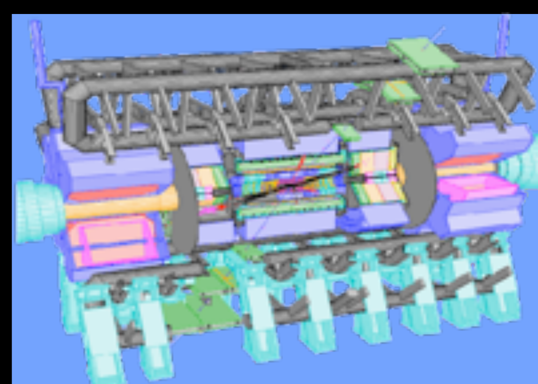
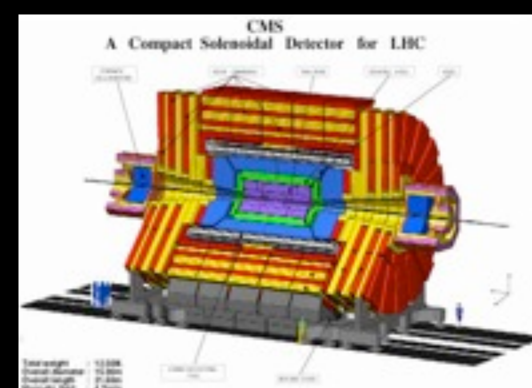
LHC ready for di-muon decays to search for rare process

$B \rightarrow \mu\mu$

Maria Smizanska
Lancaster University, UK





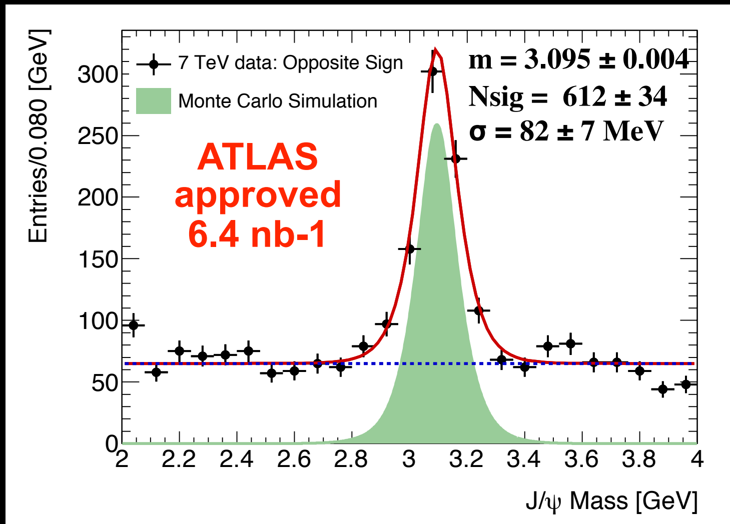
Layout of the talk

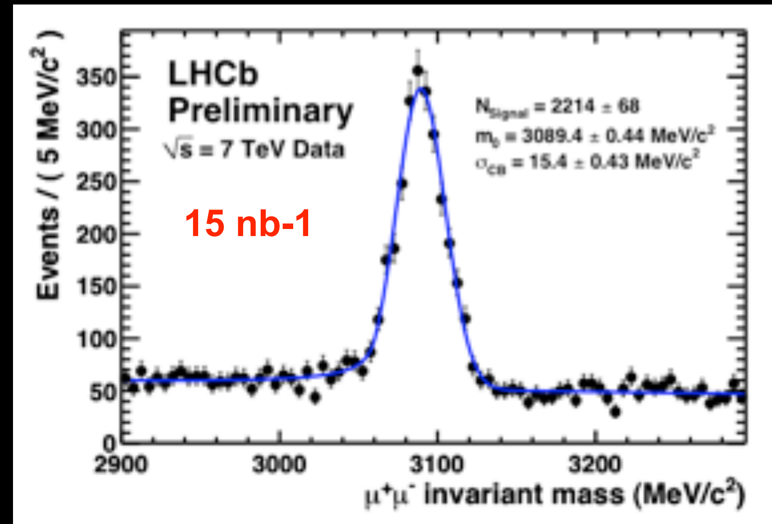
- LHCb, ATLAS, CMS - first results on di-muon performance with J/ψ signals

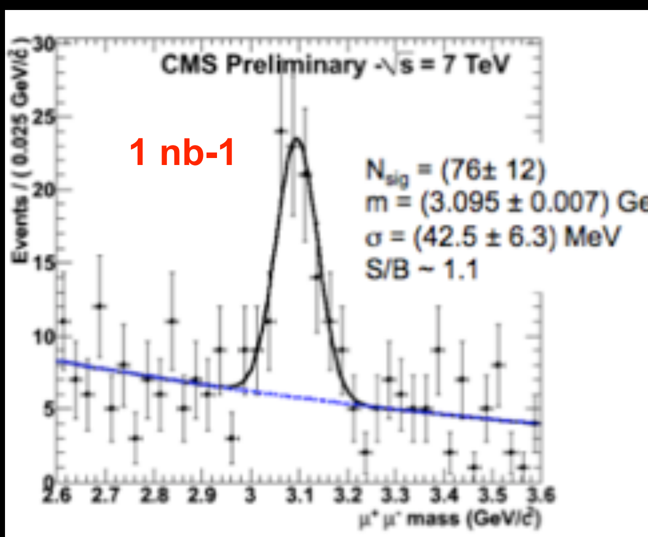
- Bs →μμ current experimental status
- Physics motivations

- Expected sensitivity for B→ μμ from simulations
- LHC perspective

LHC di-muon signals with first few nb-1



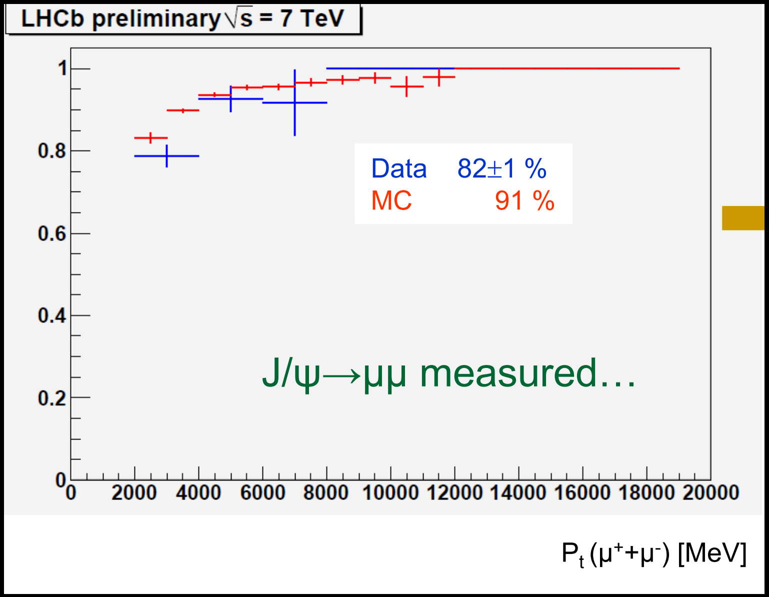


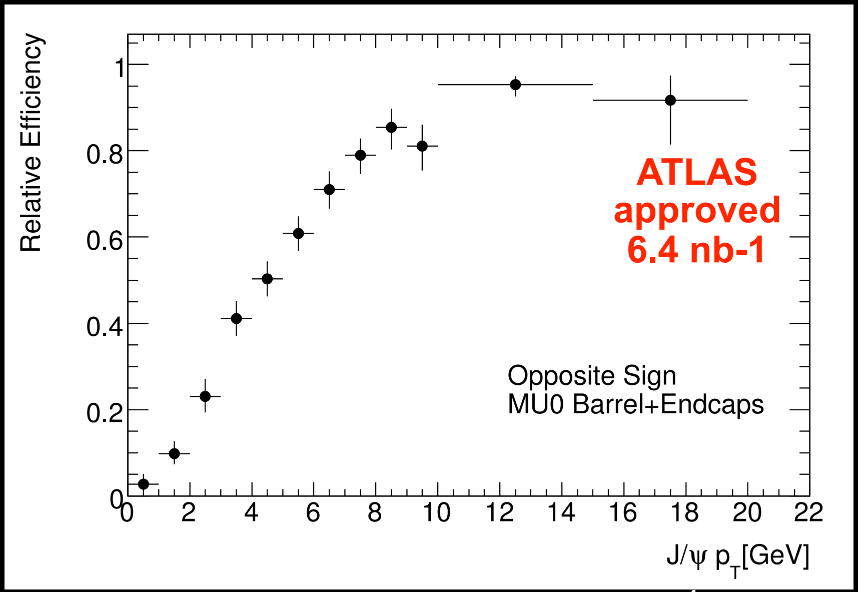


- All experiments used Min bias triggers
- all experiments determine mass identical to PDG! This result is consequence of excellent work on understanding detector material, mg fields, alignments using cosmics, 900 GeV data.
- Jpsi mass sensitive to material but less to mislignments.
- More statistics will allow to use Jpsi for further improvement in understanding detector.
- Nsig and background levels not to be compared between experiments at this stage - selection criteria not the same - each collaboration chosen their own (and many various) - goal is to understand performance.

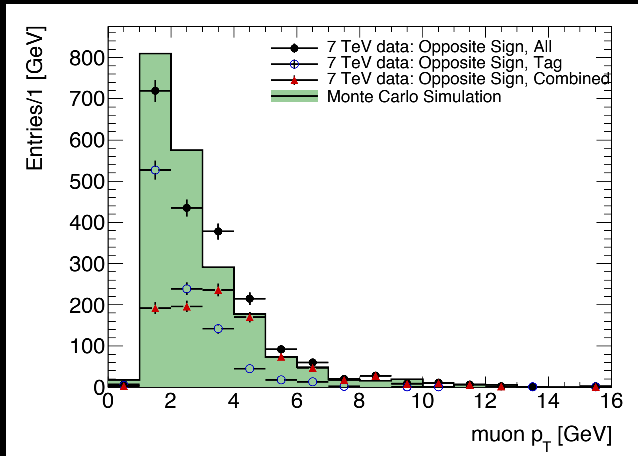
First measurements of L1 muon-trigger efficiencies using J/ψ candidates comparison of LHCb and ATLAS coverage

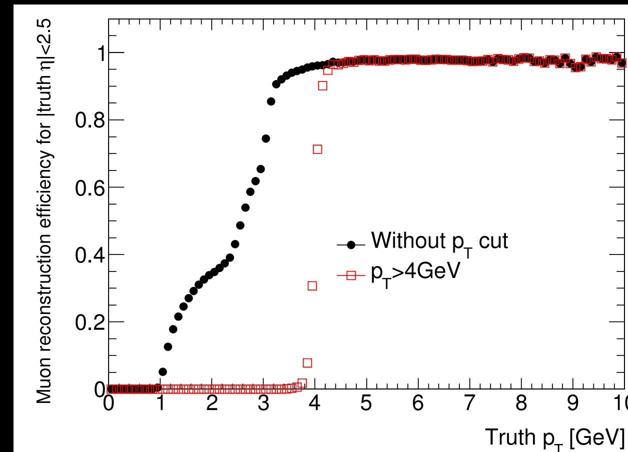
- LHCb detector is designed to register forward muons $1.9 < \eta < 4.9$ hence cover lower pT muons/di-muons. ATLAS/CMS are designed to cover more central region $|\eta| < 2.5$
- First measurements of di-muon trigger efficiency are now done - illustrate this difference.
- For ATLAS L1MU0 trigger (shown here) will be limited to $\mathcal{L} <\sim 10^{31}$ cm^{-2} s^{-1} later replaced by di-muon L1 triggers of thresholds 4, 6 GeV. Same strategy in CMS.



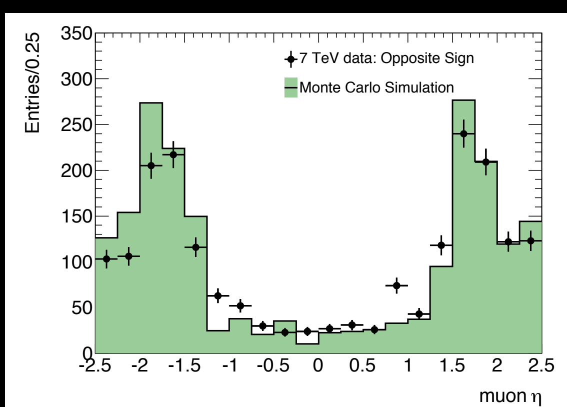


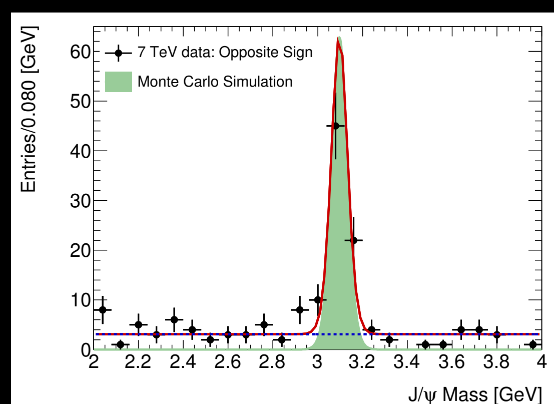
More on performance of early J/ψ in ATLAS

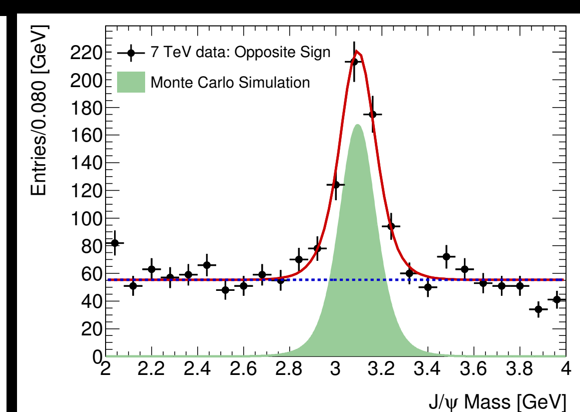




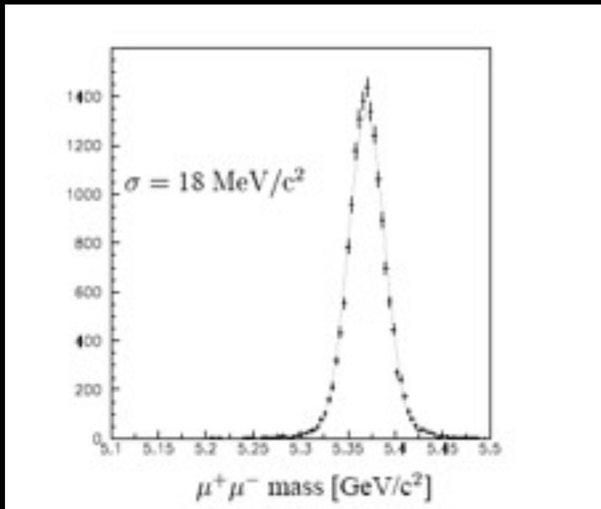
- Min bias triggers allowed to approach very low pT muons (top)
- consequently excess of high eta muons (bottom)
- Barrel mass resolution 2.5 better than endcap - corresponds to MC



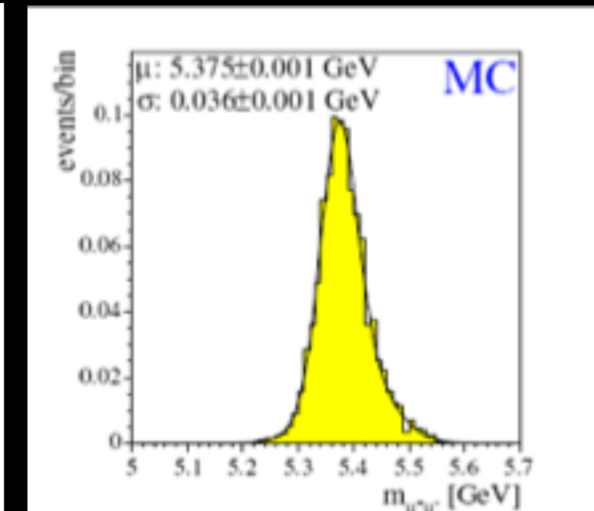




MC simulations of mass resolutions for Bs→μμ

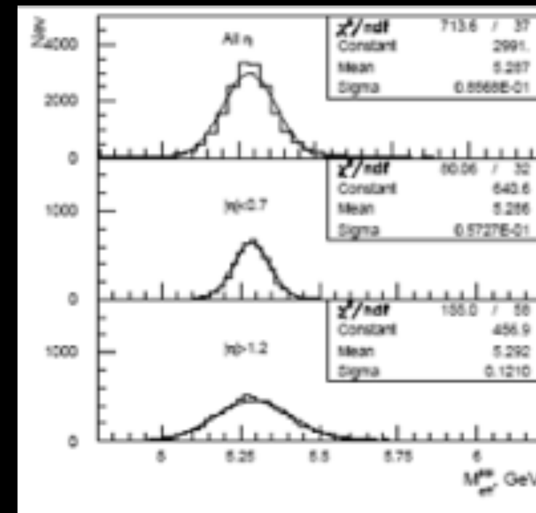


LHCb σ =18 MeV



CMS σ=36 MeV,

4 Tesla $p_{T>}$ 3-6 GeV



ATLAS σ = 84 MeV

2 Tesla pT > 6 GeV

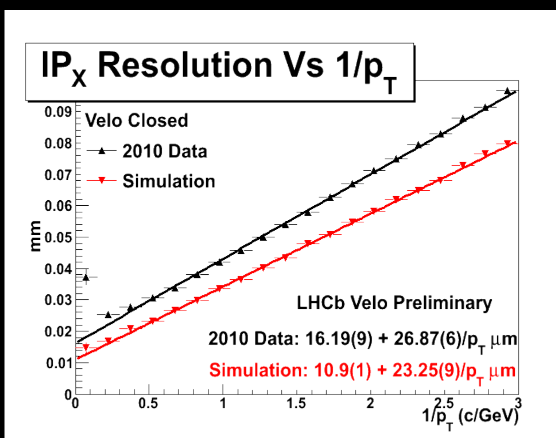
- Even if current experimental coverage of di-muon with Min bias trigger and relaxed muon selections is not as simulated for standard triggers and selections at higher luminosities, it is seen that the observed relative resolutions between experiments

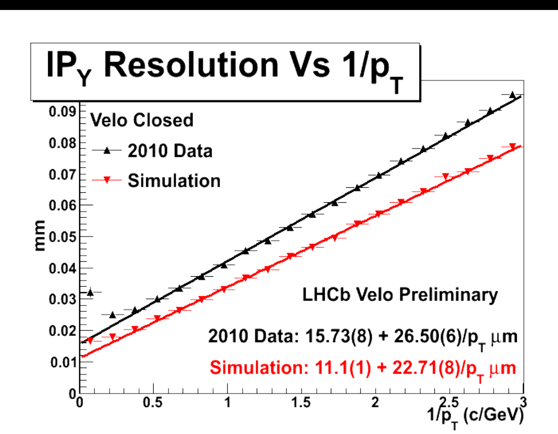
J/ψ 15 MeV LHCb / 42MeV CMS/ 82 MeV ATLAS

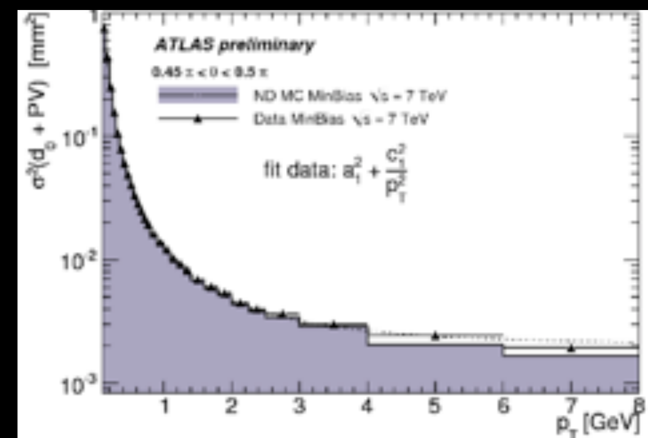
- scale same way as those predicted for Bs- μμ.

Tracking performance - impact parameter resolutions - with early data

- Vertex and lifetime resolution are essencial for sensitive Bs-μμ measurement
- LHC experiments are studying J/ψ vertex performance, results will be published soon, but not yet public. I am not authorized to show any...
- Impact parameters resolution of tracks - is a good measure of lifetime resolution -here shown to illustrate current status
- Ultimate d0 resolutions not yet achieved at LHC experiments: beam size still larger, min bias triggers - low number of tracks to build PV, most of tracks very low pT.

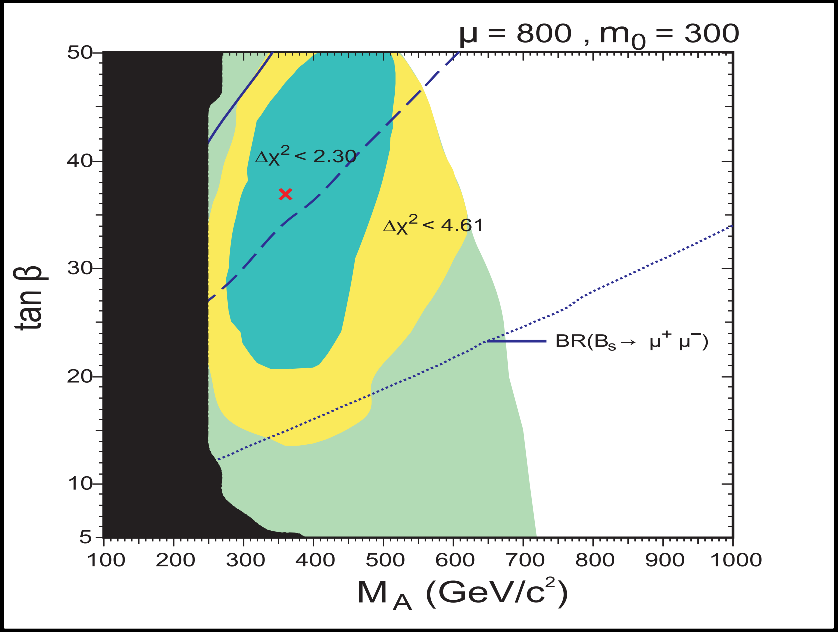






Physics motivations to measure B → μμ

- The SM prediction has been computed to be Br(Bs→ μ+μ−) = (3.35 ± 0.32) × 10−9 using the measurement of the Bs0 oscillation frequency at Tevatron (ΔMs = 17.8 ± 0.1 ps−1) , which significantly reduces the uncertainties in the SM prediction.
- the MSSM, branching ratio Br(Bs→ μ+μ−) is known to increase as the sixth power of the ratio of Higgs vacuum expectation values, tan β. Any improvement on this limit is therefore particularly important for SUSY models with large tan β.



- Best fit and χ2 contours in the plane (MA , tan β) MA is the mass of the CP-odd neutral Higgs in the MSSM, with large tan β.
- the fit to several observables, including the anomalous magnetic moment of the muon.
- The dark area is excluded by previous measurements.
- The lines indicate the excluded region when B(Bs → μ+μ−) < 10−7 (continous), 2 × 10−8(dashed), or 5 × 10−9 (dotted).

- Important constraint to theory will be measurement of ratio of the two decay probabilities:

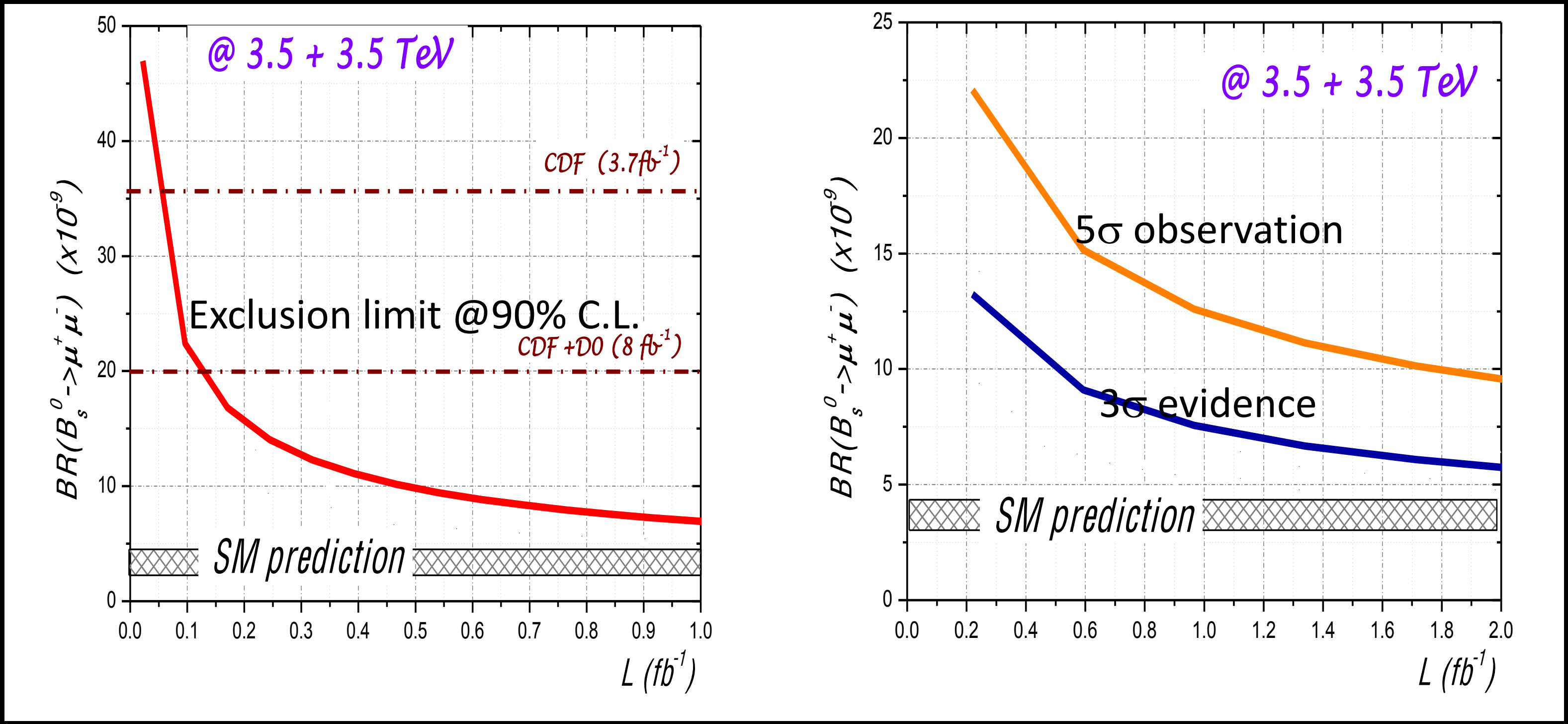
Br(Bs→ μ+μ−) /Br(Bd→ μ+μ−)

Current Experimental Limits on B $\rightarrow$ $\mu\mu$

	$B_s \rightarrow \mu\mu$	$B_d \rightarrow \mu\mu$	
SM	**3.35+- 0.032 10^{-9}**	**0.9 10^{-10}**	arXiv:0806.4846
CDF 3.7 fb-1	4.3 $*10^{-8}$ 95%CL	7.6$*10^{-9}$ 95%CL	CDF Public Note 9892
D0 5 fb-1	5.3 $*10^{-8}$ 95%CL	11.1$*10^{-7}$ 95%CL (700pb-1)	DØ Note 5906-CONF
Belle 78 fb-1	-	1.6 $*10^{-7}$ 90% CL	PRD68, 111101
BaBar 111 fb-1	-	0.61$*10^{-7}$ 90% CL	PRL94, 221803

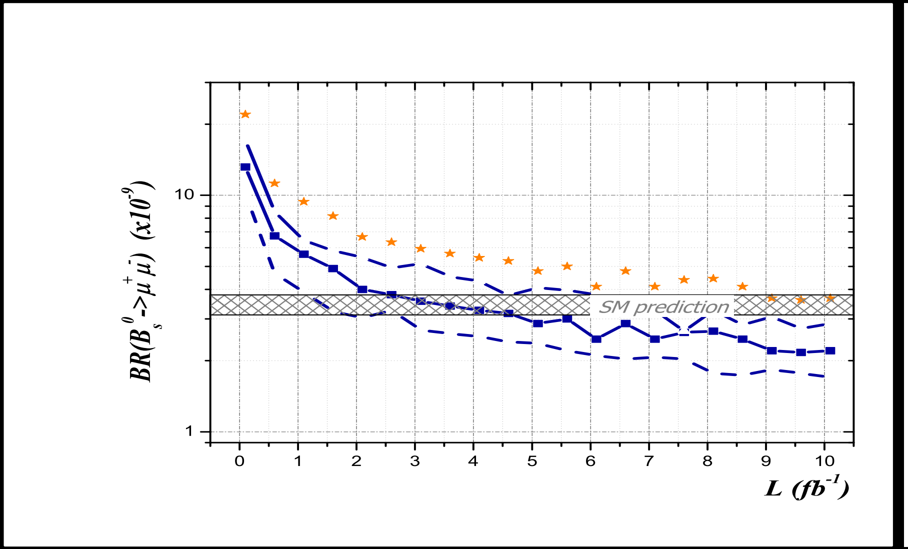
- Current experimental limits - still factor 15(Bs) / 80 (Bd) above SM predicitons
- Leave space for possible New physics effects

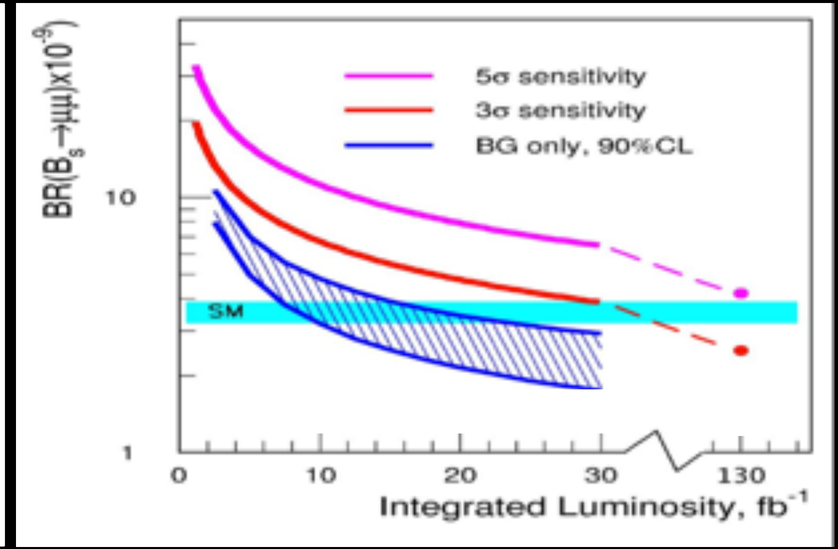
LHCb prospects on Bs→μμ with 0.1 - 2 fb-1



- at 0.15 fb-1 LHCb will take over the exclusion limits of CDF+D0 after they analyse full statistics of 8 fb-1

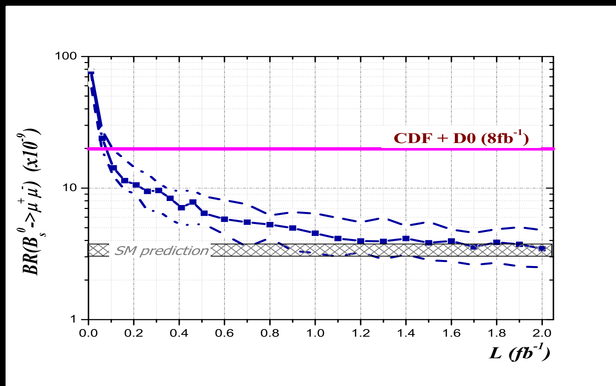
LHC sensitivities on Bs→μμ with 1-10 and more fb-1

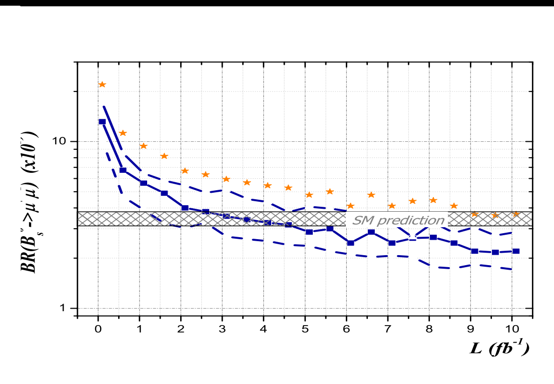


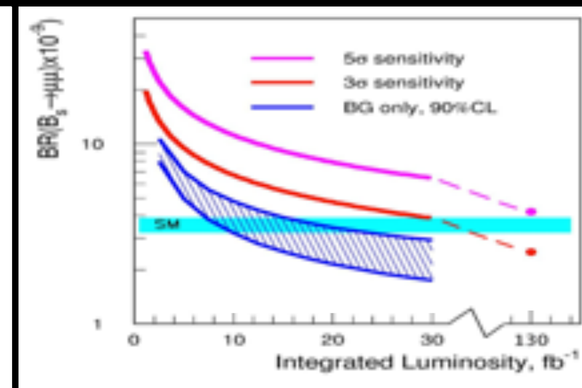


- Left: LHCb 3σ Bs signature. Dashed lines define the 90% probability region due to the limited MC statistics used to evaluate the expected background. Orange stars indicate the luminosity needed for a 5σ discovery. experimental limits.
- Right: ATLAS, CMS study for 14 TeV: 3(5) σ Bs signatures and 90%CL exclusion limit (blue) , uncertainty due to limited MC. The trigger menus for > 10^{33} applied.
- At low instantaneous luminosities < ~ 10^{32} the low pT muon triggers will be applied in ATLAS and CMS, with possible sensitivity 1.9×10^{-8} for 1 fb-1 at 95% CL.

LHC prospects on Bs→μμ







- 0.15 fb-1 LHCb overtakes CDF+D0 after they analyse 8 fb-1
- 2-3 fb-1 LHCb excludes BR down to SM. ATLAS,CMS: with 10fb-1
- 3σ evidence LHCb with 5 fb-1 ; ATLAS, CMS with 30 fb-1
- 5σ observation LHCb 3 years@ 2 x 10^{32}; ATLAS, CMS 1 year @10^{34}

- LHCb leading over period until LHC luminosity gets to nominal value 10^{34}
- ATLAS CMS benefit as luminosity increase to few times 10^{33} and 10^{34}
- hence will substantially contribute to LHC potential as soon as 10^{34} and after detector upgrade when 10^{34} - 10^{35}
- ATLAS, CMS will then concentrate on Bs/Bd ratio

Summary

- Early **J/ψ** data taken with Min bias trigger show excellent agreement with expected performance
- Reproducing PDG mass – pT scale understood at low pT sector – result of nice work done at 900 GeV, but earlier with cosmics and test beams.
- Di-muon resolutions determined with early data will improve as muon selections gets to standard. Relative resolutions between experiments scale with Bs-mm MC predictions.
- Impact parameter resolutions currently higher than terminal, but correspond to MC. Will improve with beam, PV, advanced alignments.
- With ~ 2 fb-1 LHCb can overtake CDF+D0 in Bs- $\mu\mu$ after they analyse 8 fb-1
- 5 sigma measurement of SM expected value when LHC delivers 10 fb-1
- ATLAS, CMS will significantly contribute to LHC potential as instantaneous luminosity gets to few times 10^{33} and to a nominal LHC 10^{34} and after detector upgrade with 10^{34} up to 10^{35}