Hyperon structure with BESIII

- strange and complex

14th International Workshop on the Physics of Excited Nucleons, York, UK, June 17-21 2024

Prof. Dr. Karin Schönning, Uppsala University

Outline

- Prologue
- Electromagnetic Form Factors
- Recent results from BESIII
  - Cross sections and effective form factors
  - Spin analyses
- Summary

Prologue

Strong interactions manifest in *e.g.* hadron structure and size

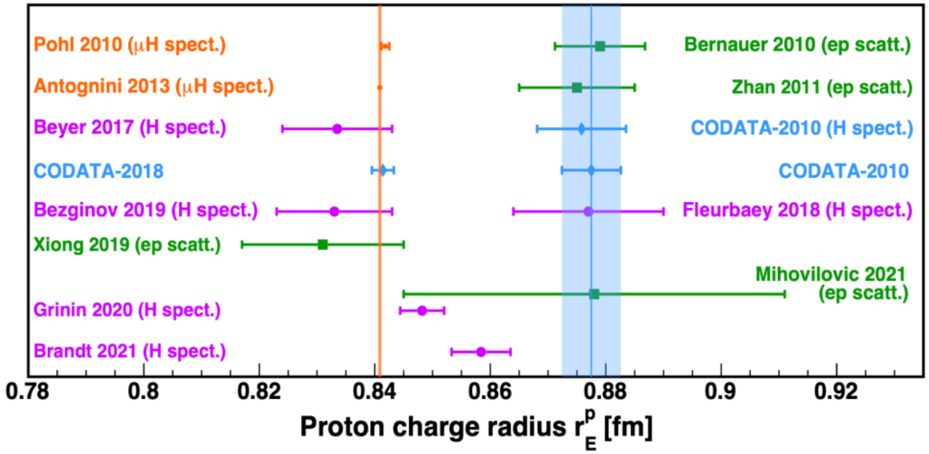
→ quantities at the femtometer scale!

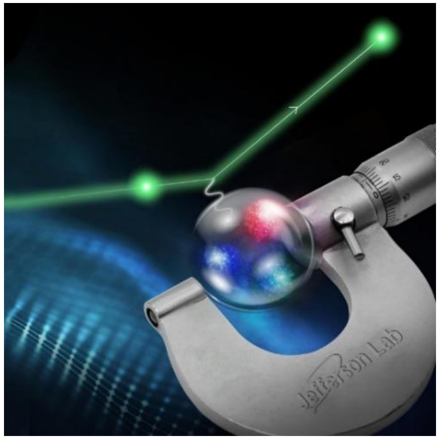
Protons: several independent techniques applicable

→ rapid progress the last decade!

Now: Precision instrument to understand the strong interaction!

Picture credit: J. Zhou (Duke U.), NuPECC LRP draft





Picture cred. Y-H Lin, U. Bonn

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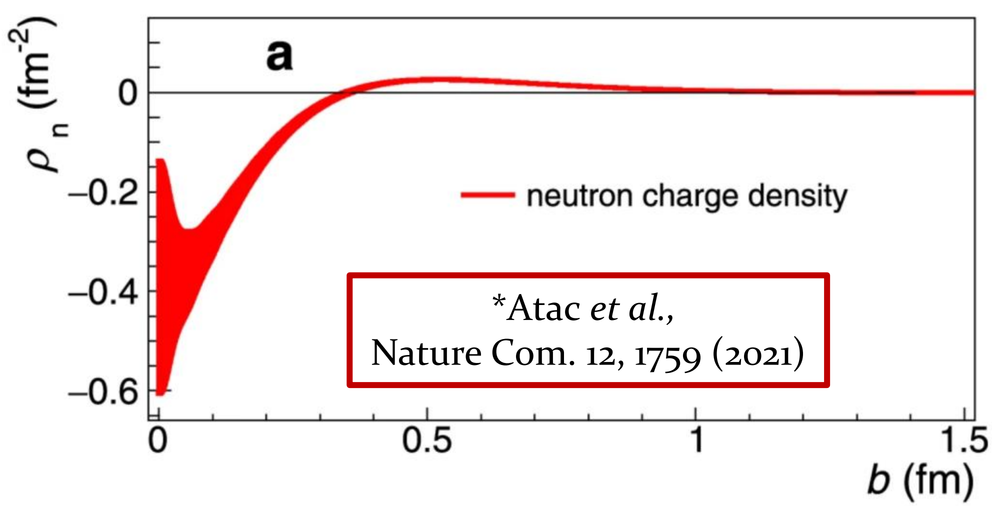
Prologue

The proton is insanely stable ($\tau > 10^{34}$ y).

What about the less stable neutron ($\tau \sim 15$ min)?

Electron scattering data + lattice QCD:

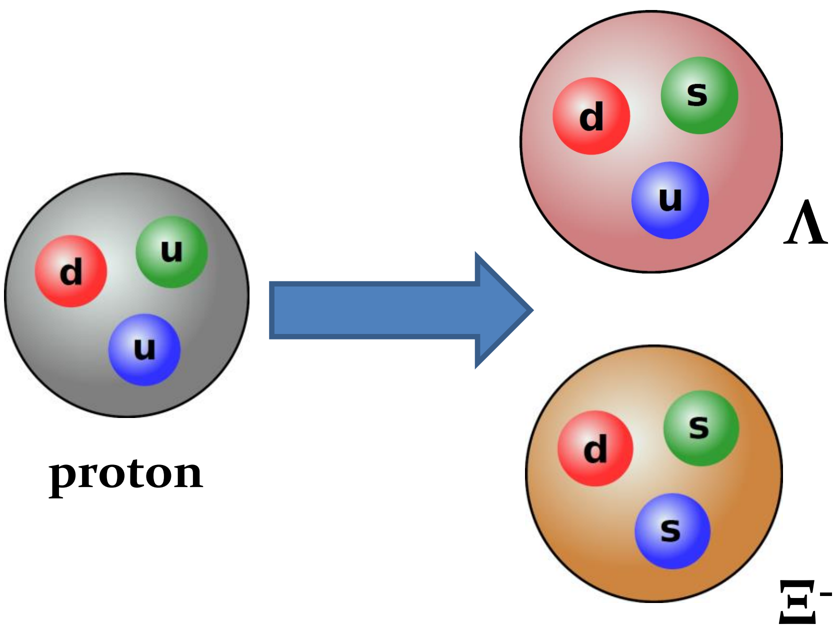
The asymmetric distribution of negative *d* quarks and the positive *u* quark results in a negative squared charge radius.*



*Atac *et al.*,
Nature Com. 12, 1759 (2021)

Next step: Hyperons

Question: *How does the heavy strange and charm quarks affect the strong interaction dynamics?*



Challenge: Hyperons are unstable!

Proton: $\tau > 10^{34}$ y

Neutron: $\tau \sim 15$ min

Strange hyperons: $\tau \sim 10^{-10}$ s

Charm hyperons: $\tau \sim 10^{-13}$ s

Next step: Hyperons

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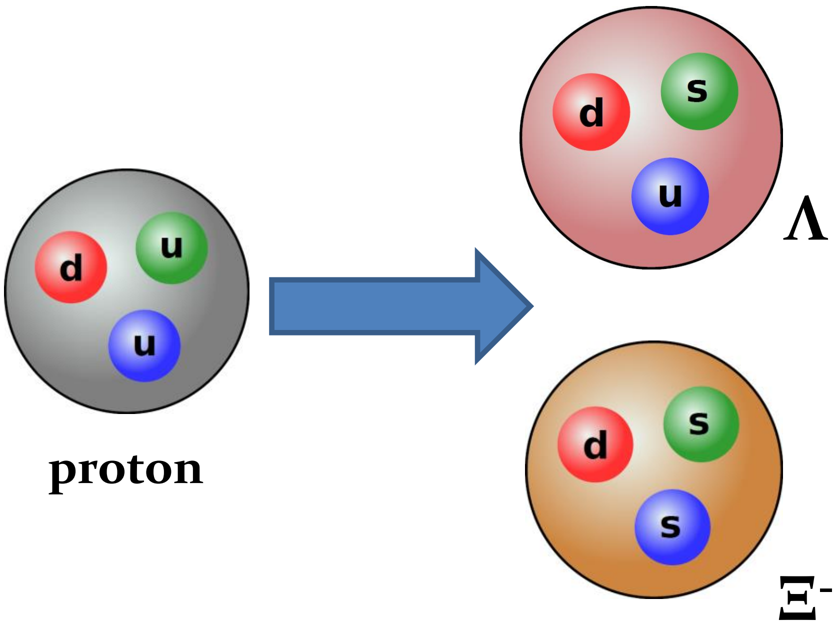


Challenge: Hyperons are unstable!

Proton: $\tau > 10^{34}$ y

Neutron: $\tau \sim 15$ min

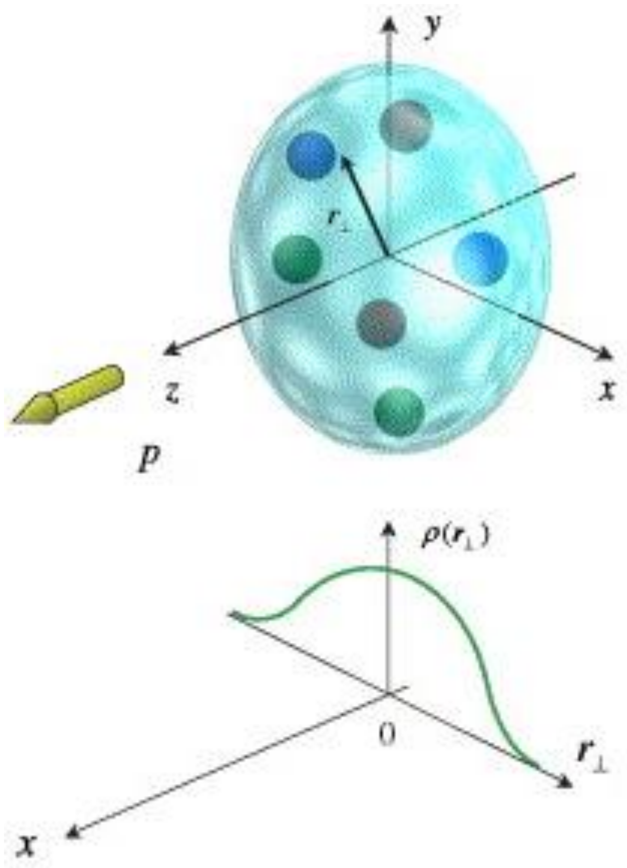
Strange hyperons: $\tau \sim 10^{-10}$ s

Charm hyperons: $\tau \sim 10^{-13}$ s

Solution: Time-like Electromagnetic form factors!

Electromagnetic Form Factors

- Probed in hadron – photon interactions
- Analytic functions of momentum transfer q^2
- Quantify the deviation from point-like behaviour.



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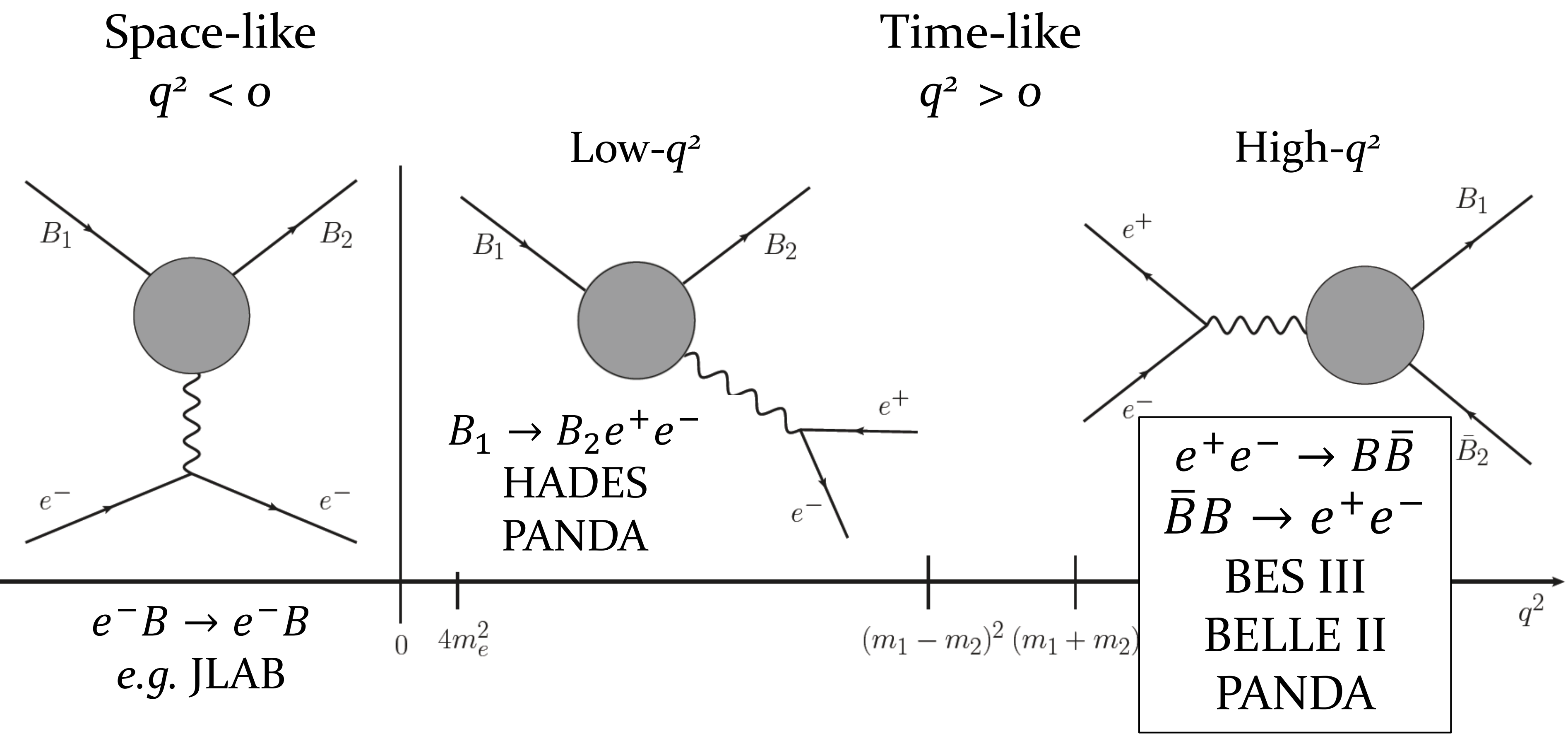
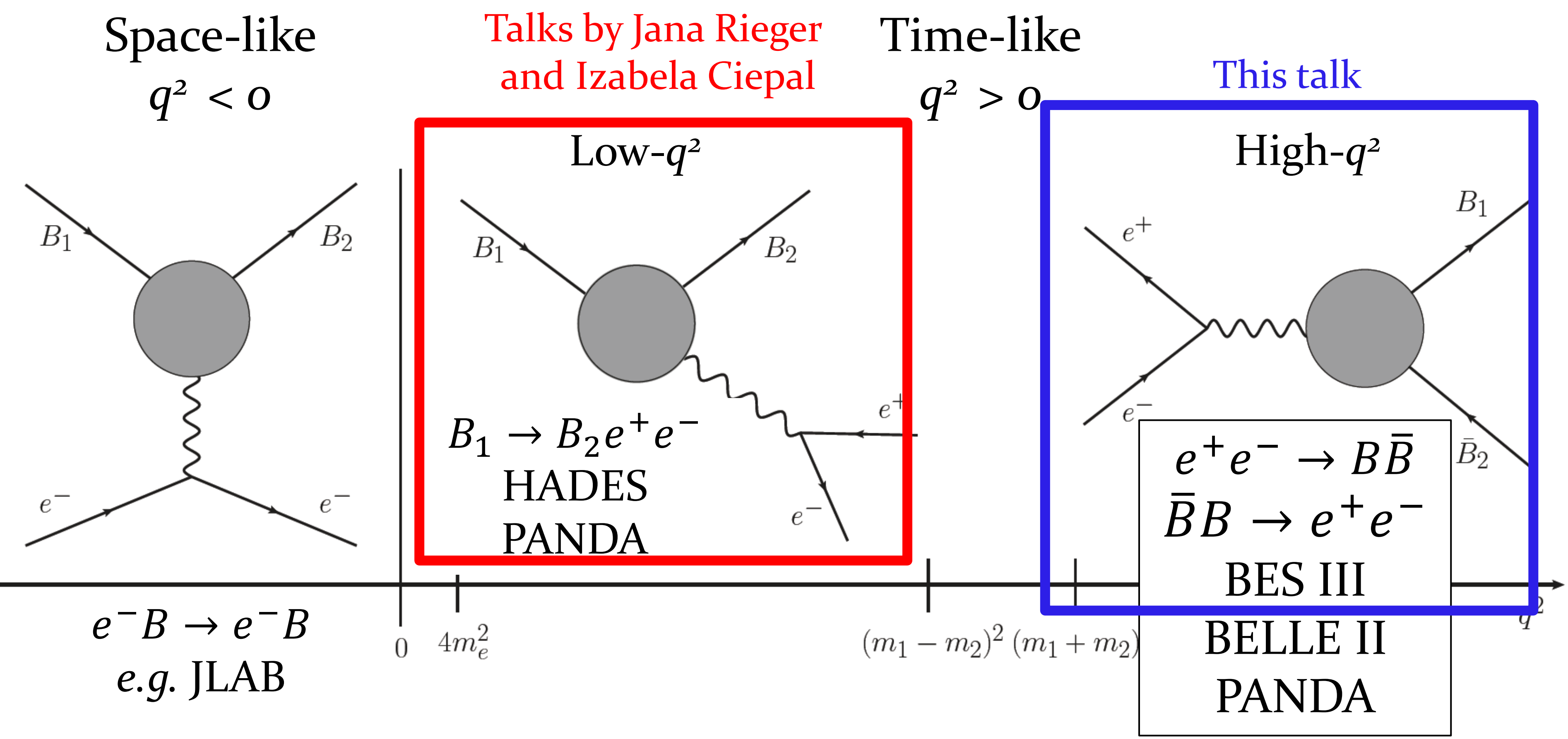
Space-like *vs.* time-like FF's



Cred. E. Perotti, PhD thesis (UU 2020)

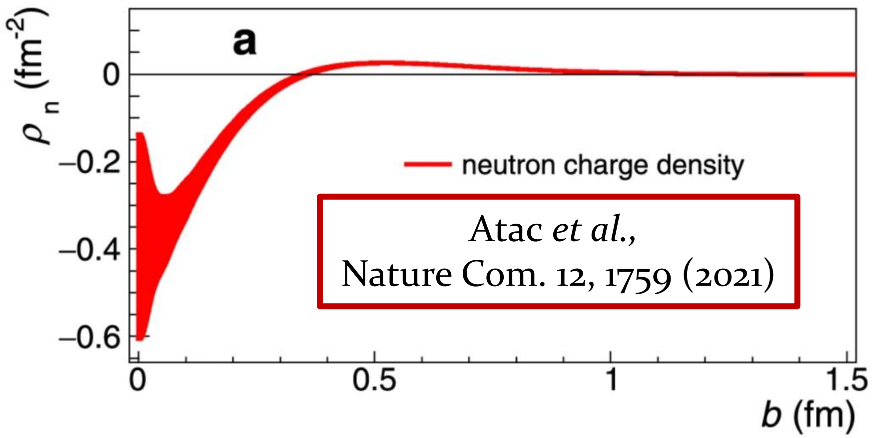
Space-like *vs.* time-like FF's



Cred. E. Perotti, PhD thesis (UU 2020)

Space-like form factors

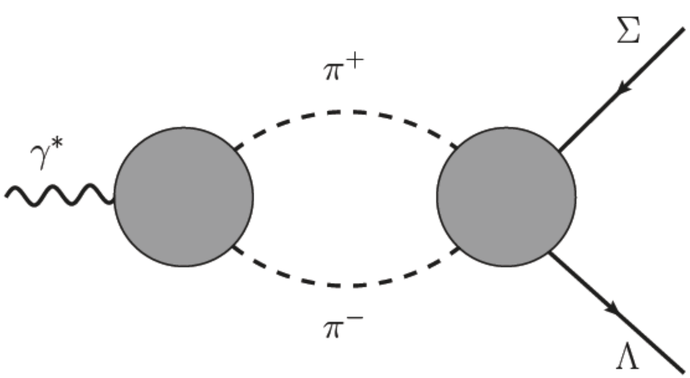
- Number of EMFFs = $2J+1$ → spin ½ baryons have 2.
- Sachs FFs: the electric G_E and magnetic G_M
  - Charge radius: $< r_E^2 > = 6 \frac{dG_E(q^2)}{dq^2}|_{q^2=0}$
  - Magnetic radius: $< r_M^2 > = \frac{6}{G_M(0)} \frac{dG_M(q^2)}{dq^2}|_{q^2=0}$



Atac *et al.*,
Nature Com. 12, 1759 (2021)

Time-like form factors

- Related to space-like EMFFs *via* dispersion relations.
- Are complex:
  - $G_E(q^2) = |G_E(q^2)| \cdot e^{i\Phi_E}$, $G_M(q^2) = |G_M(q^2)| \cdot e^{i\Phi_M}$
  - Ratio $R = \frac{|G_E(q^2)|}{|G_M(q^2)|}$ accessible from baryon scattering angle.
  - $\Delta\Phi(q^2) = \Phi_M(q^2) - \Phi_E(q^2)$ = phase between G_E and G_M
  - Phase a reflection of intermediate fluctuations of the γ^* into *e.g.* $\pi\pi$ or $\pi\pi\pi$



→ Polarises final state!

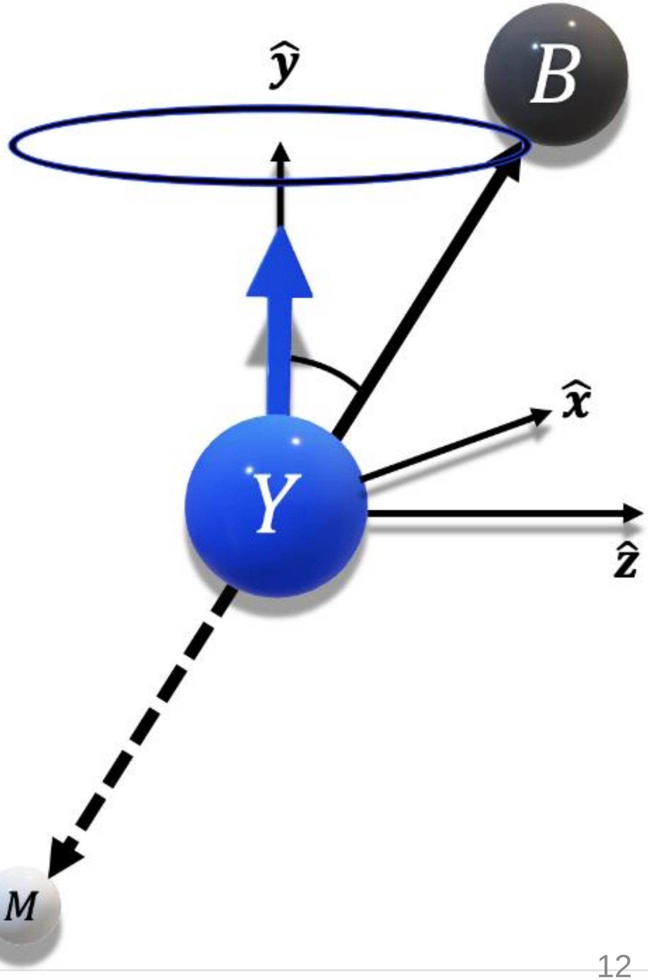
Picture credit:
Elisabetta Perotti, PhD Thesis,
Uppsala U. (2020)

Advantage of hyperons

Polarisation experimentally accessible by the weak, parity violating decay:

Example:

$$I(\cos\theta_p) = N(1+\alpha_\Lambda P_\Lambda \cos\theta_p)$$



Nucleon *versus* hyperon EMFFs

Asymptotic behaviour as $|q^2| \to \infty$: SL ~TL

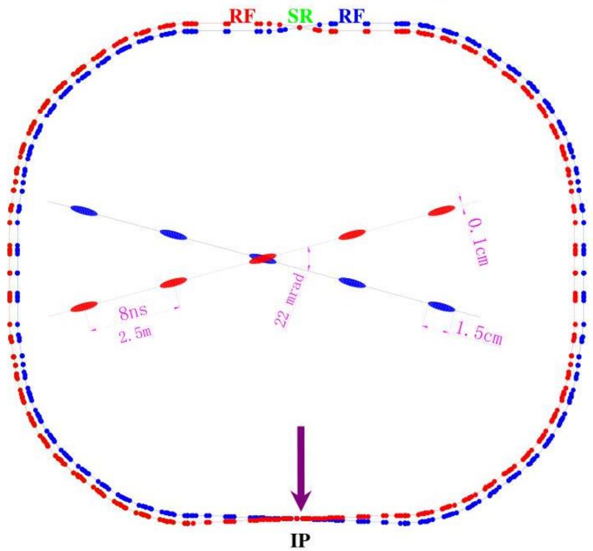
- Nucleons: SL and TL accessible.
- Hyperons: Only TL accessible, but also phase!
  Should be a scale q^2_{asy} where SL = TL ↔ $\Delta\Phi(q^2) \to 0$

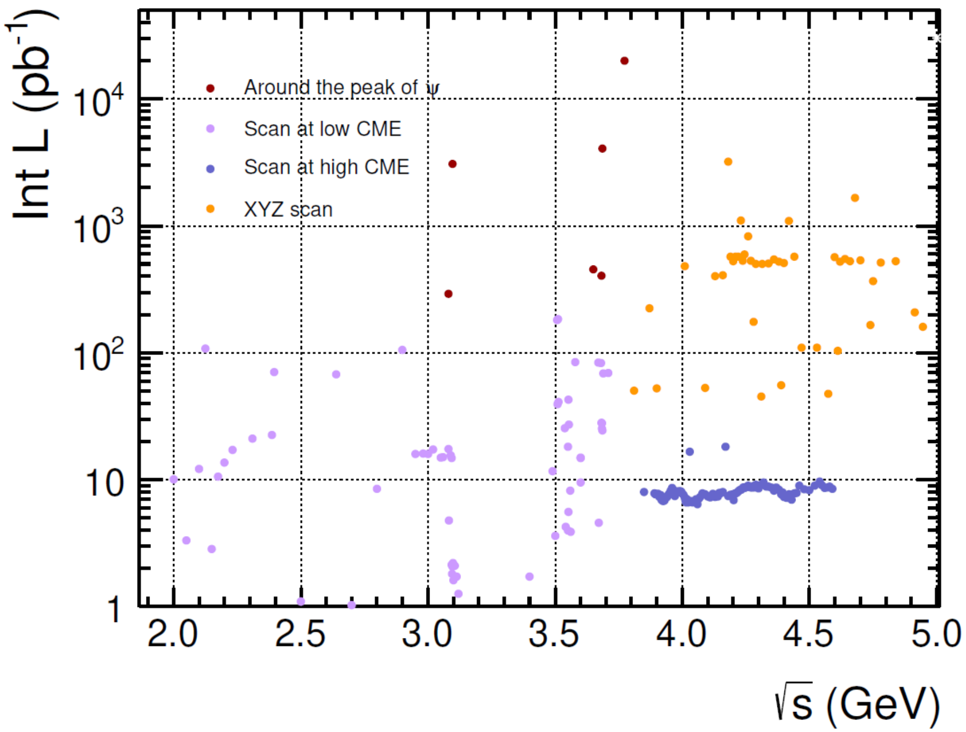
Zero crossings: How many times do the FFs cross zero?

- Information about SL from the TL behaviour!

The BESIII experiment

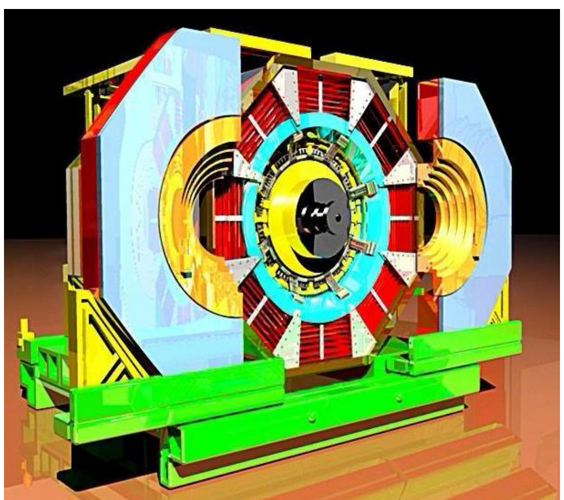
- Study $e^+e^- \to B\bar{B}$, where $B = p, n, \Lambda, \Sigma, \Xi, \Lambda_c^+$
- Beijing Electron Positron Collider (BEPC II):
  - e^+e^- collider within 2.0 – 4.95 GeV.
  - Optimised in the τ-charm region.

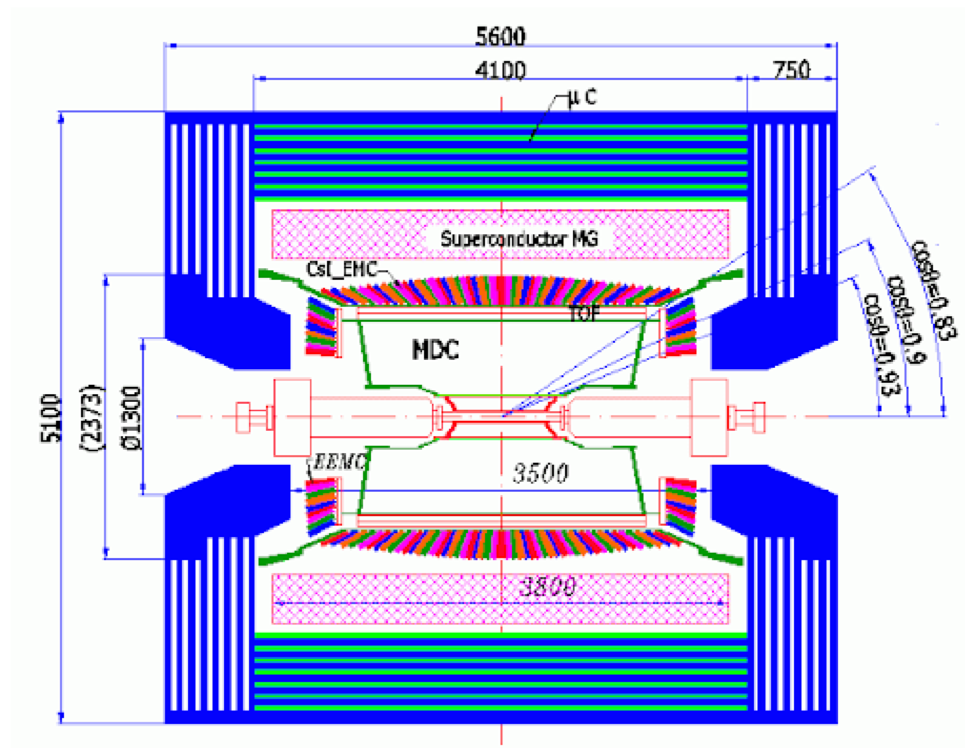




The Beijing Spectrometer (BESIII)

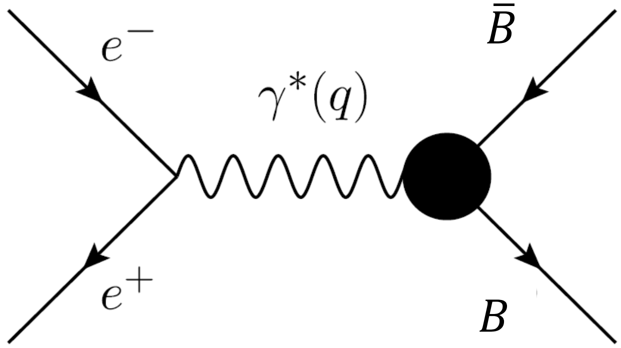
- Near 4π coverage
- Tracking, PID, Calorimetry
- Broad physics scope – see *e.g.* talks by Xiaoyan Shen & Xiaorong Zhou





$B\bar{B}$ production in BESIII

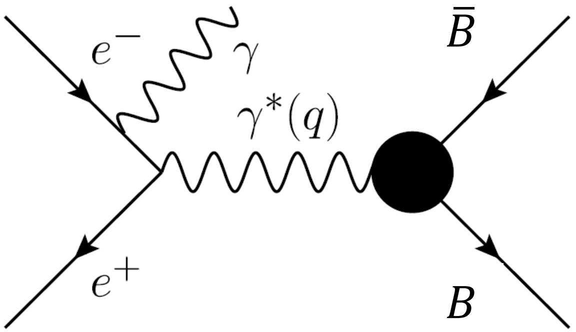
Energy Scan



$$e^+e^- \to B\bar{B}$$

- Simple final state
- "Simple" formalism → Straight-forward to analyse
- Requires dedicated data campaigns

Initial State Radiation (ISR)



$$e^+e^- \to e^+e^-\gamma_{ISR} \to \gamma_{ISR}B\bar{B}$$

- ISR photon tagged or untagged
- Effective cross section much smaller than in direct $e^+e^- \to B\bar{B}$
- Possible to benefit from large data samples collected at *e.g.* J/Ψ

Production cross sections

- Energy dependence give information about the quark dynamics through
  - The *effective form factor:* $G_{eff} \propto \sqrt{\sigma}$
  - Di-quark correlations
  - Coupling to vector mesons
  - Coupling to $B\bar{B}$ bound states

- Convenient quantity for studies of
  - Protons and (semi-) stable neutrons
  - Small hyperon data samples

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Proton and Neutron EMFFs

Energy dependence of effective form factor:

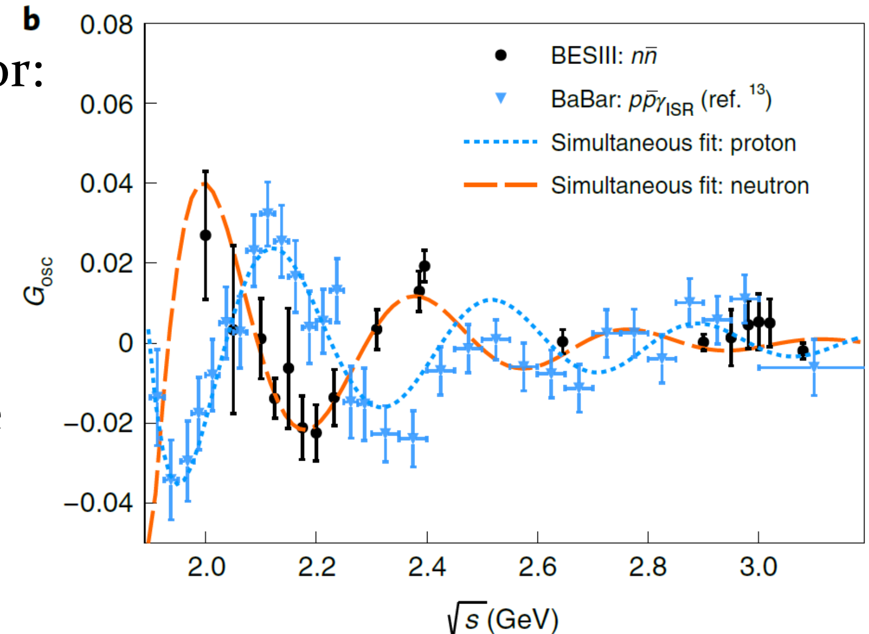
$G_{eff} = G_0 + G_{osc}$

G_0 : Dipole-like behaviour

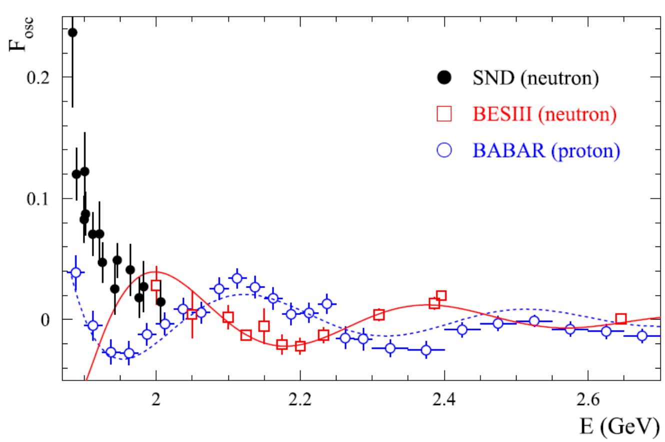
G_{osc}: Oscillating behaviour

BESIII: Oscillations for p and n have same frequency but different phase:

$\Delta D = D_p - D_n = 125^\circ \pm 12^\circ$



SND: Smaller frequency for neutron oscillations.



BESIII proton EMFFs:

Phys. Rev. D 91, 112004 (2015)

Phys. Rev. D 99, 092002 (2019)

Phys. Rev. Lett. 124, 042001 (2020)

Phys. Lett. B 817, 136328 (2021)

BESIII neutron EMFFs:

BESIII, Nature Phys. **17**, p 1200–1204 (2021)

BESIII, Phys. Rev. Lett. 130, 151905 (2023)

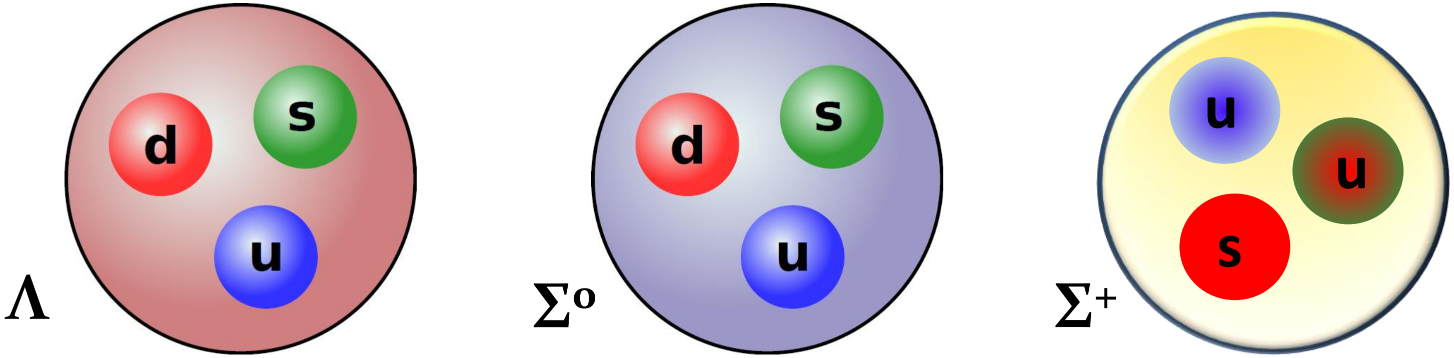
SND: Eur. Phys. J. C (2022) **82**: 761

Single-strange hyperons

Diquark correlations in baryons?

- The Σ^0 has isospin 1 whereas Λ has isospin 0
  - Different isospin in the *ud* diquark for Λ and Σ^0

    → Difference in cross section and form factors expected.*
- In Σ^+, the *uu* should have same spin structure as the *ud* in Λ.
  - Similar cross sections expected.*



*Dobbs *et al.*,: Phys. Lett. B 739, 90 (2014)

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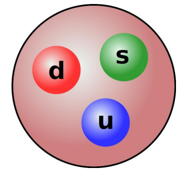
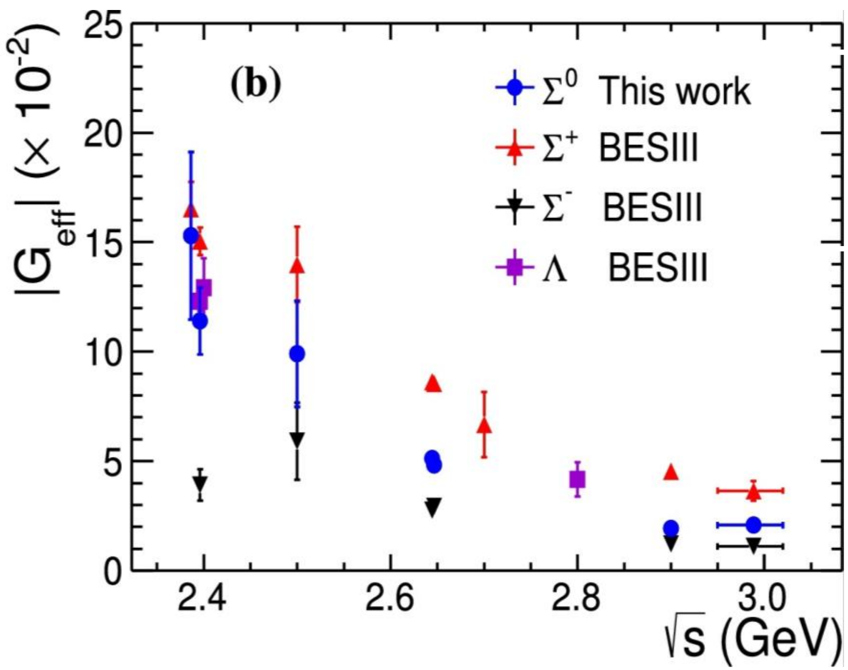
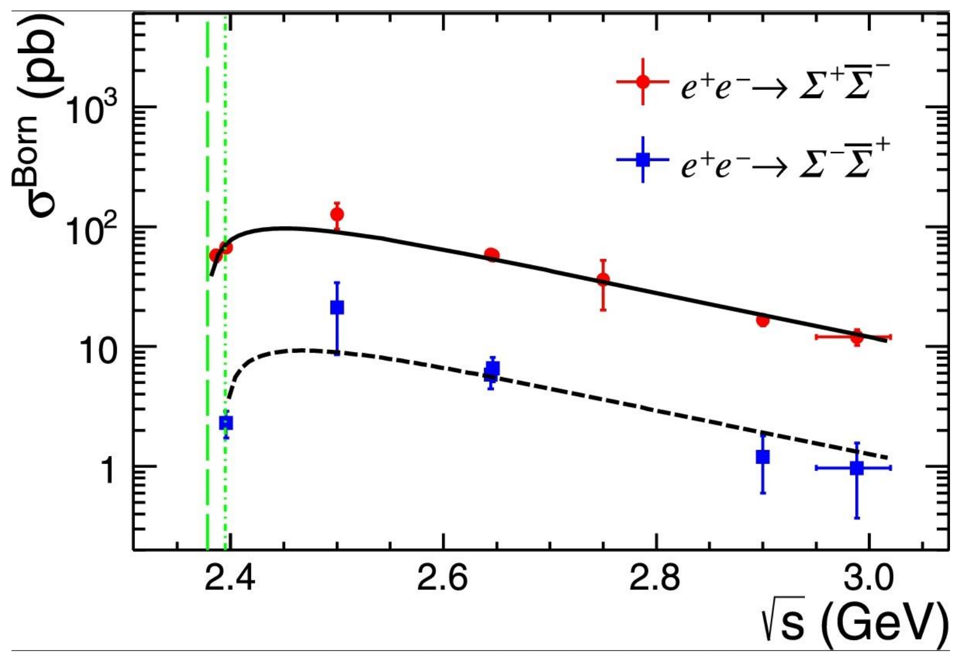


Λ and Σ hyperons

- Energy scan data between 2.386 GeV and 2.98 GeV.
- Λ/Σ^{+} G_{eff} similar as expected from diquark correlations.[*,**,***]
- Σ^{+}/Σ^{-} cross section ratio ~ 9[**]



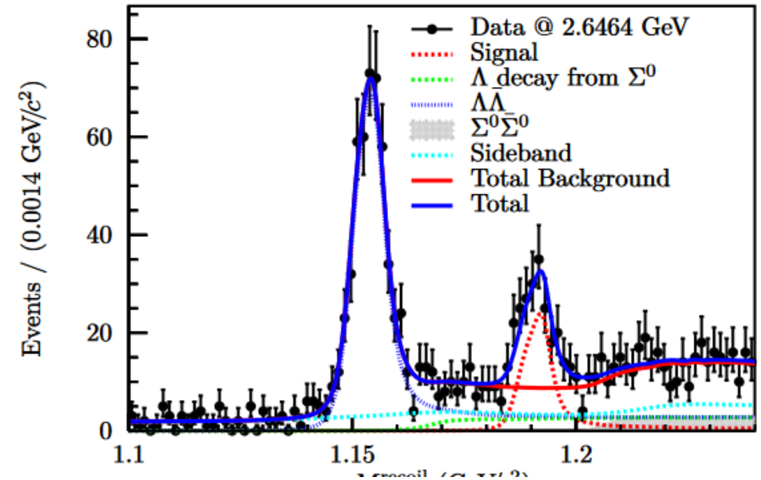


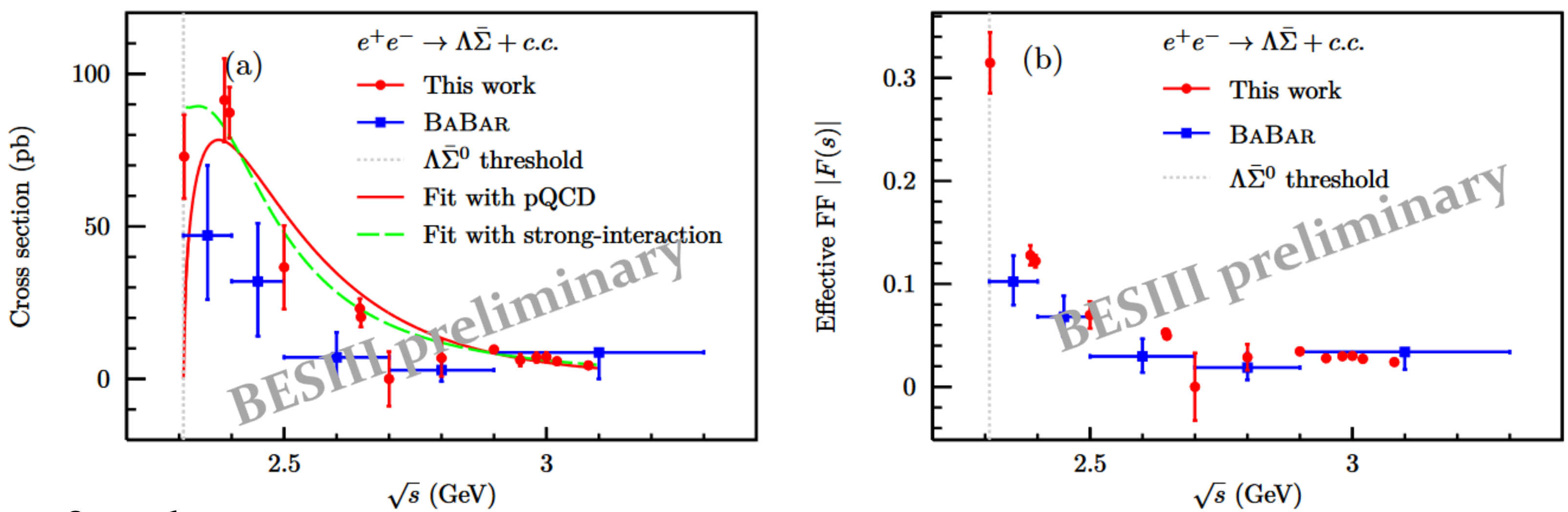
* BESIII: Phys. Lett. B 831, 137187 (2022)
** BESIII: Phys. Lett. B 814, 136110 (2021)
*** BESIII: Phys. Rev. D 97, 032013 (2018)

BESIII

New: $\Sigma^0\Lambda$ Transition Form Factor*

- Probed in $e^+e^- \to \Sigma^0\overline{\Lambda} + c.c.$
- More precise than BaBar ISR data.
- Slightly larger cross section measurements than BaBar.
- Plateau near threshold.





*arXiv: 2308.03361v1

Λ production with ISR

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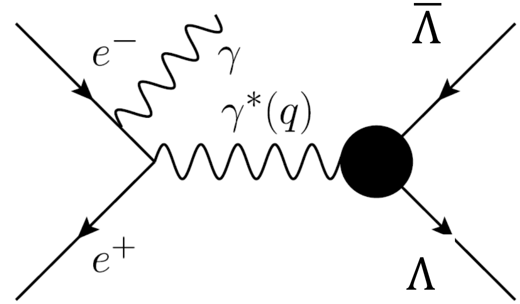
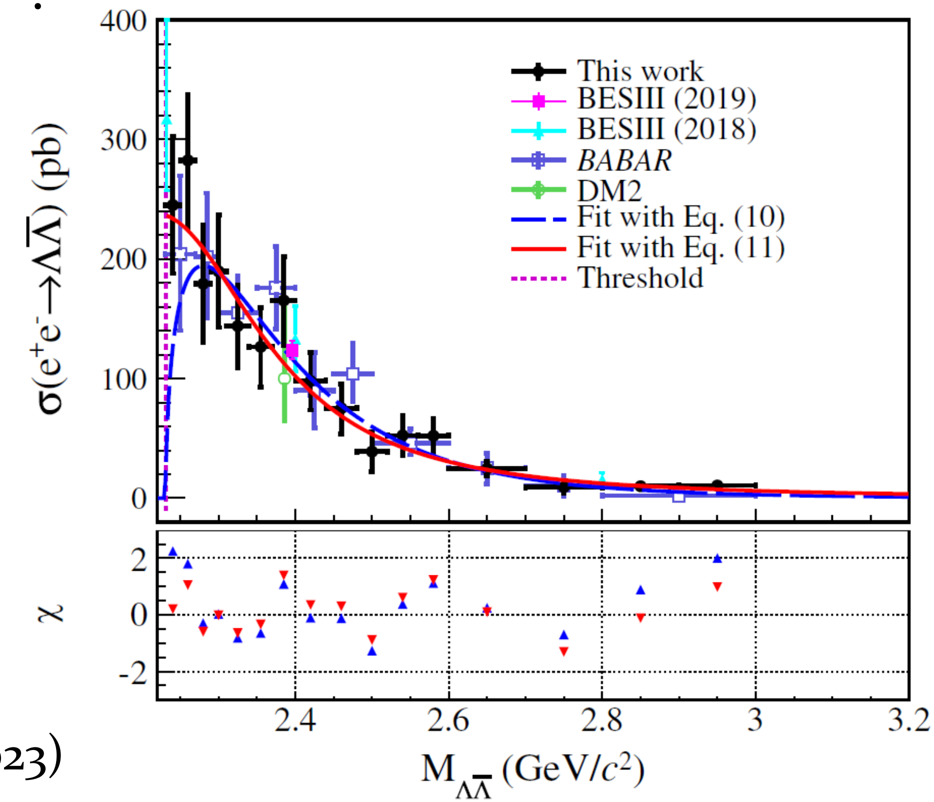
- ISR method applied on 12 fb^{-1} of data between 3.773 GeV and 4.258 GeV*.
- The $e^+e^- \rightarrow \Lambda\bar{\Lambda}$ cross section measured in 16 energy points between 2.231 GeV and 3.0 GeV.
- Cross section enhancement at threshold, observed by BaBar and BESIII, confirmed.

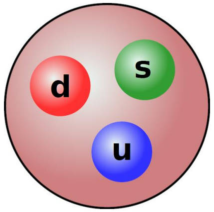




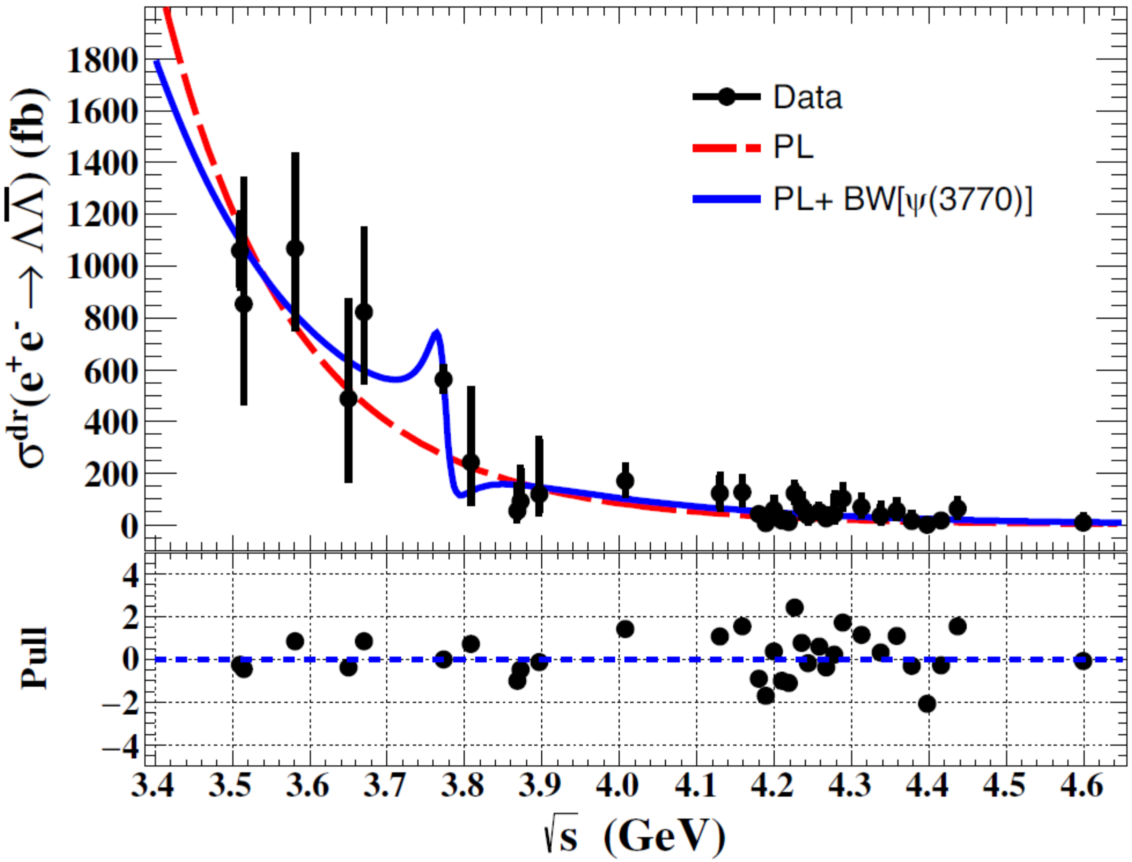
BESIII

*Phys. Rev. D 107, 072005 (2023)

Production of Λ at high q^2



- $\Lambda\bar{\Lambda}$ production near vector charmonia*,**
- $BR(\Psi \to \Lambda\bar{\Lambda}) > 10$ times larger than assumed in previous studies by CLEO-c***.

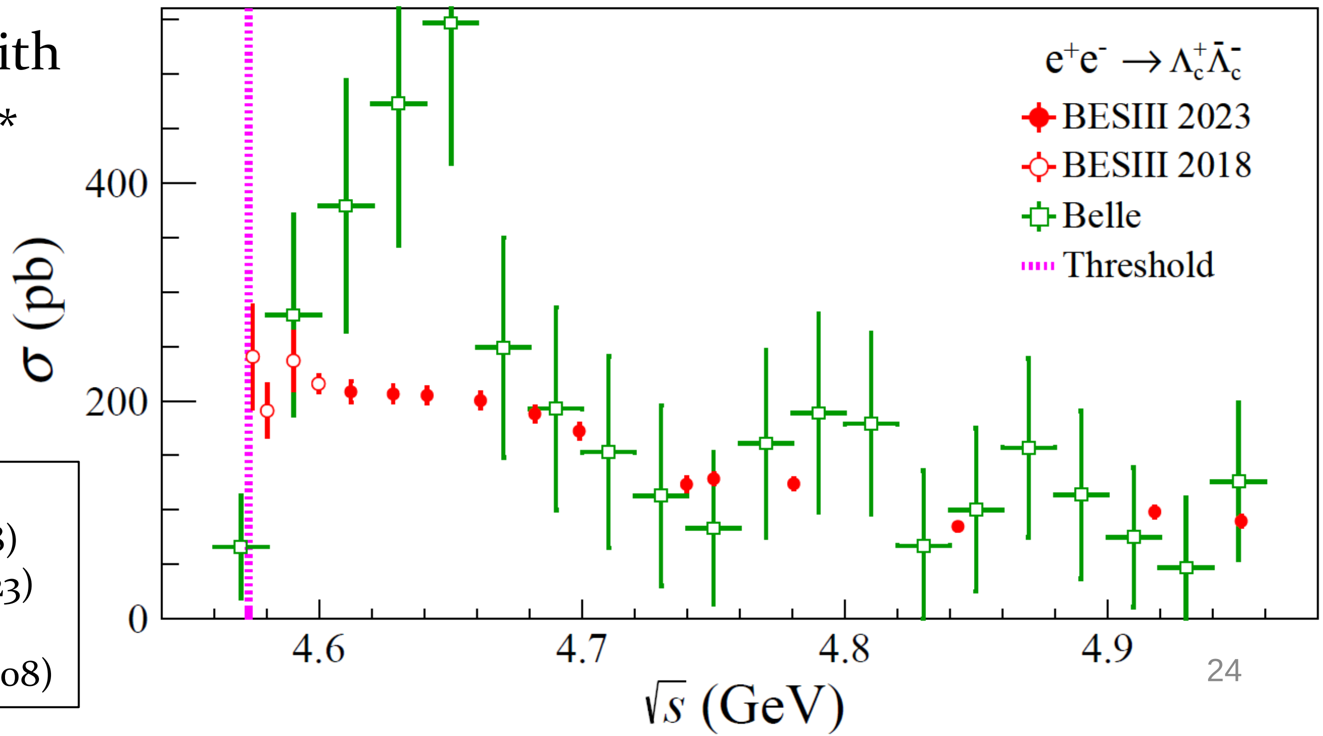


* BESIII: Phys. Rev. D 104, L091104 (2021)
** BESIII: Phys. Rev. D 105, L011101 (2022)
*** Dobbs *et al.*: Phys. Rev. D 96, 092004 (2017); Phys. Lett. B 739, 90 (2014)

Single-charm Λ_c^+ baryons

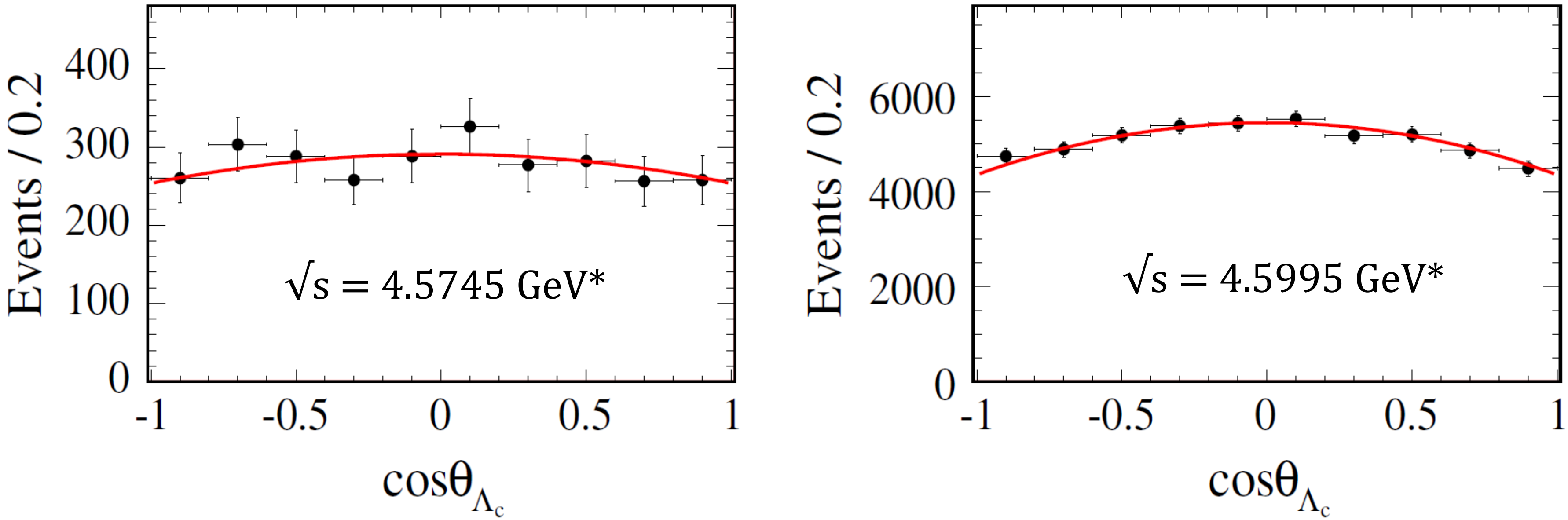
BESIII energy scans published in 2018* and 2023**

- Very precise cross section measurements
- First direct measurement of Λ_c^+ form factors
- Sharp rise in cross section near threshold
- Disagreement with Belle ISR data*** near 4.6 GeV
- No discernible G_{eff} oscillations



BESIII:
*Phys. Rev. Lett. 120, 132001 (2018)
** Phys. Rev. Lett. 131, 191901 (2023)
Belle:
***Phys. Rev. Lett. 101, 172001 (2008)

Single-charm Λ_c^+ baryons



Angular distributions enable extraction of ratio R = $|G_E/G_M|$ of Λ_c^+ near threshold* and away from threshold**.

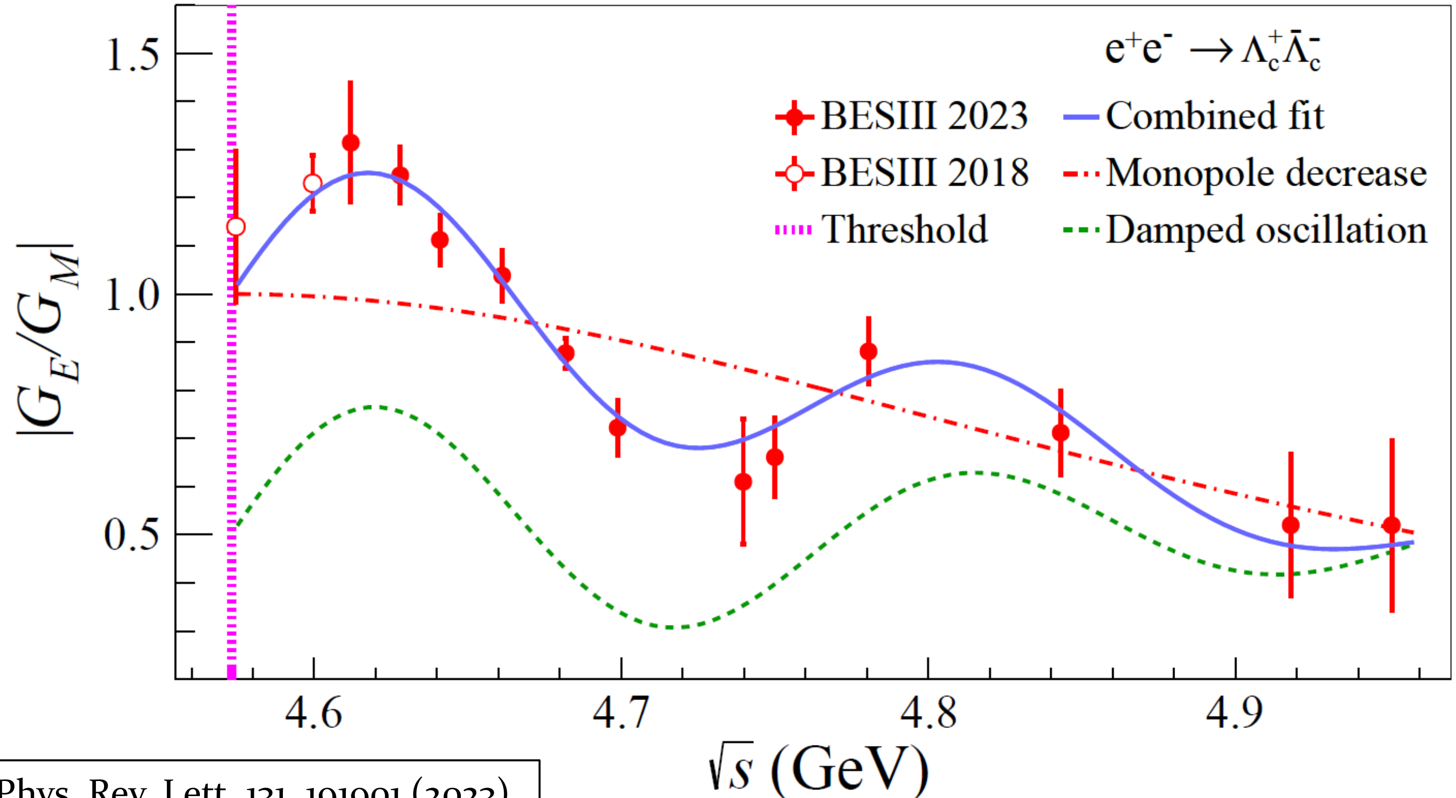
BESIII:
*Phys. Rev. Lett. 120, 132001 (2018)
** Phys. Rev. Lett. 131, 191901 (2023)

Single-charm Λ_c^+ baryons

Energy dependence of R = $|G_E/G_M|$* :

- Described by monopole model + damped oscillations

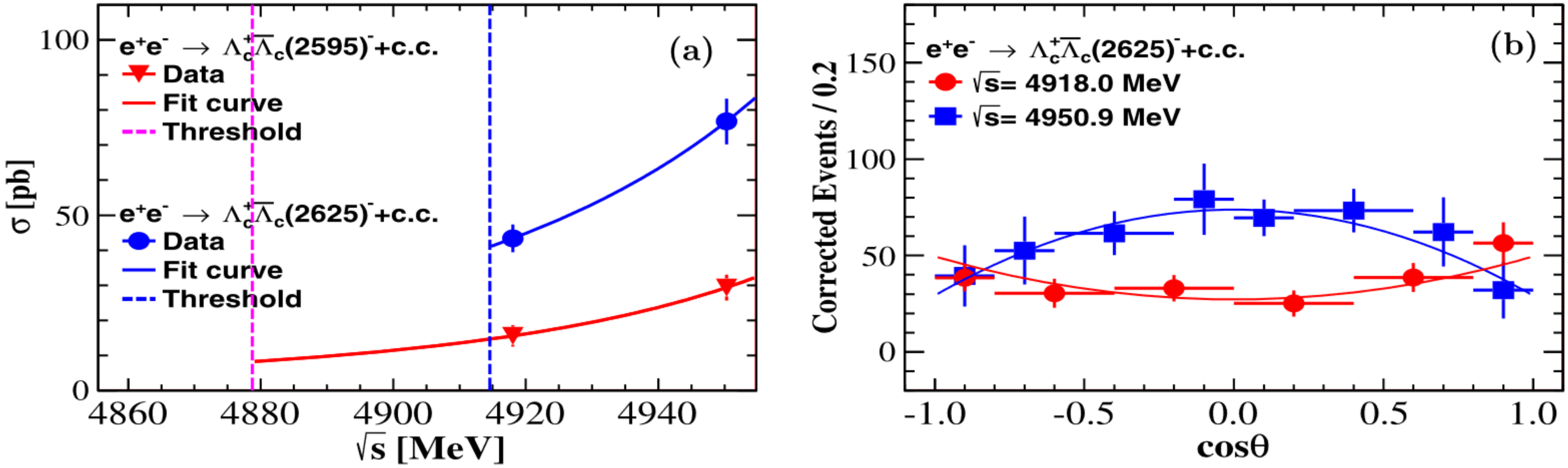
  → Oscillation frequency ~3.5 times larger than for the proton



*BESIII: Phys. Rev. Lett. 131, 191901 (2023)

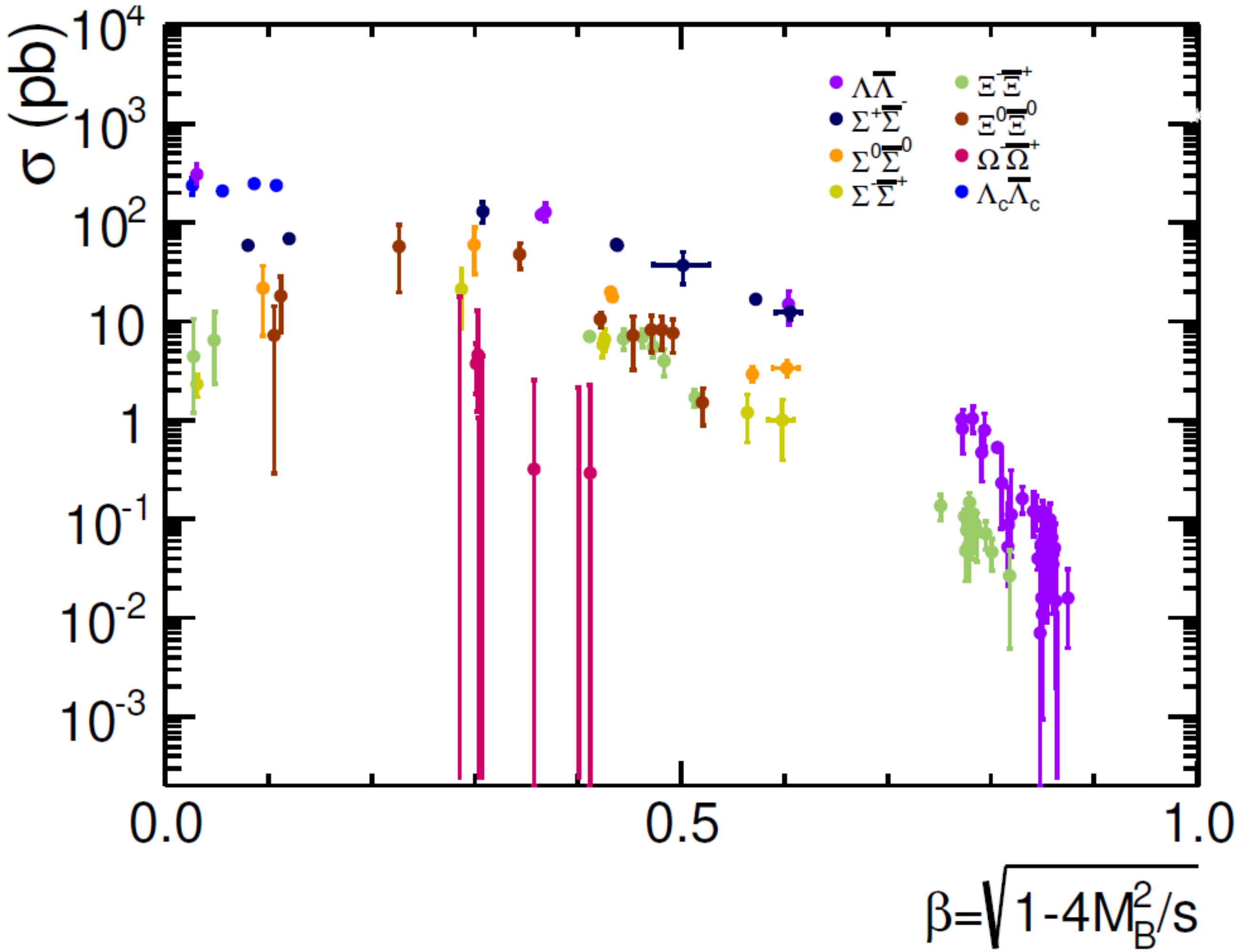
$\Lambda_c^*\Lambda_c$ transition EMFF

- $\Lambda_c^*(2595)$ and $\Lambda_c^*(2625)$ studied in $e^+e^- \to \Lambda_c^*\overline{\Lambda}_c$ + c.c.
- Transition described by 3 form factors: G_E , G_M and G_C.
- Access to $\frac{|G_E|^2+3|G_M|^2}{|G_C|^2}$ through Λ_c^* angular distribution.



*BESIII: Phys. Rev. D 109.L071104 (2023)

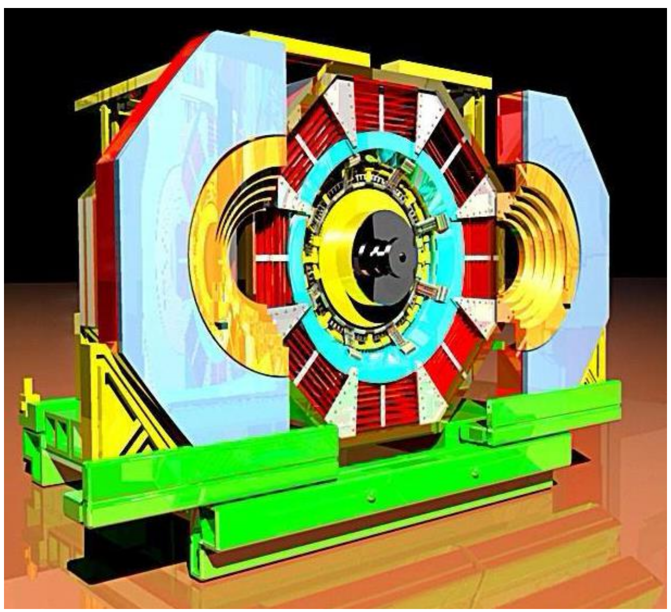
Overview of $e^+e^- \rightarrow Y\bar{Y}$ production with BESIII

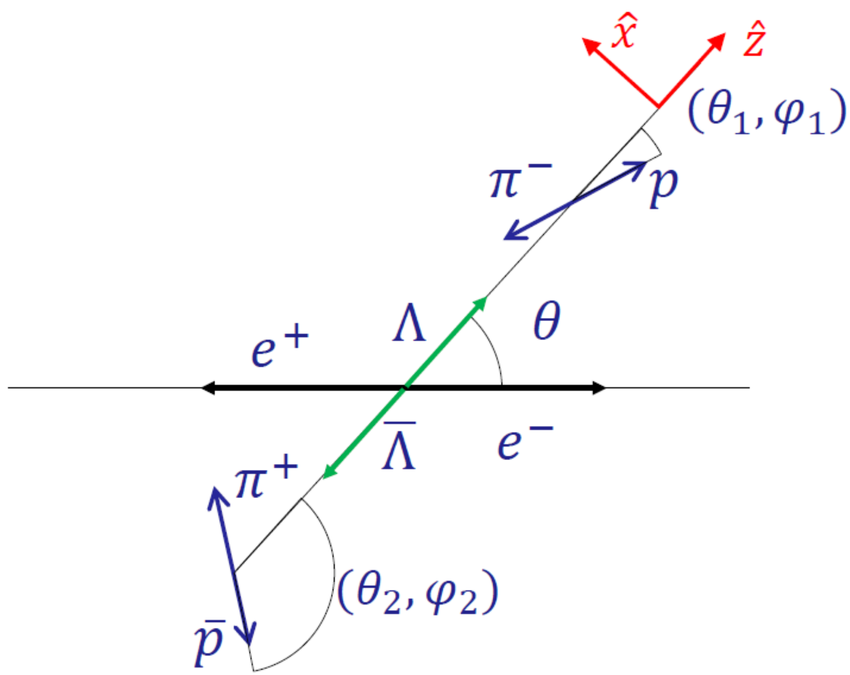


Schönning, Batoszkaya, Adlarson & Zhou, Chin. Phys. *C* **47** 052002 (2023)

Spin Analysis

Consider $e^+e^- \to \bar{Y}Y, Y \to BM + c.c$





Spin Analysis

Production parameters of spin ½ baryons:

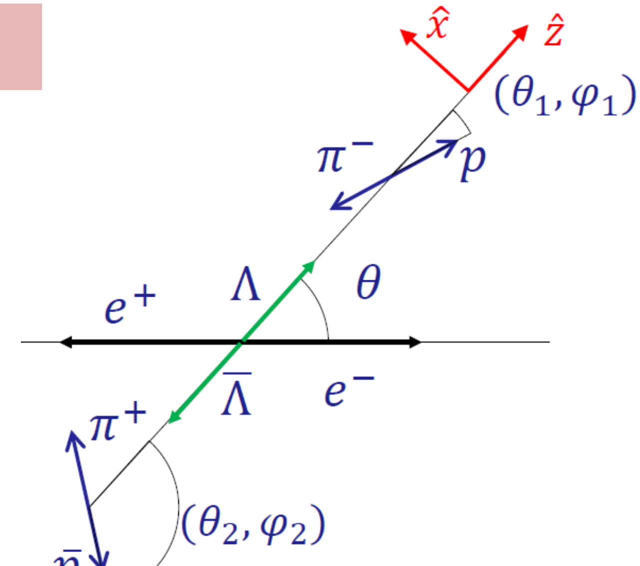
- Angular distribution parameter $\eta = \frac{\tau - R^2}{\tau + R^2}$ where $\tau = q^2/4M^2_B$
- Phase $\Delta\Phi$

Decay parameters for 2-body decays: α_1 and α_2. If CP symmetry, $\alpha_1 = -\alpha_2 = \alpha$

Unpolarized part   Polarised part   Correlated part

$$W(\xi) = F_0(\xi) + \eta F_5(\xi) + \alpha^2\left(F_1(\xi) + \sqrt{1-\eta^2}\cos(\Delta\Phi)\,F_2(\xi) + \eta F_6(\xi)\right)$$
$$+\alpha\sqrt{1-\eta^2}\sin(\Delta\Phi)\left(F_3(\xi) + F_4(\xi)\right)$$

$$\mathcal{T}_0(\xi) = 1$$
$$\mathcal{T}_1(\xi) = \sin^2\theta\sin\theta_1\sin\theta_2\cos\phi_1\cos\phi_2 + \cos^2\theta\cos\theta_1\cos\theta_2$$
$$\mathcal{T}_2(\xi) = \sin\theta\cos\theta\left(\sin\theta_1\cos\theta_2\cos\phi_1 + \cos\theta_1\sin\theta_2\cos\phi_2\right)$$
$$\mathcal{T}_3(\xi) = \sin\theta\cos\theta\sin\theta_1\sin\phi_1$$
$$\mathcal{T}_4(\xi) = \sin\theta\cos\theta\sin\theta_2\sin\phi_2$$
$$\mathcal{T}_5(\xi) = \cos^2\theta$$
$$\mathcal{T}_6(\xi) = \cos\theta_1\cos\theta_2 - \sin^2\theta\sin\theta_1\sin\theta_2\sin\phi_1\sin\phi_2$$



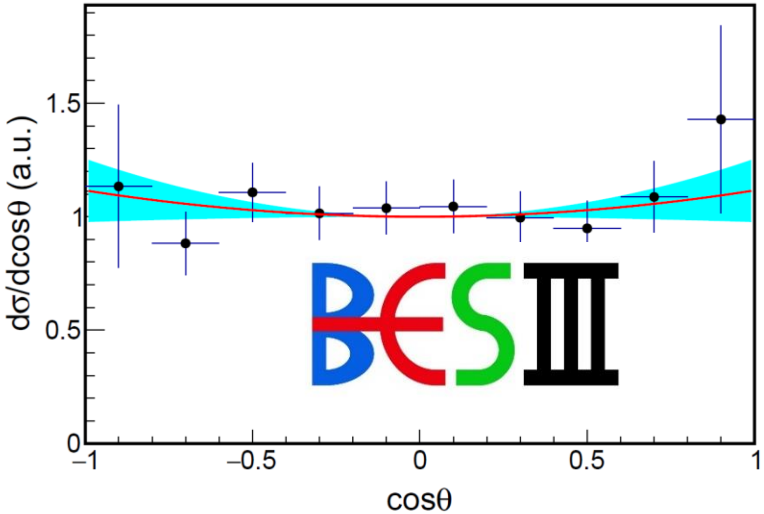
*Fäldt & Kupsc, PLB 772 (2017) 16.

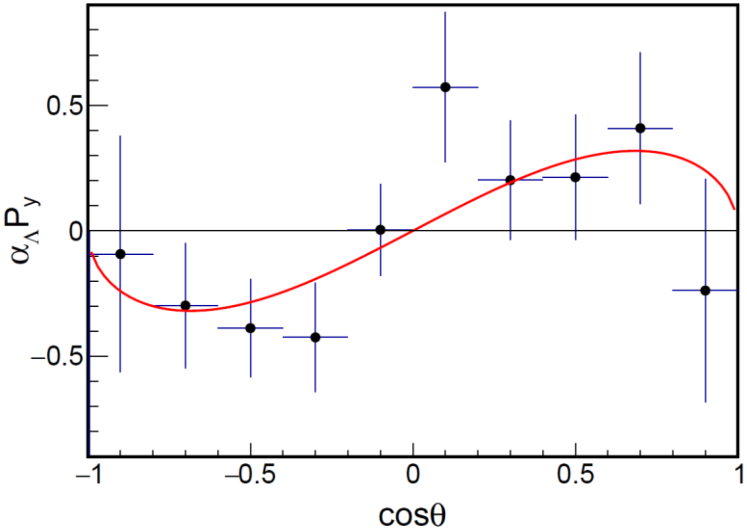
First complete measurement of Λ EMFF

- New BESIII data at 2.396 GeV with 555 exclusive $\bar{\Lambda}\Lambda$ events in sample.
  - $R = |G_E/G_M| = \mathbf{0.96 \pm 0.14 \pm 0.02}$
  - $\Delta\Phi = \mathbf{37^o \pm 12^o \pm 6^o}$
  - $\sigma = 118.7 \pm 5.3 \pm 5.1$ pb

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

- Most **precise** result on R and σ
- **First** conclusive result on ΔΦ



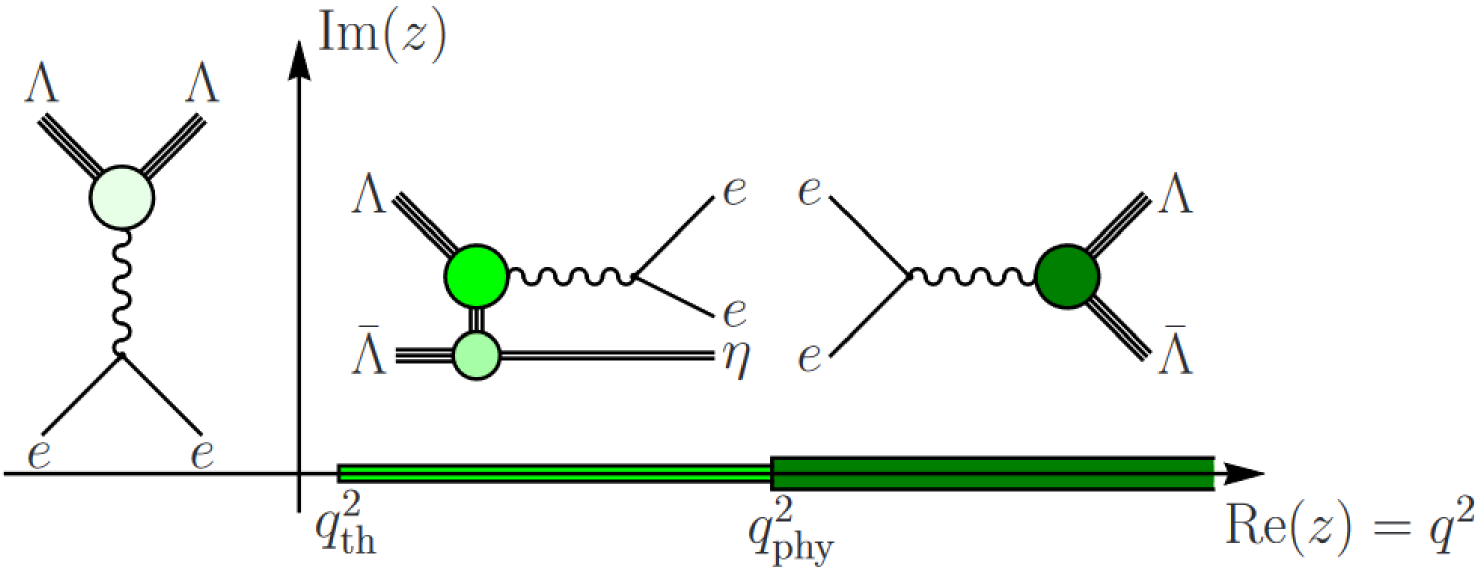


Theory interpretation

Dispersive calculations by Mangoni, Pacetti & Tomasi-Gustafsson*:

- Few data points → ambiguous solution

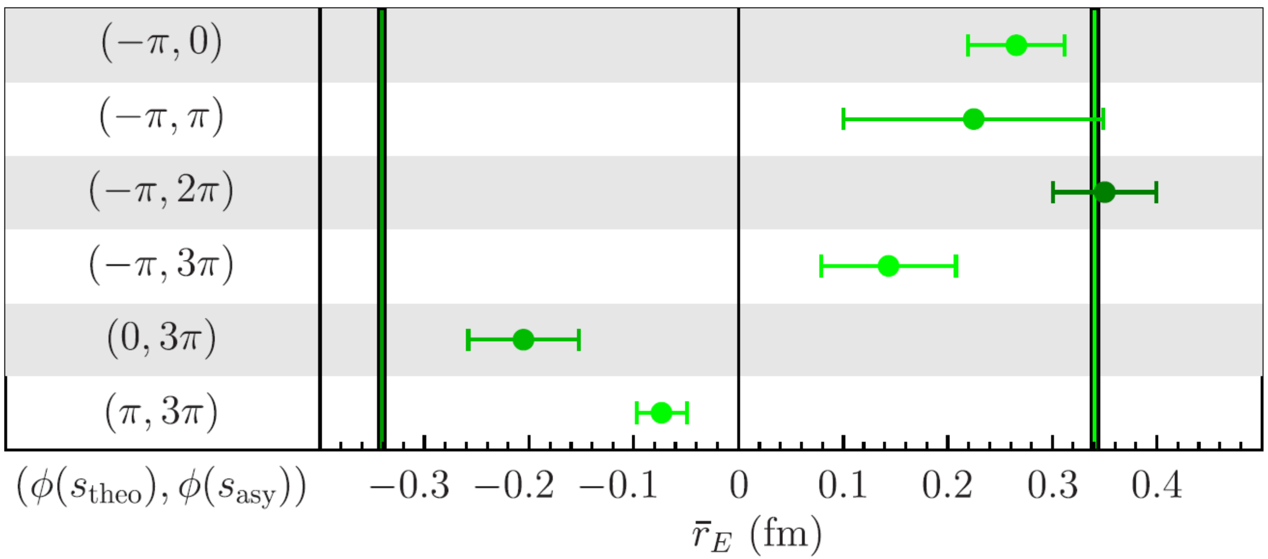
  → scenarios for phase value at q^2_{th} and q^2_{asy}



Picture credit: *Mangoni *et al.*, Phys. Rev. D 104, 116016 (2021)

Theory interpretation

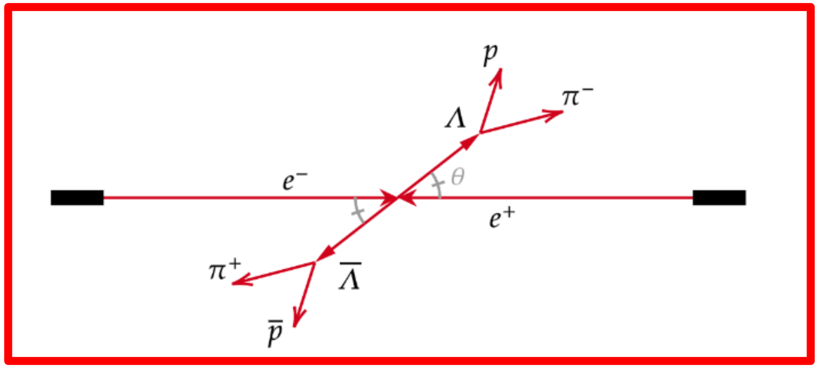
Fit by Mangoni *et al.** of data from ** and *** to different phase scenarios
→ extraction of charge radius!

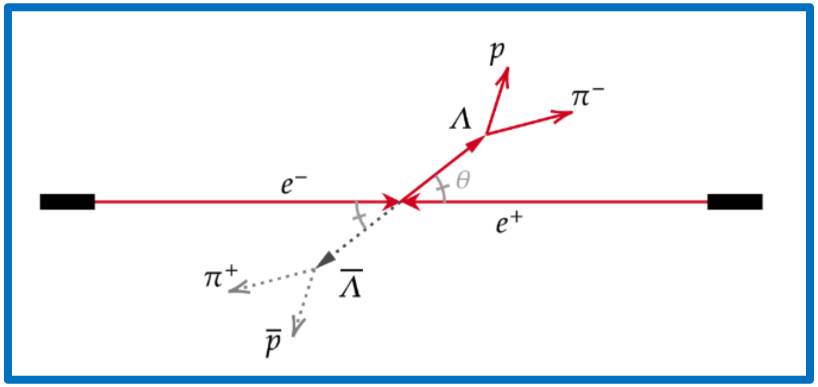


*Mangoni *et al.*, Phys. Rev. D 104, 116016 (2021)
**BESIII: Phys. Rev. Lett. 123, 122003 (2019)
***BaBar: Phys. Rev. D 76, 092006 (2007)

New: Energy dependent Λ and Σ^+ Spin Analysis

- Utilizes scan data collected in 2015.
- Combines **double-tag** and **single-tag** data.

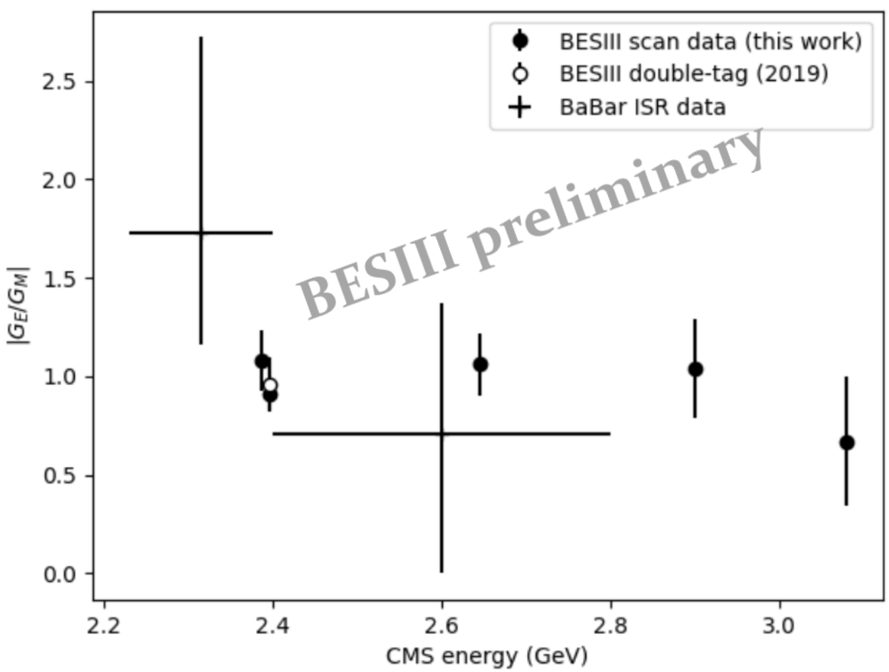


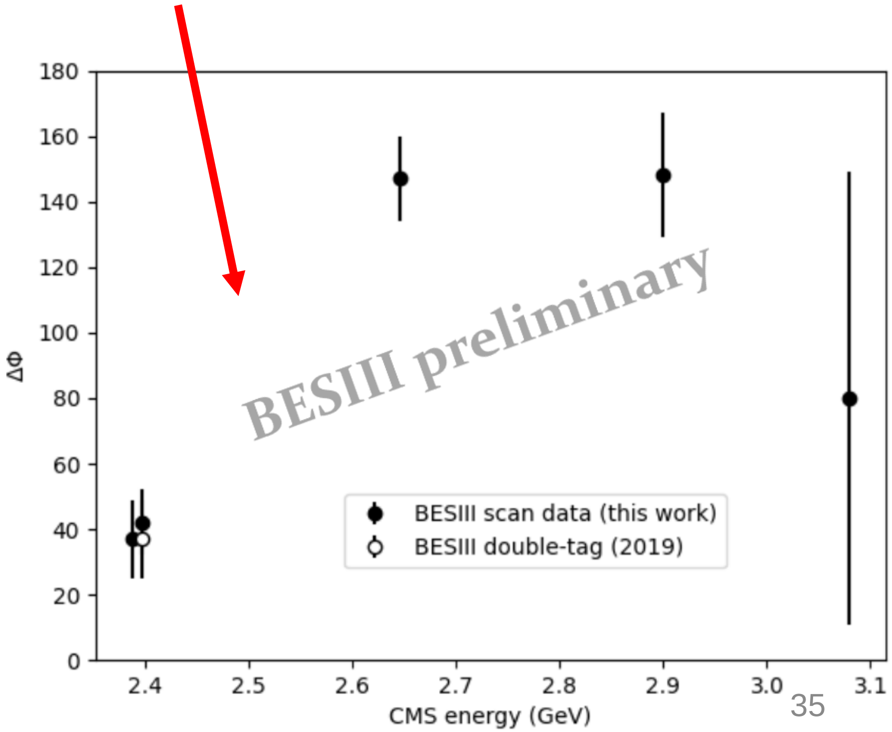


New: Energy-dependent Λ Spin Analysis

Five data points within 2.386 < q < 3.08 GeV.

- The ratio $R = |\frac{G_E(q^2)}{G_M(q^2)}|$ fairly constant and consistent with 1.
- Rapid (~ 90°) change of the phase ΔΦ between q~2.4 GeV and 2.6 GeV.



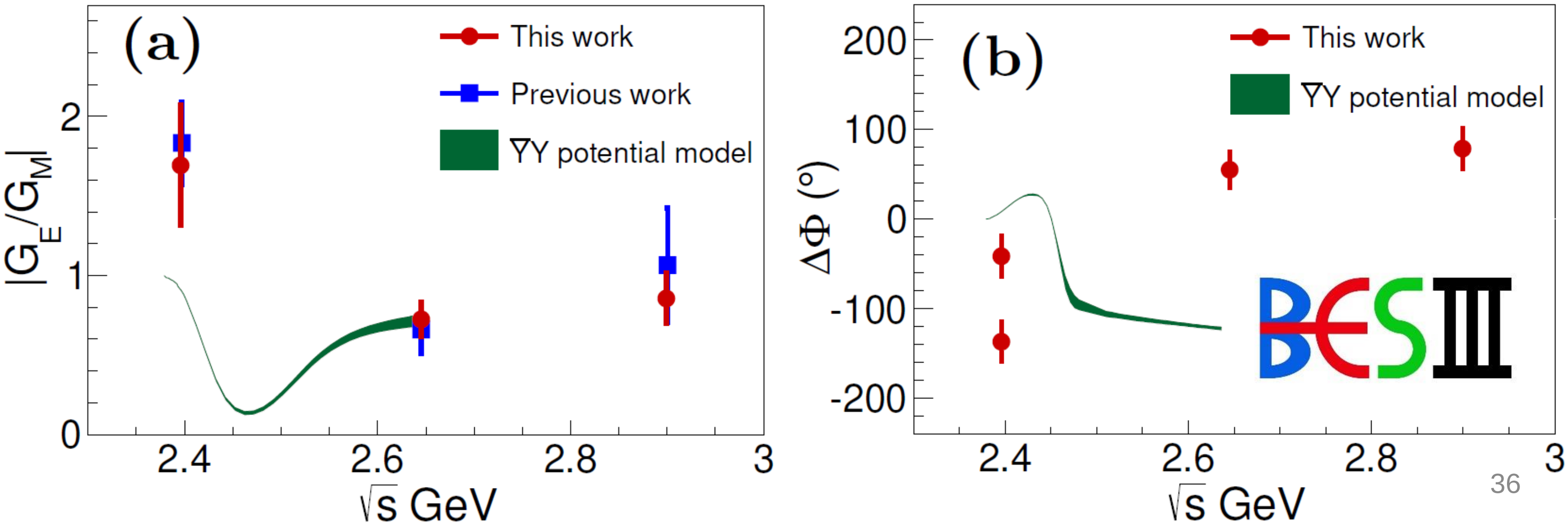


New: Σ^+ Spin Analysis

- Energy dependence of R and $\Delta\Phi$ in three different points*
  - Double-tag $e^+e^- \to \Sigma^+\bar{\Sigma}^- \to p\pi^0\bar{p}\pi^0$ at 2.64 GeV and 2.9 GeV
  - Single-tag $e^+e^- \to \Sigma^+\bar{\Sigma}^- \to p\pi^0 X + c.c.$ at 2.396 GeV

    $\to \Delta\Phi$ / 180° – $\Delta\Phi$ ambiguity
- Better precision in *R* than before**.
- Comparison with $Y\bar{Y}$ potential model ***.

*Phys. Rev. Lett. 132, 081904 (2024)
** Phys. Lett. B 814, 136110 (2021)
*** Haidenbauer *et al.*, Phys. Rev. D 103, 014028 (2021)



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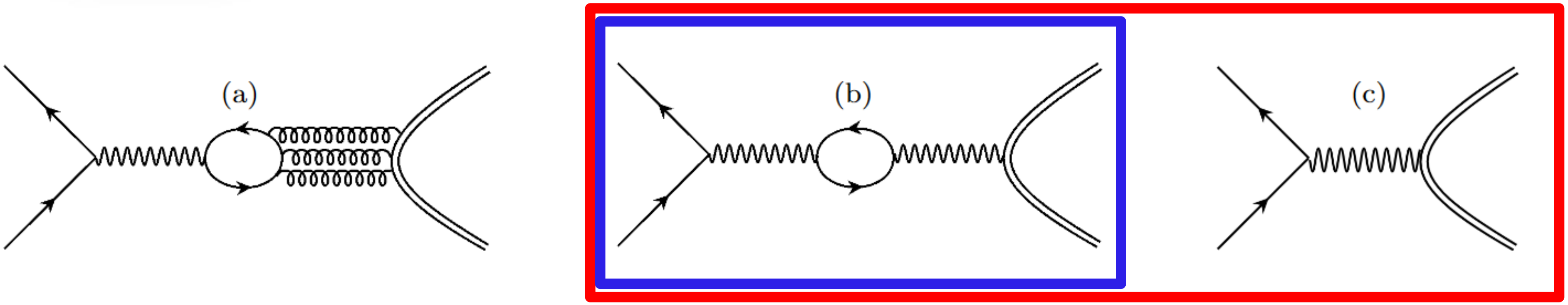
New: First complete measuerement of the $\Sigma^0\Lambda$ Transition EMFFs



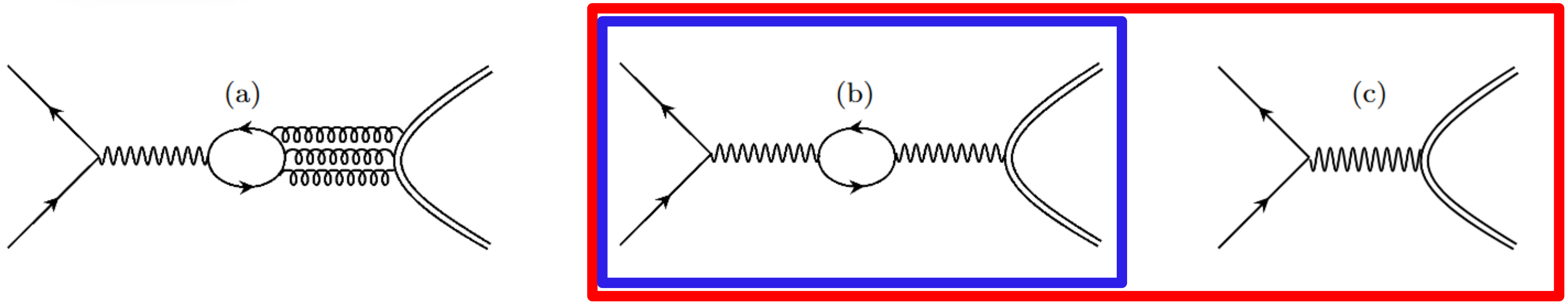
Also at q = M(J/Ψ), the $e^+e^- \to \Sigma^0\overline{\Lambda} + c.c.$ process is predominantly **electromagnetic** (b, c), since

- Strong processes (a) are suppressed by $\frac{m_d - m_u}{q} \sim 10^{-3}$ due to isospin violation.
- Ratio between cross section at J/Ψ and at the continuum in agreement with expectations from EM processes, and with other EM transitions such as $e^+e^- \to \mu^+\mu^-$ and $e^+e^- \to \eta\pi^+\pi^-$.

At the J/Ψ mass, the cross section is enhanced by **vacuum polarization**

*BESIII, arXiv[hep-ex]:2309.04139 (2023)

New: First complete measurement of the $\Sigma^0\Lambda$ Transition EMFFs



Also at q = M(J/Ψ), the $e^+e^- \to \Sigma^0\overline{\Lambda} + c.c.$ process is predominantly **electromagnetic** (b, c), since

- Strong processes (a) are suppressed by $\frac{m_d - m_u}{q} \sim 10^{-3}$ due to isospin violation.
- Ratio between cross section at J/Ψ … expectations from EM processes, and with other EM transitions such as $e^+e^- \to \mu^+\mu^-$ and $e^+e^- \to \eta\pi^+\pi^-$.

Enables extraction of EMFFs!

At the $J/$… enhanced by **vacuum polarization**

Yields high precision!

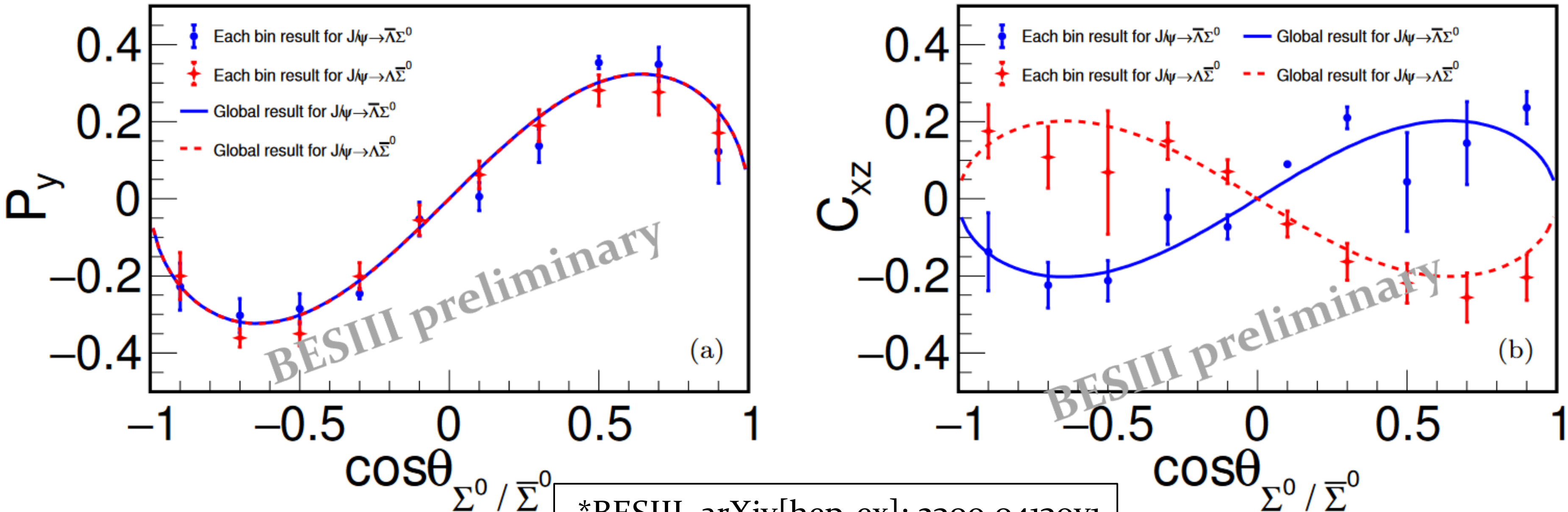
*BESIII, arXiv[hep-ex]:2309.04139 (2023)

New: First complete measuerement of the $\Sigma^0\Lambda$ Transition EMFFs

High-precision EMFF measurement:

- $R = |G_E/G_M| = 0.860 \pm 0.029 \pm 0.010$
- $\Delta\Phi_1(\bar{\Lambda}\Sigma^0) = 1.011 \pm 0.094 \pm 0.010$ rad
- $\Delta\Phi_2(\Lambda\bar{\Sigma}^0) = 2.128 \pm 0.094 \pm 0.010$ rad

CP test: $\Delta\Phi_{CP} = |\pi - (\Delta\Phi_1 + \Delta\Phi_2)| = 0.003 \pm 0.133 \pm 0.014$ rad



*BESIII, arXiv[hep-ex]: 2309.04139v1

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Summary

- Hadron structure is a tool to understand the strong interaction.
- Time-like form factors most viable structure function for hyperons.
- Many new results from the BESIII experiment
    - single- and double strange hyperons
    - charm baryons
- Spin polarised and correlated hyperon-antihyperon pairs provide information about space-like structure *e.g.* charge radius.
- More data collected → STAY TUNED !!!

Thanks for your attention!

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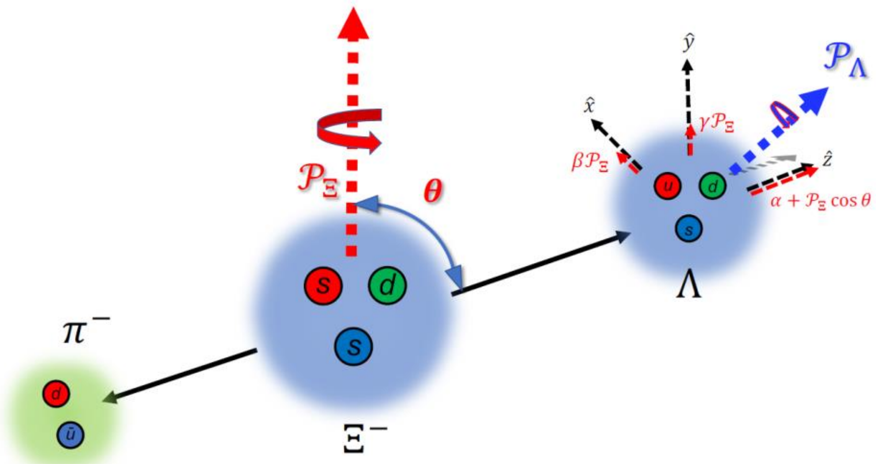
Backup

CP tests with BESIII

- **Polarised** and **entangled** hyperon-antihyperon pairs enable CP tests in hyperon decays
- **Sequentially decaying** multi-strange and charm hyperons enable
  - Production- and decay parameters
- A **combination** of the two approaches enables separation of strong and weak decay phases

→ More sensitive CP tests!



New: CP tests in Ξ decays into neutral and charged final state baryons

BESIII

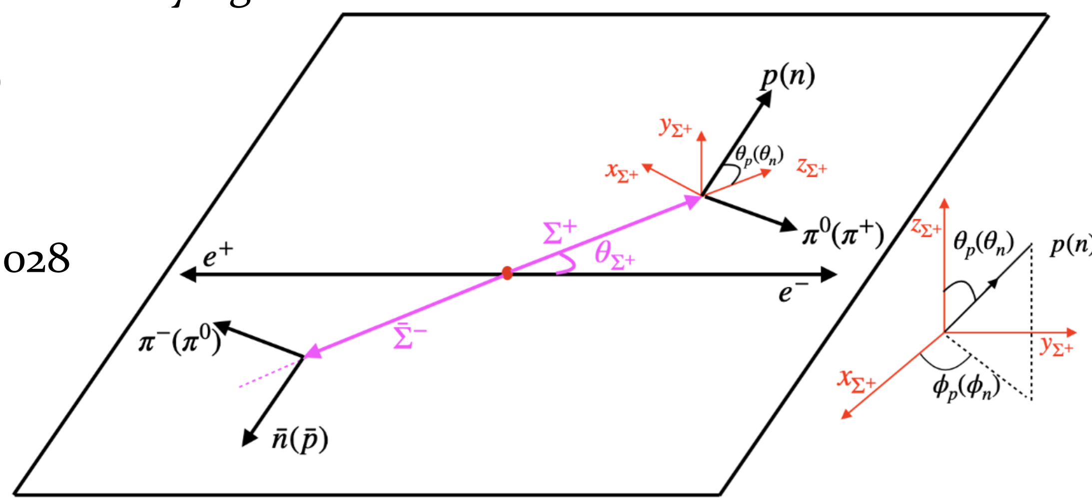
*Phys. Rev. Lett. 132, 101801 (2023)

TABLE I. The production and decay asymmetry parameters, the weak- and strong-phase differences from Ξ^- decay, the tests of CP symmetry, and the ratios of decay asymmetry parameters, $\alpha_{\Lambda 0}/\alpha_{\Lambda -}$ and $\bar{\alpha}_{\Lambda 0}/\alpha_{\Lambda +}$. The first and second uncertainties are statistical and systematic, respectively.

Parameters	This work	Previous result
$\alpha_{J/\psi}$	$0.611 \pm 0.007^{+0.013}_{-0.007}$	$0.586 \pm 0.012 \pm 0.010$ [18]
$\Delta\Phi_{J/\psi}$ (rad)	$1.30 \pm 0.03^{+0.02}_{-0.03}$	$1.213 \pm 0.046 \pm 0.016$ [18]
α_Ξ	$-0.367 \pm 0.004^{+0.003}_{-0.004}$	$-0.376 \pm 0.007 \pm 0.003$ [18]
ϕ_Ξ (rad)	$-0.016 \pm 0.012^{+0.004}_{-0.008}$	$0.011 \pm 0.019 \pm 0.009$ [18]
$\bar{\alpha}_\Xi$	$0.374 \pm 0.004^{+0.003}_{-0.004}$	$0.371 \pm 0.007 \pm 0.002$ [18]
$\bar{\phi}_\Xi$ (rad)	$0.010 \pm 0.012^{+0.003}_{-0.013}$	$-0.021 \pm 0.019 \pm 0.007$ [18]
$\alpha_{\Lambda -}$	$0.764 \pm 0.008^{+0.005}_{-0.006}$	$0.7519 \pm 0.0036 \pm 0.0024$ [37]
$\alpha_{\Lambda +}$	$-0.774 \pm 0.009^{+0.005}_{-0.005}$	$-0.7559 \pm 0.0036 \pm 0.0030$ [37]
$\alpha_{\Lambda 0}$	$0.670 \pm 0.009^{+0.009}_{-0.008}$	0.75 ± 0.05 [29]
$\bar{\alpha}_{\Lambda 0}$	$-0.668 \pm 0.008^{+0.006}_{-0.008}$	$-0.692 \pm 0.016 \pm 0.006$ [17]
$\delta_P - \delta_S$ (rad)	$0.033 \pm 0.020^{+0.008}_{-0.012}$	$-0.040 \pm 0.033 \pm 0.017$ [18]
$\xi_P - \xi_S$ (rad)	$0.007 \pm 0.020^{+0.018}_{-0.005}$	$0.012 \pm 0.034 \pm 0.008$ [18]
A^Ξ_{CP}	$-0.009 \pm 0.008^{+0.007}_{-0.002}$	$0.006 \pm 0.013 \pm 0.006$ [18]
$\Delta\phi^\Xi_{CP}$ (rad)	$-0.003 \pm 0.008^{+0.003}_{-0.007}$	$-0.005 \pm 0.014 \pm 0.003$ [18]
A^-_{CP}	$-0.007 \pm 0.008^{+0.002}_{-0.003}$	$-0.0025 \pm 0.0046 \pm 0.0012$ [37]
A^0_{CP}	$0.001 \pm 0.009^{+0.005}_{-0.007}$	...
A^Λ_{CP}	$-0.004 \pm 0.007^{+0.003}_{-0.004}$	...
$\alpha_{\Lambda 0}/\alpha_{\Lambda -}$	$0.877 \pm 0.015^{+0.014}_{-0.010}$	1.01 ± 0.07 [29]
$\bar{\alpha}_{\Lambda 0}/\alpha_{\Lambda +}$	$0.863 \pm 0.014^{+0.012}_{-0.008}$	$0.913 \pm 0.028 \pm 0.012$ [17]

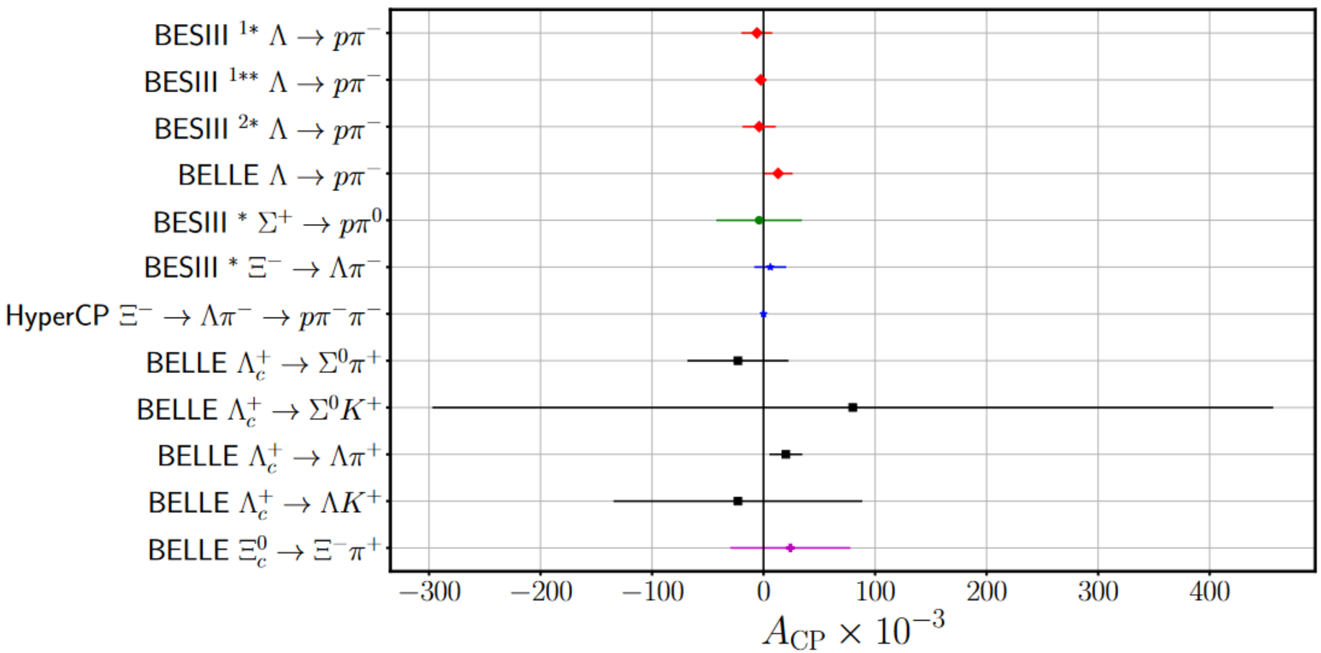
New: CP tests in Σ decays into neutrons

- Polarised and entangled $\Sigma^+\bar{\Sigma}^-$ pairs J/Ψ decays*
- Select events where $\Sigma^+ \to n\pi^+, \bar{\Sigma}^- \to \bar{p}\pi^0$ or c.c.
- First CP precision test of any hyperon decaying into a neutron.
- Decay parameters α_+ $(\Sigma^+ \to n\pi^+)$ and $\bar{\alpha}_-$ $(\bar{\Sigma}^- \to \bar{n}\pi^-)$ measured.
- $A_{CP} = \frac{\alpha_+ + \bar{\alpha}_-}{\alpha_+ + \bar{\alpha}_-} = 0.080 \pm 0.052 \pm 0.028$



*Phys. Rev. Lett. 131, 191802 (2023)

CP tests, world data



BESIII:

Nature Phys. **15**, p 631-634 (2019)

Phys. Rev. Lett. 125, 052004 (2020)

Nature 606, 64-69 (2022)

Phys. Rev. Lett. 129, 131801 (2022)

Phys. Rev. D 108, L031106 (2023)

Belle:

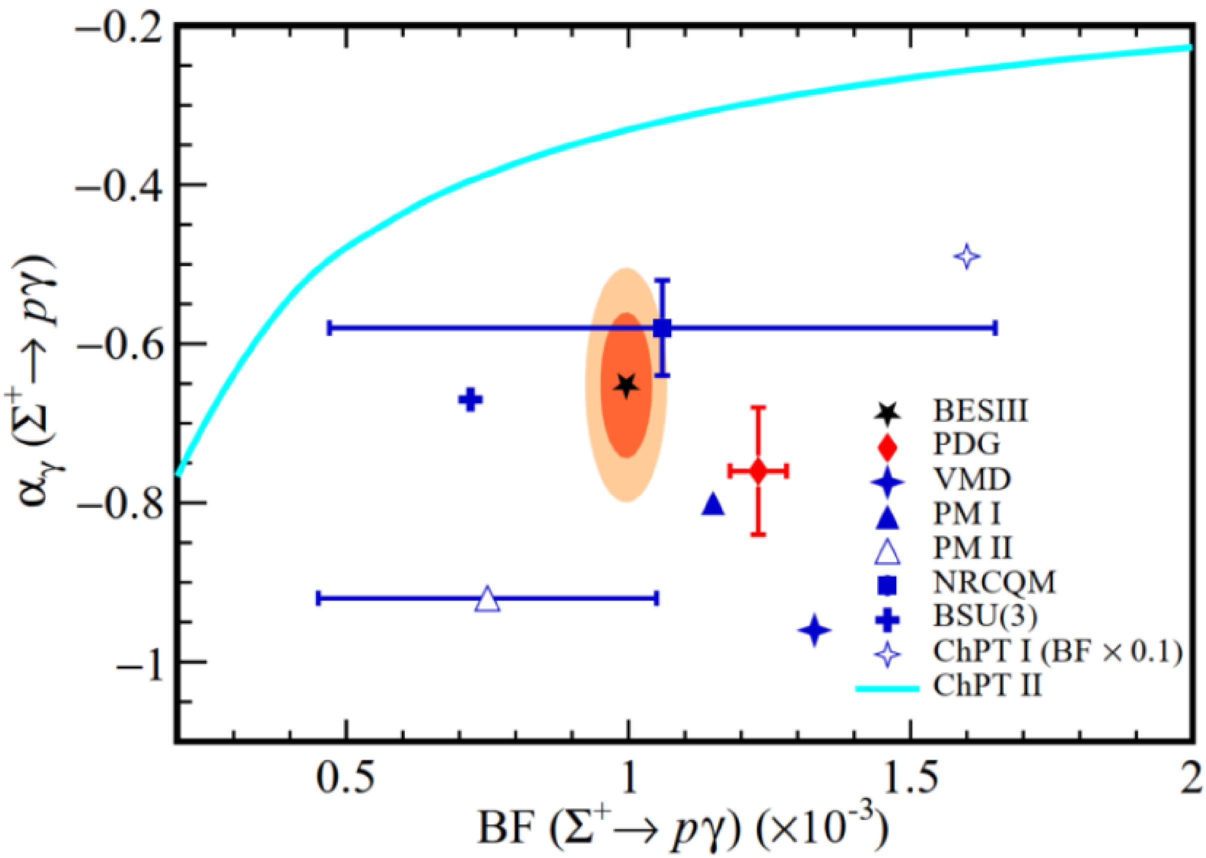
Sci. Bull. 68, 583-592 (2023)

HyperCP:

Phys. Rev. Lett. 93, 262001, 2004.

New: The $\Sigma^+ \to p\gamma$ decay

*Phys. Rev. Lett. 130, 211901 (2023)



Most precise measurement so far.

4.2σ lower than previous world average.

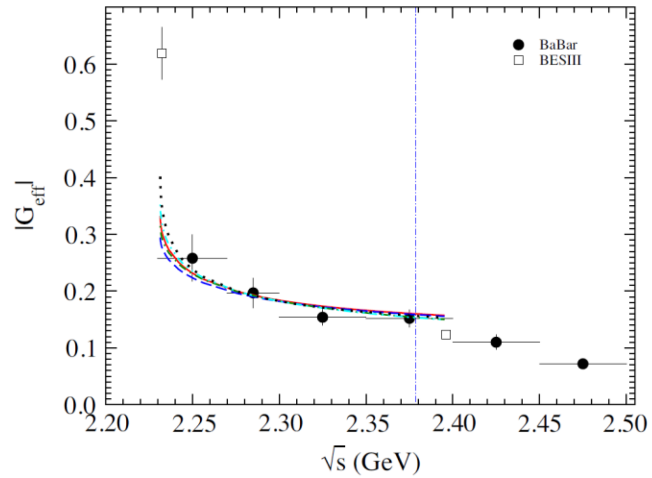
Hara's theorem:

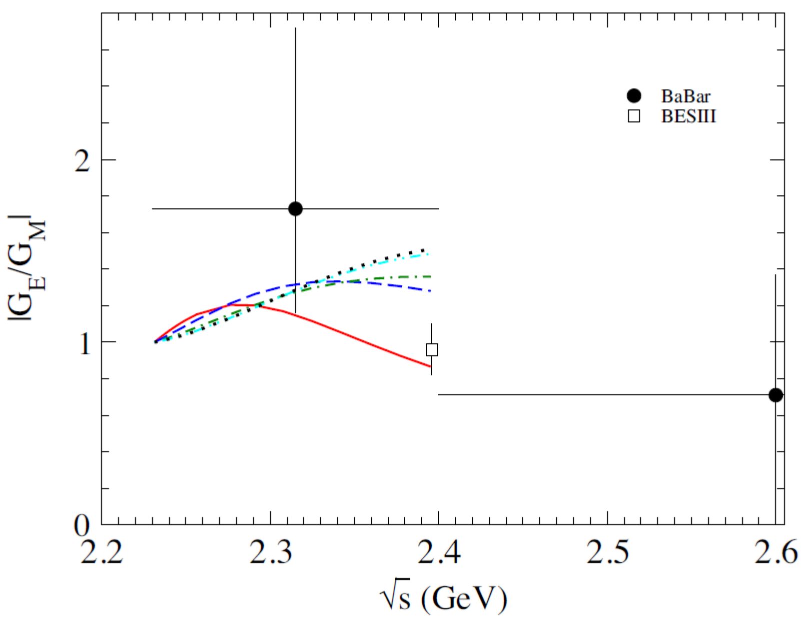
Parity violating amplitudes vanish in the limit of SU(3) flavour symmetry.

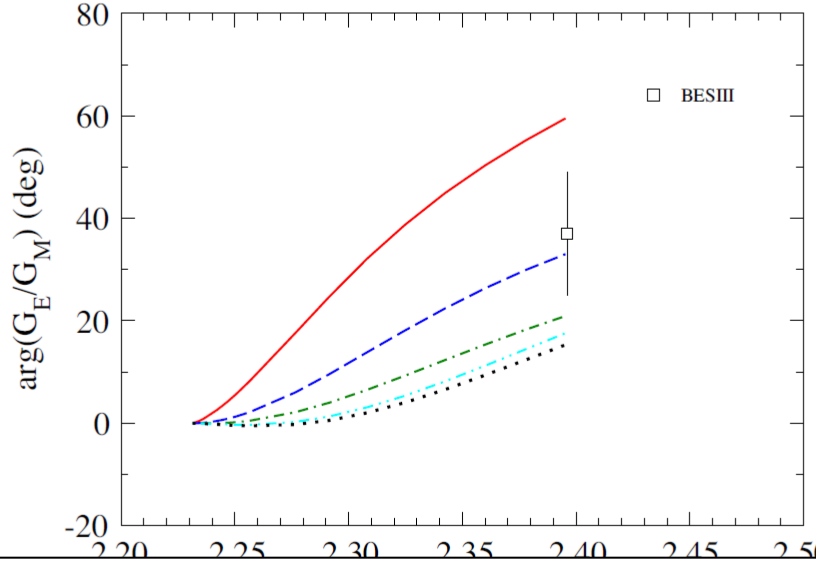
Theory Interpretation of Λ EMFFs

Theoretical study of the $e^+e^- \to Y\bar{Y}$ by Haidenbauer, Meissner and Dai*

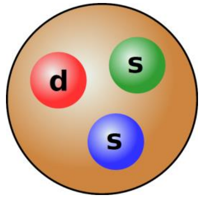
- $Y\bar{Y}$ potentials derived using ChEFT with $\bar{p}p \to \bar{Y}Y$ data from PS185.
- Spin-dependent observables much more sensitive to the $Y\bar{Y}$ potential.
- Fairly good agreement with BESIII data.





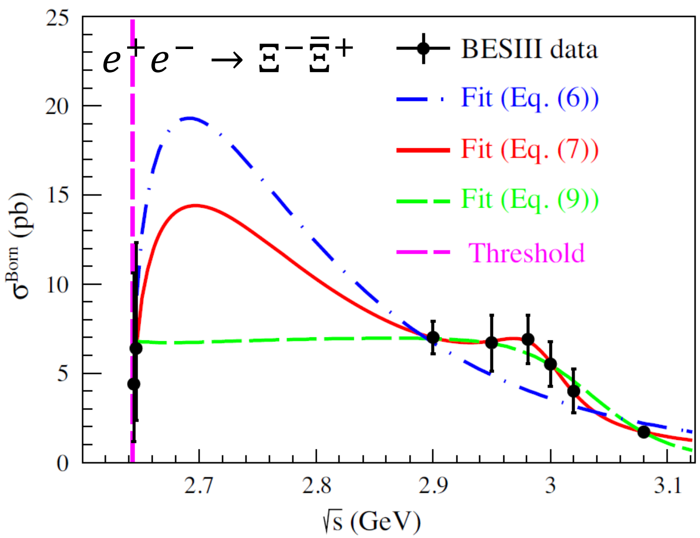


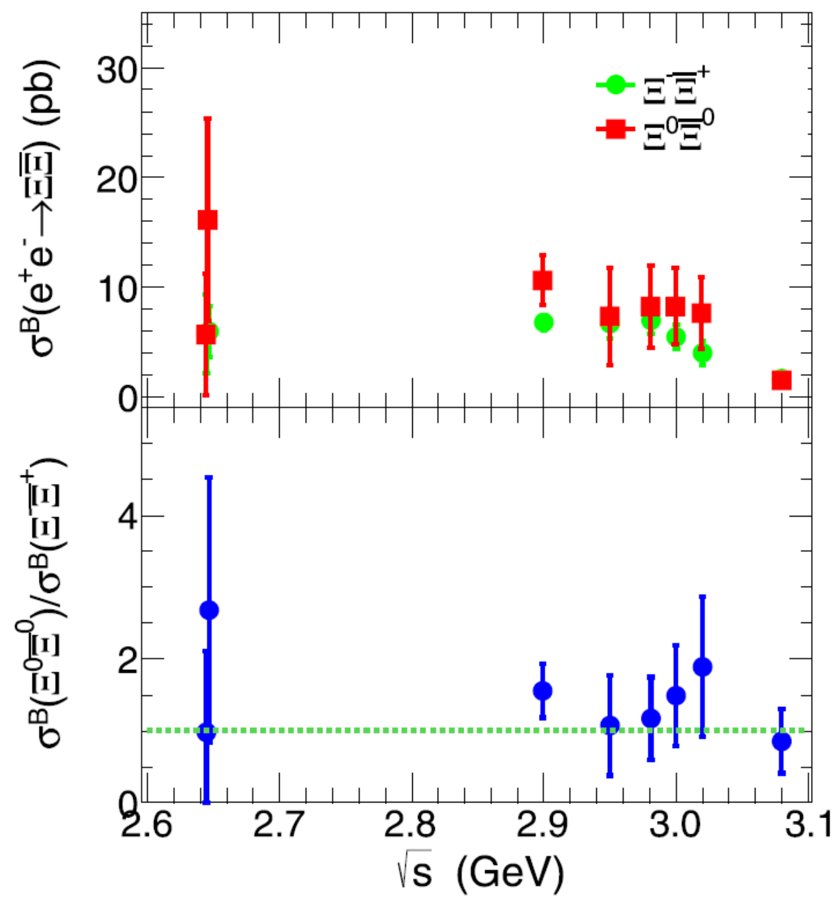
* Haidenbauer *et al.*, Phys. Rev. D 103, 014028 (2021)



Double-strange Ξ hyperons

- $e^+e^- \to \Xi^-\bar{\Xi}^+$ and $e^+e^- \to \Xi^0\bar{\Xi}^0$ studied for the first time.
- Possible resonance around 3 GeV.





Ξ^- BESIII: Phys. Rev. D 103, 012005 (2021)
Ξ^0 BESIII: Phys. Lett. B 820, 136557 (2021).