Strange Hadron Spectroscopy with Secondary KL beam in Hall D

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KLF Collaboration Meeting, Feb. 12, 2020 at JLab

Strange Hadron Spectroscopy with Secondary K_L Beam in Hall D

Experimental Support:

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Members of 62 Universities

Outline

Future Prospects with K_L Facility at JLab

- Electron Beam
- Compact Photon Source (Sean Dobbs)
- Be Target and K_L Beam(Igor Strakovsky)
- Flux Monitor (Stuart Fegan)
- LH_2/LD_2 Target Chris Keith)

Strange Baryon Spectroscopy

- Perspectives in Exciting Hyperons(Jose Goity)
- LQCD for Hyperon Spectroscopy (David Richards)

Strange Meson Spectroscopy

- Status of K-pi studies (Shankar Adhikari)

Seminar: Scattering and Form Factors from LQCD

(Colin Morningstar)

DAQ and Trigger

-DAQ for KLF (Sergey Furletov)

-Trigger for KLF (Sergey Furletov)

DIRC Upgrade *(Justin Stevens)*

PAC47 Final Report

Scientific Rating: N/A
Recommendation: C2

Title: "Strange Hadron Spectroscopy with a Secondary K_L Beam in Hall D"

Spokespersons: M. Amaryan (contact), M. Bashkanov, S. Dobbs, J. Ritman, J. Stevens, I. Strakovsky

Motivation: The spectroscopy of strange baryons and mesons, including their fundamental strong interactions, is the focus of this proposal. New and unique data can be obtained with an intense K_L beam aimed at a hydrogen/deuterium target, using the GlueX apparatus to detect final state particles.

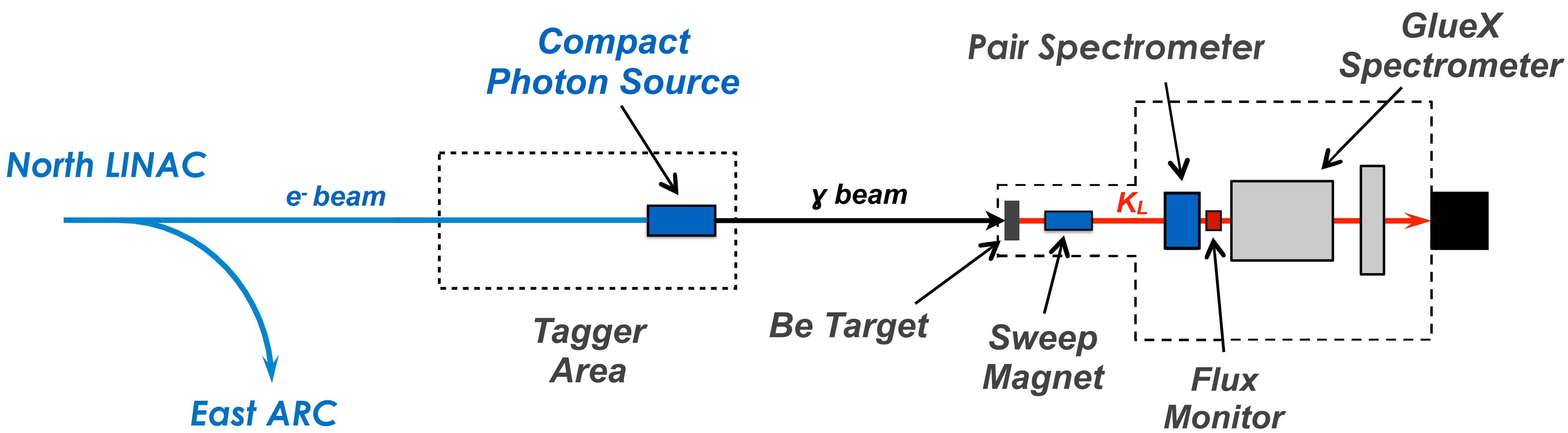
Measurement and Feasibility: The most significant technical aspect of this proposal is the addition of a Compact Photon Source (CPS) in the beamline leading into Hall D, which will have significant attendant cost and will impose an estimated six months changeover time for alternate running of GlueX. It is also important to be sure that GlueX can handle the background rates from neutrons and other beam-induced contaminants. It seems quite feasible that the GlueX detector can manage to detect the final state particles with enough particle discrimination to meet the spectroscopy needs.

Issues: Several points of discussion concerned the PAC. A) the missing mass technique to replace the direct proton detection at very low values of $|t|$ was only presented in the open session and the details of the underlying simulations should be clarified; B) a realistic simulation including beam backgrounds is to be presented with details to be spelled out and documented thoroughly; C) A realistic project management plan needs to be developed to realize the experiment; D) The analysis and extraction of key physics parameters requires theory guidance, which is now included within the group of proposing authors and makes use of JPAC.

This facility will add a new physics reach to JLab, and the PAC is looking forward to see the idea being materialized, in conjunction with the plans for Hall D as spelled out in the white paper provided to us.

Summary: The collaboration should return to the PAC with a well documented proposal. Simulations addressing backgrounds and the low $|t|$ region are necessary. Also, a well-formed plan is needed to build the beamline and prepare for data taking with GlueX.

Hall-D beamline and GlueX Setup



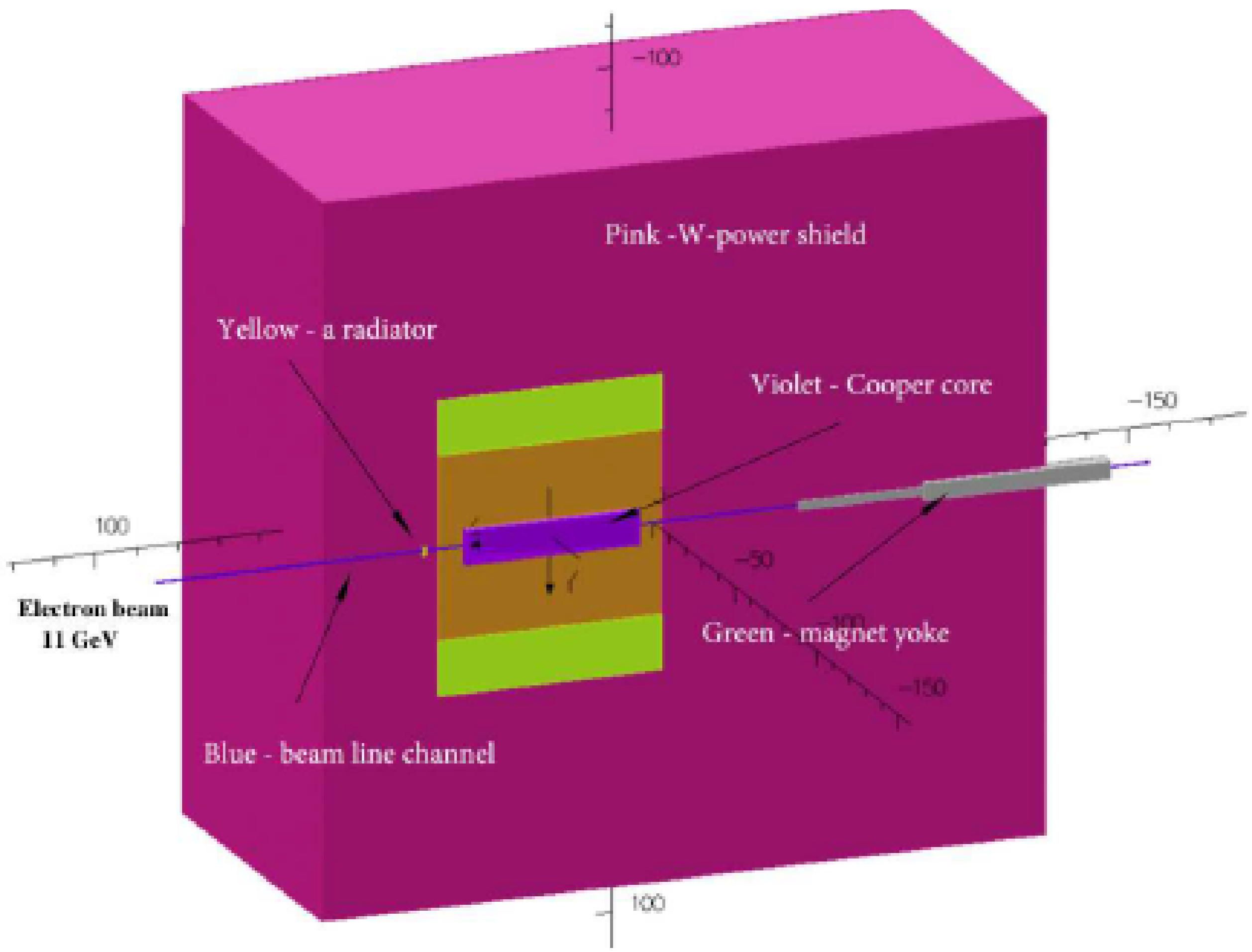
Electron Beam Parameters

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

Bunch spacing $64\ ns$

Confirmed by accelerator experts

Compact Photon Source

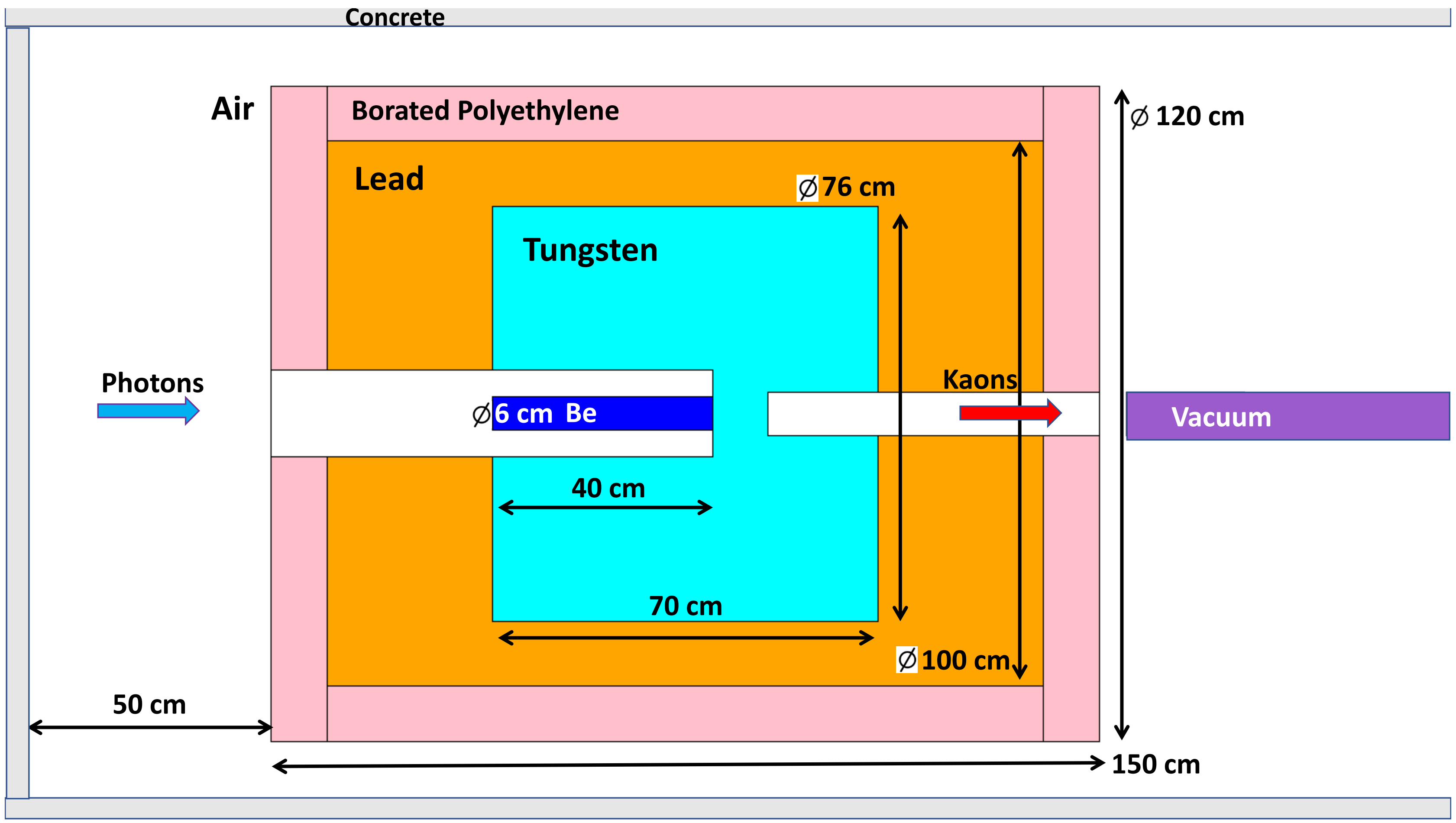


Conceptual design is completed for Halls A&C

The details of the CPS are designed by the CPS Collaboration

Meets RadCon Radiation Requirements

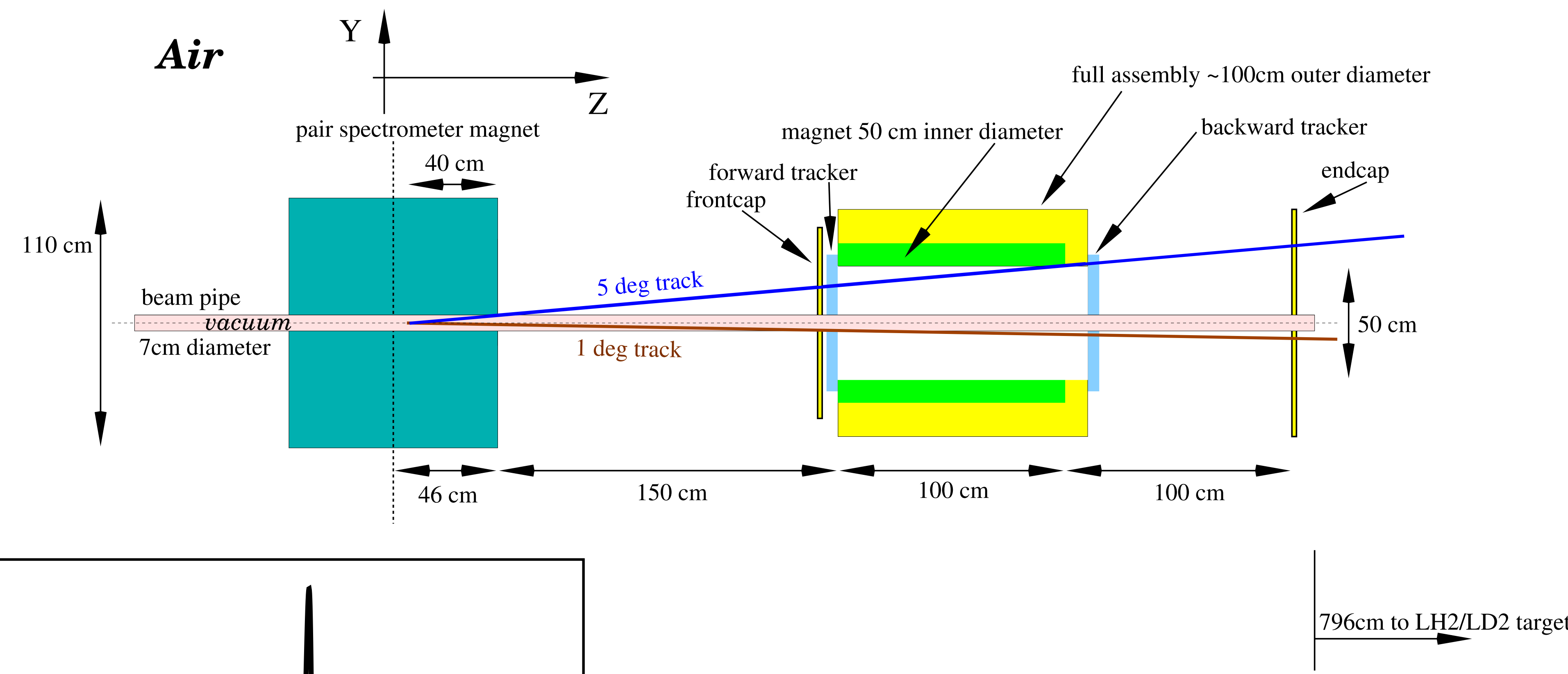
Be Target Assembly: Conceptual Design

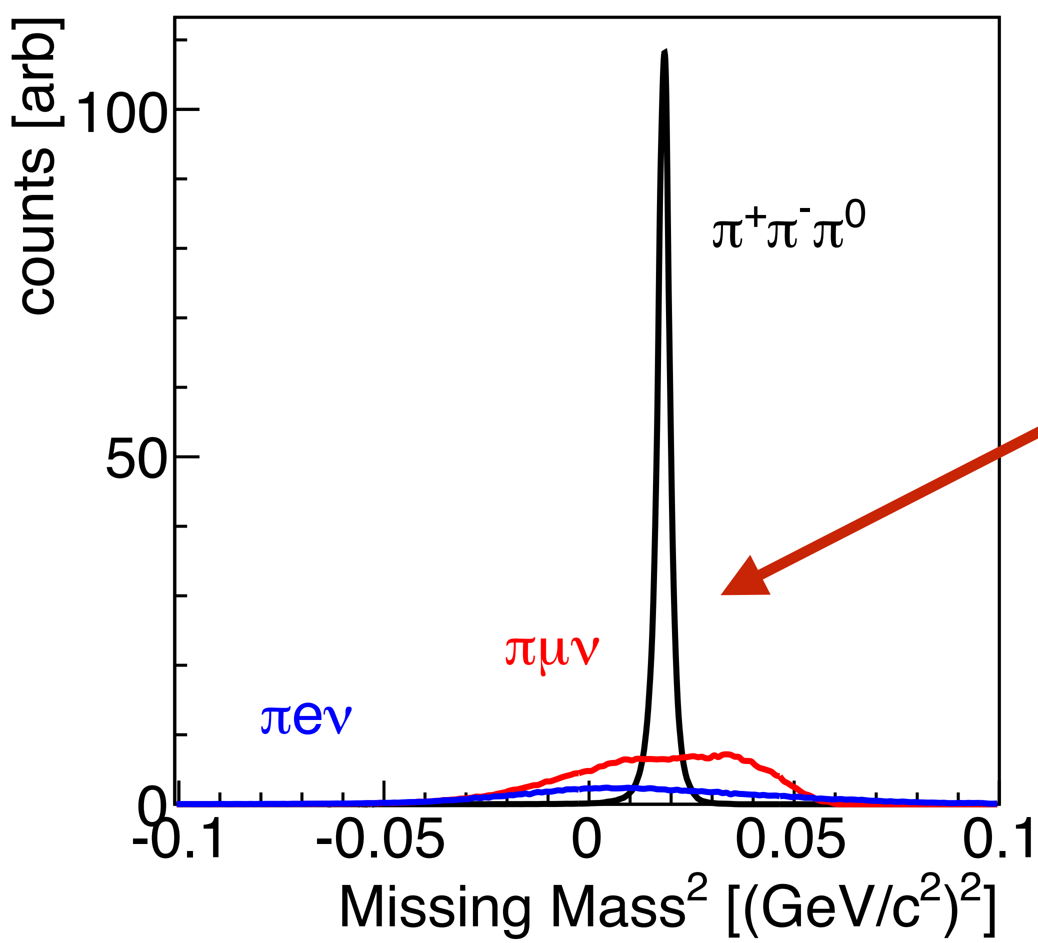


-Meets RadCon Radiation Requirements

-Conceptual Design Endorsed by Hall-D Engineering Staff

Flux Monitor





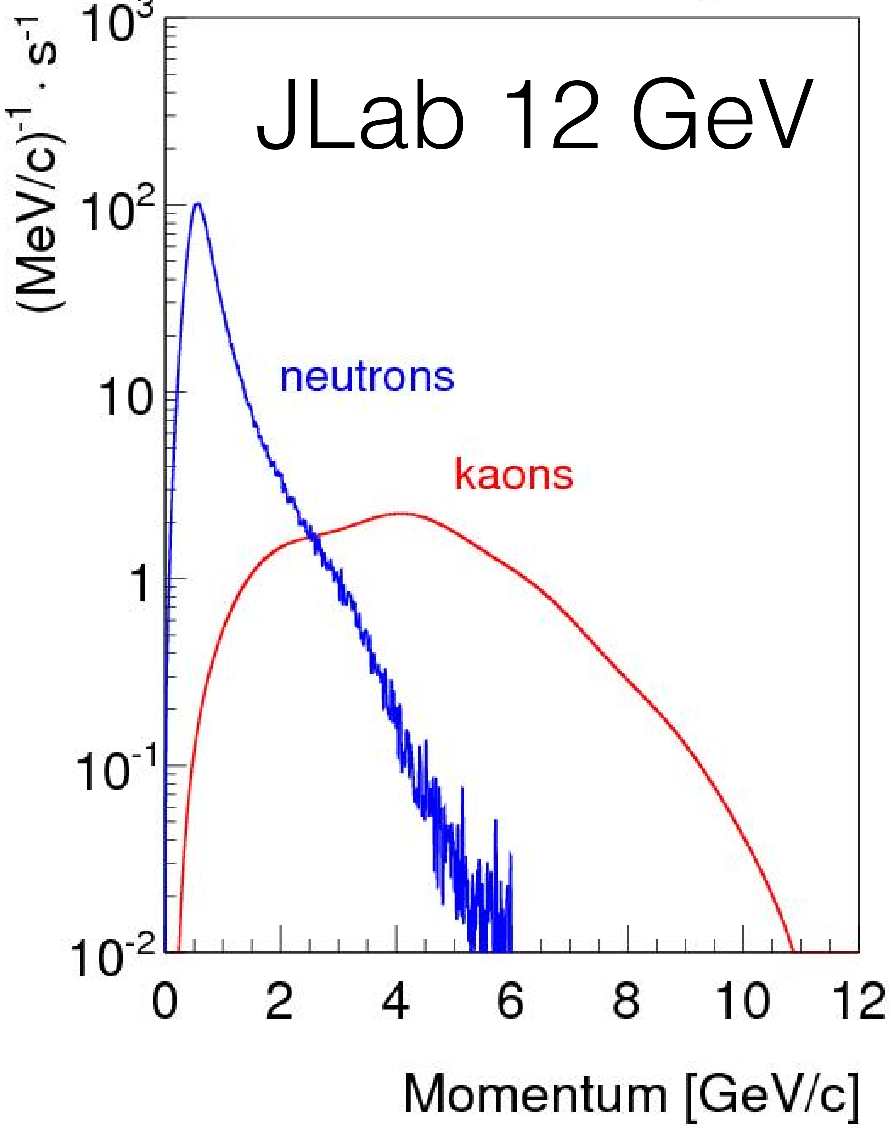
Reconstructed K_L

via missing (π^0)

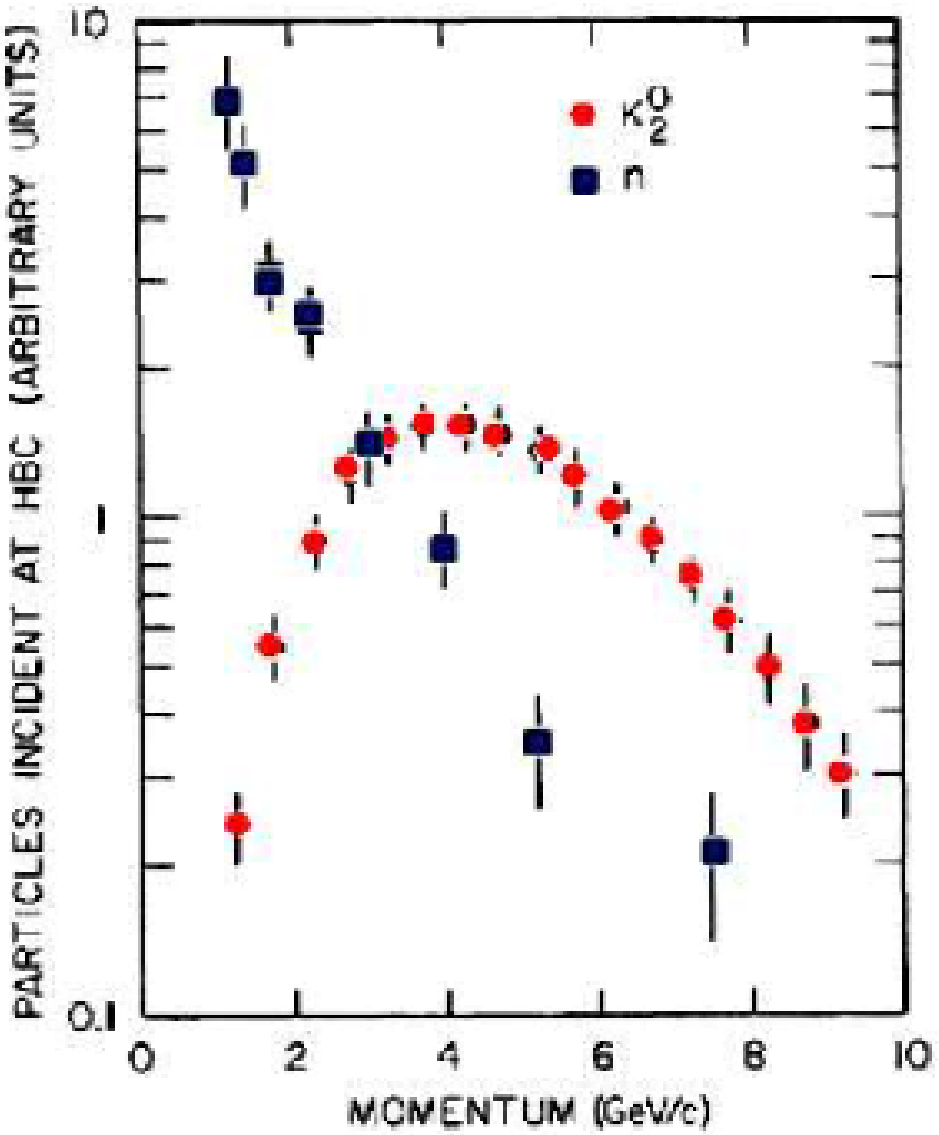
Flux measurement stat. err. <1%

Estimated syst. err. ~5%

K_L Beam Flux



SLAC 16 GeV

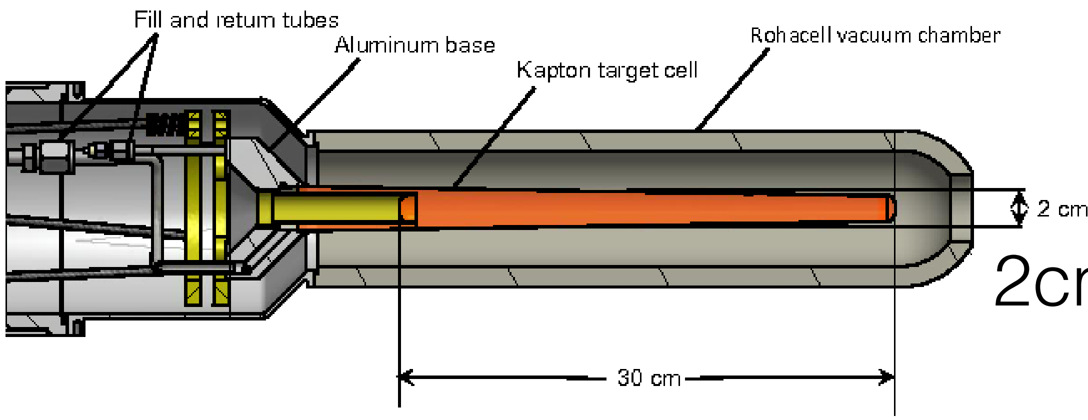


$$N(K_L)/sec \sim 10^4$$

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

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

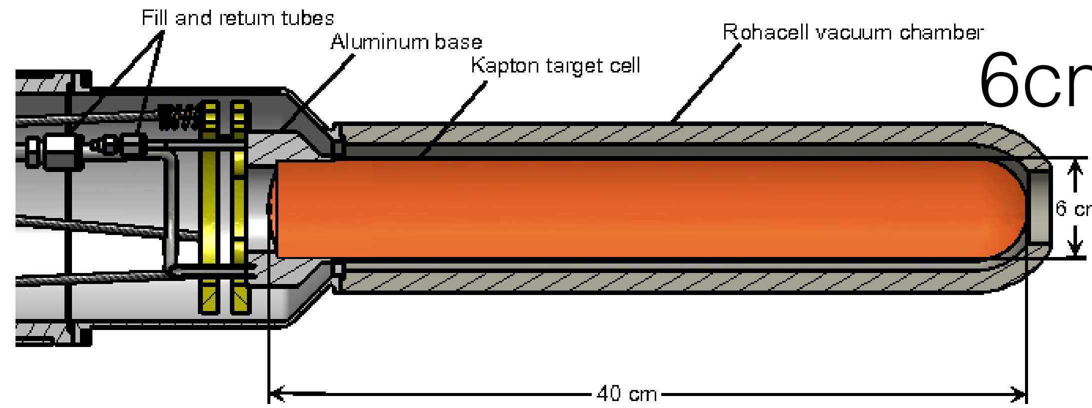
The GlueX liquid hydrogen target.



2cm

30cm

Current



6cm

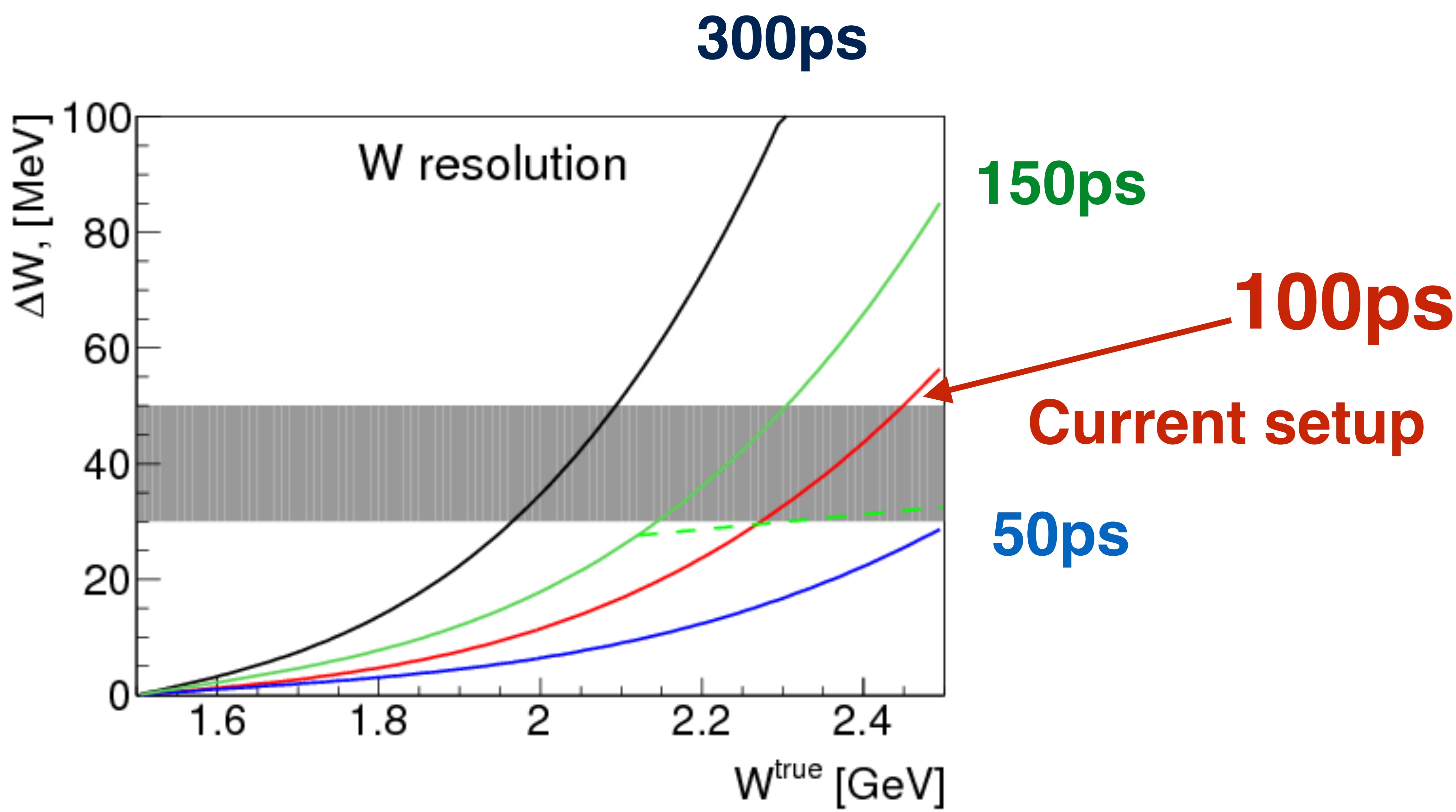
6cm

40cm

Proposed & Feasible

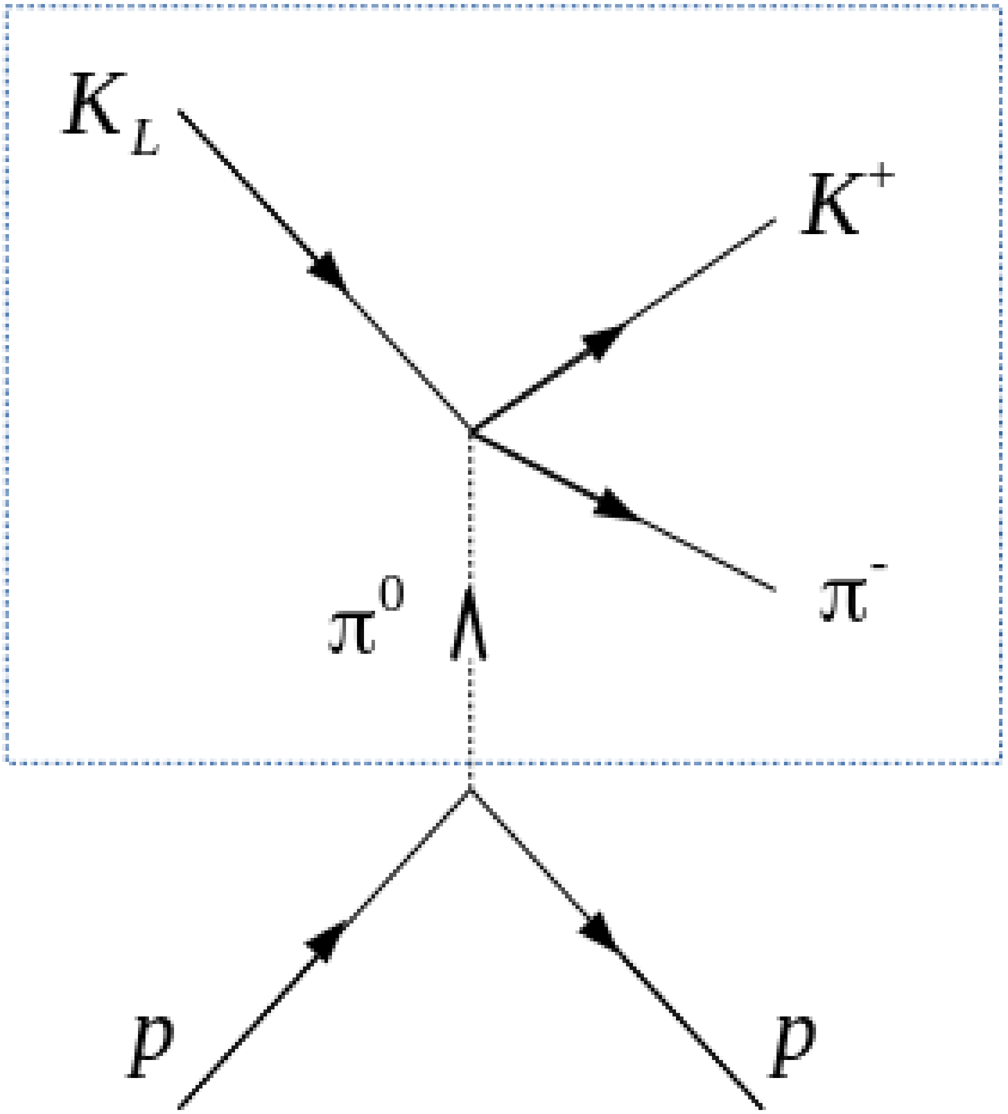
Longer and ticker target is needed to enhance production rate

Conceptual design has been endorsed by the JLAB target group


300ps
150ps
100ps
Current setup
50ps
W resolution
ΔW, [MeV]
100
80
60
40
20
0
1.6
1.8
2
2.2
2.4
W^true [GeV]

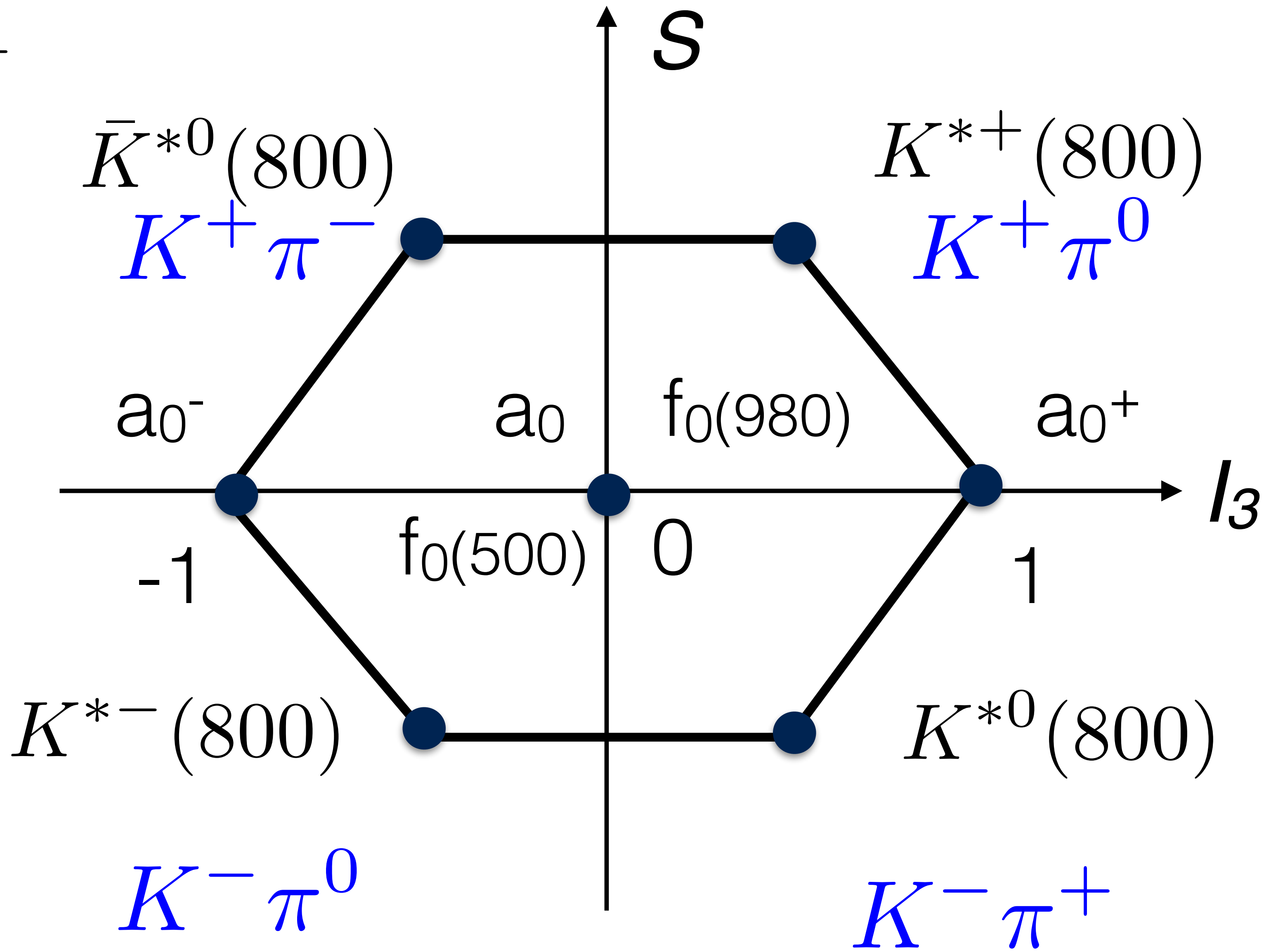
Strange Meson Spectroscopy

$K\pi$ **Scattering**



Scalar Meson Nonet

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



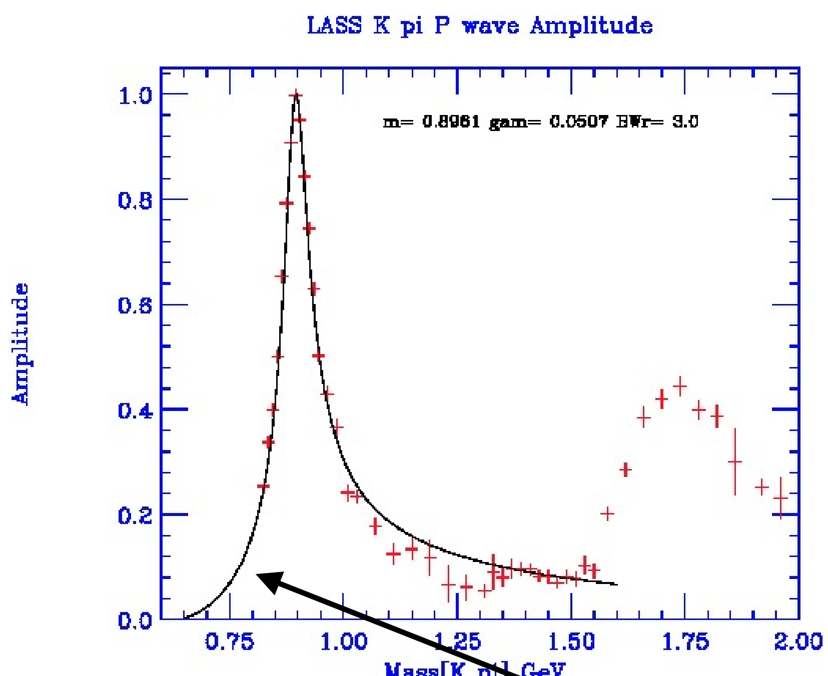
Four states called κ

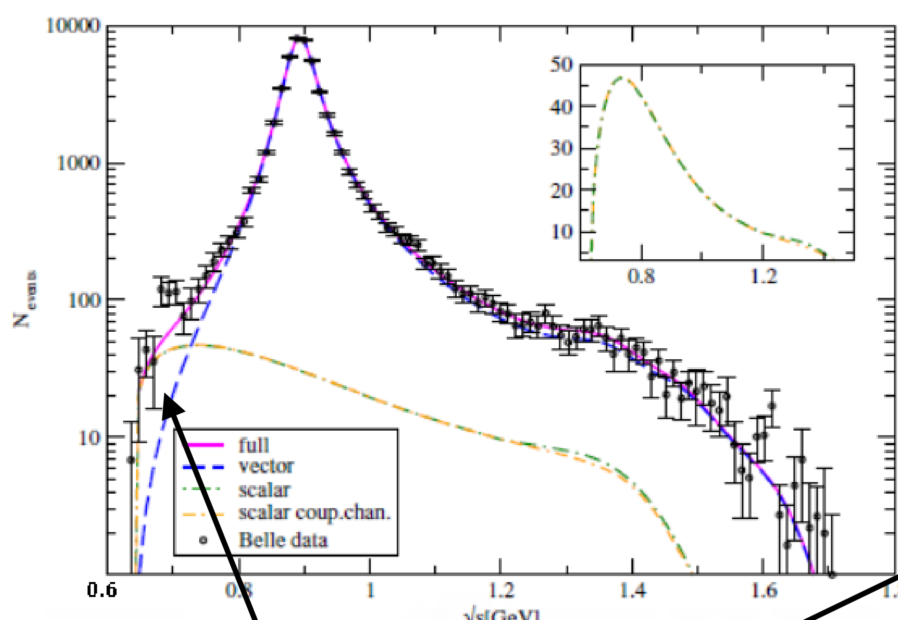
still need further confirmation(PDG)

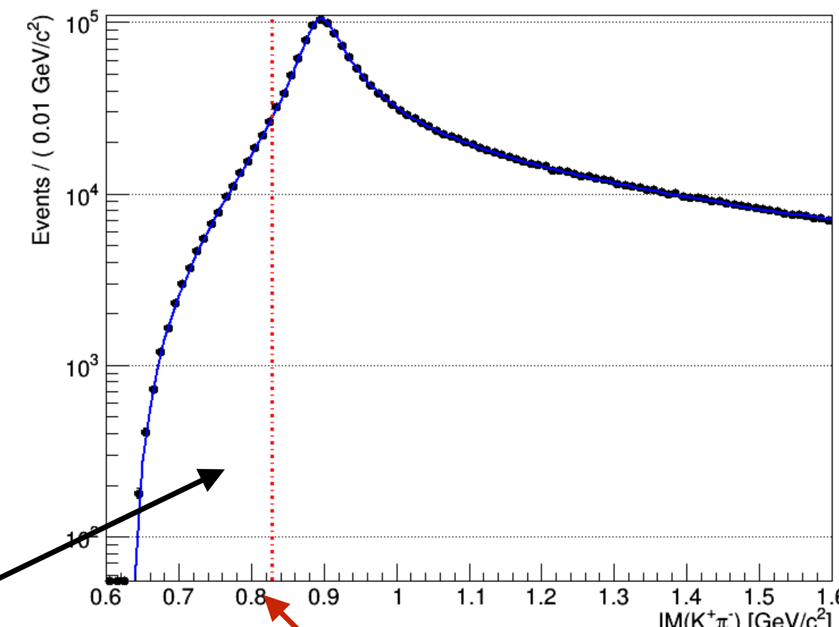
We can measure all of them

Proposed Measurements

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





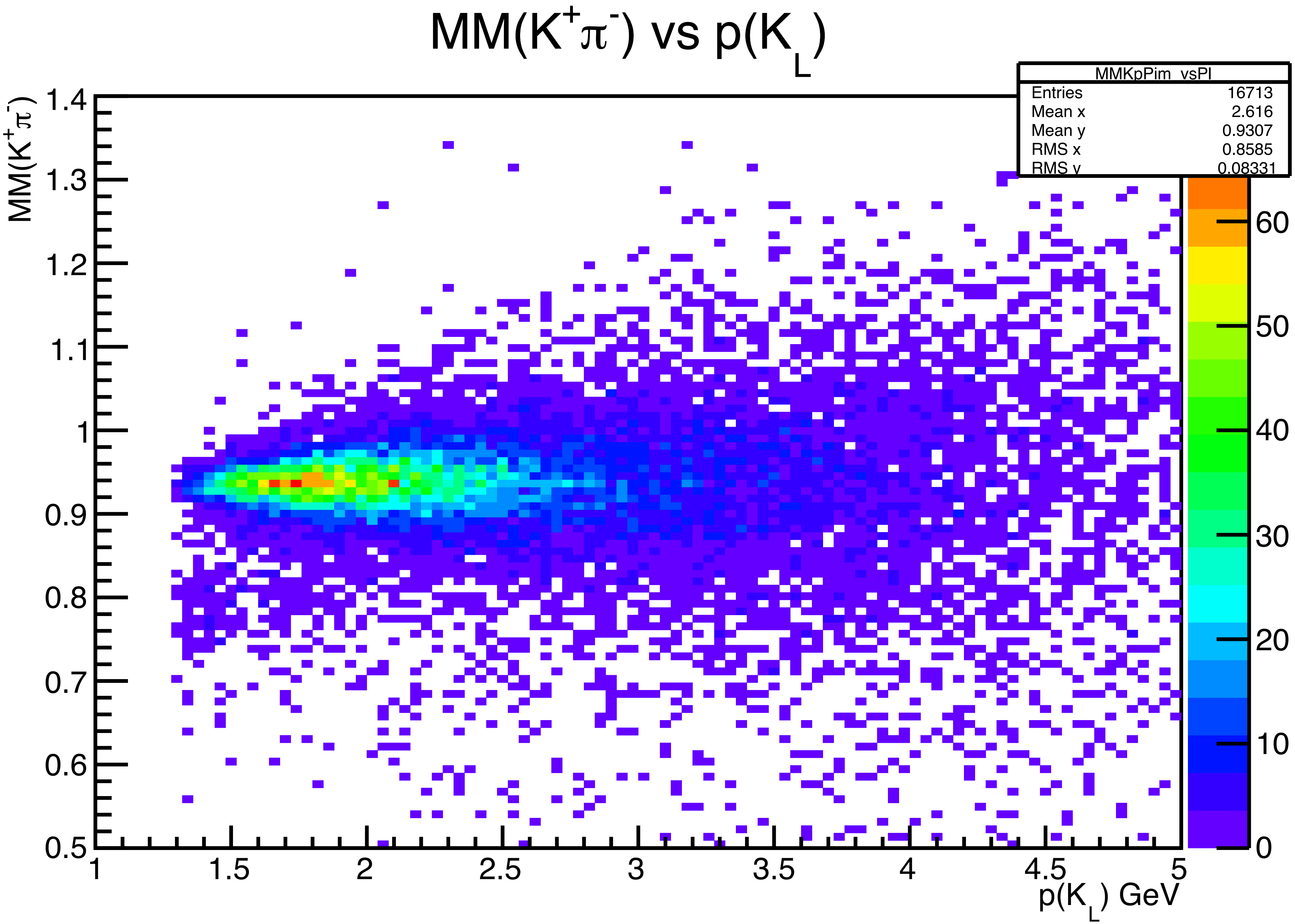


$\mathbf{M(K\pi)(GeV)}$ $\mathbf{M(K\pi)(GeV)}$ $\mathbf{M(K\pi)(GeV)}$

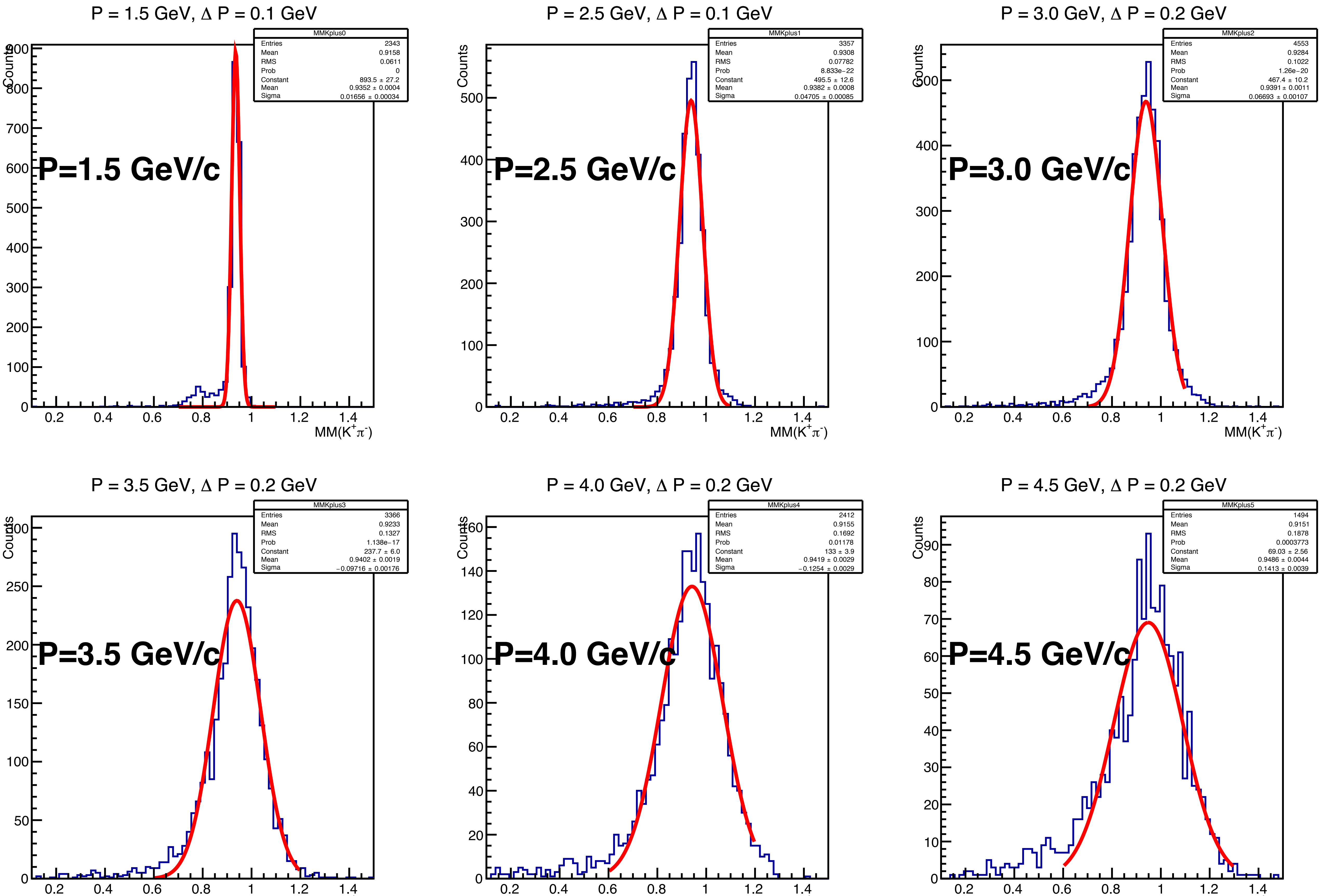
region of $\kappa(800)$

SLAC Lower limit

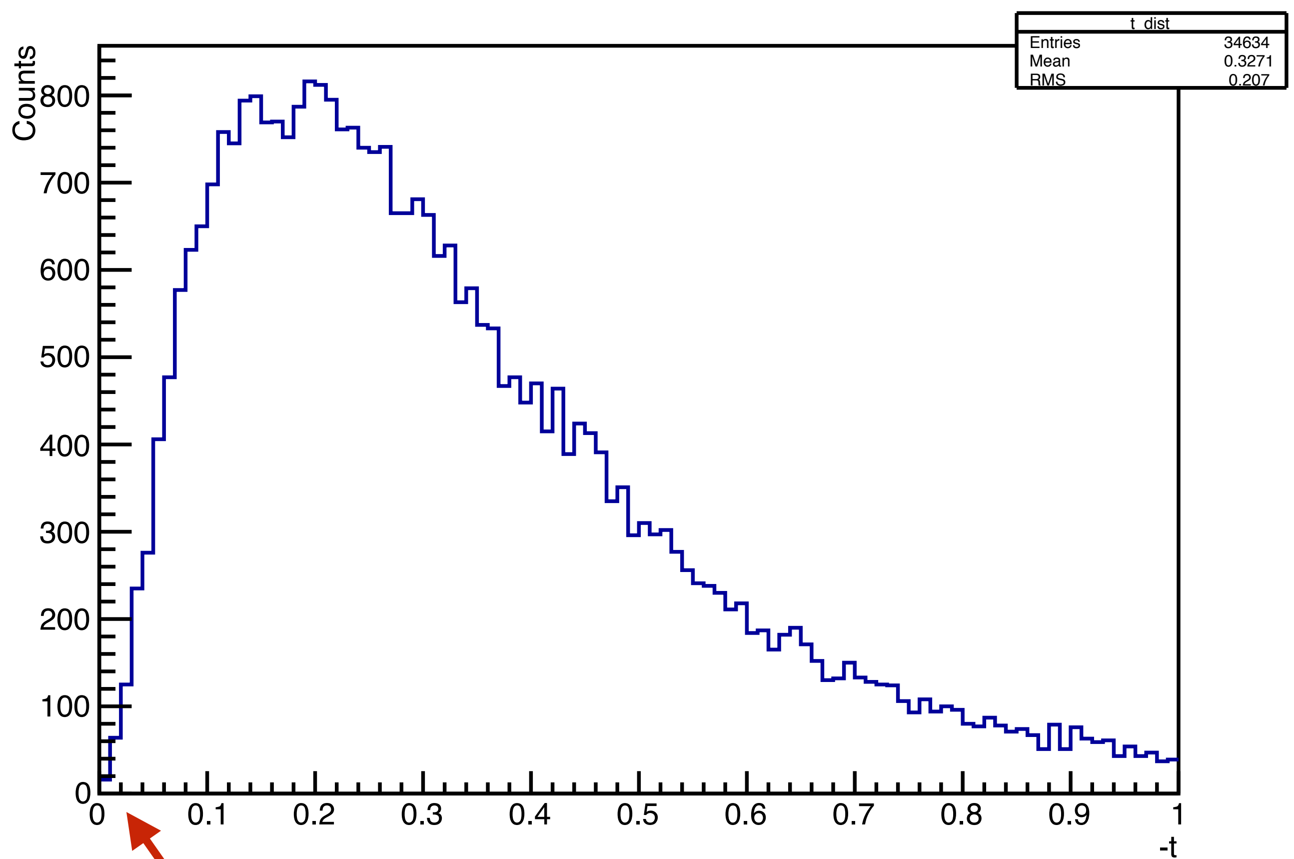
Missing Mass of $K^+\pi^-$ system



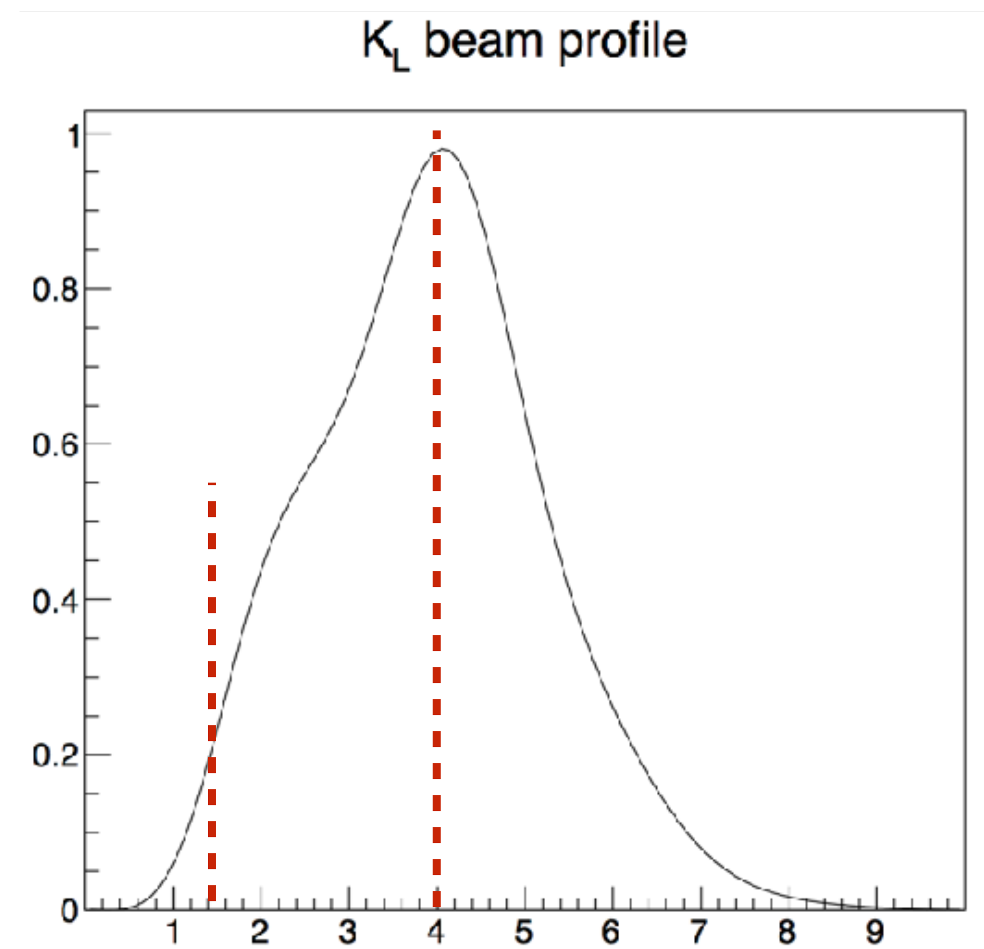
Missing Mass $MM(K^+\pi^-)GeV$



Proton reconstructed via missing mass



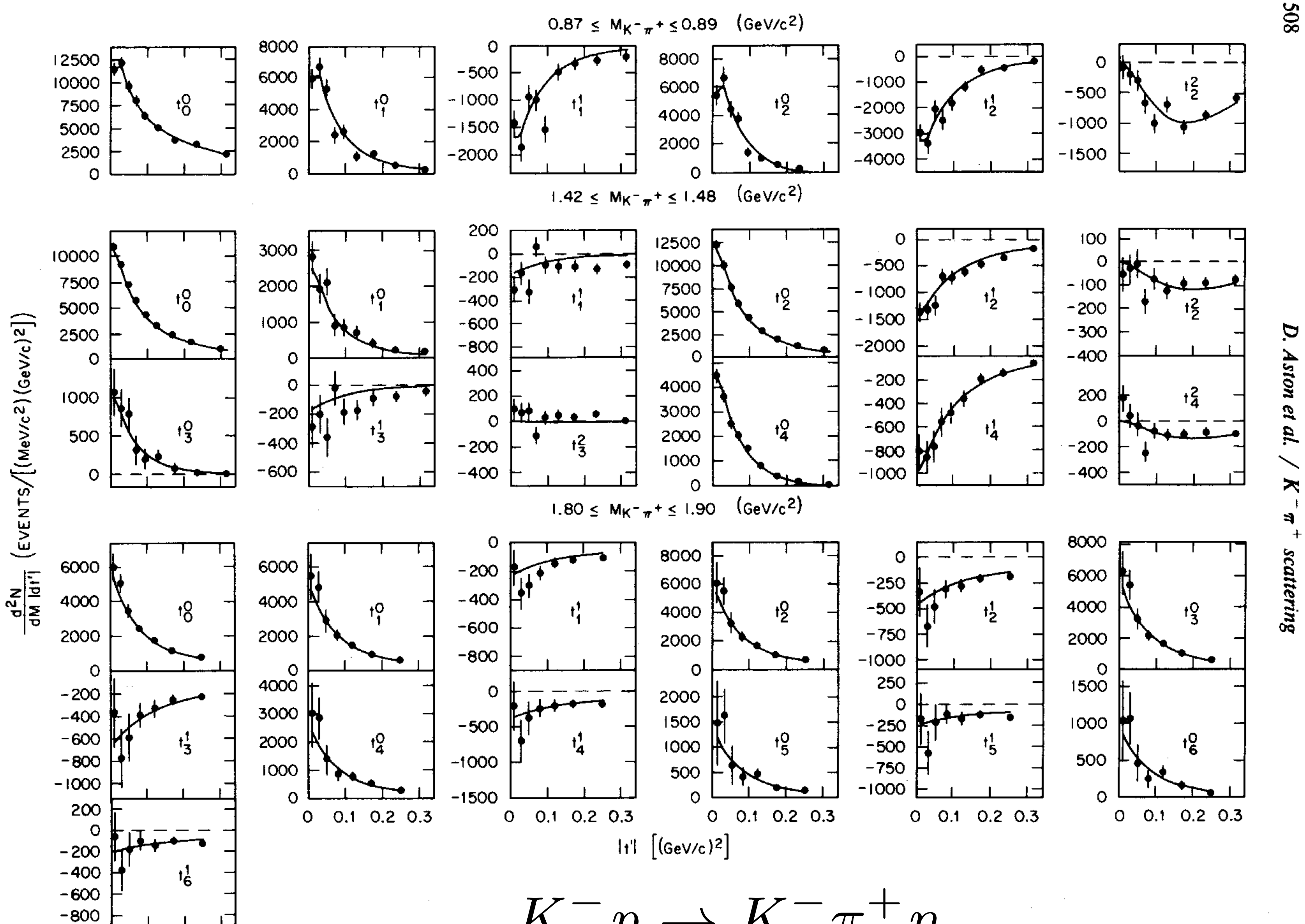
$-t, (GeV/c)^2$



$P(K_L), GeV/c$

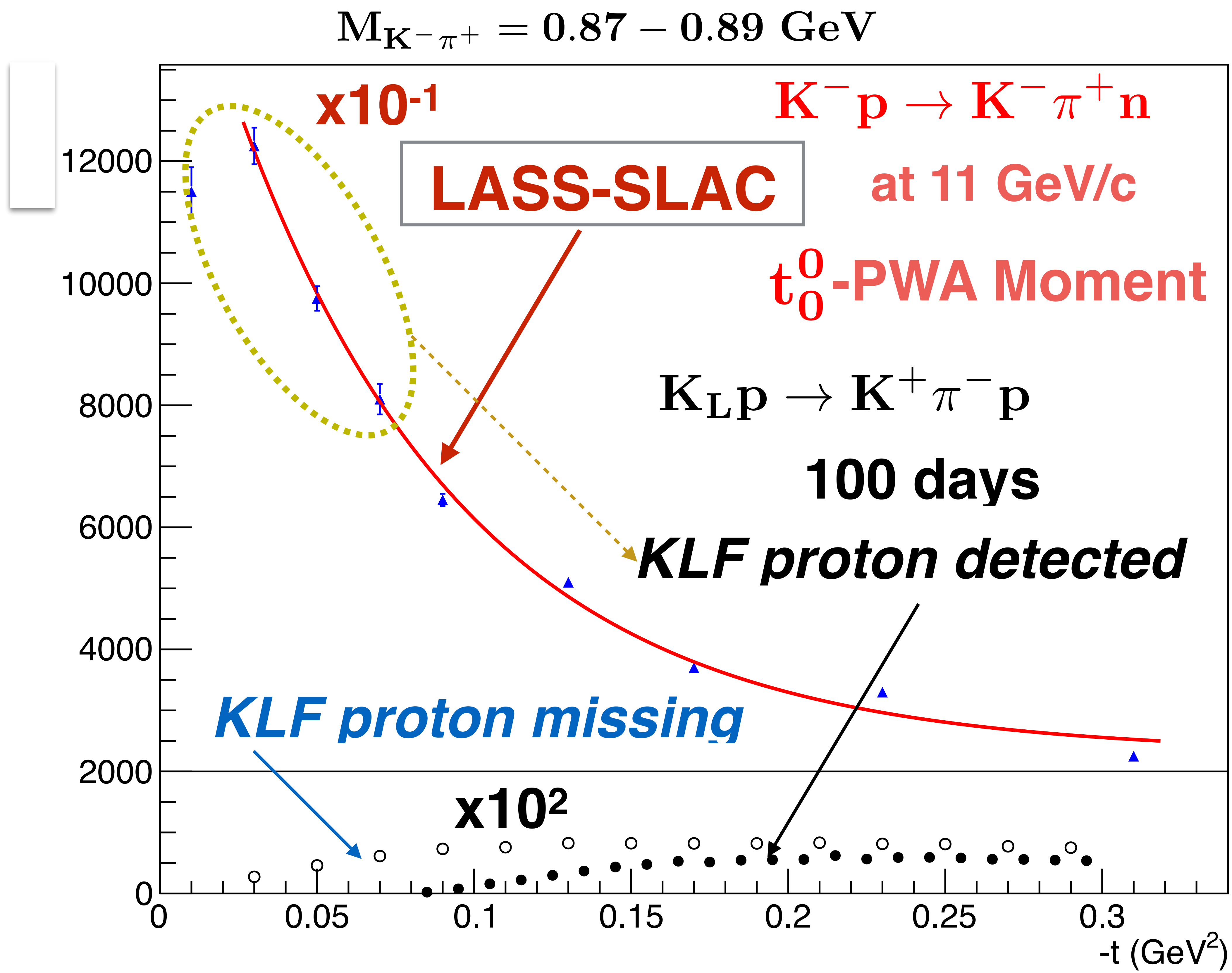
Down to pion pole

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.

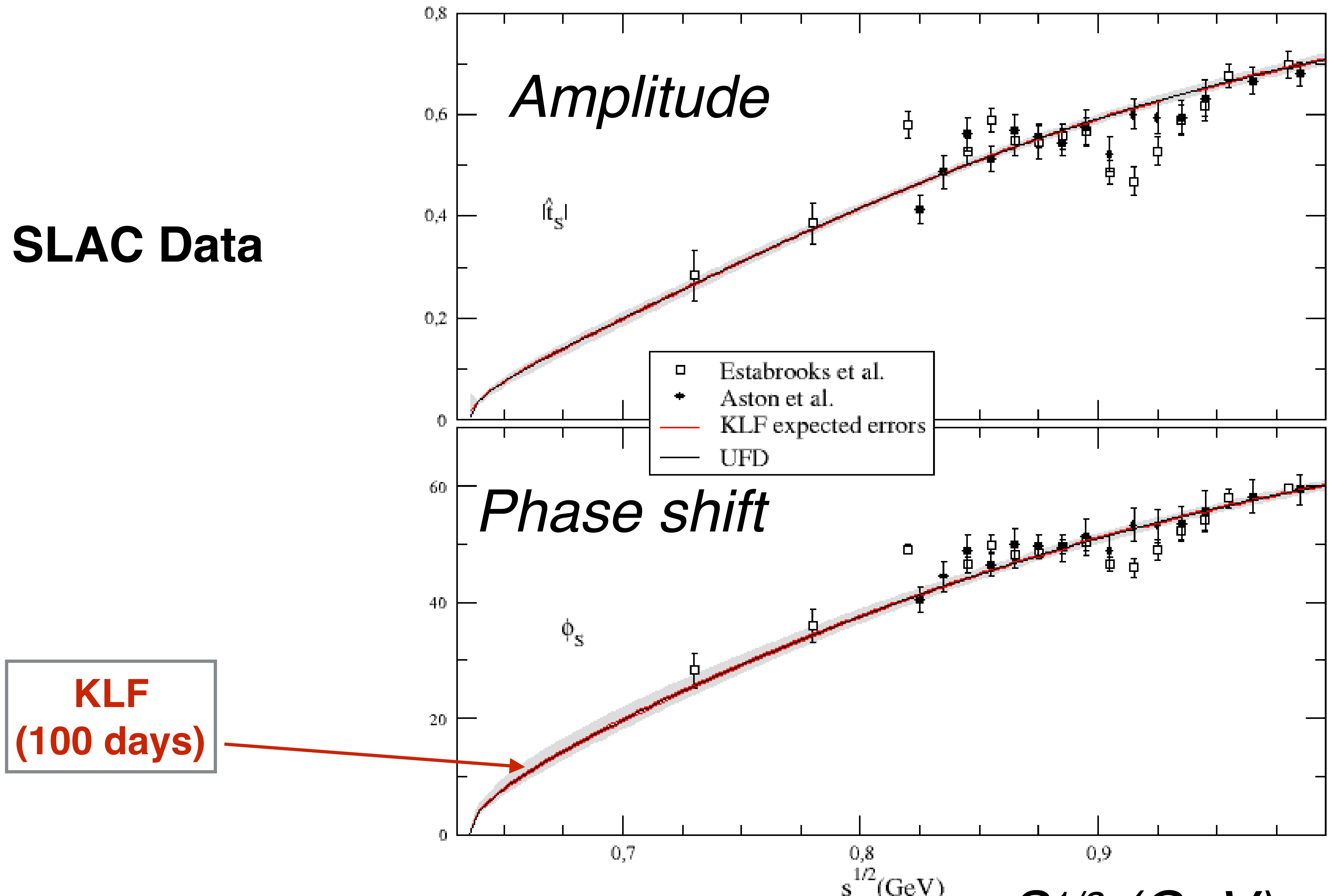


Two orders of magnitude higher statistics with KLF plus down to the threshold of M(K-pi)!

Projected Measurements

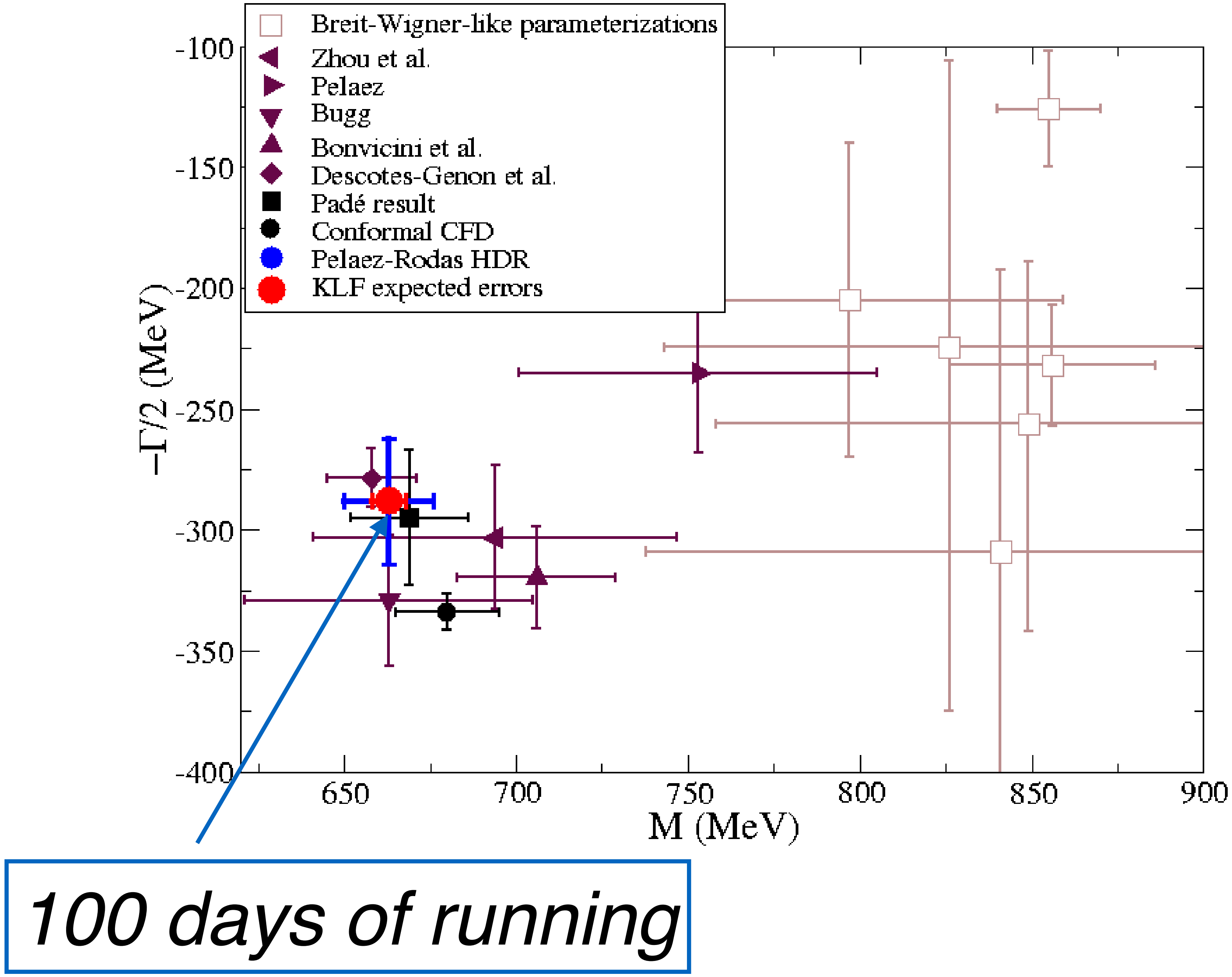
I=3/2+1/2 *S-wave*

SLAC Data



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

Width and Mass of κ (800)



Measurement with KLF will reduce:
Uncertainty in the mass by factor of two
Uncertainty in the width by factor of five!

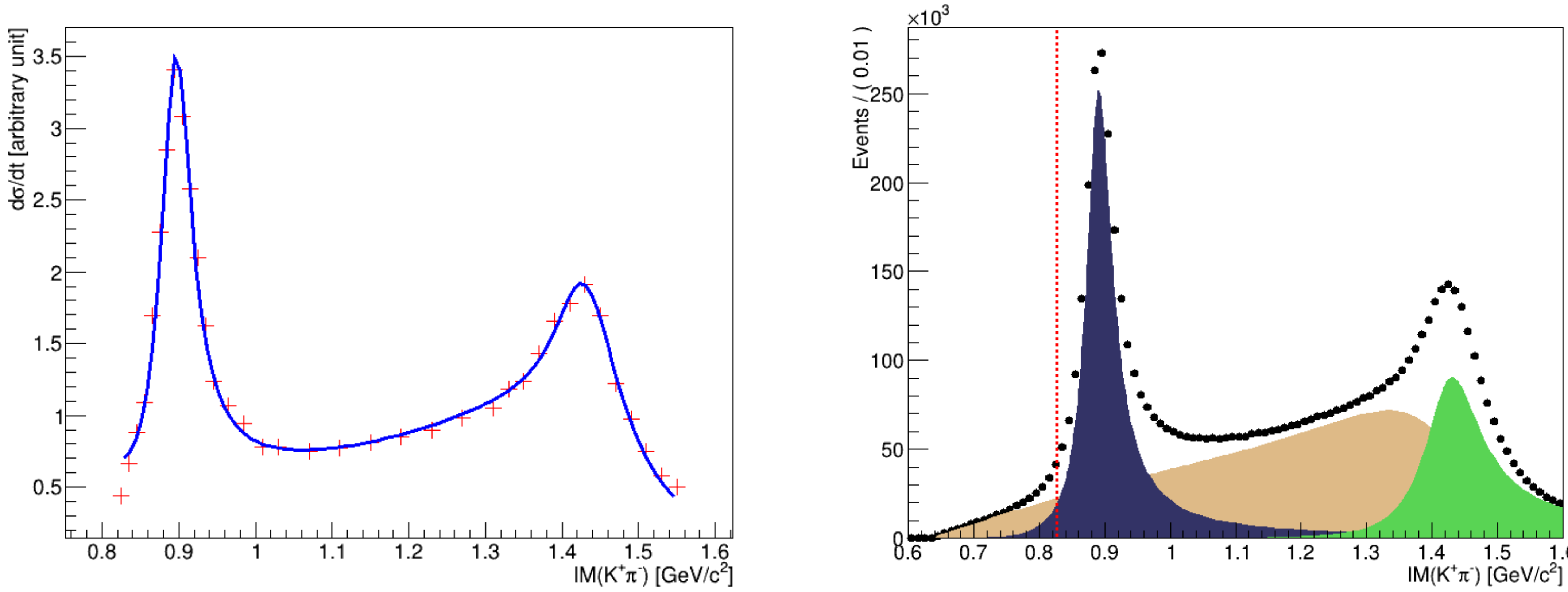
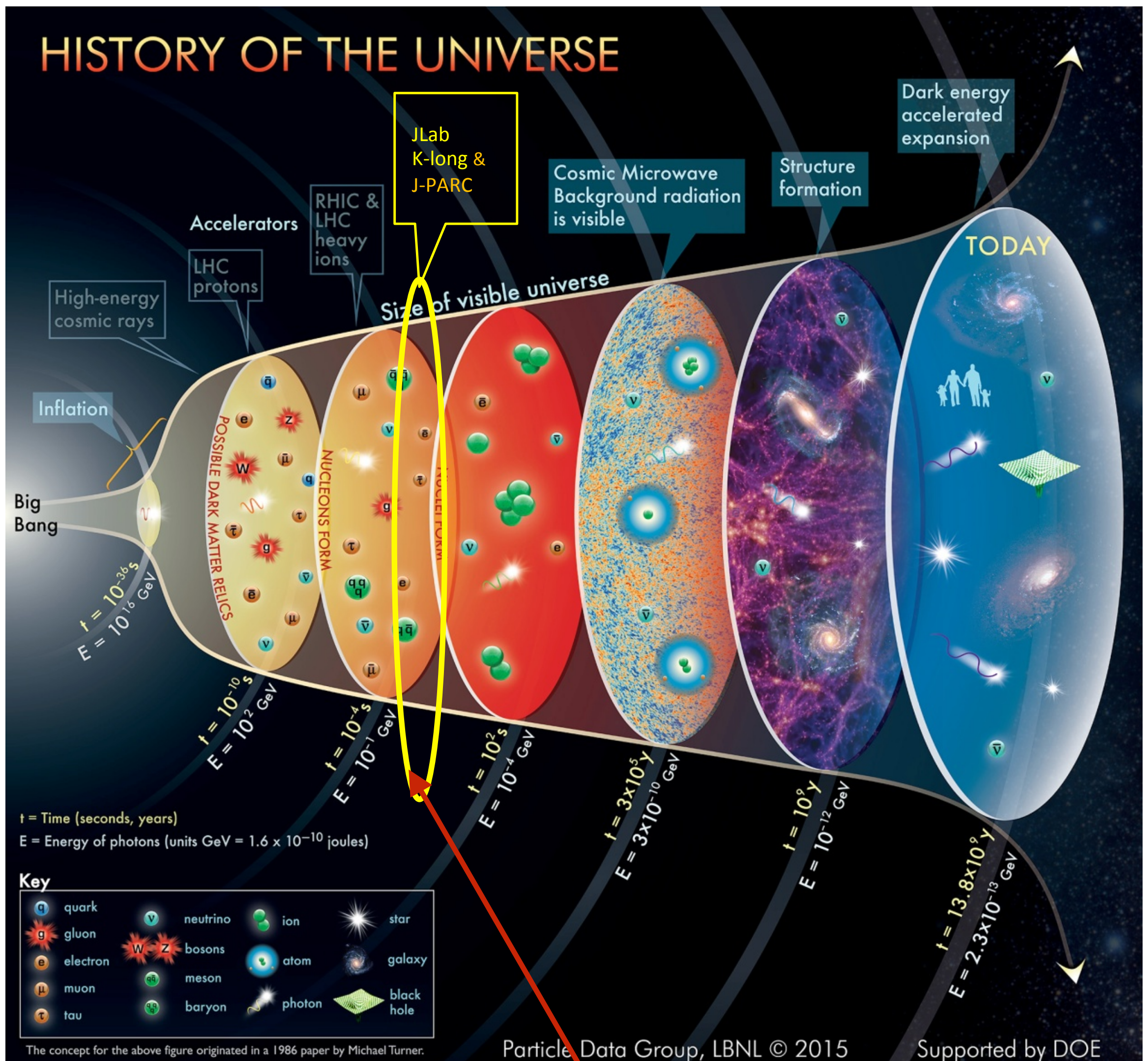
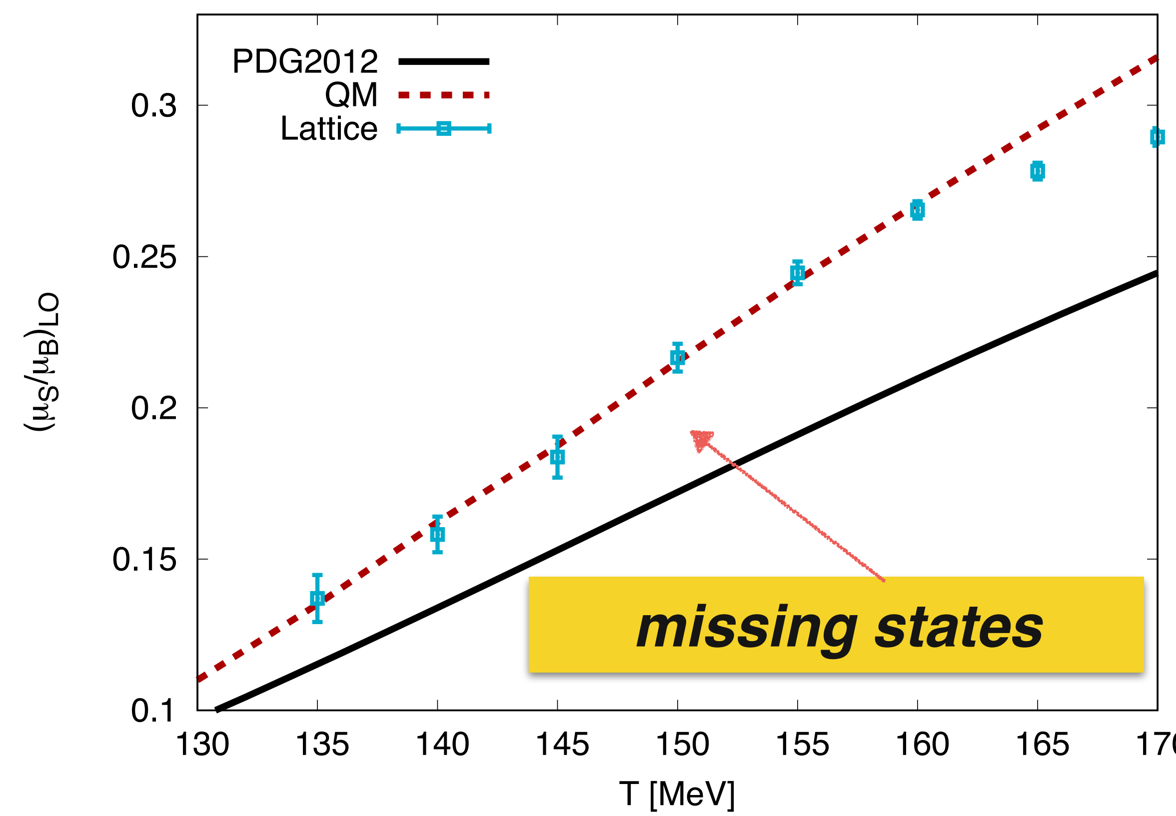


Figure 28: Left panel: Cross section of $K^-p \to K^+\pi^-n$ as a function of the invariant mass from LASS results [122]. The blue line is the fit to the cross section using composite model containing two RBW, spin-1 and spin-2, and S-wave LASS parameterization. Right panel: Expected distribution of the $K^+\pi^-$ invariant mass below 1.6 GeV from KLF after 100 days of run. The dark blue function represents the $K^+\pi^-$ P-wave, light brown the S-wave and green the D-wave. The dashed line represents the threshold of $K\pi$ invariant mass in LASS results [122].

Evolution of Early Universe at Freeze-out

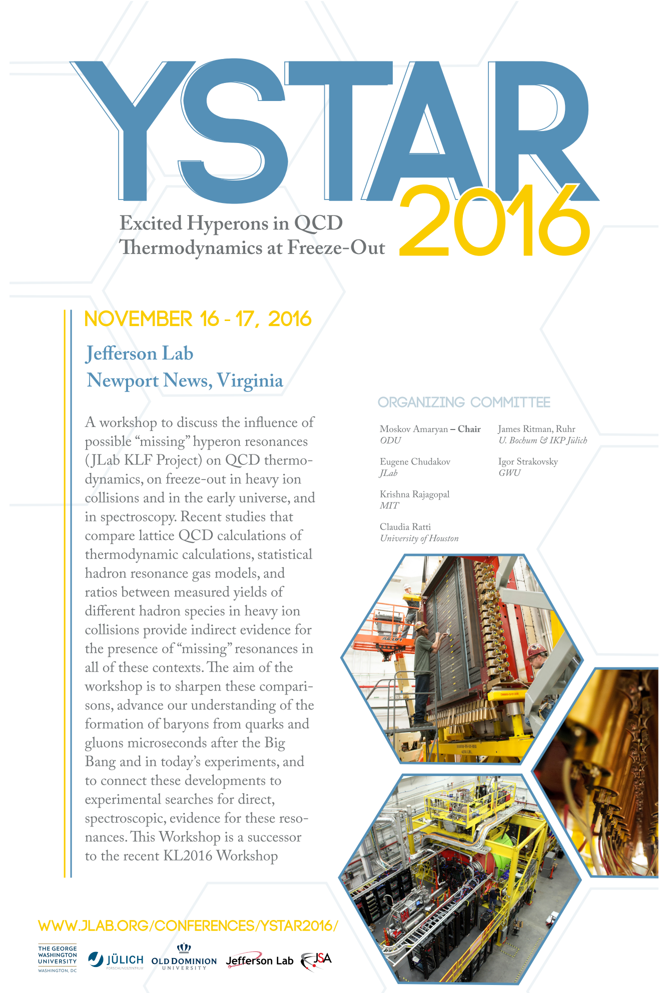


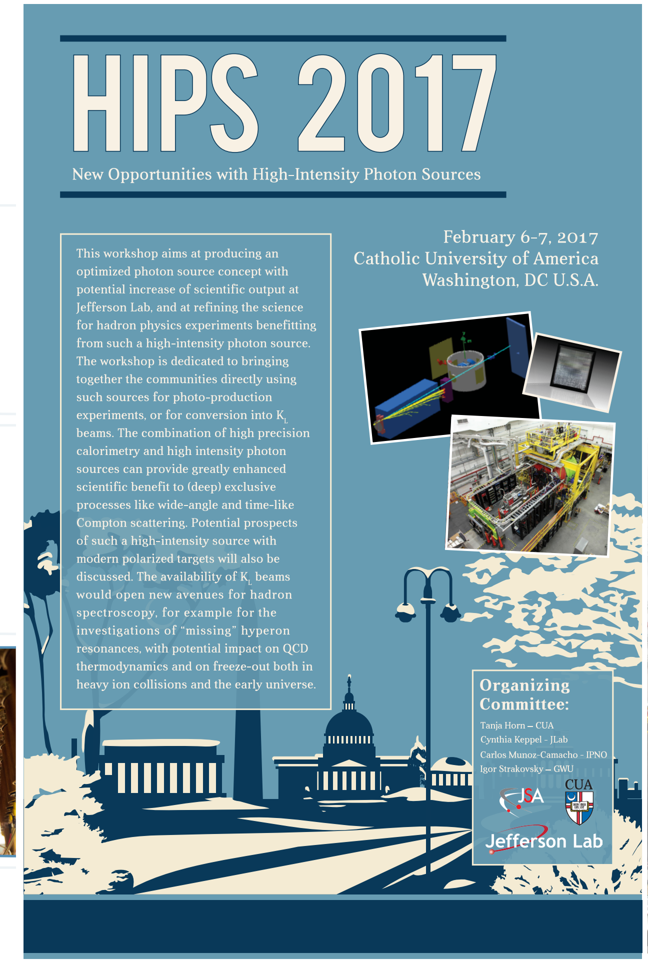
Chemical Potential

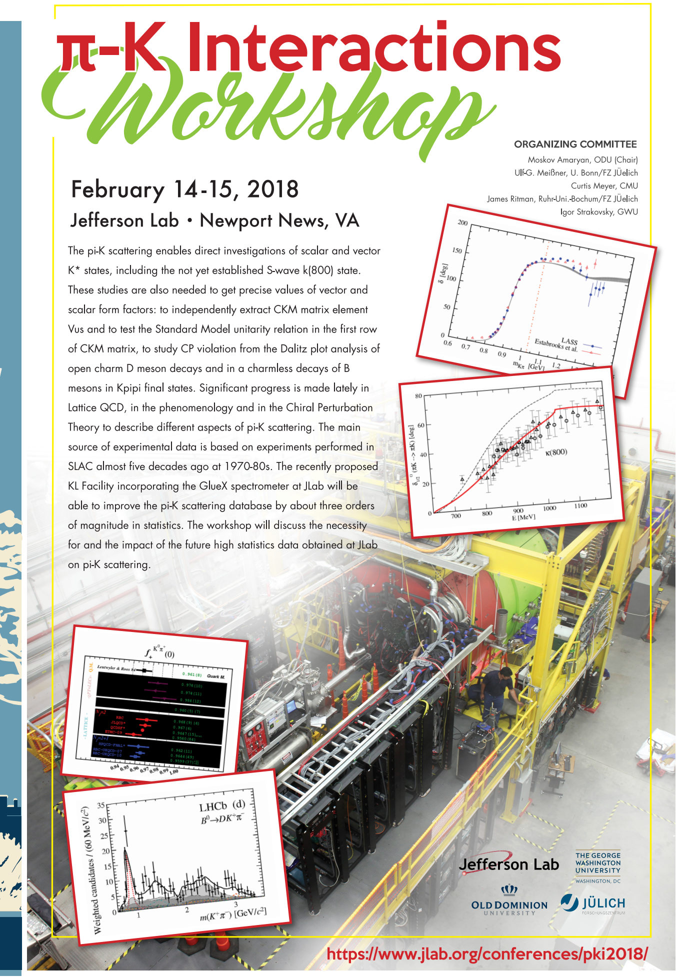


YSTAR2016 Proceedings arXiv: 1701.07346

We are here: $1\mu s$ After the Big Bang







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 of $K\pi$ Scattering

-The KLF will have a very significant impact on our knowledg on $K\pi$ 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*(800) and by factor of five the uncertainty on its width

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

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 κ
- KLF Project will have a strong impact on
  -Thermodynamics of an Early Universe

Summary: ***From TAC Report***

Feasibility: The project appears to be technically feasible. The cost (without local labor) was estimated at about $6M (taking into account the recent CPS estimate), including about $1M for the Flux Monitor, which may become a foreign contribution.

Summa Summarum

The KLF is a great project for strange hadron spectroscopy!

Thank you !