Study of the central exclusive production of $\pi^+\pi^-$, $K^+K^-$ and $p\bar{p}$ pairs in proton-proton collisions at $\sqrt{s} = 510$ GeV with the STAR detector at RHIC

Tomáš Truhlář
for the STAR collaboration

Faculty of Nuclear Sciences and Physical Engineering
Czech Technical University in Prague

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Central exclusive production and experimental setup

Central exclusive production:

- Colliding protons stay intact and are measured in the Roman Pots
- Produced central system $X$ is well separated by rapidity gaps from the outgoing protons $p$
- Central system $X$ is fully measured in the TPC and in the TOF systems
- Double Pomeron Exchange is expected to be dominant at the RHIC energies
- Each proton "emits" a Pomeron, the Pomerons fuse and produce neutral system $X$
- Focusing on $p + p \rightarrow p h^+ h^- p$, where $h^+ h^-$ stands for $\pi^+ \pi^-$, $K^+ K^-$ and $p \bar{p}$
- For the exclusive process $p_{T}^{\text{miss}} = (\vec{p}_1 + \vec{p}_2 + \vec{h}_+ + \vec{h}_-) = 0$
  because of the conservation of momentum $\Rightarrow$ events with small $p_{T}^{\text{miss}}$ are Exclusive

STAR’s unique capabilities for CEP study:

- High-resolution tracking of charged particles in the TPC covering $|\eta| < 1$ and full azimuthal angle
- Precise particle identification through the measurement of dE/dx and TOF
- Forward rapidity Beam-Beam Counters $2.1 < |\eta| < 5.0$ used to ensure rapidity gaps
- Silicon Strip Detectors in Roman Pots allowing full reconstruction of the forward proton momentum
Data sample & event selection

Data sample:
- Data from proton-proton collisions at $\sqrt{s} = 510$ GeV
- 622M CEP triggers were analyzed

Events selection:
- Exactly two tracks in Roman Pots inside the $p_x, p_y$ fiducial region with all eight silicon planes used in reconstruction
- Exactly two primary TPC tracks matched with two TOF hits and originating from the same vertex
- Total charge of those tracks equals 0 (looking for $h^+ h^-$)
- $|z$-position of vertex$| < 80$ cm
- Good TPC track quality cuts and $|\eta| < 0.7$
- Four momentum transfer squared $t$ at the proton vertices $0.12$ GeV$^2 < -t < 1.0$ GeV$^2$
- Sum of the transverse momentum of the measured particles $p_T^{\text{miss}} < 100$ MeV
- Particles were identified using the dE/dx and TOF
- After all the above selection criteria: 62077 $\pi^+ \pi^-$, 1697 $K^+ K^-$ and 125 $p\bar{p}$
Results, summary and outlook

Summary:
- The first results on the central exclusive production of $\pi^+\pi^-$, $K^+K^-$ and $p\bar{p}$ pairs in proton-proton collisions at $\sqrt{s} = 510$ GeV measured by the STAR experiment at RHIC have been presented.
- Invariant mass of $\pi^+\pi^-$ shows the expected features, a drop at about 1 GeV and a peak consistent with the $f_2(1270)$.
- Measurement of the diffractively scattered protons allowed full control of the interaction's kinematics and verification of its exclusivity.

Outlook:
- There are ongoing studies of $\pi^+\pi^-$, $K^+K^-$, $p\bar{p}$ and $\pi^+\pi^-\pi^+\pi^-$ channels.
- An analysis involving the partial wave analysis in the $\pi^+\pi^-$ channel is planned.

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Tomáš Truhlář (FNSPE, CTU)