Status report

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RHICf KAKEN meeting
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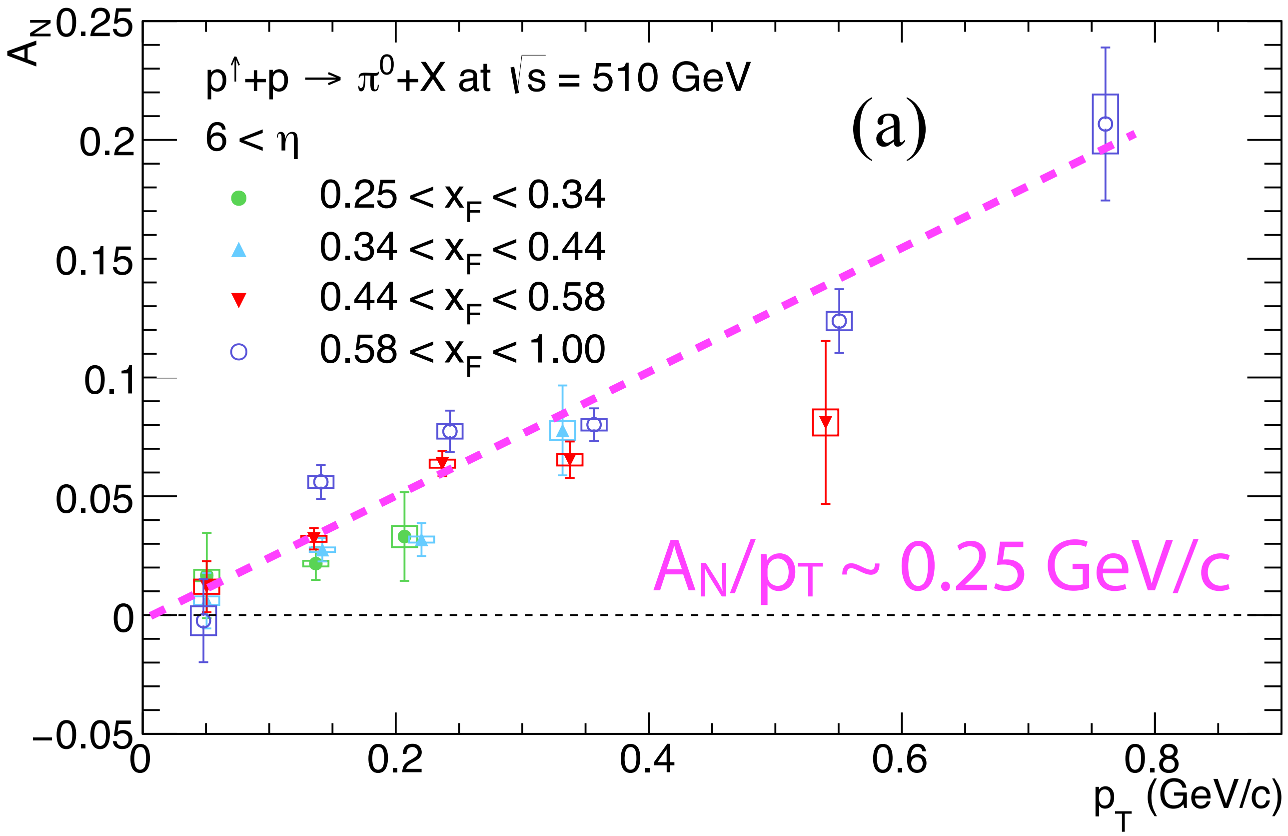
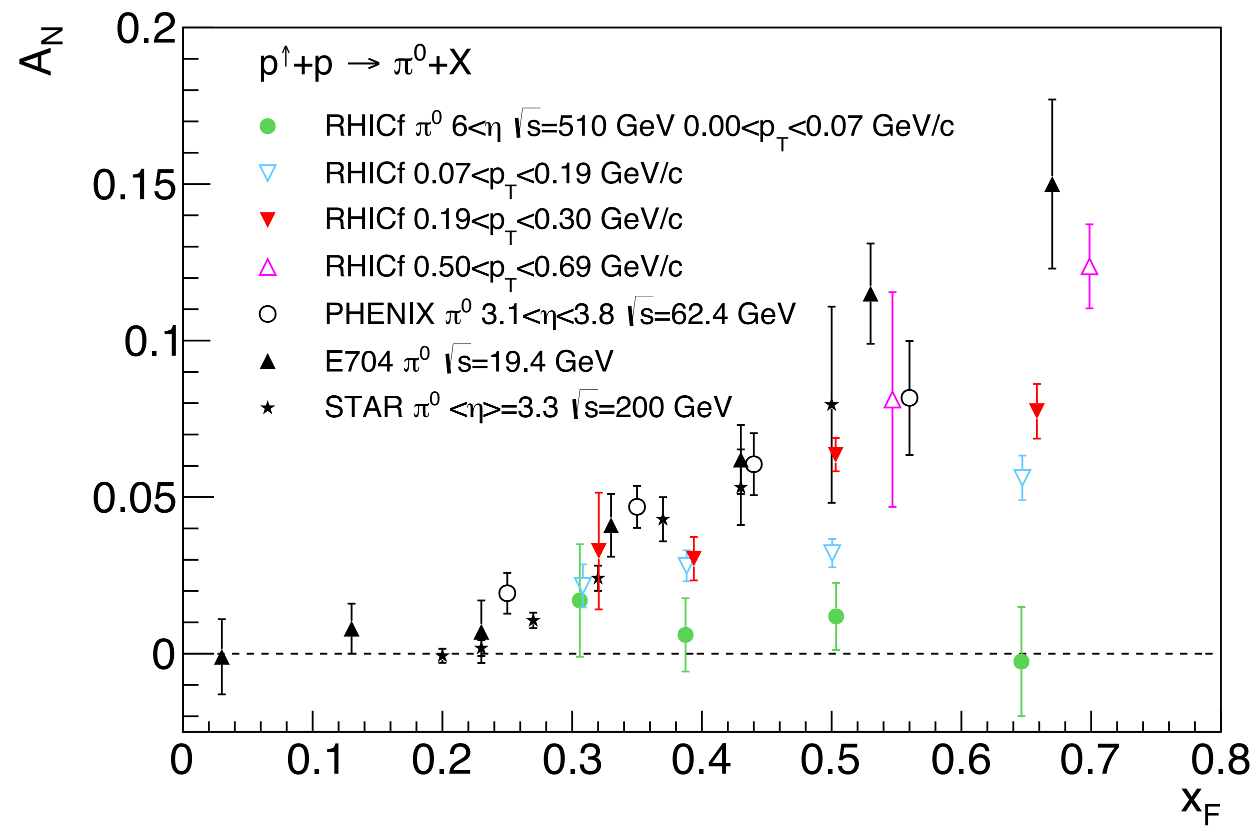
Calculation & simulation sets for RHICf-II

	Hadronic	UPC	√s (GeV)
$p^{\uparrow}$-p	Ongoing	Negligible	510
$p^{\uparrow}$-Al	Similar with p-p?		200
$p^{\uparrow}$-Au	Similar with p-p?	2π MAID?	200
etc?			

$A_N(x_F, p_T)$ in $p^{\uparrow}p \rightarrow \pi^0 X$ at $\sqrt{s} = 510$ GeV

RHICf at √s = 510 GeV

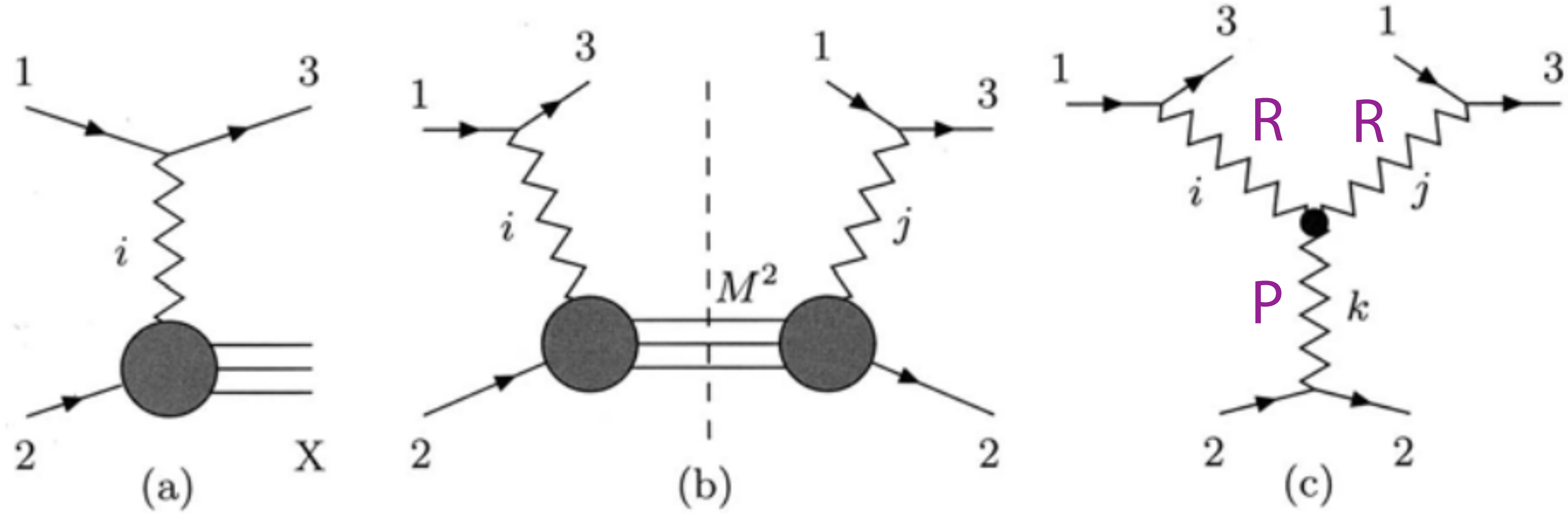




- Opposite sign compared with neutron A_N
- $|A_N|/p_T$ is about half of neutron A_N.

- A_N/x_F seems independent of $\sqrt{s}$ and η. (can QCD processes make large A_N at $p_T > 1$ GeV/c?)

Triple-regge diagram in $p^{\uparrow}p \to \pi X$



[Barone and Predazzi]

Triple-regge/pomeron diagram is valid in the limit of $M^2 \to \infty$ and $s \to \infty$ that mostly suits to the RHICf kinematics.

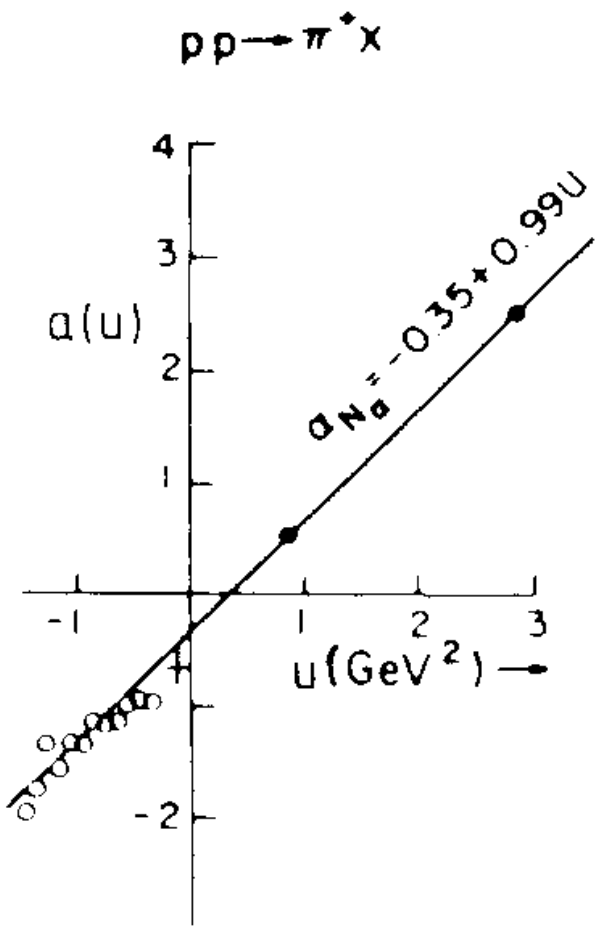
$$A(12 \to 3X) \underset{s \to \infty}{\sim} \sum_i g^i_{13}(t) g^i_{2X}(t)\, \eta_i(t) \left(\frac{s}{M^2}\right)^{\alpha_i(t)}$$

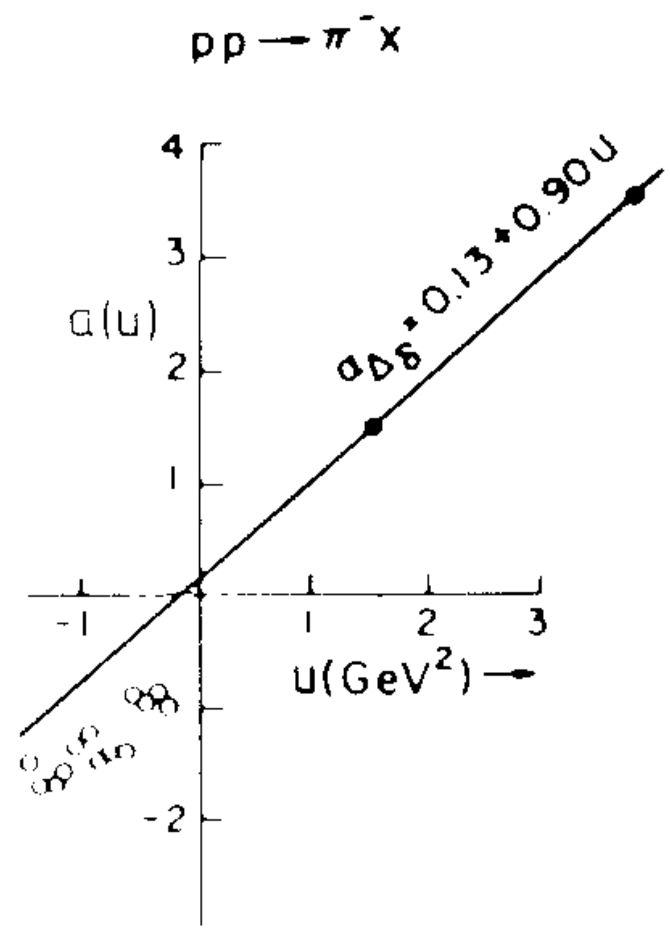
Sum over all trajectories

- g_{13}: $p \to \pi^0$ vertex function
- g_{2X}: $p+I(j) \to X$ cross section
- η: trajectory's phase
- $\alpha(t)$: regge/pomeron trajectory
- $M^2/s \sim 1 - x_F$

Regge trajectories

[Storrow, Phys. Rep. 103, 317]





$$\alpha_{N\alpha}(t) = -0.34 + 0.99t \qquad \alpha_{\Delta\delta}(t) = 0.07 + 0.92t$$

Very old but still usable as recent papers refer

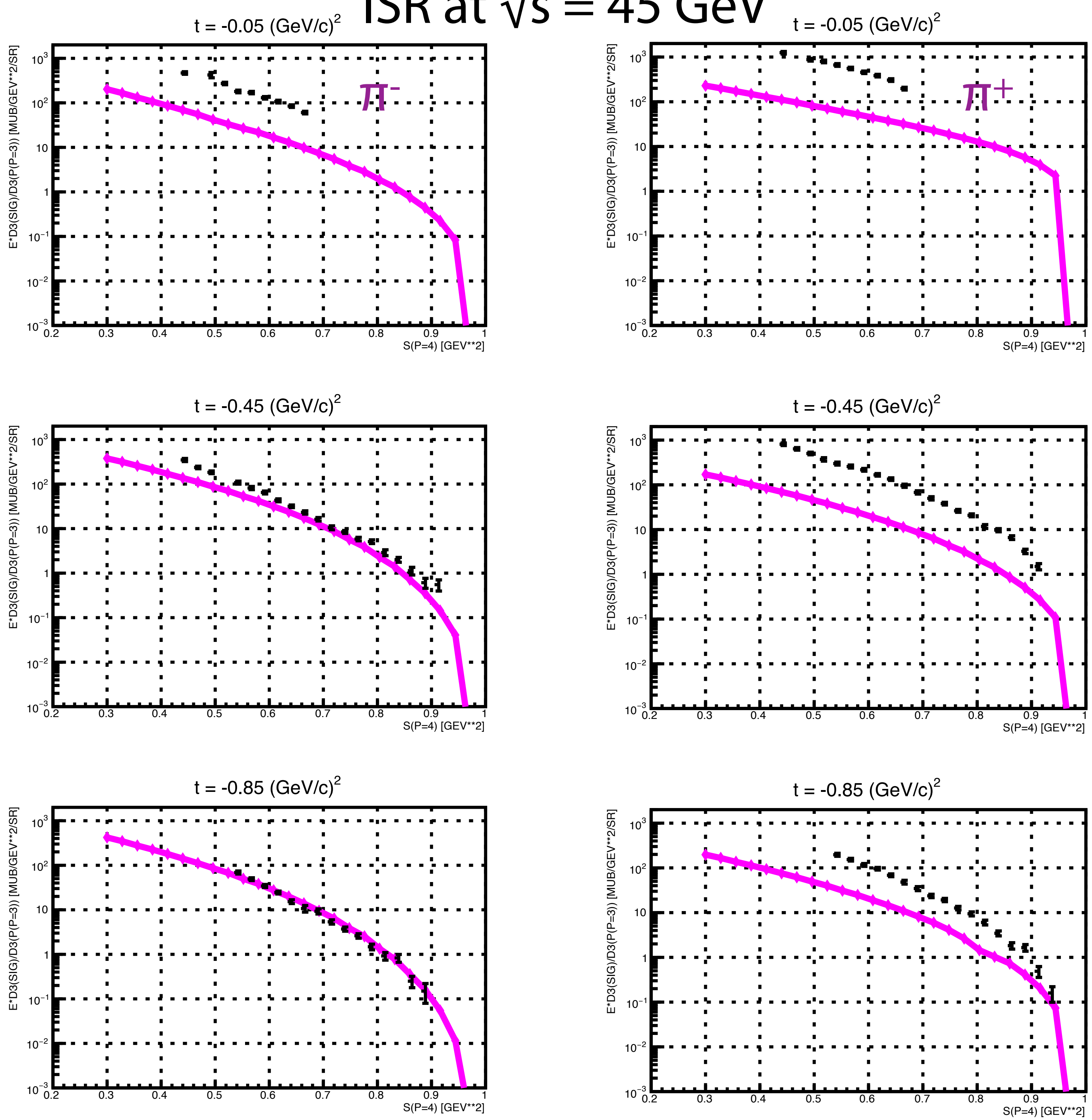
$Ed^3\sigma/dp^3$ in $p^{\uparrow}p \to \pi^{+/-}X$

π^- $$|\langle \Delta^{++}|\pi^+ p\rangle|^2 = 1$$

π^+ $$|\langle \Delta^{0}|\pi^- p\rangle|^2 = \frac{1}{3}$$ $$|\langle n|\pi^- p\rangle|^2 = \frac{2}{3}$$

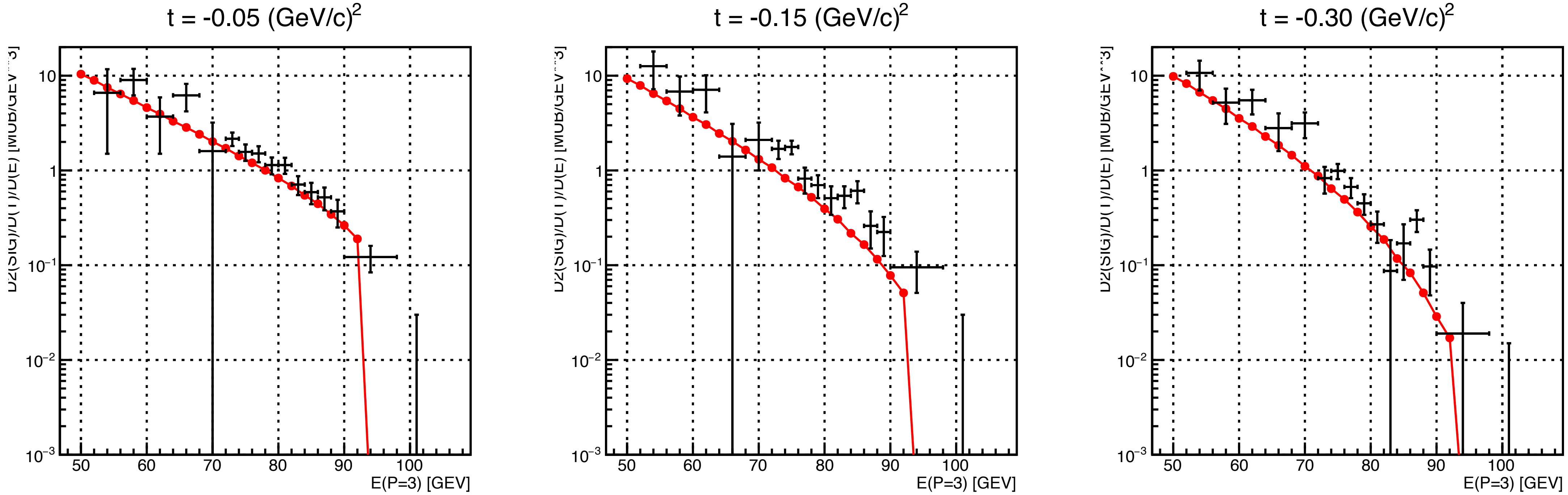
π^0 $$|\langle p|\pi^0 p\rangle|^2 = \frac{1}{3}$$ $$|\langle \Delta^{+}|\pi^0 p\rangle|^2 = \frac{2}{3}$$

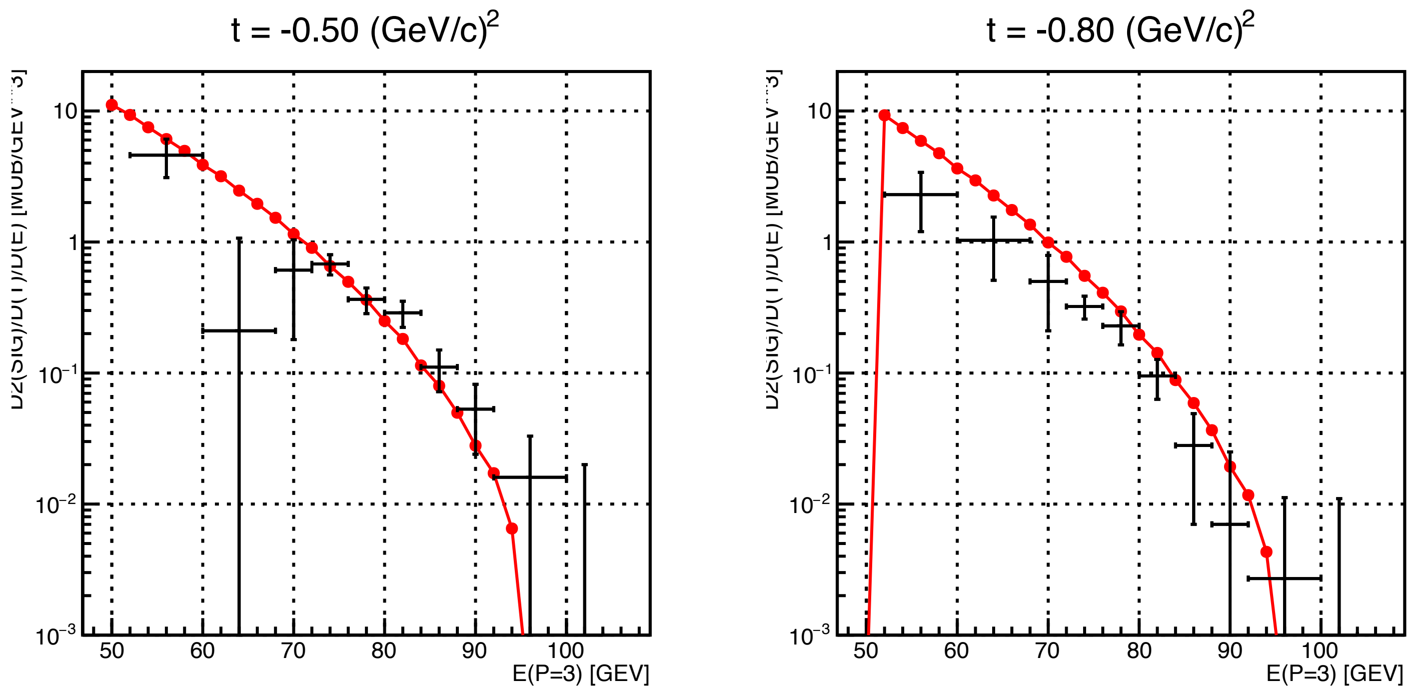
ISR at √s = 45 GeV



$Ed^3\sigma/dp^3$ in $p^{\uparrow}p \to \pi^0 X$

E350 at $\sqrt{s}$ = 13 GeV



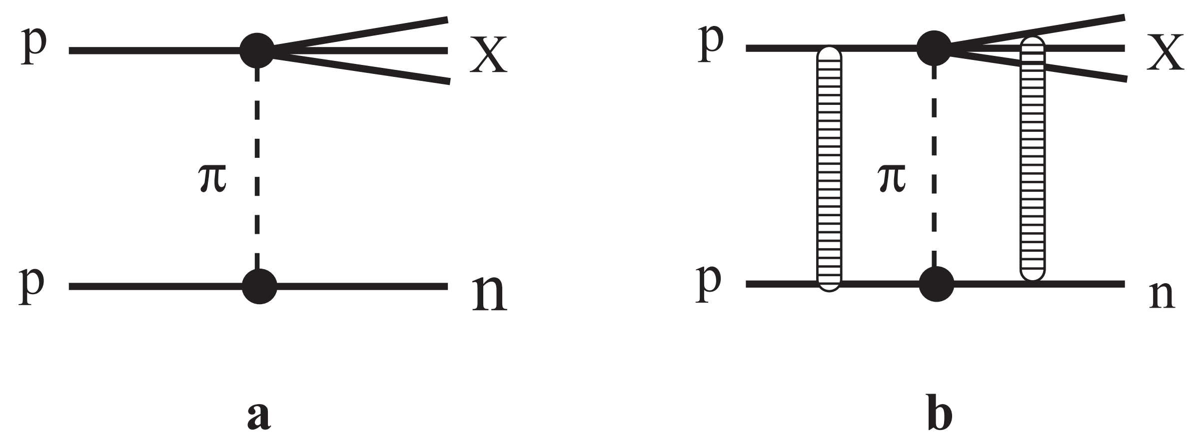


- My calculations follow the simple triple-regge diagrams driven by proton and Δ(1232) exchanges.
- Overall not so bad

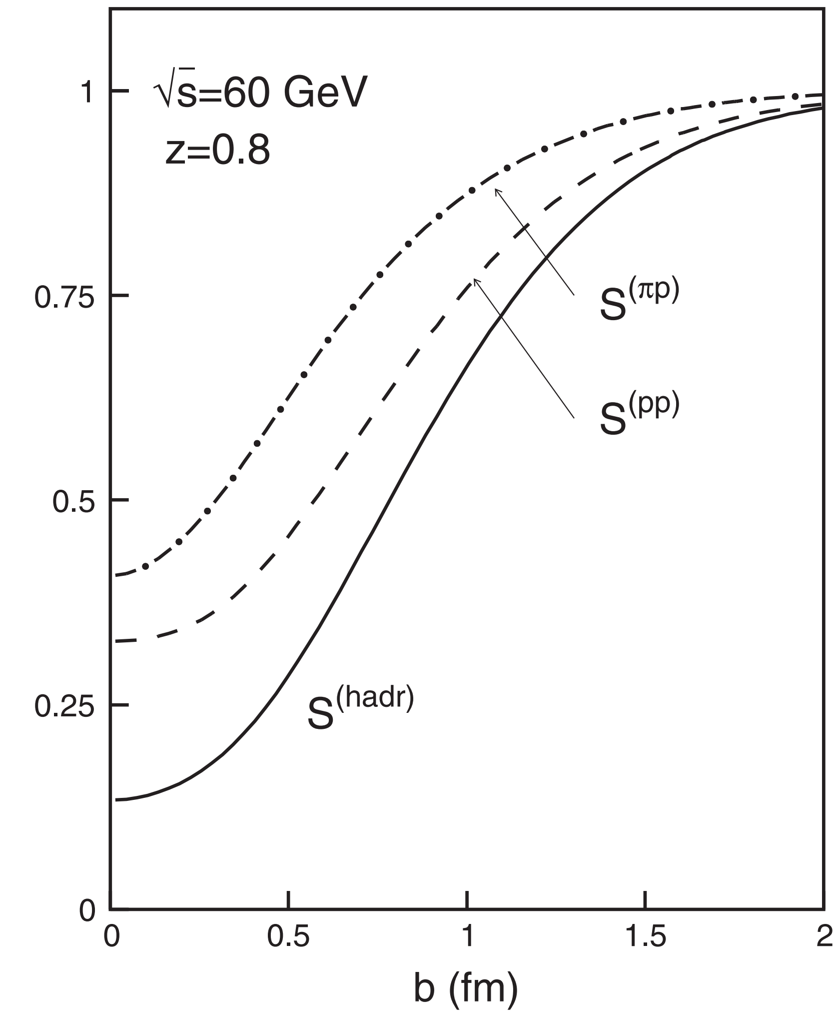
Absorptive correction and interference

[Kopeliovich, Phys. Rev. D 78, 014031]

$$A_N = 2\frac{\mathrm{Im}\, M^*_{\mathrm{flip}} M_{\mathrm{nonflip}}}{|M^*_{\mathrm{flip}}|^2 + |M^*_{\mathrm{nonflip}}|^2} \propto 2\mathrm{Im}\,\eta^*\eta$$

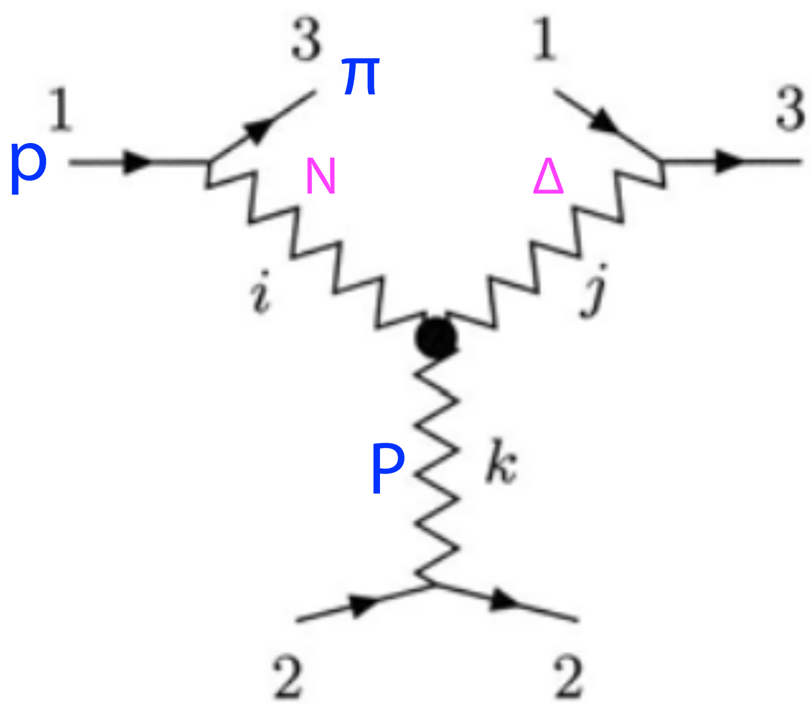


- Nonzero asymmetry is generated through phase interferences ($\mathrm{Im}[\eta_i(t)\eta_j(t)^*] \neq 0$); at least either A or B is needed.
  - A. Interference in particle exchange
  - B. Interference in absorptive correction
- E.g. for forward neutrons [Kopeliovich, PRD 84]
  - A. π-a_1 exchange interferences → leading
  - B. Absorptive correction → sub-leading

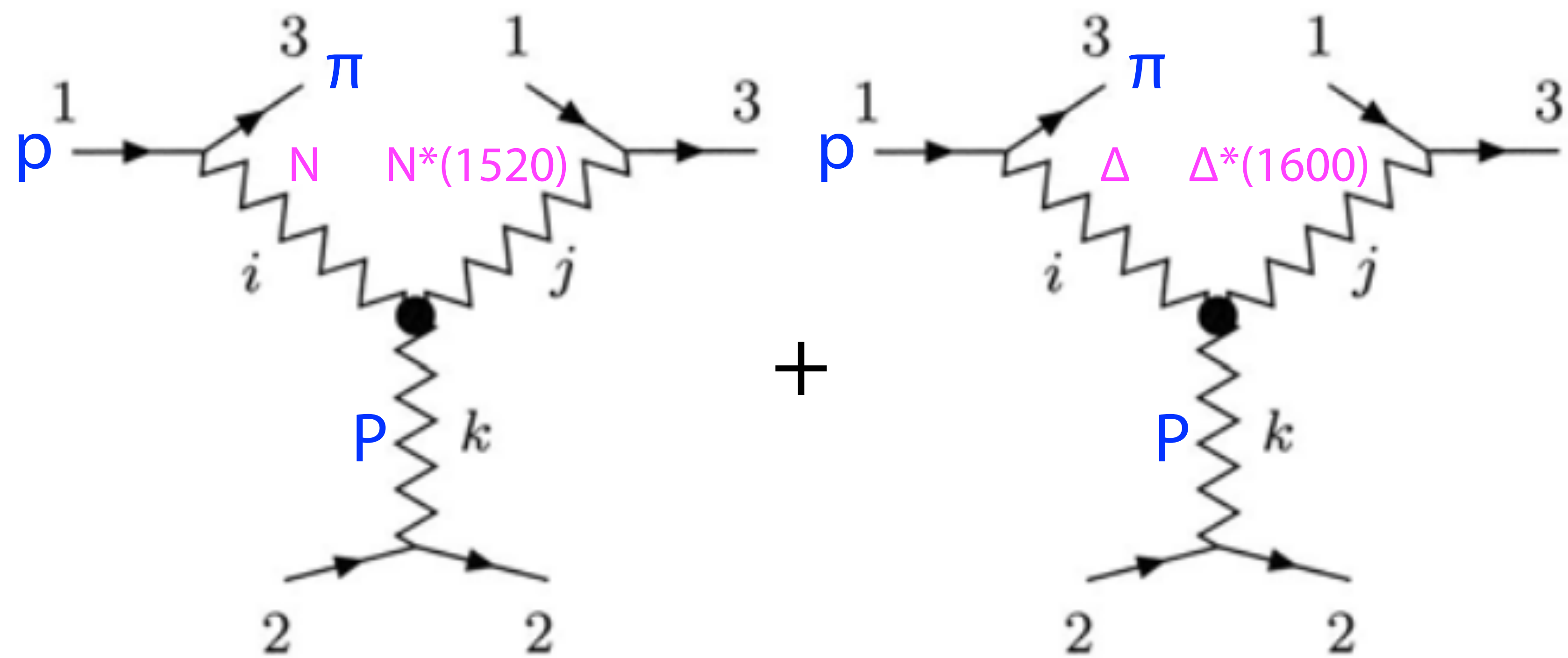


What I did for 2+ years…

My calc. (failed)



H-J Kim et. al., PRD 106, 054001



My calculation was stuck in how to make N(1/2) and Δ(3/2) coupled.
I thought this interference was necessary to generate nonzero A_N.
→ prohibited

Each phase differences of N and Δ exchanges gives sizable A_N.

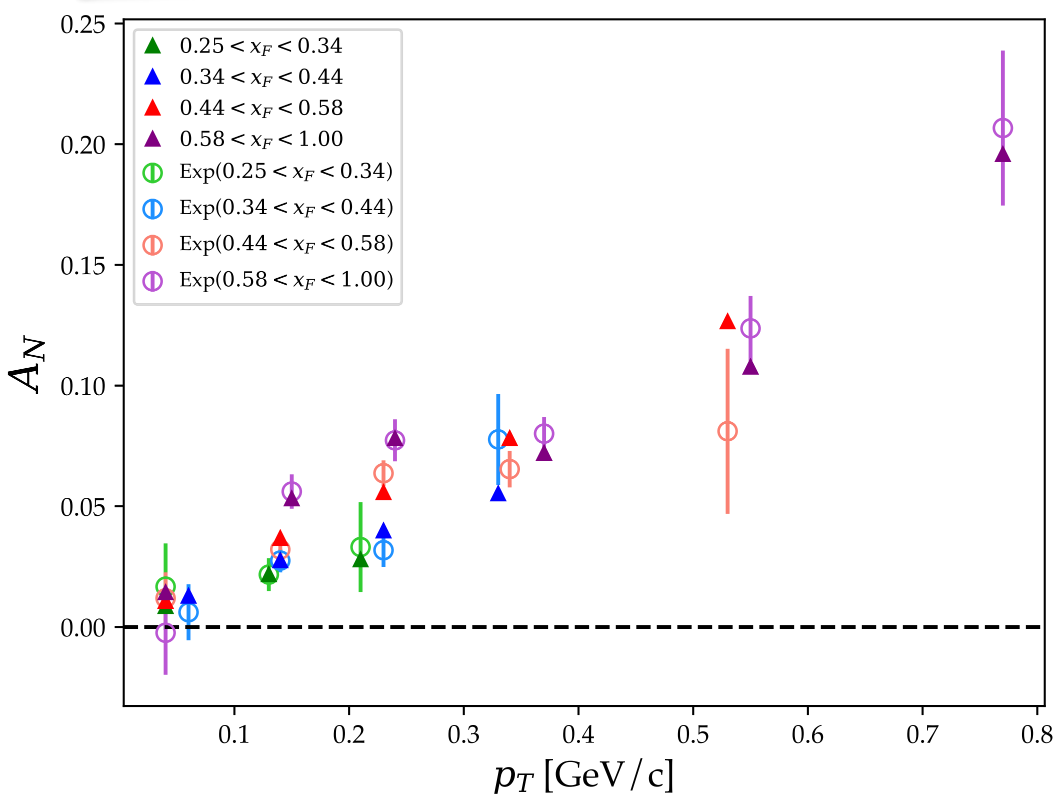
$$d\Delta\sigma_\perp = d\Delta\sigma_\perp^N + d\Delta\sigma_\perp^U$$

$$d\Delta\sigma_\perp^N = \frac{1}{s}\sum_\lambda \beta_{+\lambda}^N \beta_{-\lambda}^{N^*} 2\mathrm{Im}\mathcal{P}_N\mathcal{P}_{N^*}^* \times \sum_k G_k^{NN^*}(t)\gamma_k^{pp}(0)\left(\frac{M_X^2}{s_0}\right)^{\alpha_k(0)}$$

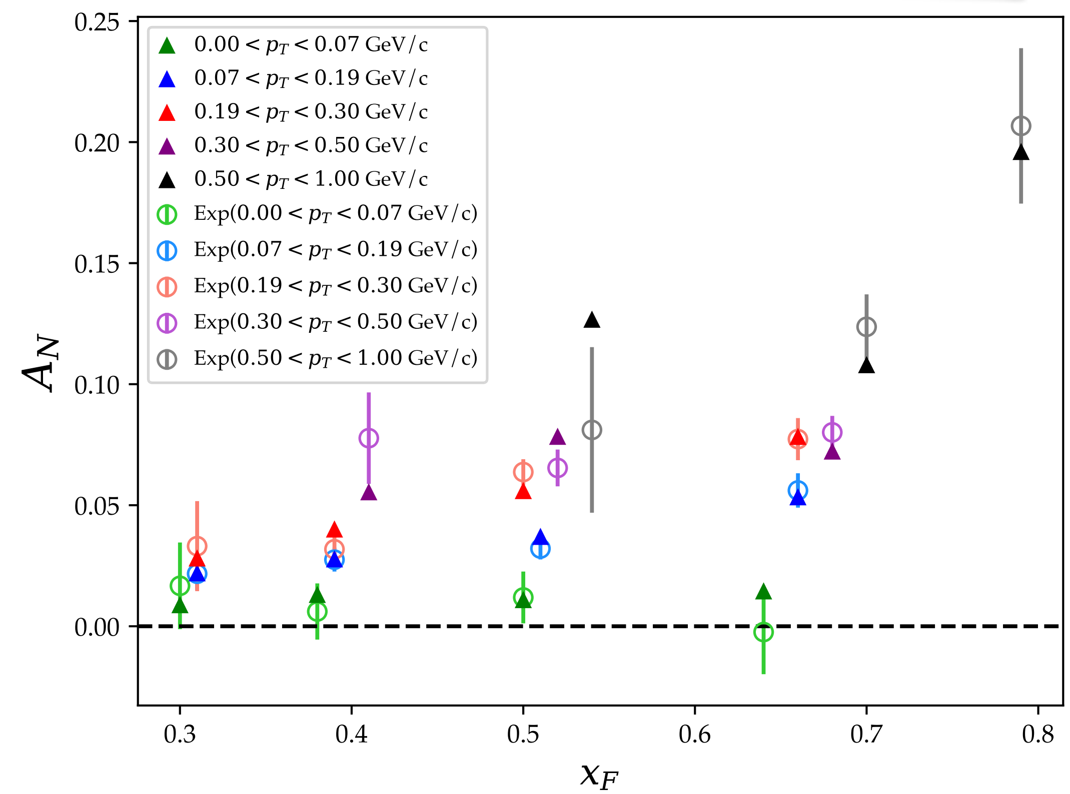
$$d\Delta\sigma_\perp^U = \frac{1}{s}\sum_\lambda (\beta_{+\lambda}^\Delta \beta_{-\lambda}^{\Delta^*}) 2\mathrm{Im}\mathcal{P}_\Delta\mathcal{P}_{\Delta^*}^* \times \sum_k G_k^{\Delta\Delta^*}(t)\gamma_k^{pp}(0)\left(\frac{M_X^2}{s_0}\right)^{\alpha_k(0)}$$

H-J Kim et. al., PRD 106, 054001

momentum p_T at $p_T < 1$ GeV$/c$. Employing baryonic triple Regge exchanges, we describe the complete RHICf data for the first time and show that the neutral pion production at low p_T can be interpreted as a diffractive one.



Great job!



determined. In the present work, we parametrize the form of the triple Regge couplings so that we can describe the RHICf data: $G^{ii}_{\mathbb{P}}(t) = G^{ii}_{\mathbb{P}}(0)e^{-B^{ii}_{\mathbb{P}}|t|}$, $G^{ij}_{\mathbb{P}}(t) = G^{ij}_{\mathbb{P}}(0)\sqrt{|t|}e^{-B^{ij}_{\mathbb{P}}|t|}/m_\pi$. We define the following parameters:

$$g^{ij}_{\mathbb{P}} \equiv G^{ij}_{\mathbb{P}}(0)/G^{NN}_{\mathbb{P}}(0), \qquad b^{ij}_{\mathbb{P}} \equiv B^{ij}_{\mathbb{P}} - B^{NN}_{\mathbb{P}} \quad (17)$$

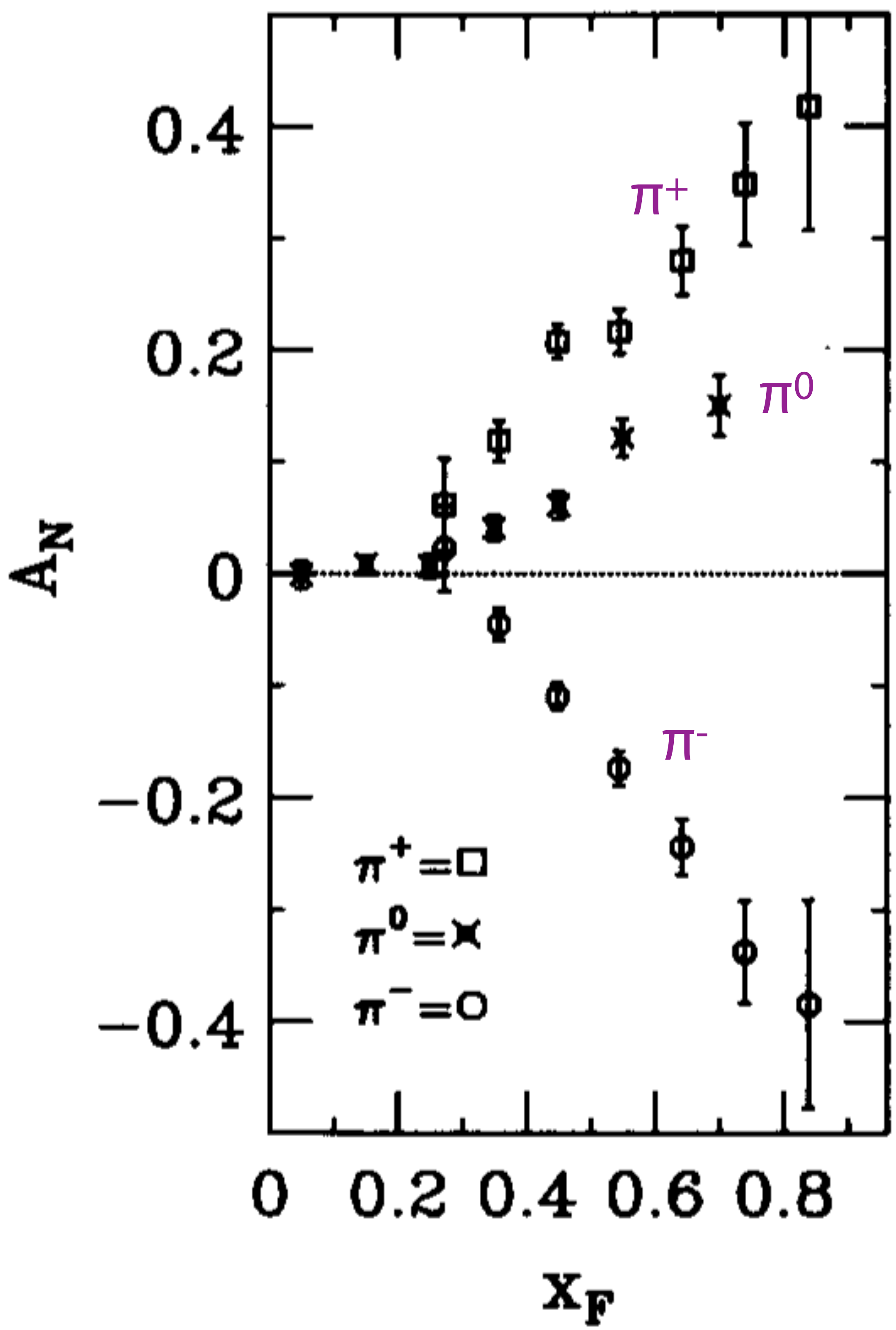
and fit them to the RHICf data. In Table I, we list the

TABLE I. Numerical values of the parameters $g^{ij}_{\mathbb{P}}$ and $b^{ij}_{\mathbb{P}}$. The first column lists the values of $g^{ij}_{\mathbb{P}}$ with i and j given whereas the second column shows the values of $b^{ij}_{\mathbb{P}}$.

	$g^{ij}_{\mathbb{P}}$	$b^{ij}_{\mathbb{P}}$[GeV^{-2}]
NN^*	0.028	0.2
$\Delta\Delta^*$	−0.018	0
N^*N^*	0.10	0
$\Delta\Delta$	0.022	0
$\Delta^*\Delta^*$	0.079	0

Are these numbers consistent with those from the π^0 cross sections? → compare RHICf or low-$\sqrt{s}$ data

$A_N(x_F, p_T)$ in $p^{\uparrow}p \rightarrow \pi X$ at $\sqrt{s} = 19.4$ GeV



E704 at $\sqrt{s} = 19.4$ GeV

- Assuming we are in the phase space where the triple-regge diagram works reasonably,
  - π^+, π^0: nucleon and Δ exchanges
  - π^-: Δ exchanges
- Interesting to see how H-J Kim's model behaves for forward neutral and charged πs, for example in the phase space of E704
- Can estimate the BG contribution of the soft process to QCD-based models?

Inclusively measured A_N is the weighted sum of A_Ns for each process: 1-diff, 2-diff, non-diff, elastic, BG etc.

$$\langle A_N \rangle = \frac{\sum_i A_{Ni}\sigma_i}{\sum_i \sigma_i}$$

Next fiscal year's plan

- An urgent need is reinforcement of the computing resources in KEK.
- Search for other processes possibly contributing to π^0 cross section and asymmetry
- Implementation of the 2π MAID model in the UPC simulation codes (no need to hurry up?)

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