



***KLF@JLab***

***Moskov Amaryan***

***Old Dominion University  
Norfolk, VA***

***STRONG2020, Munich, September 13-16, 2022***

# Outline

## ***-Introduction***

## ***-K<sub>L</sub> Facility Beamline and Hardware***

*- Electron Beam*

*- Compact Photon Source*

*- Be Target*

*- Flux Monitor*

*- K<sub>L</sub> Beam*

*- LH<sub>2</sub>/LD<sub>2</sub> Target*

## ***-Physics Motivation***

*- Hyperon Spectroscopy*

*- Strange Meson Spectroscopy*

*- Early Universe*

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## ***Summary***

# 48<sup>th</sup> PROGRAM ADVISORY COMMITTEE (PAC 48)

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August 10-14, 2020

September 25, 2020



U.S. DEPARTMENT OF  
**ENERGY**



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

# Recommendations

PAC 48 SUMMARY OF RECOMMENDATIONS								
Number	Contact Person	Title	Hall	Days Req'd	Days Awarded	Scientific Rating	PAC Decision	Topic
<a href="#">C12-18-005</a>	M. Boer	Timelike Compton Scattering Off Transversely Polarized Proton	C	50			C2	4
<a href="#">C12-19-001</a>	M. Amarian	Strange Hadron Spectroscopy with Secondary KL Beam in Hall D	D	200	200	A-	Approved	1

**Title:** Strange Hadron Spectroscopy with Secondary KL Beam in Hall D

**Spokespersons:** M. Amarian (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 TAC.

**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 JPAC 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  $\Delta$  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 and dedicated efforts of the KLF Collaboration



**comprised of 160 physicists from 68 Universities  
across 19 countries worldwide**

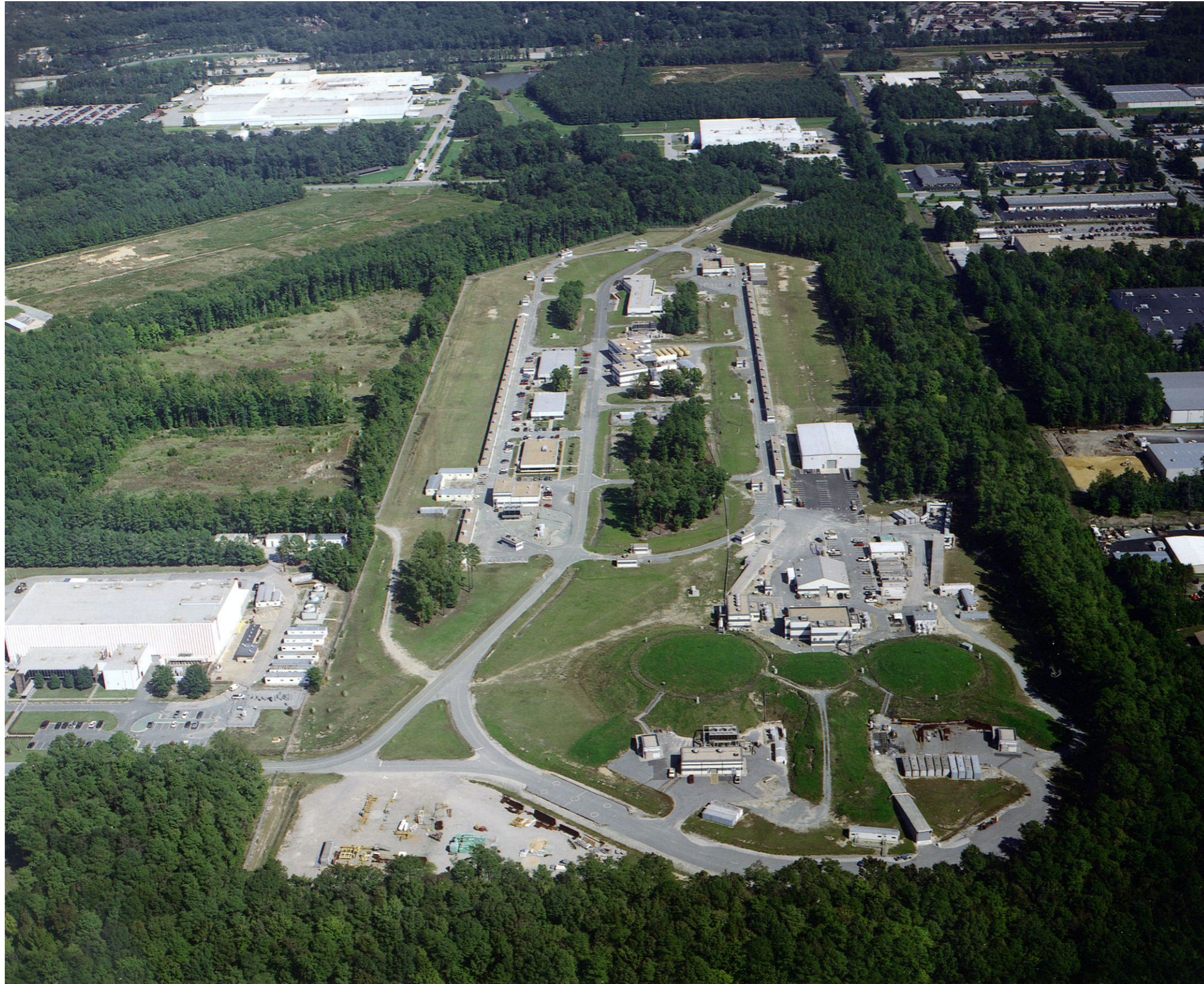
Strange Hadron Spectroscopy with Secondary  $K_L$  Beam in Hall DExperimental Support:

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

Theoretical Support:

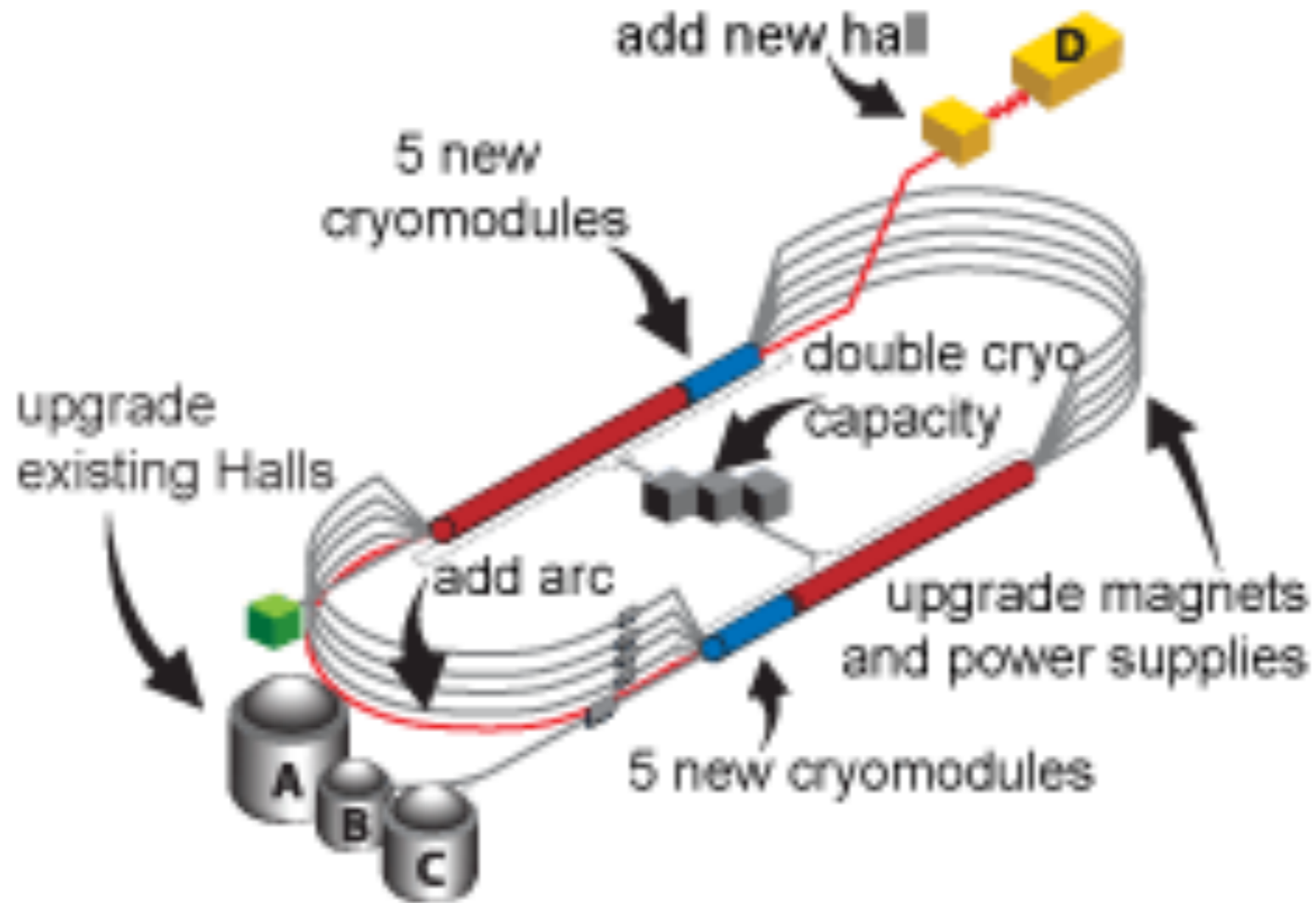
Alexey Anisovich<sup>5,44</sup>, Alexei Bazavov<sup>38</sup>, Rene Bellwied<sup>21</sup>, Veronique Bernard<sup>42</sup>, Gilberto Colangelo<sup>3</sup>, Aleš Cieplý<sup>46</sup>, Michael Döring<sup>19</sup>, Ali Eskanderian<sup>19</sup>, Jose Goity<sup>20,49</sup>, Helmut Habertzettl<sup>19</sup>, Mirza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

# Thomas Jefferson National Accelerator Facility Newport News, Virginia, Aerial View.



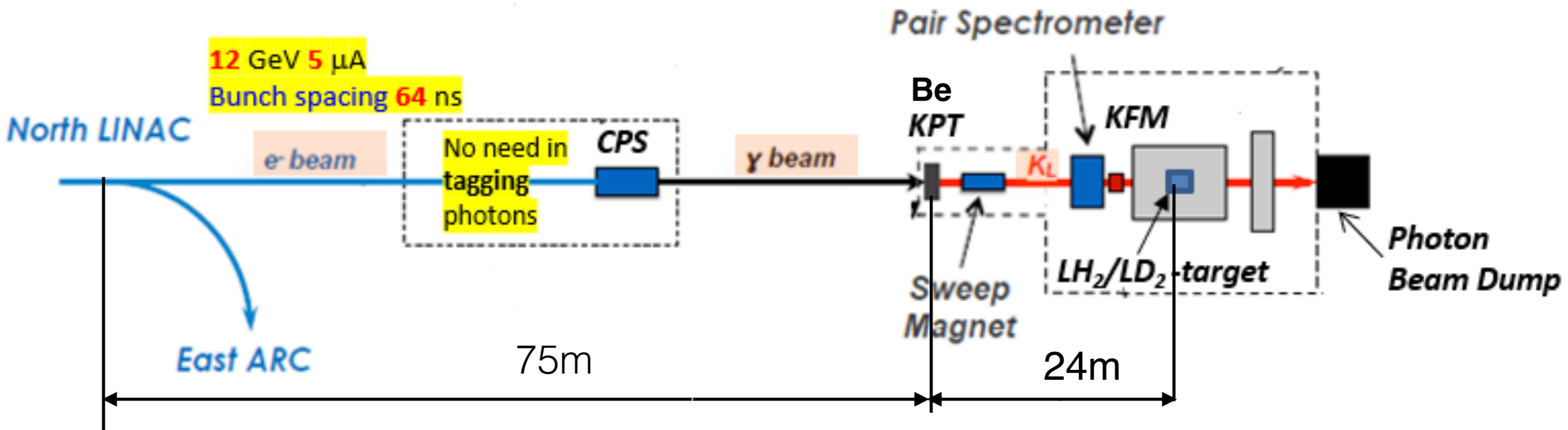
# Continuous Electron Beam Accelerator Facility (CEBAF)

## 12 GeV Electron Beam





# Hall-D beamline and GlueX Setup

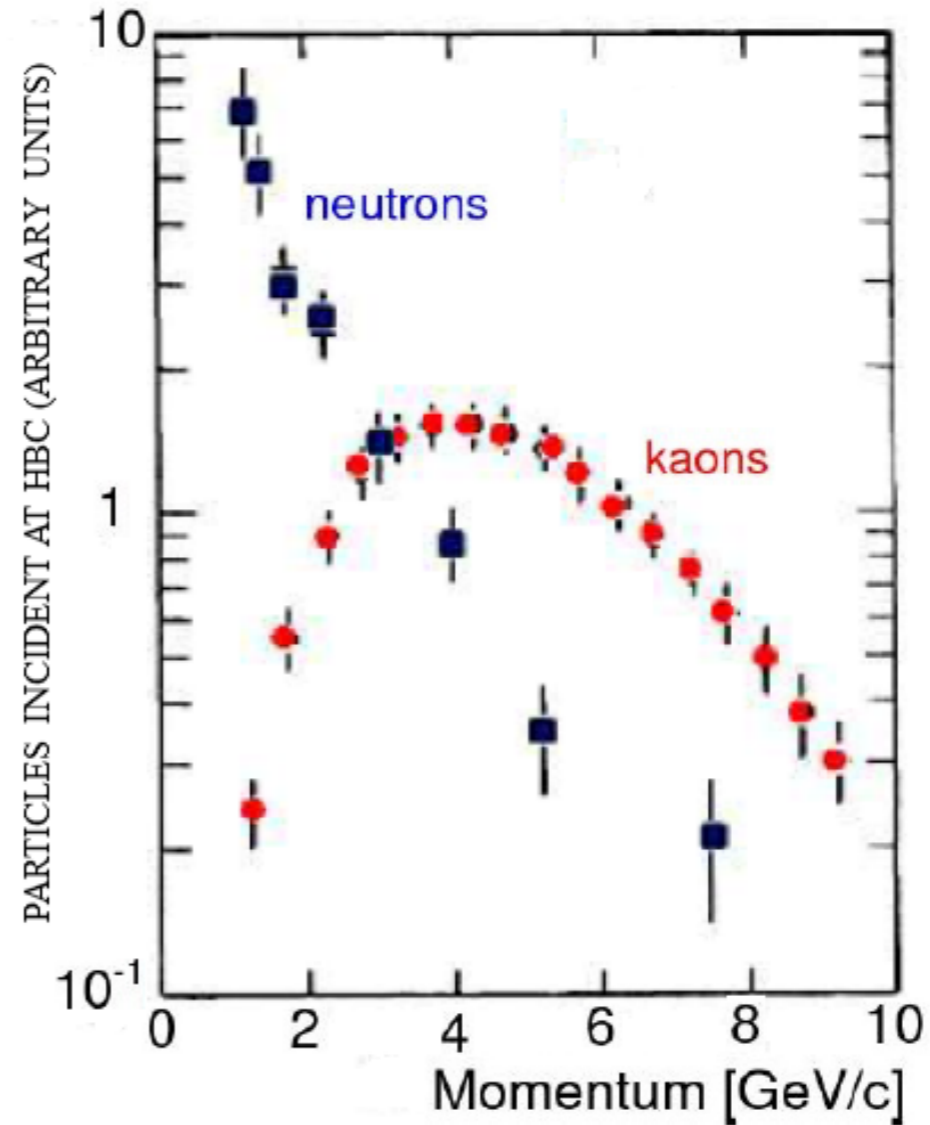
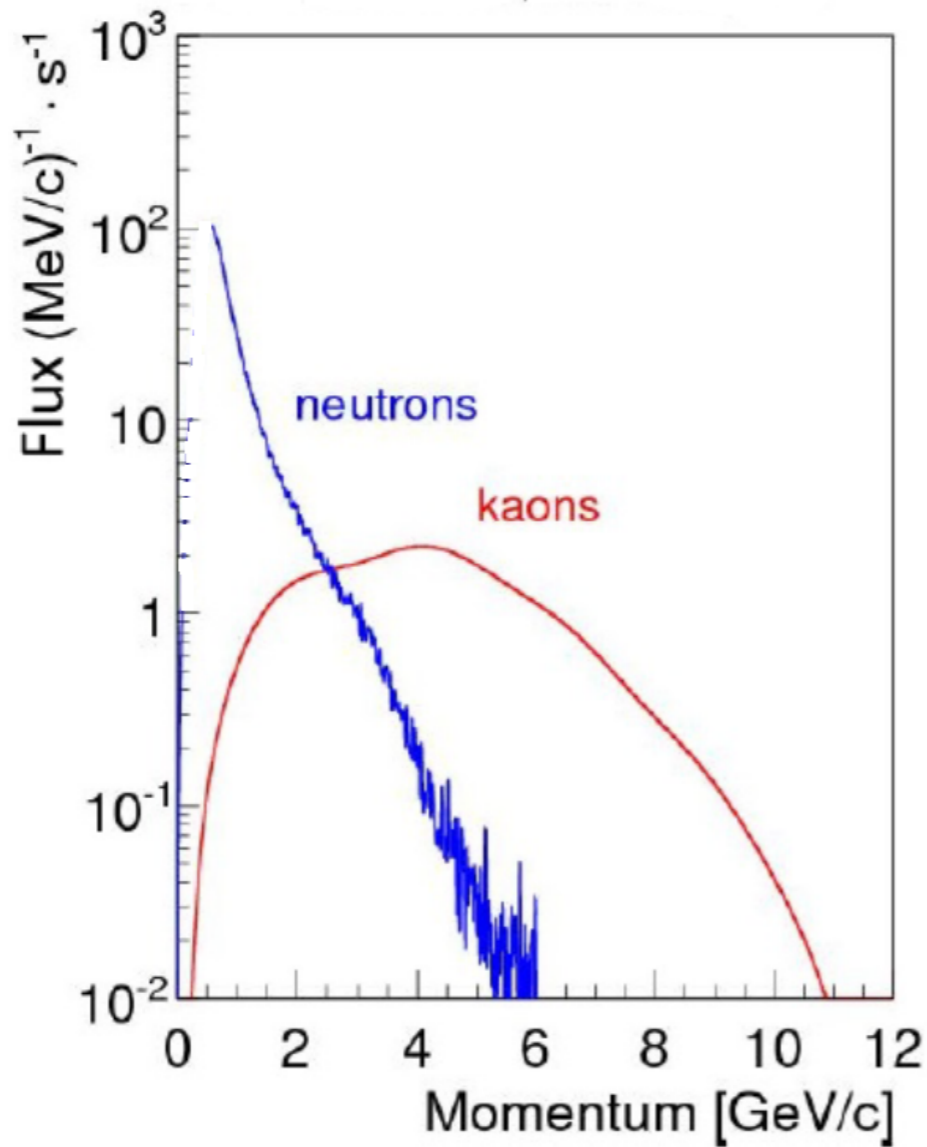


<https://arxiv.org/pdf/2008.08215.pdf>

# $K_L$ Beam Flux

JLab 12 GeV

SLAC 16 GeV



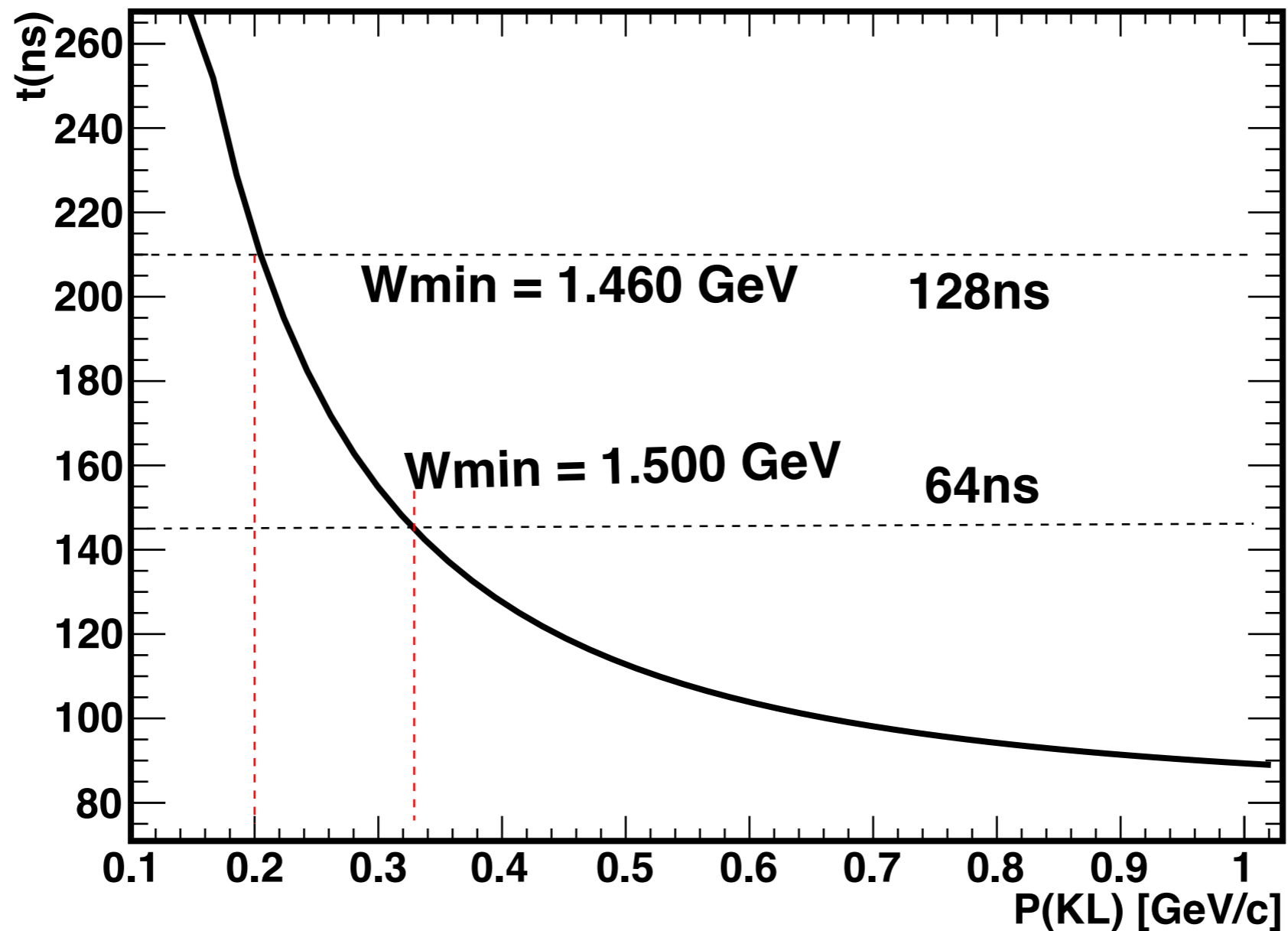
$$N(K_L)/sec \sim 10^4 \quad \longrightarrow \quad \frac{N(K_L)_{JLAB}}{N(K_L)_{SLAC}} \sim 10^3$$

# Electron Beam Parameters

$$E_e = 12 \text{ GeV} \quad I = 5 \mu\text{A}$$

$$\text{Bunch spacing} \quad 64 \text{ ns}$$

*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.

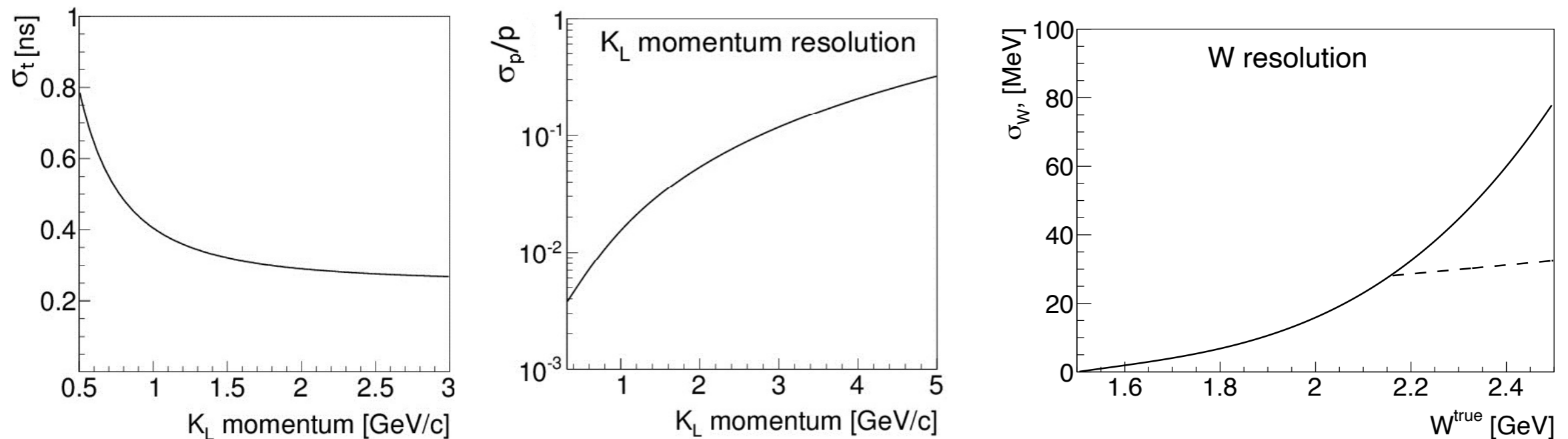


Figure 30: Left: Time resolution ( $\sigma_t$ ) for  $K_L$  beam as a function of  $K_L$ -momentum. Middle: Momentum resolution ( $\sigma_p/p$ ) as a function of momentum (note, log scale). Right: Energy resolution ( $\sigma_W$ ) as a function of energy. The dashed line shows approximate  $W$  resolution from reconstruction of the final-state particles.

# **We can do it, but why?**

- 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.**

# Hyperon Spectroscopy

*LQCD in addition to already known states*

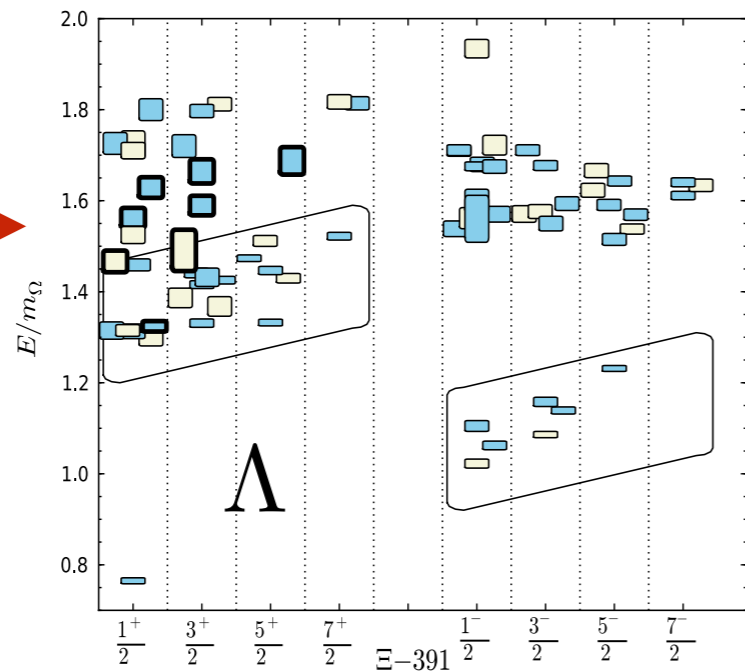
*predicts many more including hybrids (thick bordered)*

**8-states**

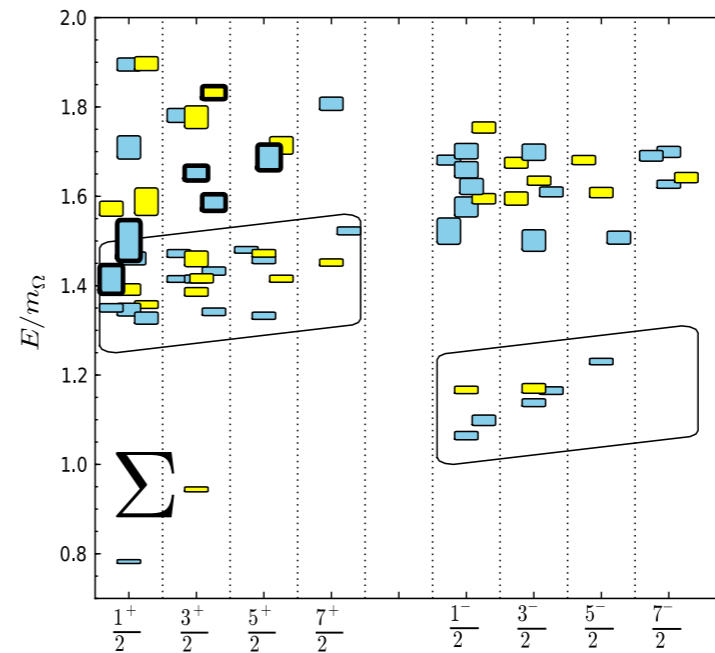
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**5-states**

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$\Sigma-391$



**6-states**

\*\*\*\*

**4-states**

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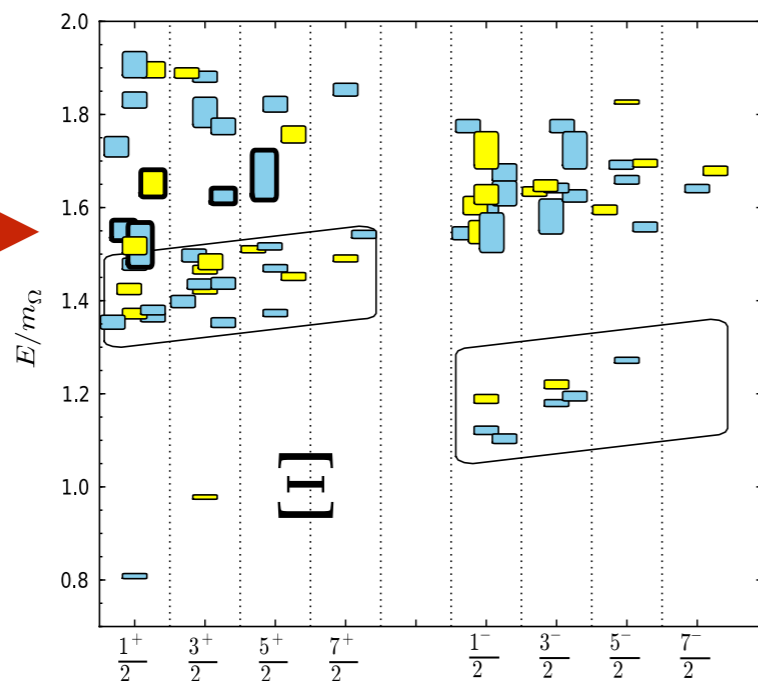


**3-states**

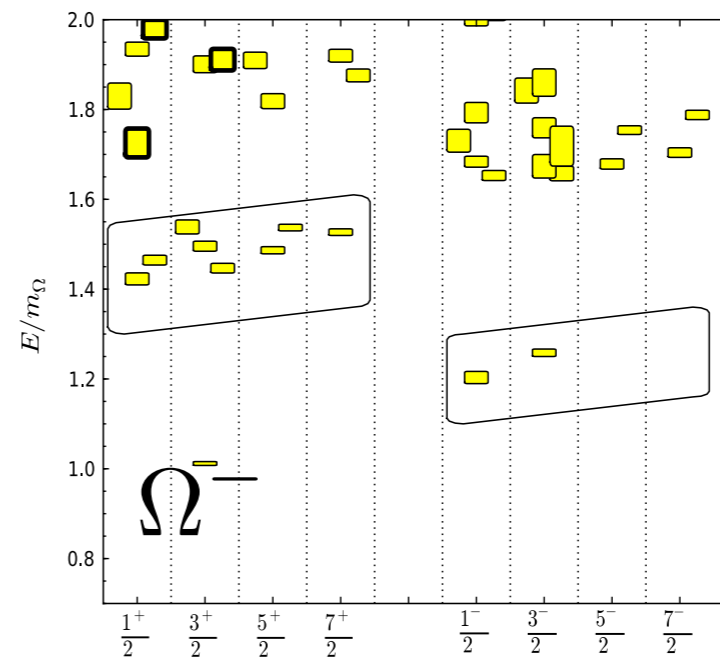
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**4-states**

\*\*\*



$\Omega-391$



**1-state**

\*\*\*\*

**1-state**

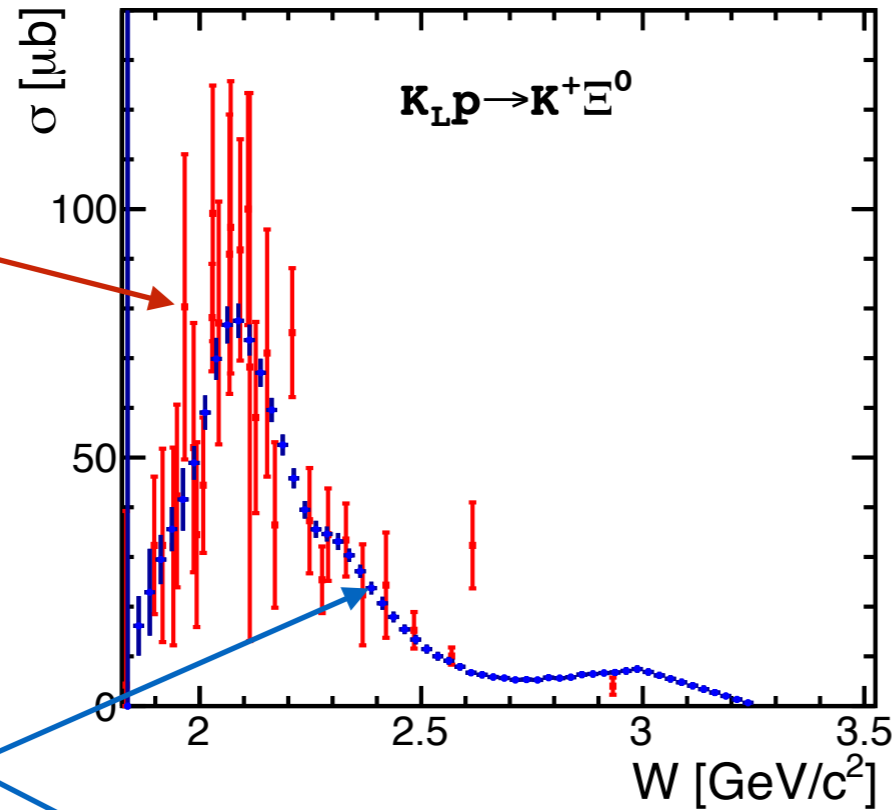
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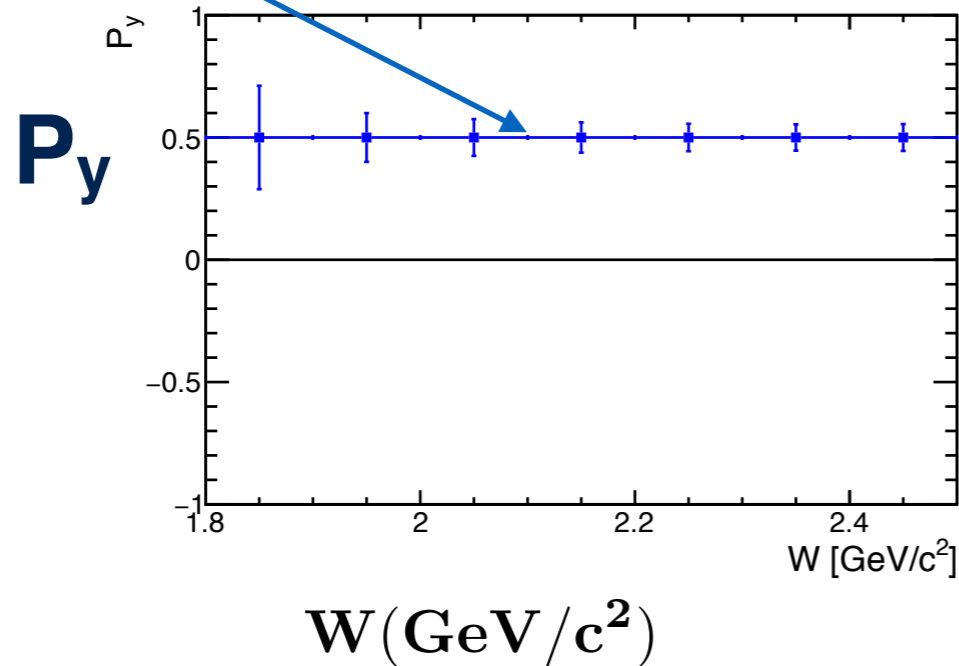
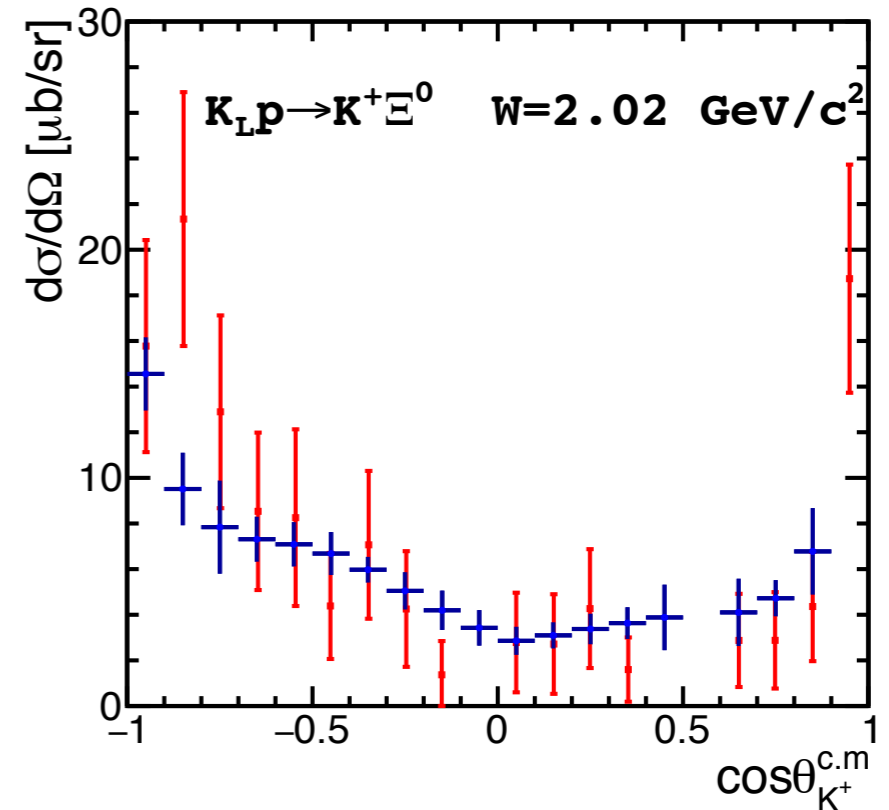
Edwards, Mathur, Richards and Wallace, Phys. Rev. D 87, 054506 (2013)

# Measurements on Proton Target

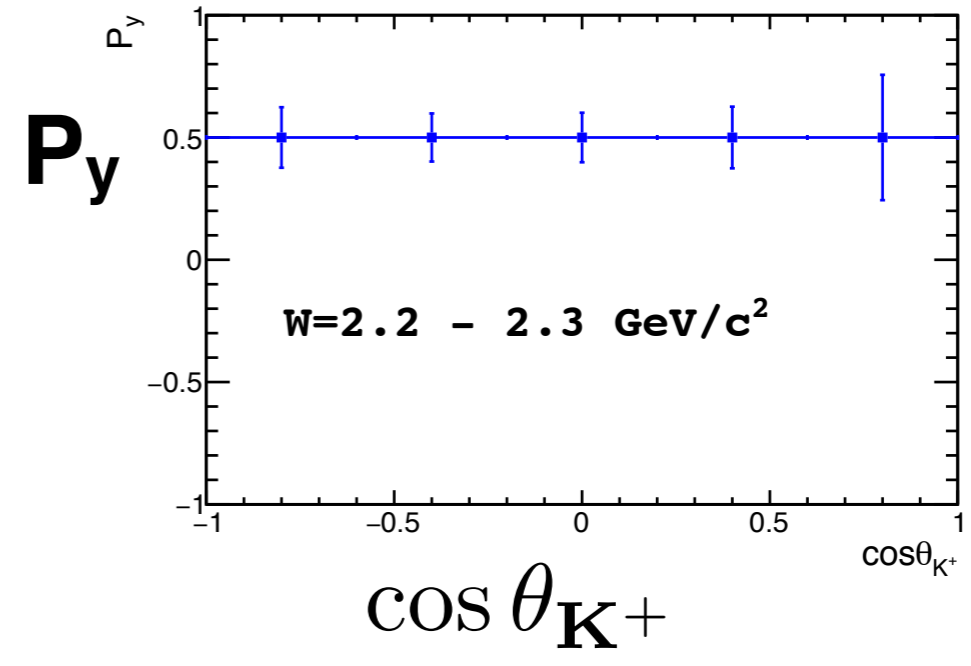
existing data



KLF 100 days

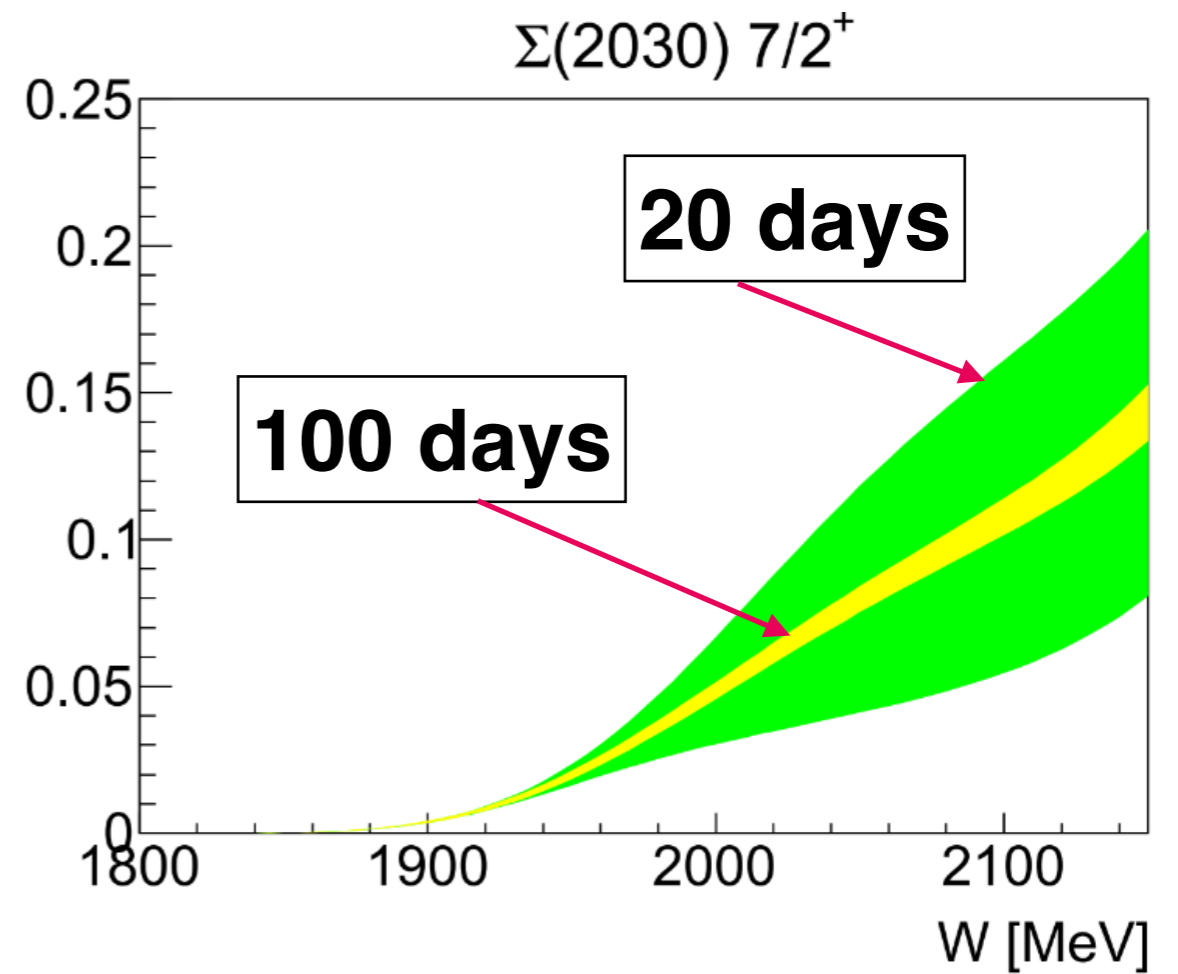
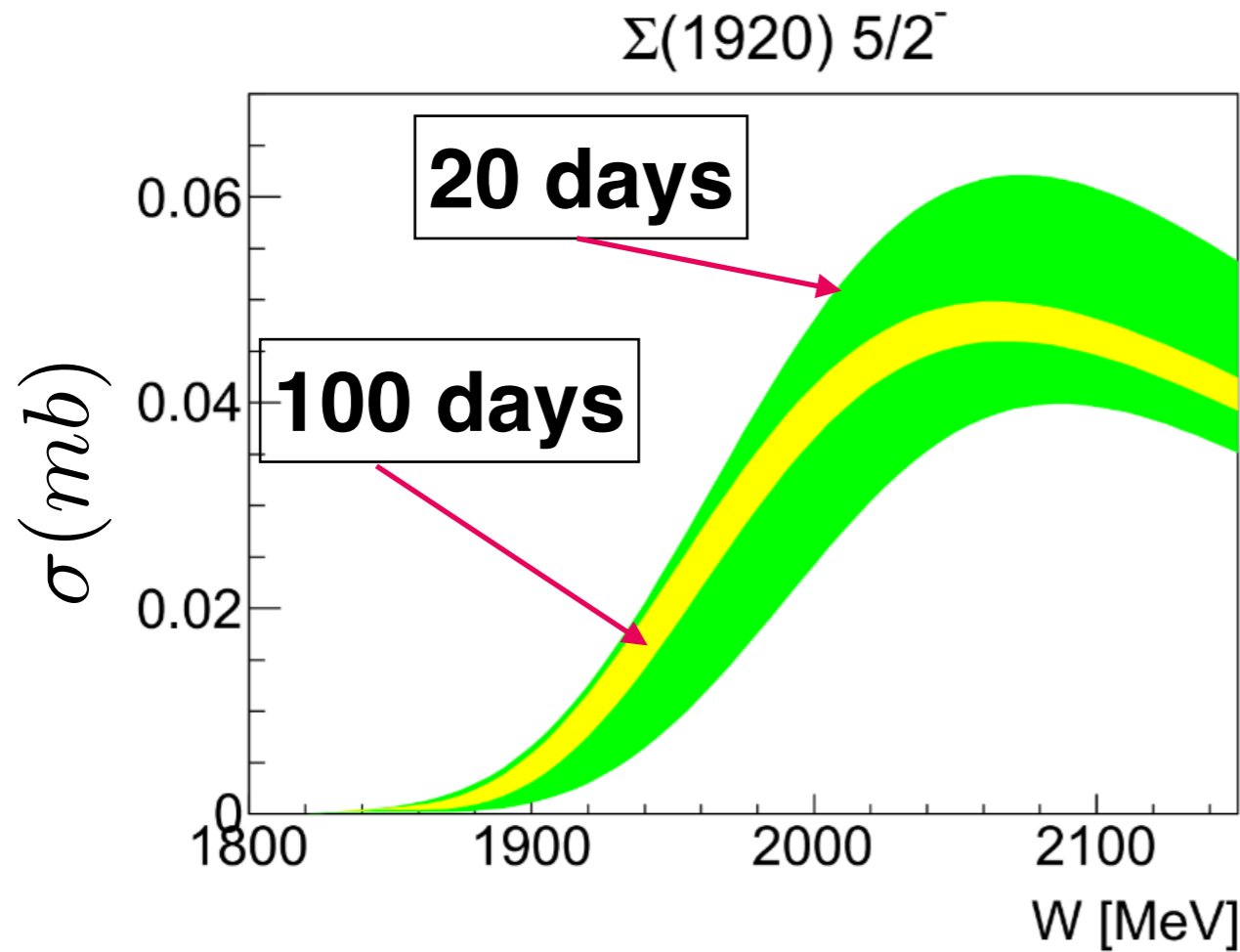
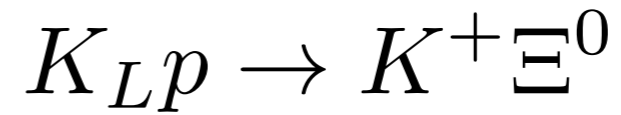


No Data



# Bonn-Gatchina PWA

Total Cross Section

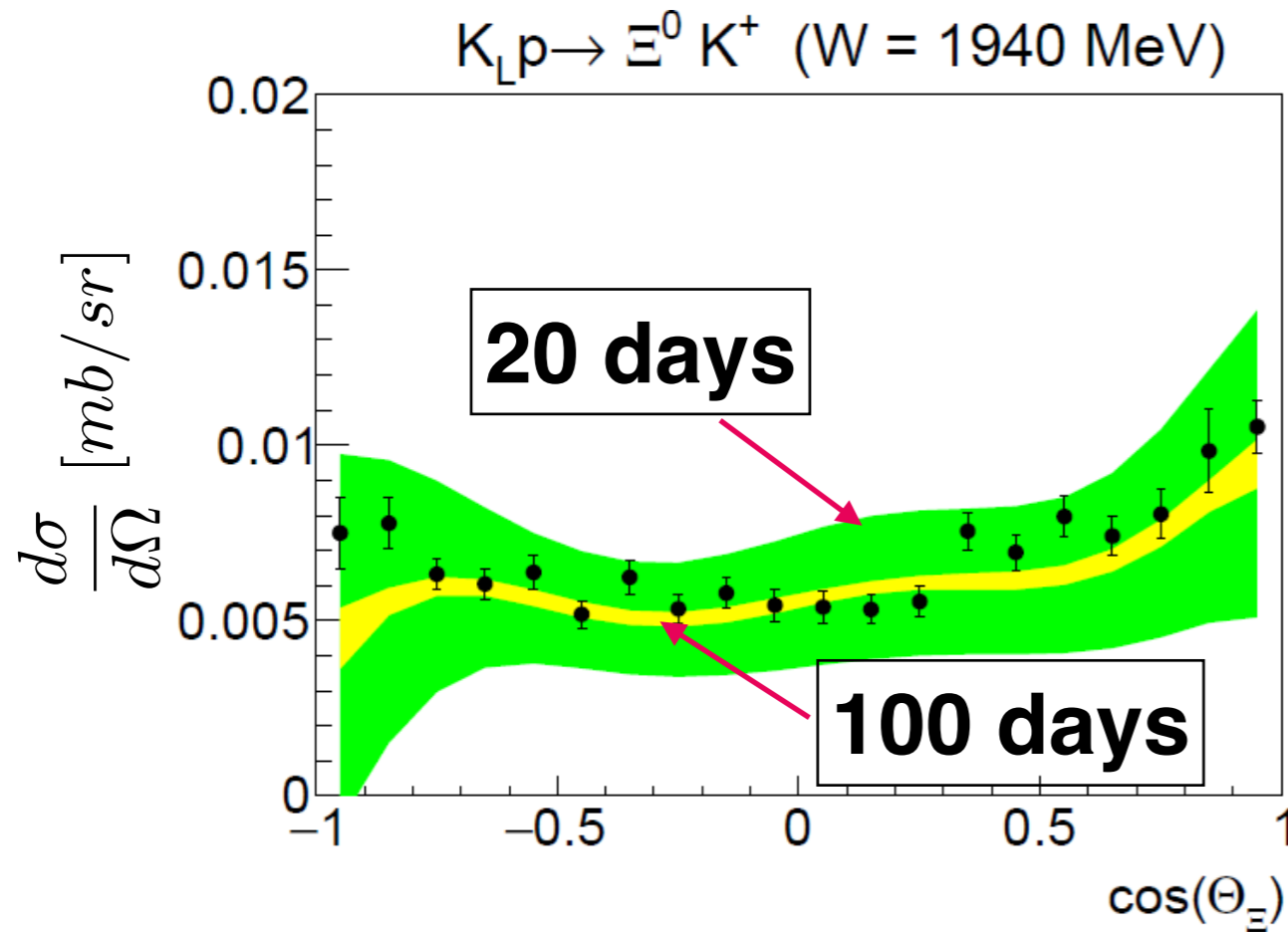


**Need 100 days of running to get precise solution**

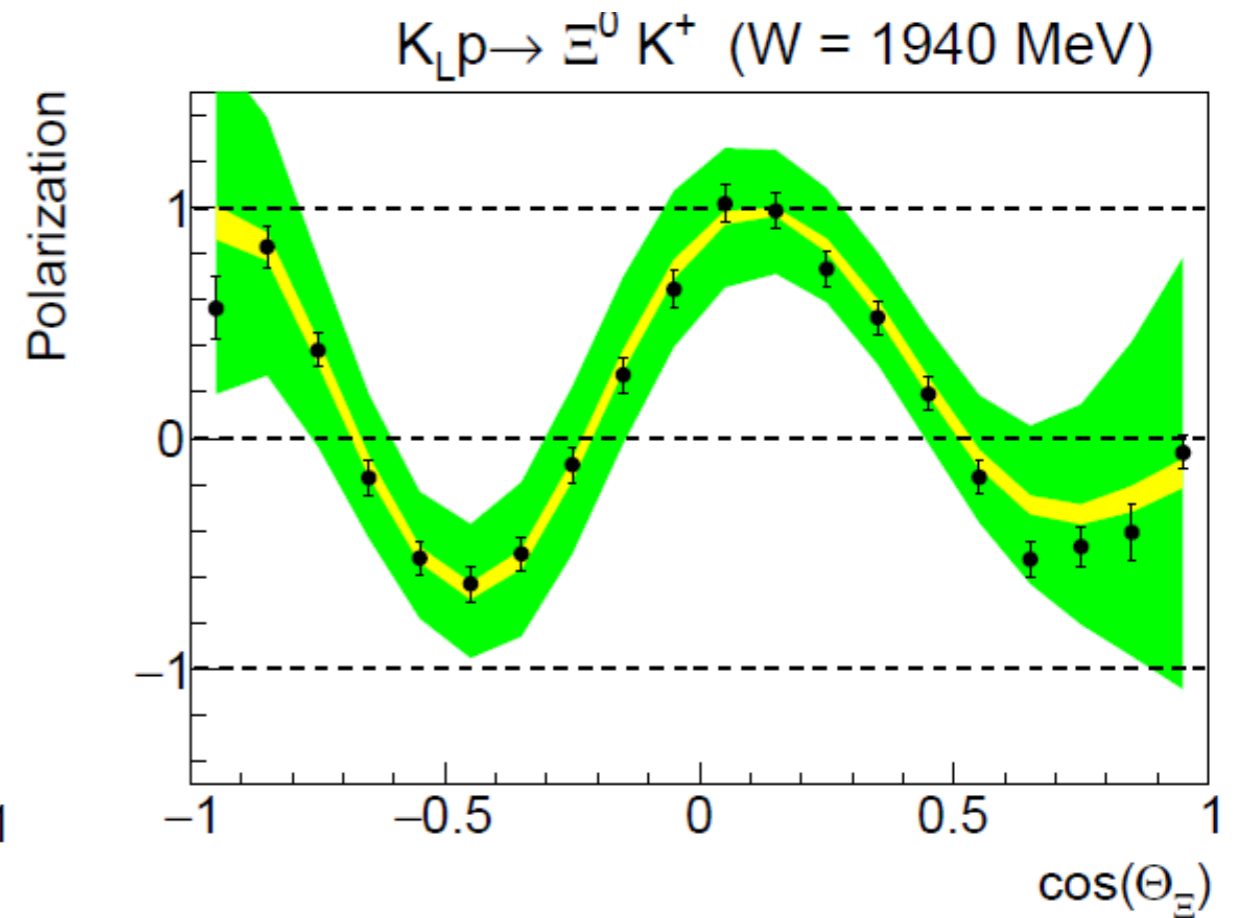


# Bonn-Gatchina PWA

## Diff. Cross Section



## Polarization



**Need 100 days of running to get precise solution**

# ***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**

$$\Lambda^*, \Sigma^*, \Xi^* \text{ \& \ } \Omega^*$$

**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.

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

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

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

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

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

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

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

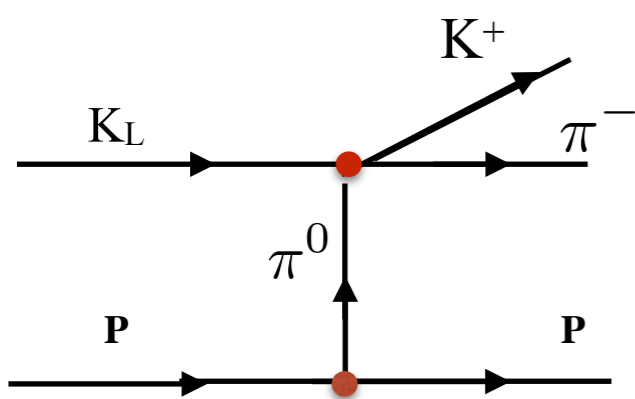
$$K_L n \rightarrow K_L \pi^0 n = \langle K_L \pi^0 | K_L \pi^0 \rangle = \frac{1}{3}(T^{\frac{1}{2}} + 2T^{\frac{3}{2}}),$$

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

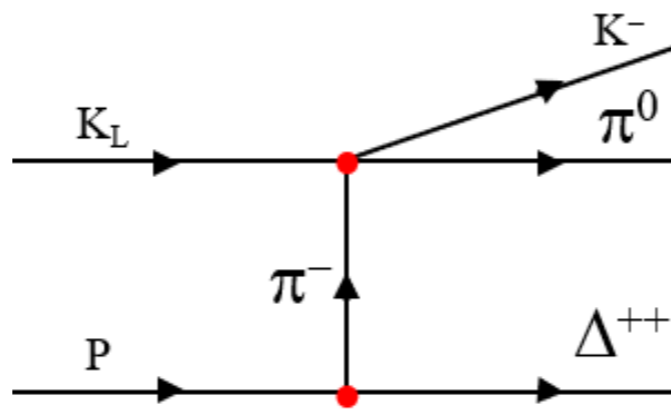
$$K_L n \rightarrow K^\pm \pi^0 \Delta^\mp = \langle K_L \pi^\pm | K^\pm \pi^0 \rangle = \pm \frac{1}{3}(T^{\frac{1}{2}} - T^{\frac{3}{2}}),$$

# Strange Meson Spectroscopy

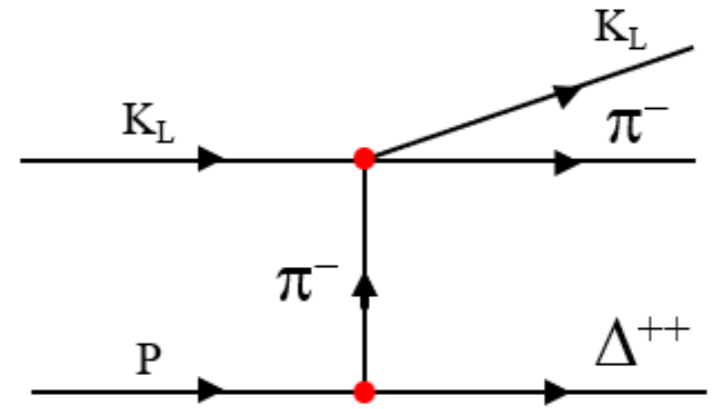
## $K\pi$ Scattering



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



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



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

# Proposed Measurements

SLAC

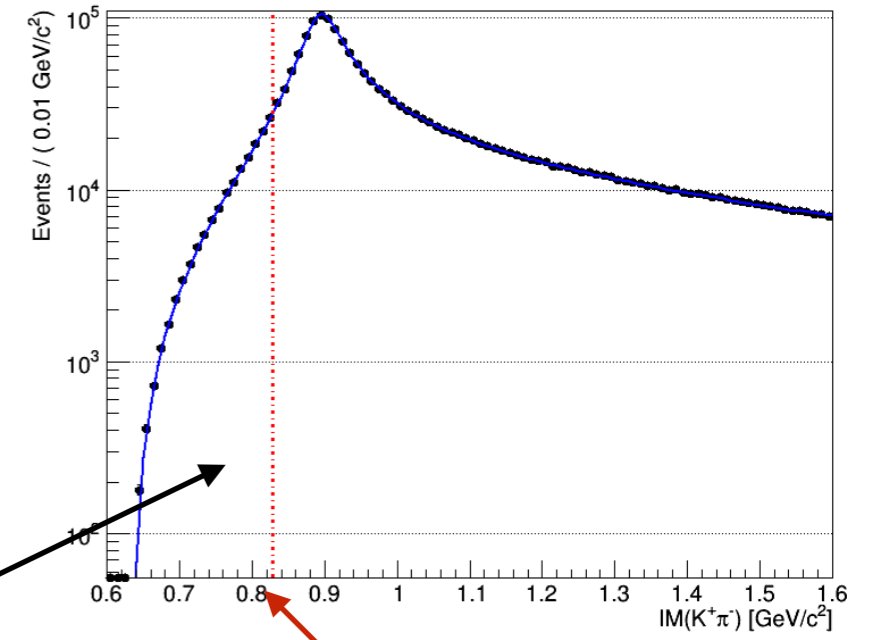
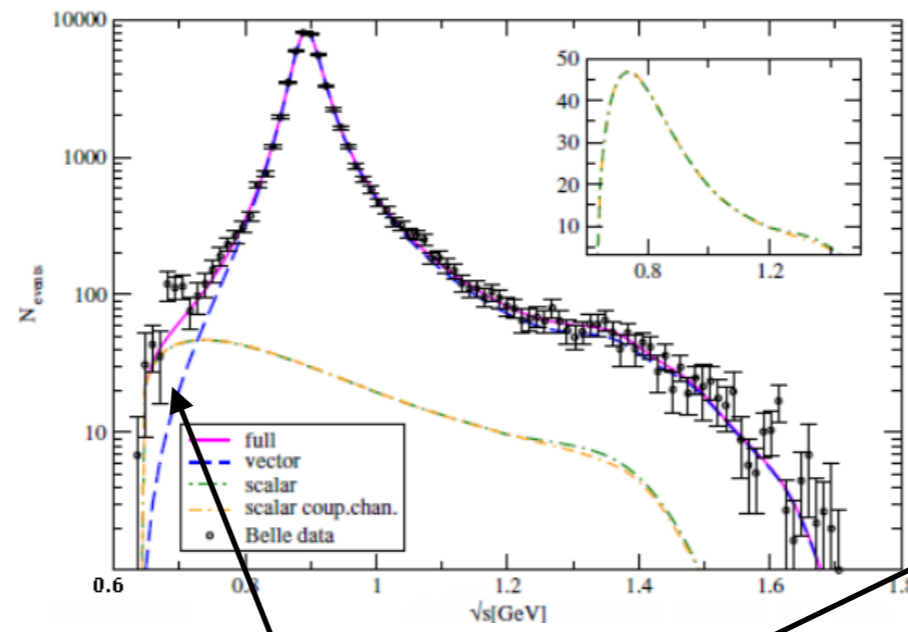
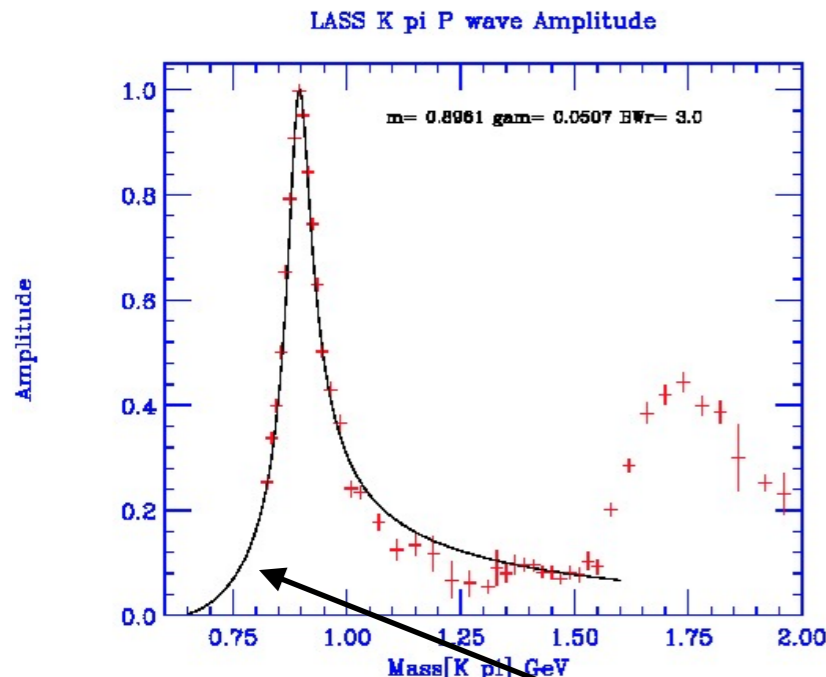
$$K^- \pi^+ \rightarrow K^- \pi^+$$

Belle

$$\tau \rightarrow K \pi \nu_\tau$$

KLF

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



$M(K\pi)$  (GeV)

$M(K\pi)$  (GeV)

$M(K\pi)$  (GeV)

region of  $\mathcal{K}(800)$

SLAC Lower limit

## KLF 100 Days

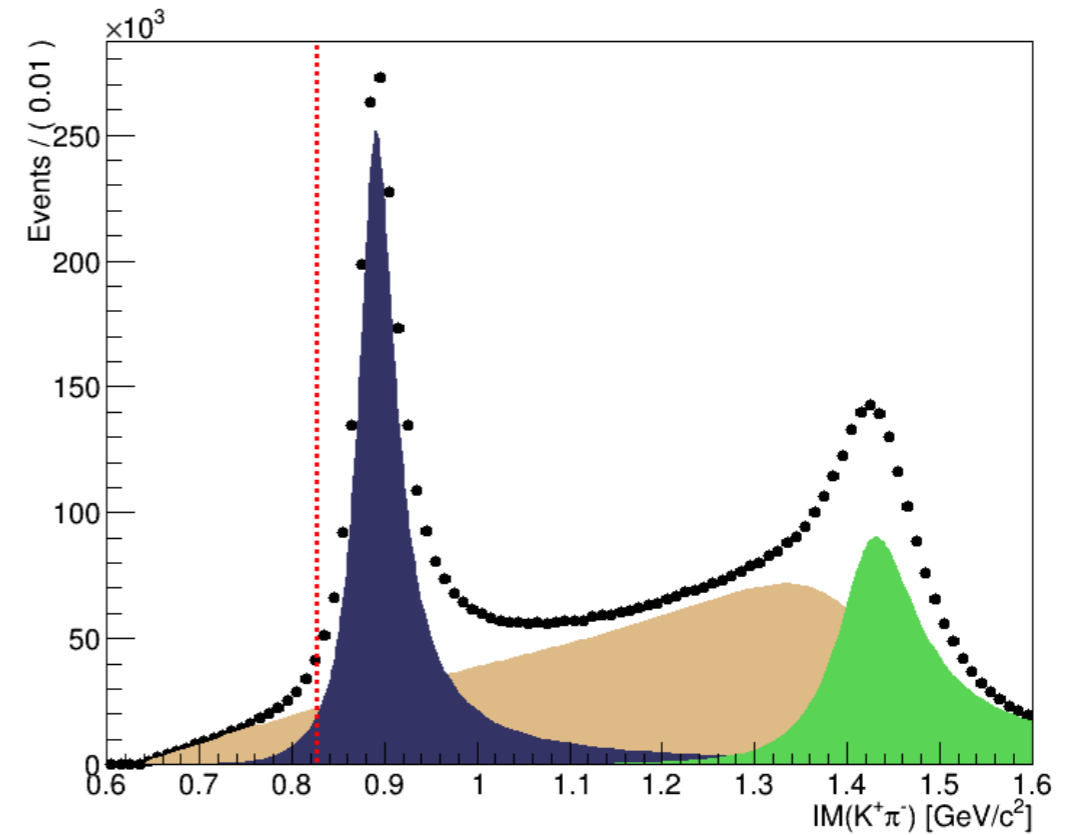
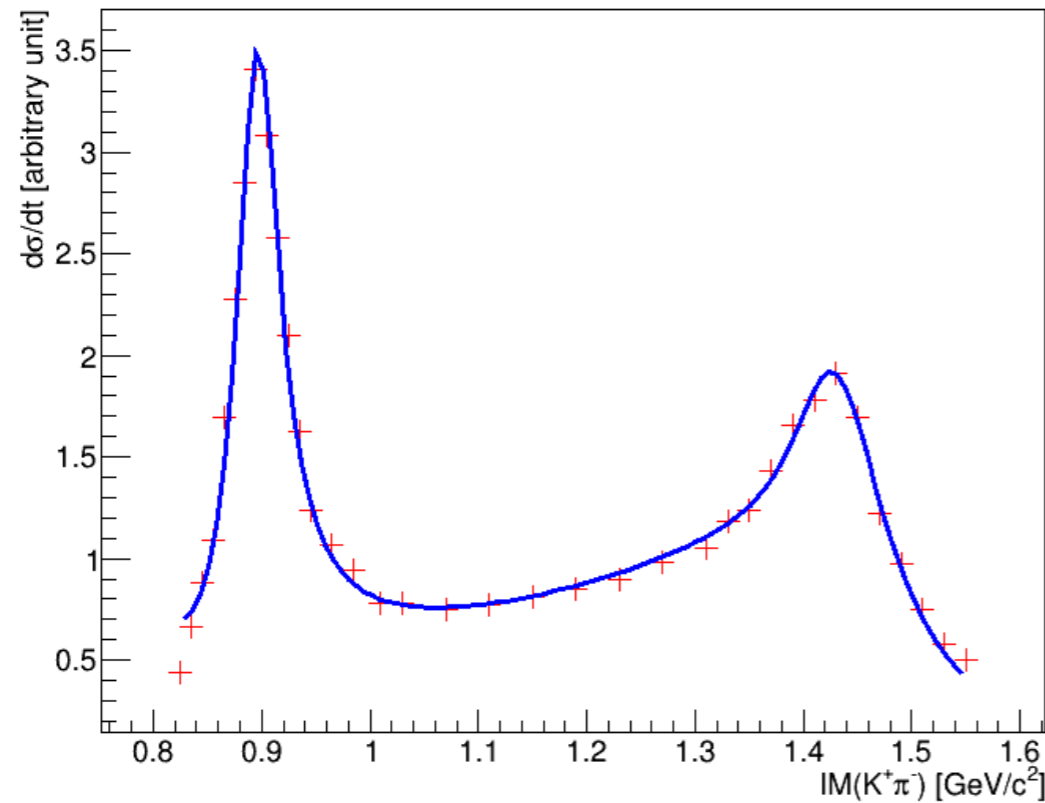
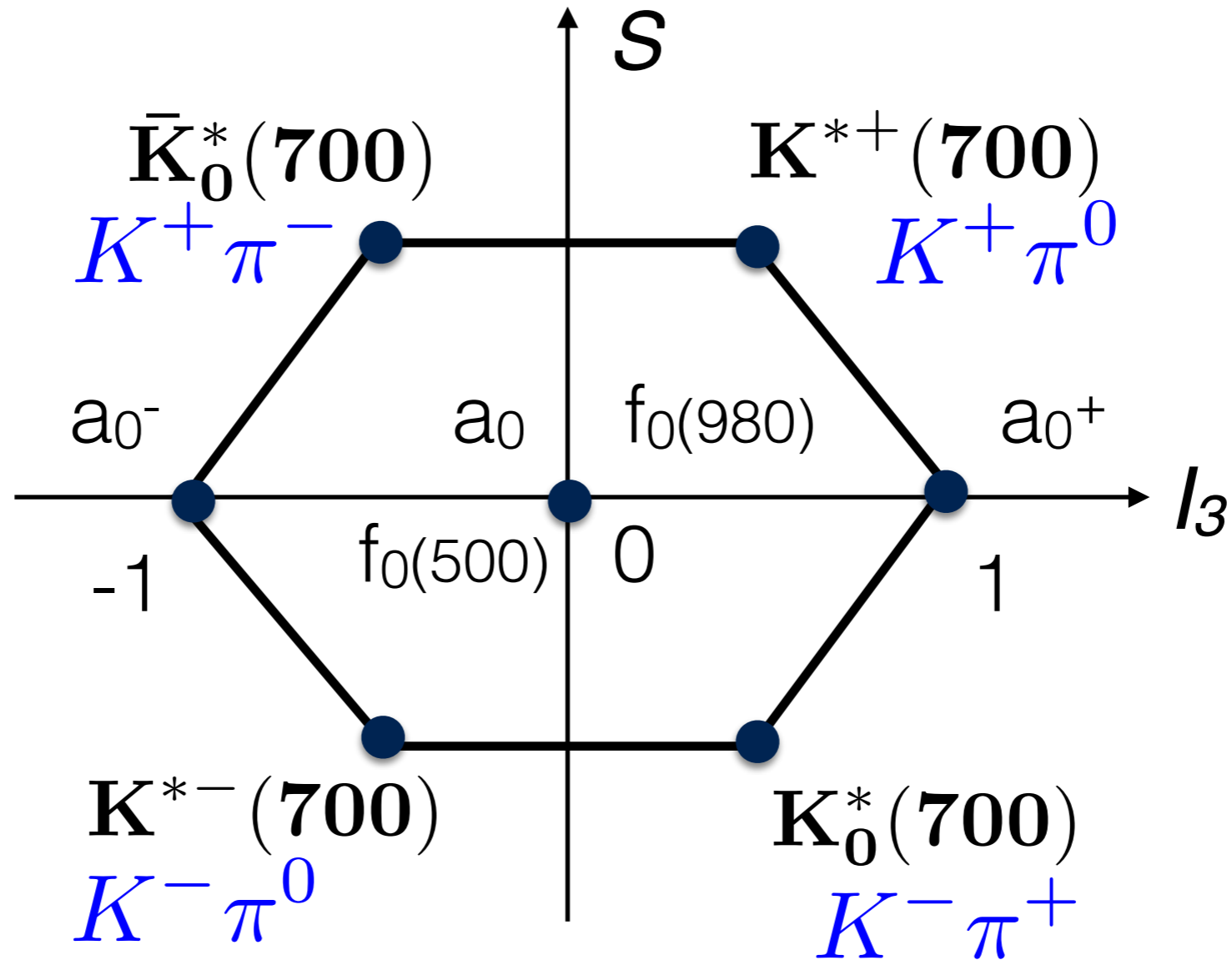


Figure 11: Left: Cross section of  $K^-p \rightarrow K^+\pi^-n$  as a function of the invariant mass from LASS results [27]. The blue line is the fit to the cross section using composite model containing two RBWs, spin-1 and spin-2, and  $S$ -wave LASS parameterization. Right: Expected distribution of 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

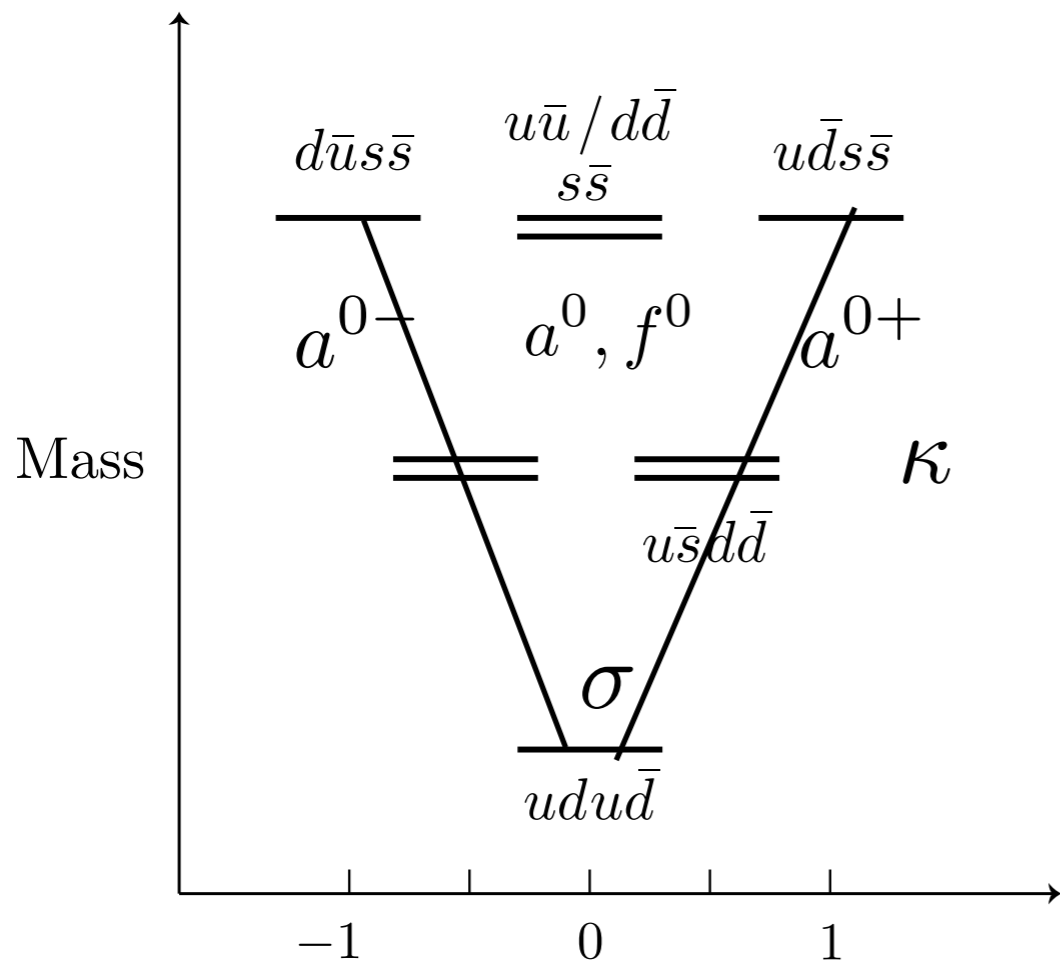
$$J^{PC} = 0^{++}$$



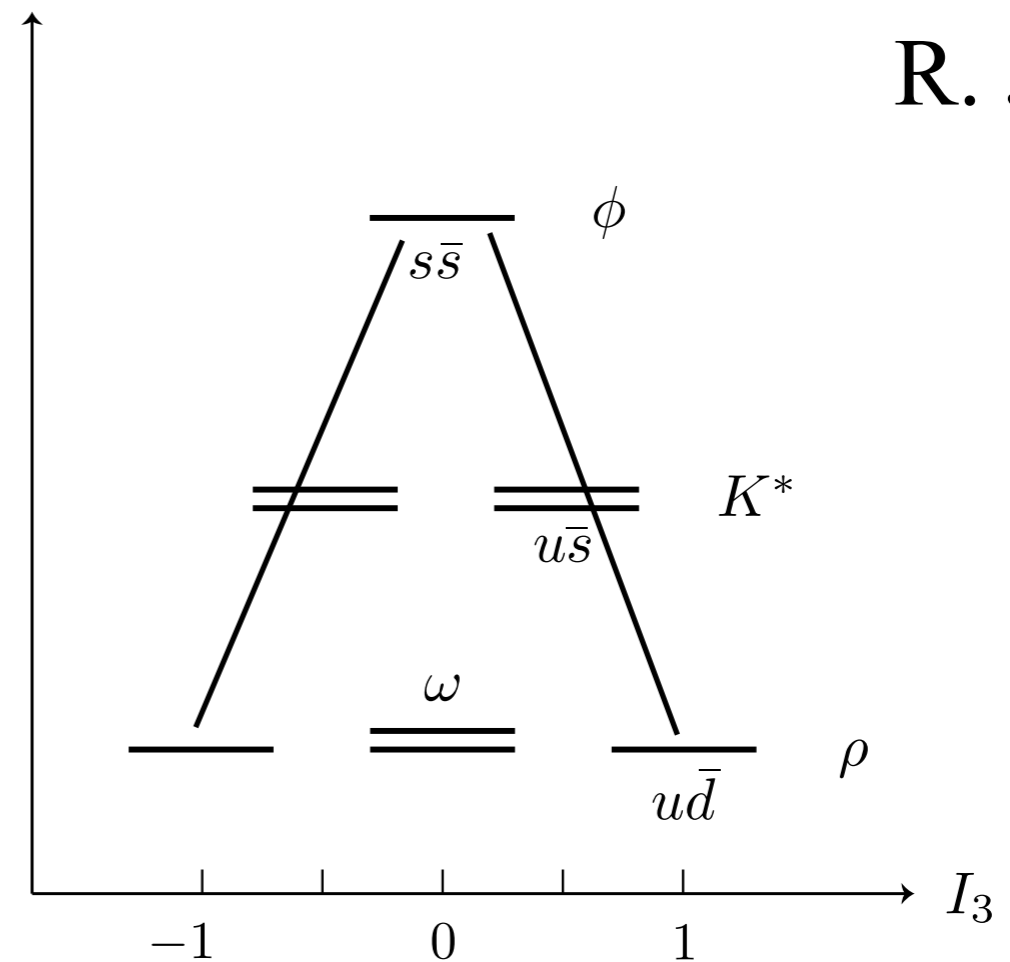
**Four states called  $\kappa$**

**still need further confirmation(PDG)**

# Scalar Mesons



# Vector Mesons



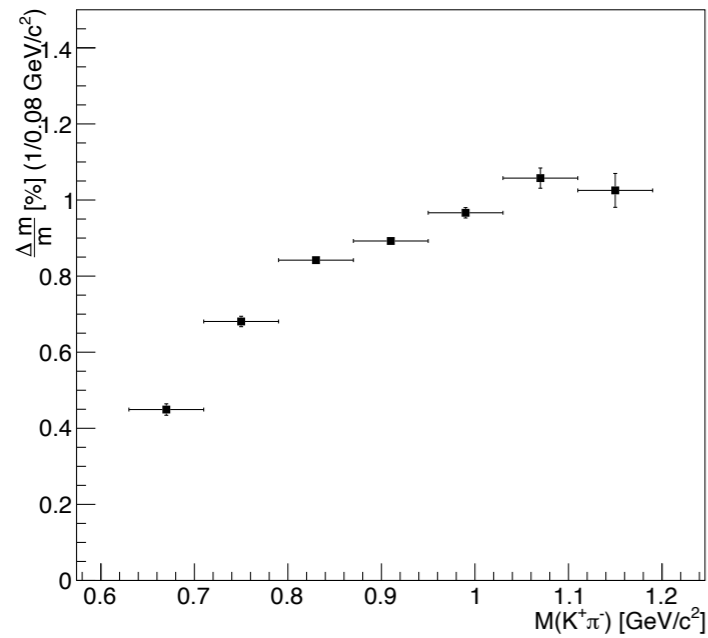
R. Jaffe

Figure 6. A cartoon representation of the masses of a  $\bar{q}\bar{q}qq$  nonet compared with a  $\bar{q}q$  nonet.

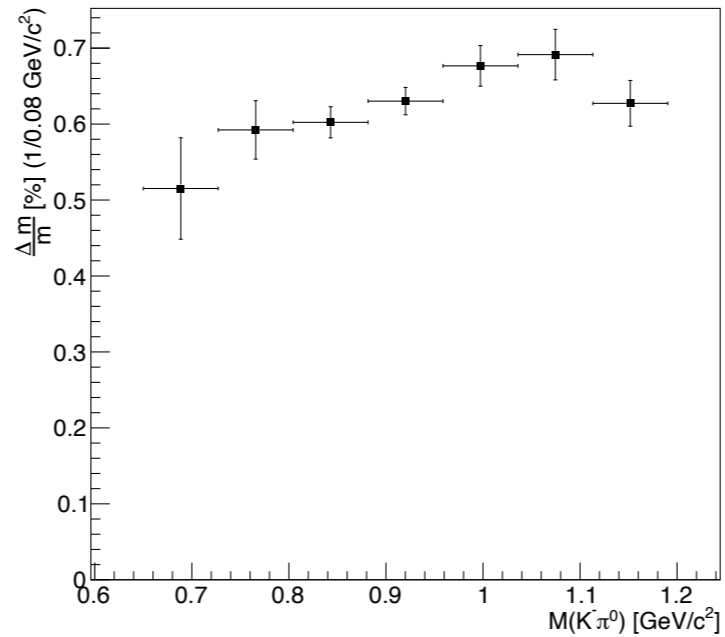
**Very different mass hierarchy  
Possibly suggesting 4q tetraquark  
structure of scalar mesons?**



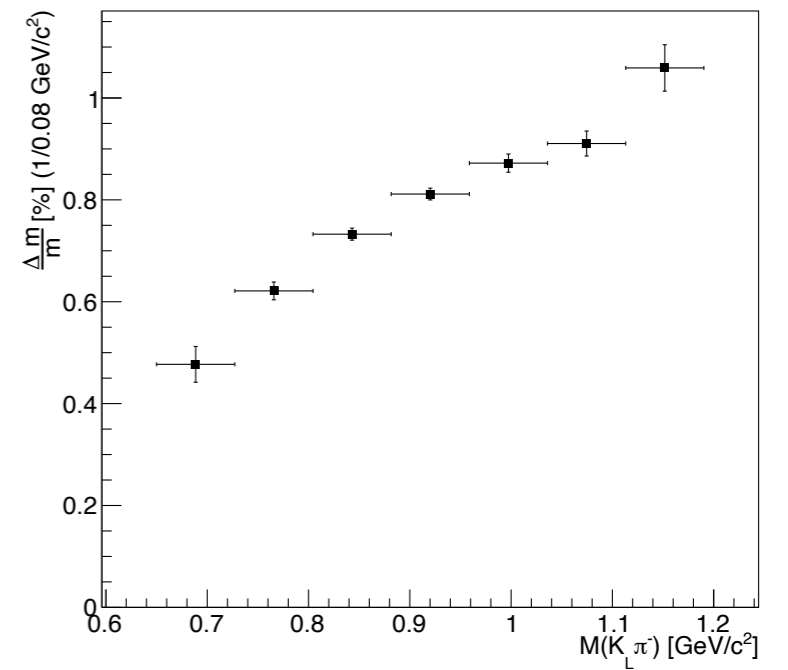
# Invariant mass resolution $\Delta m/m$ (%)



$K^+\pi^-$



$K^-\pi^0$



$K_L\pi^-$

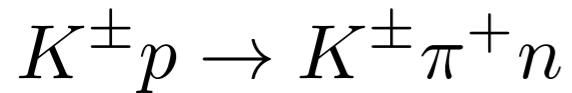
**Below 1% in all cases**

# Projected Measurements

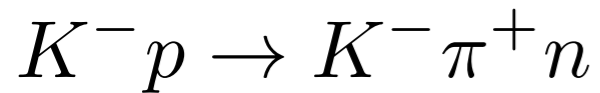
$I=3/2+1/2$

$S$ -wave

## SLAC Data

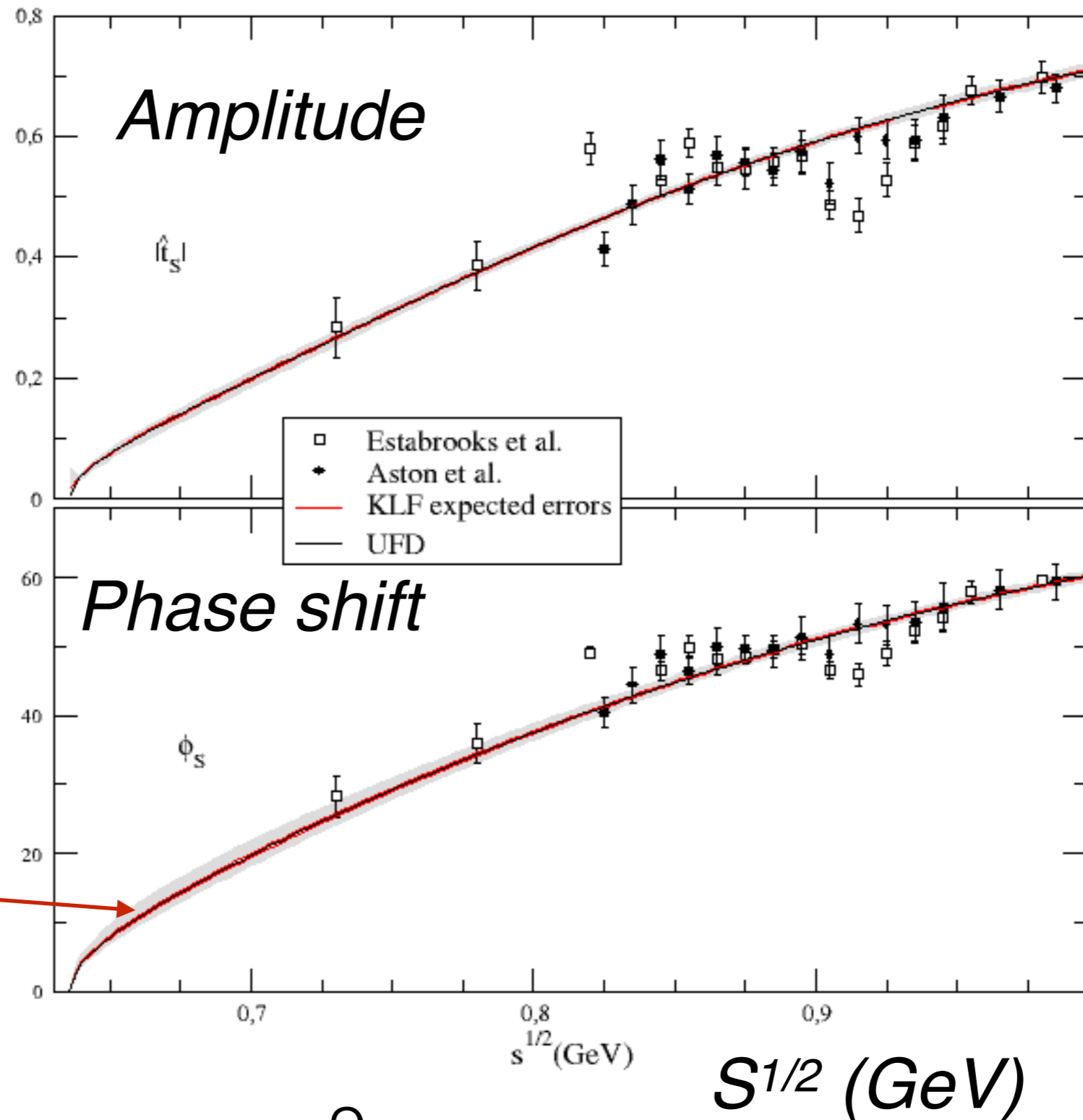


**Estabrooks(1978)**



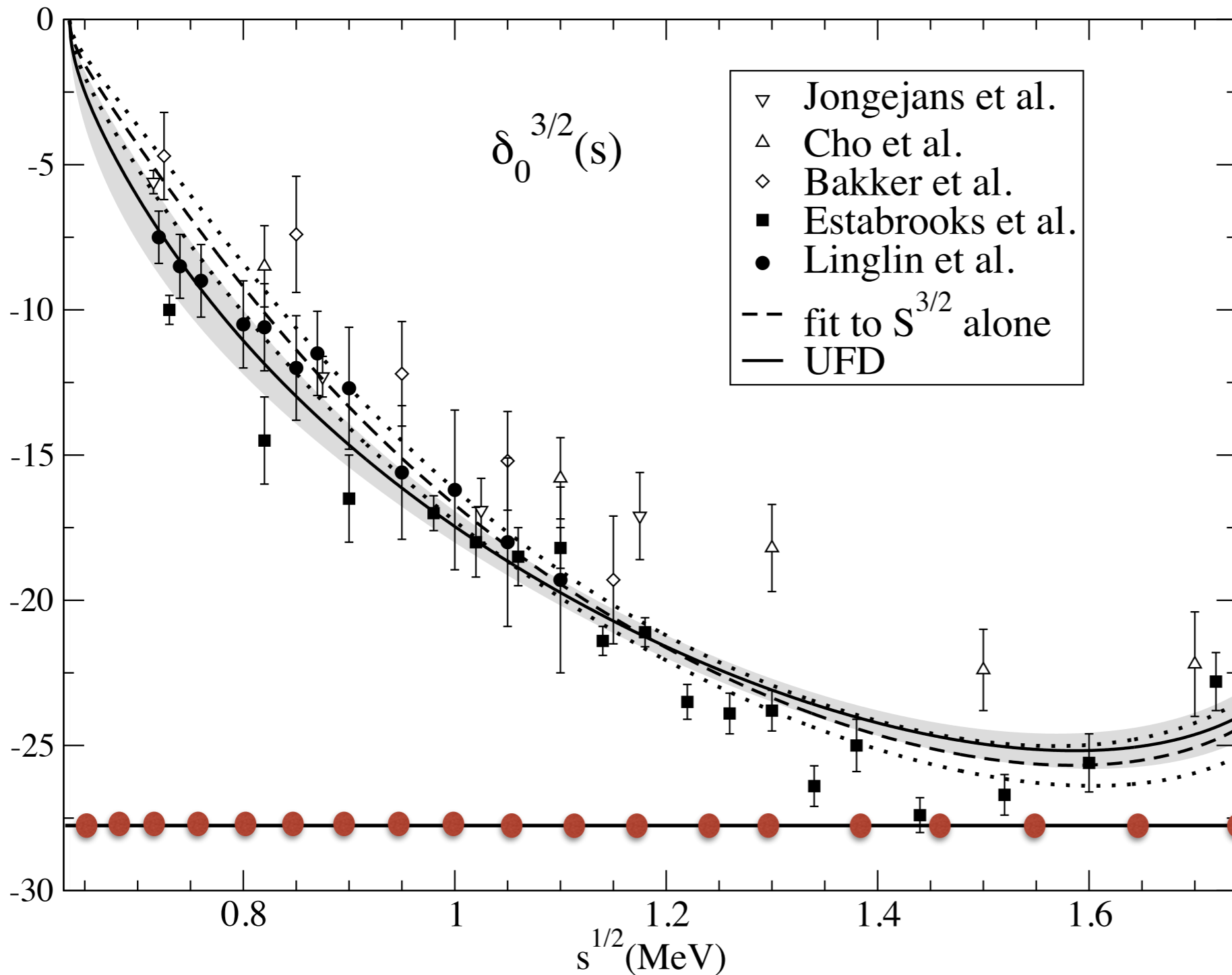
**Aston(1988)**

**KLF  
(100 days)**



$I=3/2$

$S$ -wave



4.25 GeV Saclay  
5.5 GeV CERN  
3.0 GeV ANL  
13.0 GeV SLAC  
14.3 GeV CERN

**Estabrooks(1978)**

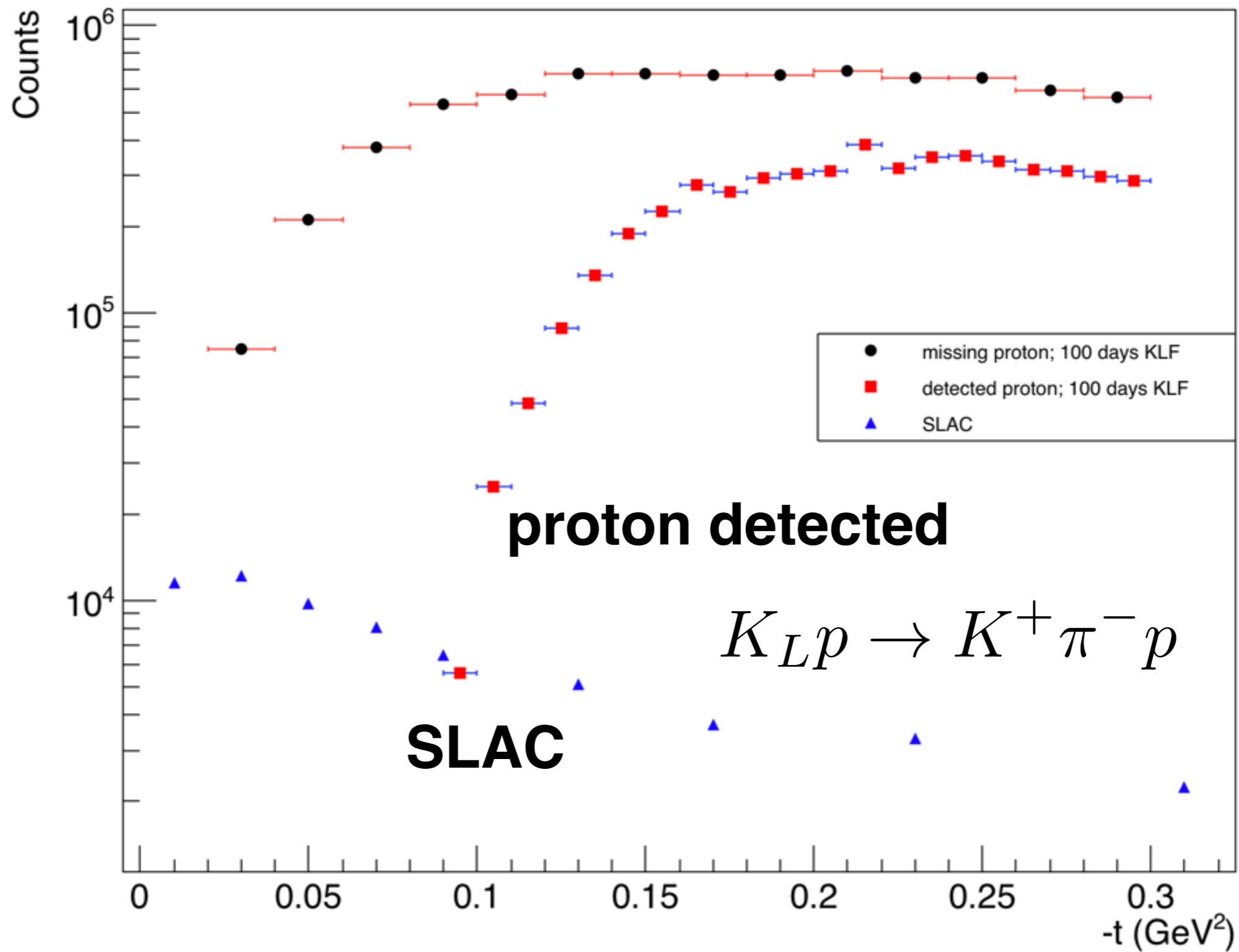
$$K^\pm p \rightarrow K^\pm \pi^+ n$$

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

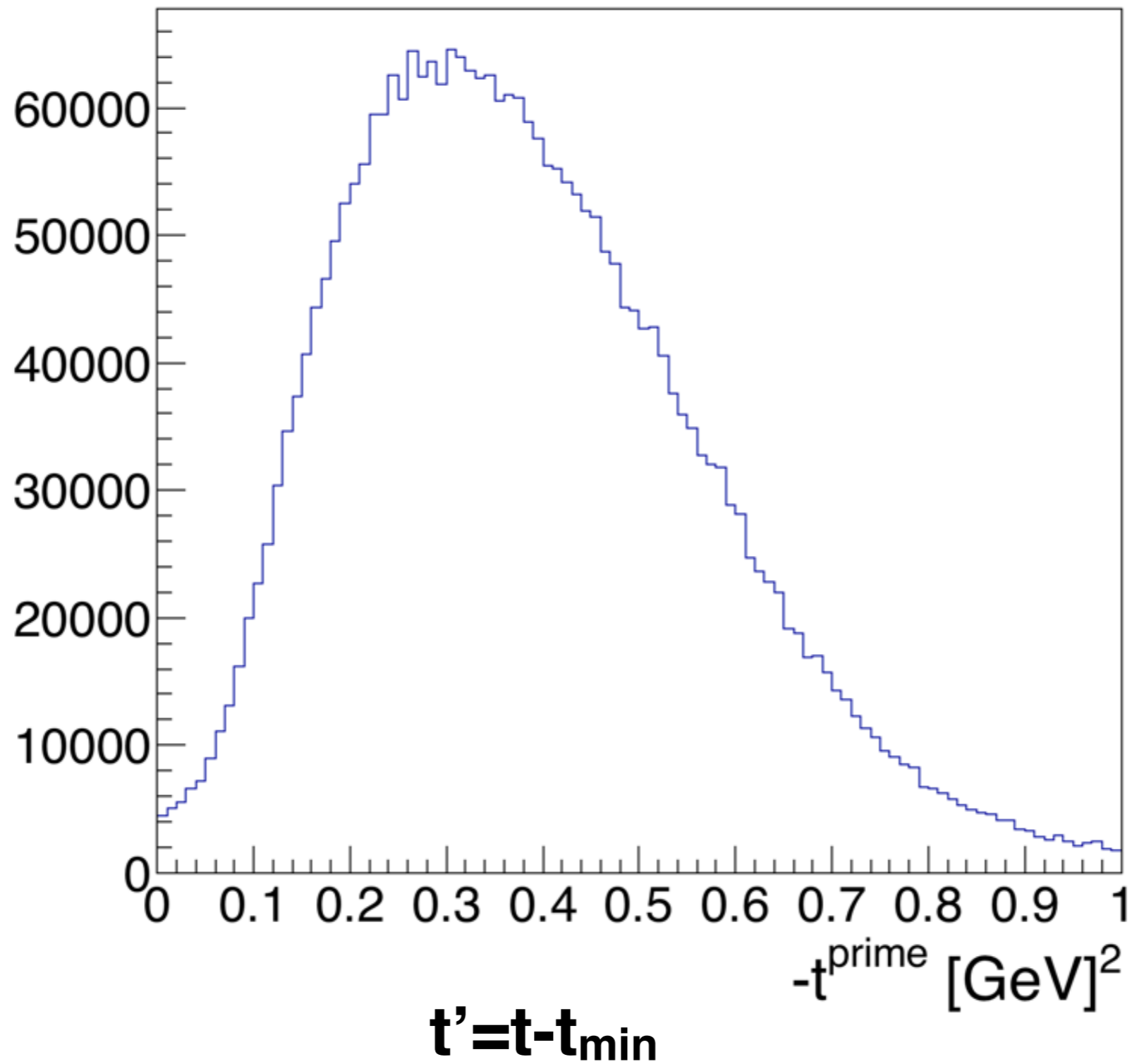
**KLF 100 days**

*From Pelaez and Rodas paper: PRD93(2016)*

# 100 days KLF



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



# Phase-shift

For  $L=0, 1$

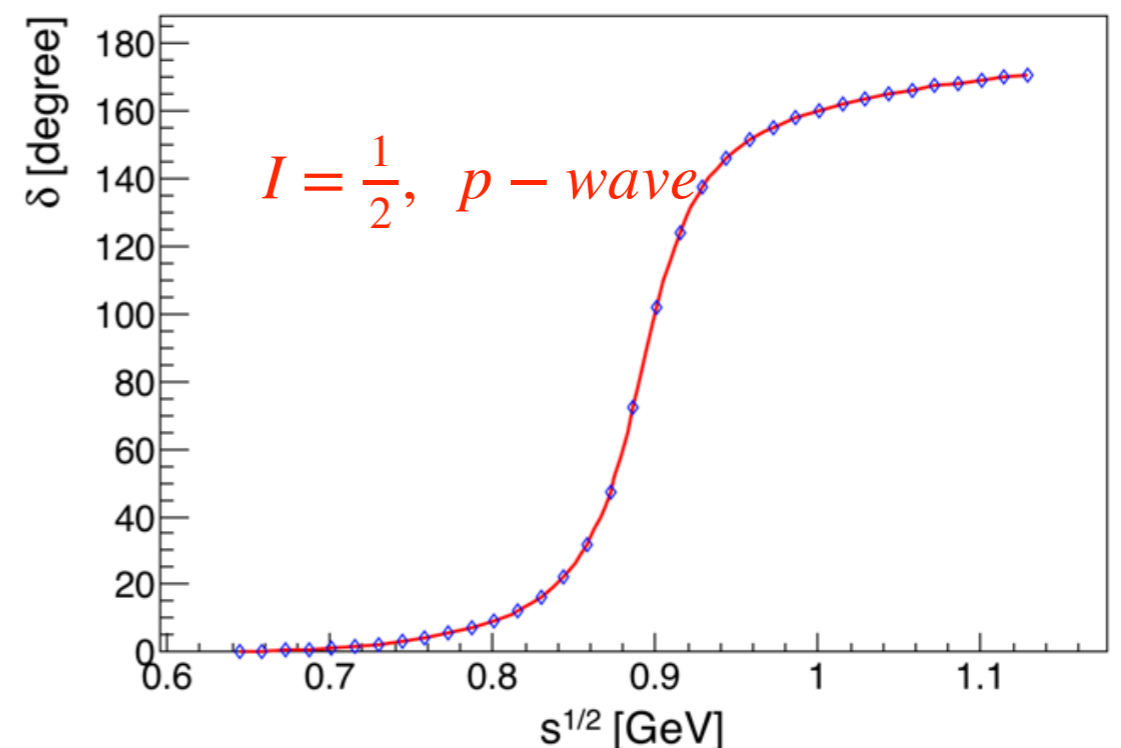
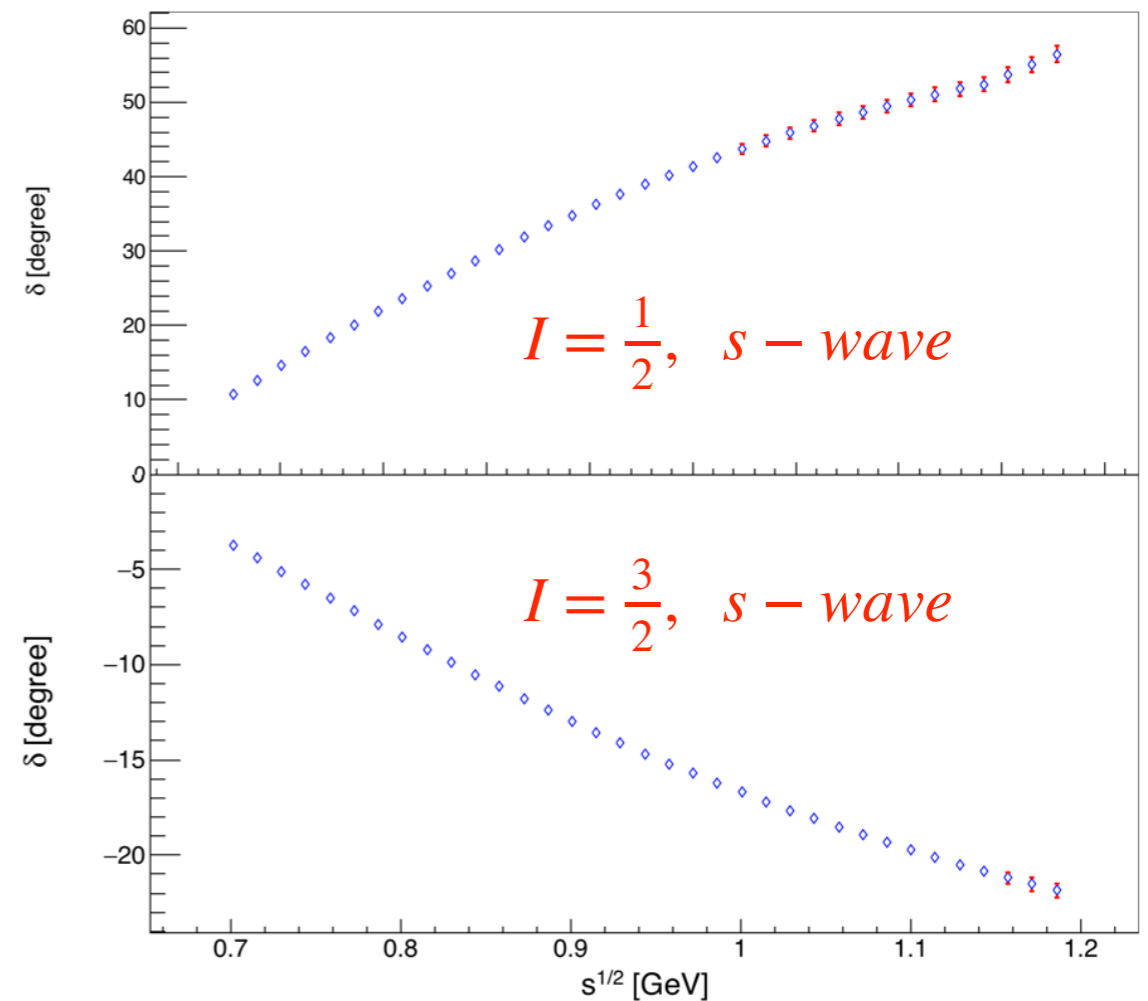
$$A^I(\cos\theta_{GJ}, \phi_{GJ}) = \frac{\sqrt{4\pi}}{q_i} \sum_{l,m} a_l^I (2l+1) Y_l^m(\cos\theta_{GJ}, \phi_{GJ})$$

In the elastic region

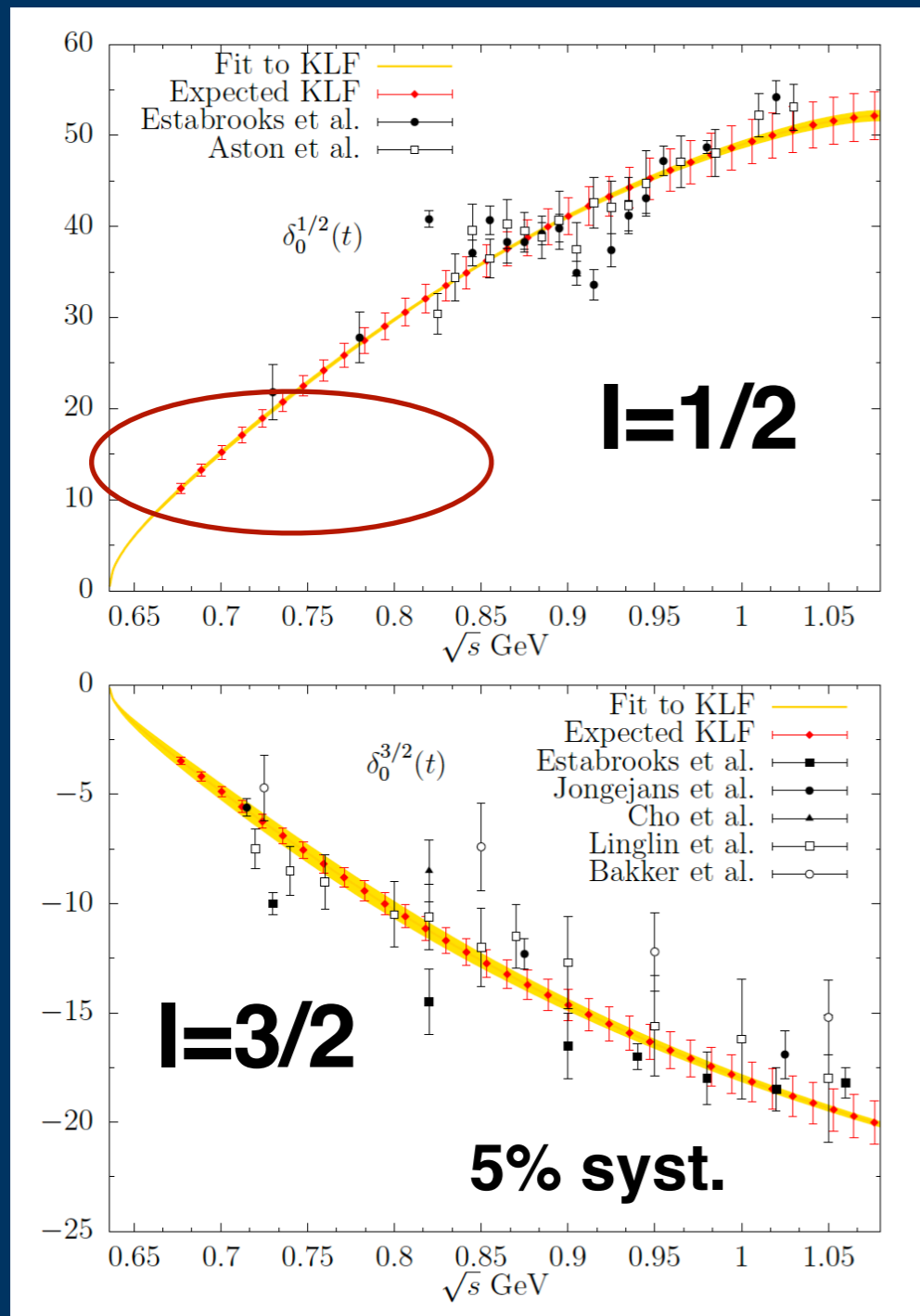
$$a_L^I = a_L^{I=1/2} + \frac{1}{2} a_L^{I=3/2}$$

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

Results include statistical uncertainty only.

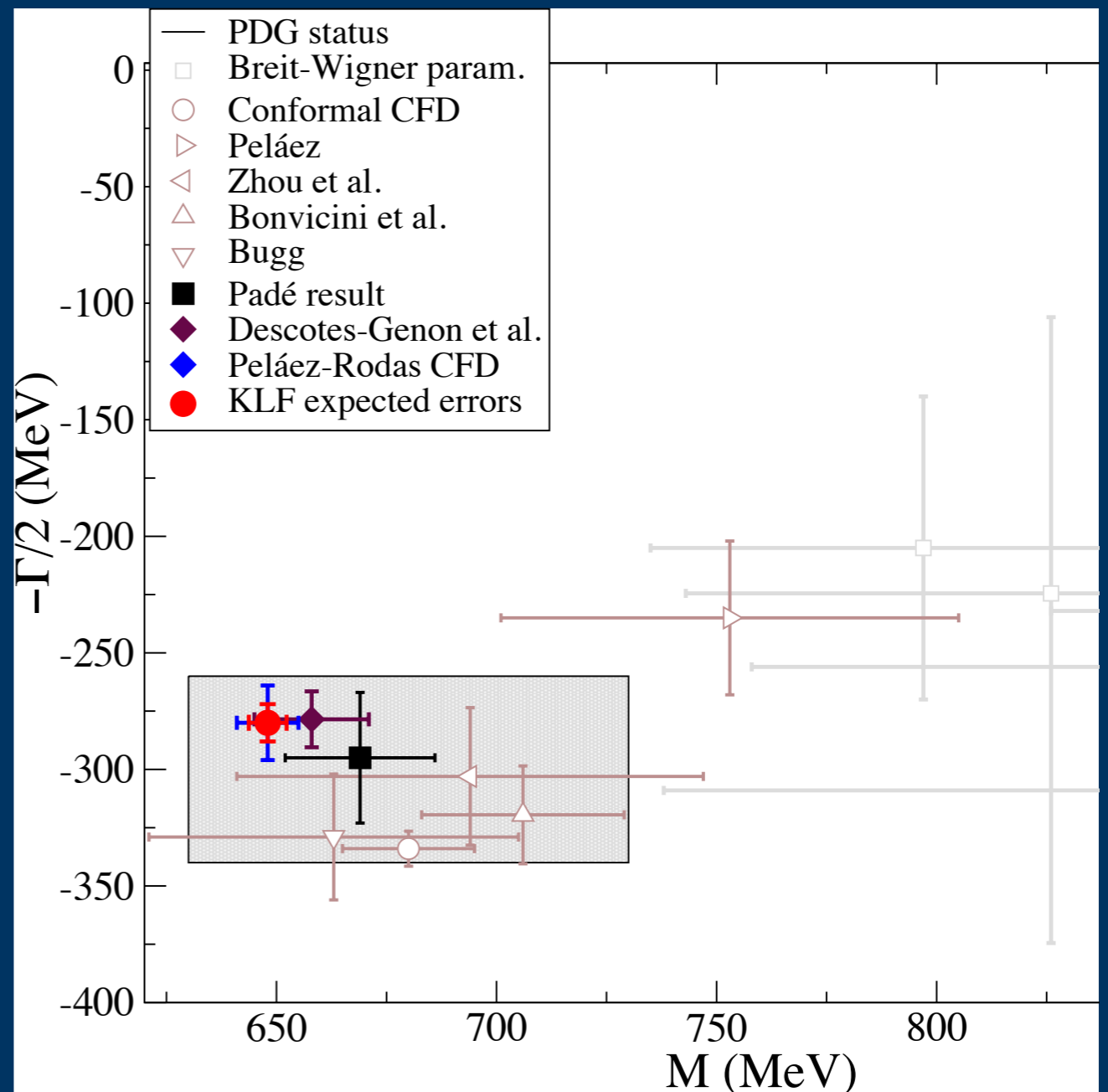


# Kappa Mass and Width



S wave phase shift,  $I = 1/2$  and  $I = 3/2$  with statistical and systematic uncertainties.

More data points are added close to threshold from KLF.



Roy-Steiner dispersion approach

J.R. Pelaez and et.al. Phys. Rev. D 93, 074025

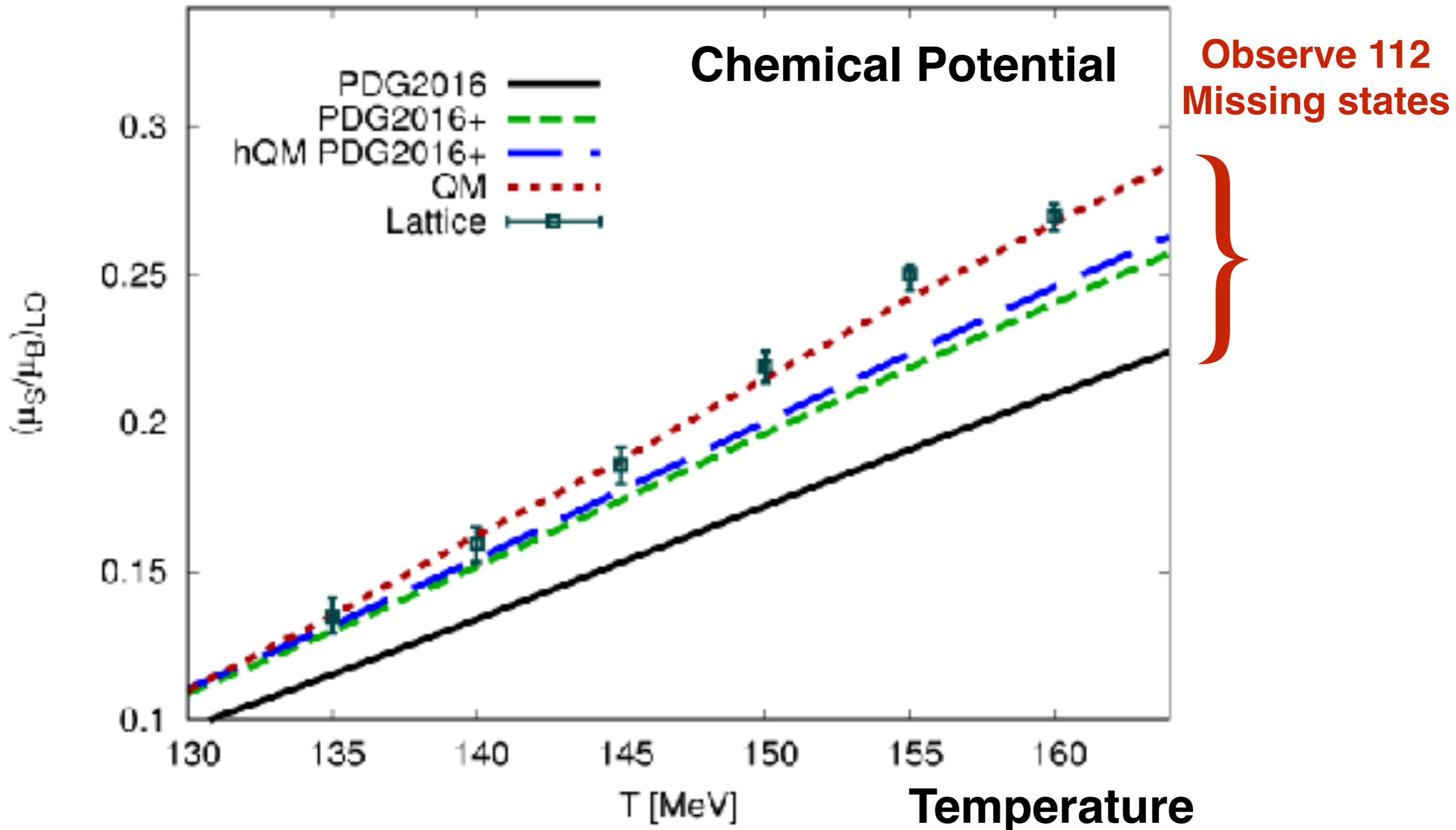
$$\sqrt{s_\kappa} \equiv M - i\Gamma/2 = 648 \pm 4 - i280 \pm 8 \text{ MeV}$$

# 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 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**



# Formation of Visible Matter during the Freeze-Out of the Universe after the Big Bang

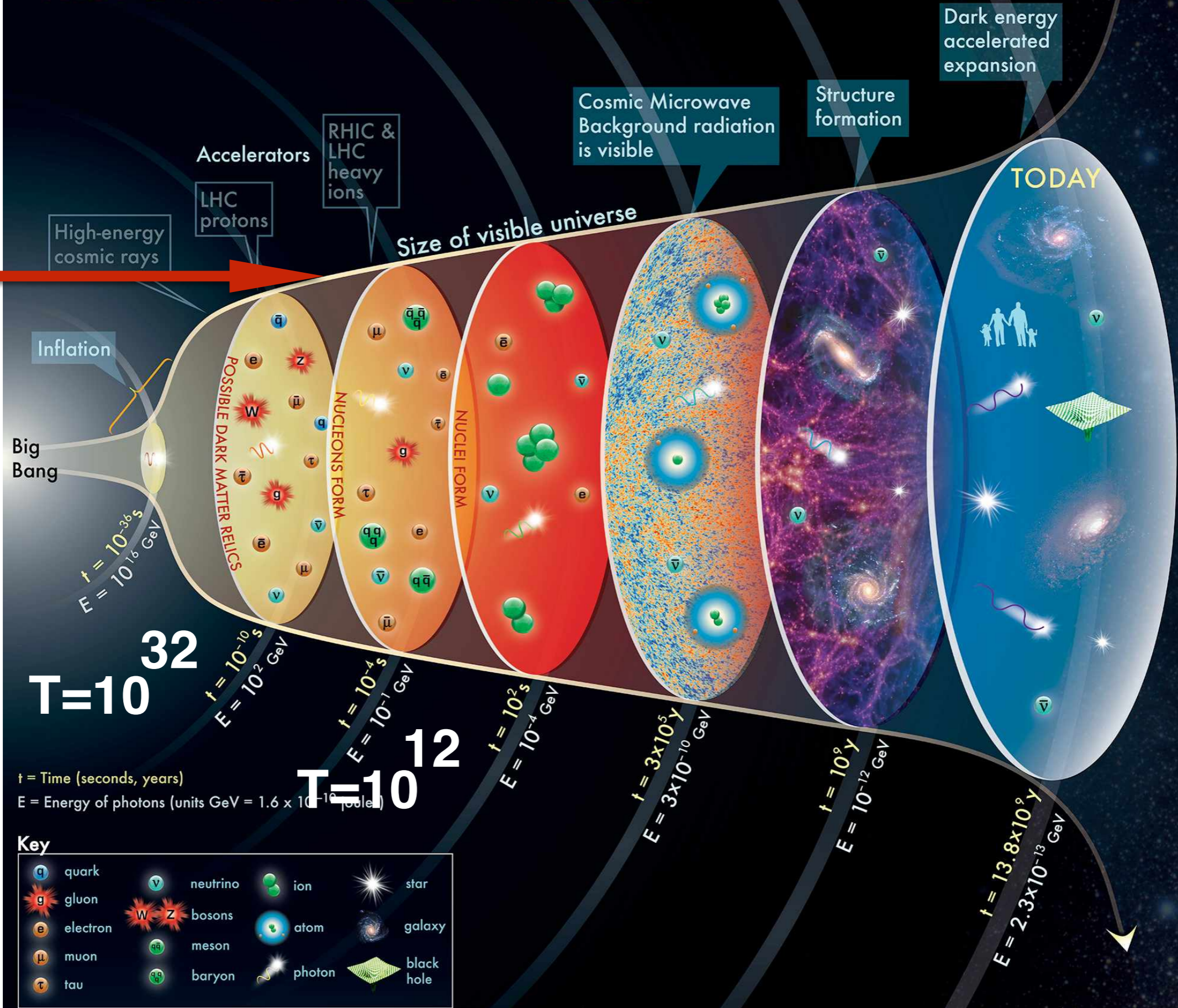


$$dU = T dS - p dV + \mu dN$$

# HISTORY OF THE UNIVERSE

1  $\mu$ s

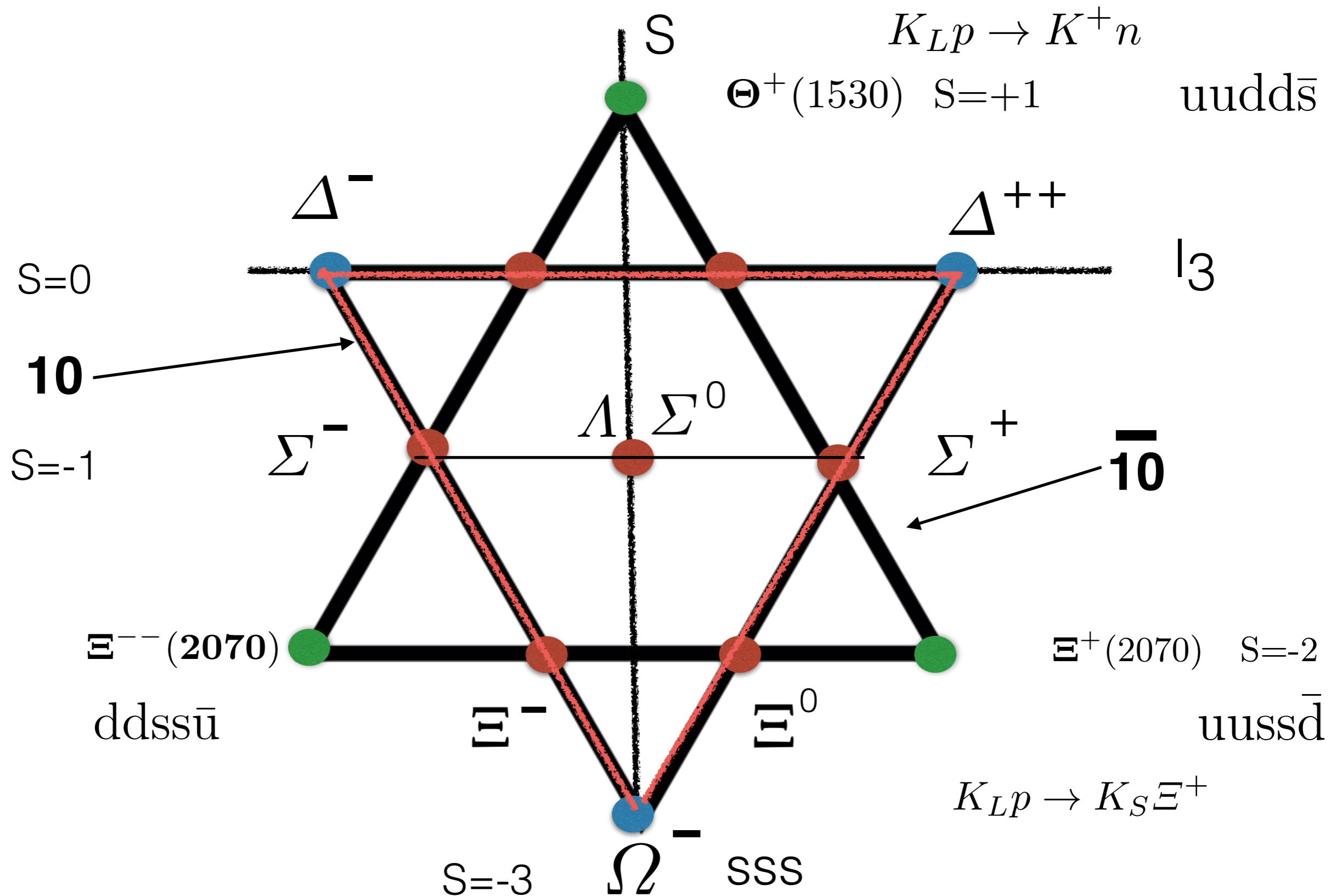
KLF



The concept for the above figure originated in a 1986 paper by Michael Turner.

**What else?**

# Pentaquarks



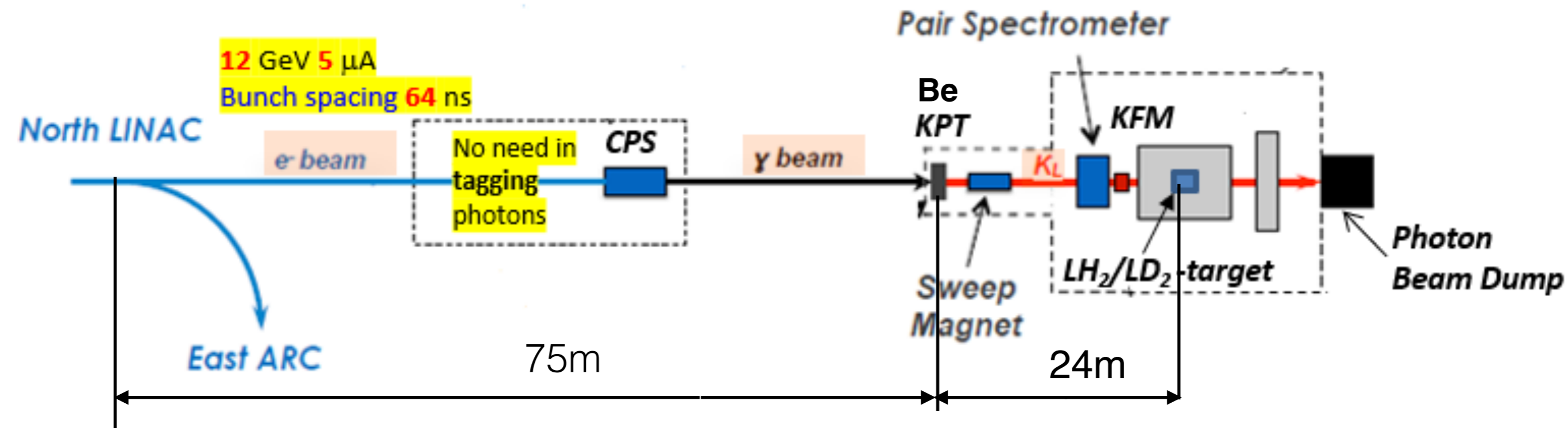
D. Diakonov, V. Petrov and M. V. Polyakov, Z. Phys. A **359**, 305 (1997).

**Is everything feasible from hardware point of view?**

**Next few slides will answer this question.**

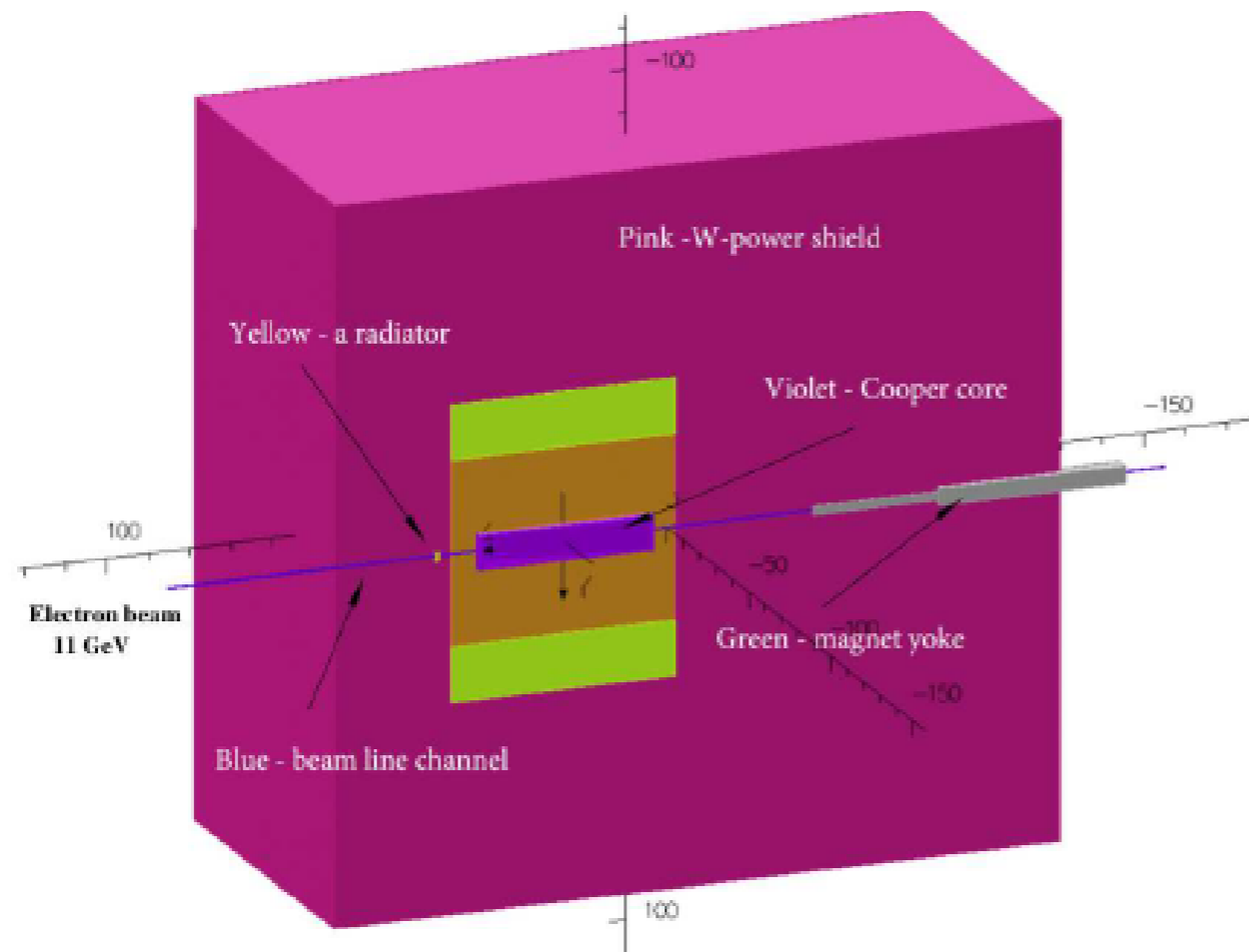
# Reminder:

## Hall-D beamline and GlueX Setup



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

# Compact Photon Source



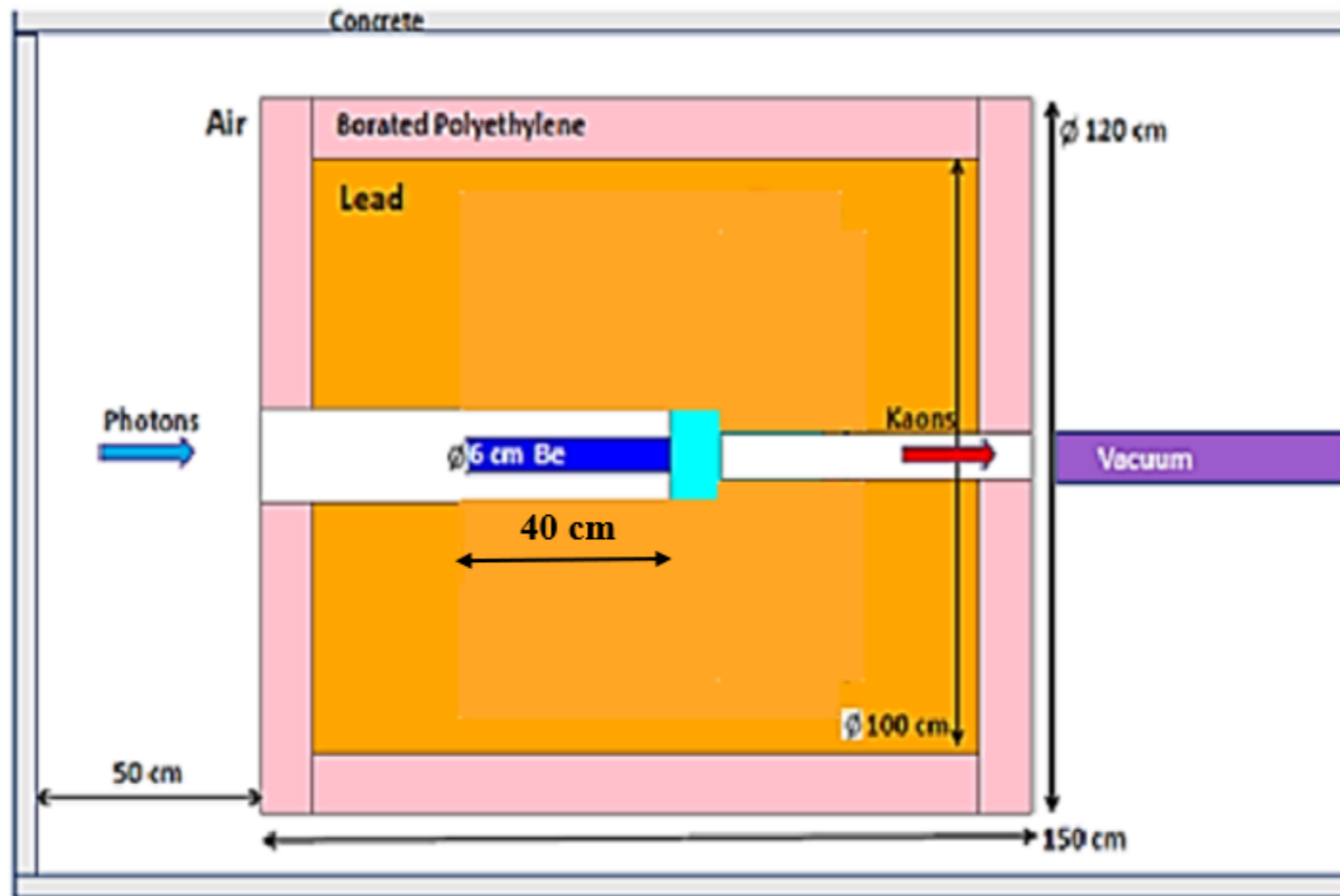
**Conceptual design is completed for Halls A&C**

**The details of the CPS are designed by the CPS Collaboration**

**Meets RadCon Radiation Requirements**

**Paper published in NIM, A957(2020)**

# *Be Target Assembly: Conceptual Design*



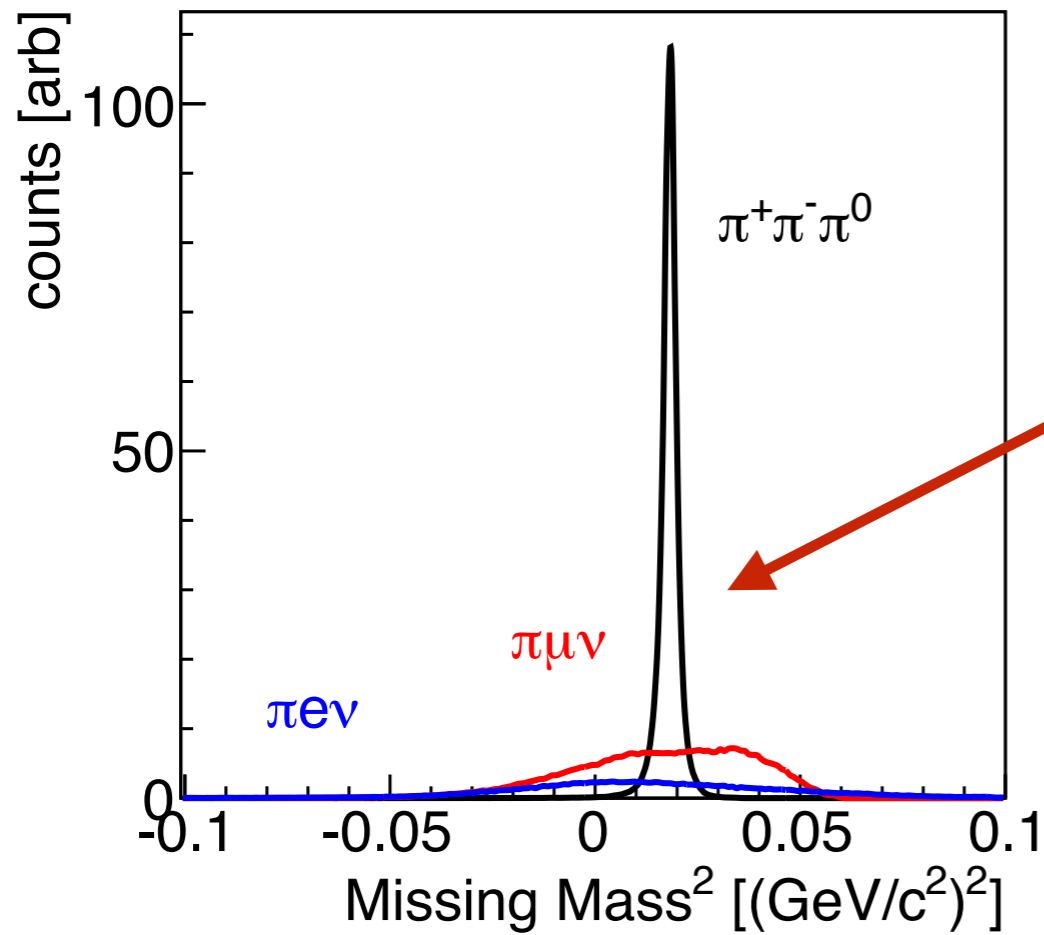
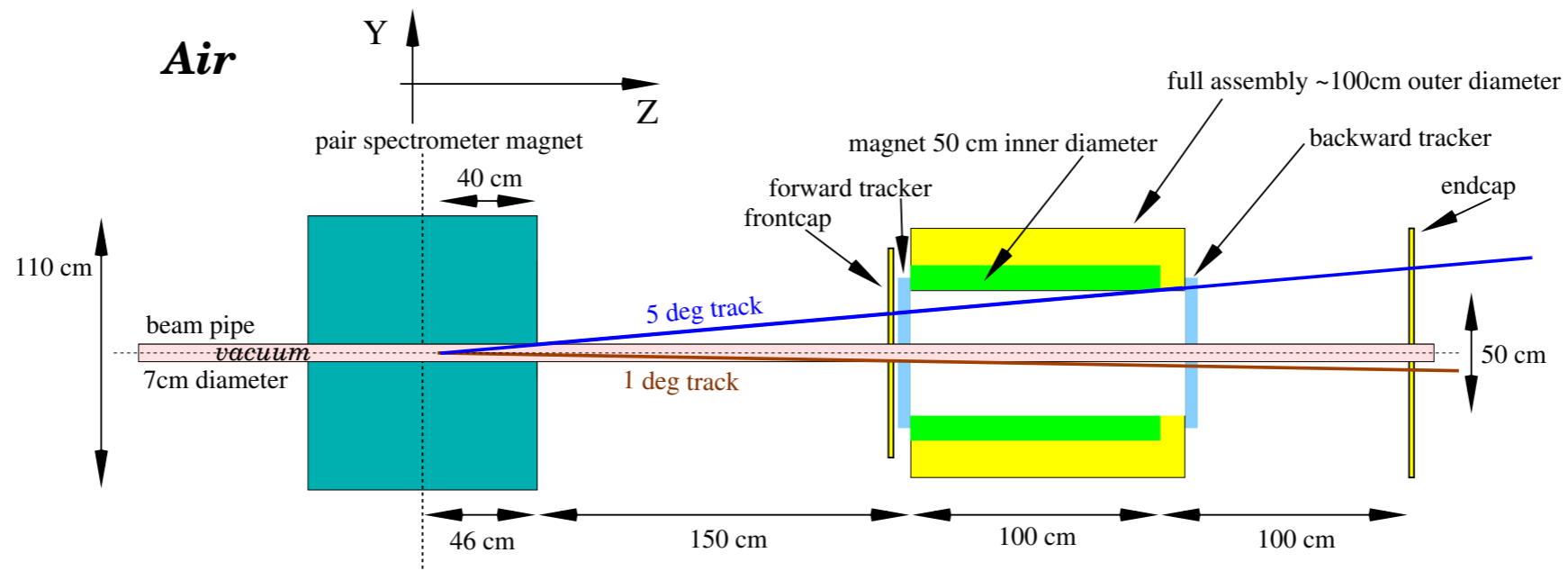
-Meets RadCon Radiation Requirements

-Conceptual Design Endorsed by Hall-D Engineering Staff

**arXiv: 2002.04442**



# Flux Monitor



796cm to LH2/LD2 target

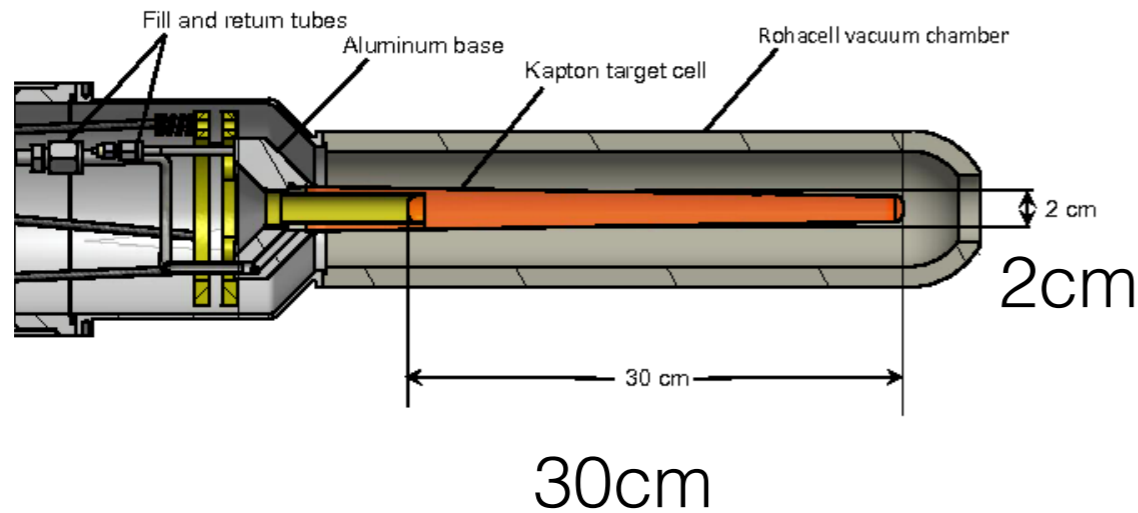
**Reconstructed  $K_L$  mass**

**Flux measurement stat. err. <1%**

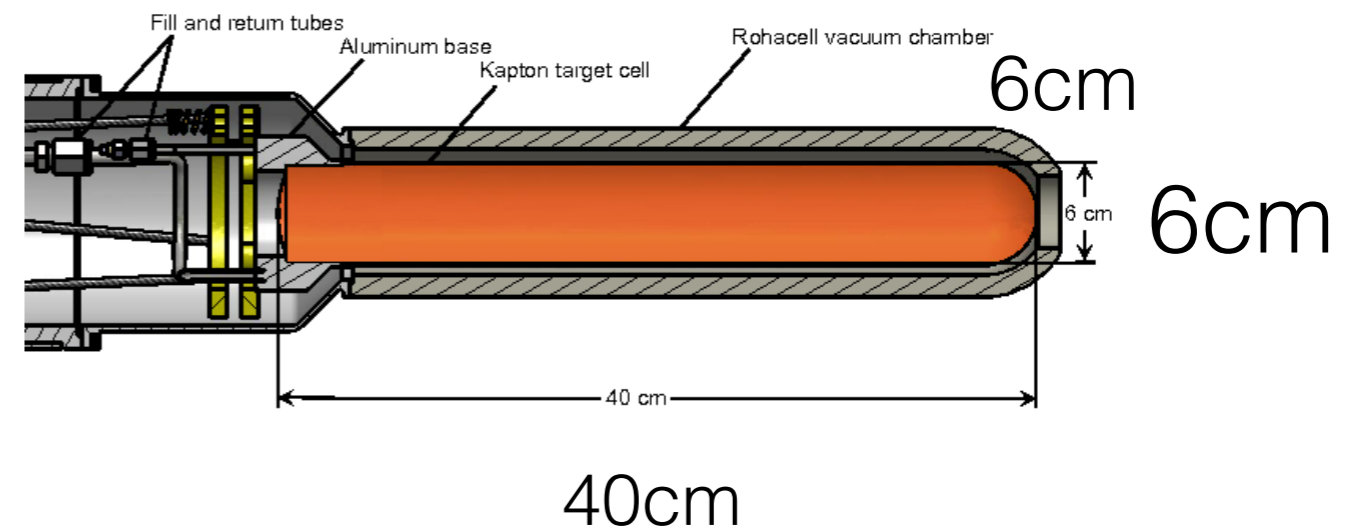
**Estimated conservative syst. err. ~5%**

# LH<sub>2</sub>/LD<sub>2</sub> Cryogenic Target for Neutral Kaon Beam at Hall D

The GlueX liquid hydrogen target.



*Current*



*Proposed & Feasible*

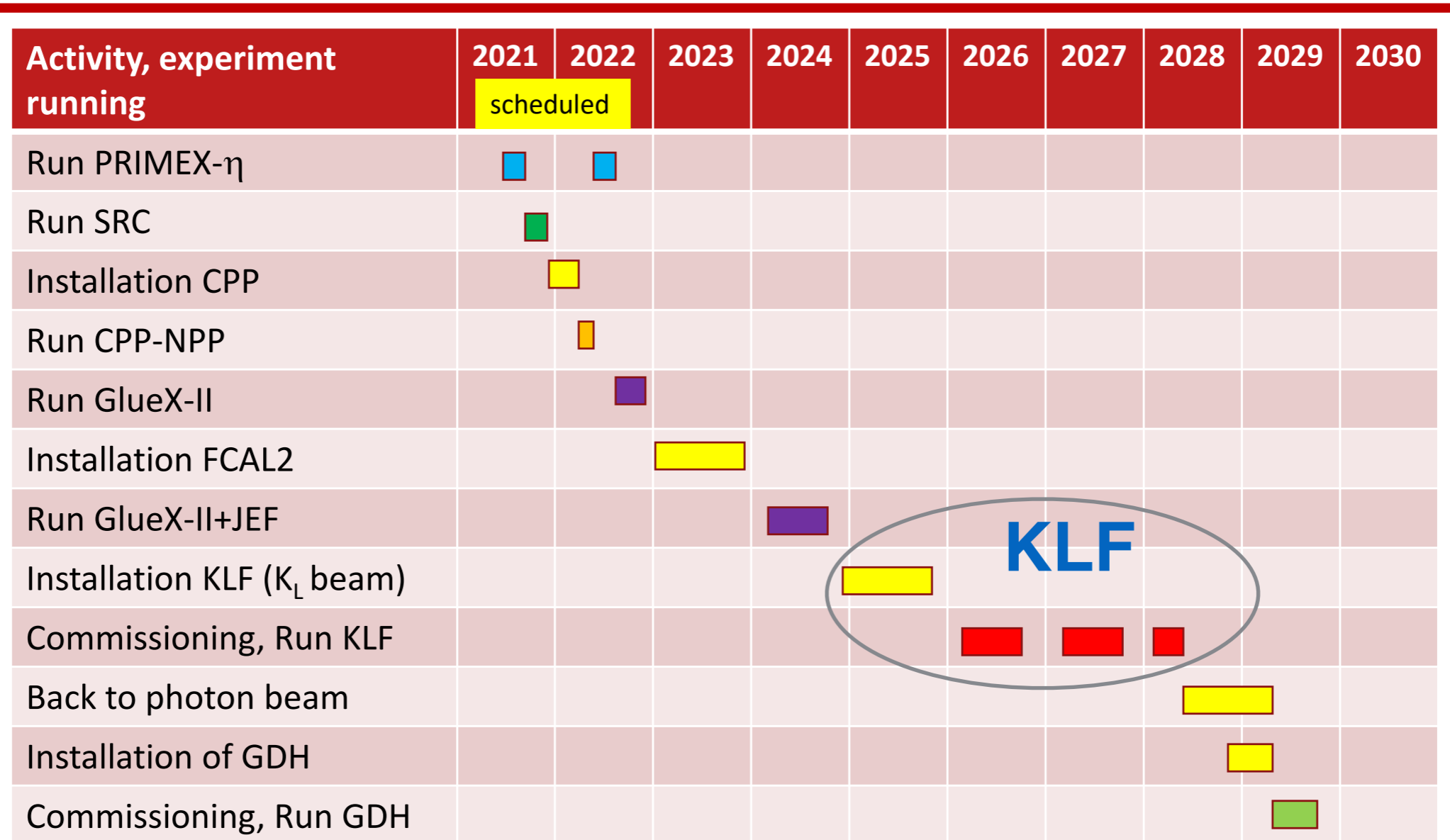
**Longer and thicker target is needed to enhance production rate**

**Conceptual design has been endorsed by the JLAB target group**

# Timeline of Design, Construction and Installation

## Scheduling Outlook

13



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

- Assumed timely construction of JEF,KLF,GDH

13

Jefferson Lab

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

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

# PHYSICS WITH NEUTRAL KAON BEAM AT JLAB KL2016

FEBRUARY 1-3, 2016  
JEFFERSON LAB  
NEWPORT NEWS, VIRGINIA

## SCOPE

The Workshop is following L012-15-001 "Physics Opportunities with Secondary KL beam at JLab" and will be dedicated to the physics of hyperons produced by the kaon beam on unpolarized and polarized targets with GlueX set up in Hall D. The emphasis will be on the hyperon spectroscopy. Such studies could contribute to the existing scientific program on hadron spectroscopy at Jefferson Lab.

The Workshop will also aim at boosting the international collaboration, in particular between the US and EU research institutions and universities.

The Workshop would help to address the comments made by the PAC43, and to prepare the full proposal for the next PAC44.

## ORGANIZING COMMITTEE

Moskov Amaryan, ODU, chair  
Eugene Chudakov, JLab  
Curtis Meyer, CMU  
Michael Pennington, JLab  
James Ritman, Ruhr-Uni-Bochum & IKP Jülich  
Igor Strakovsky, GWU

[WWW.JLAB.ORG/CONFERENCES/KL2016](http://WWW.JLAB.ORG/CONFERENCES/KL2016)



# YSTAR 2016

Excited Hyperons in QCD  
Thermodynamics at Freeze-Out

NOVEMBER 16-17, 2016

Jefferson Lab  
Newport News, Virginia

A workshop to discuss the influence of possible "missing" hyperon resonances (JLab KLF Project) on QCD thermodynamics, on freeze-out in heavy ion collisions and in the early universe, and in spectroscopy. Recent studies that compare lattice QCD calculations of thermodynamic calculations, statistical hadron resonance gas models, and ratios between measured 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 workshop is to sharpen these comparisons, advance our understanding of the formation of baryons from quarks and gluons microseconds after the Big Bang and in today's experiments, and to connect these developments to experimental searches for direct, spectroscopic, evidence for these resonances. This Workshop is a successor to the recent KL2016 Workshop

## ORGANIZING COMMITTEE

Moskov Amaryan - Chair, ODU  
Eugene Chudakov, JLab  
Krishna Rajagopal, MIT  
Claudia Ratti, University of Houston  
James Ritman, Ruhr U. Bochum & IKP Jülich  
Igor Strakovsky, GWU



[WWW.JLAB.ORG/CONFERENCES/YSTAR2016/](http://WWW.JLAB.ORG/CONFERENCES/YSTAR2016/)

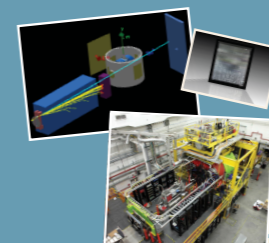


# HIPS 2017

New Opportunities with High-Intensity Photon Sources

February 6-7, 2017  
Catholic University of America  
Washington, DC U.S.A.

This workshop aims at producing an optimized photon source concept with potential increase of scientific output at Jefferson Lab, and at refining the science for hadron physics experiments benefiting from such a high-intensity photon source. The workshop is dedicated to bringing together the communities directly using such sources for photo-production experiments, or for conversion into  $K_s$  beams. The combination of high precision calorimetry and high intensity photon sources can provide greatly enhanced scientific benefit to (deep) exclusive processes like wide-angle and time-like Compton scattering. Potential prospects of such a high-intensity source with modern polarized targets will also be discussed. The availability of  $K_s$  beams would open new avenues for hadron spectroscopy, for example for the investigations of "missing" hyperon resonances, with potential impact on QCD thermodynamics and on freeze-out both in heavy ion collisions and the early universe.



## Organizing Committee:

Tanja Horn - CUA  
Cynthia Keppel - JLab  
Carlos Munoz-Camacho - IPNO  
Igor Strakovsky - GWU



# $\pi$ -K Interactions Workshop

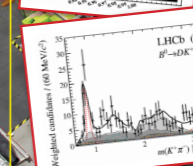
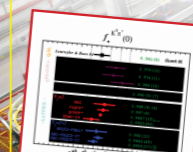
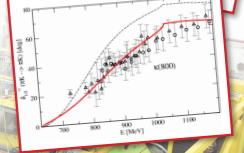
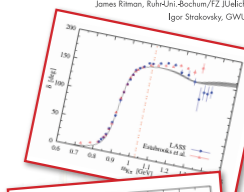
## ORGANIZING COMMITTEE

Moskov Amaryan, ODU (Chair)  
U.K.G. Meißner, U. Bonn/FZ Jülich  
Curtis Meyer, CMU  
James Ritman, Ruhr-Uni-Bochum/FZ Jülich  
Igor Strakovsky, GWU

February 14-15, 2018

Jefferson Lab • Newport News, VA

The  $\pi$ -K scattering enables direct investigations of scalar and vector  $K^*$  states, including the not yet established S-wave  $k(800)$  state. These studies are also needed to get precise values of vector and scalar form factors: to independently extract CKM matrix element  $V_{us}$  and to test the Standard Model unitarity relation in the first row of CKM matrix, to study CP violation from the Dalitz plot analysis of open charm D meson decays and in a charmless decays of B mesons in Kpipi final states. Significant progress is made lately in Lattice QCD, in the phenomenology and in the Chiral Perturbation Theory to describe different aspects of  $\pi$ -K scattering. The main source of experimental data is based on experiments performed in SLAC almost five decades ago at 1970-80s. The recently proposed KL Facility incorporating the GlueX spectrometer at JLab will be able to improve the  $\pi$ -K scattering database by about three orders of magnitude in statistics. The workshop will discuss the necessity for and the impact of the future high statistics data obtained at JLab on  $\pi$ -K scattering.



<https://www.jlab.org/conferences/pki2018/>



## 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 spectroscopy**

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

- **-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.**

***Thank you !***