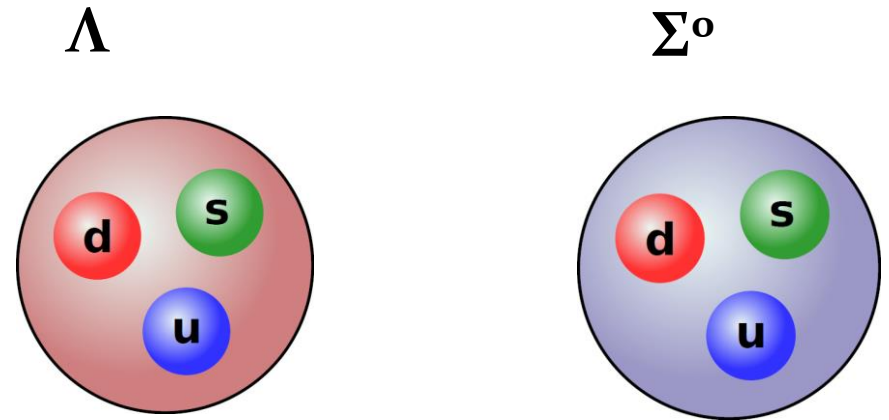
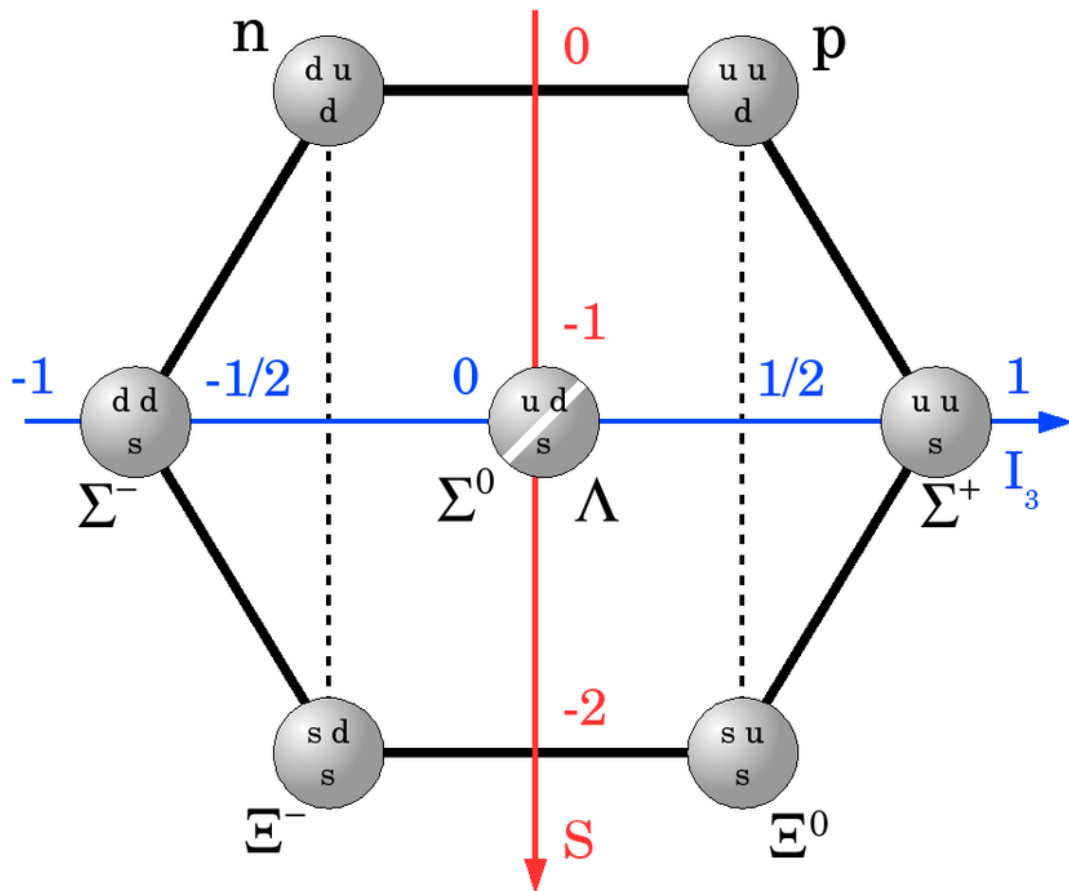


A STRANGER AMONG STRANGERS - RECENT RESULTS ON THE Σ^0 HYPERON

Karin Schönning, Nuclear Physics

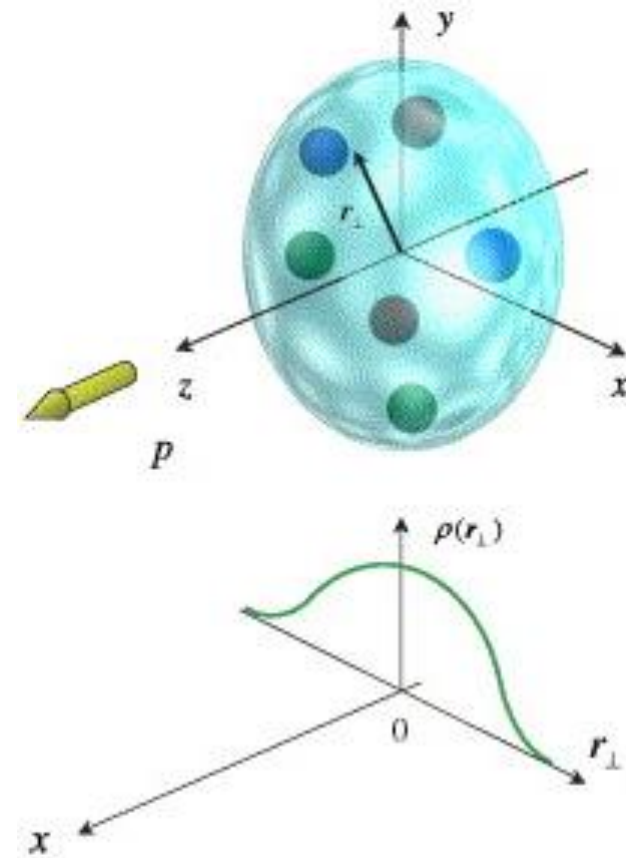
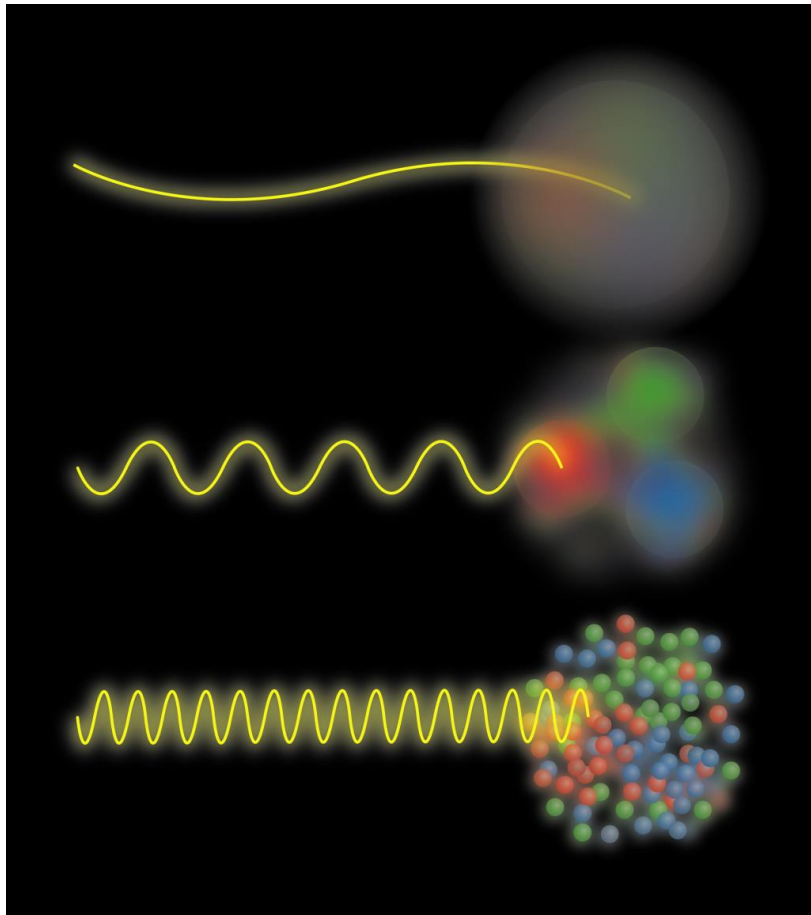
1

THE Σ^0 HYPERON

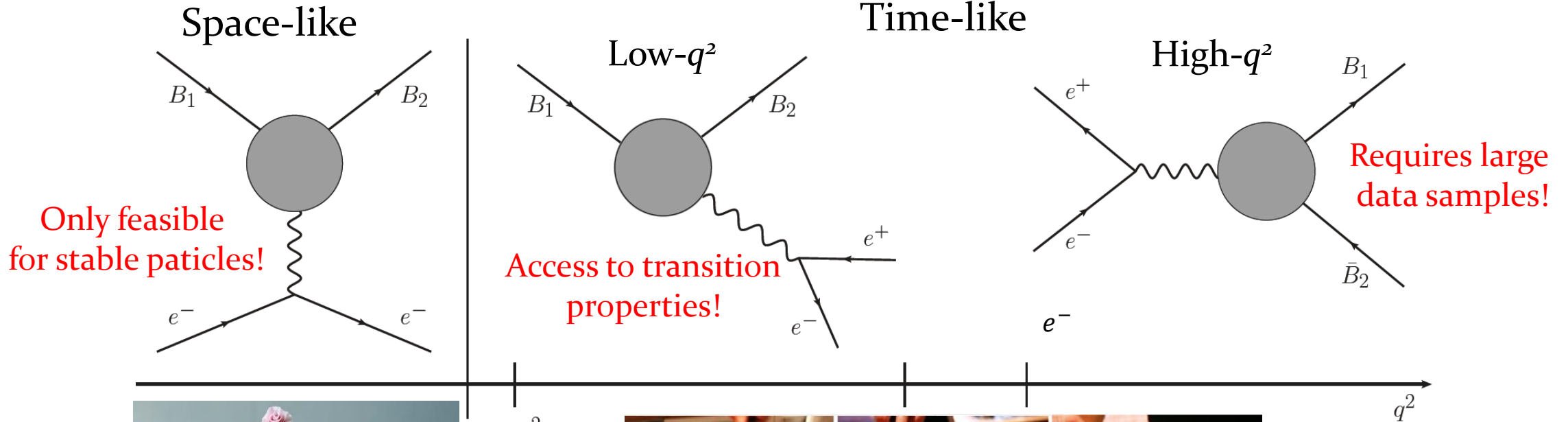


- Same quark content as Λ but different isospin \rightarrow different **production**
- Only octet baryon that **decays** electromagnetically.

EXPLORING THE INNER STRUCTURE

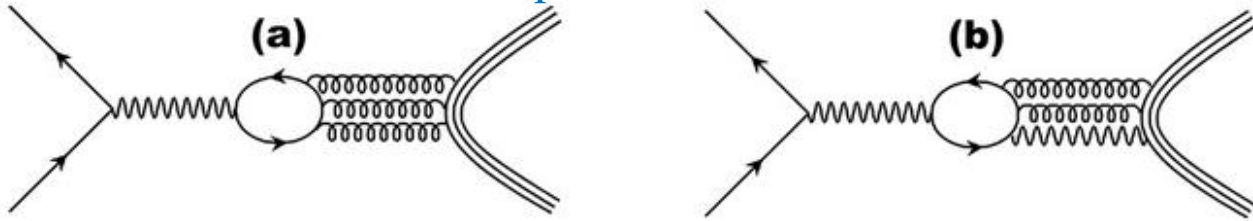


EXPLORING THE INNER STRUCTURE

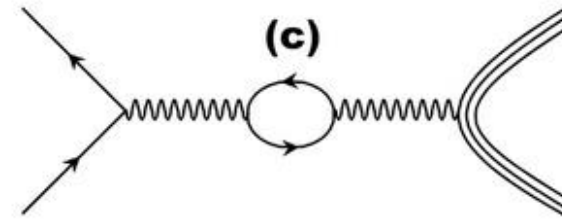


RECENT FROM THE BESIII EXPERIMENT

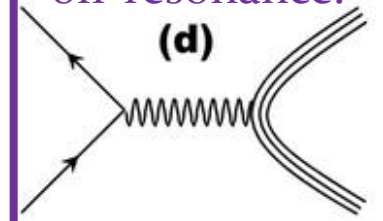
Through vector-meson decays.
Strong, isospin-conserving, yields $Y\bar{Y}$ in abundance.
Does not probe EM structure.



EM, isospin-agnostic.
Dominant only in $\Sigma^0\bar{\Lambda}$ production.



Pure EM.
Only dominant off-resonance.



[nature](#) > [nature communications](#) > [articles](#) > [article](#)

Article | [Open access](#) | Published: 11 October 2024

Extracting the femtometer structure of strange baryons using the vacuum polarization effect

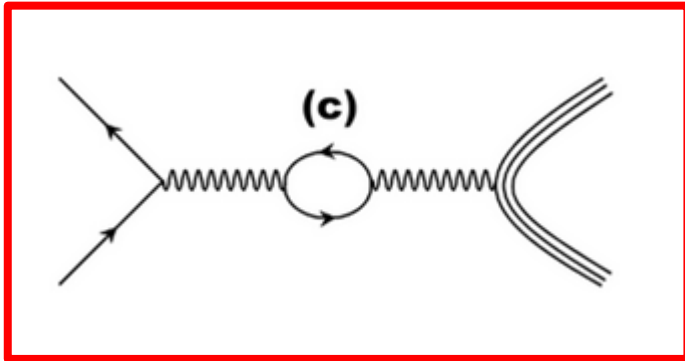
[The BESIII Collaboration](#)

[Nature Communications](#) **15**, Article number: 8812 (2024) | [Cite this article](#)

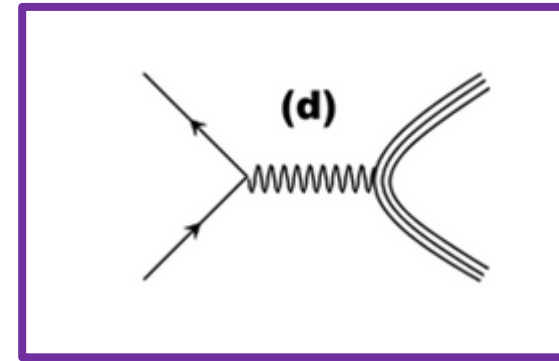
3142 Accesses | **182** Altmetric | [Metrics](#)

- Photon-hadron vertex probes structure.
- **Vacuum polarization** enhances production near J/Ψ .
→ precision measurement of transition form factor.
- Analysis and paper:
Strong involvement by [A. Kupsc](#) and [K. Schönning](#).

FEMTOMETER STRUCTURE OF STRANGE BARYONS



BES III



Results exploiting VP at J/Ψ mass,
 $e^+e^+ \rightarrow \bar{\Lambda}\Sigma^0 + c.c. :$

- $R = \left| \frac{G_E}{G_M} \right| = 0.86 \pm 0.029 \pm 0.015$
- $\Delta\Phi_{\bar{\Lambda}\Sigma^0} = 1.011 \pm 0.094 \pm 0.010 \text{ rad}$
- $\Delta\Phi_{\Lambda\Sigma^0} = 2.128 \pm 0.094 \pm 0.010 \text{ rad}$

Nature Comm. 15, 8812 (2024)

Compare to best off-resonance
 measurement of $e^+e^+ \rightarrow \Lambda\bar{\Lambda}$:

- $R = \left| \frac{G_E}{G_M} \right| = 0.96 \pm 0.14 \pm 0.02$
- $\Delta\Phi_{\Lambda\bar{\Lambda}} = 0.64 \pm 0.21 \pm 0.10$

Phys. Rev. Lett. 123, 122003 (2019)

MATTER-ANTIMATTER ASYMMETRY



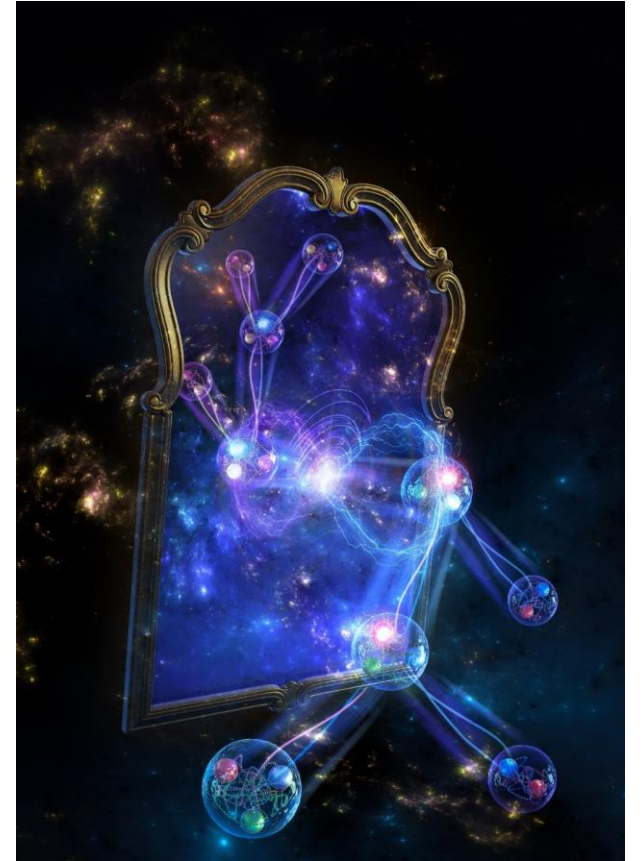
Baryogenesis: Dynamic generation of matter-antimatter asymmetry.

Possible if the three *Sakharov criteria* are fulfilled.

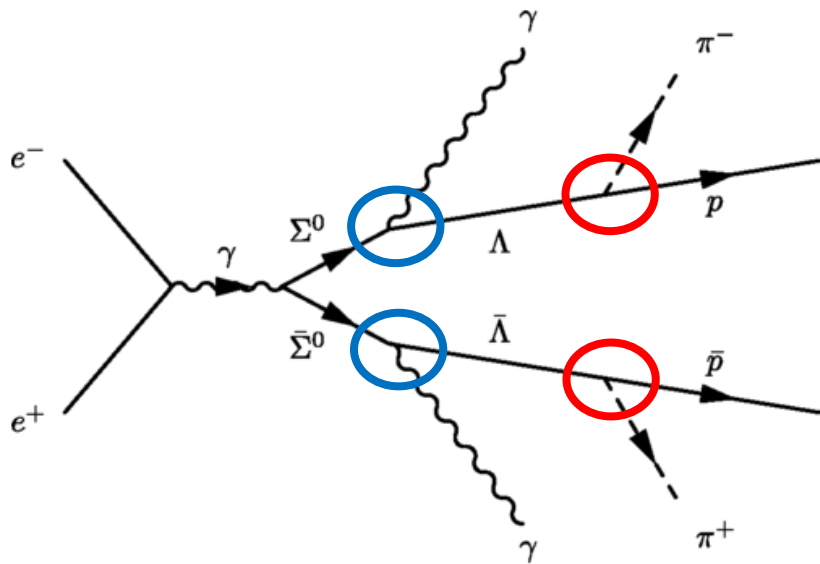
One is that processes must exist that violates the conservation of *charge conjugation (C)* and *charge conjugation and parity (CP)*.

CP VIOLATION

- **Weak interaction:** Well-established through Cabibbo-Kobayashi-Maskawa mechanism.
 - Experimentally verified.
 - Too small to explain matter-antimatter asymmetry.
- **Strong interaction:** Empirically found to be **unnaturally small**.
 - Vanishing neutron EDM.
- Hyperon decays provide tests of CP conservation.



STRONG AND WEAK SYMMETRY TESTS IN Σ^0 DECAYS

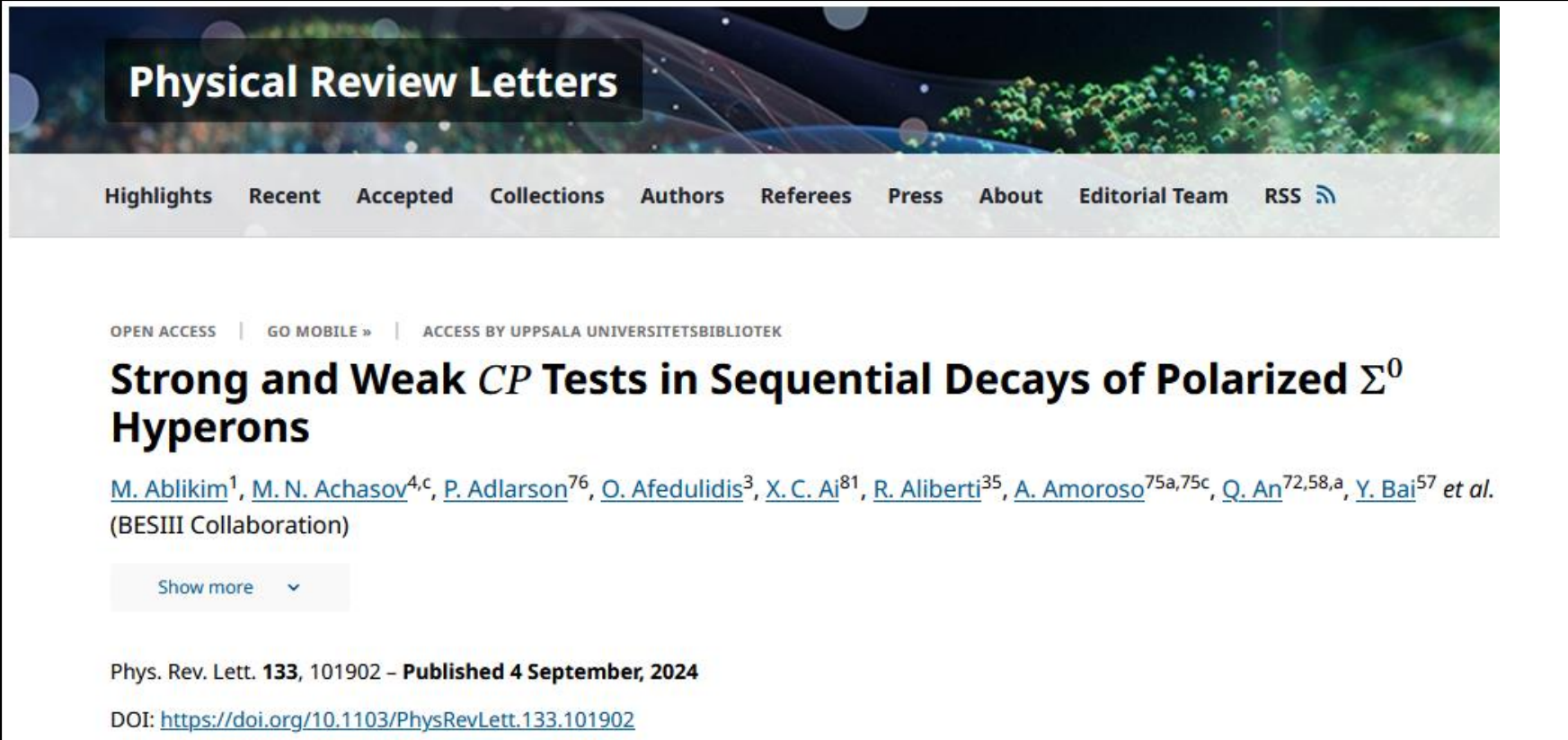


Idea from S. Nair, E. Perotti and S. Leupold, *Phys. Lett. B* 788, 535-541 (2019):

- $\Sigma^0 \rightarrow \Lambda \gamma$ decay amplitude:
 - Magnetic parity-conserving moment
 - Electric parity-violating moment (\leftarrow should be extremely small!)
- Decay distributions of Σ^0 and $\bar{\Sigma}^0$ provide C and CP tests

Covariant formalism for polarized and entangled $\Sigma^0 \bar{\Sigma}^0$ pairs by Fäldt and Schönning, *Phys. Rev. D* 101, 033002 (2020)

RECENT FROM THE BESIII EXPERIMENT



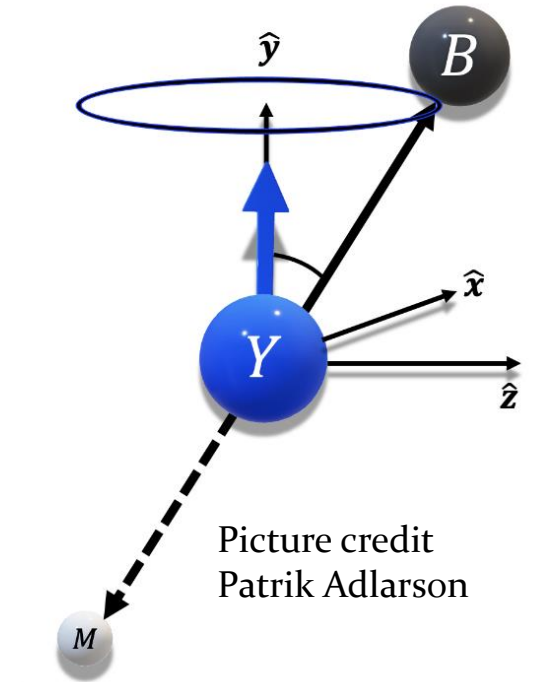
The image shows a screenshot of a Physical Review Letters article page. At the top, there is a navigation bar with links for Highlights, Recent, Accepted, Collections, Authors, Referees, Press, About, Editorial Team, and RSS. Below this, there are links for OPEN ACCESS, GO MOBILE, and ACCESS BY UPPSALA UNIVERSITETSBIOTEK. The main title of the article is "Strong and Weak CP Tests in Sequential Decays of Polarized Σ^0 Hyperons". The authors listed are M. Ablikim¹, M. N. Achasov^{4,c}, P. Adlarson⁷⁶, O. Afedulidis³, X. C. Ai⁸¹, R. Aliberti³⁵, A. Amoroso^{75a,75c}, Q. An^{72,58,a}, and Y. Bai⁵⁷ et al. Below the authors' names is a "Show more" button with a downward arrow. At the bottom of the article preview, it says "Phys. Rev. Lett. 133, 101902 – Published 4 September, 2024" and provides the DOI: <https://doi.org/10.1103/PhysRevLett.133.101902>.

- Initiated and supervised by [K. Schönning](#), in collaboration with IHEP Beijing, [P. Adlarson](#) (UU) and [A. Kupsc](#) (UU).
- Related student project by [Annele Heikkilä](#) (2019) and [Benjamin Verbeek](#) (2022).

STRONG AND WEAK CP TESTS IN Σ^0 DECAYS

Results:

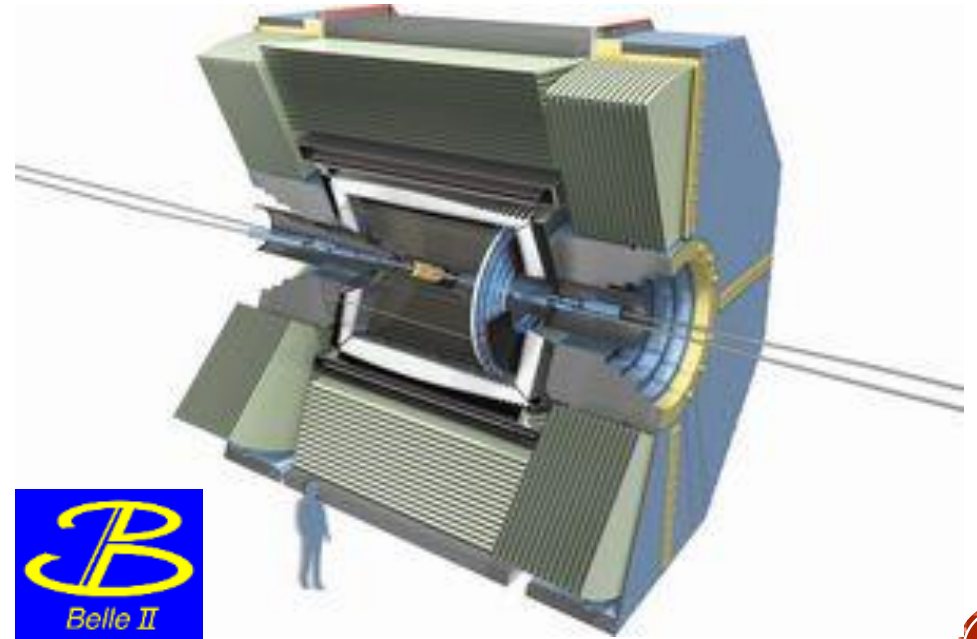
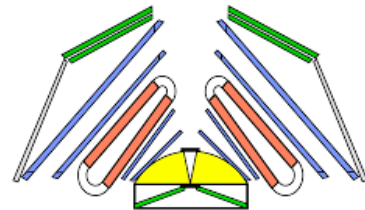
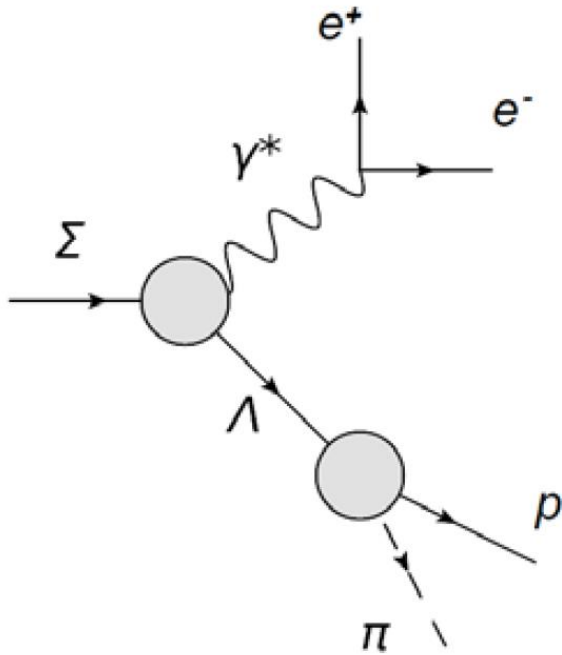
- Parameter α_{Σ^0} related to **parity violation in Σ^0 decay**: $0.0017 \pm 0.0021 \pm 0.0018$
 - SM prediction by Nair, Leupold and Perotti $\sim 10^{-12}$
- Parameter A_{CP}^{Σ} related to **strong CP violation in Σ^0 decay**: $\alpha_{\Sigma^0} + \bar{\alpha}_{\bar{\Sigma}^0} = (0.4 \pm 2.9 \pm 1.3) \cdot 10^{-3}$
 - SM prediction by Nair, Leupold and Perotti $\sim 10^{-14}$
- Parameter A_{CP}^{Λ} related to **weak CP violation** in subsequent Λ decay: $\frac{\alpha_{\Lambda} + \bar{\alpha}_{\bar{\Lambda}}}{\alpha_{\Lambda} - \bar{\alpha}_{\bar{\Lambda}}} = (-3.0 \pm 6.9 \pm 1.5) \cdot 10^{-2}$
 - SM prediction $\sim 10^{-5}$



ONGOING Σ^0 STUDIES AT UU

Probing structure with the Dalitz decay $\Sigma^0 \rightarrow \Lambda e^+ e^-$:

- PANDA@HADES (Jana Rieger and Malin Bohman)
- Belle II (Bianca Scavino)



BES III

CP tests
Hadron structure
Hadron interactions

CP tests
Baryon number violation

 PANDA



 NNBAR

