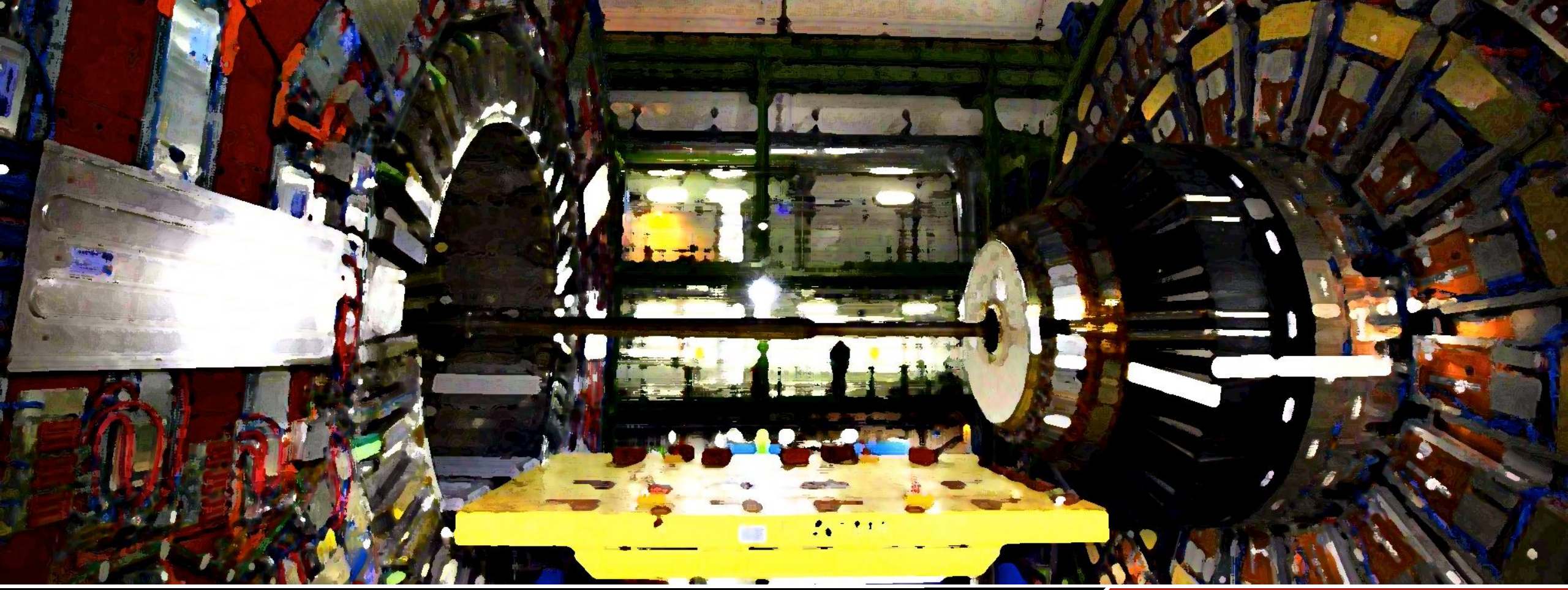

Trigger algorithm for HSCP

RPC Phase-II point of view

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on behalf of the RPC group

2018.11.30
Joint P2 Muon Upgrade + P2 L1 Muon Algorithms Workshop

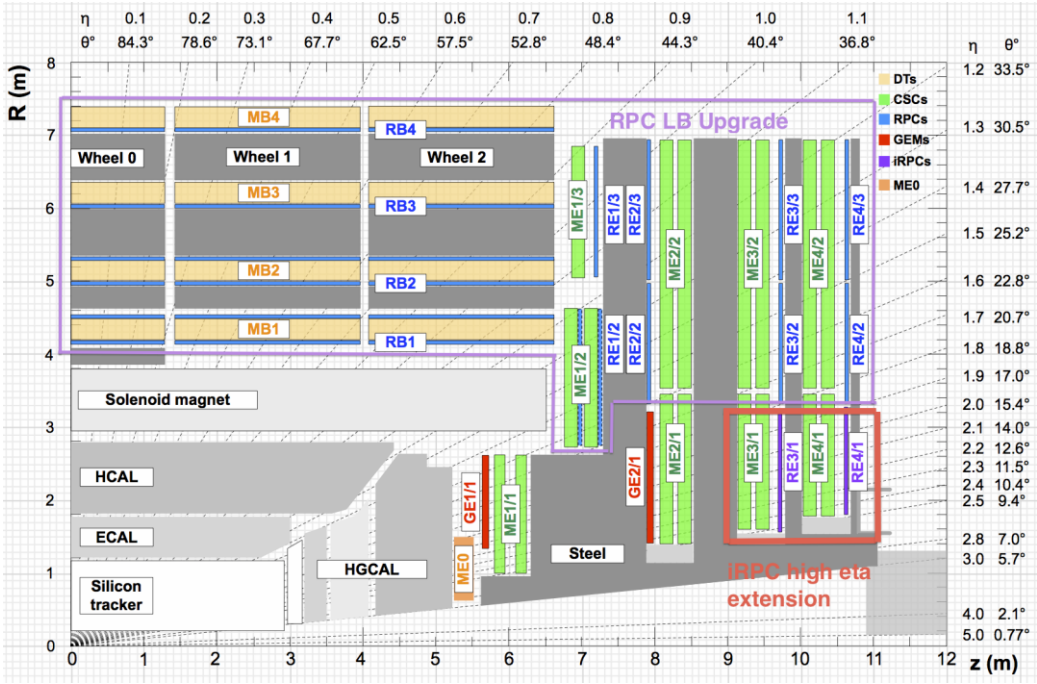
Introduction

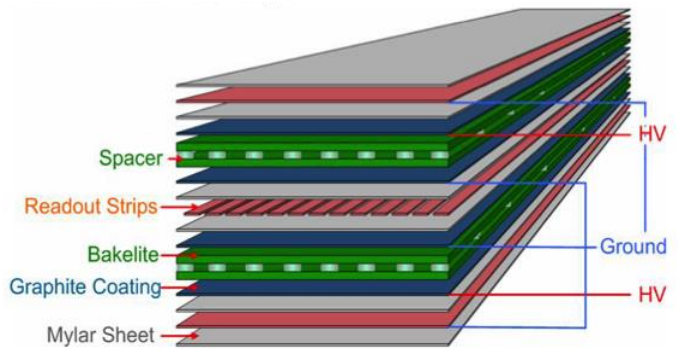
- Many BSM predict Heavy Stable particles (e.g, LSP in SUSY)
- These particles can have nonzero electric charge, Heavy Stable Charged Particles (HSCP)
  - Stable enough (>ns) to travel through the CMS detector
- Signature is similar to a slowly moving muon-like particle
  - High dE/dX, large Time of Flight
  - CMS have performed very nice analysis combining both information
    - Based on SingleMuon + MET trigger
    - Note: there was HSCP-dedicated trigger with RPC when bx=50ns

RPC Phase-II upgrade

Two upgrades in Phase-II

- Link system upgrade of present system
  - Same chambers, replace electronics
  - Necessary for the HL-LHC
    after >10 years of operation until the Run-3
  - Provide timing information (~25ns → 2ns)
    - Extra smearing due to signal propagation along the strip
- iRPC upgrade in the high-|η| region
  - Extends to |η|<2.4 in RE3/1 & RE4/1
  - Improved RPC chamber design allows to run at lower threshold
  - New front-end electronics at both ends of the strips
  - Precise timing and 2D measurement (2cm, <1.5ns)
    - Cancel out the smearing due to sig. propagation time

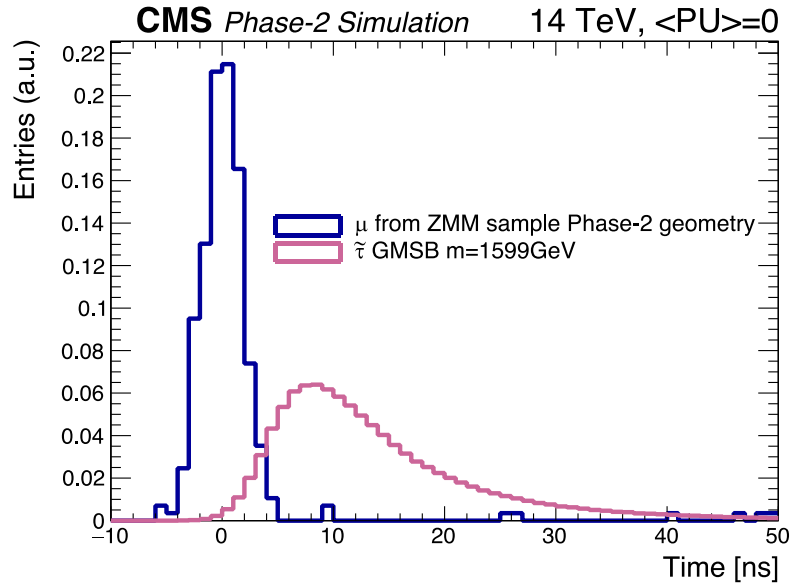


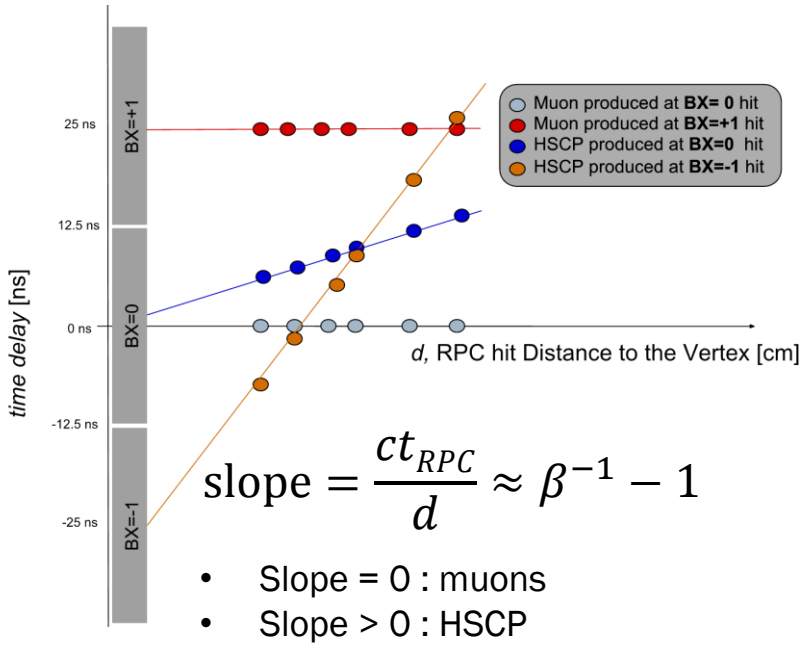


HSCP trigger with RPC

RPC-ToF can be used trigger algorithm for HSCP

- HSCP hits are detected as delayed signals
  (detector clocks are synchronized to muons)
- Finding hit patterns with RPC time/distance > 0
  will provide very good separation of HSCP from muons





$$\text{slope} = \frac{ct_{RPC}}{d} \approx \beta^{-1} - 1$$

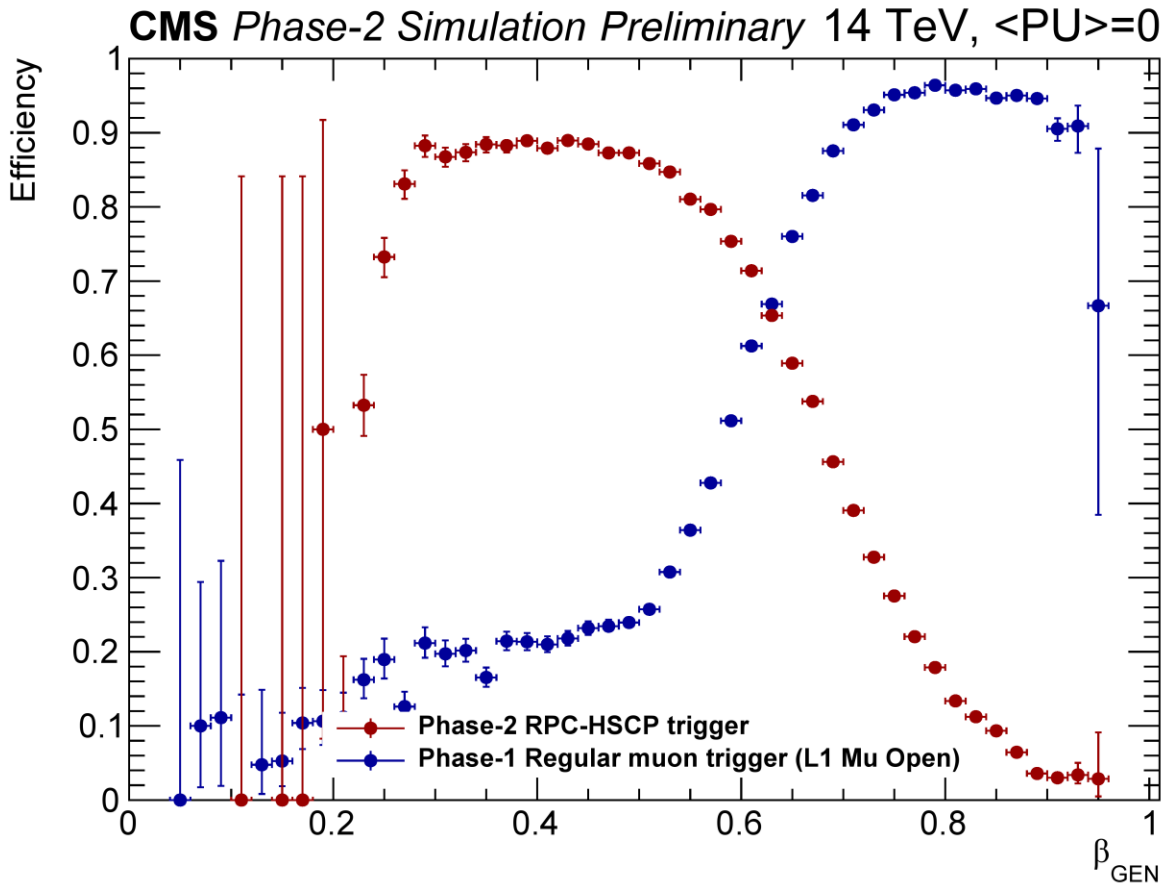
- Slope = 0 : muons
- Slope > 0 : HSCP
- Slope < 0 : unphysical or cosmic

We have proposed a L1 trigger algorithm for HSCP

(in the Muon Phase-II TDR)

- At least 3 RPC hits correlated in space (4-6 layers in $|\eta|<1.9$)
- Linear fit to find β, fit error < 30%, slope > 0
- No bx=0 restriction - increases acceptance in small β
- Not applicable for forward region with only 2 RPC hits

HSCP trigger performance



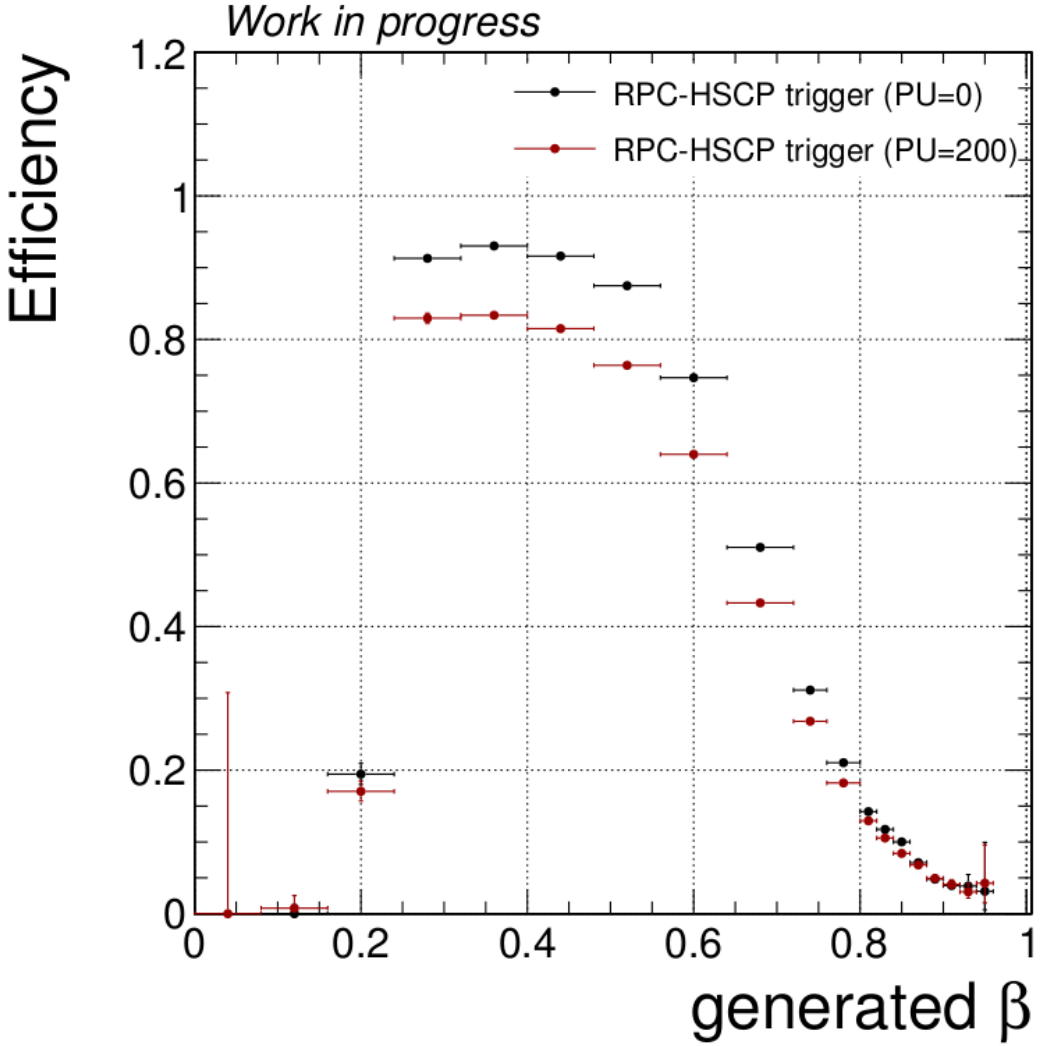
RPC-TOF "fitting" algorithm

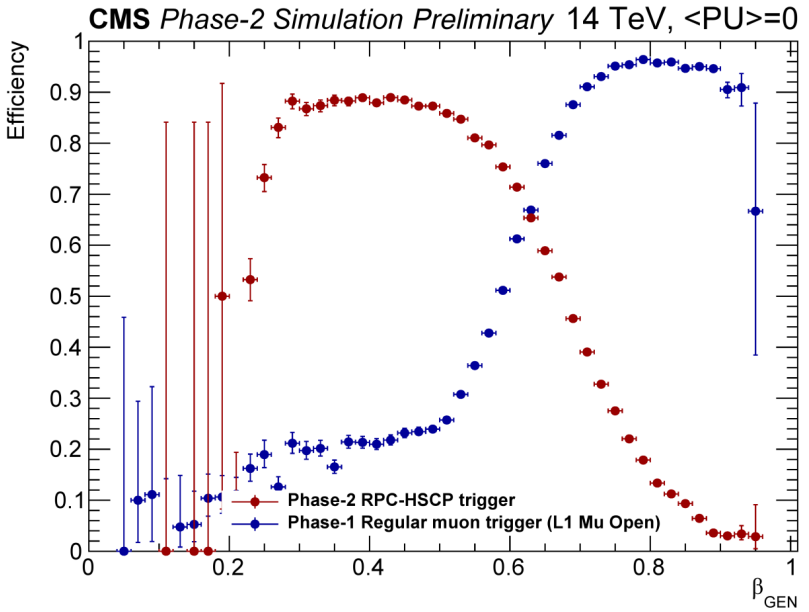
- At least 3 RPC hits correlated in space (4-6 layers in $|\eta|<1.9$)
- Linear fit to find β, fit error < 30%, slope > 0
- No bx=0 restriction - increases acceptance in small β

Recovers slow particles of $\beta < 0.7$

Efficiency drop in $\beta < 0.3$ corresponds to extreme cases which spans >3 BX

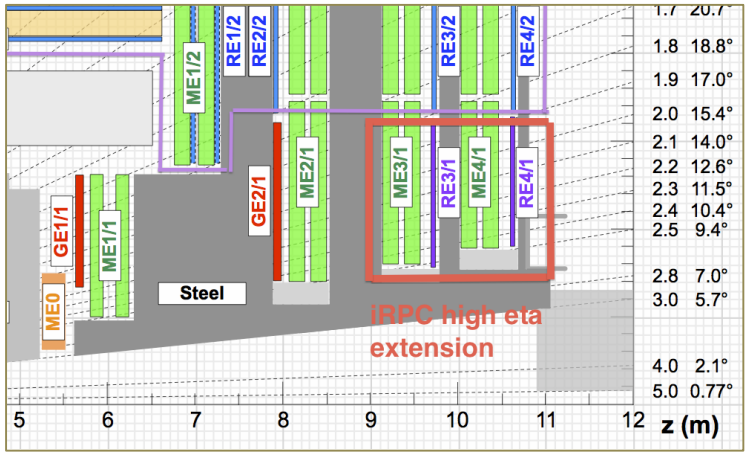
Trigger performance at high PU





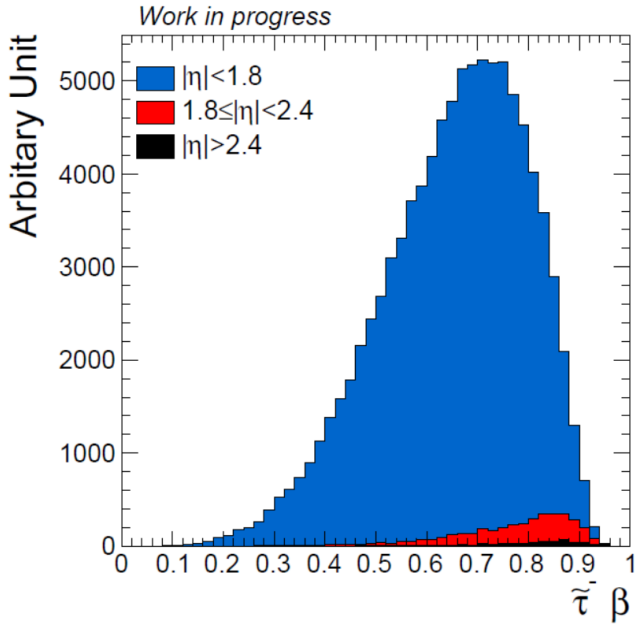
We observe efficiency drop at high PU, combinatorial backgrounds affect fit quality and decrease efficiency

HSCP trigger algorithm for iRPC

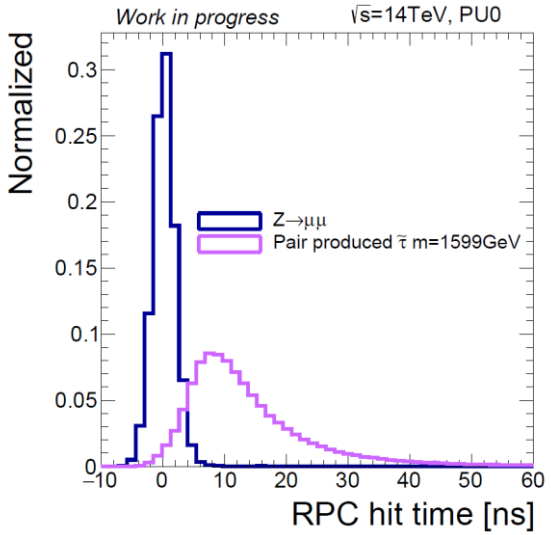


High-η region is challenging for HSCP trigger

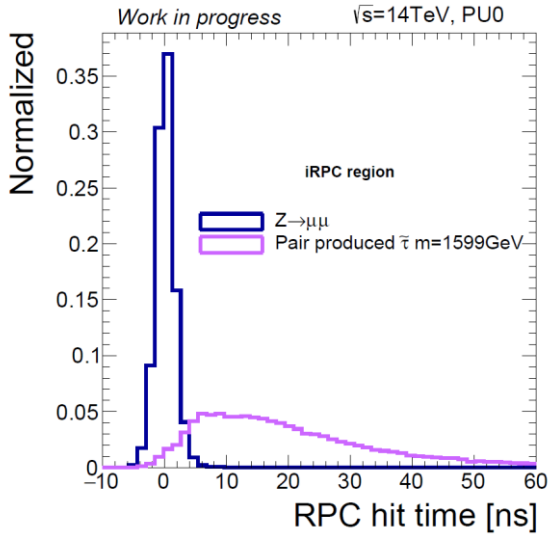
- High multiplicity: muons, punch-though, pileup, etc
- Fake signals from combinatorial backgrounds
- Small bending angle by B-field
- Only two RPC layers ⟶ more information is needed
- Higher β: Need better time resolution



- All region



- iRPC region

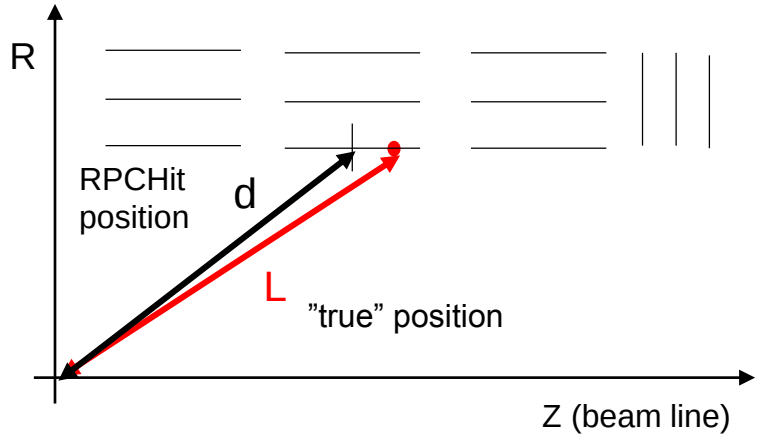


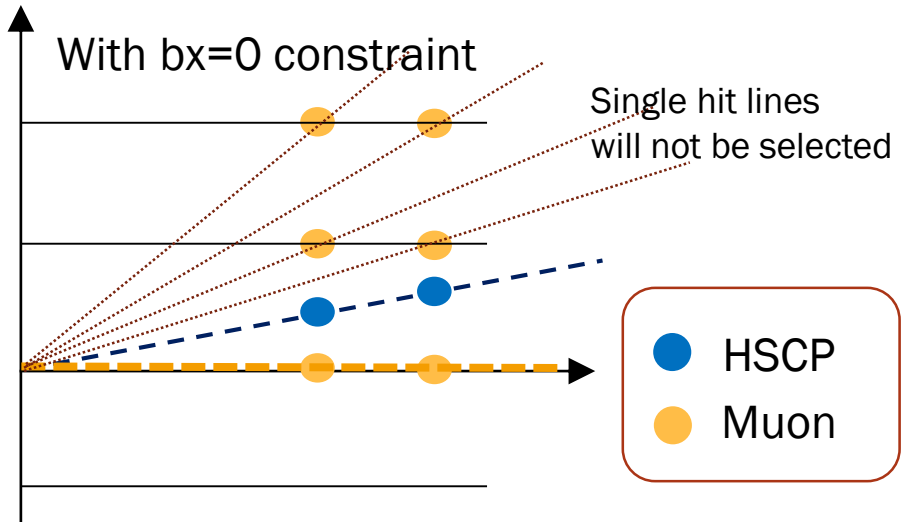
HSCP trigger algorithm for iRPC

Proposing a new algorithm

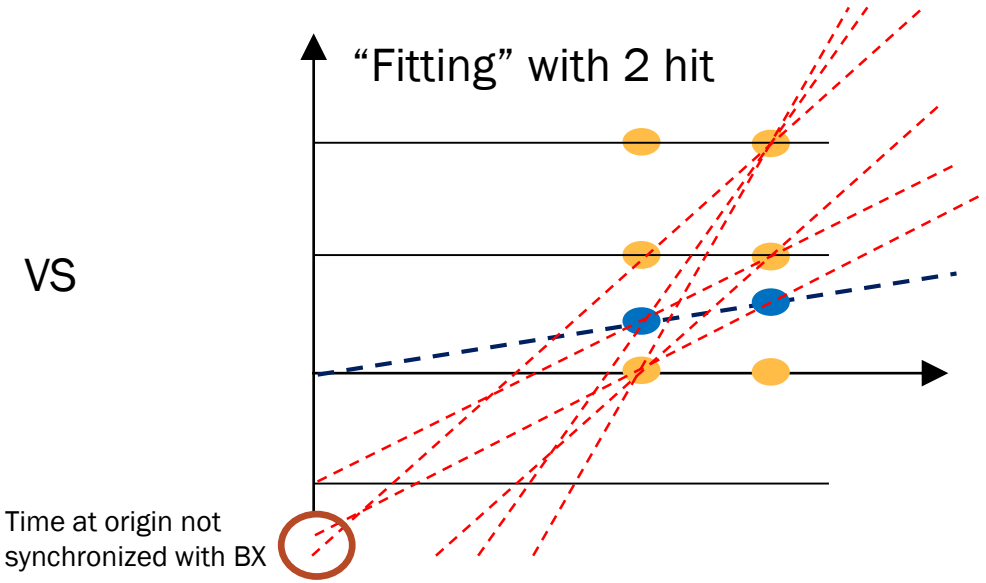
- Assume a HSCP is originated at bx=0
  - Bx assignment should come from different source
  - Track trigger could be the best candidate
- β at each stations can be computed,

  $\beta_i^{-1} = vt_i/L_i \approx 1+ct_i^{RPCHit}/d_i$
- Finally take $<\beta> = \Sigma\beta_i/N$ and error from the RMS

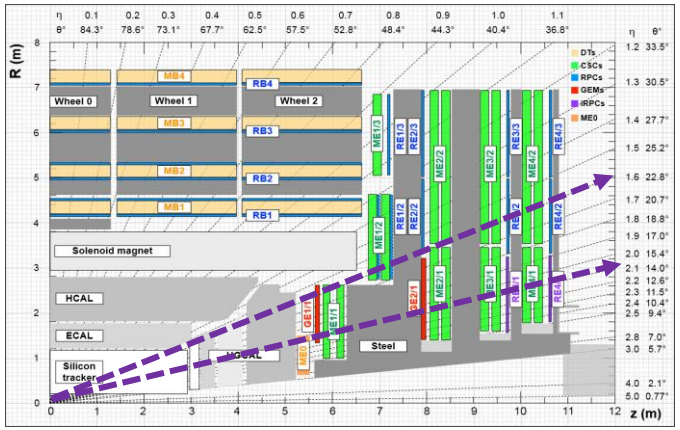




VS

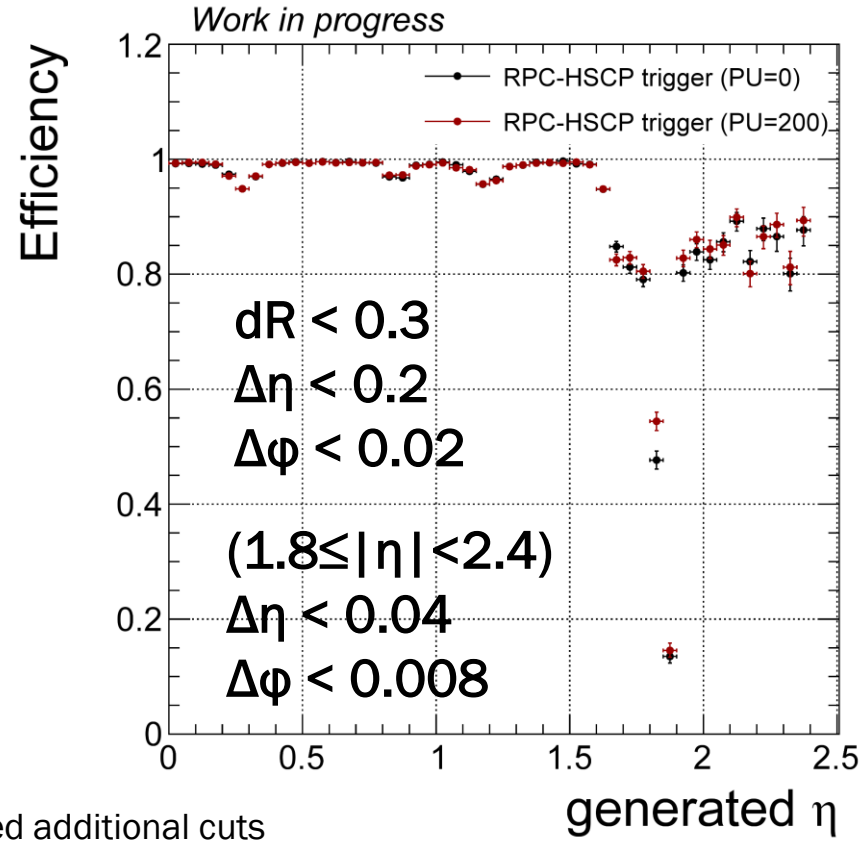


Matching efficiency



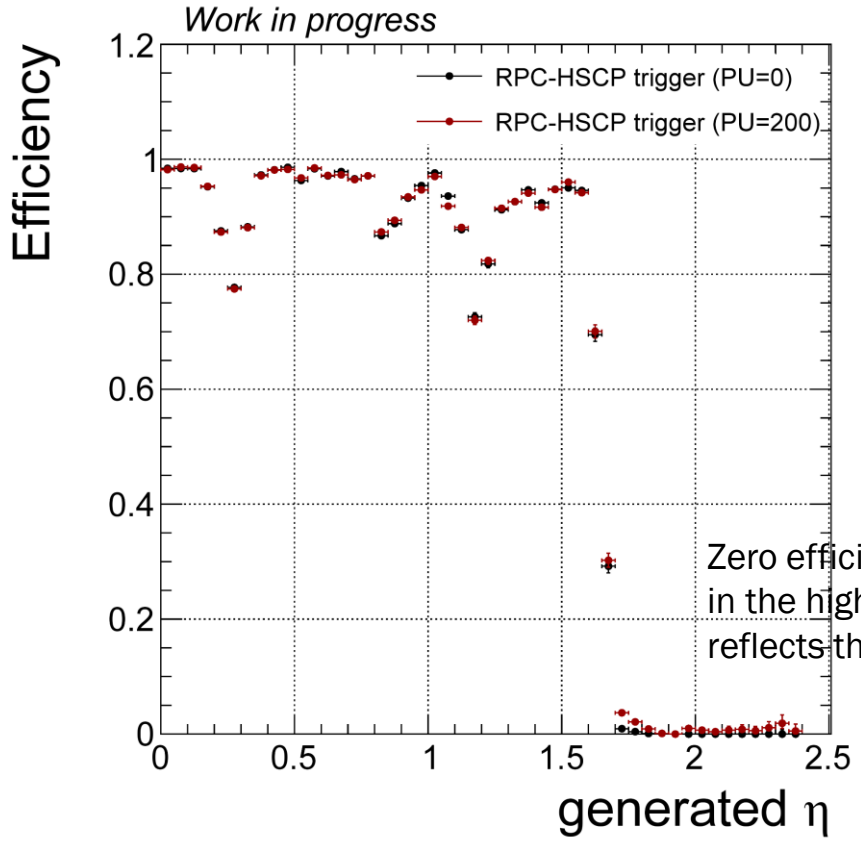
There are efficiency drop due to the geometry, ~80% in high-eta region

- ≥ 2hits



Introduced additional cuts
to reduce combinatorial background,
But keep >99% of hits

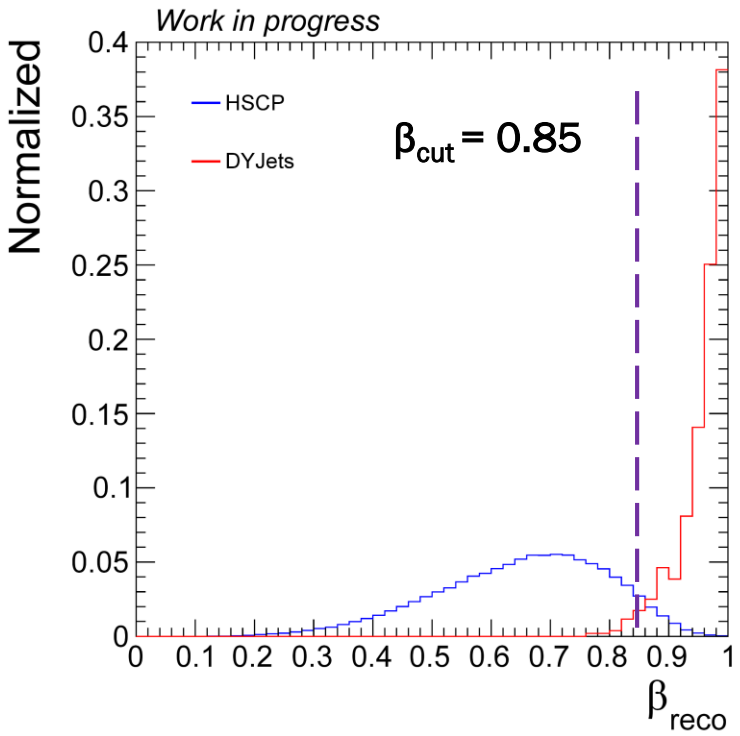
- ≥ 3hits



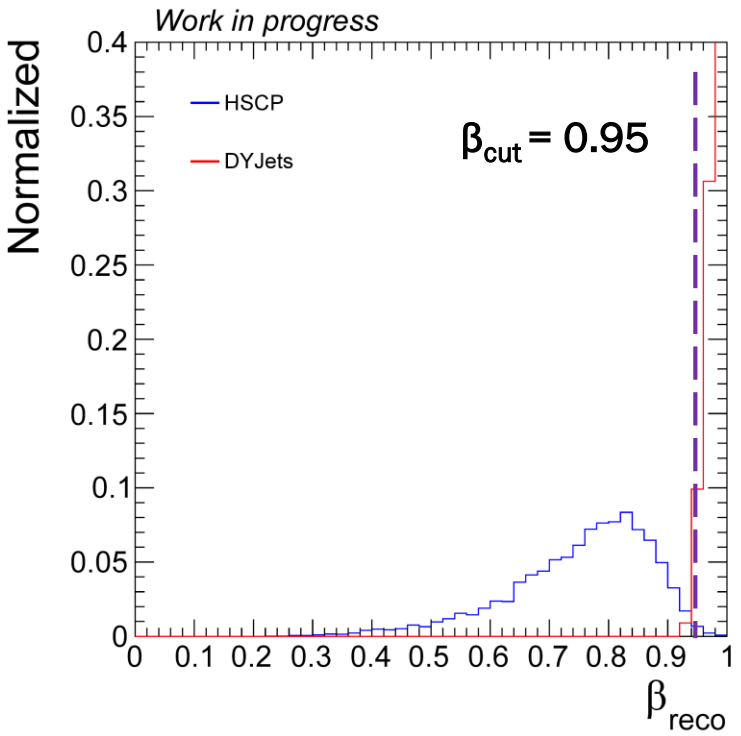
Zero efficiency
in the high eta region,
reflects the geometry

|η|-dependent β cuts

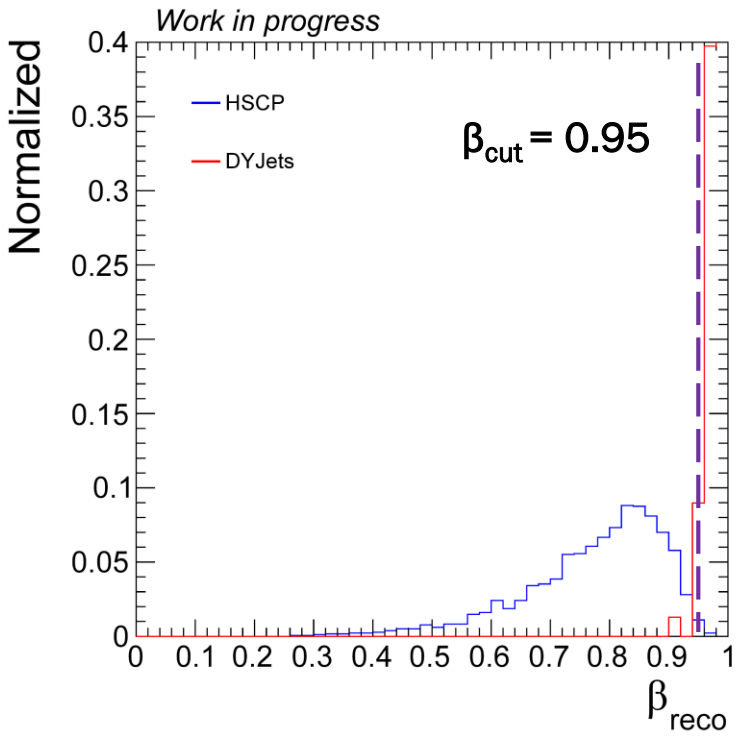
|η| < 1.6



1.6 ≤ |η| < 2.1



2.1 ≤ |η| < 2.4

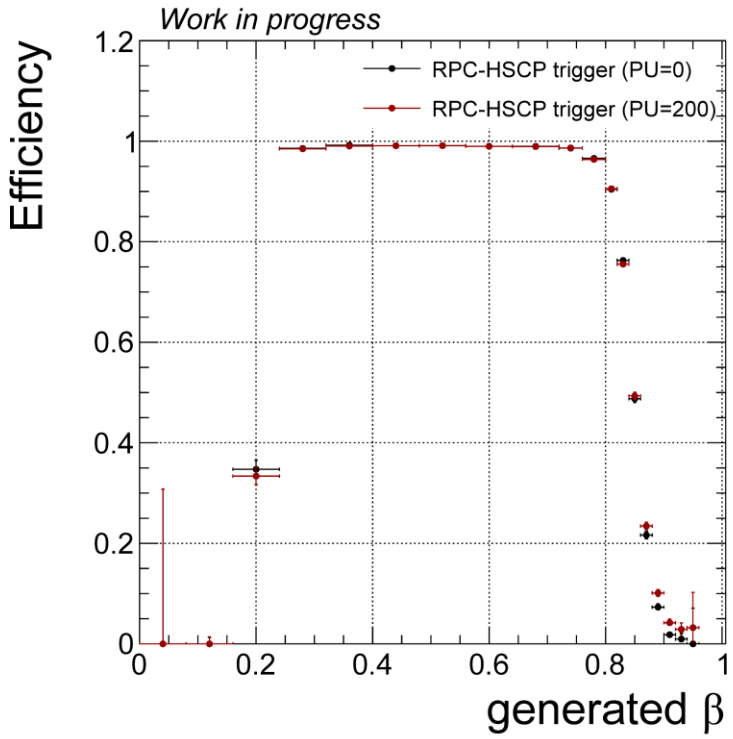


Optimal cut value depends on |η|

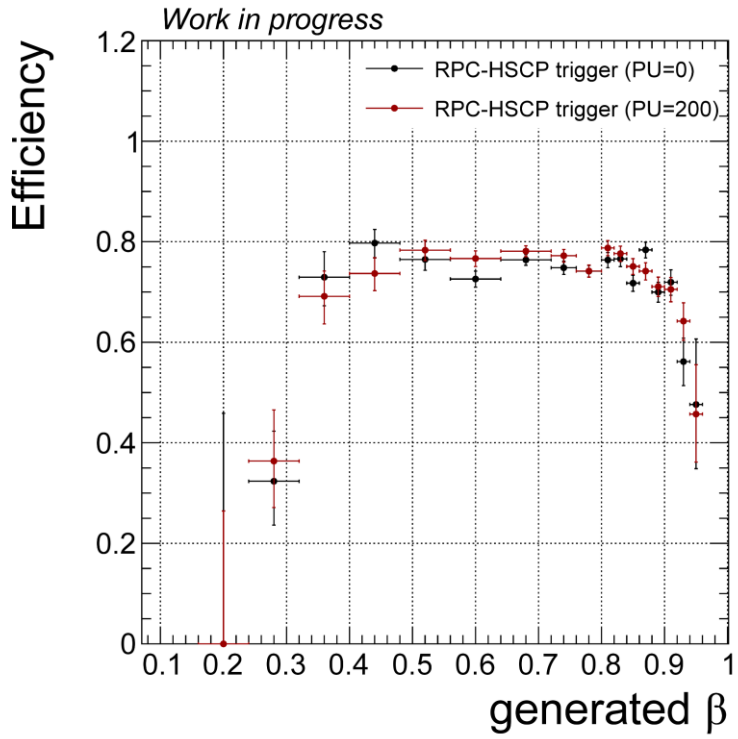
We can increase β thanks to be better resolution

Efficiency with new algorithm

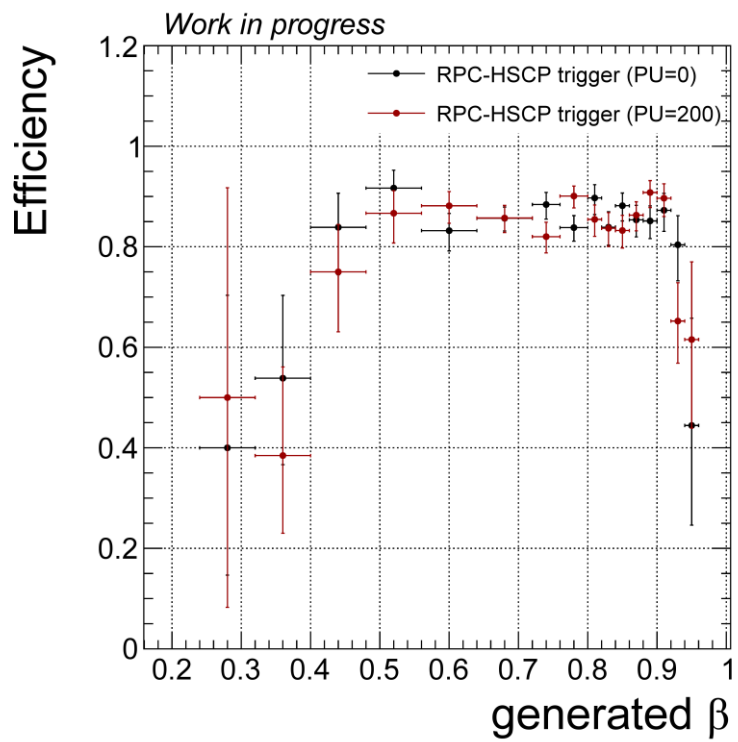
$|\eta| < 1.6$



$1.6 \leq |\eta| < 2.1$



$2.1 \leq |\eta| < 2.4$



New algorithm works for all region at very high efficiency

Summary

- Trigger algorithms for HSCP are proposed
- Fitting algorithm works for the existing RPCs,
  as a complements the regular muon trigger at low beta region
- We show an algorithm to cover the iRPC region
- Constraining at Bx=0 simplifies the algorithm and dramatically improves the efficiency
- Combination with other detector information is necessary for the correct Bx assignment