$B_s \to \mu\mu(\gamma)$

At LHCb

Liverpool HEP Xmas Meeting

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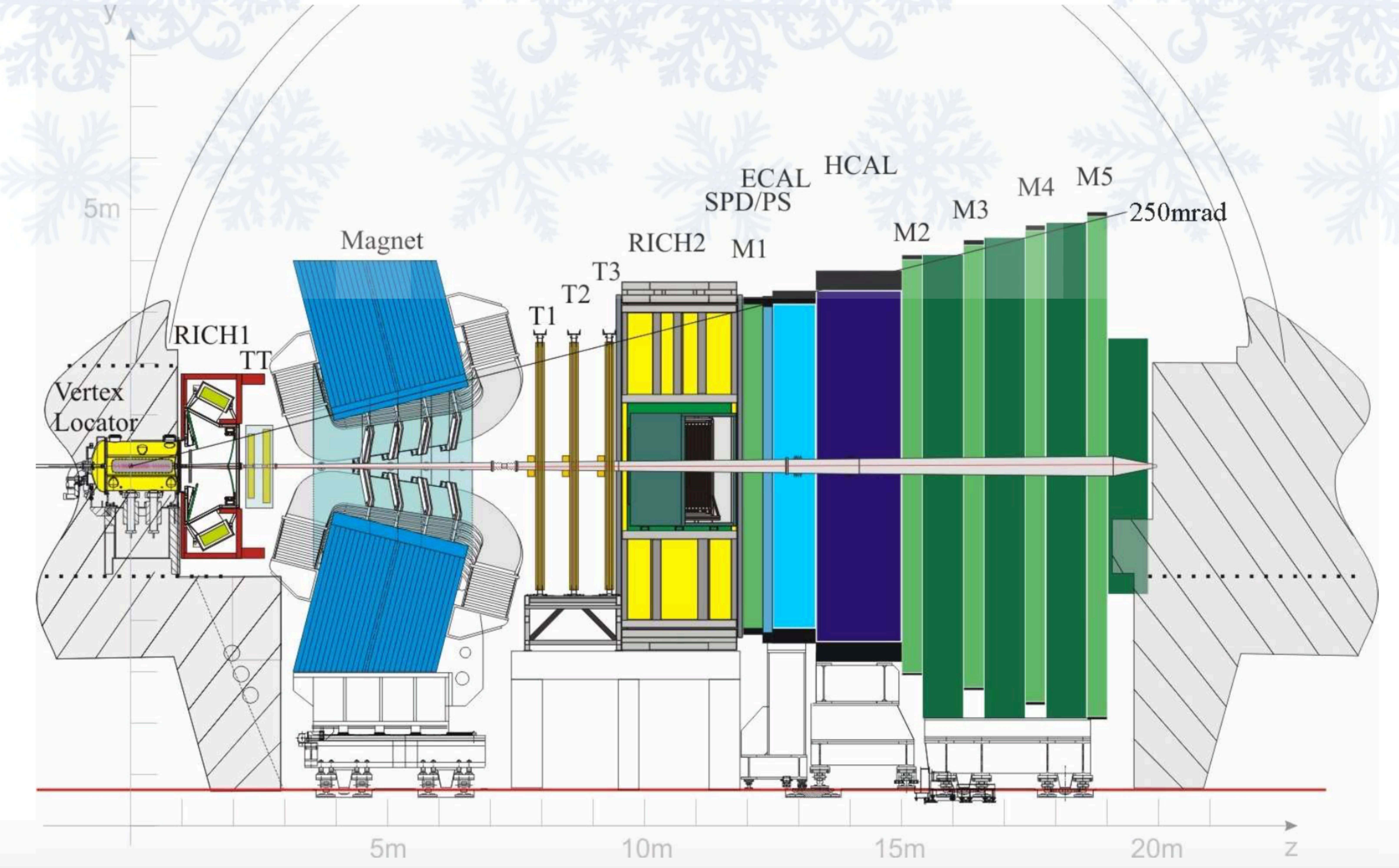
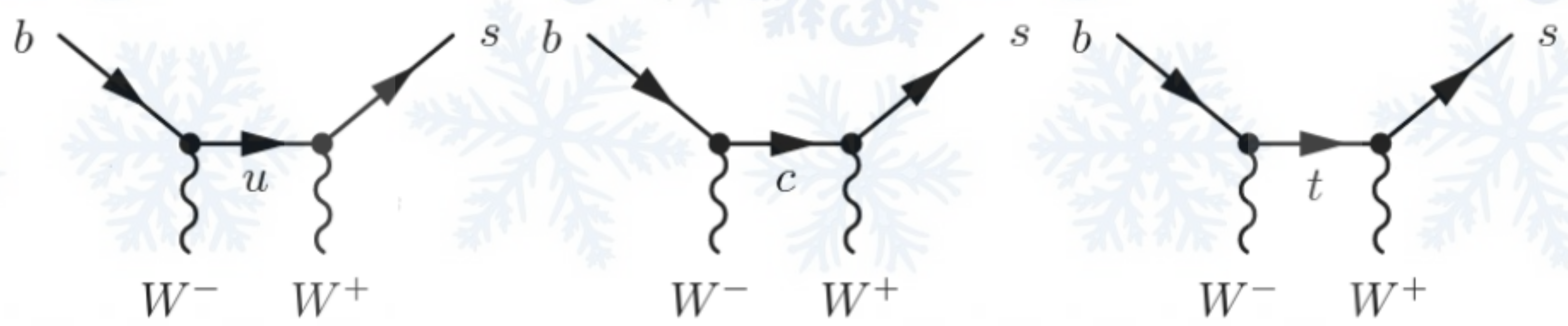
LHCb

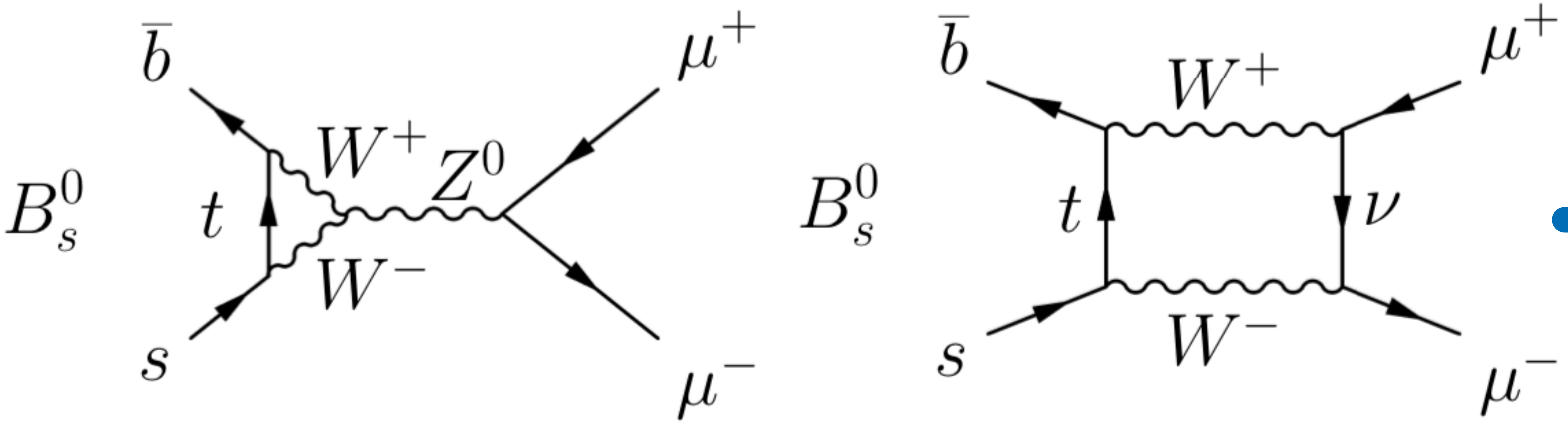


y
5m
Magnet
RICH1
TT
Vertex
Locator
T1
T2
T3
RICH2
M1
SPD/PS
ECAL
HCAL
M2
M3
M4
M5
250mrad
5m
10m
15m
20m
z

Rare Decays



Rare decays are powerful tools for probing NP interactions.
Flavour-Changing-Neutral-Currents forbidden at leading-order (making certain decays extremely rare).

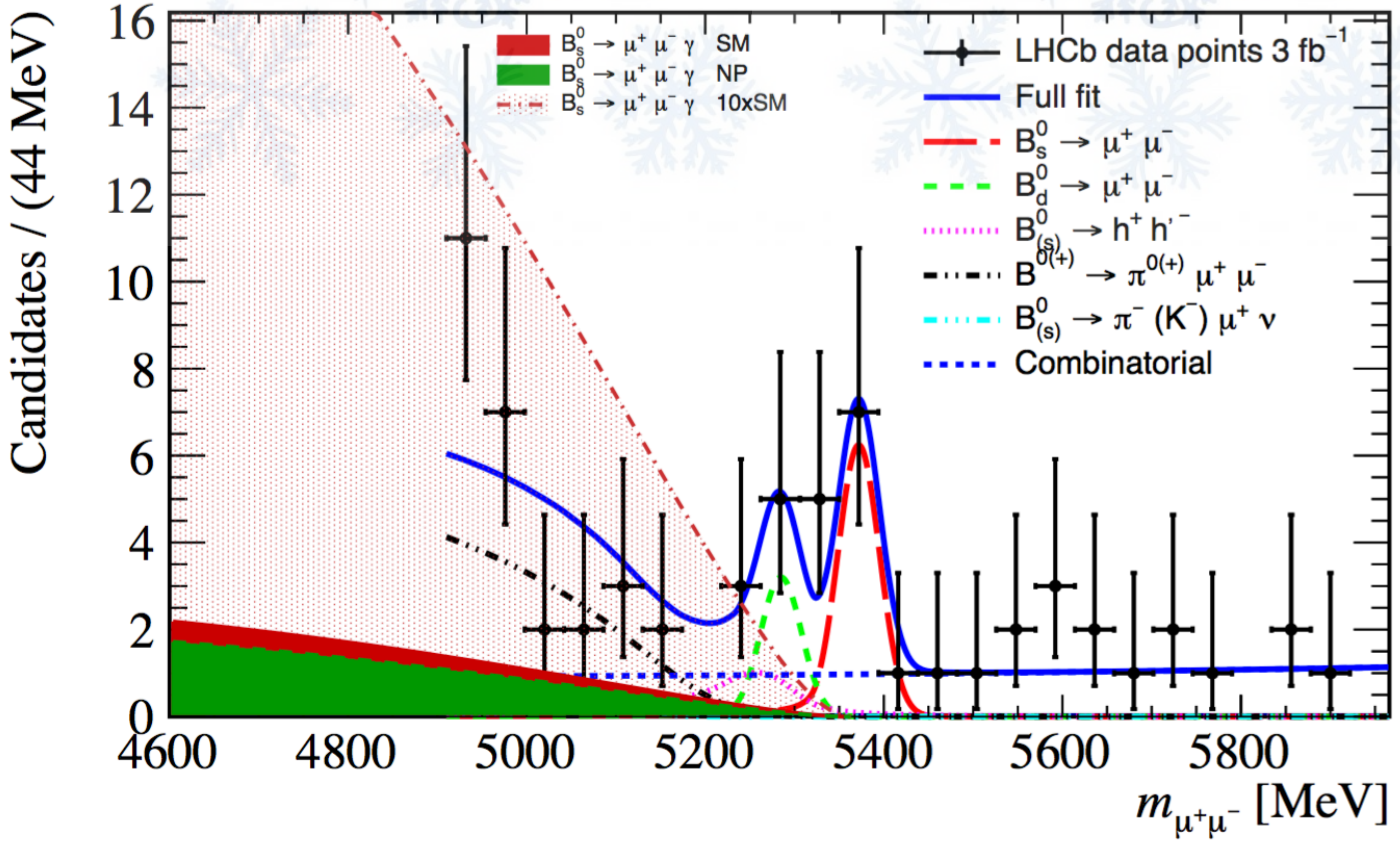


Suppressed to the order 10^{-9}

Motivation

- Rare decays with well known SM predictions are interesting, as even small deviations from the SM are significant.
- Decays that are suppressed in the SM are not necessarily surpassed in New Physics models
- $B_s \to \mu\mu\gamma$ Branching ratio has never before been measured
- Sensitive to different new physics couplings than $B_s \to \mu\mu$
- Analysis can be performed simultaneously to $B_s \to \mu\mu$
- $B_s \to \mu\mu\gamma$ is also a background for $B_s \to \mu\mu$

Analysis Strategy



No photon reconstruction, so missing energy shows up as a lower dimuon mass range.

Use standard $B_s \to \mu\mu$ trigger and selection

Search for $B_s \to \mu\mu\gamma$ in the left shoulder of the dimuon invariant mass distribution

Datasets and tools already in place from the last (and ongoing) analysis rounds of $B_s \to \mu\mu$

Previous round

- The $B_s \to \mu\mu$ decay has been observed with a significance of 7.8σ through the previous analysis of LHCb collaboration using Run I and part of Run II dataset (up to Sept. 2016)

- The measured BR is in agreement with the SM prediction, of $(3.65 \pm 0.23) \times 10^{-9}$

- With the same data, an evidence of the decay $B_d \to \mu\mu$ with 3.2σ significance was observed (1.8σ and 2.6σ from LHCb and CMS data, respectively).

- The measured BR is in this case $(3.9^{+1.6}_{-1.4}) \times 10^{-10}$, which is 2.2σ above the SM prediction, $(1.06 \pm 0.09) \times 10^{-10}$

Analysis

$B_s \to \mu\mu$ analysis round 2 - BR and effective lifetime measurements

$B_s \to \mu\mu\gamma$ analysis round 1 - no limit yet

My Role:

$B_s \to \mu\mu$	$B_s \to \mu\mu\gamma$
Creating all MC Ntuples	Creating all MC Ntuples
Background Efficiencies	Background Efficiencies
	MC Signal Efficiencies
	Final fit to data

Currently working on MC Efficiencies

$$\epsilon_{Tot} = \epsilon_{Gen} \times \epsilon_{Rec} \times \epsilon_{Sel} \times \epsilon_{PID} \times \epsilon_{Trig}$$

Which can be used to find expected yields:

$$\mathscr{B}(B^0_{s,d} \to \mu^+\mu^-) = \frac{N_{B^0_{s,d}\to\mu^+\mu^-}}{2 \times \mathscr{L}_{int} \times \sigma_{pp\to b\bar{b}} \times f_{s,d} \times \epsilon_{B^0_{s,d}\to\mu^+\mu^-}}$$

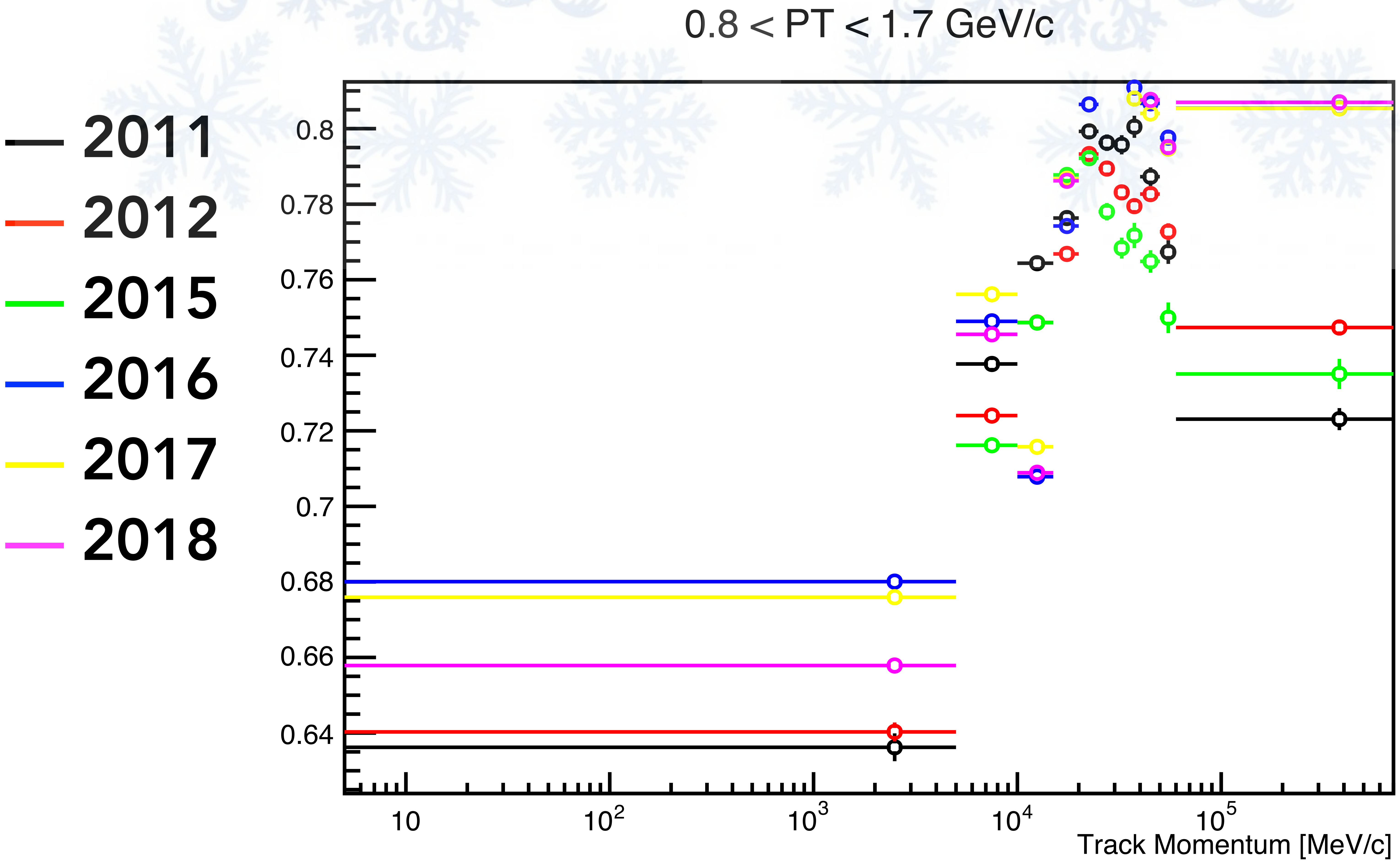
$$\mathscr{B}(B^0_{s,d} \to \mu^+\mu^-) = \frac{\mathscr{B}_{norm}}{N_{norm}} \times \frac{\epsilon_{norm}}{\epsilon_{B^0_{s,d}\to\mu^+\mu^-}} \times \frac{f_{norm}}{f_{s,d}} \times N_{B^0_{s,d}\to\mu^+\mu^-}$$

Large uncertainties in these measurements, so we use normalisation channels:

$B^0 \to K\pi$: Two body final state with similar kinematics of final state particles

$B^+ \to J/\psi(\to \mu\mu)K^+$: Two muons in final state and abundant signal

Particle Identification - Muon ID



Use PIDCalib software to produce performance histograms from data samples

Convolve the histograms with the MC samples to produce overall PID efficiencies for each channel

Summary

- $B_s \to \mu\mu$ Analysis nearing completion - Early 2020
- On track to complete $B_s \to \mu\mu\gamma$ analysis in similar timeframe

Other Activities

- Organised and ran the CERN/Liverpool Summer School
- Completed LTA at CERN including shift work
- Appointed RD Trigger Liaison
- ESIPAP school in January 2020

Thank you and Merry Christmas!