UNIVERSITY of York

Ω^- and the other exotics production at K_LF-22GeV

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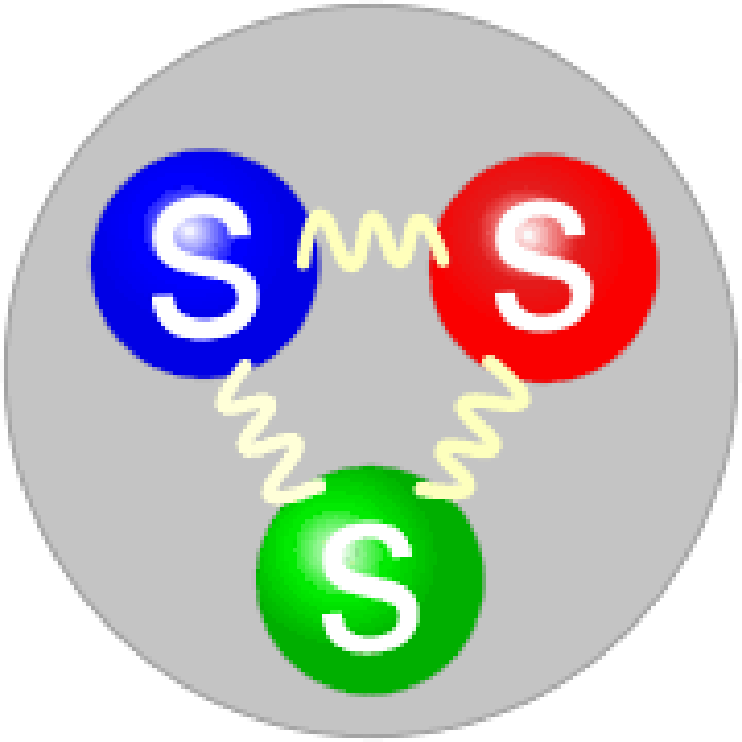
Why Omega



Baryon summary table, PDG

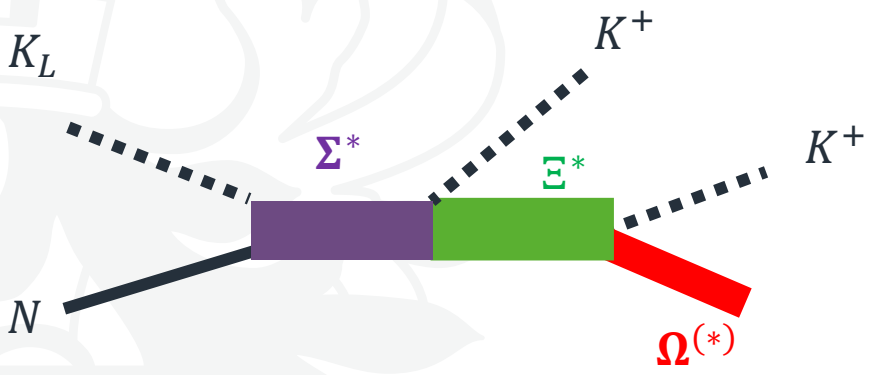
p	$1/2^+$	****	$\Delta(1232)$	$3/2^+$	****	Σ^+	$1/2^+$	****	Ξ^0	$1/2^+$	****	Λ_c^+	$1/2^+$	****			
n	$1/2^+$	****	$\Delta(1600)$	$3/2^+$	***	Σ^0	$1/2^+$	****	Ξ^-	$1/2^+$	****	$\Lambda_c(2595)^+$	$1/2^-$	***			
$N(1440)$	$1/2^+$	****	$\Delta(1620)$	$1/2^-$	****	Σ^-	$1/2^+$	****	$\Xi(1530)$	$3/2^+$	****	$\Lambda_c(2625)^+$	$3/2^-$	***			
$N(1520)$	$3/2^-$	****	$\Delta(1700)$	$3/2^-$	****	$\Sigma(1385)$	$3/2^+$	****	$\Xi(1620)$		*	$\Lambda_c(2765)^+$		*			
$N(1535)$	$1/2^-$	****	$\Delta(1750)$	$1/2^+$	*	$\Sigma(1480)$		*	$\Xi(1690)$		***	$\Lambda_c(2880)^+$	$5/2^+$	***			
$N(1650)$	$1/2^-$	****	$\Delta(1900)$	$1/2^-$	**	$\Sigma(1560)$		**	$\Xi(1820)$	$3/2^-$	***	$\Lambda_c(2940)^+$		***			
$N(1675)$	$5/2^-$	****	$\Delta(1905)$	$5/2^+$	****	$\Sigma(1580)$	$3/2^-$	*	$\Xi(1950)$		***	$\Sigma_c(2455)$	$1/2^+$	****			
$N(1680)$	$5/2^+$	****	$\Delta(1910)$	$1/2^+$	****	$\Sigma(1620)$	$1/2^-$	*	$\Xi(2030)$	$\geq \frac{5}{2}$?	***	$\Sigma_c(2520)$	$3/2^+$	***			
$N(1685)$		*	$\Delta(1920)$	$3/2^+$	***	$\Sigma(1660)$	$1/2^+$	***	$\Xi(2120)$		*	$\Sigma_c(2800)$		***			
$N(1700)$	$3/2^-$	***	$\Delta(1930)$	$5/2^-$	***	$\Sigma(1670)$	$3/2^-$	****	$\Xi(2250)$		**	Ξ_c^+	$1/2^+$	***			
$N(1710)$	$1/2^+$	***	$\Delta(1940)$	$3/2^-$	**	$\Sigma(1690)$		**	$\Xi(2370)$		**	Ξ_c^0	$1/2^+$	***			
$N(1720)$	$3/2^+$	****	$\Delta(1950)$	$7/2^+$	****	$\Sigma(1730)$	$3/2^+$	*	$\Xi(2500)$		*	$\Xi_c'^+$	$1/2^+$	***			
$N(1860)$	$5/2^+$	**	$\Delta(2000)$	$5/2^+$	**	$\Sigma(1750)$	$1/2^-$	***				$\Xi_c'^0$	$1/2^+$	***			
$N(1875)$	$3/2^-$	***	$\Delta(2150)$	$1/2^-$	*	$\Sigma(1770)$	$1/2^+$	*	Ω^-	$3/2^+$	****	$\Xi_c(2645)$	$3/2^+$	***			
$N(1880)$	$1/2^+$	**	$\Delta(2200)$	$7/2^-$	*	$\Sigma(1775)$	$5/2^-$	****	$\Omega(2250)^-$		***	$\Xi_c(2790)$	$1/2^-$	***			
$N(1895)$	$1/2^-$	**	$\Delta(2300)$	$9/2^+$	**	$\Sigma(1840)$	$3/2^+$	*	$\Omega(2380)^-$		**	$\Xi_c(2815)$	$3/2^-$	***			
$N(1900)$	$3/2^+$	***	$\Delta(2350)$	$5/2^-$	*	$\Sigma(1880)$	$1/2^+$	**	$\Omega(2470)^-$		**	$\Xi_c(2930)$		*			
$N(1990)$	$7/2^+$	**	$\Delta(2390)$	$7/2^+$	*	$\Sigma(1900)$	$1/2^-$	*				$\Xi_c(2980)$		***			
$N(2000)$	$5/2^+$	**	$\Delta(2400)$	$9/2^-$	**	$\Sigma(1915)$	$5/2^+$	****				$\Xi_c(3055)$		**			
$N(2040)$	$3/2^+$	*	$\Delta(2420)$	$11/2^+$	****	$\Sigma(1940)$	$3/2^+$	*				$\Xi_c(3080)$		***			
$N(2060)$	$5/2^-$	**	$\Delta(2750)$	$13/2^-$	**	$\Sigma(1940)$	$3/2^-$	***				$\Xi_c(3123)$		*			
$N(2100)$	$1/2^+$	*	$\Delta(2950)$	$15/2^+$	**	$\Sigma(2000)$	$1/2^-$	*				Ω_c^0	$1/2^+$	***			
$N(2120)$	$3/2^-$	**				$\Sigma(2030)$	$7/2^+$	****				$\Omega_c(2770)^0$	$3/2^+$	***			
$N(2190)$	$7/2^-$	****	Λ	$1/2^+$	****	$\Sigma(2070)$	$5/2^+$	*									
$N(2220)$	$9/2^+$	****	$\Lambda(1405)$	$1/2^-$	****	$\Sigma(2080)$	$3/2^+$	**				Ξ_{cc}^+		*			
$N(2250)$	$9/2^-$	****	$\Lambda(1520)$	$3/2^-$	****	$\Sigma(2100)$	$7/2^-$	*									
$N(2300)$	$1/2^+$	**	$\Lambda(1600)$	$1/2^+$	***	$\Sigma(2250)$		***				Λ_b^0	$1/2^+$	***			
$N(2570)$	$5/2^-$	**	$\Lambda(1670)$	$1/2^-$	****	$\Sigma(2455)$		**				$\Lambda_b(5912)^0$	$1/2^-$	***			
$N(2600)$	$11/2^-$	***	$\Lambda(1690)$	$3/2^-$	****	$\Sigma(2620)$		**				$\Lambda_b(5920)^0$	$3/2^-$	***			
$N(2700)$	$13/2^+$	**	$\Lambda(1710)$	$1/2^+$	*	$\Sigma(3000)$		*				Σ_b	$1/2^+$	***			
			$\Lambda(1800)$	$1/2^-$	***	$\Sigma(3170)$		*				Σ_b^*	$3/2^+$	***			
			$\Lambda(1810)$	$1/2^+$	***							Ξ_b^0, Ξ_b^-	$1/2^+$	***			
			$\Lambda(1820)$	$5/2^+$	****							$\Xi_b(5945)^0$	$3/2^+$	***			
			$\Lambda(1830)$	$5/2^-$	****							Ω_b^-	$1/2^+$	***			
			$\Lambda(1890)$	$3/2^+$	****												
			$\Lambda(2000)$		*												
			$\Lambda(2020)$	$7/2^+$	*												
			$\Lambda(2050)$	$3/2^-$	*												
			$\Lambda(2100)$	$7/2^-$	****												
			$\Lambda(2110)$	$5/2^+$	***												
			$\Lambda(2325)$	$3/2^-$	*												
			$\Lambda(2350)$	$9/2^+$	***												
			$\Lambda(2585)$		**												

Number of 3- and 4-star Resonances

Baryon	2004	2020
N^*	15	21
Δ	10	12
Λ	14	14
Σ	10	9*
Ξ	6	6
Ω	2	2

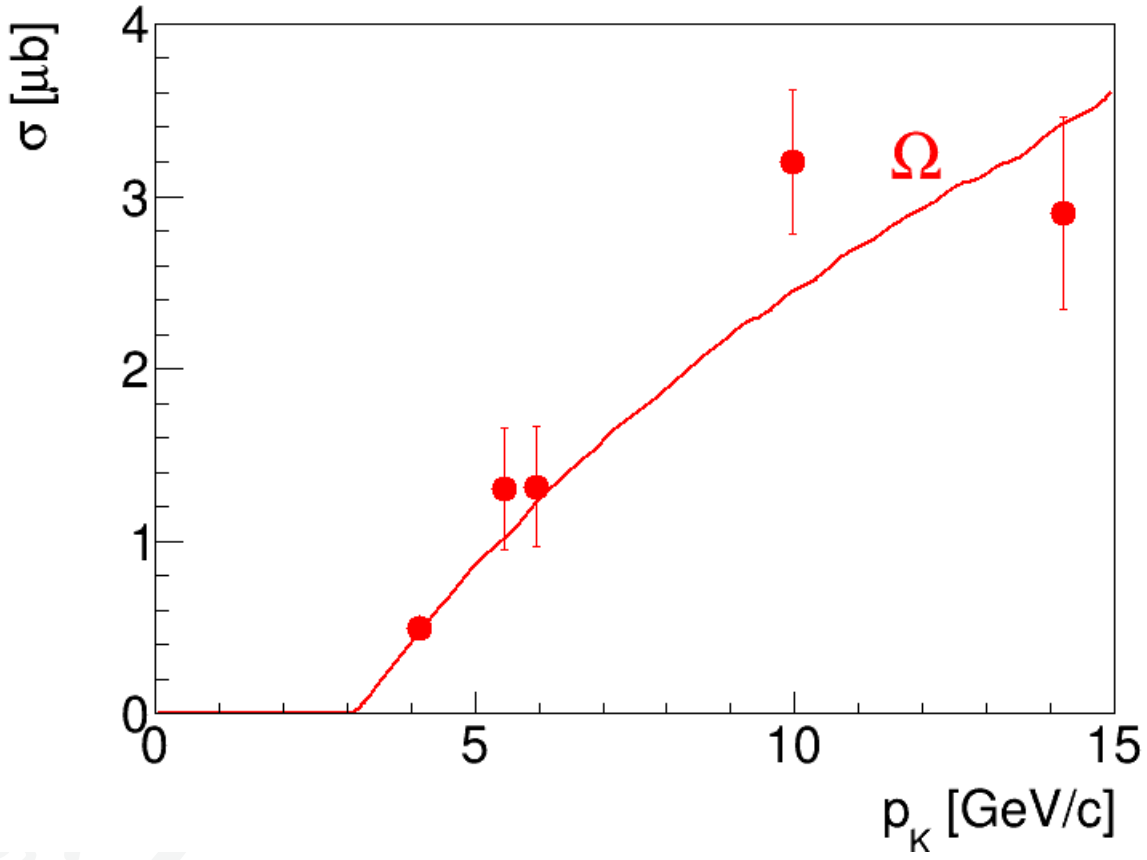
*$\Sigma(2250)$ was downgraded

Omega production



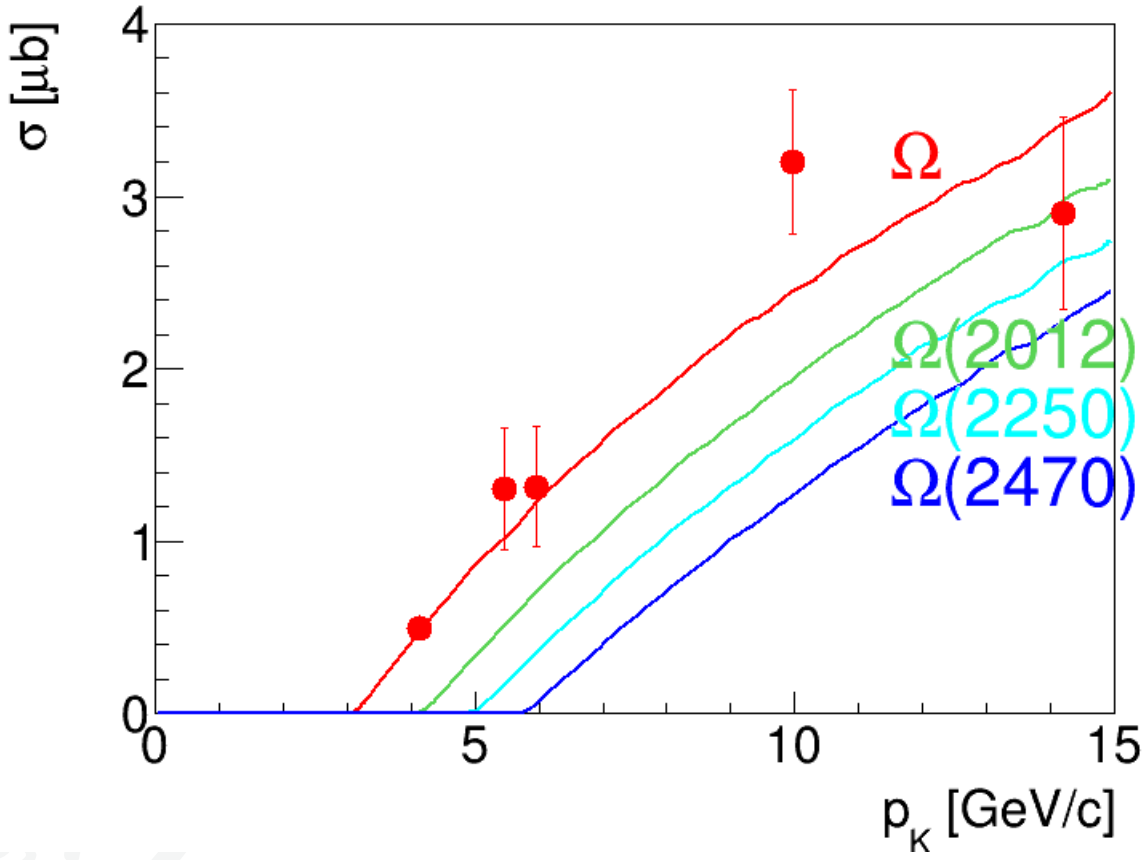
$$\sigma(K^- p \to \Omega X) = \sigma\left(K^0 p \to \Omega X\right)$$

Omega Cross section



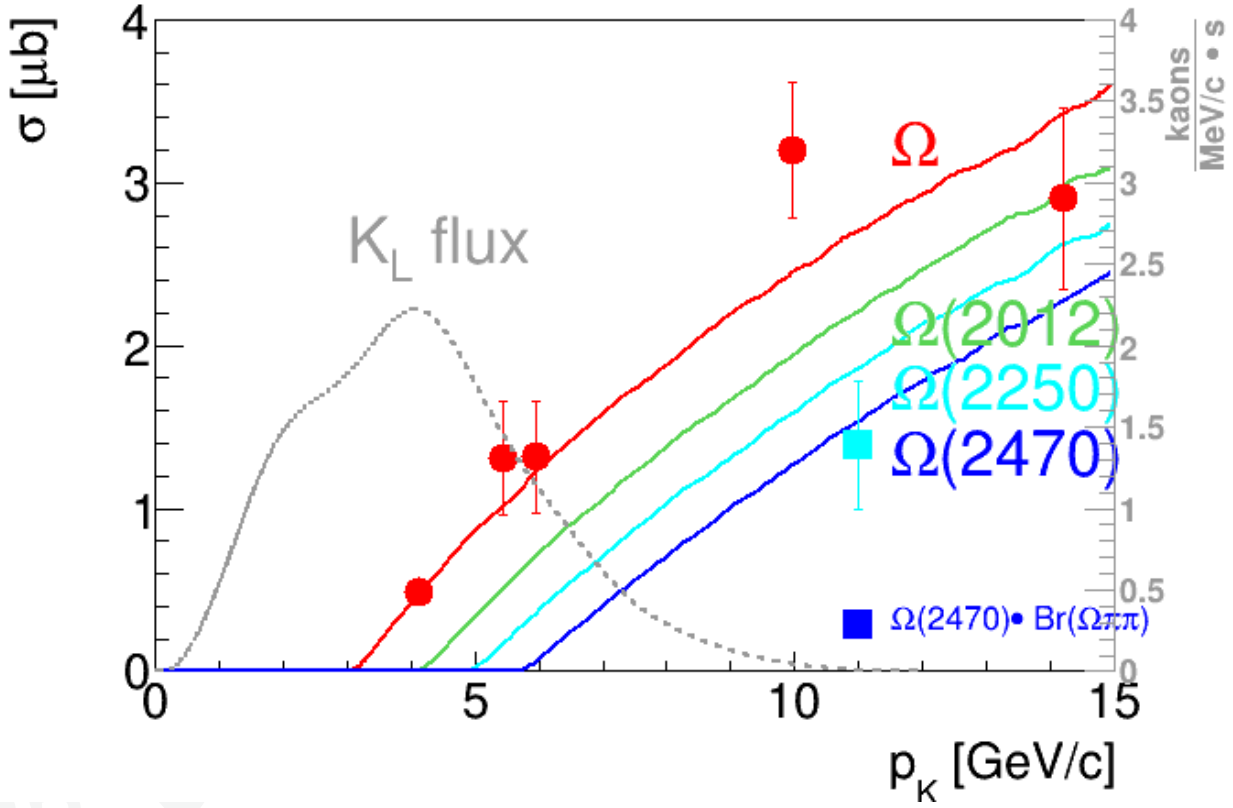
$\sigma(K^- p \to \Omega X) \sim \frac{PhaseSpace}{Q}$ (fit curve)

Omega Cross section



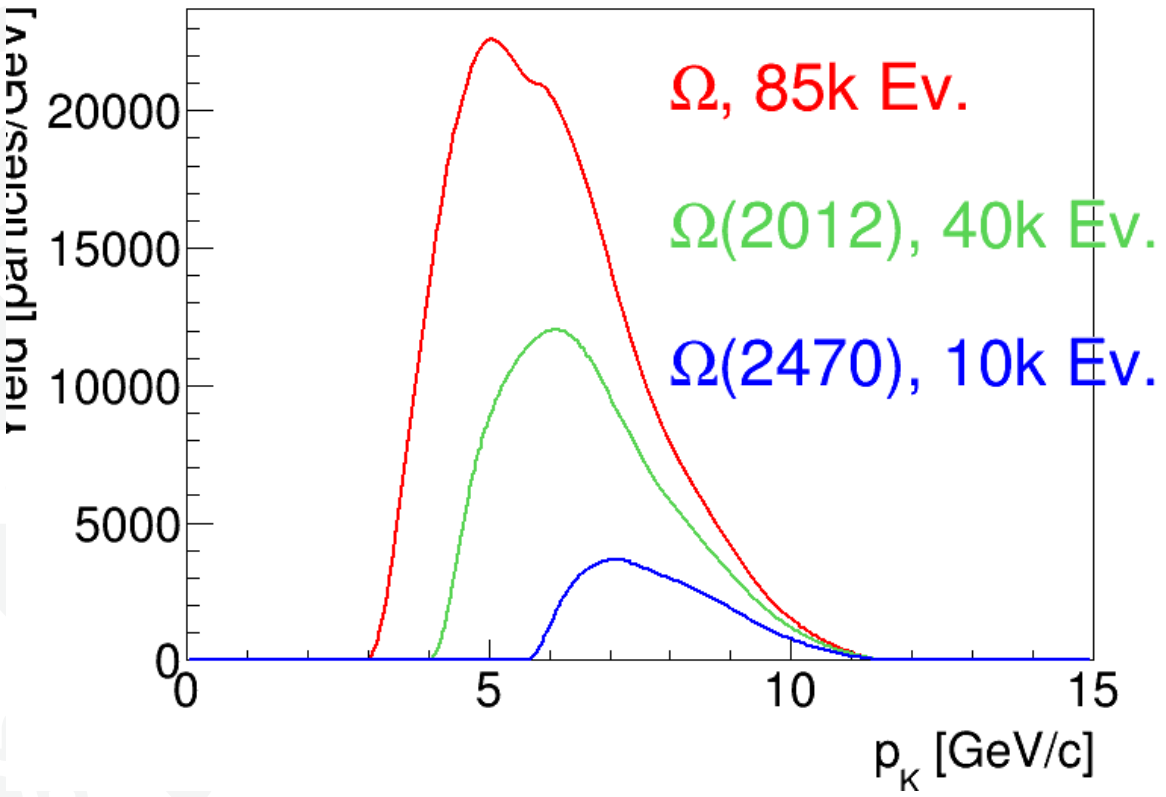
$\sigma(K^- p \to \Omega X) \sim \frac{PhaseSpace}{Q}$ (fit curve)

Omega Yield



$\sigma(K^- p \to \Omega X) \sim \frac{PhaseSpace}{Q}$ (fit curve)

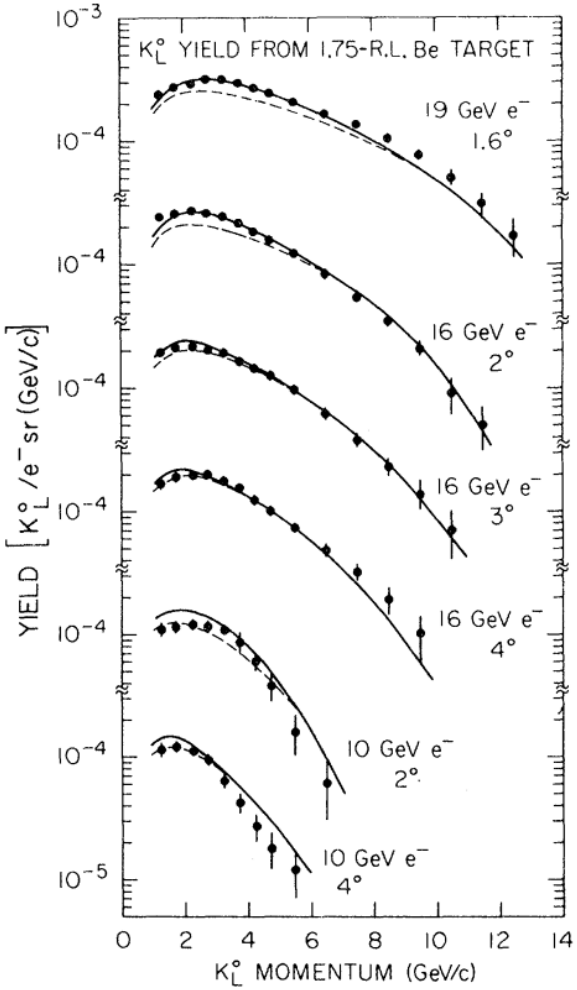
Omega Yield

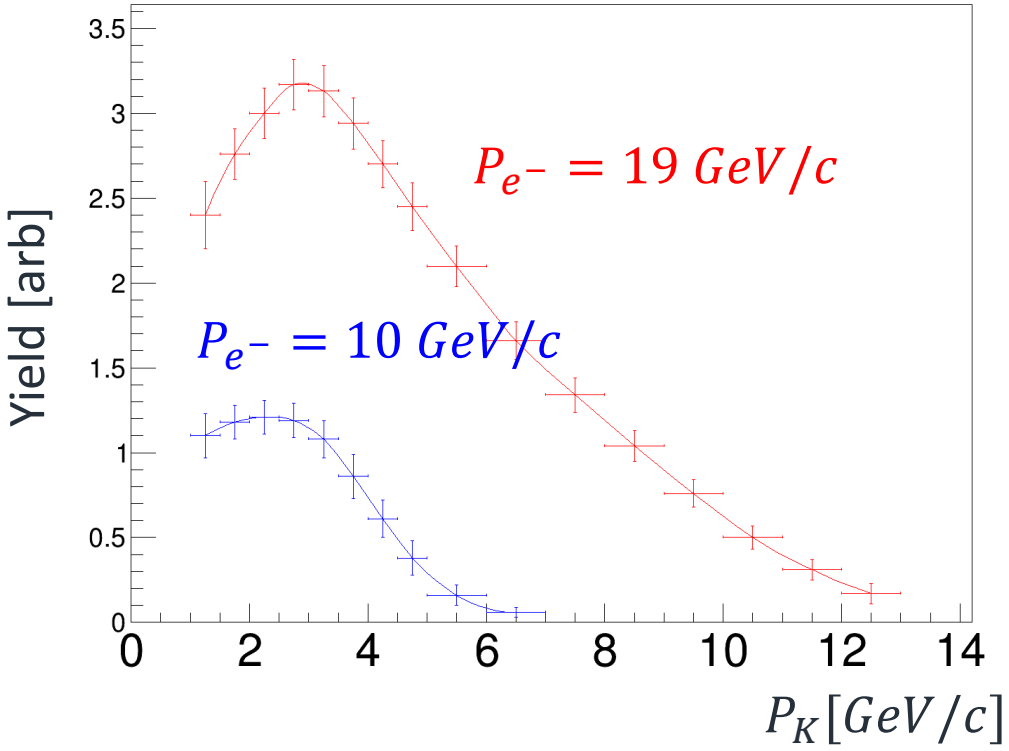


$\sigma(K^- p \to \Omega X) \sim \frac{PhaseSpace}{Q}$ (fit curve)

12 GeV -> 20 GeV

$e^- Be \rightarrow K_L + X; \Theta_K < 2^o$

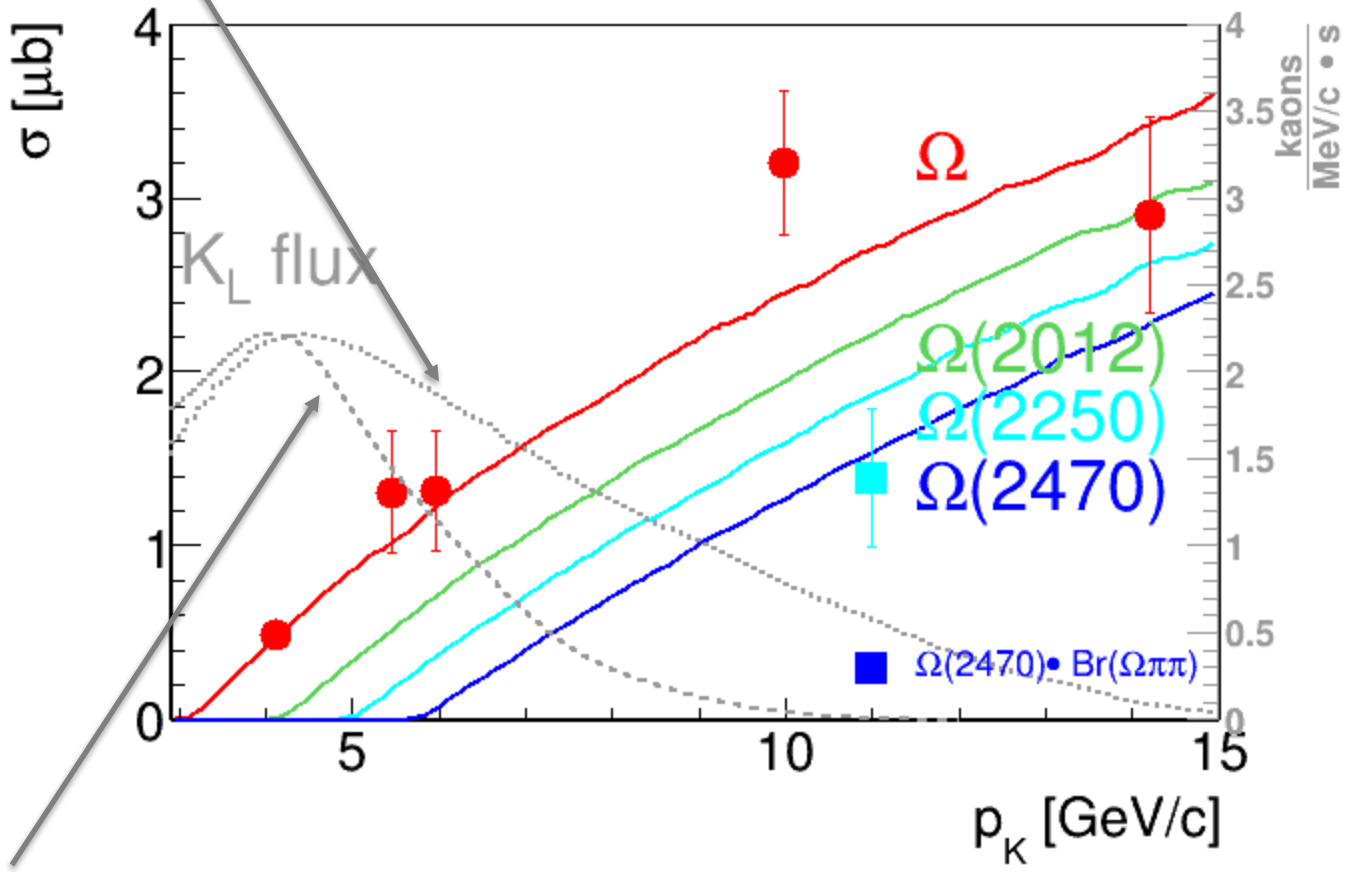




PhysRev D7, 708, (1973)

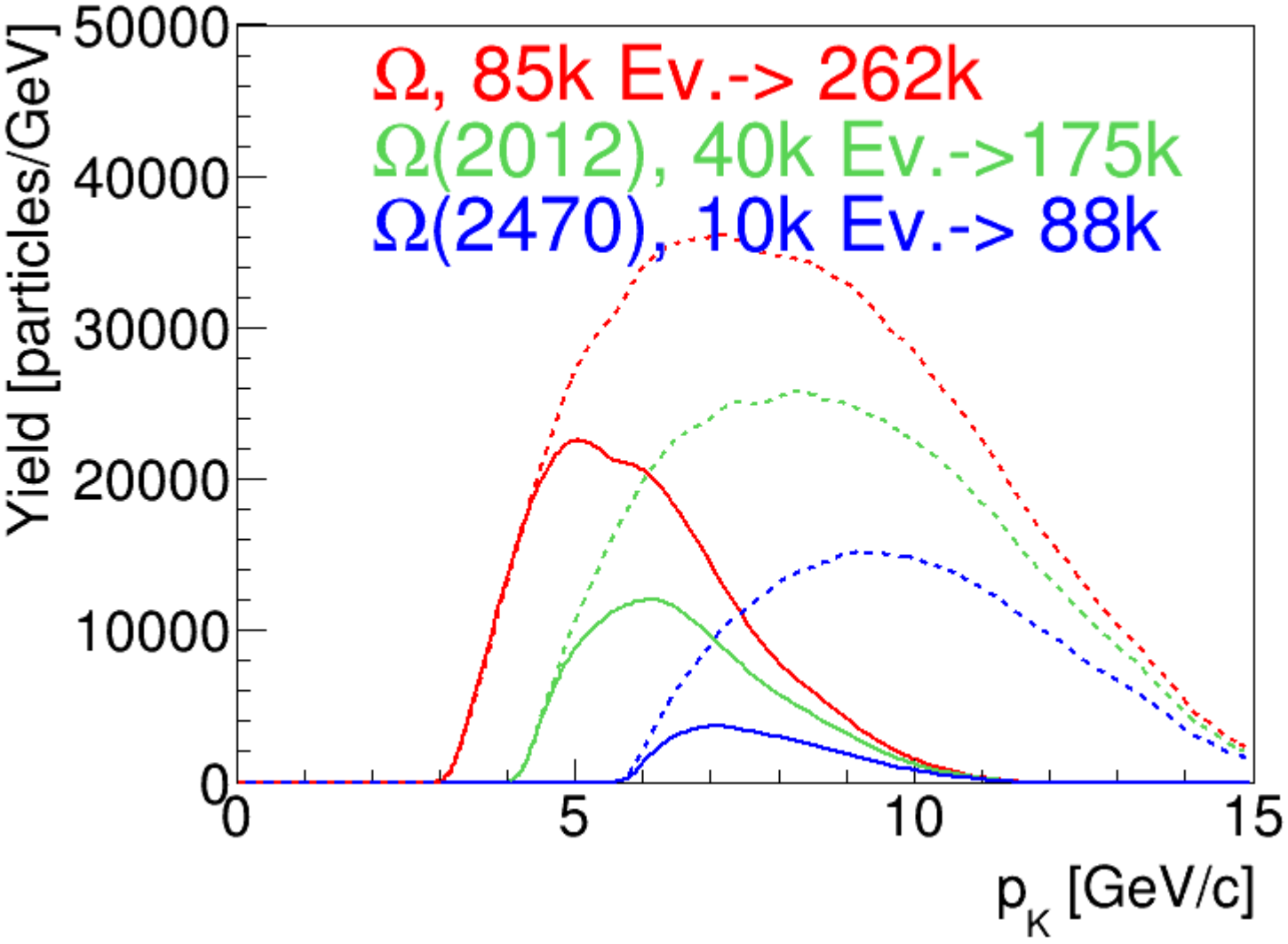
Omega Yield

$P_{e^-} = 19\ GeV/c$



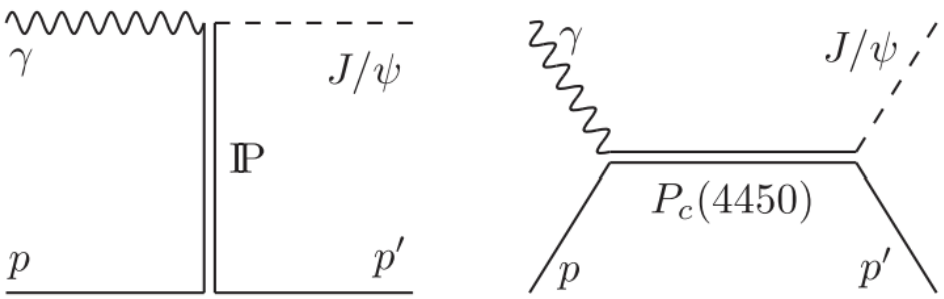
$P_{e^-} = 12\ GeV/c$

Omega Yield

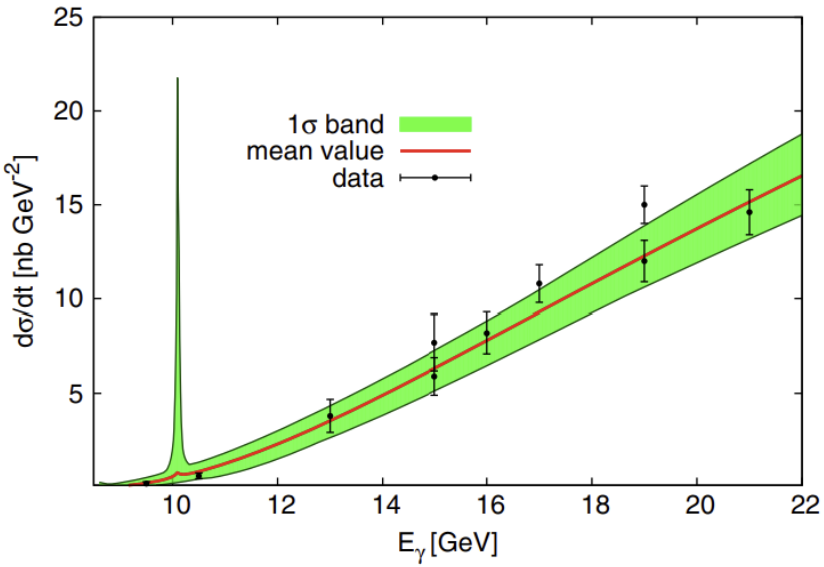

Ω, 85k Ev.-> 262k
Ω(2012), 40k Ev.->175k
Ω(2470), 10k Ev.-> 88k
Yield [particles/GeV]
50000
40000
30000
20000
10000
0
0
5
10
15
p_K [GeV/c]

Strange-Charm exotics

Hidden charm pentaquarks



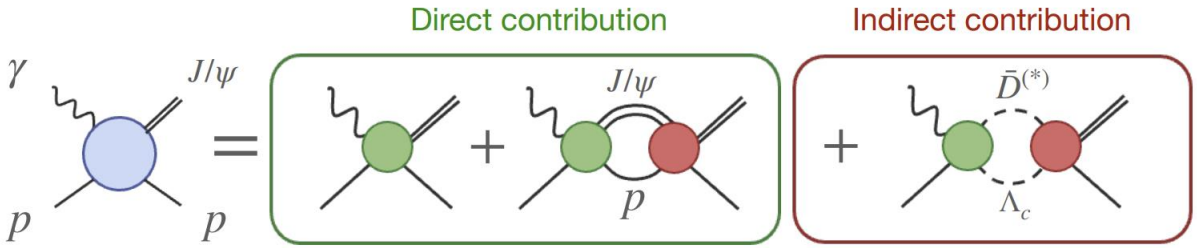
(a) Pomeron exchange (b) Resonant contribution

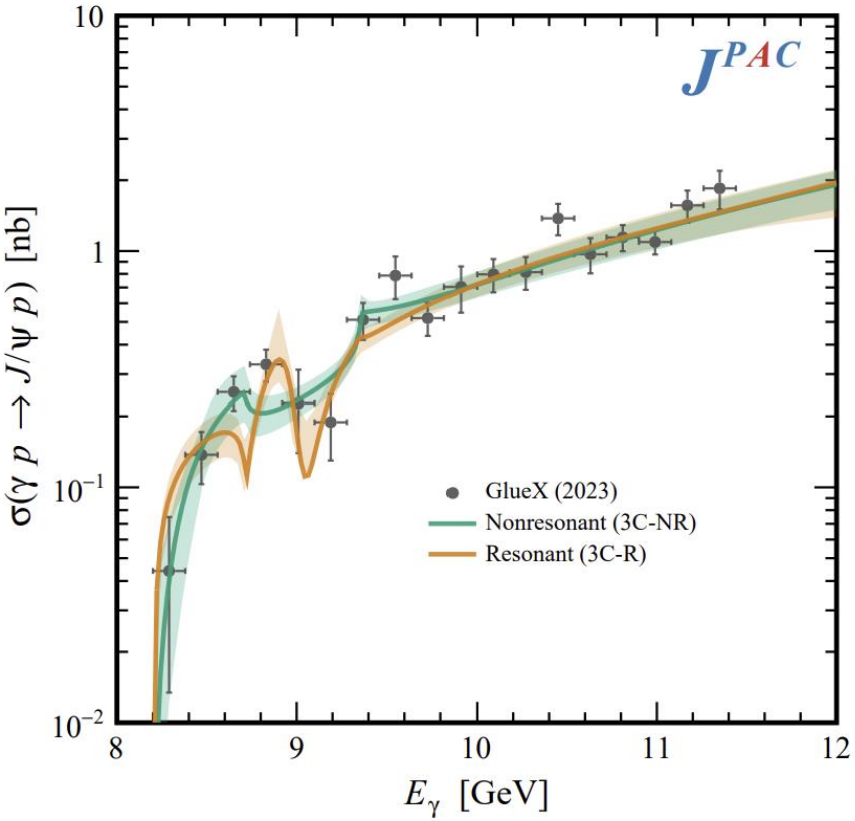


(a) $J_r = 3/2$, $\sigma_s = 0$ MeV

Phys Rev D94, 034002 (2016)

Hidden charm pentaquarks





Phys. Rev. D108, 054018, (2023)

Hidden charm pentaquarks J-PARC

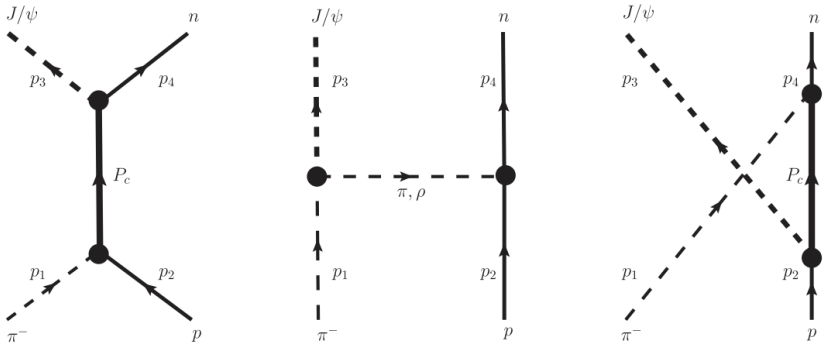


FIG. 1. Feynman diagrams for the $\pi^- p \to J/\psi n$ reaction.

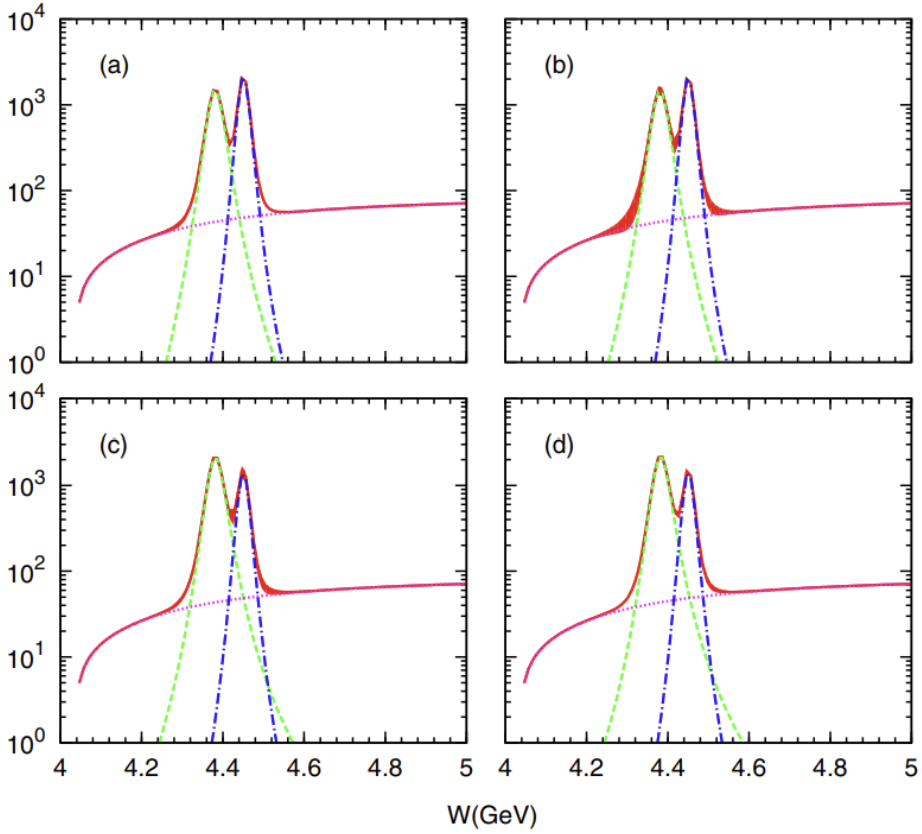
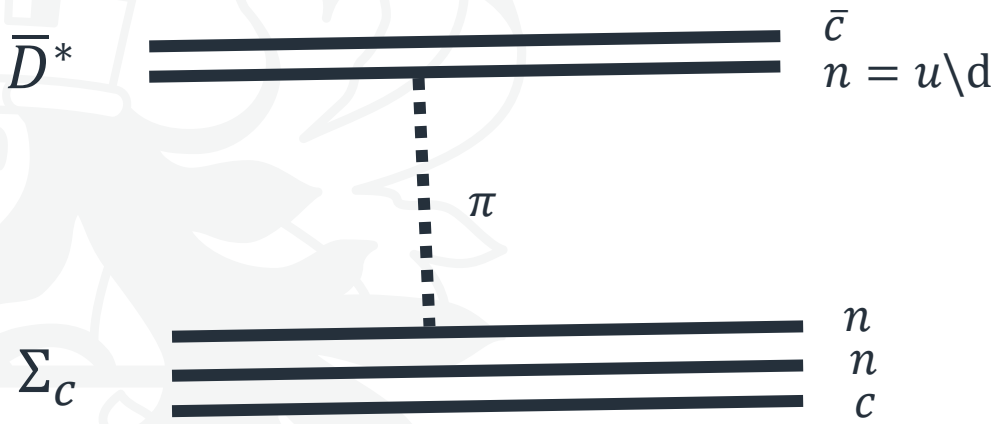


FIG. 2. The total cross sections for the $\pi^- p \to J/\psi n$ reaction

Phys Rev D93, 034009, (2016)

Hidden charm pentaquarks: KLF



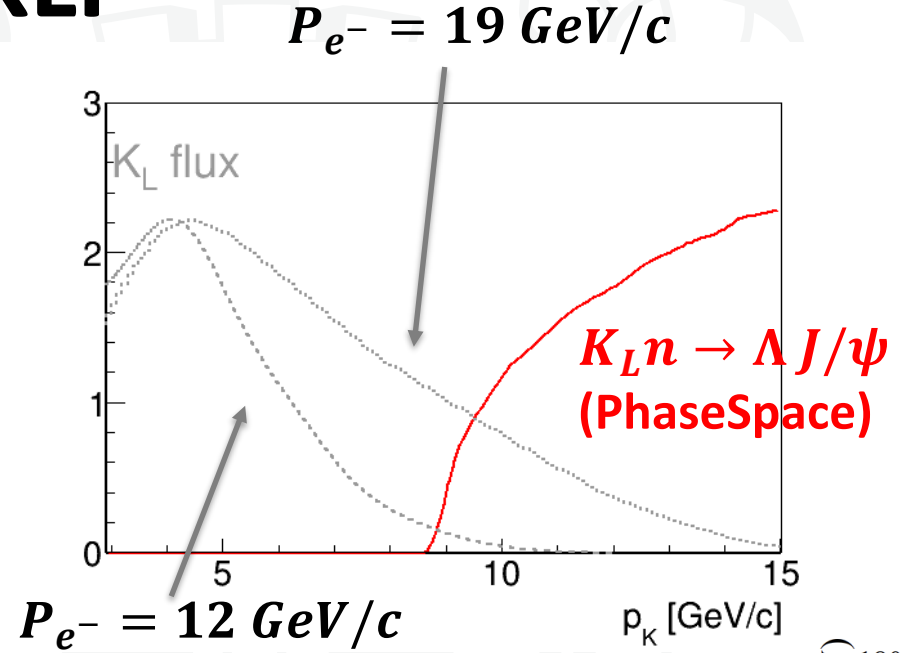
Molecule:

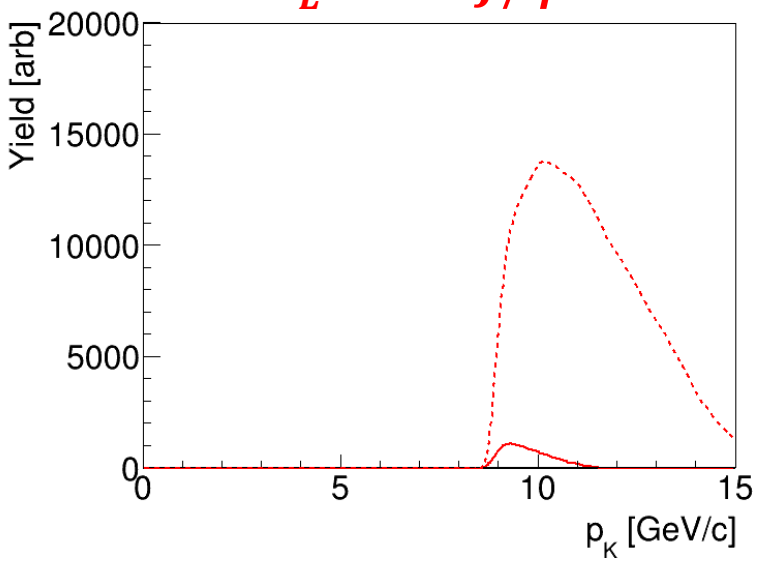
- Pion does not couple to s-quark
- Weaker long range pion exchange

Pentaquark:

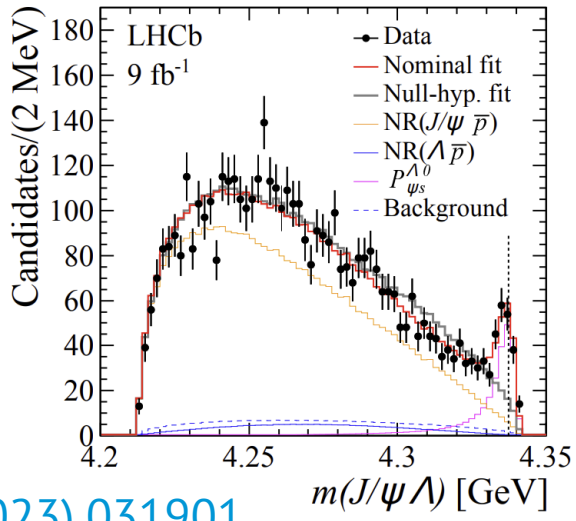
- Colour-magnetic force
  $\Delta E(QQ) = \frac{4\pi\alpha_s}{9m_i m_j}|\Psi(0)|^2\sigma_i\sigma_j$
- Suppressed for s-quark
- Smaller attraction/repulsion

Hidden charm pentaquarks: KLF





$K_L n \to \Lambda J/\psi$
$K_L p \to \Sigma^+ J/\psi$
$K_L n \to \Sigma^0 J/\psi$



$B^- \to \Lambda\ J/\psi\ \bar{p}$

[Phys. Rev. Lett. 131 (2023) 031901]

Conclusion

- Omega at KLF is measurable
  - decent statistics
- Require further simulations (acceptance/efficiency)
- 22 GeV JLab might be advantageous
  - Can run with 32ns or even 16ns bunch spacing
- Hidden-charm strange pentaquarks
  - S-channel
  - Different production mechanism& background
  - Molecule vs pentaquark