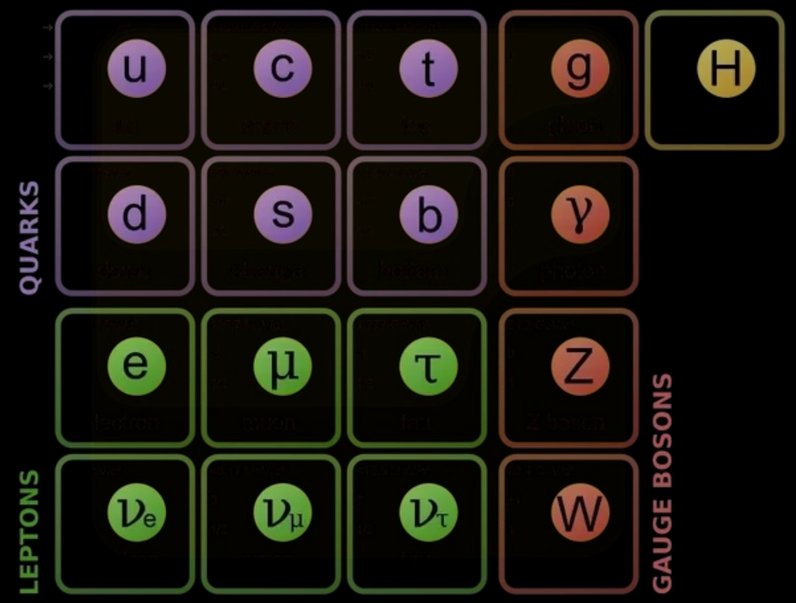
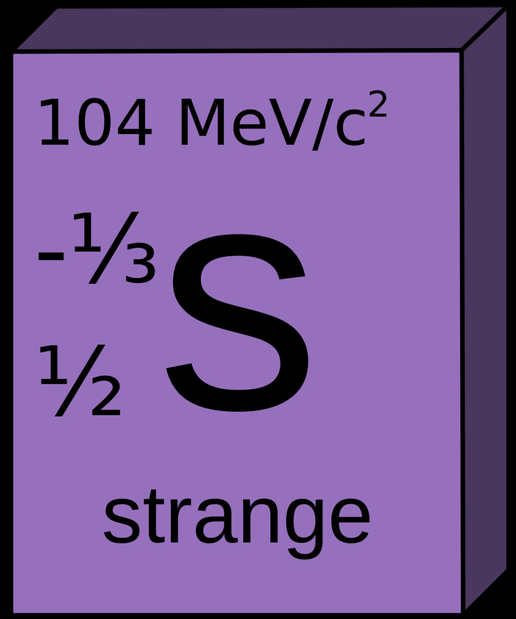
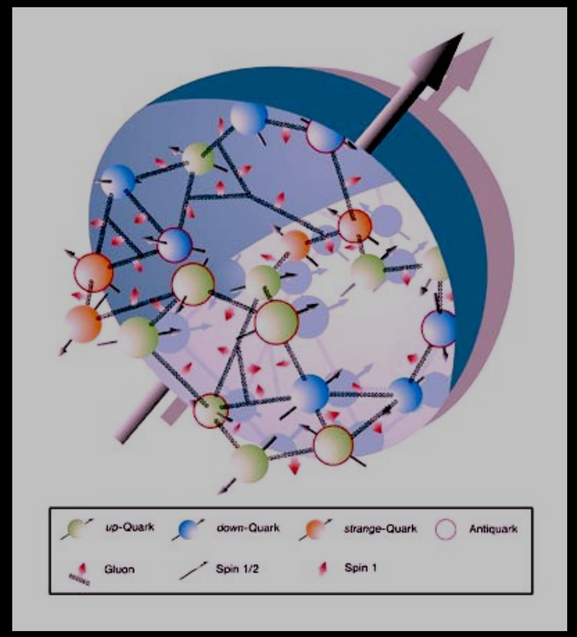
ELUCIDATING STRANGENESS with ELECTROMAGNETIC PROBES







QCD PUZZLES

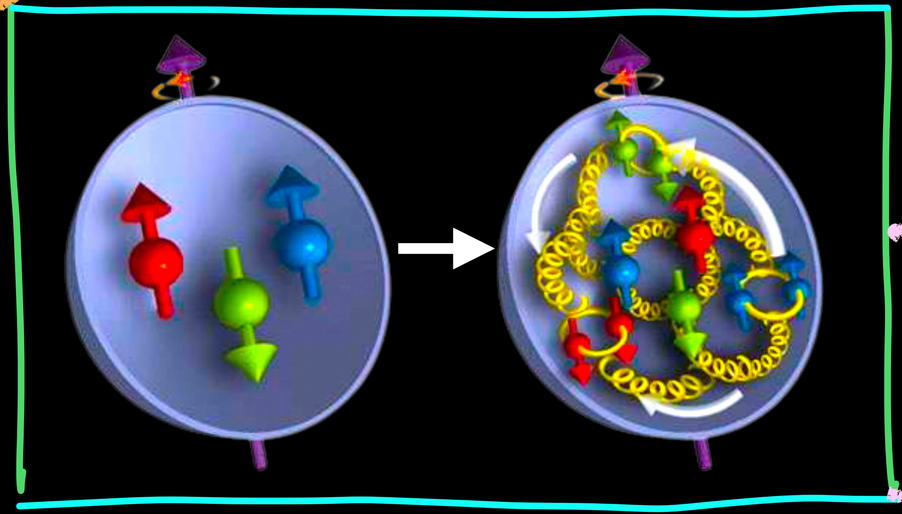
ISGUR & CAPSTICK

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

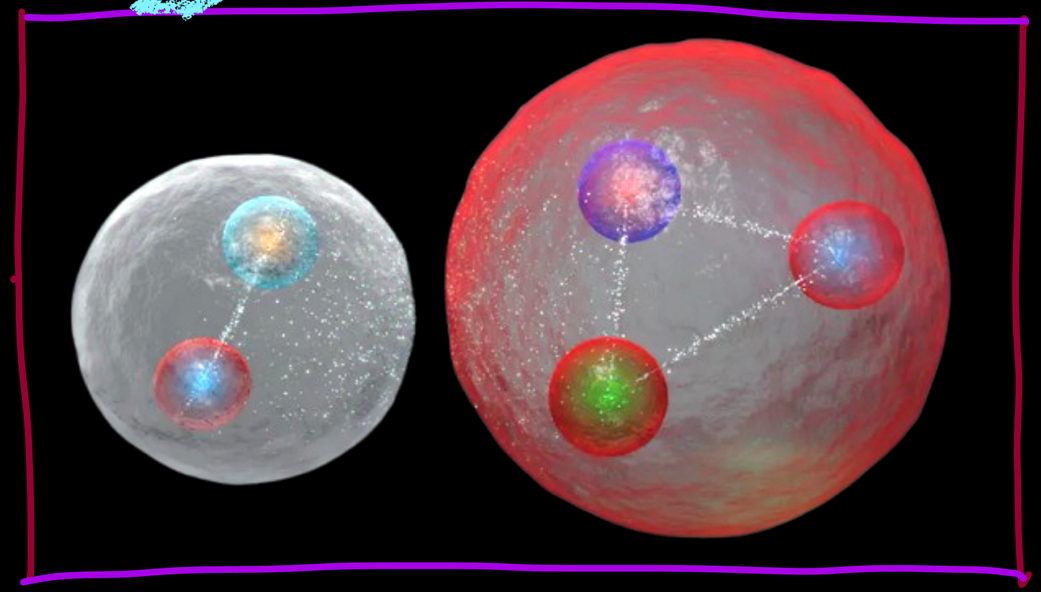
State, J^P	Predicted masses (MeV)							
$\Xi\frac{1}{2}^+$	1305							
$\Xi\frac{3}{2}^+$	1505							
$\Xi^*\frac{1}{2}^-$	1755	1810	1835	2225	2285	2300	2320	2380
$\Xi^*\frac{3}{2}^-$	1785	1880	1895	2240	2305	2330	2340	2385
$\Xi^*\frac{5}{2}^-$	1900	2345	2350	2385				
$\Xi^*\frac{7}{2}^-$	2355							
$\Xi^*\frac{1}{2}^+$	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



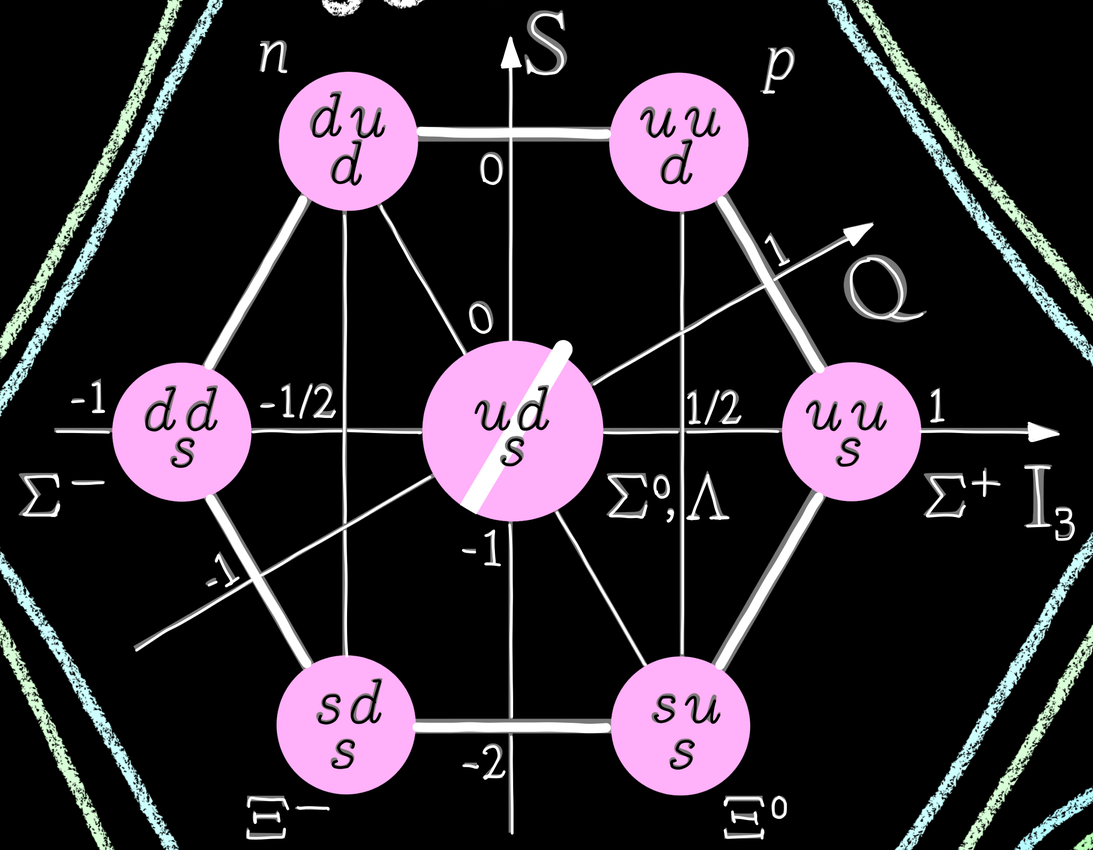
MESON-BARYON MOLECULES



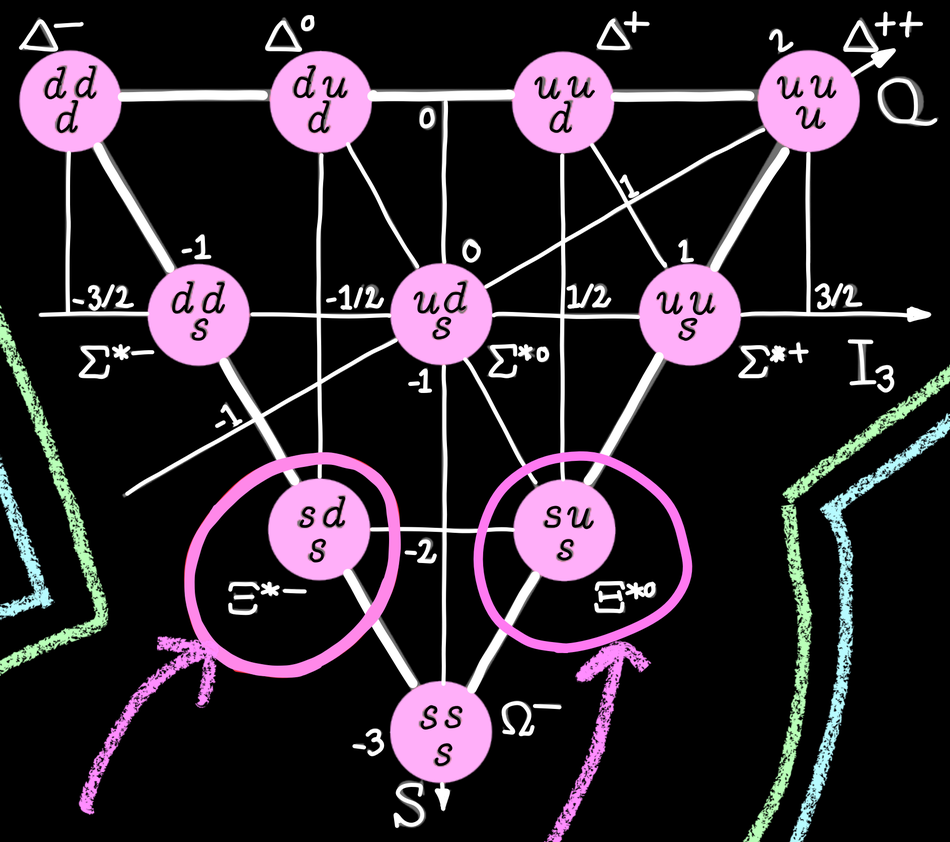
DO WE UNDERSTAND BARYONS?

BARYONS

OCTET



DECUPLET



EXCITED CASCADES

THE 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

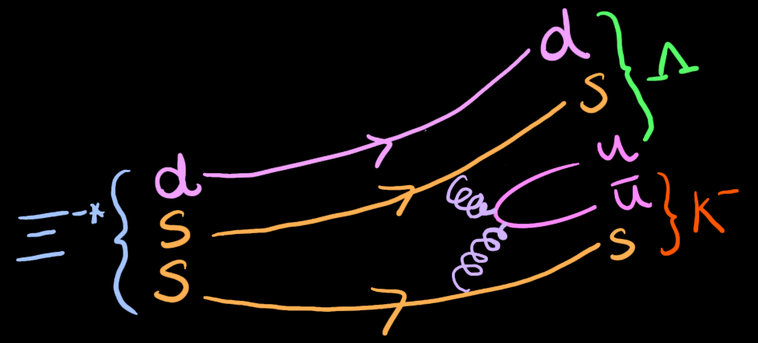
NOT MUCH PROGRESS IN PAST 4 DECADES

MISSING J^P and BRANCHING RATIOS

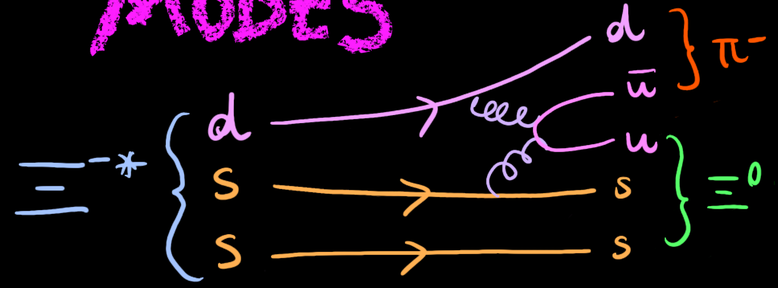
Ξ(1690) $I(J^P) = \frac{1}{2}(?^?)$

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

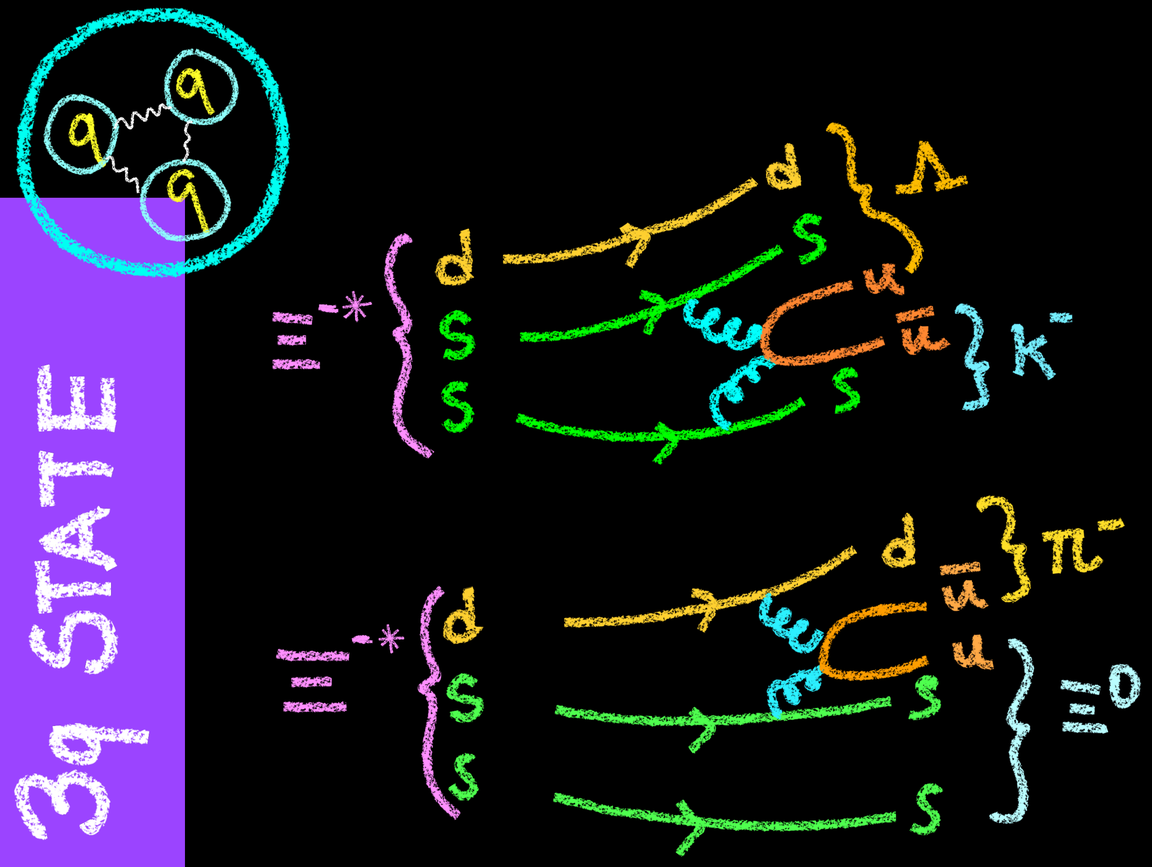


POSSIBLE DECAY MODES

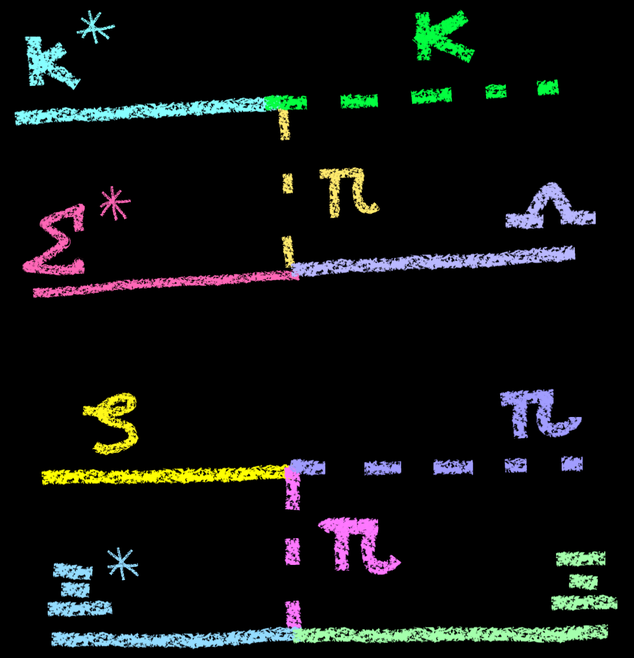


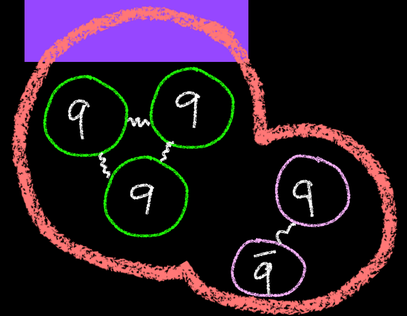
THEORETICAL MODELS

3q STATE



MOLECULAR

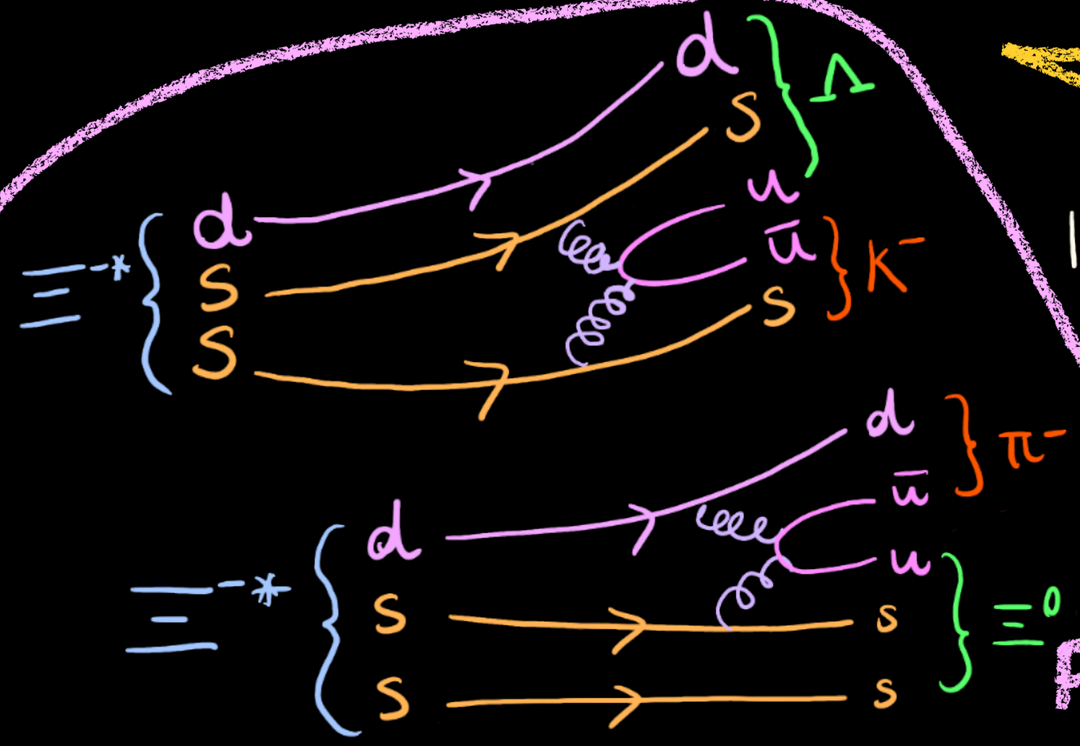




SU(3) CLEBSCH-GORDAN

FROM DECUPLET

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



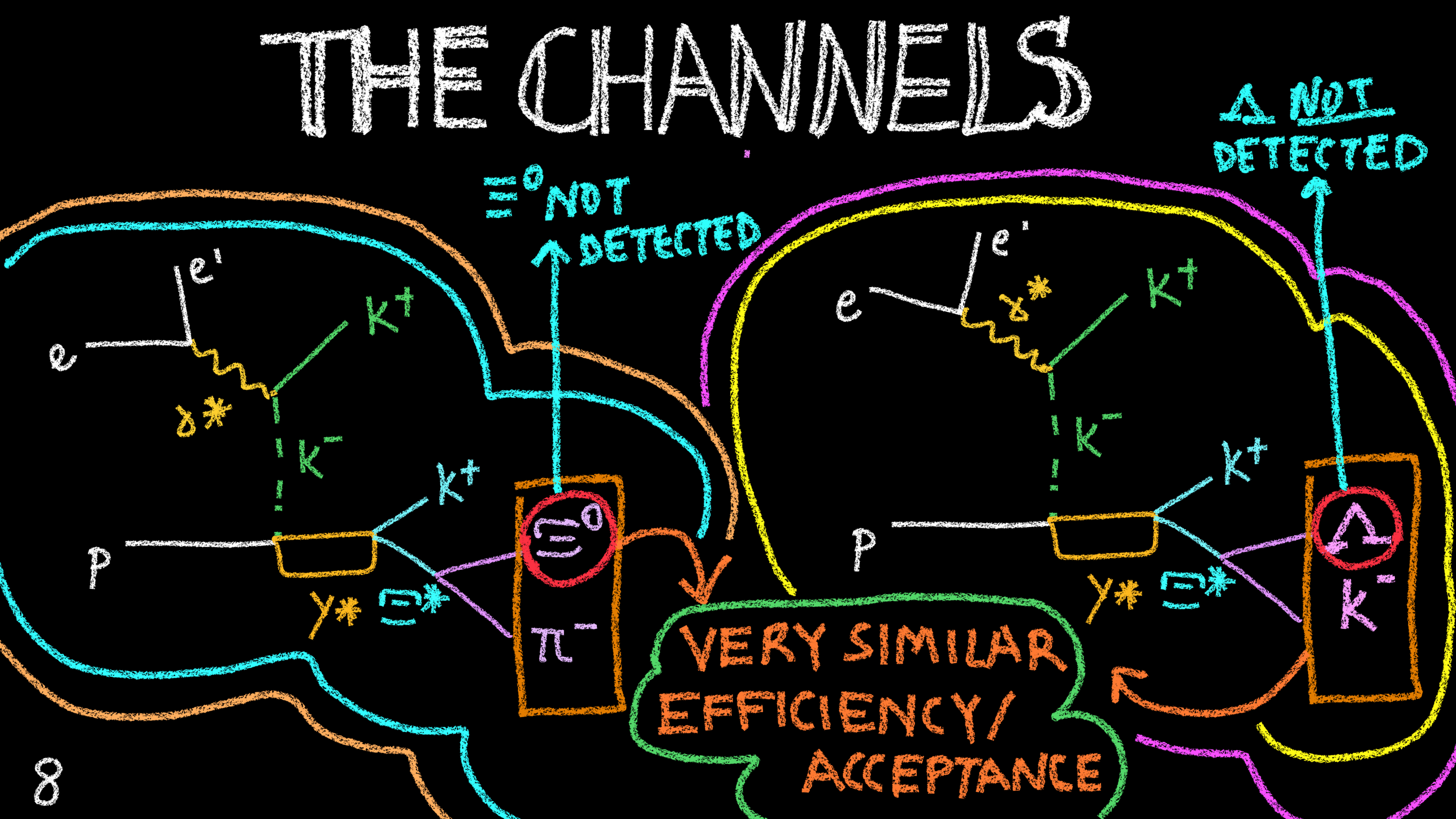
TWO OF THE POSSIBLE CHANNELS

FROM OCTET

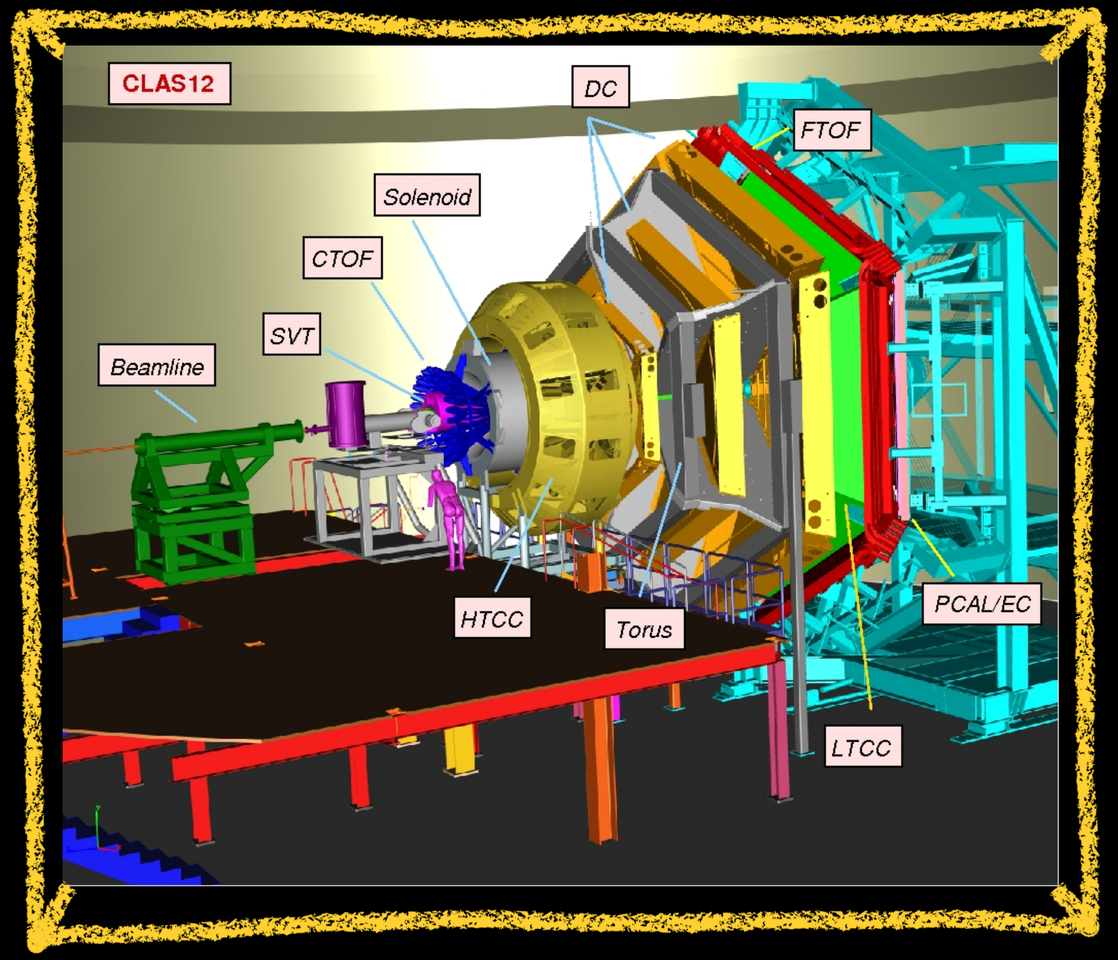
$$|\Xi^*\rangle = \frac{1}{2}|\Xi\pi\rangle + \frac{1}{2}|\Sigma\bar{K}\rangle - \frac{1}{2}|\Xi\eta\rangle + \frac{1}{2}|\Lambda\bar{K}\rangle$$

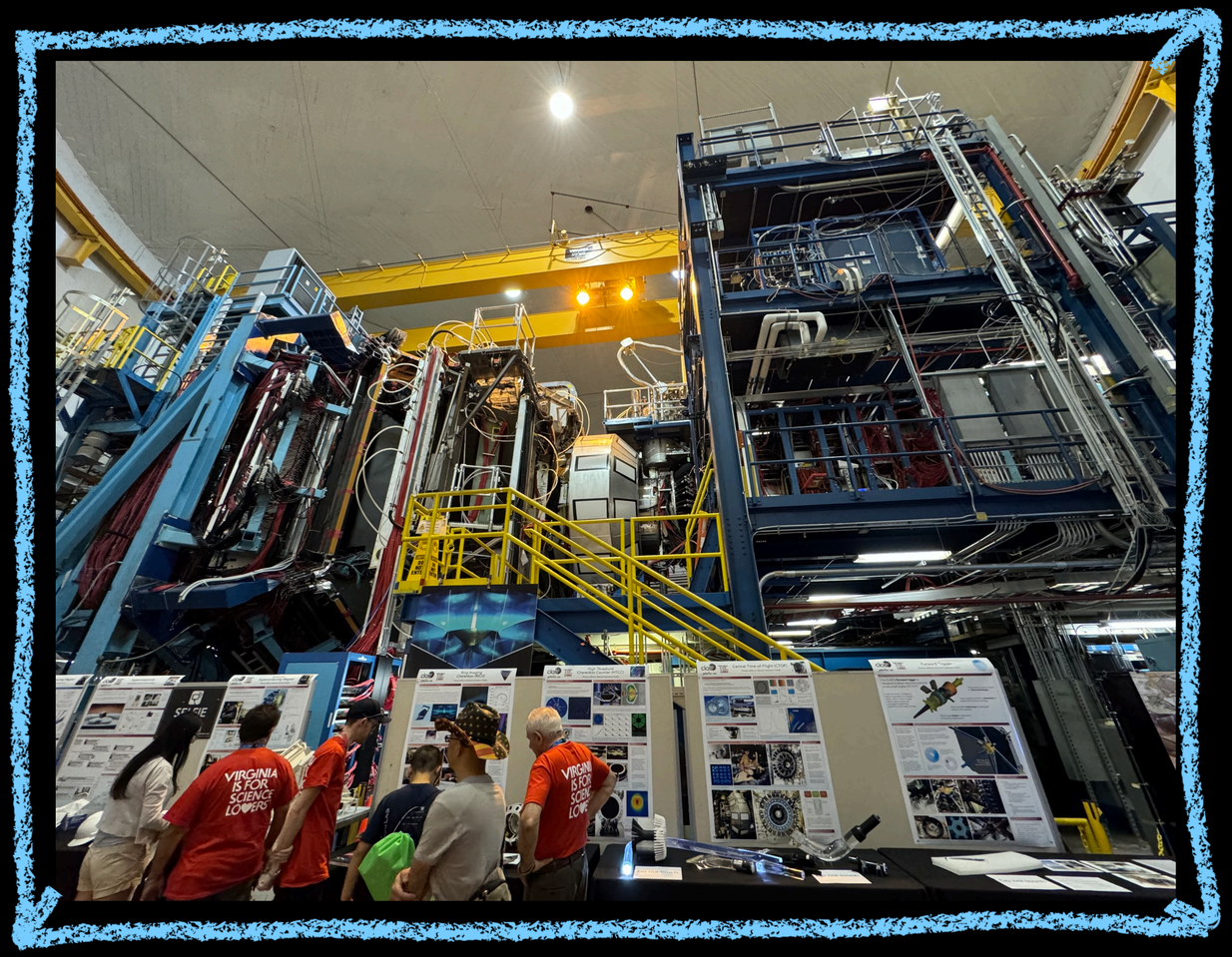
ALL CHANNELS POSSIBLE!

THE CHANNELS

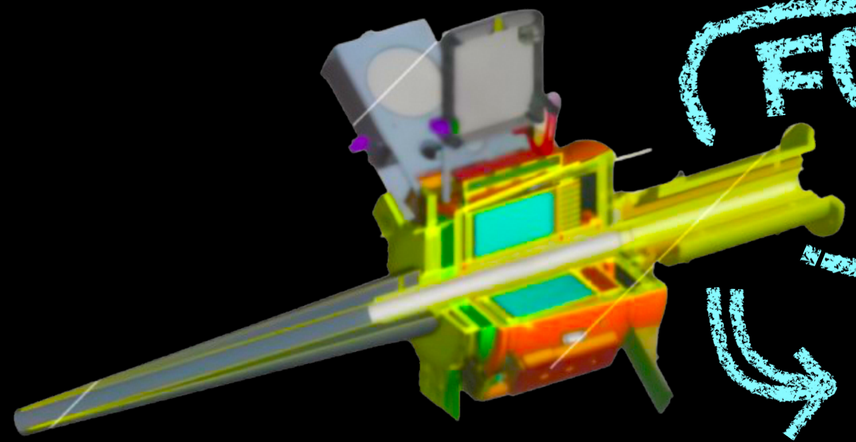


CLAS12


CLAS12
DC
FTOF
Solenoid
CTOF
SVT
Beamline
HTCC
Torus
PCAL/EC
LTCC

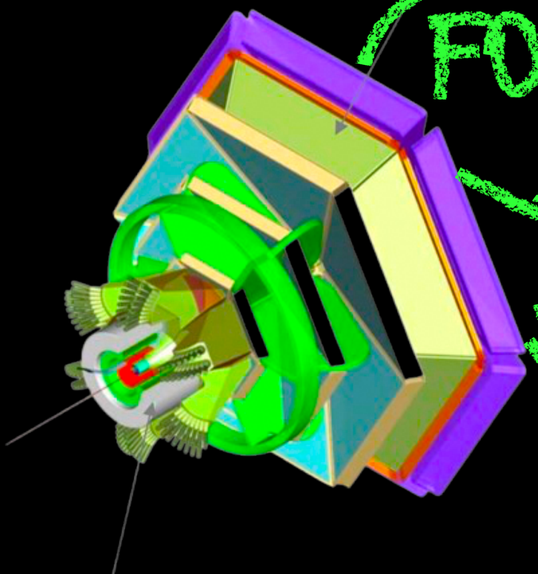

VIRGINIA IS FOR SCIENCE LOVERS

DETECTORS



FORWARD TAGGER

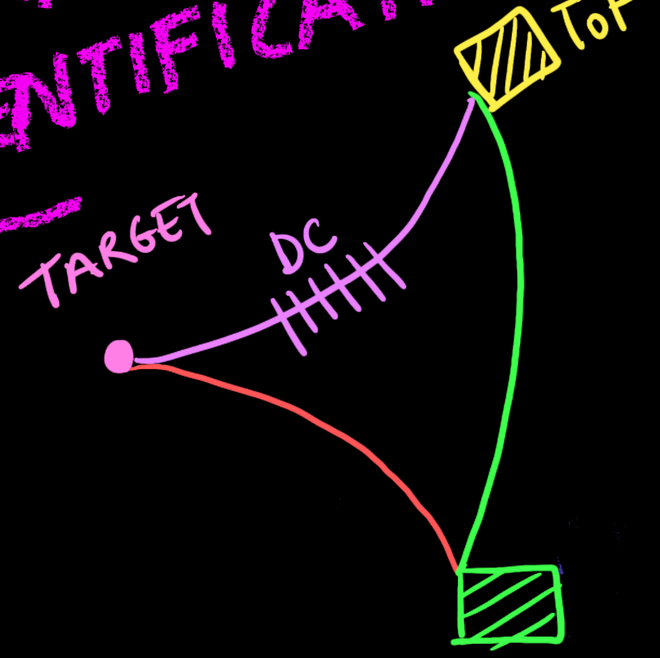
* $2.5^\circ < \theta < 4.5^\circ$
* LOW Q^2
* CALORIMETER



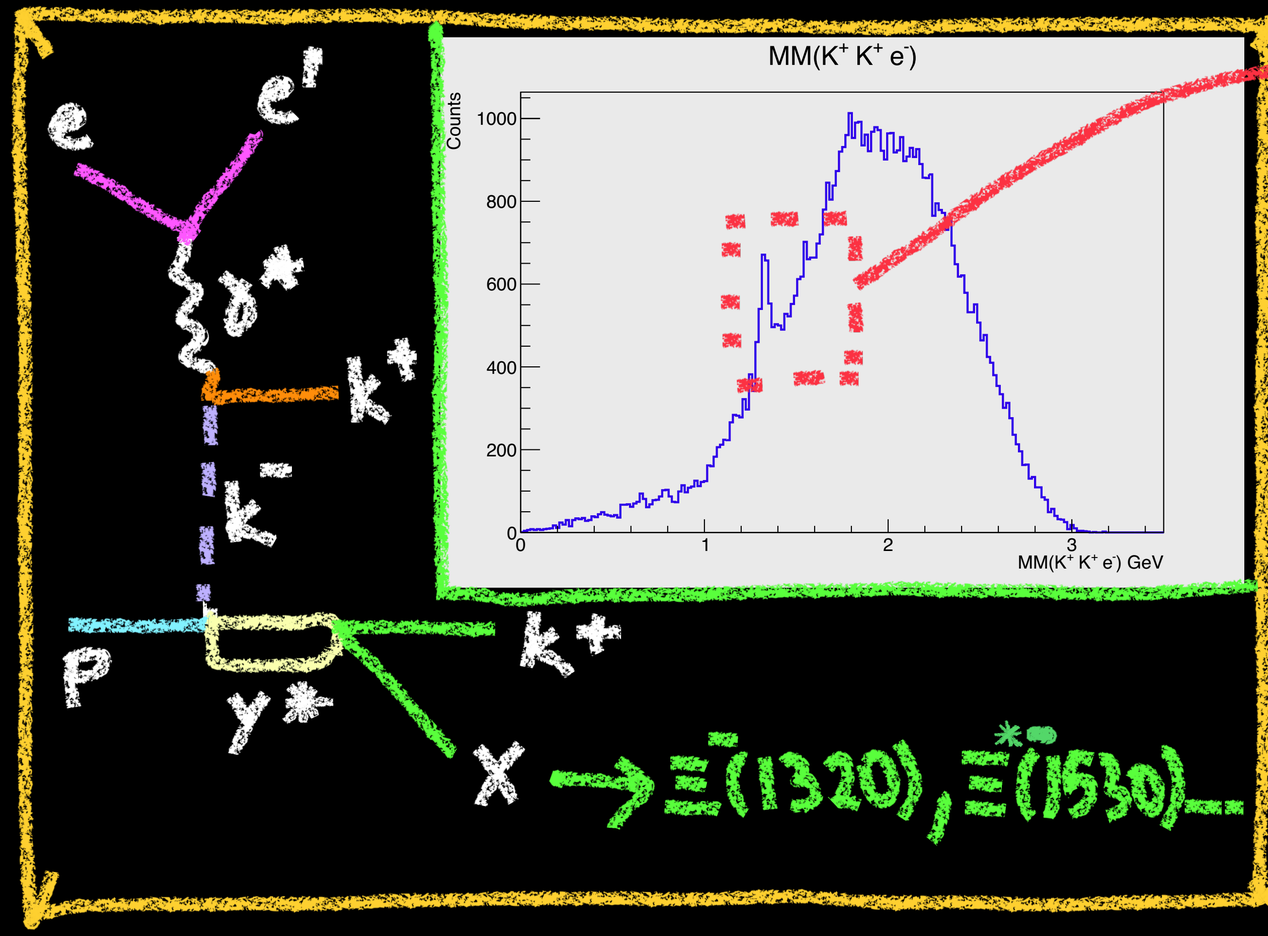
FORWARD DETECTOR

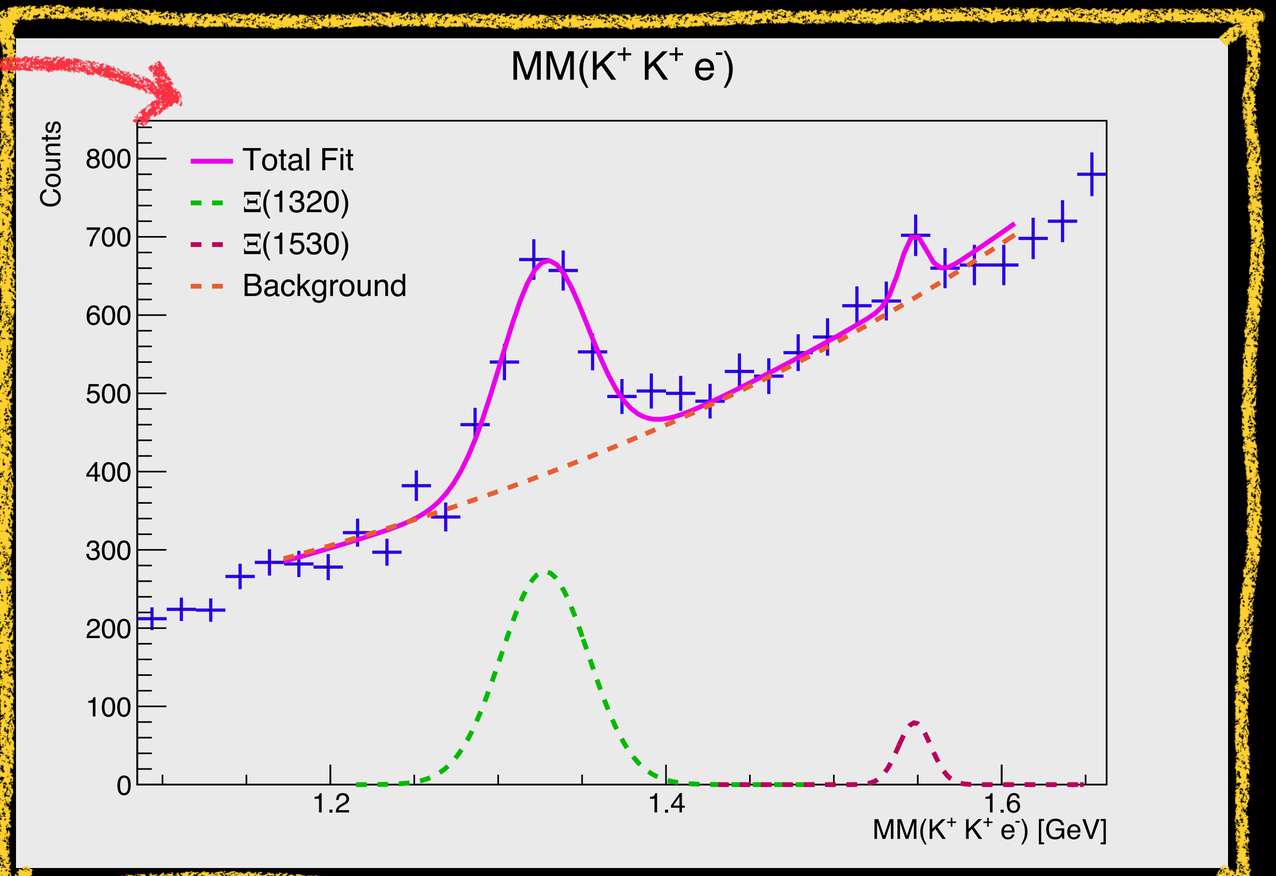
* $5^\circ < \theta < 35^\circ$
* HIGH Q^2
* MAGNETIC SPECTROSCOPY

PARTICLE IDENTIFICATION



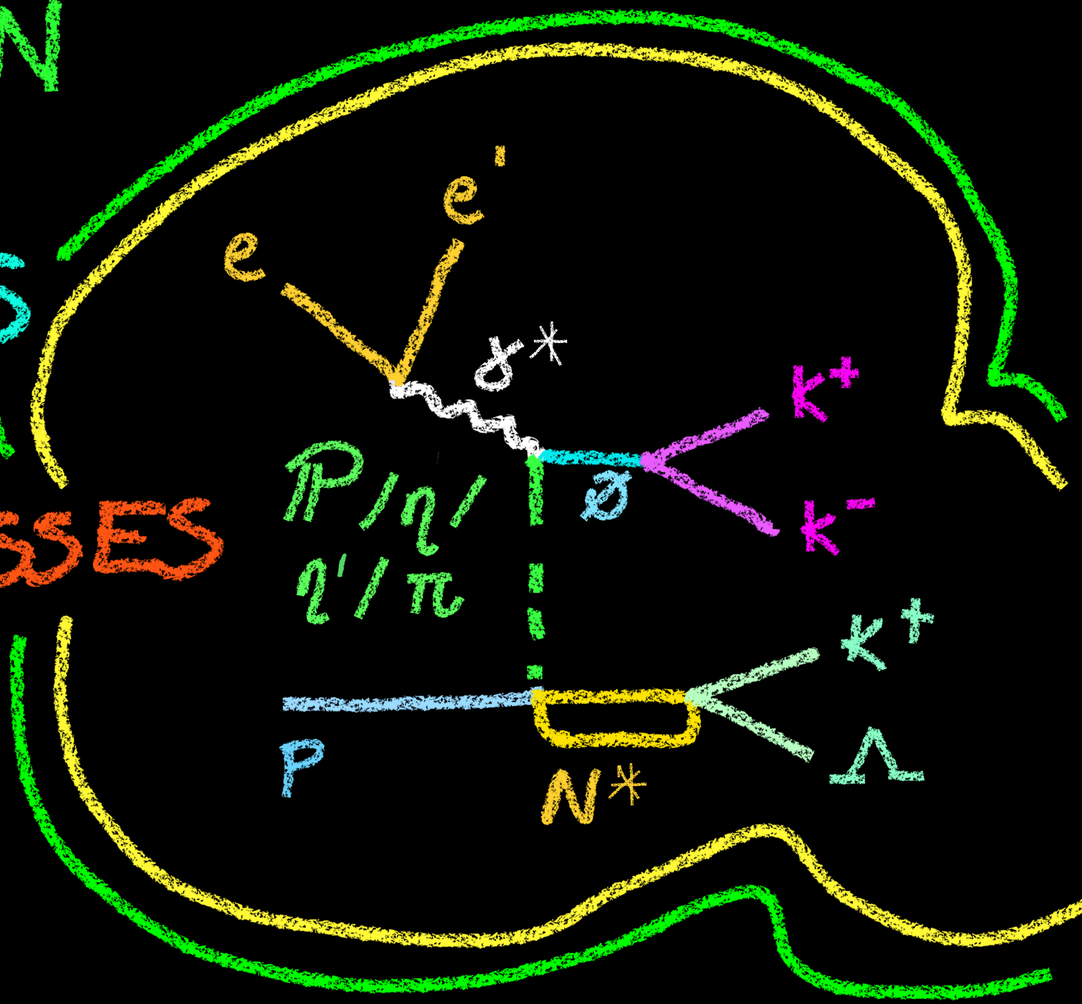
FORWARD DETECTOR





BACKGROUND

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



Kaon ID

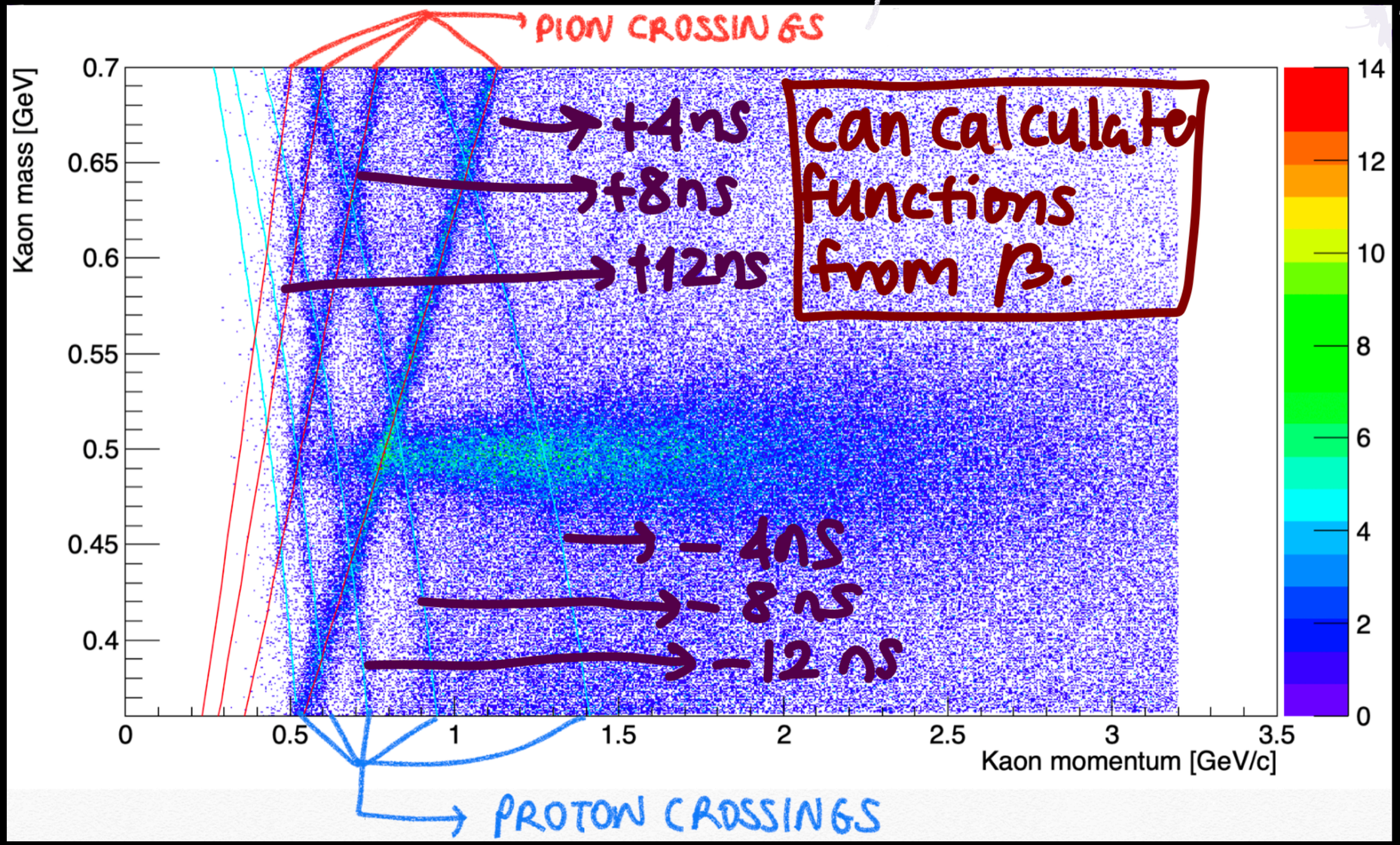
PDF's used in s-weights don't have to be 1-D.

↳ can use kaon mass as a discriminatory variable (it's a 2D PDF)

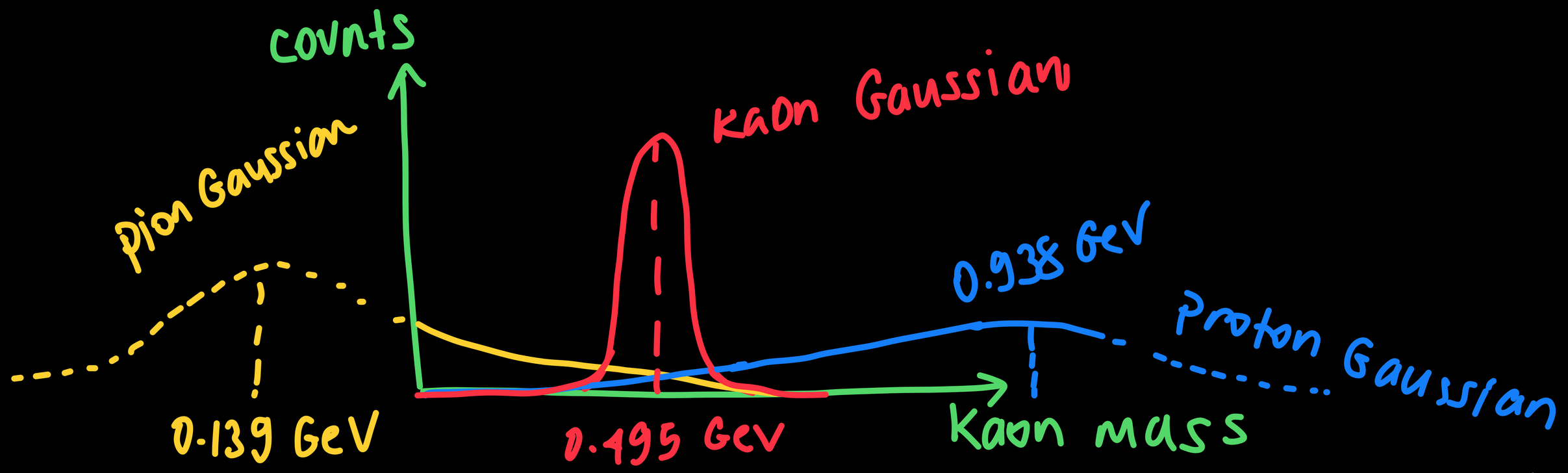
↳ can utilise both kaons (sequential s-weighting)

TWO KAONS USED TO PLOT KAON MASS VS KAON MOMENTUM.

PDF's are not as simple as example, but we can still make a good model.

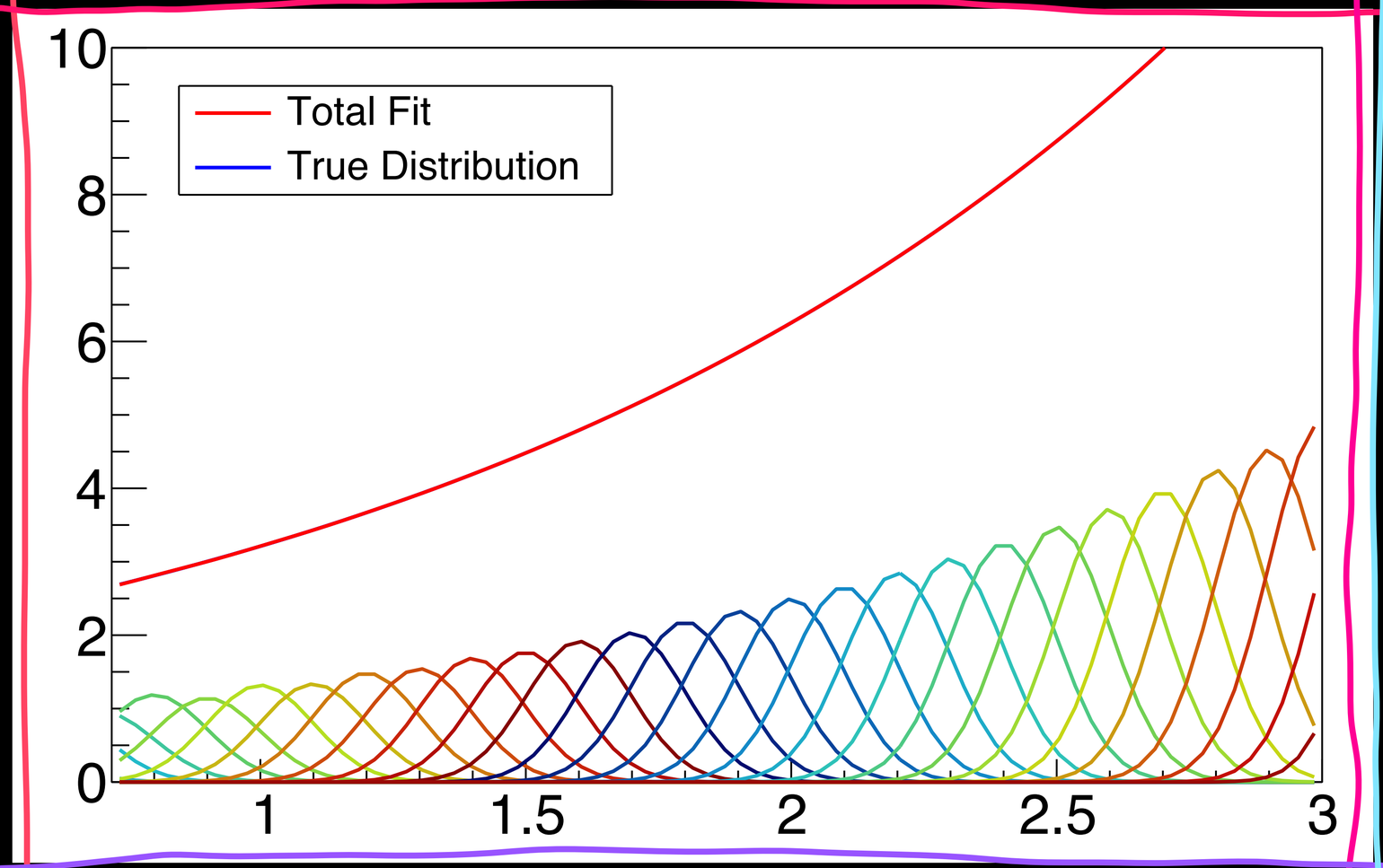


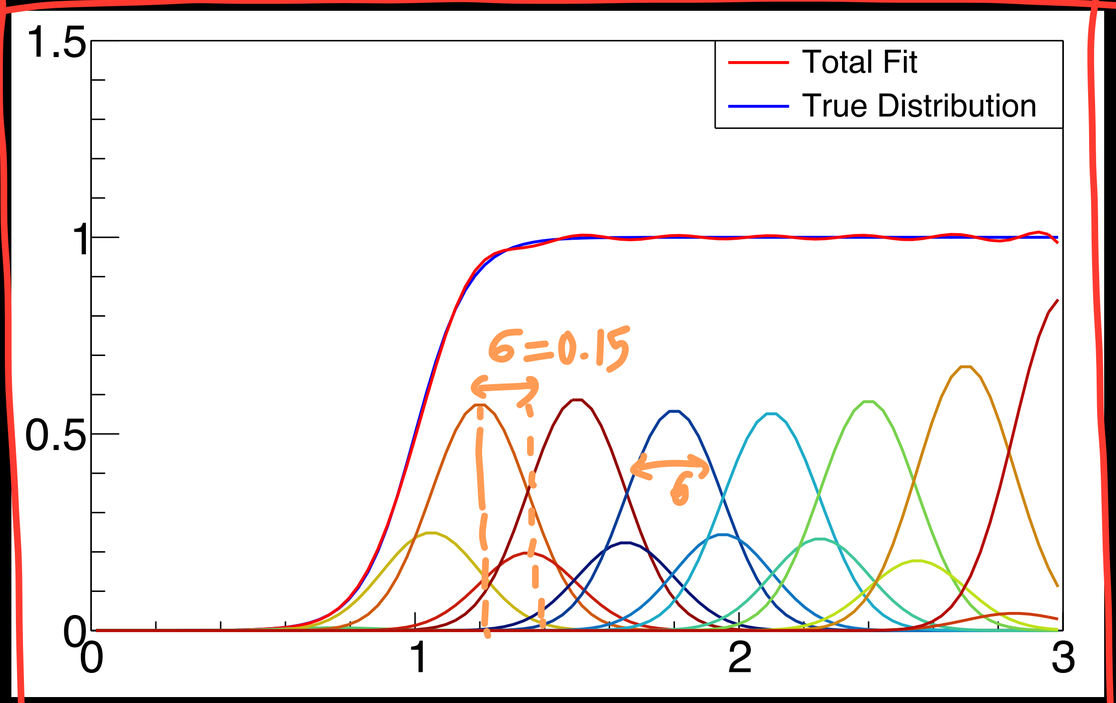
- Model signal with Gaussian at kaon mass
- Model background with the sum of 1 Gaussian at pion mass and 1 Gaussian at proton mass.



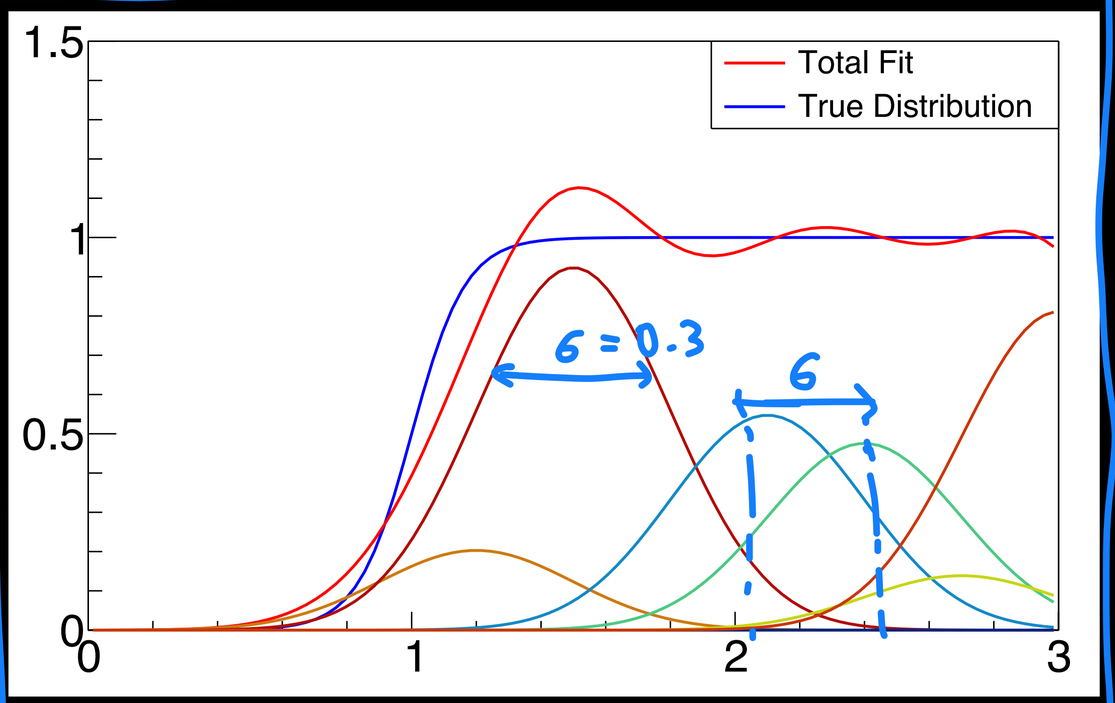
GAUSSIAN SAMPLING

1. HAS PROPER ASYMPTOTICAL BEHAVIOUR.
2. POSITIVELY DEFINED.
3. CONTROL of SMOOTHNESS.
4. FLEXIBLE.
5. NO CROSS-CORRELATION.
6. ONE PARAMETER PER GAUSSIAN (HEIGHT).





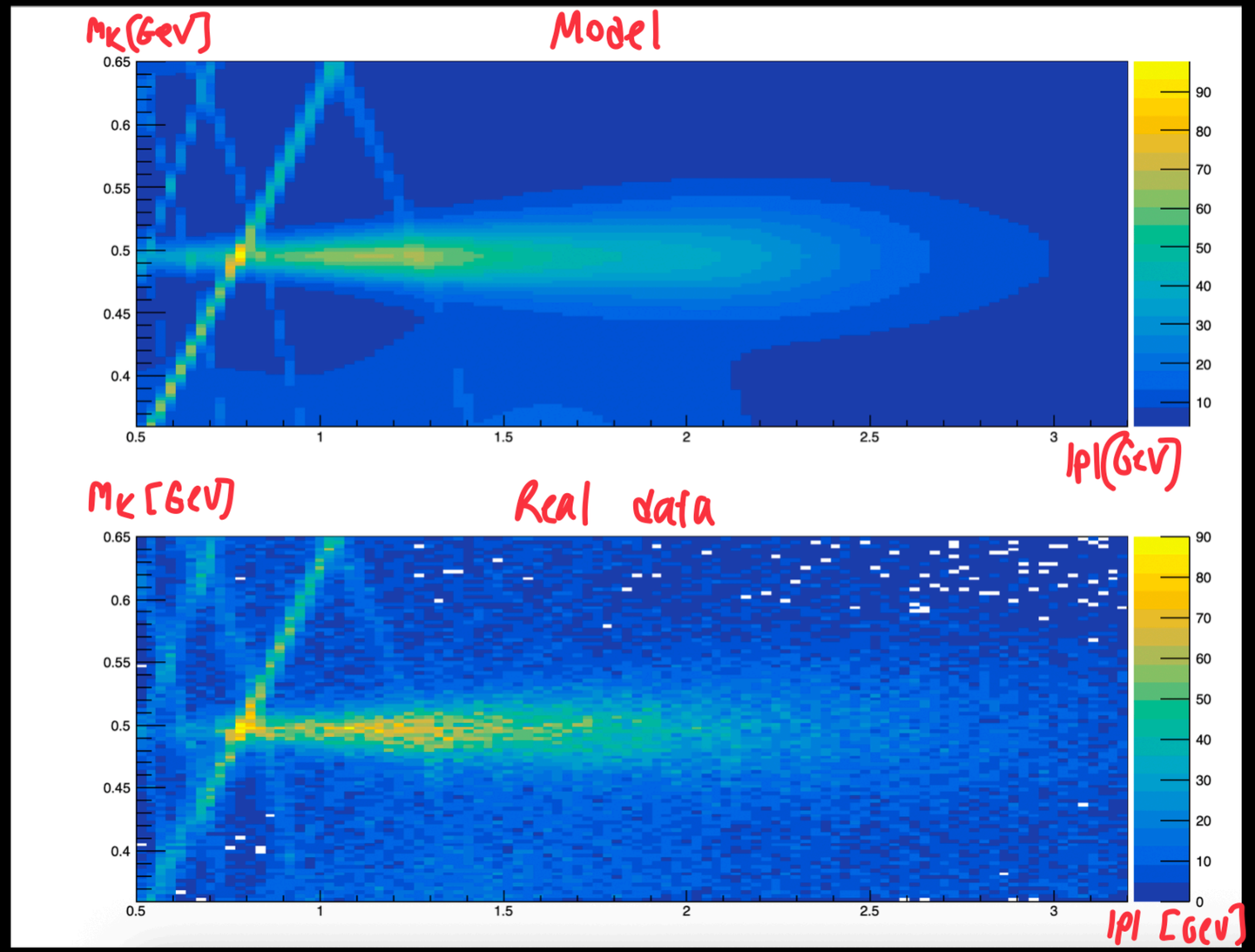
GAUSSIAN WIDTH : 0.15



GAUSSIAN WIDTH: 0.3

- SMOOTHNESS of FIT DEPENDS ON σ & BEHAVIOUR of FUNCTION.

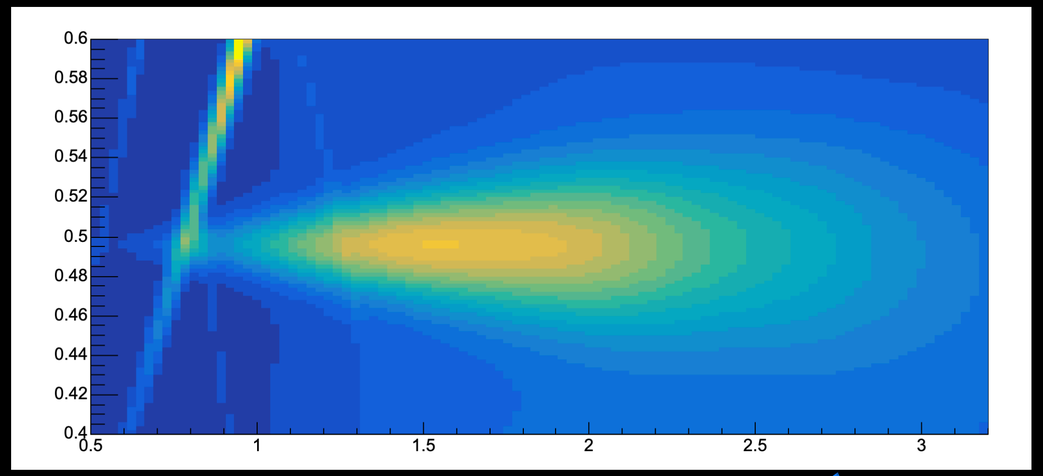
IF WE PUT IT ALL TOGETHER...



BOTH KAONS USED TO FIT, NO DISCRIMINATION

FIT BOTH KAONS SEPARATELY

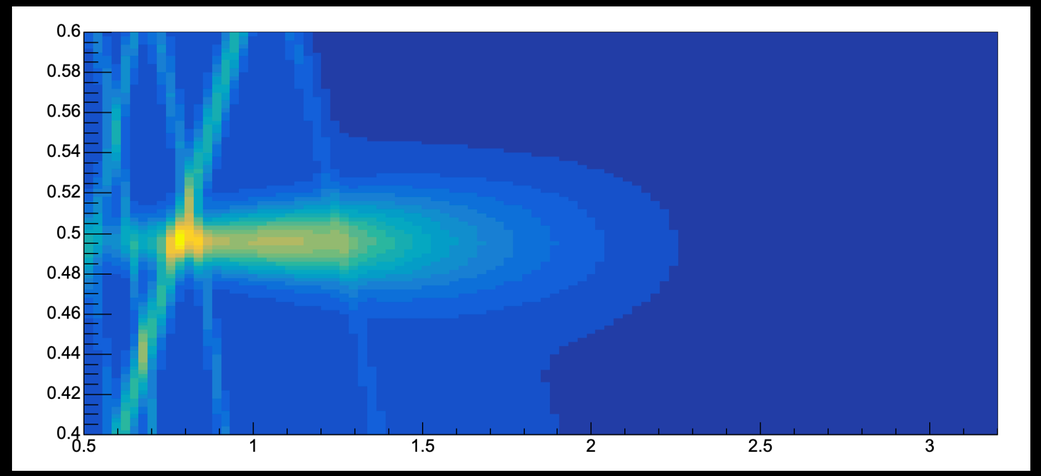
KAON 1 - FIT



m_K [GeV]

$|\vec{p}|$ [GeV]

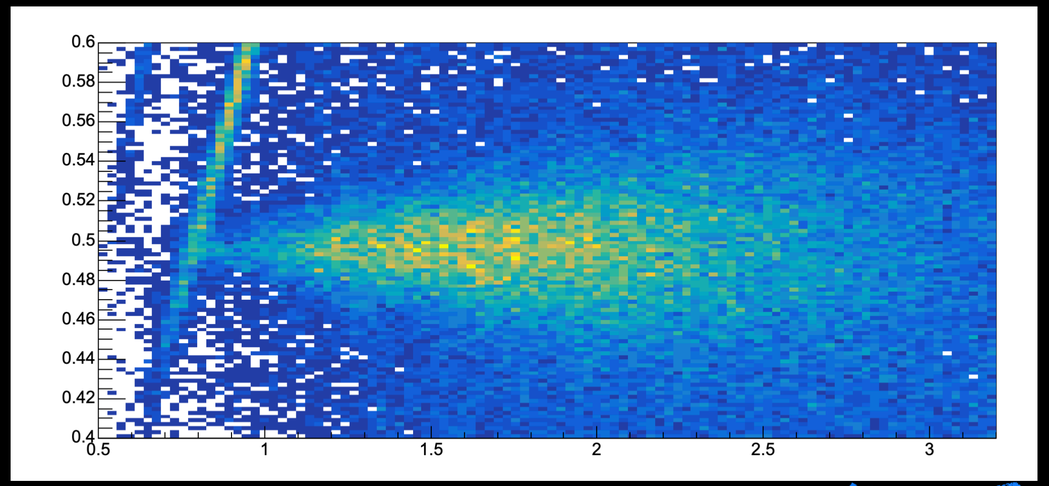
KAON 2 - FIT



m_K [GeV]

$|\vec{p}|$ [GeV]

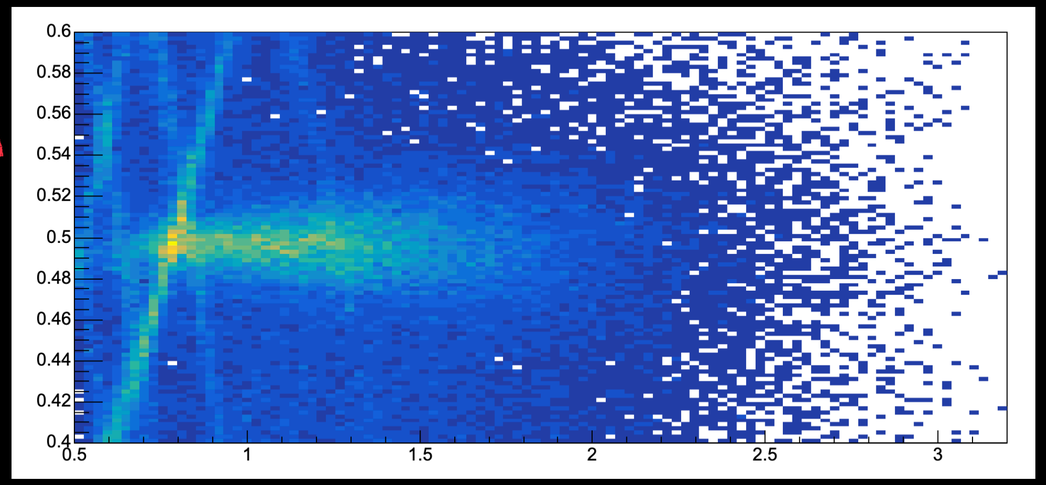
KAON 1 - DATA



m_K [GeV]

$|\vec{p}|$ [GeV]

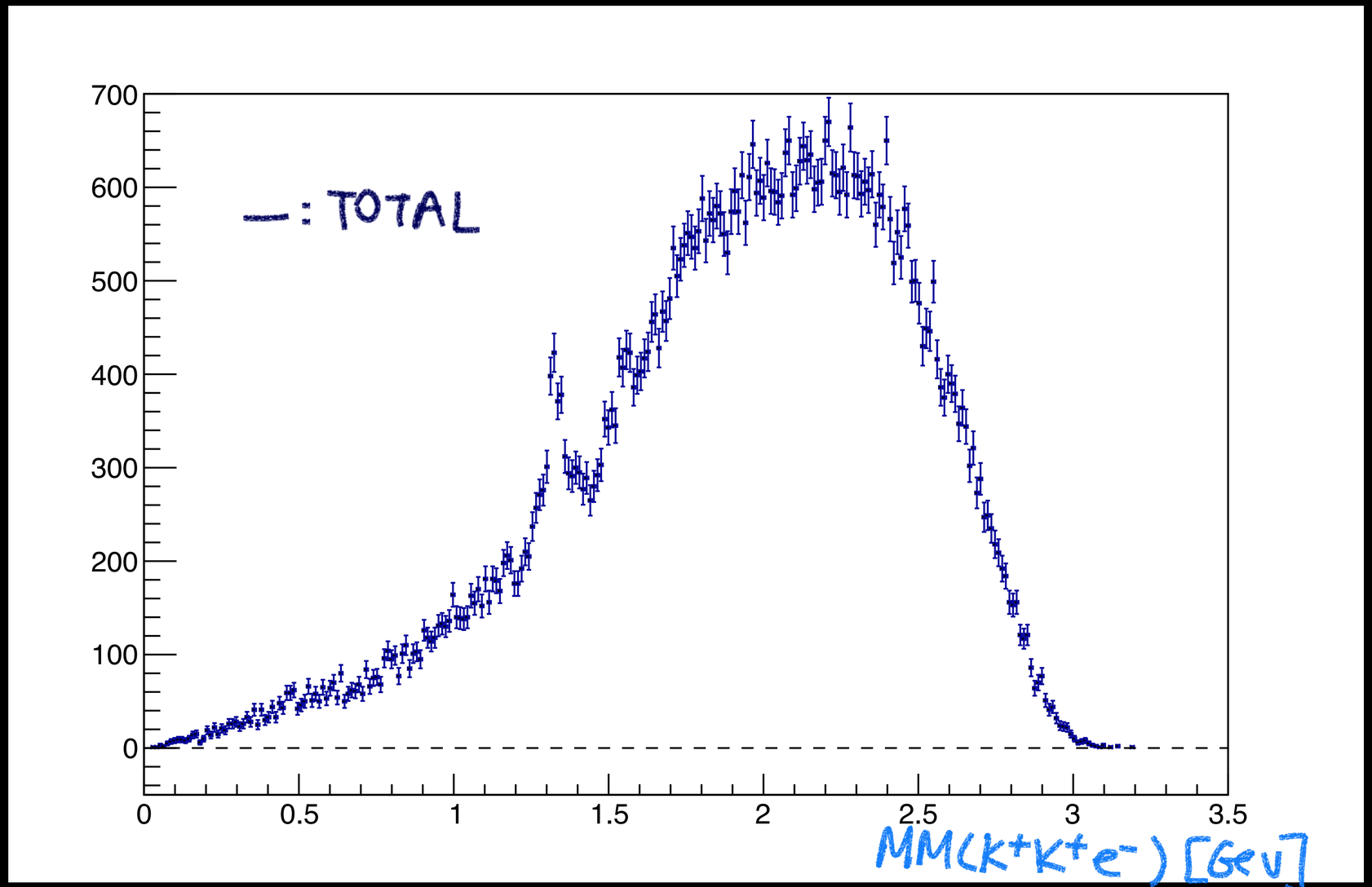
KAON 2 - DATA



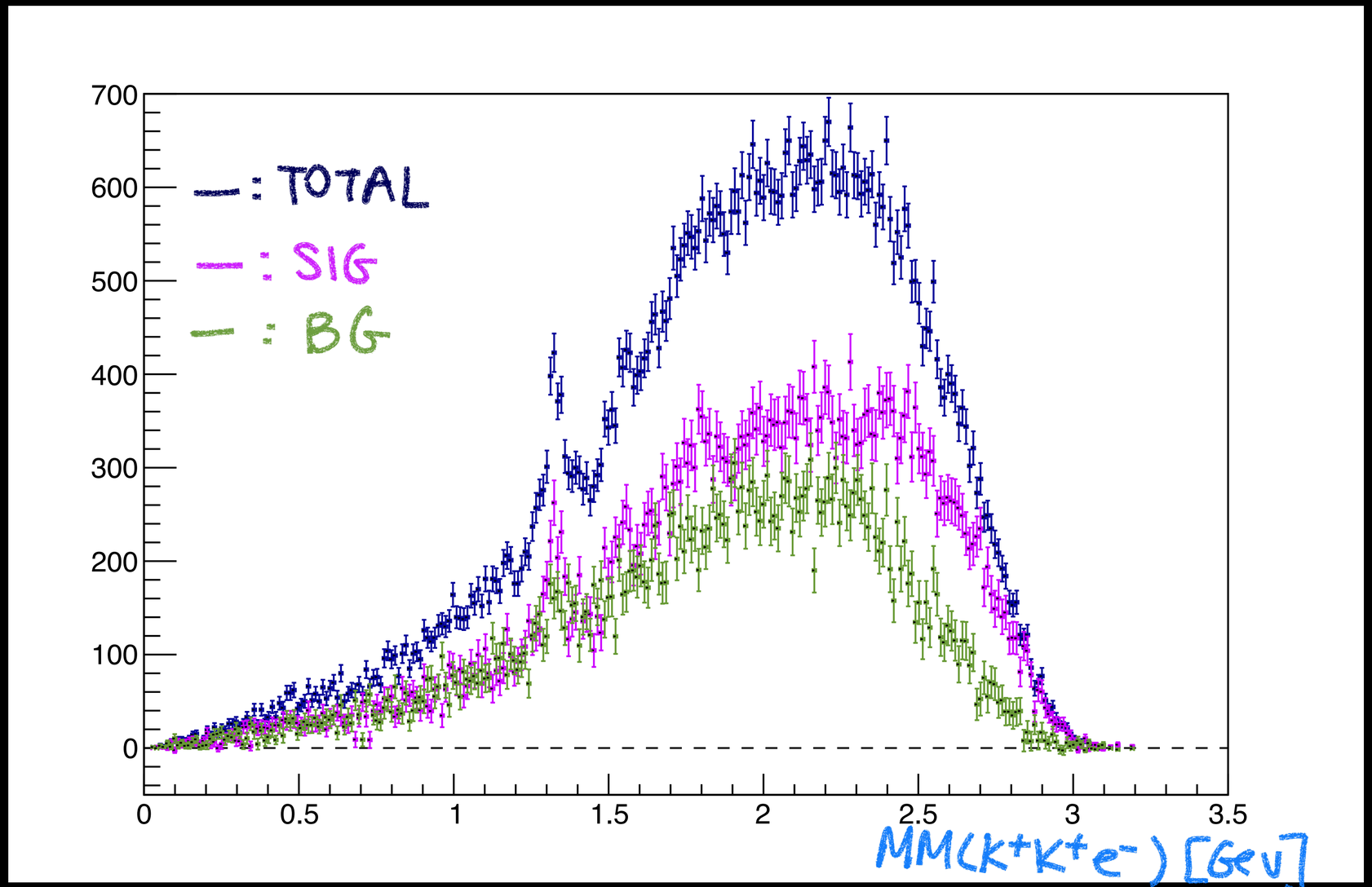
m_K [GeV]

$|\vec{p}|$ [GeV]

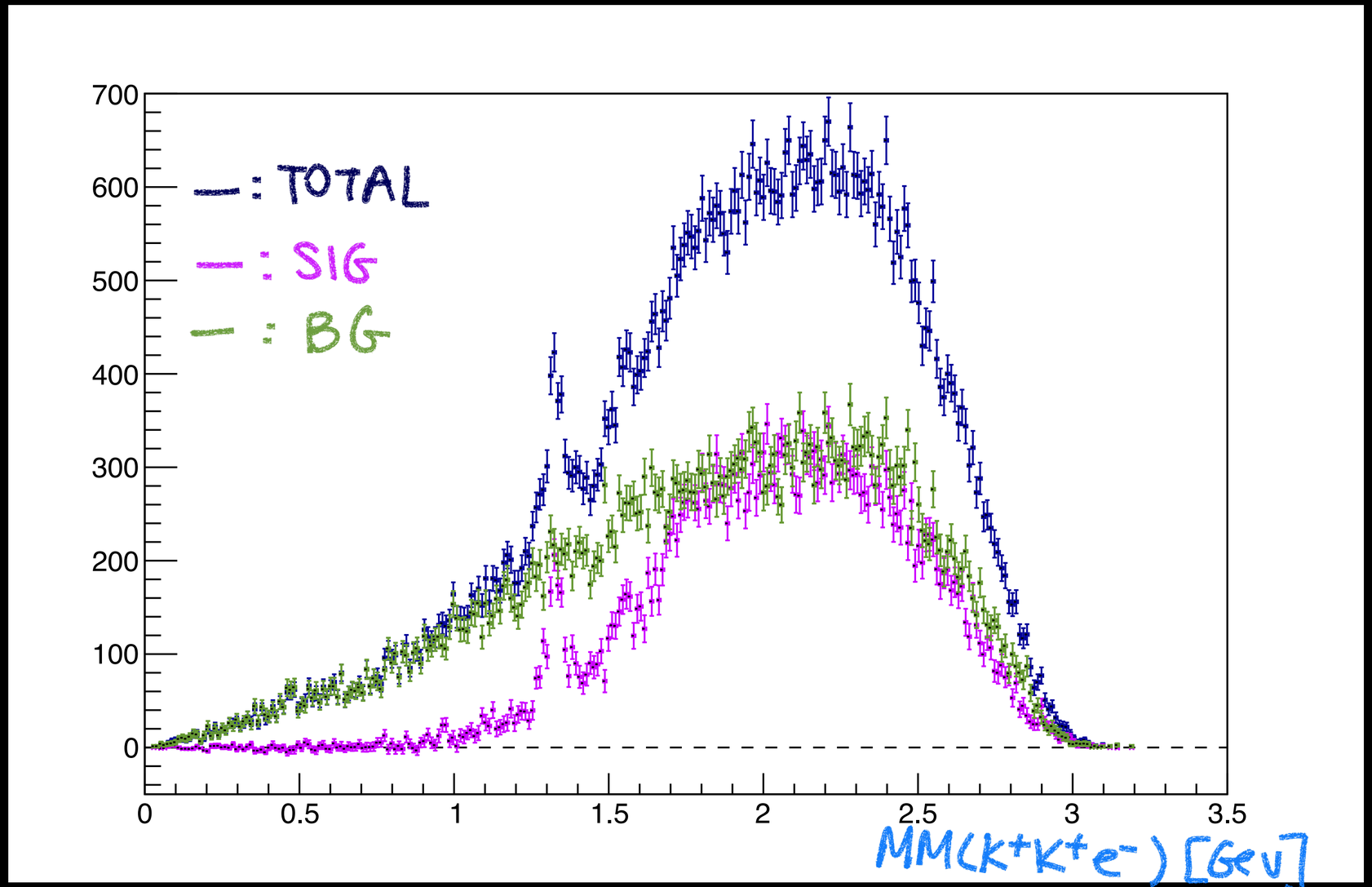
TOTAL MISSING MASS ($K^+K^+e^-$)



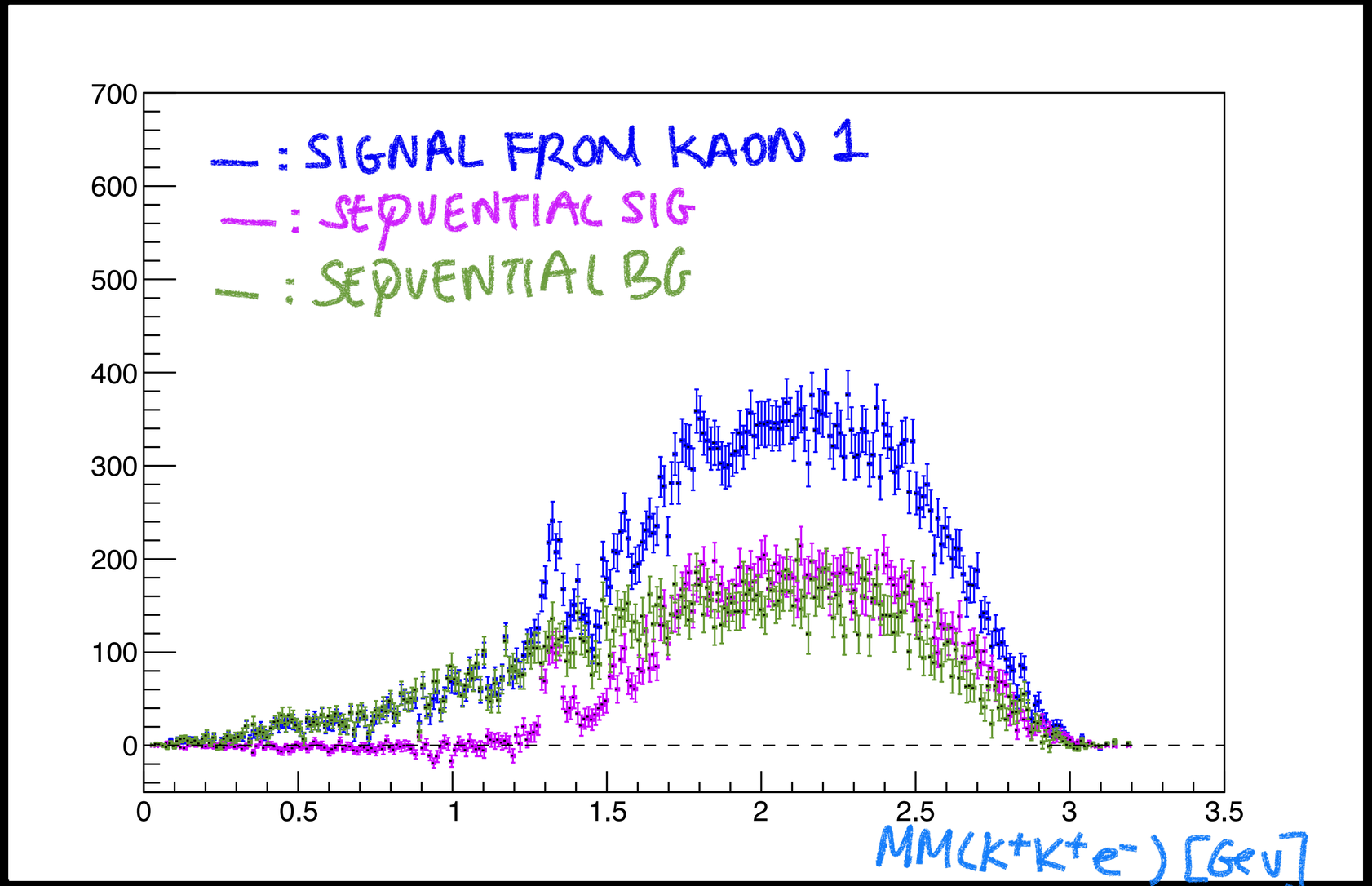
S-WEIGHTED MM($K^+K^+e^-$) FROM KAON 1



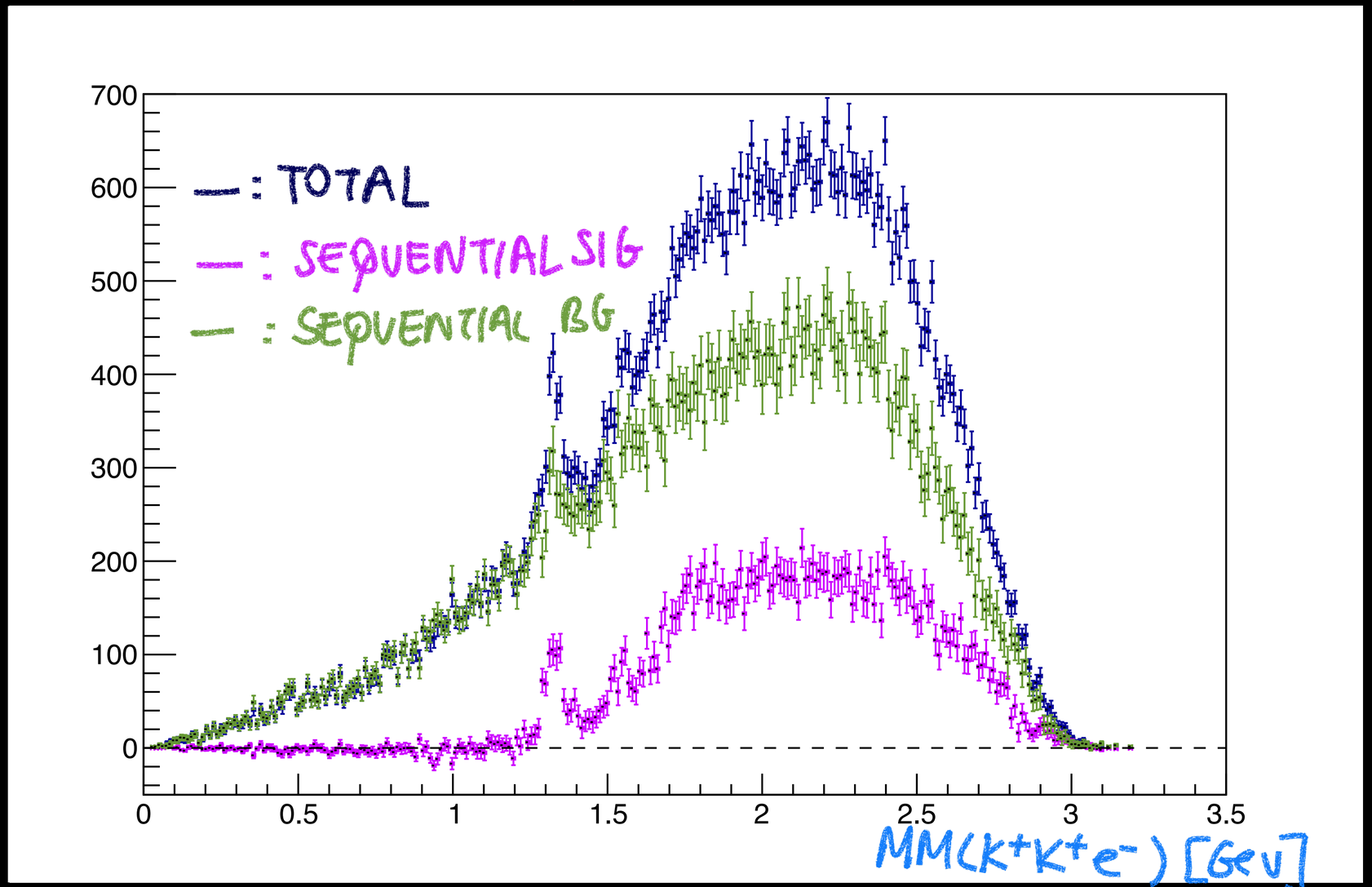
S-WEIGHTED MM($K^+K^+e^-$) FROM KAON 2

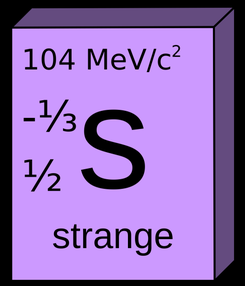


S-WEIGHTED MM($K^+K^+e^-$) FROM KAON 1 & KAON 2

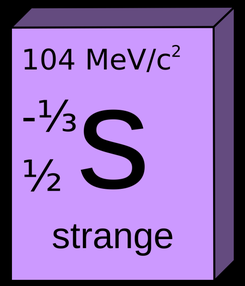


S-WEIGHTED MM($K^+K^+e^-$) FROM KAON 1 & KAON 2



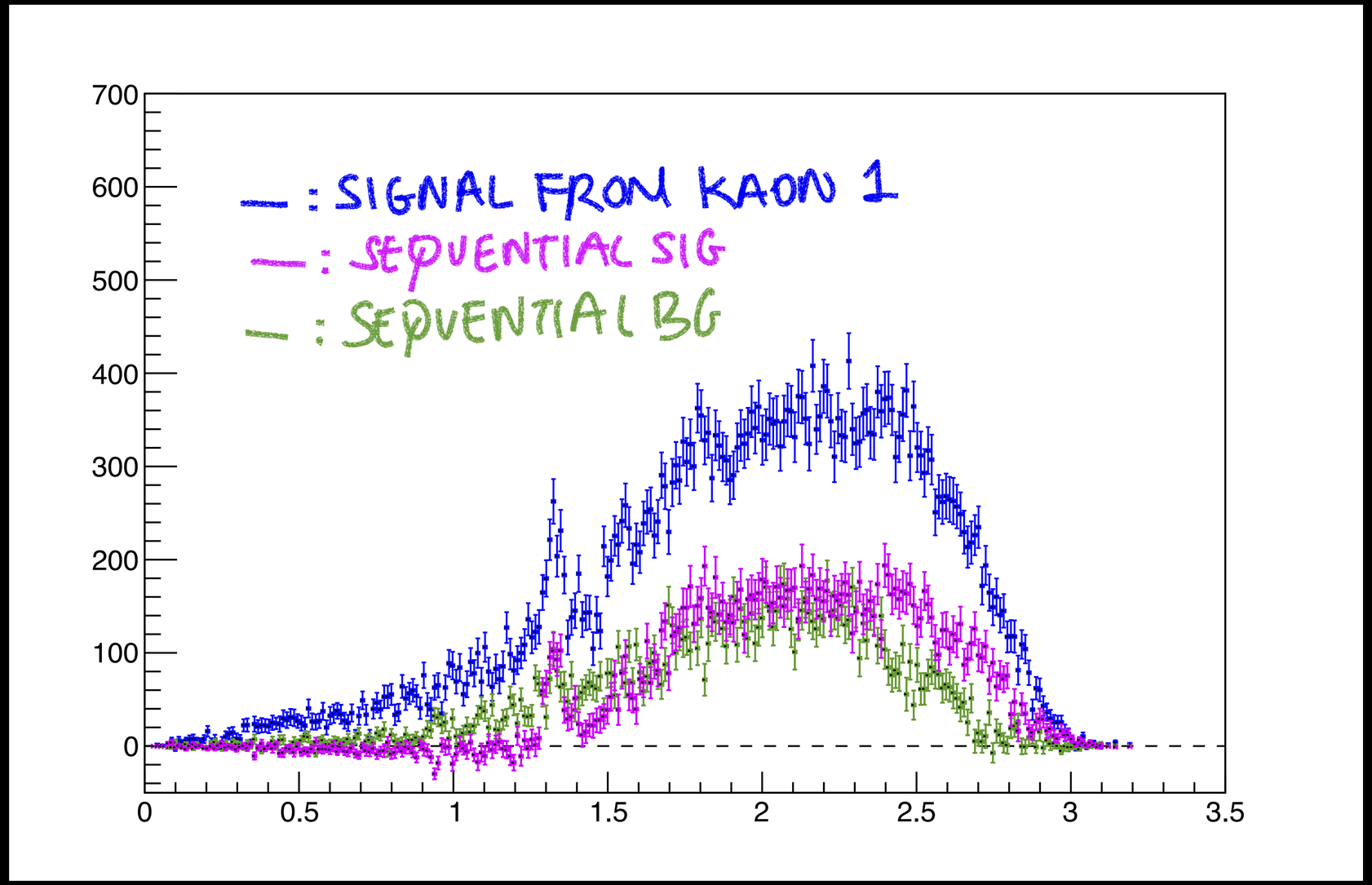


CONCLUSIONS

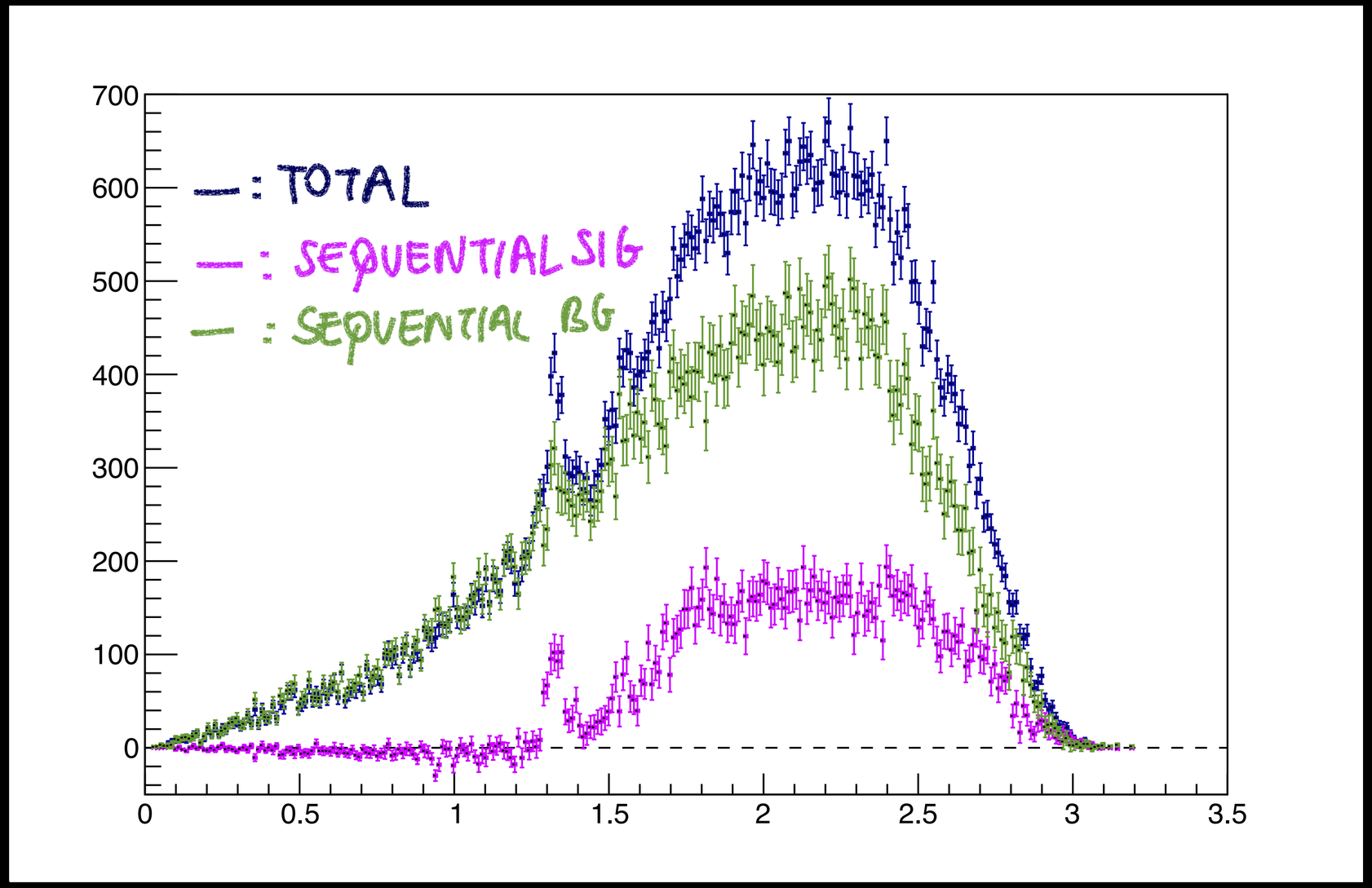


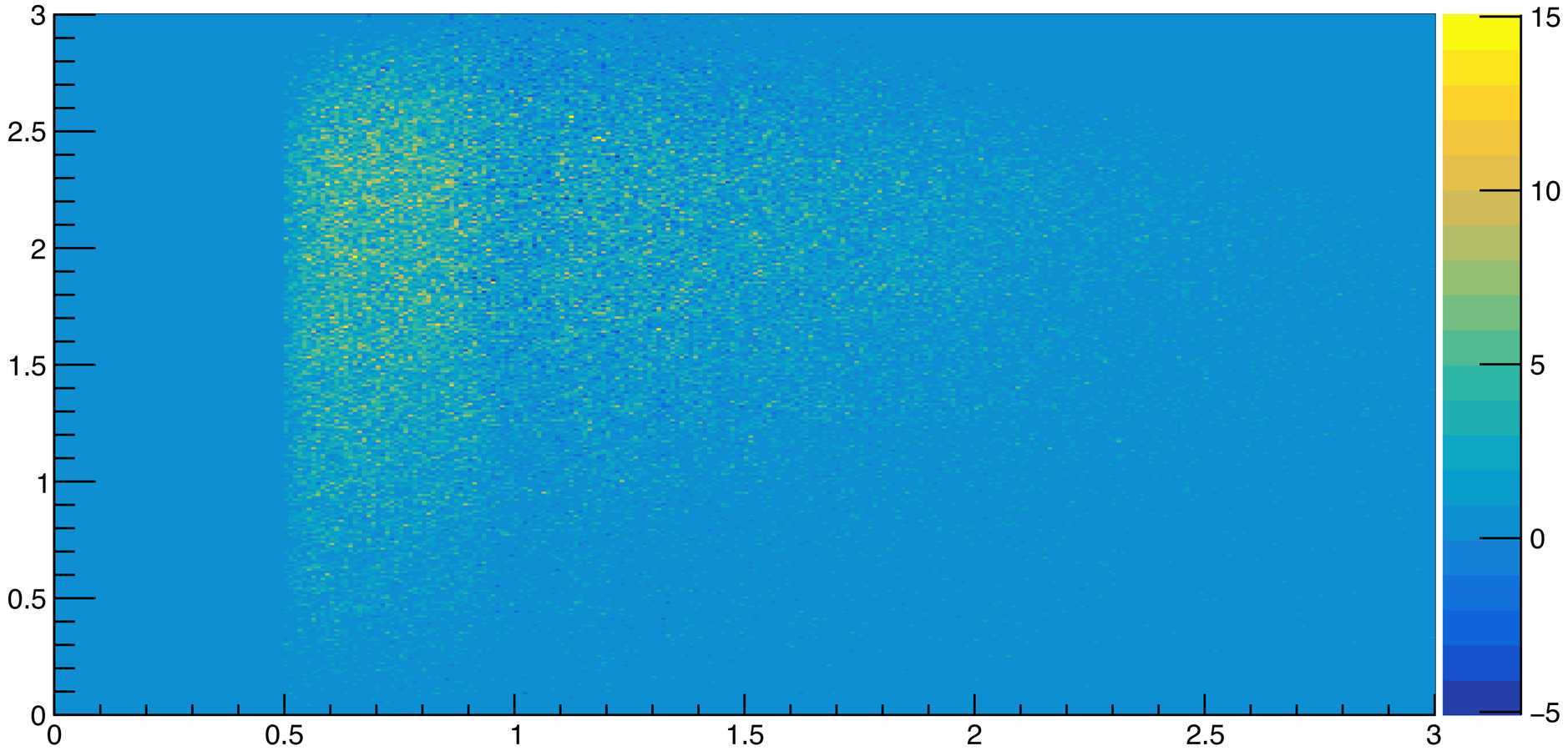
1. New universal technique of particle ID
2. Testing on different run groups (RGA, RGB, RGM)
3. New way of clean analysis of strange channels (strange, very strange, very very strange).
4. Clean cascade extraction
5. Additional sequential s-weights to eliminate physical background.

S-WEIGHTED MM($K^+K^+e^-$) FROM KAON2 & KAON 1



S-WEIGHTED MM($K^+K^+e^-$) FROM KAON2 & KAON1




3
2.5
2
1.5
1
0.5
0
0
0.5
1
1.5
2
2.5
3
15
10
5
0
−5