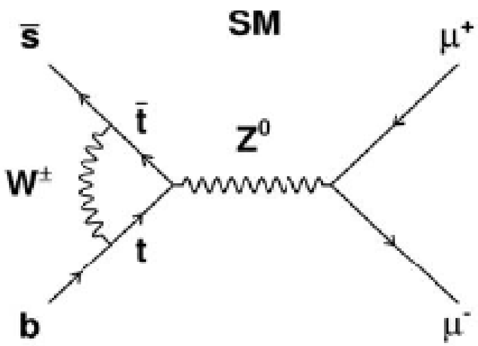
Bs → $\mu+\mu-$ in LHCb

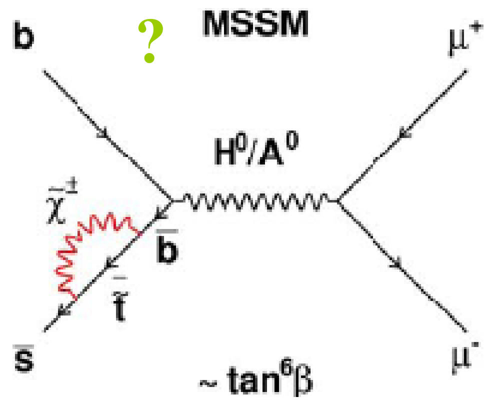
Diego Martínez Santos
Universidade de Santiago de Compostela (USC) (Spain)

Winter Meeting, Santiago de Compostela

PROGRAMA NACIONAL DE BECAS FPU



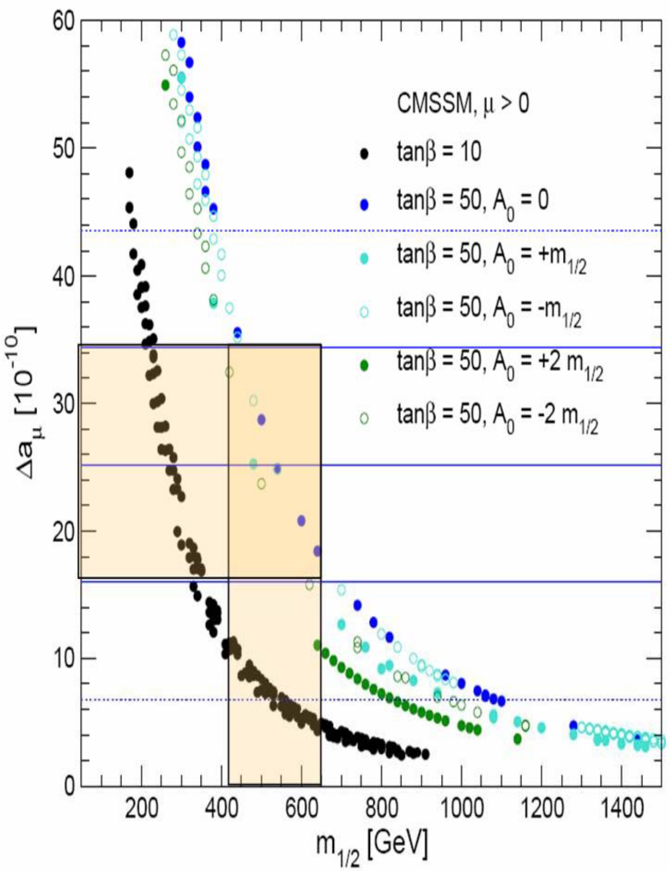
- Motivation
- LHCb conditions
- Soft Bs → μμ selection
- N-counting method
  Backgrounds
- Exclusion/discovery potential of LHCb
- Normalization effect
- mSUGRA examples



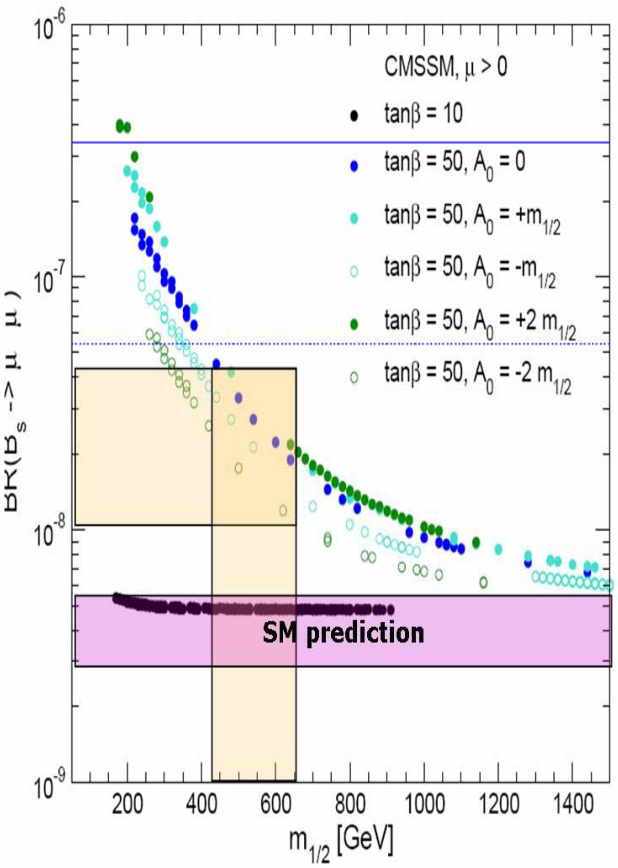
Motivation: BR (Bs → μμ) sensitive to New Physics (NP)

- Accurate SM prediction: (3.4 ± 0.5) 10 $^{-9}$ (*)
- Could be **enhanced** by $\tan^6 ß$ (**SUSY**)
- **CMSSM**: Relation with *Muon Anomalous Magnetic Dipole Moment* $a_\mu = (g-2)/2$
  Current value of aμ - aμ(SM) → if tanß ~ 50 gaugino mass are in ~400 – 600 GeV → BR(Bs → μμ) ~ 1-4 x 10 $^{-8}$
- Sensitive to several other models

aμ - aμ(SM)



BR (Bs → μμ)

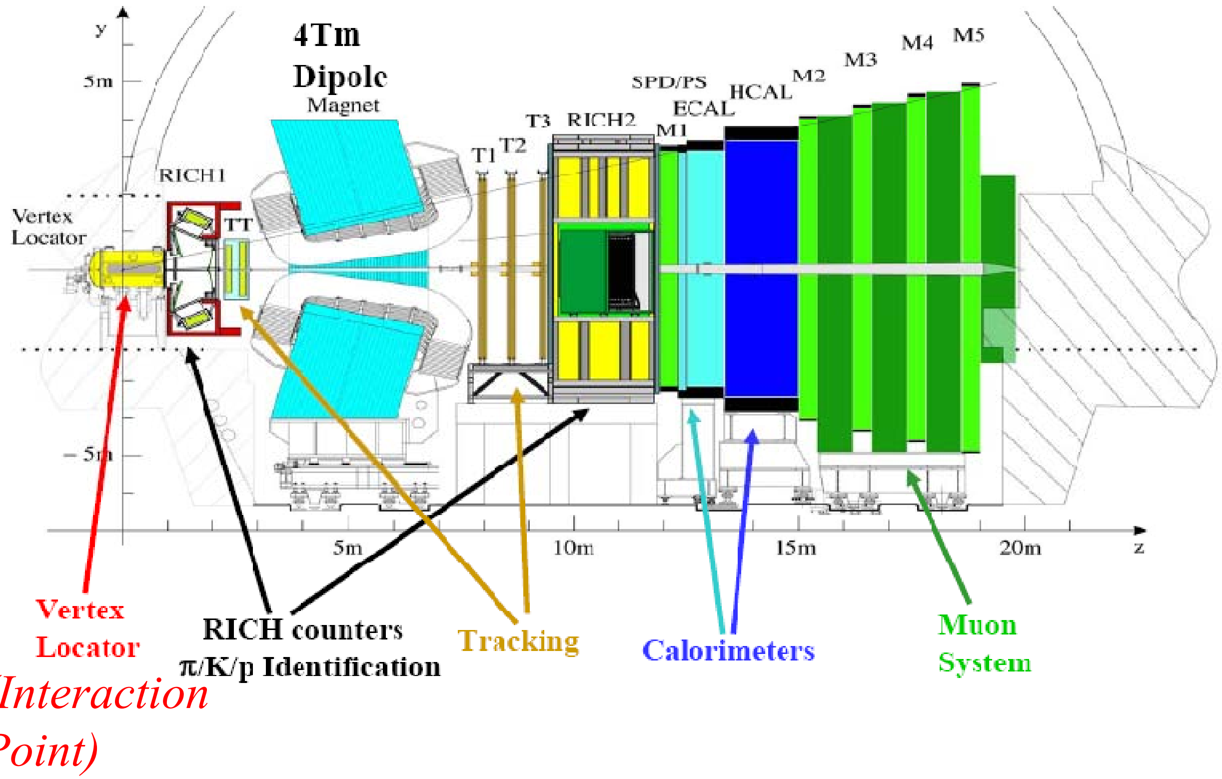


(*) A.Buras et. al. Phys.Lett.B. 566 (2003) 115

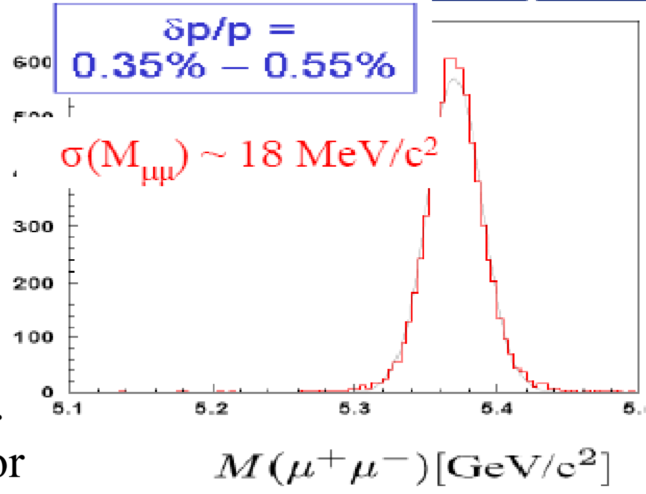
LHCb conditions

- b produced at low angle
- L ~ 2- 5 x 10^{32} $cm^{-2}s^{-1}$
- ~5 x 10^{11} bb/fb^{-1}
- Trigger dedicated to select b events (~90% for reconstructed Bs → μμ)
- Total efficiency on Bs→μμ (detection + reconstruction + trigger + selection) ~ 10 %

The LHCb detector: single arm forward spectrometer: 15-300 mrad (1.9 <η<4.9)



LHCb conditions (II). Tracking & muon IDentification



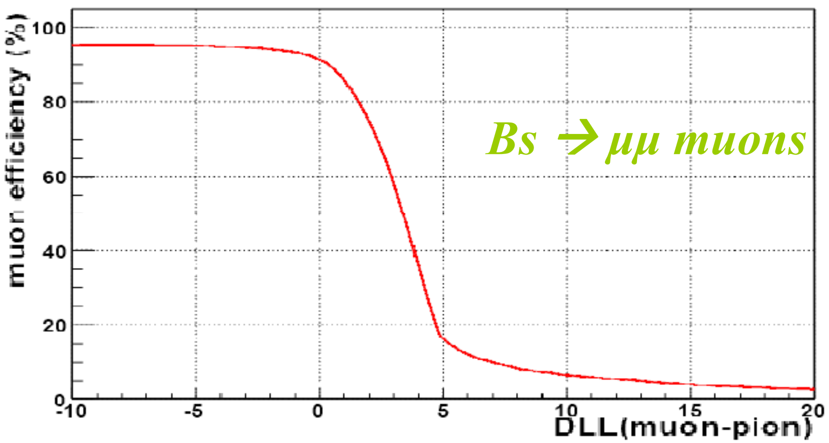
•Excellent tracking resolution

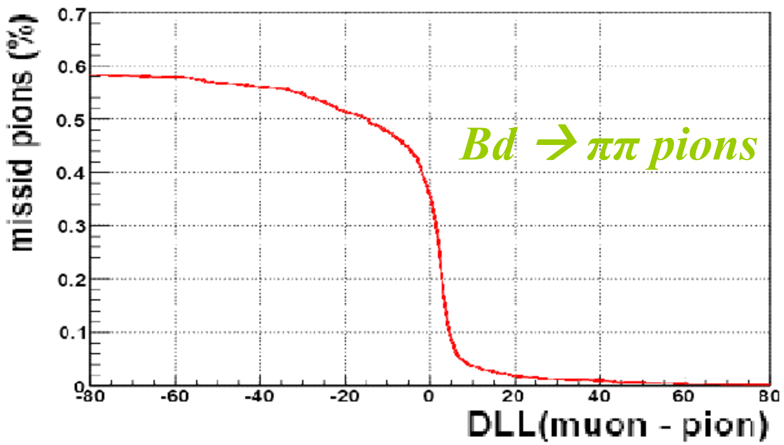
•Invariant Mass Resolution in BS peak ~ 18 MeV

→ ***Reduction of search window (less background)***

•LHCb muon ID variable (s) : DLL(μ – π), DLL(μ – K)… Combines Muon System & Calorimeters info (& RICH for kaons) → ***95 % efficiency for 0.6 % of missID pions***

(hits in certain Field Of Interest (depending on p) in M.Chambers are required before use DLL)





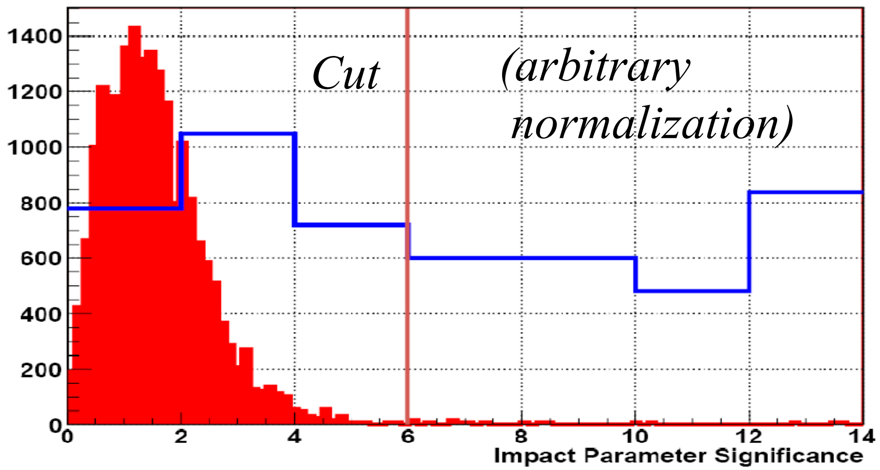
Bs → μμ Event Selection

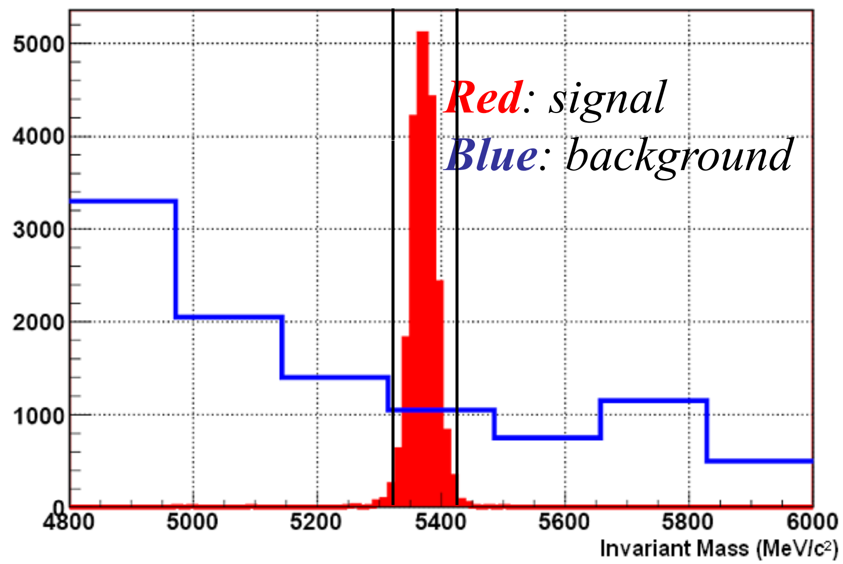
•Very soft cuts are applied in order to keep most of the signal events, but removing an important amount of background

• ~ 400 K background events/fb^{-1} expected after selection - and 35.4 Bs → μμ for SM BR.

•But **most** of these 400 K **are not significant**, (see next slides)

•Mass window: 60 MeV
•Vertex Chi2 < 14
•B IPS < 6
•Z (SV – PV) > 0
•pointing angle < 0.1 rad
•Hits in FOI's of Muon Chambers





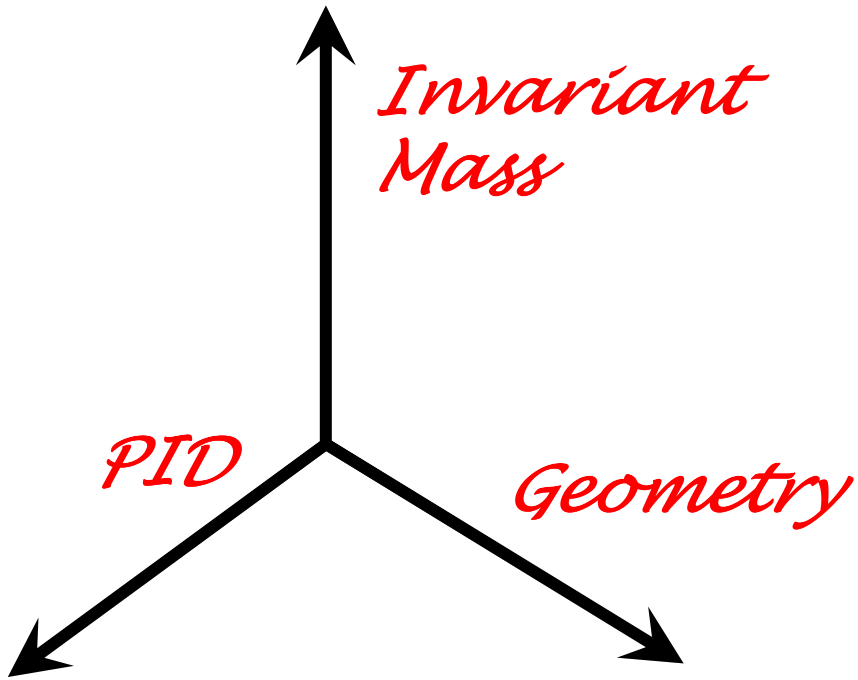
N- counting Experiment

Counting: Take a variable (or a set of), make some cuts and look at the surviving events

N-Counting: Do not cut in your set of variables, but make a counting bin - by - bin.

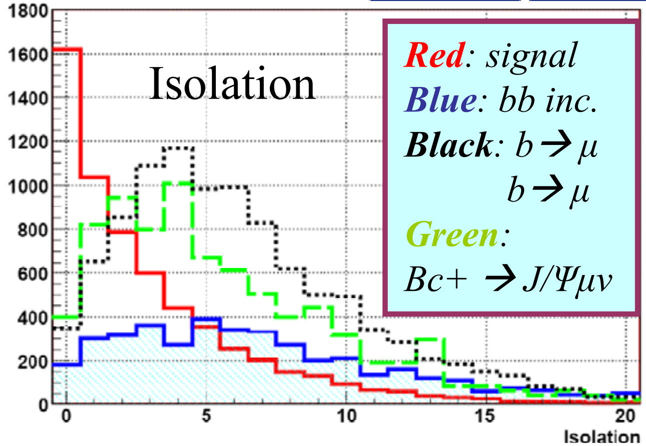
Bs→ μμ Analysis: N-Counting in a 3D space, composed by:

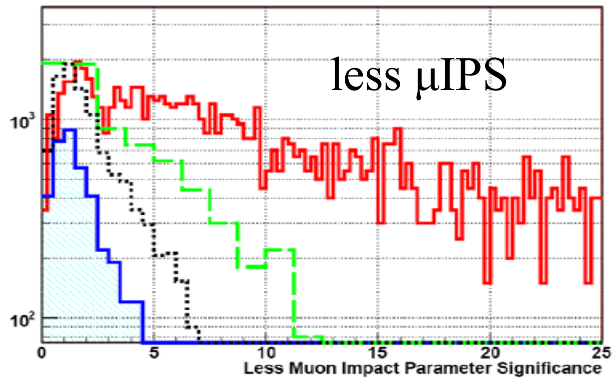
→Geometrical likelihood: [0,1]
→PID Likelihood: [0,1]
(Combines DLL(μπ) DLL(μK) of both 'muons')
→Invariant Mass: [-60, +60] around Bs peak

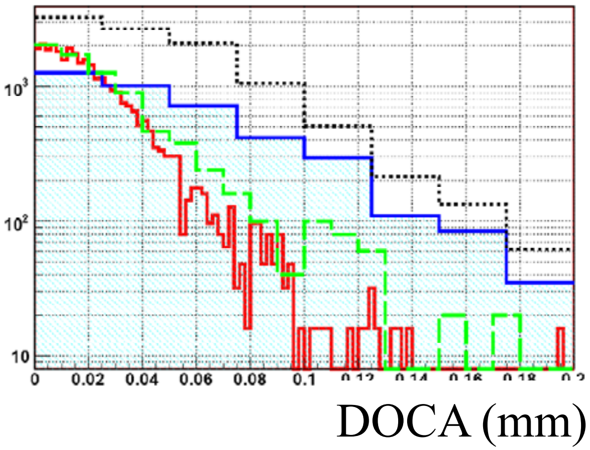


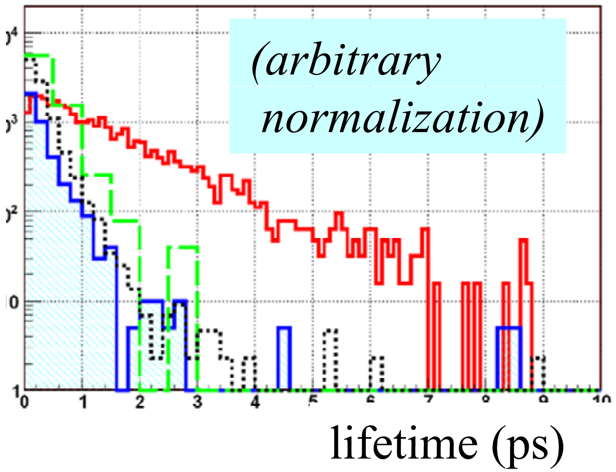
Geometrical Variables

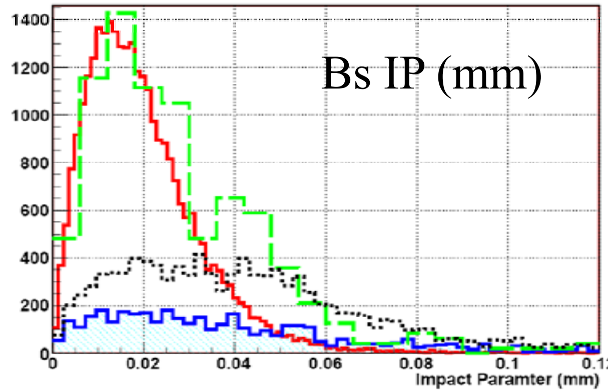
- **lifetime**
- **muon Impact Parameter Significant (IPS)**
- **DOCA**: distance between tracks making the vertex
- **B Impact Parameter (IP) to PV**
- **Isolation*:*** Idea: muons making fake Bs→μμ might came from another SV's → For each muon; remove the other μ and look at the rest of the event: How many good - SV's (forward, DOCA, pointing) can it make?









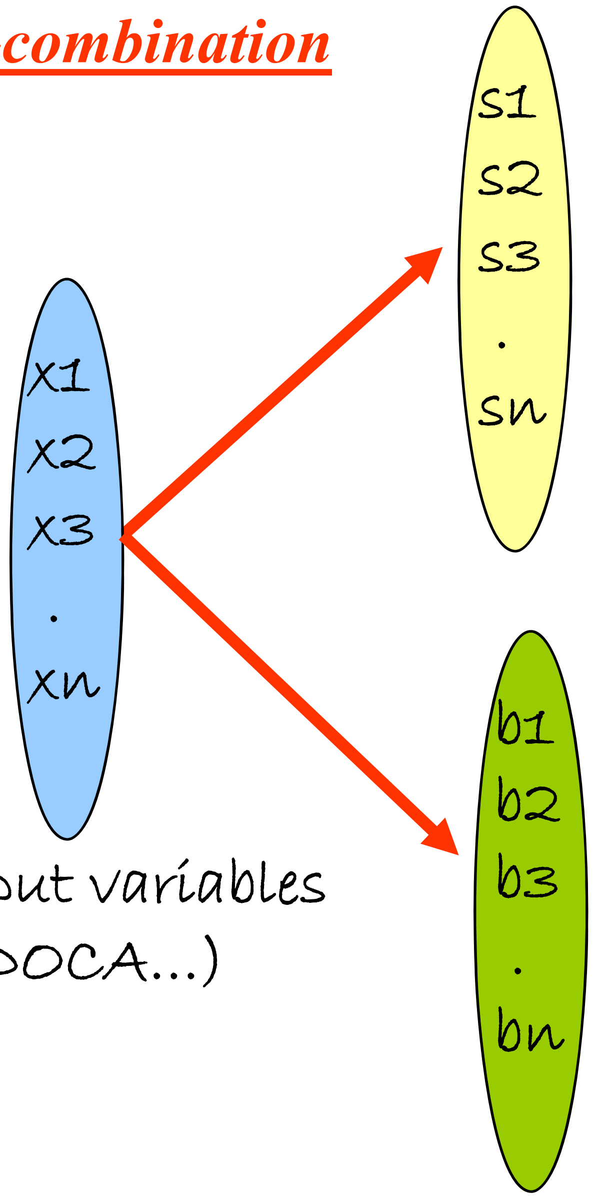


Method for variable-combination

•For constructing Geometry & PID likelihoods, we have made some operations over the input variables. Trying to make them uncorrelated

•A very similar method is described by Dean Karlen, *Computers in Physics Vol 12, N.4, Jul/Aug 1998*

•The main idea:



n input variables (IP, DOCA...)

→n variables which, for signal, are **independent** and Gaussian (sigma 1) - distributed

→ $\chi^2_S = \Sigma\, s_i^2$

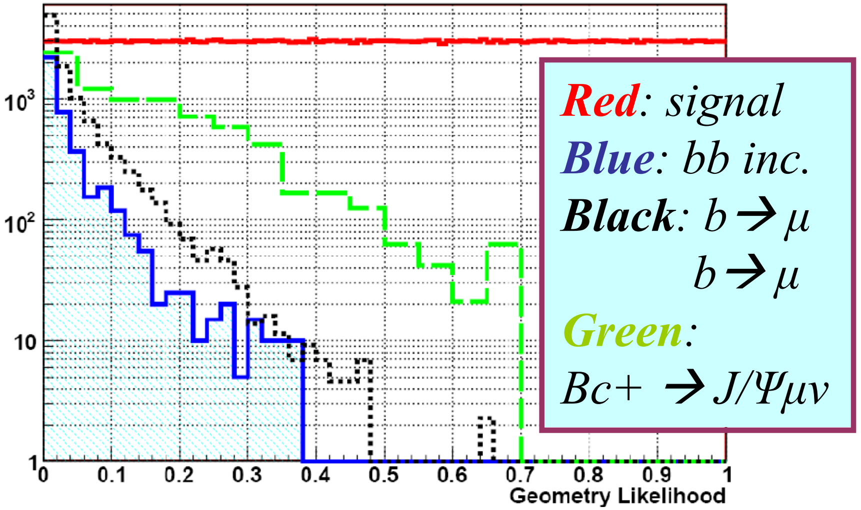
→ same, but for background

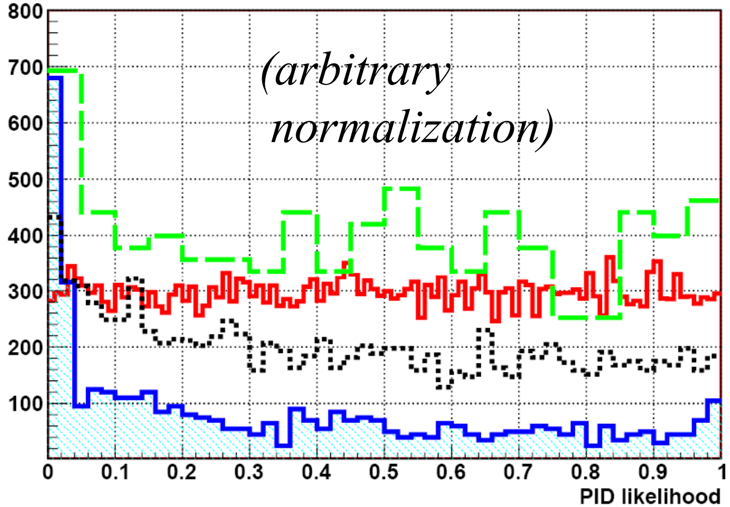
→ $\chi^2_B = \Sigma\, b_i^2$

$$\boxed{\chi^2 = \chi^2_S - \chi^2_B}$$

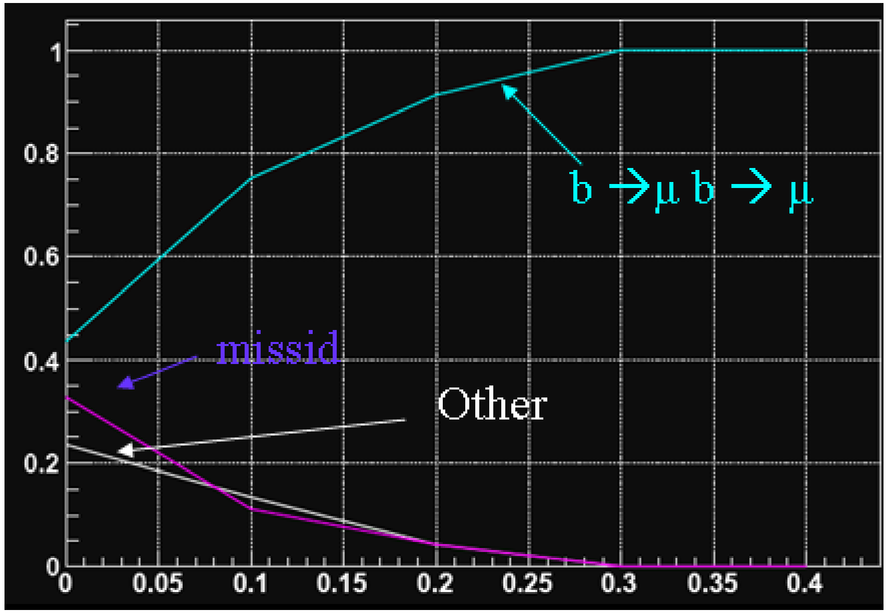
And made it uniform for signal (→flat distribution)

N- counting Experiment (II): \Backgrounds



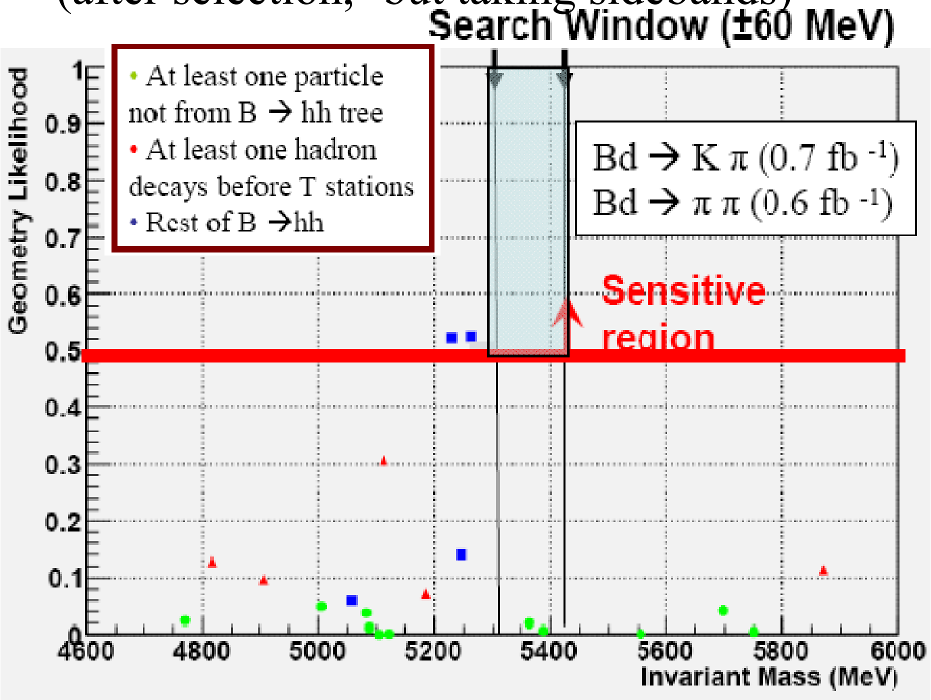


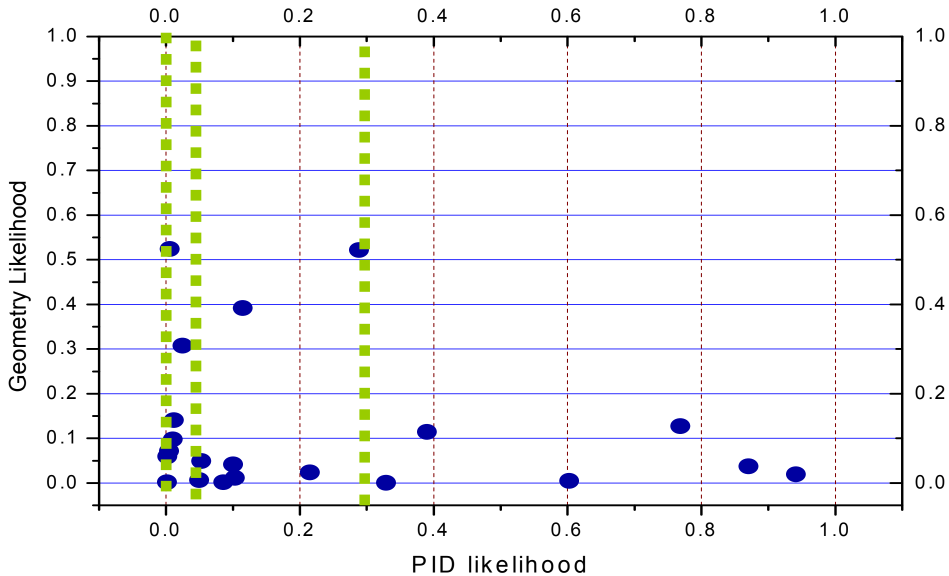
- Geometry (GL) < 0.5 → large background
- b→μ b→μ % in bb sample increases with geometry
  - identified as main source of background
  - < 210 evts/fb $^{-1}$ @ 90 % CL for GL > 0.5



N- counting Experiment (II):
B → h+h- background

(after selection, -but taking sidebands)





→Was shown that probability to missid a pion from B → ππ is ~ 0.6 %

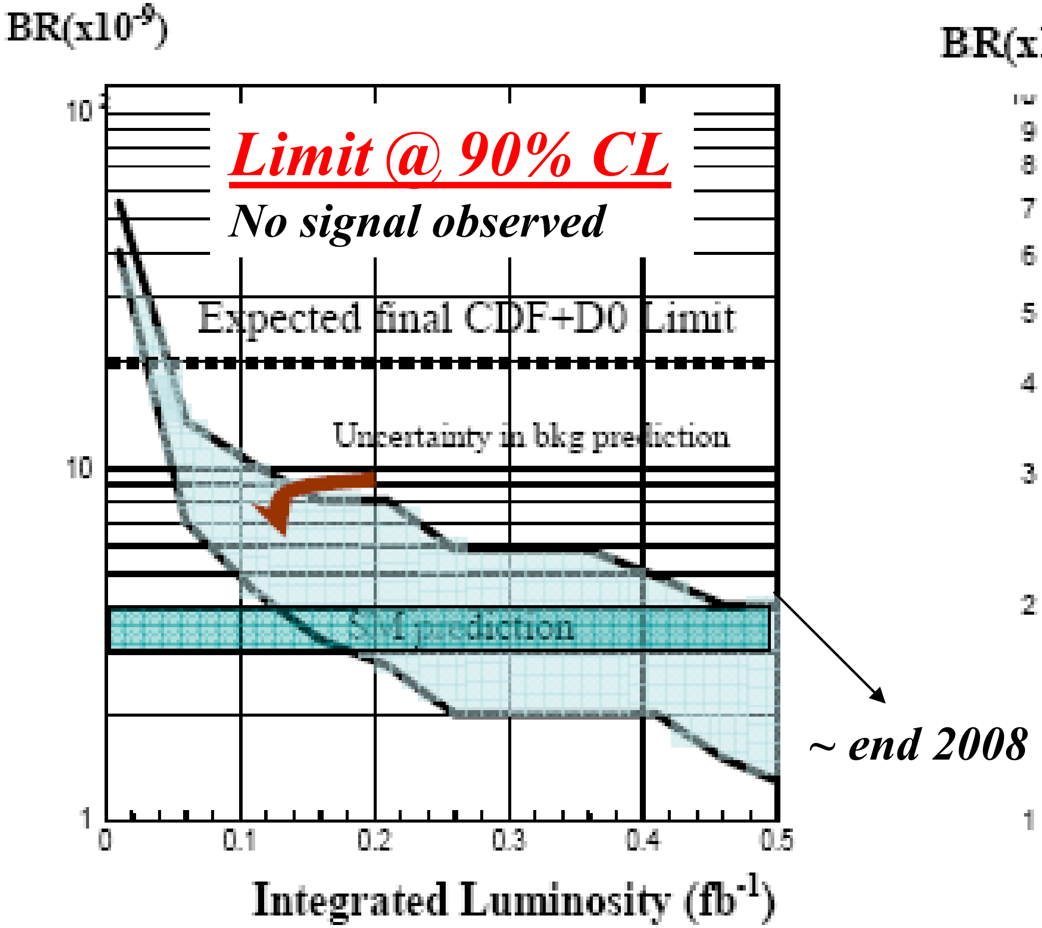
→'Survivors' still fall in low PIDL values.

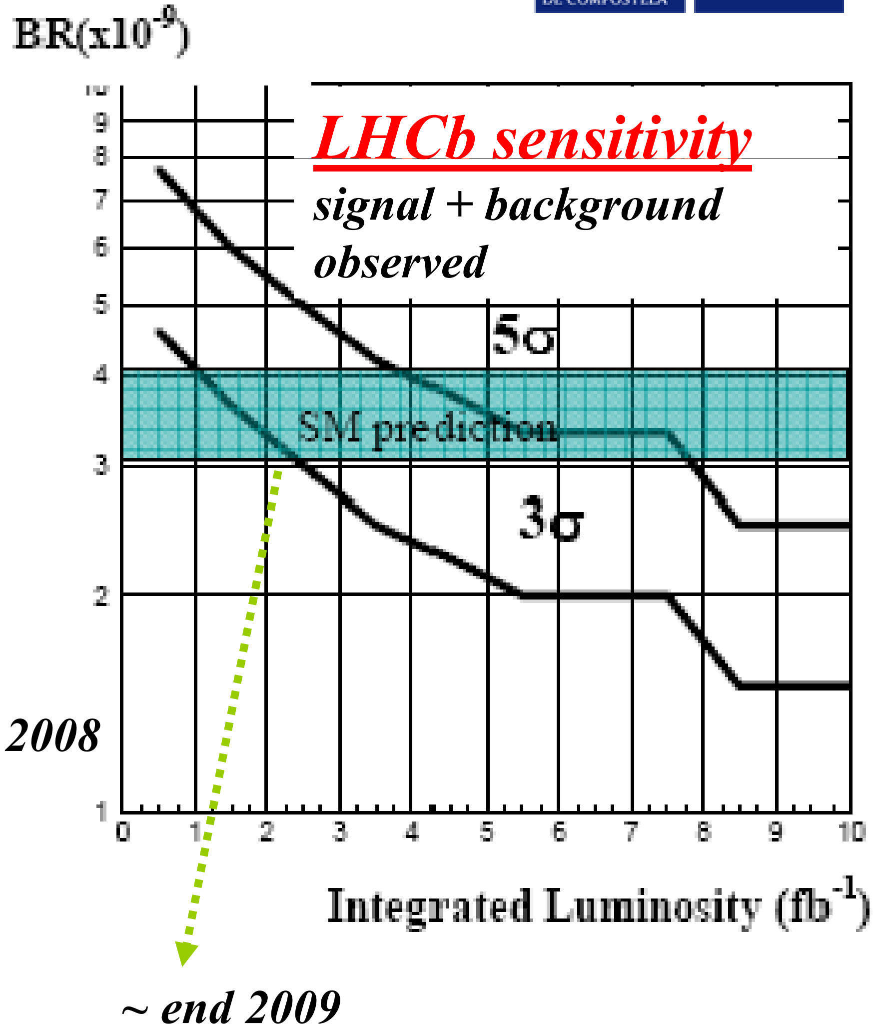
→Decays in flight degraded in mass and geometry

→Wrong particle mass assignation causes also a mass degradation

B →hh NEGLIGIBLE (~ 2 evts) in comparison to ~210 evtents/fb-1 from b →μ b →μ)

LHCb potential





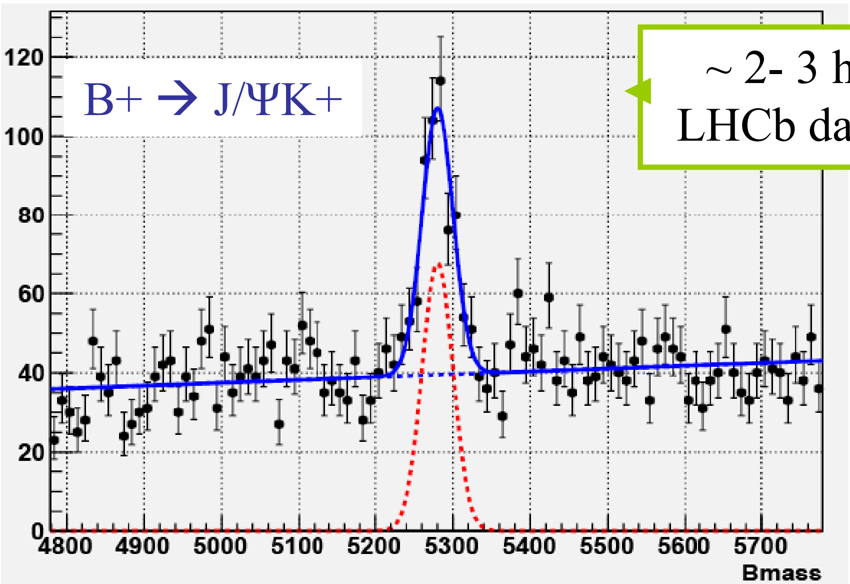
No signal observed in 2008 → BR ≤ BR (SM)

Normalization

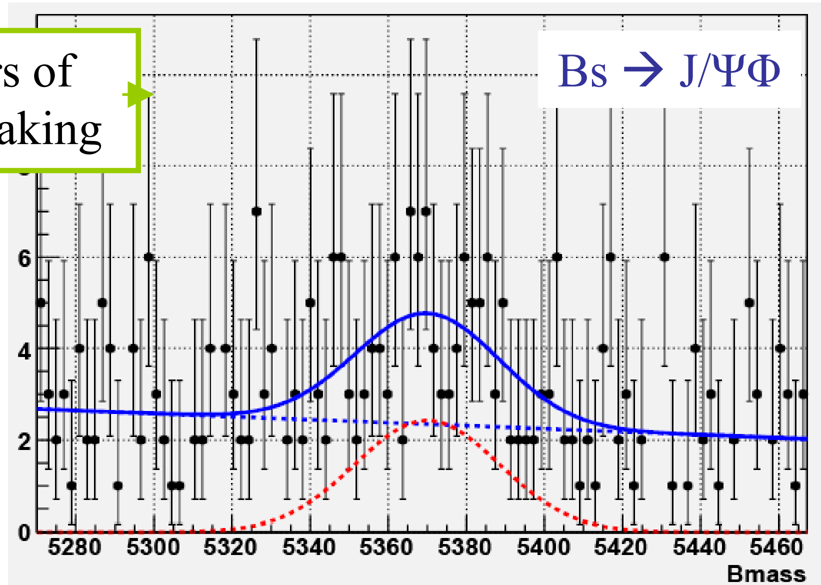
•Using B+ → J/ΨK+ and Bs → J/ΨΦ

•Implies uncertainties of ~14 % (due to uncertainty in b quark hadronization) in 1st case and ~ 35 % in 2nd (due to uncertainty in Bs → J/ΨΦ BR)

•Uncertainties in the number of events for both normalization channels are completely negligible in comparison with those above



~ 2- 3 hours of LHCb data taking



Some mSUGRA-implications examples

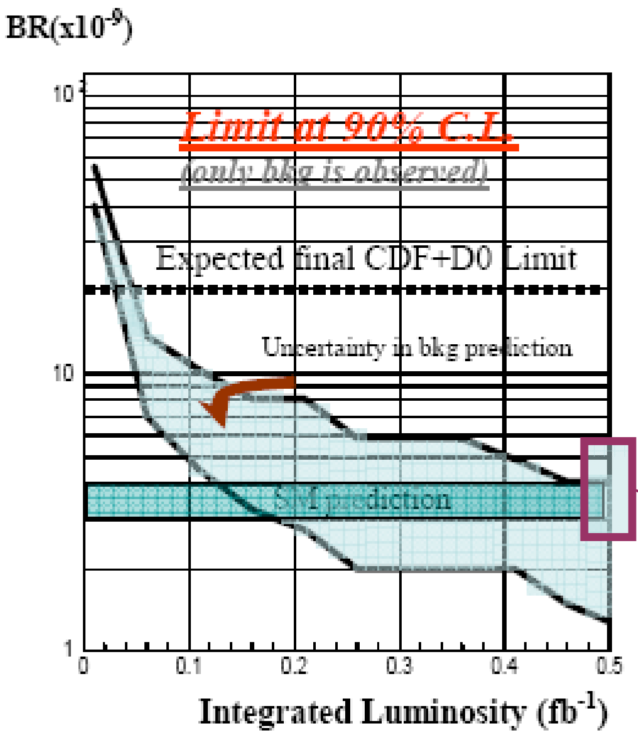
calculations using the program *SoftSUSY* from Ben Allanch (Cambridge) ; BR's computed using program from Athanasios Dedes (Durham)

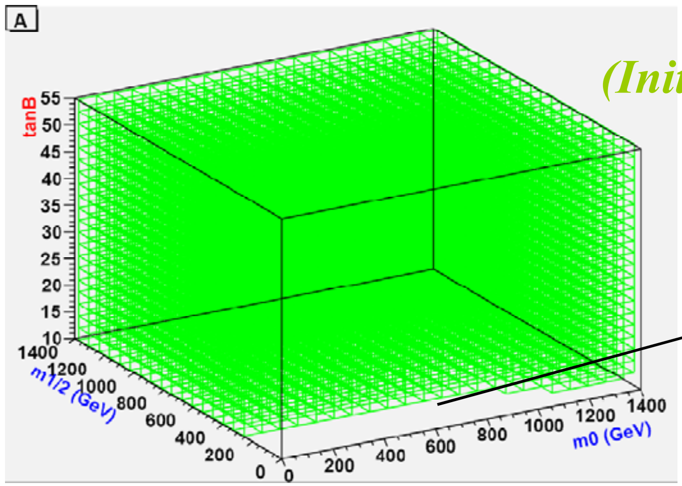
<u>CMSSM parameter values chosen:</u>

$m_{1/2}$ in [0, 1400 GeV]
m_0 in [0,1400 GeV]
$A_0 = 0$
$\mu > 0$

Other constraints:
h0 > 114 GeV
mW = 80.398 ± 0.025 GeV

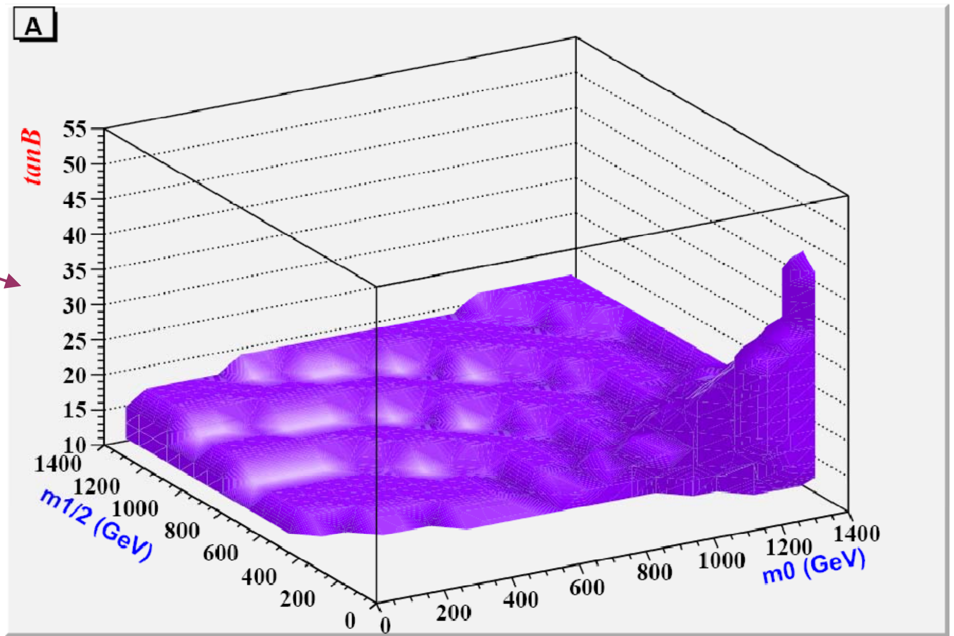
Exclusion





(Initial Phase Space)

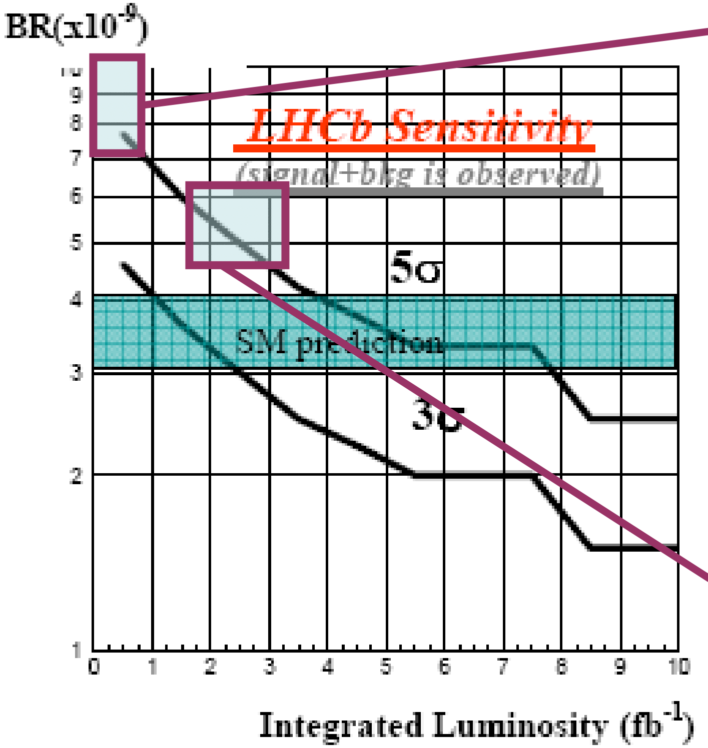
Higgs mass constraint makes this region empty

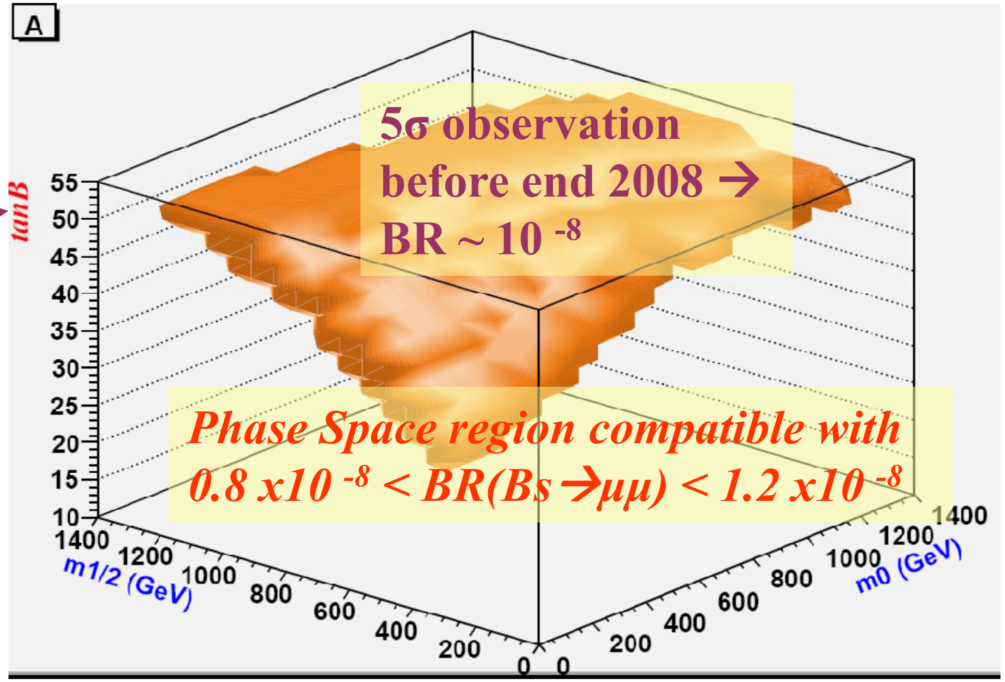


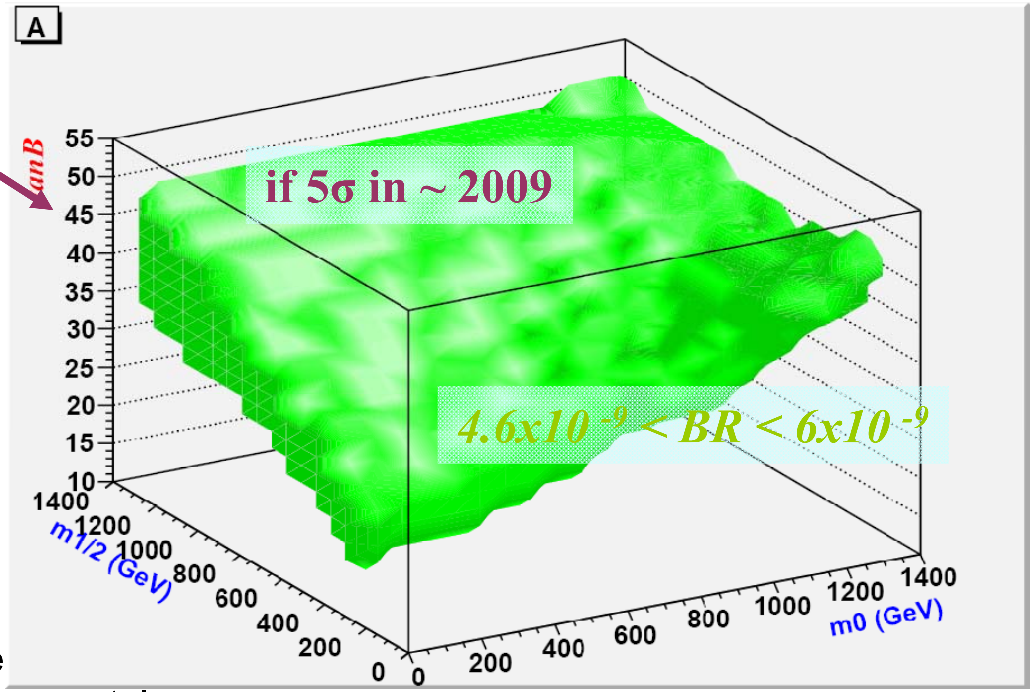
Only background observed in 2008 would indicate low tanß or/and high m0 with low m1/2

~ end 2008 if only background is observed

In case of Bs → μμ Observation

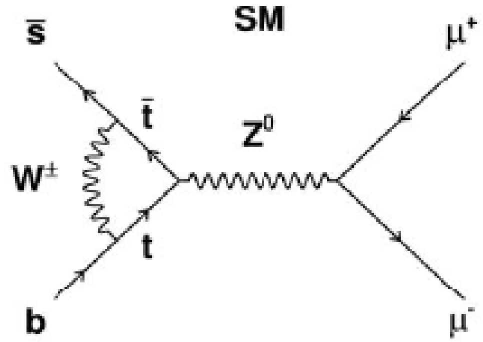




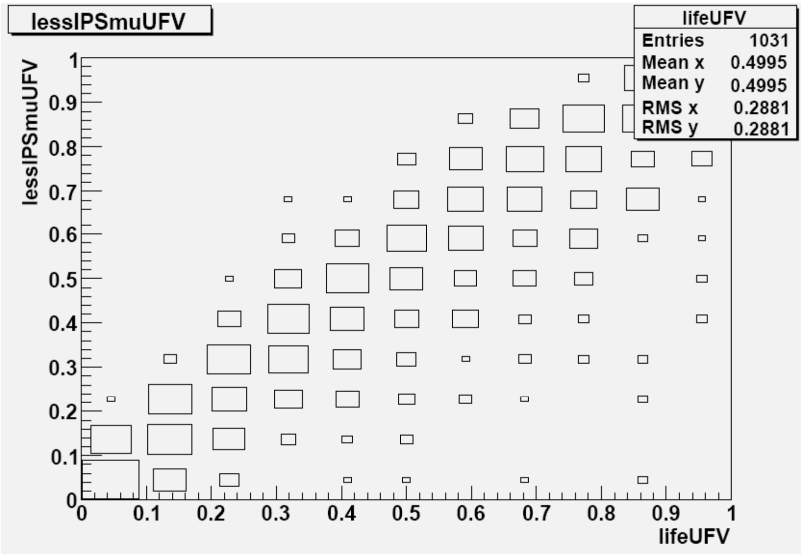


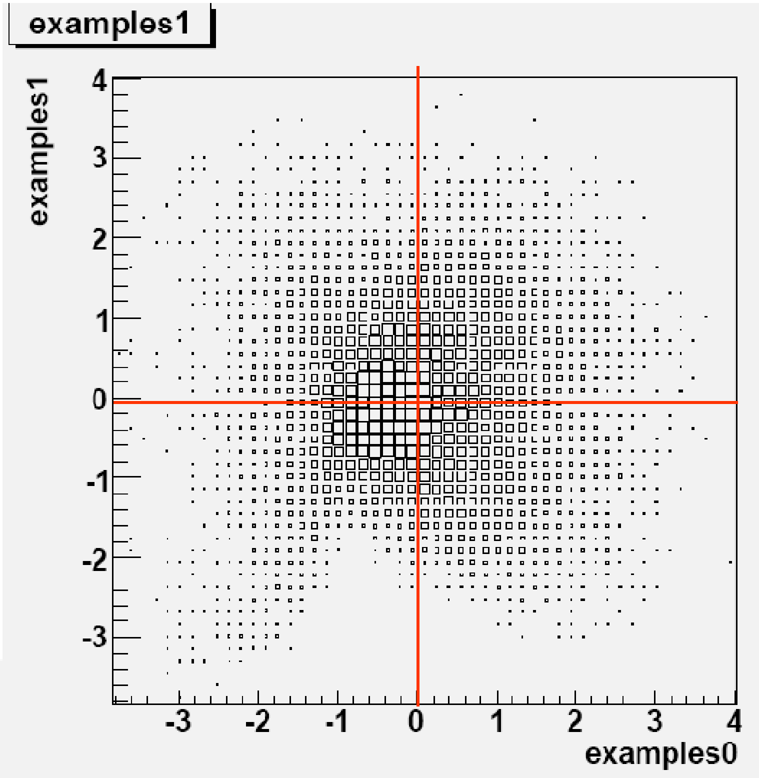
mSUGRA Phase Space is strongly reduced as function of the BR seen (and its accuracy)

Backup Slides



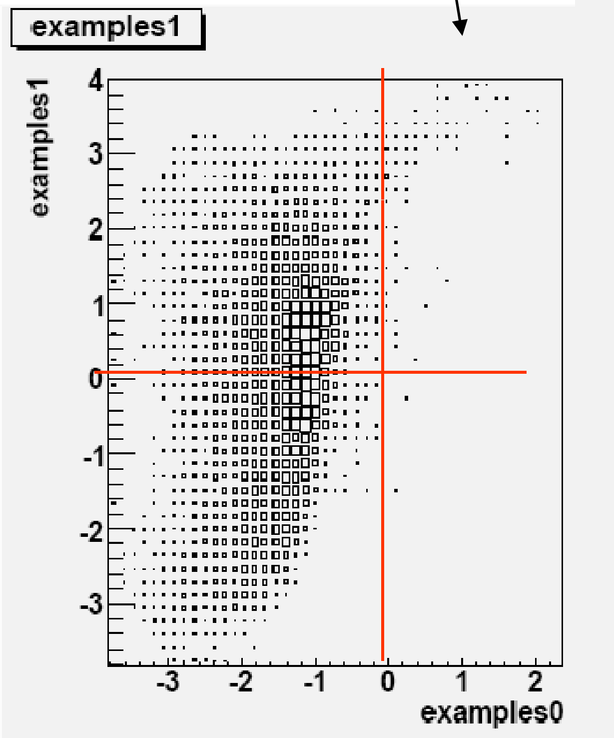
Correlation for signal (very small for background)





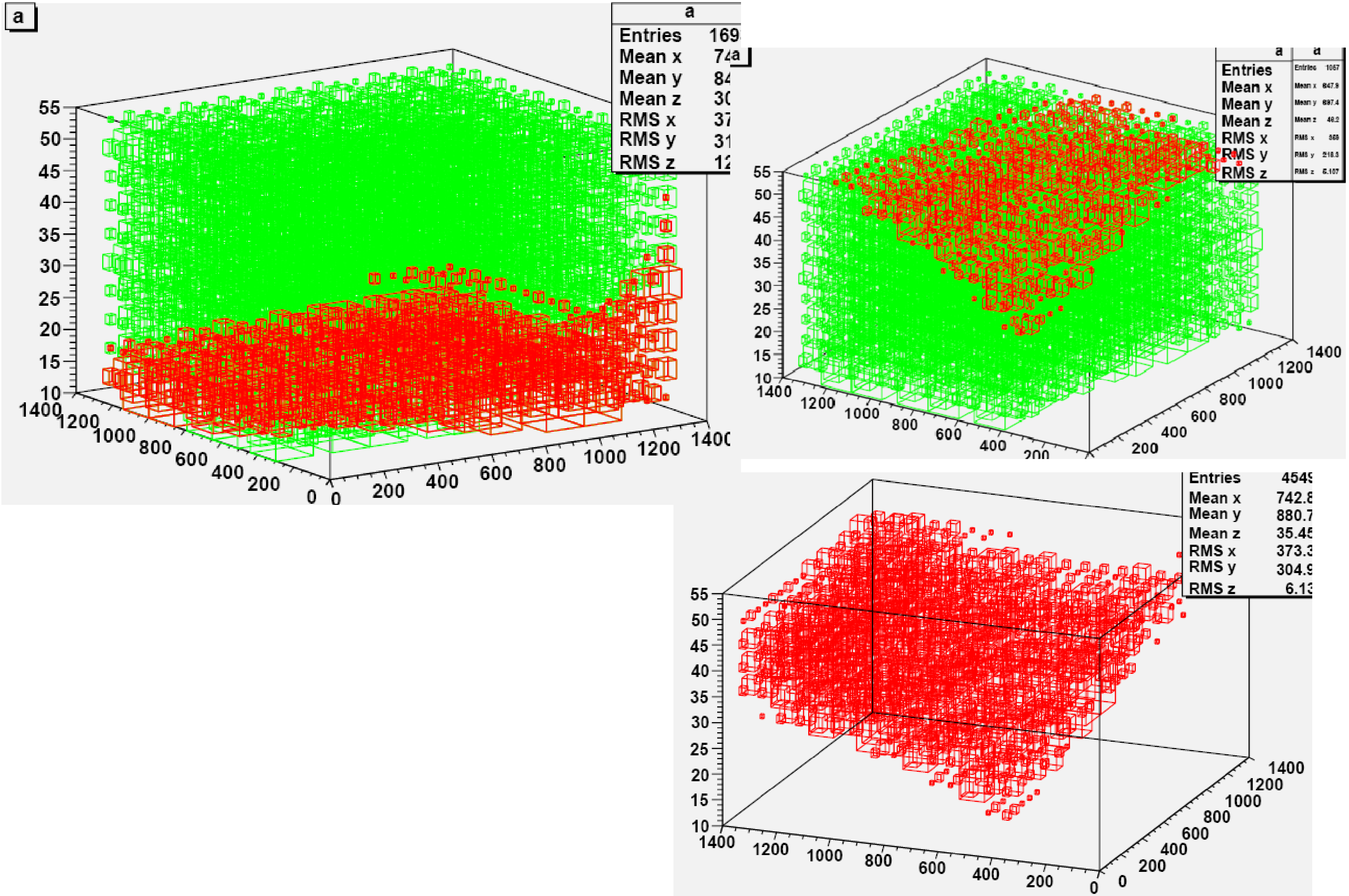
signal independent Gaussian variables (for signal)

signal independent Gaussian variables (for background)



→ Same procedure making a 2D Gaussian for Background

go de


a
Entries
Mean x
Mean y
Mean z
RMS x
RMS y
RMS z
Entries
Mean x 742.8
Mean y 880.7
Mean z 35.45
RMS x 373.3
RMS y 304.9
RMS z 6.13