

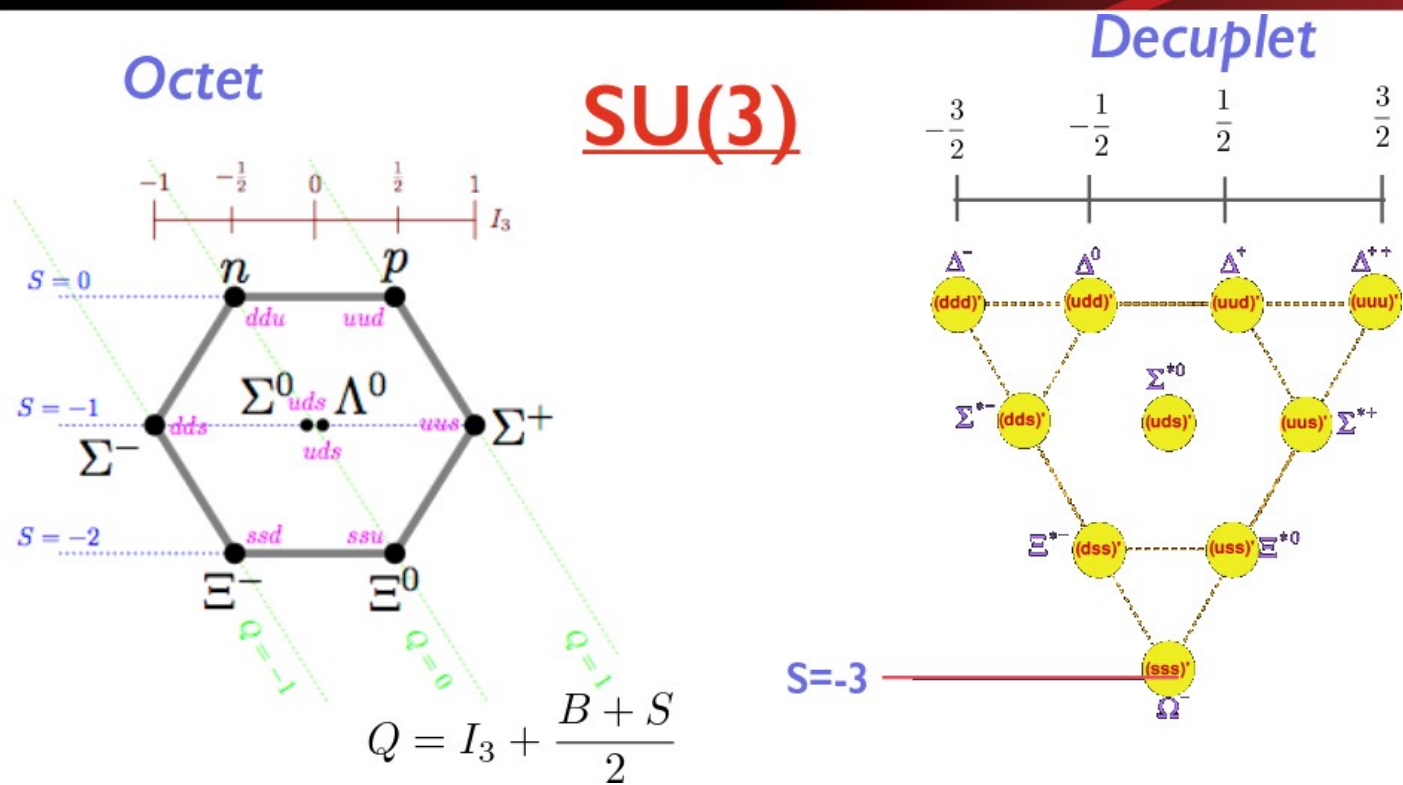
# Toward a $K_L$ program at JLab

Simon Taylor / JLab

May 17, 2016

- ◆ Motivation for a  $K_L$  beam
  - ◆ Existing measurements
- ◆ Hall D beam line and GlueX apparatus
  - ◆ Preliminary simulation results

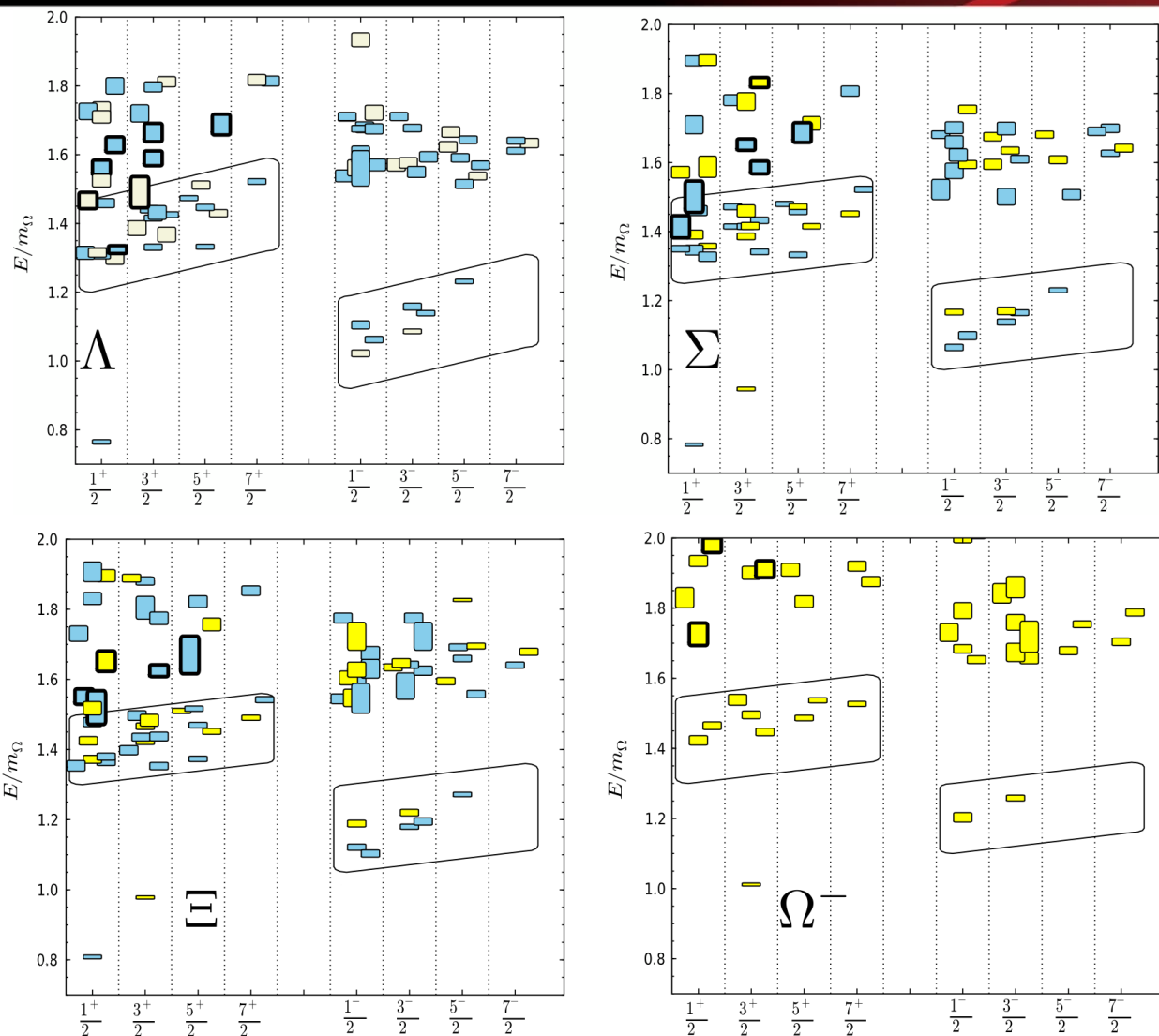
# Motivation



- ◆ Constituent Quark Model successful framework for mapping out 3-quark baryon states
  - ◆ But there are many predicted but missing states...
  - ◆ Hyperons (  $\Lambda$ 's,  $\Sigma$ 's,  $\Xi$ 's,  $\Omega$ 's ) are less well-understood than  $N^*$ 's,  $\Delta$ 's
  - ◆ What about hybrids (states with “valence glue”) and multi-quark(>3) states?

# Lattice QCD results

Thick borders:  
hybrid states



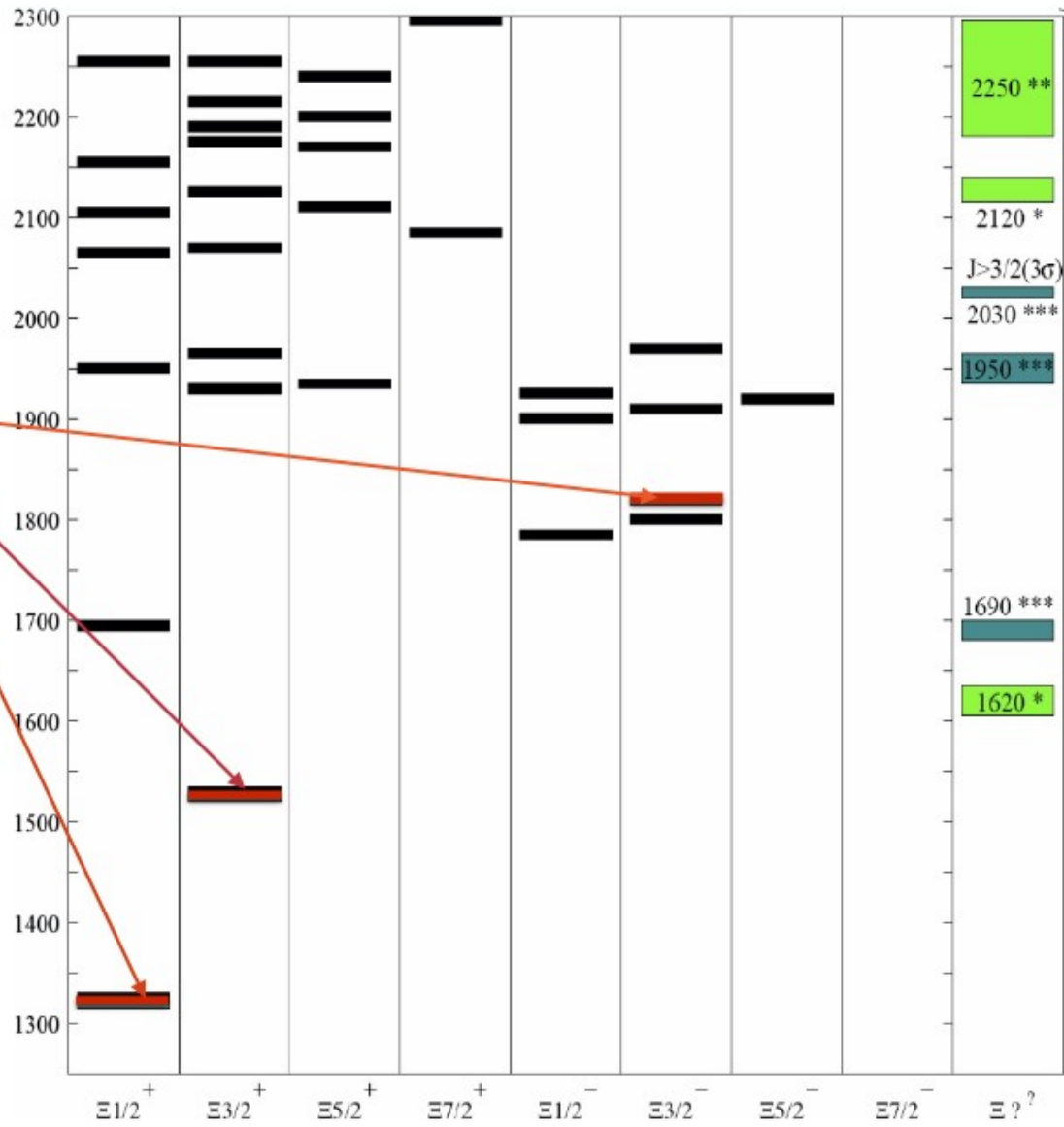
Edwards, Mathur, Richards and Wallace, Phys. Rev. D 87, 054506 (2013)

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# $\Xi^*$ and $\Omega^*$ status

Cascades:

well known

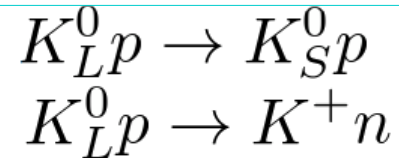


◆ Situation for  $\Omega$ 's is worse: only one well-known state...

Black bars: quark model calculations

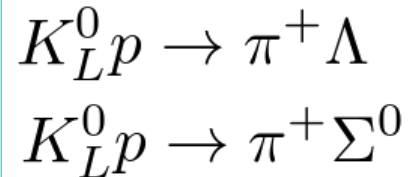
# Reactions of interest

Elastic and charge-exchange

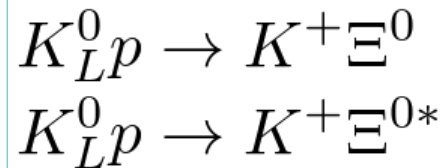


◆ Existing data with  $K_L$  beam is sparse ... especially for polarization measurements

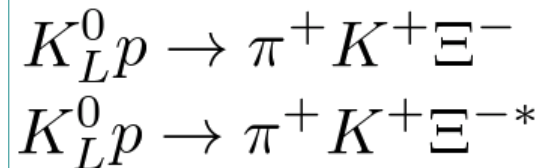
Two-body with  $S=-1$



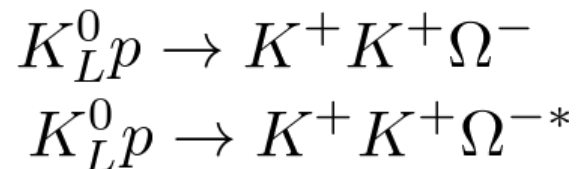
Two-body with  $S=-2$



Three-body with  $S=-2$



Three-body with  $S=-3$



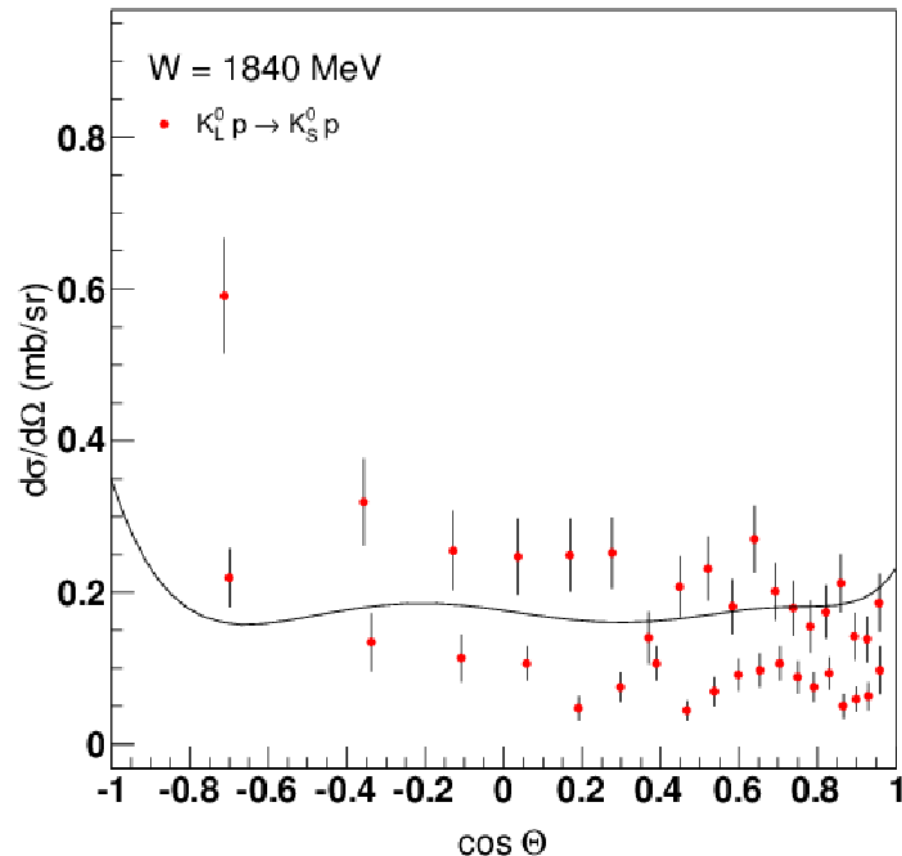
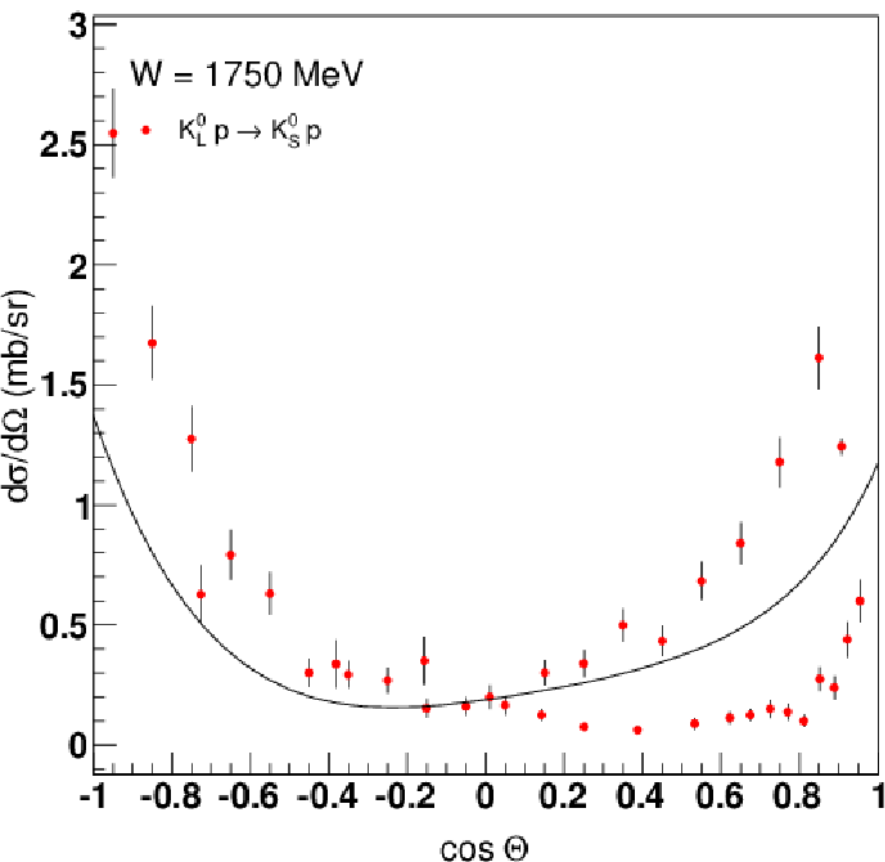
# Differential cross sections

$$\frac{d\sigma}{d\Omega} = \lambda^2 (|f|^2 + |g|^2)$$

$$f(W, \theta) = \sum_{l=1}^{\infty} [(l+1)T_{l+} + lT_{l-}] P_l(\cos \theta)$$

$$g(W, \theta) = \sum_{l=1}^{\infty} [T_{l+} - T_{l-}] P_l^1(\cos \theta)$$

D.M. Manley



◆ To extract resonance parameters, need coupled-channel Partial Wave Analysis...

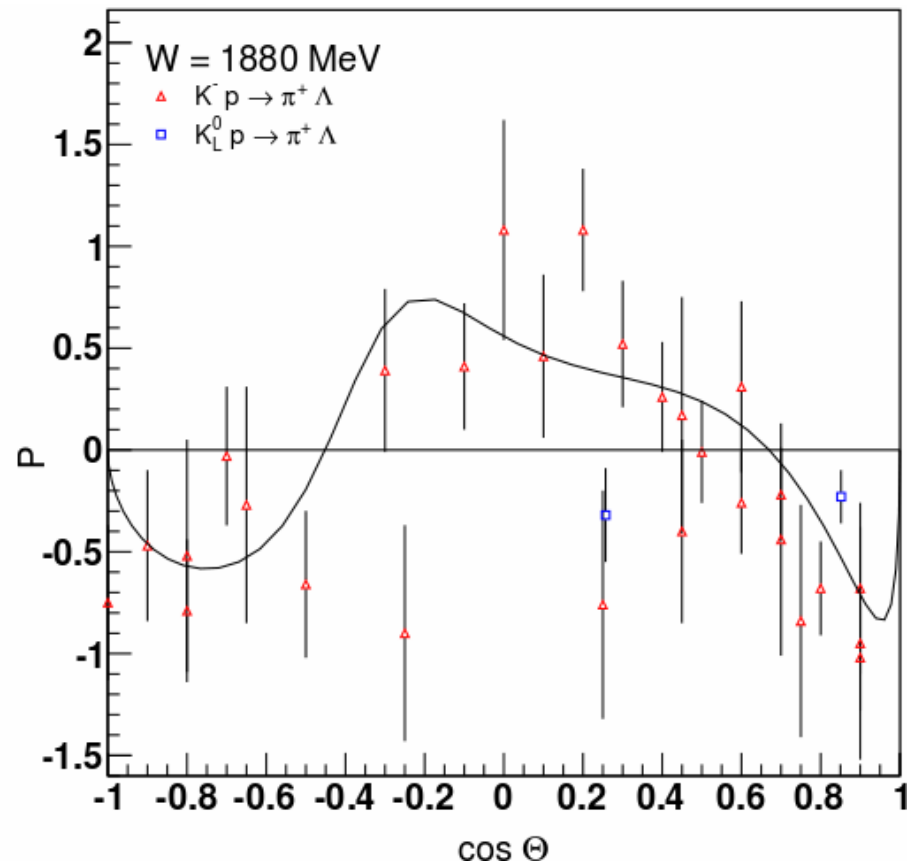
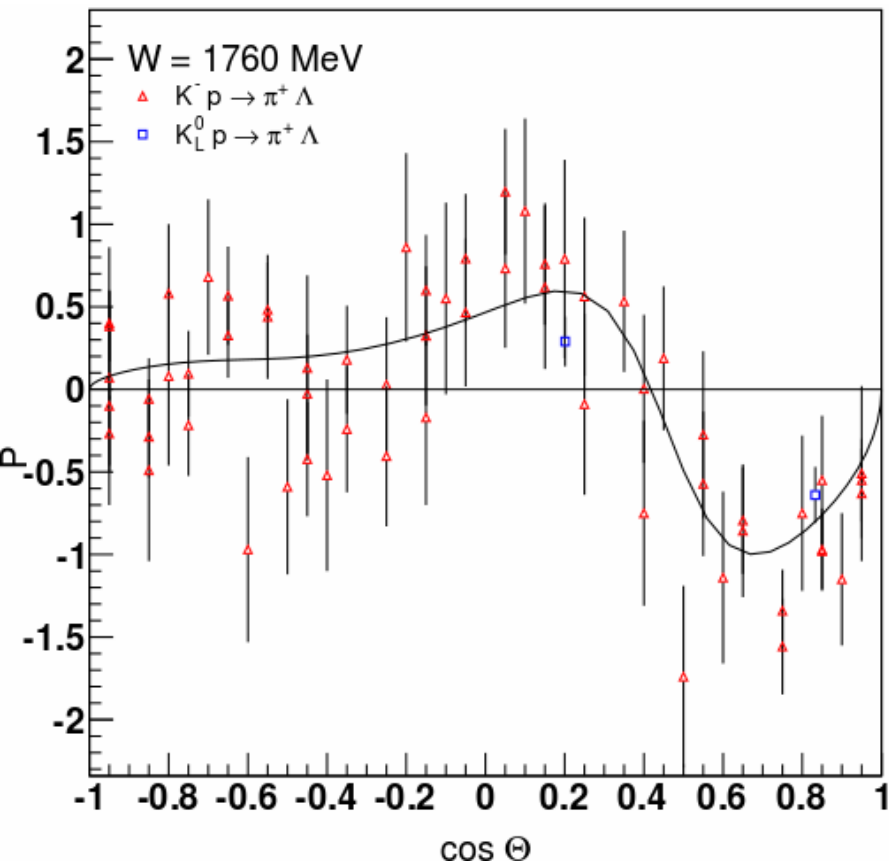
# Polarization observables

$$P \frac{d\sigma}{d\Omega} = 2\lambda^2 \text{Im}(fg^*)$$

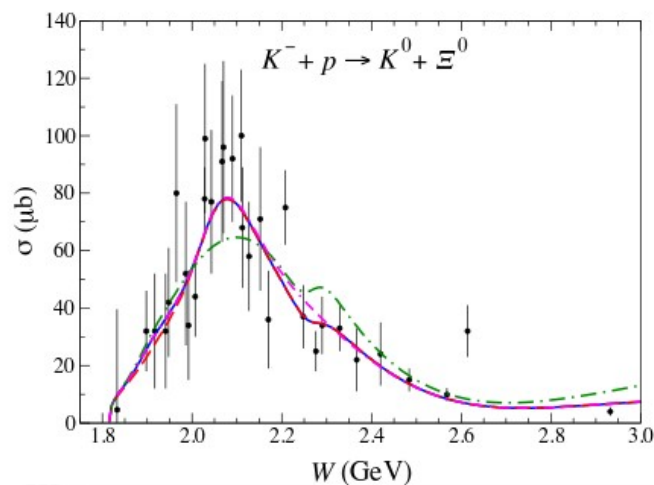
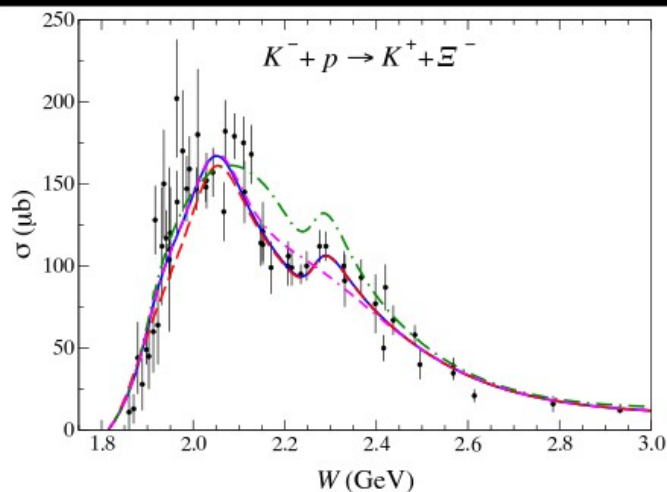
$$f(W, \theta) = \sum_{l=1}^{\infty} [(l+1)T_{l+} + lT_{l-}] P_l(\cos \theta)$$

$$g(W, \theta) = \sum_{l=1}^{\infty} [T_{l+} - T_{l-}] P_l^1(\cos \theta)$$

D.M.Manley

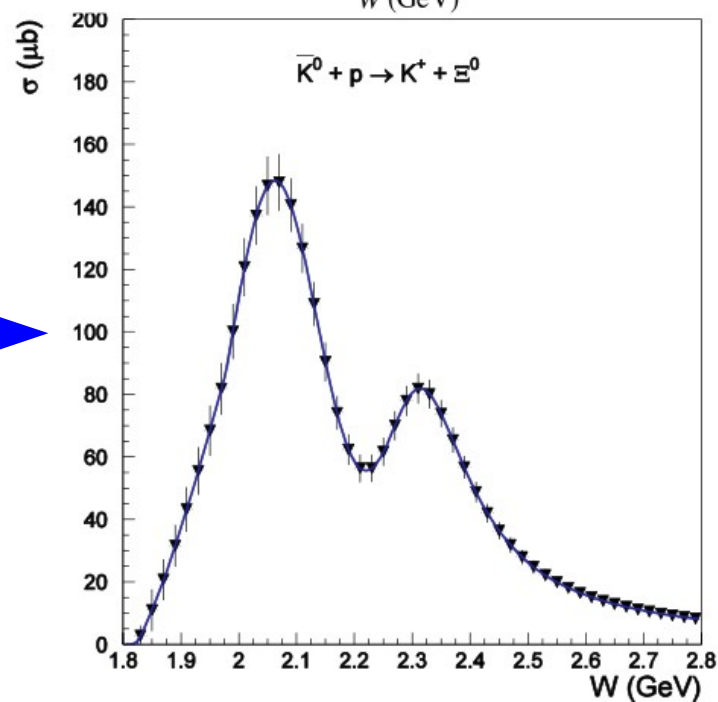


# $\Xi$ physics



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

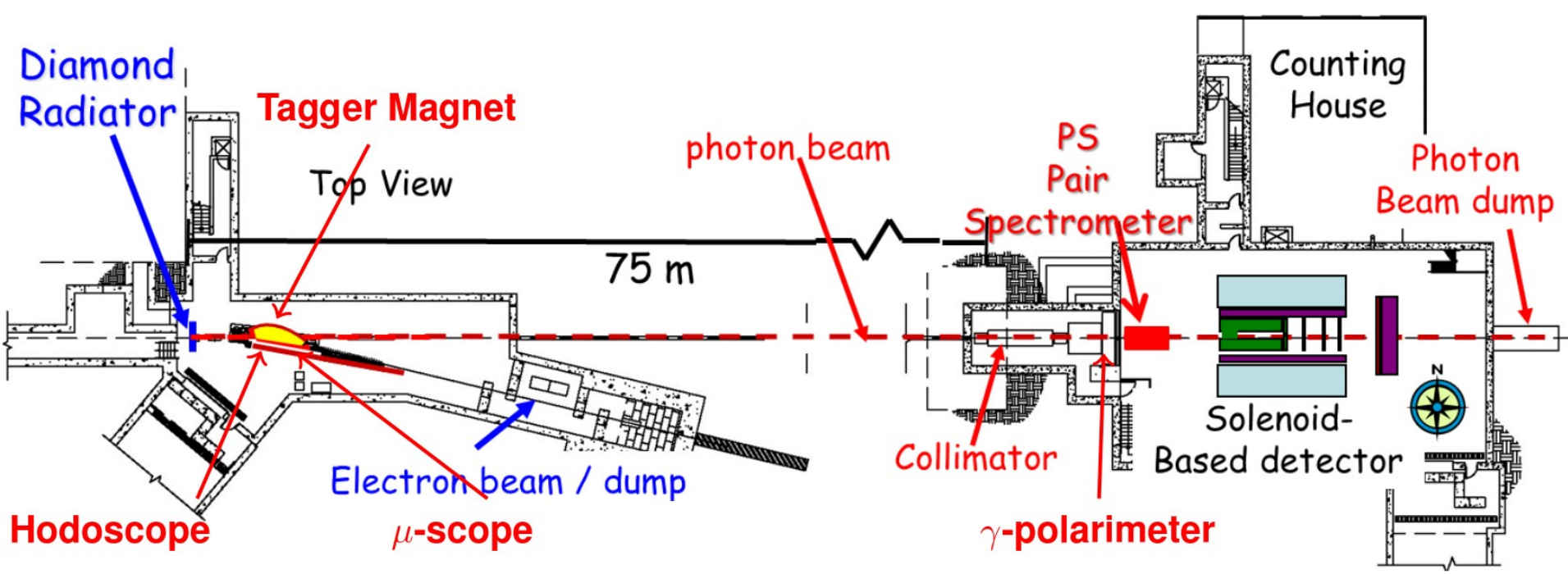
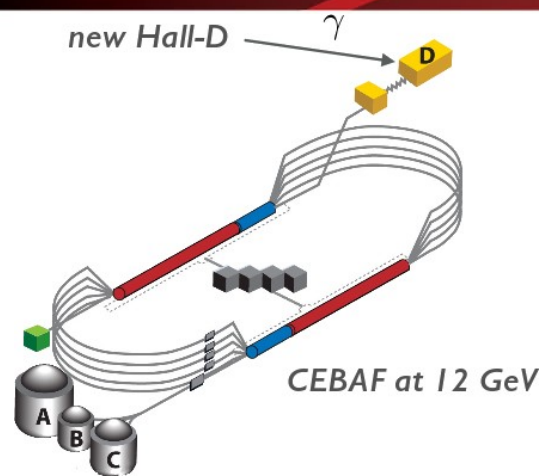
Simulation with GlueX:  
1 day at  $10^4$   $K_L/s$



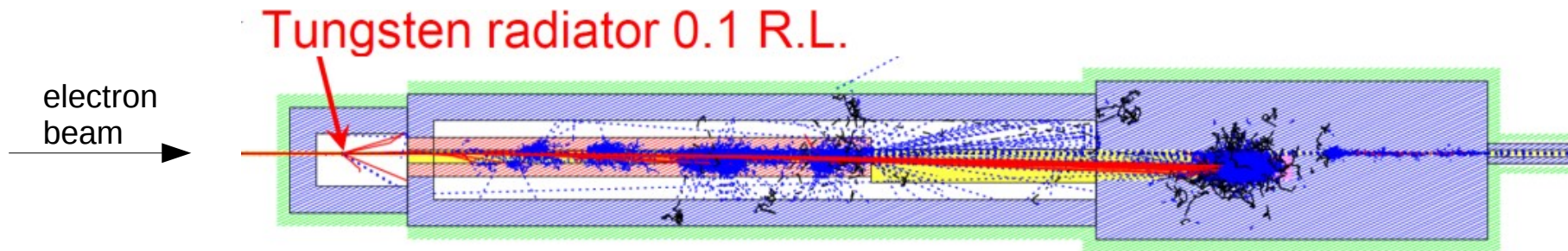


# CEBAF and Hall D complex

Aerial View



# Photon beam source

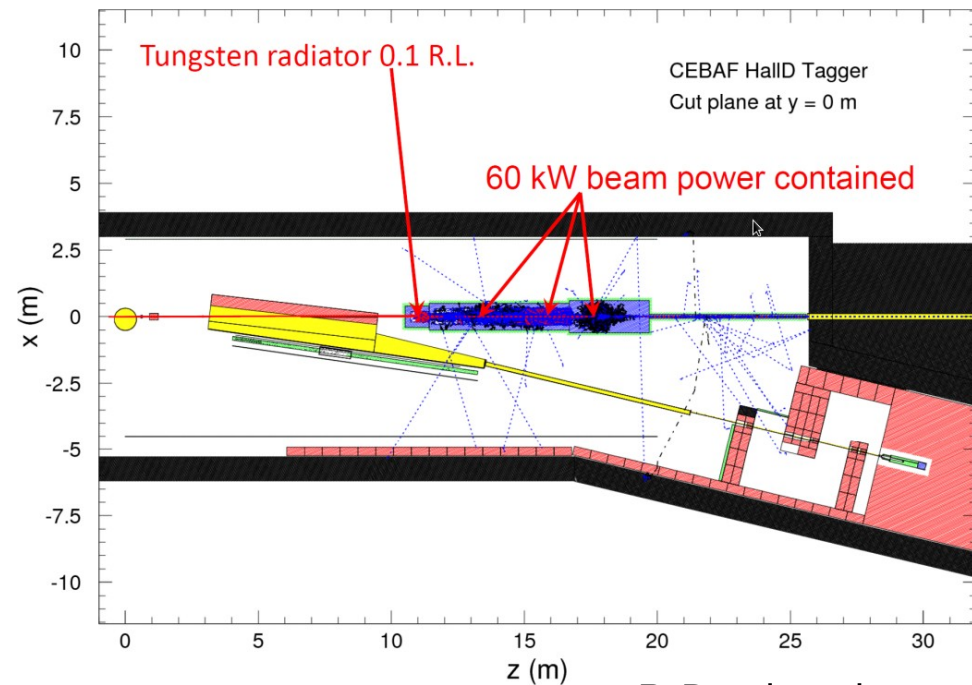


- $K_L$  program requires high photon flux

- Using existing radiator/tagger configuration with thicker radiator not feasible
- Dose rates and activation would be unacceptable

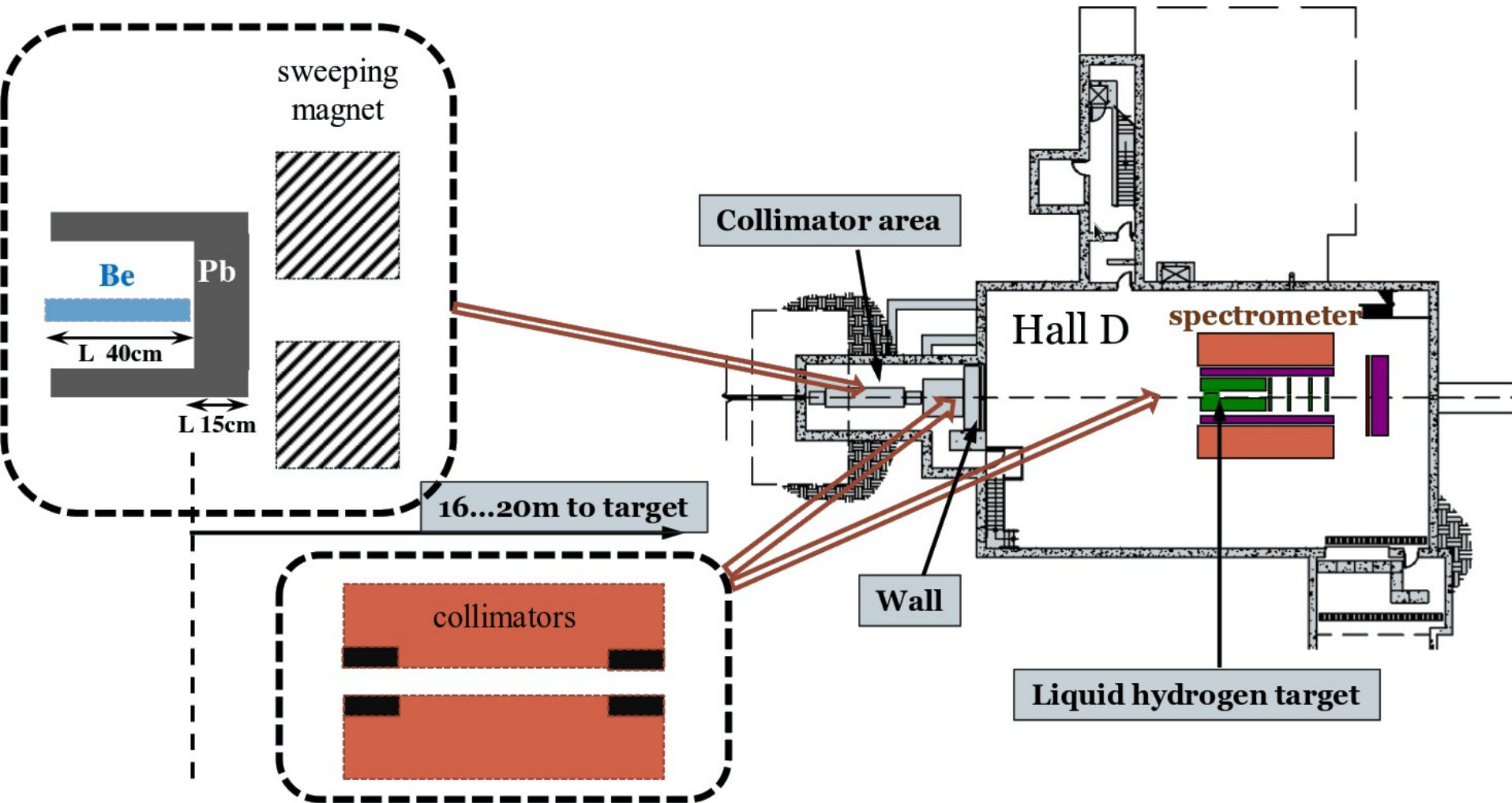
- Solution:

**“Compact Gamma Source”**

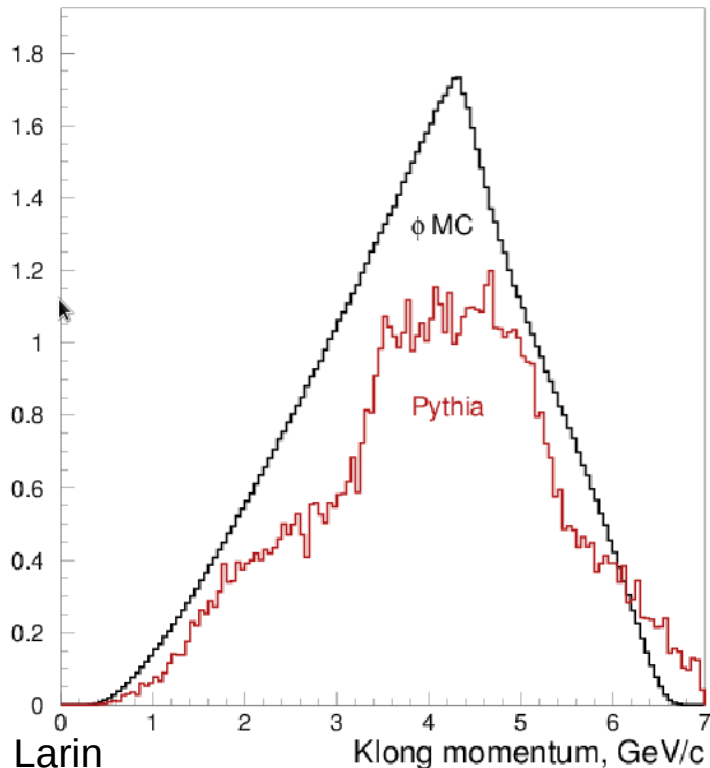


P. Degtiarenko

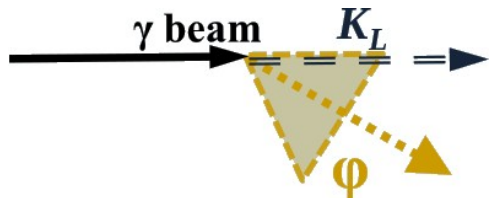
# Beam line into Hall D



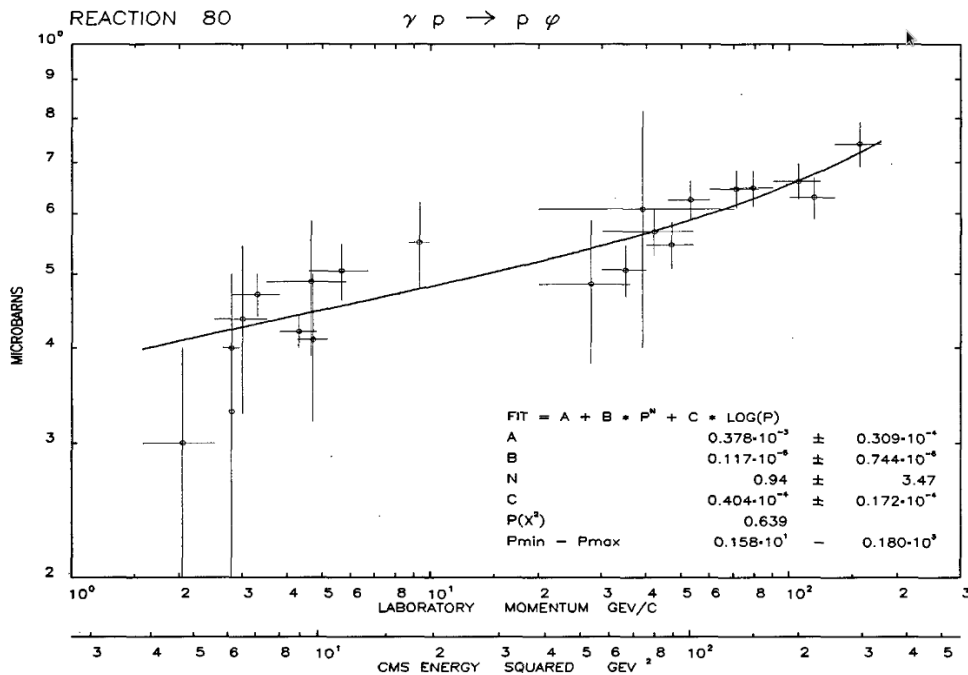
Entries / 50 MeV



I. Larin

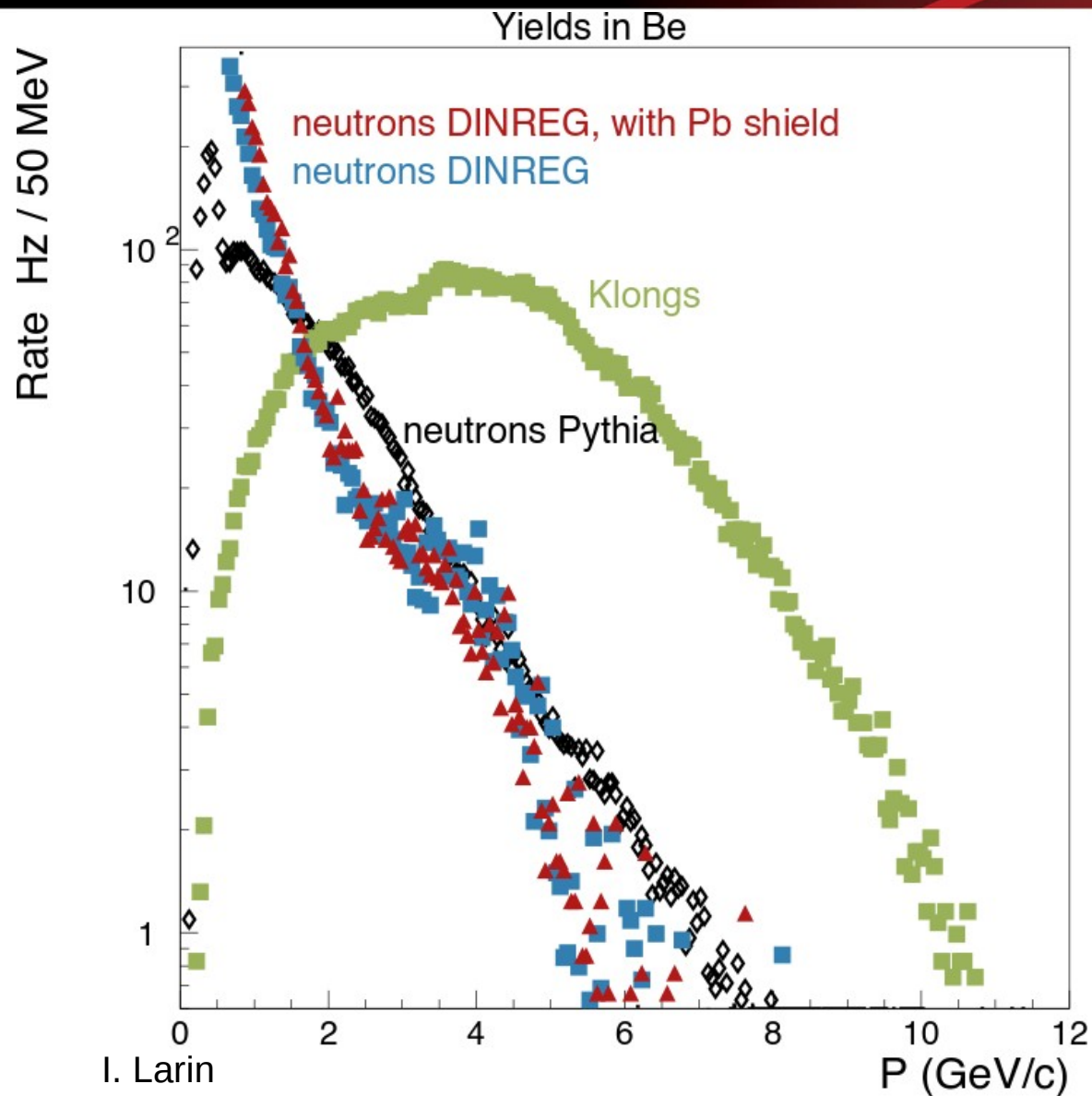


- $\phi(1020)$  decays are good source for  $K_L$ 's
- $BR(\phi \rightarrow K_L K_S) = 34\%$
- Photoproduction cross section  $\sim 500$  nb @ 5 GeV

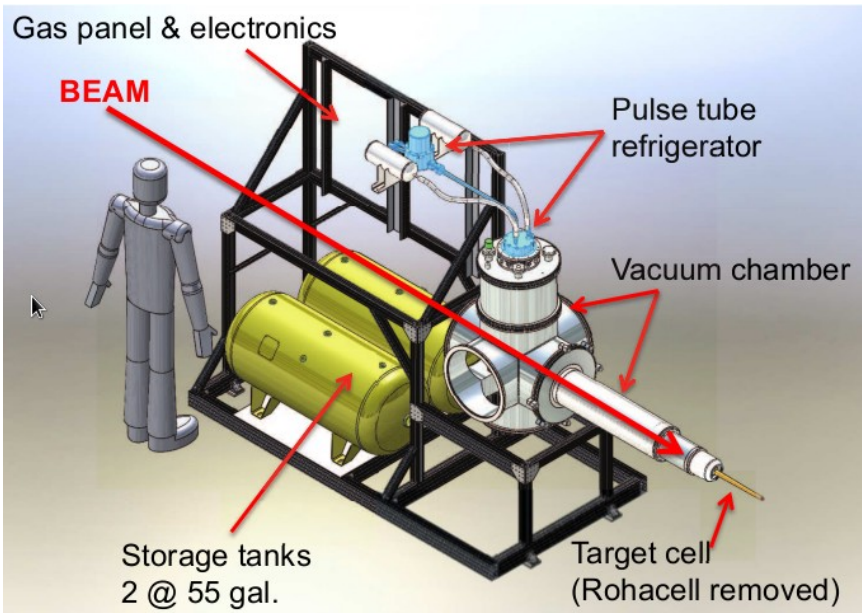


- 5  $\mu$ A  $e^-$  beam, 5% radiation length radiator  $\rightarrow \sim 7000$   $K_L$ /s on GlueX target

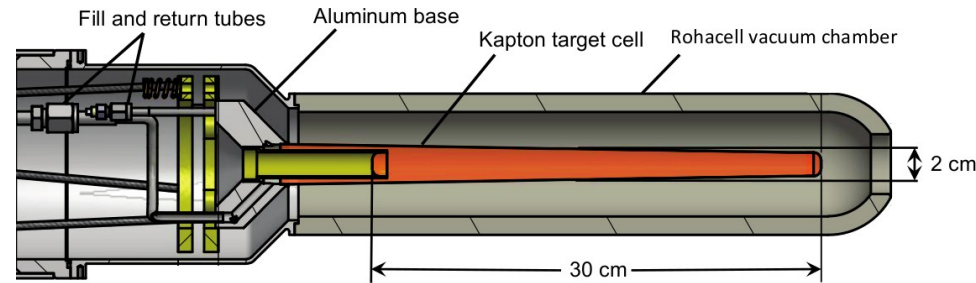
# Neutron background



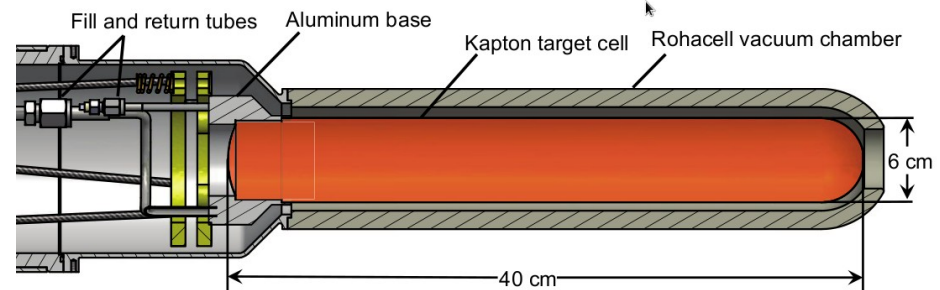
# Cryogenic target



## Existing LH2 target



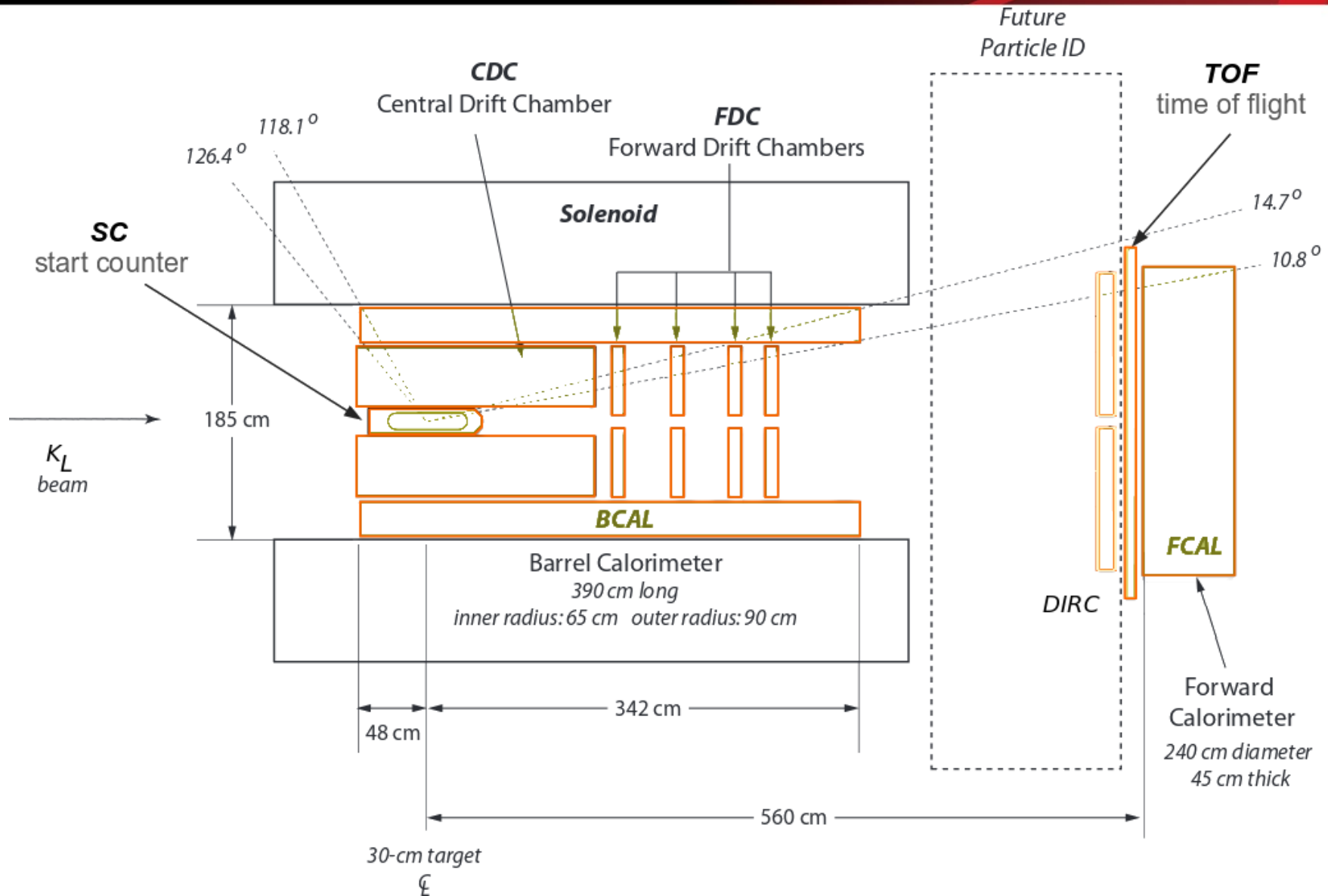
## Conceptual design for $K_L$ program



C. Keith

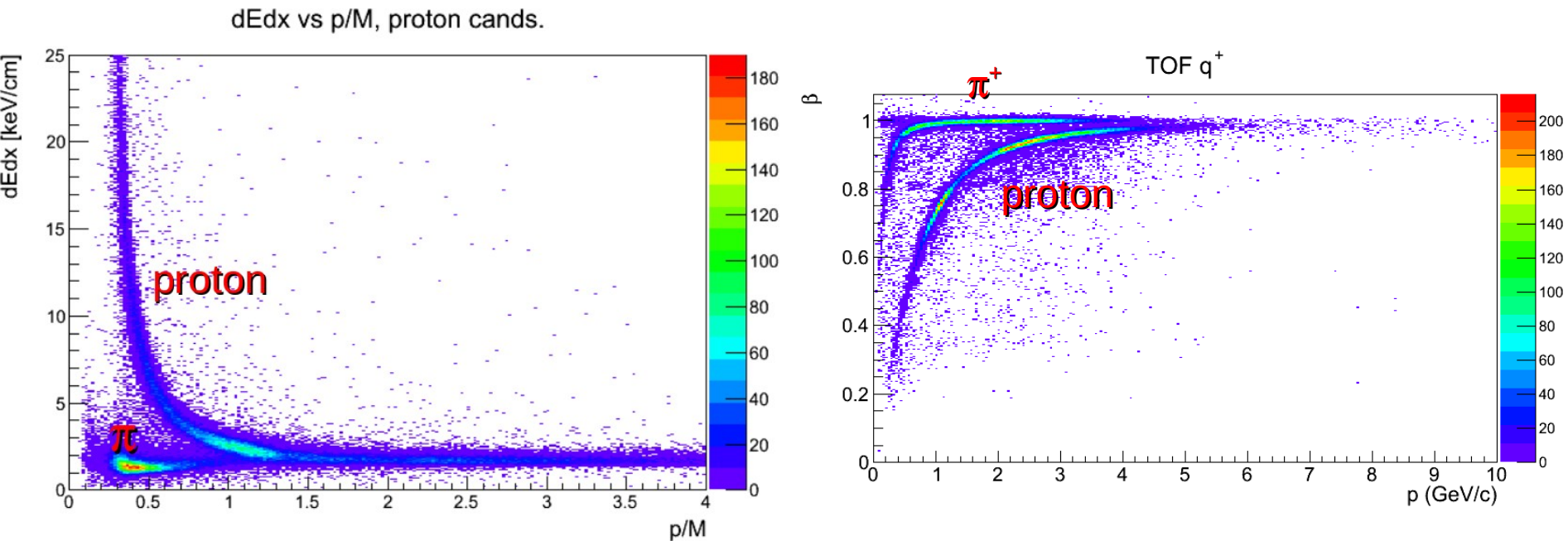
- ◆ Polarized target feasible: butanol ( $C_4H_{10}O$ ) frozen spin

# The GlueX detector



# Particle identification

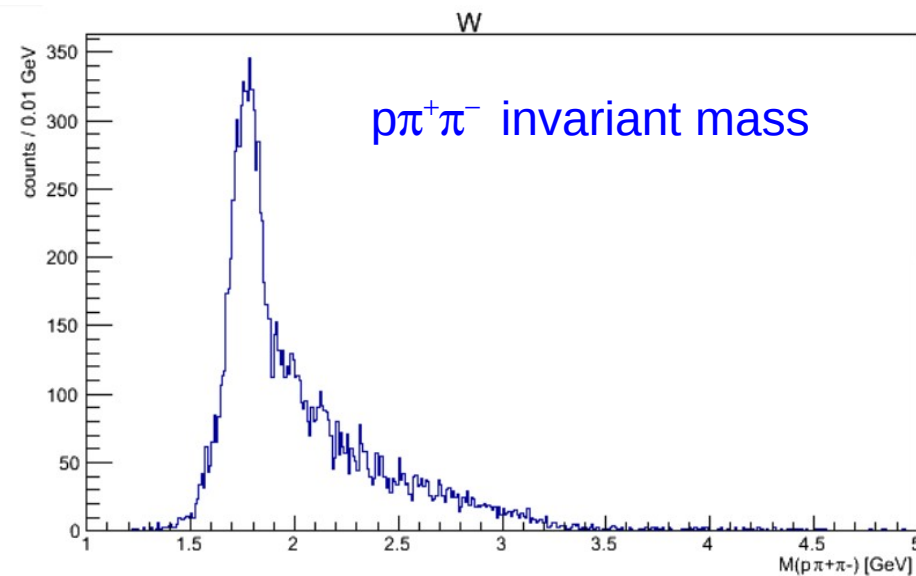
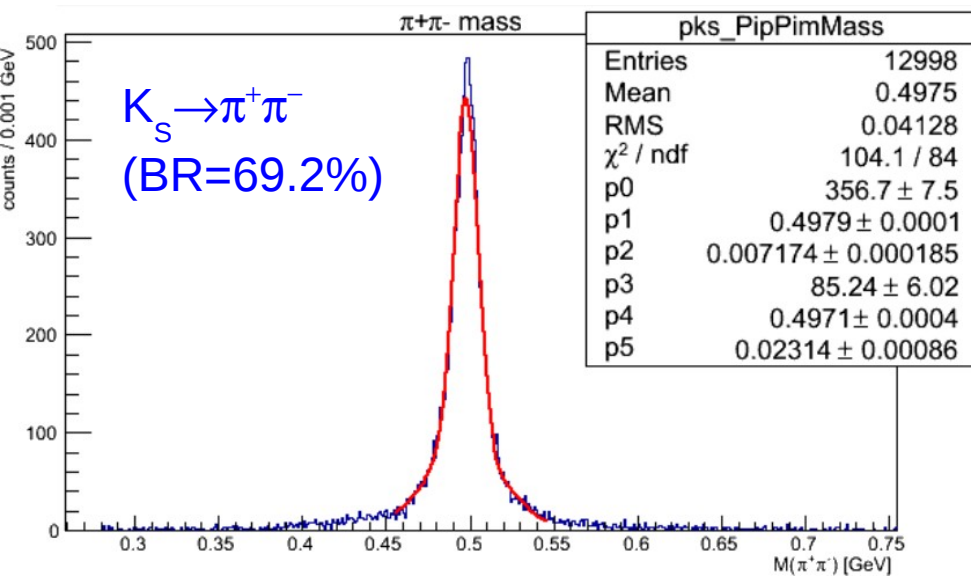
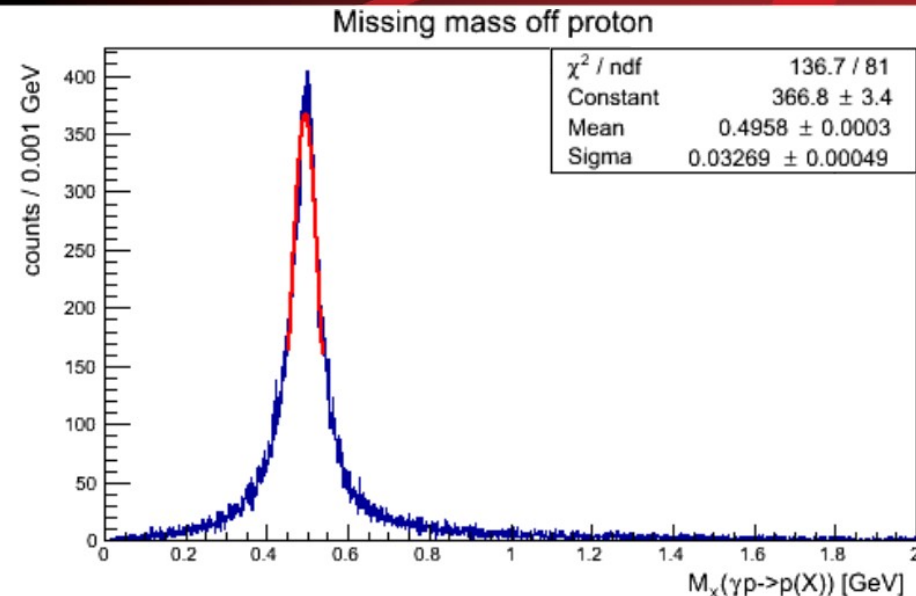
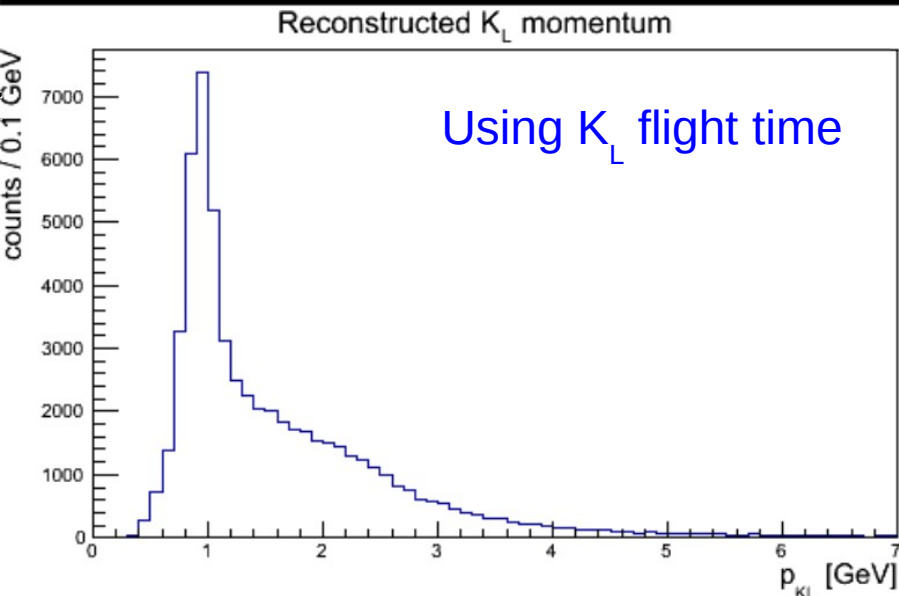
- ◆ Energy loss in drift chambers, time-of-flight to outer detectors



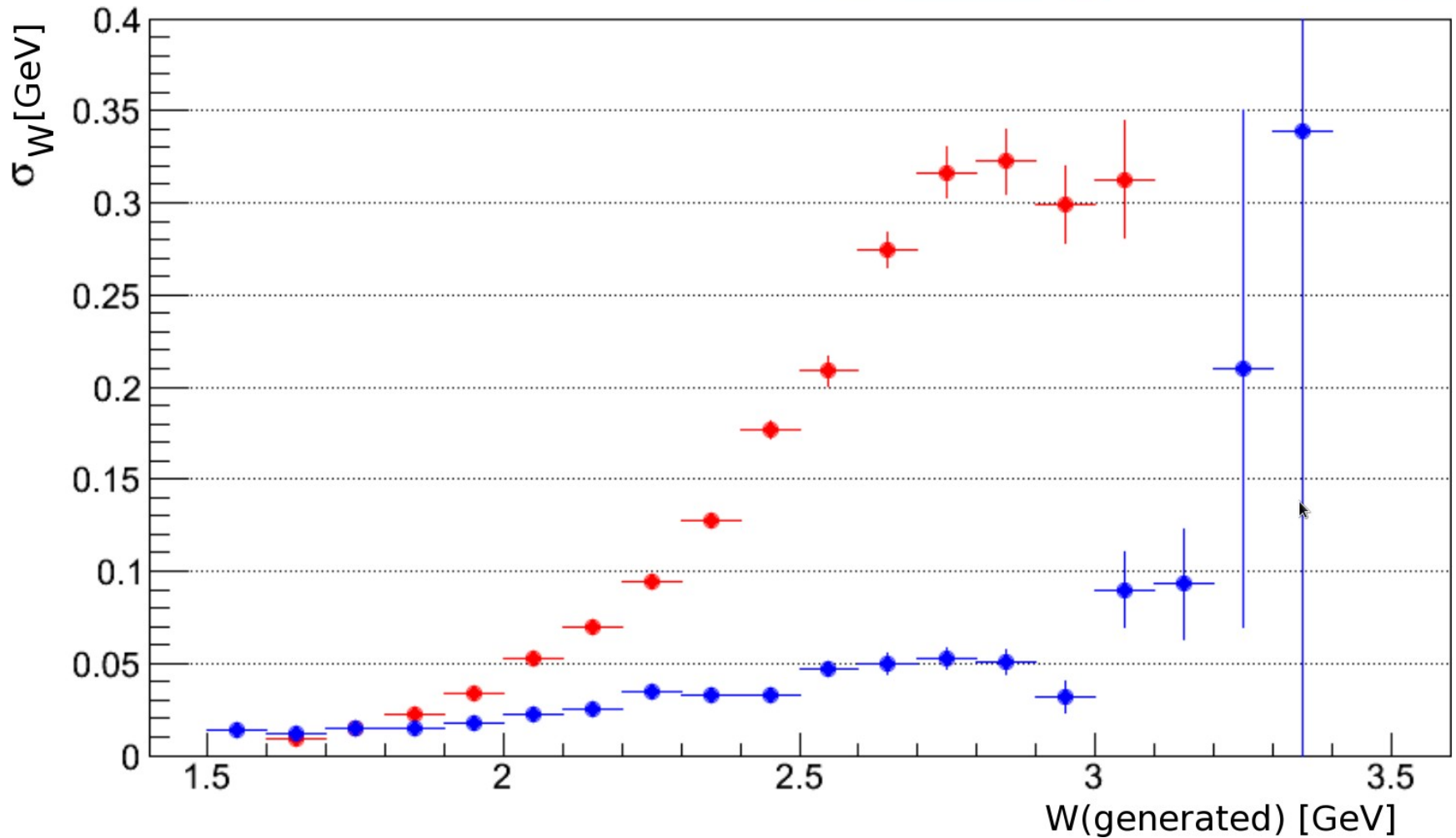
(simulated  $K_L p \rightarrow p K_S$  events)



# Example: $K_L p \rightarrow p K_S$



# W resolution



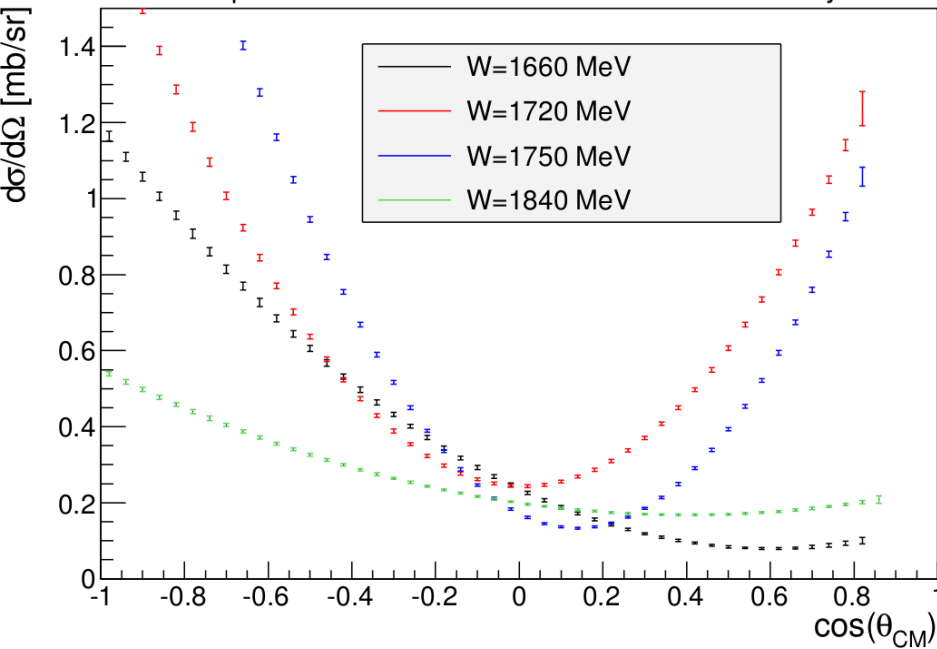
Red points:  $W$  derived from  $K_L$  flight time

Blue points: invariant mass of final state particles

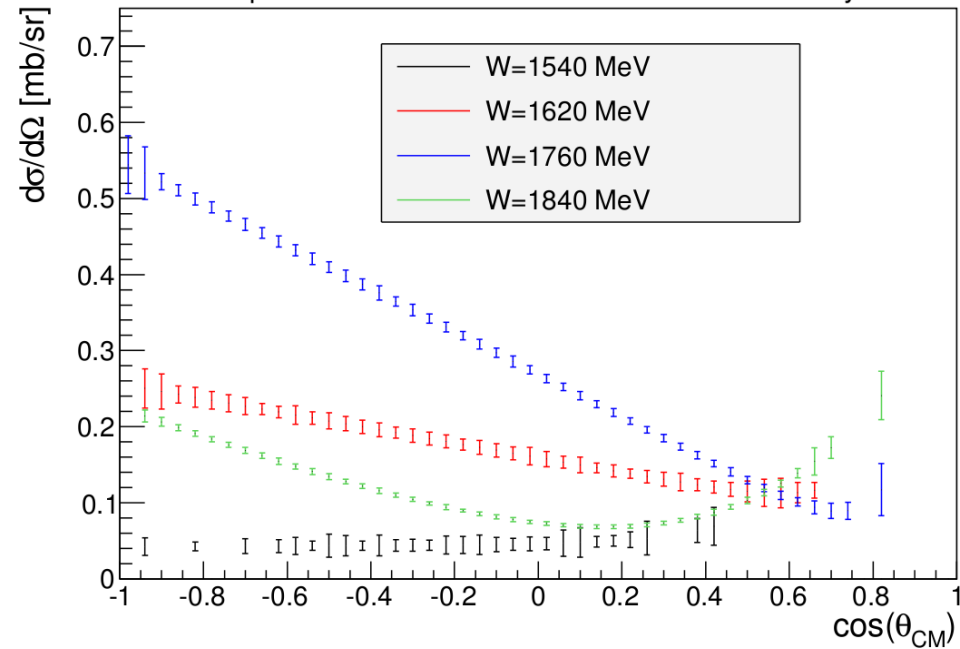
# Projected statistical uncertainties



Expected cross sections + uncertainties in 100 days



Expected cross sections + uncertainties in 100 days



# More information

PHYSICS WITH NEUTRAL KAON BEAM AT JLAB

## KL2016

**FEBRUARY 1-3, 2016**  
**JEFFERSON LAB**  
**NEWPORT NEWS, VIRGINIA**

### SCOPE

The Workshop is following Lol12-15-001 "Physics Opportunities with Secondary KL beam at JLab" and will be dedicated to the physics of hyperons produced by the kaon beam on unpolarized and polarized targets with GlueX set up in Hall D. The emphasis will be on the hyperon spectroscopy. Such studies could contribute to the existing scientific program on hadron spectroscopy at Jefferson Lab.

The Workshop will also aim at boosting the international collaboration, in particular between the US and EU research institutions and universities.

The Workshop would help to address the comments made by the PAC43, and to prepare the full proposal for the next PAC44.

### ORGANIZING COMMITTEE

Moskov Amaryan, ODU, chair  
 Eugene Chudakov, JLab  
 Curtis Meyer, CMU  
 Michael Pennington, JLab  
 James Ritman, Ruhr-Uni-Bochum & IKP Jülich  
 Igor Strakovsky, GWU

[WWW.JLAB.ORG/CONFERENCES/KL2016](http://WWW.JLAB.ORG/CONFERENCES/KL2016)



KL2016 workshop proceedings:  
<https://arxiv.org/abs/1604.02141>

Talks are online:  
<https://www.jlab.org/conferences/kl2016/program.html>



# Summary

- Constituent Quark Models and lattice calculations predict a large number of hyperon states yet to be seen experimentally
  - $K_L$  beam can provide access to these states
- An experimental program using  $K_L$  beam is feasible in Hall-D using the GlueX detector