A New Expected Upper Limit on the Rare Decay $B_s \to \mu^+\mu^-$ with the DØ Experiment

Isabelle Ripp-Baudot

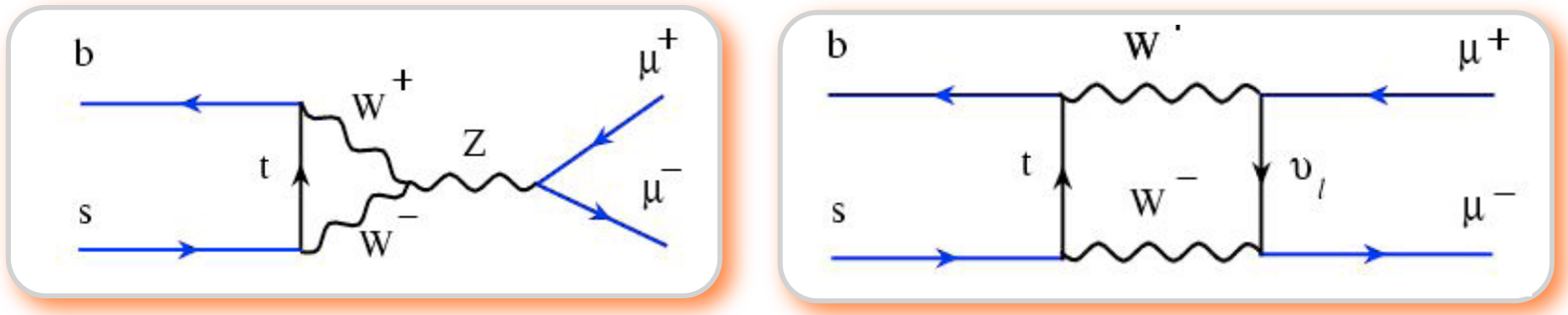
IPHC -CNRS/IN2P3 and Strasbourg University

on behalf of the DØ collaboration

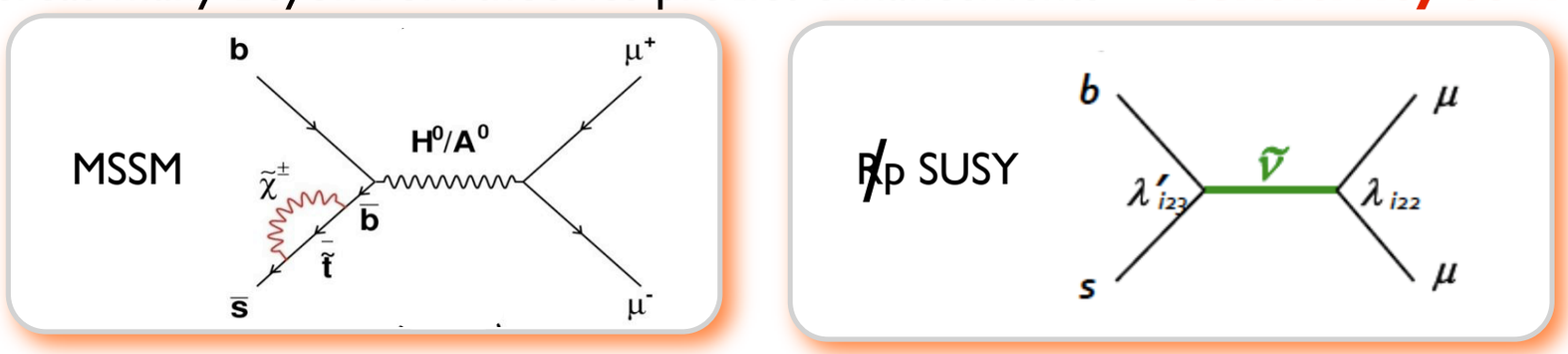
motivation

- FCNC processes have very low rate in SM:

$$\mathcal{B}(B_s \to \mu^- \mu^+)_{SM} = (3.6 \pm 0.3)\times 10^{-9}$$ A.J. Buras, 0904.4917[hep-ph]



- whereas many Beyond SM theories predict enhancements → **sensitivity to new physics**.



- best current limit: $< 5.8\times10^{-8}$ (95% CL) by CDF with 2 fb^{-1} PRL 100, 101802 (2008)

- DØ-Run II previous limits on $\mathcal{B}(B_s \to \mu^- \mu^+)$:
  - $< 5.0\times10^{-7}$ (95% CL) with 240 pb^{-1} PRL 94, 071802 (2005)
  - $< 1.2\times10^{-7}$ (95% CL) with 1.3 fb^{-1} PR D 76, 092001 (2007)
  - $< 9.3\times10^{-8}$ (95% CL) with 2 fb^{-1} preliminary
  - in this talk: preliminary with 5 fb^{-1}

- **still room for new physics** in this decay!

experimental environment

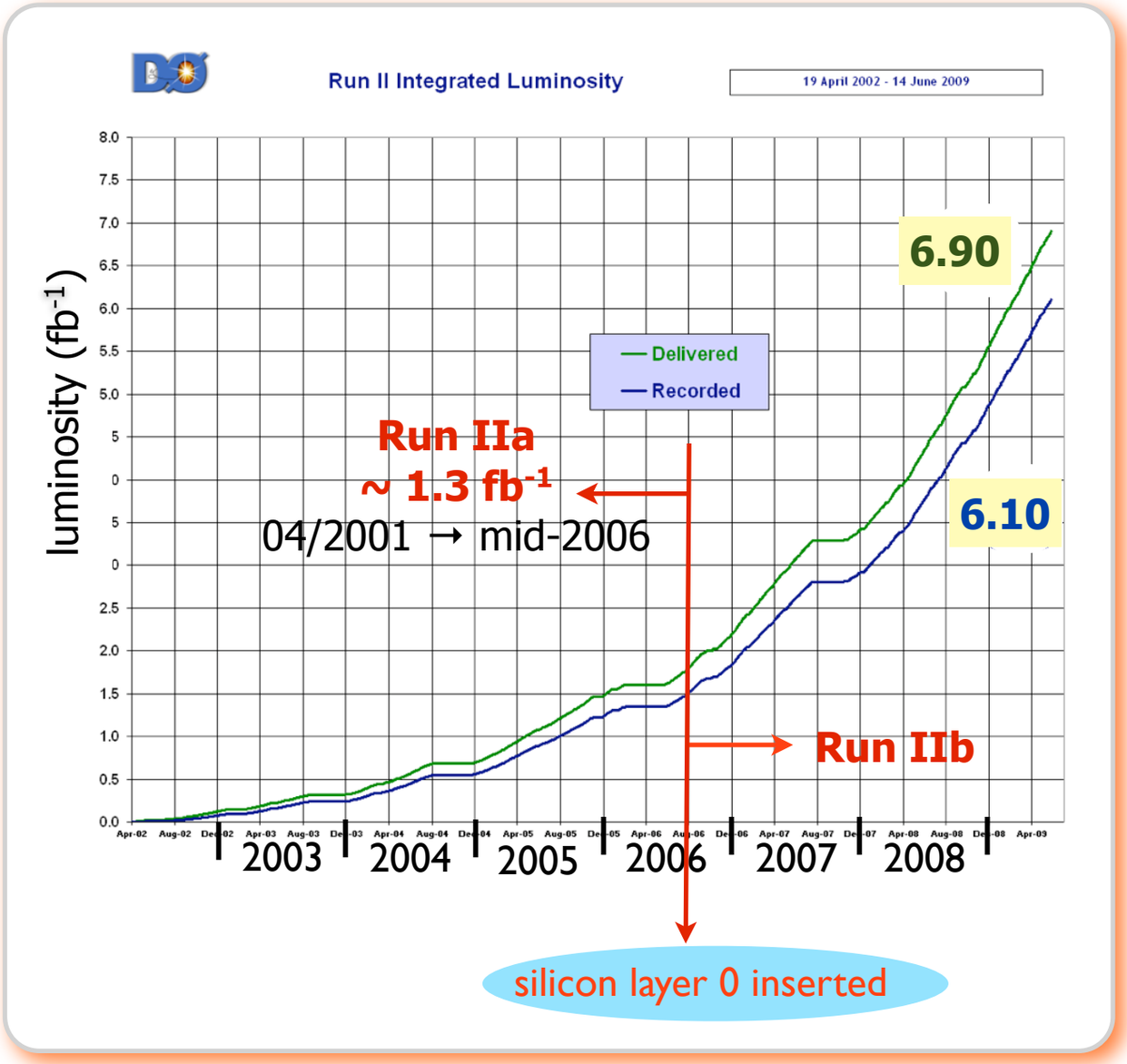
Run II (since 2001):
- $\sqrt{s}$ = 1.96 Tev,
- inst. lumi ≲ 3.5×10^{32} $cm^{-2}s^{-1}$,
- total lumi. > 6 fb^{-1} recorded by DØ.

Tevatron offers:
- unique opportunity to study B_s,
- large $b\bar{b}$ production rate,
- high integrated luminosity.

But also:
- high track multiplicity environment.

☞ **good muon** identification with **wide acceptance** (|η| < 2) in DØ

→ highly **selective triggers**



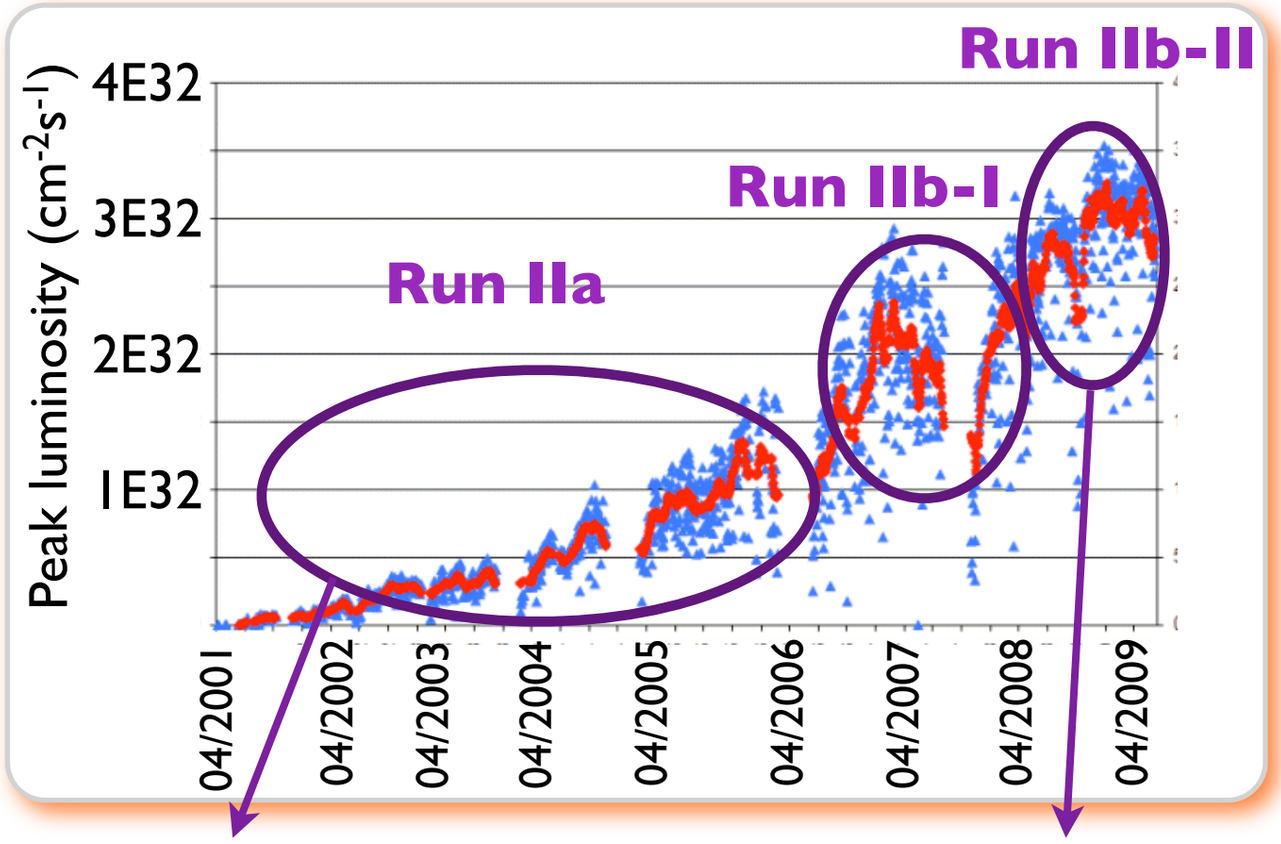
data sample

Complete set of **di-μ triggers** in DØ Run II < Dec/2008, corresponding to **5 fb^{-1}** of integrated luminosity.

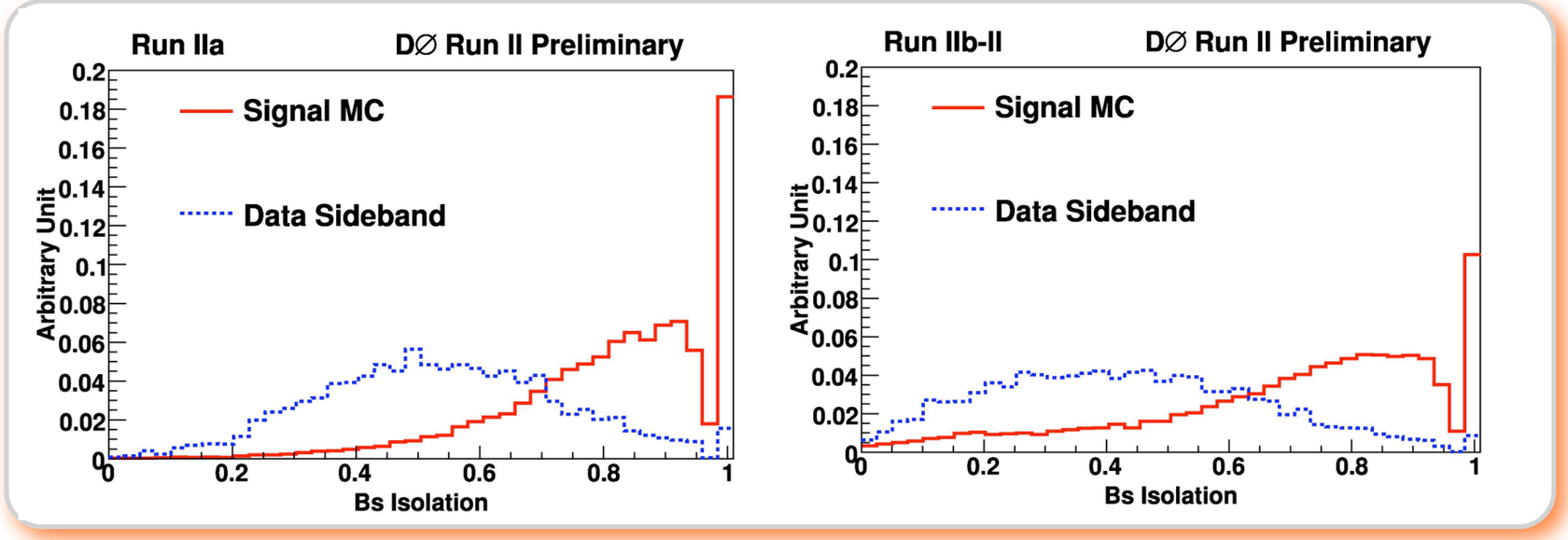
Data are divided in 3 independant sub-samples corresponding to different trigger lists:

- Run IIa: 1.3 fb^{-1}
- Run IIb-I: 1.9 fb^{-1}
- Run IIb-II: 1.6 fb^{-1}

→ underlying differences w.r.t. the instantaneous luminosity.



Isolation = $\dfrac{p_T(B)}{p_T(B) + \sum p_T(trk)}$ in cone ΔR<1



$B_s \to \mu\mu$ measurement method

Normalization to $B^+ \to J/\psi K^+ \to \mu\mu K^+$, with B.R. $\sim 10^{-5}$.

$B^0 \to \mu\mu$ suppressed by $|V_{td}/V_{ts}|^2$: neglected

from MC

same reconstruction & selection than $B_s \to \mu\mu$: syst. cancellation.

$$\mathcal{B}(B_s^0 \to \mu\mu) = \frac{N(B_s \to \mu\mu)}{N(B^+ \to J/\psi K^+)} \times \frac{\varepsilon(B^+)}{\varepsilon(B_s^0)} \times f\left(\frac{b \to B^+}{b \to B_s^0}\right) \times \mathcal{B}(B^+ \to J/\psi K^+, J/\psi \to \mu\mu)$$

observed

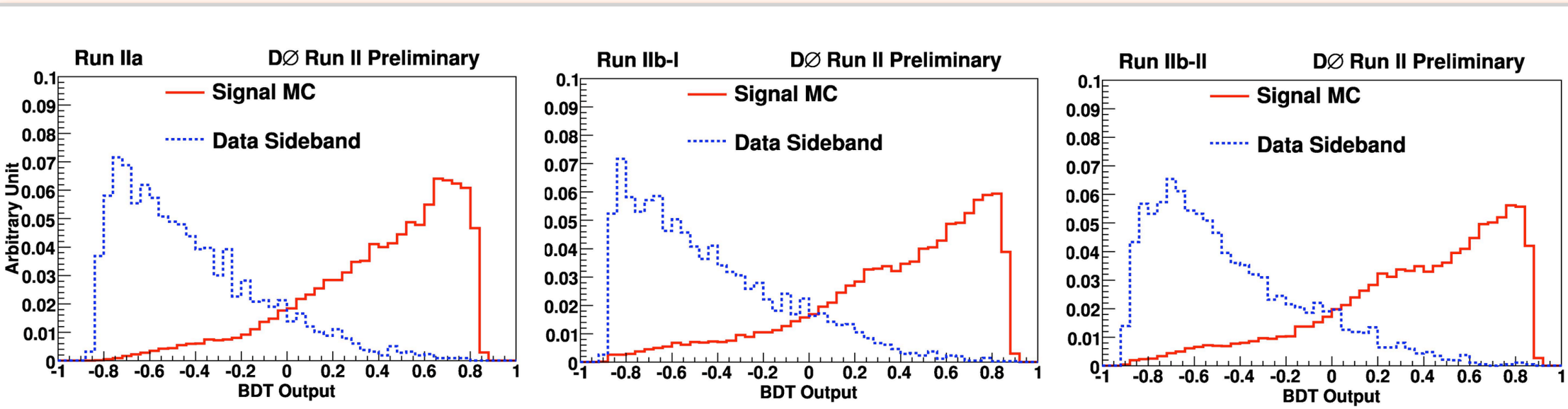
2006 PDG values used for consistency with CDF

$B_s \to \mu\mu$ selection

- preselection by sequential cuts: μ, q(μμ), $p_T(\mu)$, angle(μμ), $IP(\mu)/\sigma_{IP}$, $p_T(B)$, $L(B)/\sigma_L$, $\sigma_L(B)$, $\chi^2(vtx)$.
- further background rejection: **Boosted Decision Tree** built with 5 discriminating variables:

L_{xy}/σ_{Lxy}, IP/σ_{IP}, χ_{vtx}^2, B_s isolation, $p_T(\mu\mu)$.

- training: signal = MC, background = sideband data.
- one additional track for B^+ reconstruction.



Optimization:

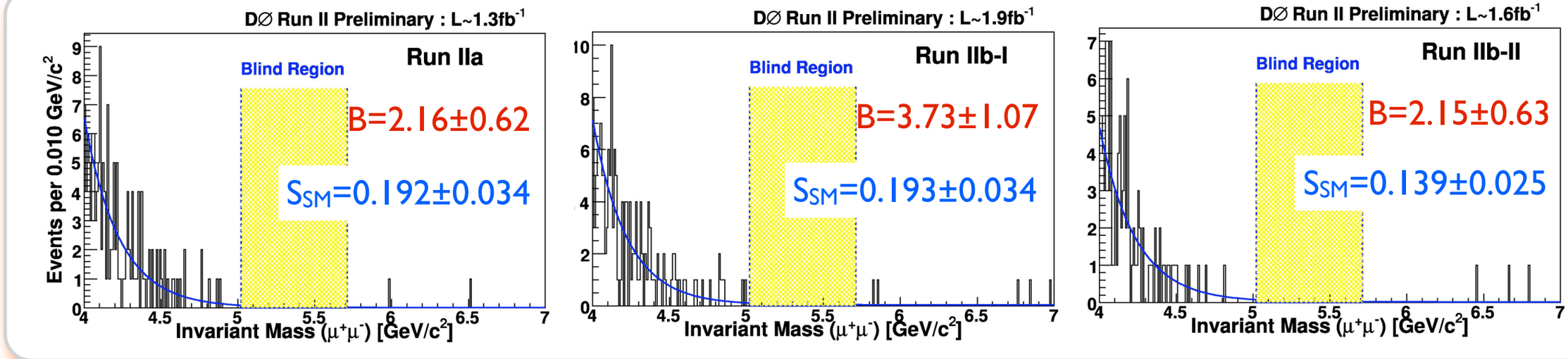
- maximize the *Punzi* parameter $P = \dfrac{S}{\alpha/2 + \sqrt{B}}$ with α=2 for 95 % CL. physics/0308063

- **signal region blinded**, S taken from SM for optimization.

$B_s \to \mu\mu$ observation

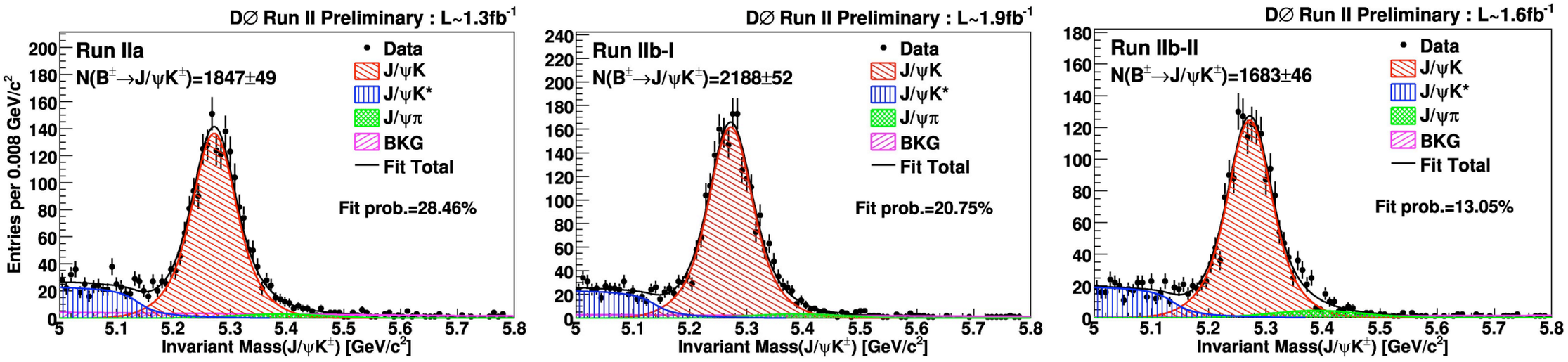
$B_s \to \mu\mu$

Background **B**: $B_s \to K^+K^-$ and $B^0 \to K^+\pi^-$ contributions + combinatorial background.



$B^+ \to J/\Psi K^+$

Background: $B \to J/\psi\, K^*$ + $B^+ \to J/\psi\, \pi^+$ contributions + combinatorial background.



$B_s \to \mu\mu$ expected limit

- signal region remains **blind**, upper limit calculated assuming no signal in the blind region:
  observed N($B_s \to \mu\mu$) = estimated N(background)

- **expected 95% (90%) CL upper limits on $B_s \to \mu\mu$ with 5 fb^{-1} of D∅ data:**

Run IIa:	< 9.4	$(7.6)\times10^{-8}$
Run IIb-I:	< 11.0	$(9.9)\times10^{-8}$
Run IIb-II:	< 13.0	$(10.0)\times10^{-8}$

combined upper limit: 5.3 (4.3)x10^{-8}

- main syst.: f_s/f_d, observed N(B^+), $p_T(B_s)$ spectrum.

- sensitivity with 2008 PDG values is about 10 % lower.

- improvements (in progress):
  - include single-μ triggers,
  - improve selection to reduce the background.

and then... open the box!

conclusion and outlook

- DØ reports the current **world best sensitivity on $B_s \to \mu\mu$**, which is at the same level than CDF result.

- Tevatron limits are now a factor 10 above the SM:
  - still room for new physics ☺ ,
  - add data and combine DØ with CDF.

- Very good performance from the Tevatron:
  - 5 fb^{-1} analysed in this measurement,
  - more than **6 fb^{-1} already stored**,
  - twice as much data expected at the end of Tevatron RunII.

→ **further significant reduction of theoretical parameter space can be expected as more data are included.**