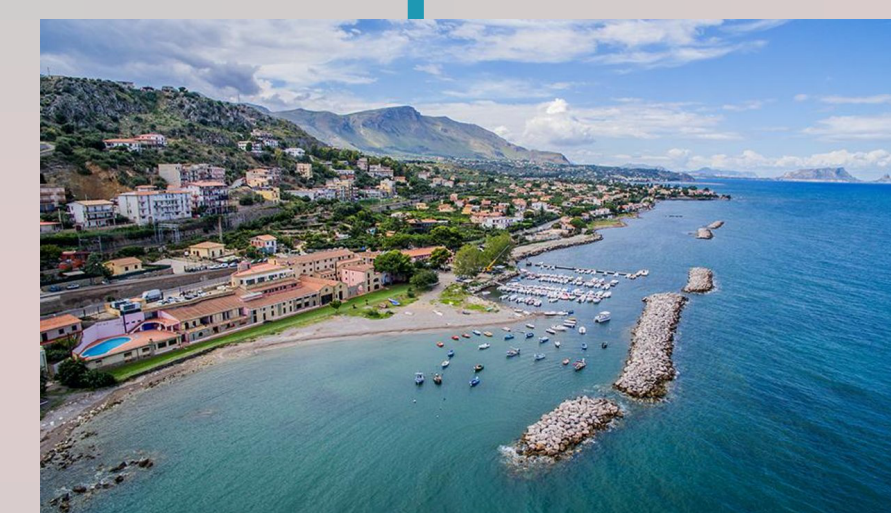
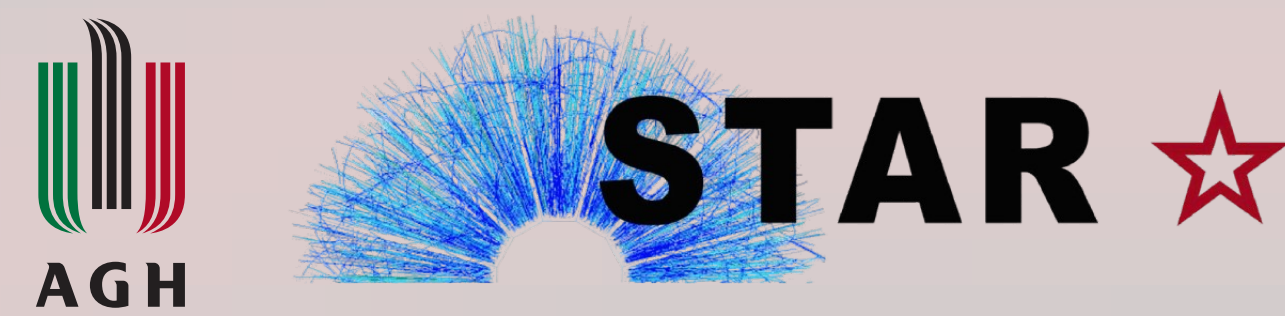


Single diffraction and elastic scattering in proton-proton collisions with the STAR detector at RHIC

Mariusz Przybycien, AGH University of Krakow
(on behalf of the STAR Collaboration)

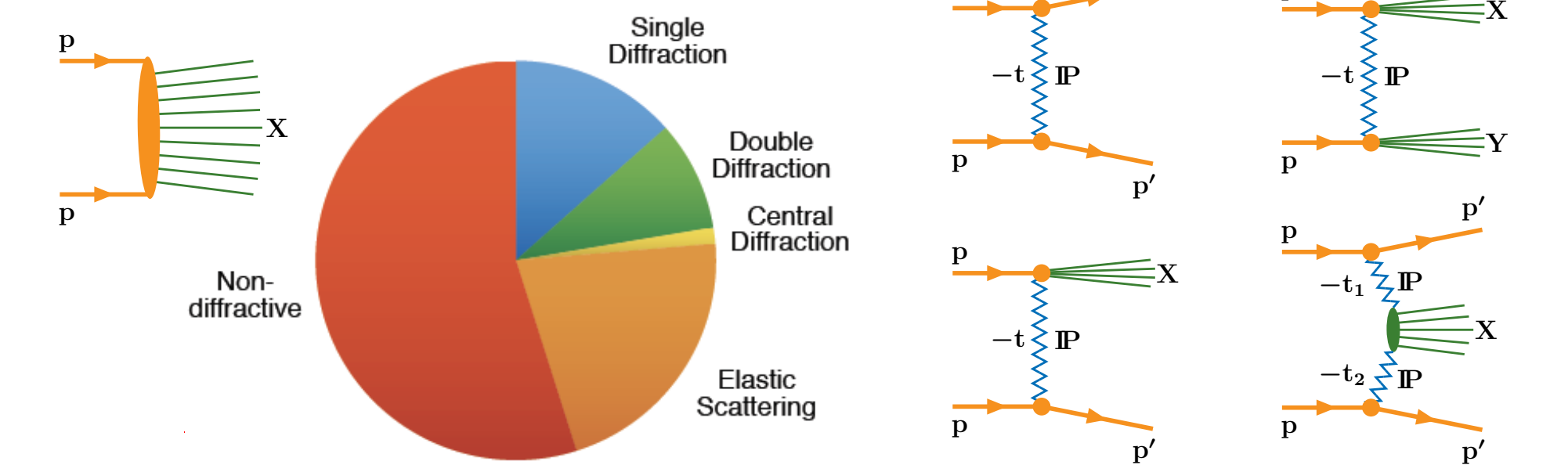


Trabia, Sicily, September 8-14, 2024

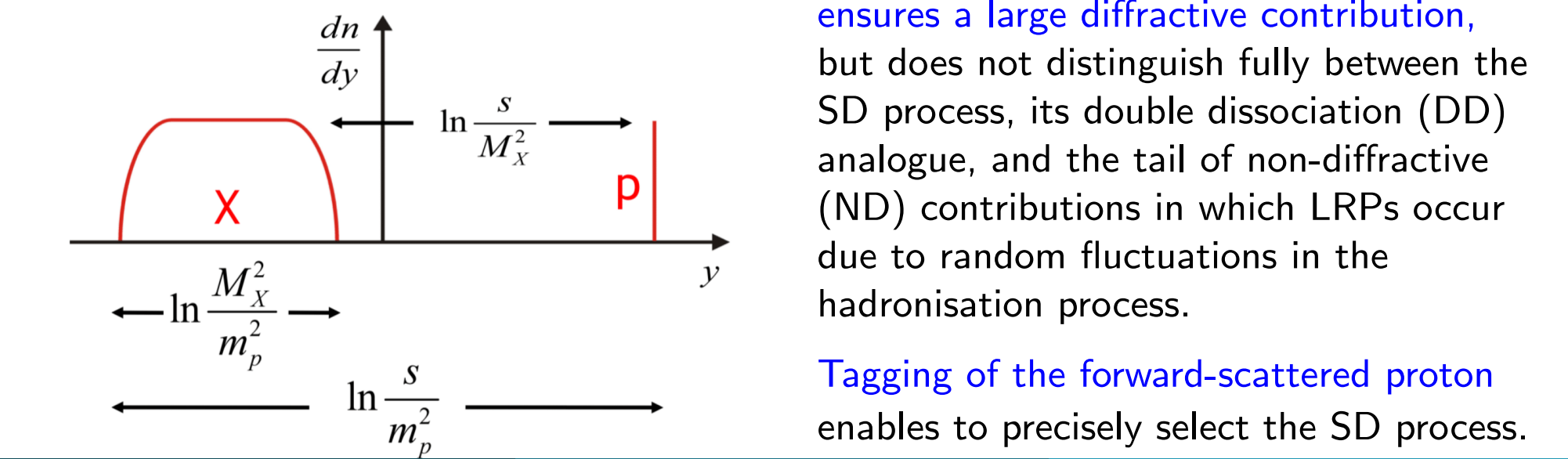


Diffraction in proton-proton scattering

Decomposing the total pp cross section:



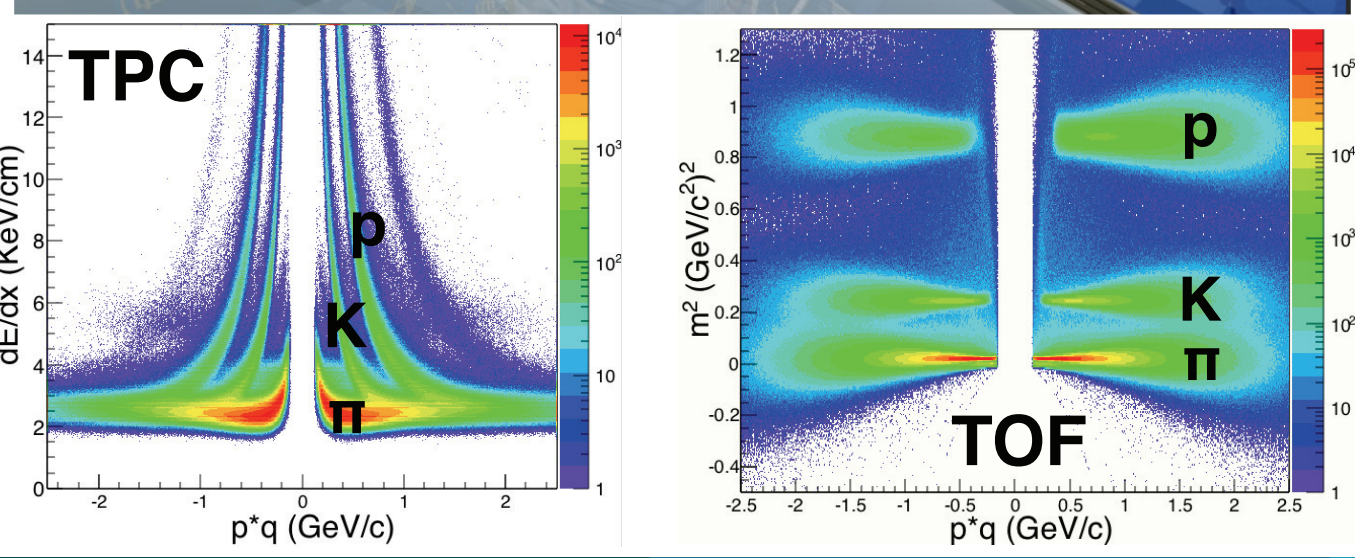
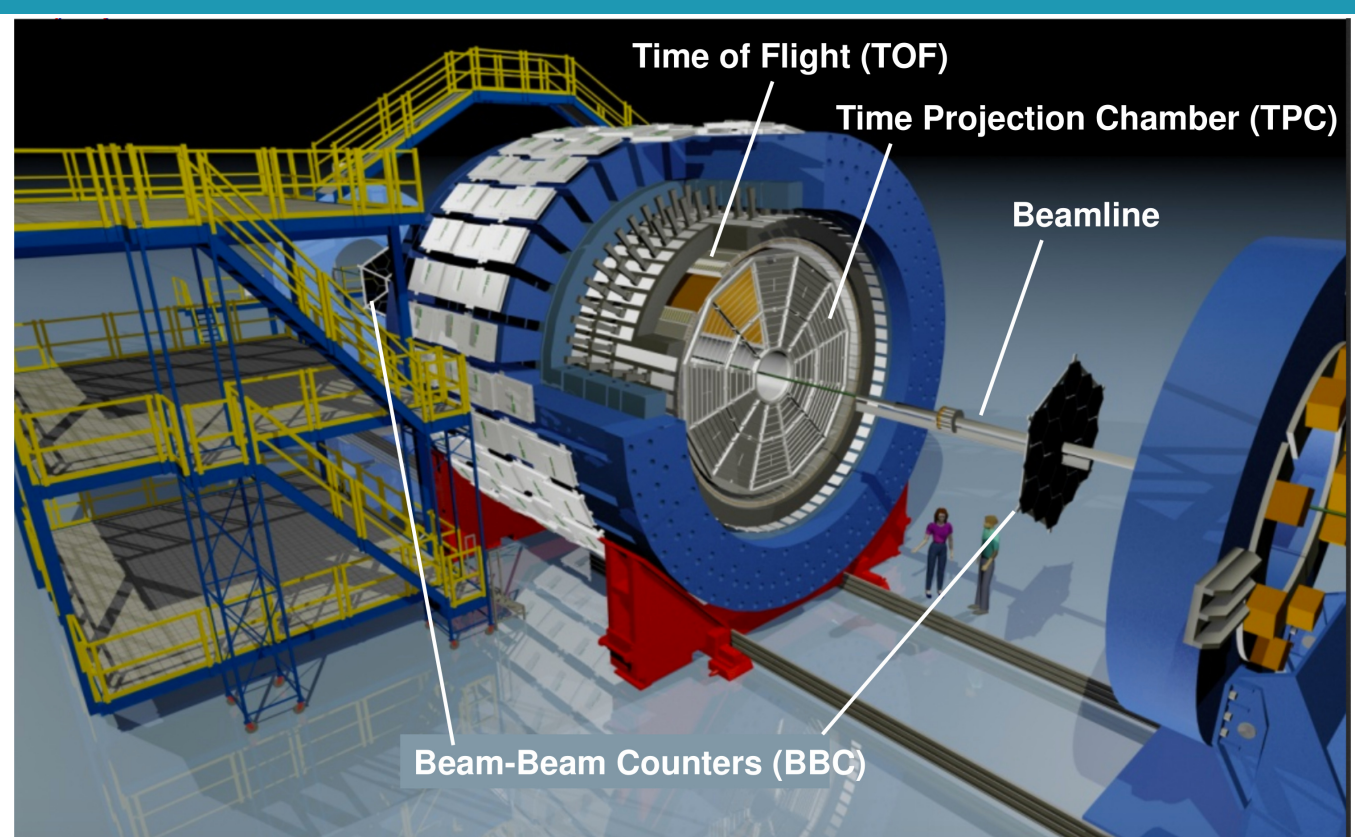
Rapidity gaps in single diffraction (SD):



Presence of a large rapidity gap (LRG) ensures a large diffractive contribution, but does not distinguish fully between the SD process, its double dissociation (DD) analogue, and the tail of non-diffractive (ND) contributions in which LRP's occur due to random fluctuations in the hadronisation process.

Tagging of the forward-scattered proton enables to precisely select the SD process.

Solenoidal Tracker At RHIC experiment



TPC: $dE/dx, L$

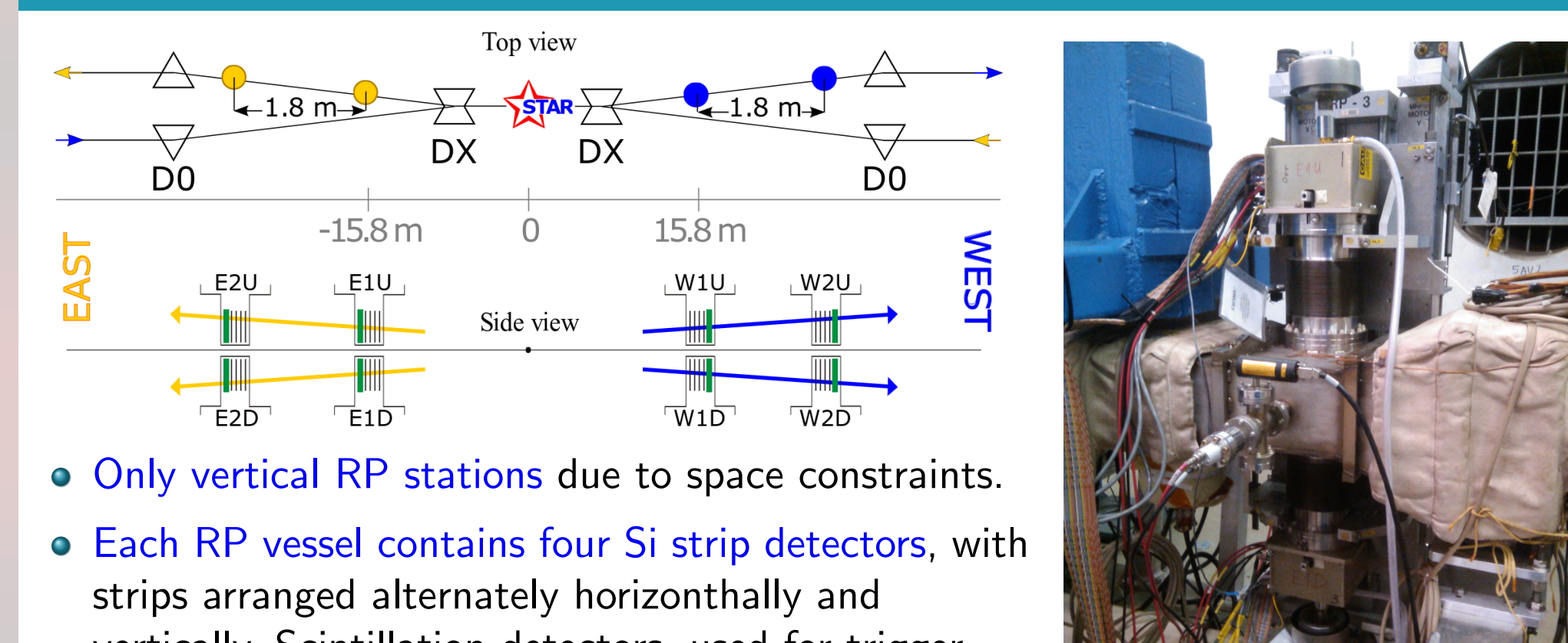
ToF: measures $\beta = \frac{L}{ct}$, $m^2 c^2 = p^2 (1/\beta^2 - 1)$

TPC and ToF coverage: $|\eta| < 1, 0 < \phi < 2\pi$

BBC: Scintillator tiles located at $3.3 < |\eta| < 5$

ZDC-SMD: Calorimeters located at $z = \pm 18$ m from IP, with position detectors inserted between the modules.

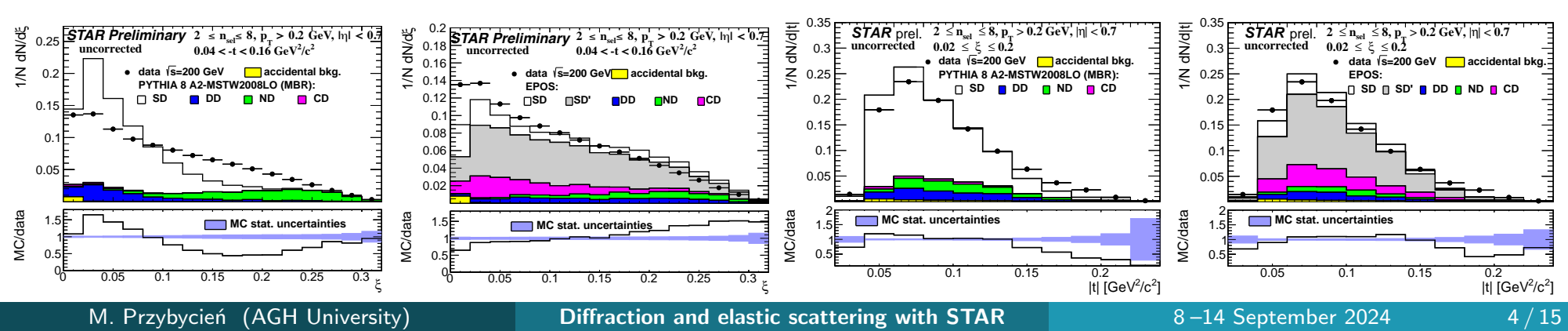
STAR Roman Pot system



- Only vertical RP stations due to space constraints.
- Each RP vessel contains four Si strip detectors, with strips arranged alternately horizontally and vertically. Scintillation detectors, used for trigger, are placed in each RP station behind Si planes.
- Scattering angles at IP and momentum losses of protons are reconstructed from local positions and angles measured in RP stations, based on the known geometry of the setup and magnetic field of the DX dipoles (bending only in x-z plane).
- No special beam optics is required - RPs can participate in all physics pp runs.
- Continuous excellent detector performance in Run 15 and Run 17.

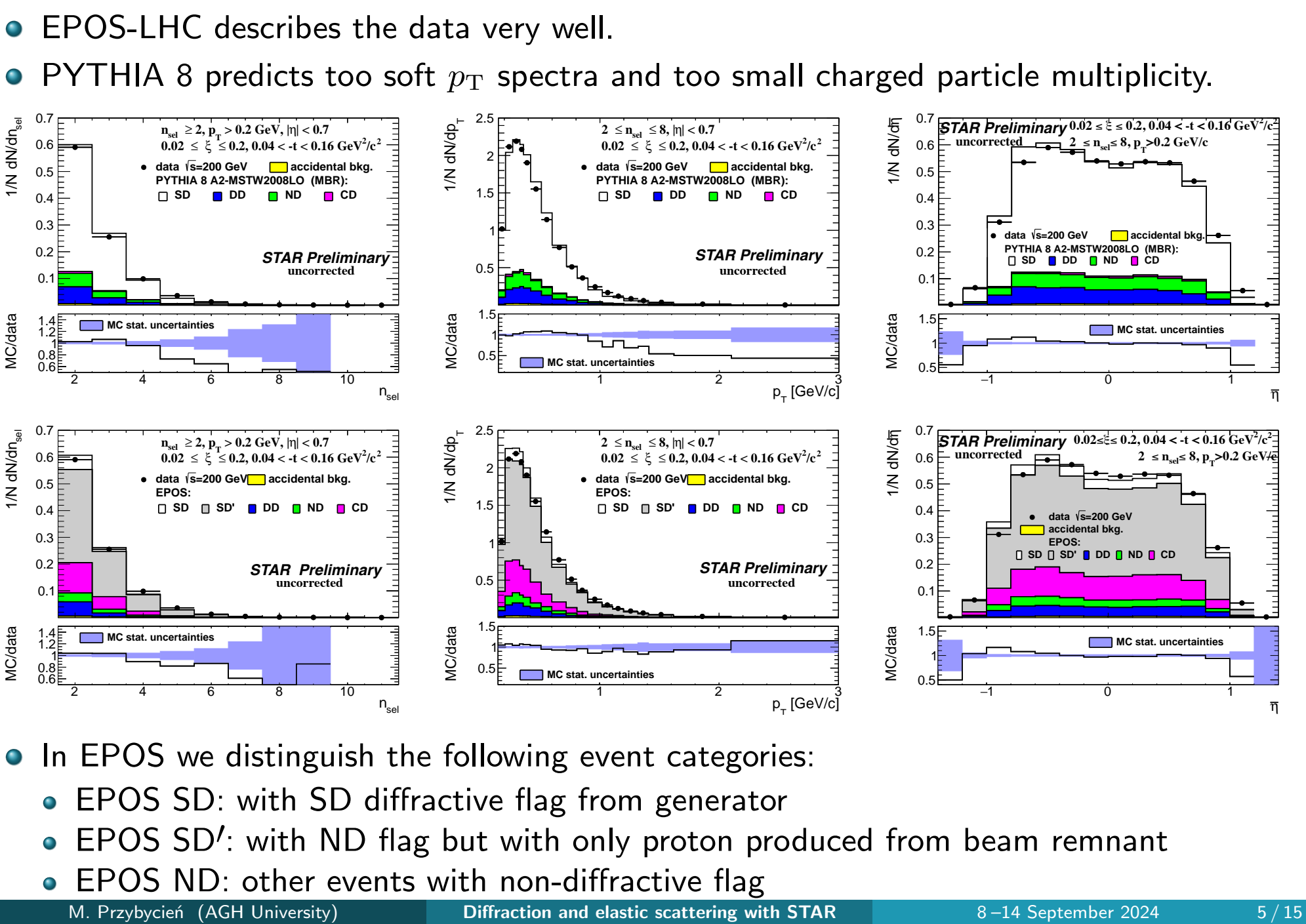
Single diffraction in proton-proton scattering at STAR

- Events selection and fiducial region in the SD measurement at $\sqrt{s} = 200$ GeV:
- Exactly one proton candidate in the RP system with: $0.02 < \xi < 0.2$ where $\xi = 1 - E_p/E_{beam} \approx \frac{M_X^2}{s}$, and M_X is the invariant mass of the diffractive system, $0.04 < -t < 0.16$ GeV² where $-t = p_T^2$, and p_T is related to the intact proton.
- Charged particles, identified with help of TPC and ToF, were required to have $p_T > 0.2$ GeV/c and $|\eta| < 0.7$.
- The fiducial region is further restricted to events with the number of charged particles within $2 \leq n_{ch} \leq 8$.
- Background sources:
 - Accidental background: random overlap of signals from two different collisions - estimated using randomly triggered data: $< 1\%$ for $\xi > 0.02$, and $> 10\%$ for $\xi < 0.02$.
 - Single source background: originating from DD, CD and ND events - determined using PYTHIA 8 (MBR) and EPOS-LHC predictions (excluding SD').



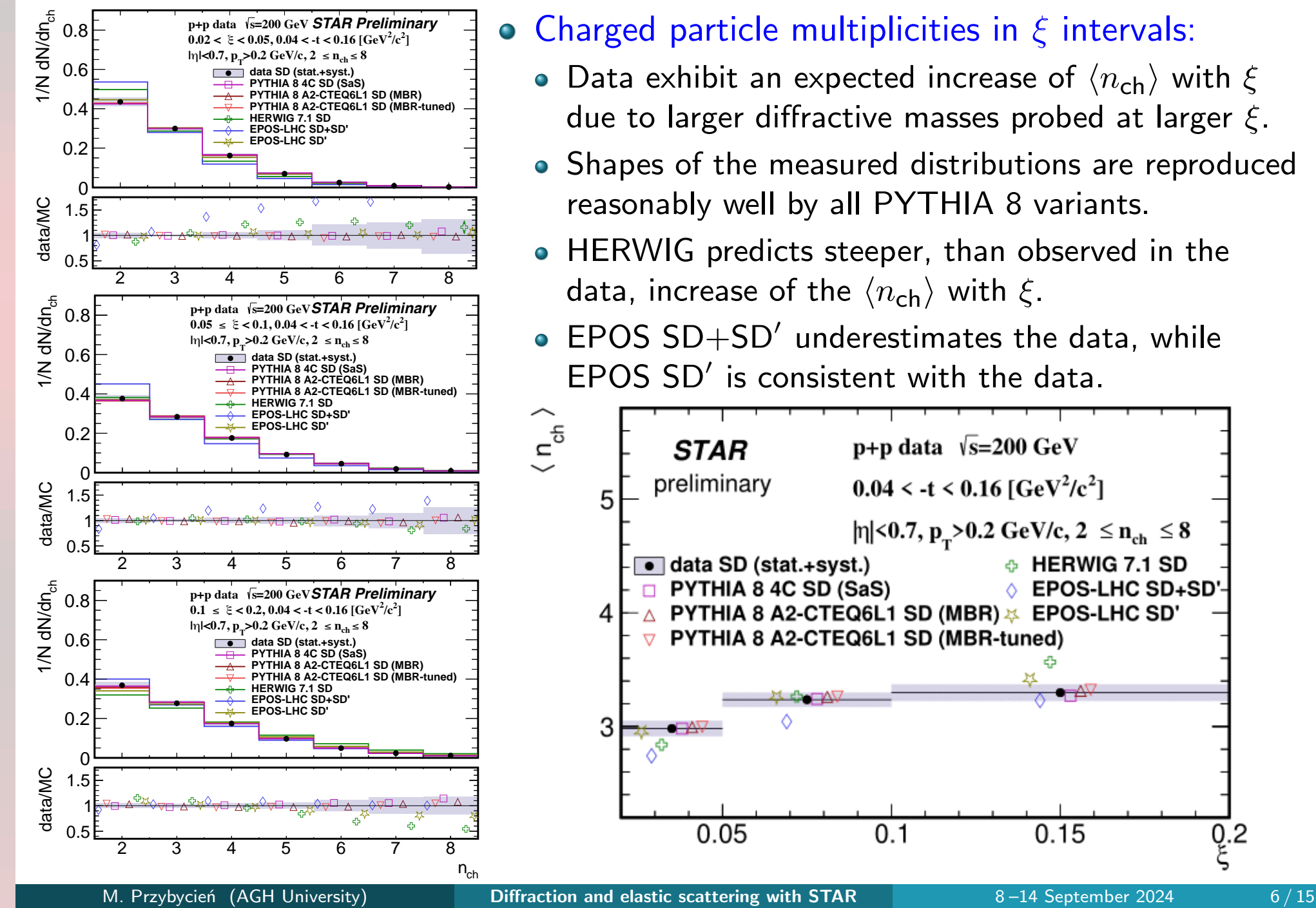
M. Przybycien (AGH University) Diffraction and elastic scattering with STAR 8-14 September 2024 4 / 15

Charged particle production in SD at STAR



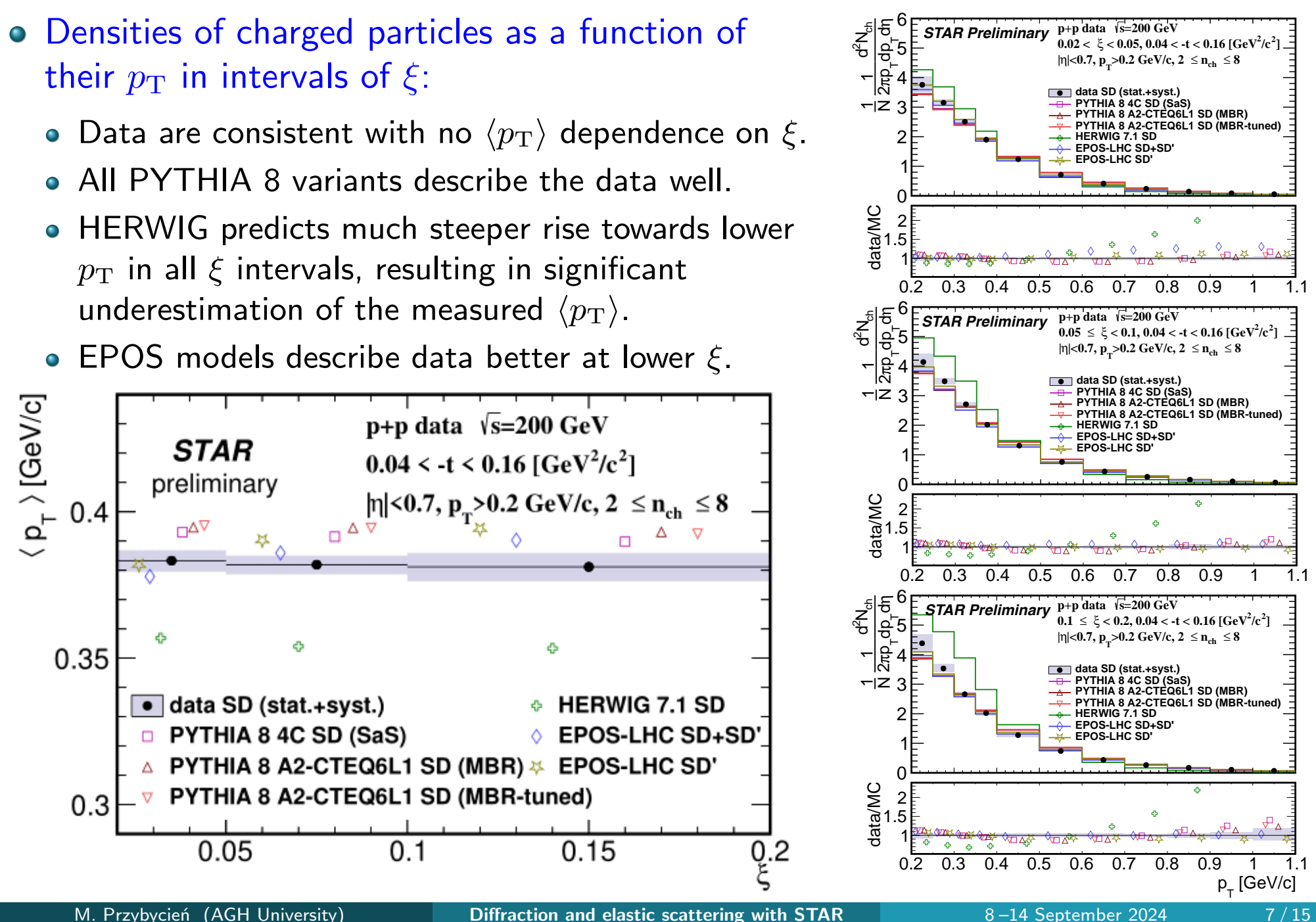
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Single diffraction in proton-proton scattering in STAR



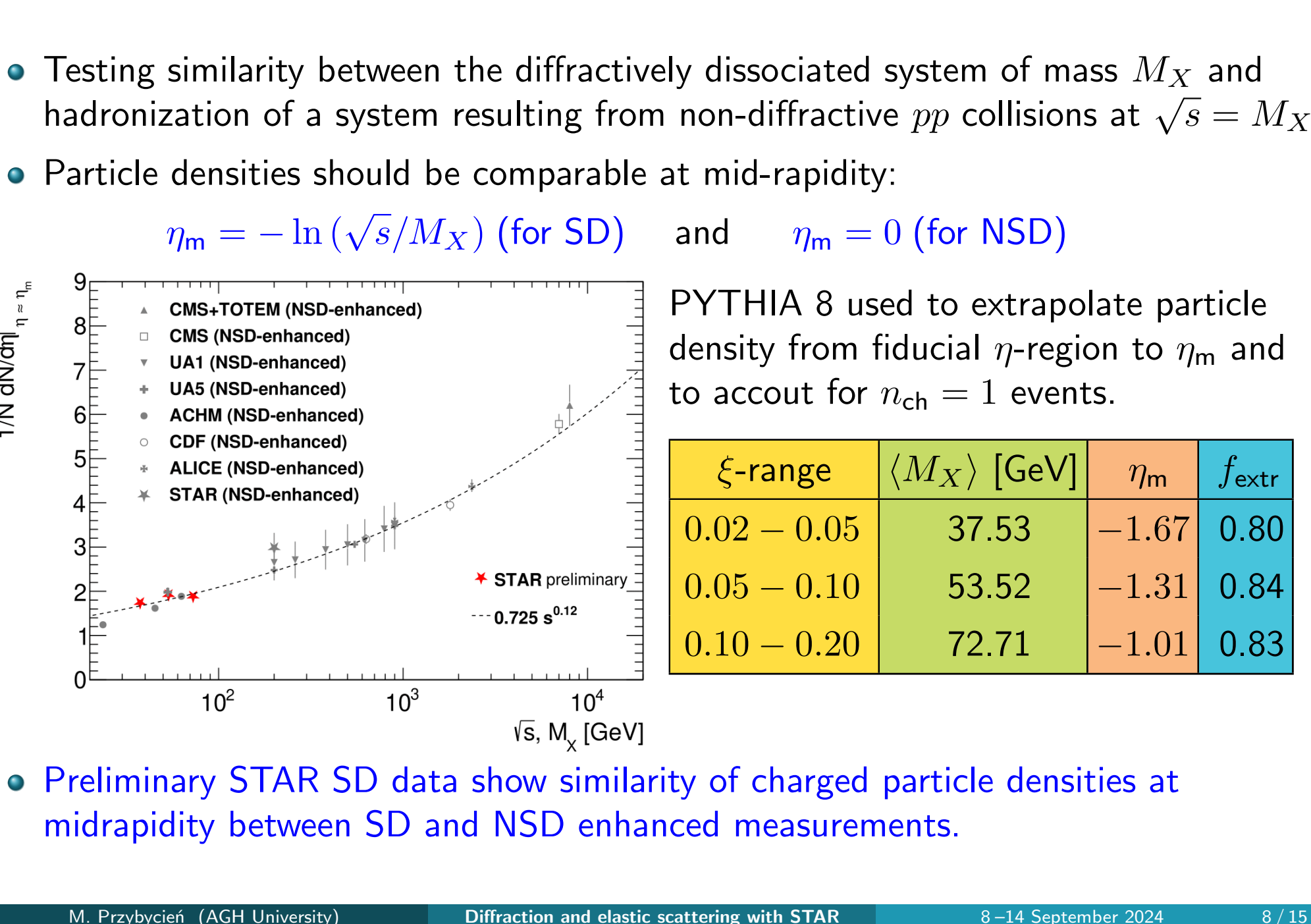
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Transverse momenta yields and dependence of $\langle p_T \rangle$ on ξ



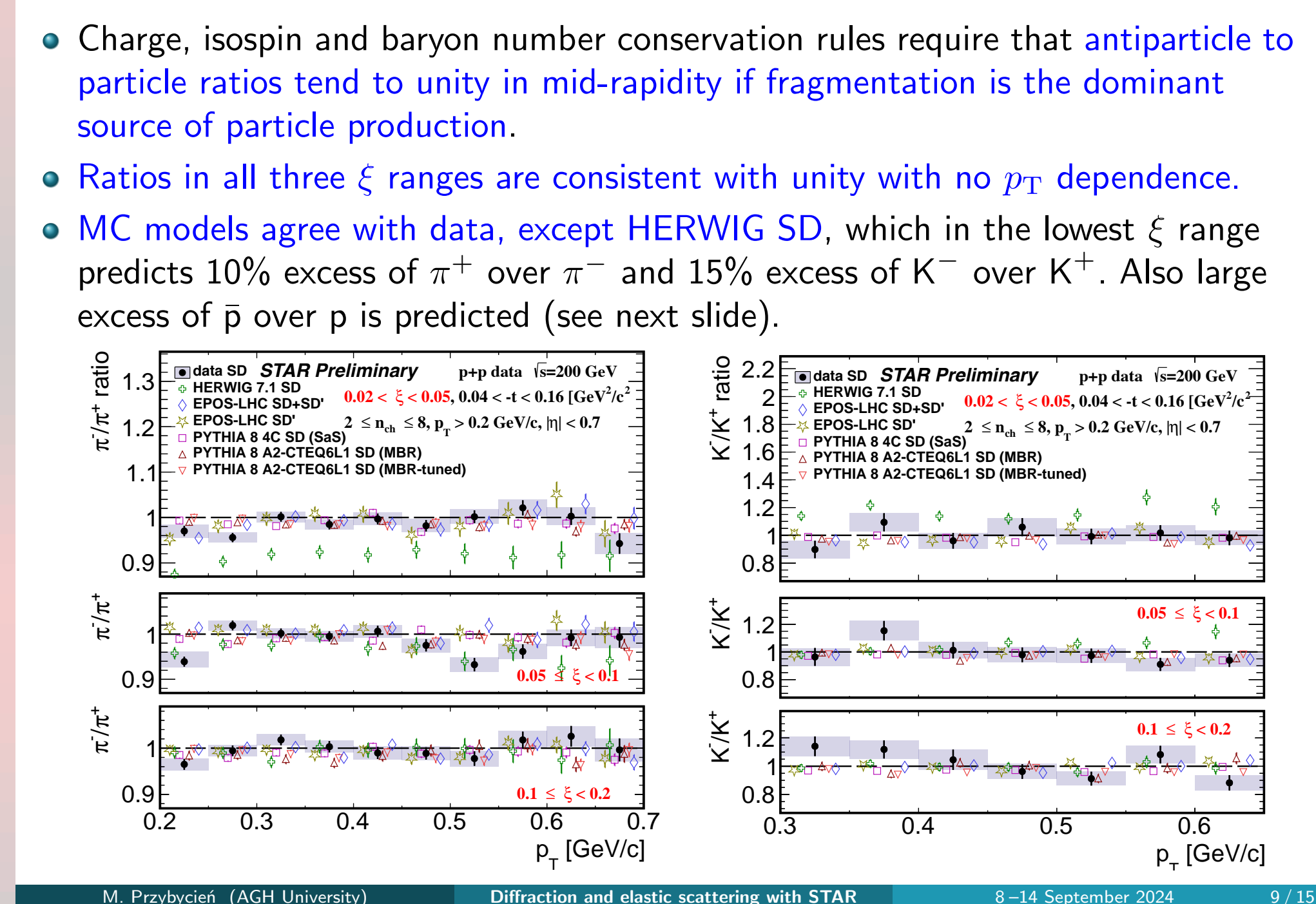
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Comparison of single with non-single diffraction



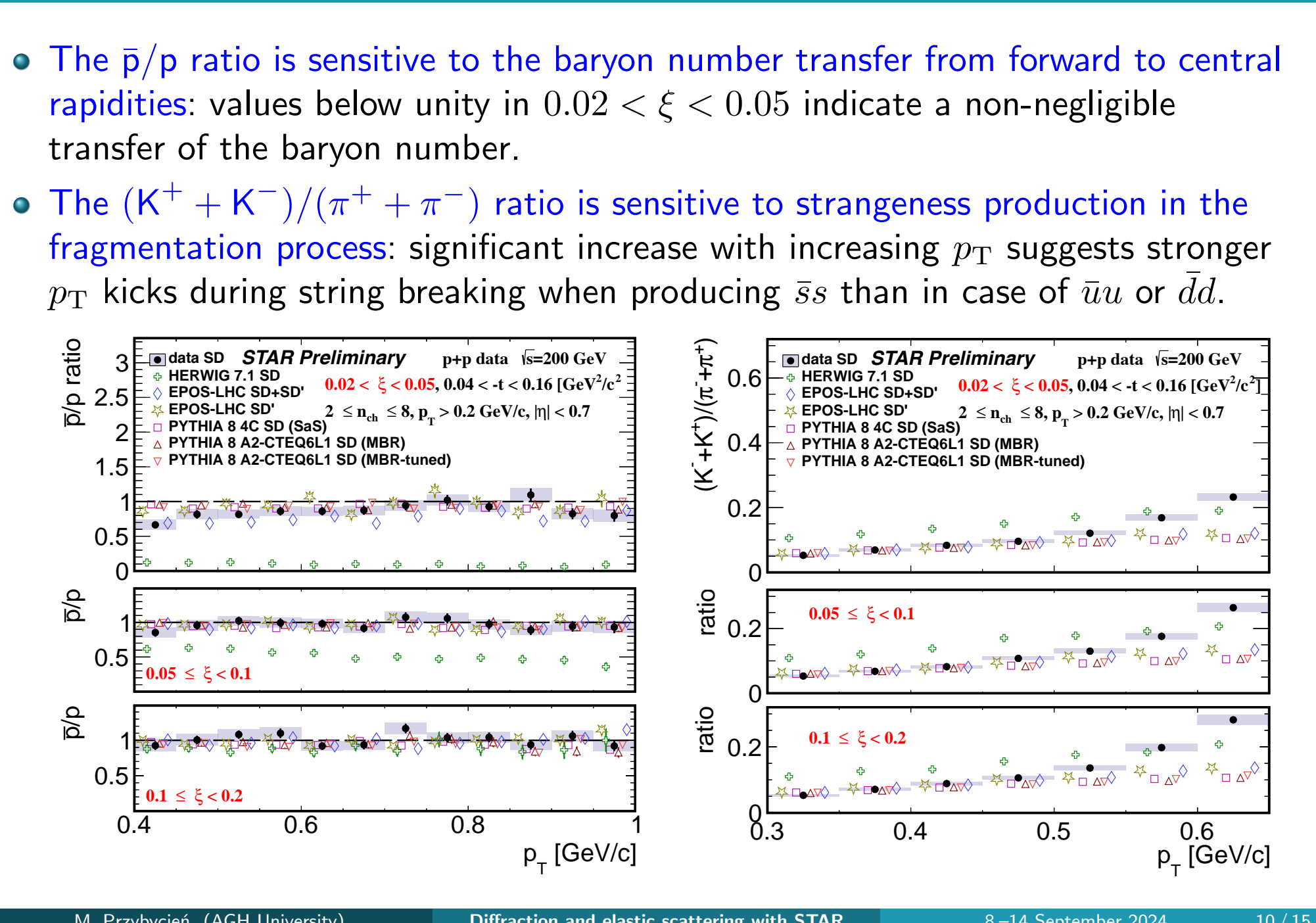
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STAR results on particle production $\pi^\pm, K^\pm, \bar{p}, p$ in SD



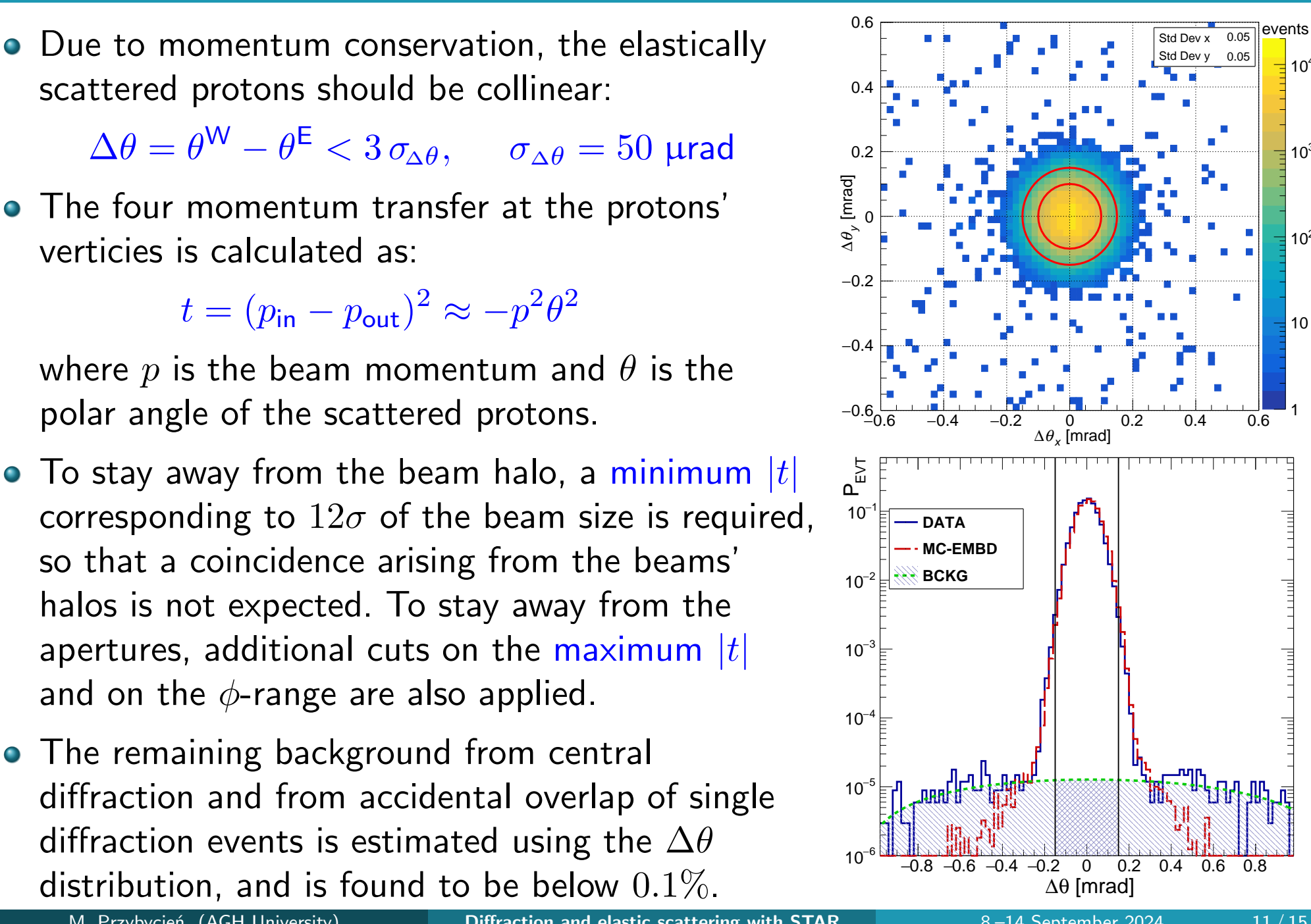
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STAR results on particle production $\pi^\pm, K^\pm, \bar{p}, p$ in SD



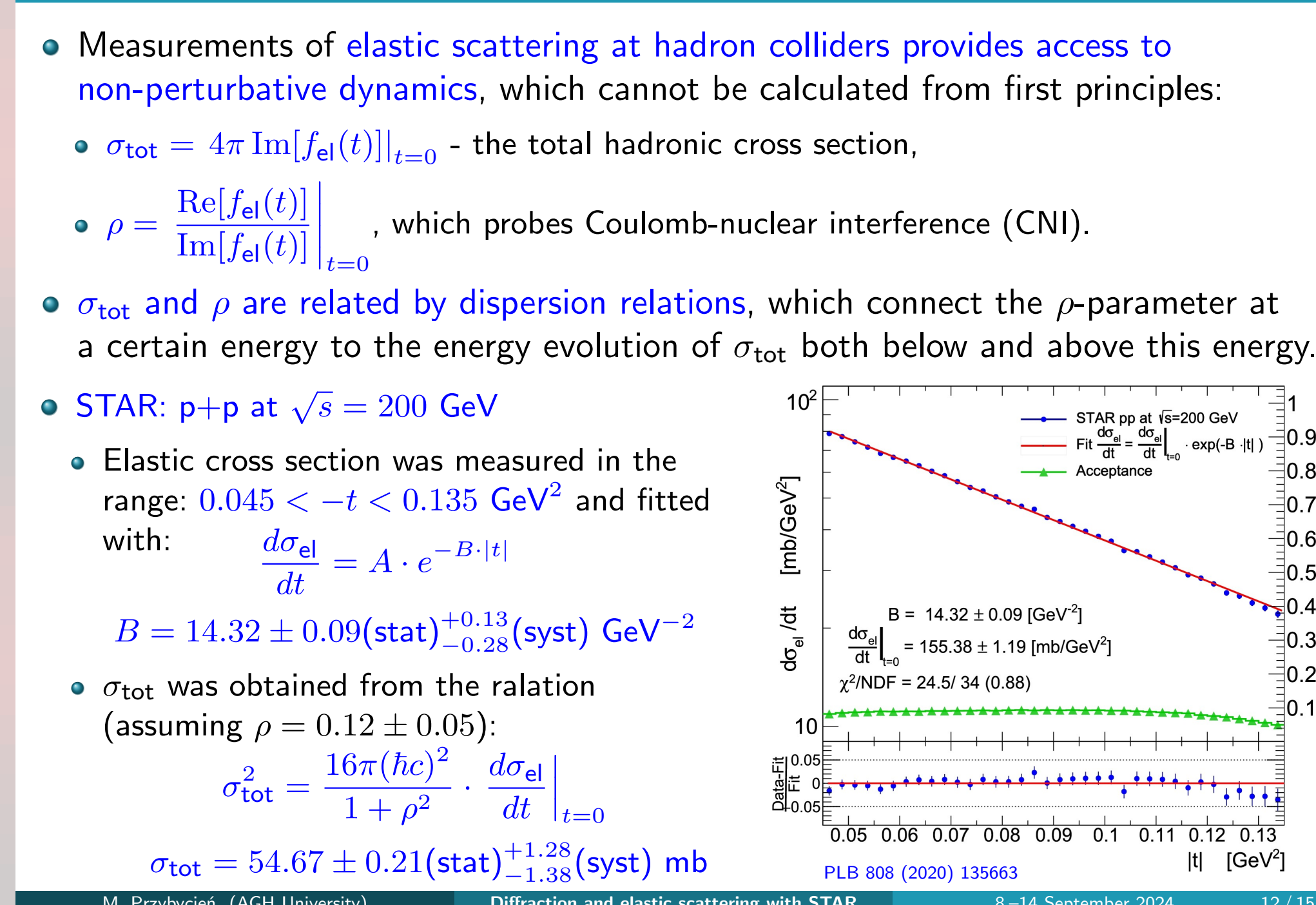
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Measurement of elastic proton-proton scattering in STAR



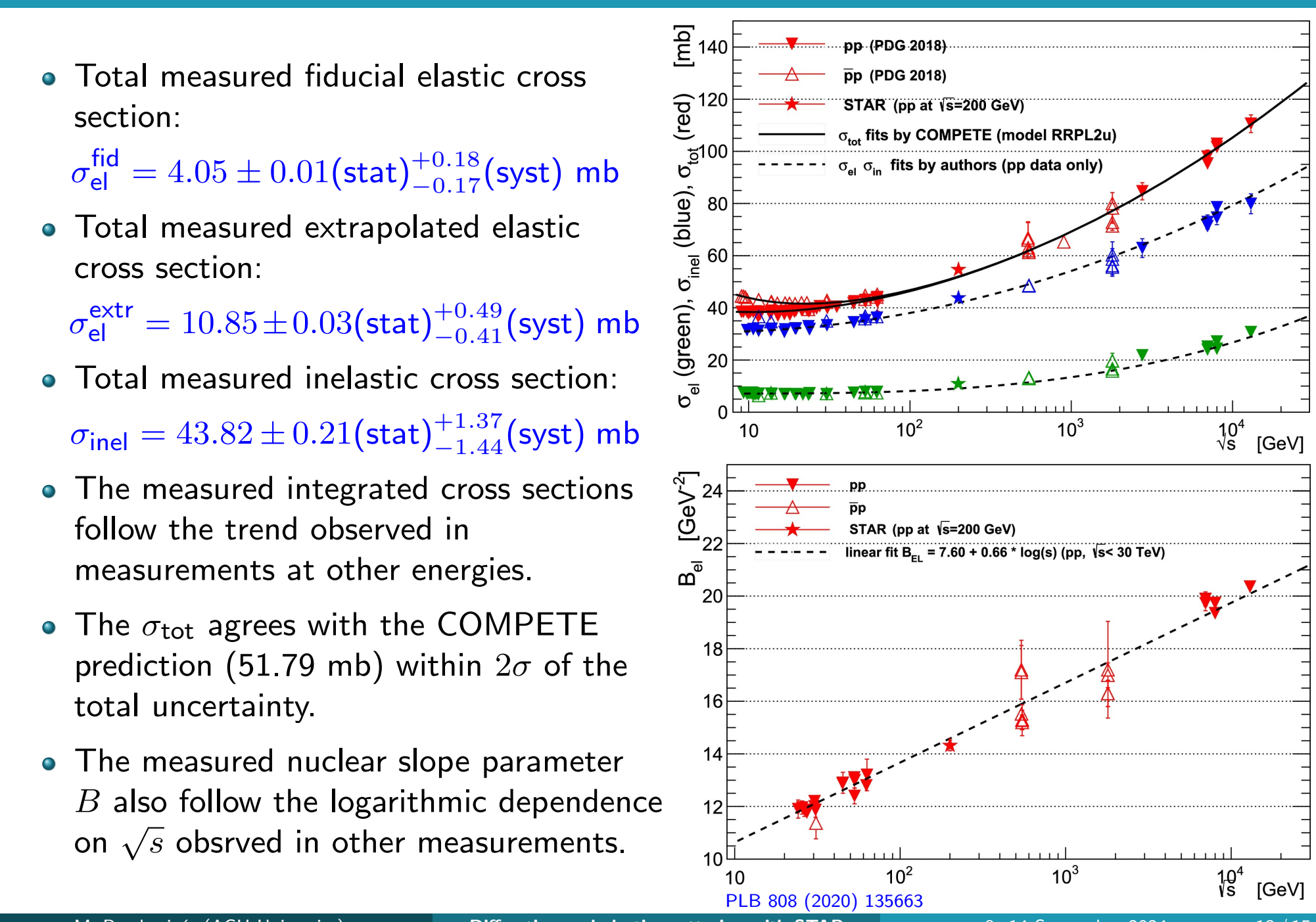
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Elastic, inelastic and total proton-proton cross sections



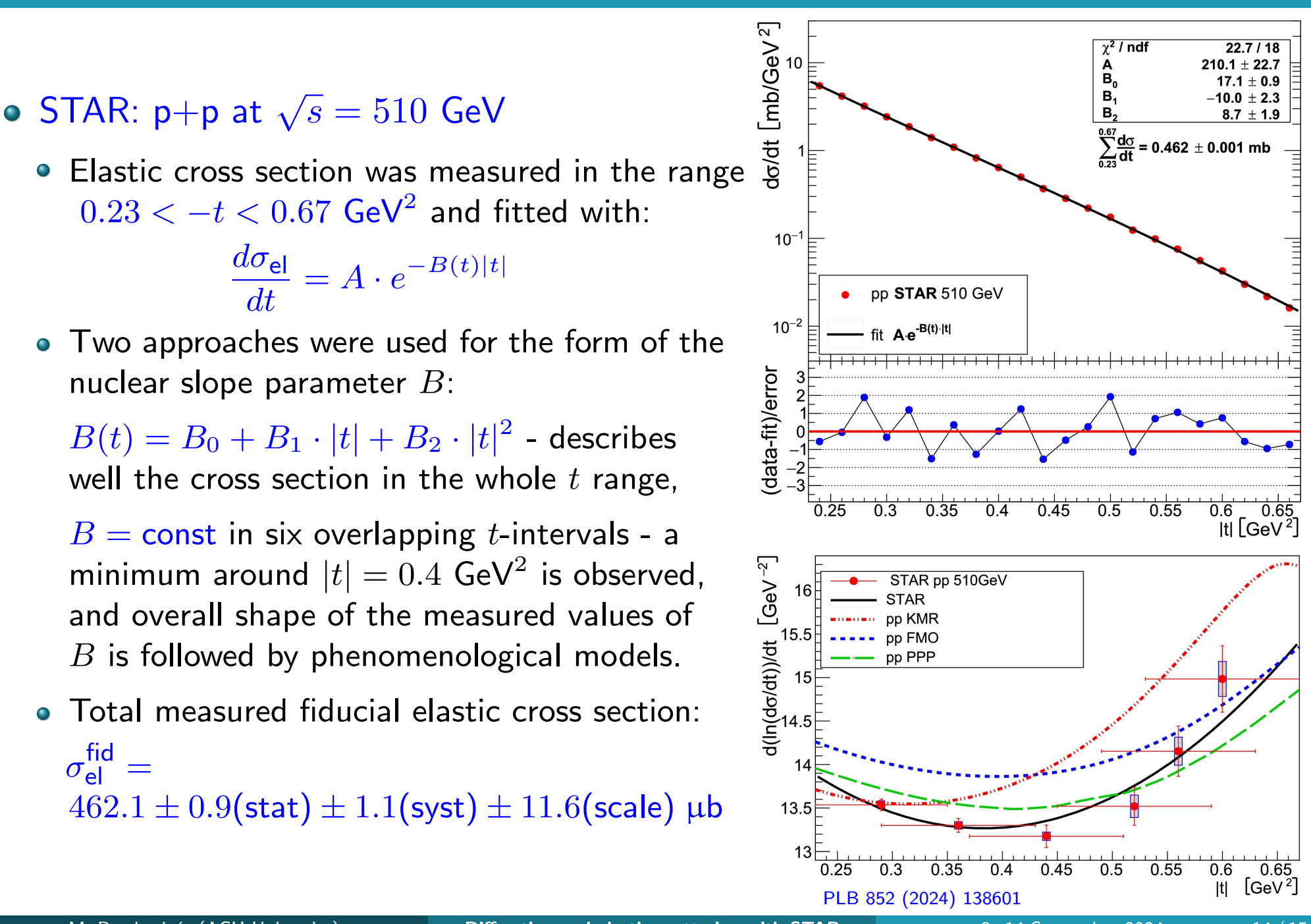
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Elastic, inelastic and total proton-proton cross sections



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Elastic scattering in proton-proton collisions



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Summary

- In diffractive-like analyses at STAR uses the Roman Pot detectors to measure the forward-scattered intact protons.
- Charged-particle production spectra have been measured in SD process at $\sqrt{s} = 200$ GeV
- Significant differences are observed between the measured and predicted by MC models distributions of ξ . EPOS-LHC and PYTHIA (MBR) without suppression of diffractive cross sections at large ξ provide the best description of the data.
- Similarity between the dissociation of diffractively produced system of mass M_X and hadronization of the system resulting from non-diffractive pp collisions at $\sqrt{s} \approx M_X$ reported for the first time by the UA4, was confirmed with much better precision.
- π^-/π^+ and K^-/K^+ production ratios are close to unity and consistent with most of model predictions except for HERWIG 7.1 SD.
- p/p production ratio shows a significant deviation from unity in $0.02 < \xi < 0.05$ range indicating a non-negligible baryon number transfer from forward to central region.
- $(K^+ + K^-)/(\pi^+ + \pi^-)$ ratio suggests that $s\bar{s}$ suppression in fragmentation process (factor 0.2 in PYTHIA 8) is too strong in diffractive system and p_T kicks during string(cluster) breaking producing $s\bar{s}$ is larger compared to $d\bar{d}$ or $u\bar{u}$.
- STAR measured also the differential cross section for elastic proton-proton collisions at $\sqrt{s} = 510$ GeV in the range $0.23 < -t < 0.67$ GeV² and studied its t -dependence.

Thank you for reading to the end!