Nuclear effects in single spin asymmetry at small angles

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Outline

- Motivation & introduction
- Proton and light nuclear target
- Gold
- Conclusions

Spin-flip Pomeron interaction?

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Our goal:

Study the **spin-flip Pomeron** interaction.

Our method:

Study of the single spin asymmetry $A_N(t)$ in the CNI region in *p+A* elastic collisions.

$$A_N \frac{d\sigma^{pp}}{dt} = 2\mathrm{Im}[\phi_{++}\phi_{+-}^{*}]$$

$$\frac{d\sigma^{pp}}{dt} = |\phi_{++}|^2 + |\phi_{+-}|^2$$

Why CNI region?

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Let’s assume that **Pomeron** can flip the spin.

Then, due to the same phase factor there is no prediction for the hadronic single spin asymmetry.

Solution is the interference with EM amplitude.

CNI (Coulomb-nuclear interference) region = a kinematical region of very low 4-momentum transfer squared, *-t,* where the interference electromagnetic-hadron terms dominates

Why nuclear target?

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Two motivations:

Polarimetry – was actual 10 years ago, expected smaller errors at *pA* elastic scattering than for *pp*.

Reggeons – experimental data mostly from RHIC ($E_{LAB} = 100$ GeV $\approx \sqrt{s} = 14$ GeV). Expected a contribution mainly from the iso-vector Reggeons.

If we use the nucleus with the zero isospin (e.g. Carbon), these Reggeons are excluded. For other nuclei Reggeons are suppressed as $1/A$. B. Kopeliovich, hep-ph/9801414

How to calculate it?

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Coulomb spin-flip and non-flip amplitude are known, as well as no-flip hadronic amplitude from data. Spin-flip hadron amplitude can be parametrized as

$$r_5 = \frac{m_p \phi^h_{+-}}{\sqrt{-t}\ \mathrm{Im}\phi^h_{++}}$$

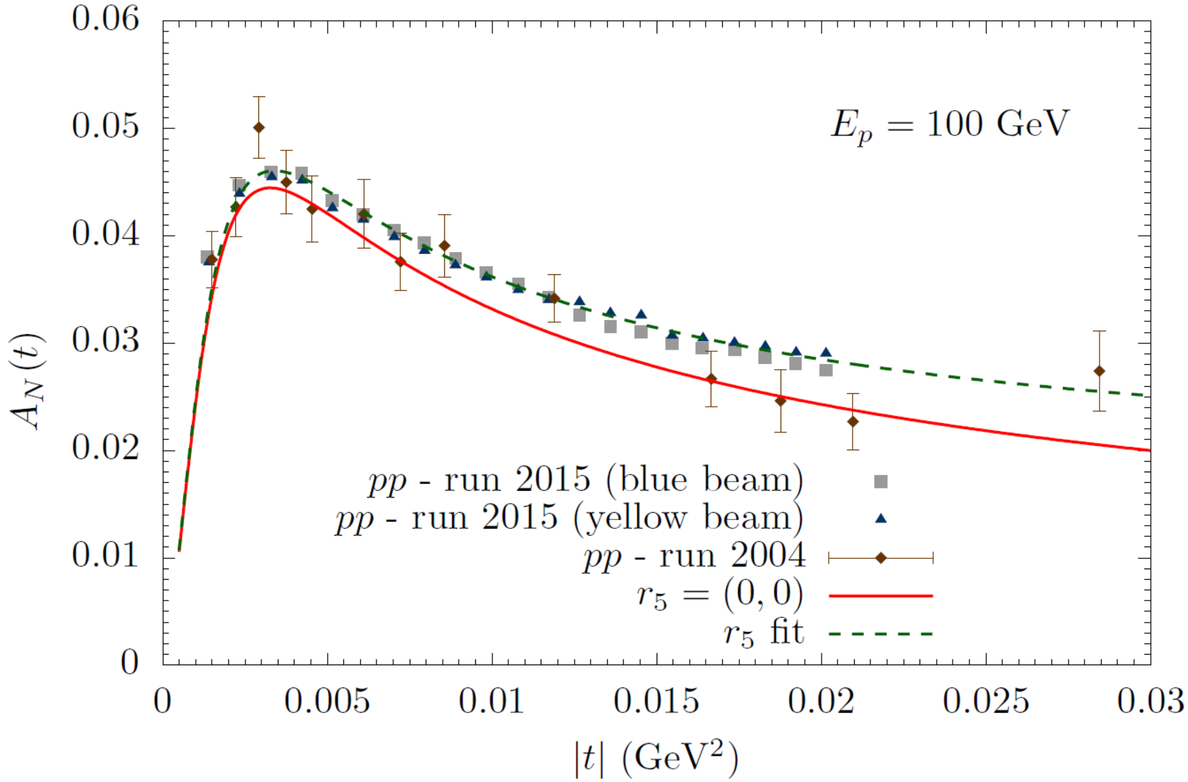
ϕ^h_{++}- non-flip amplitude
ϕ^h_{+-}- single spin-flip amplitude

Assuming $r_5 = 0$ the asymmetry $A_N(t)$ can be fully predicted.

L.I.Lapidus & B.Kopeliovich Sov. J. Nucl. Phys. 19(1974) 114

Experimental data for *pp*

Data from H-Jet experiment indicate **non-zero r_5** for *pp*.



However, here we have $r_5 = r_{5,\mathbb{P}} + r_{5,\mathbb{R}}$ $\Rightarrow$ small r_5 does not mean small $r_{5,\mathbb{P}}$...

Experimental data for *pC*, *pAl*

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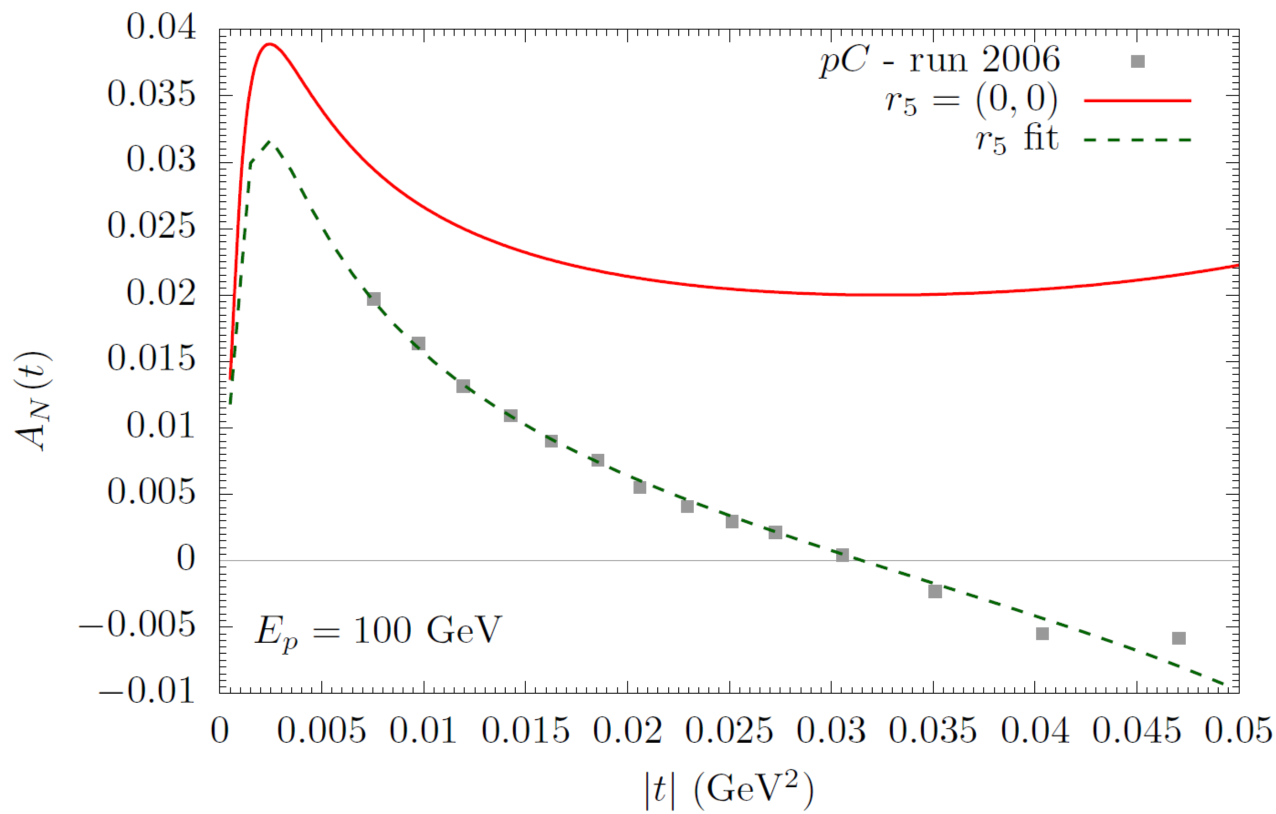

pC indicates higher (∼10x) r_5 then ***pp*** ⇒ significant contribution from Reggeons in ***pp***.

Similar situation also for ***pAl.***

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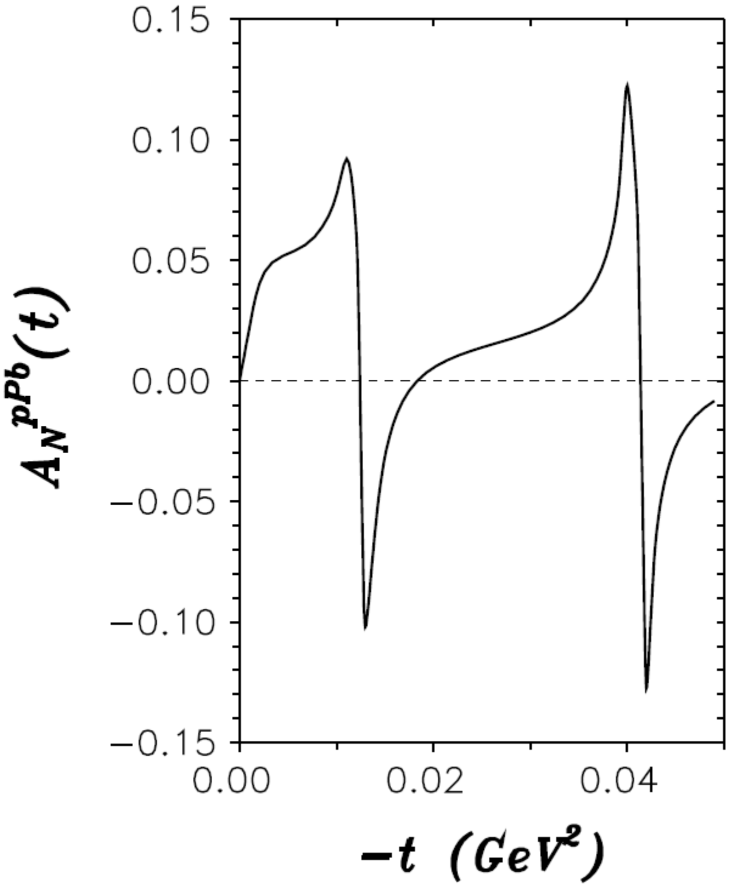
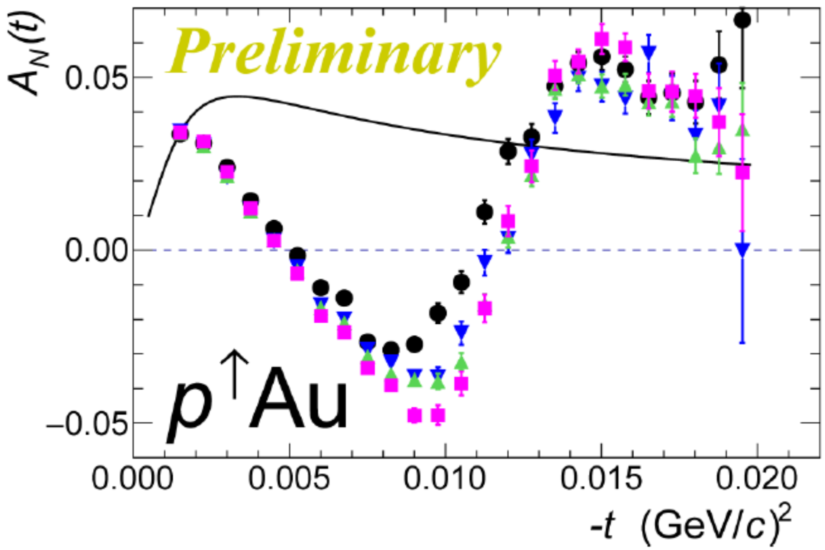
…but the Gold is the challenge

Estimation of $r_{5,\mathbb{P}}$ form Carbon is sufficient, for Gold the situation is more complicated. However, take a look at it…



B. Kopeliovich, hep-ph/9801414



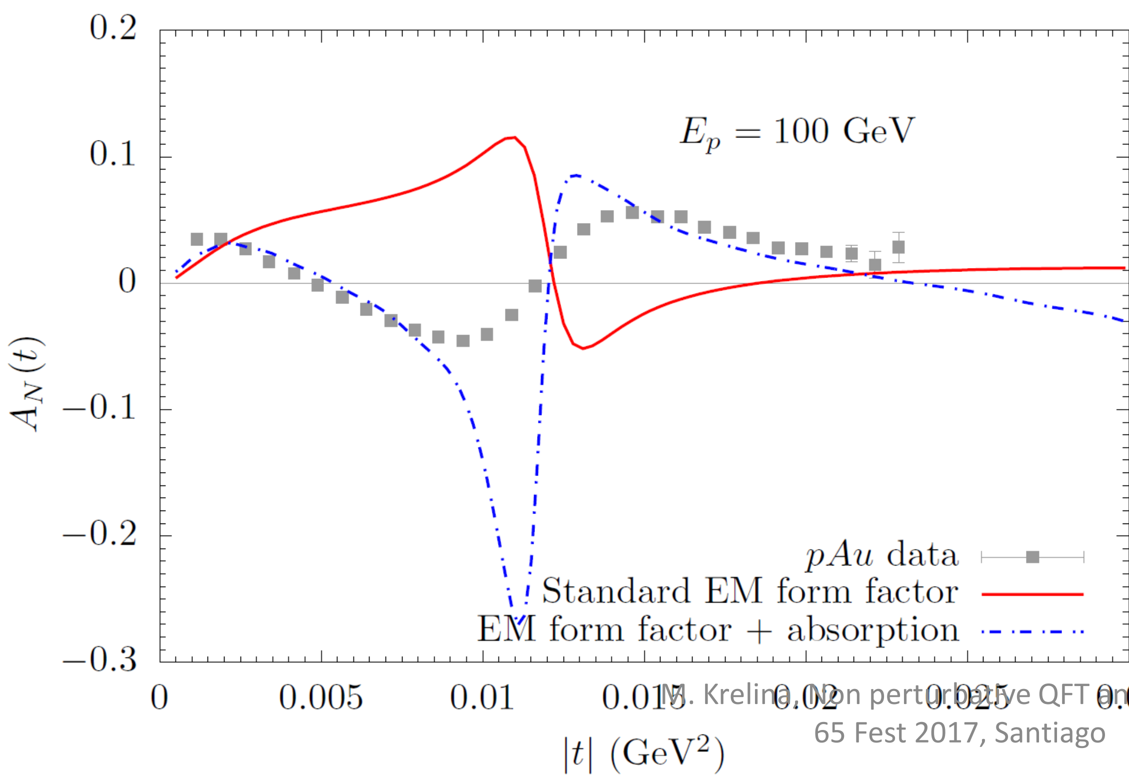
From a talk by Andrei Poblaguev (SPIN2016)

Data has nearly inverse trend than theoretical calculations.

Wrong EM form factor

We want to understand the *t* dependence ⇒ need to revise the calculation. We start from the Glauber. We found that the source of the trouble is the incorrect electromagnetic form factor, where we discovered the importance of the absorption

$$\phi_{\text{em}}(q) = \sqrt{\pi} Z \alpha_{em} \left(\frac{2}{q^2} + \frac{\mu_p - 1}{q} \right) F_A^{em}(q^2) e^{i\delta_{pA}} \otimes \boldsymbol{e^{-\frac{1}{2}\sigma_{tot}^{pp} T_A(b)}}$$



The electromagnetic amplitude gets the main contribution from the ultra-peripheral collisions, $b > R_A$, while the hadronic amplitude is non-zero only at small impact parameters, $b < R_A$.

Due to the coherence in the momentum space.

Other corrections

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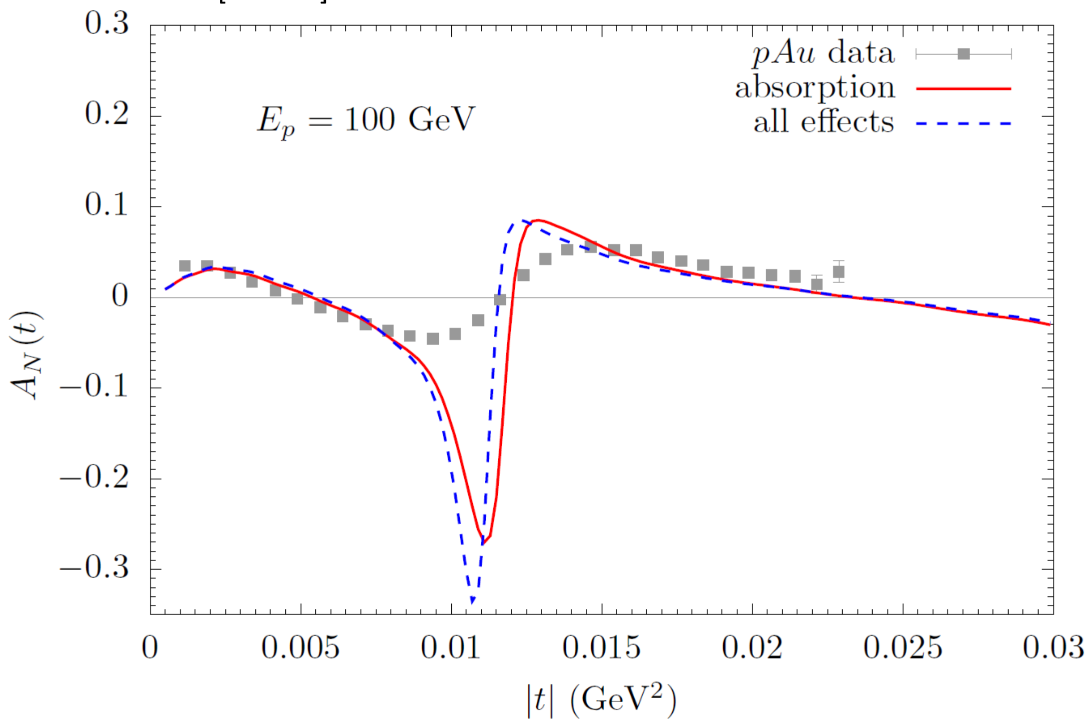
To have a full description we should add other correction such as Gribov correction or nucleon-nucleon correlations.

Gribov corrections – effectively increase the *pA* cross section

B. Z. Kopeliovich, Int. J. Mod. Phys. A31 no. 28n29, (2016) 1645021, arXiv:1602.00298 [hep-ph].
B. Z. Kopeliovich, I. K. Potashnikova, and I. Schmidt, Phys. Rev. C73 (2006) 034901, arXiv:hep-ph/0508277 [hep-ph].

NN correlations – effectively reduce the nuclear thickness function

M. Alvioli, C. Ciofi degli Atti, B. Z. Kopeliovich, I. K. Potashnikova, and I. Schmidt, Phys. Rev. C81 (2010) 025204, arXiv:0911.1382 [nucl-th].



Further adjustments

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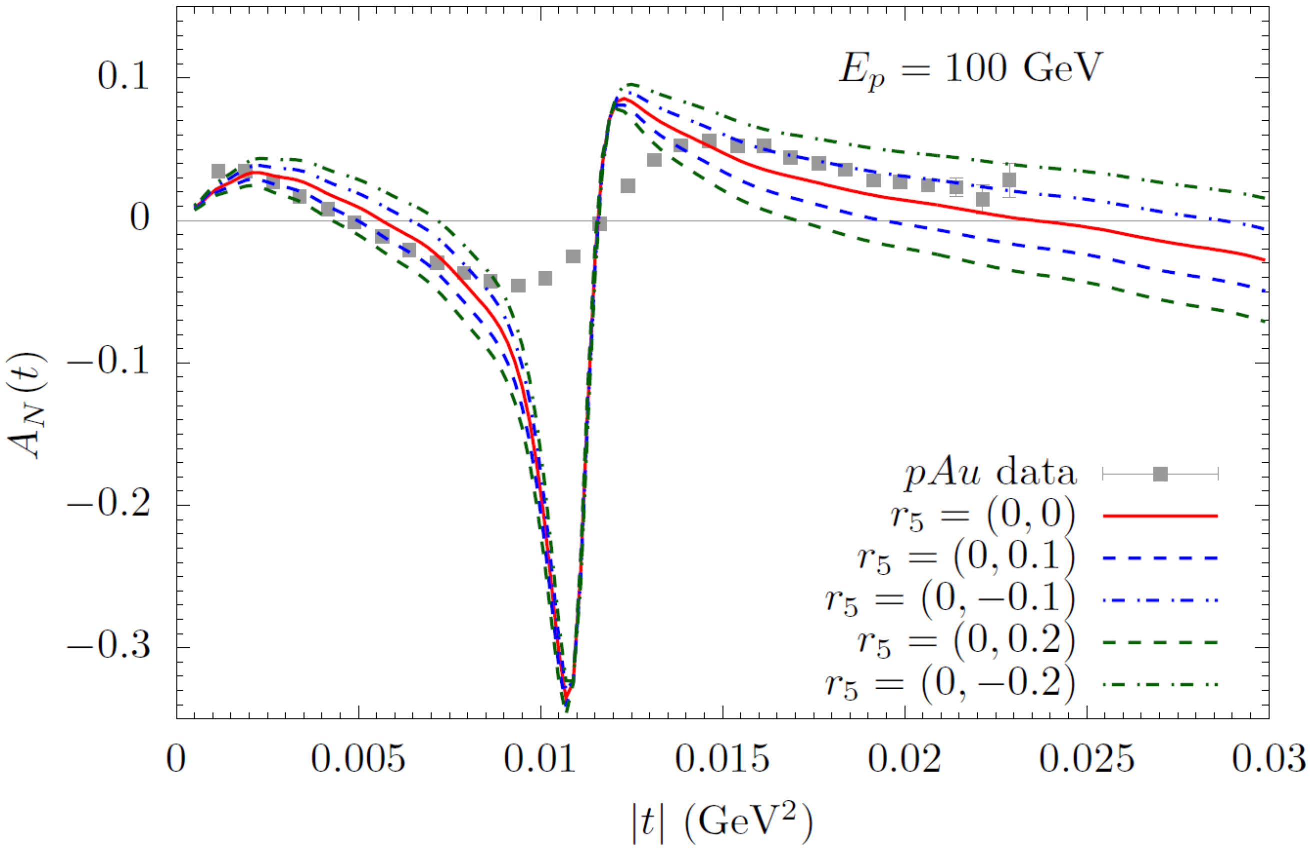
Finally, we can make some adjustment by non-zero r_5



The result looks reasonable, good agreement at low and high *t*, good position of the cross points.

Conclusions

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- We study the CNI region to see the effect of spin-flip hadronic amplitude.
- We are interested into the nuclear target because of exclusion or suppression of Reggeons.
- Indicated small r_5 in *pp* at RHIC does not report about Pomeron spin-flip interaction, it is combination of Pomeron and Reggeon.
- Data for *pC* indicated higher r_5 then in *pp*. It can be interpreted that the pomeron r_5 is suppressed in *pp*. Similar situation for *pAl*.
- More complex situation in case of Gold target. Unexpected experimentally measured *t* dependence.
- A novel mechanism of interference of electromagnetic UPC with central hadronic collisions is proposed attempting at explanations of *pAu* data for CNI generated $A_N(t)$.
- We included other expected correction. Finally we have good agreement at low and high *t*, good positions of the crossing points.
- Nevertheless, an accurate determination of r_5 from *pAu* data is not possible so far.

Thank you for your attention

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