Efficiency-Corrected Yields of $K^{+} \Lambda^{*}_{1520}$ Channel

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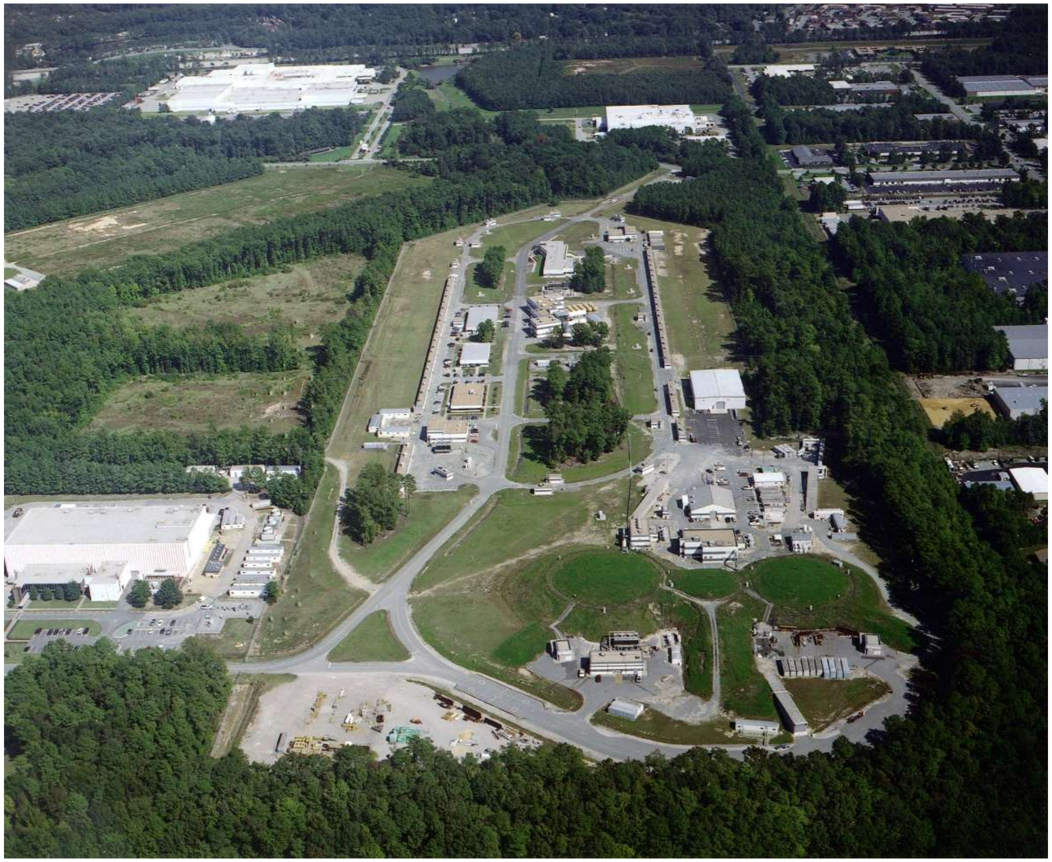
Experiment – JLab



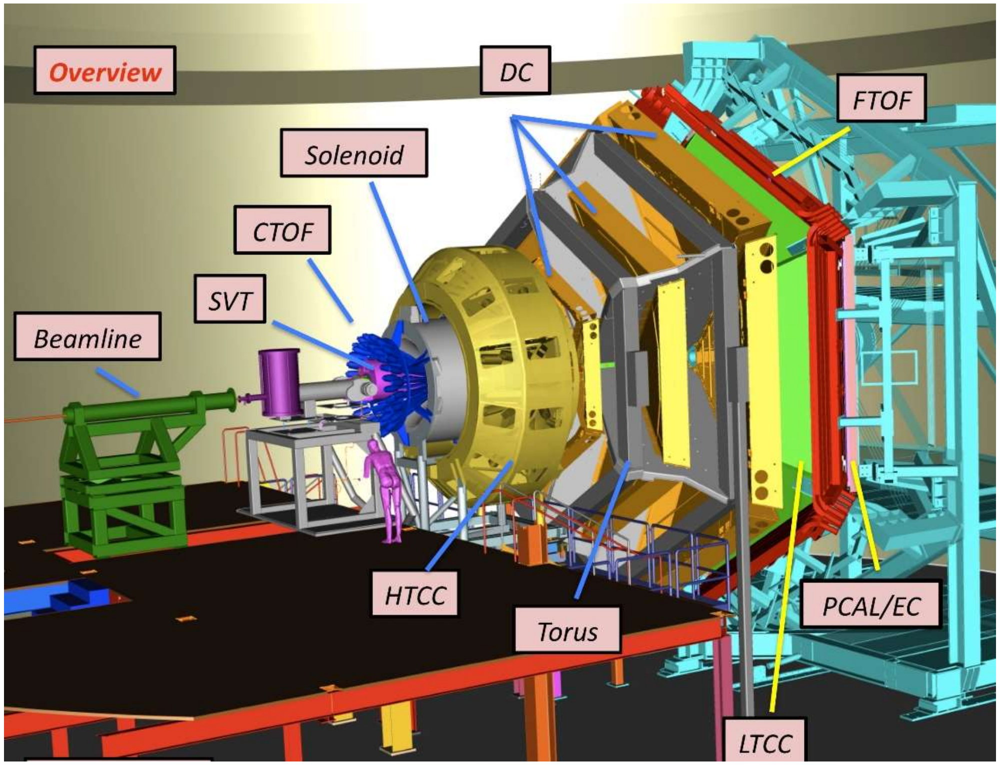
Thomas Jefferson National Laboratory, Virginia

Experiment – CLAS12 Detector

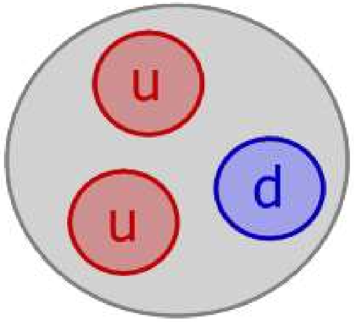
Important Features:

Electron beam incident on proton target

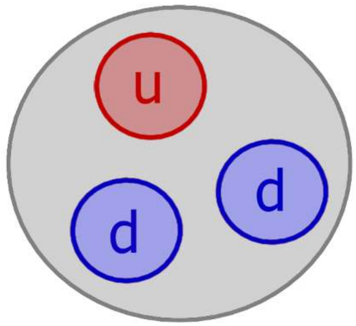
Detector elements provide measurements to determine four-momentum and vertex position of each final-state particle



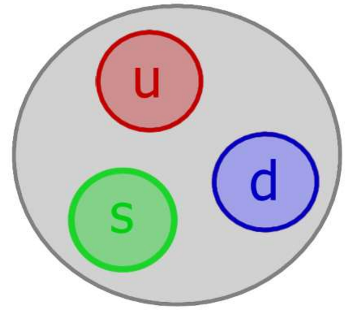
Background – Quarks and Baryons



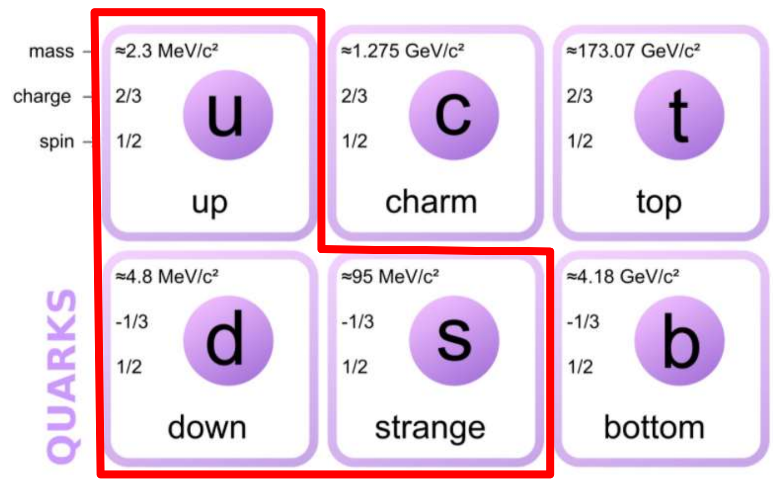
Proton (p)
2 up 1 down
Net charge = +1



Neutron (n)
1 up 2 down
Net charge = 0

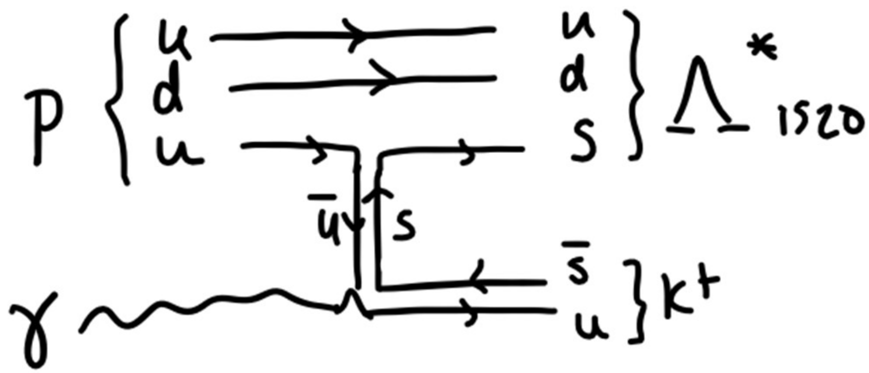


Lambda (Λ)
up down strange



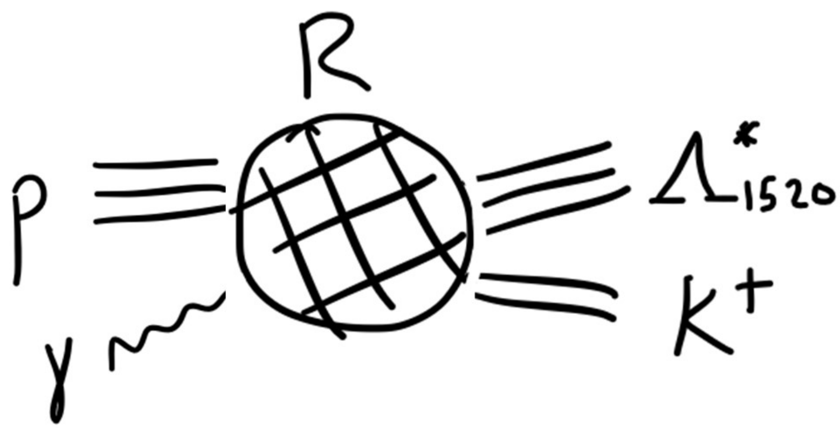
Reaction – $e\,p \rightarrow e\,\Lambda^{*}_{1520}\,K^{+}$

T-Channel:

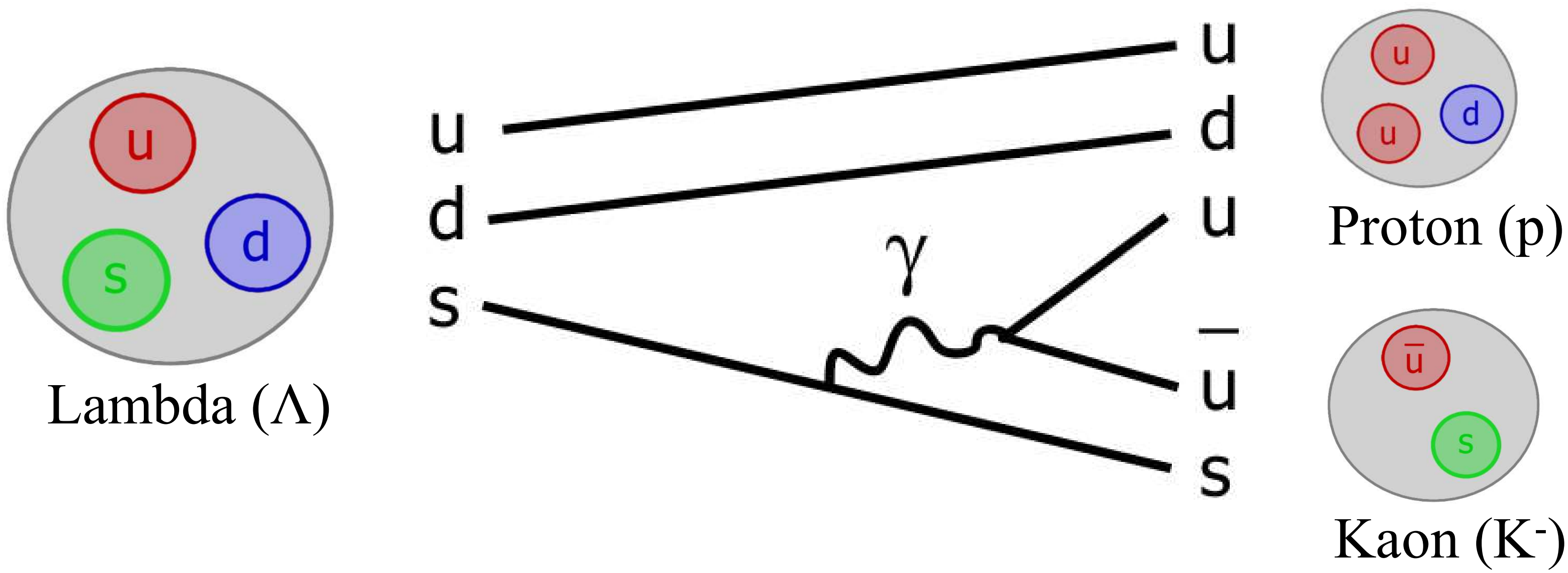


Time

Resonance:



Reaction – $\Lambda^{*}_{1520} \rightarrow p\,K^{-}$



The Λ decays so fast, it doesn't reach the detector before it breaks down

We use the end particles to reconstruct the Λ

Background – Invariant Mass

Invariant mass:

Vector $\vec{V} = \langle E, p_x, p_y, p_z \rangle$, taking natural units where c = 1

$|\vec{V}| = \sqrt{E^2 - p^2} = \text{Mass}$

Invariant mass of a system:

Add the vectors of each particle in the system

Take the magnitude of the sum of the vectors

Center of mass energy *W*:

Invariant mass of the final-state hadrons

Motivation – Missing Resonance

Signal – what we're looking for (resonance)

looks like peaks

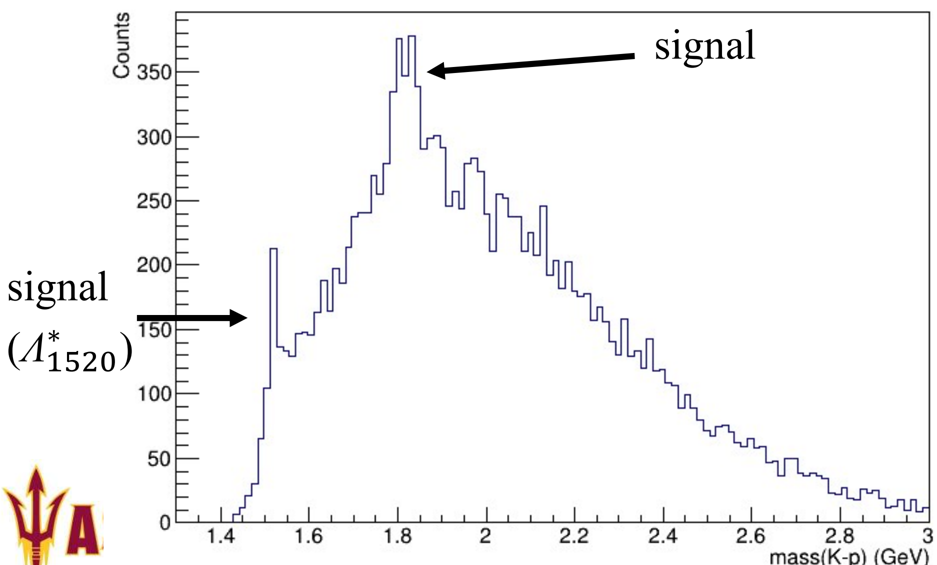
Background – not useful data

looks like a mound of data

Looking for "missing resonance"

(predicted states not yet observed)

Mass of K^-p (usually decays from a Λ)



Observed Resonances:

PDG Nucleon Resonance Summary

Particle	J^P	overall	$N\gamma$	$N\pi$	$\Delta\pi$	$N\sigma$	$N\eta$	ΛK
$N(2000)$	$5/2^+$	**	**	*	**	*	*	
$N(2040)$	$3/2^+$	*		*				
$N(2060)$	$5/2^-$	***	***	**	*	*	*	*
$N(2100)$	$1/2^+$	***	**	***	**	**	*	*
$N(2120)$	$3/2^-$	***	***	**	**	**		**
$N(2190)$	$7/2^-$	****	****	****	****	**	*	**
$N(2220)$	$9/2^+$	****	**	****			*	*
$N(2250)$	$9/2^-$	****	**	****			*	*
$N(2300)$	$1/2^+$	**		**				
$N(2570)$	$5/2^-$	**		**				
$N(2600)$	$11/2^-$	***		***				
$N(2700)$	$13/2^+$	**		**				

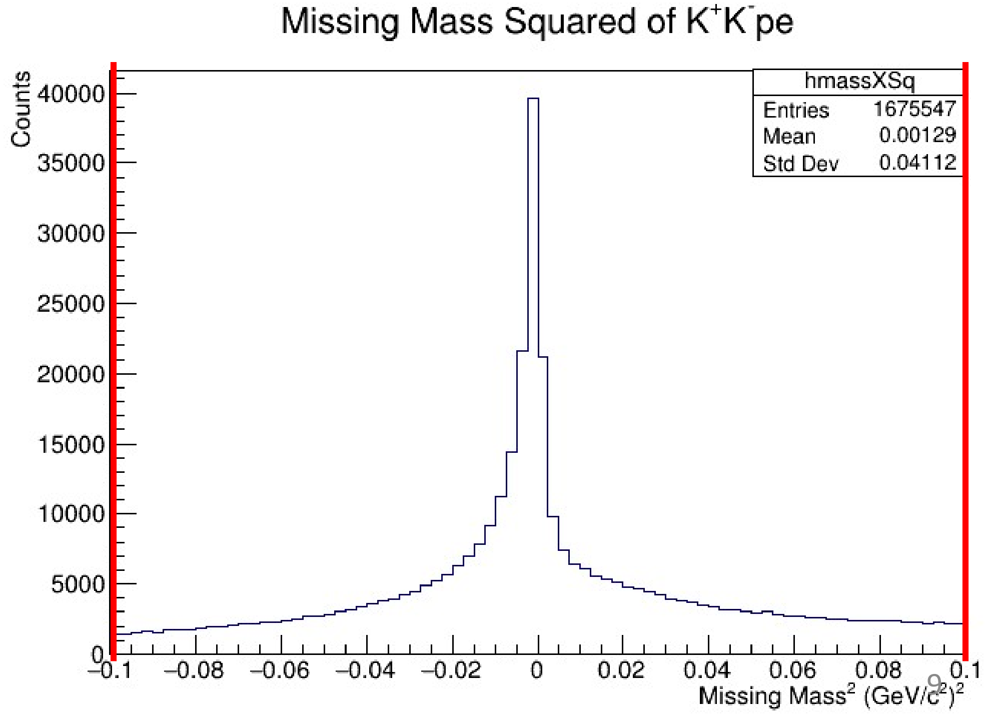
**** Existence is certain.
*** Existence is very likely.
** Evidence of existence is fair.
* Evidence of existence is poor.

Analysis – Event Selection

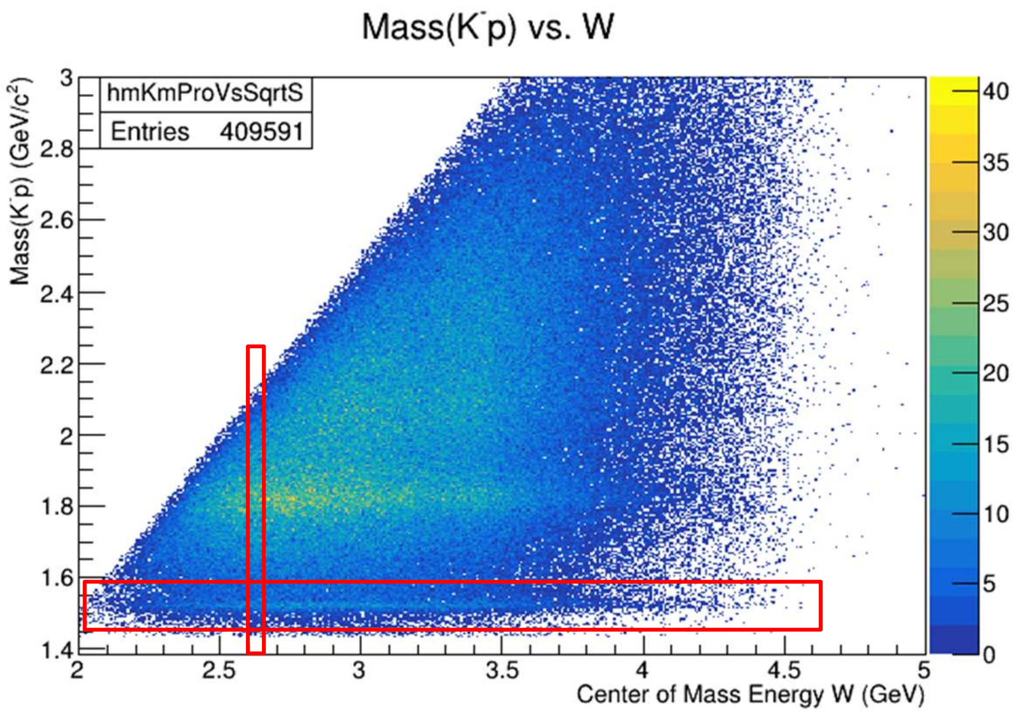
Choose final particles $K^+ K^- p\ e$

Implement missing mass cut to remove outliers in the data

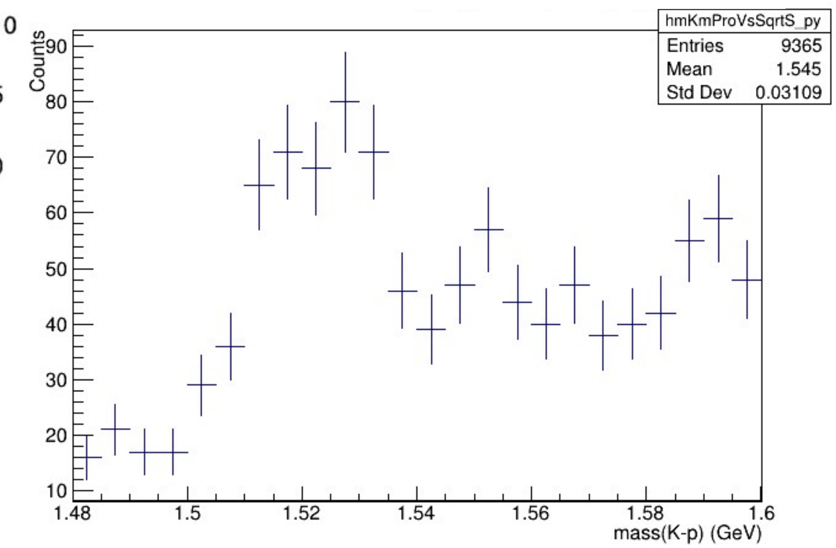
Keep events within 3σ from the mean



Analysis of yields for fixed slices of *W*



Mass(K^-p) at W between 2.54-2.6 GeV

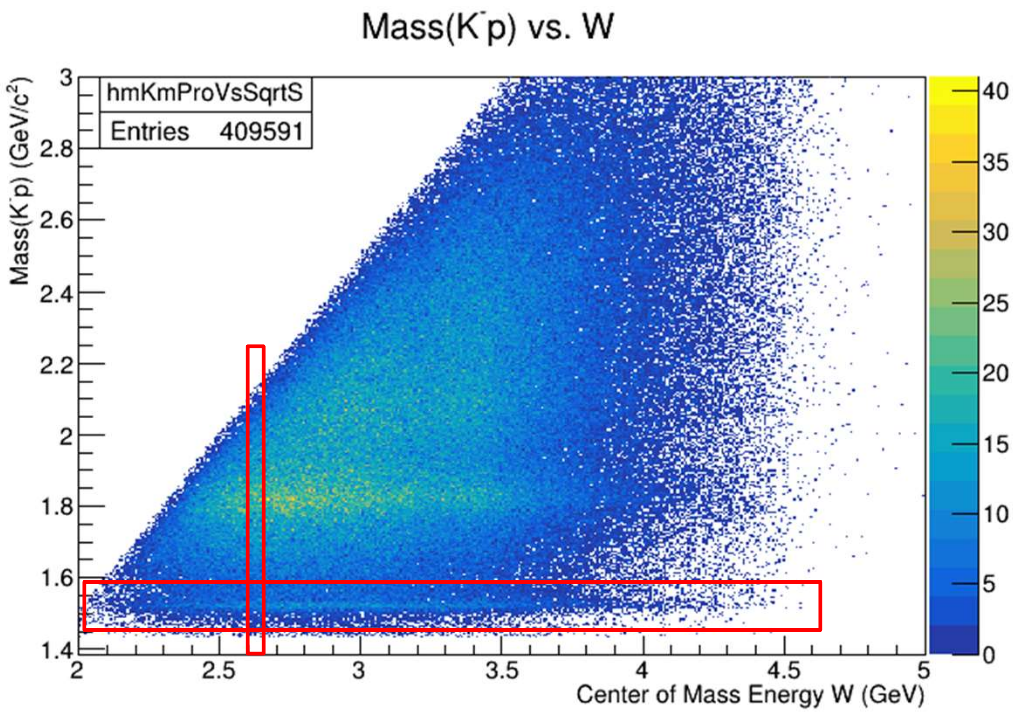


Focus on 1.520 mass range (1.48-1.56 GeV)

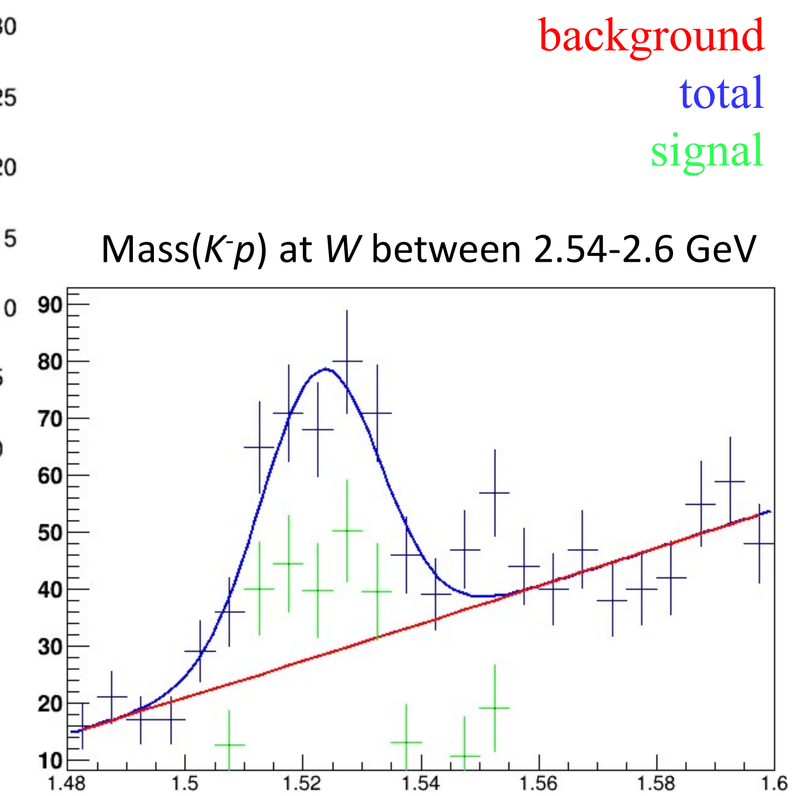
Cut up *W* into bins (ex. *W* = 2.54-2.6 GeV)

Project onto y axis →

Analysis of yields for fixed slices of *W*



Repeat for all bins from $W = 2$ to 5 GeV
Plot Yield vs W



Potential Resonances

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$N(2120)$	$3/2^-$	***	***	**	**	**		**
$N(2190)$	$7/2^-$	****	****	****	****	**	*	**
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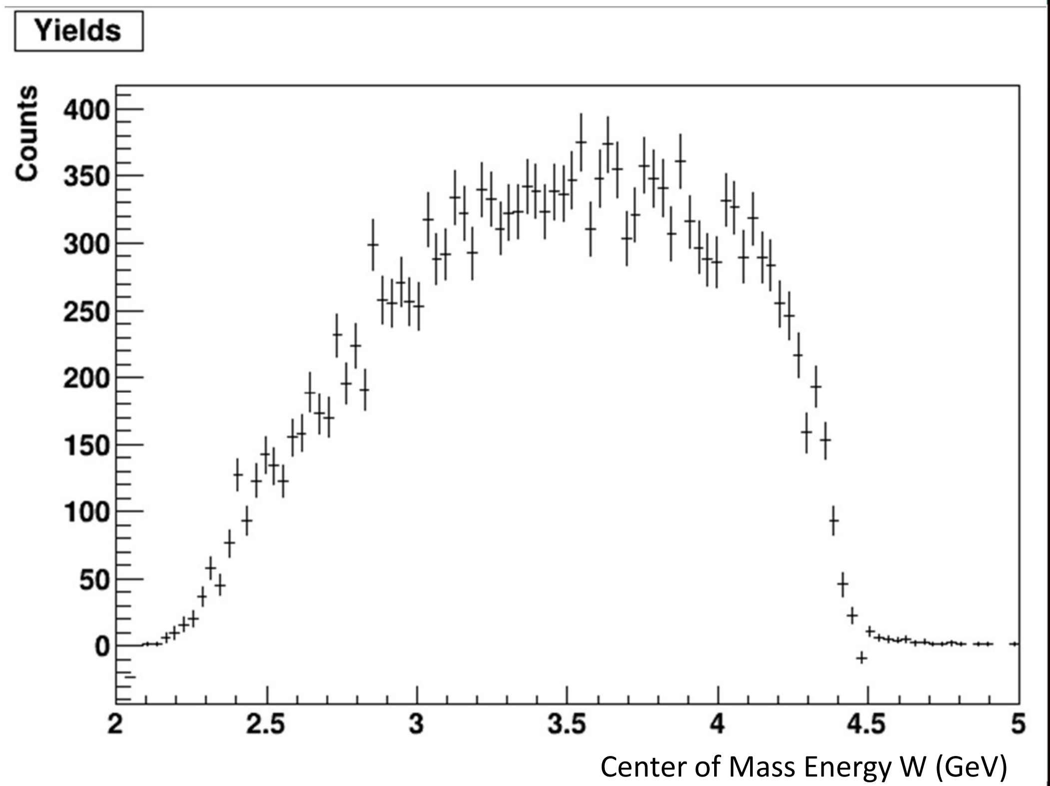


Need to correct with efficiencies to determine if there are resonances

Efficiencies of K^+K^-p system

Made an event generator to create particles in the reaction

$$e\,p \rightarrow e\,R^*$$

$$\hookrightarrow K^+\Lambda^*_{1520}$$

$$\hookrightarrow p\,K^-$$

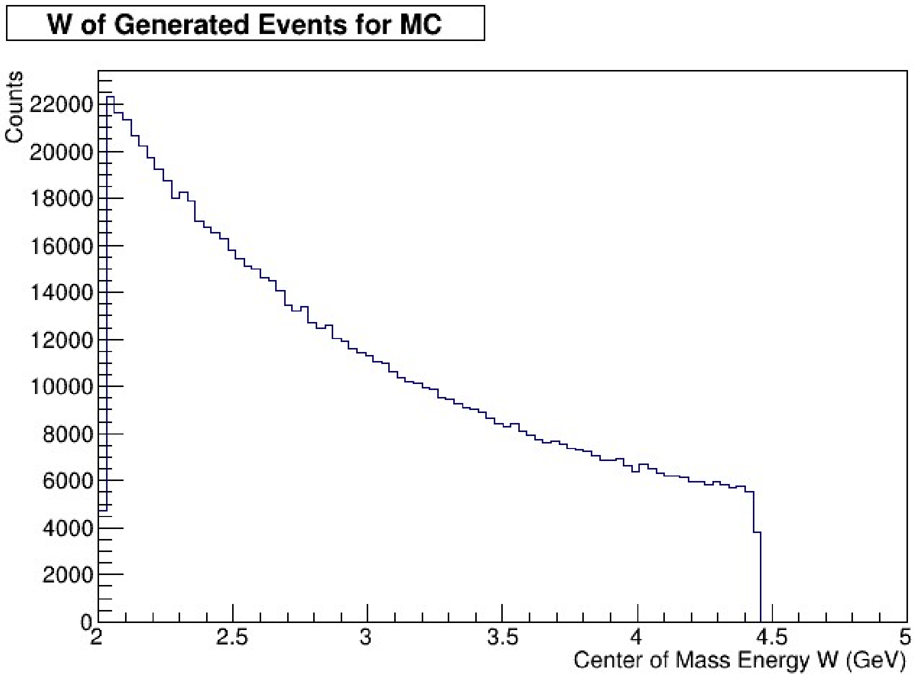
Put generated events through Monte Carlo to model the detector response

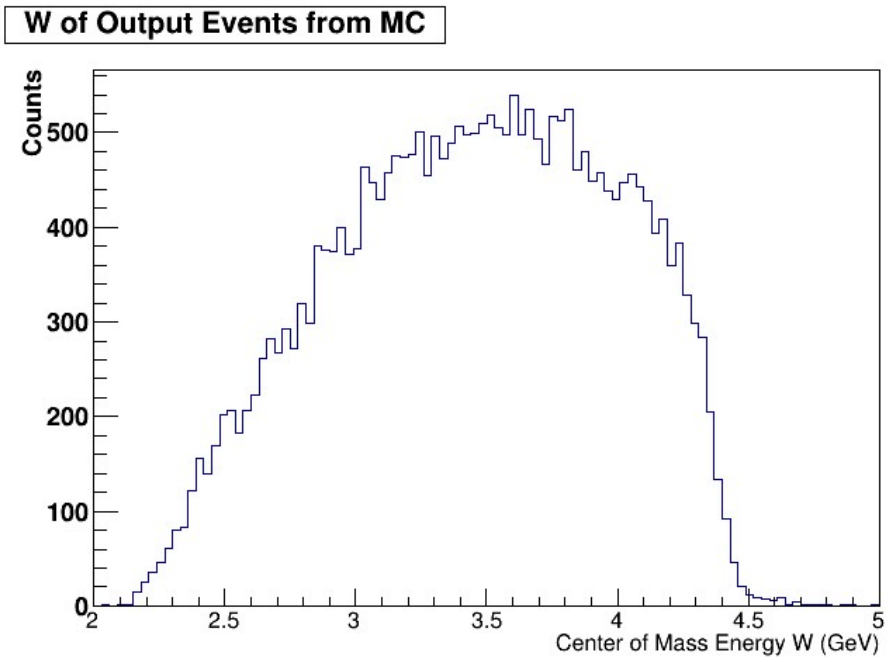
ASU

Efficiencies of K^+K^-p system

Create histograms:

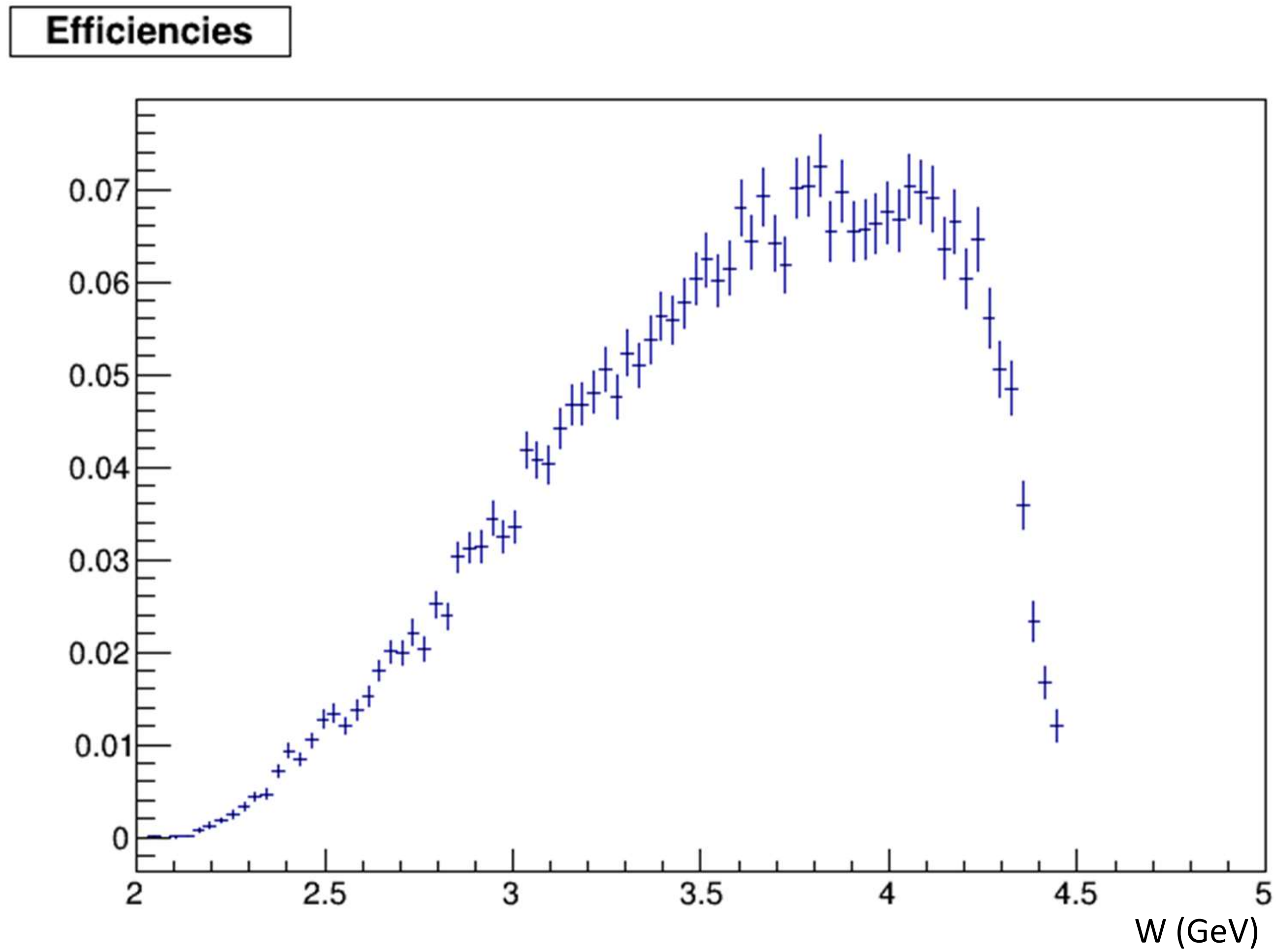
- *W* of all events generated in K^+K^-p channel
- *W* of the events that make it through MC simulation





Divide counts of *W* of output events by those of *W* of input events to get detector efficiencies per W bin

Efficiencies of K^+K^-p system



Divide yields by efficiencies to get efficiency-corrected yields

Efficiency-Corrected Yields

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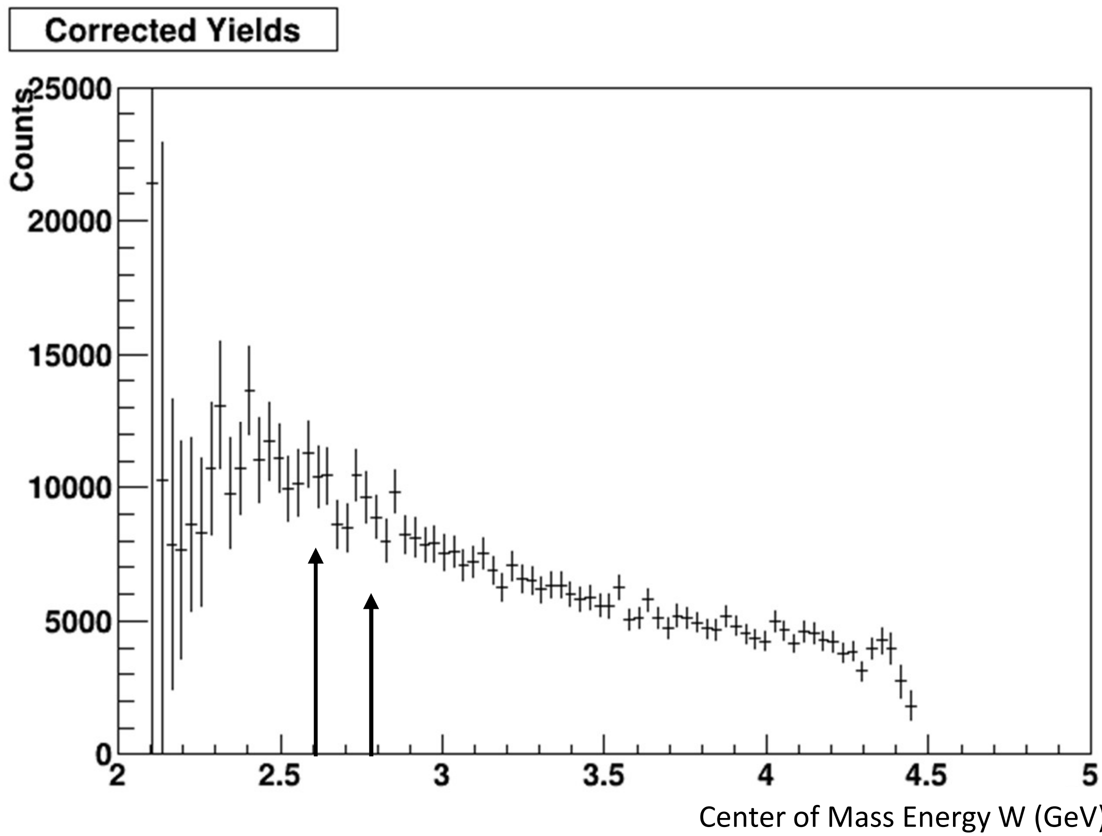

Looking for "peaks" that indicate a resonance
Most peaks seem to be within error of surrounding points
To reduce error at low energies, would need more MC events

Conclusions

More MC is required to identify high-mass nucleon resonances in this channel

Future

Generate more MC
Add/compare other datasets from JLab

Acknowledgements

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