Small-x and forward measurements in ALICE

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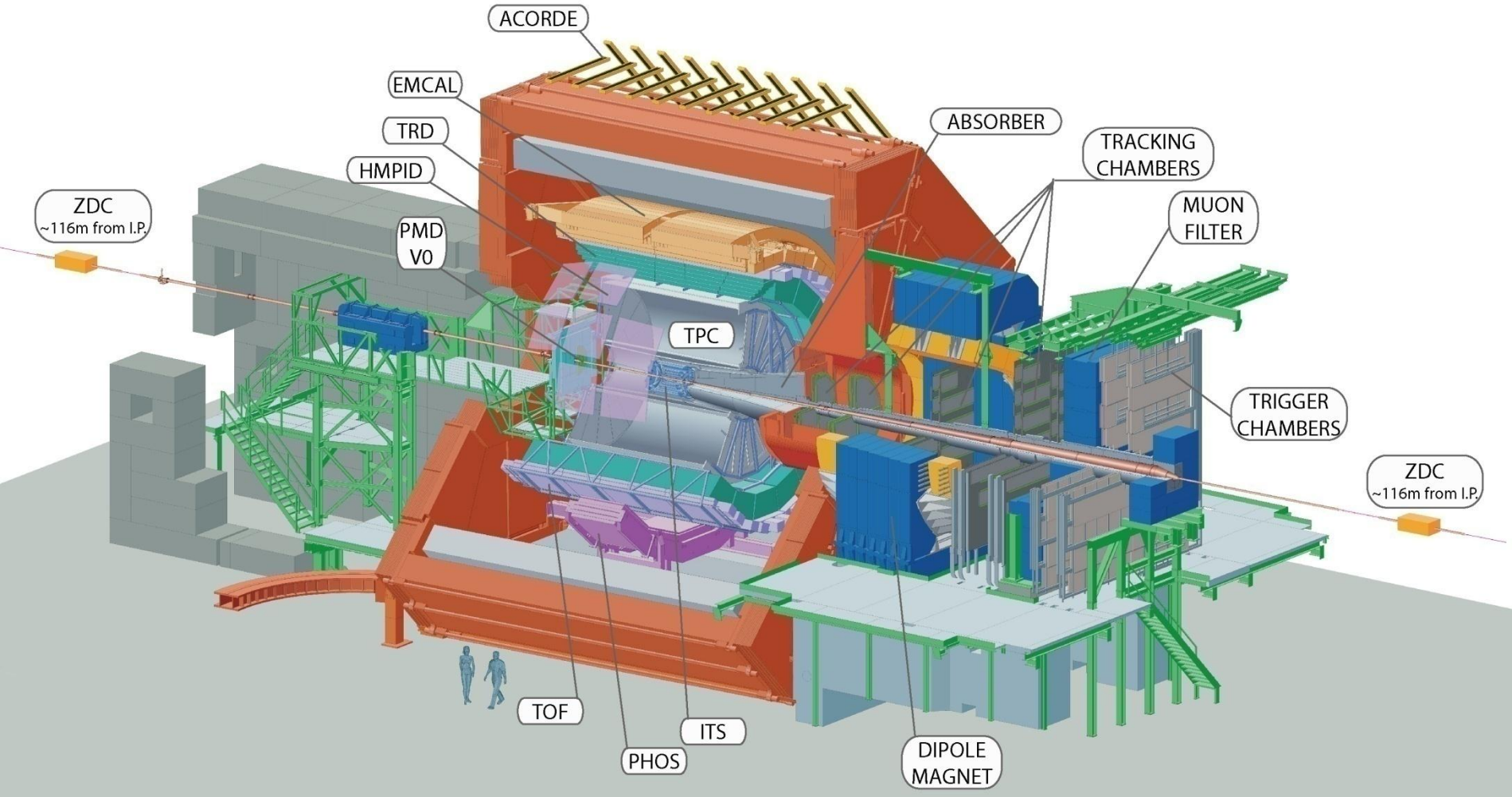
XIX International Workshop on Deep-Inelastic Scattering and Related Subjects (DIS 2011), 11-15 April 2011, Newport News VA U.S.A.

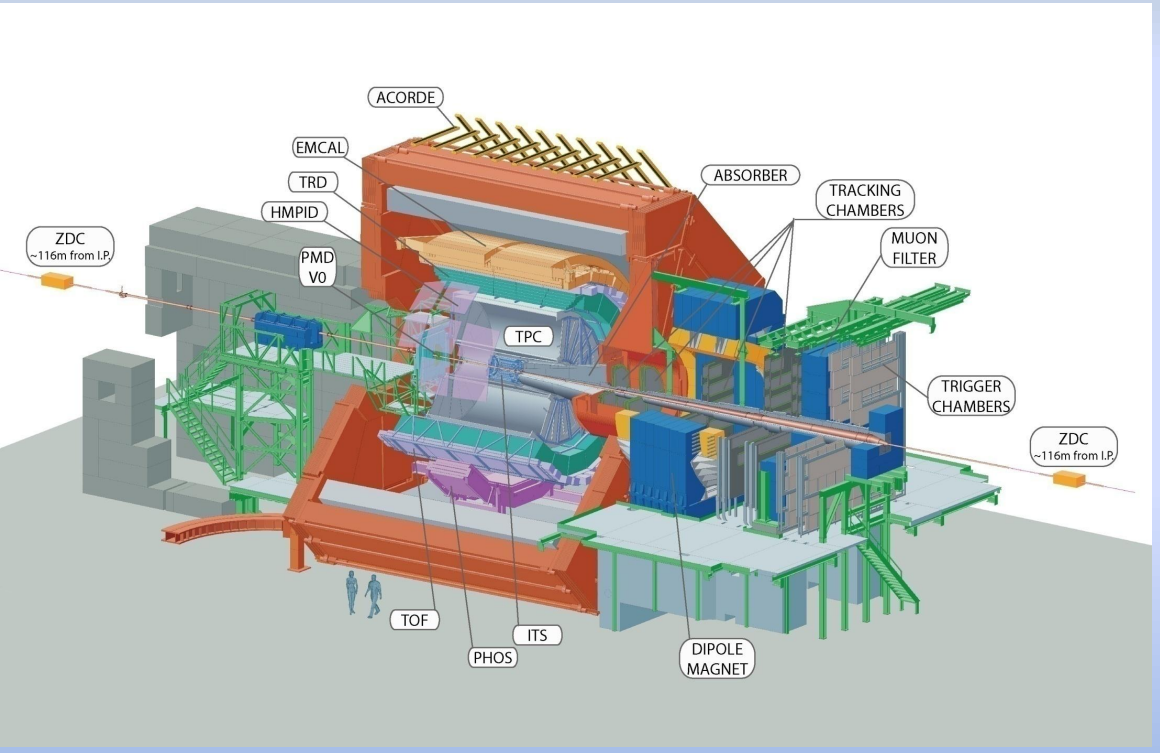
Outline

- The ALICE Experiment
- Exclusive particle production in p+p collisions at 7 TeV
- Exclusive particle production in ultra-peripheral Pb+Pb collisions at 2.76 TeV
- Outlook – Future runs and heavier final states
- Conclusions

A Large Ion Collider Experiment = ALICE



A Large Ion Collider Experiment = ALICE

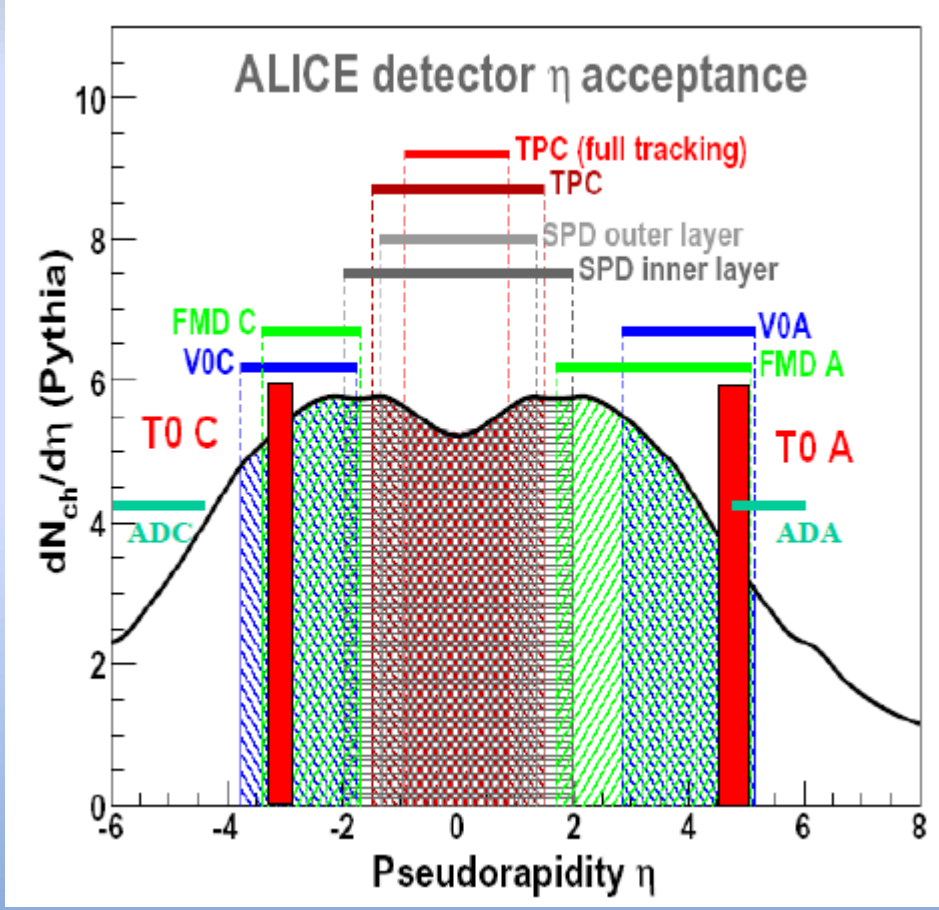


- A central tracking system (ITS + TPC) with particle identification (TOF + TRD + HMPID).
- Acceptance $|\eta| \leq 0.9$, $p_T > 100$ MeV/c
- Partial electromagnetic calorimeter coverage (PHOS + EMCAL)

- A muon arm at forward rapidities $-2.5 \geq \eta \geq -4.0$.
- Tracking and identification of muons, with Level-0 muon trigger.

- V0, T0 counters for triggering and vertex determination.
- Forward charged particle and photon multiplicity detectors (FMD, PMD)
- Zero-Degree Calorimeters (ZDC) – 118 m from interaction point.

A Large Ion Collider Experiment = ALICE



- Good coverage for charged particles $-4.0 \leq \eta \leq +5.0$.
- V0 detectors used to define rapidity gaps, both offline and online (Level-0 trigger).
- Only limited coverage for neutral particles.

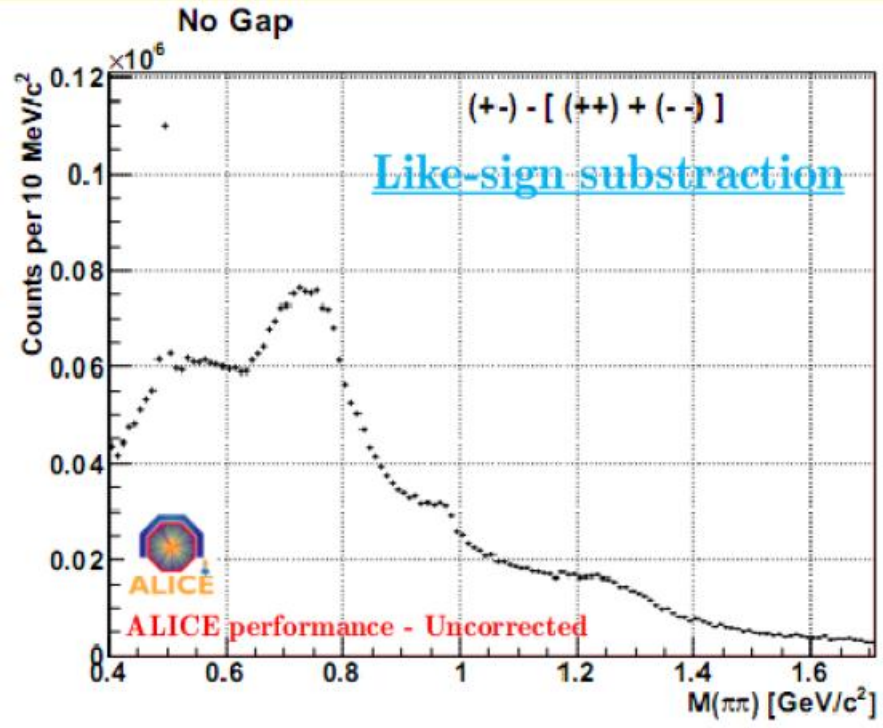
- AD Detector array being installed for better rapidity gap coverage
- Plastic scintillators covering $5.5 \leq |\eta| \leq 7.5$ on both sides.

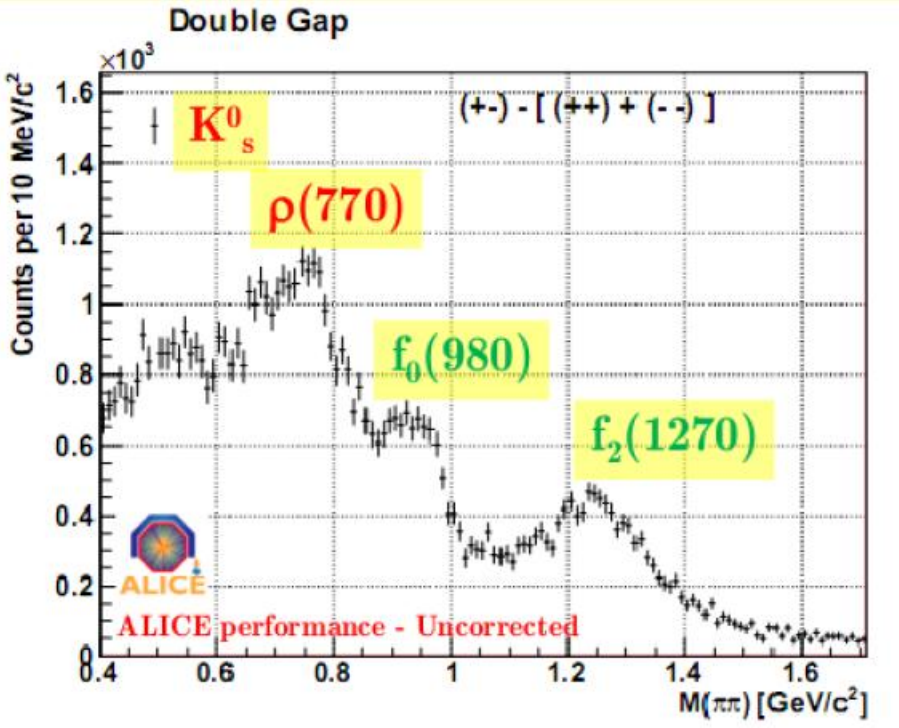
Exclusive production in pp collisions at 7 TeV

- 361 M events w/ CINT1B trigger analysed.
  CINT1B: Or between SPD, V0A, V0C. Sensitive to 1 ch.particle.
- 32.3 M events selected with primary vertex and exactly 2 TPC+ITS tracks.
  29.2 M events with no gap
  1.6 M events with gap on A-side
  1.4 M events with gap on C-side
  0.15 M events with gaps on both sides

⇒ Investigate particle production in events with exactly 2 tracks and gaps on both sides

Exclusive production in pp collisions at 7 TeV

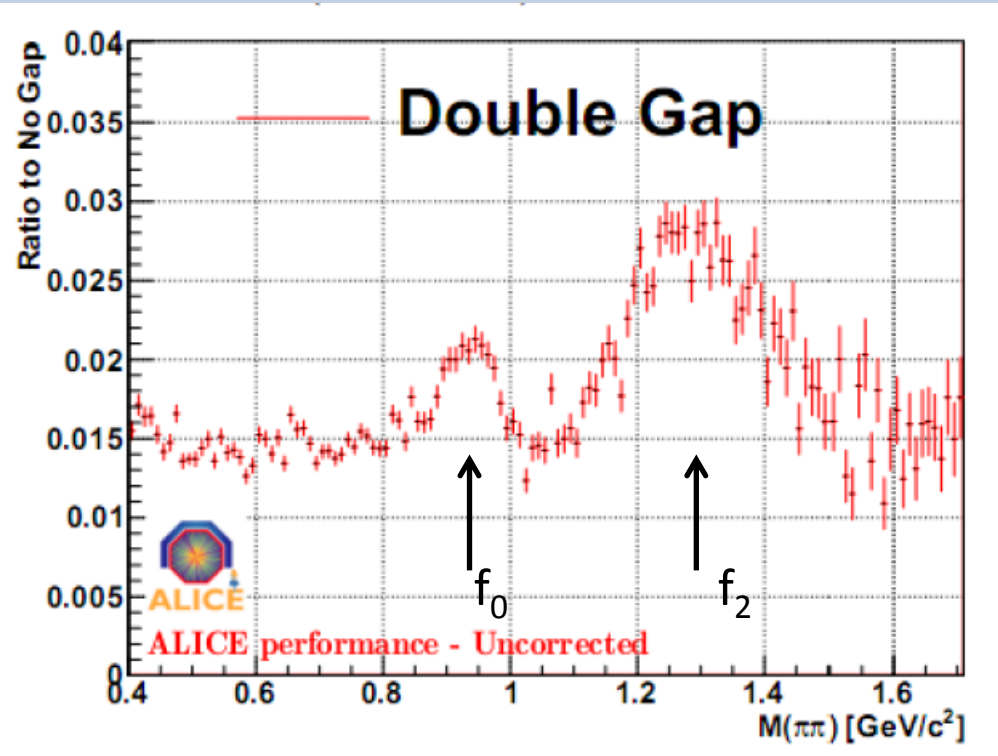




M_{inv} distribution for 2-track events without gaps. Like-sign contribution subtracted.

M_{inv} distribution for 2-track events with gaps on both sides. Like-sign contribution subtracted.

Exclusive production in pp collisions at 7 TeV



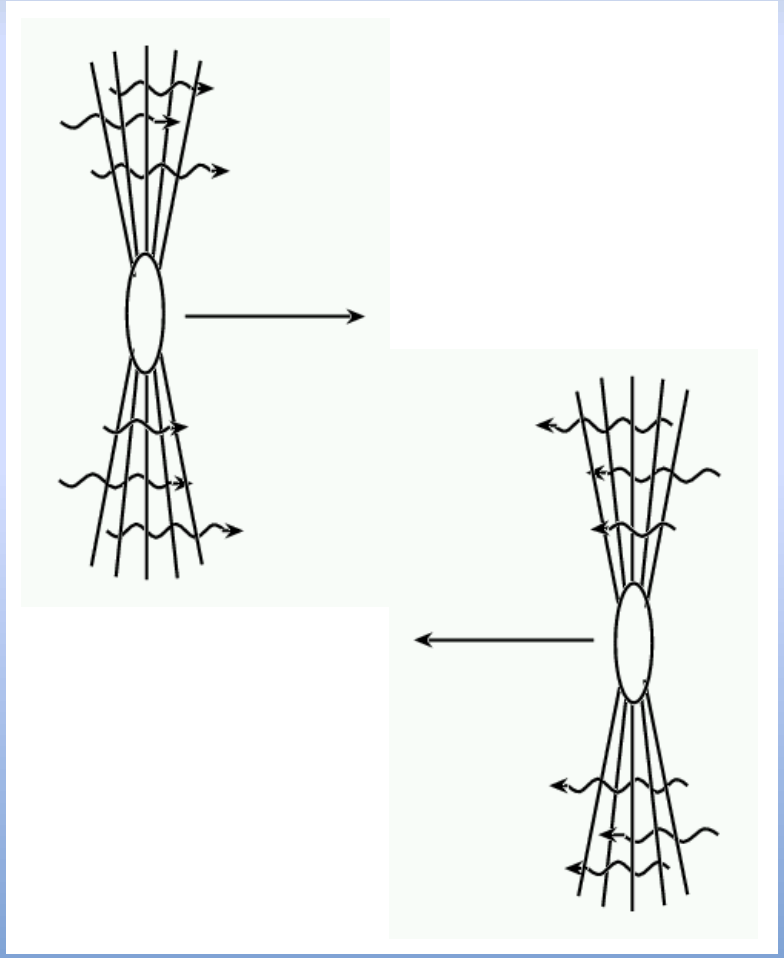
Ratio of M_{inv} distribution for 2-track events with gaps on both sides to events without gaps.

⇒ Some structure appears indicating IP+IP production of f_0 and f_2 mesons.

⇒ Purity and backgrounds have to be investigated further, especially from neutrals.

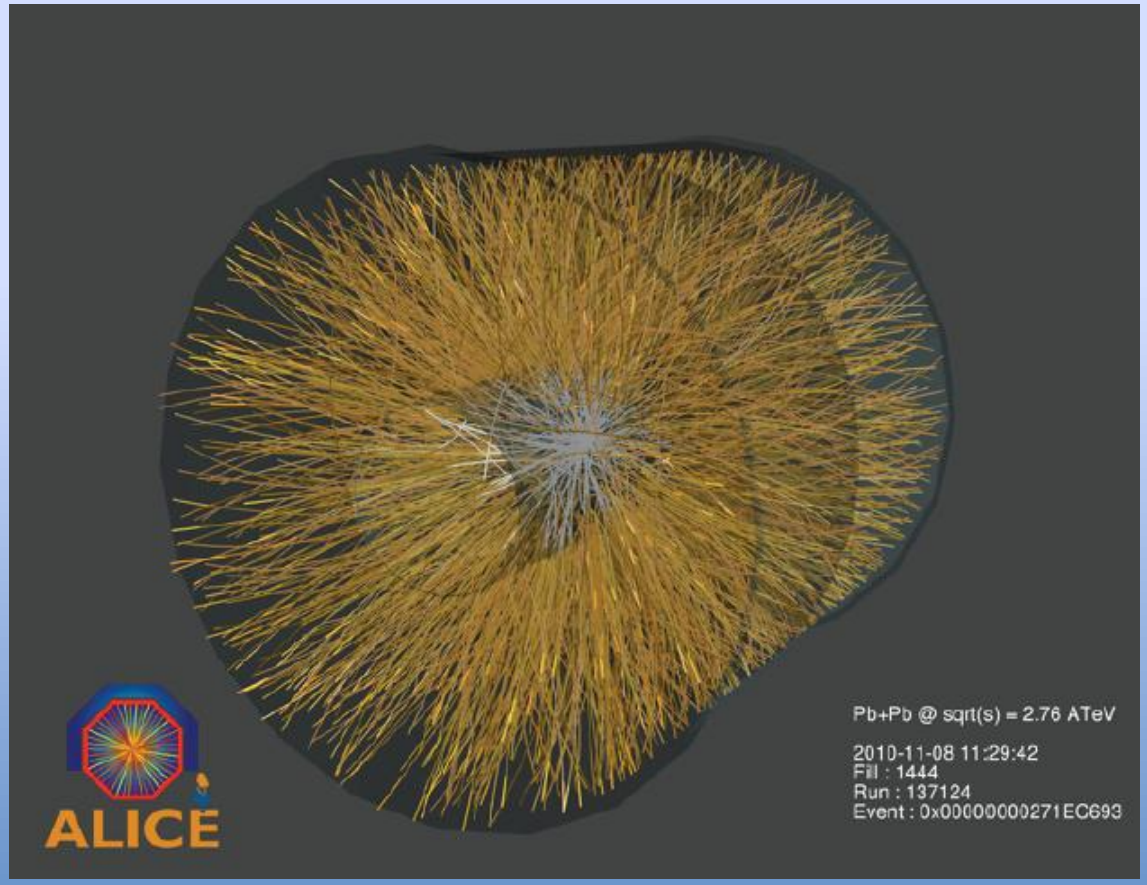
Ultra-Peripheral Collisions - Definition

- Two ions (or protons) pass by each other with impact parameters $b > 2R$.
- Only Electromagnetic interactions are possible.
- The equivalent photon spectrum extends to $\approx \gamma\hbar c/R$, making LHC also the most powerful photon collider.
- Number of photons scales like Z^2 for a single source $\Rightarrow$ exclusive particle production in heavy-ion collisions dominated by electromagnetic interactions.



Ultra-peripheral Pb+Pb Collisions

- First heavy-ion collisions at the LHC on 8. November 2010.
- About 12 M min. bias collisions collected by ALICE during Nov – Dec 2010.



Tracks in the ALICE TPC in a central Pb+Pb Collision.

Ultra-peripheral Pb+Pb Collisions

- First heavy-ion collisions at the LHC on 8. November 2010.
- About 12 M min. bias collisions collected by ALICE during Nov – Dec 2010.
- 3 triggers for ultra-peripheral collisions active during the run:

  OM2 – TOF only trigger: ≥2 hits in TOF.

  CCUP2 – TOF+SPD+V0 trigger: ≥2 hits in TOF + ≥2 hits in SPD + veto on V0A and V0C.

  CMUP1 – Muon arm + V0 trigger: at least one muon candidate + veto on V0A.

OM2 applied during the early, low-luminosity part of the run, CMUP1 and CCUP2 applied during the later parts, CCUP2 scaled down by factor 5 - 30

Ultra-peripheral Pb+Pb Collisions - Expectations

- The UPC triggers sensitive to a variety of final states:
  $\gamma\gamma \rightarrow e^+e^-$, $\gamma\gamma \rightarrow \mu^+\mu^-$, $\gamma\gamma \rightarrow f_2(1270) \rightarrow \pi^+\pi^-$,
  $\gamma I\!P \rightarrow J/\Psi \rightarrow e^+e^-$ etc.

- But the dominant channel will be exclusive photoproduction of $\rho^0 \rightarrow \pi^+\pi^-$.
  Total cross section: 3.9 b. (S.R. Klein, J. Nystrand Phys. Rev. C 60 (1999) 014903)
  ALICE Acceptance: ≈ 9%.

- Coherent production characterised by low transverse momentum of the final state, determined by the nuclear form factor, $p_T < \approx 100$ MeV/c.

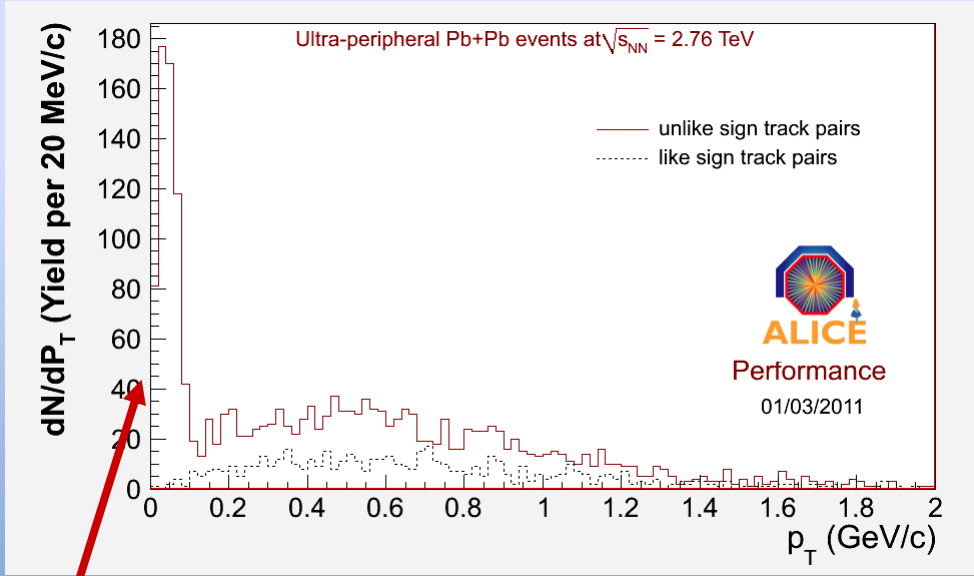
Ultra-peripheral Pb+Pb Collisions – First Results

Analysis of the events with UPC triggers:

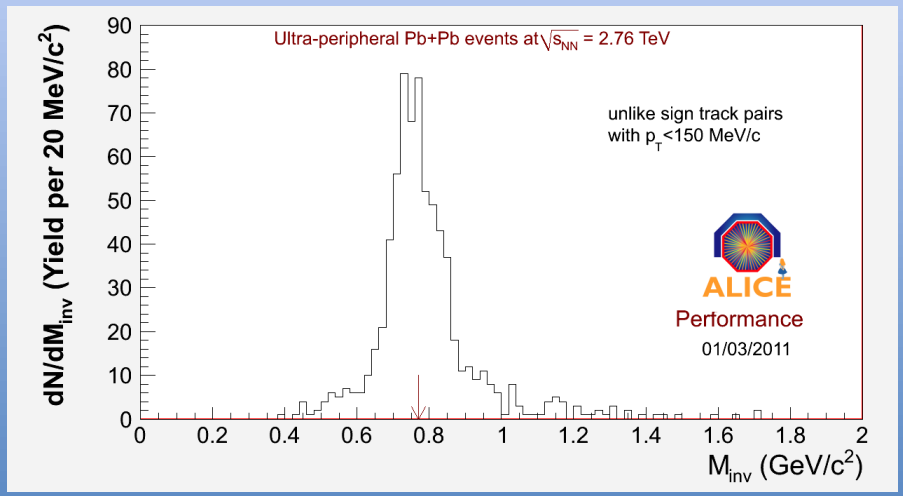
Start with OM2 trigger (TOF only).

Select events with 2 reconstructed tracks.

Plot m_{inv} and total p_T for these events



Uncorrected M_{inv} distribution of events in the low p_T peak indicates ρ^0 production. The peak may be distorted by experimental effects (min. p_T for a track) and a non-resonant $\pi\pi$ term.

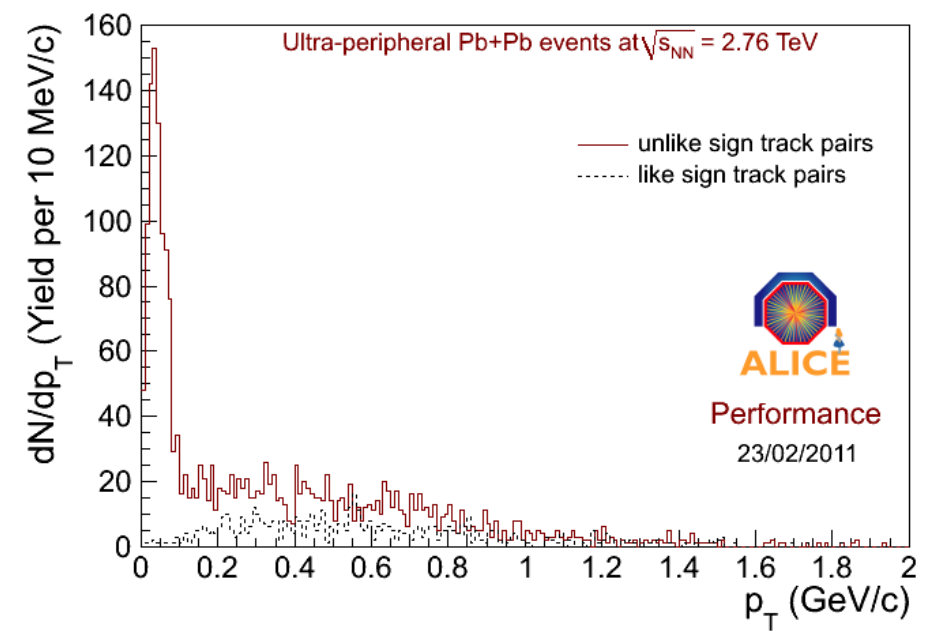


Coherent peak at low p_T seen in unlike-sign combinations, absent in like-sign combinations.

Ultra-peripheral Pb+Pb Collisions – First Results

Analysis of the events with UPC triggers:

Similar analysis for the CCUP2 trigger.



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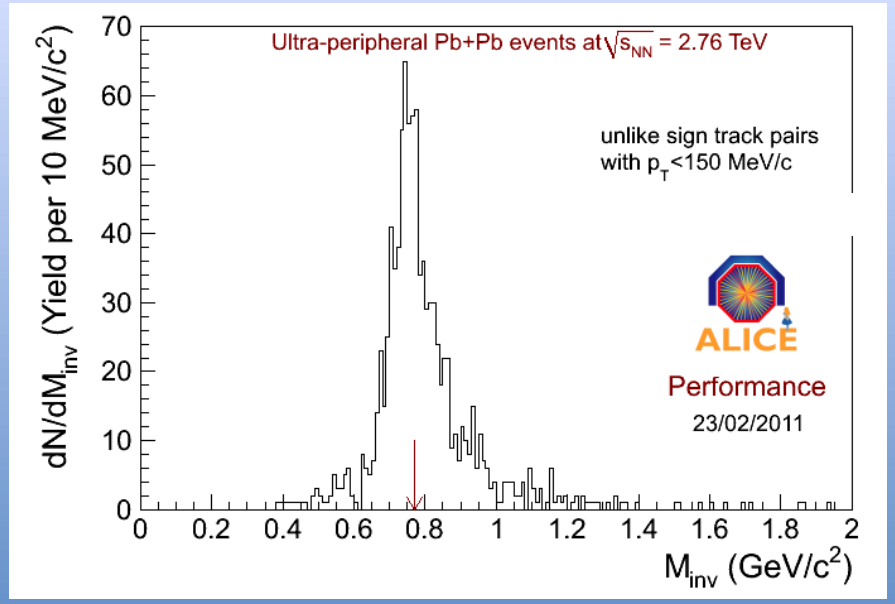
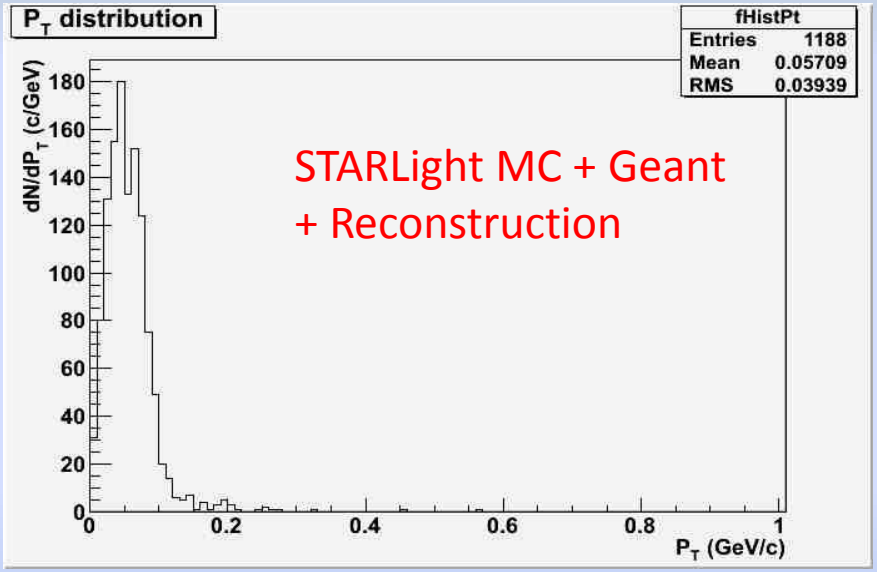
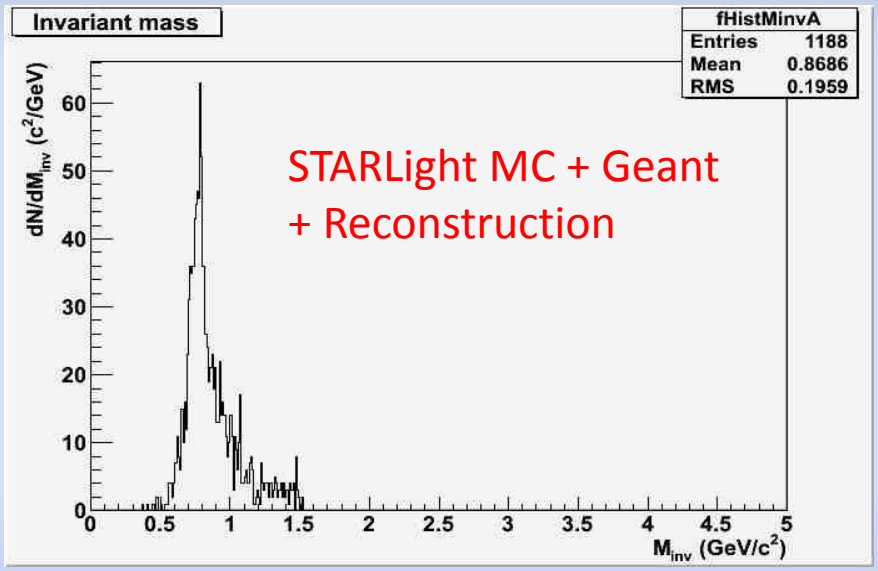
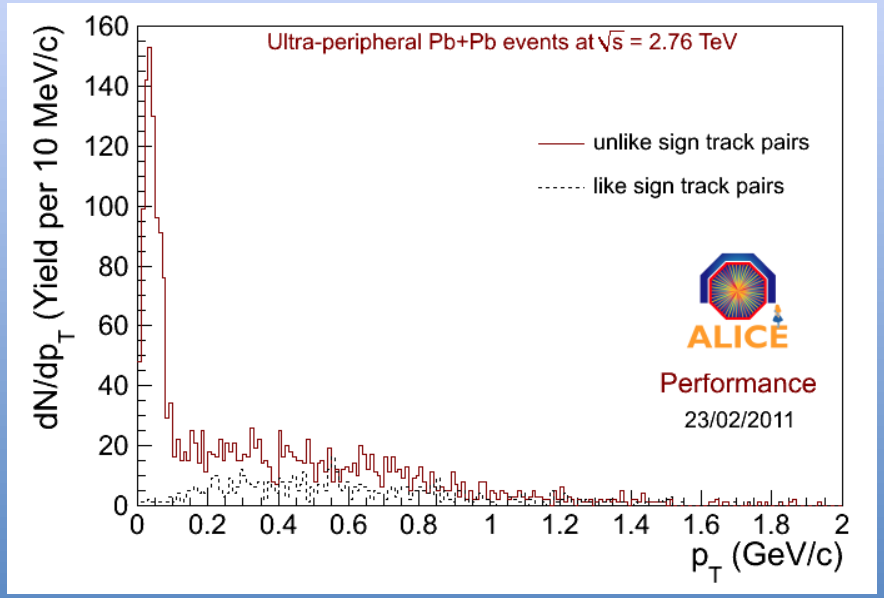


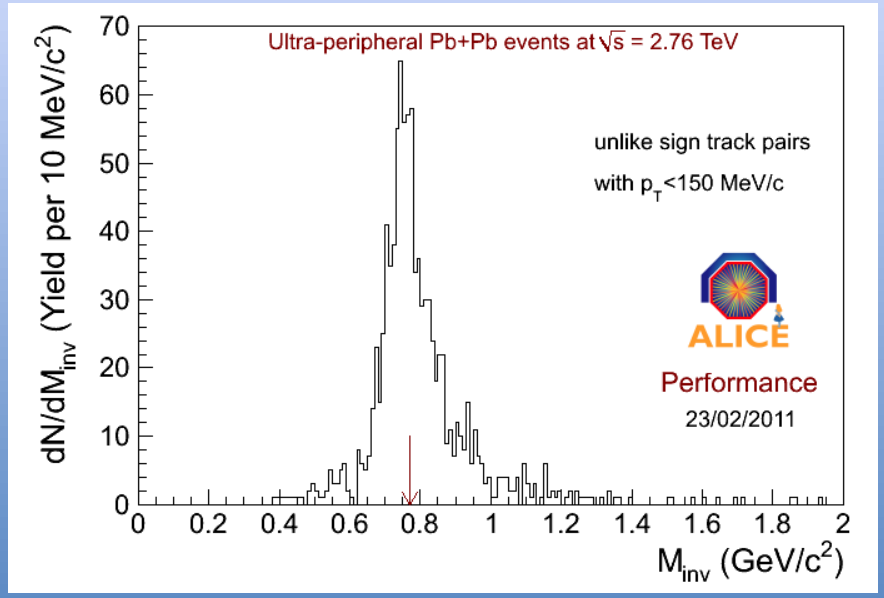
Both trigger samples show coherent photoproduction of ρ^0.

Ultra-peripheral Pb+Pb Collisions – First Results









Ultra-peripheral Pb+Pb Collisions – Outlook

Data from 2010:

- Determine the ρ^0 photoproduction cross section
  Mid-rapidity $\leftrightarrow$ γ-nucleon CM energy $W_{\gamma p}$ = 45 GeV.
  Earlier measurements with fixed target electron beams $W_{\gamma p}$ = 3 – 4 GeV and by STAR at RHIC $W_{\gamma p}$ = 12.5 GeV.
- Use ZDC information to study production with and without nuclear break up.
- Search for $J/\Psi \rightarrow e^+e^-$ and for $\gamma\gamma \rightarrow e^+e^-$ in data taken with the OM2 and CCUP2 triggers.
- Analyse data from the muon arm trigger. Search for photoproduction of $J/\Psi \rightarrow \mu^+\mu^-$ and for $\gamma\gamma \rightarrow \mu^+\mu^-$.

Ultra-peripheral Pb+Pb Collisions – Outlook

Future runs (not a complete list):

- Develop the triggers to reduce background rates and avoid scale-down.

  Both SPD and TOF have the possibility to apply cuts on "topology" at Level-0. Coherent production of high-mass particles have two tracks back-to-back in TOF.

- Obtain high-statistics sample of photoproduced J/Ψ. Should provide a measure of the nuclear gluon shadowing.

- Probe $\gamma\gamma \rightarrow e^+e^-$ and $\mu^+\mu^-$ at high invariant masses. Search for strong field QED effects.

- Measure photoproduction of ϒ.

Conclusions

- The Ultra-Peripheral Collision triggers in ALICE worked.
- Photoproduction of ρ^0 observed. Cross section to be determined.
- Search ongoing for J/ Ψ and heavier states. Candidates have been found.
- Improved UPC triggers and higher luminosities in future heavy-ion runs will enable rarer final states to be probed.