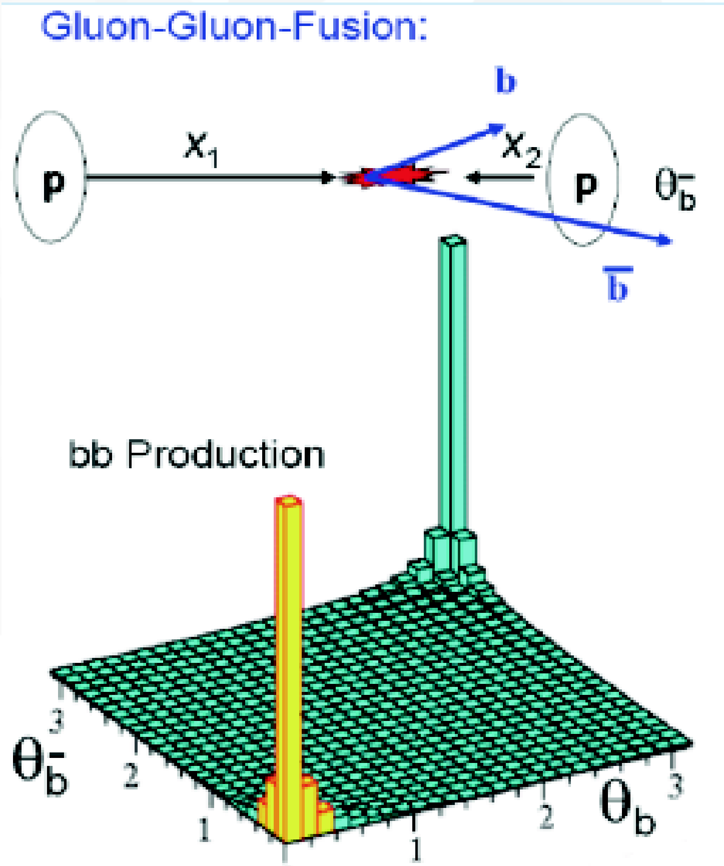
LHCb: Physics Results and Upgrade Activities

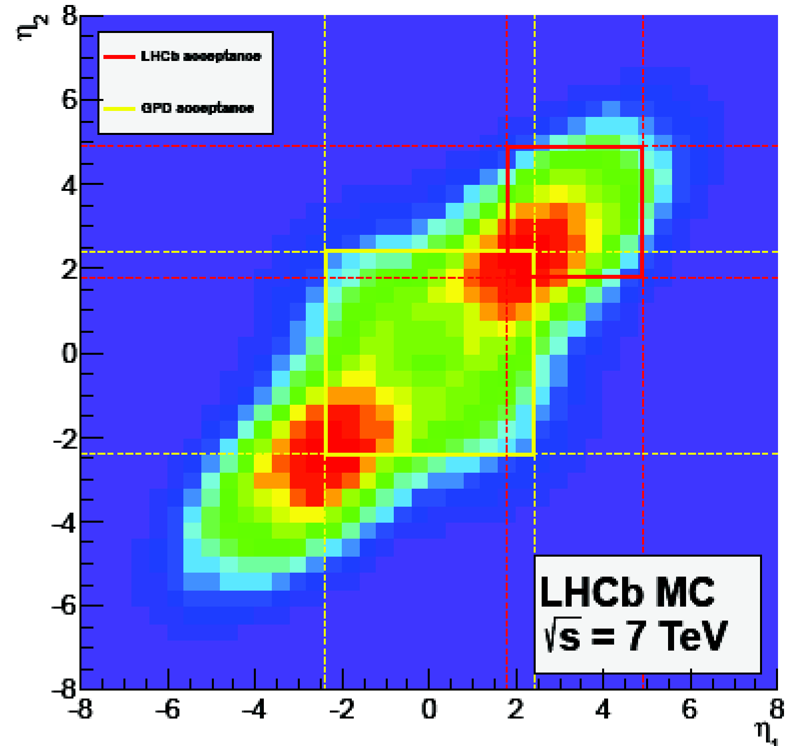
Physics Results & upgrade introduction	DL
RICH upgrade	Gabriele Simi
Trigger upgrade	Silvia Amerio

b Production at LHCb

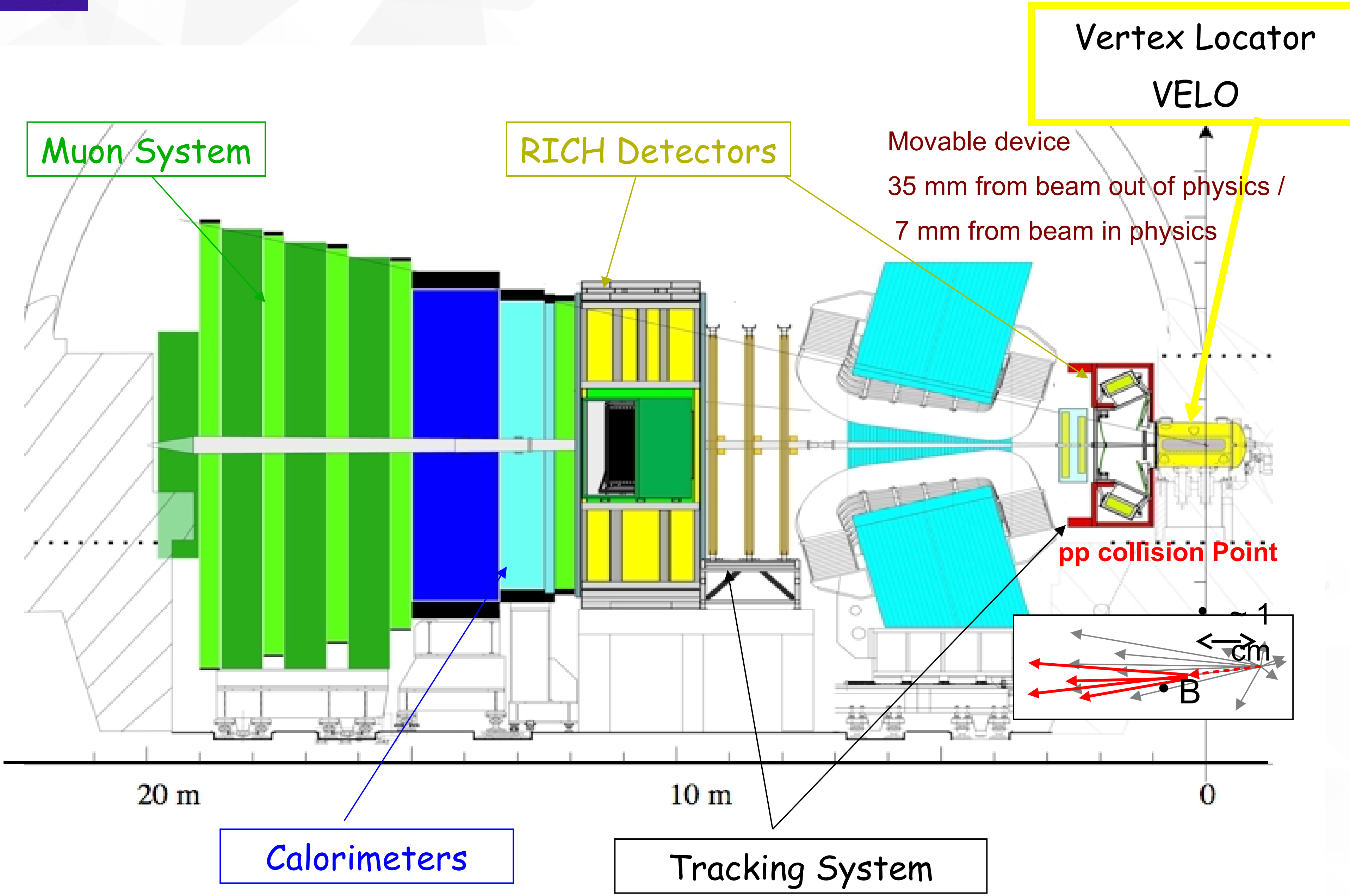


All b-hadron species produced :
B_u, B_d, B_s, B_c, Λ_b, Ξ_b,...
and c-hadrons as well

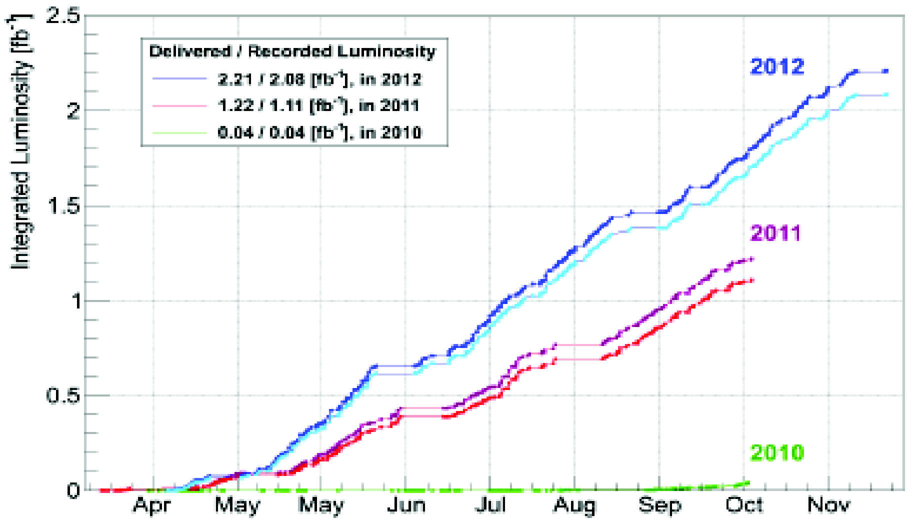
Acceptance



LHCb Detector



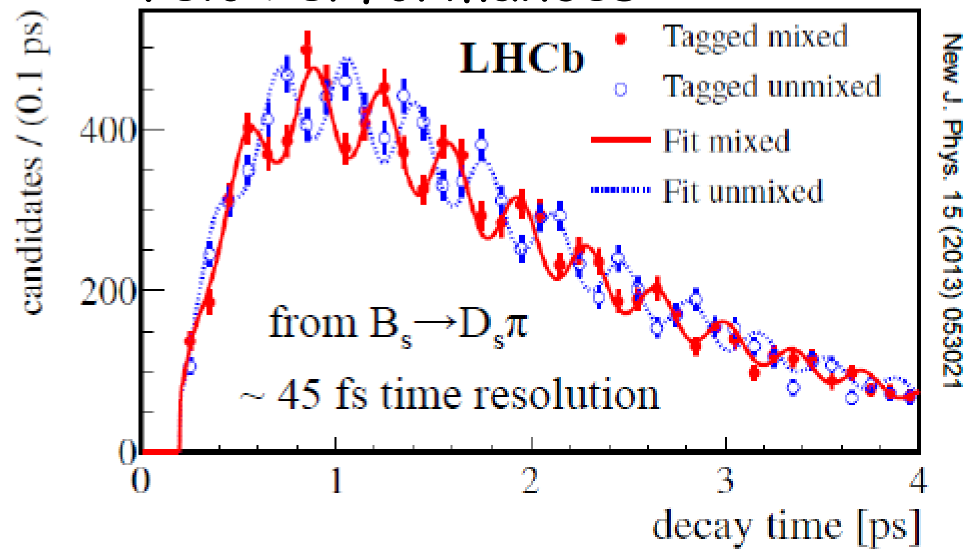
LHCb Performances

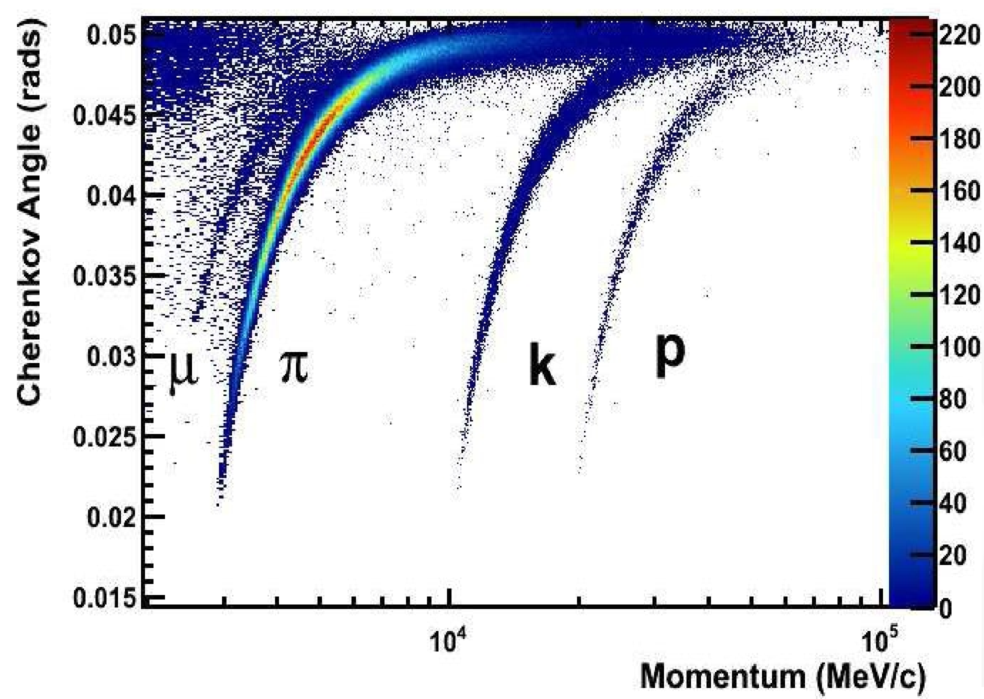


Data collection with *pp* collisions:

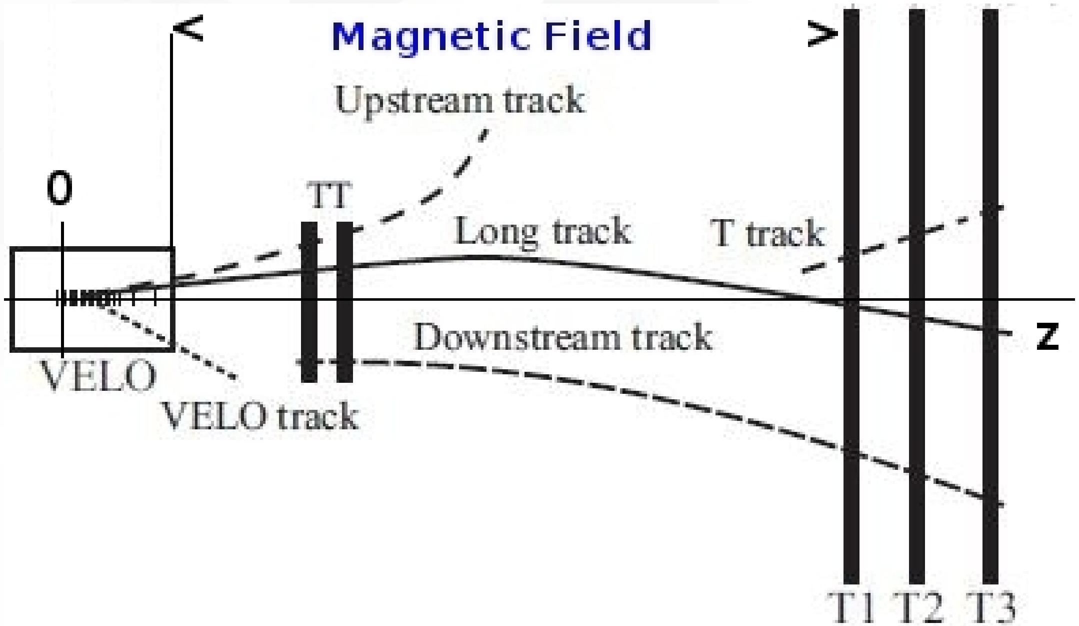
2010 38 pb^{-1} $\sqrt{s} = 7\,\mathrm{TeV}$,
2011 1.1 fb^{-1} $\sqrt{s} = 7\,\mathrm{TeV}$,
2012 2.0 fb^{-1} $\sqrt{s} = 8\,\mathrm{TeV}$.

Velo Performances





Tracking System



Upgrade requirement:
keep the same performances in harsher conditions

New VELO   New TT   New $T_{1/2/3}$

Current Performances:

$\delta p/p: 0.35\% - 0.55\%$ low-high p
$\sigma_{IP} = 14\,\mu m + 35\,\mu m/p_T$

Track finding efficiency:

-long	94% (p>10 GeV/c)
-upstream	75% (p>1 GeV/c)
-downstream	80% (p>5 GeV/c)

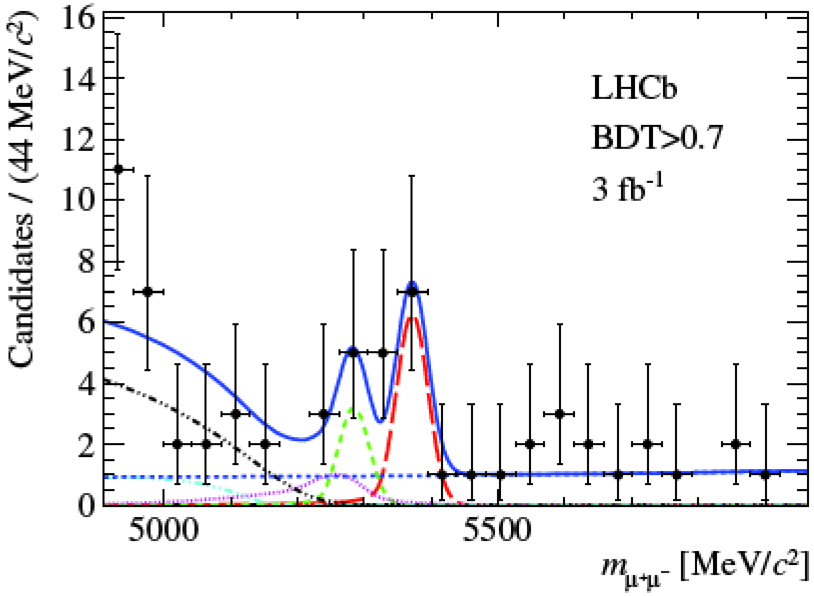
Ghost fraction:

-long	9%
-upstream	15%

Material budget (average):
VELO: 17.5% X_0
TT+T-station: 14% X_0

Physics Results

Rare Decays: $B_s \to \mu^+\mu^-$

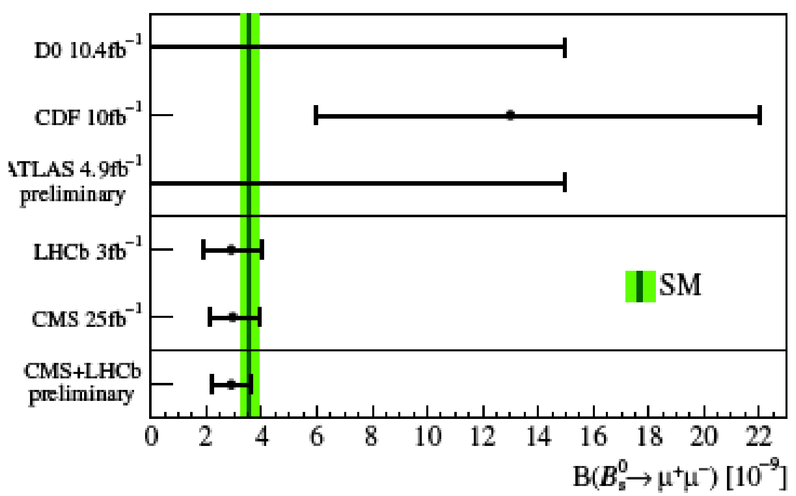


$$Br(B_s \to \mu\mu) = 2.9^{+1.1}_{-1.0}(stat.)^{+0.3}_{-0.1}(sys.) \times 10^{-9}$$

$$Br(B_d \to \mu\mu) < 7.4 \times 10^{-10} \text{ @95 CL}$$

$$Br(B_d \to \mu\mu) < 6.3 \times 10^{-10} \text{ @90 CL}$$

Naive combination



The upgraded LHCb:

$Br(B_s)$ ~ 5%

$Br(B_d)/Br(B_s)$ ~ 35%

theory uncertainty ~ 5%

$$\mathcal{B}(B_s^0 \to \mu^+\mu^-) = (2.9 \pm 0.7) \times 10^{-9}$$

$$\mathcal{B}(B^0 \to \mu^+\mu^-) = \left(3.6^{+1.6}_{-1.4}\right) \times 10^{-10}$$

Consistent with SM preedictions

$$\mathcal{B}^{SM}(B_s^0 \to \mu^+\mu^-) = (3.65 \pm 0.23) \times 10^{-9}$$

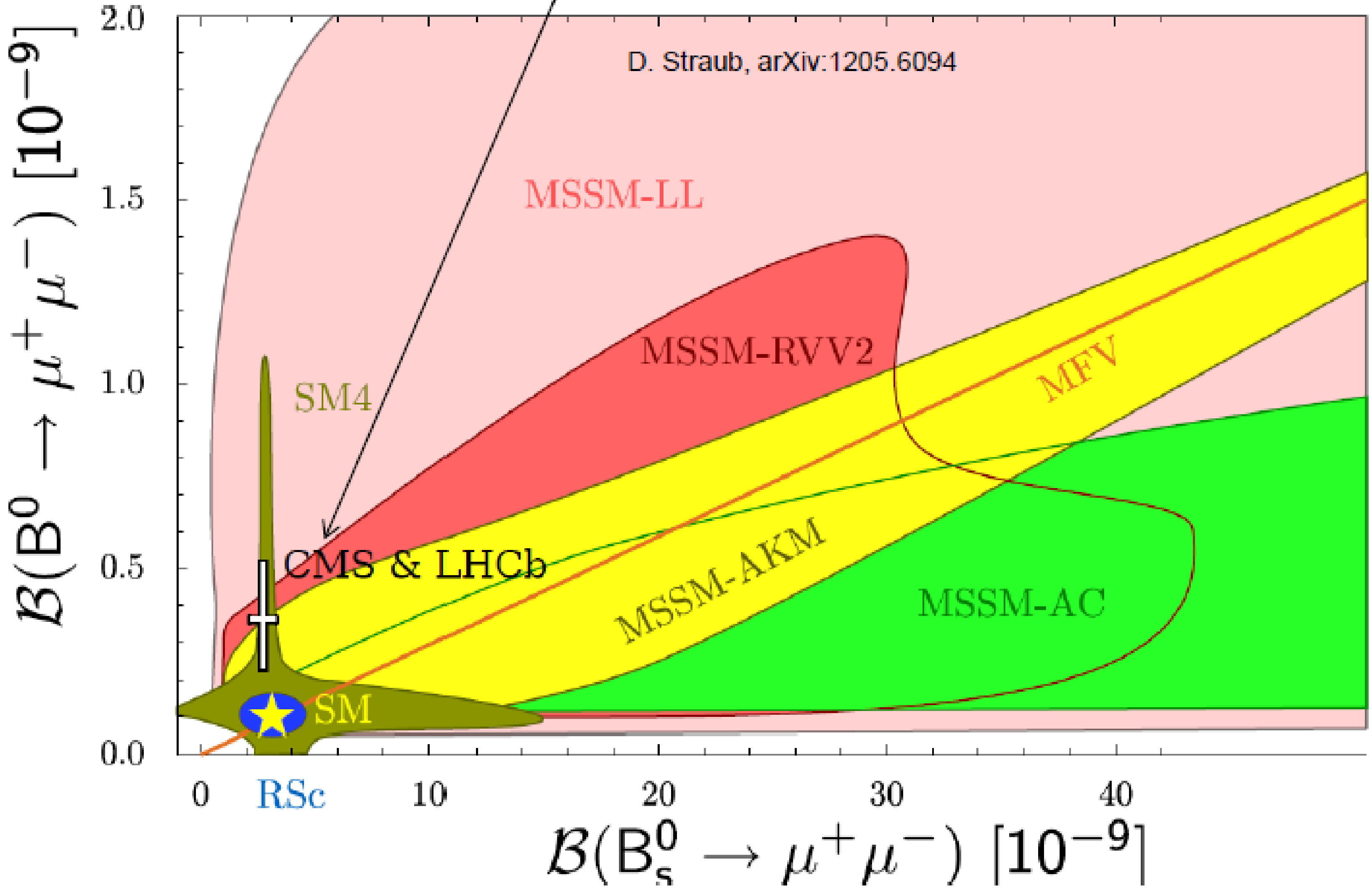
Impact on Super Symmetric Models

CMS-PAS-BPH-13-007
LHCb-CONF-2013-012

combining CMS & LHCb →

$$BR(B^0 \to \mu^+\mu^-) = (3.6^{+1.6}_{-1.4}) \times 10^{-10}$$

$$BR(B^0_S \to \mu^+\mu^-) = (2.9 \pm 0.7) \times 10^{-9}$$



Mixing phase, ϕ_s

CP violation in the interference between mixing and decay:

$B \to J/\psi Ks$ favored $\to \sin(2\beta)$

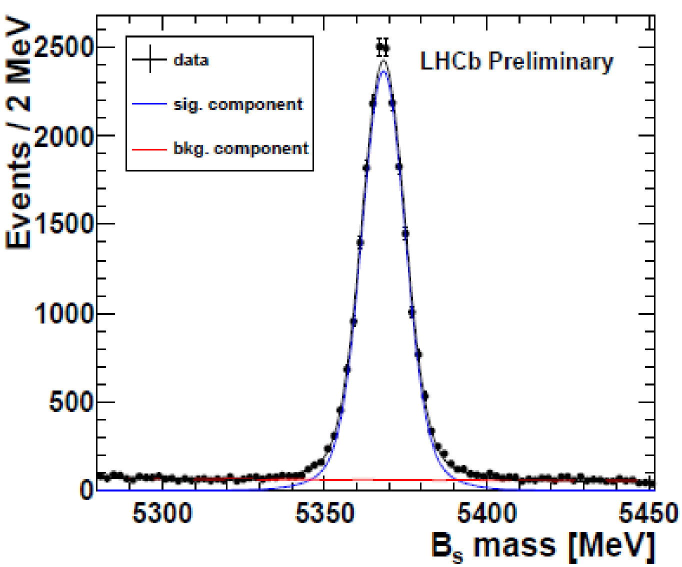
$Bs \to J/\psi V$ suppressed $\to \sin(2\Phi s)$ $\Phi s \sim -2\beta s$

Contribution from physics beyond SM can effect measured Φs

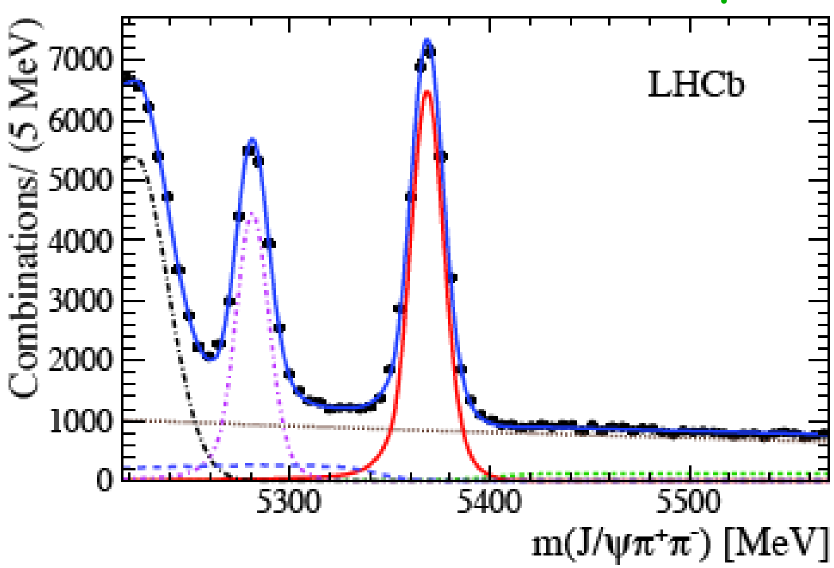
$Bs \to J/\psi\Phi$: very complex measurement, needs:

- flavor tagged time dependent angular analysis to disantangle CP-even from CP-odd components

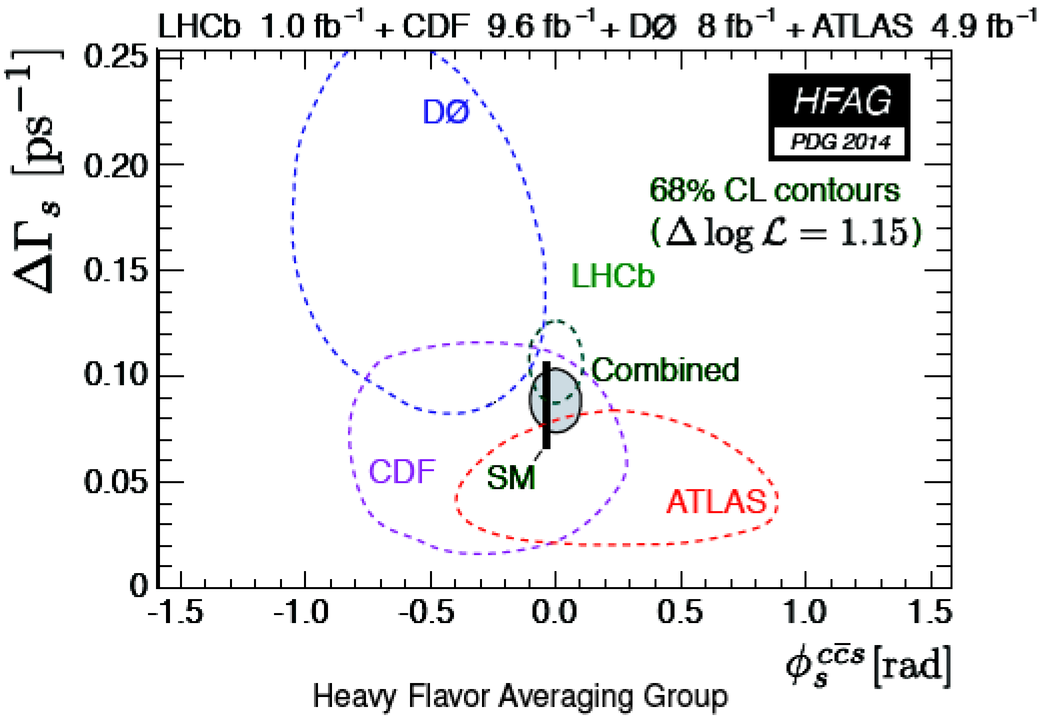
$Bs \to J/\psi\pi\pi$: dominated by CP-odd via f(980) amplitude, angular analysis not needed



27100±200 of $Bs \to J/\psi\pi\pi$



Mixing phase, ϕ_s combination



World average with LHCb 1 fb^{-1}: $\phi_s = 0.00 \pm 0.07$ rad

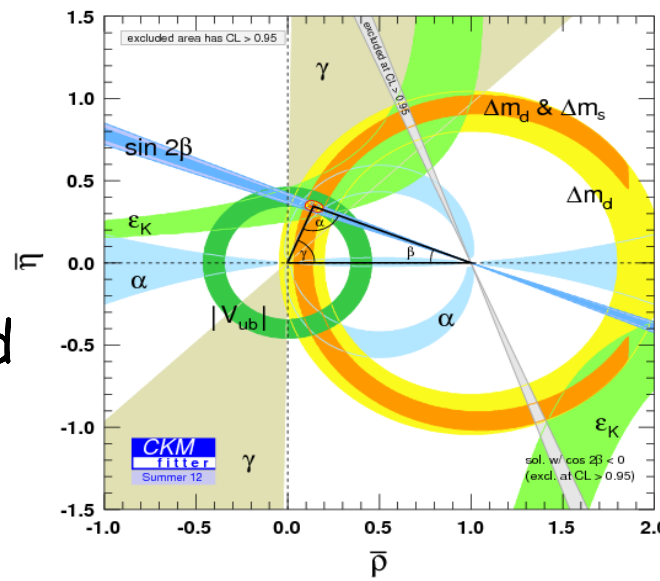
Upgraded LHCb:
$\delta\phi_s \sim 0.007$ *rad* ($B^0_s \rightarrow J/\psi\varphi$ & $B^0_s \rightarrow J/\psi\,\pi\pi$)
$B^0_s \rightarrow \varphi\varphi$ $B^0_s \rightarrow K^{*0} K^{*0}$ to search for NP

CP Violation: γ, B^0 decays

The least well-determined CKM angle

$$\gamma = \arg\left(\frac{-V_{ud}V_{ub}^*}{V_{cd}V_{cb}^*}\right)$$

SM fit: $\gamma = (67.7^{+4.1}_{-4.6})^o$



Bs → Ds K: Interference between mixing and decay amplitude generate CP violation:

- weak phases γ, ϕ_m and strong phases δ
- measure decay amplitudes as function of proper time to extract physical parameters
- need of flavor tagging

New Physics can be searched:

1. over-constrain SM (CKM fit)
2. comparing γ_{exp} obtained by tree/loop/box processes

Upgraded LHCb:
Exploit both 1. and 2. $\delta\gamma < 1^o$

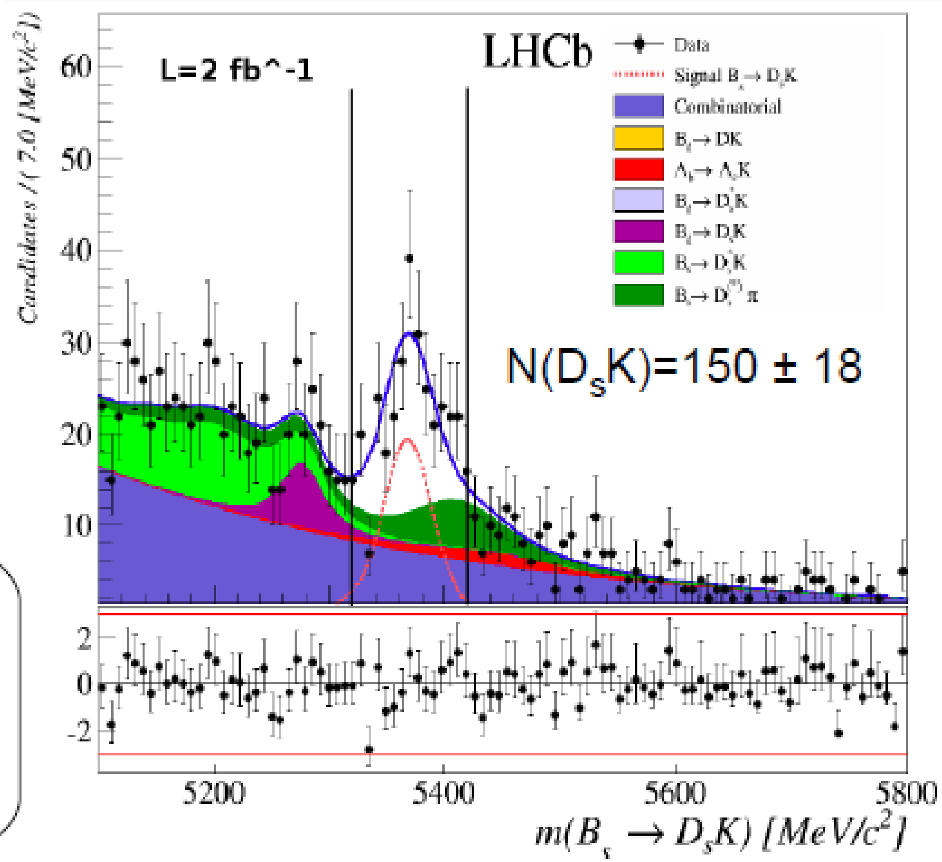
Measurement of γ with $B_s \to D_s K$

A.Bertolin
S.Gallorini
A.Lupato
M.Rotondo
L.Sestini

- General interests on $B_s \to D_s^{(*)} K^{(*)}$ modes: sensitive to $\gamma - 2\beta_s$
- Time Dependent analysis of $B_s \to D_s K$ with 1 fb^{-1} (CERN/NIKHEF/Krakow) will be submitted pretty soon: D_s modes considered are $D_s \to KK\pi$, $K\pi\pi$, $\pi\pi\pi$

- We joined the effort for the update of the analysis @ $3fb^{-1}$

- Results are statistically limited: added $D_s \to KK\pi\pi^0$
  - Higher BF ☺ (6%) but much lower efficiency (π^0) ☹ (<10%)
  - Yields and S/N comparable with $D_s \to K\pi\pi$: added 5% to the total signal yield
  - This new mode is included in the official code

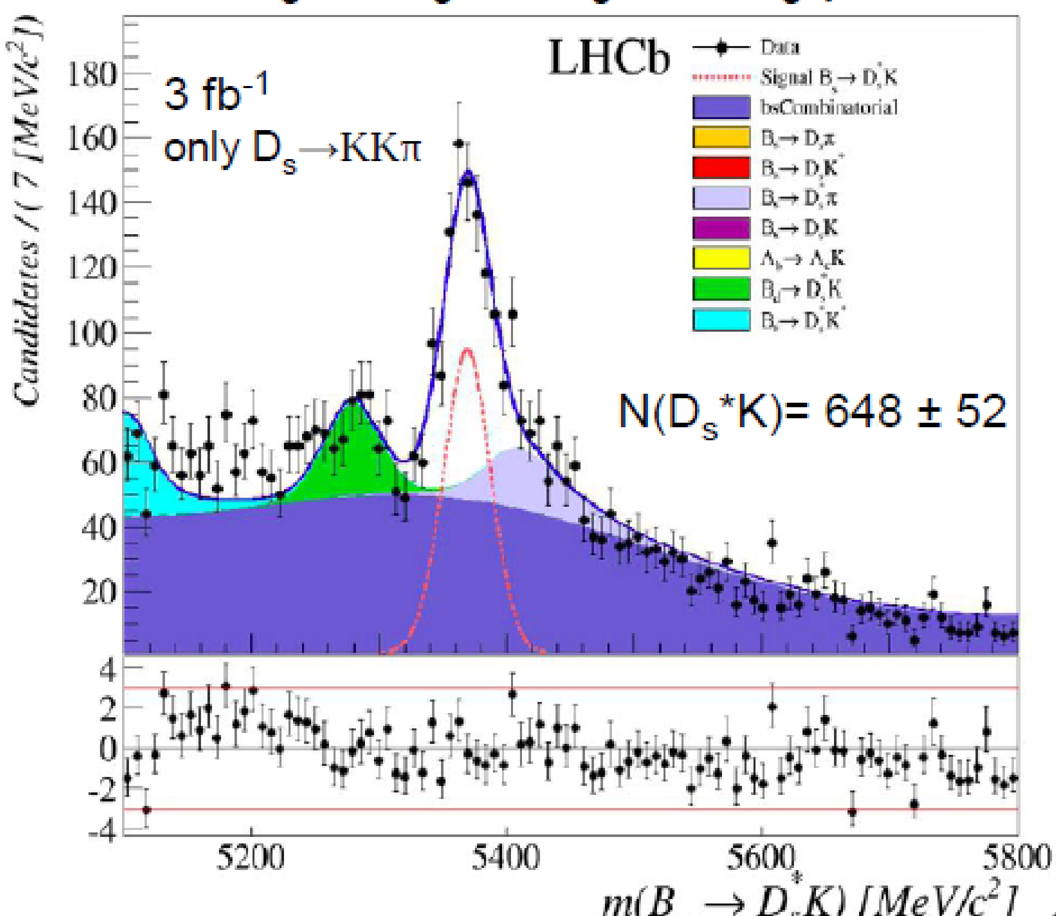


- With the full run-1 statistics, using all the 4 D_s decay modes expected $\sigma(\gamma) \sim 20°$
- Prel. results expected for Winter 2015

First obervation of $B_s \to D_s^*K$

- Non -trivial- contribution to γ through time-dependent analysis combined with $B_s \to D_sK/\pi$
- First step: observation of $B_s \to D_s^*K$ and measurement of $\frac{BF(B_s \to D_s^* K)}{BF(B_s \to D_s^* \pi)}$

$B_s \to D_s^*K$ ($D_s^* \to D_s\gamma$)



- Preliminary result aiming to CKM2014: waiting for the WG approval!
  - Publication by early next year
- Second step: measurement of the CPV parameters and combination with $B_s \to D_sK$

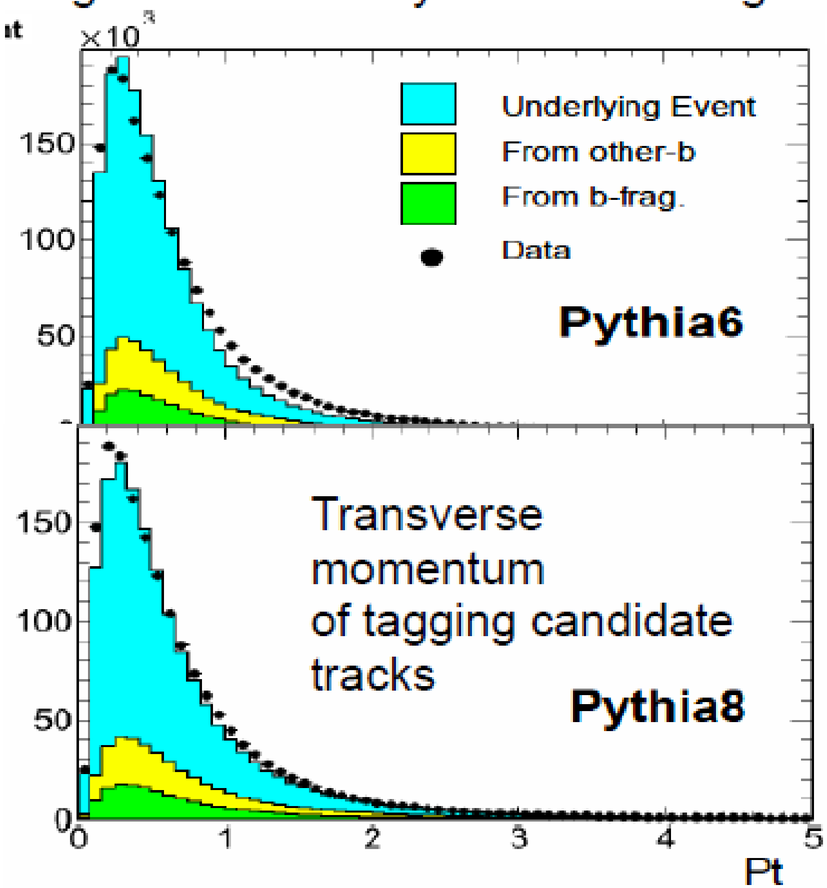
A.Bertolin
S.Gallorini
A.Lupato
M.Rotondo
L.Sestini

Tagging and b-quark fragmentation

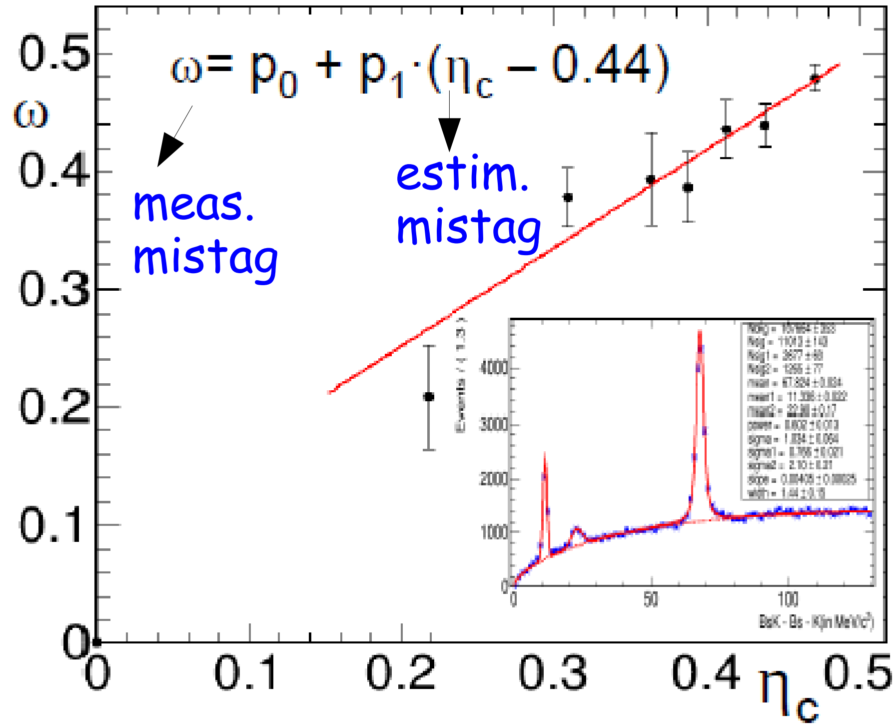
G.Busetto
M.Rotondo

- Contributions to the Same Side Kaon tagger: crucial for the B_s TD measurements

- Kaon production strongly affected by the b-quark fragmentation
  - Activity is part of the ongoing effort of the general Run2–Pythia8 MC-tuning



- New SSK calibration channel
  - Self tagged $B_{s2}^{*} \rightarrow B^{+}K^{-}$



- These studies are going to be included in the SSK Tagging paper in preparation

Other planned activities for the 2015

- b-jets @ LHCb
  - Study of a b-jet trigger
  - Measurement of $b\bar{b}$-cross in the forward region
  - Search for $b\bar{b}$ resonaces

S. Amerio
D. Lucchesi

- Semileptonic Decays @ LHCb

M. Rotondo
G. Simi

LHCb Upgrade

The Upgraded Detector

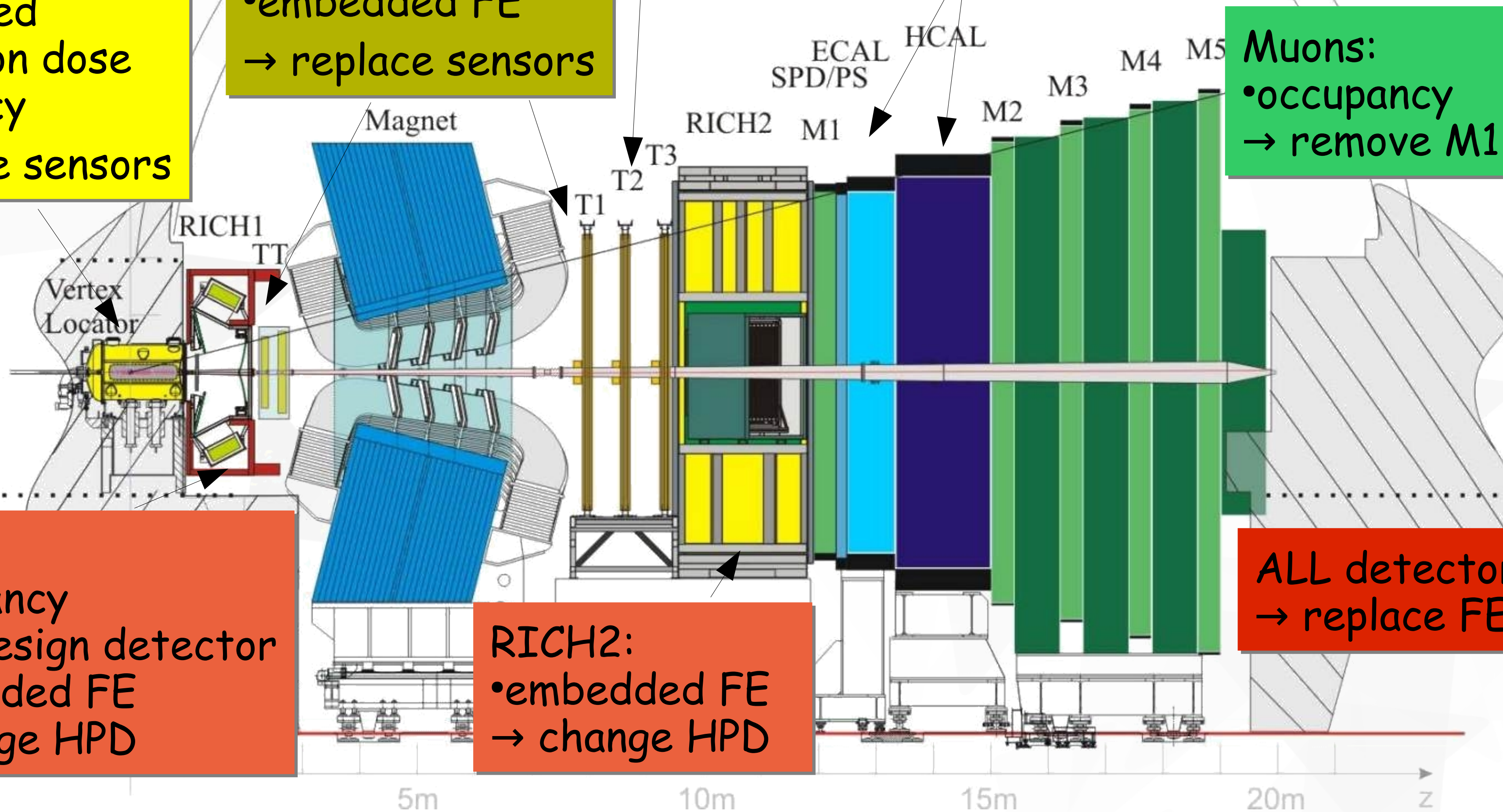
Outer tracker:
•occupancy
→ re-design detector

Calorimeters:
•occupancy
→ remove SPD & PS
→ reduce HV & PM gain

VErtex LOcator (VELO):
•integrated radiation dose
•occupancy
→ change sensors

Si tracker:
•embedded FE
→ replace sensors

Muons:
•occupancy
→ remove M1

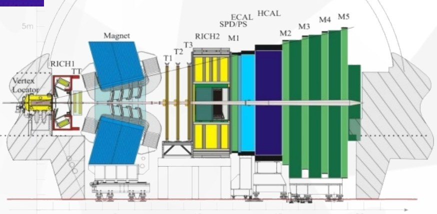


RICH1:
•occupancy
→ re-design detector
•embedded FE
→ change HPD

RICH2:
•embedded FE
→ change HPD

ALL detectors:
→ replace FE

Upgrade strategy and Consequences



40 MHz

DAQ

40 MHz

LLT: μ,e/γ, hadrons

10 MHz

HLT: event recon.

20 kHz

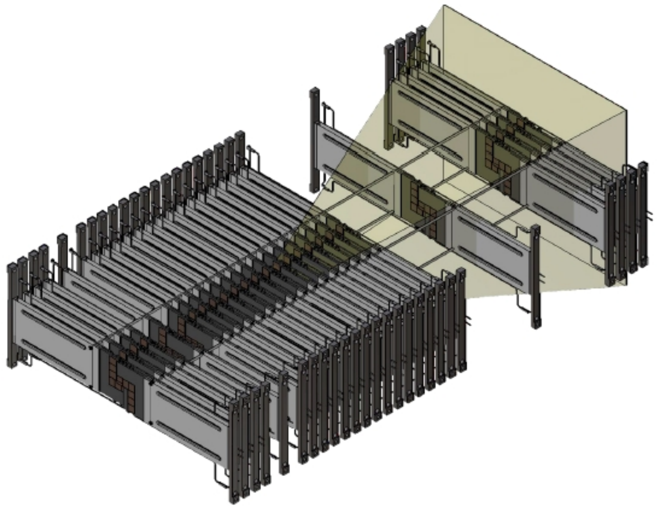
Storage

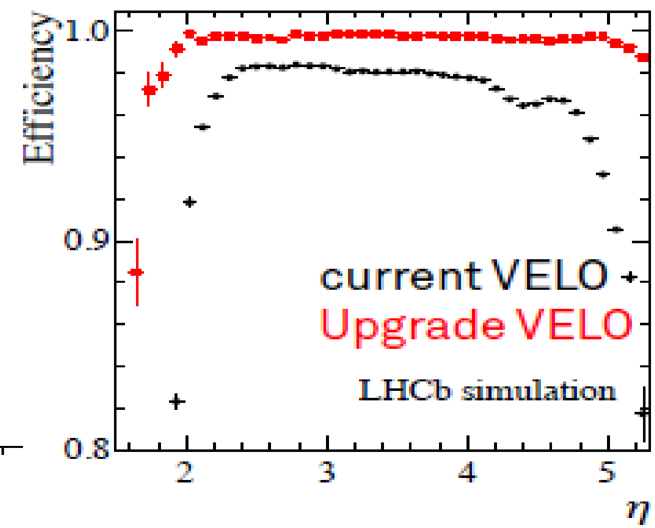
To run a 25 ns bunch crossing, $\sqrt{s}$=14 TeV, luminosity level $\mathcal{L}=1\times10^{33}cm^{-2}s^{-1}$ and sustain up to $\mathcal{L}=2\times10^{33}cm^{-2}s^{-1}$:

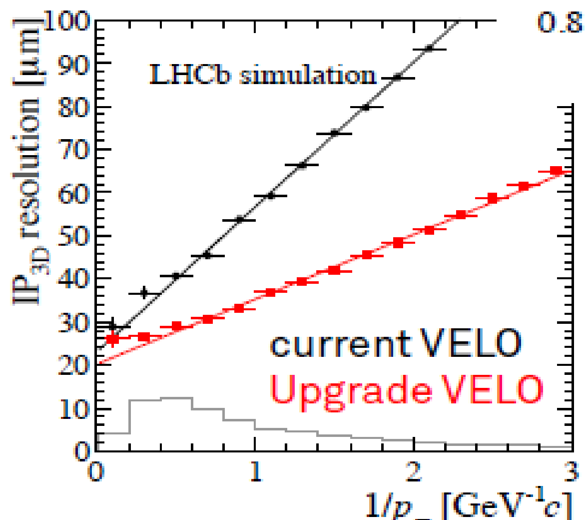
- Remove Level 0 bottleneck
- Read-out full detector at 40 MHz
  - Replace front-end and back-end electronics
  - Replace detectors with embedded electronics
- New trigger fully software using High Level Trigger farm with very fast software

The New VELO

- Operate in vacuum with movables halves, retracted during beam injection
- Square pixel sensors 55x55 μm^2
- Enlarge acceptance:
  - move closer to beam 5.5 mm → 3.5 mm
- Low material budget
  - Sensor thickness 200 μm
  - RF foil thickness 300 μm → 150 μm
  - CO_2 cooling with micro-channel
- Withstand high radiation doses
  - cope with instantaneous luminosity up to $2\times10^{33} cm^{-2} s^{-1}$

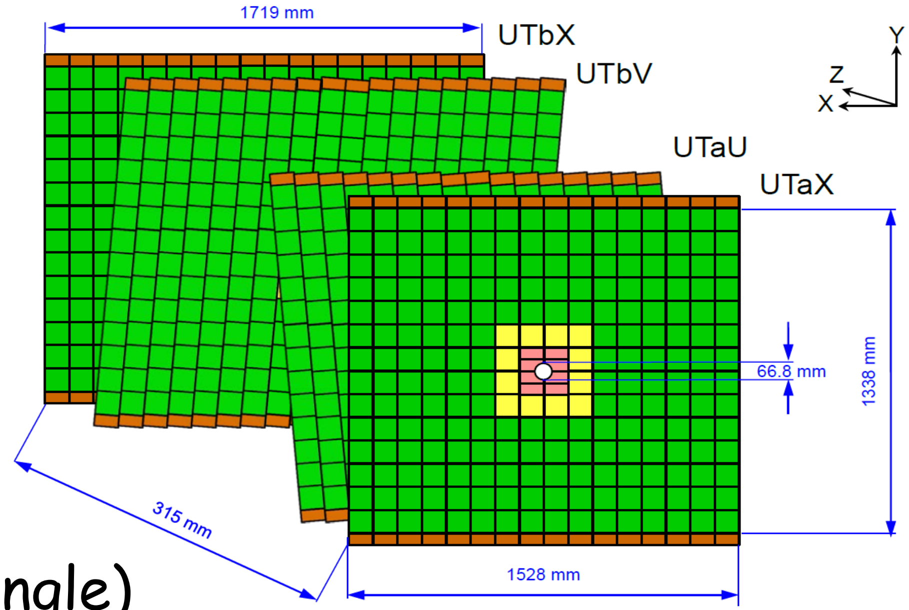




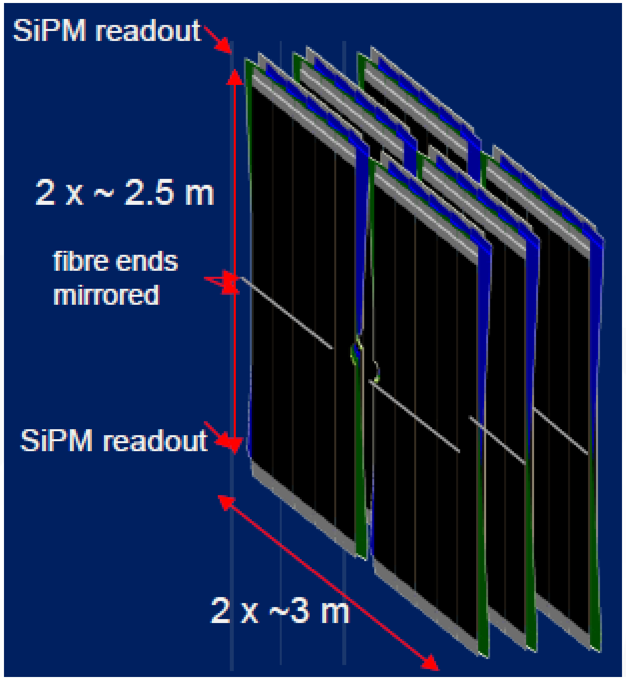


New Tracking System

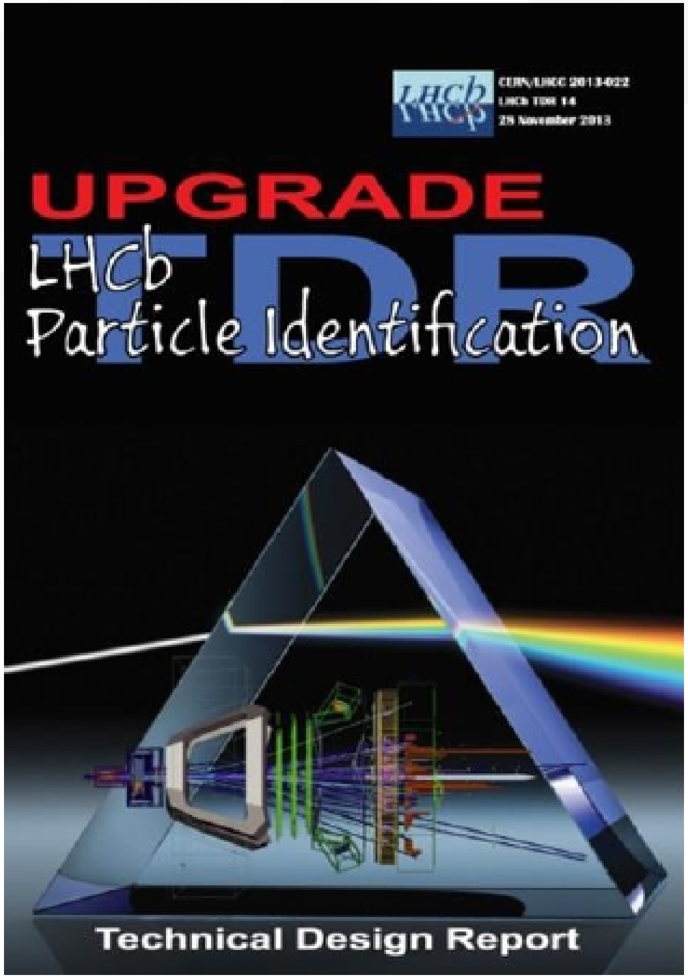
Upstream tracker (UT) :
silicon strip detector variable pitch
to match different occupancies



T-Station : fiber tracker
- 3 stations of X-U-V-X (±5° stereo angle) scintillating fibre planes
- every plane, 5 layers of Ø=250 μm fibres, 2.5 m long
- 40 MHz readout and Silicon PMs at periphery



Particle Identification Upgrade



RICH : Gabriele

Calorimeter

- Remove Scintillating Pad Detector and Pre-Shower

Muon System

- Remove M1, station before ECAL
- R&D on high granularity detector

Padova People and Requests

Nome	Quelifica		FTE(%)
Amerio Silvia	Assegnista	CSN I	**70**
Bertolin Alessandro	Ricercatore	CSN1	**100**
Busetto Giovanni	Prof. Ordinario	CSN II	**30**
Collazuol Gianmaria	Ricercatore	CSN II	**20**
Gallorini Stefano	Assegnista		**100**
Lucchesi Donatella	Prof. Associato	CSN I	**70**
Lupato Anna	Dottoranda	CSN1	**100**
Morandin Mauro	Dirigente di Ricerca	CSN I	**100**
Sestini Lorenzo	Dottorando	CSN1	**100**
Rotondo Marcello	Ricercatore	CSN I	**70**
Simi Gabriele	Ricercatore	CSN I	**70**
Totale Ricercatori		11	8.3

	Qualifica	**Aff.**	**%**
Bellato Marco Angelo	Primo Tecnologo	CSN V	**30**
Benettoni Massimo	Primo Tecnologo	CSN I	**40**
Gianelle Alessio	Tecnologo	CSN I	**100**
Montecassiano Fabio	Tecnologo	CSN V	30
Totale Tecnologi		4	2

Richieste locali :

Supporto Calcolo : 4 m.u.

Officina meccanica : 6 m.u.

Officina elettronica : 1 m.u.

Richieste CSN1 :

Usiamo gli algoritmi standard

MI : 1 k€/FTE

ME : 2 m.u./FTE +

1 m.u/FTE service task

1 m.u. = 3.8 k€

Consumo : 1.5 k€/FTE

Richieste CSN1

Capitolo	*Descrizione*	Parziali		Totale	
		Richiesta	SJ	Richieste	SJ
MISSIONI	1. 1. Missioni interne: usaimo l'algoritmo di CSN1 1kE*FTE	10.50			
	2. group + 1 mu data preservation + 2 mu test linee trigger 2015 Tot=31mu*3.8kE=118kE	118.00		128.50	0.00
MISSIONI					
CONSUMO	1. 1. Metabolismo Cern + Padova; 1.5kE*FTE	15.50			
	2. 2. ARRIAX FPGA DevKit per sviluppi DAQ	10.00			
	3. 3. materiale per struttura di supporto upgrade RICH	5.00		30.50	0.00
APPARATI	1. Materiale per la struttura di supporto per RICH (upgrade)	35.00	15.00	35.00	15.00