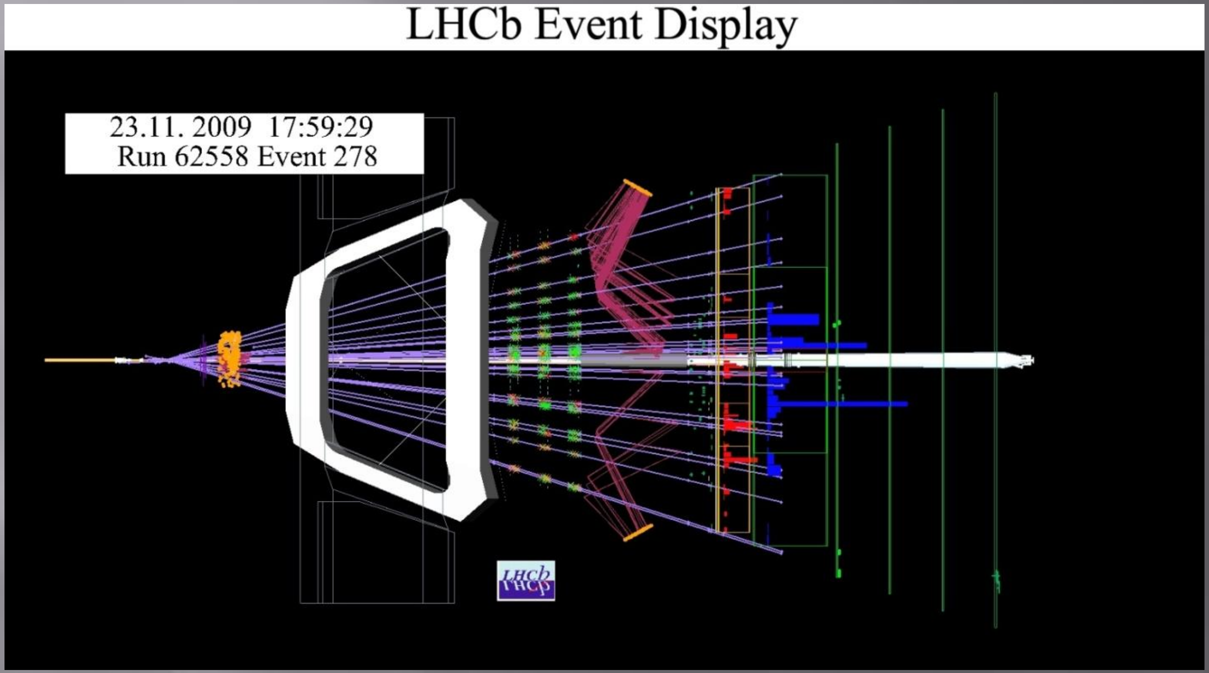
SEARCH FOR THE RARE TWO MUONS B_S DECAY. ANALYSIS USING THE FULL 2010, AUTUMN DATA SAMPLES.



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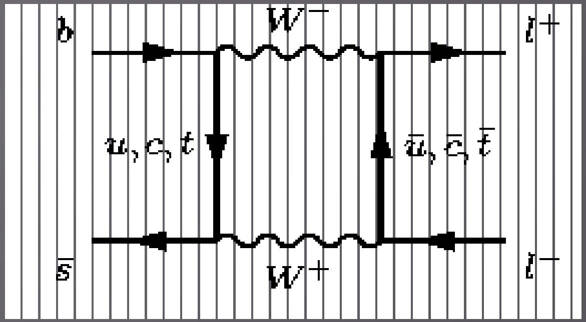
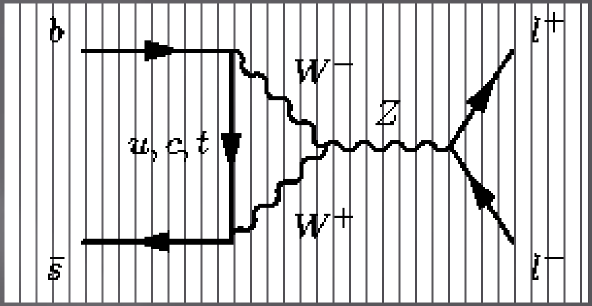
Standard Model diagrams and existing upper limits

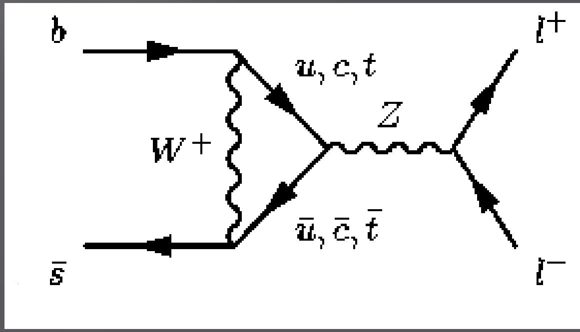
- We are looking for some evidence of possible enhancements of the Standard Model . In SM all possible $B_s \to 2\,\mu$ diagrams give branching ratio **(3.2±0.2) •10^{-9}**
- Observed and expected upper limits at the Tevatron now :

  CDF observed limit at $L = 3.7$ fb^{-1} :
  Br ($B_s \to 2\mu$) < 3.6 •10^{-8} (90% C.L.)

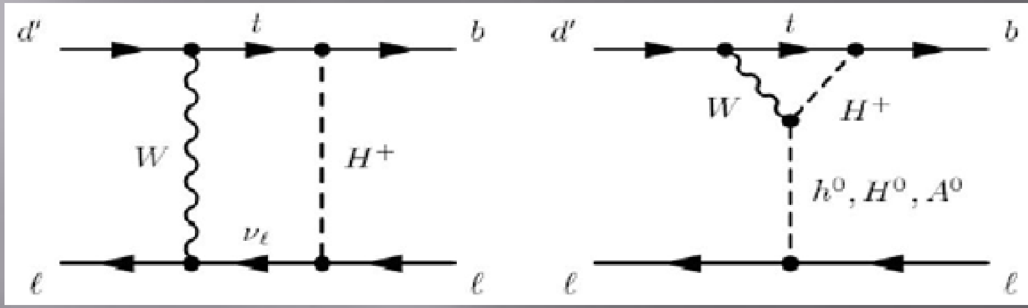
  D0 observed limit at $L = 6.1$ fb^{-1} :
  Br ($B_s \to 2\mu$) < 4.2 •10^{-8} (90% C.L.)



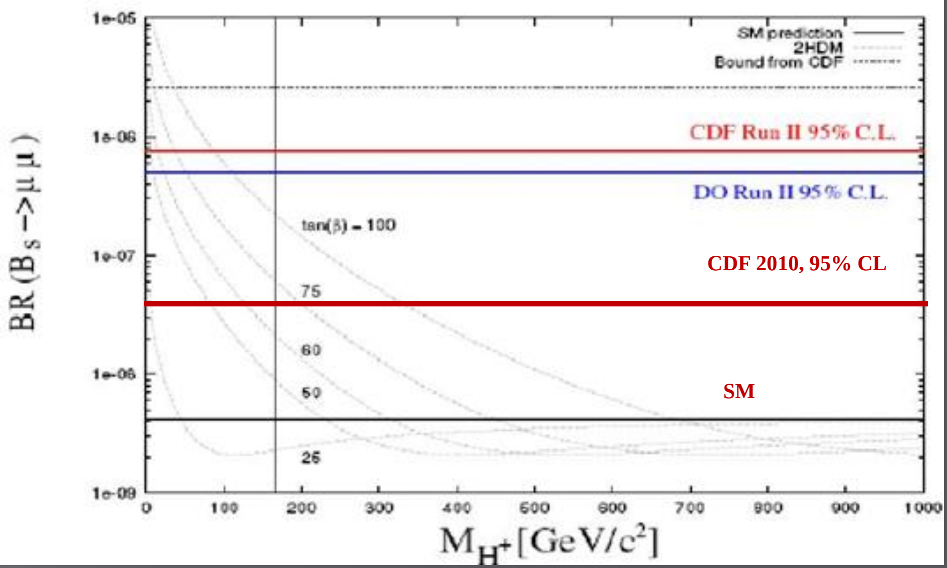




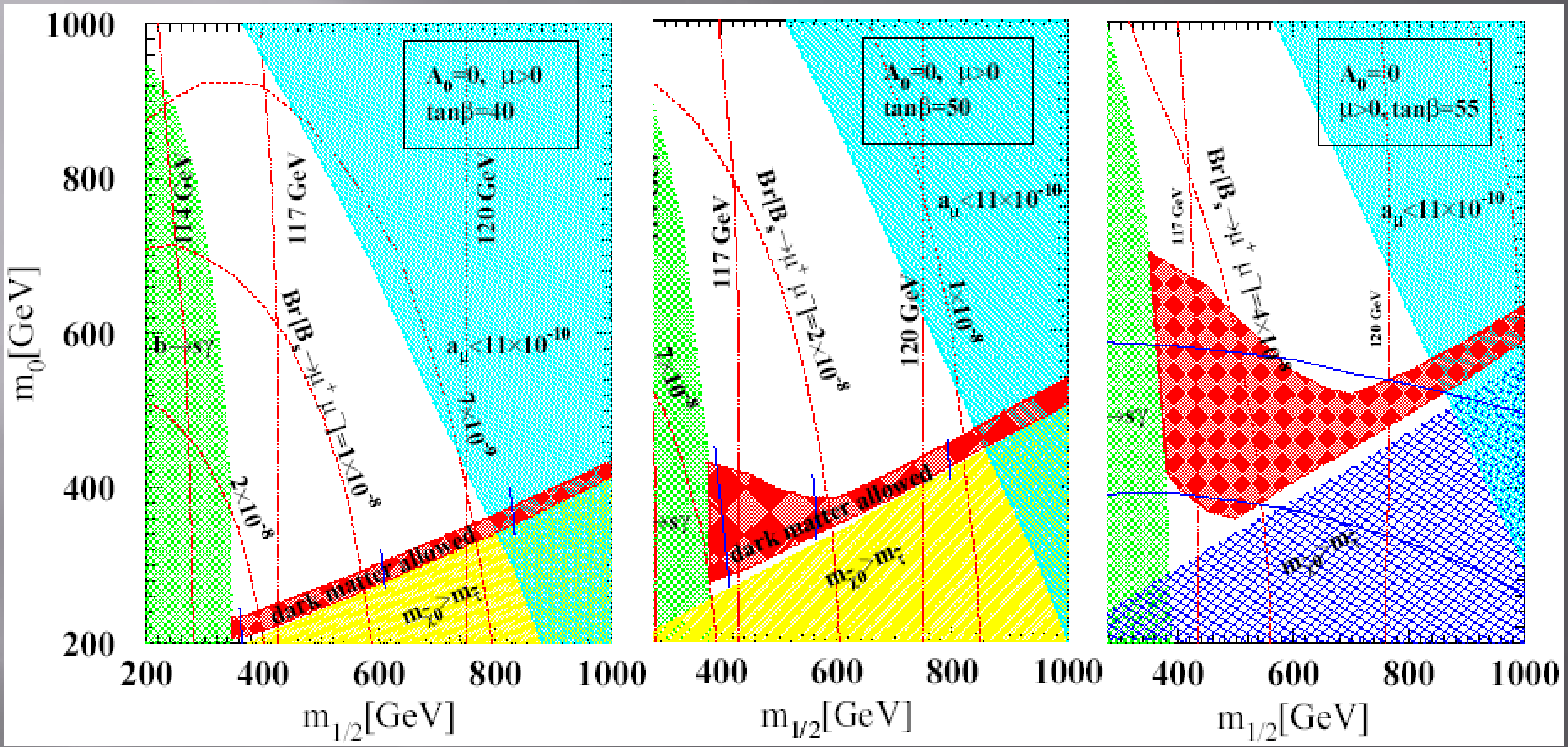
Two-Higgs doublet model diagrams



$$BR(SUSY) \propto BR(SM) \cdot \frac{m_b^4 \cdot (\tan\beta)^6}{m_{H^0}^4}$$

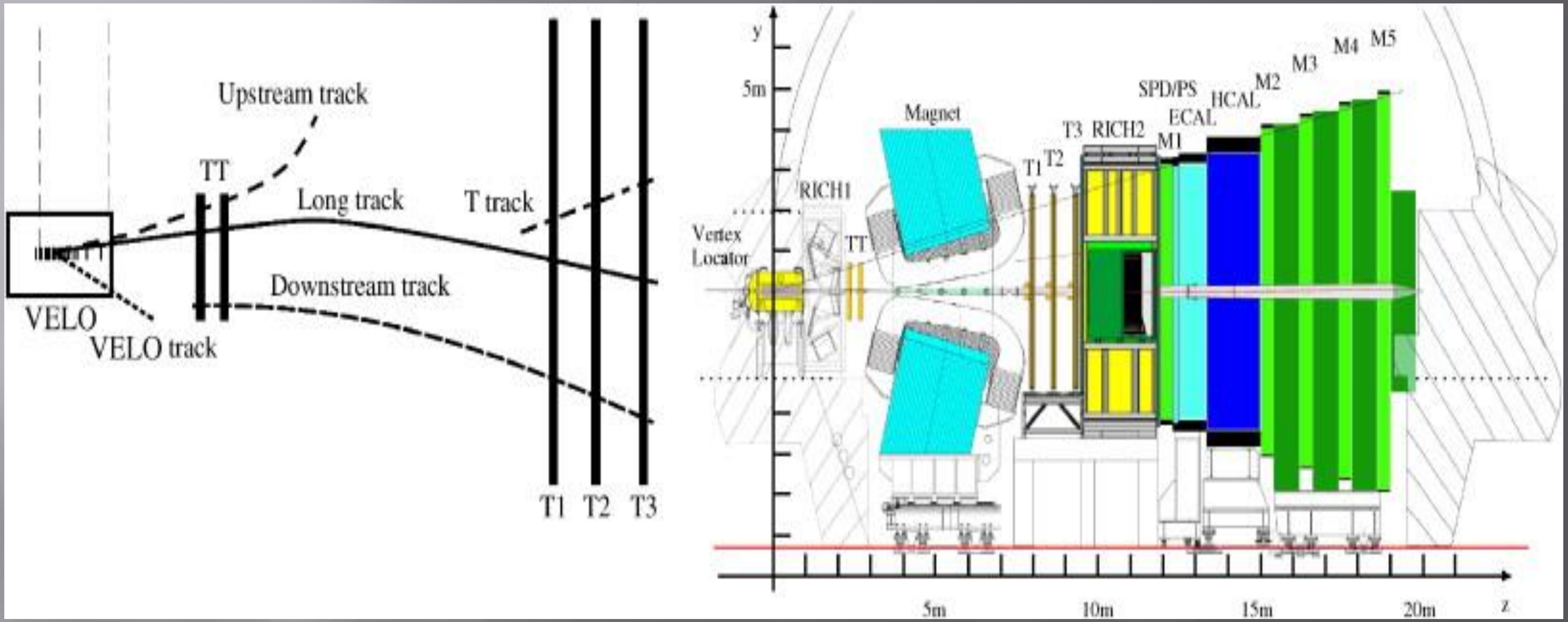


mSUGRA model



• Using these plots and measured the $B_s \to 2\mu$ branching ratio we can predict the Higgs boson mass . If Higgs boson will be discovered with the predicted mass we have a chance to explain the dark matter phenomenon in the Universe

LHCb detector



M1, M2, M3, M4, M5 – muon stations
RICH1, RICH2 – Cherenkov detectors
TT, T1,T2,T3 – tracking stations
VELO (Vertex Locator) – vertex detector

- The total integrated luminosity recorded - $\int Ldt = 34\ pb^{-1}$.
  $\int Ldt = 31\ pb^{-1}$ used for the analysis

What was done

- LHCb sensitivity to the upper limit of the $B_s \to \mu^+ \mu^-$ branching ratio was estimated using the real data
- *the Neural Network method* from TMVA package was used to separate the signal from the background
- *the kinematic parameters - the minimum muon pT and pT of the B_s* were included additionally to the geometric variables (B_s lifetime, muon and B_s impact parameters)
- *the strong cut pT > 2 GeV was applied* for muons in the normalization channel $B^+ \to J/\Psi(2\mu) + K^+$. It allows to keep the trigger efficiency ratio $eff\_trig_{Norm} / eff\_trig_{Signal} > 1$ during the calculating of the sensitivity to the upper limit
- *the $B_s \to \mu^+ \mu^-$ signal MC and the full 2010 year autumn dimuon data sample* were used to estimate the sensitivity
- *the bb→μμX Monte–Carlo events* were used to train the MVA methods
- *the Feldman-Cousin approach* (*arXiv:physics/9711021*) calculating the confidence intervals was applied to estimate the sensitivity to the signal from $B_s \to \mu^+ \mu^-$.

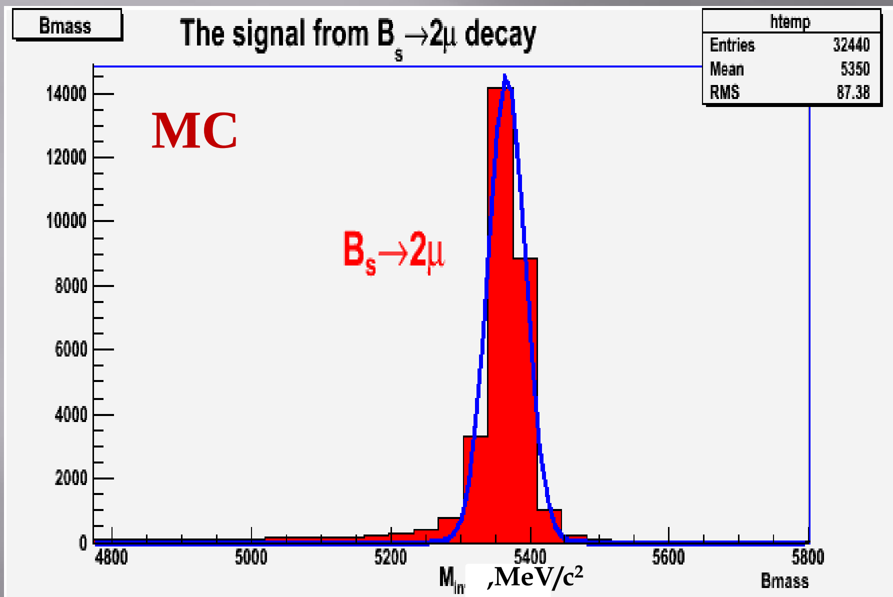
Analysis details. Preliminary cuts

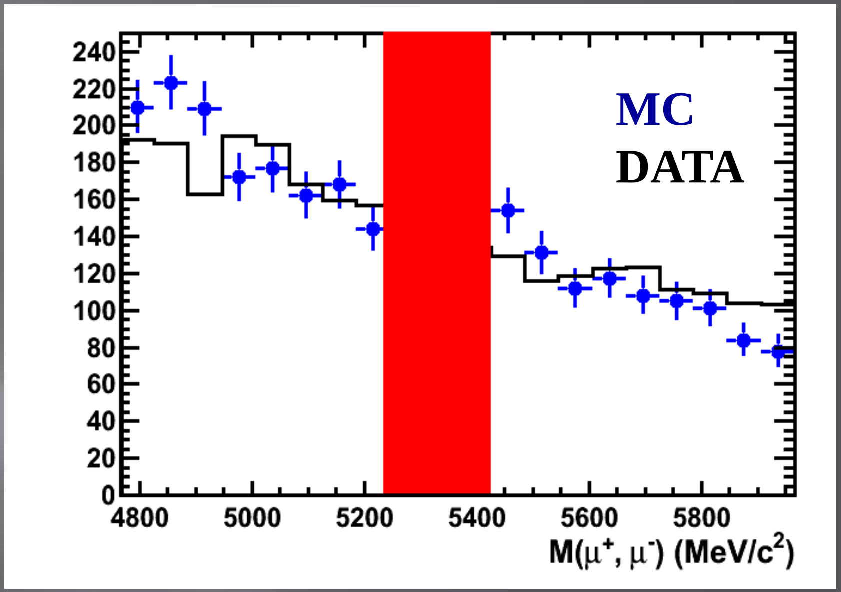
- **The preliminary restrictions were done for the events parameters :**

- Minimum $pT_{\mu1,2} > 0.5\ GeV$
- Transverse momentum B_s cut - $pT_{Bs} > 0.7\ GeV$
- Muon track impact parameter significance cut - $IPS\_\mu > 3.5$
- Bs decay distance significance cut - $DOFS(B_s) > 12$
- Secondary vertex χ^2 cut: $Vchi2 < 14$
- Mass window: M_{Bs} $- 0.06 < B_s\ mass < M_{bs} + 0.06\ GeV$ for the signal
- Mass window: M_{Bs} $- 0.6 < B_s\ mass < M_{bs} + 0.6\ GeV$ for the background
- B_s meson impact parameter significance cut - $IPS\_Bs < 6$
- Minimum distance between muon tracks - $DOCA < 0.3\ mm$

•After all preliminary cuts 20K MC bb→μμX background events and 20K signal events were used to train the Neural Network
• Next the 8524 data events from the $B_s \to 2\mu$ signal sidebands and 15K of the signal events were used for testing and calculating of the sensitivity

Analysis details. Signal and background invariant mass shape



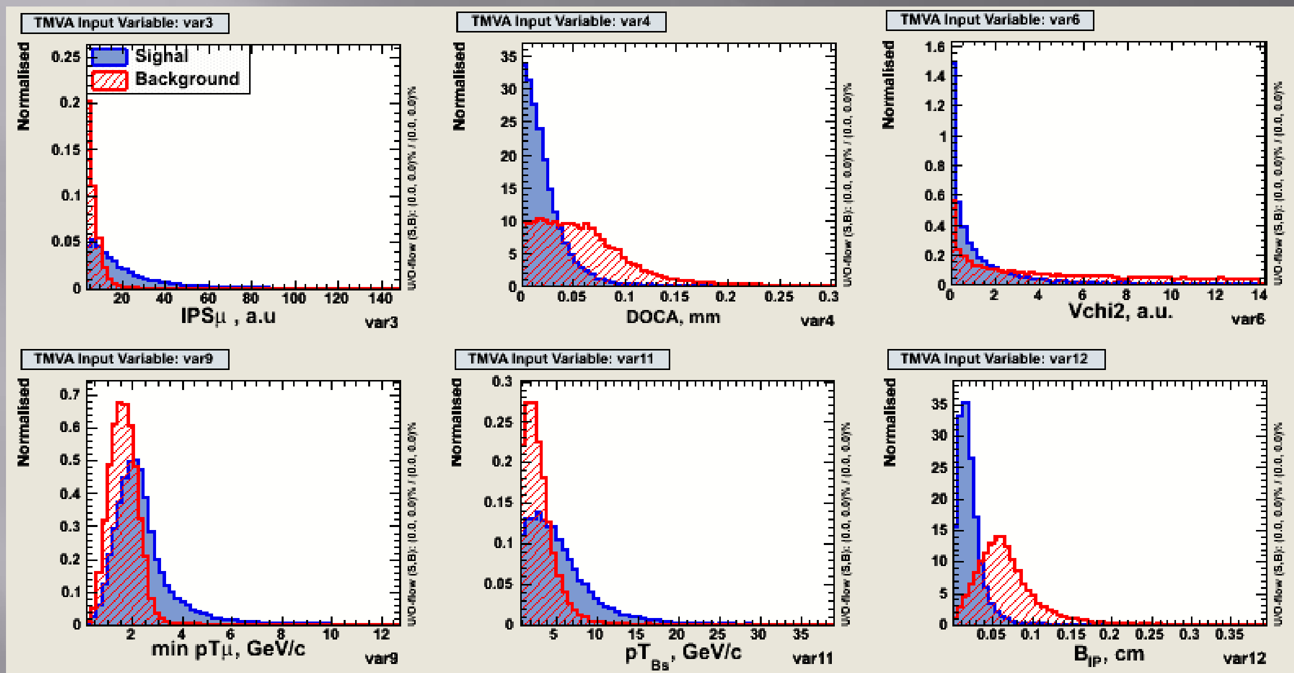


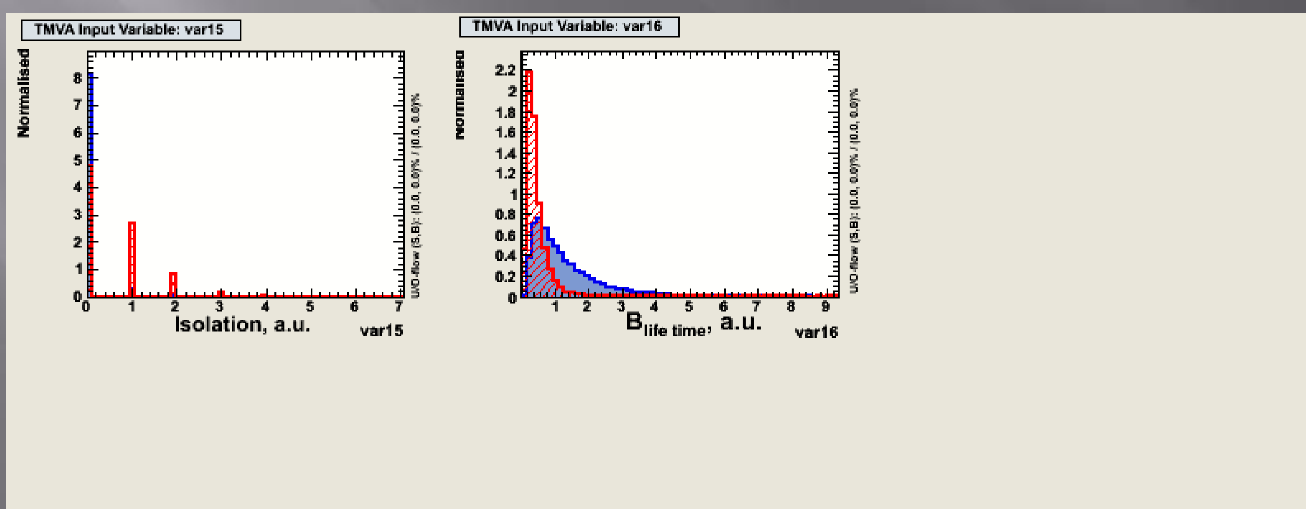
• The estimated experimental invariant mass resolution - $\Delta M_{Bs\to 2\mu}$ = 26.9±0.2 MeV/c²

- The dimuon background shape observed in the sidebands of the data is in a reasonable agreement with the expectation from the dimuon MC

Input variables for TMVA methods

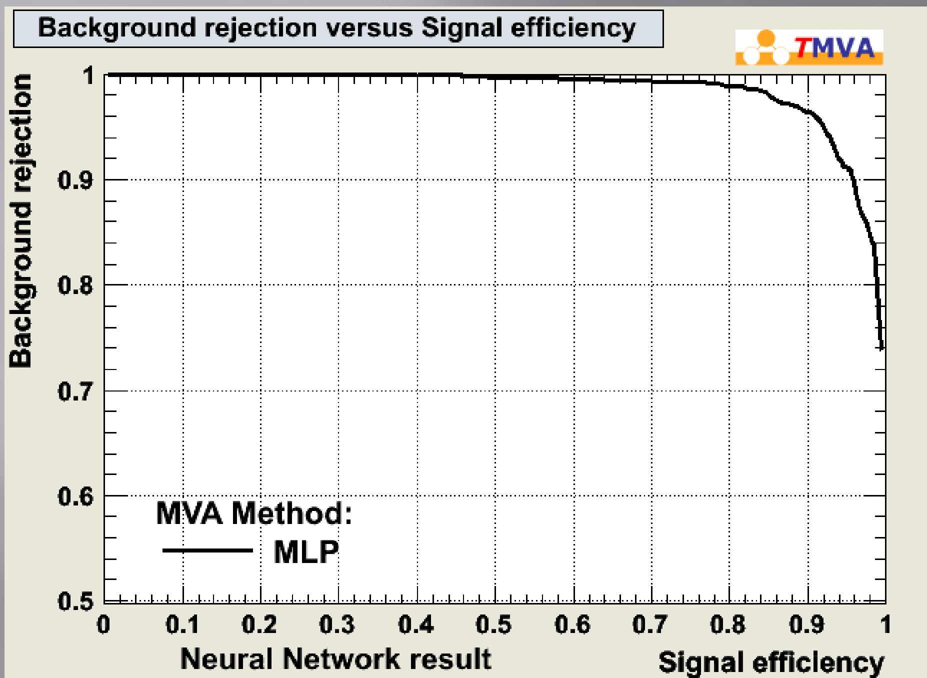
• The eight parameters were used to train and test the MVA methods:

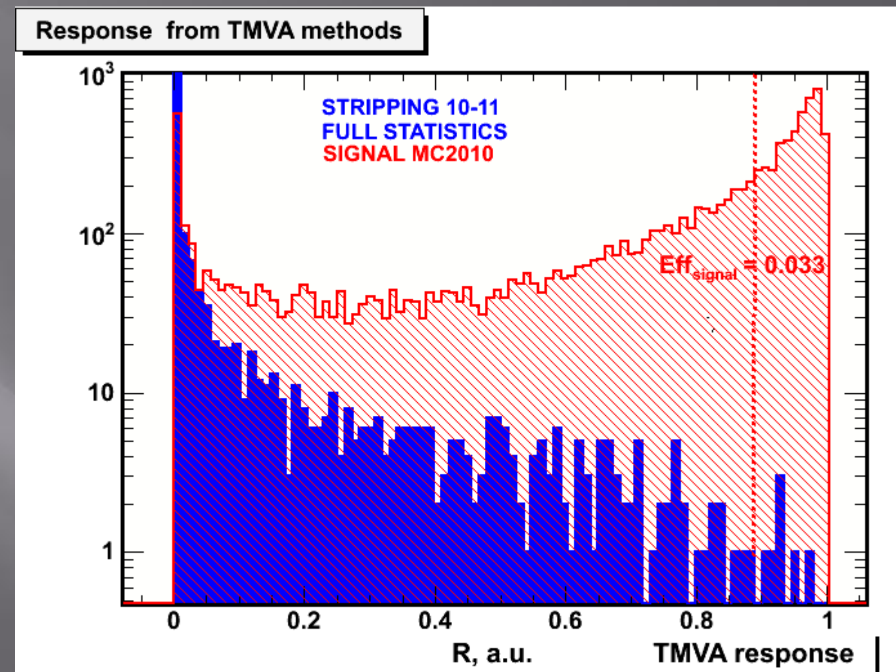




- IPSμ
- DOCA
- Vchi2
- min pTμ
- pT_{Bs}
- B_{ip}
- Muon isolation
- B_s life time

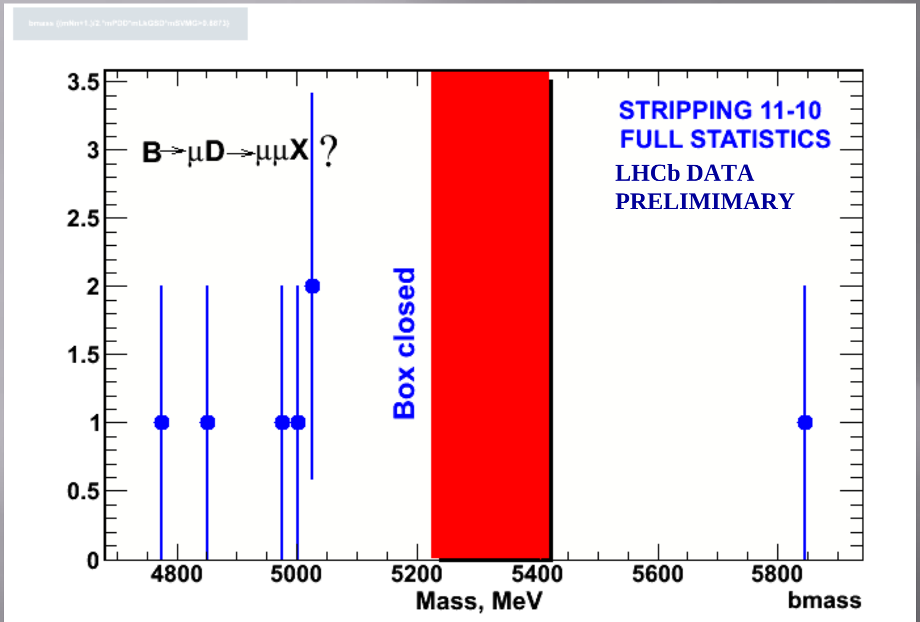
Neural Network method analysis result

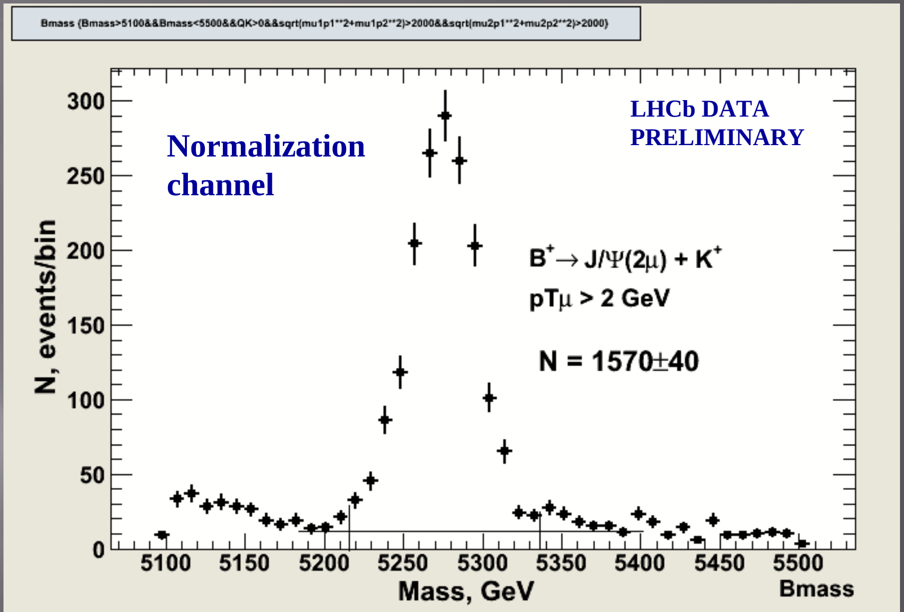




- The neural network demonstrates a good background rejection power
- The result is consistent with other LHCb Bs2μμ group analyses

Analysis results. Sensitivity to the possible signal from $B_s \to 2\mu$ decays





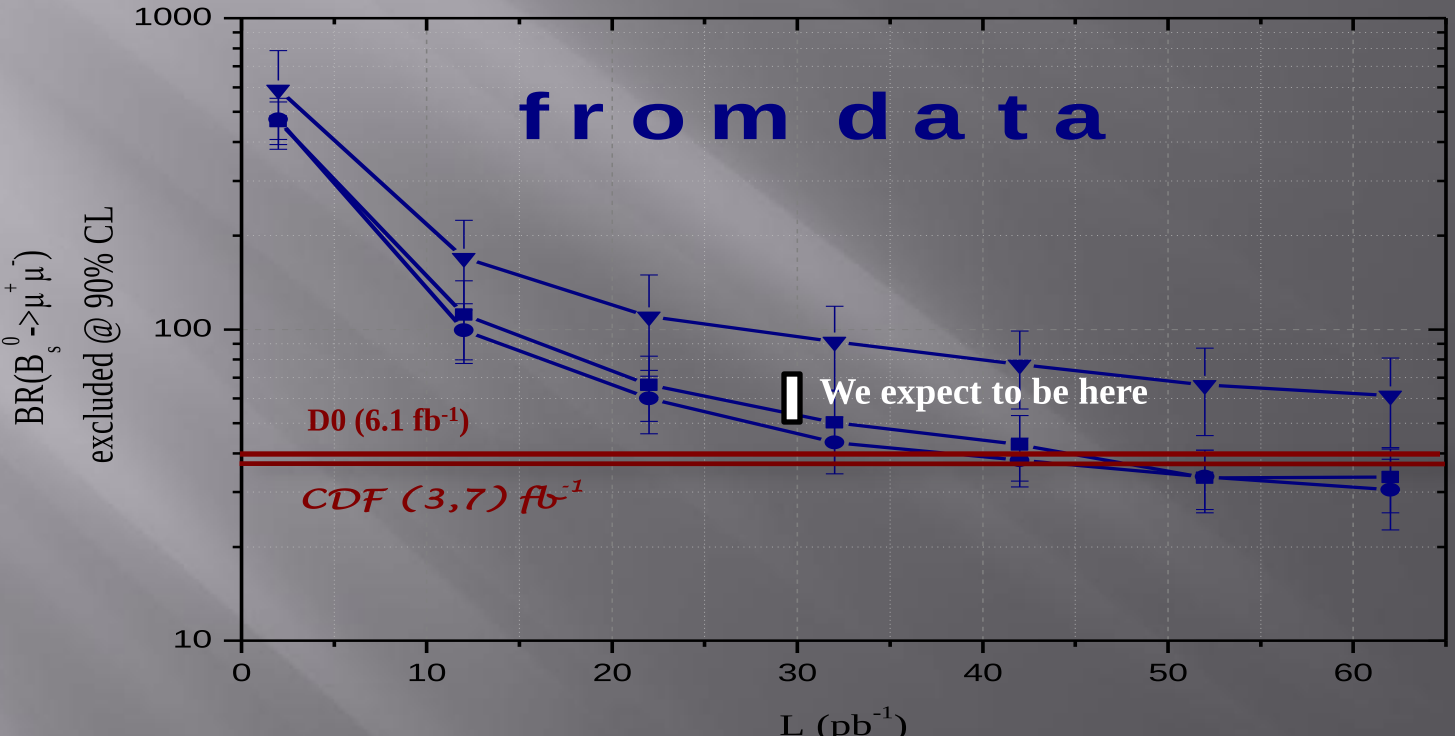
fd/fs = 3.6±0.5, eff_{norm}/eff_{signal} = 0.17

$Br(B^+ \to J/\Psi(2\mu)K^+) = 5.98\times10^{-5}$, N=1570±40

$$Br = N_{signal} \times eff_{norm}/eff_{signal} \times 1/N_{B+} \times f_d/f_s$$

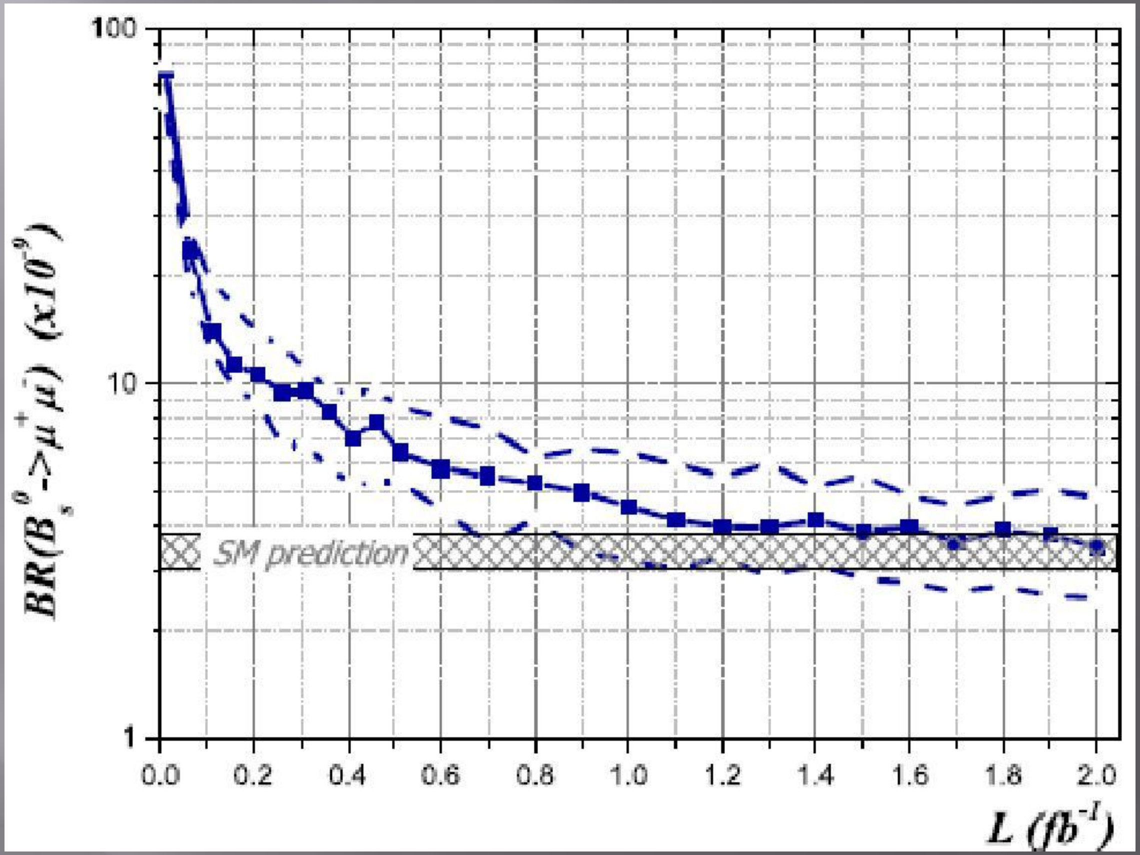
- Sensitivity for 90% CL at $\int Ldt = 31pb^{-1}$ – **$(5.7\div7.7)\times10^{-8}$** (Feldman–Cousin method)
- Can be improved by 20÷30% using the difference between the invariant mass shapes for the signal and background and the understanding of the background events nature in the left sideband

Sensitivity to the upper limit



LHCb sensitivity for the ∫Ldt =31 pb^{-1} is close to the D0 result for the ∫Ldt =6.1 fb^{-1}

Sensitivity to the upper limit



•Now the sensitivity curve to the expected upper limit is very similar to the prediction of the LHCb Roadmap document

Conclusions

- Our estimate for the LHCb sensitivity to the upper limit of the $B_s \to \mu^+ \mu^-$ branching ratio is consistent with the other LHCb Bs2μ group studies
- There are some key points of the analysis technology:
- the Neural Network method was used to separate the signal from the background
- the kinematic parameters were included additionally to train and test the Neural Network
- the strong cut pT > 2 GeV/c for the muon minimum pT in the normalization channel $B^+ \to J/\Psi(2\mu) + K^+$ helps to avoid of the triggers efficiency calculation
- the understanding of the background events nature in the left sideband of the invariant mass spectrum can be used to improve the sensitivity

This work was done at the great support of many LHCb colleagues. Thanks !

Special thanks to Igor Smirnov for the useful discussions.

Спасибо и с наступающим Новым 2011 годом!