Gluon helicity distributions

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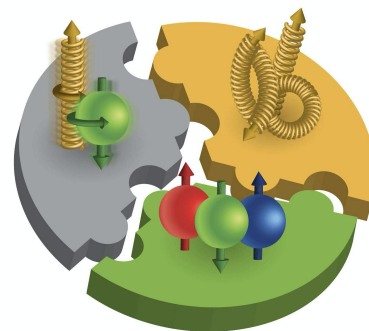*College of William & Mary
and Jefferson Lab*

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Proton spin puzzle

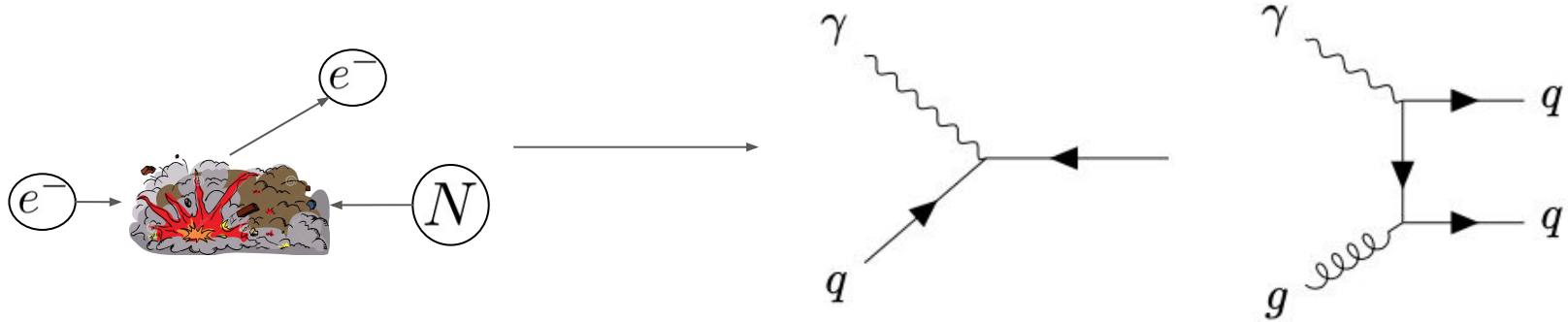- What is the decomposition of the proton spin?

$$\frac{1}{2} = \frac{1}{2}\Delta\Sigma + L_q + \Delta G + L_g$$

- current extraction of $\Delta\Sigma$ is around 0.3

- spin: parton distribution functions (PDFs)

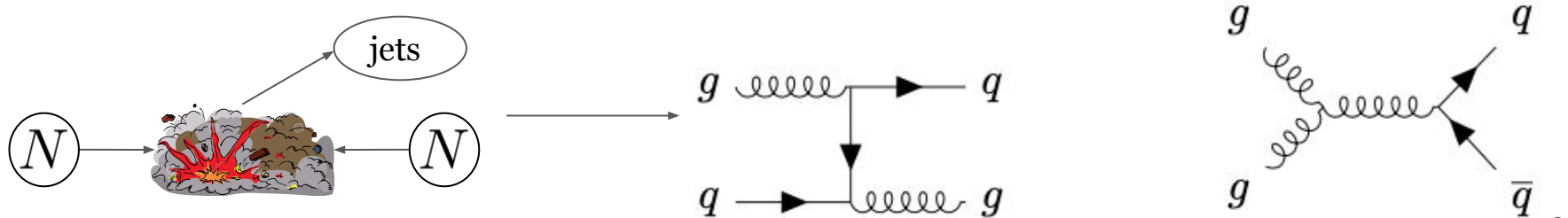- orbital angular momentum: TMDs and GPDs

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Jets as probes for gluons

In inclusive DIS, sensitivity to gluon PDFs only appears at NLO

On the other hand, in jet production, gluon diagrams appear at its lowest order
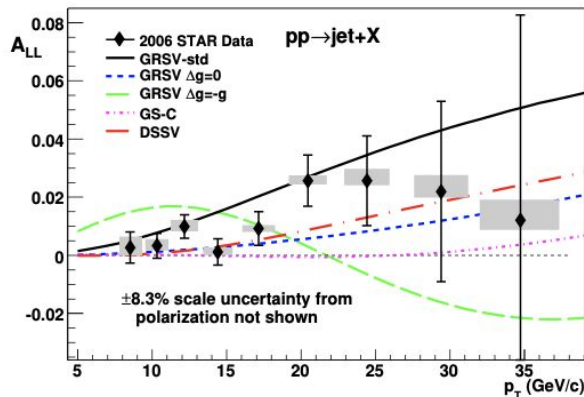

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Polarized jets

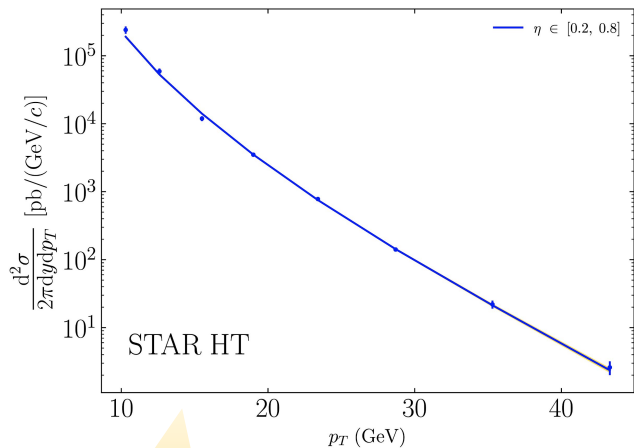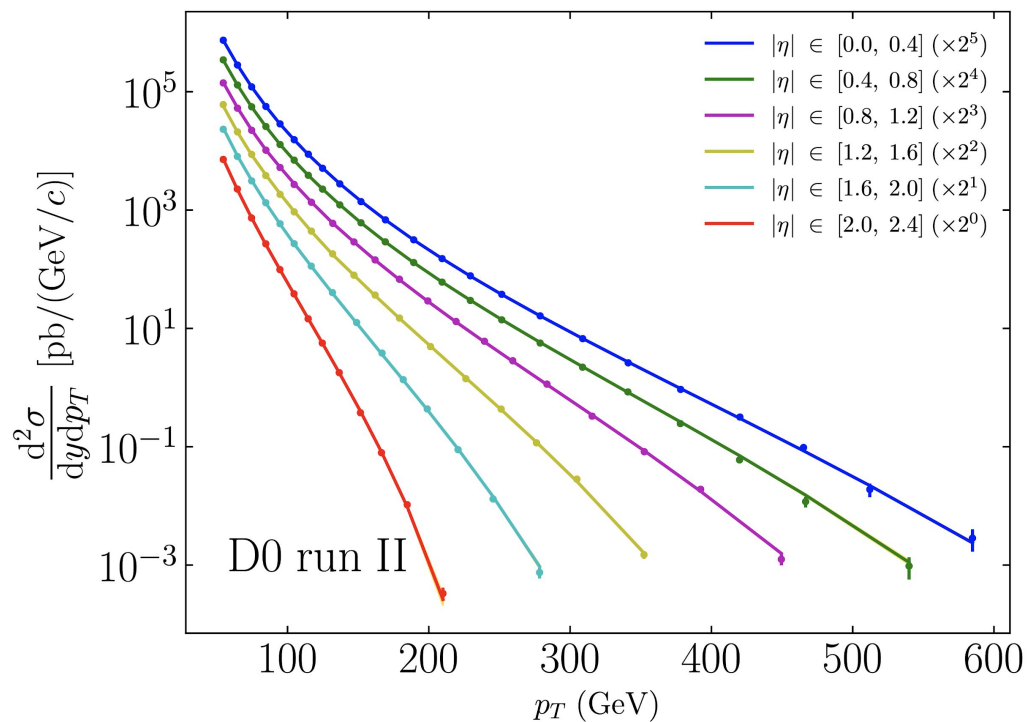- RHIC measures double longitudinal spin asymmetry

$$A_{LL}^{\text{jets}} = \frac{\sigma^{++} - \sigma^{+-}}{\sigma^{++} + \sigma^{+-}} = \frac{\Delta\sigma\left(\Delta g, \ldots\right)}{\sigma\left(g, \ldots\right)}$$

- $\sigma^{+\pm}$ are differential cross sections when proton beams have equal *or* opposite helicity
- denominator is spin-averaged cross section

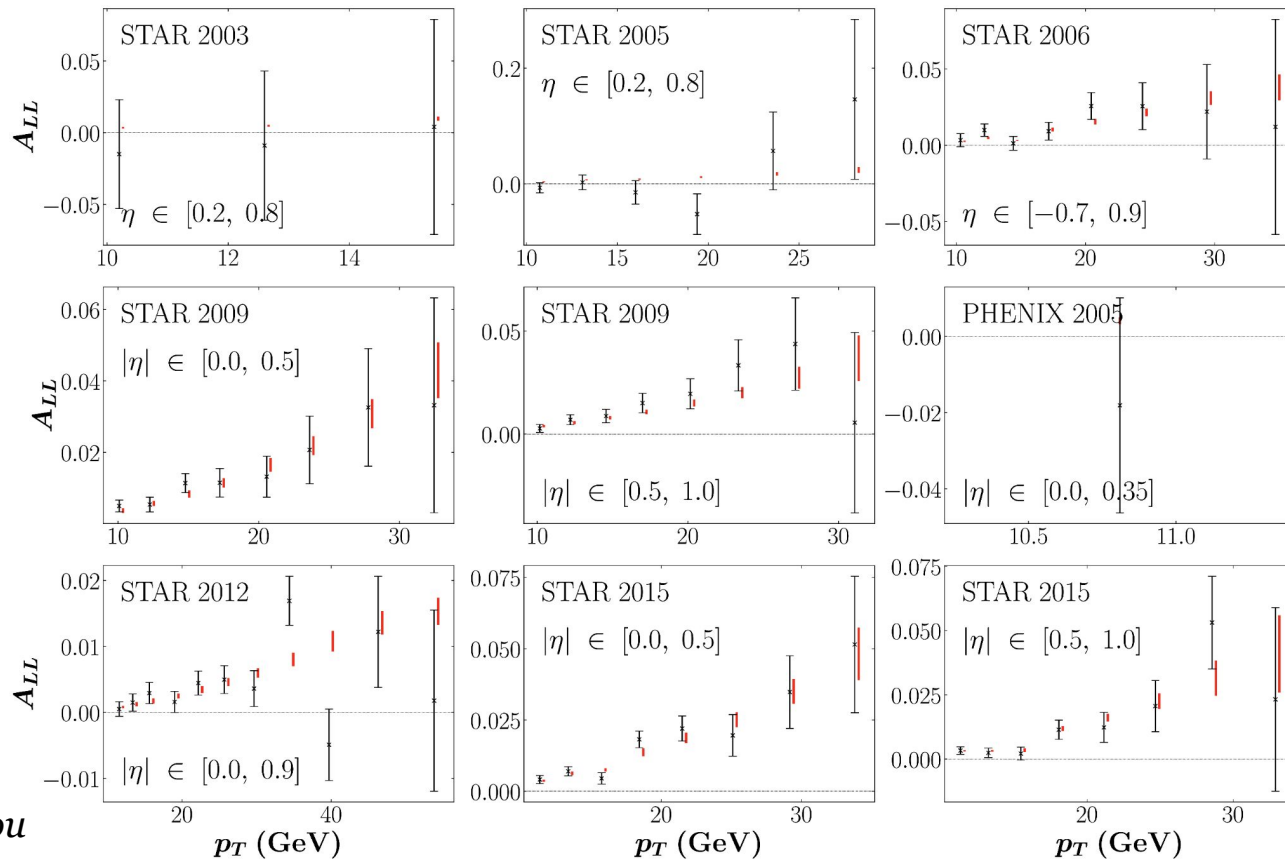- A_{LL}^{jets} is also sensitve to unpolarizd PDFs, **simultaneous** analysis is needed!

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4

Unpolarized jets (including **RHIC** upolarized jets)

D0 run II

STAR HT

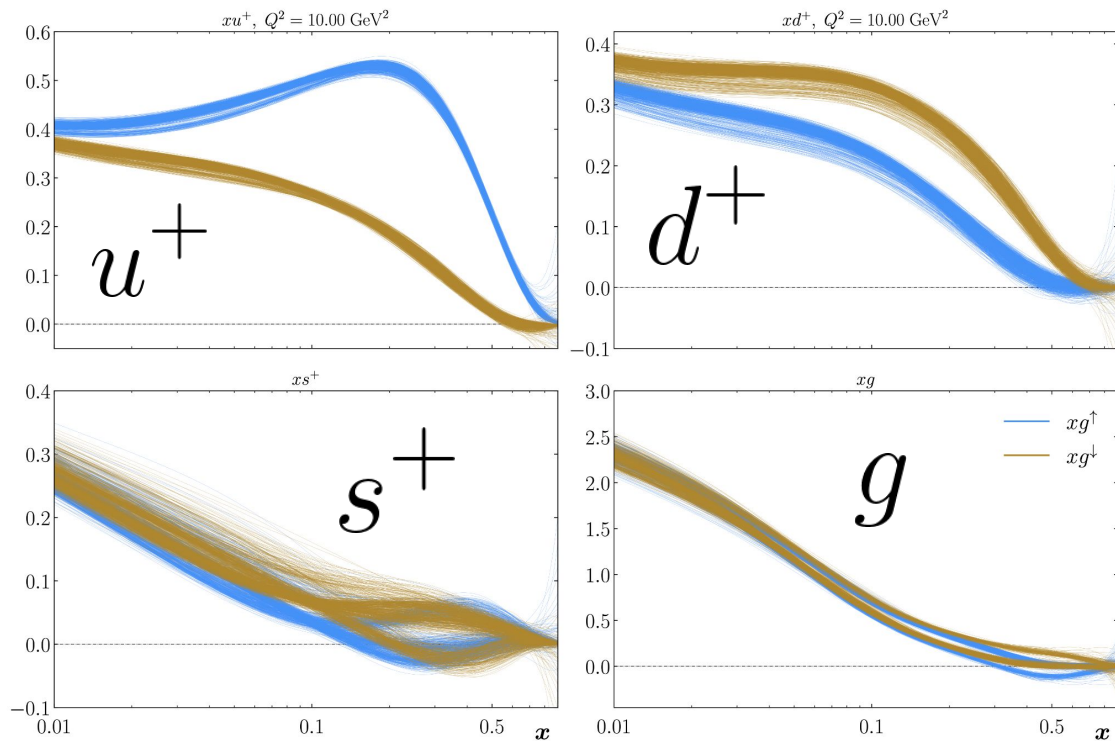First inclusion of upolarized RHIC jets! ($\sqrt{S}$ = 200 GeV)
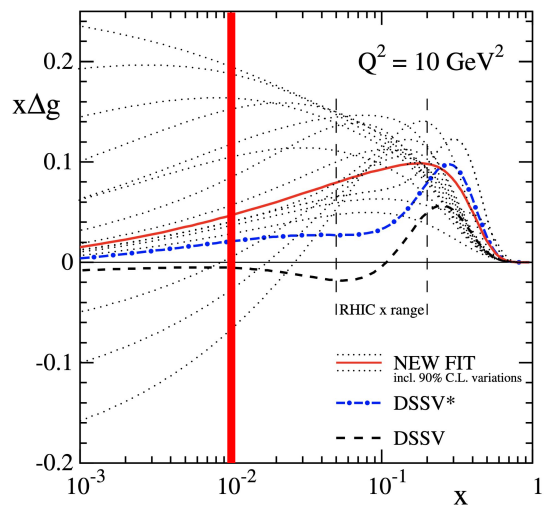
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Jet asymmetry

$\chi^2 = 0.722$

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Helicity decomposition

- First simultaneous determination of individual helicity PDFs
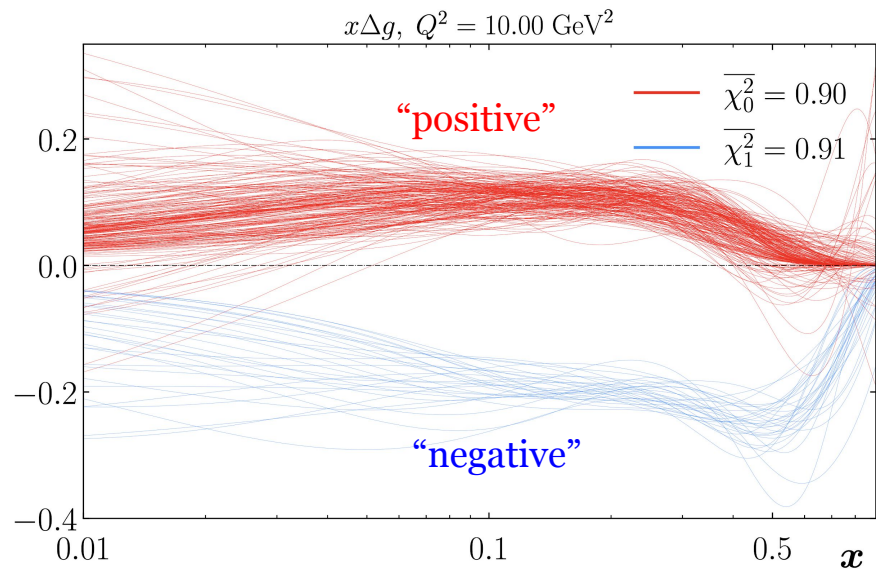
- Consistent treatment of uncertainties!

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Compare with DSSV

DSSV 14: positive helicity gluon

JAM: positive and negative helicity gluons

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Theory assumptions

SU(2) only

$\downarrow$

SU(2) and SU(3)

$\downarrow$

SU(2) and SU(3), and PDF positivity
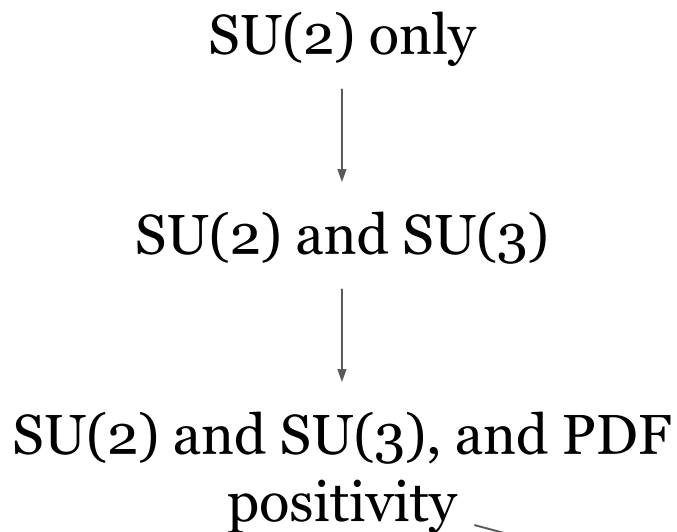
- more constraint
- more bias
- less data driven

$$|\Delta f_i(x)| \leqslant |f_i(x)|$$

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Theory assumptions

$x\Delta g,\ Q^2 = 10.00\ \mathrm{GeV}^2$

SU(2)
+ SU(3)
$+ \Delta f \leq |f|$

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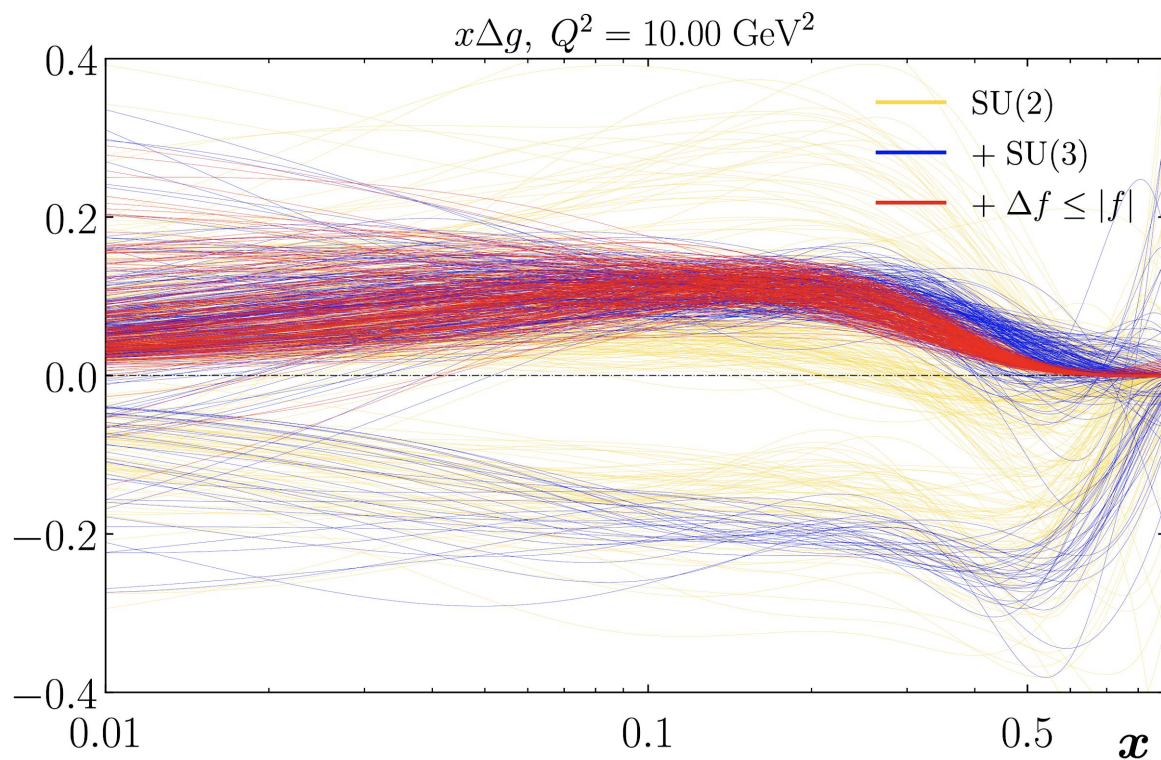
$$\int_{0.05}^{1} \Delta g\left(x, Q^2 = 10\ \mathrm{GeV}^2\right) \mathrm{d}x$$

- **SU(2)**: 0.04 ± 0.33
  - positive: 0.2 ± 0.18
  - negative: -0.48 ± 0.13
- **+ SU(3)**: 0.13 ± 0.26
  - positive: 0.23 ± 0.04
  - negative: -0.56 ± 0.04
- **+ positivity**: 0.21 ± 0.03

- DSSV 14: 0.2 ± 0.05

$x\Delta g$

0.1

DSSV 14

|RHIC x range|
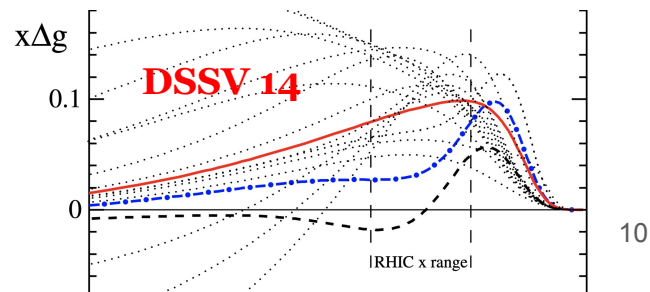
Conclusion

- Unpolarized jet data (Tevatron and RHIC) is well fitted.

- Polarized jet data can constrain gluon helicity.

- Gluon helicity PDFs depend largely on theory assumptions, SU(2/3) and positivity constraints.

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Thank you!

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