K-Long Facility for JLab and its Scientific Potential

Igor Strakovsky*
The George Washington University

- KL2016 Workshop.
- Spectroscopy of Hyperons.
- Status of $K_L p$ data.
- Opportunity with K_L beam.
- Neutron Background.
- Expected $K_L p$ data.
- Summary.

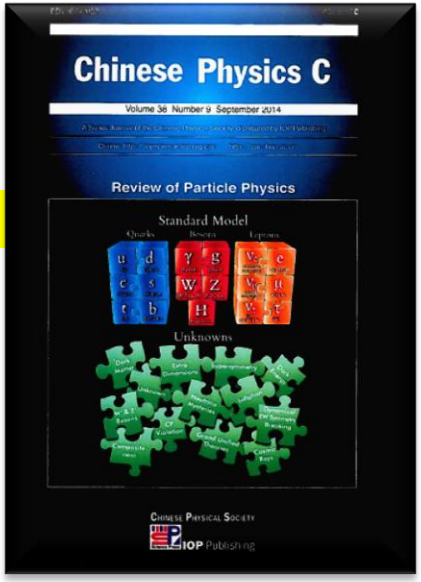
* Supported by DOE DE-SC0014133

Speakers: Amaryan, Chudakov, Albrow, Richards, Ramos, Schumacher, Oset, Zou, Kamano, Santopinto, Szczepaniak, Mathieu, Passemar, Taylor, Oh, Larin, Kohl, Keith, Noumi, Ziegler, Mai, Goity, Ohnishi, Nakayama, Degtyarenko, Myhrer, Filippi, Manley

60 people & 30 talks

https://www.jlab.org/conferences/kl2016/

Baryon Sector at PDG14



GW INS — Data Analysis Center — Institute for Nuclear Studies, The George Washington University

GW Contribution

K.A. Olive *et al* Chin Phys *C* **38**, 090001 (2014)

p	$1/2^+$	****
n	$1/2^+$	****
$N(1440)$	$1/2^+$	****
$N(1520)$	$3/2^-$	****
$N(1535)$	$1/2^-$	****
$N(1650)$	$1/2^-$	****
$N(1675)$	$5/2^-$	****
$N(1680)$	$5/2^+$	****
$N(1685)$		*
$N(1700)$	$3/2^-$	***
$N(17$[illegible]$)$	$1/2^+$	[illegible]
$N(1$[illegible]$)$	$3/2^+$	[illegible]
$N(1$[illegible]$)$	[illegible]	**
$N($[illegible]$5)$	[illegible]	***
$N($[illegible]$0)$	[illegible]	**
$N($[illegible]$95)$	[illegible]	**
$N(1900)$	$3/2^+$	***
$N(1990)$	$7/2^+$	**
$N(2000)$	$5/2^+$	**
$N(2040)$	$3/2^+$	*
$N(2060)$	$5/2^-$	**
$N(2100)$	$1/2^+$	*
$N(2120)$	$3/2^-$	**
$N(2190)$	$7/2^-$	****
$N(2220)$	$9/2^+$	****
$N(2250)$	$9/2^-$	****
$N(2600)$	$11/2^-$	***
$N(2700)$	$13/2^+$	**

$\Delta(1232)$	$3/2^+$	****
$\Delta(1600)$	$3/2^+$	***
$\Delta(1620)$	$1/2^-$	****
$\Delta(1700)$	$3/2^-$	****
$\Delta(1750)$	$1/2^+$	*
$\Delta(1900)$	$1/2^-$	**
$\Delta(1905)$	$5/2^+$	****
$\Delta(1910)$	$1/2^+$	****
$\Delta(1920)$	$3/2^+$	[illegible]
$\Delta(1930)$	$5/2$[illegible]	[illegible]
$\Delta(1940)$	[illegible]	[illegible]
$\Delta(1950)$	$7/2^+$	[illegible]
$\Delta(2000)$	$5/2^+$	[illegible]
$\Delta(21$[illegible]$)$	$1/2^-$	[illegible]
$\Delta($[illegible]$)$	[illegible]	[illegible]
$\Delta(2300)$	$9/2^+$	**
$\Delta(2350)$	$5/2^-$	*
$\Delta(2390)$	$7/2^+$	*
$\Delta(2400)$	$9/2^-$	**
$\Delta(2420)$	$11/2^+$	****
$\Delta(2750)$	$13/2^-$	**
$\Delta(2950)$	$15/2^+$	**
Λ	$1/2^+$	****
$\Lambda(1405)$	$1/2^-$	****
$\Lambda(1520)$	$3/2^-$	****
$\Lambda(1600)$	$1/2^+$	***
$\Lambda(1670)$	$1/2^-$	****
$\Lambda(1690)$	$3/2^-$	****
$\Lambda(1800)$	$1/2^-$	[illegible]
$\Lambda(1810)$	$1/2^+$	[illegible]
$\Lambda(1820)$	$5/$[illegible]	[illegible]
$\Lambda(1830)$	[illegible]$/2^-$	[illegible]
$\Lambda(1890)$	$3/2^+$	[illegible]
$\Lambda(2000)$		
$\Lambda(2$[illegible]$)$	$7/2^+$	[illegible]
$\Lambda(2100)$	$7/2^-$	****
$\Lambda(2110)$	$5/2^+$	***
$\Lambda(2325)$	$3/2^-$	*
$\Lambda(2350)$	$9/2^+$	***
$\Lambda(2585)$		**

Σ^+	$1/2^+$	****
Σ^0	$1/2^+$	****
Σ^-	$1/2^+$	****
$\Sigma(1385)$	$3/2^+$	****
$\Sigma(1480)$		*
$\Sigma(1560)$		**
$\Sigma(1580)$	$3/2^-$	*
$\Sigma(1620)$	$1/2^-$	**
$\Sigma(1660)$	$1/2^+$	***
$\Sigma(1670)$	$3/2^-$	****
$\Sigma(1690)$		**
$\Sigma(1750)$	$1/2^-$	***
$\Sigma(1770)$	$1/2^+$	*
$\Sigma(1775)$	$5/2^-$	****
$\Sigma(1840)$	[illegible]	[illegible]
$\Sigma(1880)$	[illegible]$/2^+$	**
$\Sigma(1915)$	[illegible]	****
$\Sigma(1940)$	[illegible]	***
$\Sigma(2000)$	$1/2^-$	*
$\Sigma(203$[illegible]$)$	$7/2^+$	[illegible]
$\Sigma($[illegible]$)$	[illegible]	*
$\Sigma(2080)$	$3/2^+$	**
$\Sigma(2100)$	$7/2^-$	*
$\Sigma(2250)$		***
$\Sigma(2455)$		**
$\Sigma(2620)$		**
$\Sigma(3000)$		*
$\Sigma(3170)$		*

Ξ^0	$1/2^+$	****
Ξ^-	$1/2^+$	****
$\Xi(1530)$	[illegible]	[illegible]
$\Xi(162$[illegible]$)$		*
$\Xi(1690)$		***
$\Xi(1820)$	[illegible]	***
$\Xi(195$[illegible]$)$		***
$\Xi(2030)$	$\geq \frac{5}{2}?$	***
[illegible]		*
$\Xi(2250)$		**
$\Xi(2370)$		**
$\Xi(2500)$		*
Ω^-	$3/2^+$	[illegible]
$\Omega($[illegible]$0)^-$		[illegible]
$\Omega($[illegible]$80)^-$		[illegible]
$\Omega($[illegible]$70)^-$		

Λ_c^+	$1/2^+$	****
$\Lambda_c(2595)^+$	$1/2^-$	***
$\Lambda_c(2625)^+$	$3/2^-$	***
$\Lambda_c(2765)^+$		*
$\Lambda_c(2880)^+$	$5/2^+$	***
$\Lambda_c(2940)^+$		***
$\Sigma_c(2455)$	$1/2^+$	****
$\Sigma_c(2520)$	$3/2^+$	***
$\Sigma_c(2800)$		***
Ξ_c^+	$1/2^+$	***
Ξ_c^0	$1/2^+$	***
$\Xi_c'^+$	$1/2^+$	***
$\Xi_c'^0$	$1/2^+$	***
$\Xi_c(2645)$	$3/2^+$	***
$\Xi_c(2790)$	$1/2^-$	***
$\Xi_c(2815)$	$3/2^-$	***
$\Xi_c(2930)$		*
$\Xi_c(2980)$		***
$\Xi_c(3055)$		**
$\Xi_c(3080)$		***
$\Xi_c(3123)$		*
Ω_c^0	$1/2^+$	***
$\Omega_c(2770)^0$	$3/2^+$	***
Ξ_{cc}^+		*
Λ_b^0	$1/2^+$	***
Σ_b	$1/2^+$	***
Σ_b^*	$3/2^+$	***
Ξ_b^0, Ξ_b^-	$1/2^+$	***
Ω_b^-	$1/2^+$	***

N Δ Λ Σ Ξ Ω

- Check of **PDG Listings** reveals that resonance parameters of many established states **are not well determined.**

- **PDG14** has **112 Baryon Resonances** (**58** of them are **4*** & **3***).
- For example in case of **SU(6)** x **O(3)**, it would be required **434** resonances, if all revealed multiplets were completed (**three 70** & **four 56**).

- There are **many more states** in **QCD** inspired models than **currently observed**.

Baryon Resonances

- **Three light quarks** can be arranged in **6** baryonic families, **N***, **Δ***, **Λ***, **Σ***, **Ξ***, & **Ω***.
- **Number of members** in a family that can exist **is not arbitrary**.
- If **$SU(3)_F$** symmetry of **QCD** is controlling, then:

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

- Number of experimentally identified resonances of each baryon family in PDG summary tables is **17 N***, **24 Δ***, **14 Λ***, **12 Σ***, **7 Ξ***, & **2 Ω***.
- **Constituent Quark** models, for instance, predict existence of no less than **64 N***, **22 Δ*** states with **mass < 3** GeV.

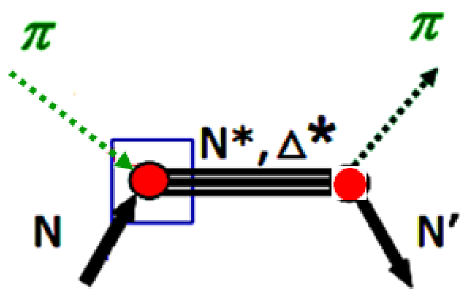
- Seriousness of "**missing-states**" problem is obvious from these numbers.

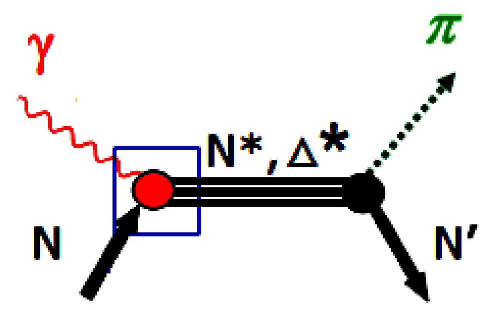
- To complete **$SU(3)_F$** multiplets, one needs no less than **17 Λ***, **41 Σ***, **41 Ξ***, & **24 Ω***.

B.M.K. Nefkens, πN Newsletter, **14**, 150 (1997)

Non-Strange Sector

- **S**-channel Baryon Resonances.





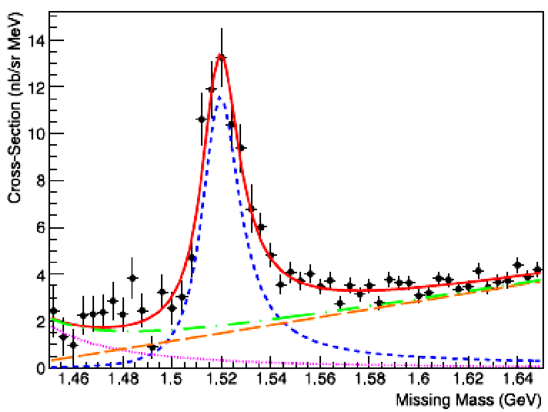
- In **elementary particle physics** involving energies less than **3** GeV in **W** the study of **lightest meson** (π^0, η & so on) photoproduction has always been **complementary** tool to elastic **πN** scattering.

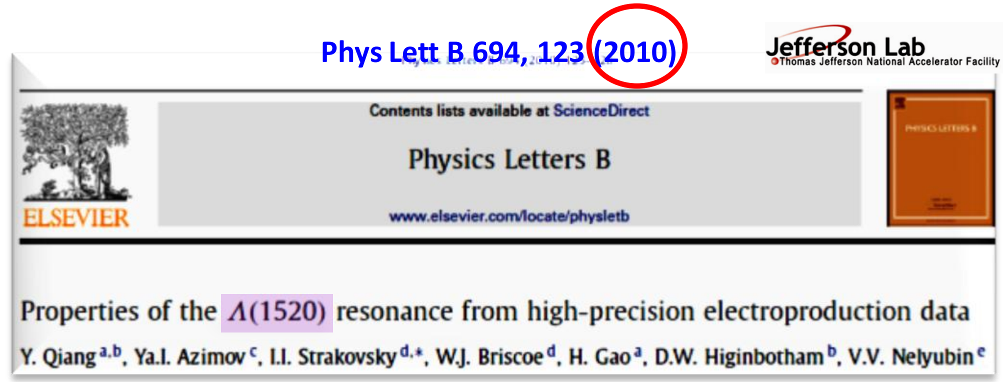
- **EM** production does not give equally good information for **Hyperon Spectroscopy**. New high-quality **data** from **measurements** with high-quality **Kaon beams** for wide range of **reactions** are critically needed.

Spectroscopy of Hyperons

- Our current "experimental" knowledge of Λ^*, Σ^*, Ξ^*, & Ω^* resonances is far **worse** than our knowledge of **N*** & Δ^* resonances, though they are **equally fundamental**.

- **Pole** position in complex energy plane for **hyperons** has began to be studied only recently, first of all for **Λ(1520)**.




Phys Lett B 694, 123 (2010)

Jefferson Lab
Thomas Jefferson National Accelerator Facility

Contents lists available at ScienceDirect

Physics Letters B

www.elsevier.com/locate/physletb

ELSEVIER

Properties of the $\Lambda(1520)$ resonance from high-precision electroproduction data

Y. Qiang[a,b], Ya.I. Azimov[c], I.I. Strakovsky[d,*], W.J. Briscoe[d], H. Gao[a], D.W. Higinbotham[b], V.V. Nelyubin[e]

- Clearly, complete understanding of **three-quark bound** states requires to learn about baryon resonances in ``**strange sector**" as well.

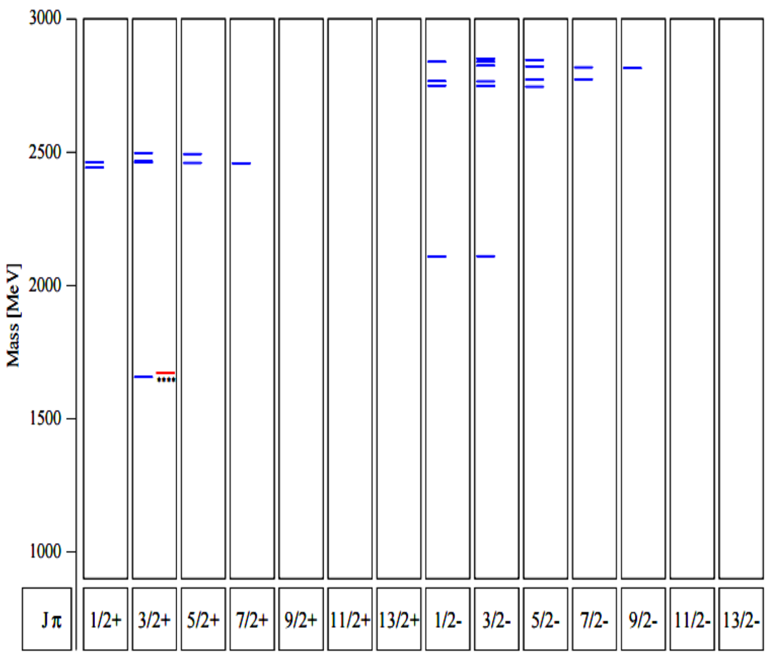
- One of secondary beam problems is that **K^- yield** is less than **π^- one** by factor of about **500**.
- This is main reason why there are limited exp data for **Kaon** induced measurements & moreover there are negligible amount of **polarized** experiments.

Very Strange Resonances &
Problem of "Missing" States

- Experimental knowledge of hadron spectrum is incomplete: more excited states are expected to exist.

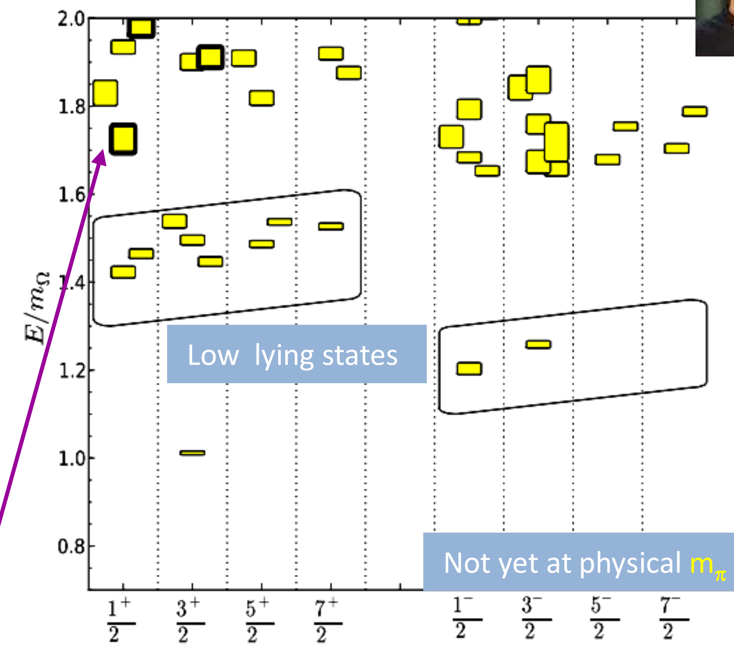

R. Koniuk and N. Isgur, Phys Rev Lett **44**, 845 (1980)

- Ω baryon spectrum in **QM**.



U. Lőring *et al* Eur Phys J A **10**, 447 (2001)

- Ω baryon spectrum in **LQCD**.



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

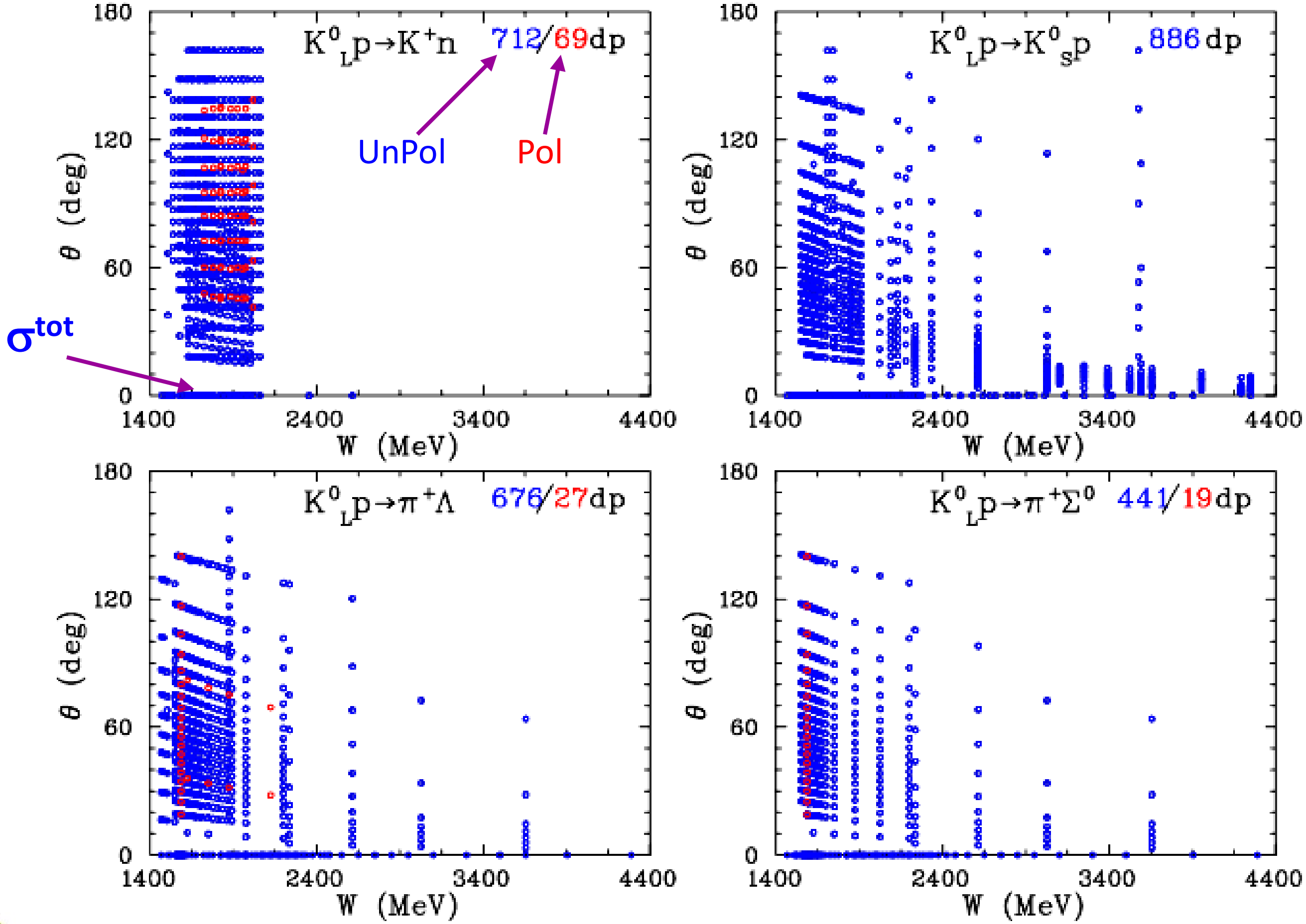
Thick frame: **Hybrid states**

World K-long Data

W = 1.45 – 5.05 GeV

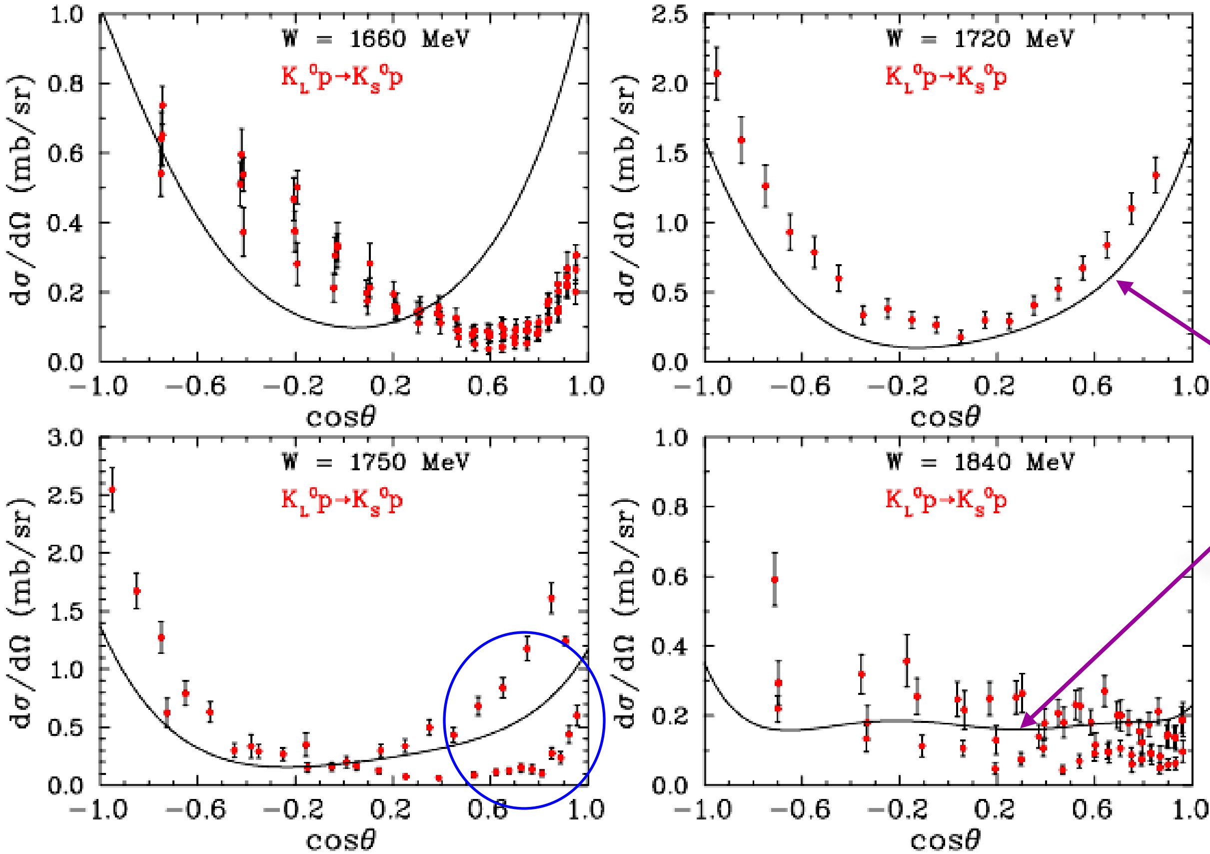
SAID: http://gwdac.phys.gwu.edu/

- Limited number of K_L induced measurements (1961 – 1982) **2426 dσ/dΩ**, **348 σ^{tot}**, & **115 P** observables do not allow today to **feel comfortable** with **Hyperon Spectroscopy** results.



- Most of **data** were obtained from **old** low statistics **measurements** with hydrogen **Bubble Chambers**.
- **Overall systematics** of previous experiments varies between **15%** and **35%** & **Energy binning** is much broader than hyperon widths.
- There were no measurements using **polarized target**. It means that there are no double polarized observables which are critical for **complete experiment** program.
- We are not aware of any data on **neutron** target.

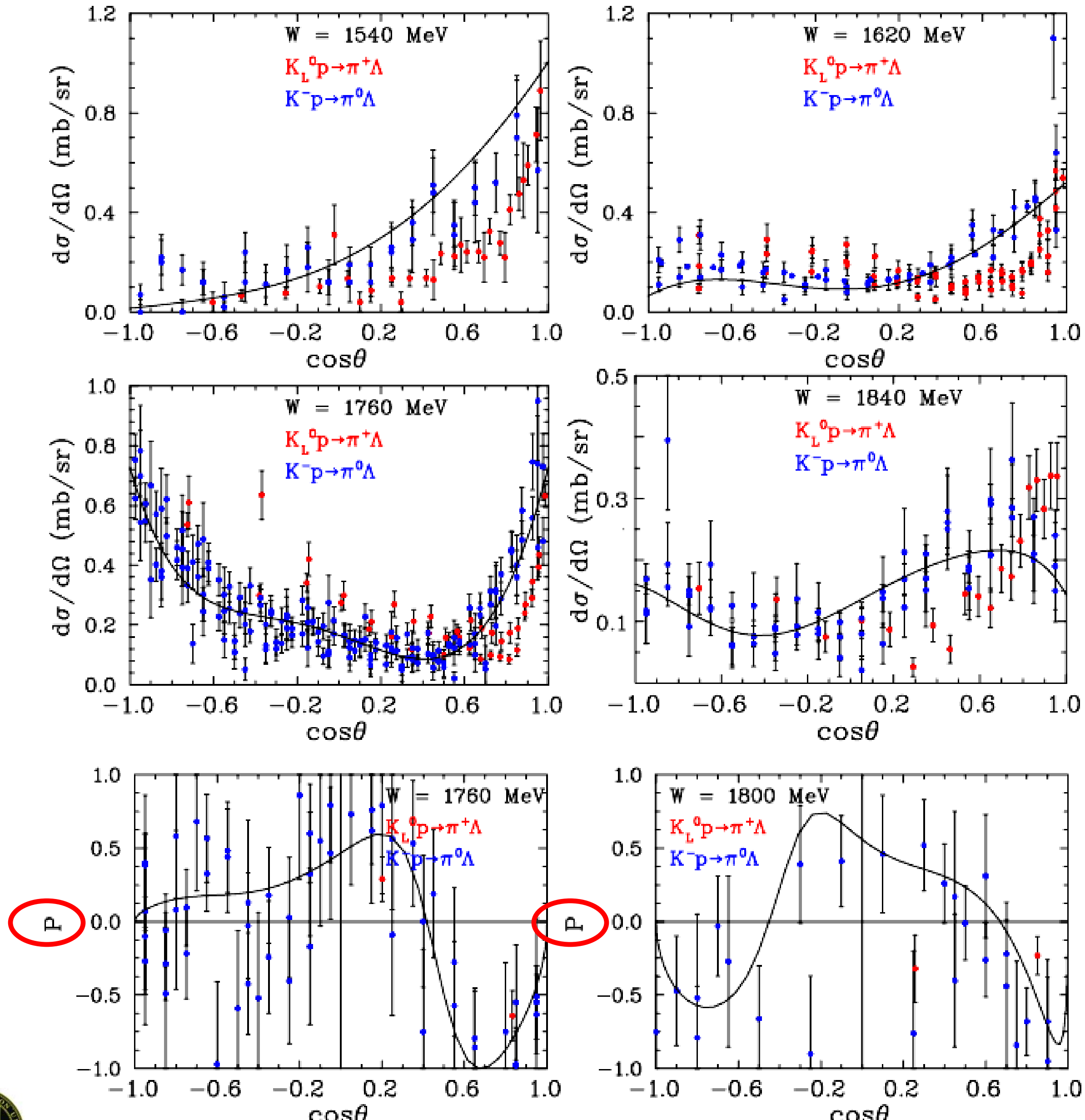
Data for $K_L p \to K_S p$



- No **dσ/dΩ** data are available for **$K_L p \to K_L p$** below W = **2950** MeV.
- **PWA** (**KSU**&**GW**) predictions at lower & higher energies tend to agree worse with data than in non-strange case.

Courtesy of Mark Manley, KL2016

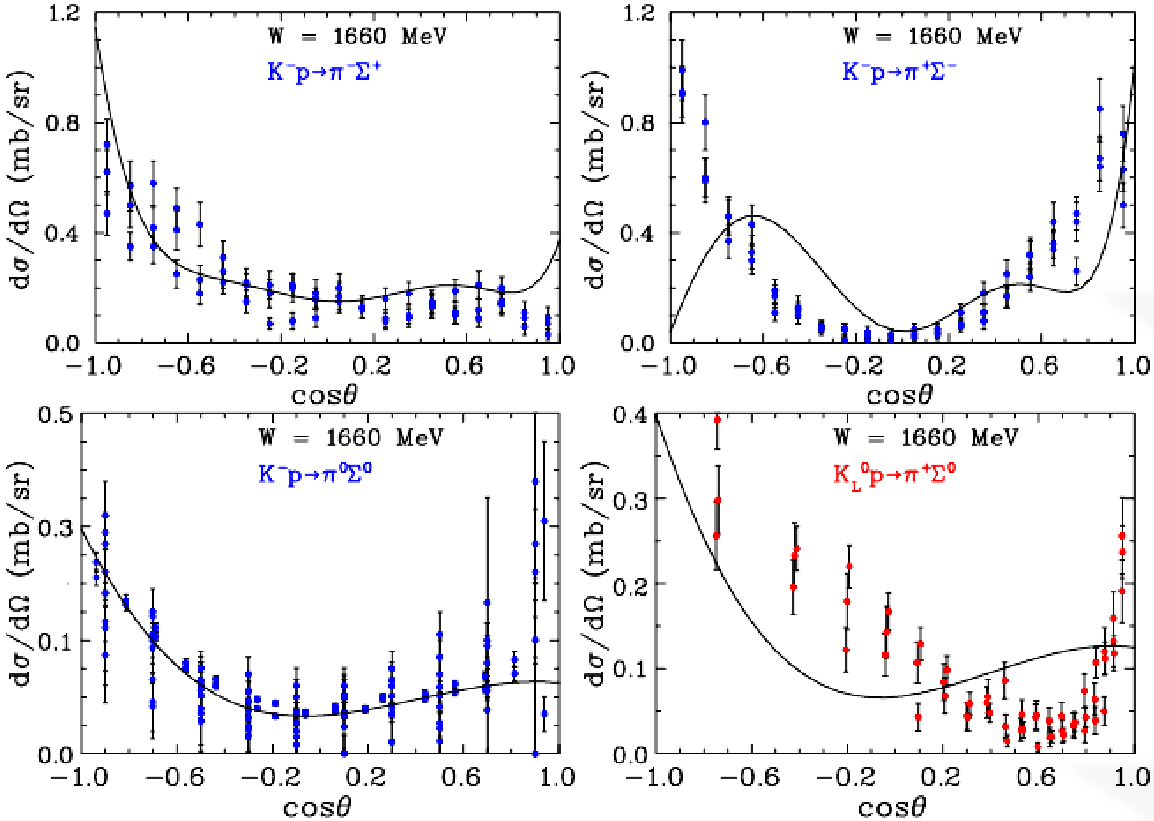
Data for $K_L p \to \pi^+ \Lambda$ & $K^- p \to \pi^0 \Lambda$



- $K^- p \to \pi^0 \Lambda$ & $K_L p \to \pi^+ \Lambda$ amplitudes imply that their observables measured at same energy should be identical except for small differences due to isospin-violating mass differences in hadrons.
- No **dσ/dΩ** data for $K^- p \to \pi^0 \Lambda$ are available at **W** < **1540** MeV, although data for $K_L p \to \pi^+ \Lambda$ are available at such energies due to longer K_L **life time**.
- At **1540** MeV & higher, dσ/dΩ and **polarization data** for both reactions are in fair agreement.

Courtesy of Mark Manley, KL2016

Data for $K_L p \to \pi^+ \Sigma^0$ & $K^- p \to \pi\Sigma$



Courtesy of Mark Manley, KL2016

- Reactions $K_L p \to \pi^+\Sigma^0$ & $K_L p \to \pi^0\Sigma^+$ are Isospin selective (only **I = 1** amplitudes are involved) & $K^- p \to \pi^0\Sigma^0$ is isospin selective fpr **I = 0** whereas reactions $K^- p \to \pi^-\Sigma^+$ & $K^- p \to \pi^+\Sigma^-$ involve both **I = 0** & **I = 1** amplitudes.

  New measurements with K_L-beam would lead to better understanding of Σ^* states & help constrain **amplitudes** for $K^- p \to \pi\Sigma$ reactions

- No **dσ/dΩ** data are available for $K_L p \to \pi^0\Sigma^+$ & very few (none recent) for $K^- p \to \pi^0\Sigma^0$ or $K^- p \to \pi^+\Sigma^-$.

- Quality of $K_L p$ data is comparable to that for $K^- p$ data.
  It would be advantageous to combine $K_L p$ data in a new coupled-channel **PWA** with available $K^- p$ measurements.

- PDG lists only two results on **BR** to $K\Sigma$ $\Lambda(2100)7/2^-$ (BR < **3%**)
  $\Sigma(2030)7/2^+$ (BR < **2%**).

Physics Opportunities

- New high-statistics data from **measurements** with high-quality **K-long beam**, with good angle & energy coverage for wide range of reactions are critically needed for **Hyperon Spectroscopy**.

- Here we review what can be learned by studying $\mathbf{K_L p}$ scattering leading to **two-body** final states (1st stage).
  At later stages, we plan to do $\mathbf{K_L n}$ on $\mathbf{LD_2}$ & aka **FROST** with hydrogen & deuterium.

- Mean lifetime of $\mathbf{K^-}$ is **12.38** ns ($c\tau$ = **3.7** m) whereas mean lifetime of $\mathbf{K_L}$ is **51.16** ns ($c\tau$ = **15.3** m).
  Thus, it is possible to perform measurements of $\mathbf{K_L p}$ scattering at **lower energies** than $\mathbf{K^- p}$ scattering due to higher beam flux.

PHYSICAL REVIEW VOLUME 138, NUMBER 5B 7 JUNE 1965

First paper on subject

Photoproduction of Neutral K Mesons*

CP-violation (1964)
Hot topic!

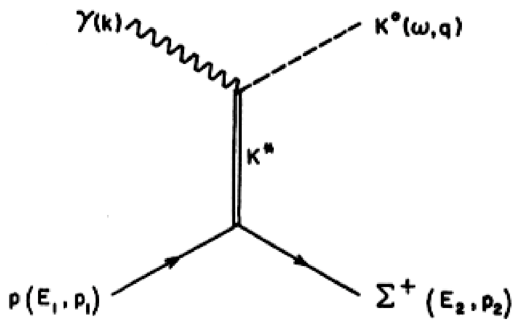
S. D. DRELL AND M. JACOB†
Stanford Linear Accelerator Center, Stanford University, Stanford, California

(Received 6 January 1965)

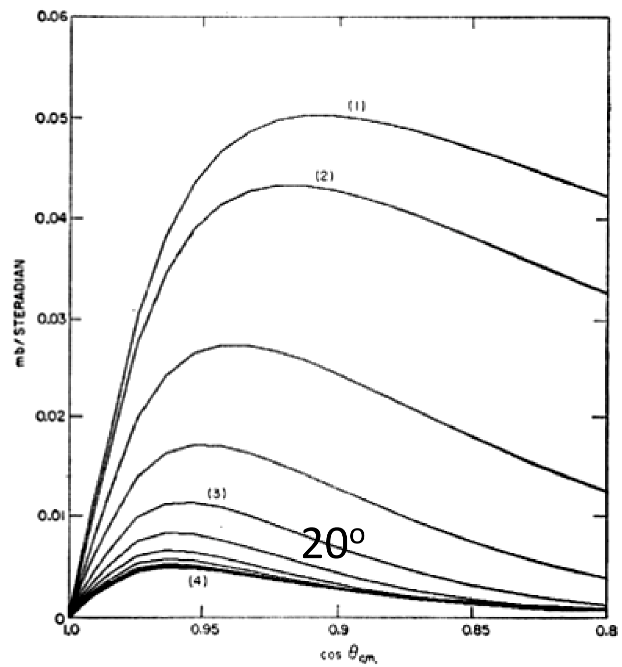
Photoproduction of a neutral K-meson beam at high energies from hydrogen is computed in terms of a K^* vector-meson exchange mechanism corrected for final-state interactions. The results are very encouraging for the intensity of high-energy K_2 beams at high-energy electron accelerators. A typical magnitude is 20 μb/sr for a lower limit of the K^0 photoproduction differential cross section, at a laboratory peak angle of 2°, for 15-BeV incident photons.

FIG. 1. K^* exchange in photoproduction.

[Not dominant]



50 μb/sr



Our motivation in carrying out this calculation is to emphasize the strong suggestion that an intense "healthy" K_2 beam will emerge from high-energy electron accelerators (SLAC in particular) and will be available for detailed experimental studies.

FIG. 3. Center-of-mass differential cross section at 10 BeV. Curve (1) gives the Born approximation. Curve (2) is obt after subtraction of the $j=\frac{1}{2}$ partial wave. Curves (3) and (respectively obtained after the $j=\frac{1}{2}, \frac{3}{2}, \frac{5}{2}, \frac{7}{2}$, and all partial have been corrected for absorption in final state. The result shown as directly obtained from and drawn by the compute

A bit of History

The possibility that useful K_L beam could be made at electron synchrotron by photoproduction was being considered, & 1965 prediction for SLAC by Drell & Jacob was optimistic.

8.B.5
8.B.6
Nuclear Physics B23 (1970) 509-524. North-Holland Publishing Company

PHOTOPRODUCTION OF K^0 MESONS FROM PROTONS AND FROM COMPLEX NUCLEI

M. G. ALBROW ‡, D. ASTON, D. P. BARBER, L. BIRD ‡‡, R. J. ELLISON, C. HALLIWELL, A. E. HARCKHAM ‡‡‡, F. K. LOEBINGER, P. G. MURPHY, J. WALTERS ‡‡ and A. J. WYNROE
Schuster Laboratories, The University of Manchester, Manchester M13 9PL
R. F. TEMPLEMAN
Daresbury Nuclear Physics Laboratory, Daresbury, Near Warrington, Lancs.

Received 16 July 1970

Sci-Tech DARESBURY

We were at Manchester Univ. close to Daresbury 5 GeV e-synchrotron.

CP-violation

PHYSICAL REVIEW D VOLUME 7, NUMBER 3 1 FEBRUARY 1973

Production of K_L^0 Mesons and Neutrons from Electrons on Beryllium Above 10 GeV*

G. W. Brandenburg, A. D. Brody, W. B. Johnson, D. W. G. S. Leith, J. S. Loos,† G. J. Luste,‡ J. A. J. Matthews, K. Moriyasu,§ B. C. Shen,‖ W. M. Smart,** F. C. Winkelmann, and R. J. Yamartino
Stanford Linear Accelerator Center, Stanford University, Stanford, California 94305

(Received 14 August 1972)

SLAC NATIONAL ACCELERATOR LABORATORY

Systematics of particle anti-particle processes through intrinsic property of K-longs

JLab LoI12-15-001

A Letter of Intent to Jefferson Lab PAC-43.

Physics Opportunities with a Secondary K_L^0 Beam at JLab.

Moskov J. Amaryan (spokesperson),[1,*] Yakov I. Azimov,[2] William J. Briscoe,[3] Eugene Chudakov,[4] Pavel Degtyarenko,[4] Gail Dodge,[1] Michael Döring,[3] Helmut Haberzettl,[3] Charles E. Hyde,[1] Benjamin C. Jackson,[5] Christopher D. Keith,[4] Ilya Larin,[1] Dave J. Mack,[4] D. Mark Manley,[6] Kanzo Nakayama,[5] Yongseok Oh,[7] Emilie Passemar,[8] Diane Schott,[3] Alexander Somov,[4] Igor Strakovsky,[3] and Ronald Workman[3]

[1] *Old Dominion University, Norfolk, VA 23529*
[2] *Petersburg Nuclear Physics Institute, Gatchina, St. Petersburg 188300, Russia*
[3] *The George Washington University, Washington, DC 20052*
[4] *Thomas Jefferson National Accelerator Facility, Newport News, Virginia 23606*
[5] *The University of Georgia, Athens, GA 30602*
[6] *Kent State University, Kent, OH 44242*
[7] *Kyungpook National University, Daegu 702-701, Korea*
[8] *Indiana University, Bloomington, IN 47405*

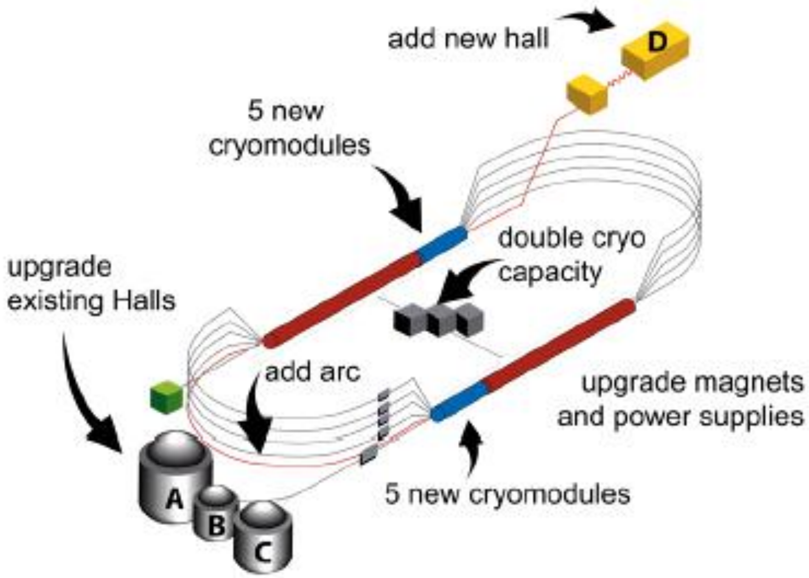
(Dated: May 14, 2015)

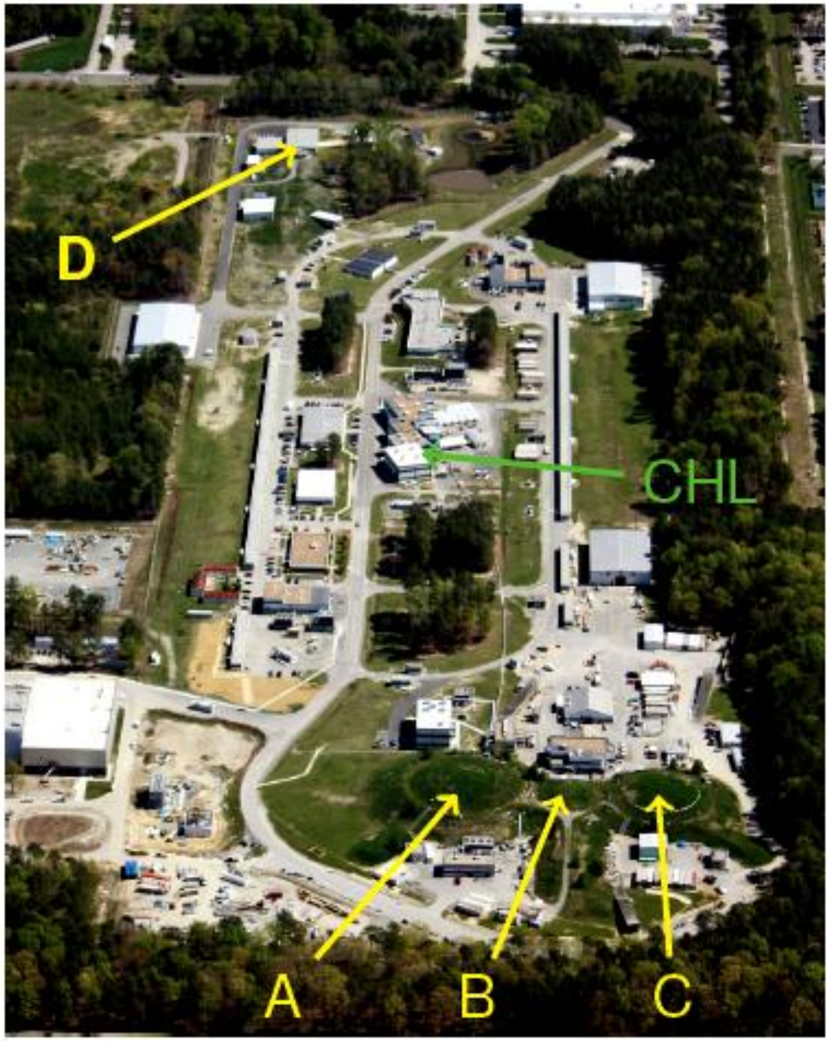
Hyperon Spectroscopy

- We plan to submit a full **Proposal** for **JLab PAC45** in **2017**.

CEBAF Upgrade to 12 GeV

Jefferson Lab
Thomas Jefferson National Accelerator Facility





Upgrade Goals

- Accelerator: 6 GeV $\Rightarrow$ 12 GeV
- Halls A,B,C: e^- <11 GeV, $< 100\ \mu$A
- Hall D: e^- 12 GeV $\Rightarrow$ γ-beam

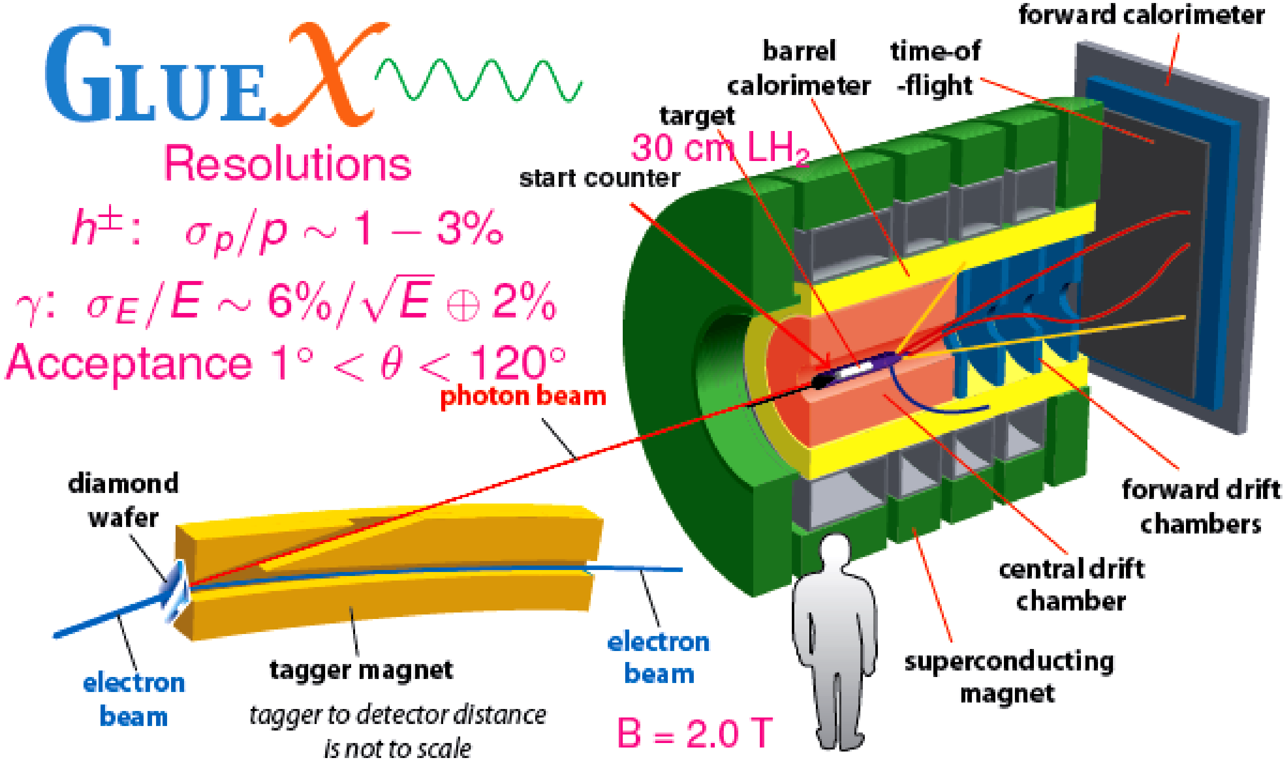
Upgrade Status

- Reached 12 GeV in Dec 2015
- Halls A,D: finished
- Halls B,C: about a year to go

Courtesy of Eugene Chudakov, KL2016

E.Chudakov KL2016. Feb 2016 Overview of *Hall D* 3 / 32 Jefferson Lab

Hall D/GlueX Spectrometer and DAQ



Detectors

- CDC, FDC
- BCAL, FCAL
- TOF, ST

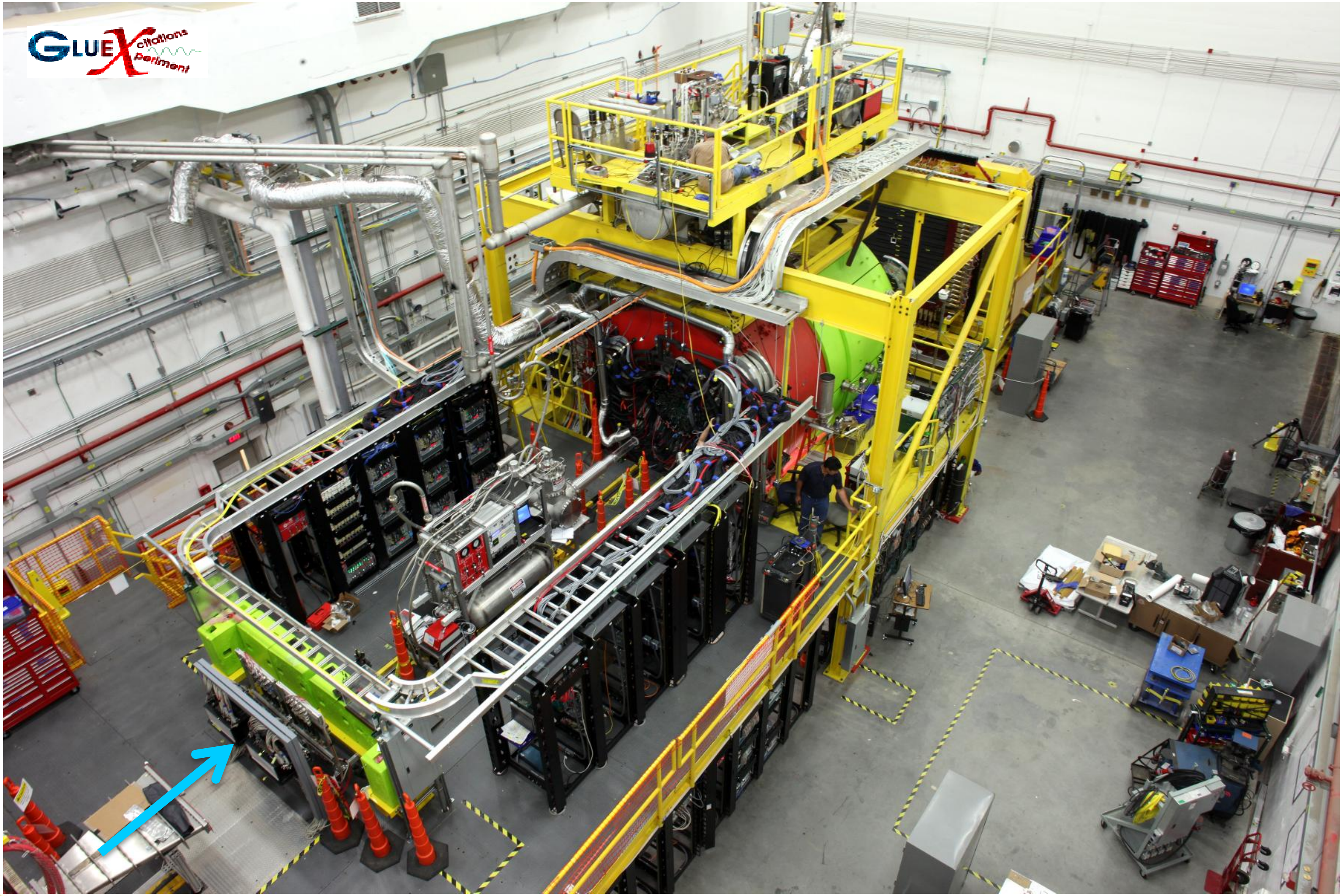
Plans to add

- 2017 L3
- 2018 Cherenkov

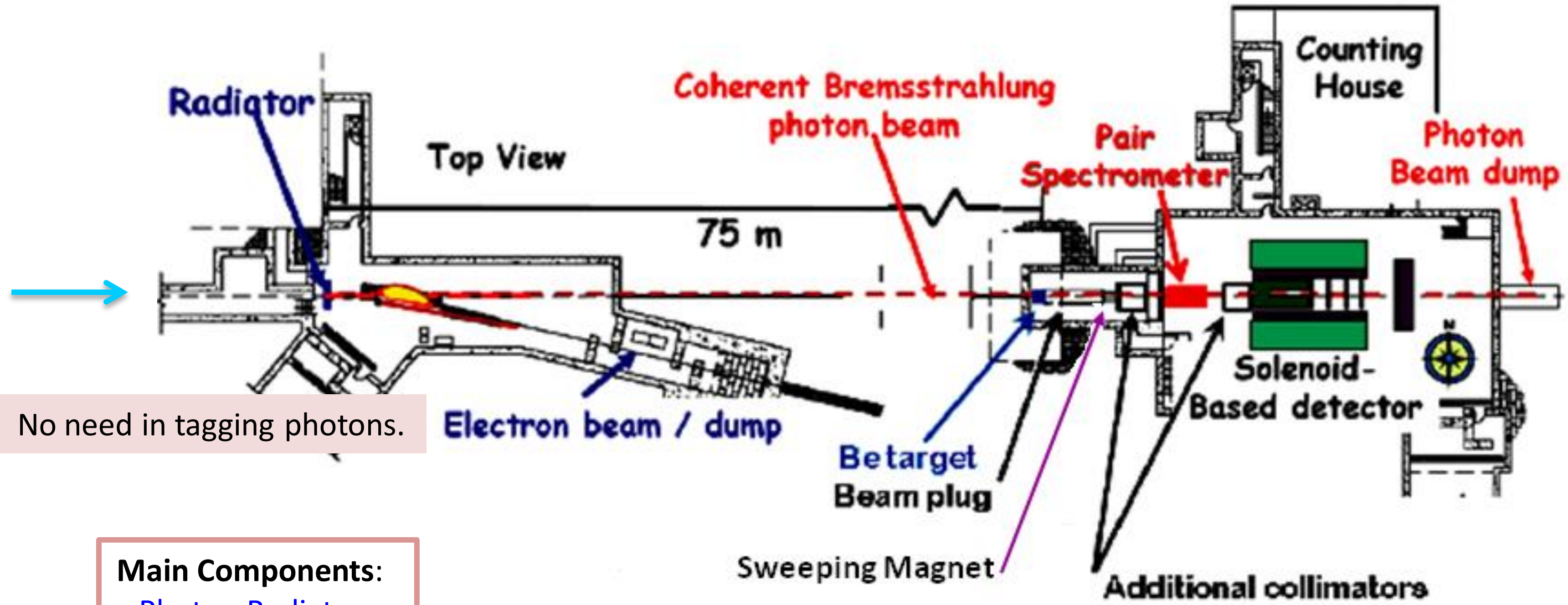
Photoproduction γp 15 kHz for a 100 MHz beam
Beam 10 MHz/GeV: inclusive trigger 20 kHz ⇒ DAQ ⇒ tape
Beam 100 MHz/GeV: inclusive trigger 200 kHz ⇒ DAQ ⇒ L3 farm ⇒ tape

Courtesy of Eugene Chudakov, KL2016

Hall D / GlueX



Hall D Beam Line Set up for K-longs



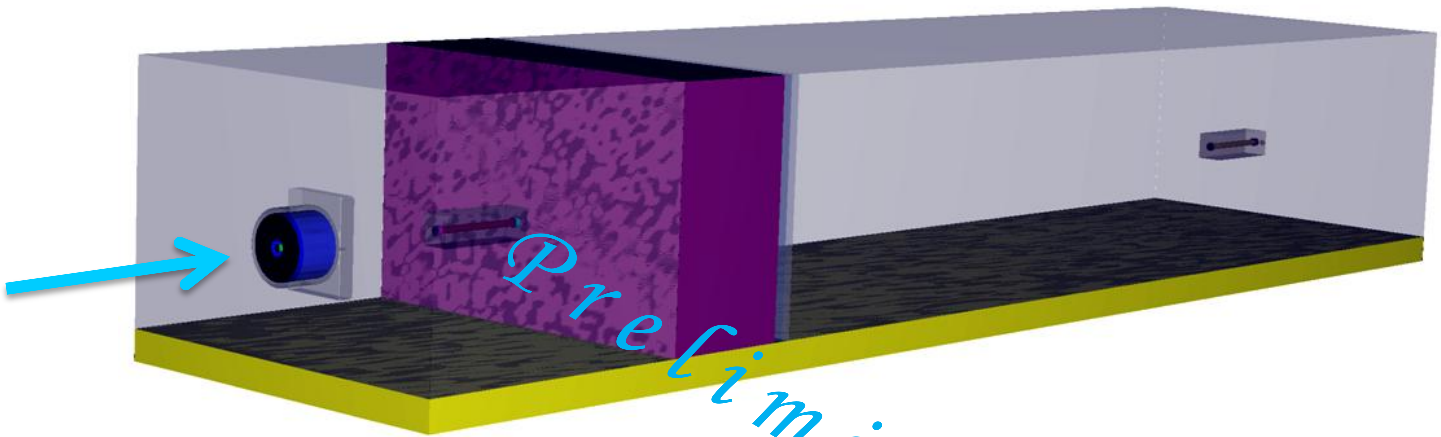
No need in tagging photons.

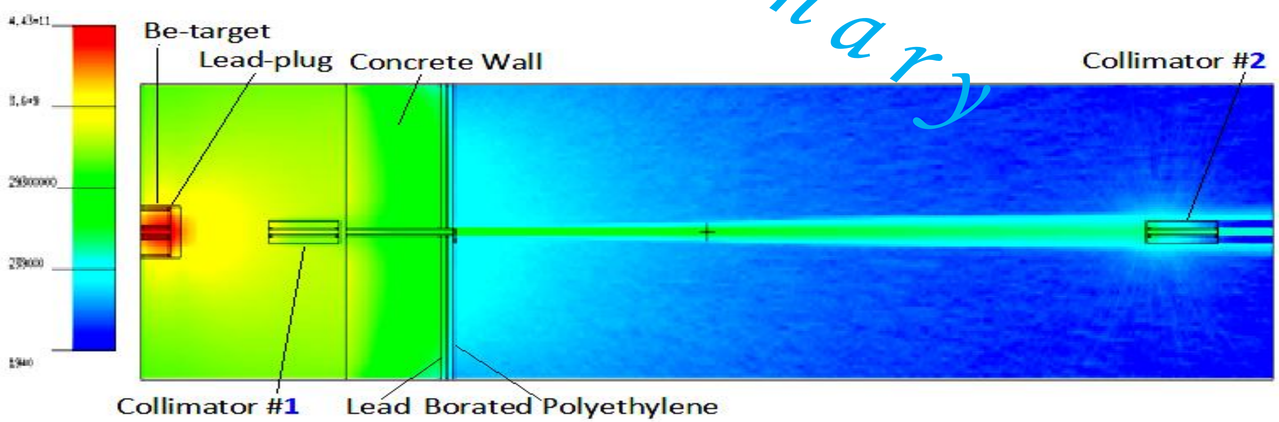
Main Components:
- Photon Radiator.
- Be-target.
- Beam plug.
- Sweeping Magnet.
- Pair Spectrometer.

- **Electrons** are hitting **W-radiator**.
- **Photons** are hitting **Be-target**.
- **K_Ls** are hitting the **LH_2-target** within **GLueX** setting.

Expected Neutron Background

- Most important and unpleasant **background** for K_L comes from **neutrons**.



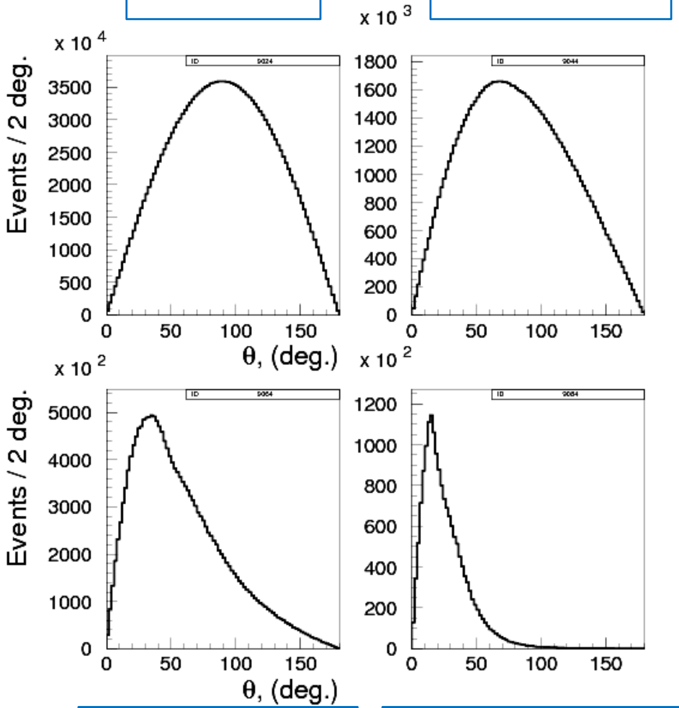


Expected Neutron Background

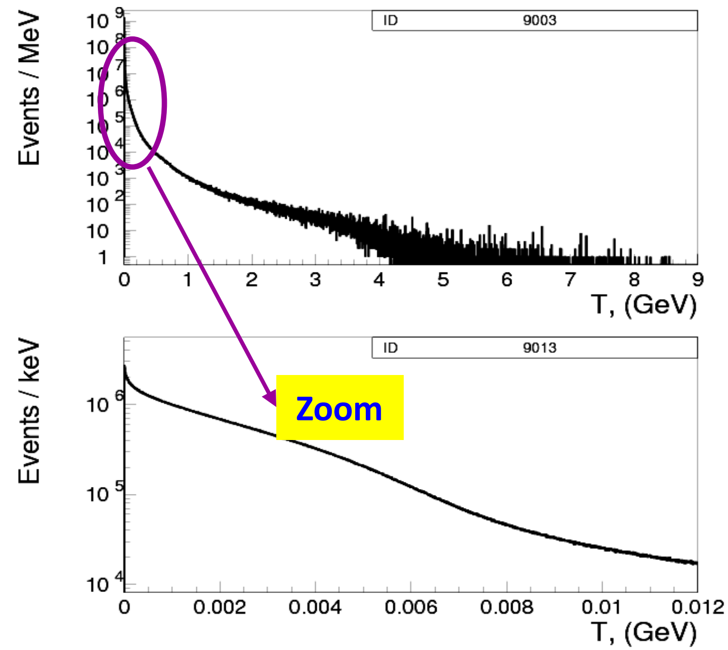
- Using **DINREG** code, we generated **6 x 10^9** 12-GeV **e^-** (I = **5** μA) which hit **10%** R.L. tungsten radiator.

- The exiting is **~10^{13} n/s**.
- **99%** of neutrons associated with **T** < **90** MeV while **0.6%** of them are for **T** > **125** MeV.

1 – 5 MeV | **20 – 50 MeV**



120 – 250 MeV | **500 – 1000 MeV**



Courtesy of Ilya Larin, KL2016

- For future neutron calculations, we use **MCNP6** transport code.

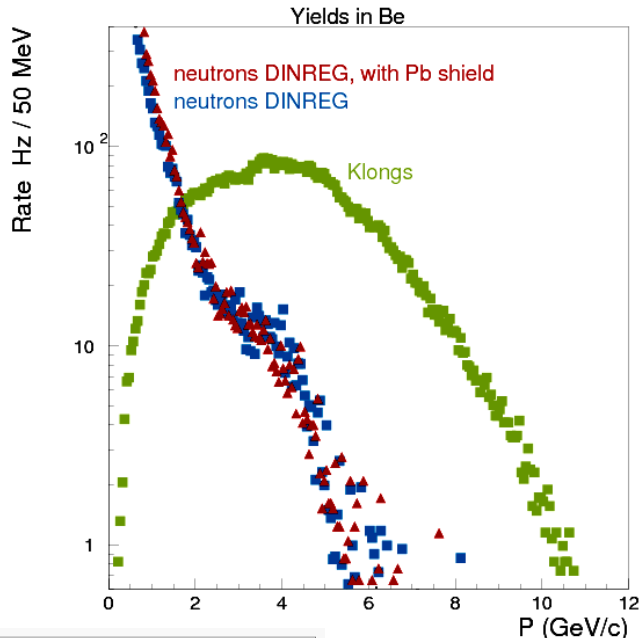
Rate of Neutrons and K_Ls on GlueX LH_2-target

Jefferson Lab — Thomas Jefferson National Accelerator Facility

MC @ 12 GeV

SLAC NATIONAL ACCELERATOR LABORATORY

@ 16 GeV



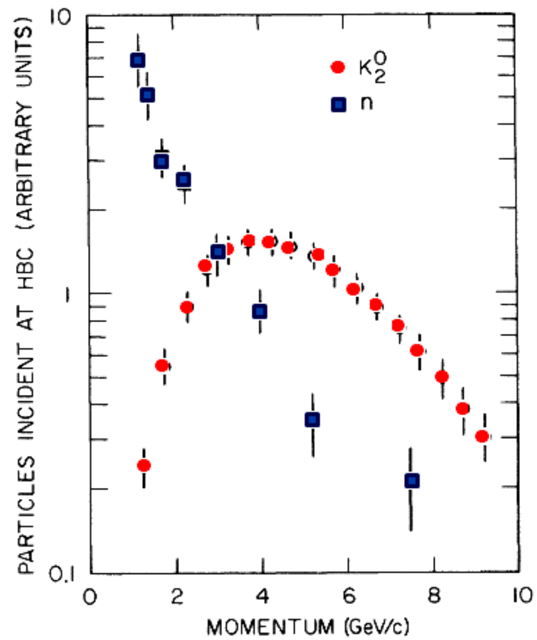
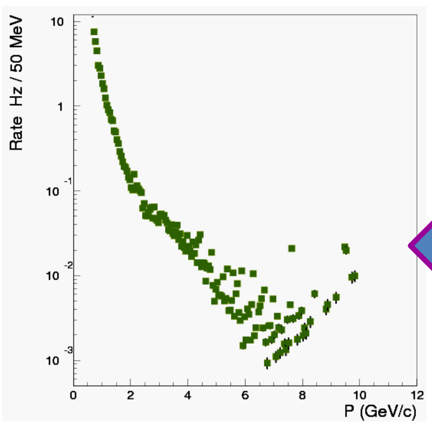


FIG. 2. Comparison of the neutron and K_2^0 fluxes at the hydrogen bubble chamber for 2° production with 16-GeV electrons.

A.D. Brody *et al* Phys Rev Lett **22**, 966 (1969)



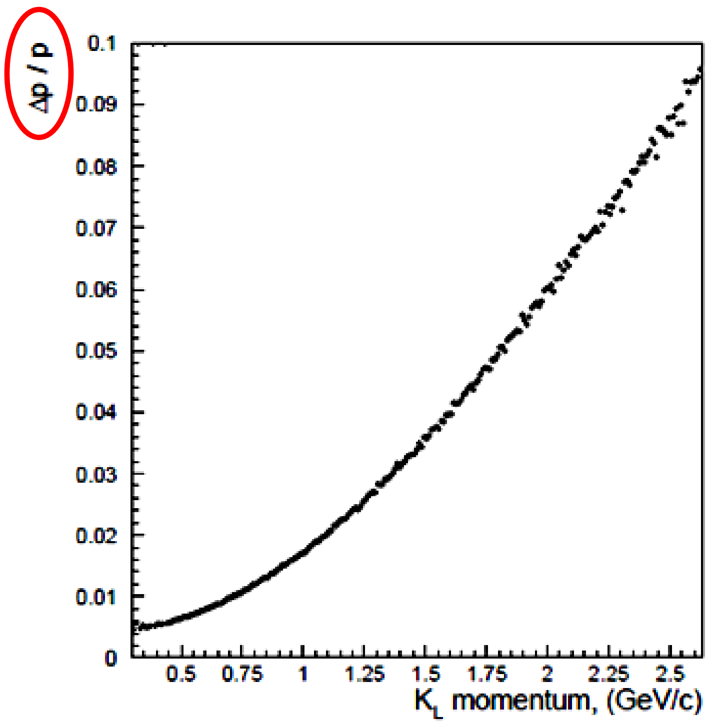
Flux ratio **n/K_L**

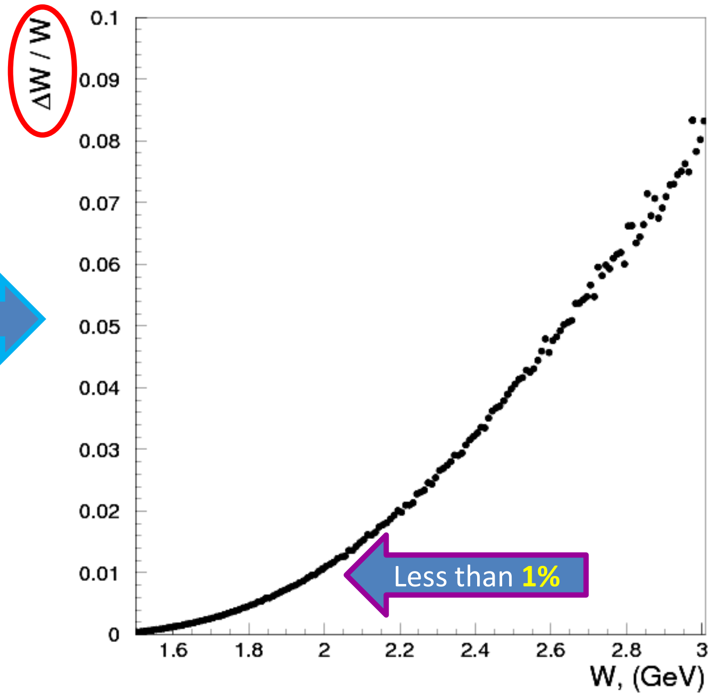
- **Preliminary Conclusion**: **Neutron Flux** in **Hall D** is **tolerable**.

Expected Energy-Resolution

- Delivered with **60** ns bunch spacing avoids overlap in range of **p** = **0.35** – **10.0** GeV/c.
  G0 used **32** ns D. Androic *et al* Nucl Inst & Meth in Phys Res A 646, 59 (2011)

- Momentum measured with **TOF** between **SC** (surrounded **LH_2**) & **RF** from CEBAF.





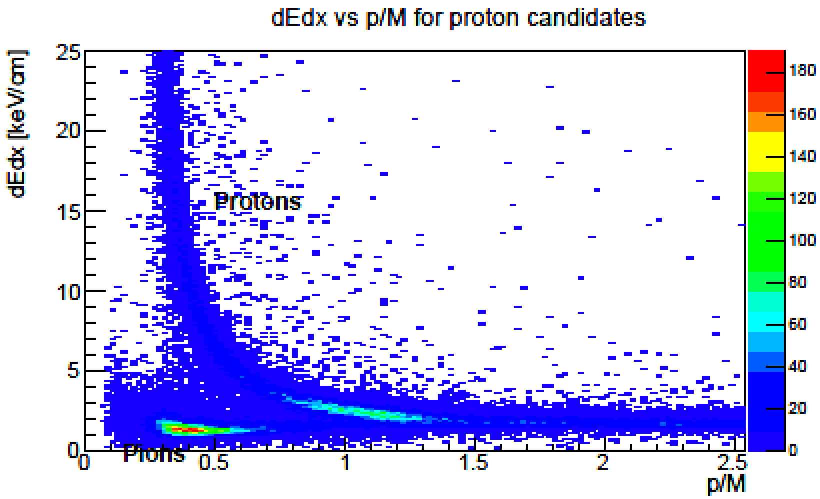
- Momentum resolution **Δp/p** is growing with momentum: for **1** GeV/c is **1.7**%, for **2** GeV/c is **6**%.

- For W < **2.1** GeV, **ΔW** < **20** MeV which is suitable to study **Hyperons** with Γ = **30** – **50** MeV.

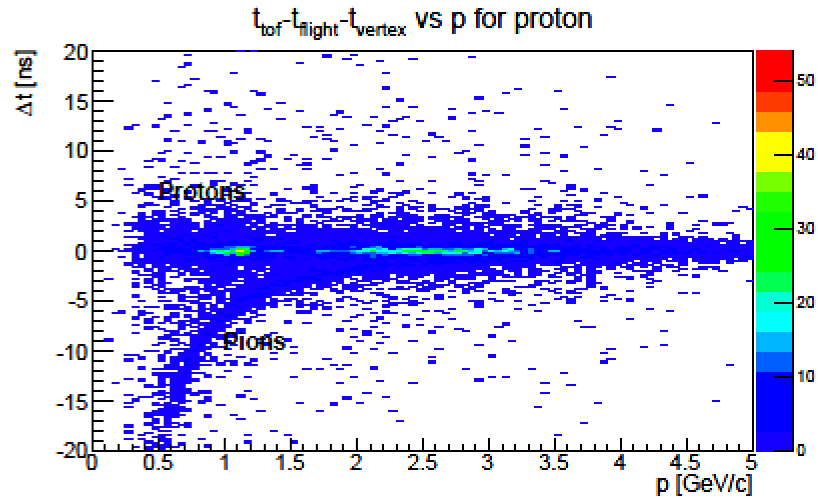
Courtesy of Ilya Larin, KL2016

Expected Particle Identification

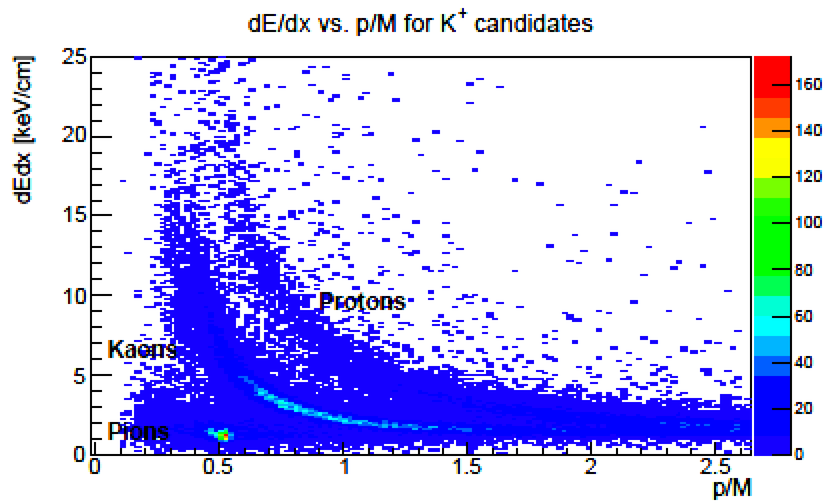
- dE/dx for **pK_S**.



- Time difference at primary ``vertex" for proton hypothesis for **pK_S** using TOF.



- dE/dx for **$K^+\Xi^0$**.

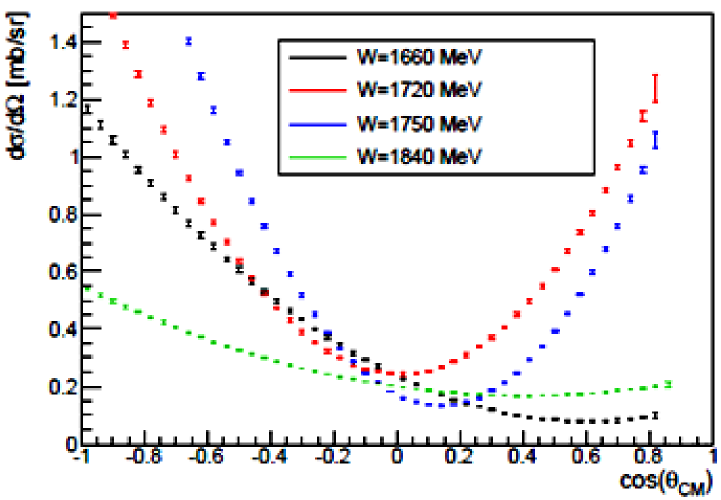


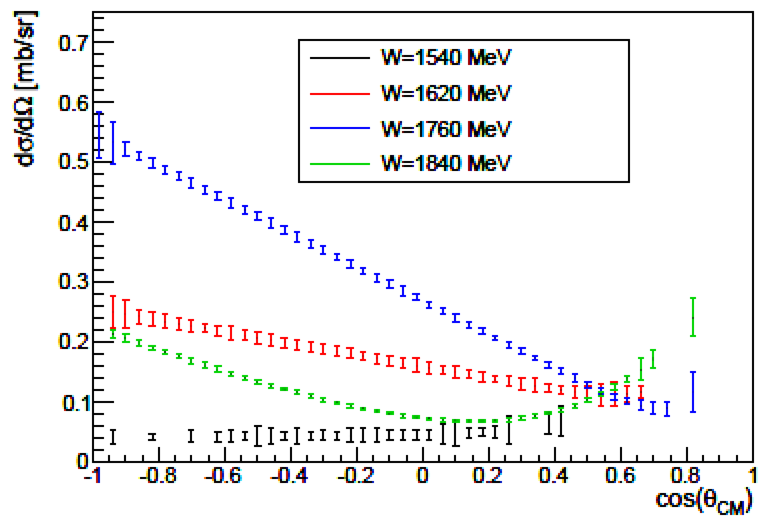
Courtesy of Simon Taylor, KL2016

Expected Cross Sections

- GlueX measurements will span **cosθ** from **–0.95** to **0.95** in c.m. above **W** = **1490** MeV.

- Cross section uncertainty estimates (statistics only) for **$K_Lp \to pK_S$** & **$K_Lp \to \pi^+\Lambda$**.



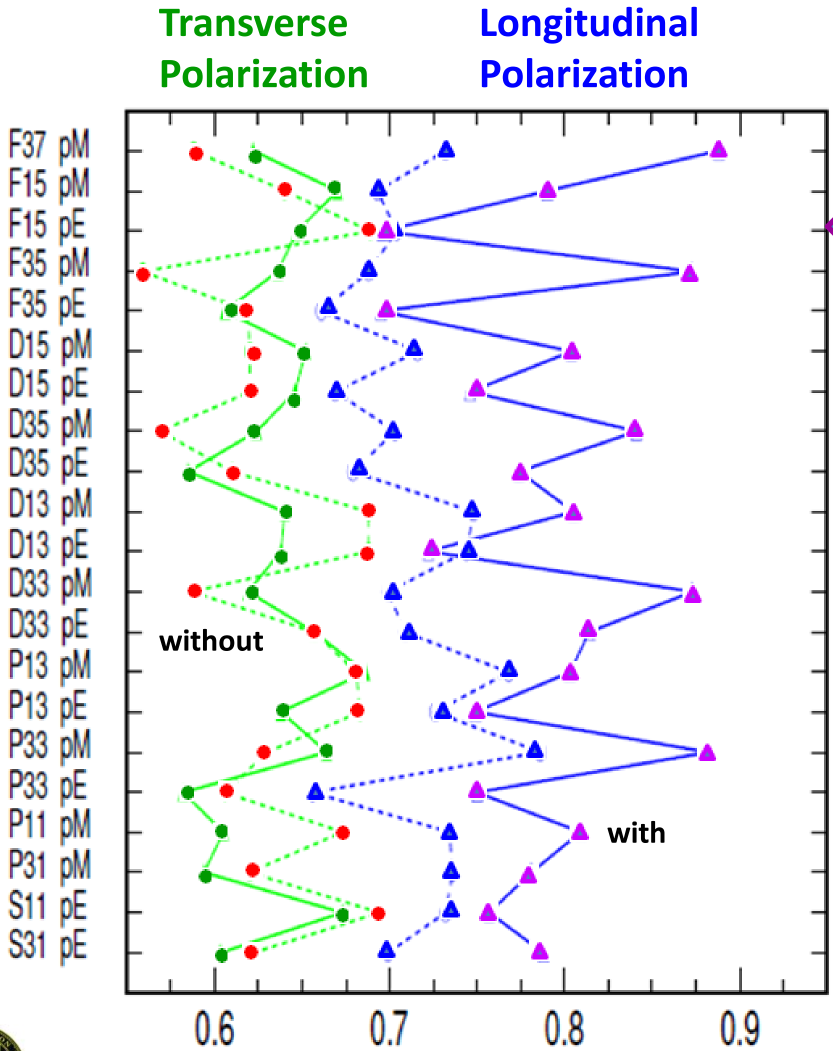


- K_L rate is **10^4** K_L/s.
- Uncertainties correspond to **100** days of running time.

Courtesy of Simon Taylor, KL2016

JLab E-03-105

- Prove motivation of JLab Proposal *Pion Photoproduction from Polarized Target* for **FROST** Project.



Average ratio of uncertainties of amplitudes **with** & **without** expected FROST data.

- Greatest effect naturally requires measurement of all possible quantities as accomplished by **FROST**.

π^+ **E**: S. Strauch *et al* Phys Lett B **750**, 53 (2015)
More results are coming...

- **KSU**&**GW** plan to do **PWA** including available $\mathbf{K_L p}$ & $\mathbf{K^- p}$ data plus expected **GlueX** data to show potential impact of new **Hall D** measurements.

- **JLab K-long Facility** would advance **Hyperon Spectroscopy** & study of **strangeness** in nuclear & hadronic physics. **It may extract very many missing strange states.**
  To complete $\mathbf{SU(3)_F}$ multiplets, one needs no less than **17** Λ^*, **41** Σ^*, **41** Ξ^*, & **24** Ω^*.

- Quality of $\mathbf{K_L p}$ data may be comparable to that for $\mathbf{K^- p}$ ones.
  It would be advantageous to combine $\mathbf{K_L p}$ data in new coupled-channel **PWA** with available $\mathbf{K^- p}$ data.

- Those include studies of **baryon** spectroscopy, particularly search for "**missing resonances**" with hadronic beam data that would be analyzed together with **photo**- & **electro-**production data using modern **coupled-channel** analysis methods.

- Discovering of missing **low-lying baryon states** would assist in constructing new models for apparent **properties** of **QCD**, thereby improving our understanding of this strongly coupled **non-linear quantum field theory.**

- Full Proposal is coming for **PAC45** in **2017**, **WELCOME** to **JOIN US**.

Thank You












Moskov Amaryan
Yakov Azimov
Bill Briscoe
Eugene Chudakov
Pavel Degtyarenko
Michael Döring
Alexander Laptev
Ilya Larin
Maxim Mai
Mark Manley
James Ritman
Simon Taylor

Thank you for attention

igor@gwu.edu

List To-Do

K_L

- **Engineering**:
  - CPS, including Sweeping Magnet.
  - Cooling system for Be-target.
  - FROST Polarized target (long shot).

- **MC**:
  - Neutron background calculations.
  - K_L flux determination (Pair Spectrometer ?).
  - Background calculations for **K_Lp** two-body reactions.
  - Projected **$d\sigma/d\Omega$** and **P** data induced by **K_L**.
  - Systematics study.
- **PWA**:
  - Status of current **K_Lp** & **K^-p** databases & **PWA** with expected data.

Wallpaper: Courtesy of Mike Pennington, KL2016

Project X: Physics Opportunities

Fermilab

Table 1: Comparison of the K_L production yield. The BNL AGS kaon and neutron yields are taken from RSVP reviews in 2004 and 2005. The Project X yields are for a thick target, fully simulated with LAQGSM/MARS15 into the KOPIO beam solid angle and momentum acceptance [68].

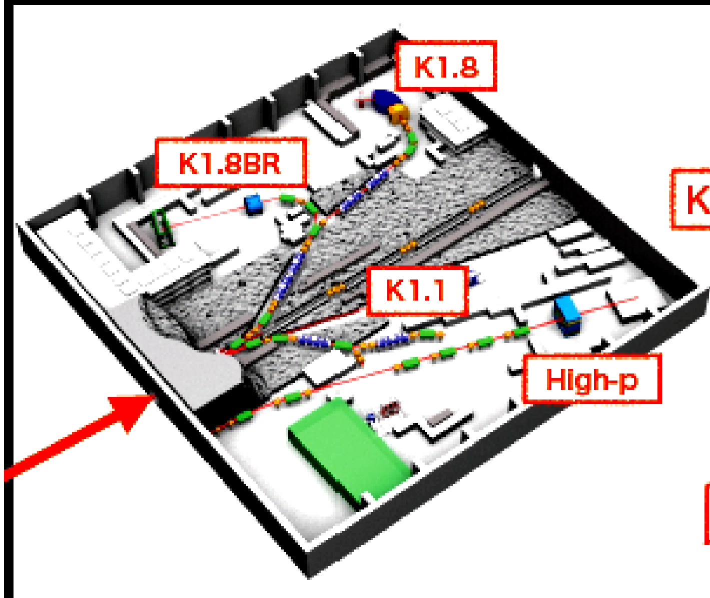
Project	Beam energy (GeV)	Target (λ_I)	p(K_L) (MeV/c)	K_L/s (into 500 μsr)	n/K_L (E_n > 10 MeV)
BNL AGS	24	1.1 Pt	300–1200	60×10^6	~1:1000
Project X	3	1.0 C	300–1200	450×10^6	~1:2700

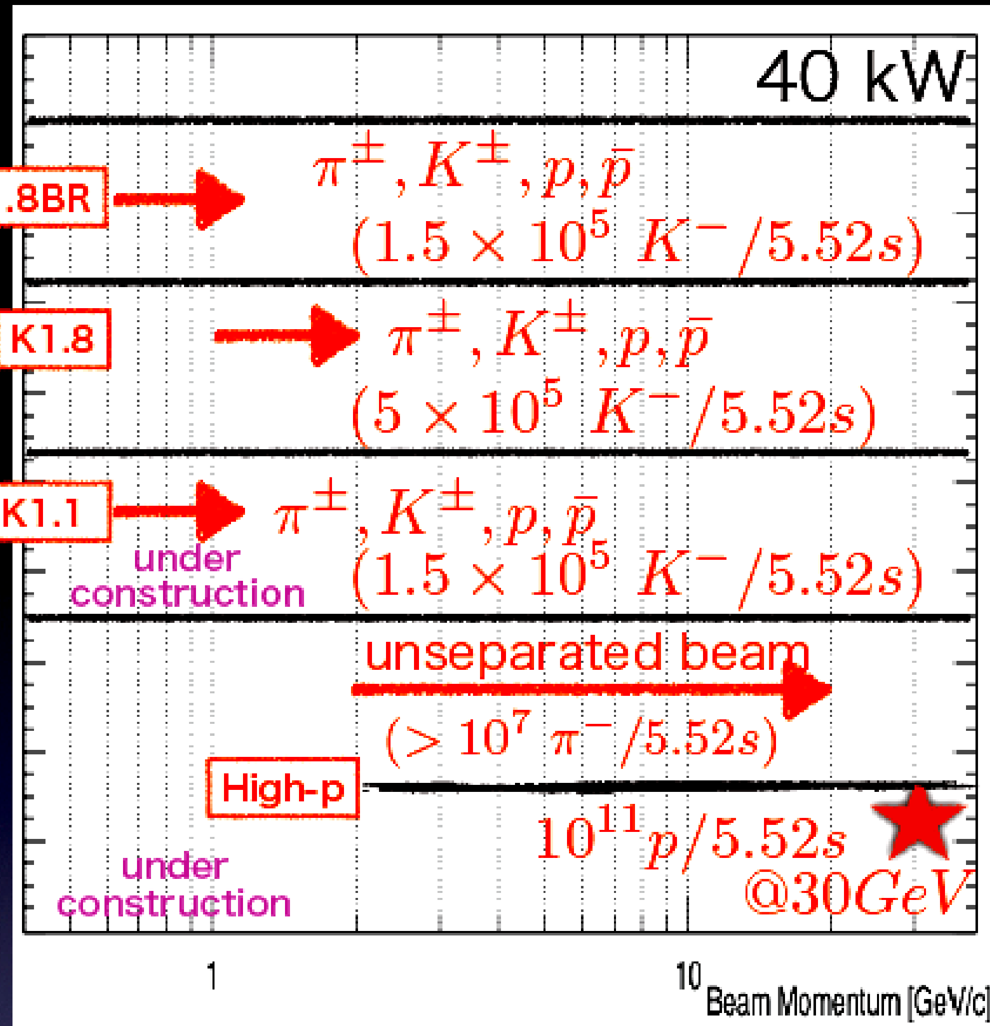
arXiv:1306.5022, arXiv:1306.5009, arXiv:1306.5024

- First stage of **Project X** aims for **neutrinos**.
- Proposed **K_L beam** can be used to study **rare decays** & **CP-violation**.
- It may be impossible to use for Hyperon Spectroscopy because of **momentum range** & **n/K_L** ratio.

J-PARC

Japan Proton Accelerator Research Complex





Two beam lines are under operation

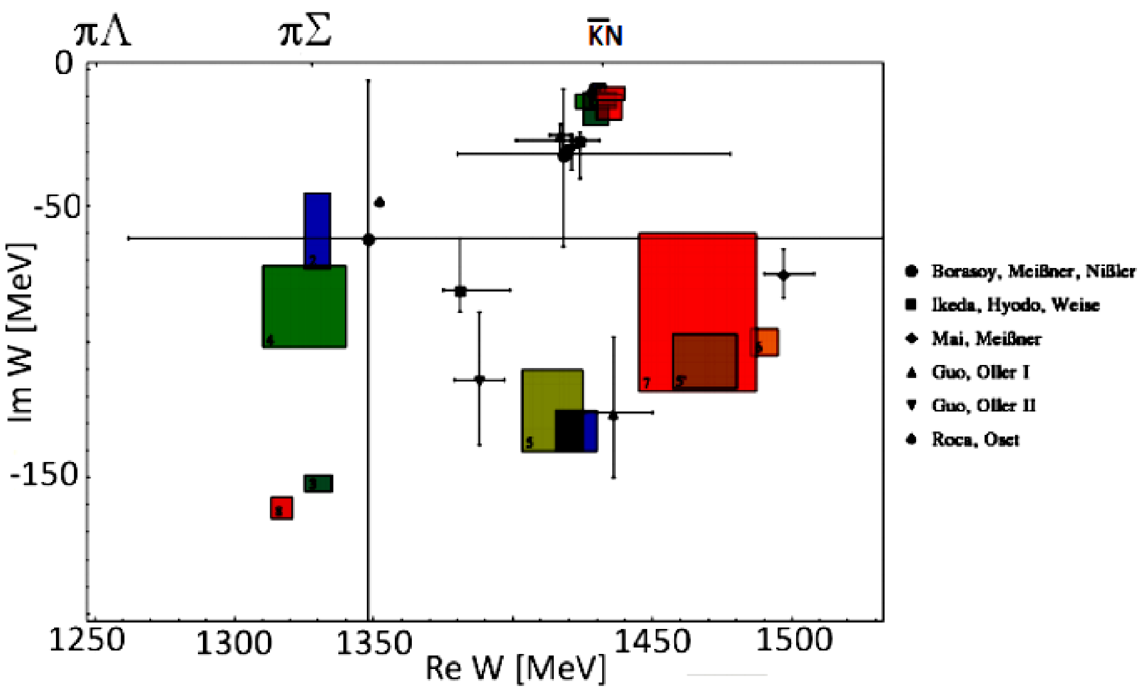
K1.1 & High-p beam lines are under construction

Courtesy of Hiroaki Onishi, KL2016

Λ(1405) Lane-shape

- Double pole structure of **Λ(1405)** in complex energy plane for eight solutions that describe scattering & **SIDDHARTA** Collaboration data.

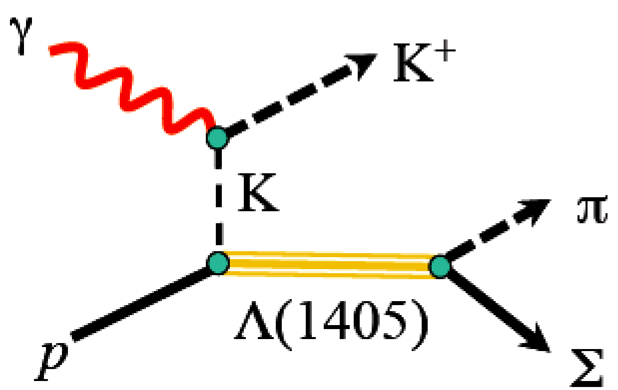
M. Bazzi *et al* (SIDDHARTA Collaboration) Phys Lett B **704**, 113 (2011)

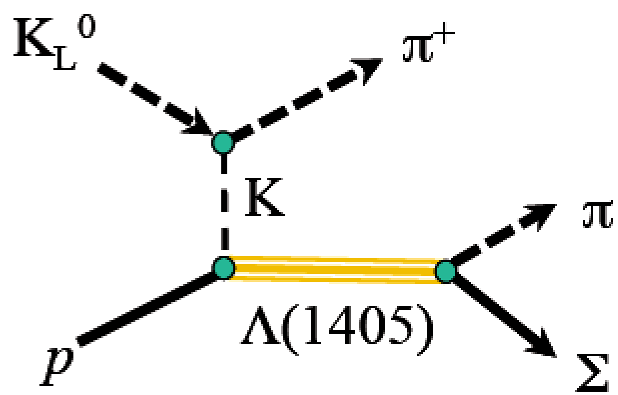


- **Two poles** in all solutions on **2nd Riemann sheet**.
- Stable position of narrow pole.
- Position of second pole is rather unstable.

Courtesy of Maxim Mai, KL2016

Outlook at GlueX for Λ(1405) Line-Shape Measurement





- Measurement may be feasible

$$K_L^0 p \rightarrow \Lambda(1405)\pi^+ \rightarrow \Sigma^{+0-}\pi^{-0+}\pi^+$$

Courtesy of Reinhard Schumacher, KL2016