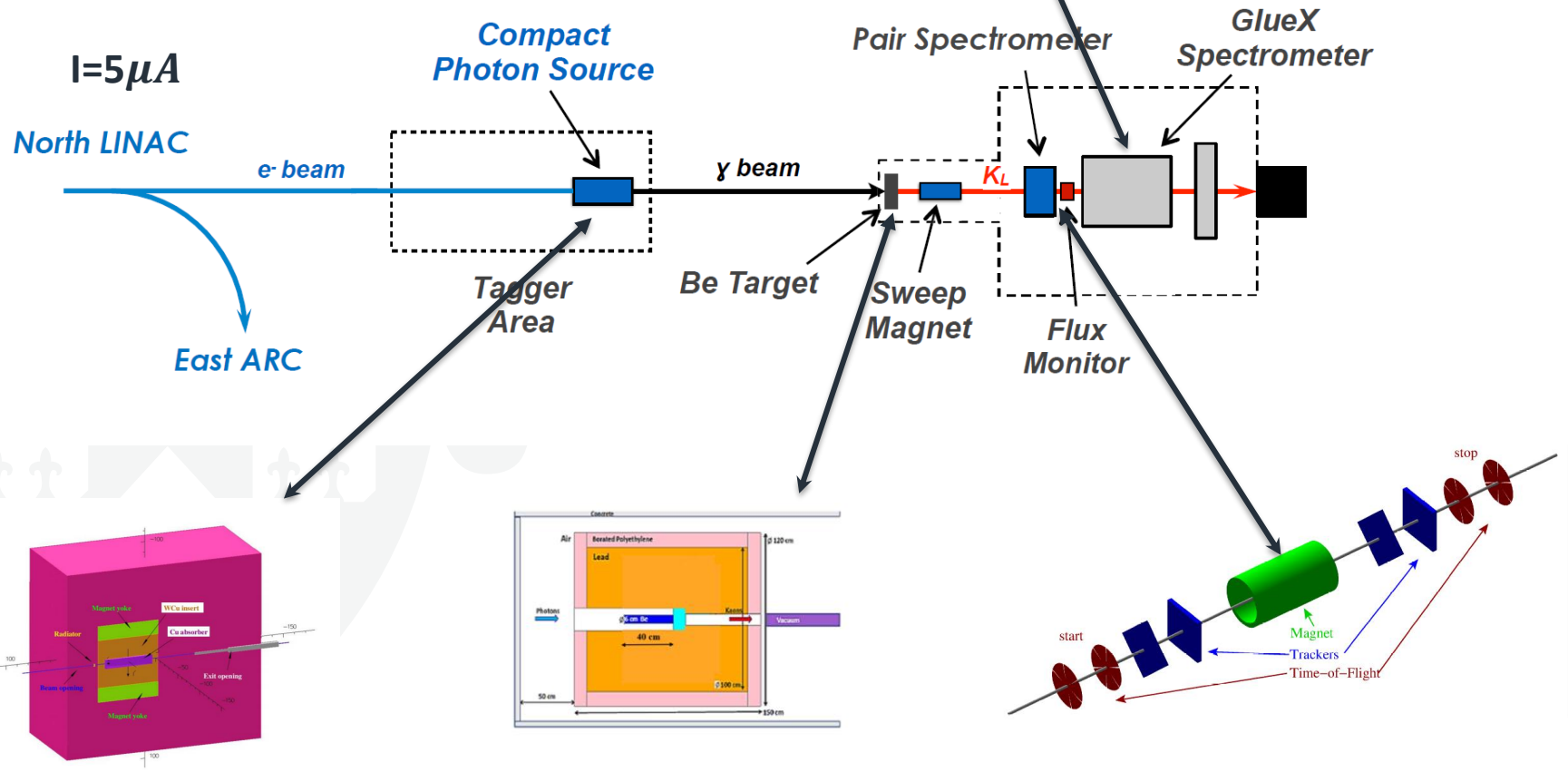
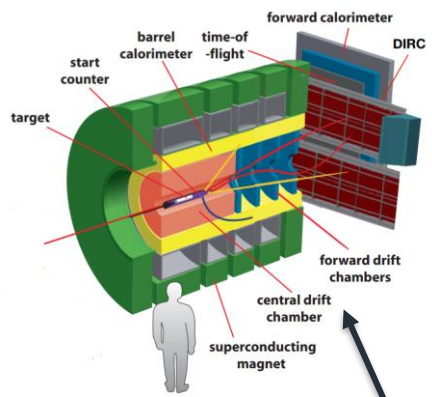




Hyperon spectroscopy at K_L -Facility

Outlook

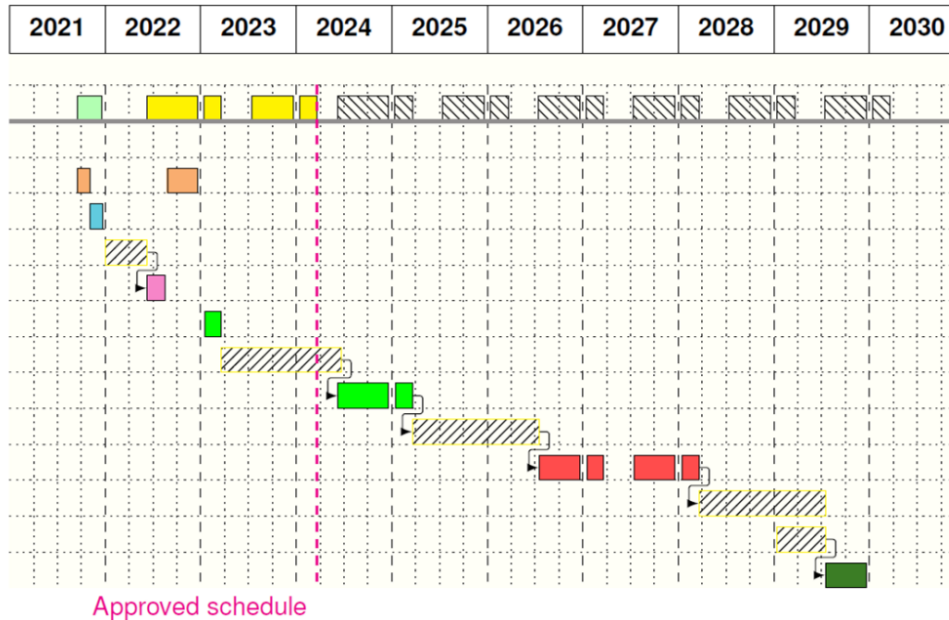
- K_L FACILITY IN A NUTSHELL
- TIMELINE
- LIMITATIONS
- HYPERONS
 - Σ -factory
 - Λ^* , Ξ^* , Ω^*
 - Exotic states (cusps, dynamically generated resonances, hadronic molecules)
- Y-N INTERACTIONS



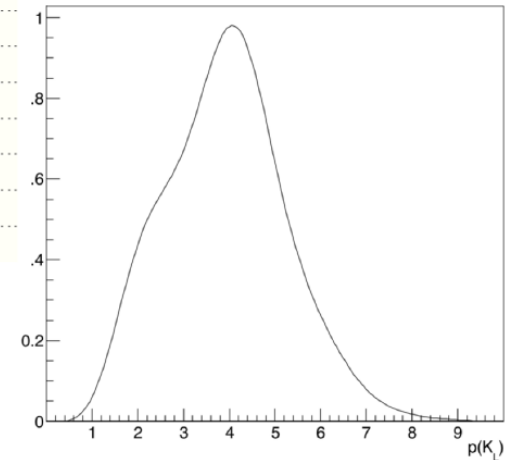
Hall D plans



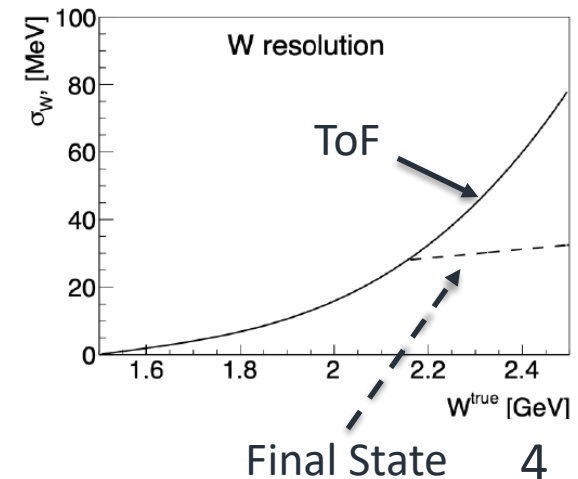
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K_L beam profile



- Intense K_L beam $\sim 10^4$ kaons/s on a target
 - Broad momentum range
 - Controlled by Flux Monitor
 - Excellent W reconstruction
 - Time-of-flight
 - Final state
- Proton and neutron target
 - Approved 100 days LH_2 target
 - Approved 100 days LD_2 target
- Low background level
- Exclusive final states



KLF



Be target



cryo target



24m time-of-flight

Beam structure:
 $I = 5\mu A$



64ns

KLF



Be target



cryo target



24m time-of-flight

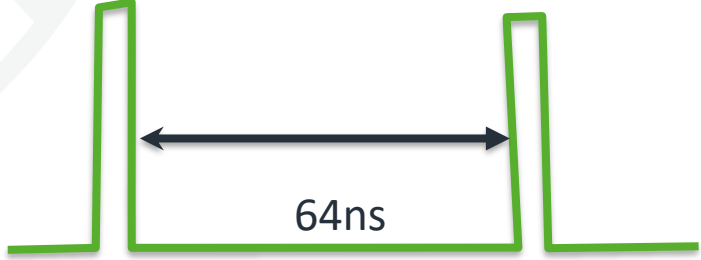
Beam structure:
 $I = 5\mu A$



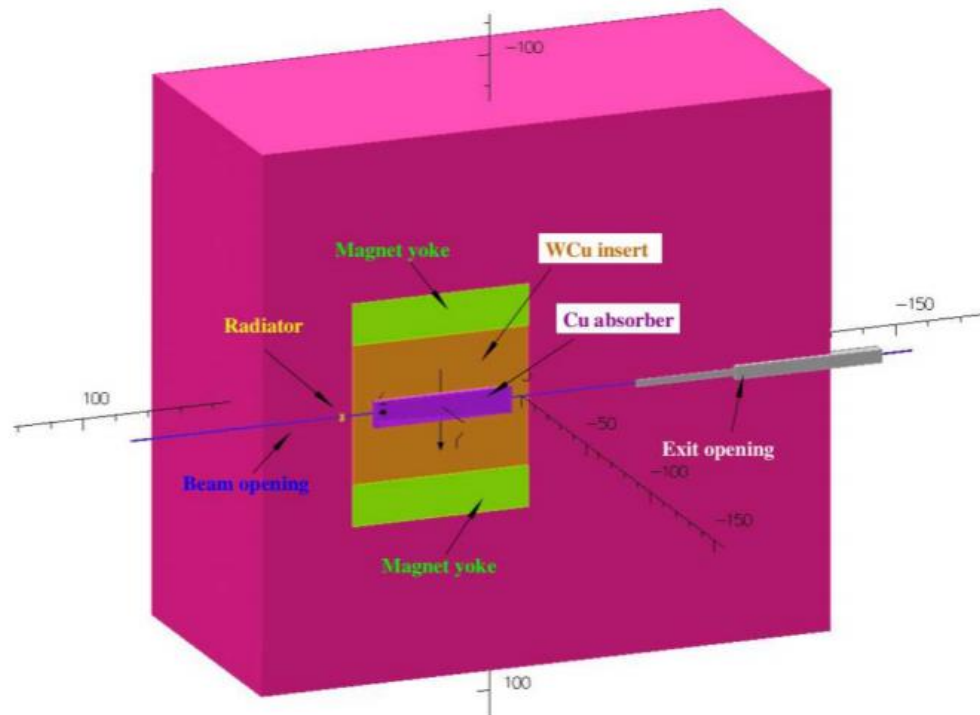
Beam structure:
 $I = 5\mu A$



Beam structure:
 $I = 10\mu A$



Compact photon source



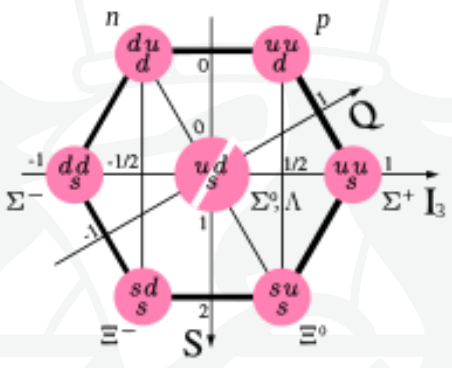
~100 tons



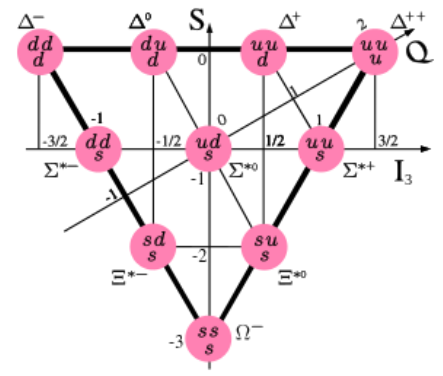
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Hyperons

Hyperons



Octet: N^* , Λ^* , Σ^* , Ξ^*
 Decuplet: Δ^* , Σ^* , Ξ^* , Ω^*



	LQCD* ($M < 2M_\Omega$)	"Observed", PDG
N^*	62	21
Δ^*	38	12
Λ^*	71	14
Σ^*	66	9
Ξ^*	73	6
Ω^*	36	2

*R.G. Edwards et al, Phys.Rev.D 87 (2013) 5, 054506

Theory limitations

Kaon beam brings one unit of strangeness:

- No associated kaons for Λ^* , Σ^* production
- 1 associated kaon for Ξ^*
- 2 associated kaons for Ω^*



Good

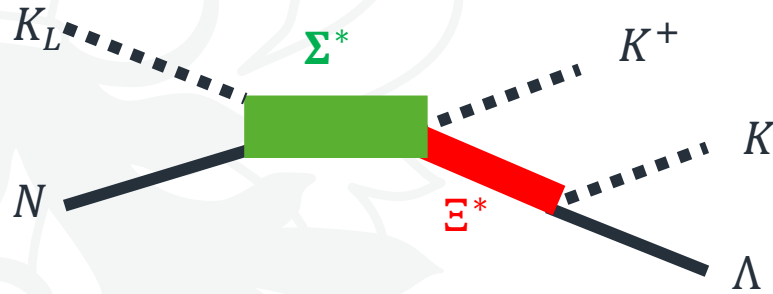


Acceptable



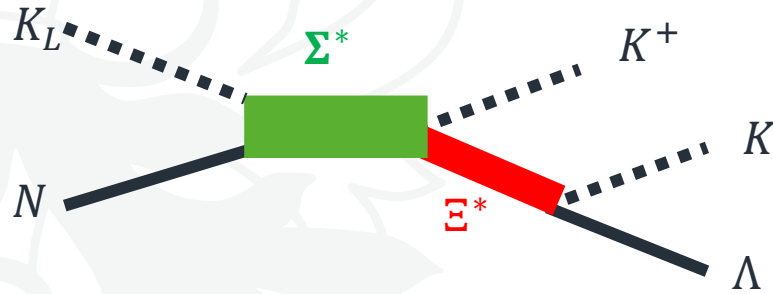
**Simplified,
model dependent analysis only**

Strange beams?

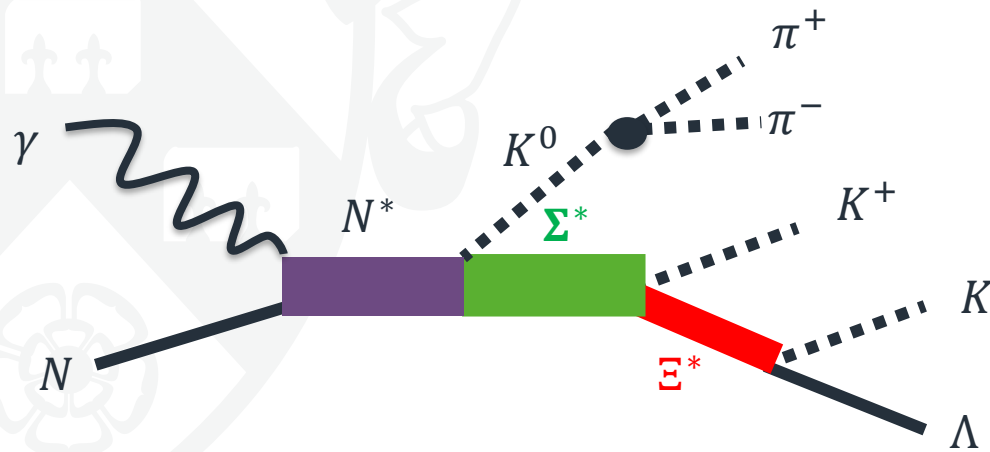


Direct Σ^* production

Strange beams?



Direct Σ^* production



Associated production

Sigma factory

$$K_L p \rightarrow \Sigma^* \rightarrow K_S p$$

$$K_L p \rightarrow \Sigma^* \rightarrow \pi^+ \Lambda$$

$$K_L p \rightarrow \Sigma^* \rightarrow K^+ \Xi^0$$

$$K_L p \rightarrow \Sigma^* \rightarrow \pi^0 \Sigma^+$$

$$K_L p \rightarrow \Sigma^* \rightarrow \eta \Sigma^+$$

$$K_L p \rightarrow \Sigma^* \rightarrow \omega \Sigma^+$$

$$K_L p \rightarrow \Sigma^* \rightarrow \eta' \Sigma^+$$

2 Body Final state

Pure Σ^* channels

Self-polarising observables

$$K_L p \rightarrow K^+ n$$

Non-resonant background

New findings: $\pi\Lambda/\pi\Sigma$

Isospin amplitudes



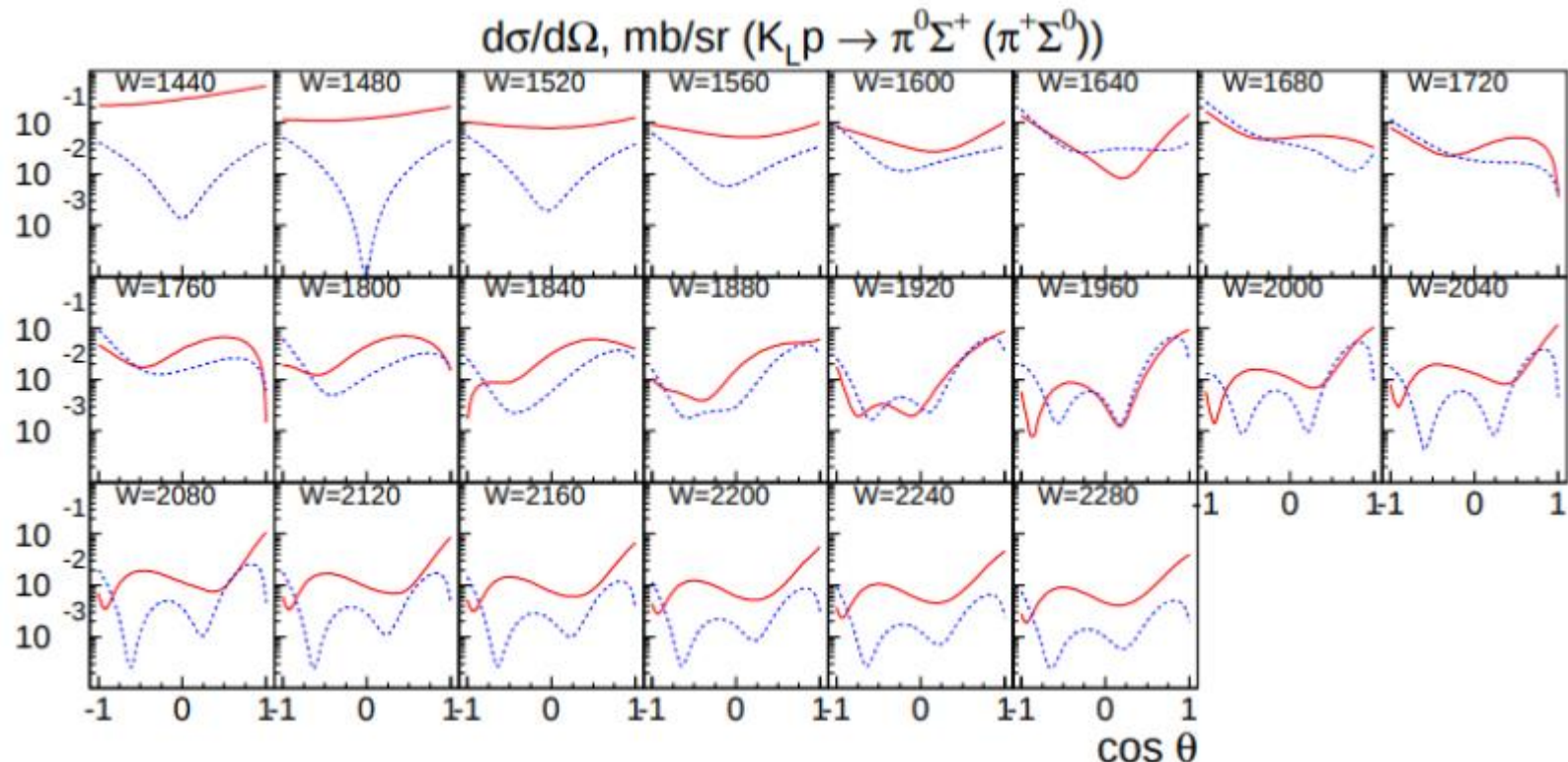
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$$|A(K^- p)|^2 = \frac{1}{2}(|A_1|^2 + |A_0|^2 + 2\text{Re}(A_1 A_0^*))$$

$$|A(K^0 n)|^2 = \frac{1}{2}(|A_1|^2 + |A_0|^2 - 2\text{Re}(A_1 A_0^*))$$

$$|A(K^0 p)|^2 = |A_1|^2.$$

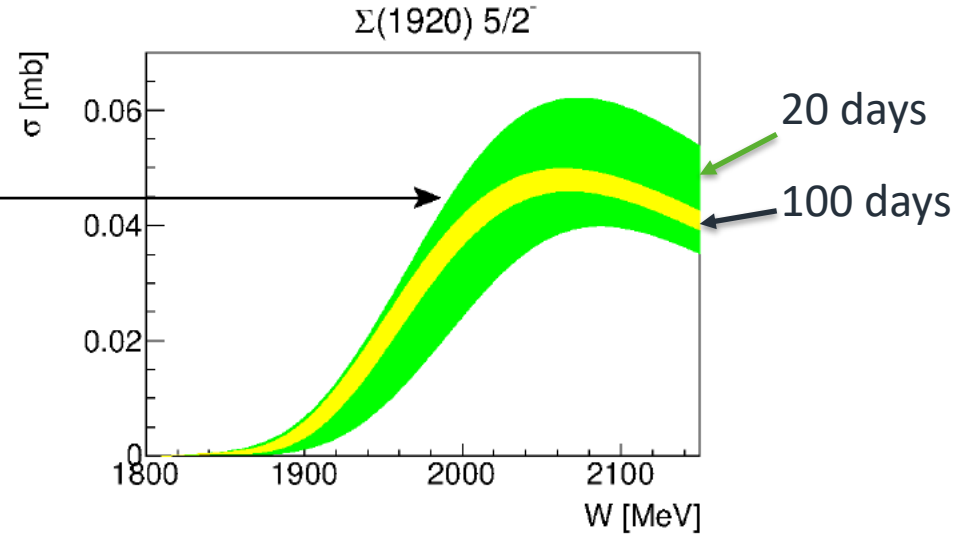
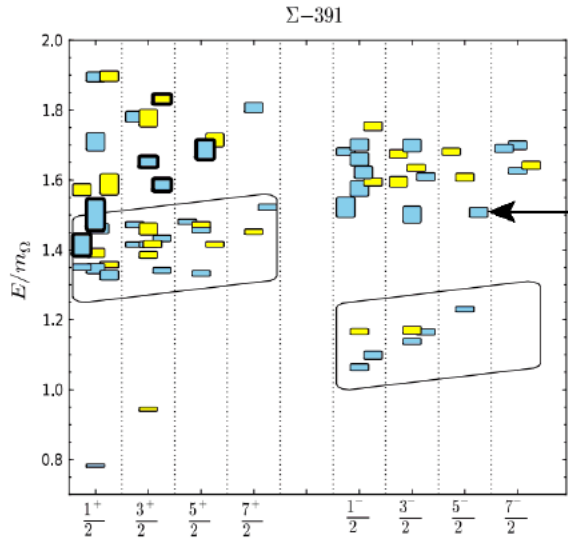
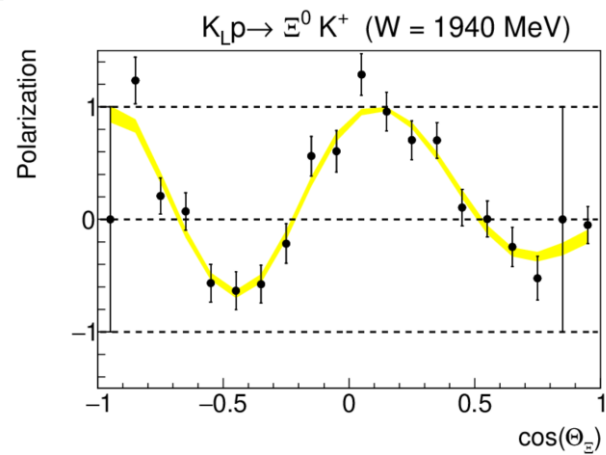
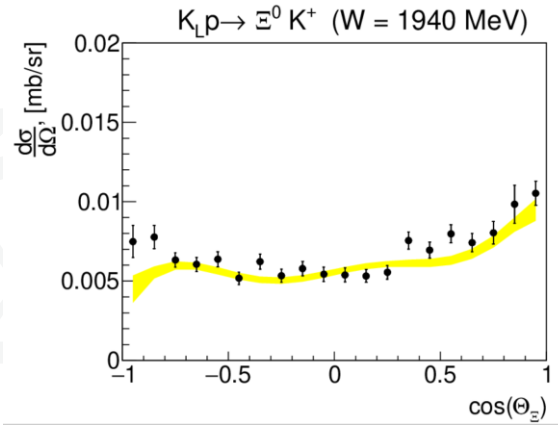
[arXiv:2008.08215v3](https://arxiv.org/abs/2008.08215v3)
KLF proposal 2020



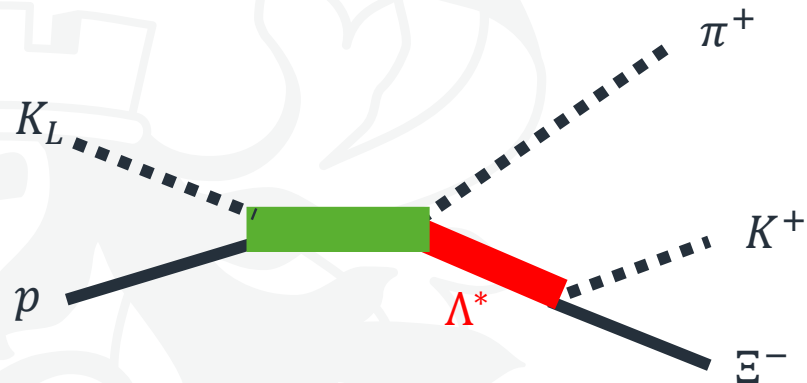
Expected results



$$K_L p \rightarrow K^+ \Xi^0$$



Excited Λ^*



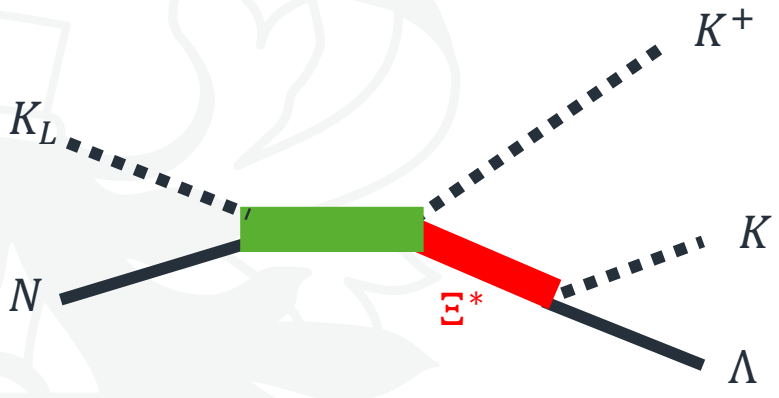
Associated production



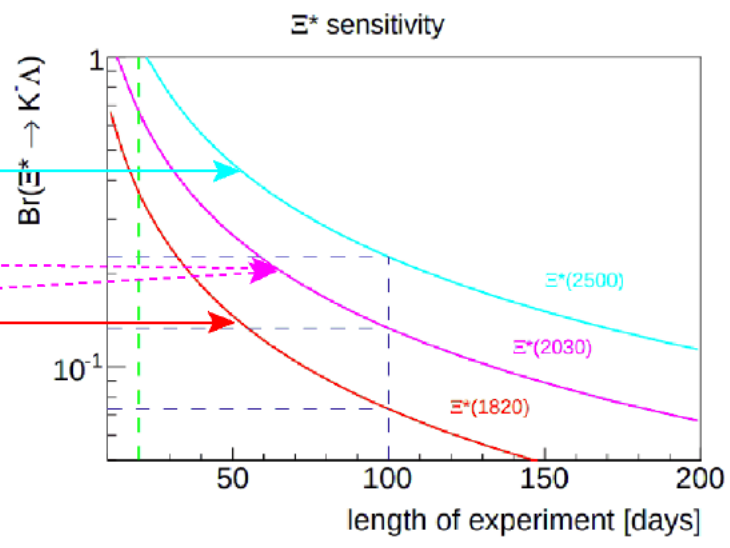
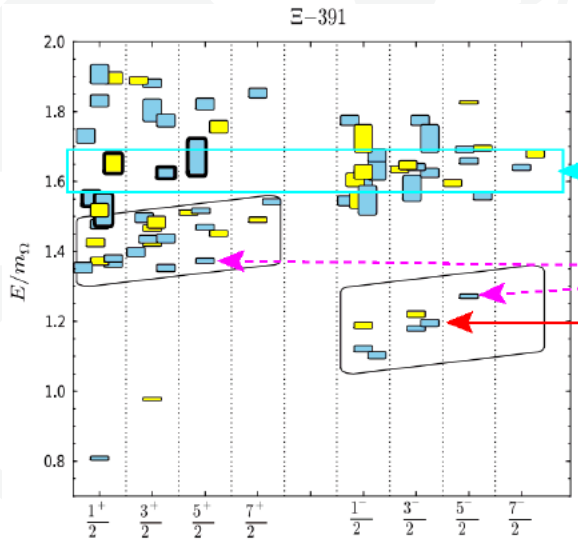
Direct formation

- Interference effects
- $\Lambda - \Sigma$ mixing
- Model-independent PWA
- Different background

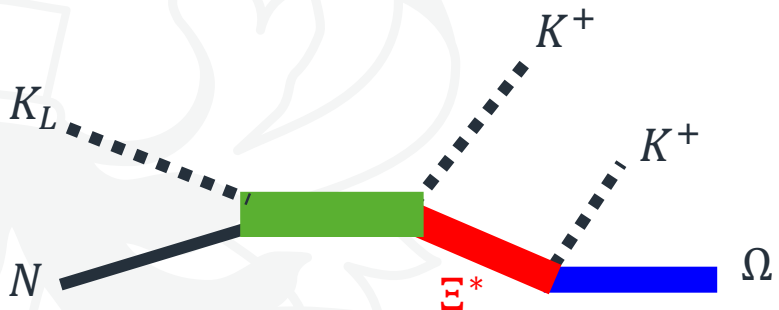
Excited Ξ^* in associated production



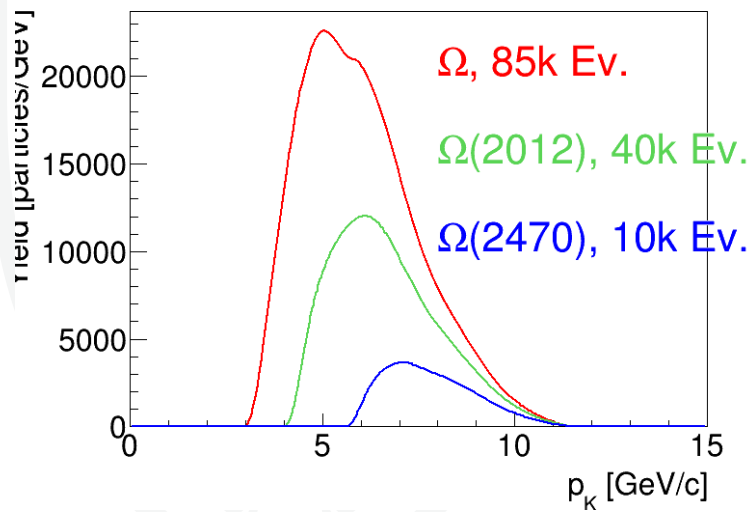
- $\Xi^* \rightarrow \Lambda K$
- $\Xi^* \rightarrow \Xi \pi$
- $\Xi^* \rightarrow \Xi \eta$
- $\Xi^* \rightarrow \Xi \omega$
- $\Xi^* \rightarrow \Sigma K$



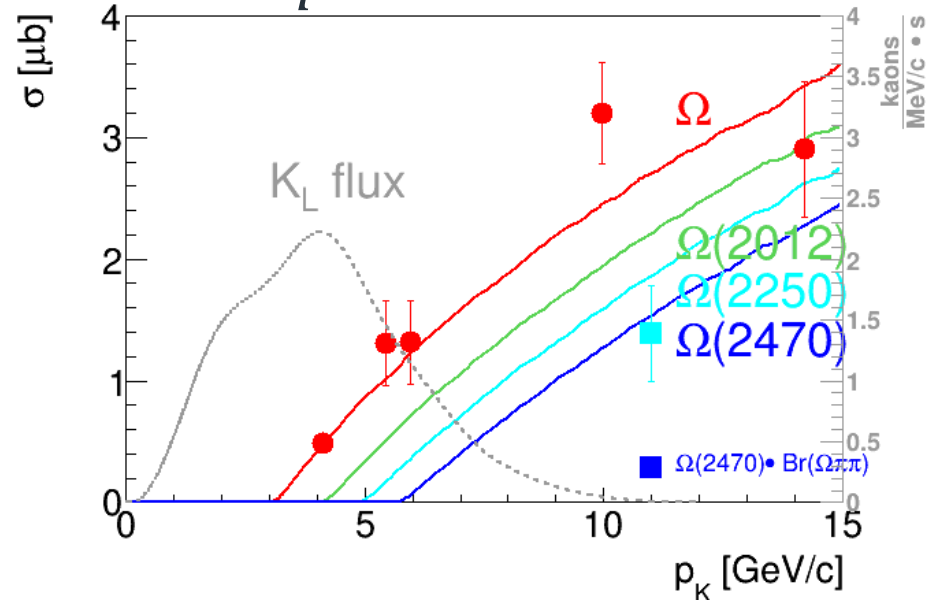
Excited Ω^* in associated production



Expected Yield



$$\bar{K}p \rightarrow \Omega^* X$$





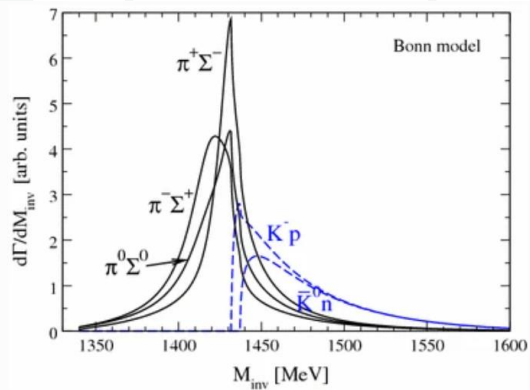
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Why Strangeness?

Molecules and cusps



$\Lambda_b \rightarrow J/\psi \Lambda(1405)$



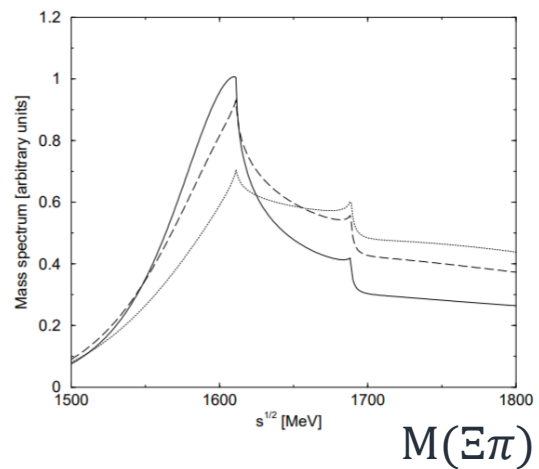
- Many thresholds
 - Cusps
 - Molecules
 - Dynamic resonances

- $\Lambda(1670), \bar{K}N$ vs $\pi\Sigma$ vs $\eta\Lambda$
- $\Sigma(1620)$

• [L. Roca](#), [M. Mai](#), [E. Oset](#) & [Ulf-G. Meißner](#)

States?
Decay channels?
Resolution?

$\Xi(1620)$



$\Xi\pi, \Lambda\bar{K}, \Sigma\bar{K}, \Xi\eta$

$M(\Xi\pi)$

A. Ramos, E. Oset , C. Bennhold

Strangeness is a key

- Many thresholds
 - Cusps
 - Molecules
 - Dynamic resonances

Light quark sector:

- + high statistics
- + easy to produce
- too broad
- too many interferences

Strange sector:

- + high statistics
- + easy to produce with K_L
- + perfect width
- + decent spacing

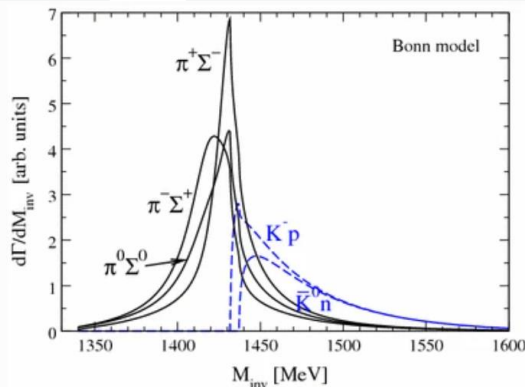
Heavy quark sector:

- low statistics
- hard to produce
- too narrow

Strangeness is a key

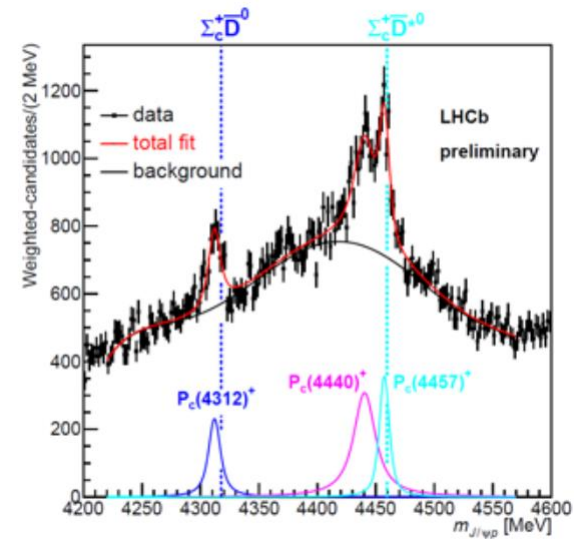
- Many thresholds
 - Cusps
 - Molecules
 - Dynamic resonances

$\Lambda_b \rightarrow J/\psi \Lambda(1405)$



• [L. Roca](#), [M. Mai](#), [E. Oset](#) & [Ulf-G. Meißner](#)

$\Lambda(1405) \leftrightarrow \pi \Sigma / \bar{K} N$ -molecule

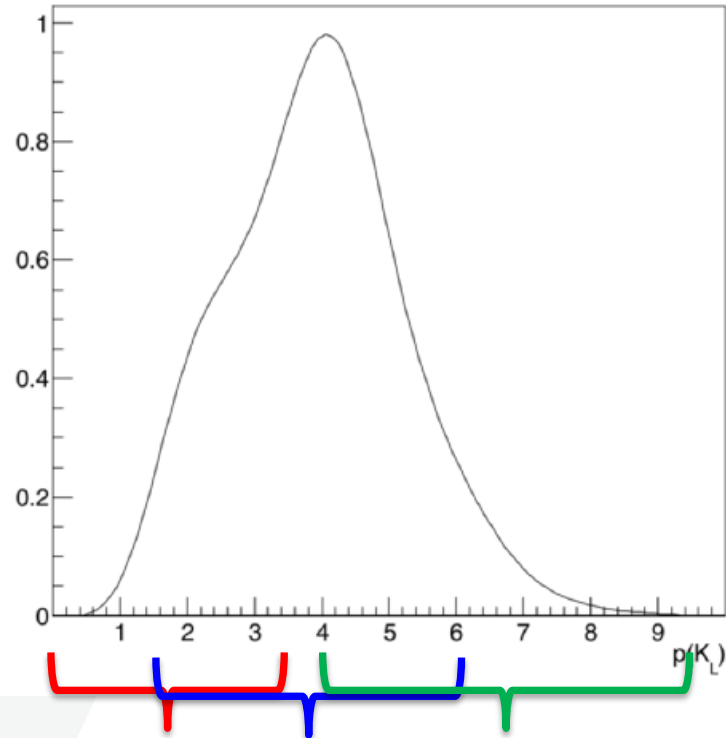


$P(4450) \leftrightarrow \bar{D}^* \Sigma_c$ -molecule

Continuous beam \rightarrow small systematics

KLF spectroscopy

K_L beam profile

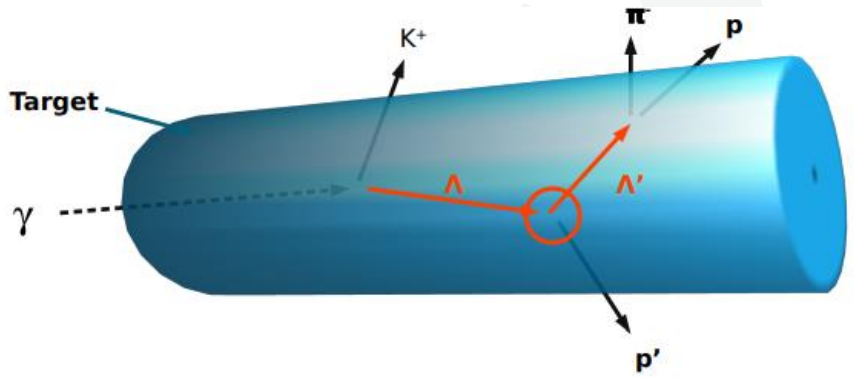


Direct formation

Meson spectroscopy

Associated production

Hyperon-nucleon Scattering



Cross sections

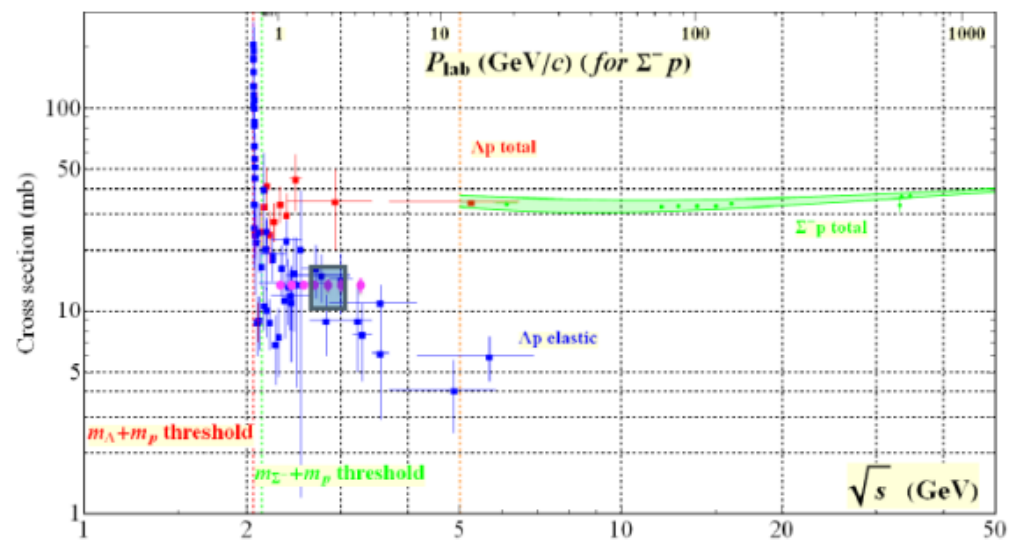
- Λp
- $\Sigma^- p$
- $\Sigma^+ p$
- Λd

Polarization observables

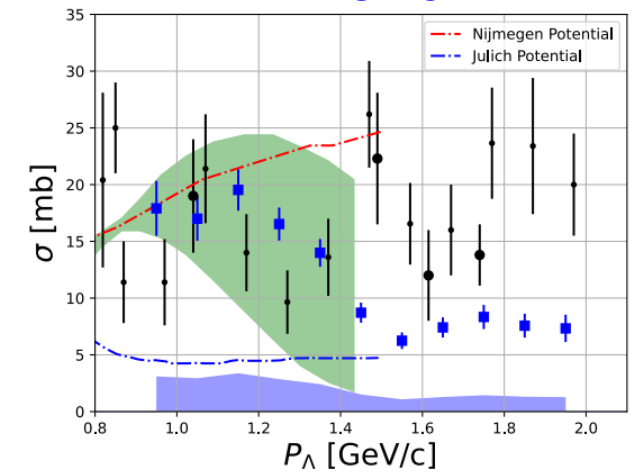
- Λn
- $\Sigma^- p$
- Λd
- Λp

PhysRevLett.127.272303 (2021)

KLF



CLAS



J. Haidenbauer and U.-G. Meißner, Phys. Rev. C 72, 044005 (2005)
 T. A. Rijken, V. G. J. Stoks, and Y. Yamamoto, Phys. Rev. C 59, 21 (1999).

Statistics

Inclusive reconstruction (with background suppression)

Reaction	Statistics (events)
$K_L p \rightarrow K_S p$	2.7M
$K_L p \rightarrow \pi^+ \Lambda$	7M
$K_L p \rightarrow K^+ \Xi^0$	2M
$K_L p \rightarrow K^+ n$	60M
$K_L p \rightarrow K^- \pi^+ p$	7M

**Inclusive \rightarrow Fully exclusive ($K_L p \rightarrow K^+ \Xi^0$):
2M \rightarrow 200k**

Possible improvements



- 24 GeV electron beam \rightarrow Ω production studies
- More intense beam (CPS, shielding, radiator...)
- Theory

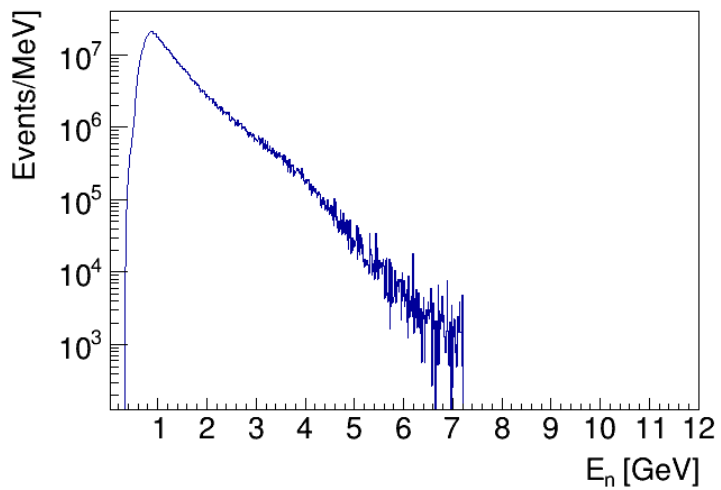
New collaborators welcome!!!

More information at <https://wiki.jlab.org/klproject>

Neutron beam

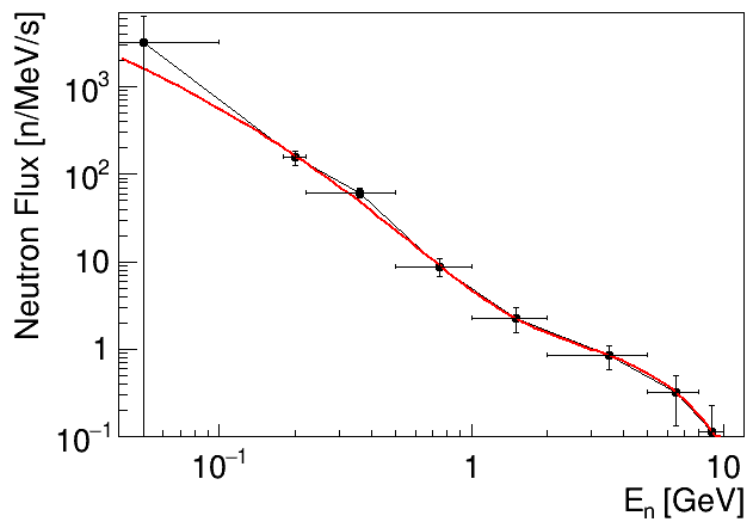


Neutron induced reactions (hadrons)



np reaction X-sections from SAID

Neutron flux



Low energy Neutron induced reactions-> Nuclear structure