



Baryon-antibaryon Production in Au+Au Ultra-Peripheral Collisions at RHIC

Xin Wu

(for the STAR Collaboration)

University of Science and Technology of China

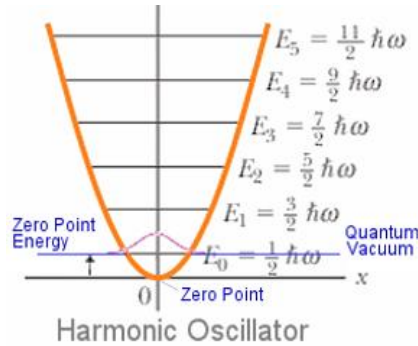


The 21st International Conference on Strangeness in Quark Matter
3-7 July 2024, Strasbourg, France

Xin Wu, flash talk in SQM, Strasbourg



The vacuum is not empty!
→ Zero point energy

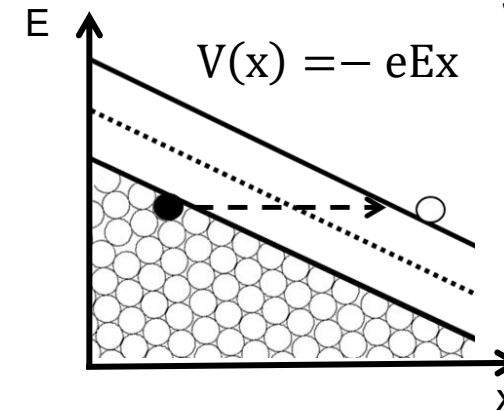


Indirect
observables:

Lamb shift
Casimir effect

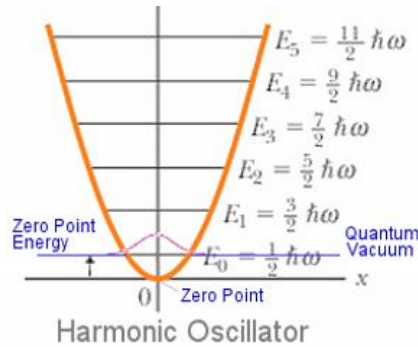
The Schwinger mechanism

J. Schwinger, PR 82 (1951) 664



**Extreme
external
field to
spark the
vacuum!**

The vacuum is not empty!
→ Zero point energy

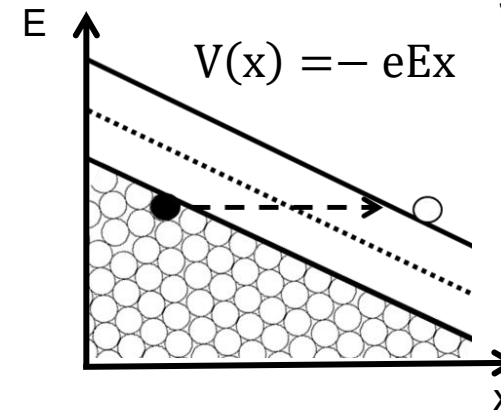


Indirect
observables:

Lamb shift
Casimir effect

The Schwinger mechanism

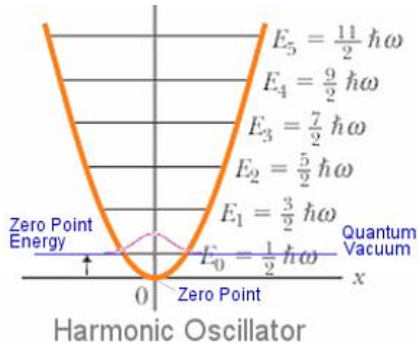
J. Schwinger, PR 82 (1951) 664



**Extreme
external
field to
spark the
vacuum!**

Can we directly “see” the vacuum quantum fluctuation?

The vacuum is not empty!
 → Zero point energy

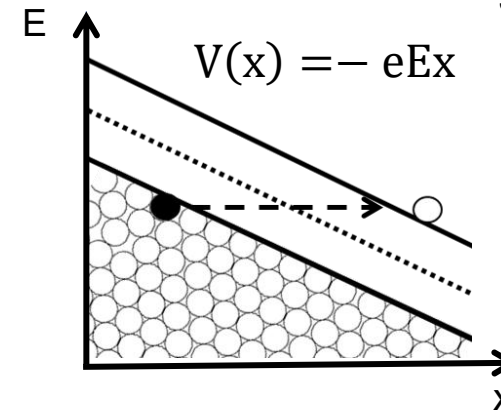


Indirect observables:

Lamb shift
 Casimir effect

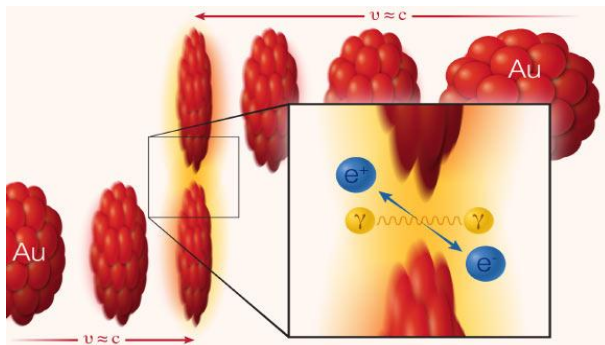
The Schwinger mechanism

J. Schwinger, PR 82 (1951) 664



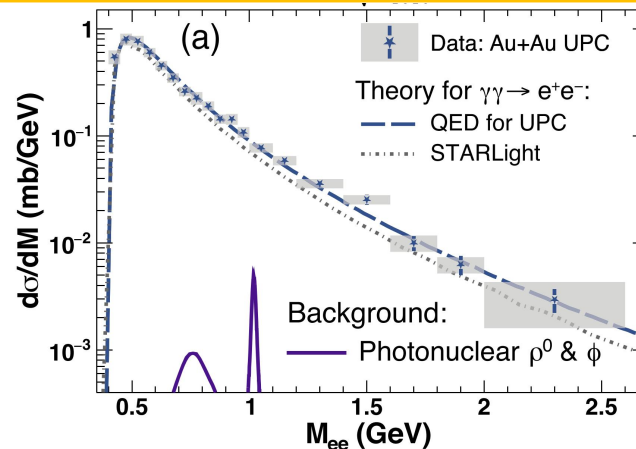
Extreme external field to spark the vacuum!

Can we directly “see” the vacuum quantum fluctuation?



Breit-Wheeler process

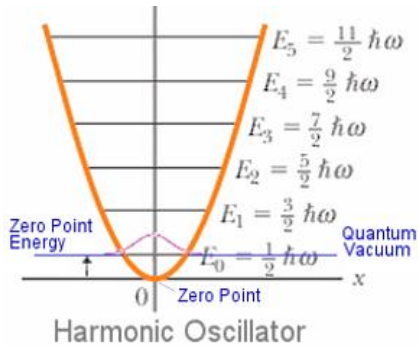
Image credit: Brookhaven National Laboratory



STAR, PRL121 (2018) 132301, PRL127 (2021) 052302

- $\gamma\gamma \rightarrow l^+l^-$ has been measured
- QED theory describes data very well

The vacuum is not empty!
 → Zero point energy

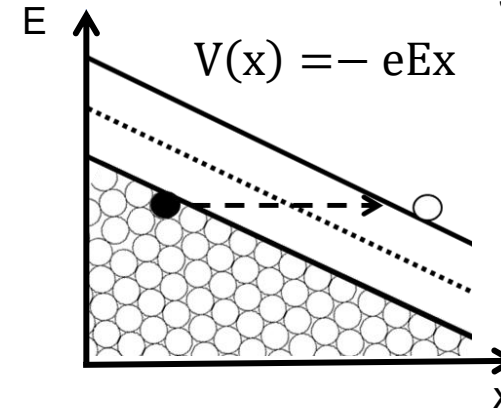


Indirect observables:

Lamb shift
 Casimir effect

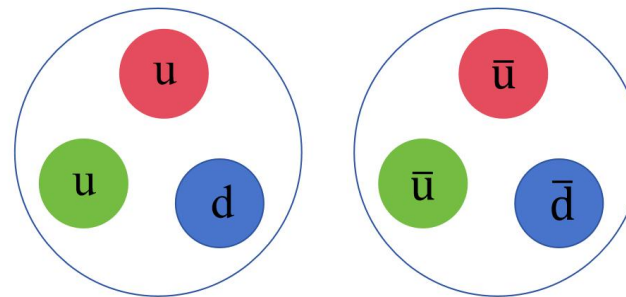
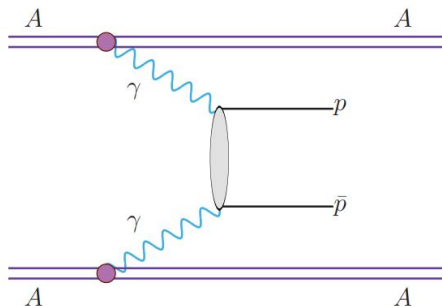
The Schwinger mechanism

J. Schwinger, PR 82 (1951) 664



Extreme external field to spark the vacuum!

How about higher-order QED vacuum excitation?



- Can $\gamma\gamma$ produce more complex baryon antibaryon pairs?

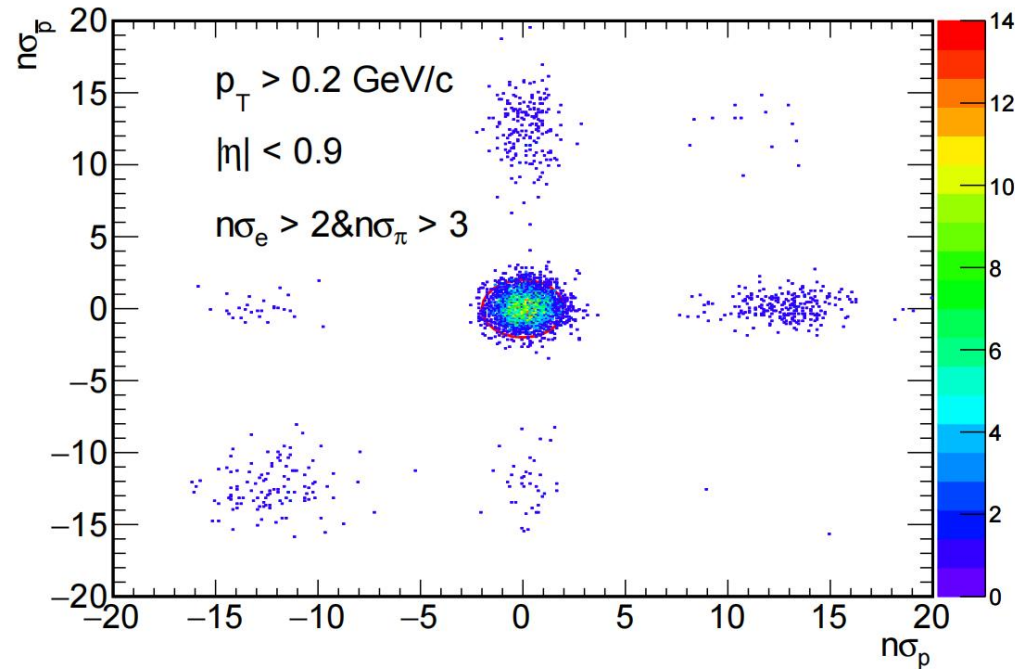
M. Klusek-Gawenda et al.,
 PRD107 (2023) 036020

Baryon/Antibaryon: more complex system

Measure Proton-antiproton Pair Production in UPCs



- Dataset: Au+Au ultra-peripheral collisions (UPCs) at $\sqrt{s_{NN}} = 200$ GeV taken in 2010, 2011 and 2014

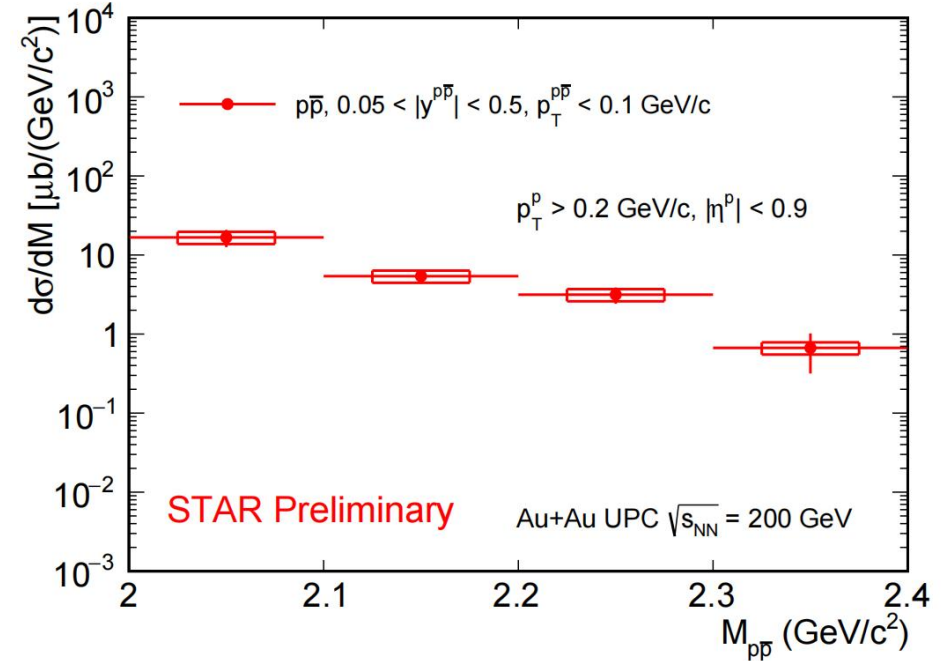
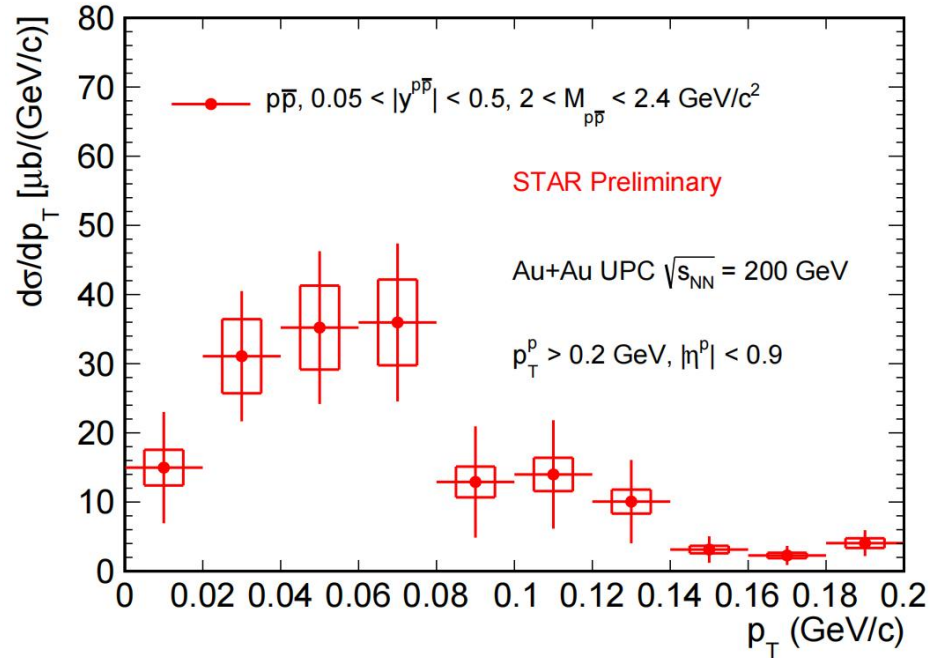


$$n\sigma_x = \frac{1}{\sigma} \log \frac{\langle dE/dx \rangle^{Measured}}{\langle dE/dx \rangle_x^{Theory}}$$

$$\chi_{p\bar{p}}^2 = n\sigma_p^2 + n\sigma_{\bar{p}}^2 < 4$$

- Coincidence between two ZDCs
- Events with only two charged tracks
- Protons and antiprotons identified by Time Projection Chamber

Measure Proton-antiproton Pair Production in UPCs



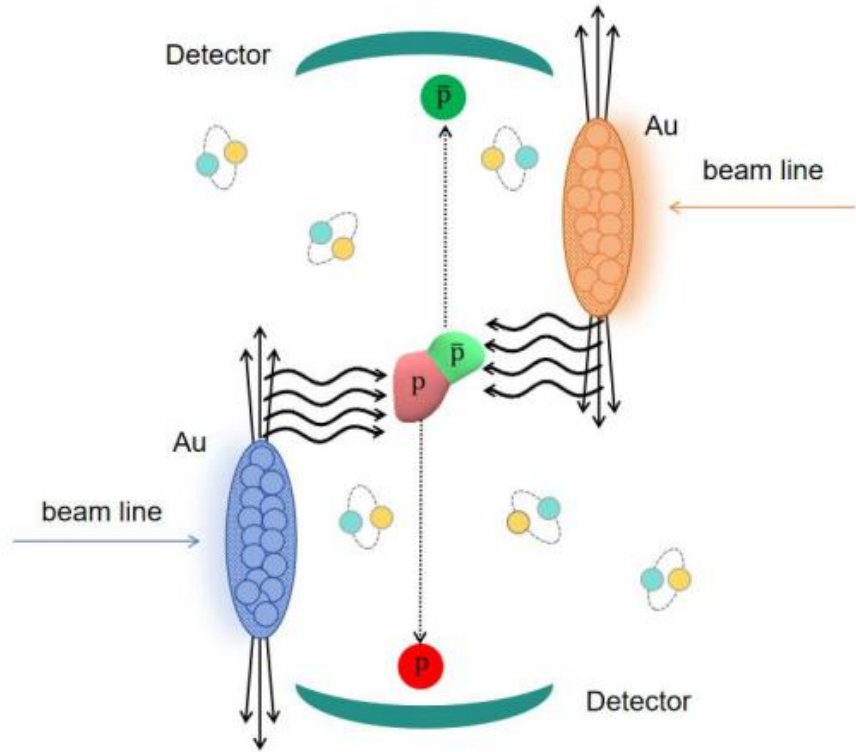
- The $p\bar{p}$ pairs produced at very low p_T
- Decreasing trend from 2 to 2.4 GeV/c²

First measurement of baryon-antibaryon pair production in UPCs!

Low- p_T $p\bar{p}$ Production Mechanism



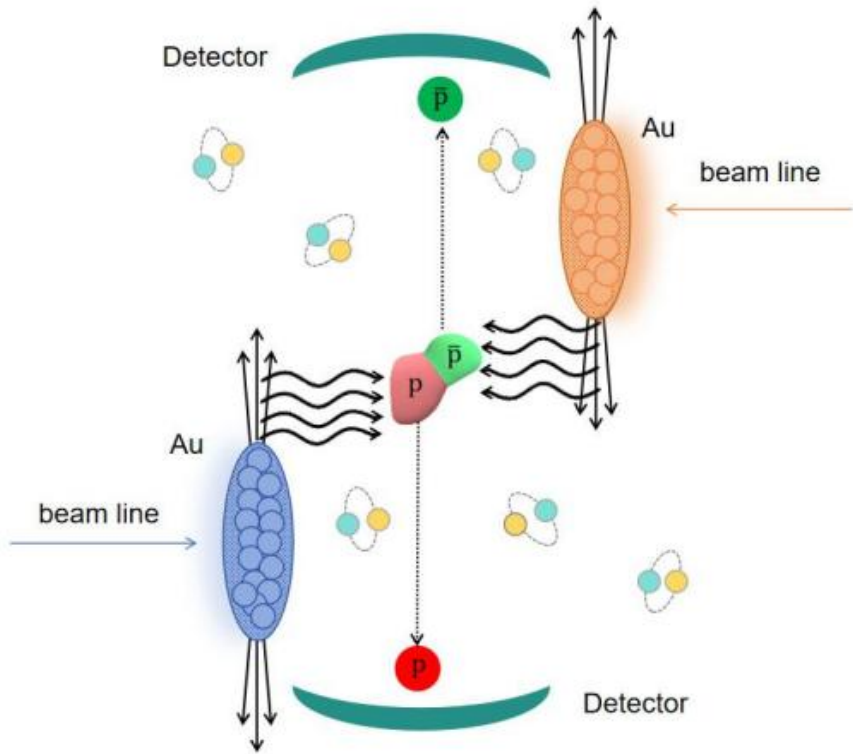
- Vacuum Excitation



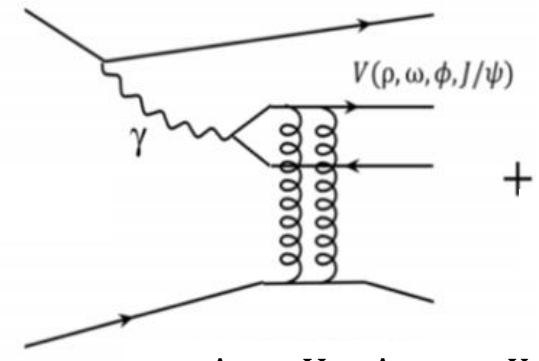
Low- p_T $p\bar{p}$ Production Mechanism



- Vacuum Excitation



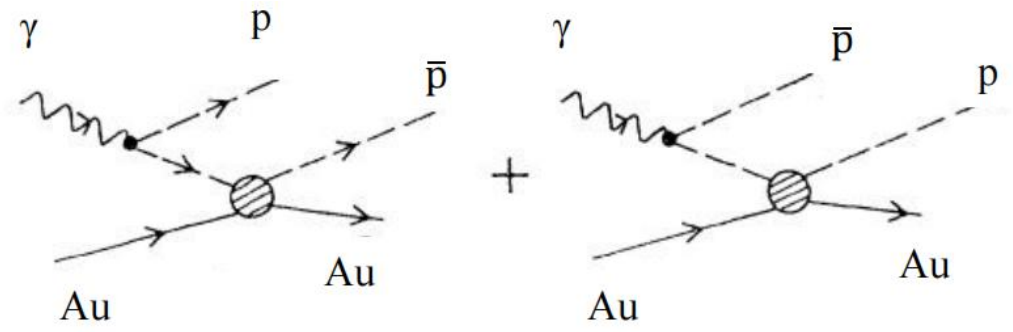
- Background: γA interaction



S. Klein,
ARNPS55 (2005) 271

$$\gamma + Au \rightarrow V + Au \rightarrow p\bar{p}X + Au$$

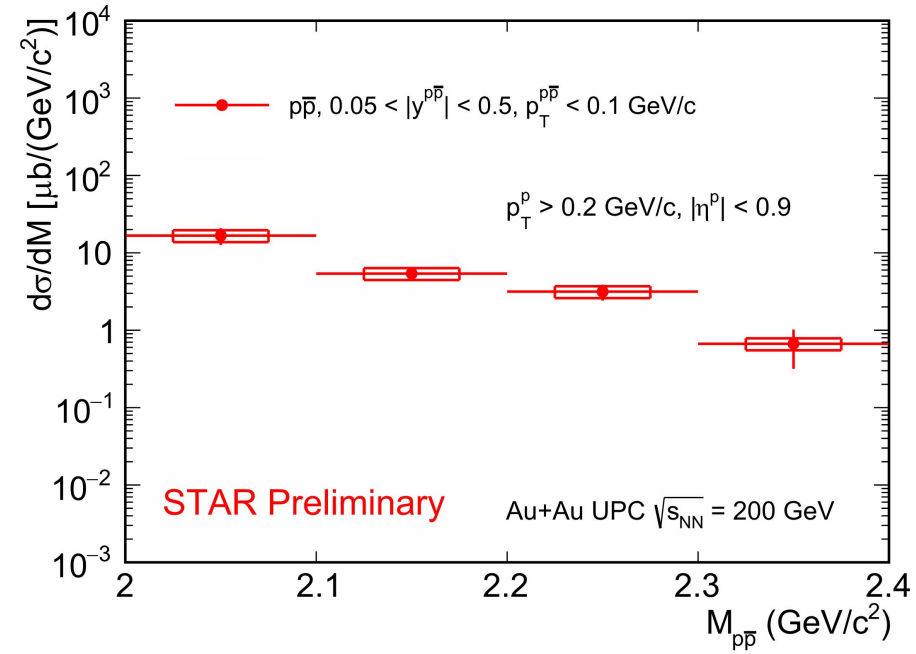
Vector mesons: J/ψ ...



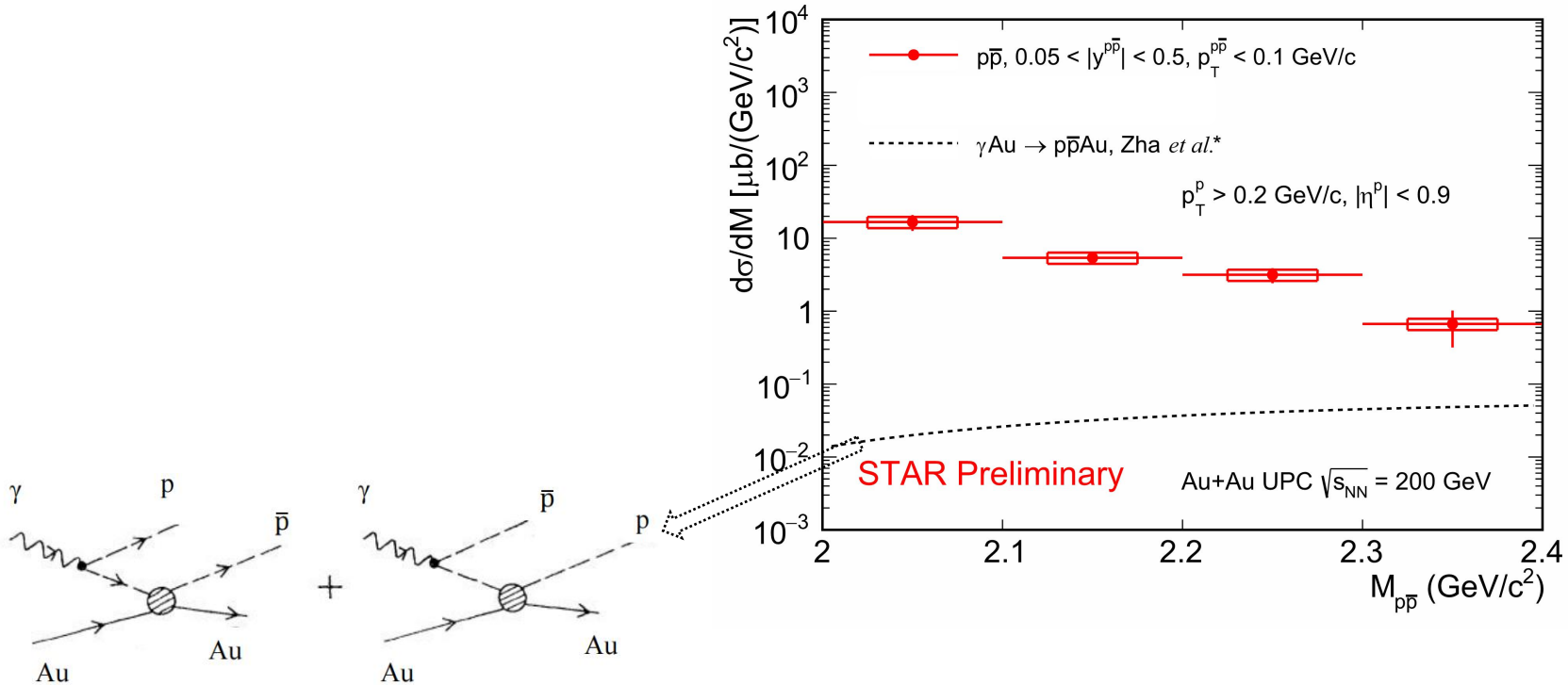
P. Södding,
PLB19 (1966) 702

Drell-Södding Process

Comparison with Model Calculation



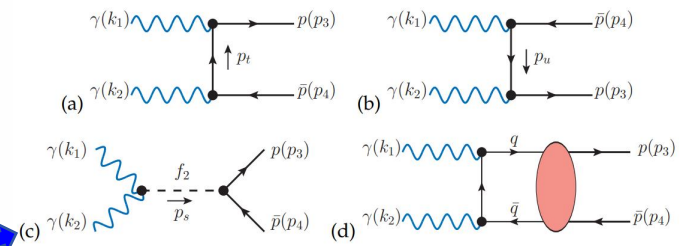
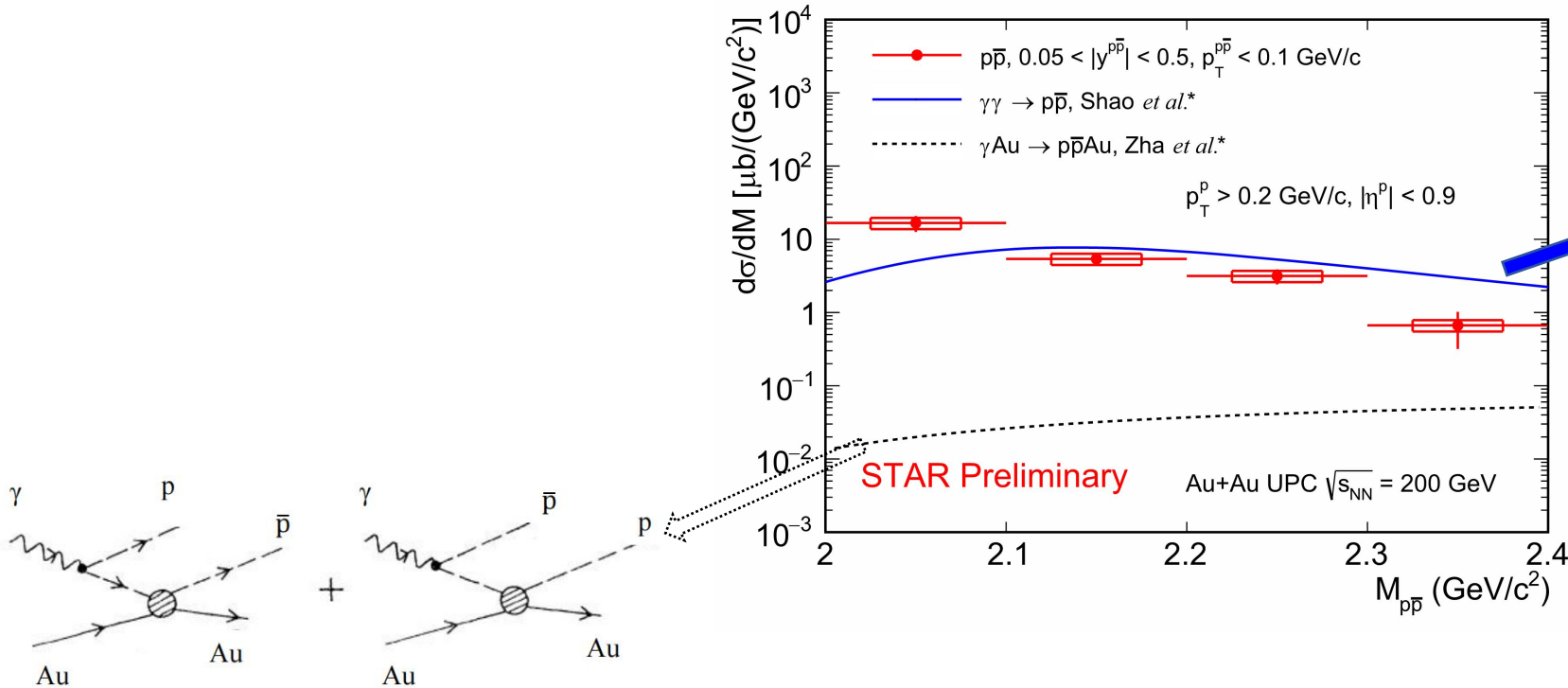
Comparison with Model Calculation



W. Zha et al., PRC97 (2018) 044910 and private communication

- Drell-Soding process significantly lower than the measurement

Comparison with Model Calculation

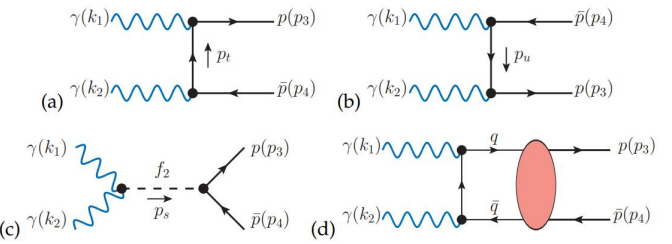
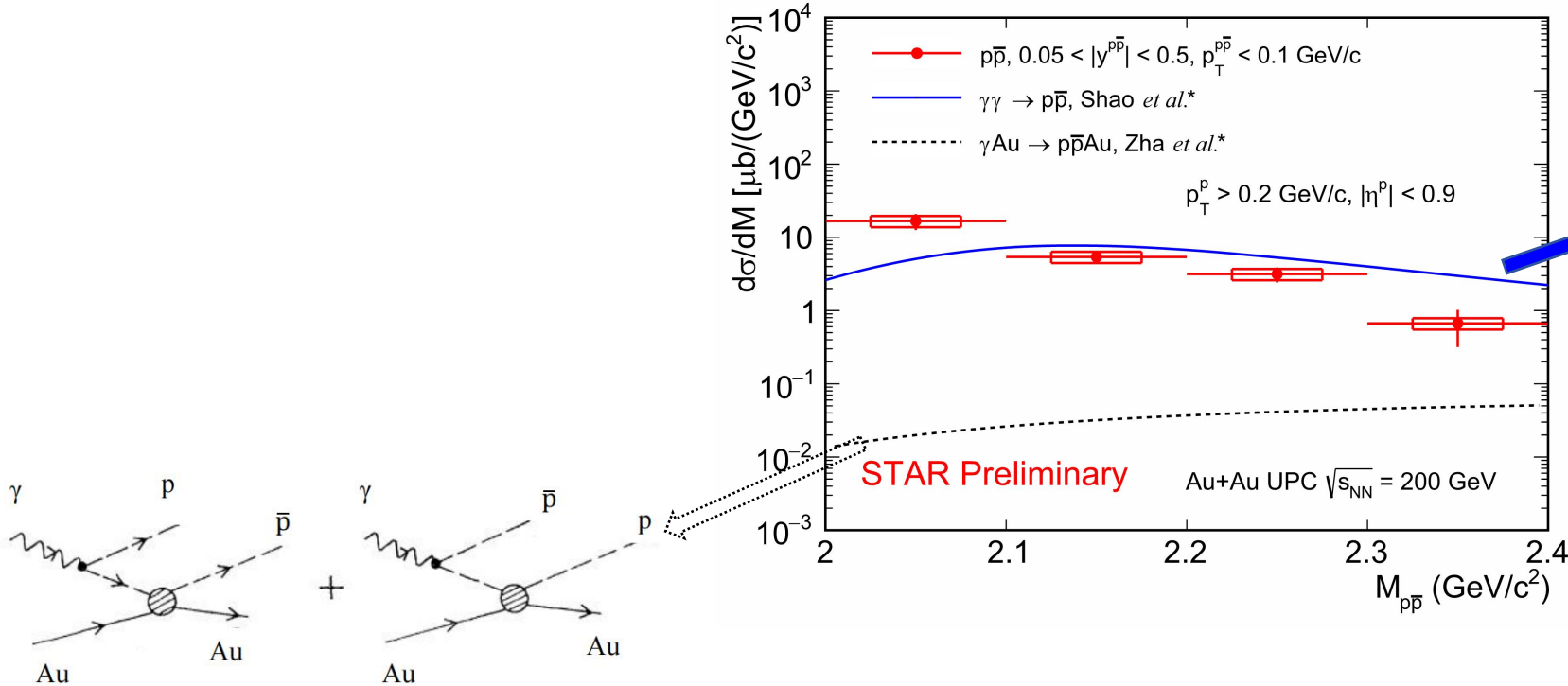


D. Shao et al., PRD107 (2023) 036020 and private communication

W. Zha et al., PRC97 (2018) 044910 and private communication

- Drell-Soding process significantly lower than the measurement
- $\gamma\gamma \rightarrow p\bar{p}$ process more consistent with the data

Comparison with Model Calculation



D. Shao et al., PRD107 (2023) 036020 and private communication

W. Zha et al., PRC97 (2018) 044910 and private communication

- Drell-Soding process significantly lower than the measurement
- $\gamma\gamma \rightarrow p\bar{p}$ process more consistent with the data

First observation of the $\gamma\gamma \rightarrow$ baryon-antibaryon process in heavy-ion UPCs!

Thank you for your attention!