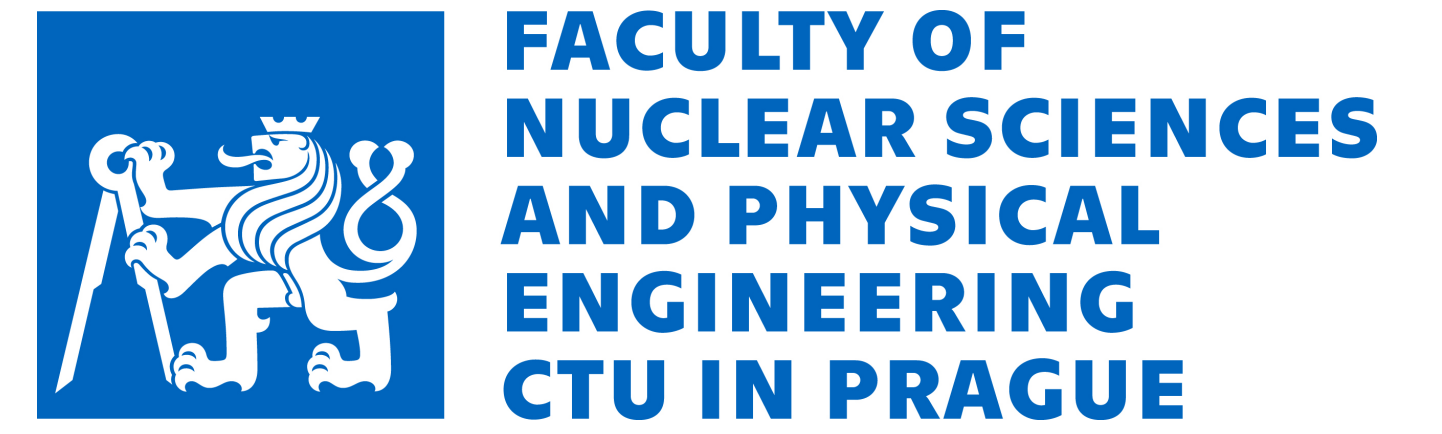


Study of the central exclusive production of $\pi^+\pi^-$, K^+K^- and $p\bar{p}$ pairs in proton-proton collisions at $\sqrt{s} = 510$ GeV with the STAR detector at RHIC



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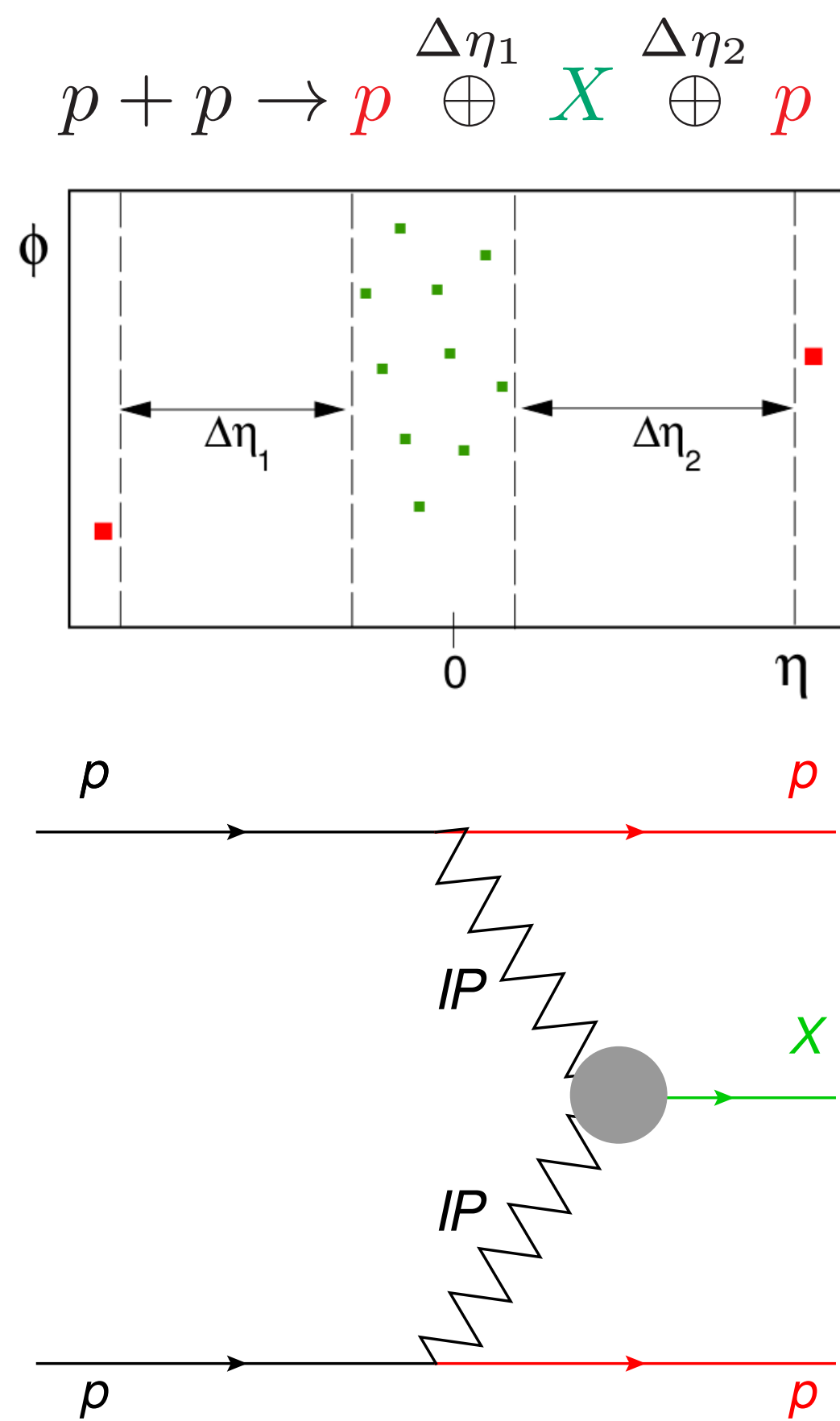


ABSTRACT

We report on the measurement of the central exclusive production process $pp \rightarrow pXp$ in proton-proton collisions at RHIC with the STAR detector at $\sqrt{s} = 510$ GeV. At this energy, this process is dominated by a Double Pomeron Exchange mechanism. The tracks of the centrally produced system X were reconstructed in the central detector of STAR, the Time Projection Chamber and the Time of Flight systems, and identified using the ionization energy loss and the time of flight method. The diffractively scattered protons, moving intact inside the RHIC beam pipe after the collision, were measured in the Roman Pots system allowing full control of the interaction's kinematics and verification of its exclusivity. The preliminary results on the invariant mass distributions of centrally produced $\pi^+\pi^-$, K^+K^- and $p\bar{p}$ pairs measured within the STAR acceptance are presented.

1. CENTRAL EXCLUSIVE PRODUCTION (CEP)

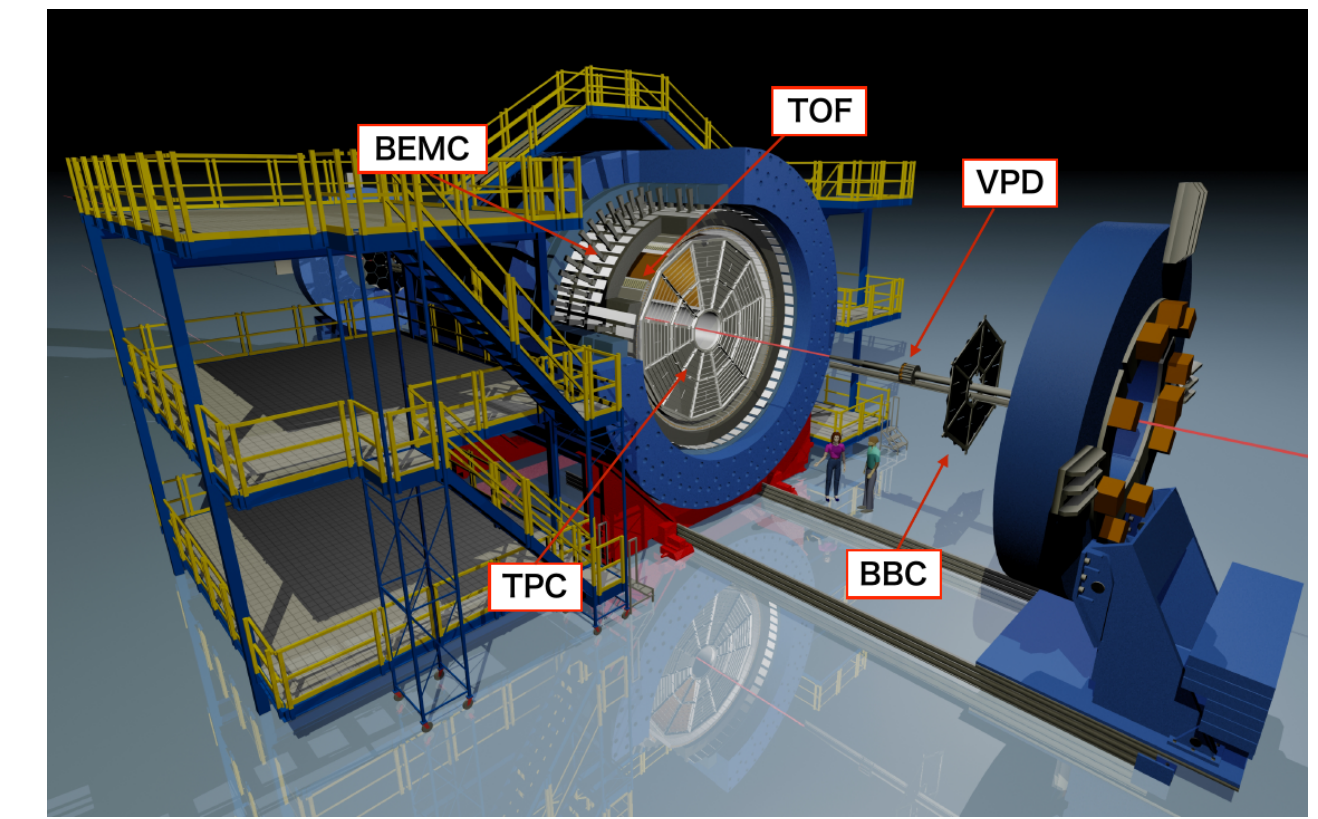
- Colliding protons stay intact and are measured in the Roman Pots
- Produced **central** system X is well separated by rapidity gaps from the outgoing protons p
- Central** system X is fully measured in the Time Projection Chamber (TPC) and in the Time of Flight (TOF) systems
- Double Pomeron Exchange 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 $p_T^{miss} = (\vec{p}_1 + \vec{p}_2 + \vec{h}_+ + \vec{h}_-)_T = 0$ because of the conservation of momentum \Rightarrow events with small p_T^{miss} are **Exclusive**



2. EXPERIMENTAL SETUP

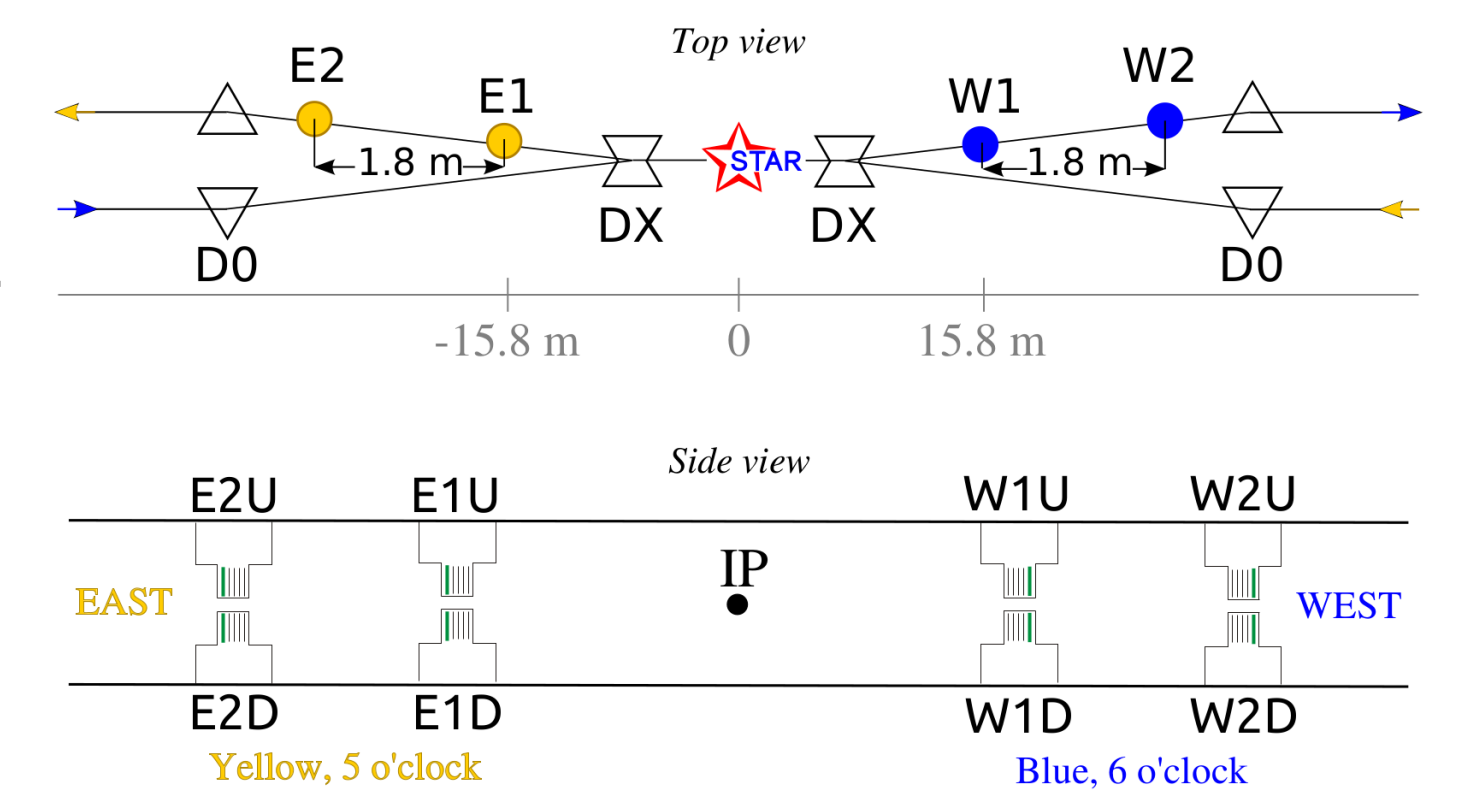
STAR's unique capabilities for CEP study:

- 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 (RP) for measurement of forward protons



Roman Pot Phase II*:

- Roman Pot Phase II* has been used since 2015 and allowing full reconstruction of the forward proton momentum
- Eight Silicon Strip Detector (SSD) packages installed in RP vessels with active area of roughly $79 \text{ mm} \times 49 \text{ mm}$
- Each package contains a scintillation trigger counter and four SSDs (two measuring horizontal and two vertical coordinate) with spatial resolution of $\approx 30 \mu\text{m}$
- Detectors are mounted in four stations, two stations on each side of STAR
- Each station contains one RP above and one RP below the beamline



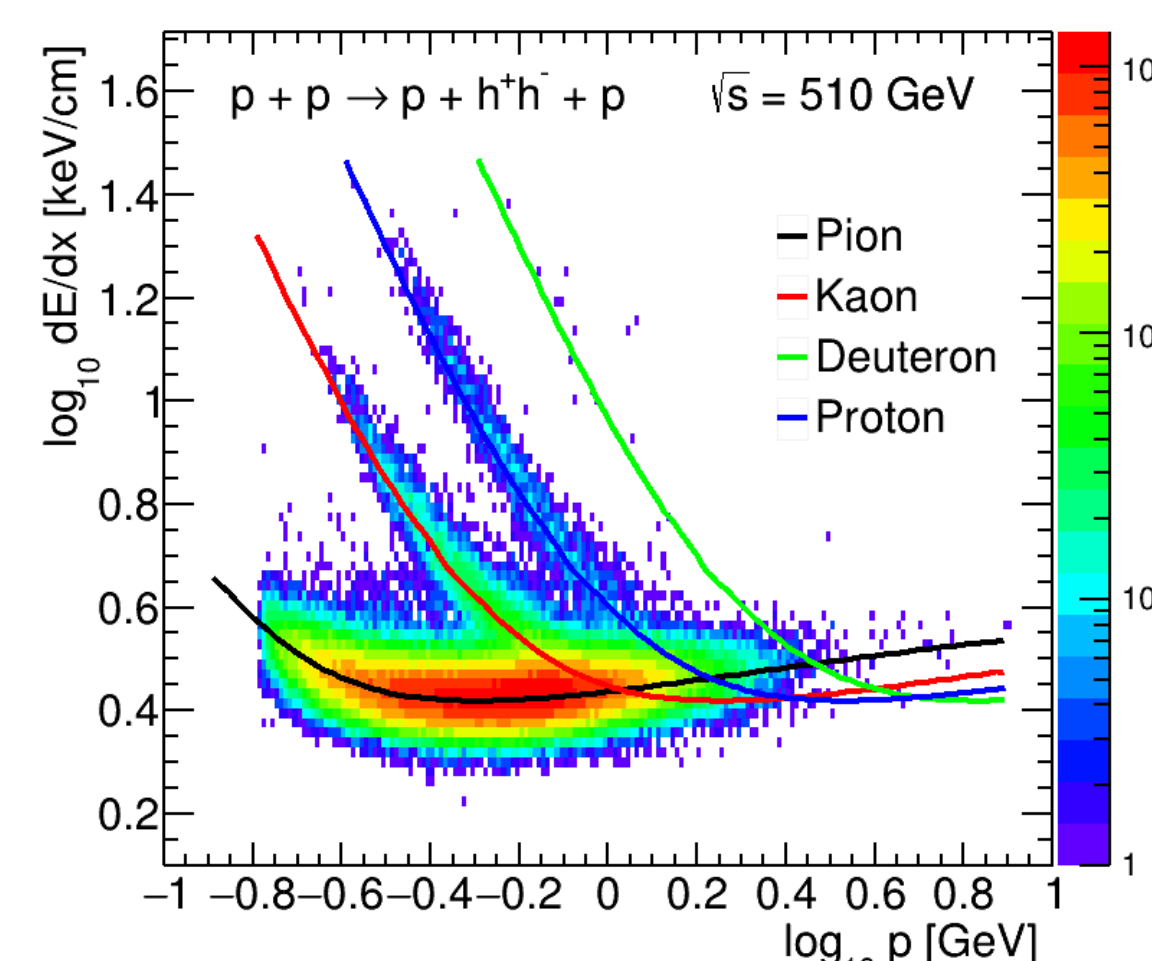
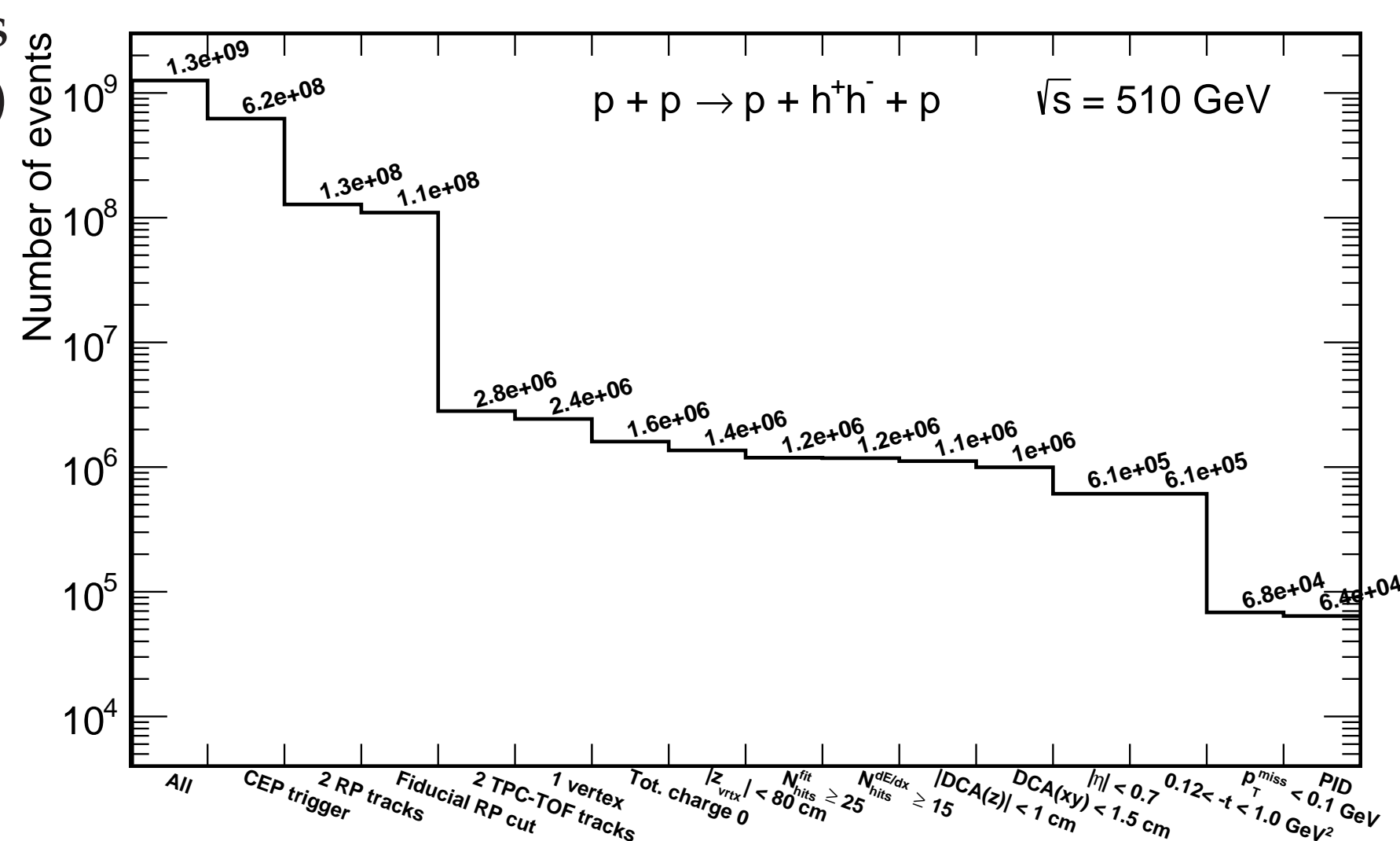
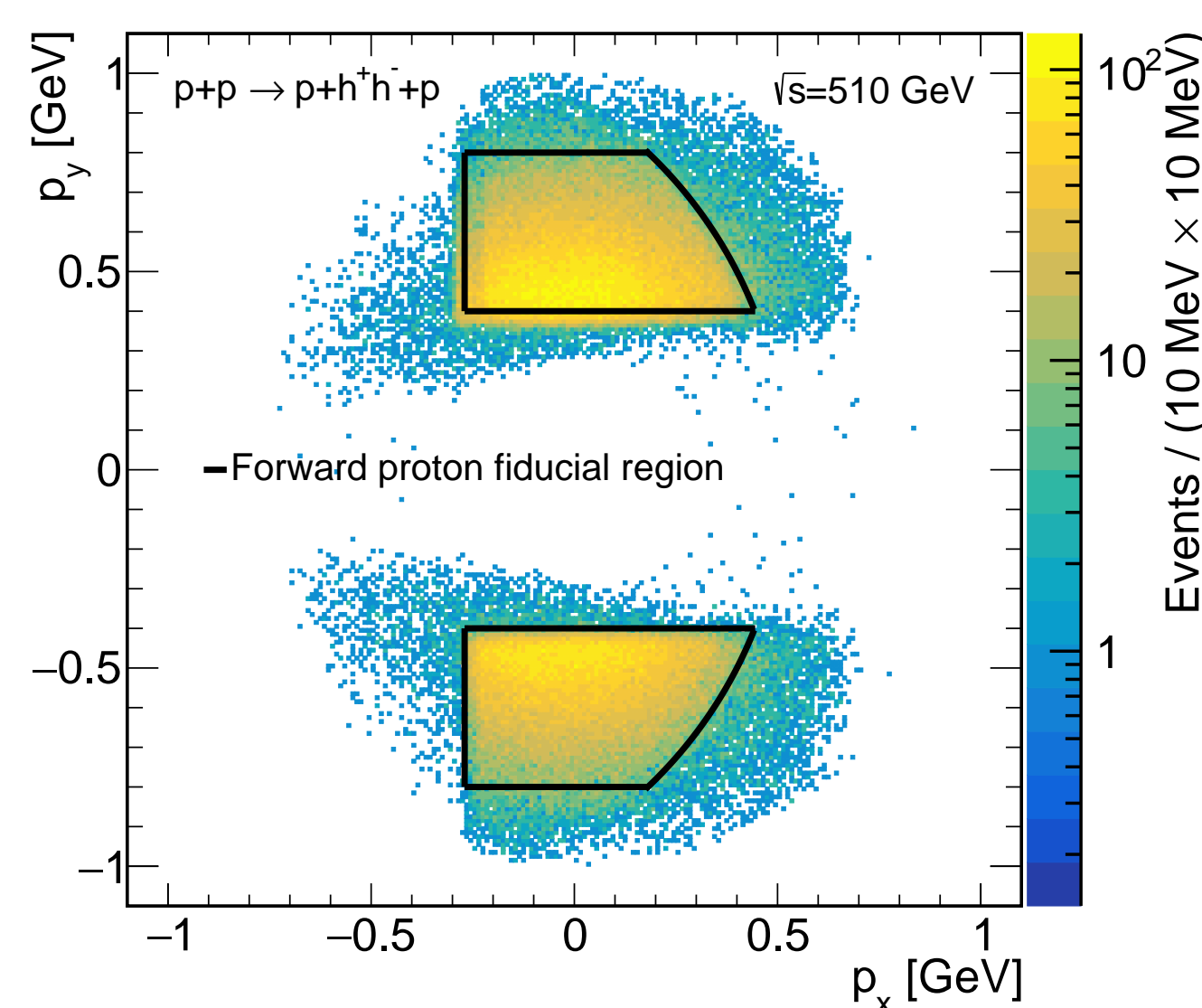
3. DATA SAMPLE & EVENT SELECTION

Data sample:

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

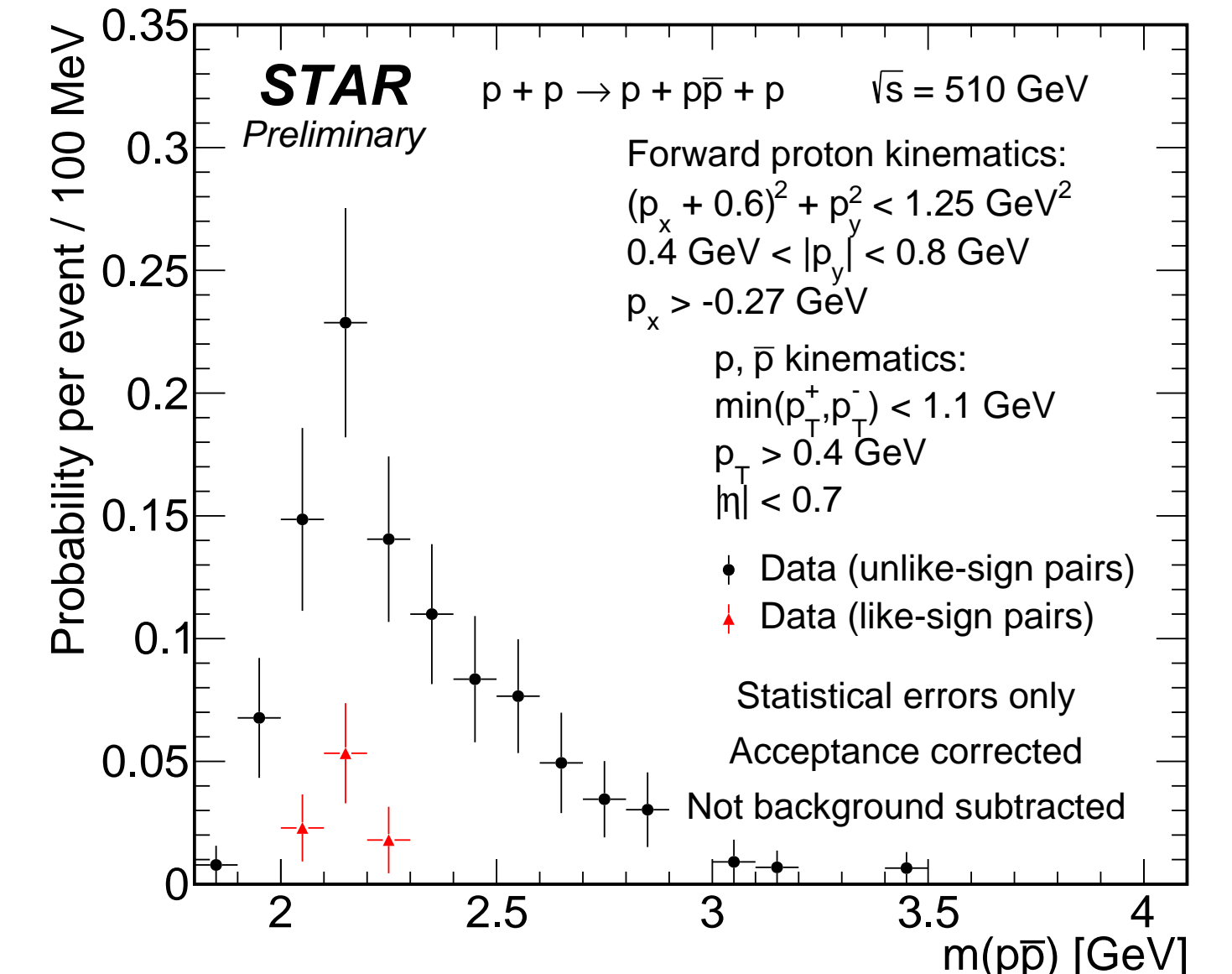
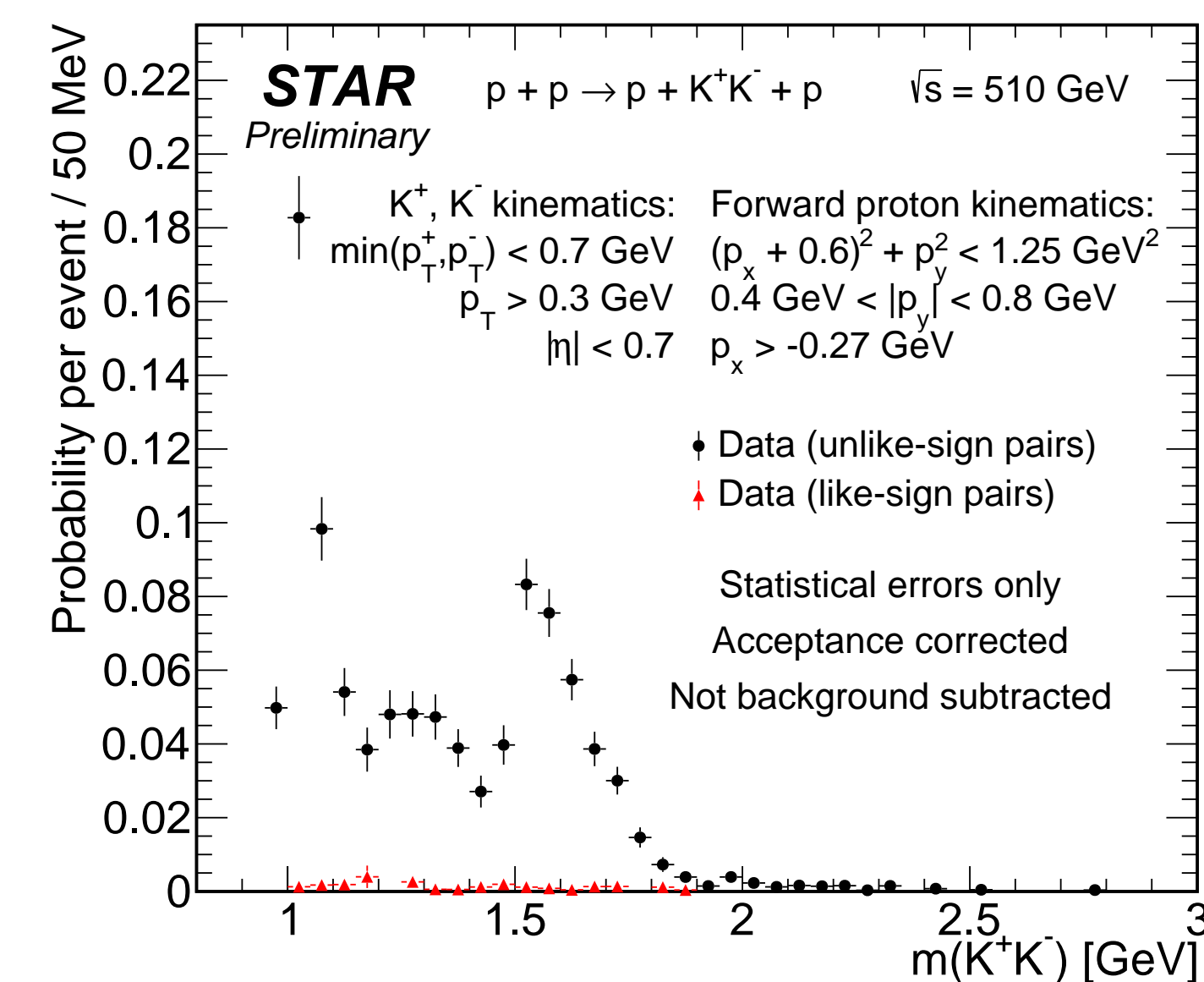
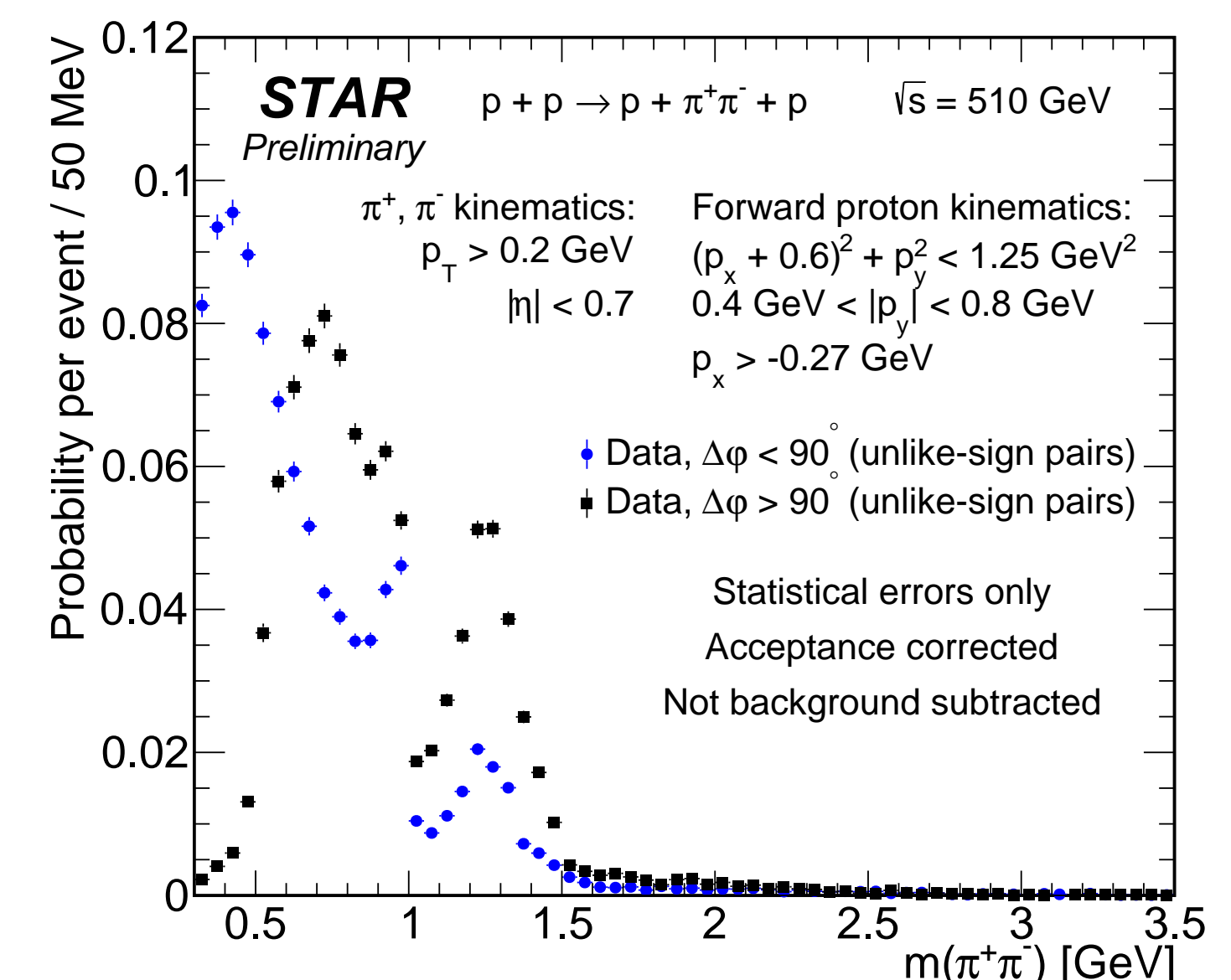
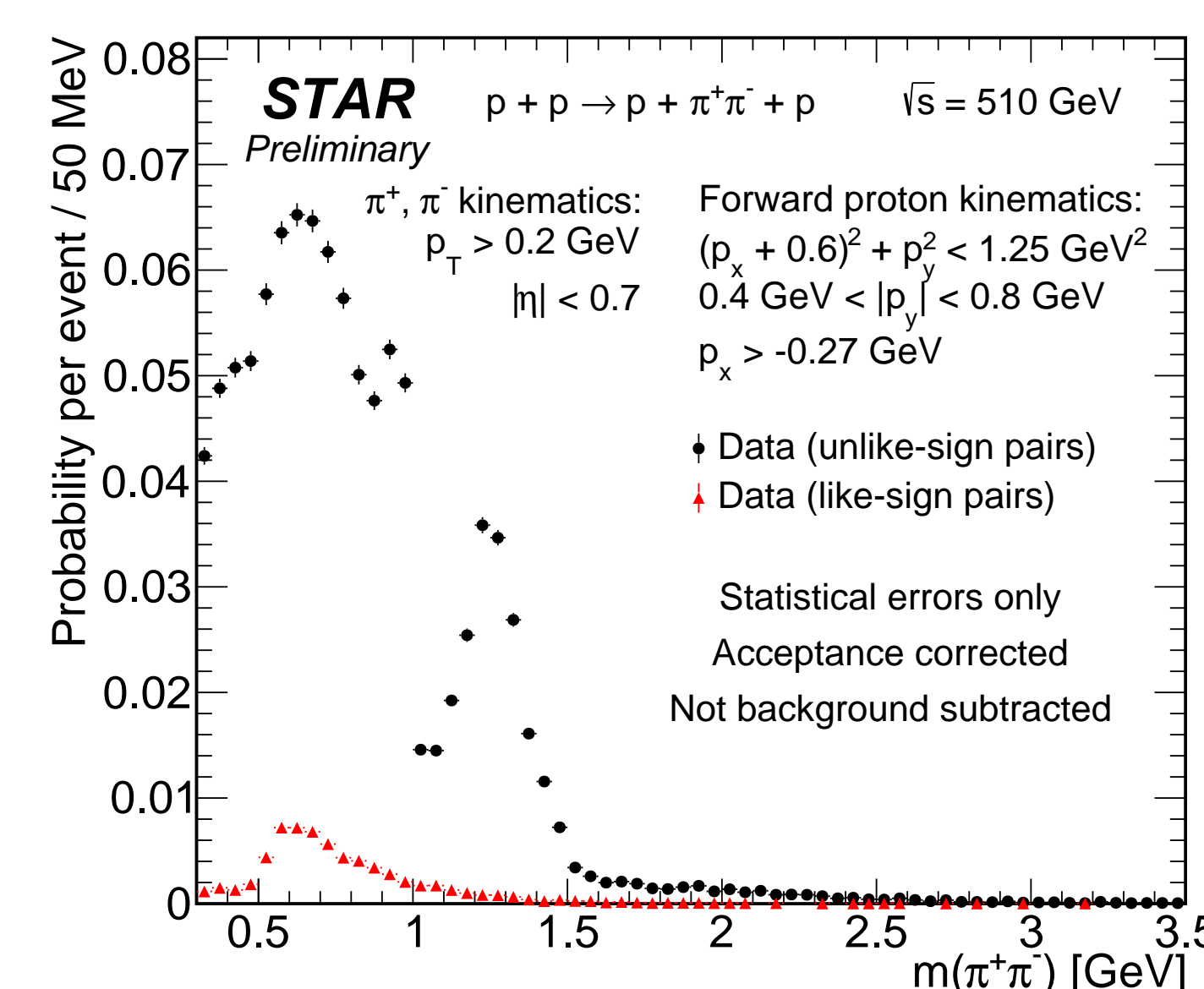
Event selection:

- 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 zero (looking for h^+h^-)
- $|z\text{-position of vertex}| < 80 \text{ cm}$
- Good quality TPC tracks cuts
 - $N_{hits}^{fit} \geq 25$
 - $N_{hits}^{dE/dx} \geq 15$
 - $|DCA(z)| < 1 \text{ cm}$
 - $DCA(xy) < 1.5 \text{ cm}$
 - $|\eta| < 0.7$
- Four momentum transfer squared t at the proton vertices $0.12 \text{ GeV}^2 < -t < 1.0 \text{ GeV}^2$
- Sum of the transverse momentum of the measured particles $p_T^{miss} < 100 \text{ MeV}$
- Particles were identified using the measurement of dE/dx and TOF (m^2 method)
- After all the above selection criteria: 62077 $\pi^+\pi^-$, 1697 K^+K^- and 125 $p\bar{p}$



4. RESULTS

- We present the invariant mass distributions of centrally produced $\pi^+\pi^-$, K^+K^- and $p\bar{p}$ pairs measured within the STAR acceptance
- The invariant mass distribution of $\pi^+\pi^-$ in two regions of $\Delta\varphi$, where $\Delta\varphi$ is the difference of azimuthal angles of the forward protons
- Invariant mass of $\pi^+\pi^-$ shows the expected features, a dip at about 1 GeV and a peak consistent with the $f_2(1270)$



ACKNOWLEDGMENT

- The work was supported from the project LTT18002 of the Ministry of Education, Youth, and Sport of the Czech Republic and from European Regional Development Fund-Project "Center of Advanced Applied Science" No. CZ.02.1.01/0.0/0.0/16-019/0000778.



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education



5. SUMMARY & OUTLOOK

- 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
- There are ongoing studies of $\pi^+\pi^-$, K^+K^- , $p\bar{p}$ and $\pi^+\pi^-\pi^+\pi^-$ channels and an analysis involving the partial wave analysis is planned