Recent results from LHCb and future prospects

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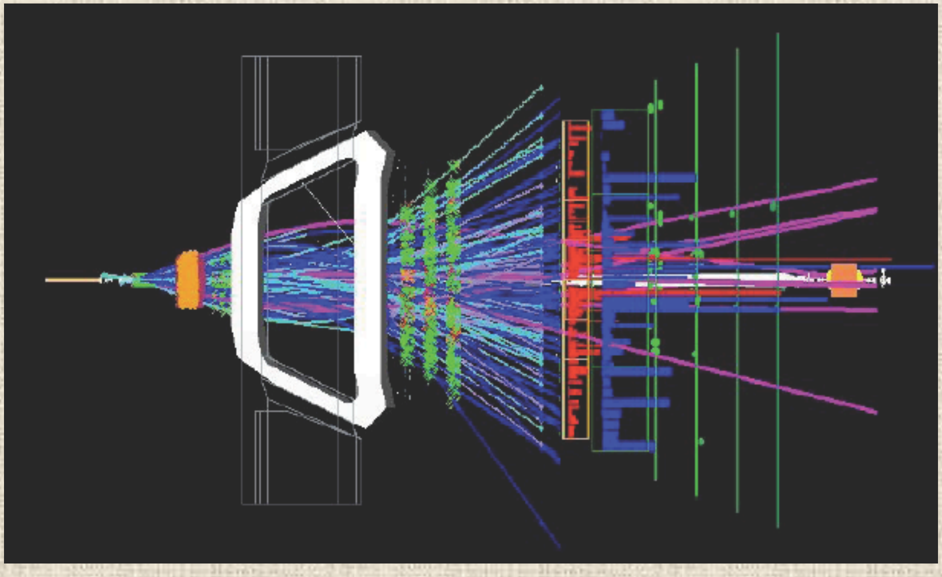
LHC-US Meeting – 19/10/2012 - Fermilab

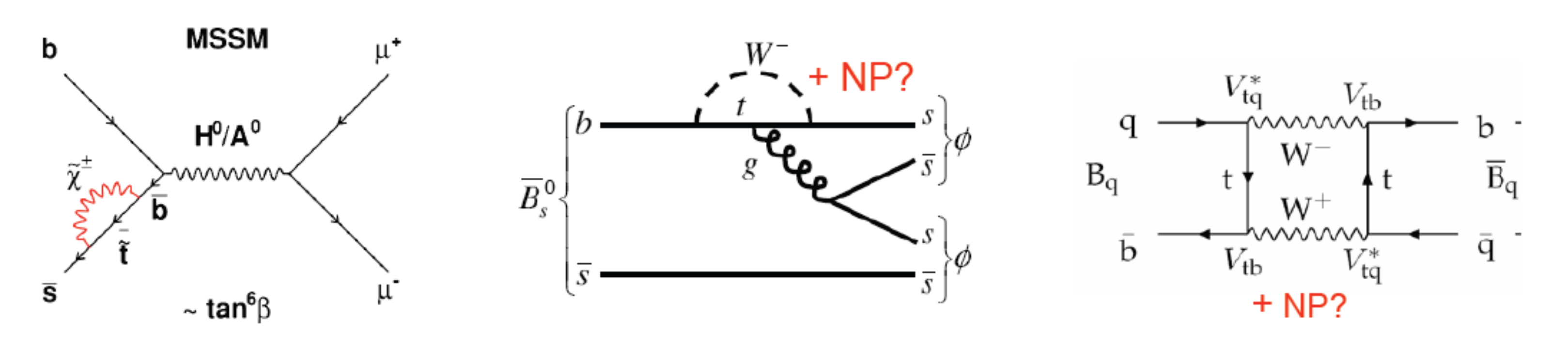
Outline of the talk:



- The LHCb physics programme
- The experiment and the data taking in 2012
- The detector performances: trigger, tracking, particle identification
- Highlights on LHCb results & implications for New Physics searches
- The LHCb Upgrade
- Conclusions

LHCb Physics Programme

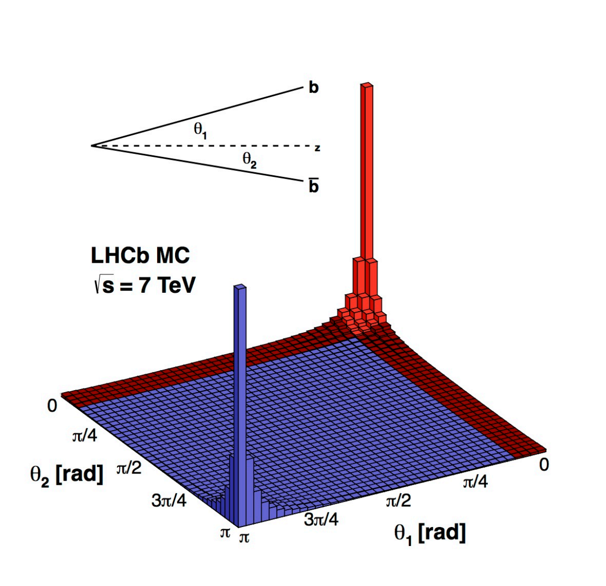
Search for New Physics (NP) which may appear in CP violation or in rare decays mediated by new particles at high mass scale - via their effects in loop diagrams (e.g.: compare CKM quantities determined in tree and loop process)

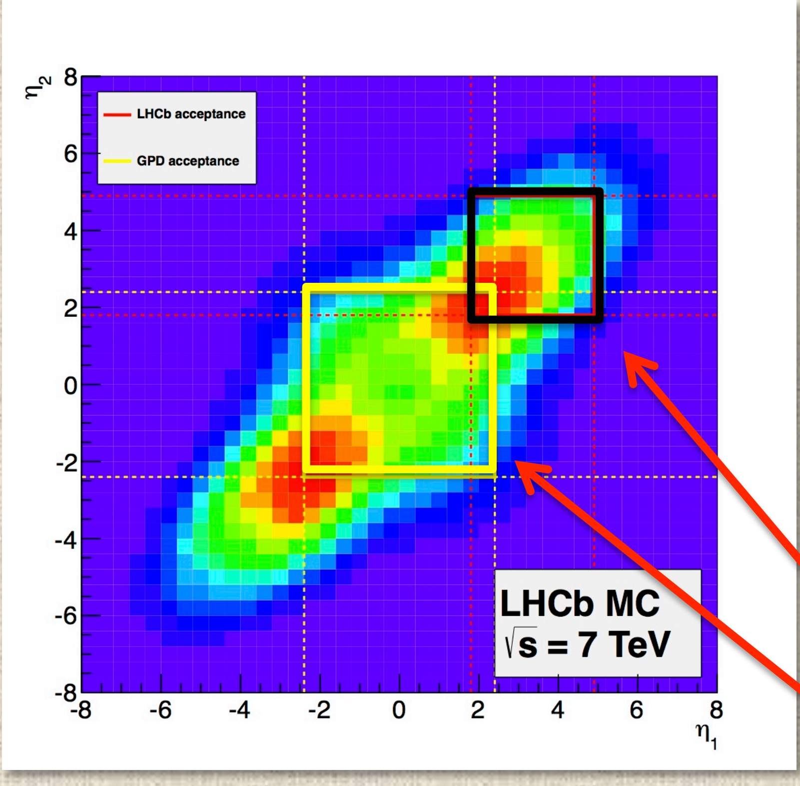


This approach is complementary to direct searches in ATLAS & CMS: once NP discovery will be made, its non trivial flavor structure has to be determined

- CPV — B_s oscillation phase ϕ_s, asymmetries (a_{sl})
  CKM angle γ in tree and loop mediated decays
  Mixing and CP Asymmetries in charm decays
- Rare decays — Helicity structure in $B_d \rightarrow K^*\mu\mu$, $B_s \rightarrow \phi\gamma$
  FCNC in loops ($B_{d,s} \rightarrow \mu\mu$, $D \rightarrow \mu\mu$)

+ b and c production studies, spectroscopy, forward electro-weak physics, exotica, etc...





b quark production in LHCb

- Cross section predictions (PYTHIA8)

$\sigma_{\mathbf{inelastic}}$ ~ 70 - 80 mb
$\sigma_{\mathbf{bb}}$ ~ 500 μb [14 TeV]

$\sigma_{\mathbf{bb}}$ measured at 7 TeV ~ 280 μb
(~75 μb in LHCb acceptance) PLB 694 (2010) 209

- All b-hadrons species produced at LHC ($B^{\pm}$, B^{0}, B_s, B_c, Λ_b ...)
- operated since end of 2011 at 4 10^{32} cm^{-2} s^{-1}
  (design luminosity was x 2 lower)
  pileup with 50 ns bunch spacing <μ> ~ 1.7
- ~ 30 kHz of bb events in LHCb [7 TeV]

LHCb acceptance : $2 < \eta < 5$

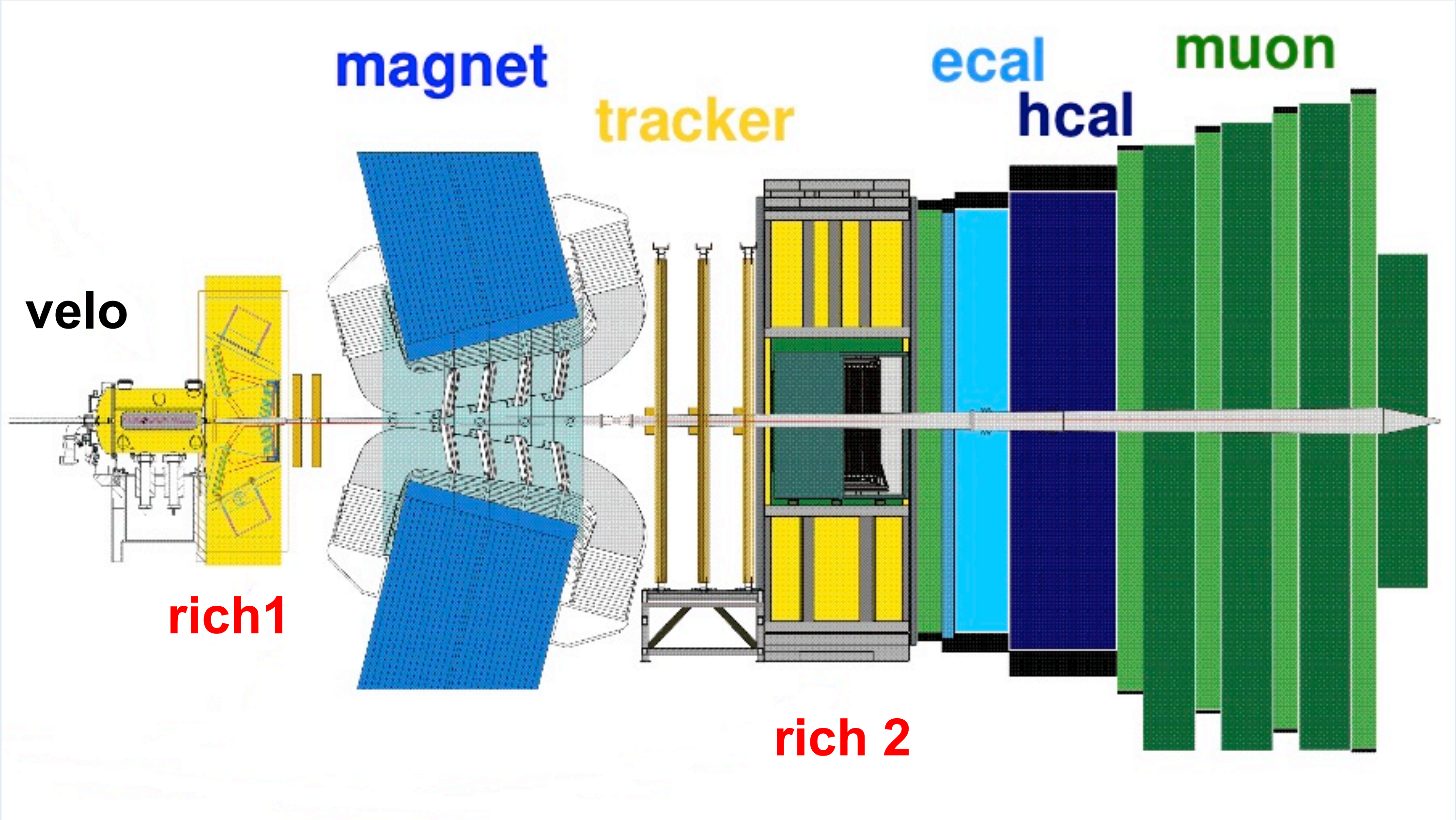
ATLAS and CMS: $|\eta| < 2.5$

The LHCb detector

Brasil, China, France, Germany, Ireland, Italy, Netherlands, Pakistan, Poland, Romania, Russia, Spain, Switzerland, UK, Ukraine, US*, CERN

60 institutes, ~ 750 members

74 papers >100 conf. contr.



VELO: 21 (R+φ) silicon stations
- Movable:7mm when stable beams

RICH1: C_4F_{10} + AEROGEL
- π/K separation for 2<p<60 GeV

Tracking: Si + straw tubes + 4Tm
- δp/p=0.45%

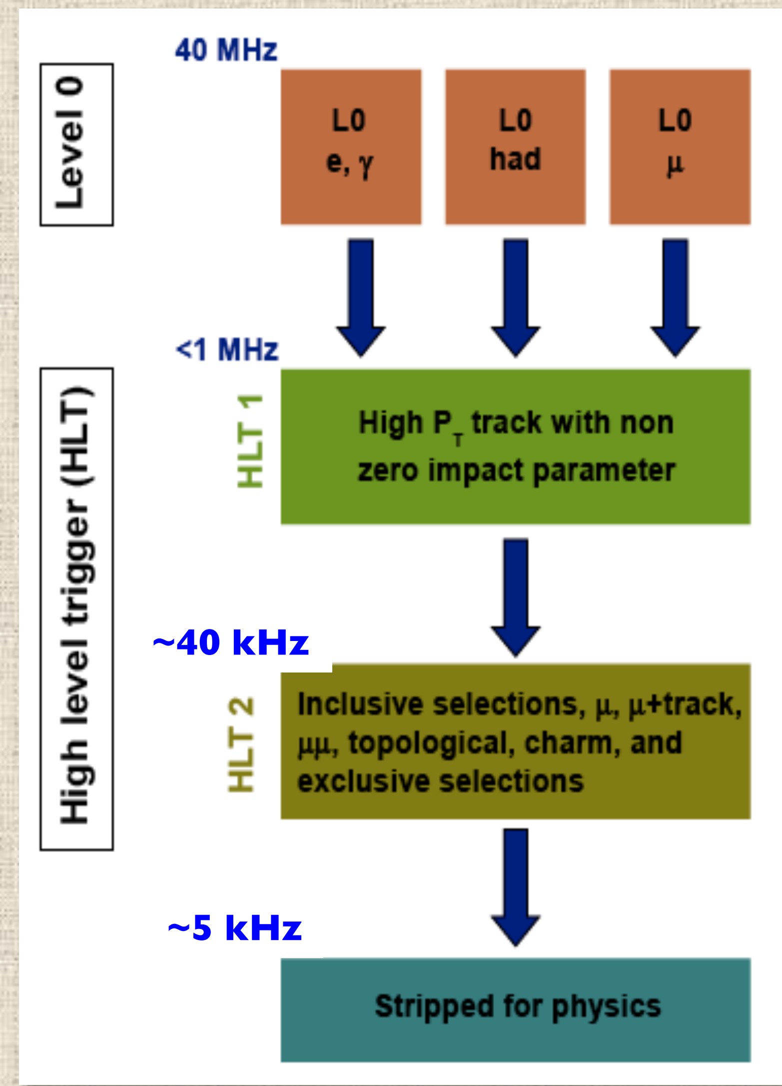
RICH2: CF_4
- π/K separation for 20<p<100 GeV

CALO:
- ECAL: lead+scintillating tiles
- HCAL: iron+scintillation tiles

MUON MWPC+GEM: π/μ separation

* In 2012 two new members: Cincinnati and Maryland. MIT should join in November

The LHCb Trigger



- L0 hardware trigger

- Search for high p_T μ, γ, e and h candidates
CALO p_T > 3.6 GeV - MUON p_T > 1.5 GeV
- Output rate 950 kHz (~ max allowable)

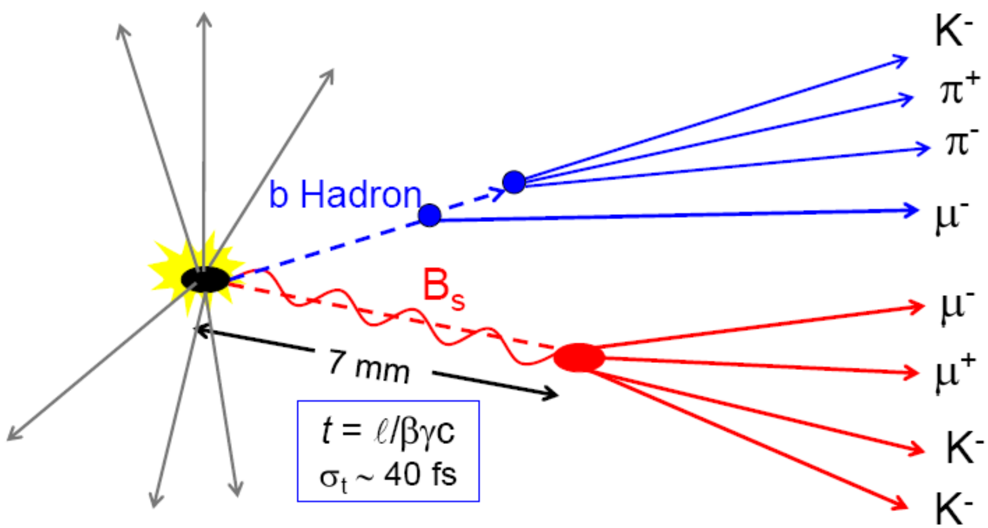
- High Level Trigger software farm

- HLT1 adds impact parameter cuts
- HLT2 performs global event reconstruction
- Physics output rate up to 5 kHz in 2012

- HLT operation in 2012

- Increase the no. of CPU installed (+10%)
- Deferred trigger during LHC inter-fills (adds +20% in CPU)
- Optimization of HLT to increase efficiency in K_S triggering

B meson decays topology



Excellent vertex resolution: to resolve fast B_s oscillation.

Background reduction: Very good mass resolution
Good particle identification (K/π)

High statistics: Efficient trigger for hadronic and leptonic states

At L0 trigger level (7 TeV)

min.bias : cc : bb

250 : 20 : 1

VELO

Tracking

RICH

CALO

Muon

L0 x HLT

B decays with $\mu\mu$	$\varepsilon_{\mathbf{(L0 \times HLT)}}$	~ 70-90 %
B decays with *hadrons*	$\varepsilon_{\mathbf{(L0 \times HLT)}}$	~ 20-50 %
Charm decays :	$\varepsilon_{\mathbf{(L0 \times HLT)}}$	~ 10-20 %

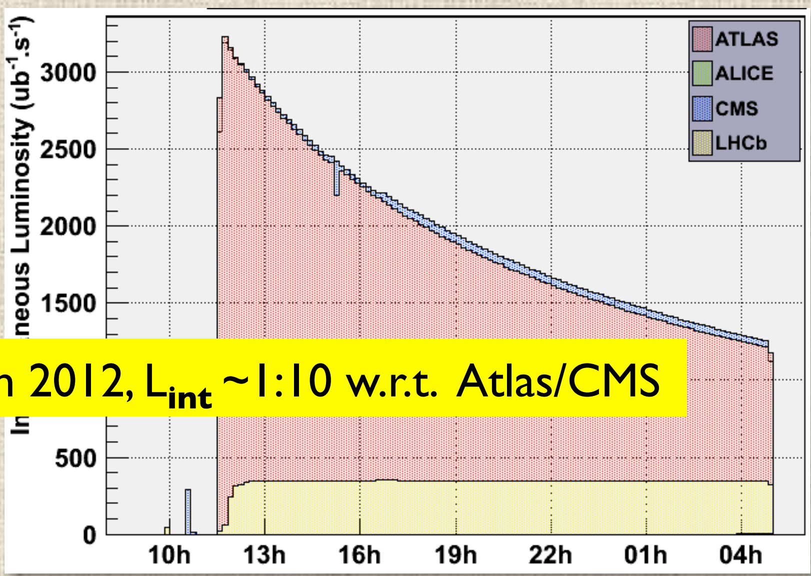
(trigger efficiencies for off-line selected events)

Flavor tagging plays a key role

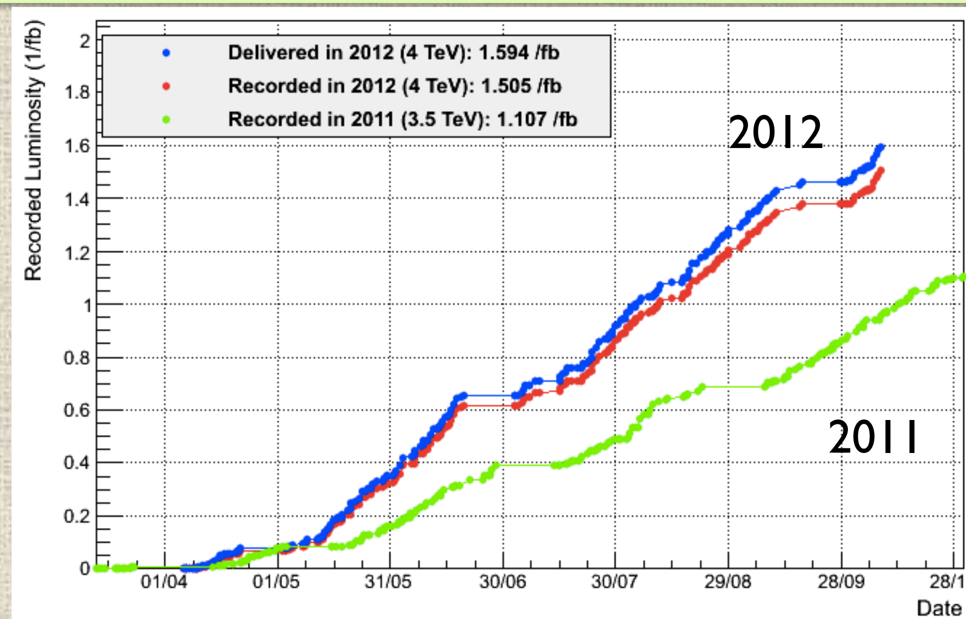
σ_{cc} ~ 6 mb (~1.7 mb in LHCb acceptance) :
LHC is a charm factory !

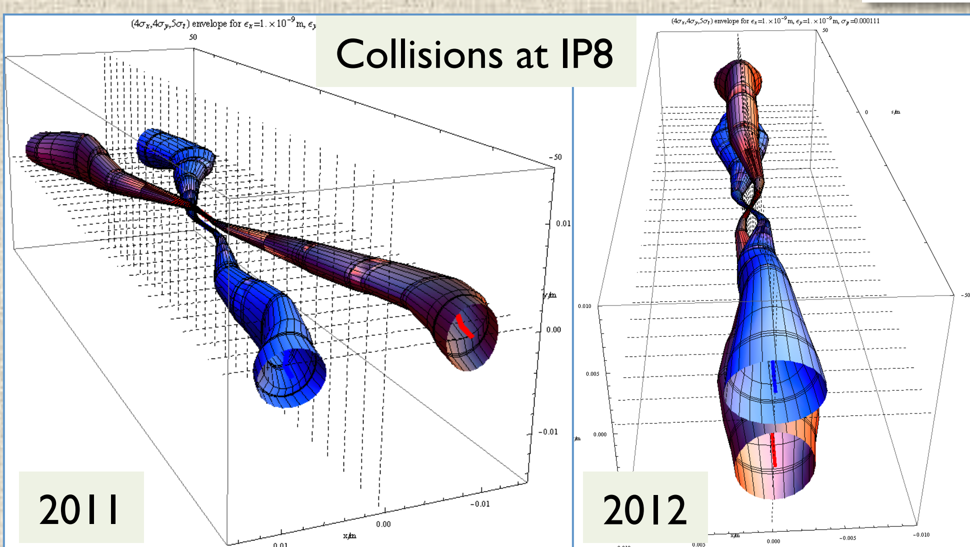
Great LHC performance, excellent running of LHCb detectors (~99% of channels operational, ~95% data taking efficiency), and luminosity leveling

1/fb in 2011 – 1.5/fb collected in 2012 - Plan to reach 2.2/fb by the end of the year



In 2012, L_{int} ~1:10 w.r.t. Atlas/CMS



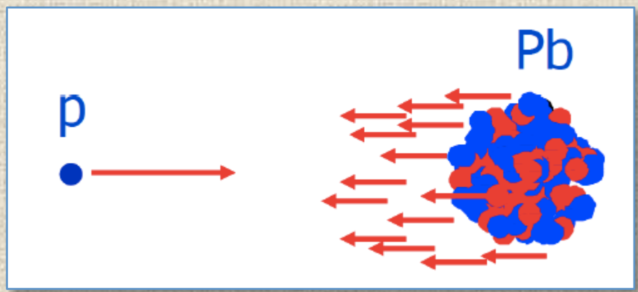


In 2012:
collisions in LHCb done in the VERTICAL plane, to minimize systematic effects during magnet swaps (polarity UP/DOWN)

In the HORIZONTAL plane, beam crossing angles are different for UP/DOWN magnet configuration

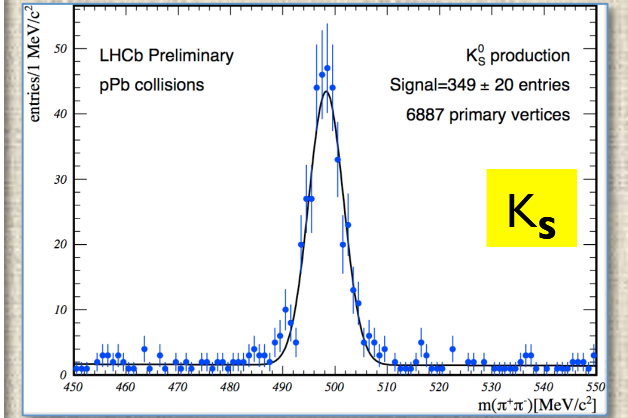
LHCb test run with pA collisions

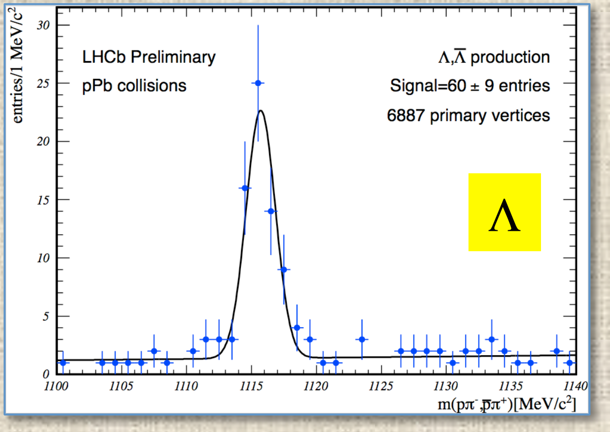
On Sept. 13 – *pA* test run in LHCb
Very good and stable conditions
No problem of multiplicities in the detector (similar to *pp*)
K_s , Λ , J/ψ peaks reconstructed offline



➜ *LHCb is able to contribute to pp and pA physics:*

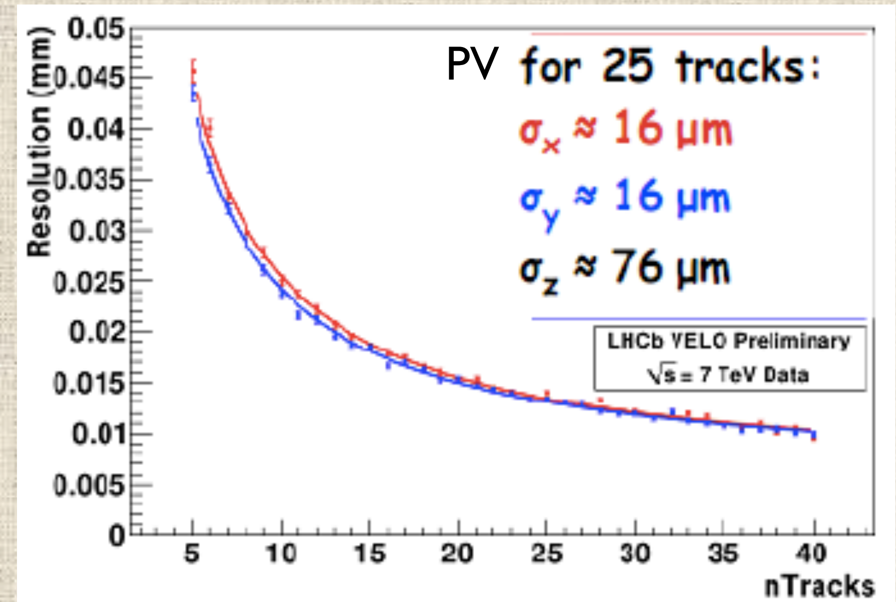
- soft QCD measurements
  - ➜ particle multiplicities and production ratios
  - ➜ strangeness production ($V^0, \phi, K^*, \ldots$) and Λ-polarization
  - ➜ energy flow and underlying event measurememts
- J/ψ-related measurements
  - ➜ production cross sections of charmonium states
  - ➜ polarization studies
- “advanced” topics
  - ➜ low mass DY and in general physics probing low-x
  - ➜ isolated photon- and jet-production
  - ➜ open charm, Υ-production, b-cross-section, . . .

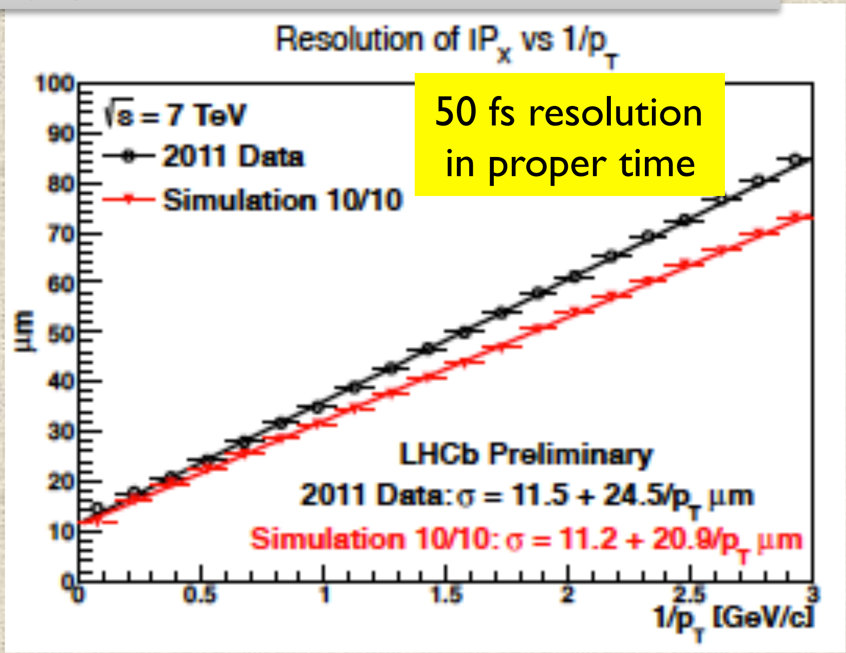


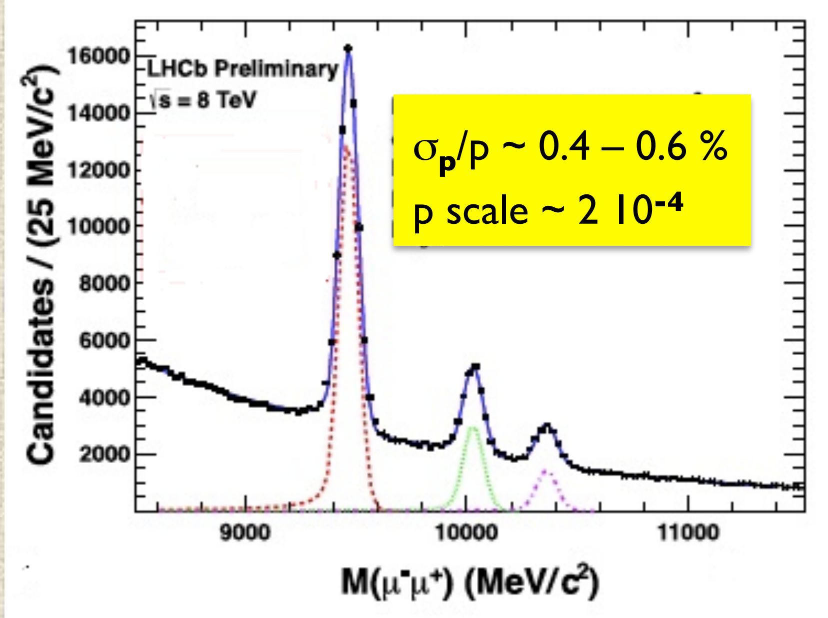


LHCb will take data in *pA, Ap* runs
Limited luminosity (~10^{26} cm^{-2} s^{-1}) but interesting kinematic domain (PID equipped) in forward region

Primary vertex (PV), impact parameter (IP) and invariant mass resolutions





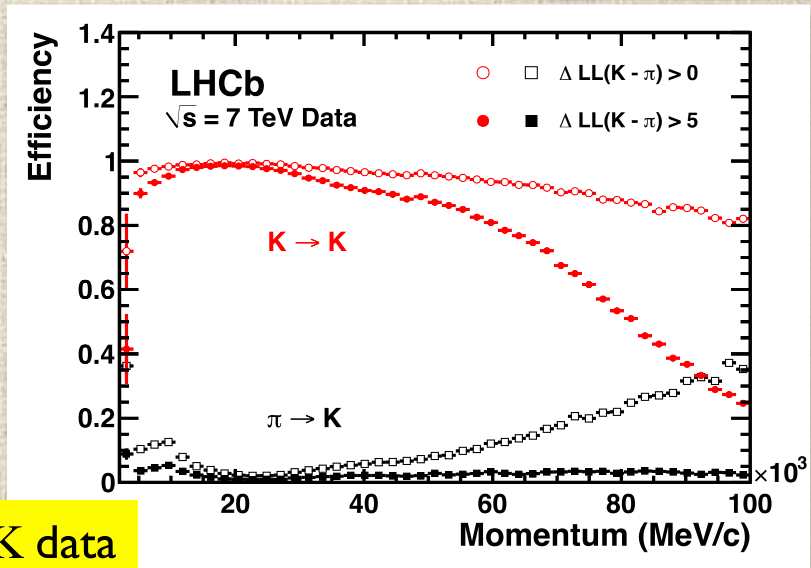


Inv. mass resolutions very near to MC:

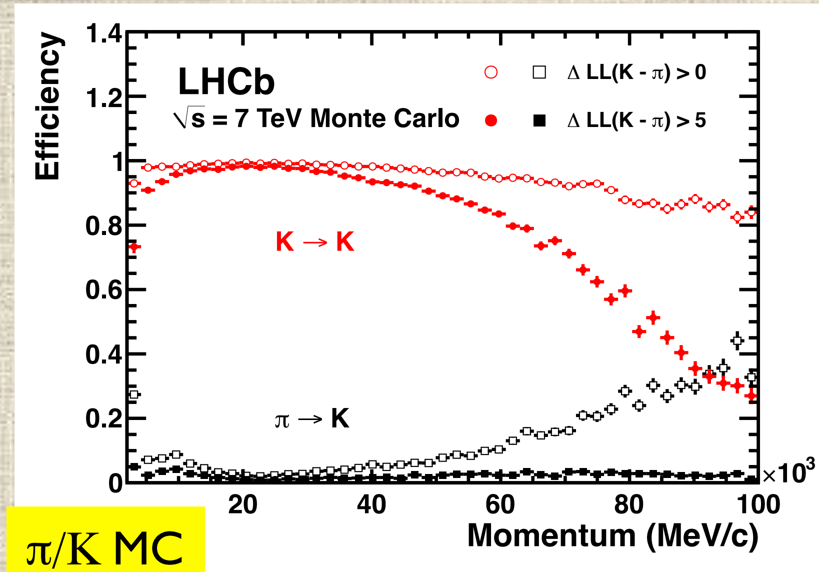
- $J/\psi \rightarrow \mu\mu$ (σ = 13 MeV)
- $B \rightarrow K\pi$ (σ = 25 MeV)
- $B_s \rightarrow J/\psi\, \phi$ (σ = 7 MeV)
- $\Upsilon(1S) \rightarrow \mu\mu$ (σ = 47 MeV)

World best measurement of b-hadron masses (PLB 708 (2012) 241)

Particle identification

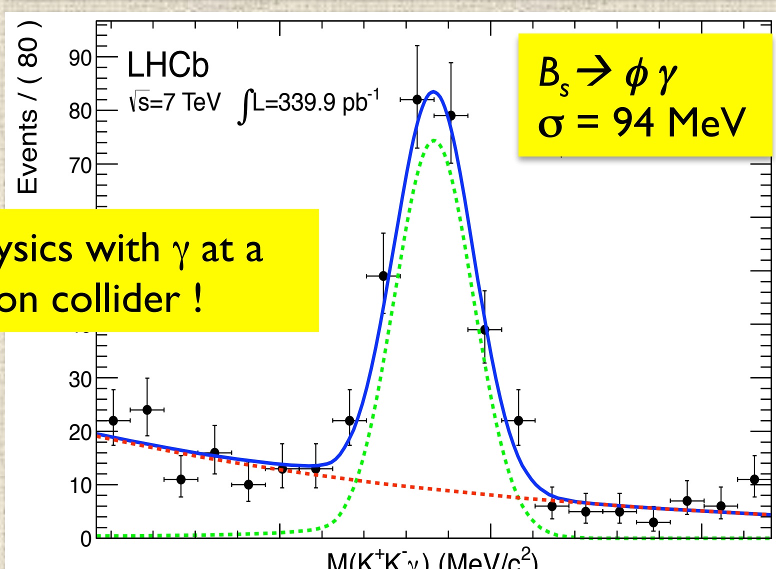


π/K data



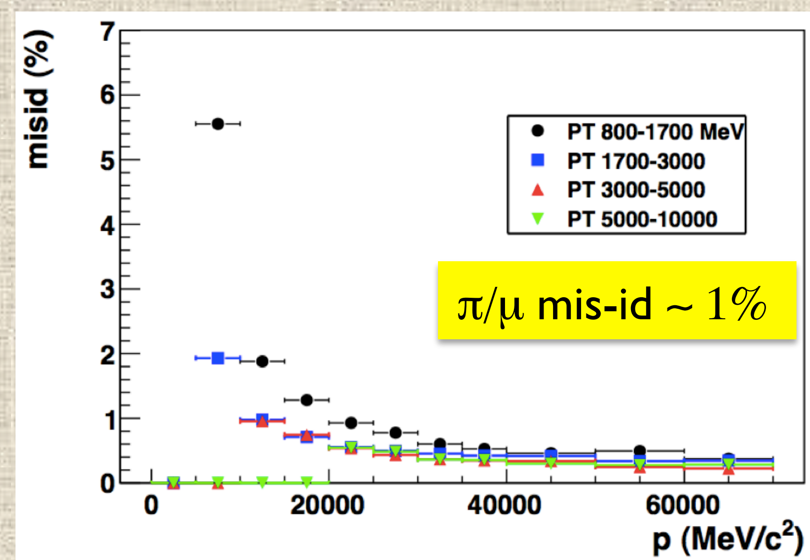
π/K MC

Large samples of clean final states for PID calibration, efficiency and purity determination based on data - PID performance near to the MC expectations



$B_s \rightarrow \phi\, \gamma$
σ = 94 MeV

B physics with γ at a hadron collider !



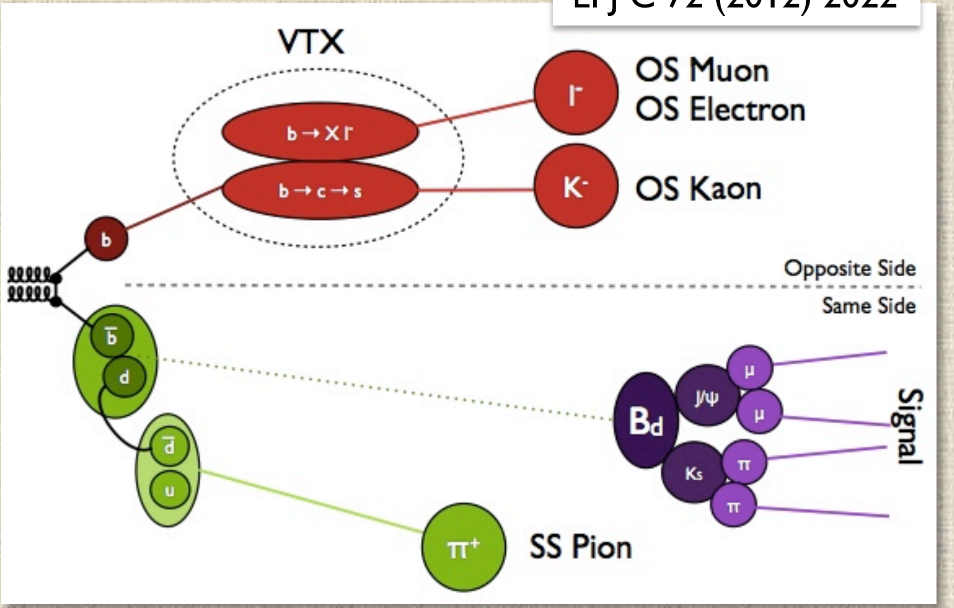
π/μ mis-id ~ 1%

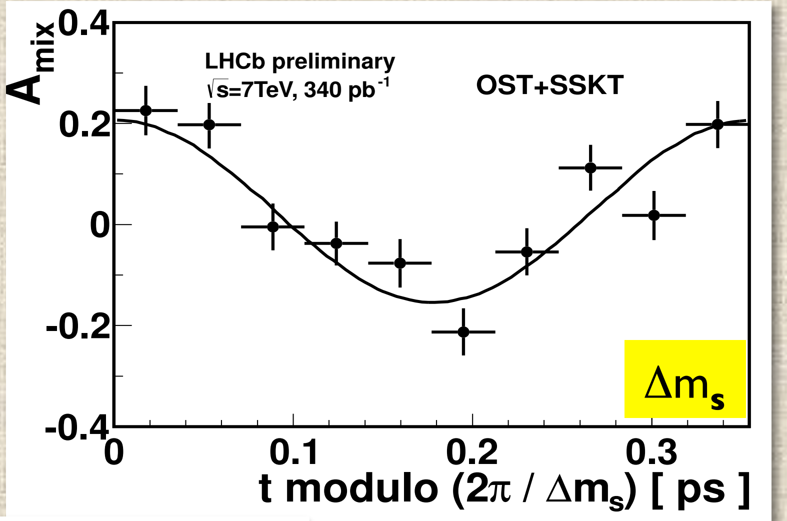
Flavor tagging

Tagging algorithms with Neural Network:

- opposite side – exploits decays of associated b hadron
  - lepton, kaon, vertex ($\varepsilon_{tag}D^2 \sim 2.3\%$)
- same side – uses remnants of signal hadronization
  - SS kaons (B_s) ($\varepsilon_{tag}D^2 \sim 1.3\%$)
  - SS pions (B^0, B^+)

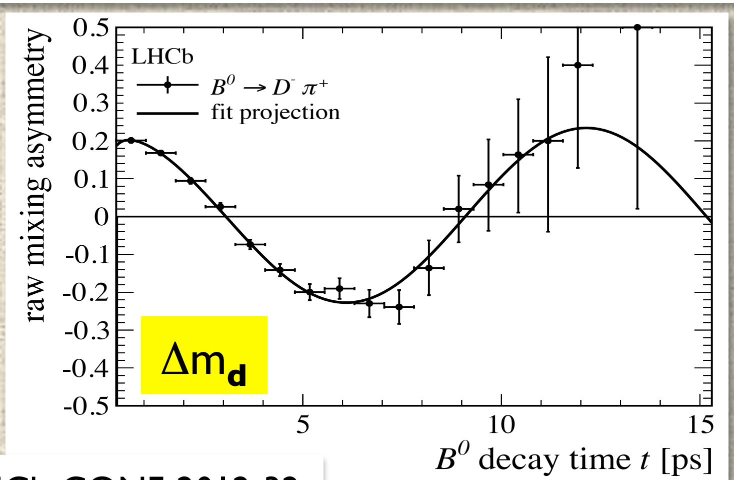
EPJ C 72 (2012) 2022





PLB 709 (2012) 177

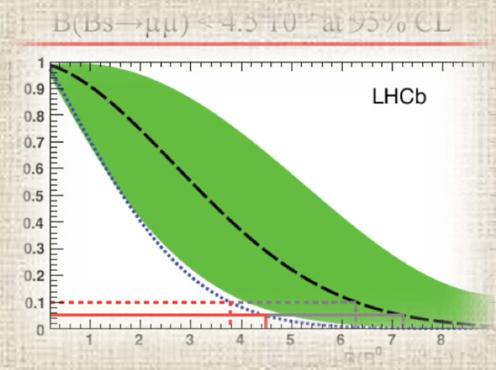
$$\Delta m_s = 17.725 \pm 0.041\ (\text{stat.}) \pm 0.026\ (\text{syst.})\ \text{ps}^{-1}$$

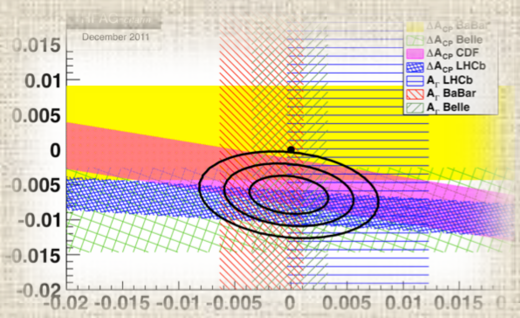


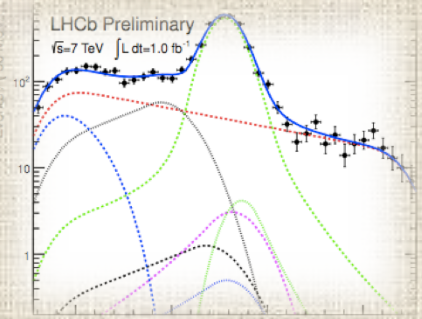
LHCb-CONF-2012-32

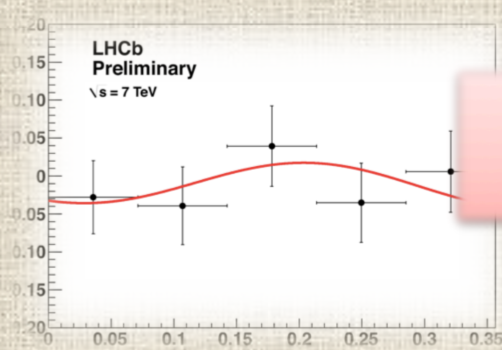
$$\Delta m_d^{\text{LHCb}} = 0.516 \pm 0.005(\text{stat.}) \pm 0.003(\text{syst.})\ \text{ps}^{-1}$$

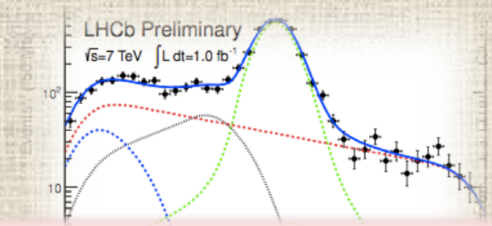
world best measurements

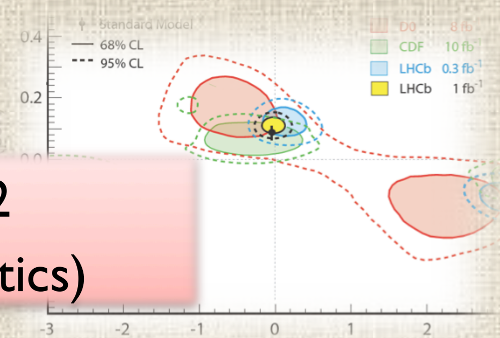




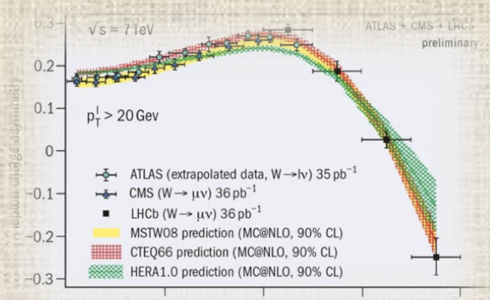


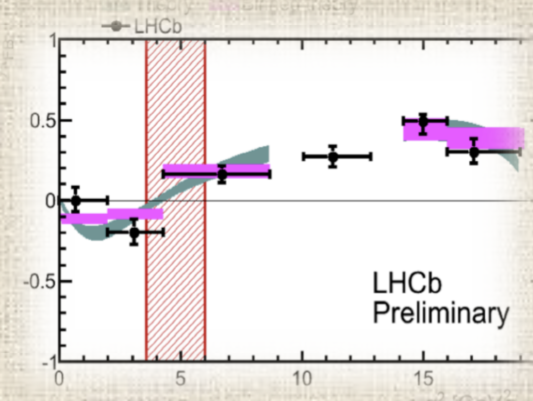


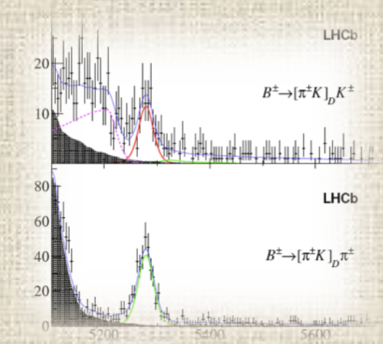




Selected highlights of 2012
LHCb results (with 1/fb statistics)







LHCb physics highlights (I)

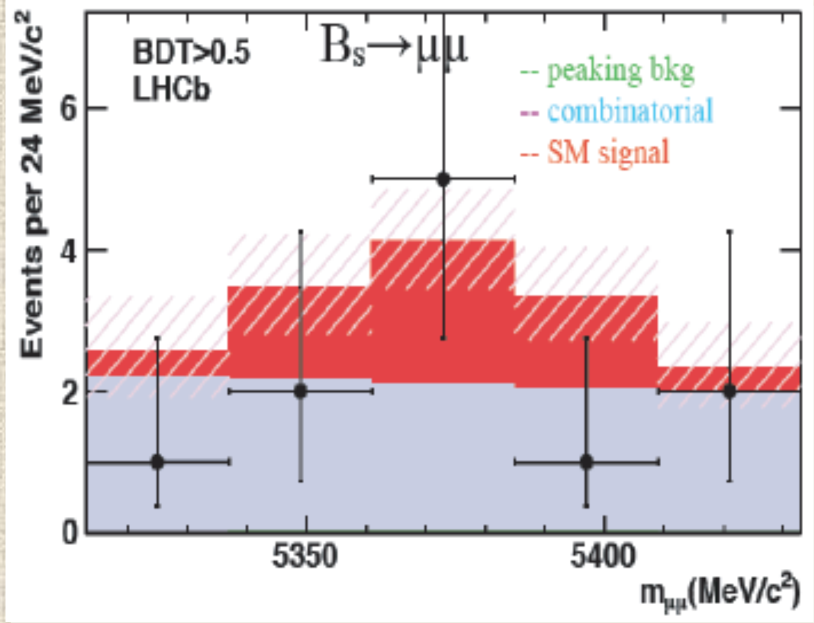
The rare decay $B_s \to \mu^+\mu^-$

Very rare decay sensitive to New Physics
Precise predictions in SM: BR = 3.2±0.2 10^{-9}
Very clean experimental signature

BR < 4.5 x10^{-9} @ 95%CL (LHCb)
(Atlas/CMS/LHCb combination BR < 4.2 x10^{-9})

Update with 2012 data ready soon

PRL 108 (2012) 231801



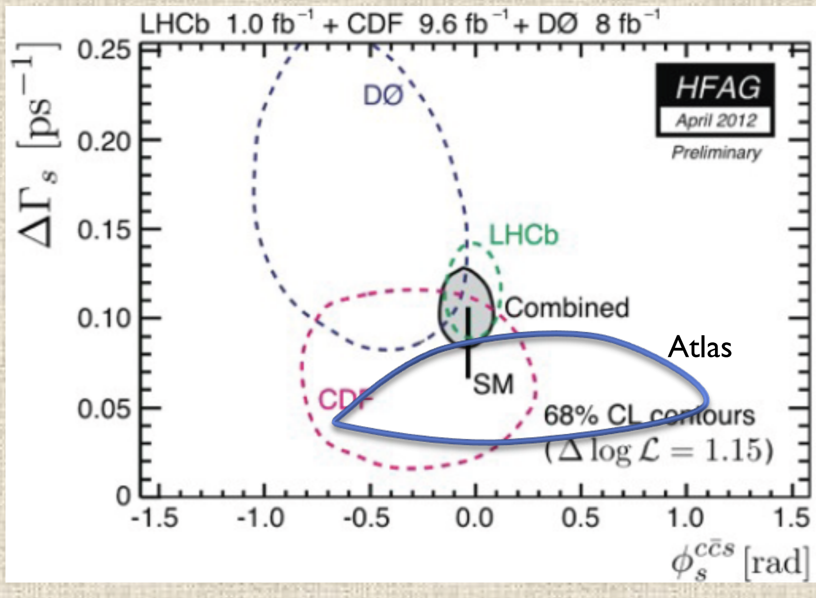
Measurement of the B_s mixing phase ϕ_s from $B_s \to J/\psi\phi$ and $B_s \to J/\psi\pi\pi$

ϕ_s= -0.002 ± 0.083 ± 0.027 rad

First measurement of non zero $\Delta\Gamma_s$ and removal of ϕ_s sign ambiguity

Anomaly seen by CDF and D0 not confirmed by LHCb

LHCb-CONF-2012-002



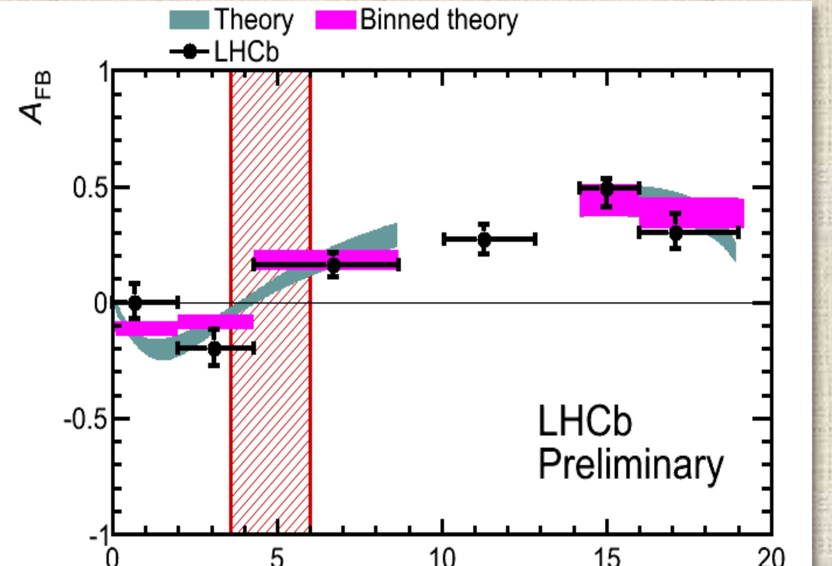
LHCb physics highlights (II)

Rare decay $B\to K^*\mu^+\mu^-$

Measurement of A_{FB} $q_0^2 = (4.9^{+1.1}_{-1.3})\ \mathrm{GeV}^2/c^4$

+ other angular variables, sensitive to RH currents
+ isospin asymmetries in $B\to K^{(*)}\mu^+\mu^-$
(puzzling non-zero value in $B\to K\mu\mu$)

arXiv 1205.3422



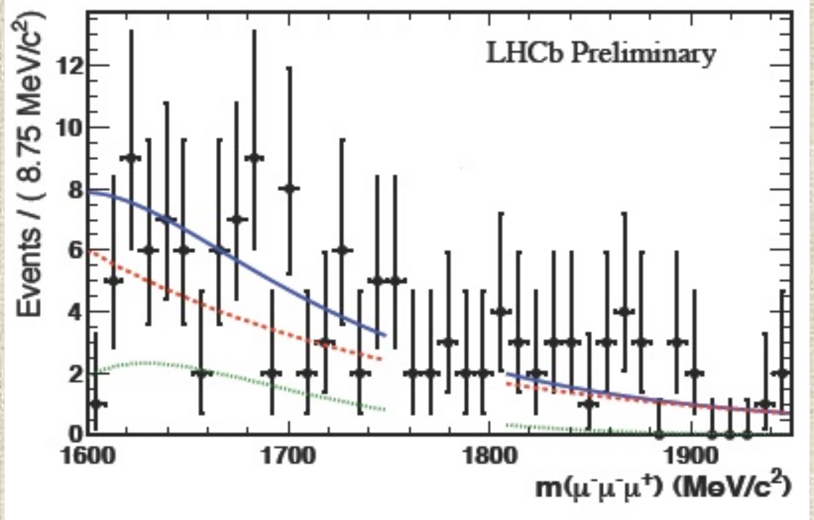
LHCb-CONF-2012-08

LFV decay $\tau\to\mu\mu\mu$

~ 10^{11} τ decays/y in LHCb (from $D_s\to\tau\nu_\tau$)
Normalisation to $D_s\to\phi(\mu\mu)\pi$

BR < 6.3 10^{-8} (90% CL)
Proof of principle for a hadron collider:
B factories limits: < 2 10^{-8} (90% CL)
Good prospects for future

LHCb-CONF-2012-15



LHCb physics highlights (III)

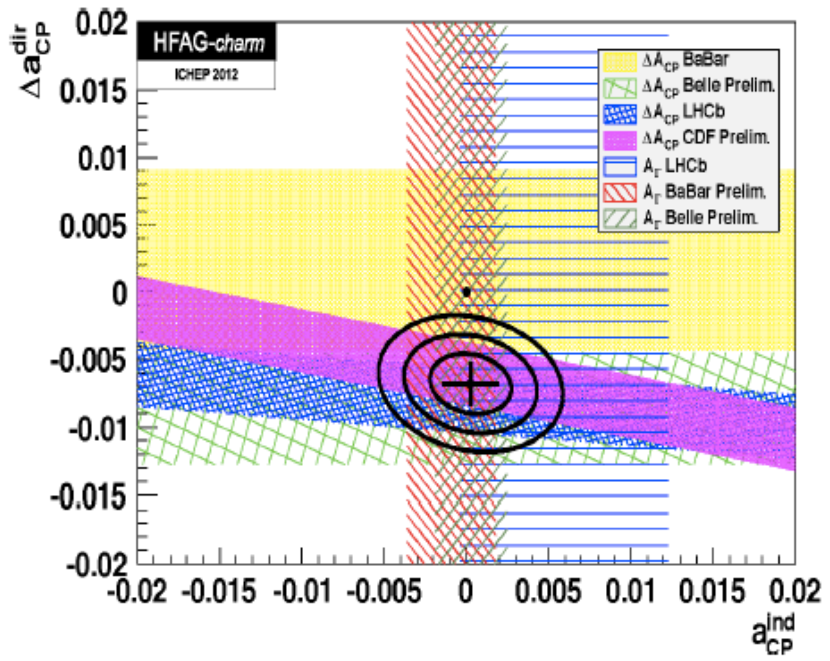
CPV in charm SCS decays ($D^0 \rightarrow h^+h^-$)

Hint of CPV≠0 from LHCb
(and later from CDF and Belle)

HFAG fit from ICHEP 2012
$\Delta A^{CP}_{dir} = (-0.68 \pm 0.15)\ \%$

NP or explicable within SM ?
More data & confirmation in other D channels needed

PRL 108 (2012) 111602



Electroweak physics

LHCb forward acceptance provides very interesting PDF studies

- take large-x / small-x from *pp*
- two distinct regions in (x,Q^2)
- inaccessible to other experiments

Complementarity w.r.t. ATLAS & CMS

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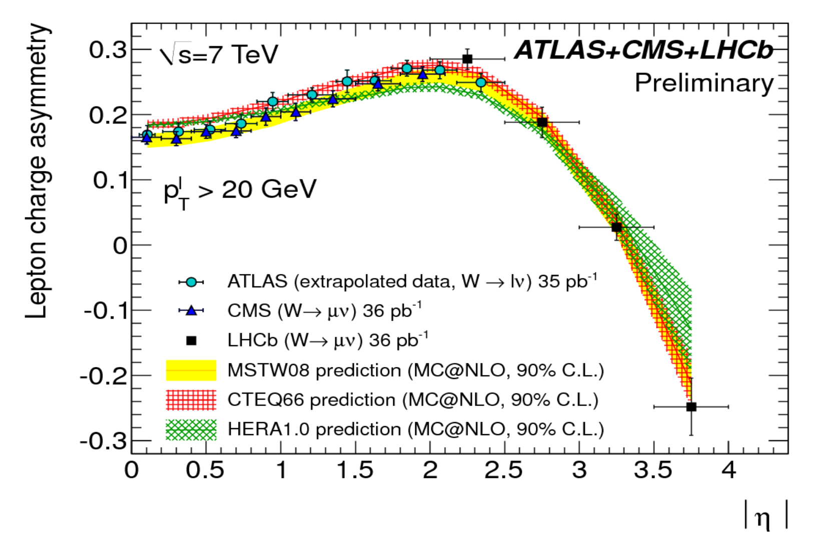


Study of CPV in B_s mixing

Time integrated asymmetry in B_s mixing tagged by specific flavor final state (e.g. muons)

$$a_{sl}^{s} = \frac{\Gamma(\overline{B}_s^0(t) \to f) - \Gamma(B_s^0(t) \to \overline{f})}{\Gamma(\overline{B}_s^0(t) \to f) + \Gamma(B_s^0(t) \to \overline{f})}$$

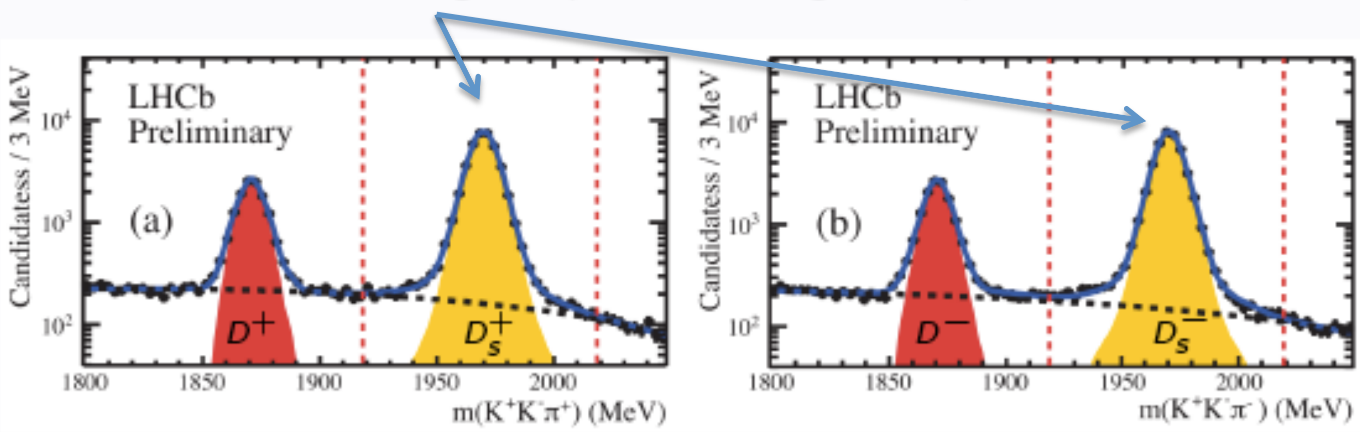
Measured by D0 with semi-leptonic events (μ and di-μ)

$A_{sl}^{\mu\mu} = (-0.79 \pm 0.20)\%$ (mix of a_{sl}^{d} and a_{sl}^{s})

~ 4σ tension with SM

Difficult to reconcile with ϕ_s LHCb data

- SM prediction: $a_{sl}^{s} = (1.9 \pm 0.3) \times 10^{-5}$ *(arXiv: 1205.1444)*
- Use as final state $D_s^{\pm} X \mu^{\mp} \overset{(-)}{\nu}$, $D_s^{\pm} \to \varphi \pi^{\pm}$



- Time-integrated measurement:
  - Effect of small production asymmetry eliminated due to large Δm_s
- Detection asymmetries estimated from calibration samples
- Residual detector asymmetries averaged out using magnet-up and magnet-down data (roughly equal-sized datasets)

LHCb measurement:

$$a^s_{sl} = (-0.24 \pm 0.54 \pm 0.33)\%$$

LHCb-CONF-2012-22

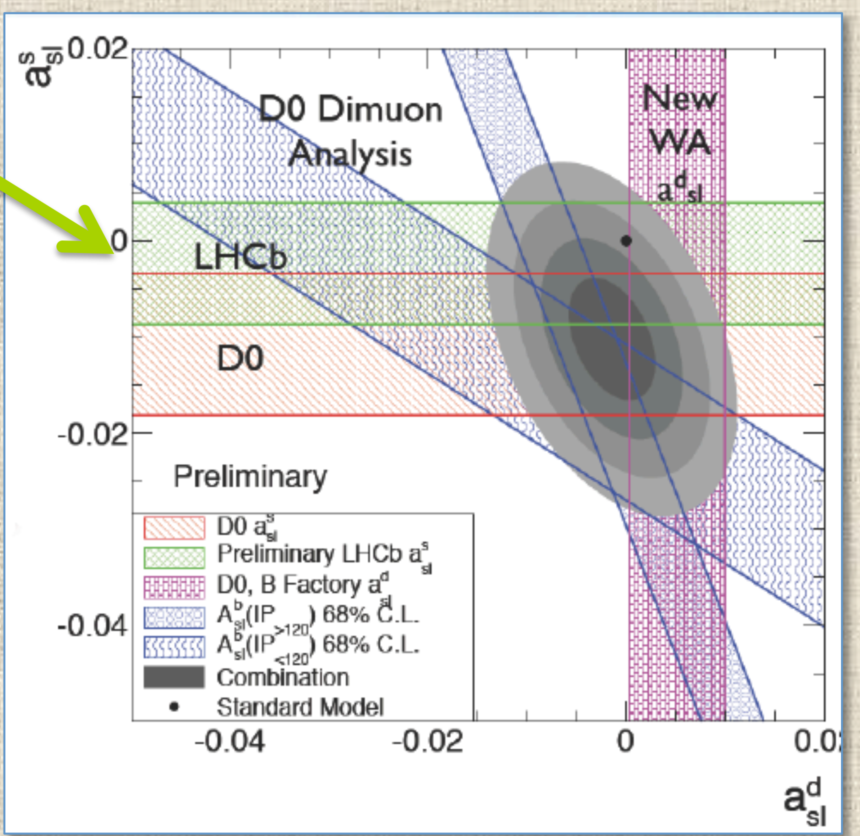
Combination (using also new WA from B-factories)

a_{sl} (B_d) = (-0.15 ± 0.29) %

a_{sl} (B_s) = (-1.02 ± 0.42) %

Fitted $a_{sl}(B_s)$: ~ 2.5σ from SM

More precision from LHCb needed to solve a_{sl} (B_s) issue



Lifetime measurements as probe of NP

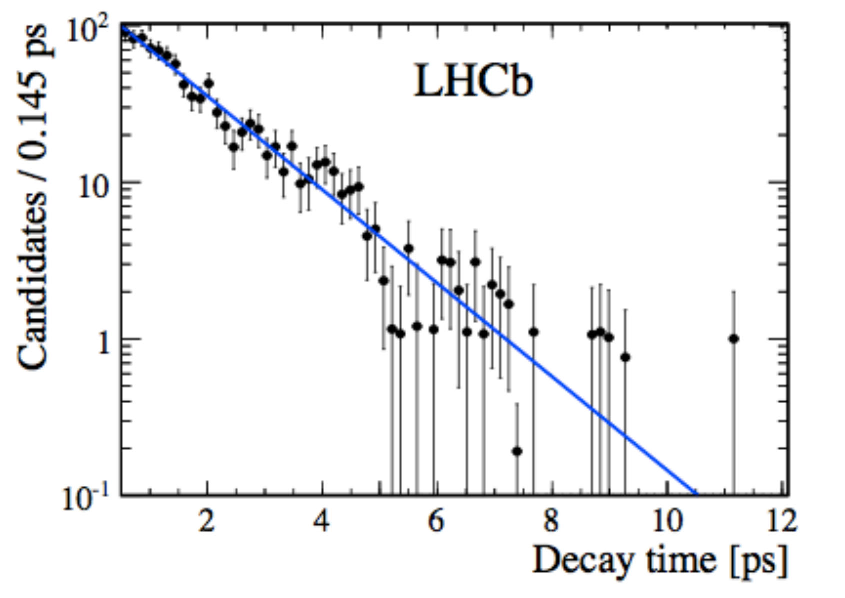
PLB 716 (2012) 393

$B_s \rightarrow K^+ K^-$

- B charmless decays as probe of NP – dominated by penguin diagrams
- CP-even final state: decay dominated by B_s light mass eigenstate

$\tau_{KK} \sim \Gamma_L^{-1} = 1.455 \pm 0.046 \pm 0.006$ ps

Further statistics available from other samples



PRL 109 (2012) 152002

$B_s \rightarrow J/\psi\, f_0$

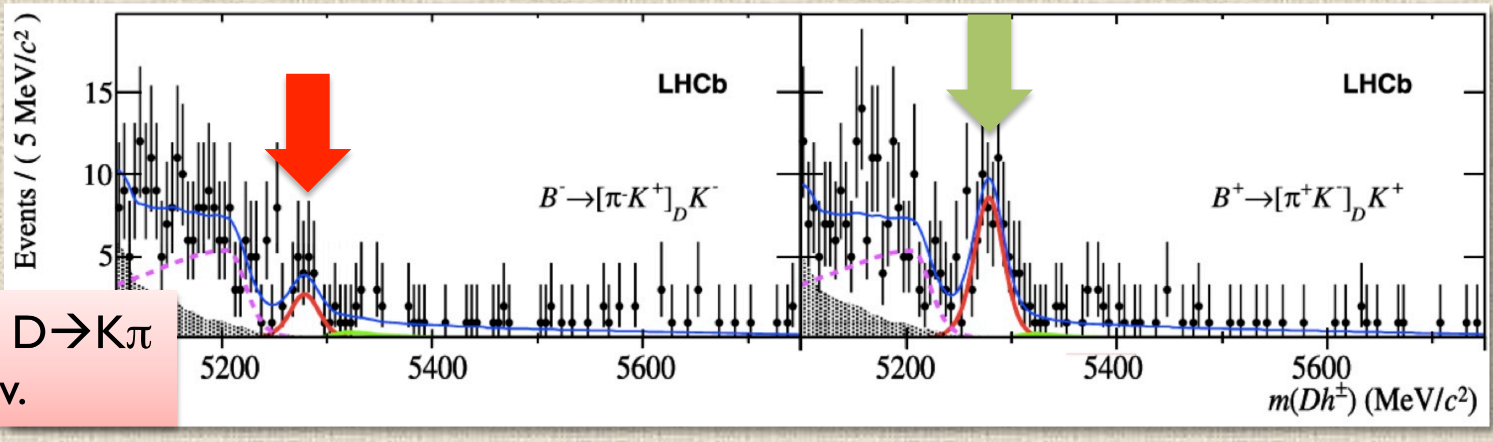
- Pure CP-odd final state: decay dominated by B_s heavy mass eigenstate

$\tau_{J/\psi f} \sim \tau(B_H) = \Gamma_H^{-1} = 1.700 \pm 0.040 \pm 0.026$ ps

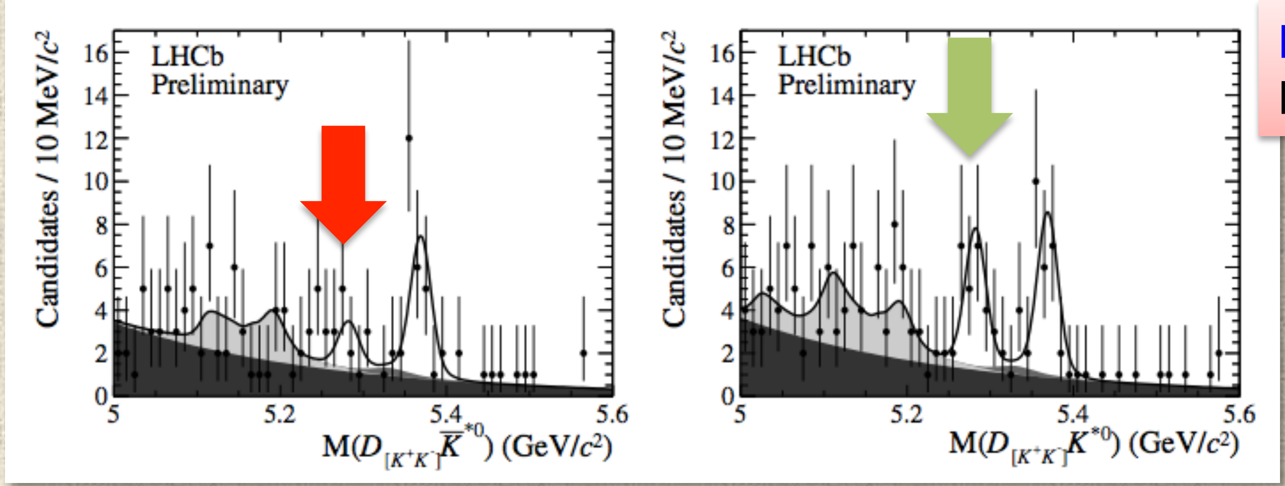
Uncertainties on Γ_s are comparable to that from angular analysis of $B_s \rightarrow J/\psi\, \phi$
Independent of the measurement of ϕ_s (can be used as input to the ϕ_s fit)

The first LHCb measurements of γ (CKM2012)

The increasing statistics of LHCb starts to populate the suppressed hadronic decays useful for the determination of γ



$B^+ \to DK^+$ (ADS) – $D \to K\pi$
B^- 23 ev. – B^+ 73 ev.



$B^0 \to DK^*$ (GLW) – $D \to KK$
B^- 7 ev. – B^+ 20 ev.

First observation !

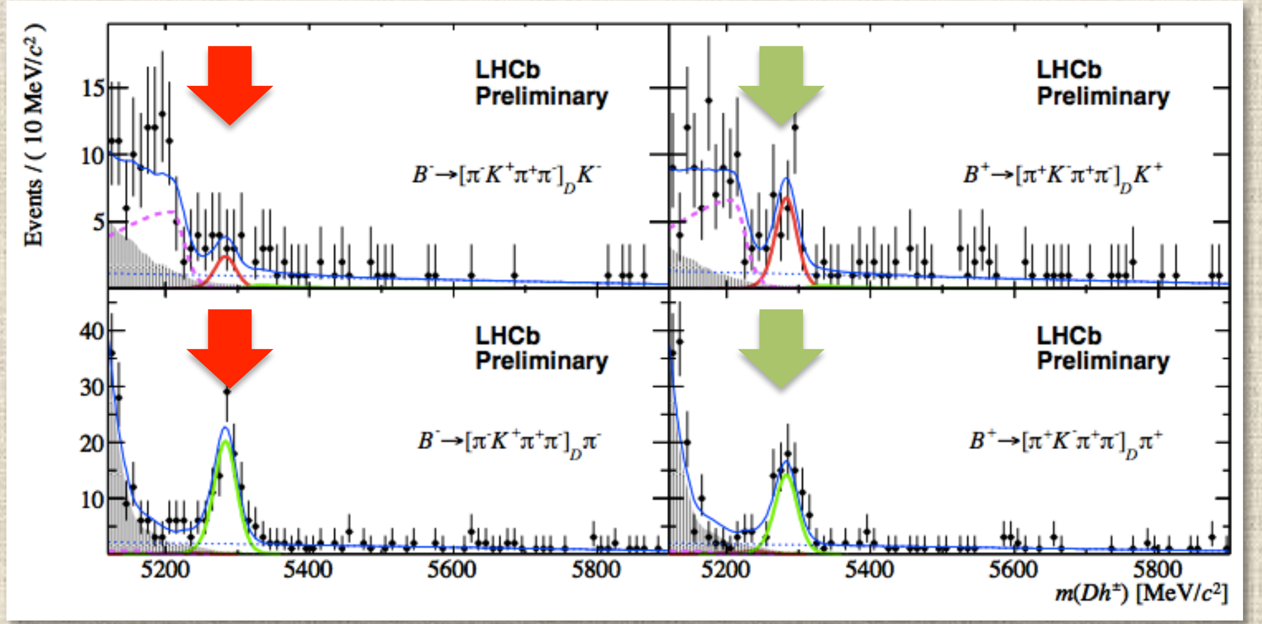
$B^0 \to DK^{0*},\ D \to hh$

$B^+ \to DK^+$ (ADS) – $D \to \pi K \pi\pi$

B^- 11 ev. – B^+ 29 ev.

$B^+ \to D\pi^+$ (ADS) – $D \to \pi K \pi\pi$

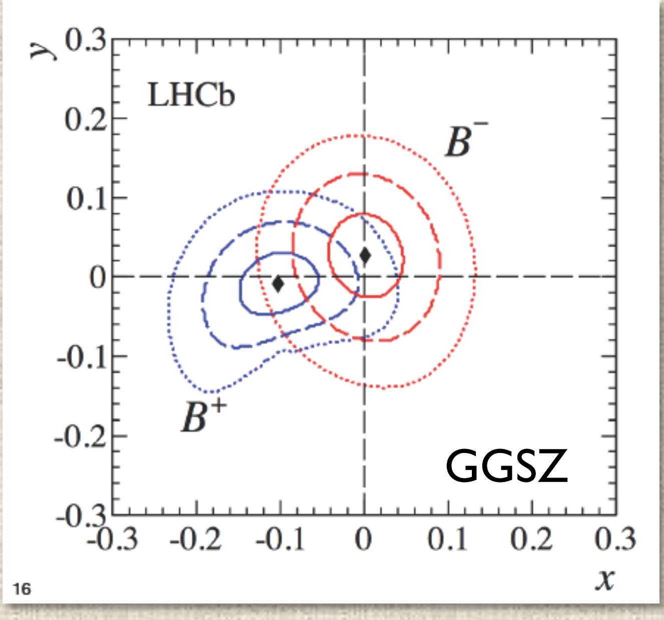
B^- 87 ev. – B^+ 68 ev.



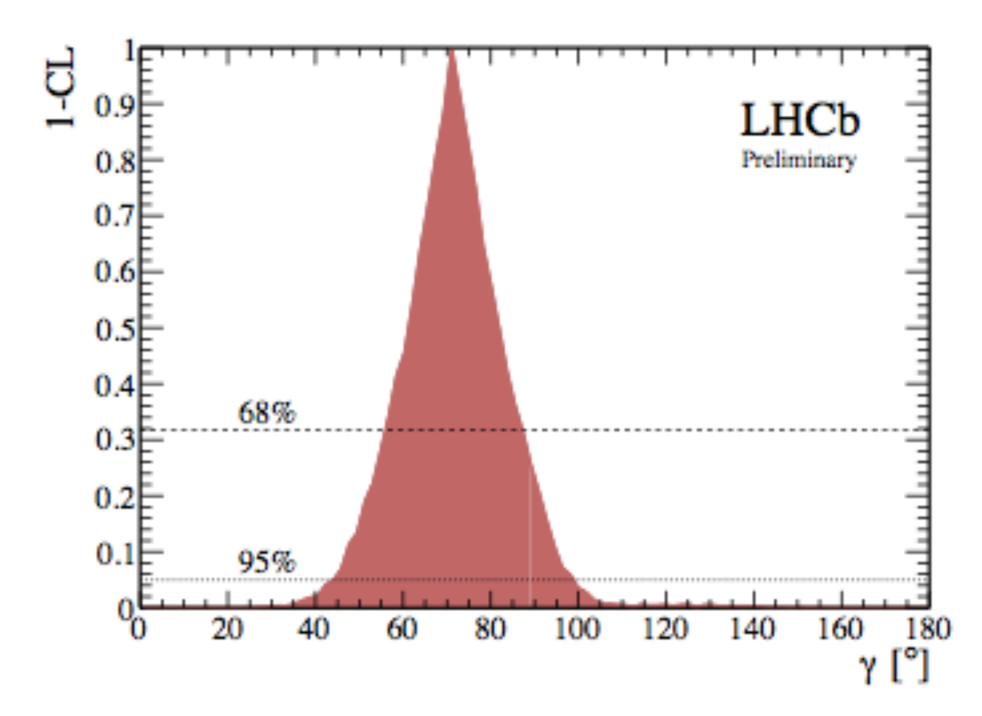
Prospects: by the end of 2012 (with 1/fb data sample) LHCb will determine γ from the global combination of the following (tree) measurements from time-independent analyses

• $B^+ \to DK^+$, with $D \to hh$	[GLW/ADS*]	PLB 712 (2012) 203
• $B^+ \to D\pi^+$, with $D \to hh$	[GLW/ADS]	PLB 712 (2012) 203
• $B^+ \to DK^+$, with $D \to K_s hh$	[GGSZ]	arXiv 1209.5869
• $B^+ \to D\pi^+$, with $D \to K_s hh$	[GGSZ]	arXiv 1209.5869
• $B^+ \to DK^+$, with $D \to \pi K \pi\pi$	[ADS*]	LHCb-CONF-2012-30
• $B^+ \to D\pi^+$, with $D \to \pi K \pi\pi$	[ADS*]	LHCb-CONF-2012-30
• $B^+ \to DK^+\pi\pi$, with $D \to hh$	[GLW*/ADS]	LHCb-CONF-2012-21
• $B^0_{(s)} \to DK^{*0}$, with $D \to hh$	[GLW/ADS]	LHCb-CONF-2012-24
• $B^0_{(s)} \to DKK$ with $D \to hh$	[GLW/ADS*]	PRL 109 (2012) 131801

* First observations



Constraints on (x,y) obtained in the analysis of $B^+ \to DK^+$ with $D \to K_S h^+ h^-$



Constraints on γ obtained from GGSZ and ADS/GLW analysis of $B^+ \to DK^+$

LHCb-CONF-2012-32

Combinations of $B^+ \to DK^+$ modes gives $\gamma = 71^{+17}_{-16}$ deg

An error similar to the one obtained from full fits at B factories

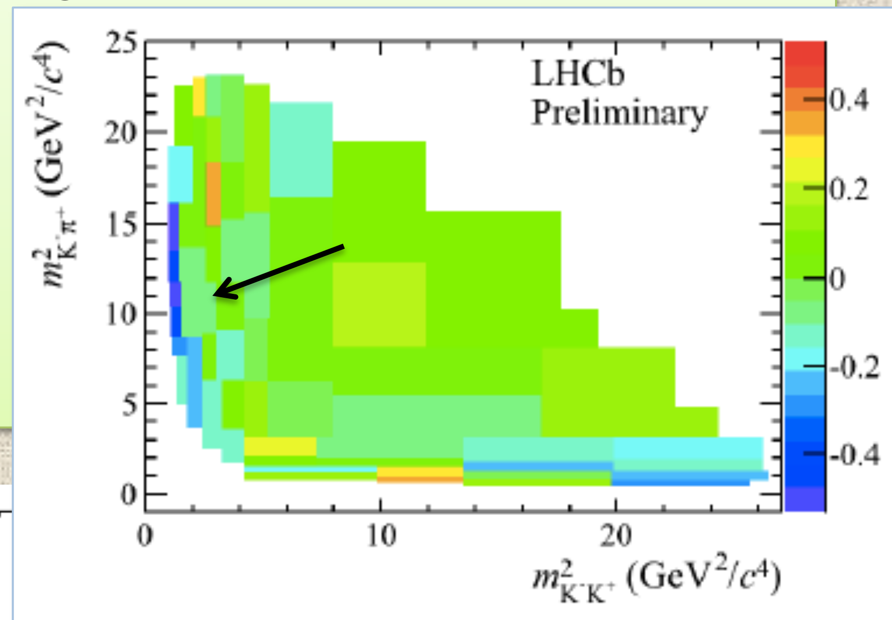
Further info will come from the determination of γ from time dependent analysis and from B to charmless decays (NP could affect penguin diagrams)

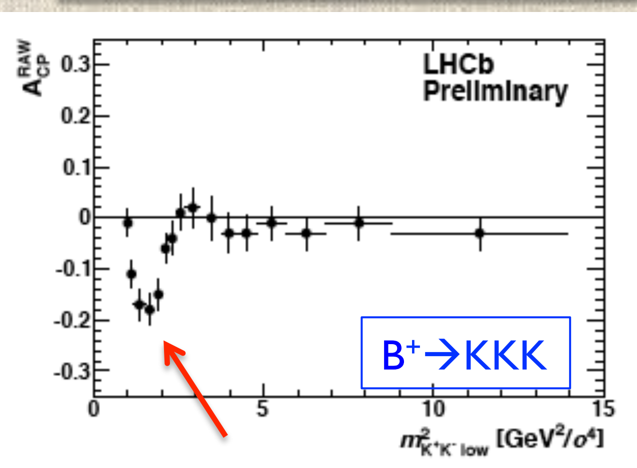
CPV in $B \to hhh$ charmless decays

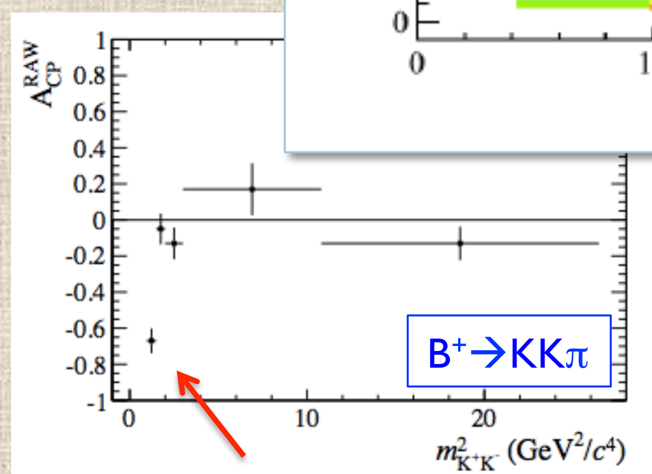
Study of NP effects in the weak phase from interfering patterns of 2 body resonances in the Dalitz plot
Dominant diagrams: $b \to u$ tree and $b \to s$ (d) penguins
Measuring CPV in 3 body decays:

$B^+ \to K\pi\pi$, $B^+ \to KKK$, $B^+ \to \pi\pi\pi$, $B^+ \to KK\pi$

$A_{CP}(K\pi\pi) = 0.034 \pm 0.012$
$A_{CP}(KKK) = - 0.046 \pm 0.012$
$A_{CP}(\pi\pi\pi) = 0.120 \pm 0.028$
$A_{CP}(KKK) = - 0.153 \pm 0.050$







LHCb-CONF-2012-18
LHCb-CONF-2012-28

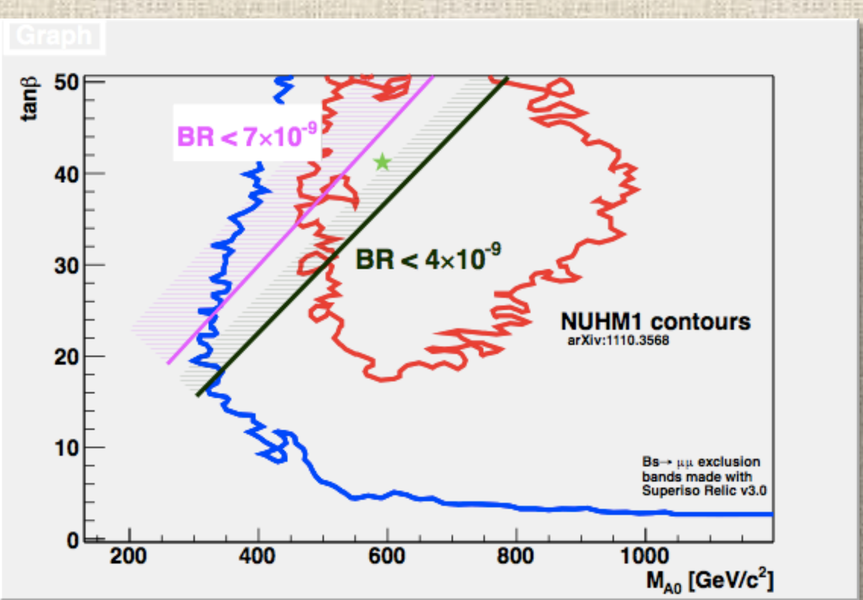
Study of CPV across Dalitz plot (A_{CP} vs m^2_{hh}): large CPV in specific resonance areas
Typically at low m^2 . More experimental work needed as well as on theory side

Implications of LHCb results on New Physics (I)

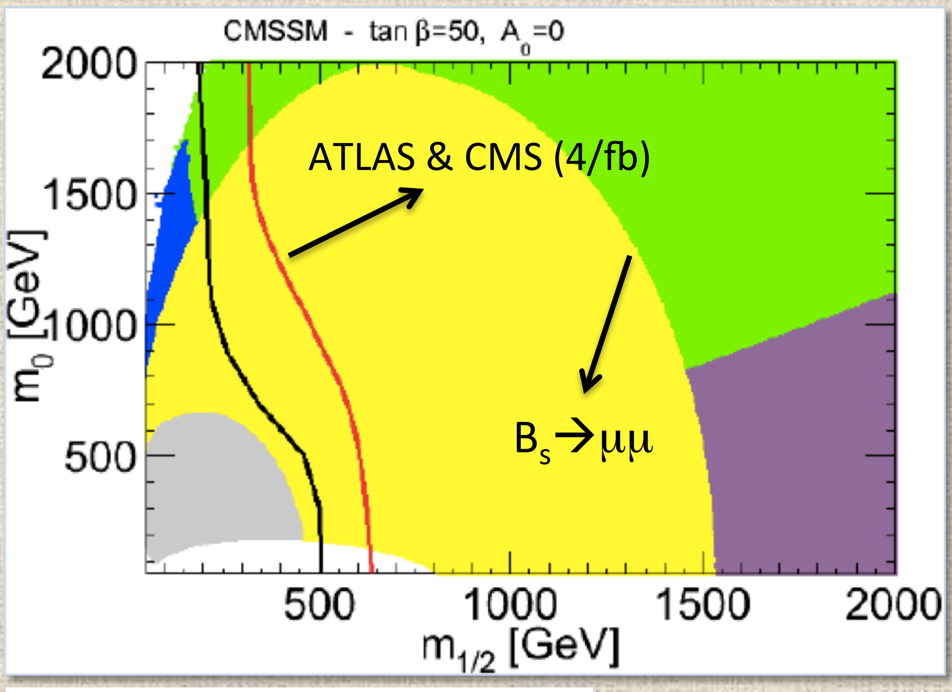
→ Hints of SM deviations of previous measurements have not been confirmed.
However, more precise measurements are mandatory

- $BR(B_s \rightarrow \mu\mu)$ sets strong bounds on mass scales in SUSY (at least in high *tan* β models), complementary to direct searches in ATLAS and CMS
- LHCb results enter the SUSY and CKM fits, starting to impose severe bounds on several models and flavor variables

These implications will become stronger with the full data sample 2011-2012 (> 3/fb)

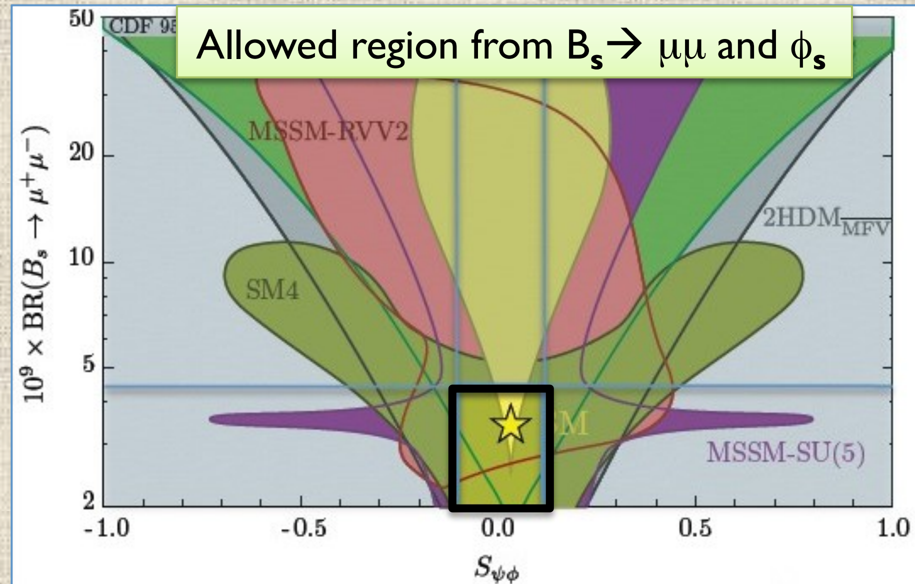


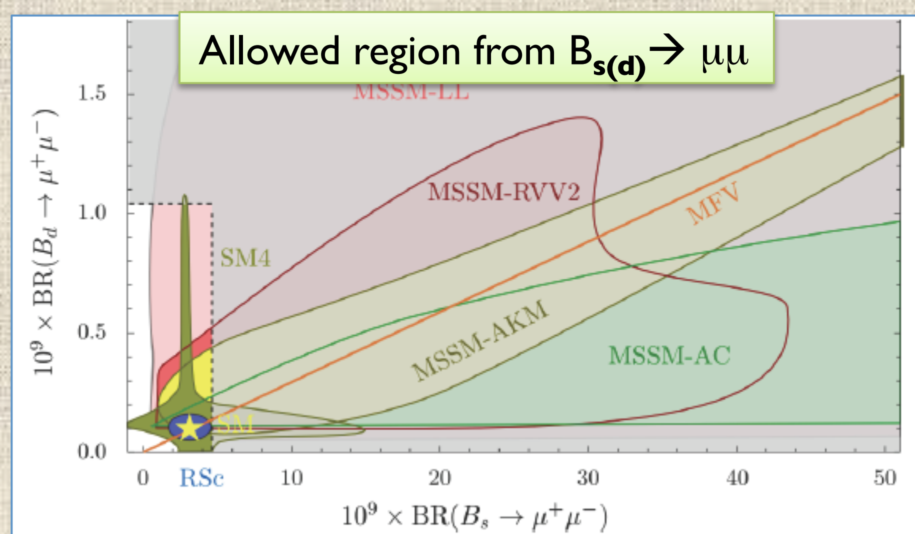
arXiv 1201.5359

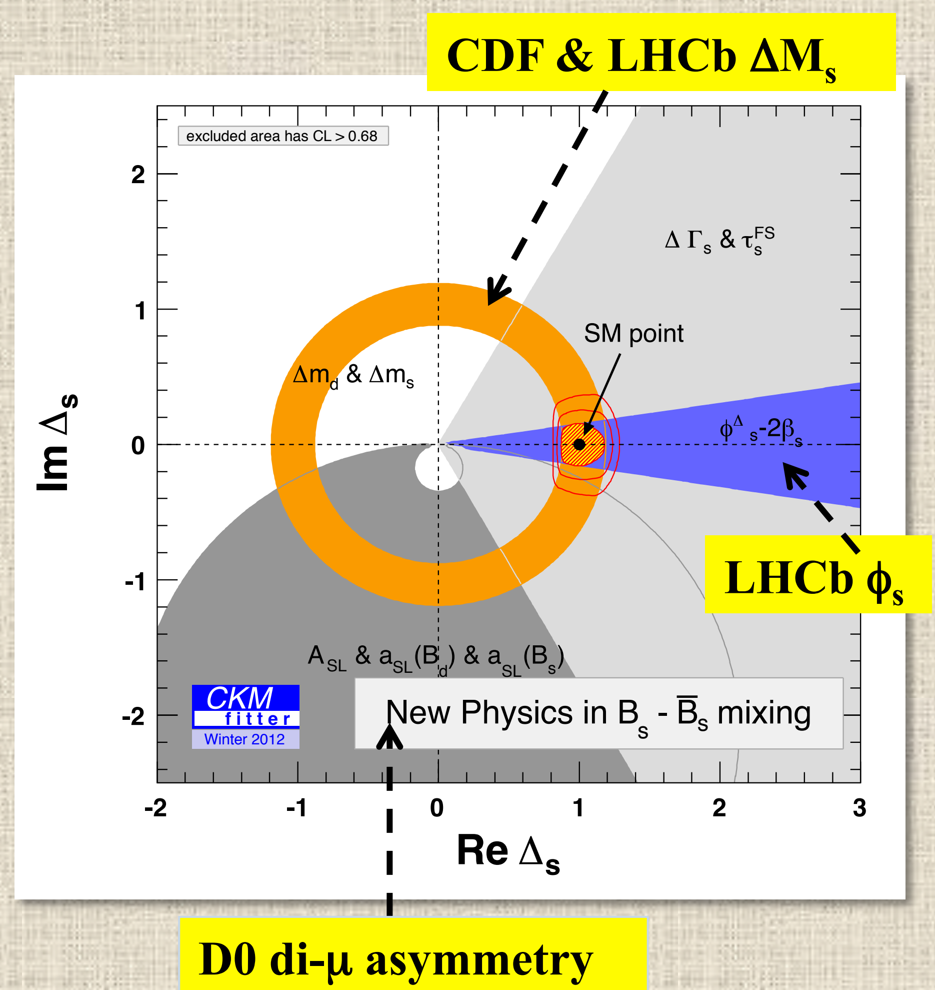


F. Mahmoudi - arXiv 1205.3099

Implications of LHCb results on New Physics (II)

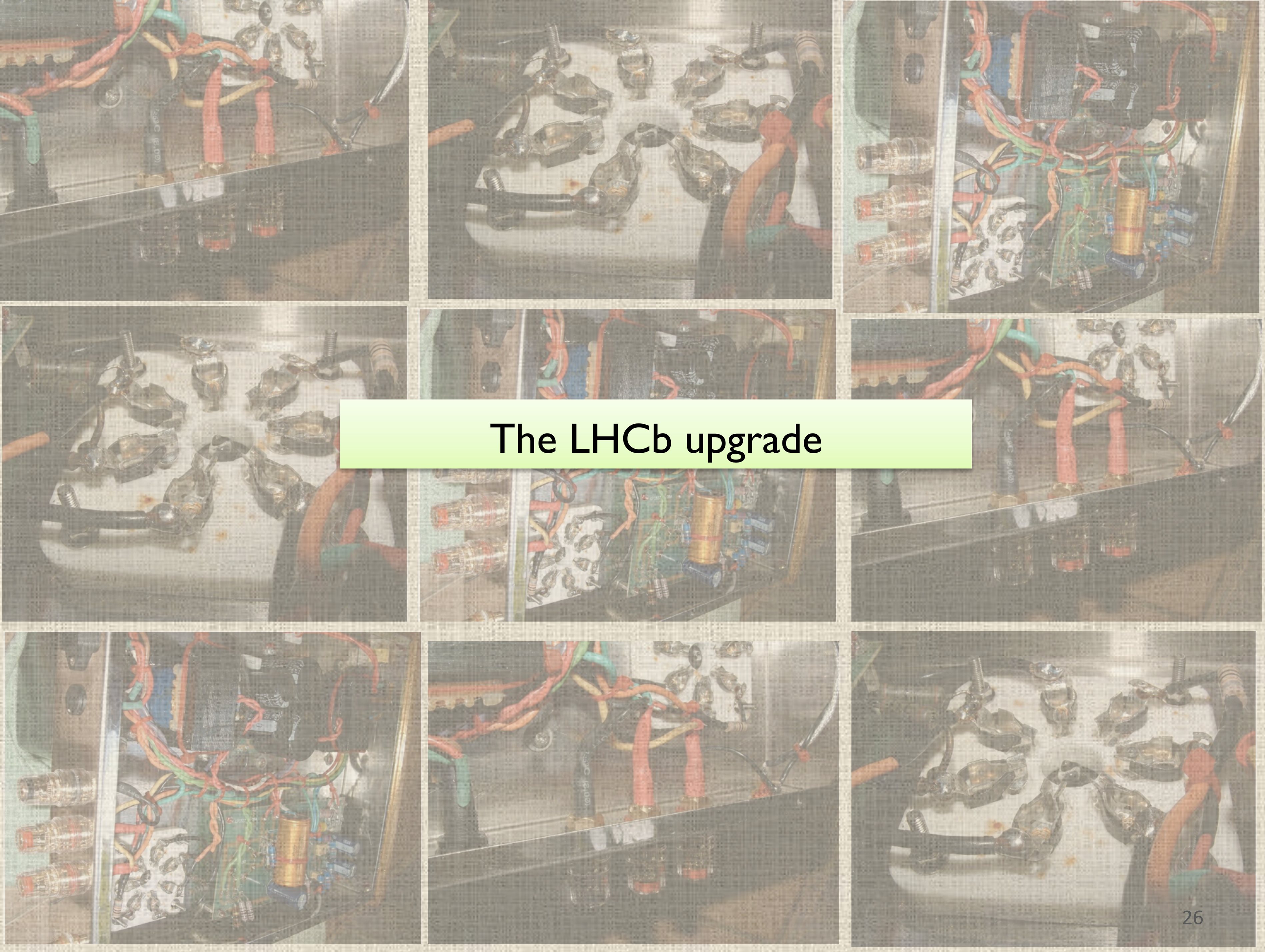






D. Straub - arXiv 1107.0266 and Moriond2012

A. Lenz et al. - arXiv 1203.0238



The LHCb upgrade

Why the LHCb Upgrade ?

- The flavor sector offers a very rich complementarity to the High Energy Frontier (ATLAS & CMS) searches for New Physics
- Recent LHCb results have shown the potentialities of Flavor Physics at LHC and the good performances of the detector
- LHCb is unique for NP searches in B_s (and works well also for B_d).
  Huge sample of charm available.
  Complementary also in respect to Super-B factories
- LHCb is unique in his forward geometry (and also for "exotica" New Physics searches)
- Operation of High Luminosity LHC (HL-LHC) is compatible with LHCb and luminosity can be tuned to LHCb needs

▶ *Future prospects* (a personal view)

A flavor theorist's shopping list

"Minimalistic" list of key (quark-) flavour-physics observables:

- γ from tree ($B \to DK$, ...) ← LHCb
- $|V_{ub}|$ from exclusive semilept. B decays
- $B_{s,d} \to \mu\mu$ ← LHCb
- CPV in B_s mixing ← LHCb
- $B \to K^*\mu\mu$ (angular analysis) ← LHCb
- $B \to \tau\nu$, $\mu\nu$
- $K \to \pi\nu\nu$
- CPV in D mixing ← LHCb

The LHCb Upgrade will push the exp. precision up to where NP may appear
+
Broadening physics spectrum: search NP in forward region

LHCb data taking perspectives and its upgrade

Based on 2011 experience, LHCb can collect ~ 1.5/fb per "normal" LHC year

- **2012 @8 TeV and 2015-16-17 @13 TeV**

By the end of 2017 → **~ 7/fb** collected.
Reaching ultimate theory precision in flavor variables will need more statistics.

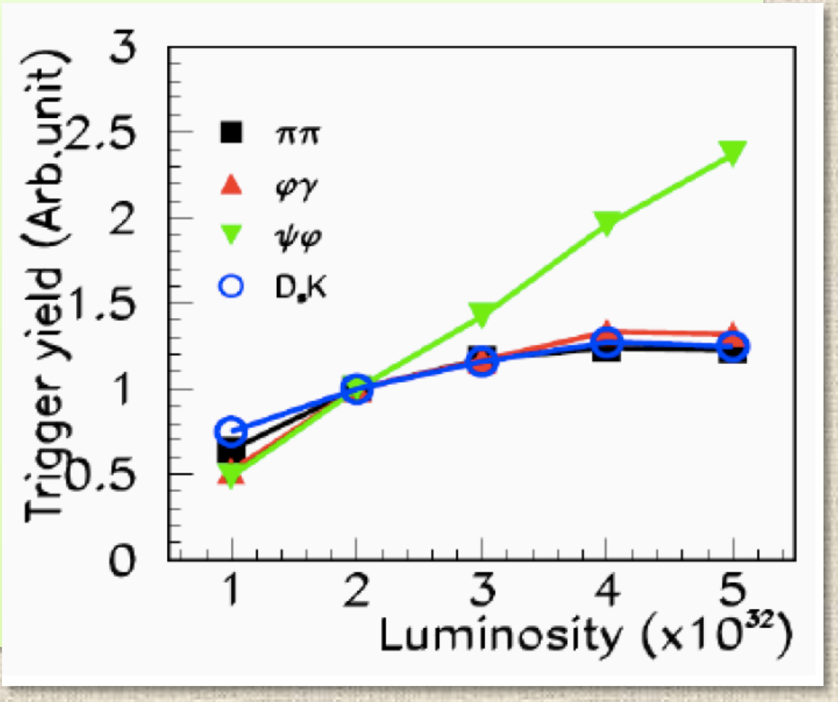
Current LHCb limitation is in L0 trigger rate capability (< 1 MHz) that does not allow to profit from an increase in luminosity

Upgrade plans:

- 1 MHz → 40 MHz readout
- Full software trigger (better yield for charm and hadronic triggers)
- Up to L ~ 2 10^{33} $cm^{-2}s^{-1}$ to collect 50/fb

Expected yields increase (w.r.t. 2011):

- **x10** in muonic channels
- **x20** in hadronic channels ($B_s \rightarrow \phi\phi$, DK, charm, etc...)



The schedule of the LHCb upgrade

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)

- LHCb Upgrade preparation

2012-13 R&D, technological choices, preparation of subsystems TDRs

2014 Funding/Procurements

2015-19 Construction & installation

"Framework TDR for the Upgrade" submitted to LHCC and F. Agencies in June 2012

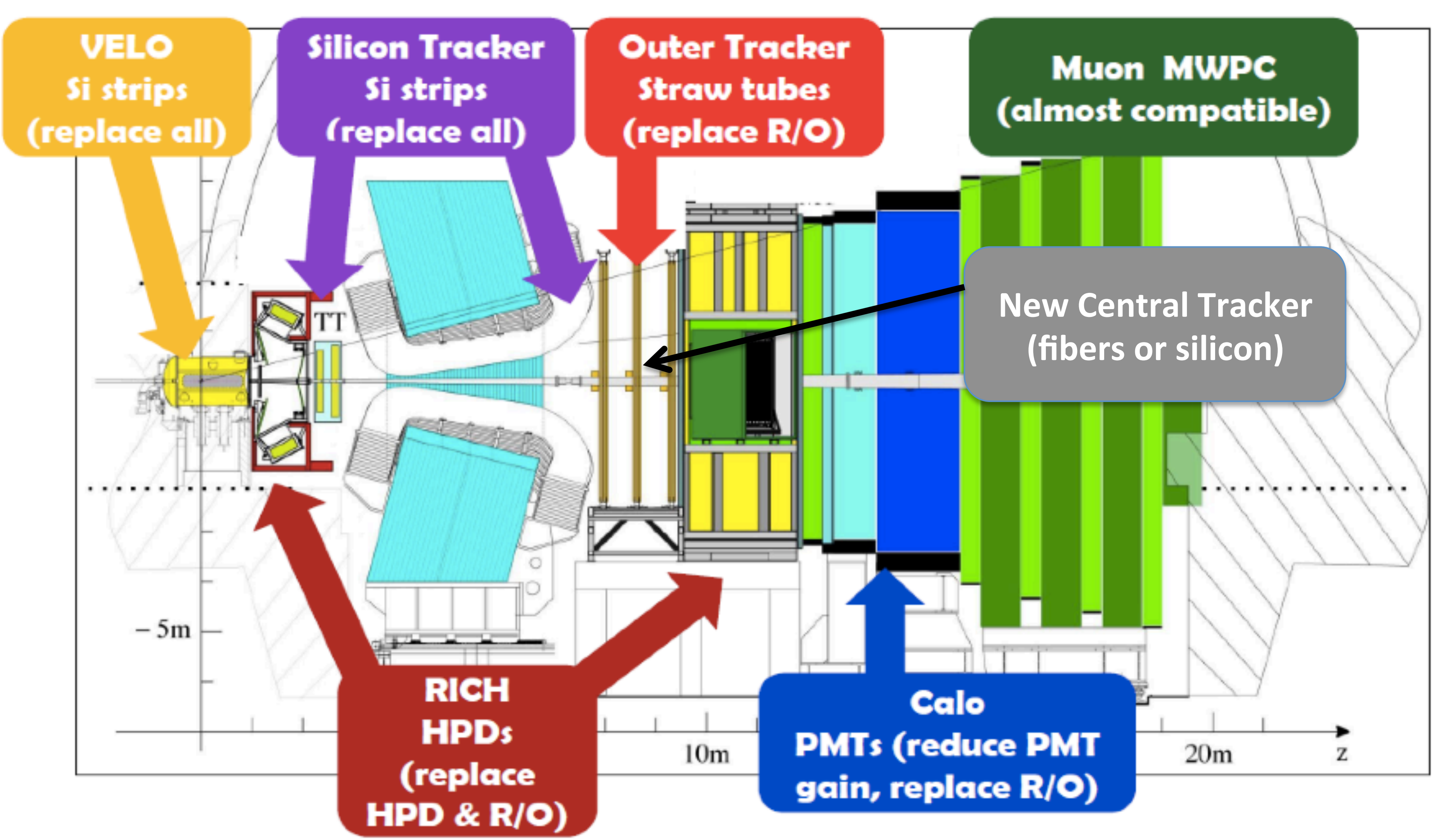
Two documents prepared for the European Strategy Group for Particle Physics:

- LHCb collab. – The LHCb Upgrade – LHCb-PUB-2012-008
- LHCb collab. & 40 theorists – Implications of LHCb measurements and future prospects - LHCb-PUB-2012-009

→ Very positive outcome for the LHCb Upgrade from ESPG Krakow meeting

→ The Upgrade has been endorsed (for approval) by the LHCC in September meeting

LHCb detector modifications for the upgrade



VErtex LOcator

Completely new modules and FE electronics

Two major options under consideration:

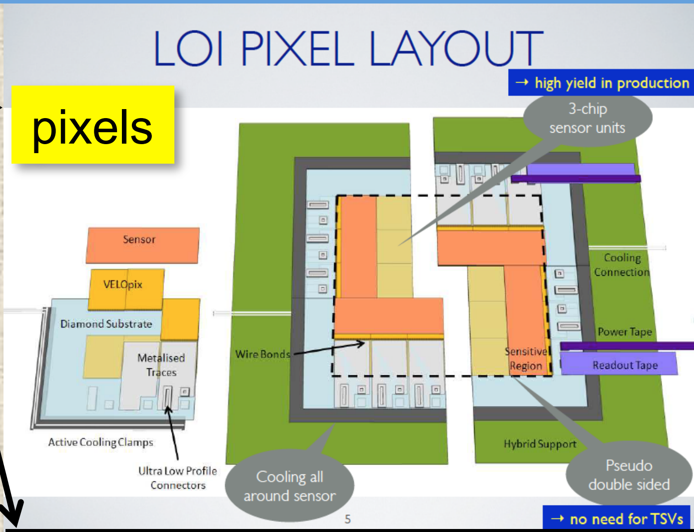
- STRIPS (40 MHz implementation pushes boundaries)
- PIXEL (based on Timepix R&D)

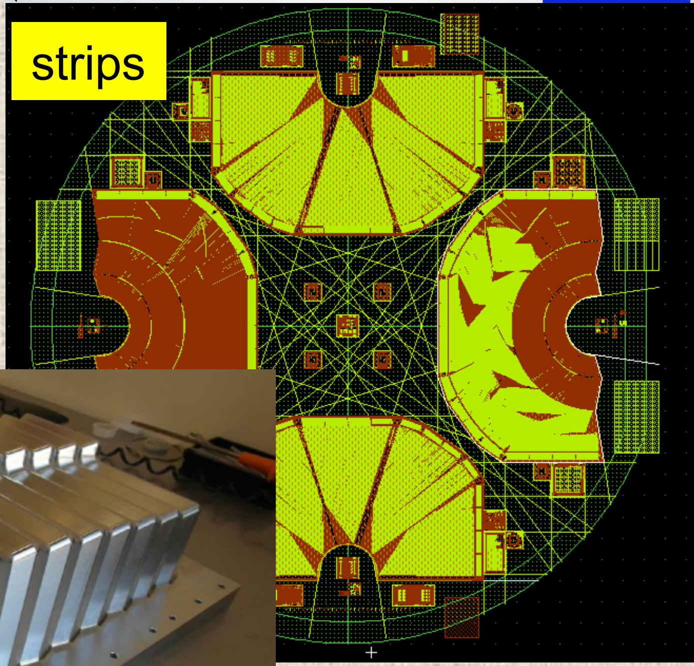
Challenges

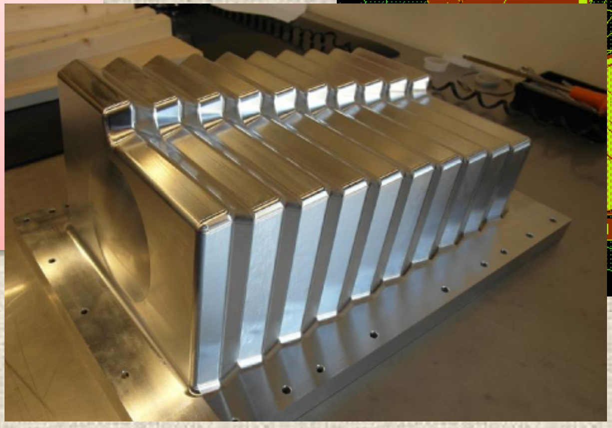
- Huge data rates (up to 12 Gbit/s)
- High radiation levels (~370 MRad or $8\ 10^{15}\ n_{eq}/cm^2$)

Common developments

- New module cooling interface
- New RF foil
- All without sacrifices in material budget
- Nearer to BEAM ?

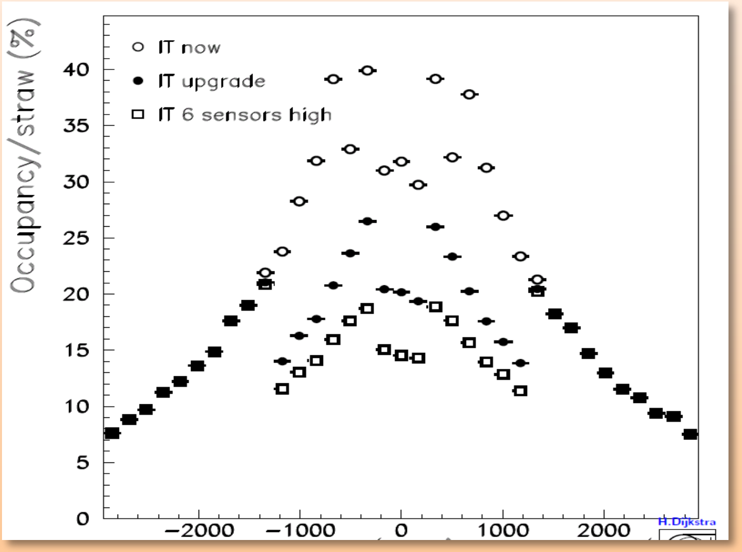


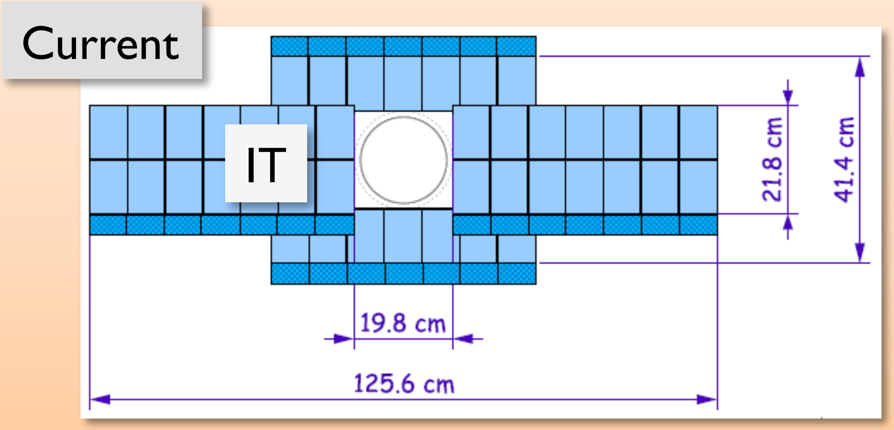


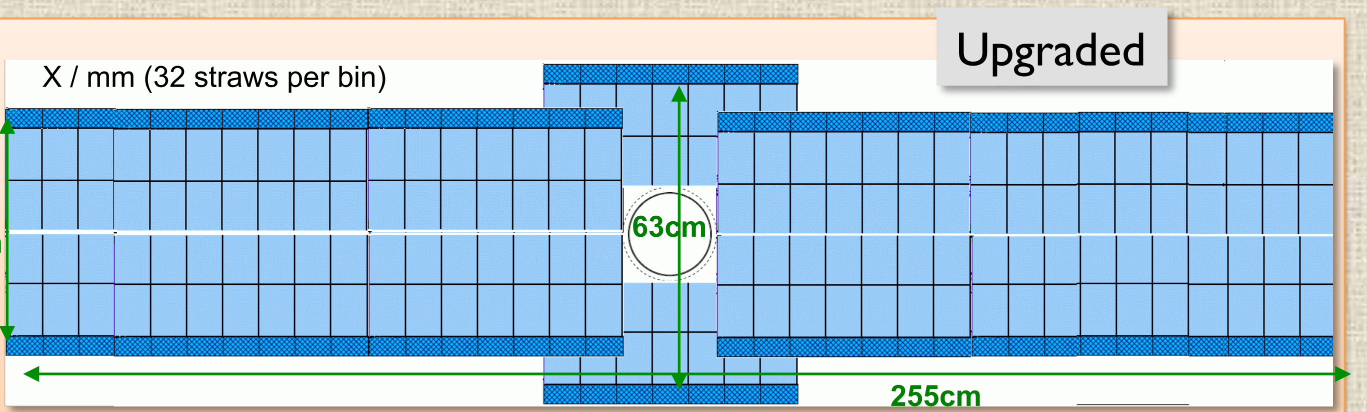


TRACKER – Silicon Option

Increase size + decrease mass of IT to cure the OT occupancy problem







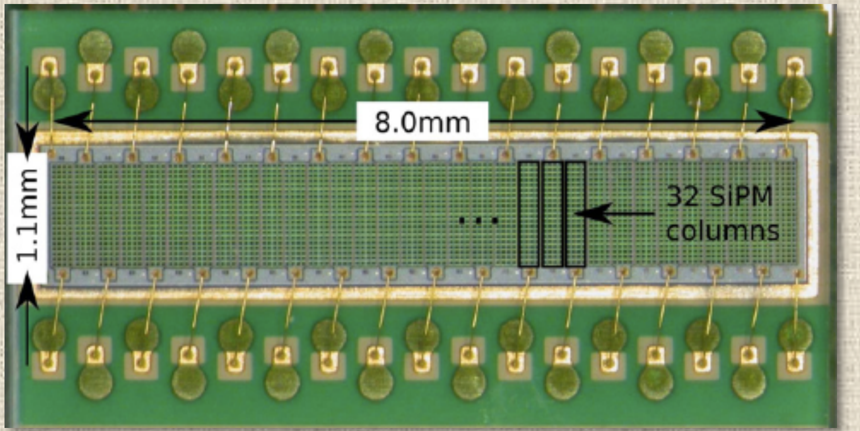
Challenges:
- Mass reduction
- Cooling
- Cost

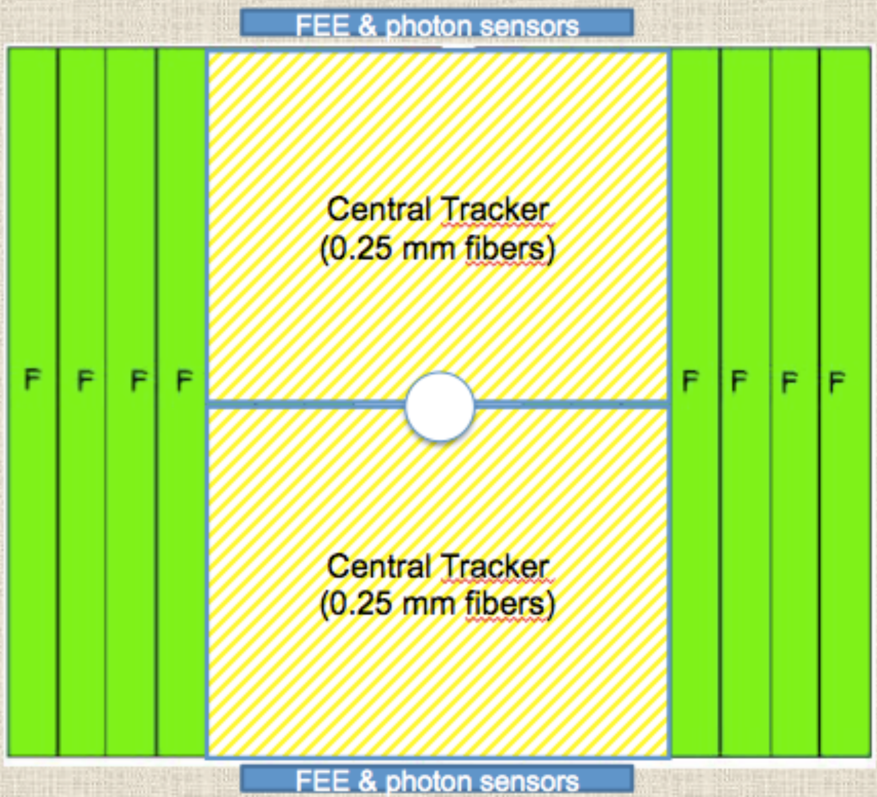
- From 126x22(41) cm to 255x42(63) cm
- Increase number of sensors/layer by nearly factor 4, ×3.3 for 10 layers.
- "η" coverage: IT/(IT+OT)= 33% → 54%

TRACKER – Central Tracker Option

Sci. Fi. central tracker

- Inner part - w/ scintillating fibers modules (Sci.Fi.)
- Outer part – w/ current straw tubes





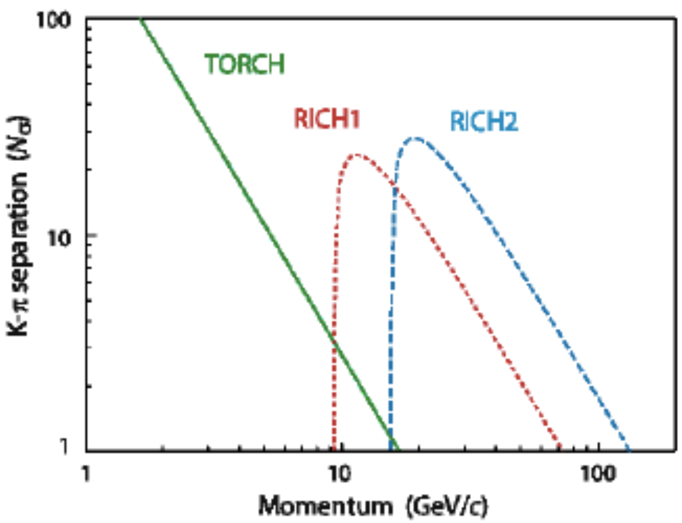
- 5 layers of densely packed 250 μm diameter fibers, readout with 128-channel Silicon Photomultipliers (SiPM)
- 2.5m long fibers elements, readout on top and at bottom of stations

Challenge: fibers and SiPM can sustain the occupancy and radiation ? (~ 1 Mrad)

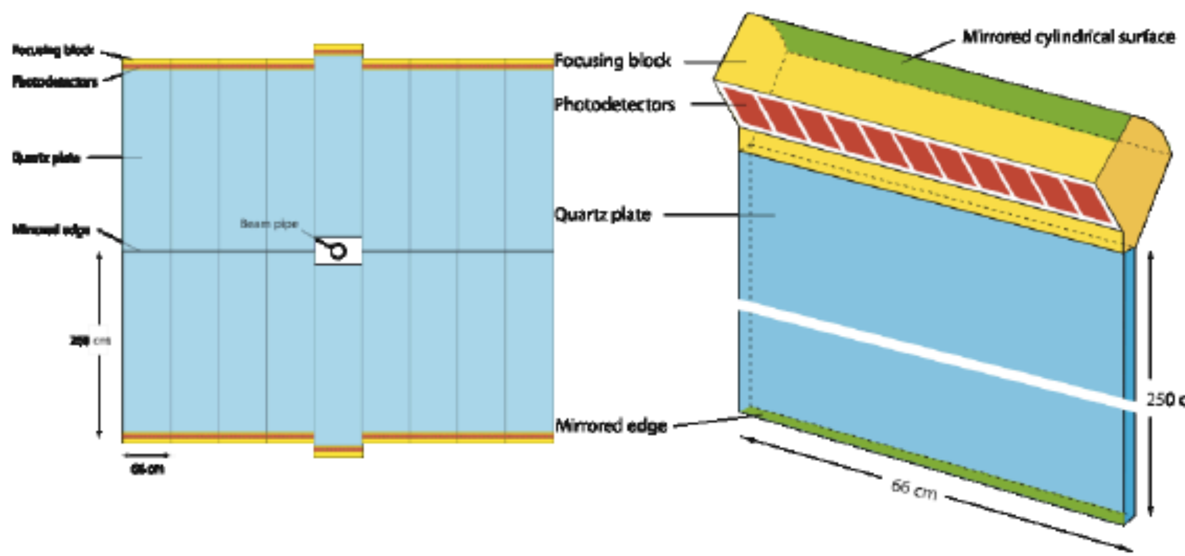
Particle ID

- RICH-1 and RICH-2 detectors remain
  - Readout baseline: replace pixel HPDs by MaPMTs & readout out by 40 MHz ASIC
  - Alternative: new HPD with external readout
- Low momentum tracks: replace Aerogel by Time-of-Flight detector “TORCH” (=Time Of internally Reflected CHerencov light)
  - 1 cm thick quarz plate combining technology of time-of-flight and DIRC
  - Measure ToF of tracks with 10-15 ps (~70 ps per foton).

K-π separation vs p in upgrade:



TORCH detector:



Calorimeters and MUON systems are upgraded to stand 40 MHz readout scheme and a luminosity of 2 10^{33} cm^{-2} s^{-1}.

Conclusions

Thanks to LHC performances and luminosity leveling technique, ***LHCb*** has collected over 1 fb^{-1} in the 2011 run, 1.5 fb^{-1} in 2012 - and is planning to more than triple the statistics

Analyses in the core physics channels are well advanced, with areas of "world record" measurements: $B_s \rightarrow J/\psi\ \phi$, $B_s \rightarrow \mu\mu$, $B_d \rightarrow K^* \mu\mu$, B_s mixing and charm physics. A large amount of other channels under study

Standard Model shows its solidity but still room available for New Physics: ***LHCb*** is complementing ATLAS & CMS searches for Supersymmetry

Very good perspectives for future new measurements in CPV in b and c decays, CKM angle γ, radiative and rare decays, and in non-flavor physics

The ***LHCb*** upgrade will contribute significantly to a full exploitation of LHC and to increase the opportunities of New Physics discovery in the next decades