Study of timing and time resolution with high energy photons

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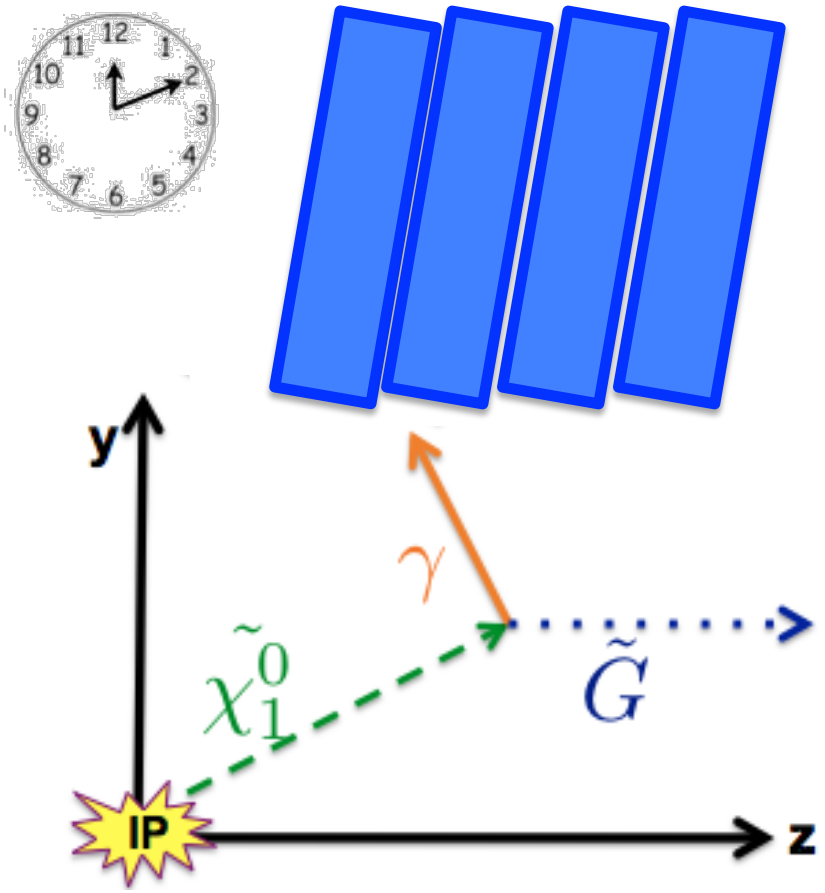
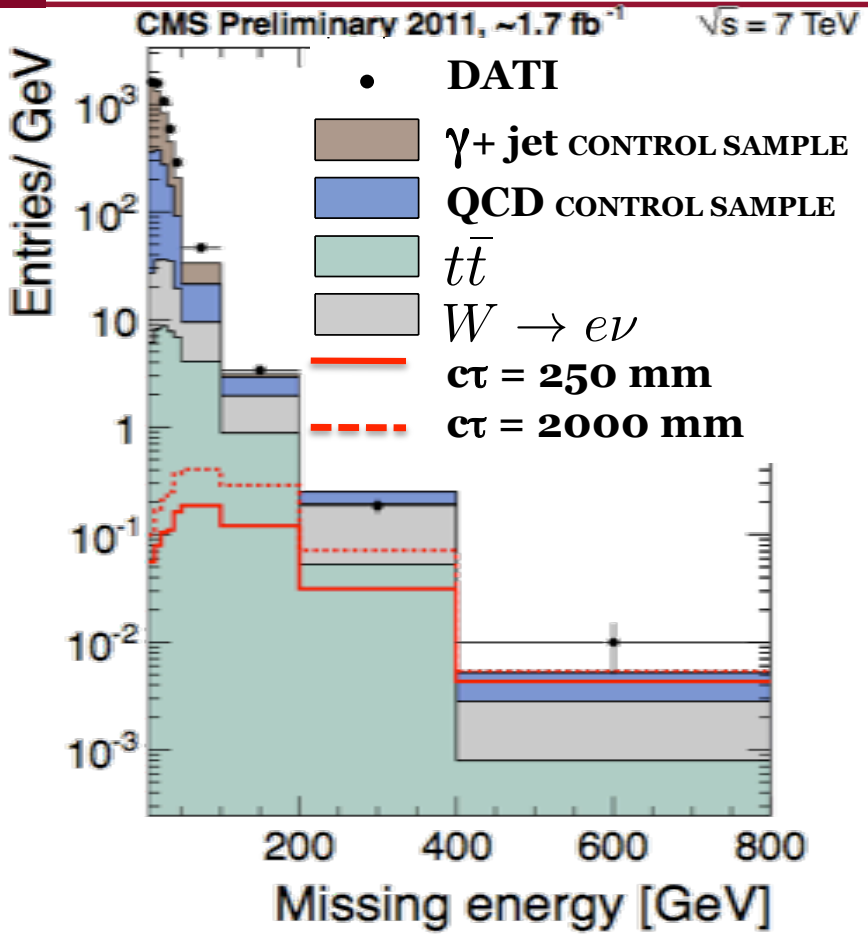
MOTIVATIONS

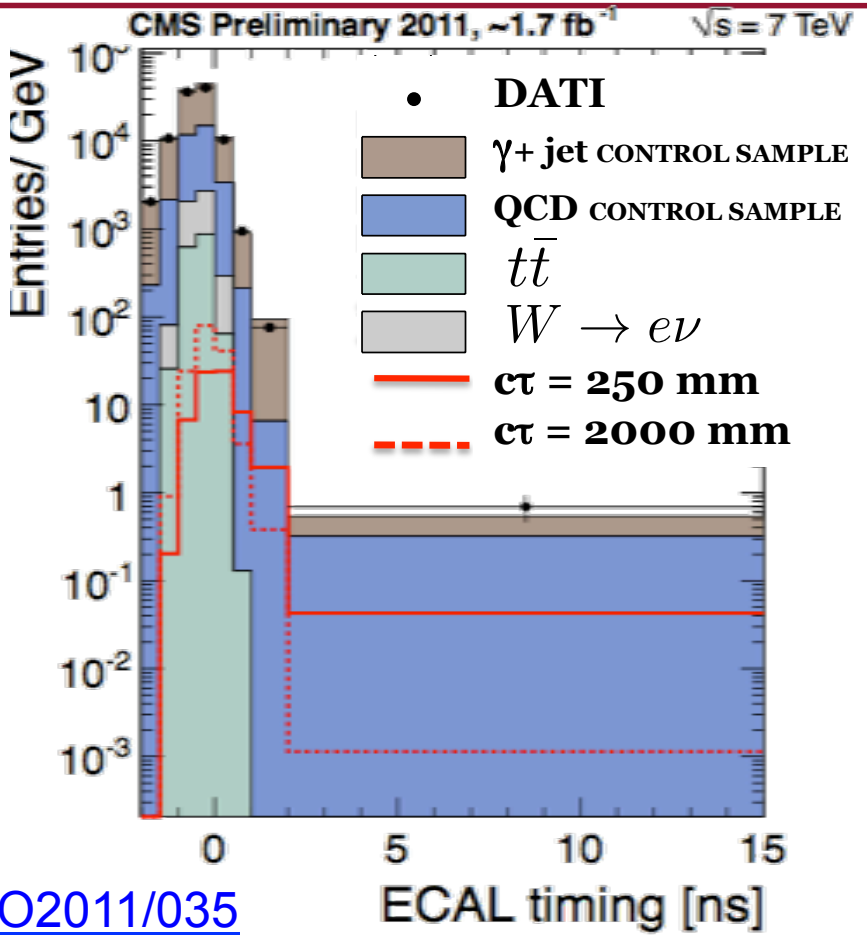
- We are interested in the study of displaced photons produced from the decay of long-lived neutral particles (eg. neutralino)
- An excellent time resolution is needed in order to identify out of time photons.
- Also important for background rejection (beam halo, cosmic rays, out of time interactions, …)



$c\tau$ = 1,100,1000 mm

GMSB ANALYSIS





EXO2011/035

- Perform a Likelihood fit to MET and ECAL time distributions to extract signal yield and put UL on GMSB xsection.
- Need to obtain a reasonable value for ECAL timing systematics at high energy (P_T (γ)〉100 GeV) and to remove timing offset

ANALYSIS STRATEGY

- Compute of photon time using recHits in the supercluster
- Aim at improving the time resolution, and correct the offset using average time of the event
- Study time resolution as a function of energy (E1), η and #recHits used in average time calculation
  - Use a MC GMSB signal with zero lifetime for neutralino as a clean sample of MC events with one prompt isolated and energetic photon
  - Compare with a γ + jets control sample of data from run2011A

DATASET AND SELECTION

- **DATA:**
  - Photon/Run2011A-May10ReReco-v1-AOD
  - Photon/Run2011A-PromptReco-v4-AOD
  - Photon/Run2011A-05Aug2011-v1-AOD
  - Photon/Run2011A-PromptReco-v6-AOD

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- **MC:** GMSB/Lambda-100_CTau-1_7TeV_pythia6_cff-Summer11-PU_S4_START42_V11-v1-AODSIM-

Trigger used:

HLT_Photon75_CaloIdVL_IsoL_v* (run〈165121)

HLT_Photon90_CaloIdVL_IsoL_v* (run〉165121)

EB-16 TT32 with timing problems excluded.

Photon ID details:

Criteria	Requirement (tight)
$\|\eta\|$	< 1.4
$P_T(\gamma)$	> 100 GeV
Good Vertex	vndof $\geq 4, d_0 < 2, \|z\| < 24$
Halo Veto	CSC Tight
S_{Minor}	$0.15 < S_{Minor} < 0.3$
ECAL time	> -2.0 ns
HCAL Iso	$\sum$HCAL/E $(\gamma) < 0.05$ and $\sum$HCAL < 2.4 GeV
ECAL Iso	$\sum$ECAL/E $(\gamma) < 0.05$ and $\sum$ECAL < 2.4 GeV
TRK Iso	$\sum P_T/P_T(\gamma) < 0.1$

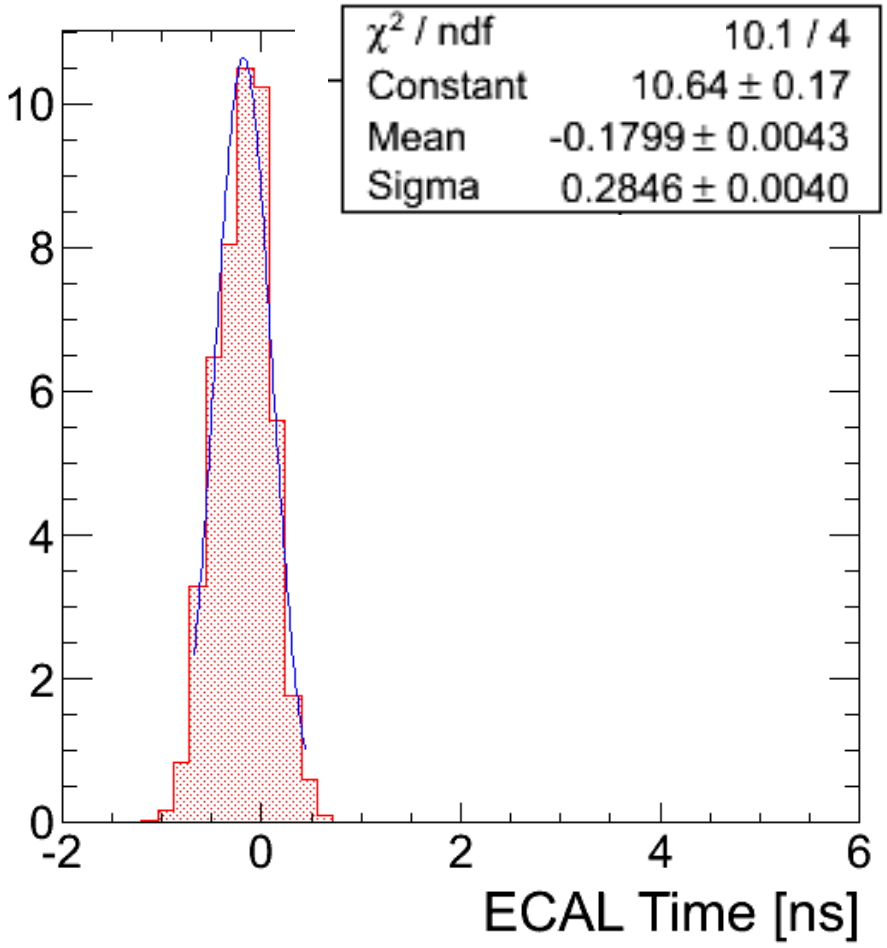
PHOTON TIME IN ECAL

Weighted ECAL Time

$$T_{PhotReco} = \frac{\sum \frac{T_i}{\sigma_i^2}}{\sum \frac{1}{\sigma_i^2}}$$

$$i = 0, ..., nXtal$$

- The sum is over all the crystals belonging to the photon cluster
- E(xtal)〉1GeV



- uncertainty on recHit time measurement depends on energy
- estimated by the equation obtained at test beam (CMS PAPER CFT-09-006)

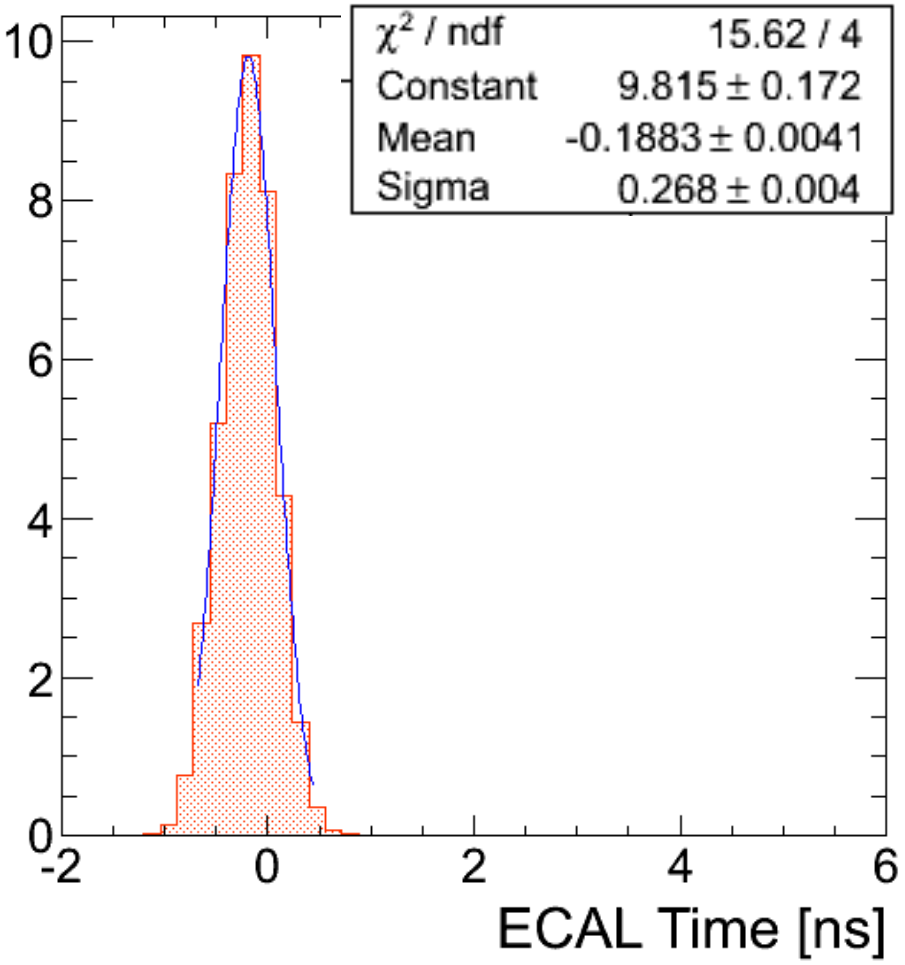
AVERAGE EVENT TIME

Weighted Mean Time

$$T_{MEAN} = \frac{\sum \frac{T_i}{\sigma_i^2}}{\sum \frac{1}{\sigma_i^2}}$$

$$i = 0, \ldots, nXtal$$

- exclude 2 most energetic isolated photons (signal photons)
- E(xtal)〉1GeV



- uncertainty on recHit time measurement depends on energy
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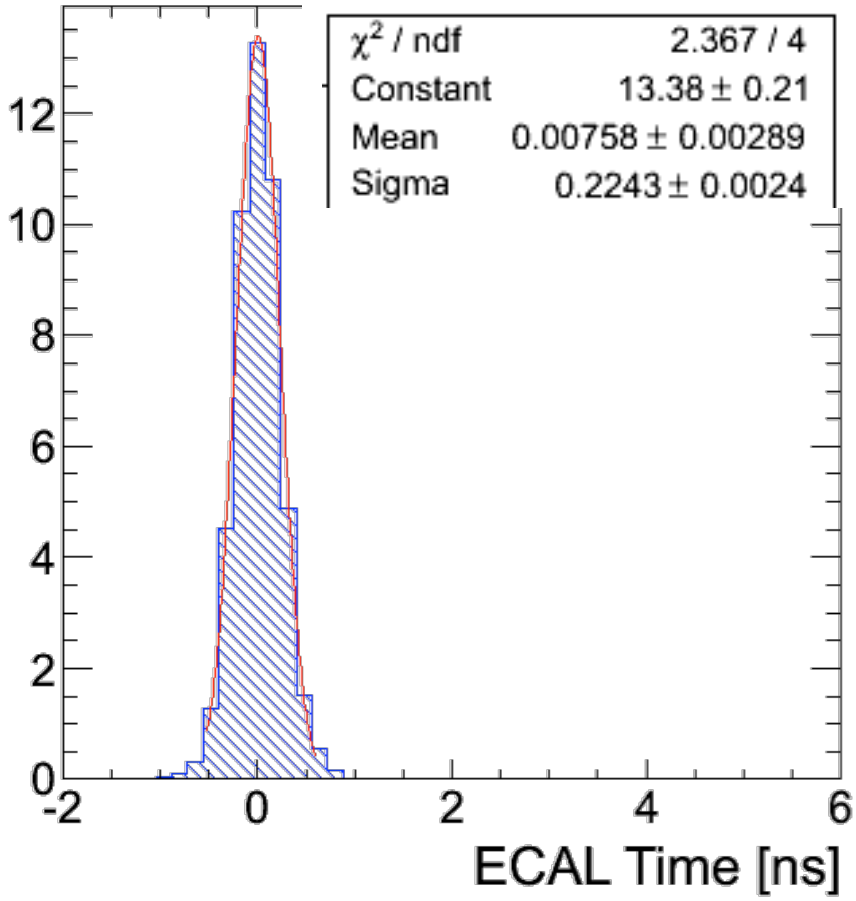
PHOTON TIME AFTER SUBTRACTION

$$T_{phot} = T_{coll} + T_{phot}^{int}$$

$$T_{MEAN} = T_{coll} + T_{MEAN}^{int}$$

$$\Rightarrow \quad T_{phot}^{new} = T_{phot}^{int} - T_{MEAN}^{int}$$

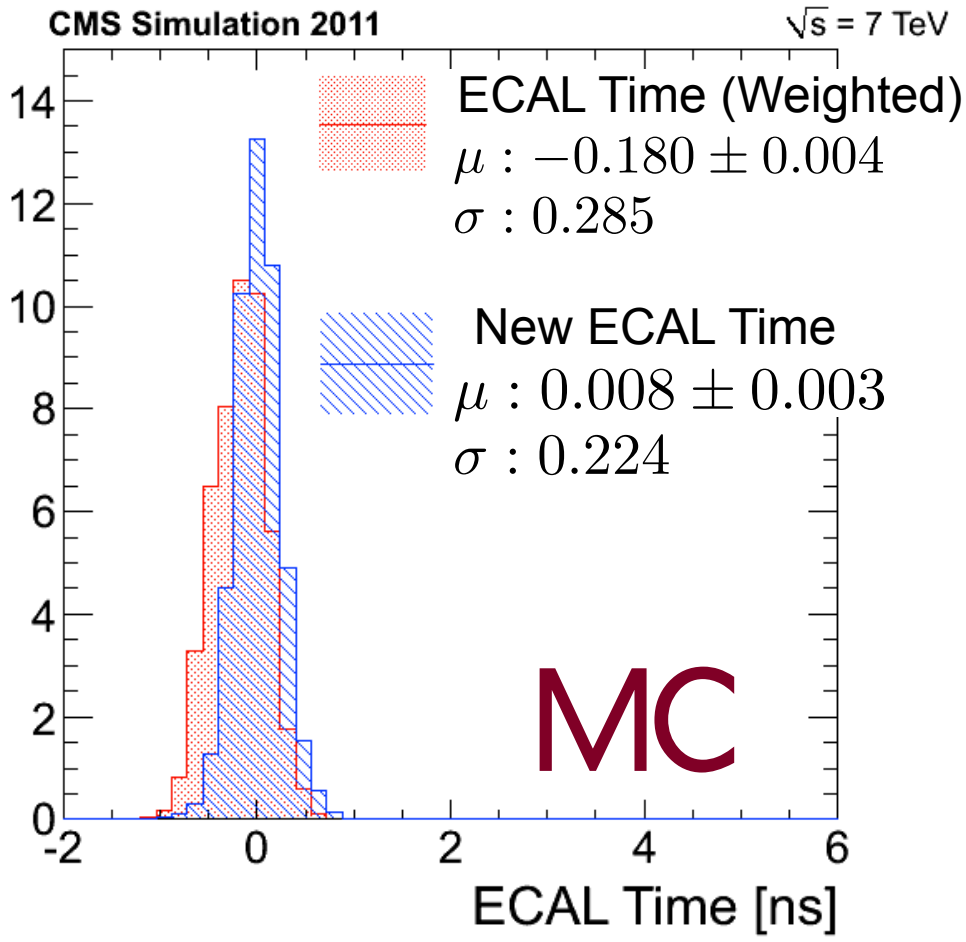
$$\sigma_{phot}^{new} = \sqrt{(\sigma_{phot}^{int})^2 + (\sigma_{MEAN}^{int})^2} \simeq \sigma_{MEAN}^{int}$$

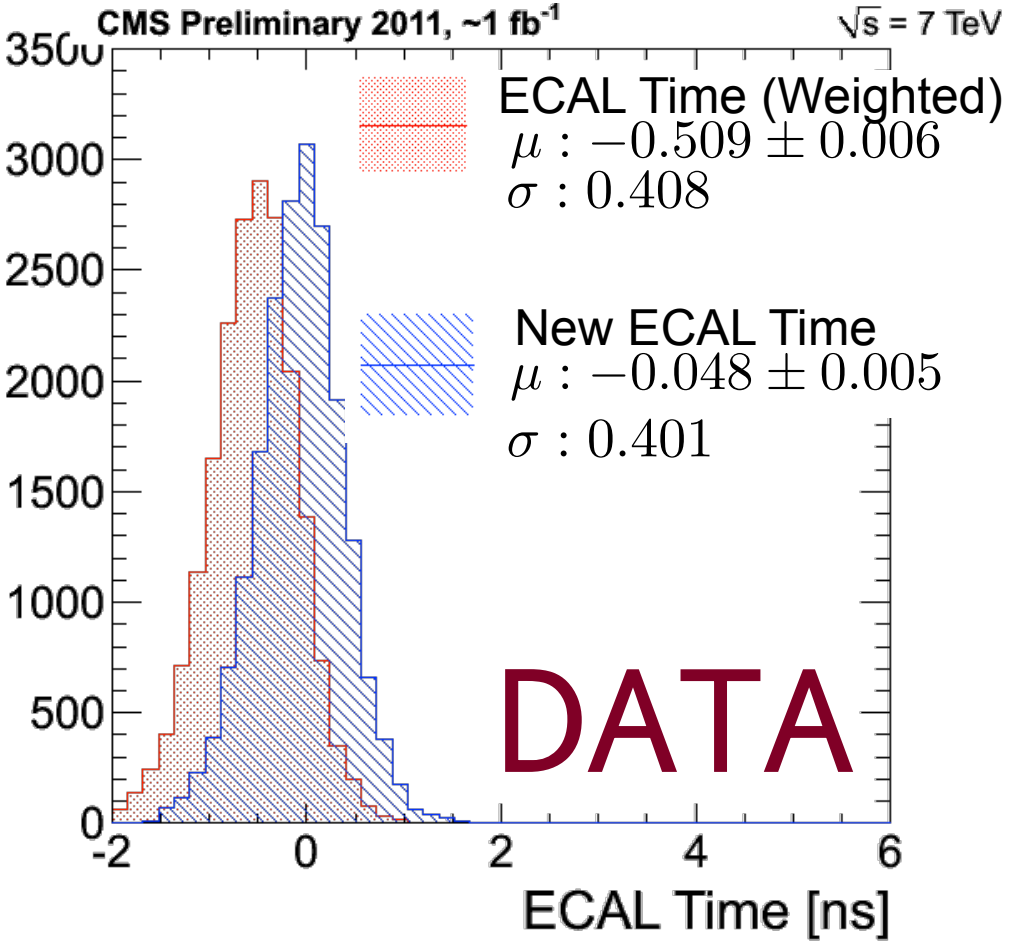


- T_{coll} is different event by event: we don't know precisely where and when parton-parton collisions occur during bunch-crossings

- In this way we can reduce the uncertainty due to the position of the beam-spot and the time of interaction

CORRECTED PHOTON TIME

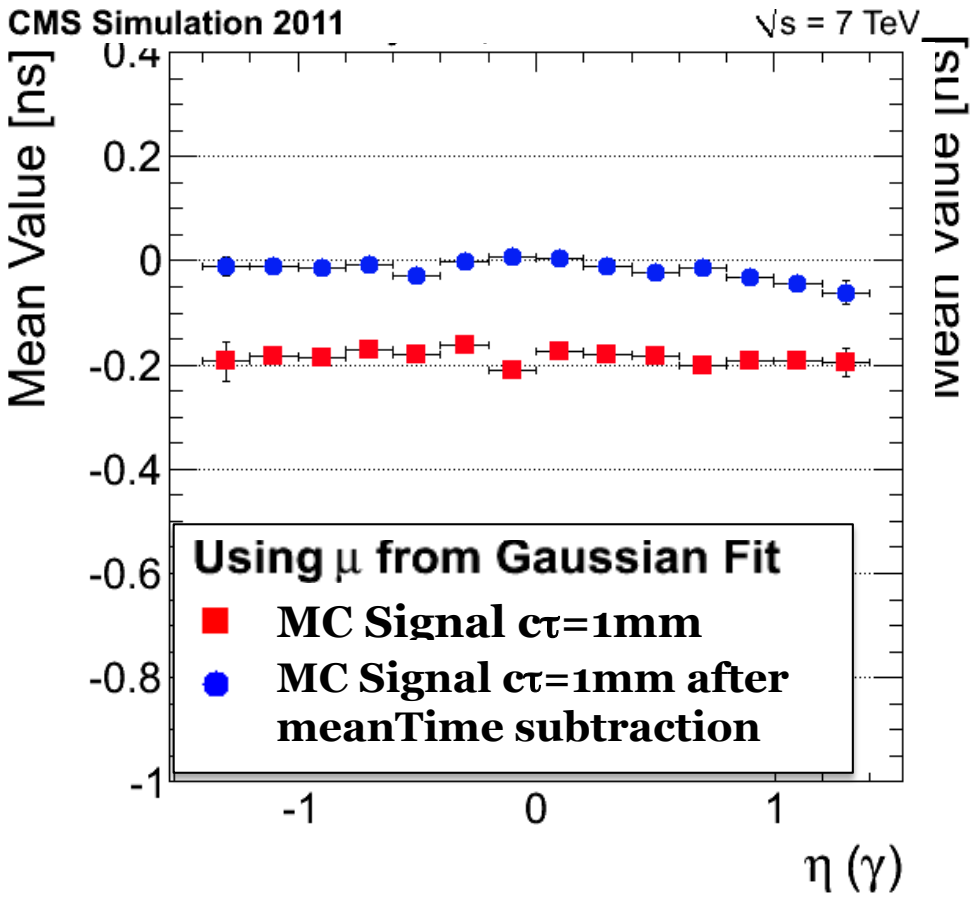




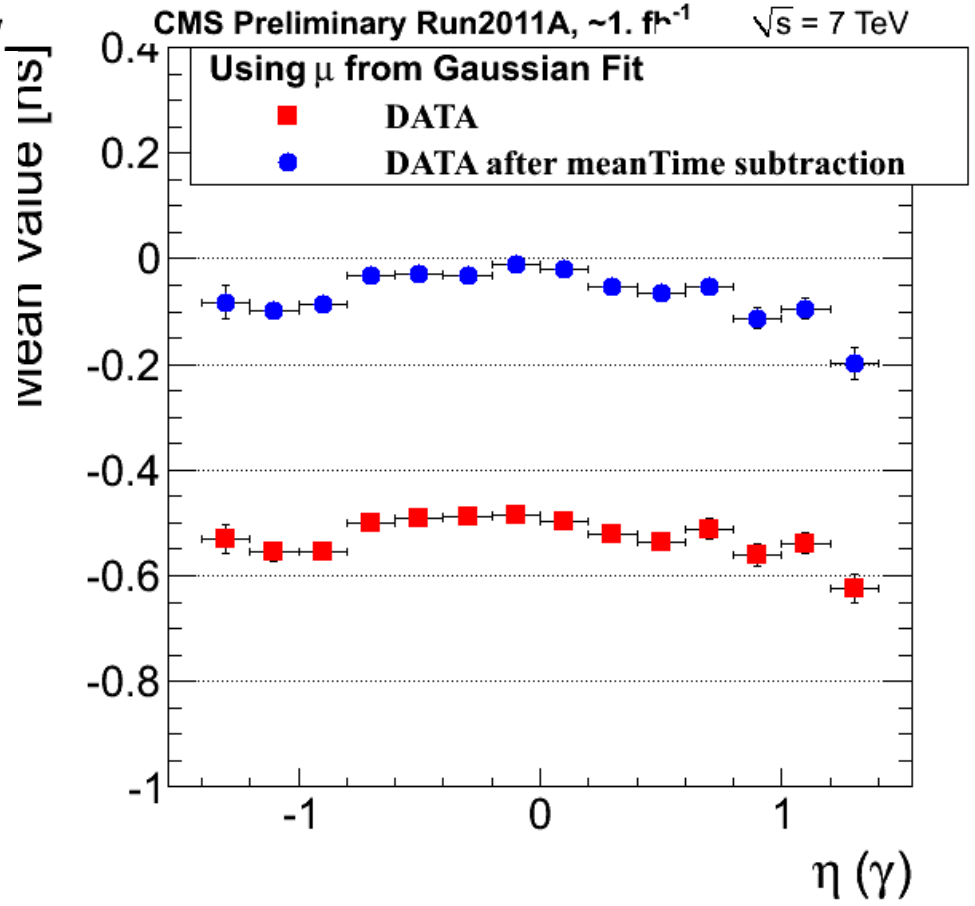
- Resolution improvement by 20% in MC. No improvement in data
- Offset moves to zero in MC and data

OFFSET VS η

MC

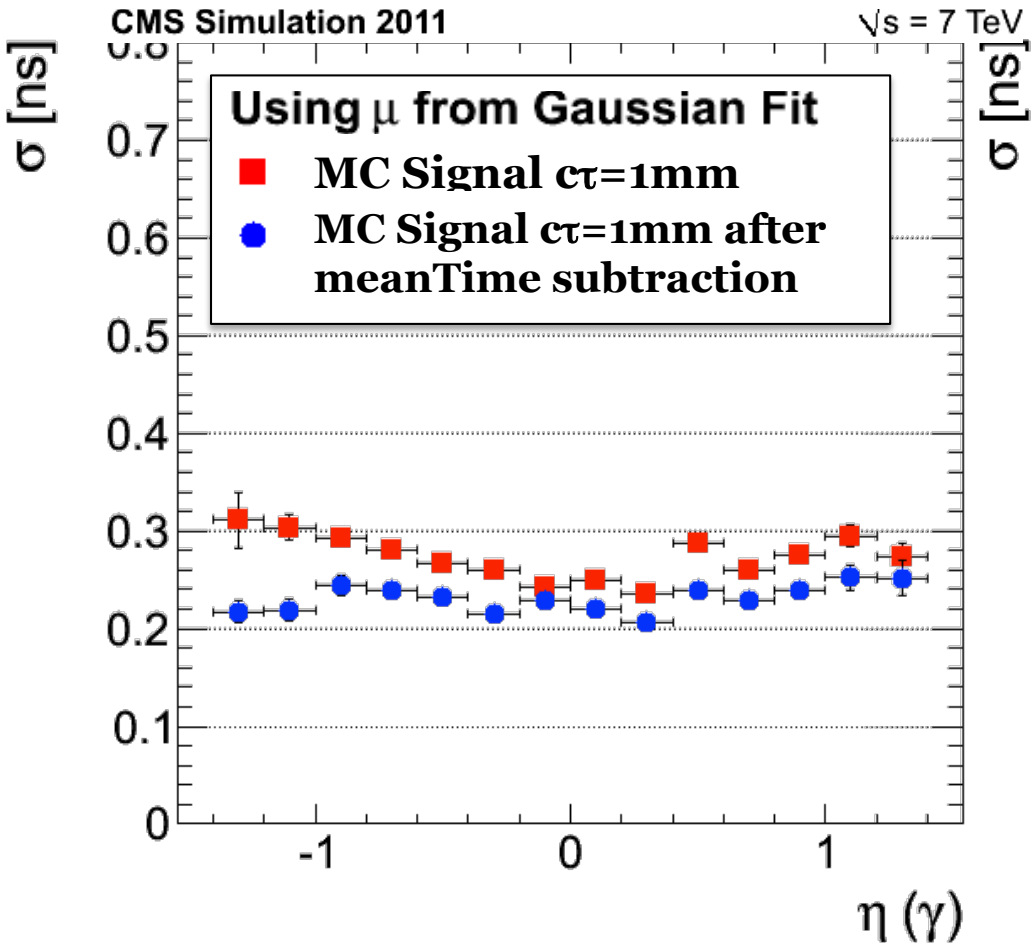


DATA



RESOLUTION vs η

MC



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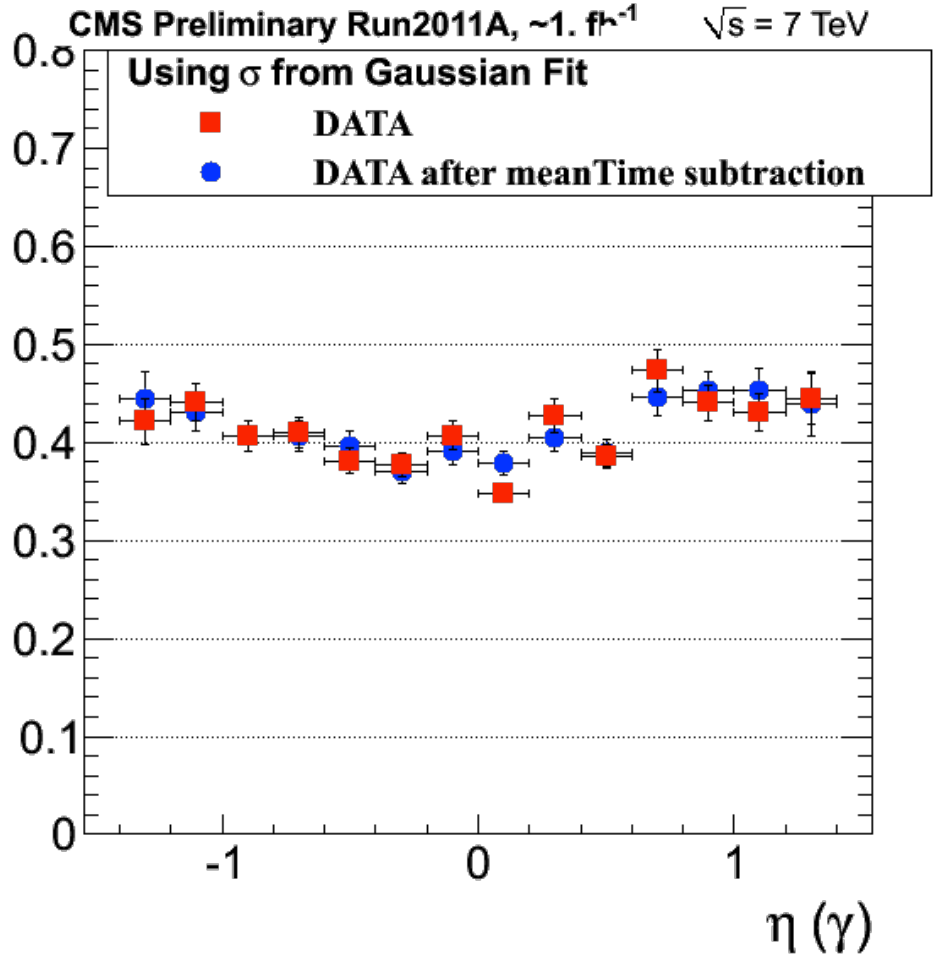
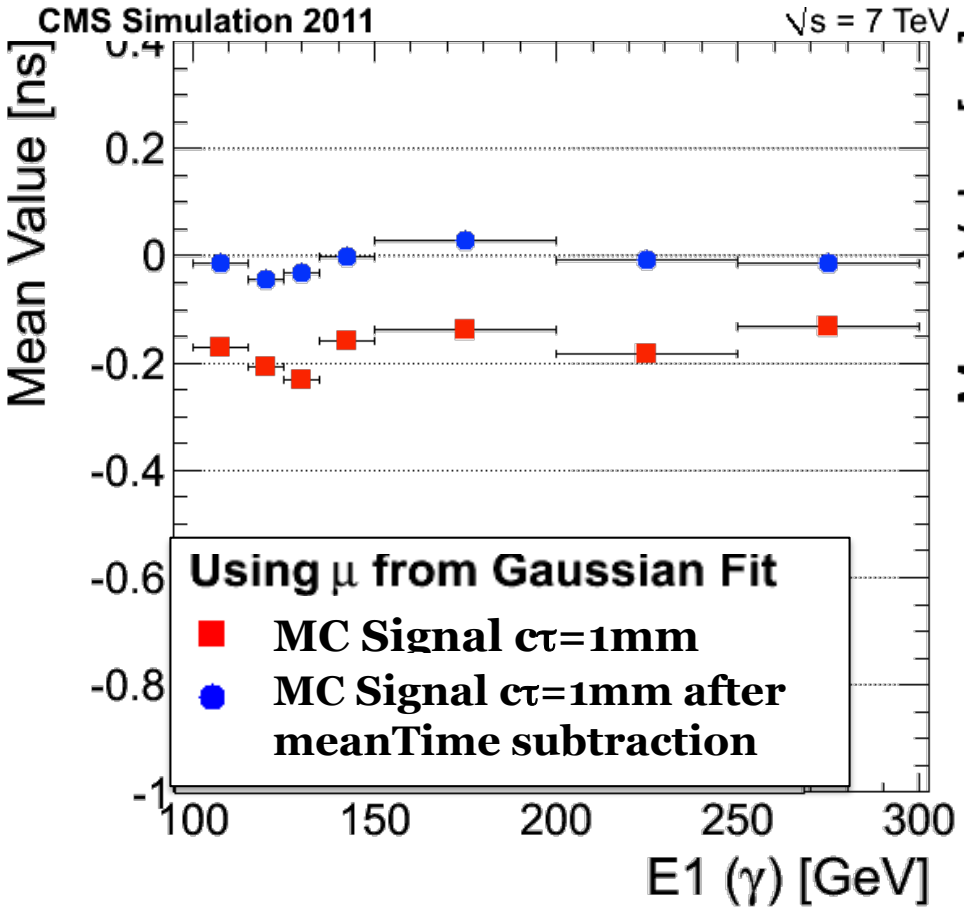
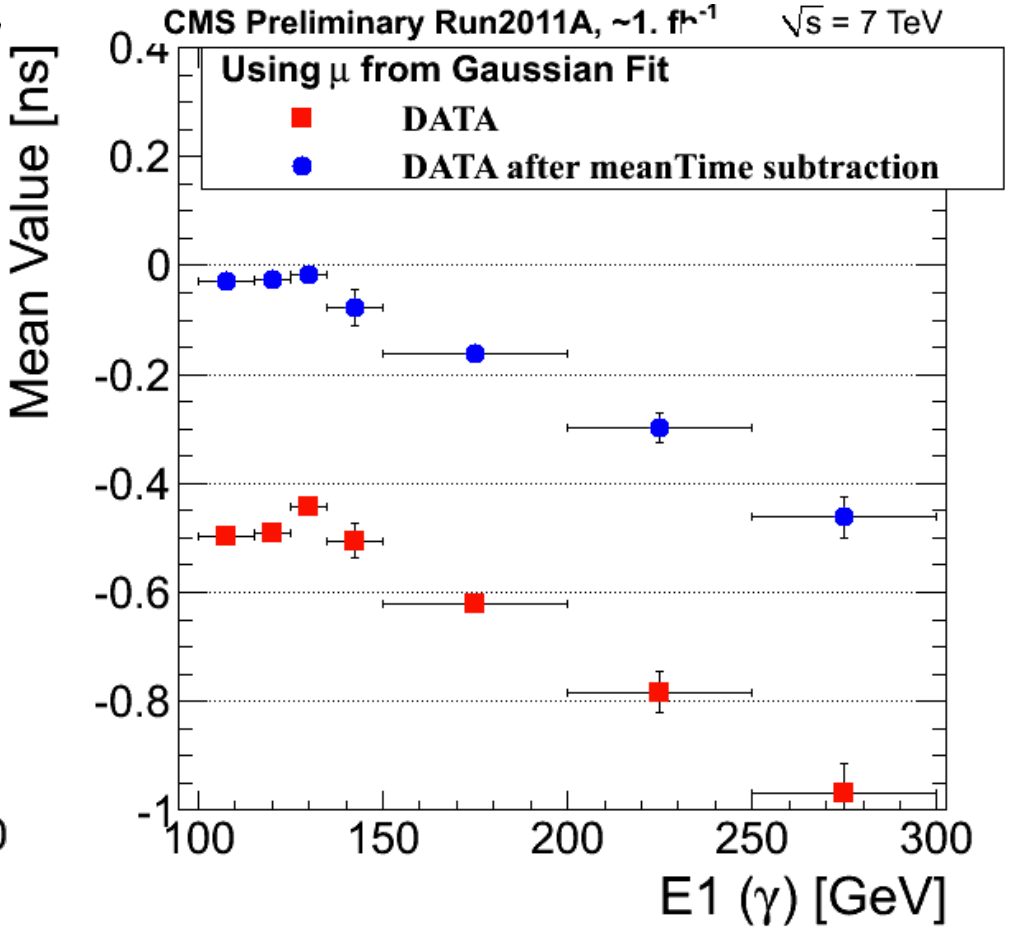


OFF SET vs E

MC

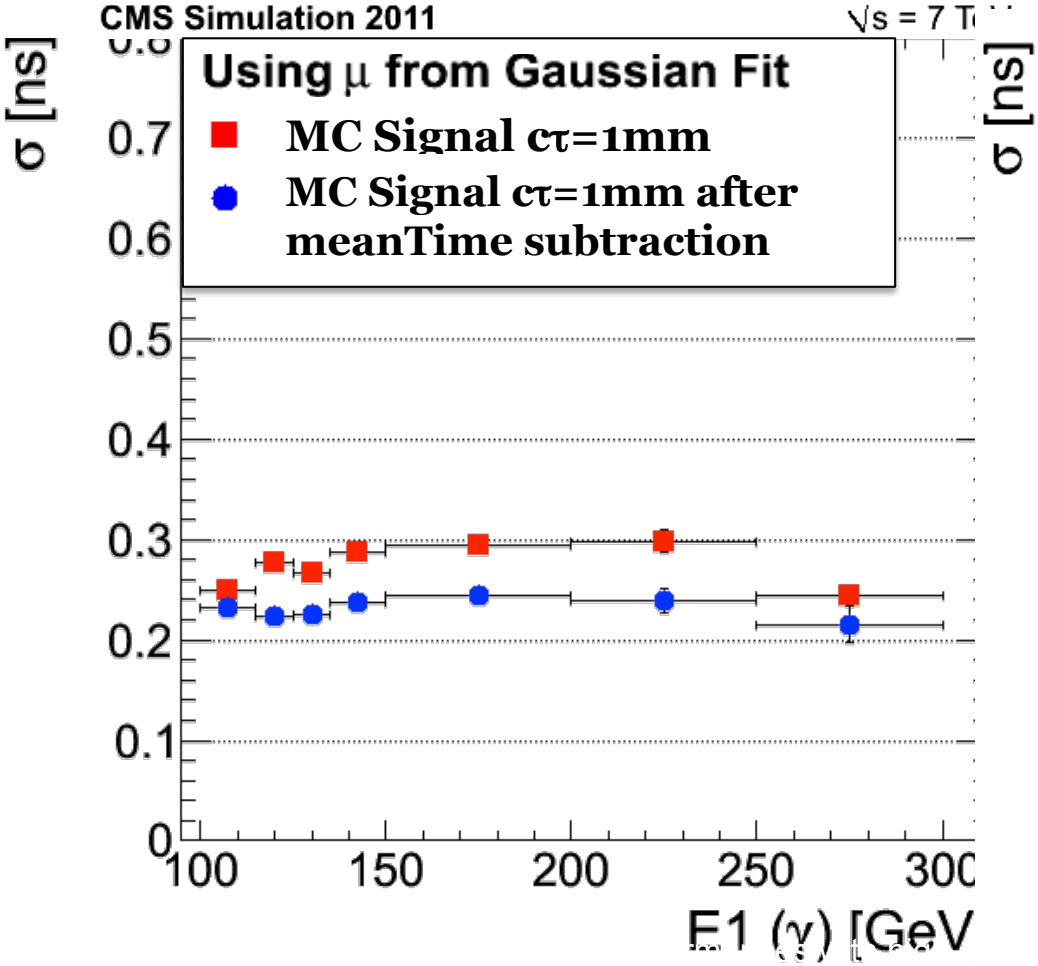


DATA



RESOLUTION vs E

MC



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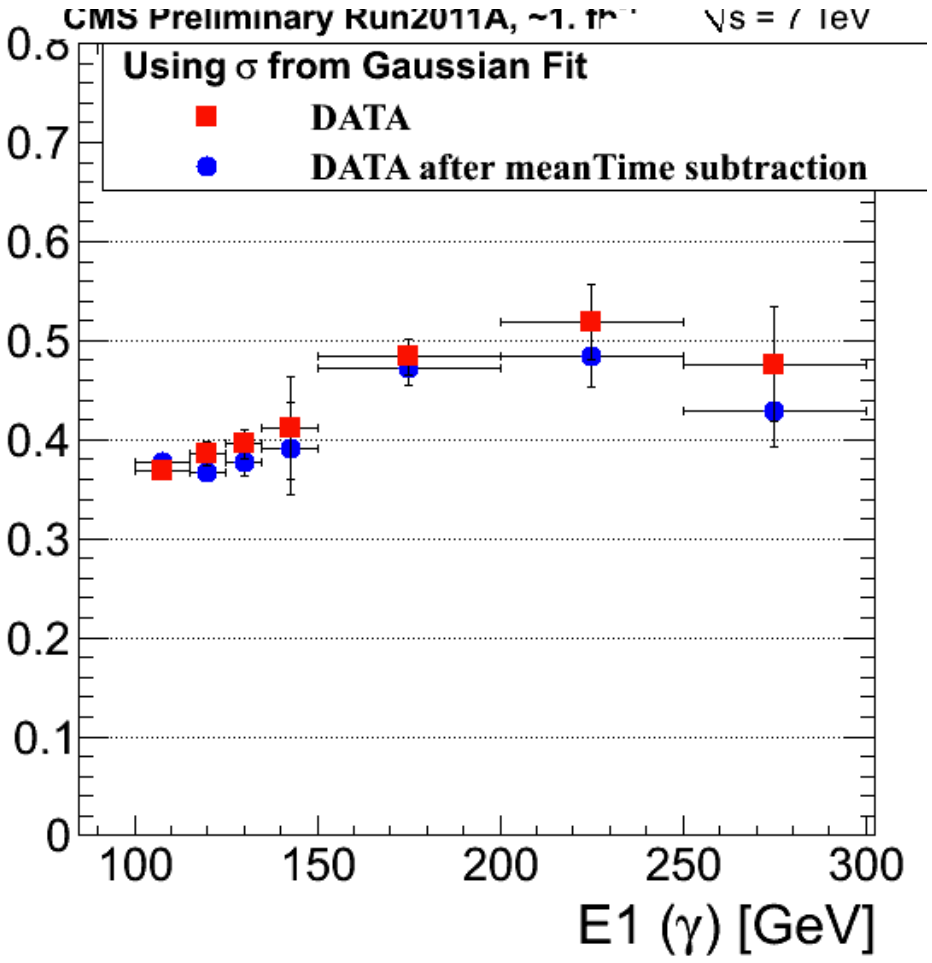
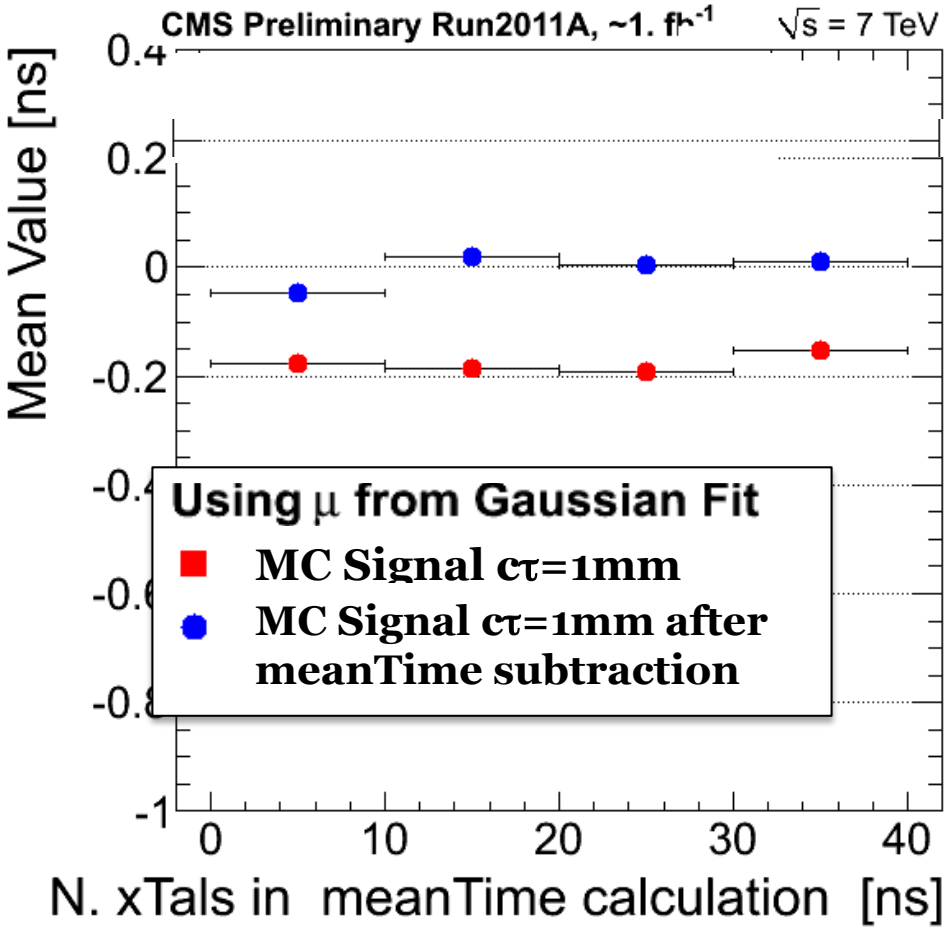


OFF SET vs #RECHITS

MC



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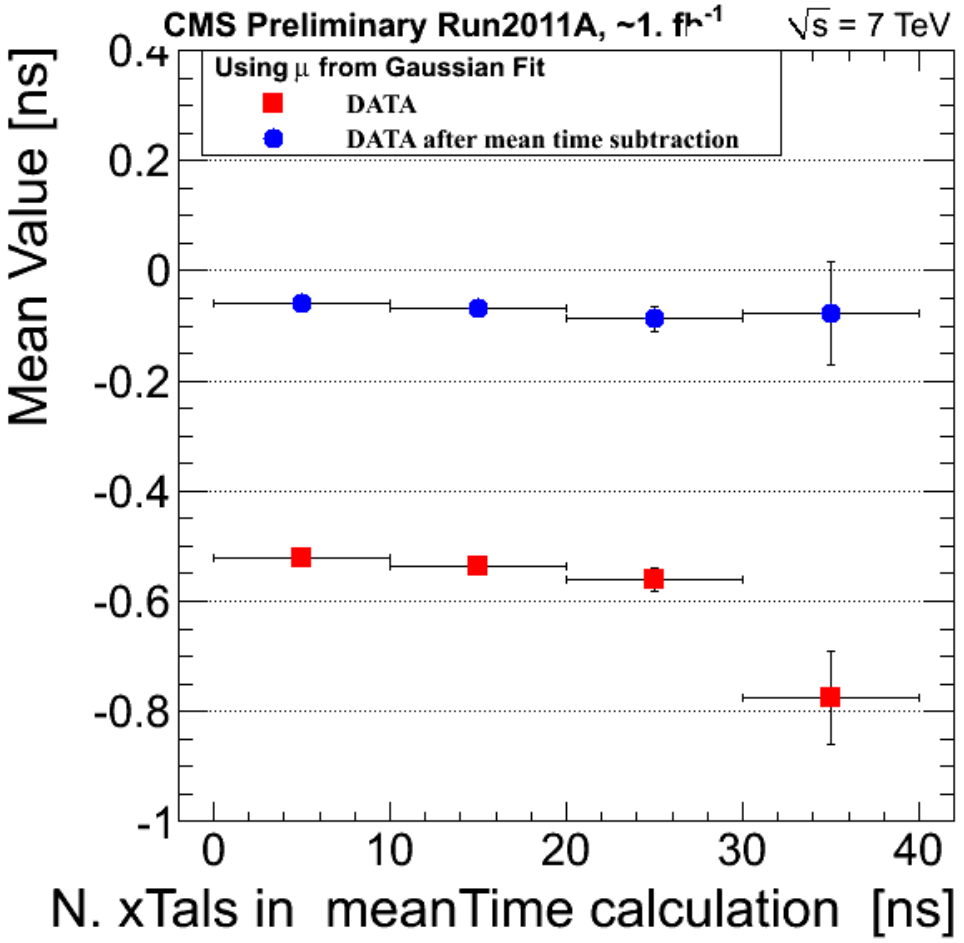
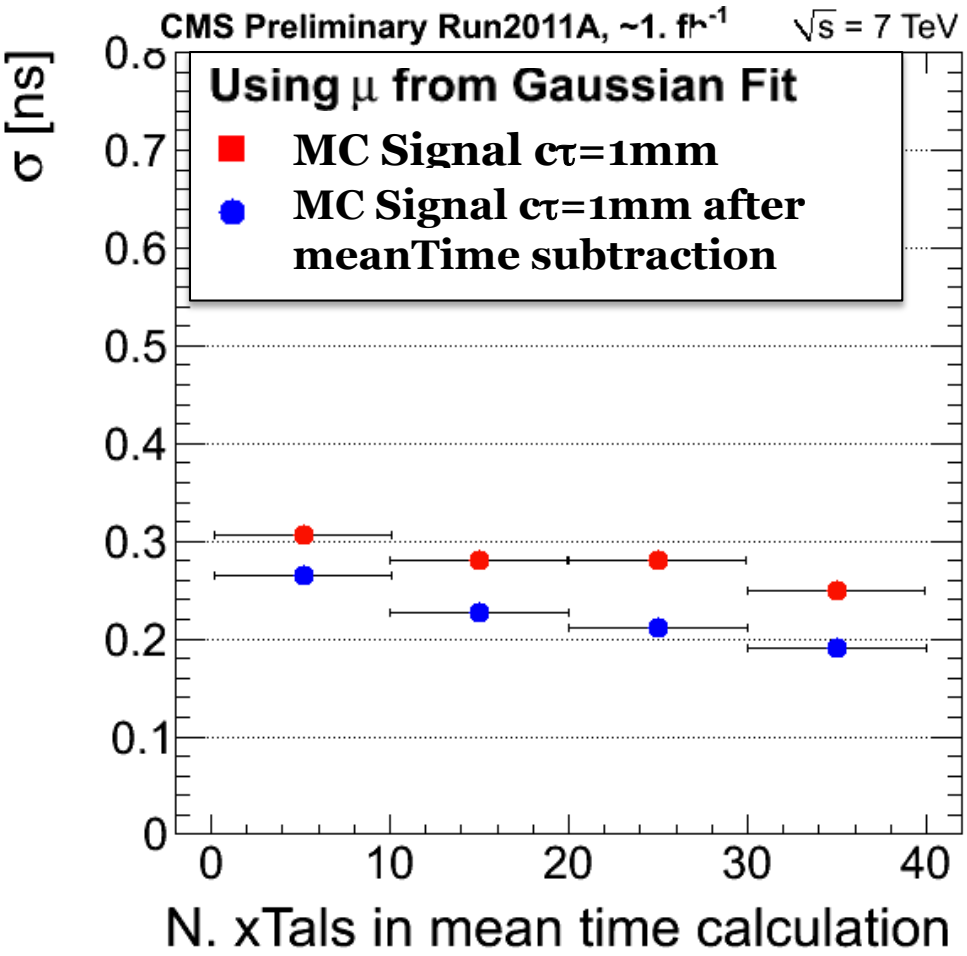


RESOLUTION VS #RECHITS

MC



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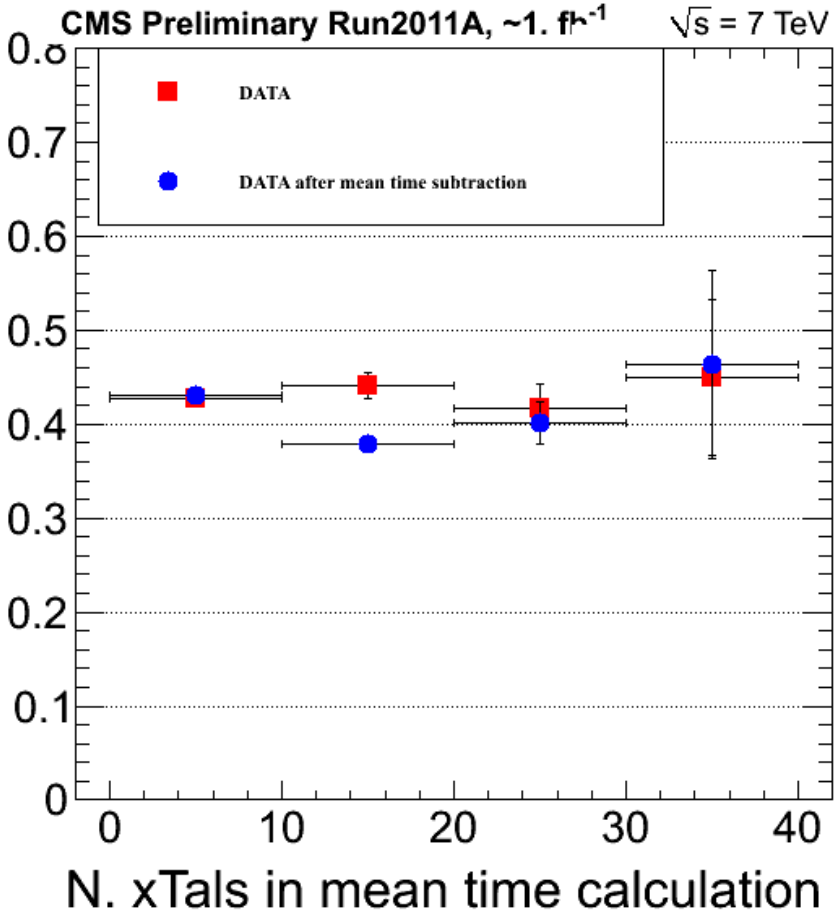
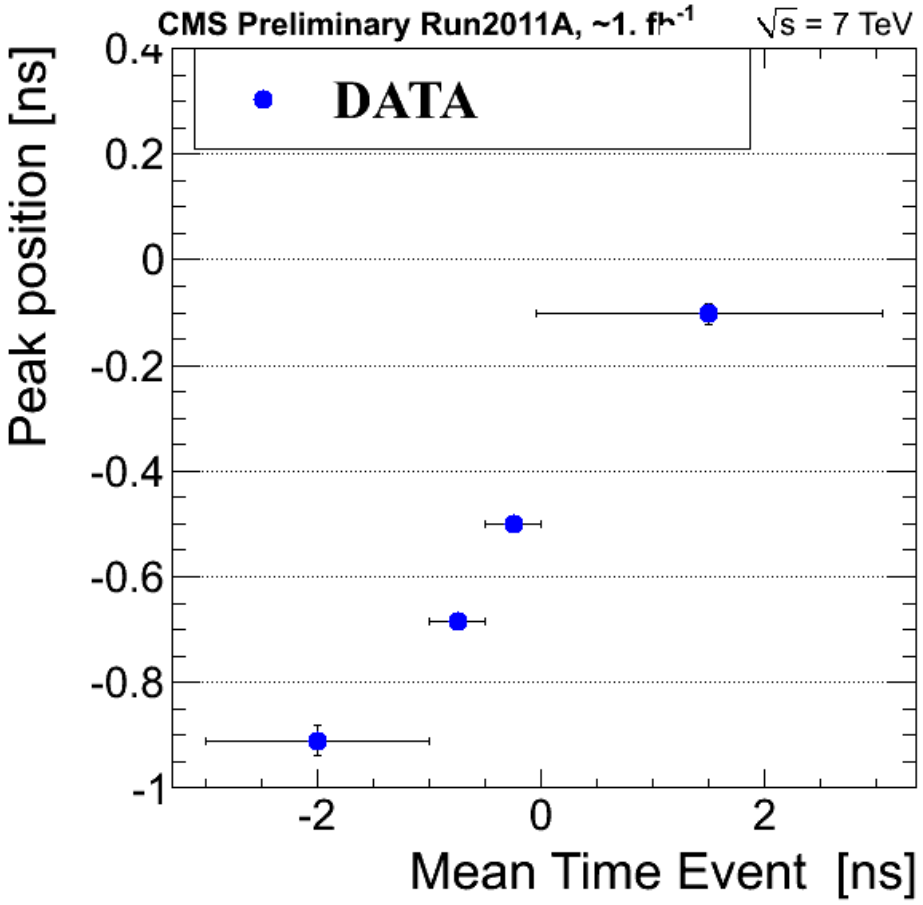
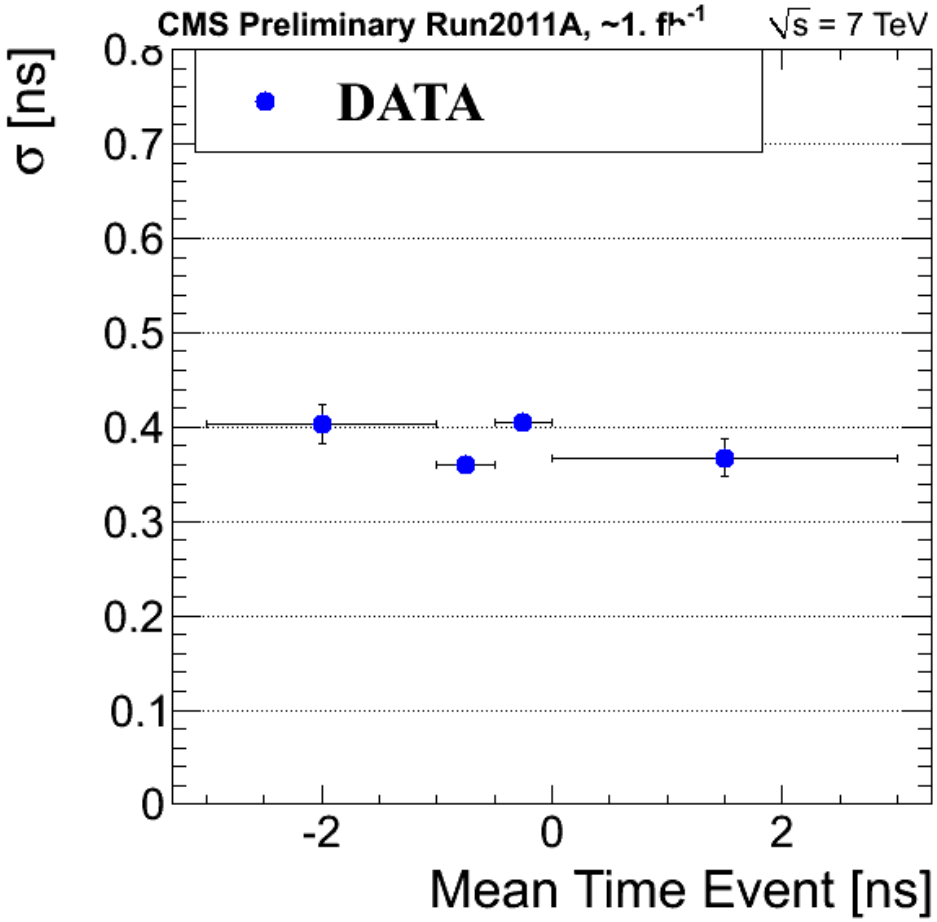


ECAL Time vs Average Event Time





- Offset and resolution of ECAL Time, no correction applied
- No significant deviation between in and out time objects

CONCLUSIONS

- Use of average event time to remove offset and improve resolution in photon time calculation

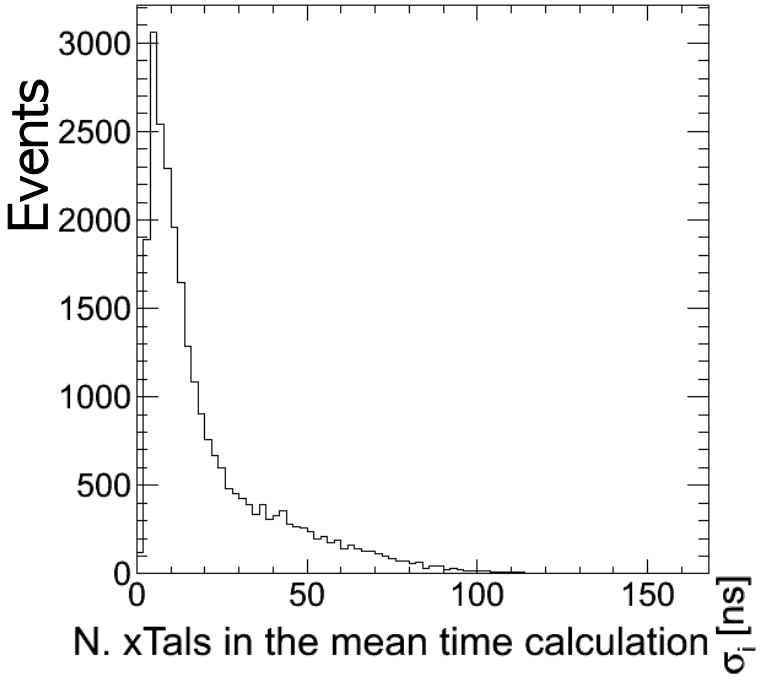
- Method works as expected on MC:
  - offset of new time distribution moves to zero (also in data)
  - flatter trend vs E, #recHits and η
  - 20% improvement in MC resolution

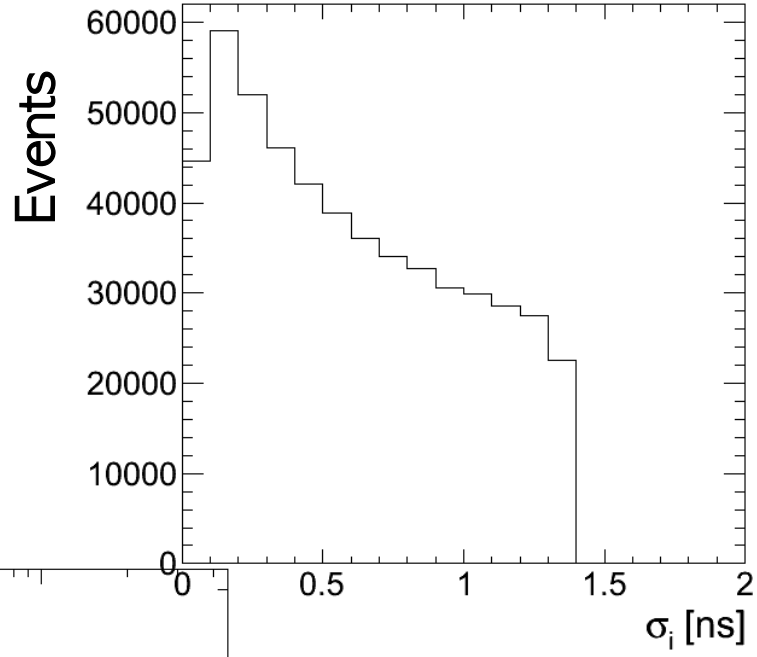
- Open issues:
  - On data we don't observe any improvements. We need to investigated if is due to intercalibration effects or other reasons

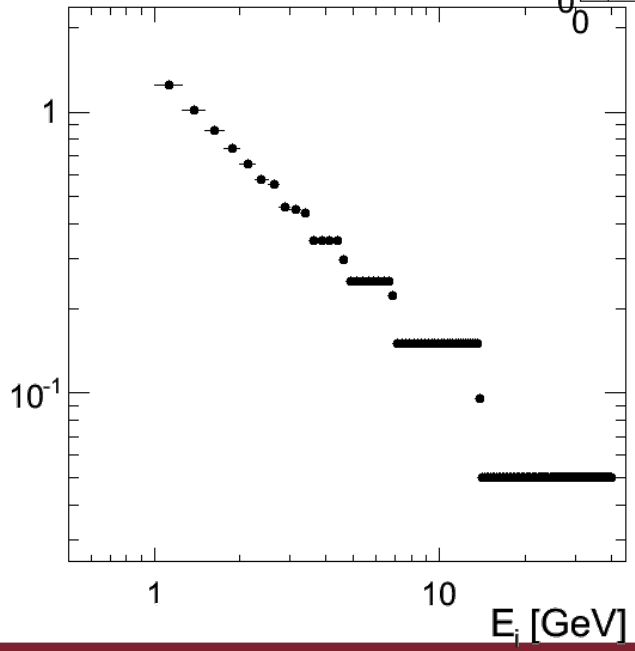
  - Can we assume, say, 0.5 ns systematic uncertainty for the time resolution on data, to use in our GMSB analysis?

BACKUP

MEAN TIME CALCULATION







$$\sigma_i = \frac{N\sigma_n}{E_i[GeV]} \;:$$

$$= \frac{35.1[ns] \times 0.042[GeV]}{E_i[GeV]}$$

γ + JETS CONTROL SAMPLE

- One photon passes the selection described
- Less than three jets
- The most energetic jet (jet1) is back to back with respect to the photon
- $0.7 < p_T^{jet1} / p_T^{\gamma} < 1.3$
- $p_T^{jet2} / p_T^{\gamma} < 0.1$

$\sqrt{s} = 7$ TeV