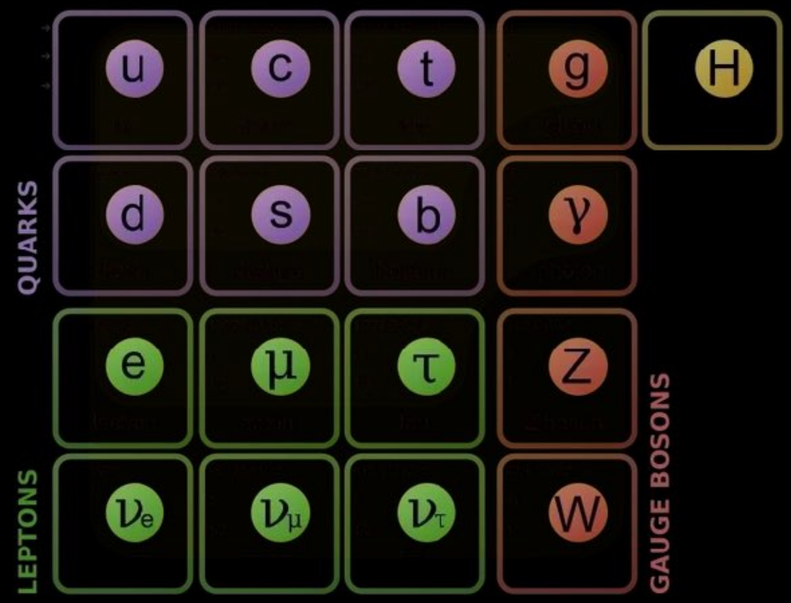
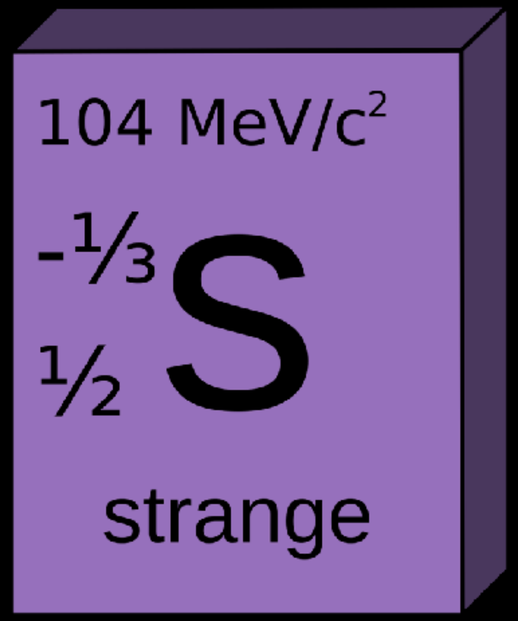
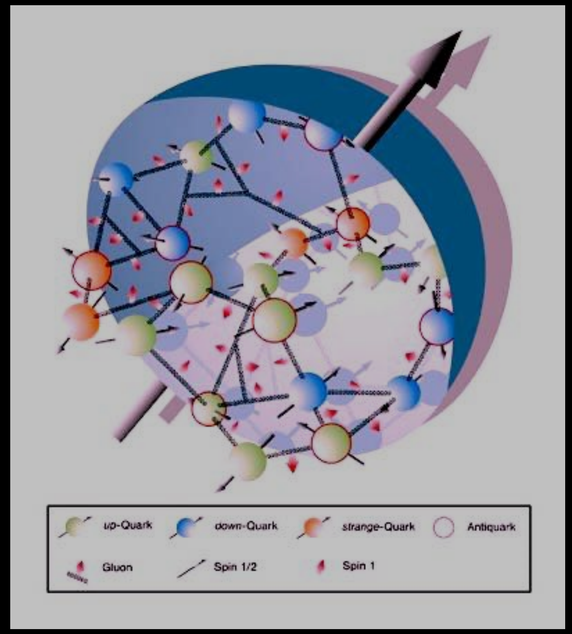
ELUCIDATING STRANGENESS with ELECTROMAGNETIC PROBES







ASLI ACAR - UNIVERSITY of YORK

QCD PUZZLES

ISGUR & CAPSTICK

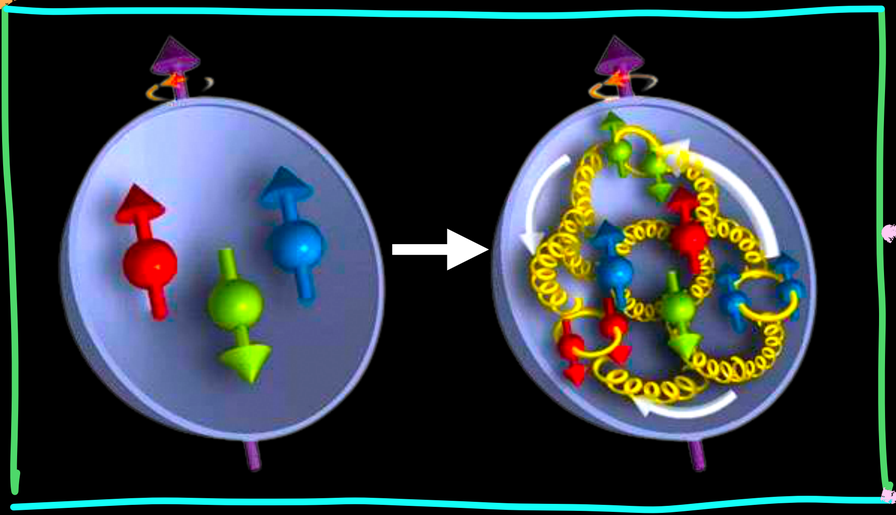
TABLE VIII. The Ξ and Ω baryons below 2400 and 2500 MeV, respectively.

State, J^P	Predicted masses (MeV)							
$\Xi\frac{1}{2}^+$	1305							
$\Xi\frac{1}{2}^+$	1505							
$\Xi^*\frac{1}{2}^-$	1755	1810	1835	2225	2285	2300	2320	2380
$\Xi^*\frac{3}{2}^-$	1785	1880	1895	2240	2305	2330	2340	2385
$\Xi^*\frac{5}{2}^-$	1900	2345	2350	2385				
$\Xi^*\frac{7}{2}^-$	2355							
$\Xi^*\frac{1}{2}^+$	1840	2040	2100	2130	2150	2230	2345	
$\Xi^*\frac{3}{2}^+$	2045	2065	2115	2165	2170	2210	2230	2275
$\Xi^*\frac{5}{2}^+$	2045	2165	2230	2230	2240			
$\Xi^*\frac{7}{2}^+$	2180	2240						

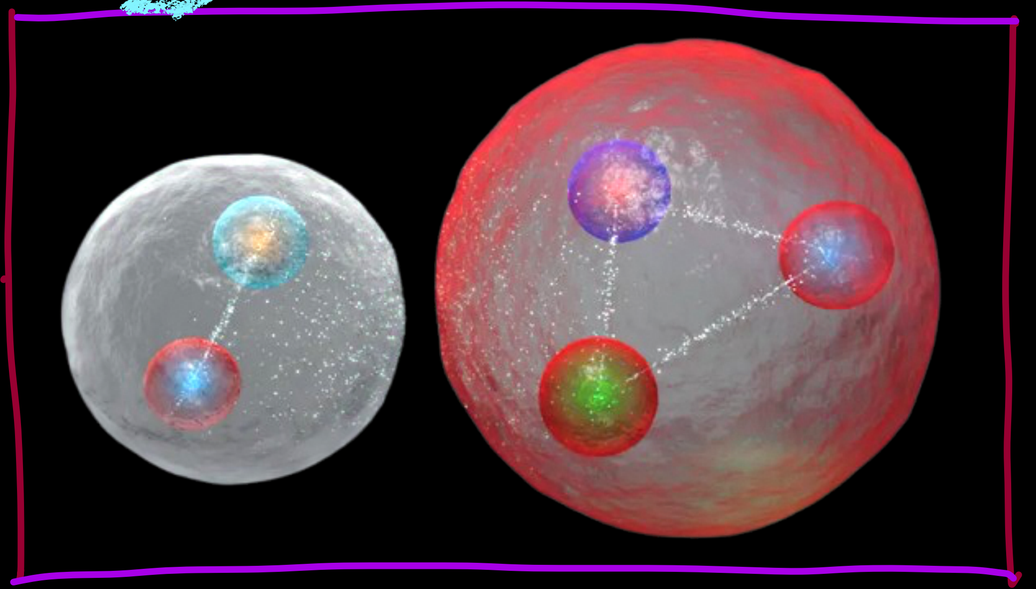
44 STATES

RELATIVIZED QUARK MODEL





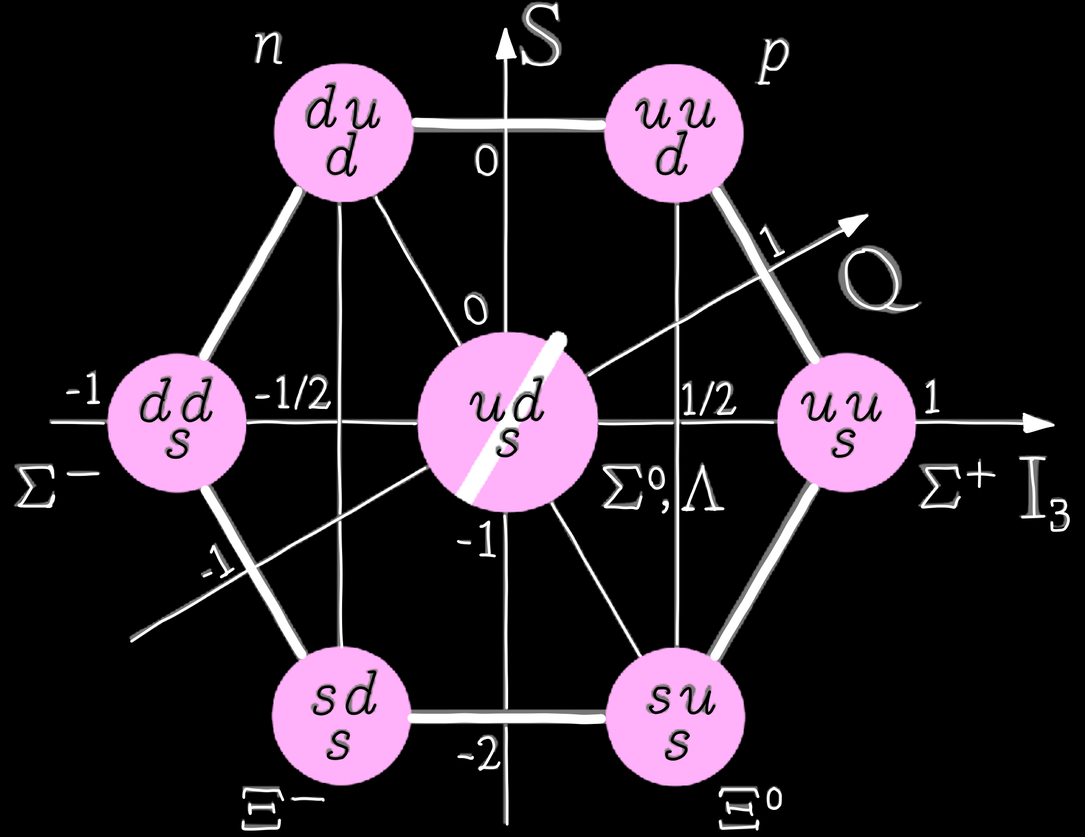
MESON-BARYON MOLECULES



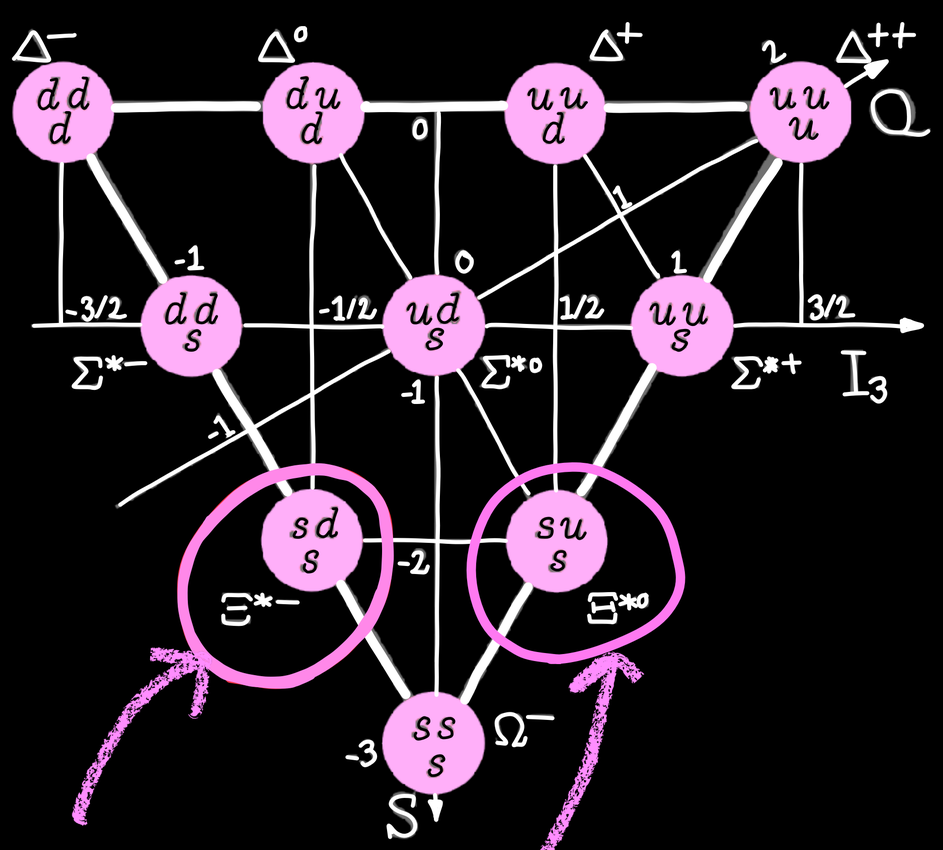
DO WE UNDERSTAND BARYONS?

BARYONS

OCTET

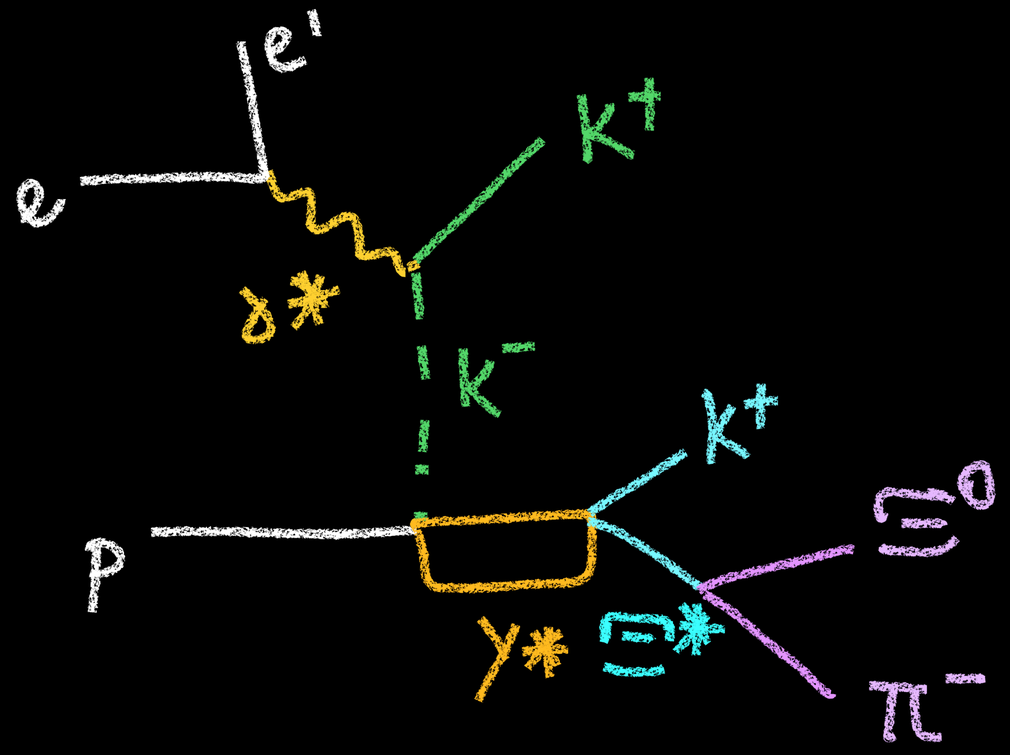


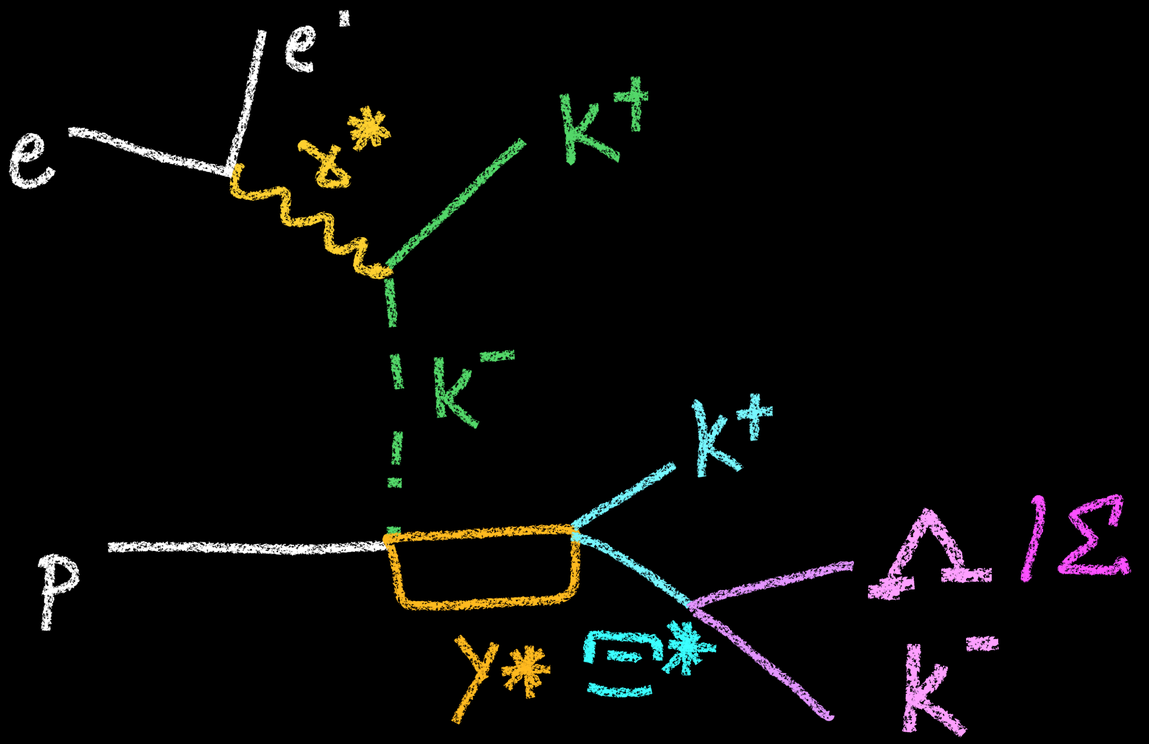
DECUPLET



EXCITED CASCADES

THE CHANNELS





$\Lambda/\Sigma/\Xi^0$ NOT DETECTED

THE MISSING STATES

Current Particle	Current Status	Previous Mass	Previous Status	Mass from MPS (MeV)
$\Xi(1318)$	**** ✓	1320	**** ✓	1320 ± 6
$\Xi(1530)$	**** ✓	1530	**** ✓	1541 ± 12
$\Xi(1620)$	* ?	1630	** ?	
$\Xi(1690)$	***	1680	**	
$\Xi(1820)$	***	1820	***	1822 ± 6
$\Xi(1950)$	***	1940	**	
$\Xi(2030)$	***	2030	***	2022 ± 7
$\Xi(2120)$	* ?	2120	* ?	
$\Xi(2250)$	***	2250	*	2214 ± 5
$\Xi(2370)$	** ?	2370	** ?	2356 ± 10
$\Xi(2500)$	* ?	2500	** ?	2505 ± 10

NOW 1981

6 EXCITED STATES IN PDG

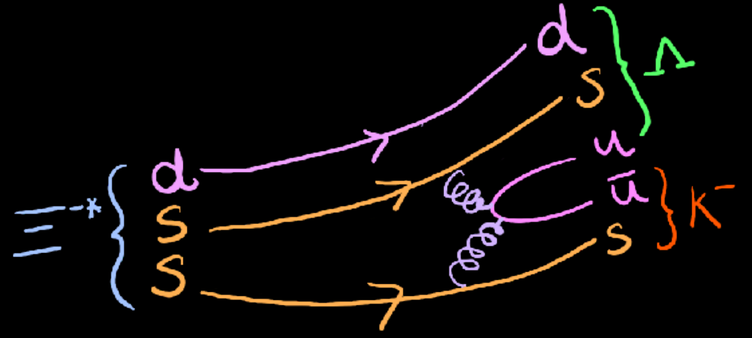
NOT MUCH PROGRESS IN PAST 4 DECADES

MISSING J^P & BRANCHING RATIOS

Ξ(1690) $I(J^P) = \frac{1}{2}(?^?)$

Mass $m = 1690 \pm 10$ MeV [c]
Full width $\Gamma < 30$ MeV

Ξ(1690) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\Lambda\overline{K}$	seen	240
$\Sigma\overline{K}$	seen	70
$\Xi\pi$	seen	311
$\Xi^-\pi^+\pi^-$	possibly seen	213

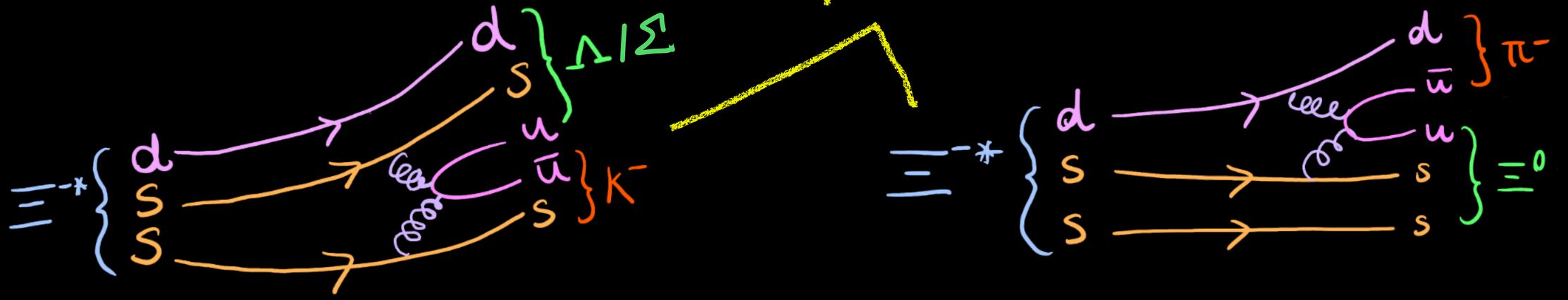


POSSIBLE DECAY MODES



3Q vs MOLECULE

POSSIBLE CHANNELS



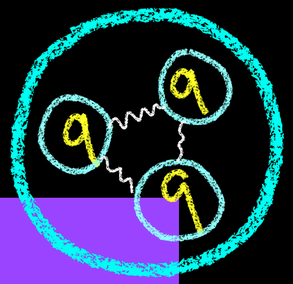
$$|\Xi^*\rangle = \frac{1}{2}|\Xi\pi\rangle + \frac{1}{2}|\Sigma\bar{K}\rangle + \frac{1}{2}|\Xi\eta\rangle - \frac{1}{2}|\Lambda\bar{K}\rangle$$

FROM DECUPLET

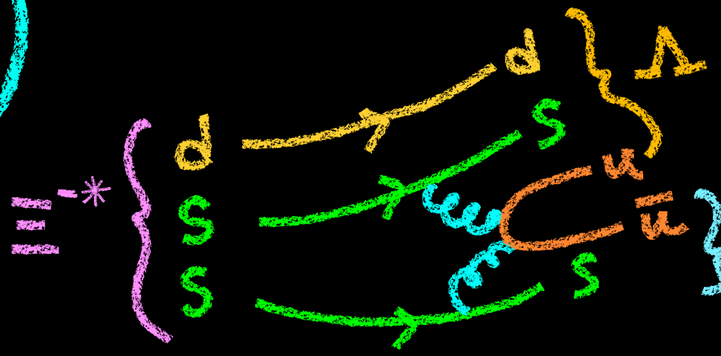
FROM OCTET

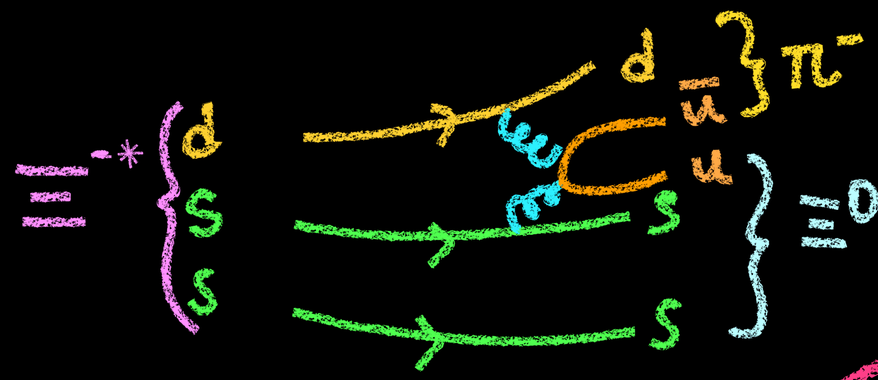
$$|\Xi^*\rangle = \frac{1}{2}|\Xi\pi\rangle + \frac{1}{2}|\Sigma\bar{K}\rangle - \frac{1}{2}|\Xi\eta\rangle + \frac{1}{2}|\Lambda\bar{K}\rangle$$

3Q vs MOLECULE

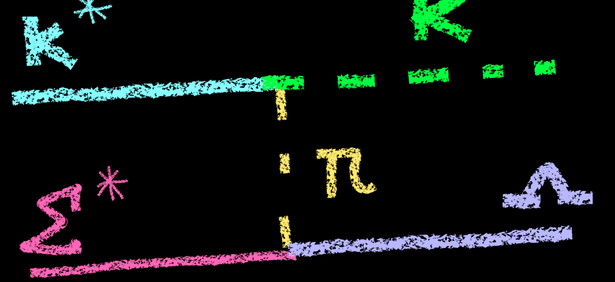


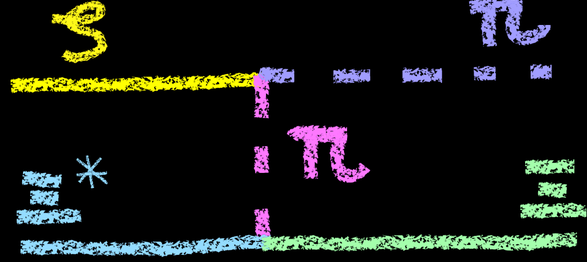
3q STATE





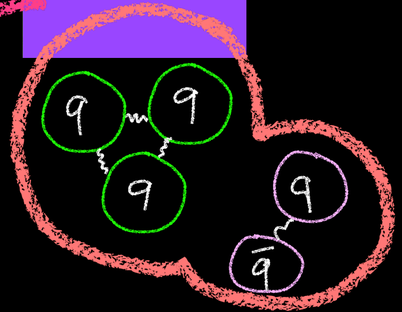
MOLECULAR





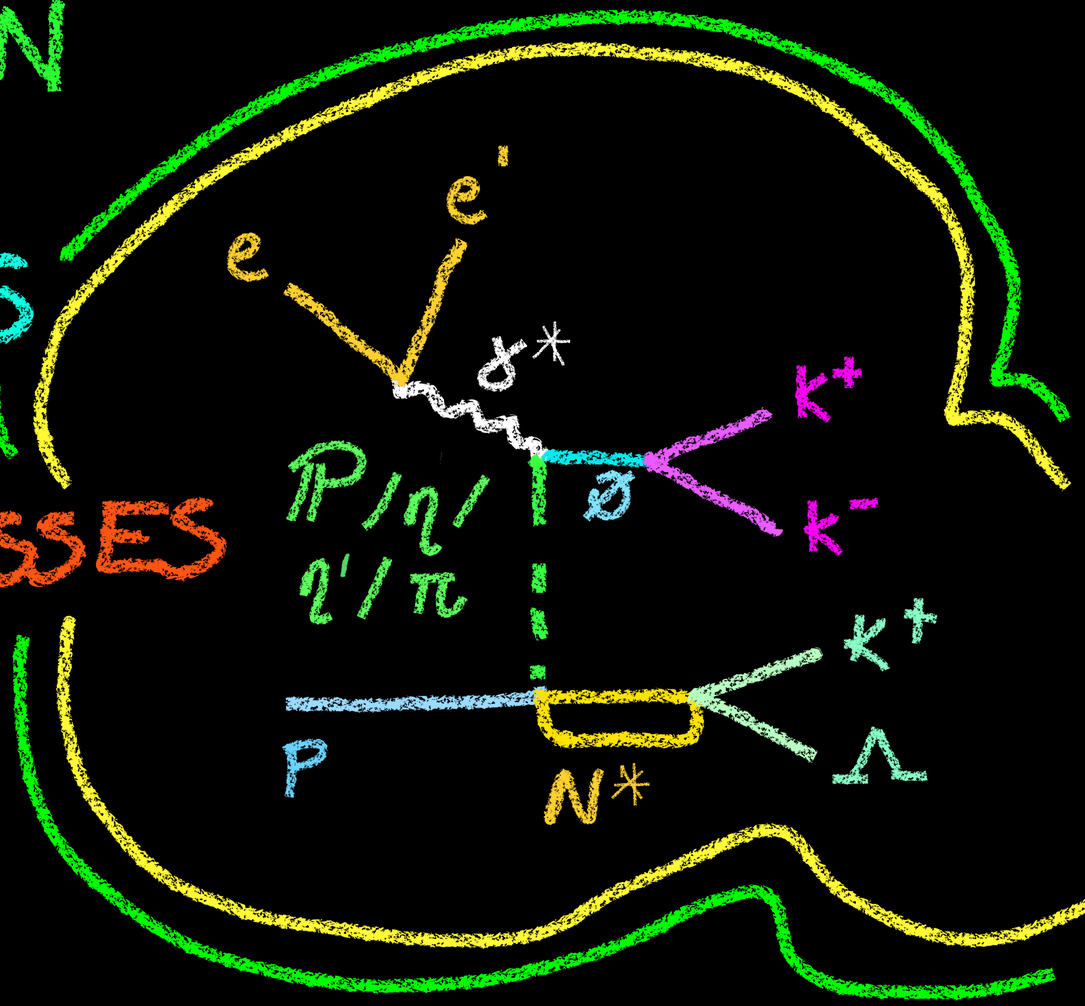
BR = 1

BR ≠ 1



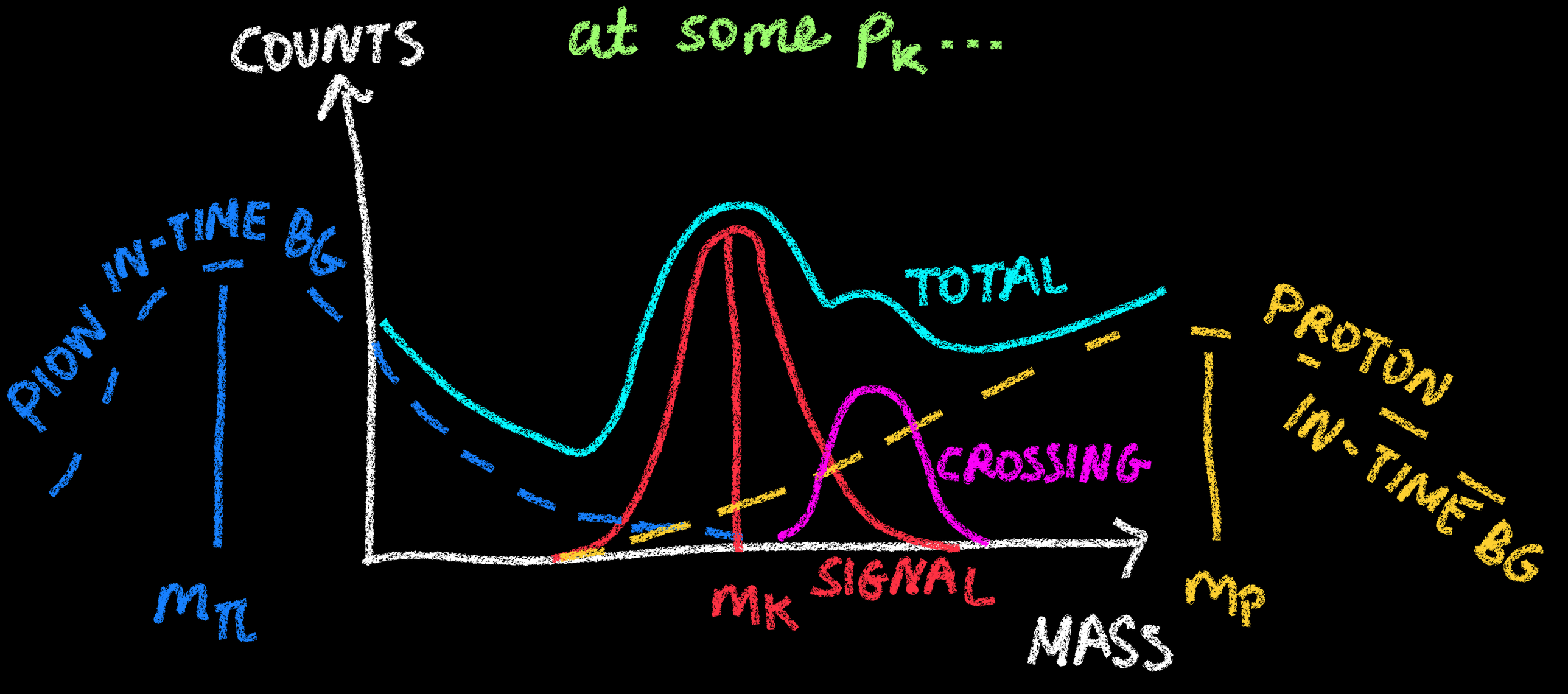
BACKGROUND

1. K/π MISIDENTIFICATION
2. OUT OF TIME PARTICLES
3. OTHER PHYSICAL PROCESSES



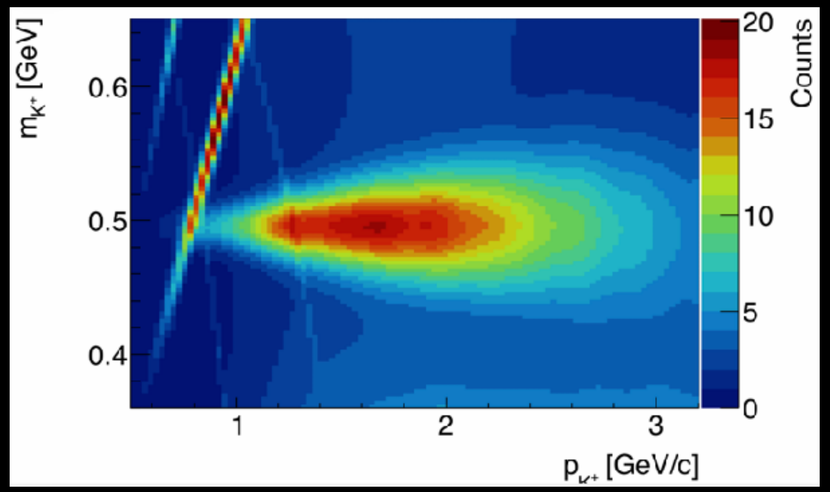
DEALING WITH KAONS...

THE MODEL

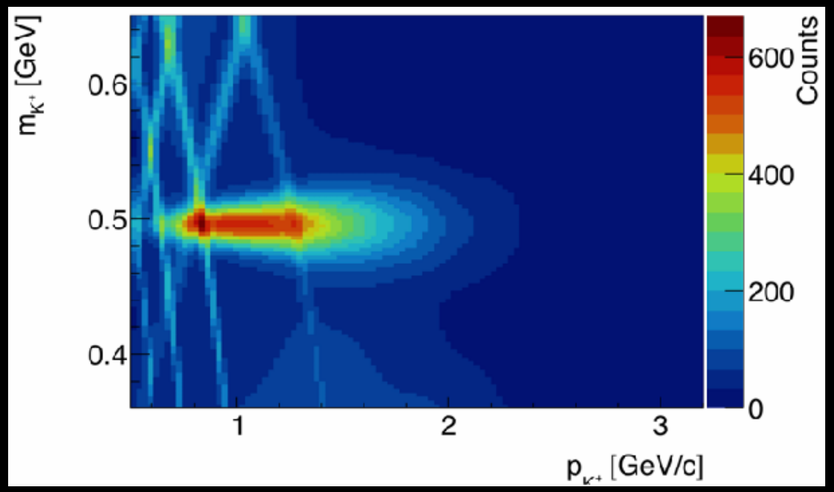

COUNTS
at some p_K ...
PION IN-TIME BG
TOTAL
PROTON IN-TIME BG
CROSSING
SIGNAL
m_π
m_K
m_p
MASS

MODEL vs DATA

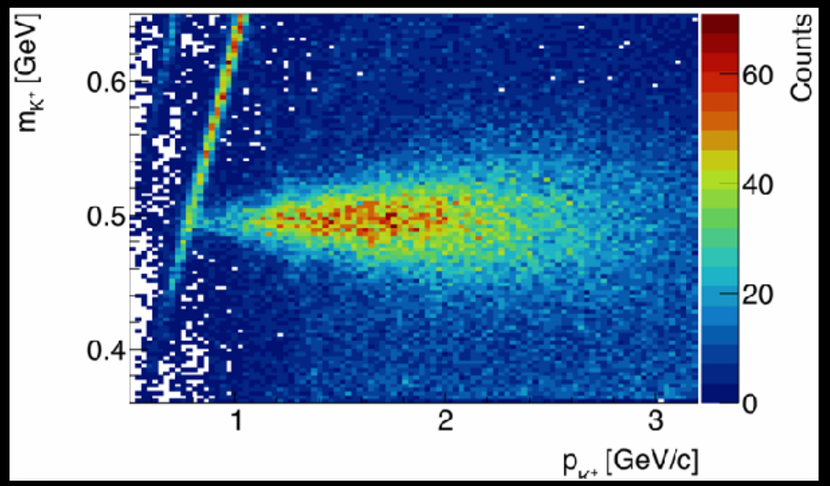
KAON 1 MODEL



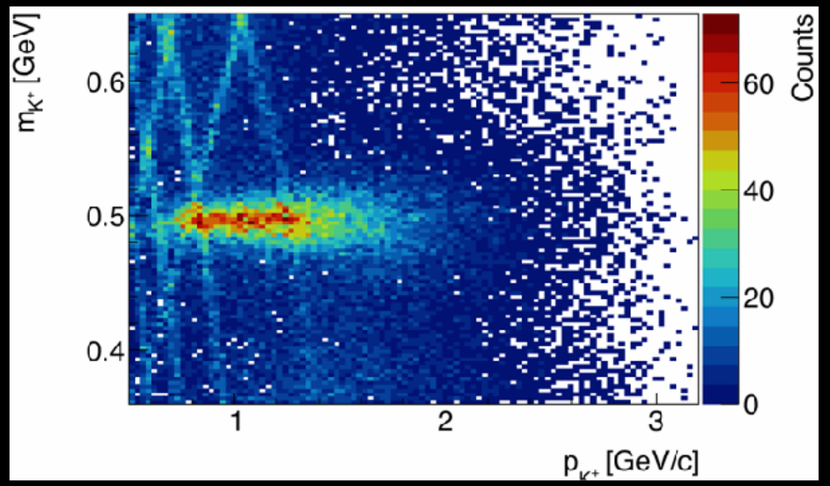
KAON 2 MODEL



KAON 1 DATA

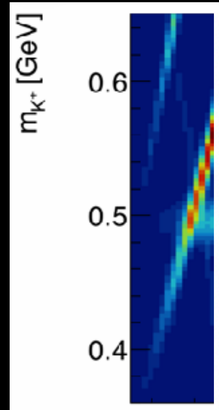


KAON 2 DATA



MODEL vs DATA

KAON 2 MODEL KAON 1 MODEL



Developing Multi-Dimensional, Sequential sWeighting Routines for Reaction Selection with Emphasis on Kaon Identification at CLAS12

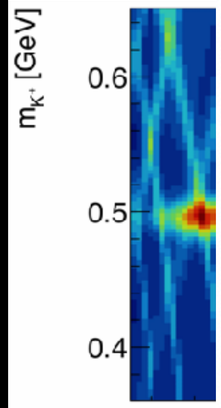
A. Acar[a], M. Bashkanov[a], D.P. Watts[a], M. Nicol[a]

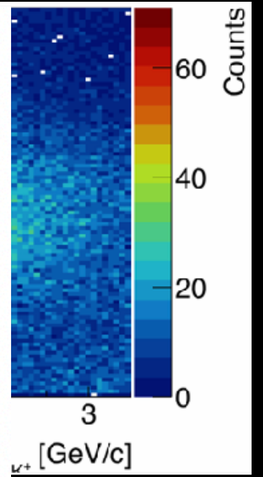
[a]*School of Physics, Engineering and Technology, Department of Physics, University of York, Heslington, York, Y010 5DD, UK*

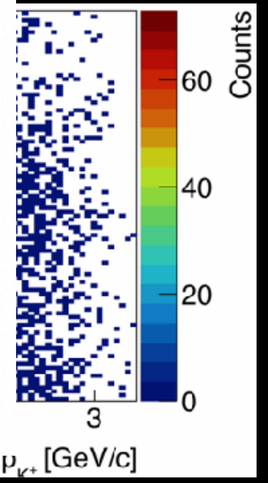
arXiv:2610.02246v1

Abstract

In nuclear and particle physics experiments, event selection is often a multidimensional classification problem which involves several correlated observables. The widely used sWeight technique provides a statistically rigorous means of separating signal and background using discriminating variables, but its conventional formulation is generally applied to a single discriminating variable or a simultaneous multidimensional fit. In this paper we present a novel extension of the widely used sWeight technique, in which an arbitrary number of discriminating variables can be used to construct a multidimensional sequential framework. This method allows the extraction of signal distributions in controlled variables in a rigorous way. Particular attention is given to the treatment of signal and background correlations, as well as the propagation of statistical uncertainties through successive weighting stages. The method yields high-purity signal samples even in the presence of large and correlated backgrounds. As a benchmark application, the validity of this technique is demonstrated on kaon identification in a dataset collected with the CLAS12 detector at the Thomas Jefferson National Laboratory for cascade baryon searches. The final workflow is shown to be robust and consistent across different run periods and beam/detector conditions, demonstrating minimal systematical uncertainties associated with the method. Statistical uncertainties are proved to be evaluable using a bootstrap-based procedure. The method provides a general framework for multidimensional event weighting and is intended for application in complex analyses requiring robust signal selection in the presence of complex correlated backgrounds.

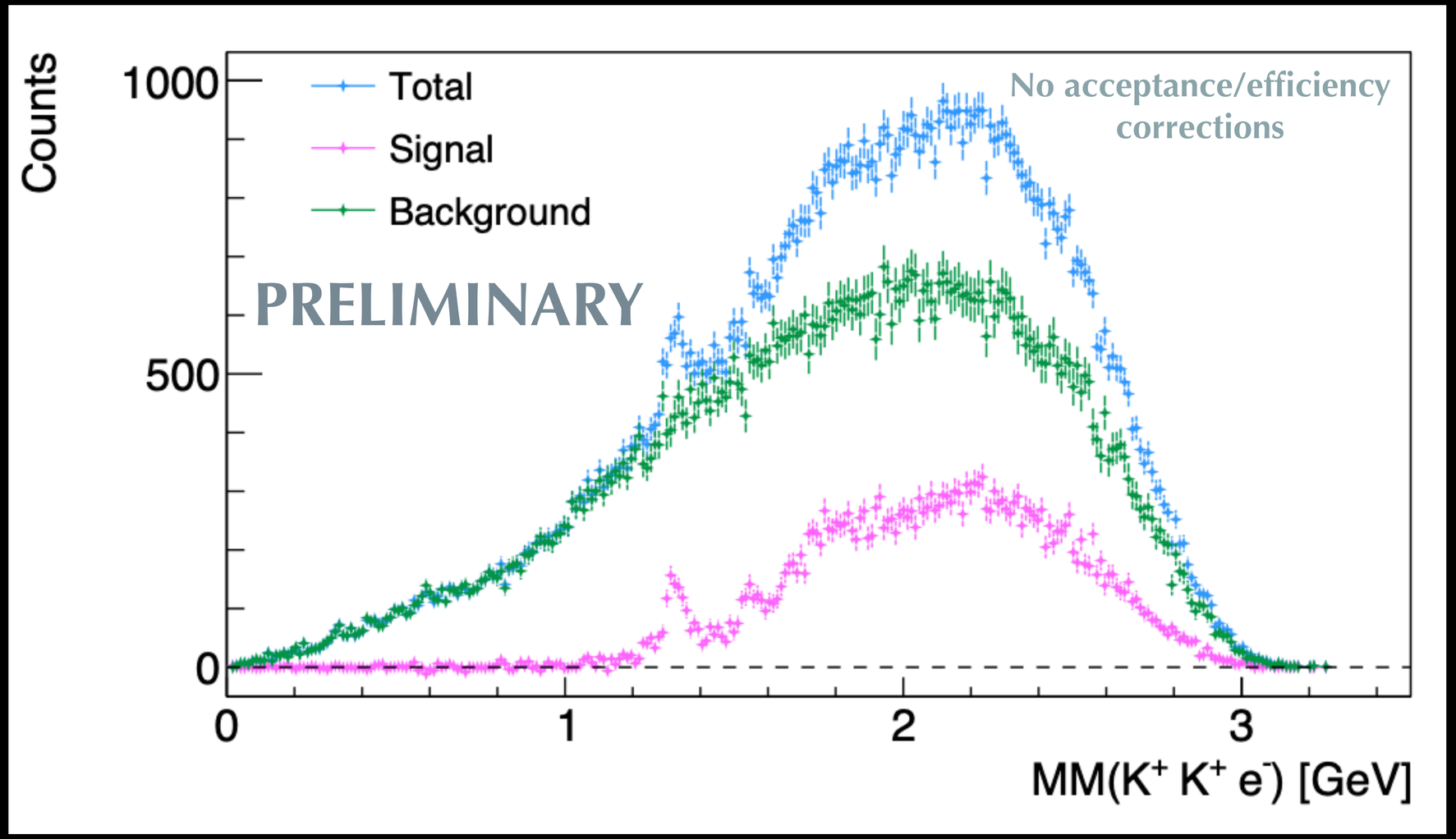




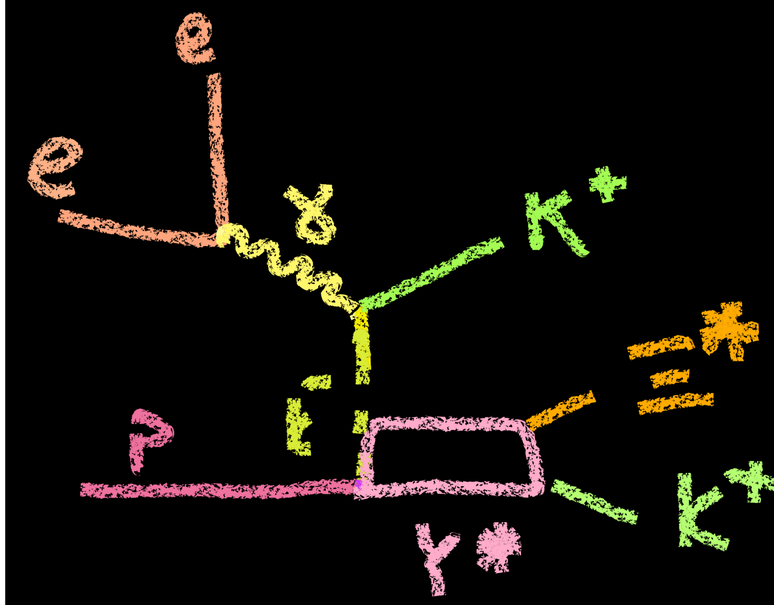


CASCADE DISTS.

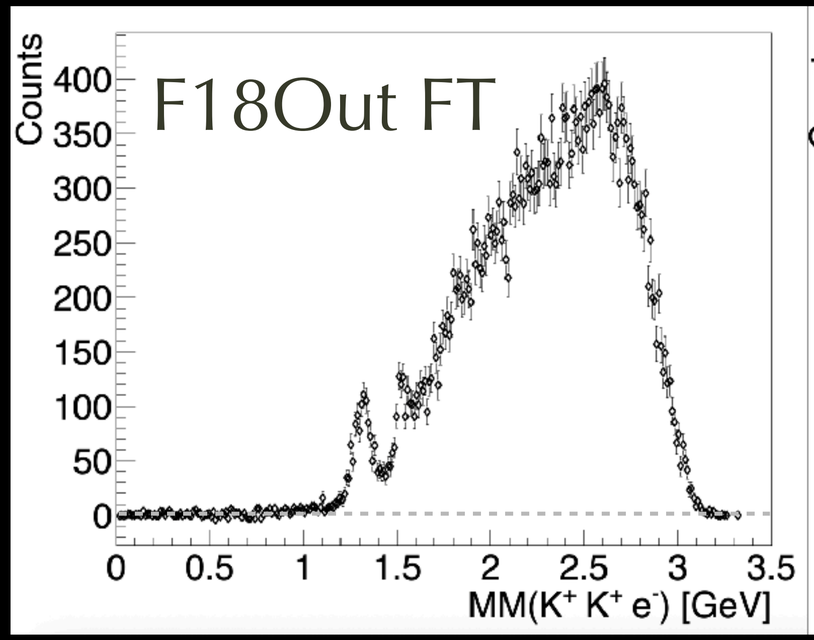
BENCHMARK: CASCADES

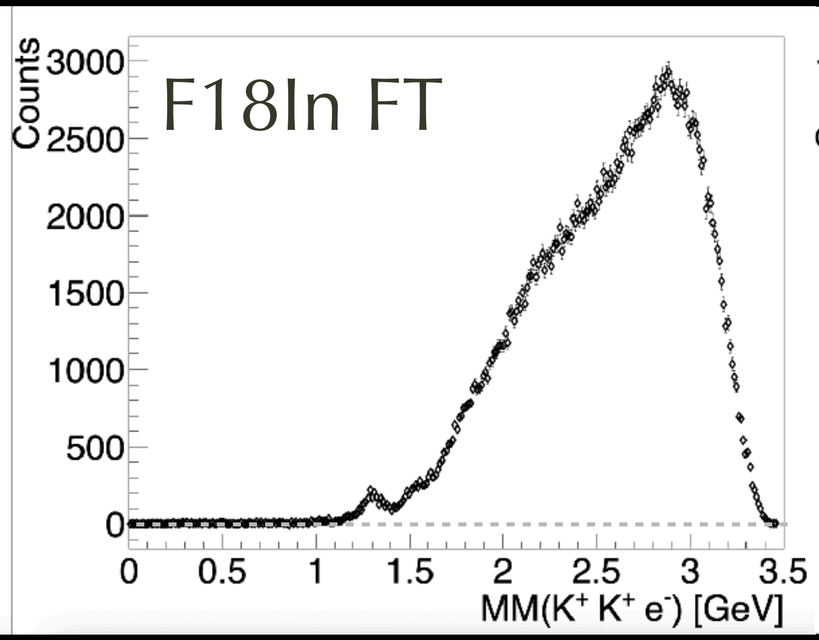


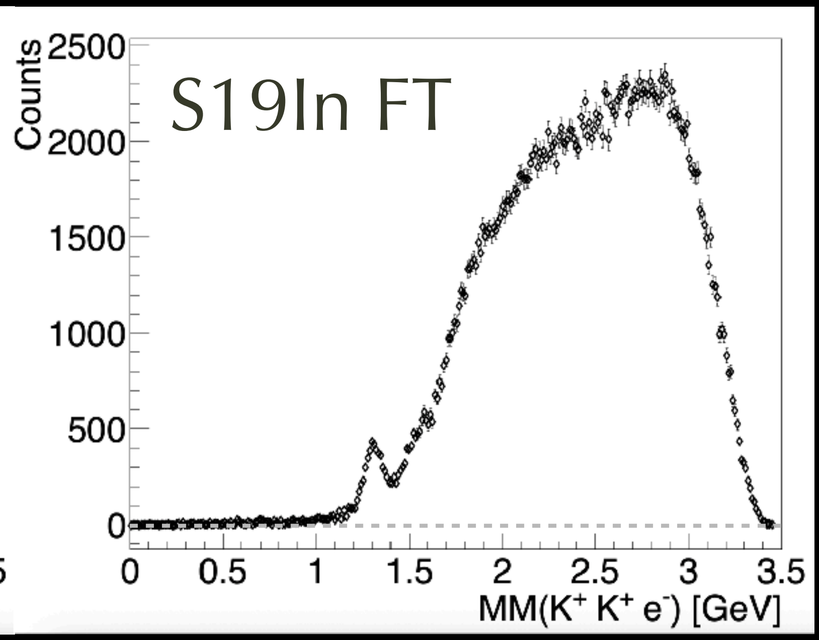
WEIGHTED RESULTS FROM ← SWEIGHTS



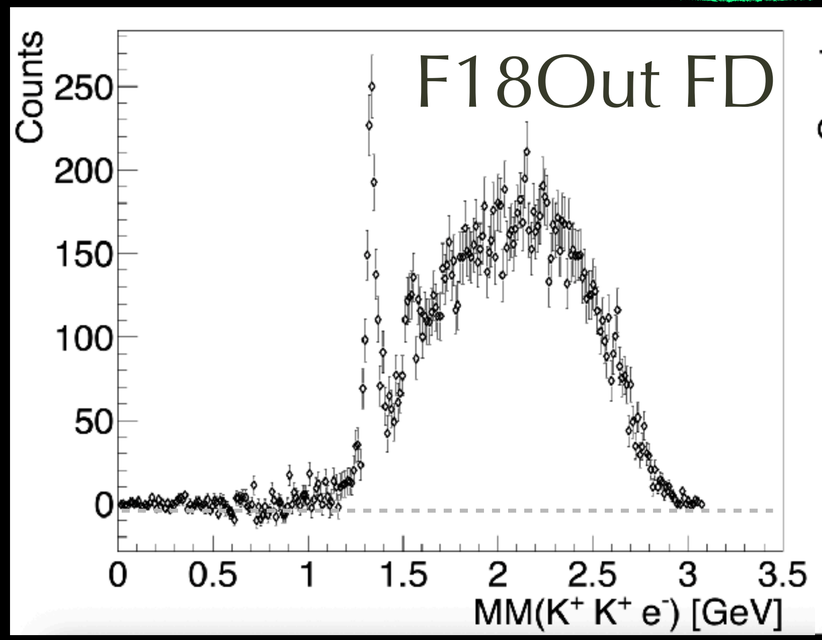
RESULTS FOR e^- IN FT

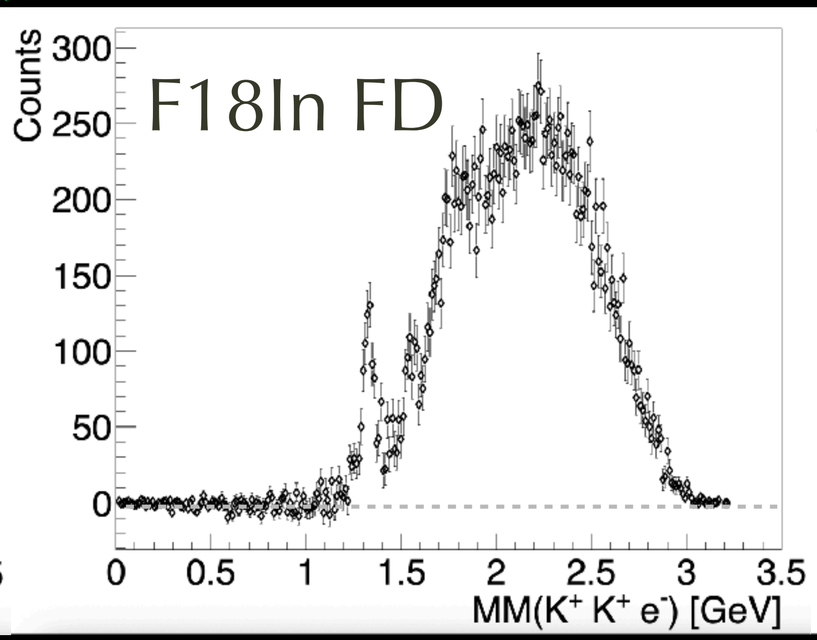


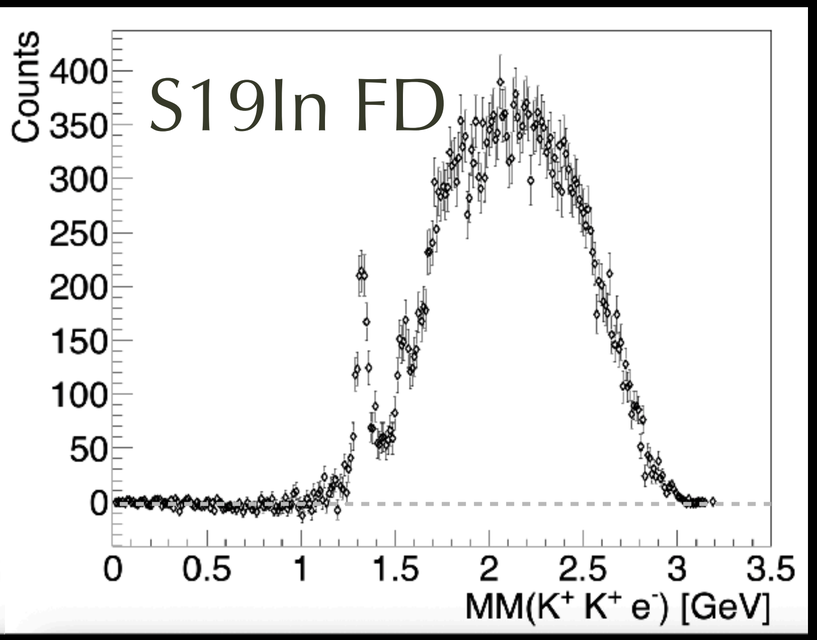




RESULTS FOR e^- IN FD

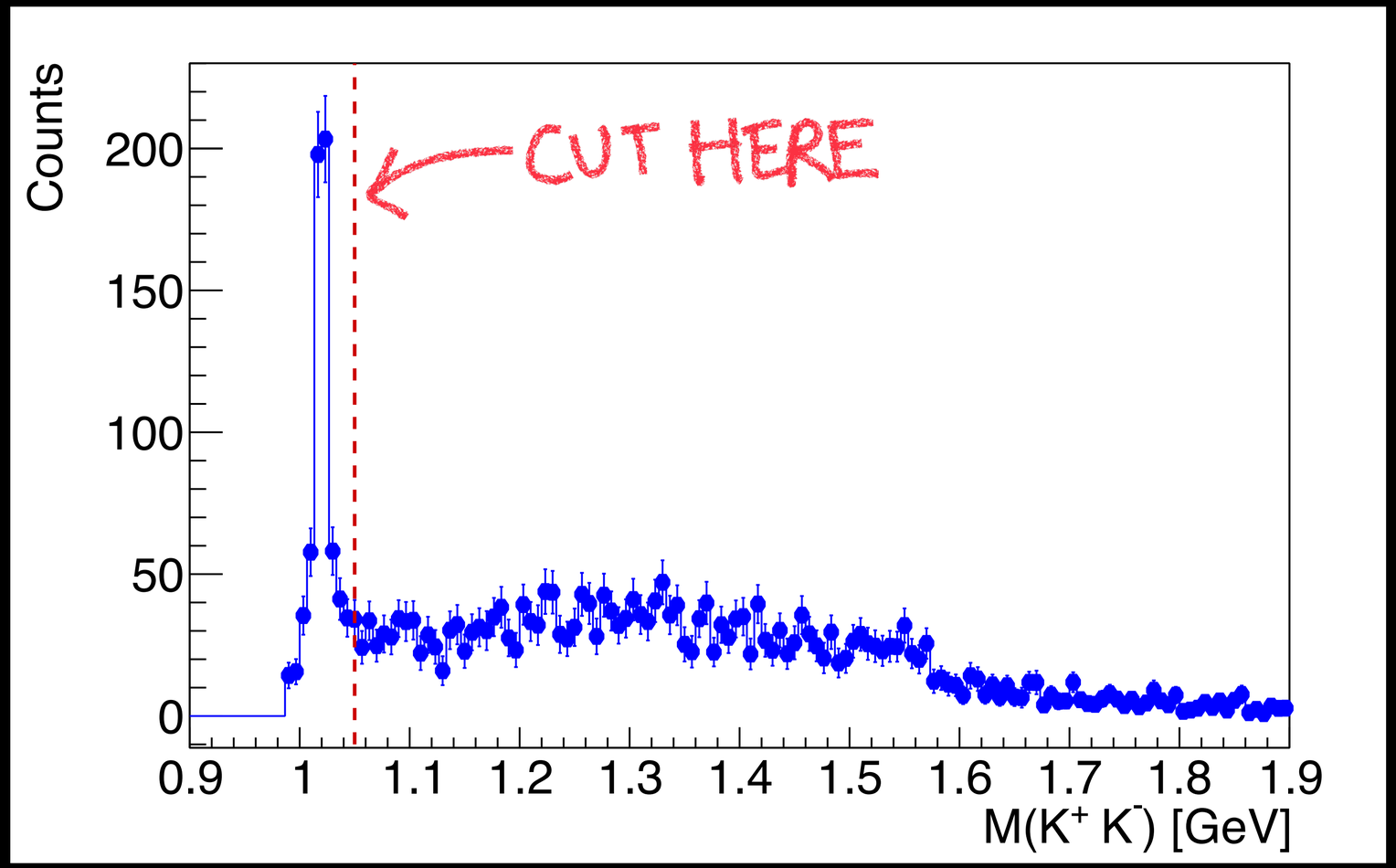


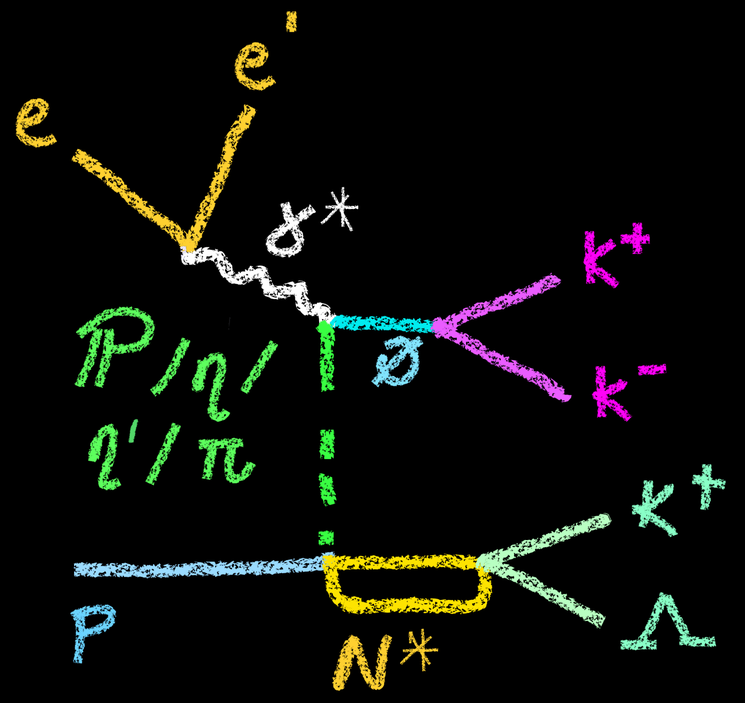




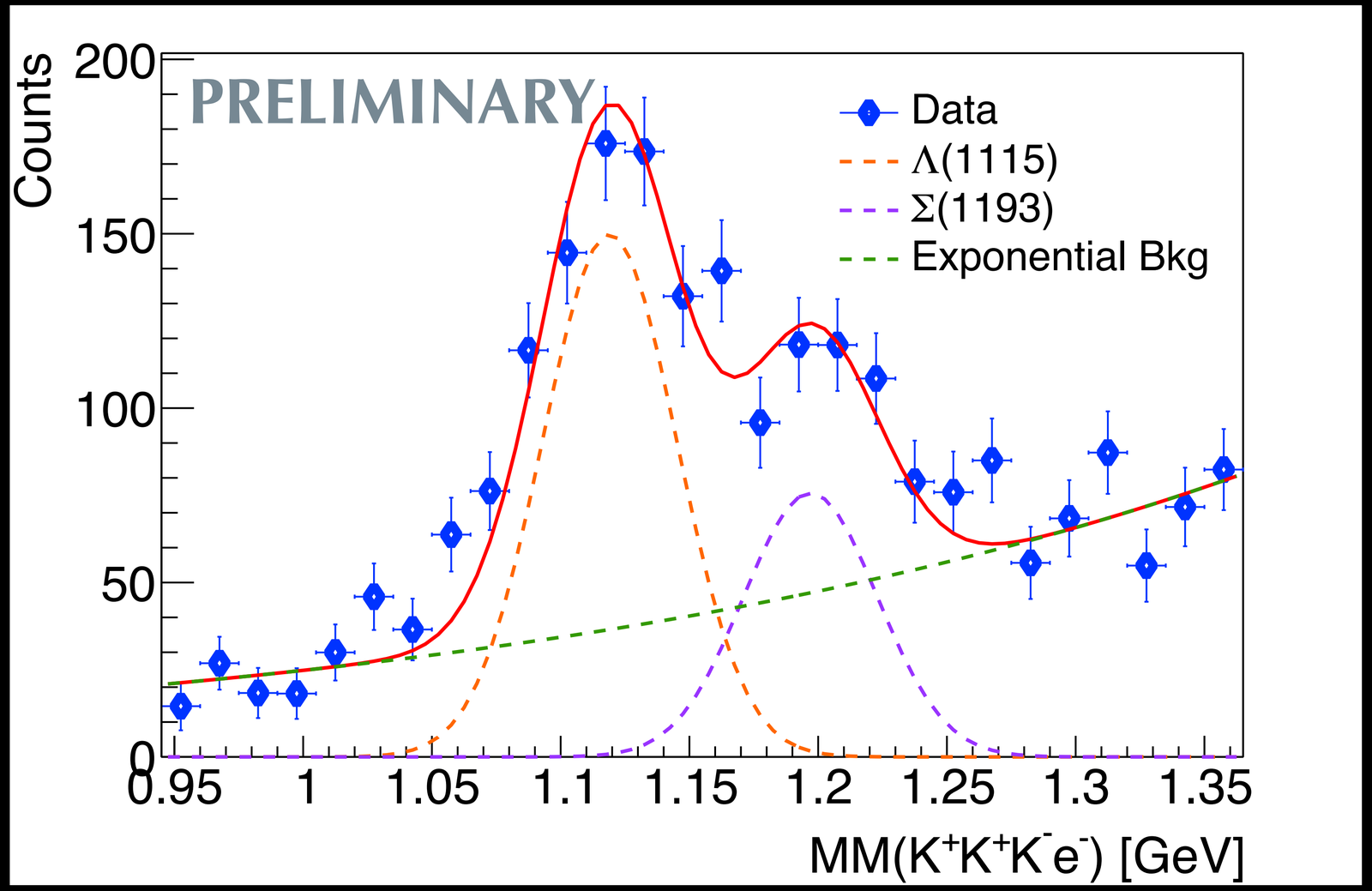
Λ(Σ)K BRANCH

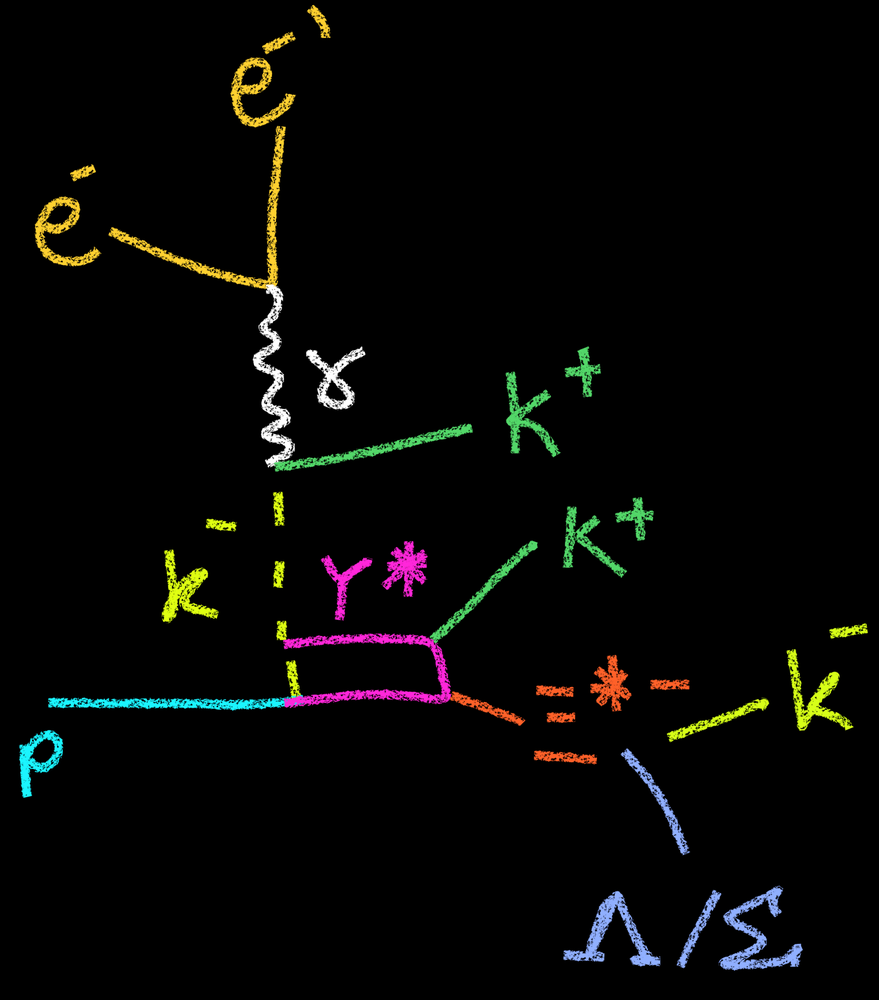
PHYSICAL BACKGROUND



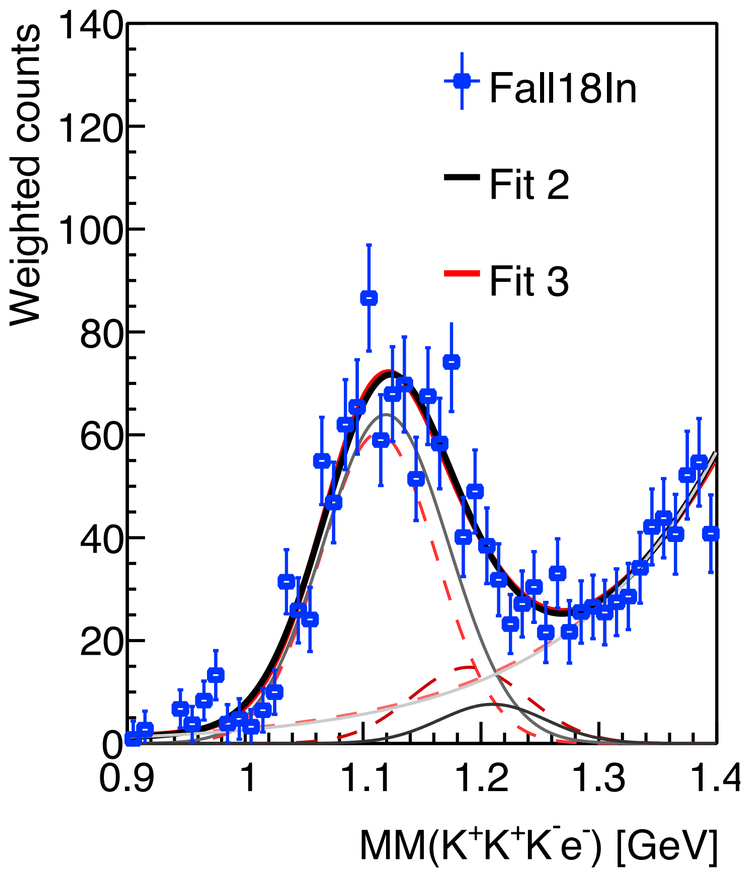


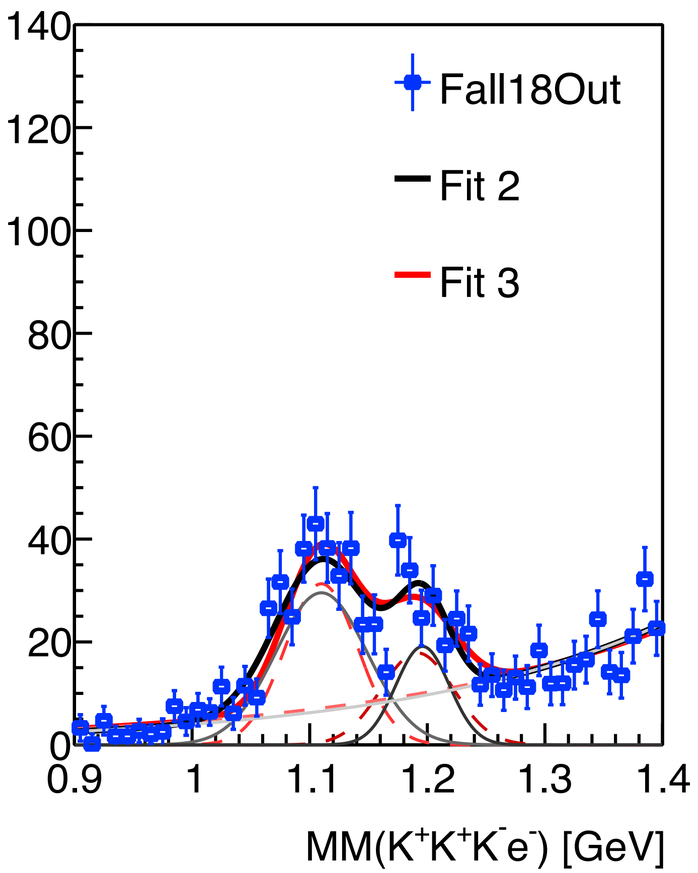
$\Xi^* \to \Sigma K^- / \Lambda K^-$

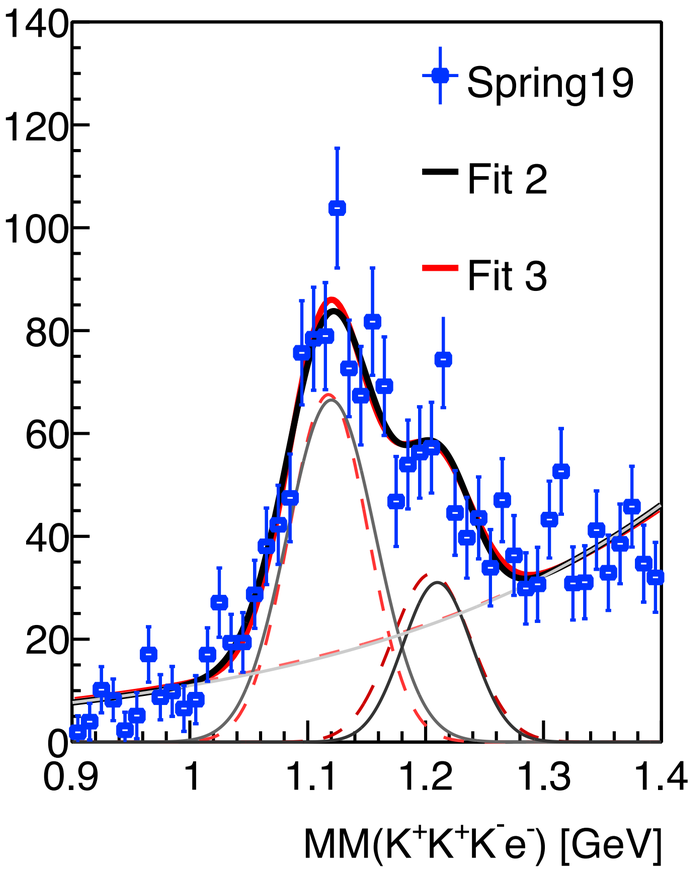




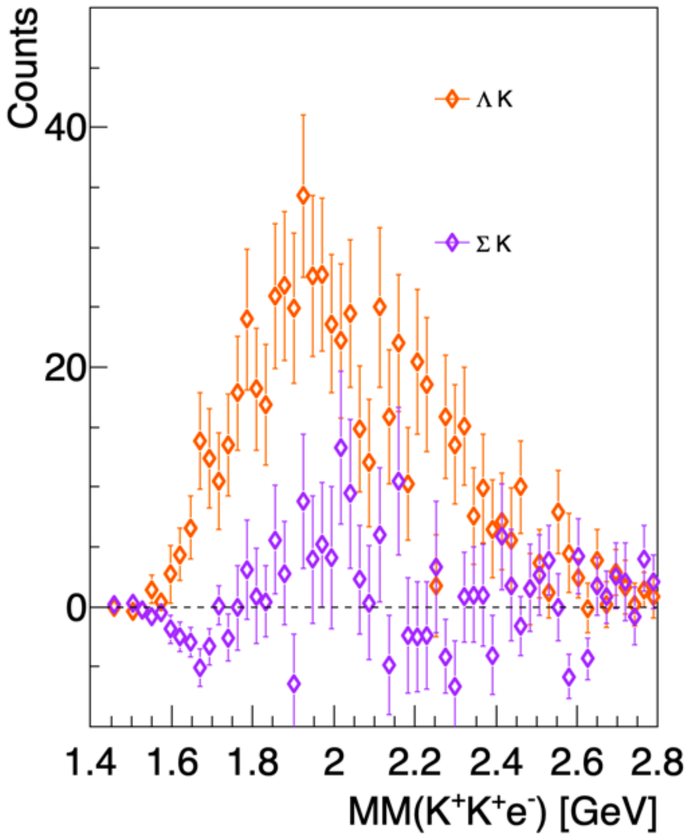
ALL FT FITS

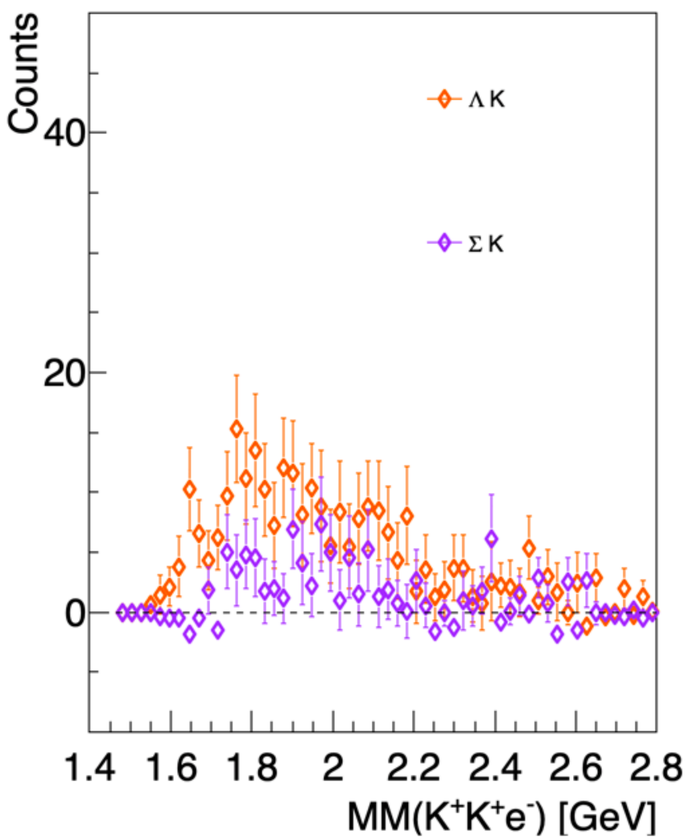

Weighted counts
Fall18In
Fit 2
Fit 3
MM(K+K+K-e-) [GeV]

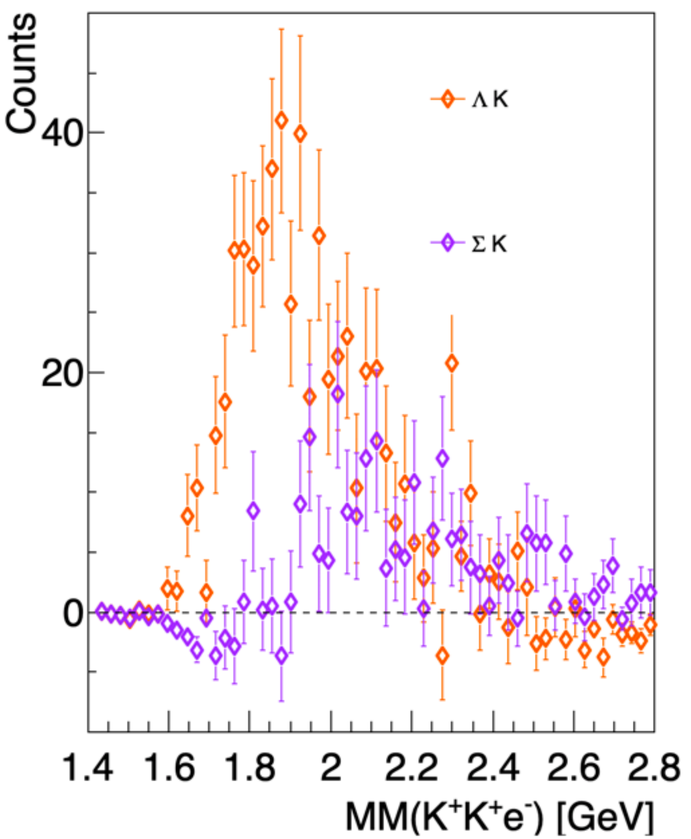

Fall18Out
Fit 2
Fit 3
MM(K+K+K-e-) [GeV]


Spring19
Fit 2
Fit 3
MM(K+K+K-e-) [GeV]

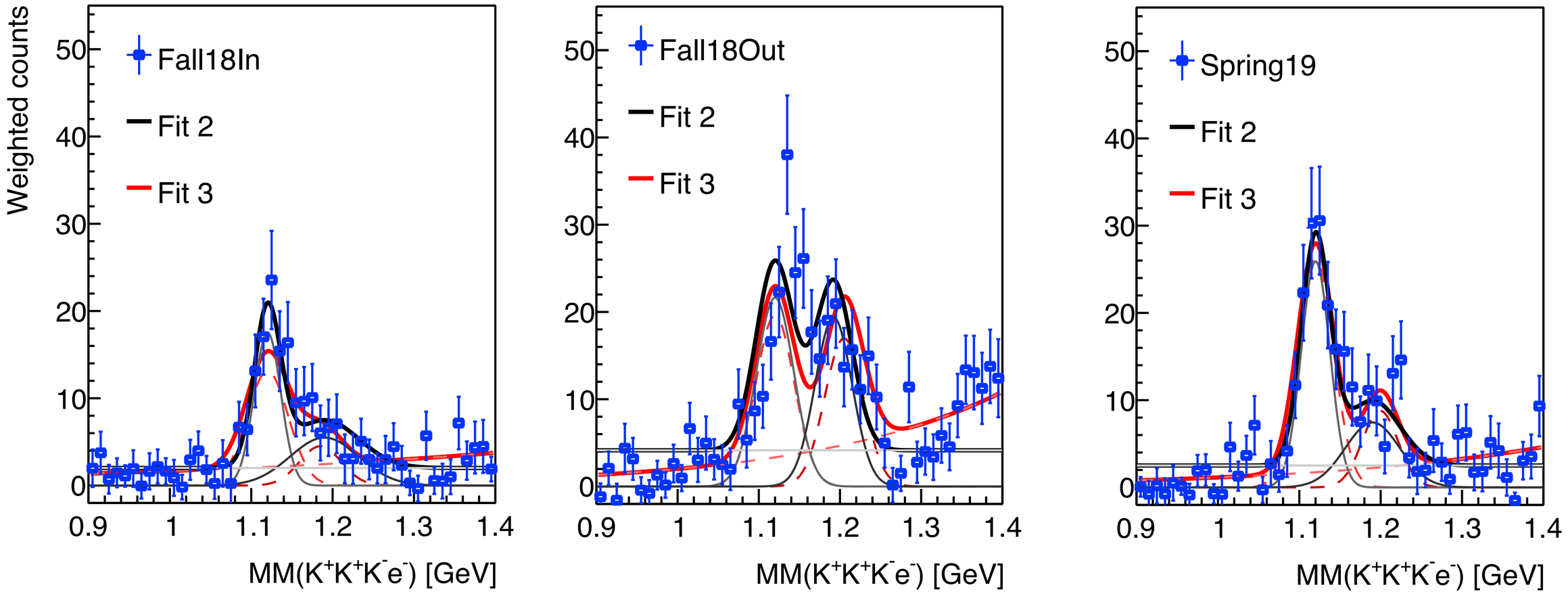
ALL FT YIELDS



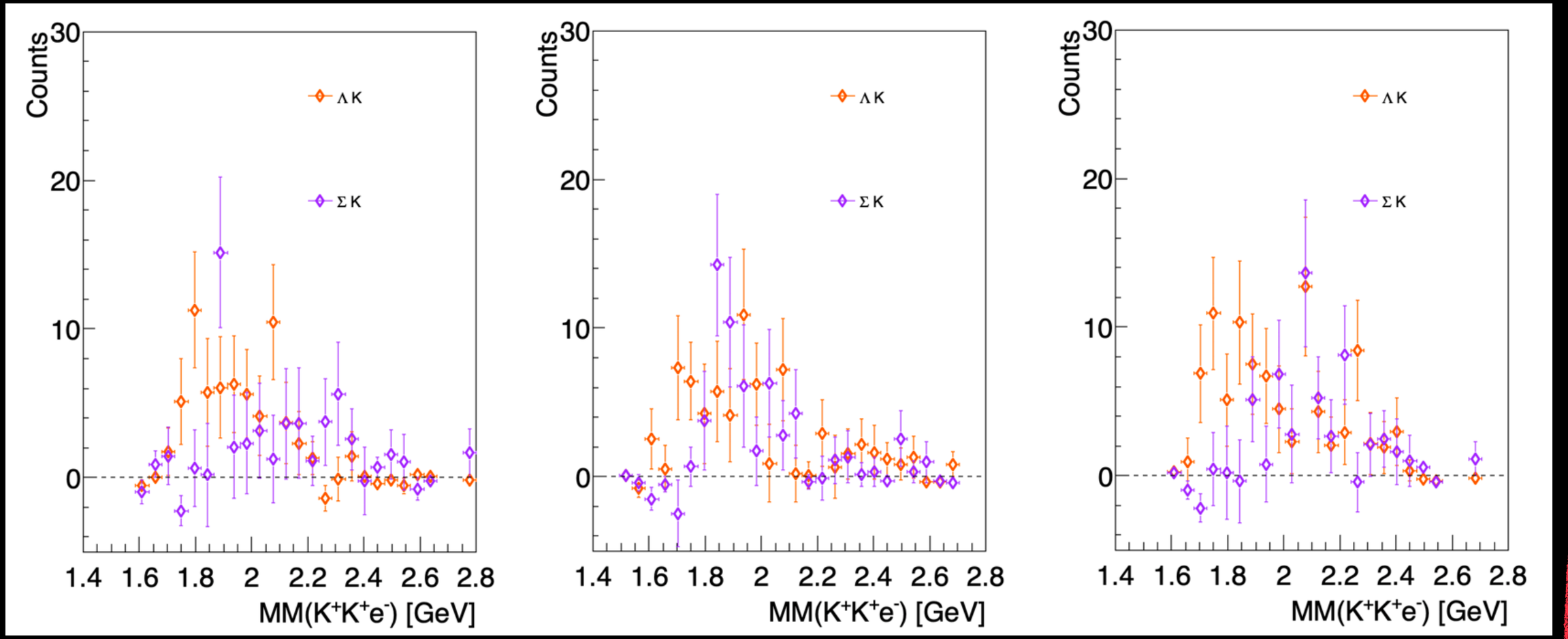




ALL FD FITS

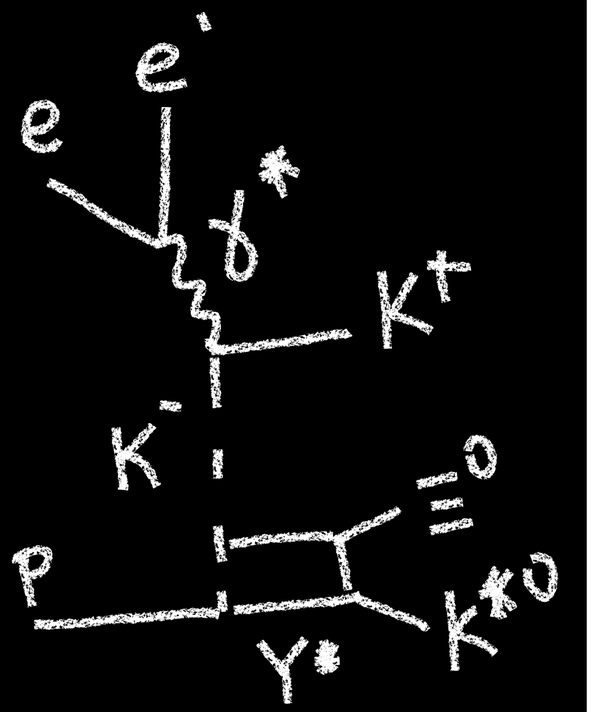

Weighted counts
Fall18In
Fit 2
Fit 3
MM(K+K+K-e-) [GeV]
Fall18Out
Fit 2
Fit 3
MM(K+K+K-e-) [GeV]
Spring19
Fit 2
Fit 3
MM(K+K+K-e-) [GeV]

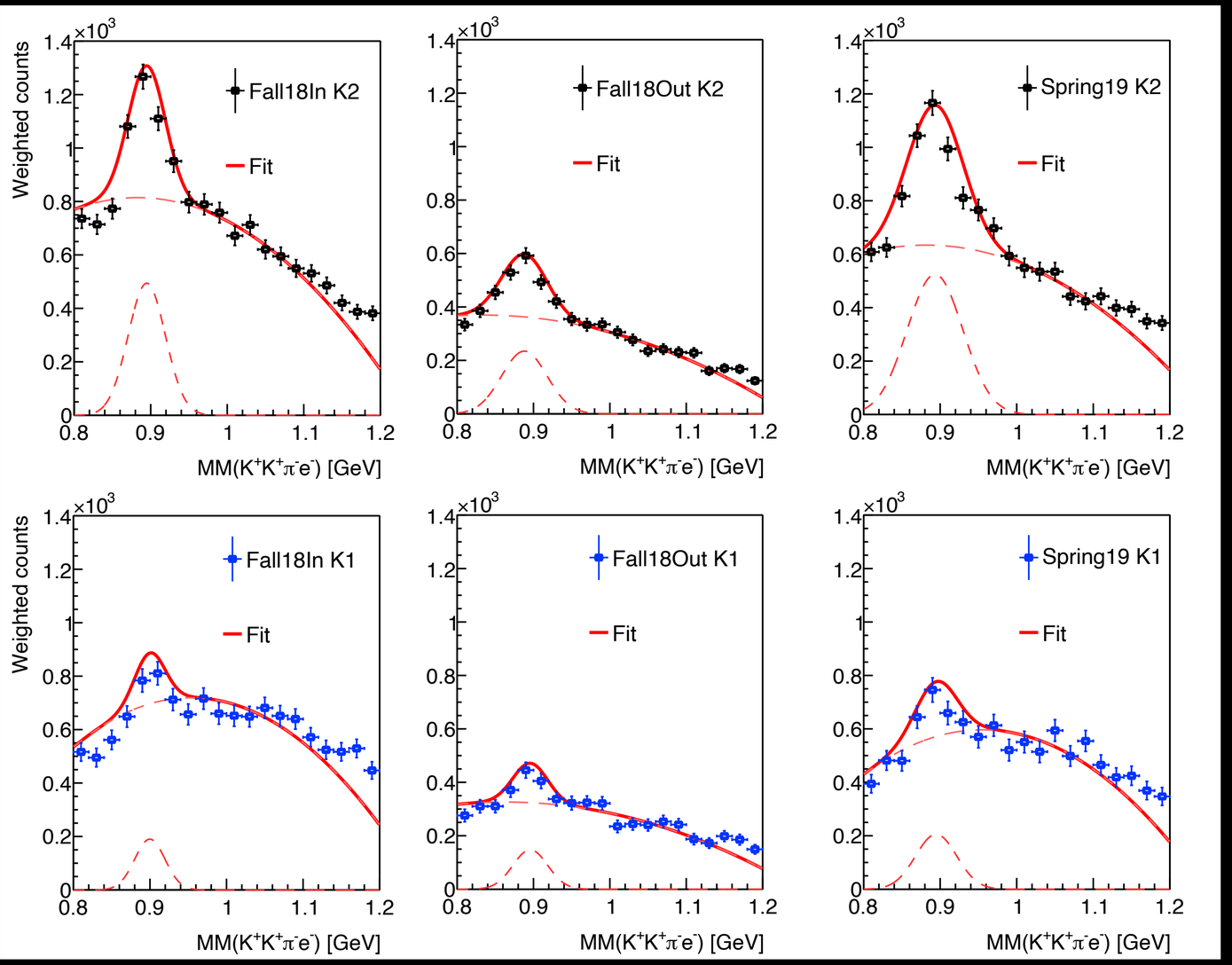
ALL FD YIELDS

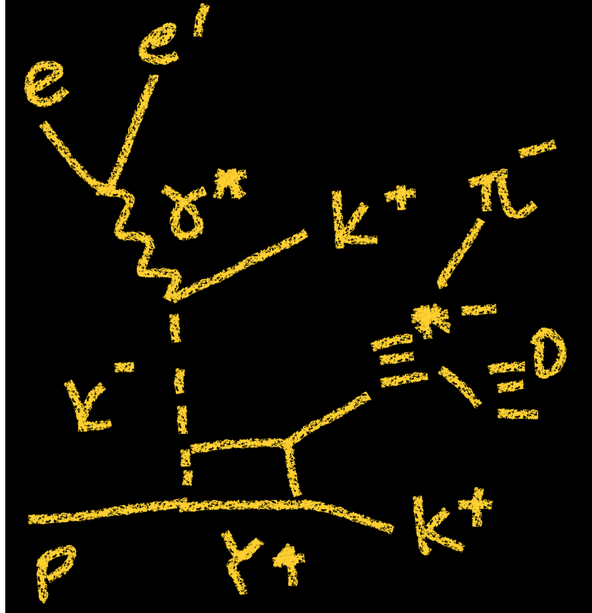


$\Xi^- \pi^-$ BRANCH

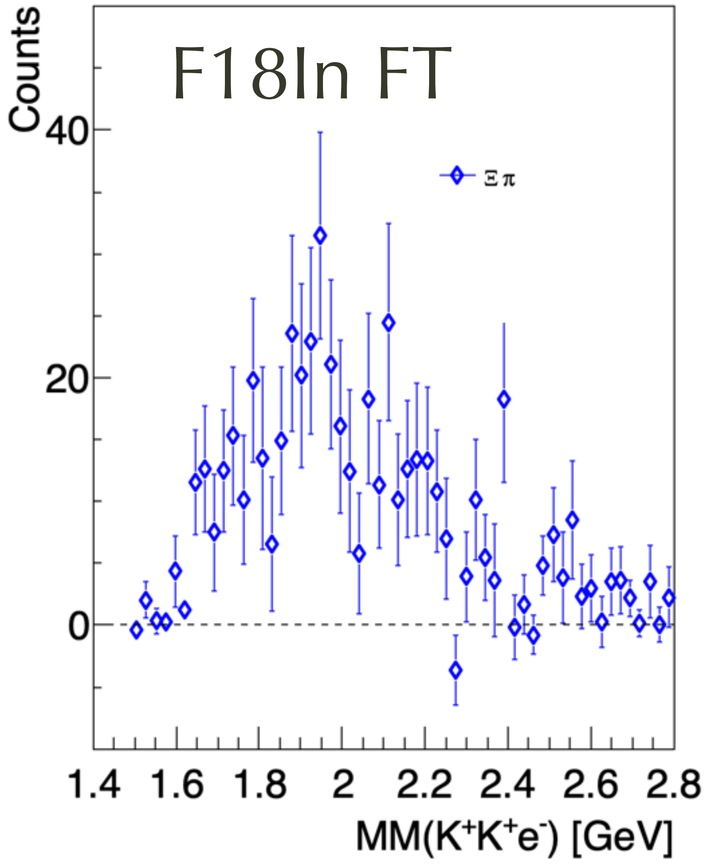
PHYSICAL BACKGROUND FT

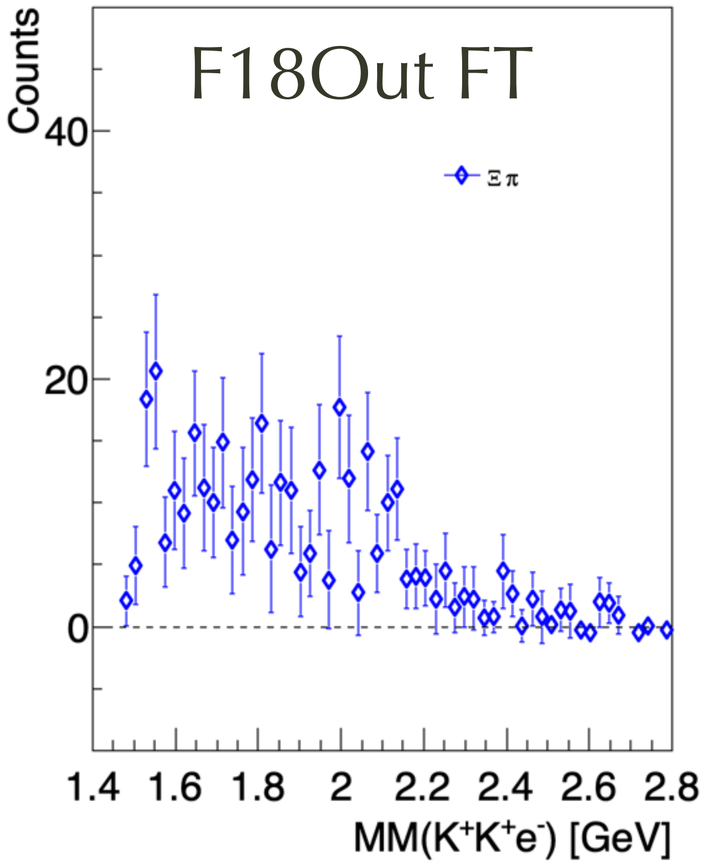


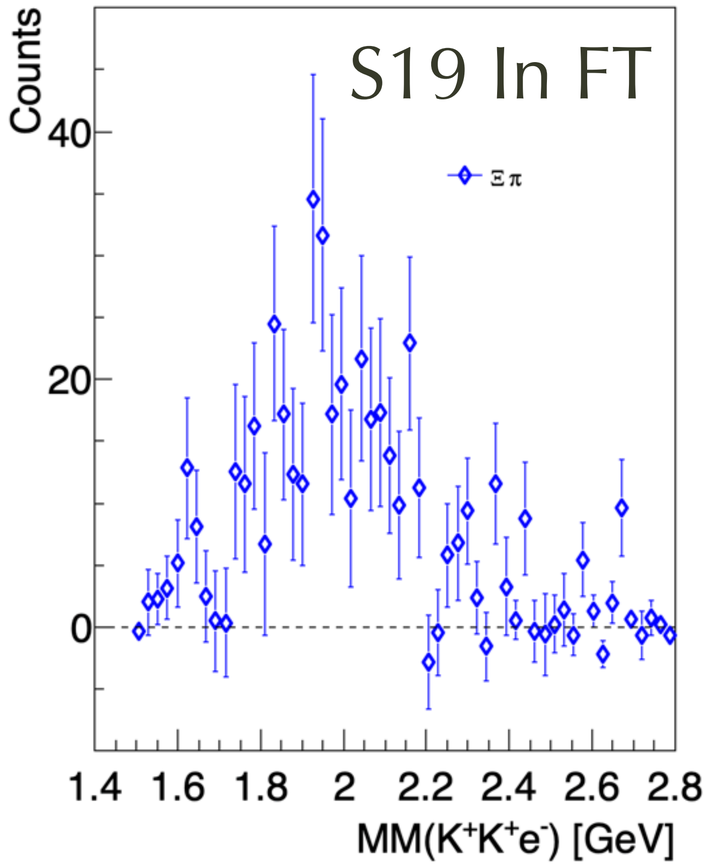




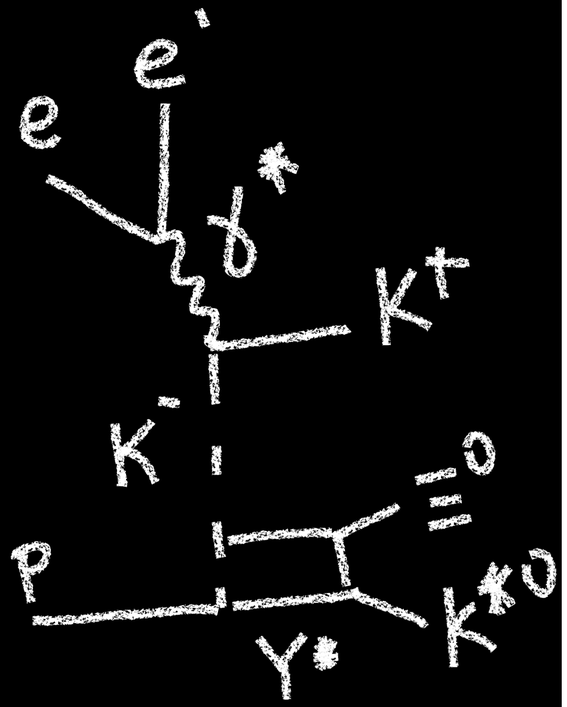
ALL FT YIELDS

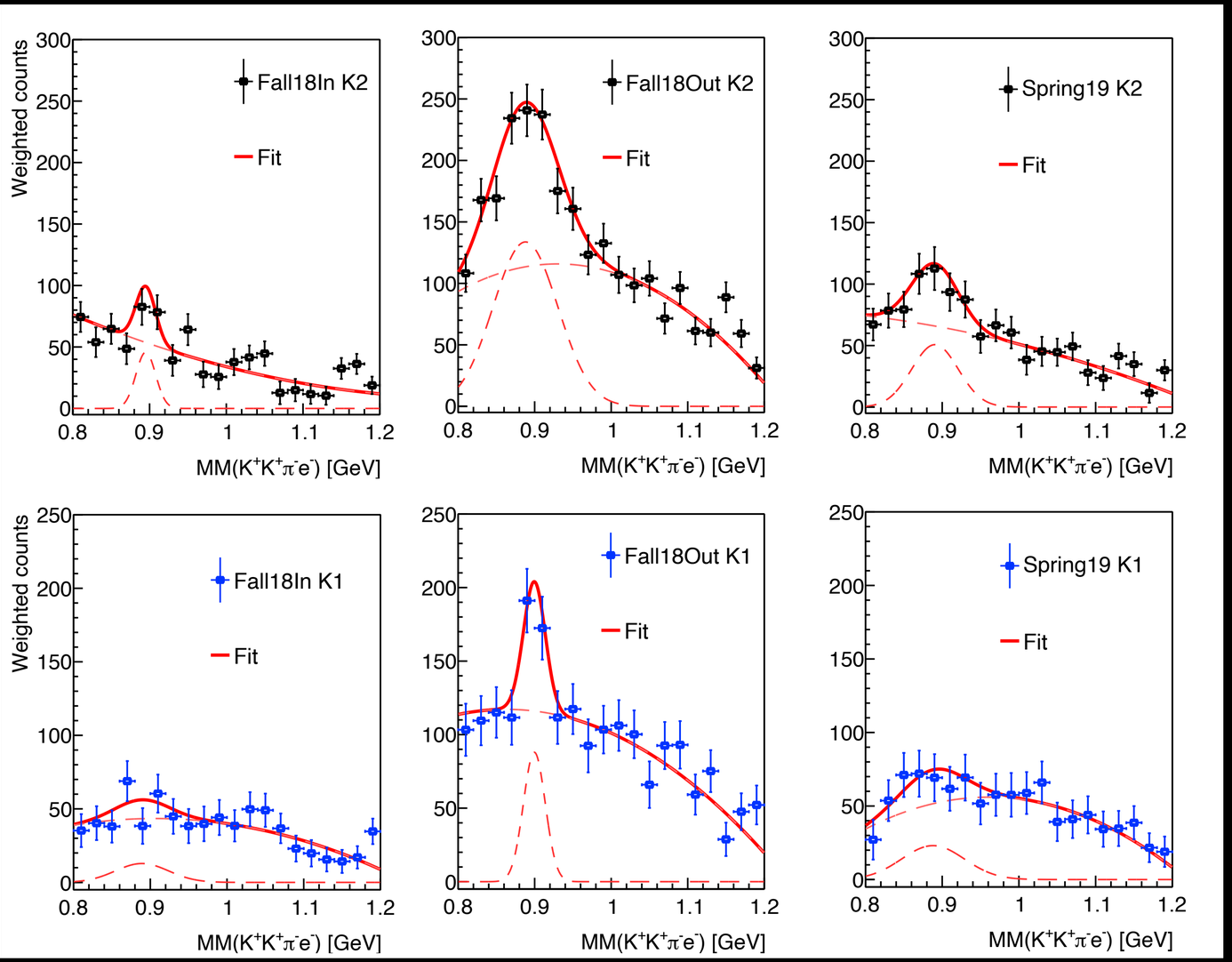


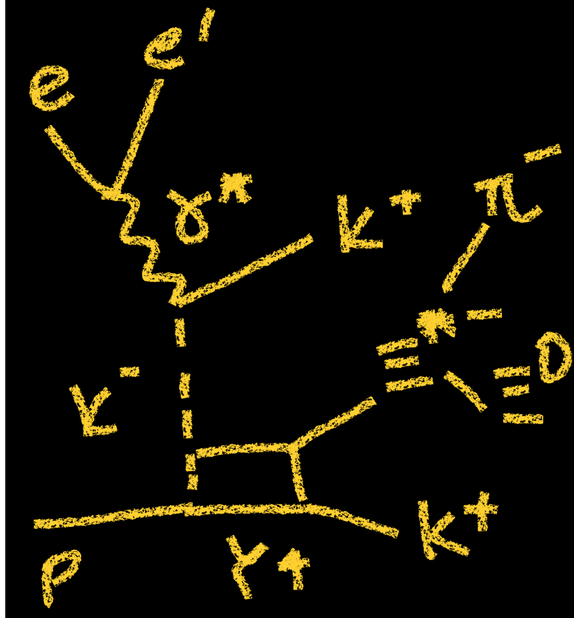




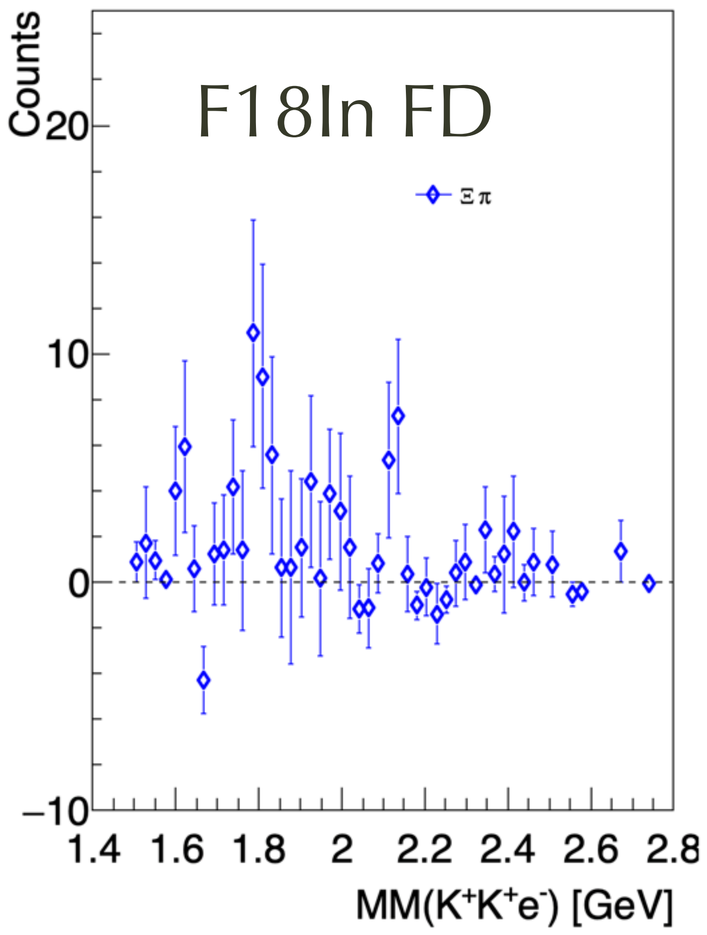
PHYSICAL BACKGROUND FD

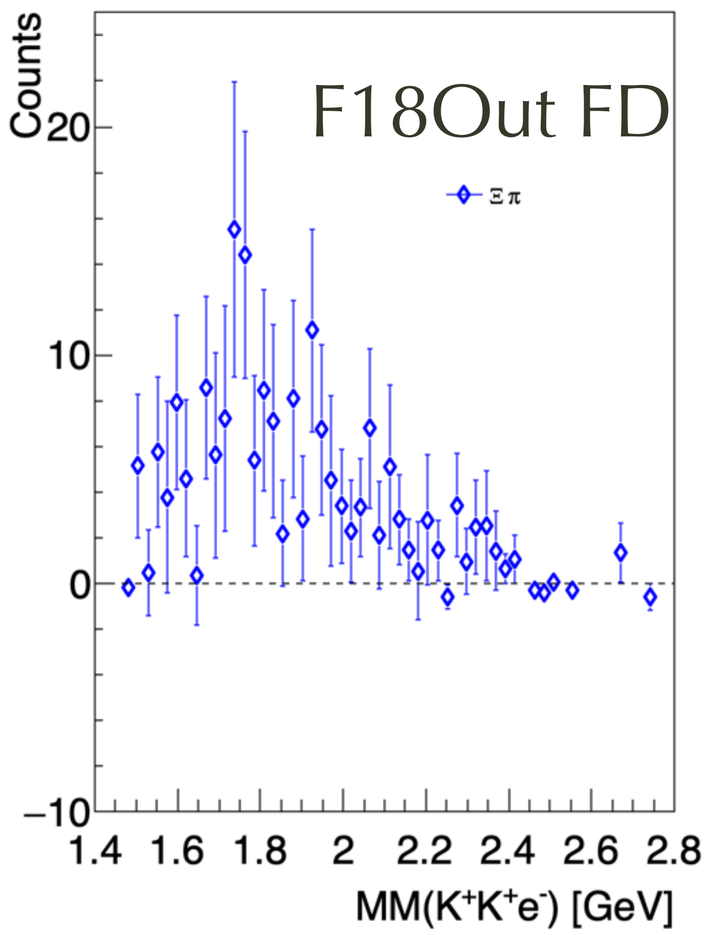


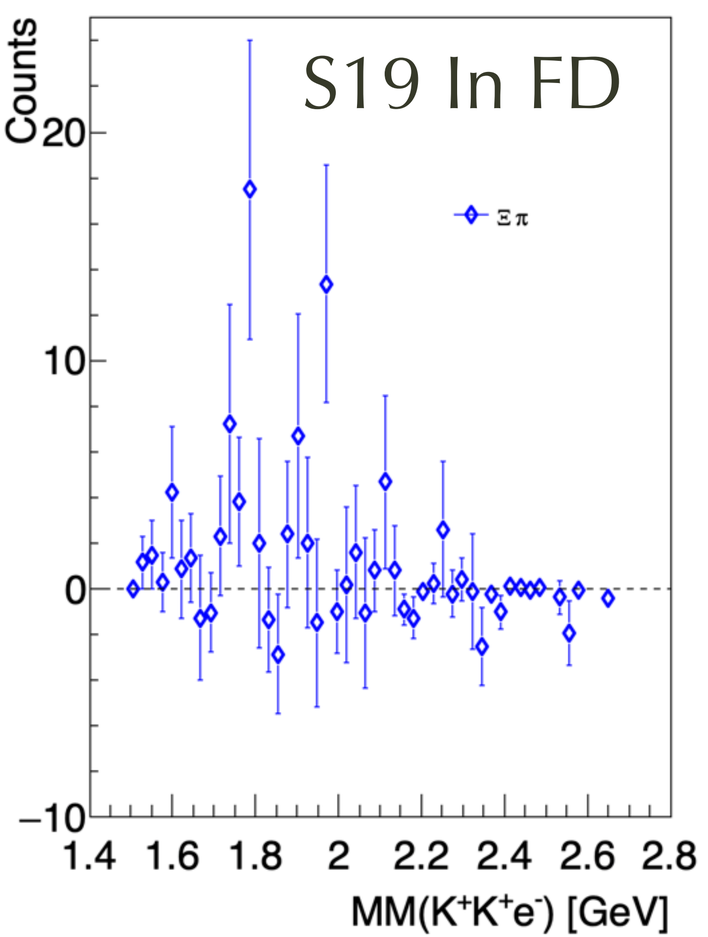




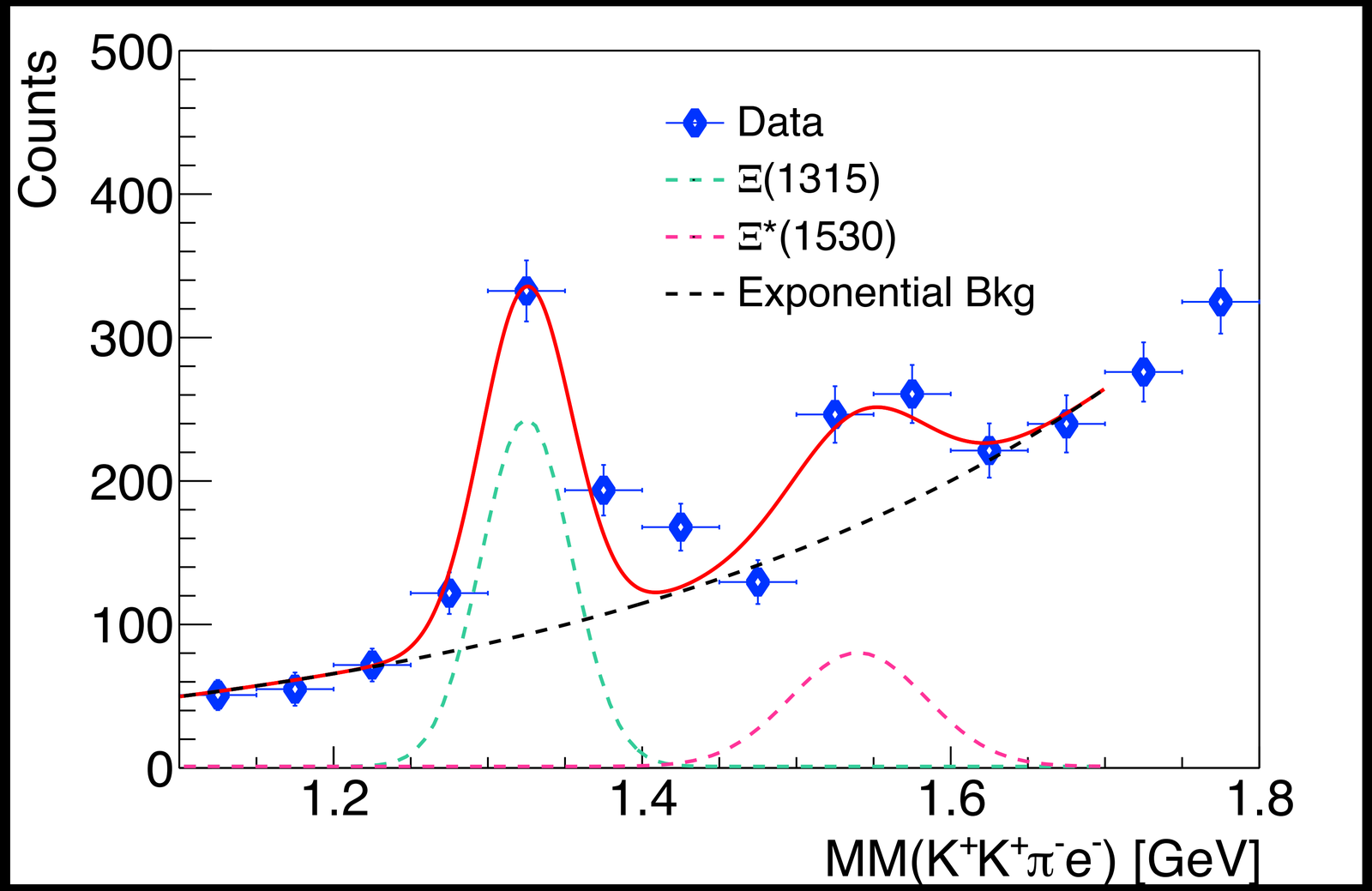
ALL FD YIELDS

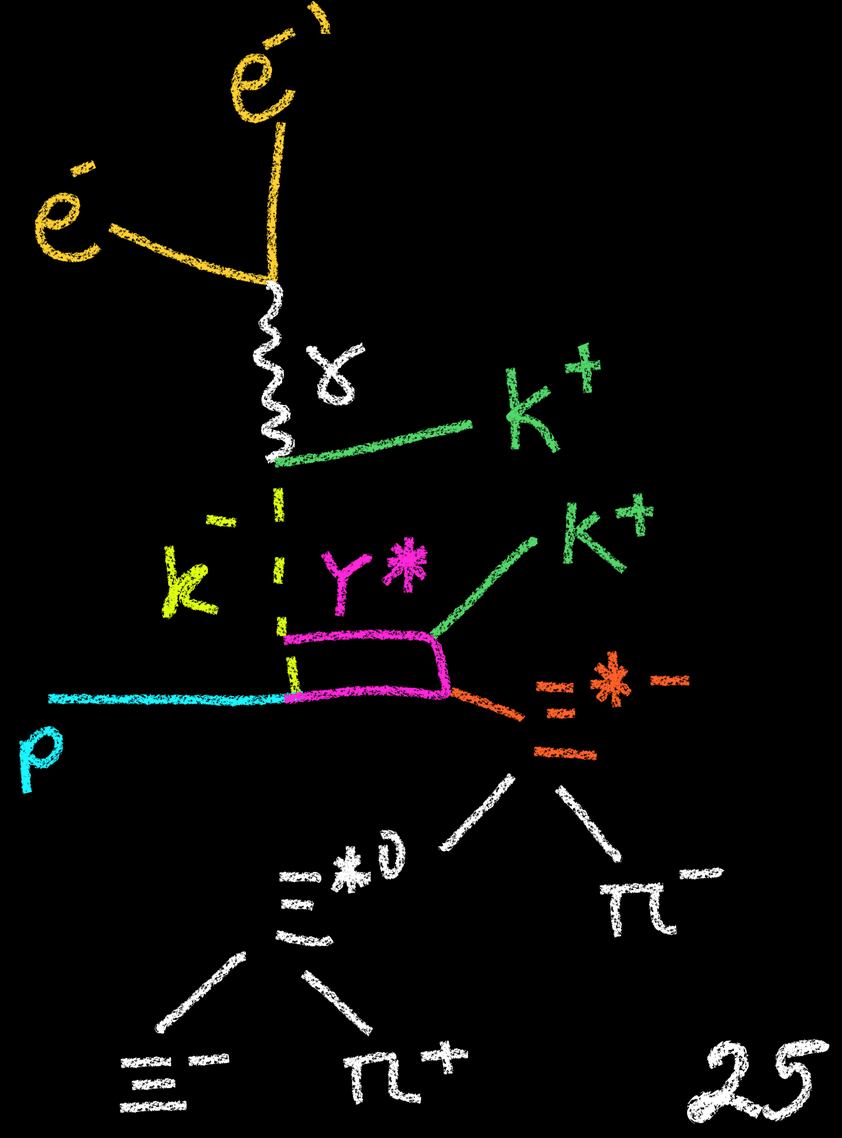






NEW BRANCHING?



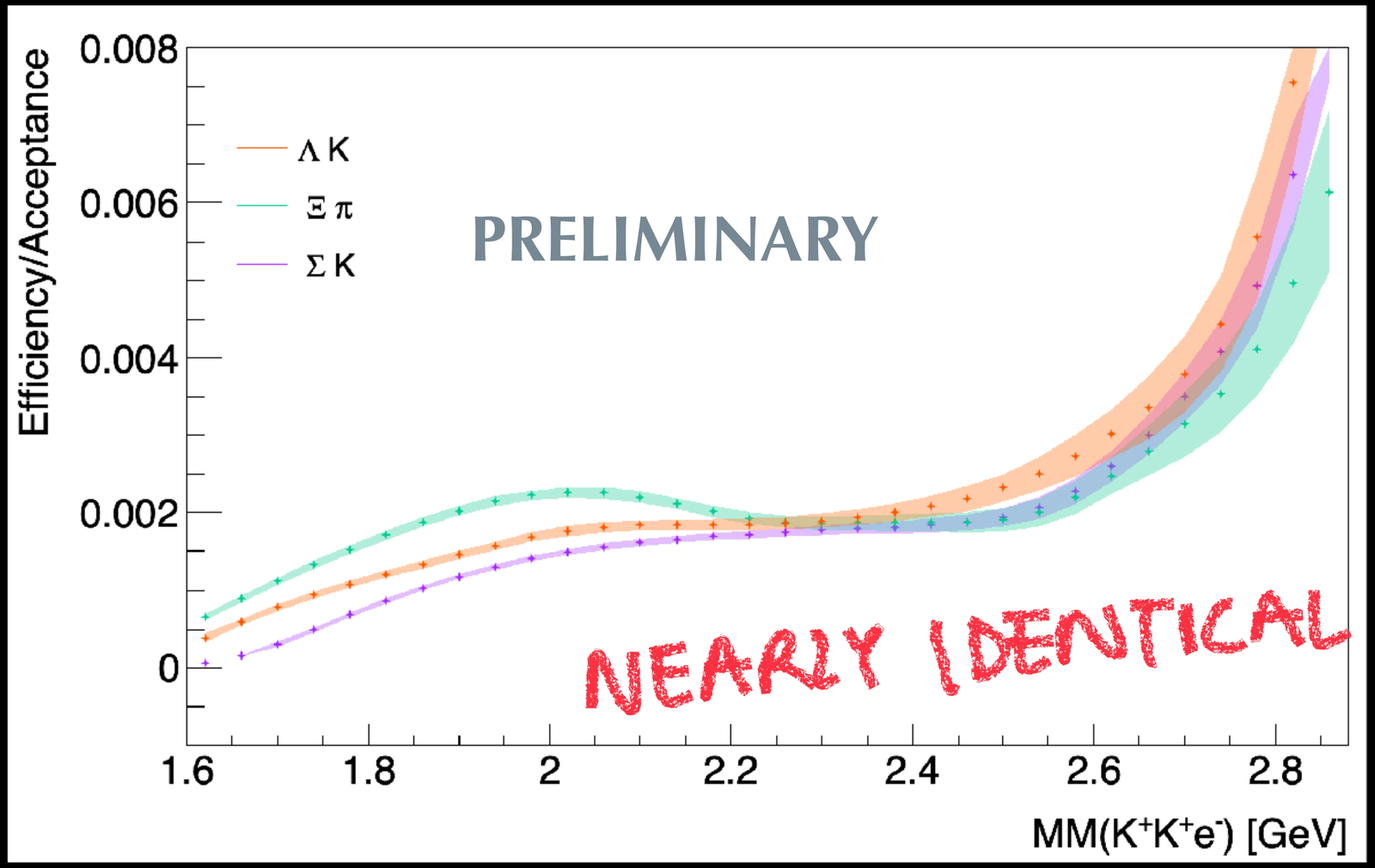


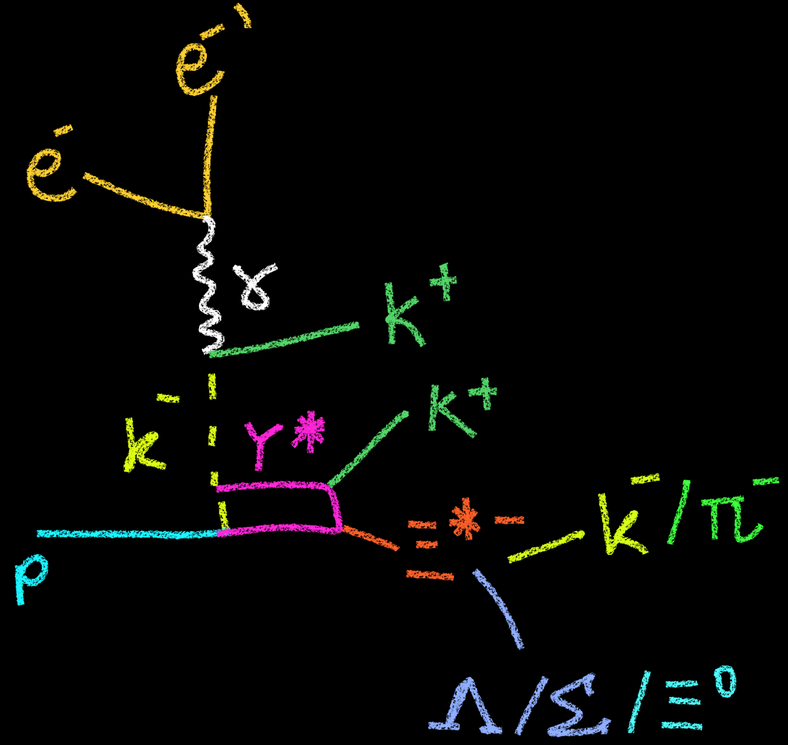
TOTAL YIELDS

Run Period	Raw ΛK	Raw ΣK	Raw $\Xi\pi$	Eff Corr. ΛK	Eff Corr. ΣK	Eff Corr. $\Xi\pi$
e^- in FD						
Fall 18 In.	57	27	47	39714	23834	26763
Fall 18 Out.	49	45	107	21670	20155	15660
Spring 19 In.	61	30	51	56483	20966	56879
e^- in FT						
Fall 18 In.	500	43	387	511401	57663	290762
Fall 18 Out.	217	65	258	1986940	478045	748124
Spring 19 In.	523	110	366	1068920	76386	431750

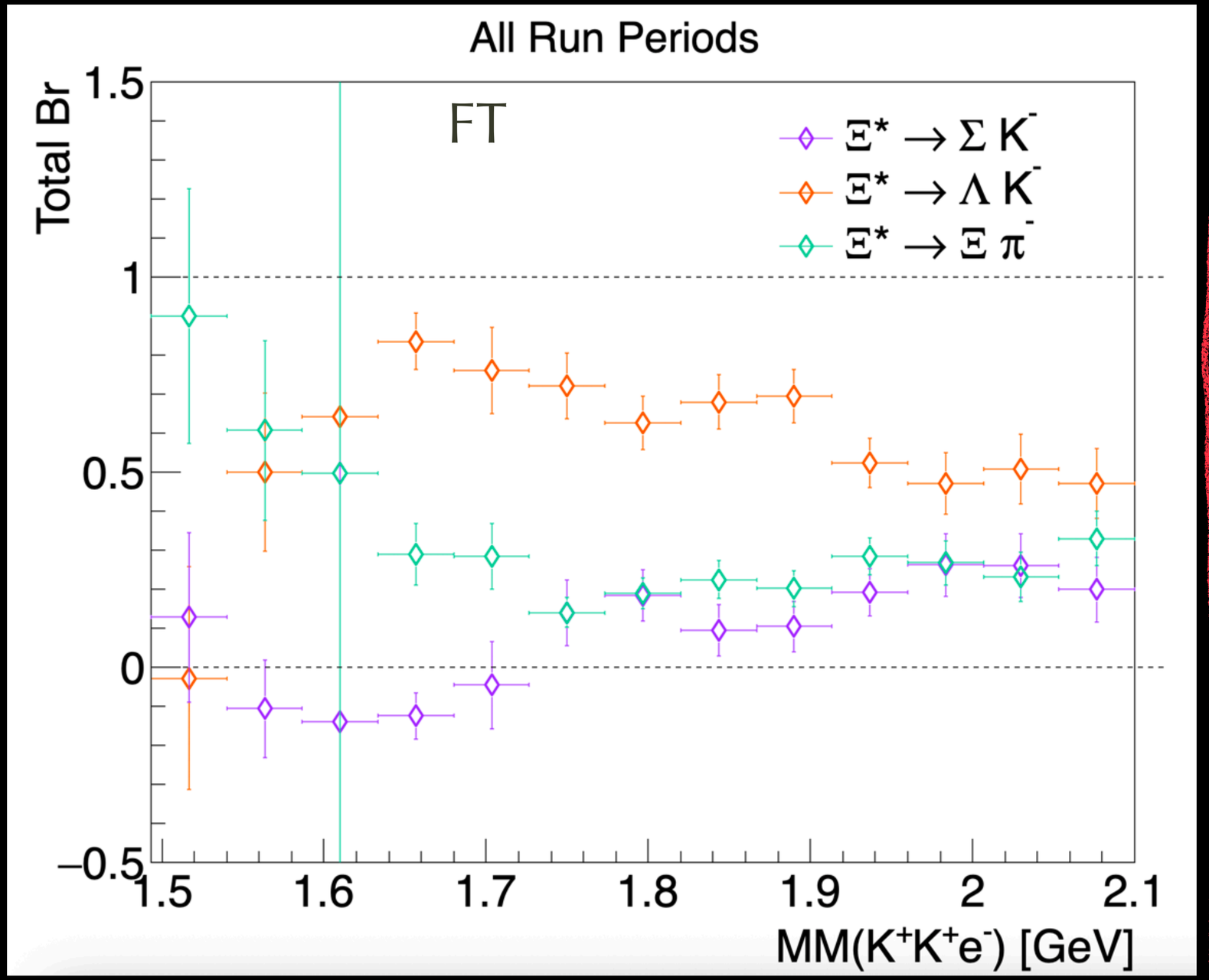
BRANCHINGS

ACCEPTANCE/EFFICIENCY

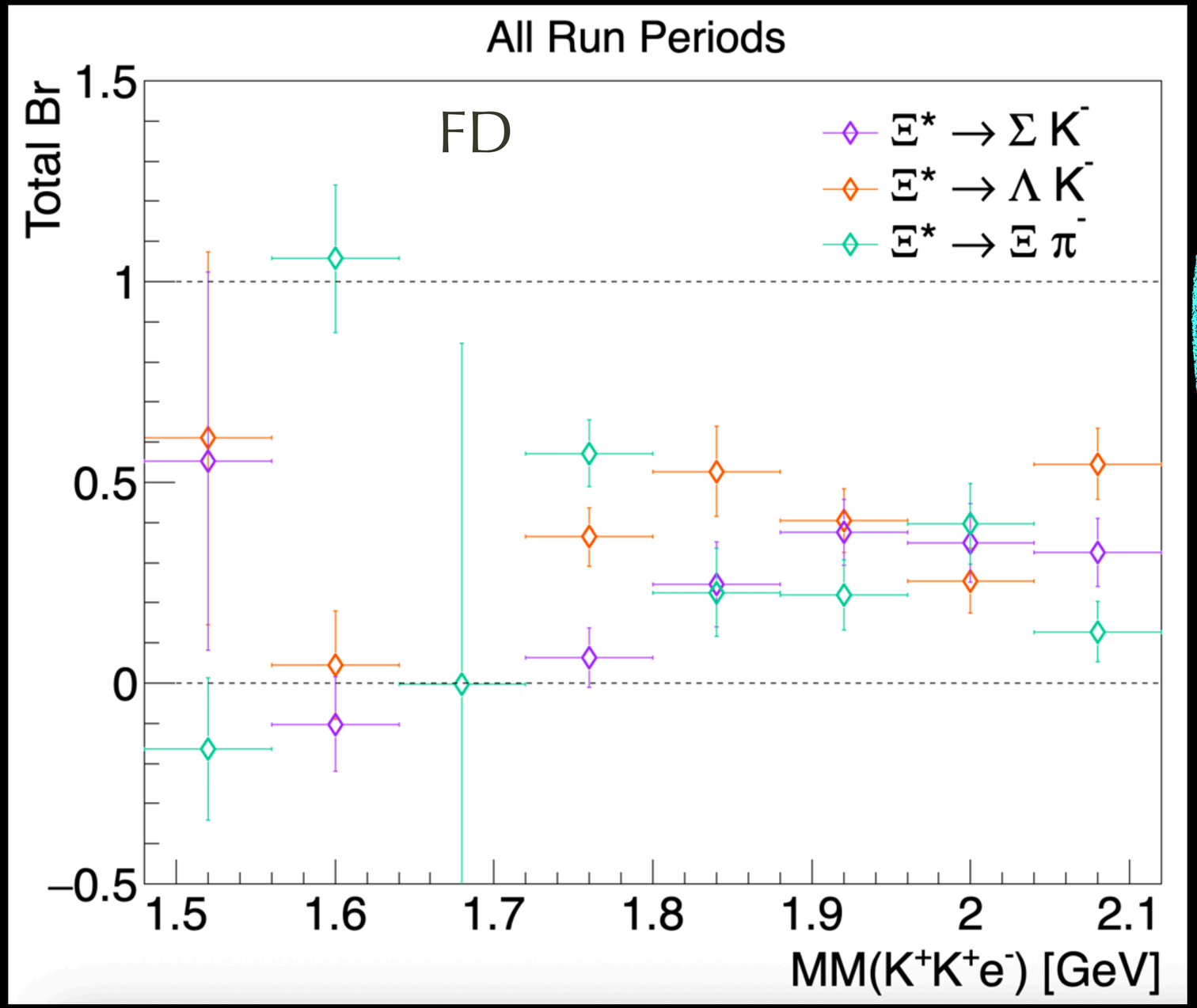




COMBINING ALL RUN PERIODS

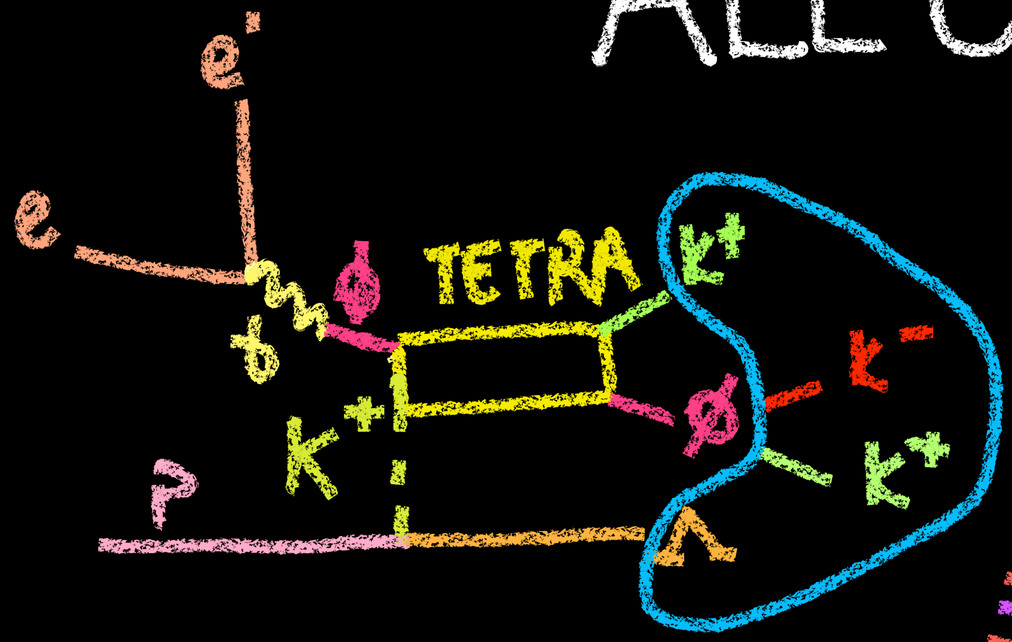


COMBINING ALL RUN PERIODS

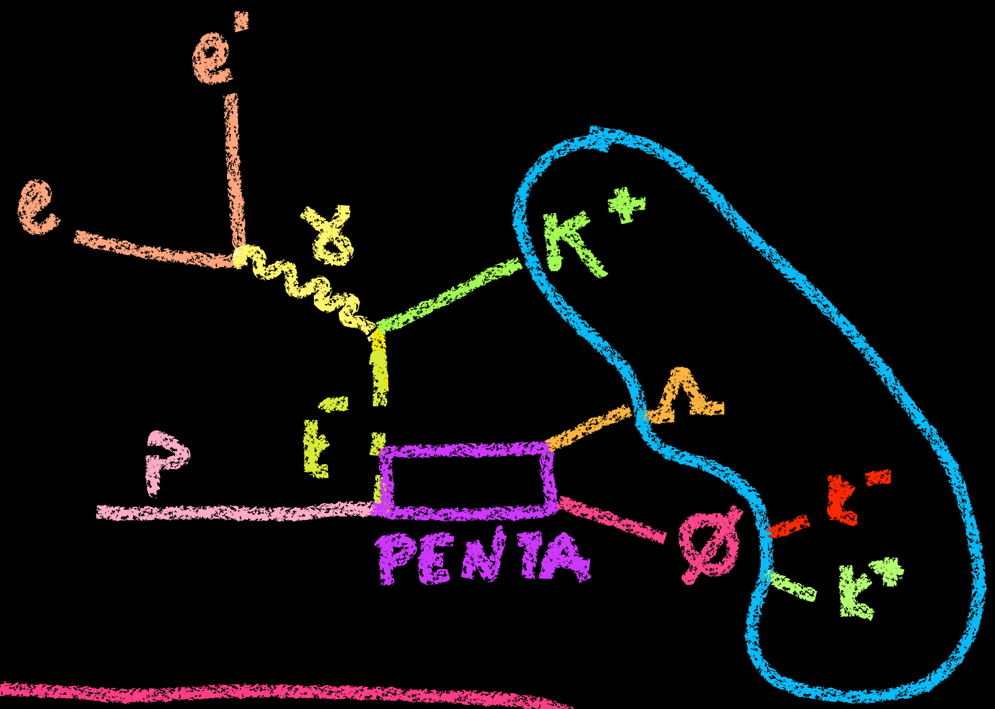


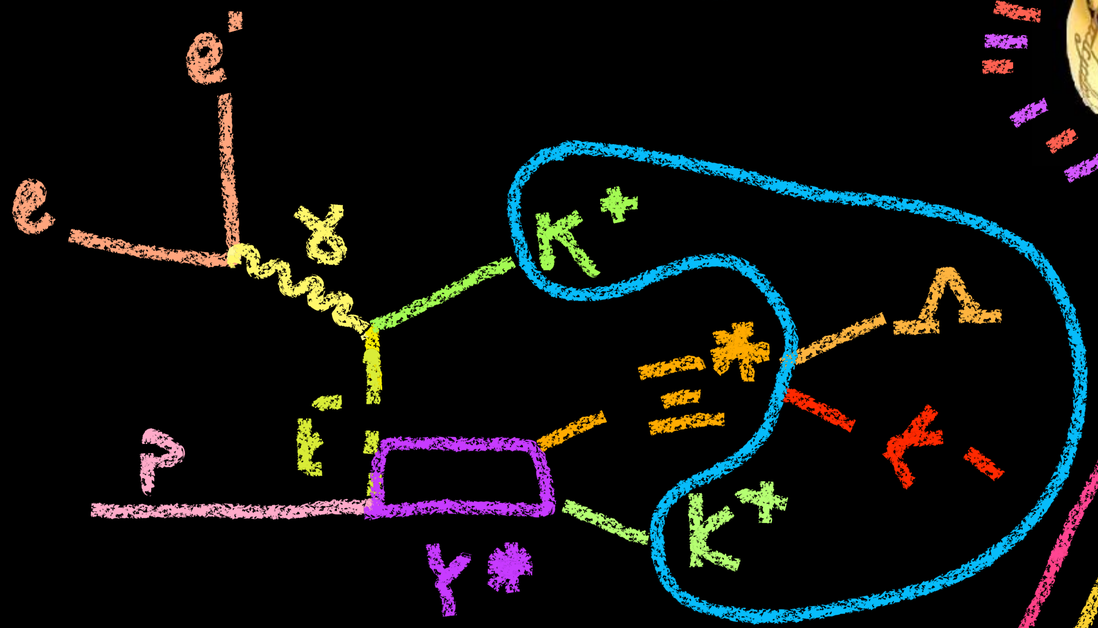
OTHER EXOTICS AS BACKGROUND...

ALL CHANNELS





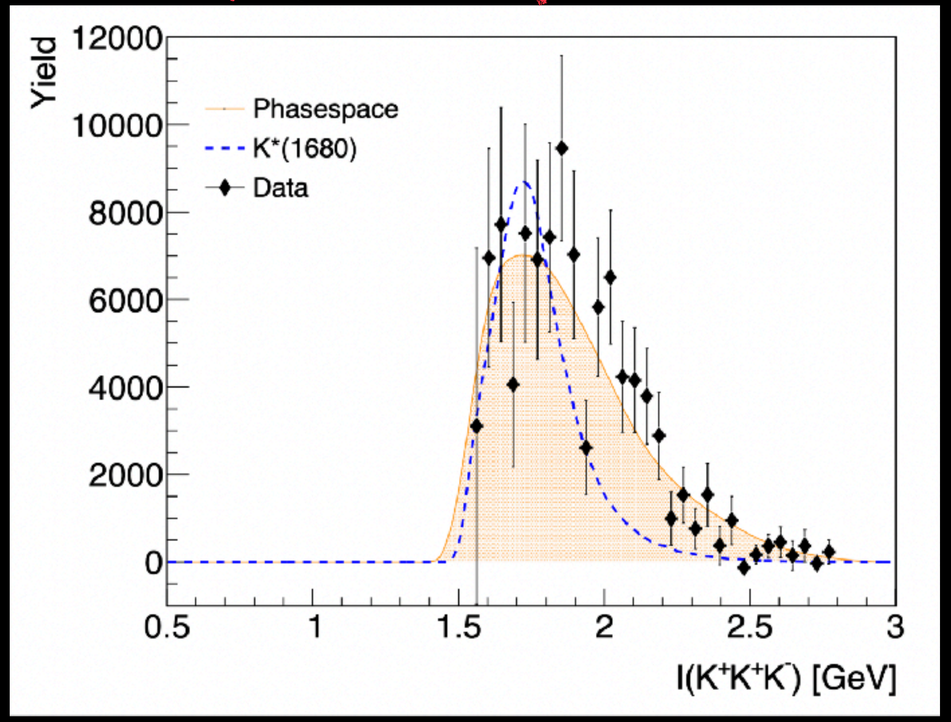




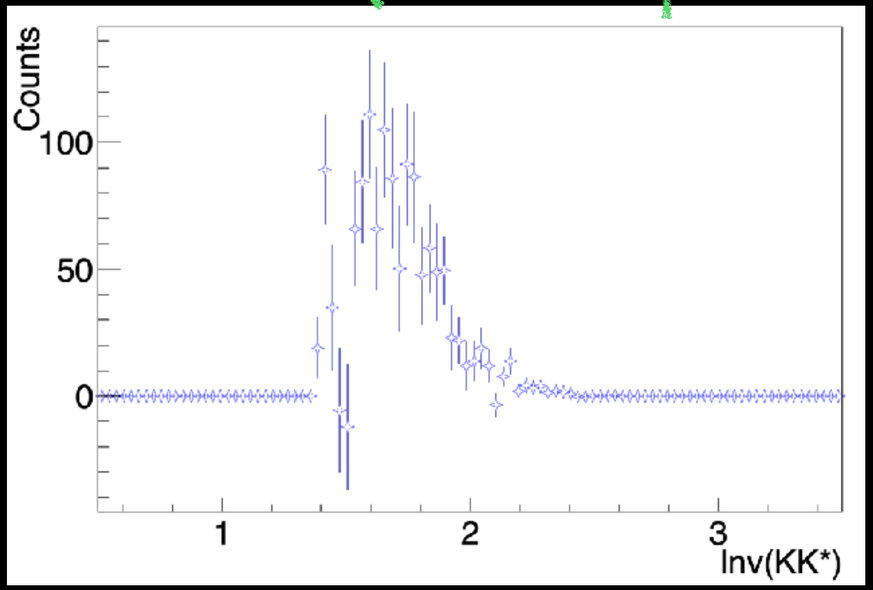
ONE FINAL STATE TO RULE THEM ALL

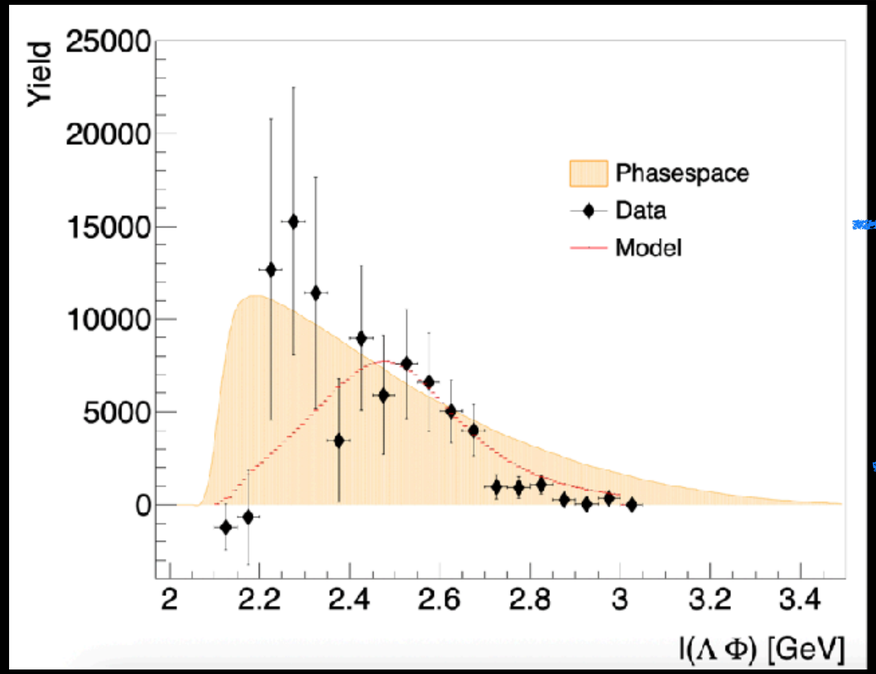
POSSIBLE CHANNELS

ØK



KK*



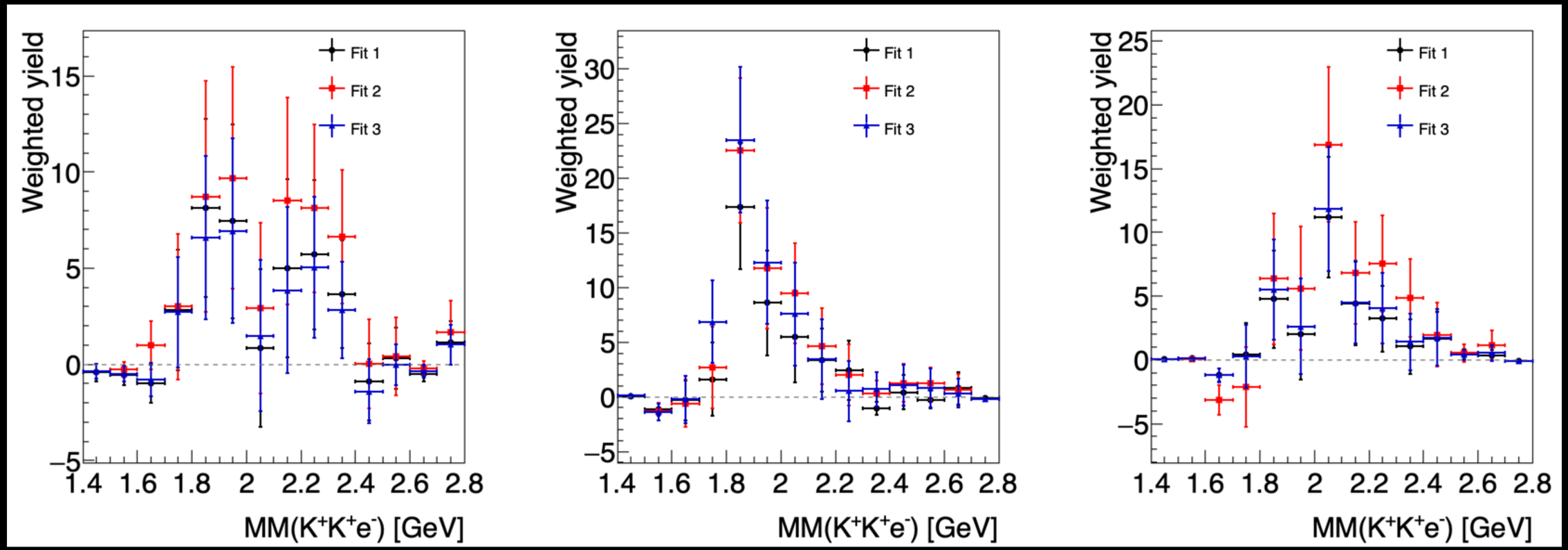


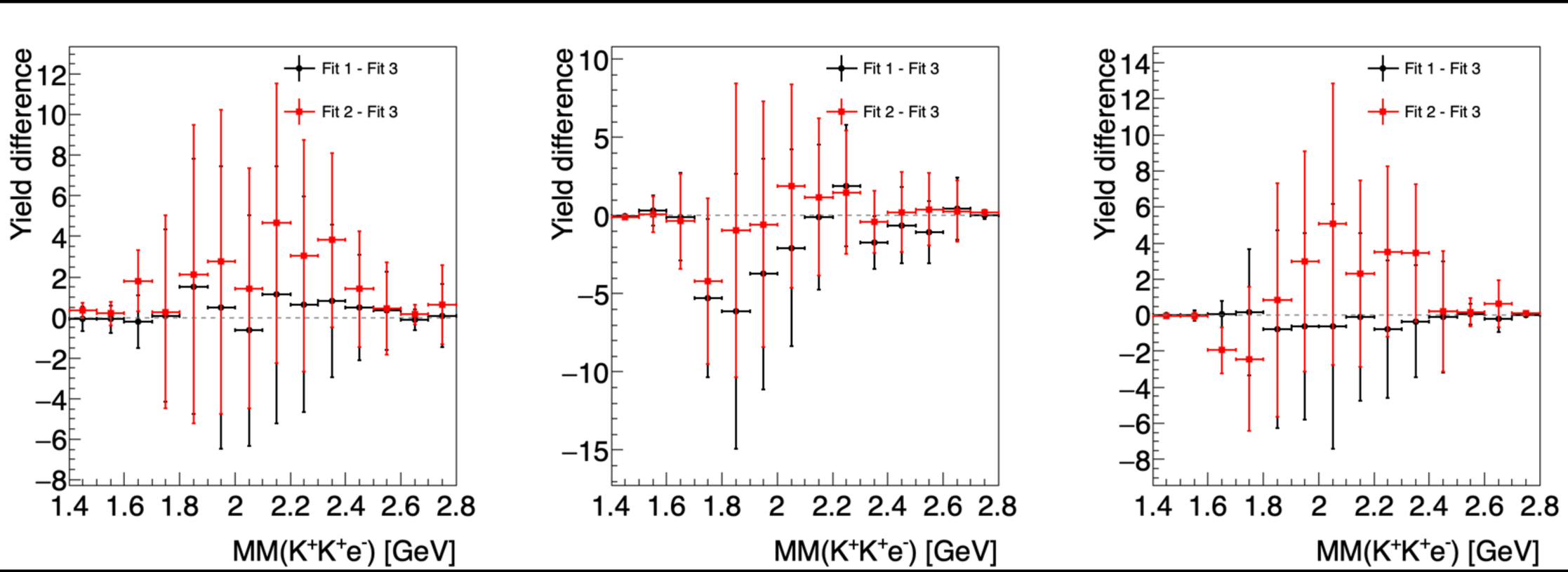
ΛØ

CONCLUSIONS

- Kaon ID Submitted
- Cascade decay channels
  - ΛK, ΣK, $\Xi\pi$, $\Xi\pi^+\pi^-$ (?)
  - Preliminary total branchings
  - Fits & simulations
- Possible exotics
  - Tetraquarks: ϕK, KK^* $(S=2)$
  - Pentaquarks: $\Lambda\phi$, $\Sigma\phi$
- Analysis Note !


STAY TUNED


Weighted yield
Fit 1
Fit 2
Fit 3
MM(K⁺K⁺e⁻) [GeV]
Weighted yield
Fit 1
Fit 2
Fit 3
MM(K⁺K⁺e⁻) [GeV]
Weighted yield
Fit 1
Fit 2
Fit 3
MM(K⁺K⁺e⁻) [GeV]


Yield difference
Fit 1 - Fit 3
Fit 2 - Fit 3
MM(K⁺K⁺e⁻) [GeV]
Yield difference
Fit 1 - Fit 3
Fit 2 - Fit 3
MM(K⁺K⁺e⁻) [GeV]
Yield difference
Fit 1 - Fit 3
Fit 2 - Fit 3
MM(K⁺K⁺e⁻) [GeV]