Strange Hadron Spectroscopy with Secondary KL Beam in Hall-D

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(on behalf of K LONG FACILITY *Collaboration)*

PAC47, JLab, July 30, 2019

Outline

Current Status

- Hyperon Spectroscopy
- Strange Meson Spectroscopy

Future Prospects with K_L Facility at JLab

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

Summary

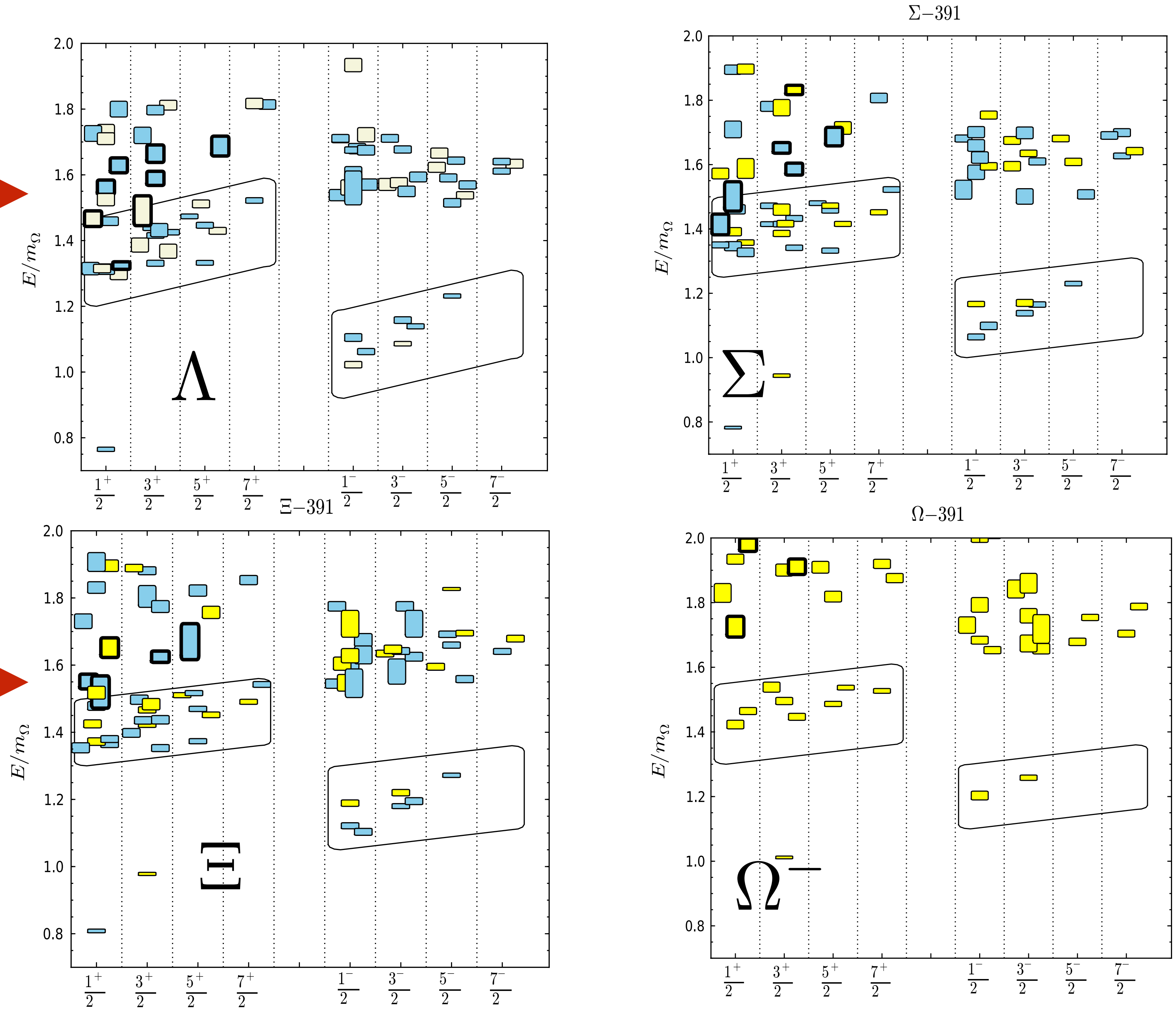
Hyperon Spectroscopy

*According to **LQCD** there should be*

many more states including hybrids (thick bordered)

8-states
****
5-states
***

6-states
****
4-states
***

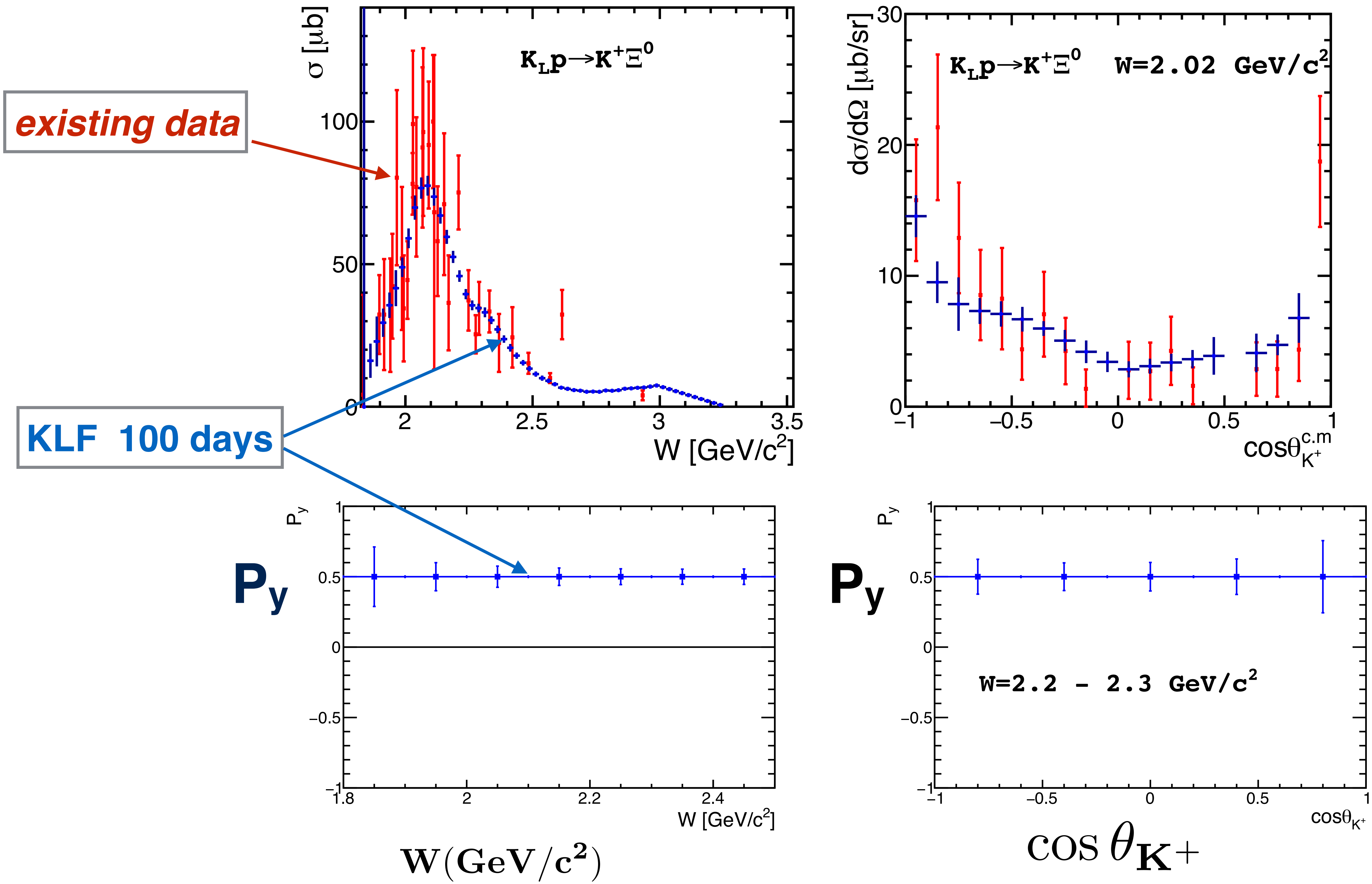


3-states
****
4-states
***

1-state
****
1-state
***

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

Measurements on Proton Target



Search for Hyperon Resonances with PWA

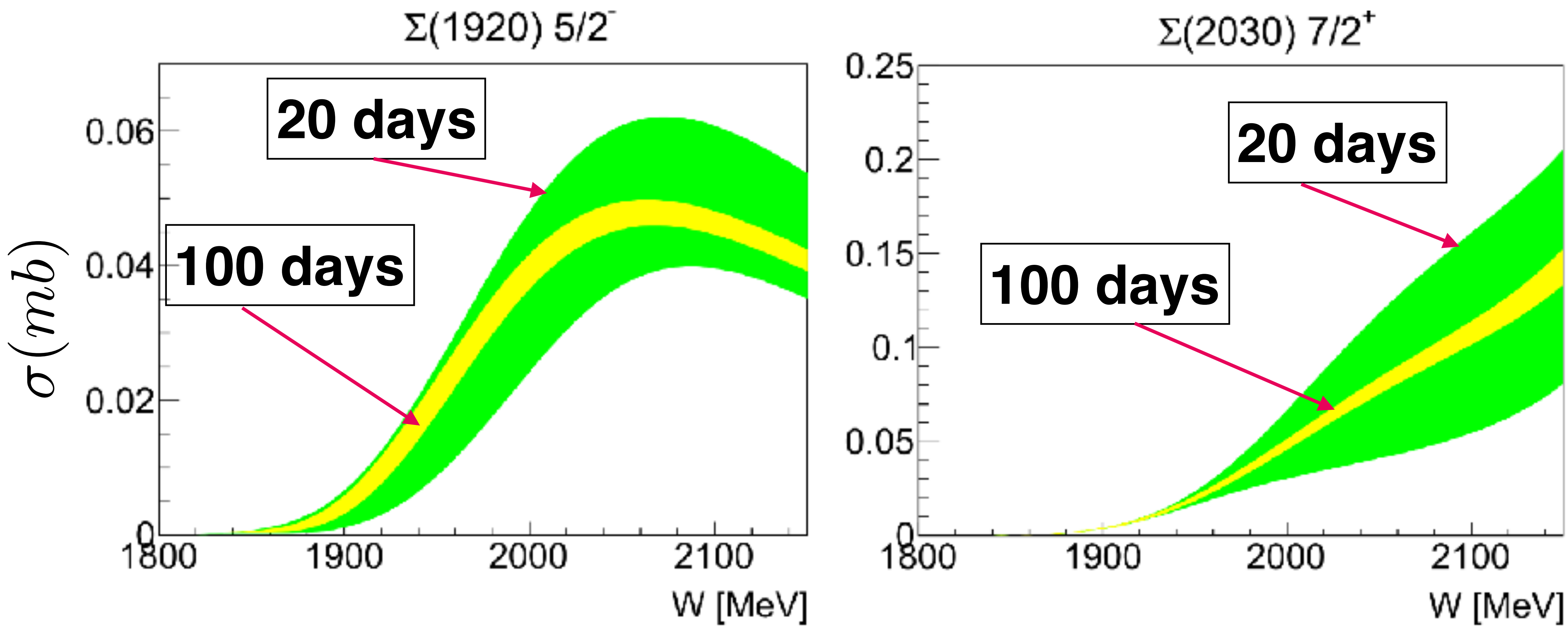
For Scattering experiments on both
proton & neutron targets one needs to determine:

- **-differential cross sections**
- **-self polarization of strange hyperons**
- **-perform coupled-channel PWA**
- **-look for poles in complex energy plane (contrary to naïve bump hunting)**
- **-identify all $\Lambda^*, \Sigma^*, \Xi^*$ & Ω^* up to 2400 MeV**

we use KN scattering data with statistics generated according to expected K-long Facility (KLF) data for 20 and 100 days to show PWA sensitivity to obtain results close to the best fit

Bonn-Gatchina PWA

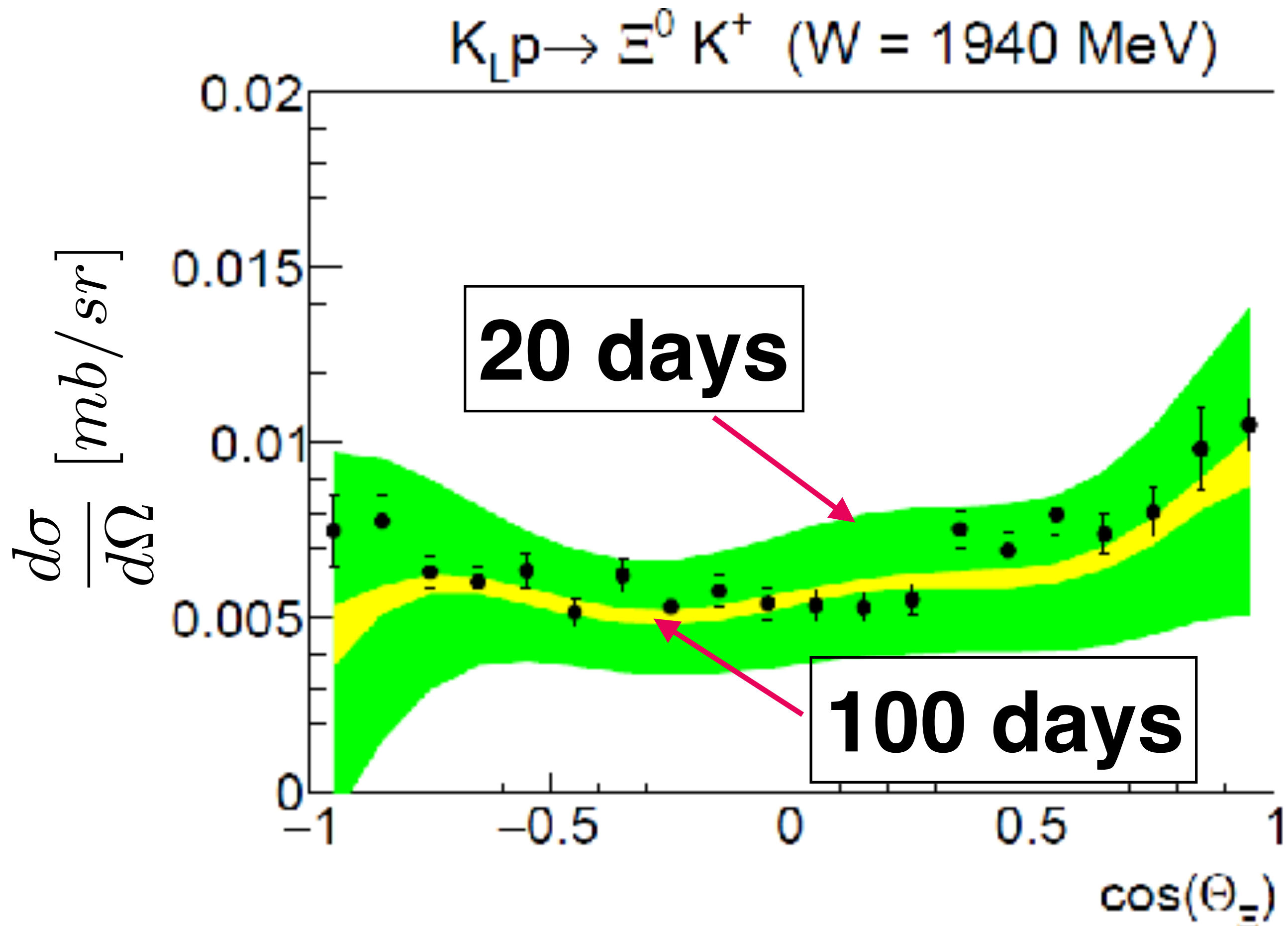
Total Cross Section $K_L p \to K^+ \Xi^0$



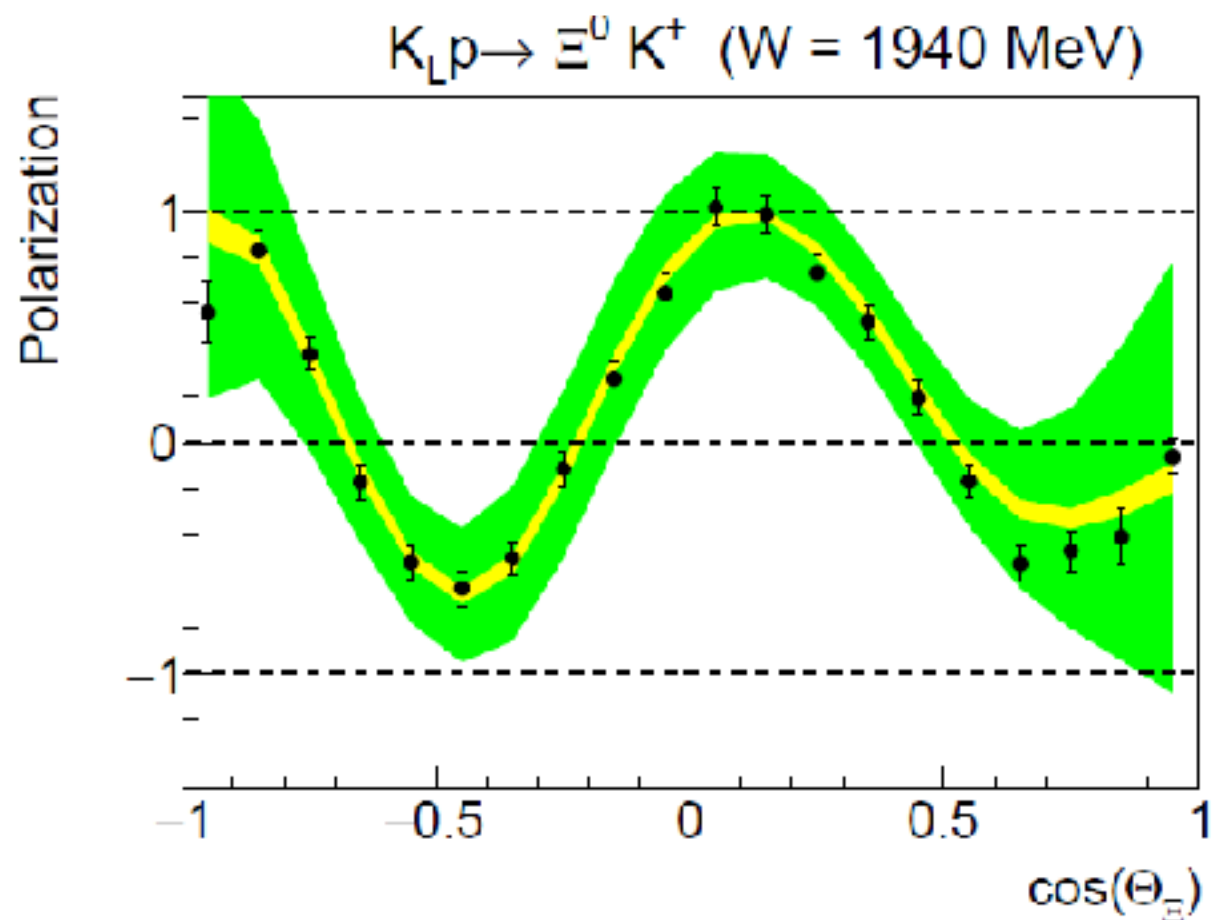
Obviously: at least 100 days needed to get precise solution

Bonn-Gatchina PWA

Diff. Cross Section



Polarization



Again: at least 100 days to get precise solution

Some Numerical Results

Simulated $\Sigma(1920)\ 5/2^-$

$$\begin{cases} 100d\ M = 1.923 \pm 0.010 \pm 0.010\ GeV \\ \Gamma = 0.321 \pm 0.01 \pm 0.010\ GeV \\ 20d\ M = 1.977 \pm 0.021 \pm 0.025\ GeV \end{cases}$$

$$\Gamma = 0.327 \pm 0.025 \pm 0.025\ GeV$$

$$PDG2018\ M = 1.775 \pm 0.005$$

LQCD M=

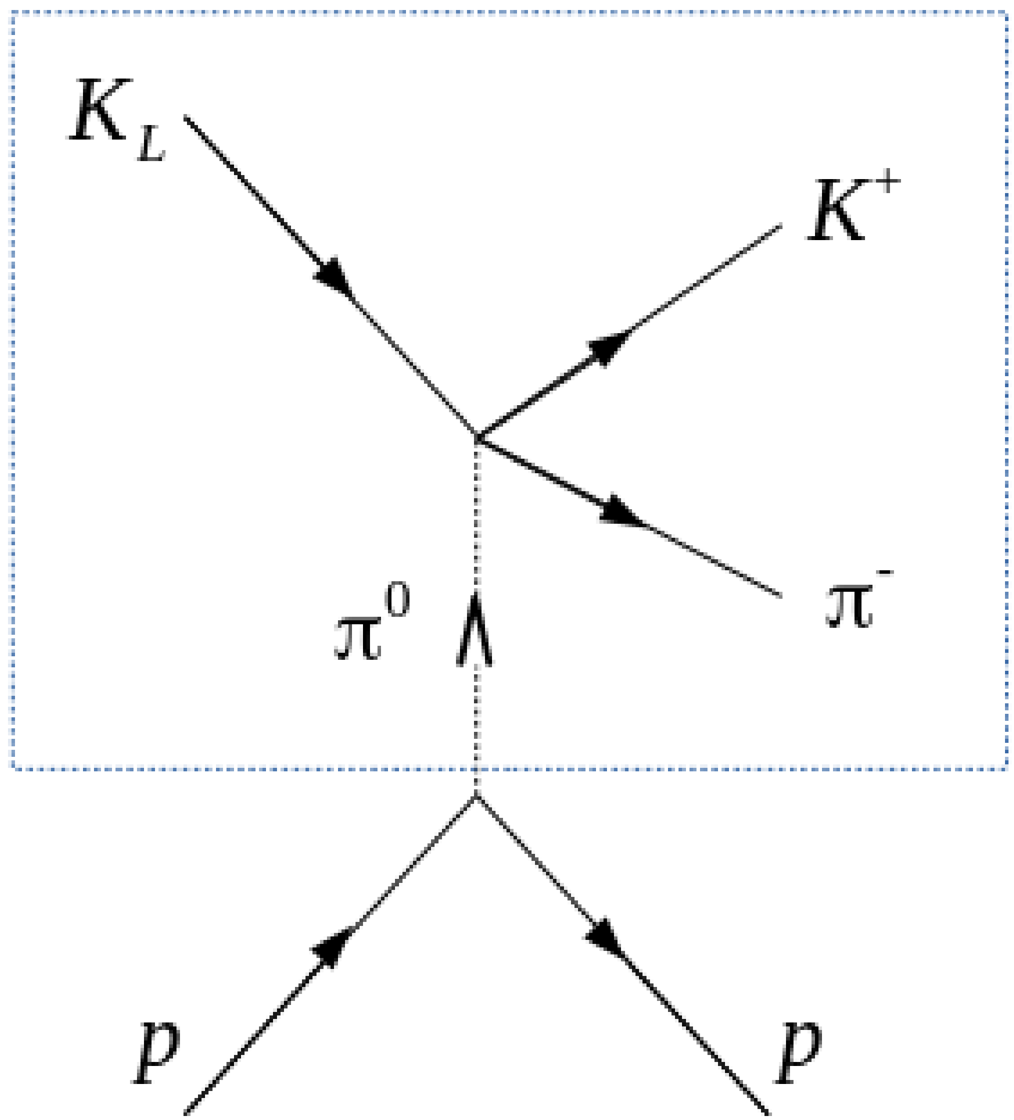
2.027 GeV
2.487 GeV
2.659 GeV
2.781 GeV

R.G. Edwards et al., PRD 87,no.5. 054506 (2013)

LQCD Results are still in progress

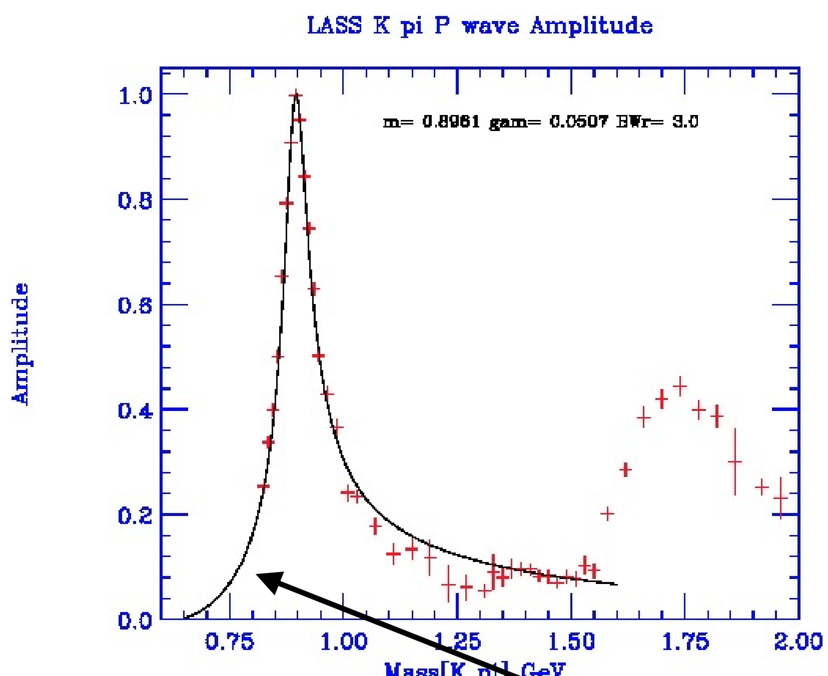
Strange Meson Spectroscopy

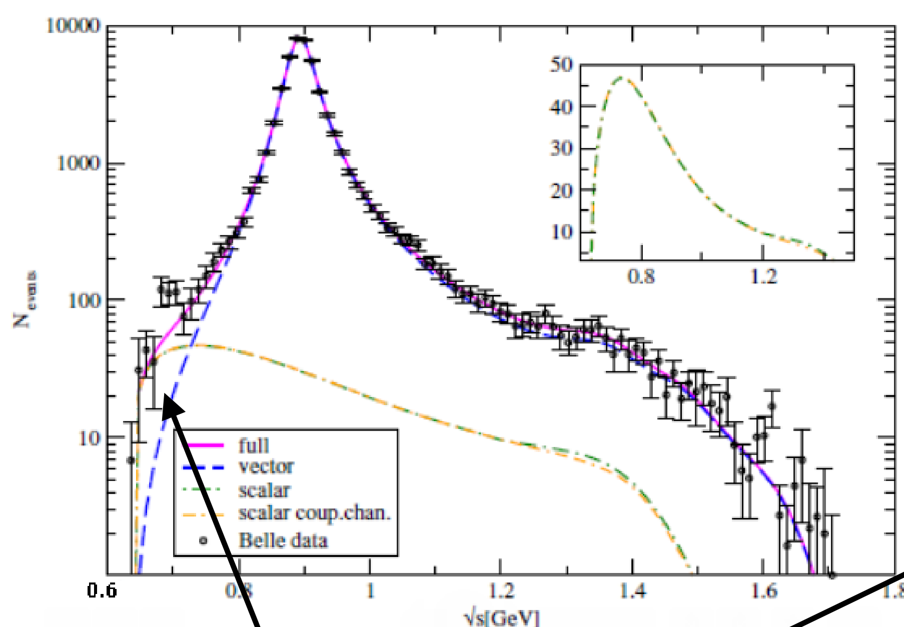
$K\pi$ **Scattering**

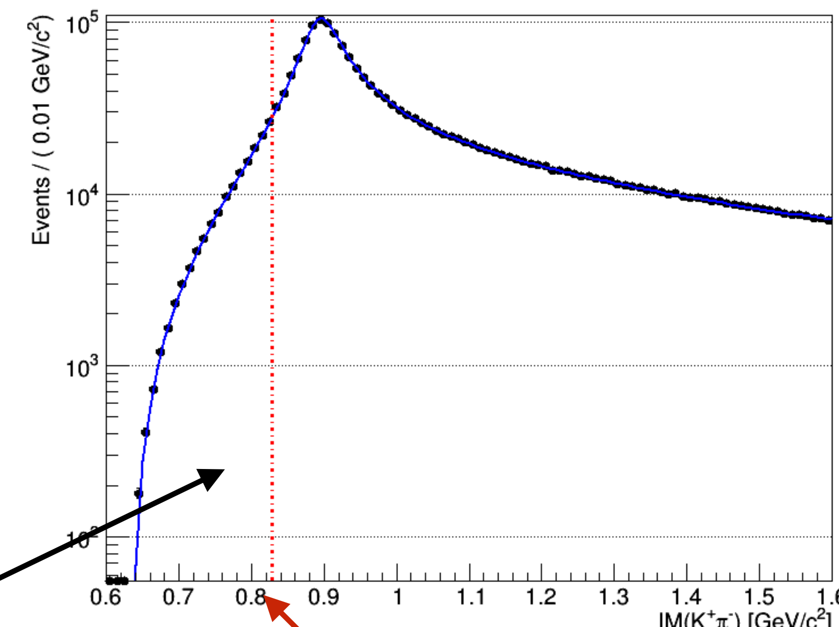


Proposed Measurements

SLAC	Belle	KLF
$K^-\pi^+ \to K^-\pi^+$	$\tau \to K\pi\nu_\tau$	$K_L\pi^0 \to K^+\pi^-$



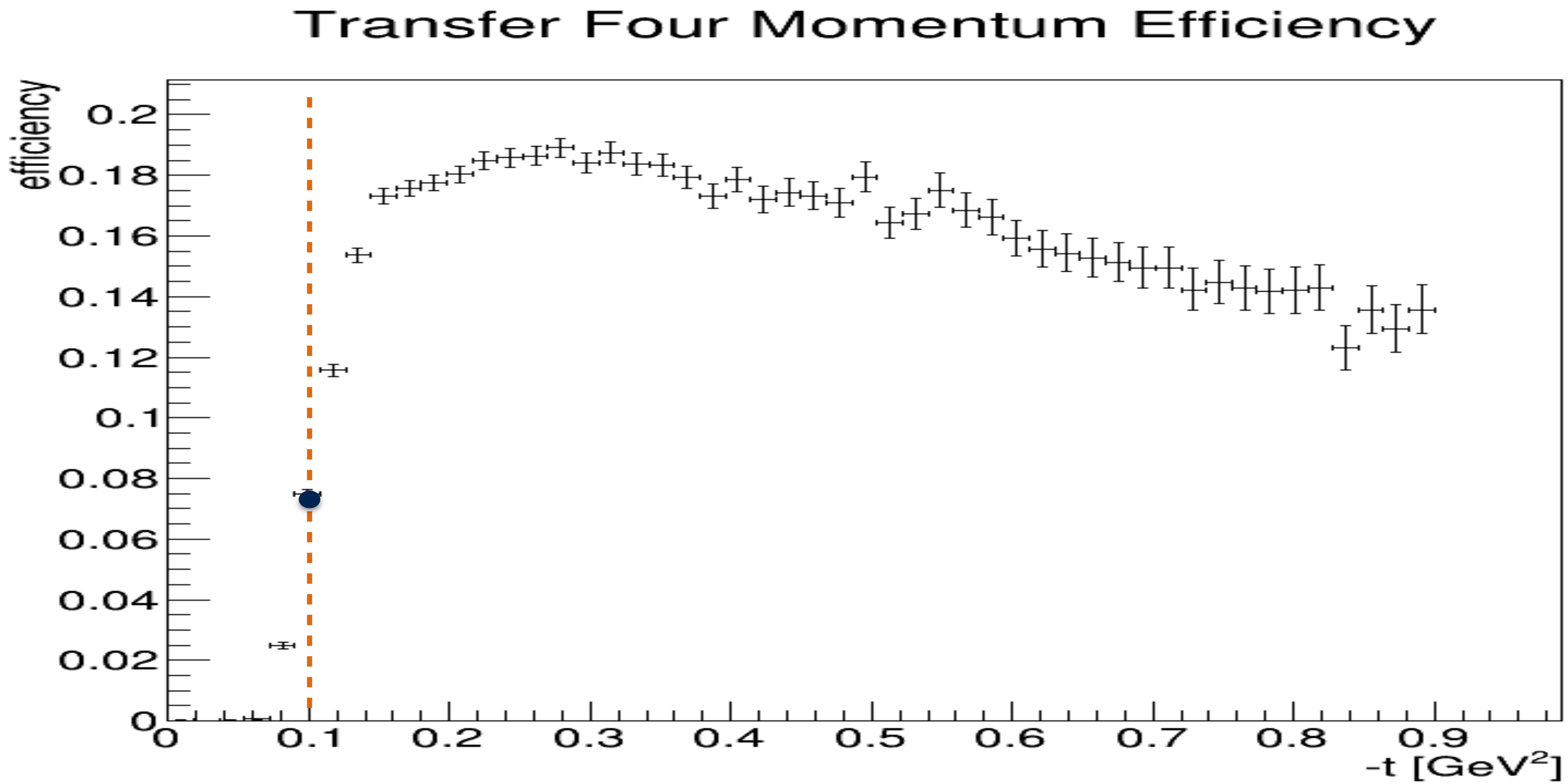




$\mathbf{M(K\pi)(GeV)}$ $\mathbf{M(K\pi)(GeV)}$ $\mathbf{M(K\pi)(GeV)}$

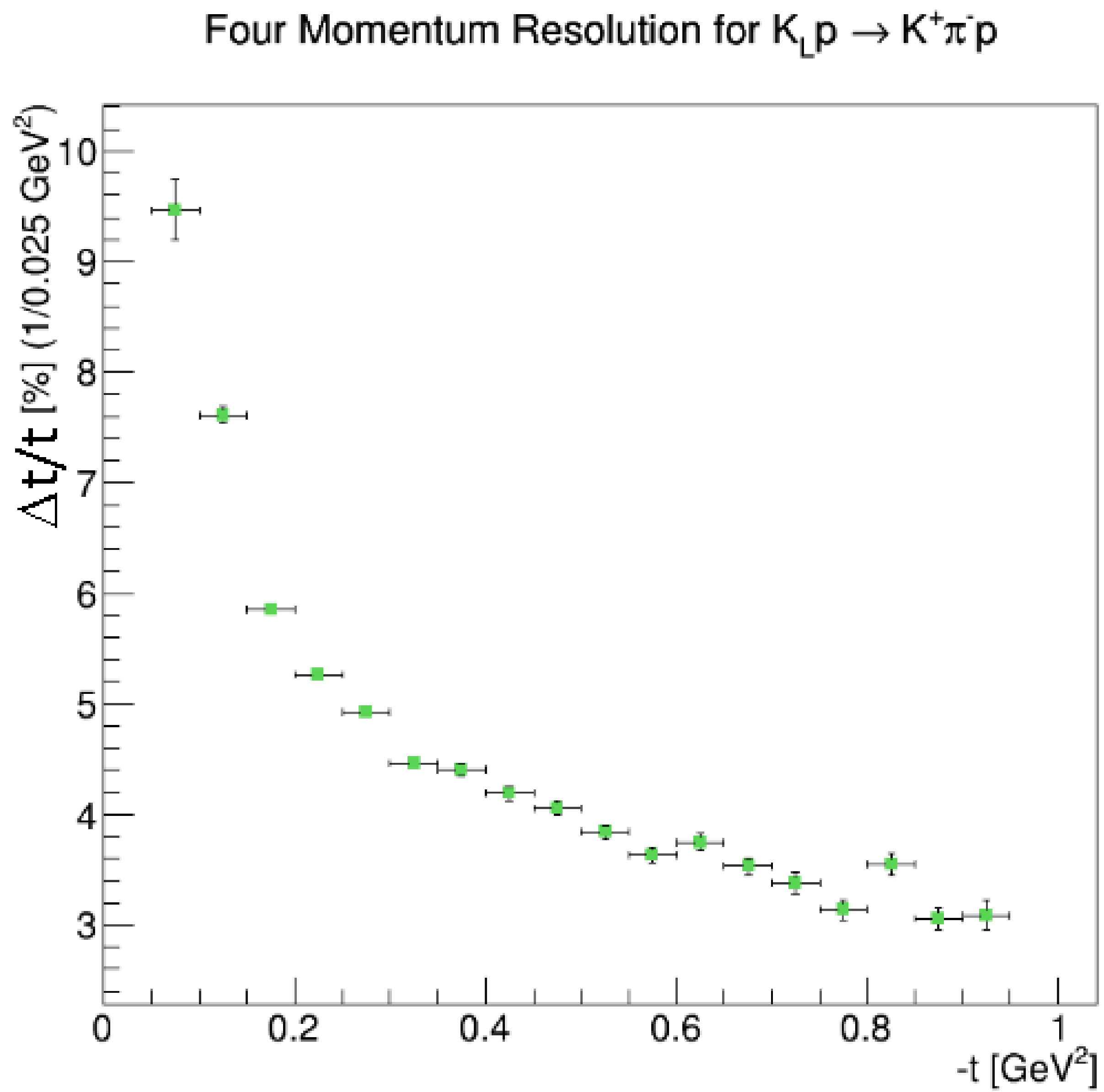
region of $\kappa(800)$

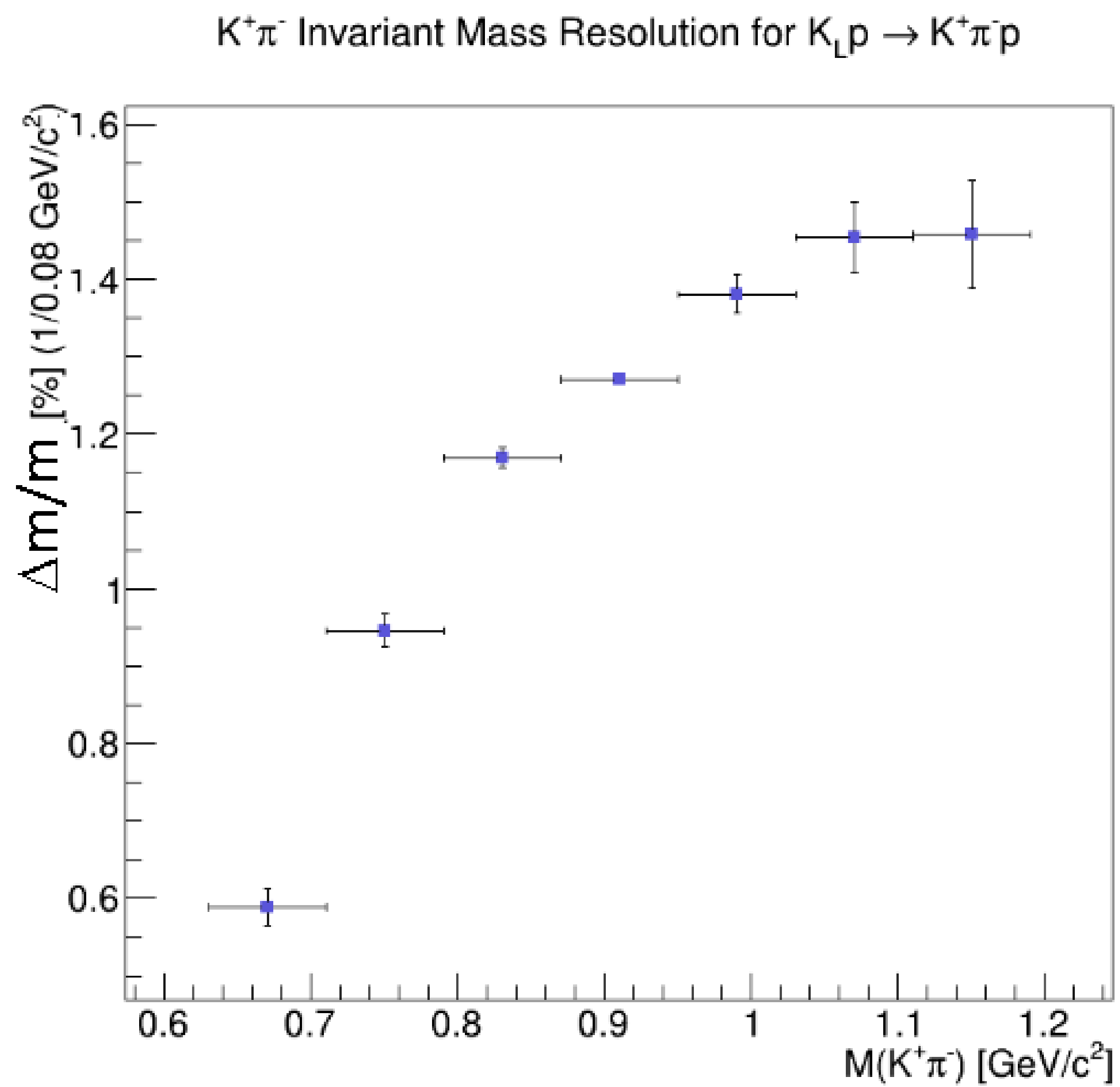
SLAC Lower limit



t-down to 0.1 GeV^2 is measurable
with proton being detected

$K\pi$ ***Scattering Resolutions***

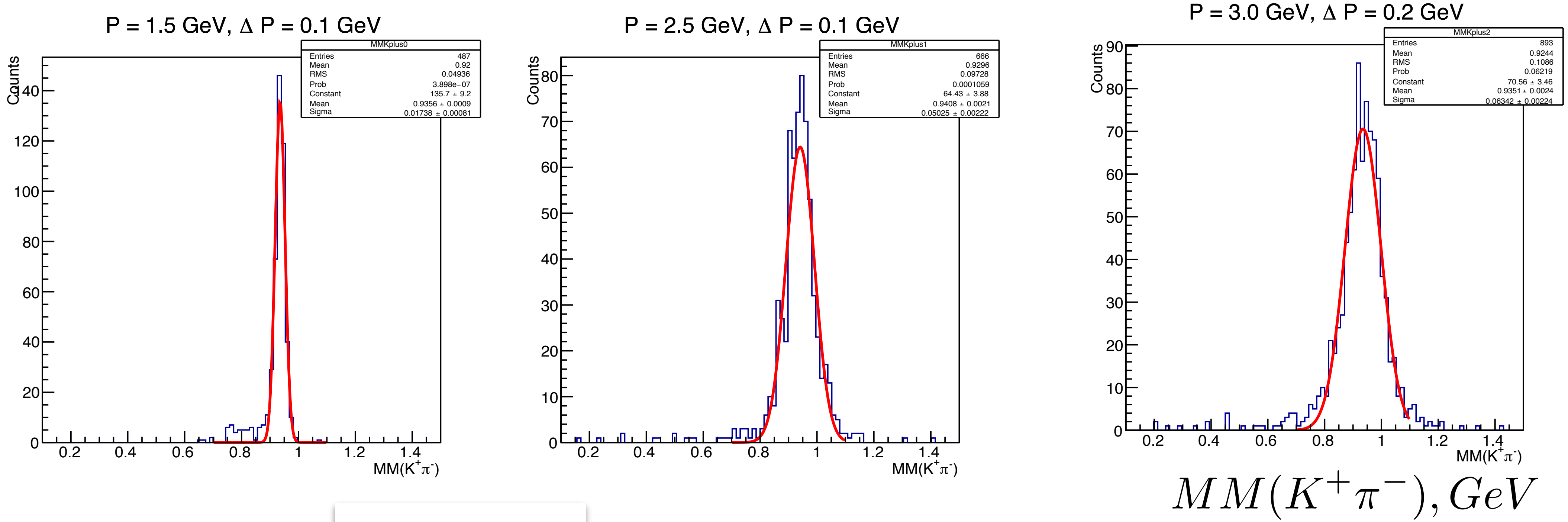


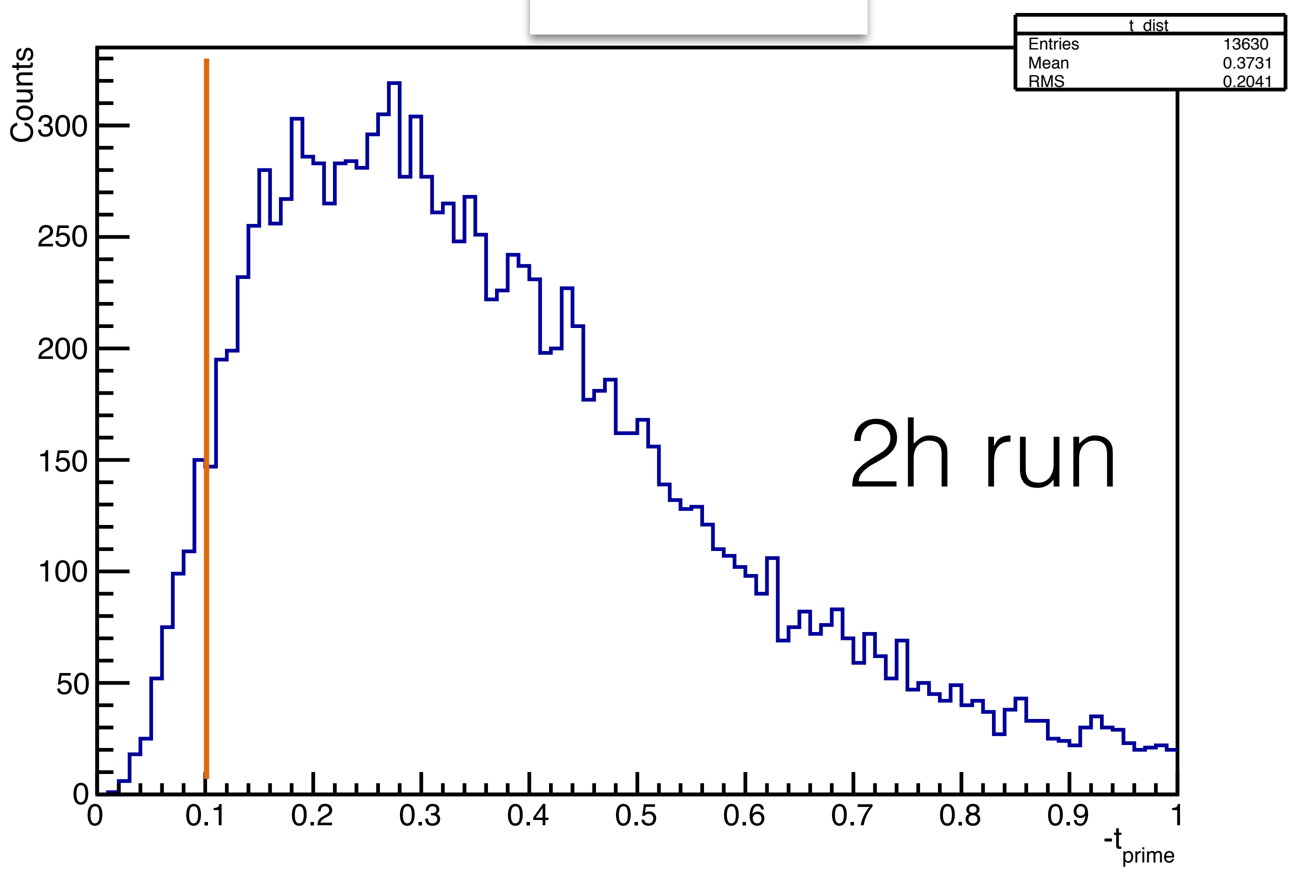


-Good resolution at low-t is needed to be close to pion pole

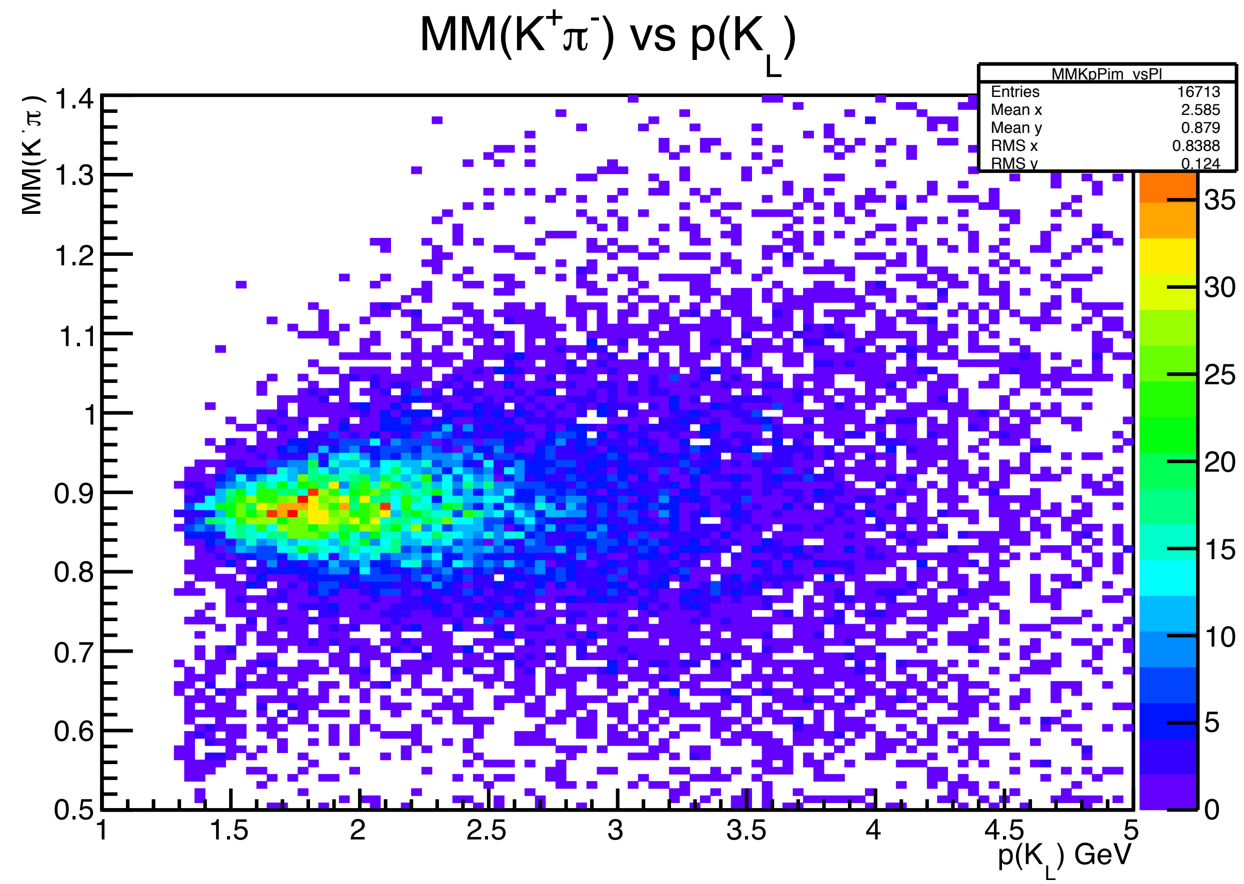
-Binning in ~10 MeV will cover almost entire elastic K-pi scattering range

Missing Mass of $K^+\pi^-$ system in

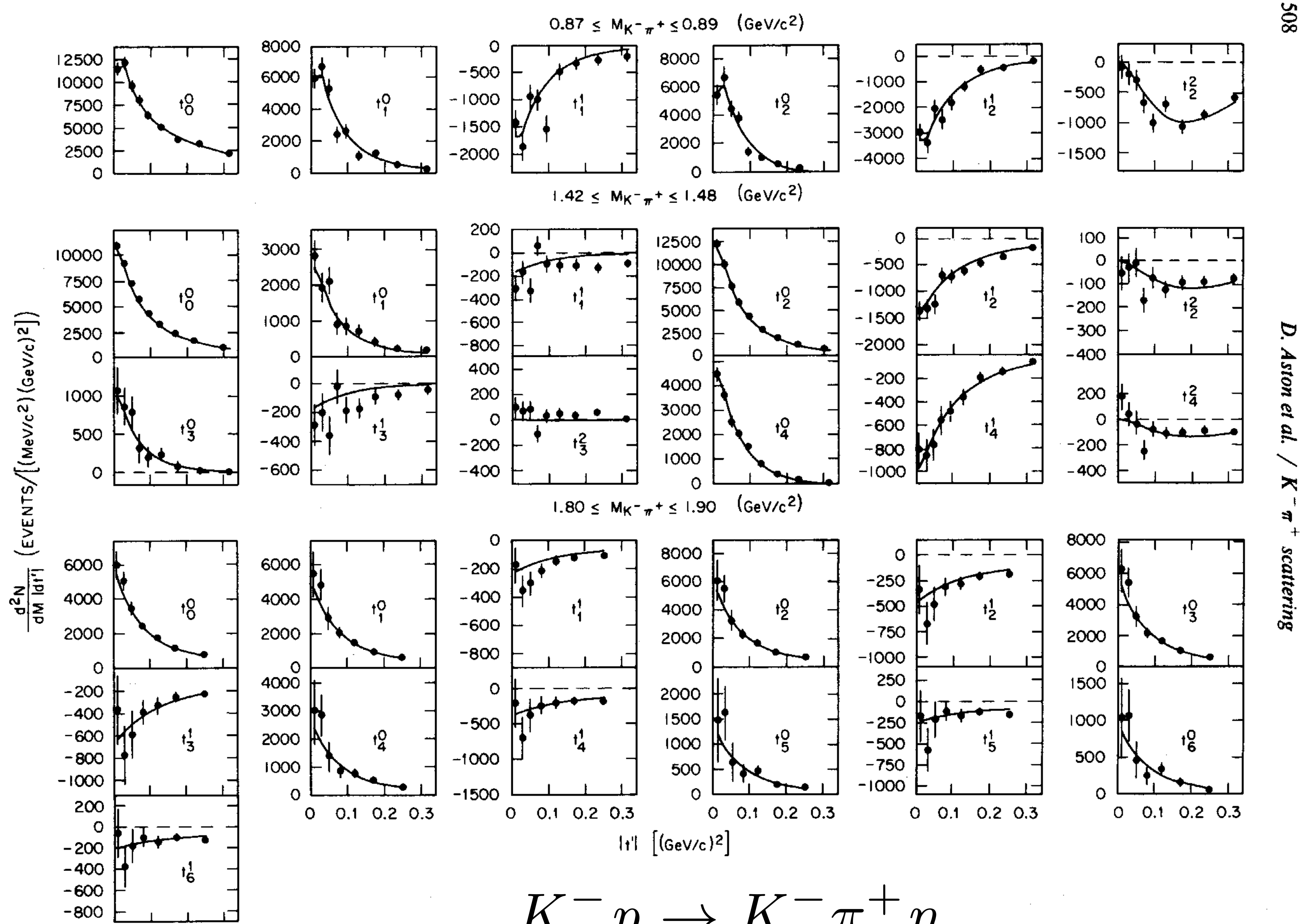




-t, GeV²

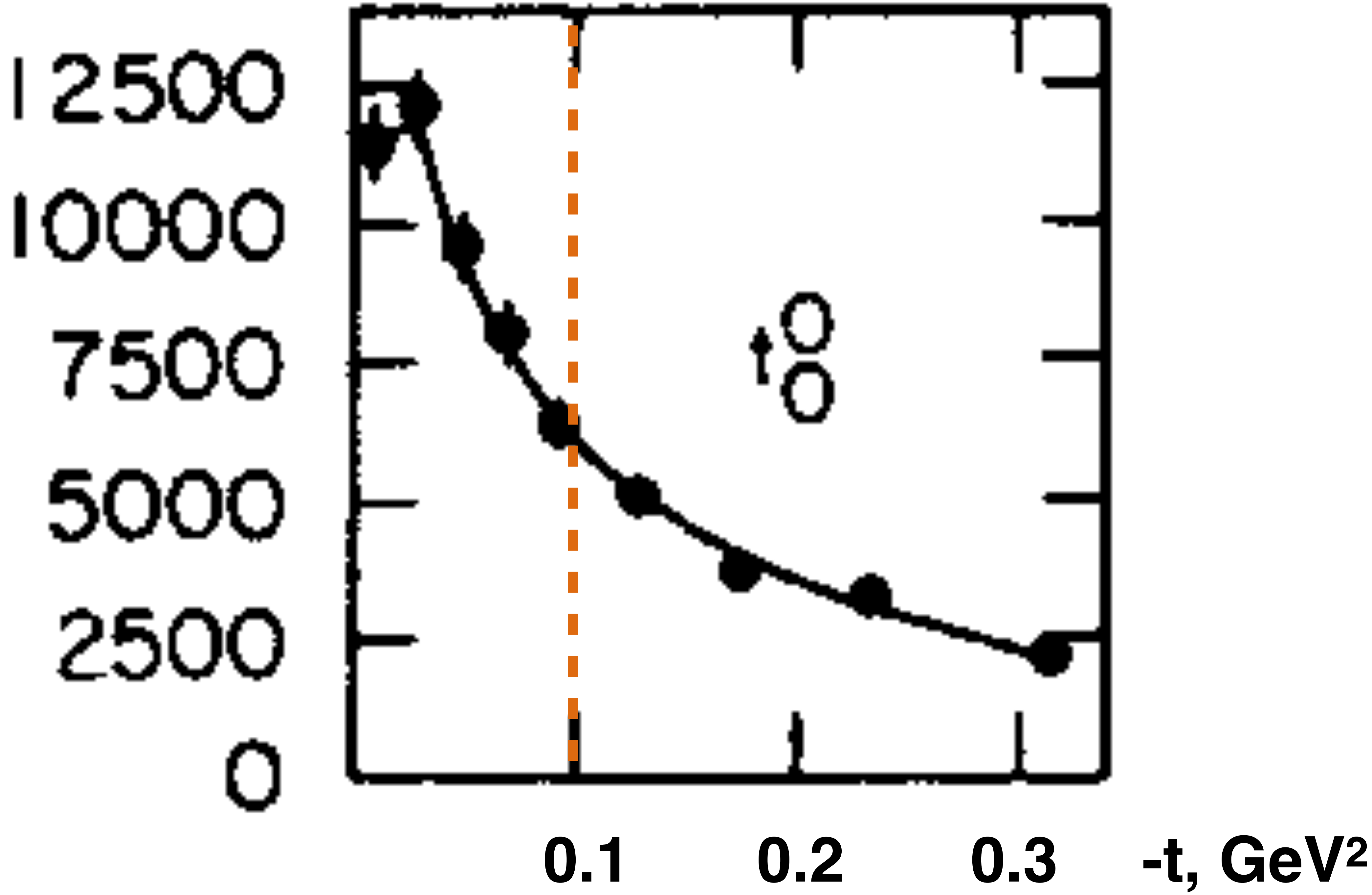


NPB296 Aston et al., LASS at SLAC at 11 GeV



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

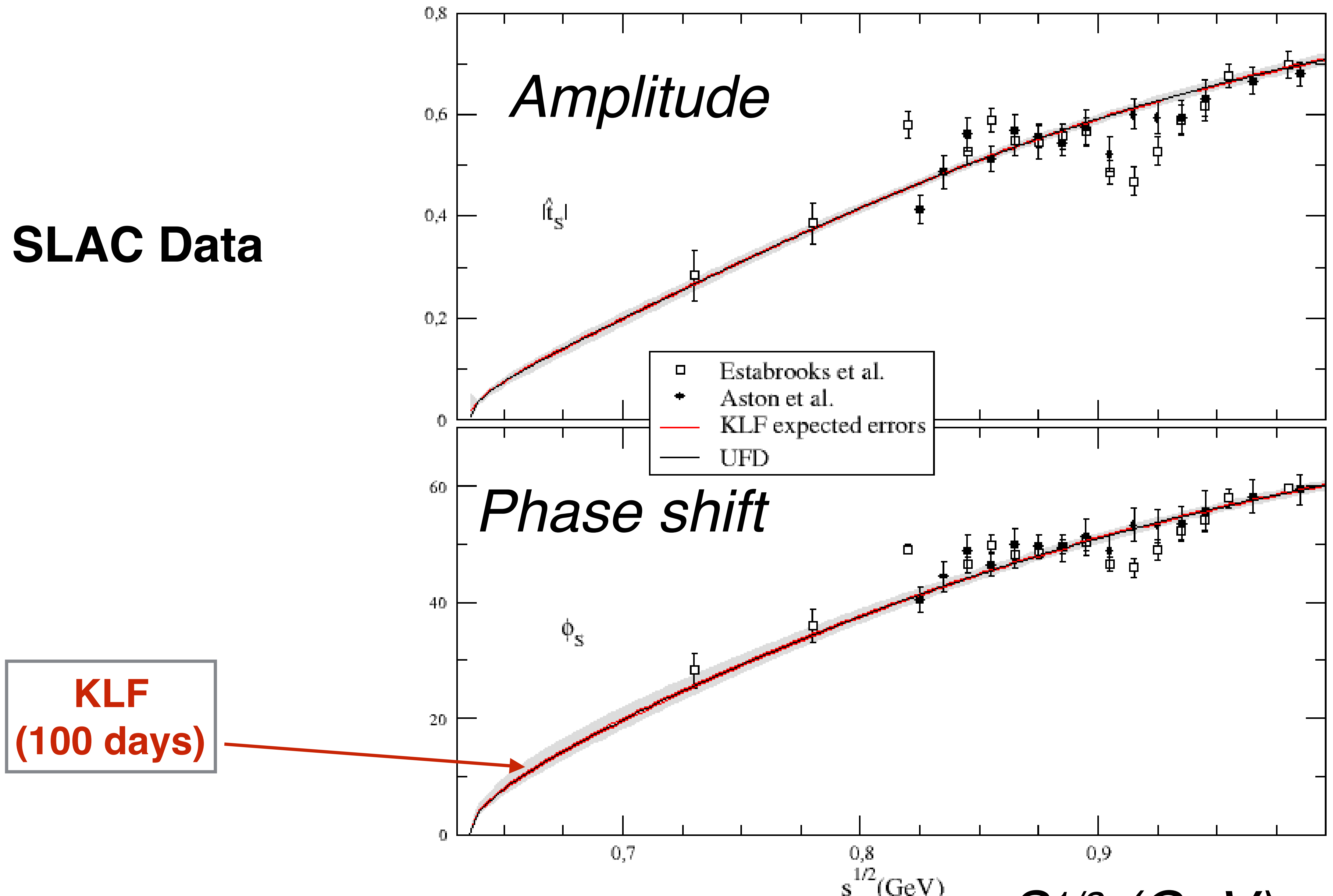
Fig. 9. The acceptance corrected unnormalized $K^-\pi^+$ moments as a function of $|t'|$. Three different mass regions are shown; $0.87 \leqslant M_{K\pi} \leqslant 0.89$ GeV$/c^2$, $1.42 \leqslant M_{K\pi} \leqslant 1.48$ GeV$/c^2$, and $1.80 \leqslant M_{K\pi} \leqslant 1.90$ GeV$/c^2$. The curves are the result of a fit to the production model described in the text.


12500
10000
7500
5000
2500
0
0.1
0.2
0.3
-t, GeV²

Projected Measurements

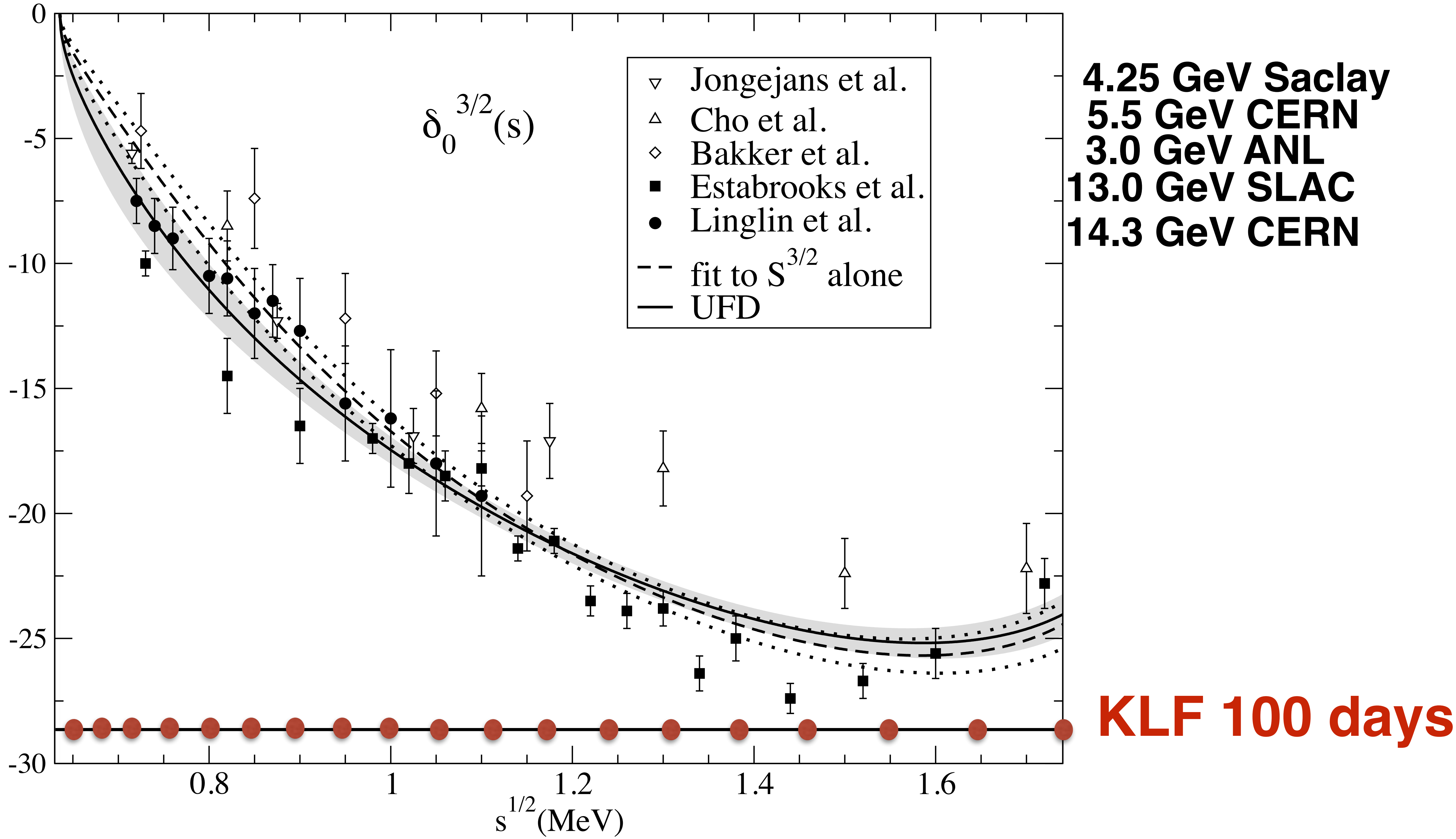
I=3/2+1/2 *S-wave*

SLAC Data



$S^{1/2}$ (GeV)

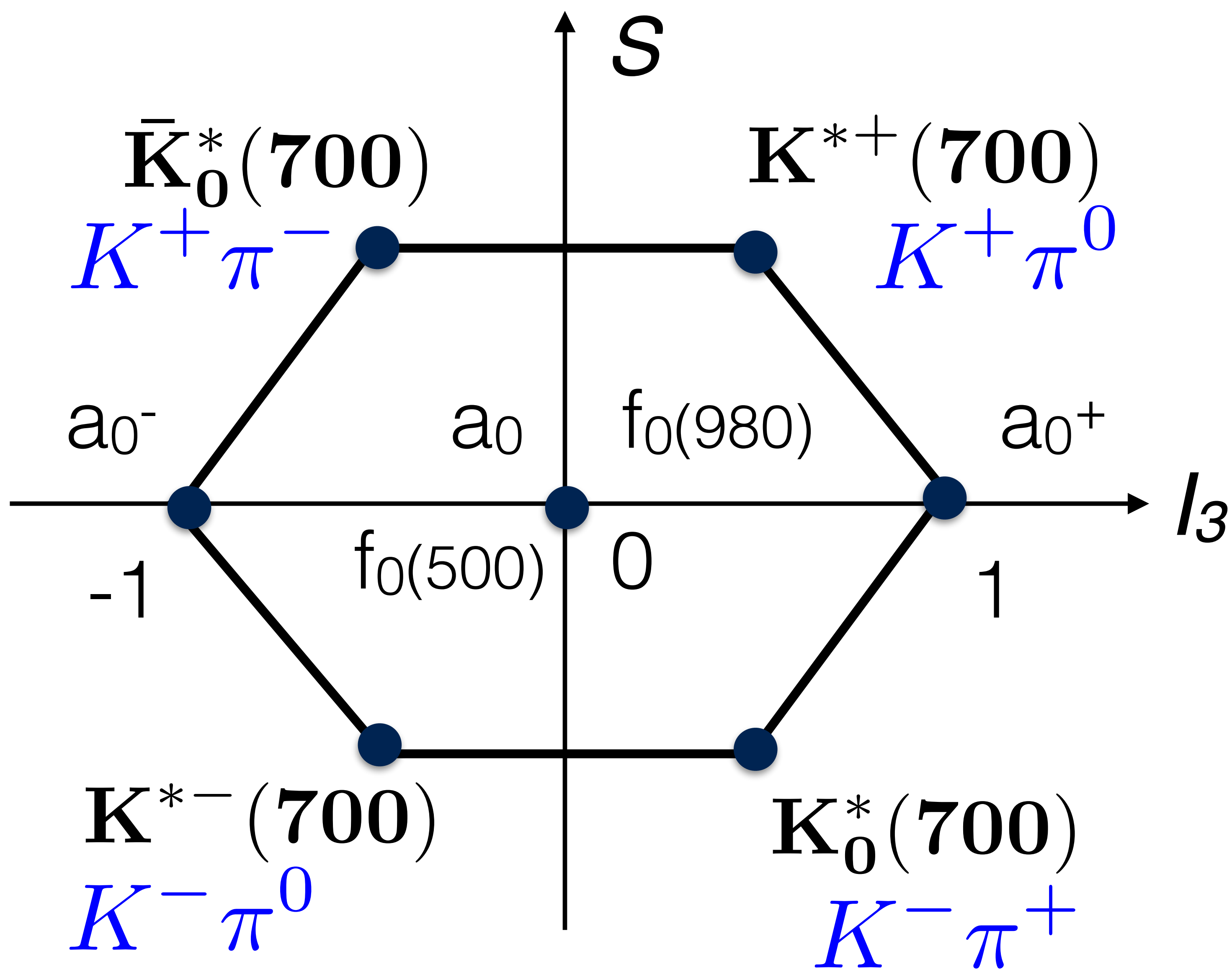
I=3/2 S-wave



From Pelaez and Rodas paper: PRD93(2016)

Scalar Meson Nonet

$J^{PC} = 0^{++}$

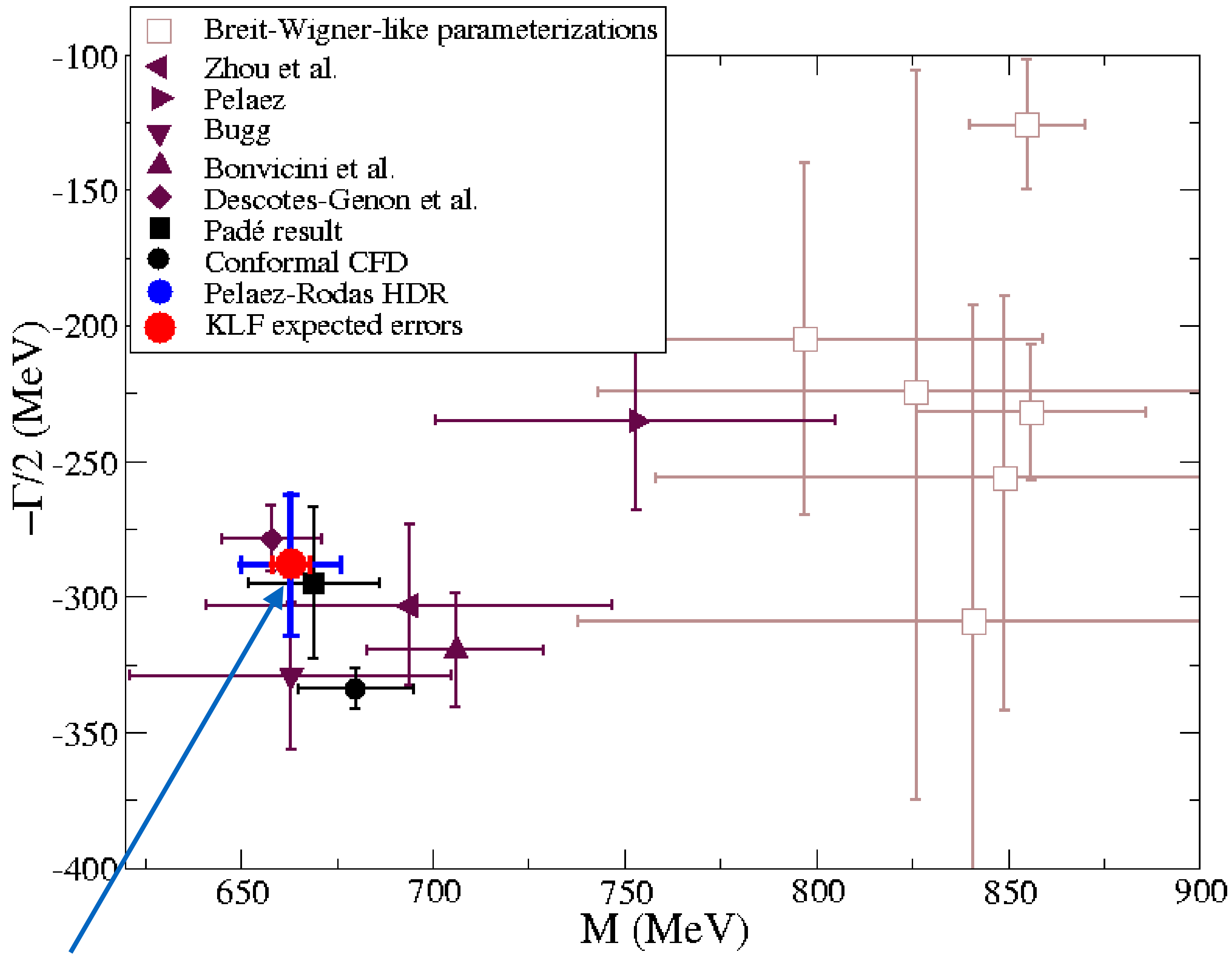


Four states called κ

still need further confirmation(PDG)

We can measure all of them

Width and Mass of κ (800)



100 days of running

Summary of $K\pi$ Scattering

-The KLF will have a very significant impact on our knowledge $K\pi$ on scattering amplitudes

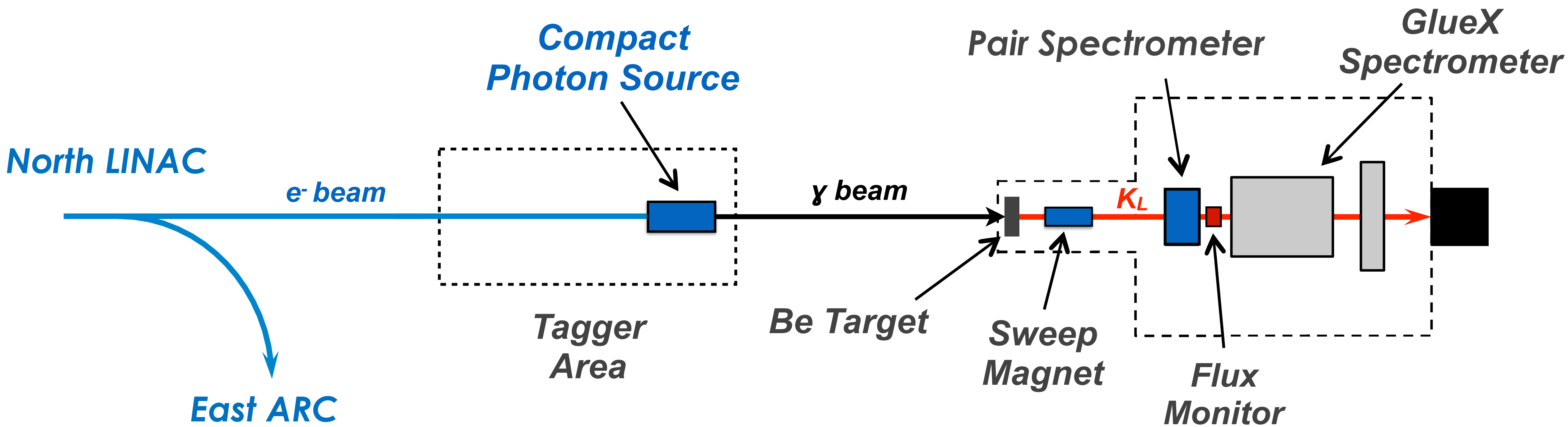
-It will certainly improve still conflictive determination of heavy K*'s parameters

-It will help to settle the tension between phenomenological determinations of scattering lengths from data versus ChPT and LQCD

-Finally, and very importantly, it will reduce by more than a factor of two the uncertainty in the mass determination of K*(700) and by factor of five the uncertainty on its width, and therefore on its coupling

-It will help to clarify debates of its existence, and therefore a long standing problem of existence of the scalar nonet

Hall-D beamline and GlueX Setup



Electron Beam Parameters

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

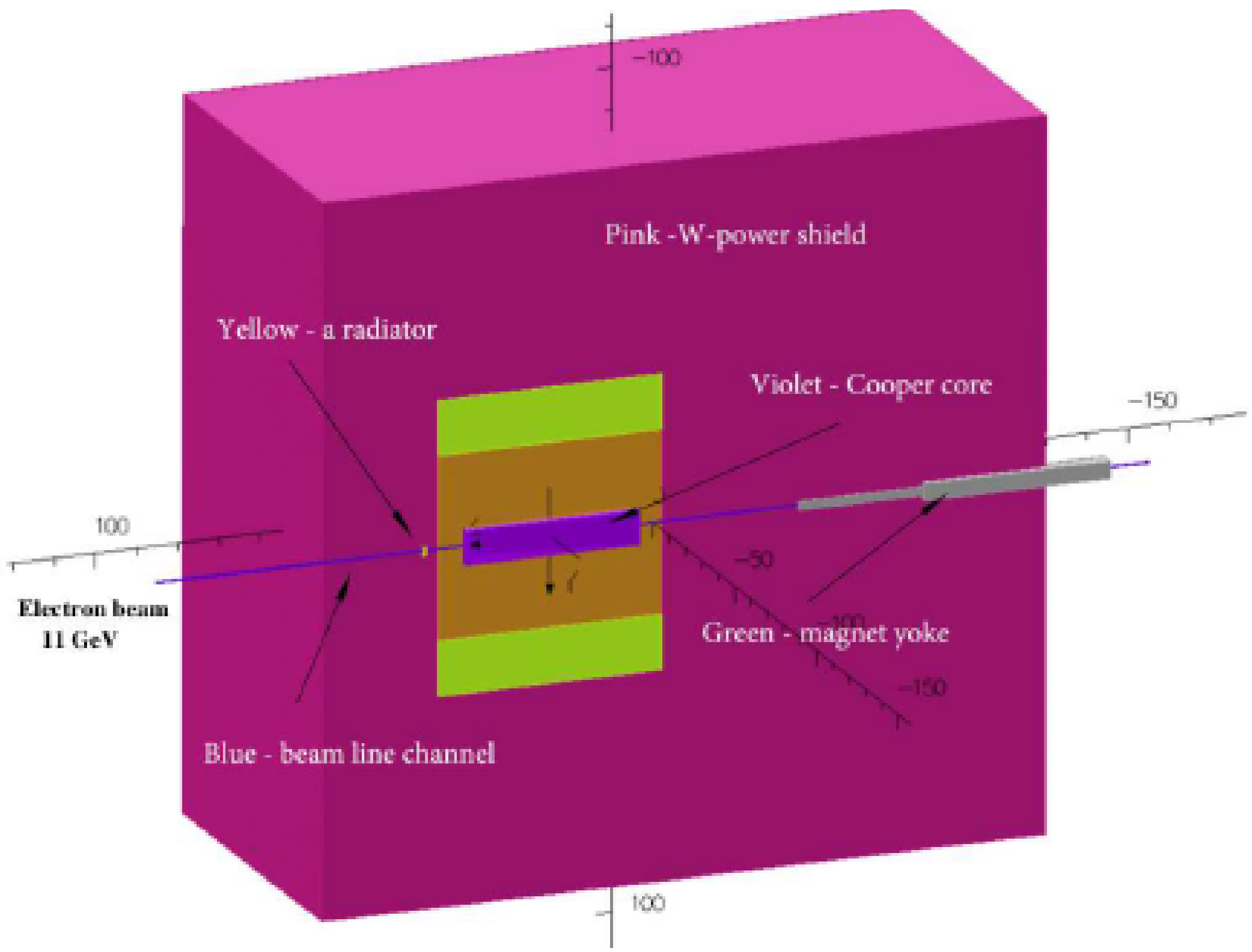
Bunch spacing $64\ ns$

No major problems.

Doable !

Confirmed by accelerator experts

Compact Photon Source

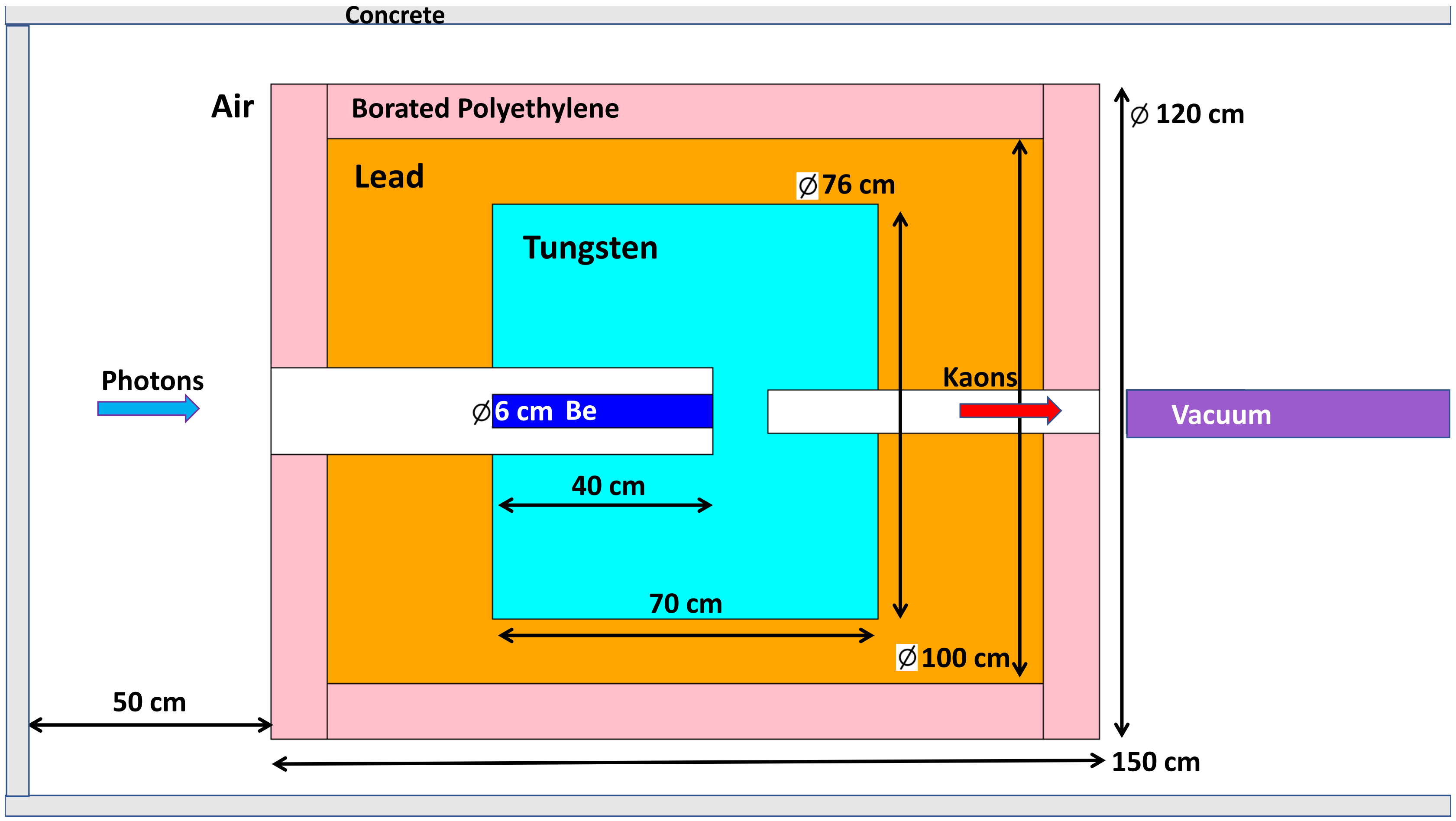


Conceptual design is completed for Halls A&C

The details of the CPS are designed by the CPS Collaboration

Meets RadCon Radiation Requirements

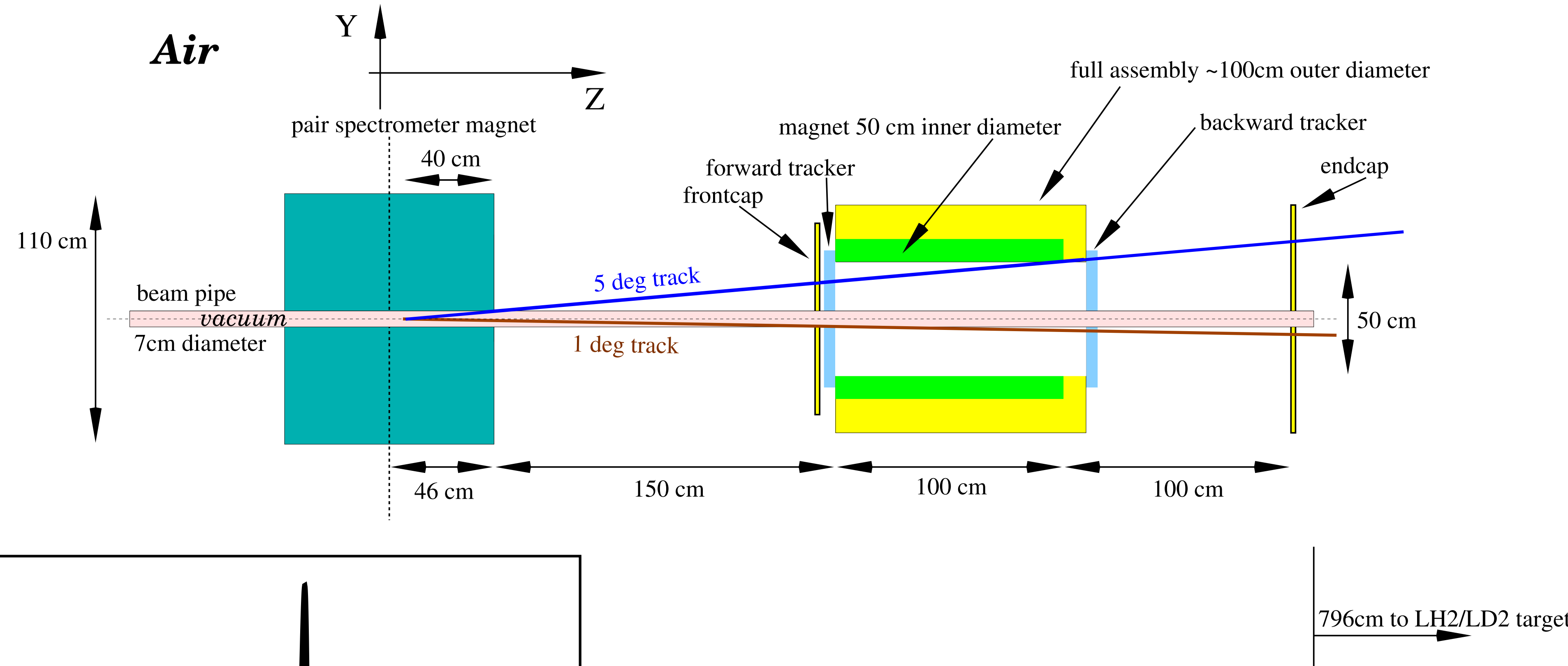
Be Target Assembly: Conceptual Design

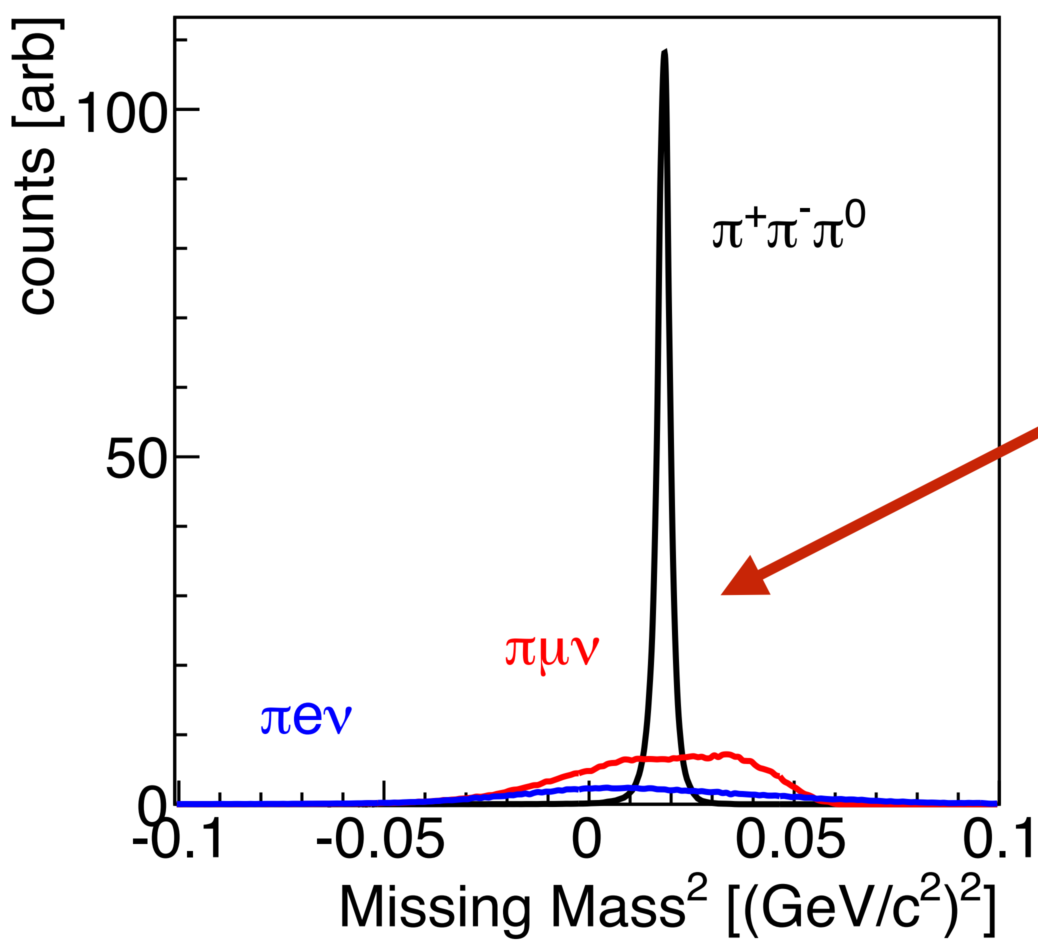


-Meets RadCon Radiation Requirements

-Conceptual Design Endorsed by Hall-D Engineering Staff

Flux Monitor



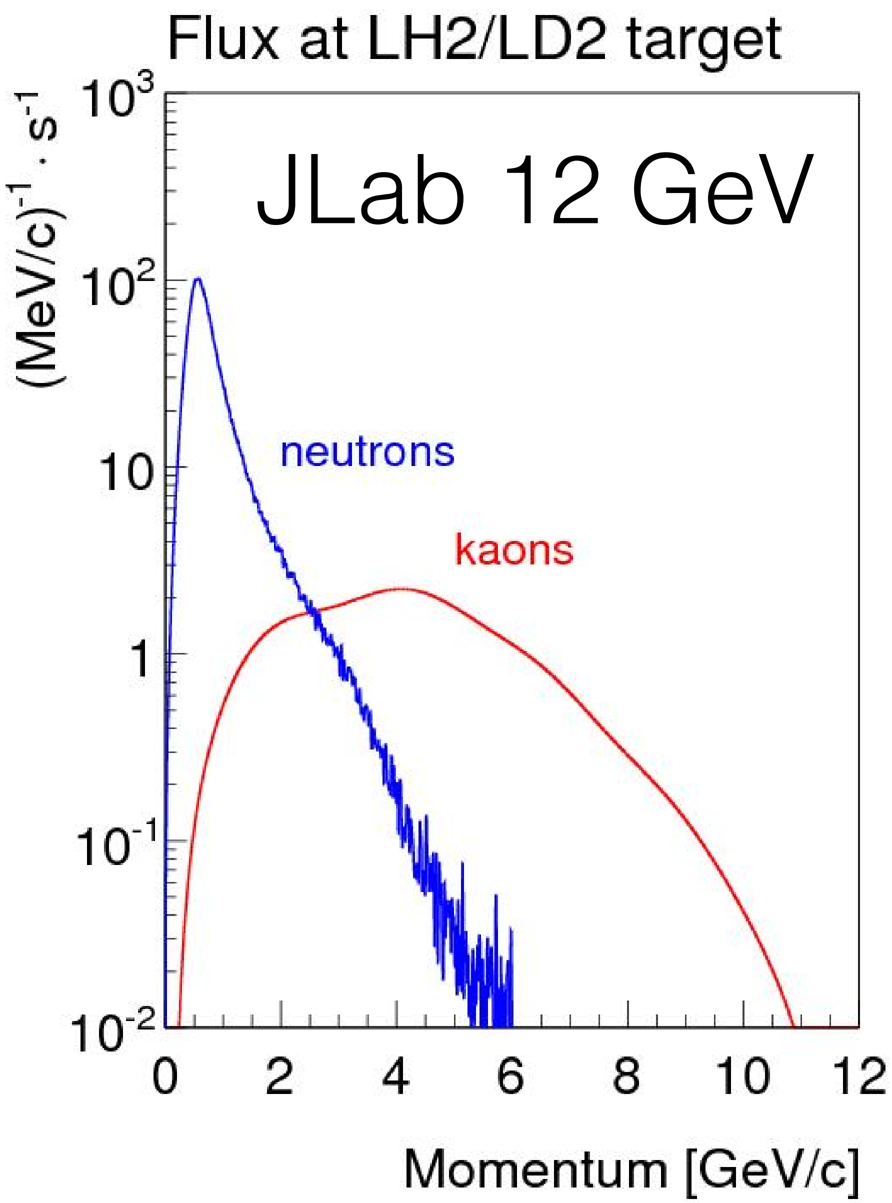


Reconstructed K_L mass

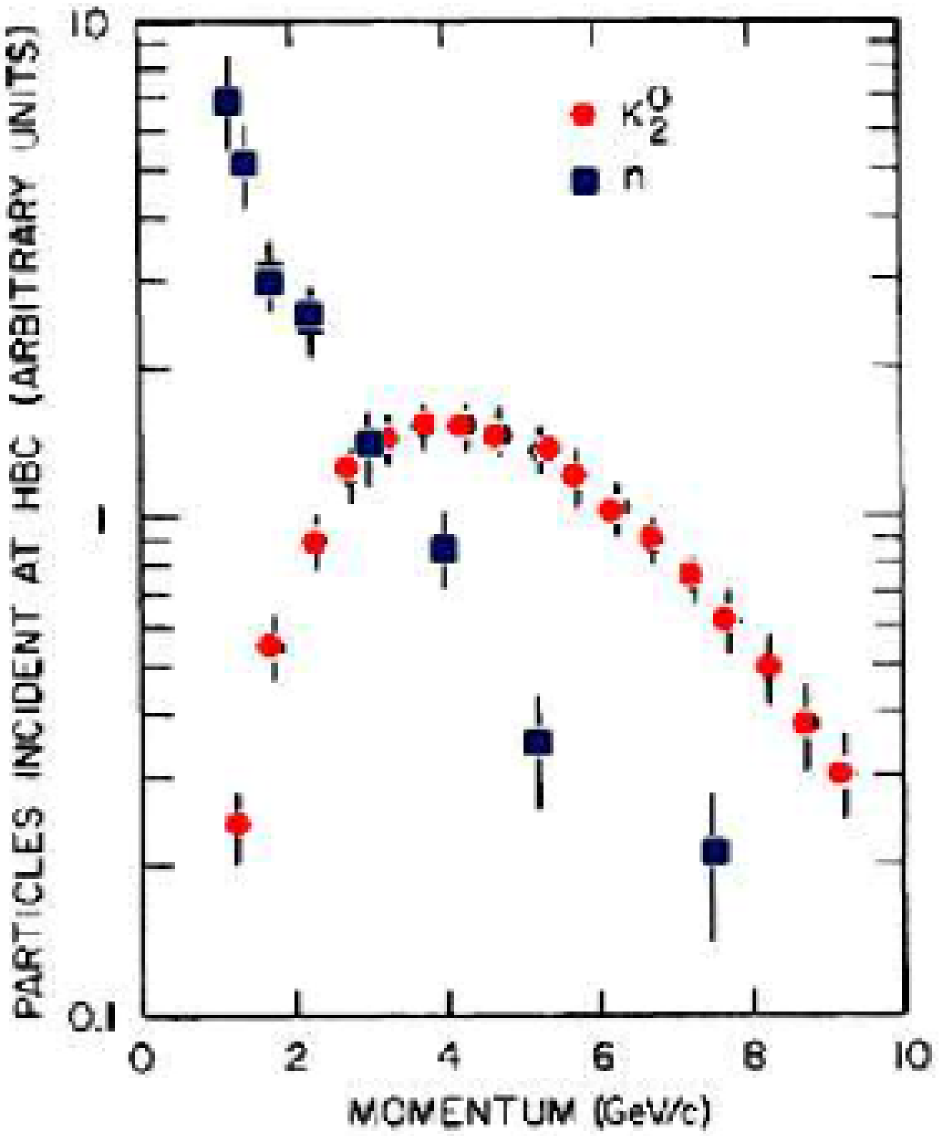
Flux measurement stat. err. <1%

Estimated syst. err. ~5%

K_L Beam Flux

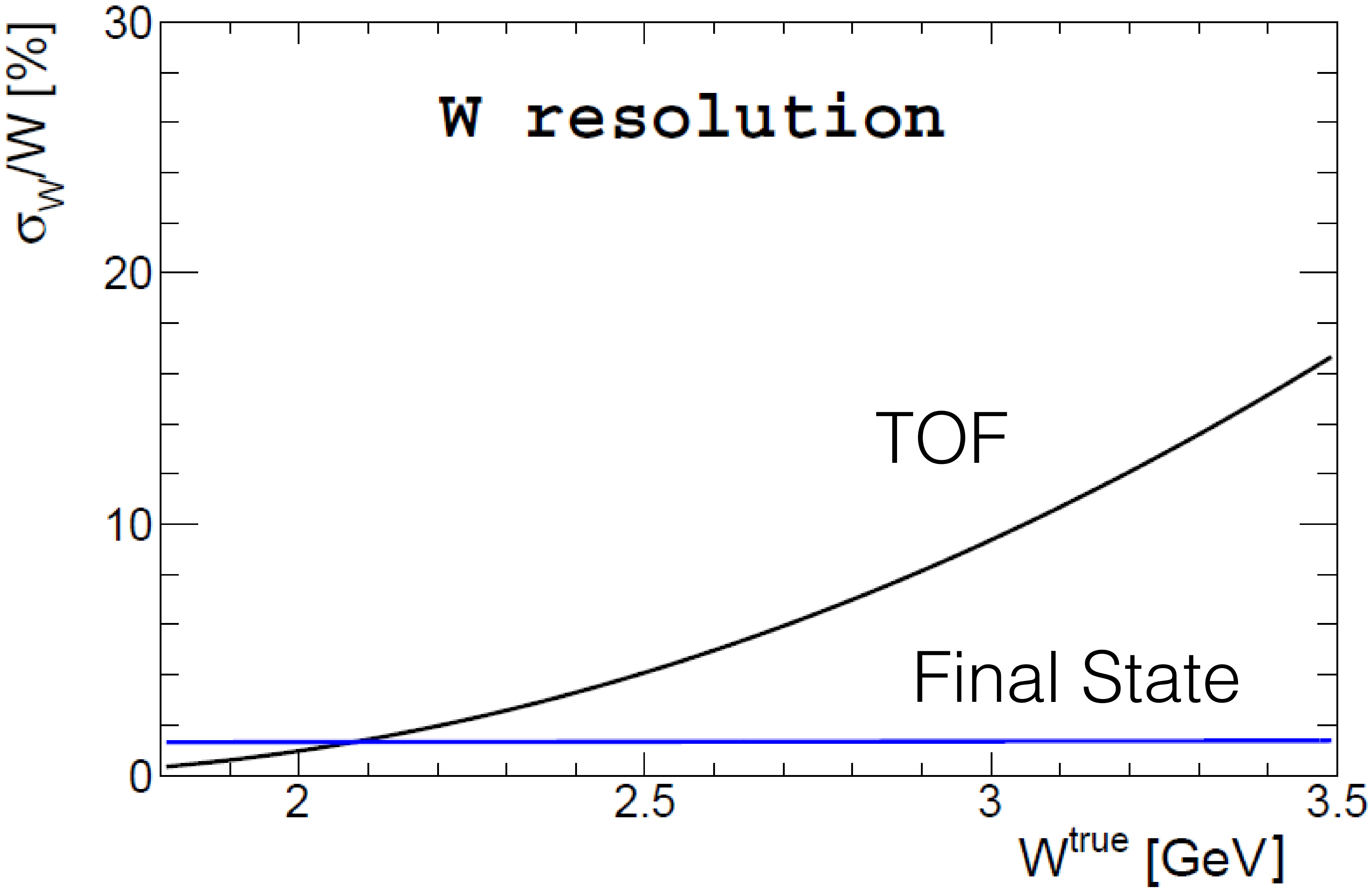


SLAC 16 GeV



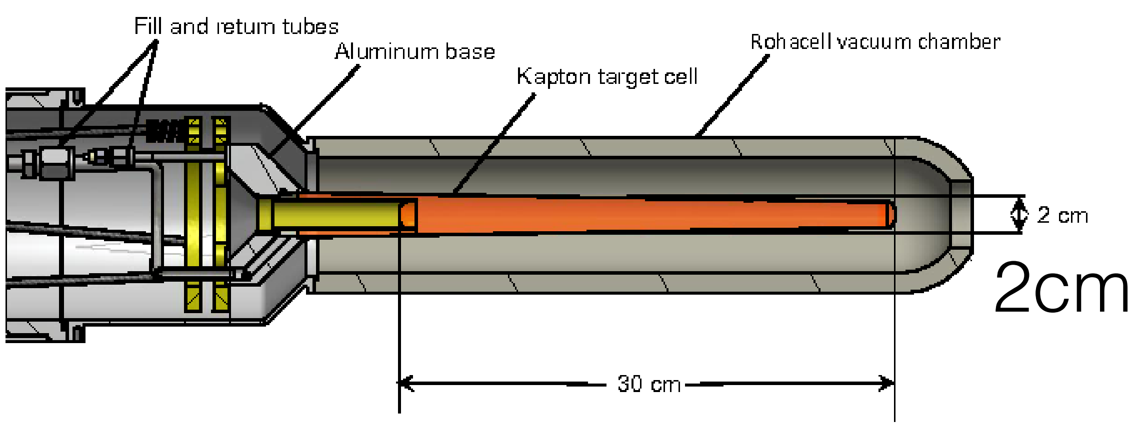
$$N(K_L)/sec \sim 10^4$$

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


W resolution
TOF
Final State
σ_W/W [%]
W^{true} [GeV]
30
20
10
0
2
2.5
3
3.5

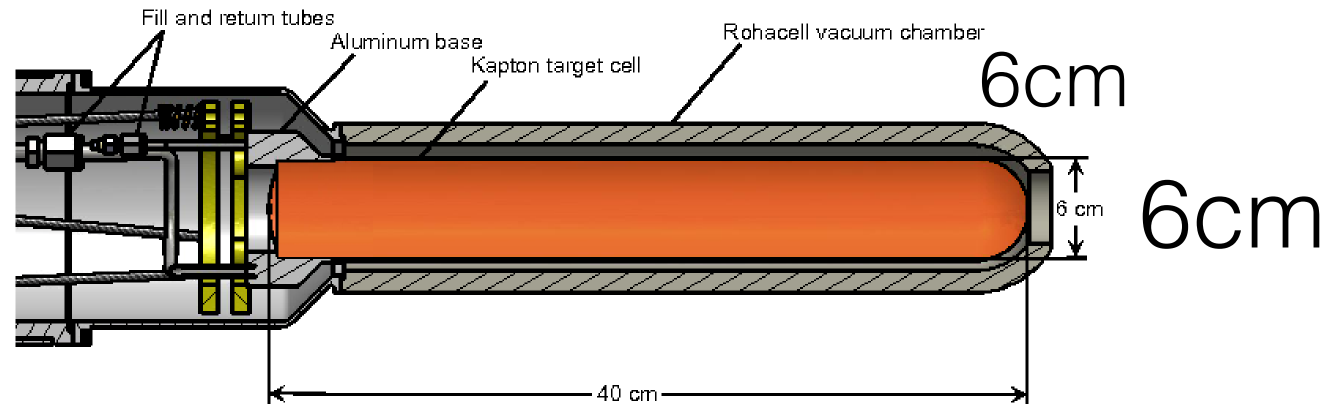
LH_2/LD_2 Cryogenic Target for Neutral Kaon Beam at Hall D

The GlueX liquid hydrogen target.



30cm

Current

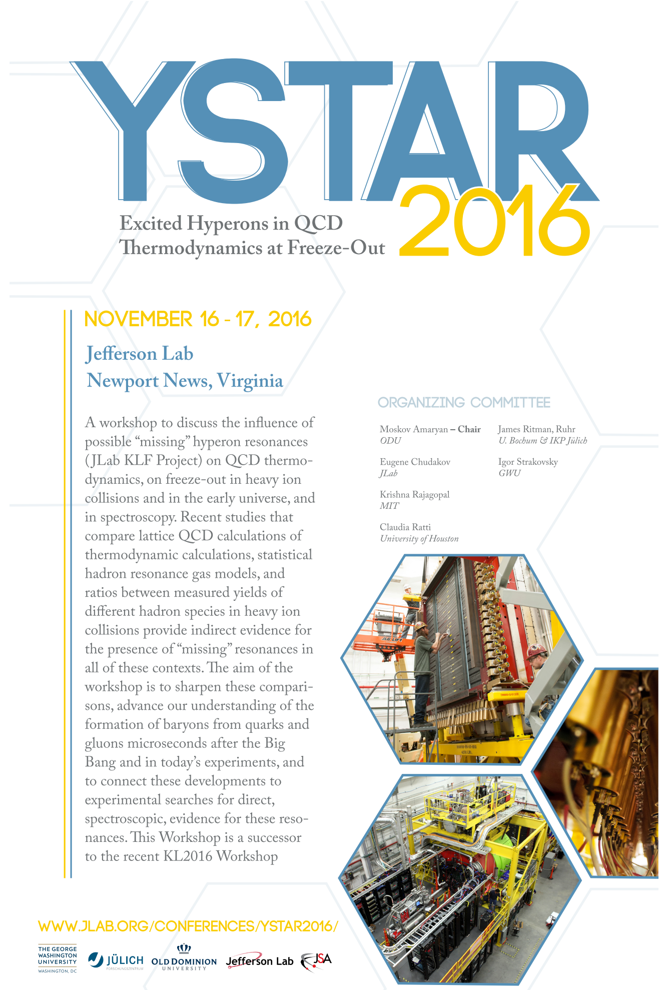


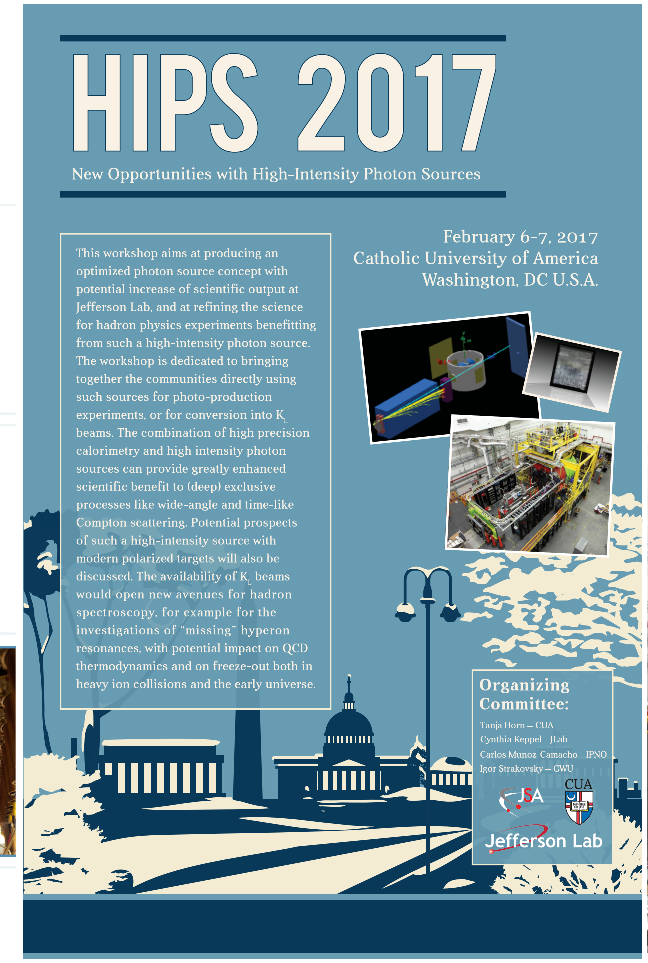
40cm

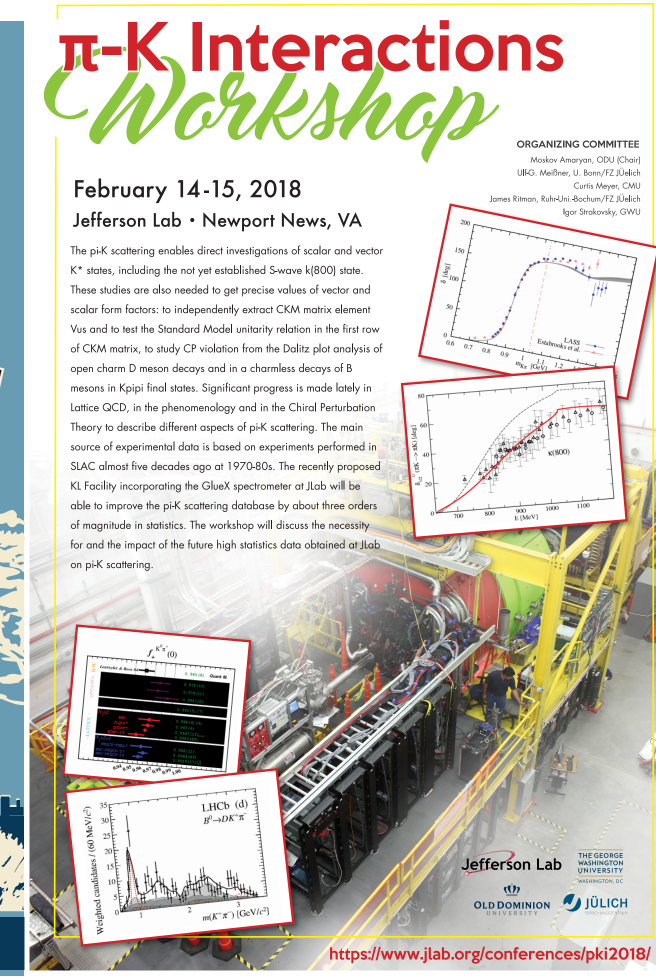
Proposed & Feasible

Longer and ticker target is needed to enhance production rate

Conceptual design has been endorsed by the JLAB target group







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

SUMMARY

- -Proposed KL Facility has a unique capability to improve existing world database up to three orders of magnitude
- -In Hyperon spectrsocopy
  PWA will allow to unravel and measure pole positions and widths of dozens of new excited hyperon states
- -In Strange Meson Spectroscopy
  PWA will allow to measure excited K* states including scalar K*(700) states
- To accomplish physics program
  100 days per LH2 and LD2 is required
- All components of KL Facility considered are feasible

-With total cost of the project below $10M

Thank you !

Date: June 14, 2019

Proposal for JLab PAC47

Strange Hadron Spectroscopy with Secondary K_L Beam in Hall D

Experimental Support:

S. Adhikari[35], M. J. Amaryan (Contact Person, Spokesperson)[35], A. Austregesilo[39], M. Baalouch[42], M. Bashkanov (Spokesperson)[57], V. Baturin[35], V. V. Berdnikov[52,32], T. Black[55], W. Boeglin[30], W. J. Briscoe[53], V. D. Burkert[33], E. Chudakov[33], P. L. Cole[3], O. Cortes-Becerra[53], V. Crede[45], D. Day[12], P. Degtyarenko[33], S. Dobbs (Spokesperson)[45], G. Dodge[35], A. G. Dolgolenko[31], H. Egiyan[33], P. Eugenio[45], S. Fegan[51], A. Filippi[49], S. Furletov[33], L. Gan[55], A. Gasparyan[20], G. Gavalian[33], D. I. Glazier[19], V. S. Goryachev[31], L. Guo[30], A. Hayrapetyan[18], G. M. Huber[50], A. Hurley[54], C. E. Hyde[35], I. Illari[51], D. G. Ireland[19], K. Joo[44], V. Kakoyan[56], G. Kalicy[52], M. Kamel[30], C. D. Keith[33], C. W. Kim[51], G. Krafft[33], S. Kuhn[35], S. Kuleshov[43], A. B. Laptev[28], I. Larin[1], D. Lawrence[33], D. I. Lersch[45], W. Li[54], V. E. Lyubovitskij[49,46,47,51], D. Mack[33], D. M. Manley[27], H. Marukyan[56], V. Matveev[31], M. McCaughan[33], B. McKinnon[19], C. A. Meyer[39], F. Nerling[16,14], G. Niculescu[22], A. Ostrovidov[45], Z. Papandreou[40], K. Park[33], E. Pasyuk[33], L. Pentchev[33], W. Phelps[53], J. W. Price[11], J. Reinhold[30], J. Ritman (Spokesperson)[7,25], D. Romanov[32], C. Salgado[34], T. Satogata[33], A. M. Schertz[54], S. Schadmand[25], D. I. Sober[52], A. Somov[33], S. Somov[32], J. R. Stevens (Spokesperson)[54], I. I. Strakovsky (Spokesperson)[53], V. Tarasov[31], S. Taylor[33], A. Thiel[19], D. Watts[57], L. Weinstein[35], D. Werthmüller[57], T. Whitlatch[33], N. Wickramaarachchi[35], B. Wojtsekhowski[33], N. Zachariou[57], J. Zhang[12]

Theoretical Support:

A. V. Anisovich[8,15], A. Bazavov[13], R. Bellwied[24], V. Bernard[38], G. Colangelo[4], A. Cieply[41], M. Döring[53], S. Eidelman[36,37], A. Eskandarian[53], J. Goity[33,21], H. Haberzettl[53], M. Hadžimehmedović[50], R. L. Jaffe[10], B. Z. Kopeliovich[51], H. Leutwyler[4], M. Mai[53], V. Mathieu[29], M. Matveev[15], U.-G. Meißner[8,26], V. Mokeev[33], C. Morningstar[39], B. Moussallam[38], K. Nakayama[2], V. Nikonov[8,15], Y. Oh[59], R. Omerović[50], H. Osmanović[50], J. R. Pelaez[29], A. Pilloni[33], D. Richards[33], D.-O. Riska[23], A. Rodas[29], J. Ruiz de Elvira[4], H-Y. Ryu[9], E. Santopinto[17], A. V. Sarantsev[8,15], J. Stahov[50], A. Švarc[58], A. Szczepaniak[6,33], R. L. Workman[50], B. Zou[5],

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