



**BARYONS
2025**



Spectroscopic study of baryons using high-momentum hadron beams at J-PARC

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Baryon spectroscopy at J-PARC

* Systematic c - and s -baryon spectroscopy:

Dynamics of non-trivial QCD vacuum

⇒ Dynamics of Effective degrees of freedom reflects level structure, production and decay rates.

- **Diquark correlation**

- ud diquark: Λ_c/Σ_c
- us/ds diquark: Ξ
- ss diquark (Only axial vector diquark): Ω

- **Origin of spin-dependent forces and Internal quark motion**

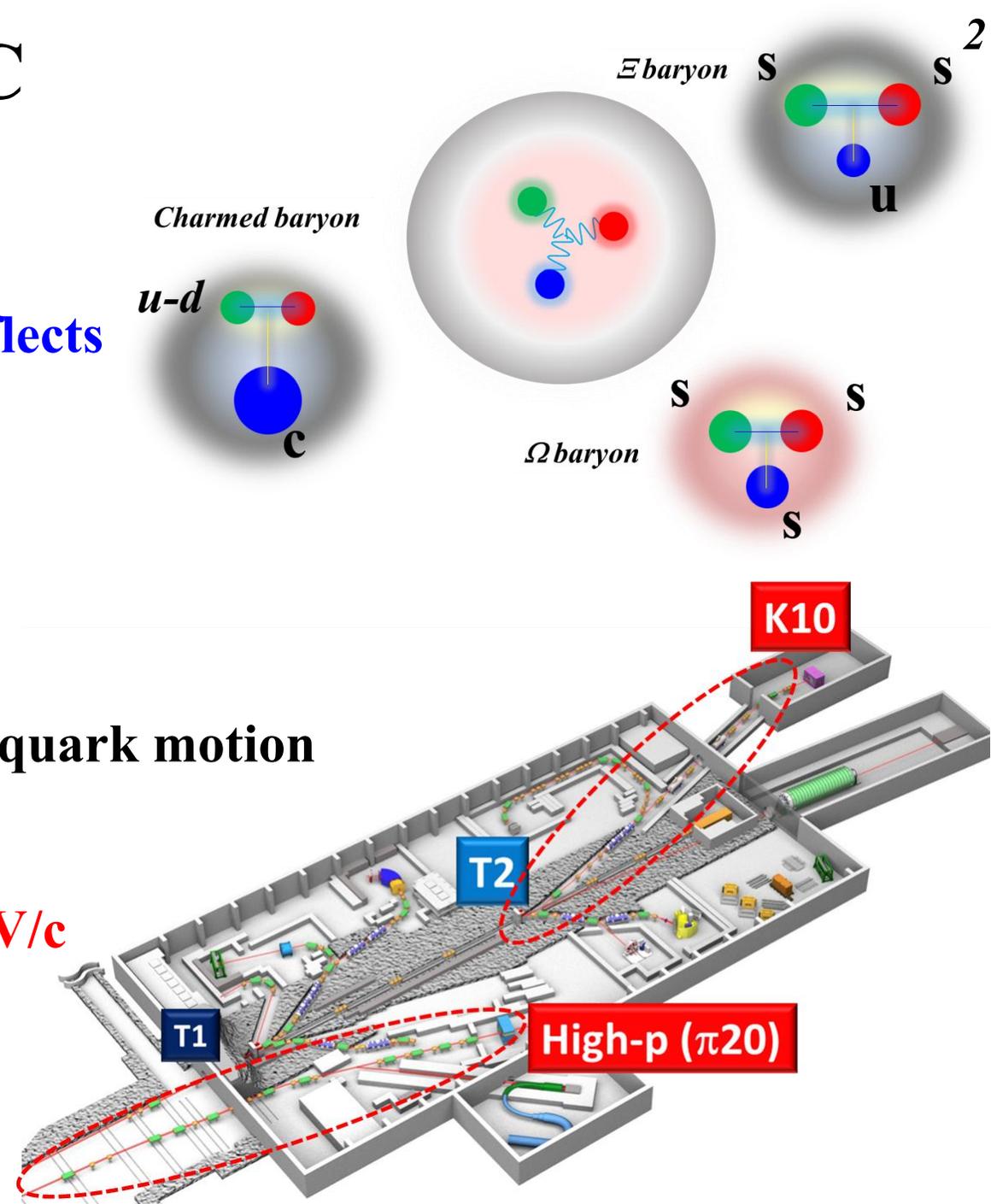
- Excited state data of Λ_c/Σ_c , Ξ , Ω systems

- **$\pi 20$: π beam (unseparated beam) up to 20 GeV/c**

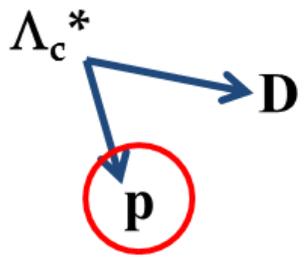
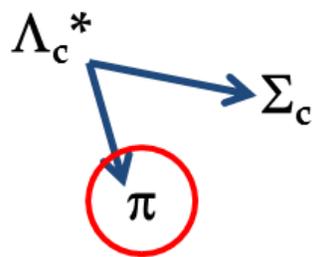
- $>10^7$ /spill for π^- + $>10^5$ /spill for K^- & \bar{p}

- **K10: K^- & \bar{p} beam up to 10 GeV/c**

- $>10^6$ /spill w/ high-purity: $K/\pi \sim 1/2$, $\bar{p}/\pi \sim 2/1$

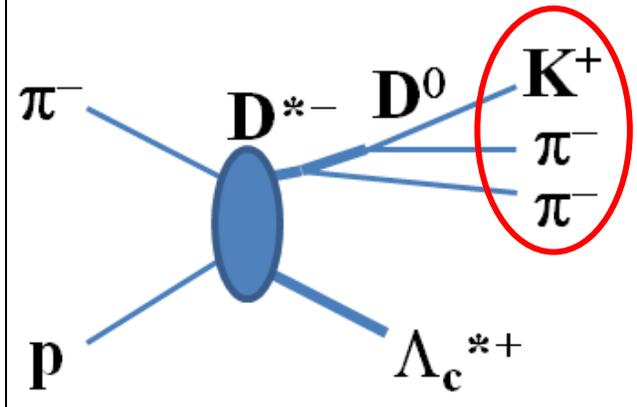
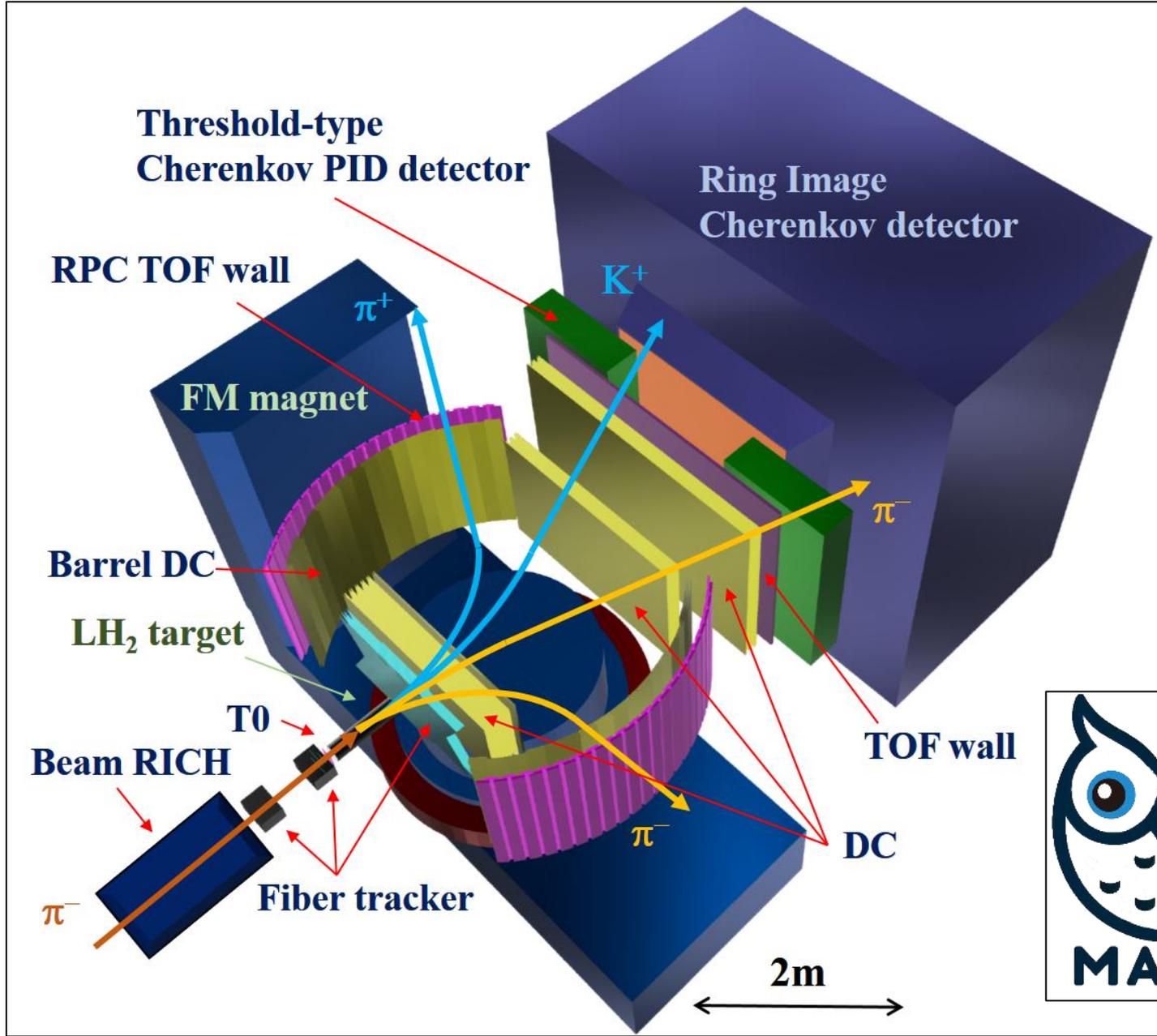


MARQ spectrometer at $\pi 20$



Decay measurement
* Branching ratios

π^\pm & p : < 4.0 GeV/c

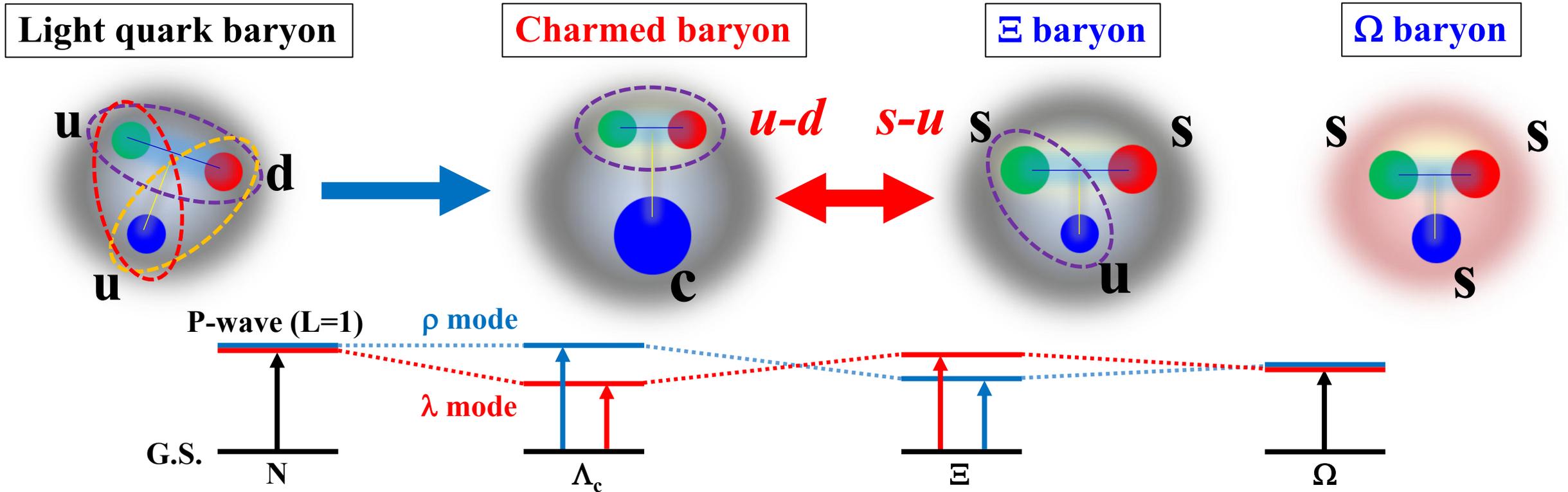


Missing mass measurement
* Production rate

K^+ & π^- : 2–16 GeV/c
Slow π_s^- : 0.5–1.7 GeV/c



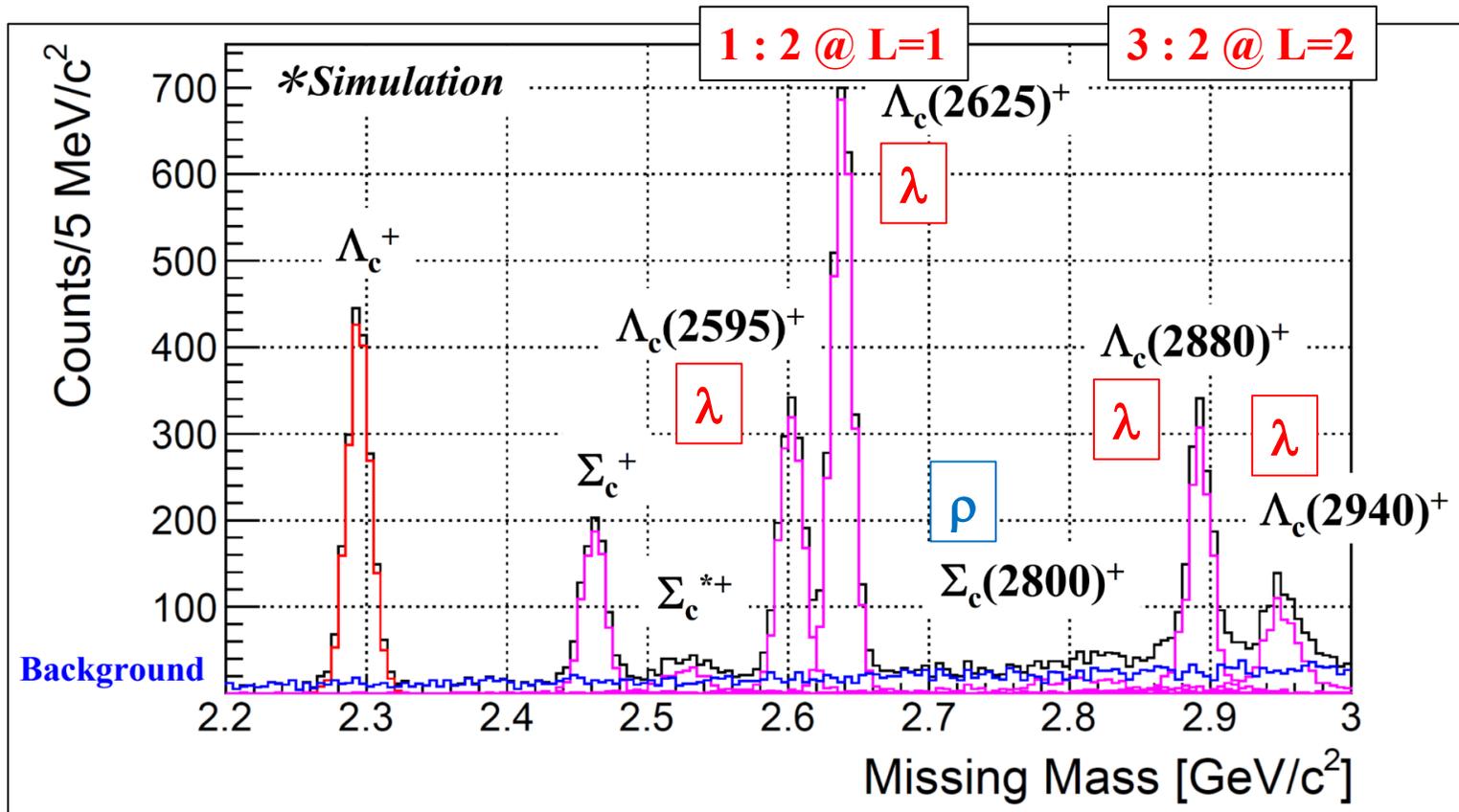
Heavy flavors for revealing diquark correlation



* Systematic studies for baryon systems with heavier flavors: c & s

- Charmed baryon (E50): ud diquark correlation
- Ξ baryon (E97): us/ds diquark correlation \Rightarrow Flavor dependence
- Ω baryon (P85): ss diquark (Axial-vector diquark) correlation \Rightarrow Reference system

Expected mass spectrum: $\pi^- p \rightarrow D^{*-} Y_c^{*+}$



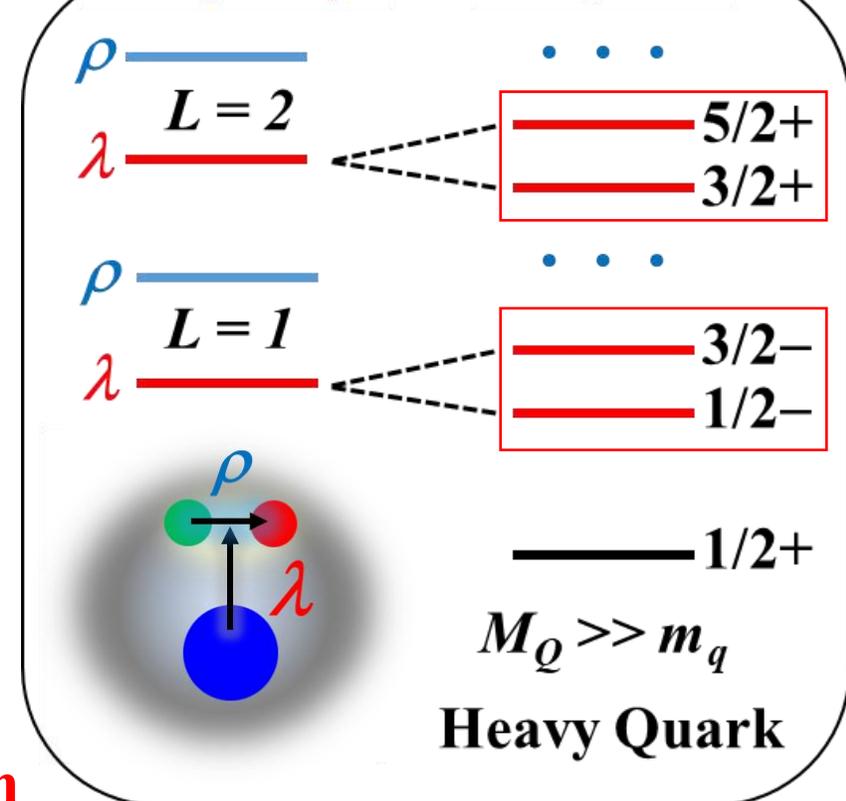
• Production rates $\Rightarrow \lambda/\rho$ mode assignment

* Production cross section(0°): Overlap of wave function

- Production rate of LS doublet = $L : L+1$
- Angular distribution (t -dependence: $d\sigma/dt$) contains structure information.
- Decay measurements: Branching ratio (Γ) and decay angles (J^P)

* Production rate of LS doublet = $L : L+1$

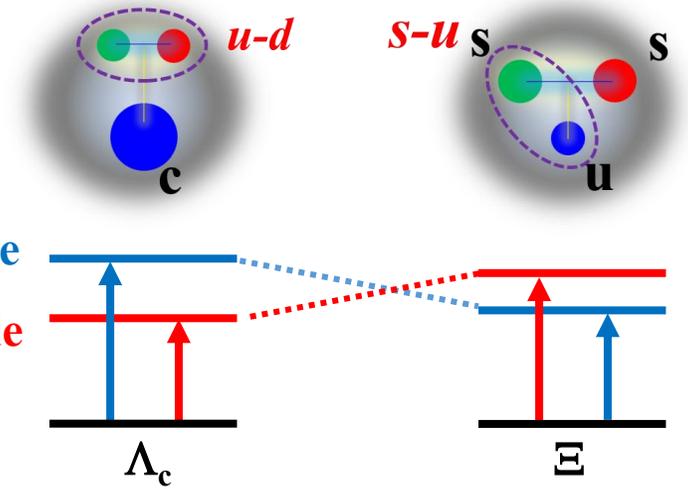
Isotope shift — σ -dep. Int.



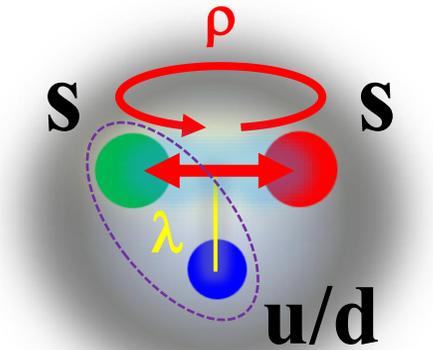
HQ doublet

Studies of Ξ baryons

- Ξ baryon: us/ds diquark correlation
 - Excitation energy: ρ mode $<$ λ mode
 - Strength of us/ds correlation: LS splitting
 - * Production rate of LS partner = 1:2 (L:L+1 w/ L=1)



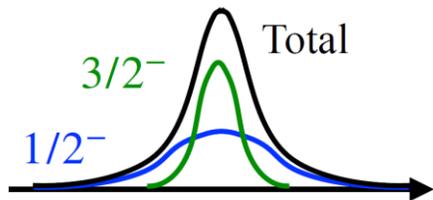
Weakly correlated us/ds



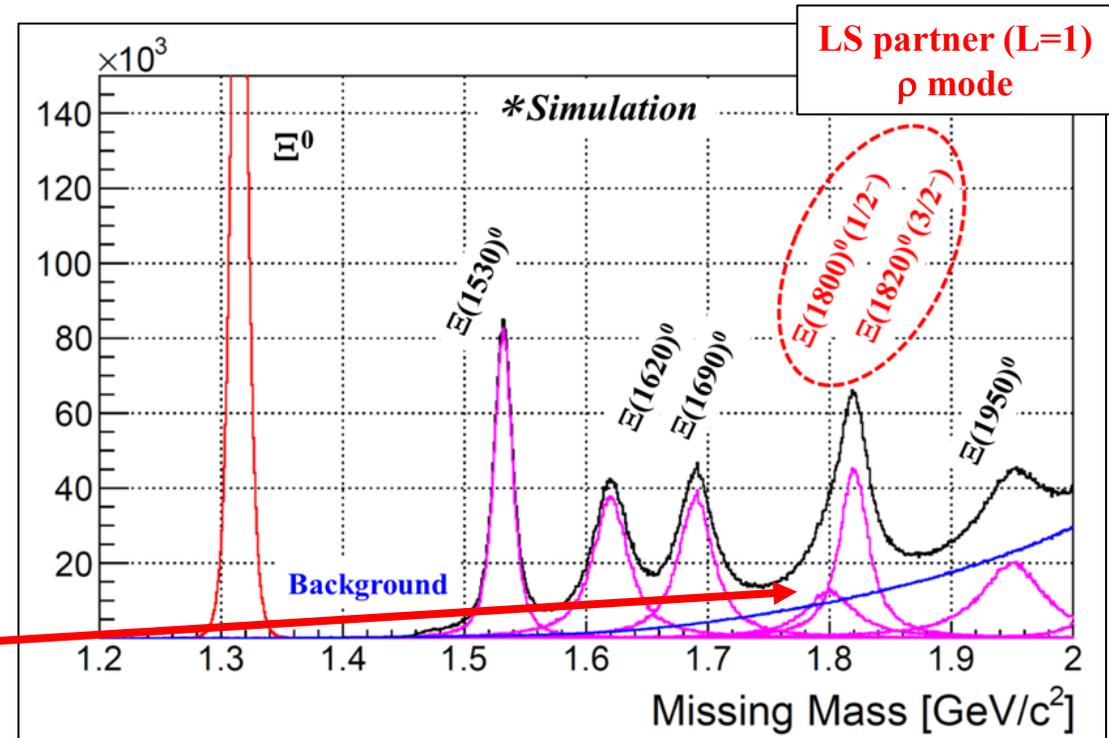
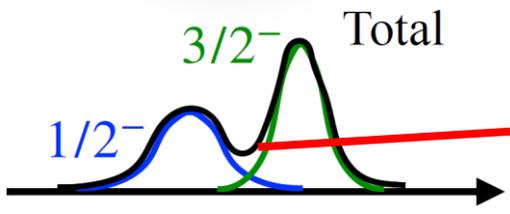
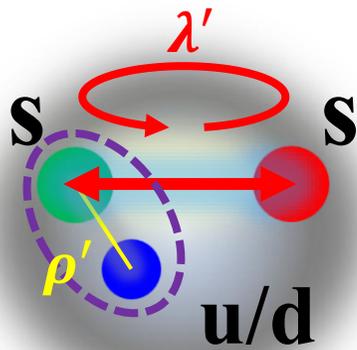
$$\rho = \frac{\sqrt{3}}{2} \lambda' + \frac{1}{2} \rho'$$

$$\lambda = -\frac{1}{2} \lambda' + \frac{\sqrt{3}}{2} \rho'$$

LS partner (L=1)
 ρ mode

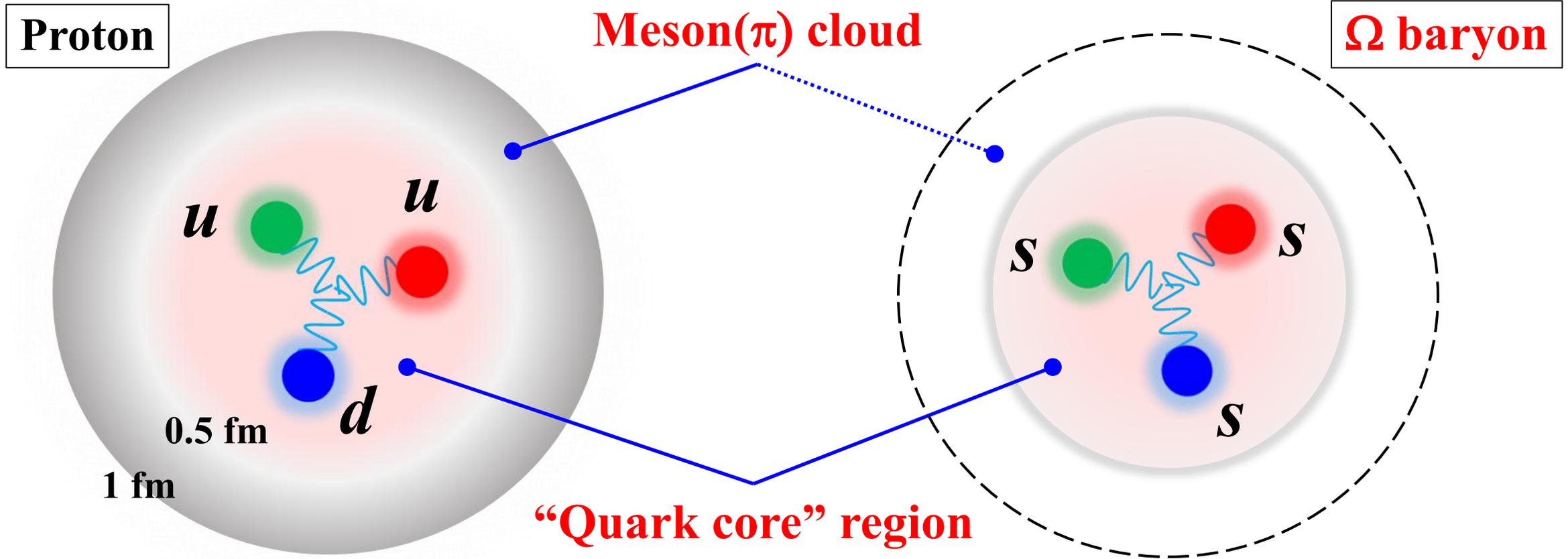


Strongly correlated us/ds



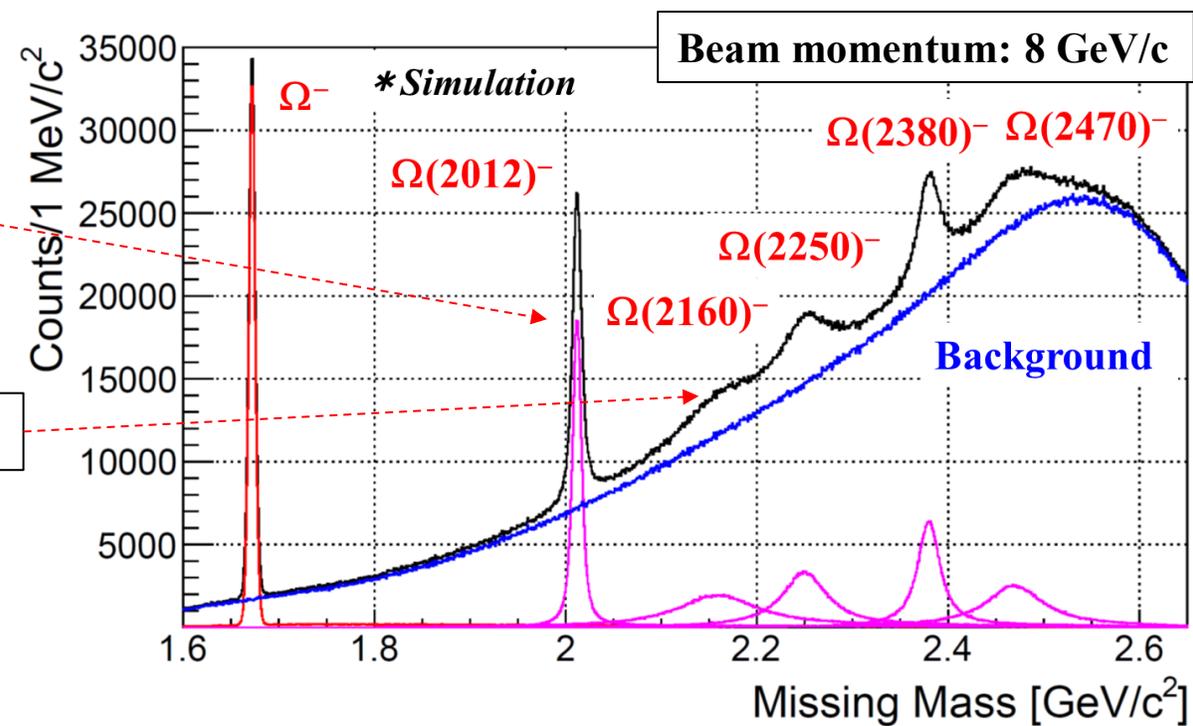
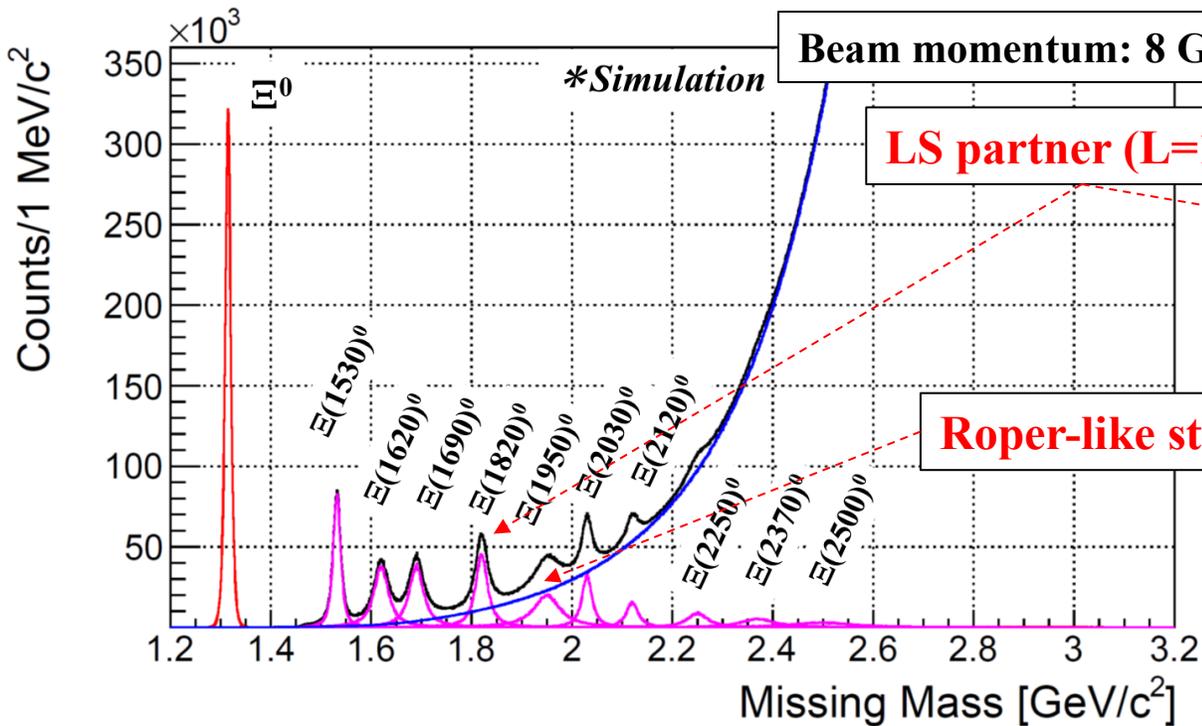
* $\Xi(1800)^0(1/2^-)$: Assumed in simulation

Role of Ω baryon



- $\Omega(sss)$ baryon: **Flavor symmetric** system
- **Free from Pion Cloud:** Investigation of **“Quark core”** region (Non-perturbative region)
- Only axial-vector diquark \Rightarrow Reference system
- * **Origin of spin-dependent forces and internal quark motion(spatial information)**

Expected mass spectra of Ξ^* and Ω^* by $K^- p$ reaction



- **Reaction: $K^- p \rightarrow K^+ \Xi^{*-} / K^- p \rightarrow K^{*0} \Xi^{*0}$**
 - **Beam: 5–8 GeV/c**
- **Missing mass: K^+ / K^{*0}**
 - **Mass resolution: $\Delta M \sim 7 \text{ MeV}(\sigma)$**

- **Reaction: $K^- p \rightarrow \Omega^{*-} K^{*0} K^+$**
 - **Beam: 7–10 GeV/c**
- **Missing mass: $K^{*0} \& K^+$**
 - **Mass resolution: $\Delta M \sim 5 \text{ MeV}(\sigma)$**

*** High momentum transfer = Highly excited state**

⇒ Systematic studies: Identify λ/ρ modes, SS/LS forces and internal quark motion

Summary

- **How quarks build hadrons ?**
 - Understanding of non-trivial QCD dynamics in baryon structure: Λ_c/Σ_c , Ξ , Ω
 - High-intensity & High-momentum hadron beam at J-PARC: $\pi 20$ and K10
- **Spectroscopy experiment of heavier flavor baryons**
 - Systematic spectroscopy experiments of Λ_c/Σ_c , Ξ , Ω baryons
 - Diquark correlation
 - *ud* diquark: Λ_c/Σ_c
 - *us/ds* diquark: Ξ
 - *ss* diquark (Only axial vector diquark): Ω
 - Origin of spin-dependent forces and Internal quark motion
 - Excited state data of Λ_c/Σ_c , Ξ , Ω systems

**J-PARC hadron experimental facility promotes systematic baryon spectroscopy.*