

Physics Studies and Related Issues

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- High Level Trigger related news.
- Participation in CSA07 exercise
- Invisible Higgs: status presented by S. Bansal
- Study of $B_s \rightarrow \mu\mu\gamma$ with A.Nayak
- Study of $Z \rightarrow \tau\tau \rightarrow e + \mu + X$ final states with S. Bansal

India-CMS meeting, BARC, July 2007.

CSA07: Computing Software and Analysis challenge in 2007

- Mainly during September, October & November, 2007.
Process 100M events, 50% of load expected in 2008.
- Test the workflow and dataflow associated with the data handling and computing model of CMS. Test alignment, Calibration, Trigger, Reconstruction, use of DataBase etc.
- Major components:
Preparation of ~ 100 M simulated and reconstructed datasets.
Realistic situation at startup with misaligned detector.
Generation of 14 streams according to HLT bits (RAW data to HLT).
Details of streaming being finalised.
- Skimming of datasets and subsequent reconstruction at Tier1 centres.
Skimmed datasets, propagated to T2s.
Analysis to be performed at T2 s.
T2 s must host data of interest to the corr. geographic region.

Participation in Physics activities of CMS

- Well-defined topics being pursued with good rate of progress.
Relevant Twiki pages maintained where details can be found.
- Regular presentations made at meetings at CERN, with good communications with concerned group coordinators.
Electroweak Physics with τ final state.
(March 26, May 11, July 3 and 17)
Measurement of $B_s \rightarrow \mu\mu\gamma$
(Feb 20, April 17, May 29, June)
Invisible Higgs
(May 29, June 16)
- Taking part in CMS-wide milestone exercises during HLT 07 and CSA07 (earlier in CSA06) through data production and analysis.
MC generation of special events, configuration files, Skimming etc.

Trigger Studies, present status

- Trigger studies using CMSSW is an important milestone in CMS during 07.
Report submitted to LHCC on June 20:
<https://twiki.cern.ch/twiki/pub/CMS/HighLevelTrigger06ExerciseDocumentation/HLT-LHCC2007-021.pdf>
- Contribution to HLT report to LHCC and CMS AN-2007/009 (~ 85 CMS authors including S.Bansal, K.Mazumdar) re. efficiency of special trigger path (MET + VBF jets for Invisible Higgs).
- Most of the studies now start from evaluating trigger efficiencies and we participated in checking trigger efficiencies for various channels of our interest.
Results were given as feed back to optimise some of the trigger thresholds.
- HLT studies being finalised for CMSSW version 131 HLT6.
CMSSW version 160, in quite new format, to be released on August 10!

- Will the 160 triggers be identical to the HLT-exercise ones? No!
 - HF response different: jet rates a bit higher.
 - HCAL noise better simulated: need **retuning** of L1 and HLT!
 - ⇒ We need to re-evaluate trigger efficiency of Invisible Higgs channel.

τ studies in Electroweak group

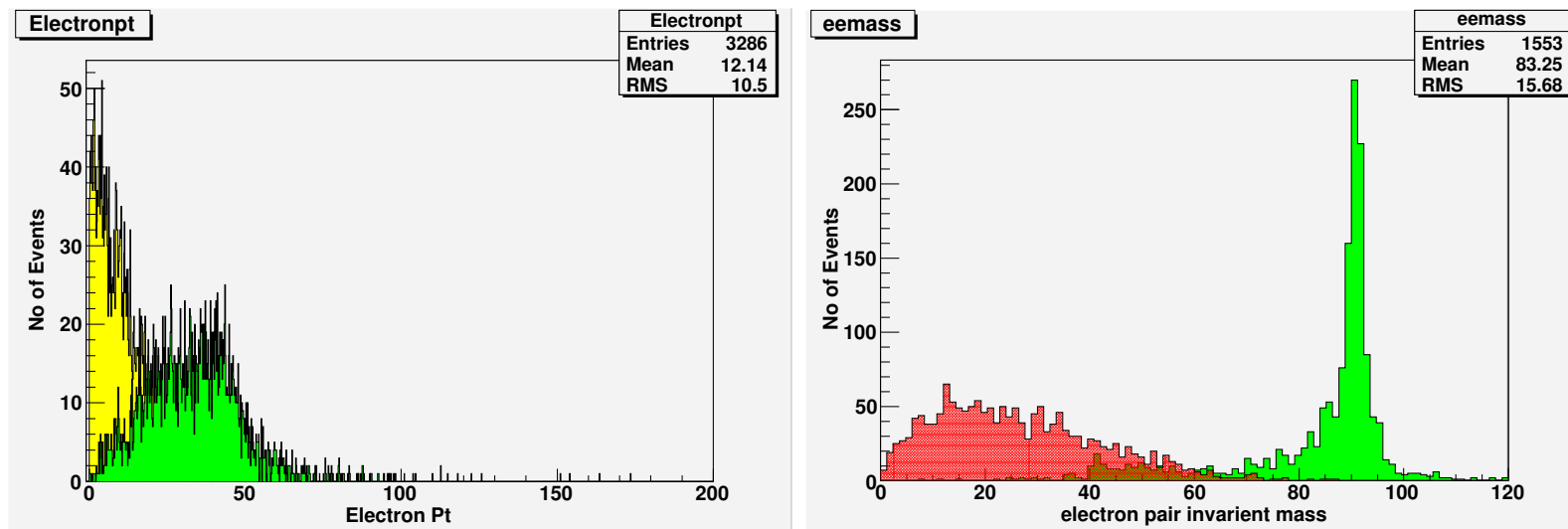
- τ production at LHC is a physics topic of CMS with $\mathcal{L} = 100 \text{ pb}^{-1}$
 \implies measurement of $Z \rightarrow \tau\tau$ cross-section and comparison with $Z \rightarrow \mu\mu$ rate.
Also measurement of tau decay branching ratios.
- $Z \rightarrow \tau\tau \rightarrow e + \mu$ is a clean channel, though smaller than $Z \rightarrow \tau\tau \rightarrow \ell + \text{jets}$.
Drell yan background is absent.
Other potential backgrounds: $t\bar{t}$, W^+W^- .
Important backgrounds for searches like $H/A \rightarrow \tau\tau \rightarrow e, \mu$
channels with final state jets + E_T^{miss} (eg. Invisible Higgs) one of the backgrounds is
 $Z + 2 \text{ jets}$ with $Z \rightarrow \nu\nu$ and $Z \rightarrow \ell^+\ell^-$ when low energy ℓ^\pm s are not measured.
- Preliminary analysis strategy to select $Z \rightarrow \tau\tau \rightarrow e + \mu$ vis-a-vis background channels
show encouraging results. \rightarrow to be imported into CMSSW.

Trigger studies

Note in signal channel leptons have low $P_T \implies$ trigger efficiency is moderate.

Trigger efficiency estimated using CMSSW 131 HLT6.

Signal data: Spring07 inclusive $Z \rightarrow \tau\tau$ sample at cern.



softer distribution: $\tau \rightarrow e$ harder spectrum: $Z \rightarrow \tau\tau$

Mass distrn.: Green: $Z \rightarrow e e$, Red: $Z \rightarrow \tau\tau$, each $\tau \rightarrow e$

Status of Skim file for $Z \rightarrow \tau\tau \rightarrow e + \mu$ selection

- For CSA07 exercise, at present, our skim depends only on HLT condition.
- Single-lepton HLT conditions have high p_T cut off \implies not particularly suitable.
 \implies resort to X-channel trigger in addition to single lepton trigger conditions.

High Level Trigger condition	thresholds	purity	eff.
emusequence : $e + \mu$	(8, 7) GeV	30%	10%
Logical OR: emusequence + Single el., isolated + Single el., Non-isolated + Single mu, isolated + Single mu, Non-isolated	(8, 7) GeV 15 GeV 17 GeV 11 GeV 16 GeV	15%	35%

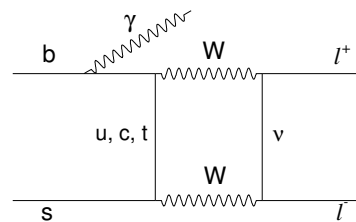
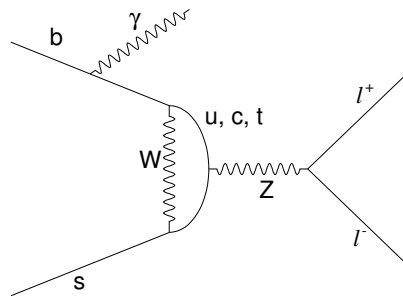
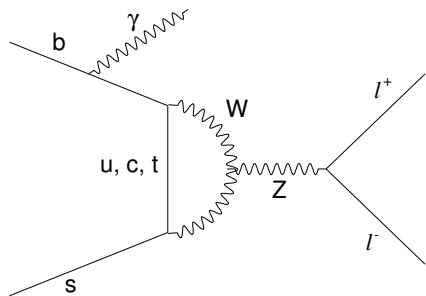
B-physics at LHC

- Goal of heavy flavour physics is now shifting from understanding of CKM paradigm (SM) to search for physics Beyond the Standard Model (BSM) appearing in loops
⇒ look for signs of BSM in rare processes with B-hadrons.
- Obvious comparison between LHCb and CMS/ATLAS ⇒ CMS may be doing better in some channels during first few years.
- CMS: accessible p_T of B-hadrons $\sim 5 - 300$ GeV, $|\eta| \leq 2.5$. BUT no PID
LHCb: $p_T \sim 1 - 300$ GeV, $2 \leq \eta \leq 5.0$, Has PID to reconstruct exclusive channels.
- CMS, ATLAS can do b-physics during early period of LHC running, lumi $\sim 10^{32-33}$.
At high luminosity, doing B-physics is difficult.
LHCb will take data with lumi $\leq 10^{33}$ for several years.
- During 2009-2011, expect CMS, ATLAS: $\mathcal{L} = 30 \text{ fb}^{-1}$
During 2009-2013, expect LHCb: $\mathcal{L} \geq 10 \text{ fb}^{-1}$.

$$B_s \rightarrow \mu\mu$$

- At LHC, the QCD production rate of bottom pair is very high
 $\sigma(b\bar{b}) \sim 500 \mu\text{b}$, about 10% of the events will have a B_s meson.
- B_s physics is relatively new.
Very interesting results can be obtained from Bs physics within few years of LHC.
eg., Bs oscillation, $B_s \rightarrow J/\psi\phi$, $B_s \rightarrow \mu\mu$, $B_s \rightarrow \mu\mu\gamma$
Caveat: Tevatron will run till 2009! CDF, D0 are well-understood detectors!!!!
- $B_s \rightarrow \ell^+\ell^-$ decay is loop-driven and helicity suppressed, hence low branching ratio in Standard Model.
 $\mathcal{B}(B_s \rightarrow \mu\mu) \sim 3.5 \times 10^{-9}$, $\mathcal{B}(B_s \rightarrow ee) \sim 10^{-14}$ (since $m_\mu^2 \gg m_e^2$).
Can be enhanced highly due to *New Physics* \implies interesting physics topic with early data.
- With 30 fb^{-1} in CMS expect $\mathcal{B}(B_s \rightarrow \mu\mu) < \sim 6 \times 10^{-9}$ at 90% CL.

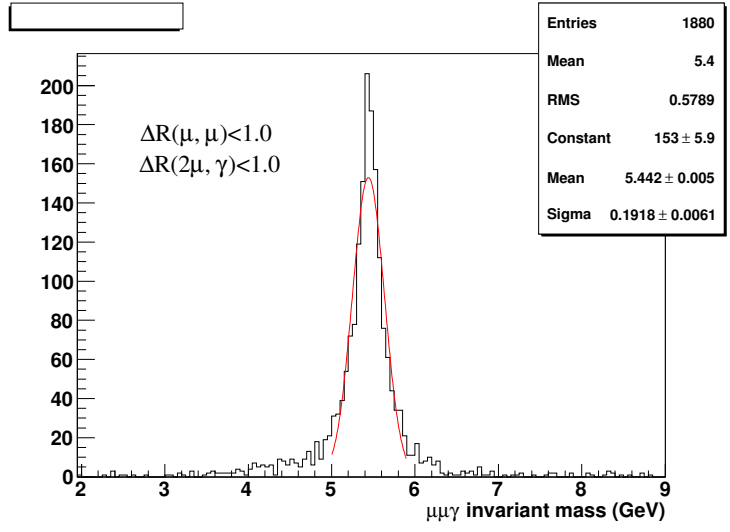
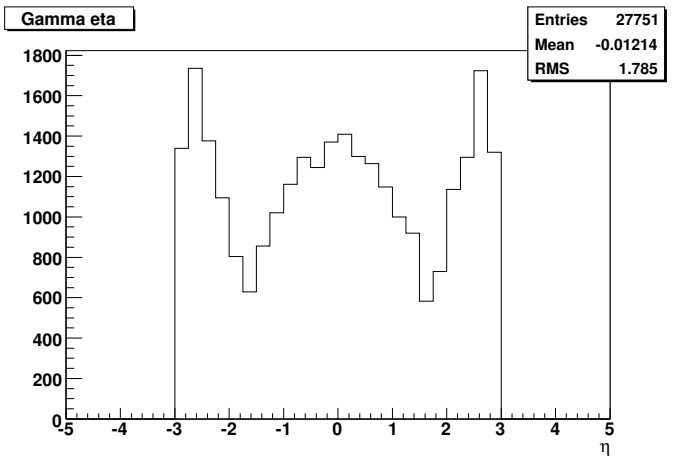
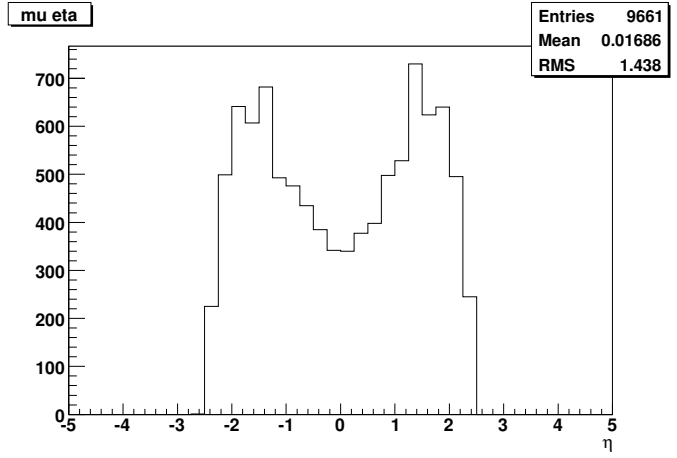
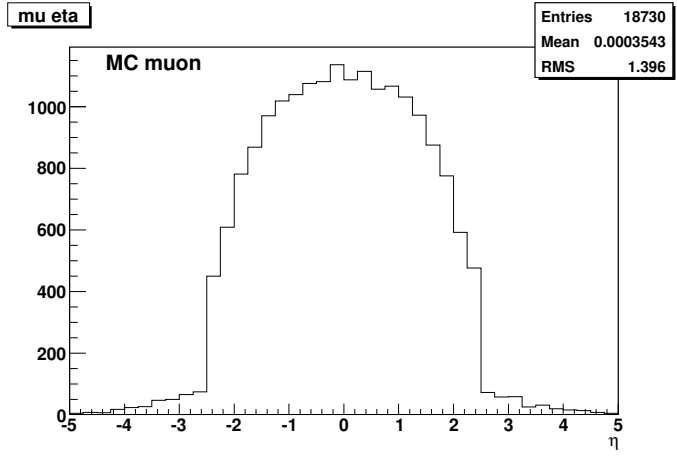
$$B_s \rightarrow \mu\mu\gamma$$



- $\mathcal{B} (B_s \rightarrow \mu\mu\gamma)$ is of **similar** order to $\mathcal{B} (B_s \rightarrow \mu\mu)$ in SM since it is not helicity suppressed.
- New Physics interaction type (vector, axial-vector, pseudoscalar) can pull up one of them!
- With good identification and measurement capabilities for muons and photon, CMS should be able to do well in both $B_s \rightarrow \mu\mu$ and $B_s \rightarrow \mu\mu\gamma$ channels.
- Low p_T physics topics, different problems than usual searches at LHC! Requires high statistics and good control of systematics as well.

Status of $B_s \rightarrow \mu\mu\gamma$ study

- Data production during 2007: configuration files supplied to production team in March. Event generation through modified pythia for channels: $B_s \rightarrow \mu\mu\gamma$, $B_d \rightarrow \mu\mu\pi^0$
Kinematic preselection and particle filters in cfg files to expediate generation of useful events.
- Spring07 signal sample with CMSSW 131 available during May, but not at CERN, accessed through grid using CRAB.
Efficiency for analysis during development stage is not good.
- Preliminary analysis: atleast two muons with product charge = -1 and a photon within $\Delta R_{\mu\mu,\gamma} \leq 1.0$
Kinematic selections, to be tightened for realistic situation.
- Plot invariant mass and fit a gaussian.



Trigger studies for $B_s \rightarrow \mu\mu\gamma$

- b-physics needs totally separate condition for event triggering. Final state particles have relatively low p_T .
- Dedicated trigger strategies evolved for various channels. eg., Displaced di-muon vertex trigger for B_s events.
- Trigger condition at HLT for our channel: combination of nearby ECAL cluster information for candidate photon.
- Trigger studies using CMSSW v131 HLT 2/3/5 with privately generated sample and recently produced Spring07 sample. \rightarrow trigger efficiency very low.
- Our studies showed that a larger mass window necessary for di-muon invariant mass. Being implemented in trigger code.
- Efficiency is to be evaluated with the latest and gretest code in HLT6.

Condition

- Embarked on few physics topics based on different conditions.
Not easy to keep pace with activities at CERN, though able to manage till now, thanks to Sunil (and Jasbir) and Arun (and Tariq).
There are berths for more!
- Working on this channel will enable us to be in main stream of physics activities.
Different groups in similar/same channels work in complementary way.
- Plan to take part in CSA07.
- Analysis code need to be developed with the new data format, AOD, of CMSSW version 160, may be using CMS-standard tools which are being developed currently.