The K_L Facility at

Moskov Amaryan

$\pi - K$ ***Interactions Workshop, February 14-15, 2018***

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 15, 2015)

Strange Hadron Spectroscopy with a Secondary K_L Beam at GlueX

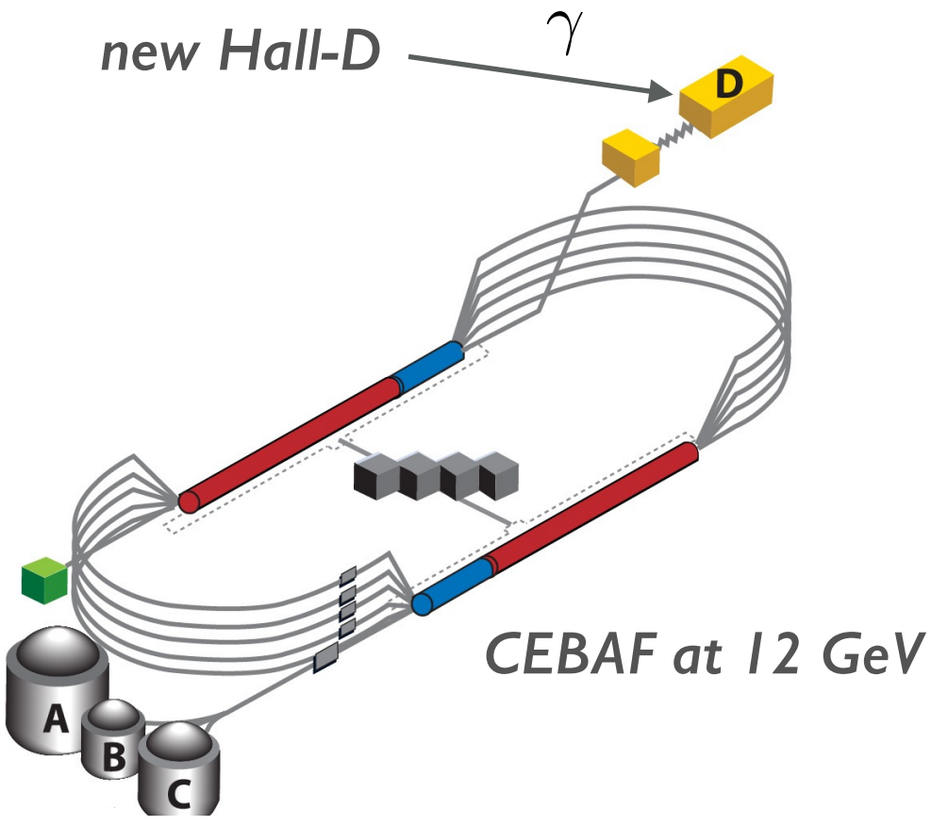
S. Adhikari[12], H. Al Ghoul[13], A. Ali[17], M. J. Amaryan[40,*,†], E. G. Anassontzis[2], A. V. Anisovich[20,14], A. Austregesilo[32], M. Baalouch[40], F. Barbosa[32], A. Barnes[9], M. Bashkanov[10,†], T. D. Beattie[44], R. Bellwied[22], V. V. Berdnikov[37], T. Black[41], W. Boeglin[12], W. J. Briscoe[15], T. Britton[32], W. K. Brooks[46], B. E. Cannon[13], E. Chudakov[32], P. L. Cole[23], V. Crede[13], M. M. Dalton[32], A. Deur[32], P. Degtyarenko[32], S. Dobbs[42], G. Dodge[40], A. G. Dolgolenko[29], M. Döring[15,32], M. Dugger[1], R. Dzhygadlo[17], R. Edwards[32], H. Egiyan[32], S. Eidelman[4,31], A. Ernst[13], A. Eskandarian[15], P. Euginio[13], C. Fanelli[35], S. Fegan[36], A. M. Foda[44], J. Frye[24], S. Furletov[32], L. Gan[41], A. Gasparian[39], G. Gavalian[32], V. Gauzshtein[47,48], N. Gevorgyan[50], D. I. Glazier[16], K. Goetzen[17], J. Goity[32,21], V. S. Goryachev[29], L. Guo[12], H. Haberzettl[15], M. Hadžimehmedović[49], H. Hakobyan[46], A. Hamdi[17], S. Han[53], J. Hardin[35], A. Hayrapetyan[19], T. Horn[7], G. M. Huber[44], C. E. Hyde[40], D. G. Ireland[16], M. M. Ito[32], B. C. Jackson[18], N. S. Jarvis[6], R. T. Jones[9], V. Kakoyan[50], G. Kalicy[7], M. Kamel[12], C. D. Keith[32], C. W. Kim[15], F. J. Klein[15], C. Kourkoumeli[2], S. Kuleshov[46], I. Kuznetsov[47,48], A. B. Laptev[30], I. Larin[29], D. Lawrence[32], M. Levillain[39], W. I. Levine[6], K. Livingston[16], G. J. Lolos[44], V. E. Lyubovitskij[47,48,33,46], D. Mack[32], M. Mai[15], D. M. Manley[27], U.-G. Meißner[20,54], H. Marukyan[50], V. Mathieu[24], P. T. Mattione[32], M. Matveev[14], V. Matveev[29], M. McCaughan[32], M. McCracken[6], W. McGinley[6], J. McIntyre[9], C. A. Meyer[6], R. Miskimen[34], R. E. Mitchell[24], F. Mokaya[9], V. Mokeev[32], K. Nakayama[18], F. Nerling[17], Y. Oh[28], H. Osmanović[49], A. I. Ostrovidov[13], R. Omerović[49], Z. Papandreou[44], K. Park[32], E. Pasyuk[32], M. Patsyuk[35], P. Pauli[16], R. Pedroni[39], M. R. Pennington[16], L. Pentchev[32], K. J. Peters[17], W. Phelps[12], E. Pooser[32], B. Pratt[9], J. W. Price[5], N. Qin[53], J. Reinhold[12], D. Richards[32], D.-O. Riska[11], B. G. Ritchie[1], J. Ritman[3,26,†], L. Robison[42], D. Romanov[37], H-Y. Ryu[43], C. Salgado[38], E. Santopinto[25], A. V. Sarantsev[20,14], R. A. Schumacher[6], C. Schwarz[17], J. Schwiening[17], A. Semenov[44], I. Semenov[44], K. K. Seth[42], M. R. Shepherd[24], E. S. Smith[32], D. I. Sober[7], D. Sokhan[16], A. Somov[32], S. Somov[37], O. Soto[46], N. Sparks[1], J. Stahov[49], M. J. Staib[6], J. R. Stevens[51,†], I. I. Strakovsky[15,†], A. Subedi[24], A. Švarc[45], A. Szczepaniak[24,32], V. Tarasov[29], S. Taylor[32], A. Teymurazyan[44], A. Tomaradze[42], A. Tsaris[13], G. Vasileiadis[2], D. Watts[10], D. Werthmüller[16], N. Wickramaarachchi[40], T. Whitlatch[32], M. Williams[35], B. Wojtsekhowski[32], R. L. Workman[15], T. Xiao[42], Y. Yang[35], N. Zachariou[10], J. Zarling[24], Z. Zhang[53], B. Zou[8], J. Zhang[52], X. Zhou[53], B. Zihlmann[32]

Currently 178 members from 54 institutions

How to make a kaon beam?

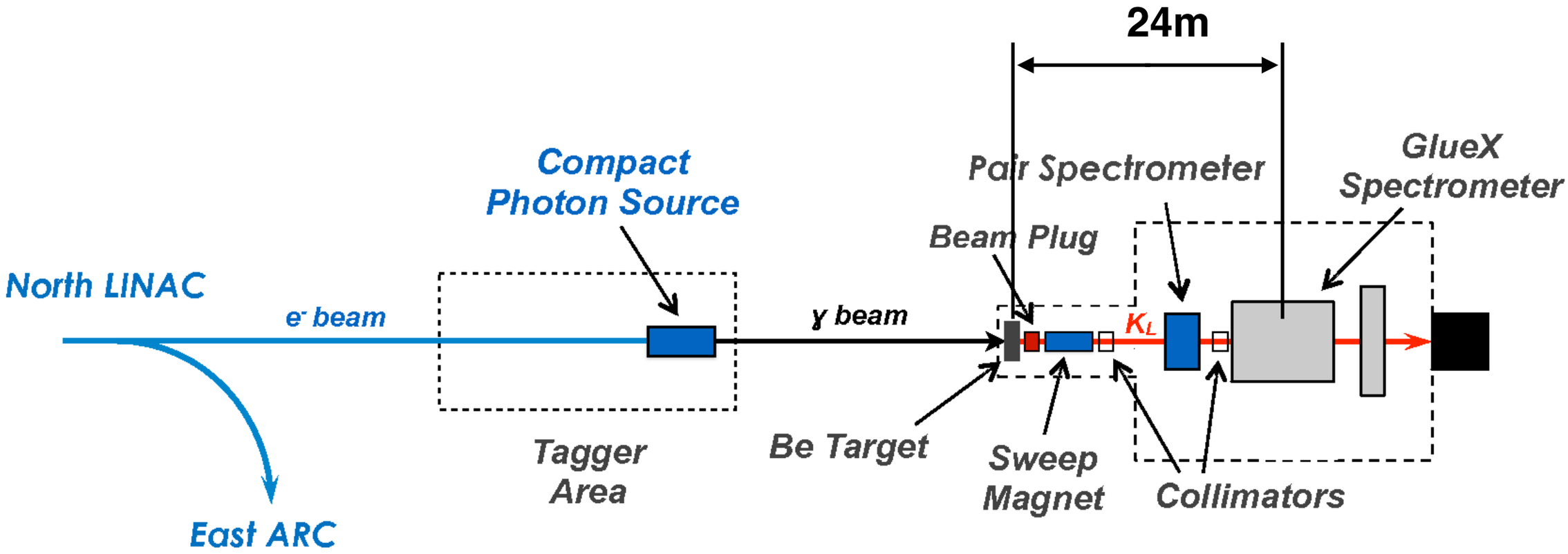
Thomas Jefferson National Accelerator Facility

Aerial View



CEBAF at 12 GeV

Hall-D beamline and GlueX Setup



K^0_L beam (continued)

-Electron beam with $I_e = 5\mu A$

-Delivered with 64 ns bunch spacing avoids overlap in the range of P=0.3-10.0 GeV/c

-Momentum measured with TOF

-K^0_L flux mesured with pair spectrometer

-*Side remark: Physics case with polarized targets is under study and feasible*

Rate of neutrons and K^0_L on GlueX target

- **PRL22.996 (1969) Brody et al.**

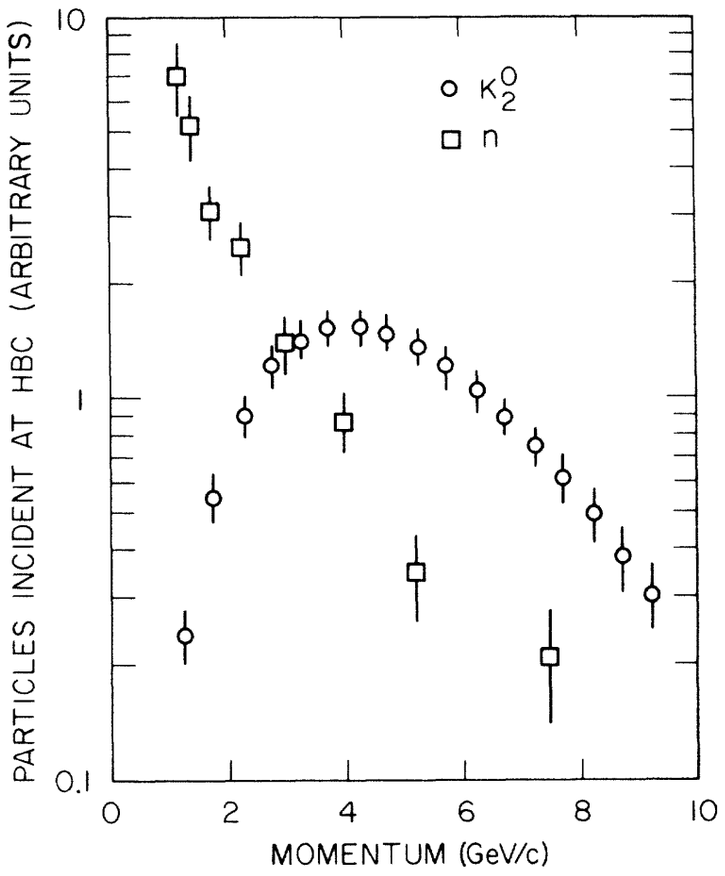
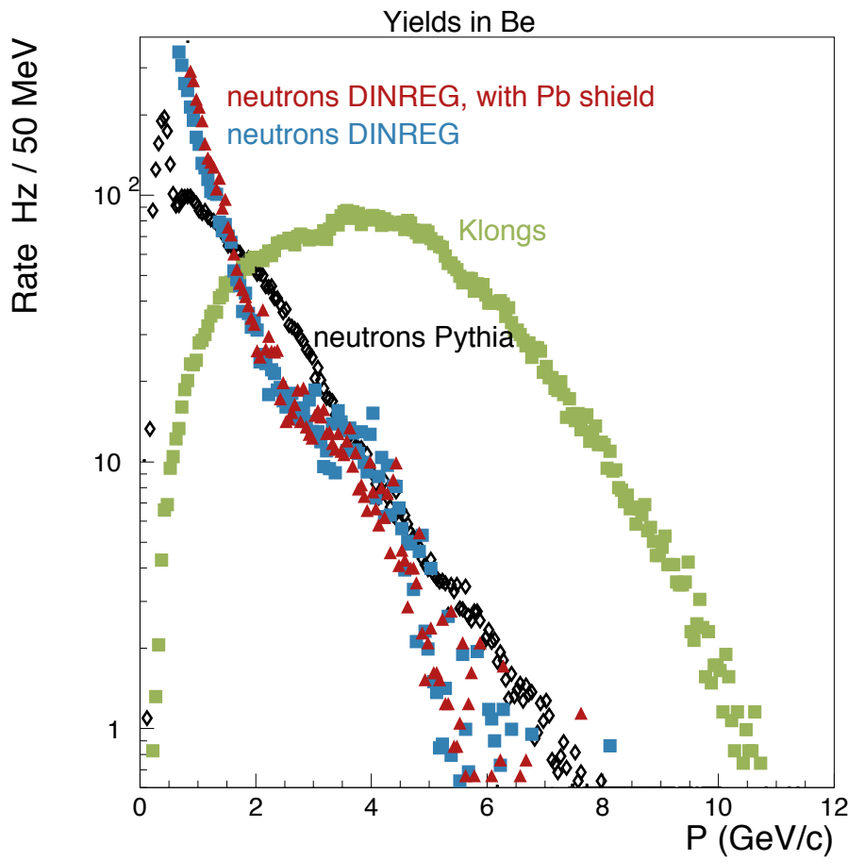


FIG. 2. Comparison of the neutron and K_2^0 fluxes at the hydrogen bubble chamber for 2° production with 16-GeV electrons.

- **JLAB**



- **With a proton beam ratio $n/K_L = 10^3$-10^4**

- **ProjectX (Fermi Lab) arXiv:1306.5009**

Table III-2: 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.

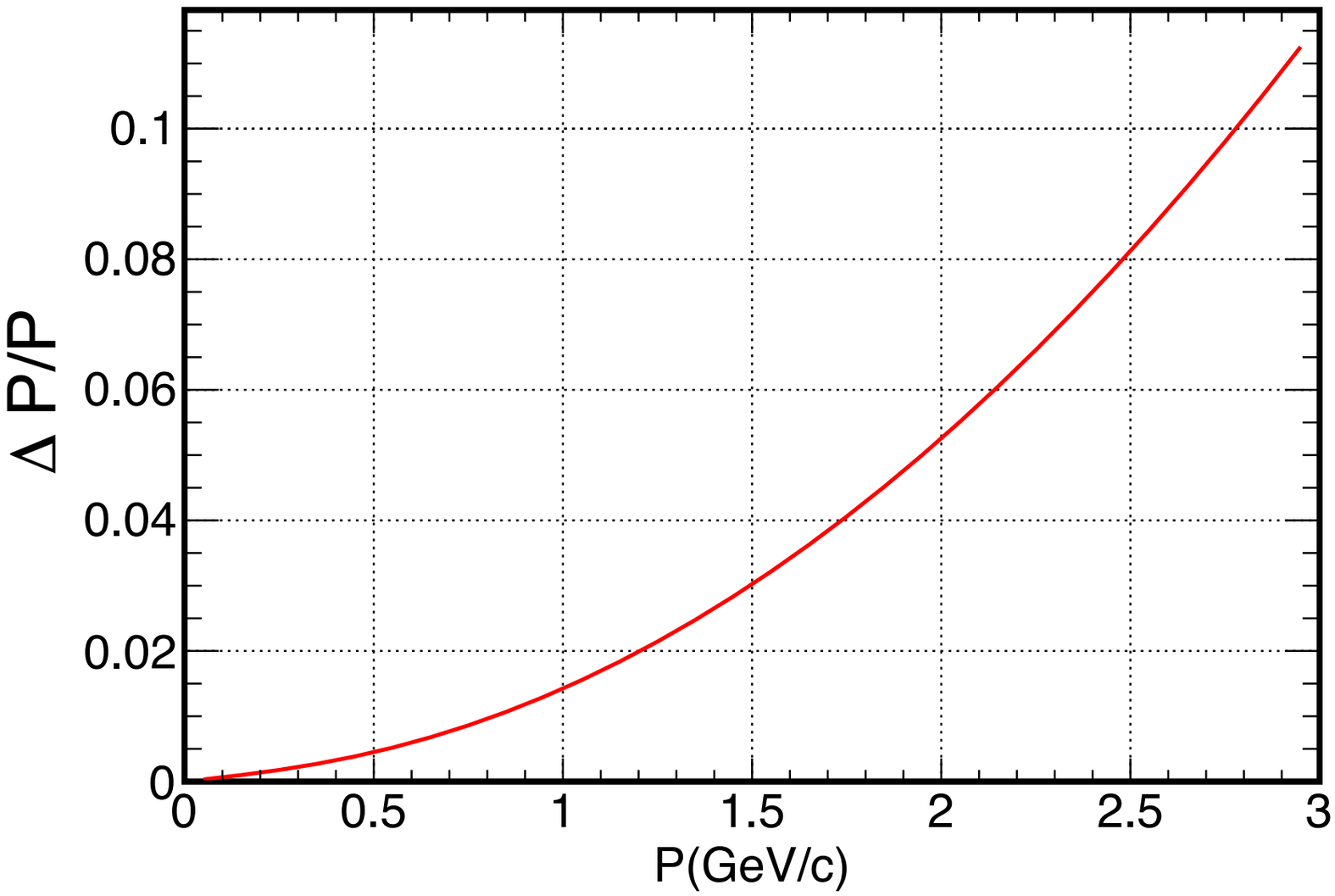
Beam energy	Target (λ_I)	$p(K)$ (MeV/c)	K_L/s into 500 μsr	$K_L : n$ ($E_n > 10$ MeV)
BNL AGS	24 GeV	1.1 Pt	300-1200	60×10^6	$\sim 1 : 1000$
Project X	3 GeV	1.0 C	300-1200	450×10^6	$\sim 1 : 2700$

KL beam can be used to study rare decays
However it will be extremely difficult to use for spectroscopy measurements because of n/K Ratio

K^0_L beam

- **Electron beam** $E_e = 12GeV; I_e = 5\mu A$
- **Radiator (rad. length)** 10%
- **Be target (R=3cm)** $L = 40cm$
- **LH2 target(L=30cm)** $R = 3cm$
- **Distance Be-LH2** $24m$
- **K_L Rate/sec** $\sim 10^4$

K_L Momentum Resolution



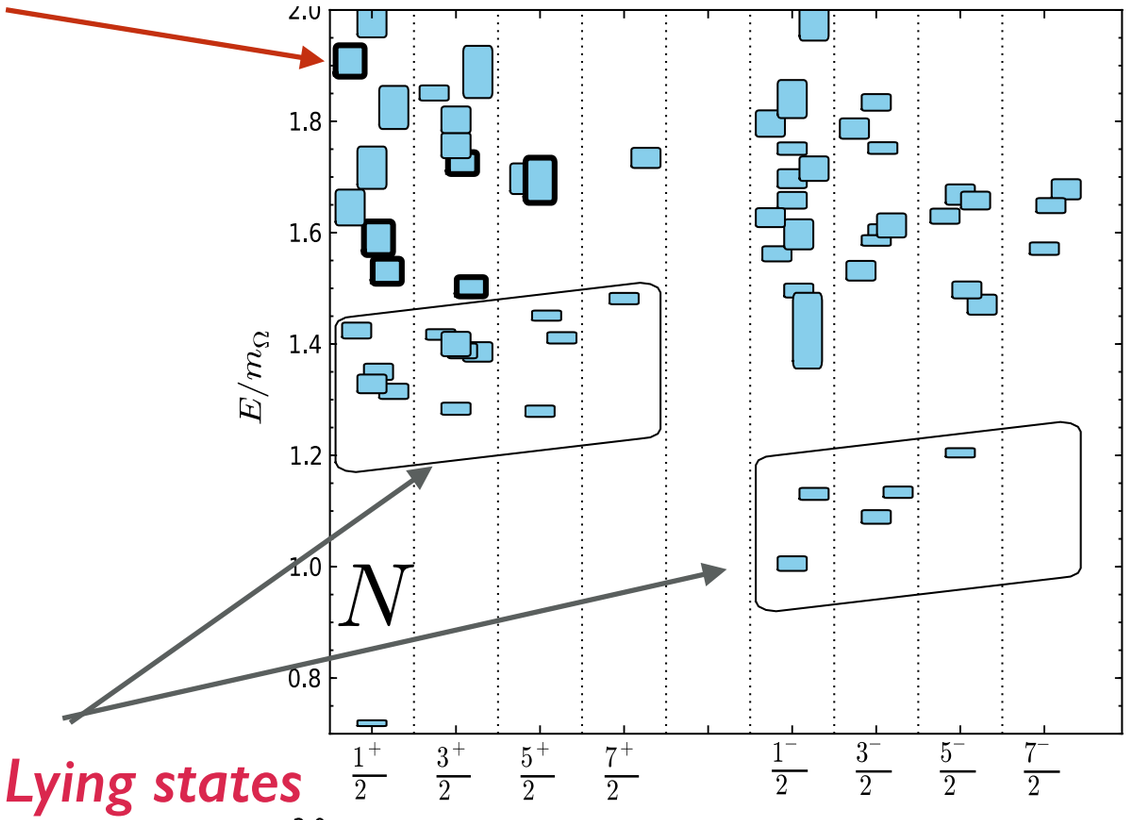
Time-of-Flight, L=24m; $\Delta t = 250ps$

Not everything could be measured with electron and photon beams

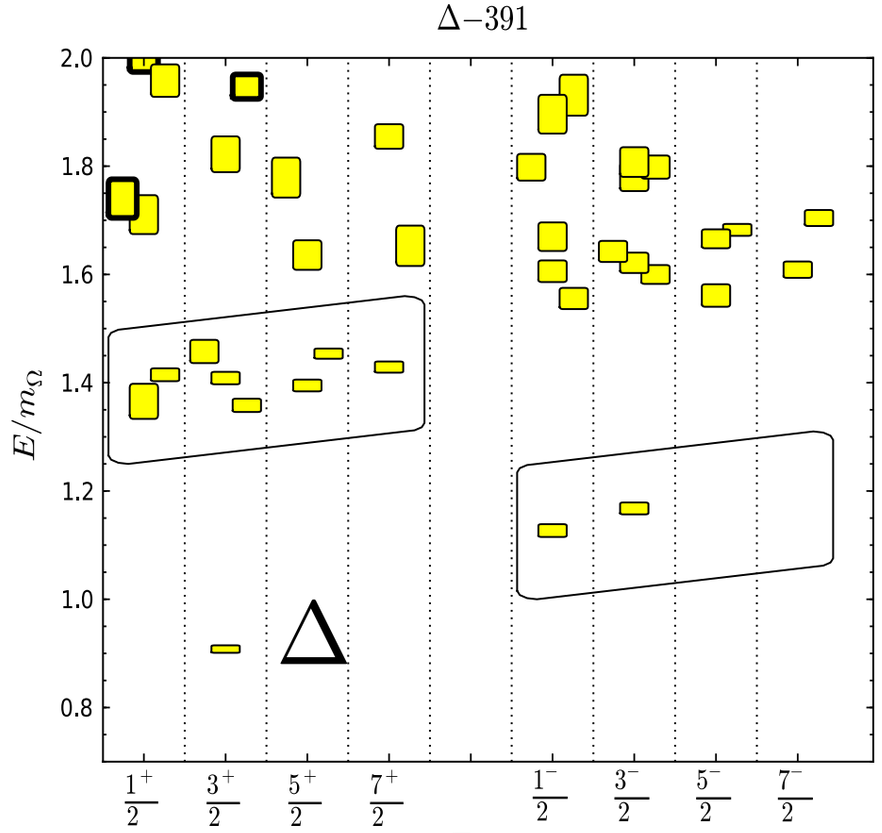
What can be done with kaon beams ?

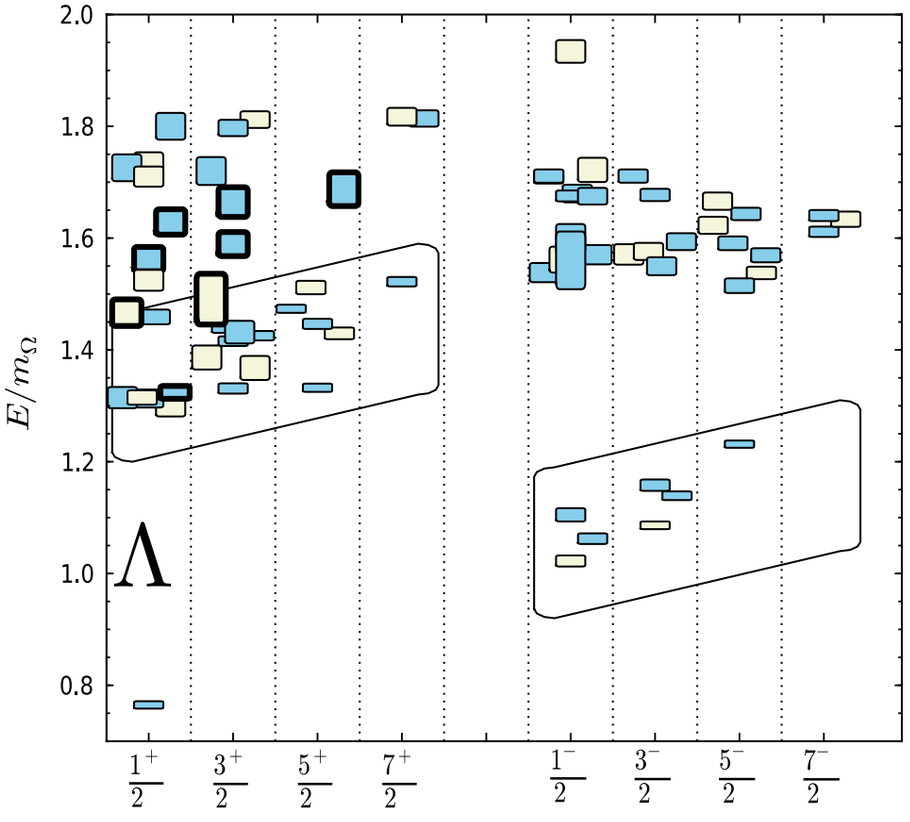
Lattice QCD calculations

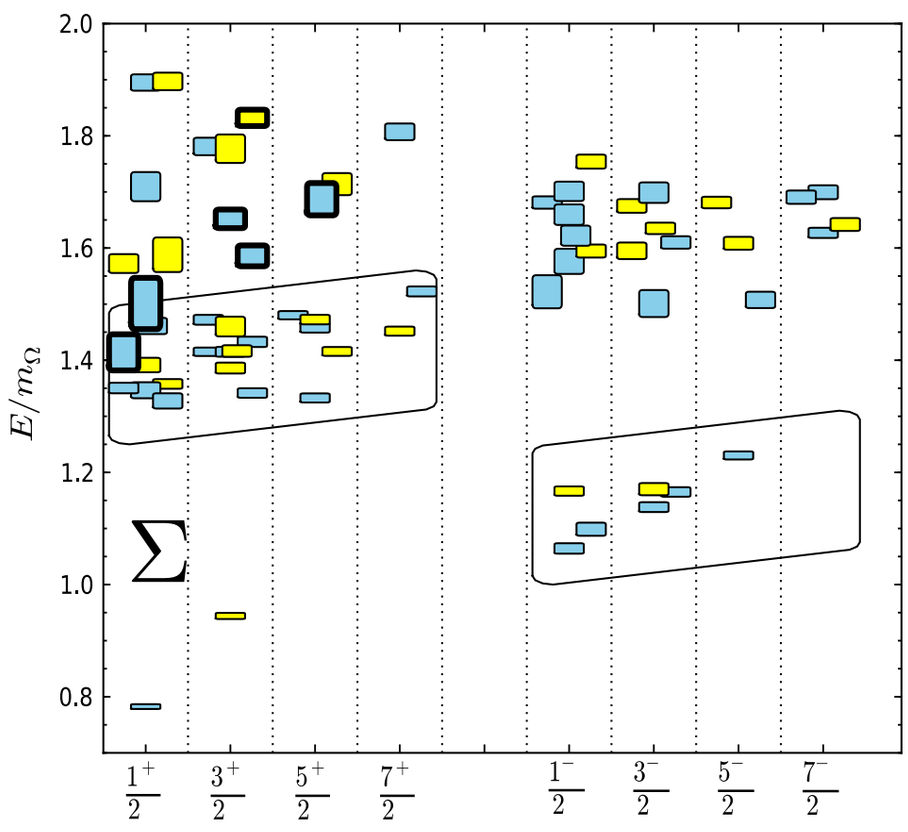
Thick borders: Hybrid states



Low Lying states

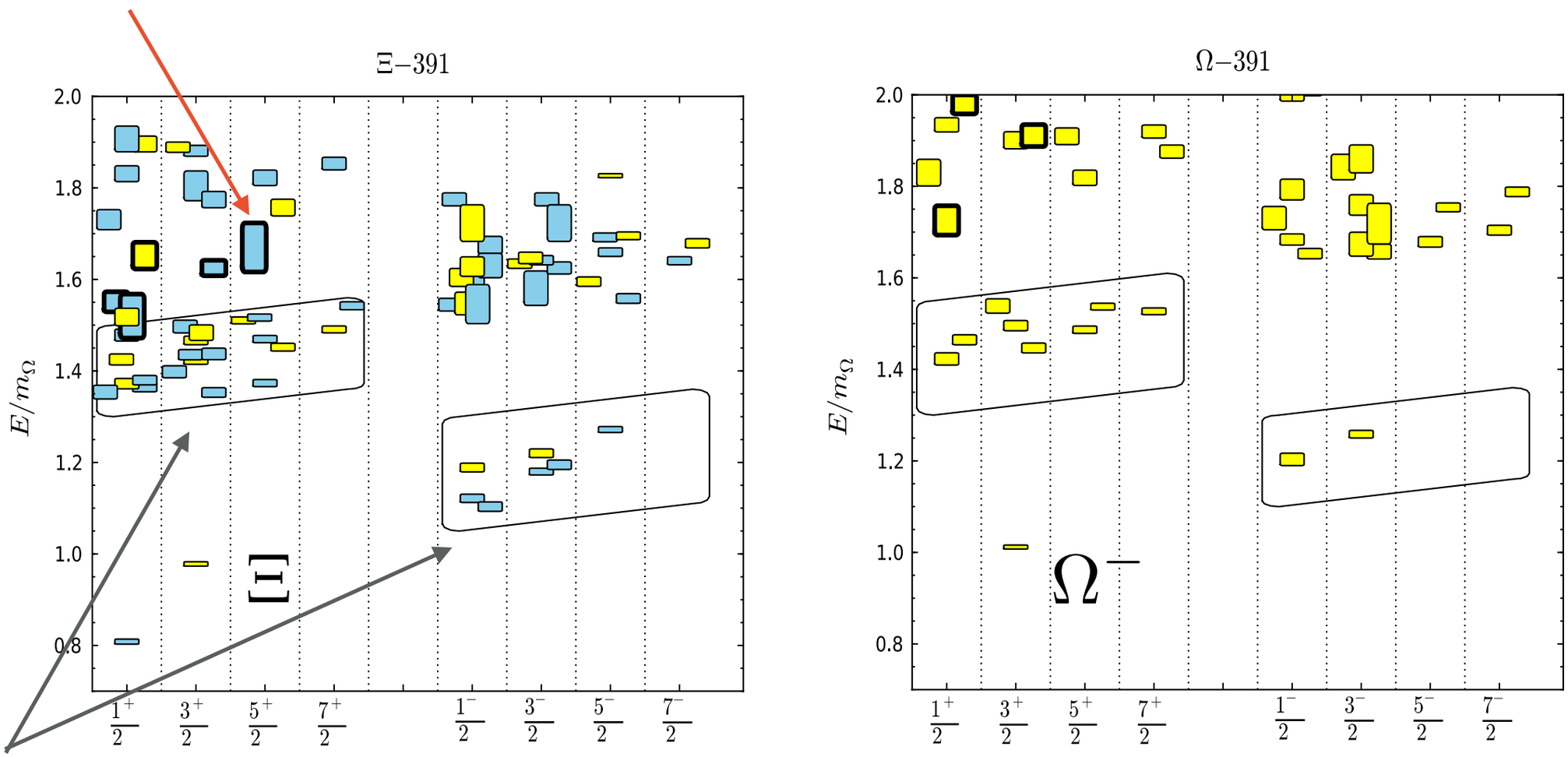






Lattice QCD calculations

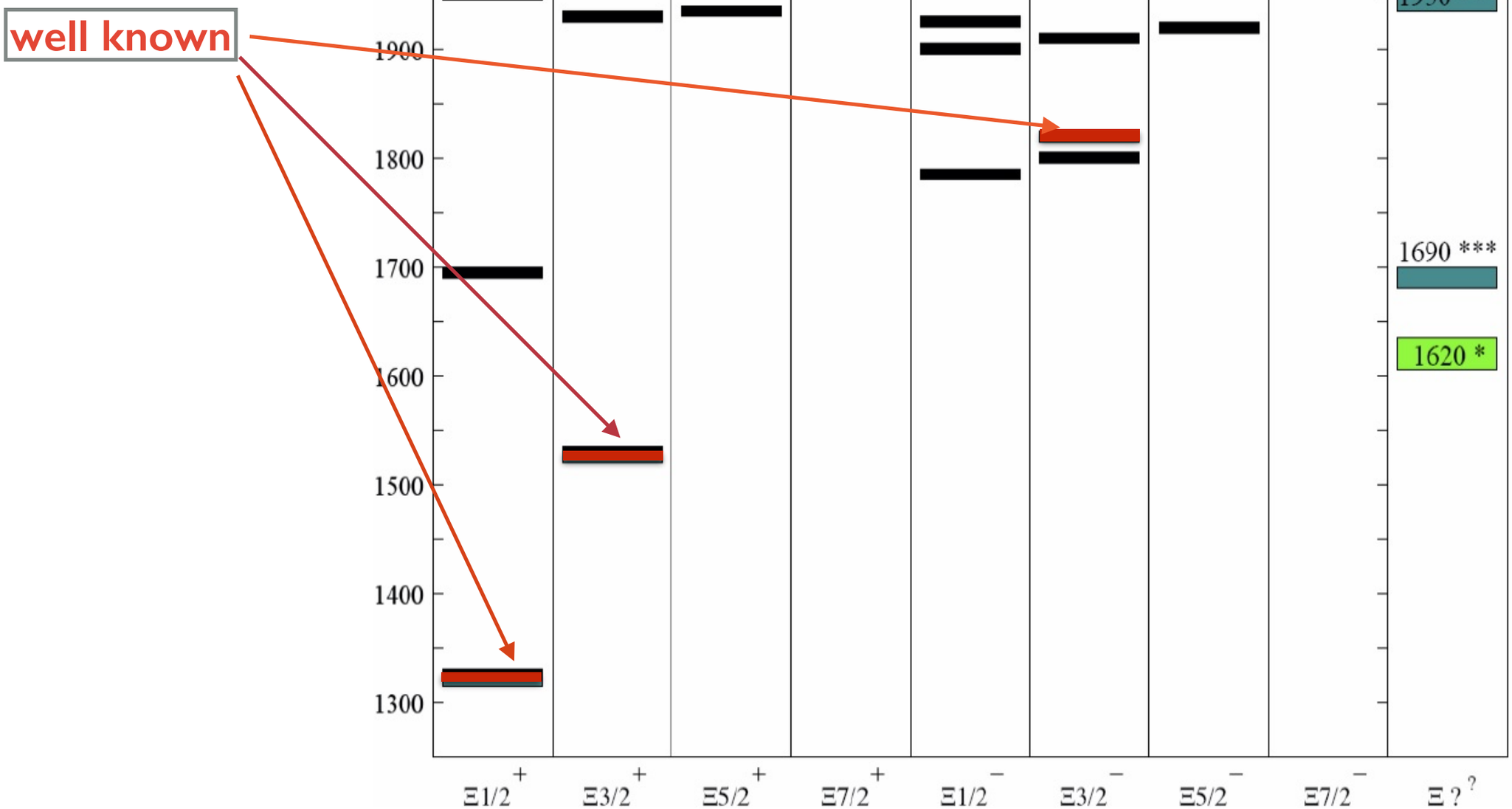
Thick borders: Hybrid states



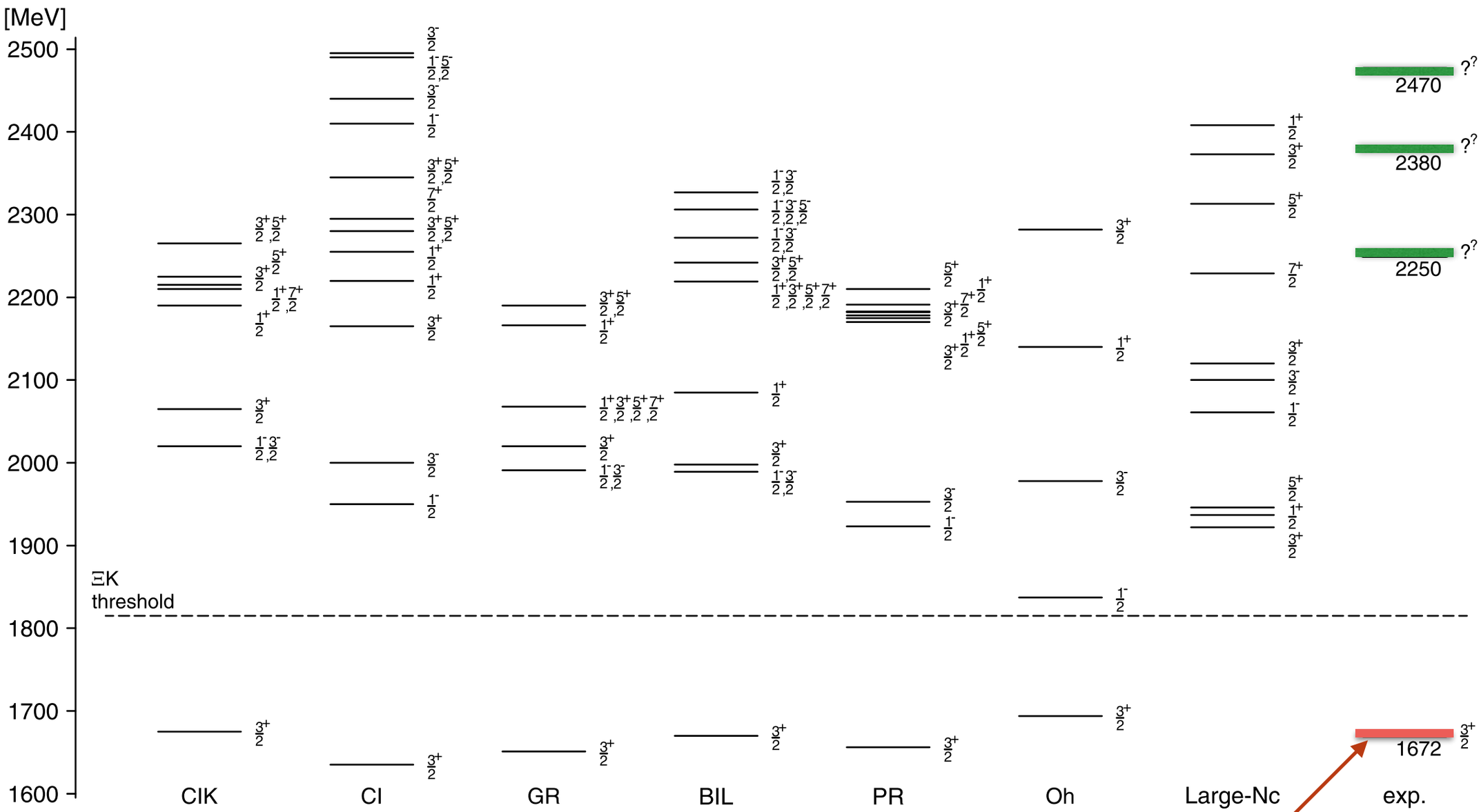
Low Lying states

Edwards, Mathur, Richards and Wallace
Phys. Rev. D 87, 054506 (2013)

Status of Ξ^*


well known
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
2250 **
2120 *
J>3/2(3σ)
2030 ***
1950 ***
1690 ***
1620 *
Ξ1/2+
Ξ3/2+
Ξ5/2+
Ξ7/2+
Ξ1/2−
Ξ3/2−
Ξ5/2−
Ξ7/2−
Ξ ??

Status of Ω^{-*}



only one well known state?

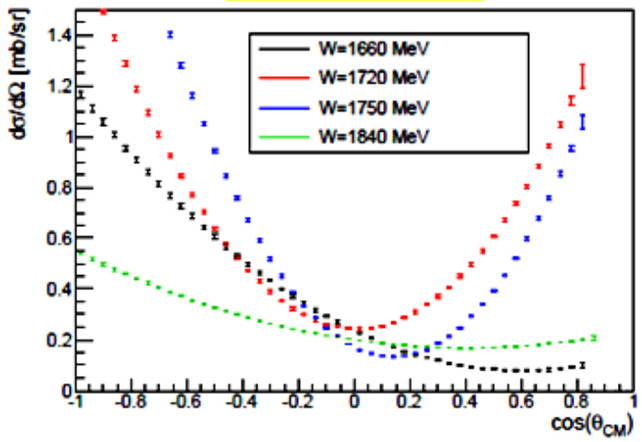
Expected Cross Sections vs Bubble Chamber Data

- **GlueX** measurements will span **cosθ** from **–0.95** to **0.95** in c.m. above **W** = **1490** MeV.
- K_L rate is **10^4 K_L/s**
- Uncertainties correspond to **100** days of running time.
- Cross section uncertainty estimates (statistics only) for

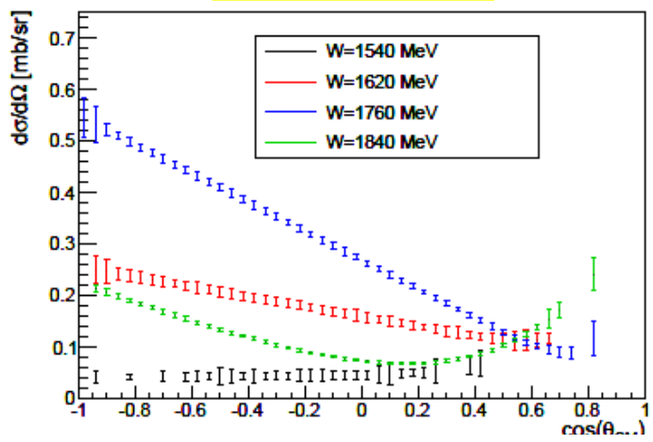
Courtesy of Simon Taylor, KL2016
Mark Manley, KL2016

Expected **GlueX** Data

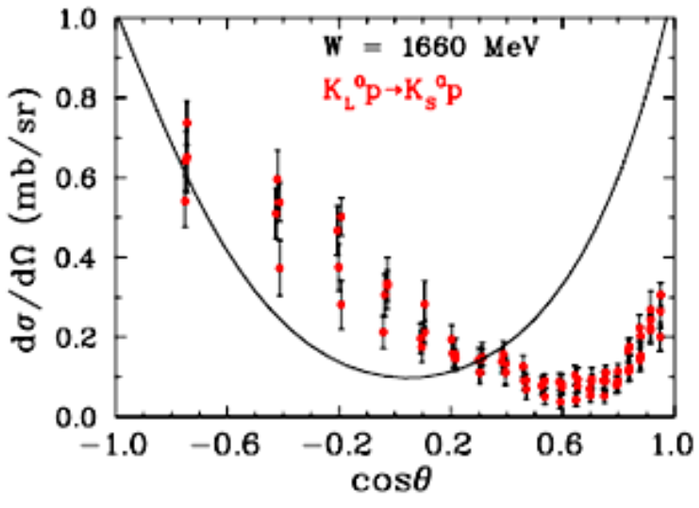
$K_Lp \rightarrow K_Sp$

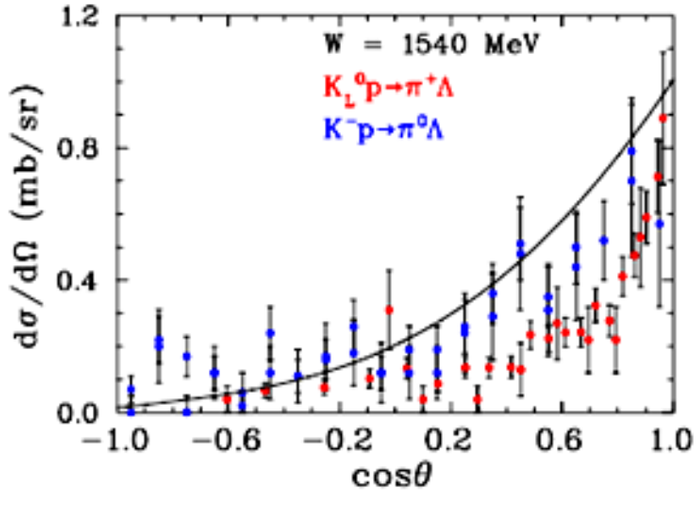


$K_Lp \rightarrow \pi^+\Lambda$



BC Data

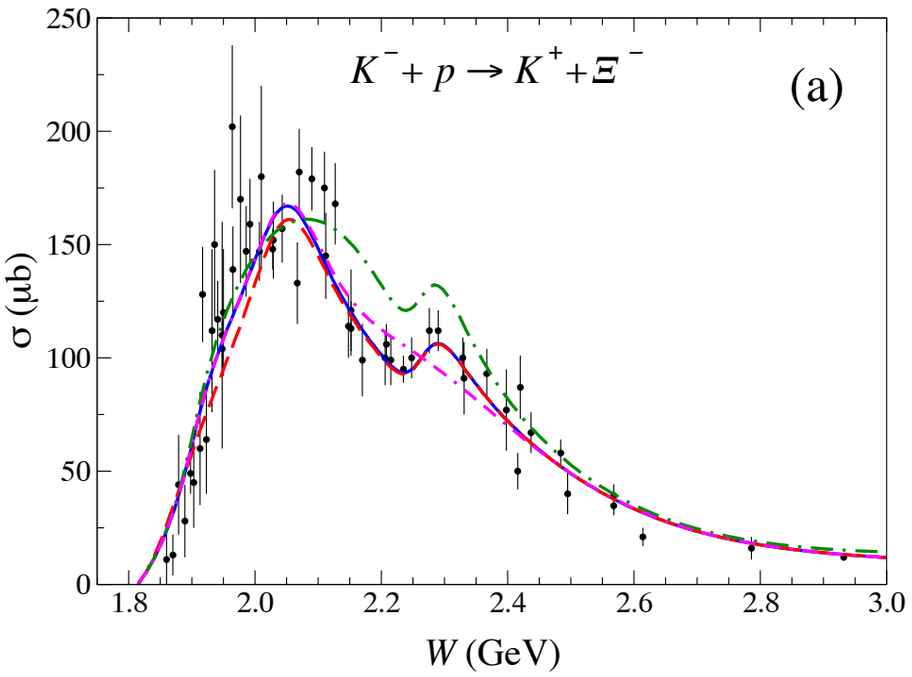


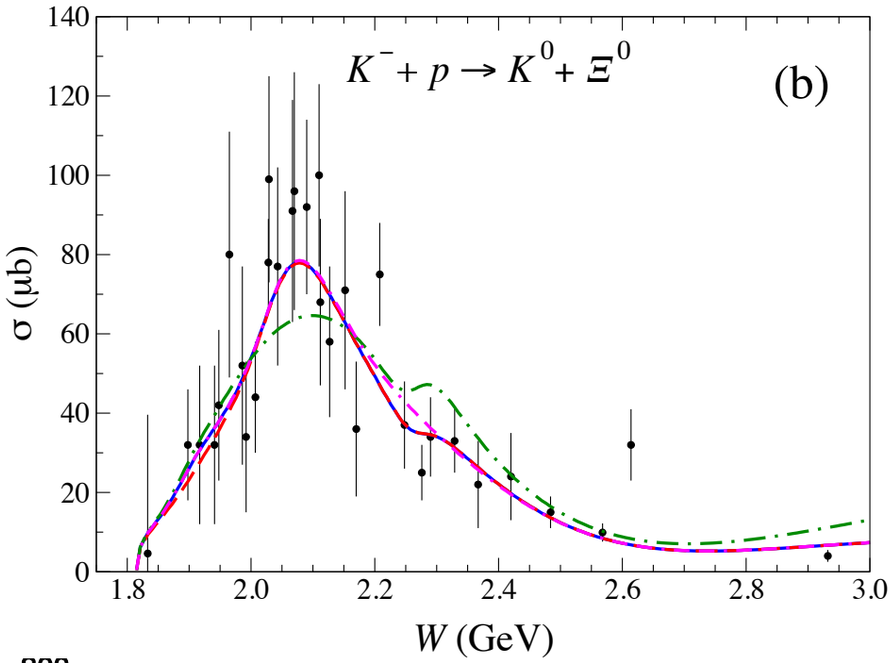


More details in KL2016 Workshop Proceedings

arXiv: 1604.02141

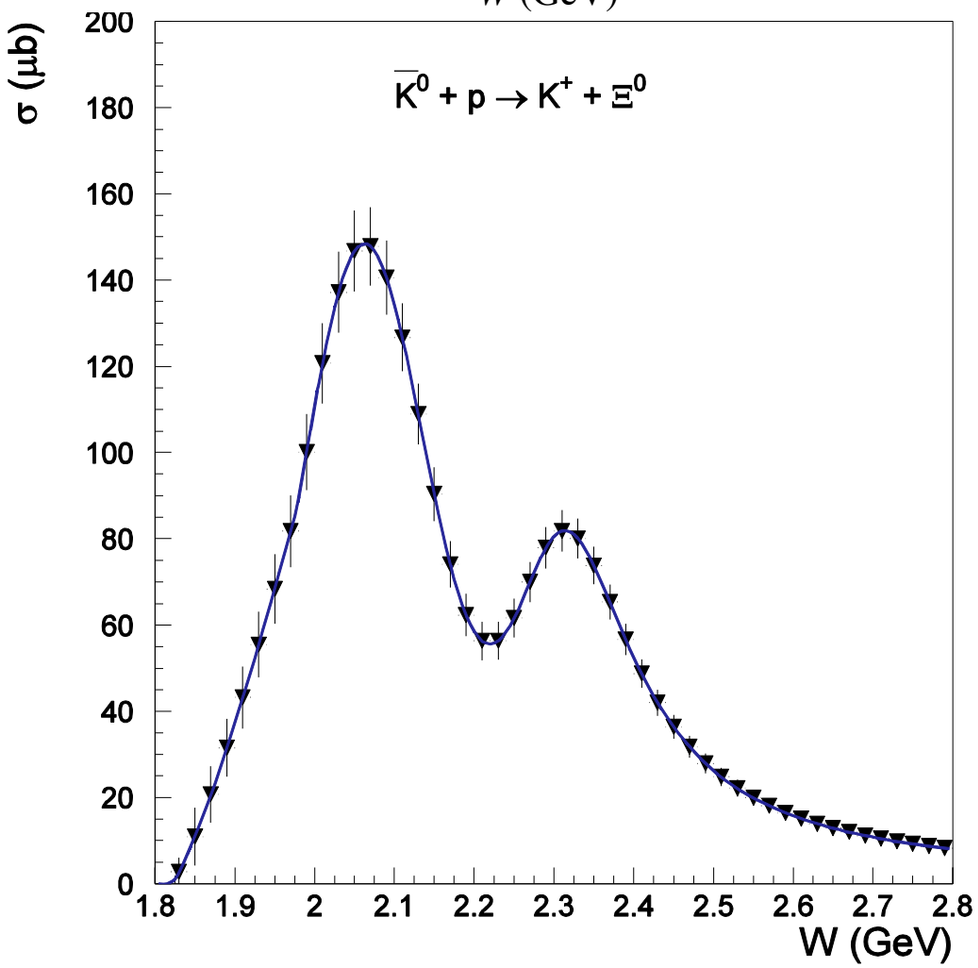
World Data on Ξ





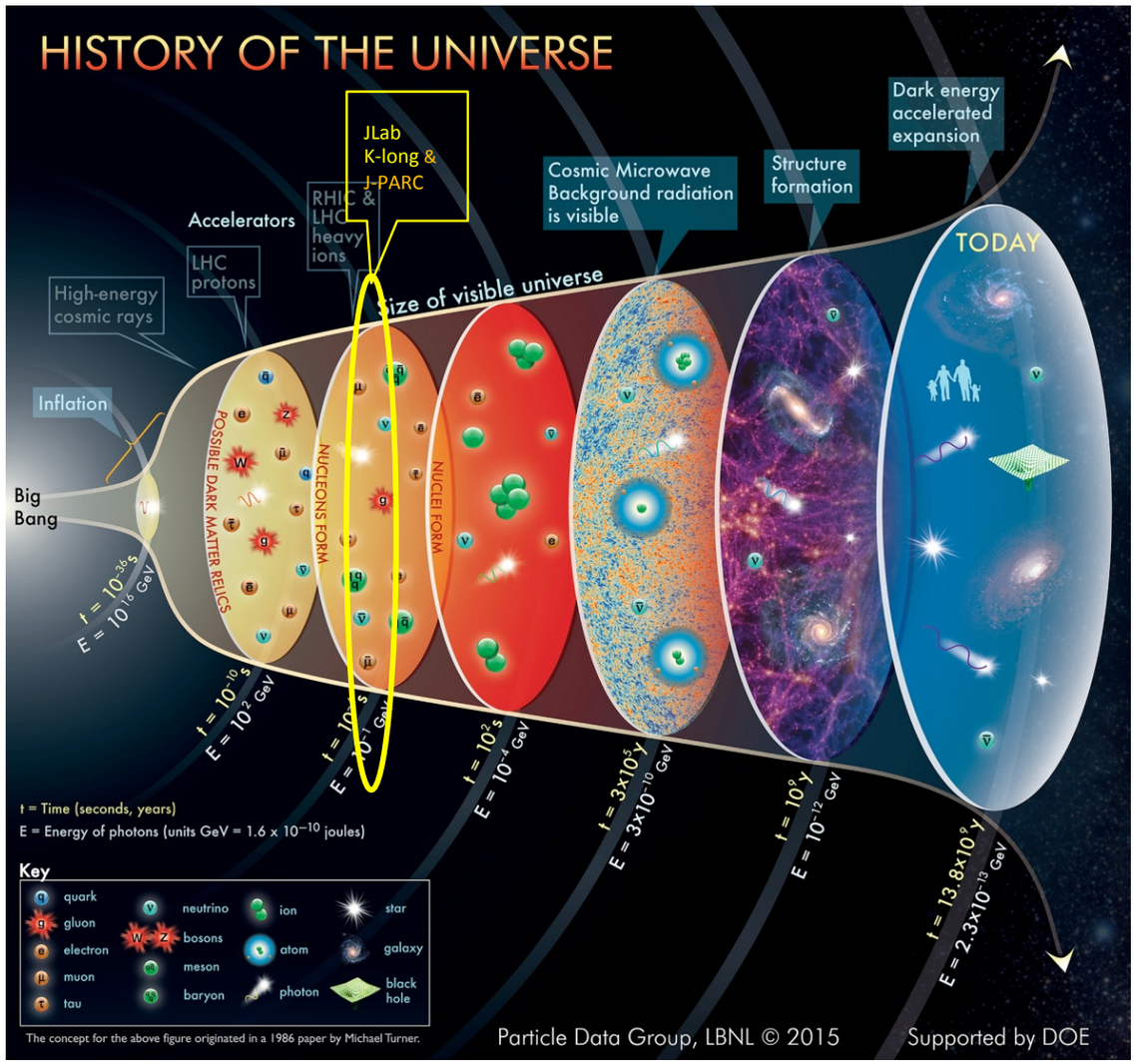
Simulated with GlueX

10^4 K_L/sec, one day of running

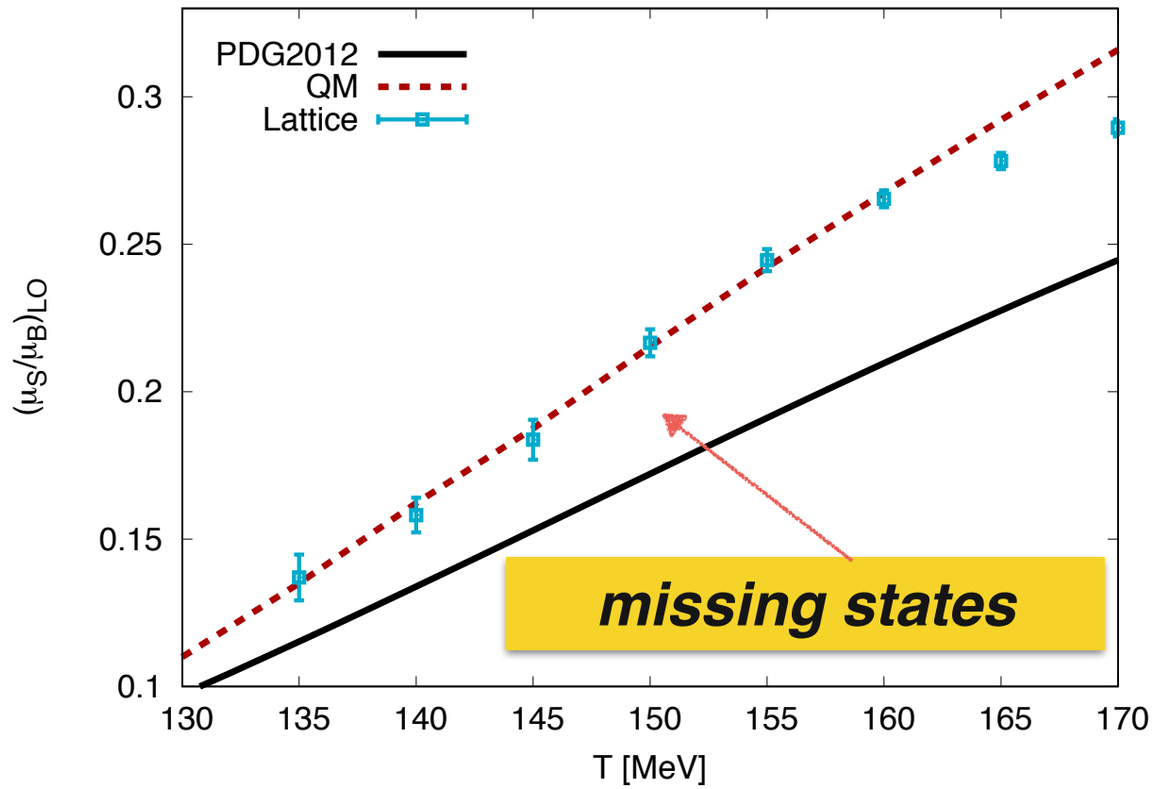


Jackson, Oh, Haberzettl, Nakayama
Phys. Rev. C 91, 065208 (2015)

How Important are Missing Hyperons for the Evolution of an Early Universe at Freeze-out

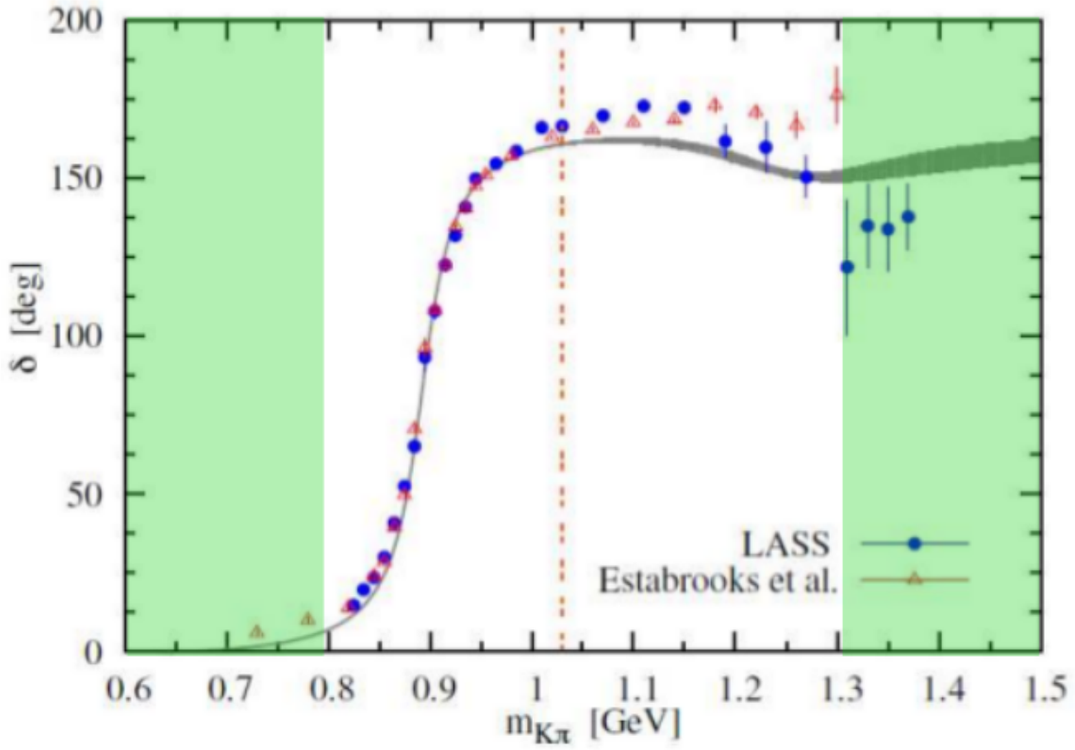


Chemical potential

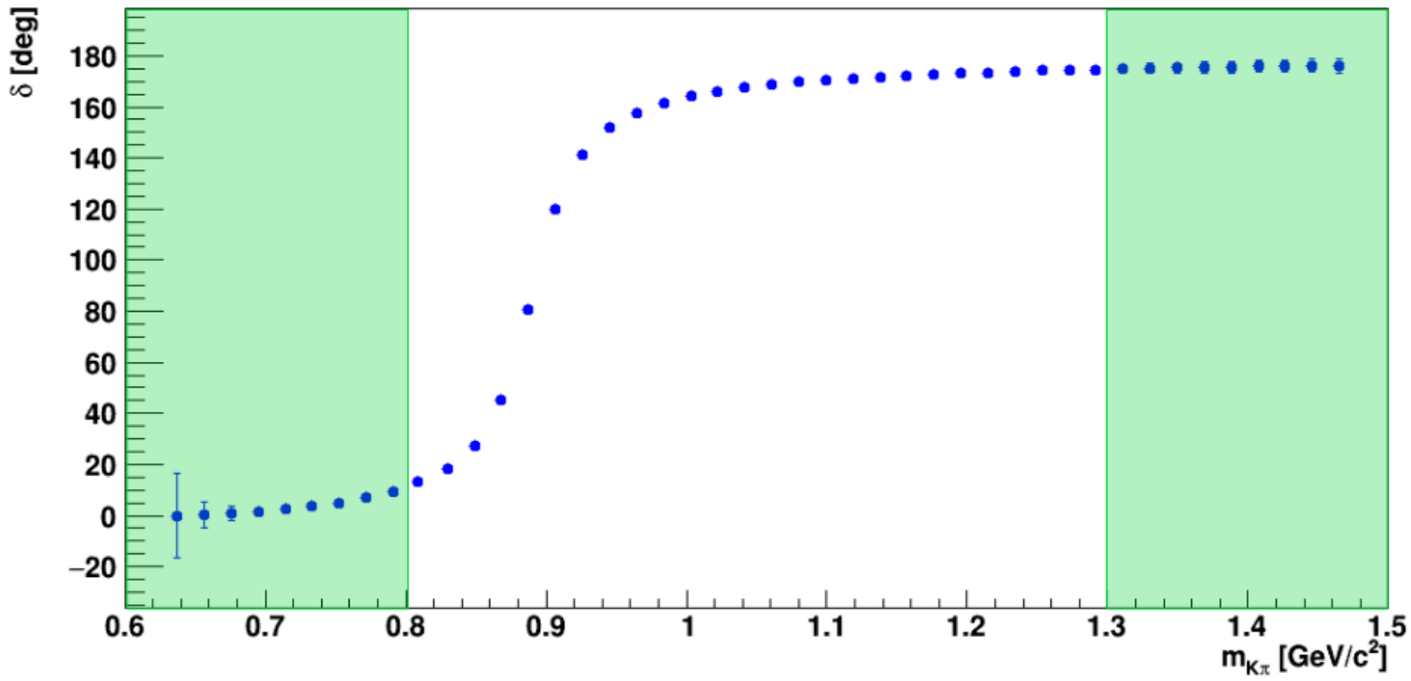


YSTAR2016 Proceedings arXiv: 1701.07346

$K-\pi$ Scattering



Current status



KLF Projected for 100 days

Summary

-KL Facility is feasable at JLAB with intensity ~10^4/s

-It has a potential to observe dozens of missing hyperons

-Significant improvement in K-pi scattering database

Looking forward to learn more during this workshop!