# Transverse Polarization of the $\Lambda$ measured in Au-Au Collisions

- Polarization definition and models
- Measurements in pp and pA
- E896 setup and data analysis
- E896 results
- Comparison to pp and pA data
- Conclusions

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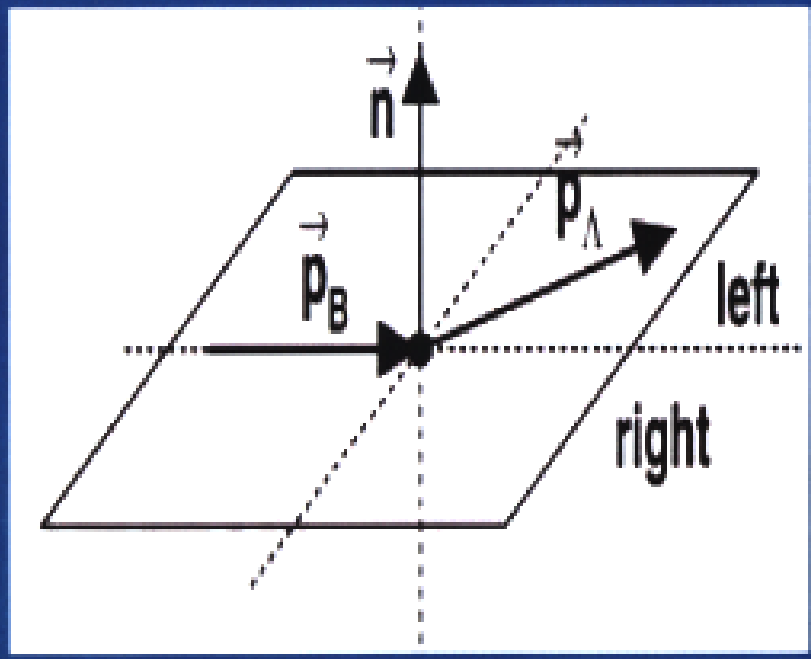
# What is transverse polarization ?




- Preferred spin direction of $\Lambda$ perpendicular to reaction plane Measure angular distribution of decay proton in rest frame of $\Lambda$
- **$dN/d\cos\theta = A(\cos\theta)\,(1+\alpha P\cos\theta)$**
- $\alpha$ = 0.65 ($\Lambda$-decay asymmetry parameter = s- and p-wave interference term)
- $A(\cos\theta)$ = detector acceptance
- P = polarization
- + or - $\cos\theta$ = spin up or down

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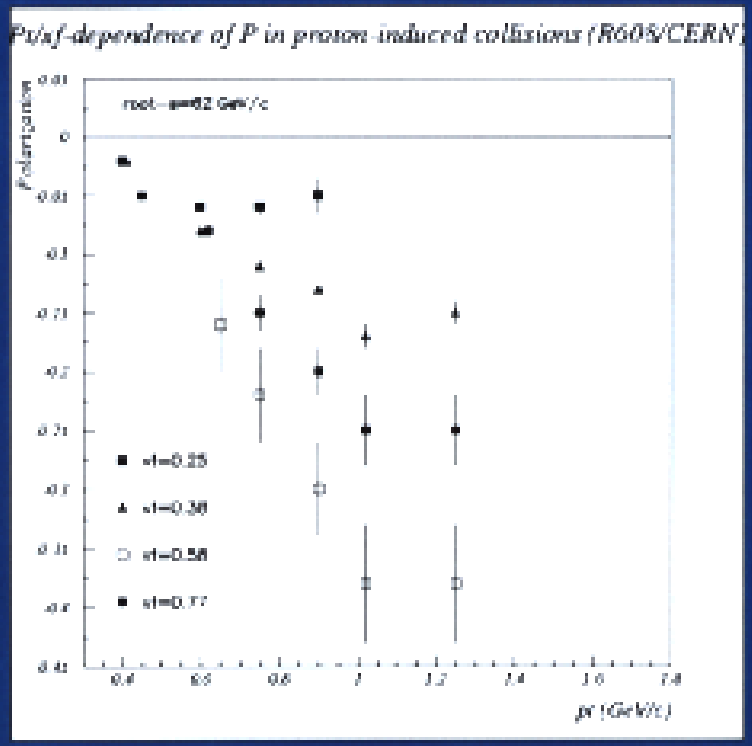
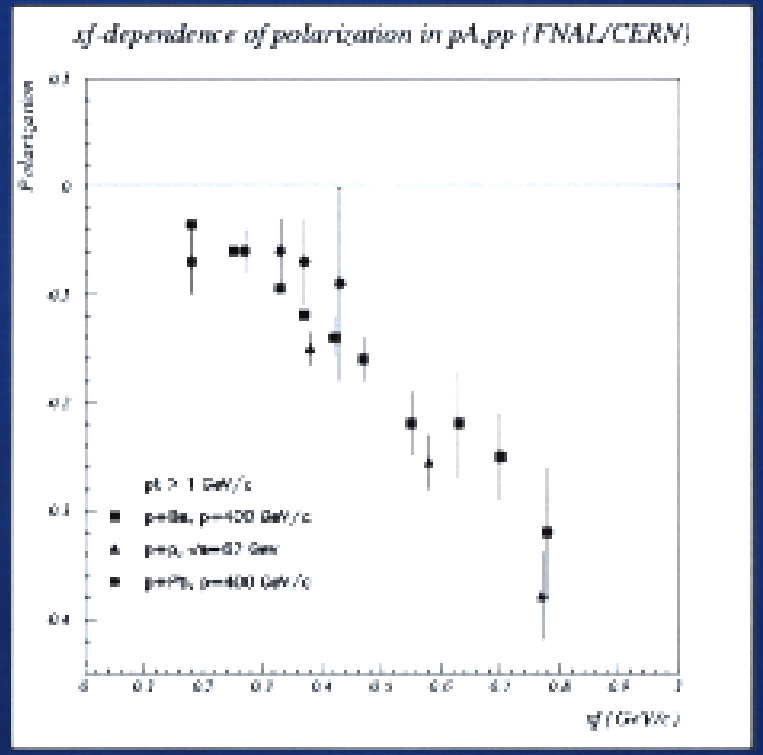
# Key measurements in pp and pA

- $p_t$-dependence




- $x_f$-dependence

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# Summary of HEP results

- $\Lambda$ is negatively polarized with respect to production plane
- for $p_t < 1$ GeV/c the polarization is linearly increasing with $p_t$ with increasing slope as a function of $x_f$
- for $p_t > 1$ GeV/c the polarization is constant with $p_t$ but still increases linear as a function of $x_f$
- effects due to incident energy and target size (in pA reactions) are small ($P = -1.1\ A^{-0.15}$)
- other hyperons: $\Sigma$: neg.P and decrease with $x_f$, $\Xi$: pos.P and constant with $x_f$, Anti-$\Lambda$ and Anti-$\Sigma$: P=0, Anti-$\Xi$ shows polarization

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# Models on the Quark Level

- Parton Recombination Model
  - polarization due to Thomas precession in quark recombination process
  - valence di-quark recombines with sea s-quark
  - slow sea s-quark has transverse momentum component
  - strong push in longitudinal direction from recombination
  - spin of s-quark interacts with Thomas precession vector
- Lund Model
  - color field between di-quark and collision region
  - color field materializes into s-sbar pair
  - generate pair has angular momentum perpendicular to string which has to be compensated by spin of pair

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# Heavy Ion Models

- Disappearance of polarization due to QGP
  - color field in QGP possesses momentum
  - color field provides transverse momentum to s-sbar pair
  - no correlation between inherent transverse momentum and spin of s-quark
- Simple rescattering
  - any final state interaction of the Lambda itself or the decay proton can potentially destroy the preferred spin direction
  - measurements at high transverse momentum and high Feynman-x should reduce rescattering probability

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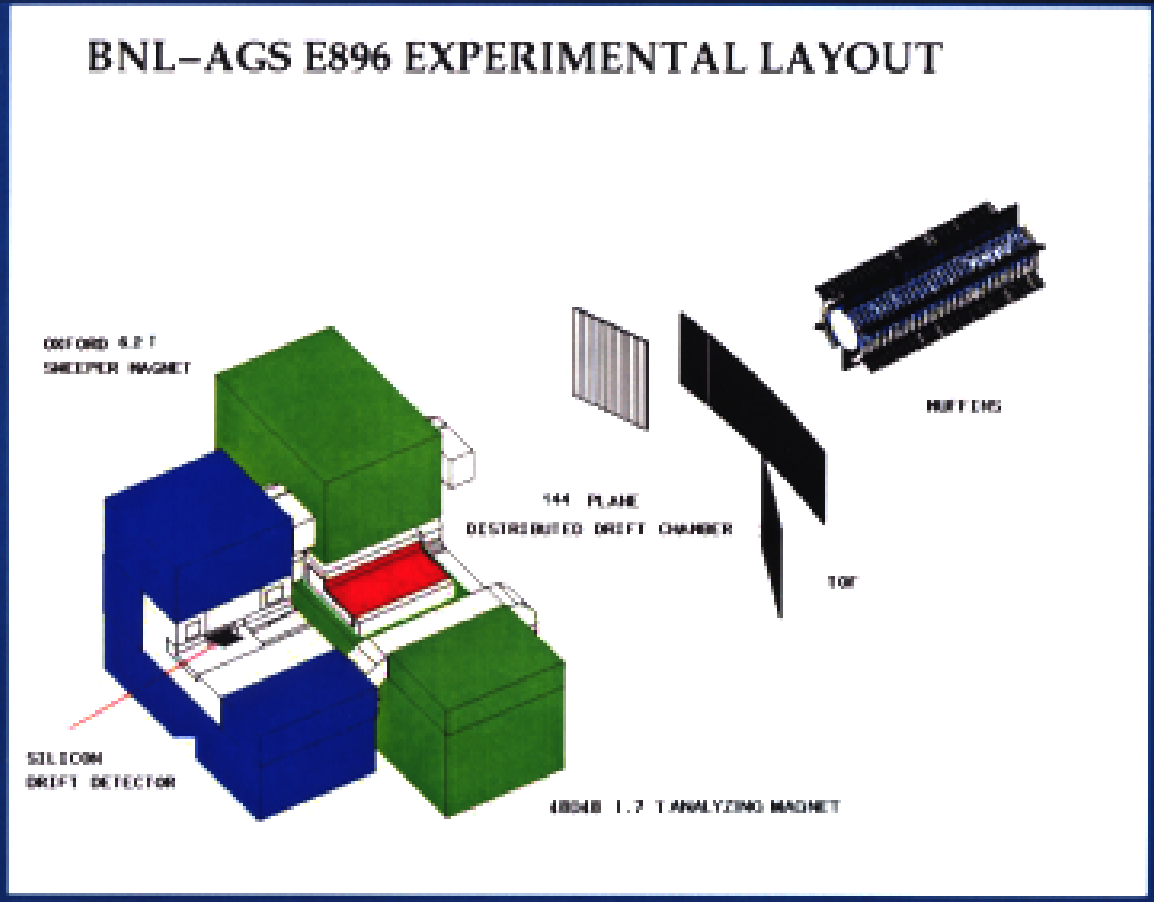
# E896 Experimental Layout

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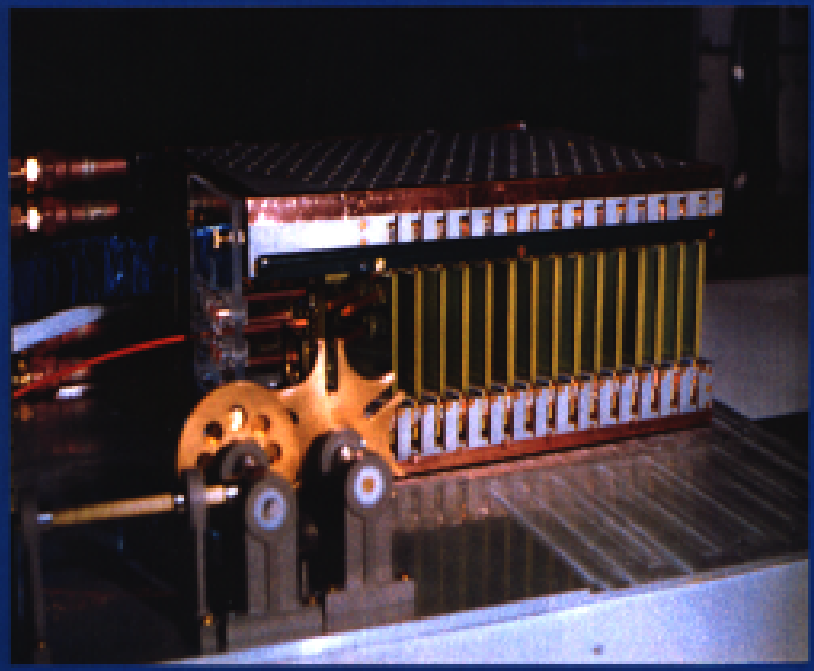
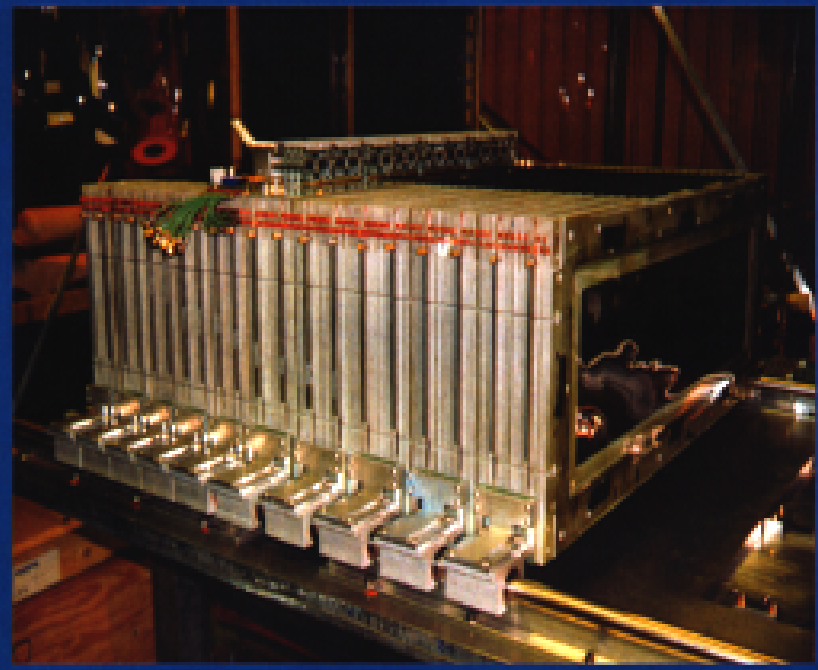
# E896 Tracking Detectors

## Silicon Drift Detector Array



## Distributed Drift Chamber



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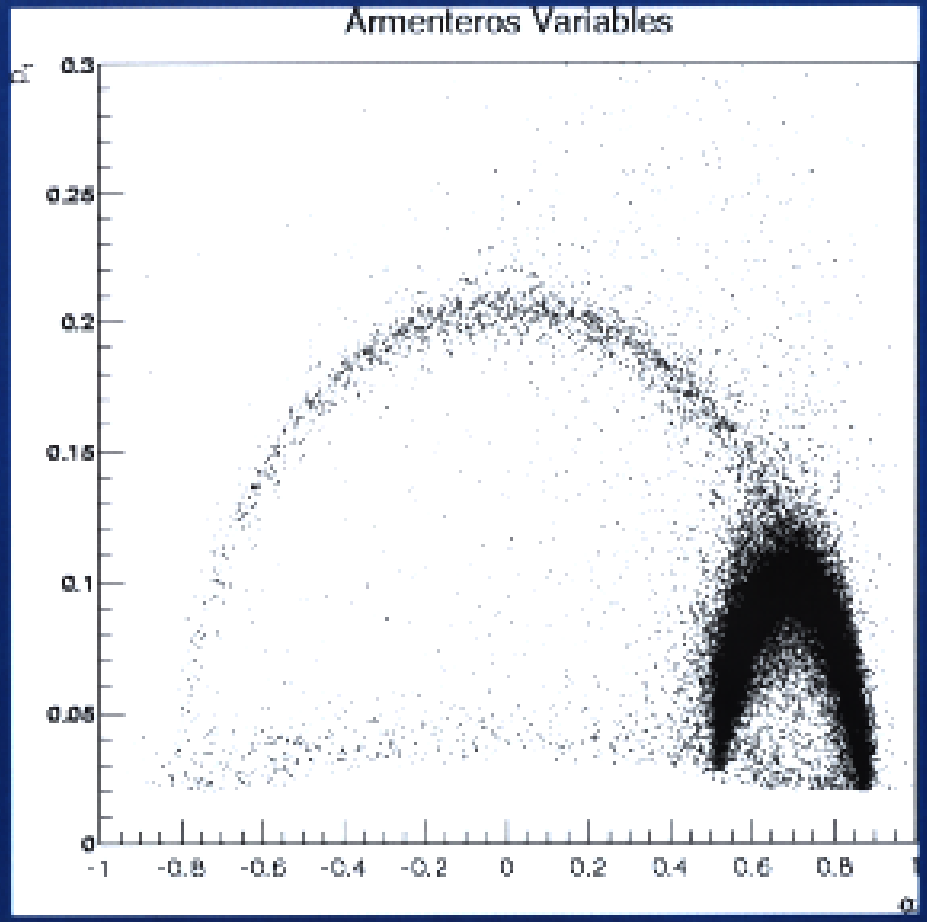
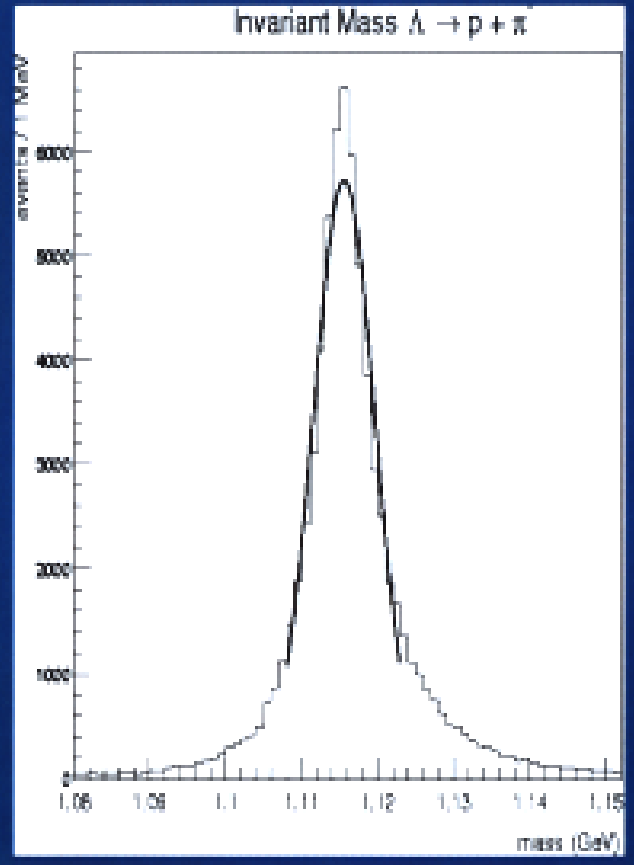
# E896-DDC Λ sample

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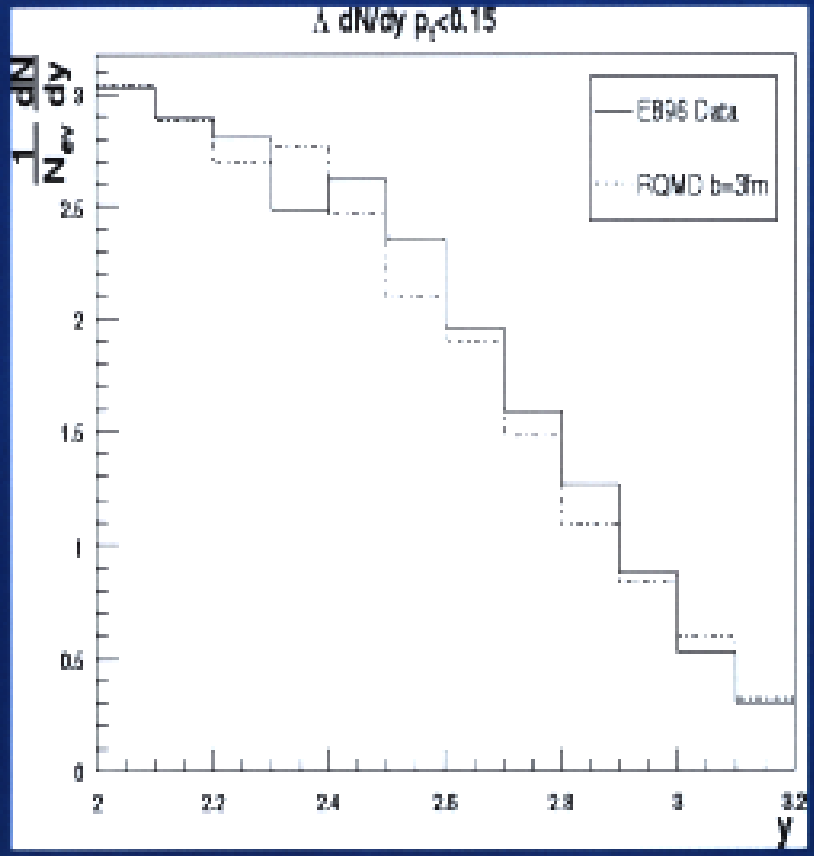
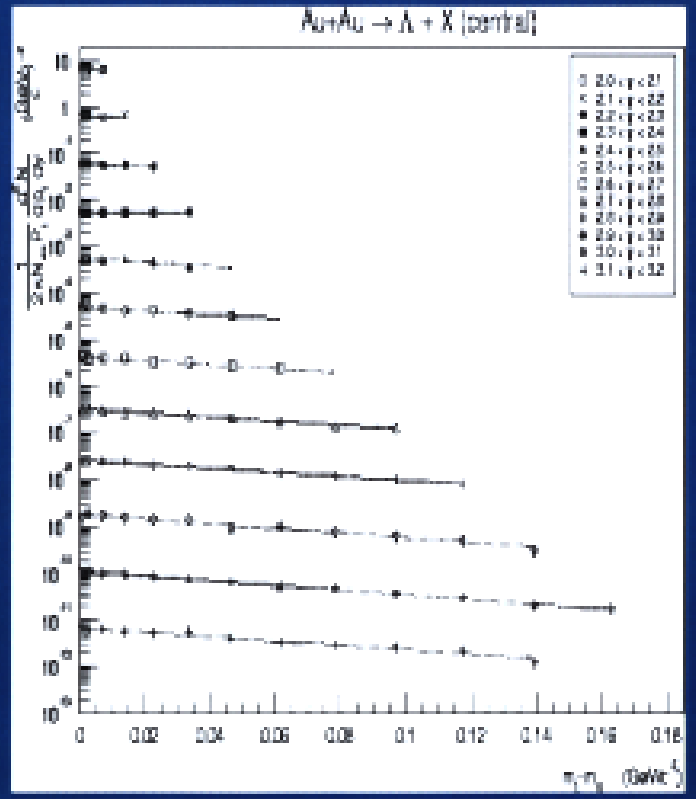
# E896-DDC Λ results

- rapidity distribution




- $m_t$ distributions

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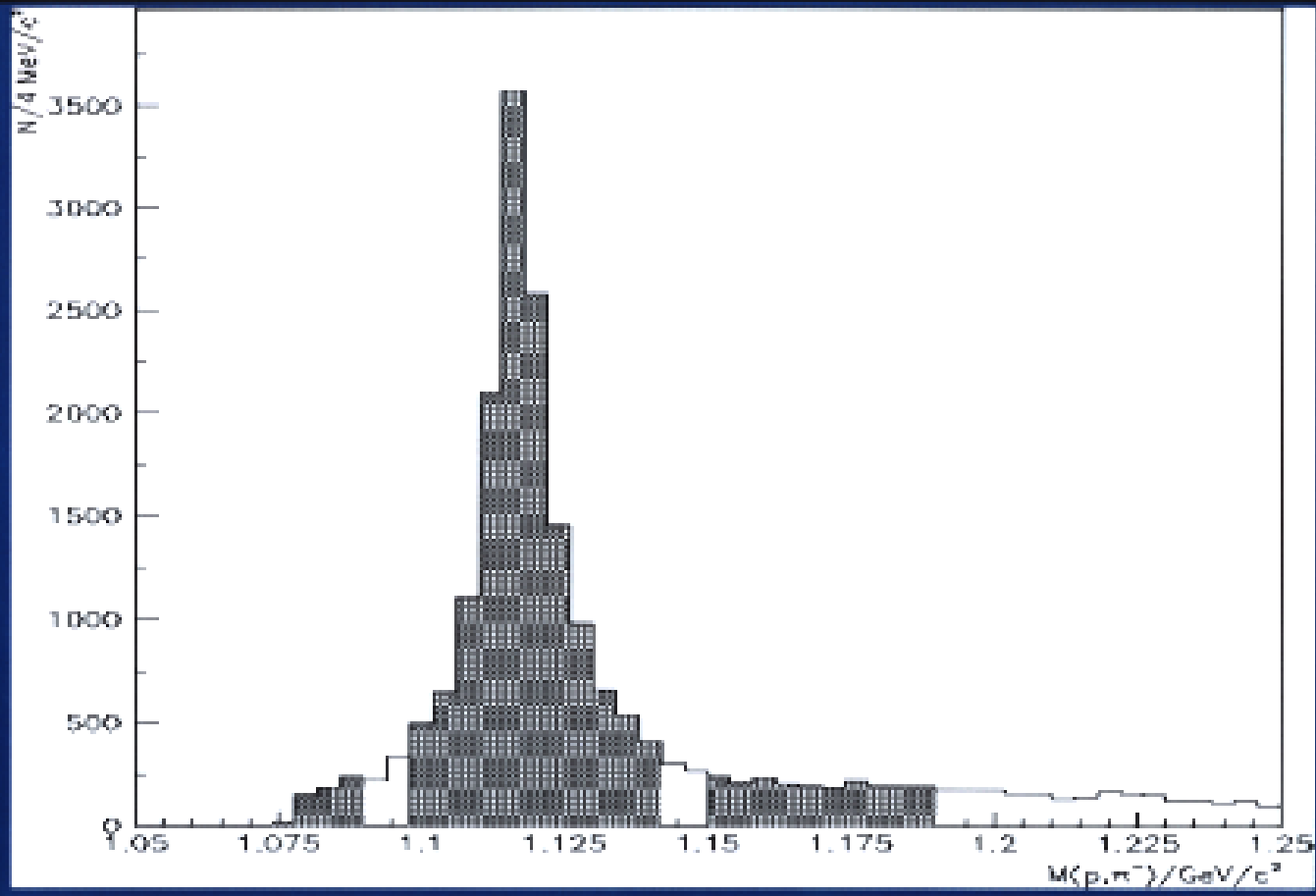
# E896-SDDA Λ sample

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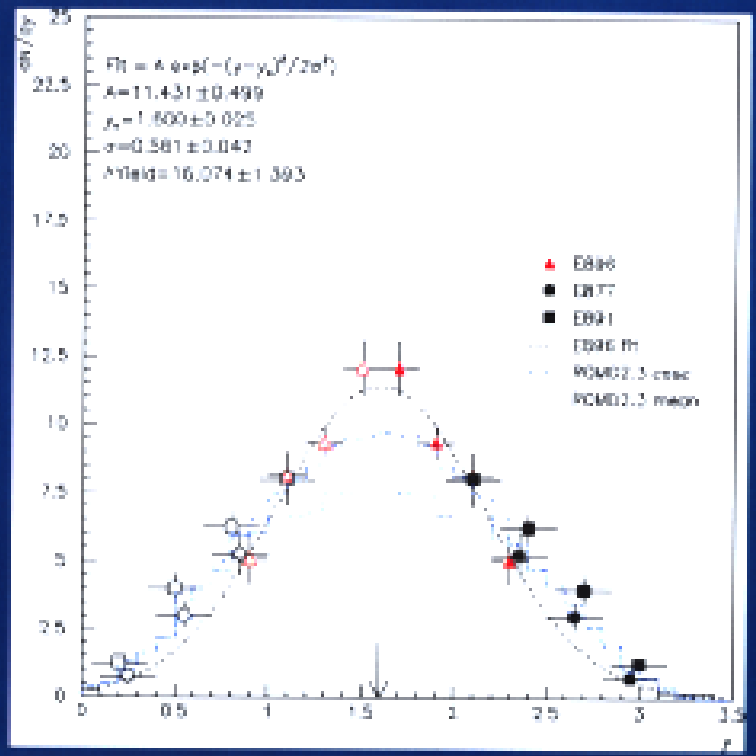
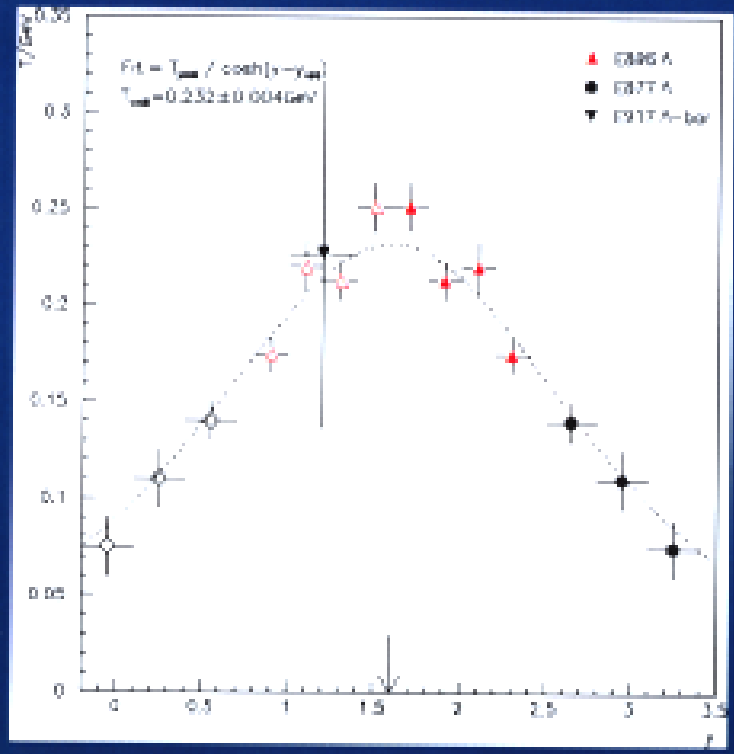
# E896-SDDA Λ results

- rapidity distribution




slope dependence

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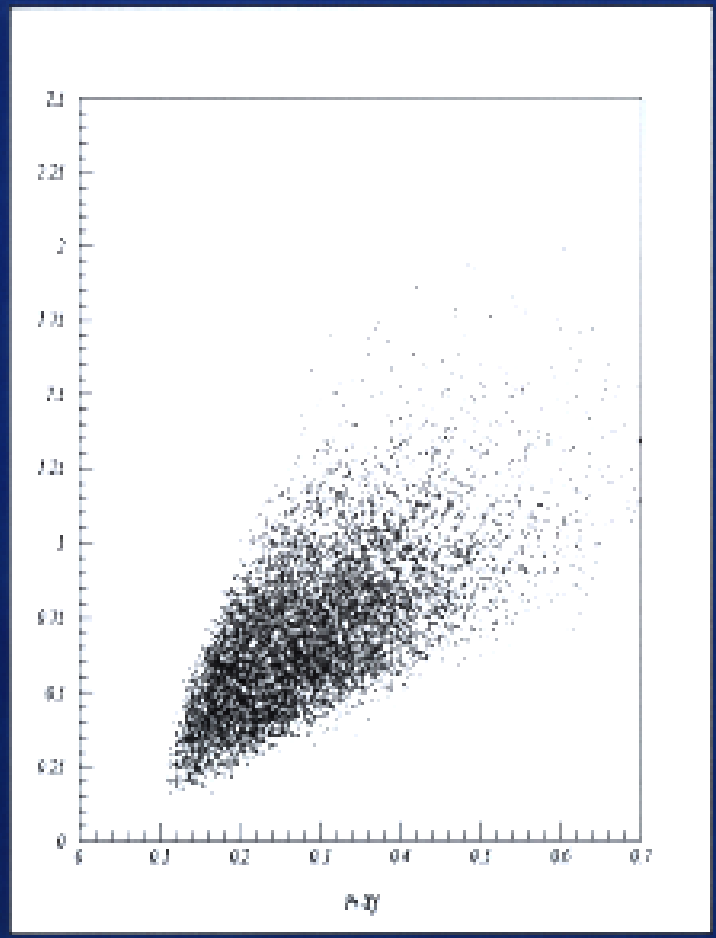
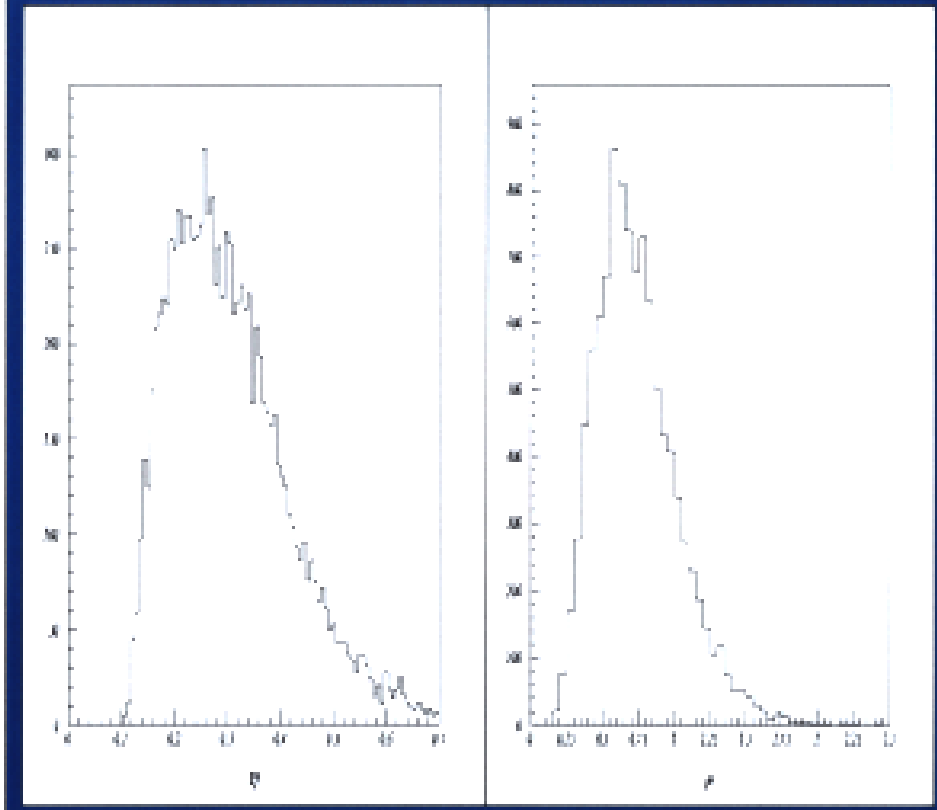
# E896-SDDA $p_t$ and $x_f$ coverage





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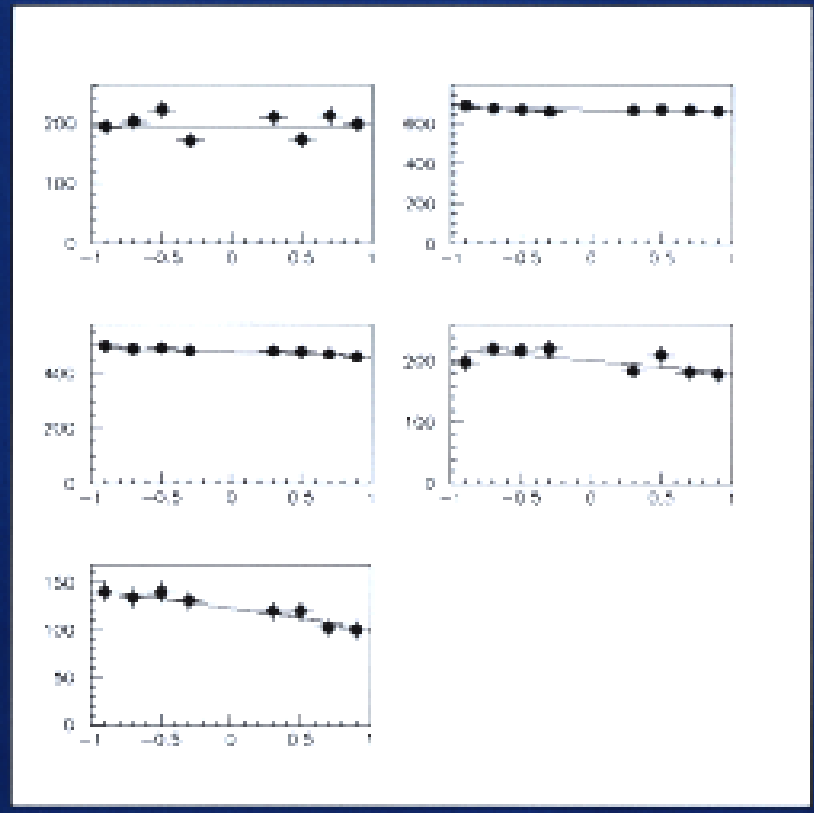
# E896-SDDA polarization results

- cos $\theta$ in 5 $x_f$ bins
- $x_f$ = 0.1-0.2 , $\langle p_t \rangle$=0.57 GeV/c
- $x_f$ = 0.2-0.3, $\langle p_t \rangle$=0.79 GeV/c
- $x_f$ = 0.3-0.4, $\langle p_t \rangle$=1.23 GeV/c
- $x_f$ = 0.4-0.5, $\langle p_t \rangle$=1.61 GeV/c
- $x_f$ > 0.5, $\langle p_t \rangle$=1.98 GeV/c



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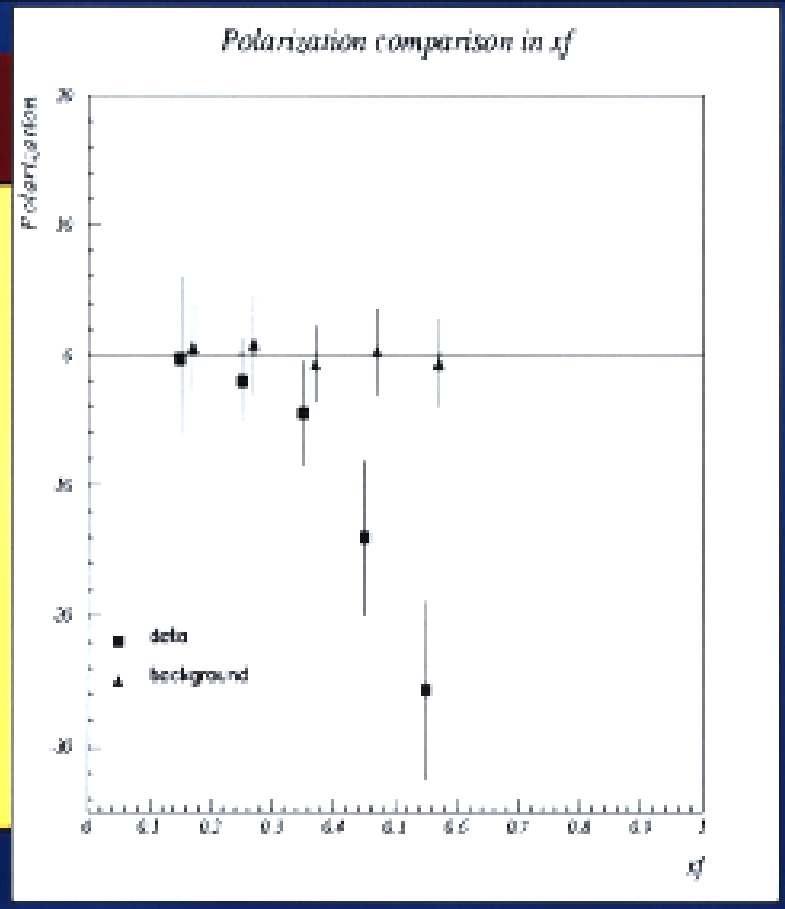
# E896-SDDA polarization results

| Range | P in % |
|---|---|
| $x_f$ =0.1–0.2 | -0.3+-6.0% |
| $x_f$ =0.2–0.3 | -2.1+-3.2% |
| $x_f$ =0.3–0.4 | -4.5+-3.9% |
| $x_f$ =0.4–0.5 | -14.1+-5.9% |
| $x_f$ >0.5 | -25.7+-7.6% |

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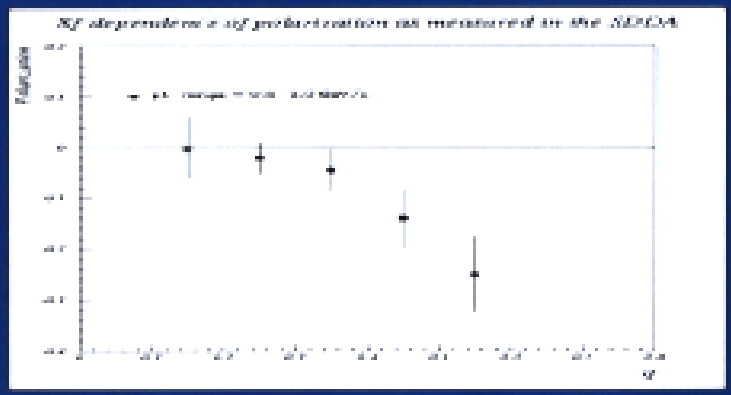
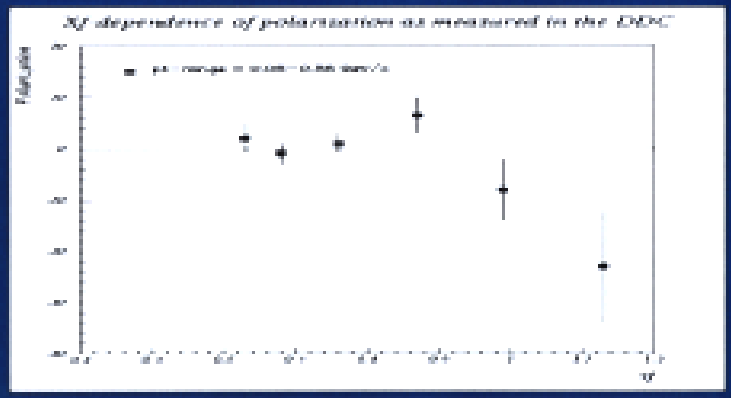
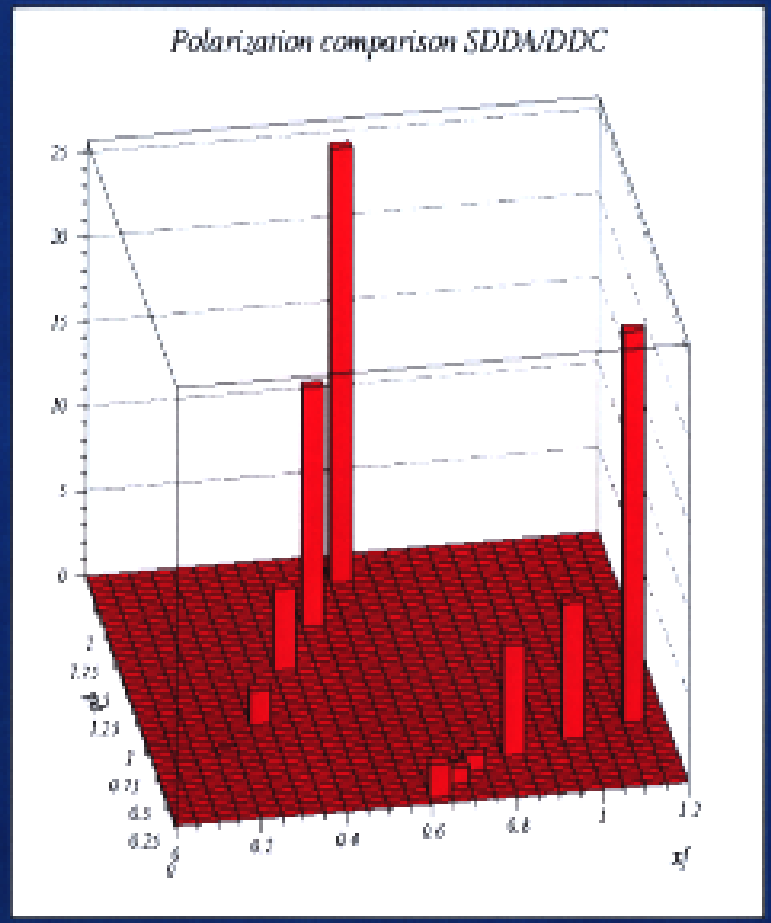
# SDDA / DDC data in pt and xf

- **SDDA measurement**



- **DDC measurement**



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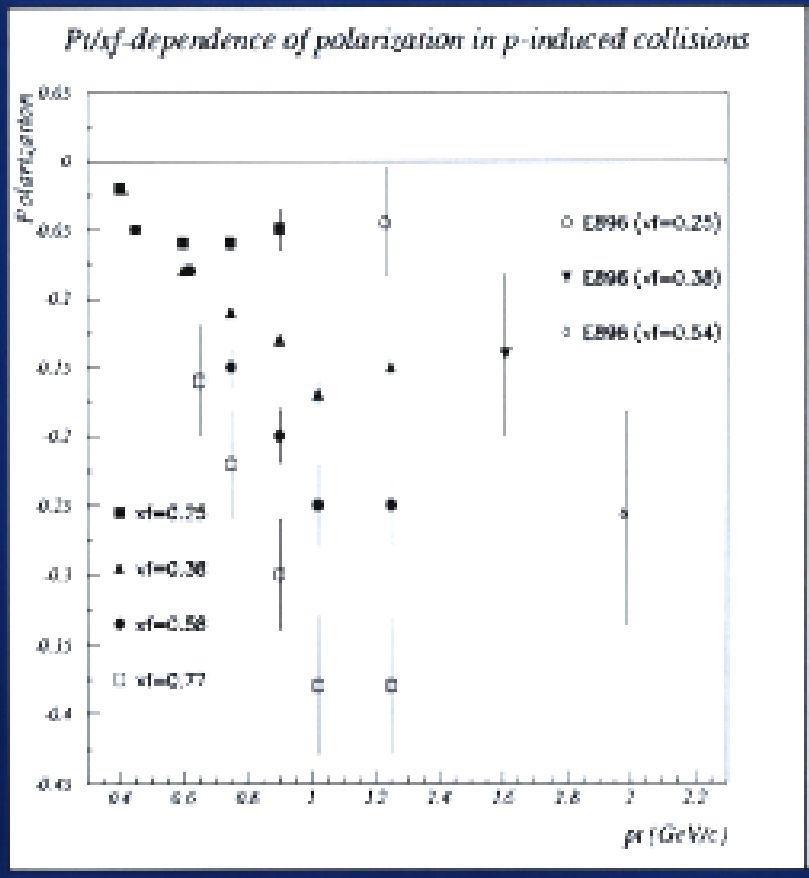
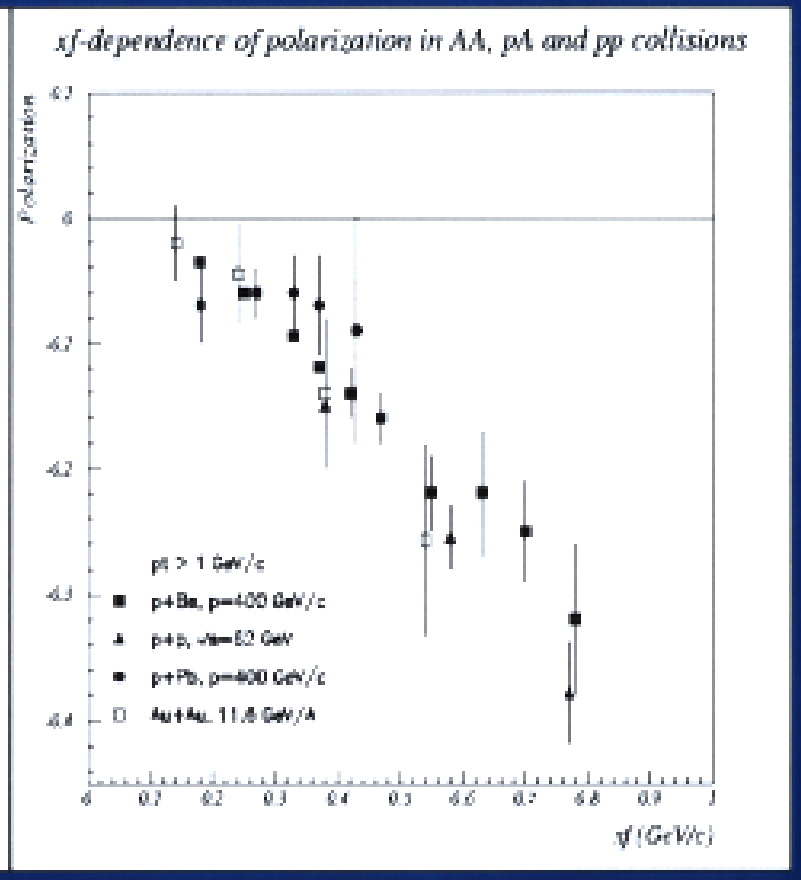
# Comparison to pp and pA data

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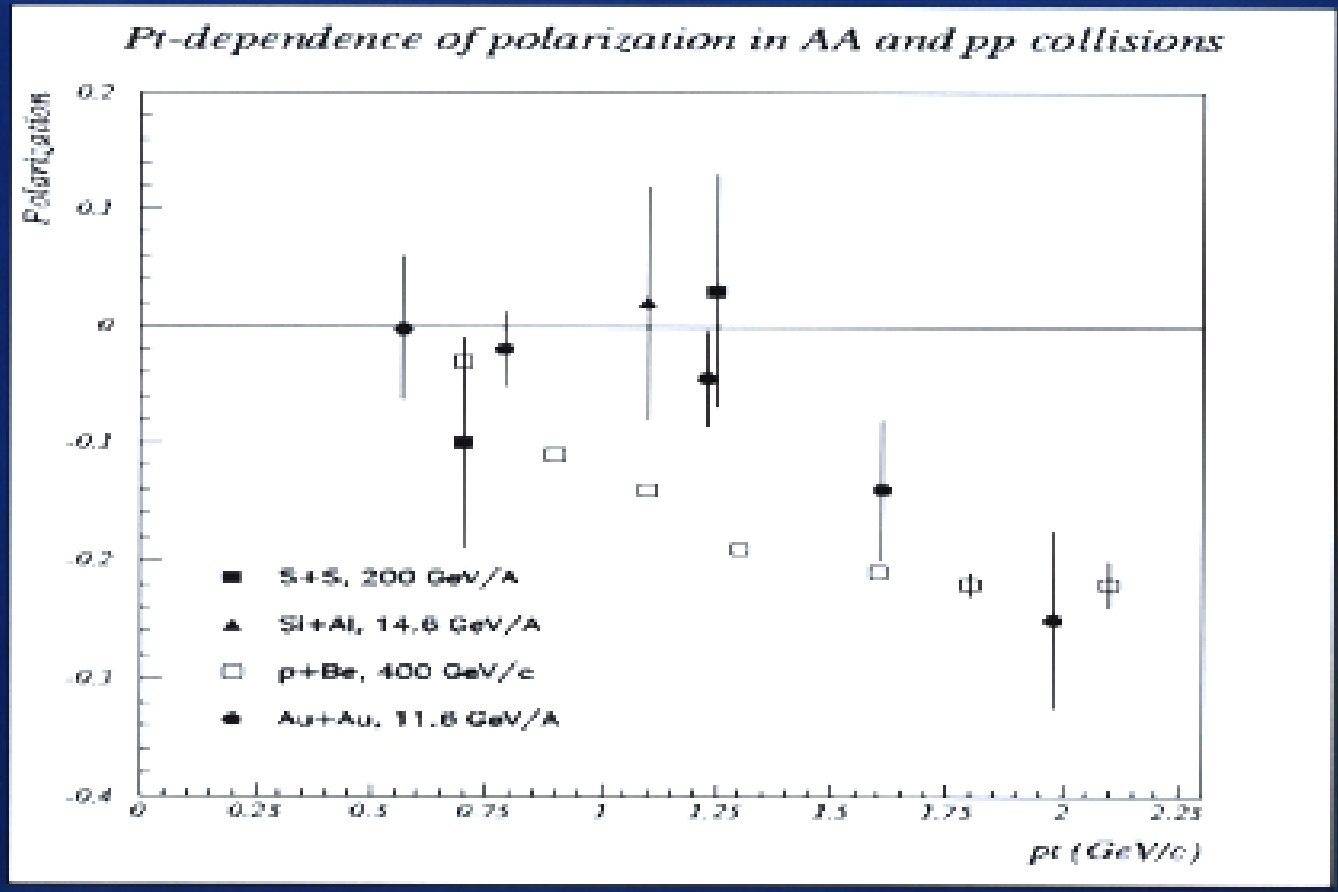
# Comparison to pp/pA/AA data

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# Conclusions

- The transverse polarization of $\Lambda$'s as measured in pp- and pA- reactions has been confirmed in heavy ion collisions
- There is no disappearance of polarization at high $p_t$ and $x_f$
- The $\Lambda$ production mechanism seems to be identical in pp and AA collisions
- $\Lambda$ polarization seems more suppressed at mid and low $p_t$ and $x_f$ in AA collisions than in pp-collisions (rescattering effect ?)

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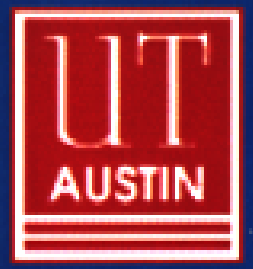
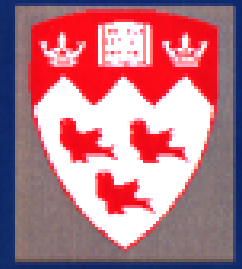
# Collaborating Institutions

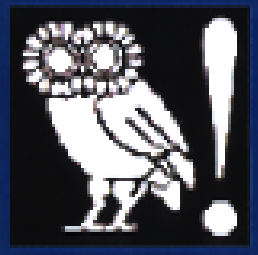


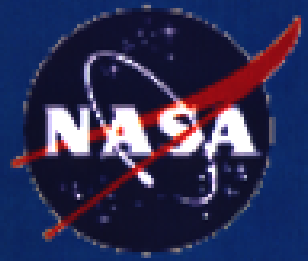














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