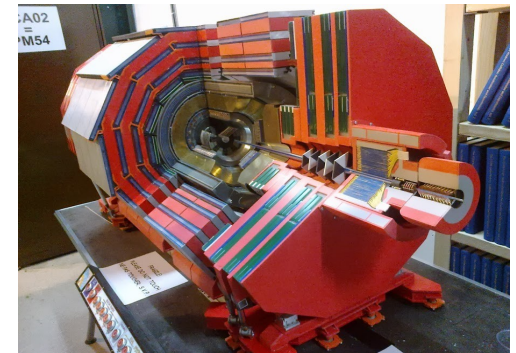
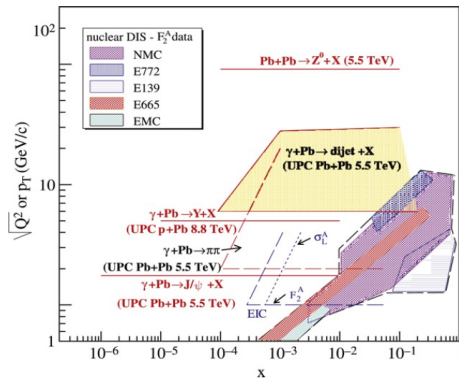


Results (and future prospects) of the CMS experiment in photon-induced collisions in pPb/PbPb collisions

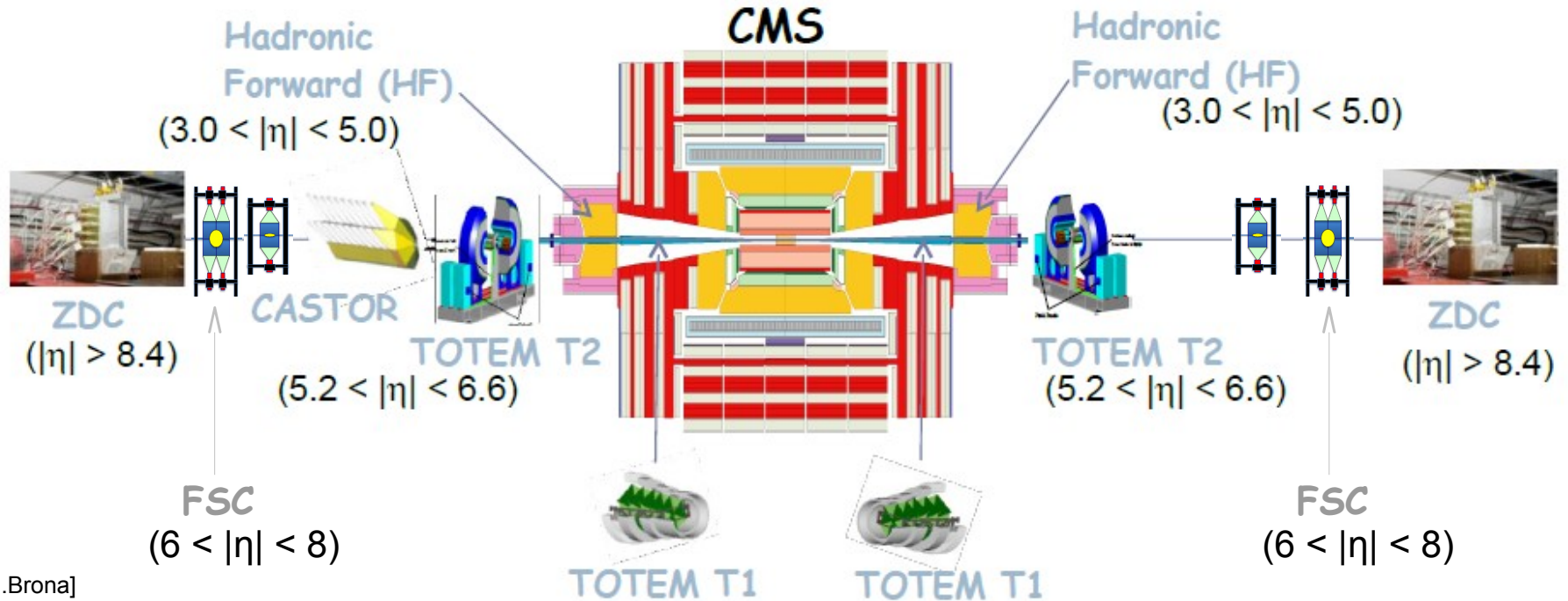
Igor Katkov

On behalf of the CMS Collaboration

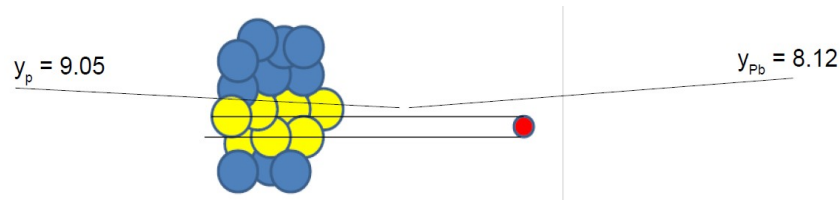


PhotonLHC2014: Workshop on photon-induced collisions at the LHC
CERN, Geneva, 2-5 June 2014

Experimental instrumentation



[G.Brona]



+ TOTEM
Roman Pots

Rich forward instrumentation around common interaction region of CMS and TOTEM experiments

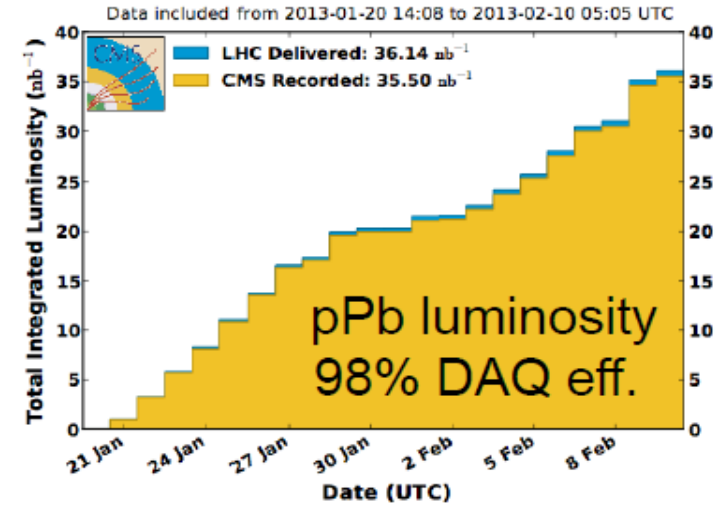


Overview: data, status, prospects



Period	Species	Energy	Lumi
Dec. 2010	Pb+Pb	2.76 TeV	7 μb^{-1}
Dec. 2011	Pb+Pb	2.76 TeV	150 μb^{-1}
Mar. 2011	p+p	2.76 TeV	230 nb^{-1}
Jan. 2013	p+Pb	5.02 TeV	35 nb^{-1}
Feb. 2013	p+p	2.76 TeV	5.4 pb^{-1}

CMS Integrated Luminosity, pPb, 2013, $\sqrt{s} = 5.02 \text{ TeV/nucleon}$

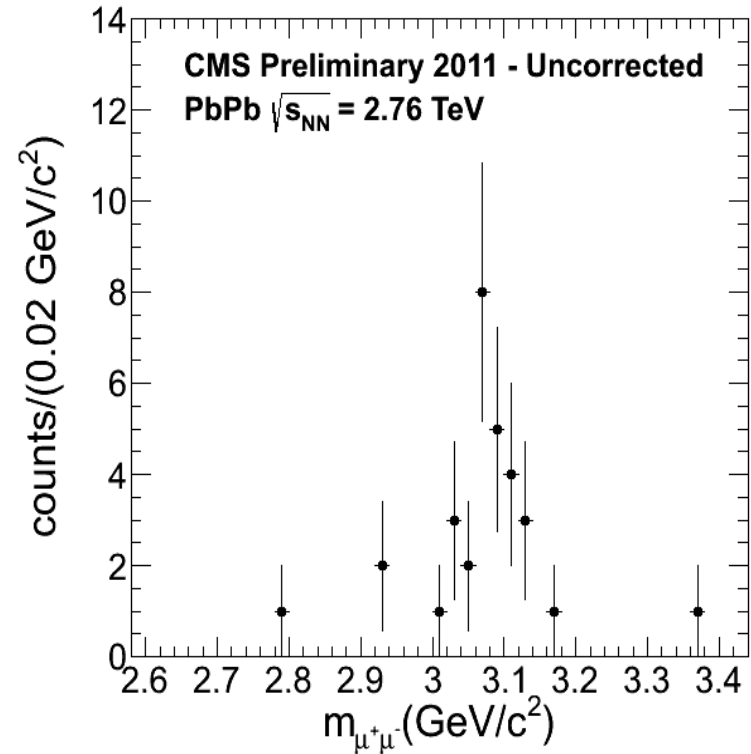
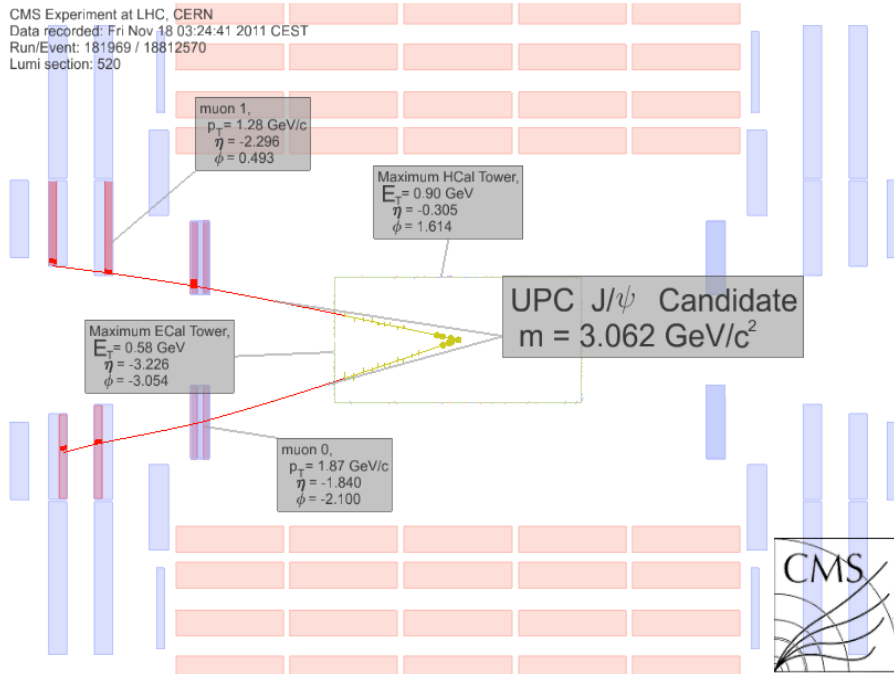


	UPC J/ψ	UPC Υ	$\gamma\gamma \rightarrow l^+l^-$	Gaps
PbPb	Preliminary/ performance results	Lack of statistics		
pPb	In progress	In progress	Preliminary/ performance results	Preliminary/ performance results



UPC J/ψ in PbPb collisions

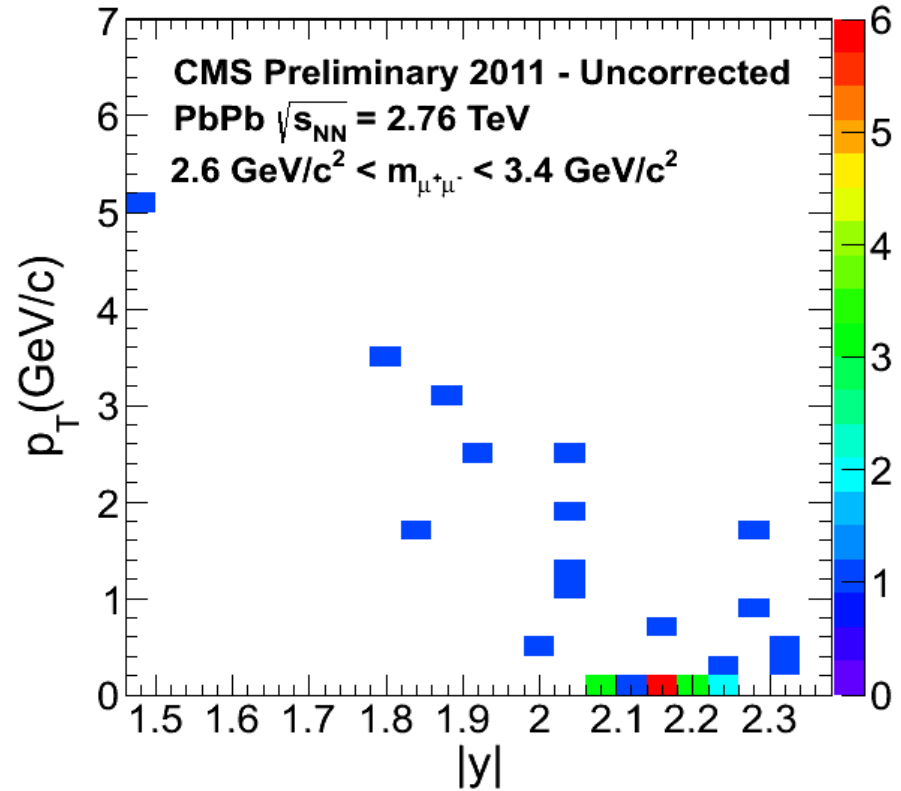
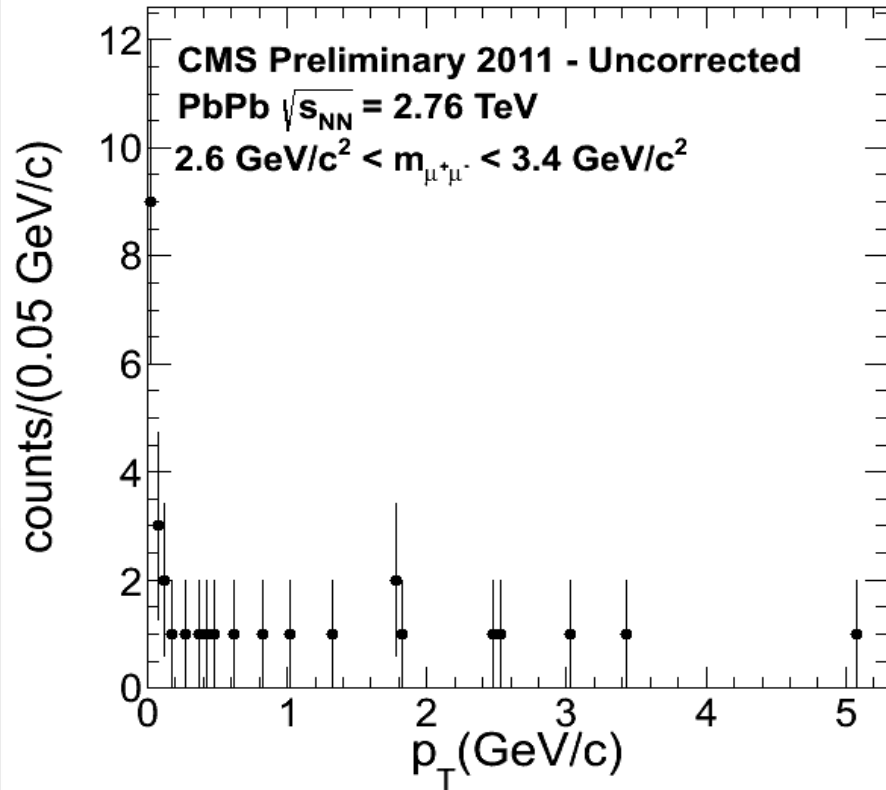
[CMS DP-2012-017]



- Single muon trigger with additional requirement of at least one active ZDC and veto on double-sided minbias activity
- Additional offline cleaning



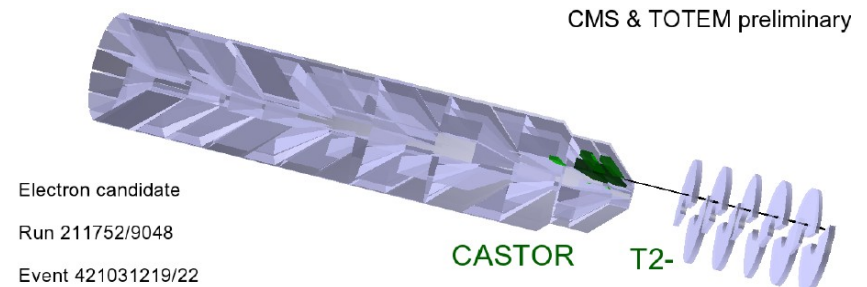
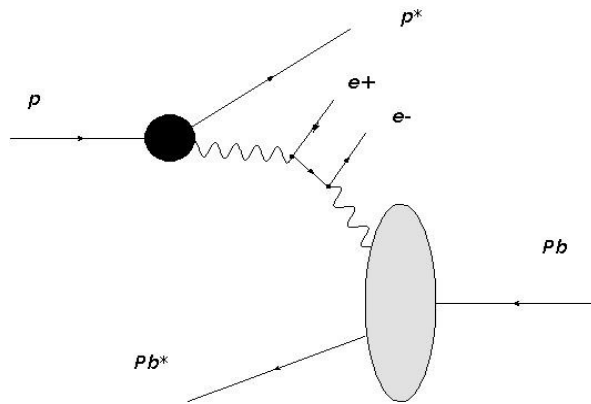
UPC J/ ψ in PbPb collisions



- Correlations with ZDC signals should help solving projectile-target ambiguities to compare to HERA data

Collisions of pPb in 2013

- Highlight of the run: parallel data taking of CMS and TOTEM
- Tracker + calorimeter capabilities in a very wide angular range
- In sync to exchange triggers
 - CMS central detectors and TOTEM roman pots
 - Electromagnetic energy deposit in very forward CMS and TOTEM/T2 low multiplicity

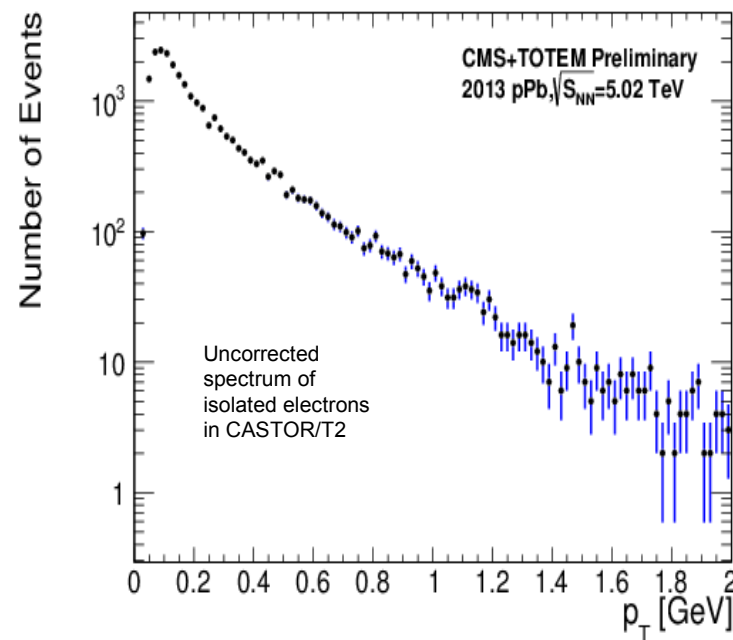
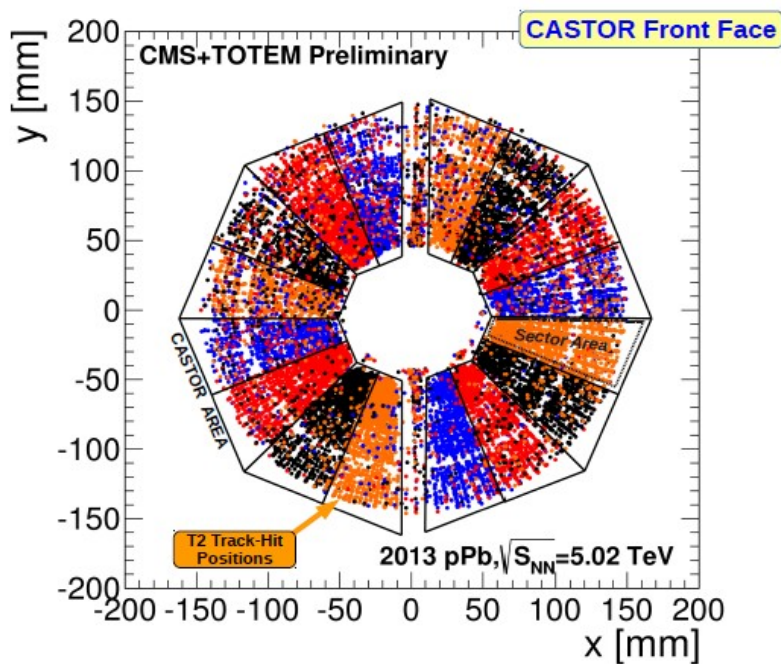


320 GeV (CASTOR), $\eta = -5.97$ (T2)

[CMS DP-2014-002]

Isolated forward electrons in pPb

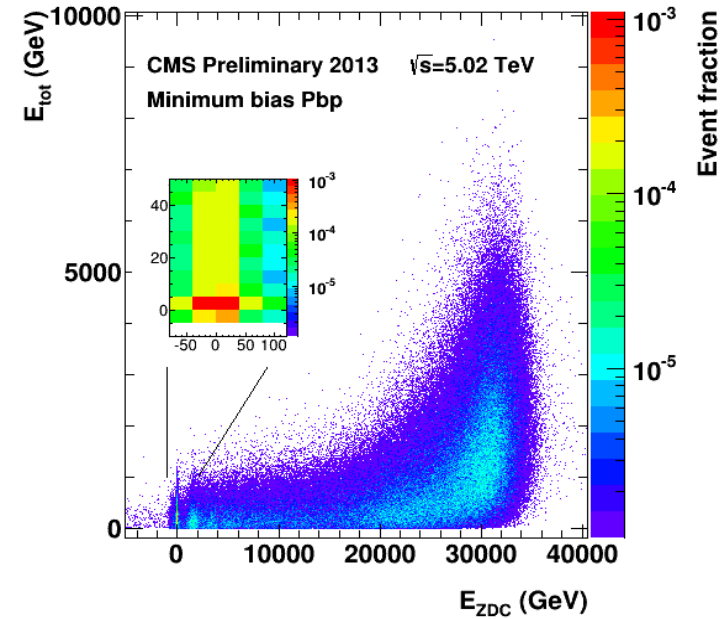
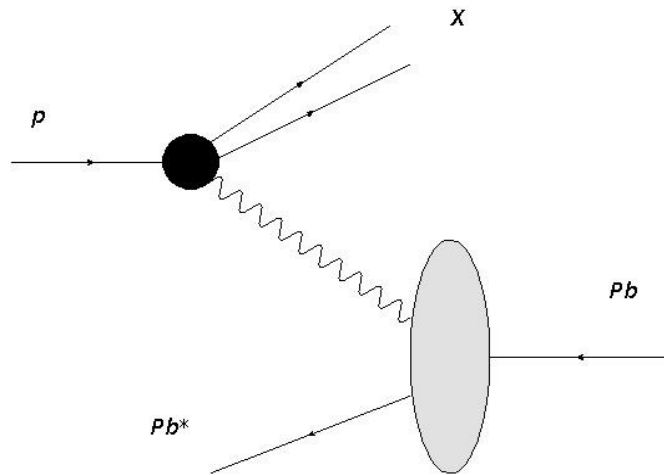
[CMS DP-2014-014]



- Based on combined CMS-TOTEM trigger
 - Relative alignment
 - Transverse momentum spectrum of forward electrons

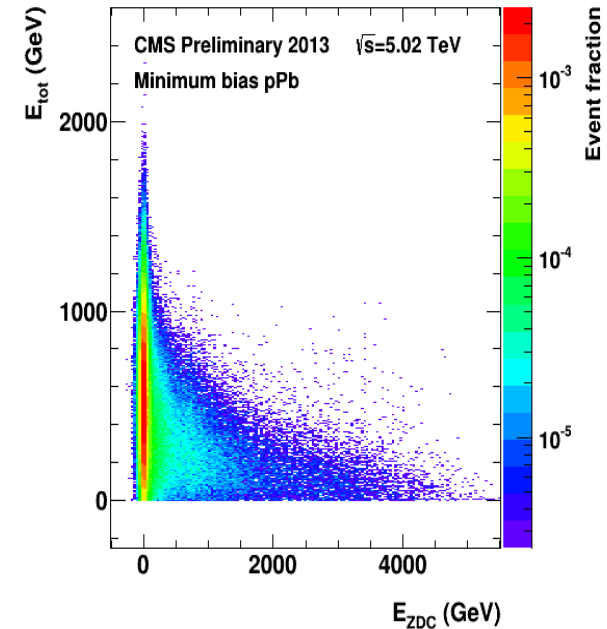
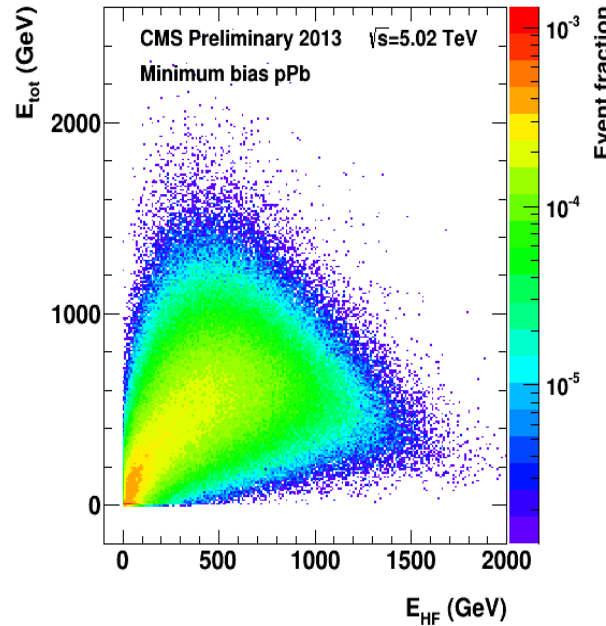
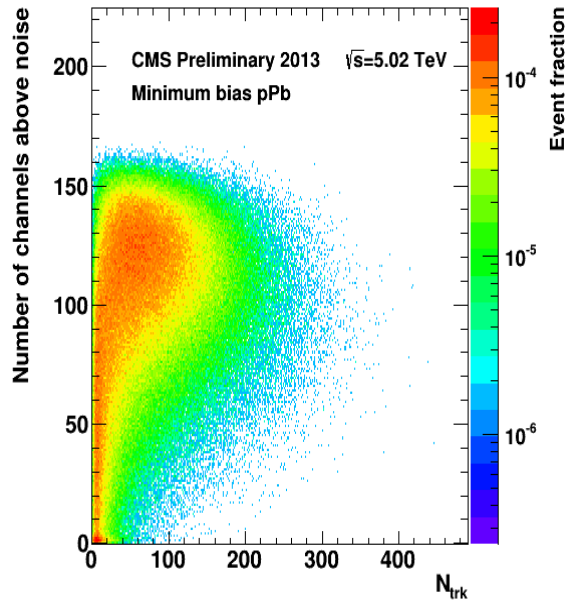
Topologies with gaps in pPb

[CMS DP-2013-035]

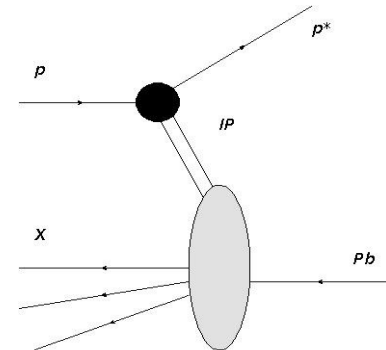


- γ -p \rightarrow X: events with activity in the central detector and no activity in a very forward calorimeter and ZDC (lead beam fragmentation region) \rightarrow can be interpreted as inelastic interactions of protons and photons emitted from the lead beam that stays intact upon the emission

Topologies with gaps in pPb

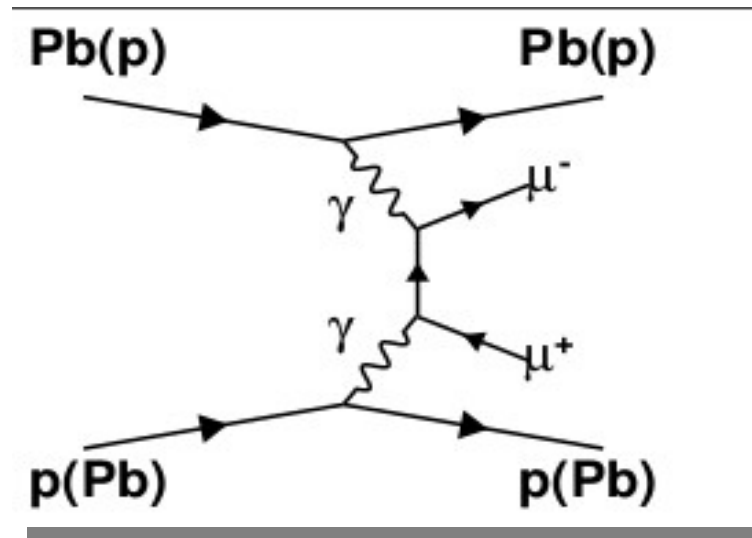


- Correlation between activity measured in the range $5.2 < \eta < 6.6$ and
 - Number of tracks in the central region, $\eta \sim 0$
 - Energy measured in the range $3 < \eta < 5$
 - Energy on neutrals measured at zero degree, $\eta > 8$
- Events at (0,0) indicate presence of topologies with rapidity gaps



Study of $\gamma\gamma$ -interactions in pPb

- Theoretically clean, pure QED process: $\gamma\gamma \rightarrow \mu^+\mu^-$
- Luminosity candle
- Scan a wide range of invariant masses



[CMS public twiki: [CMSExclusiveGGMMHighmass](#)]



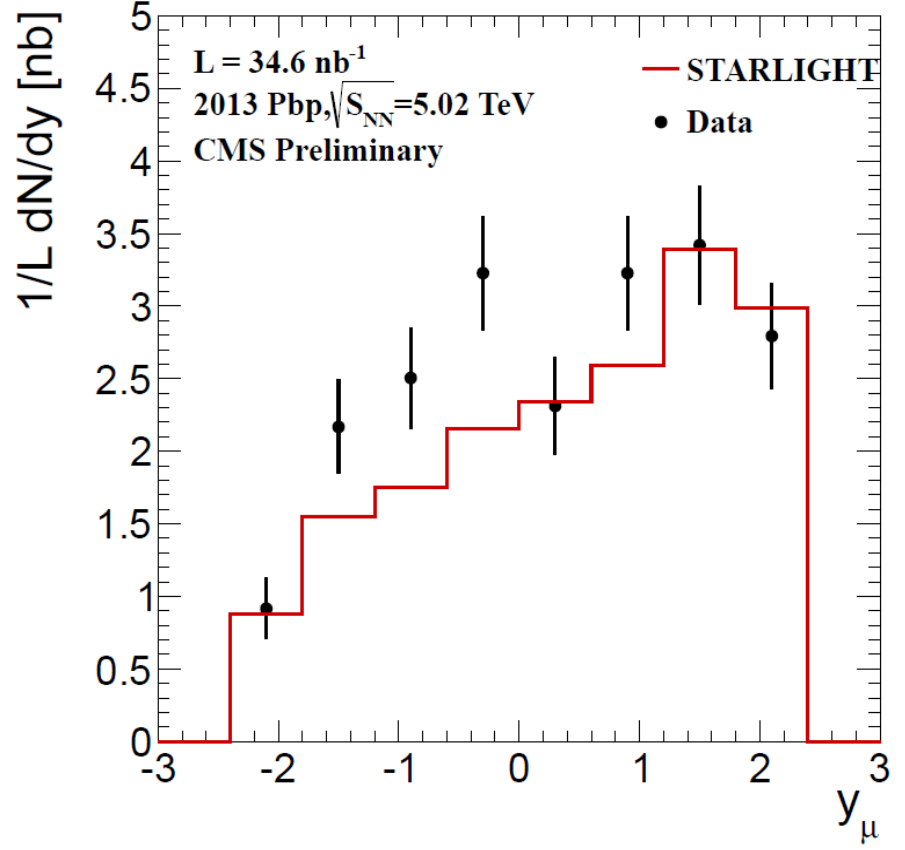
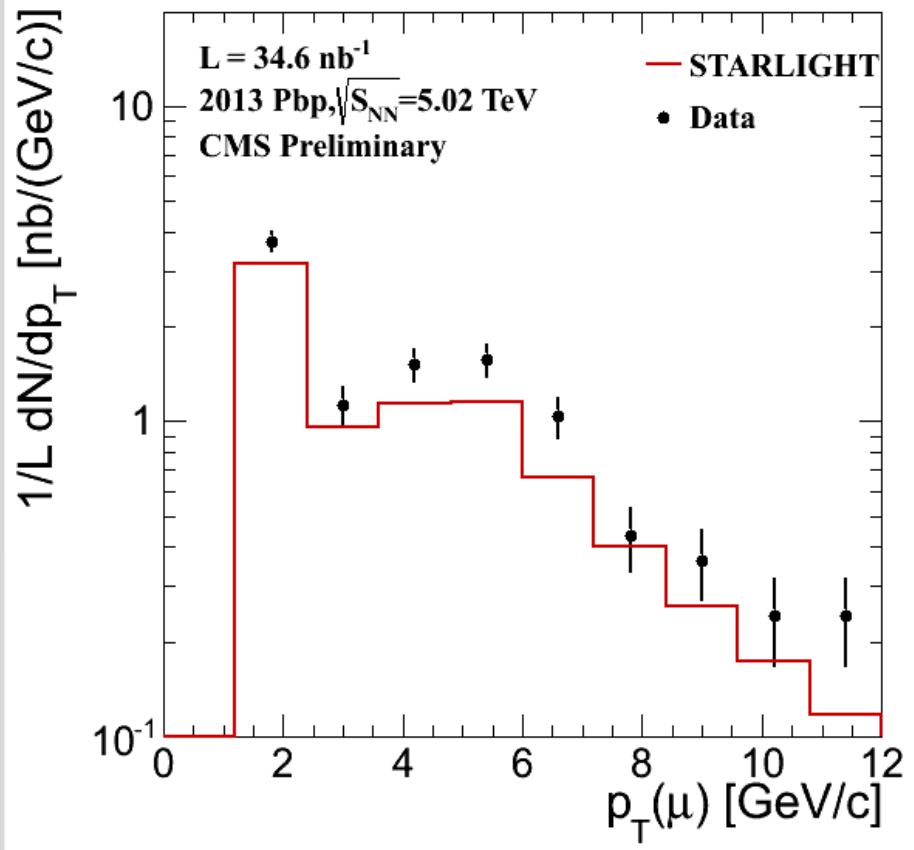
Study of $\gamma\gamma$ -interactions in pPb: analysis flow

- Data and simulation
 - pPb collisions of 2013, $L \sim 35/\text{nb}$, single muon triggers and track multiplicity veto
 - STARLIGHT MC [1]
pPb ($\gamma\gamma$) \rightarrow pPb ($\mu^+\mu^-$), invariant mass range 4 - 100 GeV, $\sigma \sim 1.4$ mb
- Calorimeter exclusivity:
 - Towers matched to muons not considered ($r = 0.3$)
 - No additional towers above noise
- Good quality muon tracks, $|\eta| < 1.8$, $p_T > 3$ GeV:
 - $4.5 < m(\mu^+\mu^-) < 99.5$ GeV/ c^2 (excluding range of 8-12 GeV/ c^2)
 - $0.05 < p_T(\mu^+\mu^-) < 0.3$ GeV/ c^2 (down to 0 and up to 0.4 for a systematic check)
- Muon exclusivity:
 - $|\Delta\phi(\mu^+\mu^-)| > 2.8$
 - $|\Delta p_T(\mu^+\mu^-)| < 1.0$ GeV/ c
 - No tracks other than muons

[1] Baltz, Gorbunov, Klein, Nystrand, Phys.Rev. C80 (2009) 044902

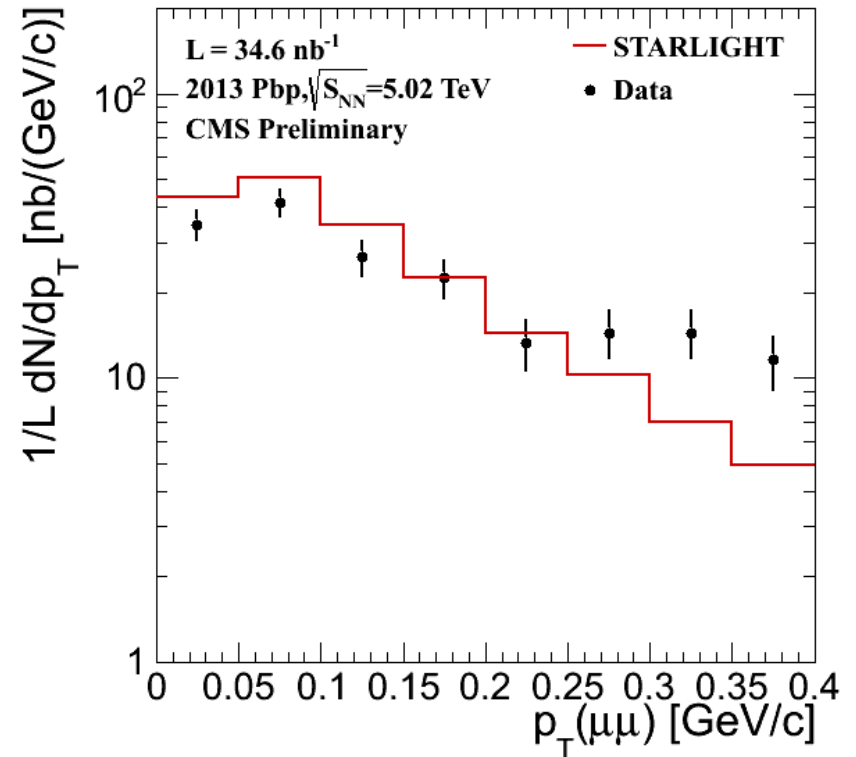
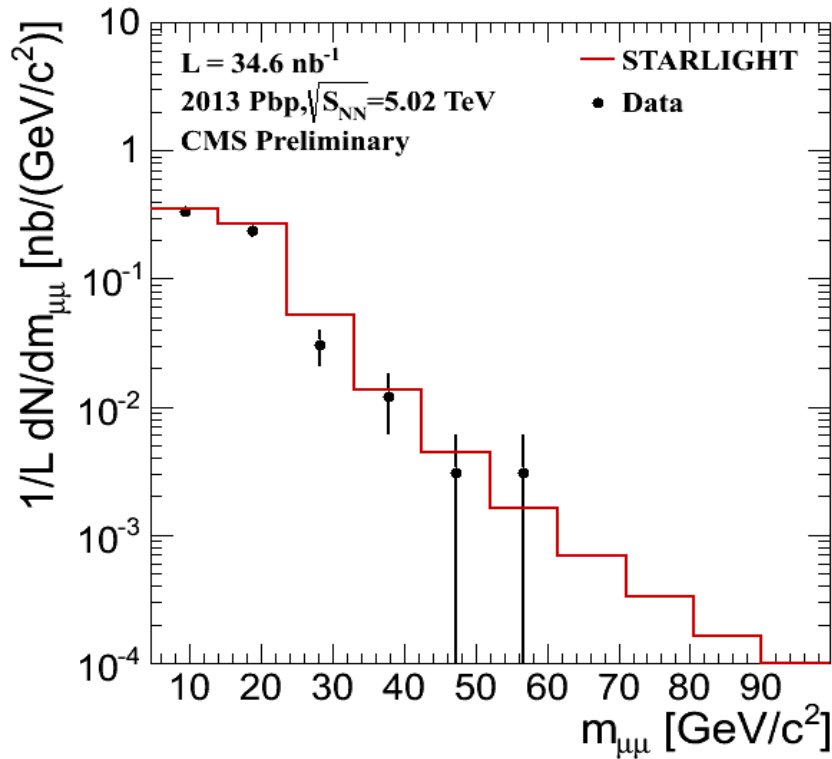


Study of $\gamma\gamma$ -interactions in pPb: single muon variables



■ Good description of data by STARLIGHT folded with CMS detector simulation

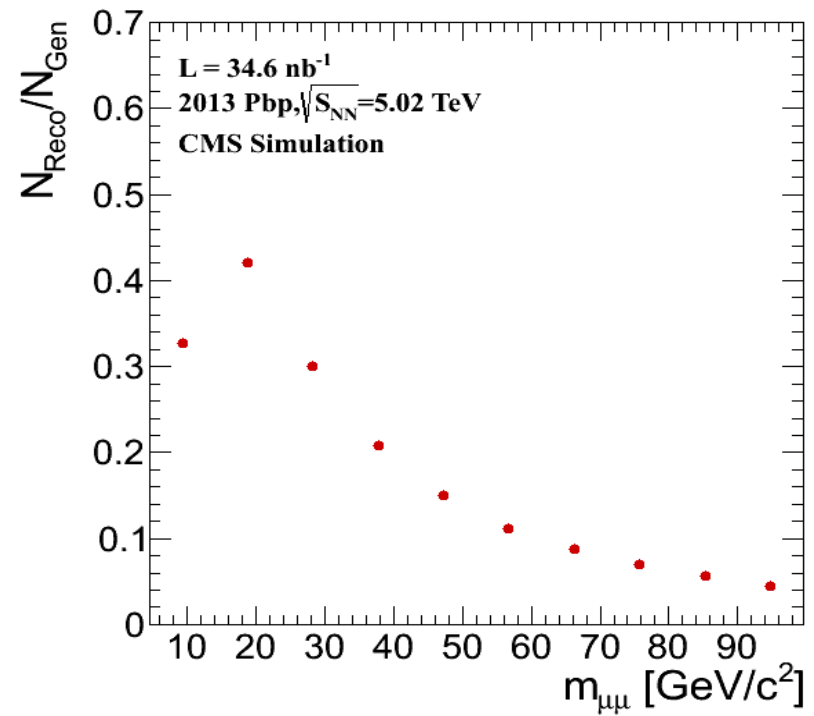
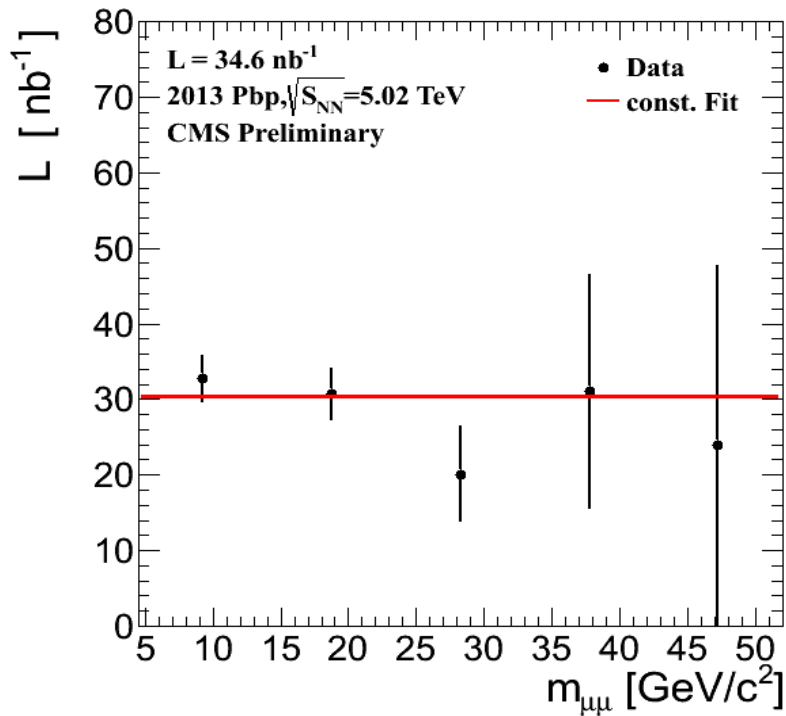
Study of $\gamma\gamma$ -interactions in pPb: invariant mass and p_T of muon pair



- Good reach in invariant mass
- STARLIGHT simulation includes only exclusive $\gamma\gamma$ -processes

Study of $\gamma\gamma$ -interactions in pPb: luminosity cross-check

$$\mathcal{L}(\gamma\gamma \rightarrow \mu\mu) = \frac{N_{Data}^{\mu\mu}}{\epsilon^{\mu\mu} \times \sigma_{\gamma\gamma \rightarrow \mu\mu}} = (30.4 \pm 2.2(stat.) \pm 3.9(syst.)) nb^{-1}$$





Summary

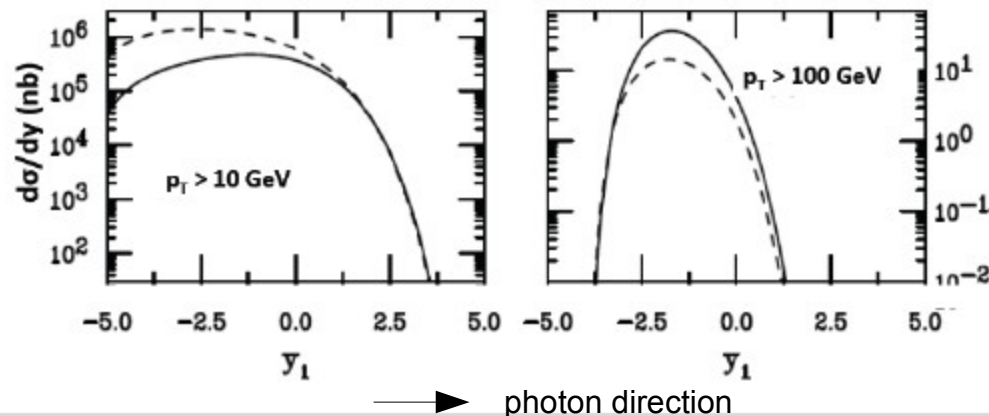


- Several very encouraging results on ultra-peripheral collisions in CMS
 - Exclusive Υ in PbPb
 - Events with gap topologies in pPb
 - Transverse momentum of isolated forward electrons in pPb
 - Photoproduction of muon pairs up to high invariant masses in pPb

- The full potential of already collected data, excellent forward instrumentation and powerful combination of CMS and TOTEM are still to be explored

- Besides hot topics for the era of high energy/luminosity
 - Heavy flavours and jets
 - Light-light scattering and Higgs production...
- ... measuring UPC $\psi(2S)$, Y in PbPb should become definitely feasible
- More specific proposals are being drafted for the LPCC Forward Physics Working Group Yellow Report

UPC di-jet production x-section as a function of y
w/o shadowing:
direct (solid) vs resolved (dashed) photons



[R. Vogt et al
UPC Yellow Report]