Measurement of the background in the Muon system of CMS during Run 2

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Introduction

- CMS = Compact **Muon** Solenoid

- Essential role for many CMS physics program

- Background particles in the muon system could have important consequences in the performance of detector (mis-identification/trigger, worse resolution, radiation effect on electronics, ageing…)

- Higher instantaneous luminosity induces more background in the muon system

- A better understanding/analysing of the background is valuable for maintaining robust operation and future upgrade choices

CMS muon system during Run 2
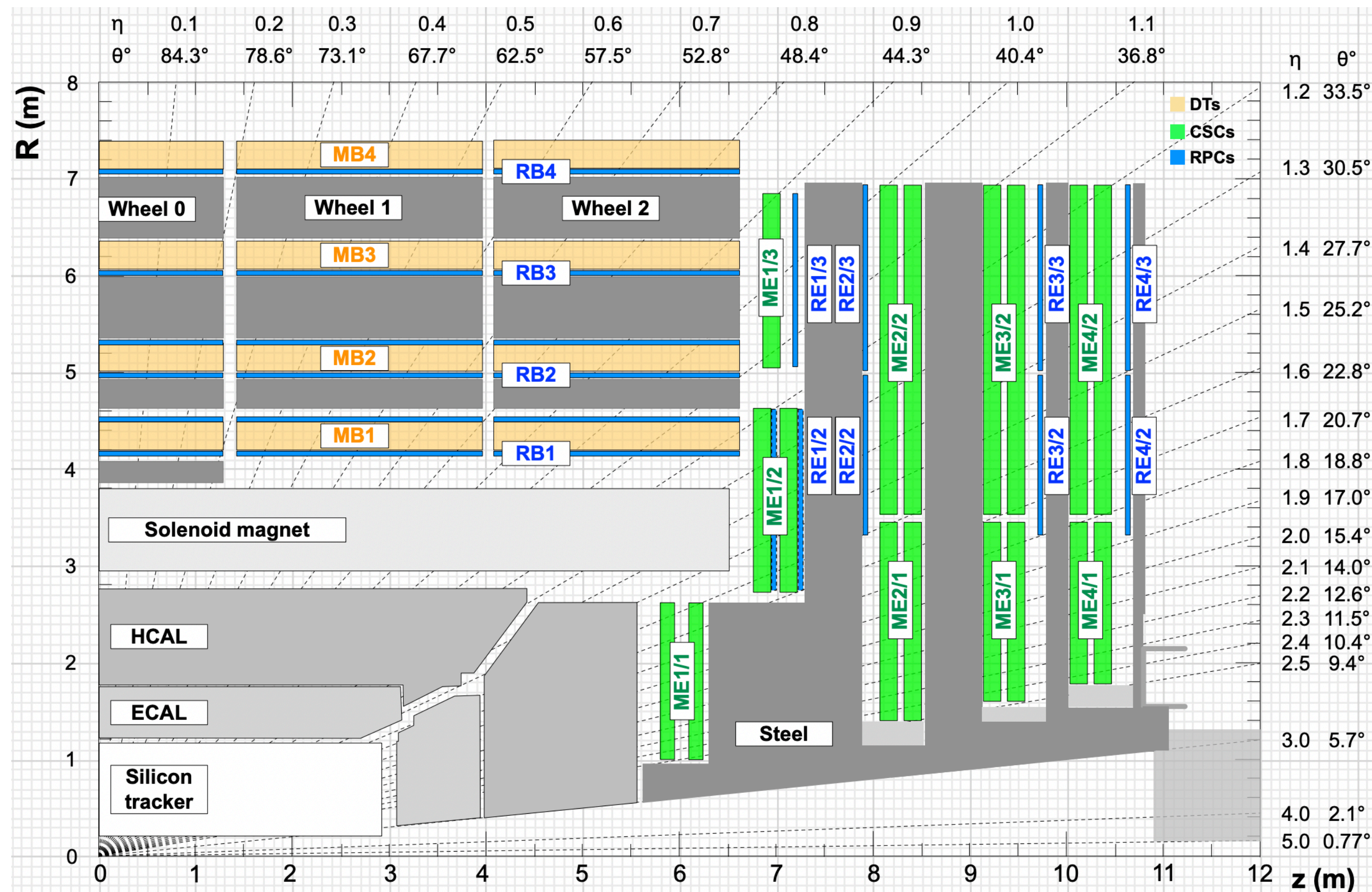
- DT: $|\eta| < 1.2$, drift chambers (spatial measurement/trigger)

- CSC: $0.9 < |\eta| < 2.4$, (trigger information and precise position information) has fast response time

- RPC: $|\eta| < 1.9$, double-gap chambers operated in avalanche mode, at both the barrel and endcap, very fast response time for trigger
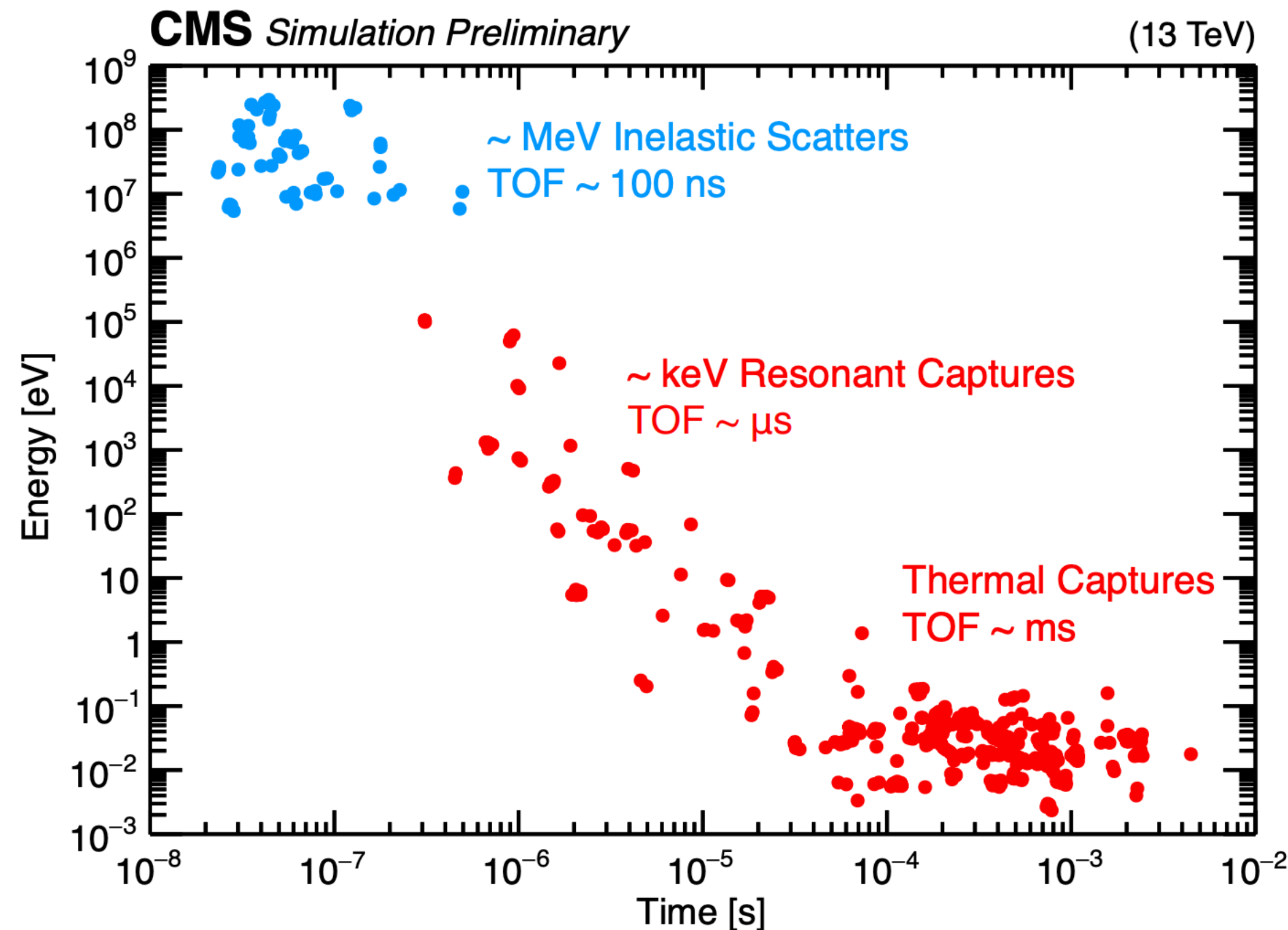
MB = DT = Drift Tube

ME = CSC = Cathode Strip Chamber

RB and RE = RPC = Resistive Plate Chamber

High redundancy and robust!

Background for muon detectors

CMS *Simulation Preliminary* (13 TeV)

~ MeV Inelastic Scatters
TOF ~ 100 ns

~ keV Resonant Captures
TOF ~ μs

Thermal Captures
TOF ~ ms

Energy [eV]

Time [s]

- Hits/tracks in the muon system that are not associated with targeted physics process (L1A)

- Could come from neutron induced hits, hadron punch through, cosmic, beam halo, pile-up …

- The background could have very different life time depending on nature, from few to O(1000) bunch crossings

LHC fill scheme

Fill Scheme 25ns_2556_2544_2215_2332_144bpi (2018)   -   Fill 7315
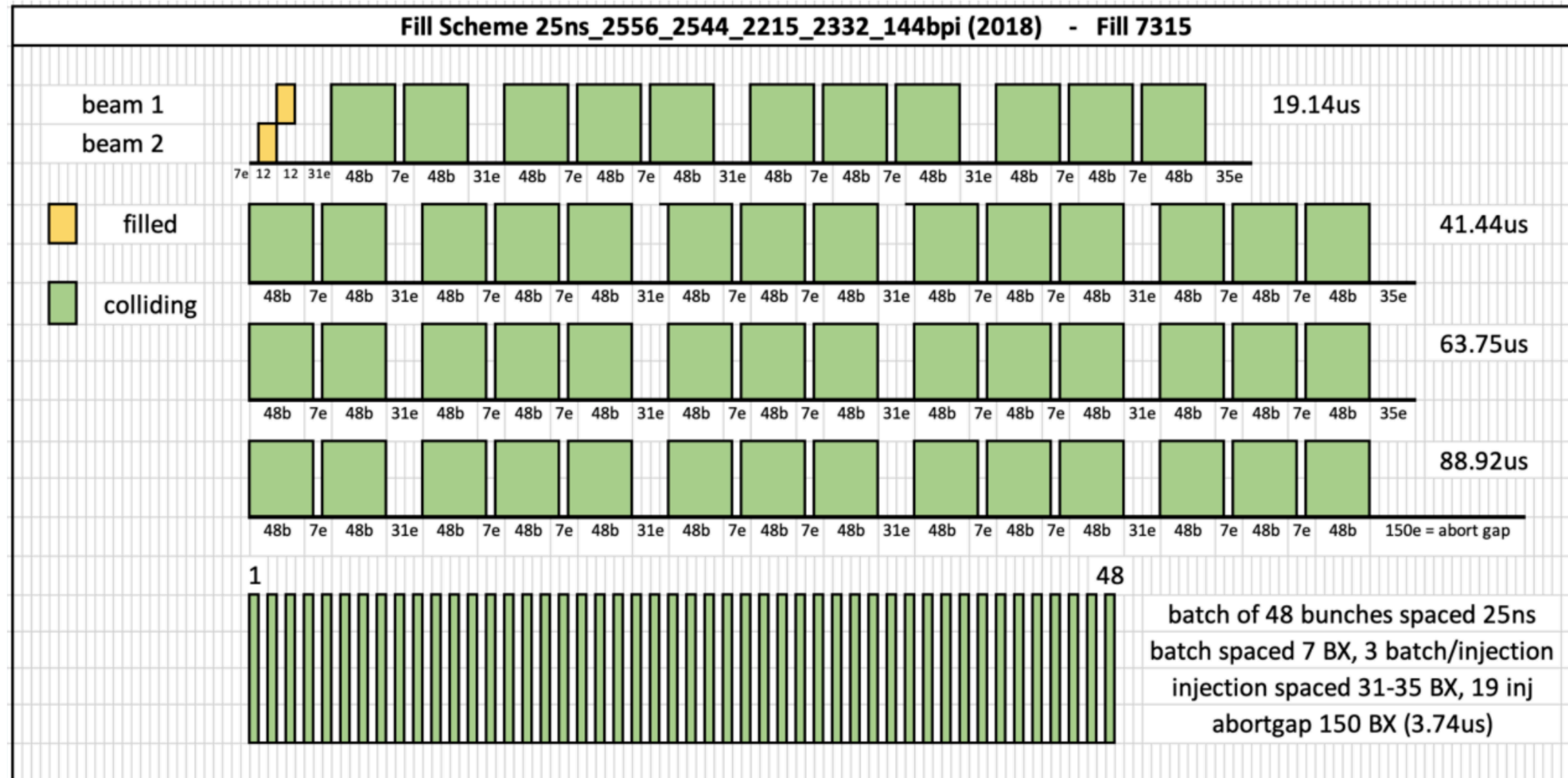
- The LHC fill schemes used for luminosity production during 2018
- One orbit consists of 3564 buckets (3564 bunch crossing ID, BX ID) spaced 25 ns
- Consecutive non-filled buckets with length of 7, 31 or 35 BX are due to the injector chain
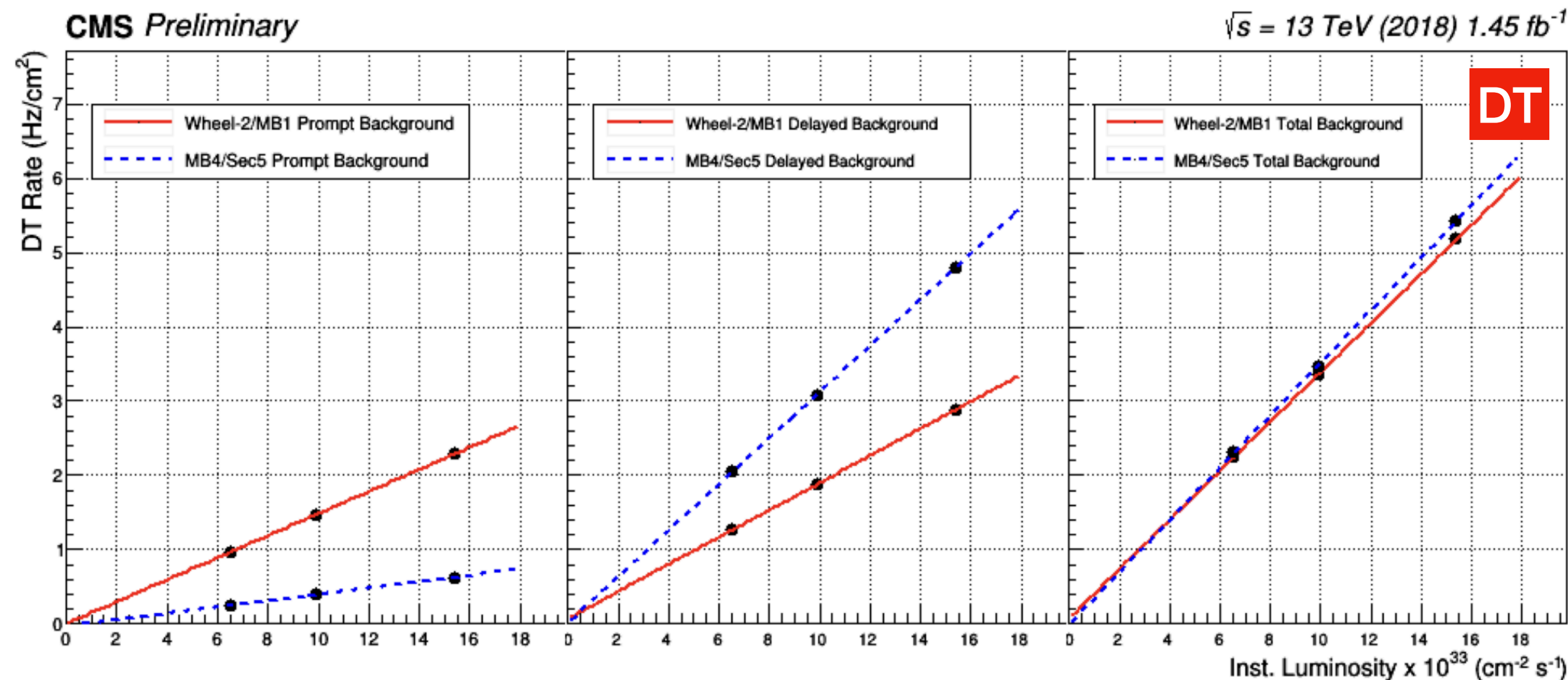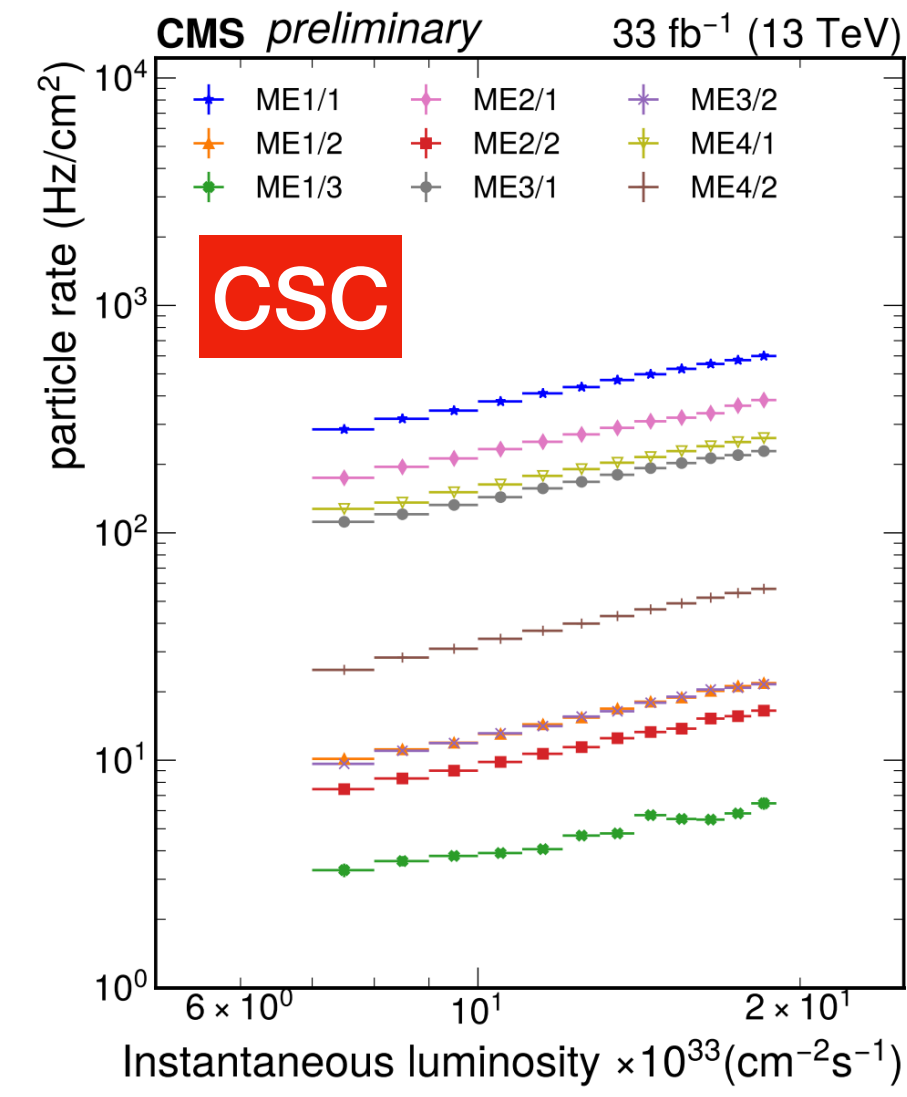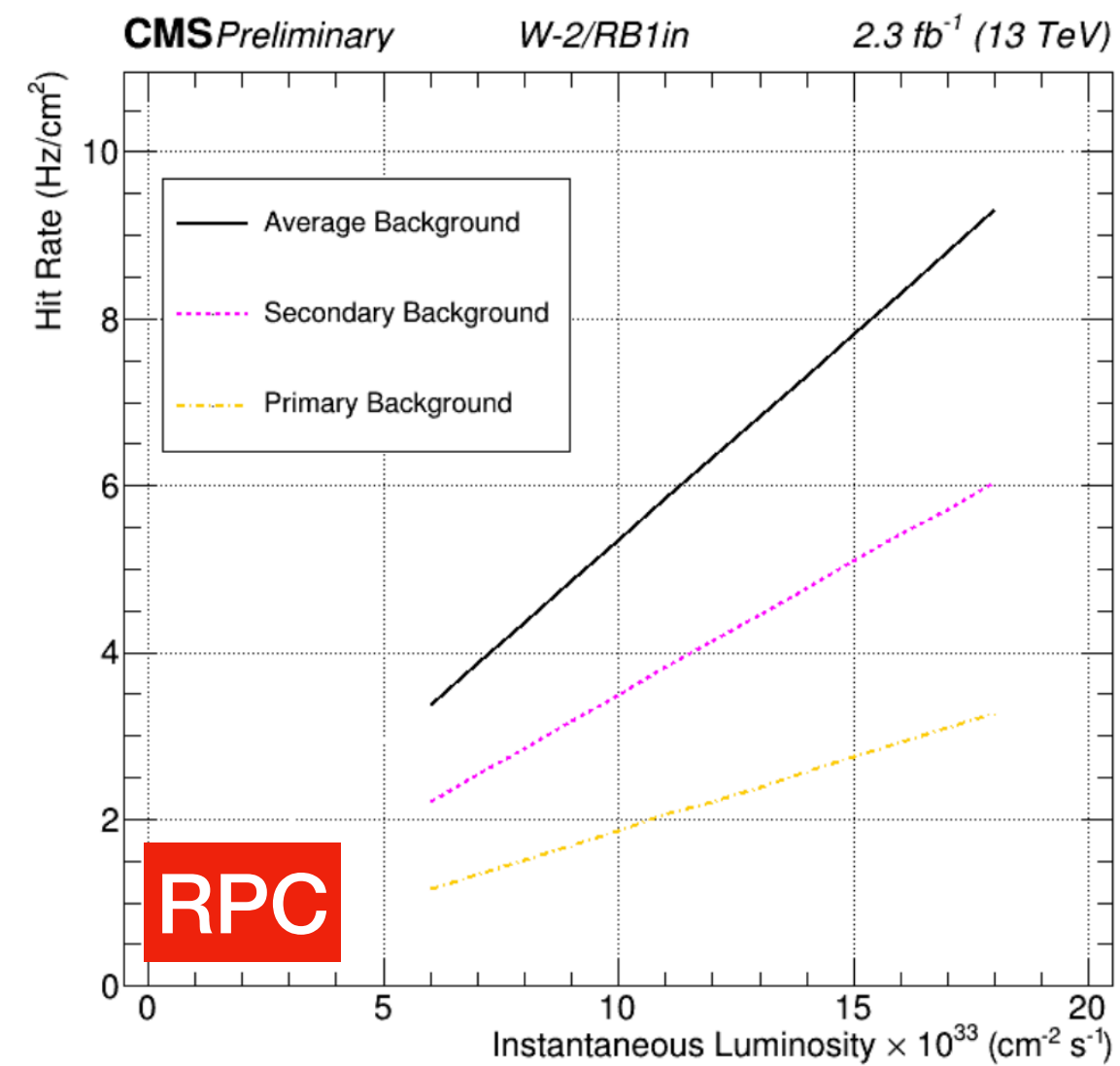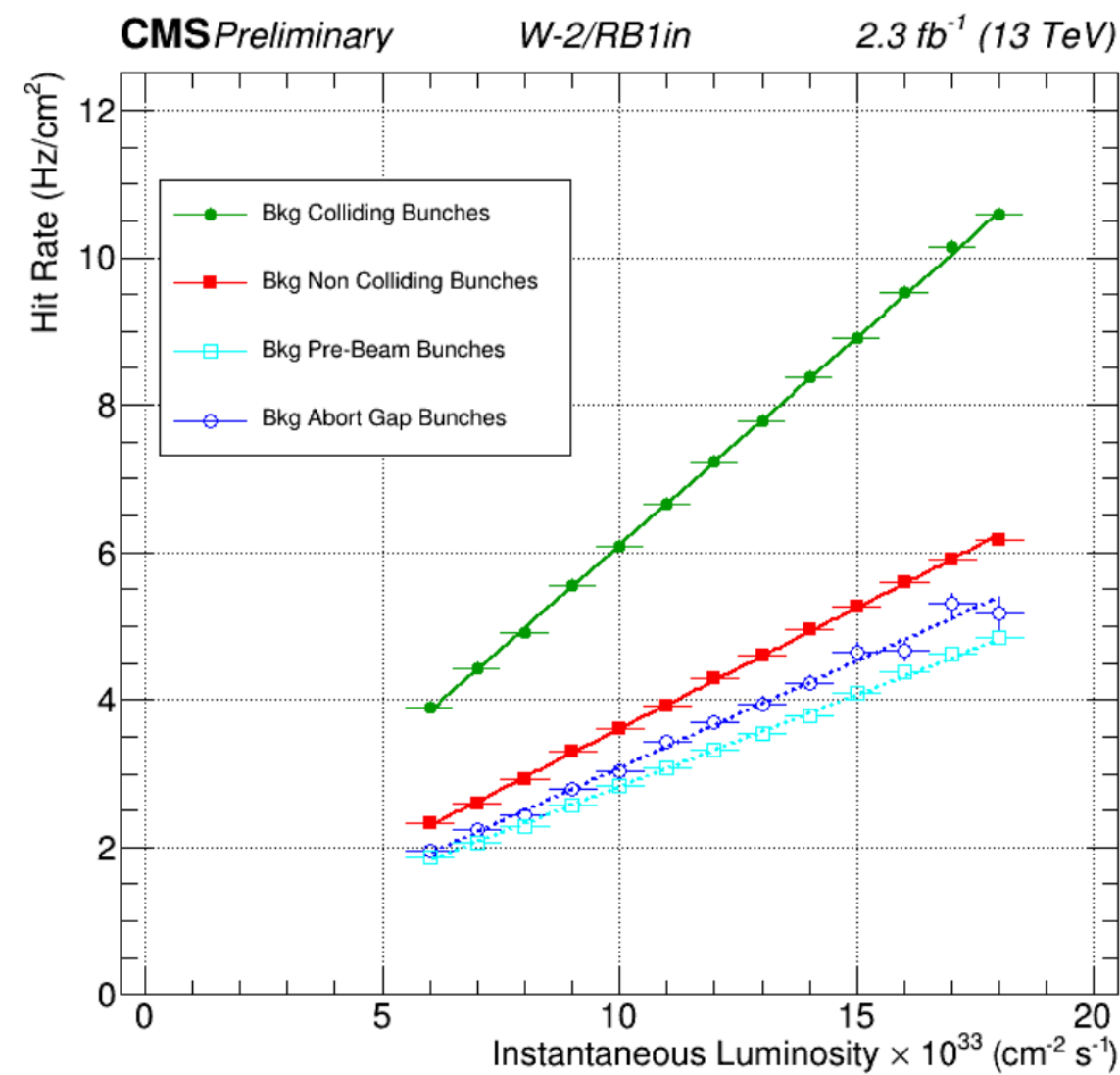
Background rate vs BX ID
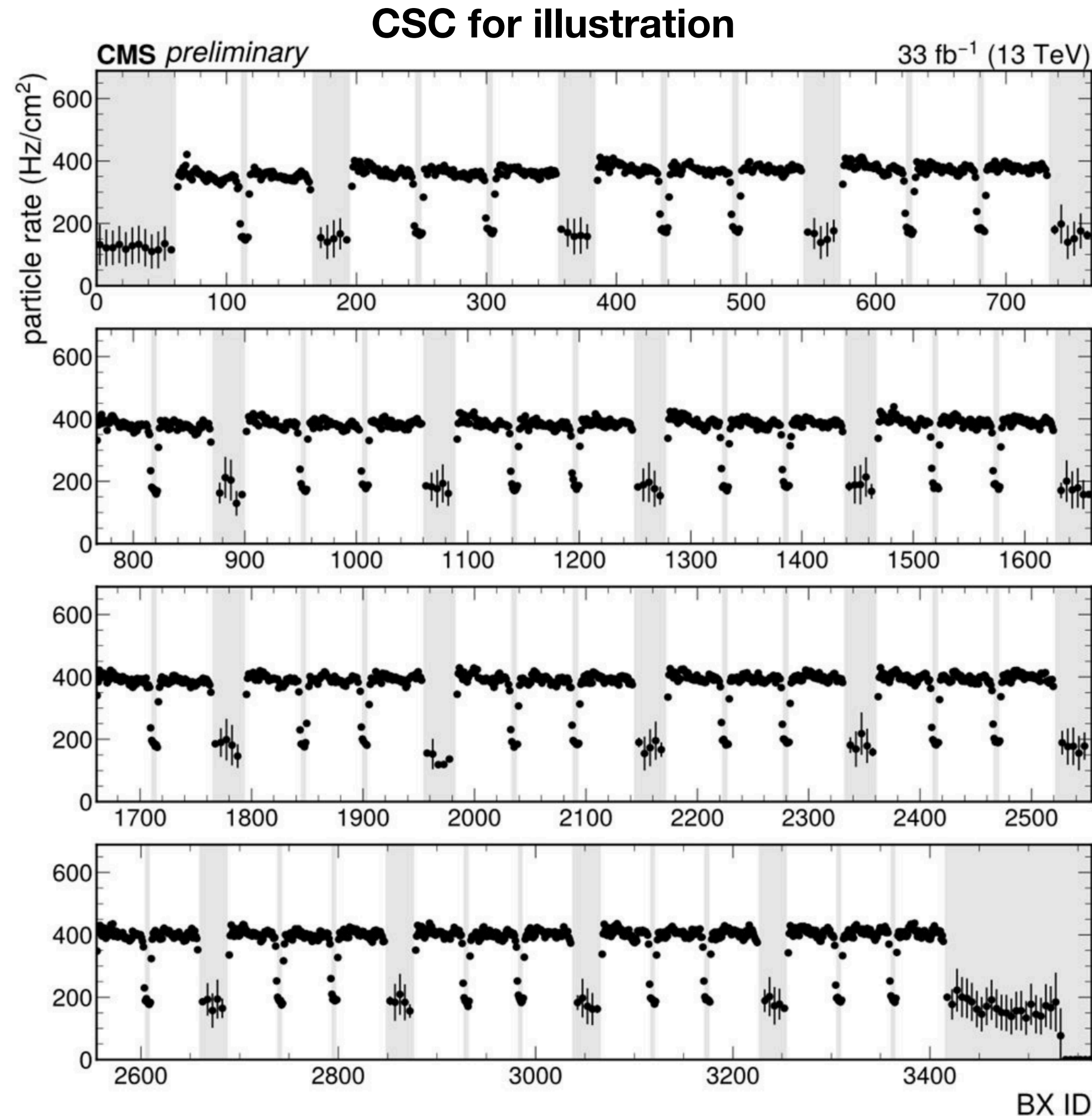
- Use partial zero bias dataset from 2018 data taking (August - November)

- Unlike physics trigger, zero bias triggers can fire in any BX

- Useful to estimate slow neutron background that gradually dies out in the non-colliding bunches

Selected analysis details
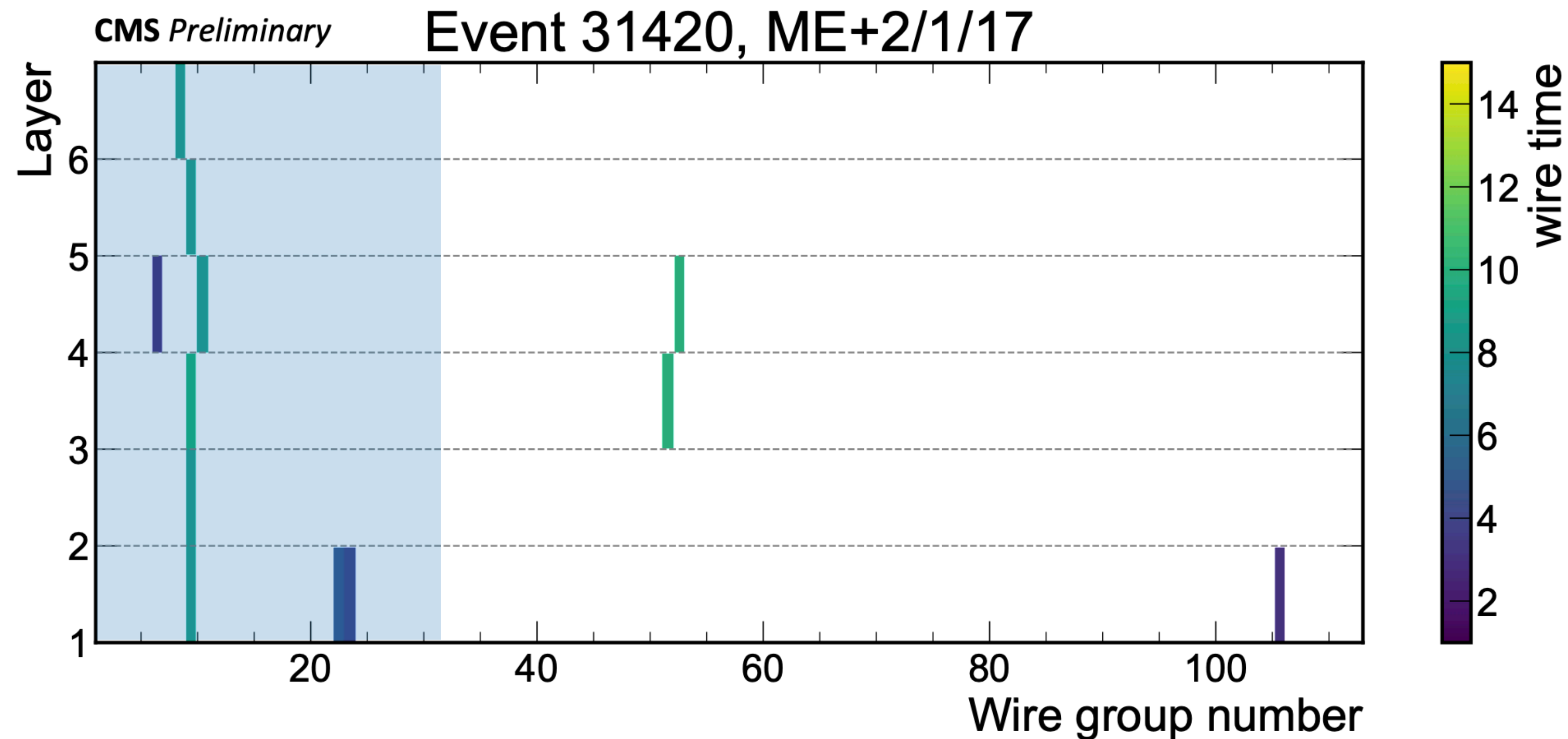
- Unlike DT/RPC, the readout of CSC chamber relies on "self-trigger" in additional to CMS L1A

- In order for a CSC to be readout, a track is expected and is often from muon

- Only use part of CSC that doesn't have track associated with muon for background counting
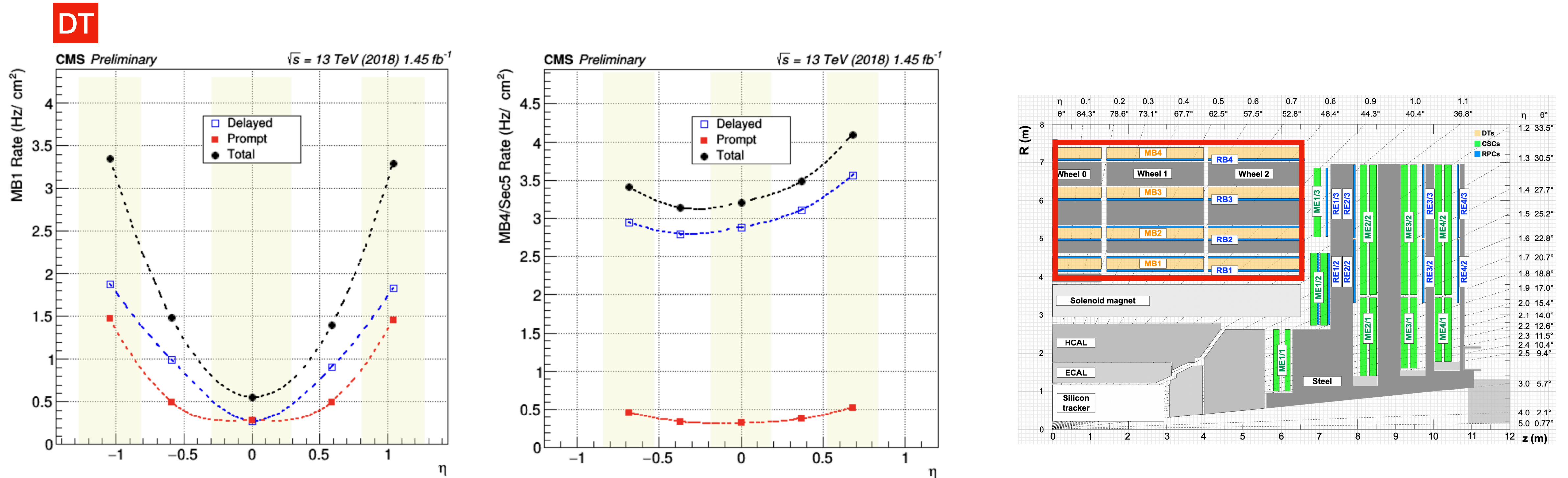
Background rate vs luminosity

- For all 3 sub-detectors in the muon system, inclusive background rate is linearly dependent on instantaneous luminosity

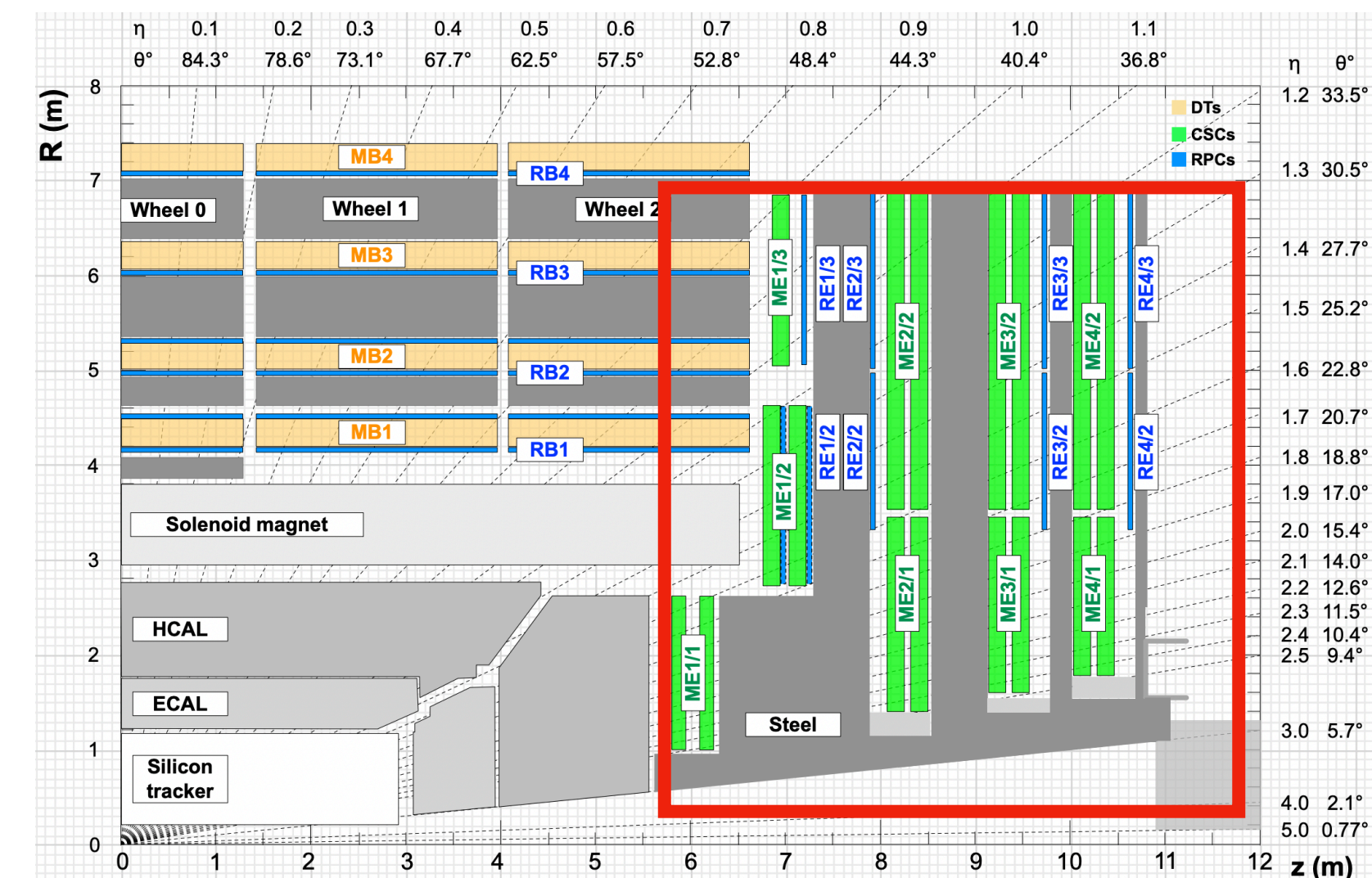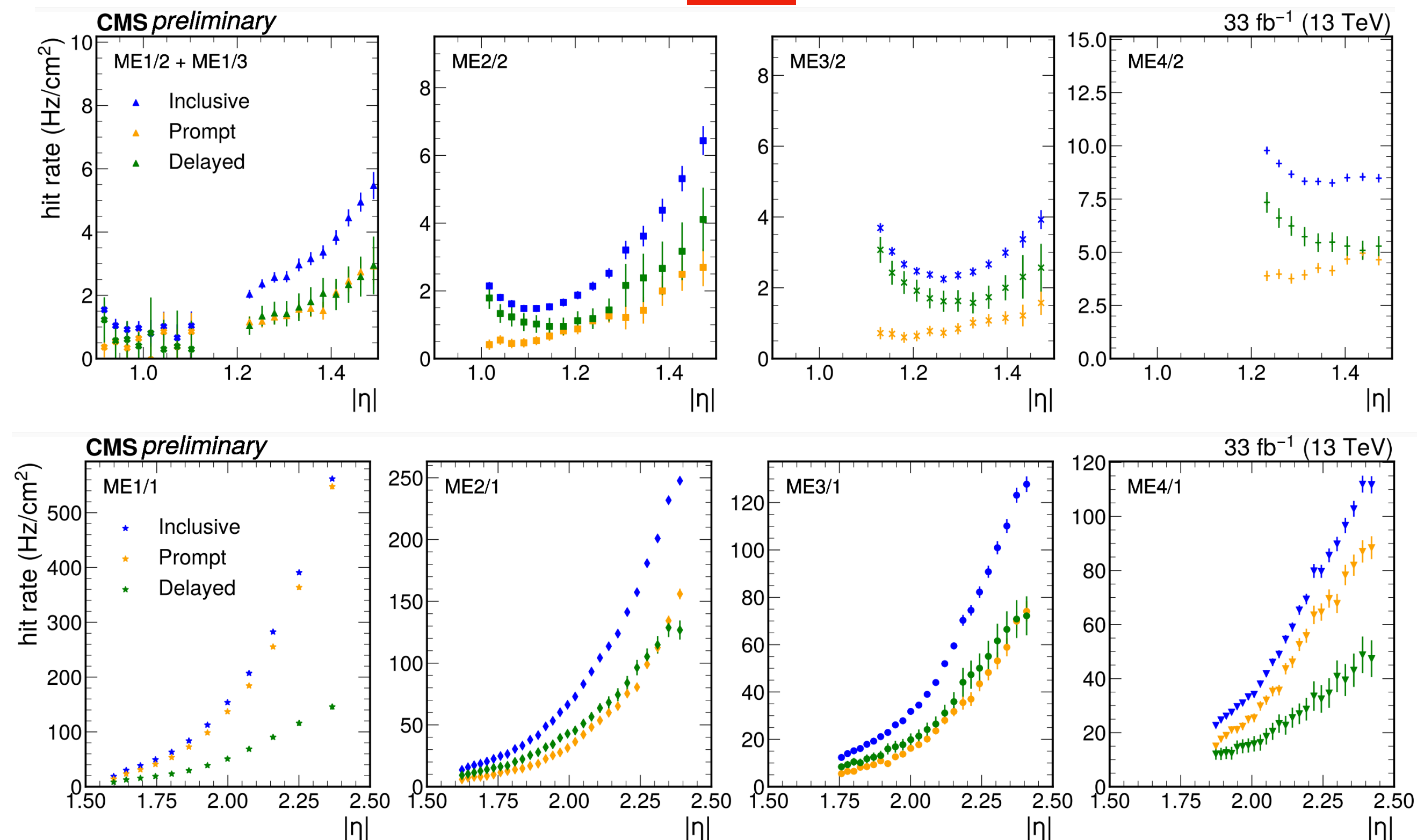- Split also into prompt and delayed components, also linearly dependent on luminosity

Background rate vs η at barrel

- For chambers close to IP, rate dominated by prompt components, more dependent on η

- For chambers far away from IP, dominated by delayed background, less η dependent

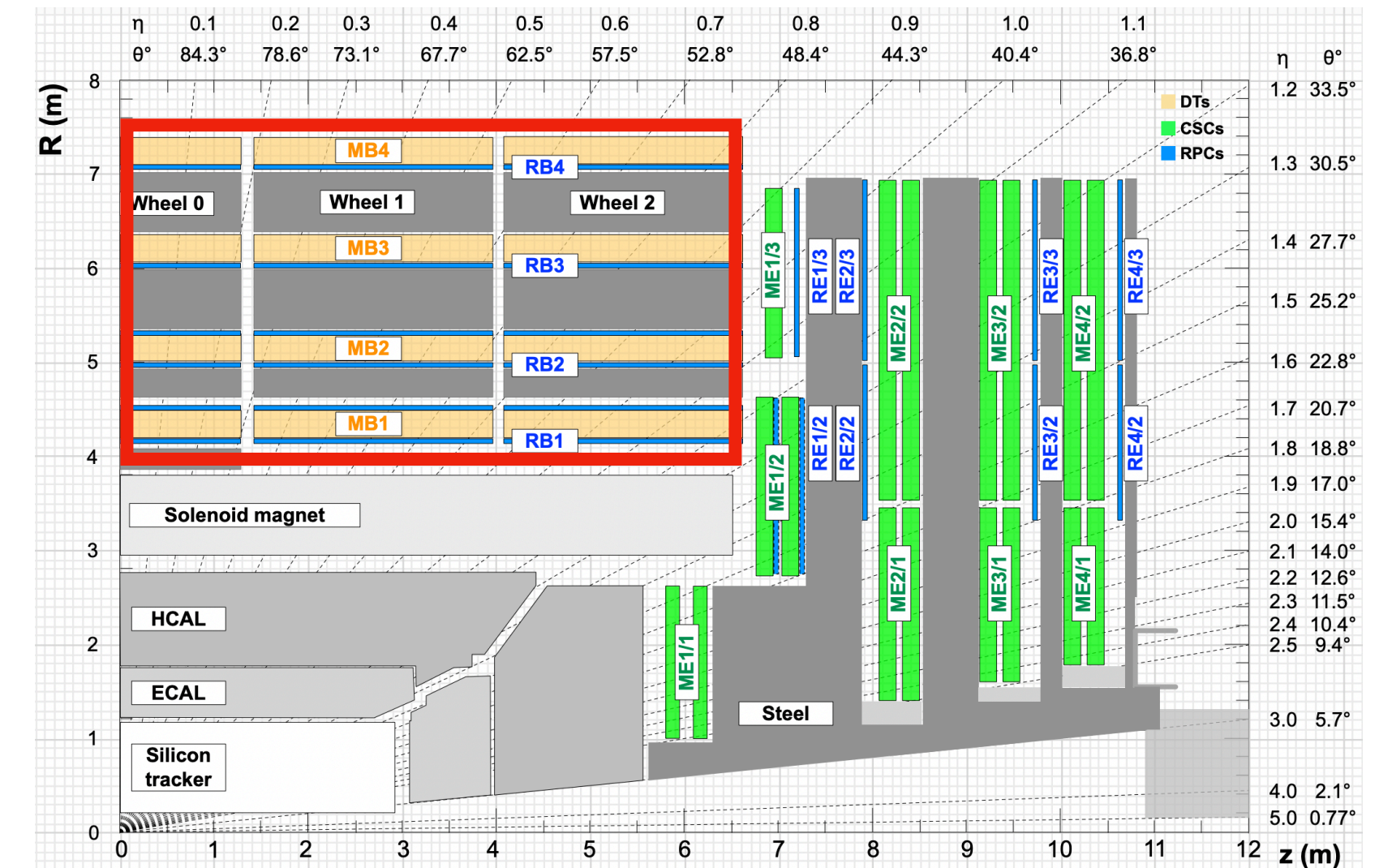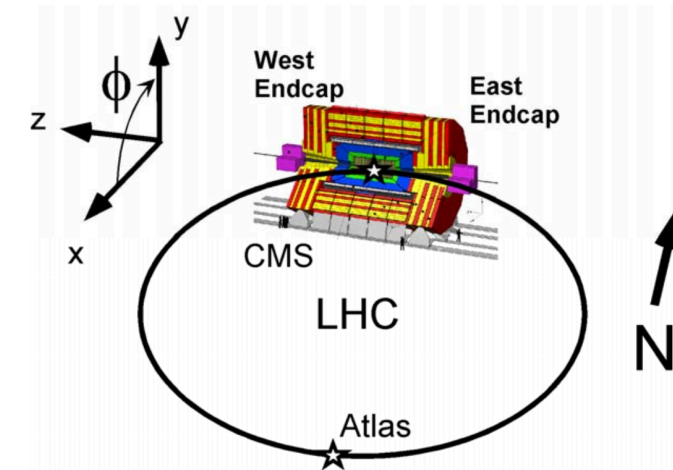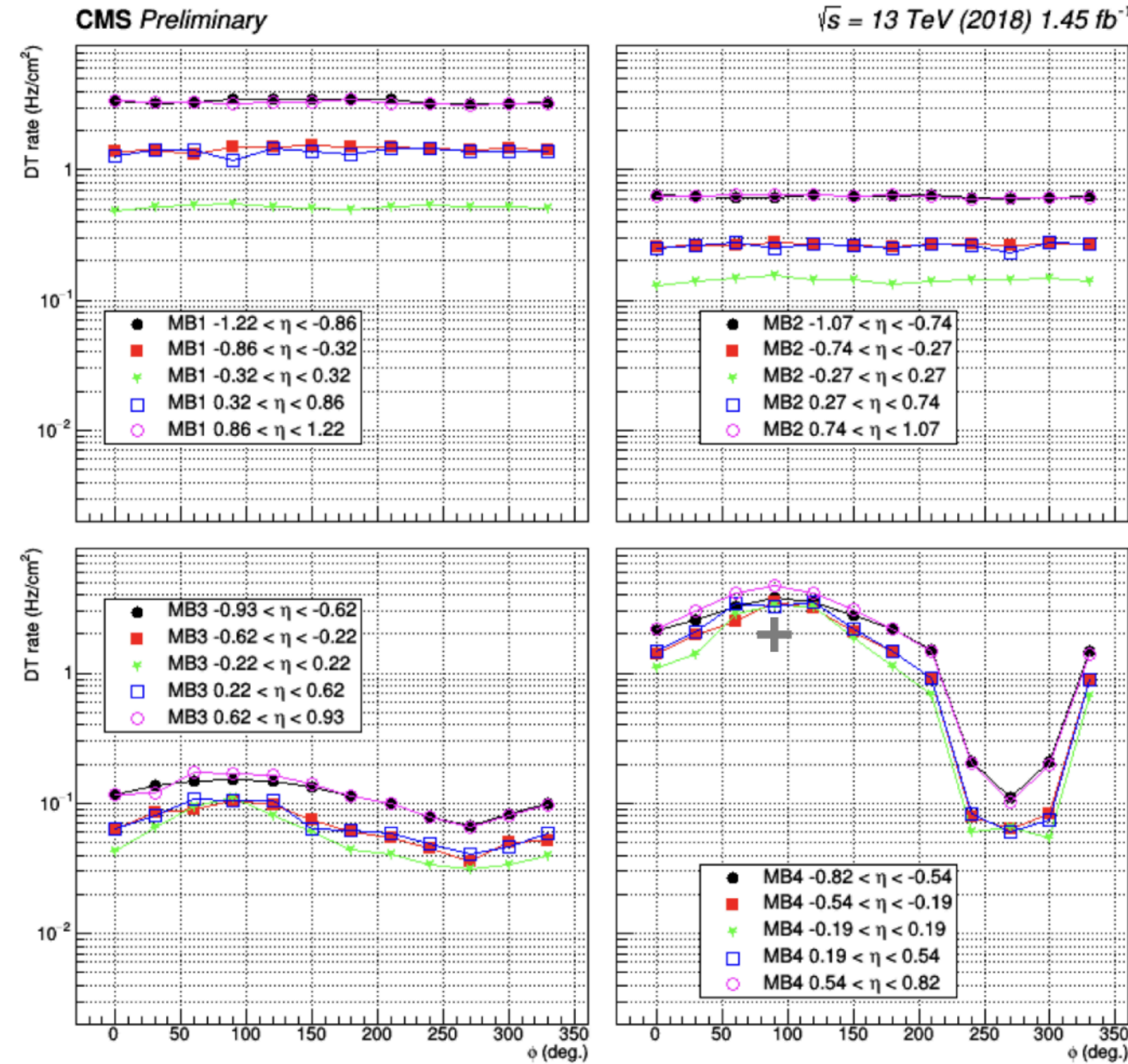- Similar trend observed for RPC

- Background rate at endcap region is steeply correlated with η, mostly high |η| → high rate

- Slight in crease of rate when getting close to the low |η| region, due to back scatter from the wall
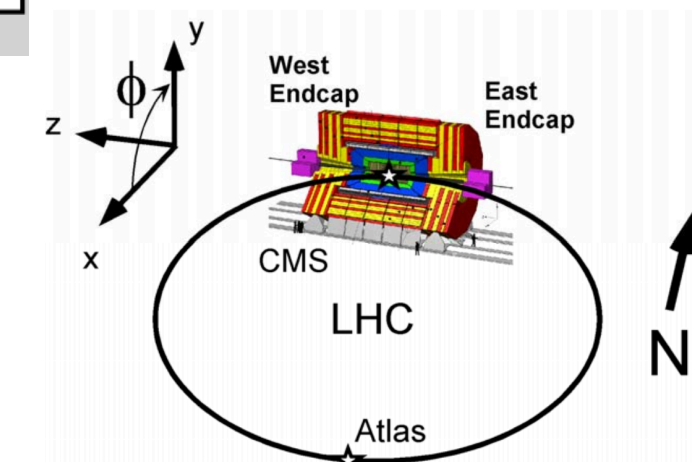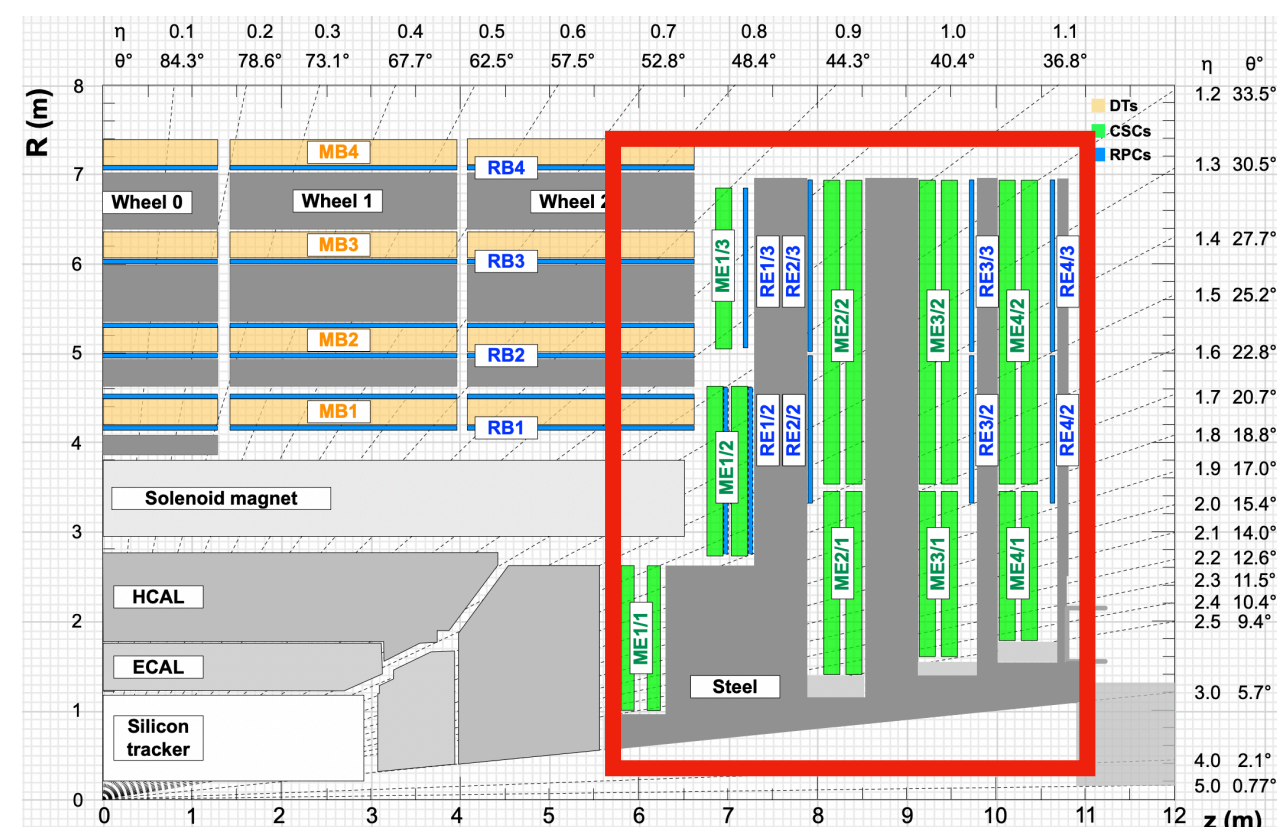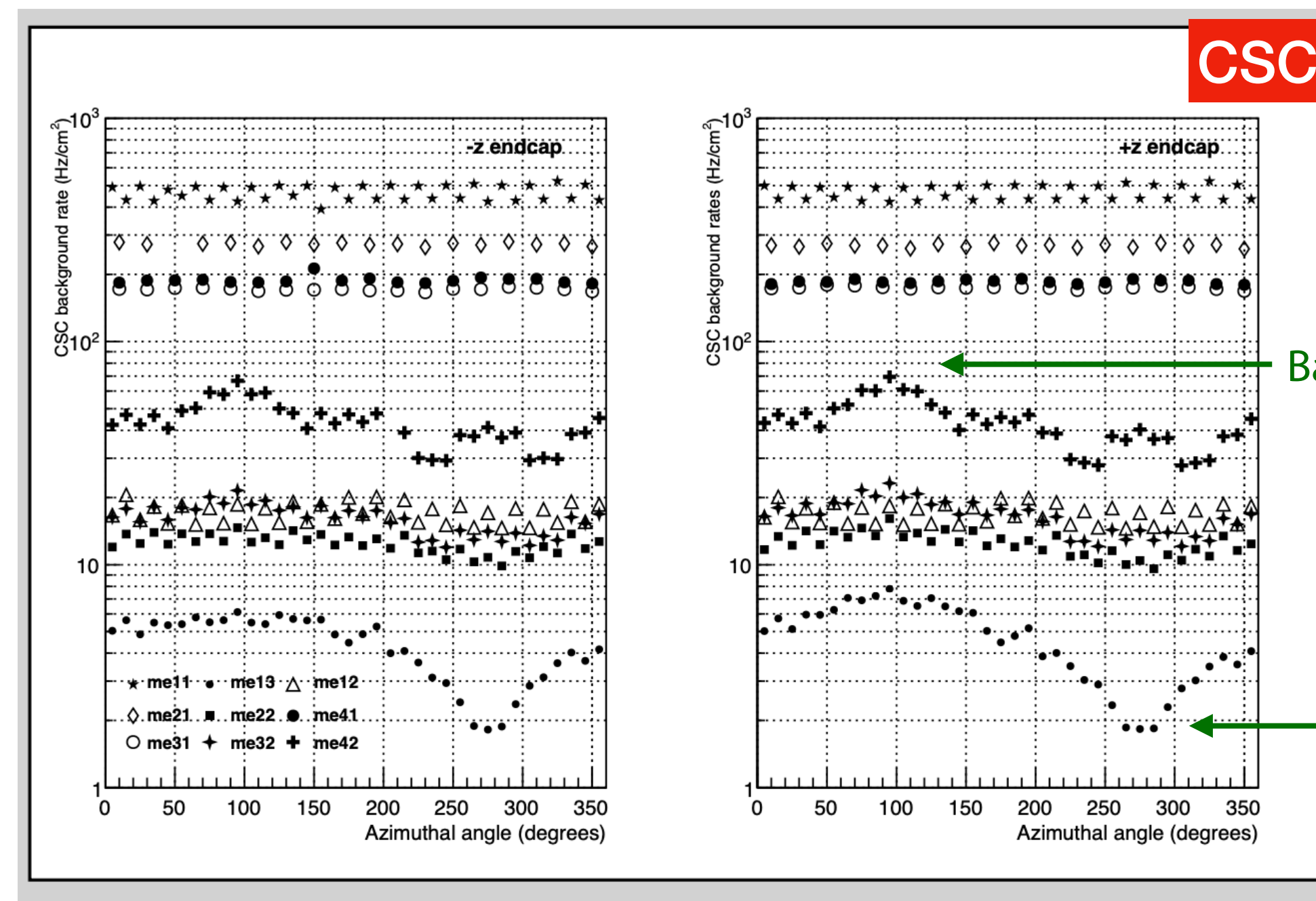
- Similar trend for RPC

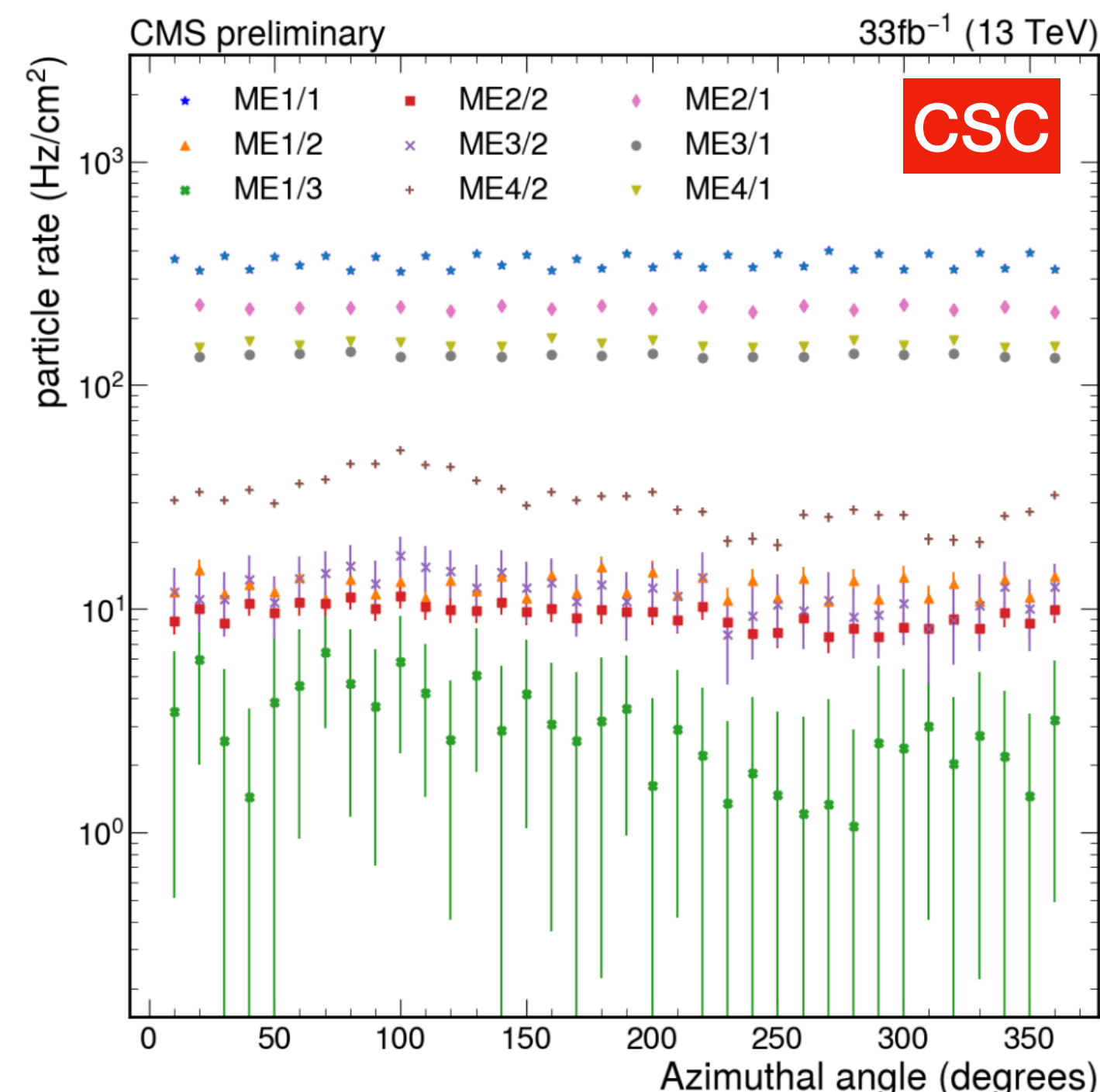# Rate vs φ at barrel

- Background rate is overall stable vs φ, and decrease as going from IP to edge of detector

- Except the outermost layer of chamber, MB4 has higher rate than MB3 due to again back scattering of the wall

- Top of MB4 has higher rate than bottom: effect of cavern geometry

Rate vs φ at endcap

CMS preliminary — 33fb^{-1} (13 TeV)

particle rate (Hz/cm^2)

ME1/1, ME1/2, ME1/3, ME2/2, ME3/2, ME4/2, ME2/1, ME3/1, ME4/1 — CSC

Inner rings

Outer rings

Azimuthal angle (degrees)

CSC

CSC background rate (Hz/cm^3)

-z endcap   +z endcap

Back scatter from beam pipe

Driven by cavern geometry

me11, me13, me12, me21, me22, me41, me31, me32, me42

Azimuthal angle (degrees)

- (Left) offline analysis using data, @ 1e34 cm^{-2}s^{-1}

- (Right) online analysis using trigger primitive, @1.4e34 cm^{-2}s^{-1}

- Background rate and trend vs φ agrees across 2 orders of magnitude

Summary

- A systematic study on background rate for all CMS muon sub-system is performed

- The relations between background rate and instantaneous luminosity/eta/phi have been presented

- The contributions from prompt and delayed contributions of the background are carefully evaluated using the zero bias dataset

Backup