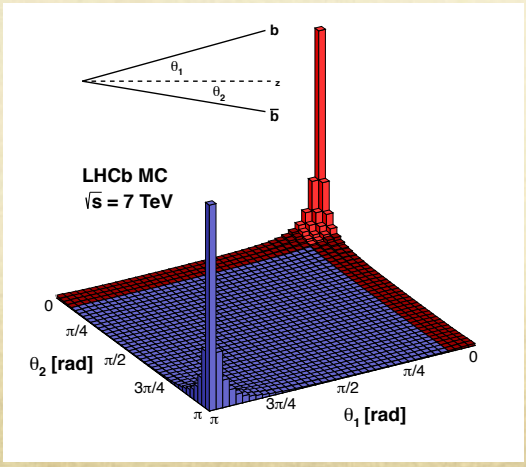
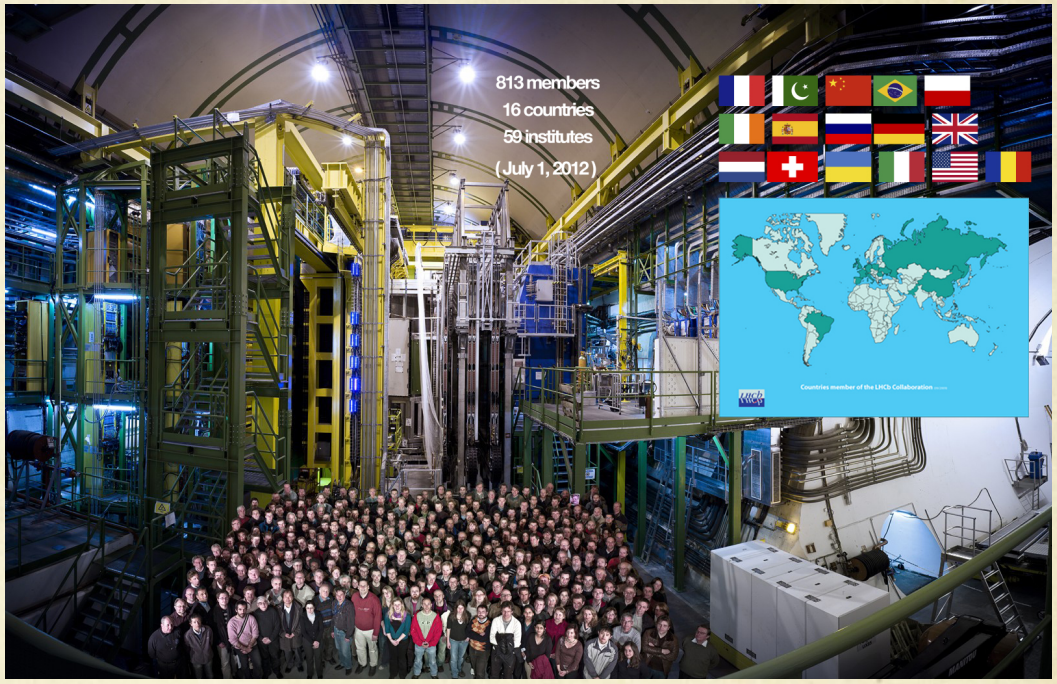
LHCb-Pisa
Stato 2013-Preventivi 2014

M.J.Morello – 28 giugno 2013

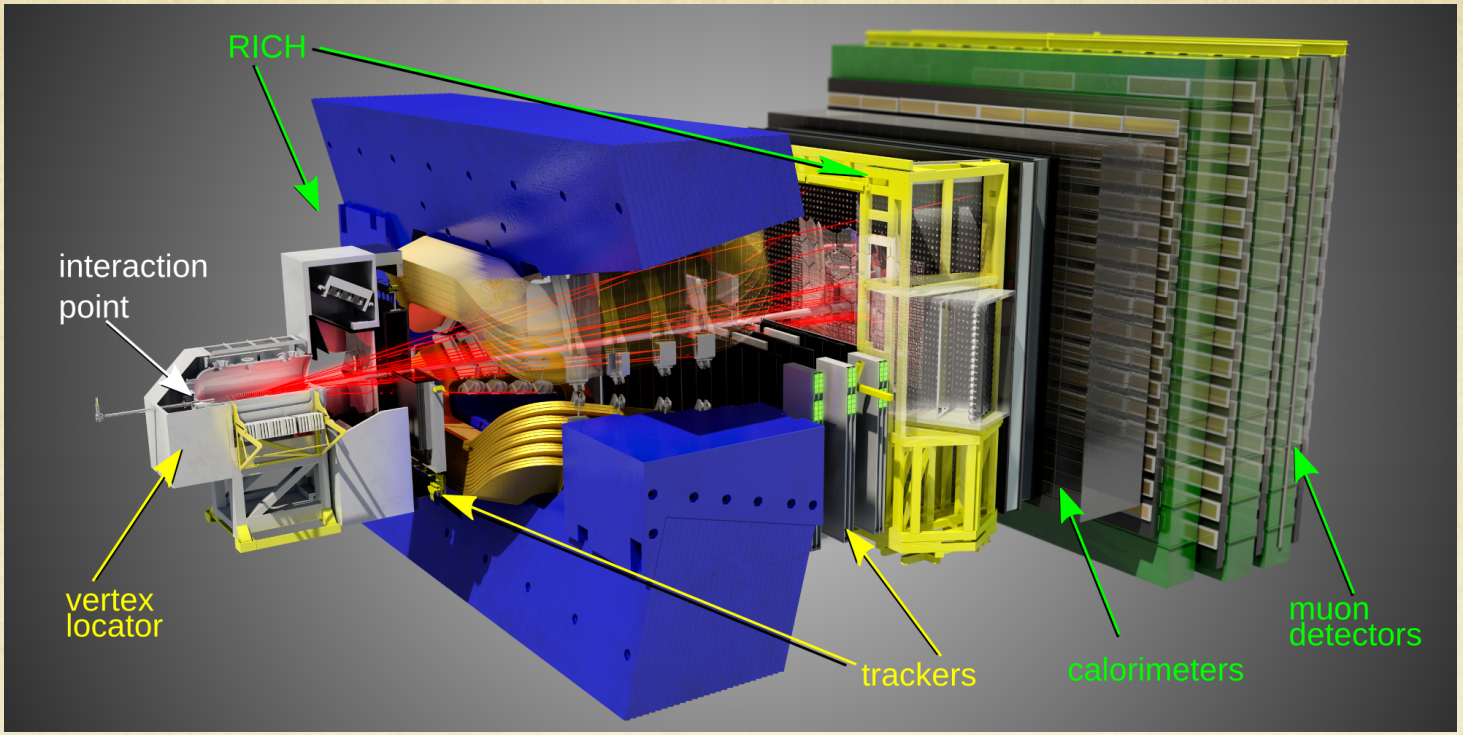
The LHCb experiment

- pp collisions at 7-8TeV
- Large b-quark production in the forward region
- Full b-hadrons spectrum
- Lpeak = $3-4 \times 10^{32}$ $cm^{-2}s^{-1}$
- $L_{int}=3.1fb^{-1} \rightarrow (10^{12}$ bbar pairs)





- Specialized b-physics and charm
- Forward single arm spectrometer
- Acceptance $2 < \eta < 5$

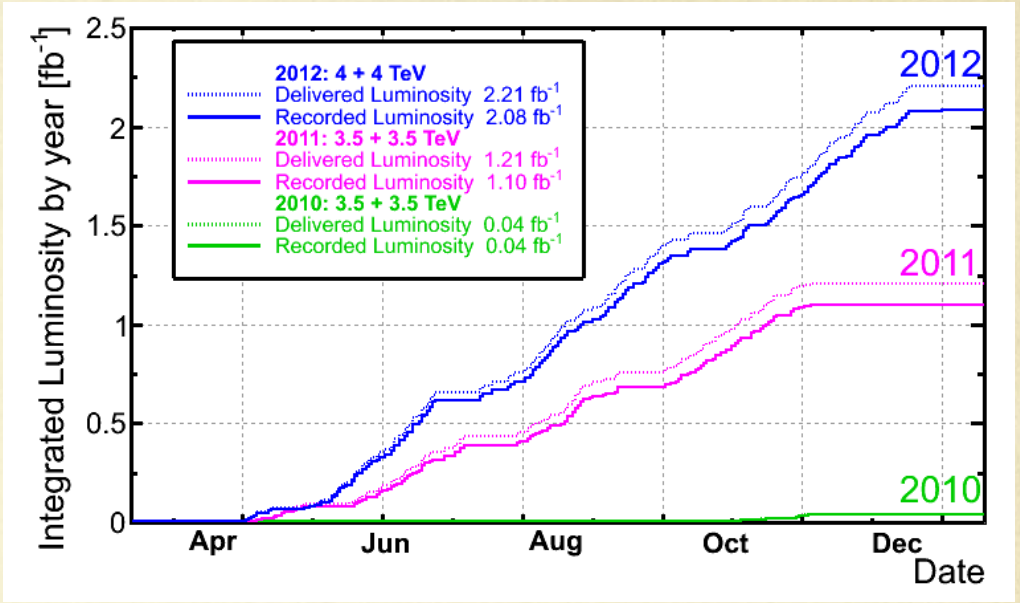


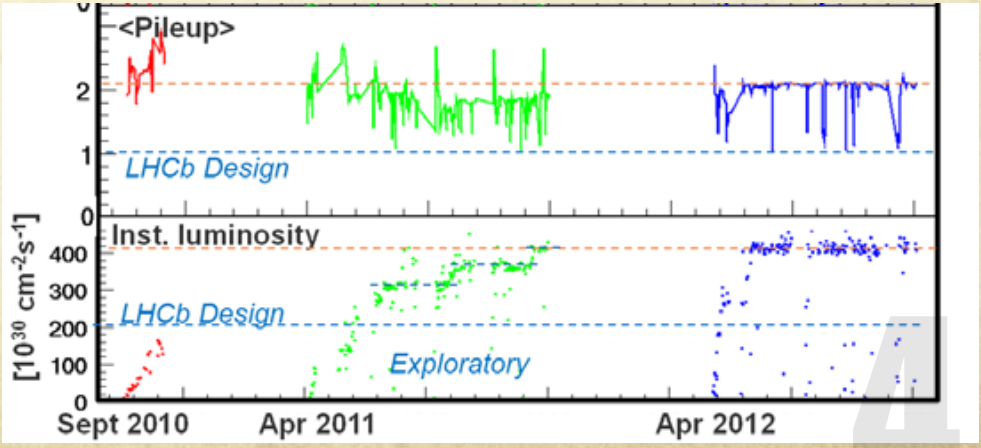
LHCb detector

- VELO: Excellent vertex and IP resolution.
  - $\sigma(d) \approx 24\ \mu m$ at p_T=2GeV/c,
  - Lifetime resolution ≈ 45fs ≈ 0.1 $\tau(D_0)$
- Excellent tracking resolution: $\delta p/p$ = 0.4–0.6% at 5–100 GeV.
- RICH – very good particle identification for π and K.
- The polarity of the magnet is regularly reversed during data taking

Data taking

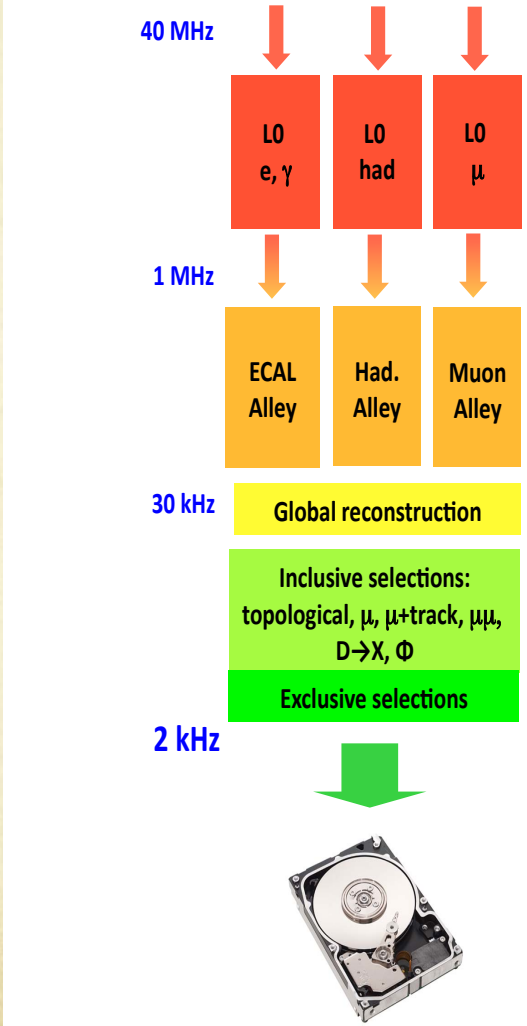
- High efficiency
  - Recorded/delivered ≈94%
- On tape 1.1 in 2011 at 7 TeV + 2.0fb^{-1} in 2012 at 8 TeV.
- Automatic luminosity leveling
  - vertical beam displacements.
- Already managed luminosities and occupancies higher than LHCb design.
- Next run foreseen in 2015 at 14 TeV (detector unchanged).





Trigger System

- Level-0 (custom electronics)
  - 1MHz output
  - Largest p_T(or E_T) of hadron/e/γ/μ
  - Typical tresholds 1.5 → 3.5 GeV/c
- HLT (commercial CPUs)
  - Stage1: partial event reconstruction, selection based on IP, pT on single track
  - Stage2: Full event reconstruction



Level-0

High-p_T signals in calorimeter and muon systems

HLT1

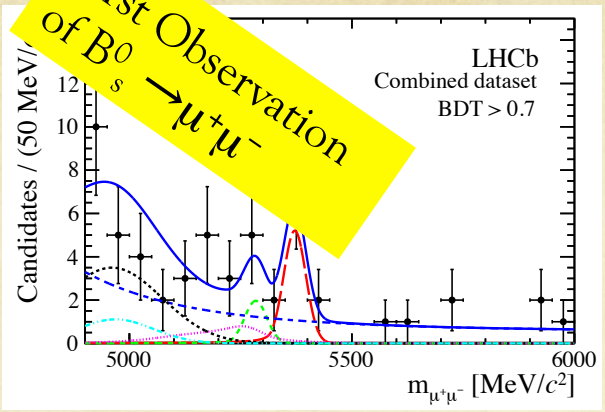
Associate L0 signals with tracks, especially those in VELO displaced from PV

HLT2

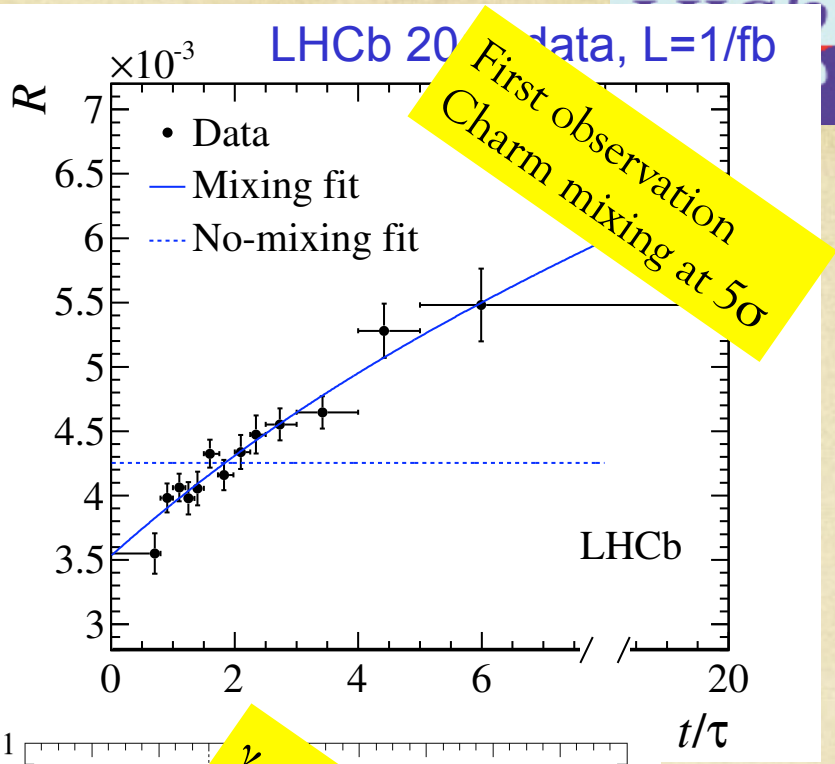
Full detector information available
Continue to look for inclusive signatures, augmented by exclusive selections in certain key channels.

In 2013

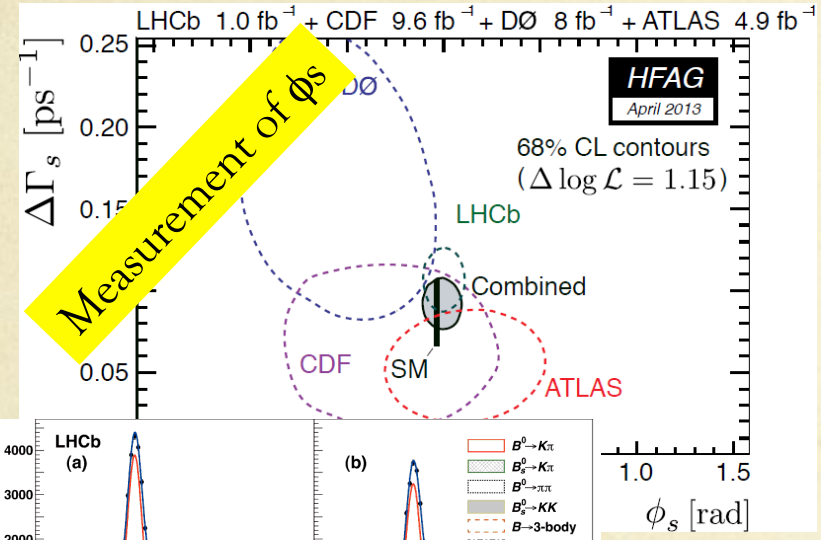
First Observation of $B^0_s \to \mu^+\mu^-$



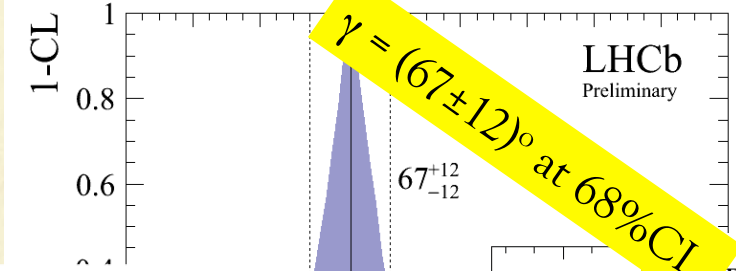
First observation Charm mixing at 5σ



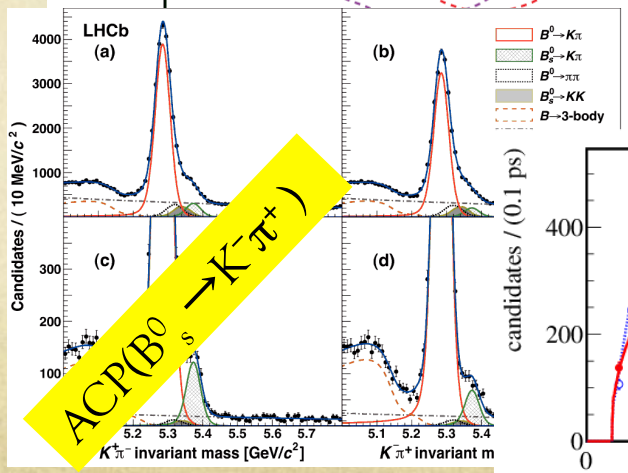
Measurement of ϕ_s



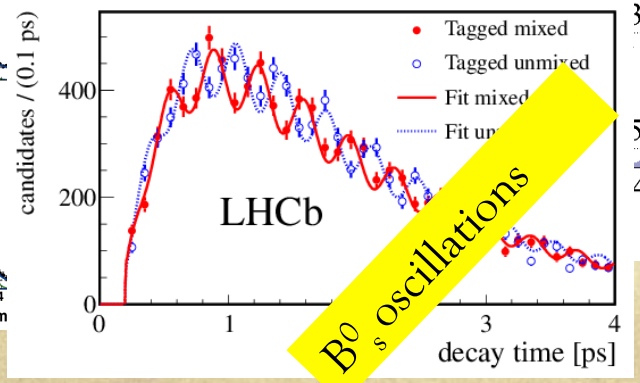
$\gamma = (67 \pm 12)^\circ$ at 68%CL



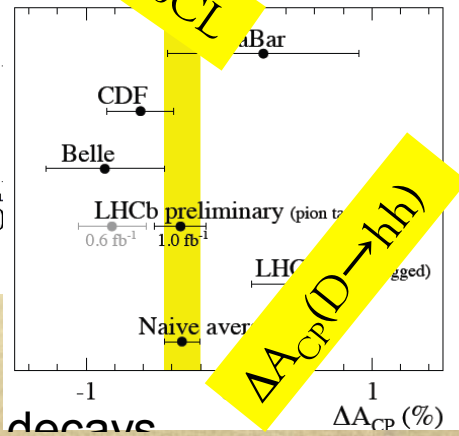
ACP($B^0_s \to K^-\pi^+$)



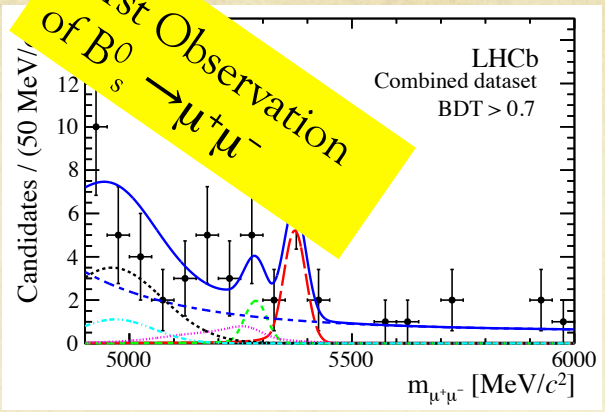
B^0_s oscillations

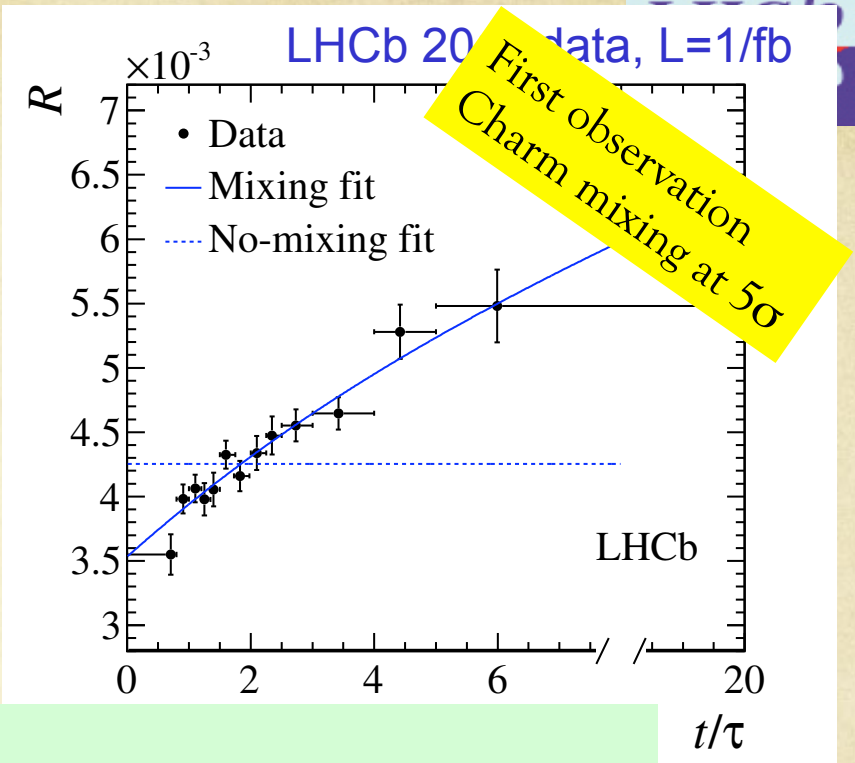


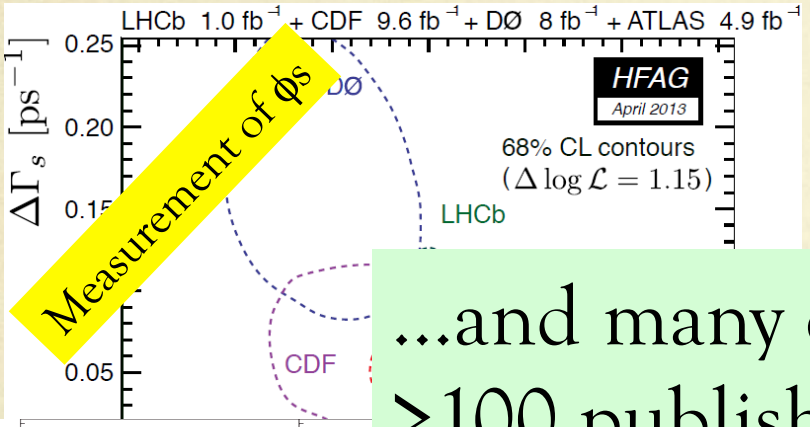
$\Delta A_{CP}(D \to hh)$



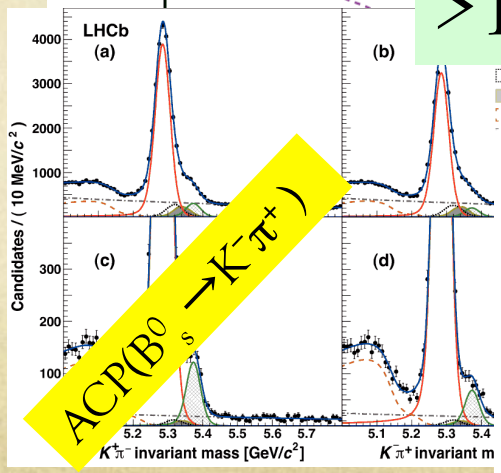
In 2013

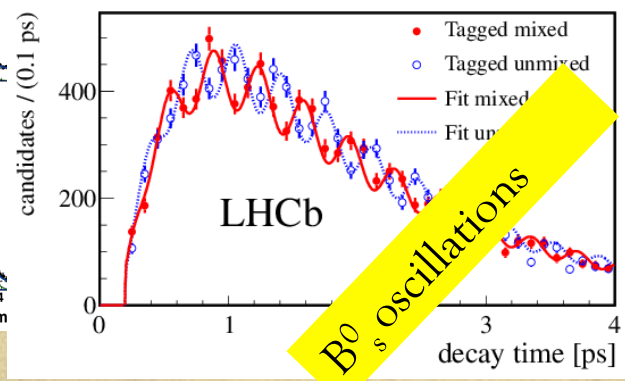


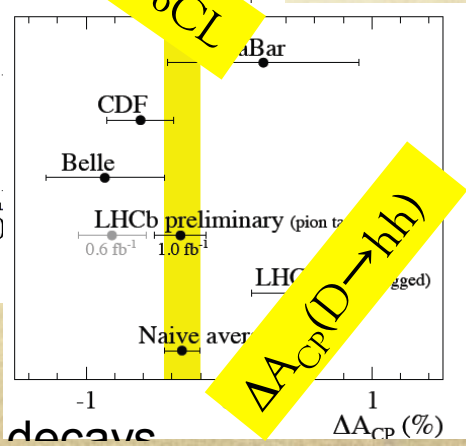




...and many others.
>100 published papers in 2 years







LHCb schedule

P. Campana Ottobre 2012

2013-14	Long Shutd. 1 / LHCb maintenance, first infrastructures for upgrade
2015-17	LHCb data taking (13-14 TeV) / 40 MHz protos in test
2018-19	Long Shutd. 2 / LHCb upgrade installation [Atlas/CMS upgrades phase 1]
≥ 2019	Upgraded LHCb in data taking (14 TeV)

2012-13	R&D, technological choices, preparation of subsystems TDRs
2014	Funding/Procurements
2015-19	Construction & installation

- *March 2011, "Letter of Intent for the LHCb Upgrade" submitted to LHCC* ✔
  → Endorsement of physics case. Review of proposed trigger concept (40 MHz)
- *June 2011 → LHCC endorses the LOI, green light for TDR preparation* ✔
- *June 2012, Submission of "Framework TDR for the LHCb Upgrade" to LHCC* ✔
- *September 2012 → LHCC endorses the FTDR* ✔
- *October 2012, Presentation of "Framework TDR" and of "Addendum to MoU for the Common Items of the LHCb Upgrade" to RRB and to Funding Agencies* ✔
- *Fall 2013, Submission of LHCb subsystems TDRs to LHCC*

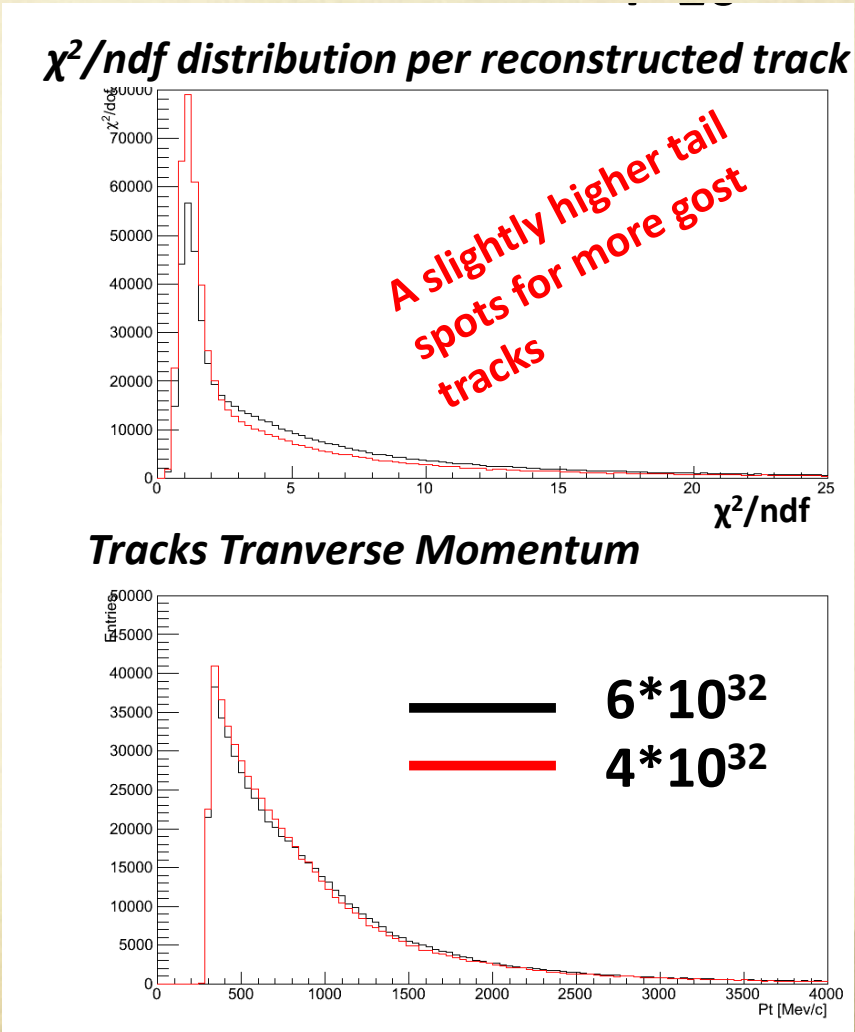
Initial commitments of Pisa group

- Contribute to maintaining, updating, and improving the tracking-related software in order to fulfill the needs of the experiment, especially those regarding data taking.
- Future runs at higher collision energy are expected to put additional demands on the data processing system.
- The planned LHCb upgrade for 2018 foresees an increased input rate to the HLT from now 1MHZ to 10-40MHz. This requires a significantly faster running time of the HLT algorithms, in particular the vertex and main tracker reconstruction. A part of the improved algorithms can be developed in the LS1 (2013/14) and then be tested in the 14TeV running period starting 2014/15.

G. Punzi 20/06/2012 – Preventivi 2013

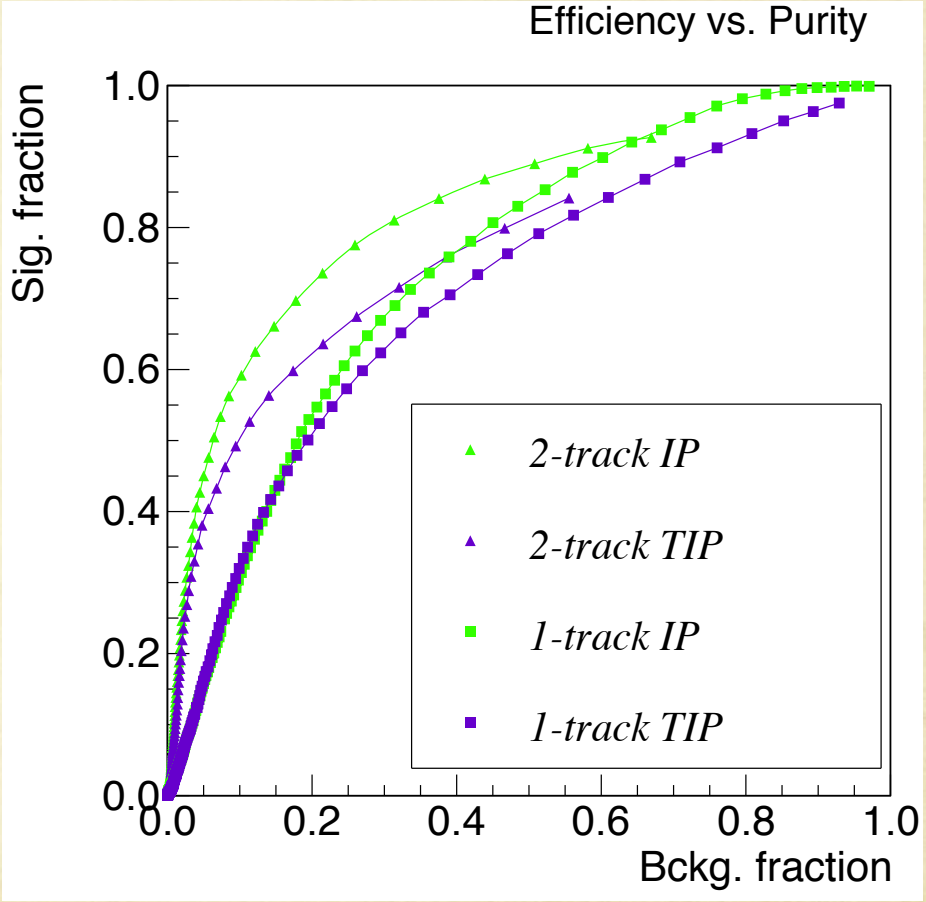
HLT offline Monitoring

- Pisa contributed to HLT monitoring software.
- Important for early identification of various types of trigger/detector issues.



Triggering on transverse plane

- Current HLT1 selection strongly based on 3D impact parameter cut
- Requires finding primary vertices
  - Sensitive to luminosity conditions
- In view of increasing luminosity, we studied alternative selections:
  - Demonstrated powerful alternative selections based only on transverse quantities.
  - Faster to calculate and more robust.
  - Good for higher Luminosities.
  - Will be tested for 2015 run.



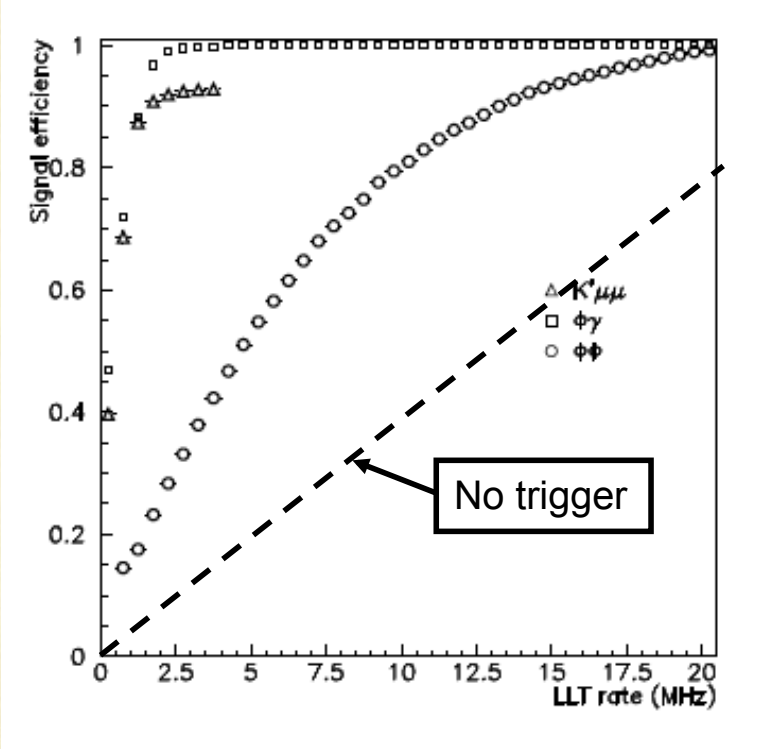
Minimum Bias D0→Kpi

LHCb-Upgrade

- Per sfruttare l'alta luminosita' LHCb sta pianificando di upgradare l'intero detector.
  - Lavori programmati per 2018-19 (LS2) e presa dati nel 2020
  - L_{peak} = 4 x10^{33} (x10 rispetto al precedente run) e con sqrt(s)=14TeV
  - Read-out of all detectors at 40MHz (= bunch crossing frequency)
- Goals
  - Integrare 50 fb^{-1} di dati (in 10 years)
  - x10 canali muonici
  - x20 canali adronici.
- Trigger Strategy for the Upgrade is almost unchanged
  - LLT → throttle to reduce rate 1−40 MHz (calorimeter for hadrons).
  - HLT→ more powerful (and expensive) farm. x10 faster than 2012.
  - Write on tape at 20KHz (today 5KHz)

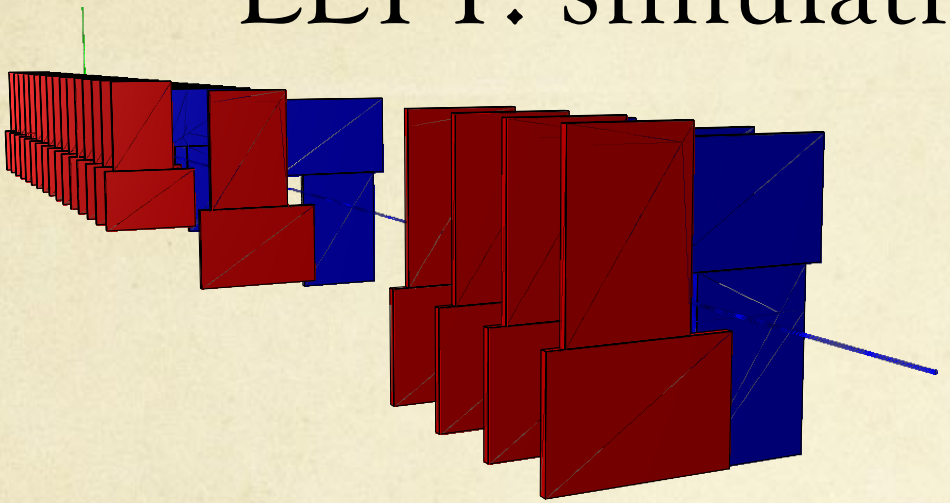
Low Level Track Trigger

- New proposal to:
  - avoid clogging bandwith/CPUs resources
  - allow longer HLT execution time
  - reach LHCb physics goals much sooner.



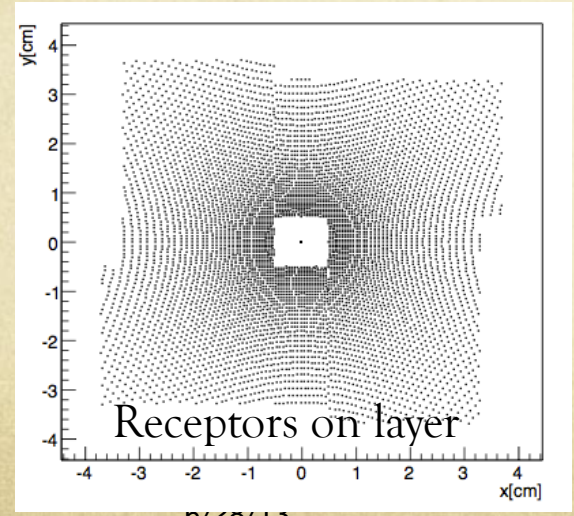
- Move HLT1 functionality to Level-0 of the trigger to make it much faster. Programming firmware in FPGA instead of C++ in CPUs
  - Pisa post-doc (similfellow) is already enrolled in HTL group.
  - Maintenance/optimization of HLT is a Pisa responsibility.

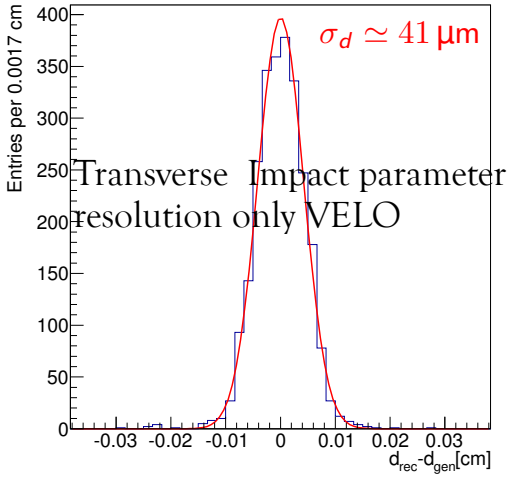
LLTT: simulation studies

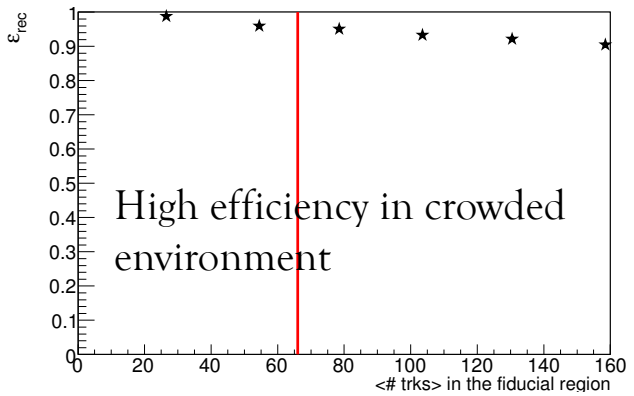


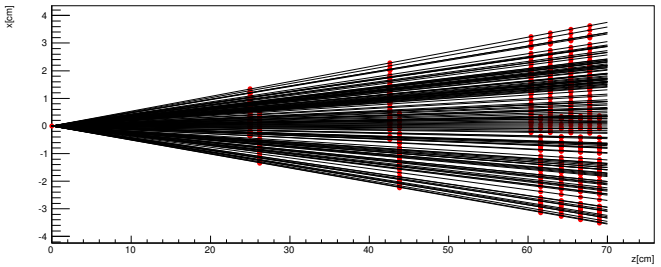
- Parametric simulation of LHCb detector
  - as “n” different layers (VELO+UT+FT);
  - today: last 6 VELO-Pixel layers:
    - VELO-Pixel geometry (LHCb-INT-2013-025)
    - Hit resolution = 12 µm
    - Hit efficiency = 95%
    - Pixel size = 55 µm

Use a strongly parallel algorithm based on neuro-biological analogy [NIM A 453 (2000) 425-429]



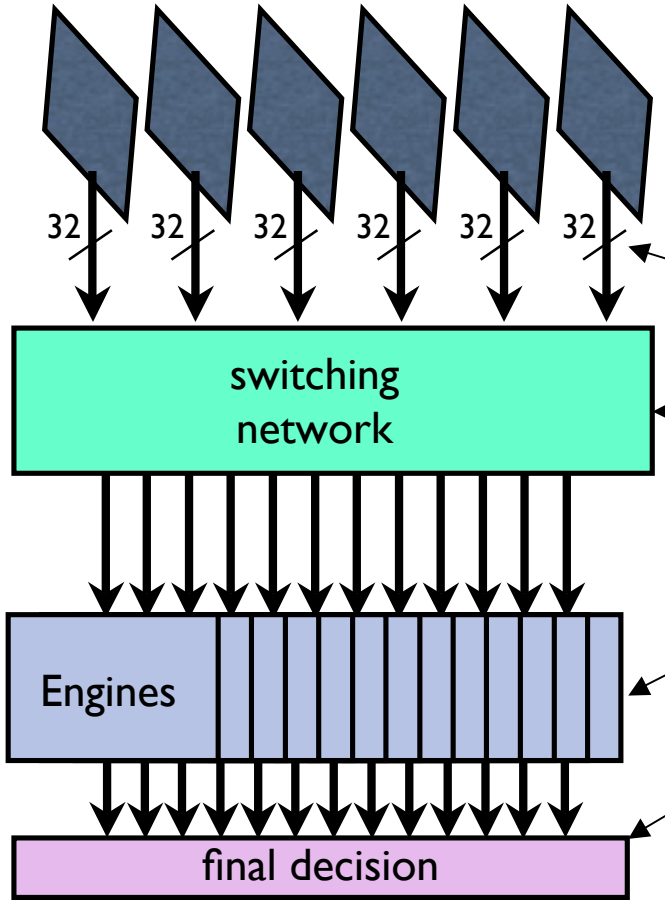






160 tracks

LLTT Architecture and Timing



ITEM	Latency
Connections	(small)
Switch	60 ns
Processing engines	250 ns
Clustering	500 ns
TOTAL	**< 1 µs**

Dimostrata la fattibilita' di tracking a 40MHz a LHC

LLTT status

- Discusso in dettaglio al Low Level Trigger Workshop del 19/06/2013
- Proposto alla CSN1 come parte di LHCb-Upgrade
  - Feedback positivo dai referees
    - Fara' parte del proposta di LHCb-Upgrade da sottoporre al CTS
- Si e' unito all'impresa il gruppo INFN-Milano
- Per il 2013-14 intendiamo portare avanti uno studio di R&D per ottenere l'approvazione dalla Collaborazione e far parte di un TDR sul trigger.
  - Lo sviluppo e' fondamentalmente di programmazione FPGA
  - LLTT utilizza elettronica (TELL40,AMC40, StratixV chip) gia' prevista nel DAQ di LHCb-Upgrade.

Richieste LHCb consumi 2014

- Fase di sviluppo
  - Computer molto performante per compilare codice FPGA → 6kE
  - 2AMC40 (2 x 6kE) + 1MiniDAQ (7kE)→ 19kE
  - Consumi per allestimento del laboratorio → 7kE
- Fase di testing nel Run del 2015 (2 possibili opzioni che dipendono dalle scelte che LHCb e dal progresso dei prototipi)
  - Opzione 1 (elettronica nuova)
    - 2 TELL40 naked (6kE) + 1crateATCA(16 kE) +1MiniDAQ (7kE)→ 29kE
  - Opzione 2 (elettronica vecchia)
    - 8 TELL62 → 30kE
- Richieste risorse di sezione: modesto spazio di laboratorio

Persone e percentuali

	2012	2013	
F. Bedeschi	0.7	0.7	Dir. di Ricerca
A. Lusiani	-	0.3	Ricercatore
P. Marino	-	1.0	Dottorando
M.J. Morello	0.7	0.7	Ricercatore
G. Punzi	0.7	0.7	Prof. Associato
F. Spinella	-	0.3	Tecnologo
S. Stracka	-	1.0	Assegnista
J. Walsh	-	0.7	Primo Ricercatore
F. Lionetto	-	-	Laureanda
A. Piucci	-	-	Laureando
Tot (FTE)	2.1	5.4	

Importanti contributi da S. Leo (oggi a g-2/CDF a FNAL) e F. Ruffini (oggi in azienda).

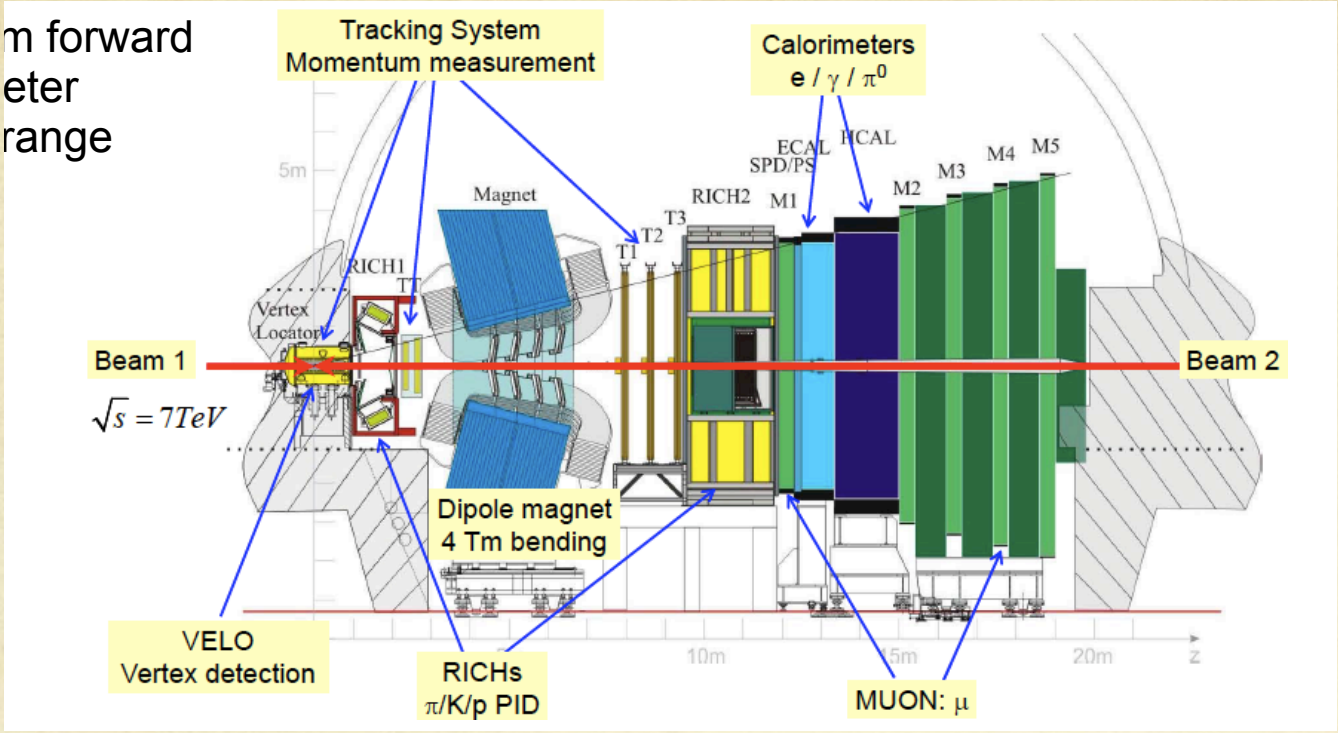
Richieste Finanziarie

Missioni		63 kEuro
Consumi	Allestimento lab. + metabolismo	15kEuro
Inventariabile	Computer, crate, boards, switch, ecc.	55kEuro
TOT		133kEuro

MI → 6kE
3.8kE x 15mu per ME → 57kE

Backup

m forward
eter
range



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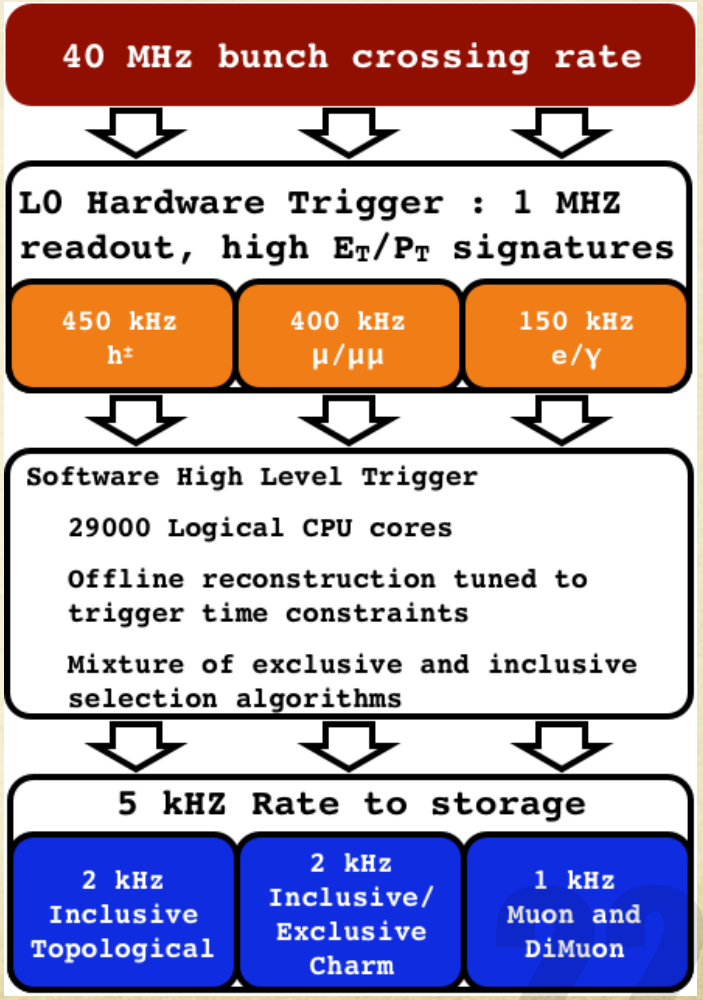

Publication status and statistics

2010	Internal review	Submitted	Accepted	Published	Total
PAPER				2	2
CONF		7			7
2011					
PAPER				44	44
CONF		61			61
2012					
PAPER			4	53	57
CONF		34			34
2013					
PAPER	14	7	9	5	35
CONF		8			8

> 100 published!

Most highly cited LHCb papers

1) Strong constraints on the rare decays $B_s \to \mu^+\mu^-$ and $B^0 \to \mu^+\mu^-$

   PRL 108 (2012) 231801; 168 citations

2) Evidence for CP violation in time-integrated $D^0 \to h^-h^+$ decay rates

   PRL 108 (2012) 111602; 158 citations

3) Measurement of $\sigma(pp \to b\bar{b}X)$ at $\sqrt{s}$=7 TeV in the forward region

   PL B694 (2010) 209; 138 citations

4) First evidence for the decay $B_s \to \mu^+\mu^-$

   PRL 110 (2013) 021801; 119 citations

5) Measurement of J/ψ production in pp collisions at $\sqrt{s}$=7 TeV

   EPJ C71 (2011) 1645; 109 citations

6) Measurement of the CP-violating phase ϕ_s in the decay $B^0_s \to J/\psi\phi$

   PRL 108 (2012) 101803; 86 citations

7) Search for the rare decays $B_s \to \mu\mu$ and $B_d \to \mu\mu$

   PL B699 (2011) 330; 73 citations

8) Measurement of b-hadron production fractions in 7 TeVpp collisions

   PR D85 (2012) 032008; 55 citations

9) First observation of $B^0_s \to J/\psi f_0(980)$ decays

   PL B698 (2011) 115; 52 citations

Source: INSPIRE HEP

More publication statistics

Source: INSPIRE HEP: search cn [expt] and r cern-ph* (published only)

n.b. this misses many papers, more for some experiments than others

	ALICE	ATLAS	CMS	LHCb
Total papers	29	208	194	93
Average citations	42.1	48.8	48.5	21.6
250+	0	5	2	0
100-249	2	11	17	5
50-99	7	35	38	4
h-index	19	51	52	23

h-index: largest value of h for which h papers cited >=h times

High Luminosity