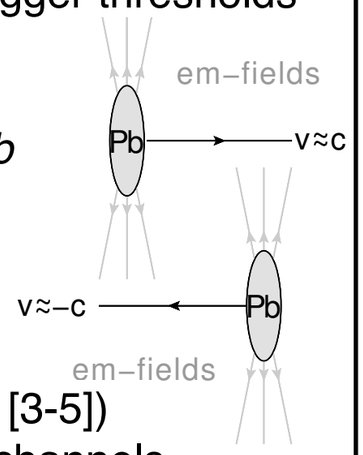
Exclusive dilepton production in ultraperipheral Pb+Pb collisions in ATLAS

Agnieszka Ogrodnik (AGH UST),
on behalf of the ATLAS Collaboration

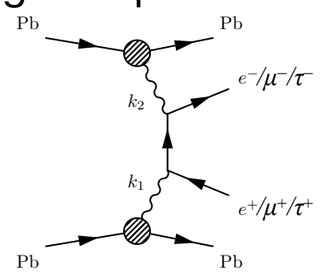
Ultraperipheral heavy-ion collisions

- **Photon-photon interactions** can be observed in **ultraperipheral heavy-ion collisions** at the LHC due to large EM fields associated with relativistic ions (cross-sections scale with $\sim Z^4$)
  - **Advantages:** low hadronic pileup, possibility of lower trigger thresholds
- EM field is treated as a beam of **quasi-real photons** with small virtuality (equivalent photon approximation)
- The EM interactions are dominant for impact parameters b larger than twice the ion radius
- Incoming **photon fluxes** are studied in detail with exclusive dilepton production measurements [1,2]
- Possibility to study **rare processes:**
  - light-by-light (LbyL) scattering (published ATLAS results [3-5])
  - Exclusive ditau production in semi-/fully-leptonic decay channels (new ATLAS measurement [6])

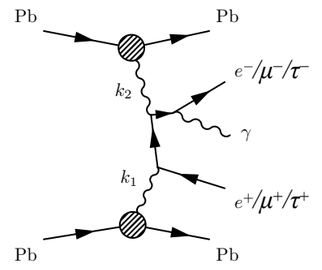


Exclusive dilepton pairs

- **Exclusive dilepton production** is a fundamental process in $\gamma\gamma$ interactions
- Provides a **benchmark** for other photon-induced processes
  - Possible **reduction of systematic** uncertainties (τ-lepton g–2)
  - Important **background** (charmonia, LbyL)
  - Useful for **performance studies** with a tag-and-probe technique



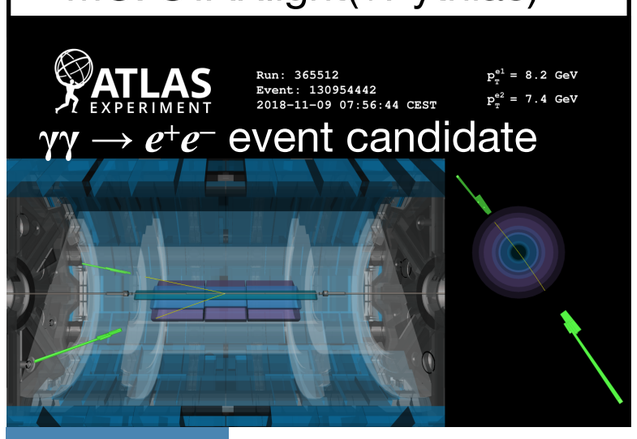
Signal (LO)



Signal with FSR

Signal

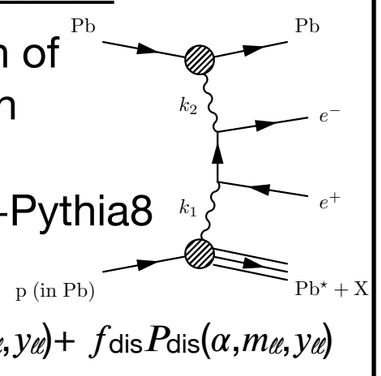
- Signature of interest: two low-p_T opposite-sign back-to-back leptons
- MC: STARlight(+Pythia8)



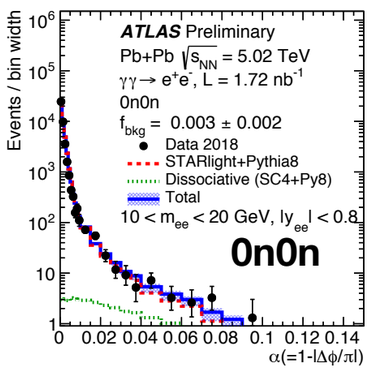
	muons	electrons
L_{int}[nb^{-1}]	0.48	1.72
$p_T^l >$	4 GeV	2.5 GeV
$\lvert\eta_l\rvert <$	2.4	2.5
$m_{ll} >$	10 GeV	5 GeV
$p_T^{ll} <$	2 GeV	2 GeV
N_{events}	12k	30k

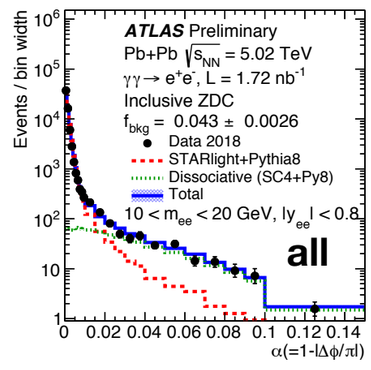
Backgrounds

- **Dissociative** production of $\ell^+\ell^-$ pairs, estimated with template fitting method (MC: LPair/SuperChic4+Pythia8 in pp collisions)



- $P(\alpha, m_{\ell\ell}, y_{\ell\ell}) = (1 - f_{dis}) P_{EPA}(\alpha, m_{\ell\ell}, y_{\ell\ell}) + f_{dis} P_{dis}(\alpha, m_{\ell\ell}, y_{\ell\ell})$

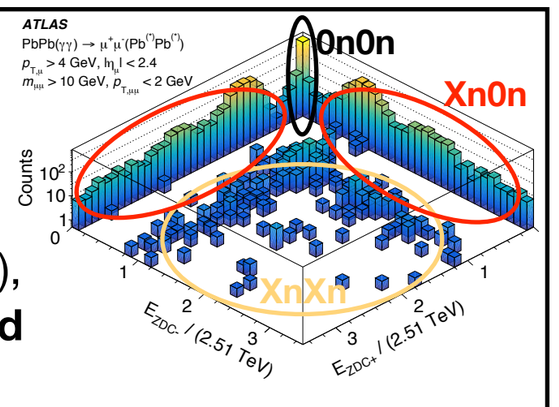




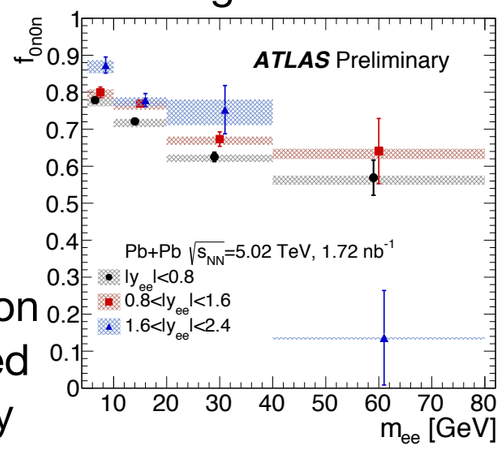
- Other backgrounds (estimated only for dielectrons using MC simulations):
  - **Upsilon(nS)** production
  - exclusive **ditau** production

Role of the ZDC

- Zero-Degree Calorimeter (ZDC), describes **forward neutron activity**

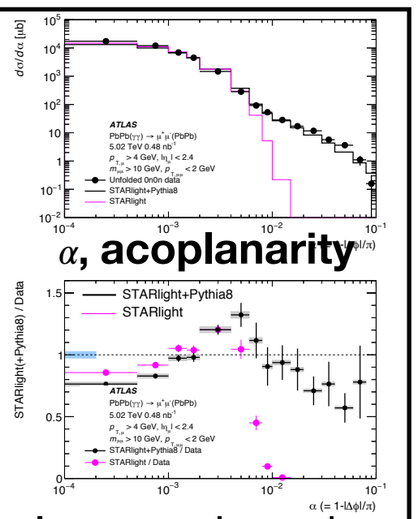


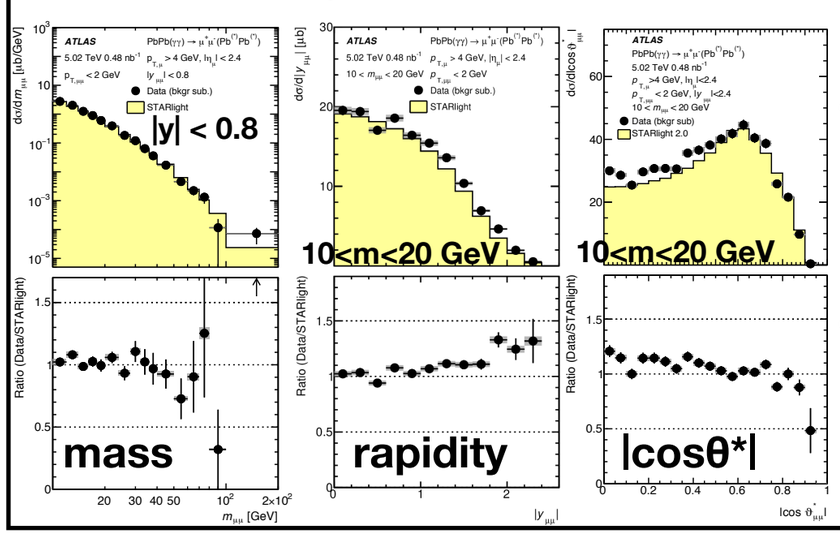
- Signal events are divided into **3 classes**
- Fractions of dissociative background differ in each class
- Observed ZDC fractions affected by the presence of **EM pileup**
- Dedicated correction procedure is applied
- Each ZDC topology selects different impact parameter ranges



Dimuon results

- Measured fiducial cross section is:
  σ = 34.1 ±0.3 (stat.) ±0.7 (syst.) μb,
  (STARlight: 32.1 μb, STARlight+Pythia8: 30.8 μb)
- Differential cross-sections in several variables in the inclusive sample and in acoplanarity in 0n0n class

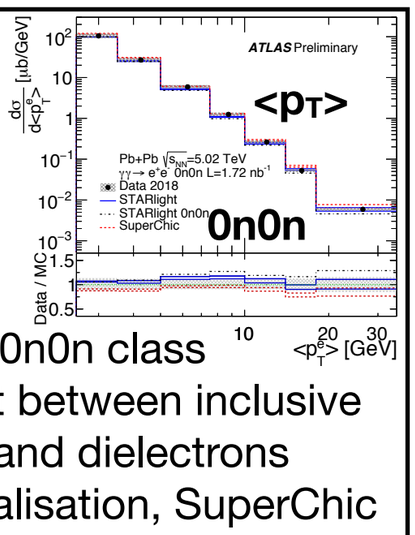




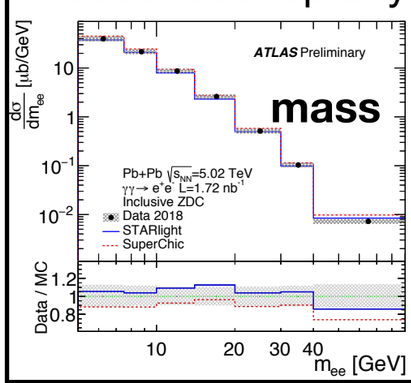
- In general good agreement found with STARlight (apart from α)
- Deviations seen in tails, especially in rapidity and α (w/o FSR in MC sample)

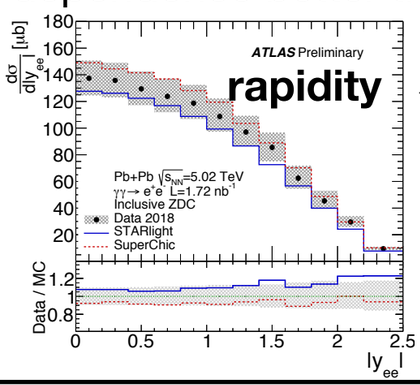
Dielectron results

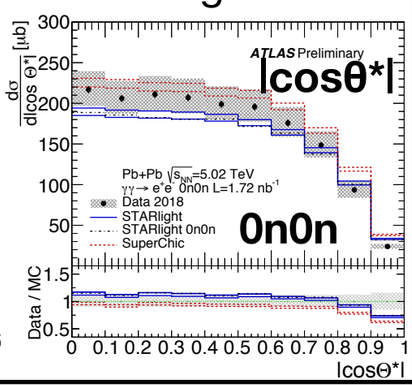
- Measured fiducial cross-section is:
  σ = 215 ±1 (stat.) $^{+23}_{-20}$ (syst.) ±4 (lumi.) μb
  (STARlight: 196.9 μb, SuperChic: 235.1 μb)
- Differential cross-sections in several variables in the inclusive sample and in 0n0n class



- Data to STARlight agreement consistent between inclusive and 0n0n class, and between dimuons and dielectrons
- STARlight and SuperChic differ in normalisation, SuperChic describes rapidity dependence better than STARlight







References: [1] Phys. Rev. C 104 (2021) 024906 [2] ATLAS-CONF-2022-025 [3] Nature Physics 13 (2017) 852 [4] Phys. Rev. Lett. 123 (2019) 052001 [5] JHEP 03 (2021) 243 [6] arXiv:2204.13478

This work was partially supported by PL-GRID infrastructure, 2020/36/T/ST2/00086 and 2020/37/B/ST2/01043 grants.