My thesis topics

Cheng-Wei Shih

National Central University, Taiwan

sPHENIX INTT analysis workshop

November 14th 2023

sPHENIX

國立中央大學

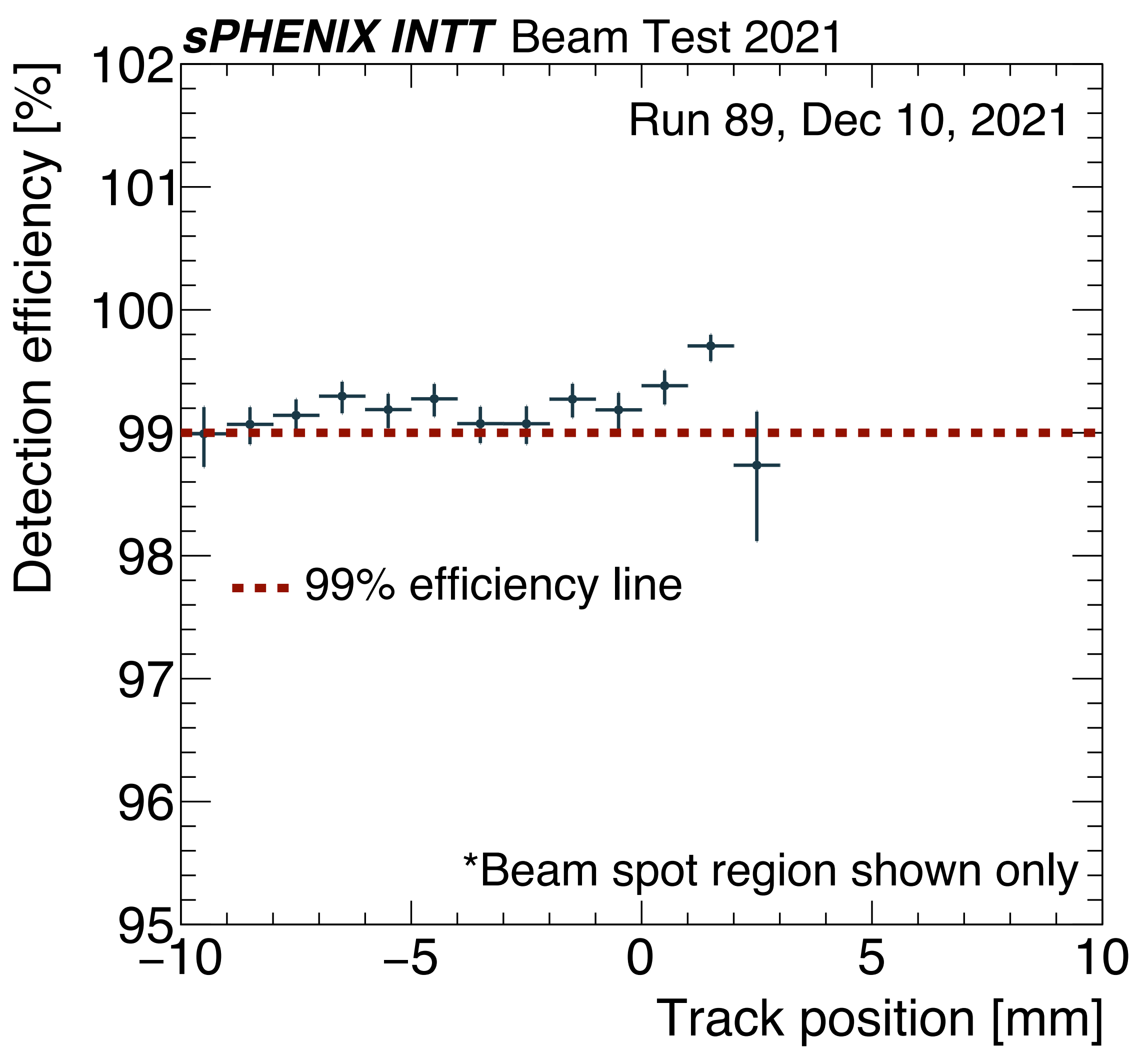
National Central University

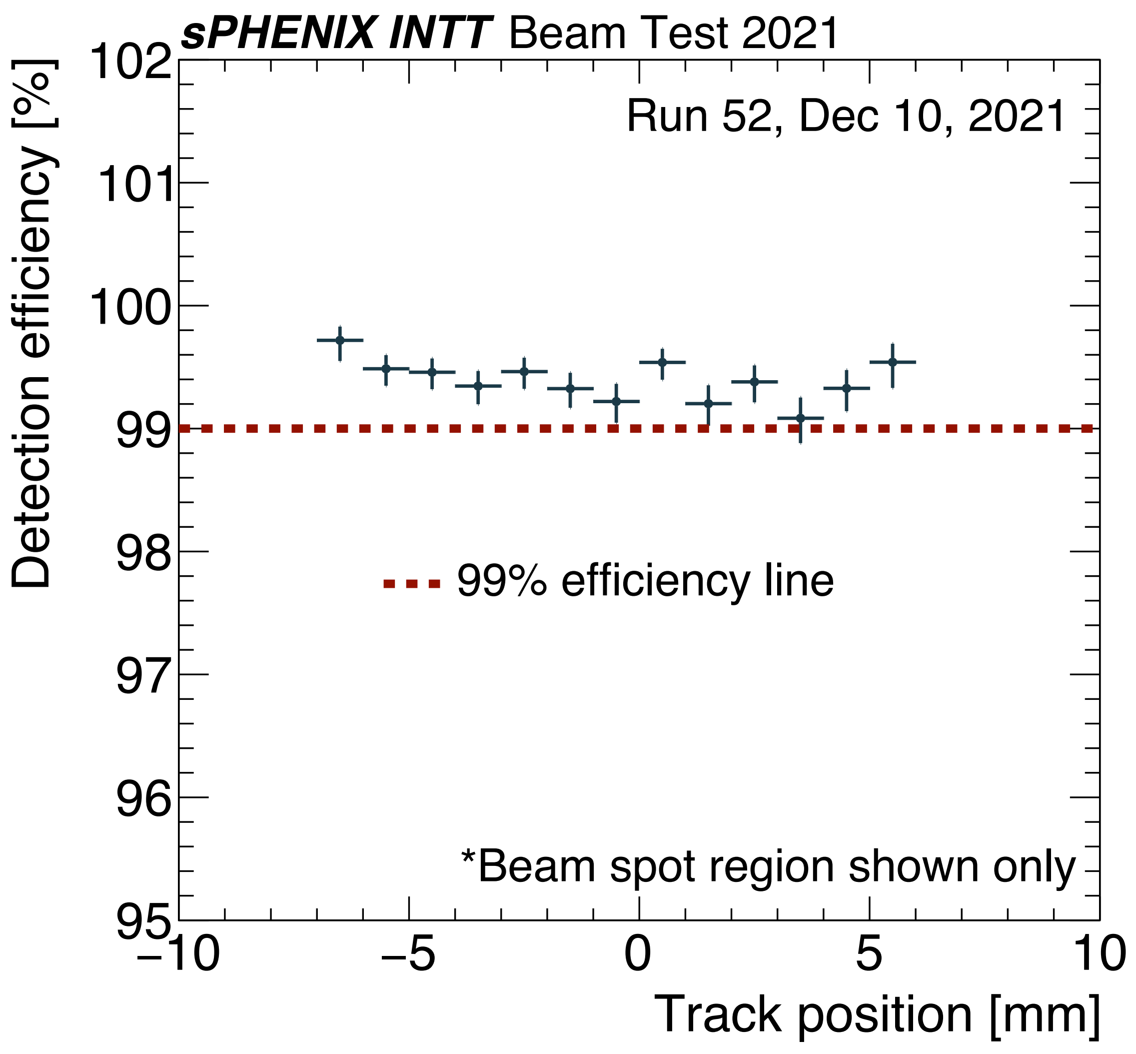
To graduate! But by how? 🫣

- Beam test 2021 publication
- Quark Matter 2023 proceeding - The Intermediate Silicon Tracker of sPHENIX
- Run 2023 - INTT dN/dη
- The gluon orbital motion measurement of proton

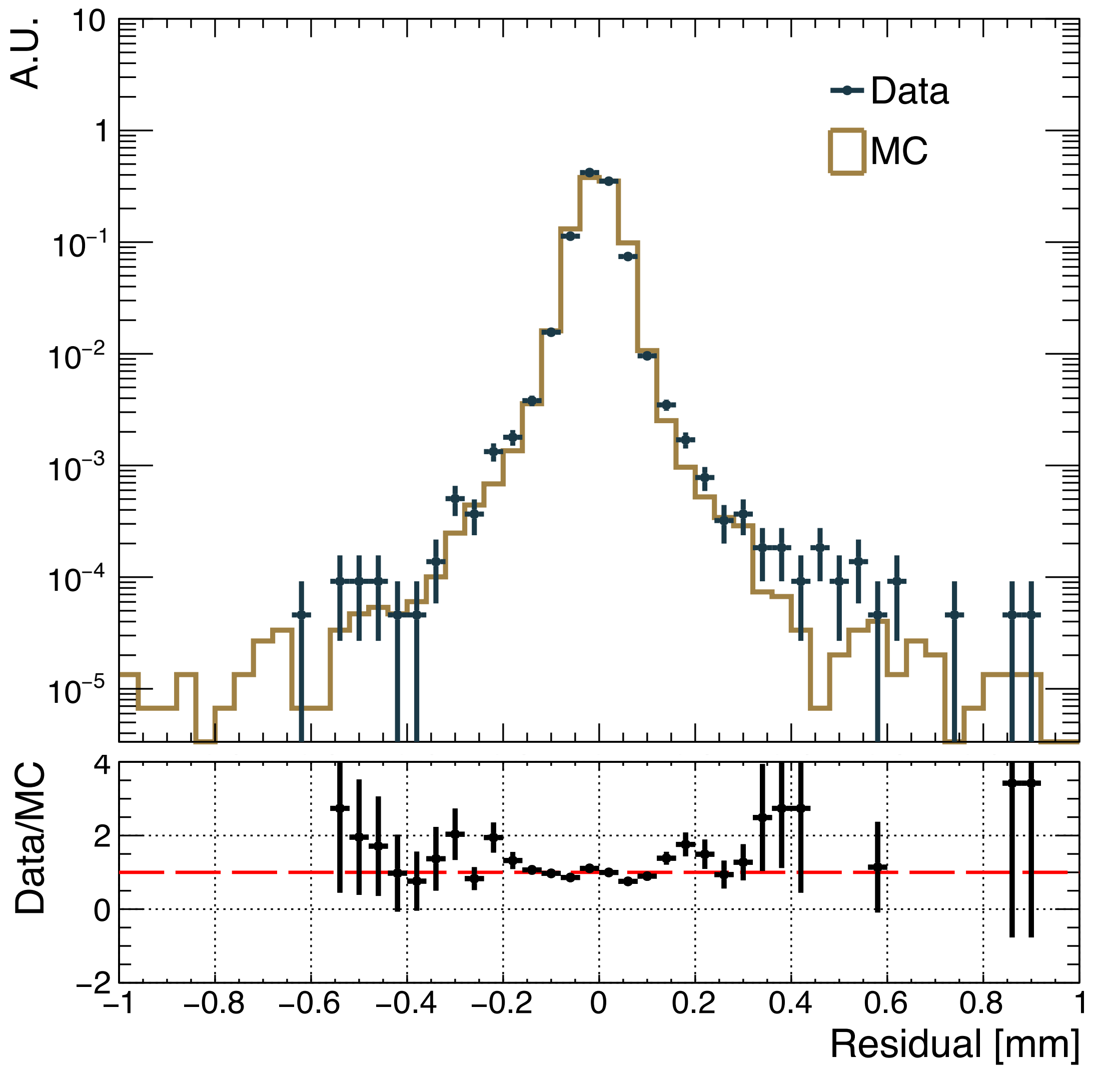
Beam test 2021

- Beam test 2021 @ ELPH Tohoku
- Configuration: 3 layers of INTT ladders + 2 scintillators (trigger)
- Bias voltage: 50 V
- Main scope: study the efficiency (to understand the 96% of second beam test)
- Deadline: before dN/dη submission

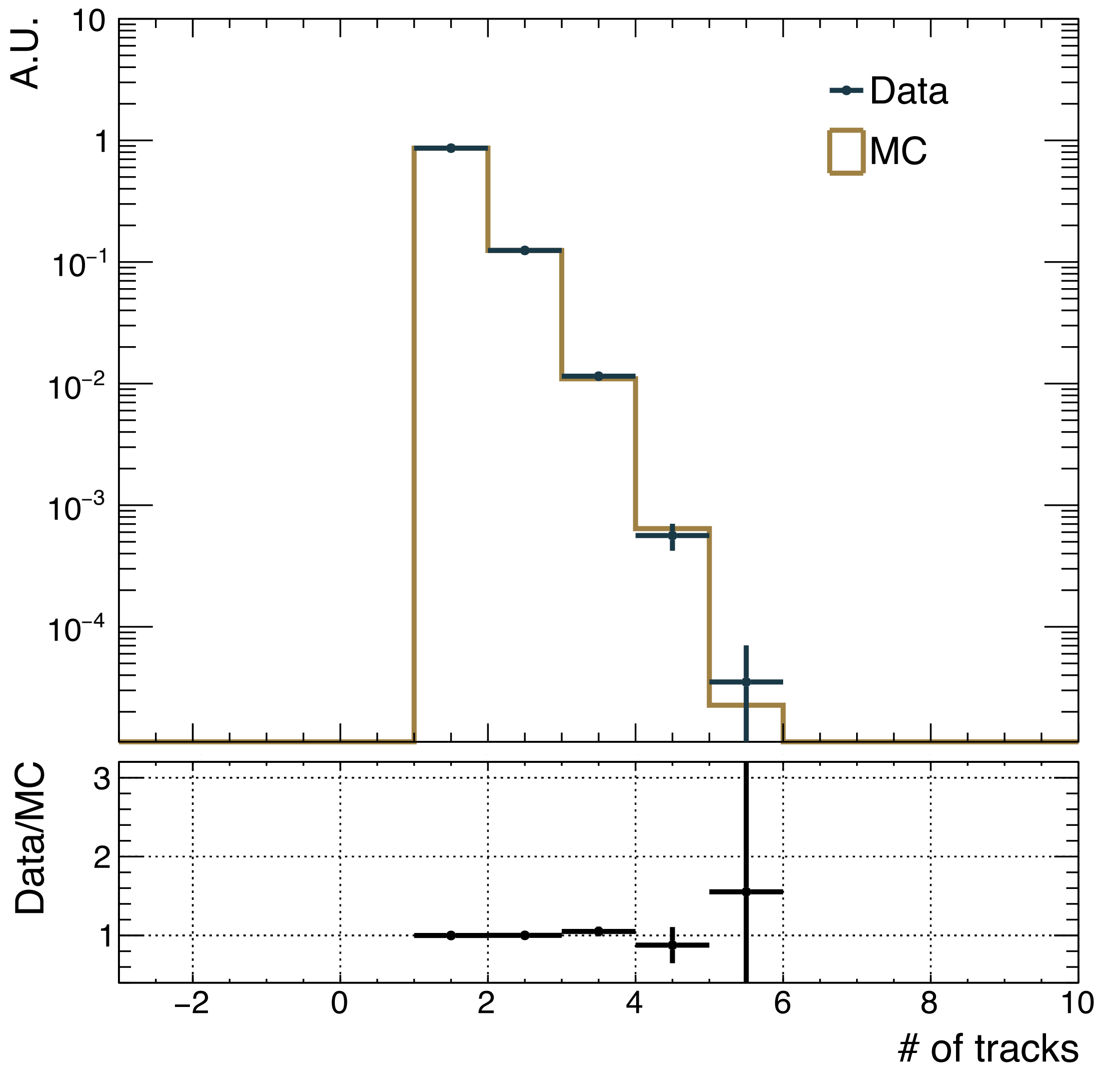




Residual distribution

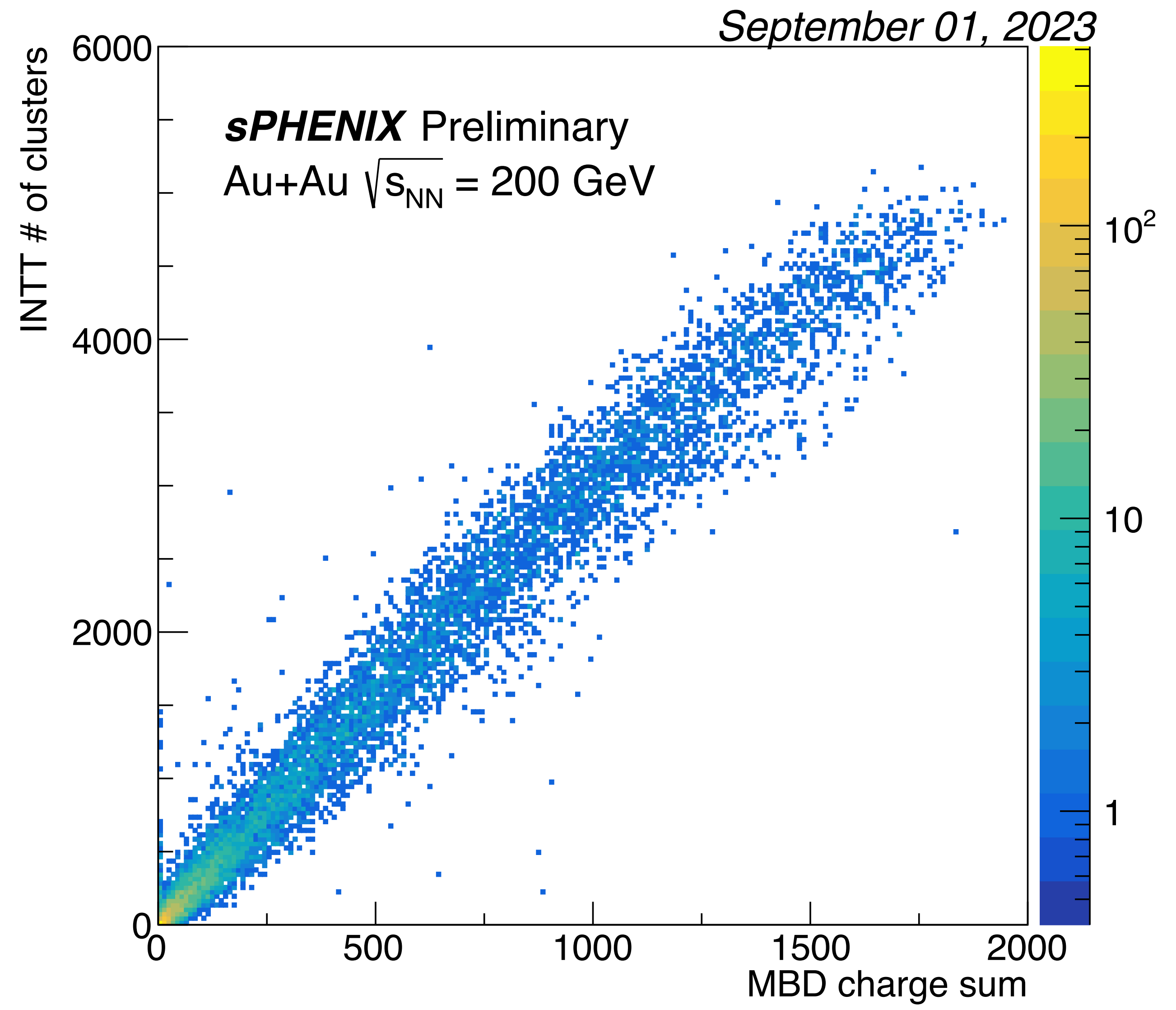


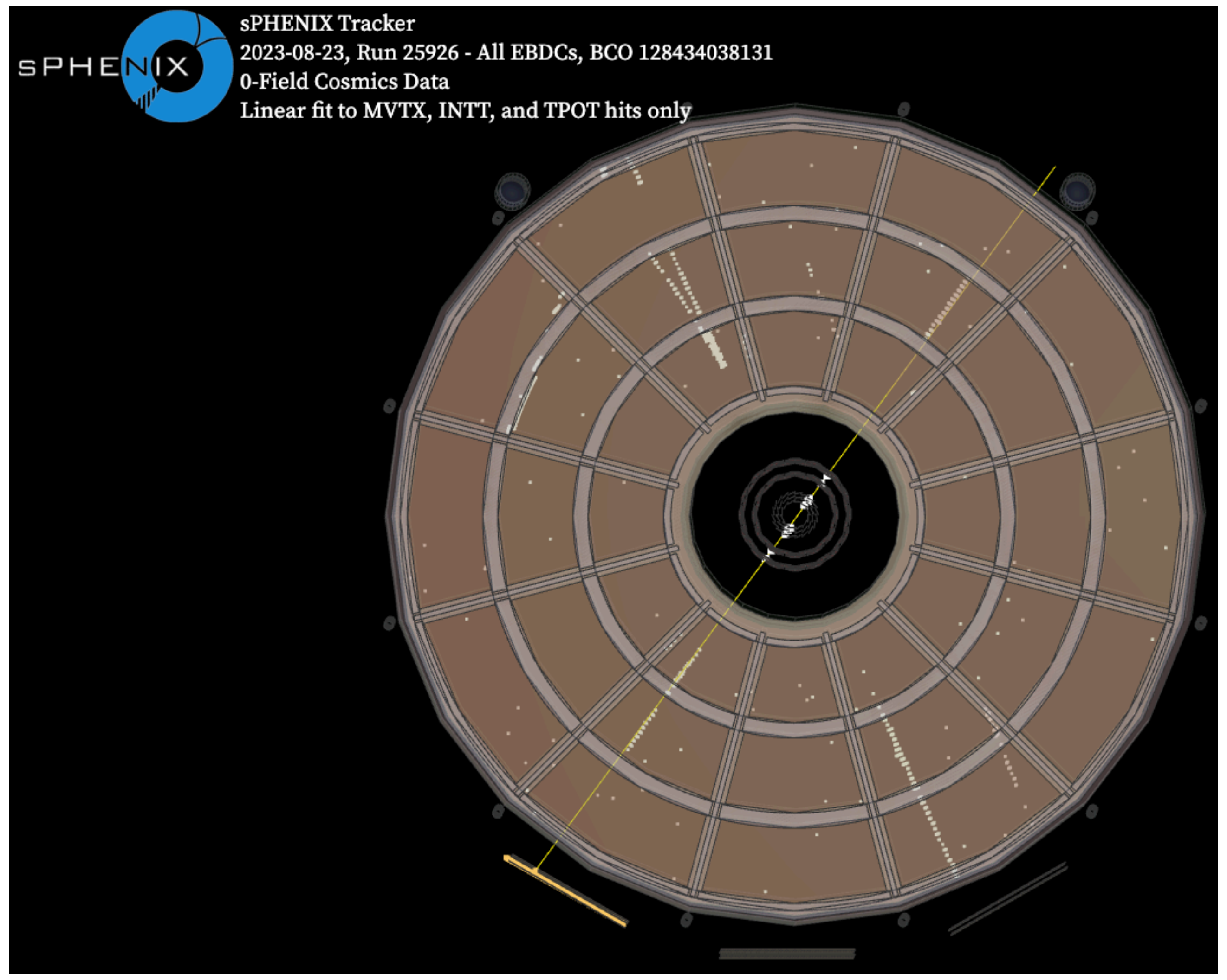
N track distribution

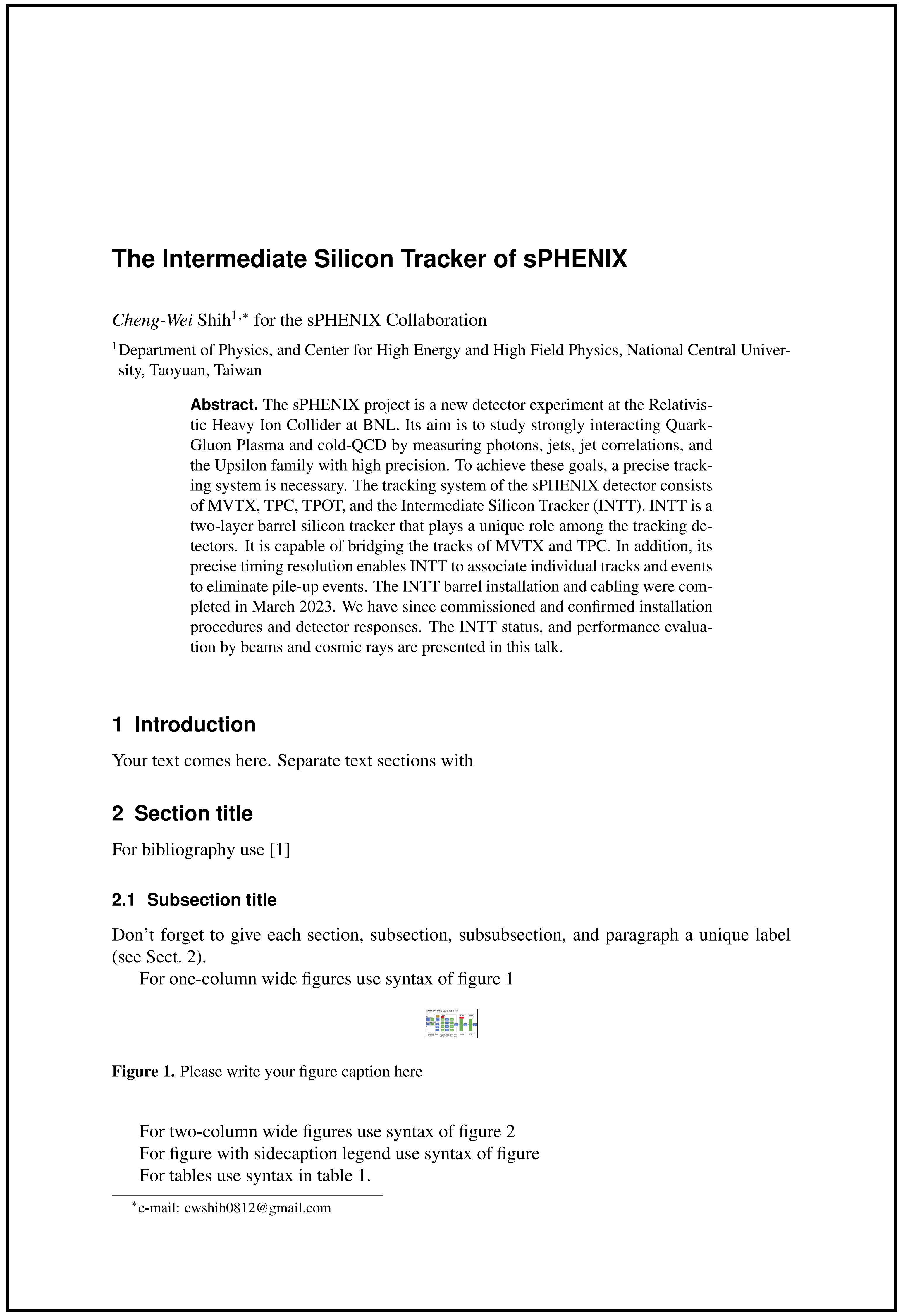


Quark Matter proceeding

- Title : The Intermediate Silicon Tracker of sPHENIX
- Scope : INTT description and commissioning
- Note : Should read PAC document first
- Deadline:
    - First draft circulating in INTT group: Nov 28 2023
    - To the sPHENIX collaboration: Dec 7th 2023
    - Submission deadline December 15th 2023







The Intermediate Silicon Tracker of sPHENIX

Cheng-Wei Shih[1,*] for the sPHENIX Collaboration

[1]Department of Physics, and Center for High Energy and High Field Physics, National Central University, Taoyuan, Taiwan

Abstract. The sPHENIX project is a new detector experiment at the Relativistic Heavy Ion Collider at BNL. Its aim is to study strongly interacting Quark-Gluon Plasma and cold-QCD by measuring photons, jets, jet correlations, and the Upsilon family with high precision. To achieve these goals, a precise tracking system is necessary. The tracking system of the sPHENIX detector consists of MVTX, TPC, TPOT, and the Intermediate Silicon Tracker (INTT). INTT is a two-layer barrel silicon tracker that plays a unique role among the tracking detectors. It is capable of bridging the tracks of MVTX and TPC. In addition, its precise timing resolution enables INTT to associate individual tracks and events to eliminate pile-up events. The INTT barrel installation and cabling were completed in March 2023. We have since commissioned and confirmed installation procedures and detector responses. The INTT status, and performance evaluation by beams and cosmic rays are presented in this talk.

1 Introduction

Your text comes here. Separate text sections with

2 Section title

For bibliography use [1]

2.1 Subsection title

Don't forget to give each section, subsection, subsubsection, and paragraph a unique label (see Sect. 2).

For one-column wide figures use syntax of figure 1

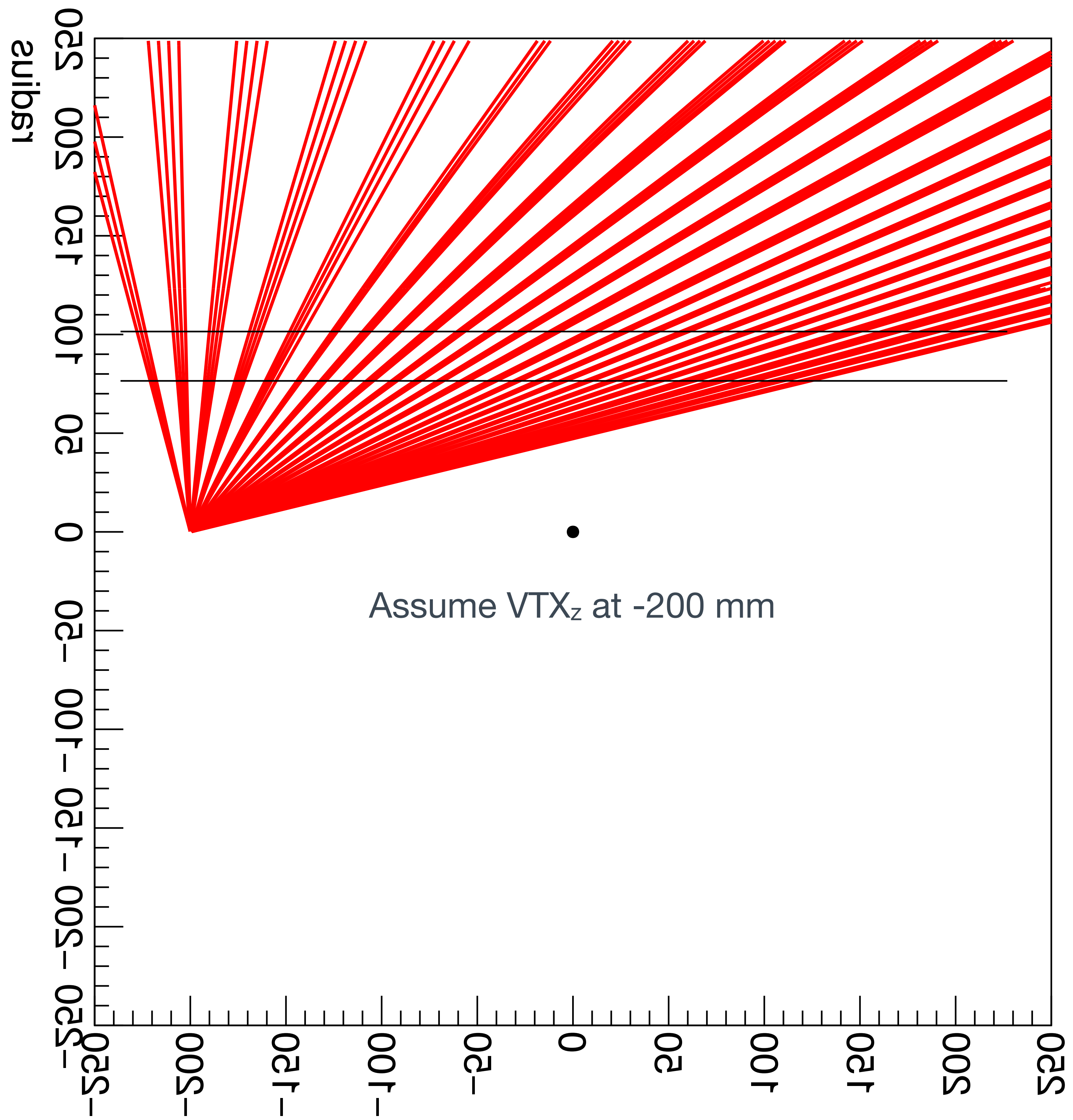
Figure 1. Please write your figure caption here

For two-column wide figures use syntax of figure 2
For figure with sidecaption legend use syntax of figure
For tables use syntax in table 1.

*e-mail: cwshih0812@gmail.com

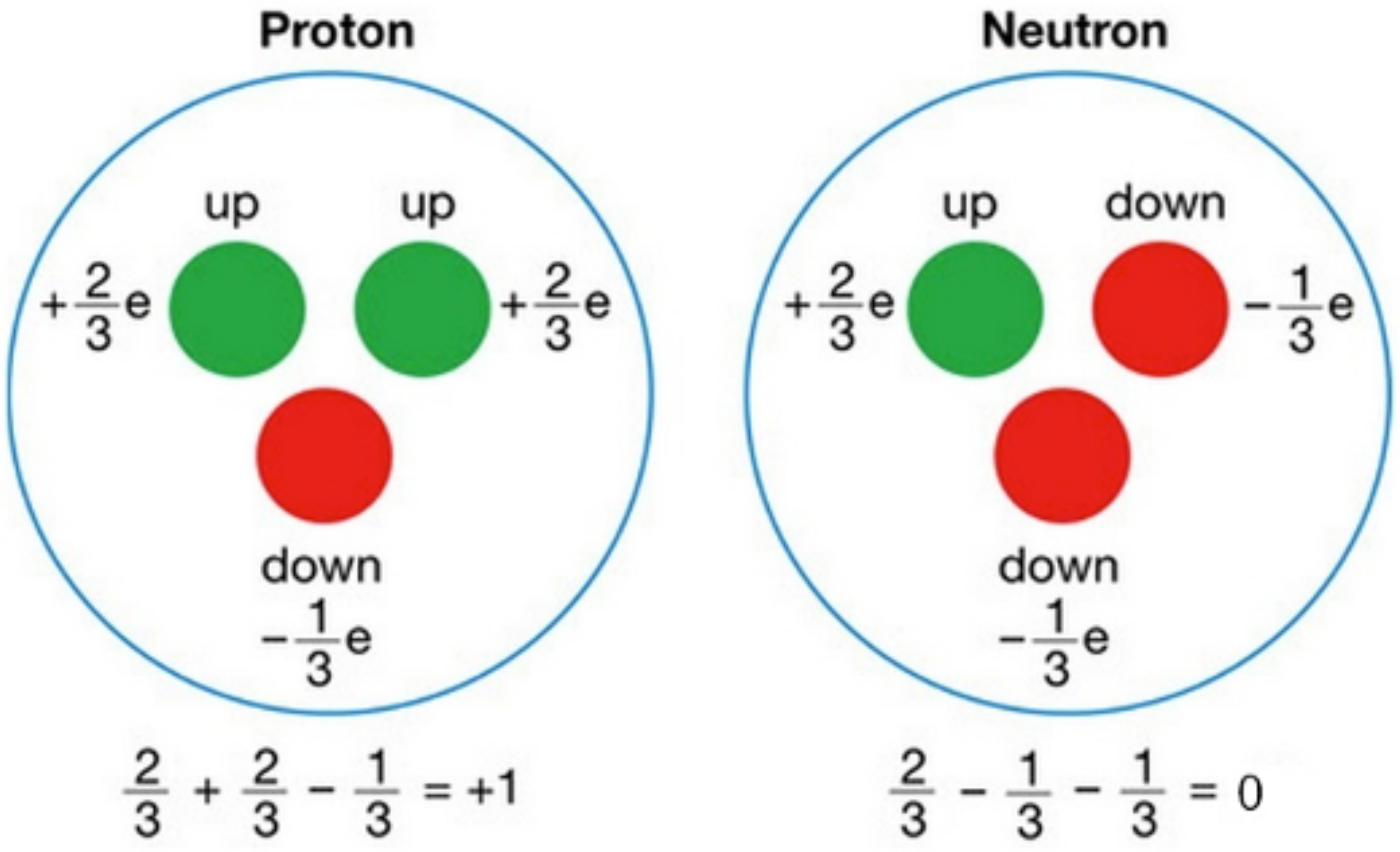
Run 23 dN/dη with INTT

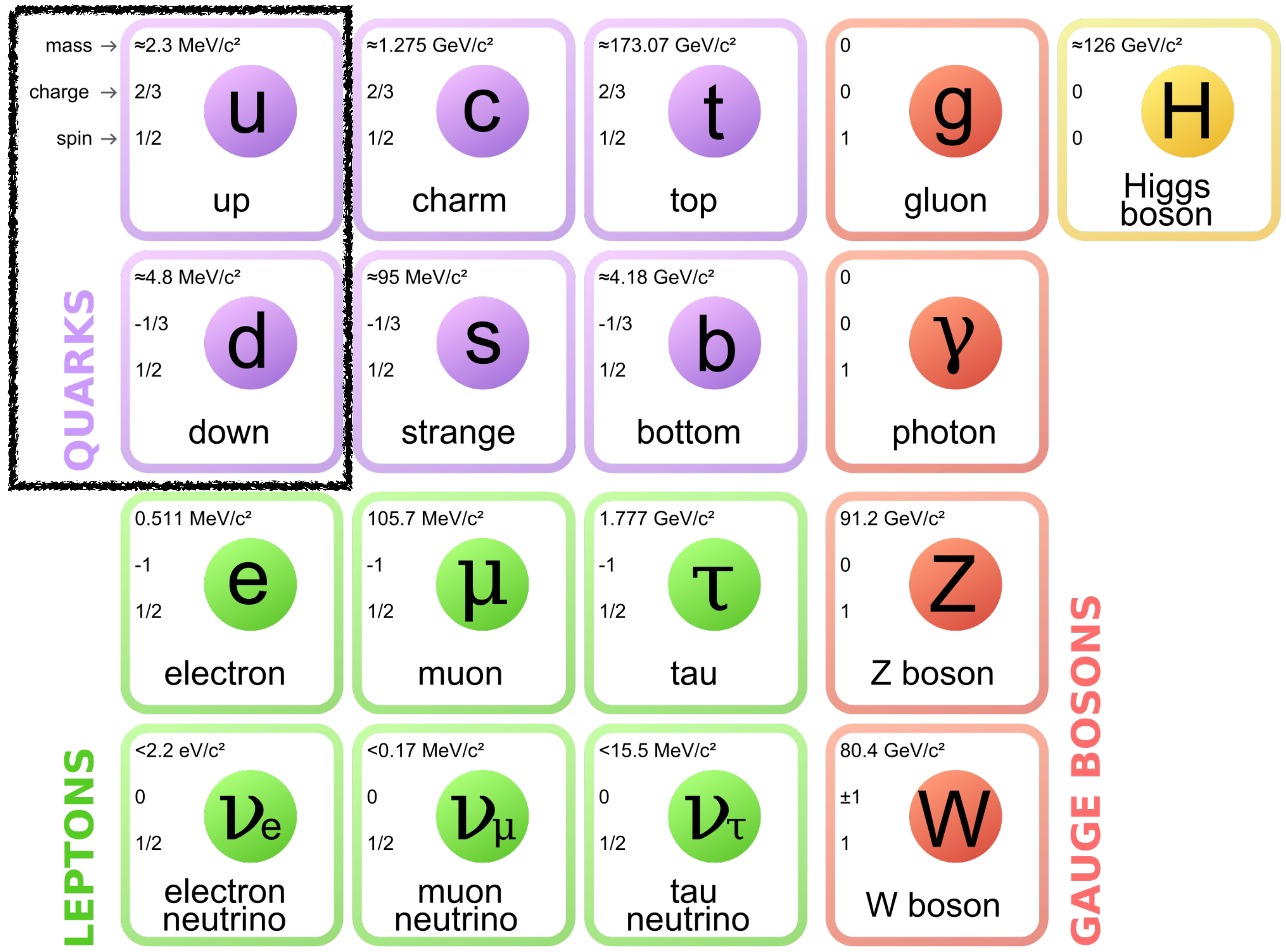
- Number of charge particles per event per pseudorapidity η with a given centrality region
- Major focused item
- Deadline : January 2024 😲
- Journal : part of INTT barrel pub.? (GIRI GIRI) 🤔
- Pressure 😱



Proton properties - charge

- Proton : charge +1, mass 938.27 MeV, spin 1/2
- Proton : known to be NOT point like particle
  - → The properties of proton should be attributed by its constituents!
  - → Valence quarks : expected to carry most of proton's properties





Materials from Itaru

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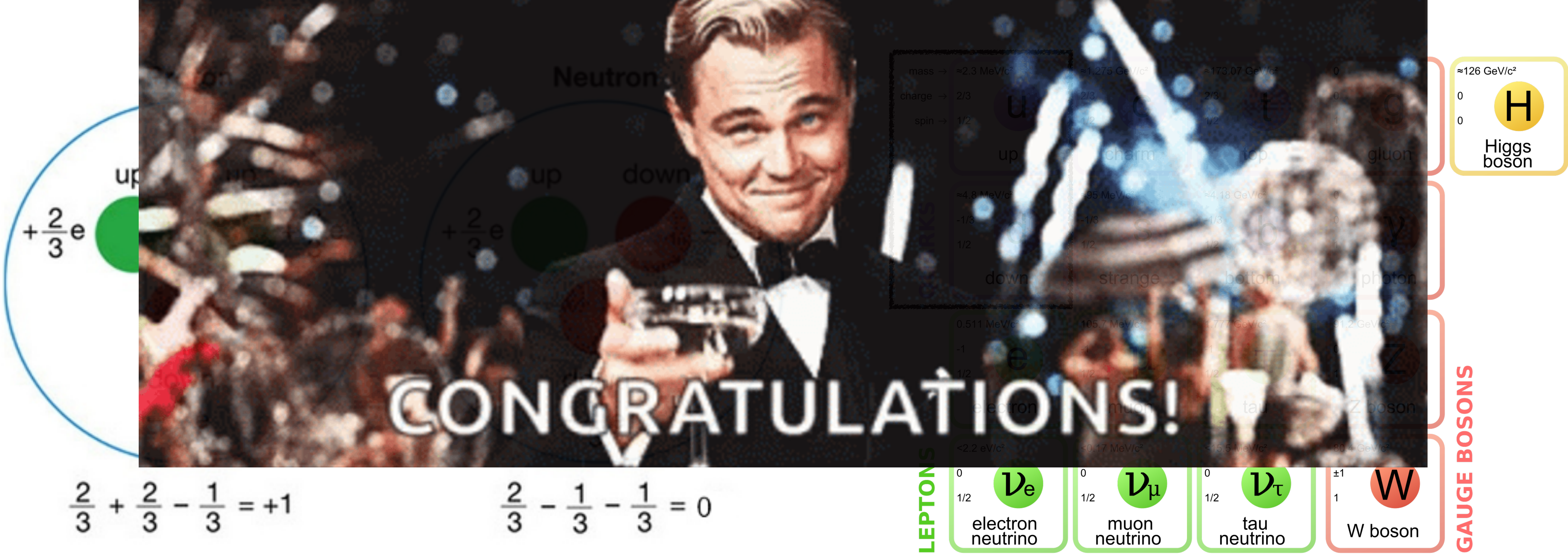

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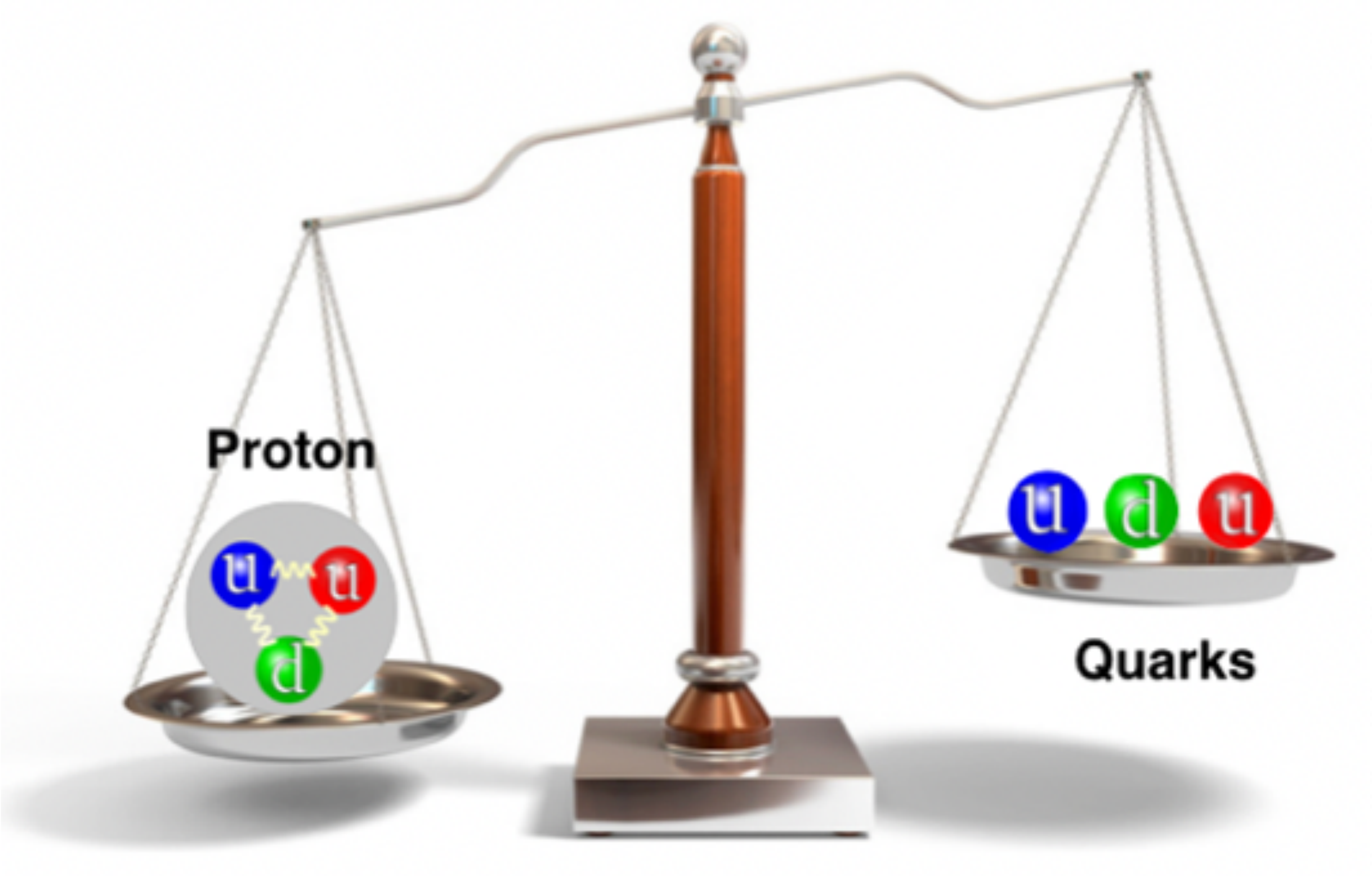
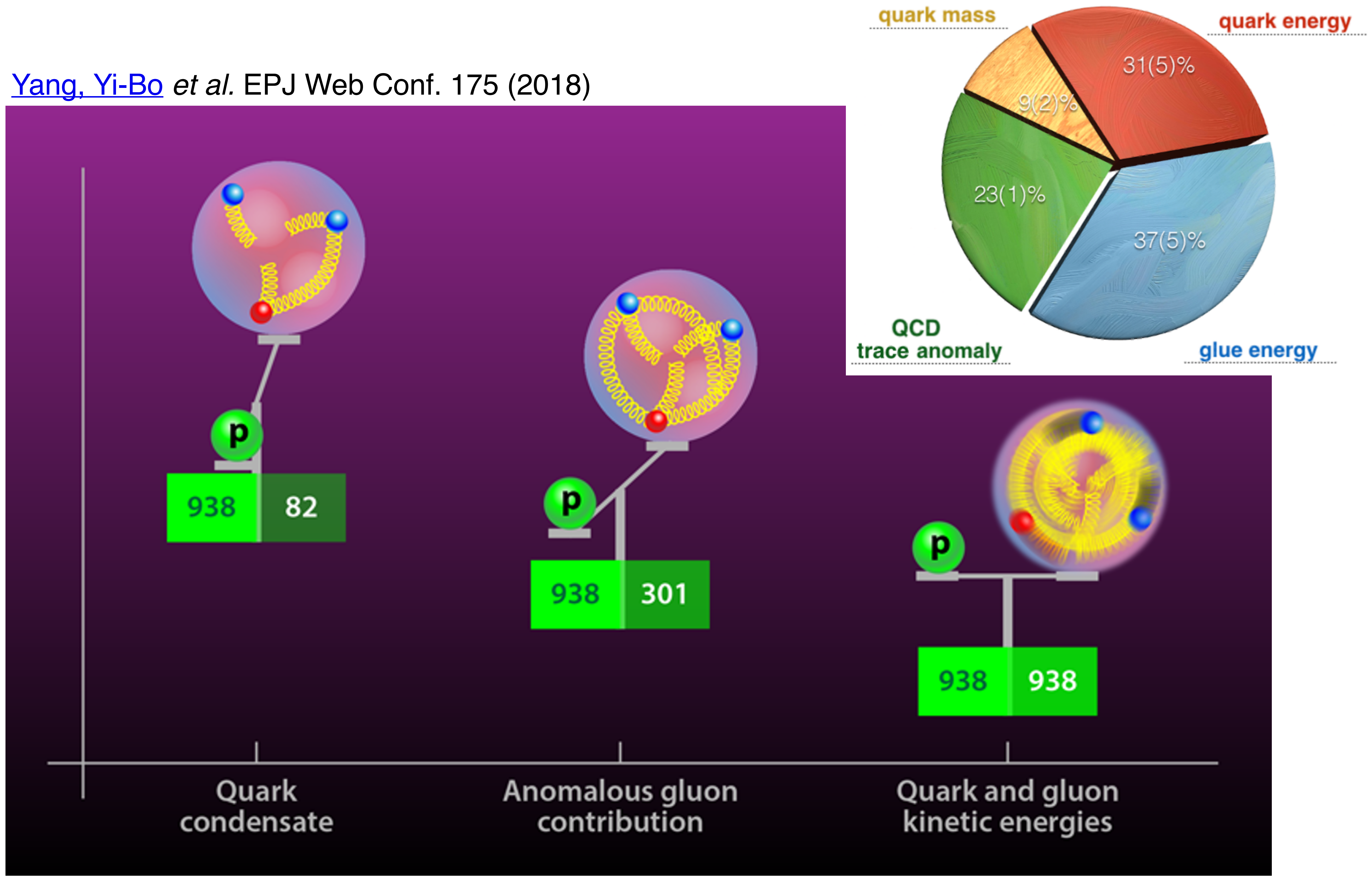


~938 MeV ~10 MeV

Yang, Yi-Bo *et al.* EPJ Web Conf. 175 (2018)



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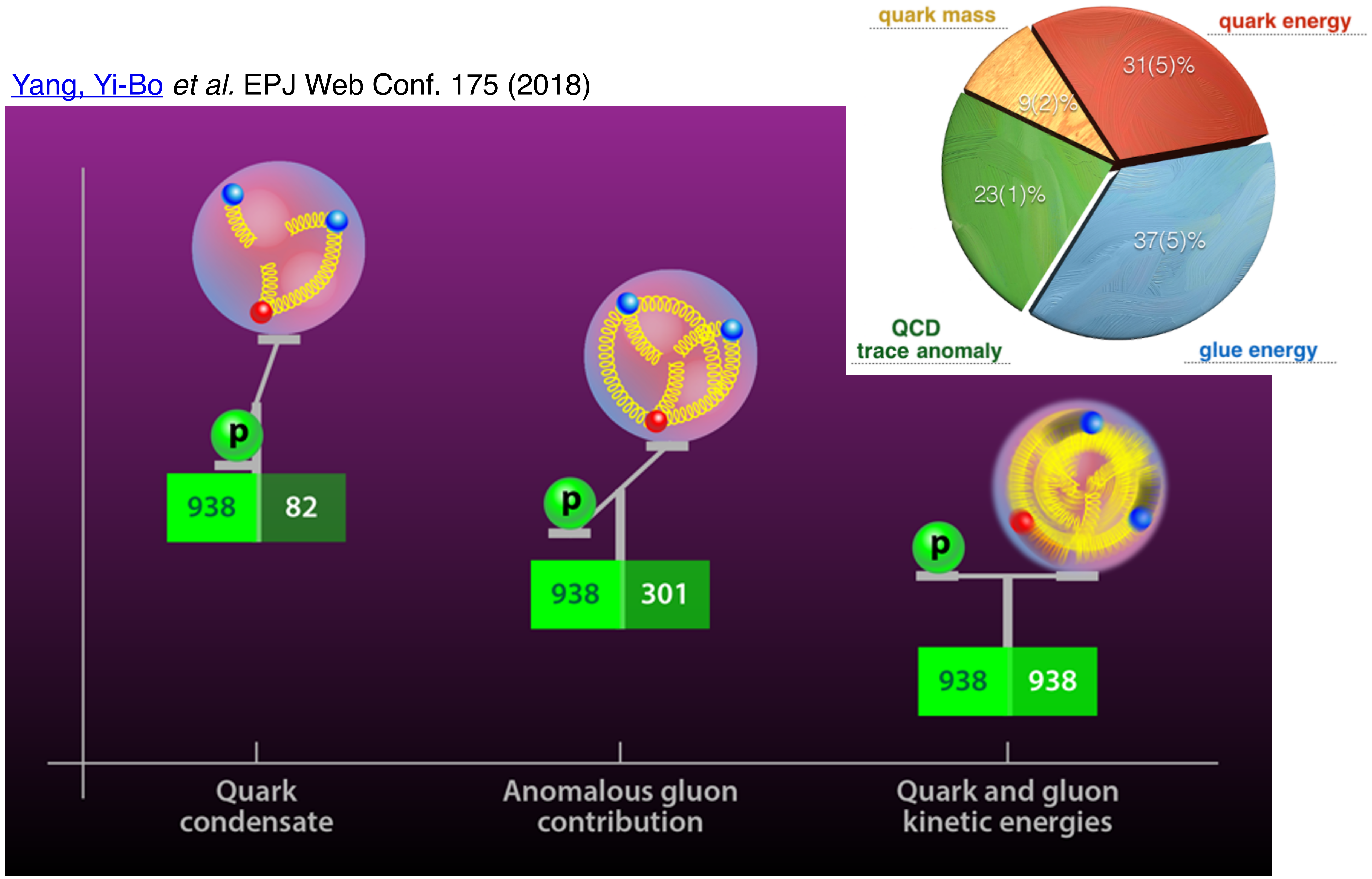

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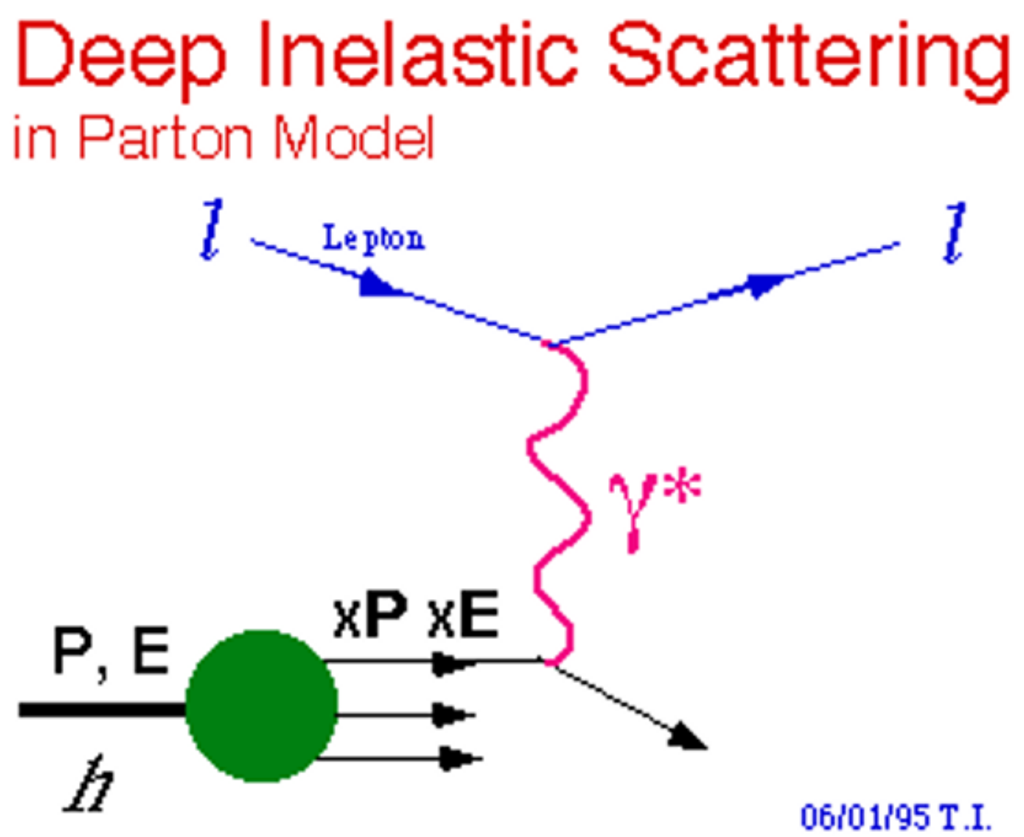
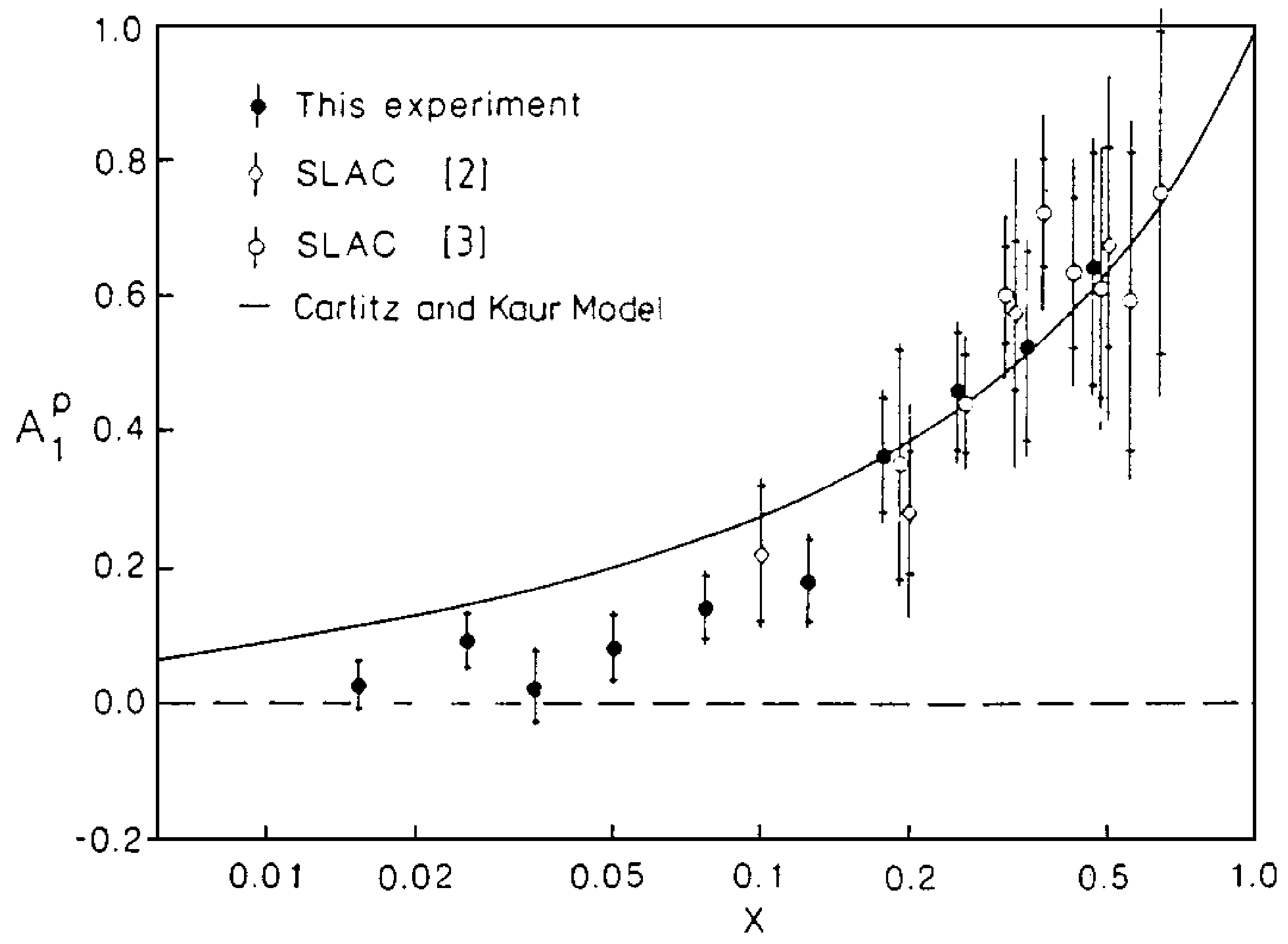
European Muon Collaboration (EMC) : let's confirm it!





EMC Publication

In conclusion, measurements have been presented of the spin asymmetries in deep inelastic scattering of polarised muons on polarised protons. The spin dependent structure function g_1 of the the proton has also been determined. The integral $\int_0^1 g_1^p(x)dx = 0.114 \pm 0.012 \pm 0.026$ is significantly lower than the value expected from the Ellis-Jaffe sum rule. Assuming the validity of the Bjorken sum rule this result implies that the asymmetry measured from polarised neutrons should be significantly negative over at least part of its x range. In addition, the result implies that, in the scaling limit, a rather small fraction of the spin of the proton is carried by the spin of the quarks.

$$\int_0^1 g_1^p(x)dx = \frac{1}{2}[\frac{4}{9}\Delta u + \frac{1}{9}\Delta d + \frac{1}{9}\Delta s] = 0.114 \pm 0.012(stat) \pm 0.026(syst)$$

x : Momentum fraction, g_1 : spin dependent structure function

~30% contribution to spin's proton
Proton spin crisis !!! 😱

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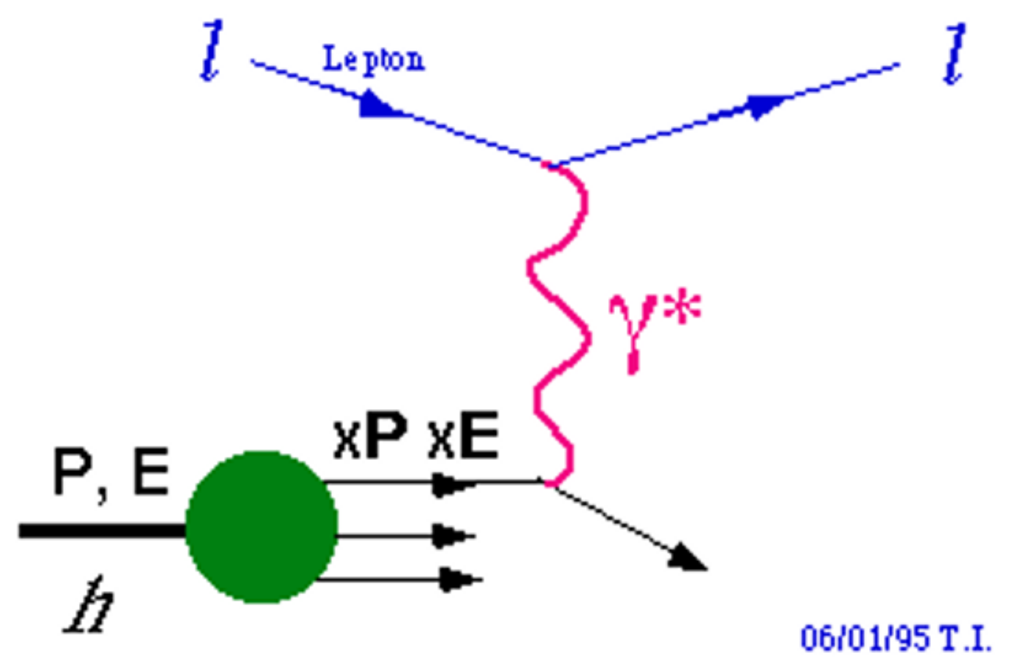
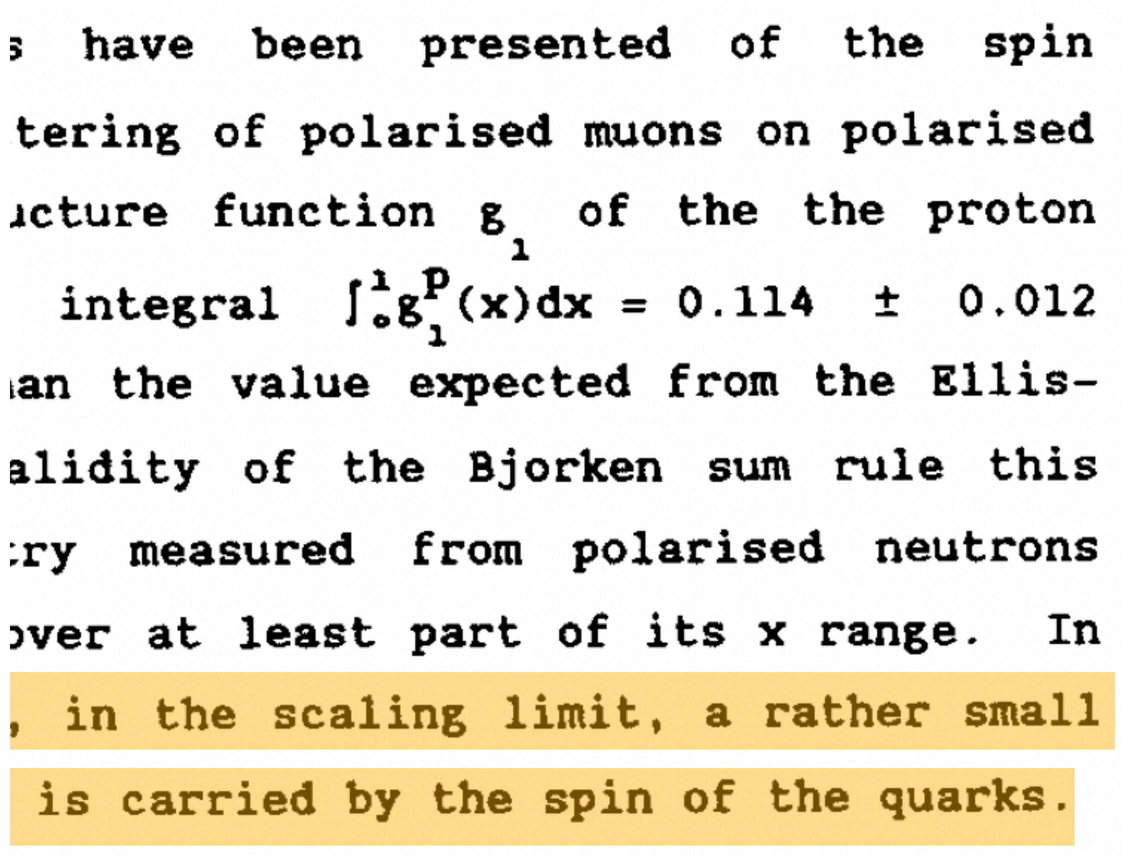
European Muon Collaboration (EMC) : let's confirm it!

Deep Inelastic Scattering
in Parton Model



[EMC Publication]



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x

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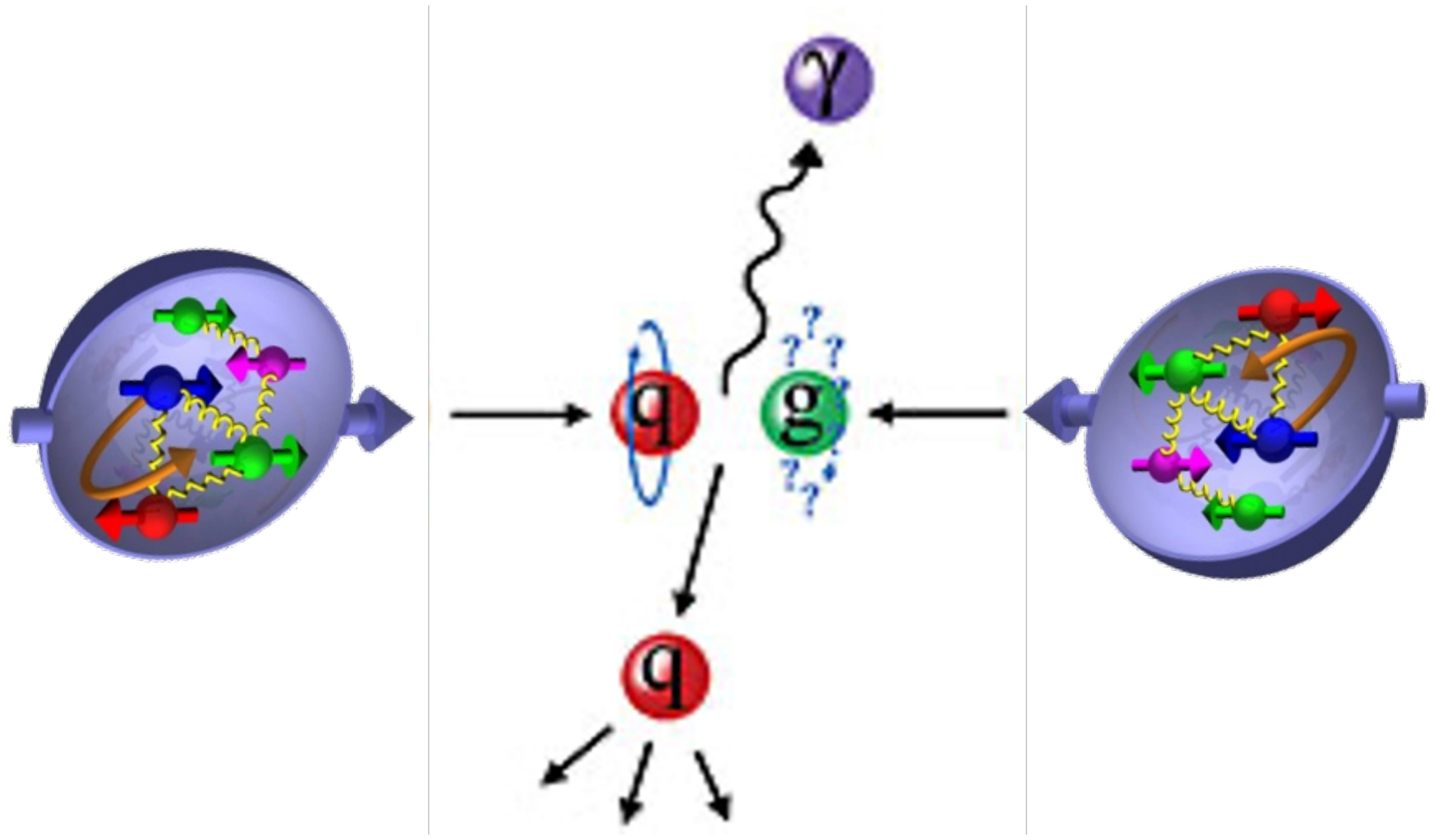
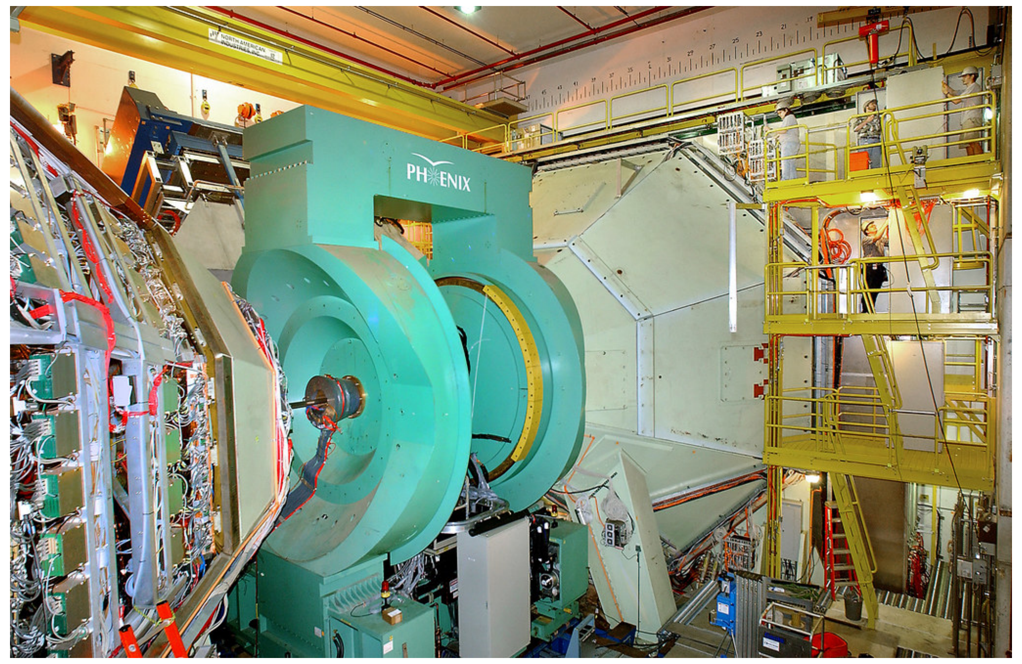
Materials from Itaru

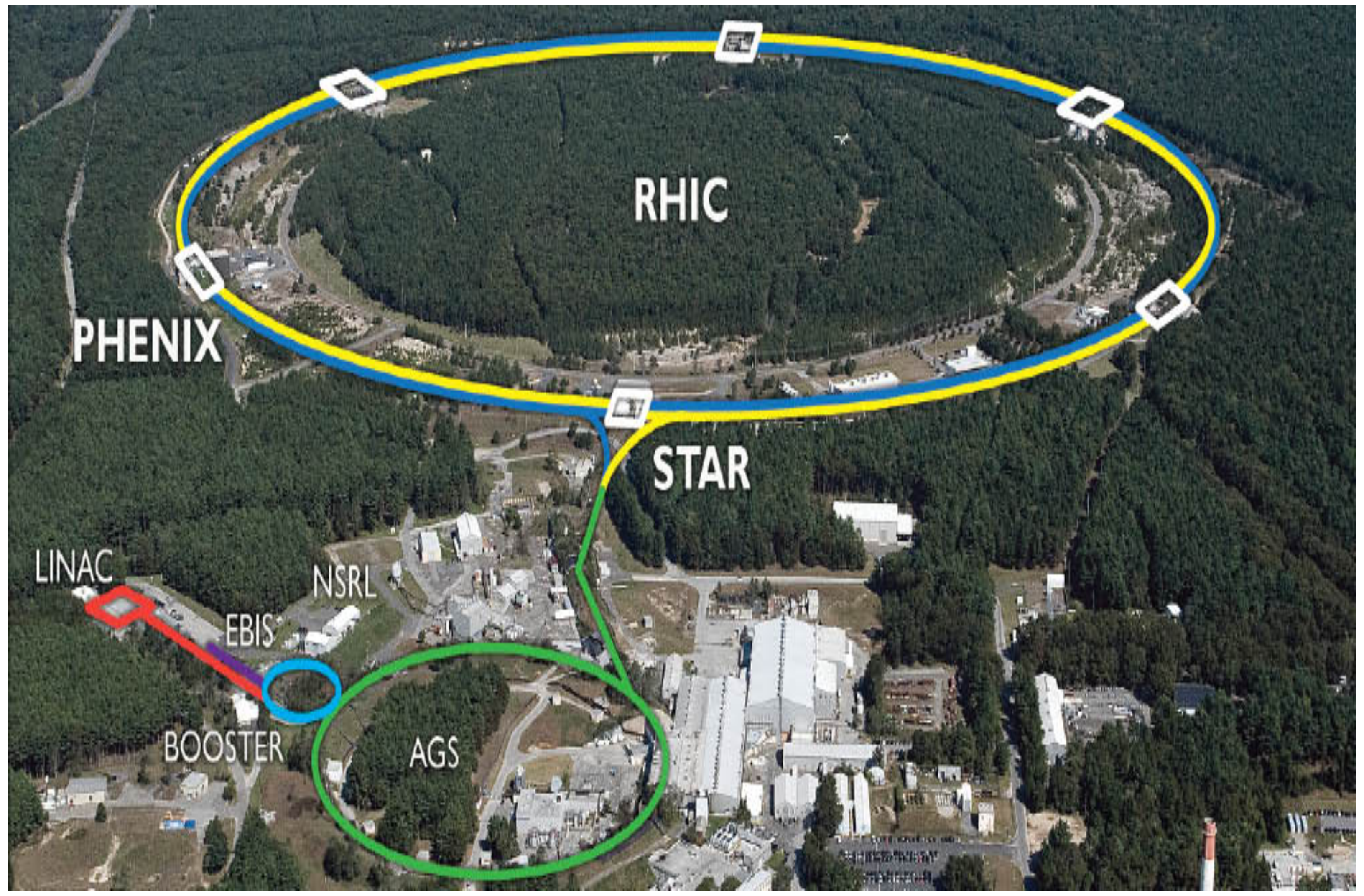
Proton properties - spin

- What else we can have inside the proton…? Gluon 🥳



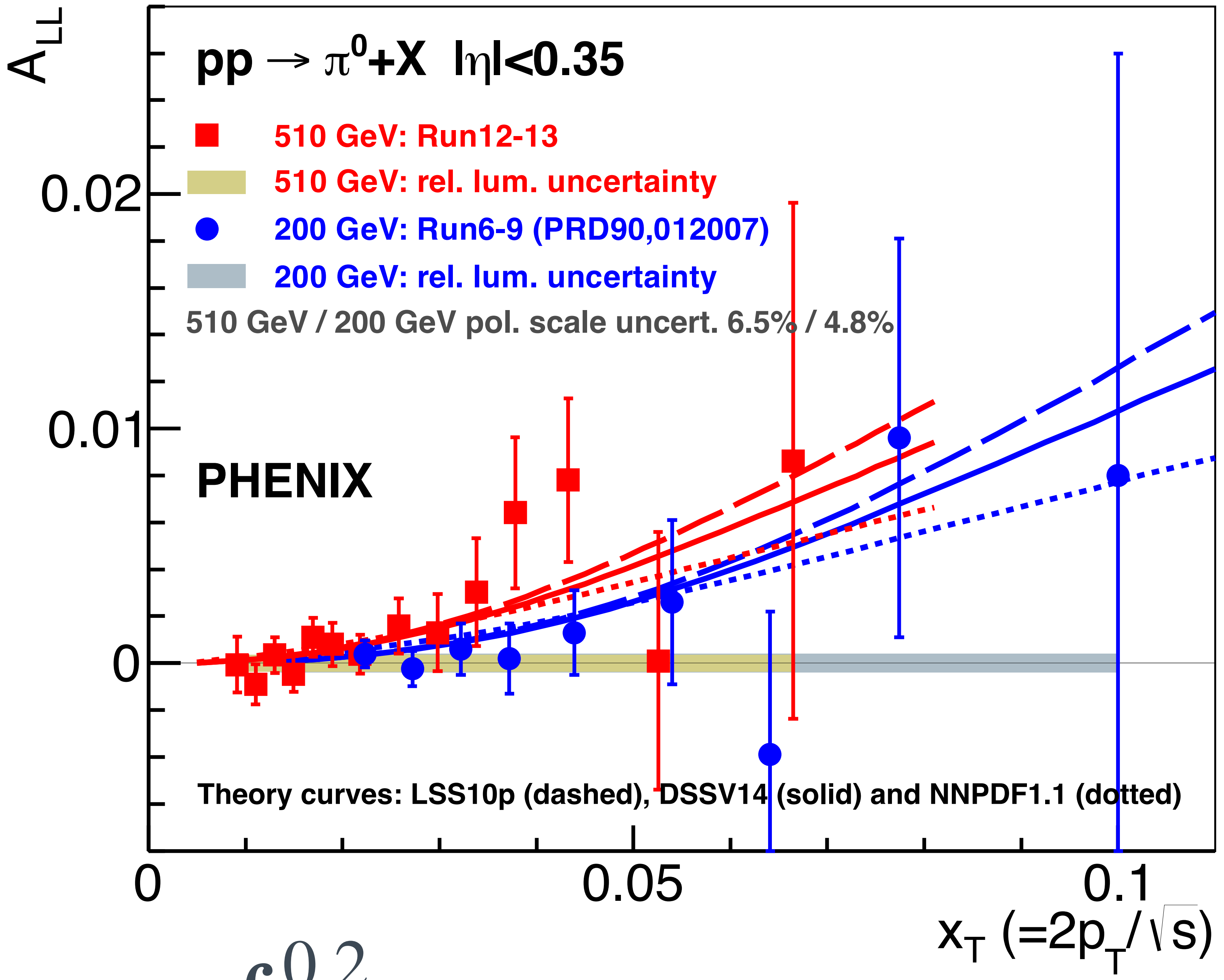
PHENIX : Let me do it!





[PRD93, 011501R (2016)](#)

Combination of 6 years of data taking!



$$\int_{0.05}^{0.2} \Delta g(x)dx = 0.2\pm^{0.06}_{0.07}$$

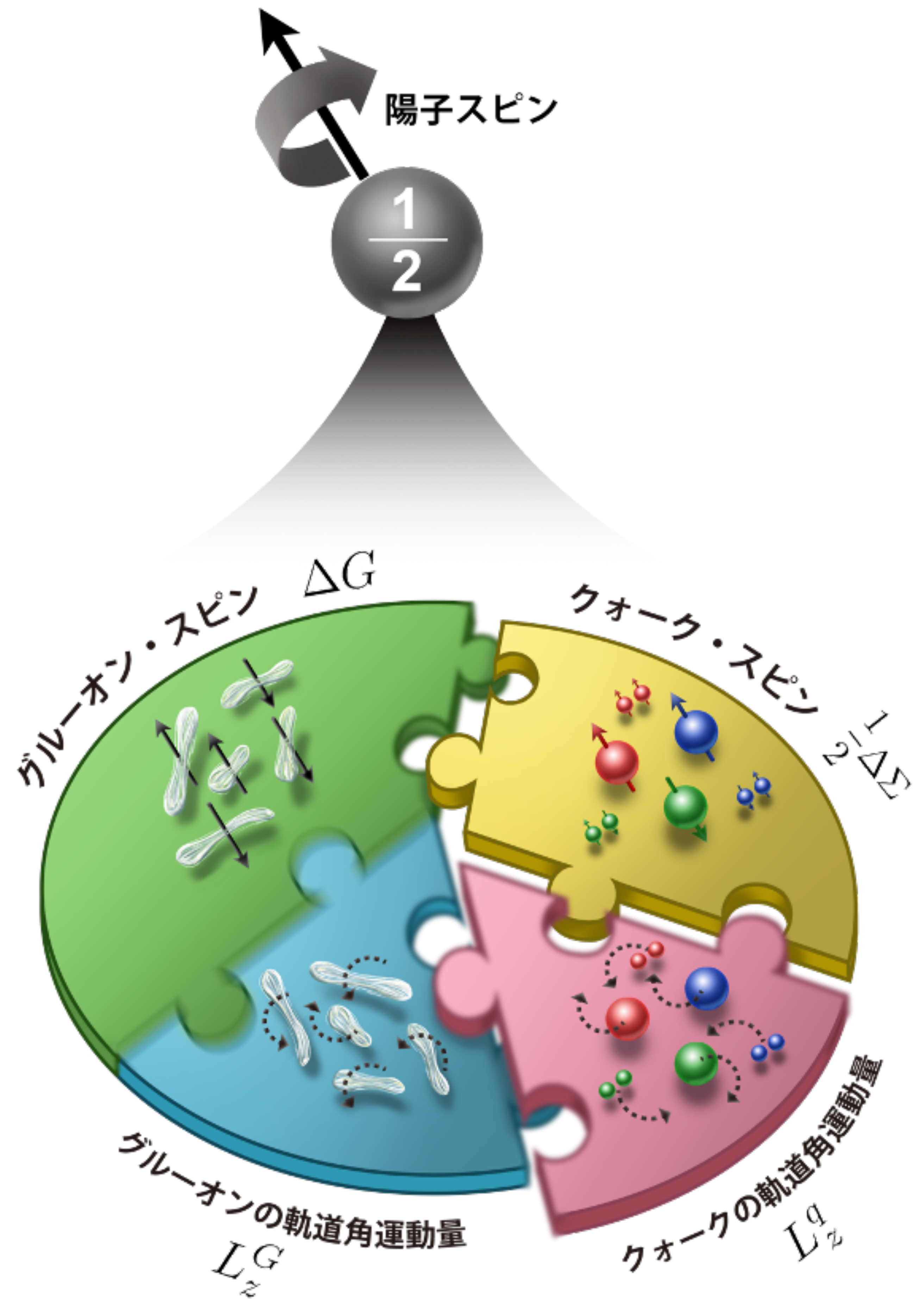
~40% of proton spin contribution
~30% missing still! 🙀

x : Momentum fraction

Materials from Itaru

Proton properties - spin

- What else we can have inside the proton…? angular momentum 🥳



Proton spin : $S_z = \frac{1}{2}$ [quark cont. + gluon cont. + angular momentum]

~ 30% ~ 40% ???

Bottleneck : L = r x p

One has to measure both components simultaneously 😲

Unless a hermetic detector and clean final state available to have a good control of kinematic → EIC 🥳 (> 10 years from now)

Materials from Itaru

Proton properties - spin

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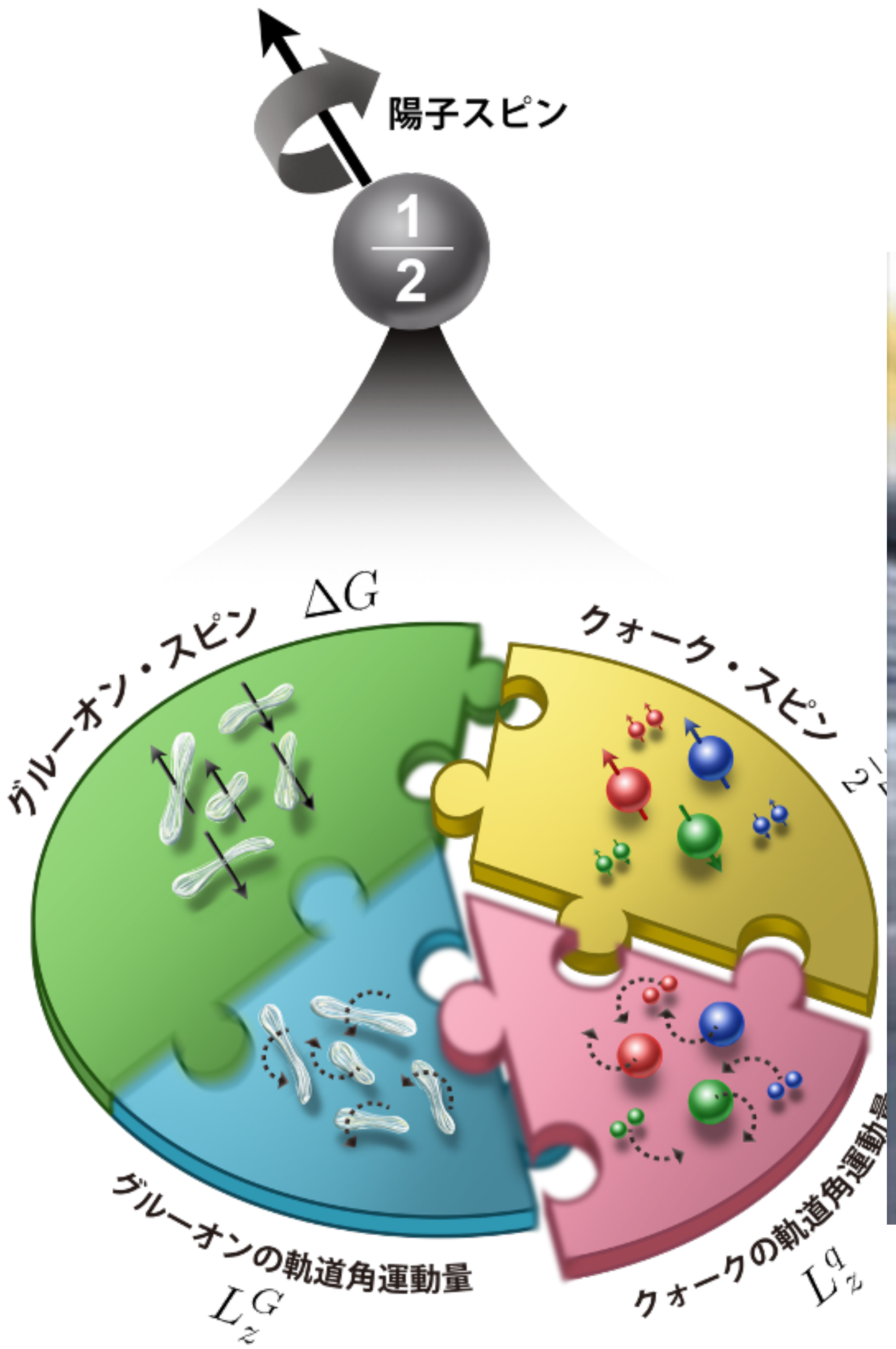

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???

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final state available to have a
10 years from now)

Materials from Itaru

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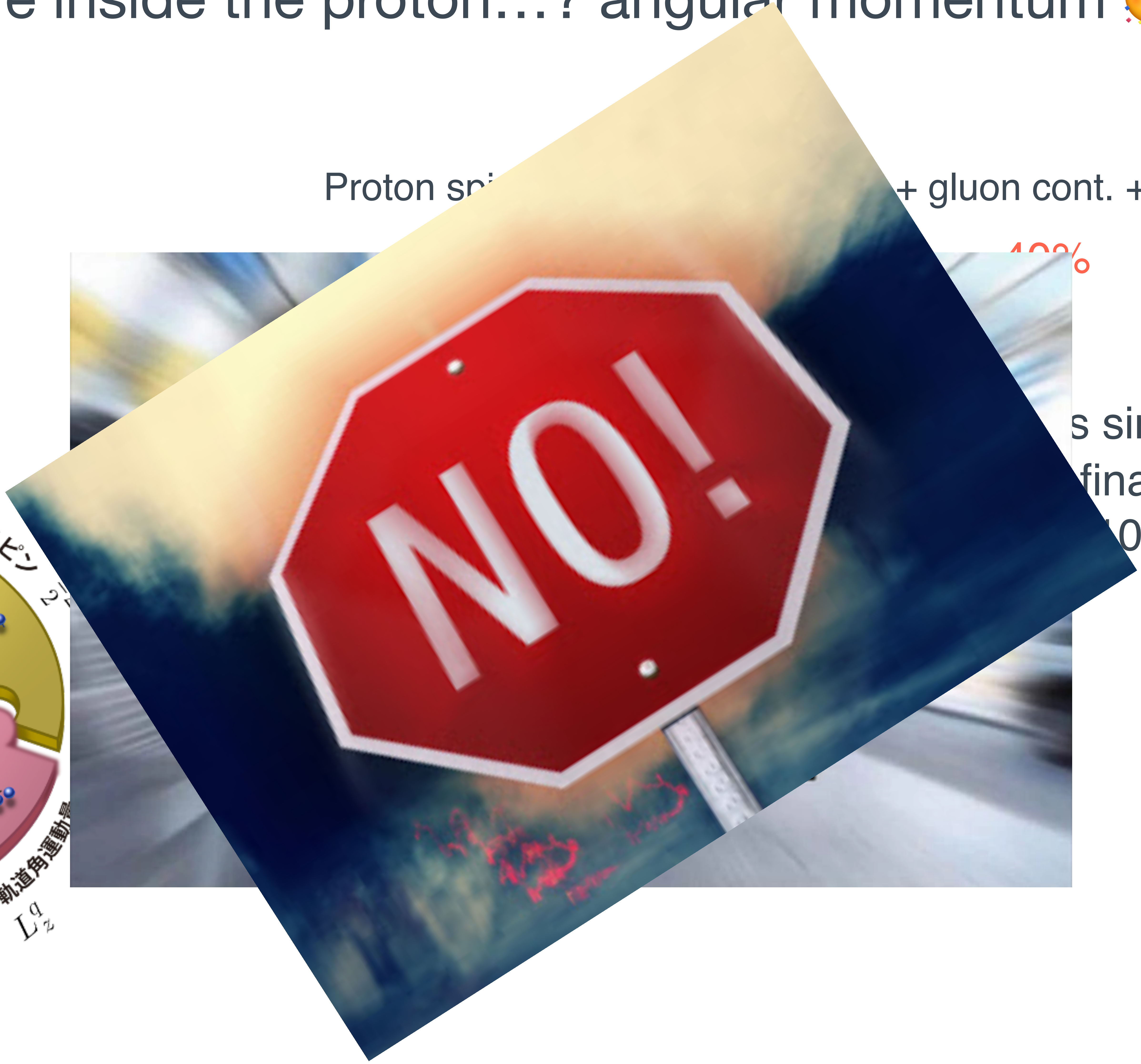

Proton spi … + gluon cont. + angular momentum]

???

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… final state available to have a

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Materials from Itaru

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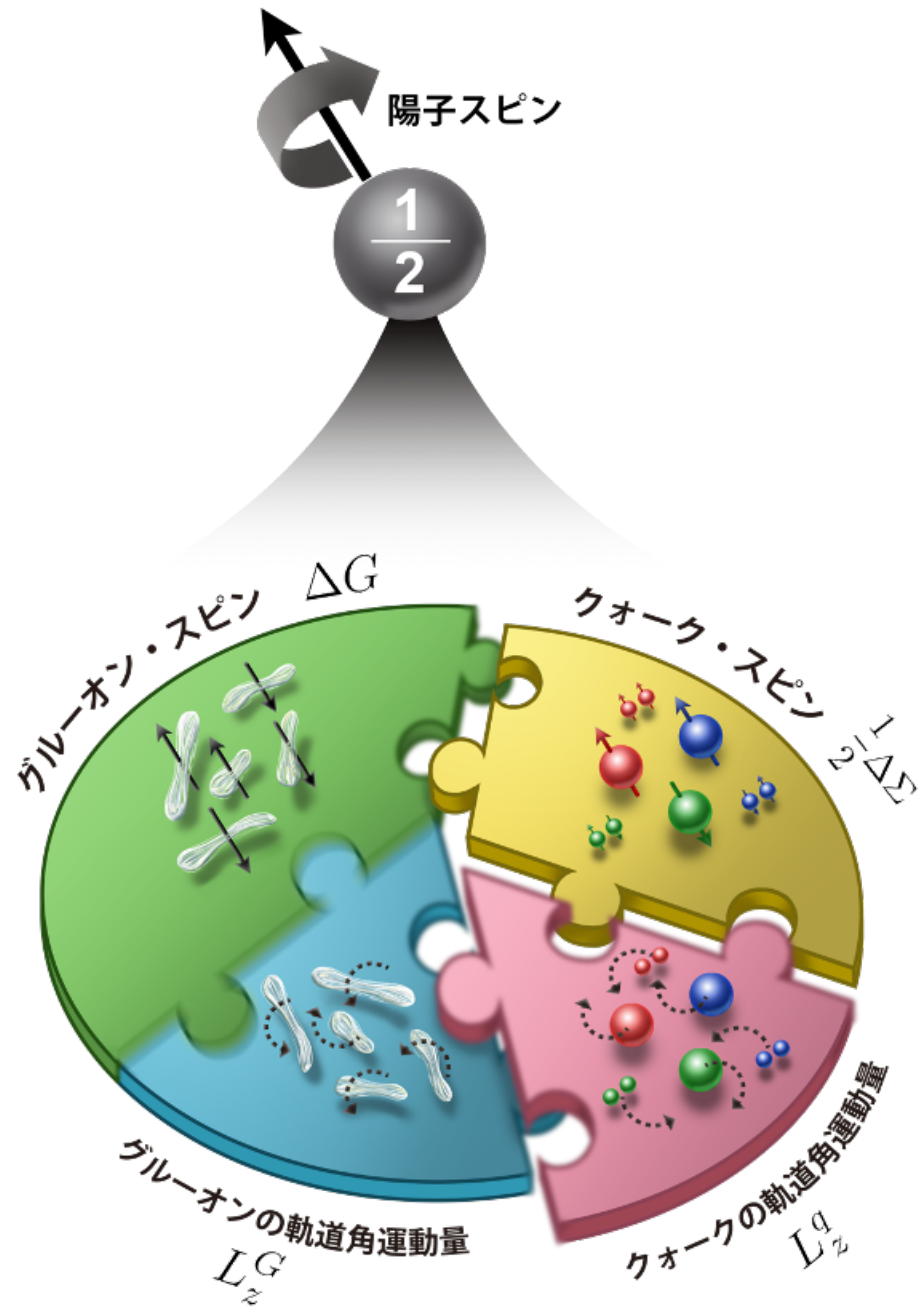

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sPHENIX

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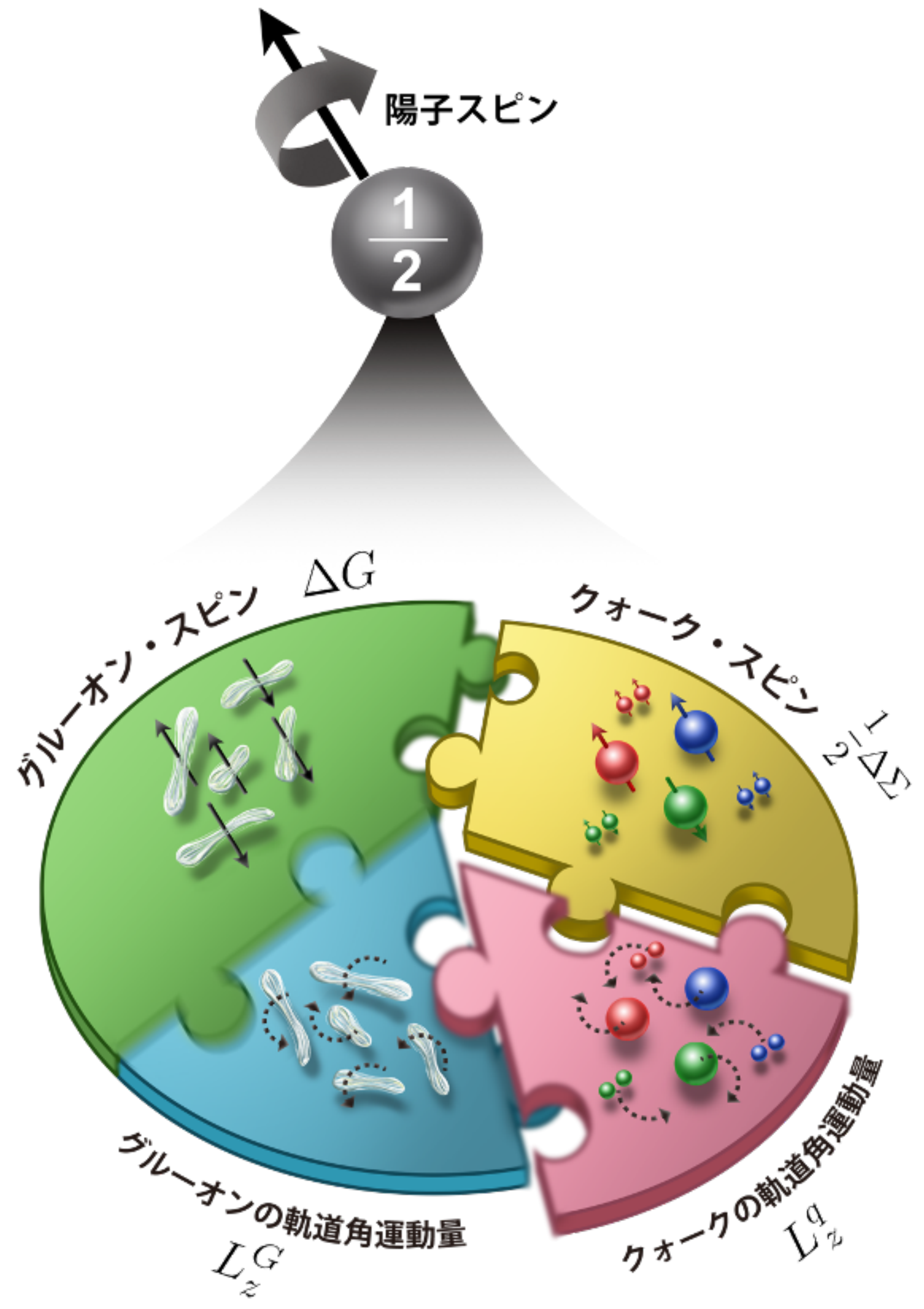

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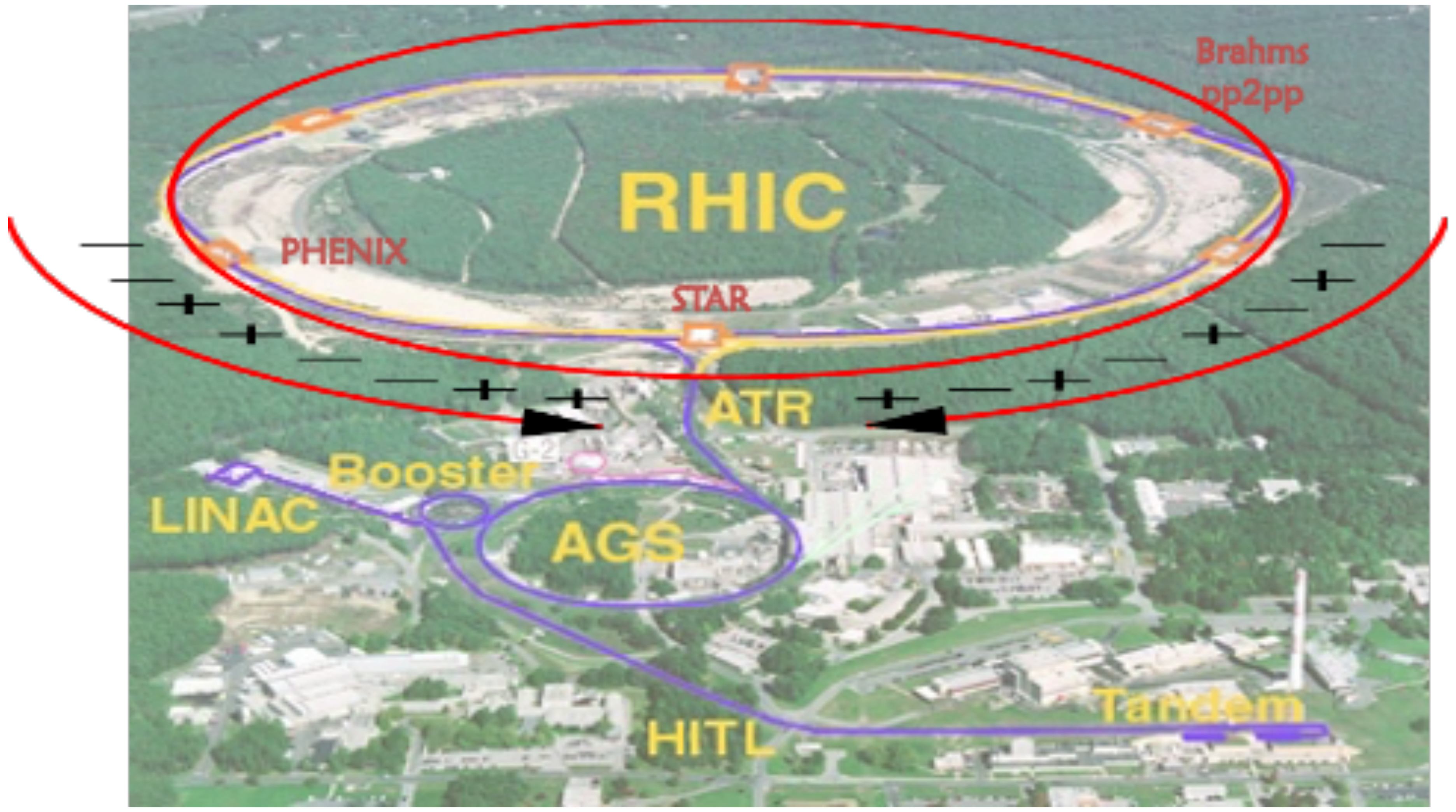
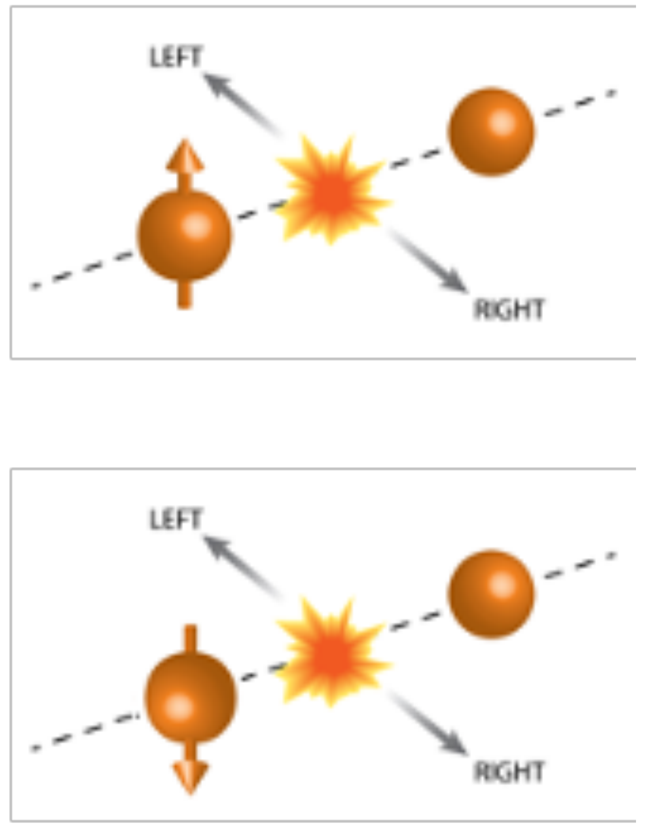
sPHENIX : let's do some valuable tests on this motion!
The gluon orbital motion measurements of proton!

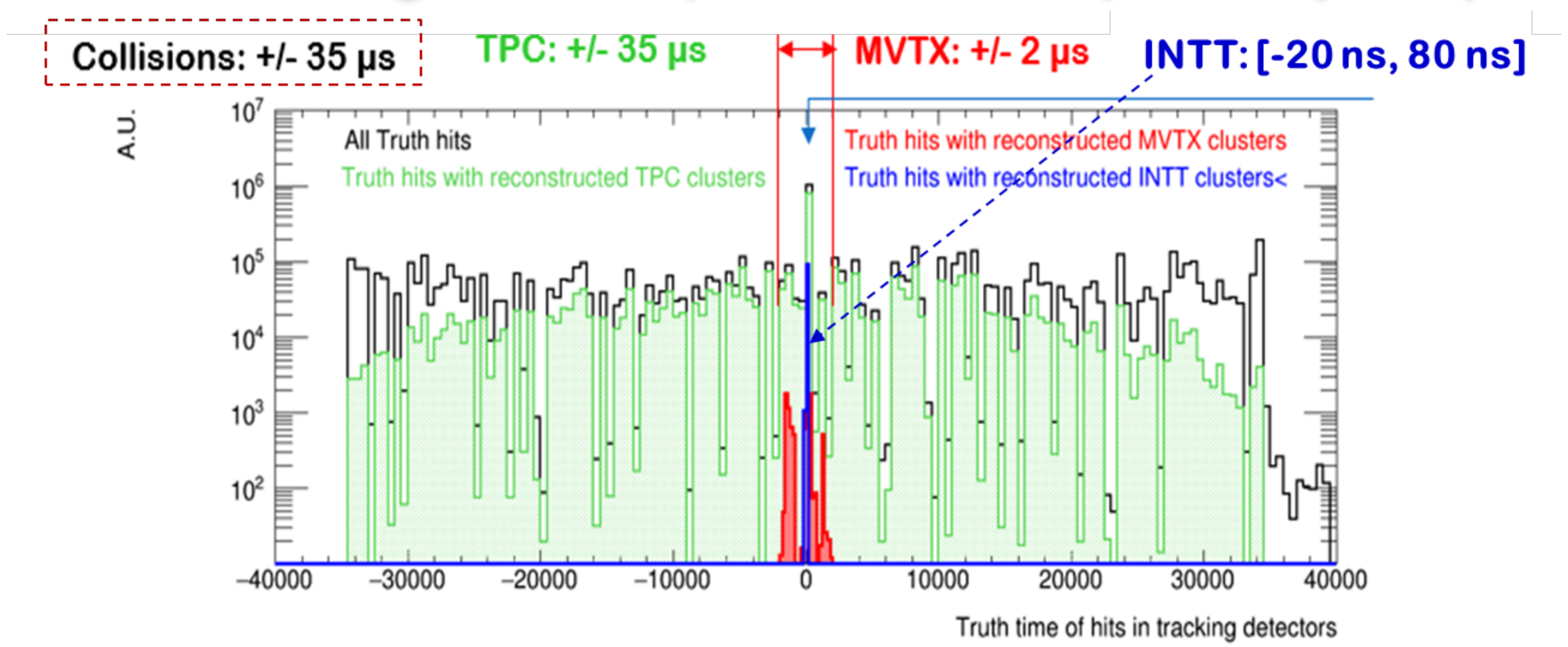
Materials from Itaru

Gluon orbital motion measurements of proton

- The production difference between different polarities is slightly different (~ 10%)
- Best way to suppress the detector effect: having bunches with different polarities in single beam (run) injection
- Bottleneck ? Good timing resolution to well separate events is MANDATORY!
- 15 kHz collision rate ~ 600 BCO no worry ? NO! It's possible the collision happens in next bunch crossing → 1 bunch-crossing timing resolution is ESSENTIAL! → INTT!







Materials from Itaru

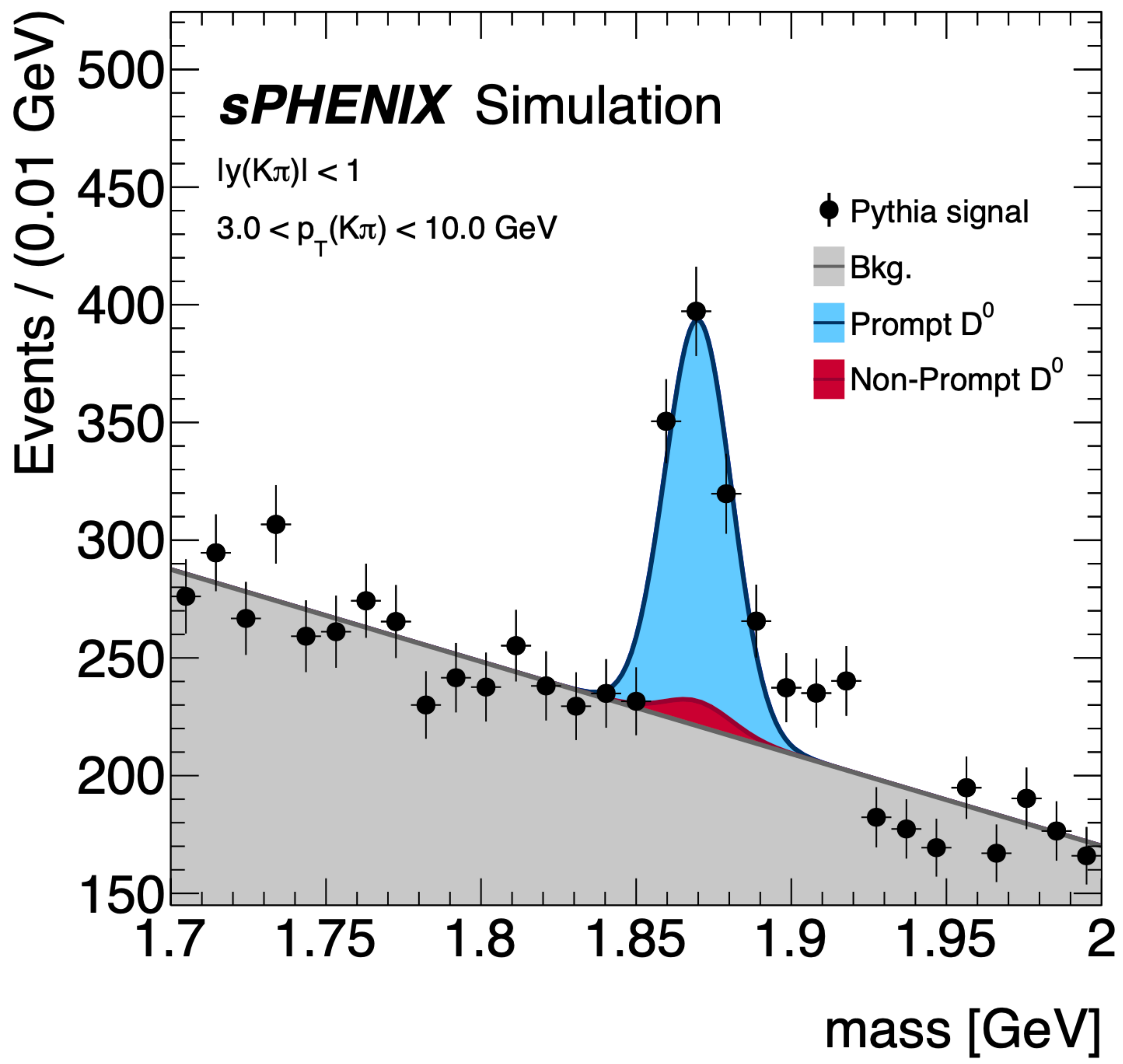
Gluon orbital motion measurements of proton

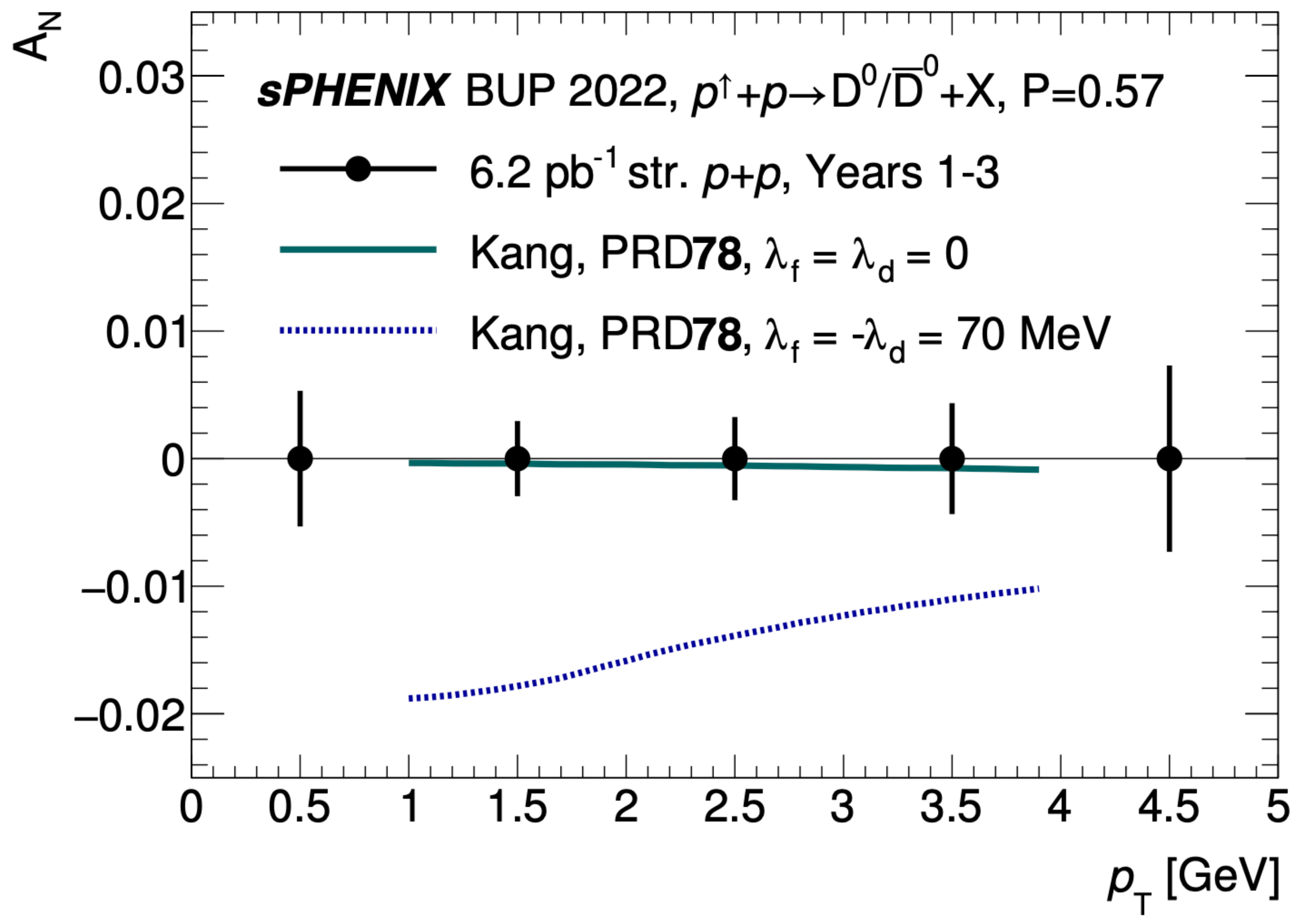
- Orbital angular motion : correlated with Sivers function
- Bottleneck: most of the experimental results were able to be described by initial-state (Sivers) and final-state (Collins) → not sensitive enough
- D^0 *and* $\bar{D}^0$ production: gluon-gluon fusion and $q\bar{q}$ annihilation → Unpolarized at the leading order → final-state effect is suppressed
- TSSA : $A_N = \dfrac{d\sigma^{\uparrow} - d\sigma^{\downarrow}}{d\sigma^{\uparrow} + d\sigma^{\downarrow}}$, a smart way to suppress the detector systematic uncertainty
- Challenges : D^0 *and* $\bar{D}^0$ tagging, low production rate, streaming readout required

Gluon orbital motion measurements of proton

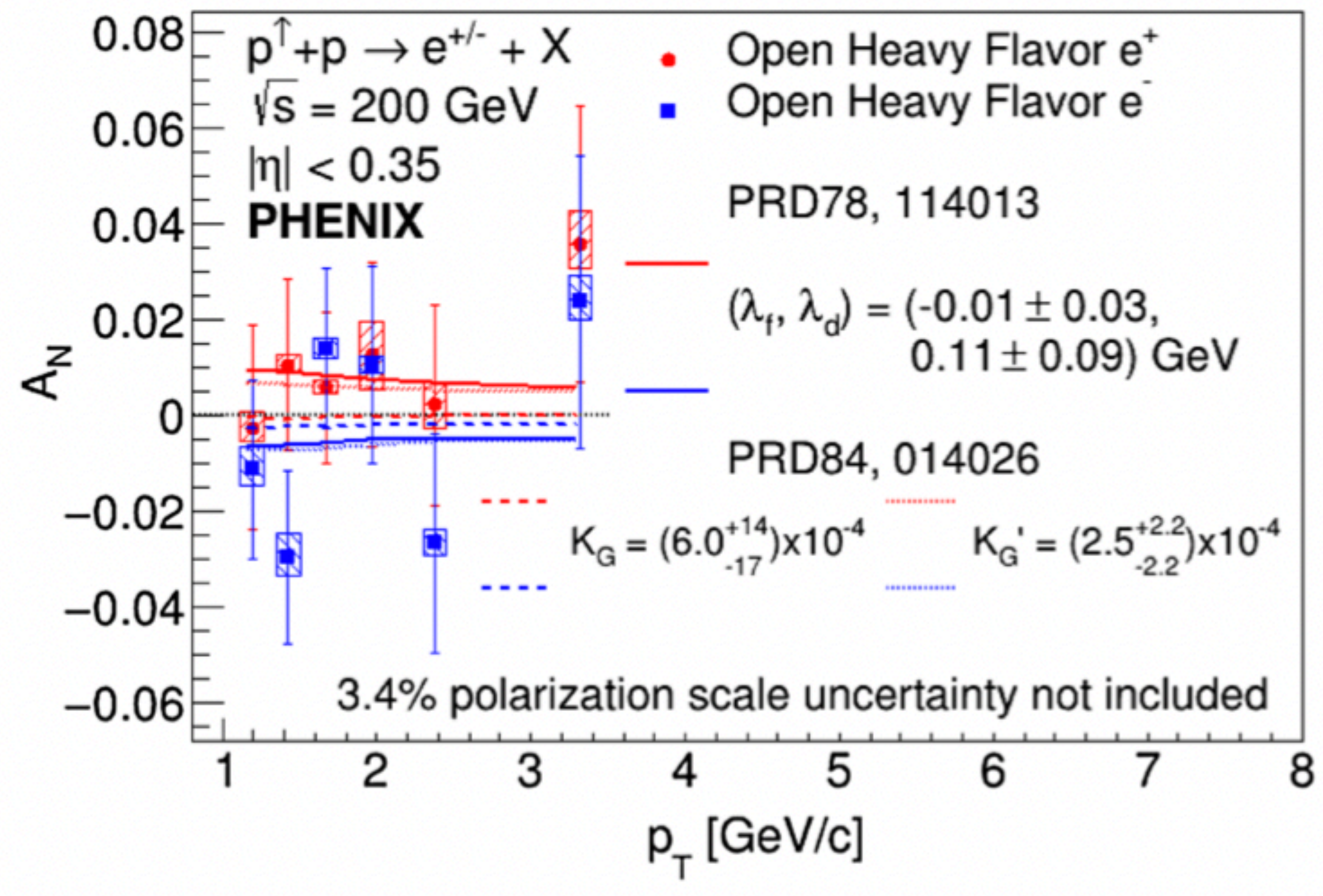
- sPHENIX statistical projection with run 24 proton proton collision (assuming 28 cryo-week scenarios)

sPH-HF-2021-001





Phys. Rev. D 107, 052012



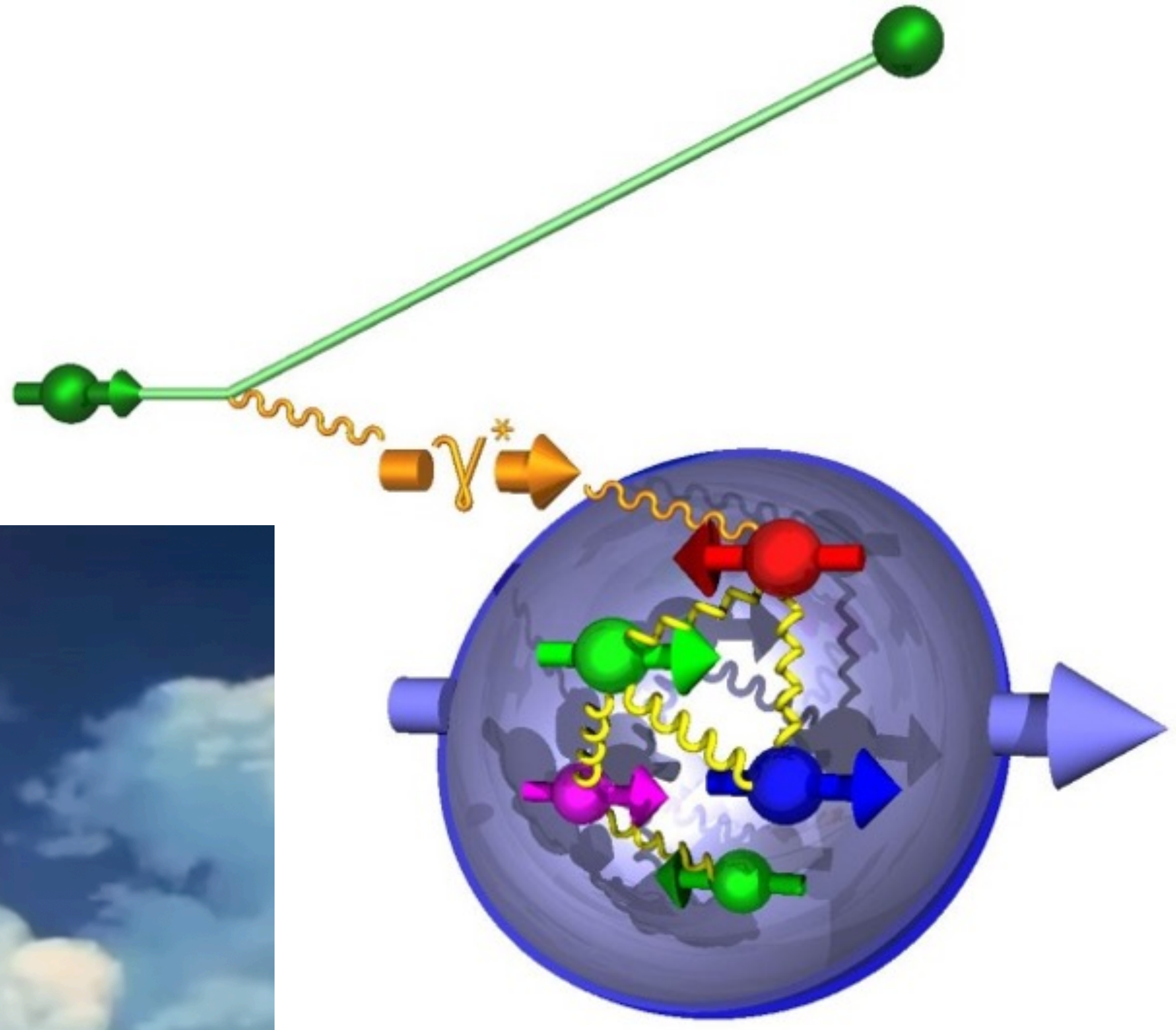
EIC - the curtain call of proton spin crisis

- Will re-measure quark contribution
- Will re-measure gluon contribution (second order contribution)
- Will measure orbital angular momentum (L = r x p)

  → One has to measure both at the same time

- Will precisely measure the proton radius ?

EIC : use electron as a probe (if you believe that electron is a fundamental particle)



庵野秀明, et al.: Evangelion, episode 26, 世界の中心でアイを叫んだけもの（1996)

Or to be continued….?

Back up