LHC ON THE MARCH
20-22 NOVEMBER 2012, PROTVINO, RUSSIA

LHCb status and overview

on behalf of LHCb collaboration

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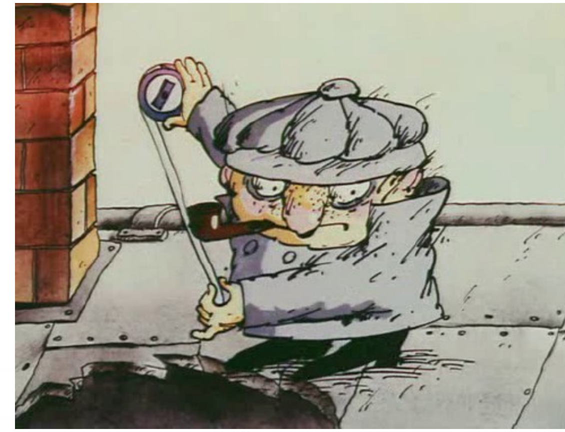
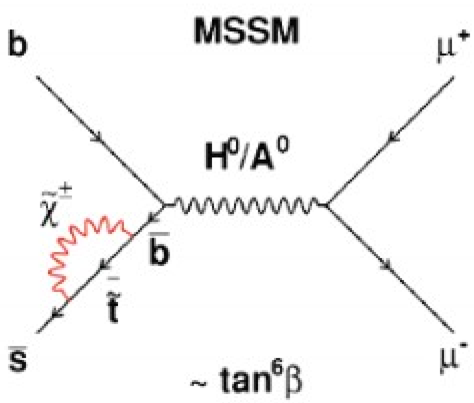
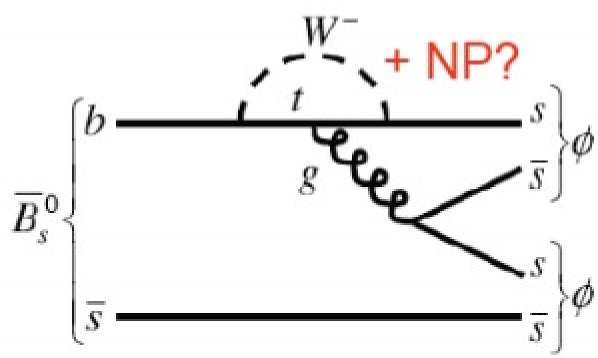
Heavy flavour physics

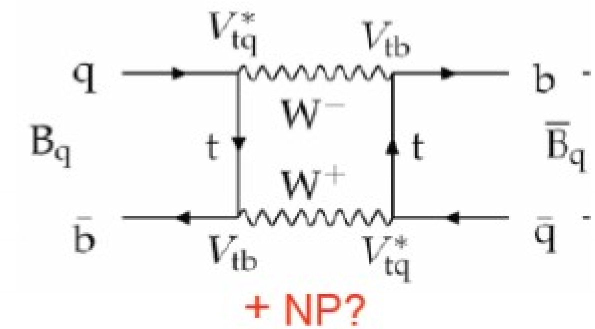
Like entering the building of the new physics through the backdoor

- Needs high agility and attentiveness
- But the reward may be really great!









Many observables, which allow to distinguish between different models

- Rare and very rare decays of beauty and charm particles
- Asymmetries: CP, forward-backward, isospin

Help from the heavy flavours:

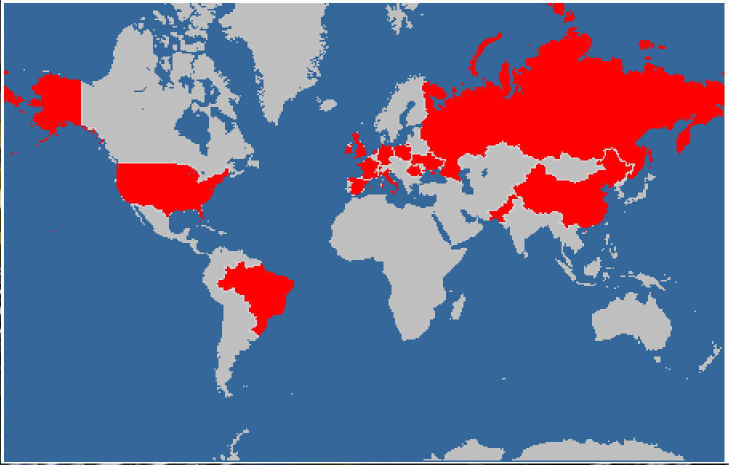
- More potentially interesting decays
- Large asymmetries are expected
- Relatively long lifetimes

Small effects → new contributions should be immediately visible!

LHCb collaboration

16 countries:

60 institutes, 819 members



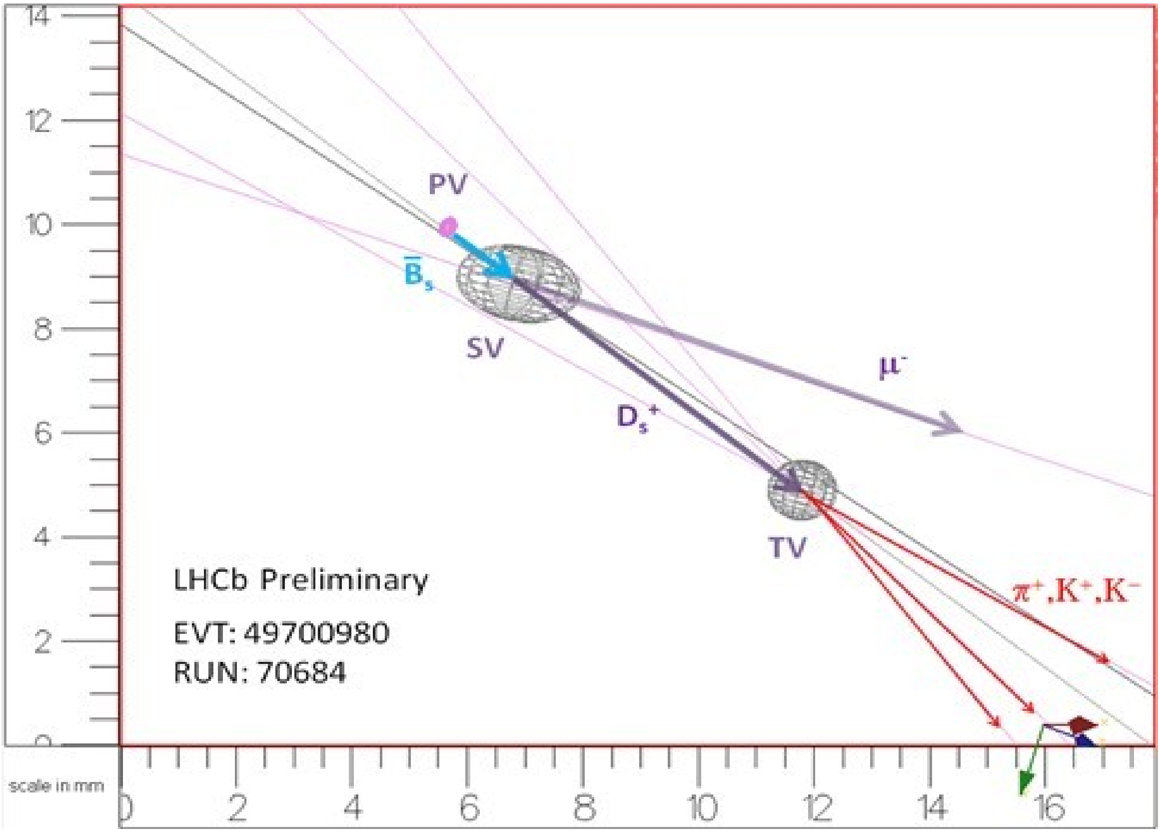
Beauty and charm decays

LHC is a Flavor Factory @ 7 TeV :

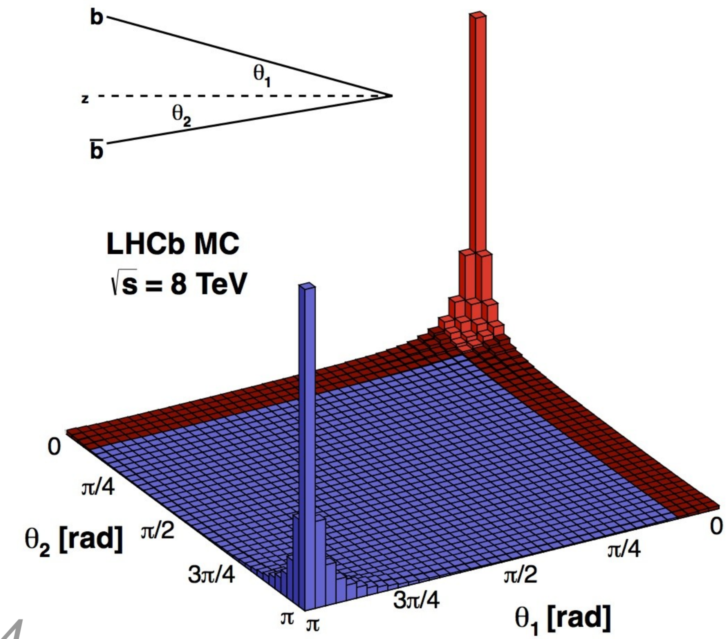
– σ(pp → ccX) = ~6 mb
[LHCb-CONF-2010-013]

– σ(pp → bbX) = ~0.3 mb
[PLB 694 (2010) 209]

All possible b- and c- species are produced



Spreading predominantly in the narrow cone around the beam



σ_{inel} ~60mb – trigger is essential!

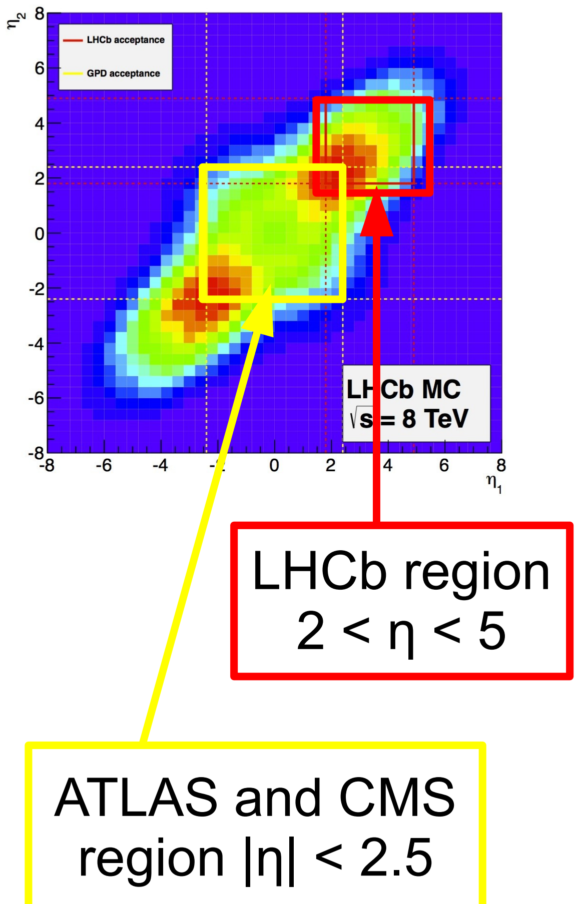
Lifetime resolution (B_s oscillation period ~350 fs)

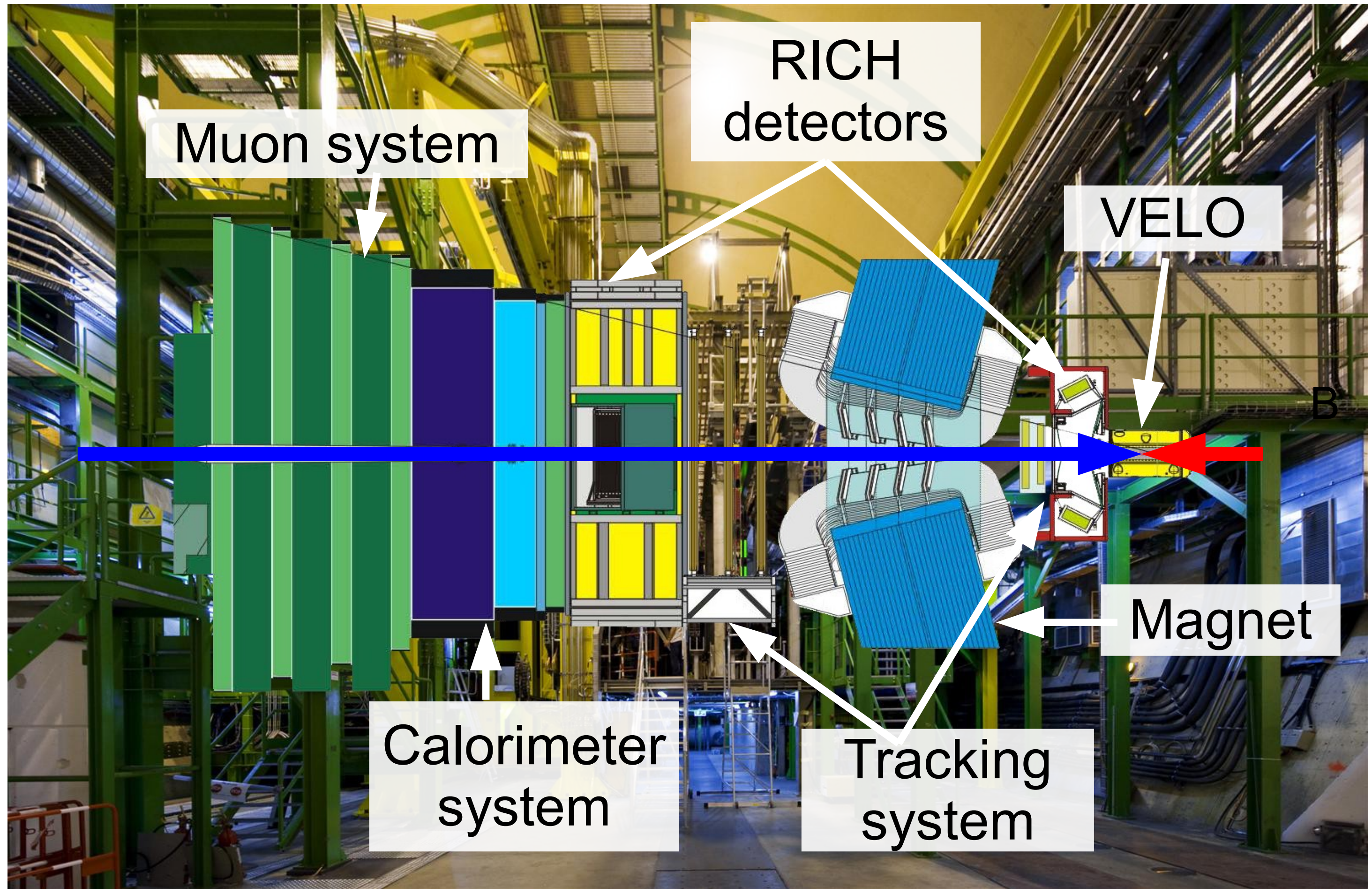
Mass resolution to reduce background

Particle identification to suppress peaking backgrounds

LHCb detector@LHC

300 mrad solid angle





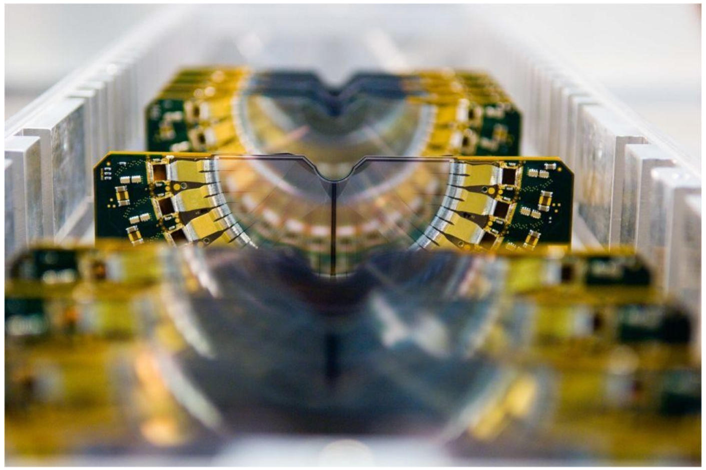
Cross-section in detector acceptance@7TeV:

σ_{bb} ~ 75μb [PLB 694 (2010) 209]

σ_{cc} ~ 1.7mb

Detector performance

VErtex LOcator



Construction:

- 2 moving halves
  - 6cm - „open“, 0.7cm - „closed“
- 21 modules in each half
  - 1 R and 1 φ-sensor glued back-to-back
  - 220μm thick, 120 mm radius

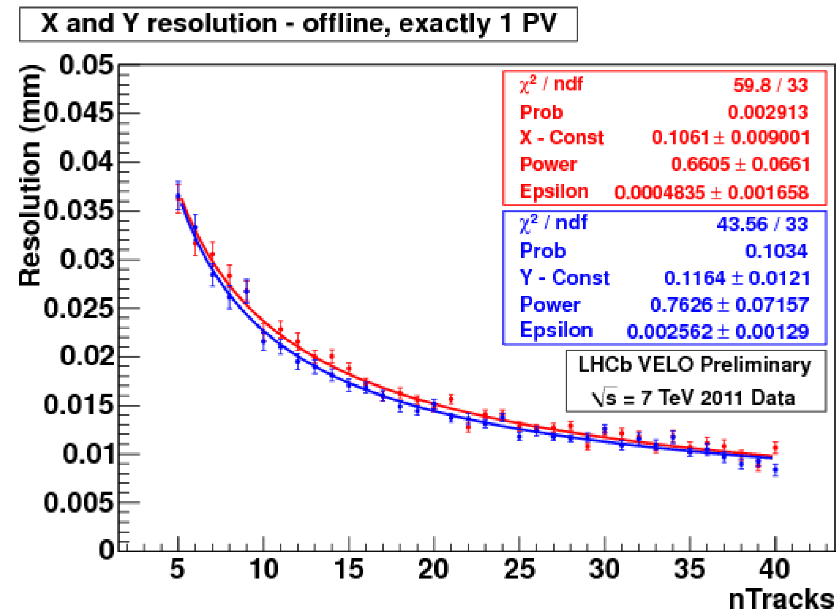
Vertex resolution for 25 tracks

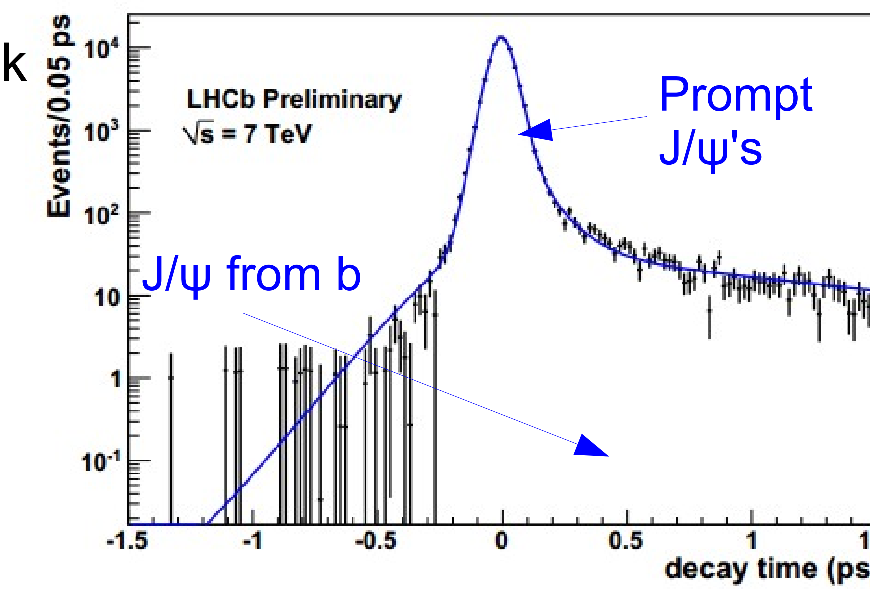
- σ_x = 16 μm
- σ_y = 16 μm
- σ_z = 76 μm

Impact parameter resolution:

- 20 μm for high-pT tracks

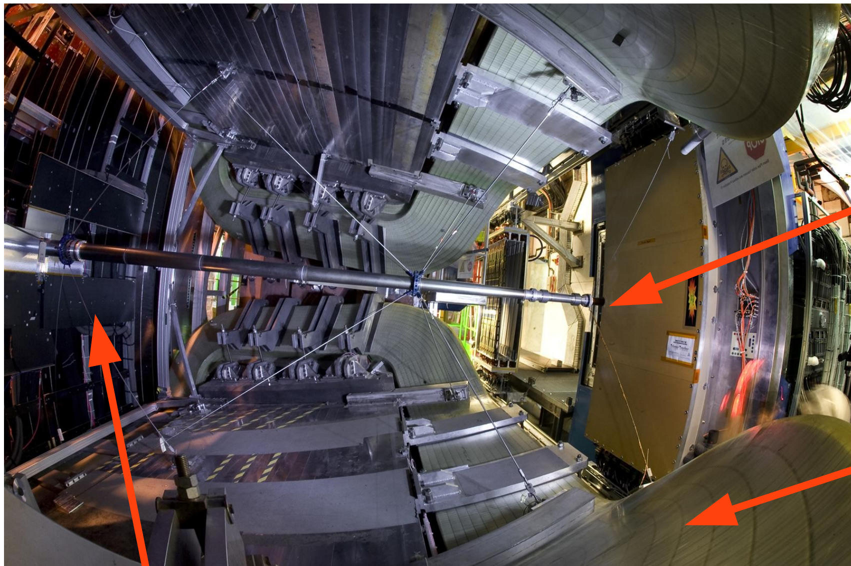
Decay time resolution: 45 fs





[LHCb-CONF-2012-002]

Tracking system



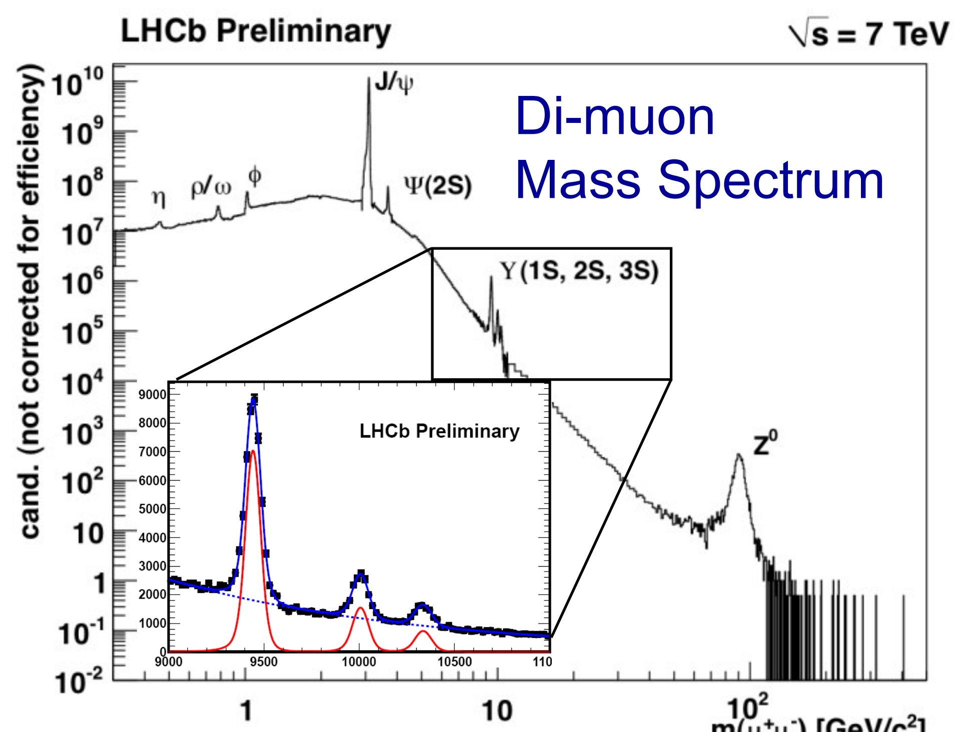
Trigger tracker(TT):
Before magnet
Reconstruction of the low-momentum particles
Reconstruction of the long-lived neutral particles
4 planes of 500 µm silicon sensors

Dipole magnet:
Bending power 4 Tm
Length 5m

T1-T3
Inner tracker:
Silicon microstrip detector
Outer tracker:
Straw tubes

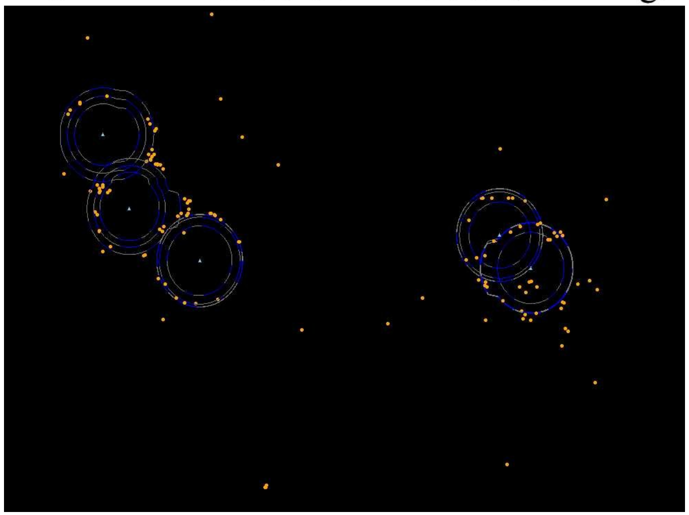
Track reconstruction efficiency:
> 96% for long tracks

Momentum resolution:
$\Delta p/p$ = 0.4% at 5 GeV/c
0.6% at 100 GeV/c



RICH detectors

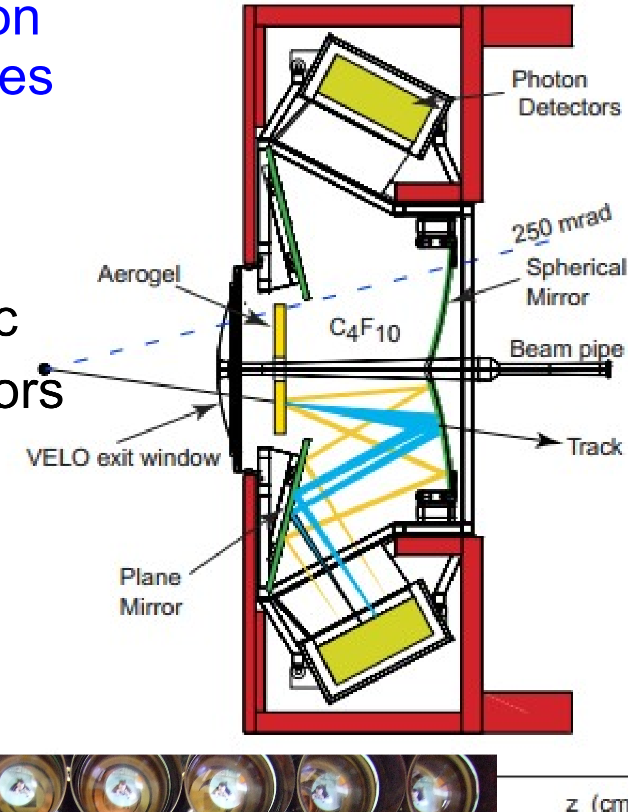
RICH2 HPD Panels with Pixels and CK Rings



Charged hadrons identification
Separation of p/K/π candidates

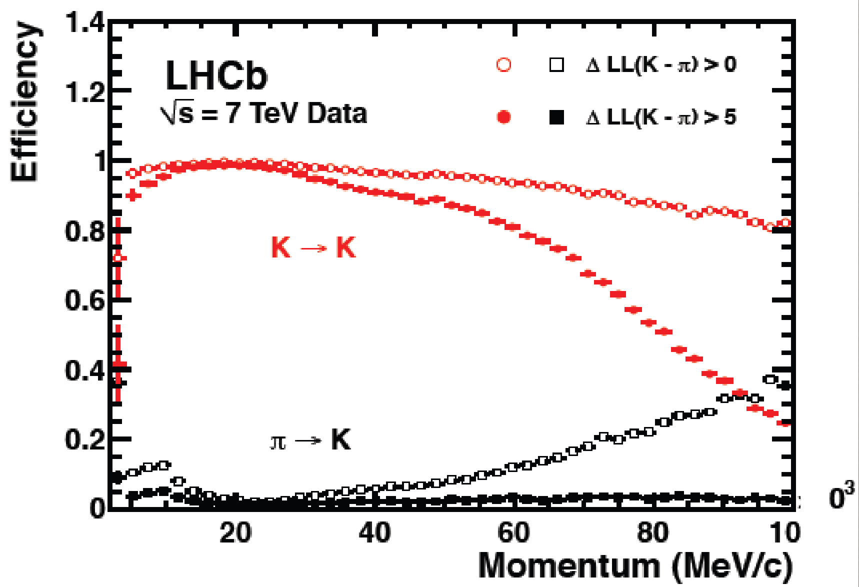
RICH1:
- before magnet
- 2 GeV/c < p_T^h < 60 GeV/c
- C_4F_{10} and aerogel radiators

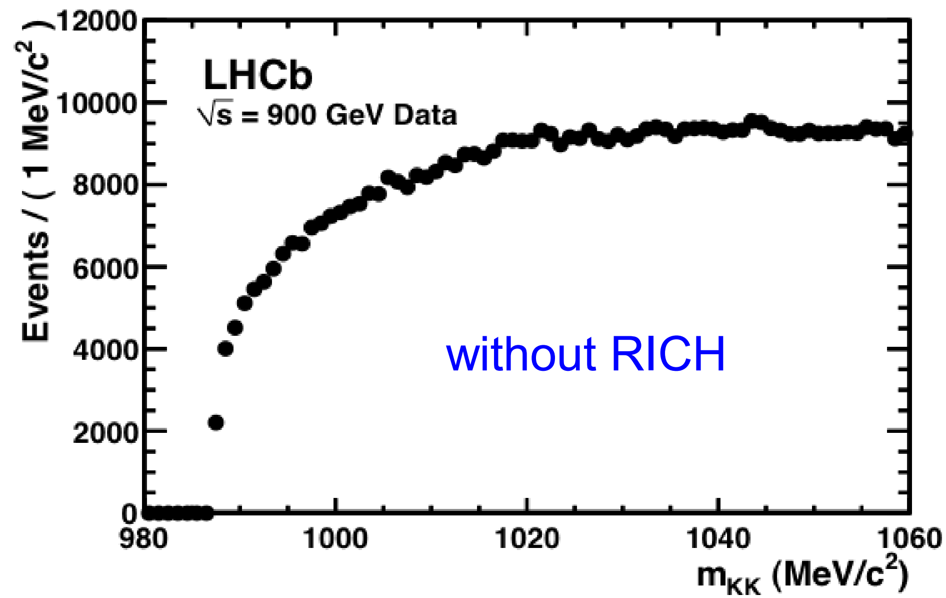
RICH2:
- after magnet
- p_T^h up to 100 GeV/c
- CF_4 radiator



Photodetectors:
hybrid photodiodes (HPD's) with pixel readout

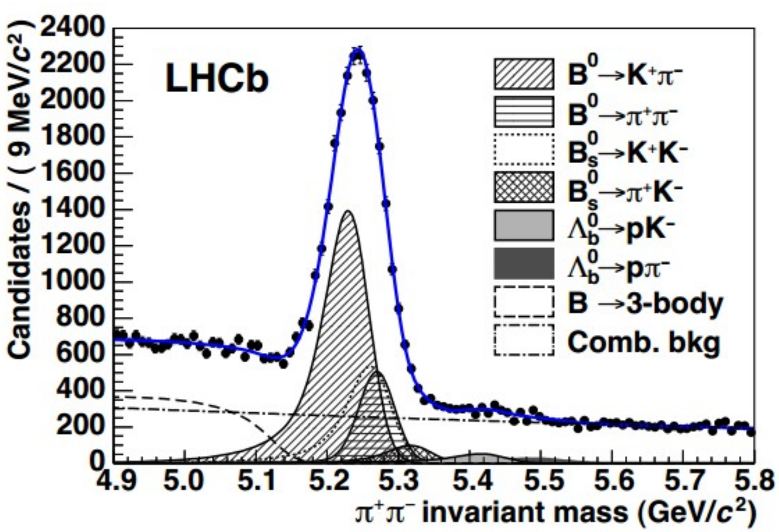
Charged hadrons identification

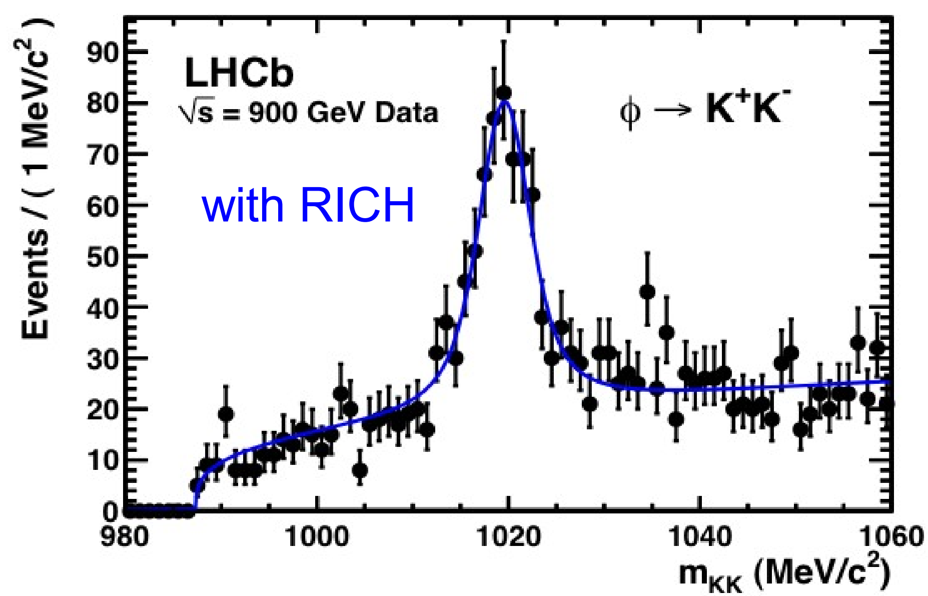




Kaon-pion separation efficiency:

~95% for ~5 % π→K mis-id probability

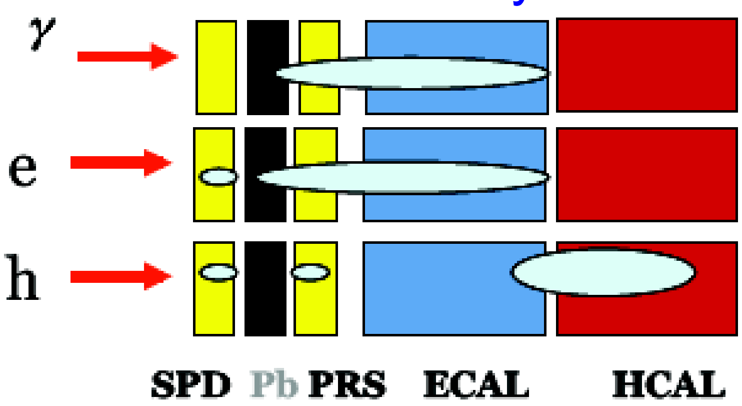


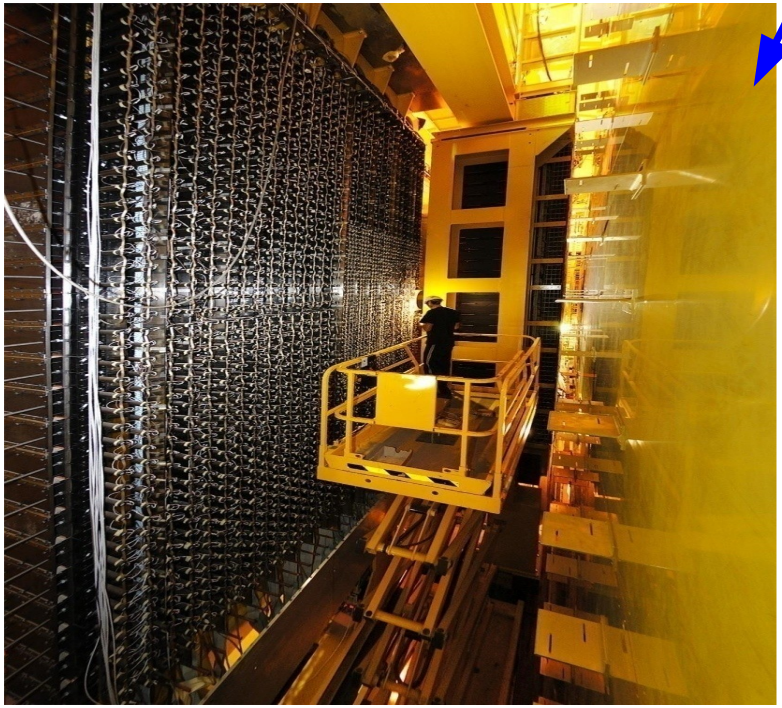


[JHEP10(2012)037]

Calorimeter system

PID with Calo system





Scitillating Pad Detector and Preshower detector

~6000 plastic scintillator pads 15 mm thick interlayed with 2.5 X_0 lead converter;

Electromagnetic calorimeter (ECAL)

Shashlik sampling technology

Alternating scintillator (4 mm)/lead (2mm) tiles

42mm thick = $25X_0$

Hadron calorimeter (HCAL)

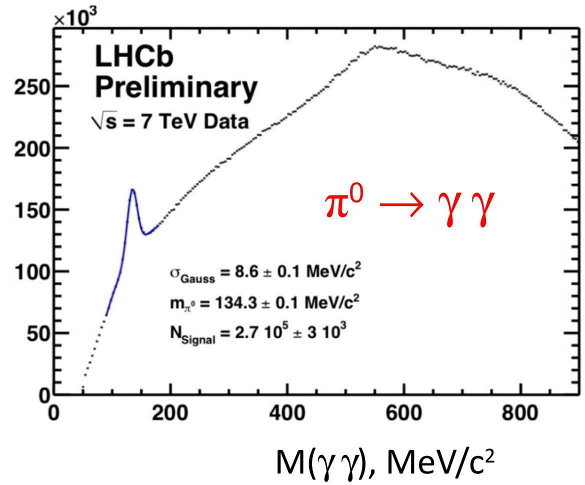
Iron plates interspaced with scintillating tiles

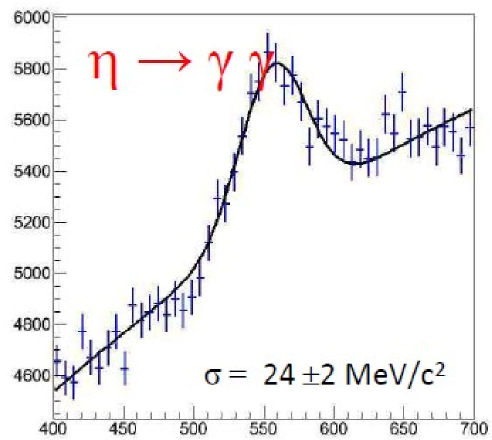
5.6 λ_I thick

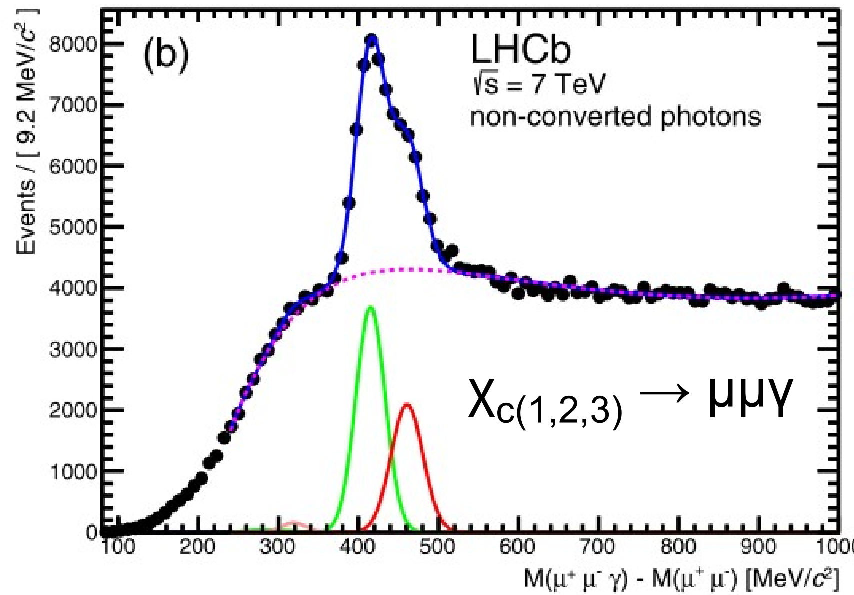
Calorimeters performance

Electron ID efficiency:

~90% for ~5% e→h mis-id probability

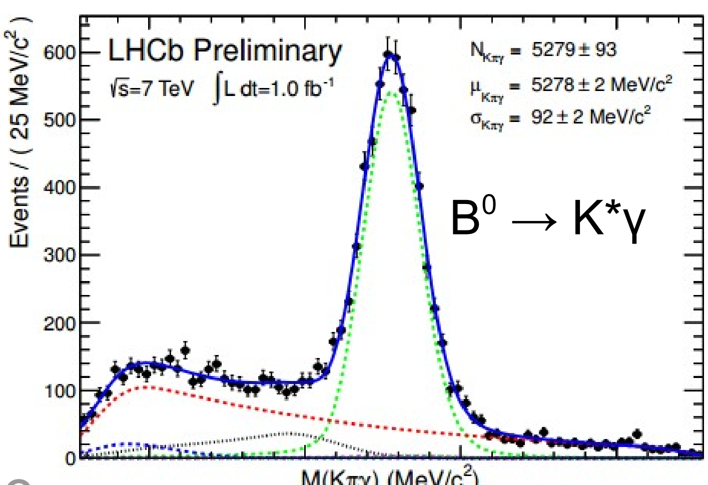


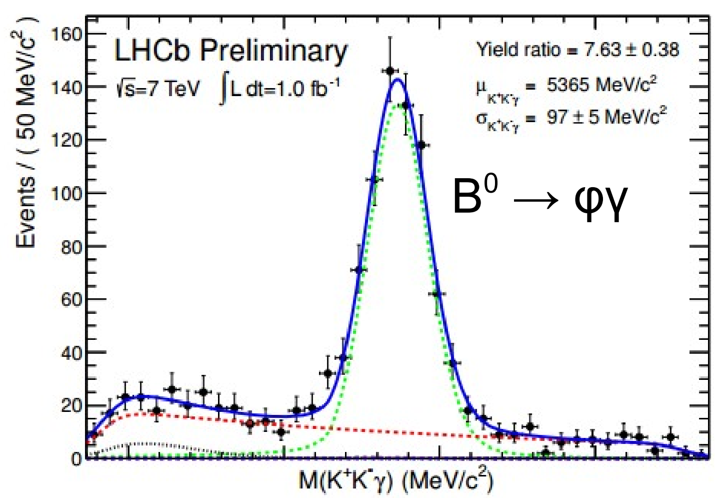




[Physics Letters B 714 (2012) 215–223]

Radiative B-decays on hadron machine! Mass resolution ~90 MeV





ECAL resolution:

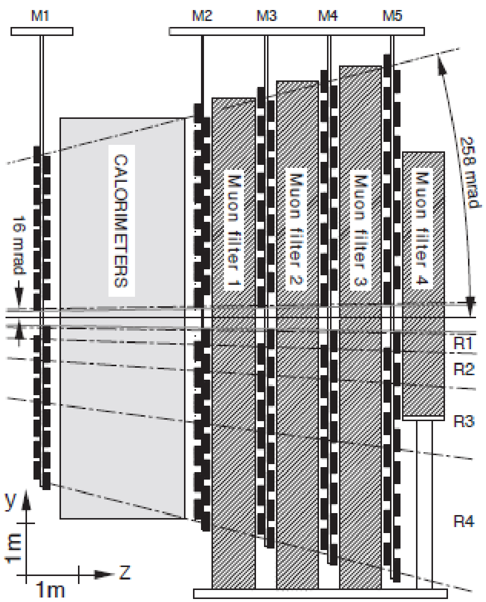
$\sigma(E)/E = 1\% \oplus 10\%/\sqrt{(E)}$

HCAL resolution:

$\sigma(E)/E = 10\% \oplus 80\%/\sqrt{E}$

Energy in GeV

Muon system



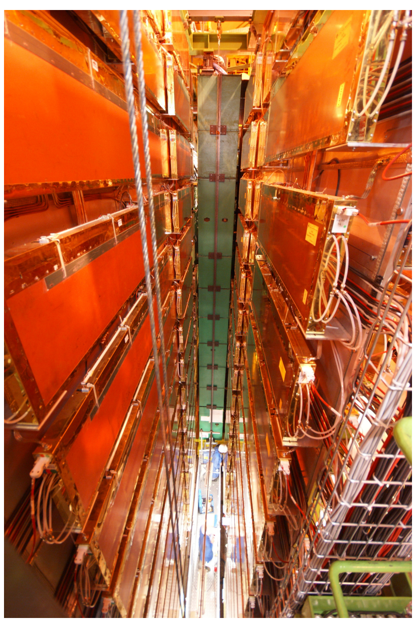
Muon reconstruction, identification and measurement of their momenta

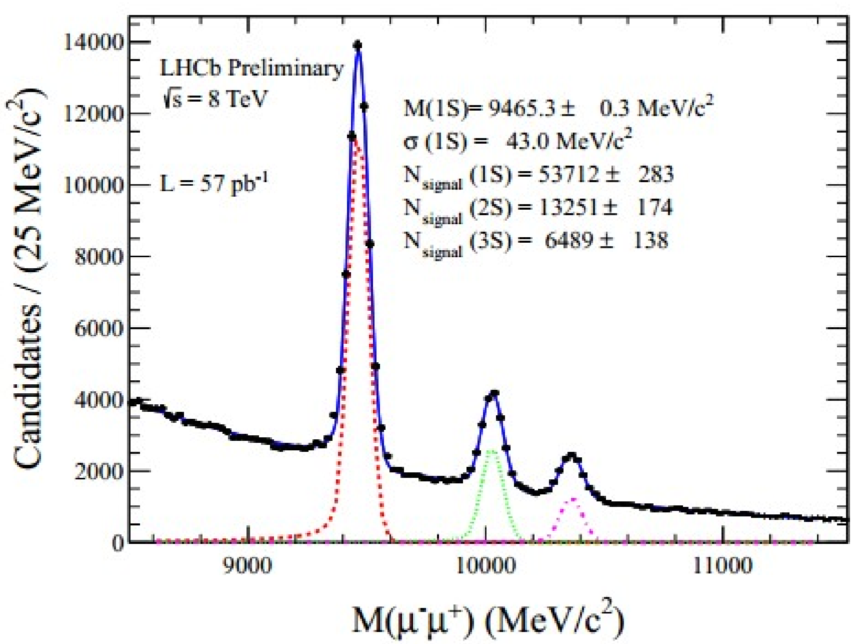
5 stations of multi-wire proportional chambers and GEM detectors interlayed with muon filter

Muon filter

between M1 and M2: calorimeter system

between M2, M3, M4 and M5: 80cm iron plates ($20\lambda_I$)



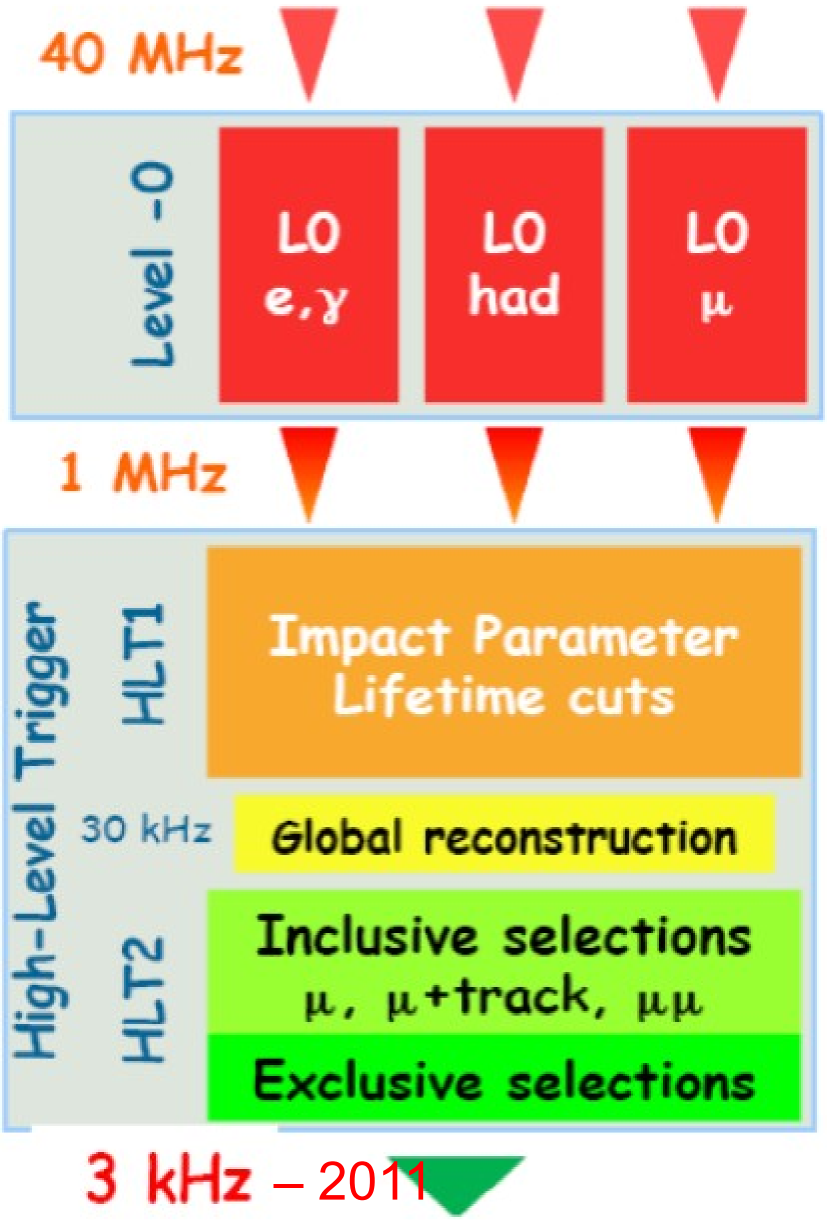


Muon ID efficiency:

~97% for 1-3% $\pi \rightarrow \mu$ mis-id probability

Momentum resolution: ~20%

LHCb trigger



3 kHz – 2011

4.5 kHz – 2012 (increased number of CPUs)

Level-0 (hardware):
Calorimeter system, muon system
High transverse momentum candidates

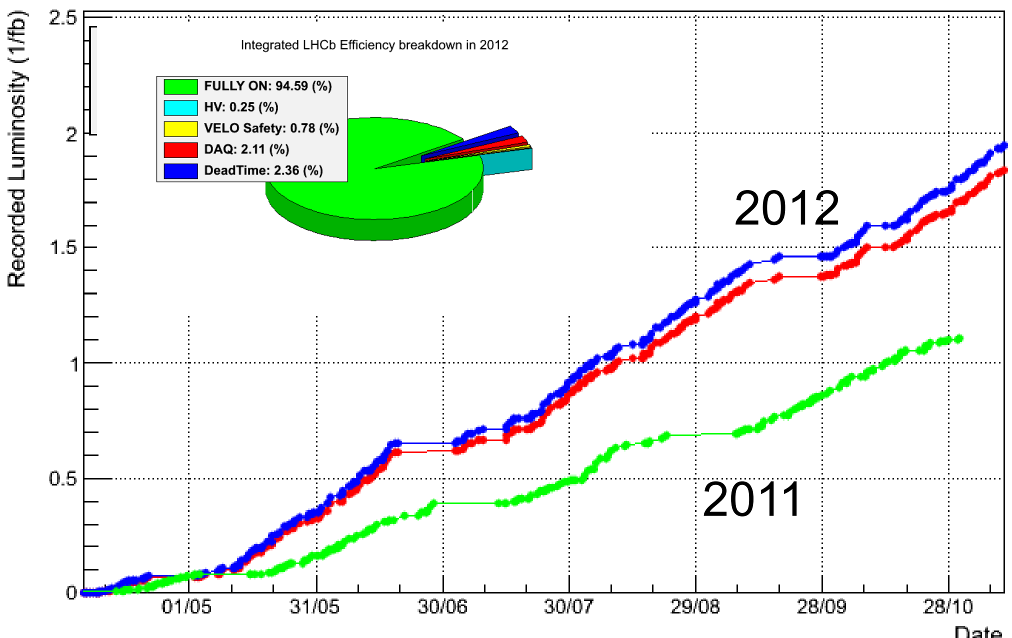
High level trigger (software):
HLT1
High-momentum tracks, impact parameters

HLT2
(Almost) fully reconstructed events
Exclusive and inclusive selections

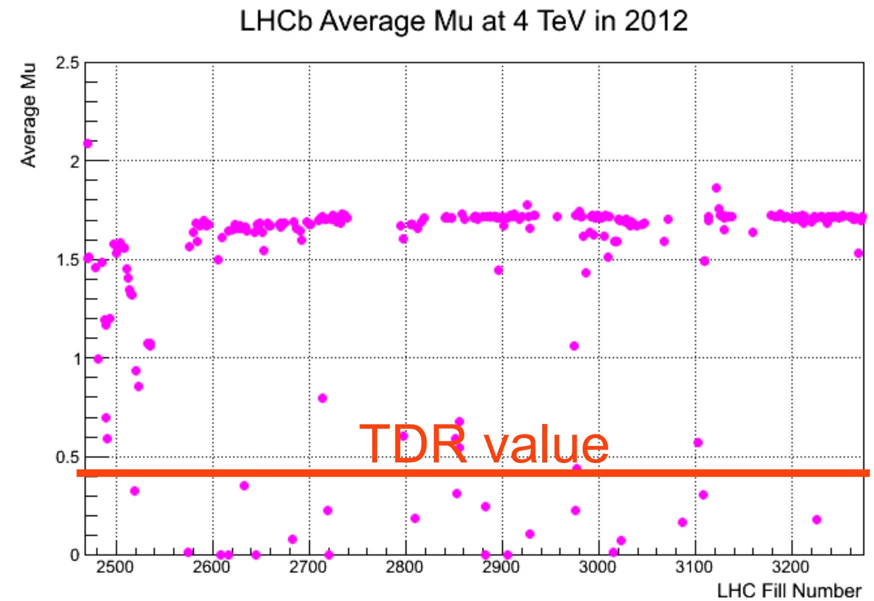
Trigger efficiencies:
- ~90% for dimuon channels
- ~30% for multi-body hadronic final states
- ~10% for charm decays

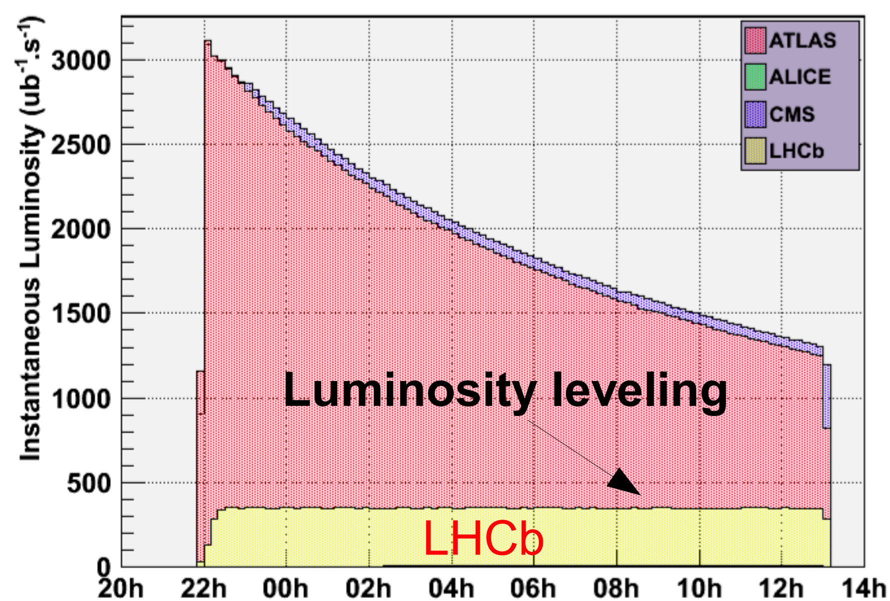
Operation

Luminosity: 4×10^{32} cm^{-2} s^{-1}
Bunch-crossing frequency: 20 MHz



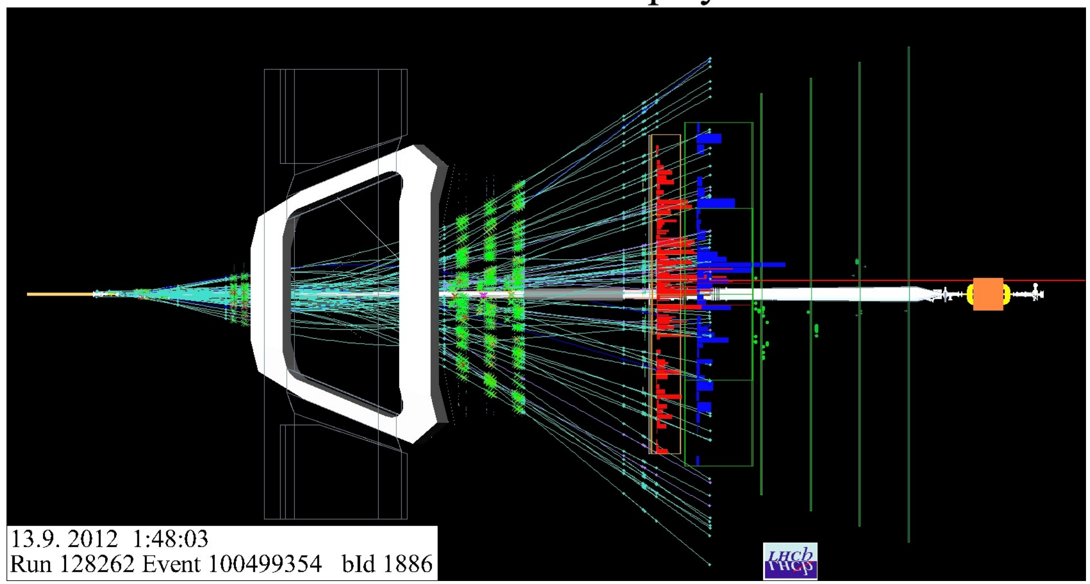
Year	Energy	Integrated lumi
2010	7 TeV	37 pb^{-1}
2011	2.76 TeV	71 pb^{-1}
2011	7 TeV	1.0 fb^{-1}
2012 (current)	8 TeV	~2.0 fb^{-1}
2012 (goal)	8 TeV	2.2 fb^{-1}





First experience with ions

LHCb Event Display



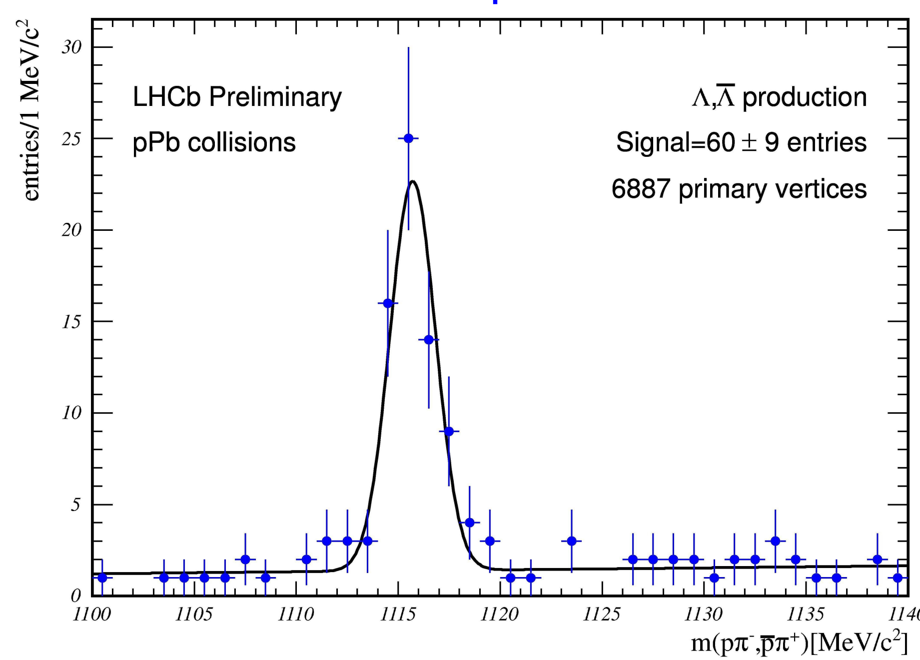
September runs with pA collisions

- Stable conditions
- Multiplicities in detector are comparable with pp collisions
- Various resonances reconstructed offline

LHCb will take data in pA runs planned

- Luminosity ~10^{26} $cm^{-2}s^{-1}$
- Production and polarization studies
  - V0, quarkonia, b-quarks etc.

Lambda production



Highlights of recent physics results

Physics topics

Beautiful...

Rare Decays

Leptonic, electroweak, radiative decays

Lepton flavour and number violating decays

See talk by Olga Kochebina

B decays to Charmonia

Lifetimes, φ_s, $\Delta\Gamma_s$ of B-mesons

Amplitude analyses

See talk by Ivan Polyakov

B decays to Open Charm

Charmless B decays

Semileptonic B decays

QCD, Electroweak and Exotica

t-quark,W, Z production and asymmetries

Search for the exotic particles

B hadrons and Quarkonia

Quarkonia production and properties

Potentially exotic quarkonia (X, Y, Z)

Production and spectroscopy of b-hadrons

See talks by Yiming Li

and Alexander Artamonov

Charm Physics

Mixing, CP-violation, rare decays of charm

Charm production and spectroscopy

and charming!

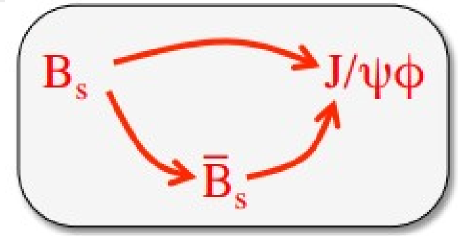
Mixing-induced CP-violation

Standard Model prediction:

$\varphi_s = -2\arg(-V_{ts}V_{tb}^*/V_{cs}V_{cb}^*) = -0.036 \pm 0.002$

[J. Charles et al. PRD 84 (2011) 033005]

New physics may induce large deviations



„Golden mode" $B_s \to J/\psi\varphi$

In many items is like „golden mode" of B^0 mixing $B^0 \to J/\psi K^*$

But:

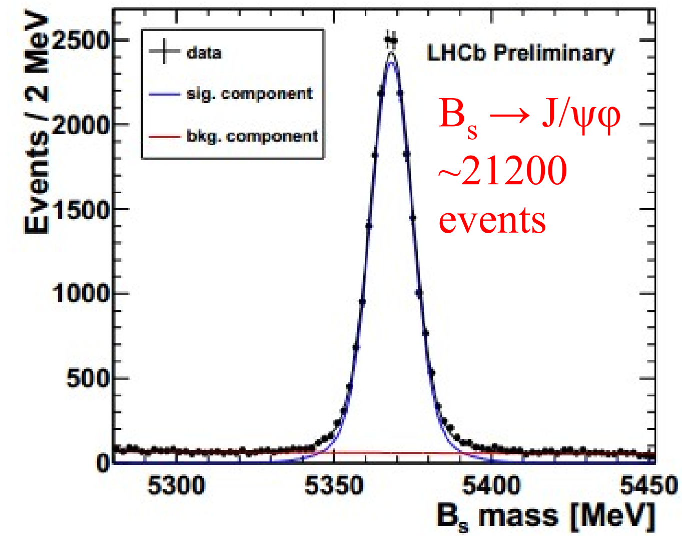
B_s oscillations are much faster

→ needs excellent proper time resolution

$\Delta\Gamma_s = \Gamma_L - \Gamma_H$ is to be measured as well

Not a CP-eigenstate

→ angular analysis is needed

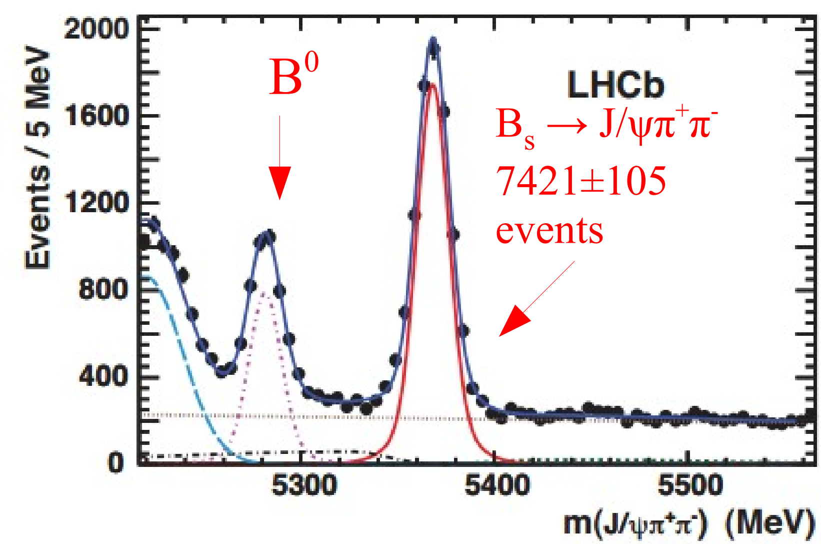


$B_s \to J/\psi\pi^+\pi^-$

Less statistics

Purely CP-odd eigenstate

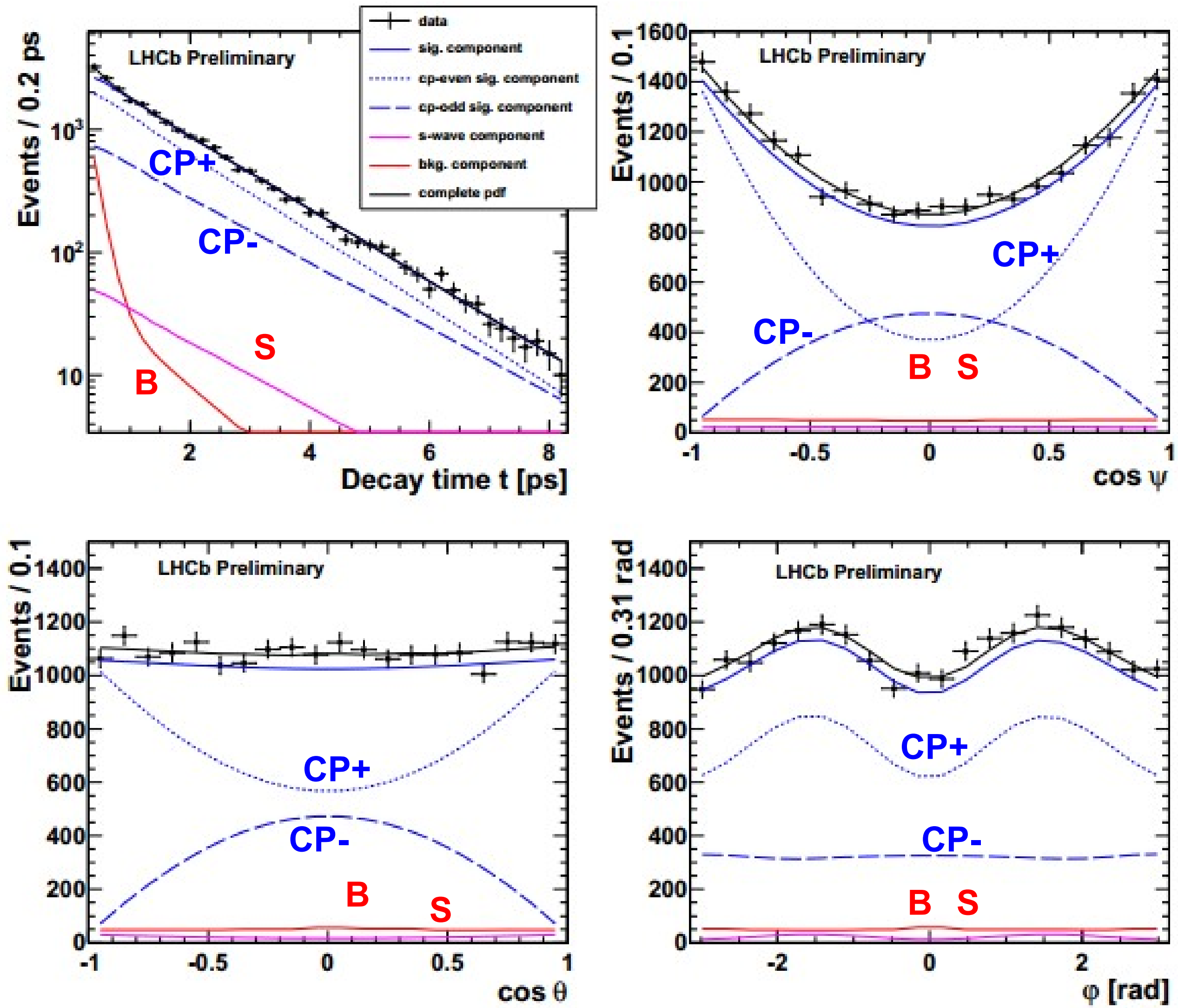
→ no angular analysis needed



φ_s in $B_s \to J/\psi\varphi$

CP+: CP-even $B_s \to J/\psi\varphi$ signal
CP-: CP-odd $B_s \to J/\psi\varphi$ signal
S: Non-resonant $B_s \to J/\psi KK$
with $J_{KK}=0$ (CP-odd)
B: background

[LHCb-CONF-2012-002]



First >5σ observation of $\Delta\Gamma_s \neq 0$!

But: Two-fold intrinsic ambiguity

$$(\phi_s, \Delta\Gamma_s, \delta_{//}, \delta_\perp, \delta_S) \Leftrightarrow (\pi - \phi_s, -\Delta\Gamma_s, -\delta_{//}, \pi - \delta_\perp, -\delta_S) \qquad \delta_{S\perp} \Leftrightarrow -\pi - \delta_{S\perp}$$

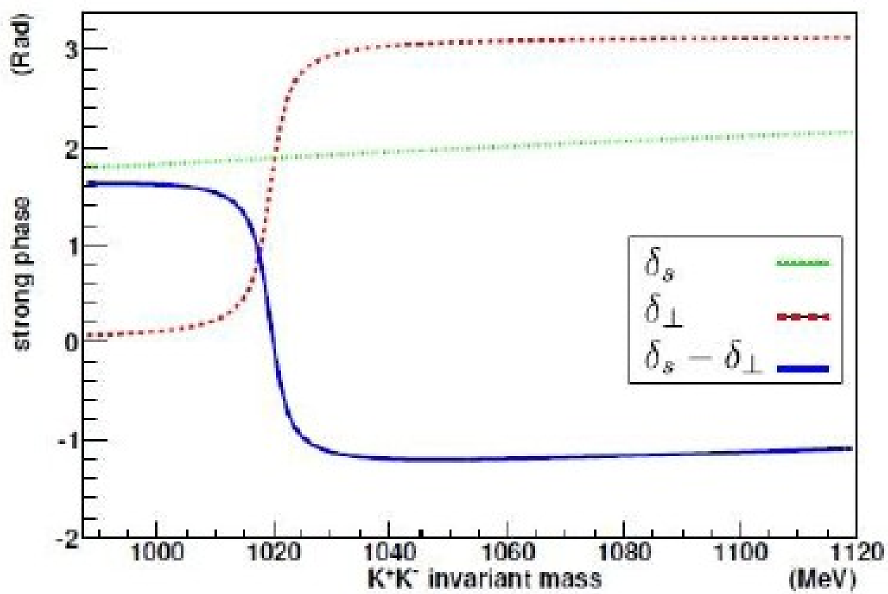
ΔΓ sign

Use wider mass window for φ → KK

988 MeV/c^2 < M(K^+K^-) < 1050 MeV/c^2

Study in 4 bins of KK mass

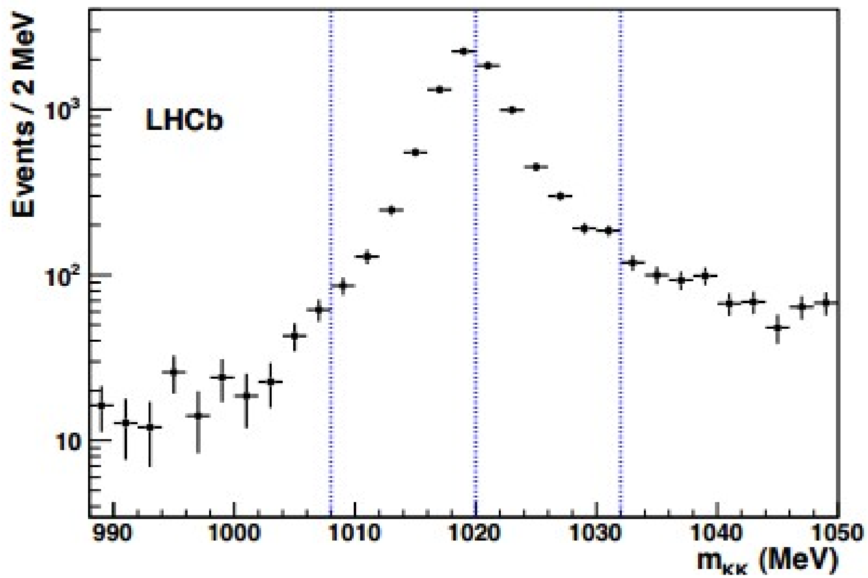
Expected:



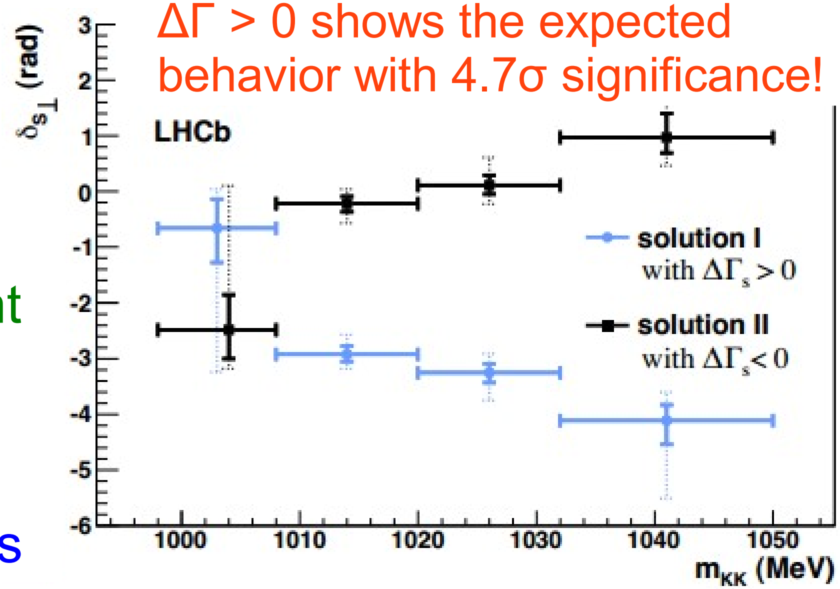
S wave strong phase (f0(980) and non-resonant contributions) grows slowly

P wave strong phase (φ contribution) grows rapidly

Difference between S-wave and P-wave phases rapidly falling



ΔΓ > 0 shows the expected behavior with 4.7σ significance!



[Phys. Rev. Lett. 108, 241801 (2012)]

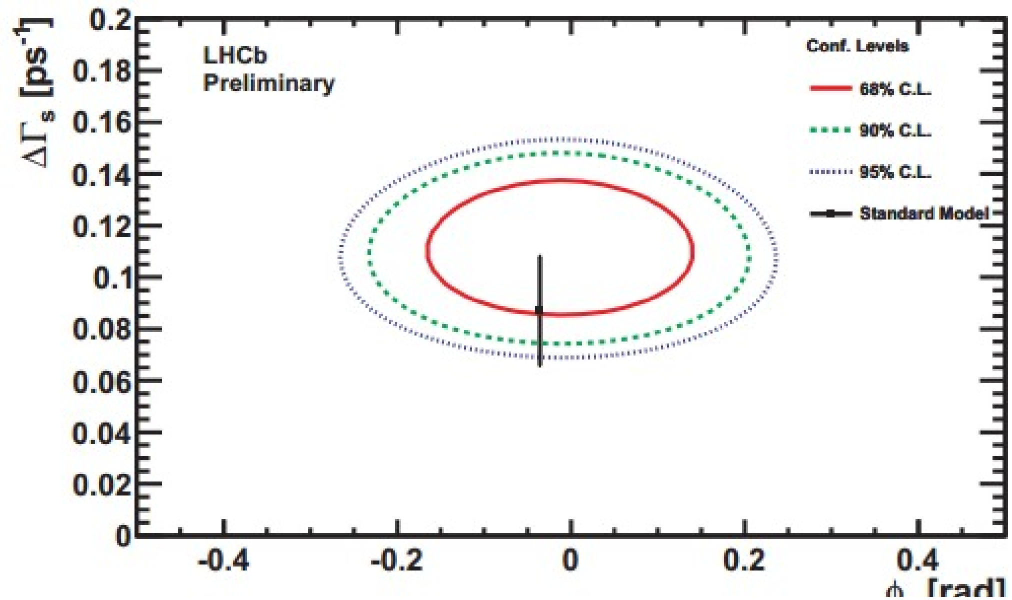
[JHEP 0909:074, 2009]

φ_s in $B_s \rightarrow J/\psi\varphi$

Total fit

Parameter	Value	Stat.	Syst.
Γ_s [ps^{-1}]	0.6580	0.0054	0.0066
$\Delta\Gamma_s$ [ps^{-1}]	0.116	0.018	0.006
$\lvert A_\perp(0)\rvert^2$	0.246	0.010	0.013
$\lvert A_0(0)\rvert^2$	0.523	0.007	0.024
F_S	0.022	0.012	0.007
$\delta_\perp$ [rad]	2.90	0.36	0.07
$\delta_\parallel$ [rad]	[2.81, 3.47]		0.13
δ_s [rad]	2.90	0.36	0.08
ϕ_s [rad]	-0.001	0.101	0.027

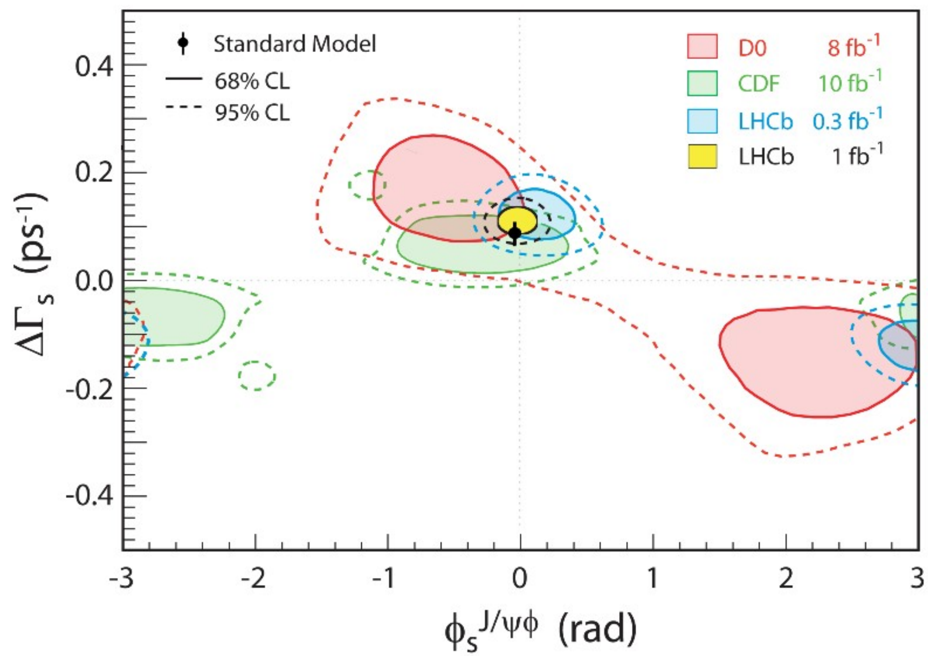
[LHCb-CONF-2012-002]



Ambiguity is solved

Word best measurements of φ_s and $\Delta\Gamma_s$ with only 1fb^{-1} of data

Both $\Delta\Gamma$ and φ_s show no deviation from the Standard Model

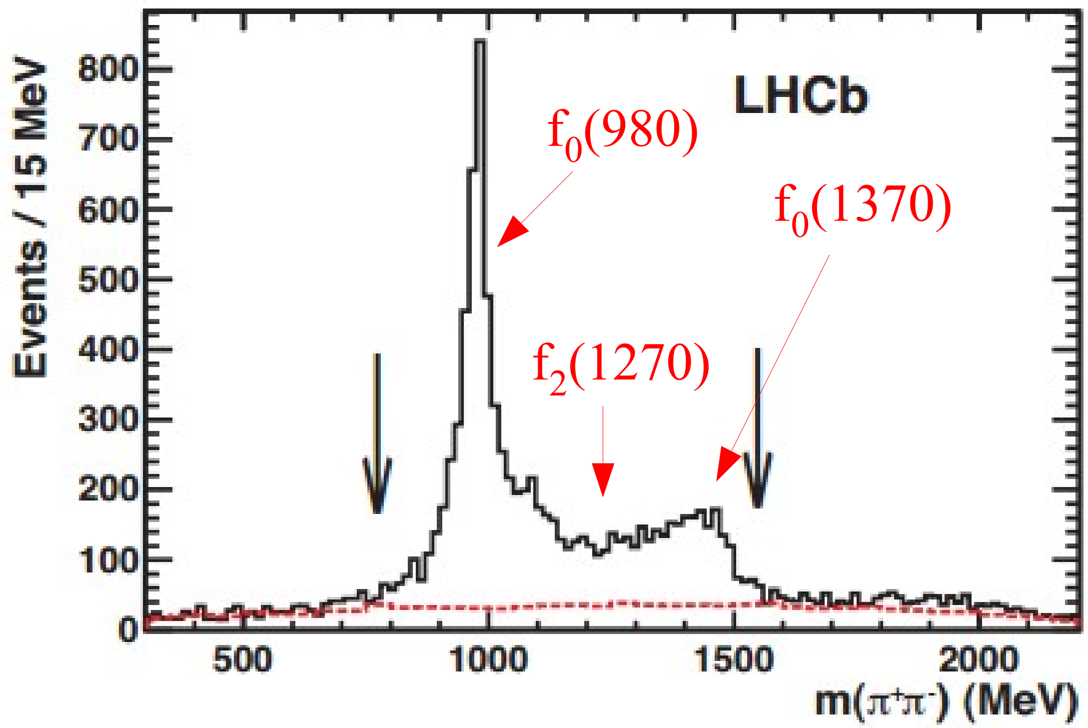


φ_s in $B_s \rightarrow J/\psi\pi^+\pi^-$

Dipion mass region:
775 MeV/c^2 < $M(\pi^+\pi^-)$ < 1550 MeV/c^2

Angular analysis proves it to be purely CP-odd system

[Phys. Rev. D 86, 052006 (2012)]



Measured value for mixing phase:

$\varphi_s = -0.02 \pm 0.17 \pm 0.02$

[Physics Letters B 713 (2012), 378-386]

Combined result from $B_s \rightarrow J/\psi\varphi$ and $B_s \rightarrow J/\psi\pi^+\pi^-$

$\boxed{\varphi_s = -0.002 \pm 0.083 \pm 0.027 \text{ (preliminary)}}$

In perfect agreement and with the Standard Model!

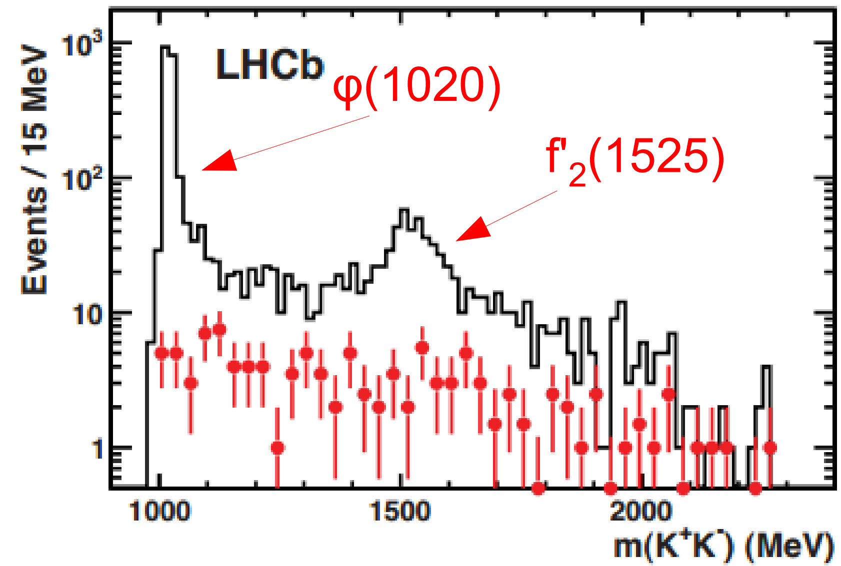
More channels for φ_s measurement

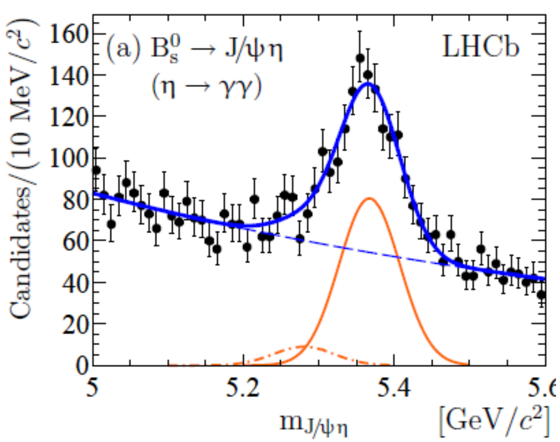
$B_s \rightarrow J/\psi K^+K^-$

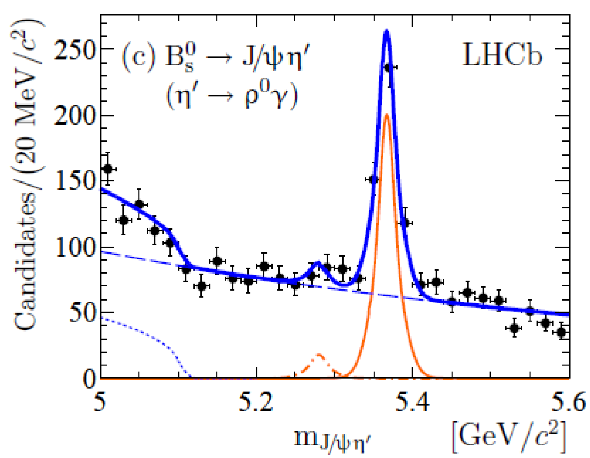
$B_s \rightarrow J/\psi f'_2(1525)$ – First observation!

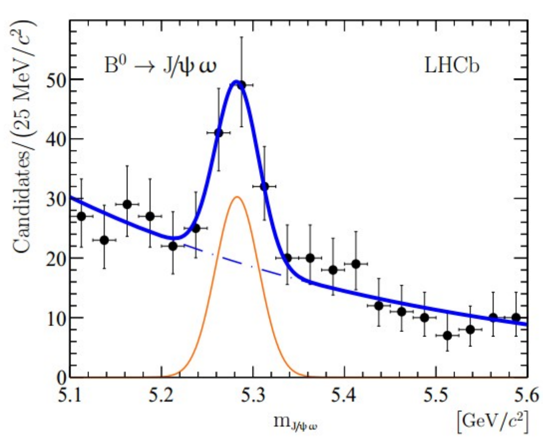
Non-resonant

[Phys Rev Lett, 108, 151801 (2012)]









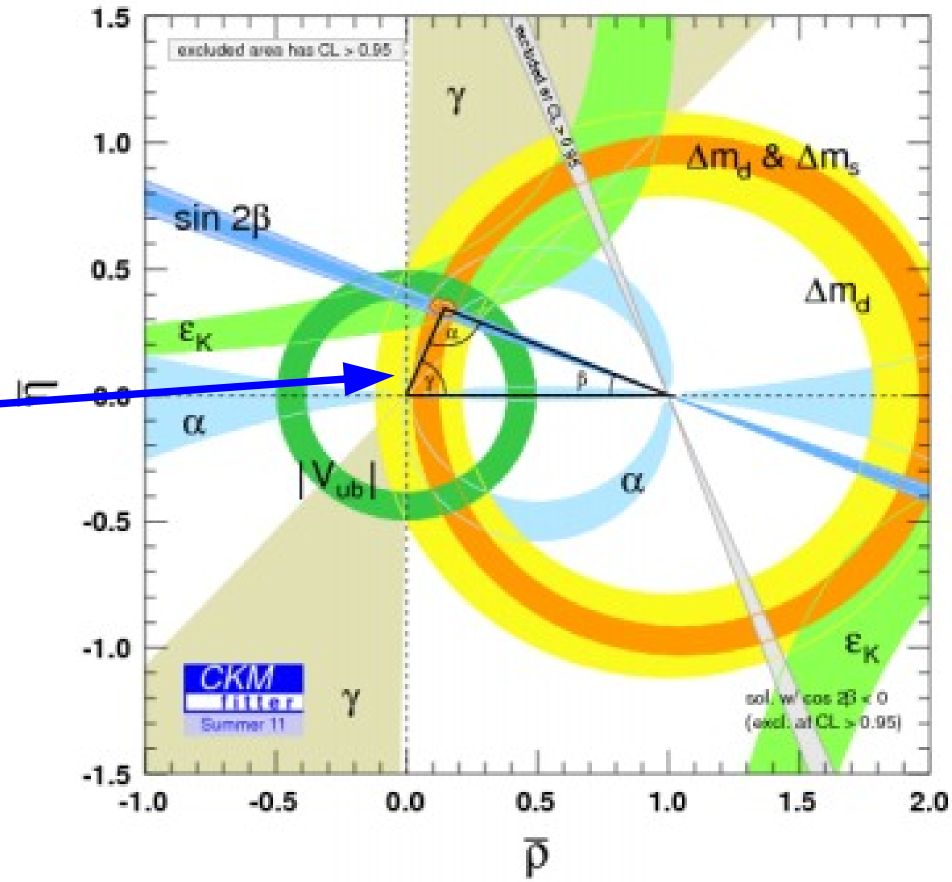
$B_s \rightarrow J/\psi\eta^{(\prime)}$

Purely CP-odd final state

$B_s \rightarrow J/\psi\omega$ – First evidence!

[arXiv:1210.2631]

Measurement of the γ angle



What is the γ angle?

Standard Model expects

$$V_{ud}V_{ub}^{*} + V_{cd}V_{cb}^{*} + V_{td}V_{tb}^{*} = 0$$

$\gamma = \arg(V_{ud}V_{ub}^{*}/V_{cd}V_{cb}^{*})$

Current uncertainties are ~10-12°

Though the theoretical prediction is quite precise

Measurement of the γ angle

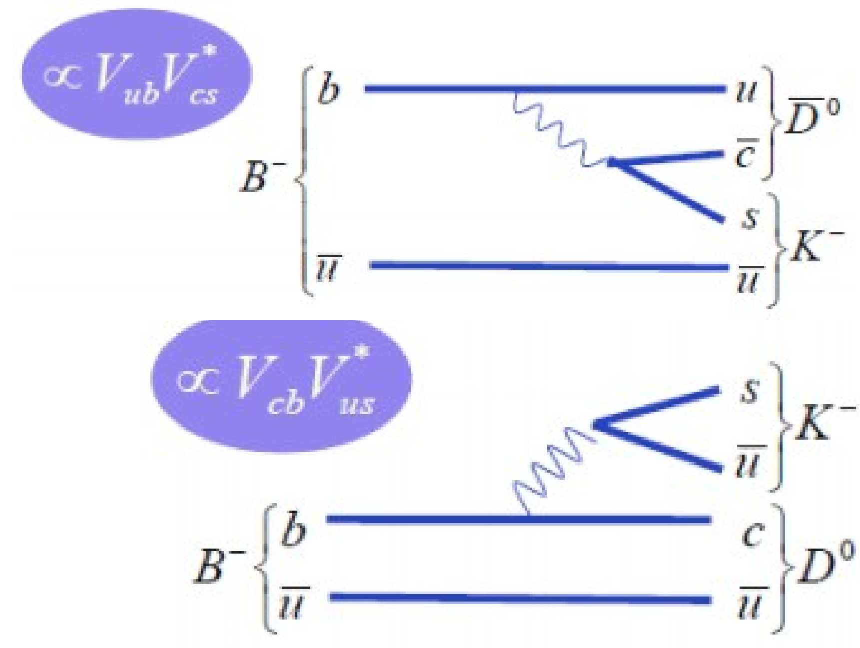
The cleanest method

$B^{\pm} \to DK^{\pm}$ (very sensitive!)

$B^{\pm} \to D\pi^{\pm}$ (less sensitive)

($D = D^0$ or $\overline{D}{}^0$)

[Phys. Lett. B265 (1991) 172]



D decay mode is accessible both for D^0 and $\overline{D}{}^0$

LHCb is making use of several D decay modes:

Gronau-London-Wyler (GLW): $D \to \pi^+\pi^-$ and $D \to K^+K^-$

[Phys. Lett. B265 (1991) 172]

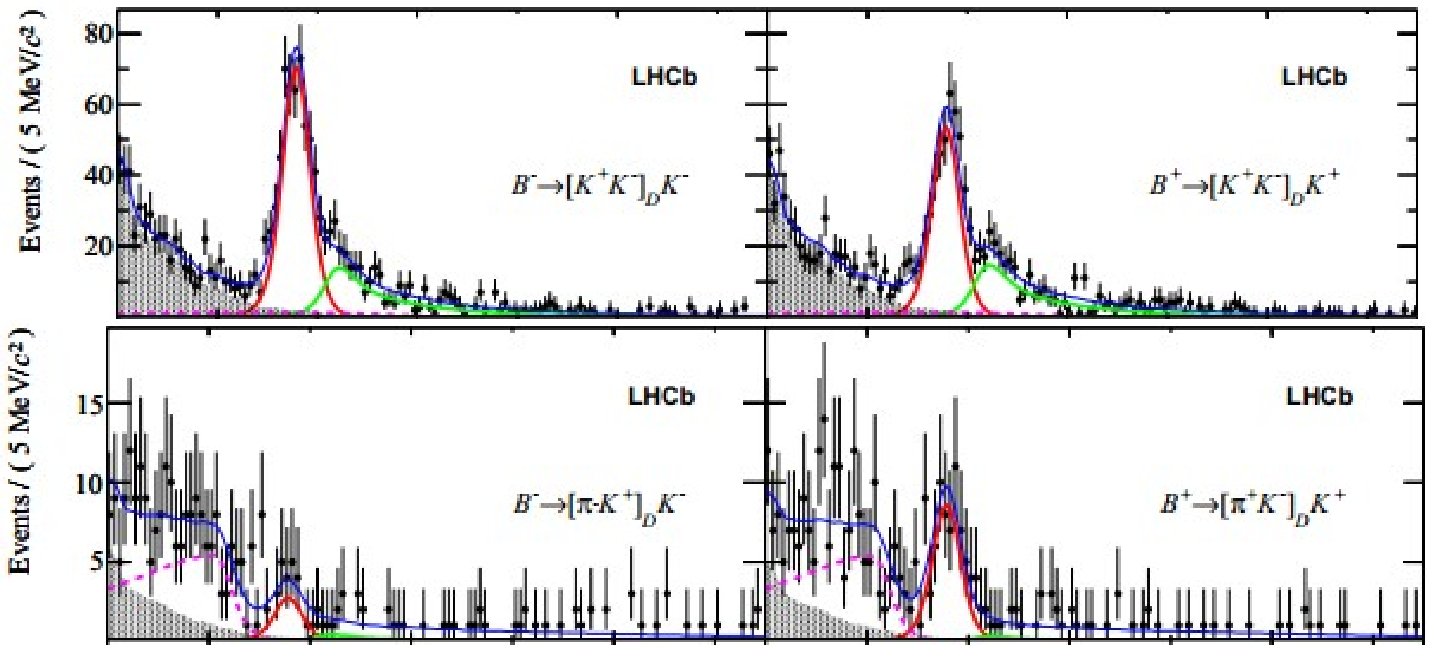
Atwood-Dunietz-Soni (ADS): $D \to \pi^{\pm}K^{\pm}$ and $D \to \pi^{\pm}K^{\pm}\pi^+\pi^-$ - Large interference!

[Phys. Rev. Lett. 78 (1997) 3257]

Giri-Grossman-Soer-Zupan (GGSZ): $D \to K^0_s h^+h^-$ ($h = \pi$, K)

[Phys. Rev. D68 (2003) 054018]

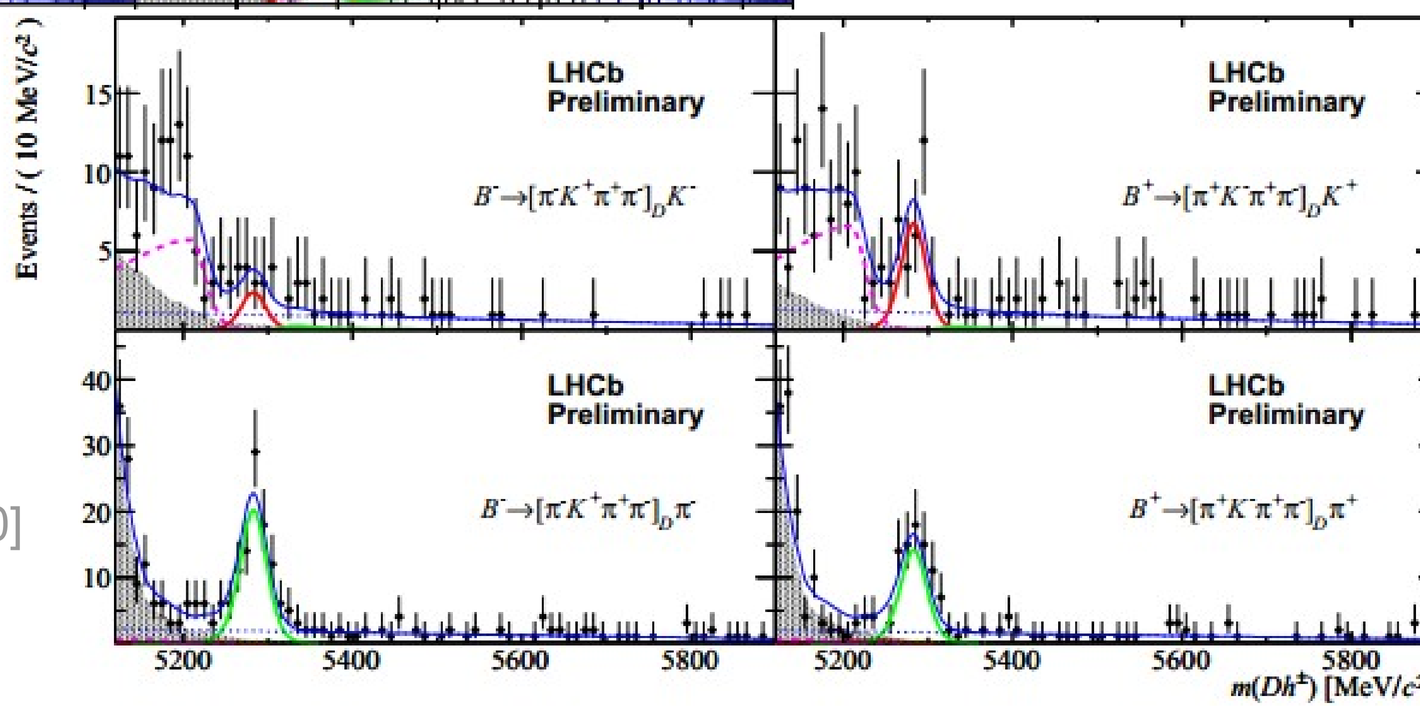
Preceding LHCb measurements



First observation of the direct CP-asymmetry in the B → DK$^\pm$ decays in a single analysis (5.8σ)

First observation of the suppressed B → $[\pi^\pm K]_D K^\pm$

[PLB 712 (2012) 203]



First observation of the suppressed ADS
B → DK$^\pm$ and
B → Dπ$^\pm$ modes
with D → $\pi^\pm K^\pm \pi^+ \pi^-$

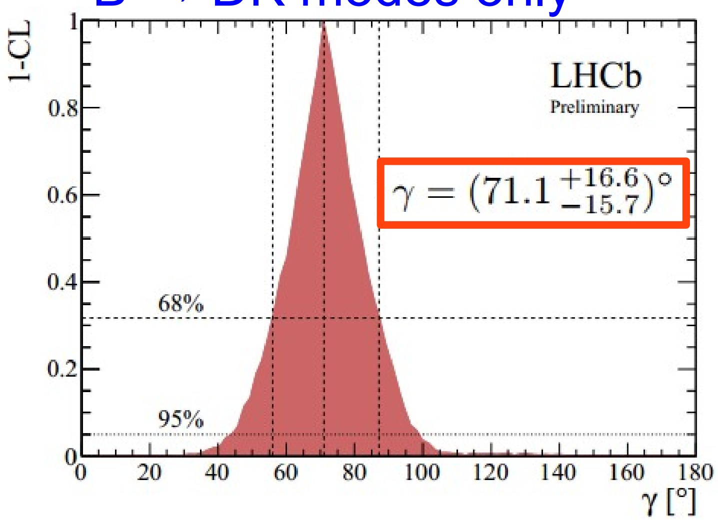
[LHCb-CONF-2012-30]

Combined result for γ angle

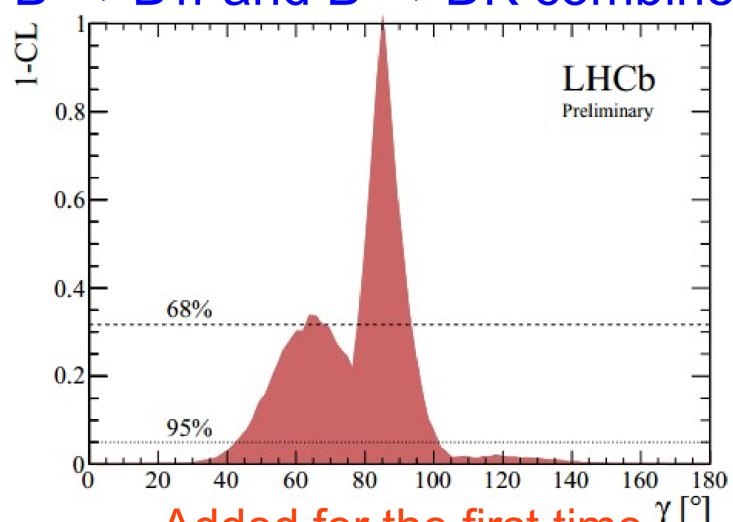
With $1fb^{-1}$ of data

$B^\pm \to DK^\pm$	GLW&ADS	PLB 712 (2012) 203
$B^\pm \to D\pi^\pm$	GLW&ADS	
$B^\pm \to DK^\pm$	GGSZ	PLB 718 (2012) 43-55
$B^\pm \to D\pi^\pm$	GGSZ	
$B^\pm \to DK^\pm$	ADS	LHCb-CONF-2012-30
$B^\pm \to D\pi^\pm$	ADS	

$B \to DK$ modes only



$B \to D\pi$ and $B \to DK$ combined



Added for the first time

[LHCb-CONF-2012-032]

$$\gamma \in [61.8, 67.8]^\circ \quad \text{or} \quad [77.9, 92.4]^\circ \quad @\,68\%\ \text{CL}$$
$$\gamma \in [43.8, 101.5]^\circ \quad @\,95\%\ \text{CL}$$

Preliminary

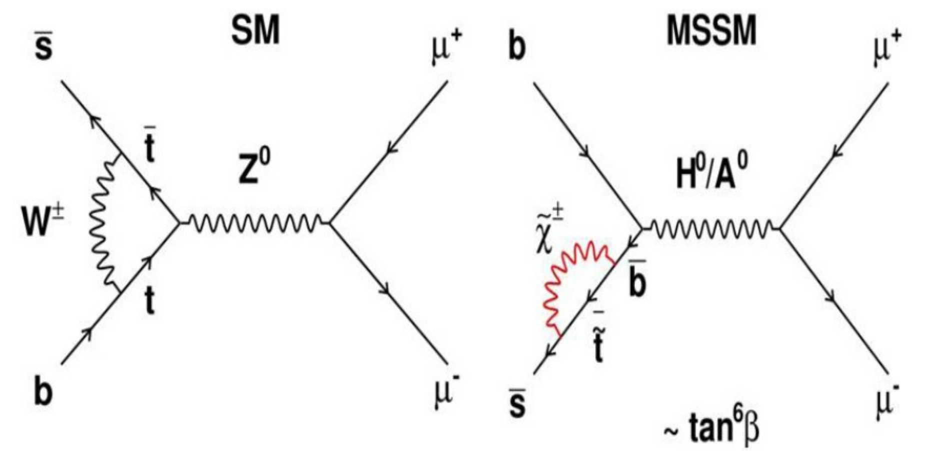
$B_{(s)} \to \mu^+\mu^-$

Theoretical branching ratio predictions:

$B(B_s \to \mu\mu) = (3.2 \pm 0.2) \times 10^{-9}$

$B(B^0 \to \mu\mu) = (0.10 \pm 0.01) \times 10^{-9}$

[arXiv:1007.5291]



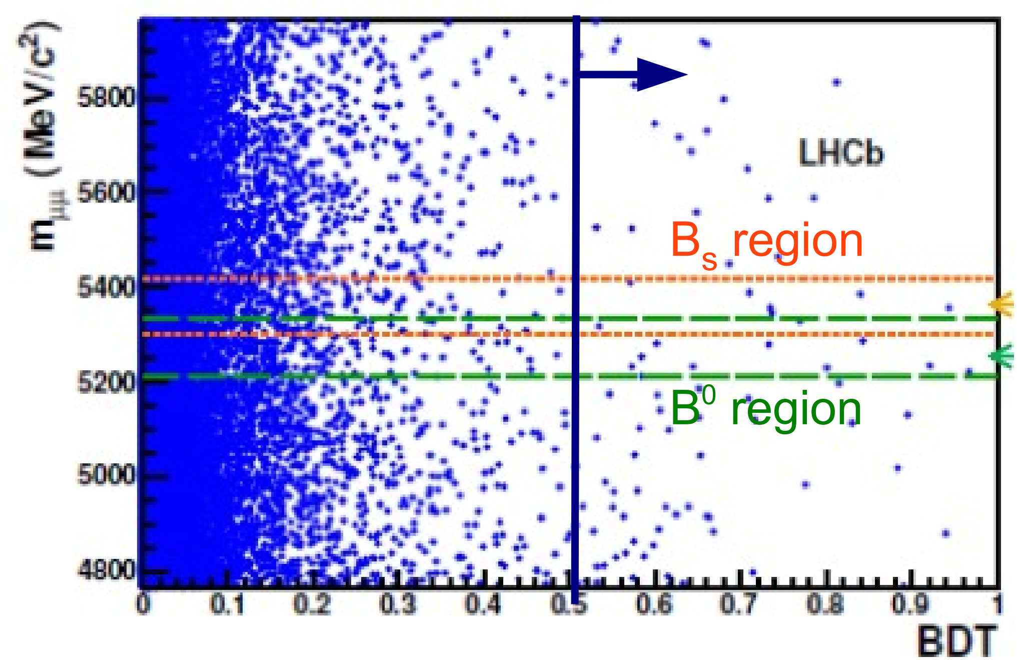
Theoretical uncertainties are very small

Sensitive to the models with extended Higgs and high tanβ

2-dimensional analysis with blinded signal mass region

- Boosted decision tree based on topological variables
- dimuon invariant mass

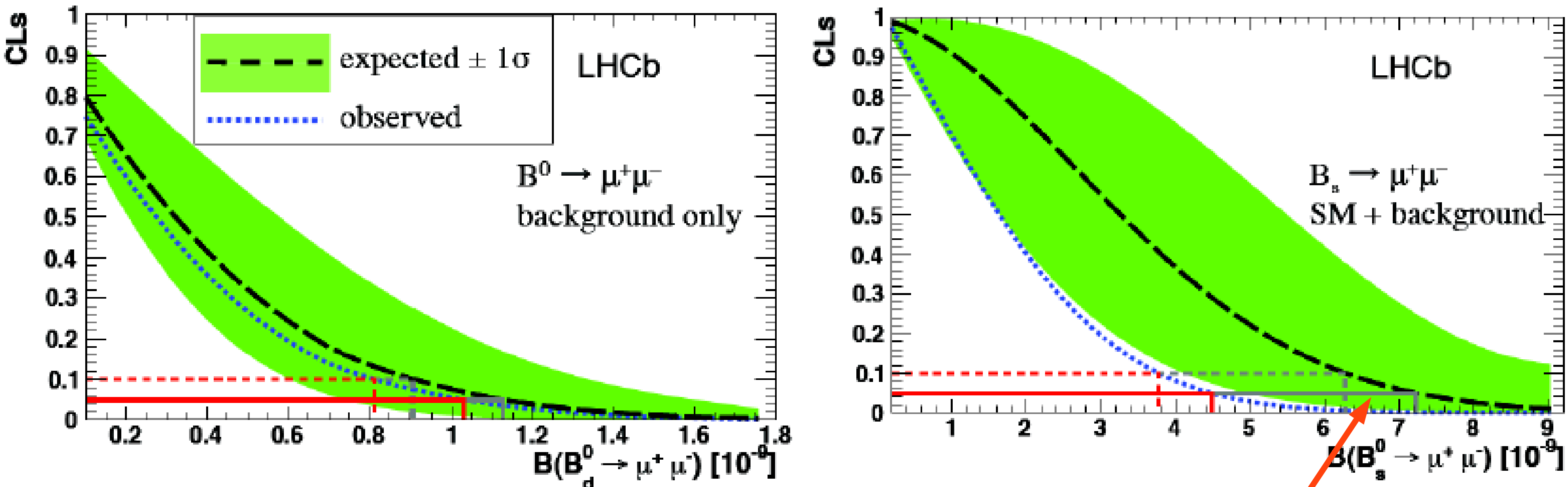
For the details see talk by Olga Kochebina



[Phys. Rev. Lett. 108 (2012) 231801]

$B_{(s)} \rightarrow \mu^{+}\mu^{-}$

2011 data ($1\,fb^{-1}$), tightest upper limits were set up



$BR(B \rightarrow \mu\mu) < 1.03 \times 10^{-9}$ @ 95%CL

$BR(B_s \rightarrow \mu\mu) < 4.5 \times 10^{-9}$ @ 95%CL

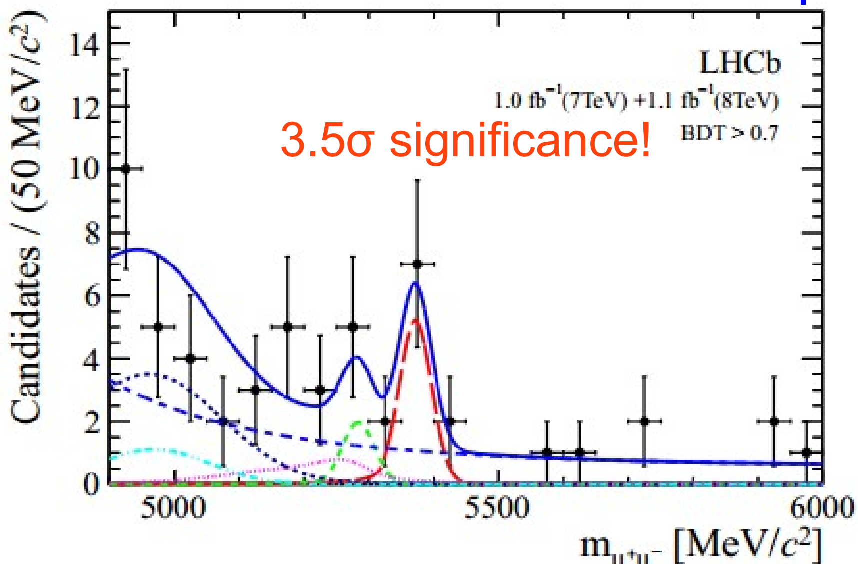
[Phys. Rev. Lett. 108 (2012) 231801]

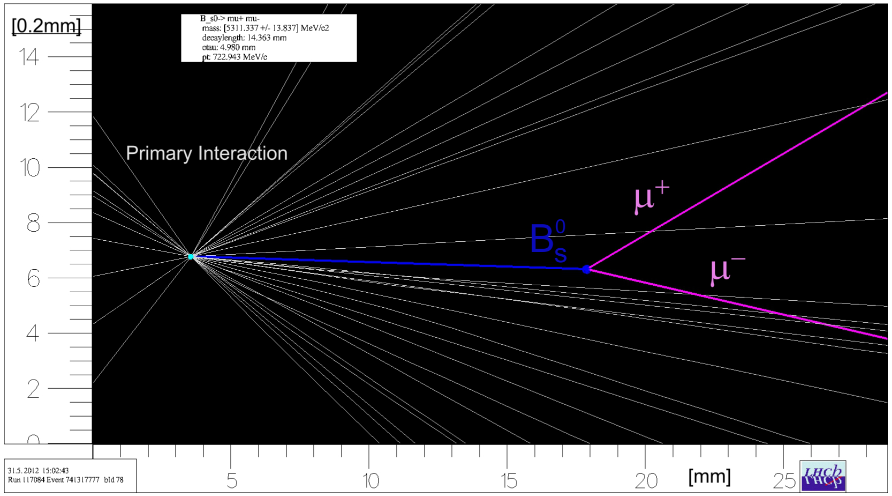
VERY close to the Standard Model!

And then first part of 2012 datasample was added ($1.1\,fb^{-1}$) and the box was opened

First evidence of $B_s \to \mu^+\mu^-$

Combined 2011+2012 datasample





Branching fraction is measured

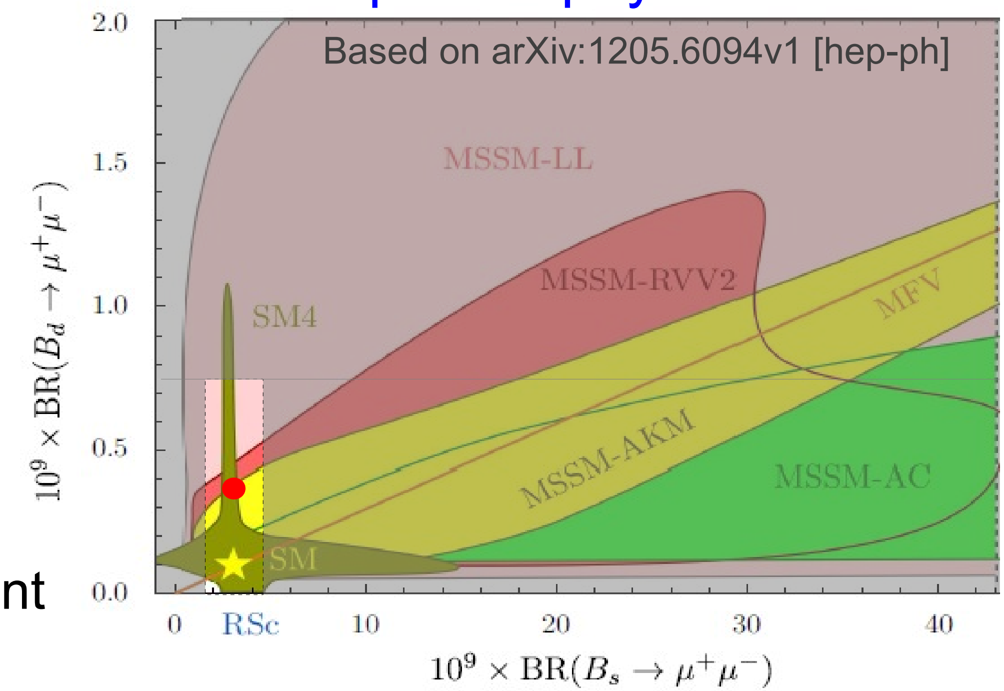
$$\mathcal{B}(B_s^0 \to \mu^+\mu^-) = (3.2\,^{+1.4}_{-1.2}(\text{stat})\,^{+0.5}_{-0.3}(\text{syst})) \times 10^{-9}$$

Tightest upper limit is set

$$\mathcal{B}(B^0 \to \mu^+\mu^-) < 9.4 \times 10^{-10}$$

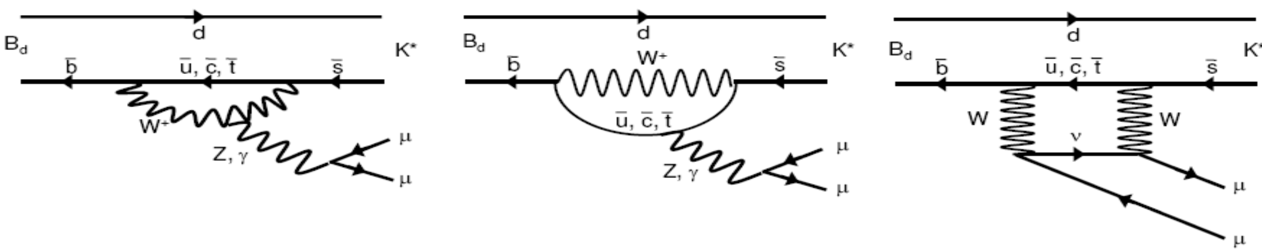
[LHCb-PAPER-2012-043]

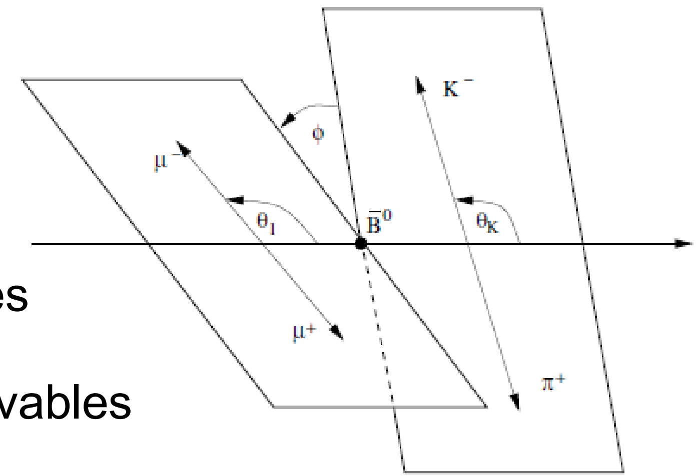
Impact to physics



The TeV-scale SUSY is almost excluded
However there are still a number of models,
which behave in the same way in this point

$B^0 \rightarrow K^*\mu+\mu-$



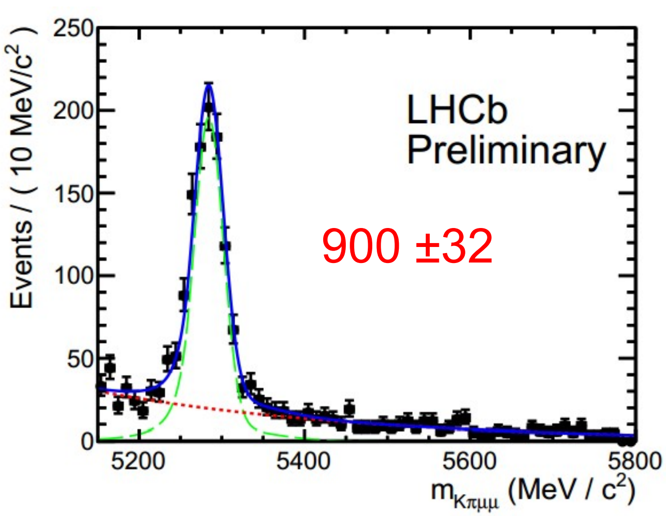


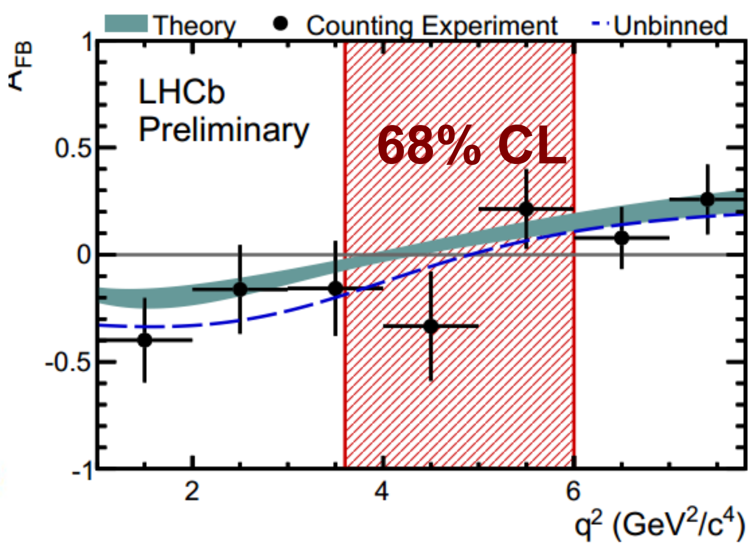
FCNC loop diagrams with b → s quark transition

The decay kinematics can be described in terms of three angles

An access to a number of interesting, theoretically clean observables

Zero crossing point theoretical prediction $q^2(A_{FB}=0)=(4\text{-}4.3)\mathrm{GeV}^2/c^4$





LHCb measurement with $1\mathrm{fb}^{-1}$ of data:

$q^2(A_{FB}=0)=4.9^{+1.1}_{-1.3}\,\mathrm{GeV}^2/c^4$ preliminary

Consistent with the Standard Model prediction

[LHCb-CONF-2012-006]

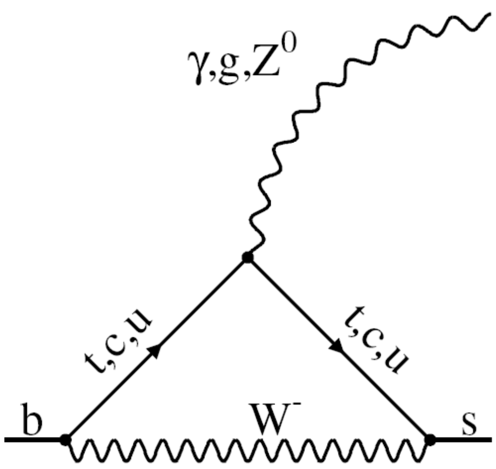
Radiative decays

Theoretical predictions for branching fractions:

$B^0 \rightarrow K^*\gamma$: $(4.3 \pm 1.4)\times 10^{-5}$
$B_s \rightarrow \varphi\gamma$: $(4.3 \pm 1.4)\times 10^{-5}$

[Eur. Phys. J. C 55 (2008) 577]

Suffer from large uncertainties from hadronic form factors!

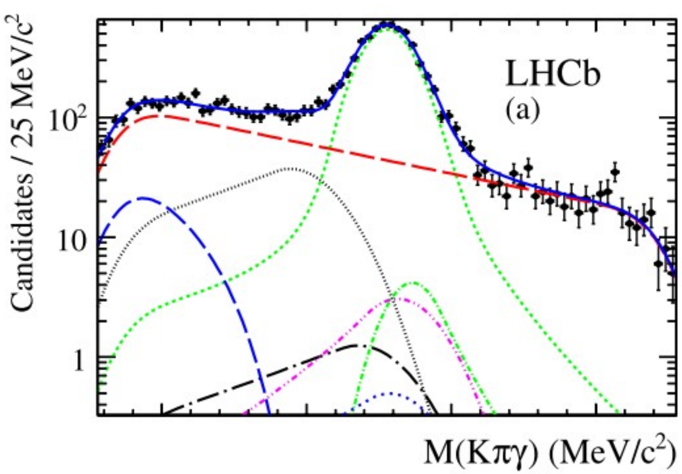


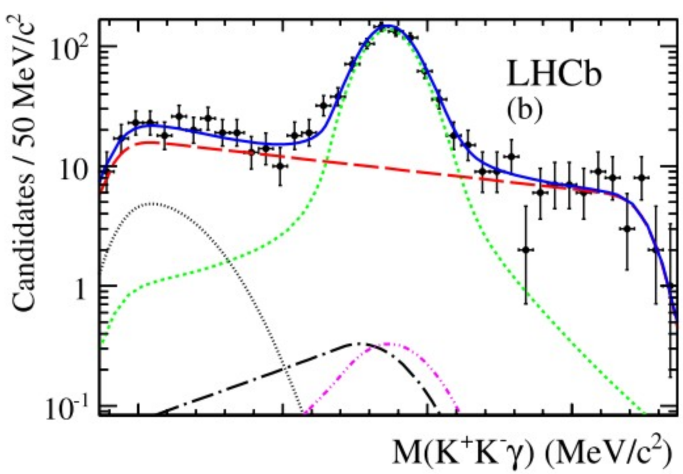
But there are observables, which don't

Ratio of branching fractions, predicted value: 1.0 ± 0.2
Direct CP-asymmetry, predicted value: $(-0.61 \pm 0.43)\%$

[Phys. Rev. D 72 (2005) 014013]

LHCb observations (1fb^{-1})



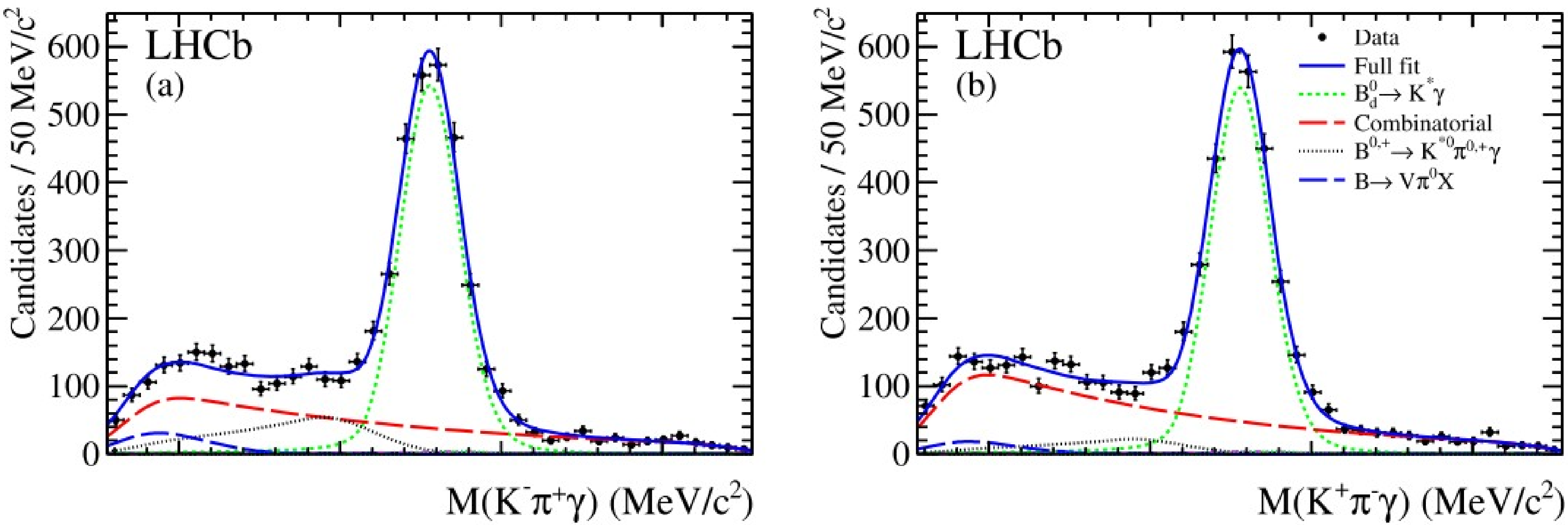


Invariant mass resolution ~90 MeV/c^2

$N_{B0 \rightarrow K^*\gamma} = 5279 \pm 93$
$N_{Bs \rightarrow \varphi\gamma} = 691 \pm 36$

[Nuclear Physics B 867 (2012) 1–18]

Direct CP-asymmetry in $B^0 \to K^*\gamma$



$N_{B0} + N_{\overline{B0}} \sim 5300 \pm 100$ events

With 1fb^{-1} of data:

$$\mathcal{A}_{CP}(B^0 \to K^{*0}\gamma) = (0.8 \pm 1.7\,(\text{stat.}) \pm 0.9\,(\text{syst.}))\%$$

$$\frac{\mathcal{B}(B^0 \to K^{*0}\gamma)}{\mathcal{B}(B_s^0 \to \phi\gamma)} = 1.23 \pm 0.06\,(\text{stat.}) \pm 0.04\,(\text{syst.}) \pm 0.10\,(f_s/f_d)$$

World best measurements, no deviation from the Standard Model!

[Nuclear Physics B 867 (2012) 1–18]

Upgrade

Upgrade motivation

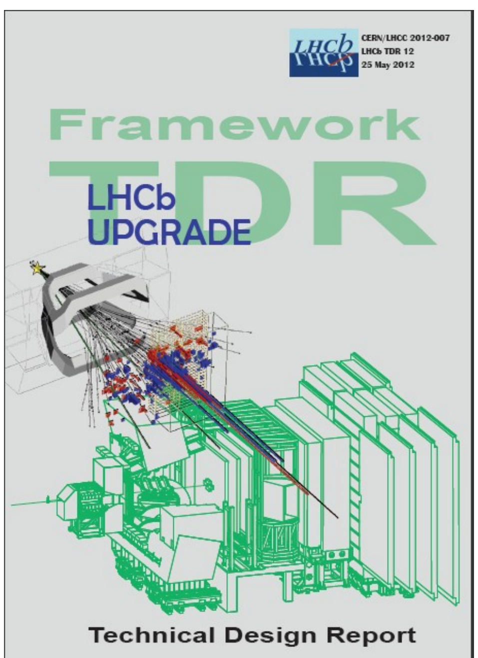
Get ready for luminosity of 10^{33} cm^{-2}s^{-1} and 40 MHz bunch crossing frequency

~5 fb^{-1}/year

„Exploration“	„Precision studies“
Search for $B^0 \to \mu^+\mu^-$	Measure $\mathcal{B}(B_s \to \mu^+\mu^-)$ to a precision of $\sim 10\%$ of SM value
Study other kinematical observables in $B^0 \to K^*\mu^+\mu^-$, e.g. $A_T(2)$	Measure $2\beta_s$ to precision $< 20\%$ of SM value
CPV studies with gluonic penguins e.g. $B_s \to \phi\phi$	Measure γ to $< 1°$ to match anticipated theory improvements
Measure CP violation in B_s mixing (A^s_{fs})	Charm CPV search below 10^{-4}
	Measure photon polarisation in exclusive $b \to s\gamma^{(*)}$ to the % level

Year	Energy	Int. Lumi.
2010	7 TeV	37 pb^{-1}
2011	2.76 TeV	71 pb^{-1}
2011	7 TeV	1.0 fb^{-1}
2012	8 TeV	2.2 fb^{-1}
2013	LHC splice repair	
2014		
2015	13 TeV 25 ns bunch crossing	> 5 fb^{-1}
2016		
2017		
2018	LHCb upgrade	
2019	5 fb^{-1}/year	
2020		
2021		
2022	LHC lumi upgrade	
2023		
2024		

Timescale



March 2011
Letter of Intent
http://cdsweb.cern.ch/record/1333091/files/LHCC-I-018.pdf

2012
Framework TDR
http://cdsweb.cern.ch/record/1443882/files/LHCB-TDR-012.pdf
R&D, technological choices

2013
Subsystem TDRs
R&D, technological choices

2014
First infrastructures for upgrade
Tender & production

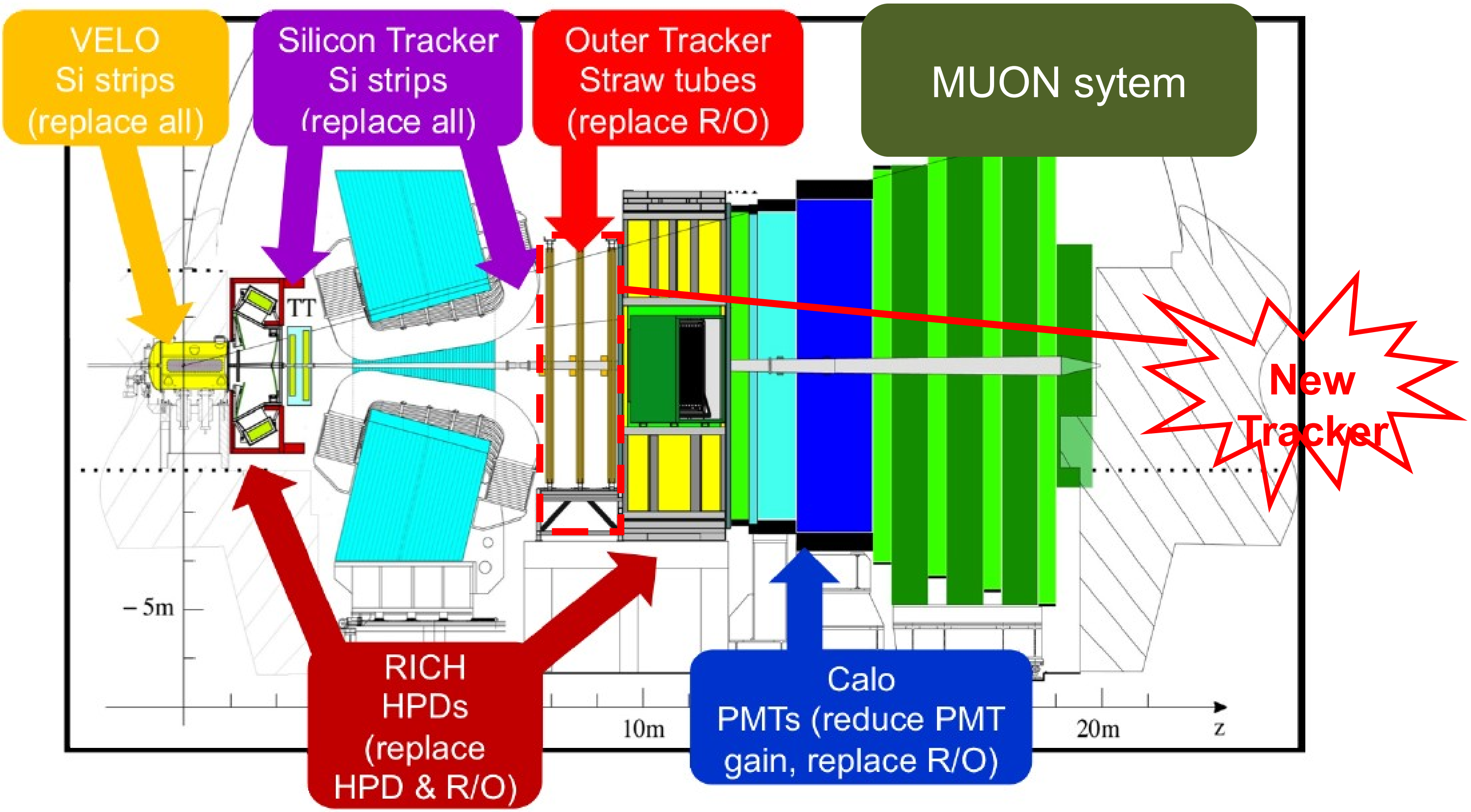
2015-2017
LHCb data taking
Acceptance testing

2018 - 2019
Installation

> 2019
Data taking

Prospects

- Purely software trigger to operate under higher occupancies
  - Access to full event information
  - ~2 times gain in signal rates for hadronic channels
- Upgrading all front-end electronics to readout at 40 MHz
- Upgrading tracking detectors
- Upgrading PID detectors



Expected sensitivities

Type	Observable	Current precision	LHCb (5 fb^{-1})	Upgrade (50 fb^{-1})	Theory uncertainty
Gluonic penguin	$S(B_s \to \phi\phi)$	-	0.08	0.02	0.02
	$S(B_s \to K^{*0}\bar{K}^{*0})$	-	0.07	0.02	< 0.02
	$S(B^0 \to \phi K^0_S)$	0.17	0.15	0.03	0.02
B_s mixing	$2\beta_s\ (B_s \to J/\psi\phi)$	0.35	0.019	0.006	~ 0.003
Right-handed currents	$S(B_s \to \phi\gamma)$	-	0.07	0.02	< 0.01
	$\mathcal{A}^{\Delta\Gamma_s}(B_s \to \phi\gamma)$	-	0.14	0.03	0.02
E/W penguin	$A_T^{(2)}(B^0 \to K^{*0}\mu^+\mu^-)$	-	0.14	0.04	0.05
	$s_0\, A_{\mathrm{FB}}(B^0 \to K^{*0}\mu^+\mu^-)$	-	4%	1%	7%
Higgs penguin	$\mathcal{B}(B_s \to \mu^+\mu^-)$	-	30%	8%	$< 10\%$
	$\frac{\mathcal{B}(B^0 \to \mu^+\mu^-)}{\mathcal{B}(B_s \to \mu^+\mu^-)}$	-	-	$\sim 35\%$	$\sim 5\%$
Unitarity triangle angles	$\gamma\ (B \to D^{(*)}K^{(*)})$	$\sim 20^\circ$	$\sim 4^\circ$	0.9°	negligible
	$\gamma\ (B_s \to D_s K)$	-	$\sim 7^\circ$	1.5°	negligible
	$\beta\ (B^0 \to J/\psi\, K^0)$	1°	0.5°	0.2°	negligible
Charm CPV	A_Γ	2.5×10^{-3}	2×10^{-4}	4×10^{-5}	-
	$A_{CP}^{dir}(KK) - A_{CP}^{dir}(\pi\pi)$	4.3×10^{-3}	4×10^{-4}	8×10^{-5}	-

http://cdsweb.cern.ch/record/1333091/files/LHCC-I-018.pdf

Conclusions

The LHCb detector is in a brilliant shape

Lots of „most precise“ measurements and „first observations“ with 1 year of datataking

The evidence of the rarest decay, $B_s \to \mu^+\mu^-$, is found with only 1.5 years of datataking

$\Delta\Gamma_s > 0$, $\varphi_s = -0.002 \pm 0.083 \pm 0.027$
Direct CP-asymmetry in the $B \to DK^\pm$
Observation of $B \to DK^\pm$ ADS modes
Angle $\gamma = (71.1^{+16.6}_{-15.7})^o$
$B \to K^*\mu\mu$: $q^2(A_{FB}=0)=4.9^{+1.1}_{-1.3}\,GeV^2/c^4$
$B \to K^*\gamma$: $A_{CP} = (0.8 \pm 1.7 \pm 0.9)\%$
...

Unfortunately, the New Physics did not show up yet

But there's still space for it left → need better precision!

Many plans for the future studies

Looking forward for more data and new perspectives!

Thank you for your attention!