Hall B - Run Group K
Color Confinement and Strong QCD
Status Update

E12-16-010 **A Search for Hybrid Baryons in Hall B with CLAS12**
Annalisa D'Angelo

E12-16-010A Nucleon Resonance Structure Studies Via Exclusive KY Electroproduction at 6.6 GeV and 8.8 GeV
Daniel Carman

E12-16-010B Deeply Virtual Compton Scattering with CLAS12 at 6.6 GeV and 8.8 GeV
Latifa Elouadrhiri

E12-16-010C Separation of the σ_L and σ_T contributions to the production of hadrons in electroproduction
Tim Hayward, Harut Avakian

Approved:
50 PAC days at 8.8 GeV
50 PAC days at 6.6 GeV

Assigned Fall 2018:
5.5 PAC days at 7.5 GeV
4.0 PAC days at 6.5 GeV

Assigned Spring 2024:
2 PAC days commissioning at 6.5 GeV
16.5 PAC days at 6.4 GeV
13.5 PAC day at 8.5 GeV

Gran Total: 42 PAC days of collected data + 30 PAC days of assigned data → **72 PAC days globally assigned**

Main Questions to Address

- The N* spectrum: what is the role of glue?

  → **Search for new baryon states -** E12-16-010

- How does meson-baryon cloud emerge?

  → **Measure the Q^2 dependence of electrocoupling amplitudes -** E12-16-010A

- How is color confinement realized in the force and pressure distributions resulting in stable nucleons?

  → **Study GPDs and their moments from DVCS -** E12-16-010B

- What is the 3D internal structure of the nucleon?

  → **Study the nucleon structure function from SIDIS -** E12-16-010C

Run Group Proposal (RG K)

"Color Confinement and Strong QCD"

Hybrid Baryons E12-16-010	Search for hybrid baryons (qqqg) focusing on 0.05 GeV^2 < Q^2 < 2.0 GeV^2 in mass range from 1.8 to 3 GeV in KΛ, Nππ, Nπ *(A. D'Angelo, V. Burkert, D.S. Carman, V. Mokeev, R. Gothe)*
KY Electroproduction E12-16-010A	Study N* structure for states that couple to KY through measurements of cross sections and polarization observables that will yield Q^2 evolution of electrocoupling amplitudes *(D.S. Carman, V. Mokeev, R. Gothe)*
DVCS E12-16-010B	Access GPDs H, E, $\widetilde{H}$, $\widetilde{E}$ using DVCS process ep → epγ and the DVMP process ep → epπ^0 *(L.Elouadrhiri, F.X. Girod)*
SIDIS E12-16-010C	Measure the proton structure functions in the deep-inelastic scattering by Rosenbluth separation performed combining RG-K and RG-A data on semi-inclusive electro-production of hadrons. (*T. Hayward, Harut Avakian*)

100 days
approved by PAC 44 and
confirmed by PAC 48 (Jeopardy)

E_b = 6.6 GeV, 50 days – 3 passes

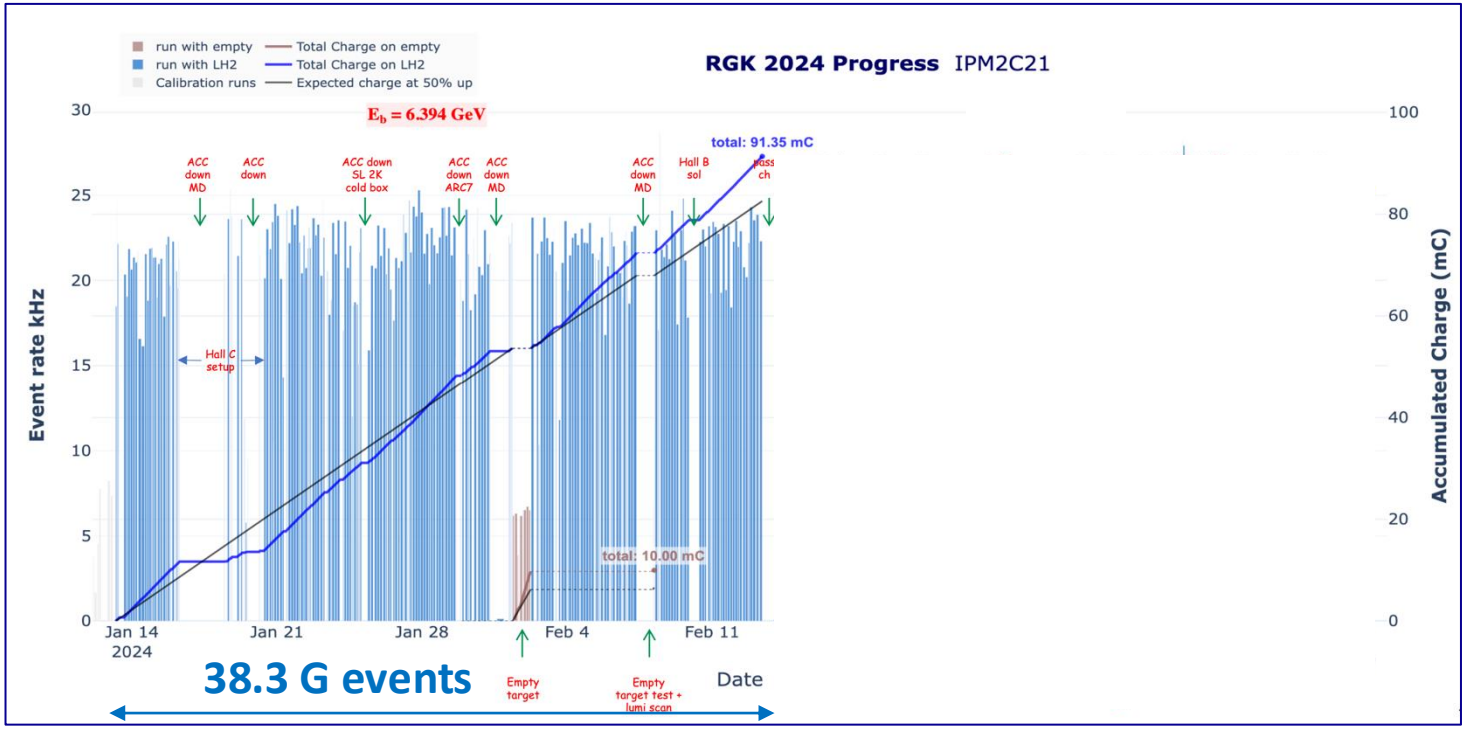
E_b = 8.8 GeV, 50 days – 4 passes

RUN CONDITIONS	
Torus Current	100% (3375 A) - negative out-bending
Solenoid	-100 %
FT	**ON @ 7.5 GeV -> OFF @ 6.5 GeV and 8.5 GeV**
Beam/Target	Polarized electrons, un-polarized LH_2 target
Luminosity	• ~ 5 10^{34} cm^{-2}s^{-1} @ 7.5 GeV ~ 0.87 10^{34} cm^{-2}s^{-1} @ 6.5 GeV 0.87 10^{35} cm^{-2}s^{-1} @ 6.4 GeV 10^{35} cm^{-2}s^{-1}@8.5 GeV **FULL LUMINOSITY**

Run Group K - SPRING 2024 Data Taking Overview

January 14 – February 13, 2024 – 33 calendar days

Production @ 3 Passes E_b=6.394 GeV



3-passes

E_e = 6.39463 GeV

I_e = 65 nA

Lum. = 0.87 10^{35} cm^{-2} s^{-1}

Run Range:

19300 – 19659

259 Production Runs

38.3 G prod events

10 Empty tgt runs @ 200 nA

0.41 G ET events (~1% full)

Accumulated Charge:

Full tgt = 91 mC

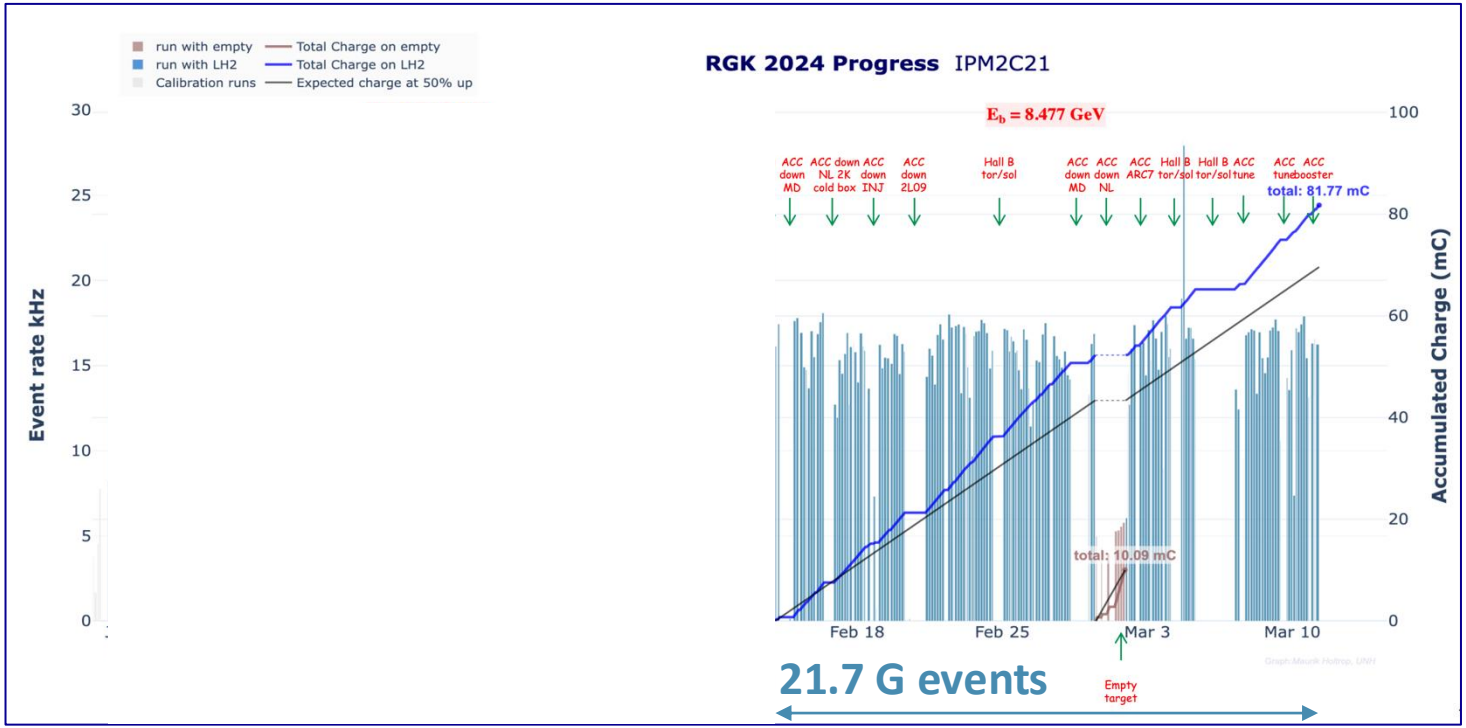
Empty tgt = 10 mC

Total = 101 mC

Run Group K - SPRING 2024 Data Taking Overview

February 13 - March 11, 2024 – 27 calendar days

Production @ 4 Passes E_b=8.477 GeV



4-passes

E_e = 8.47757 GeV

I_e =75 nA

Lum. = 10^{35} cm^{-2} s^{-1}

Run Range:

19660 – 19893

174 Production Runs

21.7 G events

8 Empty tgt runs @ 200 nA

0.32 G ET events (~1.4% full)

Accumulated Charge:

Full tgt = 81.77 mC

Empty tgt = 10 mC

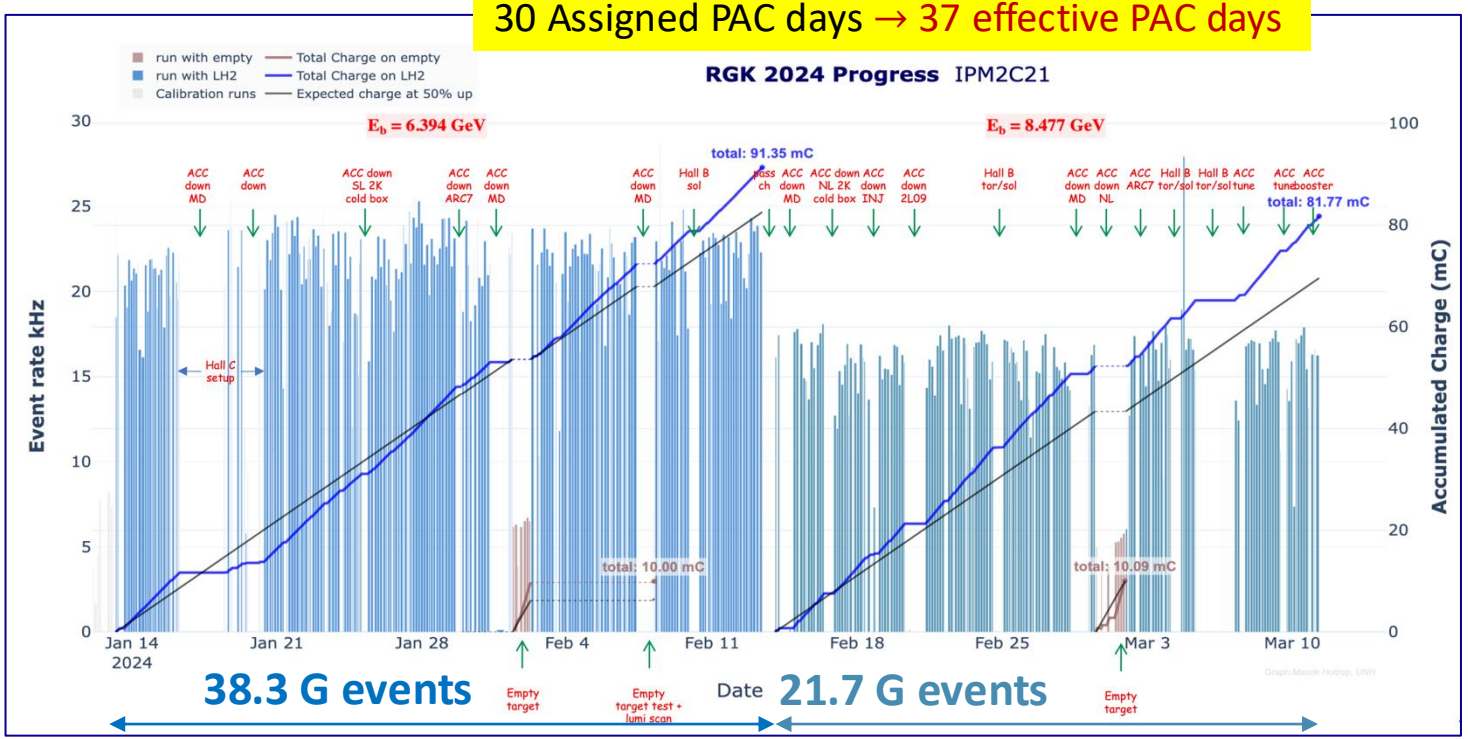
Total = 91.77 mC

Run Group K - SPRING 2024 Data Taking Overview

December 15-19, 2023 – 4 calendar days
Commissioning

January 11 - March 11, 2024 – 60 calendar days
Alignment and Production

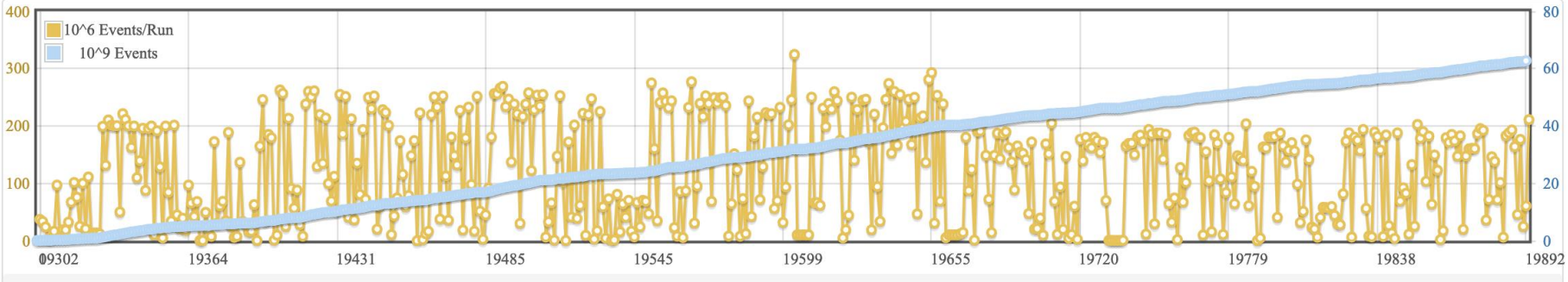
30 Assigned PAC days → 37 effective PAC days



Total

433 Production Runs
60 G events
Accumulated Charge:
Full tgt = 172.77 mC
Empty tgt = 20 mC
Total = 192.77 mC

Run Group K - SPRING 2024 Data Production



RUN CONDITIONS	
Torus Current	100% (3375 A) - negative outbending
Solenoid	-100 %
FT	**OFF**
Beam/Target	Polarized electrons, unpolarized LH_2 target
Target Position	Target center coordinates: x=0 cm; y=0 cm; z=-5 cm

RG-K 2024 EPOCHS

Beam Energy	Beam Current	Tgt	Scope/ Variation	Collected Events
6.4 GeV	60 nA	LH_2	Commissioning/RGD	3.5 G
6.4 GeV	60 nA	LH_2	production / RGK	38.3 G
8.5 GeV	75 nA	LH_2	production / RGK	21.7 G

	Events (G)	Data Size (TB)		
		EVIO	Decoded	DST
RG-K 2024	63.5	1500	525	105

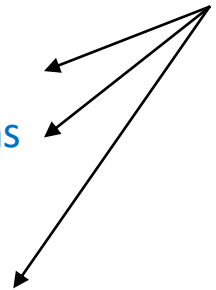
1.5 PB of EVIO data on tape

- A total of 63.5 G events have been accumulated
- Typical event number/Run 240 M @ 6.4 GeV
  200 M @ 8.5 GeV

Run Group K - Commissioning and Calibration Runs

December 15-19, 2023

- Trigger Studies - Valery Kubarosky
- Luminosity Scans
- DC HV scans - Florian Hauenstein
- Reversed solenoid polarization runs



CLAS12 Note 2026-004

Exploration of CLAS12 Drift Chamber Resolution and Efficiency

Daniel S. Carman, Florian Hauenstein, Veronique Ziegler
Jefferson Laboratory

(Dated: May 18, 2026)

Explorations of the CLAS12 drift chamber performance in terms of resolution and hit efficiency have been completed based mainly on data taken during the RG-K 2023 commissioning run and the 2024 production beam time. The resolutions were explored as a function of the high voltage configuration settings for each drift chamber region in terms of missing mass and invariant mass reconstructions for different final states spanning a broad kinematic range. The resolution was also explored as a function of the beam-target luminosity. The single-layer hit efficiency was explored as a function of the high voltage settings for each drift chamber region and as a function of the discriminator threshold setting. Finally, the drift chamber calibration protocols have undergone a new implementation since 2024 and the impact of these substantive updates is quantified.

January 11-13, 2024

- Warm/cold empty target alignment studies: zero magnetic fields – Raffaella De Vita
- DC studies
- Empty target runs
- Luminosity scans

Warm/Cold empty target Alignment

Standard procedure: DC alignment done with empty target (cold) with torus & solenoid @ zero field

• **Target "foils":** cryo-target entrance + exit windows, scattering chamber exit window

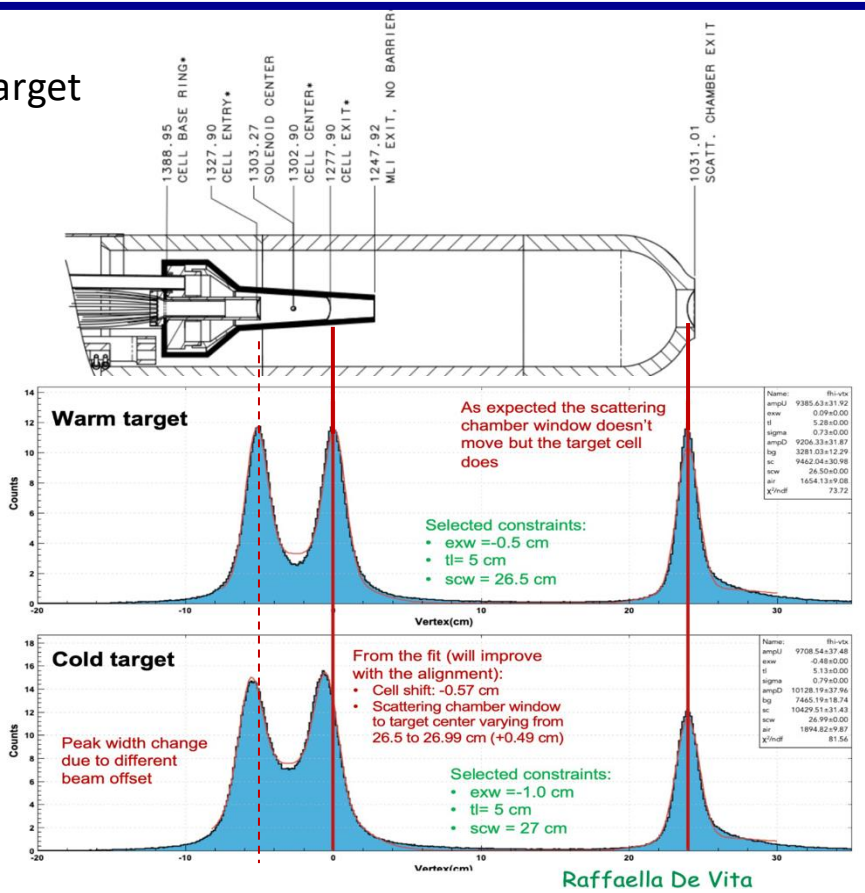
At start of RG-K run, 1 full day was dedicated to alignment runs:

• 12 hr with empty/warm target (first time)

• 12 hr with empty/cold target

Alignments have not taken **thermal contraction of cryo-target system** into account

- FEA computed upstream shift of cell by 5 mm
- Data agree with engineering calculation and survey



Spring 2024 RG-K trains: total output

3 Passes 6.4 GeV - run 19571. 216 M events (2.73 KB/ev) Total = 114 TB

591 GB	100%	DST		Custom	Projected Total Skim size
4.1 GB	0.69%	**skim4**	Jpsi TCS Wagon	yes	0.78 TB
29 GB	4.5%	**skim5**	Pi0PWagon	yes	5.1 TB
18 GB	3.0%	**skim6**	ElastWagon	Yes	3.4 TB
0.387 GB	0.07%	**skim7**	K+ K- p (ϕ)	no	0.07 TB
0.766 GB	0.13%	**skim8**	KpKpWagon	no	0.15 TB
0.558 GB	0.09%	**skim16**	DVCS	yes	0.11 TB
0.396 GB	0.07%	**skim18**	DVπ^0p	yes	0.08 TB
23 GB	3.8%	**skim21**	eK^+ (e FD)	yes	4.4 TB
4.1 GB	0.7 %	**skim1**	SIDIS (10%)	no	0.8 TB
4.0 GB	0.7%	**skim3**	Lambda Wagon(10%)	yes	0.8 TB
5.1 GB	0.9%	**skim30**	$\pi^+\pi^-p$ (RGK) (10%)	Yes	1 TB
89.4 GB	15 %	**TOTAL**			16.7 TB

Spring 2024 RG-K trains: total output

4 Passes 8.4 GeV - run 19833 194 M Events. (3 KB/ev) 65 TB

590 GB	100%	DST		Custom	Projected Total Skim size
5.5 GB	0.93 %	**skim4**	Jpsi TCS Wagon	yes	0.6 TB
25 GB	4.24%	**skim5**	Pi0PWagon	yes	2.7 TB
4.2 GB	0.71%	**skim6**	ElastWagon	yes	0.46 TB
0.475 GB	0.08%	**skim7**	K+ K- p (ϕ)	no	0.05 TB
0.853 GB	0.14%	**skim8**	KpKpWagon	no	0.09 TB
0.749 GB	0.12%	**skim16**	DVCS	yes	0.08 TB
0.648 GB	0.11%	**skim18**	DVπ^0p	yes	0.07 TB
27 GB	4.6%	**skim21**	eK^+ (e FD)	yes	2.97 TB
10.4 GB	17.6%	**skim1**	SIDIS (10%)	no	1.1 TB
4.7 GB	8%	**skim3**	Lambda Wagon(10%)	yes	0.5 TB
4.3 GB	7.3%	**skim30**	$\pi^+\pi^-p$ (RGK) (10%)	Yes	0.5 TB
83.8 GB	14.2 %	**TOTAL**			9.2 TB

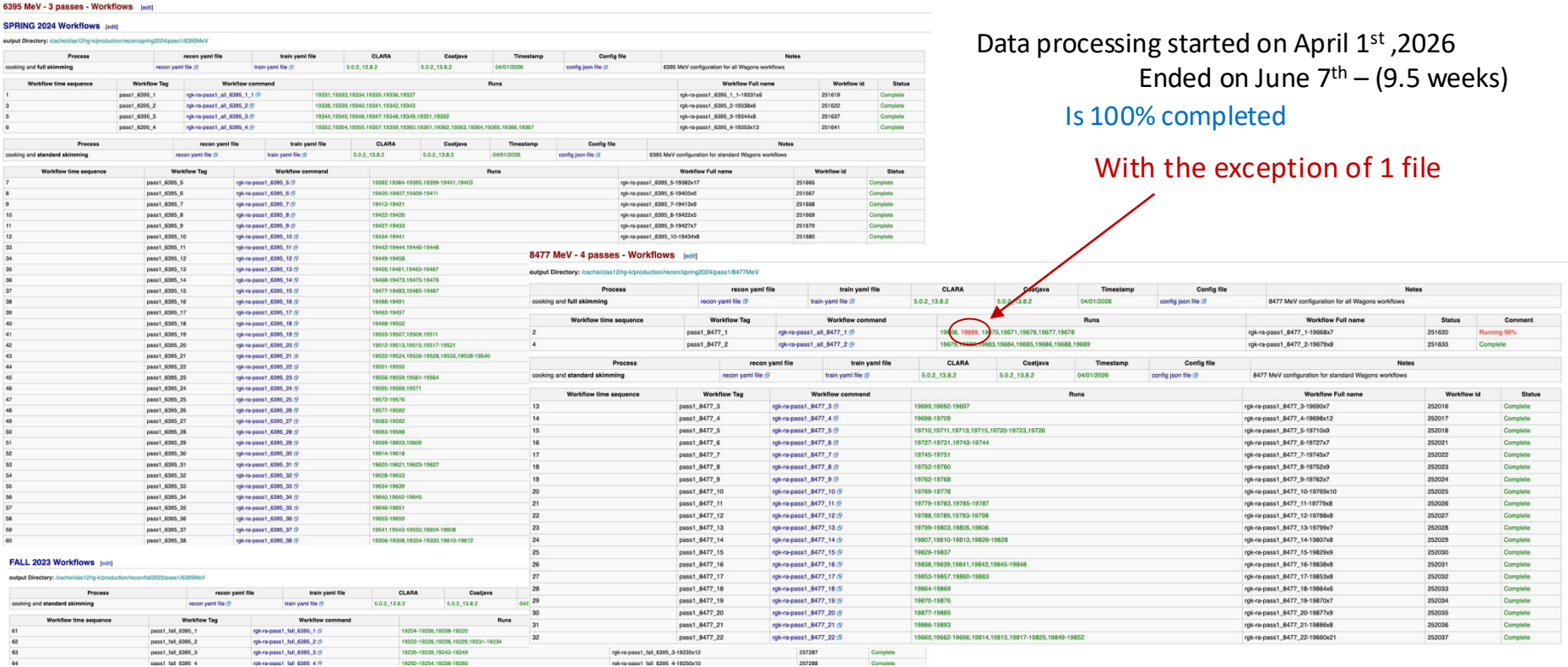
Spring 2024 RG-K Data Processing

Data processing started on April 1st ,2026

Ended on June 7th – (9.5 weeks)

Is 100% completed

With the exception of 1 file



6395 MeV - 3 passes - Workflows [edit]

SPRING 2024 Workflows [edit]

output Directory: /cache/clas12/rg-k/production/recon/spring2024/pass1/6395MeV

Process	recon yaml file	train yaml file	CLARA	Coatjava	Timestamp	Config file	Notes
cooking and **full skimming**	recon yaml file	train yaml file	5.0.2_13.8.2	5.0.2_13.8.2	04/01/2026	config json file	6395 MeV configuration for all Wagons workflows

Workflow time sequence	Workflow Tag	Workflow command	Runs	Workflow Full name	Workflow id	Status
1	pass1_6395_1	rgk-ra-pass1_all_6395_1_1	19331,19333,19334,19335,19336,19337	rgk-ra-pass1_6395_1_1-19331x6	251619	Complete
2	pass1_6395_2	rgk-ra-pass1_all_6395_2	19338,19339,19340,19341,19342,19343	rgk-ra-pass1_6395_2-19338x6	251622	Complete
5	pass1_6395_3	rgk-ra-pass1_all_6395_3	19344,19345,19346,19347,19348,19349,19351,19352	rgk-ra-pass1_6395_3-19344x8	251637	Complete
6	pass1_6395_4	rgk-ra-pass1_all_6395_4	19353,19354,19355,19357,19359,19360,19361,19362,19363,19364,19365,19366,19367	rgk-ra-pass1_6395_4-19353x13	251641	Complete

Process	recon yaml file	train yaml file	CLARA	Coatjava	Timestamp	Config file	Notes
cooking and **standard skimming**	recon yaml file	train yaml file	5.0.2_13.8.2	5.0.2_13.8.2	04/01/2026	config json file	6395 MeV configuration for standard Wagons workflows

Workflow time sequence	Workflow Tag	Workflow command	Runs	Workflow Full name	Workflow id	Status
7	pass1_6395_5	rgk-ra-pass1_6395_5	19382,19384-19395,19399-19401,19403	rgk-ra-pass1_6395_5-19382x17	251665	Complete
8	pass1_6395_6	rgk-ra-pass1_6395_6	19405-19407,19409-19411	rgk-ra-pass1_6395_6-19405x6	251667	Complete
9	pass1_6395_7	rgk-ra-pass1_6395_7	19413-19421	rgk-ra-pass1_6395_7-19413x9	251668	Complete
10	pass1_6395_8	rgk-ra-pass1_6395_8	19422-19426	rgk-ra-pass1_6395_8-19422x5	251669	Complete
11	pass1_6395_9	rgk-ra-pass1_6395_9	19427-19433	rgk-ra-pass1_6395_9-19427x7	251670	Complete
12	pass1_6395_10	rgk-ra-pass1_6395_10	19434-19441	rgk-ra-pass1_6395_10-19434x8	251680	Complete
33	pass1_6395_11	rgk-ra-pass1_6395_11	19442-19444,19446-19448			
34	pass1_6395_12	rgk-ra-pass1_6395_12	19449-19458			
35	pass1_6395_13	rgk-ra-pass1_6395_13	19459,19461,19463-19467			
36	pass1_6395_14	rgk-ra-pass1_6395_14	19468-19473,19475-19476			
37	pass1_6395_15	rgk-ra-pass1_6395_15	19477-19483,19485-19487			
38	pass1_6395_16	rgk-ra-pass1_6395_16	19488-19491			
39	pass1_6395_17	rgk-ra-pass1_6395_17	19492-19497			
40	pass1_6395_18	rgk-ra-pass1_6395_18	19498-19502			
41	pass1_6395_19	rgk-ra-pass1_6395_19	19503-19507,19509,19511			
42	pass1_6395_20	rgk-ra-pass1_6395_20	19512-19513,19515,19517-19521			
43	pass1_6395_21	rgk-ra-pass1_6395_21	19522-19524,19526-19528,19535,19538-19540			
44	pass1_6395_22	rgk-ra-pass1_6395_22	19551-19555			
45	pass1_6395_23	rgk-ra-pass1_6395_23	19556-19559,19561-19564			
46	pass1_6395_24	rgk-ra-pass1_6395_24	19565-19569,19571			
47	pass1_6395_25	rgk-ra-pass1_6395_25	19572-19576			
48	pass1_6395_26	rgk-ra-pass1_6395_26	19577-19582			
49	pass1_6395_27	rgk-ra-pass1_6395_27	19583-19592			
50	pass1_6395_28	rgk-ra-pass1_6395_28	19593-19598			
51	pass1_6395_29	rgk-ra-pass1_6395_29	19599-19603,19609			
52	pass1_6395_30	rgk-ra-pass1_6395_30	19614-19618			
53	pass1_6395_31	rgk-ra-pass1_6395_31	19620-19621,19623-19627			
54	pass1_6395_32	rgk-ra-pass1_6395_32	19628-19633			
55	pass1_6395_33	rgk-ra-pass1_6395_33	19634-19639			
56	pass1_6395_34	rgk-ra-pass1_6395_34	19640,19642-19645			
57	pass1_6395_35	rgk-ra-pass1_6395_35	19646-19651			
58	pass1_6395_36	rgk-ra-pass1_6395_36	19653-19659			
59	pass1_6395_37	rgk-ra-pass1_6395_37	19541,19543-19550,19604-19608			
60	pass1_6395_38	rgk-ra-pass1_6395_38	19306-19308,19324-19330,19610-19612			

FALL 2023 Workflows [edit]

output Directory: /cache/clas12/rg-k/production/recon/fall2023/pass1/6395MeV

Process	recon yaml file	train yaml file	CLARA	Coatjava
cooking and **standard skimming**	recon yaml file	train yaml file	5.0.2_13.8.2	5.0.2_13.8.2

Workflow time sequence	Workflow Tag	Workflow command	Runs
61	pass1_fall_6395_1	rgk-ra-pass1_fall_6395_1	19204-19206,19208-19220
62	pass1_fall_6395_2	rgk-ra-pass1_fall_6395_2	19222-19226,19228,19229,19231-19234
63	pass1_fall_6395_3	rgk-ra-pass1_fall_6395_3	19235-19239,19243-19249
64	pass1_fall_6395_4	rgk-ra-pass1_fall_6395_4	19250-19254,19256-19260

8477 MeV - 4 passes - Workflows [edit]

output Directory: /cache/clas12/rg-k/production/recon/spring2024/pass1/8477MeV

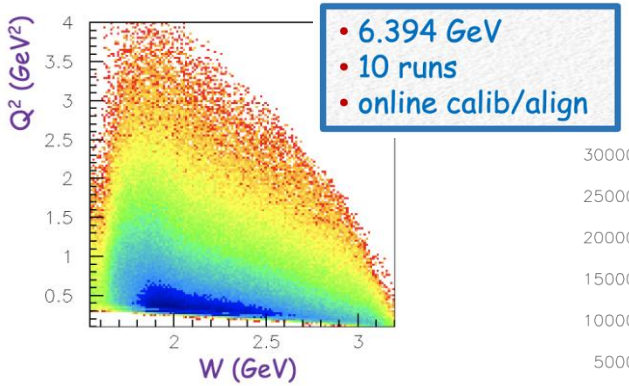
Process	recon yaml file	train yaml file	CLARA	Coatjava	Timestamp	Config file	Notes
cooking and **full skimming**	recon yaml file	train yaml file	5.0.2_13.8.2	5.0.2_13.8.2	04/01/2026	config json file	8477 MeV configuration for all Wagons workflows

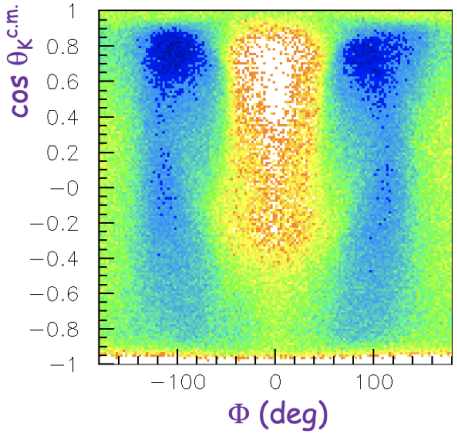
Workflow time sequence	Workflow Tag	Workflow command	Runs	Workflow Full name	Status	Comment
2	pass1_8477_1	rgk-ra-pass1_all_8477_1	19668, 19669, 19670,19671,19676,19677,19678	rgk-ra-pass1_8477_1-19668x7	251620	Running 99%
4	pass1_8477_2	rgk-ra-pass1_all_8477_2	19679,19682-19683,19684,19685,19686,19688,19689	rgk-ra-pass1_8477_2-19679x8	251633	Complete

Process	recon yaml file	train yaml file	CLARA	Coatjava	Timestamp	Config file	Notes
cooking and **standard skimming**	recon yaml file	train yaml file	5.0.2_13.8.2	5.0.2_13.8.2	04/01/2026	config json file	8477 MeV configuration for standard Wagons workflows

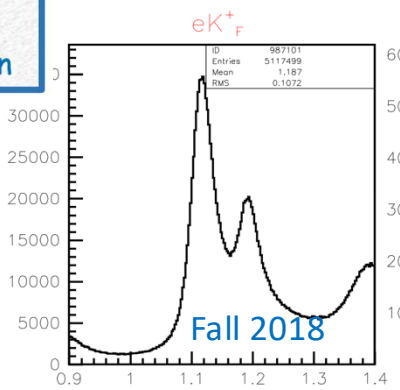
Workflow time sequence	Workflow Tag	Workflow command	Runs	Workflow Full name	Workflow id	Status
13	pass1_8477_3	rgk-ra-pass1_8477_3	19690,19692-19697	rgk-ra-pass1_8477_3-19690x7	252016	Complete
14	pass1_8477_4	rgk-ra-pass1_8477_4	19698-19709	rgk-ra-pass1_8477_4-19698x12	252017	Complete
15	pass1_8477_5	rgk-ra-pass1_8477_5	19710,19711,19713,19715,19720-19723,19726	rgk-ra-pass1_8477_5-19710x9	252018	Complete
16	pass1_8477_6	rgk-ra-pass1_8477_6	19727-19731,19743-19744	rgk-ra-pass1_8477_6-19727x7	252021	Complete
17	pass1_8477_7	rgk-ra-pass1_8477_7	19745-19751	rgk-ra-pass1_8477_7-19745x7	252022	Complete
18	pass1_8477_8	rgk-ra-pass1_8477_8	19752-19760	rgk-ra-pass1_8477_8-19752x9	252023	Complete
19	pass1_8477_9	rgk-ra-pass1_8477_9	19762-19768	rgk-ra-pass1_8477_9-19762x7	252024	Complete
20	pass1_8477_10	rgk-ra-pass1_8477_10	19769-19778	rgk-ra-pass1_8477_10-19769x10	252025	Complete
21	pass1_8477_11	rgk-ra-pass1_8477_11	19779-19783,19785-19787	rgk-ra-pass1_8477_11-19779x8	252026	Complete
22	pass1_8477_12	rgk-ra-pass1_8477_12	19788,19789,19793-19798	rgk-ra-pass1_8477_12-19788x8	252027	Complete
23	pass1_8477_13	rgk-ra-pass1_8477_13	19799-19803,19805,19806	rgk-ra-pass1_8477_13-19799x7	252028	Complete
24	pass1_8477_14	rgk-ra-pass1_8477_14	19807,19810-19813,19826-19828	rgk-ra-pass1_8477_14-19807x8	252029	Complete
25	pass1_8477_15	rgk-ra-pass1_8477_15	19829-19837	rgk-ra-pass1_8477_15-19829x9	252030	Complete
26	pass1_8477_16	rgk-ra-pass1_8477_16	19838,19839,19841,19842,19845-19848	rgk-ra-pass1_8477_16-19838x8	252031	Complete
27	pass1_8477_17	rgk-ra-pass1_8477_17	19853-19857,19860-19863	rgk-ra-pass1_8477_17-19853x8	252032	Complete
28	pass1_8477_18	rgk-ra-pass1_8477_18	19864-19869	rgk-ra-pass1_8477_18-19864x6	252033	Complete
29	pass1_8477_19	rgk-ra-pass1_8477_19	19870-19876	rgk-ra-pass1_8477_19-19870x7	252034	Complete
30	pass1_8477_20	rgk-ra-pass1_8477_20	19877-19885	rgk-ra-pass1_8477_20-19877x9	252035	Complete
31	pass1_8477_21	rgk-ra-pass1_8477_21	19886-19893	rgk-ra-pass1_8477_21-19886x8	252036	Complete
32	pass1_8477_22	rgk-ra-pass1_8477_22	19660,19662-19666,19814,19815,19817-19825,19849-19852	rgk-ra-pass1_8477_22-19660x21	252037	Complete

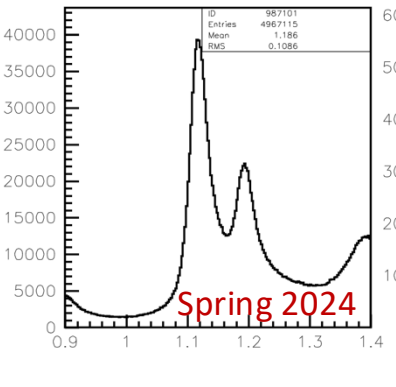
RG-K Production – KY Data analysis



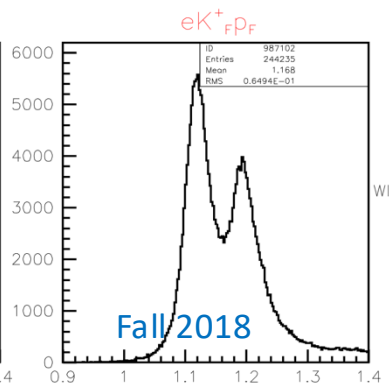


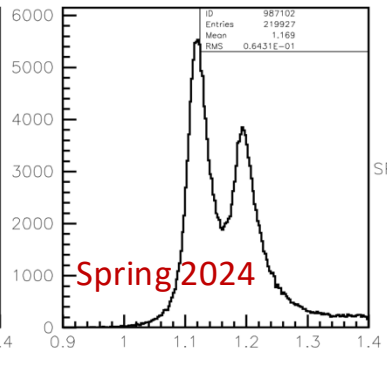
Forward k⁺



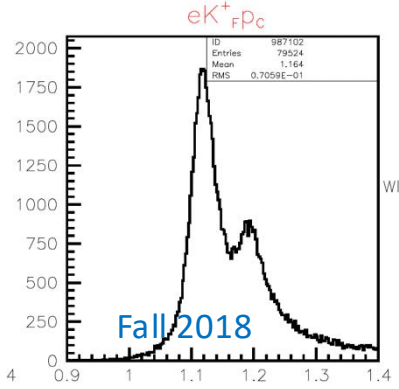


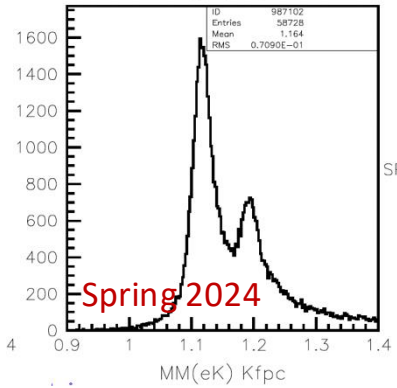
forward k⁺ forward p





forward k⁺ central p





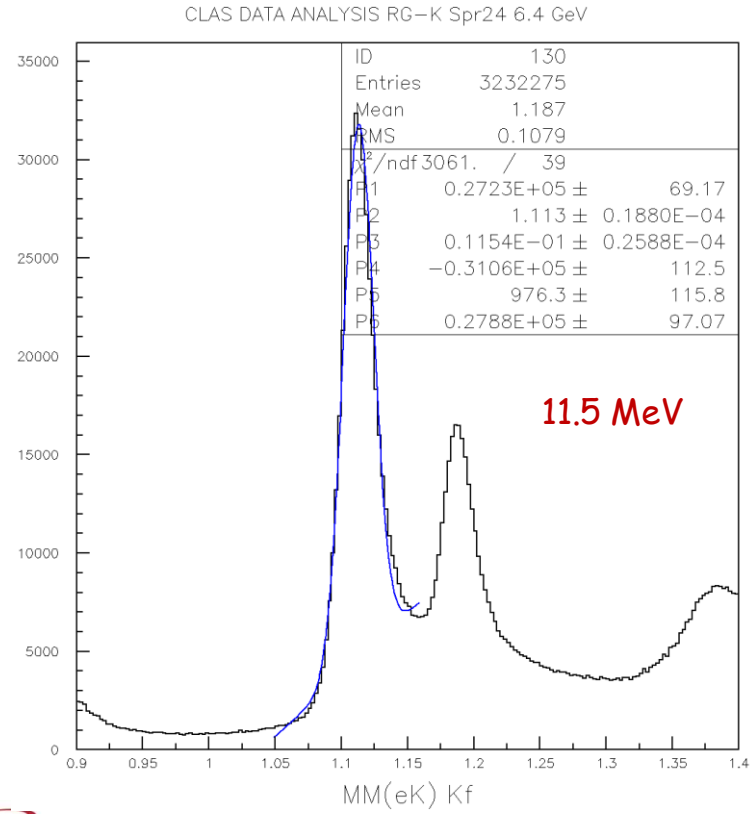
By: Daniel Carman

Resolution is improved with higher DC HV settings

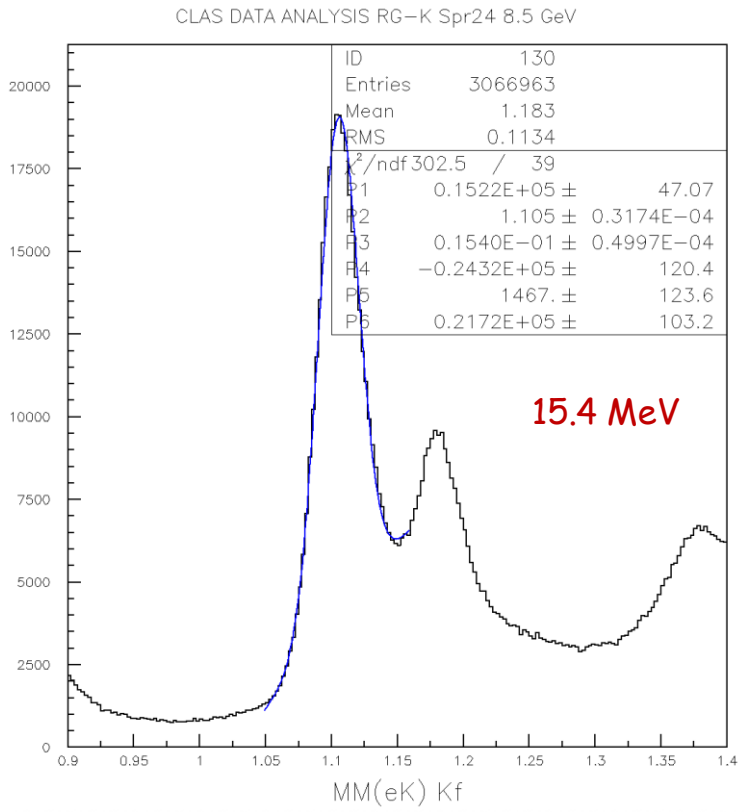
RG-K Spr24 KY Validation Studies

By: Daniel Carman

6.4 GeV



8.5 GeV



Run Group K On-going analyses

Student/Scientist	Topic
Chiara Ammendola - Roma	$ep \rightarrow e'K^+\Lambda(1520)$
Joshua Artem Tan - JLAB/ Sangbaek Lee	DVCS Beam Spin Asymmetry
Story Frantzen - MIT	DVπ^0p
Bianca Gualtieri - FIU	$ep \rightarrow e'K^+K^+\Xi^-$
Tatsuhiro Ishige	$ep \rightarrow e'K^+\,\Lambda(1405)$
Maggie Kerr	TCS
Anastasya Pavlova – MSU	$ep \rightarrow e'\pi^0 p$
Stepan Savkin – MSU	$ep \rightarrow e'\pi^+\pi^- p$
Yijie Wang - MIT	DVCS Cross Section and Elastic Scattering xsec
Harut Avagyan	SIDIS
Dan Carman/Lucilla Lanza	$ep \rightarrow e'K^+Y \qquad [\Lambda(1116), \Sigma(1193)]$
Krishna Neupane/Bhawani Singh	DV K^+K^-p
Veronique Ziegler	$ep \rightarrow e'K^+\Lambda \rightarrow e'K^+p\,\pi^-$

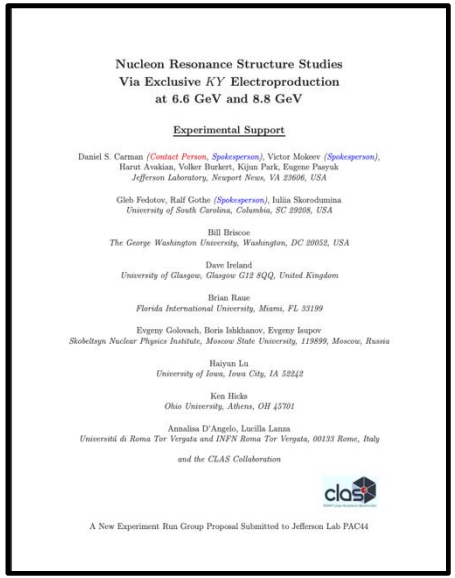
Tuesday Talks

Most analyses profit from the availability of data at 3, 4 and 5 passes combining RGK and RGA data

KY Electroproduction Studies with CLAS12 – RG-K Dataset

By Dan Carman

Proposal to PAC44, July 2016



Nucleon Resonance Structure Studies
Via Exclusive KY Electroproduction
at 6.6 GeV and 8.8 GeV

Experimental Support

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Brian Raue
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Skobeltsyn Nuclear Physics Institute, Moscow State University, 119899, Moscow, Russia

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University of Iowa, Iowa City, IA 52242

Ken Hicks
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Annalisa D'Angelo, Lucilla Lanza
Università di Roma Tor Vergata and INFN Roma Tor Vergata, 00133 Rome, Italy

and the CLAS Collaboration

A New Experiment Run Group Proposal Submitted to Jefferson Lab PAC44

current focus

#	Run	E_b (GeV)	Trig. (M)
1	RG-K Win18	6.535	7.8G
2		7.546	7.8G
3	RG-K Spr24	6.394	38.3G
4		8.478	21.7G
5	RG-K 2027	6.6	TBD
6		8.8	TBD

Program goal:

Study spectrum and structure of N* states for comparison to πN and $\pi\pi$N channels

RG-K Win18 data analysis:

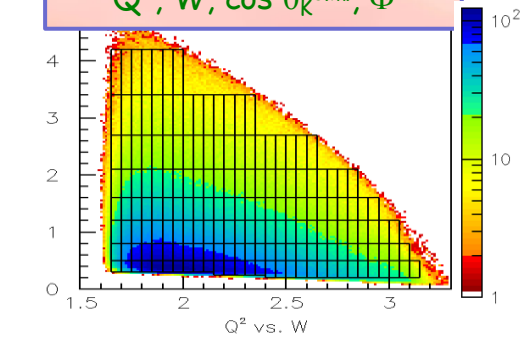
- D.S. Carman *et al. (CLAS Collaboration)*, "Recoil Polarization in K^+Y Electroproduction in the Nucleon Resonance Region with CLAS12", PRC 112, 035206 (2025).
- D.S. Carman *et al. (CLAS Collaboration)*, "Beam-Recoil Transferred Polarization in K^+Y Electroproduction in the Nucleon Resonance Region with CLAS12", PRC 105, 065201 (2022).

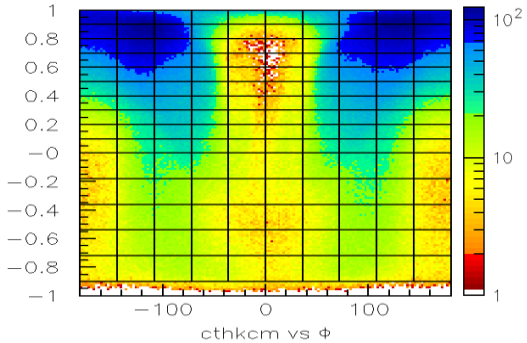
RG-K KY Binning and Yields – 6.4 GeV

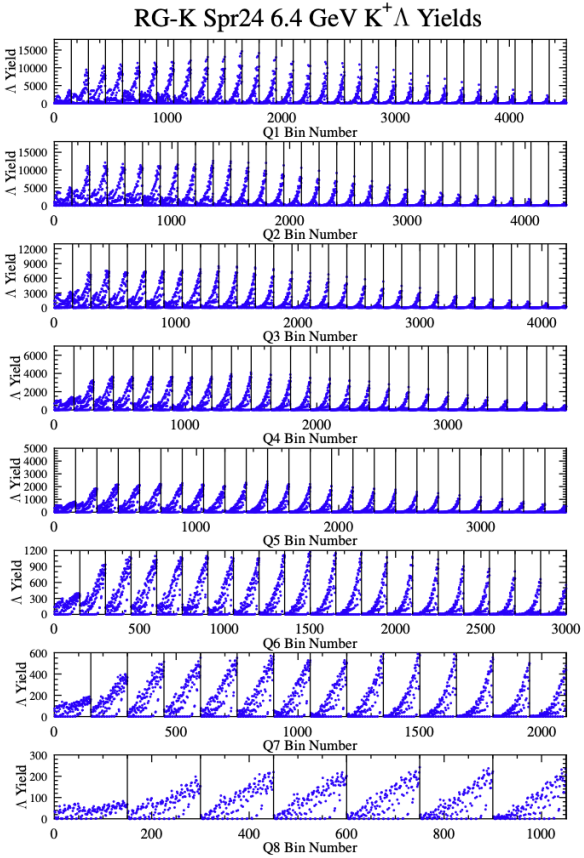
By Dan Carman

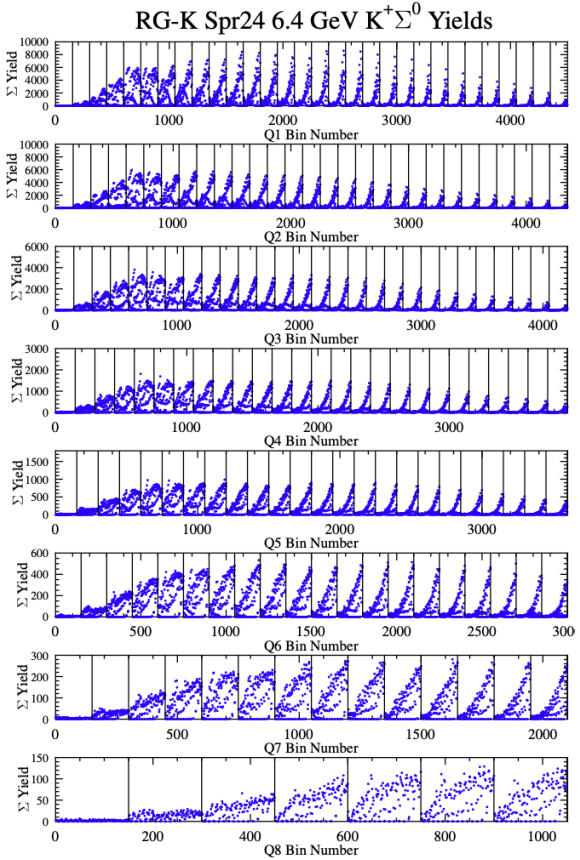
Spr24 datasets allow fine binning in the relevant kinematic variables:

Q^2, W, cos $\theta_K^{c.m.}$, Φ







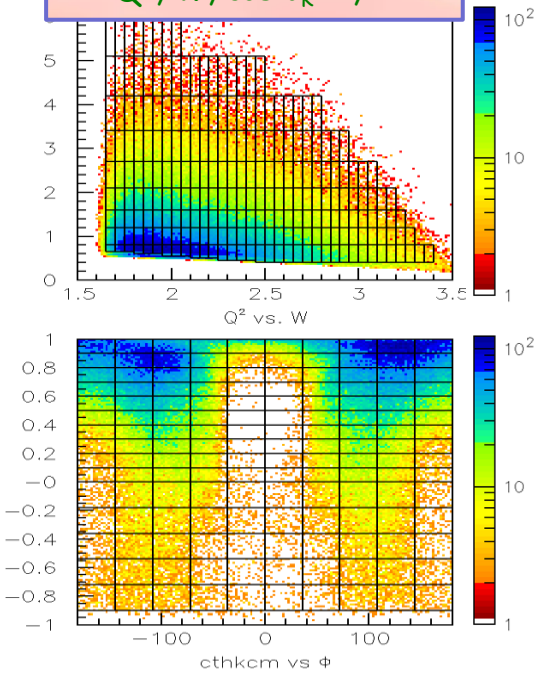


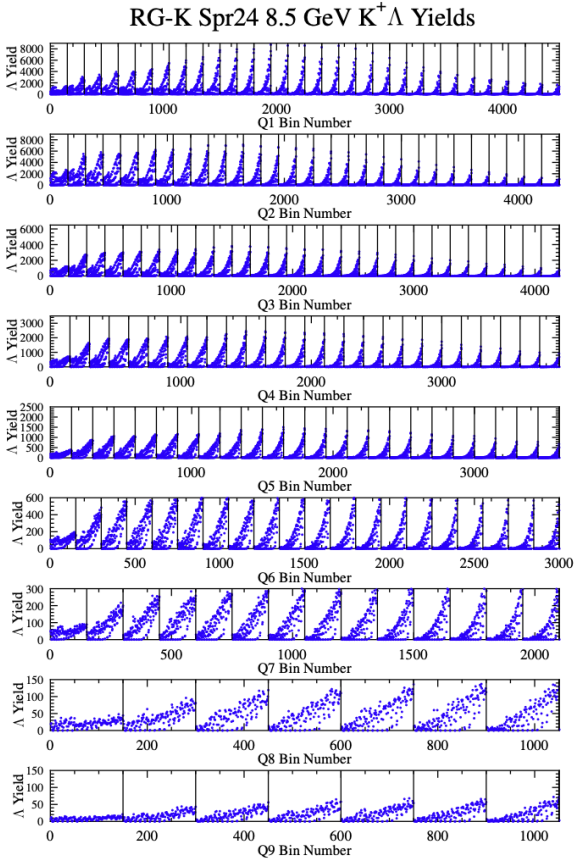
RG-K KY Binning and Yields – 8.5 GeV

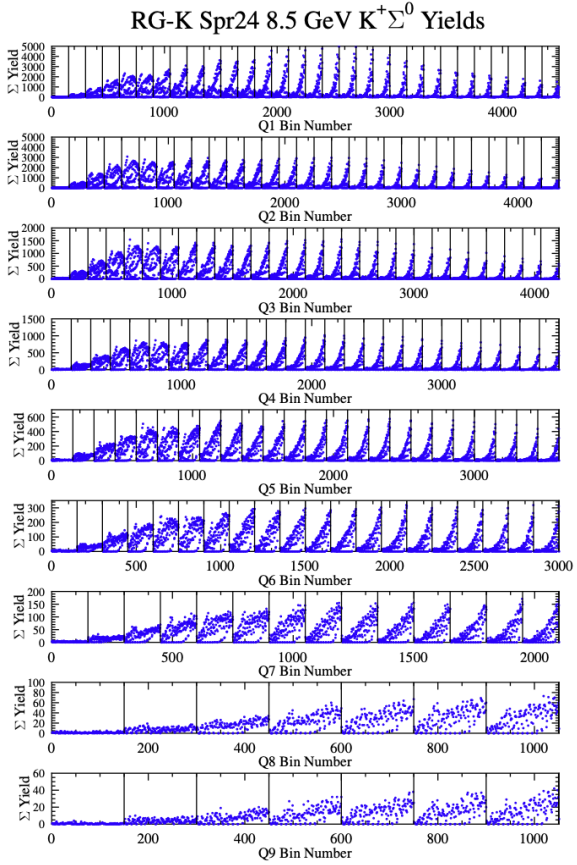
By Dan Carman

Spr24 datasets allow fine binning in the relevant kinematic variables:

Q^2, W, cos $\theta_K^{c.m.}$, Φ



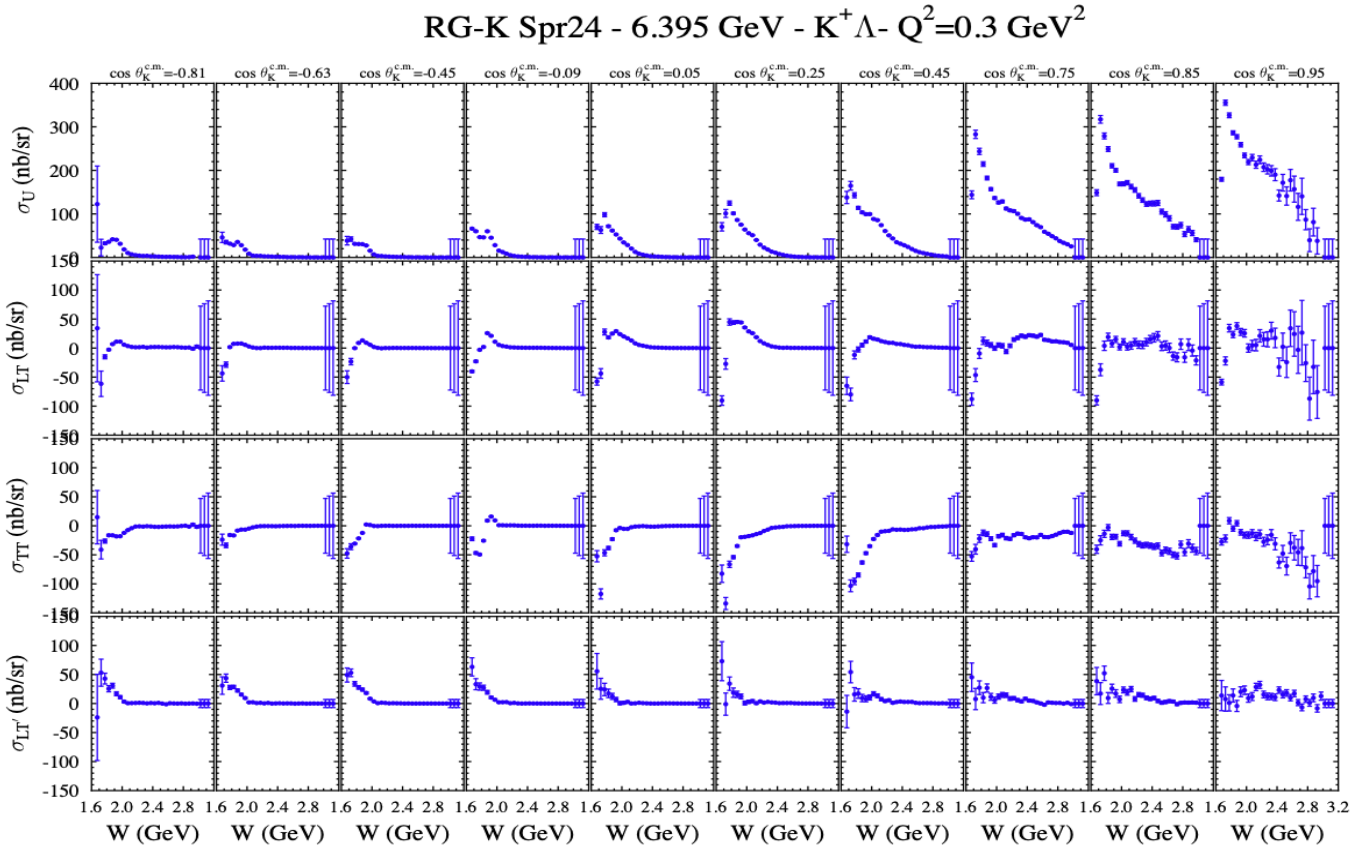




By Dan Carman

$K^+\Lambda$ Structure Functions

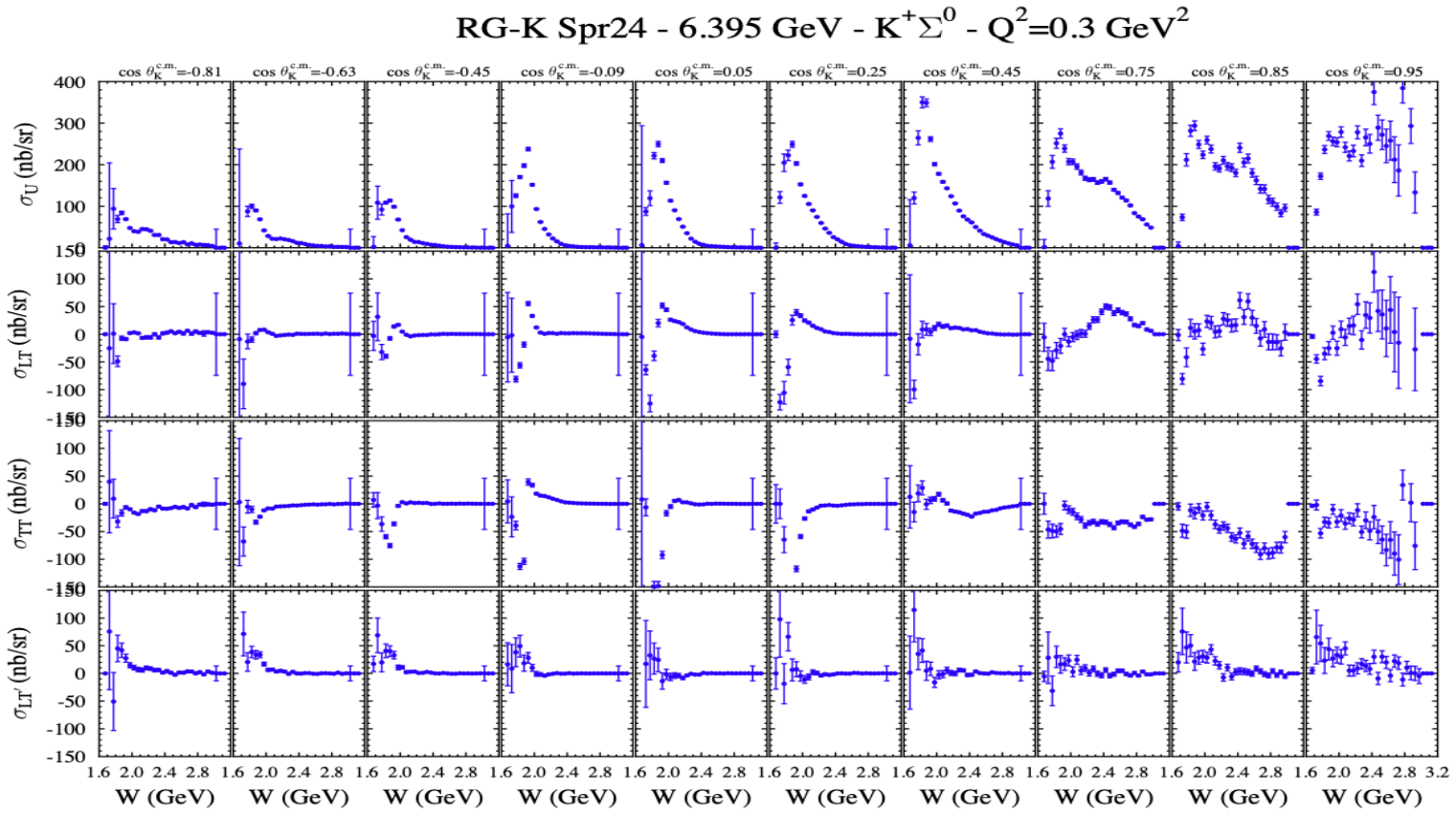
F1RST LOOK



By Dan Carman

$K^+\Sigma^0$ Structure Functions

F1RST LOOK



Jefferson Lab

clas

By Dan Carman

Summary of KY on-going analysis

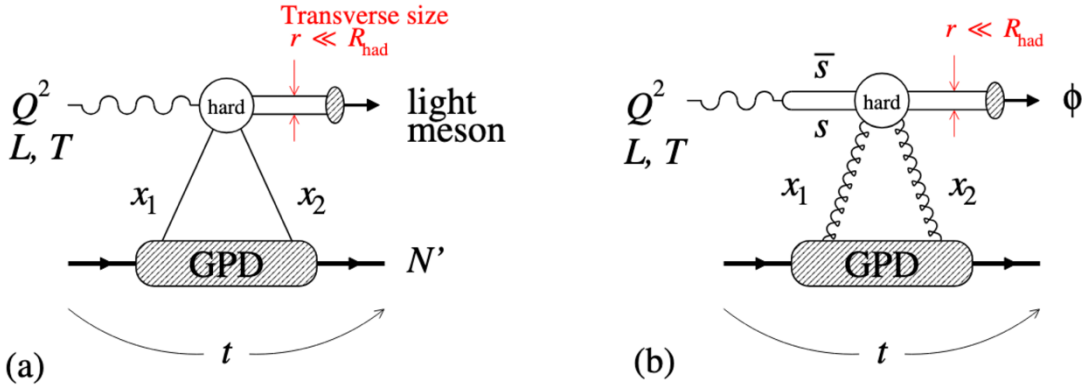
- Recent work has focused on developing the cross section extraction code/scripts. A preliminary extraction of the $K^+\Lambda$ and $K^+\Sigma^0$ differential cross sections and separated structure functions has been completed for the 6.395 GeV and 8.478 GeV RG-K Spr24 datasets
  - Two topologies have been combined: $e'K^+_F$ and $e'K^+_C p_F$
  - Note that the proton requirement is necessary in the $e'K^+_C$ topology due to the overwhelming background
- From the differential cross sections, a Φ moment analysis was carried out to extract $\sigma_U = \sigma_T + \varepsilon\sigma_L$, σ_{LT}, and σ_{TT}
- All of this is great for initial data validation but much work ahead:
  - Yield fitting has not been attempted
  - Radiative correction model (EXCLURAD) now being integrated into event generator
  - Event selection and analysis cuts have not been optimized
  - Momentum corrections have not been developed
  - Still a long way to go, but a promising start for RG-K Spr24 KY analysis …

Exclusive ϕ electroproduction

By Bhawani Singh

Clean Probe For Gluonic Structure of Nucleon

- ϕ meson a **pure** $s\bar{s}$ **state**, its coupling to light quarks (u,d) is suppressed (by OZI rule)
- Access to the gluon GPD even at low energy due to its flavor content $s\bar{s}$



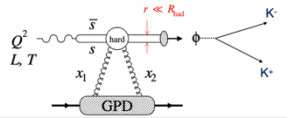
- Q^2 scaling of ϕ production cross section: opens doors to test **QCD factorization** ($\sigma_L \sim 1/Q^6$, $\sigma_L/\sigma_T \sim Q^2$)
- Change of |t|–dependence with Q^2 ➨ **gluonic radius** of the proton
- Search for **near-threshold effects** linked to intrinsic s$\bar{s}$ pairs

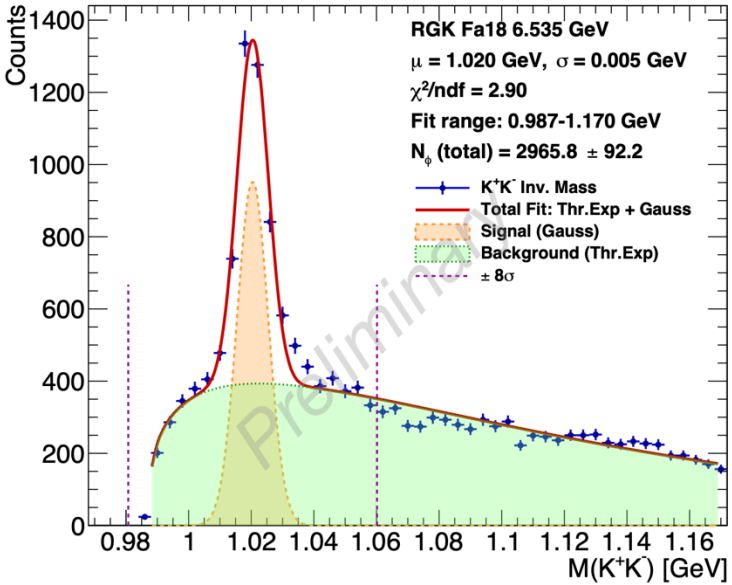
Exclusive ϕ electroproduction

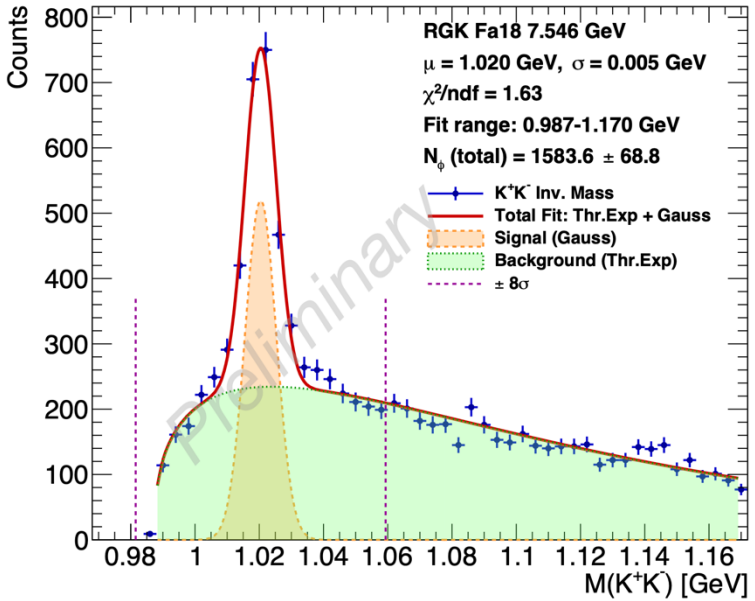
By Bhawani Singh

Run Group K: 6.5 and 7.5 GeV Beam Energies

- 6.5 and 7.5 GeV fall 2018 data, Q^2>0.6 GeV^2, after all fiducial cuts and sampling fraction cuts for electron, energy loss correction for proton, 3 sigma exclusivity cuts
- Statistics is too small





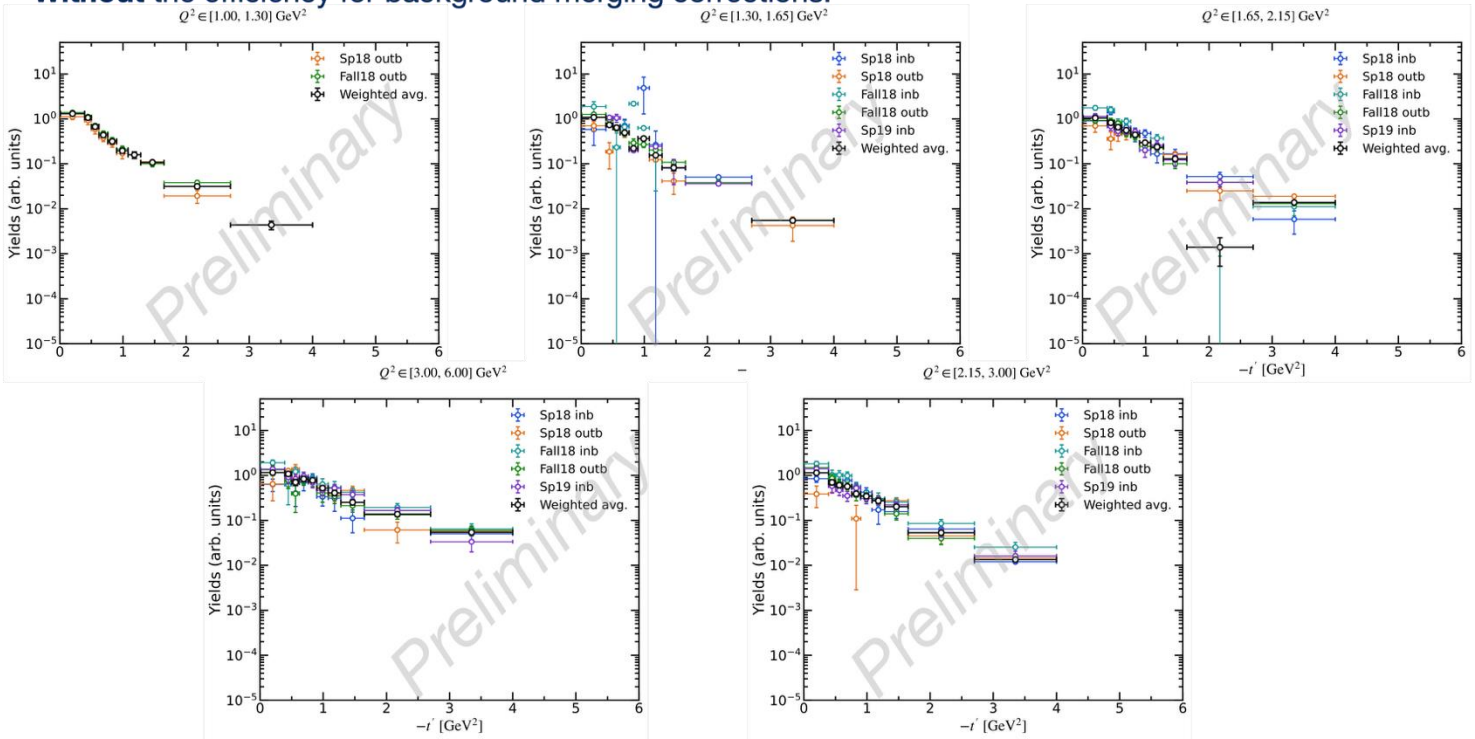


Exclusive ϕ electroproduction

By Bhawani Singh

Final reduced cross-sections RGA

- **Without** the efficiency for background merging corrections!



Timelike Compton Scattering with RG-K

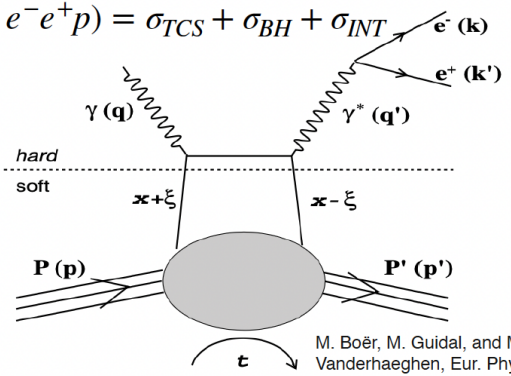
M. Kerr, L. Elouadrhiri, V. Burkert

- TCS process is time-reversed DVCS, where (quasi)real photon emitted from electron beam interacts with target nucleon, producing a timelike virtual photon which decays into the detected e^-e^+ final state
- Provides access to real and imaginary components of CFF $\mathcal{H}$ via forward-backward asymmetry, A_{FB}, and photon polarization asymmetry, $A_{\odot U}$, respectively
- TCS is a comparatively low statistics channel, benefitting from high-statistics of Sp24 RG-K run period data to expand phase space accessed by RG-A TCS measurements[1] and work towards extraction of higher level physics with TCS, such as components of CFF $\mathcal{H}$ and D-term

[1]P. Chatagnon, S. Niccolai, S. Stepanyan, et al., Phys. Rev. Lett. **127**, 262501, 2021.

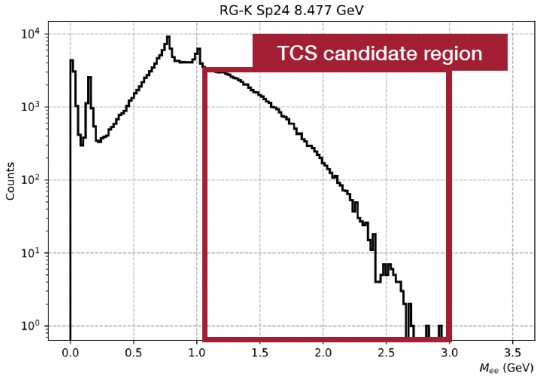
$$\sigma(\gamma p \to e^-e^+p) = \sigma_{TCS} + \sigma_{BH} + \sigma_{INT}$$

Feynman diagram of TCS process →



M. Boër, M. Guidal, and M. Vanderhaeghen, Eur. Phys. J. A **51**:103, 2015.

Distribution of full dilepton mass range for RG-K Sp24 8.477 GeV following exclusivity cuts, with TCS candidate range highlighted →



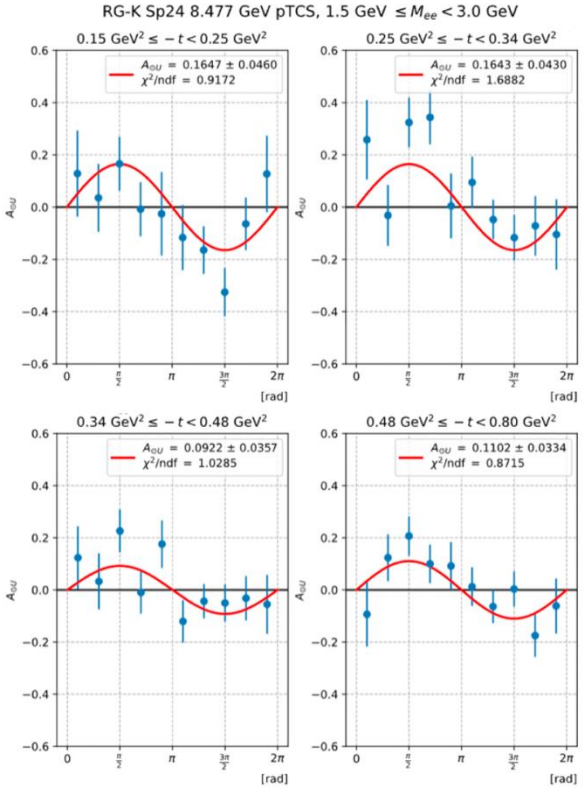
Timelike Compton Scattering with RG-K

M. Kerr, L. Elouadrhiri, V. Burkert

- Working on preliminary studies of both asymmetries in parallel with data cooking, with most progress to date on photon polarization asymmetry (shown to right in kinematic bins matching RG-A analysis)

$$A_{\odot U} = \frac{1}{P_b}\frac{N^+ - N^-}{N^+ + N^-},\ N^{\pm} = \sum_i^{N^{\pm}} PolTransf_i$$

- Photon polarization asymmetry, $A_{\odot U}$, measures difference in counts between right and left handed circularly polarized photons emitted by linearly polarized electron beam
- Analogous to DVCS BSA, but also accounting for photon polarization transfer effects (varying with kinematics)
- Plan to complete preliminary studies, write, and submit CAA to get full approval for this analysis following collaboration meeting



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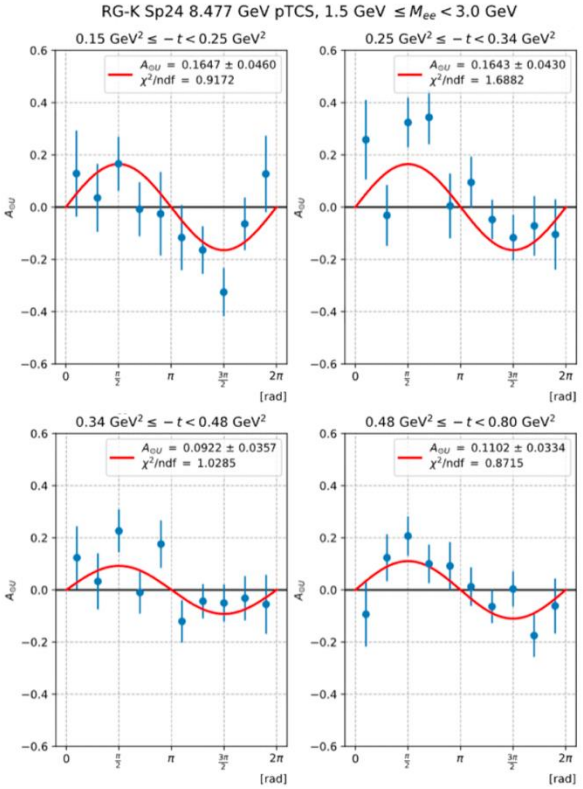


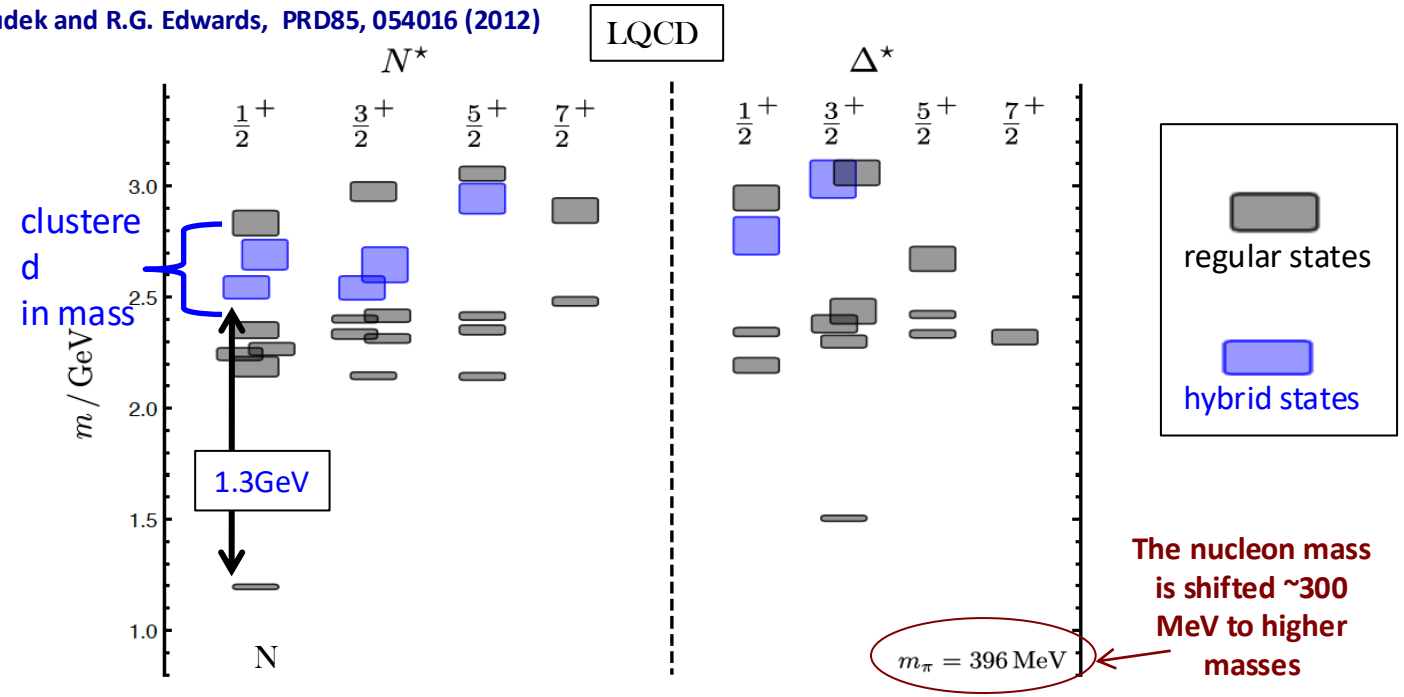
Conclusions

- ✓ Run group K has successfully collected 50 % of the data at 3 and 4 passes
- ✓ Full luminosity has been reached at 8.5 GeV with FT - OFF
- ✓ Fall 2023 and Spring 2024 Pass1 and Train skimming is complete.
- ✓ Data quality is improved compared with Fall2018 dataset.
- ✓ Data analysis on several channels, in addition to the flagship proposals, is on-going.

Thank you

Hybrid Baryons in LQCD

J.J. Dudek and R.G. Edwards, PRD85, 054016 (2012)

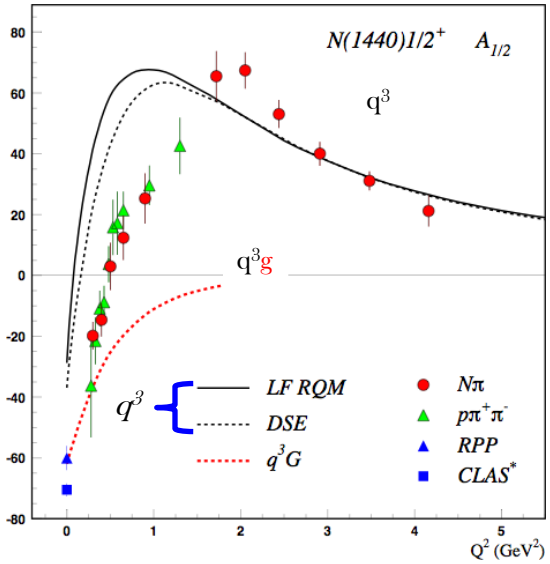


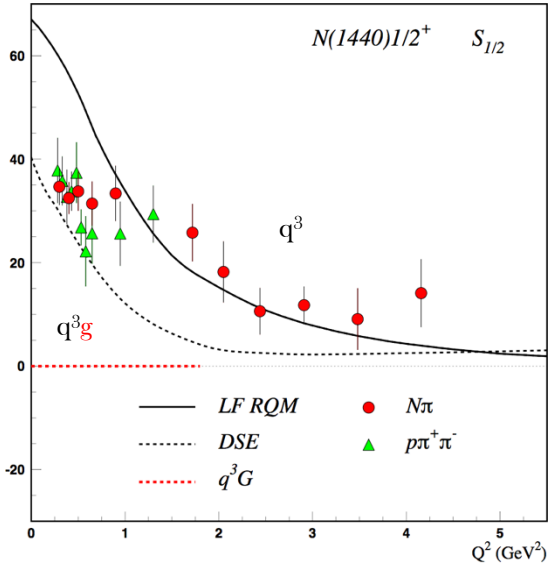
Hybrid states have same J^P values as qqq baryons. How to identify them?

- Overpopulation of N $1/2^+$ and N $3/2^+$ states compared to QM projections.
- **$A_{1/2}$ ($A_{3/2}$) and $S_{1/2}$ show different Q^2 evolution. Can we do it?**

Separating q^3g from q^3 States?

Precise CLAS results on electrocouplings clarified nature of the Roper

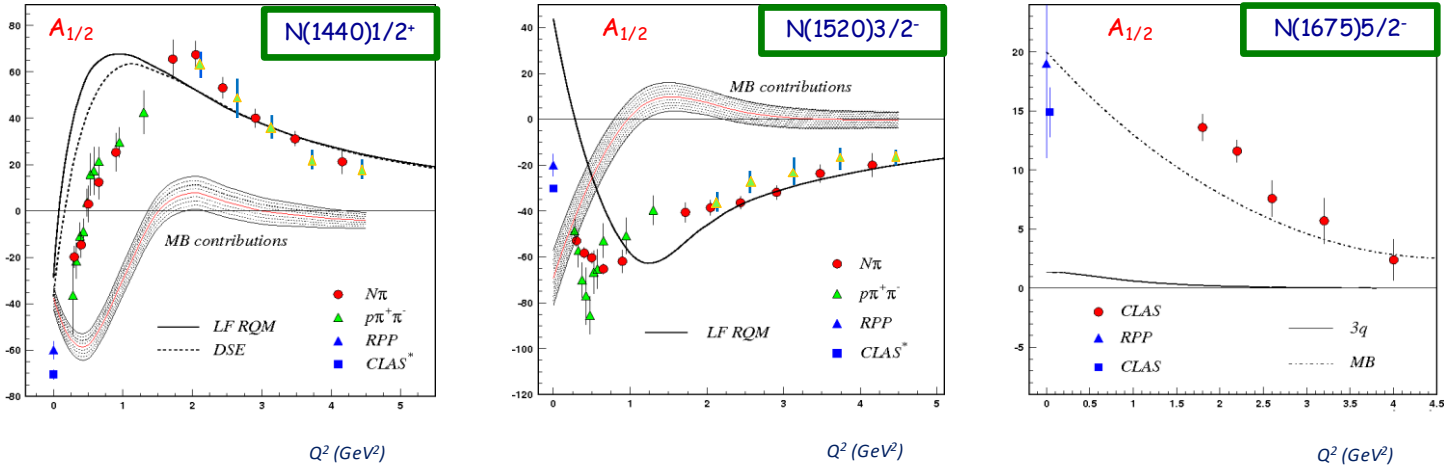




- $A_{1/2}$ and $S_{1/2}$ amplitudes at high Q^2 indicate 1st radial q^3 excitation
- Significant meson-baryon coupling at small Q^2

For hybrid "Roper", $A_{1/2}(Q^2)$ drops off faster with Q^2 and $S_{1/2}(Q^2) \sim 0$.

Q^2 Evolution of N* Electrocouplings



- Electrocouplings reveal different interplay between meson cloud and quark core:
  - -Important to study different N* states vs. distance scale
- Good agreement of the extracted N* electrocouplings from Nπ and Nππ:
  - -Compelling evidence for the reliability of the results
  - -Channels have very different mechanisms for the non-resonant background

Data from the KY channels is critical to provide an independent extraction of the electrocoupling amplitudes for the higher-lying N* states

Accessing the Forces & Pressure on Quarks

Nucleon matrix element of EMT contains:

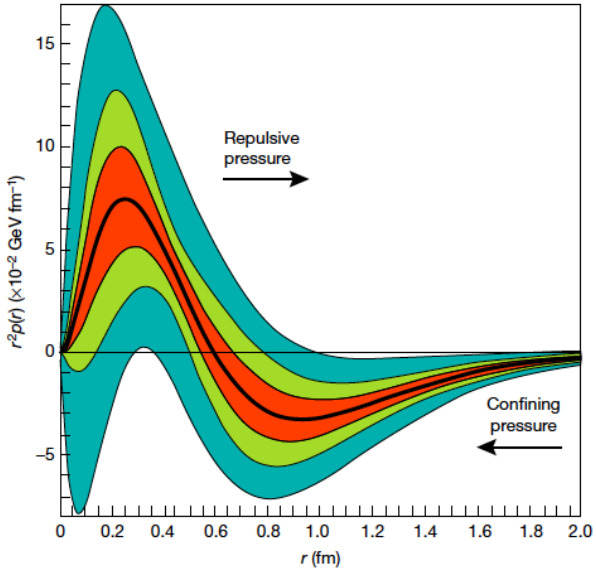
$M_2(t)$: Mass distribution inside the nucleon

$J(t)$: Angular momentum distribution

$d_1(t)$: **Shear forces and pressure distribution**

$$\int xH(x,\xi,t)\mathrm{d}x = M_2(t) + \frac{4}{5}\xi^2 d_1(t)$$

Separate $M_2(t)$ and $d_1(t)$ through measurements at small/large ξ.



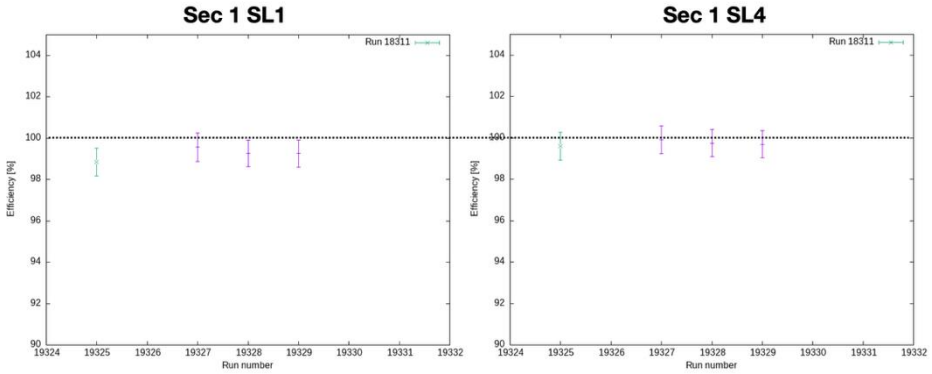
V. D. Burkert, L. Elouadrhiri & F. X. Girod
Nature, 557 396-399 (2018)

Measuring these form factors, we learn about confinement forces.

DC HV Scans

R1 DC HV setting	R2 DC HV setting	R3 DC HV setting	Current
10	11	11	40 nA
11	12	12	40 nA
9	10	10	40 nA
10	10	10	40 nA
10	10	11	40 nA
10	10	11	40 nA
10	12	11	40 nA
10	11	10	40 nA
10	11	12	40 nA
12	13	13	40 nA
11	11	11	40 nA
10	12	10	40 nA

- **HV 11,12,12**
  - **Threshold 30,45,45 (run 19327)**
  - **Threshold 45,60,60 (run 19328)**
  - **Threshold 60,60,60 (run 19329)**
- **Comparison RGD with threshold 30,45,45**



- **No decrease in efficiency for higher thresholds**

(11, 12, 12) – SPRING 2024 – 3-passes configuration

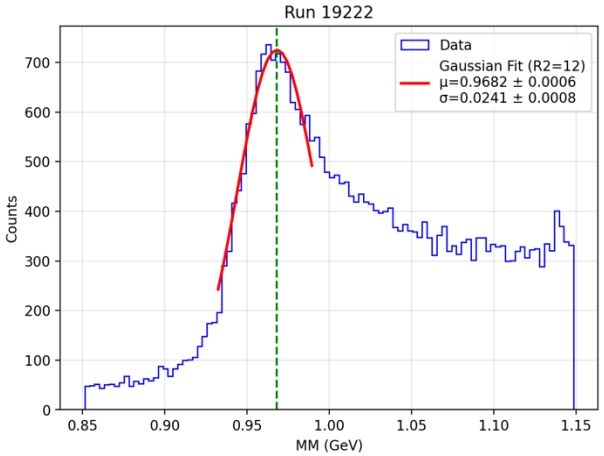
(10, 12, 11) – SPRING 2024 – 4-passes configuration

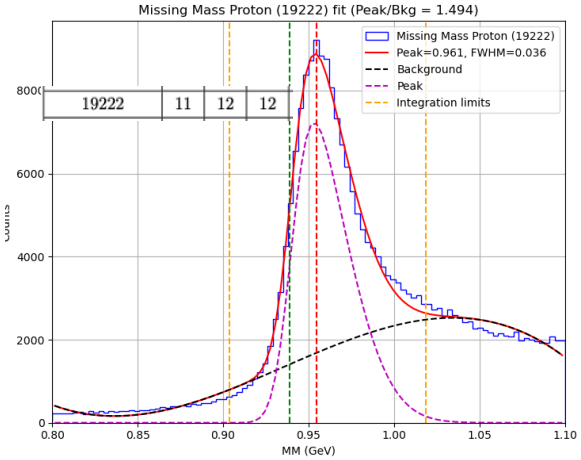
(9, 10, 10) – FALL 2018 configuration

By Florian Hauenstein

DC HV Scans

Run Number	R1	R2	R3	$N_{triggers}$
19220	10	11	11	85.98 M
19222	11	12	12	100.51 M
19223	9	10	10	100.37 M
19224	10	10	10	101.31 M
19225	10	10	11	45.80 M
19226				30.02 M
19228	10	12	11	88.51 M
19229	10	11	10	89.29 M
19238	10	11	12	75.20 M
19239	12	13	13	81.29 M
19243	11	11	11	60.22 M
19244	10	12	10	67.48 M



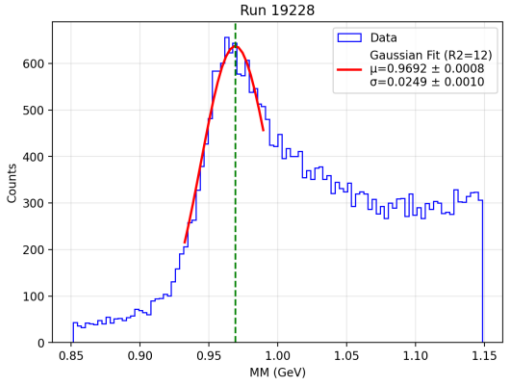


(11, 12, 12) – SPRING 2024 – 3-passes configuration

$ep \rightarrow ep\pi^+\pi^-$

By Krishna Neupane

(10, 12, 11) – SPRING 2024 – 4-passes configuration



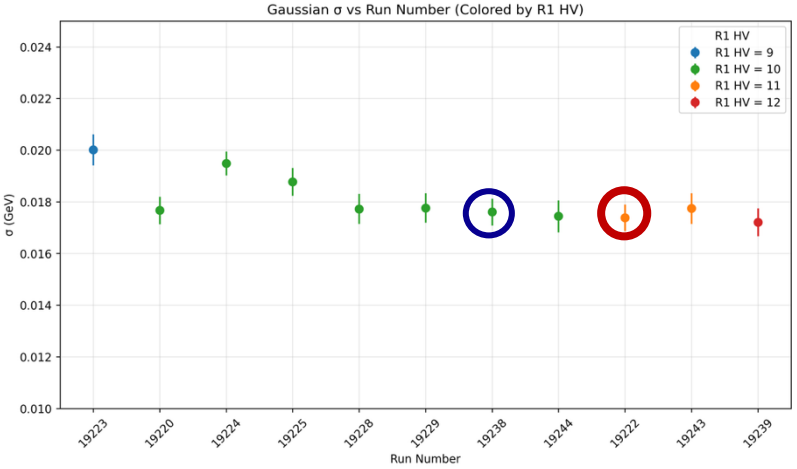
Proton missing mass

DC HV Scans

Run Number	R1	R2	R3	$N_{triggers}$
19220	10	11	11	85.98 M
19222	11	12	12	100.51 M
19223	9	10	10	100.37 M
19224	10	10	10	101.31 M
19225	10	10	11	45.80 M
19226				30.02 M
19228	10	12	11	88.51 M
19229	10	11	10	89.29 M
19238	10	11	12	75.20 M
19239	12	13	13	81.29 M
19243	11	11	11	60.22 M
19244	10	12	10	67.48 M

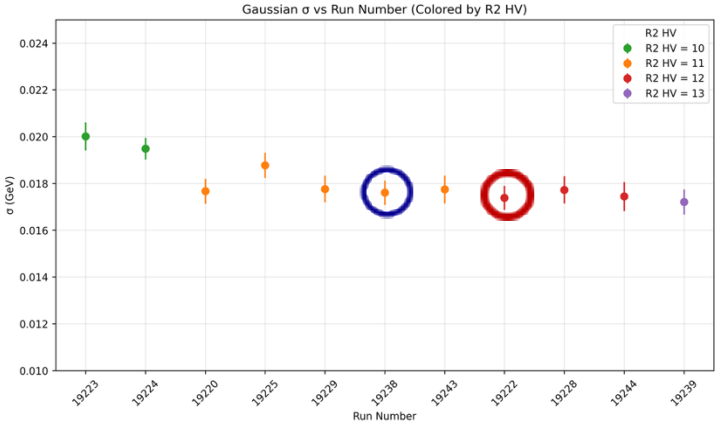
3 passes

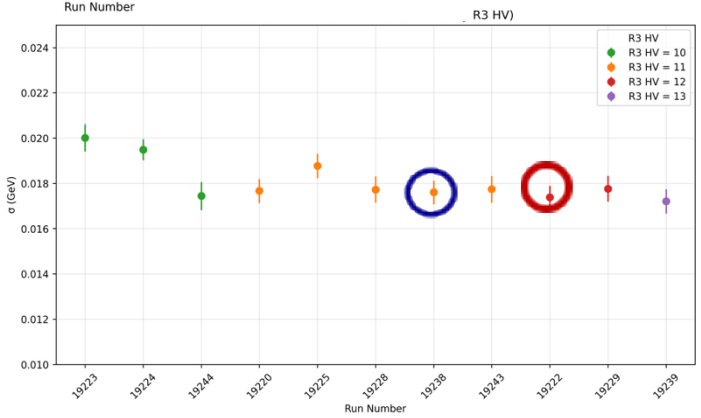
4 passes



By Krishna Neupane

DC HV has been optimized





DC HV Scans

Run Number	R1	R2	R3	$N_{triggers}$
19220	10	11	11	85.98 M
19222	11	12	12	100.51 M
19223	9	10	10	100.37 M
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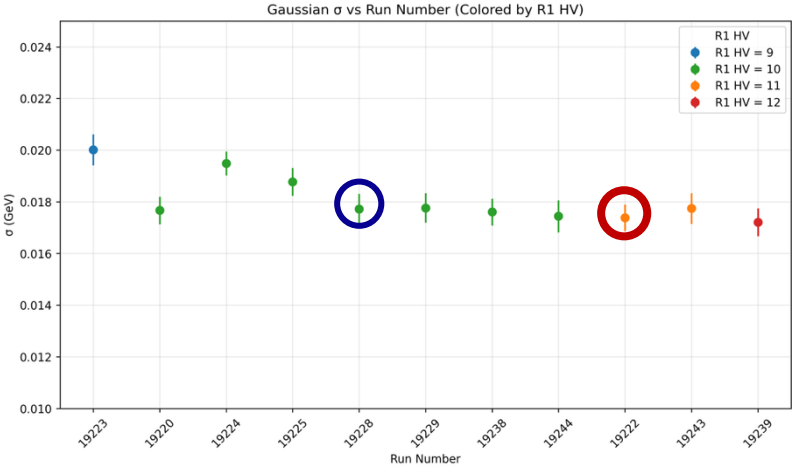
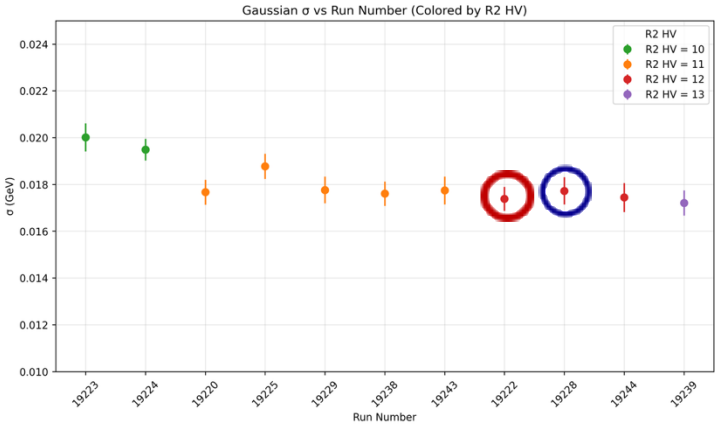
3 passes

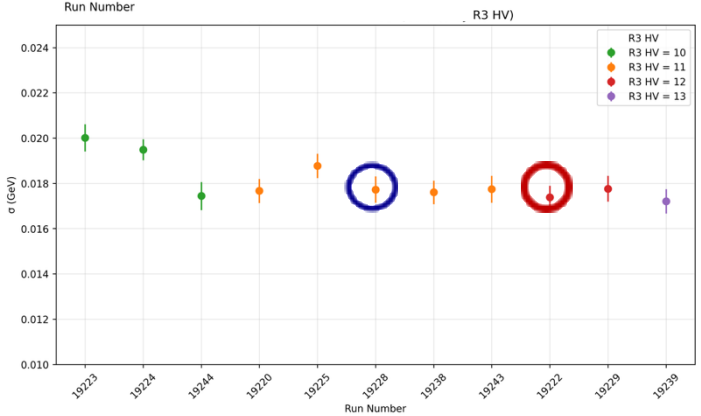
4 passes



By Krishna Neupane

DC HV has been optimized





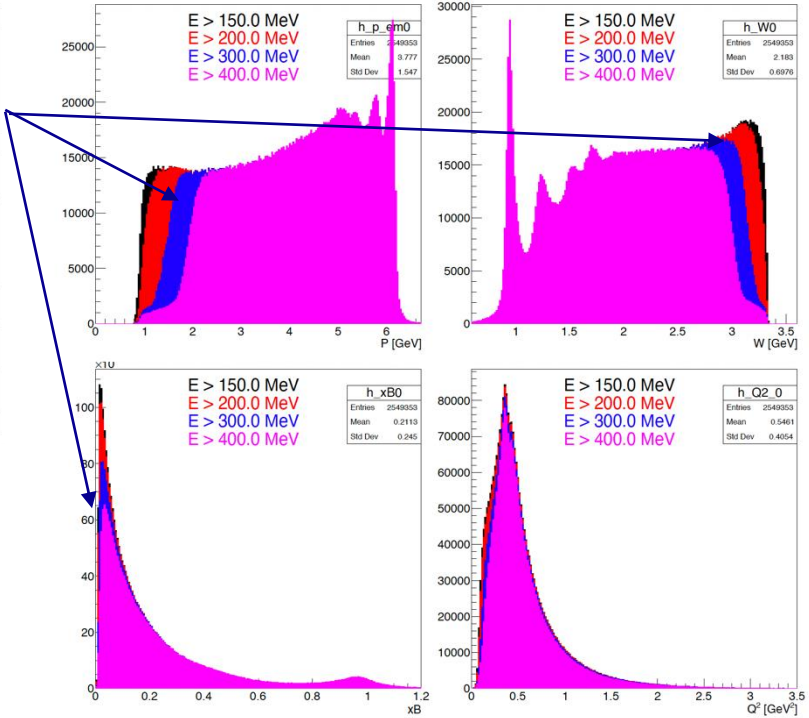
Trigger Validation Studies

TABLE I. RGK trigger files

Trigger File	Description	PCAL+ECAL	TORUS	Comments
rgk_noDC_v1.0_150MeV	No DC roads	150 MeV	Any	Production
rgk_noDC_v1.0_200MeV		200 MeV		
rgk_noDC_v1.0_300MeV		300 MeV		Production, HOLDOFF=3 us
rgk_noDC_v1.1_300MeV		300 MeV		Production, HOLDOFF=2 us
rgk_noDC_v1.2_300MeV		300 MeV		Production, HOLDOFF=1 us
rgk_noDC_empty_v1.1_300MeV		300 MeV		Empty target
rgk_noHTCC_noDC_v1.1_300MeV	no HTCC	300 MeV		wrong trigger delay
rgk_noHTCC_noDC_v2.0_300MeV	no HTCC	300 MeV		trigger delay 84 ns
rgk_out_v1.0_150MeV	With DC roads	150 MeV	Outbending	Production
rgk_out_v1.0_200MeV		200 MeV		
rgk_out_v1.0_300MeV		300 MeV		
rgk_out_v1.1_300MeV		300 MeV		Production, HOLDOFF=2 us
rgk_inb_v1.0_150MeV	With DC roads	150 MeV	Inbending	Production
rgk_inb_v1.0_200MeV		200 MeV		
rgk_v1.0_zero_150MeV	No DC roads	150 MeV	Zero	Alignment run
rgk_v1.0_zero_200MeV		200 MeV		
rgk_v1.0_30kHz_150MeV	Random 30 kHz	150 MeV	Any	Trigger Validation
rgk_v1.0_30kHz_200MeV		200 MeV		
rgk_noDC_v1.0_validation.trg		150 MeV	Any	Includes 150,200,250 and 300 MeV

TABLE II. Electron Trigger Rates

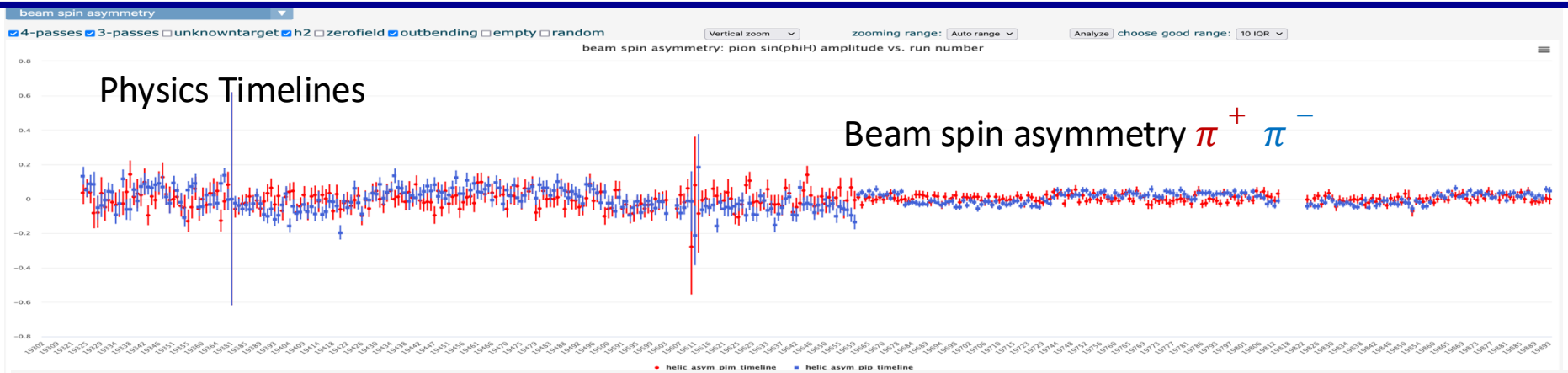
Beam Energy Trigger file	6.4 GeV rgk_noDC_v1.1_300MeV.trg	8.5 GeV rgk_noDC_v1.1_300MeV.trg
Beam current	67 nA	79.9 nA
Electron trigger rate	29.2 kHz	21.5 kHz
Faraday cup trigger rate (no prescale)	57.0 kHz	68.6 kHz
FC prescale	129	129
Faraday trigger rate	0.23 kHz	0.53 kHz
Total trigger rate (with prescale)	29.4 kHz	22.0 kHz
Data rate	620 MB/s	520 MB/s
Live time	90.9%	93.4%



Optimized trigger was chosen: no DC roads, PCAL+ECAL threshold at 300 MeV, 2 μs holdoff time

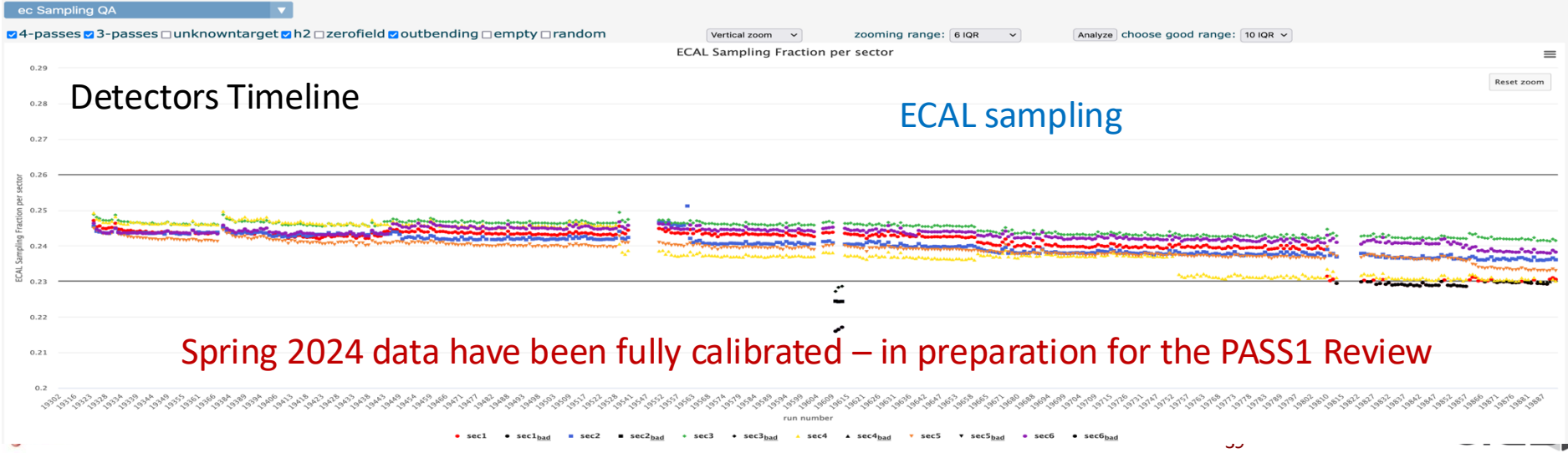
Trigger rates: 30 kHz @ 6.4 GeV and 20 kHz @8.5 GeV – Live times > 90%

RG-K Production – on-line timelines



Physics Timelines

Beam spin asymmetry π^+ π^-



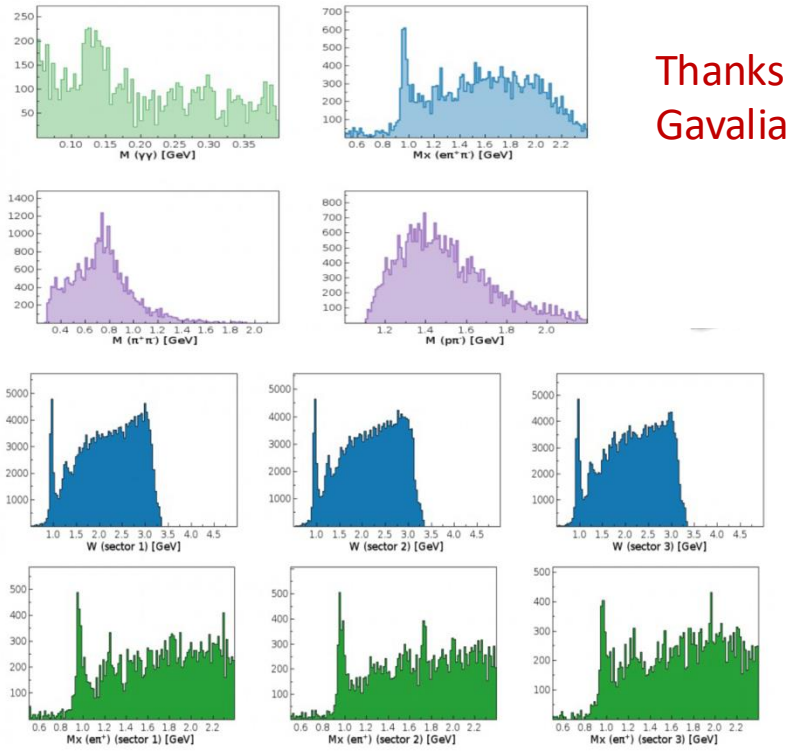
Detectors Timeline

ECAL sampling

Spring 2024 data have been fully calibrated – in preparation for the PASS1 Review

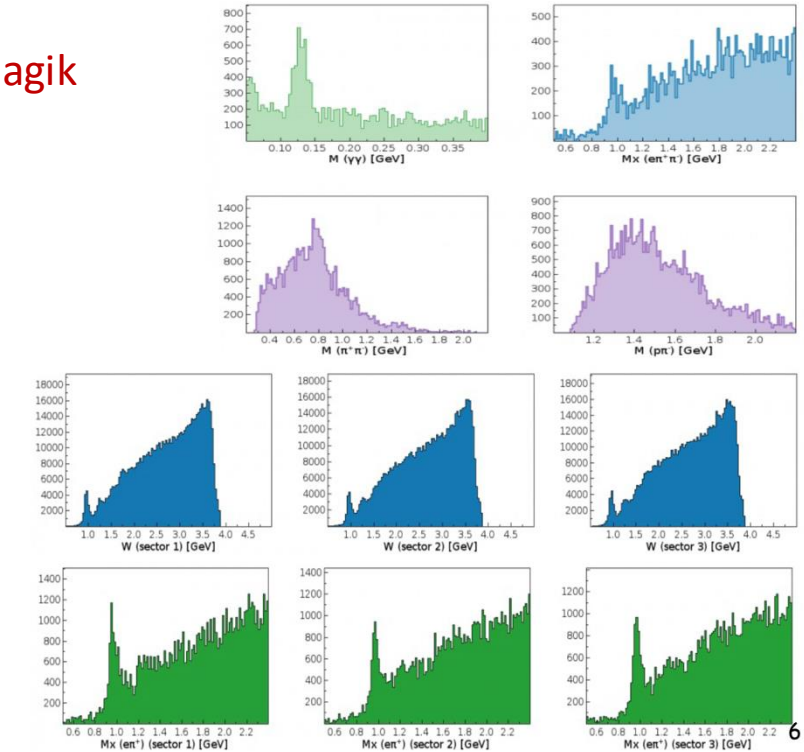
RG-K Production – on-line reconstruction

6394.63 MeV



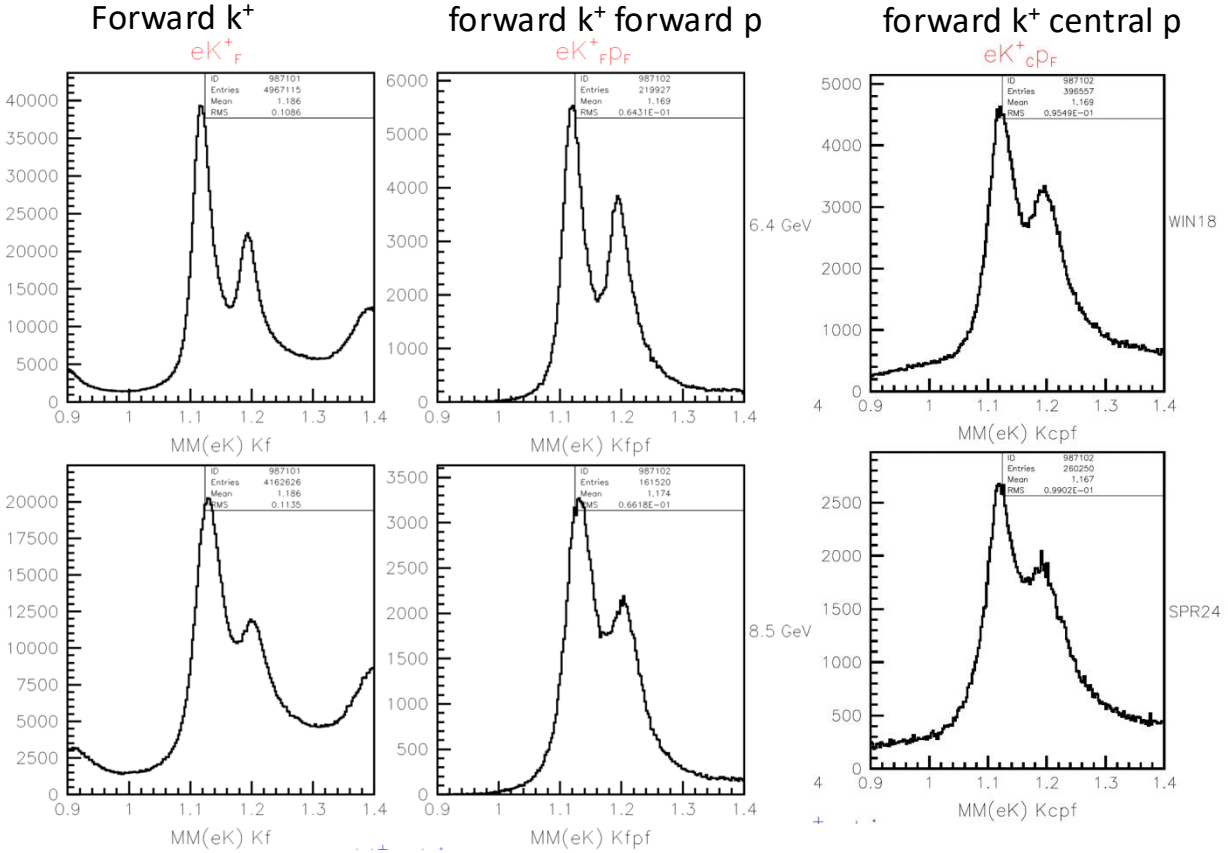
Thanks to Gagik Gavalian !

8477.57 MeV



6

RG-K Production – KY Data analysis



Comparison of 10 cooked files

E= 6.4 GeV

E= 8.5 GeV

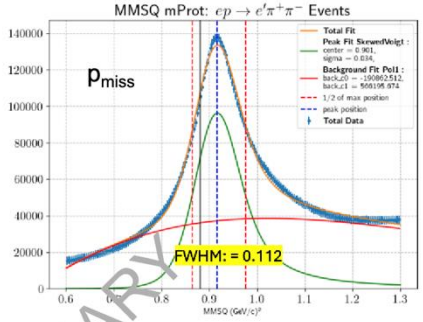
By: Dan Carman

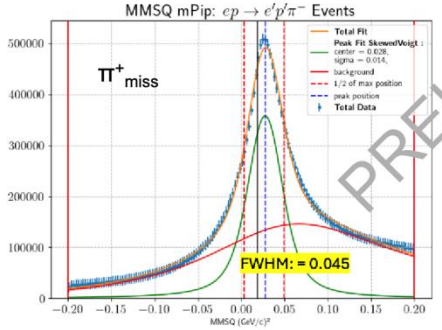
RG-K Production – on-line Data analysis

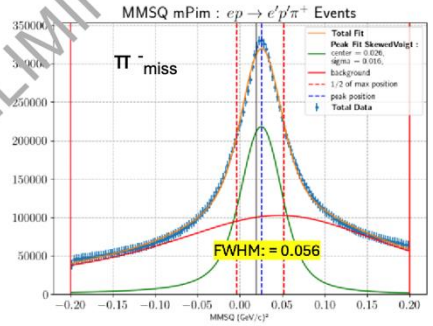
- 6.394 GeV
- 10 runs
- online calib/align

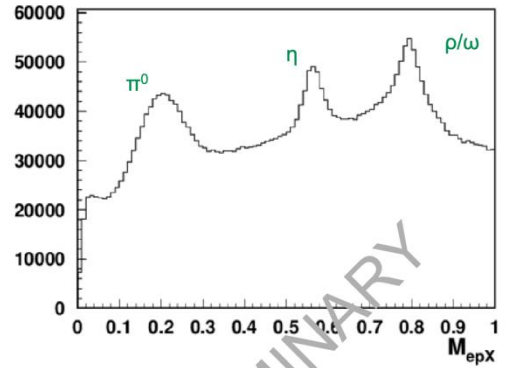
2π Analysis

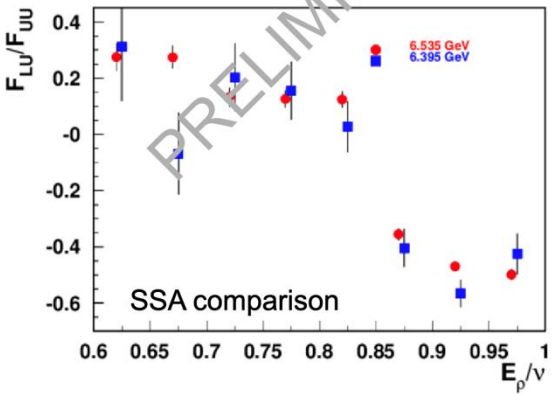
[Krishna Neupane]











Harut Havakian

RG-K Workforce

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Data Chef:
Lucilla Lanza

Run Coordinators:
Bill Briscoe
Dan Carman
Axel Schmidt
Susan Schadmand

Thanks to the Hall-B scientific staff
Thanks to all the Hall-B Engineers and Technicians
Thanks to all the Shift Takers

Thanks to the PD: Daniel Carman

Equipment

Forward Detector (FD)
- TORUS magnet
- HT Cherenkov Counter
- Drift chamber system
- LT Cherenkov Counter
- Forward TOF System
- Pre-shower calorimeter
- E.M. calorimeter

Central Detector (CD)
- SOLENOID magnet
- Silicon Vertex Tracker
- Central Time-of-Flight

Beamline
- Cryo Target
- Moller polarimeter
- Shielding
- Photon Tagger

Upgrade to the baseline
- Central Neutron Detector
- MicroMegas
- Forward Tagger
- RICH detector
- Polarized target