SLHC Muon Simulation: Status Report and Plans

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Goals of This Effort

- Ultimate SLHC Muon Simulation group goals:
  - Implementation of simulation framework describing future CMS detector and future trigger
  - Quantitative evaluation of detector and trigger performance in the SLHC luminosity environment
- Above requires detailed knowledge of the future detector and trigger upgrades
  - Latter cannot be established without reliable simulation and understanding of current detector shortcomings in high pile-up environment
- A circle that needs to be broken!

SLHC Challenges for Muon System

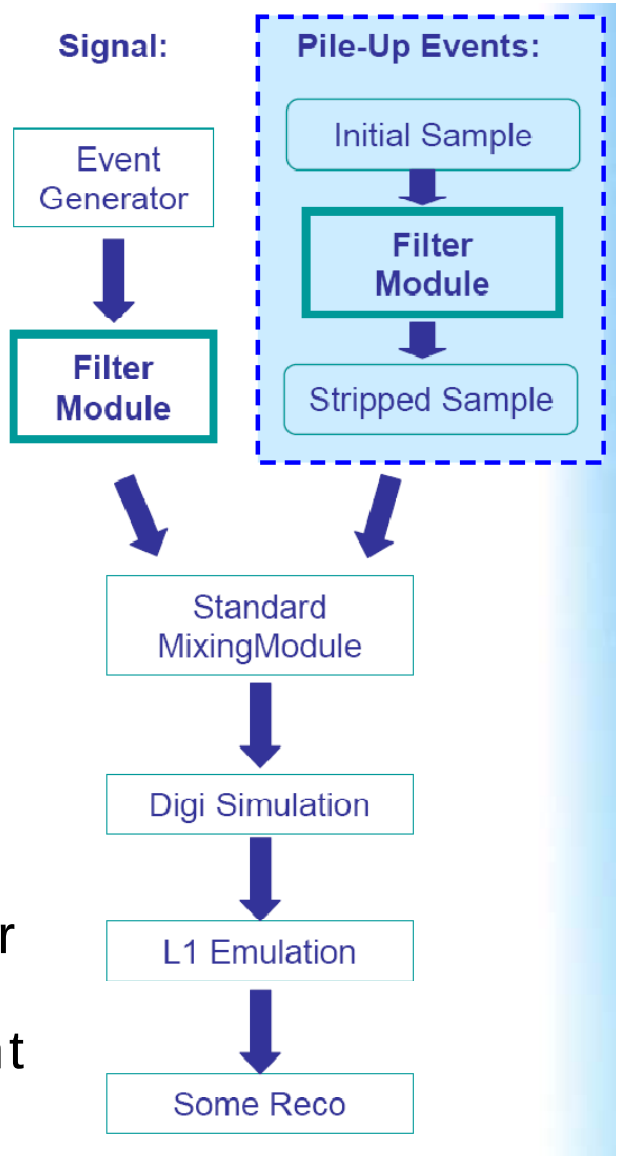
- Substantial increase in occupancies, especially in the stations closest to the interaction point
  - Degradation in stub finding will inevitably affect tracking
    - E.g. CSC currently can ship out only two stubs per chamber
    - Near stations are critical for muon trigger tracking performance333
  - Need to provide more flexibility and more redundancy:
    - Proposed ME4/2 will increase redundancy of the system
    - Electronics improvements can allow better purity and more stubs per chamber, but requires matching changes in muon track finder
- Flattening of the muon trigger momentum spectrum due to momentum misreconstruction
  - Additional information from tracking at Level 1 is likely critical
  - New muon-tracker matching capabilities in Level 1, mimimal requirements need to be understood
    - Important feedback to tracker and track trigger efforts
- Developing solutions to these challenges requires reliable simulation framework

Breaking the Circle

- Progress needs to be iterative with simulations and detector people findings feeding into each other
- Plan that we are pursuing:
  - Implement reliable simulation of the current schema in high PU environment (not trivial in itself!)
  - Determine sources of deficiencies of the existing schema
  - Find solutions to address the problem (hardware, trigger electronics and algorithms) and implement improvements in simulation
  - Iterate

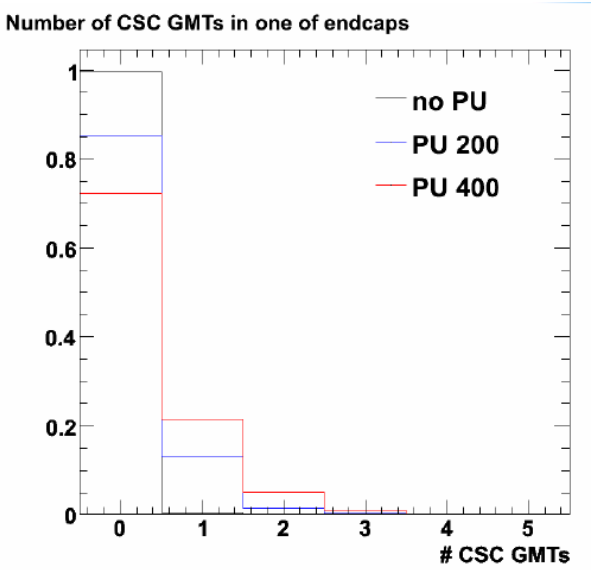
Simulation Framework

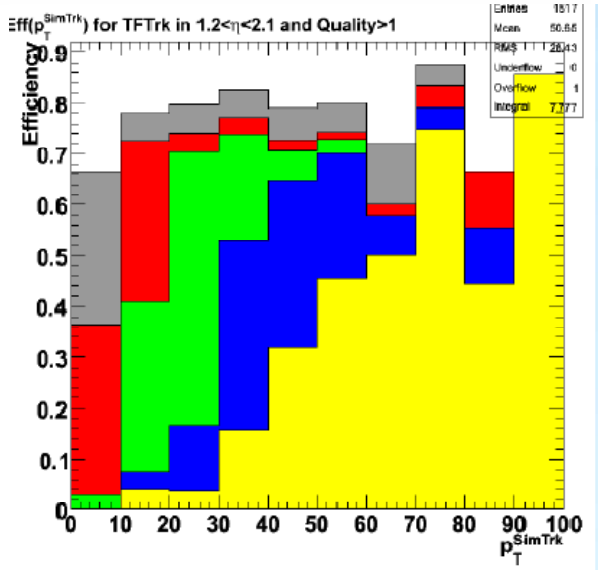
- Understanding occupancy related effects and non-muon (neutron) backgrounds make Full Geant simulation a far preferred option
- Implementation of High PU environment is difficult
  - Memory blows up much earlier than we can get to 50-200 PU per interaction
- Custom solution that we developed:
  - Full simulation in a fraction of the detector including out of time pile-up
  - Drop unnecessary information, trigger and reconstruction components to minimize memory problems and event size



High PU Simulation in 1.6.X

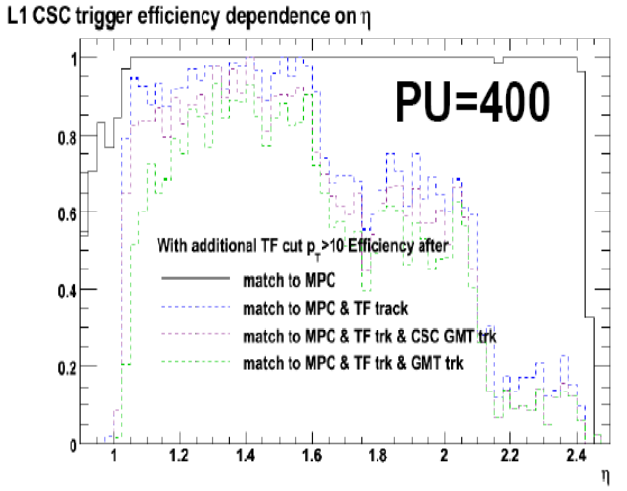
- Initial samples created in version 1.6.X:
  - Can make samples with up to 400 PU
  - Can integrate station ME4/2 in
  - Suitable for nearly all initial studies
    - Rates, purity and trigger efficiency
- Need to migrate to newer version:
  - Found (the hard way) that 1.6.X is not the best version for muon track finder
  - Version 1.6.X quickly becomes obsolete, e.g. we won't be able to integrate in the new tracker and new track trigger infrastructure

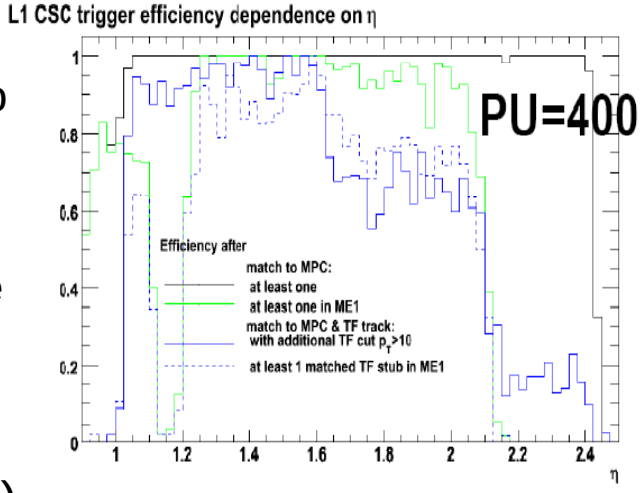




Performance Evaluation Package

- Important to achieve sufficient level of detail to separate sources of inefficiency
  - Easy to find inefficiency in global muon trigger, much harder to identify and disentangle several contributions to it
  - Unavoidable if we want to propose and work out solutions to the problems
- Requirements for the package
  - Reproduce the entire chain of trigger decision making including complex categorizations (that might continue to evolve)
    - Many small but important details related to proper definitions, matching etc.
  - Utilize trigger primitive objects:
    - Change primitives as we make improvements, but keep package as stable and transparent as possible
- Proto-version targeting CSC exists (Khotilovich), more people are joining:
  - Brownson (Vanderbilt), Perrotta (Bologna)





Common "Service" Tasks

- People started joining the work:
  - Common simulation framework:
    - Khotilovich (Texas A&M), Wilkinson (Caltech)
  - Performance evaluation package:
    - Brownson (Vanderbilt), Khotilovich (TAMU), Perrotta (Bolognia)
- But there are areas where we desperately need people and more expertise:
  - E.g. trigger primitives: definitions, creation, tuning of existing and new ones
- Also logistics problems:
  - We still don't have a package in CMSSW to keep our simulation modules, modified algorithms, primitive definitions and scripts
    - Apparently, we are all out on the allowed number of packages ☹

Trigger Component Studies

- Goal: studies leading to design, evaluation and implementation of improvements
- Three sub-areas:
  - Stub level: Khotilovich, A.S. (Texas A&M)
  - Muon Track Finder level: Acosta (Florida)
  - Muon + Tracker level: Furic, Fisher (Florida), Montanari (Bologna), Zotto, Lazzizzera, Vanini (Padova)
- Studies have started, but will need new samples to really pick up speed
- Would like to see more active participation in wide range of expertise from the Barrel side

Migration to Version 2.2.3

- Goal is to make a small number of samples useful for a wide variety of studies
- Difficult and tedious process as we need to produce test samples at each stage, but we are making progress:
  - "High PU" machinery is working – V. Khotilovich
  - ME4/2 is being integrated now – R. Wilkinson
  - Track finder tuning to include ME4/2 into triggering – Acosta's group
  - Integration of Long Barrel tracker into our samples when geometry is available
  - Tracking trigger simulation
  - Production of PU samples to be used in mixing module
  - Actual sample production
- Want to make final samples "official" to simplify access to them for everyone interested

Summary

- The good news is that the work has started
  - Even though some progress has been made, we are still in organizational stage
  - More focused and detailed studies will be done with the arrival of new samples
- We need more people to come onboard and bring more expertise
  - There are areas where the right kind of expert can make a substantial contribution with a moderate investment of their time
- Please come join us
  - SLHC Muon Simulations Twiki:
    - https://twiki.cern.ch/twiki/bin/view/CMS/SLHCMuonTriggerSimulations
  - Our meetings in Indico:
    - http://indico.cern.ch/categoryDisplay.py?categId=20