Charm Baryons at SCT Factory

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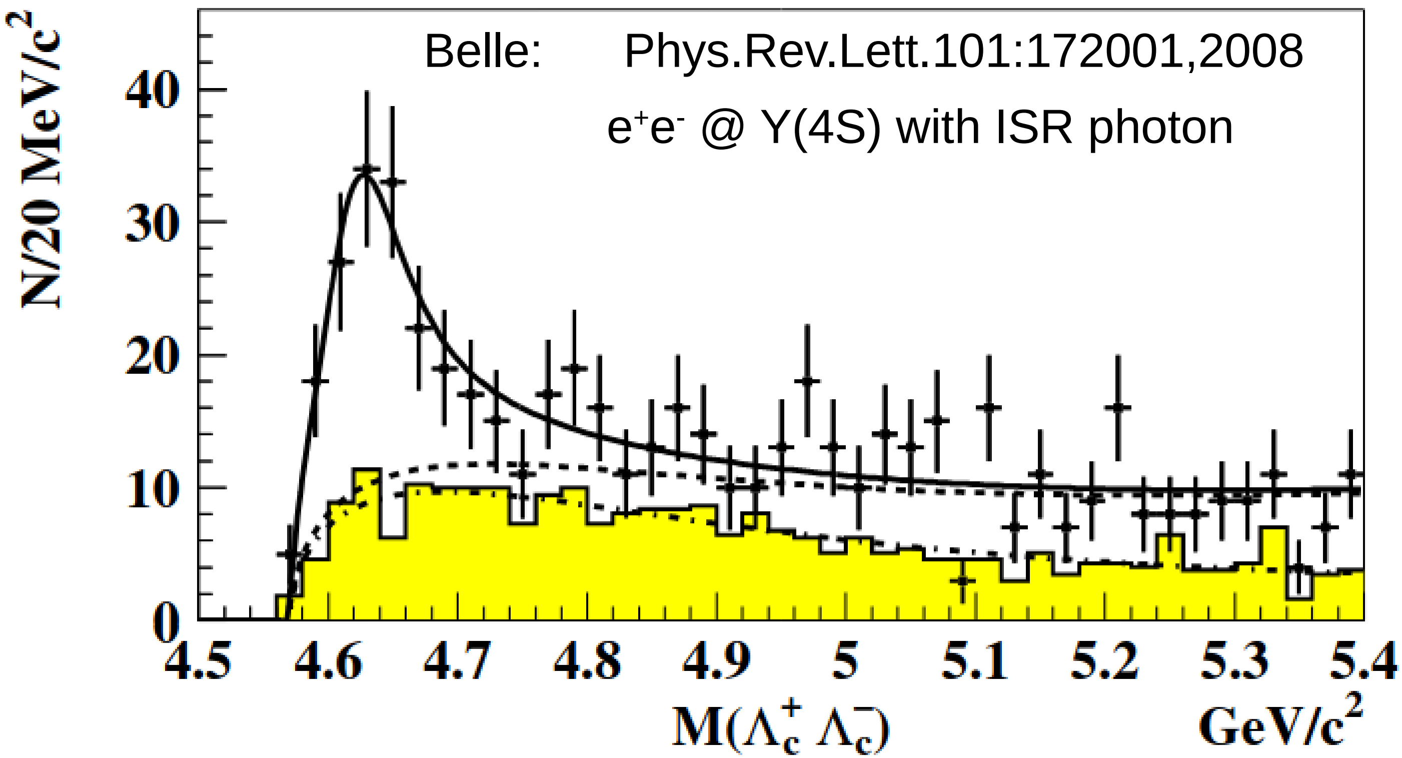
SCTF
energy and luminosity

A one-year dataset
at $\mathcal{L} = 10^{35}\ \mathrm{cm}^{-2} s^{-1}$

$2E$, GeV	Events recorded
3.1	$10^{12}\ J/\psi$
3.69	$10^{11}\ \psi(2S)$
3.77	$10^{9}\ D\bar{D}$
4.17	$10^{8}\ D_s\bar{D}_s$
$3.55 \div 4.3$	$10^{10}\ \tau\,\tau$
4.65	$10^{8}\ \Lambda_c^+\Lambda_c^-$
> 4.65	???

Charm baryon threshold

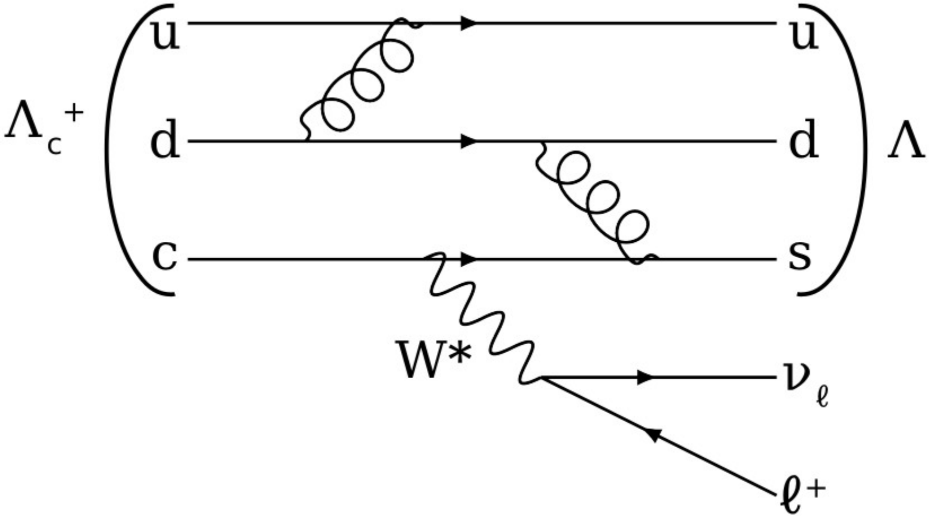
Production cross-section in e^+e^- annihilation



$\sigma(e^+e^- \to \Lambda_c \overline{\Lambda}_c) \sim 0.5\,\mathrm{nb} \,@\, 4.65\,\mathrm{GeV}$ (possible resonant enhancement)

<10 pb without resonances (predicted)

Form-factor measurement



Check and justify effective theories (like HQET) and lattice calculations (LQCD)

$$\Lambda_c^+ \to \Lambda l^+ \nu_l \;\; (l = e, \mu)$$

In HQET charm and beauty baryons' form-factors are connected

→ measurement of the Λ_c^+ semileptonic form-factor gives input to $|V_{cb}|$ and $|V_{us}|$ measurements with Λ_b^0 decays

Form-factor measurement

For arbitrary semileptonic baryon decay: $B_1(p_1, M_1) \to B_2(p_2, M_2) + l(p_l, m_l) + \nu_l(p_{\nu_l}, m_{\nu_l} = 0)$

$$\langle B_2 | \, j_\mu^V \, | B_1 \rangle = M_\mu^V = \overline{u}_2 \left[F_1^V(q^2)\gamma_\mu + \frac{F_2^V(q^2)}{M_1}\sigma_{\mu\nu}q^\nu + \frac{F_3^V(q^2)}{M_1}q_\mu \right] u_1,$$

$$\langle B_2 | \, j_\mu^A \, | B_1 \rangle = M_\mu^A = \overline{u}_2 \left[F_1^A(q^2)\gamma_\mu + \frac{F_2^A(q^2)}{M_1}\sigma_{\mu\nu}q^\nu + \frac{F_3^A(q^2)}{M_1}q_\mu \right] \gamma_5 u_1,$$

Assuming that:

- Lepton mass is small
- There are no T-odd effects
- HQET works for $c \to s l^+ \nu_l$ transition

only two parameters survives: M_{pole} and $R(q^2) = f_2(q^2)/f_1(q^2)$

$$\langle \Lambda | \, J_\mu \, | \Lambda_c^+ \rangle = \overline{u}_\Lambda \left[f_1(q^2)\gamma_\mu(1-\gamma_5) + f_2(q^2)\hat{v}_{\Lambda_c}\gamma_\mu(1-\gamma_5) \right] u_{\Lambda_c};$$

$$F_1^V(q^2) = -F_1^A(q^2) = f_1(q^2) + \frac{M_\Lambda}{M_{\Lambda_c}} f_2(q^2);$$

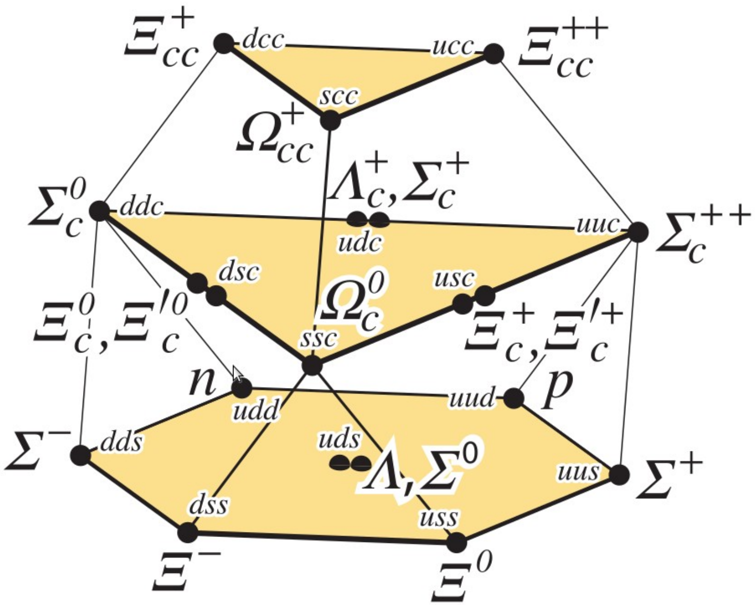
$$F_2^V(q^2) = -F_2^A(q^2) = f_2(q^2).$$

CLEO:
PRL 94 191801

$$M_{pole} = [2.21 \pm 0.08 \pm 0.14]\,\mathrm{GeV}$$

$$R = -0.35 \pm 0.05 \pm 0.04$$

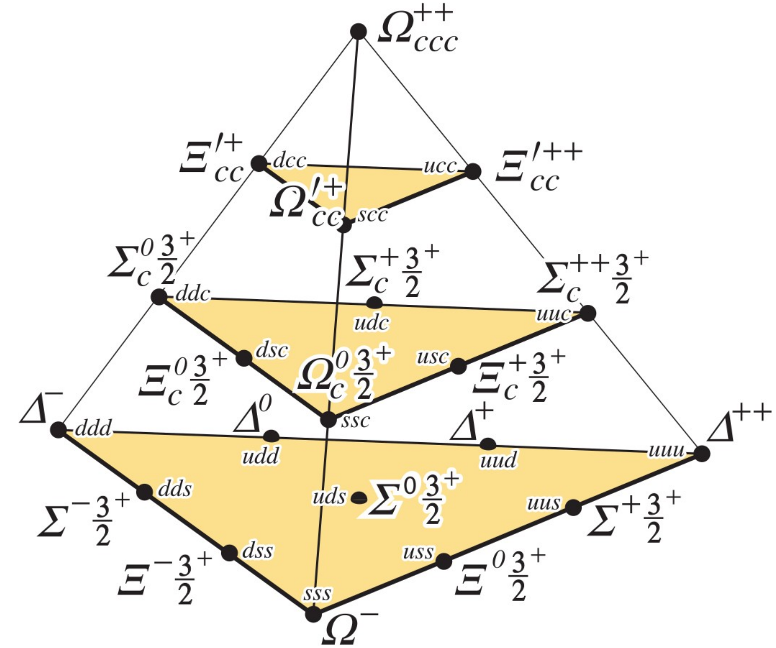
Charmed baryon spectroscopy



$$3 \times 3 = \overline{3}_A \oplus 6_S$$

q=u,d,s ↓↑↑ (q q) c ↓↓↑ (q q) c

Spin 1/2: $\Lambda_c^+, \Xi_c^+, \Xi_c^0$ $\Sigma_c^{++,+,0}, \Xi_c^{\prime +}, \Xi_c^{\prime 0}, \Omega_c^0$

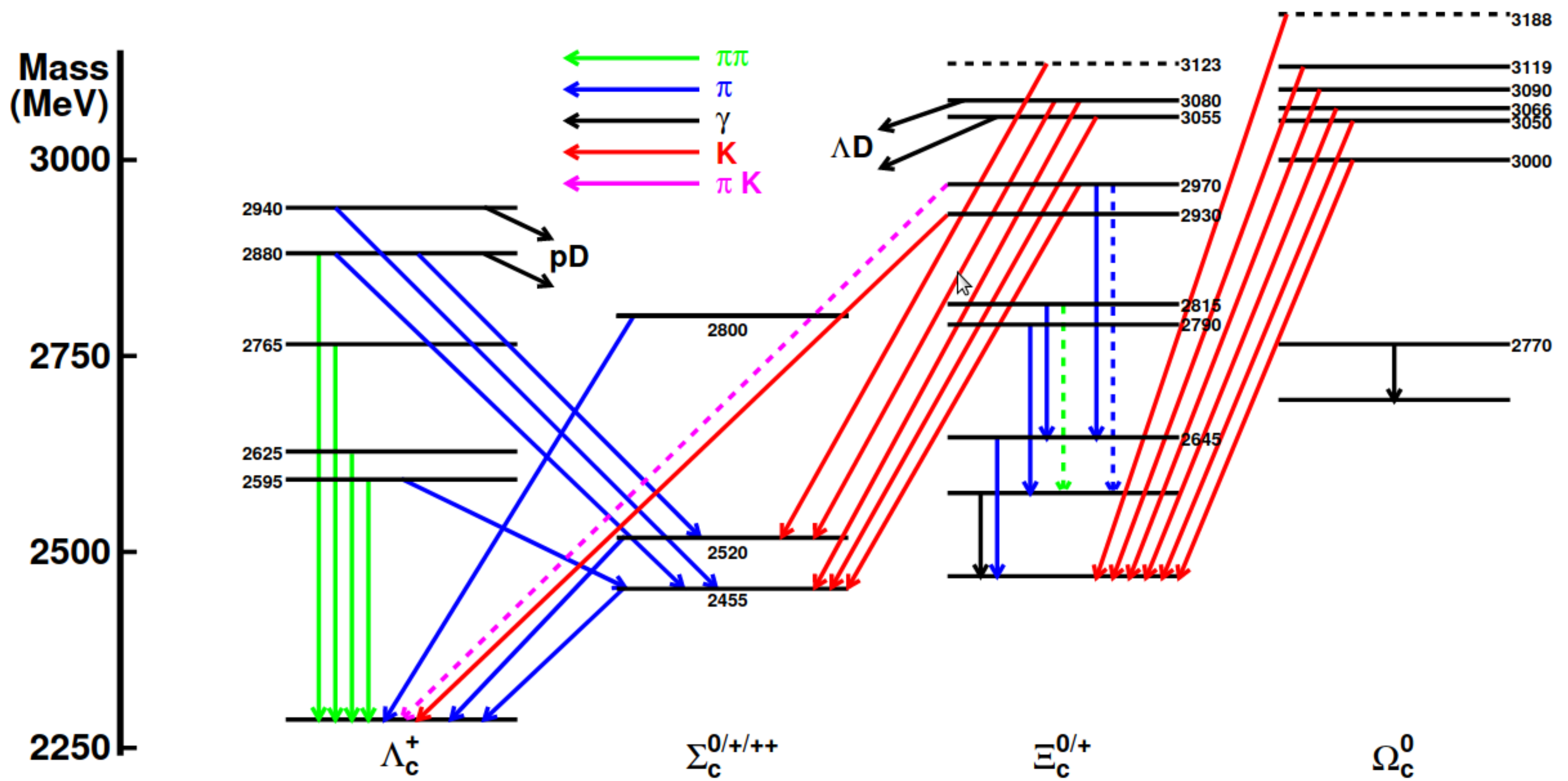


↓↓↓ (q q) c

Spin 3/2: $\Sigma_c^{*++,+,0}, \Xi_c^{*+}, \Xi_c^{*0}, \Omega_c^{*0}$

P-wave excitations: 63 states

Charmed baryon spectroscopy



Charmed baryons excitations and decays

Charmed baryons' properties

		$J^{\mathcal{P}}$	Mass	Width	Dominant decay channel
Λ_c^+	udc	$(1/2)^+$	2286.46 ± 0.14	(200 ± 6) fs	Weak
Ξ_c^+	usc	$(1/2)^+$	$2467.8^{+0.4}_{-0.6}$	(442 ± 26) fs	Weak
Ξ_c^0	dsc	$(1/2)^+$	$2470.88^{+0.34}_{-0.8}$	112^{+13}_{-10} fs	Weak
Σ_c^{++}	uuc	$(1/2)^+$	2454.02 ± 0.18	2.23 ± 0.30 MeV	$\Lambda_c^+\pi^+$
Σ_c^+	udc	$(1/2)^+$	2452.9 ± 0.4	< 4.6 MeV	$\Lambda_c^+\pi^0$
Σ_c^0	ddc	$(1/2)^+$	2453.76 ± 0.18	2.2 ± 0.4 MeV	$\Lambda_c^+\pi^-$
$\Xi_c'^+$	usc	$(1/2)^+$	2575.6 ± 3.1	—	$\Xi_c^+\gamma$
$\Xi_c'^0$	dsc	$(1/2)^+$	2577.9 ± 2.9	—	$\Xi_c^0\gamma$
Ω_c^0	ssc	$(1/2)^+$	2695.2 ± 1.7	(69 ± 12) fs	Weak
Σ_c^{*++}	uuc	$(3/2)^+$	2518.4 ± 0.6	14.9 ± 1.9 MeV	$\Lambda_c^+\pi^+$
Σ_c^{*+}	udc	$(3/2)^+$	2517.5 ± 2.3	< 17 MeV	$\Lambda_c^+\pi^0$
Σ_c^{*0}	ddc	$(3/2)^+$	2518.0 ± 0.5	16.1 ± 2.1 MeV	$\Lambda_c^+\pi^-$
Ξ_c^{*+}	usc	$(3/2)^+$	$2645.9^{+0.5}_{-0.6}$	< 3.1 MeV	$\Xi_c\pi$
Ξ_c^{*0}	dsc	$(3/2)^+$	2645.9 ± 0.5	< 5.5 MeV	$\Xi_c\pi$
Ω_c^{*0}	ssc	$(3/2)^+$	2765.9 ± 2.0	—	$\Omega_c^0\gamma$

Properties studied by

B-factories (~10^7 Λ_c^+)
and
BES III

Absolute branchins are normalized to
Br($\Lambda_c^+ \to pK^-\pi^+$)=
6.28±0.32 %

Summary

SCTF is an ideal laboratory for charm baryon study

10^8 $\Lambda_c\overline{\Lambda}_c$ pairs per year is one of the world larges (and cleanest) dataset

Near the threshold no momentum tag is needed

With polarized beams Λ_c^+ is produced with known polarization → no tag needed