Search for $B \to \mu^+\mu^-$ at CDF

Kevin Pitts
University of Illinois

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History

- 7 fb^{-1} analysis (summer 2011) showed an excess above background and (background + signal) expectation

- Using the CLs method, we observe
  - $\mathcal{B}(B_s \to \mu^+\mu^-) < 4.0\times10^{-8}$ @ 95% C.L.
- Compare to the expected limit
  - $\mathcal{B}(B_s \to \mu^+\mu^-) < 1.5\times10^{-8}$
- Central value:
  - $\mathcal{B}(B_s \to \mu^+\mu^-) < (1.8^{+1.1}_{-0.9})\times10^{-8}$

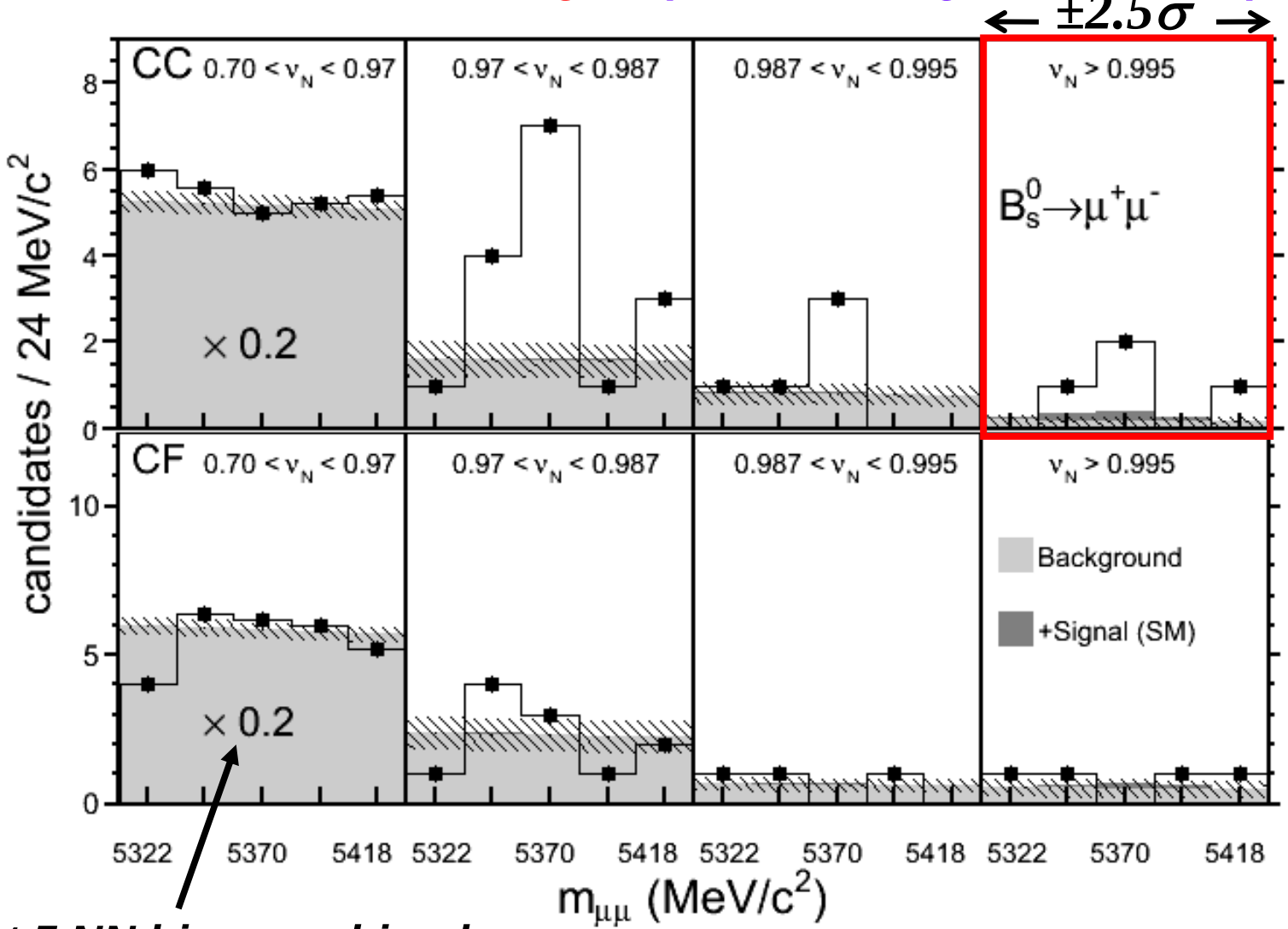
PRL 107, 191801 (2011).

Summer 2011

$B_s \to \mu^+\mu^-$ Signal Window

7 fb^{-1} result Summer 2011

- **Include assumed SM signal (almost all signal NN>0.995)**



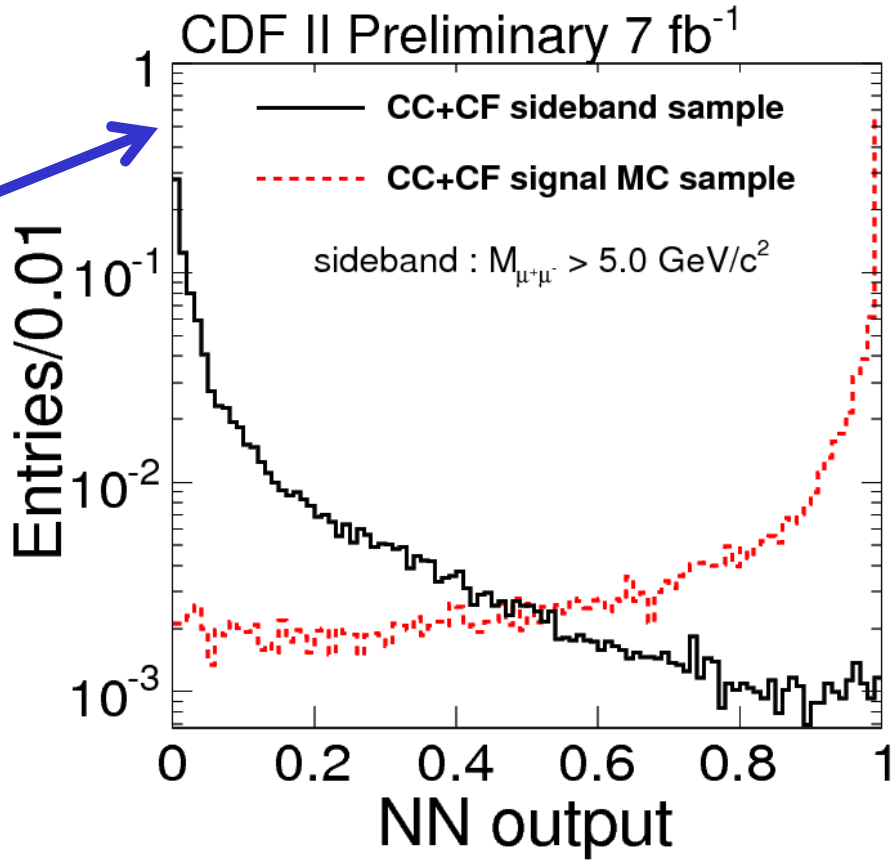
central-central

central-forward

First 5 NN bins combined

Analysis

- **7 fb^{-1} analysis featured:**
  - Use good mass resolution ($\sigma_{\mu\mu}$ = 24 MeV/c^2 at 5.3 GeV) and particle ID to reduce background.
  - Improved neural network (14 variables)
  - Blinded, optimized for best limit
  - Checked for bias and overtraining

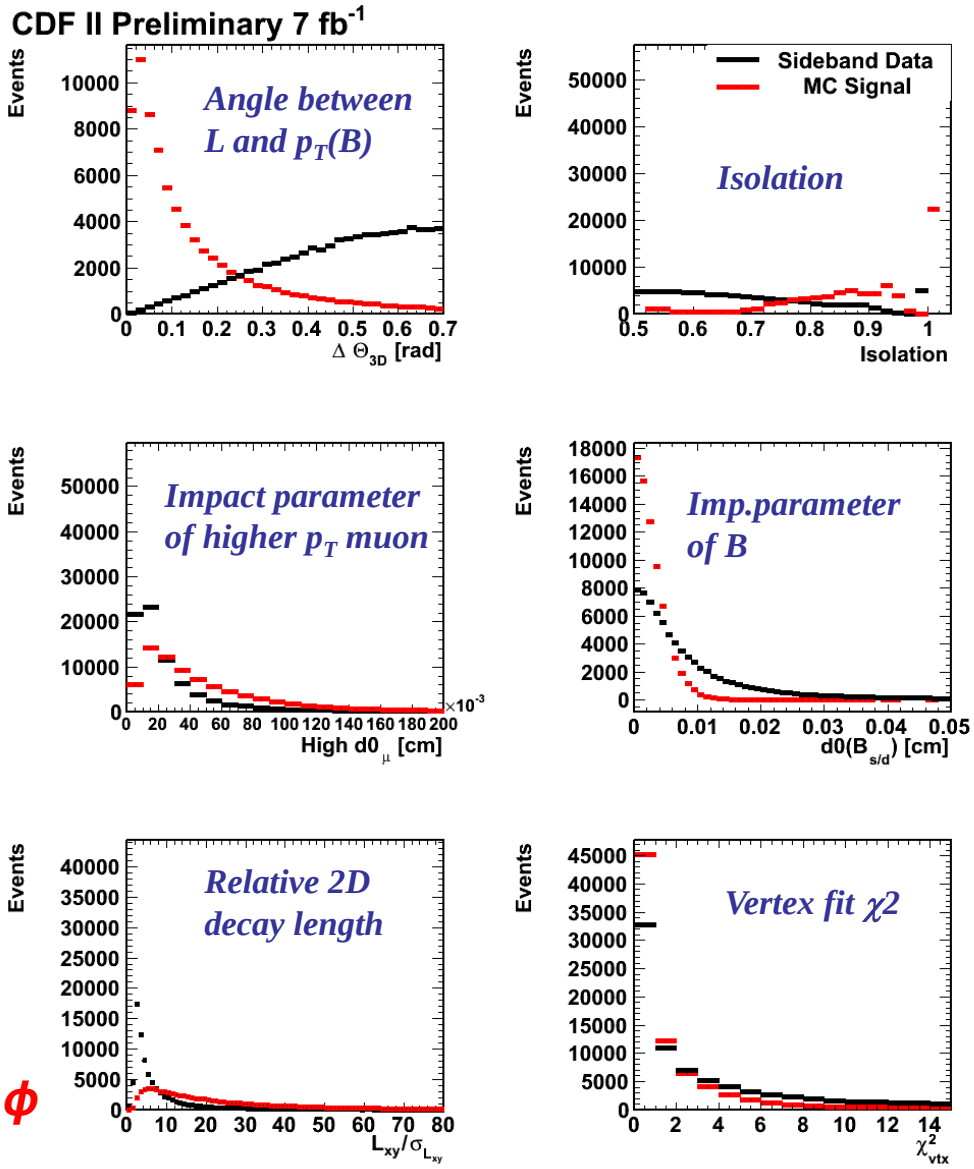


- **9.7 fb^{-1} analysis:**
  - Uses identical selection criteria from previous analysis.
  - Only change is to increase data sample by 39%.

NN Variables

Rank	Variable
1	$\Delta\alpha_{3d}$
2	Isolation
3	Larger $\lvert d_0(\mu)\rvert$
4	$\lvert d_0(B_s^0)\rvert$
5	$L_{2d}/\sigma_{L_{2d}}$
6	χ^2_{vtx}
7	L_{3d}
8	Lower $p_T(\mu)$
9	Significance of smaller $\lvert d_0(\mu)\rvert$
10	$\lambda_{3d}/\sigma_{\lambda 3d}$
11	λ_{3d}
12	Smaller $\lvert d_0(\mu)\rvert$
13	$\Delta\alpha_{2d}$
14	Significance of larger $\lvert d_0(\mu)\rvert$

- p_T reweighted to $B^+ \rightarrow J/\psi\, K$
- Isolation reweighted to $B_s \rightarrow J/\psi\, \phi$



In a nutshell

$$\mathcal{B}\left(B_s \to \mu^+\mu^-\right) = \frac{N_{B_s}}{N_{B^+}} \frac{\alpha_{B^+}}{\alpha_{B_s}} \frac{\varepsilon^{trig}_{B^+}}{\varepsilon^{trig}_{B_s}} \frac{\varepsilon^{reco}_{B^+}}{\varepsilon^{reco}_{B_s}} \frac{1}{\varepsilon^{NN}_{B_s}} \frac{f_u}{f_s} \mathcal{B}\left(B^+ \to J/\psi K^+\right) \mathcal{B}\left(J/\psi \to \mu^+\mu^-\right)$$

Measure yields

Efficiencies from data & MC

Fragmentation fractions and BR from PDG

Acceptance from Monte Carlo

Additional aspects:

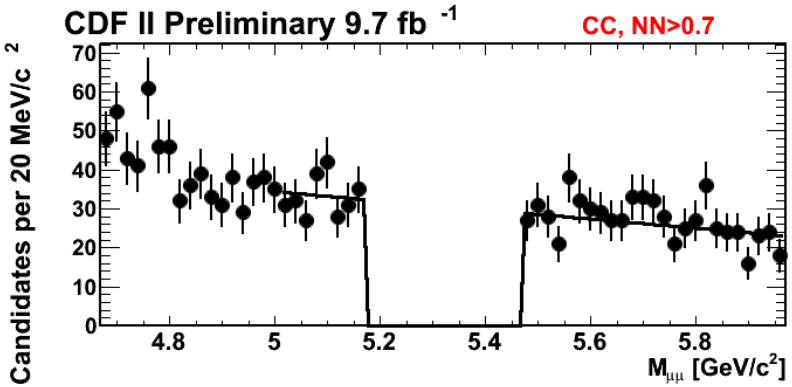
- Use neural net, optimize selection
- Extraction of N additionally requires evaluation of background contributions.
- Analysis is statistics limited
- Many systematics cancel in ratio, dominant syst. is f_u/f_s!

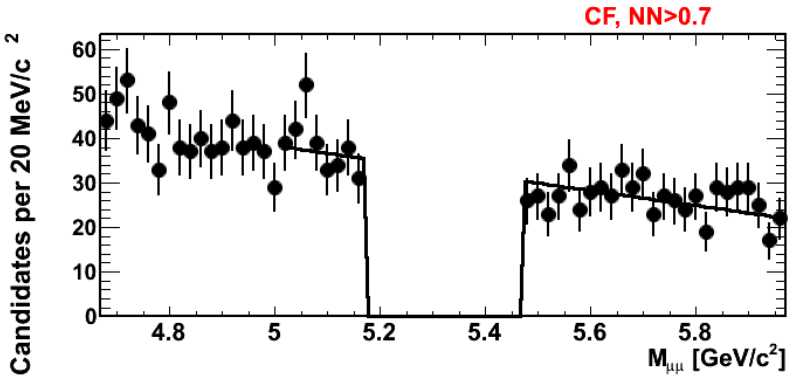
Background Estimates

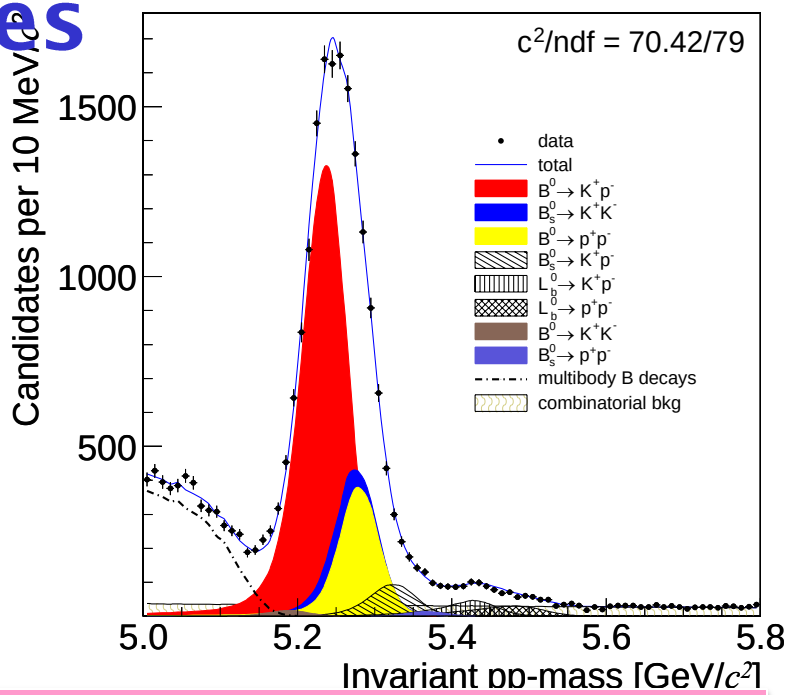
CDF Run II Preliminary $\int L\,dt$ = 6.11 fb^{-1}

Combinatoric background:

- *Estimated from sidebands*
- *Exclude partial reconstructions*

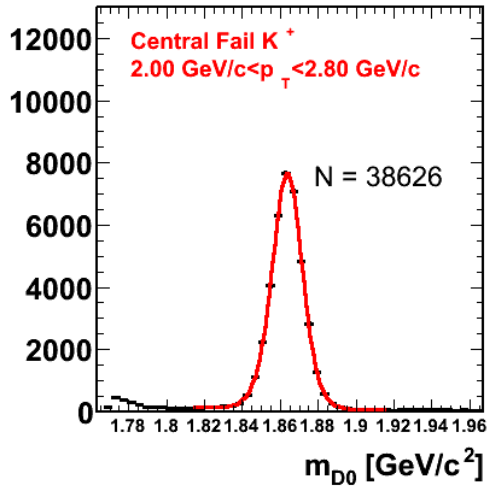






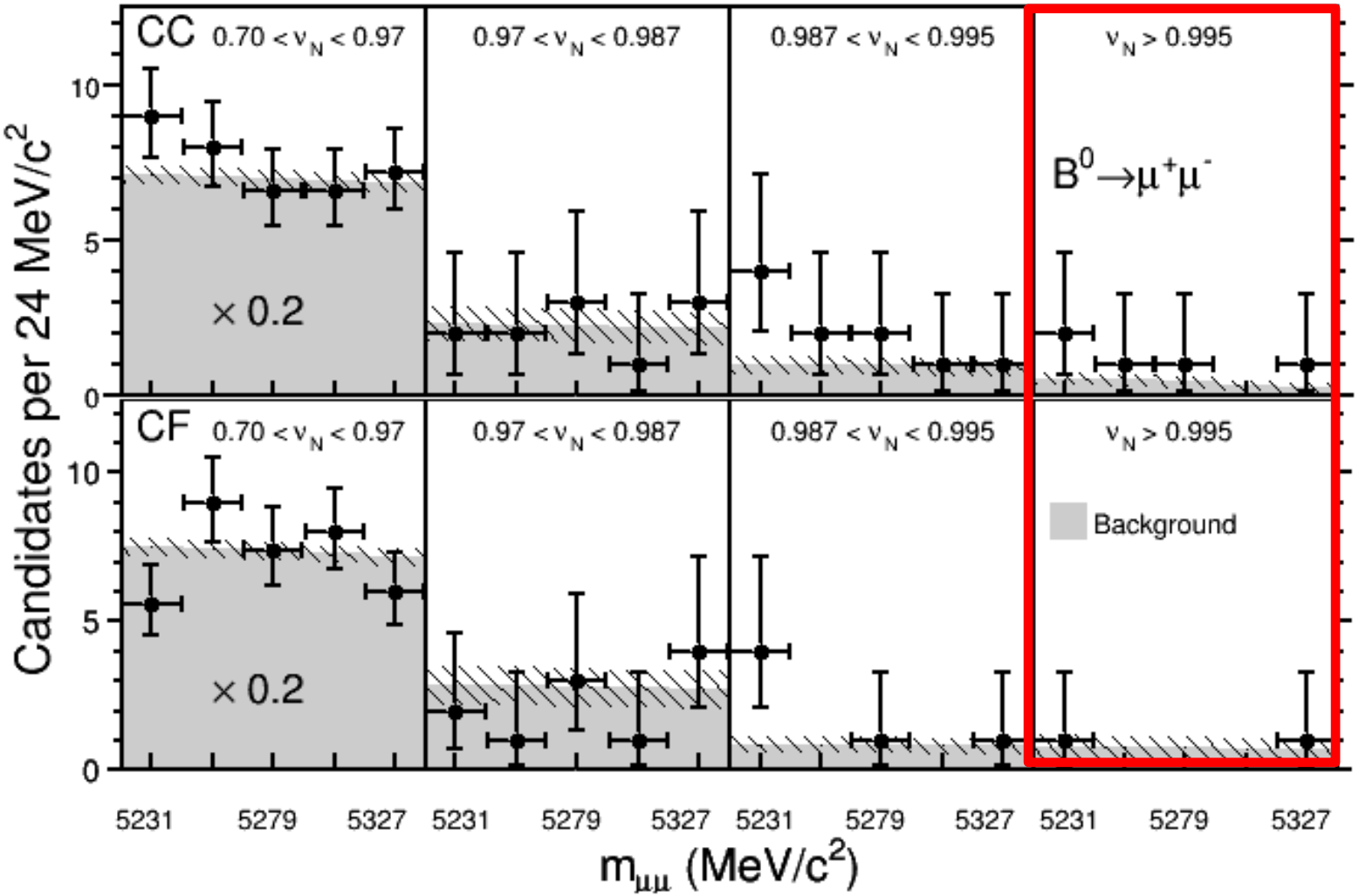
Peaking background:

- *From B → hh′*
- *Muon misID rate from D* tagged D^0*



Also check background estimates on same-sign and negative lifetime samples.

9.7 fb^{-1} B^0 result



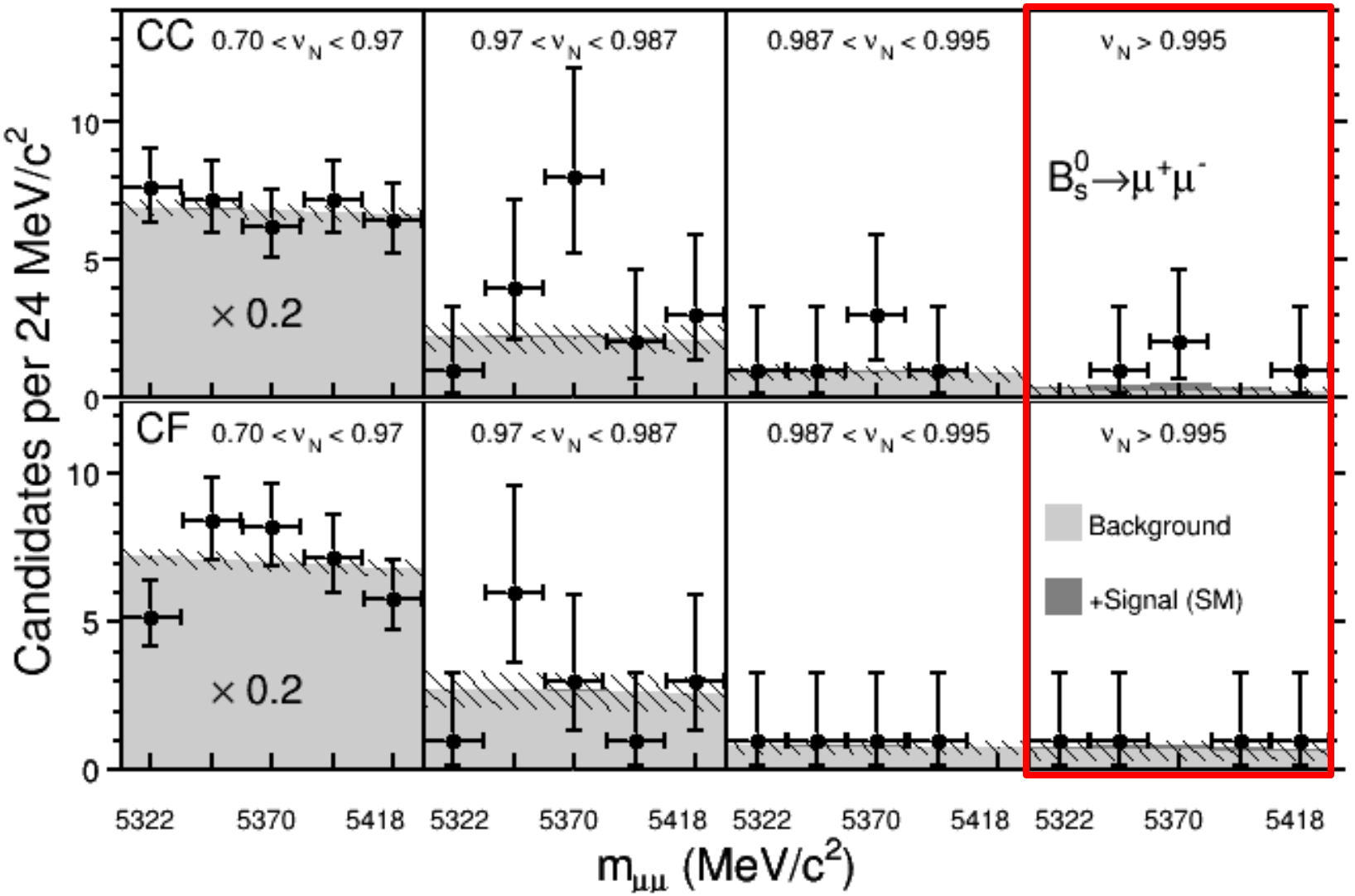
central-central

central-forward

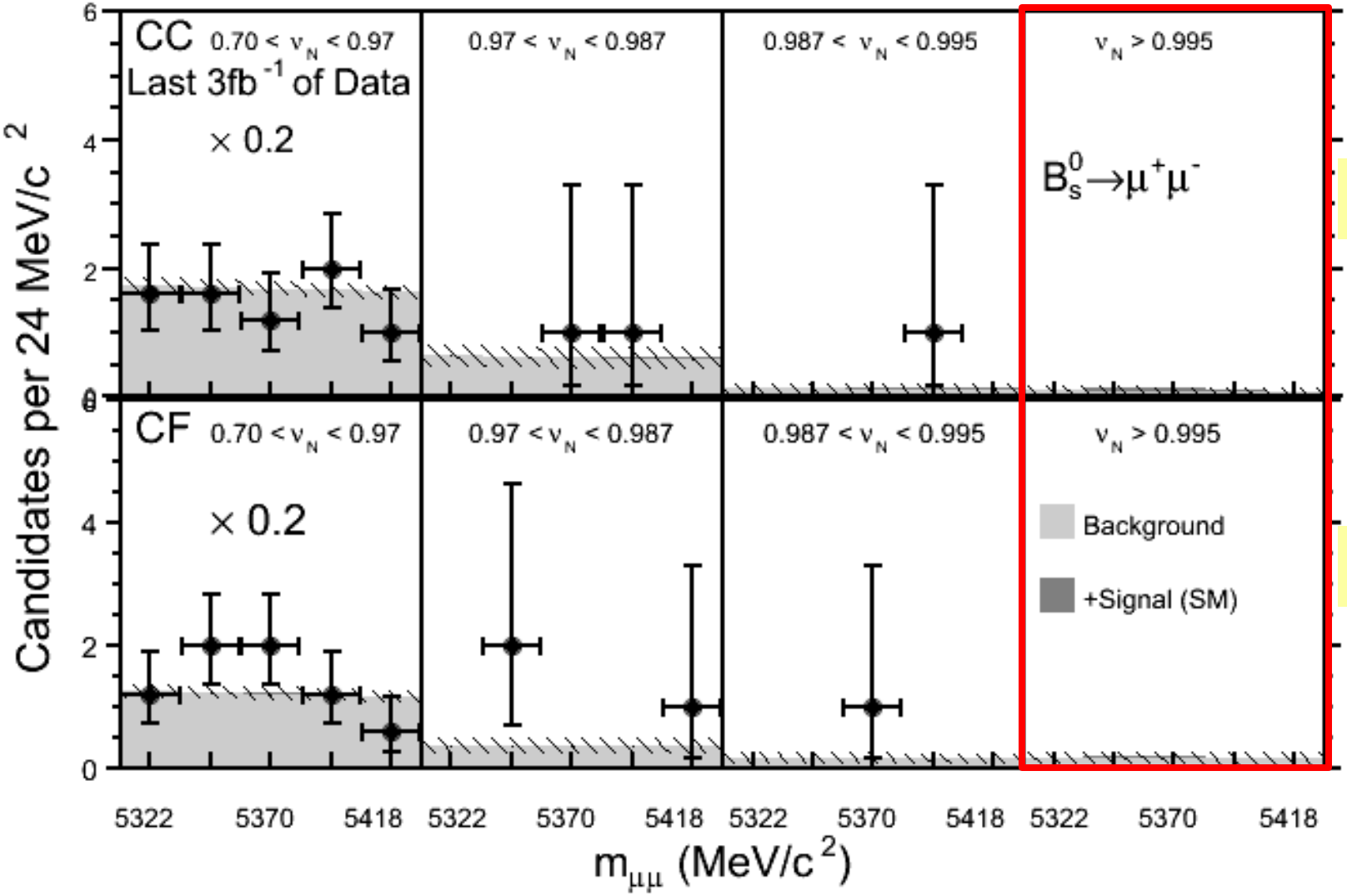
$\mathcal{B}(B^0 \rightarrow \mu^+\mu^-) < 4.6\times10^{-9}$ @ 95% C.L.

9.7 fb^{-1} B_s result

- Excess remains from 7 fb^{-1}, not supplemented with new data.
- background only p-value rises from 0.27% to 0.94%.



New data only (last 3 fb^{-1})



Summary

9.7 fb^{-1} result

- **Expected limit:**
  - $\mathcal{B}(B_s \to \mu^+\mu^-) < 1.3\times10^{-8}$ @ 95% C.L.
- **Observed Limit**
  - $\mathcal{B}(B_s \to \mu^+\mu^-) < 3.1\times10^{-8}$ @ 95% C.L.
- **Central value**
  - $\mathcal{B}(B_s \to \mu^+\mu^-) < (1.3^{+0.9}_{-0.7})\times10^{-8}$

- ***This is the final CDF result on $B \to \mu^+\mu^-$***
  - **PRD documenting full analysis in preparation.**