Paper Proposal on:
Results on Elastic Cross Sections in Proton--Proton Collisions at √s = 510 GeV

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- **Title:**

  Results on Elastic Cross Sections in Proton--Proton Collisions at √s = 510 GeV

- **PAs:**

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Proposed Target Journal: Physics Letters B

Webpage: Only a framework at this time: GPCElasticScattering510GeV

Analysis Note: to be done

Analysis Information

- Data set: Run 17, RHICf period with special $\beta^* \approx 8\ m$
- Year: 2017
- Production tag: **P18ih,** st_rp stream ,upcDSTs from microDSTs
- Triggers used: RP_ET triggers
- Embedding: no embedding needed, background and effciencies estimated from data driven method.

Abstract

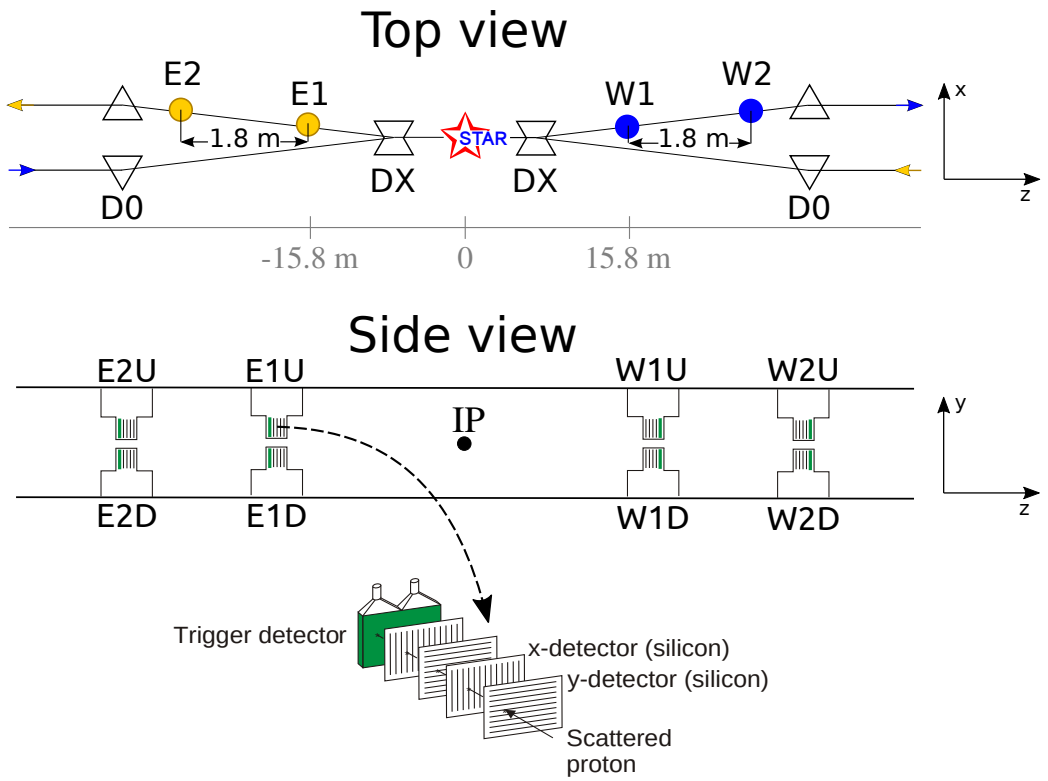
Results on Elastic Cross Sections in Proton–Proton Collisions at $\sqrt{s} = 510$ GeV

(Dated: January 3, 2021)

We report results on elastic cross sections in proton-proton collisions at $\sqrt{s} = 510$ GeV obtained with the Roman Pot setup of the STAR experiment at the Relativistic Heavy Ion Collider (RHIC). The elastic differential cross section was measured in the squared four-momentum transfer range $0.16 \leq -t \leq 1.01$ GeV^2. The value of the exponential slope parameter B of the elastic differential cross section $d\sigma/dt \sim e^{-Bt}$ in the measured $-t$ range $0.21 \leq -t \leq 0.60$ GeV^2 was found to be $B = 13.55 \pm 0.04(stat.) \pm 0.03(syst.)$ GeV^{-2} We also present the elastic cross section integrated within the STAR t-range $\sigma_{el}^{det} = 1.491 \pm 0.004(stat.) \pm 0.057(syst.)$ mb. We compare $d\sigma_{el}/dt$ in the measured t-range measured in in $p\bar{p}$ collisions at $\sqrt{s} = 546$ GeV by the UA4 experiment at the S$p\bar{p}$S collider. The measured difference in the diffractive minimum region $-t$ range $0.75 \leq -t \leq 0.99$ GeV^2 is 2.44 ± 0.28 mb. Such difference is commonly explained by the C-odd amplitude in the pp and $p\bar{p}$ elastic scattering at $\sqrt{s} = 510$ GeV.

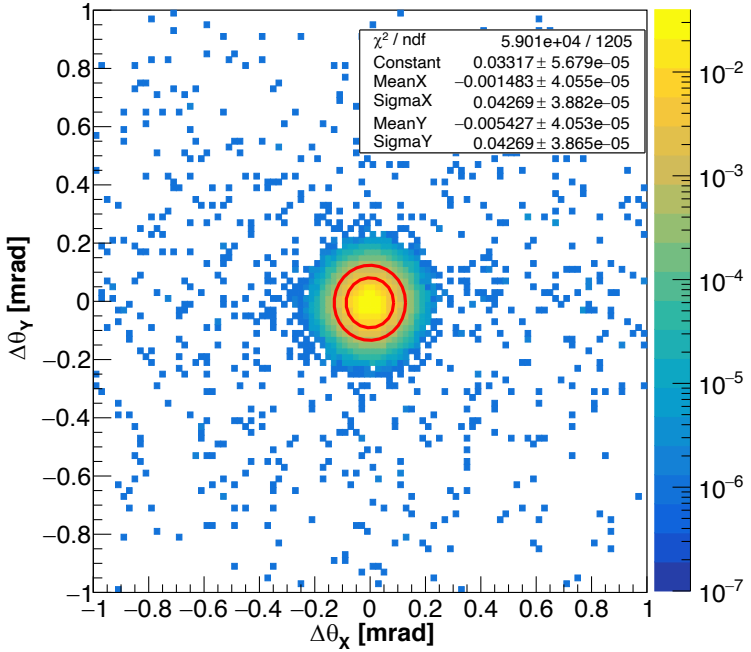
PACS numbers: 13.85.Dz, 13.85.Lg
Keywords: Elastic Scattering, Diffraction, Proton-Proton Collisions

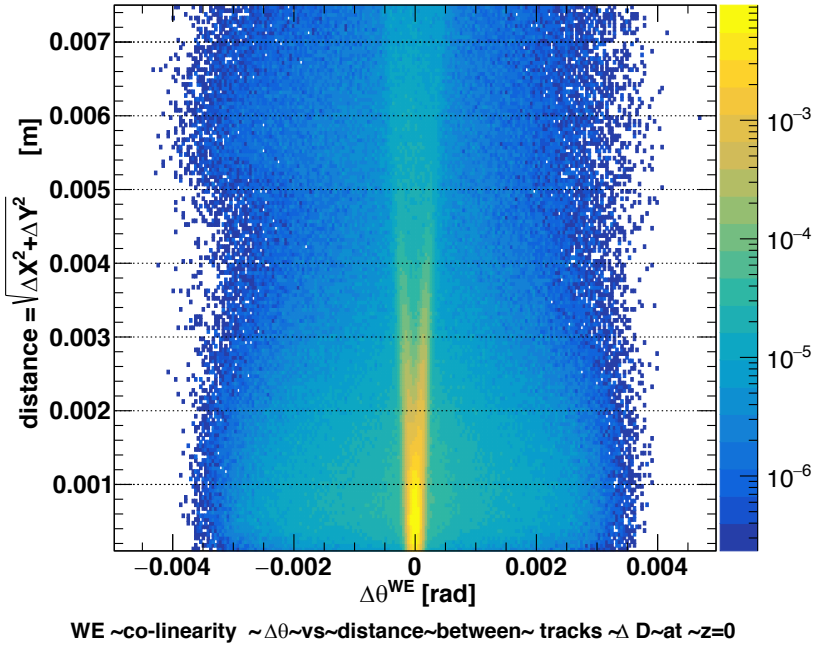
Figure 1: ExperimentaL Setup



Caption: The layout of the RPs with the STAR detector (not to scale). The Roman Pot setup at STAR for measuring forward protons. Two sets of RPs are positioned between DX and D0 magnets, at 15.8 m and 17.6 m from the IP. Top and side view are shown.

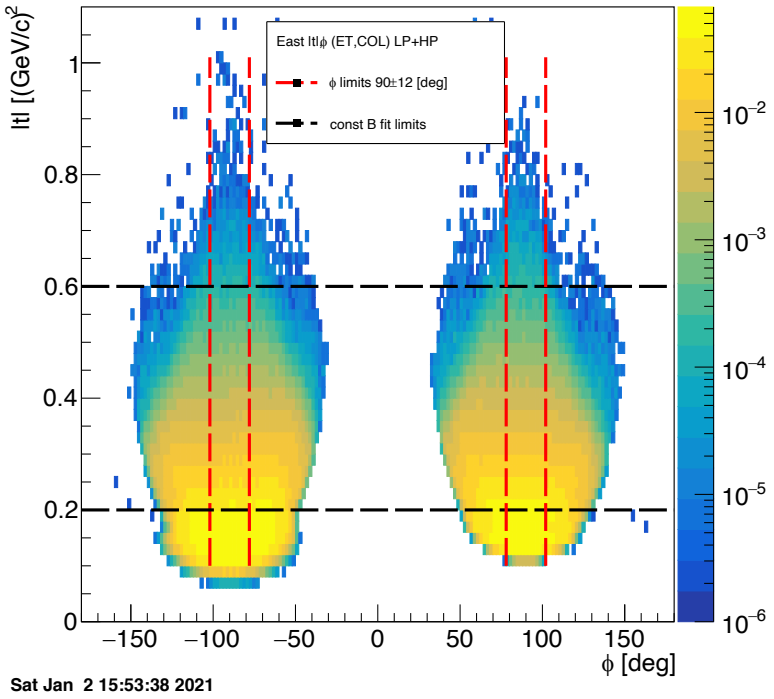
Figure 2: Collinearity





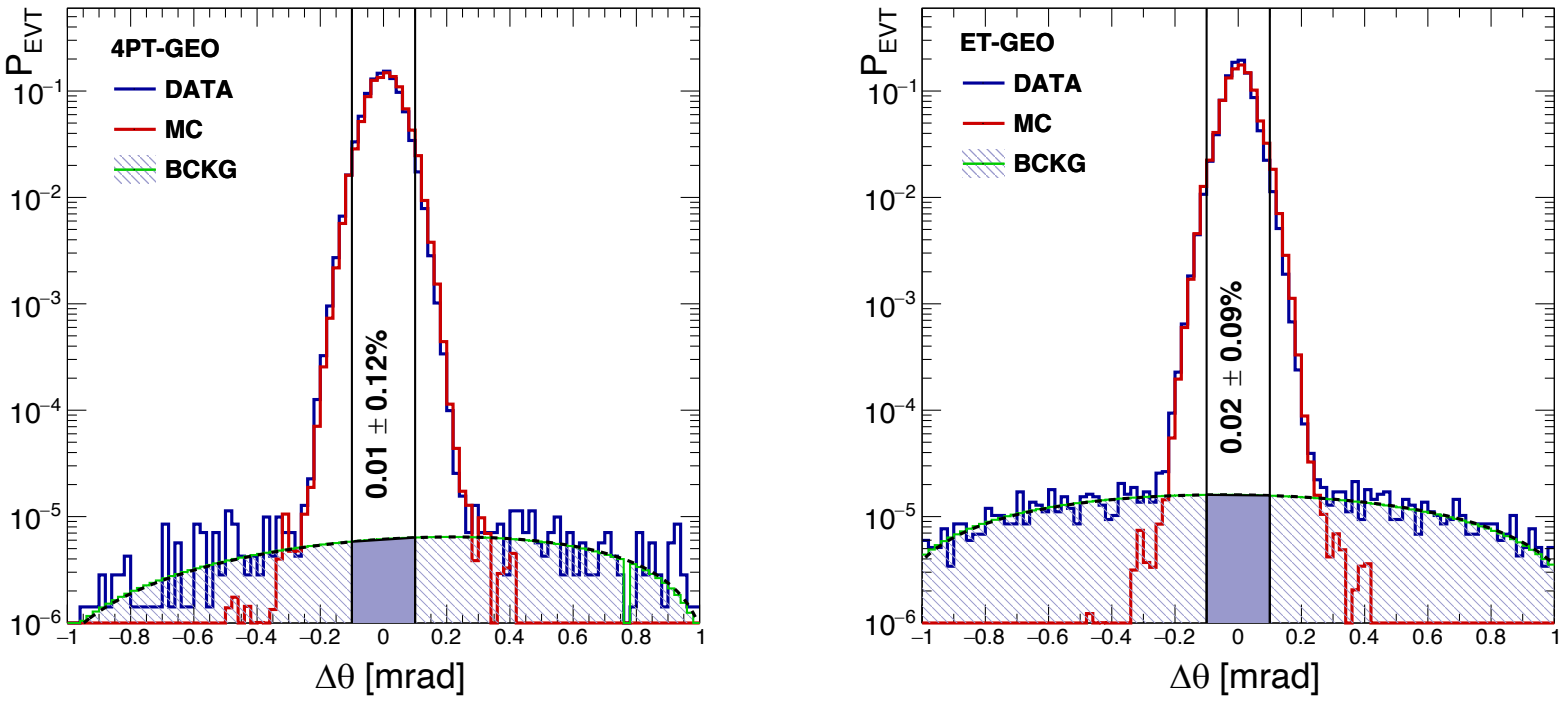
Caption: $\Delta\Theta_y$ vs $\Delta\Theta_x$ with the contours of 2σ and 3σ for 4 PT and 3Pt events. Cuts on Δ are at z=0.

Figure 3: Geometrical Acceptance – Choice of Fiducial Volume in (-t, ϕ) Space



Caption: |t| vs ϕ distributions from data for 3PT events for two elastic arms. The boundaries of geometrical acceptance cuts for B-slope fit and for the full t-region are shown.

Figure 4: Background and Collinearity in $\Delta\theta$

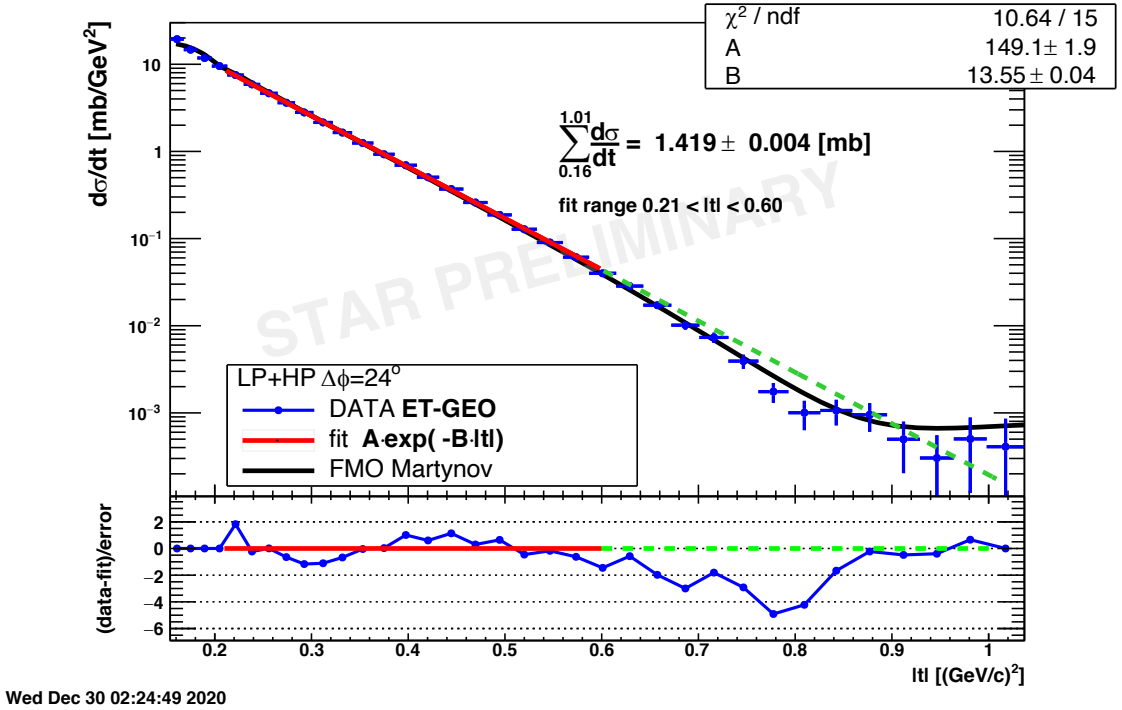


Caption: Collinearity in scattering angle Θ between the outgoing protons is shown. Background levels extrapolated from outside of $\pm 5\sigma_\theta$. They were small and therefore neglected.

Systematic Uncertainties

1. The main systematic uncertainty in the differential cross section $d\sigma/dt$ is luminosity calibration. It is estimated to be 4% at this time, which is what was achieved for the 200 GeV paper.
2. The main systematic uncertainty of comparison with UA4 is 10% normalization uncertainty of UA4 points.
3. To determine the systematic uncertainty in B-slope we varied the phase space of the fit ($\Delta\phi$, t) range , using 4PT and 3PT events), which yielded the uncertainty of 0.02.
4. The background was found to be small and was neglected.
5. The small values in 3 and 4 above are due to the fact that we chose the fiducial volume of the measurement away from the apertures and the beam halo.
6. Also small beam angular divergence allows relatively clean selection of the elastic events using colline.

Figure 5: Corrected $d\sigma_{el}/dt$ and B-slope

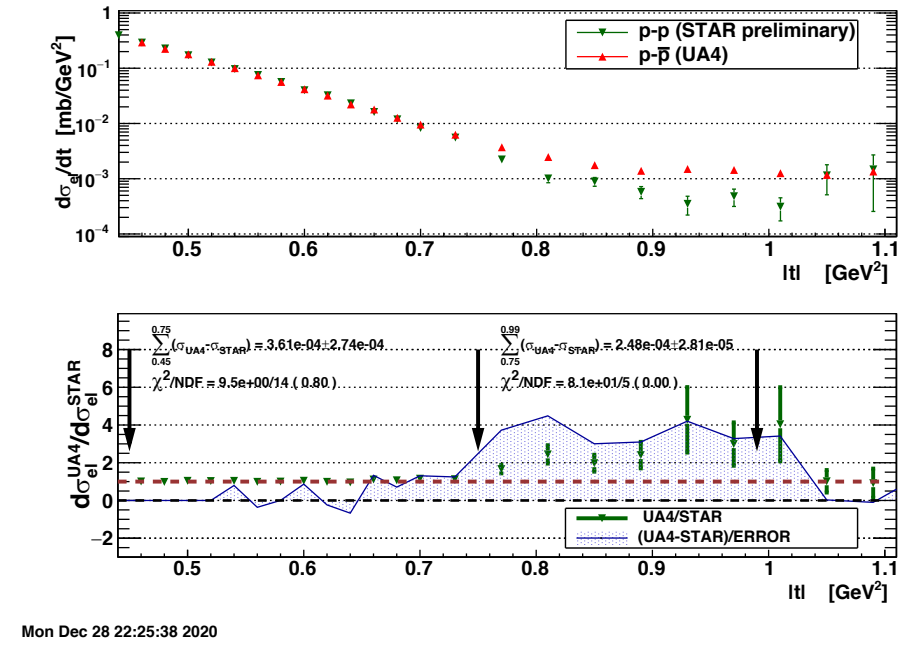


Average B = 13.55+-0.04(stat.)+-0.03(syst.)

Caption: Corrected differential cross-section dN/dt fitted with exponential $A \cdot e^{-Bt}$. The deviation from e^{-Bt} fit for $-t > 0.6$ GeV^2 is expected, due to the diffractive minimum at $-t \approx 0.85$ GeV^2 is also present.

Figure 6: The difference between pp and $p\bar{p}$ data in the dip region

To test the Odderon hypothesis it is important to compare with $p\bar{p}$ data at the same/similar energy.
STAR $\sqrt{s}$ = 510 GeV is sufficient to compare with $\sqrt{s}$ =546 of the UA4 experiment.



Caption: Comparison of STAR data with UA4 data. The upper plot shows dσ/dt and the bottom plot shows the ratio of UA4 to STAR data with the differences scaled by the uncertainties. The dip region's |t|-range is indicated by the arrows, as is the range outside of the dip region.

Conclusions

1. STAR measured elastic differential cross section in the |t|-range $0.16 < |t| < 1.01$ GeV^2.
2. The B-slope of dσ/dt in the $|t| - range\ 0.21 < |t| < 0.60\ GeV^2$ is $B = 13.55 \pm 0.04(stat.) \pm 0.03(syst.)$.
3. The measured difference in $d\sigma/dt$ between pp and $p\bar{p}$ is 2.44 ± 0.28 mb, with 10% normalization error in UA4 data.
4. The difference is consistent with existence of C-odd amplitude in pp and $p\bar{p}$ elastic scattering.
5. Integrated elastic scattering cross section, dσ/dt, within the STAR |t|-acceptance of $0.16 < |t| < 1.01\ GeV^2$ is $1.419 \pm 0.004\ (stat.)$ mb with 4% luminosity uncertainty error.