The LHCb upgrade: why and how

VI Meeting on B Physics

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Ferrara

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Outline

- Introduction (schedule)
- The physics case:
  - physics reach at 10fb^{-1} (5years) and possible scenarios
  - physics reach at 100fb^{-1} (upgrade)
  - concentrate on some core channels, discuss more what not discussed before
  - highlight channels of interest for SuperB
- How to record efficiently these data i.e. the trigger upgrade
- ~NOT speaking of technical issues such as detectors and electronics/DAQ

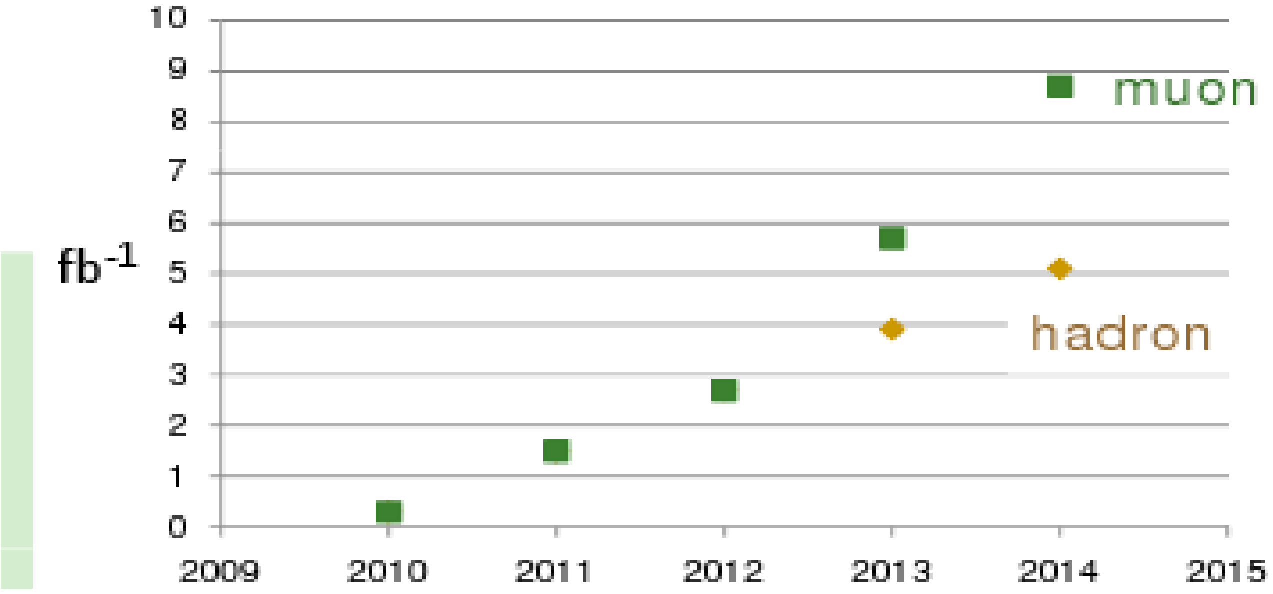
- **I try to give the most updated status so some results are not so digested**

Introduction

- LHCb upgrade must be synchronized with the machine shutdowns for LHC upgrades (even though LHCb doesn’t need LHC luminosity improvements)
- LHC plans two upgrade steps, now spaced by 5 years
  - **Phase-I** to start with 6 – 8 month extra shutdown in 2014. Includes, new IR triplets for ATLAS & CMS, LINAC4
  - **Phase-II** 2018/2019 (SLHC, up to 10^{35}, higher energy? 18 months shutdown)
  - Shutdown schedules may easily change in the future. The 2014 date represents a 1 year slip & is not a “hard” date
- These two phases are spaced out too far in time for LHCb to consider Phase II
- We should plan now for one upgrade to be installed in a shutdown in 2015
- Upgrade plan discussed with LHCC
- (obvious) LHCC recommendation: investigate systematic limits of key measurements

Expected samples before the upgrade

Year	2010	2011	2012	2013	2014
time 10^6 s	3	6	6	6	6
L $\times 10^{32}$	1	2	2	5	5
fb^{-1} muon	0.3	1.2	1.2	3	3
fb^{-1} hadron	0.3	1.2	1.2	1.2	1.2
integral L muon	0.3	1.5	2.7	5.7	8.7
integral L hadron	0.3	1.5	2.7	3.9	5.1



LHCb physics in 10fb^{-1}

By 2014 LHCb expects to accumulate 10 fb^{-1}. Allows for wide range of analyses, with high sensitivity to new physics. Some highlights:

- **Bs mixing phase** measured with uncertainty of 0.01 rad (0.5^0) (SM expectation: -0.036±.003)
- **B→K*μμ : ‘0-point’** of asymmetry measured to 7% (theory uncertanty ~8%)
- **Observation of Bs→μμ if BR at SM value**
- **R_K=BR(Kμμ)/BR(Kee)** measurement to ~4-5%
- **Precise determination of γ**
  - -tree-level value known to ~2-3^0
- Search for NP CPV in **gluonic Penguin**s, eg. Bs→ΦΦ
- **D^0 mixing** measurements x'^2,y' to 10^{-5} and searches for charm CPV to 10^{-3}

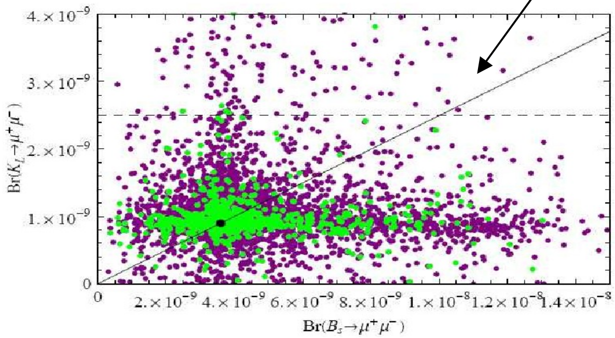
Some scenarios at 10fb^{-1}

- **The SM Higgs and nothing else**
- Imagine CMS/ATLAS see a SM Higgs and nothing else.
- In LHCb we can expect
  - $Bs \to \mu+\mu-$ discovered at SM level
  - CP angle γ at value from combined fits
  - $Bd \to K^{*0}\mu+\mu-$ zero point at SM value

Some scenarios at 10fb^{-1}

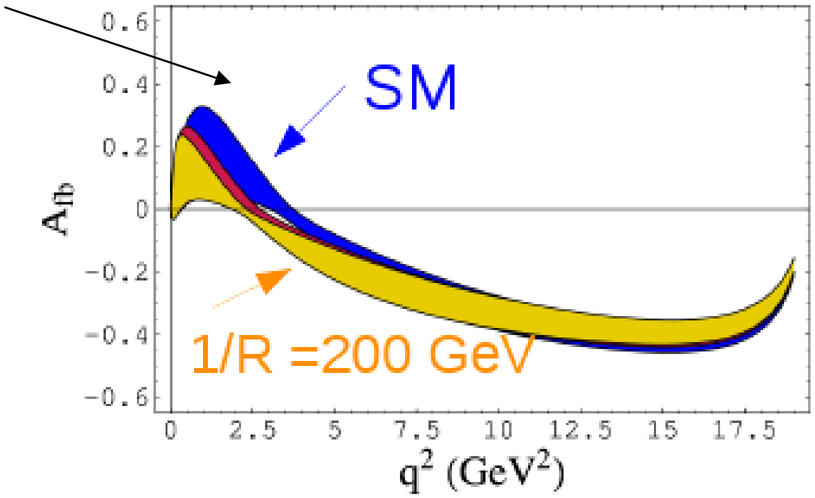
- **A SUSY spectra is discovered**
- ATLAS and CMS might discover a host of new states but many different theory models are possible:
  - Bs → μ+μ- will set very strict constraints on the Higgs sector of SUSY
  - CP measurements investigate the flavour structure
  - Bd → K*0μ+μ- will investigate handedness of SUSY couplings

- **Evidence of extra dimensions**
- The Appelquist, Cheng and Dobrescu model gives new flavour couplings, but no new phases
  - Strong effect on Bs → μ+μ- from modified Z0 penguins
  - Bd → K*0 μ+μ- is also sensitive in AFB zero point
  - As no new phases, CP violation measurements will stay at SM values.



Buras08

hep-ph/0609134v1, Fazio



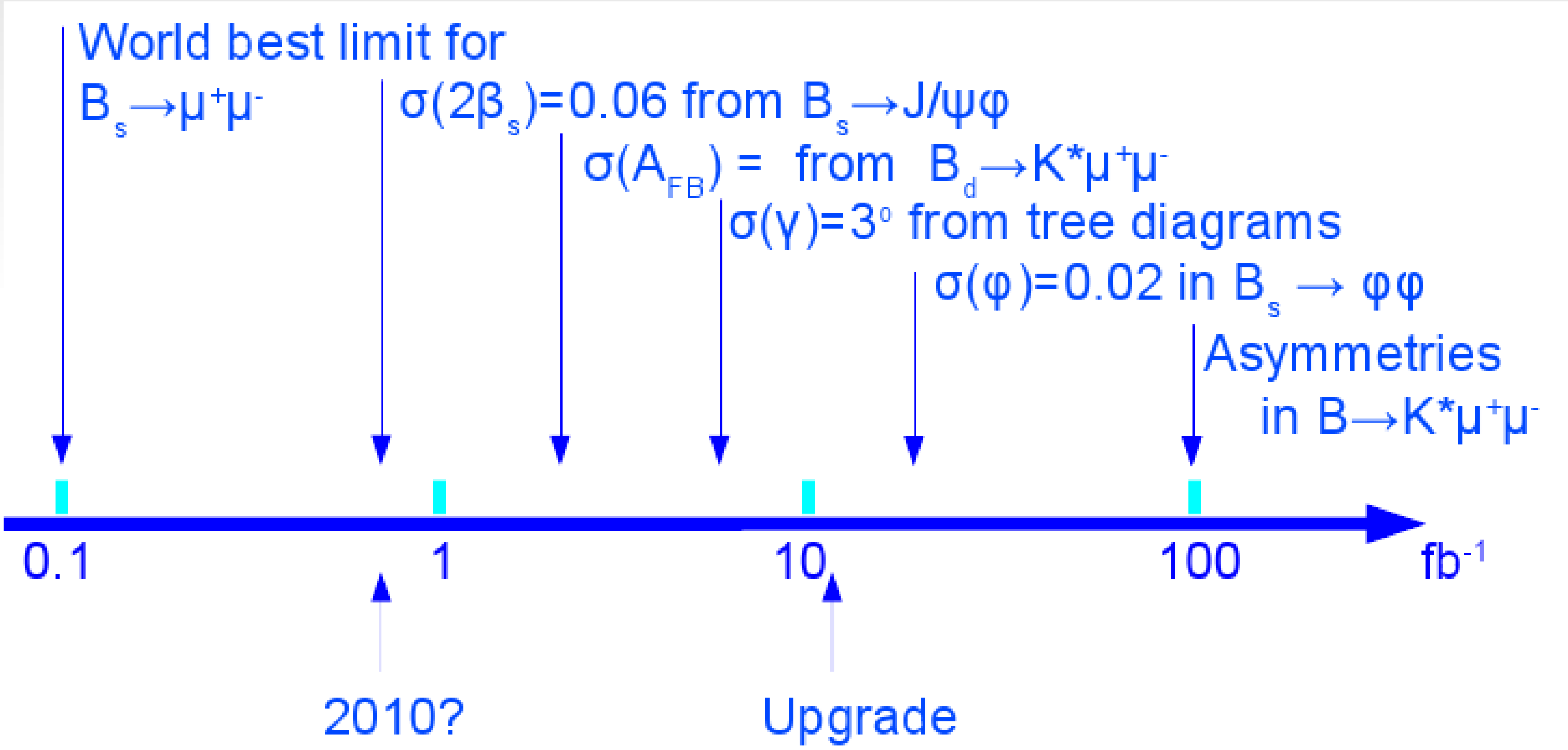
CPV measurements

	Sensitivity with 10 fb^{-1}	**Do we need 100 fb^{-1}?**
NP in boxes:		
☐ ϕ_s is the most sensitive measurement	$\sigma(\phi_s) \sim 0.01$	**Yes**
NP in penguins:		
☐ Probably the best sensitivity: β_s in $B_s \rightarrow J/\psi\phi$ & $B_s \rightarrow \phi\phi$	$\sigma(\delta\beta_s) \sim 0.05$	**Yes**
or β in $B \rightarrow J/\psi K_s$ & $B \rightarrow \phi K_s$	$\sigma(\delta\beta) \sim 0.1$	**Yes**

Rare Decays

	Sensitivity with 10 fb^{-1}	**Do we need 100 fb^{-1} ?**
NP in penguins:		
☐ Photon polarization in $B_s \to \phi\gamma$ decay:	$\sigma(A^{\Delta})= 0.09$	**Yes** (theor. uncert. ~0.01)
NP in a mixture of loop diagrams:		
☐ $B \to K^*\mu\mu$	$\sigma(s^0)$ ~ 0.3 GeV^2	**Yes** (ang distrubutions)
☐ $B_s \to \mu\mu$ ($B_d \to \mu\mu$)	>5σ observation if SM	**Yes**

Main LHCb events including the upgrade



World best limit for $B_s \rightarrow \mu^+\mu^-$

$\sigma(2\beta_s)=0.06$ from $B_s \rightarrow J/\psi\varphi$

$\sigma(A_{FB})$ = from $B_d \rightarrow K^*\mu^+\mu^-$

$\sigma(\gamma)=3^\circ$ from tree diagrams

$\sigma(\varphi)=0.02$ in $B_s \rightarrow \varphi\varphi$

Asymmetries in $B \rightarrow K^*\mu^+\mu^-$

0.1

1

10

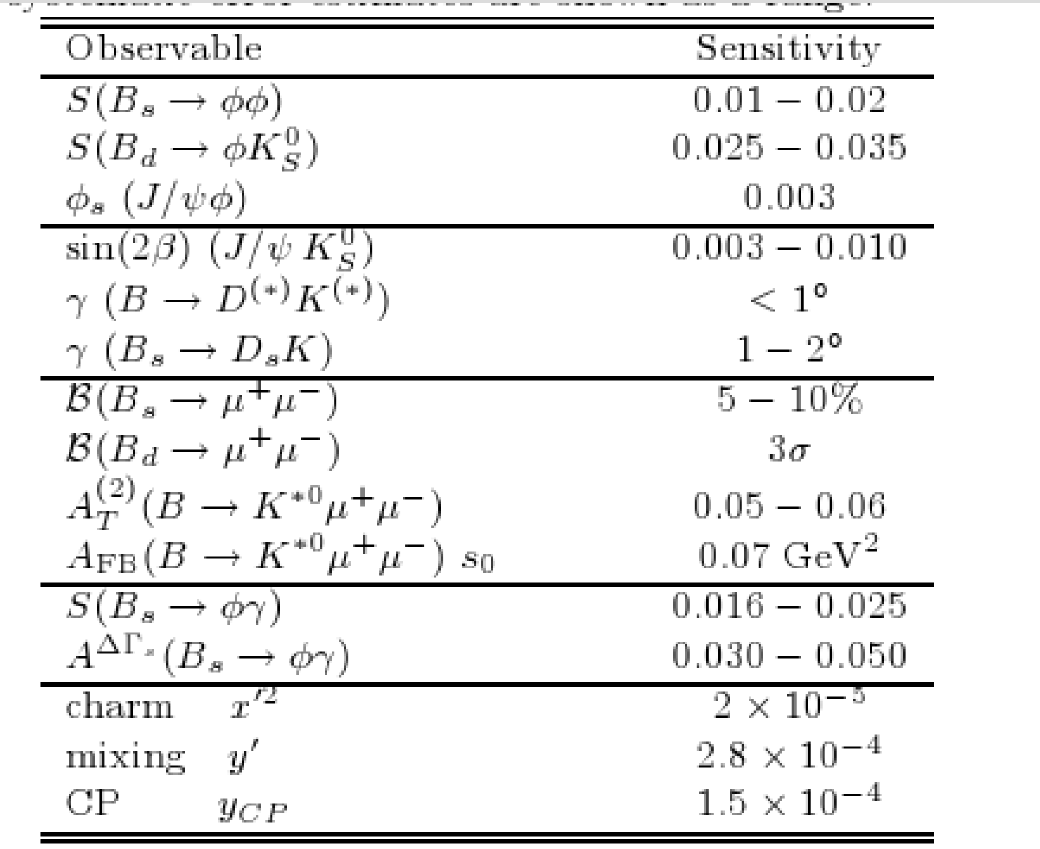
100

fb^{-1}

2010?

Upgrade

100fb-1 sensitivities in detail



Observable	Sensitivity
$S(B_s \to \phi\phi)$	$0.01 - 0.02$
$S(B_d \to \phi K^0_S)$	$0.025 - 0.035$
$\phi_s \ (J/\psi\phi)$	0.003
$\sin(2\beta) \ (J/\psi \ K^0_S)$	$0.003 - 0.010$
$\gamma \ (B \to D^{(*)}K^{(*)})$	$< 1^\circ$
$\gamma \ (B_s \to D_s K)$	$1 - 2^\circ$
$\mathcal{B}(B_s \to \mu^+\mu^-)$	$5 - 10\%$
$\mathcal{B}(B_d \to \mu^+\mu^-)$	3σ
$A_T^{(2)}(B \to K^{*0}\mu^+\mu^-)$	$0.05 - 0.06$
$A_{\rm FB}(B \to K^{*0}\mu^+\mu^-) \ s_0$	$0.07 \ {\rm GeV}^2$
$S(B_s \to \phi\gamma)$	$0.016 - 0.025$
$A^{\Delta\Gamma_s}(B_s \to \phi\gamma)$	$0.030 - 0.050$
charm x'^2	2×10^{-5}
mixing y'	2.8×10^{-4}
CP y_{CP}	1.5×10^{-4}

No dedicated physics studies now, just scaled by 10 and 20 (hadronic channels)

Main question: what about systematics??????????

Some “we cannot do” which are very interesting

- Some channels with neutrinos
  - B->τν,B->μν,
  - B->Kνν

e.g sensitive to charged Higgs

- The **inclusive** B->Xsll or Xsγ (for the round table?)
- τ->μγ,eγ etc.
- certainly more than I listed here...

maybe...

terventi. Ad esempio, dobbiamo realizzare in Italia una grande infrastruttura di ricerca, come del resto ci chiede l'Unione. Un centro, per capirci, come il Cern di Ginevra, un modello a cui far riferimento per diversi motivi».

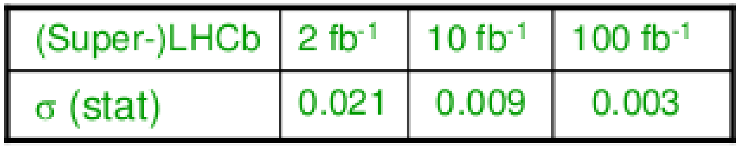
«Grande opera per attirare cervelli stranieri»

Il ministro Gelmini: nascerà in Italia sul modello del Cern e rilancerà i nostri scienziati

A snapshot of what we can do

Mixing phases

- **Bd**
  - Vast statistics will allow improvement on Bd mixing phase (= sin2β in SM).
  - Control channels will permit understanding of systematics from tagging and Penguin pollution (eg. Bs →J/ψK, R. Fleischer, Eur. Phys. J. C 10 (1999) 299)
  - Statistics will allow for 0.1° error.
- **Bs**
  - LHCb will (hopefully) see enhanced Bs mixing phase.
  - Upgraded LHCb will make precise measurement.
  - 8% relative uncertainty possible –will match current indirect error !



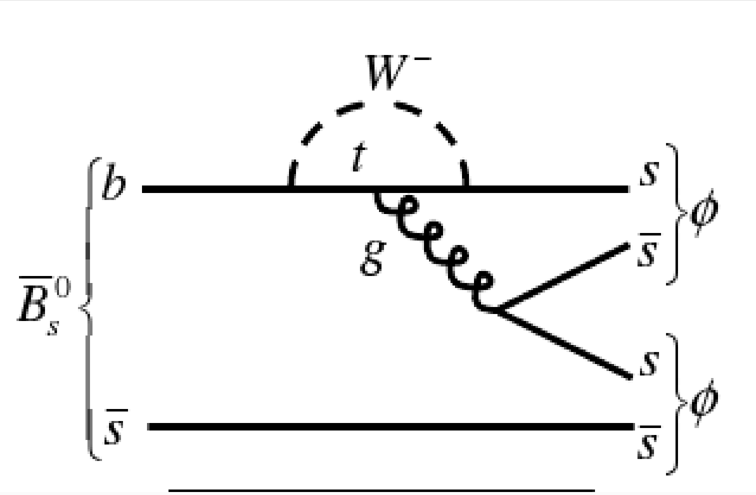
(Super-)LHCb	2 fb^{-1}	10 fb^{-1}	100 fb^{-1}
σ (stat)	0.021	0.009	0.003

CPV in gluonic penguin

- Tantalising hint of a discrepancy with sin(2β) from b->ccs
- Concentrate of the cleanest modes:
  - Bd->ΦK^0, $\eta' K^0$,$K^0 K^0 K^0$
  - with current central value 5σ is an important goal
- Bd->ΦK^0 most promising at current LHCb
  - precision at the end of LHCb 0.1
  - end of SLHCb 0.025
    - assuming 2xtrigger eff
    - same as SFF but they have the other important modes

CPV in gluonic penguin: Bs->ΦΦ

- The Bs analogue to Bd->ΦK^0: Bs→ΦΦ
- Dependence on Vts in both loop and mixing leads to SM CPV < 1%
- P→VV: need full angular analysis
- LHCb with 10 fb^{-1}: precision 0.05
- Upgrade: 62k events and a precision of 0.015 achievable – extremely interesting!
- theory systematics under study:
  - S wave contribtuions (~10%)
  - penguin pollution (debated)



$$\lambda_{\phi\phi}^{SM} = \frac{q}{p}\frac{\overline{A}_{\phi\phi}}{A_{\phi\phi}} = \underbrace{\frac{V_{tb}V_{ts}^*}{V_{tb}^*V_{ts}}}_{\text{mixing}}\underbrace{\frac{V_{tb}^*V_{ts}}{V_{tb}V_{ts}^*}}_{\text{decay}} = 1$$

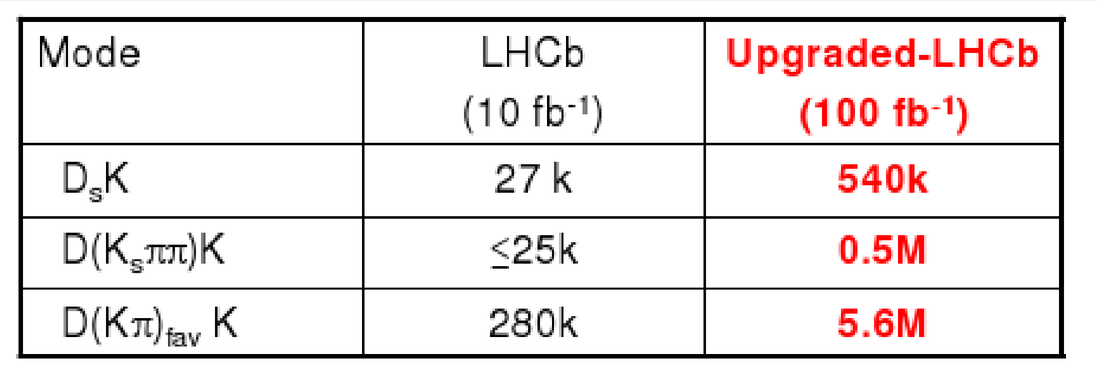
A $<1^{o}$ error on γ

- Extrapolating to 100 fb-1 only consider strategies which are theoretically clean: tree level decays

TDCPV

DALITZ PLOT

ADS/GLW



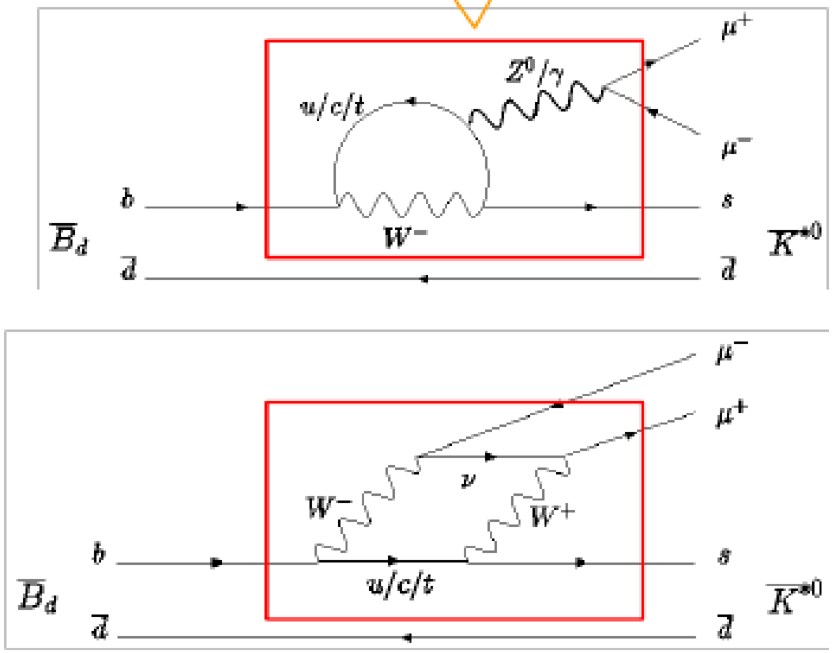
Mode	LHCb (10 fb^{-1})	**Upgraded-LHCb** **(100 fb^{-1})**
D_sK	27 k	**540k**
$D(K_s\pi\pi)K$	≲25k	**0.5M**
$D(K\pi)_{fav}$ K	280k	**5.6M**

- Bs →DsK: statistical scaling leads to 1°uncertainty for 100 fb-1
- B →D(Ksππ)K: statistical scaling leads to 1.2 ° for 100 fb-1
  - need to consider model independent method (Bondar & Poluektov) but need to derive strong phase difference between D and Dbar->Ksππ; exploiting ψ′′→DD data the residual systematics is 1.5-1° with final CLEO-c statistics BES-III (×20 stat.) coming soon
- B →D(hh)K: ADS/GLW 1-1.5°uncertainty
- largest systematic from detector asymmetry - measured in data

Bd->K*μμ

- First observed at Belle
  - Phys. Rev. Lett. 91:261601, **2003**
  - Br($B_d \rightarrow K^*\mu\mu$) = 1.22x$10^{-6}$ (PDG 06)
- Particles in Loop
  - Neutral and charged NP particles possible (replace $W^\pm$, Z^0/γ, u/c/t)
- Sensitive to NP
  - Dominated by C_7, C_9, C_{10}
  - Studies done in Higgs sector, SUSY, LH, RS, UED etc
- Can be selected by LHCb
  - ~7200 sig, 3500 bg per year (2 fb^{-1})

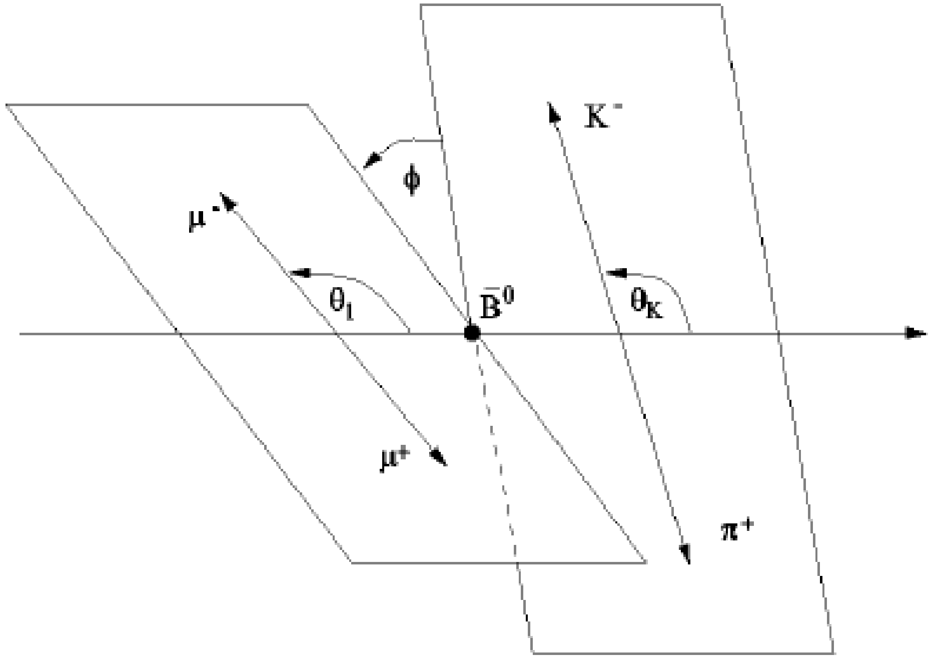
Insert your favourite NP particles here!



b → s quark transition

Bd->K*μμ

Decay Kinematics



θ_l : Angle between μ^- and $\bar{B}$ in $\mu\mu$ rest frame

θ_K : Angle between K^- and $\bar{B}$ in K* rest frame

ϕ : Angle between the K* and $\mu\mu$ decay planes

- Decay in terms of 3 Angles and 1 Invariant Mass
  - θ_l, θ_K, φ and q^2, the invariant mass squared of μ pair
  - q^2 sometimes labelled s in theory papers

Bd->K*μμ

$$\begin{aligned} I &= I_1 + I_2 \cos 2\theta_l + I_3 \sin^2\theta_l \cos 2\phi + I_4 \sin 2\theta_l \cos\phi + I_5 \sin\theta_l \cos\phi + I_6 \cos\theta_l \\ &+ I_7 \sin\theta_l \sin\phi + I_8 \sin 2\theta_l \sin\phi + I_9 \sin^2\theta_l \sin 2\phi. \end{aligned}$$

Angular Distribution

Angular Observables

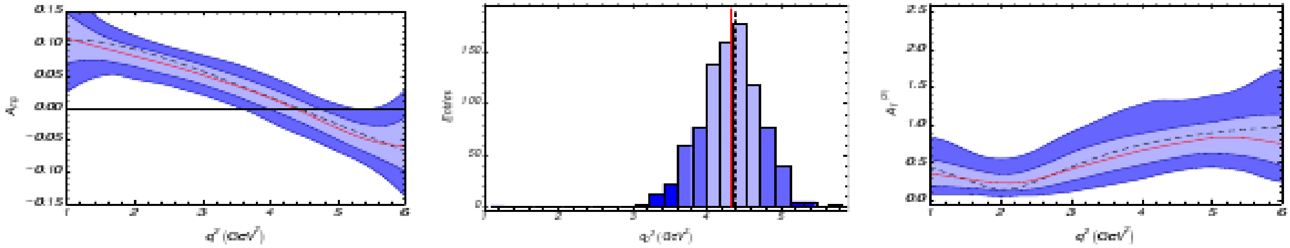
- Extract from Angular Projections…
- …or from Transversity Amplitudes
  - Use a full angular fit
- Considered A_{FB}, $A_T^{(2)}$, $A_T^{(3)}$, F_L and others

$$A_{FB} = \frac{3(\Re(A_\parallel^L A_\perp^{L*}) - \Re(A_\parallel^R A_\perp^{R*}))}{2(|A_0^L|^2 + |A_0^R|^2 + |A_\perp^L|^2 + |A_\perp^R|^2 + |A_\parallel^L|^2 + |A_\parallel^L|^2)} \qquad F_L = \frac{|A_0^L|^2 + |A_0^R|^2}{|A_0^L|^2 + |A_0^R|^2 + |A_\perp^L|^2 + |A_\perp^R|^2 + |A_\parallel^L|^2 + |A_\parallel^L|^2}$$

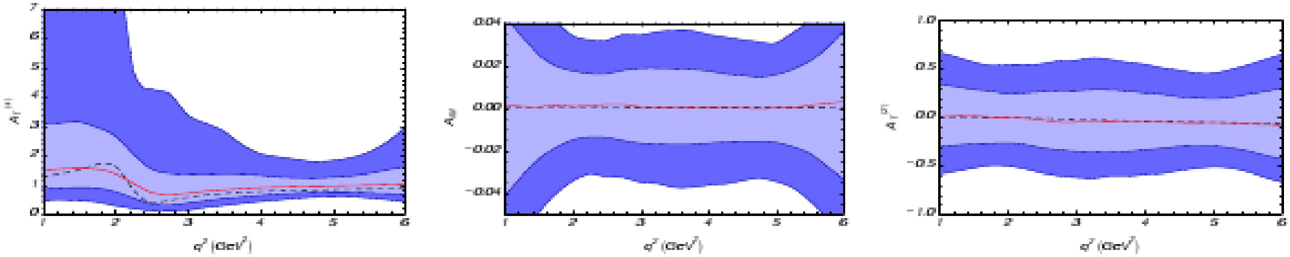
$$A_T^{(2)} = \frac{|A_\perp^L|^2 + |A_\perp^R|^2 - |A_\parallel^L|^2 - |A_\parallel^L|^2}{|A_\perp^L|^2 + |A_\perp^R|^2 + |A_\parallel^L|^2 + |A_\parallel^L|^2} \qquad A_T^{(3)} = \frac{A_{0L} A_{\parallel L}^* - A_{0R}^* A_{\parallel R}}{\sqrt{|A_0|^2 \times |A_\perp|^2}}$$

Bd->K*μμ ($2fb^{-1}$)

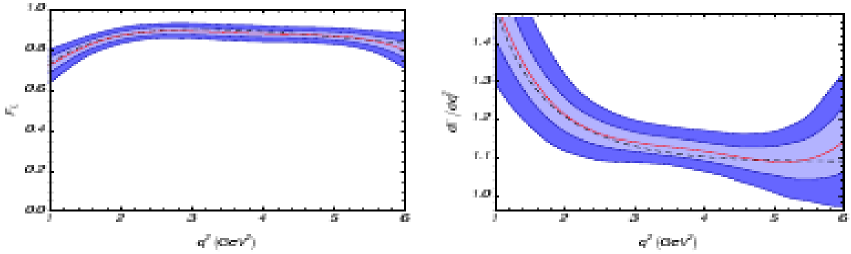
Egede et al.,



(a) $A_{\rm FB}$ (b) $A_{\rm FB}$ zero-crossing (c) $A_T^{(3)}$



(d) $A_T^{(4)}$ (e) $A_{\rm Im}$ (f) $A_T^{(2)}$

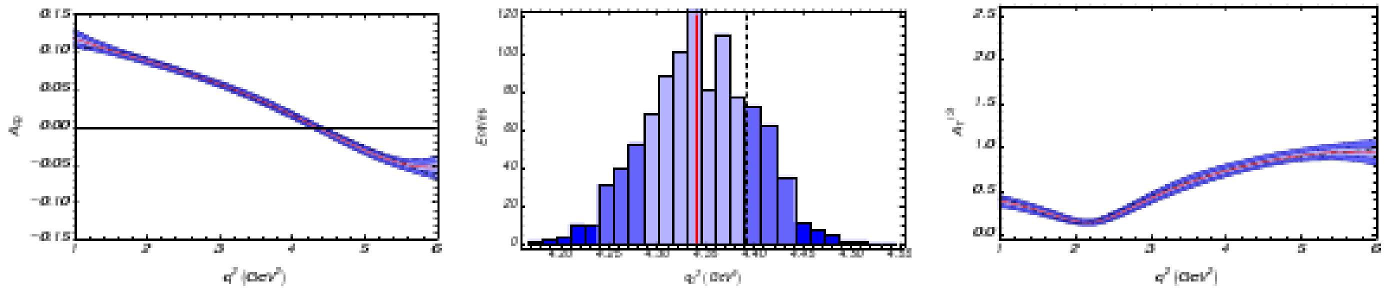


(g) $F_{\rm L}$ (h) Γ'

Bd->K*μμ (100fb^{-1})

error~1-2%

while theory at 10% NLO



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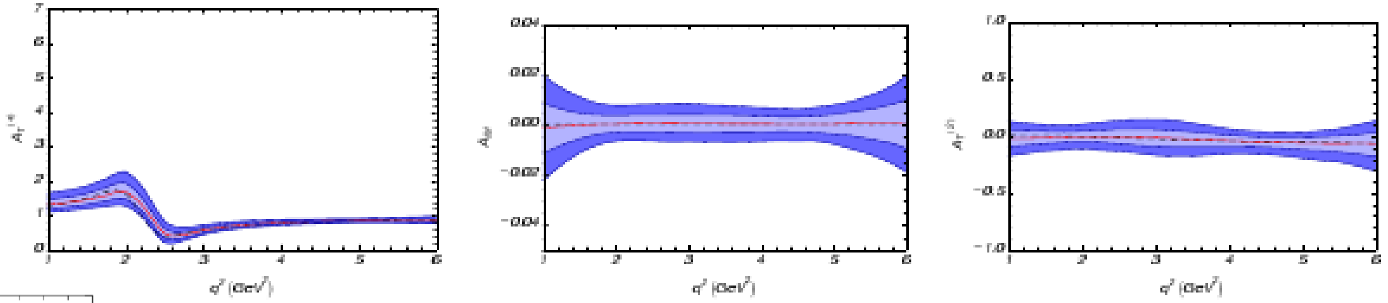
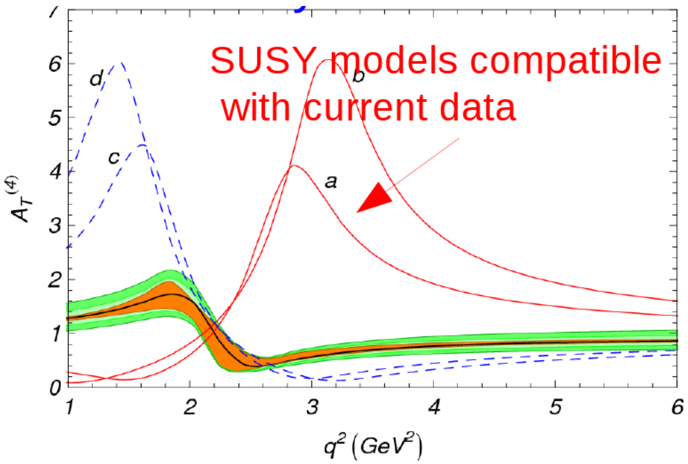
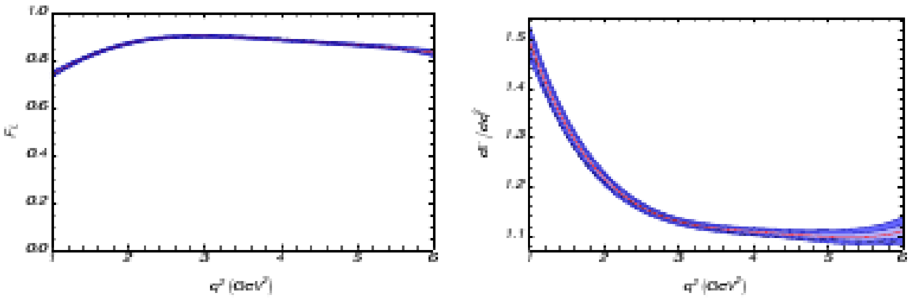


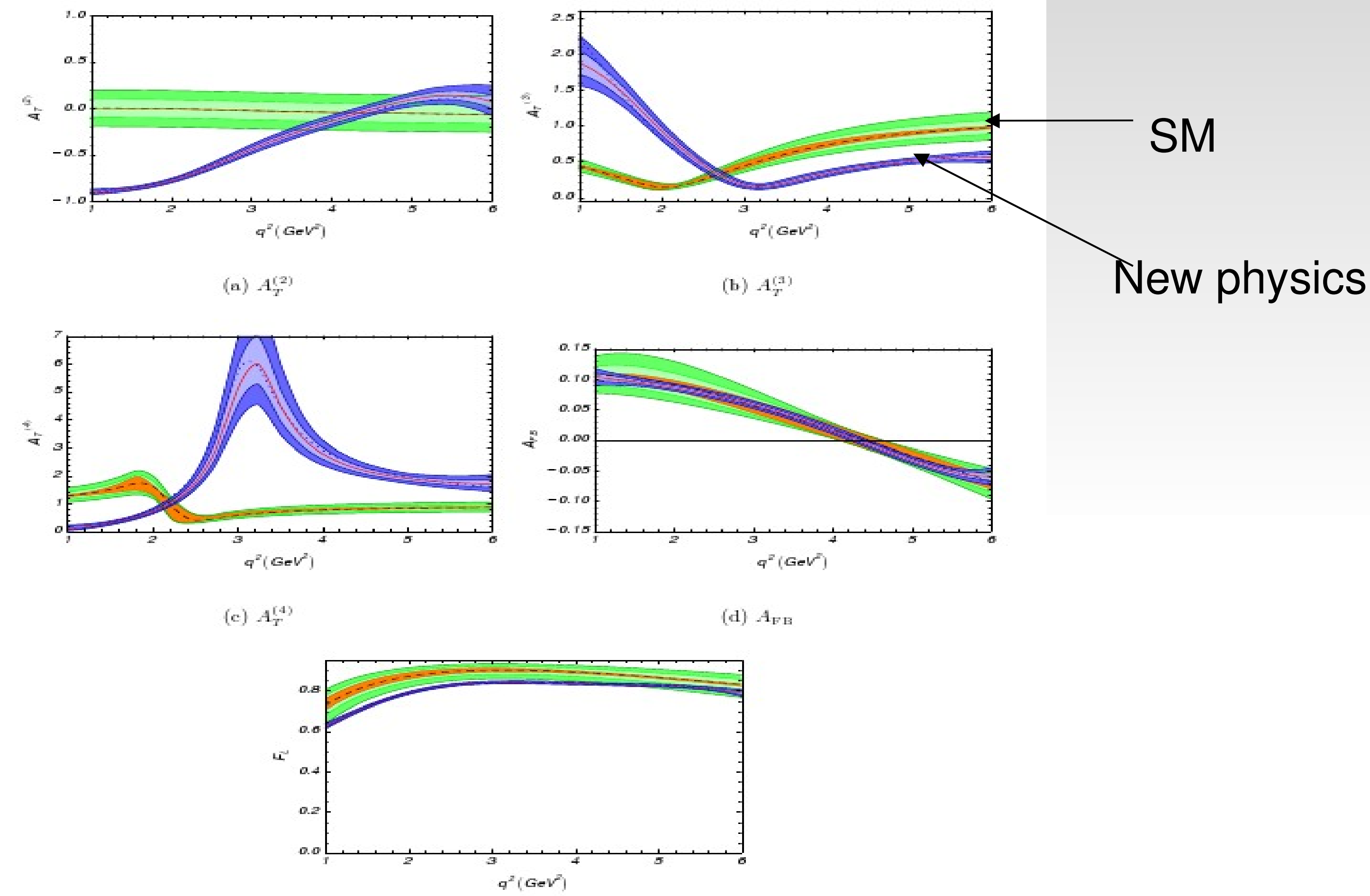
(d) $A_T^{(4)}$ (e) $A_{\rm Im}$ (f) $A_T^{(2)}$



SUSY models compatible with current data



Bd->K*μμ (10fb^{-1}) Comparison with SUSY-b



(a) $A_T^{(2)}$ (b) $A_T^{(3)}$

(c) $A_T^{(4)}$ (d) A_{FB}

SM

New physics

Non MFV model with R-parity conservation with m(g)≃1TeV m(d)≃250GeV an tan(β)=5

an example of a model for which AFB similar to SM and other distributions can discriminate

Bs->μμ

- SM prediction (Buras 06)

$$Br(B_d \to \mu^+\mu^-)^{\rm SM} = (1.03 \pm 0.09) \cdot 10^{-10}, \qquad Br(B_s \to \mu^+\mu^-)^{\rm SM} = (3.35 \pm 0.32) \cdot 10^{-9}.$$

- MFV violation prediction (Buras 06)

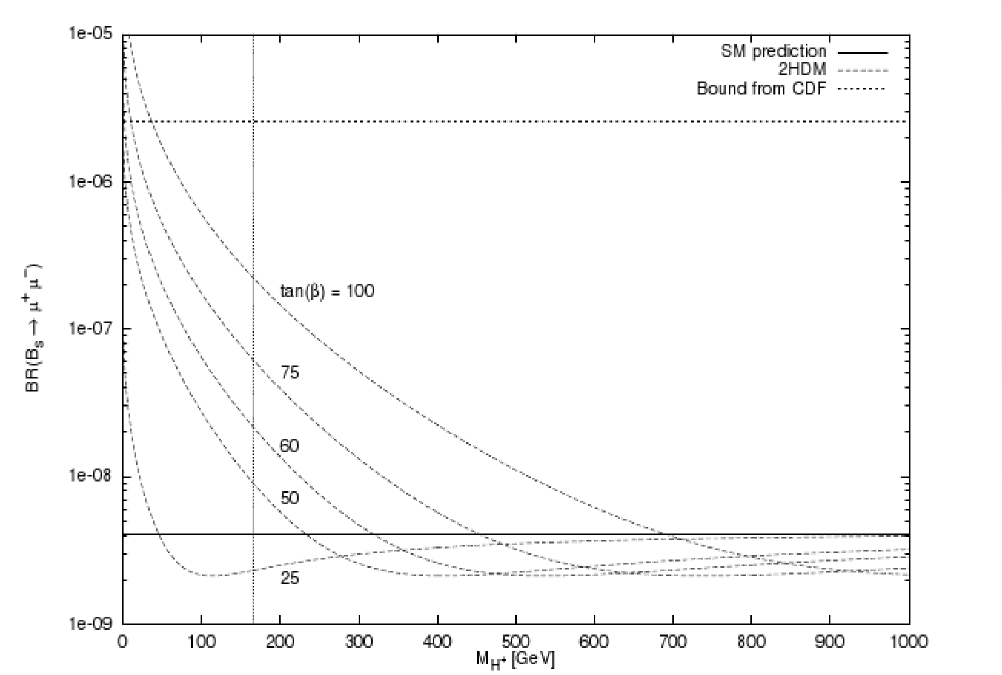
$$\frac{Br(B_s \to \mu^+\mu^-)}{Br(B_d \to \mu^+\mu^-)} = \frac{\hat{B}_{B_d}}{\hat{B}_{B_s}} \frac{\tau(B_s)}{\tau(B_d)} \frac{\Delta M_s}{\Delta M_d} = 32.4 \pm 1.9$$

- MSSM predictions, MFV, for large tanβ no squark mixing

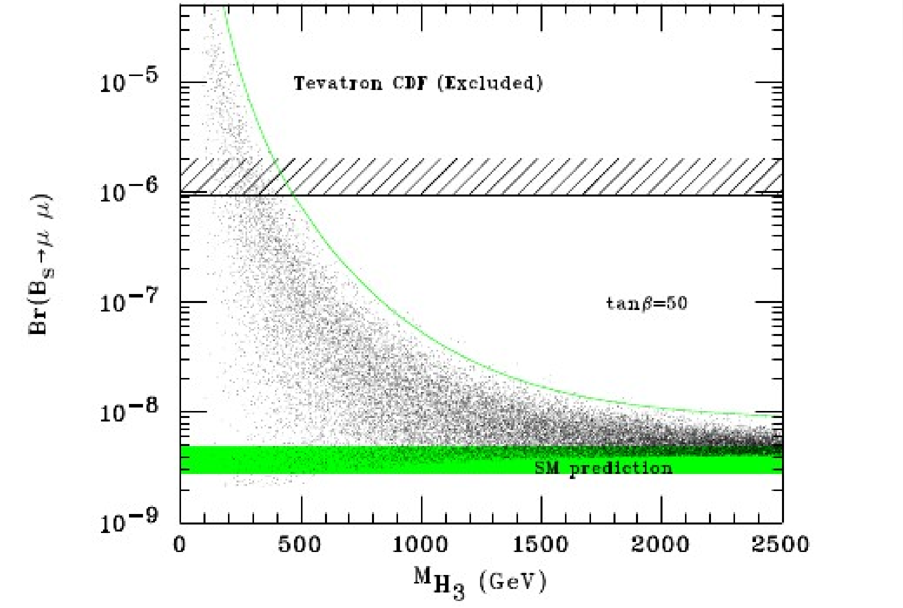
$$B(B_q \to \ell^+\ell^-)_{\rm SUSY} \quad \propto \quad \frac{m_b^2 m_\ell^2 \tan^6\beta}{M_{A^0}^4}$$

- i.e. BR enhanced wrt the SM
- models with additional Higgs bosons
- Extension to more general MSSM at all tanβ and including FV in squark mixing: BR can be even suppressed wrt to the SM

Bs->μμ: NP



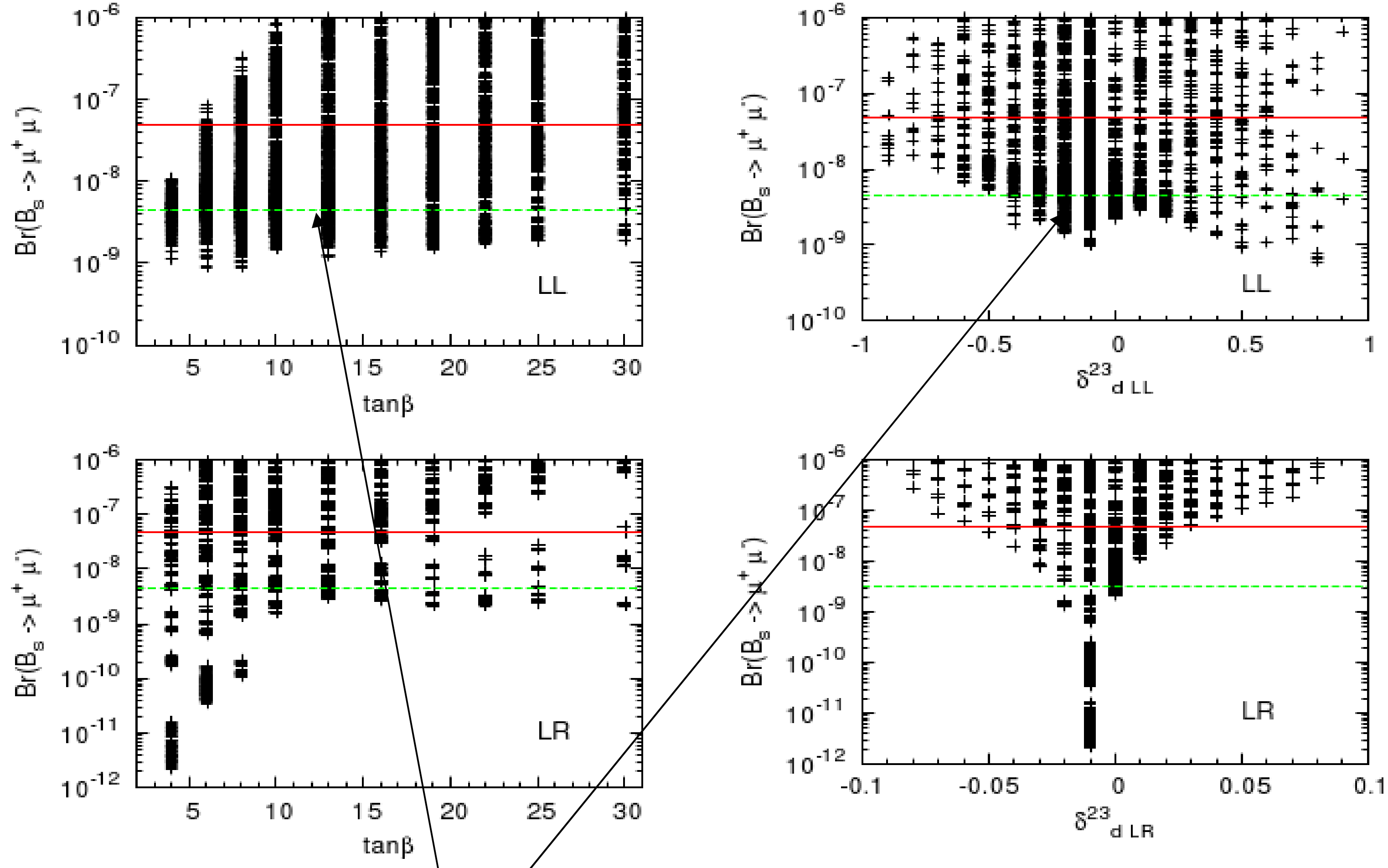
Desdes 03: MSSM Higgs penguin



Logan, Nierste00 : Higgs doublet

Bs->μμ:NP

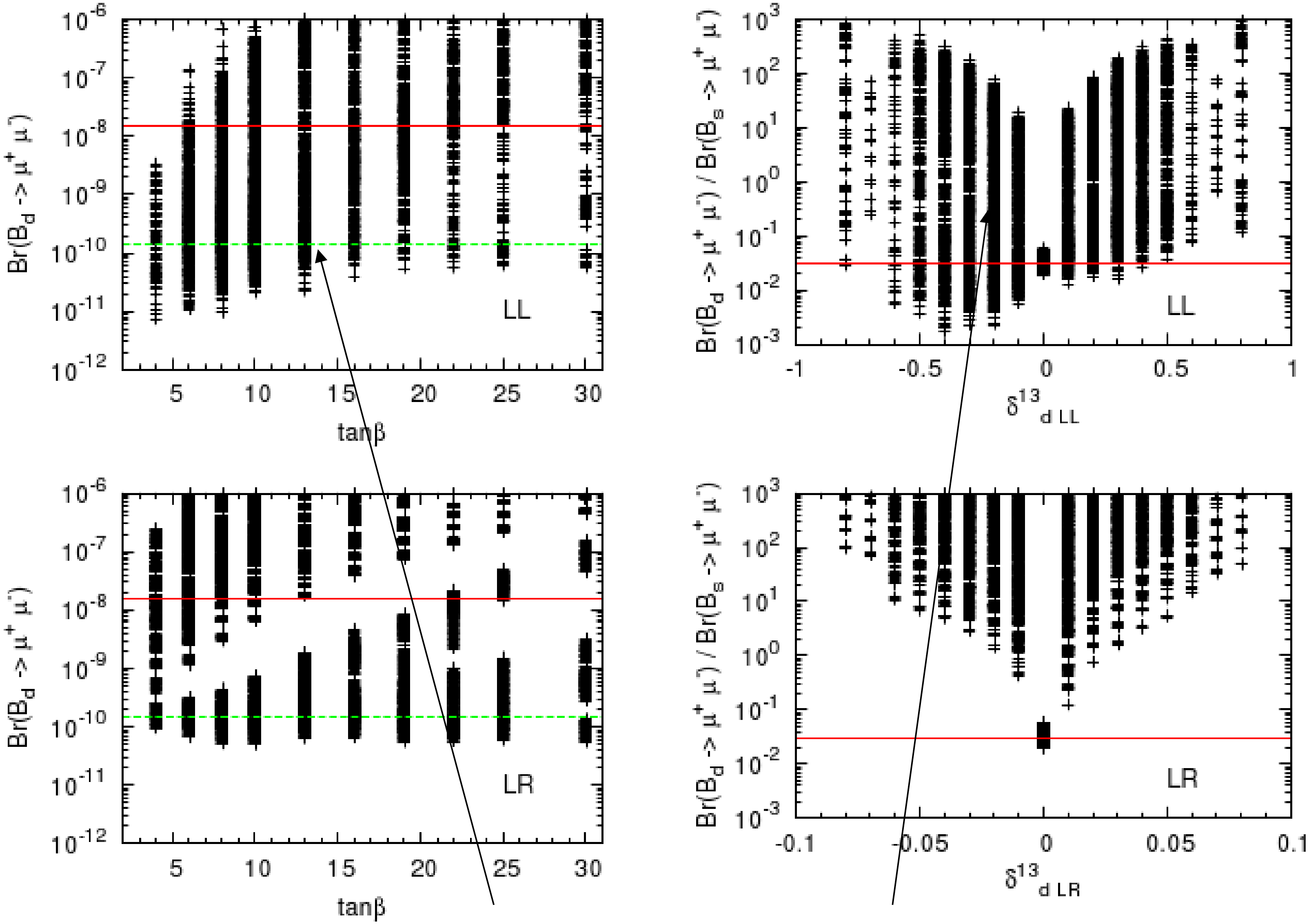
Desdes et al 2008 most general analysis in MSSM



EVEN BELOW SM PREDICTION: many thanks to Desdes from the LHCb collaboration!!!

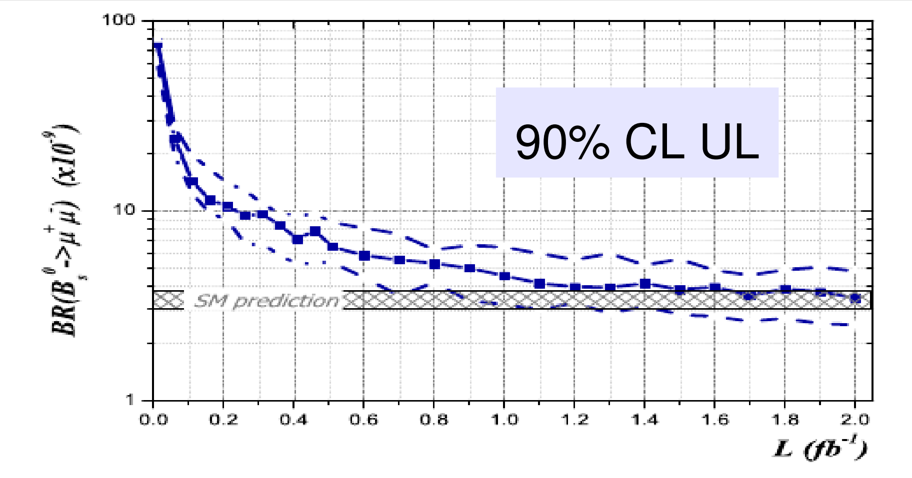
Bs->μμ:NP

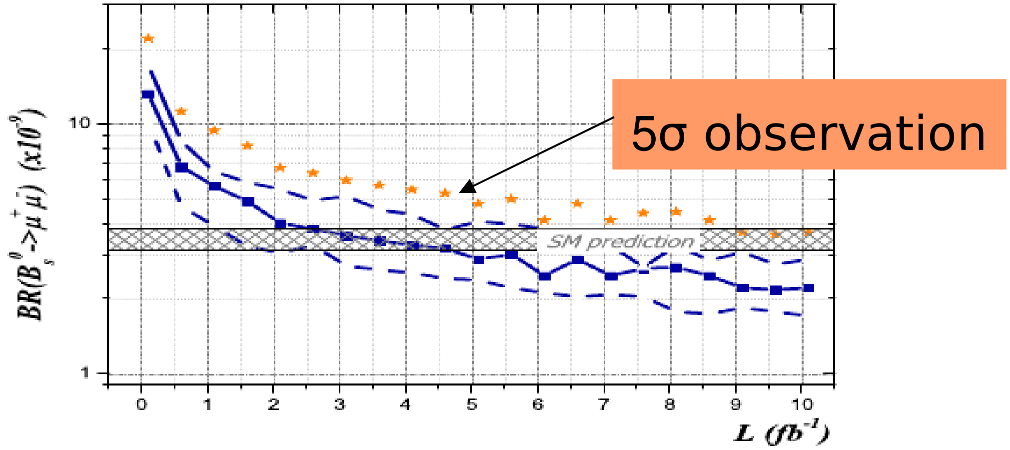
Desdes et al 2008



BR(Bs)/BR(Bd) CAN BE VERY DIFFERENT FROM MFV EXPECTATION

Bs->μμ: LHCb sensitivity





100fb^{-1} 5σ observation   BR(Bs)~10^{-9}

B$_d$→μμ observation feasible, if I we can suppress Bd→hh (dominated by decays in flight).

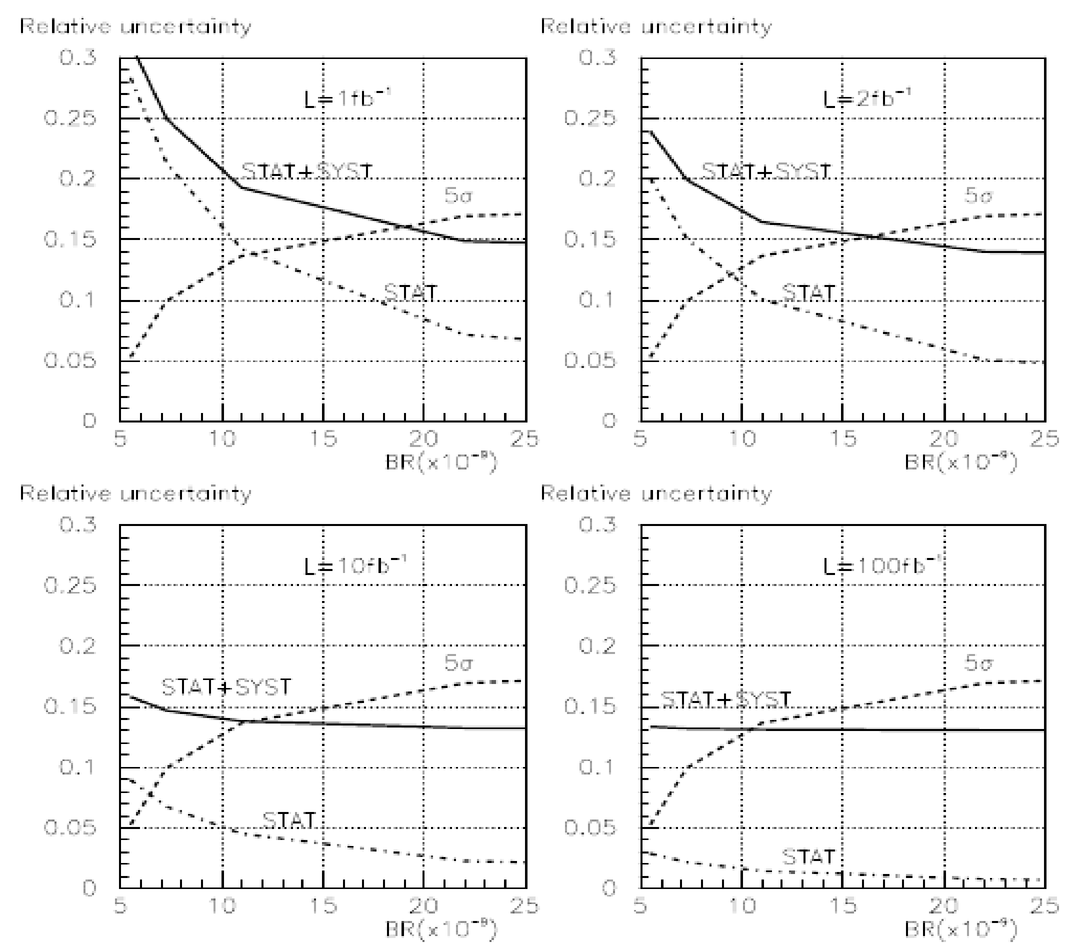
if the cuts remain the same vs L(MC backgorund Lumi only 5pb-1).

But...beware!

The BR is obtained normalising to Bd -->13% systematic irreducibile error

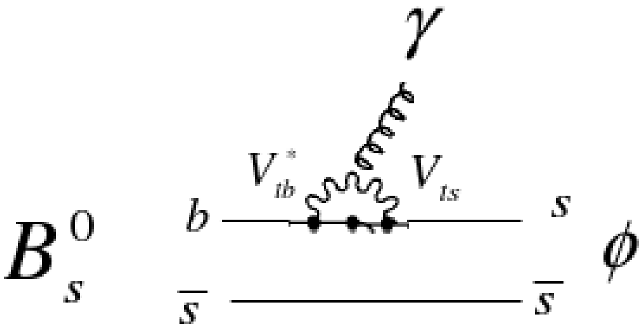
if NP enhances the BR the minimum BR which can be observed incompatible to 5σ with the SM is at high L only ~10^{-8} !!!

With BELLE (Y(5s)) the 13% could go down to 10% ->lattice?



Bs->φγ

- NP appears not only in modifications of Br, but also in asymmetries and the angular effects
- Not *so rare* decays
  - Br(B→K^{*0}γ) = (4.3±0.4)x10^{-5}
  - Br(B_s→Φγ) = (3.8±0.5)x10^{-5}
- 1-amplitude dominance and one Wilson coefficient $C_7^{eff}(\mu)$
- “Direct” asymmetries are small (<1%) for b→sγ & a bit larger *O*(10%) for b→dγ
- Photons are polarized: i.e. B decays to left handed and Bbar to right handed (up to ms/mb correction) --> mixing induced CP asymmetry almost zero if no chirality flipping interactions
- NP (LR symmetric models and MSSM) predict large chirality flippings



Bs->φγ

TDCPV->interference between mixing and decay; if chirality flipping->decay to CP eingenstate

$$\Gamma(\mathrm{B}_q(\bar{\mathrm{B}}_q) \to f^{CP}\gamma) \propto e^{-\Gamma_q t}\left(\cosh\frac{\Delta\Gamma_q t}{2} - \mathcal{A}^{\Delta}\sinh\frac{\Delta\Gamma_q t}{2} \pm \right.$$
$$\left. \pm\mathcal{C}\cos\Delta m_q t \mp \mathcal{S}\sin\Delta m_q t\right)$$

$$\tan\psi \equiv \left|\frac{A(\bar{\mathrm{B}}\to f^{CP}\gamma_R)}{A(\bar{\mathrm{B}}\to f^{CP}\gamma_L)}\right|$$

In the SM $\mathcal{S} \approx \sin 2\psi \sin\varphi,\ \mathcal{A}^{\Delta} \approx \sin 2\psi \cos\varphi,\ \mathcal{C} \approx 0.$

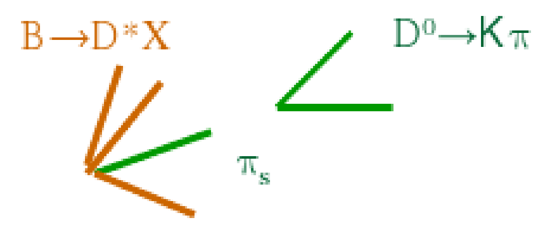
For Bd ΔΓ negligible -> only S with Φ=β

For Bs ΔΓ sizeable -> but S~sin2Φ*(~0)
->sensitivity through A^{Δ} i.e. independent of Φ=βs
ALLOWS DISTINCTION BETWEEN NP IN MIXING AND IN RIGHT HANDED CURRENTS

- Upgraded LHCb sensitivity to $A^{\Delta\Gamma}$ is 0.03
- Reaches the level of theoretical uncertainties

Charm physics

- Charm physics is now firmly part of baseline LHCb physics
- Potential to perform world-best measurements using charm from D* produced in B decays found in HLT trigger stream.
- Partially reconstruct B decay vertex to find birth position of D0 gives good proper time resolution

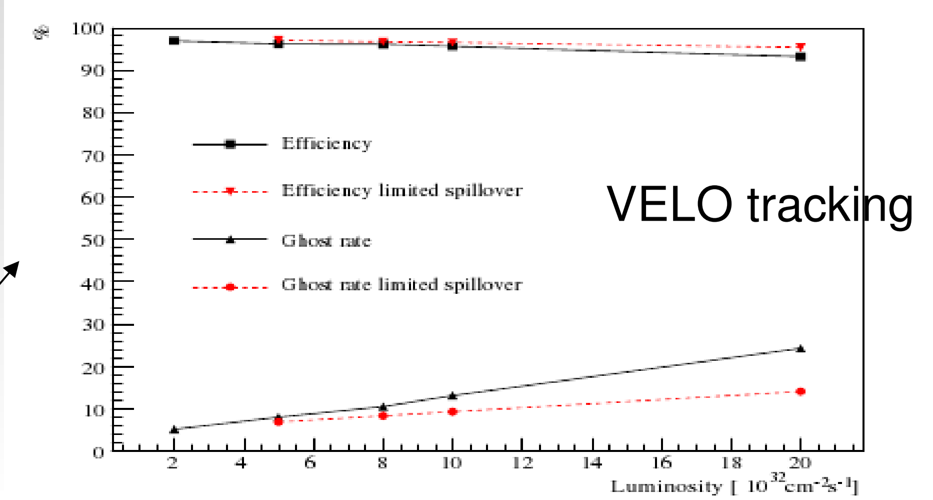


- Studies in benchmark analyses – x'^2 and y' from WS $D^0 \to K\pi$; y_{CP} from KK show great promise;
  $\sigma(x'^2) \sim 6 \times 10^{-5}$, $\sigma(y') \sim 9 \times 10^{-4}$, $\sigma(y_{CP}) \sim 5 \times 10^{-4}$ in 10fb-1
- upgrade yield in $B \to D^* X$, tagged WS $D0 \to K\pi$ $\sim 2.10^6$
- Charm CPV (in mixing, decay or mix-decay interference) is expected to be tiny in the SM, but can certainly be enhanced by NP. Particularly interesting case: SCS decays, where effects of SM and NP will be largest.
- LHCb has statistics to have world best sensitivity in charm CPV; and the upgrade can push limits much further
- eg. upgrade yield in $B \to D^* X$, $D0 \to KK$ $\sim 2.10^8$ (cf. BaBar 130k in 390 fb^{-1})
- Statistics to push sensitivity down to $< 10^{-4}$ – enough to see SM CPV ?

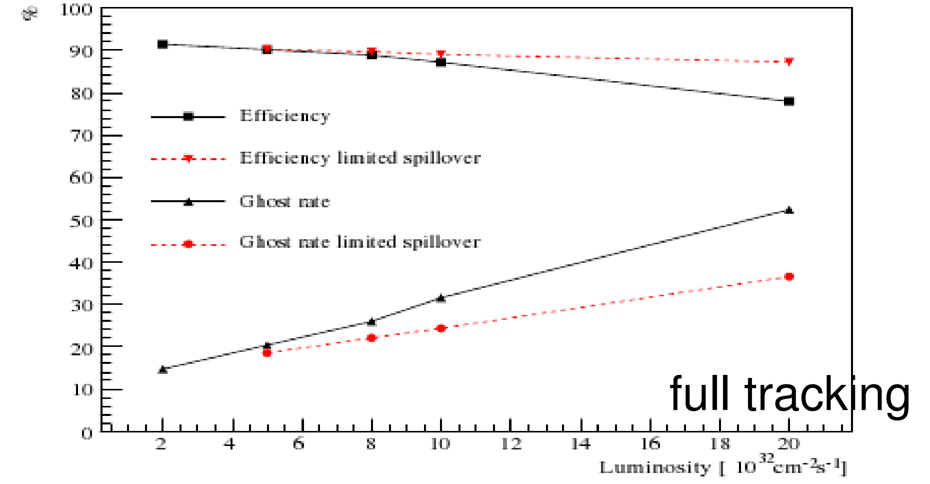
Main limitations of the present detector

Upgrade should involve (at least) factor 10 increase in statistics – so investigate the feasibility of higher luminosity running:

- Limitation from L0 trigger (see after)
- Radiation damage
  - Spec was for less than 20 fb^{-1}
  - Principally affects large η
- Tracking and particle ID:
  - Straws: significant problems from spill-over above 10^{33} $cm^{-2}s^{-1}$
  - Steady (but slow) degradation of hadron PID and tracking with lumi
  - Si tracking however fine

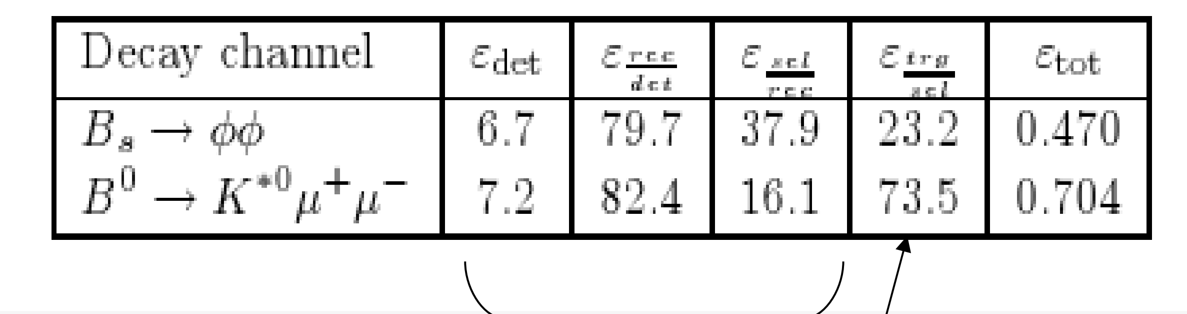


VELO tracking



full tracking

What to improve beyond L?



Decay channel	$\varepsilon_{\rm det}$	$\varepsilon_{\frac{rec}{det}}$	$\varepsilon_{\frac{sel}{rec}}$	$\varepsilon_{\frac{trg}{sel}}$	$\varepsilon_{\rm tot}$
$B_s \rightarrow \phi\phi$	6.7	79.7	37.9	23.2	0.470
$B^0 \rightarrow K^{*0}\mu^+\mu^-$	7.2	82.4	16.1	73.5	0.704

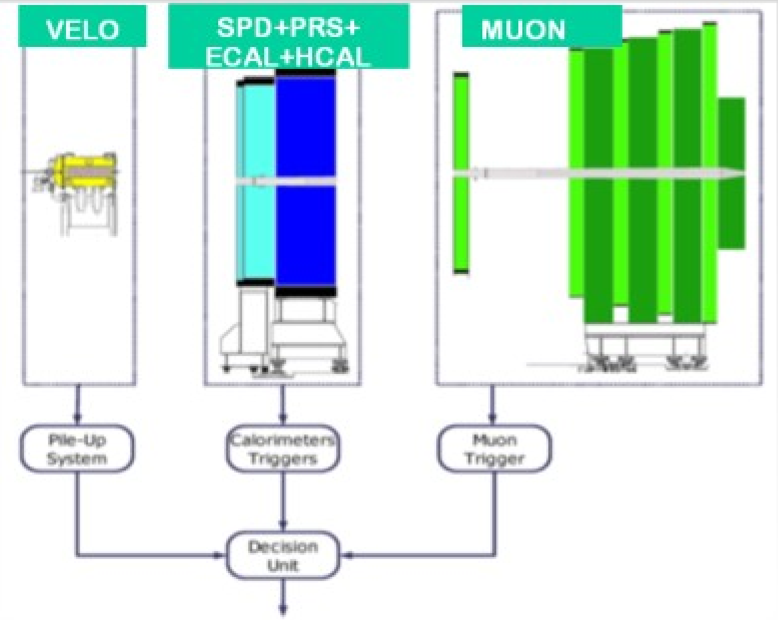
already almost at maximum possible

improve trigger efficiency for hadronic channels

The present LHCb trigger

L0 hardware based:

- largest Et hadron, e(γ) and μ
- if L=2-->$5\cdot10^{32}$,hardwired bottlenecks:
  - 1MHz max-output rate
  - Latency: 2.5μs for trigger
- L0 retention ~10-->5%

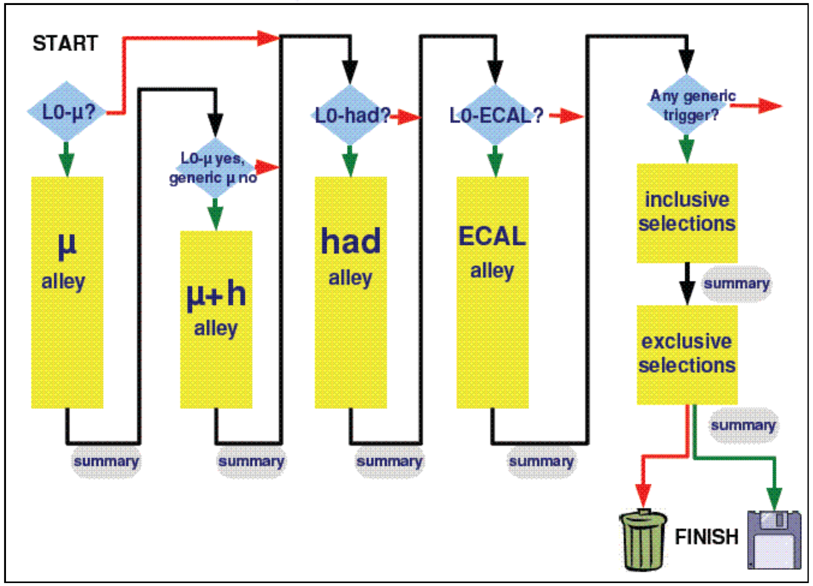


HLT PCfarm of ~2000 multicore boxes

Full detector information available

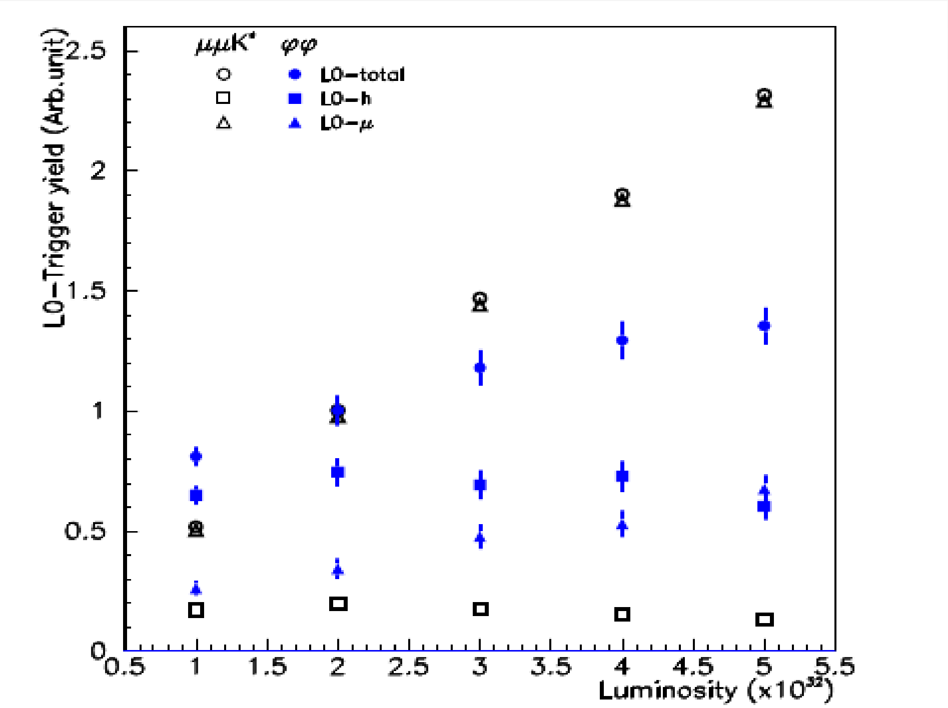
Only limit is CPU time

- ➢ First uses tracking information to **confirm L0 objects ⊕ optional IP Cut**
- ➢ rate reduced to ~**30kHz**
- ➢ Then build **inclusive** and **exclusive** selections: full event reconstruction



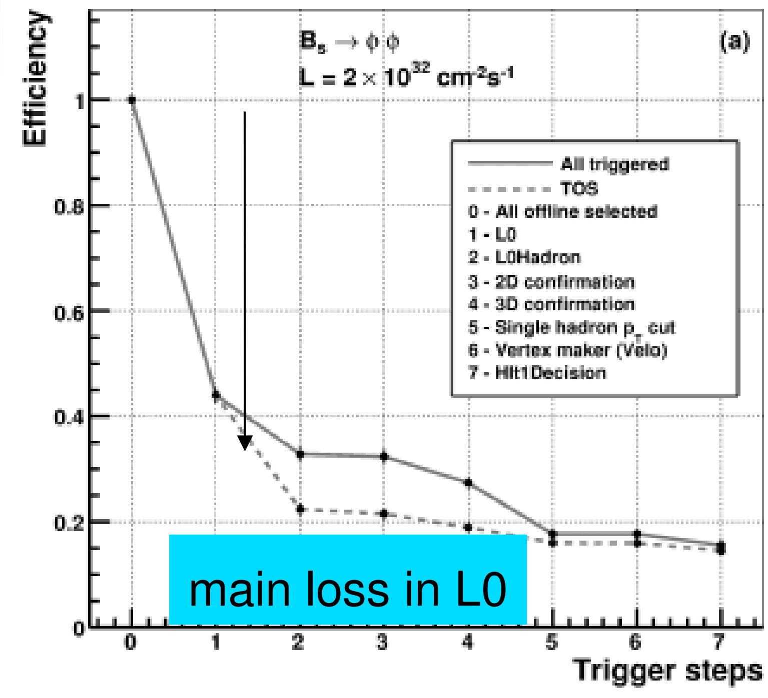
Limitation of L0 and effect on physics

- if L>2-3x10^{32} no hadron trigger gain since due to the 1MHz bottleneck -->Et cut rises
- main problem->hadron trigger



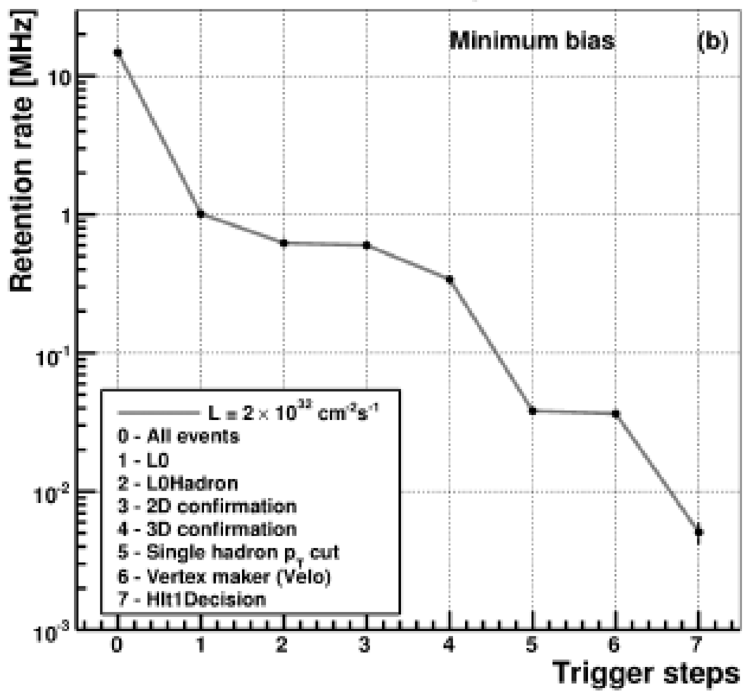
Present L0+HLT1 hadron line

- L0-Hadron: 1.3 clusters/event with Ehadron > 4 GeV. (TOS=Trigger on Signal)
- 2D/3D Confirmation: Match Clusters→VELO, IP> 100 µm: 2.2 tracks/event.
- Single hadron pT cut: Forward tracking to T-stations: pT > 2. GeV: 1.2 tracks/event.
- Velo Vertex: Vertex with other VELO tracks with IP> 100 µm (12/event): 4 vertexes/event.
- Hlt1Decision: 2nd track in vertex →T1-T3, pT2 > 1. GeV.



main loss in L0

Bs→ϕϕ efficiency: 18% (16% TOS)

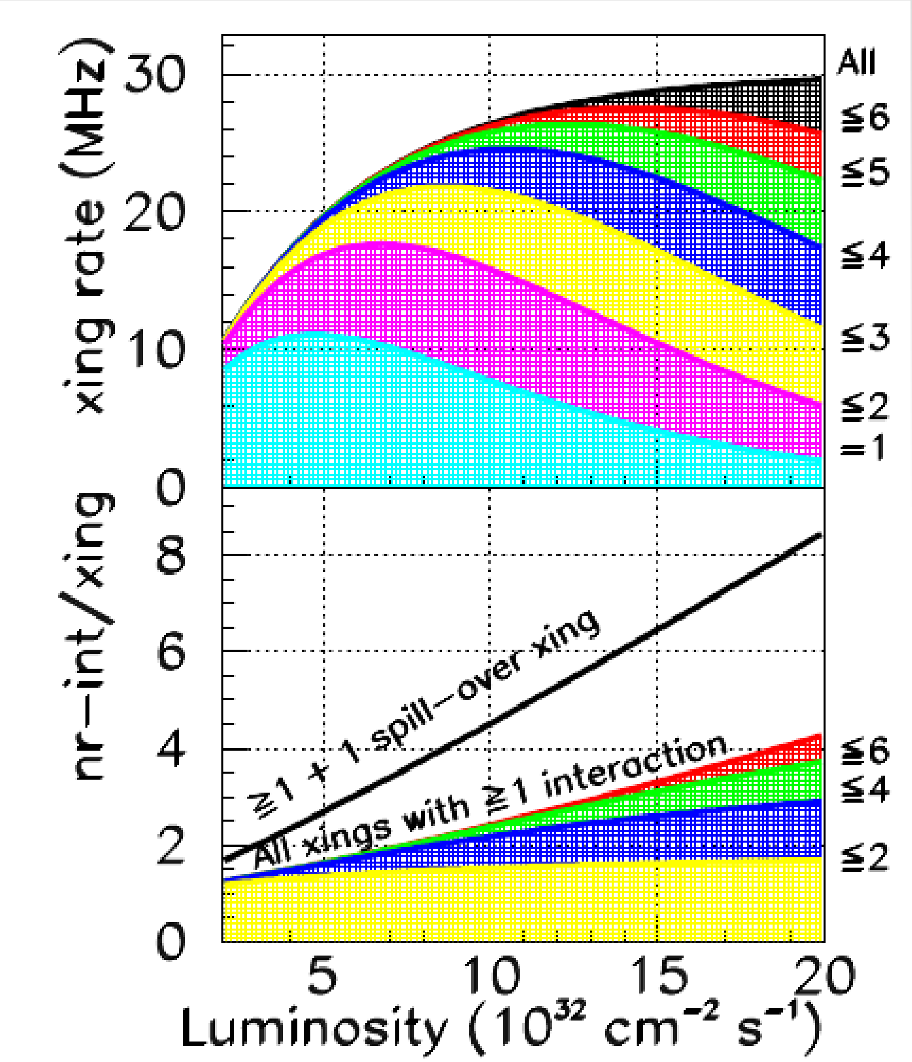


2000

Minimum bias rate: ~7 kHz

LHC and the luminosity

- Assume σ(visible) = 63 mb.
  - @2.10^{32} : ~ 10 MHz xings with ≥ 1 int.
  - @10^{33} : ~ 26 MHz xings with ≥ 1 int.
- nr-int/xings: only factor 2 increase up to @10^{33}
- spill over in the OT increases by a factor of 3

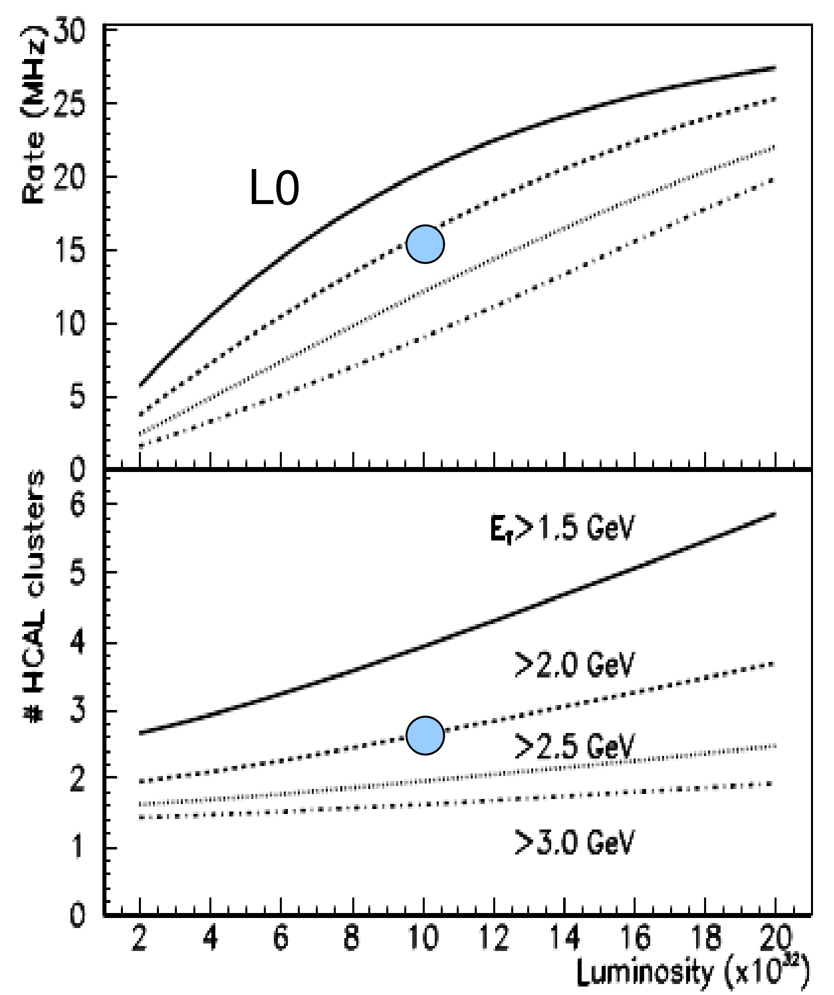


How to upgrade the trigger?

- Several (MC) studies done, conclusions:
  - Need to reconstruct all primary vertexes (PV) per bunch crossing.
  - Need to measure impact parameter (IP) of tracks to any PV.
  - Need to measure pT of tracks with significant IP
- So a design for First level trigger: cut on pT .AND.IP/track simultaneously.
- To achieve the above: perform trigger in software on a large CPU farm capable of coping with an input rate up to 30 MHz.
- This gives the additional flexibility to adapt to the physics landscape in the next decade.
- Note:
  - some FE are limited to 1 MHz read-out rate.
  - 2.5 µs is maximum time for a trigger reconstruction+decision, far too short for a CPU farm to return the trigger decision.
- As a consequence All FE electronics has to be able to read-out at 40 MHz.

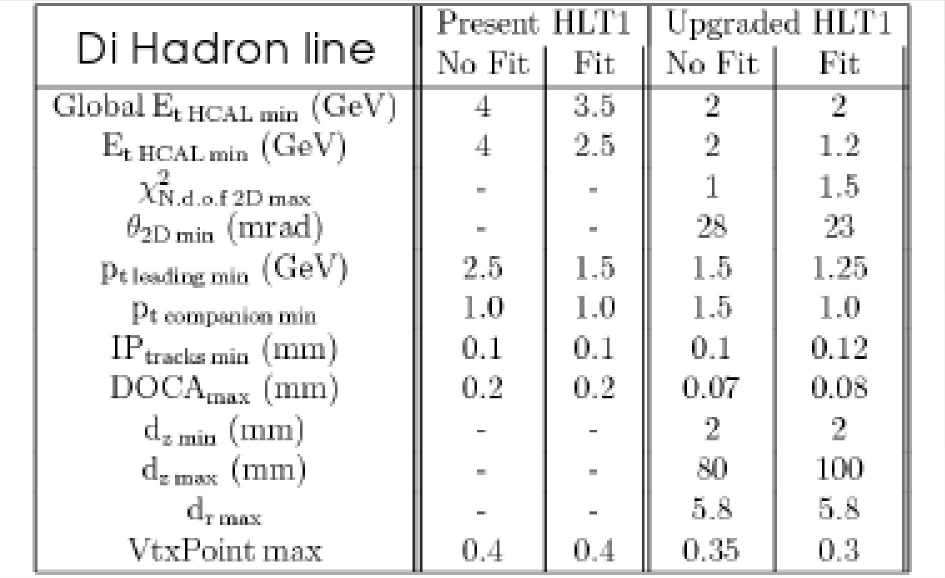
Hadron trigger at 10^{33}: min bias

- Compare 2 → 10 × 10^{32} cm^{-2} s^{-1} :
- Nr “seeds”/event 1.3 → 2.5 for 3.6→2 GeV cut.
- Input rate 1 → 15 MHz
- Prospects for full software algorithm look good, since nr “seeds”/event does not increase too much.

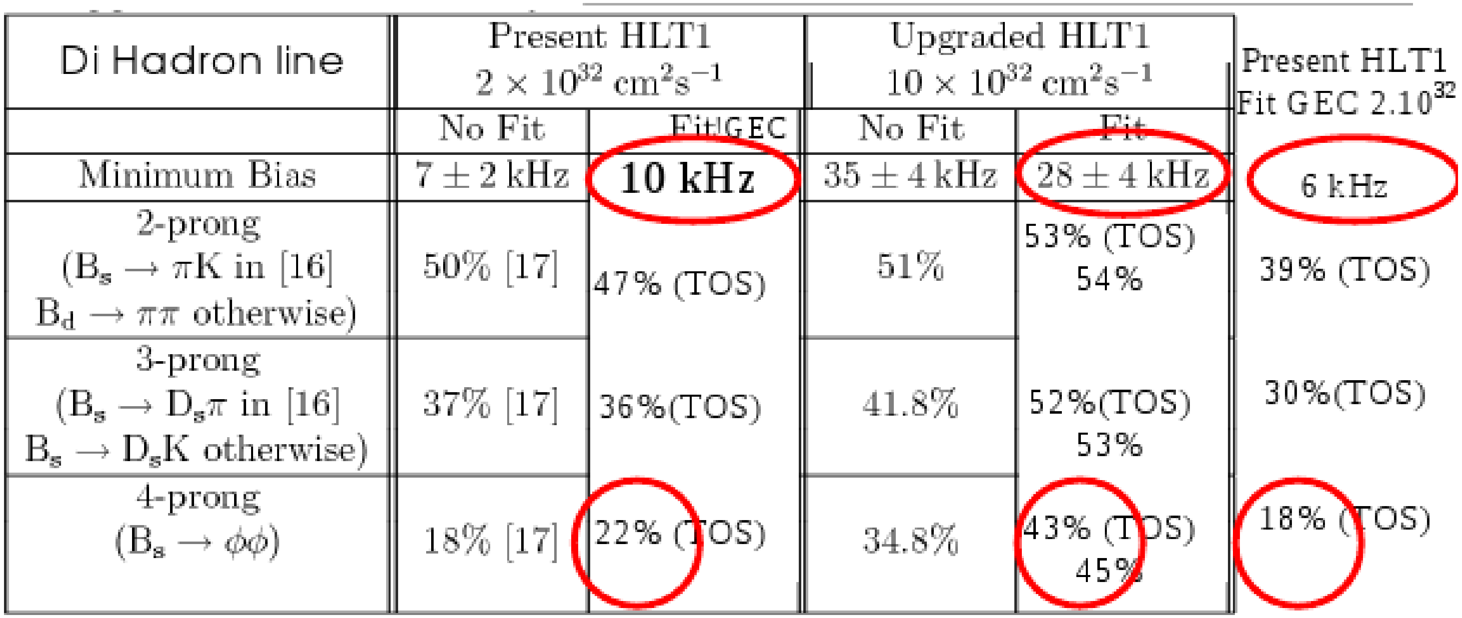


Hadron trigger at 10^{33}: new tuning of HLT1

very preliminary



Di Hadron line	Present HLT1 No Fit	Present HLT1 Fit	Upgraded HLT1 No Fit	Upgraded HLT1 Fit
Global $E_{t\ \mathrm{HCAL\ min}}$ (GeV)	4	3.5	2	2
$E_{t\ \mathrm{HCAL\ min}}$ (GeV)	4	2.5	2	1.2
$\chi^2_{\mathrm{N.d.o.f\ 2D\ max}}$	-	-	1	1.5
$\theta_{\mathrm{2D\ min}}$ (mrad)	-	-	28	23
$p_{t\ \mathrm{leading\ min}}$ (GeV)	2.5	1.5	1.5	1.25
$p_{t\ \mathrm{companion\ min}}$	1.0	1.0	1.5	1.0
$IP_{\mathrm{tracks\ min}}$ (mm)	0.1	0.1	0.1	0.12
$DOCA_{\mathrm{max}}$ (mm)	0.2	0.2	0.07	0.08
$d_{z\ \mathrm{min}}$ (mm)	-	-	2	2
$d_{z\ \mathrm{max}}$ (mm)	-	-	80	100
$d_{r\ \mathrm{max}}$	-	-	5.8	5.8
VtxPoint max	0.4	0.4	0.35	0.3



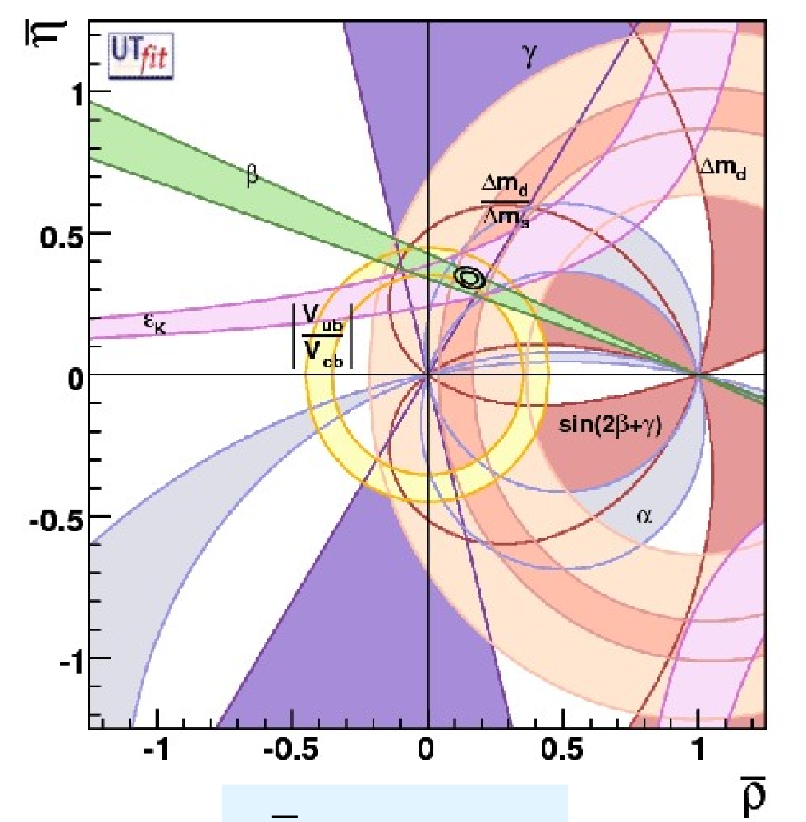
Di Hadron line	Present HLT1 2×10^{32} cm^{2}s^{-1}		Upgraded HLT1 10×10^{32} cm^{2}s^{-1}		Present HLT1 Fit GEC 2.10^{32}
	No Fit	Fit/GEC	No Fit	Fit	
Minimum Bias	7 ± 2 kHz	**10 kHz**	35 ± 4 kHz	28 ± 4 kHz	6 kHz
2-prong ($B_s \to \pi K$ in [16] $B_d \to \pi\pi$ otherwise)	50% [17]	47% (TOS)	51%	53% (TOS) 54%	39% (TOS)
3-prong ($B_s \to D_s\pi$ in [16] $B_s \to D_s K$ otherwise)	37% [17]	36%(TOS)	41.8%	52%(TOS) 53%	30%(TOS)
4-prong ($B_s \to \phi\phi$)	18% [17]	22% (TOS)	34.8%	43% (TOS) 45%	18% (TOS)

Conclusion

- Physics case for an LHCb upgrade rather solid:
    - for many observables with 10fb-1 we will not reach the theoretical limit
    - opportunity to study the nature of NP discovered during the first phase of LHC
- Trigger design can cope with rate
- need to start asap with detector and DAQ/electronics developments

the end

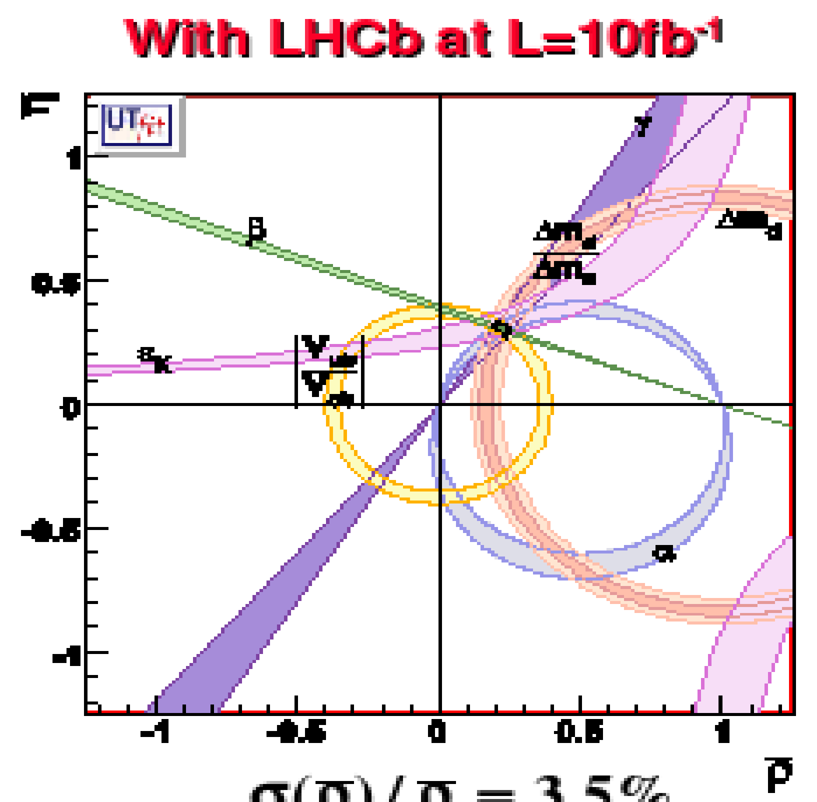
LHCb physics in $10fb^{-1}$



NOW

$\bar{\rho} = 0.155 \pm 0.022$

$\bar{\eta} = 0.342 \pm 0.014$


With LHCb at $L=10fb^{-1}$

$\sigma(\bar{\rho})/\bar{\rho} = 3.5\%$

$\sigma(\bar{\eta})/\bar{\eta} = 1.7\%$

courtesy Vagnoni

if all Standard Model