Preparing for Early Physics in CMS

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- Participation in CSA06 exercise with S. Bansal, courtesy J.Singh.

- CSA07: request for a useable Tier 2 at the earliest.

- Study of $B_s \to \mu\mu\gamma$ with A.Nayak and T.Aziz

- Study of W/Z decays to τ final states with S. Bansal and J.Singh

India-CMS meeting, Chandigarh, April 2007.

CSA06: Computing Software and Analysis challenge in 2006

- Mainly during October& November, 2006.

- 50 million event exercise to test the workflow and dataflow associated with the data handling model of CMS.

- A test at 25% of the capacity needed in 2008.

- Major components:
  Preparation of $\sim$50M simulated datasets (some with HLT-tags).
  Prompt reconstruction at T0, at 40 Hz using CMSSW.
  Application of calibration constants from offline DataBase.
  Generation of skimmed datasets, propagated to T2s.
  Splitting of an HLT-tagged sample into 10 streams.
  Physics jobs at T2s and T1s.
  T2 s must host data of interest to the corr. geographic region ....

- Final report in February, 2007: **CMS Note 2007/006, CERN/LHCC 2007-010**.
  https://twiki.cern.ch/twiki/bin/view/CMS/CSA06

CSA06 Workflow

- Simulation of events performed with CMSSWv0-8-x
  Reconstruction with CMSSWv1-0-x with main reconstruction components included
  Tracking, vertexing, standalone muon, jets, Global muon (with tracker), electrons, photons, b & tau tagging.

- Data format for physics analysis: RECO(nstruction), AOD (Analysis Object Data, subset of RECO).   Deta sets:
  1. Minimum bias (40M, 30TB)
  2. $t\bar{t}$ (6M, 20TB)
  3. $Z \rightarrow \mu\mu$ (2M, 4TB)
  4. $W \rightarrow e\nu$ (4.6M, 7TB)
  5. Jet calibration soup (1M, 3TB): dijet + Z+jet
  6. Electroweak soup (5.6M, 10TB): $W \rightarrow \ell\nu$ + Drell-Yan + WW + $H \rightarrow WW$
  7. Soft Muon Soup (2M, 4TB): Inclusive muons + J/Psi
  8. Exotics Soup (1M, 3TB): LM1 SUSY, Z (700 GeV), and excited quark (400 GeV)
 9. HLT soup (5M, 10TB): W + Drell-Yan + $t\bar{t}$ + dijets

Only Indian CSA06 activity

- Measurement of Z $(\to \ell\ell)$ + n-jets rate, $n = 1, 2, 3, ...$
  Note higher the number of jets in the event, softer is the spectrum for jet energy.

- W/Z + 2/3 jets events are serious background processes to many searches, e.g., Higgs searches in Vector Boson Fusion process (qq $\to$ qqH).
  Data-driven estimation of these Standard Model events *candles* is a must at LHC to have handles on backgrounds! MCs have various uncertainty components.

- The study will also be one of the *first physics topics at LHC* on its own.
  The rate measurments at LHC will be confirmation of SM at high Q^2 regime.
  Several QCD studies are planned with these data.

- We tried to select events of type Z$(\to \ell\ell)$ + 2/3 jets from CSA06 data which will be used to estimate the rate of Z$(\to \nu\nu)$ + 2/3 jets events .
  Thanks to A.Nikitenko for suggestion and coordination.

Analysis of Z + 2/3 jets events in CSA06 data

- Note, none of the CSA06 samples actually contained proper Z + ($\geq$) 2 jet events. (CSA06 used only Pythia generator which cannot generate these events with proper kinematics and statistics. So rate estimation was not possible.)
Special dedicated generators like ALPGEN and Madgraph are used typically.

- The participation was mainly to test our readiness.
We must know in advance how to look at data spewed out by CMS.
Also **brief description of the study went to the final report!**

- Analysed unskimmed data sets of $t\bar{t}$ and Electroweak Soup at T0 (CERN) to get the tools ready at the beginning of CSA06. $\Rightarrow$ access useful info in CMSSW (v 082) and analyse.

- Skim filter (tau-Z-and-L1filter) on *Electroweak soup* sample with $P_T^{e,\mu} \geq 15$ GeV.
Data needed for our study located at DESY and FNAL, accessed with CRAB.
Jobs submitted from lxplus at CERN (should have been from T2).
Lot of struggle initially with CRAB.

- Analysis of data corr. to ~ 300 pb^{-1}. (expect 1 fb^{-1} in 2008) Require : 2 muons with $P_T^\mu \geq 15$ GeV, $M_{\mu\mu}(80, 100)$ GeV and ≥ 1 jet with $E_T^j \geq 20$ GeV.

- Apply VBF-like criteria: E_T of two highest jets ≥ 40 GeV (tagging jets), $\Delta\eta_{j1j2} \geq 4$, $M_{jj} \geq 1$TeV etc. Veto events with 3rd jet with $E_T^j \geq 20$ GeV in the gap between two tagging jets.
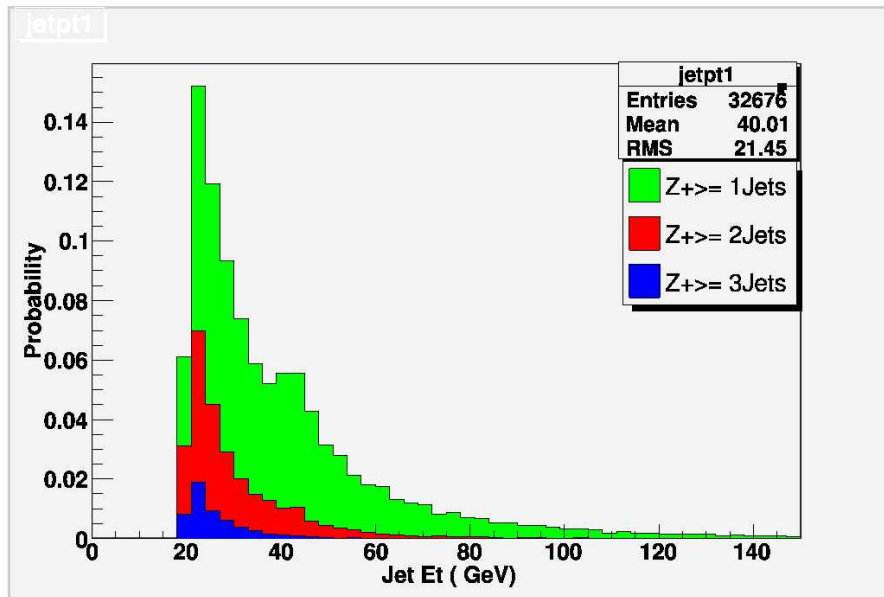
E_T **distribution of jets, normalised to 1.**

CSA07 exercise

- Scheduled during July 2007: process 100M events, 50% of 2008.

- Events: SM cocktail! with CMSSW V140/150/160
  Reconstruction at CERN T0, skimming at T1, analysis at T2.

- T2 should provide the resources for the analysis of physics channel of interest for particular physics groups of the region. $\rightarrow$ Subscription to relevant data sets as well.

- If we can't take part in CSA07 using our T2, it may be disastrous for Indian participation in CMS physics programme.
  We have been already warned by people during T2-Grid workshop in November, 2006.

- T2 is expected to cater to physicist and hence the data sample subscription needs to be discussed in advance, to be informed to relevant bodies at CERN.
  These will take time and it is not expected that smooth operation will be possible in a matter of few days of T2 turn-on.

- It is time to discuss this in detail, may be even over email to the whole India-CMS community.

Physics Commissioning of CMS

- http://cms.cern.ch/iCMS/jsp/page.jsp?mode=cms&action=url&urlkey=CMS-PHYSICS
  Subscription invited for Start-up Physics works outlined.

- Recently committed to:
  a) Electroweak Physics group: W,Z and Drell-Yan physics with τ final state.
  b) B-Physics group: measurement of $B_s \to \mu\mu\gamma$
  $\Longrightarrow$ In close touch with respective group and subgroup coordinators.
  Presented preliminary studies in group meetings at CERN.

- Taking part in production of CMS-wide data (MC generation, configuration files)
  https://twiki.cern.ch/twiki/bin/view/CMS/GeneratorProduction2007CMSSW123

- Involved in trigger studies (CMSSWv1-3-0).
  Note Triggers are going to be prioritized by CMS physics programme.

Invisible Higgs

- Invisible decay of higgs is predicted in many scenarios beyond Standard Model.

- CMS plans to search for invisible higgs in 2008, with data corr. to 1 fb^{-1}.
  Can probe upto $\mathcal{B}(H \rightarrow \text{invisible}) = 30\%$ for low Higgs mass.
  Part of Higgs group Work plan charted recently.

- Preparations during 2007 is crucial to analyse data of 2008.
  We are providing specially generated events to production team for processing.

- From LHC initial data, the study for estimation of various background rates will be very important and will be done.

- From previous study, internal note exists.
  QCD background study using ORCA not completed to estimate E_T^{miss} properly.
  Could not be elevated to CMS-Analysis and finally CMS note status.

- Everything has to be done afresh (like all other studies done with ORCA).

τ studies in Electroweak group

- W $\to \tau\,\nu$ and Z $\to \tau\,\tau$ are some of the *reasonably* abundant events at LHC. $\Longrightarrow$ One of the early physics topics: measurement of tau branching ratio of W and Z.

- Also important backgrounds for many searches.
  $\Longrightarrow$ accurate estimation of event rate is crucial and must be done from the beginning of data taking.$\to$ motivation for joining of Standard Model (τ) group.

- Leptonic decays being cleaner may be easier to study, though lower rate.
  We are inetrested in leptonic decays of τ, to be distinguished from $W, Z \to e,\ \mu$ channels and other sources of energetic leptons.

- Newly started activity! Different from τ-id group.

What we have done till now

- 2 small samples of 10000 events each.
  $Z \to \tau\,\tau$, each $\tau \to e\nu_\tau\nu_e$ and $Z \to$ e e, $Z \to \mu\,\mu$.

- gen+simu in CMSSW 120 and digi+reco+analysis in CMSSW 130 going on

- Today's presentation: only generator *preliminary* level study of 4000 events of each sample.
  Pythia generation with CKIN(1)=40 $(\hat{m} \geq 40\,\text{GeV})$

- We would like to study first how we can identify leptons from the decay of tau.
  May be E_T^{miss} in the event will be good criteria.

- Also we have to study trigger efficiency.

Transverse Momentum of the electrons and invariant mass
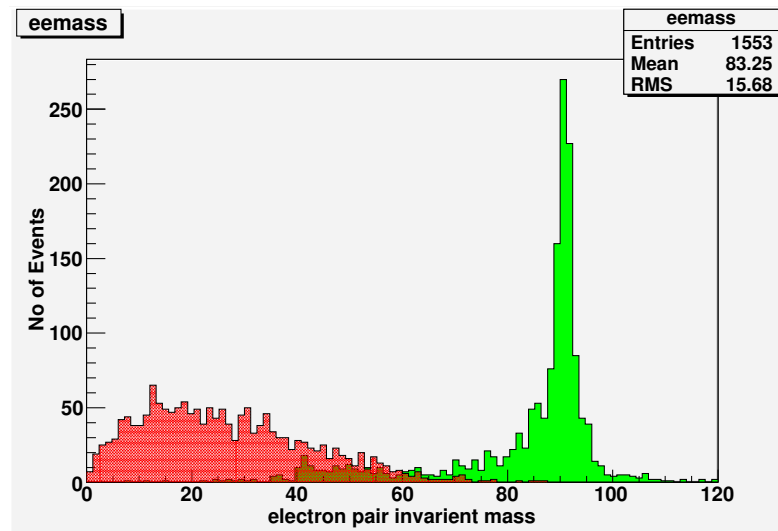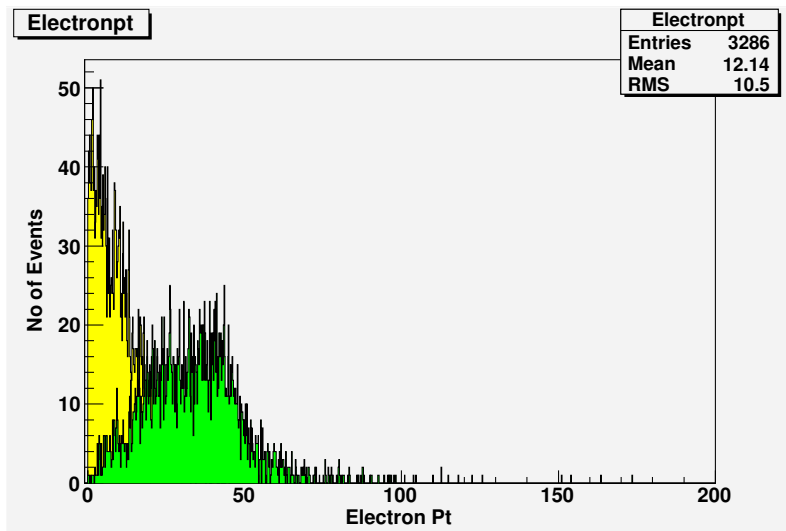

Momentum distribution: Yellow, softer distribution is due to electrons from tau decays, while green, harder spectrum: due to electrons directly from Z.

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

$B_s \to \mu\mu\gamma$ in LHC

- At LHC, the QCD production rate of bottom pair is very high
  $\sigma(b\bar{b}) \sim 500 \, \mu$b, about 10% of the events will have a B_s meson.

- B_s physics is new, very little is explored till now in experiments.
  Note B-factories can't produce B_s, $M_{Bs} = 5.36$ GeV.

- $B_s \to \ell\ell$ decay is loop-driven, hence low branching ratio in Standard Model.
  $\mathcal{B}(B_s \to \mu\mu) \sim 10^{-9}$, $\mathcal{B}(B_s \to ee) \sim 10^{-14}$ (since $m_\mu^2 >> m_e^2$).
  Can be enhanced highly due to *New Physics* $\Longrightarrow$ interesting physics topic with early
  data $\Longrightarrow$ can provide constraint on models!

- $\mathcal{B}(B_s \to \mu\mu\gamma)$ is of **similar** order to $\mathcal{B}(B_s \to \mu\mu)$ in SM since it is not helicity
  suppressed.

- With good identification and measurement capabilities for muons and photon, CMS
  should be able to do well in this channel.
  Comptetitive with LHC-b which is good in b-physics with forward detectors.
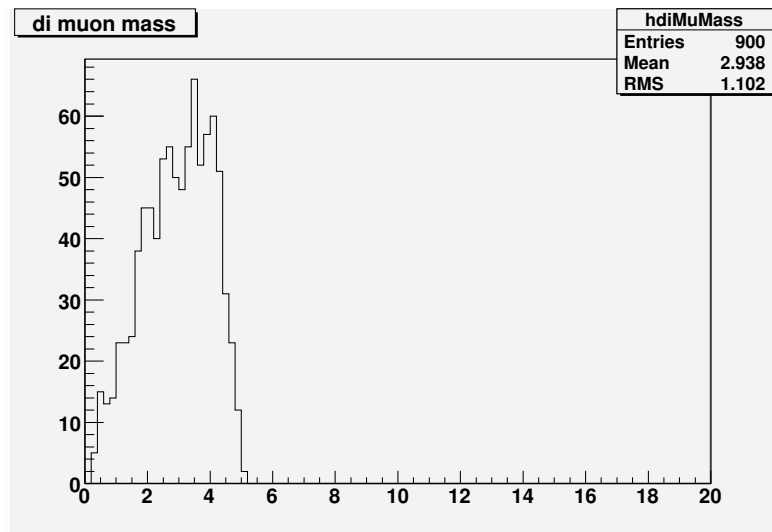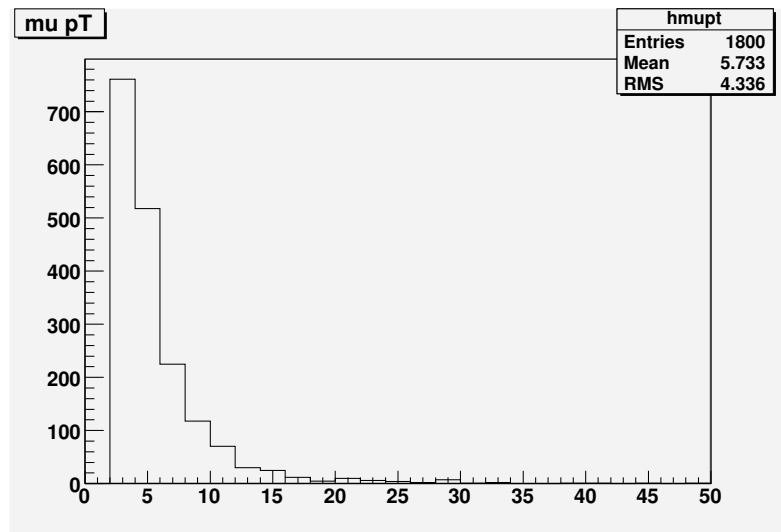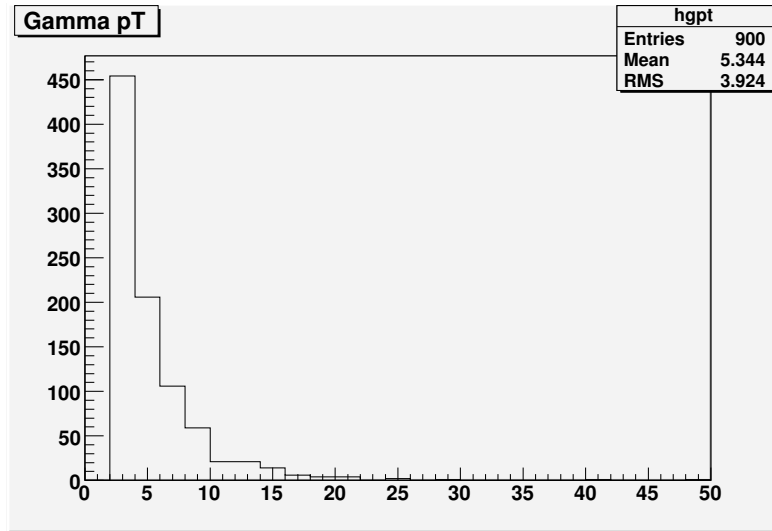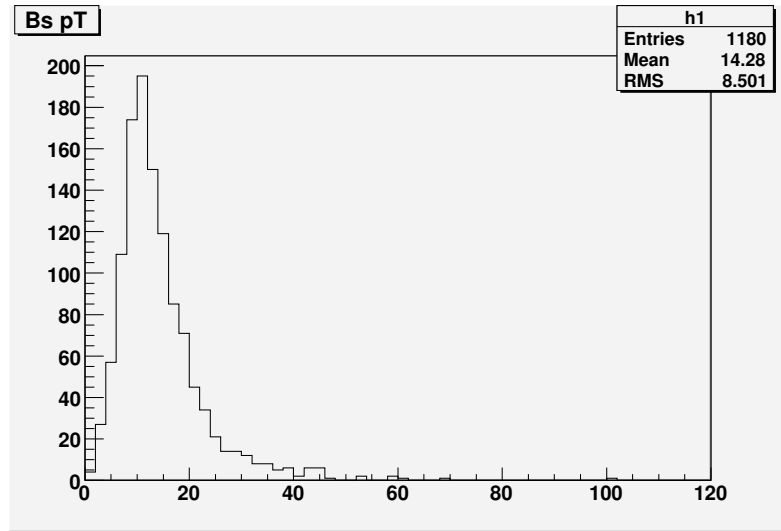
Feynman diagrams
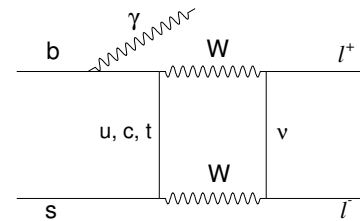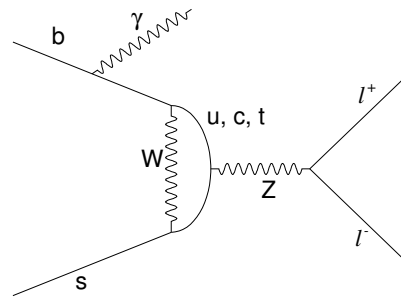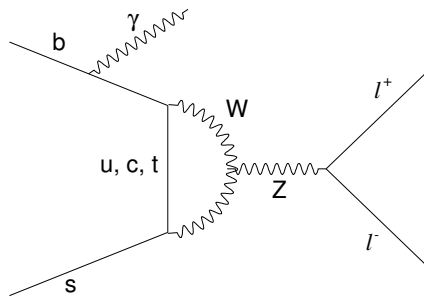
- Event rate in CMS for 1 fb^{-1} data (by 2008): $O(10)$ acc. to SM
  Expect to get more from new physics!

- SUSY particles contribute in the internal lines and increase the total rate.
  (e.g., add $\tilde{\chi}_i^{\pm}$ along $W^{\pm}$ path, h^0, H^0 along Z etc.)

- But current experimental data can be used to interprete the type of New Physics inter-
  action (vector, axial-vextor, pseudoscalar type) allowed for such a channel.
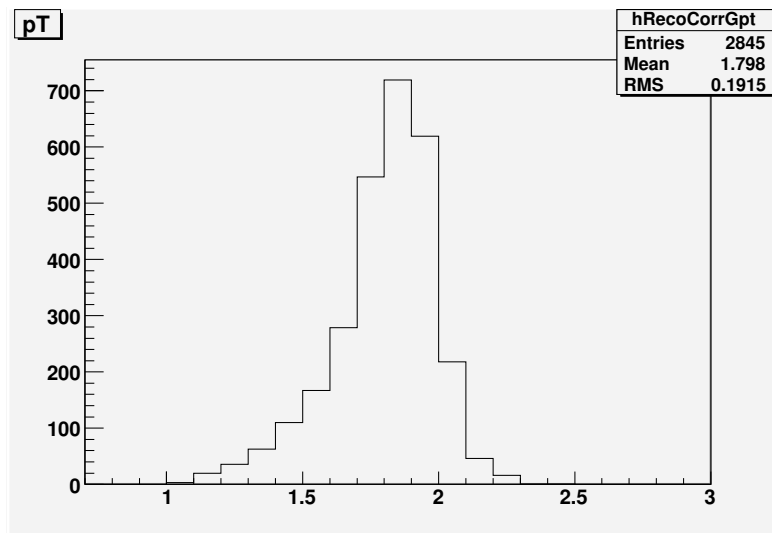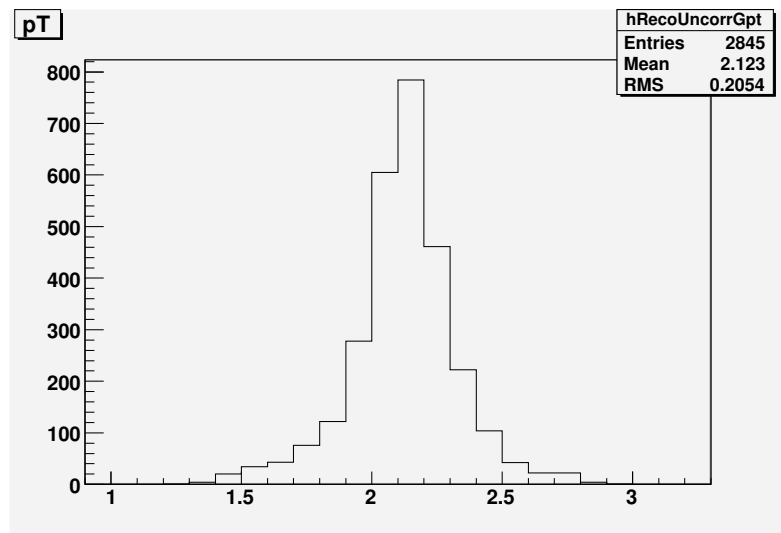
Status of $B_s \rightarrow \mu\mu\gamma$ study

- Pythia does not have many rare decays of B-mesons incorporated in it.

- EvtGen generator can be used, but yet to be incorporated within CMSSW.

- Pythia generation done with MSEL =1 , min. bias, to take care all QCD processes for $b\bar{b}$ generation.

- Modifications to be done by hand in Pythia: useful parameters:
  MDME for phase space, BRAT for branching fraction, KFDP for decay particles, (μ, μ, γ) etc.

- Preliminary generator level study done for fixing preselection to expediate generation of useful events: $p_T^\gamma \geq 2$ GeV, $p_T^\mu \geq 2.5$ GeV, $\eta^\mu \leq 2.5, \ \eta^\gamma \leq 2.7$

- $\implies$ event filter parameters (BsFilter, MuMuFilter, Gamma Filter) in configuration file for generation, given to production team alongwith generation efficiency of $\mathcal{O}(10^{-4})$.

Bs pT

h1	
Entries	1180
Mean	14.28
RMS	8.501

Gamma pT

hgpt	
Entries	900
Mean	5.344
RMS	3.924

mu pT

hmupt	
Entries	1800
Mean	5.733
RMS	4.336

di muon mass

hdiMuMass	
Entries	900
Mean	2.938
RMS	1.102

Low energy Photon simulation in CMS detector

- At present we require the photon to have $p_T \geq 2$ GeV.
  But this may be unrealistic from point of view of identification, reconstruction and background rejection.
  We need to understand the situation thoroughly.

- Detector level study done with low energy photons: how low the transverse momentum of photon, CMS can identify/measure?
  Generation + Simulation with CMSSWv120,
  Reconstruction with CMSSWv130pre5, to be repeated with 130 version.

- 2 data sets of 5000 events each, photon p_T = 1 GeV and 2 GeV. Reconstruction efficiency $\leq 0.5\%$ for 1 GeV and $\sim 60\%$ for 2 GeV photons

- Note, *corrected* photon p_T less than input value.
  Photon experts in CMS $\rightarrow$ correction factor is determined from staudies on photons of $p_T \geq 20$ GeV!
  Have to do something about photon calibration.

pT		hRecoUncorrGpt	
	Entries		2845
	Mean		2.123
	RMS		0.2054

pT		hRecoCorrGpt	
	Entries		2845
	Mean		1.798
	RMS		0.1915

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. (Higgs events requires high p_T triggers)

- Dedicated studies are going on to introduce trigger strategies for specific channels of b-physics.
  eg., Displaced vertex trigger for B_s events (life time $\sim$ 1.5 ps.
  Designed mainly for $B_s \rightarrow \psi\phi$ channel.

- We have to find out if *Displaced vertex trigger* is good enough for our $B_s \rightarrow \mu\mu\gamma$ study.
  Private samples generated for Trigger (higher level) studies with CMSSWv130, going on.

- Results awaited.