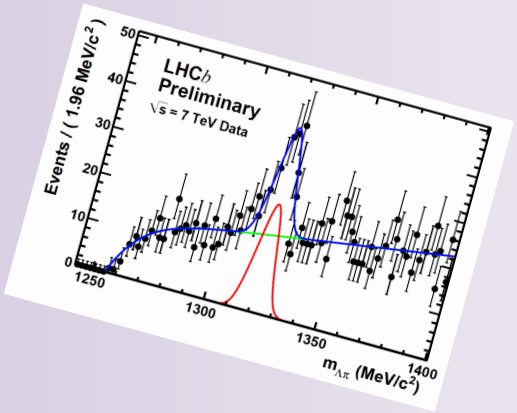


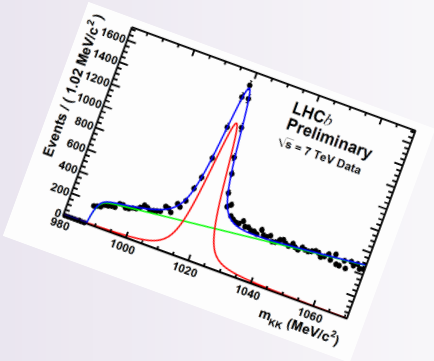


7TeV



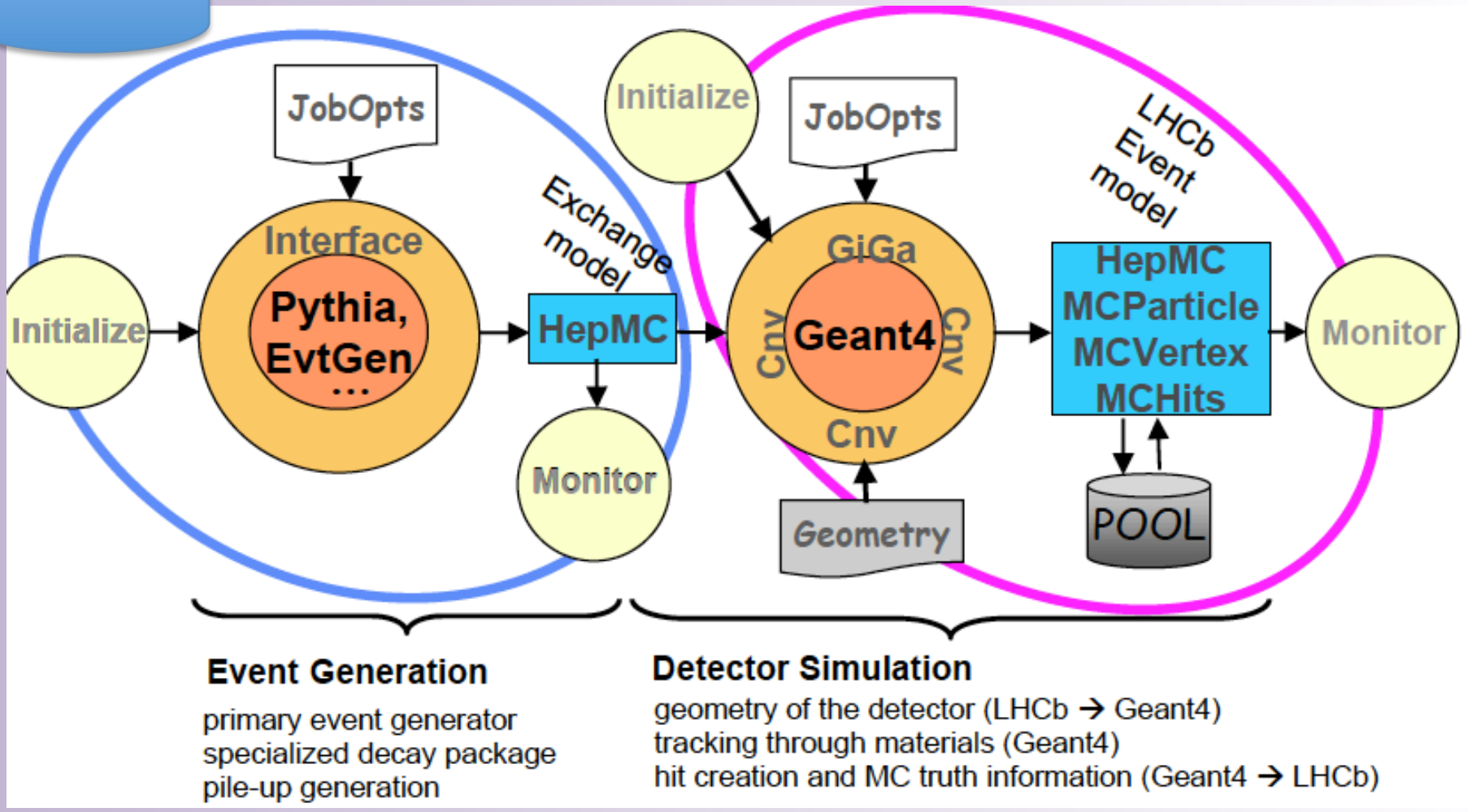




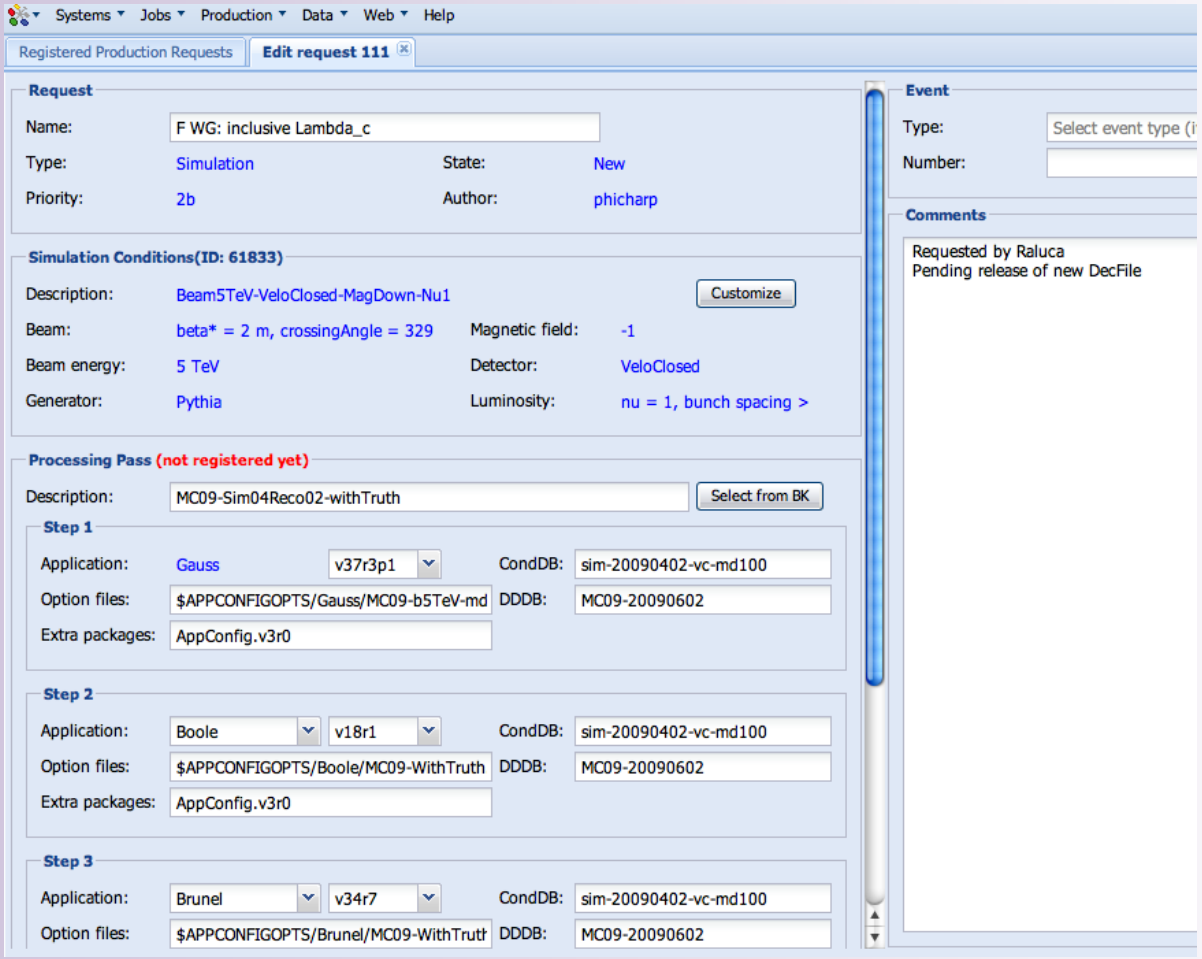


Analysis Preparation

Tier 1,2

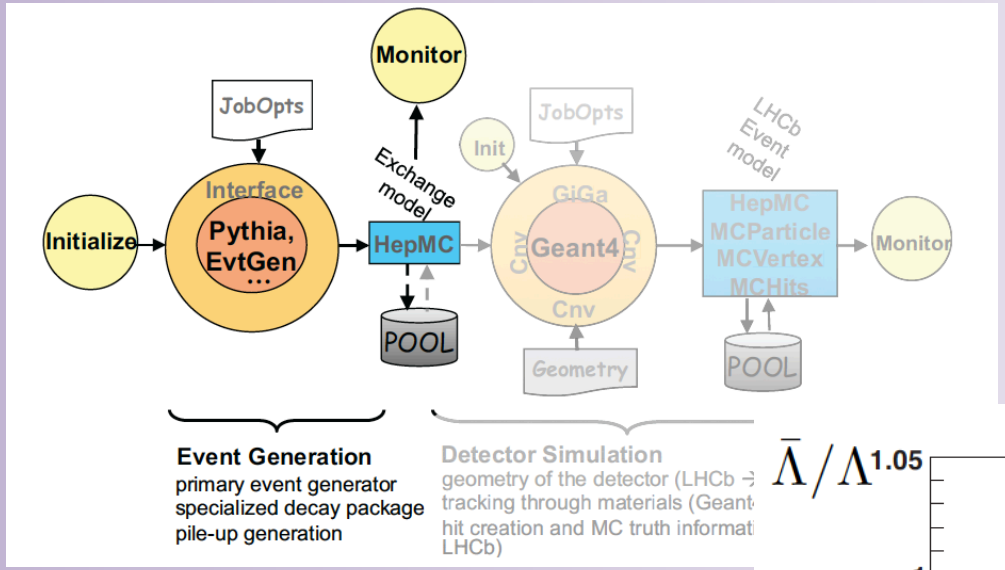


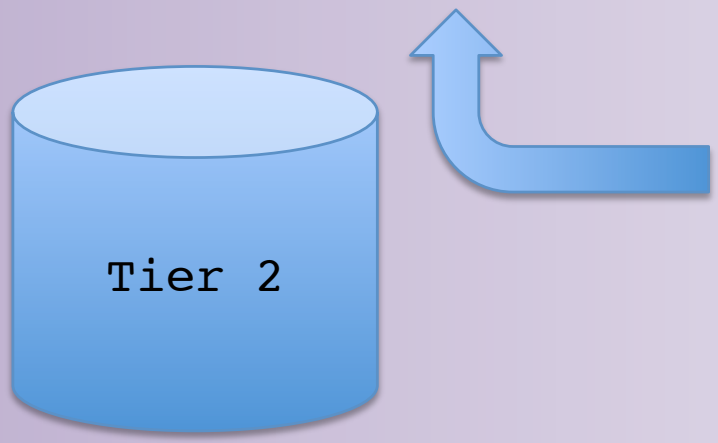
Analysis Preparation

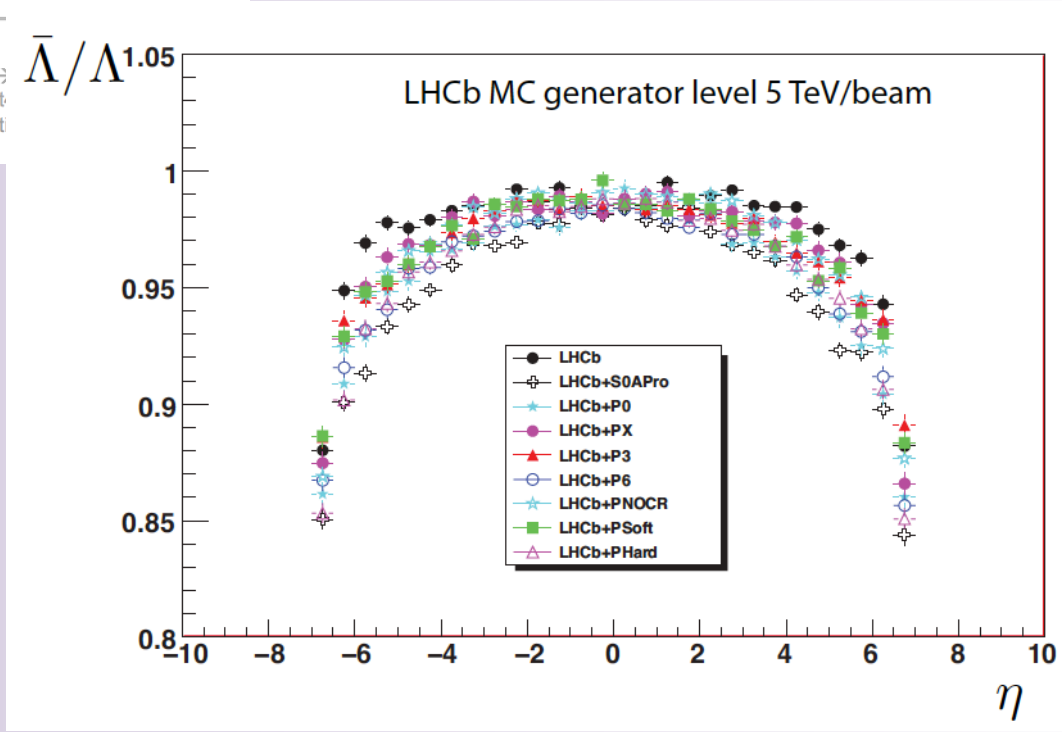


Central production requested by Physics Working Groups

Monte Carlo Tuning

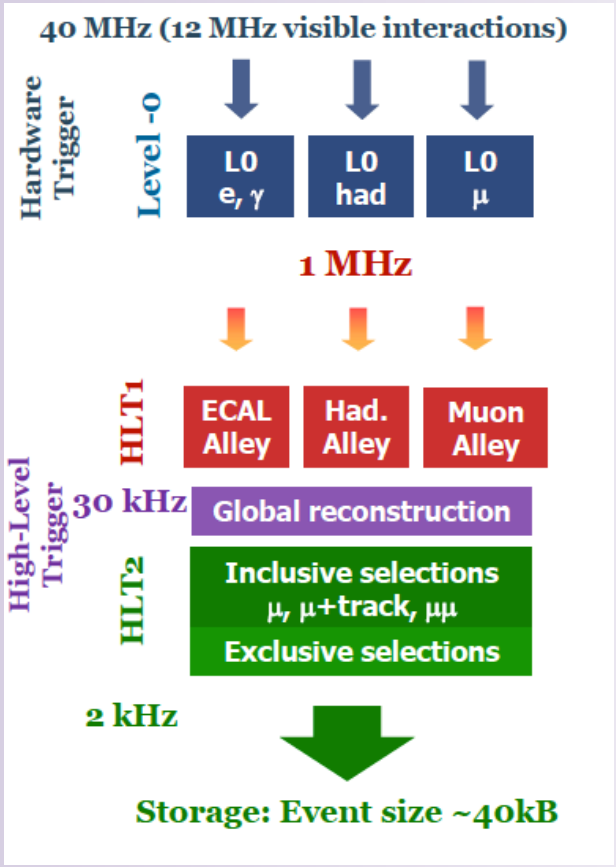






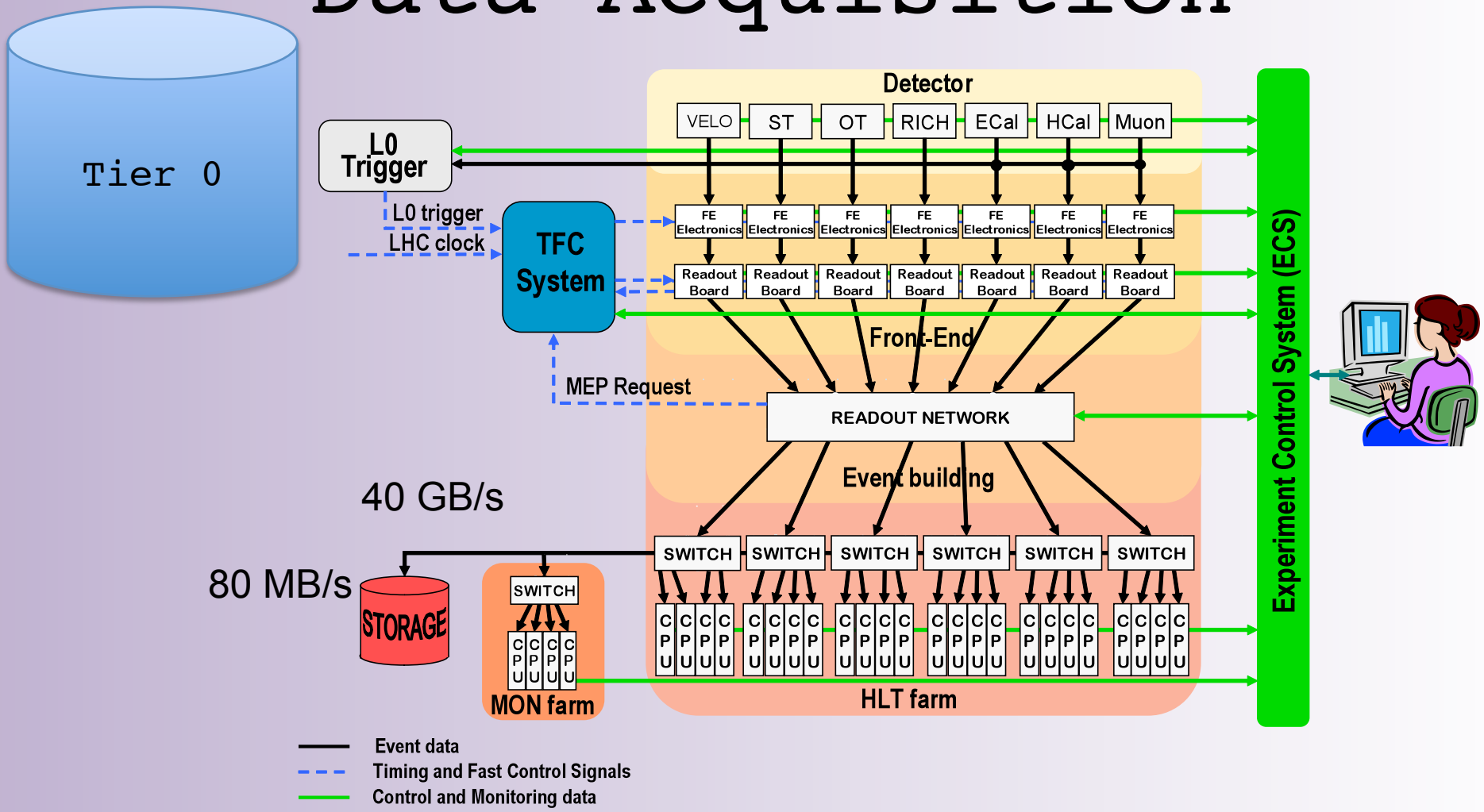
Trigger

Data reduction



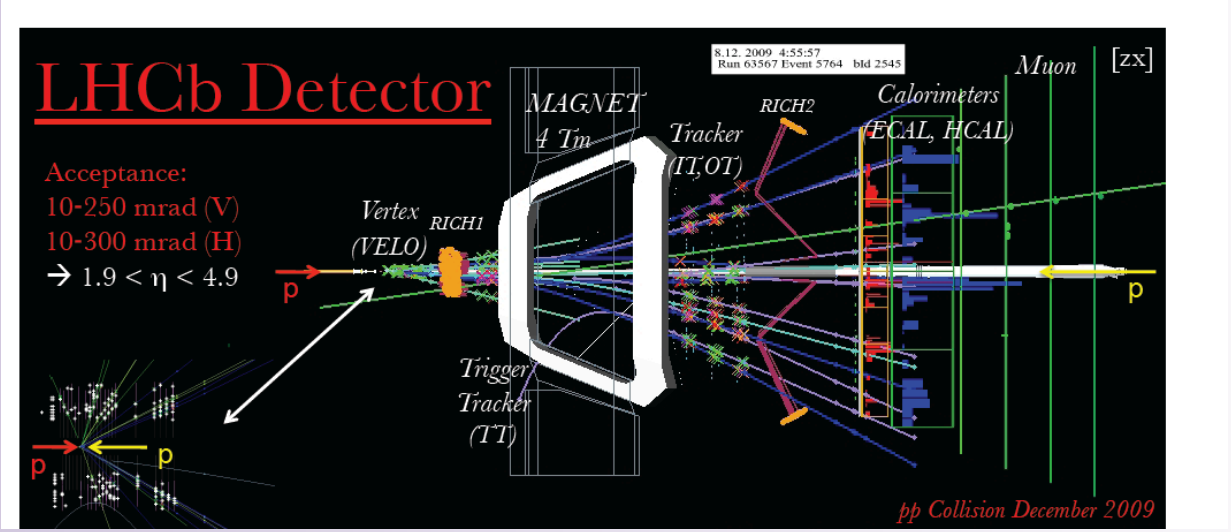
Fundamental for a Hadronic experiment!

Data Acquisition



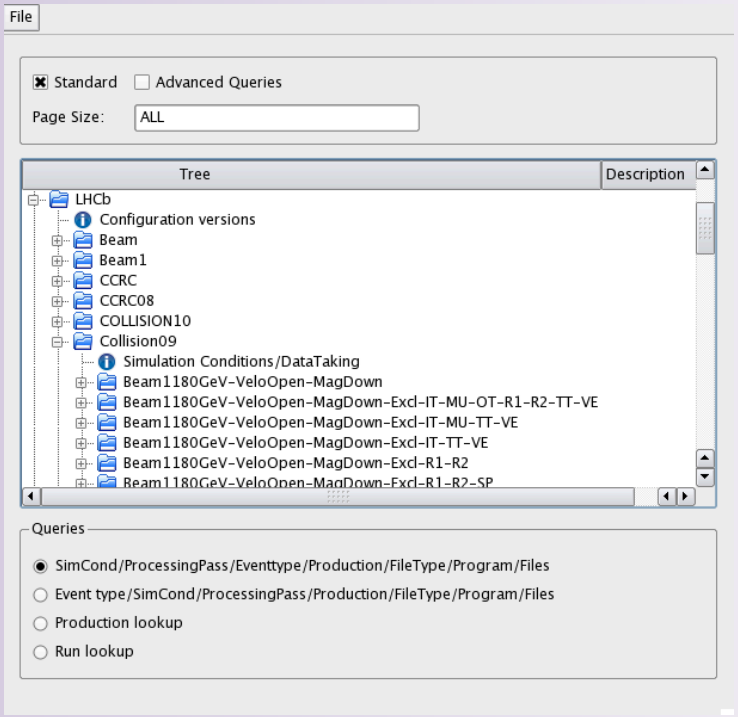
Average event size 40 kB
Average rate into farm 1 MHz
Average rate to tape 2 kHz

Event Reconstruction



- First reconstruction done in the pit.
- Data are sent to CERN.
- Register in a File Catalog (LFC)
- Replicas are sent to Tier 1 (CNAF.it …)

Accessing the data -bookeepping-



The user selects a specific production via the web interface or a gui.

Requires a grid Certificate

In Practice…


```
#-- GAUDI jobOptions generated on Thu Apr 15 09:36:47 2010
#-- Contains event types :
#--   90000000 - 1 files - 64179 events - 3.06 GBytes

from Gaudi.Configuration import *



EventSelector().Input   = [
#run 63949
"    DATAFILE='LFN:/lhcb/data/2009/DST/00006296/0000/00006296_00000002_1.dst' TYP='POOL_ROOTTREE' OPT='READ'",
#run 63815
"    DATAFILE='LFN:/lhcb/data/2009/DST/00006282/0000/00006282_00000066_1.dst' TYP='POOL_ROOTTREE' OPT='READ'",
"    DATAFILE='LFN:/lhcb/data/2009/DST/00006282/0000/00006282_00000067_1.dst' TYP='POOL_ROOTTREE' OPT='READ'",
#run 63814
"    DATAFILE='LFN:/lhcb/data/2009/DST/00006282/0000/00006282_00000065_1.dst' TYP='POOL_ROOTTREE' OPT='READ'",
#run 63813
"    DATAFILE='LFN:/lhcb/data/2009/DST/00006282/0000/00006282_00000057_1.dst' TYP='POOL_ROOTTREE' OPT='READ'",
"    DATAFILE='LFN:/lhcb/data/2009/DST/00006282/0000/00006282_00000058_1.dst' TYP='POOL_ROOTTREE' OPT='READ'",
"    DATAFILE='LFN:/lhcb/data/2009/DST/00006282/0000/00006282_00000059_1.dst' TYP='POOL_ROOTTREE' OPT='READ'",
"    DATAFILE='LFN:/lhcb/data/2009/DST/00006282/0000/00006282_00000060_1.dst' TYP='POOL_ROOTTREE' OPT='READ'",
"    DATAFILE='LFN:/lhcb/data/2009/DST/00006282/0000/00006282_00000061_1.dst' TYP='POOL_ROOTTREE' OPT='READ'",
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"    DATAFILE='LFN:/lhcb/data/2009/DST/00006282/0000/00006282_00000063_1.dst' TYP='POOL_ROOTTREE' OPT='READ'",
```
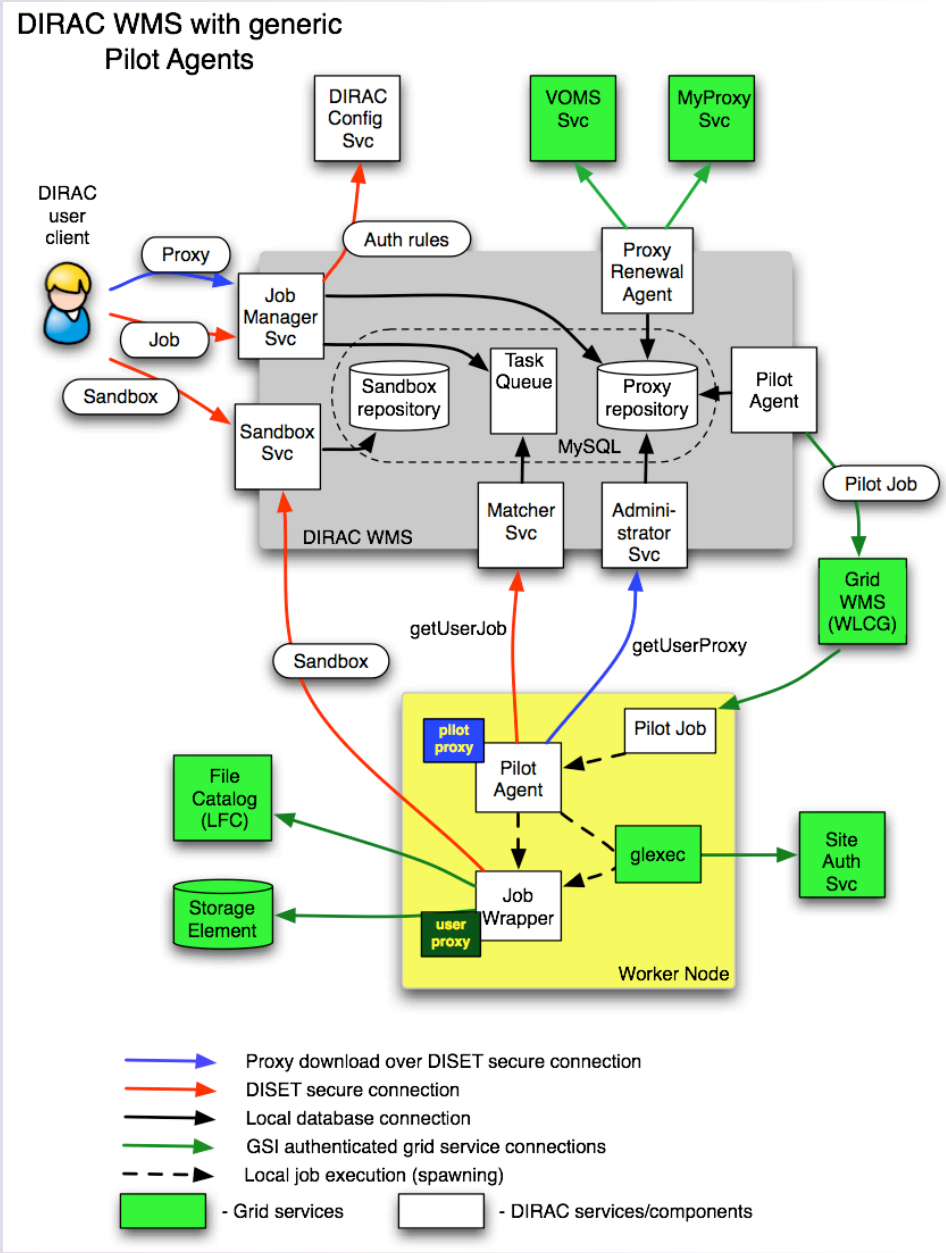
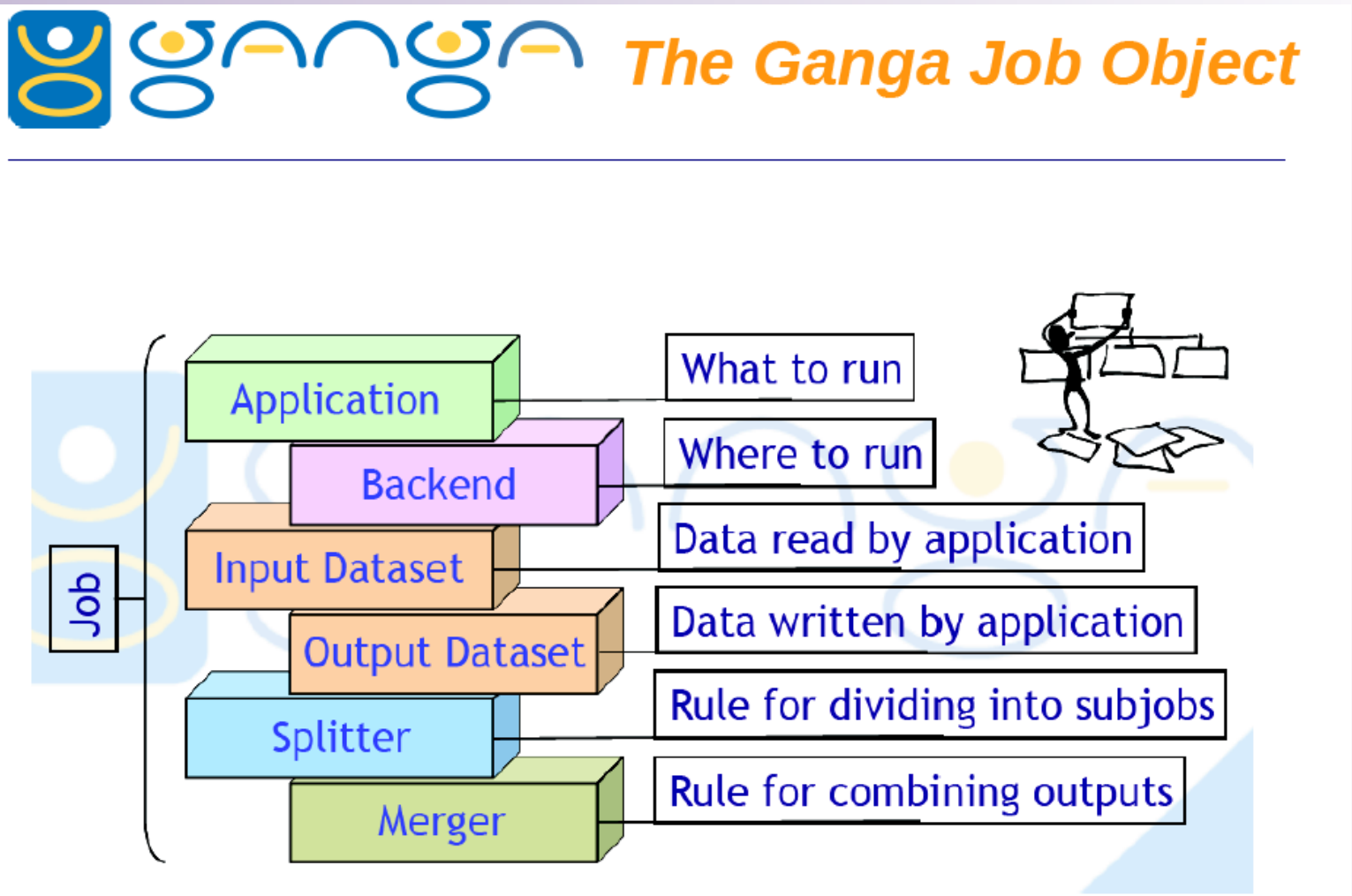

Logical File Name : The jobs can run anywhere

Submitting Jobs via Dirac

- **Late job binding**
  - A job is fetched only when all is OK
    - Software and data present
    - Site capabilities matching
- **Apply priorities centrally**
  - No site intervention
  - Users and production jobs mixed



From the user perspective

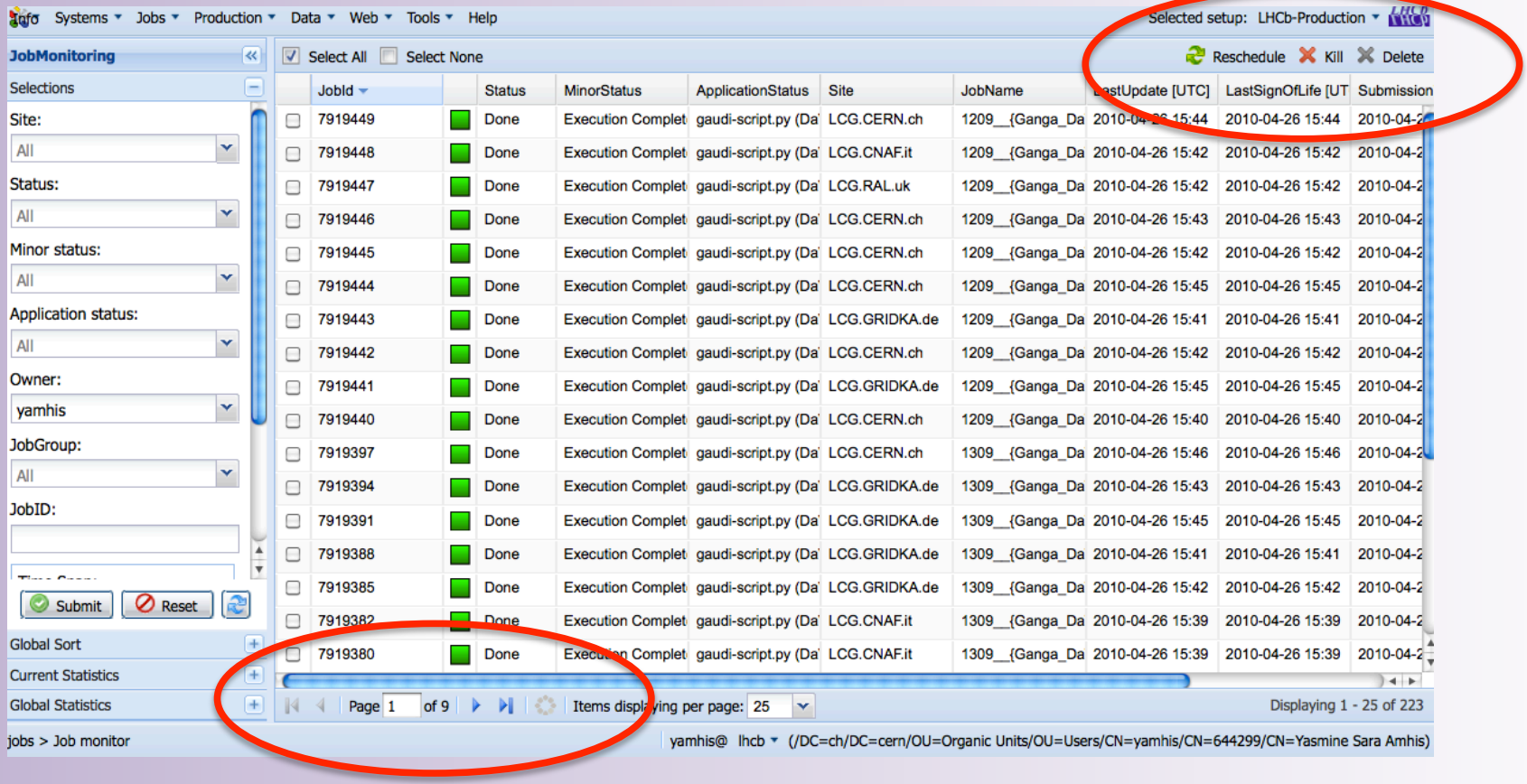


From the user perspective (bis…)

Job Create/Submit

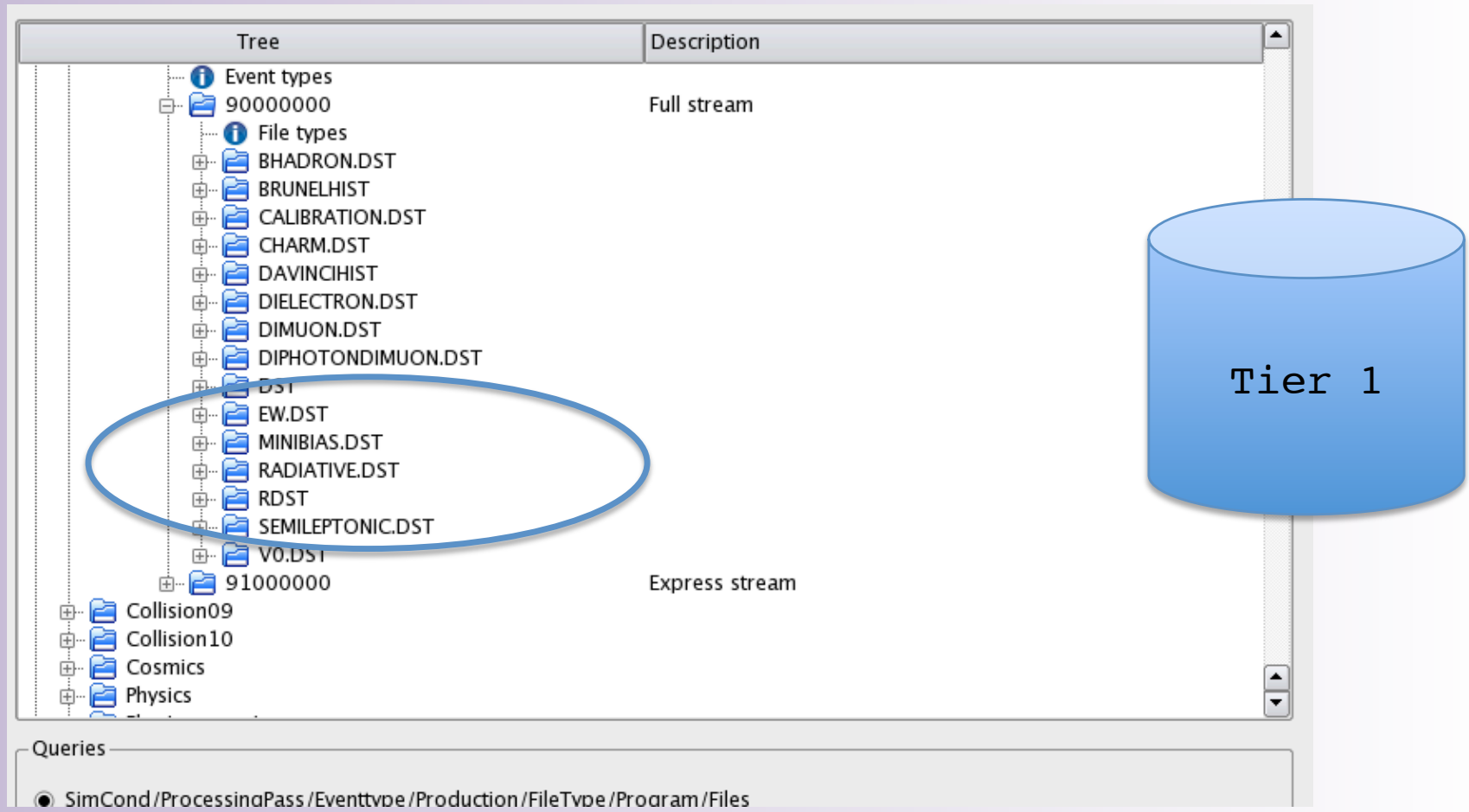
```
[In:] j = Job()
[In:] j.application = Executable(exe='/bin/hostname')
[In:] j.name = "MyTest"
[In:] print j
[In:] j.submit()

# wait until job is completed and look
# at the output directory

[In:] j.status
[In:] j.peek()
[In:] j.peek('stdout')

# The syntax for peek is very flexible see
[In:] help(j.peek)
```

Job Monitoring



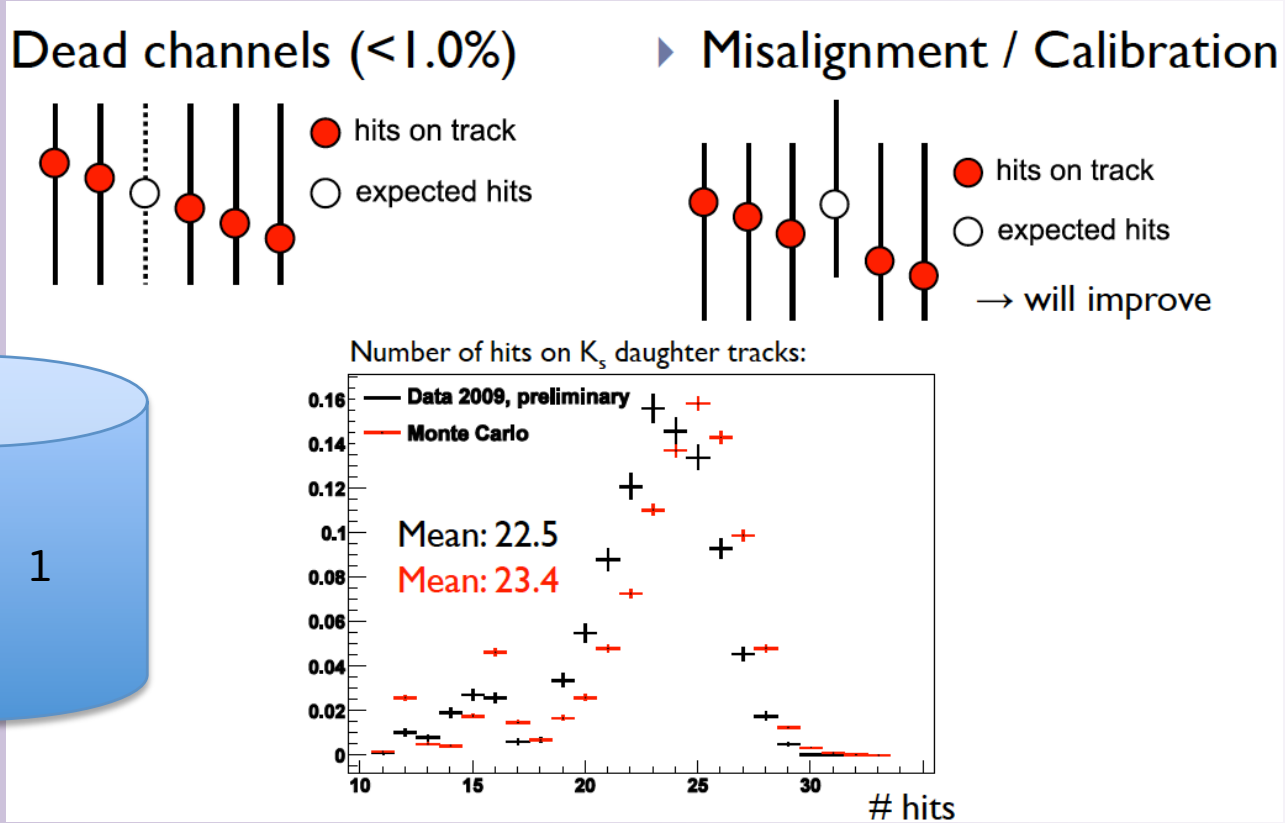
Certificate loaded in the browser

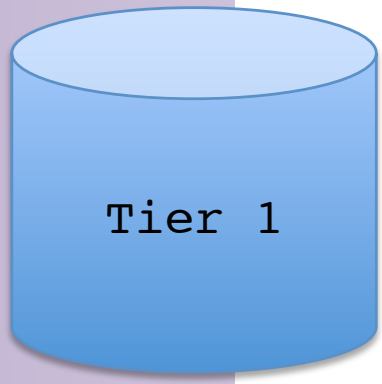
Need to strip data



Users run their jobs on specific streams

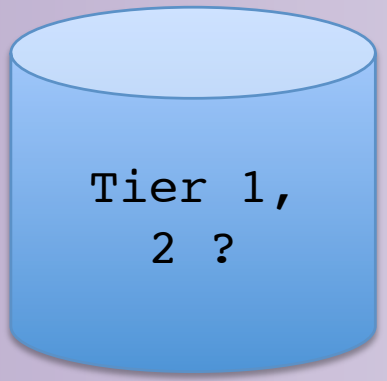
Data Reprocessing





Data reprocessed after
changes/improvements to the reconstruction

Micro-dst (next step)

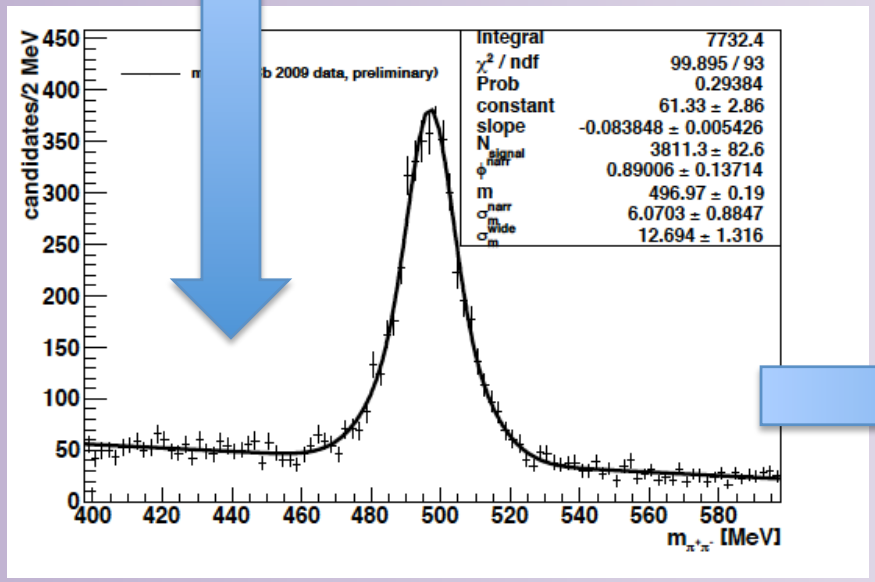


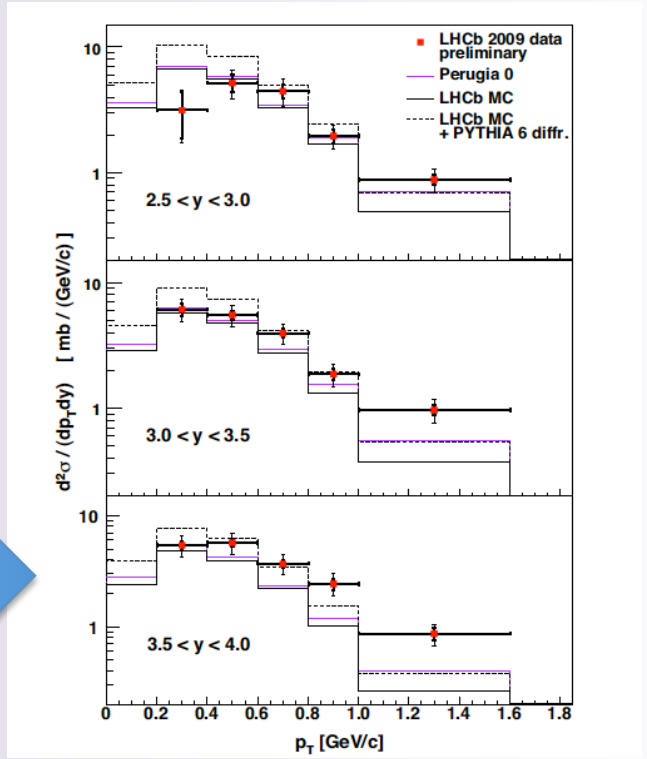
- Reduce more the data sets.
- Files shared within a physics working group.
-Files put in the Catalog and accessible via the grid.

Do the analysis

Variable	Requirement
Each π momentum	> 2 GeV/c
Each π transverse momentum	> 50 MeV/c
Each track χ^2/ndf	< 25
Each π impact parameter w.r.t. PV	> 3 mm
K^0_S decay vertex χ^2/ndf	< 25
z of K^0_S decay vertex	< 2200 mm
$\lvert z \rvert$ of PV	< 150 mm
$\cos\theta_{\text{pointing}}$	> 0.99995
K^0_S $c\tau$	> 5 mm

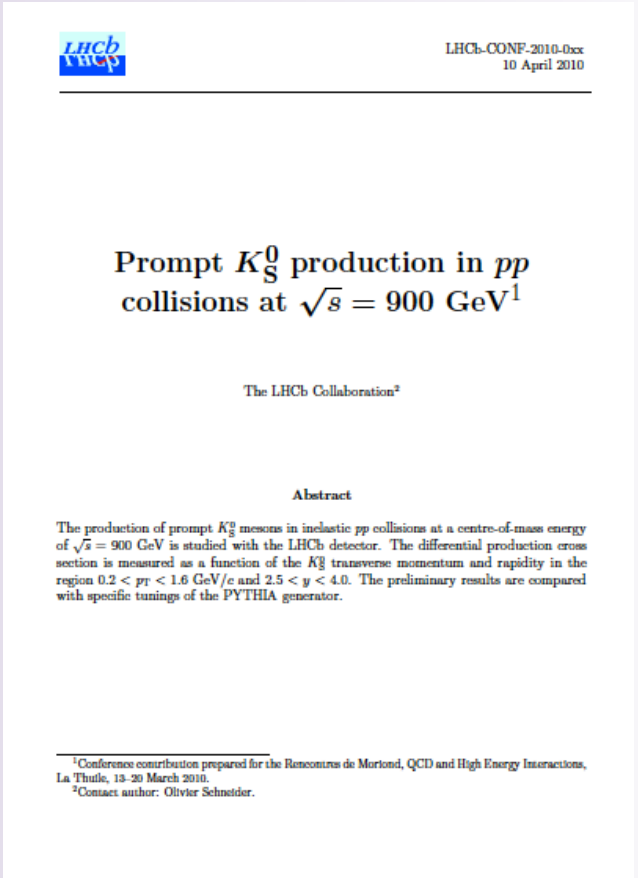
$$\sigma_i = \frac{N_i^{\text{obs}}}{\epsilon_i \times L_{\text{int}}}$$





Conclusion

- ✓ LHCb is FINALLY taking data.
- ✓ Detector commissioning.
- ✓ Reconstruction chain.
- ✓ Data efficiently processed and analysed with grid tools.
- ✓ First physics results.



LHCb-CONF-2010-0xx
10 April 2010

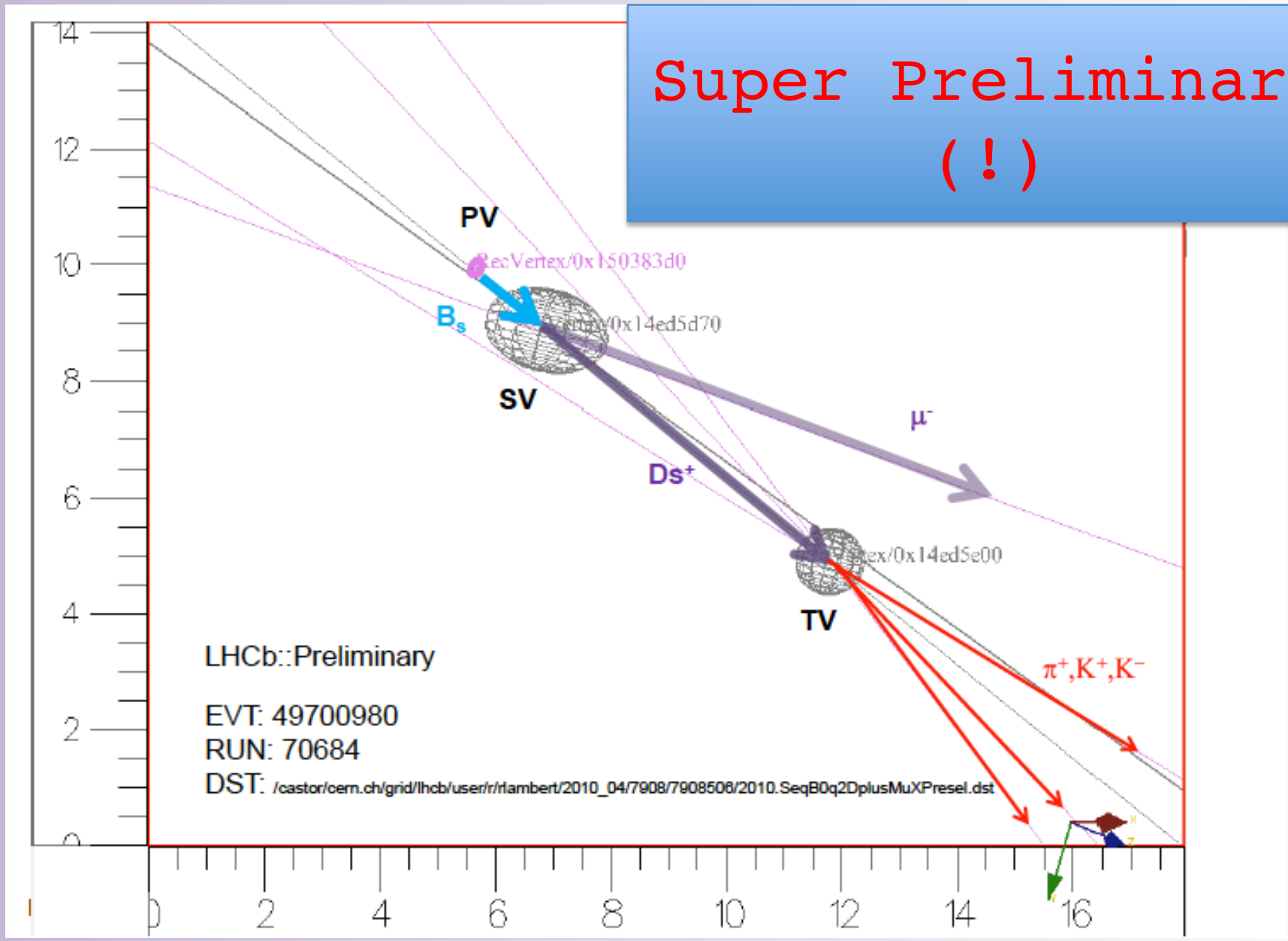
Prompt K^0_S production in pp collisions at $\sqrt{s} = 900$ GeV[1]

The LHCb Collaboration[2]

Abstract

The production of prompt K^0_S mesons in inelastic pp collisions at a centre-of-mass energy of $\sqrt{s} = 900$ GeV is studied with the LHCb detector. The differential production cross section is measured as a function of the K^0_S transverse momentum and rapidity in the region $0.2 < p_T < 1.6$ GeV/c and $2.5 < y < 4.0$. The preliminary results are compared with specific tunings of the PYTHIA generator.

[1] Conference contribution prepared for the Rencontres de Moriond, QCD and High Energy Interactions, La Thuile, 13-20 March 2010.
[2] Contact author: Olivier Schneider.

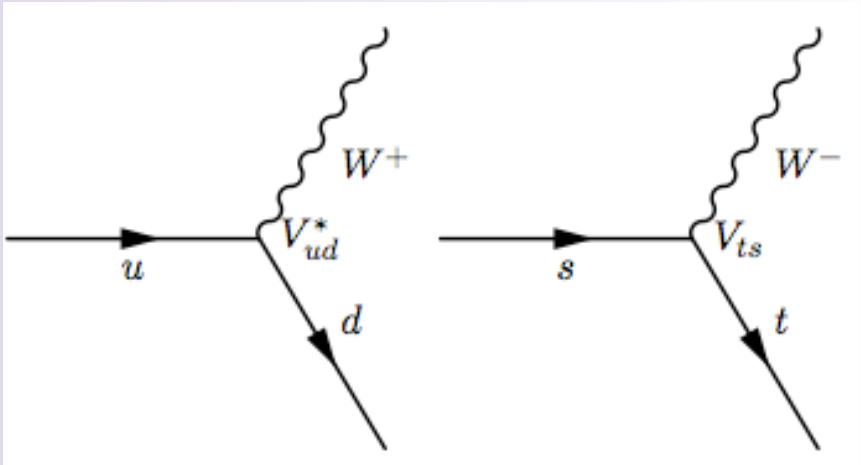

Super Preliminary
(!)
PV
SV
TV
B_s
Ds^+
μ^-
π^+,K^+,K^-
LHCb::Preliminary
EVT: 49700980
RUN: 70684
DST: /castor/cern.ch/grid/lhcb/user/r/rlambert/2010_04/7908/7908506/2010.SeqB0q2DplusMuXPresel.dst

Backup slides

LHCb Physics

Assuming matter was created in equal amounts in the Big Bang, then we need some (CP violating) mechanism to change antimatter into matter.
CP violation requires, in general, particle interactions with complex phases.
Such interactions are only found in weak processes in the SM: flavour transitions

The link between the down-type quark mass eigenstates and the SU (2) partners of the up-type quarks is given by the CKM matrix, V.



Up to order λ^3 in the Wolfenstein parameterisation, the CKM matrix is as follows:

$$\begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} \cong \begin{pmatrix} 1-\lambda^2/2 & \lambda & A\lambda^3(\rho-i\eta) \\ -\lambda & 1-\lambda^2/2 & A\lambda^2 \\ A\lambda^3(1-\rho-i\eta) & -A\lambda^2 & 1 \end{pmatrix} + \delta V$$