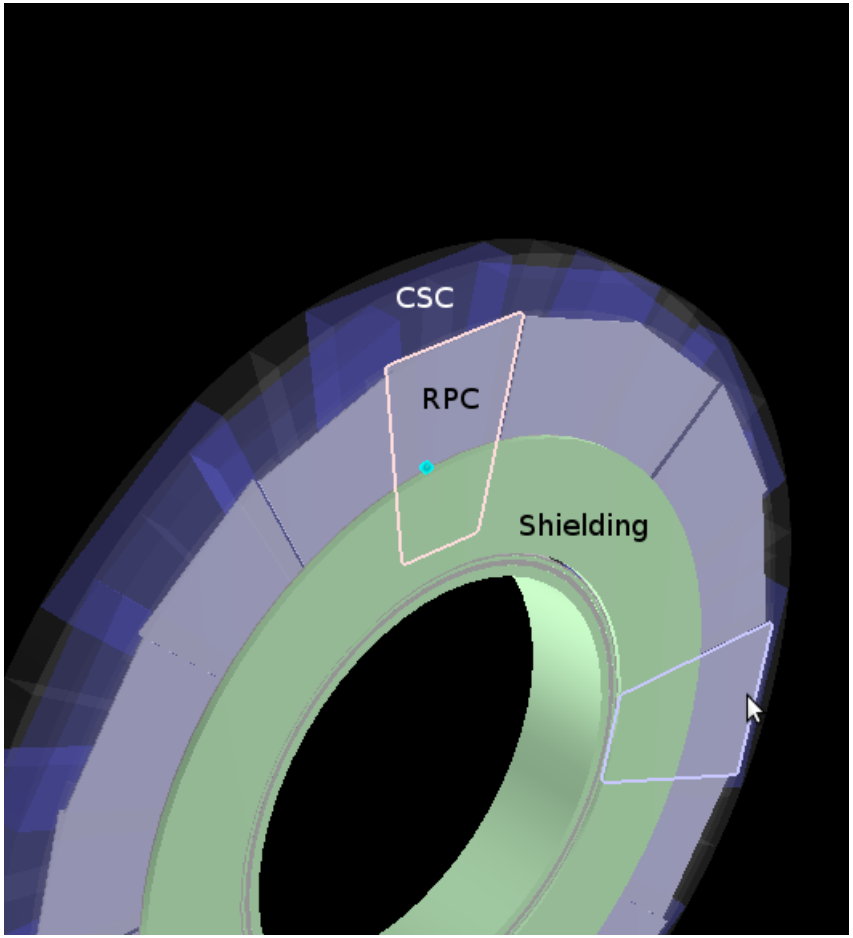


Motivations for the RPC Upgrade

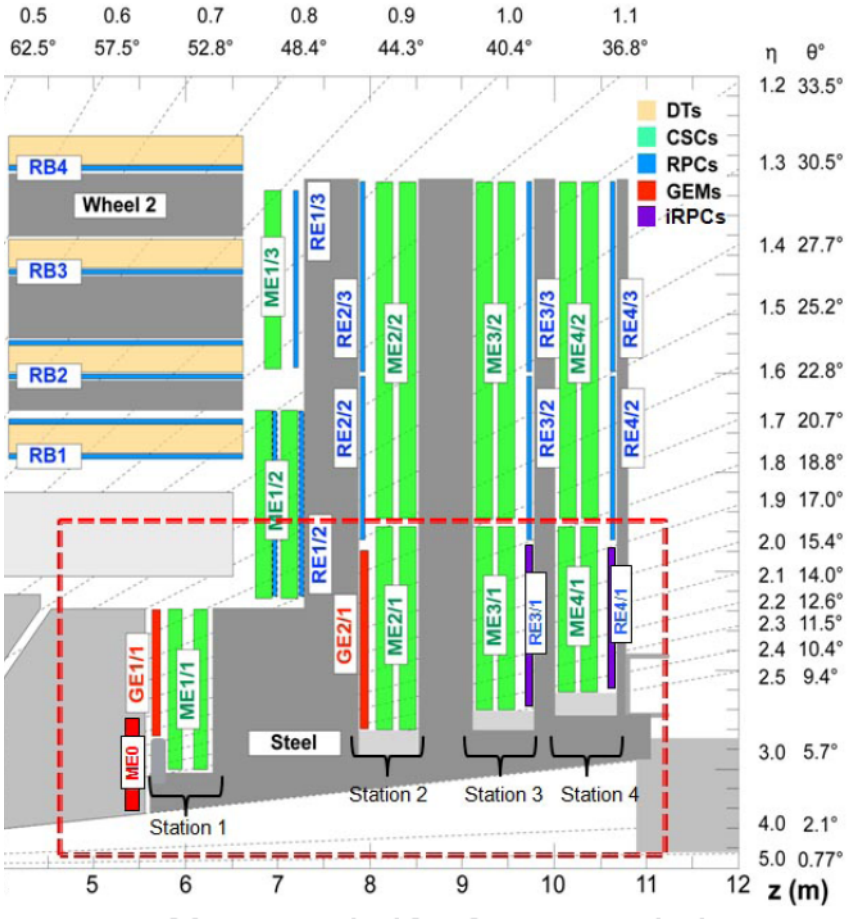
Summary of arguments

Piet Verwilligen

Università & INFN Bari

RPC Upgrade Worshop
14-15/10/2014

Upgrade of RE3/1 and RE4/1



What are we talking about?

- 2×36 10° chambers in RE3/1 and 2×36 10° chambers in RE4/1
- Foreseen in Muon TDR (1997), but up to $|\eta| < 2.1$
- RPCs able to handle high bkgnd $\mathcal{O}(500\,\mathrm{Hz/cm^2})$ rates in this zone
- Now extended up to $|\eta| < 2.4$ if integration allows

  RE3/1 $1.8 < |\eta| < 2.4$
  RE4/1 $1.9 < |\eta| < 2.4$
- RPC Technology tbd (MultiGap vs Double Gap)
- η coordinate tbd (readout both strip ends vs η-parts)

Motivation for RE3/1 & RE4/1

- **In the past $\Rightarrow$ two separate paths to motivate the upgrade:**

Technology independent

- Prove that CMS needs any kind of detectors in this zone
- **Redundancy Argument** (in Trigger & Reconstruction)
- Will be the focus of this presentation

Technology dependent

- What benefits can fast $\mathcal{O}(75\,\text{ns})$ detectors bring to CMS?
  - Pile-Up mitigation of factor 10
  - Beneficial for Double Muon trigger in $1.9 < |\eta| < 2.4$
  - Limited Physics case

CMS Technical Proposal (1994)

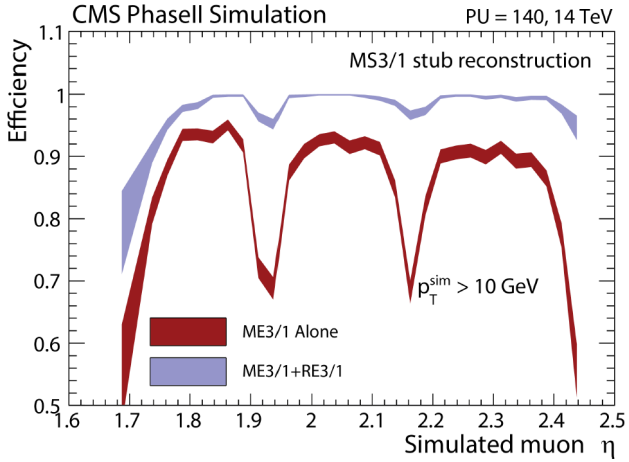
The design goals of CMS were defined as follows:

1) a very good and redundant muon system,
2) the best possible electromagnetic calorimeter (ECAL) consistent with 1),
3) a high quality central tracking to achieve 1) and 2),
4) a financially affordable detector.

Redundancy Arguments included in Technical Proposal

Use of RE3/1 and RE4/1 in L1 Trigger

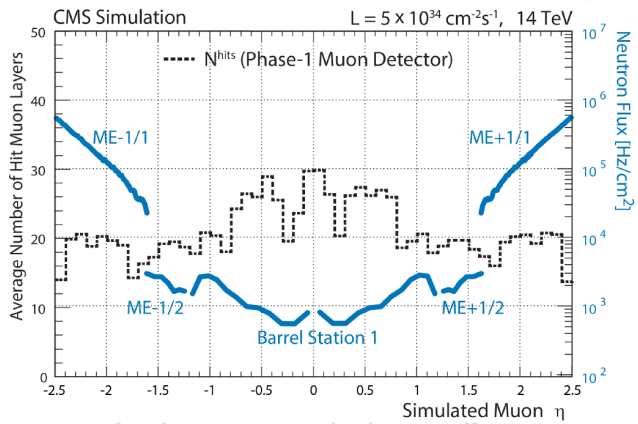
- Combination of RPC and CSC information improves Local Trigger
- inefficiency due to CSC HV-spacer
- Same for GE2/1, RE3/1 and RE4/1
- Plot included in TP [S. Dildick]



Restore redundancy in forward region

- Redundancy is missing exactly where highest background rate is expected
- Shown are the ϕ-coordinates used for bending measurement of muon track
- Plot included in TP

[A. Castanedo, A. Safanov & P. Verwilligen]



Investigations of Stand Alone Muon Reco

- Quality of Stand-Alone-Muon reco can be read from the width of the q/p_T distribution
- Core of q/p_T distr. is gaussian, but has large tails. Therefore we will be comparing the RMS of q/p_T distribution in several scenarios
- Upgrade is able to recover the core width (σ) if ME1/1 is missing at 0 PU (2019 scenario) and nearly completely at PU 140 for the RMS
- Similar Studies done for all other stations: removing ME2/1 (then ME3/1 and ME4/1) and investigating the recovery brought by the complete upgrade
- Vizualizing the recovery with:

$$\frac{(\text{No ME}X/1 \text{ station} + \text{Upgrade})}{(\text{No ME}X/1 + \text{No Upgrade})} \lesssim 1$$

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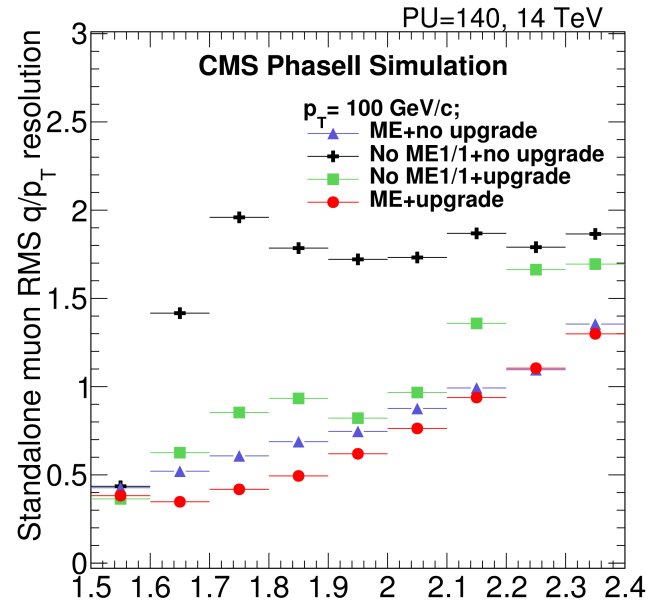

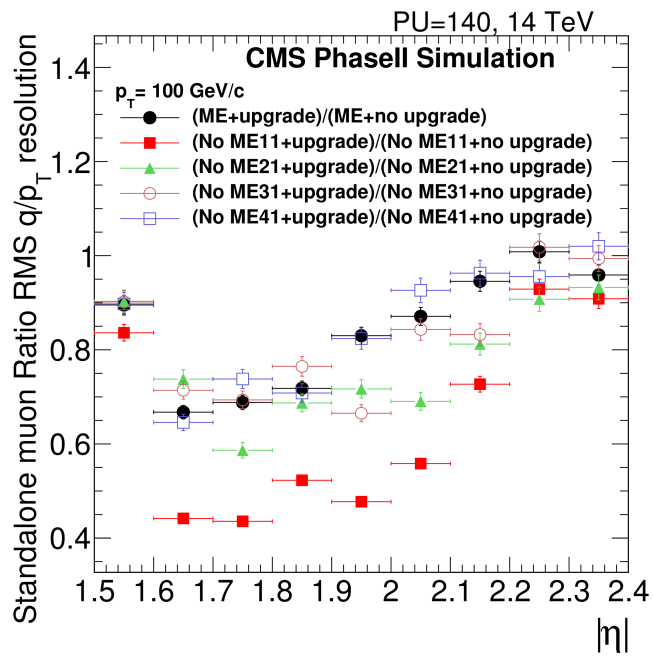

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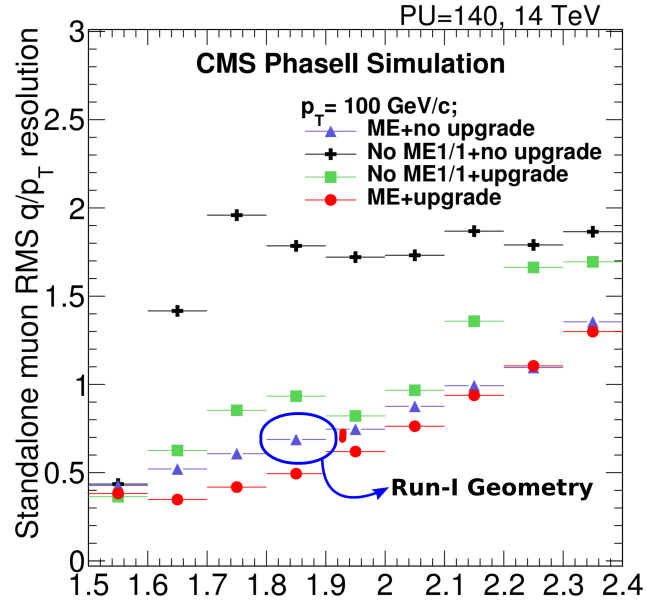

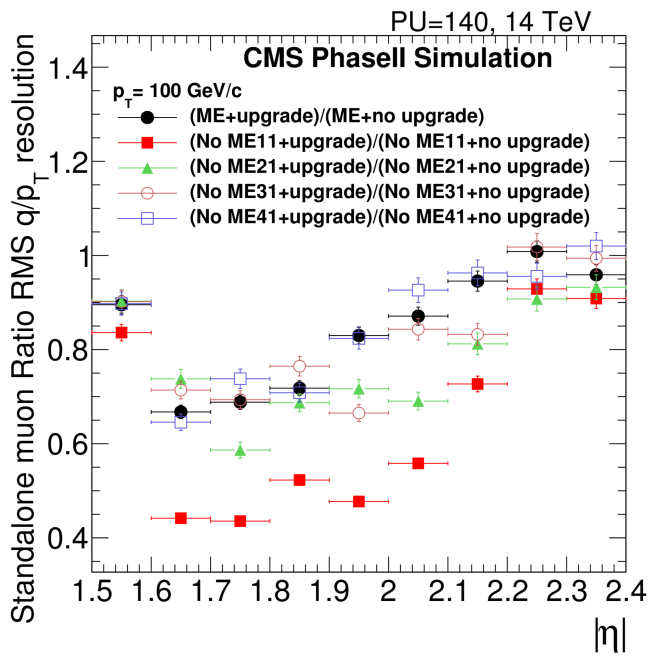

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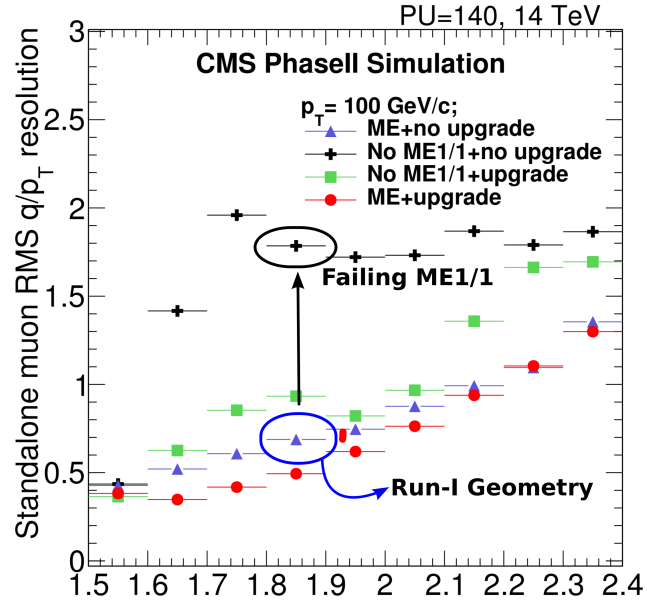

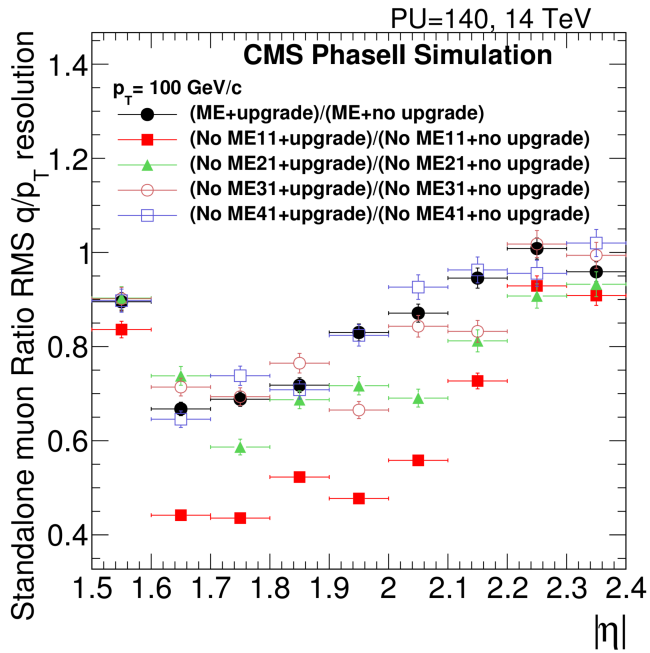

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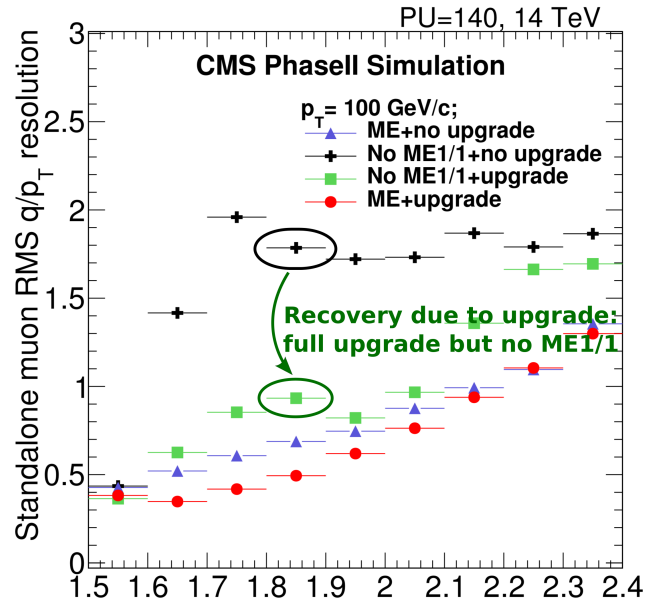

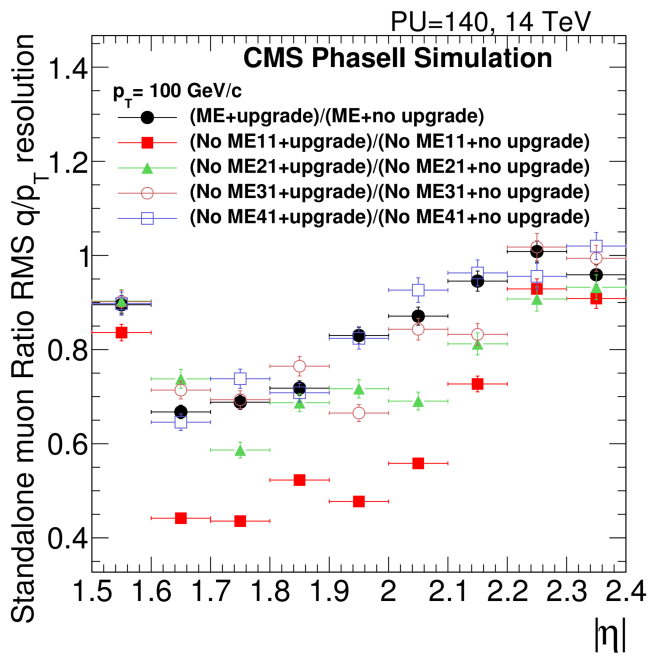

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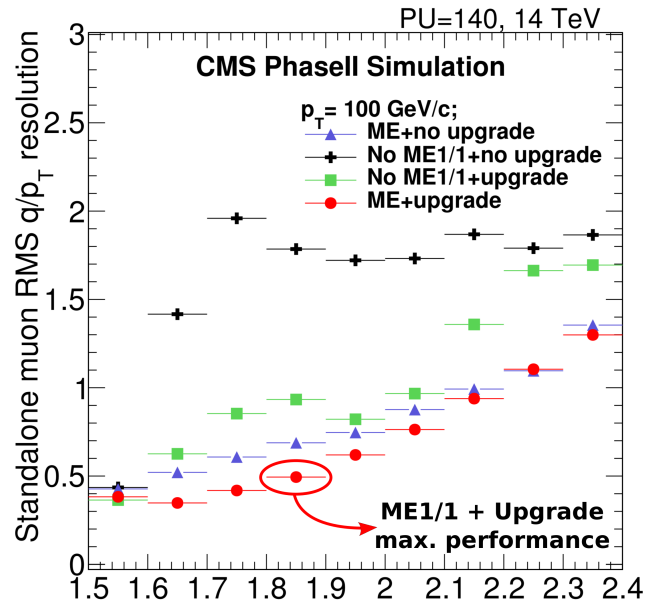

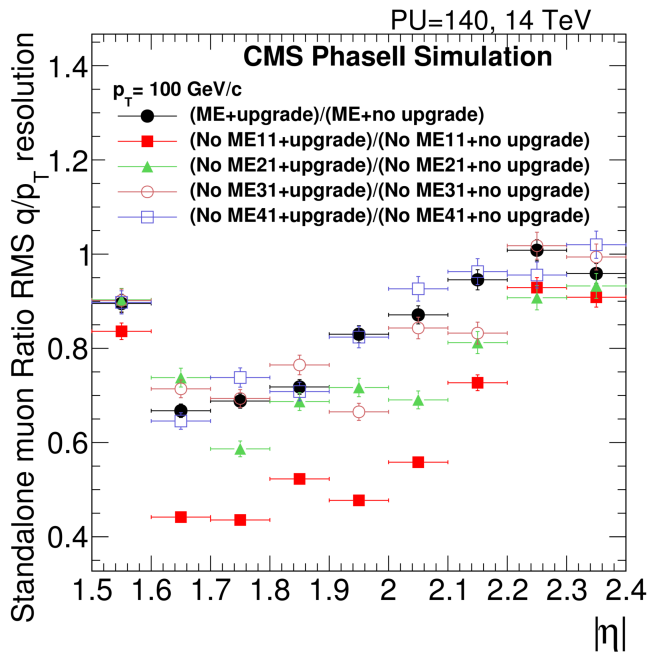

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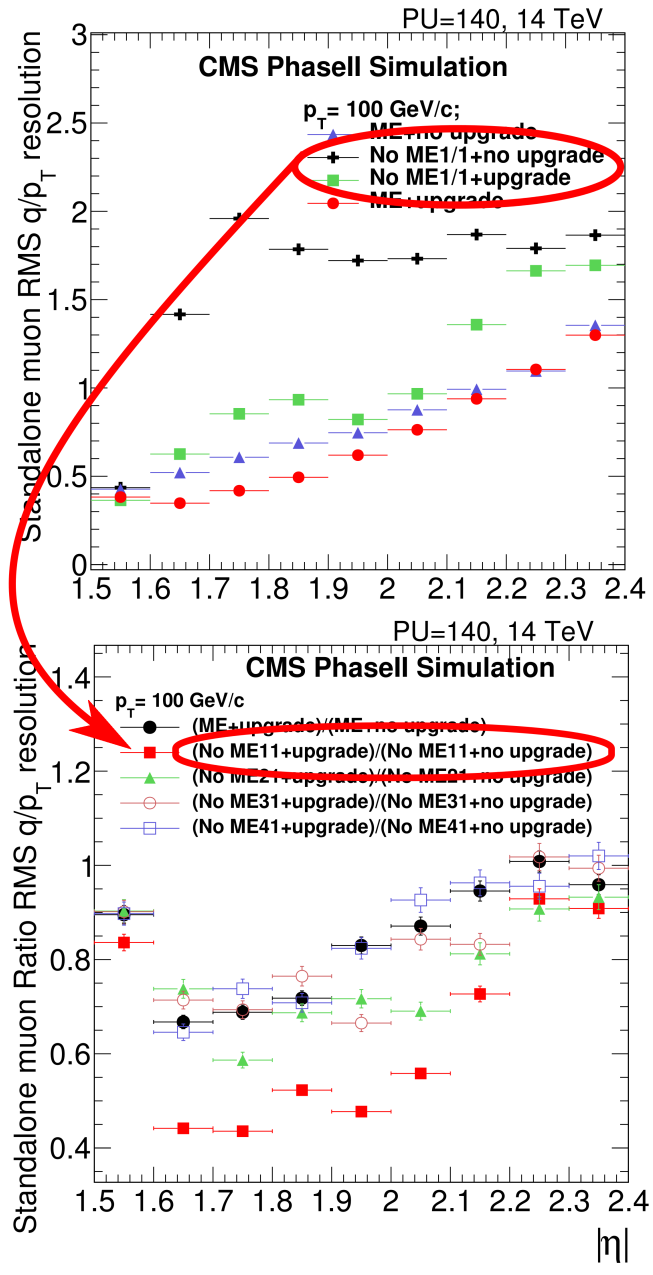


Further investigations of Hits in Stand Alone Muon Reco

- Hits & Segments used in Stand Alone Muon Fit
- Effect visible in $1.6 < |\eta| < 2.1$ and $2.1 < |\eta| < 2.4$ bins

$1.6 < |\eta| < 2.1$ bin:

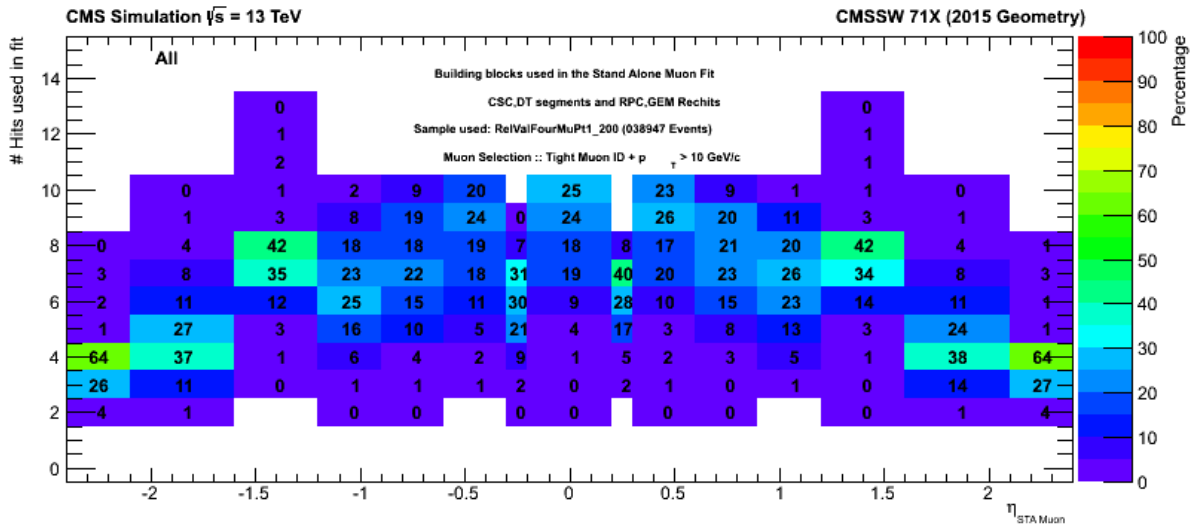
2015 94% in [3-7] hits/segments

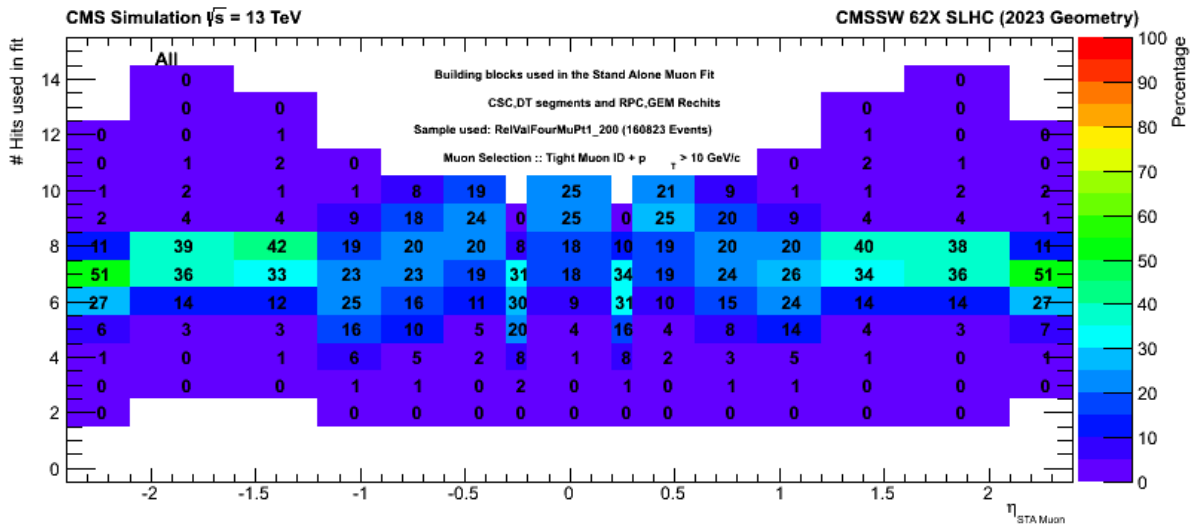
2023 89% in [6-8] hits/segments

$2.1 < |\eta| < 2.4$ bin:

2015 90% in [3-4] hits/segments

2023 95% in [5-8] hits/segments





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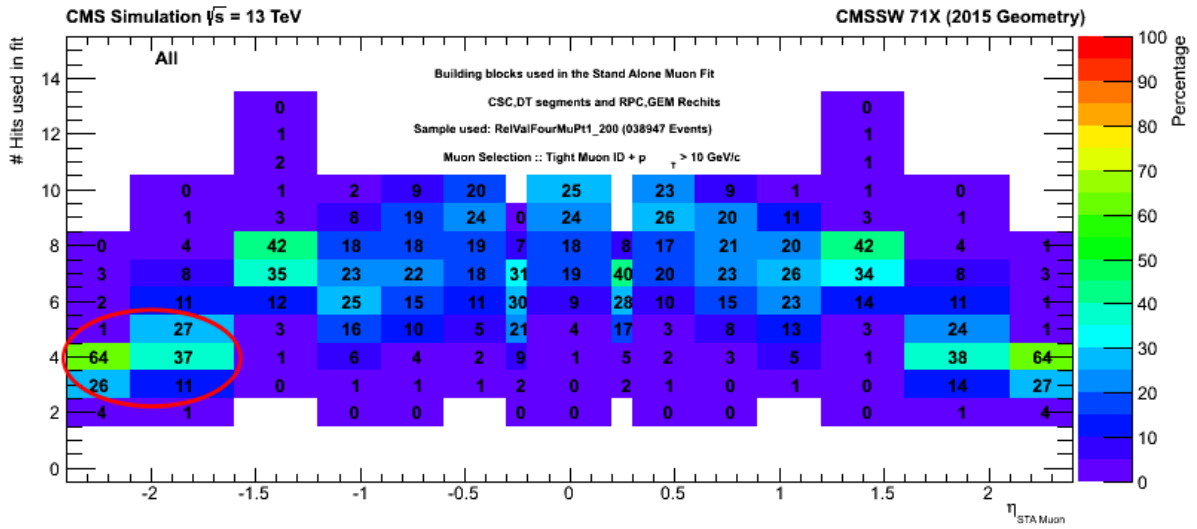
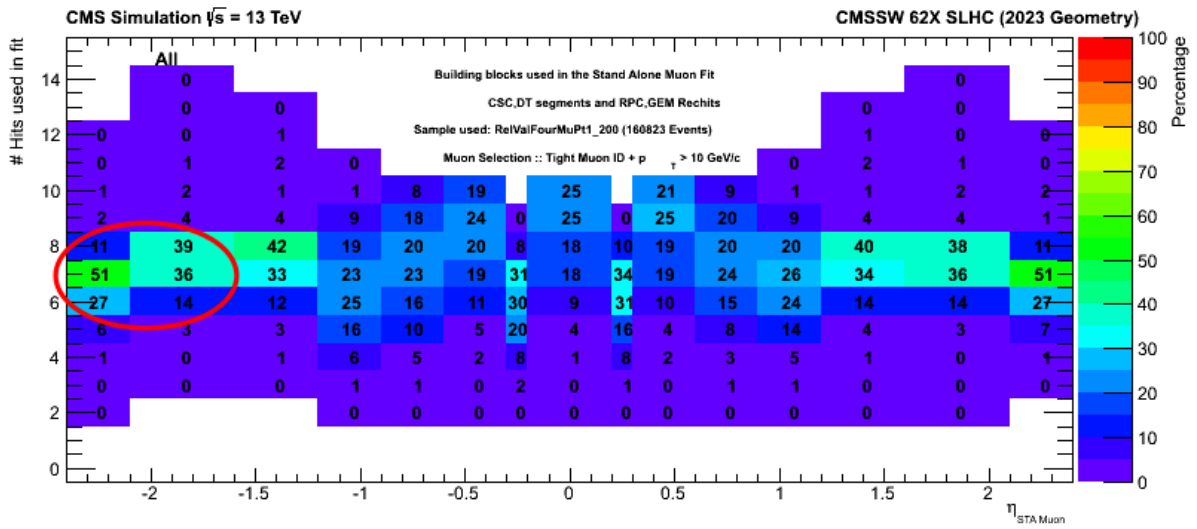
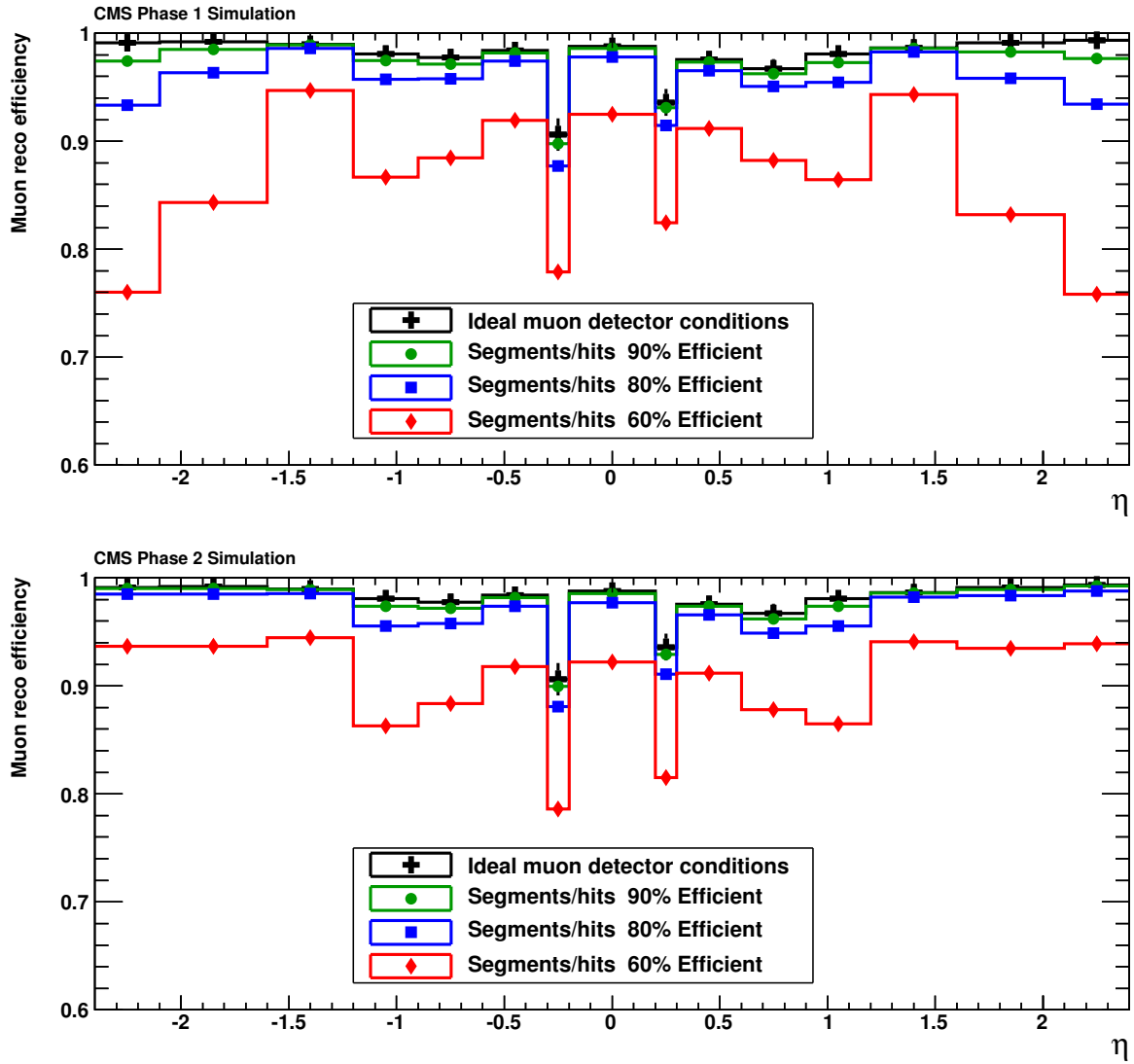




Further investigations of Hits in Stand Alone Muon Reco

- **Stand Alone Muon Reco efficiency** with ideal muon detector conditions
- Assume detector degradation for all detectors involved
- Effect largest in not-upgraded (top) scenario in $1.6 < |\eta| < 2.1$ and $2.1 < |\eta| < 2.4$ bins
- Effect mitigated in upgraded (bottom) scenario (uniform in $1.2 < |\eta| < 2.4$)
- Remaining: Barrel/Endcap transition and Barrel Gaps
- Plot included in TP

[P. Paolucci & P. Verwilligen]



Conclusion

- Efforts have been put in proving that CMS benefits from the RPC upgrade in RE3/1 and RE4/1, without specifying the technology to be used (generic RPCs).
- The redundancy argument is the strongest argument we have to defend the installation of detectors in RE3/1 and RE4/1.
- The Local Trigger (Stub) Efficiency is improved and more measurement hits are available in most difficult region. The Effect of chamber degradation is studied with a toy model.
- The toy model tells us (looking at the red line of 60% segment/rechit reco eff) that installing additional muon chambers (GEM and RPC) in the 2023 geometry leads to a recovery of the muon reconstruction efficiency with 18% in $2.1 < |\eta| < 2.4$ and 10% in $1.6 < |\eta| < 2.1$ region.
- One can observe that under the assumption of a huge loss of segment/hit reconstruction efficiency (60% efficient) the reduncancy leads to a uniform $\sim 94\%$ reconstruction efficiency in the endcap region $1.2 < |\eta| < 2.4$.