Hunting for kaons and Lambdas at AMBER

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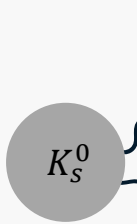

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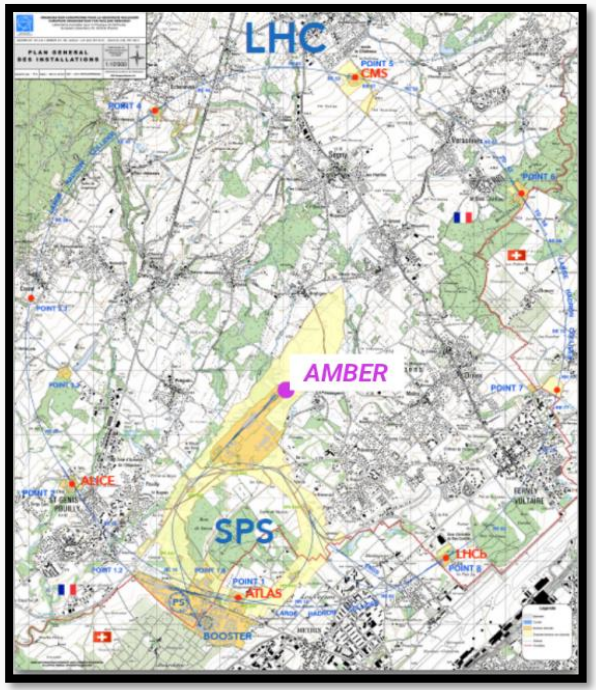
01.

What is AMBER?

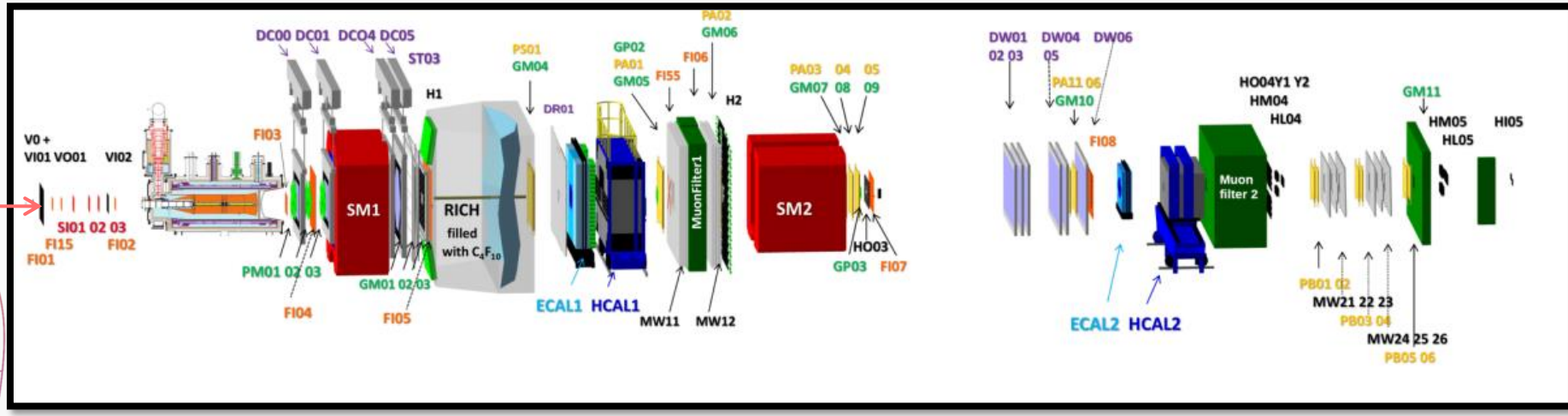
What is AMBER?



- AMBER is a fixed target experiment @CERN:
- It's the successor of the COMPASS experiment;
- It has the objective of measuring the fundamental properties of hadrons, like the proton.
- It's a new experiment that started taking data in 2023.

What is AMBER?

Apparatus for Meson and Baryon Experimental Research



Beam and Spectrometer:

- M2 beam line: either hadron or muon beams
- Large aperture dipole magnets SM1 and SM2
- Re-use of some COMPASS detectors, others new

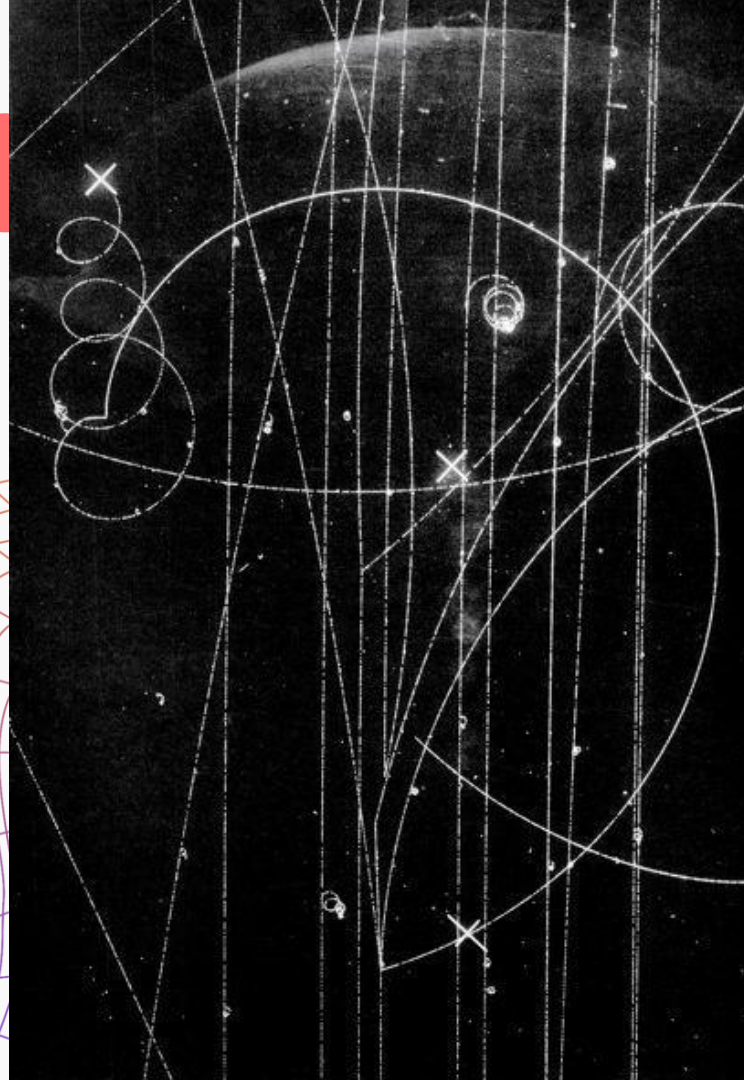
2023 Physics Goals:

- Antiproton production in proton on helium colisions:
  Input for indirect Dark Matter searches.

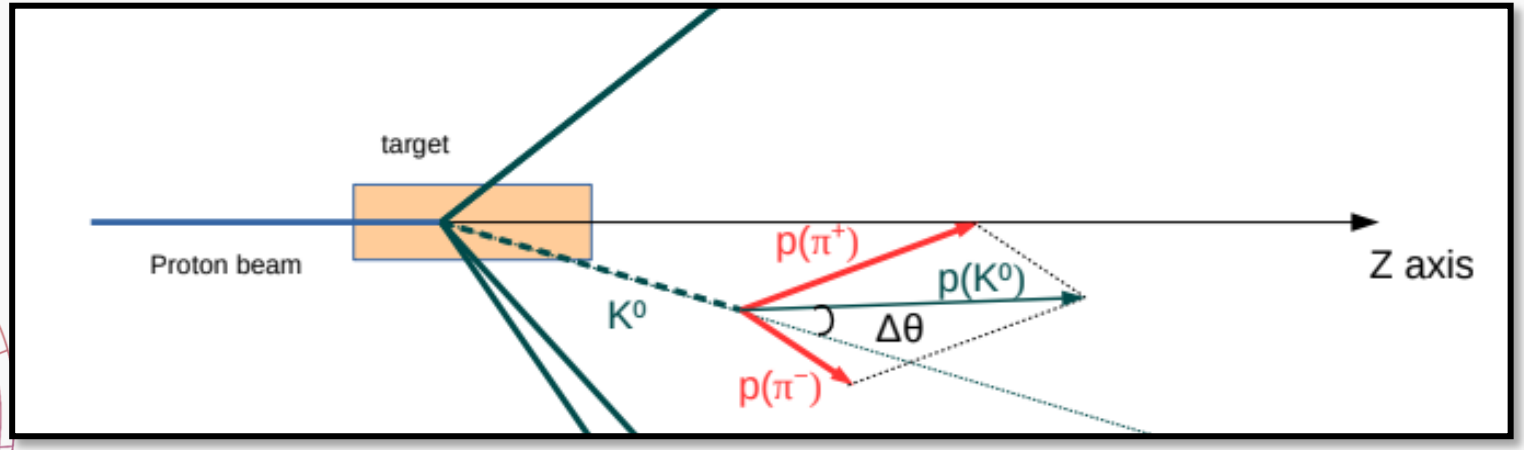
Why Kaons?

- Kaons (strange mesons) are produced abundantly in proton-helium collisions: $K^{\pm}, K^{0}$ ...
- Kaons have relative long lifetime.
- K^{0}: ~50% K_S^0, ~50%K_L^0
- K_S^0 decays are useful for verifying the spectrometer alignment quality.

Decay	BR
$K_S^0 \rightarrow \pi^+ \pi^-$	$69.20 \pm 0.05\%$



How to find K_S^0?



K_S^0 Characteristics

- Neutral particle;
- Decays in 2 pions with oposite charge;
- Mass of $0.49765\ GeV/c^2$;

How to find K_S^0?

- Interaction of the proton beam in the He target: Primary Vertex.
- Secondary Vertex (V0) in the same event with 2 opposite charged particles.

Invariant Mass Plot

By generating an invariant mass plot of the products of the Secondary Vertex and applying cuts to single out the kaons and checking if the mass peak matches with the real value.

Armenteros Podolanski plot

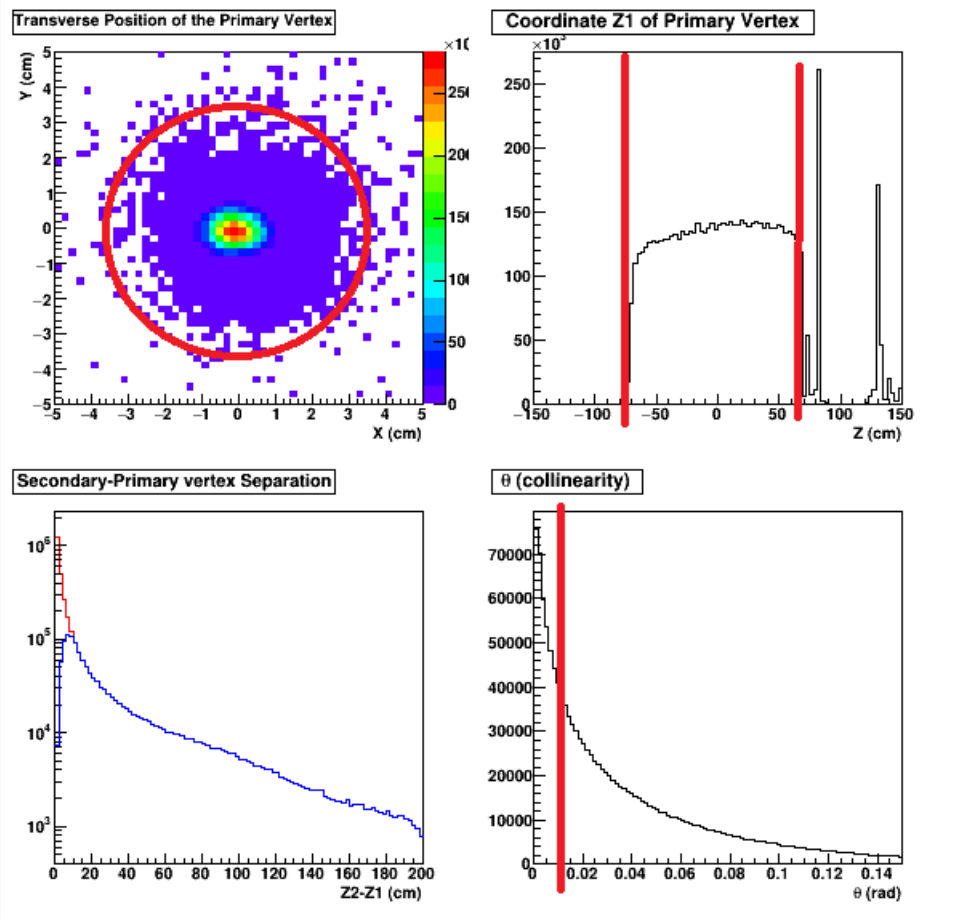
Creating a 2D plot of the transverse momentum (p_T) of one of the charged particles versus the asymmetry in longitudinal momentum (p_L) between the 2 particles.

$$\Delta s = \frac{p_{L1} - p_{L2}}{p_{L1} + p_{L2}}$$

Data analysis

Data Selection and Cuts

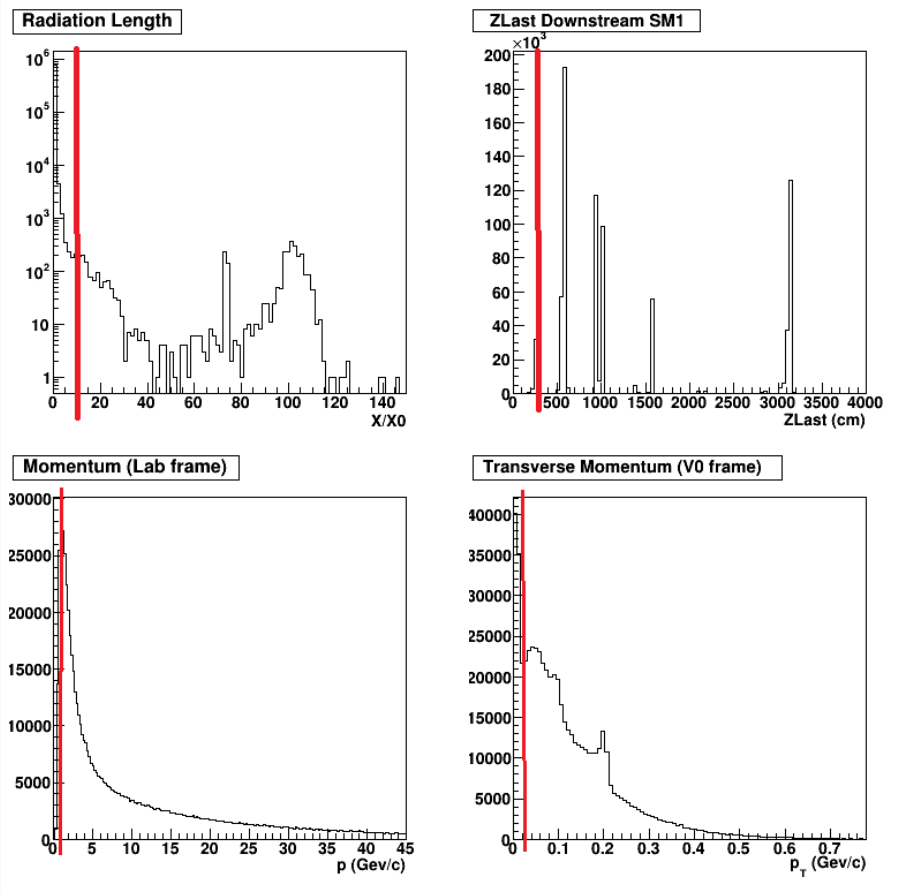
1. Transversal cut in the target region → $\mathrm{r} = \sqrt{X^2 + Y^2} < 3.6\ cm$
2. Z coordinate → $-65 < Z < 65\ cm$;
3. Secondary-Primary Vertex Separation → $Z2 - Z1 > 2\sigma$;
4. Θ collinearity → $\Theta_{coll} < 0.01$;



Data analysis

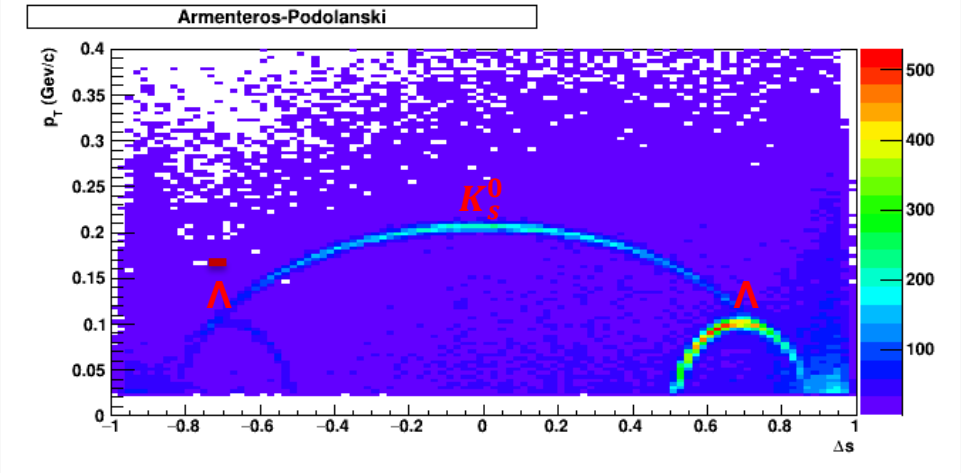
Data Selection and Cuts

5. Radiation Length $\rightarrow {}^{X}/_{X_0} < 10$;
6. Last mesured point after SM1 $\rightarrow ZLast > 300$ cm;
7. Particles momentum (Lab Frame) $\rightarrow p > 1\ Gev/c$;
8. Transverse Momentum (V0 Frame) $\rightarrow p_T > 0.023\ Gev/c$.

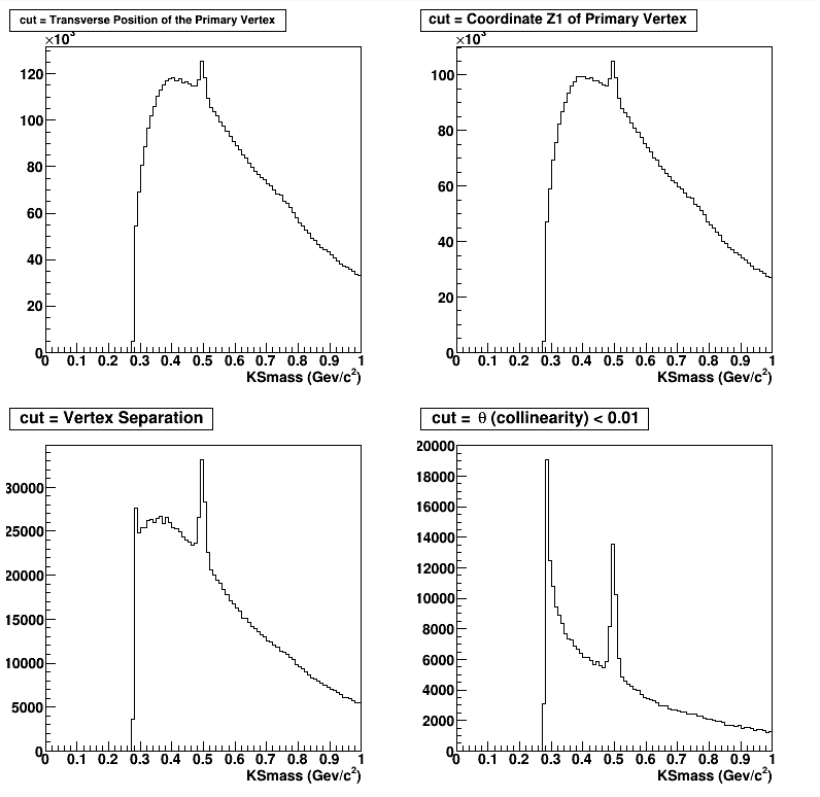


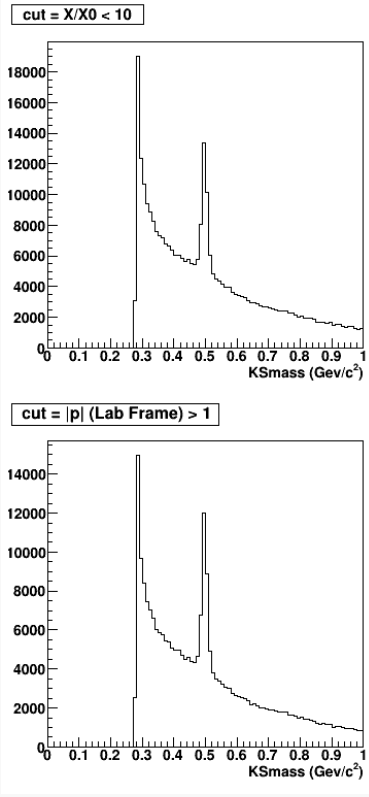
Armenteros-Podolanski Plot for Particle Identification

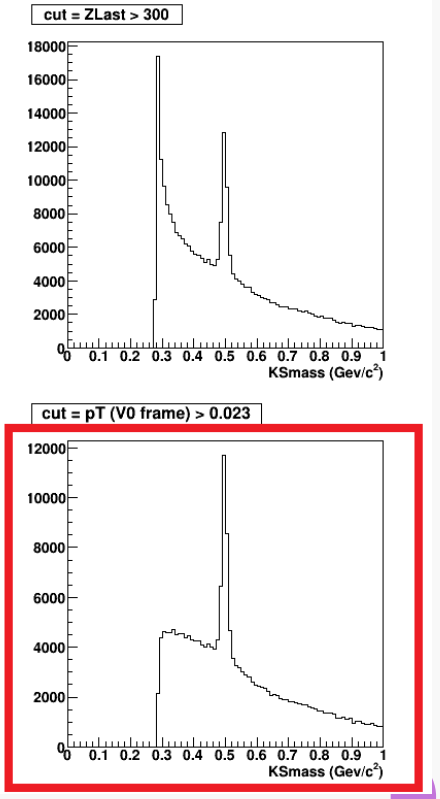
- Asymmetry between the longitudinal momentum (p_L) of the particles decayed from the K_S^0 in the Lab Frame → $\Delta s = \frac{p_{L1} - p_{L2}}{p_{L1} + p_{L2}}$
- This plot is done after the cuts mentioned previously.



K_s^o Mass spectrum After each Cut







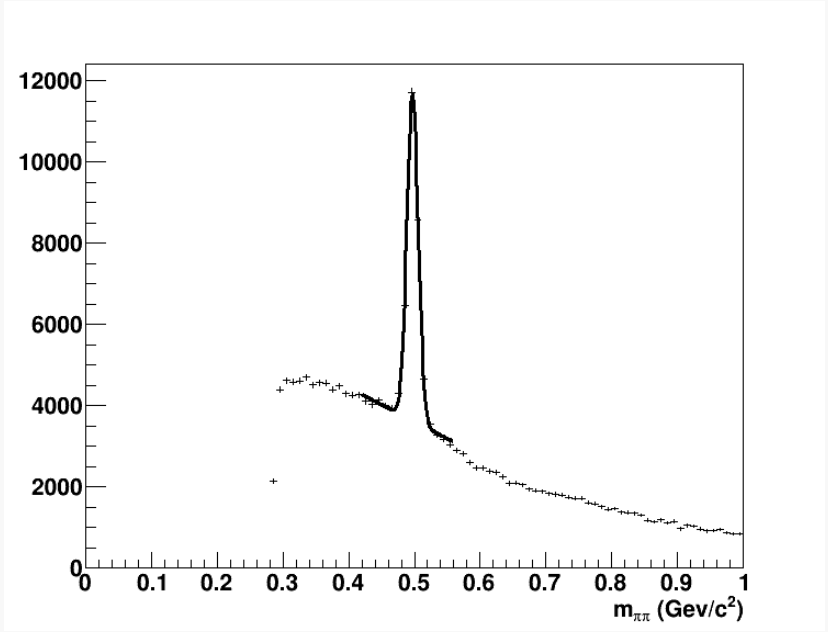
Statistics and Cut Flow

cuts	#pairs	Fraction (wrt previous)	Fraction (wrt 1st)
r<3.6 cm and -65<Z<65 cm	1101143930	--	--
Vertex Separation	23997020	21.79	21.79
Θ_{coll}<0.01	6569312	27.38	5.96
$X/X_0 < 10$	6505354	99.03	5.91
$ZLast > 300$ cm	267970	4.12	0.24
$\|p\|$ (Lab Frame) $> 1\ Gev/c$	267970	100	0.24
$p_T\ (V0\ Frame) > 0.023\ Gev/c$	212804	79.41	0.19

Comparison of K_s^0 Mass

The mass spectrum after cuts is fited with $\boldsymbol{gausn + pol1}$

- **Measured Mass (from analysis):**
  $M(Fit) = 0.494 \pm 0.0001\ Gev/c^2$
- **PDG Mass (expected value):**
  $M(K_S^0) = 0.497\ \pm 0.0005\, Gev/c^2$



Conclusions

Validated Data Quality:

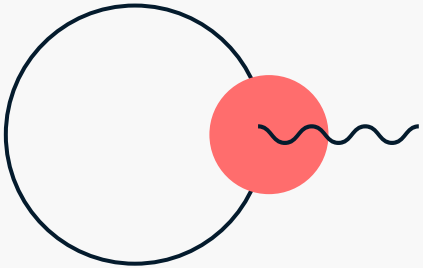
- Kaon and Lambda properties are visible in the data sample analysed (1 run)
- K0s mass is consistent with expectations.

Spectrometer Alignment:

- No significant misalignments detected.
- Data quality adequate for further physics studies.

Impact:

- Established method for quality control, used in AMBER.



Thank you