RecoMuon validation suite & PAT based $H^{\pm\pm}$ Analysis framework

5th CMS Korea Collaboration Meeting

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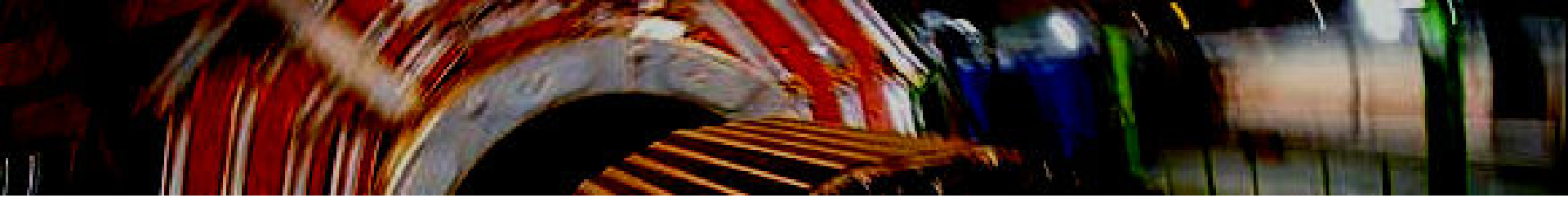


Part 1 : Muon validation

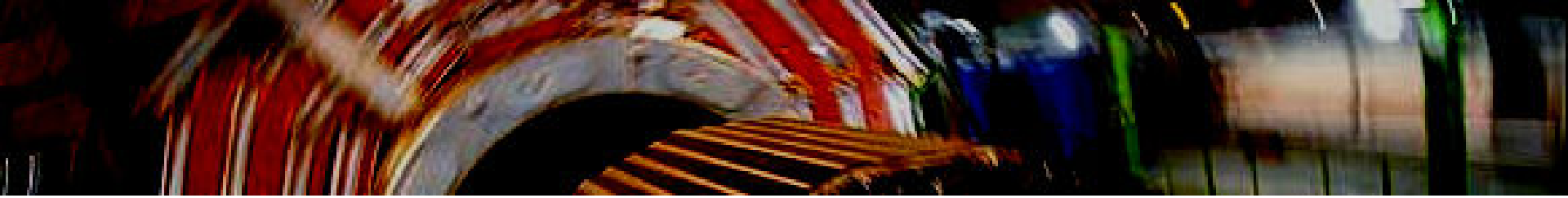
Short report on the development of muon validation suite

Status of Muon validation suite

- Validation suite is now in production stage
  - Most of packages are integrated to standard MC generation sequence – Release validation
  - Validation plots are managed with the DQM services, can be monitored via web interfaces
- And the muon validation working group is vital
  - Active discussions in the dedicated HN forum
  - Recent CMSSW version are regularly checked and validated
    - And reporting the validation status in the HN forums
    - Recent versions are validated : no differences between releases
- Still there could be more things to do
  - New plots to be added
  - Remove duplications, development in the DQM side…

DQMGenericClient

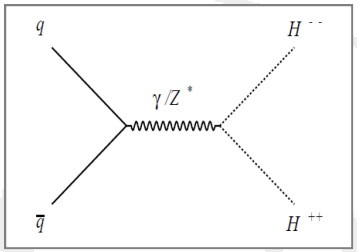
- PostProcessor have been used to produce efficiency/resolution histograms during the Harvesting step of Release validation
- Now PostProcessor got a new home and new name
  - After presentation at the DQM group, we decided to move this tool to more profit location : /DQMServices/ClientConfig with new name “DQMGenericClient”
  - Fully integrated to the DQM services
- The DQMGenericClient is the common tool for validation groups

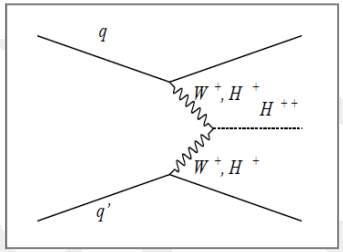


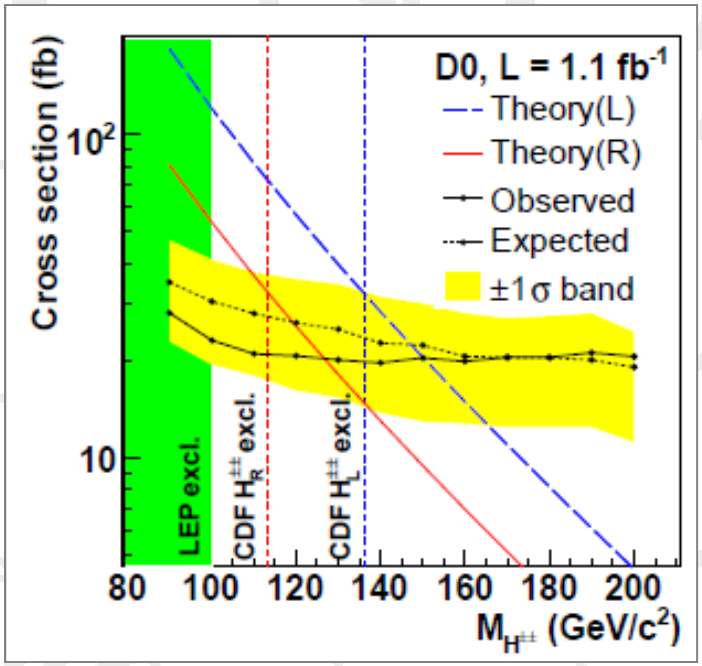
Part II : $H^{\pm\pm}$ Analysis

Current status of PAT (Physics Analysis Toolkit) based doubly charged Higgs analysis framework

Physics motivation







- Recent observation of neutrino mass could be solved by introducing Higgs triplet
- Drell-Yan process could give most clean signature
  - Independent of $H^{\pm}$ mass
  - $H^{\pm\pm}$ decays only to di-leptons in the low mass ranges
- No observation until now
  - Direct search at CDF excluded M(H)<(136, 133, 115 GeV) in the μμ, ee, and eμ channels
  - Recent D0 search ; $M(H_L)>150GeV$, $M(H_R)>127GeV$ in the 4 muon channel

Strategy

- First, follow Higgs to ZZ 4Leptons group analysis
  - Almost same final state, thus similar backgrounds, cuts
  - Similar cuts in basic object selection
- Next refine analysis dependent parts
  - Establish cuts quickly for 4 muon channel (JongSeok will show his results)
  - Extend to other channels, again based on Higgs to ZZ group analysis
- And develop concrete analysis framework
  - Consistency between analysis groups
  - Fast reaction on software changes – easy to keep the SW be most up-to-date
  - Start with 4-muon channel and compare to Jongseok's results

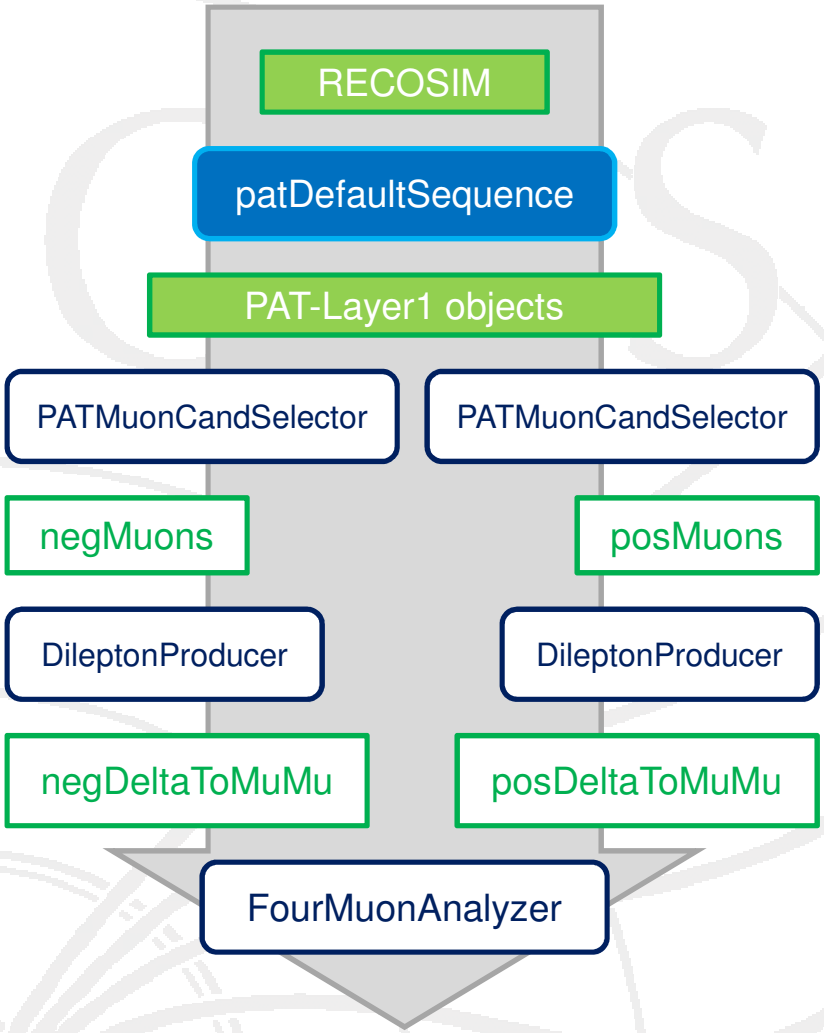
Components of Analysis Framework

- All codes are manages at the CMS-CVS
  - Since we don't have official package for doubly charged Higgs analysis yet, all codes are updated at the UserCode area
  - Code is opened to public : CVS:/UserCode/JHGoh/HiggsAnalysis/DoublyChargedHiggs
  - Please have a look and give me comments
- Attempt to Fully modulized
  - Analysis framework will be consist of multiple modules
  - Store composite particle candidate (like ZtoMuMu) in the event data – reusable for other analysis
  - FWLite based user level optimization analysis
  - Fully PAT oriented : Will be the common basis of physics analysis

PAT oriented analysis framework

- There are lots of advantage to employ PAT in the analysis
  - Many physics groups are already moved/moving to PAT based framework
  - PAT gives consecutive interface, common algorithms
  - For myself, it was successful to migrate 2_2_X codes to 3_X releases within few minutes!!!

Analysis dataflow

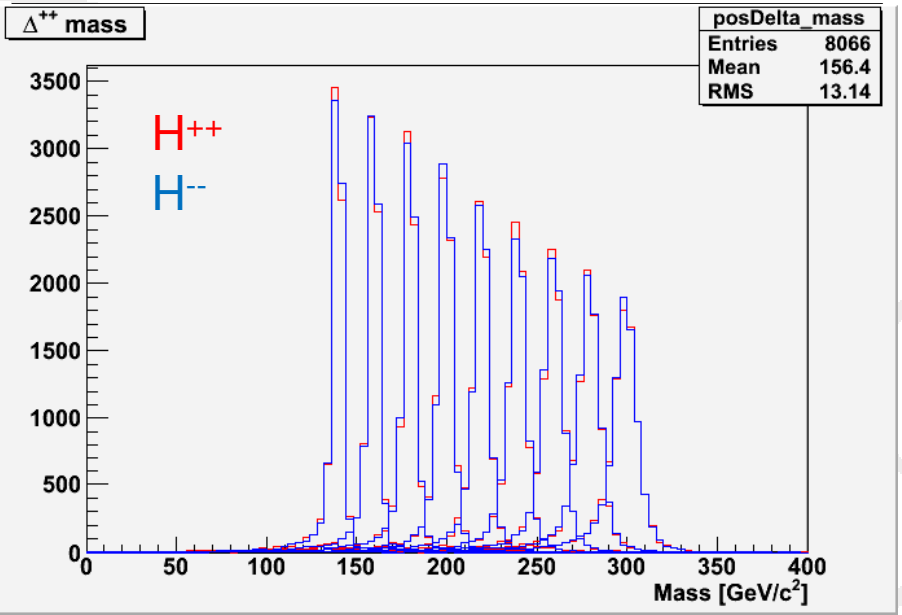


- Start from RECOSIM or PATLayer1Object
  - Most physics groups provide own set of PATLayer1
- Filtered 'good muons' are produced with PATMuonCandSelector
  - Separate muons by charge
- DileptonProducer combines SS muons, resulting H^{++}/H^{--}
- Basic selection variables are calculated and depicted by FourMuonAnalyzer

Testing the analysis framework

- To test new framework, we observe variables of the 4muon channel and compare to previous studies
  - Can be a good exercise to design the framework and give good hint to choose data formats
- Studied performance check on the PAT based analysis framework
  - Generate MC samples, run simple analyzer modules, observe histograms
- The framework should be ready for production release
  - Respond to the new releases quickly
  - There are many references – major physics groups

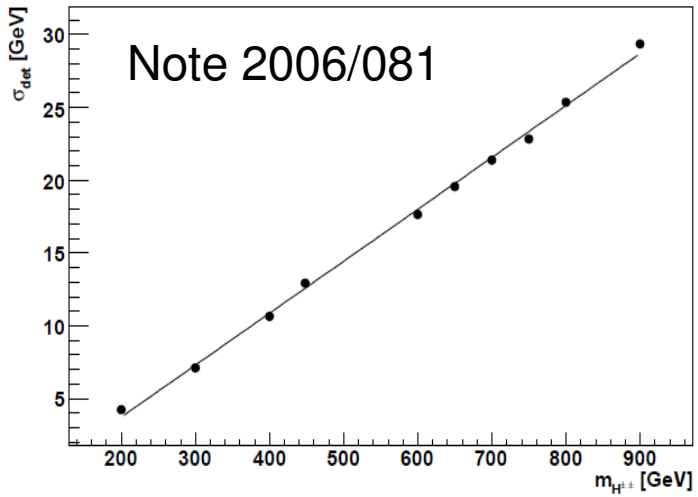
Signal sample generation

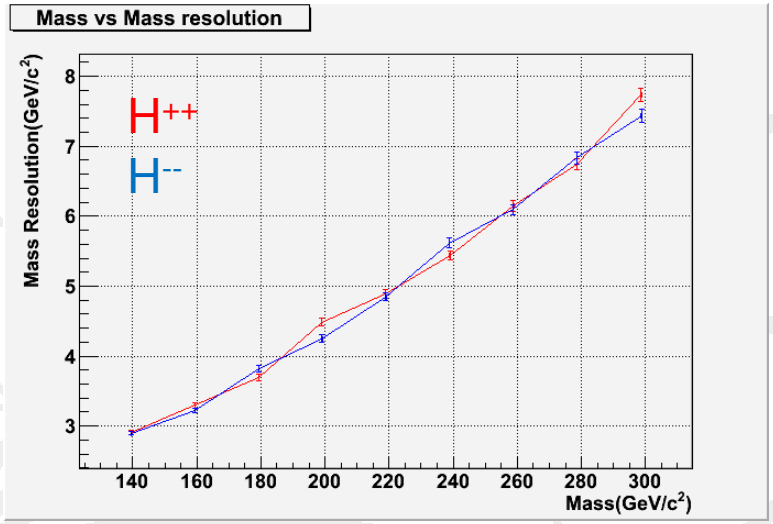



```
    'PARP(181)= 0.0      !H++ coupling with ee',
    'PARP(182)= 0.0      !H++ coupling with emu',
    'PARP(183)= 0.0      !H++ coupling with etau',
    'PARP(184)= 0.0      !H++ coupling with mue',
    'PARP(185)= 0.1      !H++ coupling with mumu',
    'PARP(186)= 0.0      !H++ coupling with mutau',
    'PARP(187)= 0.0      !H++ coupling with taue',
    'PARP(188)= 0.0      !H++ coupling with taumu',
    'PARP(189)= 0.0      !H++ coupling with taumutau',
    'PARP(190)= 0.0      !H++_L coupling with W',
    'PARP(191)= 0.0      !H++_R coupling with W'),
  parameterSets = cms.vstring('pythiaUESettings',
                              'processParameters')))
```

- Private samples are generated at the UoS cluster
  - CMSSW_2_2_13
  - Fast simulation
  - CM energy = 10TeV
- Mass bins from 140GeV to 300GeV, with 20GeV steps
- Yukawa coupling of Higgs to dimuons are set to be 0.1 and 0 for others for 4-mu samples
- All cff are available at CVS:
  UserCode/JHGoh/HiggsAnalysis/DoublyChargedHiggs/python/PYTHIA*.py
  - Use V00-00-01 tags for CMSSW_2_X releases

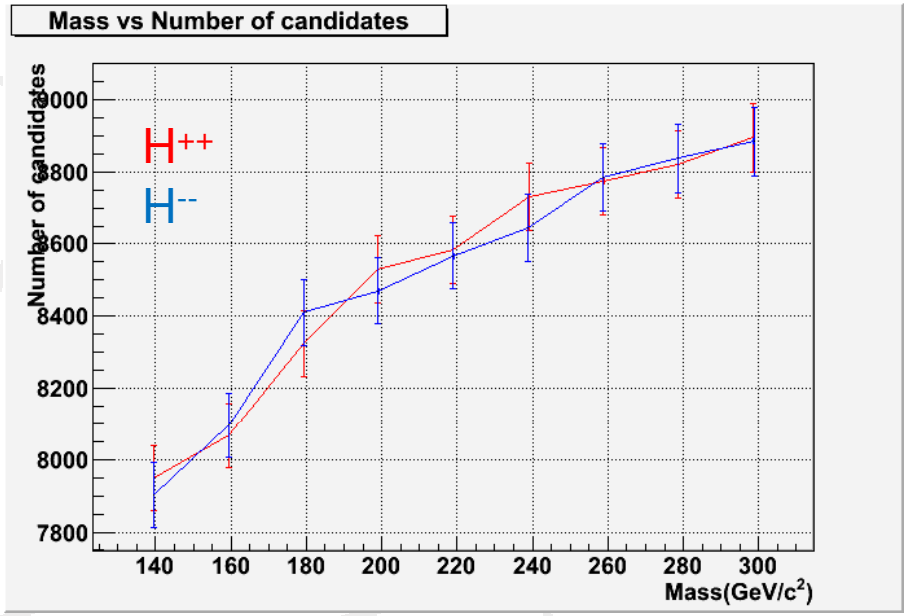
Mass resolution





- The mass resolution increases (almost) linearly with respect to the Higgs mass
- The slope of curve looks similar to the previous studies in Note 2006/081
  - Previous one is slightly steeper than this new result, but more MC samples could be needed
- Here, the resolution is measured by binned X^2-fitting on the mass distribution
  - The mass distribution is known to have long tails
  - Still, it is a good approximation

Number of Higgs candidate

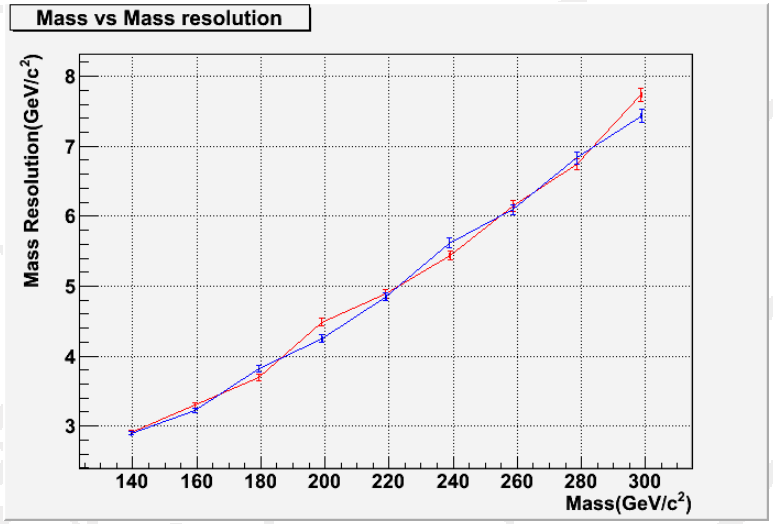


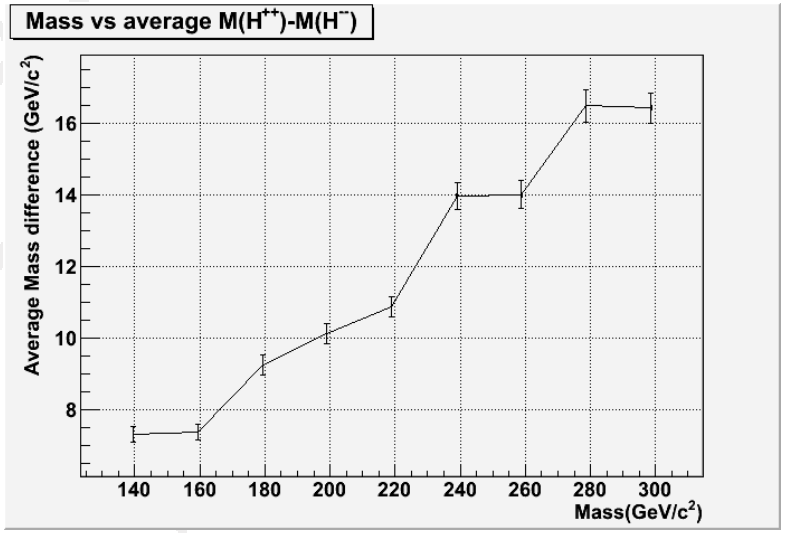
- Number of Higgs candidates increase w.r.t the Higgs mass
- Since the event number is fixed to 10k, this can be interpreted as an efficiency plot

Mass difference as a cut variable?

- If we require on-shell conditions, both of H^{++} and H^{--} should have same mass (up to decay width + detector resolution)
- Independent of MC truth Higgs mass
  - All parameters are estimated at the RECO level
  - For example, we can set up a variable

```
(Mass difference)/(Mass error) < 3
```





Extension to LFNV channel

- Once the framework is set-up, we can extend the analysis codes to other channels
  - Development of PAT based composite candidate is finished, waiting for tests – ee, eμ channel samples are needed
  - Analysis code (Histogrammer) under development
- Planning to focus on the Lepton number violating decay mode : $H^{\pm\pm} \rightarrow e^{\pm}\mu^{\pm}$
  - Still, this mode has same final state in Higgs to ZZ4Leptons channel
  - Thus we expect similar analysis strategy can be applied

Plans & On-going works

- Follow up Four muon channel analysis, with new framework
- Migration to new CMSSW release
  - We're moving to CMSSW_3_2_7 – most recent production release
- New sample generation
  - New release, other decay modes, mass bins
- Many ideas to be implemented, some are not listed in this presentation
  - Track refit, vertex qualities
  - Developing cut optimization codes using FWLite+PAT
  - Refine muon isolation/identification cuts

Questions, Answers, Suggestions

Thank you