Strange Hadron Spectroscopy with Secondary KL Beam in Hall-D

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(on behalf of  *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

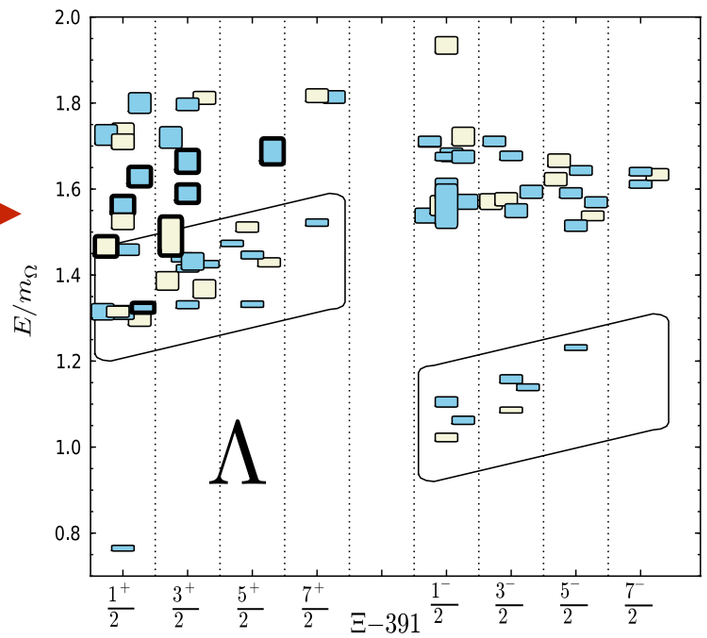
Hyperon Spectroscopy

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

many more states including hybrids (thick bordered)

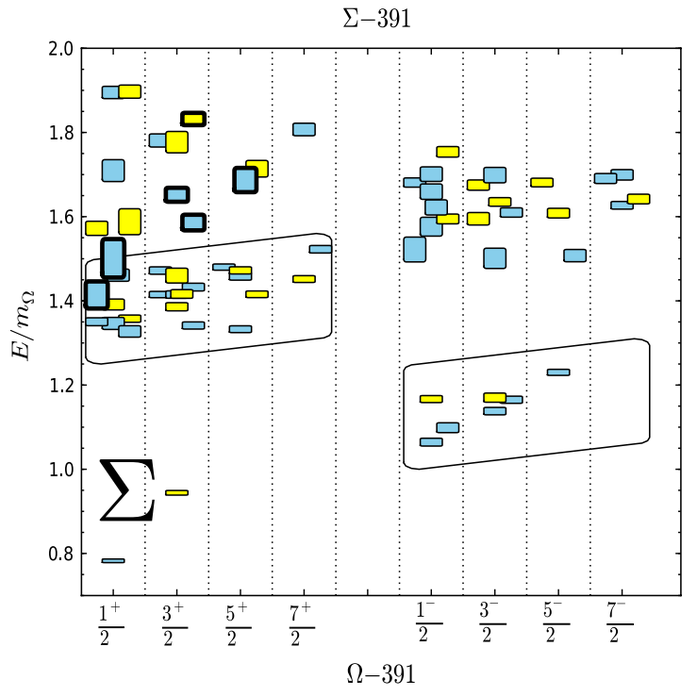
8-states
****

5-states
***



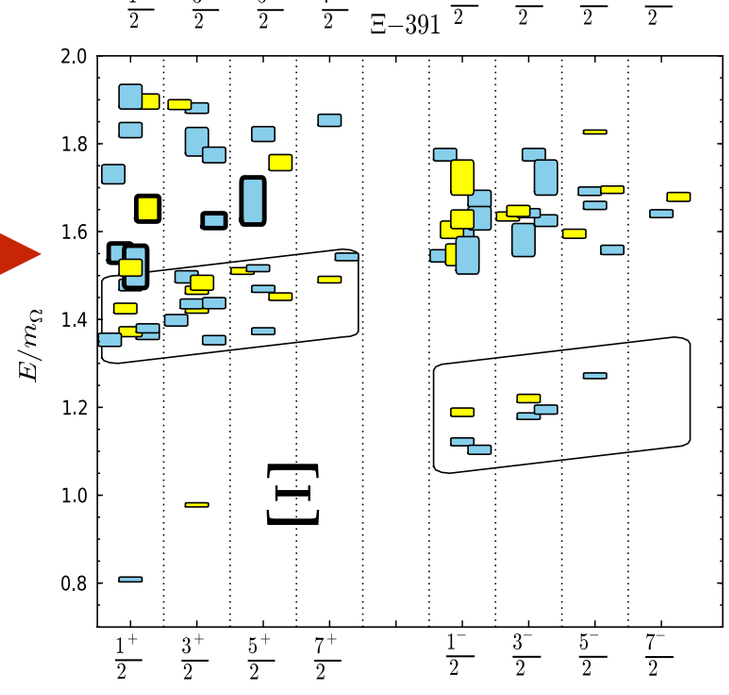
6-states
****

4-states
***



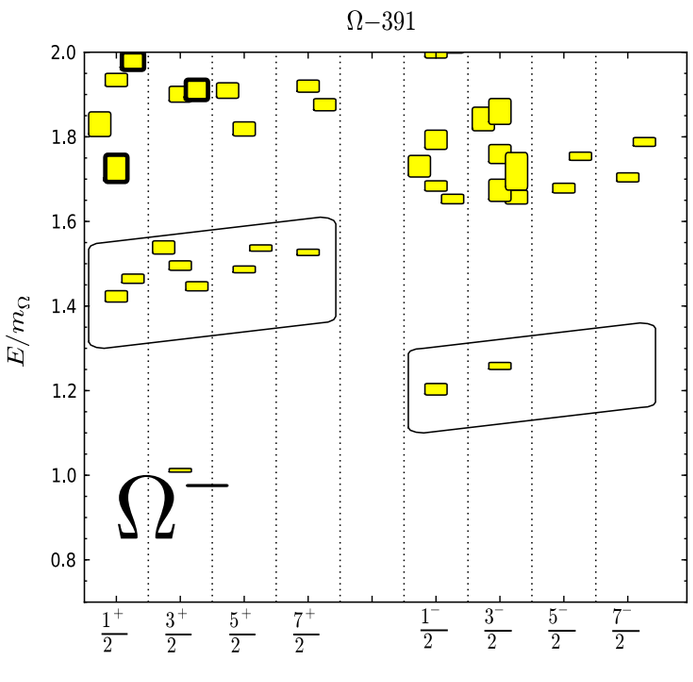
3-states
****

4-states
***



1-state
****

1-state
***

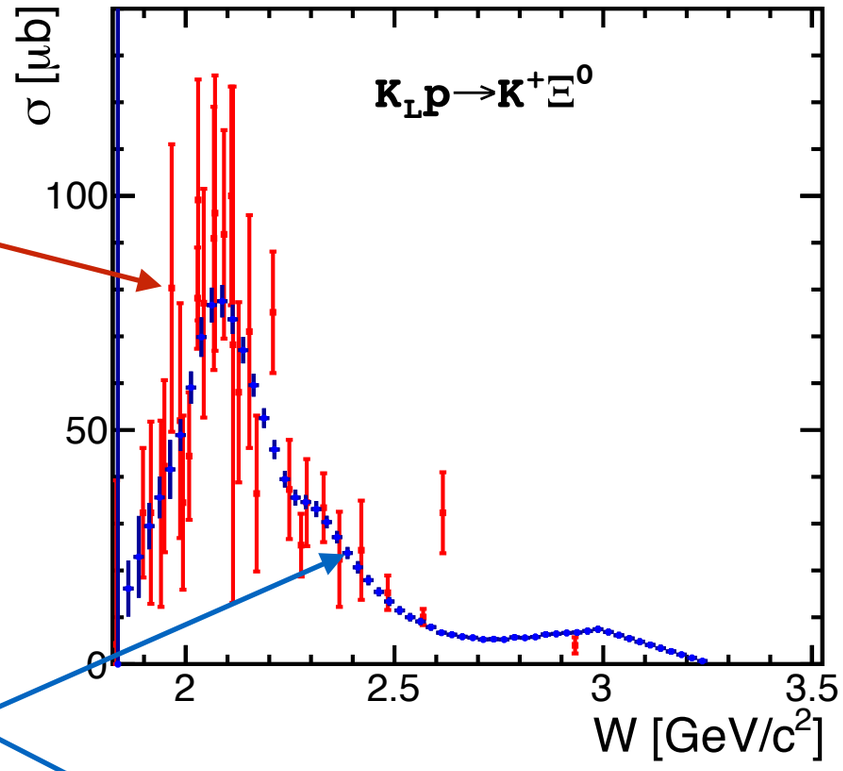


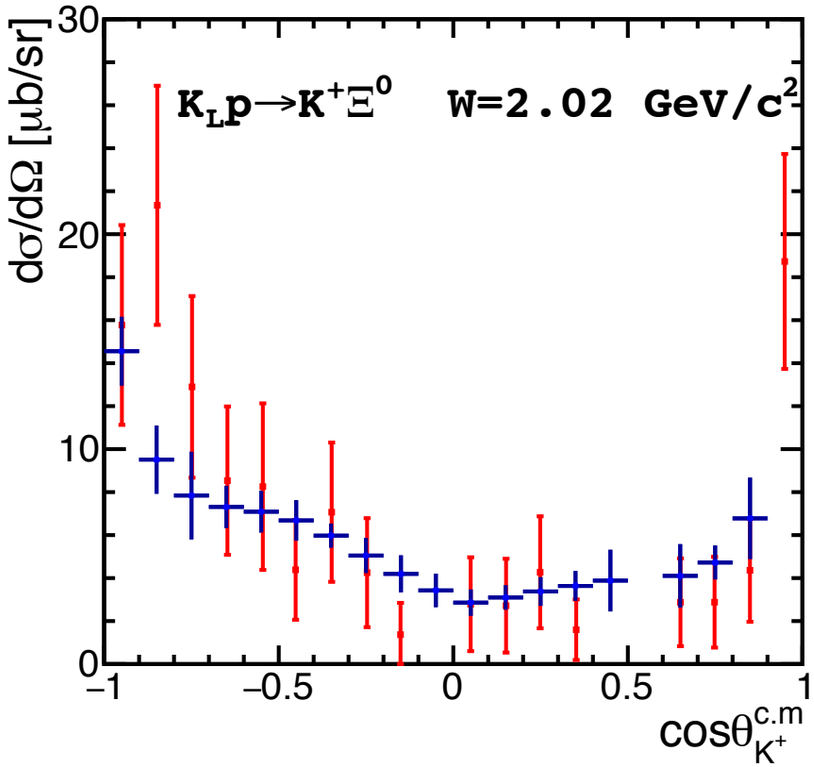
Edwards, Mathur, Richards and Wallace, Phys. Rev. D 87, 054506 (2013)

Measurements on Proton Target

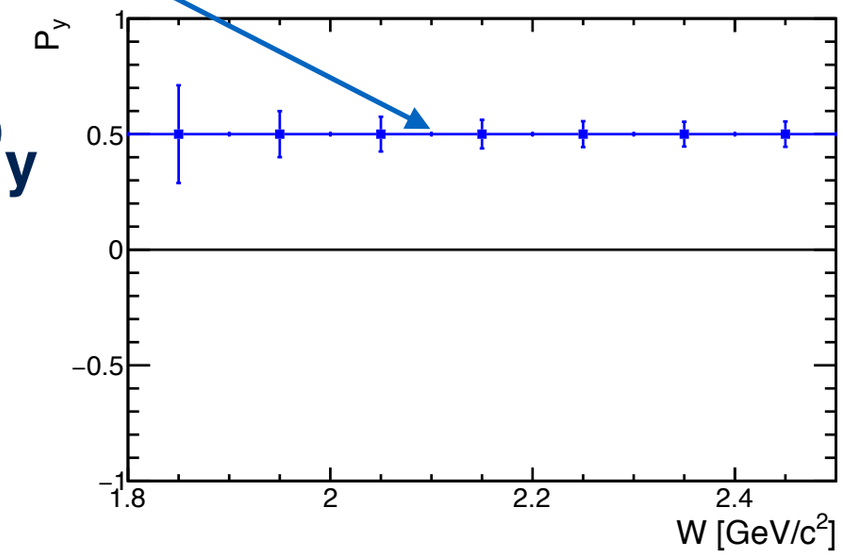
existing data

KLF 100 days



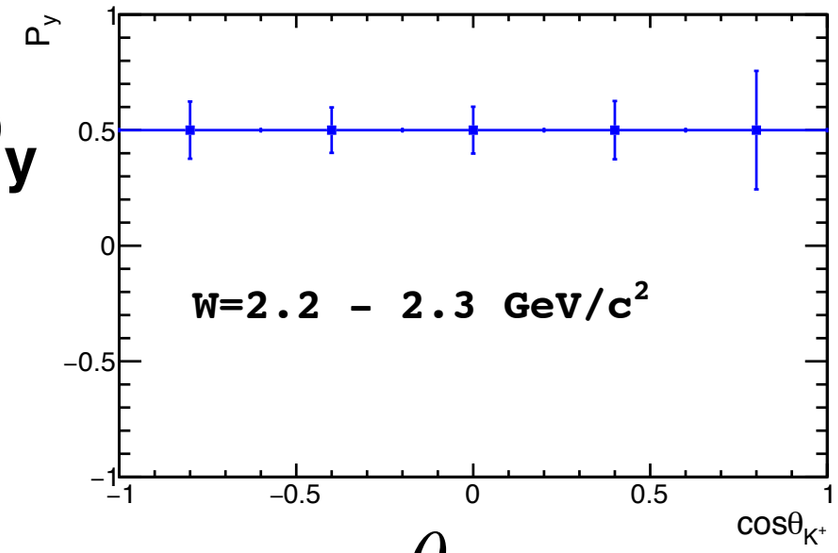


P_y



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

P_y



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

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

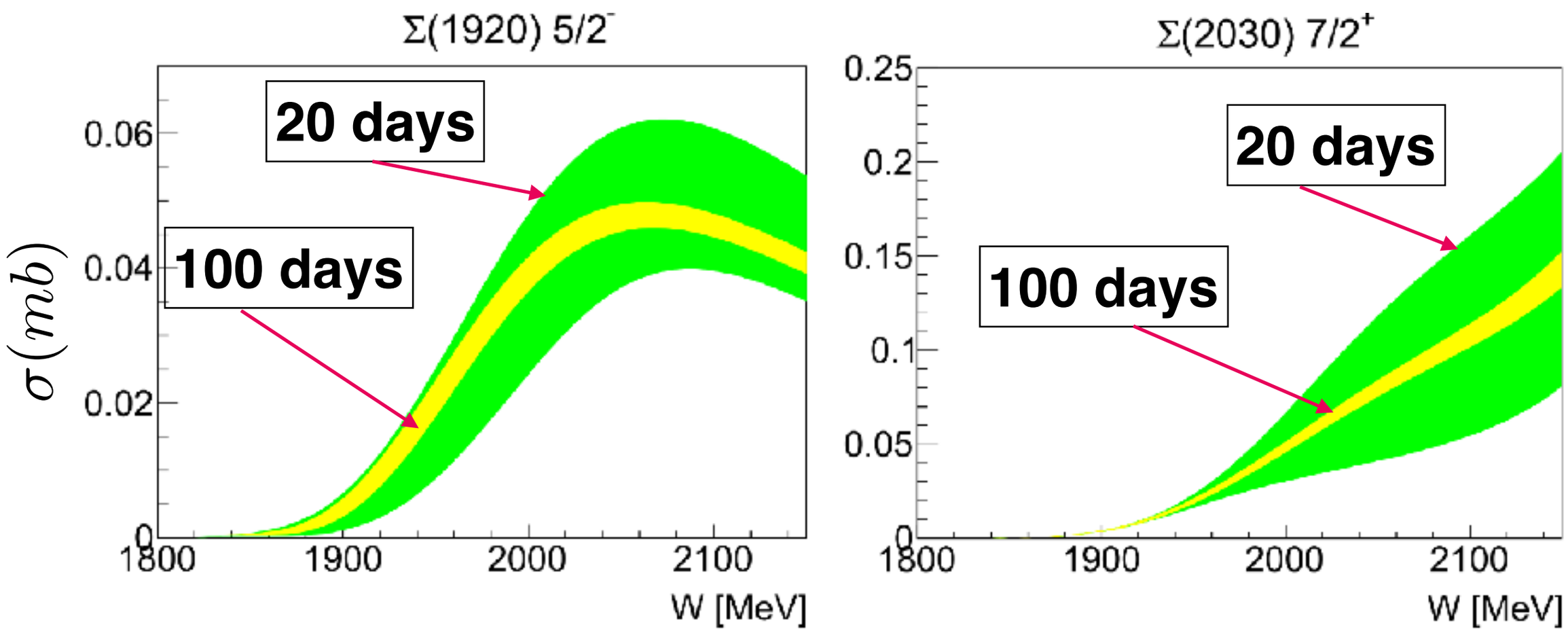
-look for poles in complex energy plane
(contrary to naïve bump hunting)

-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

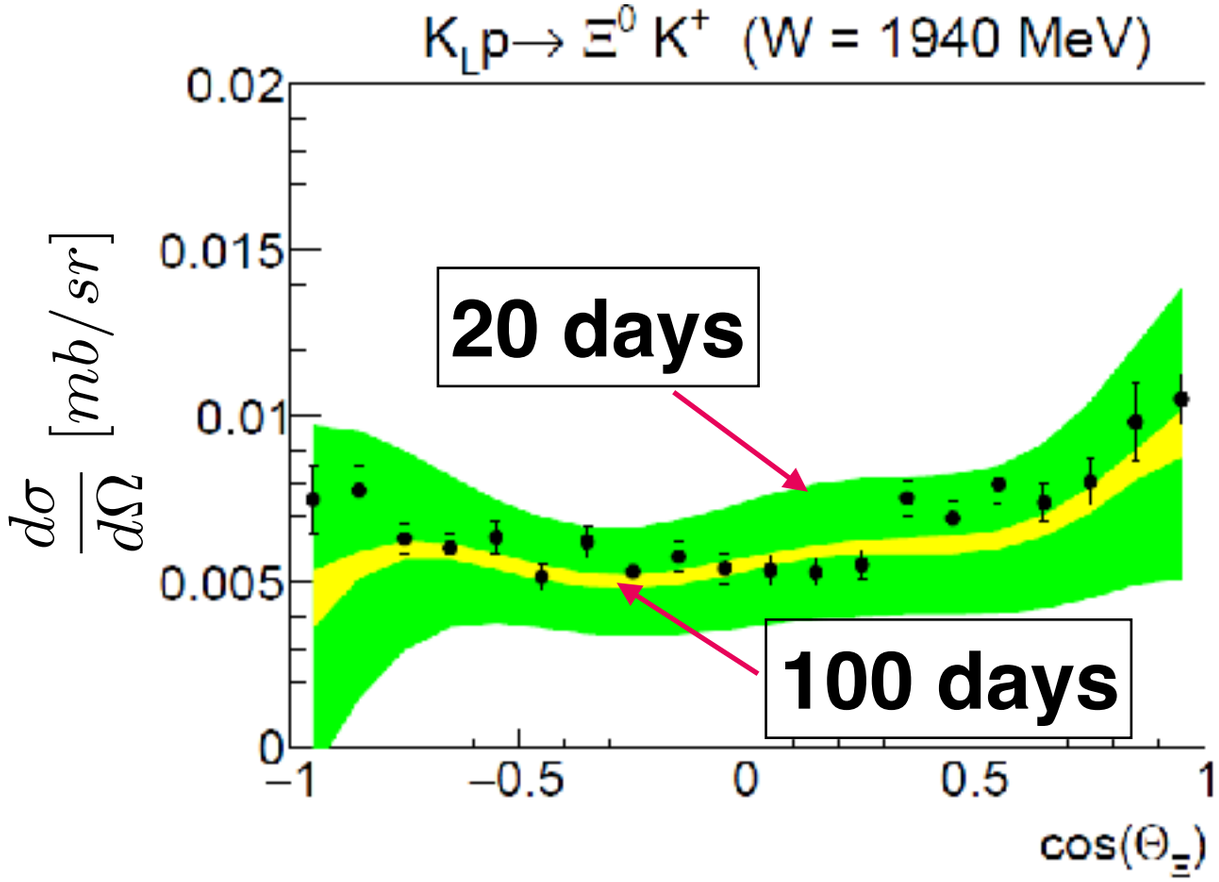
Total Cross Section $K_L p \to K^+ \Xi^0$



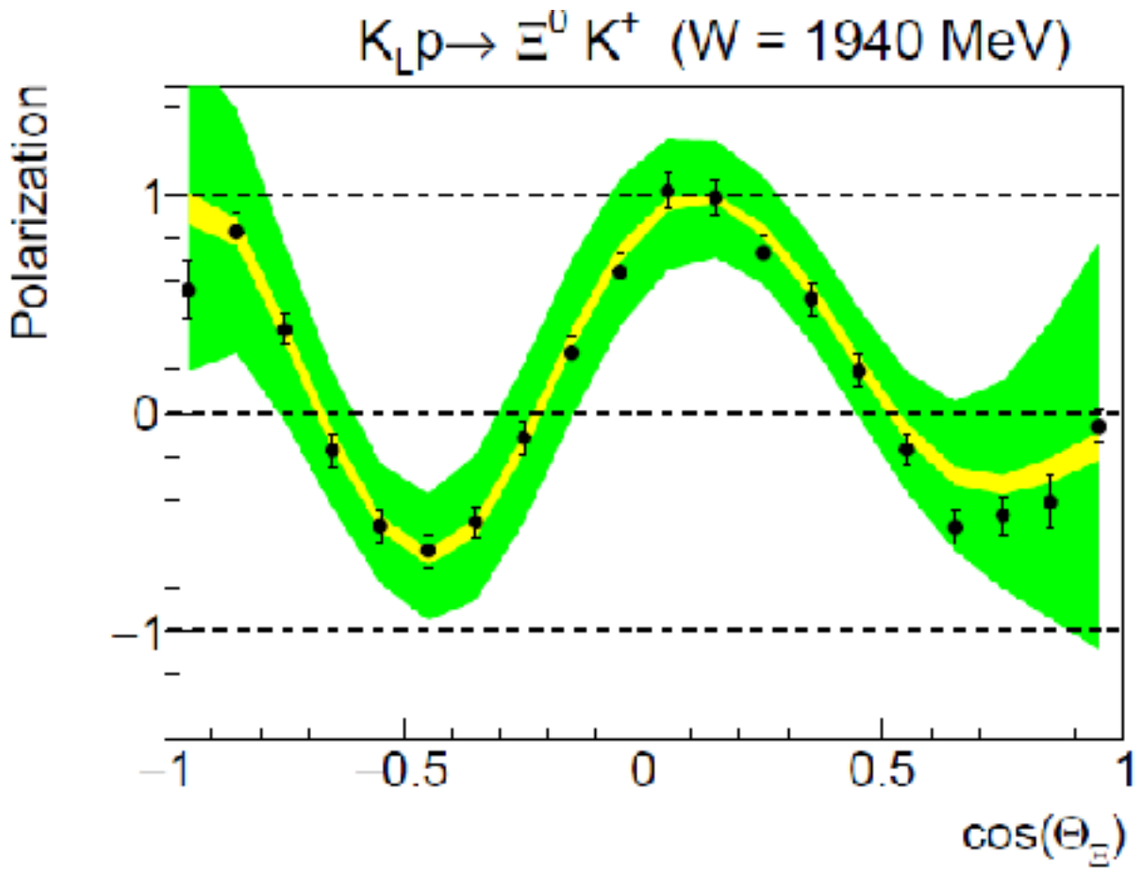
Obviously: at least 100 days needed to get precise solution

Bonn-Gatchina PWA

Diff. Cross Section



Polarization



Again: at least 100 days to get precise solution

Some Numerical Results

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

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

$$20d\ M = 1.977 \pm 0.021 \pm 0.025\ GeV$$

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

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

LQCD M=

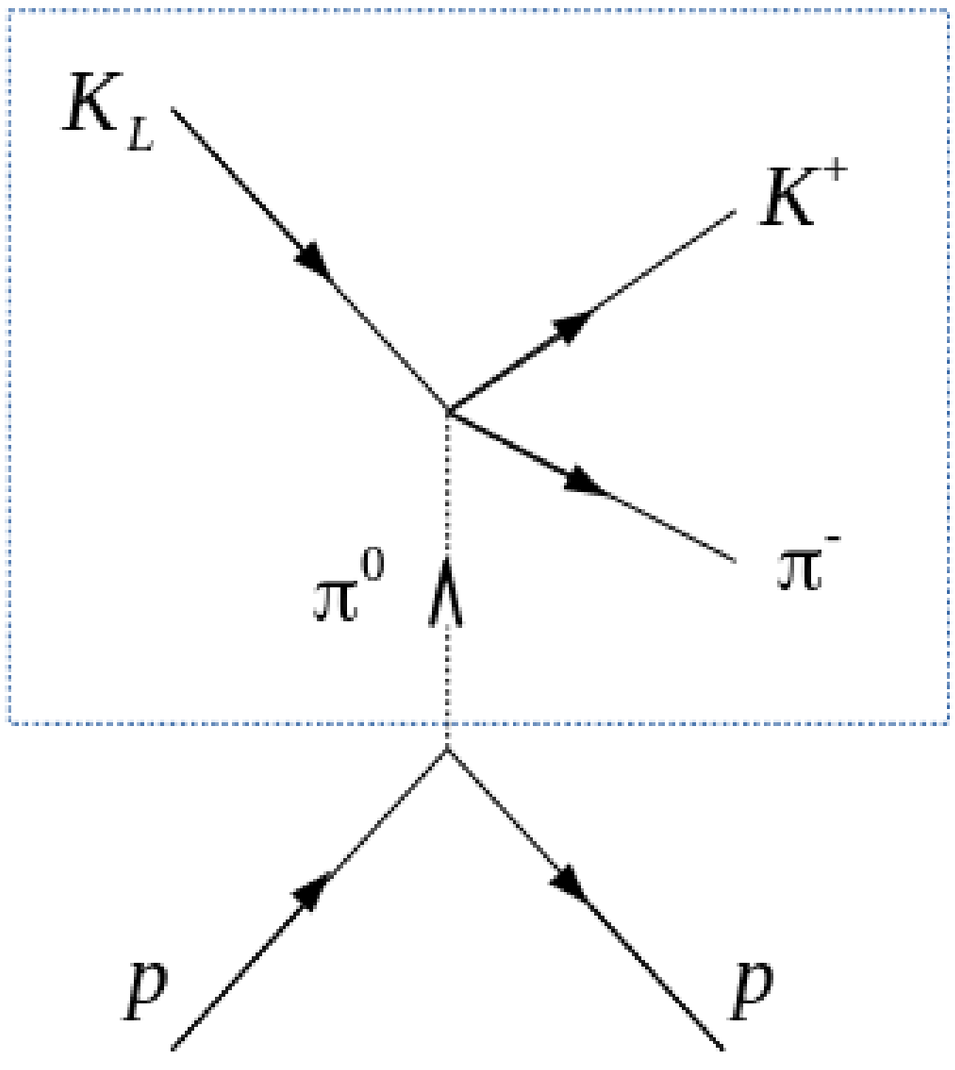
2.027 GeV
2.487 GeV
2.659 GeV
2.781 GeV

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

LQCD Results are still in progress

Strange Meson Spectroscopy

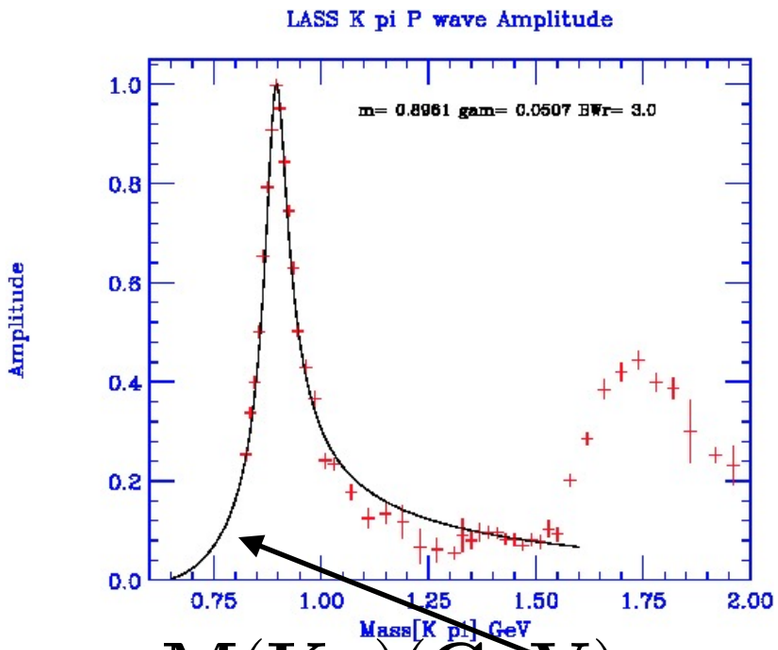
$K\pi$ Scattering



Proposed Measurements

SLAC

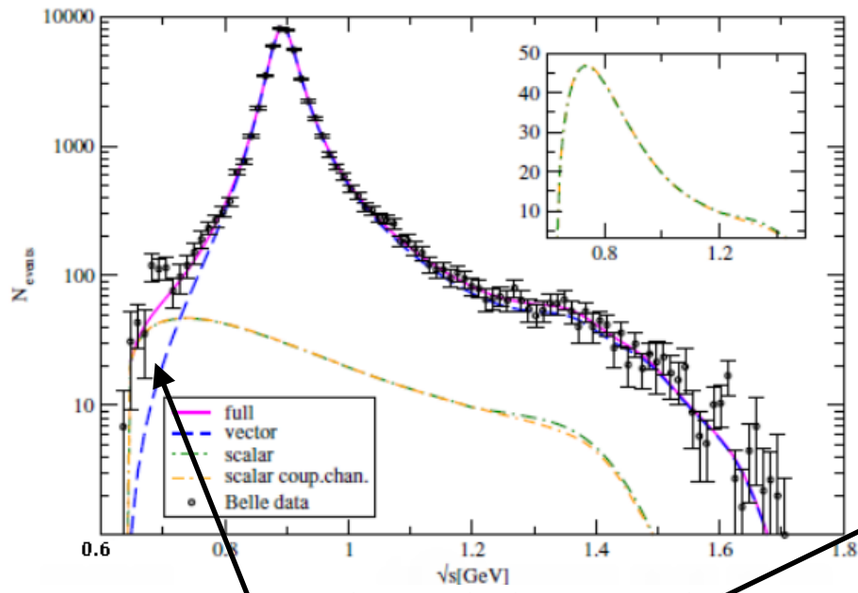
$$K^-\pi^+ \to K^-\pi^+$$



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

Belle

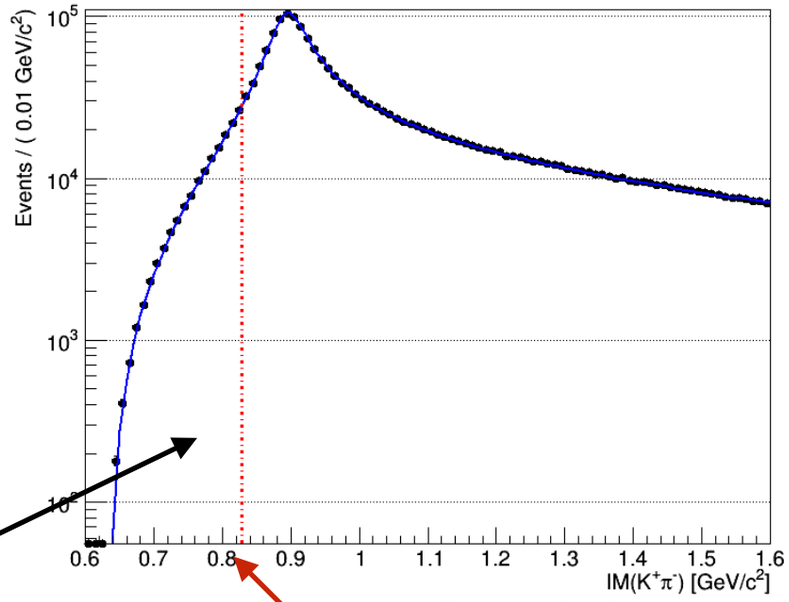
$$\tau \to K\pi\nu_\tau$$



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

KLF

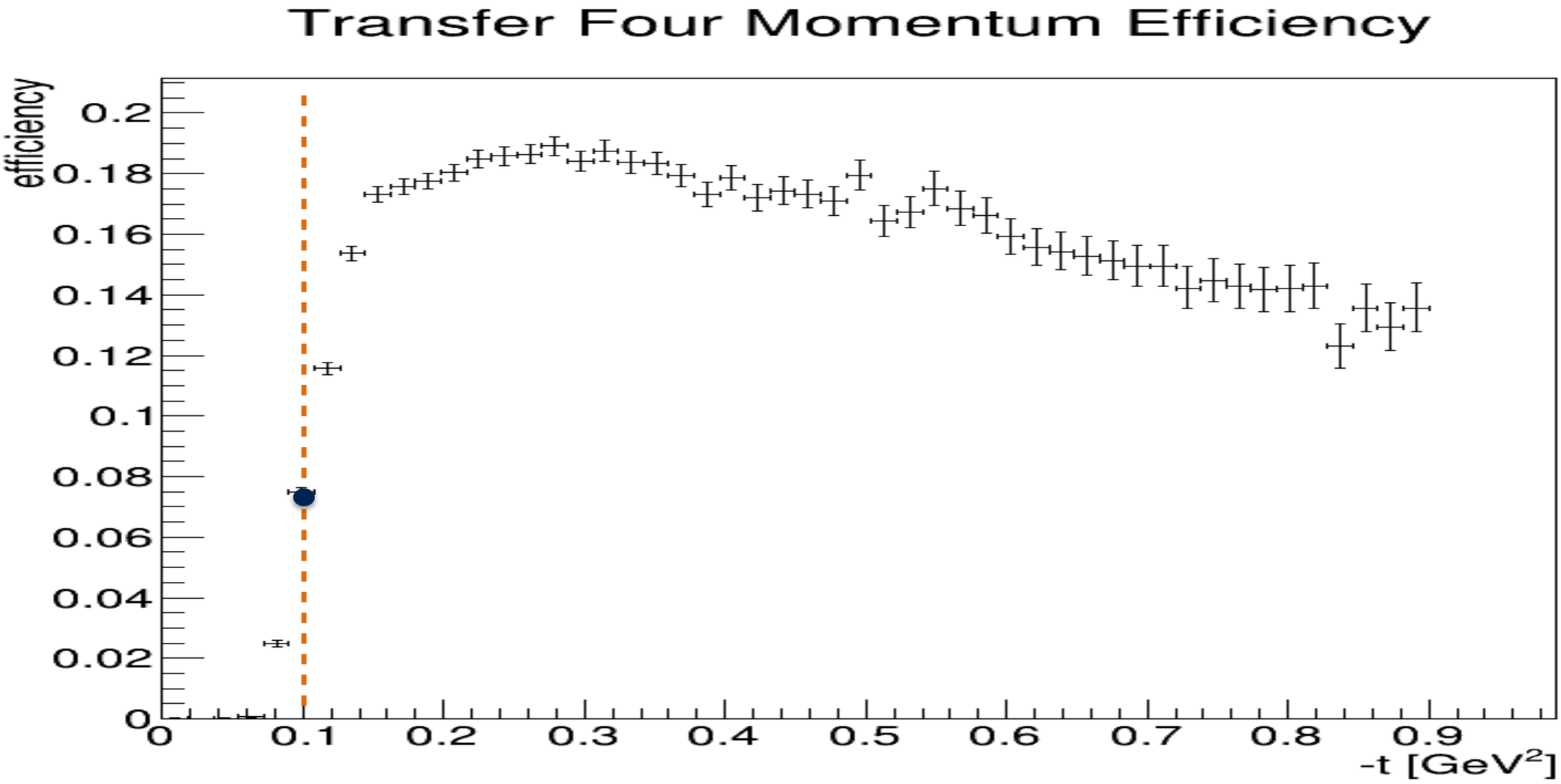
$$K_L\pi^0 \to K^+\pi^-$$



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

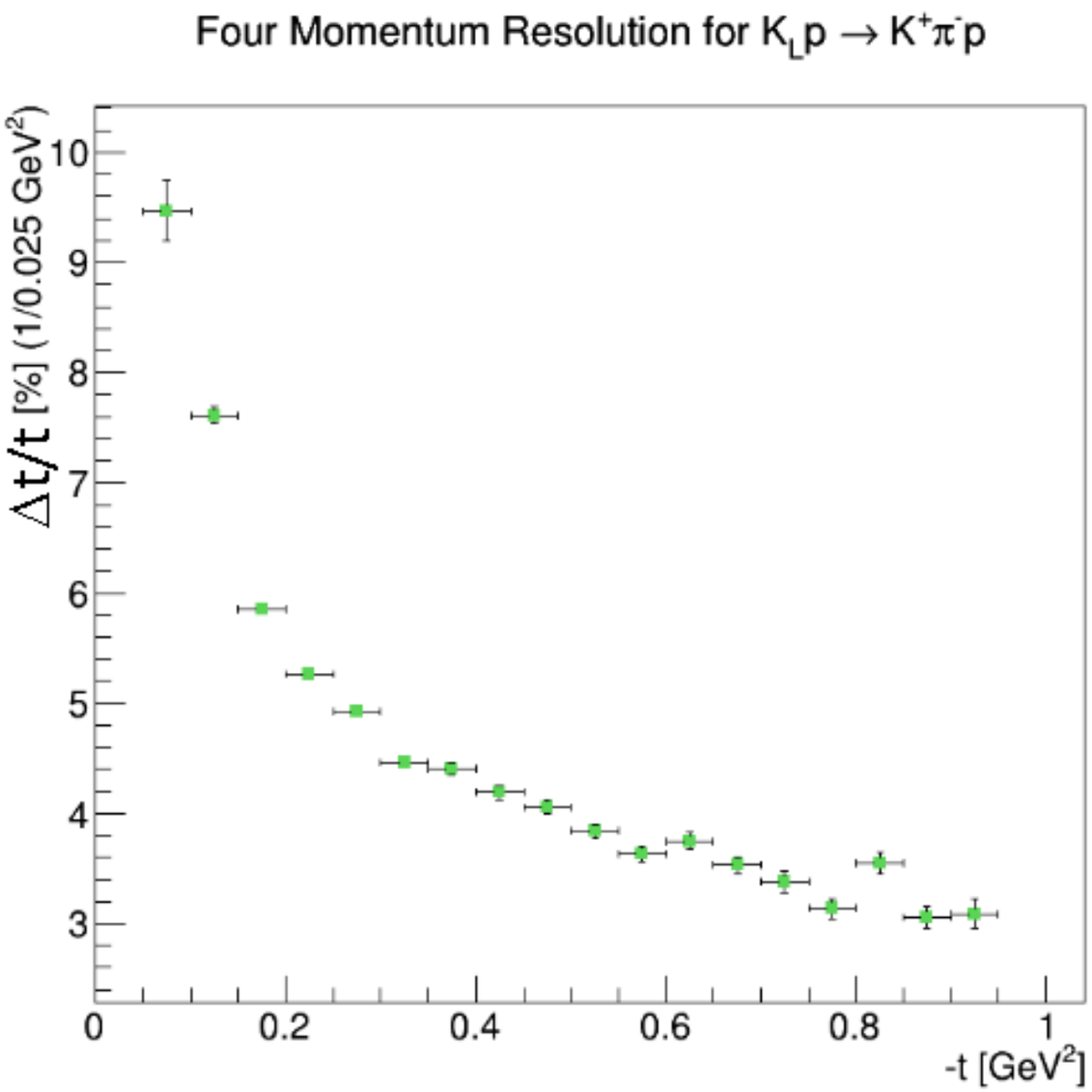
region of $\kappa(800)$

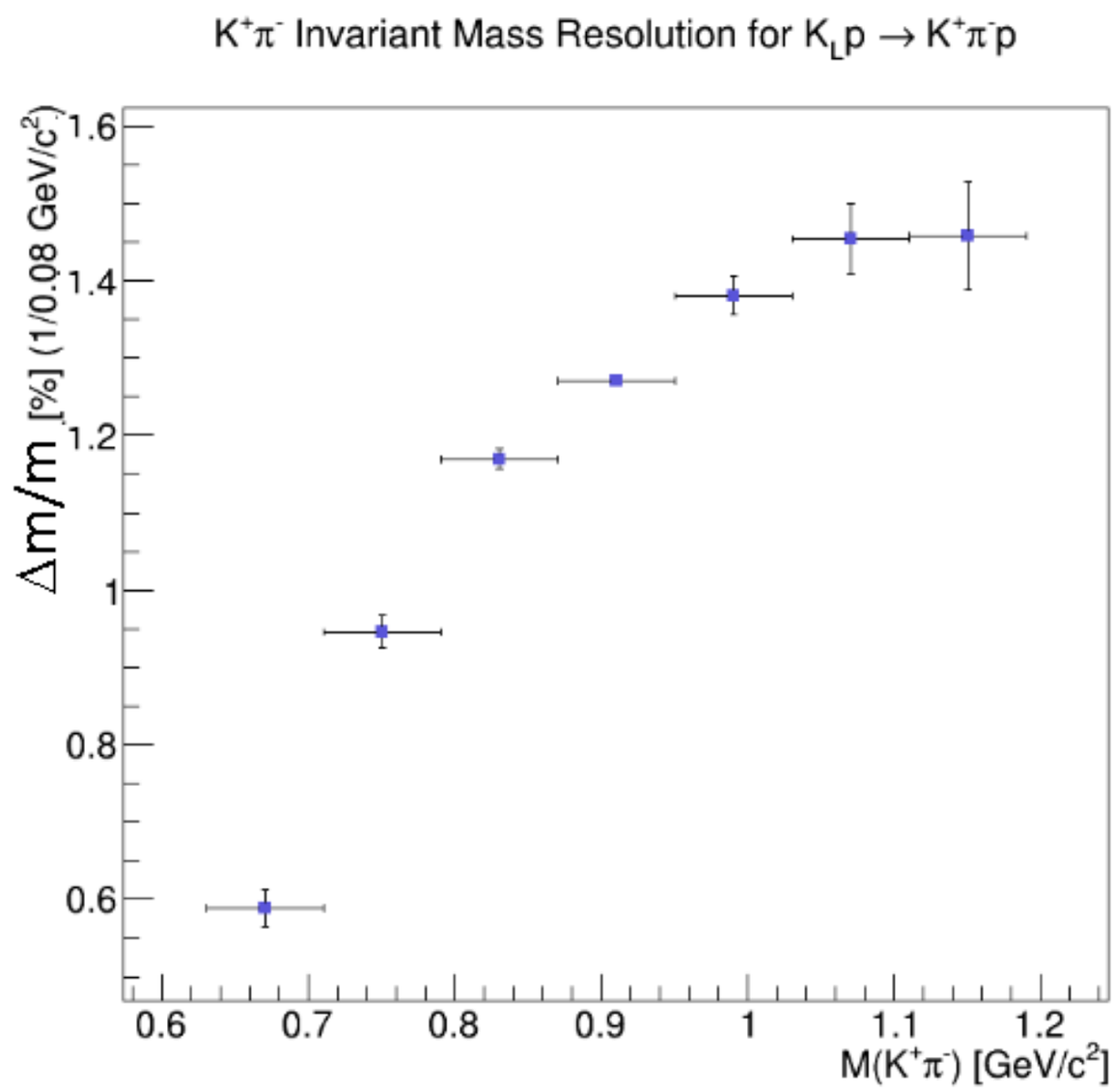
SLAC Lower limit



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

$K\pi$ *Scattering Resolutions*

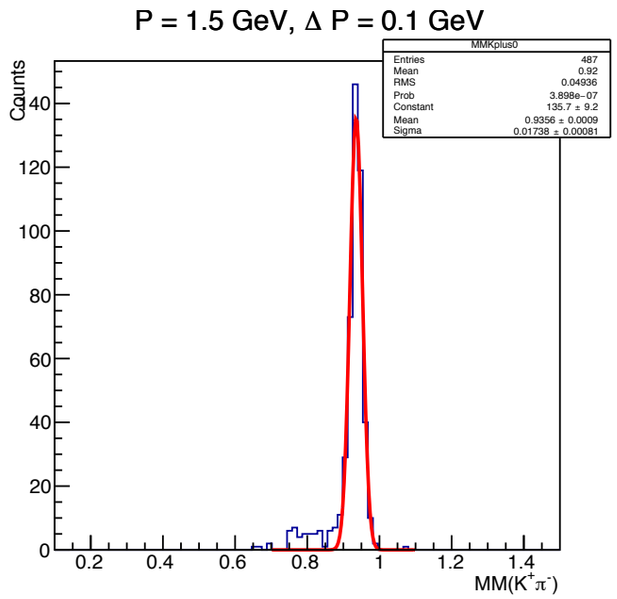


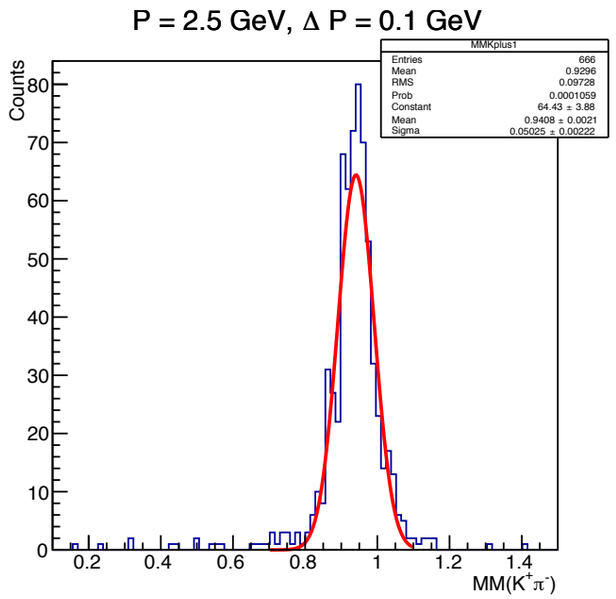


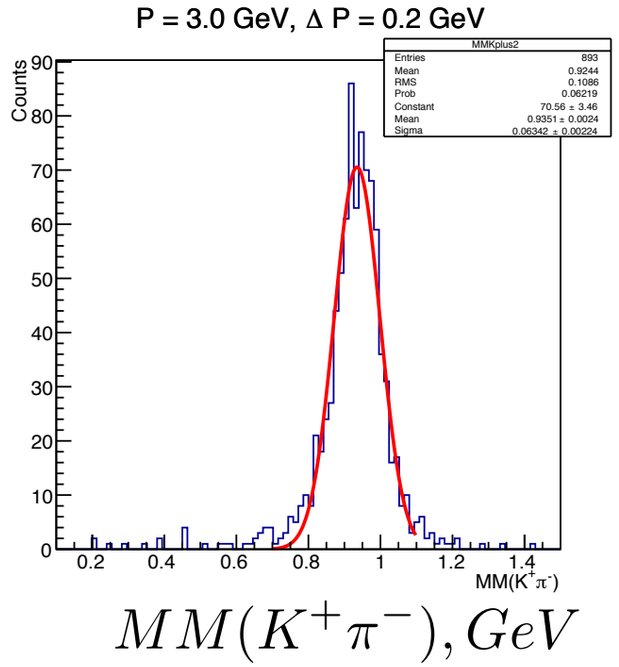
-Good resolution at low-t is needed to be close to pion pole

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

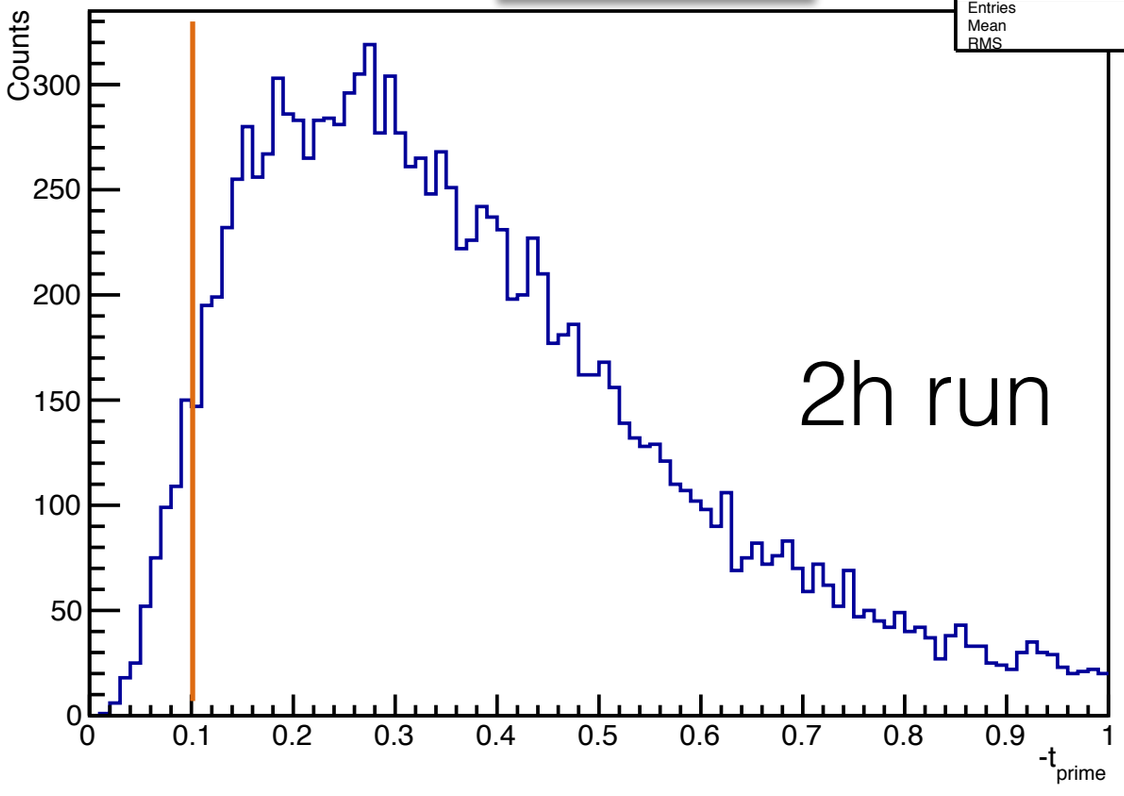
Missing Mass of $K^+\pi^-$ system





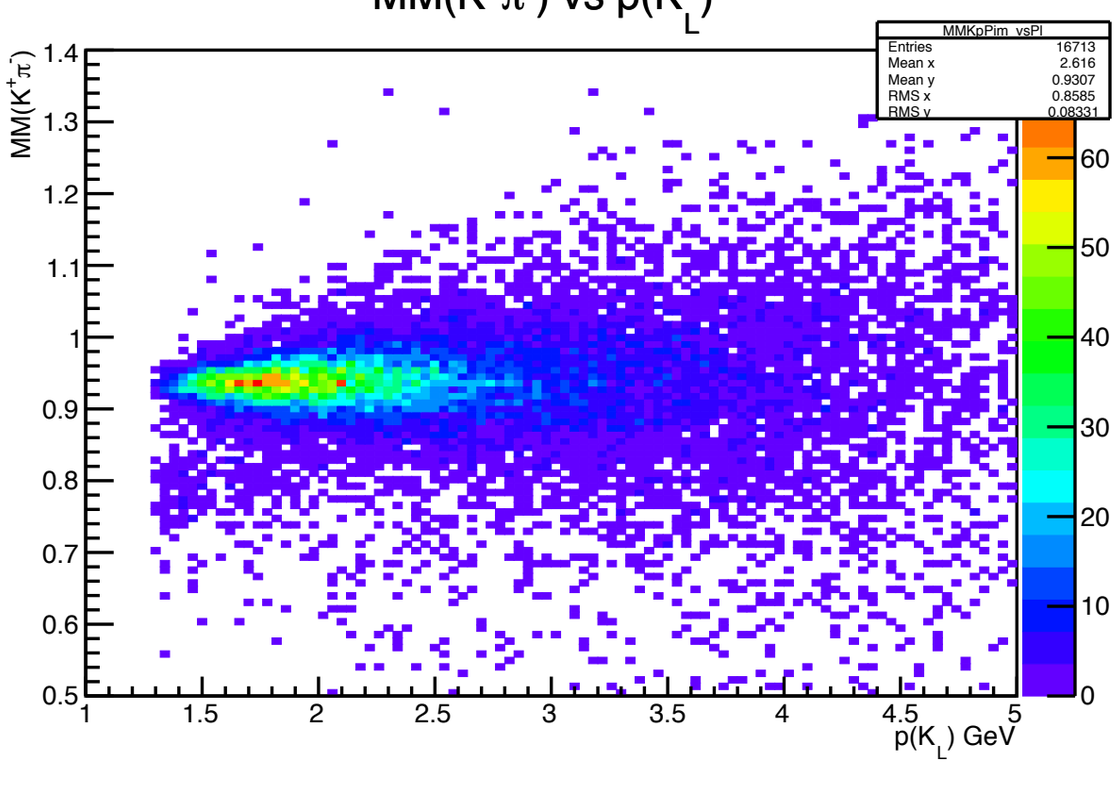


$MM(K^+\pi^-), GeV$

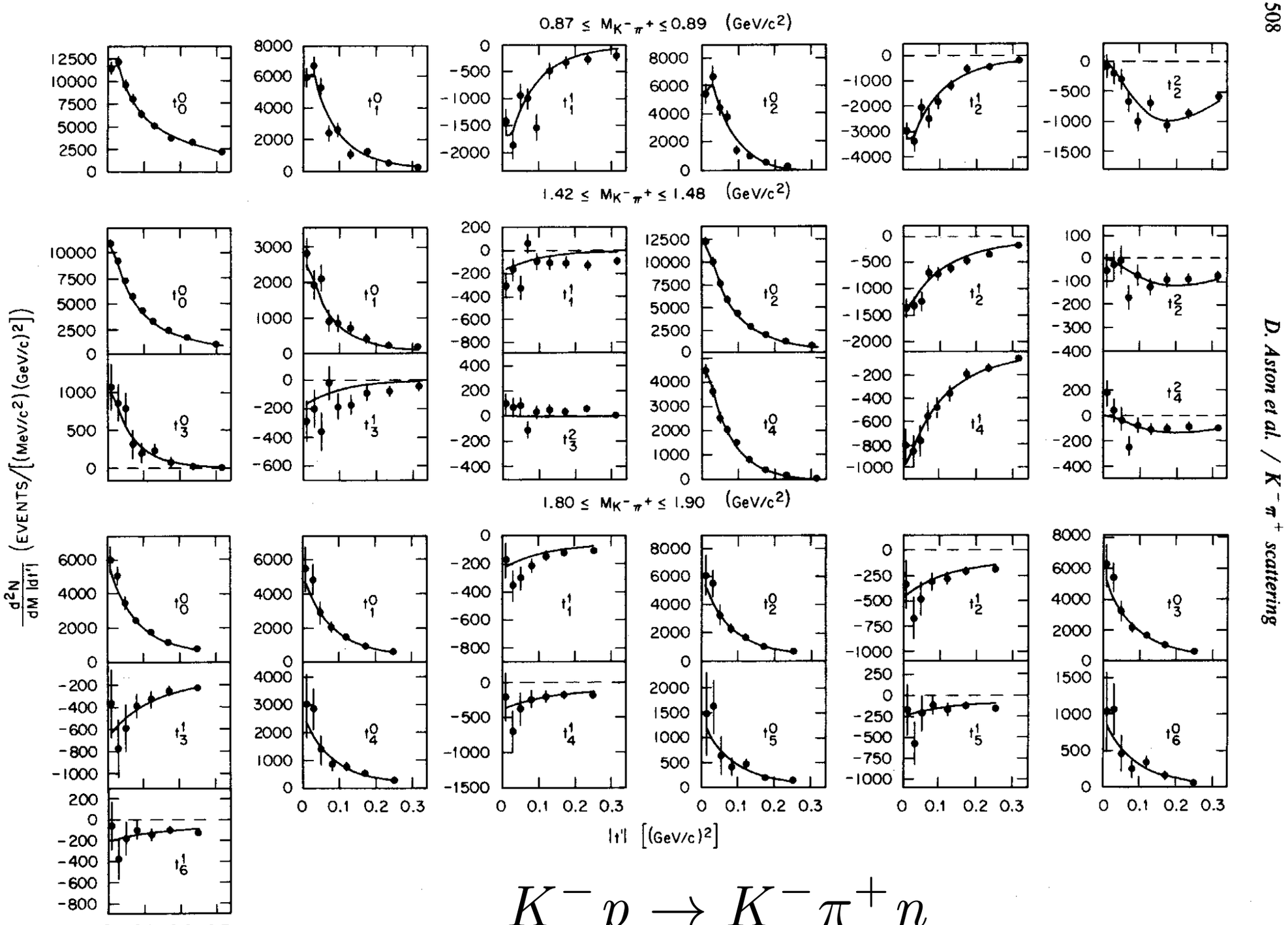


-t, GeV^2

MM(K$^+$π$^-$) vs p(K$_L$)

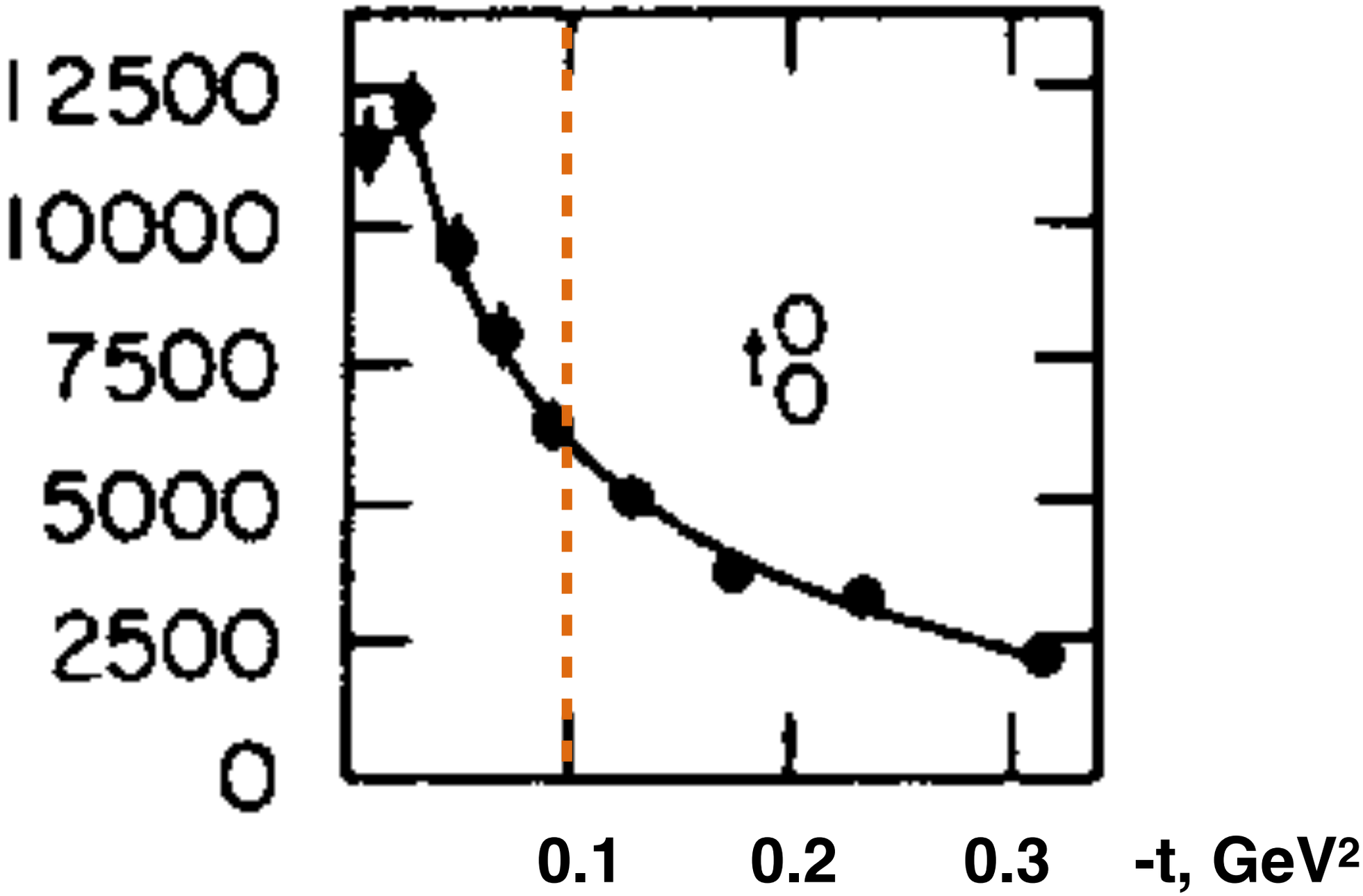


NPB296 Aston et al., LASS at SLAC at 11 GeV



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

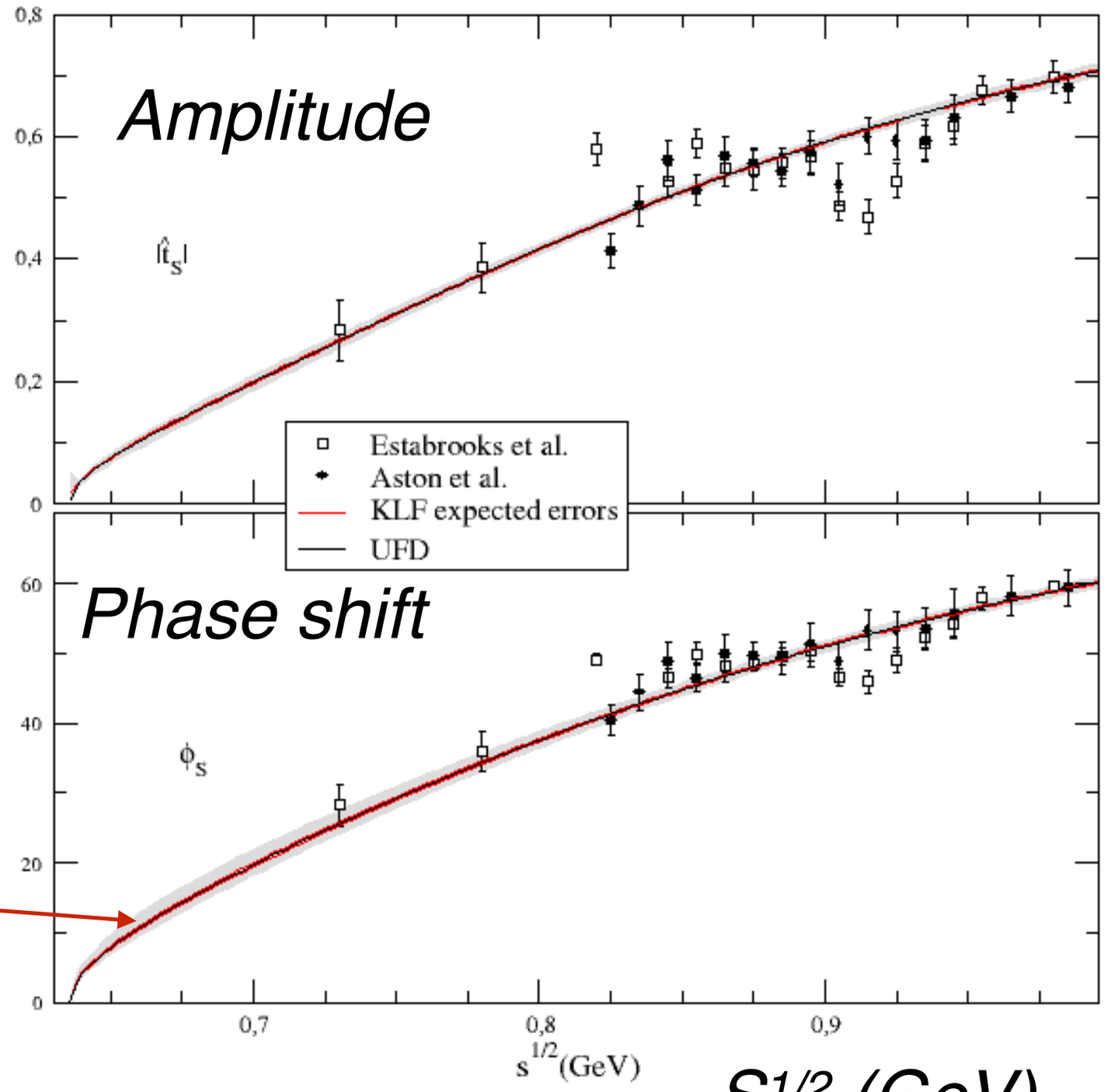
Fig. 9. The acceptance corrected unnormalized $K^-\pi^+$ moments as a function of $|t'|$. Three different mass regions are shown; $0.87 \leqslant M_{K\pi} \leqslant 0.89$ GeV/c^2, $1.42 \leqslant M_{K\pi} \leqslant 1.48$ GeV/c^2, and $1.80 \leqslant M_{K\pi} \leqslant 1.90$ GeV/c^2. The curves are the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


12500
10000
7500
5000
2500
0
t0
0.1
0.2
0.3
-t, GeV²

Projected Measurements

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

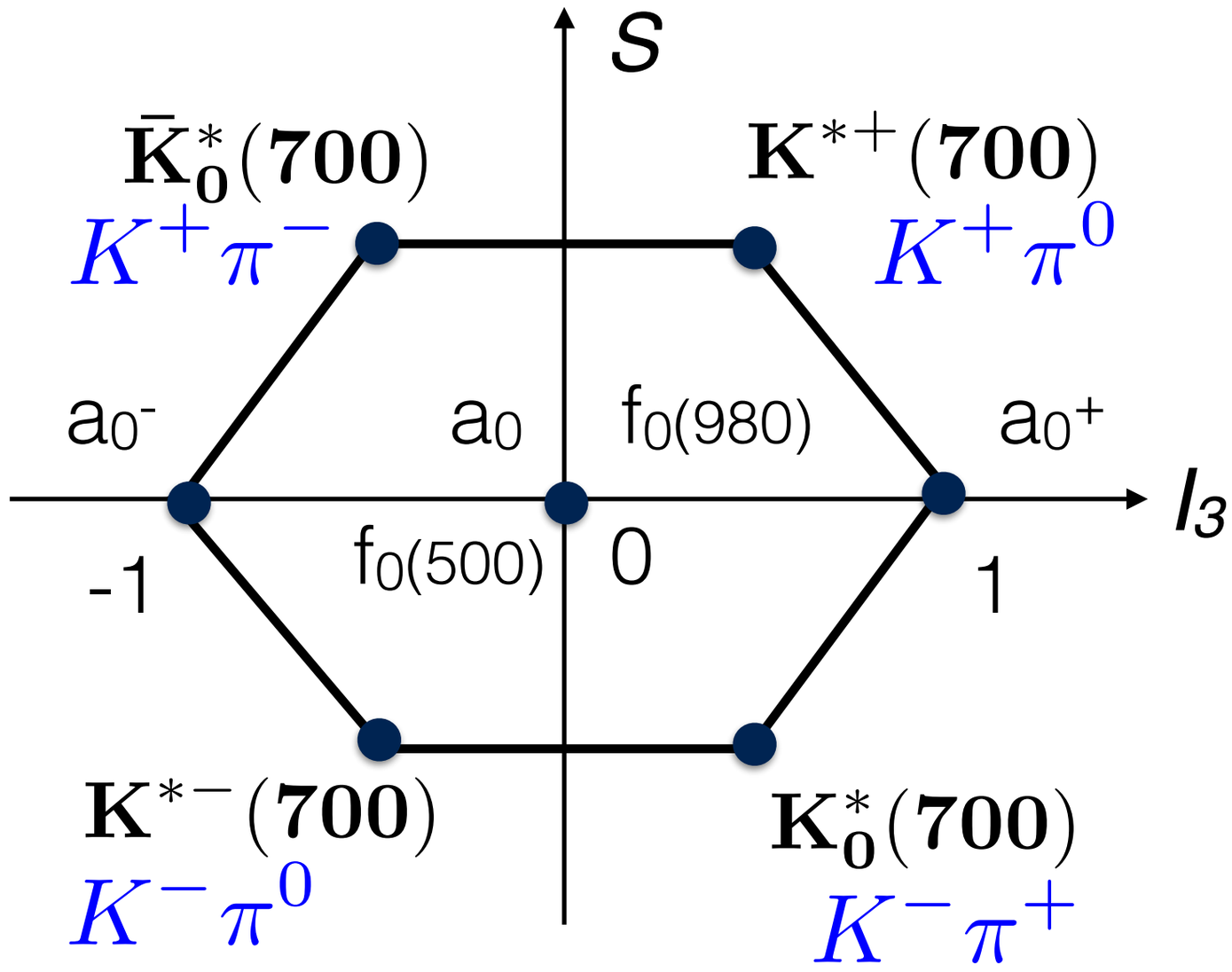
SLAC Data



KLF (100 days)

Scalar Meson Nonet

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

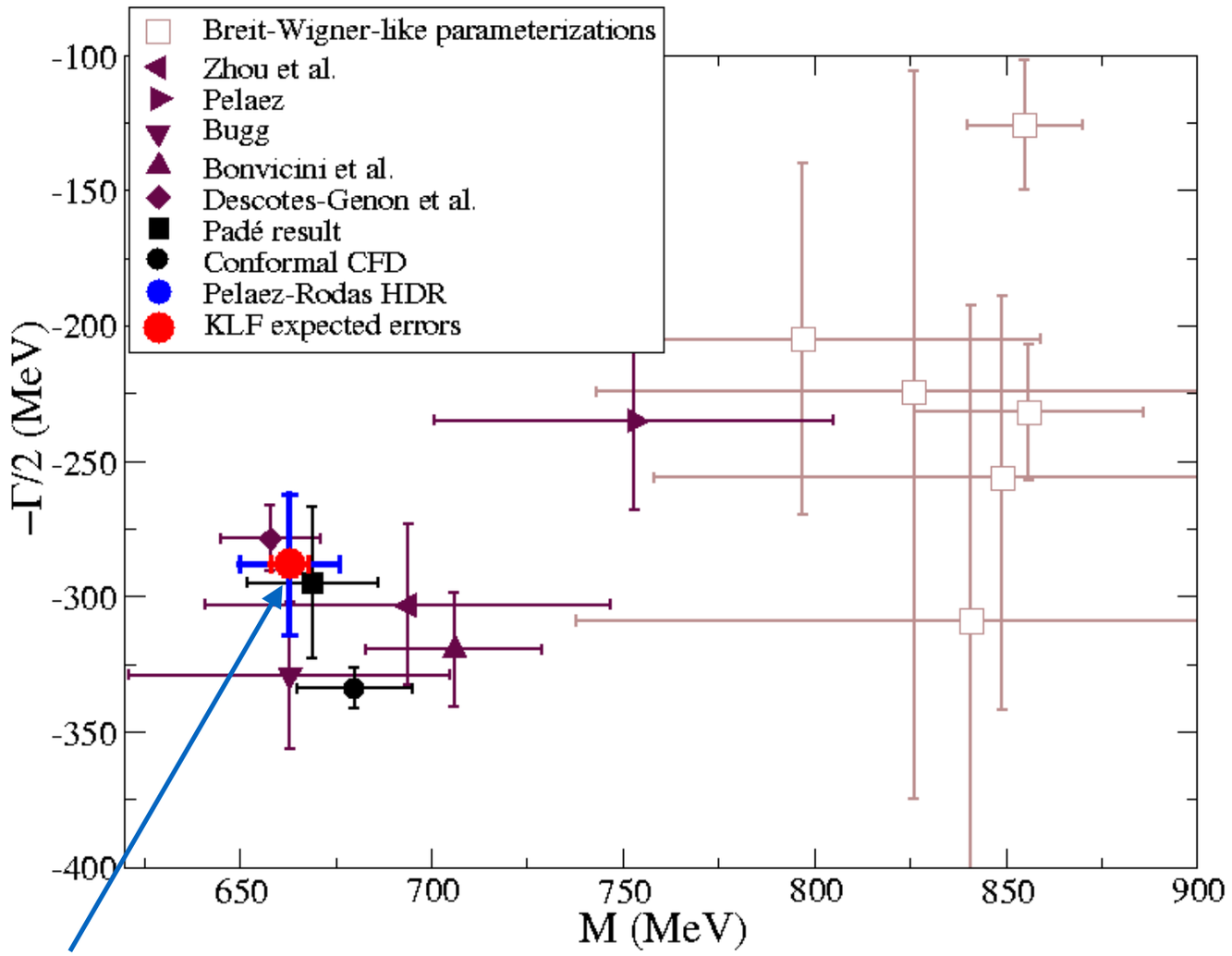


Four states called κ

still need further confirmation(PDG)

We can measure all of them

Width and Mass of $\kappa(800)$



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

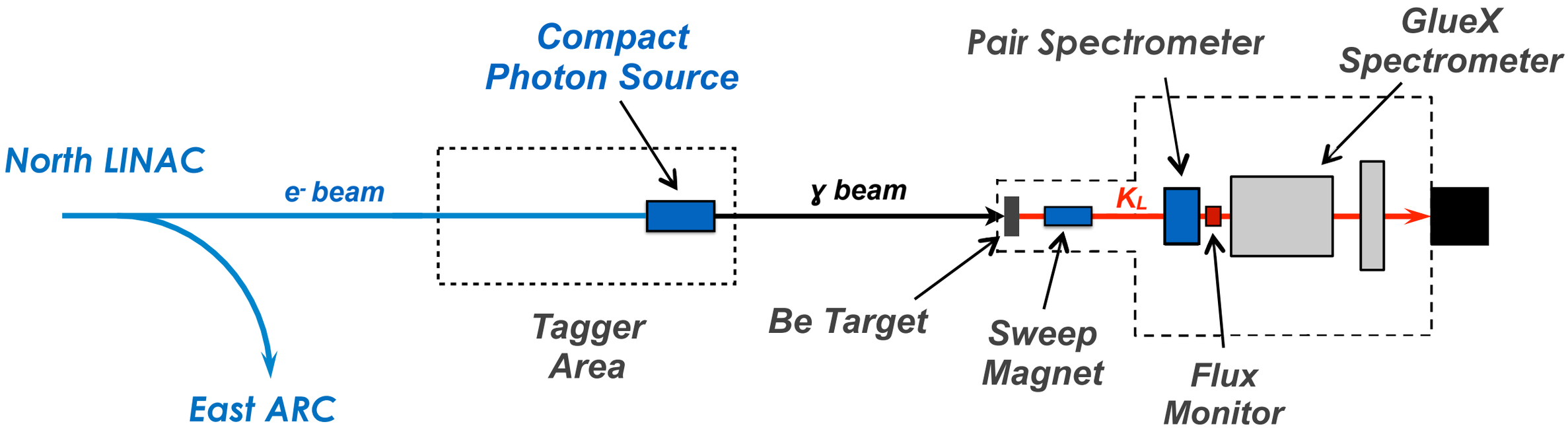
-It will certainly improve still conflictive determination of heavy K*'s parameters

-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

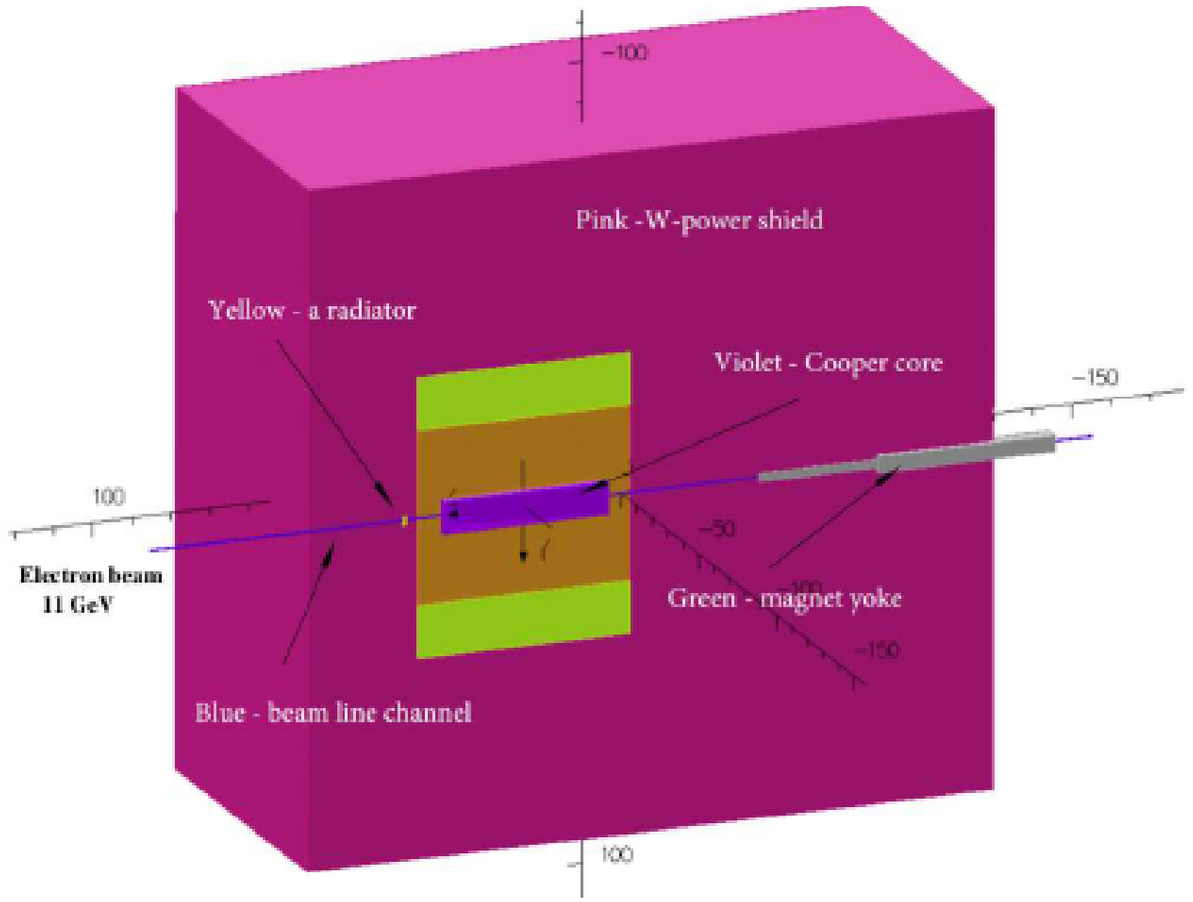
$E_e = 12\ GeV$	$I = 5\ \mu A$
Bunch spacing	$64\ ns$

No major problems.

Doable !

Confirmed by accelerator experts

Compact Photon Source

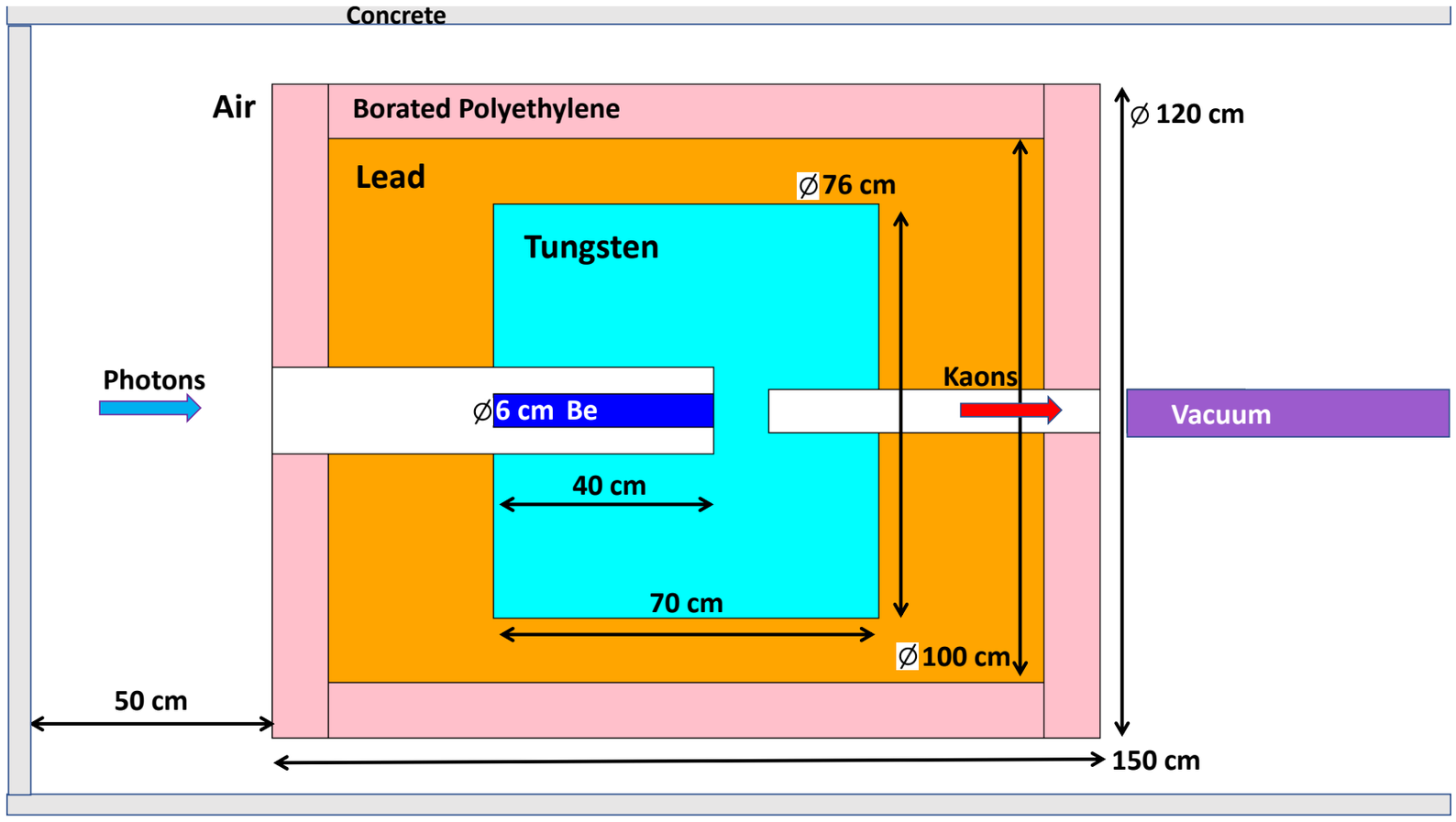


Conceptual design is completed for Halls A&C

The details of the CPS are designed by the CPS Collaboration

Meets RadCon Radiation Requirements

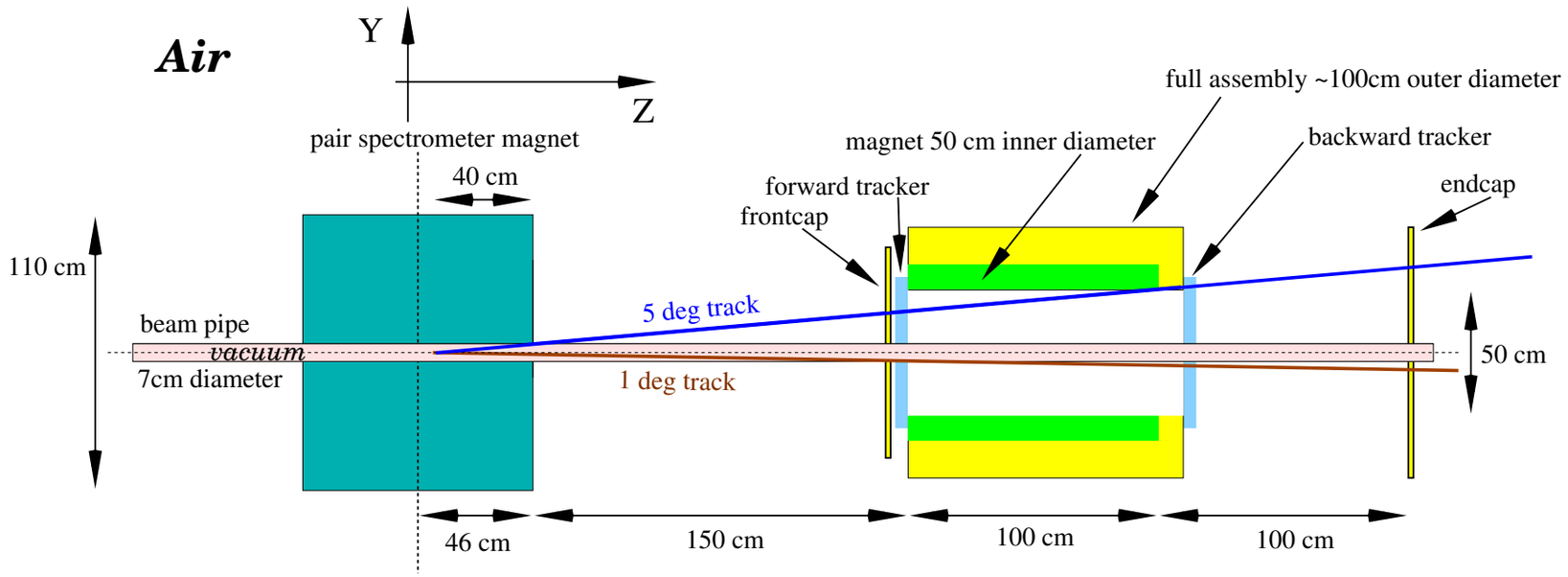
Be Target Assembly: Conceptual Design

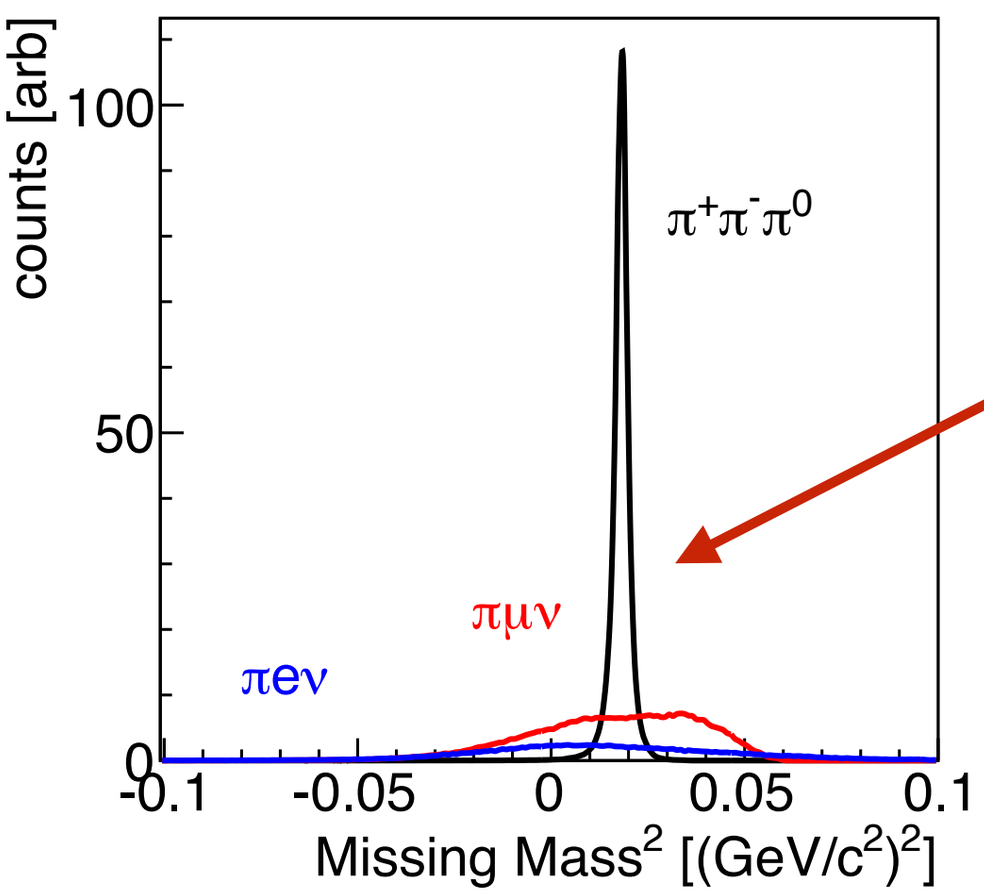


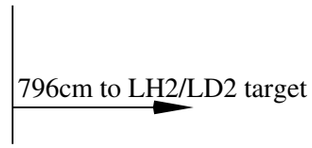
-Meets RadCon Radiation Requirements

-Conceptual Design Endorsed by Hall-D Engineering Staff

Flux Monitor





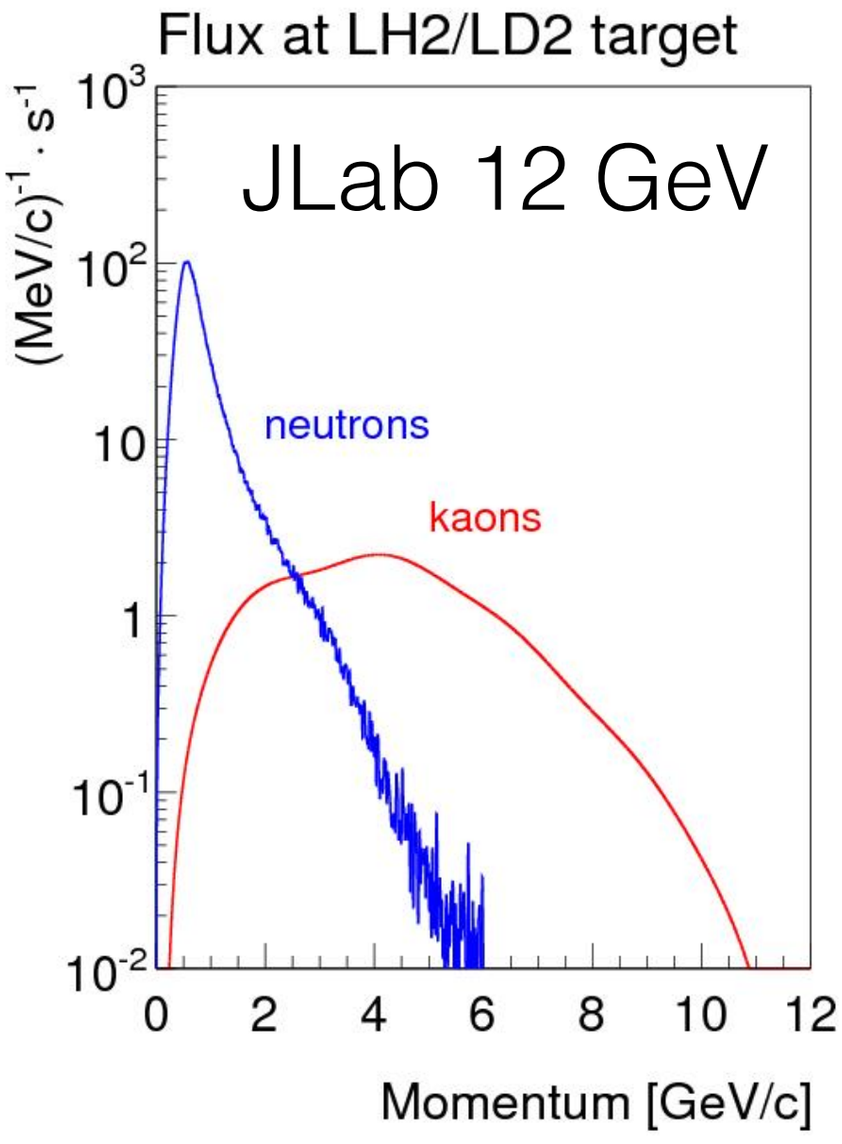


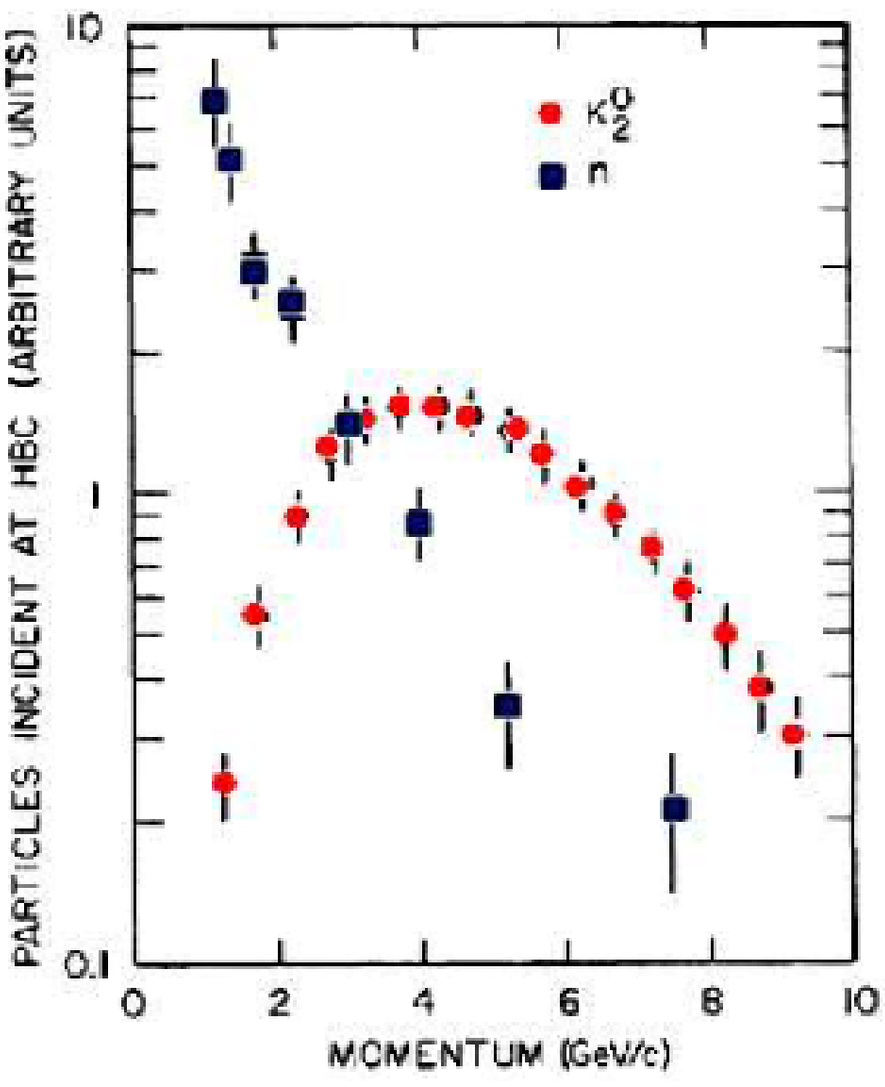
Reconstructed K_L mass

Flux measurement stat. err. <1%

Estimated syst. err. ~5%

K_L Beam Flux



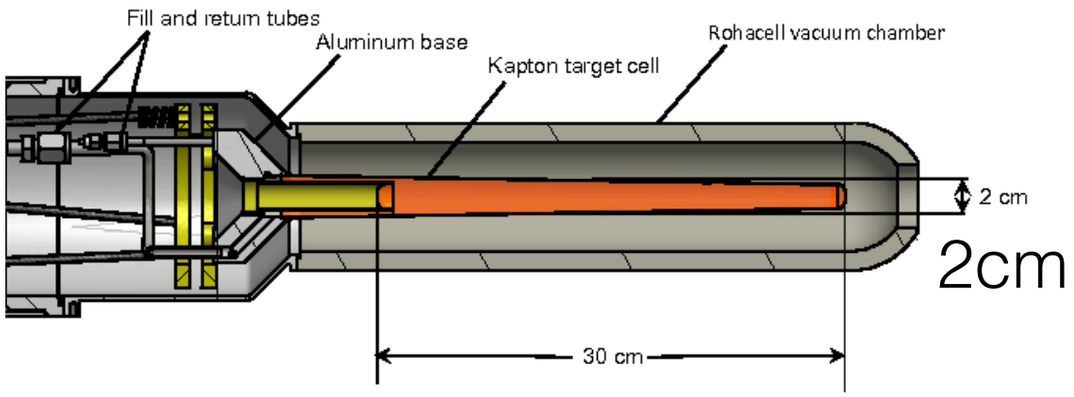


$$N(K_L)/sec \sim 10^4$$

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

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

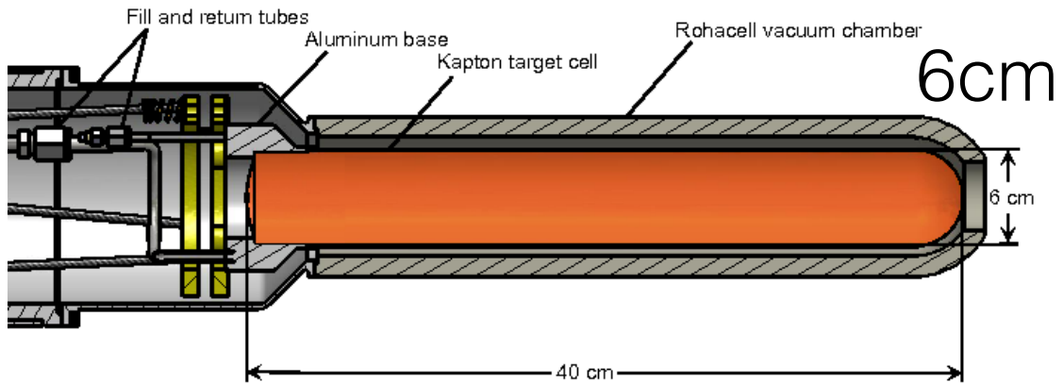
The GlueX liquid hydrogen target.



2cm

30cm

Current



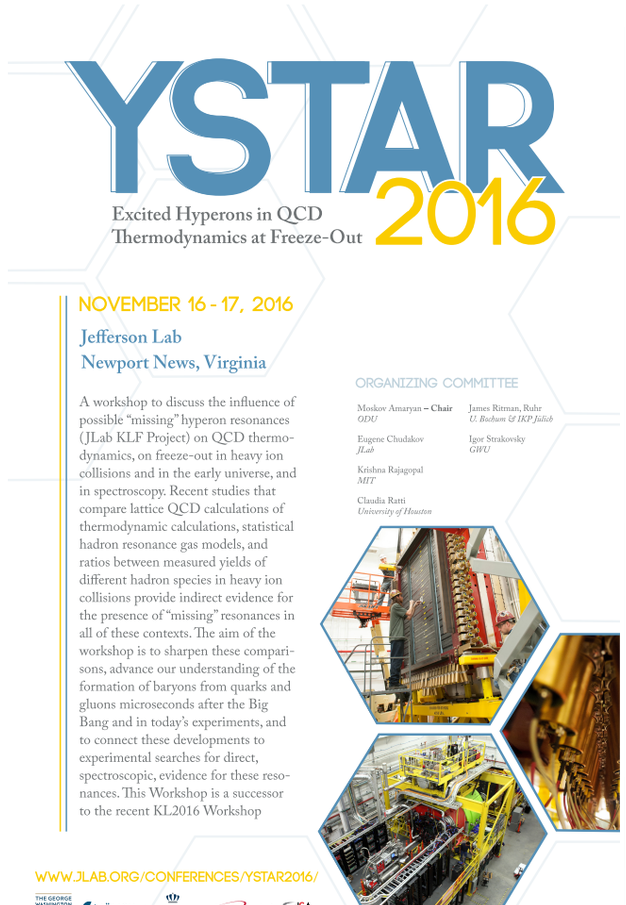
6cm

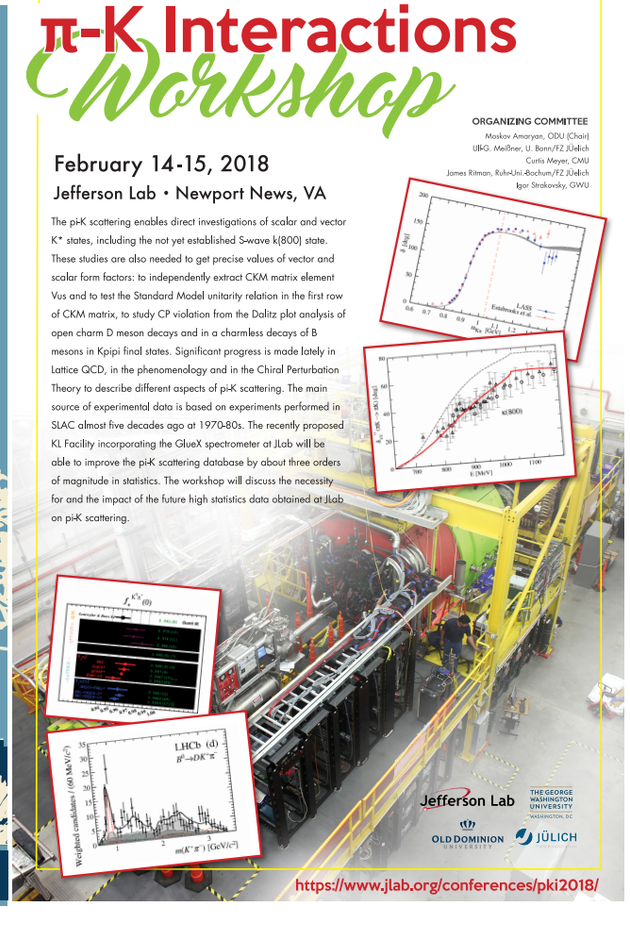
40cm

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 κ

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.

Thank you !

Date: June 14, 2019

Proposal for JLab PAC47

Strange Hadron Spectroscopy with Secondary K_L Beam in Hall D

Experimental Support:

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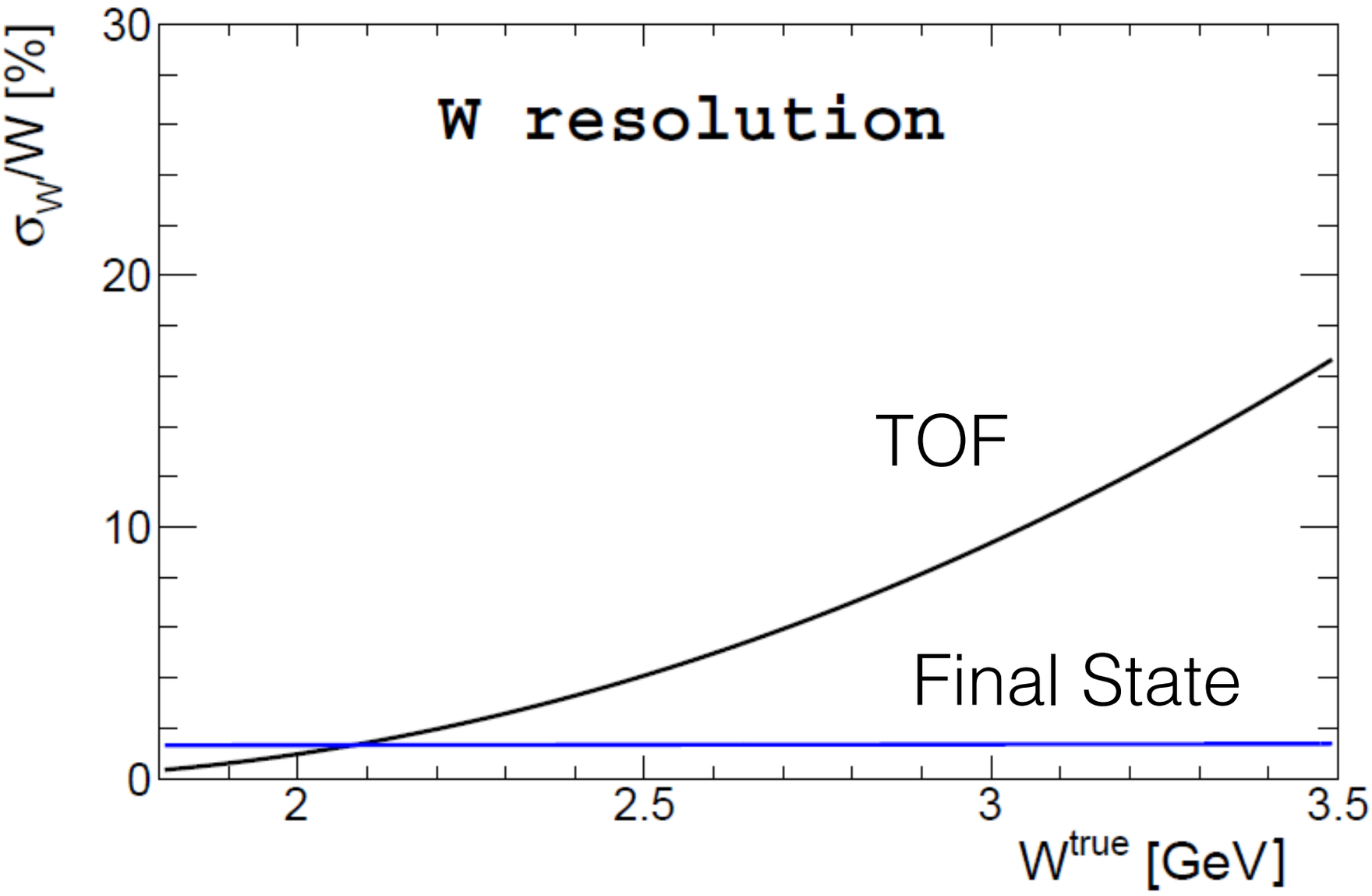
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σ_W/W [%]
30
20
10
0
2
2.5
3
3.5
W^{true} [GeV]
TOF
Final State