Progress report

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Calibration with two-photon lepton pairs

Yanwen LIU:

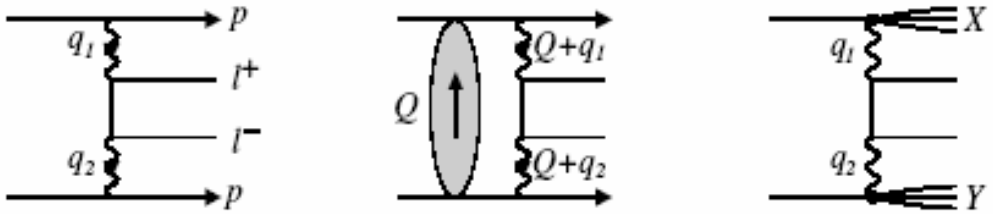
- Dimuon events studied in ORCA, including trigger effects/efficiency
- Resolutions and main background were studied
- A note in writing…

Longer term plans: study low p_T reconstruction, and a HLT trigger (p_T > 3GeV?)

Introduction : $pp \longrightarrow pe^+e^-p$

- QED process (a) production σ precisely known.

event generator LPAIR based on ME by Vermaseren



(a) (b) (c)

- Hadronic corrections [(b) (c)] small. Can suppress with experimental cuts and subtract by fitting final state kinematics.

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- Production rate considerable,

e.g. $\sigma_{(P_T>2\,\mathrm{GeV})} = 0.129\ \mathrm{nb} \pm 0.234\ \mathrm{pb}$.

CMS week, March 18, 20

A sample of 5000 $\gamma\gamma \to \mu^+\mu^-$ events with a cut of each muon $p_T > 3$ GeV are generated. With this p_T threshold, the cross section is 47.8 pb.

Out of the 5000 events, there are 631 of them having both muons identified by the reconstruction. We use the 10000 muons in the sample to estimate the muon reconstruction efficiency: for each muon that having $|\eta| < 2.5$,

The reconstruction efficiency is about 60% at 5 GeV, and reaches a plateau of $\sim 90\%$ at 7 GeV.
muons having p_T above 5 GeV. The efficiency is low in the barrel region where the closest muon station is about
With a magnetic field 4 T, soft muons have little chance to reach the muon detector [2]. The higher p_T cut does increase significantly the efficiency in the central region.

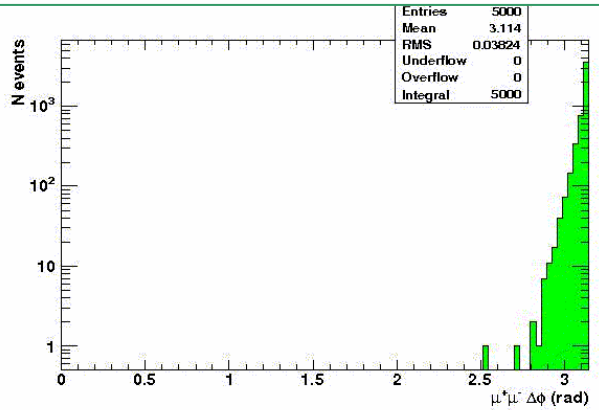
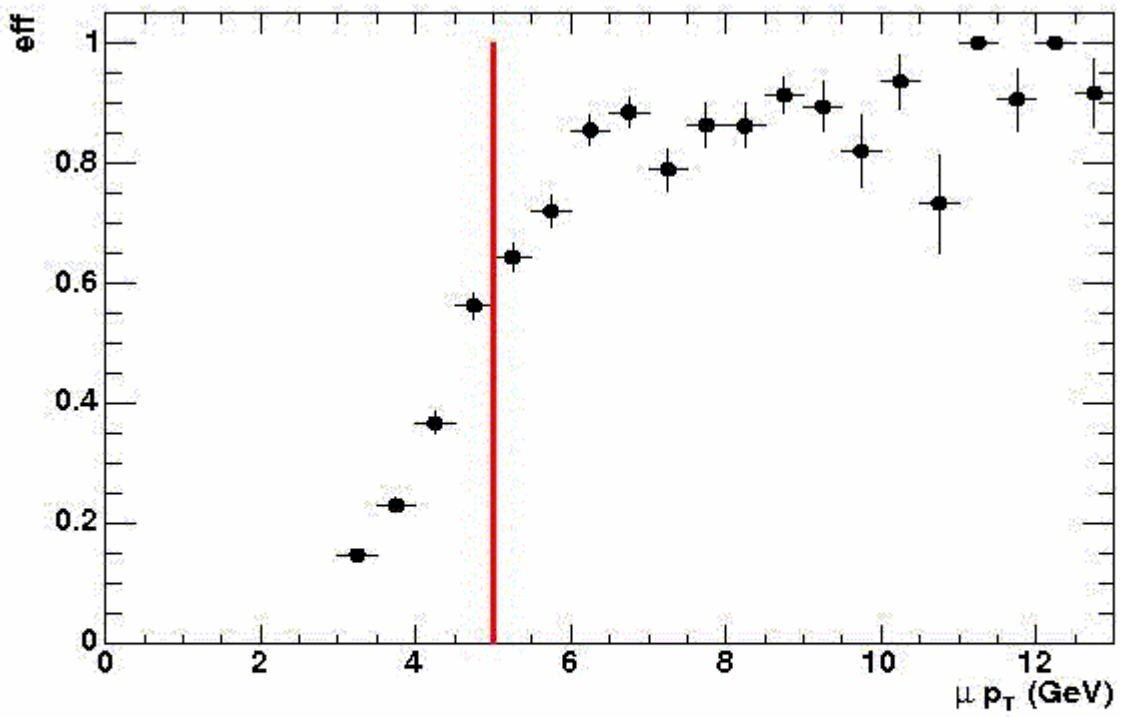


Figure 3: The azimuthal angle between the two muons ($\Delta\phi$) in the 5000 LPAIR events.

The reconstructed di-muon system transverse momentum, $\Delta\phi$ between the two muons and the di-muon invariant mass distributions are presented in Fig. 9, Fig. 10, 11, respectively.

The cross section times acceptance and reconstruction efficiency is 6.0 pb. Out of the 631 events in the sample that have both muons reconstructed, 614 events have the L1 di-muon bit set; and 261 events have the HLT di-muon bit set. The L1 trigger is virtually fully efficient for these events; and the HLT rejects about 60% of the events due to the high p_T threshold. The fraction of the events that pass the di-muon HLT is plotted as a function of the p_T of the softer muon in the event in Fig. 12. The HLT is almost fully efficient after the $p_T > 7$ GeV threshold.

If we use the 7 GeV di-muon HLT to collect the sample, the event rate will be around 2.5 pb.



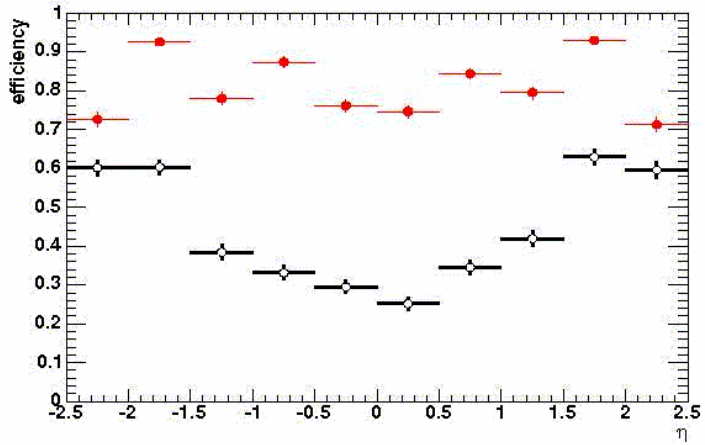
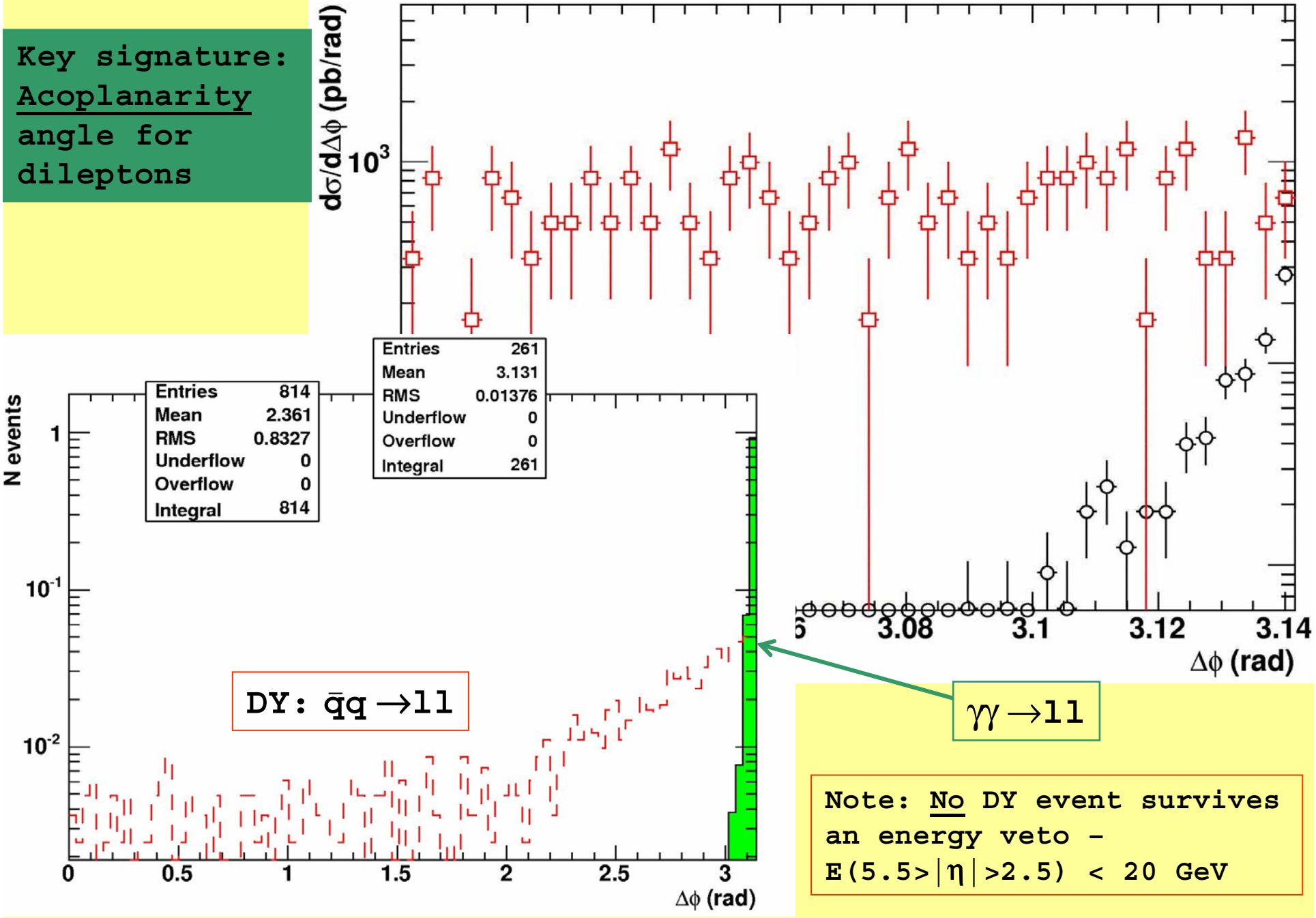


Figure 8: The muon reconstruction efficiency vs. the muon η. The open dots are from muons with p_T above 3 GeV, and the solid dots are from muons with p_T above 5 GeV.

Key signature: Acoplanarity angle for dileptons



Note: No DY event survives an energy veto – E(5.5>|η|>2.5) < 20 GeV

Invariant mass distribution driven by p_T acceptance.

Still significant around upsilon mass!

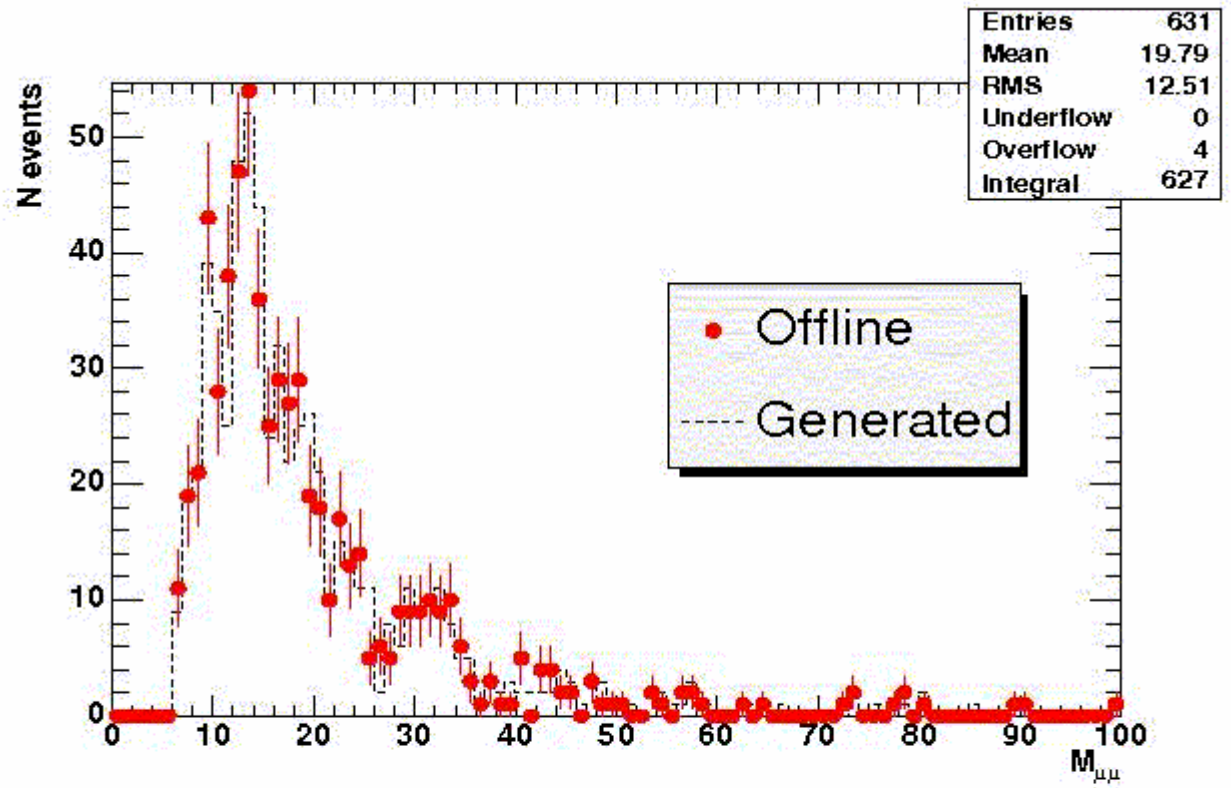


Figure 11: The reconstructed and generated di-muon mass.

Infer E_γ at initial state.

- When both leptons are observed, the energy of the $\gamma\gamma$ at initial state can be infered -assumption : their transverse momenta are small

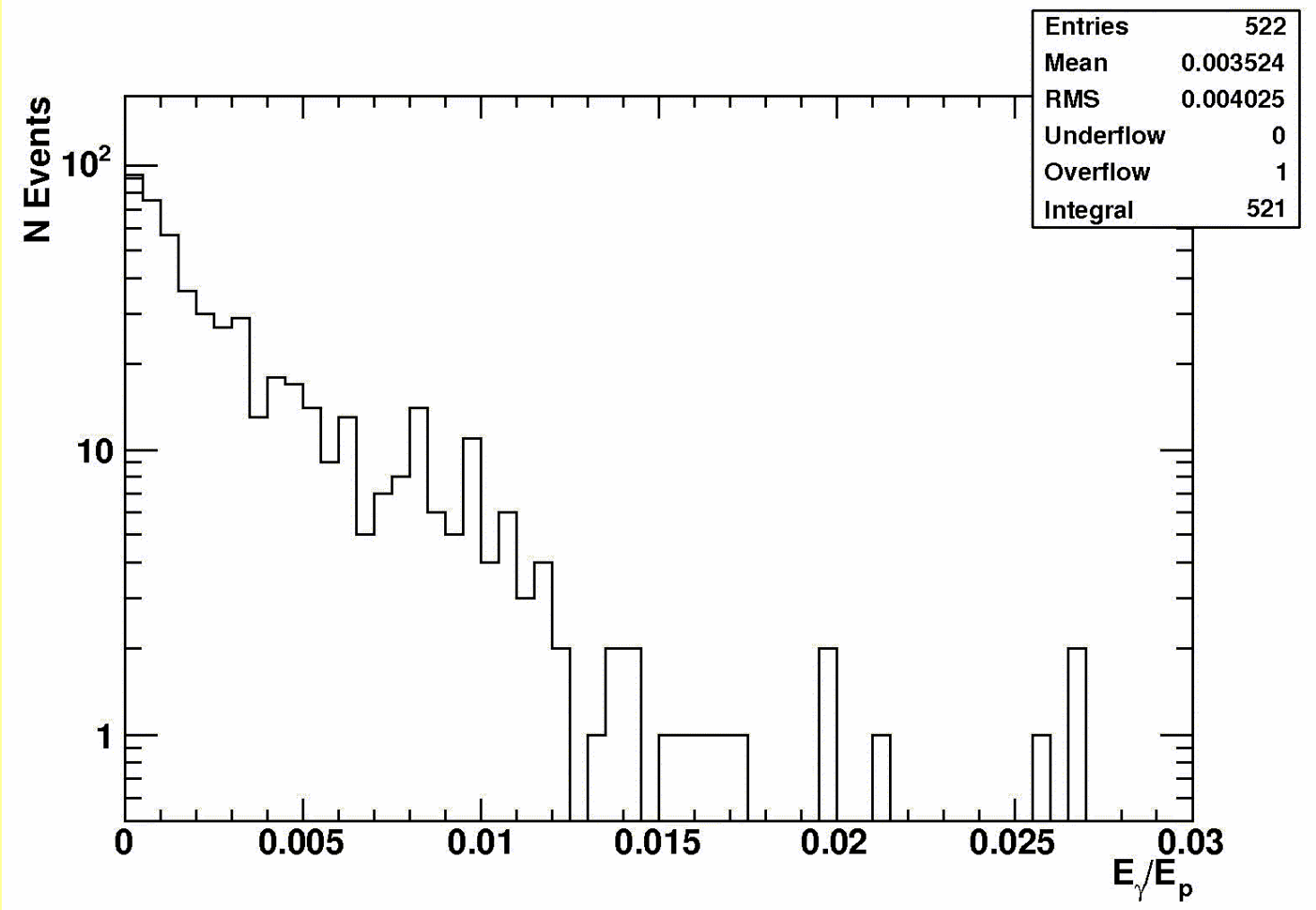
$$M_{l+l-} = 4E_{\gamma 1}E_{\gamma 2}; \quad (1)$$

$$Y_{l+l-} = \frac{1}{2}\log\frac{E_{\gamma 1}}{E_{\gamma 2}} \quad (\text{take } P_{z\gamma 2} < 0) \quad (2)$$

where, M_{l+l-}, Y_{l+l-} are the invariant mass, rapidity of the l^+l^- two body system respectively.

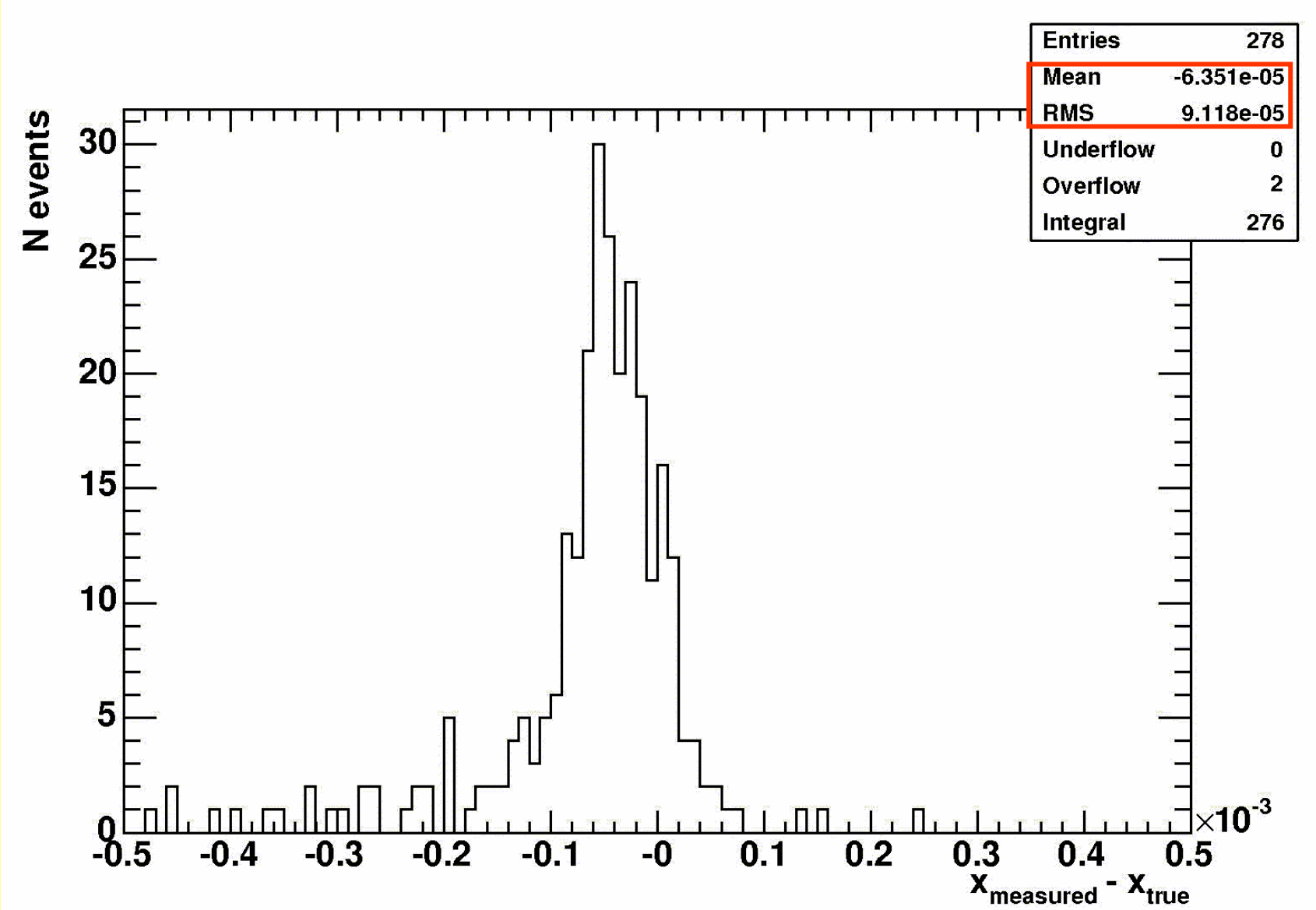
- This can be used to calibrate forward detectors.

Distribution of the proton energy loss for the reconstructed (and triggered) dimuon pairs:



Perfectly suited for FP420 momentum calibration

Resolution of the proton energy loss for the reconstructed dimuon pairs:



Conclusions:

Two-photon (exclusive) lepton pairs are excellent candidate for *in situ*, data-driven calibration of the FP420 momentum (AND of the acceptance!!)

Even using standard CMS di-muon trigger, good statistics can be collected; e.g. already for 100 pb^{-1} one will have about 300 calibration events

Resolution in energy loss is excellent, better than the beam energy smearing of 10^{-4}

Backgrounds at low lumi, when forward energy veto can be applied, should be negligible – best calibration data will be collected in 'no-pileup' conditions

Providing low p_T dedicated trigger and inclusion of upsilon photoproduction will improve that further!