Strange Hadron Spectroscopy with Secondary K_L Beam at GlueX

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Old Dominion University

The GlueX Coll. Meeting, February 20, 2019

Outline

Physics Motivation

- *Hyperon Spectroscopy*
- *Strange Meson Spectroscopy*

K_L Facility at JLab

- *Electron Beam*
- *Compact Photon Source*
- *Be Target*
- *Flux Monitor*
- *K_L Beam*
- *LH_2/LD_2 Target*

Summary

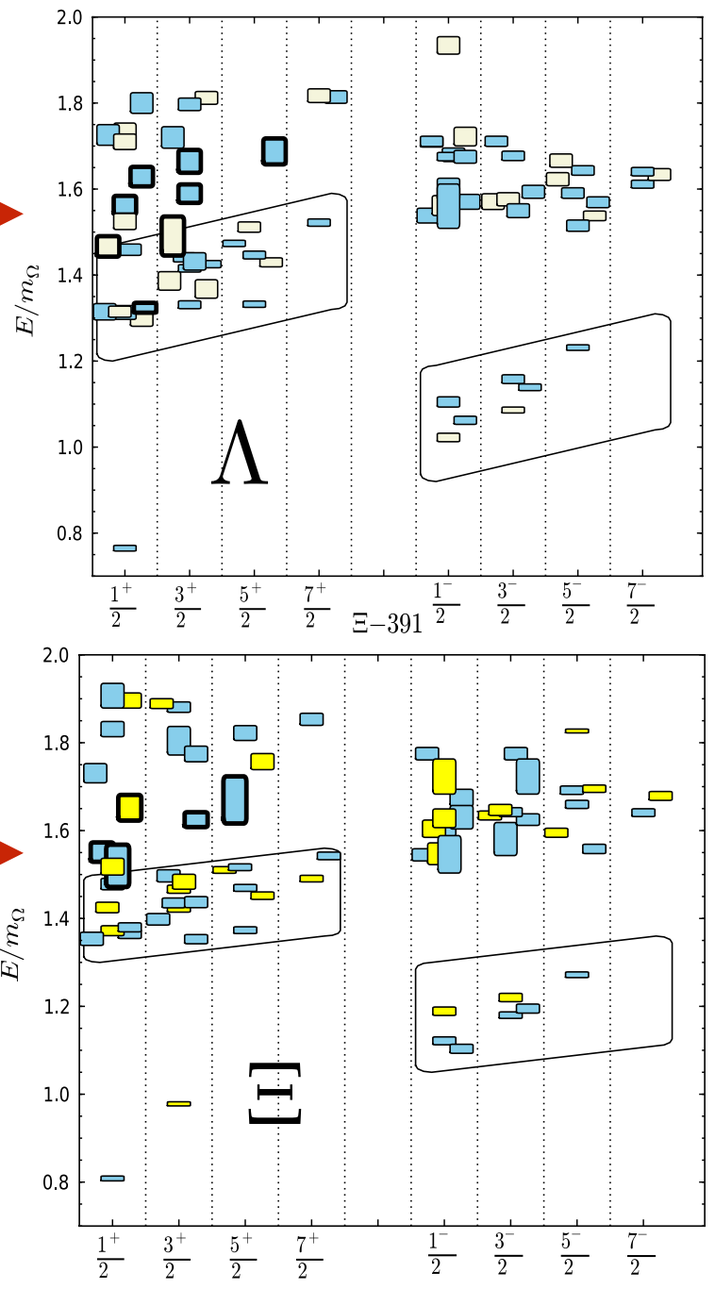
Hyperon Spectroscopy

*According **LQCD** there should be*

many more states including hybrids (thick bordered)

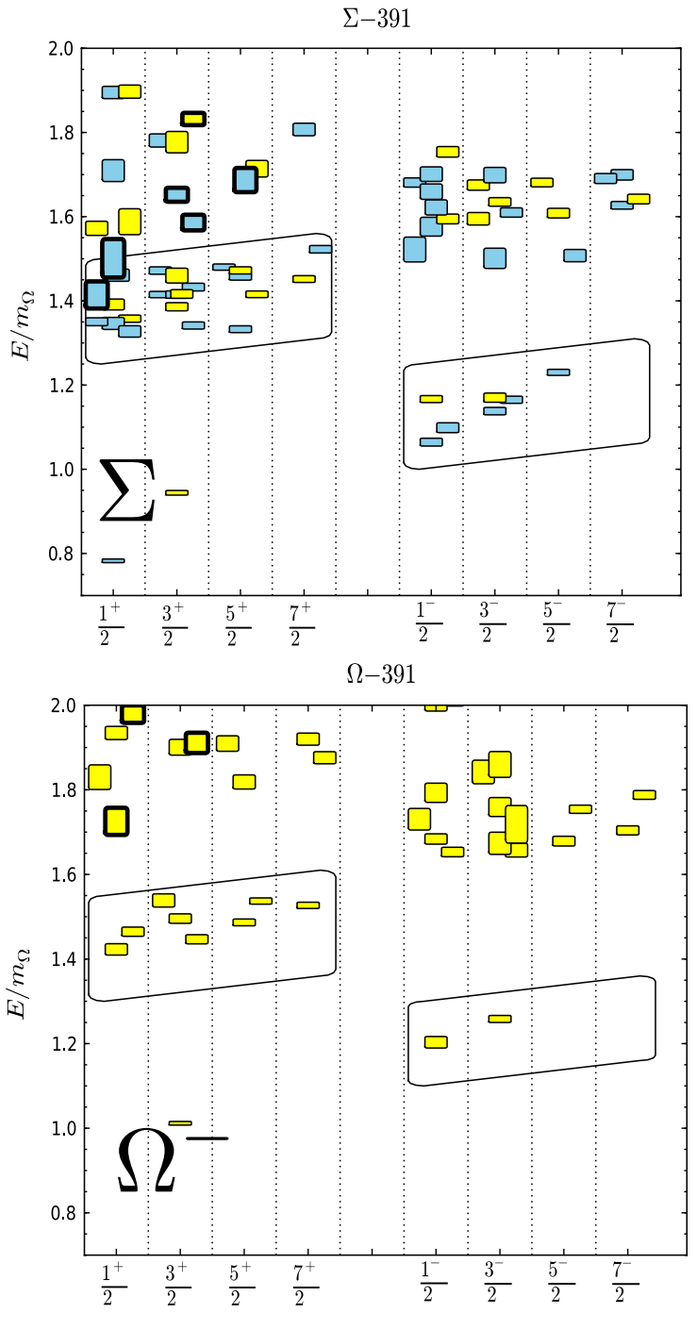
8-states
****

5-states
***



6-states
****

4-states
***



3-states
****

4-states
***

1-state
****

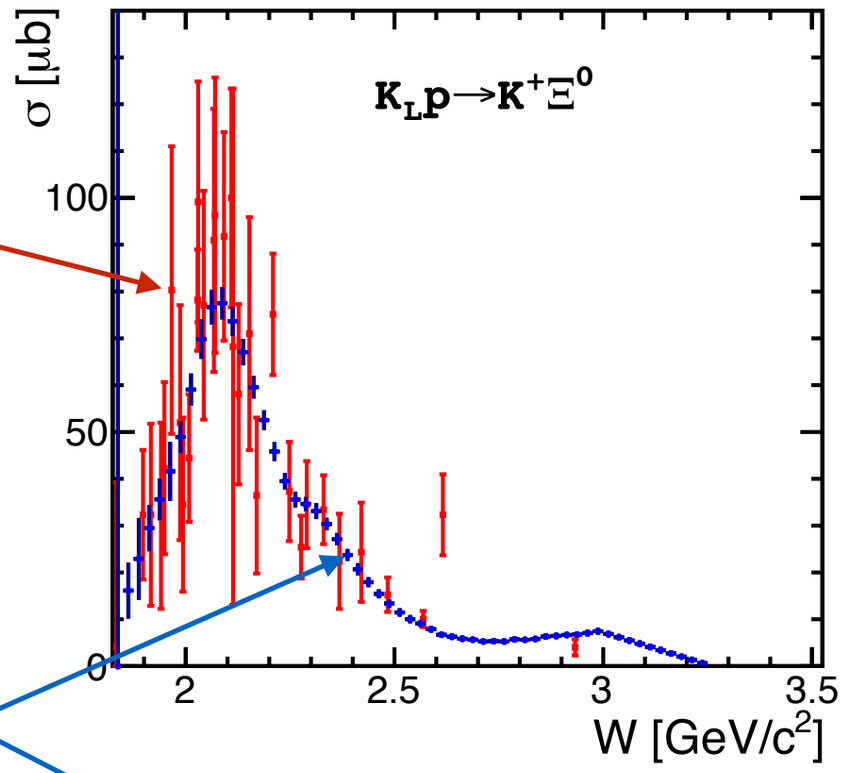
1-states
***

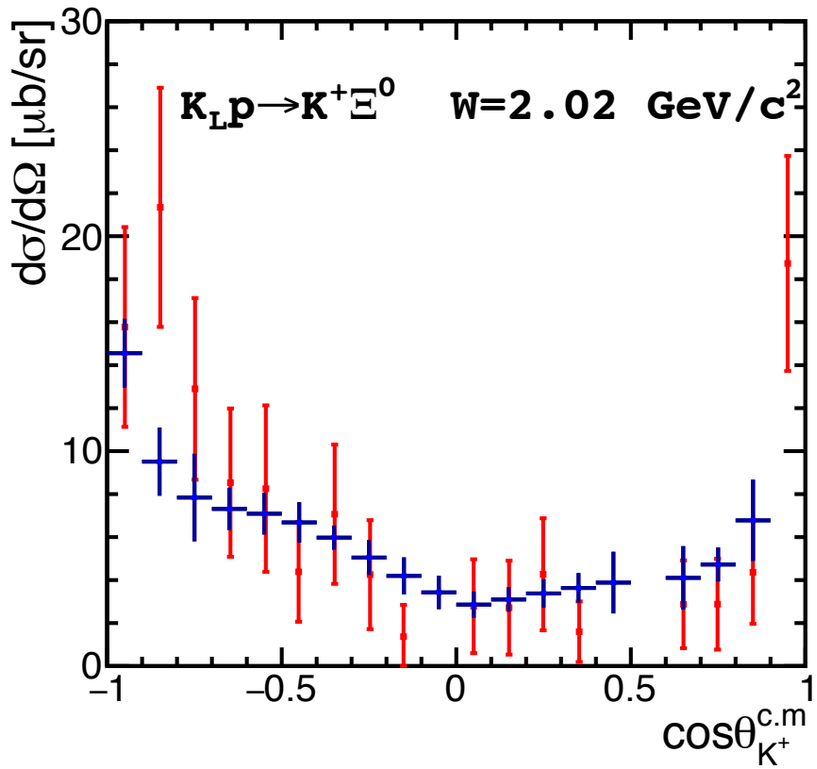
Edwards, Mathur, Richards and Wallace, Phys. Rev. D 87, 054506 (2013)

Proposed Measurements on Proton Target

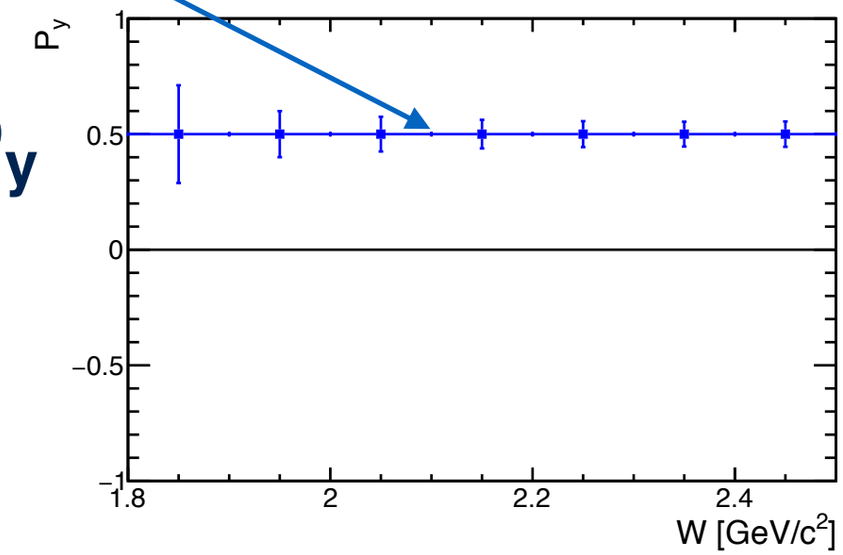
existing data

KLF 100 days



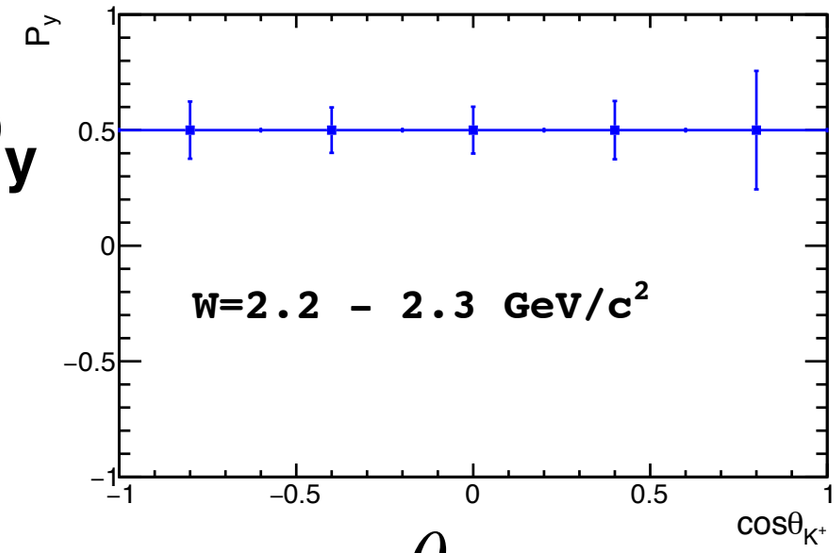


P_y



$\mathbf{W(GeV/c^2)}$

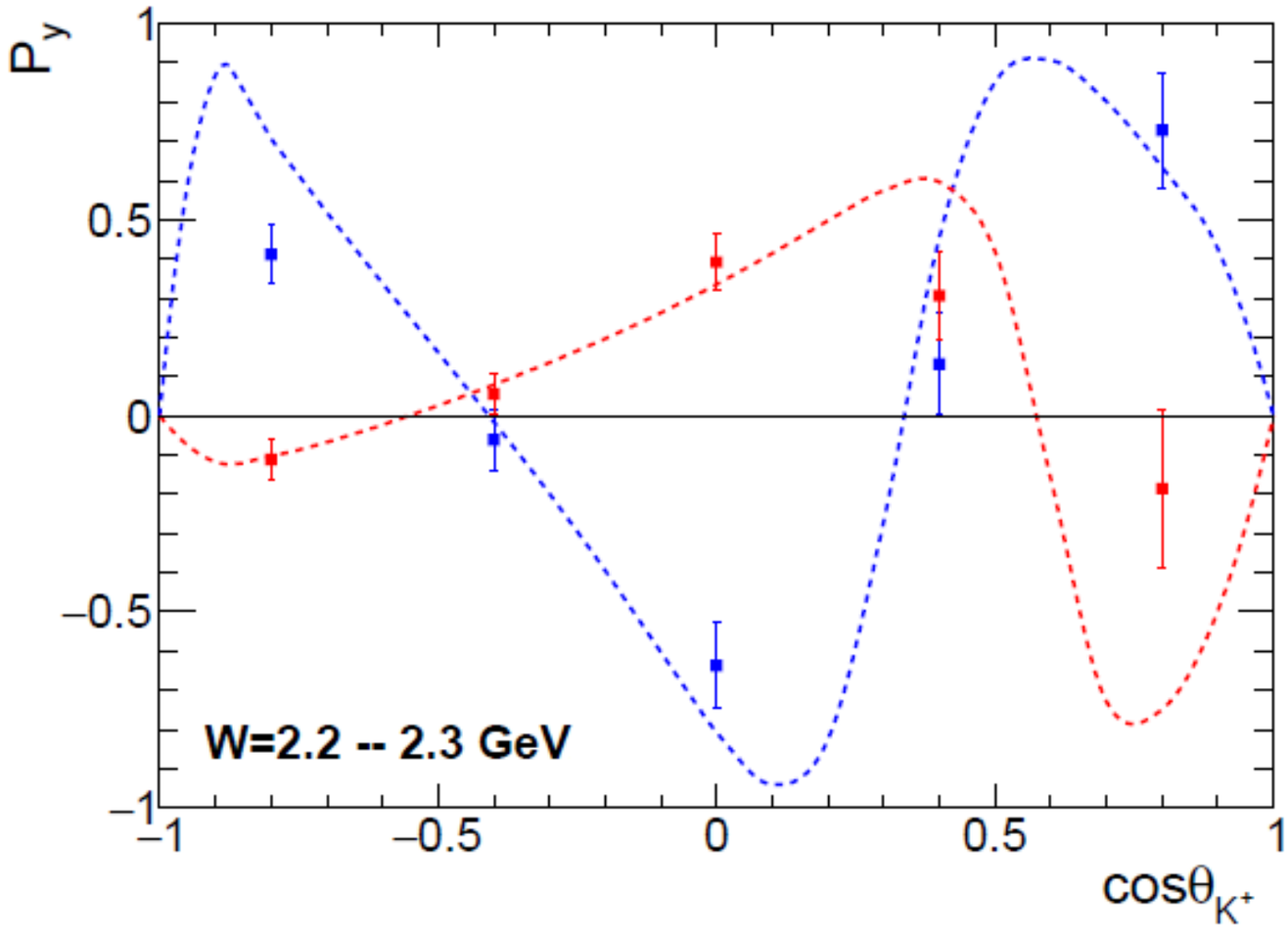
P_y



$\mathrm{COS}\ \theta_{\mathbf{K}+}$

Proposed Measurements on Neutron Target

Sensitivity to different solutions



$$K_L n \to K^+ \Xi^-$$

100 days on LD_2 target

Search for Hyperon Resonances with PWA

For Scattering experiments on both
proton & neutron targets we need to determine:

-differential cross sections &

-self polarization of strange hyperons

-perform coupled-channel PWA

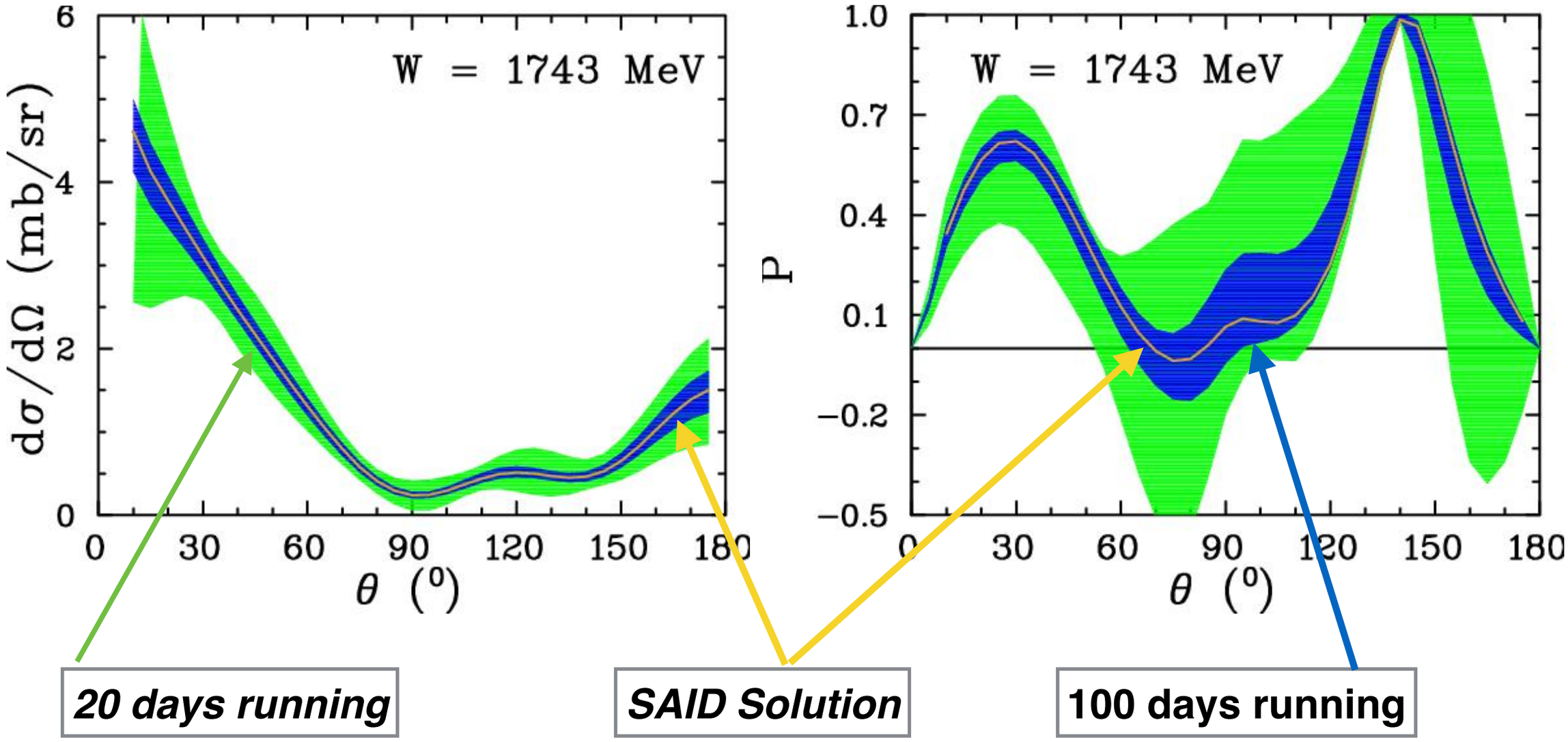
-look for poles in complex energy plane
(not naïve bump hunting)

-identify $\Lambda^*, \Sigma^*, \Xi^*$ & Ω^* **up to 2400 MeV**

As kaon nucleon scattering data are very poor

we use pion nucleon scattering data with statistics generated according to expected KLF data for 20(100) days to show PWA sensitivity to obtain results close to the best fit

Using πp Scattering

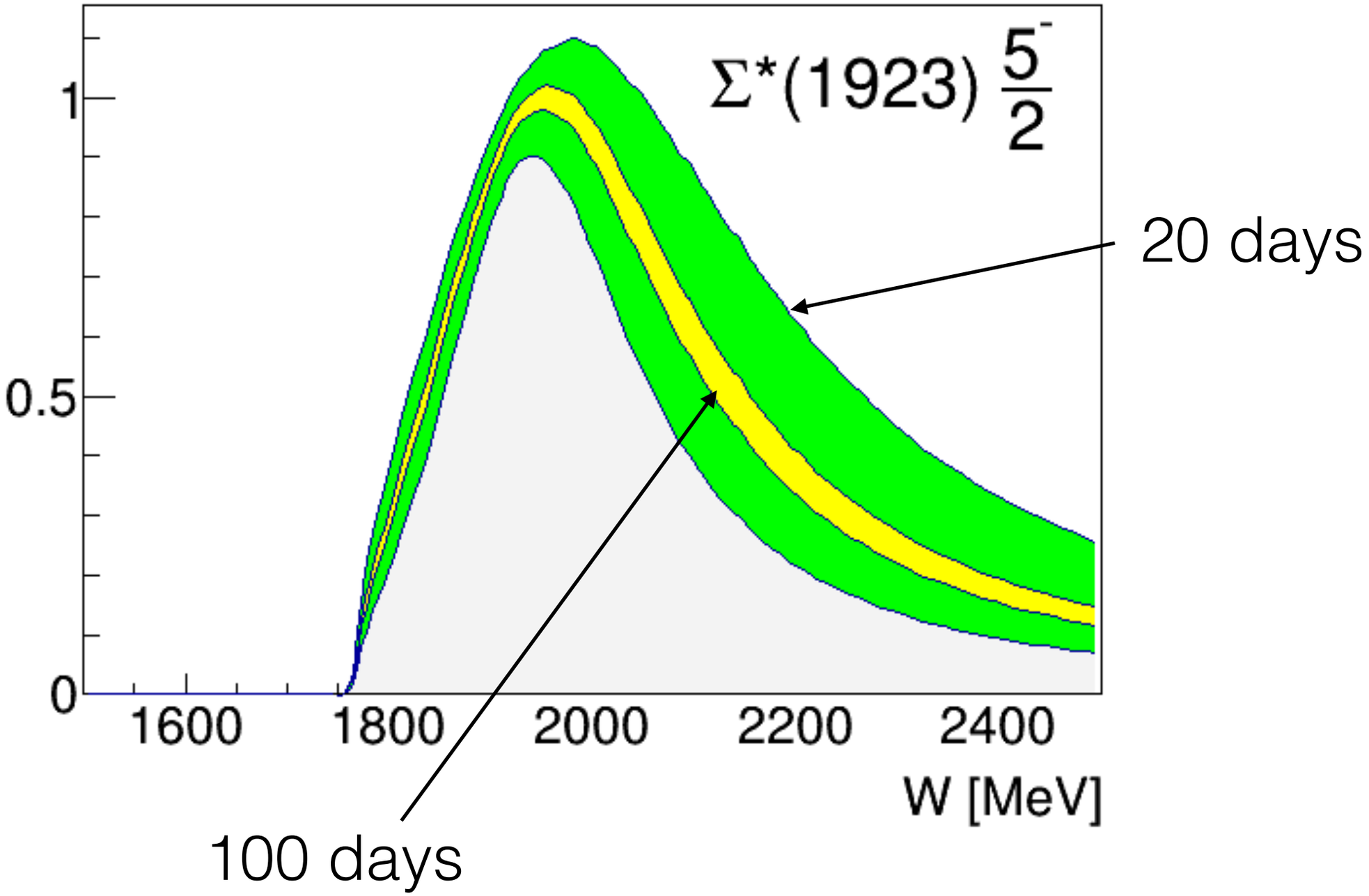


Statistics was generated according to KLF for

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

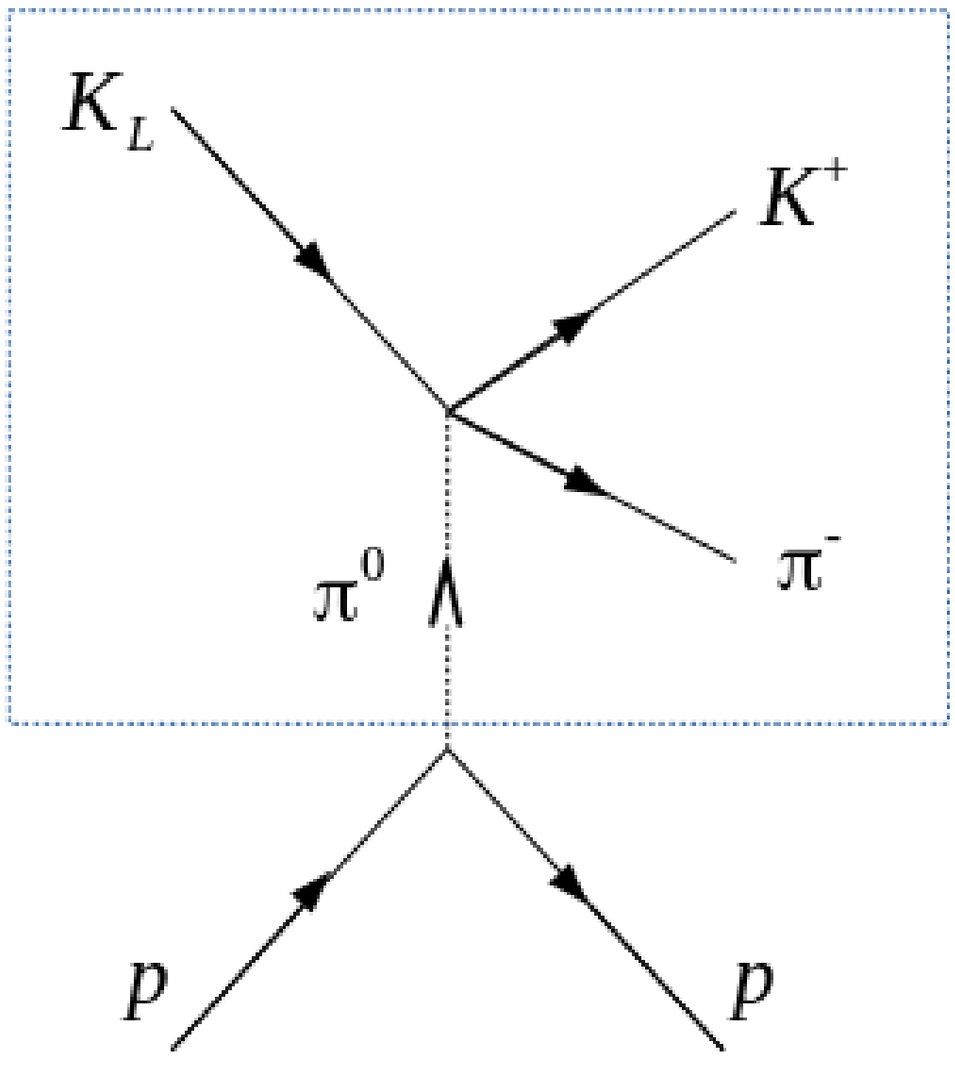
Obviously: we need at least 100 days to get unique solution

Bonn-Gatchina PWA Analysis



Strange Meson Spectroscopy

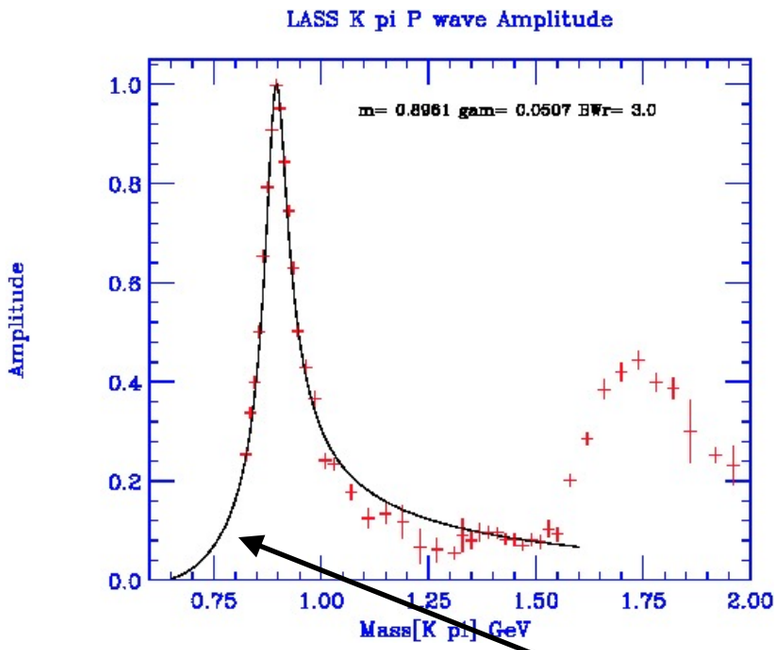
$K\pi$ Scattering



Proposed Measurements

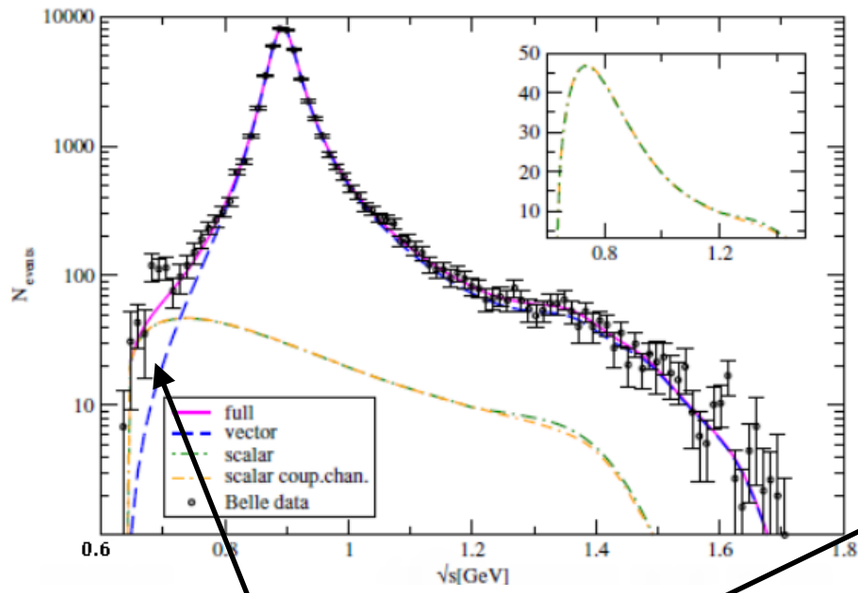
SLAC

$$K^-\pi^+ \to K^-\pi^+$$



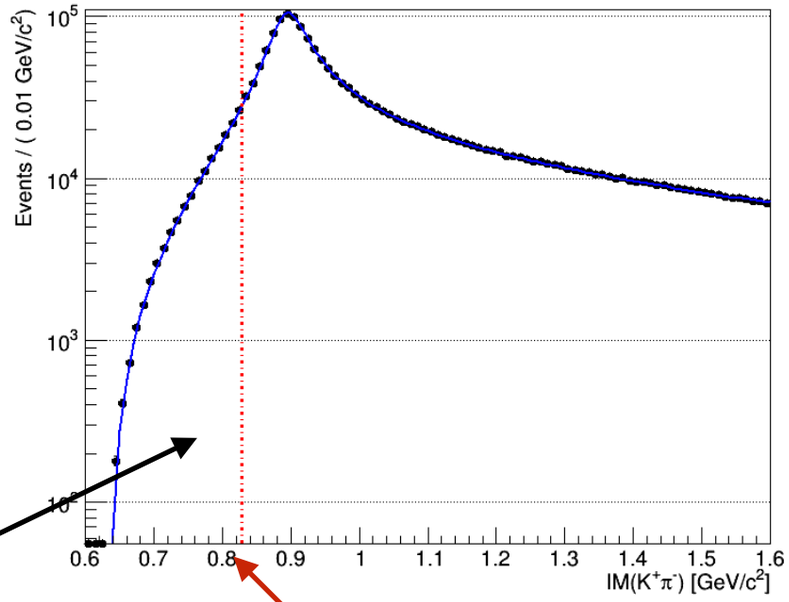
Belle

$$\tau \to K\pi\nu_\tau$$



KLF

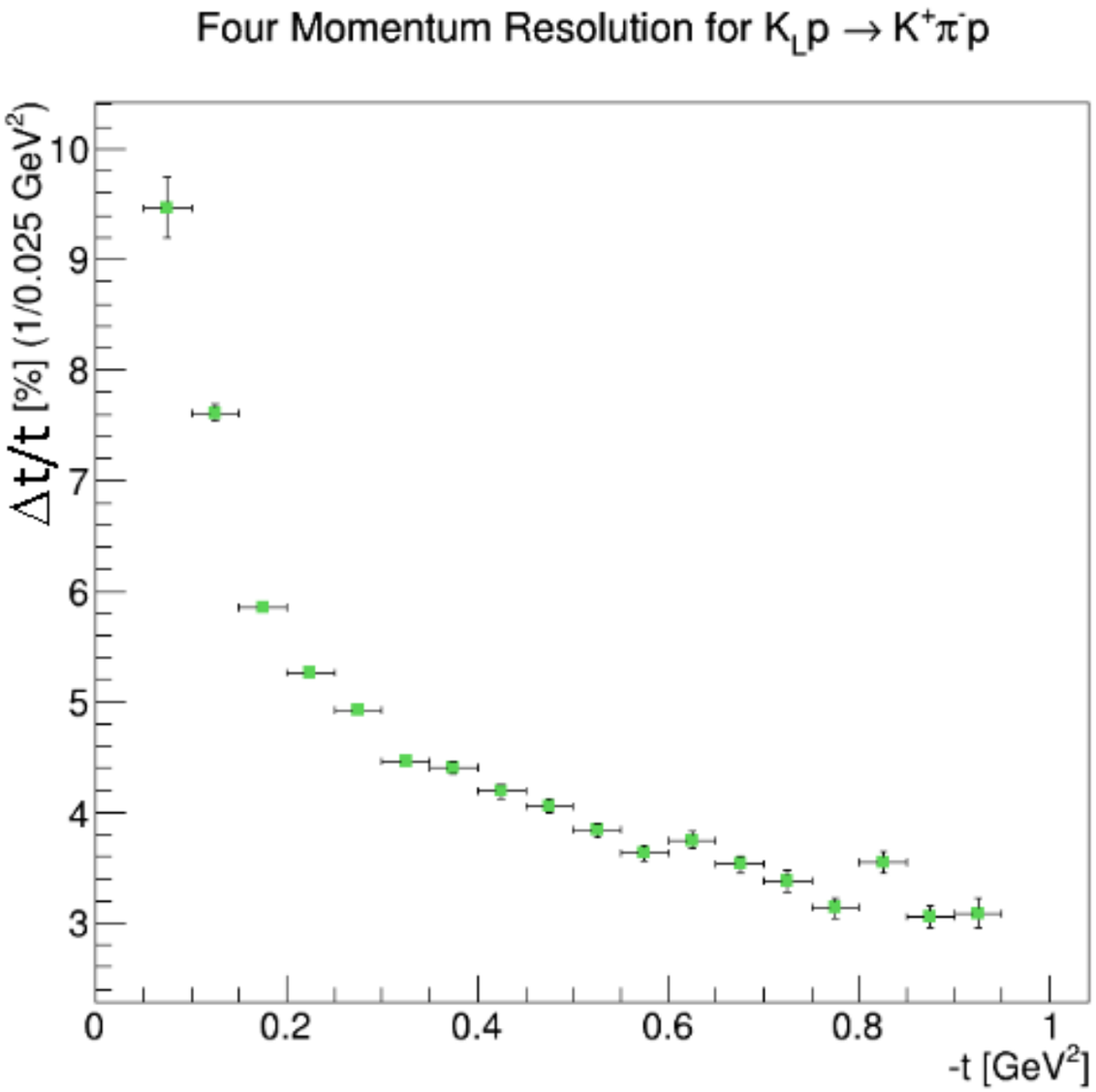
$$K_L\pi^0 \to K^+\pi^-$$

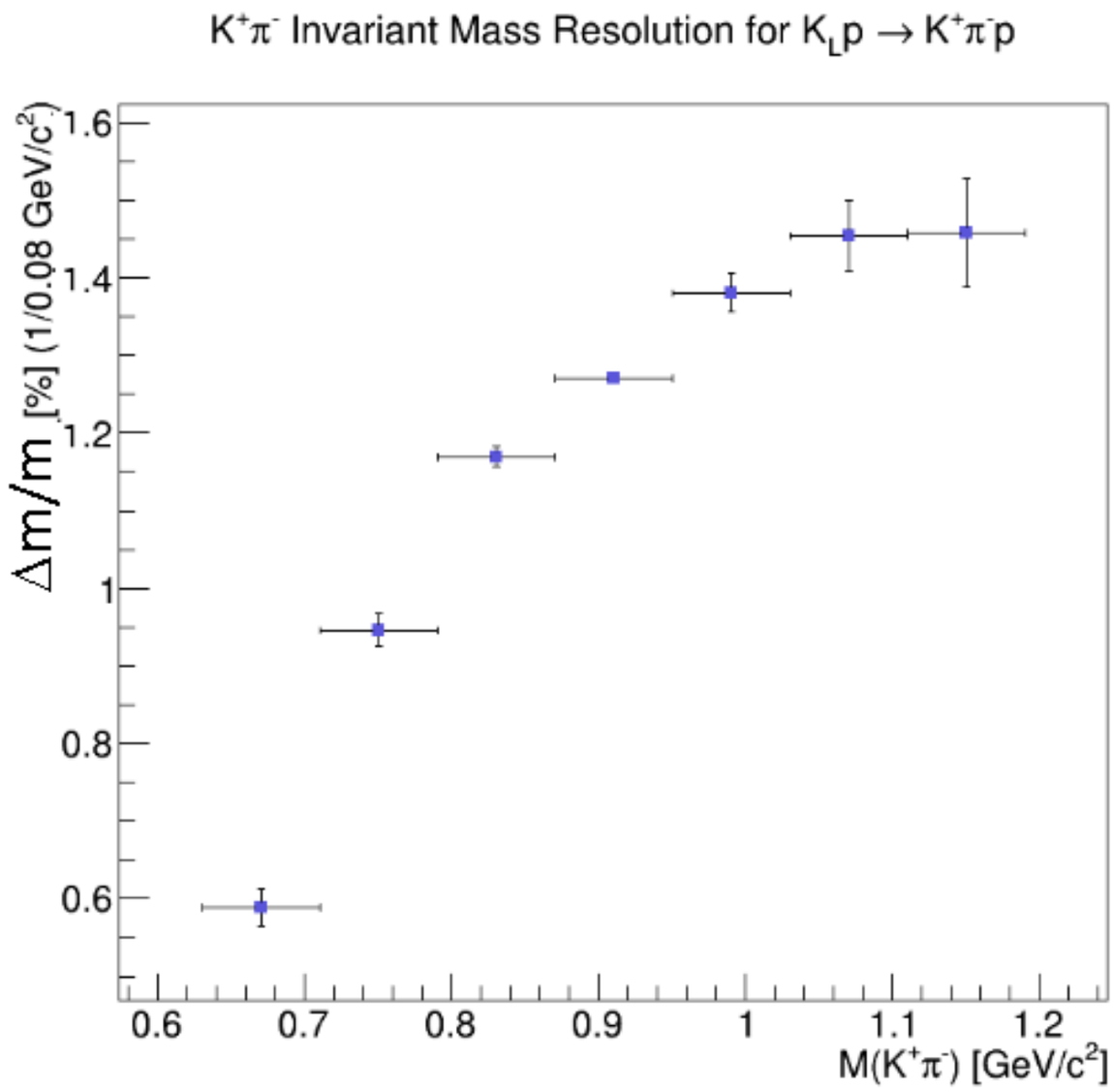


region of $\kappa(800)$

SLAC Lower limit

$K\pi$ *Scattering Resolutions*





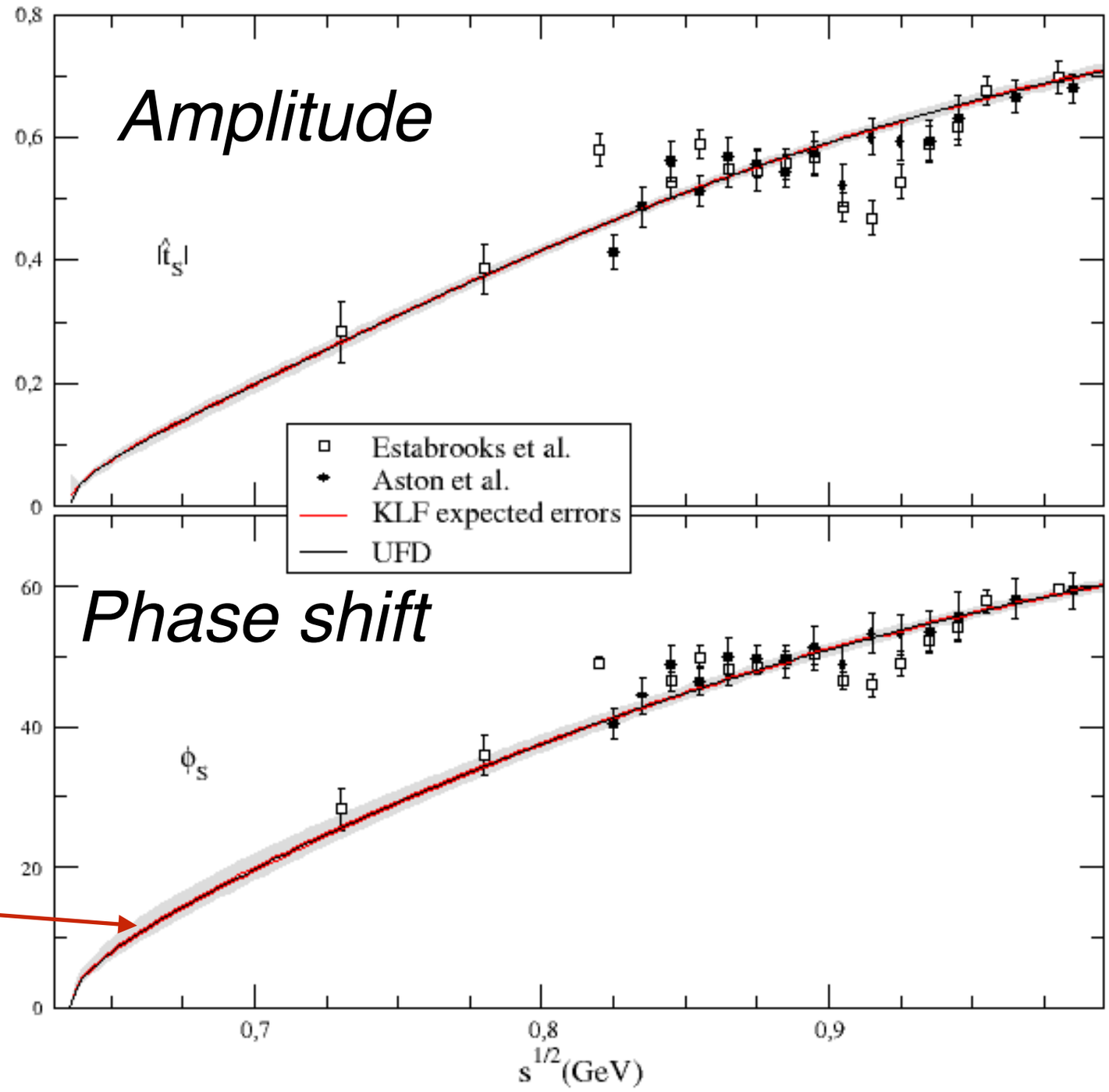
-Good resolution at low-t is needed to be on pion pole

-Binning in ~10 MeV will cover almost entire elastic K-pi scattering range

Proposed Measurement

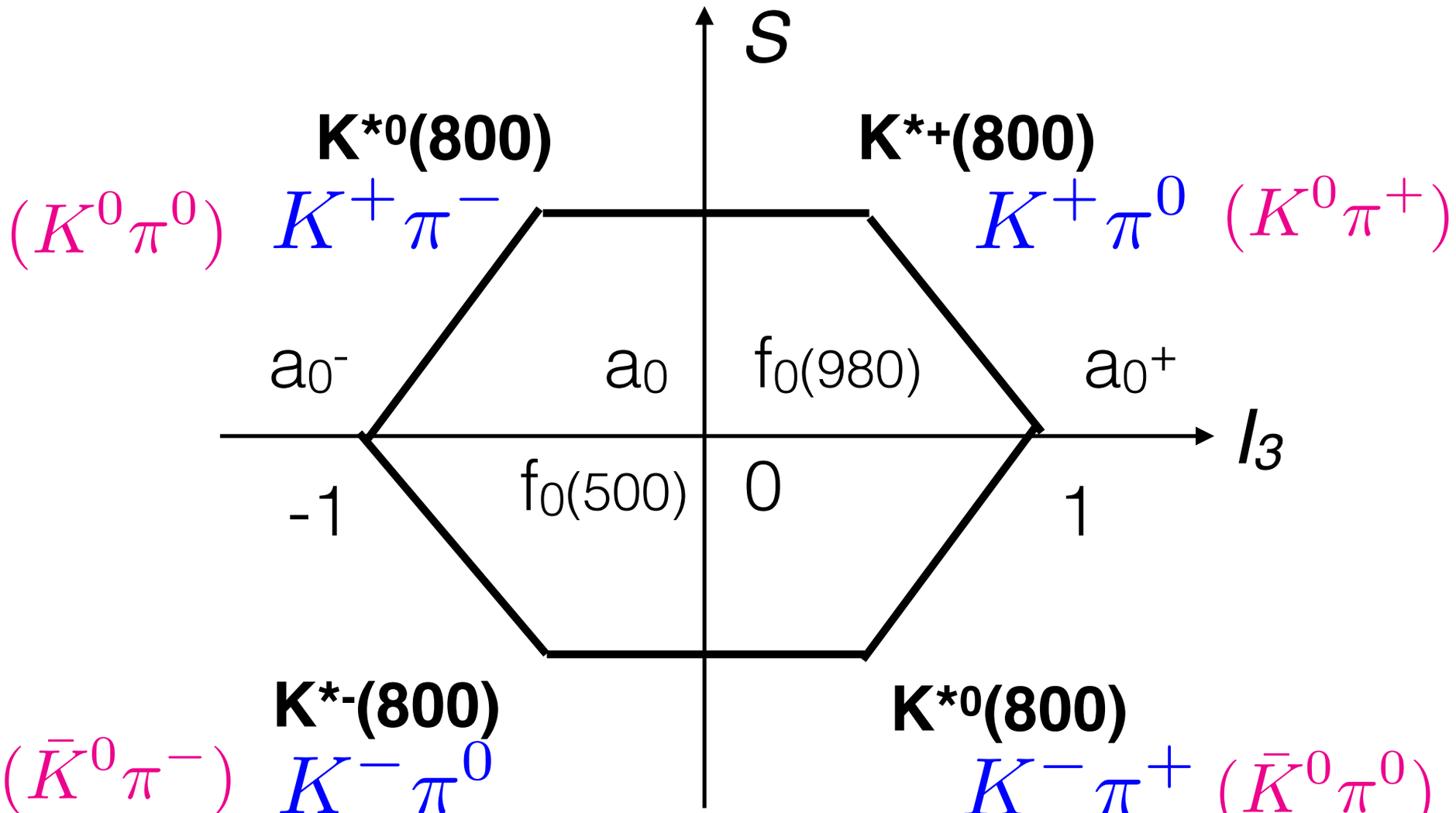
I=1/2 S-Wave

SLAC Data



KLF (100 days)

Scalar Meson Nonet

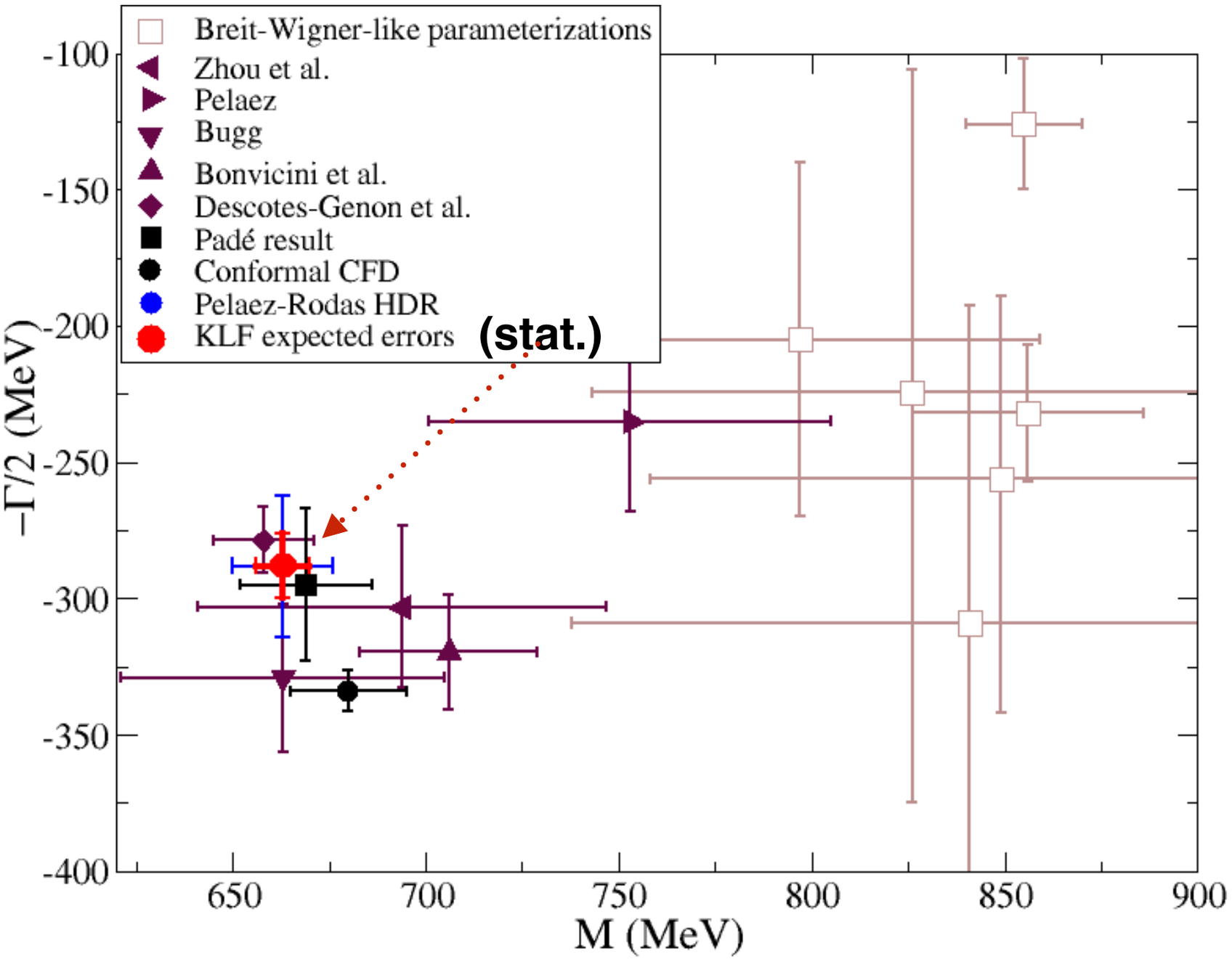


Four states called κ

still need further confirmation(PDG)

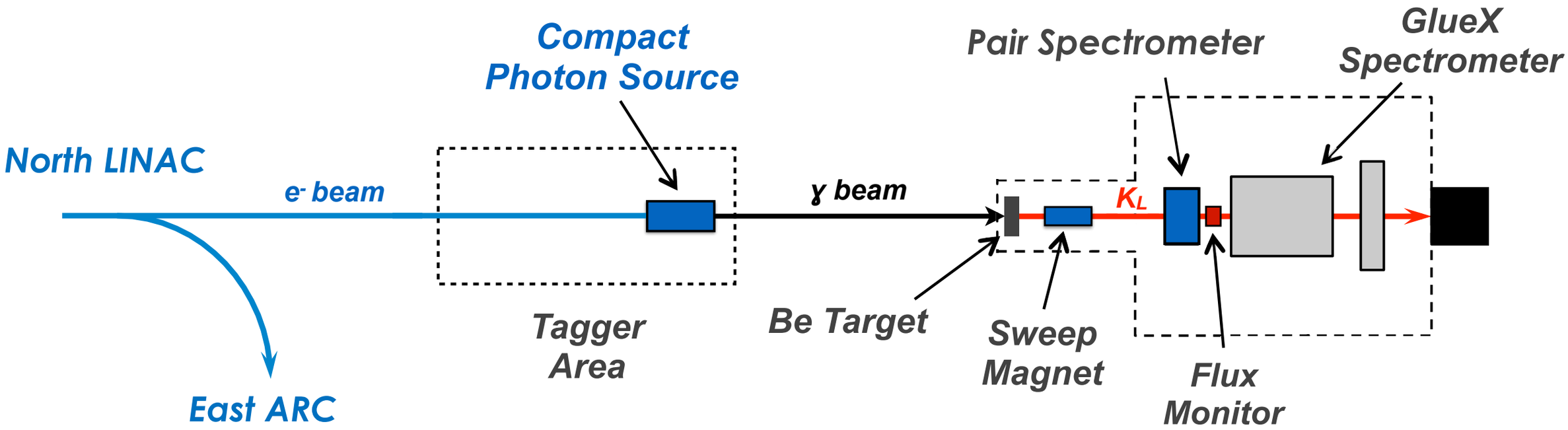
We can mesure all of them

Measurement of $\kappa(800)$



100 days of running

Hall-D beamline and GlueX Setup



Electron Beam Parameters

$E_e = 12\ GeV$ $I = 5\ \mu A$

Repetition rate $64\ ns$

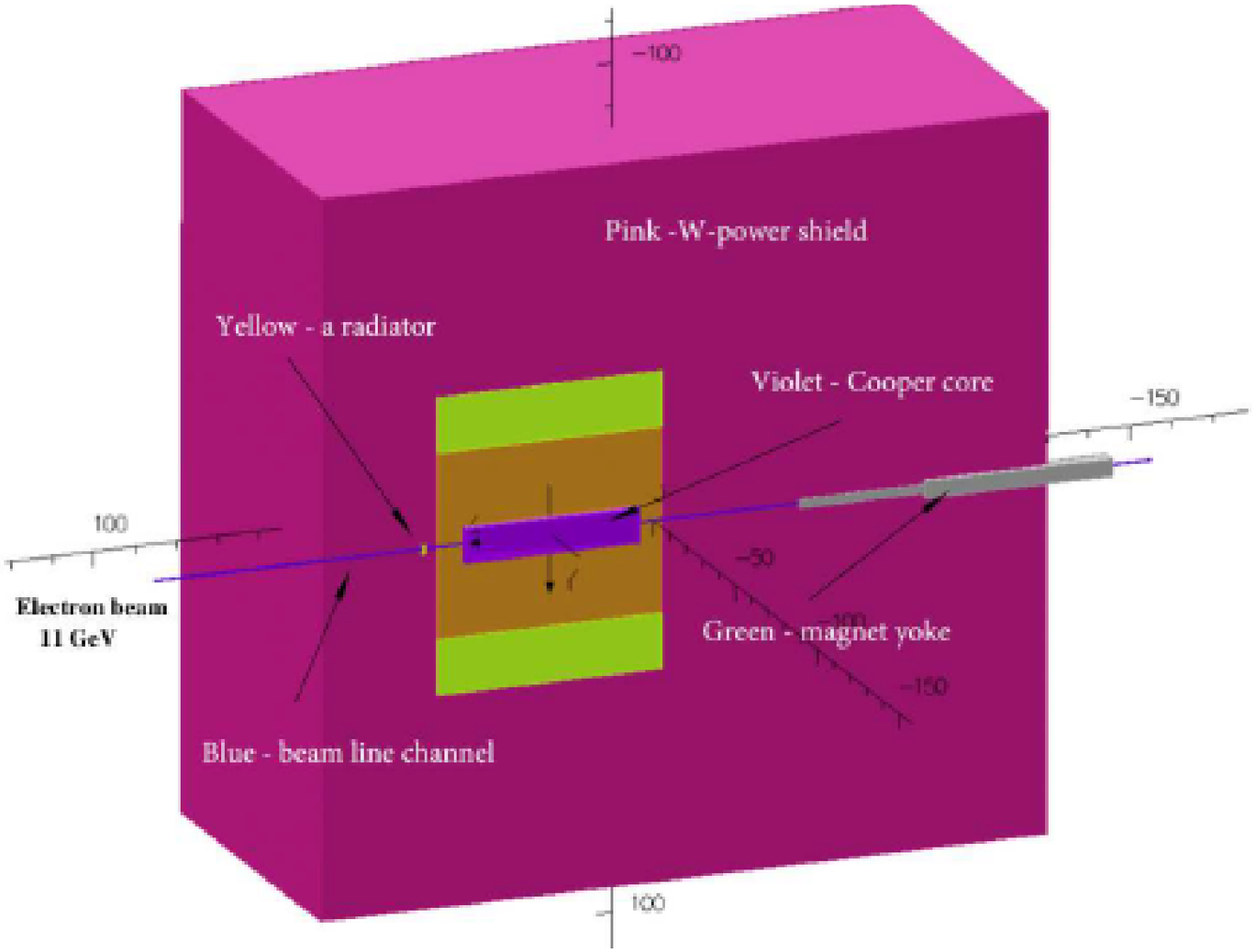
No major problems.

Doable !

Confirmed by Todd Satogata

Estimated investment ~$60 K for injector upgrade

Compact Photon Source



Conceptual design is completed for Halls C/A for I= $2.7\ \mu A$

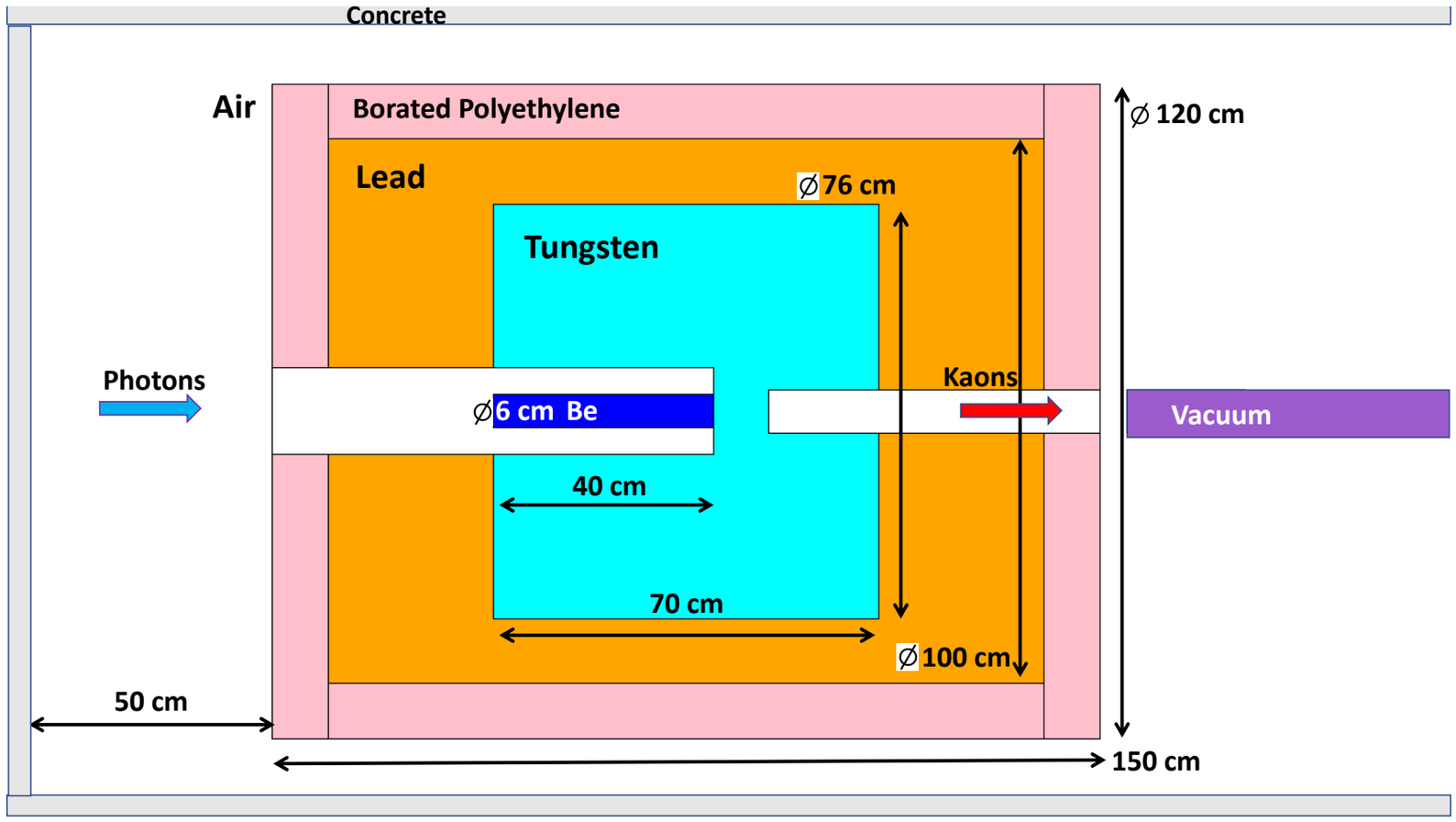
Could be extended for I= $5\ \mu A$ in Hall D

The details of the CPS are designed by the CPS Collaboration

Meets RadCon Radiation Requirements

Estimated cost $1.5-2.0 M

Be Target Assembly: Conceptual Design

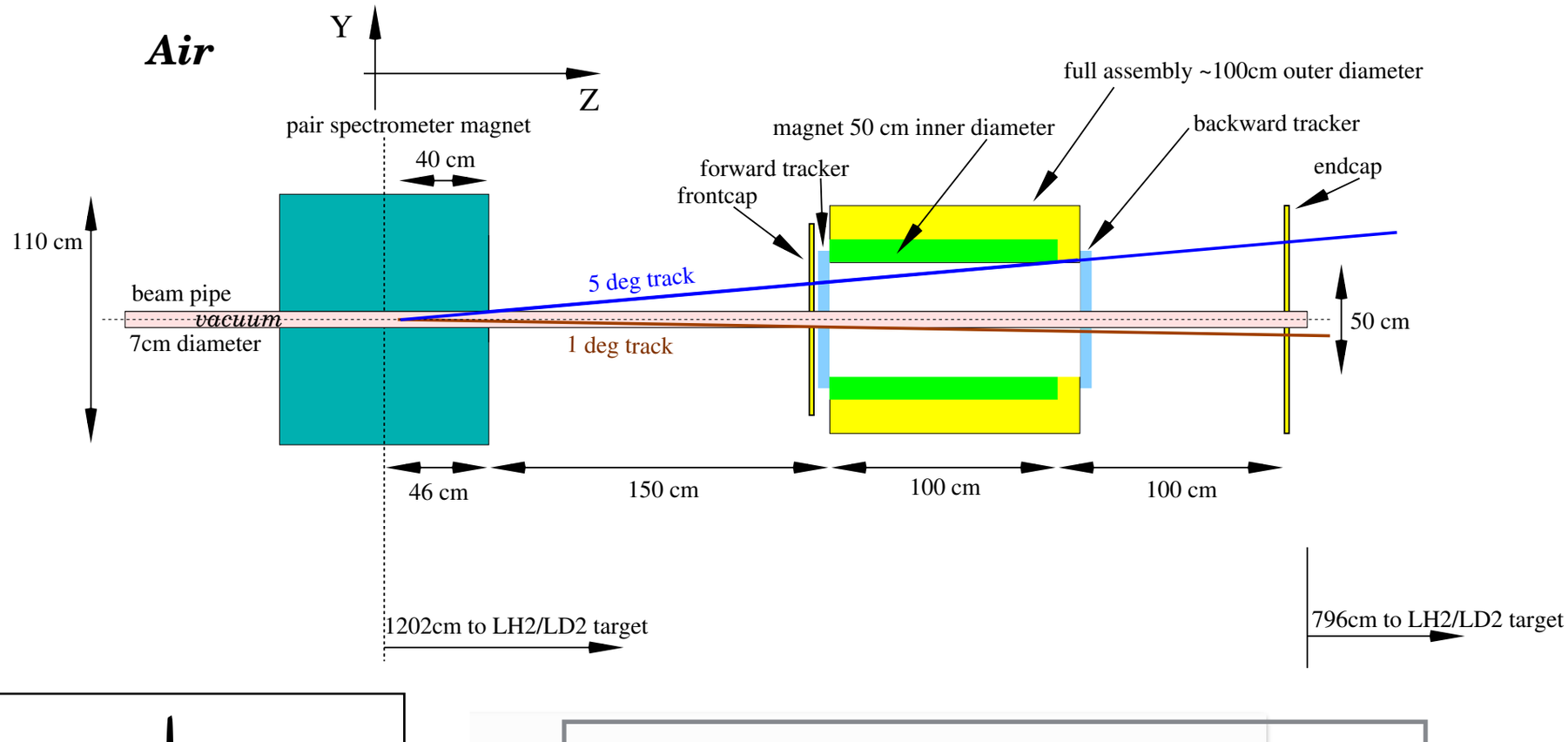


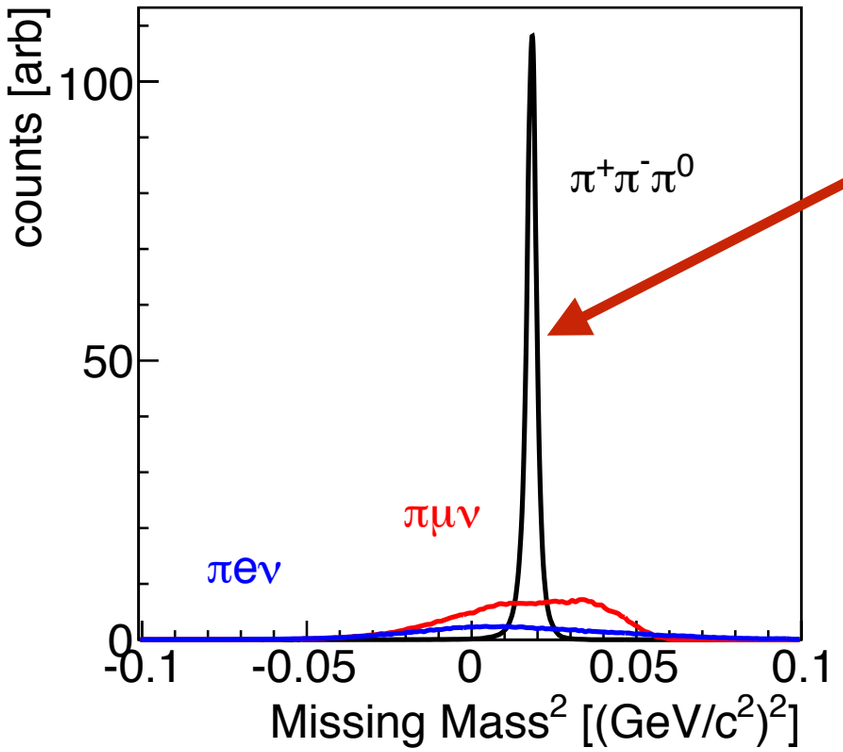
-Meets RadCon Radiation Requirements

-Conceptual Design Endorsed by Hall-D Engineering Staff (Tim Whitlatch)

Estimated cost ~$1.2 M

Flux Monitor





Reconstructed K_L mass

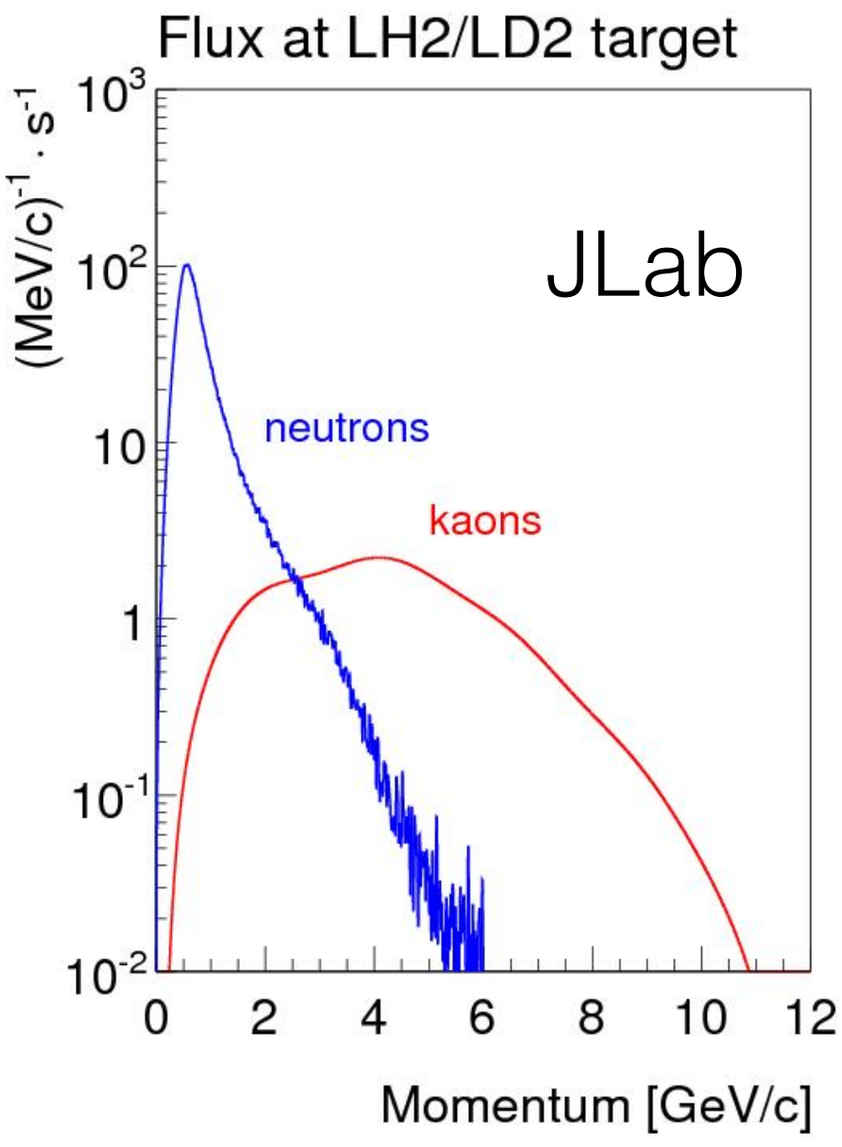
Flux measurement stat. err. <1%

Estimated syst. err. <3%

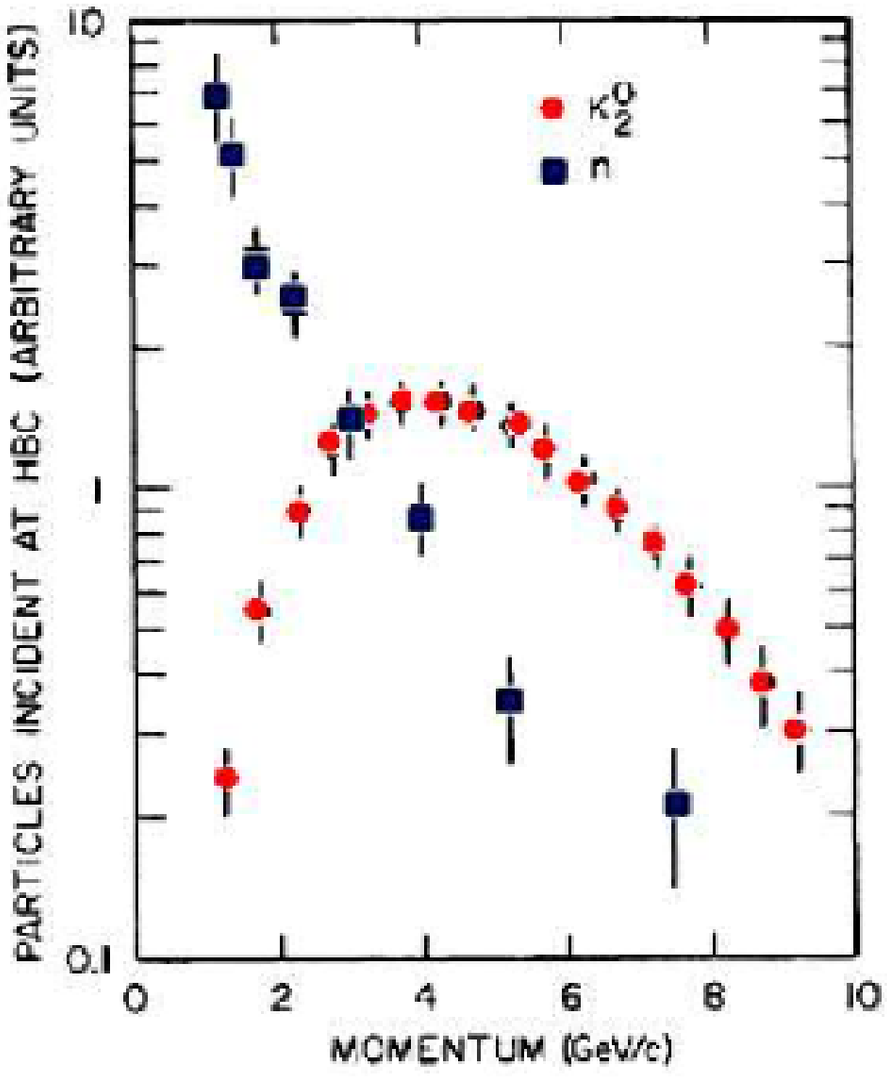
Pursuing UK funding

Estimated cost ~$ 0.7 M

K_L Beam Flux

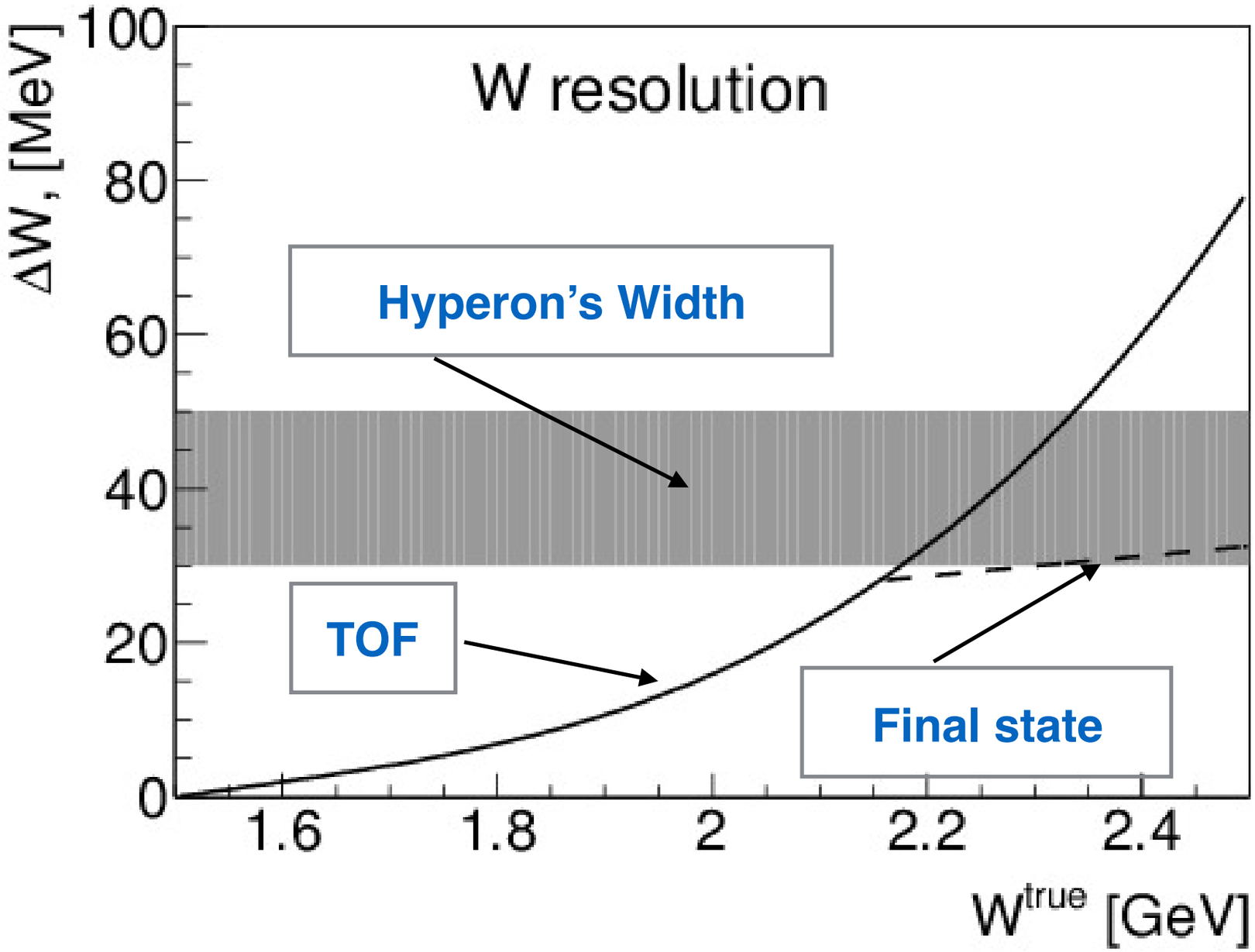


SLAC



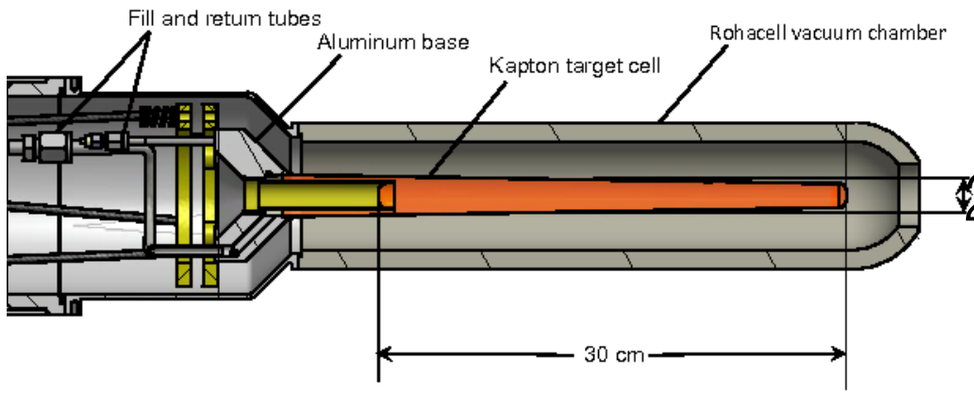
$$N(K_L)/sec \sim 10^4$$

$$\frac{N(K_L)_{JLAB}}{N(K_L)_{SLAC}} \sim 10^3$$


W resolution
ΔW, [MeV]
100
80
60
40
20
0
1.6
1.8
2
2.2
2.4
W^true [GeV]
Hyperon's Width
TOF
Final state

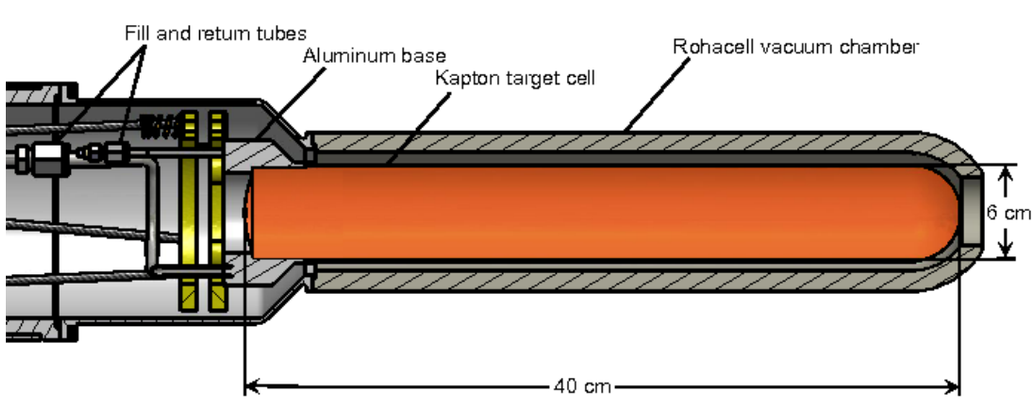
LH_2/LD_2 Cryogenic Target for Neutral Kaon Beam at Hall D

The GlueX liquid hydrogen target.



2cm

30cm



6cm

40cm

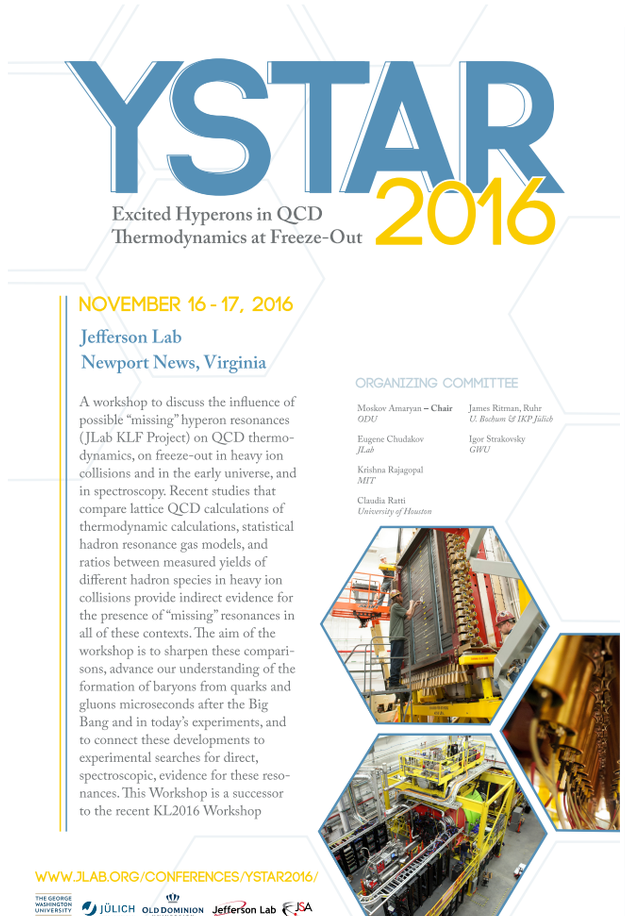
Current

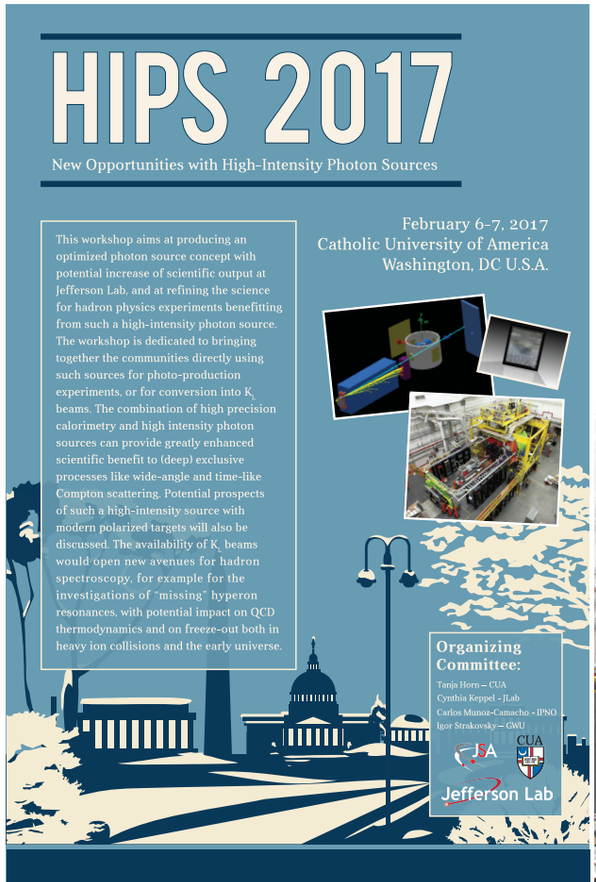
Proposed & Feasible

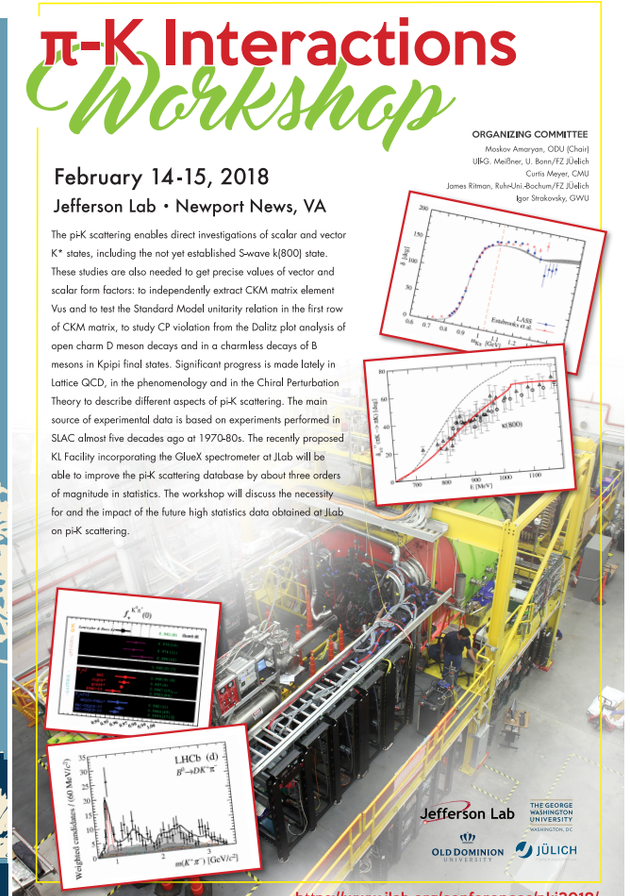
Longer and ticket target is needed to enhance production rate

Conceptual design endorsed by target group (Chris Keith)

Estimated cost ~$ 30 K







KL2016
[60 people from 10 countries, 30 talks] ***https://www.jlab.org/conferences/kl2016/***
OC: M. Amaryan, E. Chudakov, C. Meyer, M. Pennington, J. Ritman, & I. Strakovsky

YSTAR2016
[71 people from 11 countries, 27 talks] ***https://www.jlab.org/conferences/YSTAR2016/***
OC: M. Amaryan, E. Chudakov, K. Rajagopal, C. Ratti, J. Ritman, & I. Strakovsky

HIPS2017
[43 people from 4 countries, 19 talks] ***https://www.jlab.org/conferences/HIPS2017/***
OC: T. Horn, C. Keppel, C. Munoz-Camacho, & I. Strakovsky

PKI2018
[48 people from 9 countries, 27 talks] ***http://www.jlab.org/conferences/pki2018/***
OC: M. Amaryan, U.-G. Meissner, C. Meyer, J. Ritman, & I. Strakovsky

In total: 222 participants & 103 talks

Proposal:

200 Members

61 Institutions

20 Countries

A. Ali[18], M. B. Ali[47], M. J. Amaryan[44,*,†], E. G. Anassontzis[2], A. V. Anisovich[4,48], A. Austregesilo[30], M. Baalouch[45], F. Barbosa[30], J. Barlow[13], A. Barnes[7], E. Barriga[13], M. Bashkanov[10,†], A. Bazavov[39], T. D. Beattie[50], R. Bellwied[20], V. V. Berdnikov[8], T. Black[42], W. Boeglin[12], M. Boer[8], W. J. Briscoe[14], T. Britton[30], W. K. Brooks[53], B. E. Cannon[13], N. Cao[22], E. Chudakov[30], P. L. Cole[21], S. Cole[1], V. Crede[13], M. M. Dalton[30], T. Daniels[42], D. Day[58], P. Degtyarenko[30], A. Deur[30], S. Dobbs[13], G. Dodge[45], A. G. Dolgolenko[27], M. Döring[14,30], M. Dugger[1], R. Dzhygadlo[18], S. Eidelman[5,44], R. Edwards[30], H. Egiyan[30], A. Ernst[13], A. Eskandarian[14], P. Eugenio[13], C. Fanelli[36], S. Fegan[14], A. Filippi[25], A. M. Foda[50], J. Frye[23], S. Furletov[30], L. Gan[42], A. Gasparyan[41], G. Gavalian[30], M. Gauzshtein[54,55], N. Gevorgyan[61], C. Gleason[23], D. I. Glazier[17], J. Goity[30,19], V. S. Goryachev[27], K. Götzen[18], A. Goncalves[13], L. Guo[12], H. Haberzettl[14], M. Hadžimehmedović[57], H. Hakobyan[53], A. Hamdi[18], S. Han[60], J. Hardin[36], A. Hayrapetyan[16], G. M. Huber[50], A. Hurley[59], C. E. Hyde[45], T. Horn[8], D. G. Ireland[17], M. Ito[30], N. Jarvis[7], R. T. Jones[9], V. Kakoyan[61], G. Kalicy[8], M. Kamel[12], C. D. Keith[30], C. W. Kim[14], F. J. Klein[14], C. Kourkoumeli[2], G. Krafft[30], S. Kuleshov[53], I. Kuznetsov[54,55], A. B. Laptev[33], I. Larin[35], D. Lawrence[30], D. I. Lersch[13], M. Levillain[41], H. Li[7], W. Li[59], K. Livingston[17], B. Liu[22], G. J. Lolos[50], V. E. Lyubovitskij[56,54,55,53], D. Mack[30], M. Mai[14], D. M. Manley[31], M. Mazouz[47], H. Marukyan[61], V. Mathieu[30], P. T. Mattione[30], M. Matveev[48], V. Matveev[27], M. McCaughan[30], W. McGinley[7], M. McCracken[7], J. McIntyre[9], U.-G. Meißner[4,29], V. Mokeev[30], F. Nerling[18], C. A. Meyer[7], R. Miskimen[35], R. E. Mitchell[23], F. Mokaya[9], C. Morningstar[7], B. Moussallam[46], K. Nakayama[15], Y. Oh[32], R. Omerović[57], H. Osmanović[57], A. Ostrovidov[13], Z. Papandreou[50], K. Park[30], E. Pasyuk[30], M. Patsyuk[36], P. Pauli[17], R. Pedroni[41], J. R. Pelaez[34], L. Pentchev[30], M. R. Pennington[17], K. J. Peters[18], W. Phelps[14], A. Pilloni[30], E. Pooser[30], J. W. Price[6], N. Qin[43], J. Reinhold[12], D. Richards[30], D.-O. Riska[11], B. Ritchie[1], J. Ritman[51,28,†], L. Robison[43], A. Rodas[34], D. Romanov[37], C. Romero[53], J. Ruiz de Elvira[3], H-Y. Ryu[49], C. Salgado[40], E. Santopinto[24], A. V. Sarantsev[4,48], T. Satogata[30], A. Schertz[59], R. A. Schumacher[7], C. Schwarz[18], J. Schwiening[18], A. Yu. Semenov[50], I. A. Semenova[50], K. K. Seth[43], X. Shen[22], M. R. Shepherd[23], E. S. Smith[30], D. I. Sober[8], D. Sokhan[17], A. Somov[30], S. Somov[37], O. Soto[53], M. Staib[7], J. Stahov[57], J. R. Stevens[59,†], I. I. Strakovsky[14,†], A. Švarc[52], A. Szczepaniak[23,30], V. Tarasov[27], S. Taylor[30], A. Teymurazyan[50], A. Trabelsi[47], G. Vasileiadis[2], D. Watts[10], D. Werthmüller[17], T. Whitlatch[30], N. Wickramaarachchi[45], M. Williams[36], B. Wojtsekhowski[30], R. L. Workman[14], T. Xiao[43], Y. Yang[36], N. Zachariou[10], J. Zarling[23], J. Zhang[58], Z. Zhang[60], G. Zhao[22], B. Zou[26], Q. Zhou[22], X. Zhou[60], B. Zihlmann[30]

SUMMARY

- -Proposed KL Facility has unique capability to improve existing world database up to three orders of magnitude
- -In Hyperon spectroscopy
  PWA will allow to measure pole positions and widths of excited hyperon states
- -In Strange Meson Spectroscopy
  - PWA will allow to measure excited K* states including scalar f0(800) states
- - To accomplish physics program
  100 days per LH2 and LD2 is required
- -All components of KL Facility considered are feasible

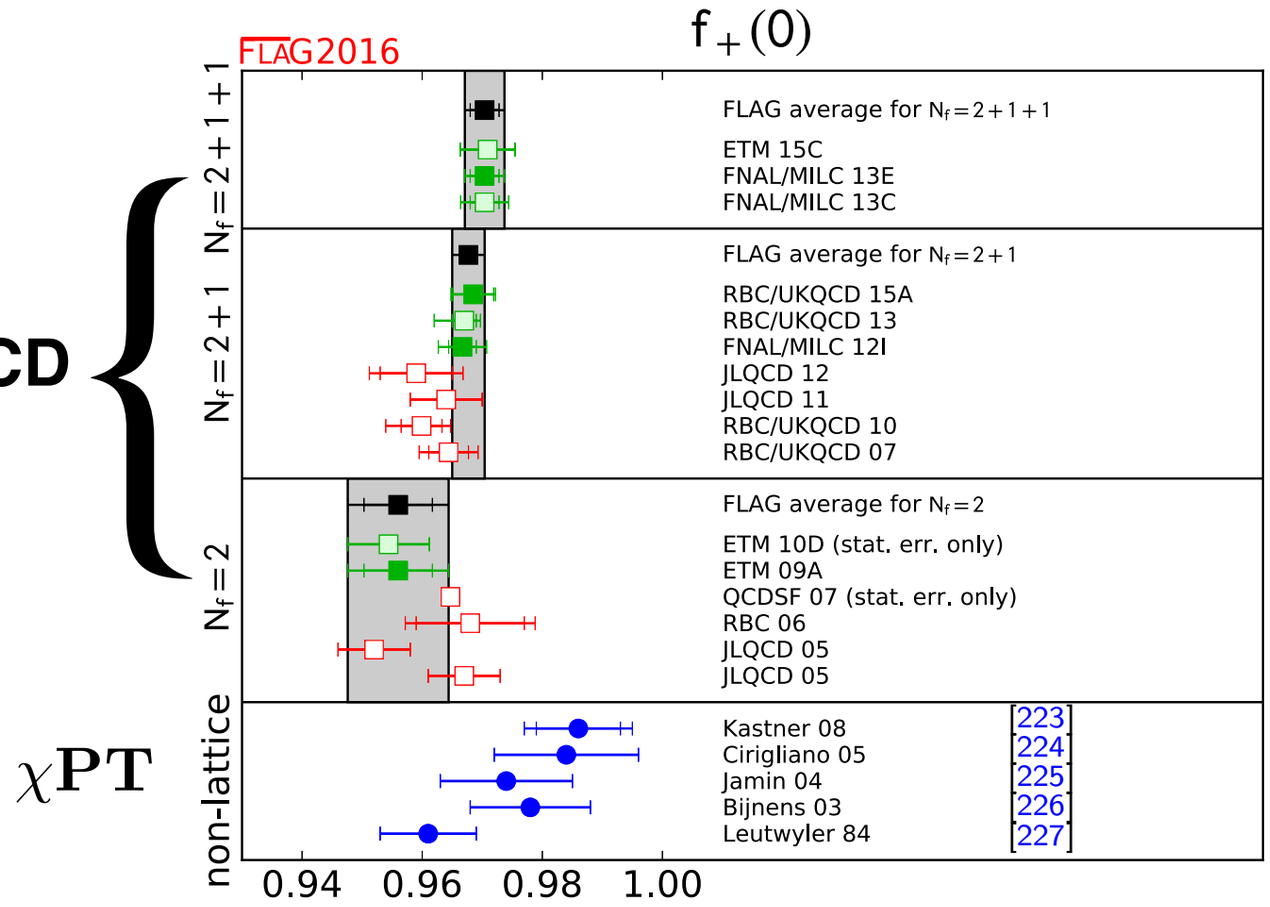
  -With total cost < $ 7 M
- - Future extension with polarized target is possible

Backup

Possible Other Impacts

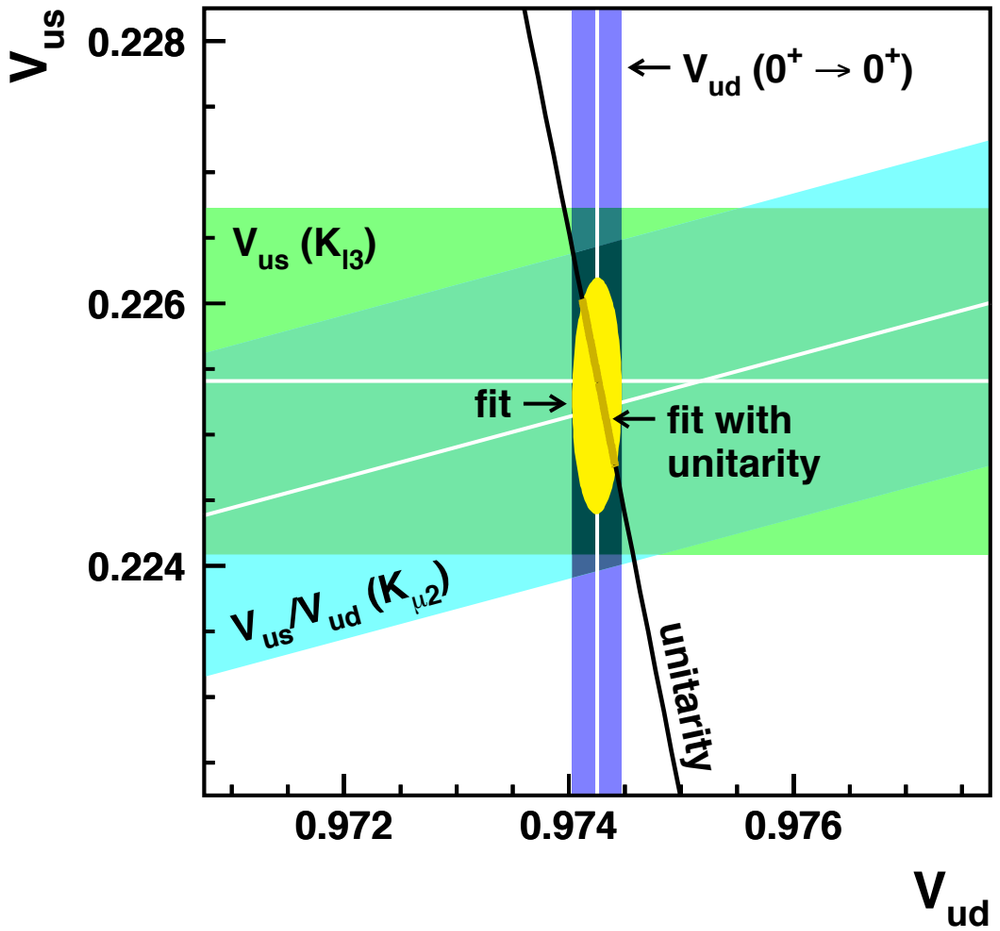
$$Br(K_L \to \pi e \nu) \sim |f_+(0) V_{us}|^2$$

$$Br(\tau \to K \pi \nu) \sim |f_+(0) V_{us}|^2$$



FLAG Collaboration **Eur.Phys.J. C77 (2017) no.2, 112**

No precise data yet !



Eur.Phys.J. C69 (2010) 399-424

test of unitarity:

$$|V_{ud}|^2 + |V_{us}|^2 + |V_{ub}|^2 = 1$$