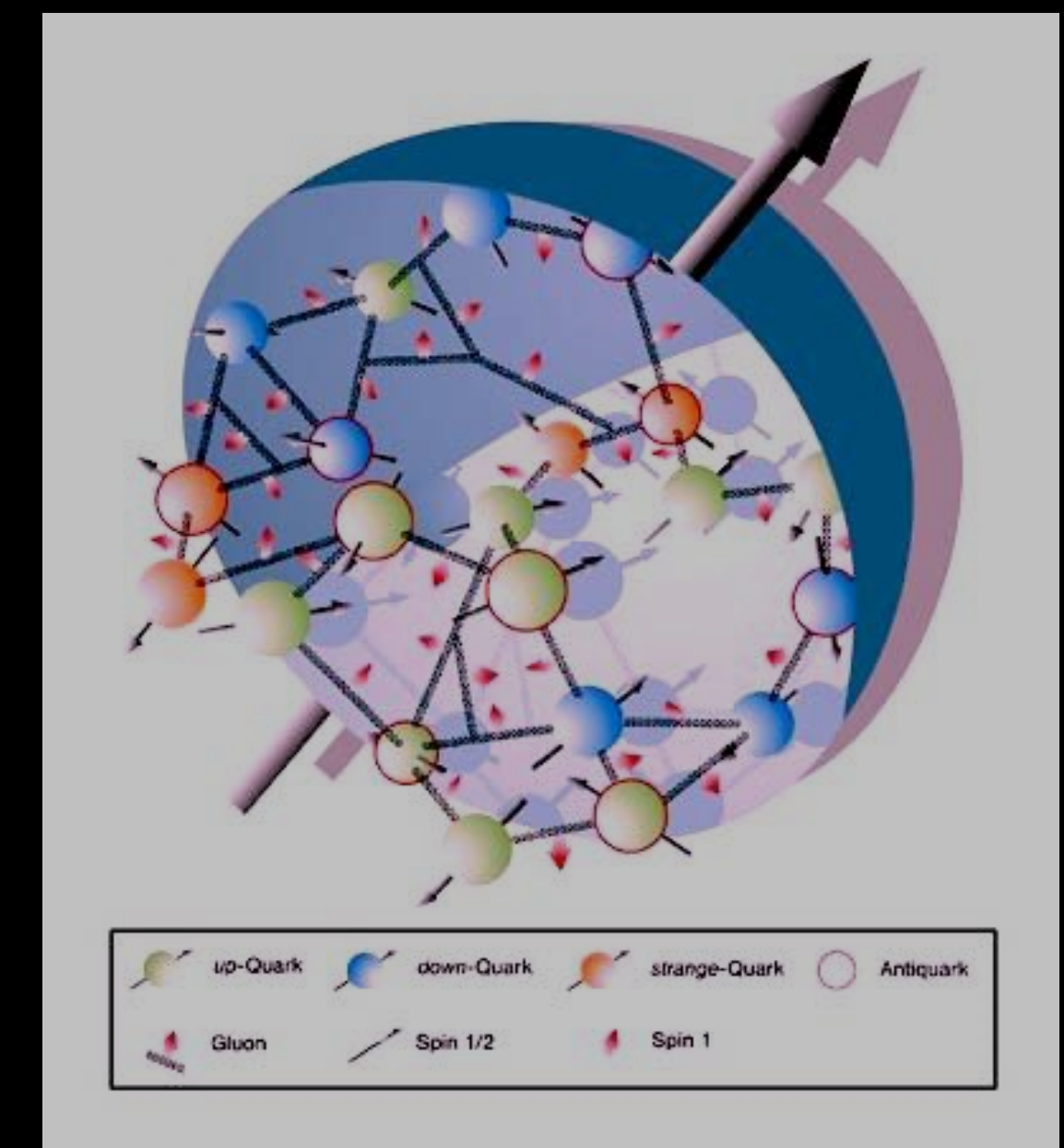
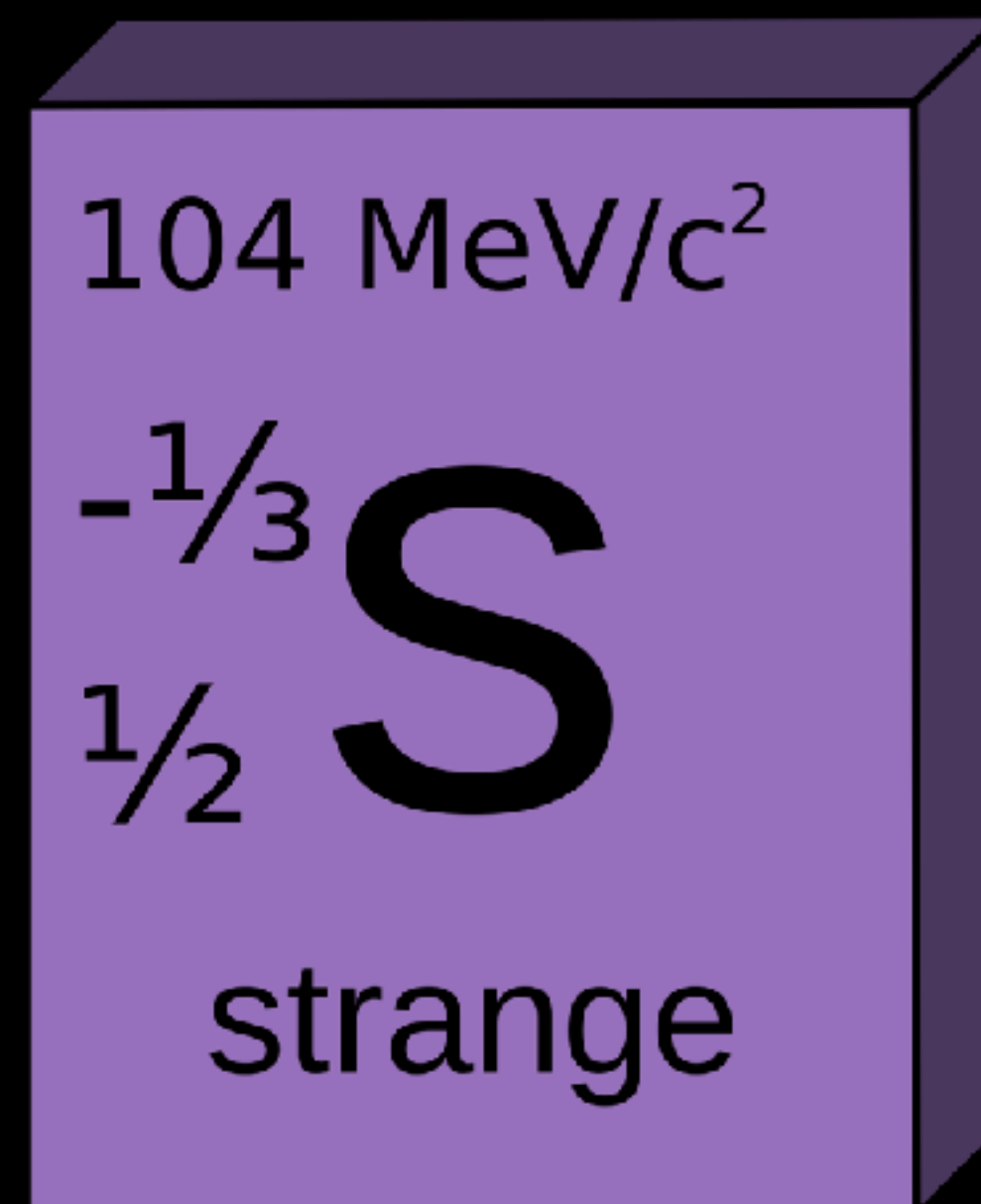
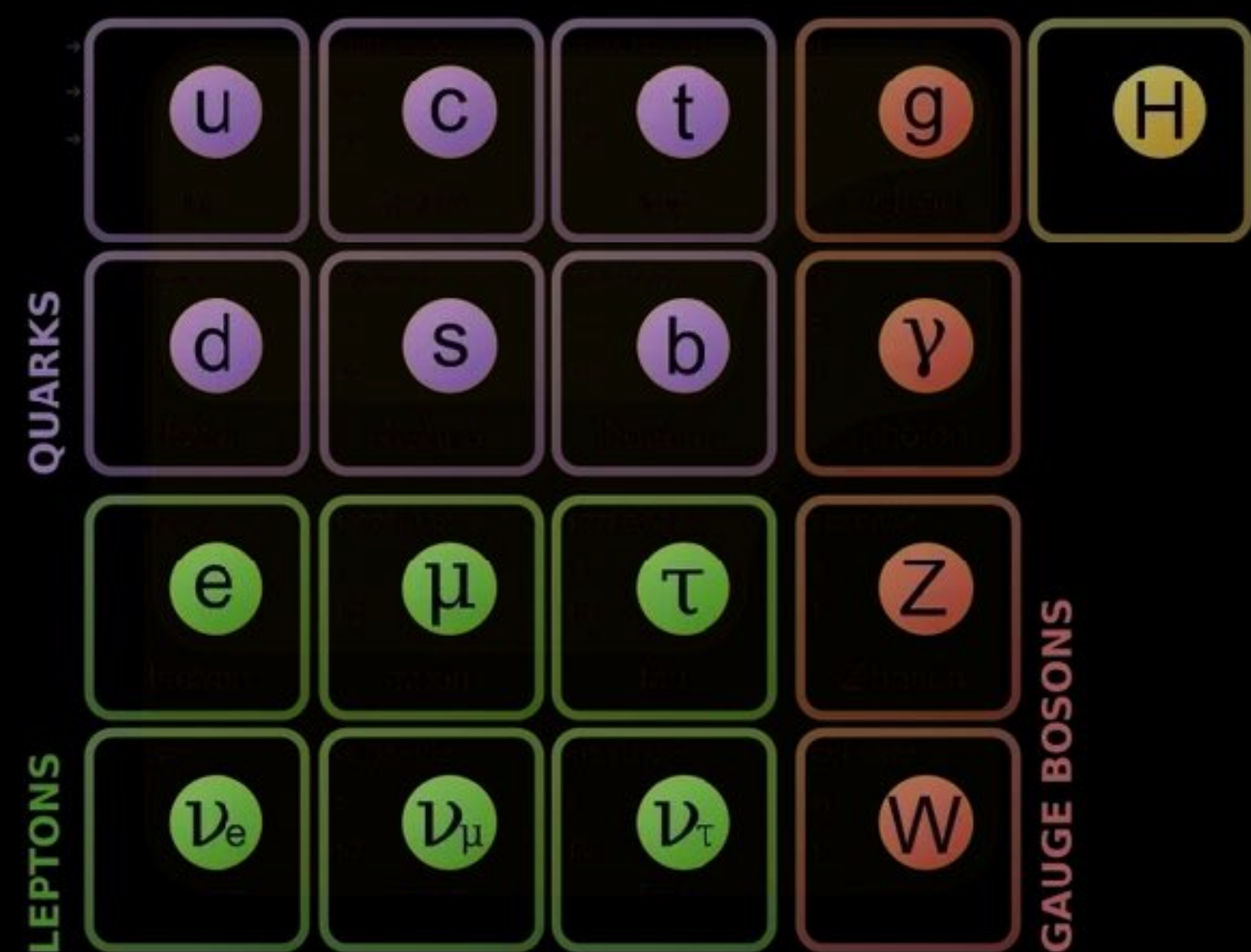


ELUCIDATING STRANGENESS

with

ELECTROMAGNETIC PROBES



ASLI ACAR & MIKHAIL BASHKANDV – UNIVERSITY of YORK

QCD PUZZLES

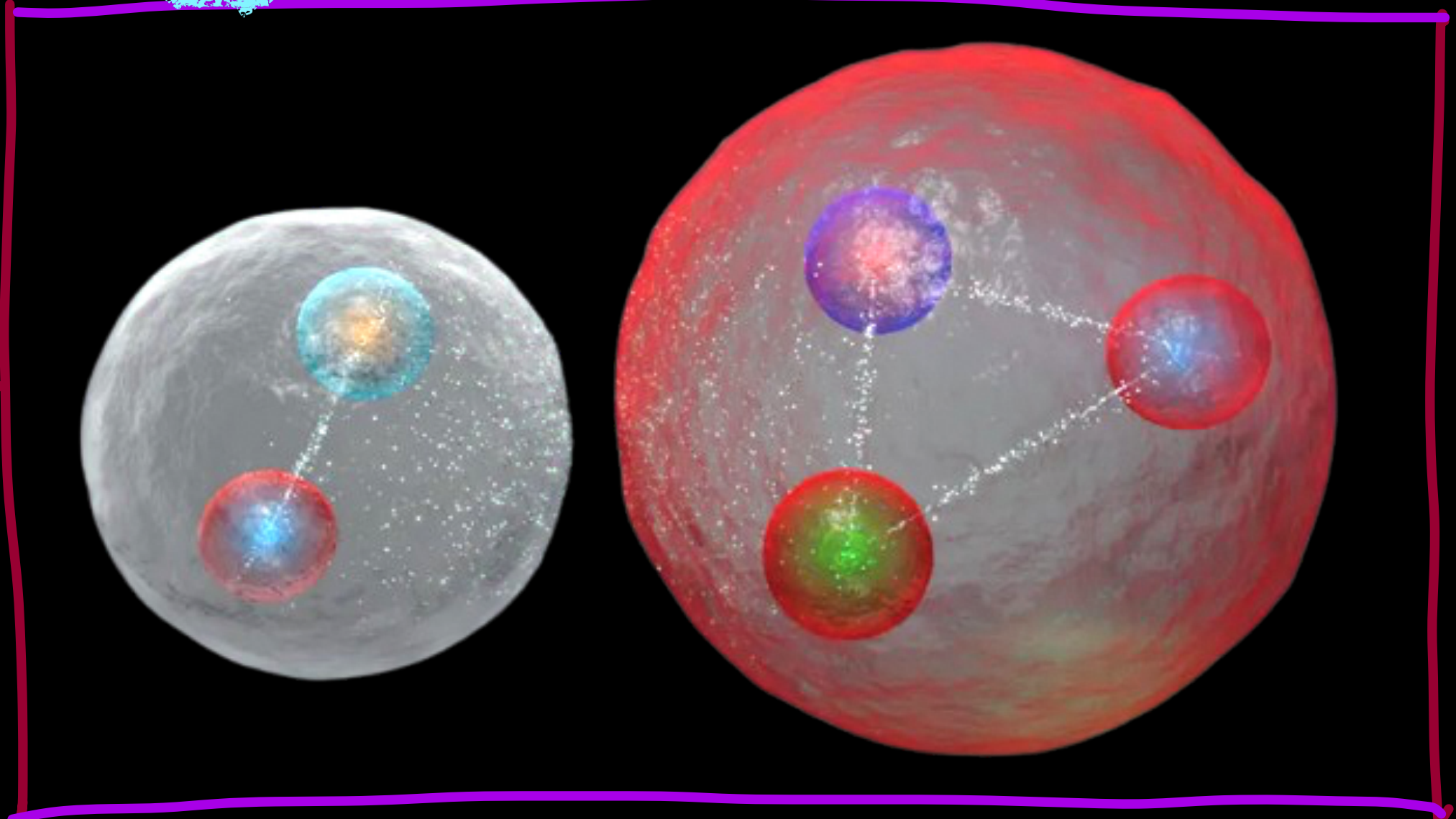
ISGUR & CAPSTICK

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

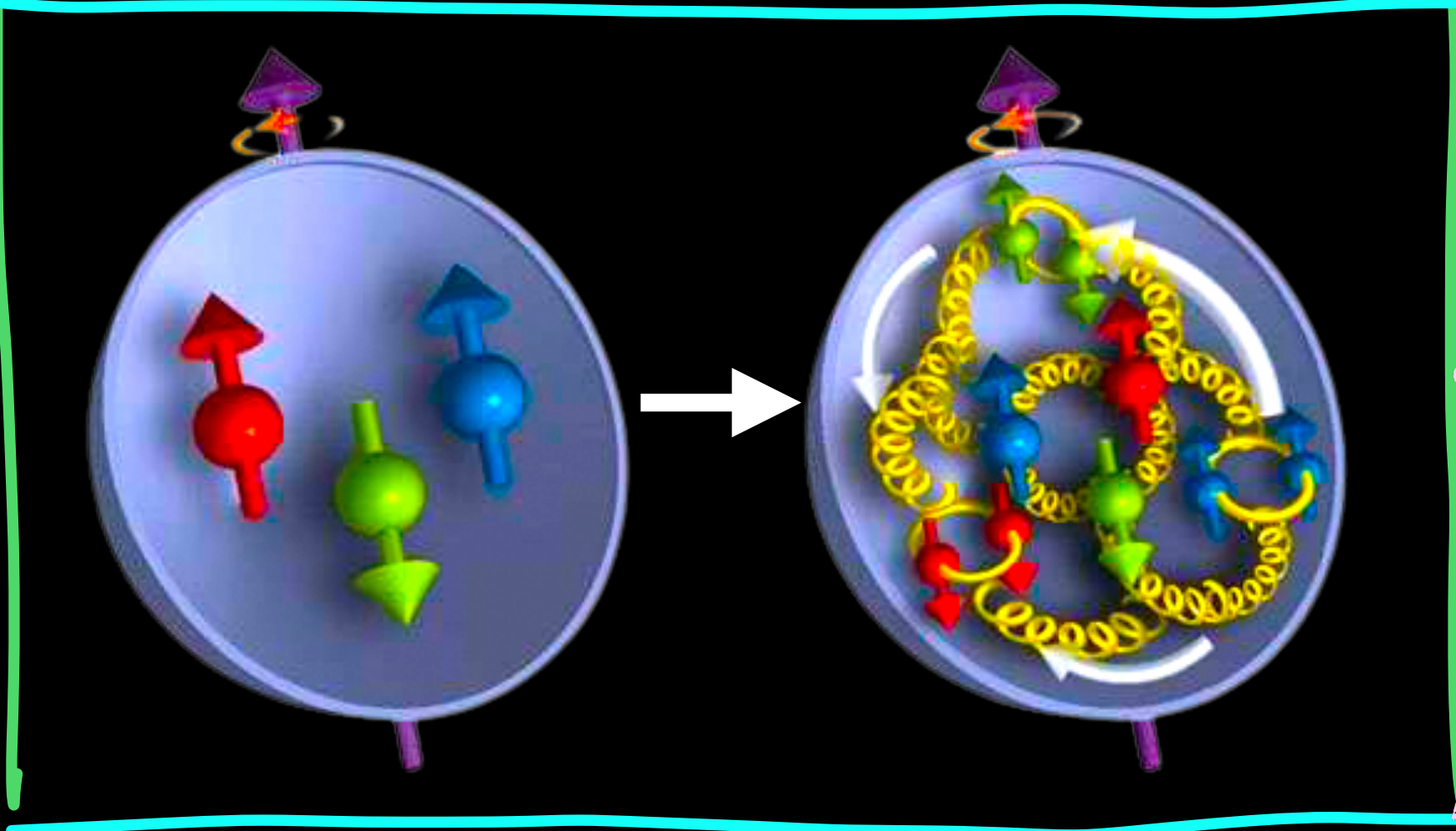
State, J^P	Predicted masses (MeV)							
$\Xi_{\frac{1}{2}}^+$	1305							
$\Xi_{\frac{1}{2}}^+$	1505							
$\Xi_{\frac{1}{2}}^-$	1755	1810	1835	2225	2285	2300	2320	2380
$\Xi_{\frac{3}{2}}^-$	1785	1880	1895	2240	2305	2330	2340	2385
$\Xi_{\frac{5}{2}}^-$	1900	2345	2350	2385				
$\Xi_{\frac{7}{2}}^-$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

MESON-BARYON MOLECULES



RELATIVIZED QUARK MODEL



DO WE UNDERSTAND BARYONS?



EXOTICS



"PENTAQUARKS"



"HADRONIC MOLECULES"



"TETRAQUARKS"

EXOTICS



"PENTAQUARKS"

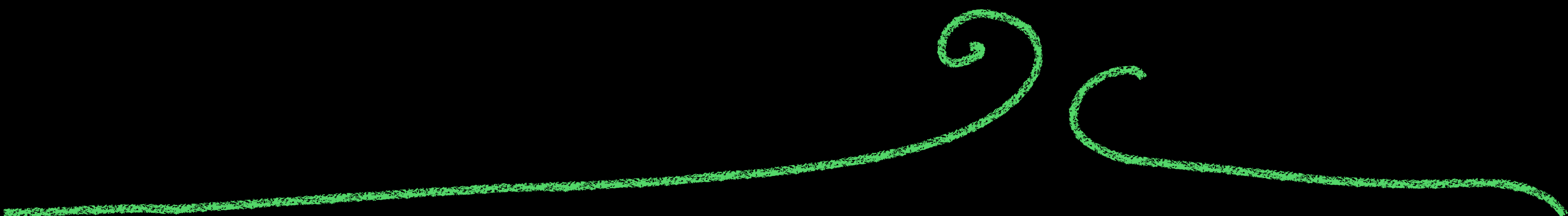
TOPIC OF TODAY



"HADRONIC MOLECULES"



"TETRAQUARKS"



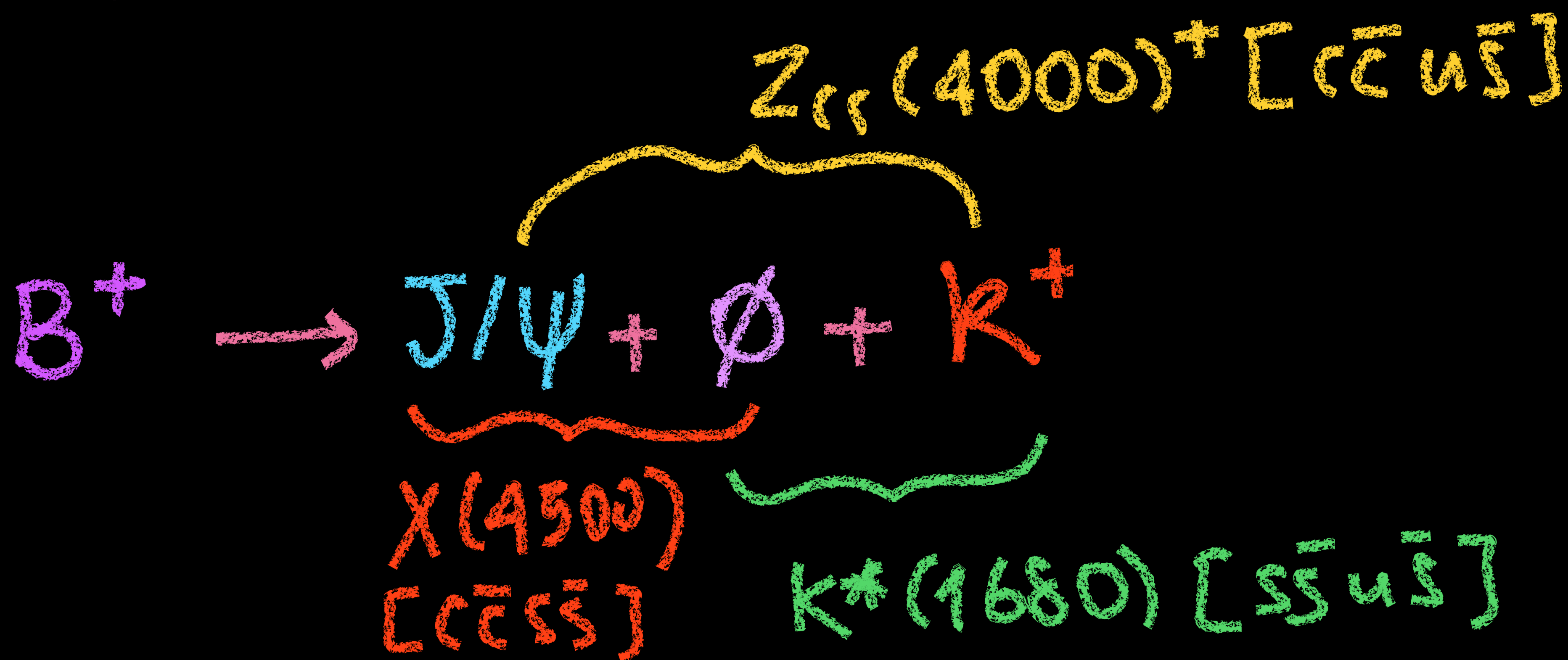
TETRAQUARKS



THE CHANNEL

PRL 127, 082001

WHAT LHCb OBSERVED...



THE CHANNEL

CLEARLY
SEEN IN DATA

B^+

$\rightarrow$

J/ψ

+

ϕ

+

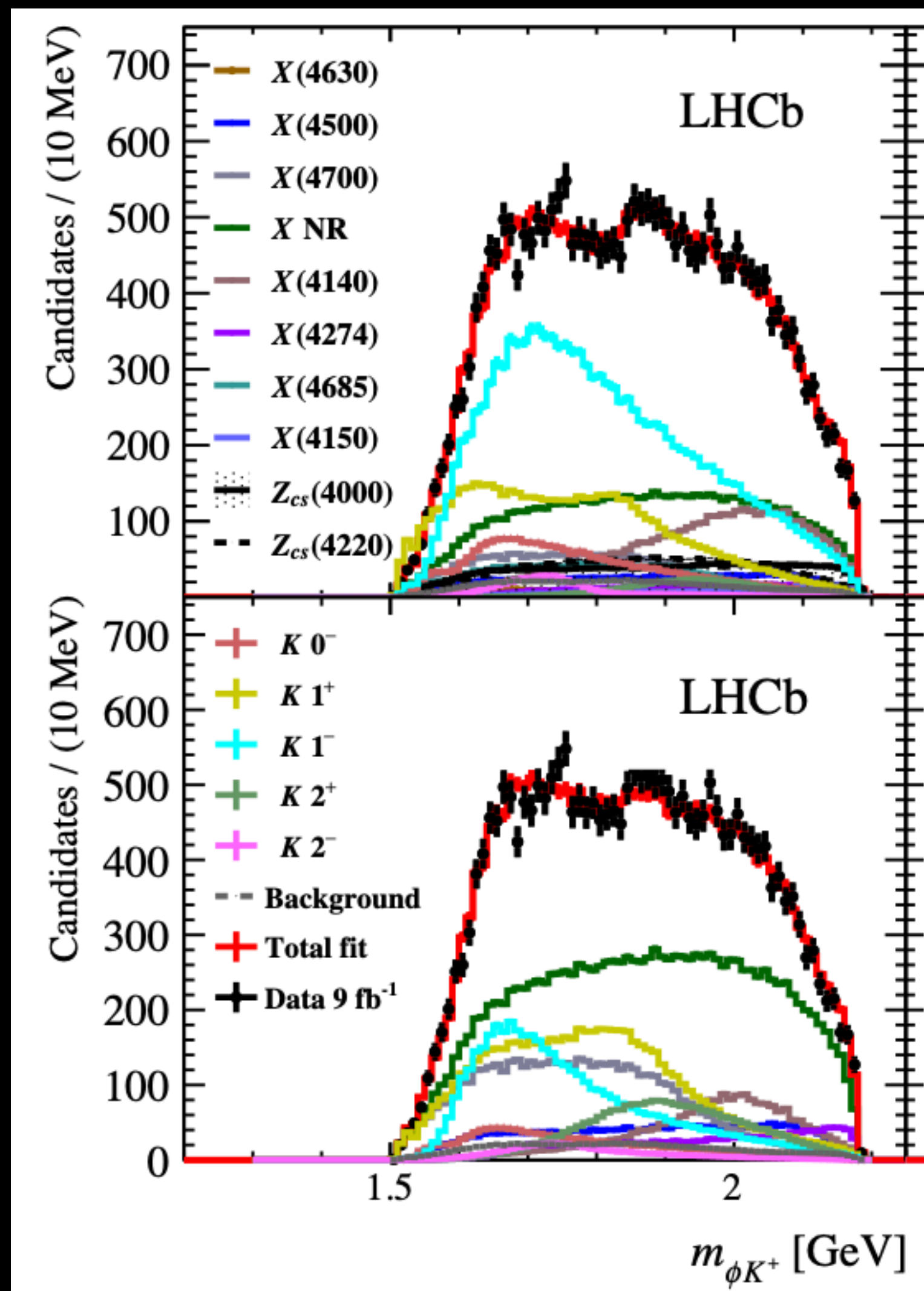
K^+

$X(4500)$
 $[c\bar{c}s\bar{s}]$

$K^*(1680) [s\bar{s}u\bar{s}] (?)$

$Z_c(4000)^+ [c\bar{c}u\bar{s}]$

THE CHANNEL



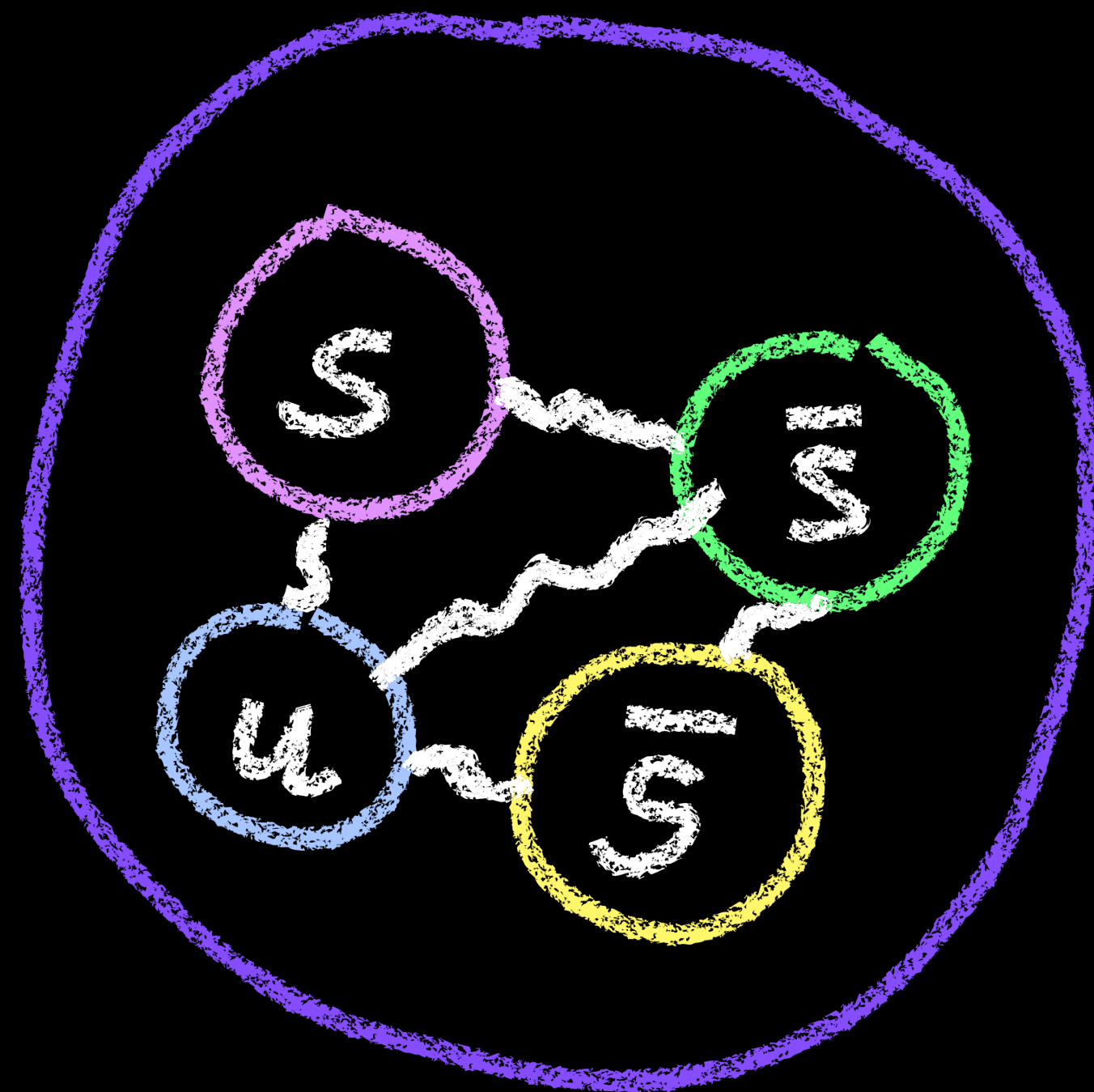
MAIN CONTRIBUTIONS
FROM:

$K(1^-)$ & $K(1^+)$

TWO DIFFERENT
MODEL FITS TO DATA.

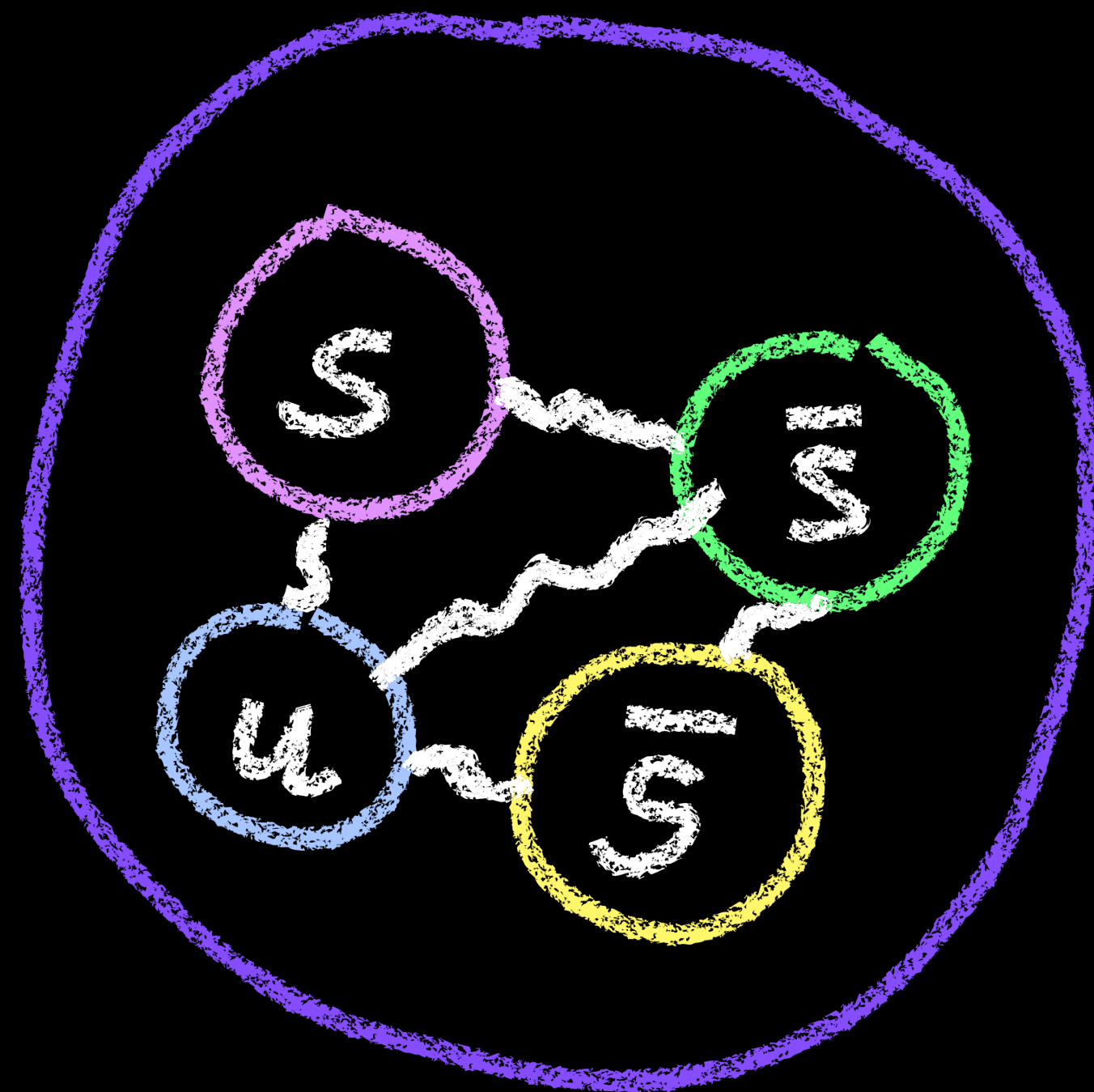
THE CHANNEL

CAN WE HAVE A TETRAQUARK PRODUCED
IN A "STRANGER" CHANNEL?



THE CHANNEL

CAN WE HAVE A TETRAQUARK PRODUCED
IN A "STRANGER" CHANNEL?

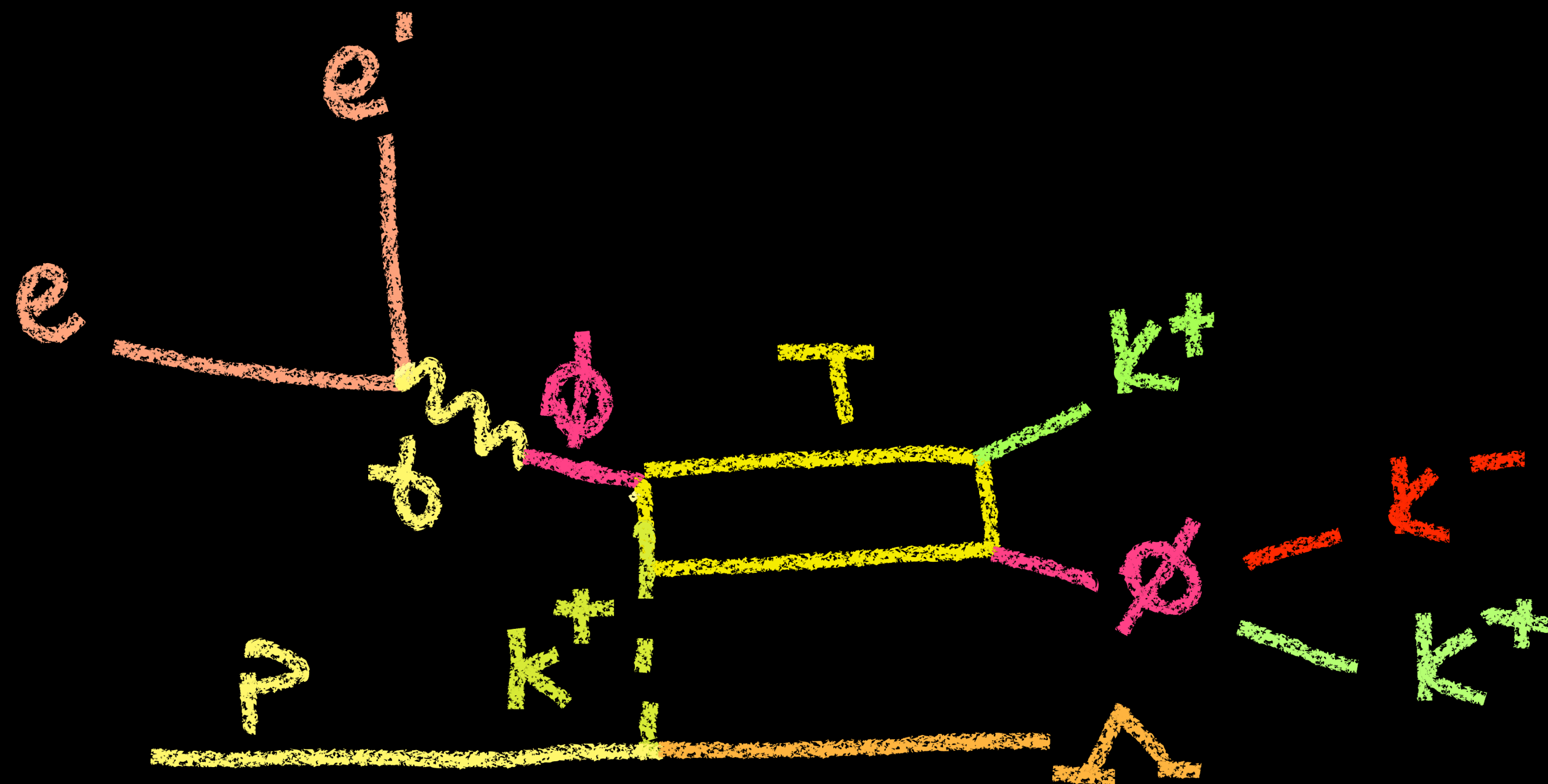
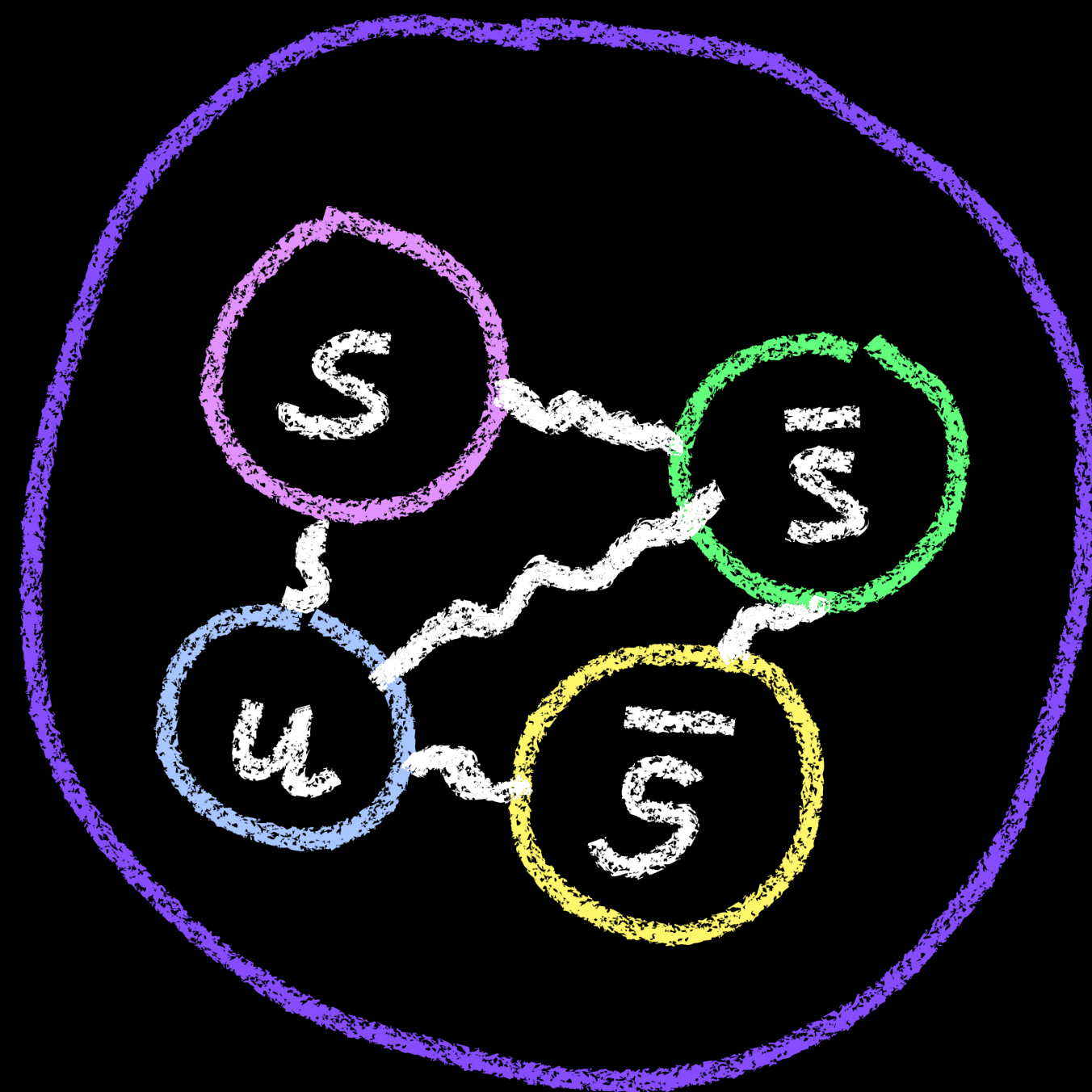


DIRECT PRODUCTION
?

EVEN BETTER?

TETRAQUARK FORM FACTOR MEASUREMENT?

"T"





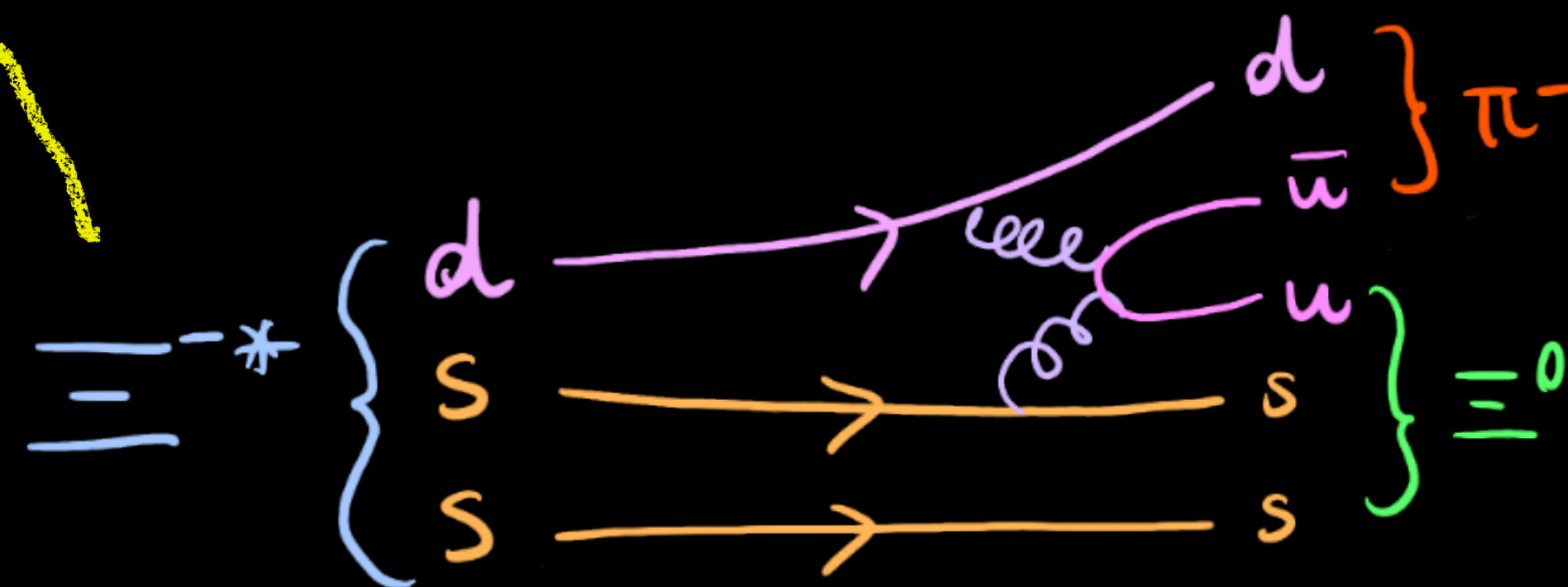
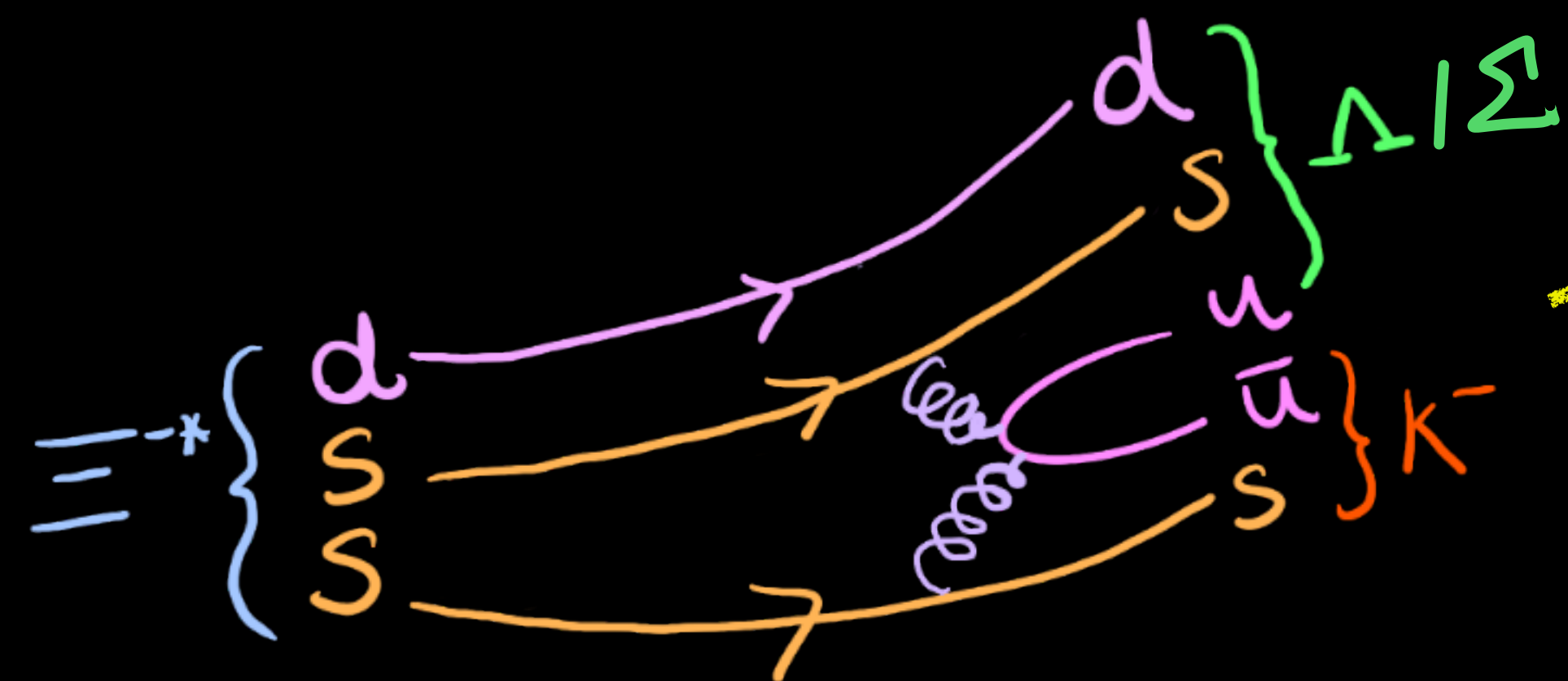
CASCADES

A decorative calligraphic banner featuring the word "CASCADES" in a white, serif, all-caps font. The text is centered and framed by two horizontal lines with ornate, swirling flourishes at each end. The top line is blue, and the bottom line is red. The background is solid black.

7

3Q vs MOLECULE

POSSIBLE CHANNELS

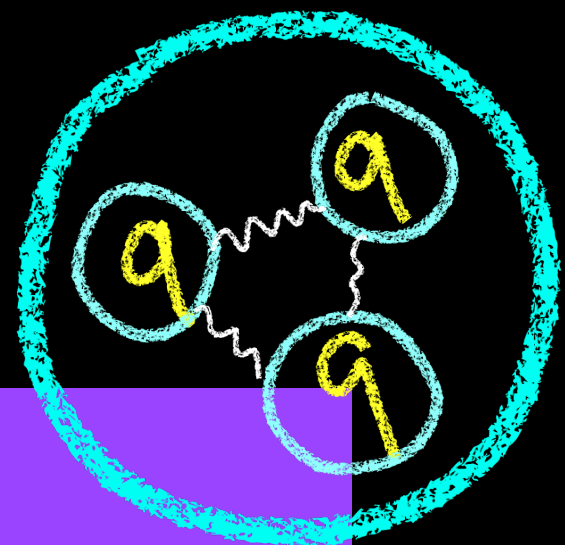


$$|\Xi^*\rangle = \frac{1}{2}|\Xi\pi\rangle + \frac{1}{2}|\Sigma\bar{K}\rangle + \frac{1}{2}|\Xi\eta\rangle - \frac{1}{2}|\Lambda\bar{K}\rangle \quad \text{FROM DECUPLET}$$

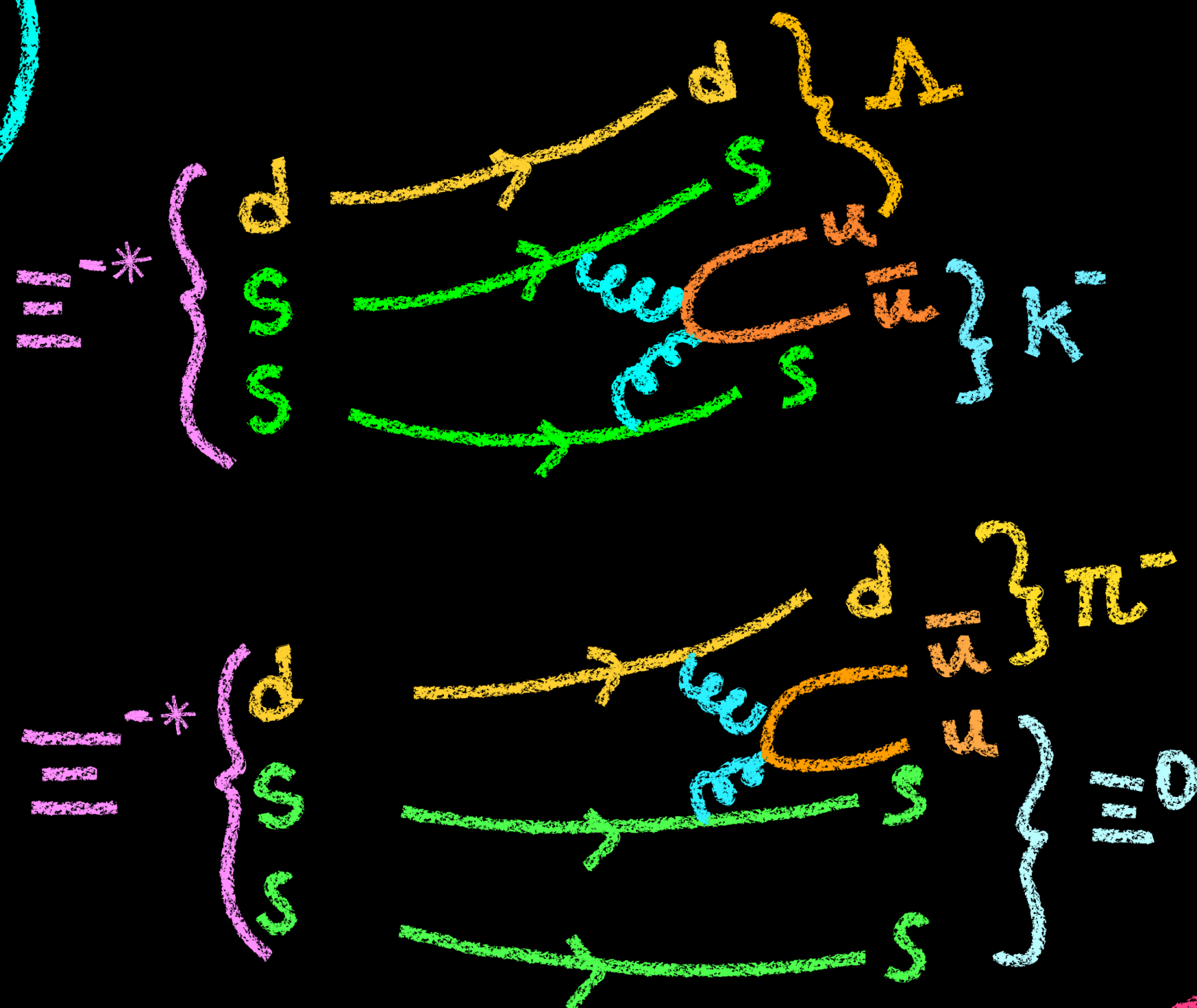
FROM OCTET

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

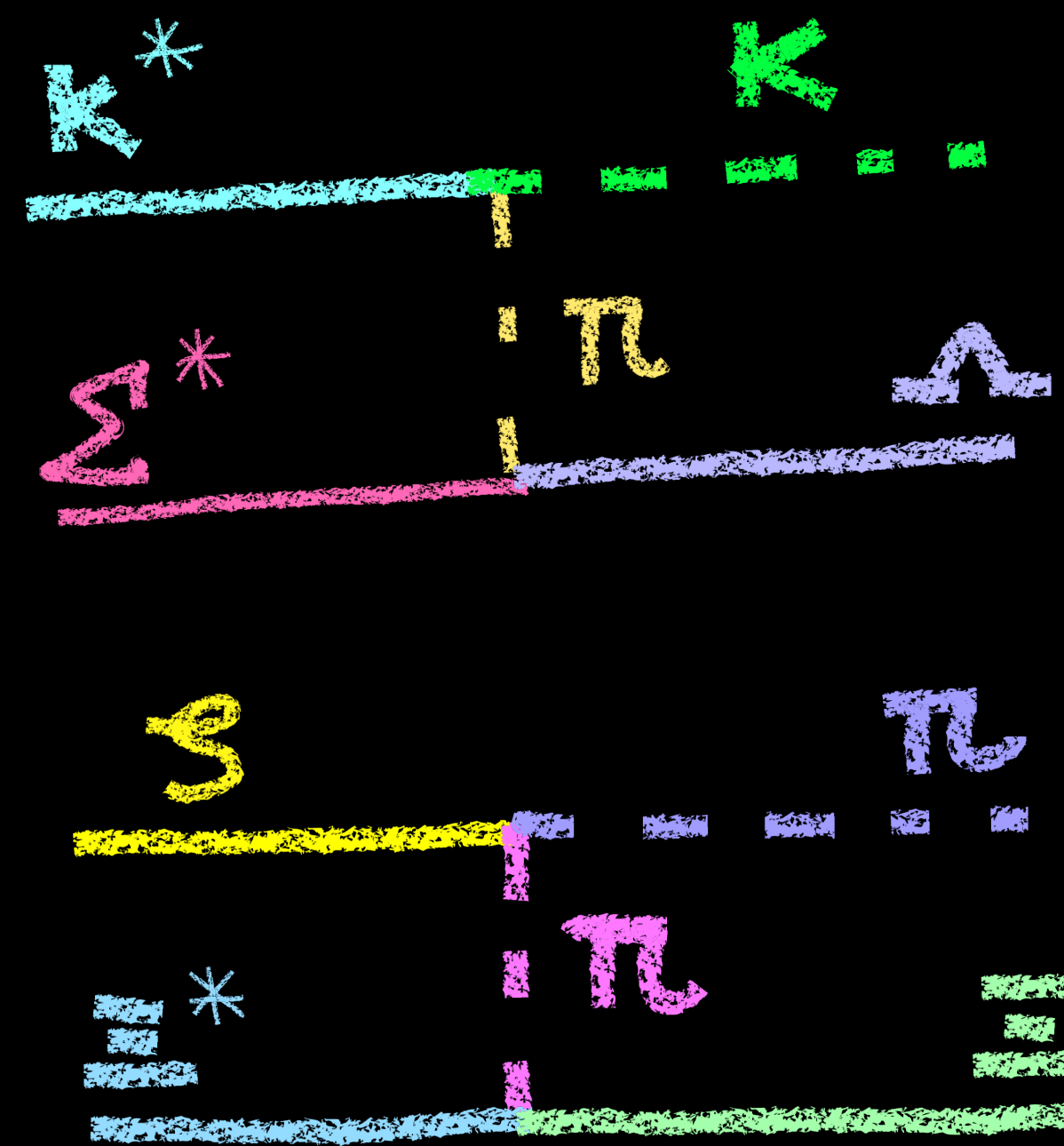
3Q vs MOLECULE



3q STATE

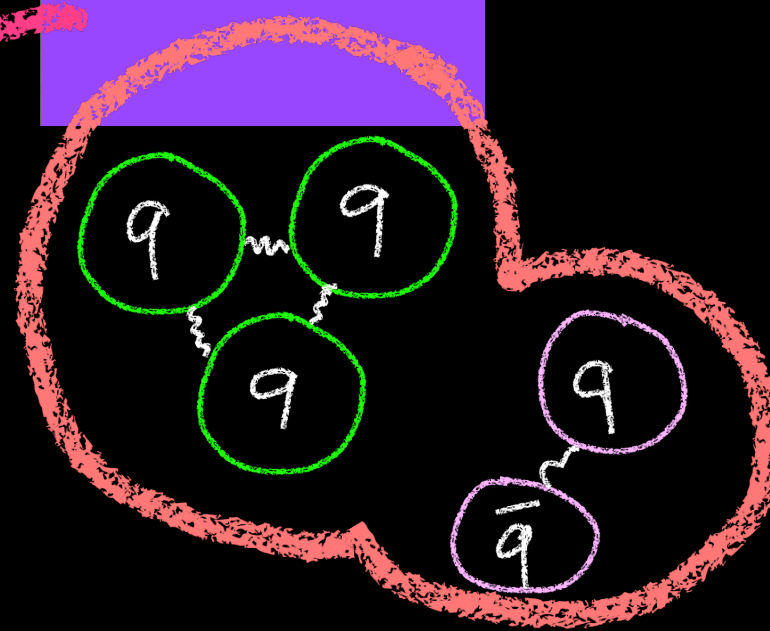


MOLECULAR

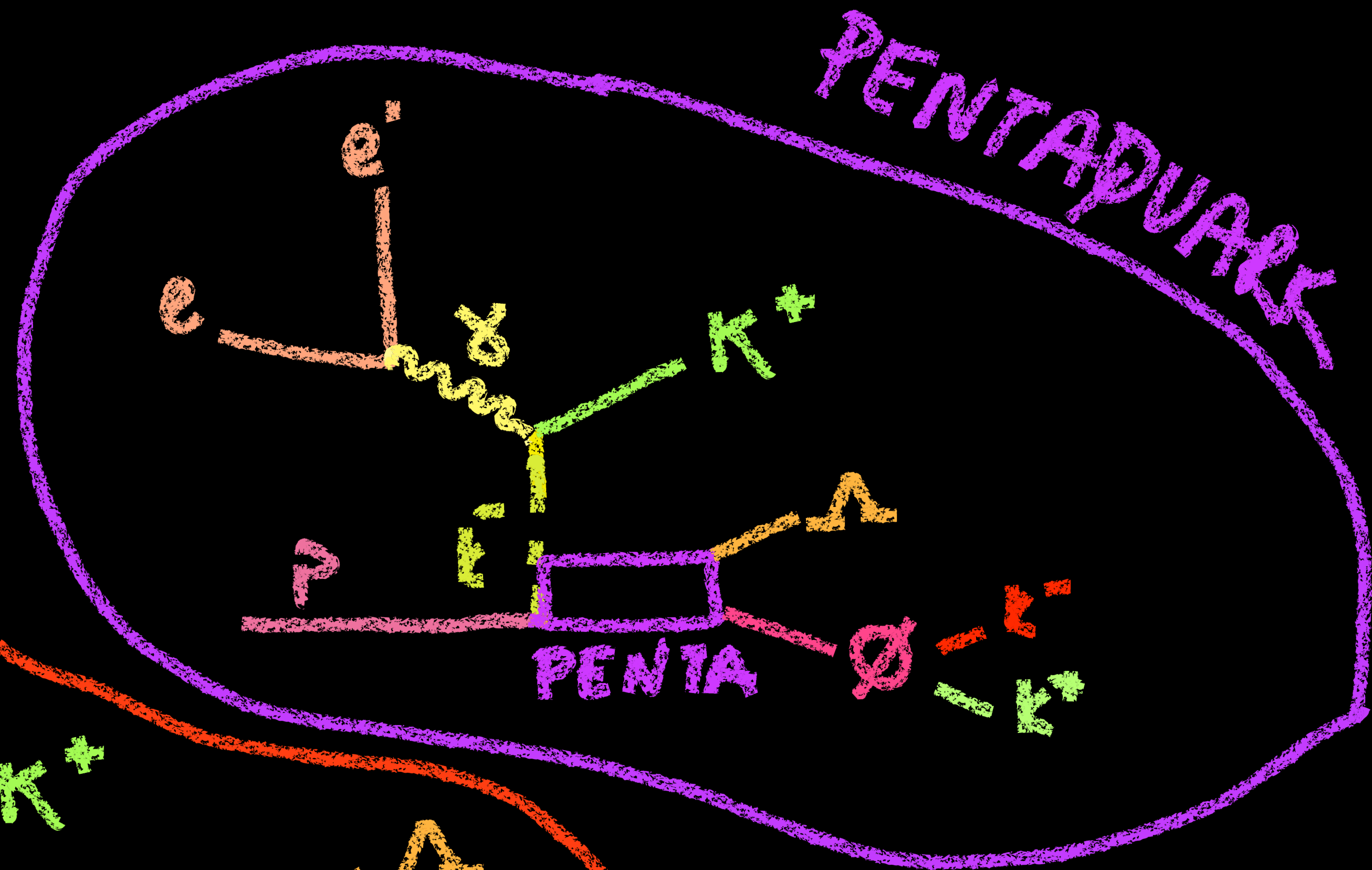


BR = 1

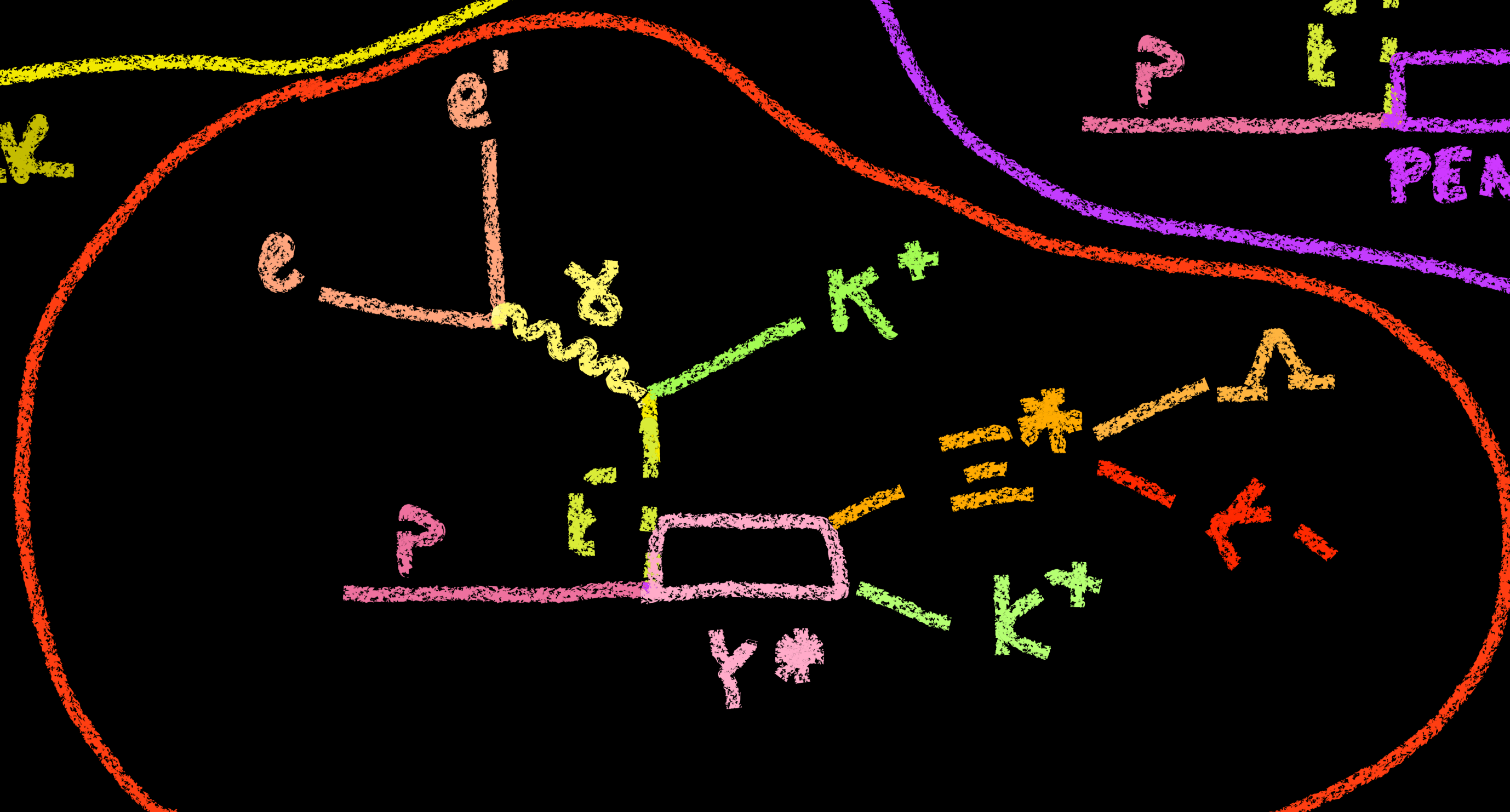
BR ≠ 1



ALL CHANNELS



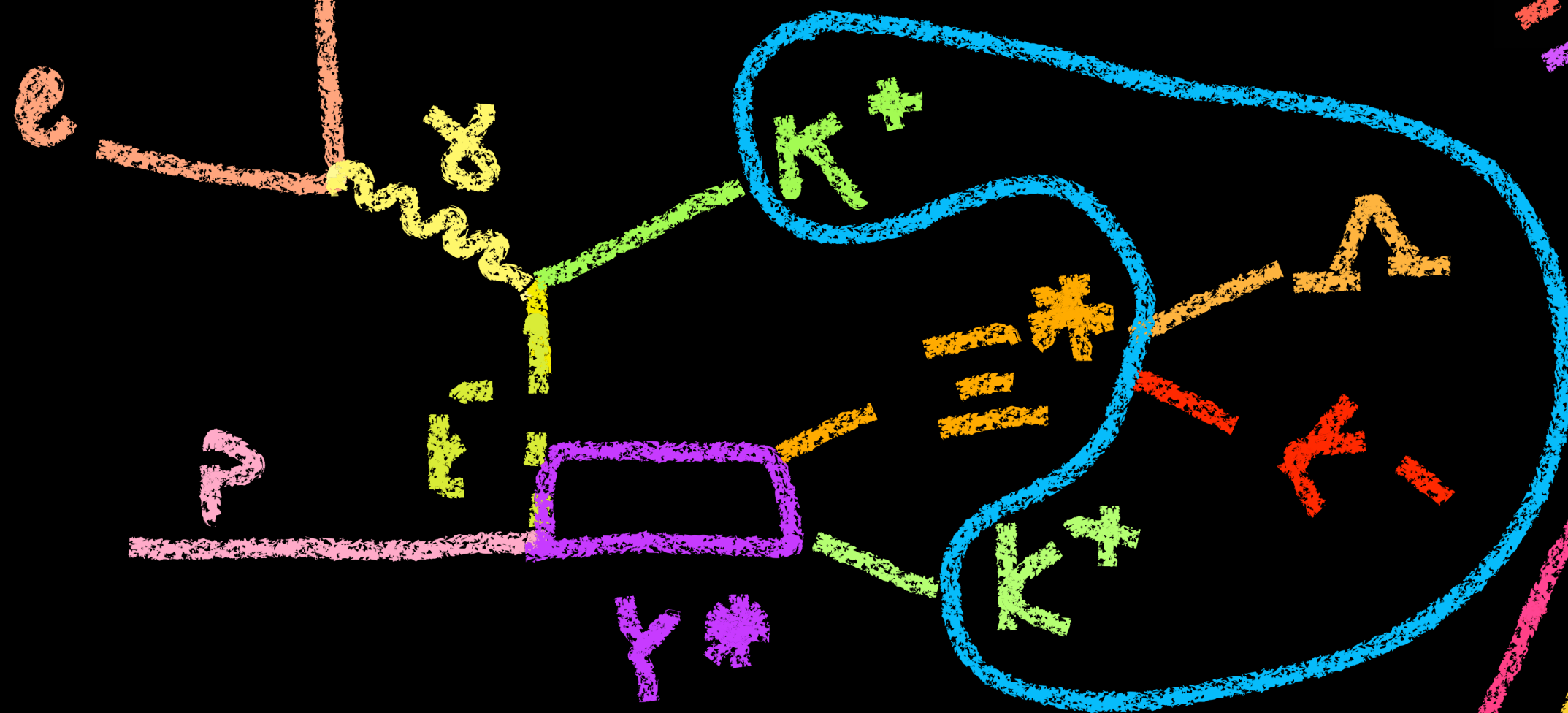
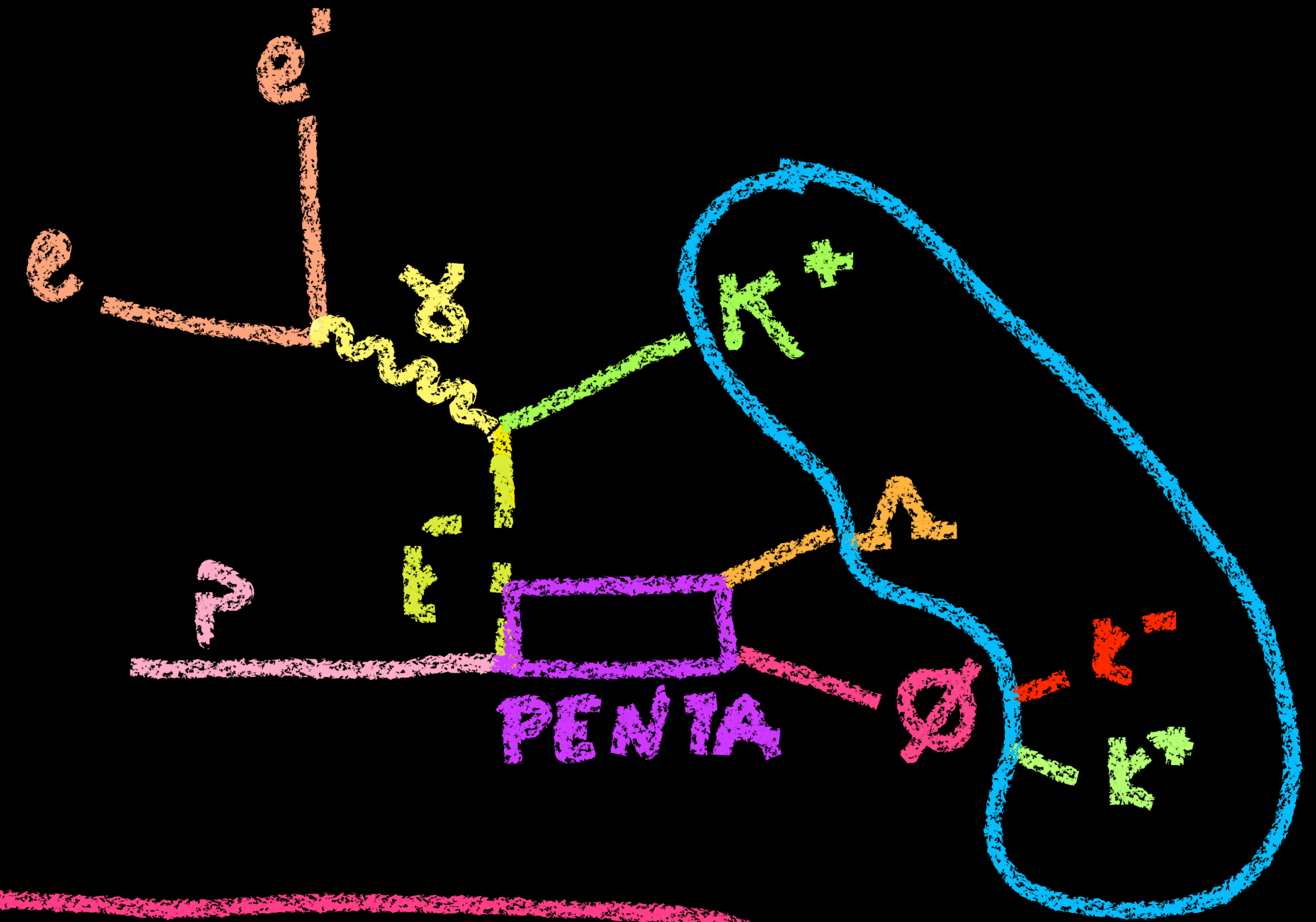
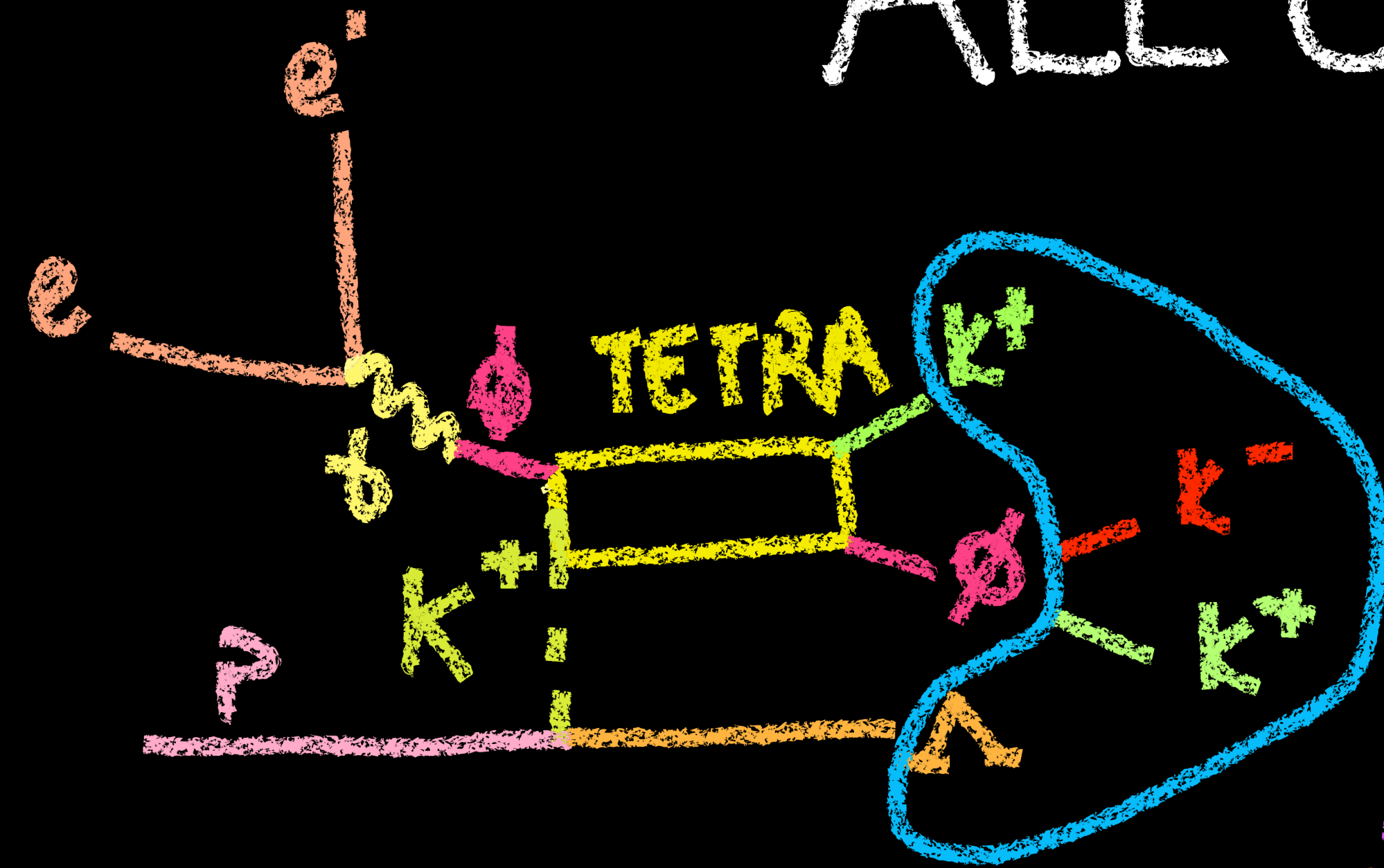
TETRAQUARK



CASCADE

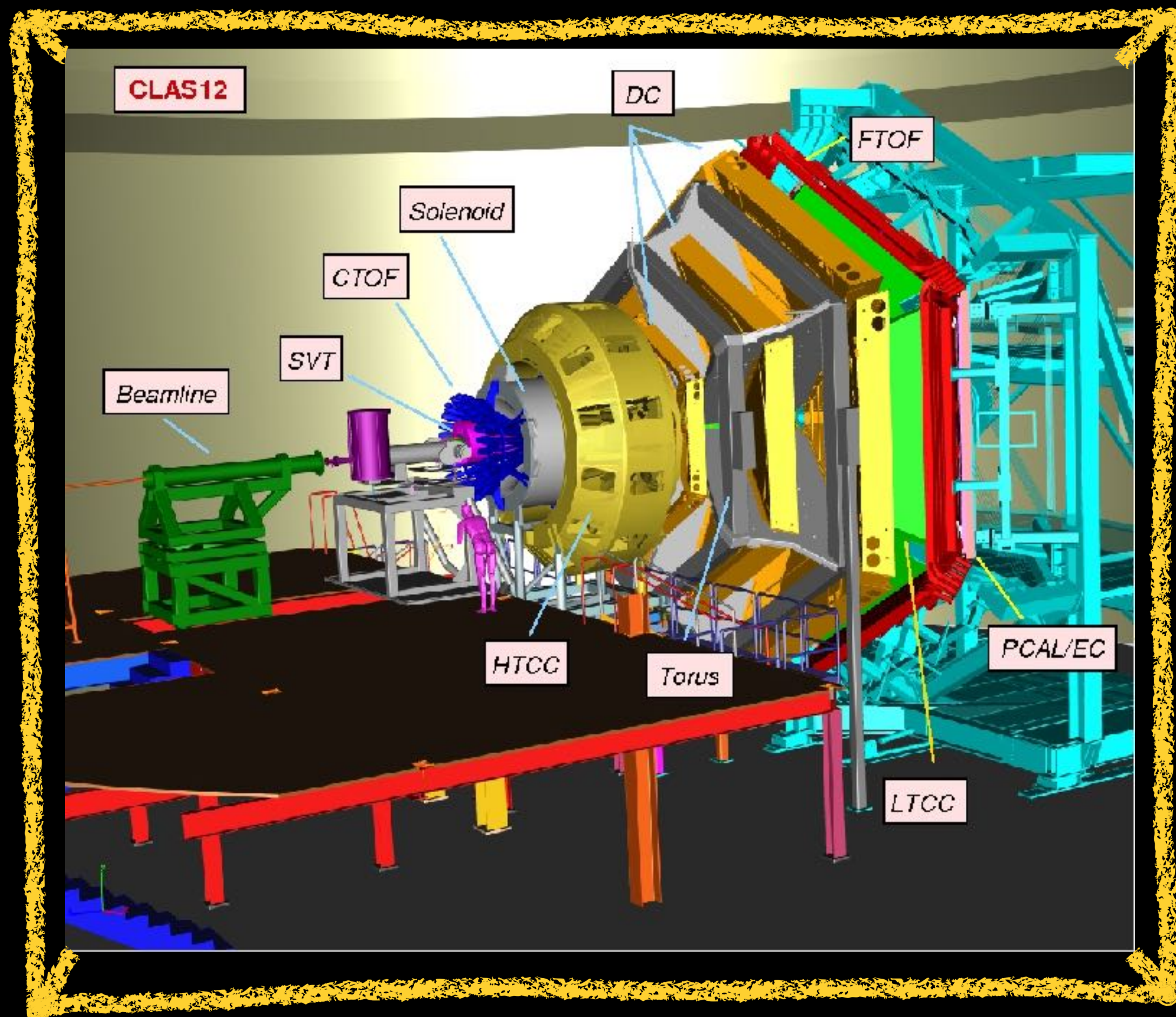
ALL CHANNELS

10



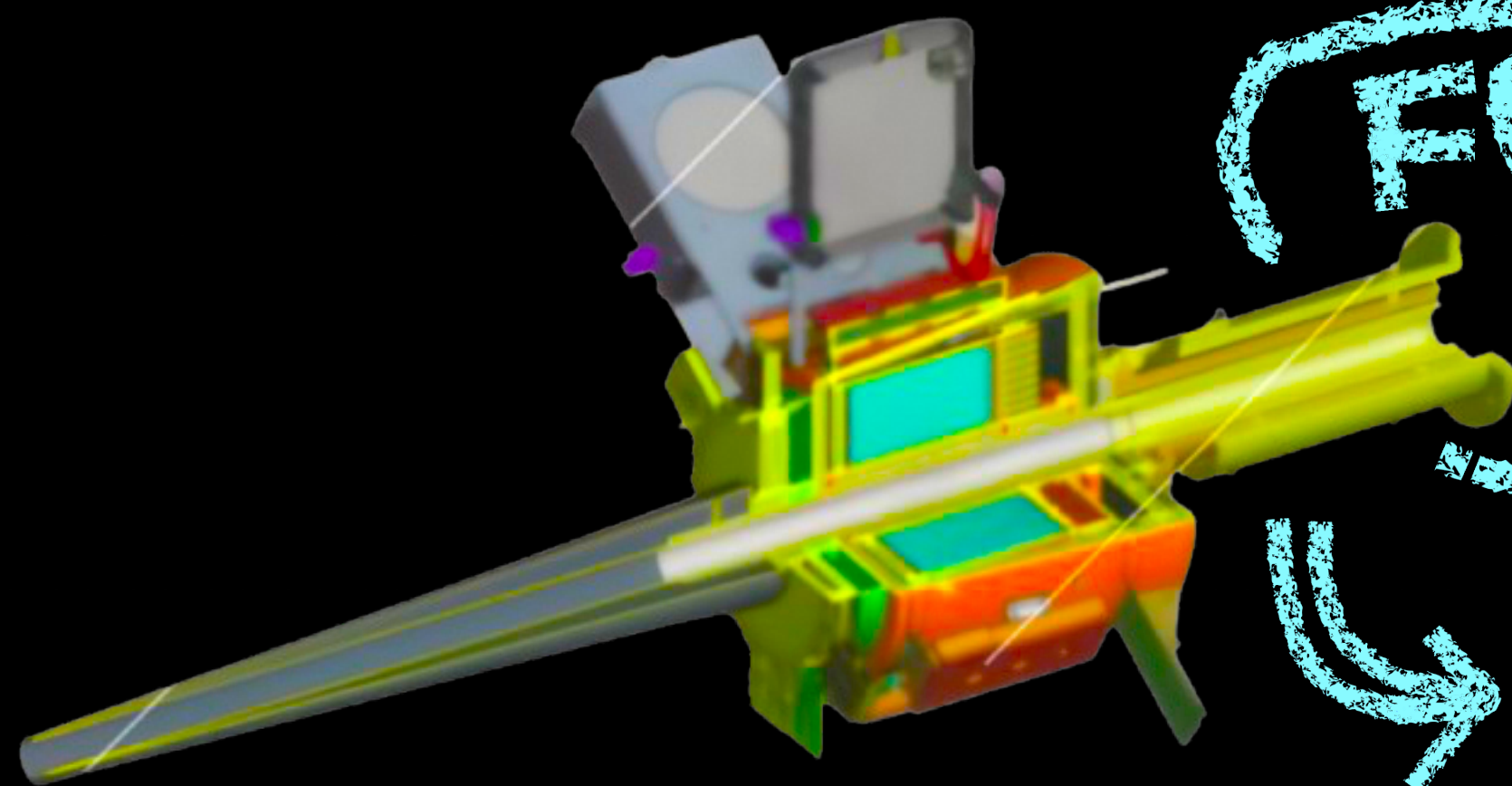
ONE FINAL
STATE TO RULE THEM ALL!

CLAS12



DETECTORS

12

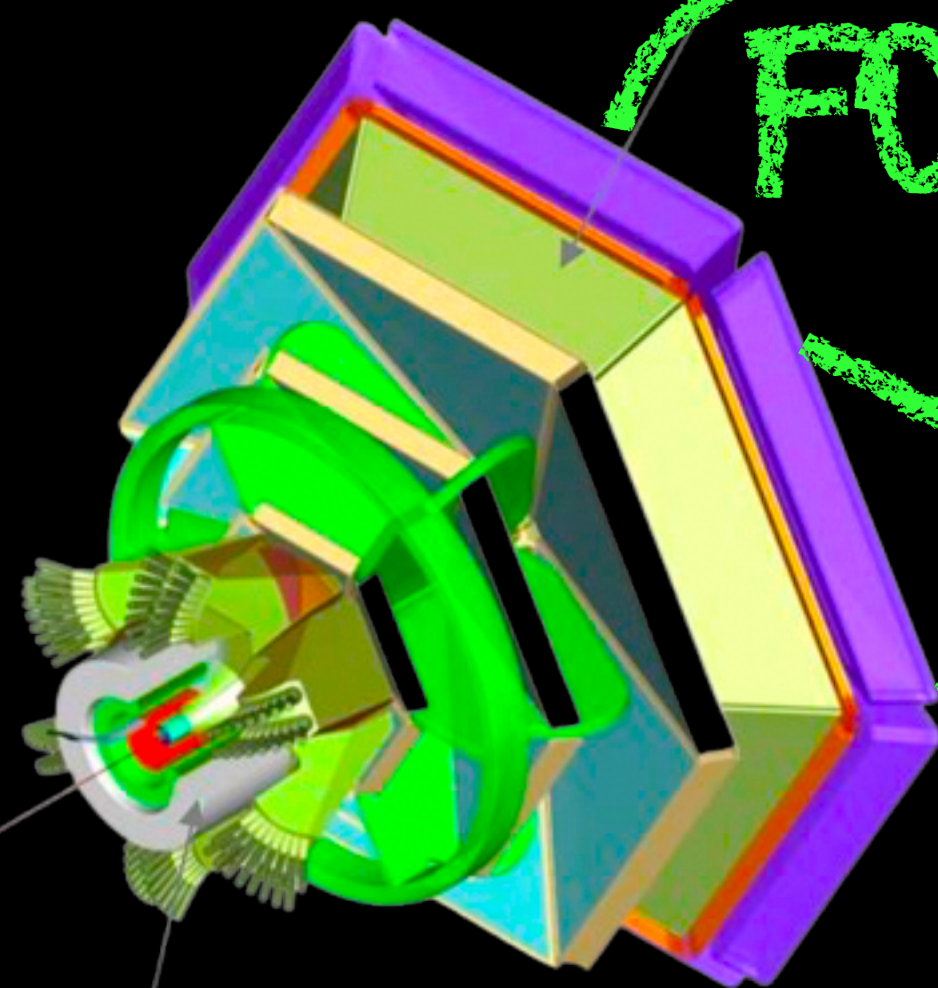


FORWARD
TAGGER

* $2.5^\circ < \theta < 4.5^\circ$

* LOW Q^2

* CALORIMETER



FORWARD
DETECTOR

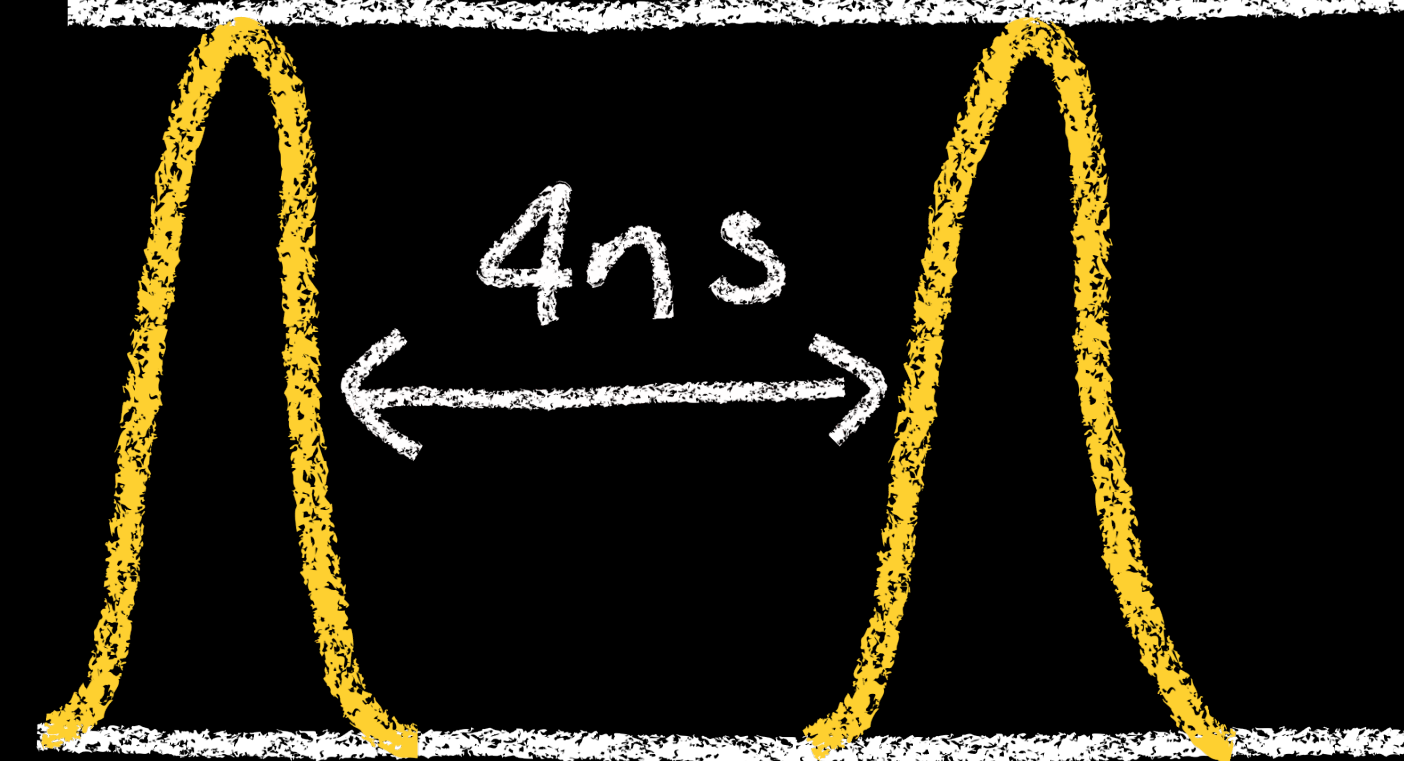
* $5^\circ < \theta < 35^\circ$

* HIGH Q^2

* MAGNETIC SPECTROSCOPY

BEAM BUNCHES

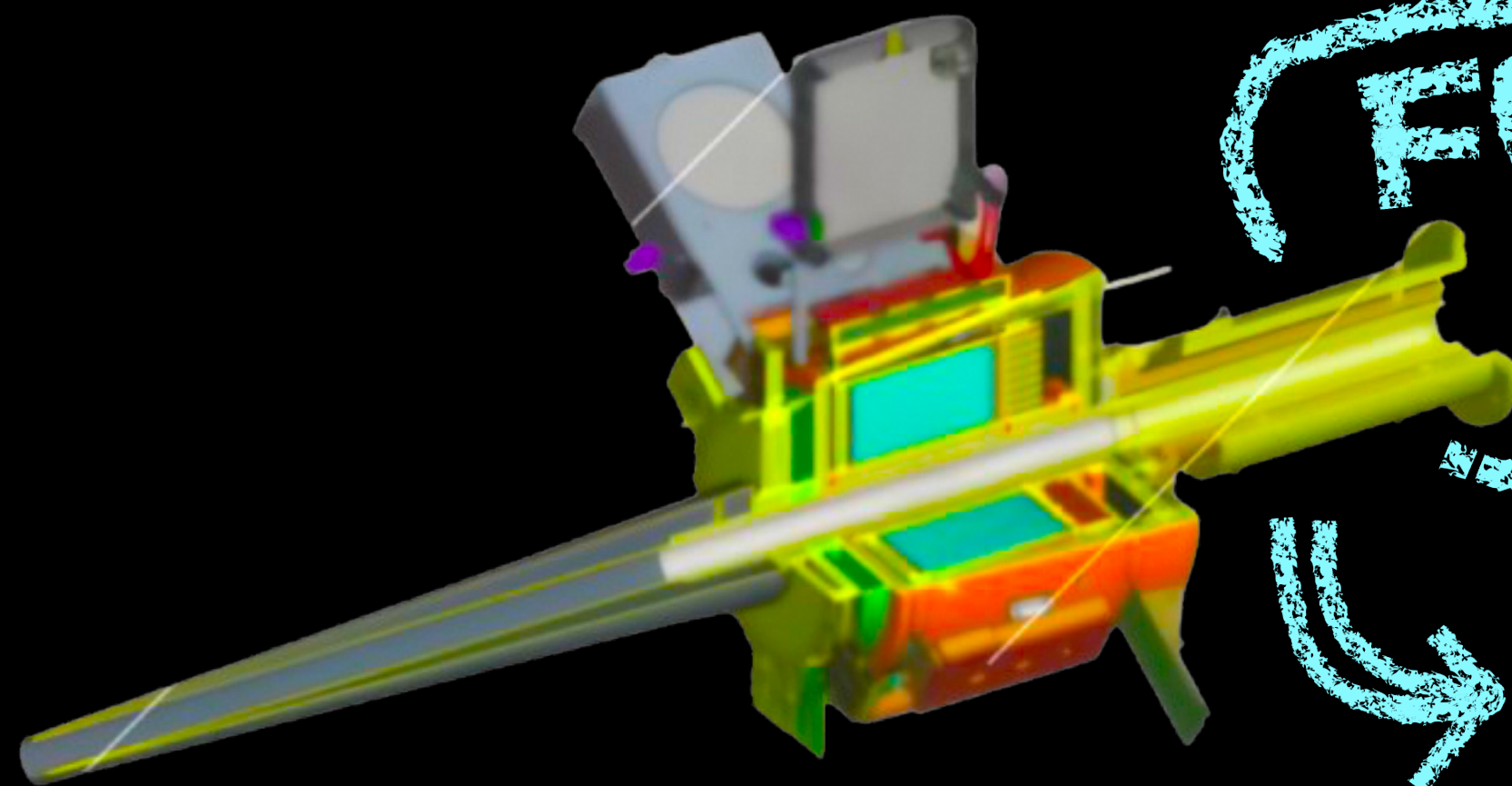
BEAM
PIPE



* BEAM BUNCHES 4 ns
APART & 150 ps
WIDE

DETECTORS

13

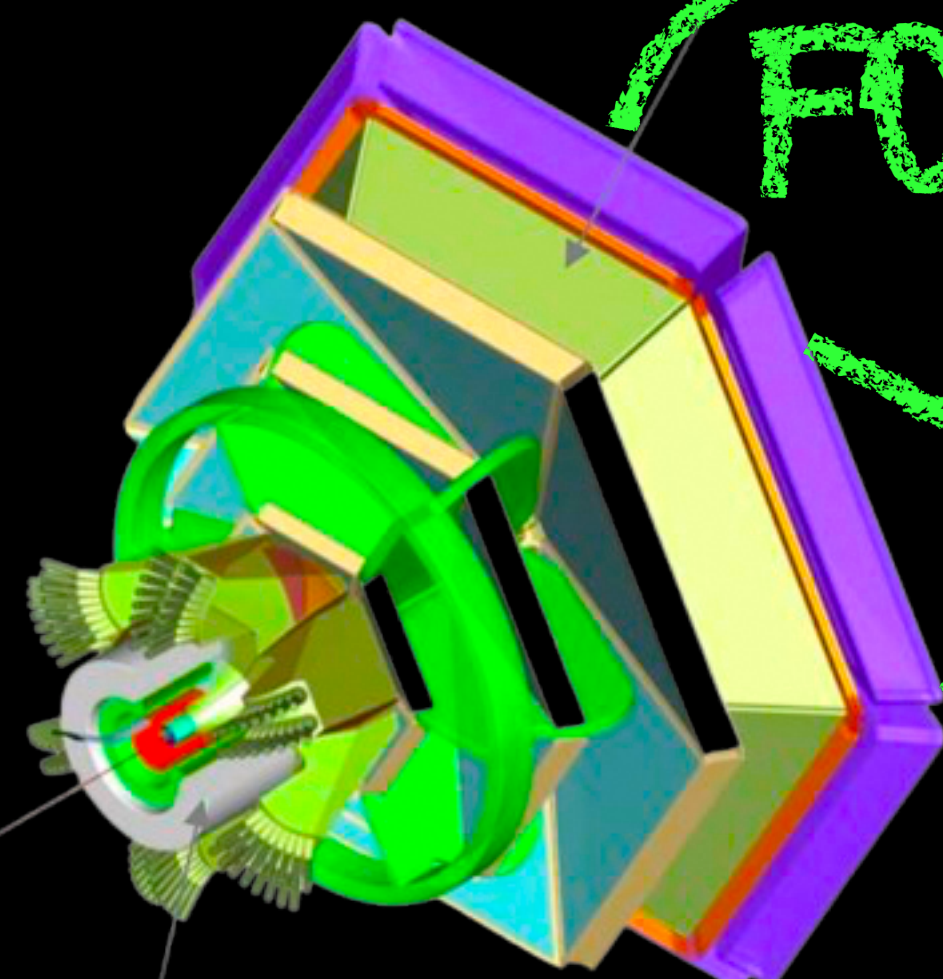


FORWARD
TAGGER

* $2.5^\circ < \theta < 4.5^\circ$

* LOW Q^2

* CALORIMETER



FORWARD
DETECTOR

* $5^\circ < \theta < 35^\circ$

* HIGH Q^2

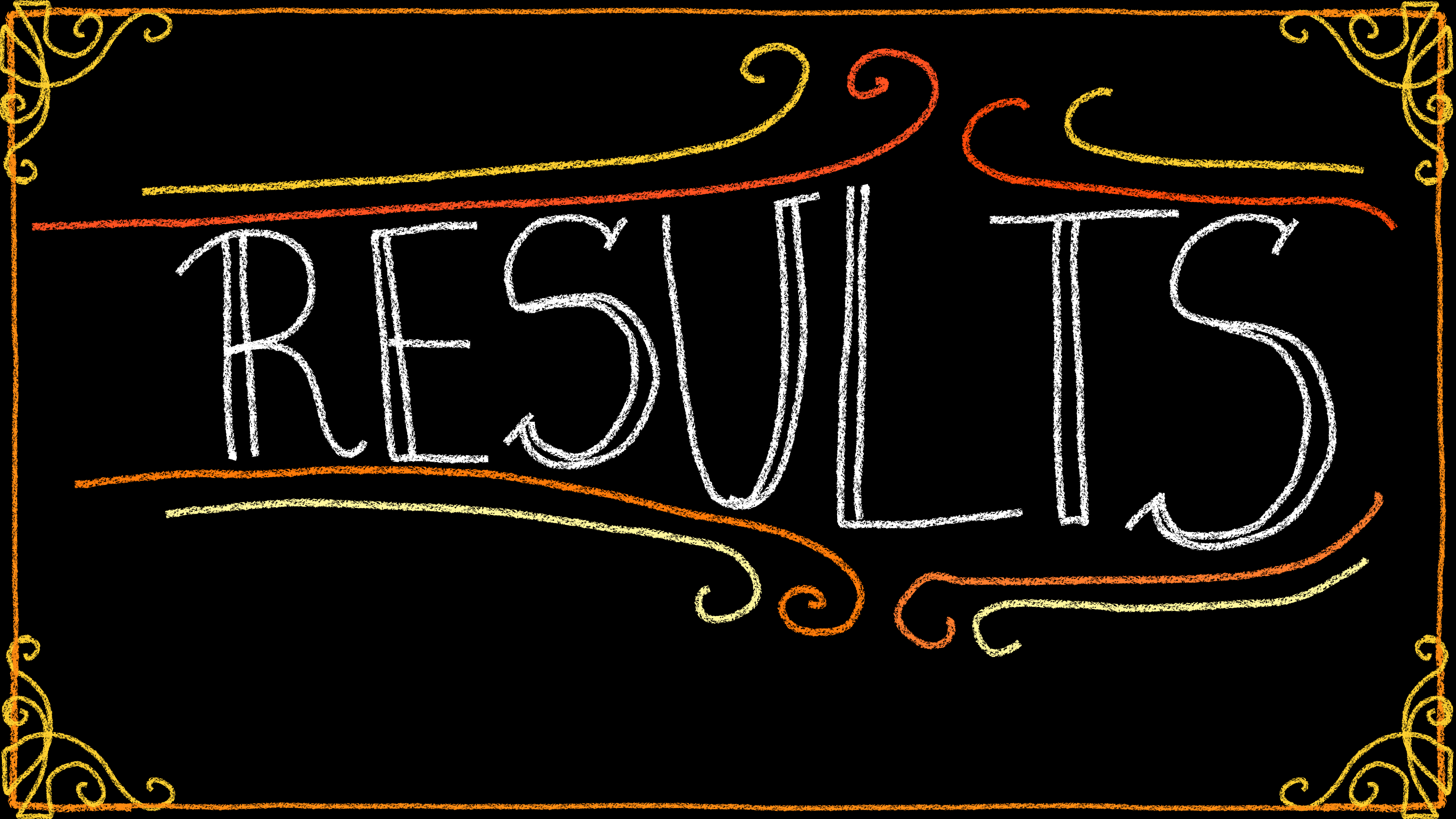
* MAGNETIC SPECTROSCOPY

PARTICLE
IDENTIFICATION

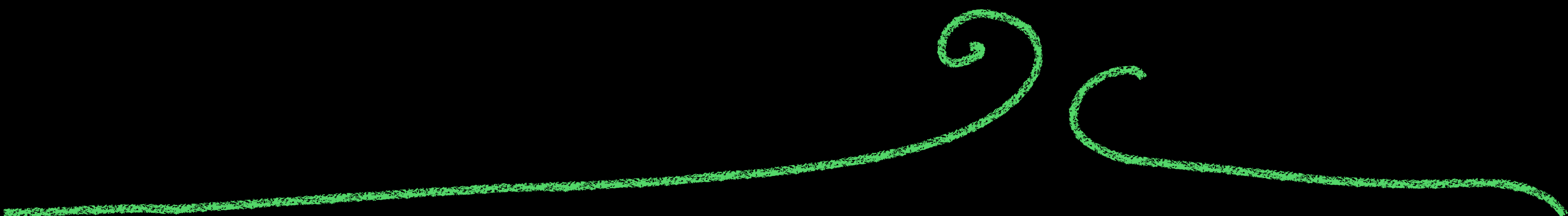
TARGET

DC

ToF



RESULTS



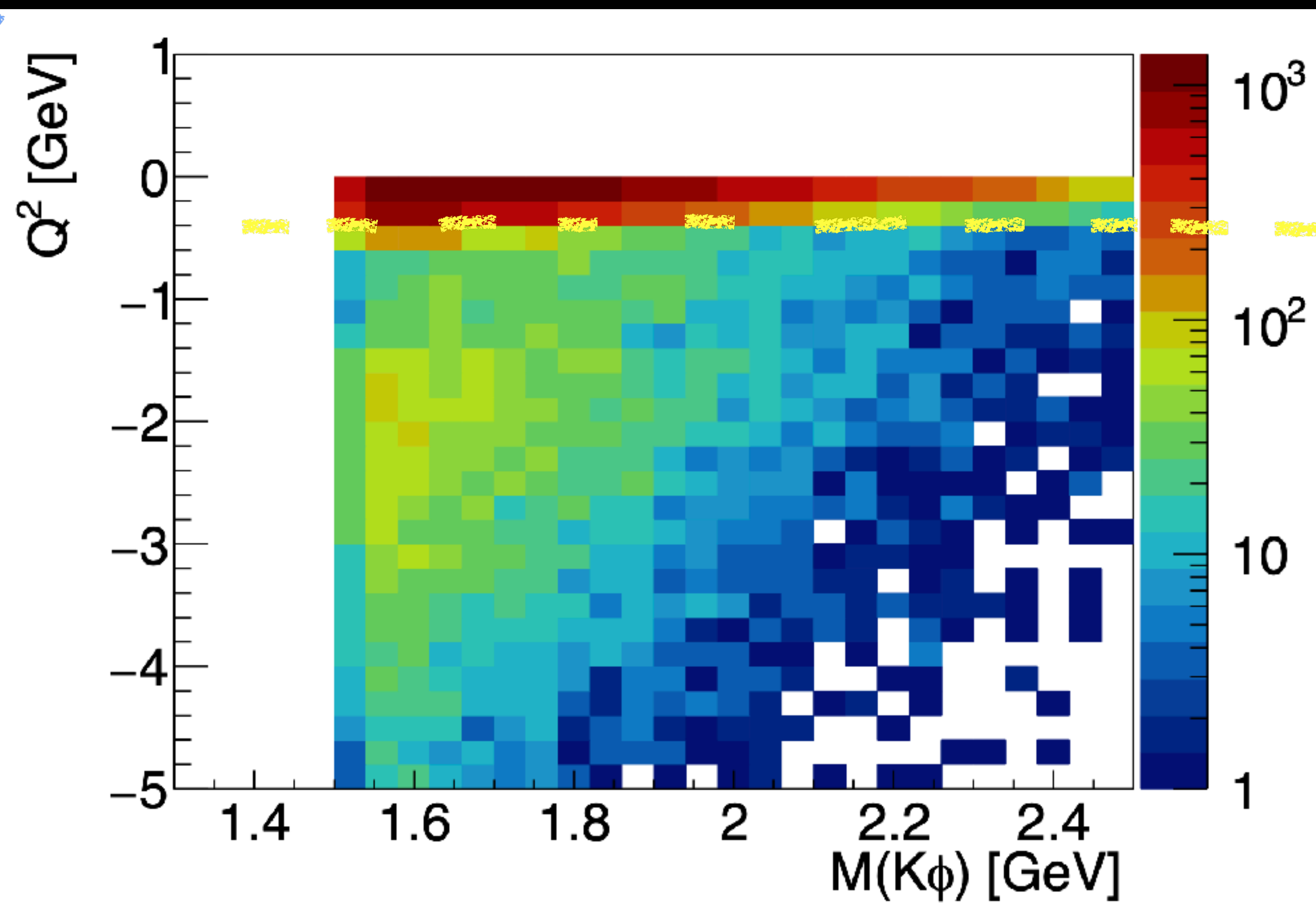
TETRAQUARKS



RESULTS

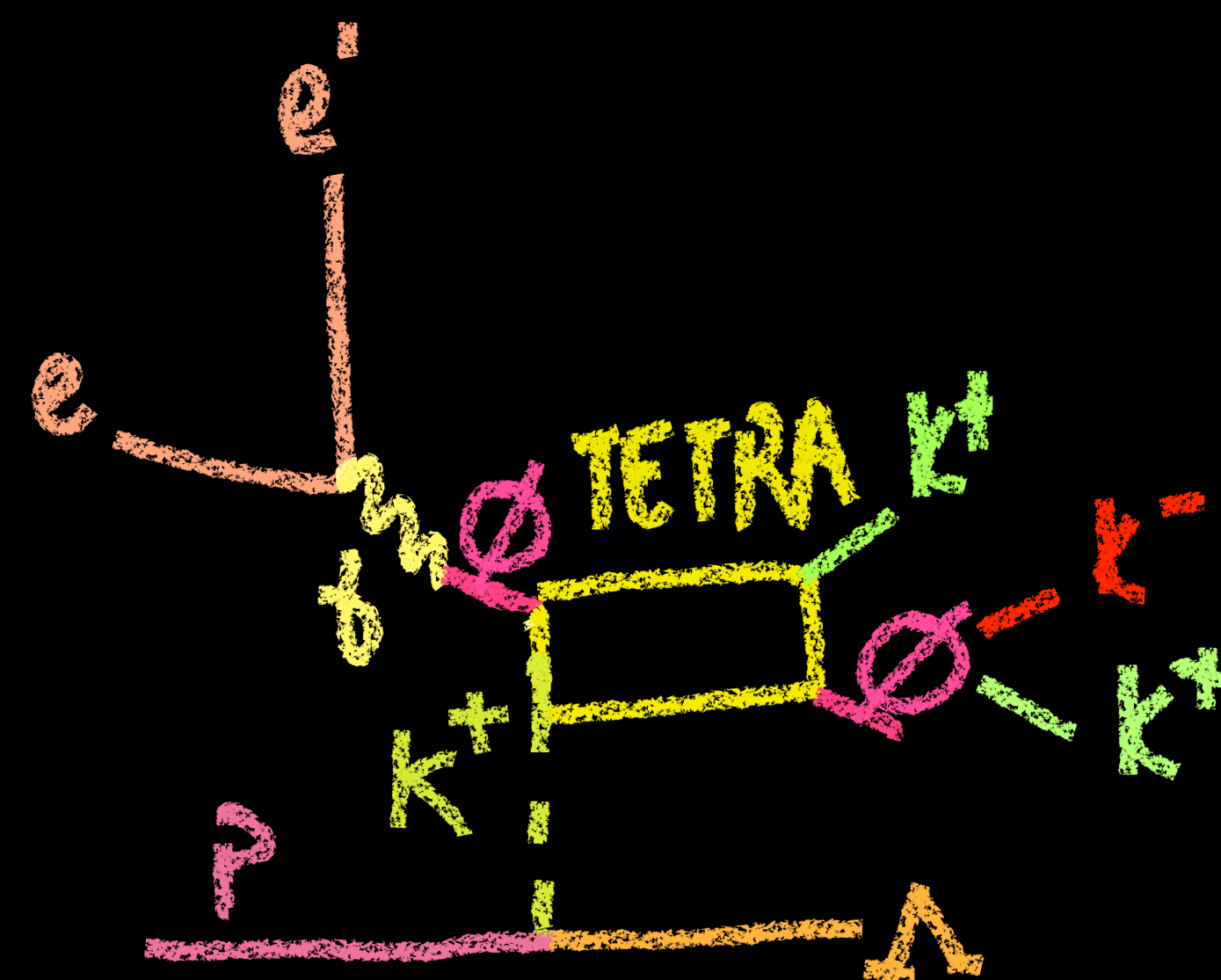
14

PROBING DIFFERENT Q^2 REGIONS



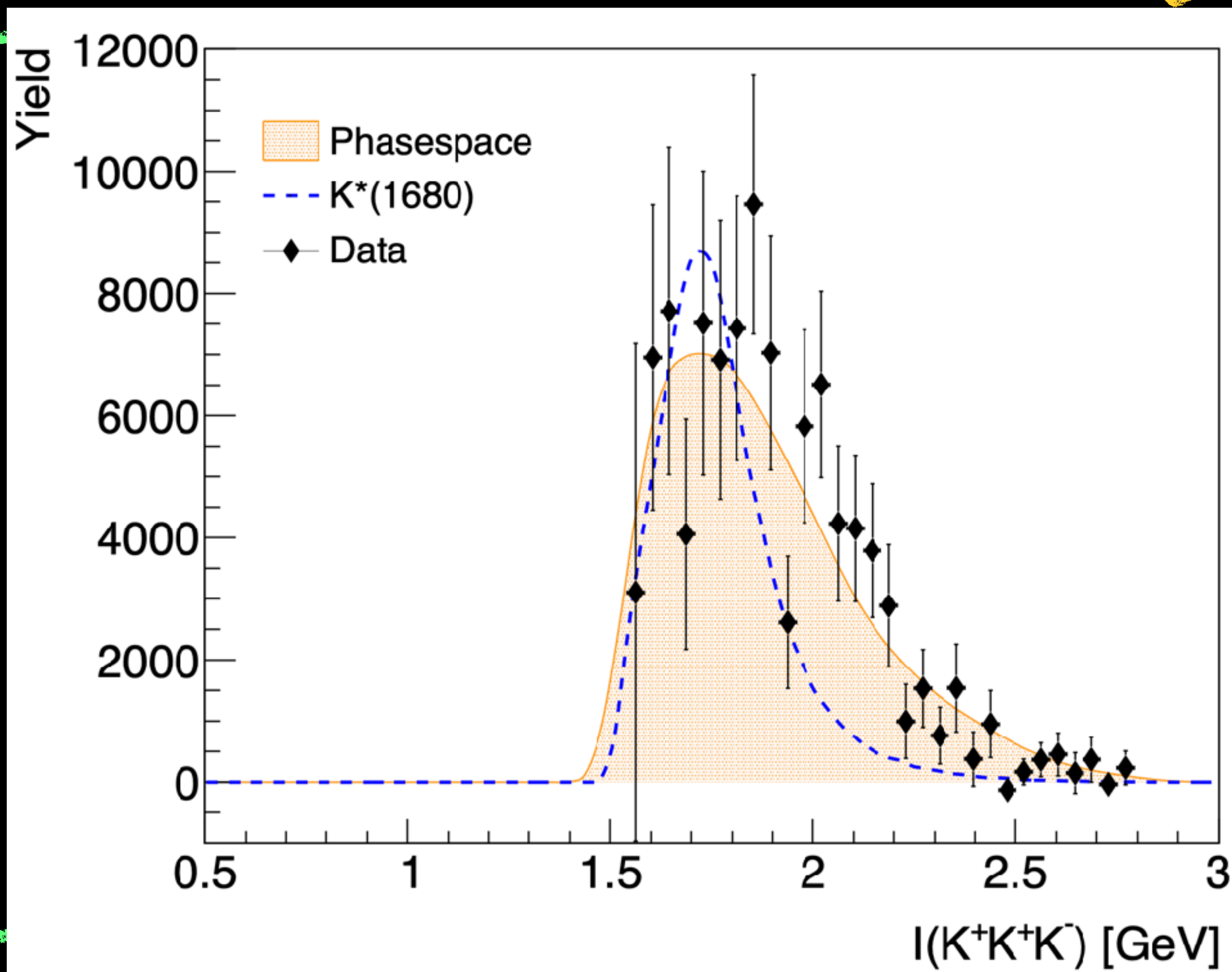
FT

FD

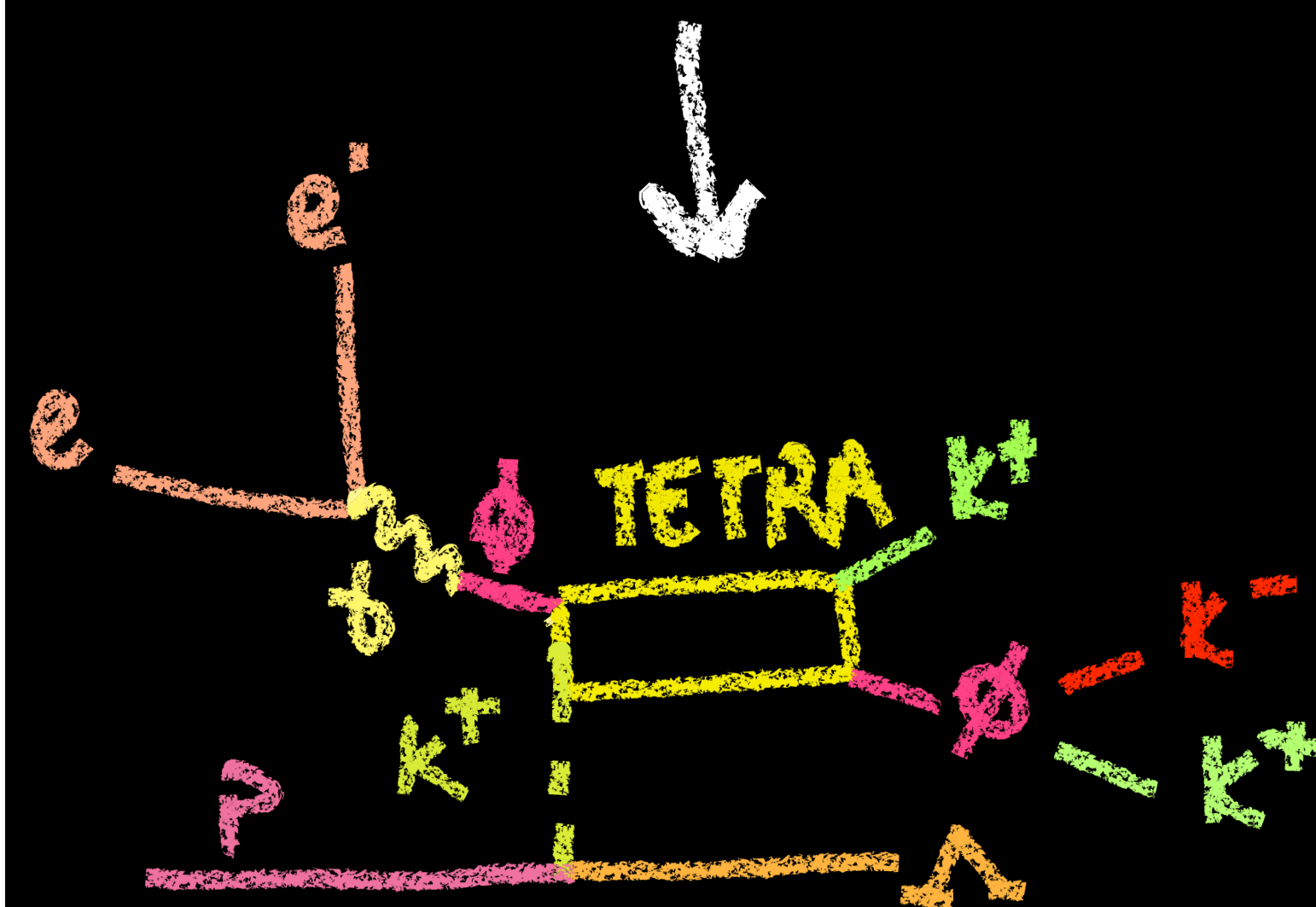


RESULTS

$$Q^2 \approx 0$$



PRODUCTION
MECHANISM



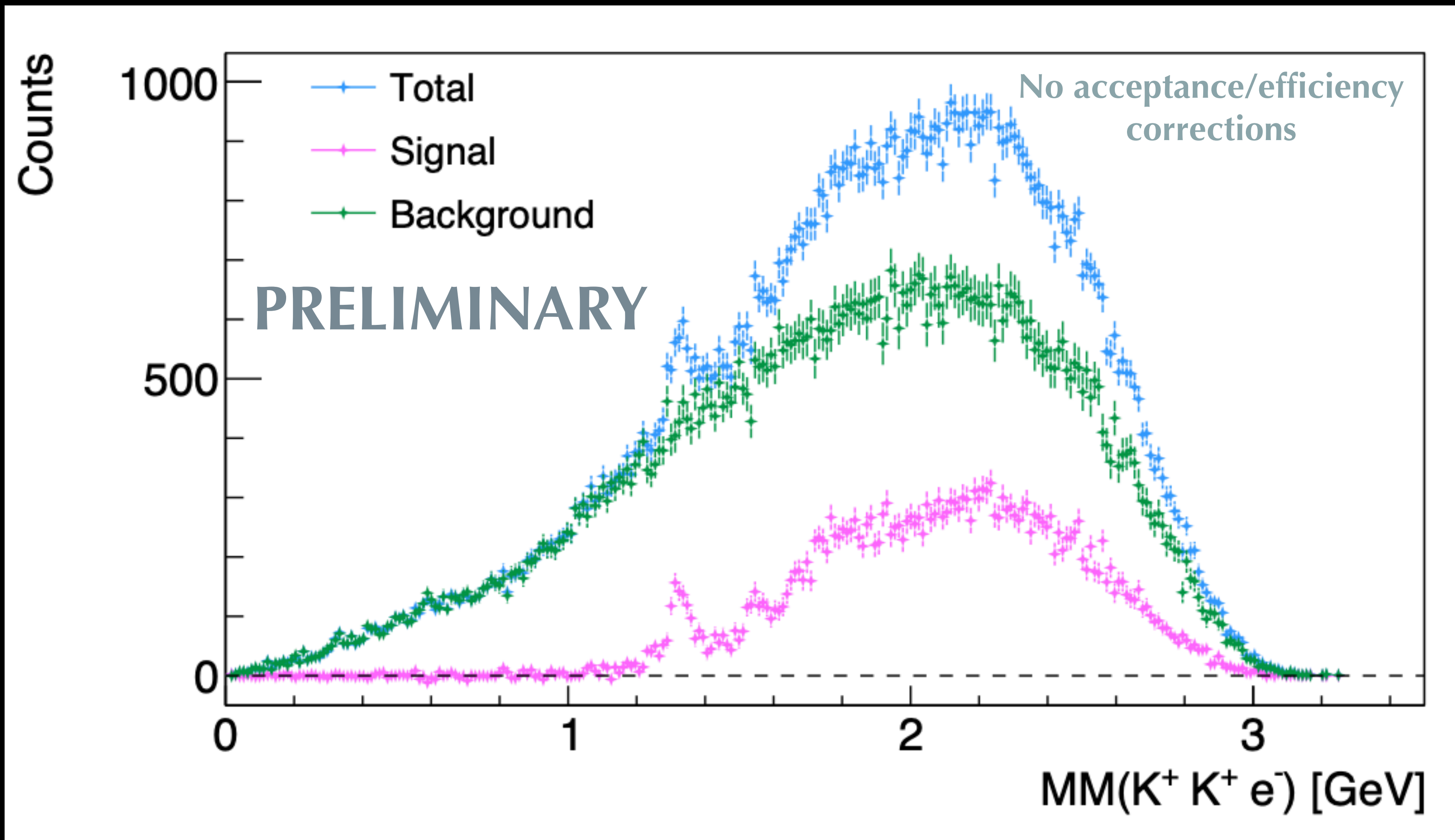
TETRAQUARK MASS
DISTRIBUTION



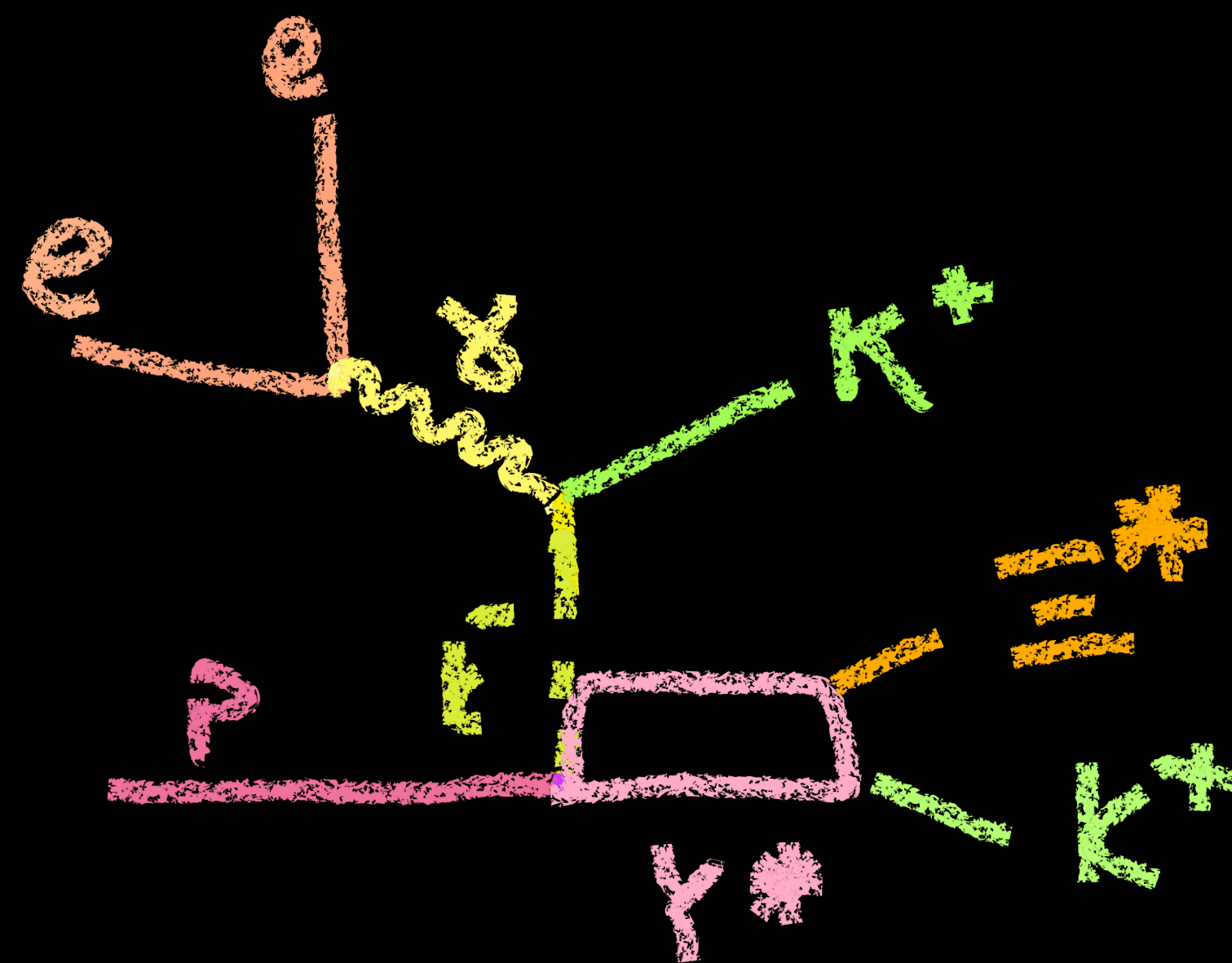
CASCADES

A decorative calligraphic banner featuring the word "CASCADES" in a white, stylized serif font. The banner is framed by two horizontal lines with elegant, swirling flourishes at each end. The top line is a vibrant red, and the bottom line is a bright blue. The background is a solid, deep black, which makes the white text and colorful lines stand out prominently.

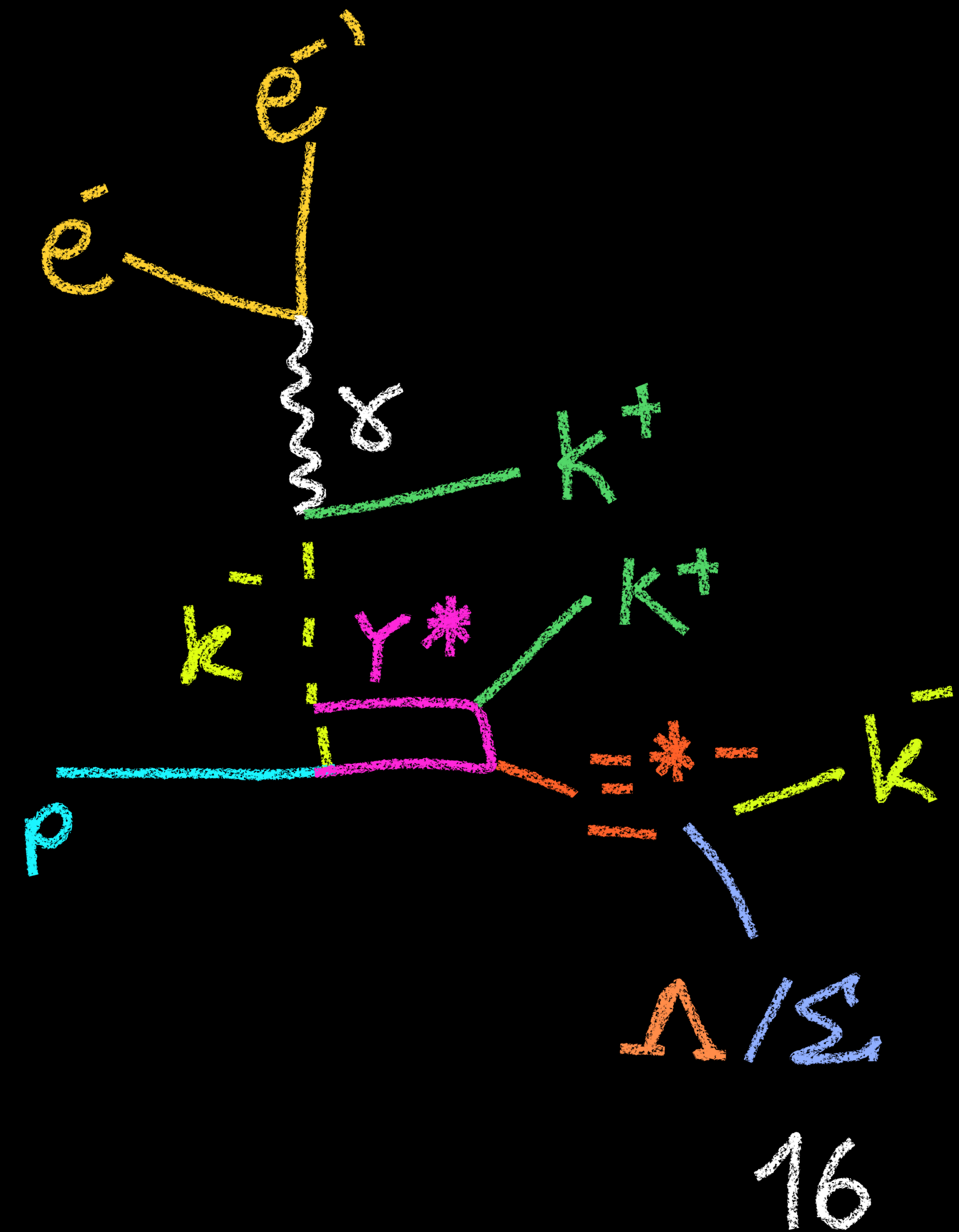
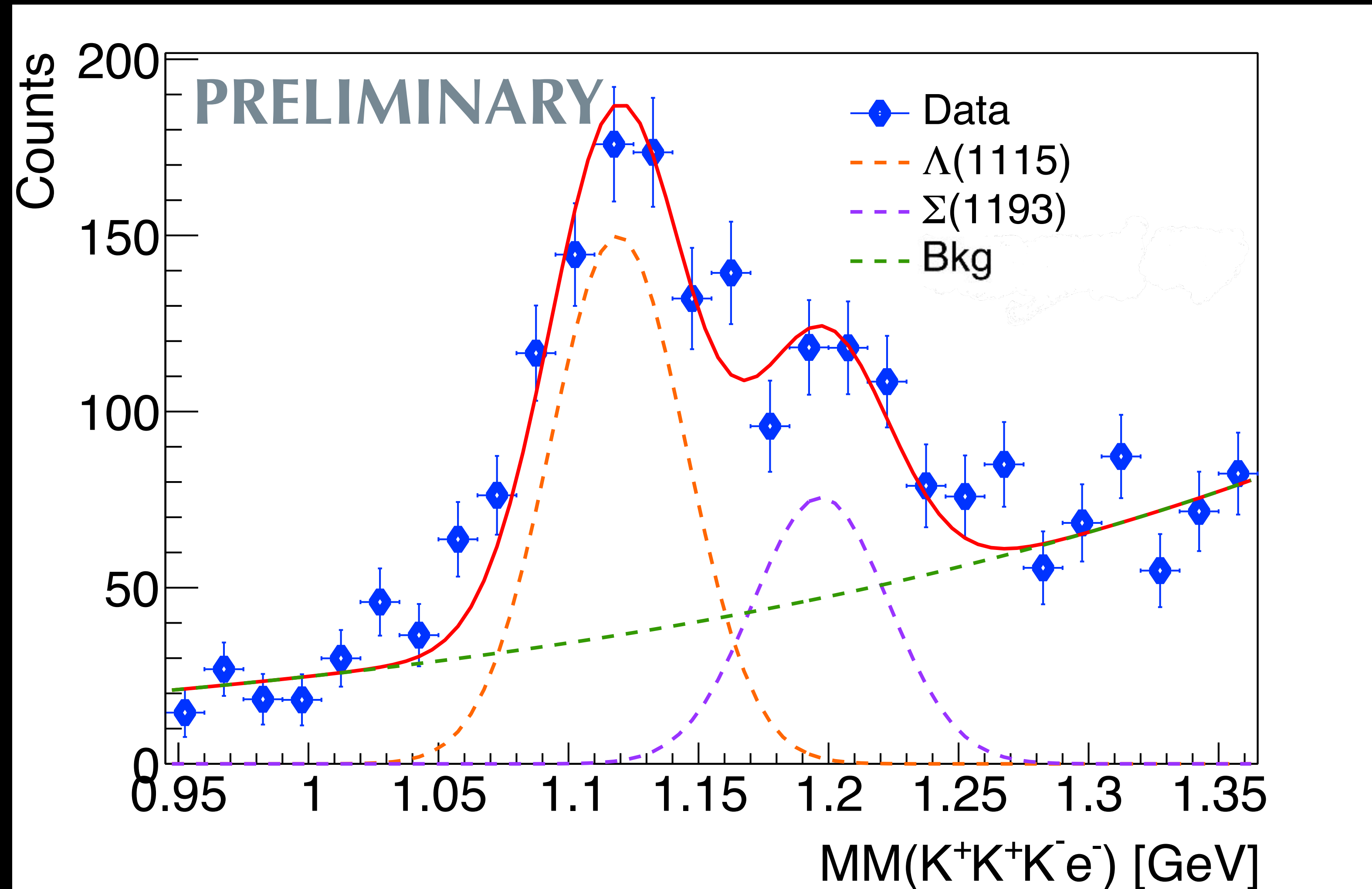
BENCHMARK: CASCADES



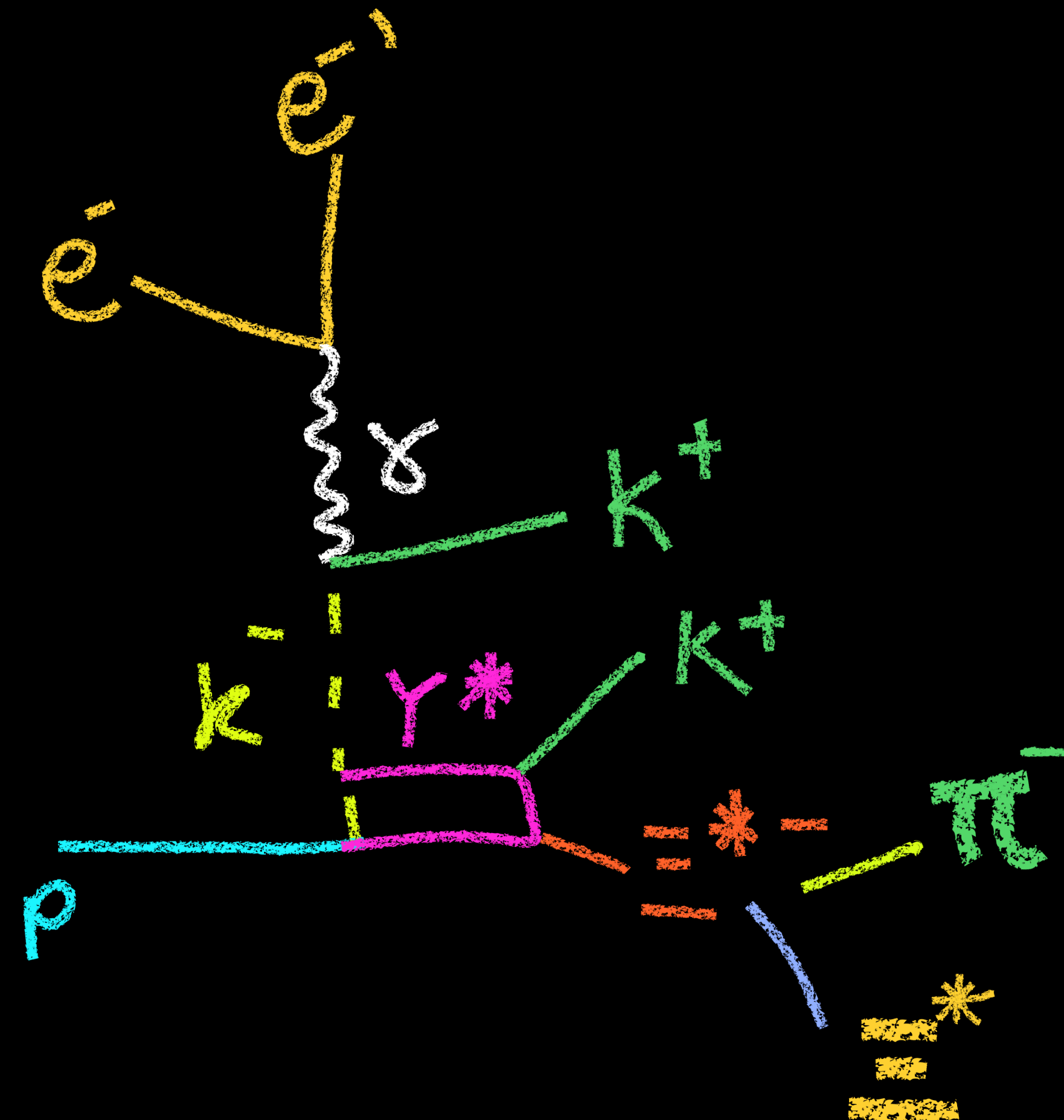
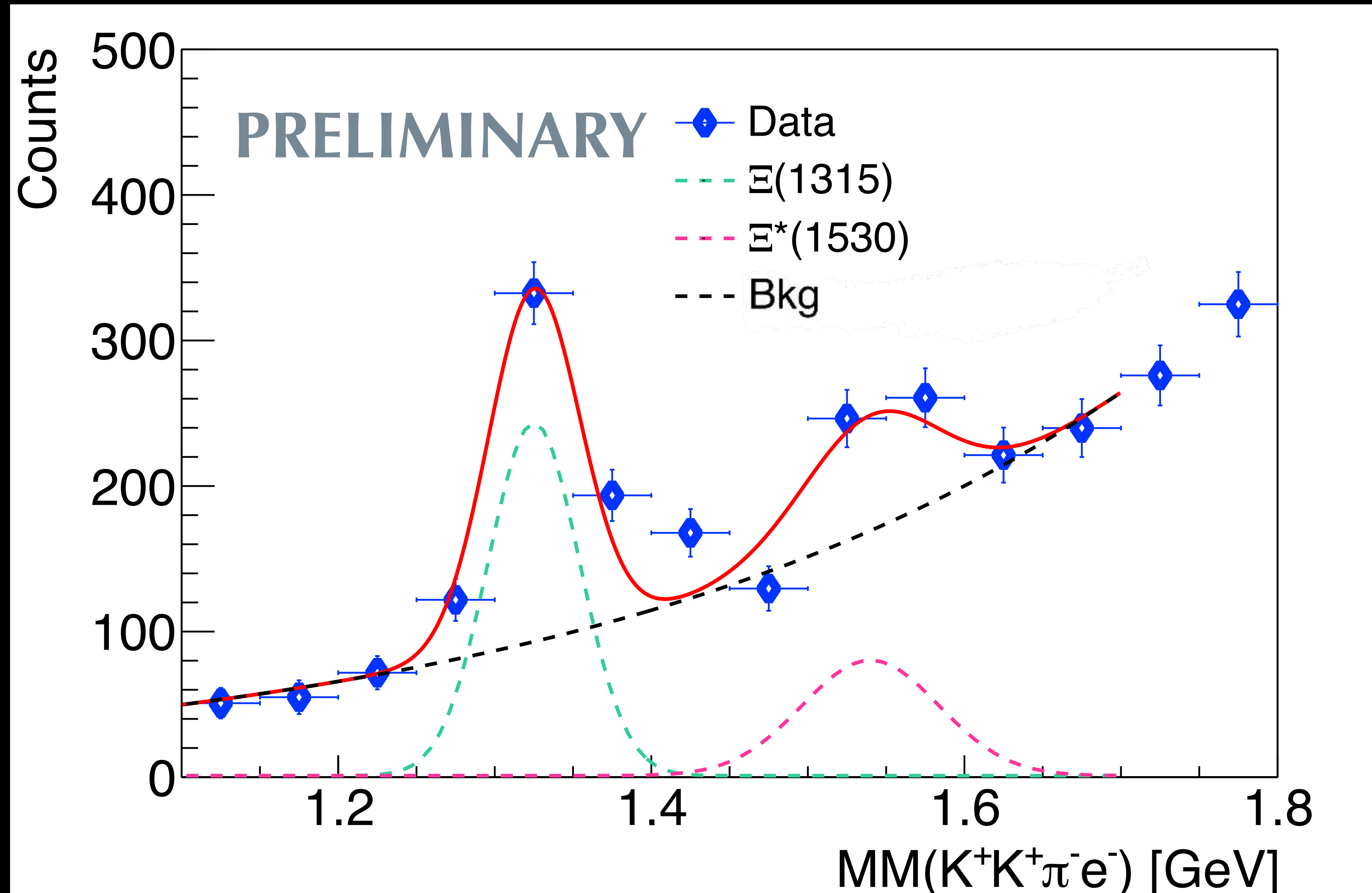
WEIGHTED
RESULTS FROM
← SWEIGHTS



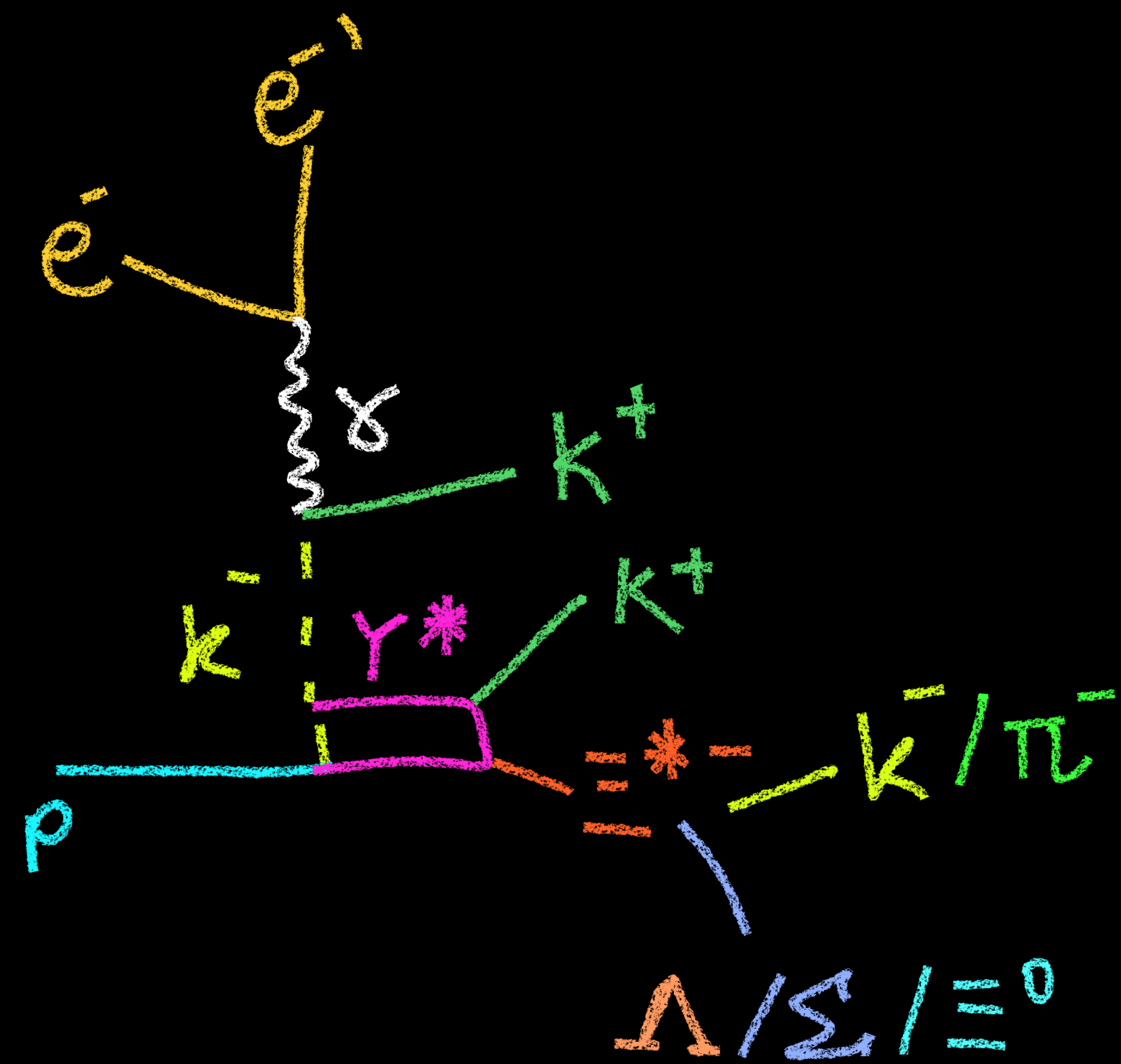
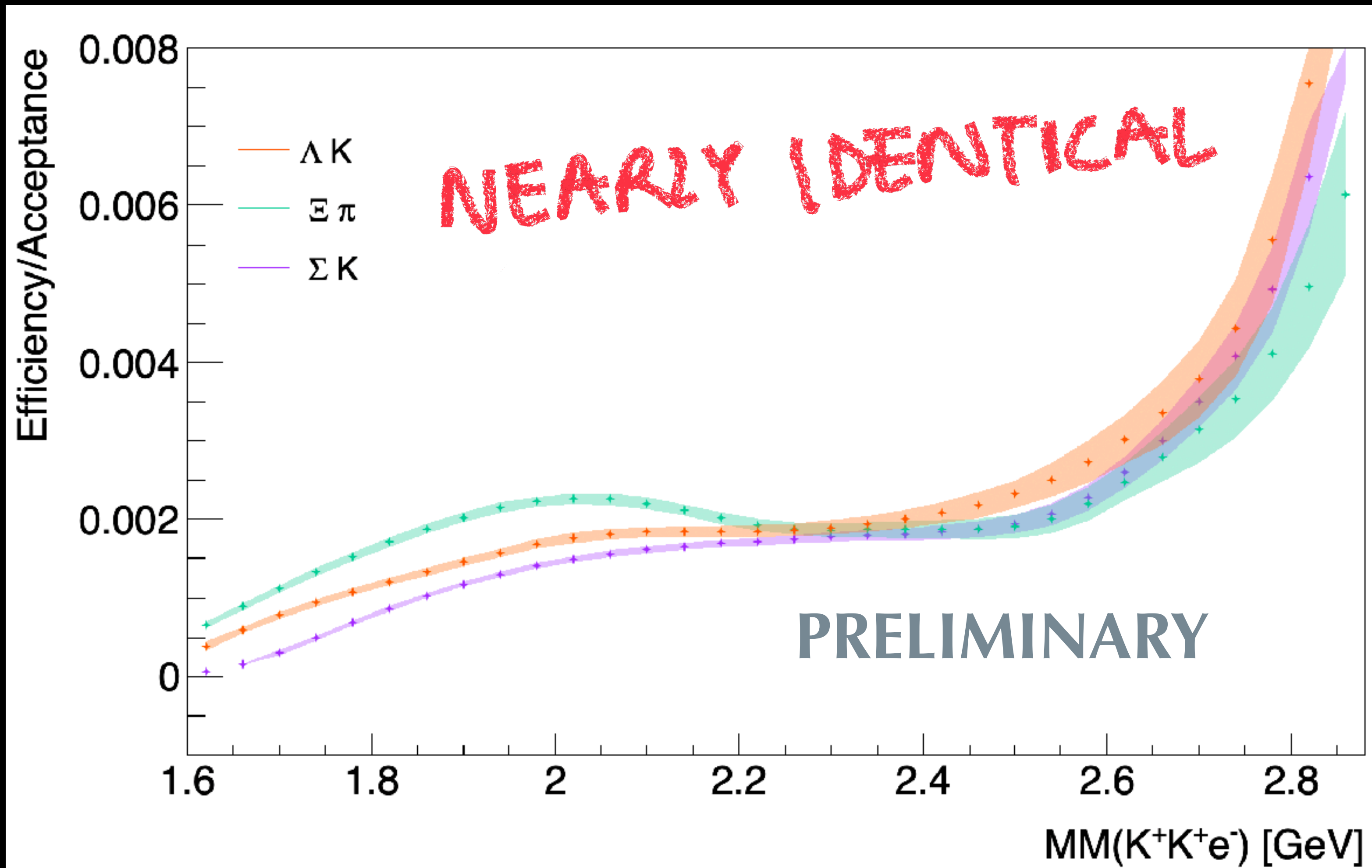
$\Xi^{*} \rightarrow \Sigma K^{-} / \Lambda K^{-}$ YIELDS



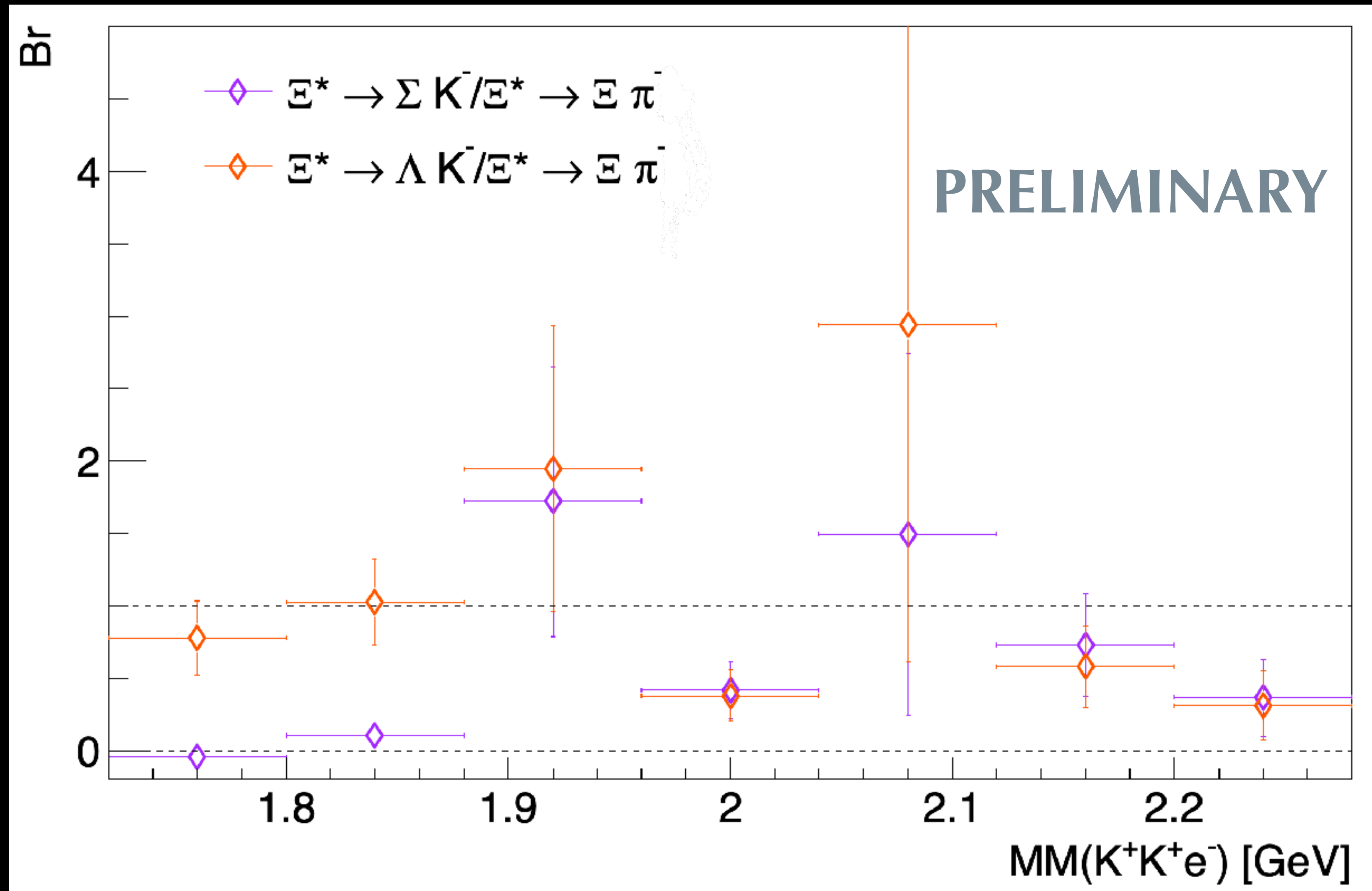
$\Xi^{*} \rightarrow \Sigma K^{-} / \Lambda K^{-}$ YIELDS



ACCEPTANCE/EFFICIENCY



RELATIVE BRANCHINGS



CONCLUSIONS

* ONE FINAL STATE TO RULE THEM ALL!

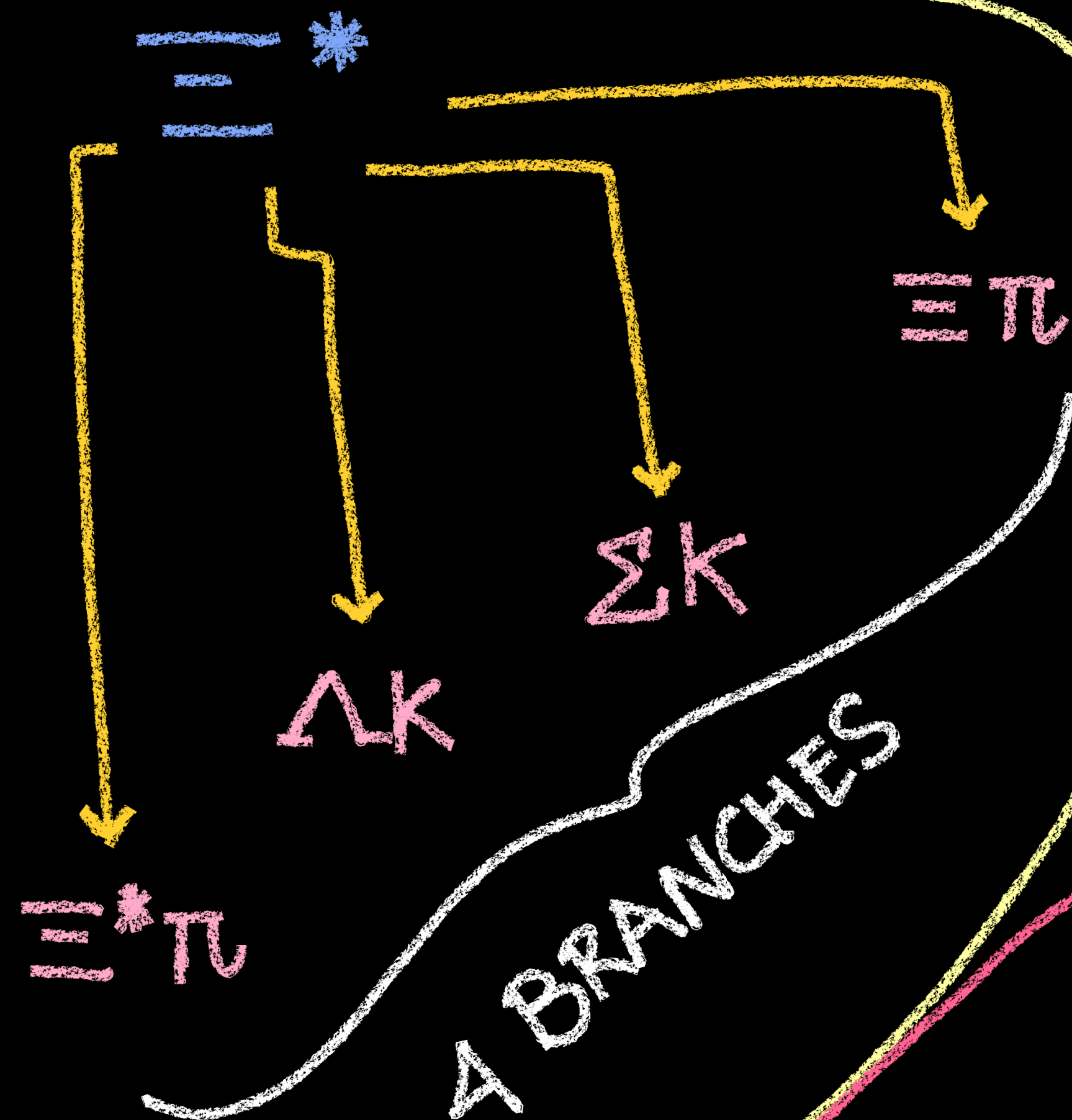
* PENTAQUARK(?), TETRAQUARK &
CASCADE

* THEORY?

* FIRST MEASUREMENT OF TETRAQUARK
FORM FACTOR?

* CASCADE MOLECULES?

CONCLUSIONS



$T \rightarrow \emptyset K$ (K $\emptyset$ SCATTERING LENGTH?)

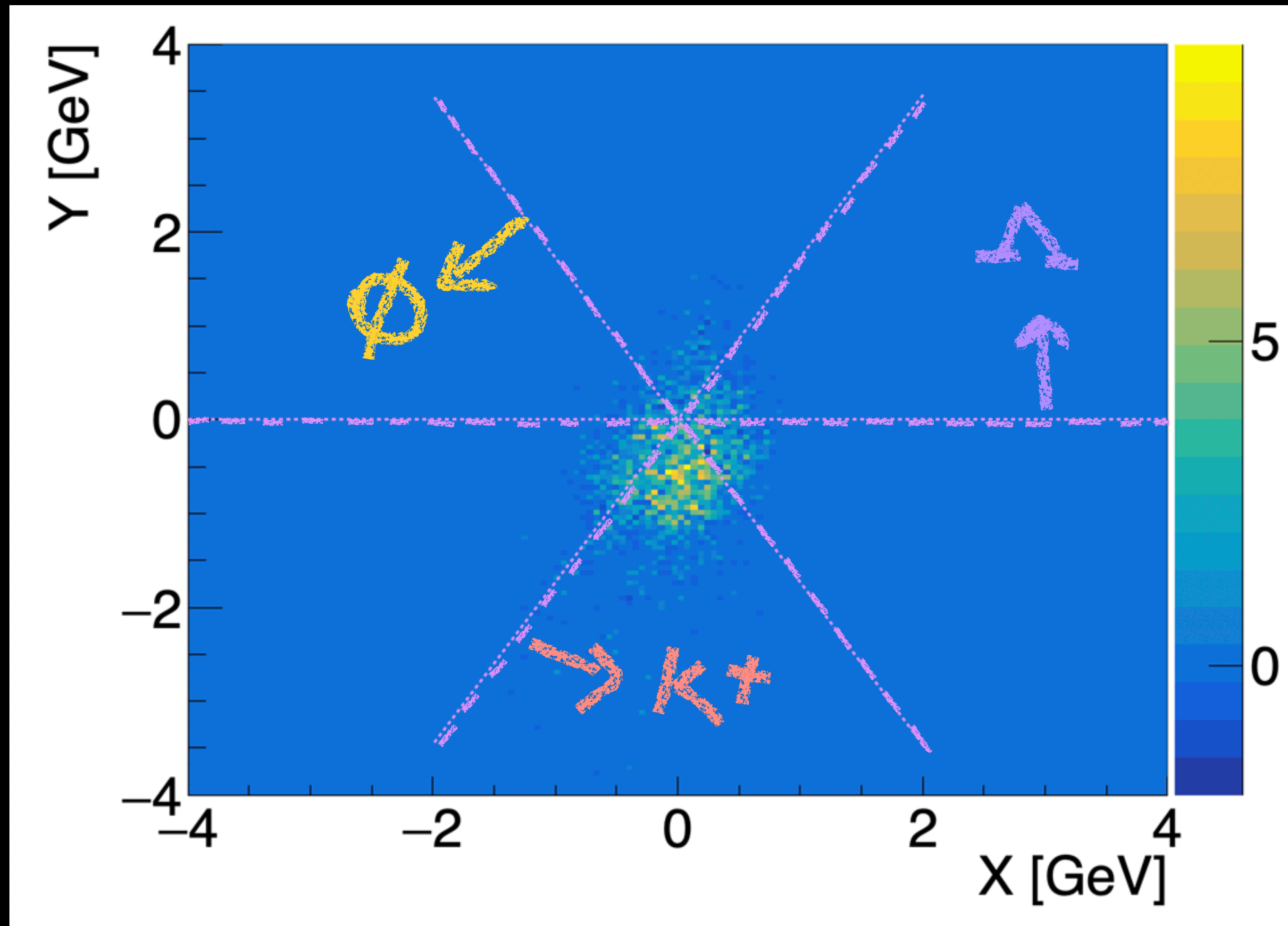
$T' \rightarrow KK^*$ ($S = +2$)

$P \rightarrow \Lambda\phi$ (?)

asli.acar@york.ac.uk

STAY TUNED

VAN HOVE



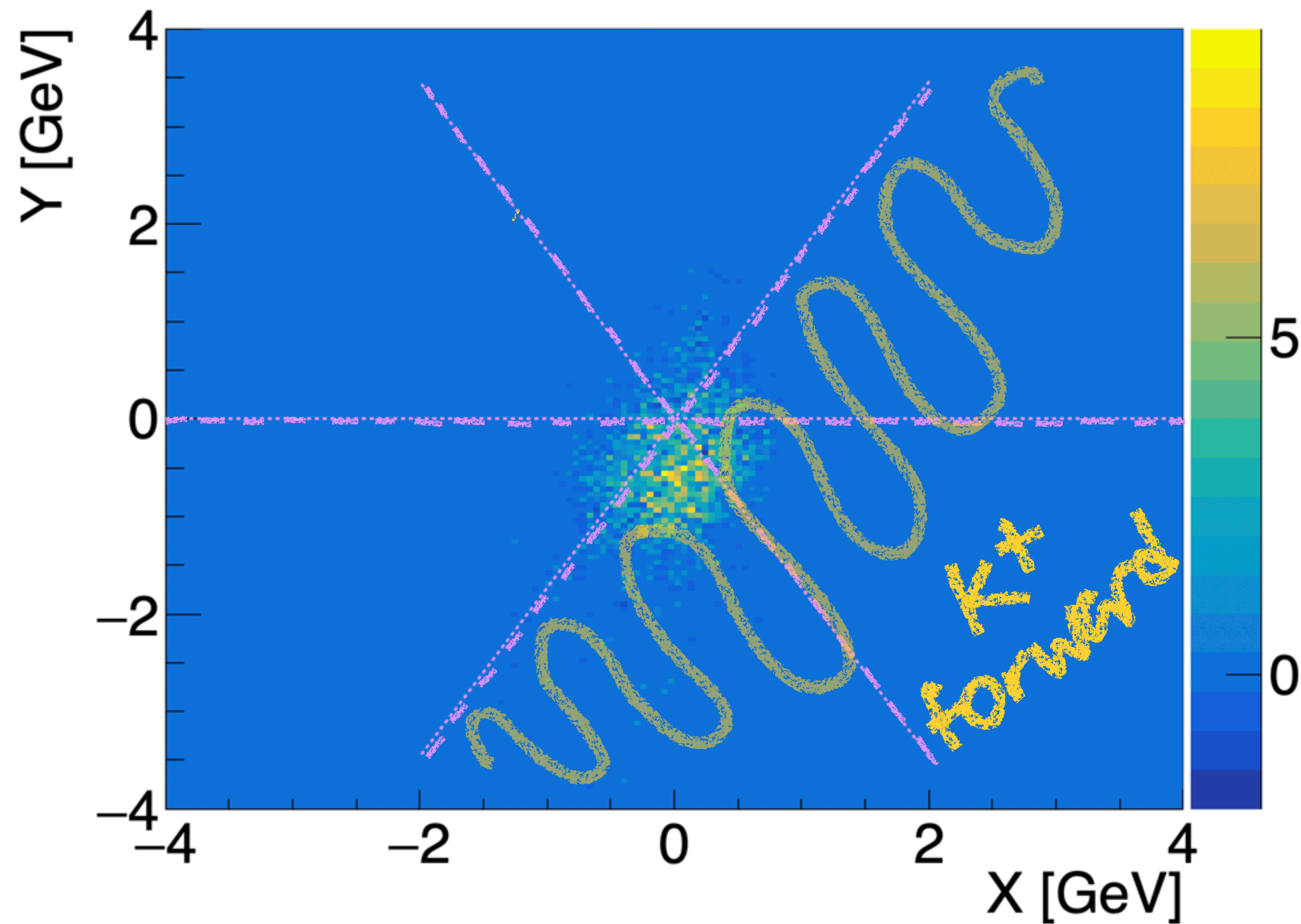
LONGITUDINAL PHASESPACE PLOTS

$$q_K + q_\phi + q_\Lambda = 0$$

$$X = \sqrt{\frac{3}{8}} (q_K - q_\phi)$$

$$Y = \frac{3}{\sqrt{8}} q_\Lambda$$

VAN HOVE

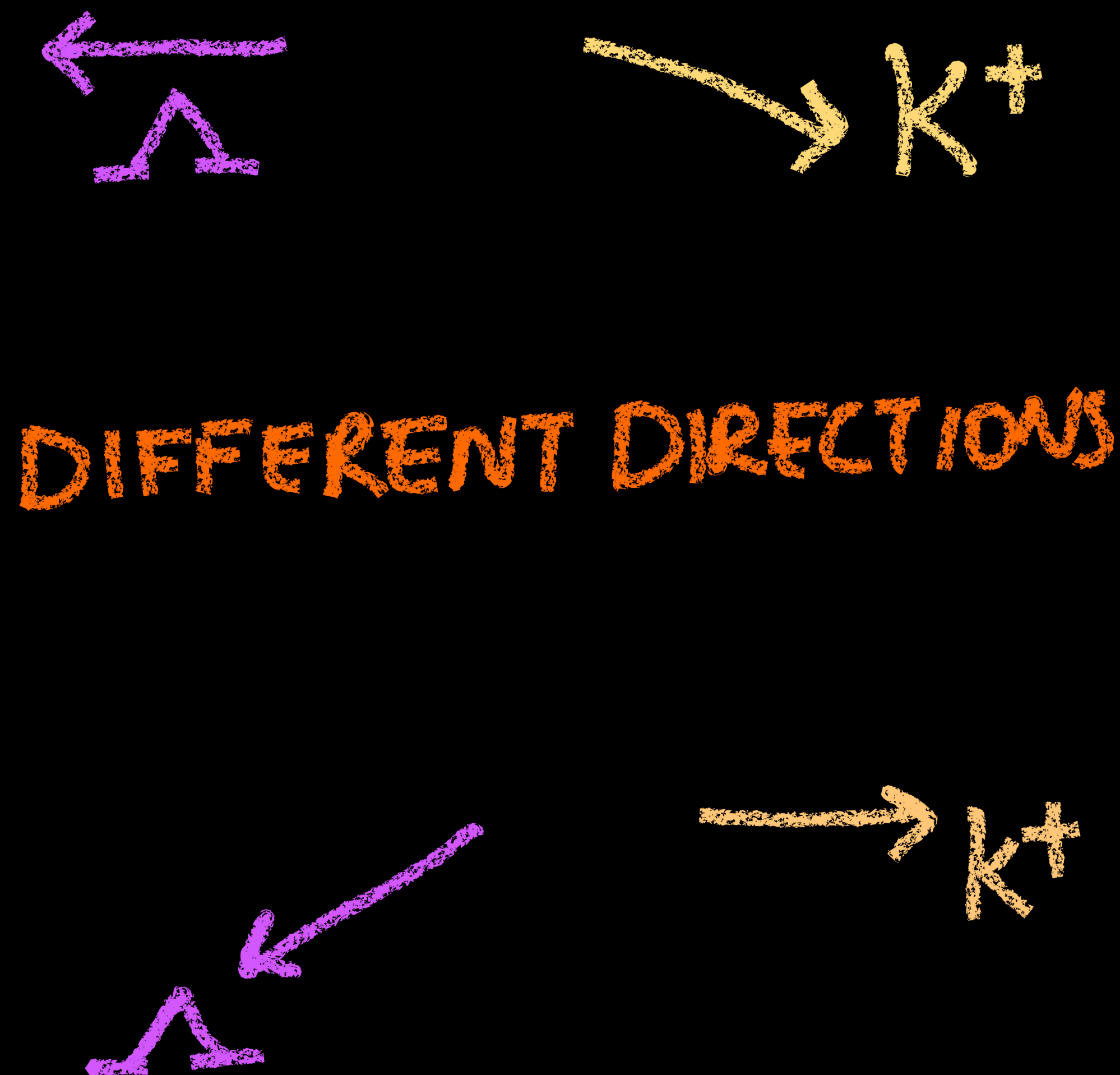
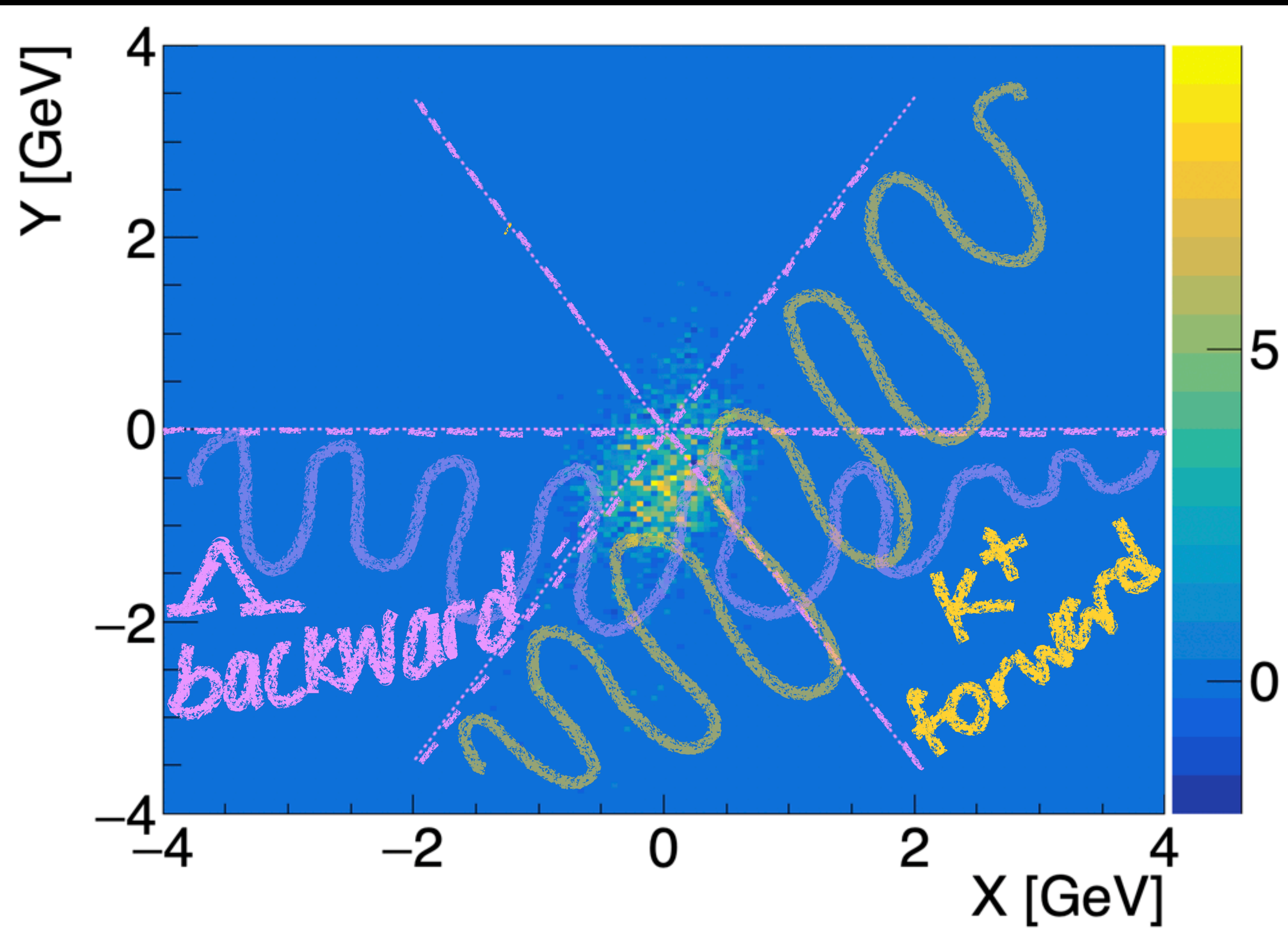


DIFFERENT DIRECTIONS

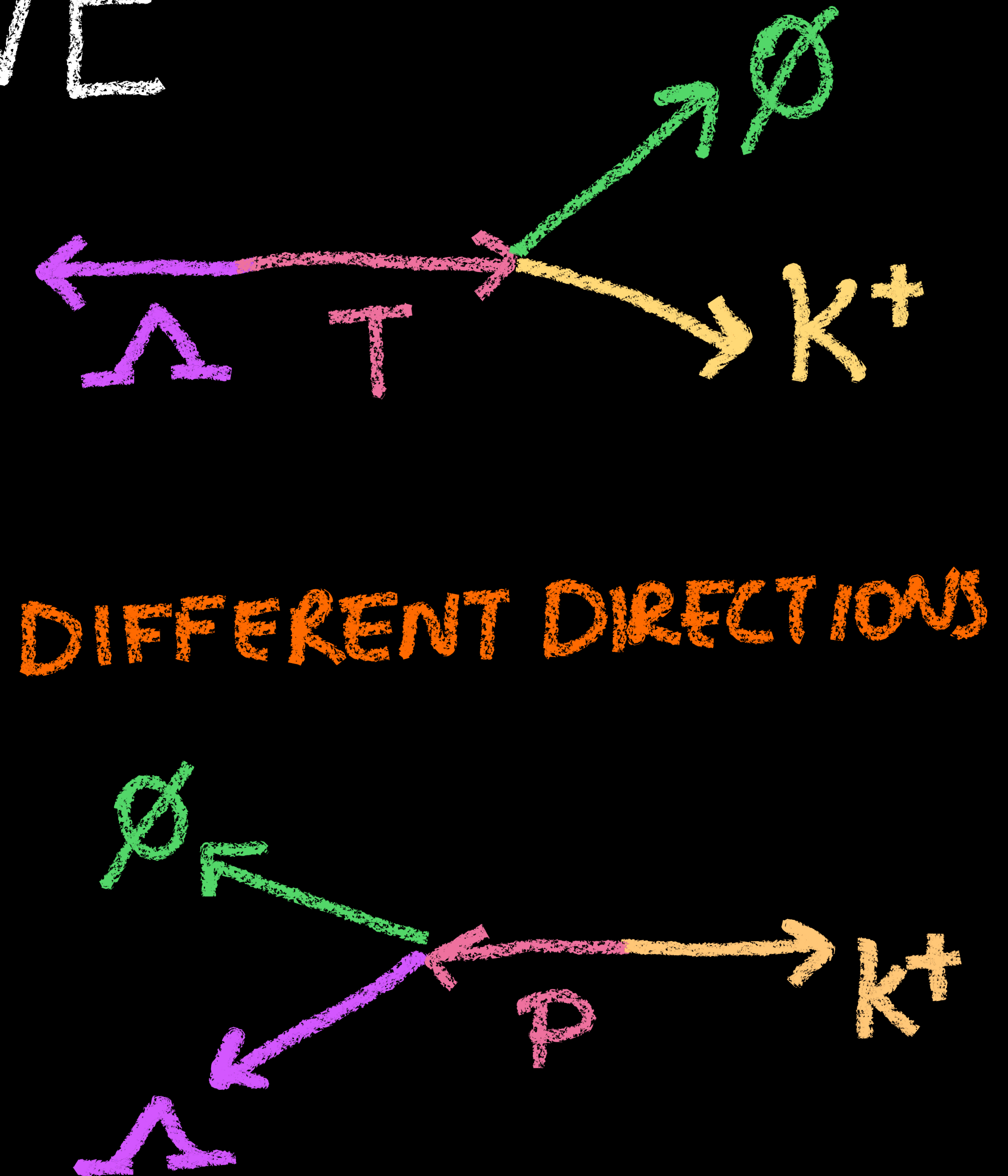
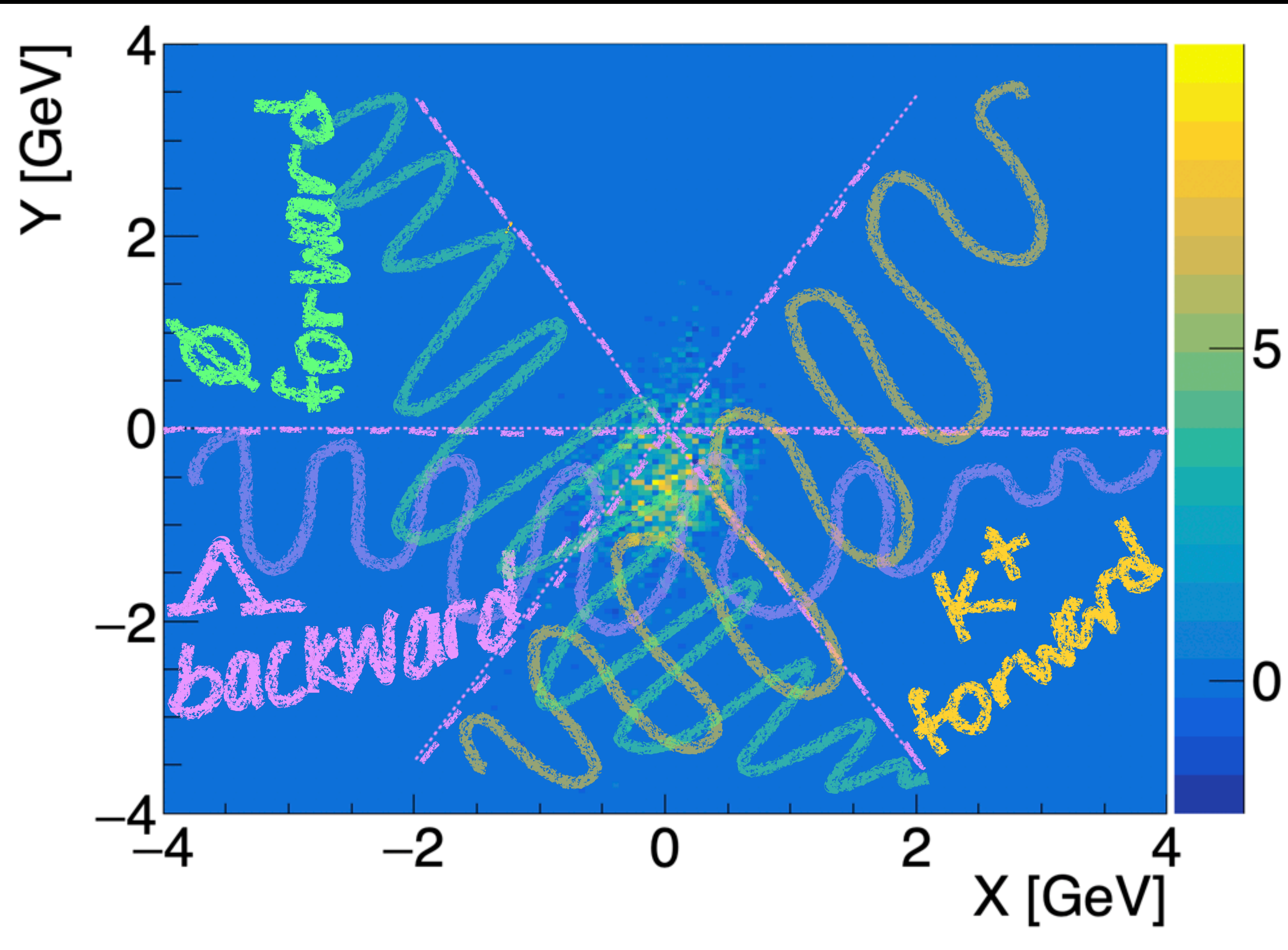
$\rightarrow K^+$

$\rightarrow K^+$

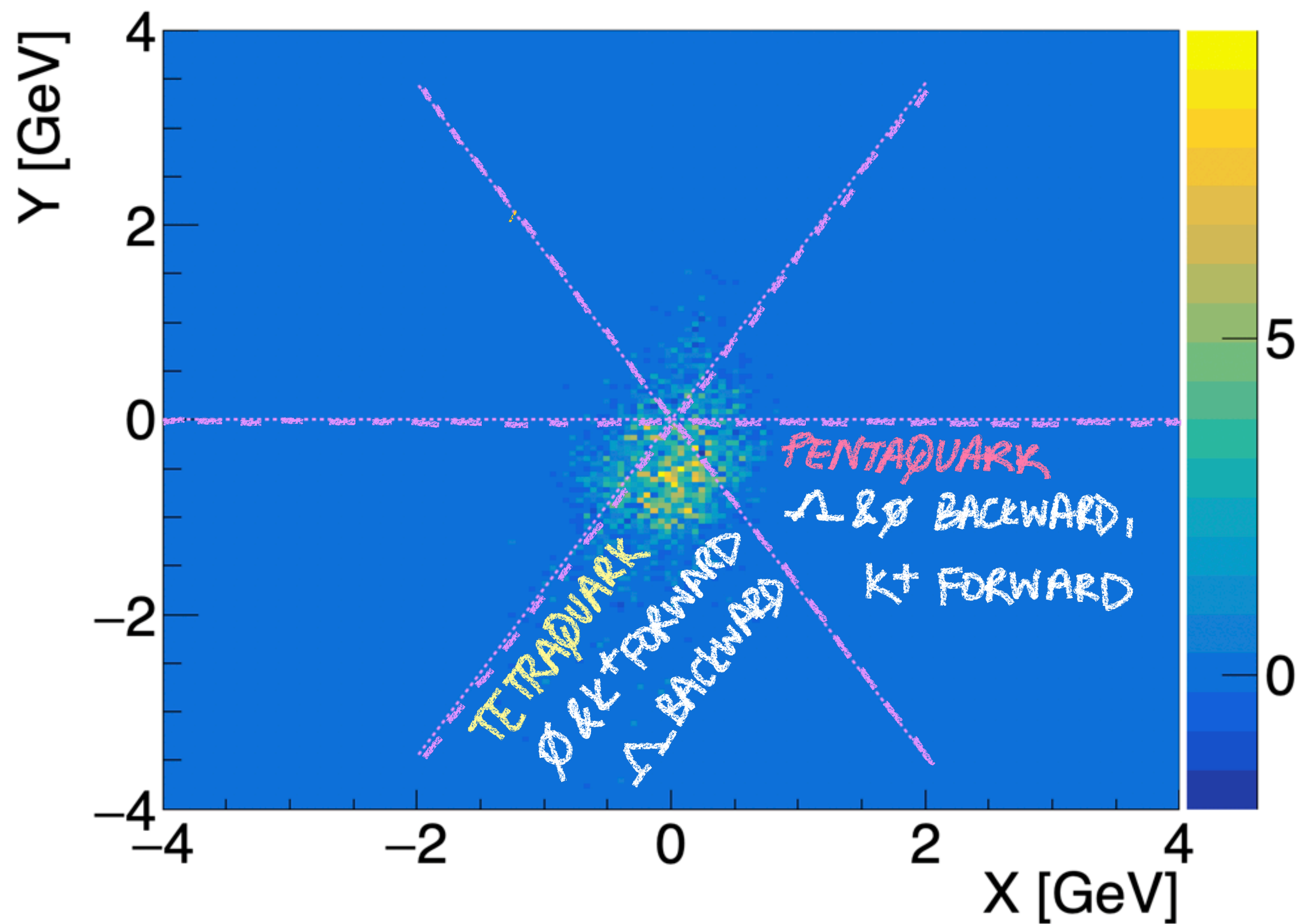
VAN HOVE



VAN HOVE



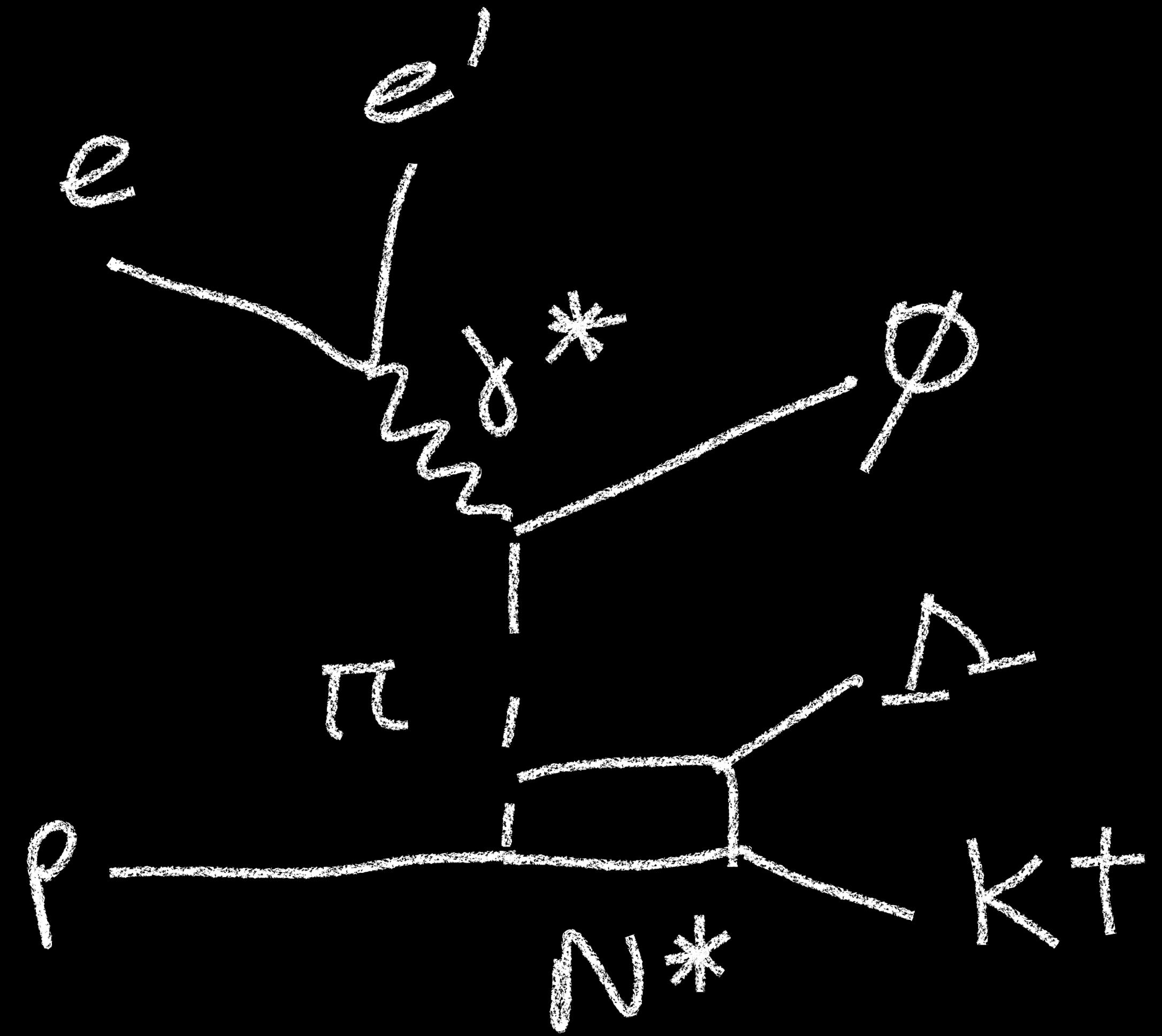
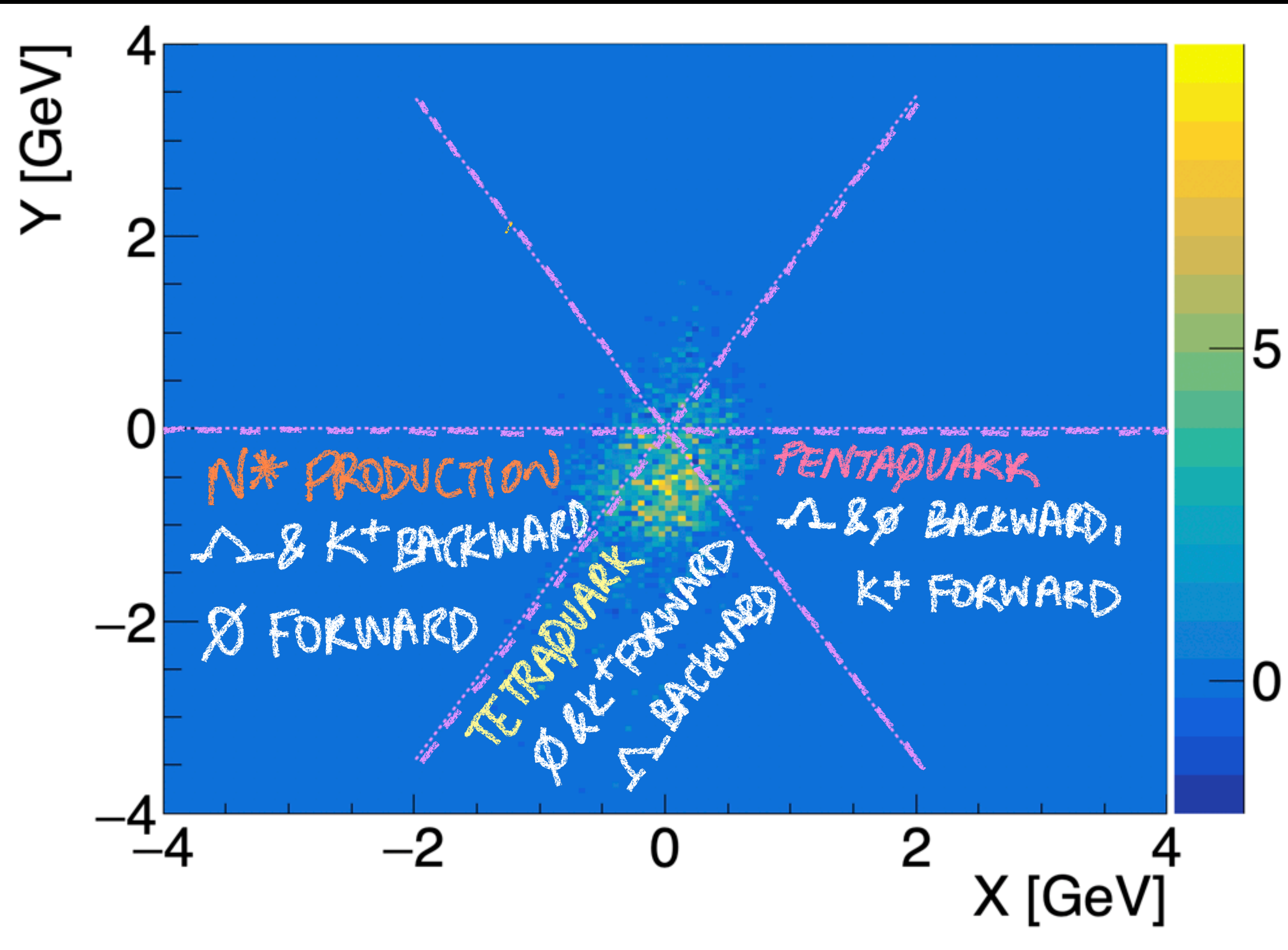
VAN HOVE



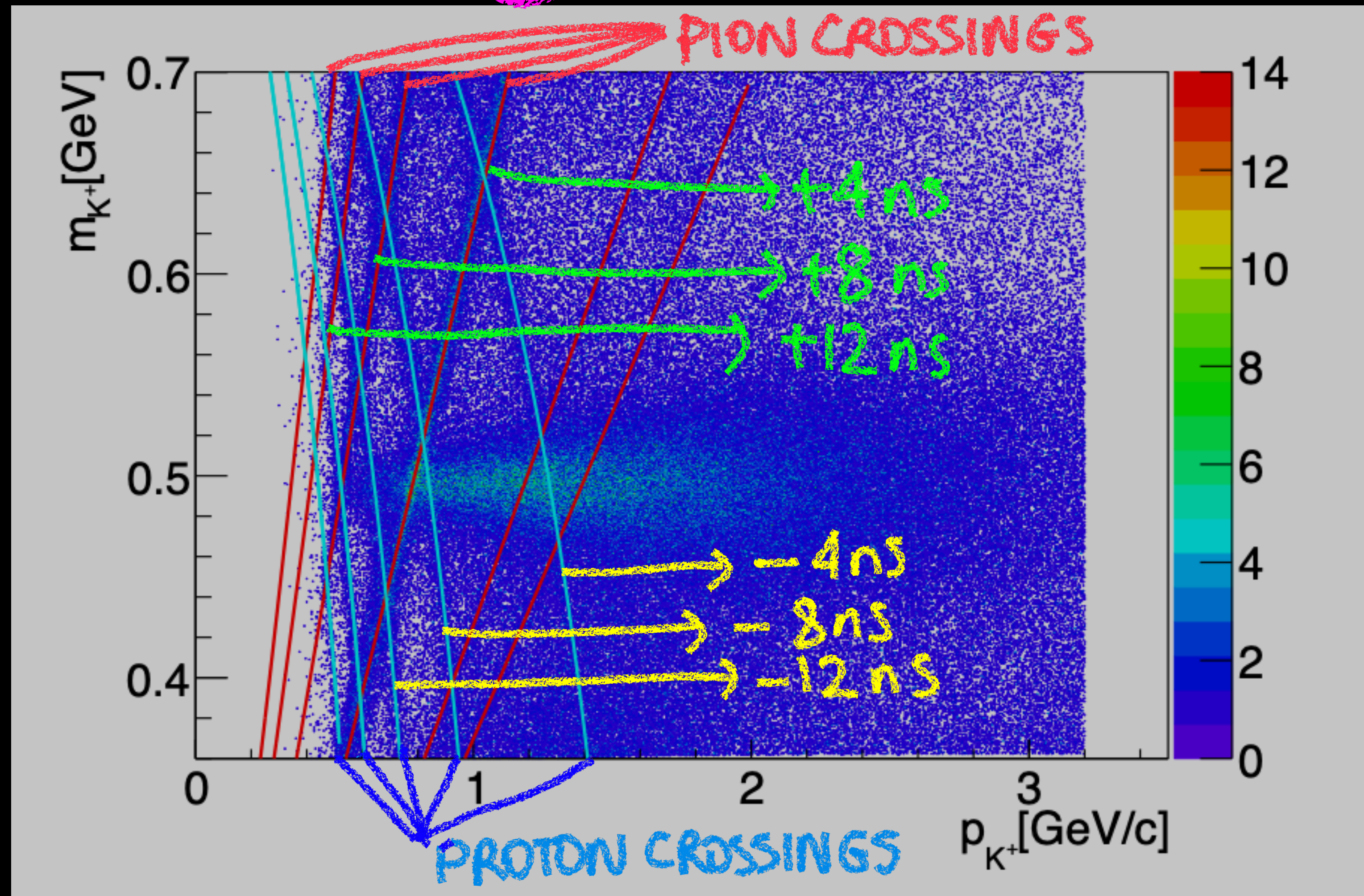
DIFFERENT DIRECTIONS



VAN HOVE



PID from TOF



OUT-OF-TIME BG



4 ns 4 ns

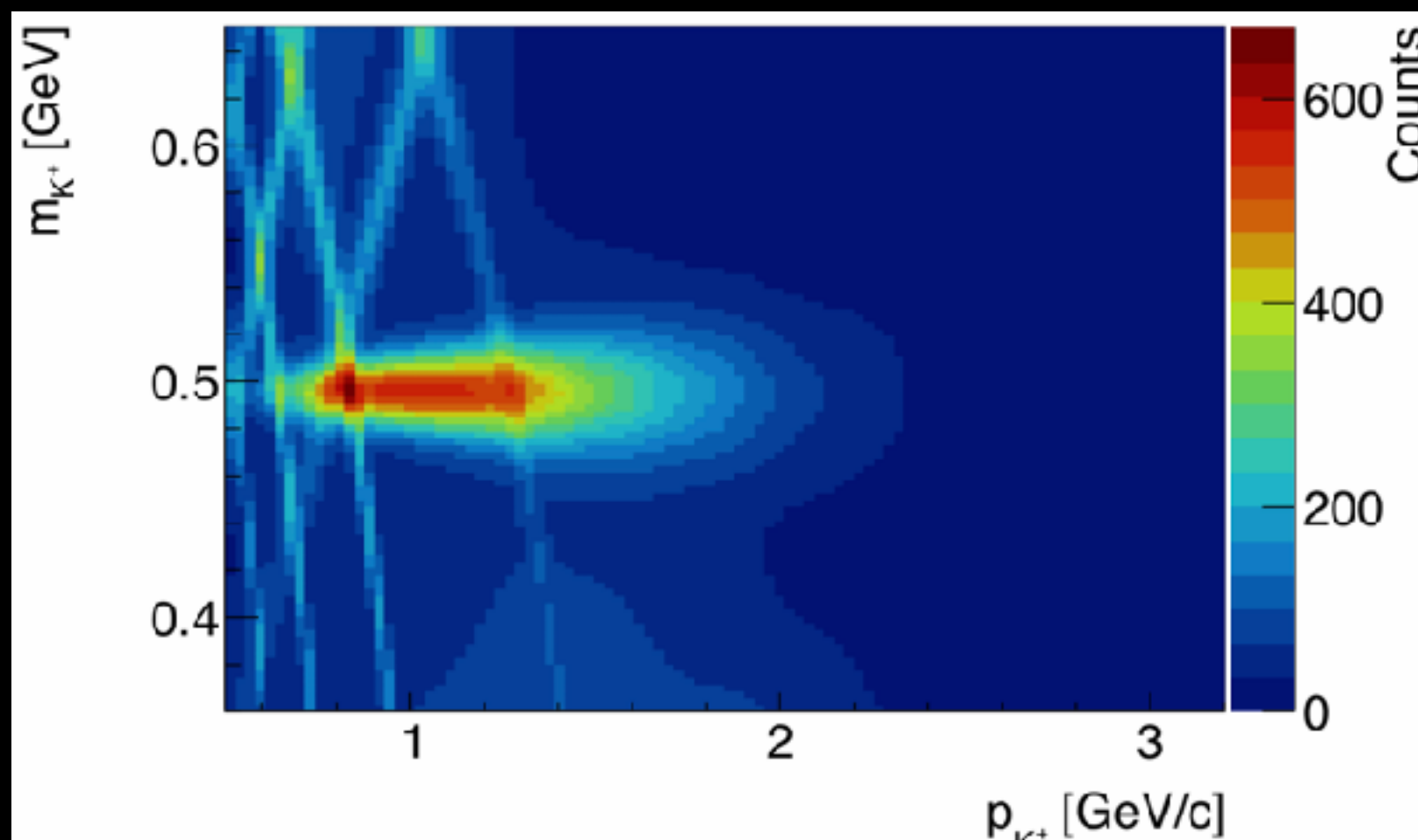
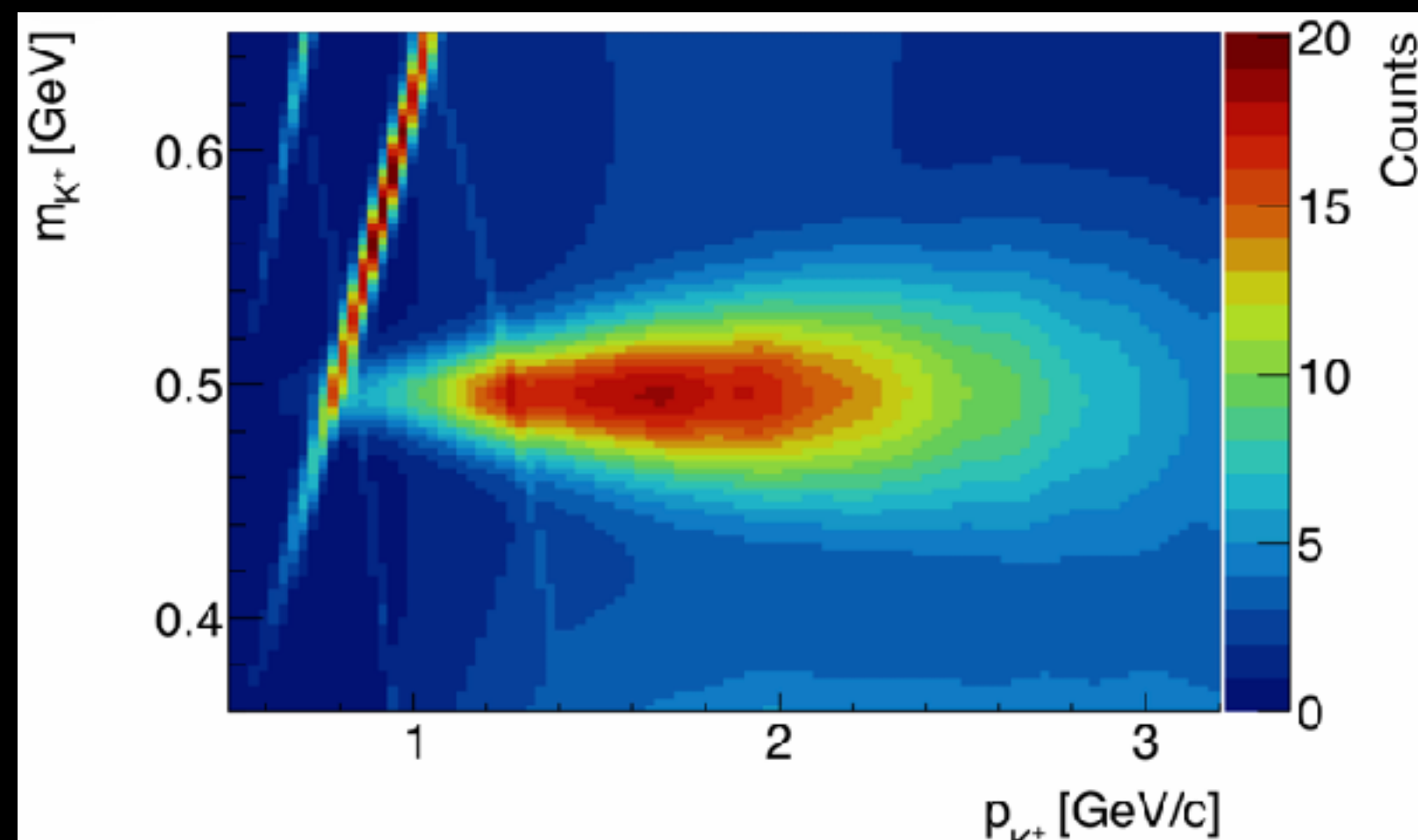
$$m^2 = \frac{|P_1|^2}{\beta^2} - |P|^2$$

MODEL

vs

DATA

KAON1 MODEL
KAON2 MODEL



KAON1 DATA
KAON2 DATA

