K-long Facility in Hall D

Moskov Amaryan
Old Dominion University

Outline

-Introduction

-Physics Motivation

- Hyperon Spectroscopy

- Strange Meson Spectroscopy

- Early Universe

- Search for Exotics

-K_L Facility Beamline and Hardware

- Electron Beam

- Compact Photon Source

- Be Target

- Flux Monitor

- K_L Beam

- LH_2/LD_2 Target

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Summary

48th PROGRAM ADVISORY COMMITTEE (PAC 48)

August 10-14, 2020

September 25, 2020

U.S. DEPARTMENT OF **ENERGY**

JSA

Prepared for the U.S. Department of Energy
under Contract DE-AC05-06OR23177

Recommendations

Number	Contact Person	Title	Hall	Days Req'd	Days Awarded	Scientific Rating	PAC Decision	Topic
		PAC 48 SUMMARY OF RECOMMENDATIONS						
C12-18-005	M. Boer	Timelike Compton Scattering Off Transversely Polarized Proton	C	50			**C2**	4
C12-19-001	M. Amarian	Strange Hadron Spectroscopy with Secondary KL Beam in Hall D	D	200	200	A-	**Approved**	1
C12-19-002	T. Gogami	High accuracy measurement of nuclear masses of Lambda hyperhydrogens	A	13.5			**C2**	5
PR12-20-001	J. Bernauer	Dark Light: Search for New Physics in e+e- Final States Near an Invariant Mass of 17 MeV Using the CEBAF Injector	INJ	55			**Deferred**	6
PR12-20-002	R. Milner	A Program of Spin-Dependent Electron Scattering from a Polarized He-3 Target in CLAS12	B	30	30	A-	**C1**	4
PR12-20-003	L. Tang	Extension request for E12-17-003: Determining the unknown Lambda-n interaction by investigating the Lambda-nn resonance	A	8.5			**C2**	5
PR12-20-004	A. Gasparian	PRad-II: A New Upgraded High Precision Measurement of the Proton Charge Radius	B	40	40	A	**C1**	2
PR12-20-005	H. Szumila-Vance	Precision measurements of A=3 nuclei in Hall B	B	60	60	A-	**Approved**	5
PR12-20-006	A. Gasparian	Precision Deuteron Charge Radius Measurement with Elastic Electron-Deuteron Scattering	B	40			**Deferred**	2
PR12-20-007	W. Li	Backward-angle Exclusive pi0 Production above the Resonance Region	C	29.4	29	B	**Approved**	4
PR12-20-008	A. Puckett	Polarization Transfer in Wide-Angle Charged Pion Photoproduction	A	2	2	B+	**Approved**	4
PR12-20-009	E. Voutier	Beam charge asymmetries for Deeply Virtual Compton Scattering on the proton at CLAS12	B	100			**C2**	4
PR12-20-010	E. Fuchey	Measurement of the Two-Photon Exchange Contribution to the Electron-Neutron Elastic Scattering Cross Section	A	2	2	A-	**Approved**	2
PR12-20-011	A. Deur	Measurement of the high-energy contribution to the Gerasimov-Drell-Hearn sum rule	D	29	33	A-	**Approved**	3

Title: Strange Hadron Spectroscopy with Secondary KL 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, are 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 proponents have answered all questions outlined in the PAC47 report. Substantial progress has been made on the issues of simulations: details on backgrounds and background reactions have been demonstrated, a demonstration of partial wave analysis for hyperon production was given. The proponents have demonstrated the measuring technique of missing mass reconstruction, allowing them to extend the measuring range both regarding small, four-momentum transfers and isospin decomposition. No show stoppers have been pointed out by the PAC.

Issues: The PAC strongly recommends that the collaboration intensify their cooperation on two issues. (1) Coordinated leadership must be established together with the host laboratory to address the various technical issues connected with the R&D efforts and construction of the K_L beam. (2) Continuous cooperation with PAC and associated members is recommended for the development of tools to master the challenges connected with the clean extraction of $K\pi$ scattering, the identification of the exchange processes at small momentum transfers, and the amplitude analysis for Δ final states.

Summary: The future K_L 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 2019 White Paper. The collaboration should now devote all its energy to turn this challenging project into an experimental facility and in parallel prepare for a successful data analysis.

This happens because of strong support from the KLF Collaboration

New Collaborators from Japan and China

comprised of 160 physicists from 68 Universities across 19 countries worldwide

Strange Hadron Spectroscopy with Secondary K_L Beam in Hall D

Experimental Support:

Shankar Adhikari[43], Moskov Amaryan (Contact Person, Spokesperson)[43], Arshak Asaturyan[1], Alexander Austregesilo[49], Marouen Baalouch[8], Mikhail Bashkanov (Spokesperson)[63], Vitaly Baturin[43], Vladimir Berdnikov[11,35], Olga Cortes Becerra[19], Timothy Black[60], Werner Boeglin[13], William Briscoe[19], William Brooks[54], Volker Burkert[49], Eugene Chudakov[49], Geraint Clash[63], Philip Cole[32], Volker Crede[14], Donal Day[61], Pavel Degtyarenko[49], Alexandre Deur[49], Sean Dobbs (Spokesperson)[14], Gail Dodge[43], Anatoly Dolgolenko[26], Simon Eidelman[6,41], Hovanes Egiyan (JLab Contact Person)[49], Denis Epifanov[6,41], Paul Eugenio[14], Stuart Fegan[63], Alessandra Filippi[25], Sergey Furletov[49], Liping Gan[60], Franco Garibaldi[24], Ashot Gasparian[39], Gagik Gavalian[49], Derek Glazier[18], Colin Gleason[22], Vladimir Goryachev[26], Lei Guo[14], David Hamilton[11], Avetik Hayrapetyan[17], Garth Huber[53], Andrew Hurley[56], Charles Hyde[43], Isabella Illari[19], David Ireland[18], Igal Jaegle[49], Kyungseon Joo[57], Vanik Kakoyan[1], Grzegorz Kalicy[11], Mahmoud Kamel[13], Christopher Keith[49], Chan Wook Kim[19], Eberhard Klemp[5], Geoffrey Krafft[49], Sebastian Kuhn[43], Sergey Kuleshov[2], Alexander Laptev[33], Ilya Larin[26,59], David Lawrence[49], Daniel Lersch[14], Wenliang Li[56], Kevin Luckas[28], Valery Lyubovitskij[50,51,52,54], David Mack[49], Michael McCaughan[49], Mark Manley[30], Hrachya Marukyan[1], Vladimir Matveev[26], Mihai Mocanu[63], Viktor Mokeev[49], Curtis Meyer[9], Bryan McKinnon[18], Frank Nerling[15,16], Matthew Nicol[63], Gabriel Niculescu[27], Alexander Ostrovidov[14], Zisis Papandreou[53], KiJun Park[49], Eugene Pasyuk[49], Peter Pauli[18], Lubomir Pentchev[49], William Phelps[10], John Price[7], Jörg Reinhold[13], James Ritman (Spokesperson)[28,68], Dimitri Romanov[26], Carlos Salgado[40], Todd Satogata[49], Susan Schadmand[28], Amy Schertz[56], Axel Schmidt[19], Daniel Sober[11], Alexander Somov[49], Sergei Somov[35], Justin Stevens (Spokesperson)[56], Igor Strakovsky (Spokesperson)[19], Victor Tarasov[26], Simon Taylor[49], Annika Thiel[5], Guido Maria Urciuoli[24], Holly Szumila-Vance[19], Daniel Watts[63], Lawrence Weinstein[43], Timothy Whitlatch[49], Nilanga Wickramaarachchi[43], Bogdan Wojtsekhowski[49], Nicholas Zachariou[63], Jonathan Zarling[53], Jixie Zhang[61]

Theoretical Support:

Alexey Anisovich[5,44], Alexei Bazavov[38], Rene Bellwied[21], Veronique Bernard[42], Gilberto Colangelo[3], Aleš Cieplý[46], Michael Döring[19], Ali Eskanderian[19], Jose Goity[20,49], Helmut Haberzettl[19], Mirza Hadžimehmedović[55], Robert Jaffe[36], Boris Kopeliovich[54], Heinrich Leutwyler[3], Maxim Mai[19], Terry Mart[65], Maxim Matveev[44], Ulf-G. Meißner[5,29], Colin Morningstar[9], Bachir Moussallam[42], Kanzo Nakayama[58], Wolfgang Ochs[37], Youngseok Oh[31], Rifat Omerovic[55], Hedim Osmanović[55], Eulogio Oset[62], Antimo Palano[64], Jose Peláez[34], Alessandro Pilloni[66,67], Maxim Polyakov[48], David Richards[49], Arkaitz Rodas[49,56], Dan-Olof Riska[12], Jacobo Ruiz de Elvira[3], Hui-Young Ryu[45], Elena Santopinto[23], Andrey Sarantsev[5,44], Jugoslav Stahov[55], Alfred Švarc[47], Adam Szczepaniak[22,49], Ronald Workman[19], Bing-Song Zou[4]

:

JLAB

KLF
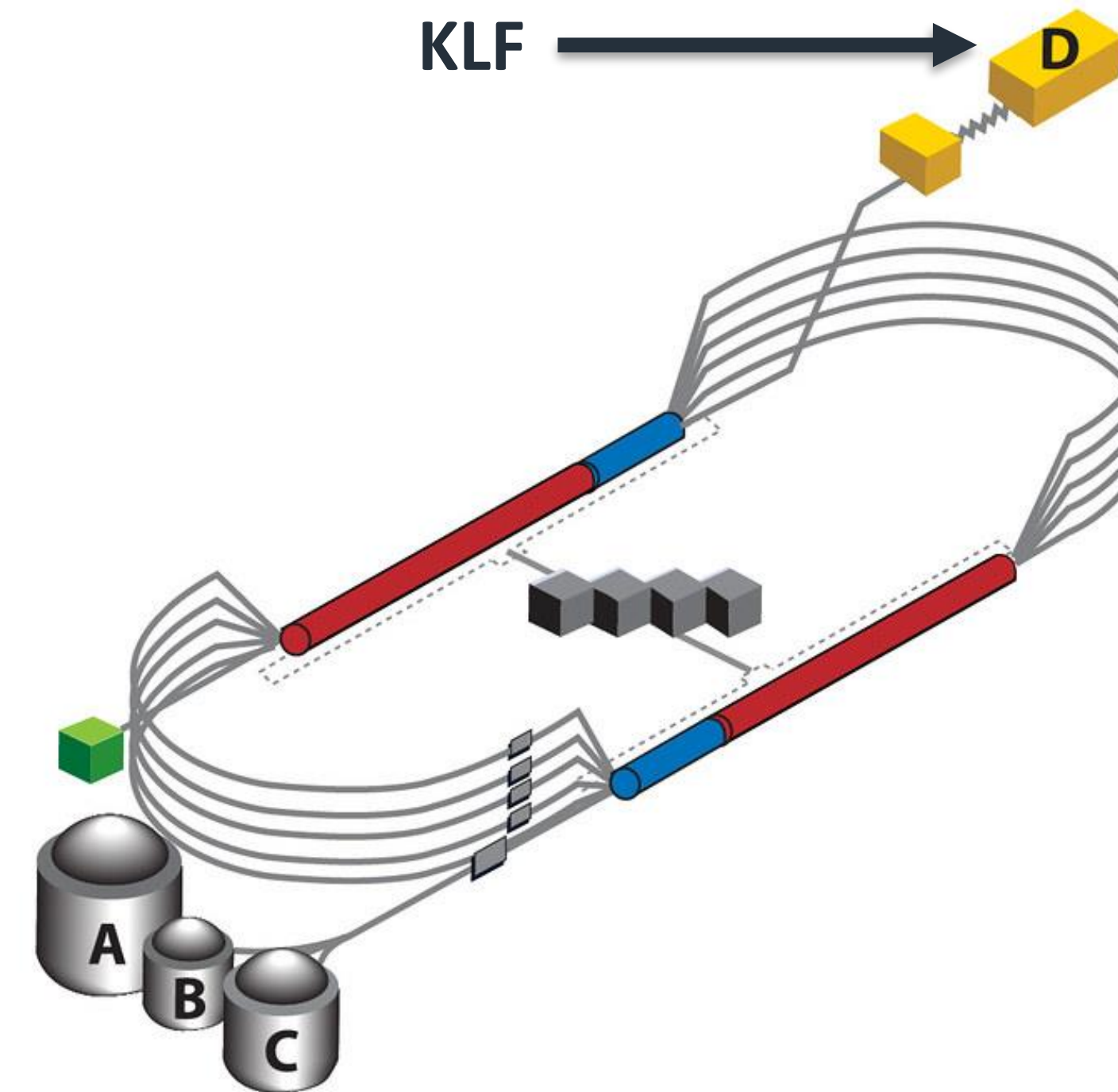
Electron Beam:
- 12 GeV
- $5\mu A$
- 128 ns bunch spacing

Hall-D beamline and GlueX Setup

https://arxiv.org/pdf/2008.08215.pdf
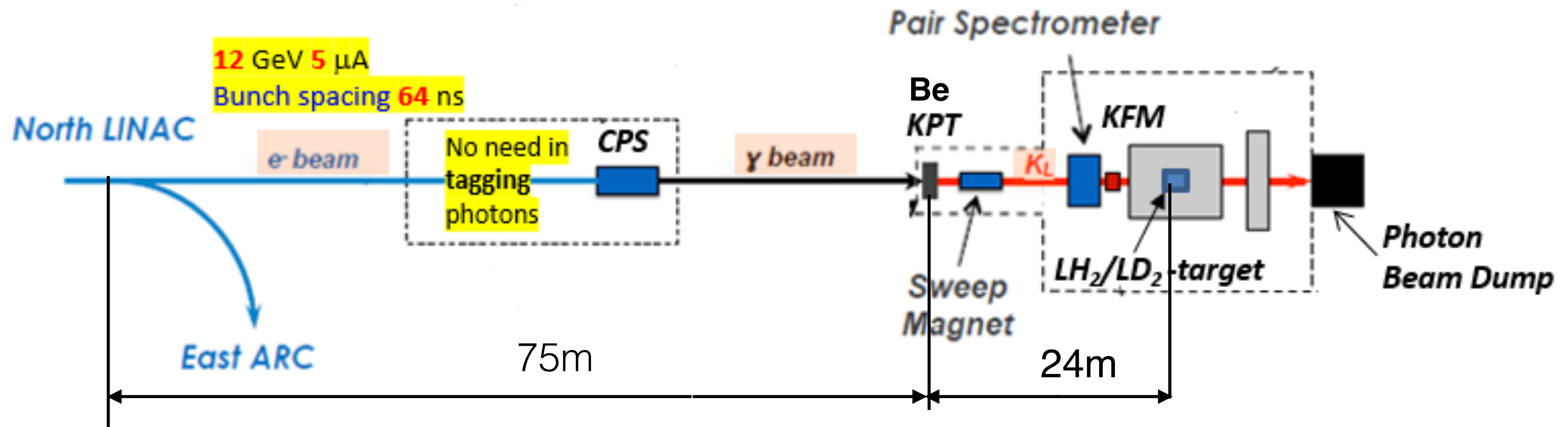
K_L Beam Flux

JLab 12 GeV   SLAC 16 GeV
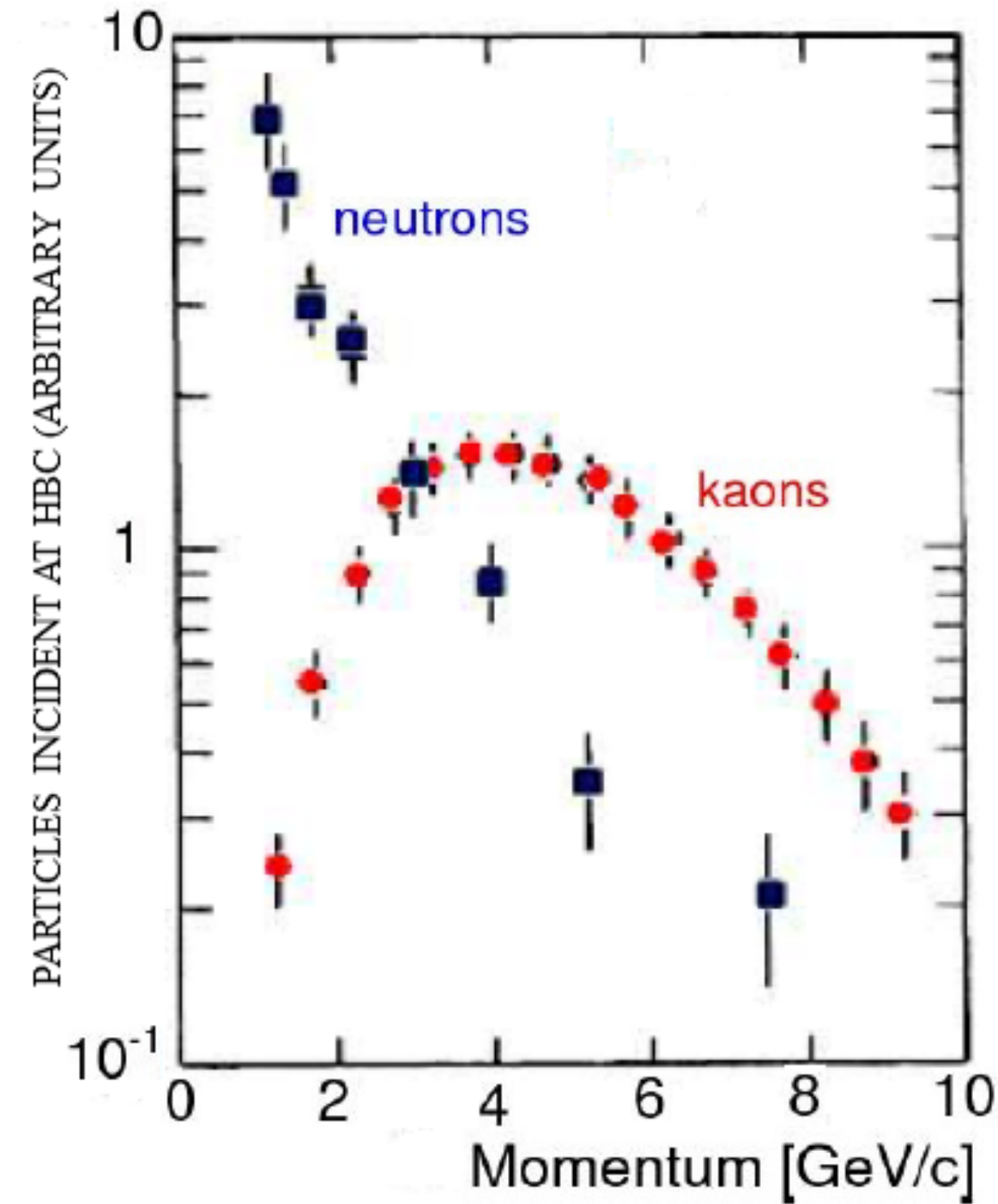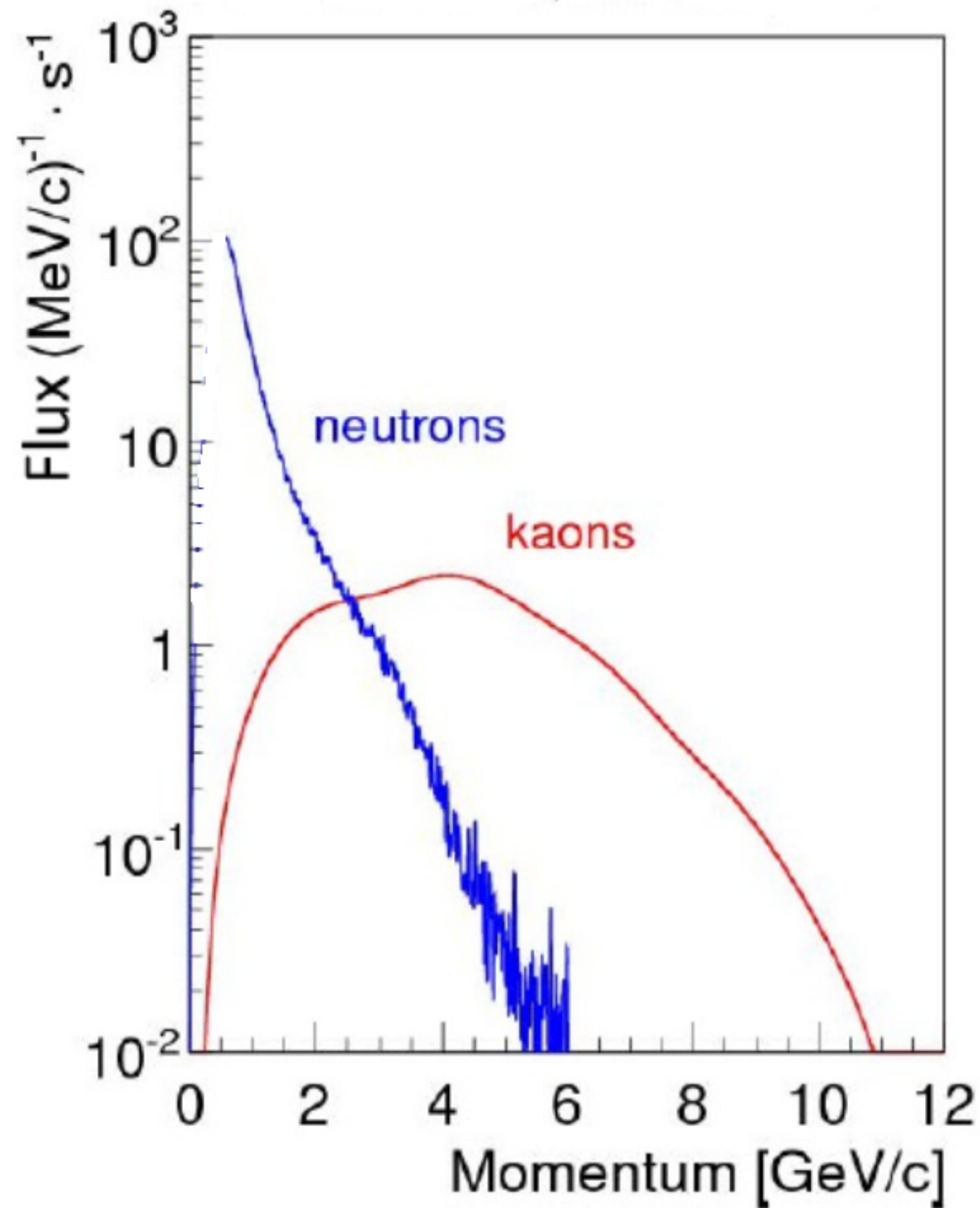
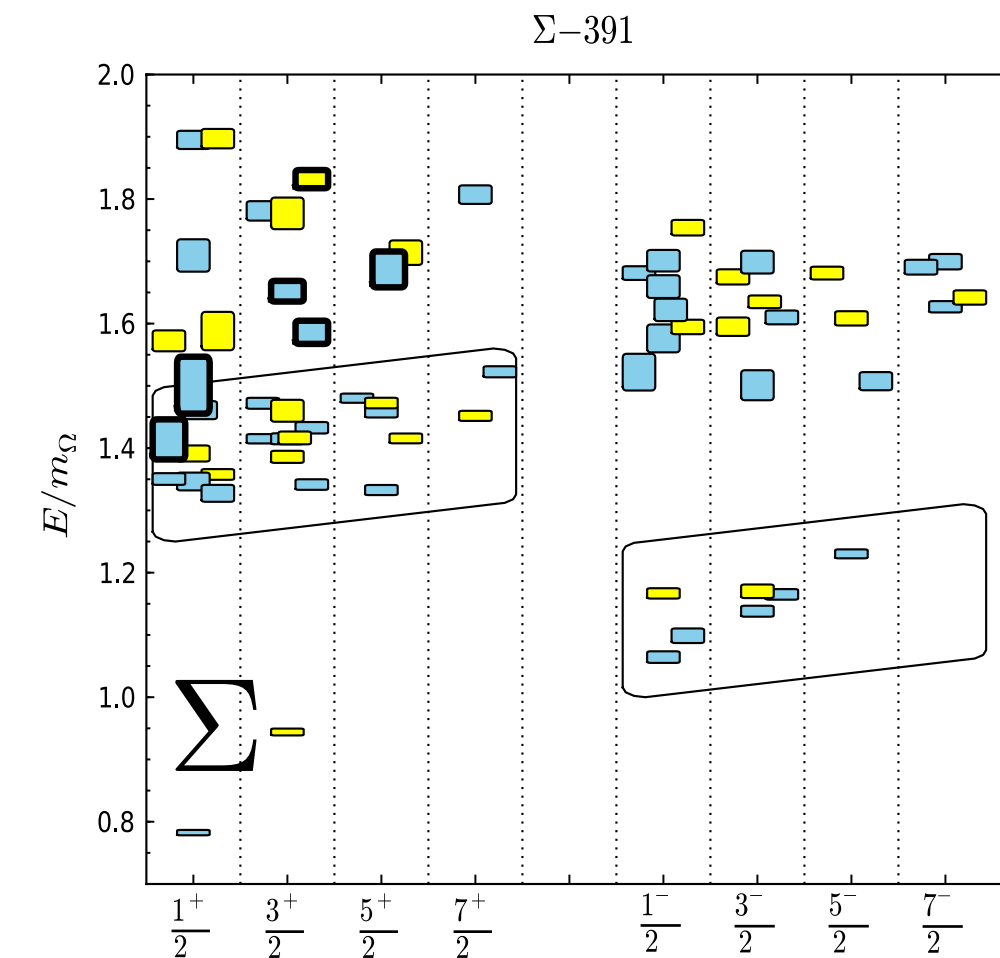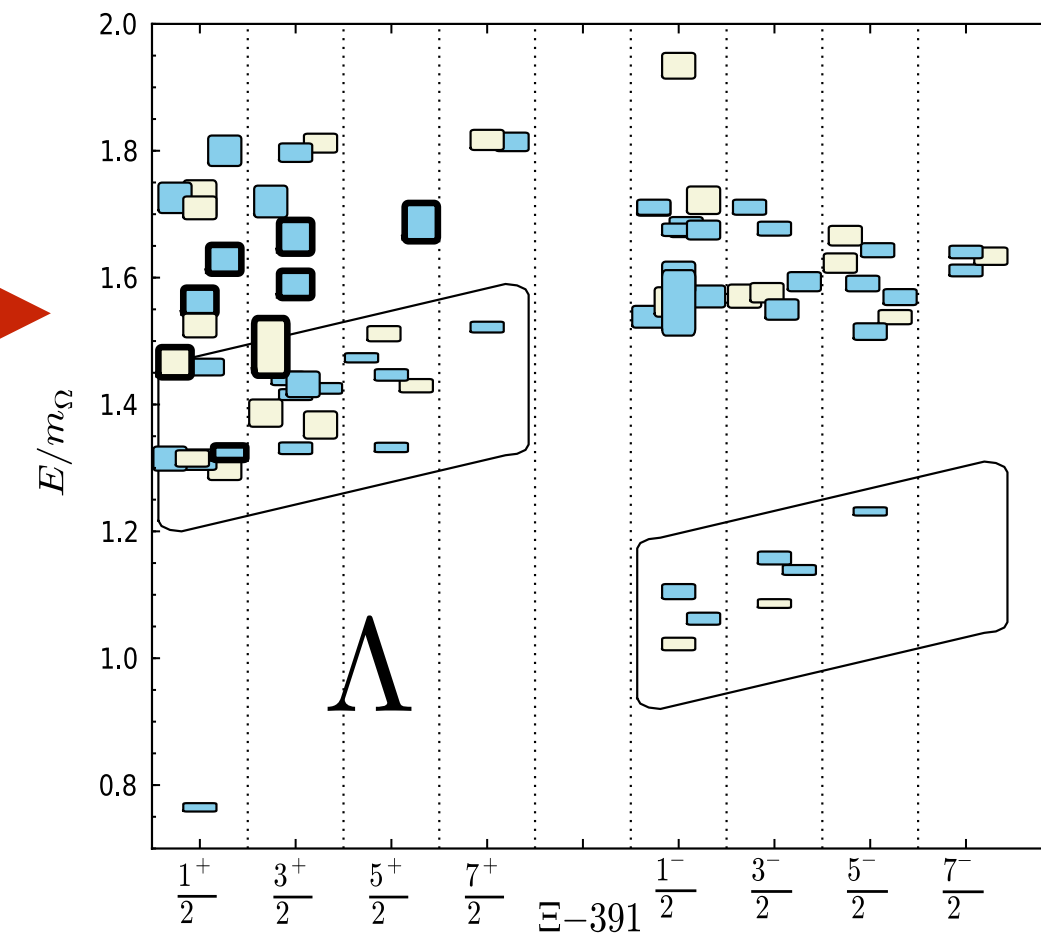$$N(K_L)/sec \sim 10^4 \quad \Longrightarrow \quad \frac{N(K_L)_{JLAB}}{N(K_L)_{SLAC}} \sim 10^3$$

Hyperon Spectroscopy

LQCD in addition to already known states

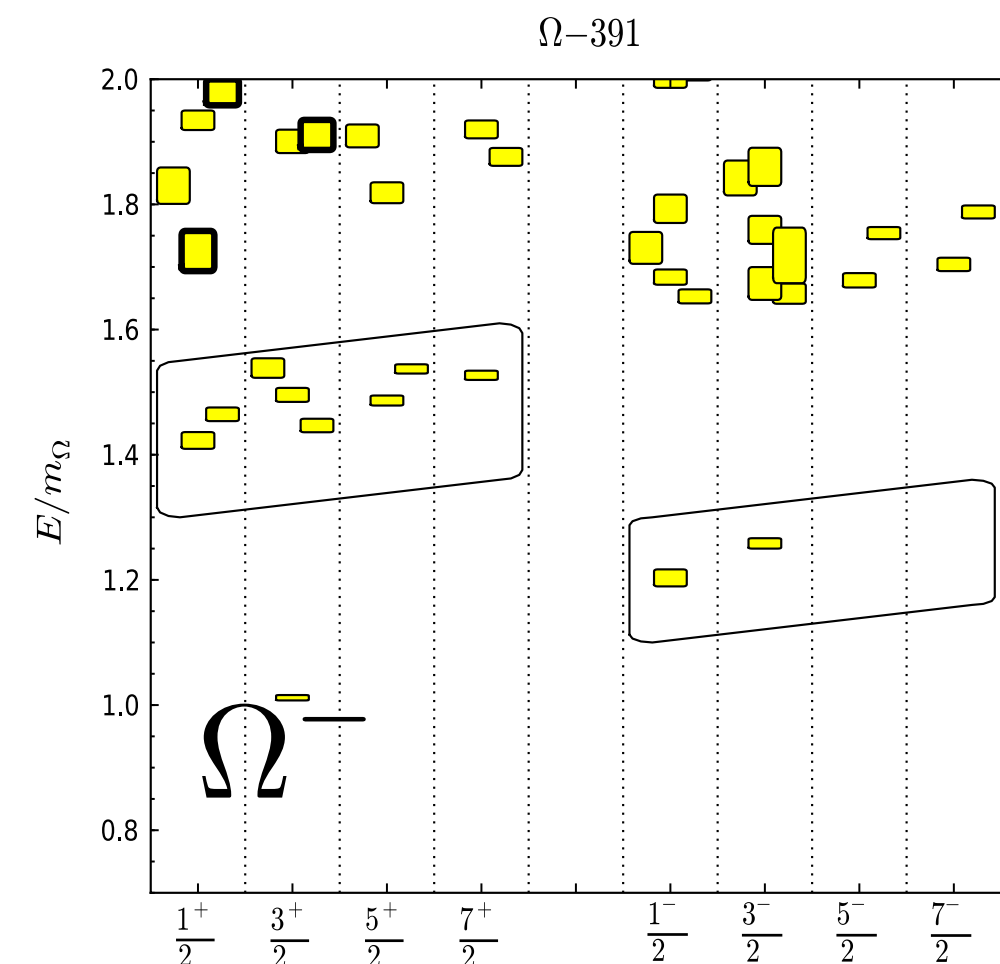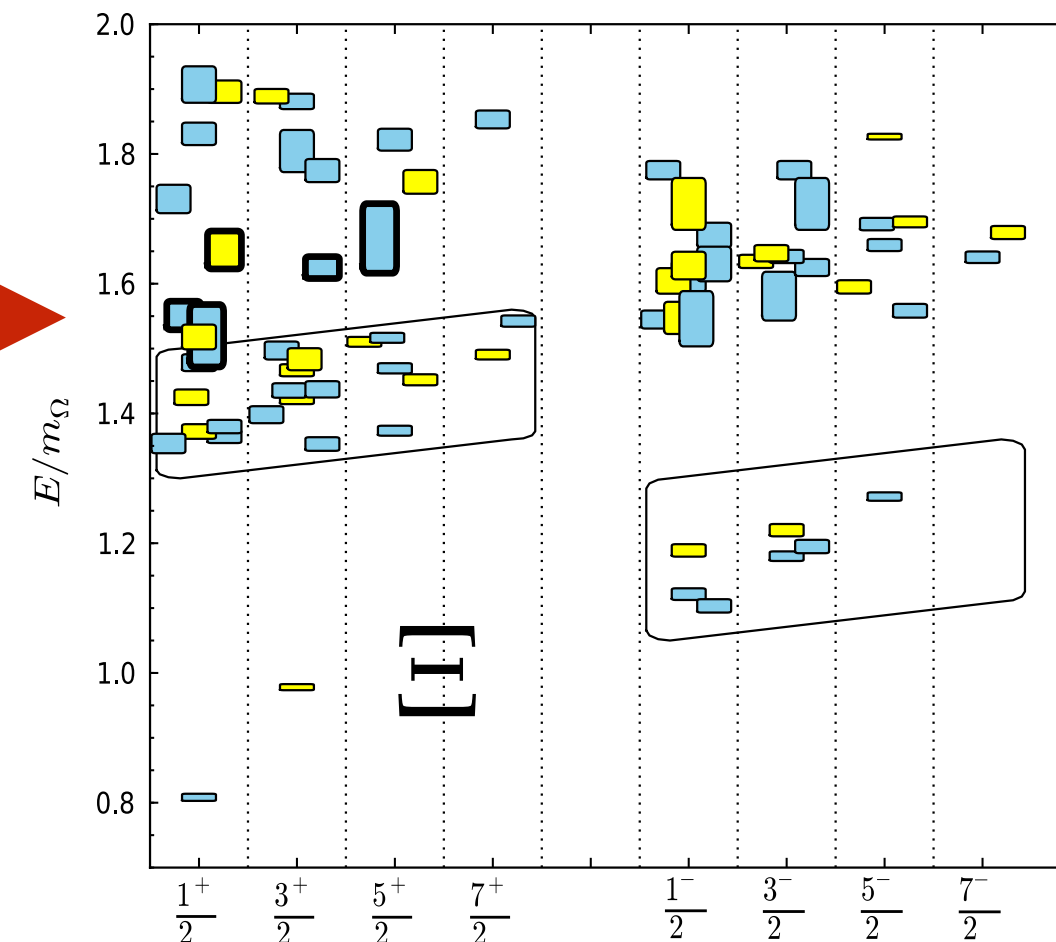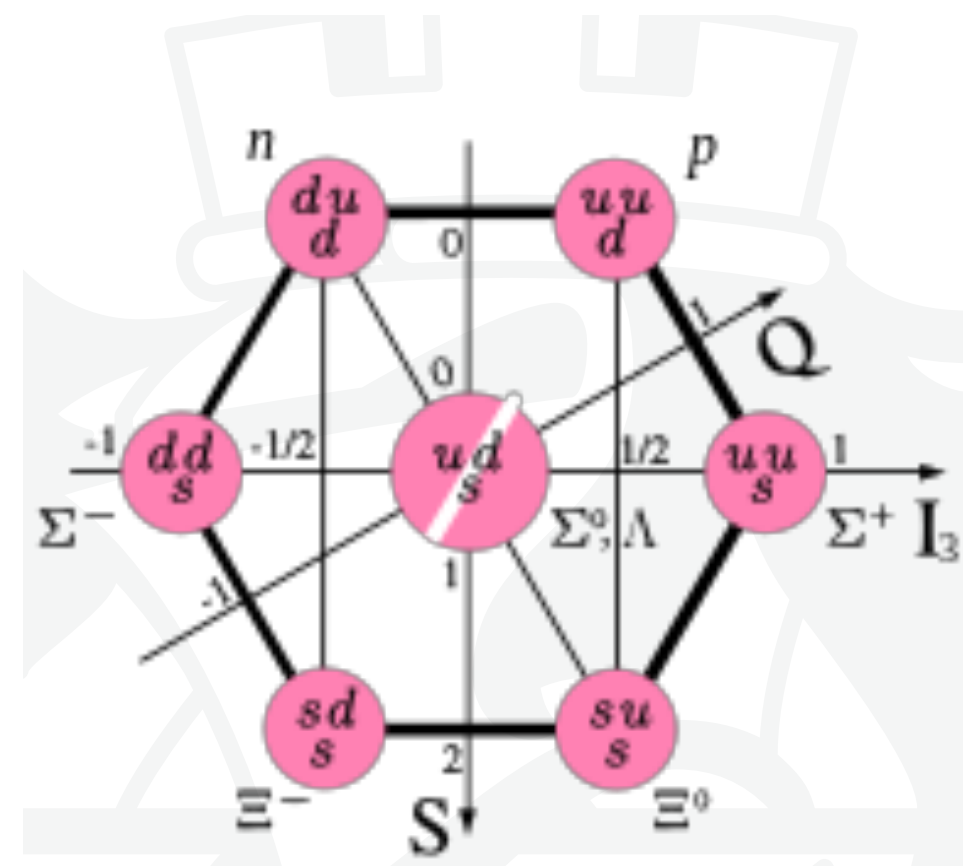*predicts many more including hybrids (thick bordered)*

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)

Octet: $N^*, \boldsymbol{\Lambda^*}, \boldsymbol{\Sigma^*}, \boldsymbol{\Xi^*}$
Decuplet: $\Delta^*, \boldsymbol{\Sigma^*}, \boldsymbol{\Xi^*}, \boldsymbol{\Omega^*}$
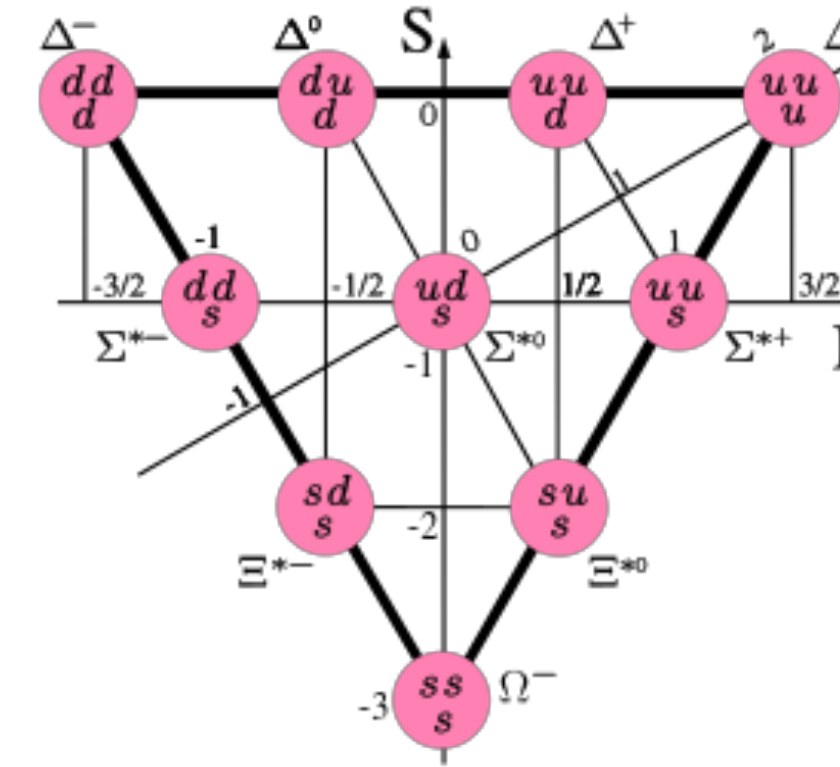
	Predicted LQCD, $M_B < 2.5\ GeV$	"Observed", PDG
N^*	64	21
Δ^*	22	12
$\boldsymbol{\Lambda^*}$	17	14
$\boldsymbol{\Sigma^*}$	43	9
$\boldsymbol{\Xi^*}$	42	6
$\boldsymbol{\Omega^*}$	24	2

212

64

Electron Beam Parameters

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

$$Bunch\ spacing \qquad 64\ ns$$

128 ns confirmed feasible
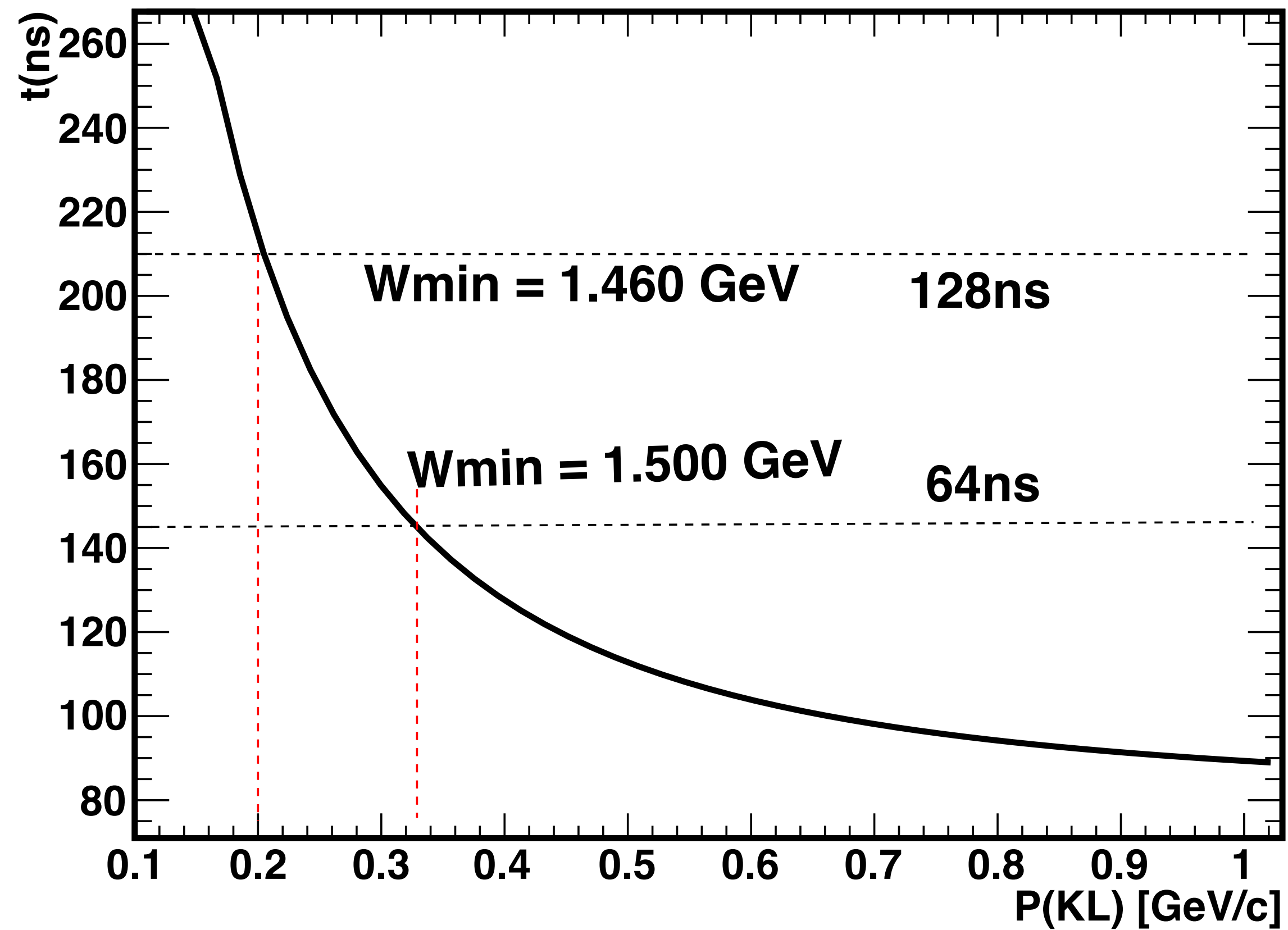
5.7 K_L Momentum Determination and Beam Resolution

The mean lifetime of the K_L is 51.16 nsec ($c\tau = 15.3$ m) whereas the mean lifetime of the K^- is 12.38 nsec ($c\tau = 3.7$ m) [1]. For this reason, it is much easier to perform measurements of $K_L p$ scattering at low beam energies compared with $K^- p$ scattering.
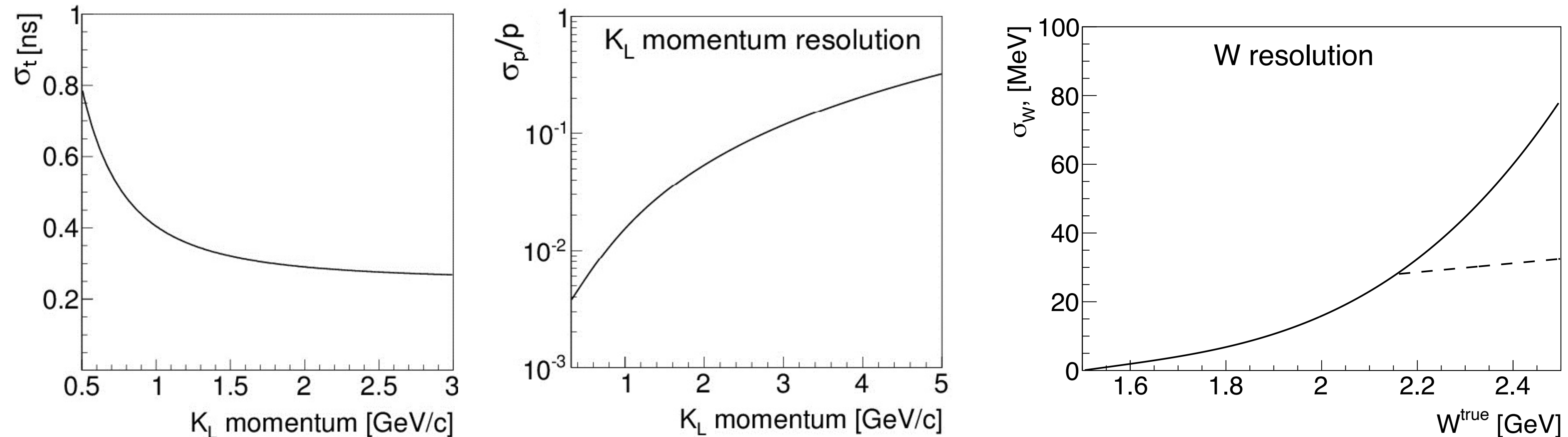
Figure 30: <u>Left</u>: Time resolution (σ_t) for K_L beam as a function of K_L-momentum. <u>Middle</u>: Momentum resolution (σ_p/p) as a function of momentum (note, log scale). <u>Right</u>: Energy resolution (σ_W) as a function of energy. The dashed line shows approximate W resolution from reconstruction of the final-state particles.

We can do it, but why should we?

- Why to use kaon beam? What is the advantage compared to electrons or photons?

- What is so special about K-long compared to charged kaon beams?

- What is the advantage of producing secondary kaon beam with EM probe, compared to the proton beam?

- How much CEBAF accelerator could make a breakthrough compared to previous results at SLAC?

- Why to do this experiment, what are we going to learn?

- How will it affect our knowledge on hyperon spectroscopy?

- What are we going to learn about strange meson spectroscopy ?

- Many more questions - some constructive and some less so - answers to which shaped the approved proposal.

2   2.5   3   3.5
W [GeV/c²]

$K_L p \rightarrow K^+ X$ $W=2.02$ GeV/c²

existing data

$K_L p \rightarrow K^+ X$ $W=2.02$ GeV/c²

$K_L p \rightarrow K^+ \Lambda X$ $W=2.02$ GeV/c²

$K_L p \rightarrow K^+ \Xi^0$ $W=2.02$ GeV/c²

KLF 100 days

$K_L p \rightarrow K^+ \Lambda X$ $W=2.02$ GeV/c²   **P$_y$**

No Data

P$_y$

$W=2.2 - 2.3$ GeV/c²

$W(GeV/c^2)$

$\cos \theta_{K+}$
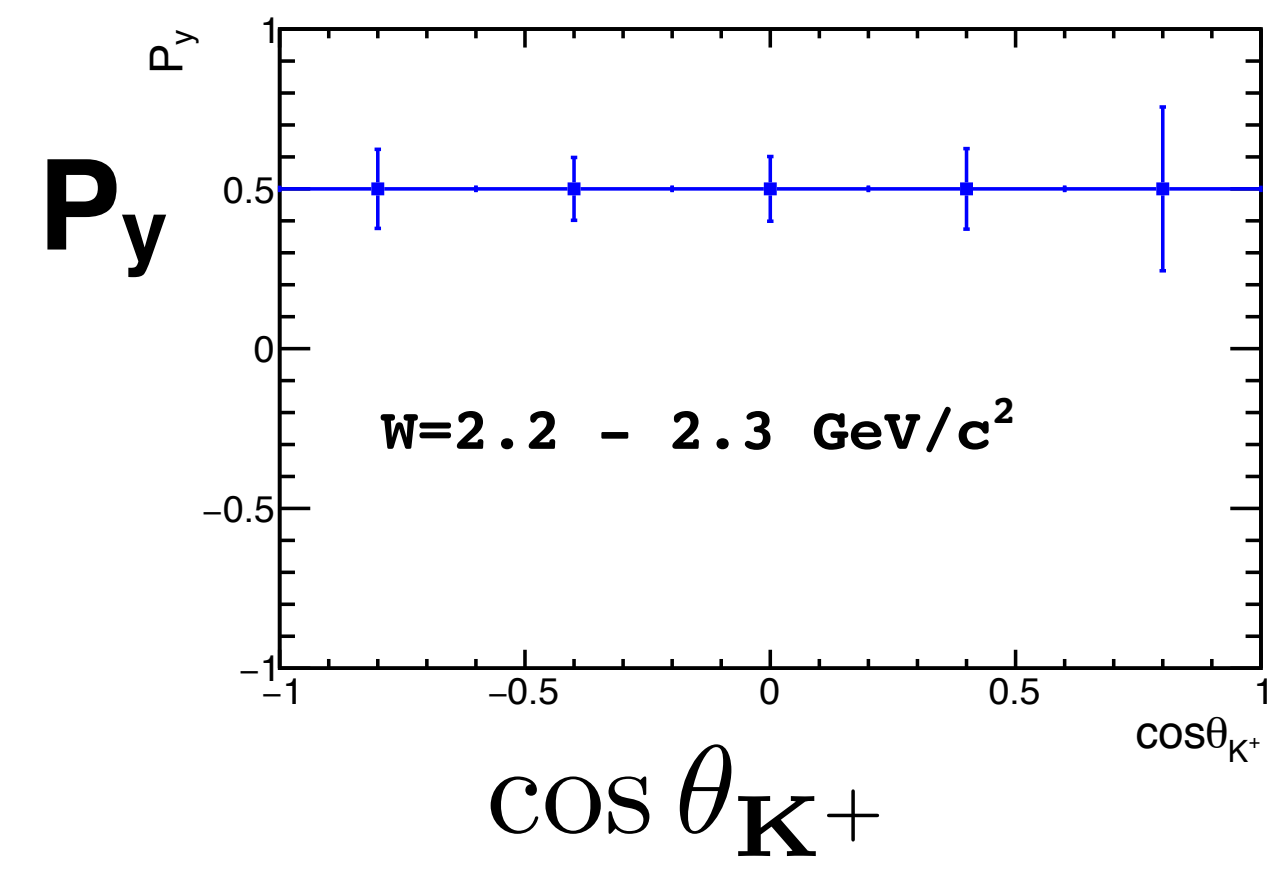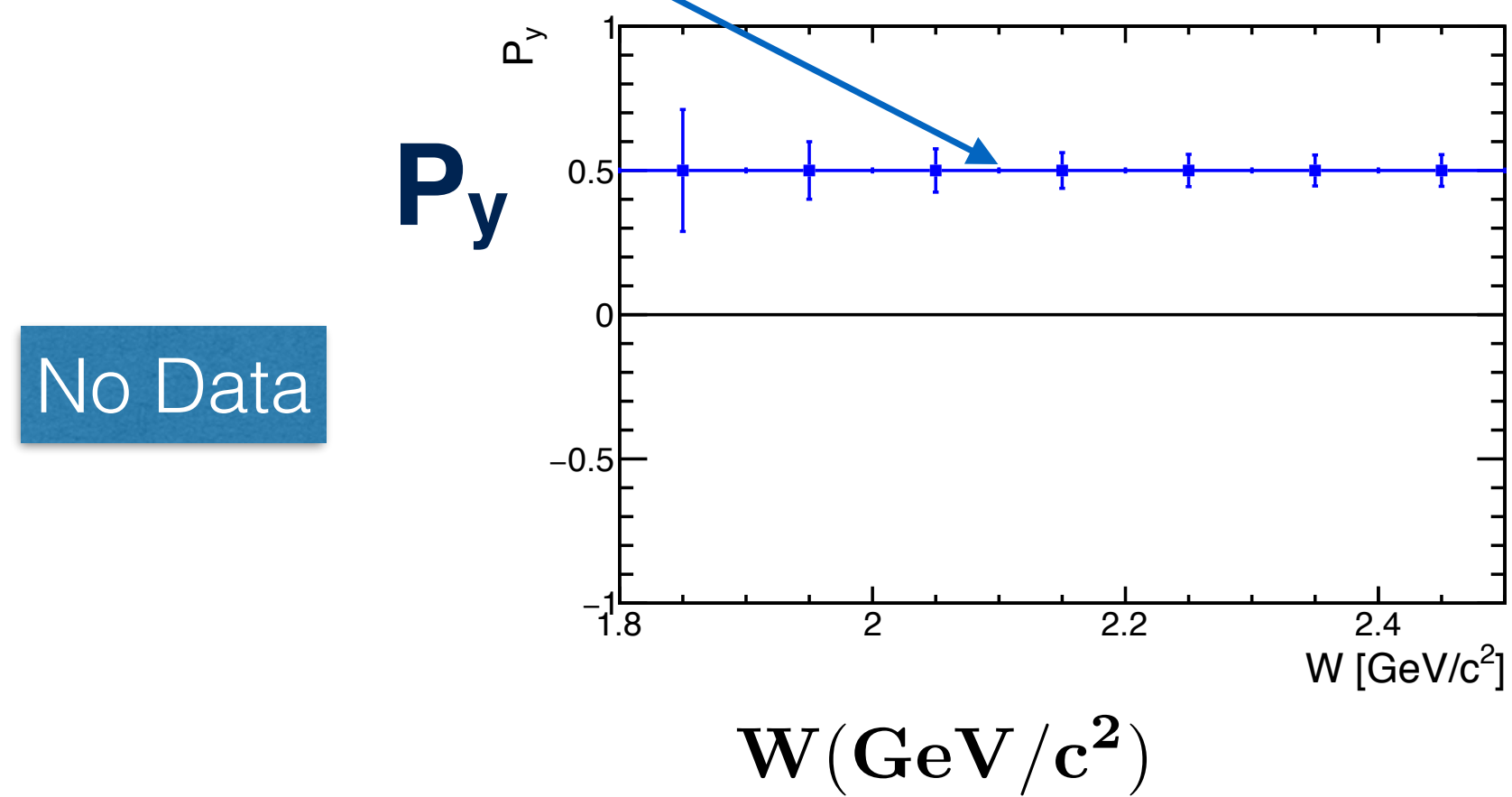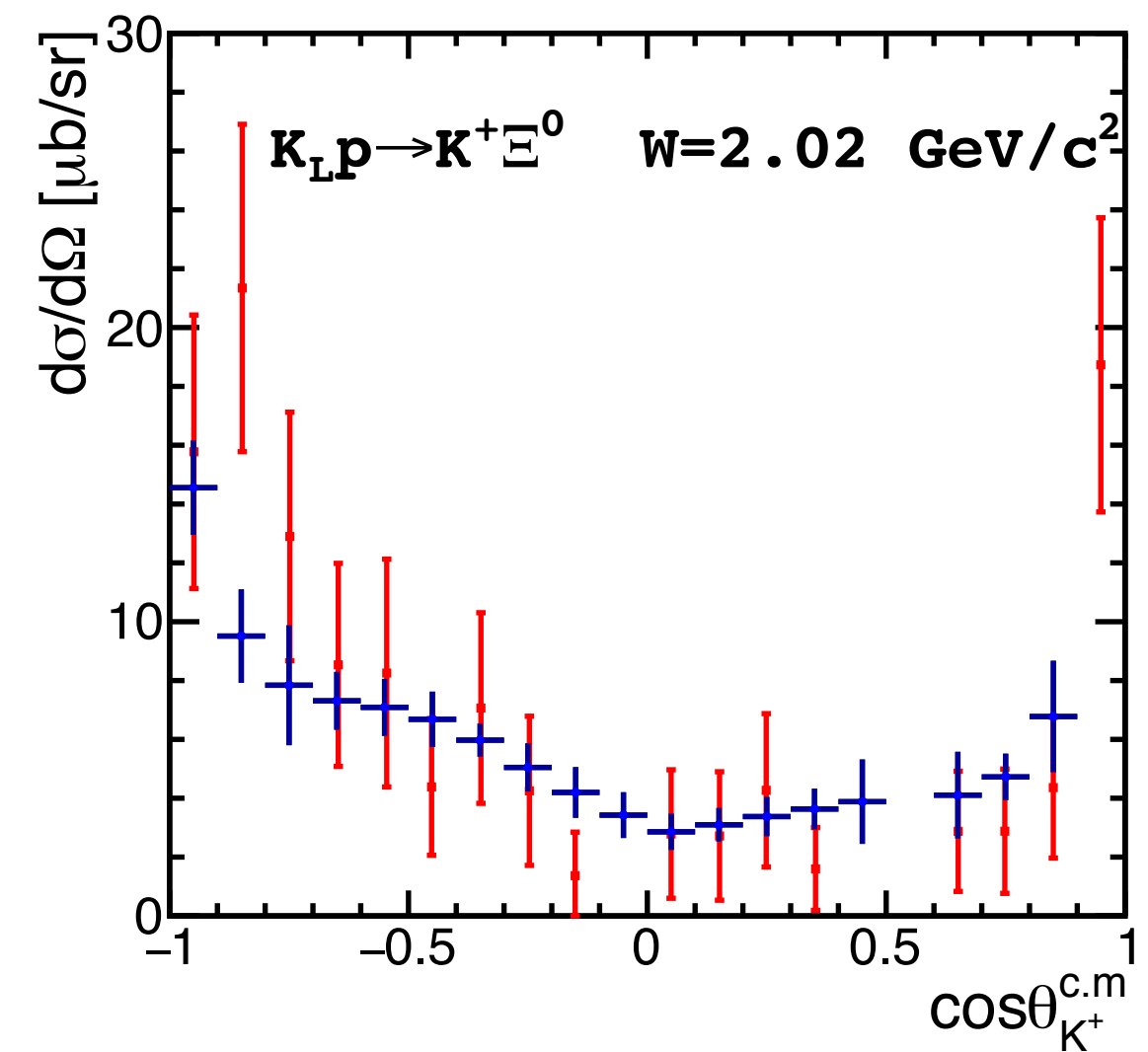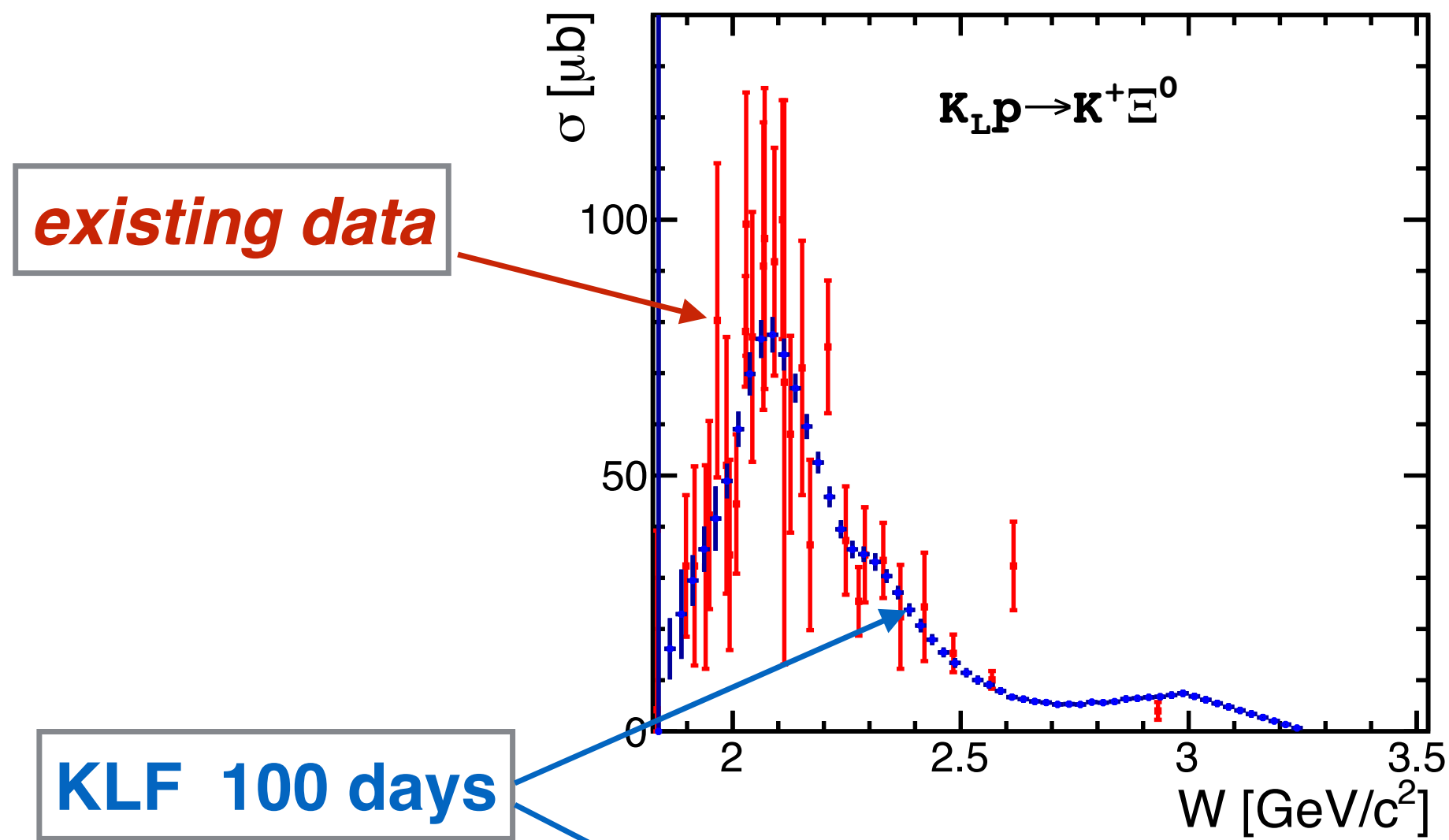
Bonn-Gatchina PWA

Total Cross Section $\quad K_L p \rightarrow K^+ \Xi^0$
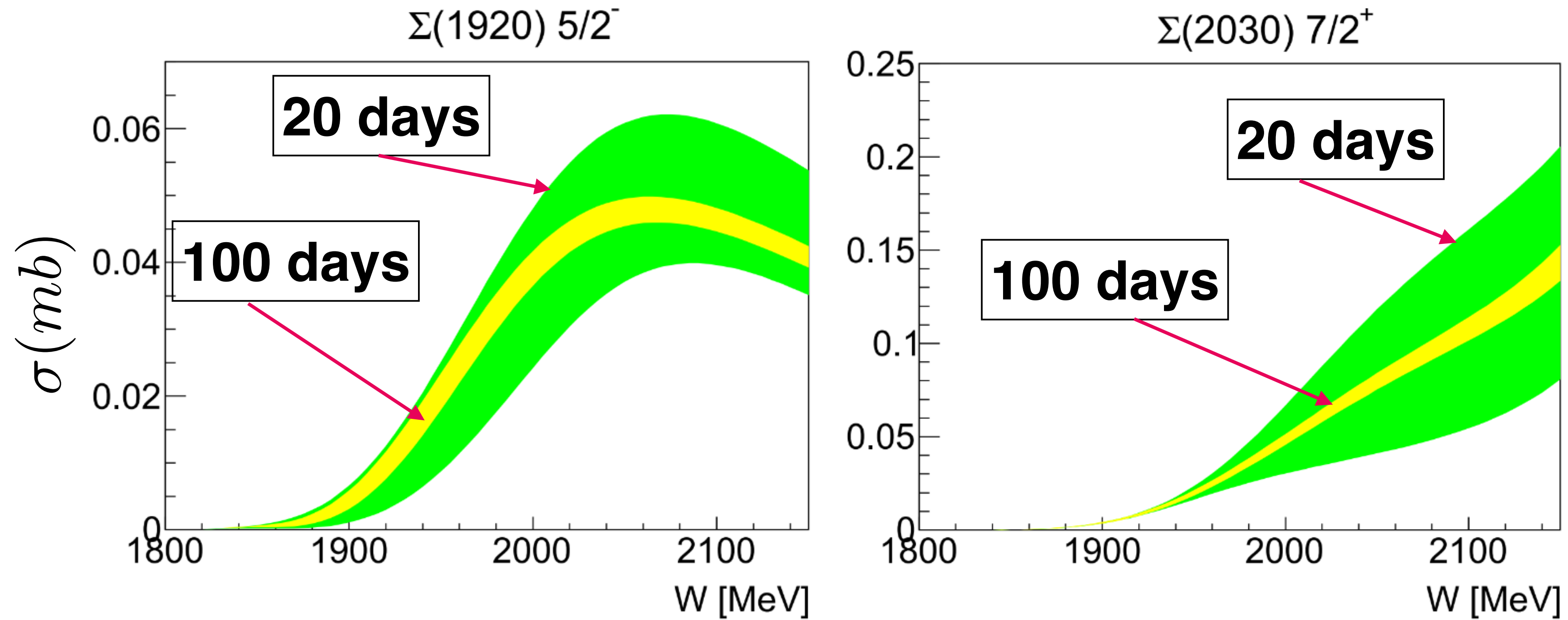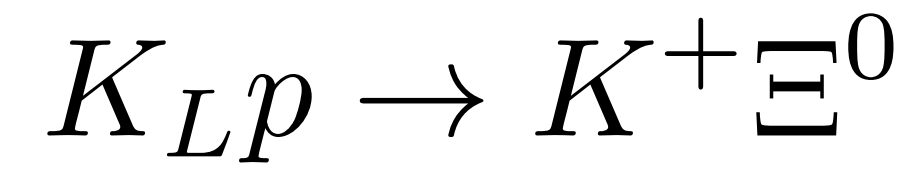
$\Sigma(1920)\ 5/2^-$

$\Sigma(2030)\ 7/2^+$

Need 100 days of running to get precise solution

Bonn-Gatchina PWA

Diff. Cross Section

Polarization

Need 100 days of running to get precise solution

Bonn-Gatchina PWA

Diff. Cross Section

Polarization

$K_L p \rightarrow \Xi^0 K^+$ (W = 1940 MeV)

20 days

100 days

$\frac{d\sigma}{d\Omega}$ [mb/sr]

$\cos(\Theta_\Xi)$

$K_L p \rightarrow \Xi^0 K^+$ (W = 1940 MeV)

Polarization

$\cos(\Theta_\Xi)$
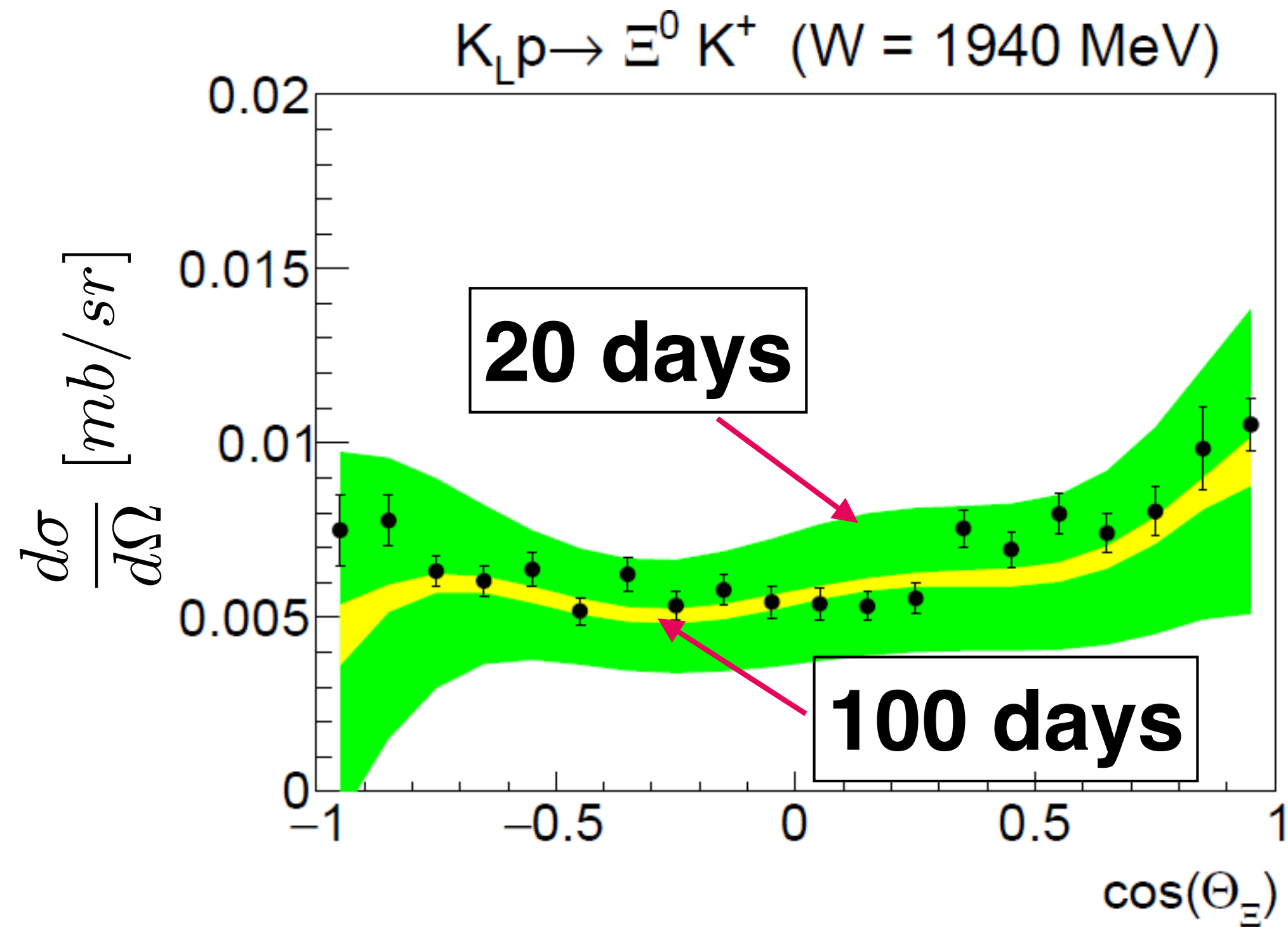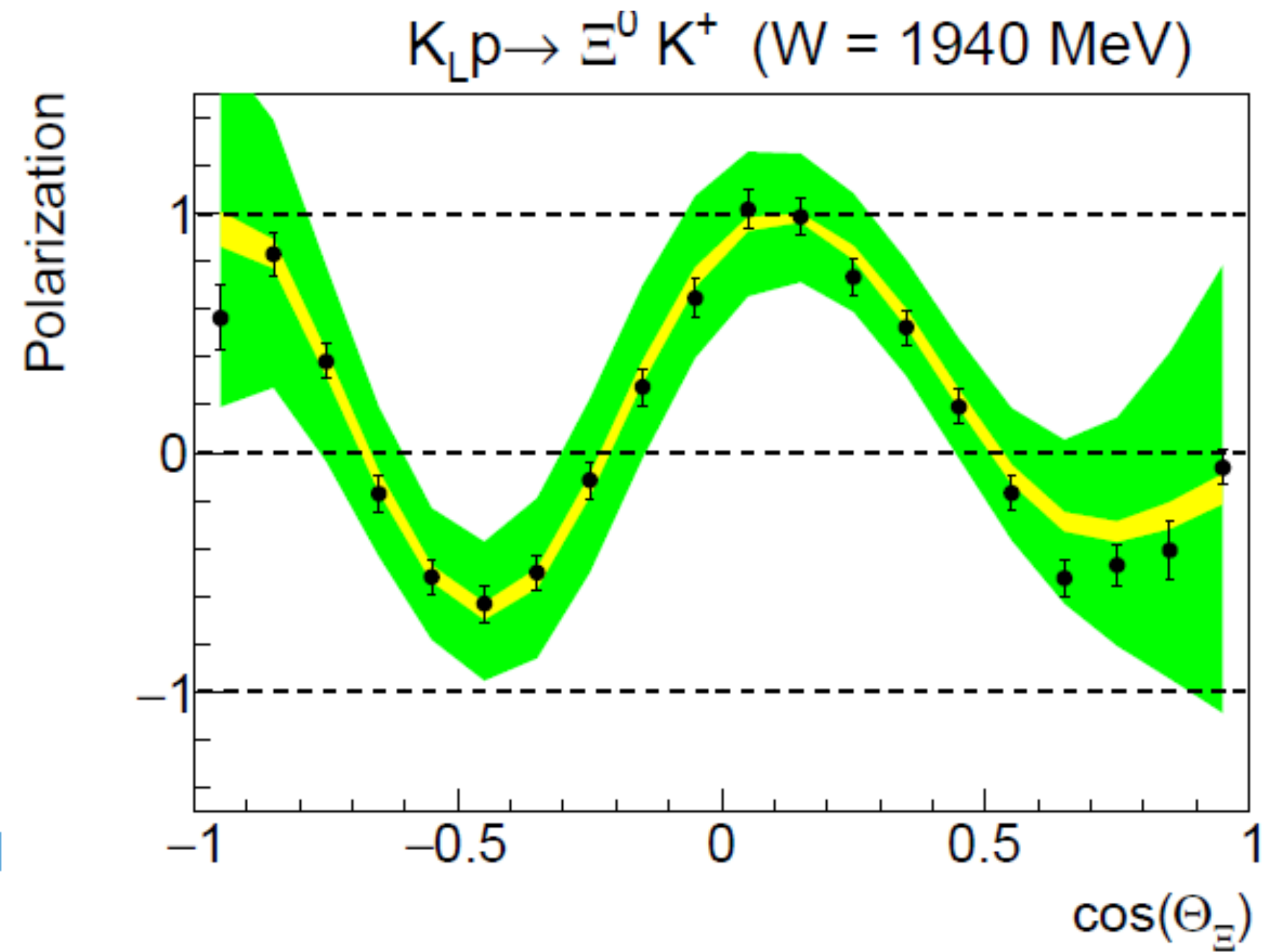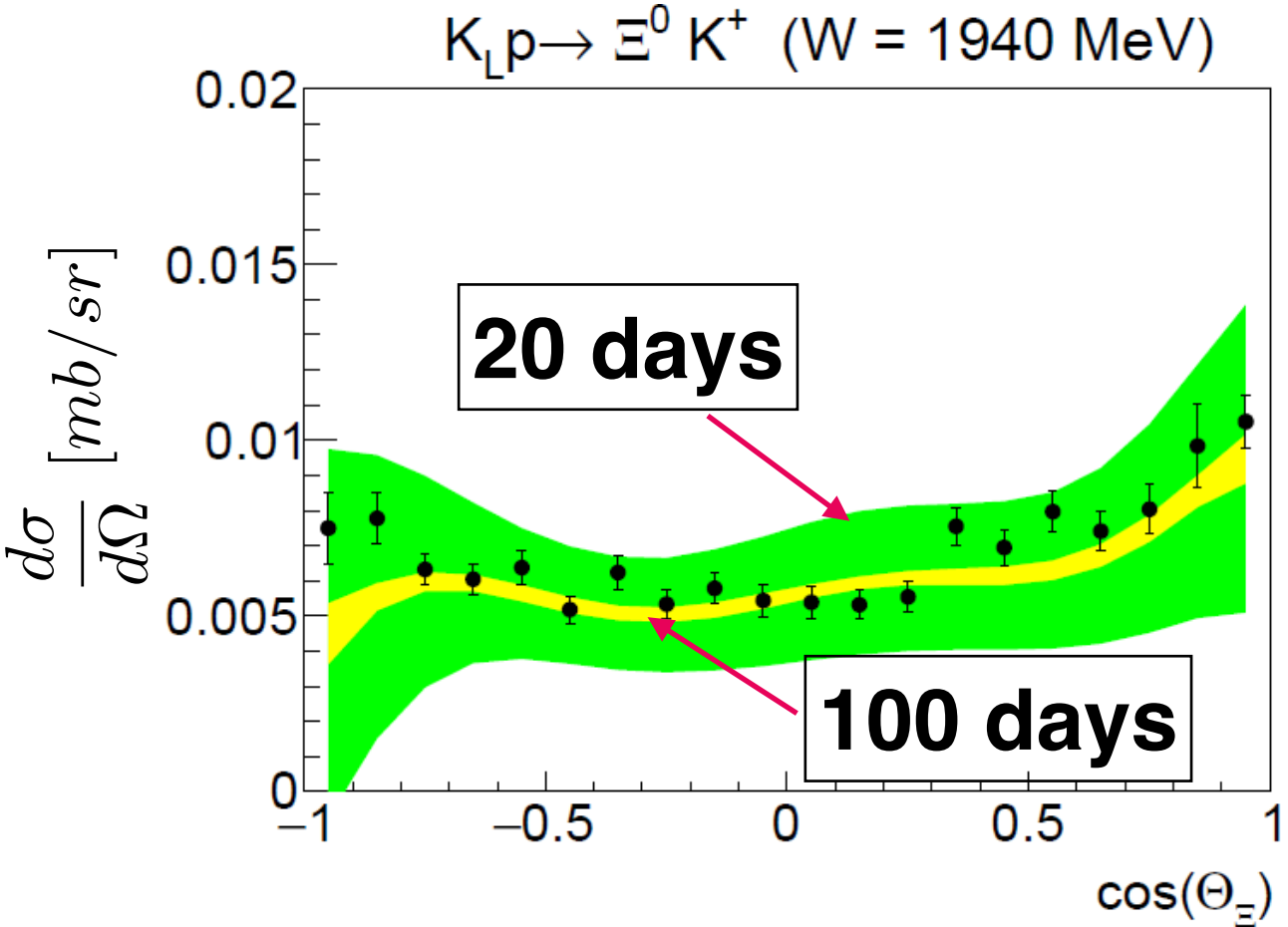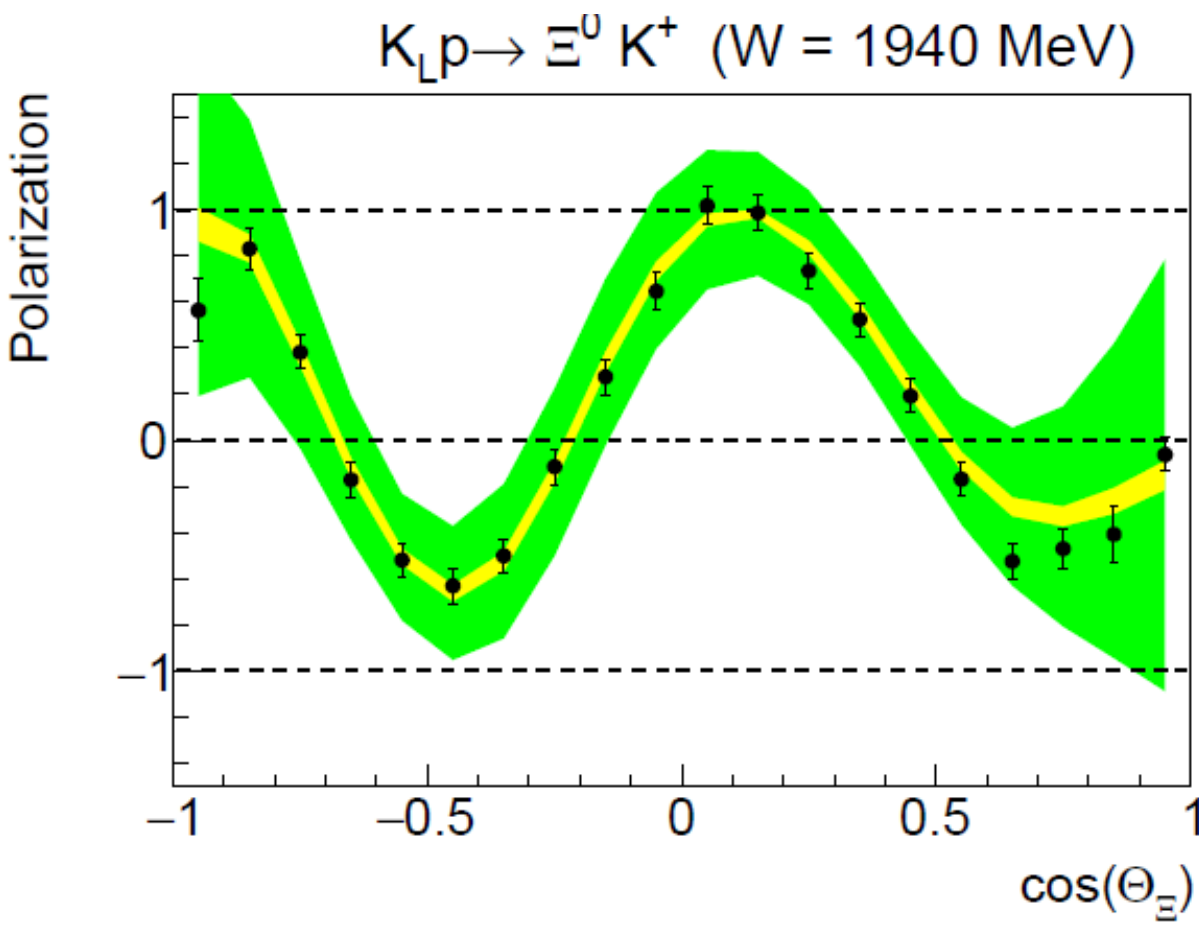
Need 100 days of running to get precise solution

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 Partial Wave Analysis**

-**look for poles in complex energy plane**

-**identify excited hyperons with masses up to 2500 MeV
In a formation and production reactions**

$$\Lambda^*, \Sigma^*, \Xi^* \ \& \ \Omega^*$$

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

Strange Meson Spectroscopy

Possible channels with proton and deuterium target and corresponding CG coefficient.

$$K_L p \rightarrow K^{\pm}\pi^{\mp}p = \left\langle K_L\pi^0 \,|\, K^{\pm}\pi^{\mp}\right\rangle = \pm\frac{1}{3}(T^{\frac{1}{2}} - T^{\frac{3}{2}}),$$

$$K_L p \rightarrow K_L\pi^0 p = \left\langle K_L\pi^0 \,|\, K_L\pi^0\right\rangle = \frac{1}{3}(T^{\frac{1}{2}} + 2T^{\frac{3}{2}}),$$

$$K_L p \rightarrow K_{(L,S)}\pi^+ n = \left\langle K_L\pi^+ \,|\, K_L\pi^+\right\rangle = \frac{1}{3}(T^{\frac{1}{2}} + 2T^{\frac{3}{2}}),$$

$$K_L p \rightarrow K^+\pi^0 n = \left\langle K_L\pi^+ \,|\, K^+\pi^0\right\rangle = -\frac{1}{3}(T^{\frac{1}{2}} - T^{\frac{3}{2}}),$$

$$K_L p \rightarrow K^-\pi^0\Delta^{++} = \left\langle K_L\pi^- \,|\, K^-\pi^0\right\rangle = \frac{1}{3}(T^{\frac{1}{2}} - T^{\frac{3}{2}}),$$

$$K_L n \rightarrow K^{\pm}\pi^{\mp}n = \left\langle K_L\pi^0 \,|\, K^{\pm}\pi^{\mp}\right\rangle = \pm\frac{1}{3}(T^{\frac{1}{2}} - T^{\frac{3}{2}}),$$

$$K_L p \rightarrow K_{(L,S)}\pi^-\Delta^{++} = \left\langle K_L\pi^- \,|\, K_L\pi^-\right\rangle = \frac{1}{3}(T^{\frac{1}{2}} + 2T^{\frac{3}{2}}),$$

$$K_L n \rightarrow K_L\pi^0 n = \left\langle K_L\pi^0 \,|\, K_L\pi^0\right\rangle = \frac{1}{3}(T^{\frac{1}{2}} + 2T^{\frac{3}{2}}),$$

$$K_L n \rightarrow K_{(L,S)}\pi^{\pm}\Delta^{\mp} = \left\langle K_L\pi^{\pm} \,|\, K_L\pi^{\pm}\right\rangle = \frac{1}{3}(T^{\frac{1}{2}} + 2T^{\frac{3}{2}}),$$

$$K_L n \rightarrow K^{\pm}\pi^0\Delta^{\mp} = \left\langle K_L\pi^{\pm} \,|\, K^{\pm}\pi^0\right\rangle = \pm\frac{1}{3}(T^{\frac{1}{2}} - T^{\frac{3}{2}}),$$

$K\pi$
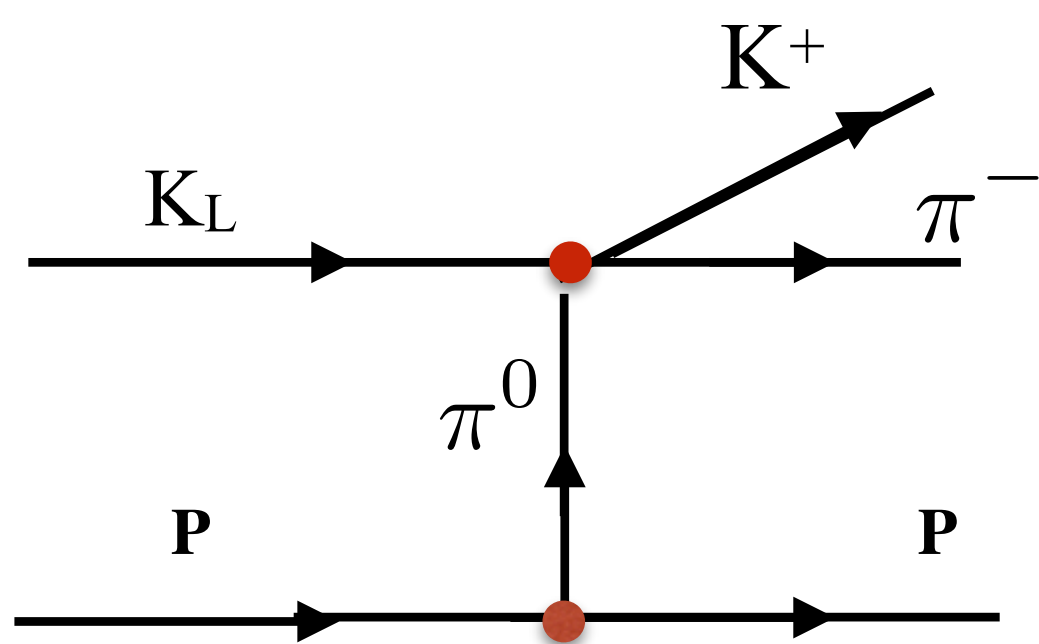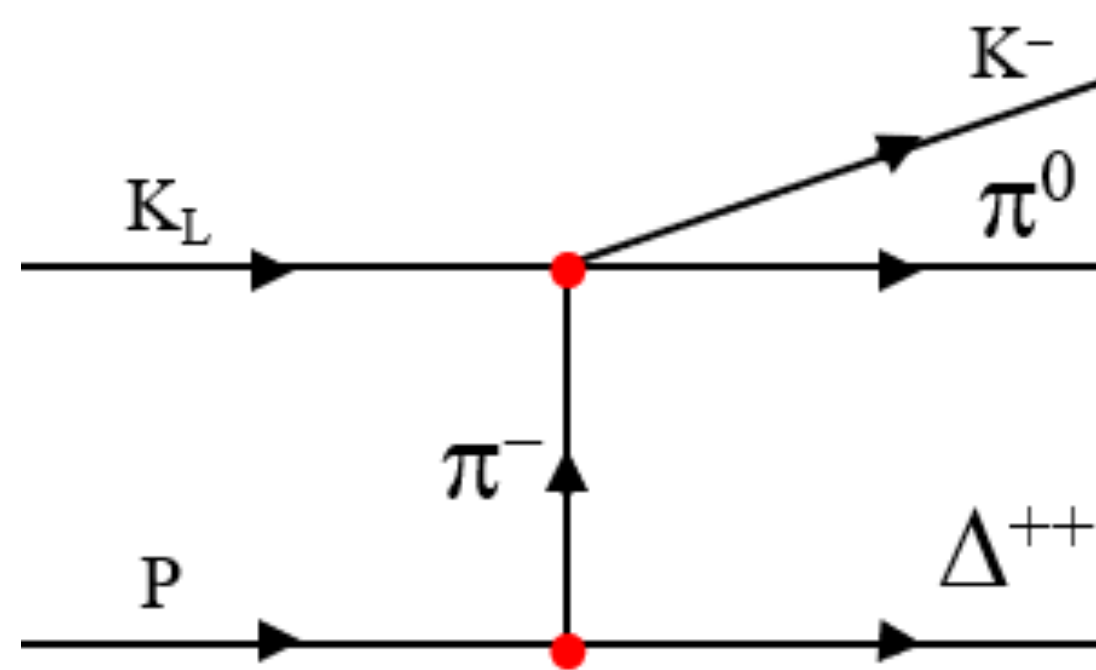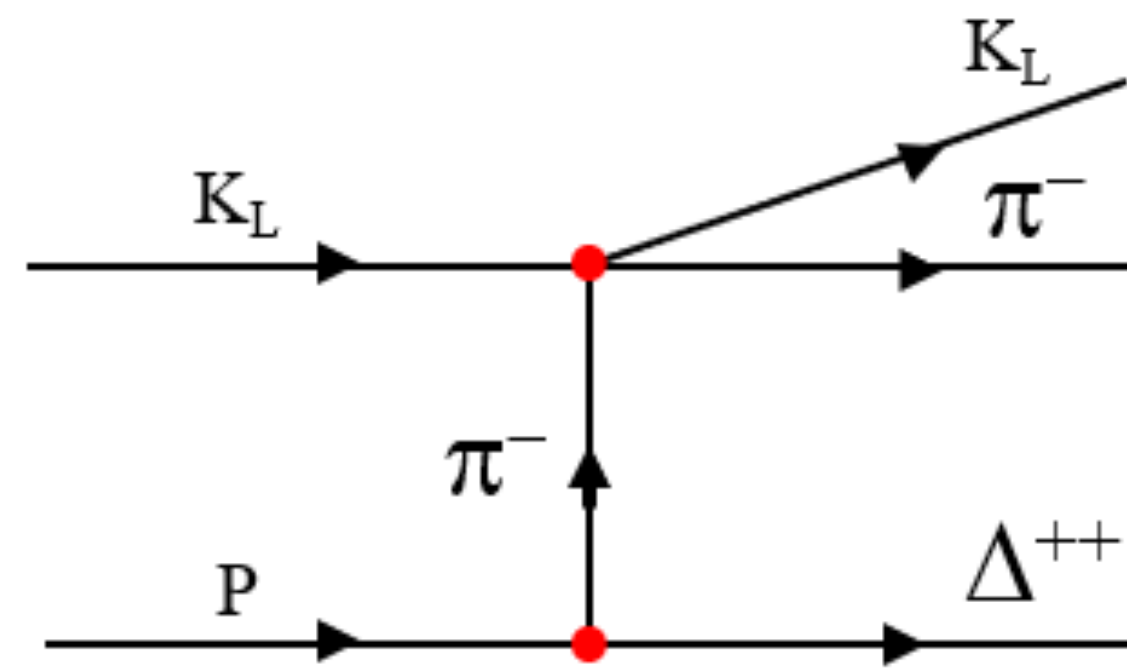
$$\frac{1}{3}(T^{1/2} - T^{3/2})$$

$$\frac{1}{3}(T^{1/2} - T^{3/2})$$

$$\frac{1}{3}(T^{1/2} + T^{3/2})$$

Proposed Measurements

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

LASS K pi P wave Amplitude

m= 0.8961 gam= 0.0507 BWr= 3.0

Amplitude

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

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

full
vector
scalar
scalar coup.chan.
Belle data

N_{evens}

$\sqrt{s}$[GeV]

Events / (0.01 GeV/c^2)

IM(K$^+\pi^-$) [GeV/c^2]

$\mathbf{M(K\pi)(GeV)}$
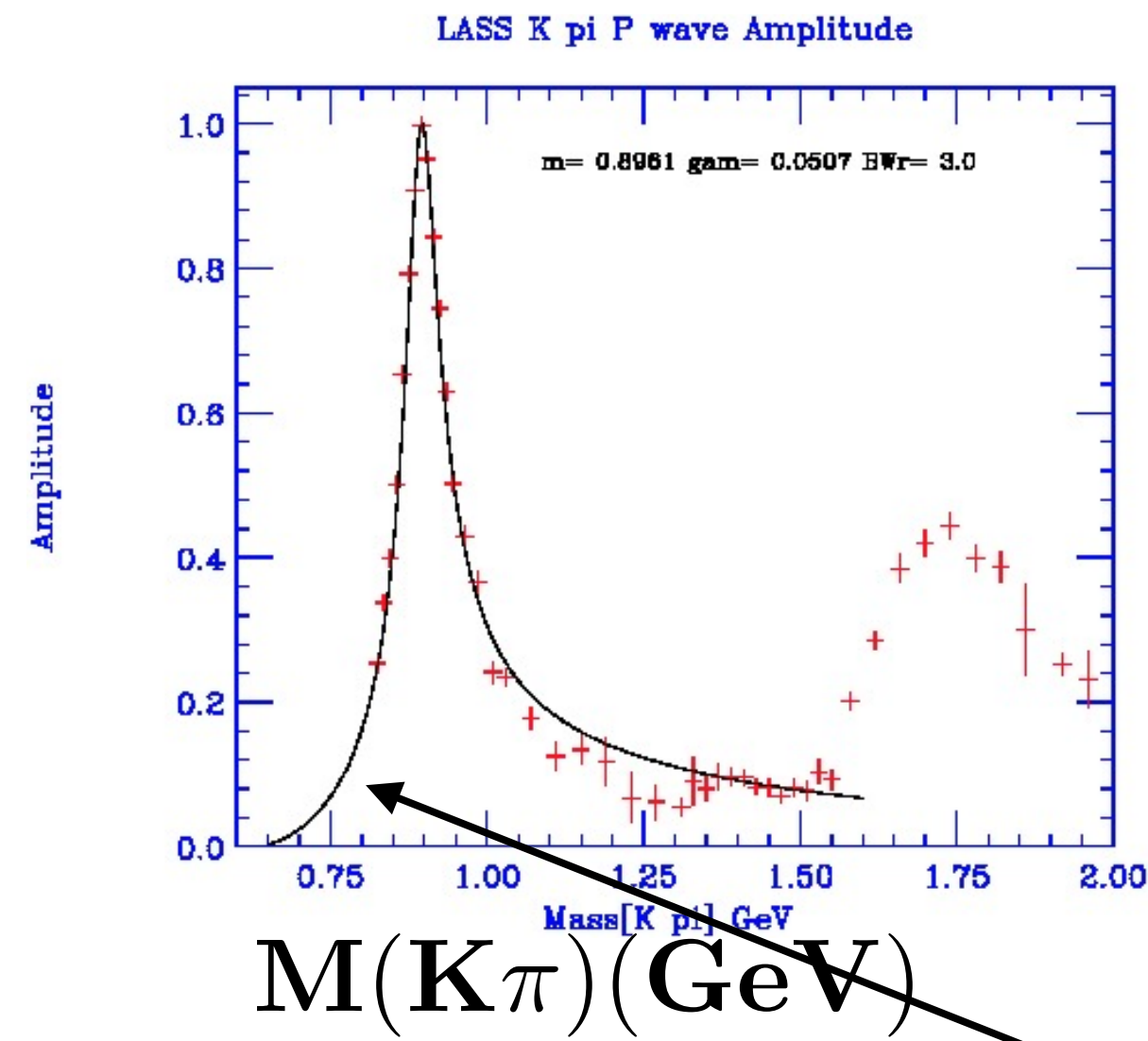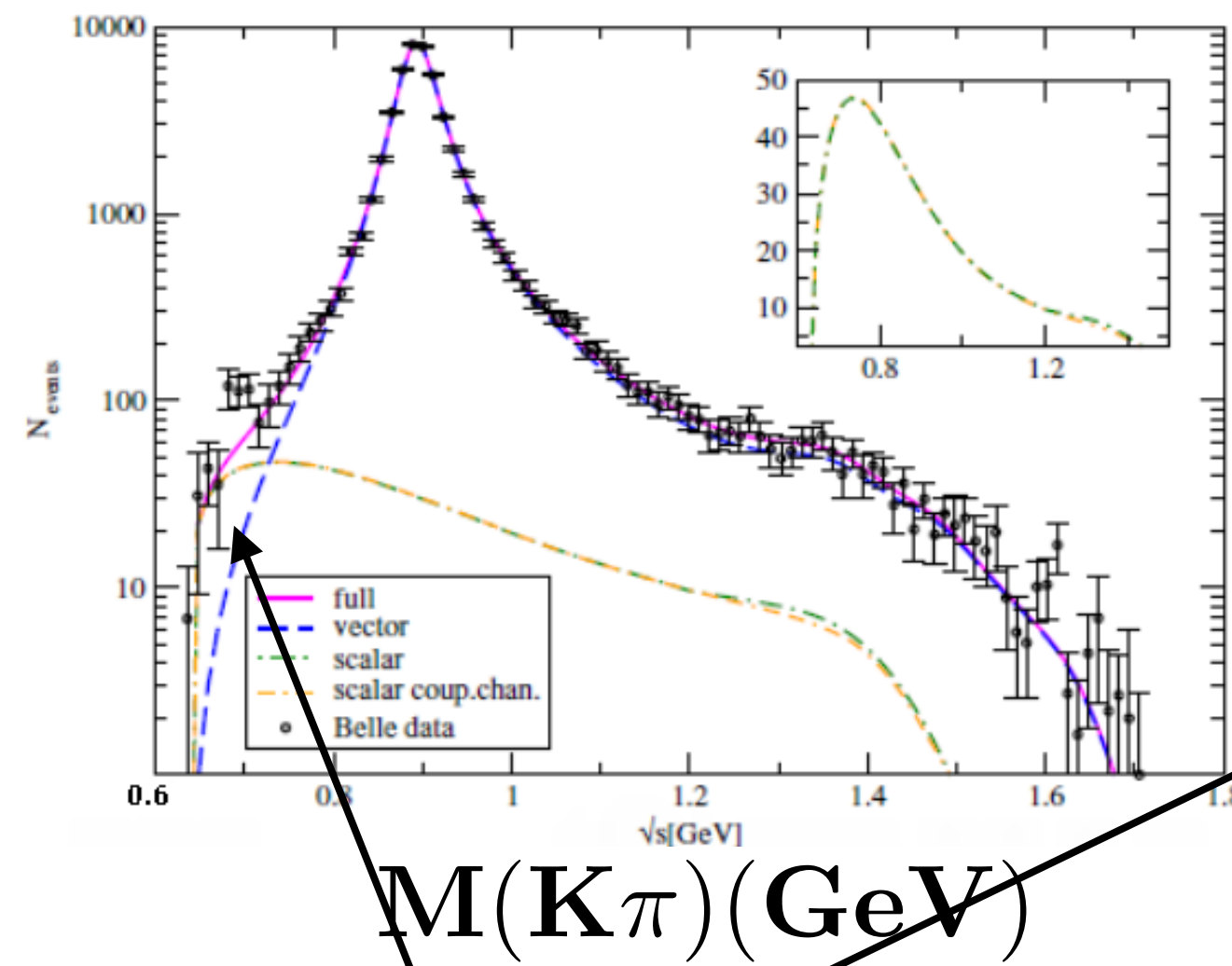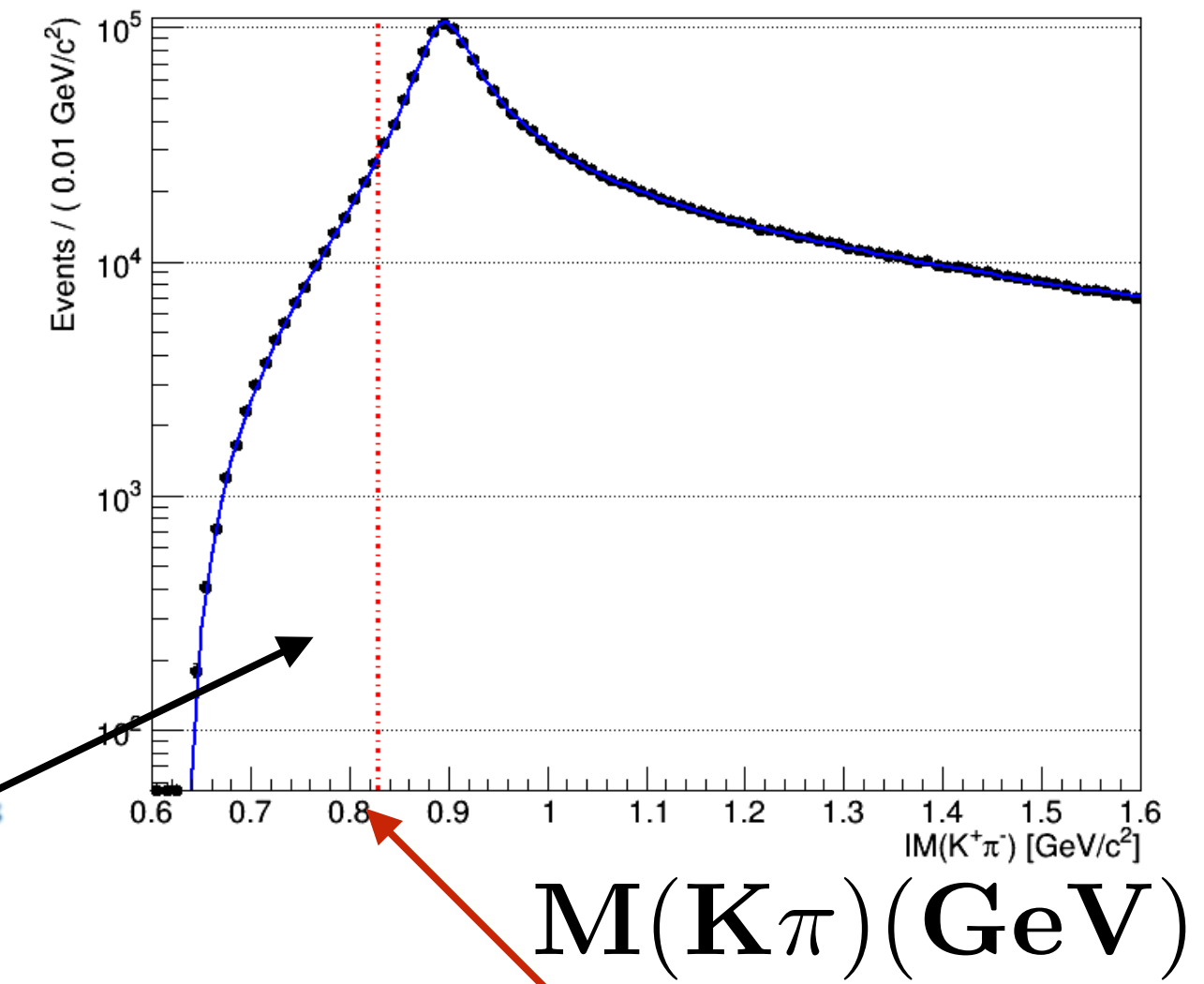
region of $\mathcal{K}\,(800)$

SLAC Lower limit
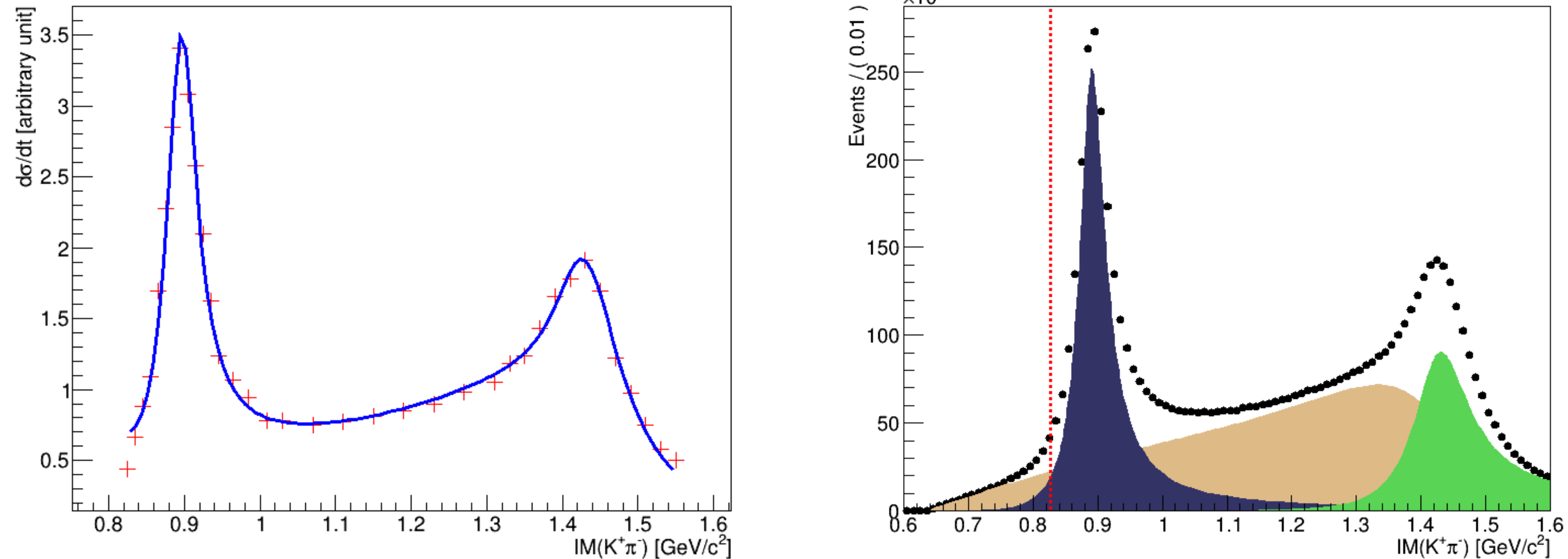
Figure 11: <u>Left</u>: Cross section of $K^- p \to K^+ \pi^- n$ as a function of the invariant mass from LASS results [27]. The blue line is the fit to the cross section using composite model containing two RBWs, spin-1 and spin-2, and S-wave LASS parameterization. <u>Right</u>: Expected distribution of the $K^+ \pi^-$ invariant mass below 1.6 GeV from KLF after 100 days of running. 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 [27].

Scalar Meson Nonet

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

$\bar{\mathbf{K}}_0^*(\mathbf{700})$ $\mathbf{K}^{*+}(\mathbf{700})$

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

S

a_0^- a_0 $f_0(980)$ a_0^+

$f_0(500)$ 0 I_3

-1   1

$\mathbf{K}^{*-}(\mathbf{700})$ $\mathbf{K}_0^*(\mathbf{700})$

$K^-\pi^0$ $K^-\pi^+$
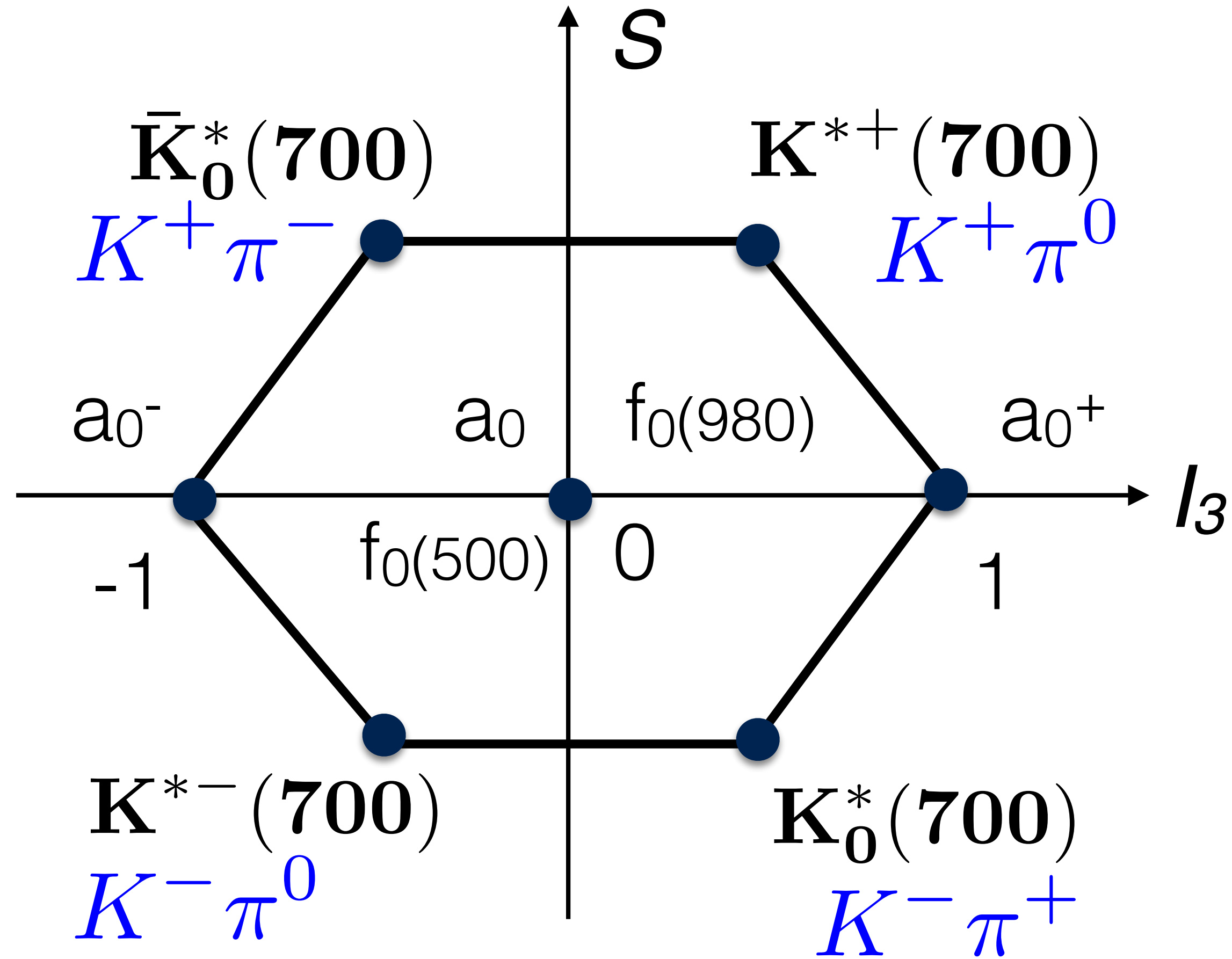
Four states called $\mathcal{K}$

still need further confirmation(PDG)
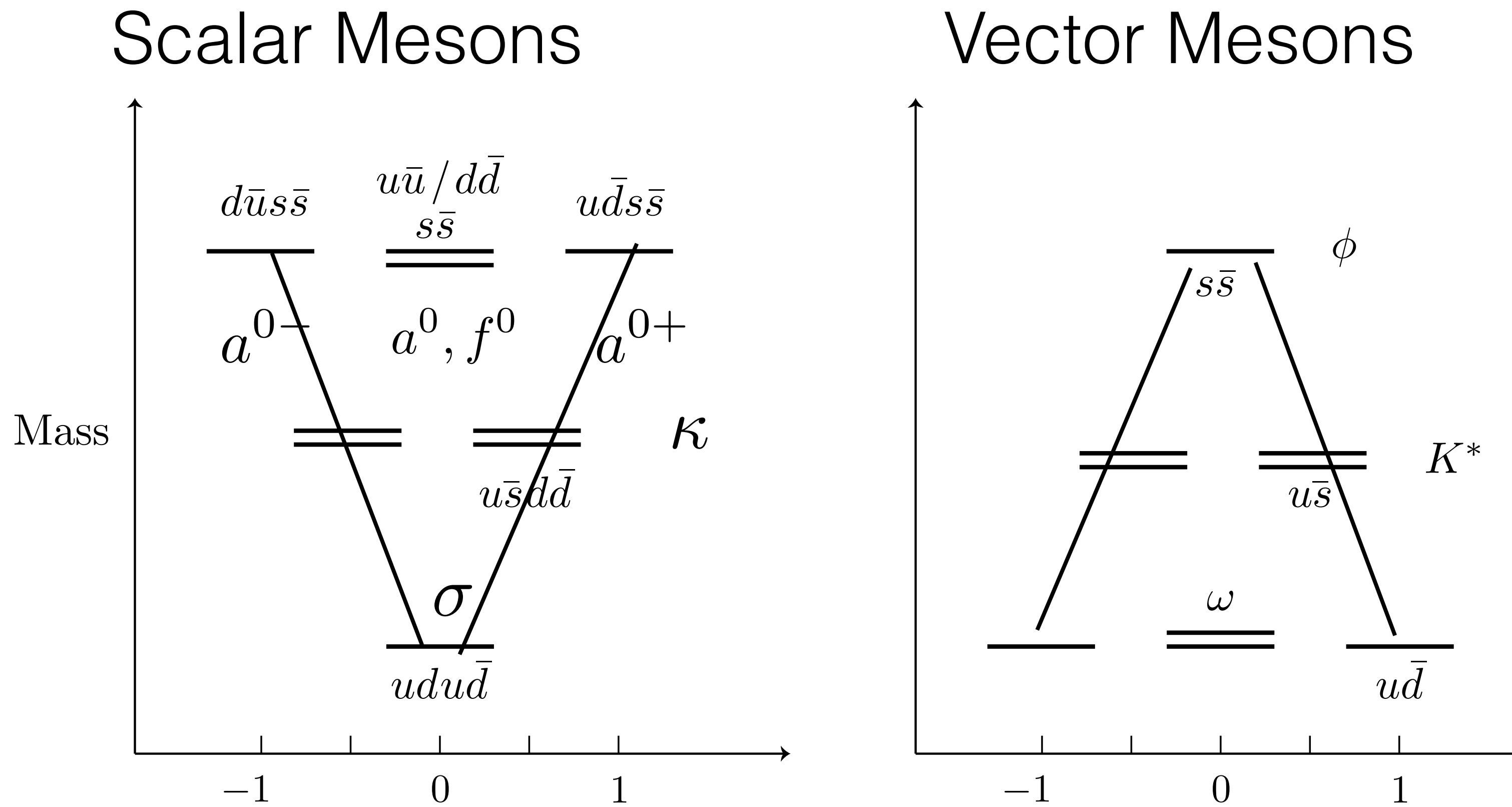
Figure 6. A cartoon representation of the masses of a $\bar{q}\bar{q}qq$ nonet compared with a $\bar{q}$

Very different mass hierarchy
Possibly suggesting 4q tetraquark

Invariant mass resolution $\Delta m/m$ (%)
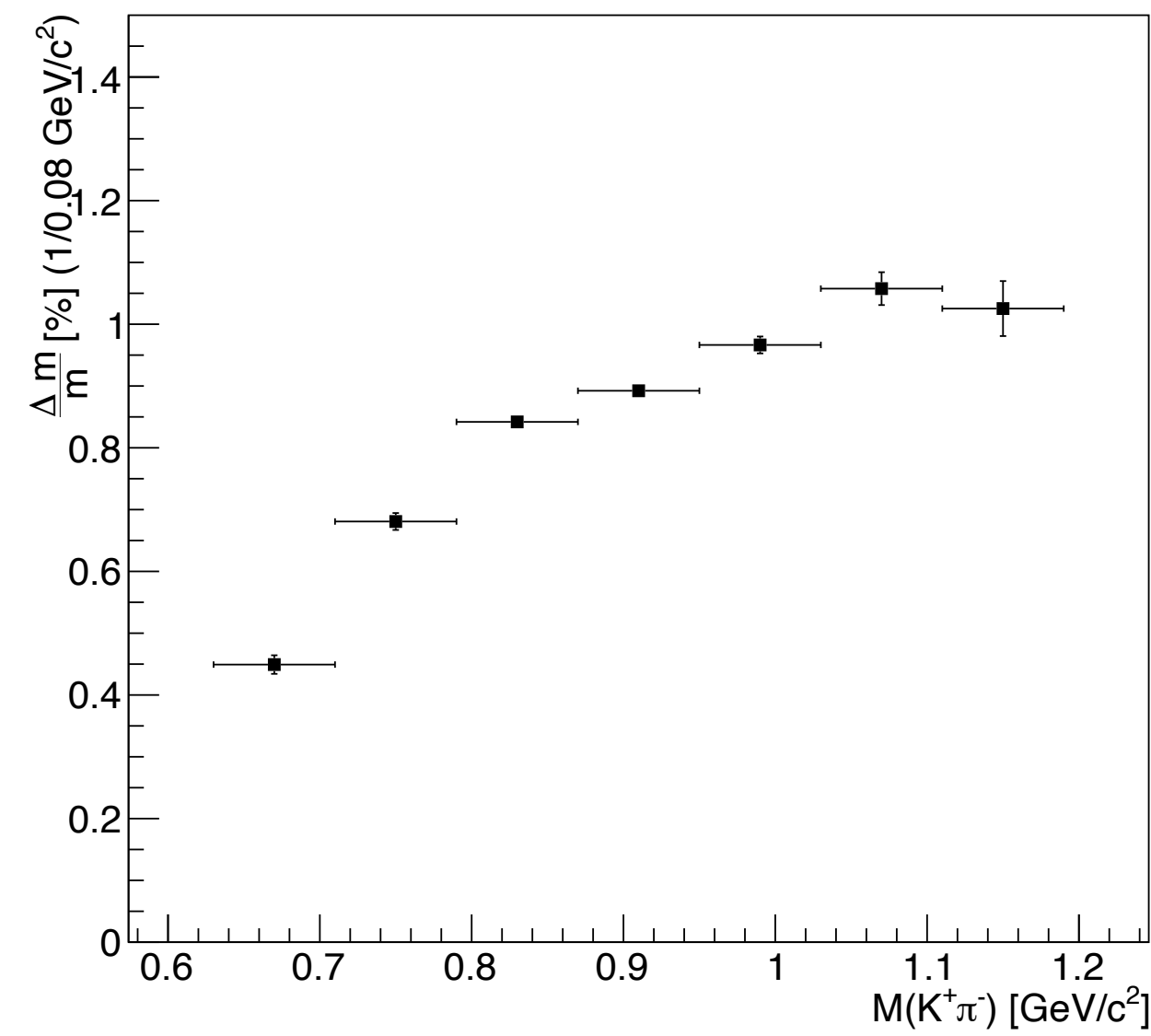
$K^+\pi^-$
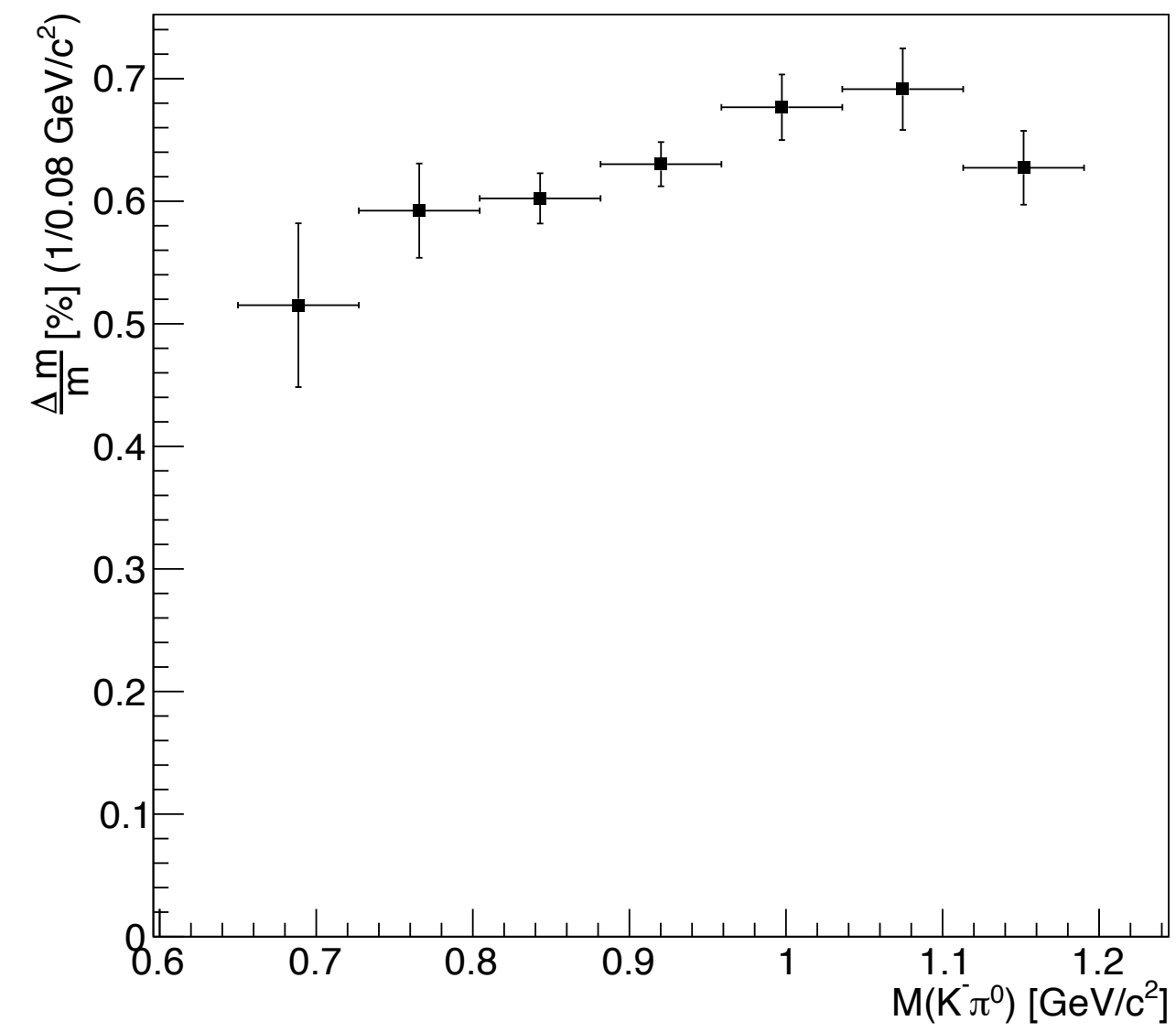
$K^-\pi^0$
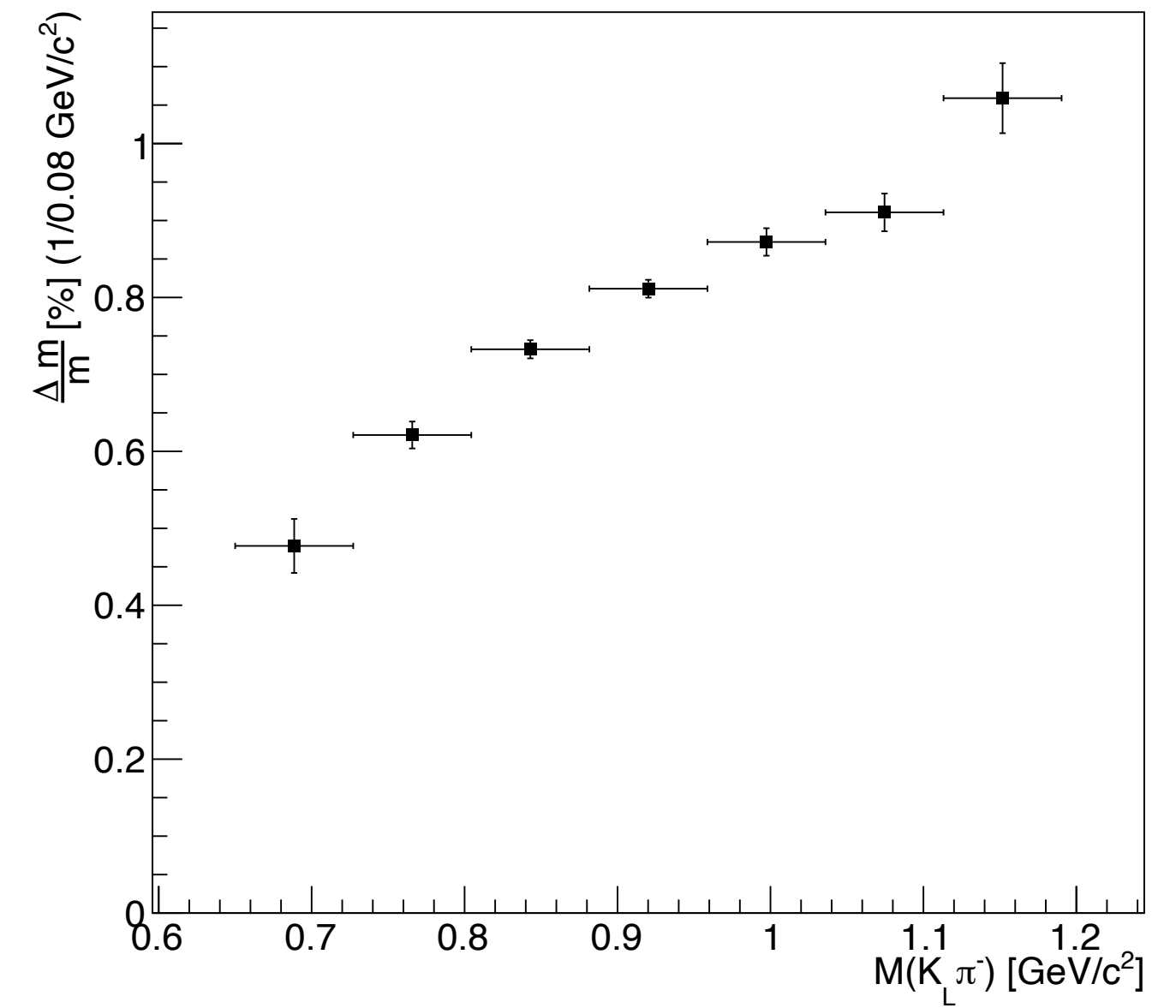
$K_L\pi^-$

Below 1% in all cases

Projected Measurements

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

SLAC Data
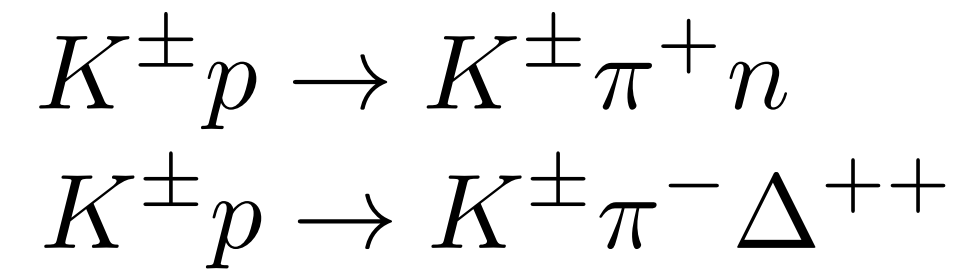
$K^{\pm}p \to K^{\pm}\pi^{+}n$
$K^{\pm}p \to K^{\pm}\pi^{-}\Delta^{++}$

Estabrooks(1978)
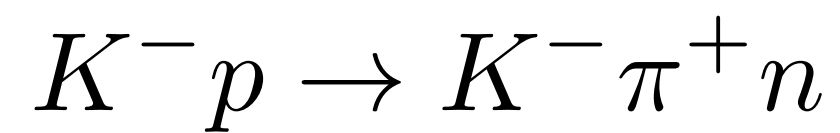
$K^{-}p \to K^{-}\pi^{+}n$

Aston(1988)

**KLF
(100 days)**

I=3/2   S-wave

$\delta_0^{3/2}(s)$

Jongejans et al. $\triangledown$
Cho et al. $\triangle$
Bakker et al. $\diamond$
Estabrooks et al. $\blacksquare$
Linglin et al. $\bullet$
fit to $S^{3/2}$ alone (dashed)
UFD (solid)
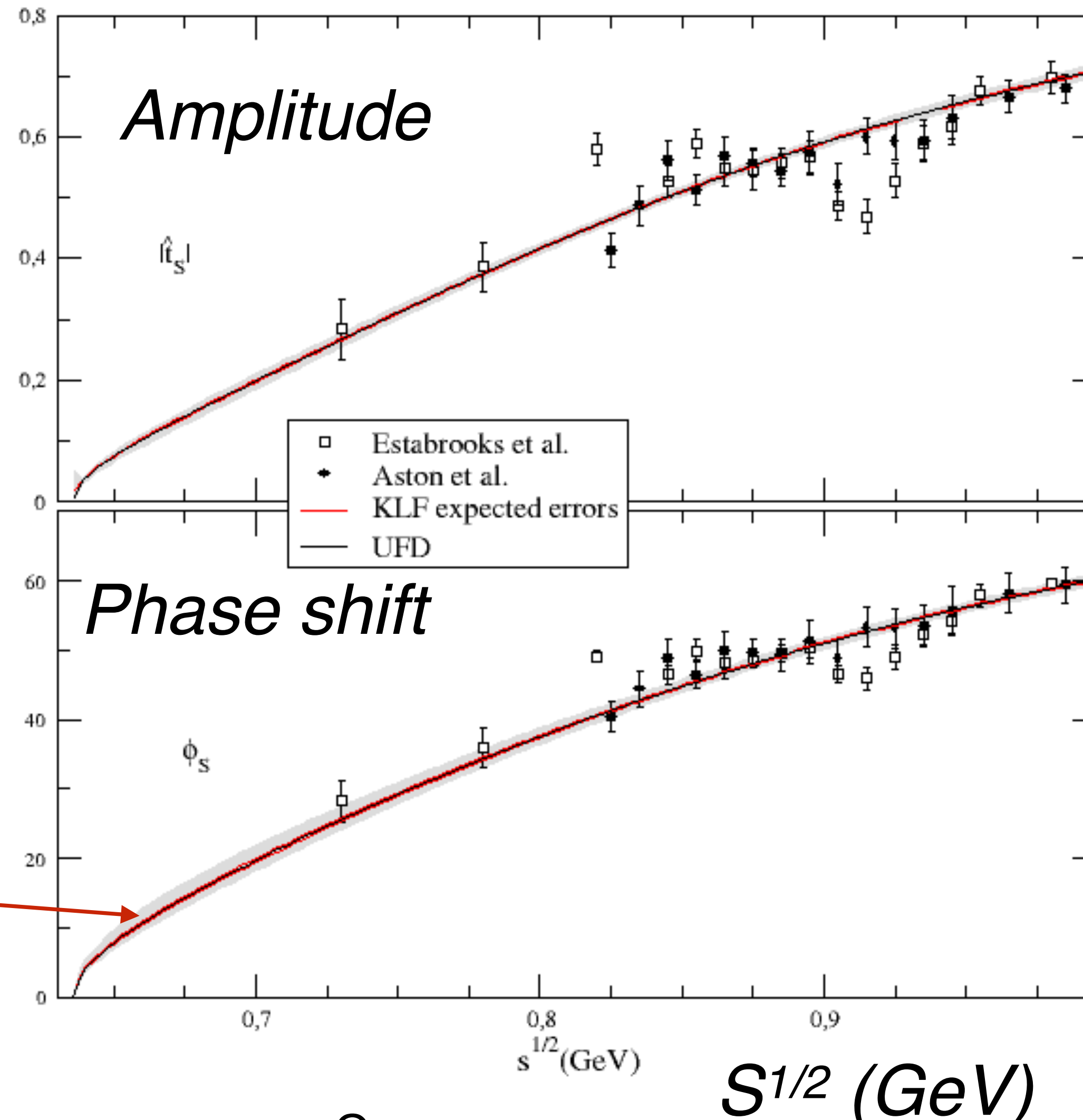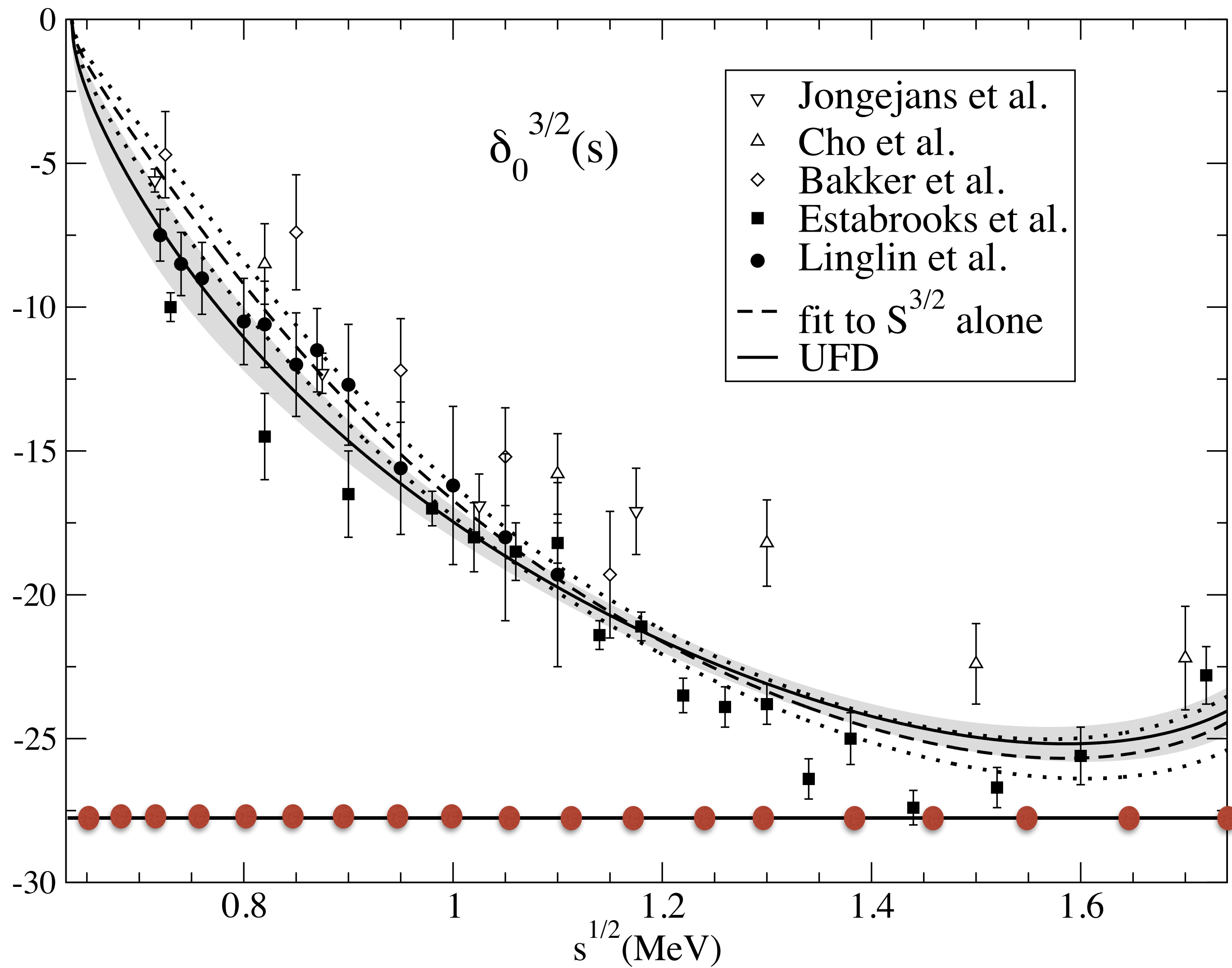
4.25 GeV Saclay
5.5 GeV CERN
3.0 GeV ANL
13.0 GeV SLAC
14.3 GeV CERN

Estabrooks(1978)

$K^{\pm}p \rightarrow K^{\pm}\pi^{+}n$

$K^{\pm}p \rightarrow K^{\pm}\pi^{-}\Delta^{++}$

KLF 100 days

$s^{1/2}$(MeV)

From Pelaez and Rodas paper: PRD93(2016)

100 days KLF

proton detected

$$K_L p \rightarrow K^+ \pi^- p$$

SLAC

Legend:
- ● missing proton; 100 days KLF
- ■ detected proton; 100 days KLF
- ▲ SLAC

Axes: Counts (vertical), $-t$ (GeV^2) (horizontal)

$$K_L p \to K^{(-,0)} \pi^{(0,-)} \Delta^{++}$$

t'=t-t$_{min}$
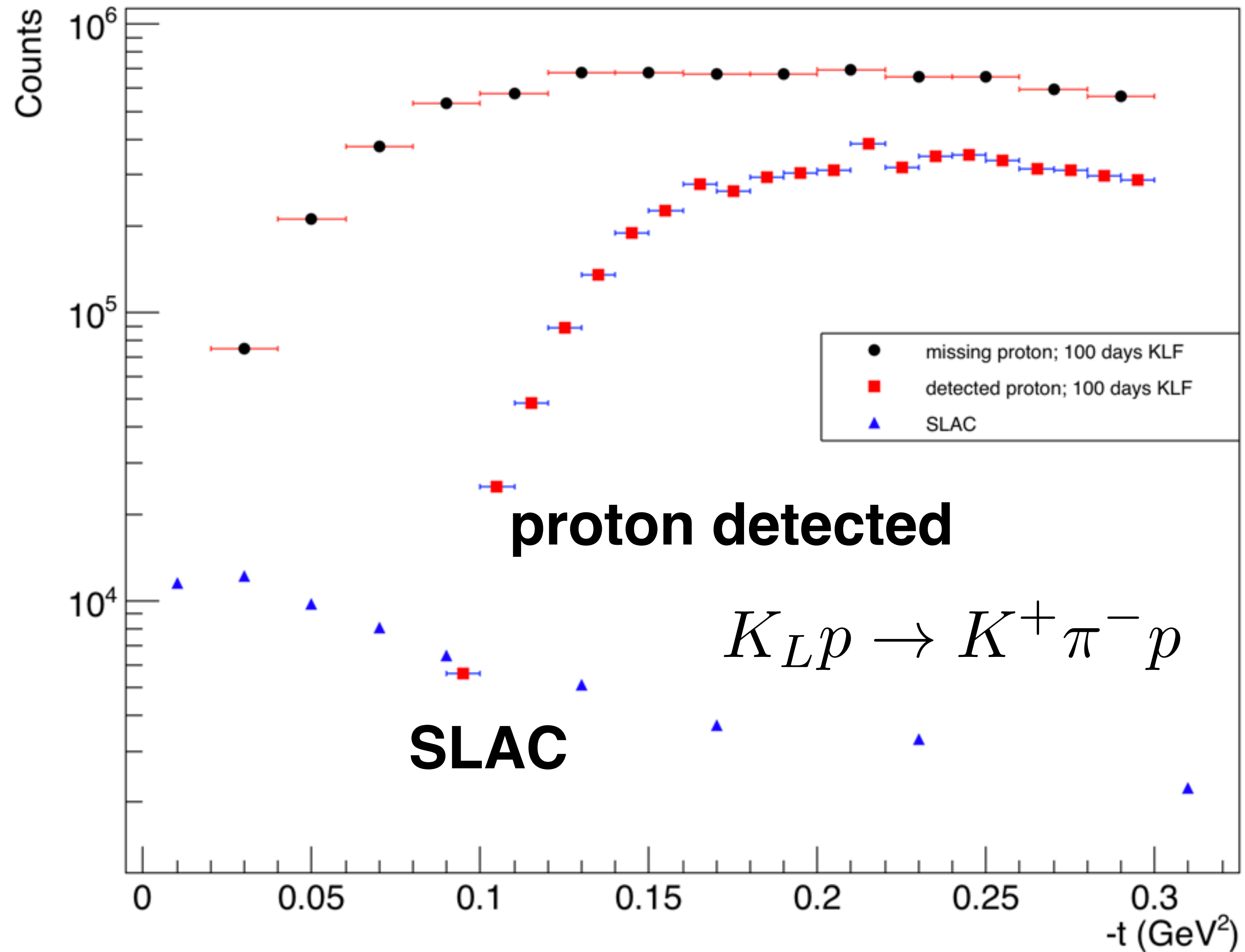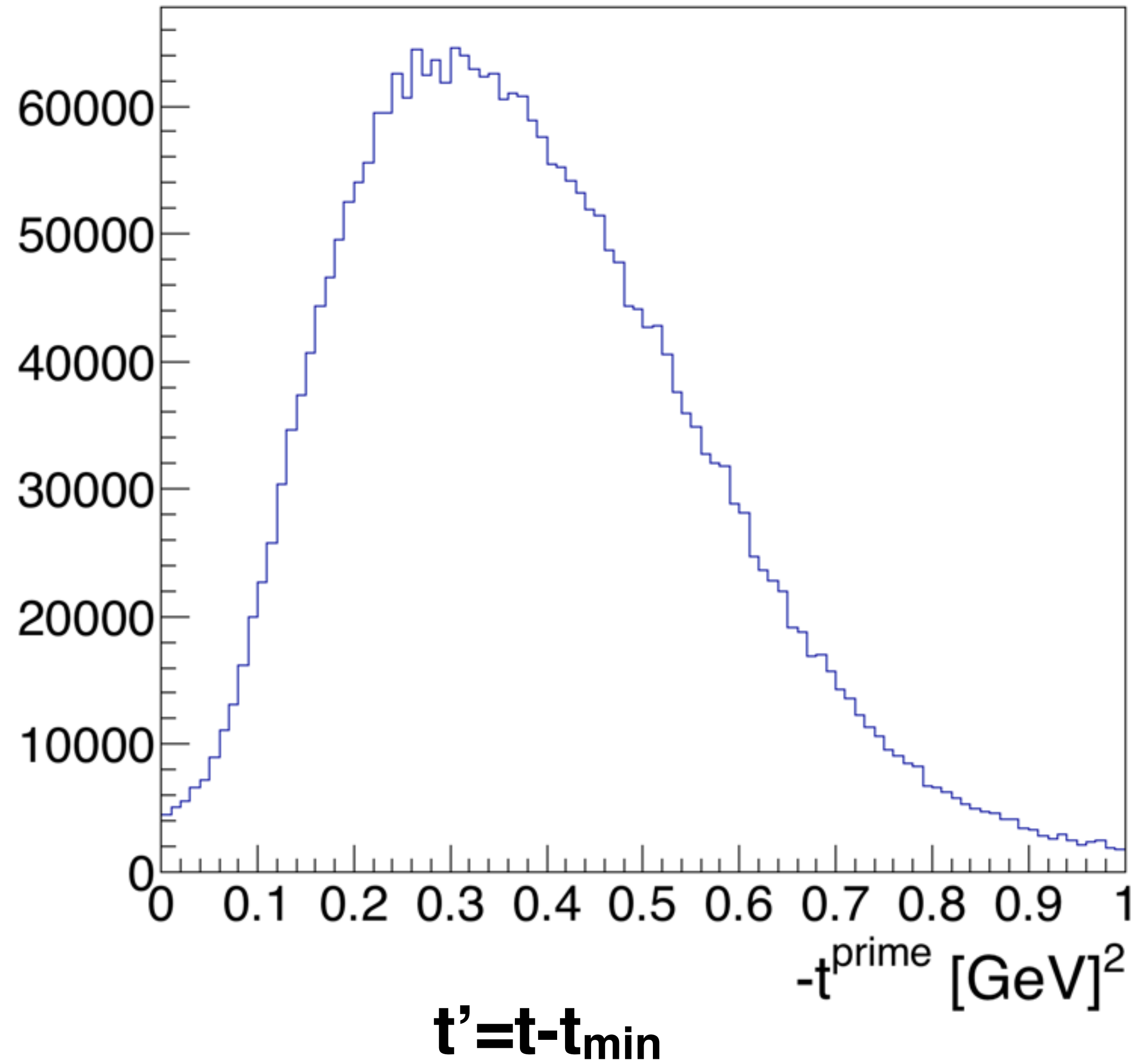
Phase-shift

For L=0, 1

$$A^I(cos\theta_{GJ}, \phi_{GJ}) = \frac{\sqrt{4\pi}}{q_i} \sum_{l,m} a_l^I (2l+1) Y_l^m(cos\theta_{GJ}, \phi_{GJ})$$

In the elastic region

$$a_L^I = a_L^{I=1/2} + \frac{1}{2} a_L^{I=3/2}$$

$$a_L^I = \sqrt{(2L+1)} \epsilon^I \sin\delta_L^I e^{\delta_L^I}$$

Results include statistical uncertainty only.

$$I = \frac{1}{2}, \quad s-wave$$

$$I = \frac{3}{2}, \quad s-wave$$

$$I = \frac{1}{2}, \quad p-wave$$

35
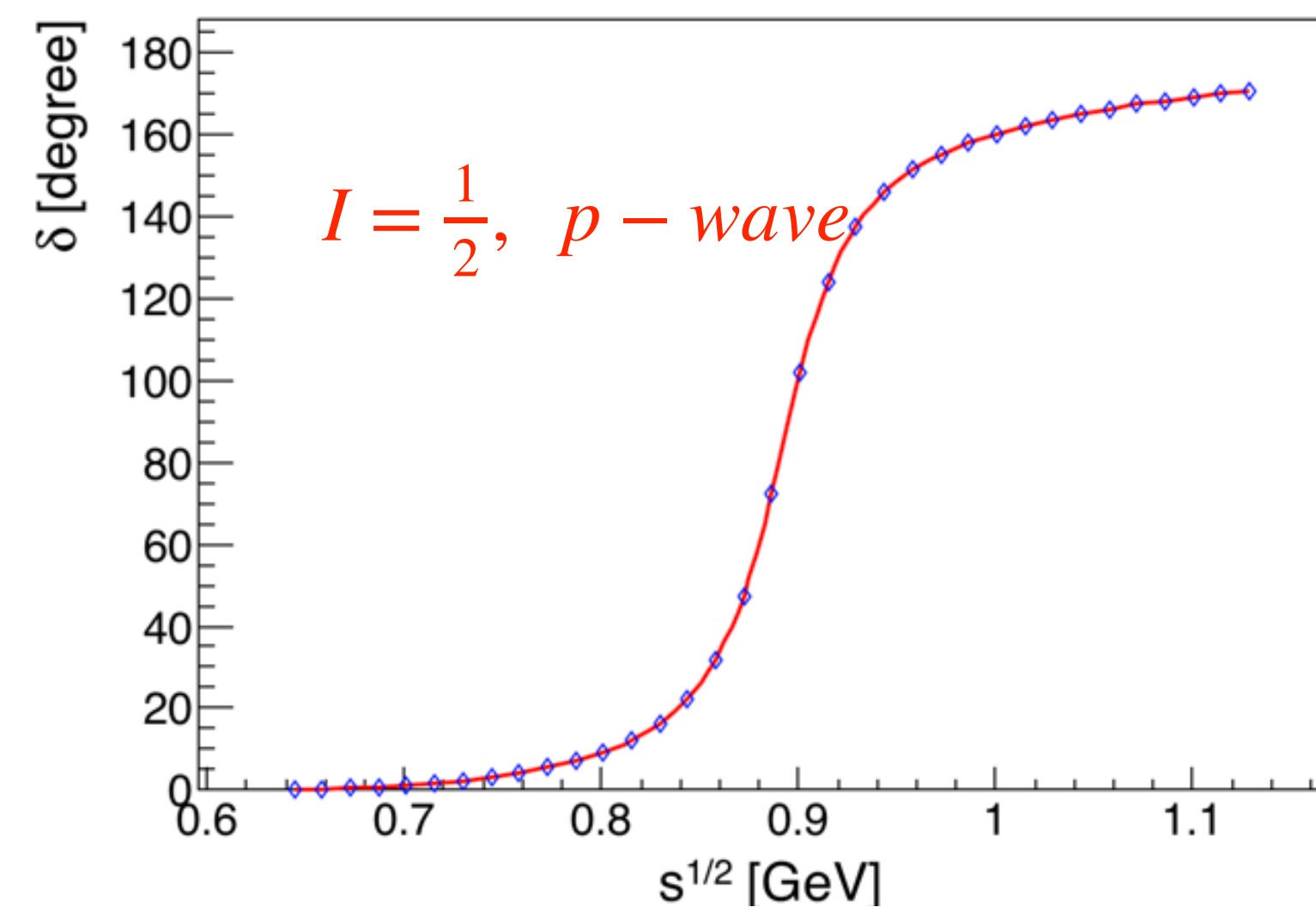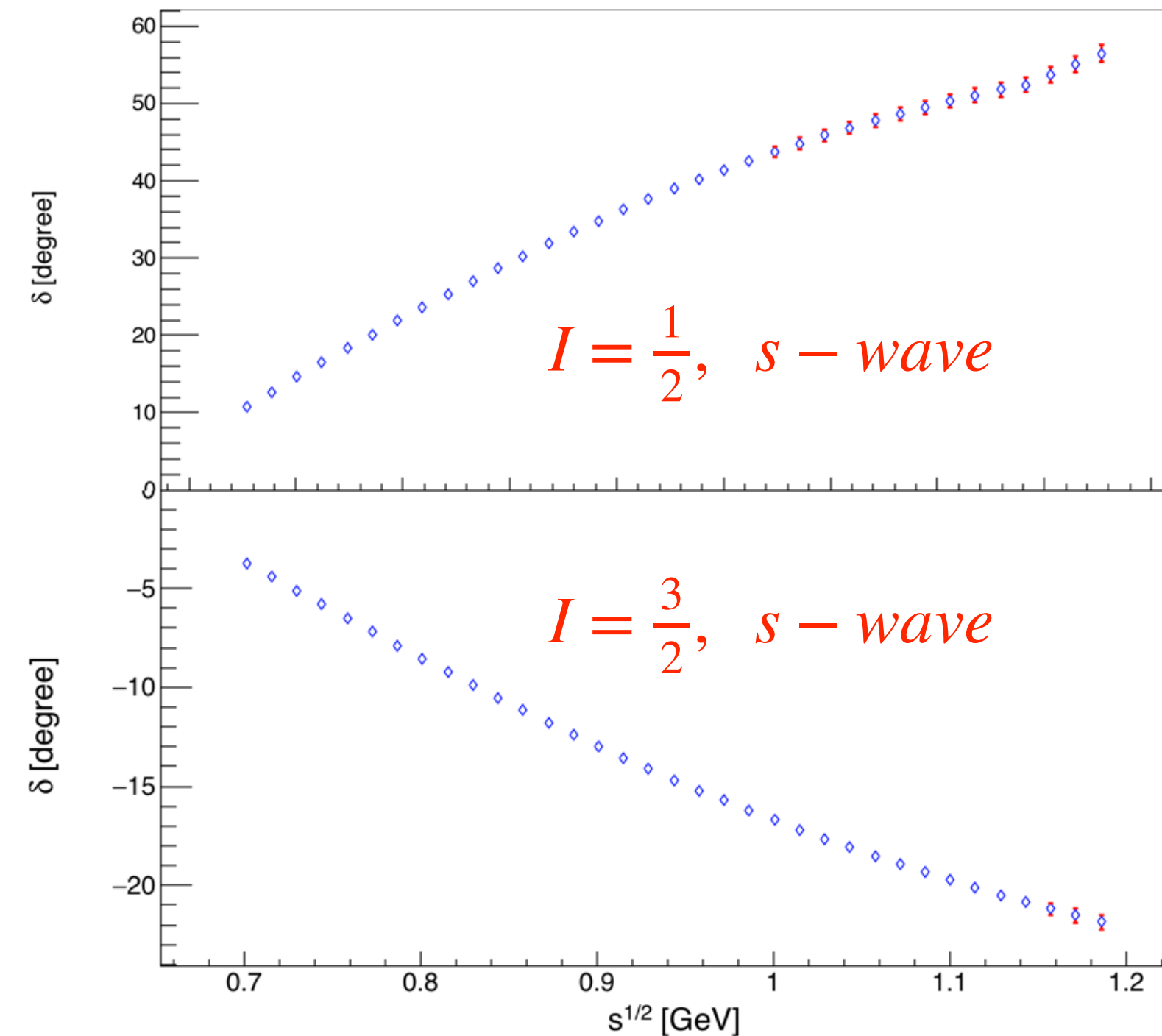
Summary of $K\pi$ Scattering

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

-It will improve on 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 the uncertainty in the mass
determination of K*(700) and by by more than a factor of two and by
factor of five the uncertainty on its width

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

Workshop on Excited Hyperons in QCD Thermodynamics at Freeze-Out (YSTAR2016) Mini-Proceedings

16th - 17th November, 2016 Thomas Jefferson National Accelerator Facility, Newport News, VA, U.S.A.

P. Alba, M. Amaryan, V. Begun, R. Bellwied, S. Borsanyi, W. Broniowski, S. Capstick, E. Chudakov, V. Crede, B. Dönigus, R. G. Edwards, Z. Fodor, H. Garcilazo, J. L. Goity, M. I. Gorenstein, J. Günther, L. Guo, P. Huovinen, S. Katz, M. Mai, D. M. Manley, V. Mantovani Sarti, E. Megías, F. Myhrer, J. Noronha-Hostler, H. Noumi, P. Parotto, A. Pasztor, I. Portillo Vazquez, K. Rajagopal, C. Ratti, J. Ritman, E. Ruiz Arriola, L. L. Salcedo, I. Strakovsky, J. Stroth, A. H. Tang, Y. Tsuchikawa, A. Valcarce, J. Vijande, and V. Yu. Vovchenko

Editors: M. Amaryan, E. Chudakov, K. Rajagopal, C. Ratti, J. Ritman, and I. Strakovsky

Abstract

This Workshop brought top experts, researchers, postdocs, and students from high-energy heavy-ion interactions, lattice QCD and hadronic physics communities together. YSTAR2016 discussed the impact of "missing" hyperon resonances on QCD thermodynamics, on freeze-out in heavy ion collisions, on the evolution of early universe, and on the spectroscopy of strange particles. Recent studies that compared lattice QCD predictions of thermodynamic properties of quark-gluon plasma at freeze-out with calculations based on statistical hadron resonance gas models as well as experimentally measured ratios between yields of different hadron species in heavy ion collisions provide indirect evidence for the presence of "missing" resonances in all of these contexts. The aim of the YSTAR2016 Workshop was to sharpen these comparisons and advance our understanding of the formation of strange hadrons from quarks and gluons microseconds after the Big Bang and in todays experiments at LHC and RHIC as well as at future facilities like FAIR, J-PARC and KL at JLab.

It was concluded that the new initiative to create a secondary beam of neutral kaons at JLab will make a bridge between the hardron spectroscopy, heavy-ion experiments and lattice QCD studies addressing some major issues related to thermodynamics of the early universe and cosmology in general.

PACS numbers: 13.75.Jz, 13.60.Rj, 14.20.Jn, 25.80.Nv.

For
Freeze

1.5

PDG 2016 PDG 2016+

Observe dozens
Missing states

Legend:
- PDG2016 — (solid black)
- PDG2016+ — (green dashed)
- hQM PDG2016+ — (blue long dash)
- QM — (red dotted)
- Lattice — (data points)

$(\mu_S/\mu_B)_{LO}$

T [MeV]

Temperature

Formation of Visible Matter during the Freeze-Out of the Universe after the Big Bang
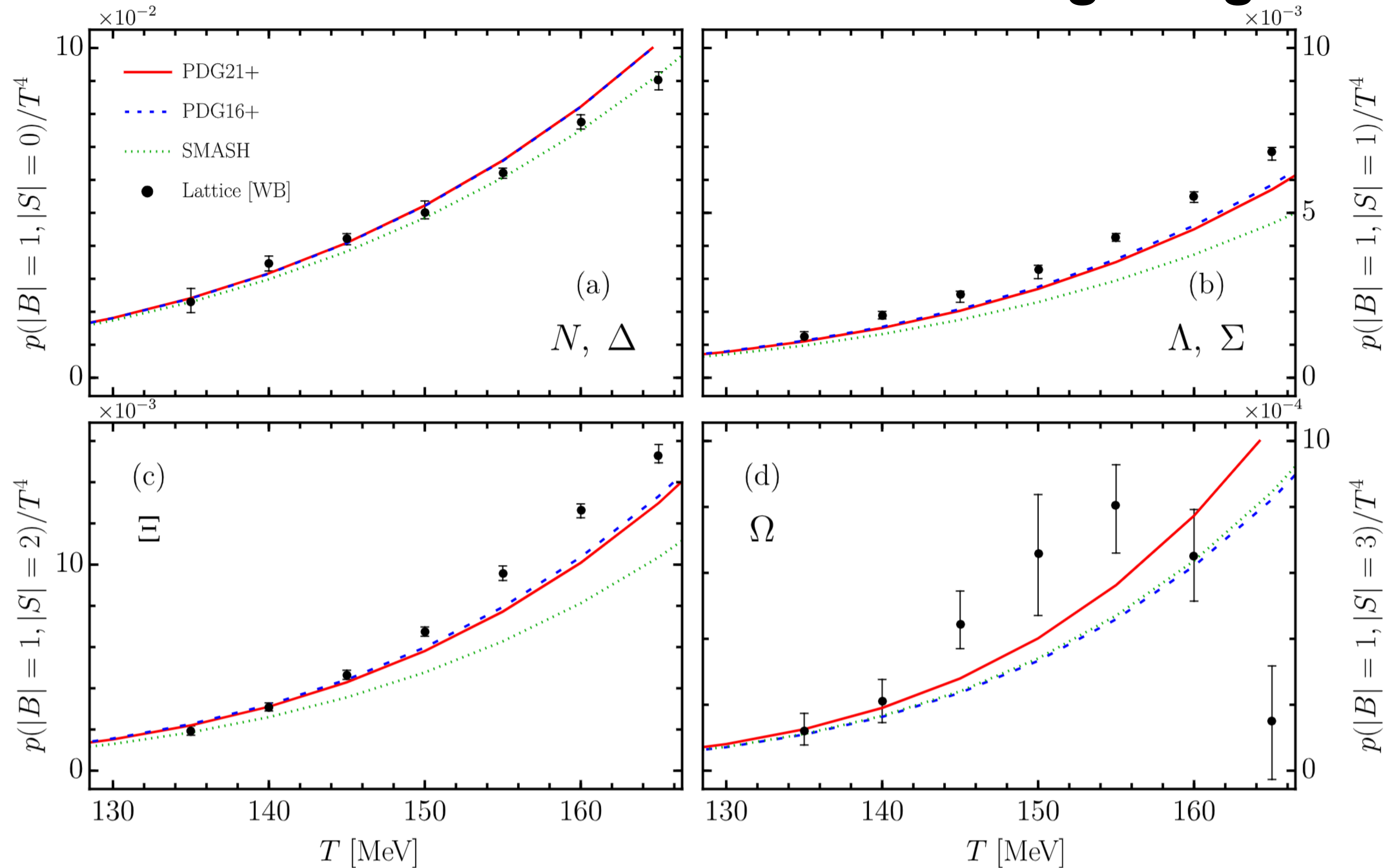
Private Communication:

Salinas San Martin, Kartein, Hammelmann, Hirayama, Parotto, Elfner,
Noronha-Hostler, Ratti, to appear soon

Needs to Observe dozens
Of Missing states

Missing K*'s
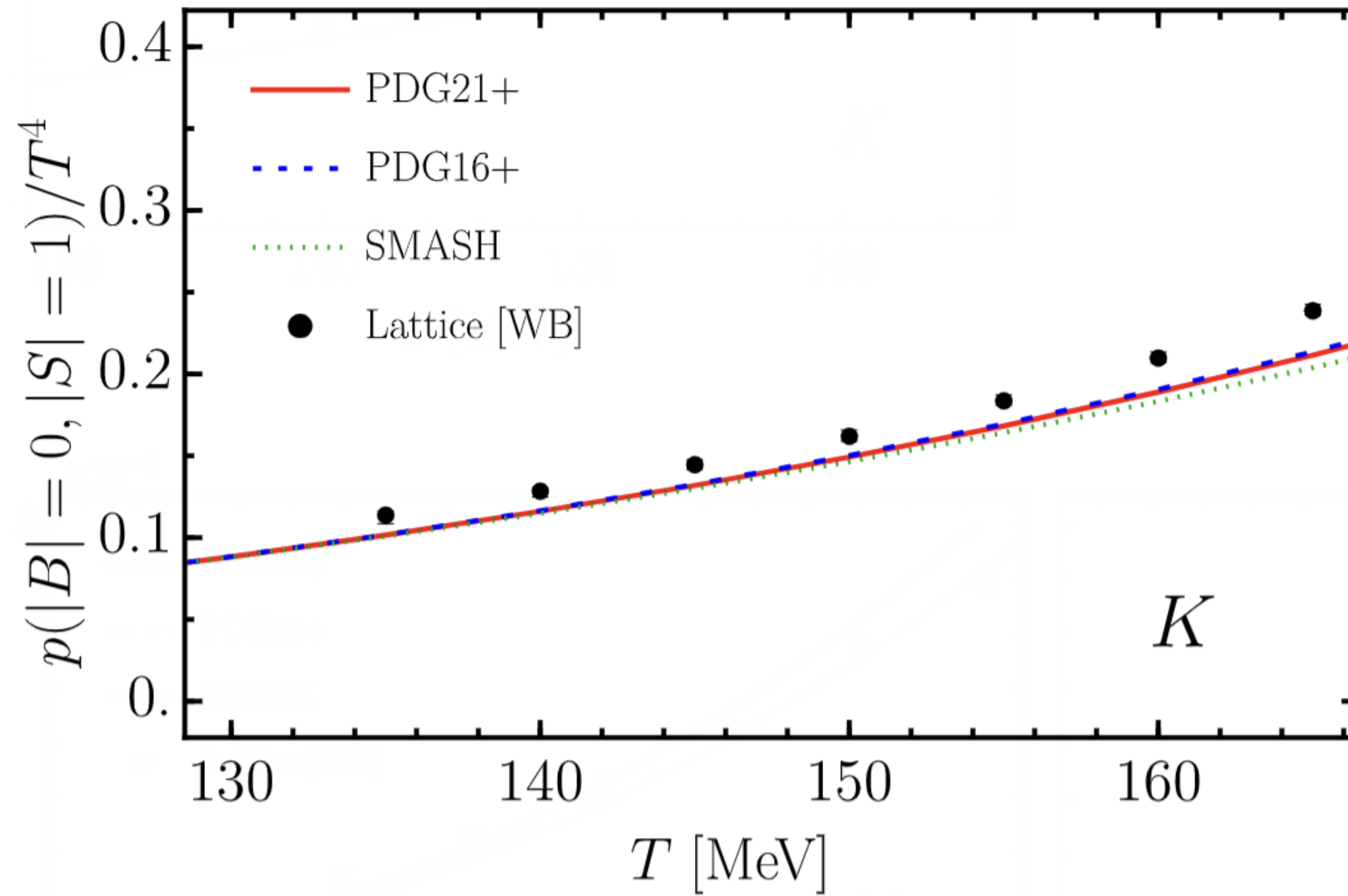
HISTORY OF THE UNIVERSE

$1\ \mu s$

KLF
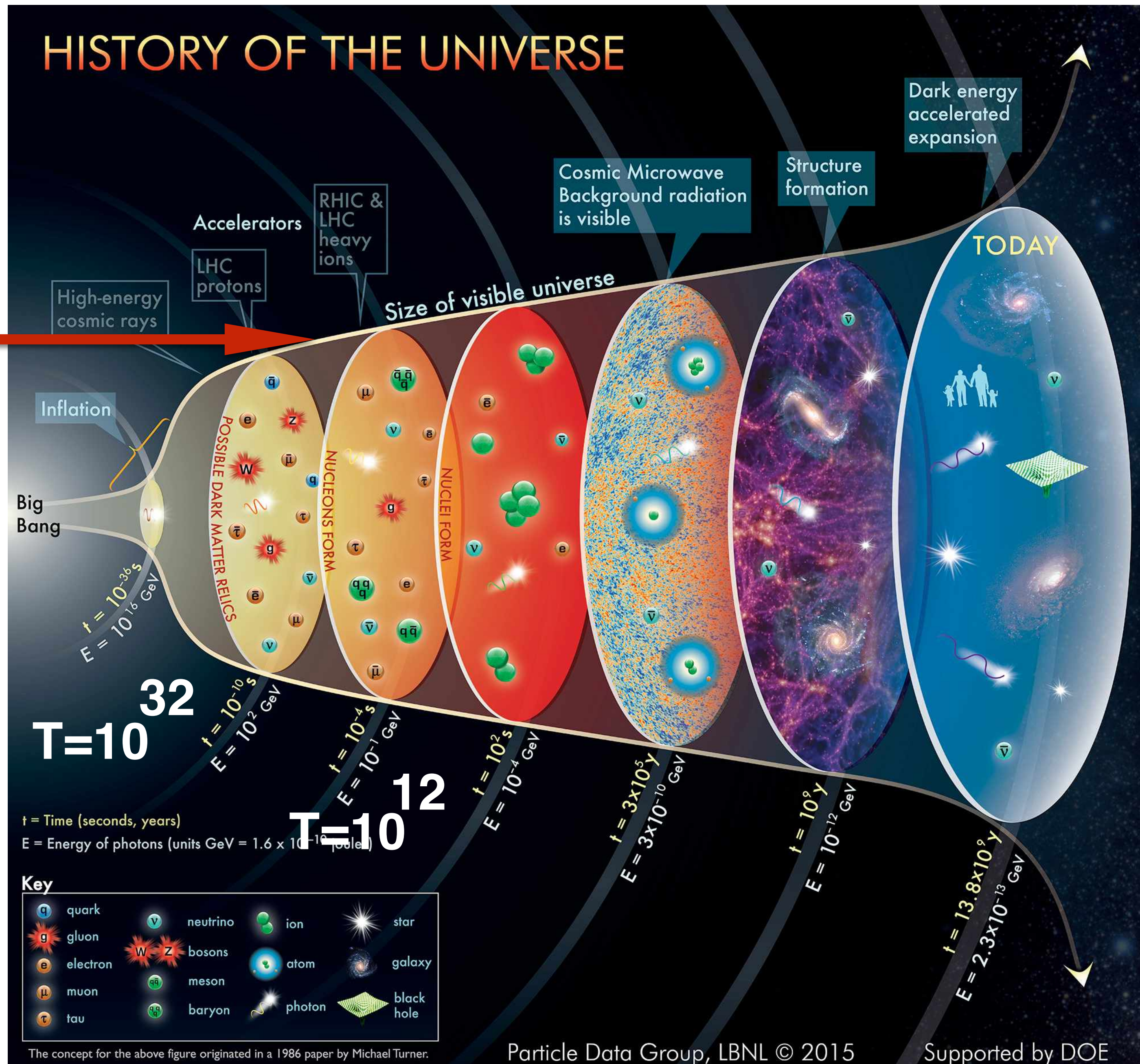
$T=10^{32}$

$T=10^{12}$

What else?

Pentaquarks

Eur. Phys. J. Plus (2022) 137:684, M.Amaryan History and geography of light pentaquark searches: challenges and pitfalls

$K_L p \rightarrow K^+ n$

$\Theta^+(1530)$ S=+1

$uudd\bar{s}$

S

Δ^- Δ^0 Δ^+ Δ^{++}

S=0

I_3

10

Σ^- $\Lambda \, \Sigma^0$ Σ^+

S=-1

$\overline{\textbf{10}}$

$\Xi^{--}(\textbf{2070})$

$\Xi^+(2070)$ S=-2

$ddss\bar{u}$

Ξ^- Ξ^0

$uuss\bar{d}$

$K_L p \rightarrow K_S \Xi^+$

S=-3 Ω^- sss
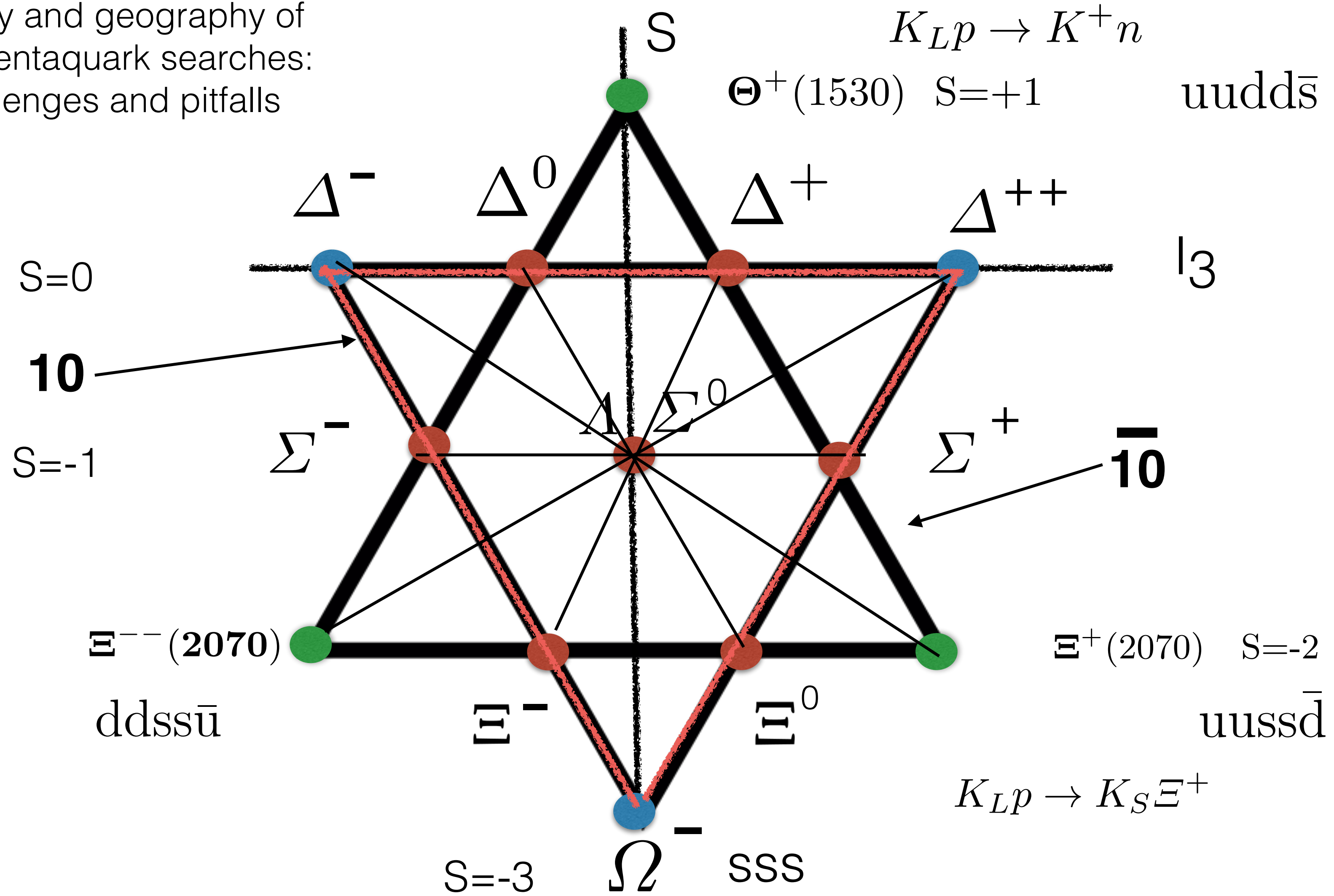
D. Diakonov, V. Petrov and M. V. Polyakov, Z. Phys. A **359**, 305 (1997).

Is everything feasible from hardware point of view?

Next few slides will answer this question.

Reminder:

Hall-D beamline and GlueX Setup

https://arxiv.org/pdf/2008.08215.pdf

Compact Photon Source

Conceptual design is
almost completed

K_L flux

LH$_2$/LD$_2$

flux monitor X 10
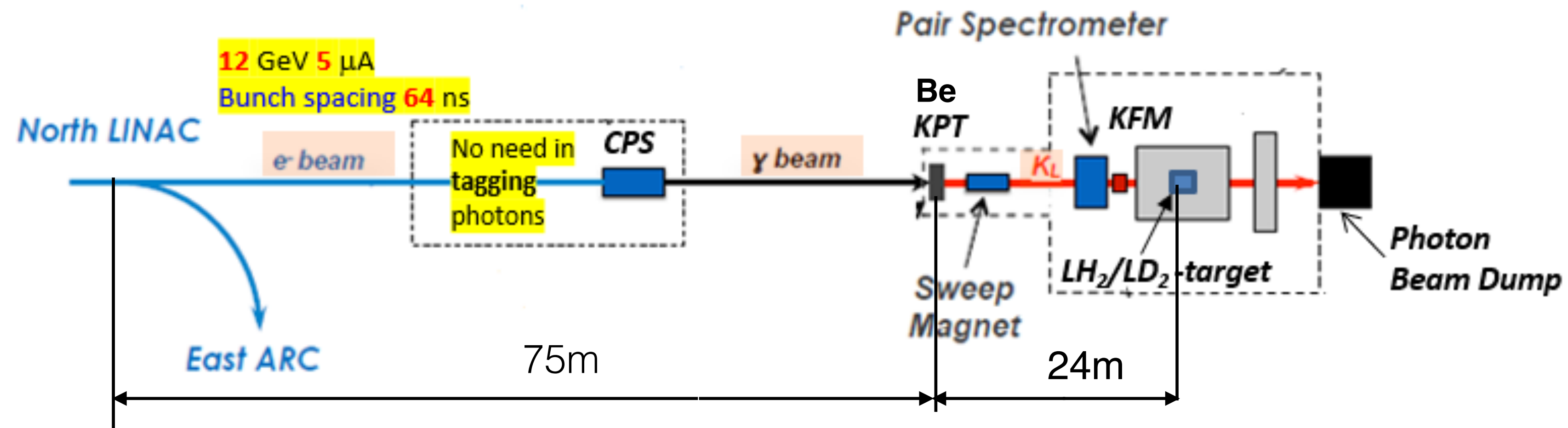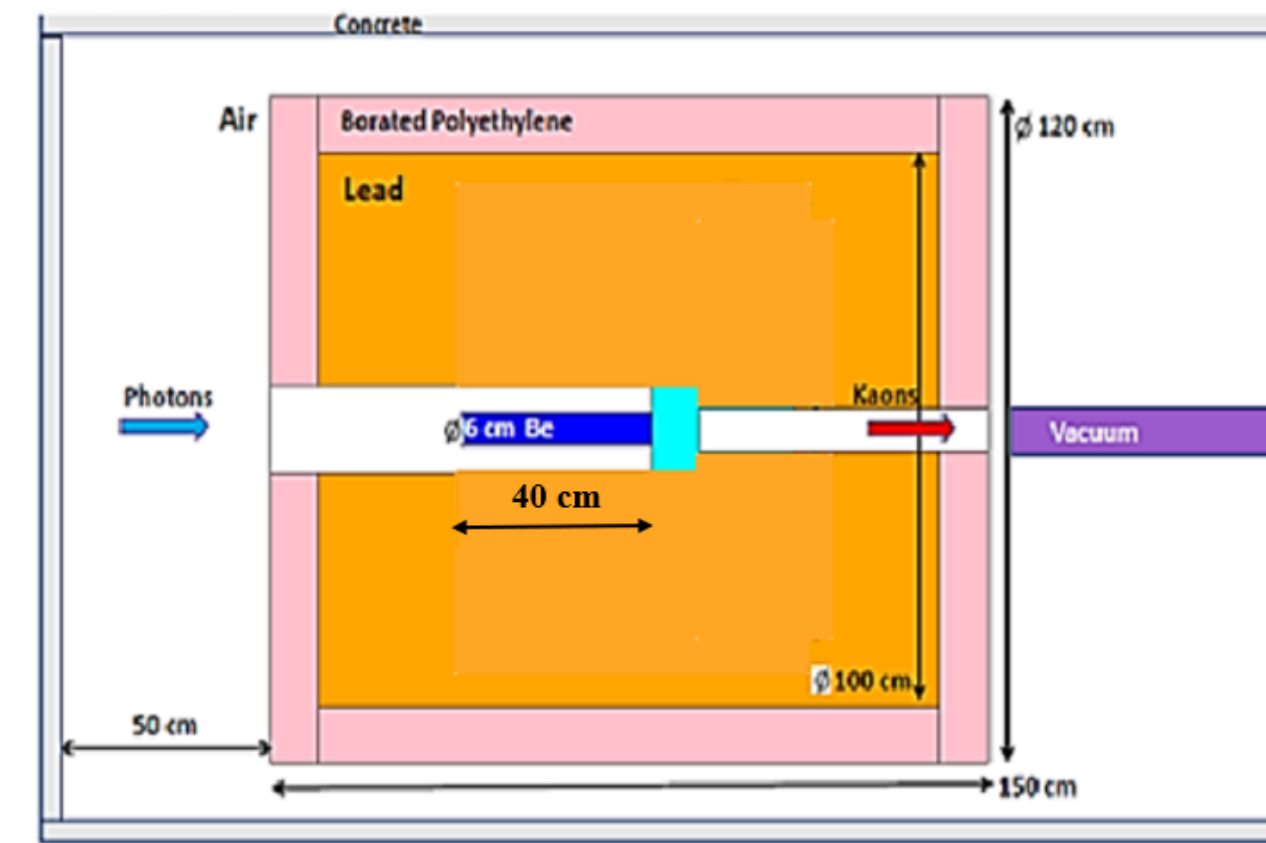
adCon Radiation Requirements

K_L Momentum [GeV/c]

Flux Monitor

ring Staff

Hall D

The GlueX liquid hydrogen target.

6cm

2cm

6cm

6cm

counts [arb]

$\pi^+\pi^-\pi^0$
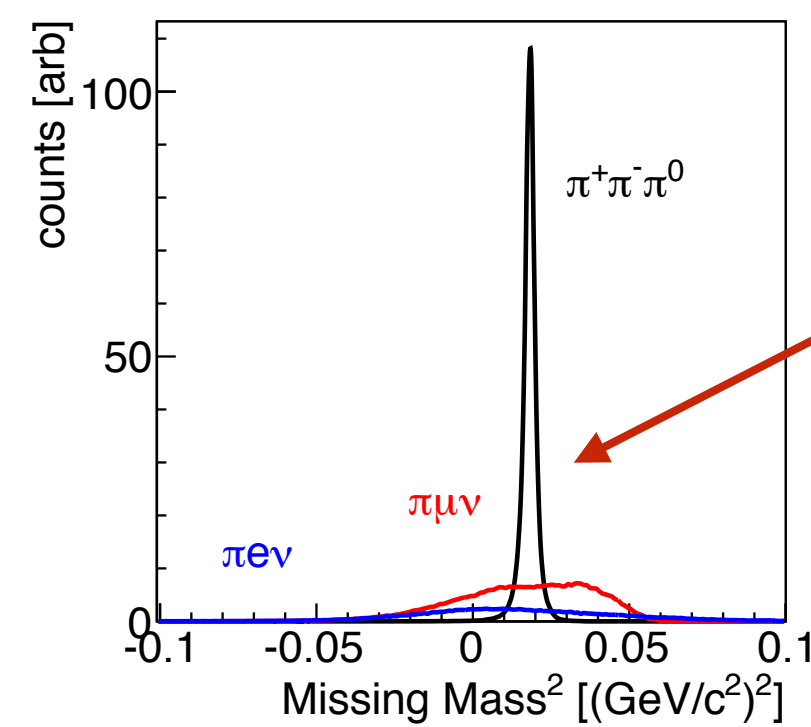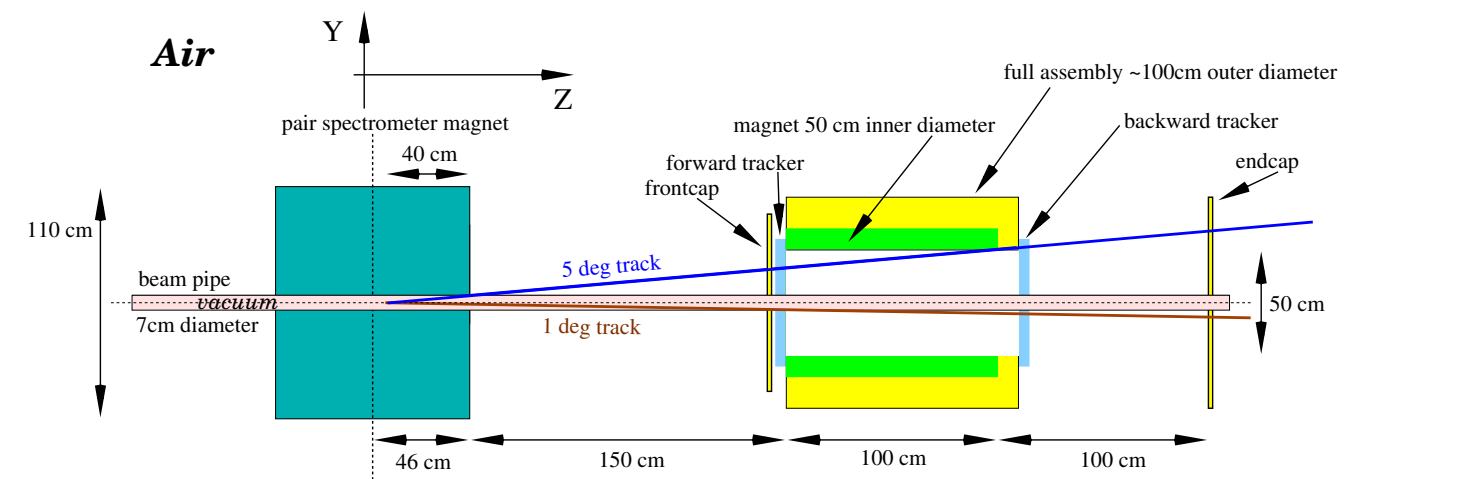
Reconstructed K$_L$ mass

$\pi^+\pi^-\pi^0$

$\pi\mu\nu$

$\pi e\nu$

Flux measurement stat. err. <1%

Estimated conservative syst. err. ~5%

Missing Mass^2 [(GeV/c^2)^2]

30cm

40cm

Current

Proposed & Feasible

Longer and ticker target is needed to enhance production rate

Conceptual design has been endorsed by the JLAB target group

Timeline of Design, Construction and Installation

Scheduling Outlook

Activity, experiment running	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
	scheduled									
Run PRIMEX-η	■	■								
Run SRC	■									
Installation CPP		■								
Run CPP-NPP		■								
Run GlueX-II			■							
Installation FCAL2			■							
Run GlueX-II+JEF				■						
Installation KLF (K$_L$ beam)					■					
Commissioning, Run KLF						■	■	■		
Back to photon beam									■	
Installation of GDH									■	
Commissioning, Run GDH										■

KLF
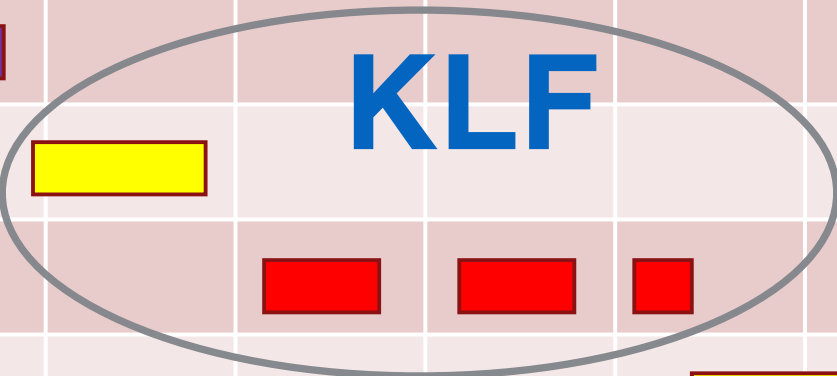
- Assumed 25 weeks/year for Hall D running
- Assumed timely budgeting for KLF and GDH

- Assumed timely construction of JEF,KLF,GDH

13

**E. Chudakov
GlueX Coll. Meeting, Oct. 2021**

Jefferson Lab

The Facility is Flexible and can be switched back to photon beam

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 spectrosocopy
PWA will allow to unravel and measure pole positions and widths of a few dozens of new excited states

- -In Strange Meson Spectroscopy
PWA will allow to measure excited K* states

- To accomplish physics program 200 days running is approved

- All components of KL Facility considered are feasible

-With total cost of the project below 2M

At the end we would like to invite everyone to join us.

Thanks for your attention!