

Investigations of Detector Signatures from Λ , Ξ and Ω Events

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Outline

- Motivation
 - Dynamic Track and Event Reconstruction
 - SttCellTrackFinder
- $\Lambda\bar{\Lambda}$ and $\Xi^-\bar{\Xi}^+$ events
- $\Omega^-\bar{\Omega}^+$ events
- Outlook and Summary

Motivation

- Hyperons might be difficult to reconstruct due to complex decay topology with *e.g.* displaced vertices

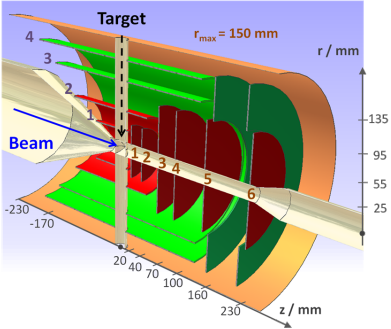
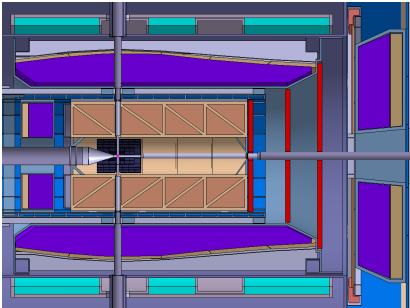
Hyperon	$c\tau$ [cm]	Mass [GeV/c^2]
Λ (uds)	8.0	1.116
Ξ^- (dss)	4.9	1.321
Ω^- (sss)	2.5	1.672

- DyTER - Dynamic Track and Event Reconstruction
- STTCellTrackFinder
 - Cellular Automaton to form tracklets from STT hits
 - Riemann fit to combine tracklets

Goal: Dynamic track finder which is as general as possible but works well for hyperon tracking

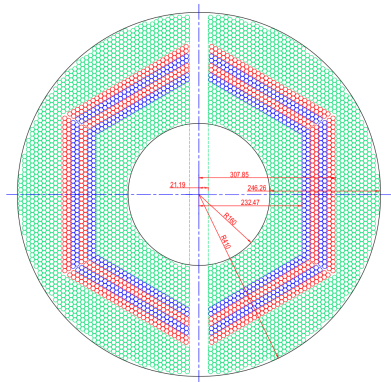
Motivation

- $\Lambda\bar{\Lambda}$, $\Xi^-\bar{\Xi}^+$ and $\Omega^-\bar{\Omega}^+$ events due to their complex decay topology
- STT, MVD and GEM for tracking
- (MVD and) SciTil for possibility of providing a t_0
- Transition: event based \rightarrow time based



STT

- 4,636 straws, 27 layers
- When straw tube is hit, gas is ionized and free electrons created
- Electrons travel towards anode wire at center of tube - signal for readout
- Maximum drift time of electrons: 200 ns
- At PANDA: 20 MHz interaction rate
 - ⇒ On average one event every 50 ns
- During drift time no more signals can be registered
 - ⇒ one straw might be occupied for the next 3 or 4 events and might not fire if hit by a particle!



STT

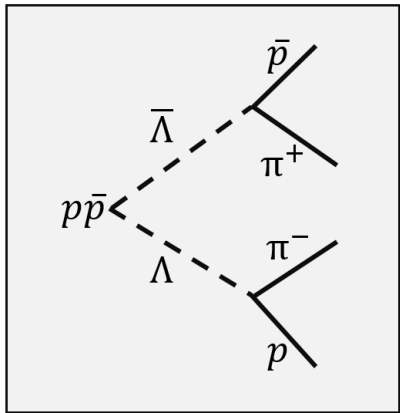
For Λ production: forward/backward asymmetry of distribution might cause spiralling in magnetic field since Λ decays almost at rest and its decay products are not given much energy

Challenges concerning spiralling tracks with many STT hits:

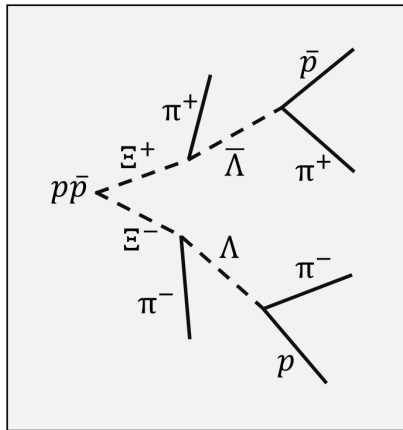
- Might be difficult to reconstruct
- Particles trapped in magnetic field - might not reach outer detectors
- Might block tubes for tracks from later events - makes later tracks harder to reconstruct

Λ and Ξ^- Events

$$p\bar{p} \rightarrow \Lambda\bar{\Lambda} \rightarrow p\pi^-\bar{p}\pi^+$$



$$p\bar{p} \rightarrow \Xi^-\bar{\Xi}^+ \rightarrow \Lambda\pi^-\bar{\Lambda}\pi^+ \rightarrow p\pi^-\pi^-\bar{p}\pi^+\pi^+$$



$$p\bar{p} \rightarrow \Lambda\bar{\Lambda} \rightarrow p\pi^-\bar{p}\pi^+$$

- 10,000 Λ events
- Beam momenta: 1.642 GeV, 7 GeV and 15 GeV
- Forward peaking distribution, $\bar{\Lambda}$ forward boosted
- EvtGen, entire decay chain specified
- Ideal track finder, standard track functor
- Target spectrometer
 - Before bug fix
 - Standard track functor (≥ 4 hits in MVD or ≥ 6 hits in MVD+STT+GEM)
 - Bug: if this track functor was used, all tracks which do not hit forward spectrometer were classified as reconstructible
 - Bug fixed in trunk

$$p\bar{p} \rightarrow \Xi^{-}\bar{\Xi}^{+} \rightarrow \Lambda\pi^{-}\bar{\Lambda}\pi^{+} \rightarrow p\pi^{-}\pi^{-}\bar{p}\pi^{+}\pi^{+}$$

- 10,000 events
- Beam momentum: 4.6 GeV
- Flat phase space distribution, isotropic
- EvtGen, entire decay chain specified
- Ideal track finder, standard track functor
- Target spectrometer
 - Before bug fix
 - Standard track functor (≥ 4 hits in MVD or ≥ 6 hits in MVD+STT+GEM)
 - Bug: if this track functor was used, all tracks which do not hit forward spectrometer were classified as reconstructible
 - Bug fixed in trunk

Bug

If a track had a SciTil hit, all tracks belonging to the same event appeared to have a SciTil hit. Fixed.

$p\bar{p} \rightarrow \Lambda\bar{\Lambda} \rightarrow p\pi^-\bar{p}\pi^+$, Before Bug Fix

- For events, only hits from final state particles
- Only tracks with ≥ 4 STT hits from final state particles

	1.642 GeV	7 GeV	15 GeV
Number of events	10,000	10,000	10,000
Events with a MVD hit	99.94 %	99.47 %	99.14 %
Events with a SciTil hit	34.64 %	3.00 %	1.36 %
Number of tracks	26,013	7,253	6,614
Tracks with a MVD hit	95.5 %	98.3 %	98.0 %
Tracks with a SciTil hit	38.7 %	5.8 %	2.9 %
Tracks with a MVD and a SciTil hit	36.9 %	5.6 %	2.7 %
Tracks with a MVD or a SciTil hit	97.3 %	98.5 %	98.2 %

- MVD itself useful for most events and tracks
- At higher beam momenta, most tracks do not reach SciTil
- MVD and SciTil together are useful at all beam momenta

$p\bar{p} \rightarrow \Lambda\bar{\Lambda} \rightarrow p\pi^-\bar{p}\pi^+$, After Bug Fix

- For events, only hits from final state particles
- Only tracks with ≥ 4 STT hits from final state particles

	1.642 GeV	7 GeV	15 GeV
Number of events	10,000	10,000	10,000
Events with a MVD hit	99.94 %	99.47 %	99.14 %
Events with a SciTil hit	34.64 %	3.00 %	1.36 %
Number of tracks	26,013	7,253	6,614
Tracks with a MVD hit	95.5 %	98.3 %	98.0 %
Tracks with a SciTil hit	15.1 %	4.2 %	2.1 %
Tracks with a MVD and a SciTil hit	14.5 %	4.2 %	2.0 %
Tracks with a MVD or a SciTil hit	96.2 %	98.3 %	98.2 %

- MVD itself useful for most events and tracks
- Most tracks do not reach SciTil
- MVD and SciTil together are useful at all beam momenta

$$p\bar{p} \rightarrow \Xi^{-}\bar{\Xi}^{+} \rightarrow \Lambda\pi^{-}\bar{\Lambda}\pi^{+} \rightarrow p\pi^{-}\pi^{-}\bar{p}\pi^{+}\pi^{+},$$

Before Bug Fix

- For events, only hits from final state particles
- Only tracks with ≥ 4 STT hits from final state particles

	4.6 GeV
Number of events	10,000
Events with a MVD hit	99.3 %
Events with a SciTil hit	77.6 %
Number of tracks	41,750
Tracks with a MVD hit	69.0 %
Tracks with a SciTil hit	81.3 %
Tracks with a MVD and a SciTil hit	55.0 %
Tracks with a MVD or a SciTil hit	95.3 %

- More tracks leave SciTil hit than MVD hit
 - Might be due to Λ and $\bar{\Lambda}$ decaying outside of MVD

$$p\bar{p} \rightarrow \Xi^- \bar{\Xi}^+ \rightarrow \Lambda \pi^- \bar{\Lambda} \pi^+ \rightarrow p \pi^- \pi^- \bar{p} \pi^+ \pi^+,$$

After Bug Fix

- For events, only hits from final state particles
- Only tracks with ≥ 4 STT hits from final state particles

	4.6 GeV
Number of events	10,000
Events with a MVD hit	99.3 %
Events with a SciTil hit	77.6 %
Number of tracks	41,750
Tracks with a MVD hit	69.0 %
Tracks with a SciTil hit	28.1 %
Tracks with a MVD and a SciTil hit	21.7 %
Tracks with a MVD or a SciTil hit	75.4 %

- More tracks leave SciTil hit than MVD hit
 - Might be due to Λ and $\bar{\Lambda}$ decaying outside of MVD

GEM hits

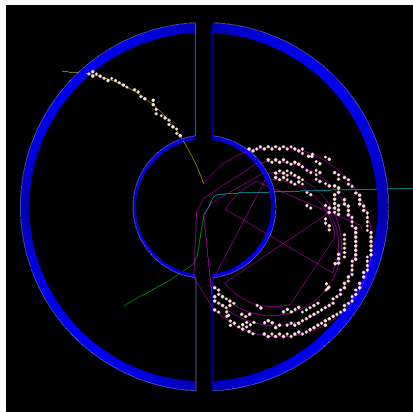
Λ events	1.642 GeV	7 GeV	15 GeV
Number of tracks with more than 4 STT hits	26,013	7,253	6,614
Fraction of these tracks with at least 1 GEM hit	45 %	10 %	9 %

Ξ events	4.6 GeV
Number of tracks with more than 4 STT hits	41,750
Fraction of these tracks with at least 1 GEM hit	44 %

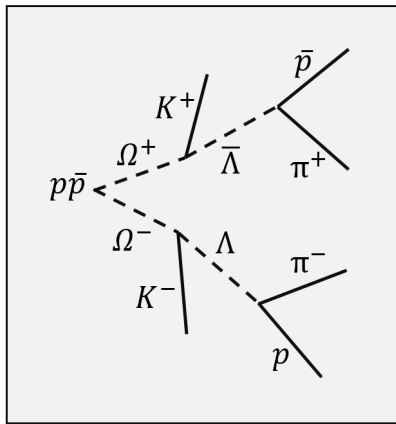
- GEM plates useful for a large fraction of events at lower beam momentum

Spiralling within the STT

- Spiralling within the STT, a concern for pions in Λ events at higher beam momentum
- Roughly 25 % of all events contain a spiralling pion
- Right Figure: 256 STT hits from π^-
- Spiralling particles, no problem for Ξ events with ~ 6 % of each kind of track having ≥ 50 STT hits



$$p\bar{p} \rightarrow \Omega^-\bar{\Omega}^+ \rightarrow \Lambda K^-\bar{\Lambda}K^+ \rightarrow p\pi^-K^-\bar{p}\pi^+K^+$$



$$p\bar{p} \rightarrow \Omega^-\bar{\Omega}^+ \rightarrow \Lambda K^-\bar{\Lambda}K^+ \rightarrow p\pi^-K^-\bar{p}\pi^+K^+$$

- 10,000 events
- Beam momentum: 5 GeV and 15 GeV
- Flat phase space distribution, isotropic
- EvtGen, entire decay chain specified
- Ideal track finder, standard track functor
- Target spectrometer
 - Standard track functor (≥ 4 hits in MVD or ≥ 6 hits in MVD+STT+GEM)

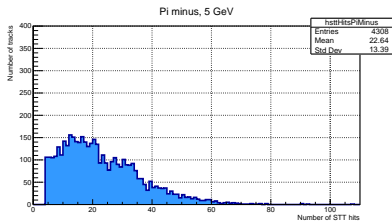


- For events, only hits from final state particles
- Only tracks with ≥ 4 STT hits from final state particles

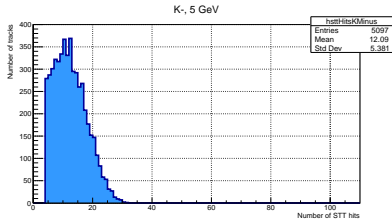
	5 GeV	15 GeV
Number of events	10,000	10,000
Events with a MVD hit	99.9 %	98.6 %
Events with a GEM hit	99.99 %	99.5 %
Number of tracks	20,765	36,000
Tracks with a MVD hit	87.3 %	59.1 %
Tracks with a GEM hit	88.7 %	54.0 %

- MVD and GEM very useful for reconstructed tracks.
- Tracks may be propagated to these detectors.

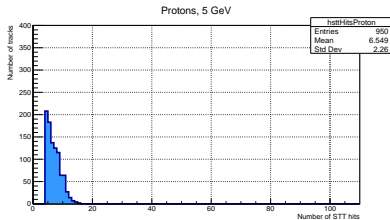
$p\bar{p} \rightarrow \Omega^-\bar{\Omega}^+ \rightarrow \Lambda K^-\bar{\Lambda}K^+ \rightarrow p\pi^-K^-\bar{p}\pi^+K^+$,
 STT hits, 5 GeV



4,308 π^- tracks



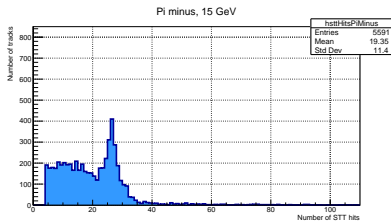
5,097 K^- tracks



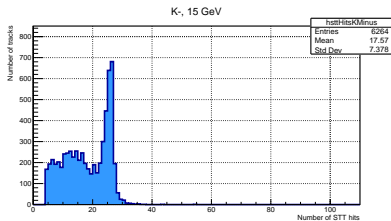
950 proton tracks

- Hit pattern similar for antiparticles
- No characteristic peak at 27 hits
- Spiralling particles no problem, only 387 tracks with ≥ 50 STT hits

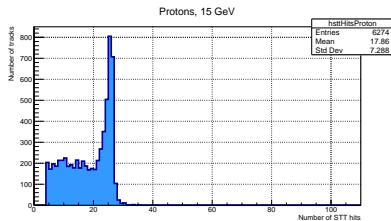
$p\bar{p} \rightarrow \Omega^-\bar{\Omega}^+ \rightarrow \Lambda K^-\bar{\Lambda}K^+ \rightarrow p\pi^-K^-\bar{p}\pi^+K^+$,
 STT hits, 15 GeV



5,591 π^- tracks



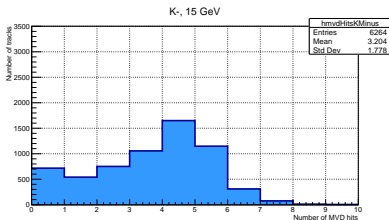
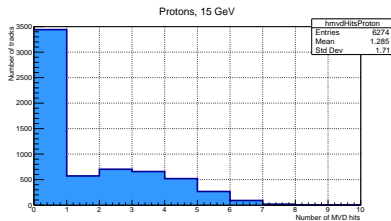
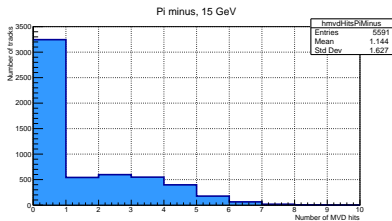
6,264 K^- tracks



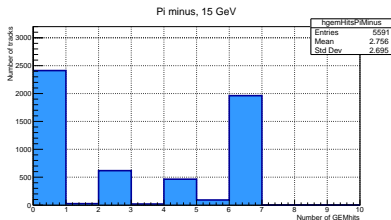
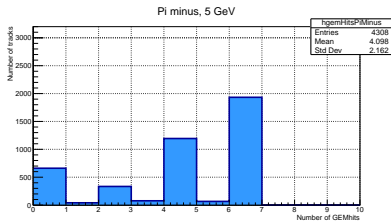
6,274 proton tracks

- Hit pattern similar for antiparticles
- Characteristic peak at 27 hits
- Spiralling particles no problem, only 267 tracks with ≥ 50 STT hits

$p\bar{p} \rightarrow \Omega^-\bar{\Omega}^+ \rightarrow \Lambda K^-\bar{\Lambda}K^+ \rightarrow p\pi^-K^-\bar{p}\pi^+K^+$,
MVD hits, 15 GeV



$p\bar{p} \rightarrow \Omega^-\bar{\Omega}^+ \rightarrow \Lambda K^-\bar{\Lambda}K^+ \rightarrow p\pi^-K^-\bar{p}\pi^+K^+$,
 GEM hits, π^-



- 3 GEM plates
- Double sided readout of GEM plates, almost only even number of hits
- Larger fraction of all reconstructed tracks hit GEM plates at lower beam momentum

Summary and Conclusions

- MVD important for all hyperon events and most tracks
- GEM plates important
 - Especially for Ω events
- Tracks reconstructed in STT could be propagated to MVD and GEM
- Spiralling within the STT only a concern for pions in Λ events at higher beam momentum

Outlook

- Thorough investigation regarding SciTil hits for Ω events
- Internal note (\sim mid October)
- Investigate performance of STTCellTrackFinder for Λ , Ξ^- and Ω^- events

Thank you!

