Λ^0 and $\overline{\Lambda^0}$ polarization at COMPASS

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On behalf of the COMPASS Collaboration

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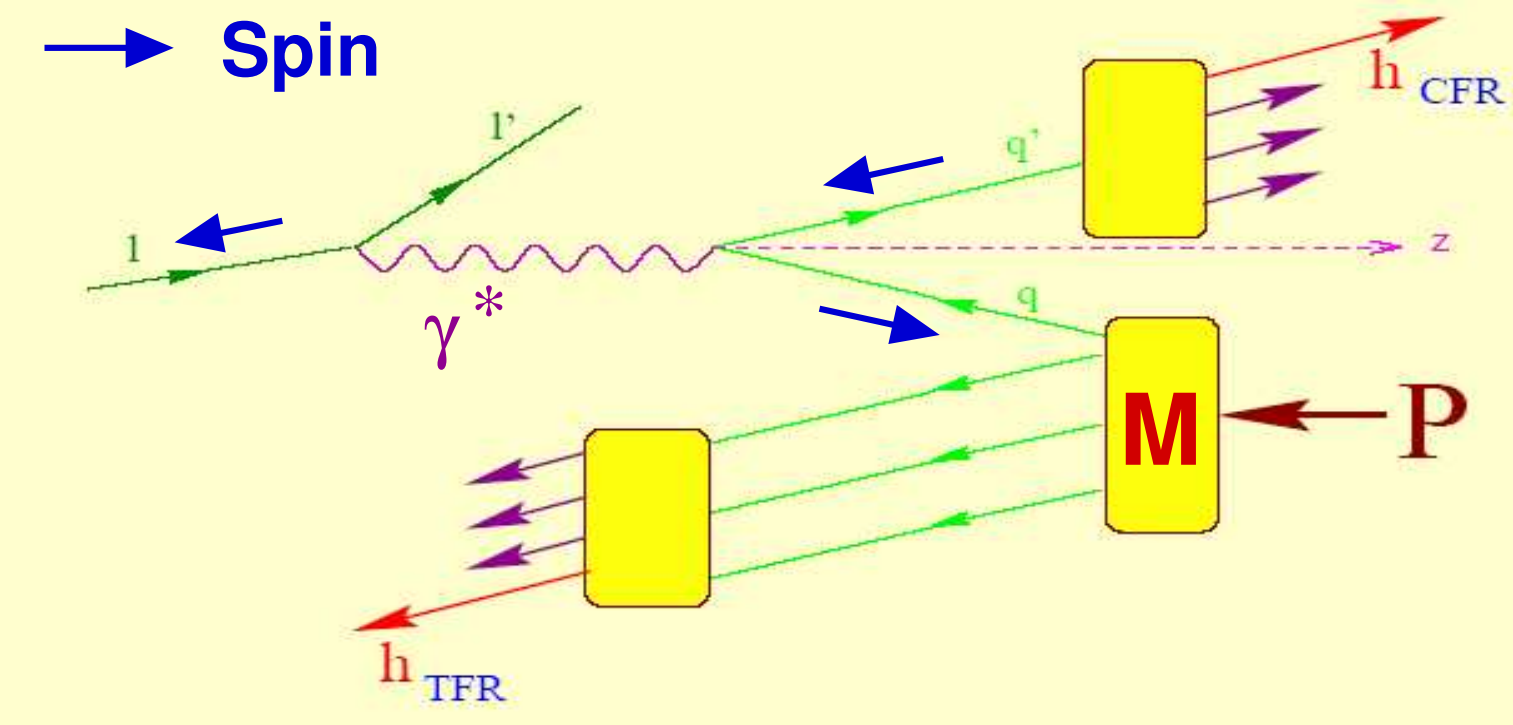
Summary:

- **Why Lambdas?**
- **The COMPASS spectrometer**
- **Method of extraction of Λ^0 and $\overline{\Lambda^0}$ polarization**
- **Preliminary results from 2002 data**

Polarized SIDIS



$$Q^2 = -q^2 = 4EE' \sin^2(\theta/2) \qquad x = \frac{Q^2}{2M(E-E')}$$

$$s = \frac{Q^2}{xy} + M^2 \qquad y = \frac{E-E'}{E}$$

Bjorken variables

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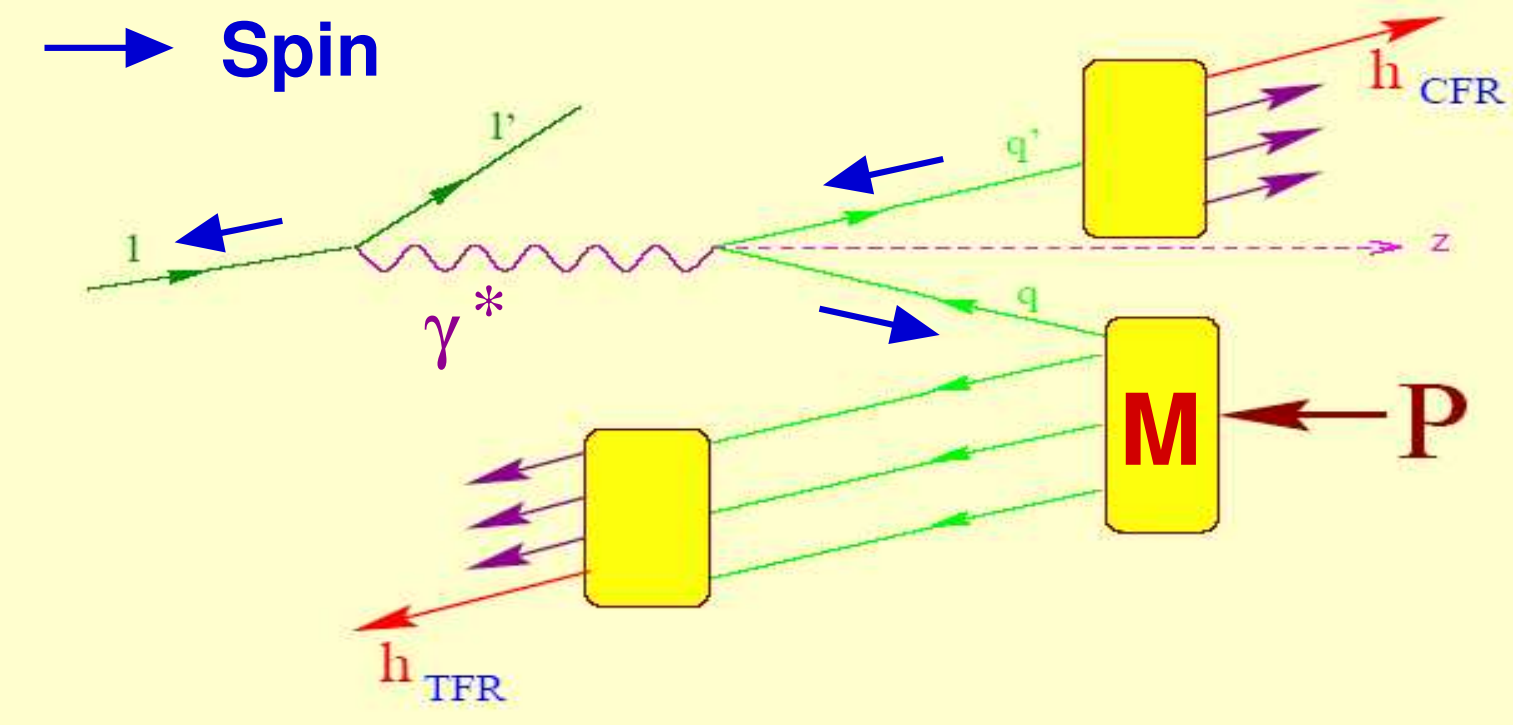

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Bjorken variables

$$x_F = \frac{2p_L^h}{\sqrt{s}} \qquad x_F < 0 \rightarrow \text{TFR}, \quad x_F > 0 \rightarrow \text{CFR}$$

Why Lambdas?

- Self analyzing weak decay $\Lambda^0 \to p\pi^-$ $\left(\overline{\Lambda^0} \to \overline{p}\pi^+\right)$

  The angular distribution of decay products depends on the polarization state of the decaying Λ^0 ($\overline{\Lambda^0}$).

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- Unique tool to study the longitudinal polarization transfer from lepton to final state hadron in SIDIS from unpolarized target.

Theoretical summary

	P_Λ		$P_{\bar\Lambda}$	
	$x_F < 0$	$x_F > 0$	$x_F < 0$	$x_F > 0$
Kotzinian *et al.*	$\ominus$	$\ominus$	$\ominus$	$\ominus$
fragmentation Model A		-6.3%		
fragmentation Model B		-3.0%		
Melnitchouk *et al.*	≈ 0			
Brodsky *et al.*	$\ominus$	$\oplus$	≈ 0	
de Florian *et al.*				
scenario 1		≈ 0		
scenario 2		$\ominus$		
scenario 3		$\oplus$		
Boros *et al.*		$\oplus$		
Ma *et al.*		$\oplus$		$\oplus$

Experimental summary

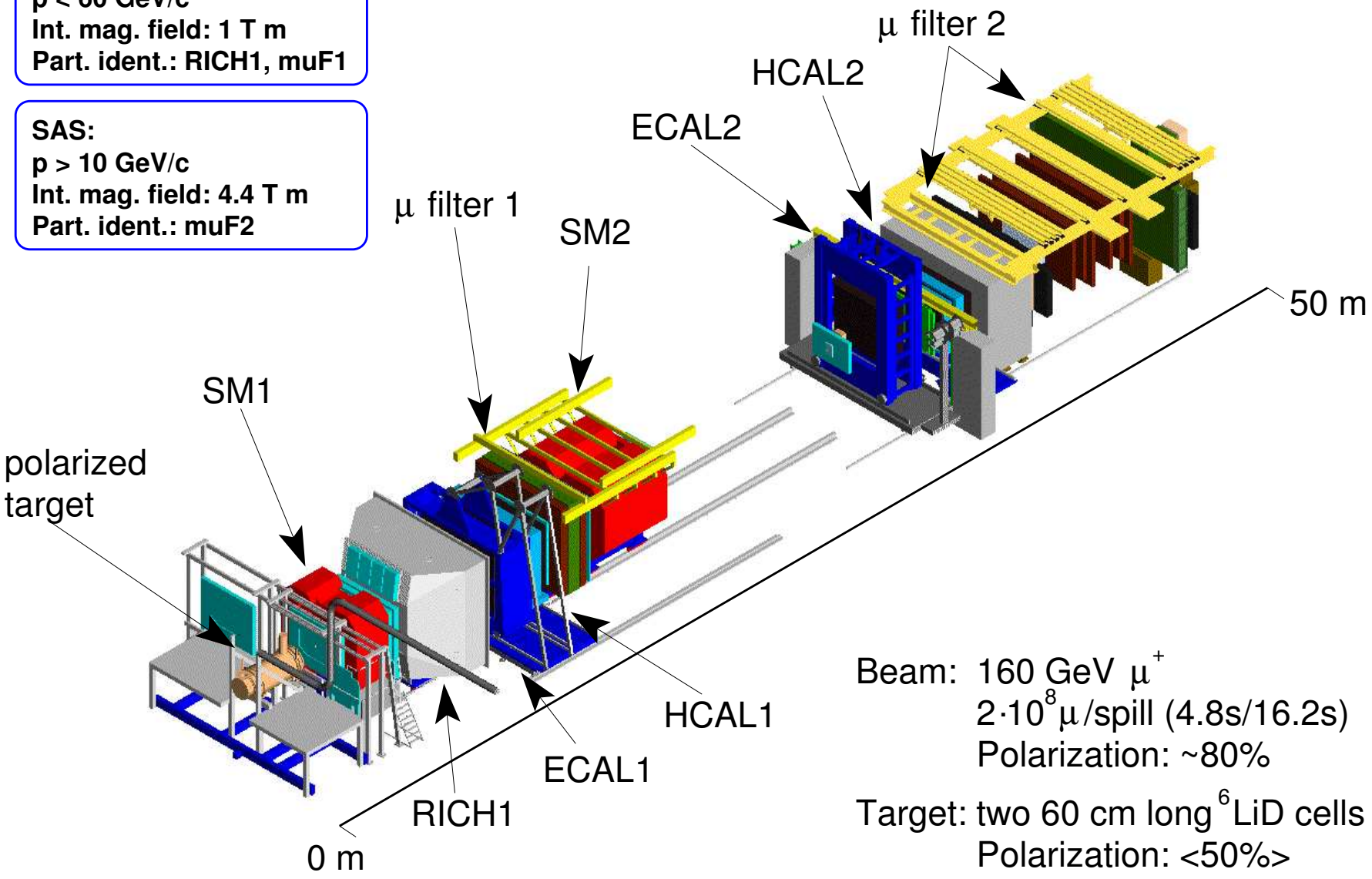
Reaction Exp.	$< E_b >$ (GeV)	Select.	N_{Λ}	P_{Λ}	$N_{\overline{\Lambda}}$	$P_{\overline{\Lambda}}$
$\overline{\nu}_\mu Ne$	40	$x_F < 0$	403	-0.63 ± 0.13		
WA49		$x_F > 0$	66	-0.11 ± 0.45		
μN	470	$0 < x_F < 0.3$	750	1.2 ± 0.5	650	-0.26 ± 0.6
E665		$x_F > 0.3$		0.32 ± 0.7		-1.1 ± 0.8
eN	27.5	$x_F > 0$	$\approx 10^4$	$\frac{P_\Lambda}{P_B D} =$		
HERMES				0.04 ± 0.08		
$\nu_\mu N$	43.8	$x_F < 0$	5608	-0.21 ± 0.04	248	0.23 ± 0.20
NOMAD		$x_F > 0$	2479	-0.09 ± 0.06	401	-0.23 ± 0.15

Site of the experiment

COMPASS spectrometer

LAS:
p < 60 GeV/c
Int. mag. field: 1 T m
Part. ident.: RICH1, muF1

SAS:
p > 10 GeV/c
Int. mag. field: 4.4 T m
Part. ident.: muF2

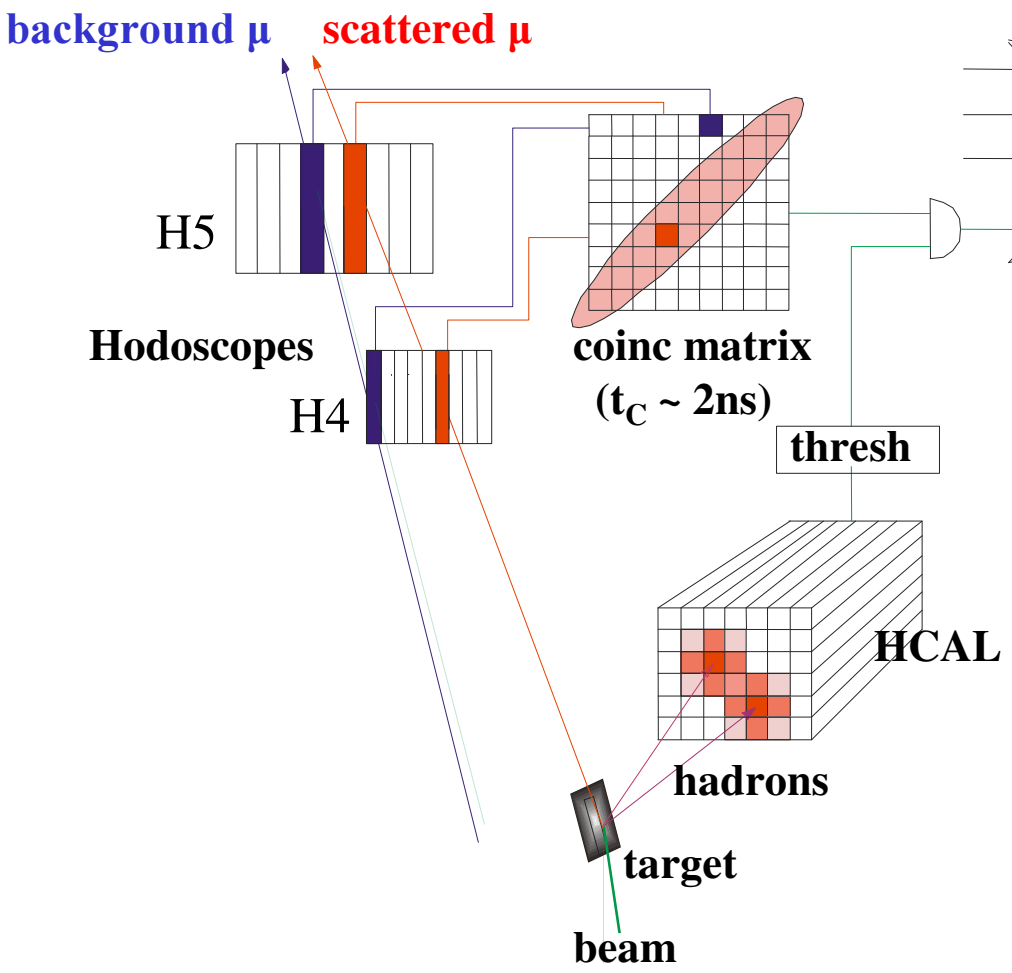


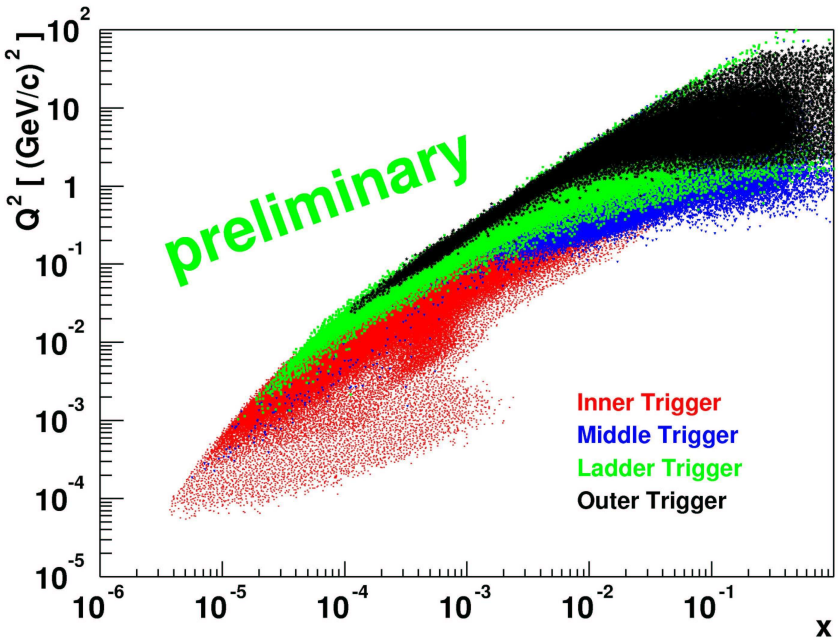
Beam: 160 GeV μ^+
$2 \cdot 10^8 \mu$/spill (4.8s/16.2s)
Polarization: ~80%

Target: two 60 cm long ^{6}LiD cells
Polarization: <50%>

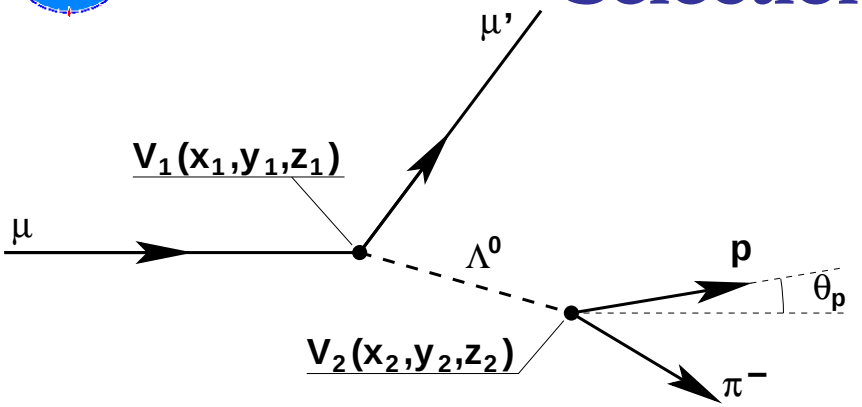
COMPASS trigger

Trigger : (H4 * H5) * (Hcal1 U Hcal2)



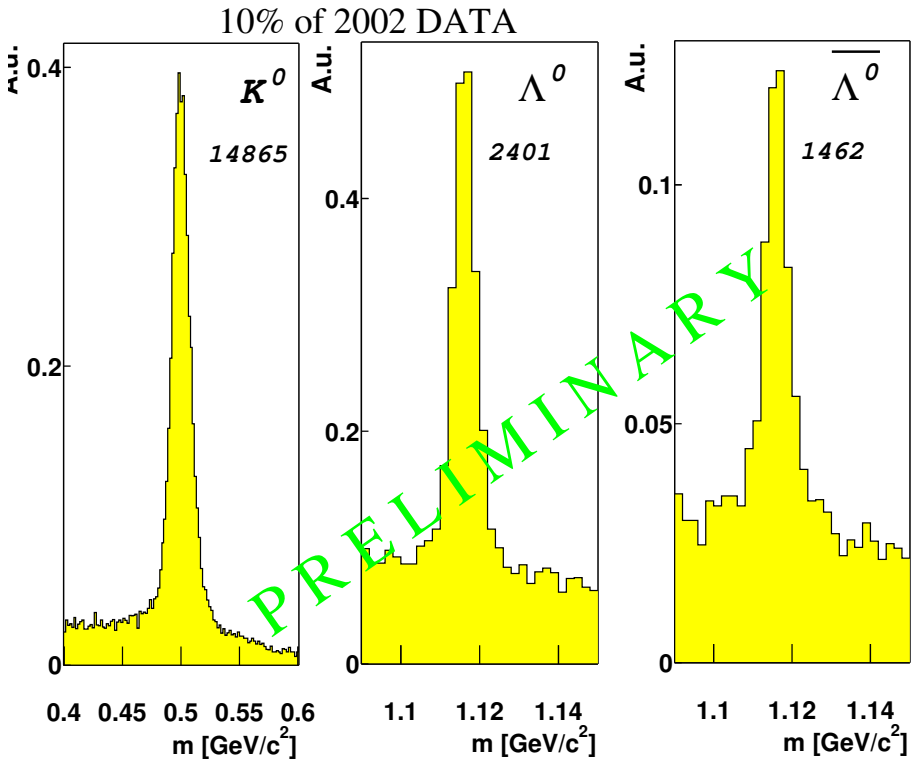


Selection of Λ^0 decays



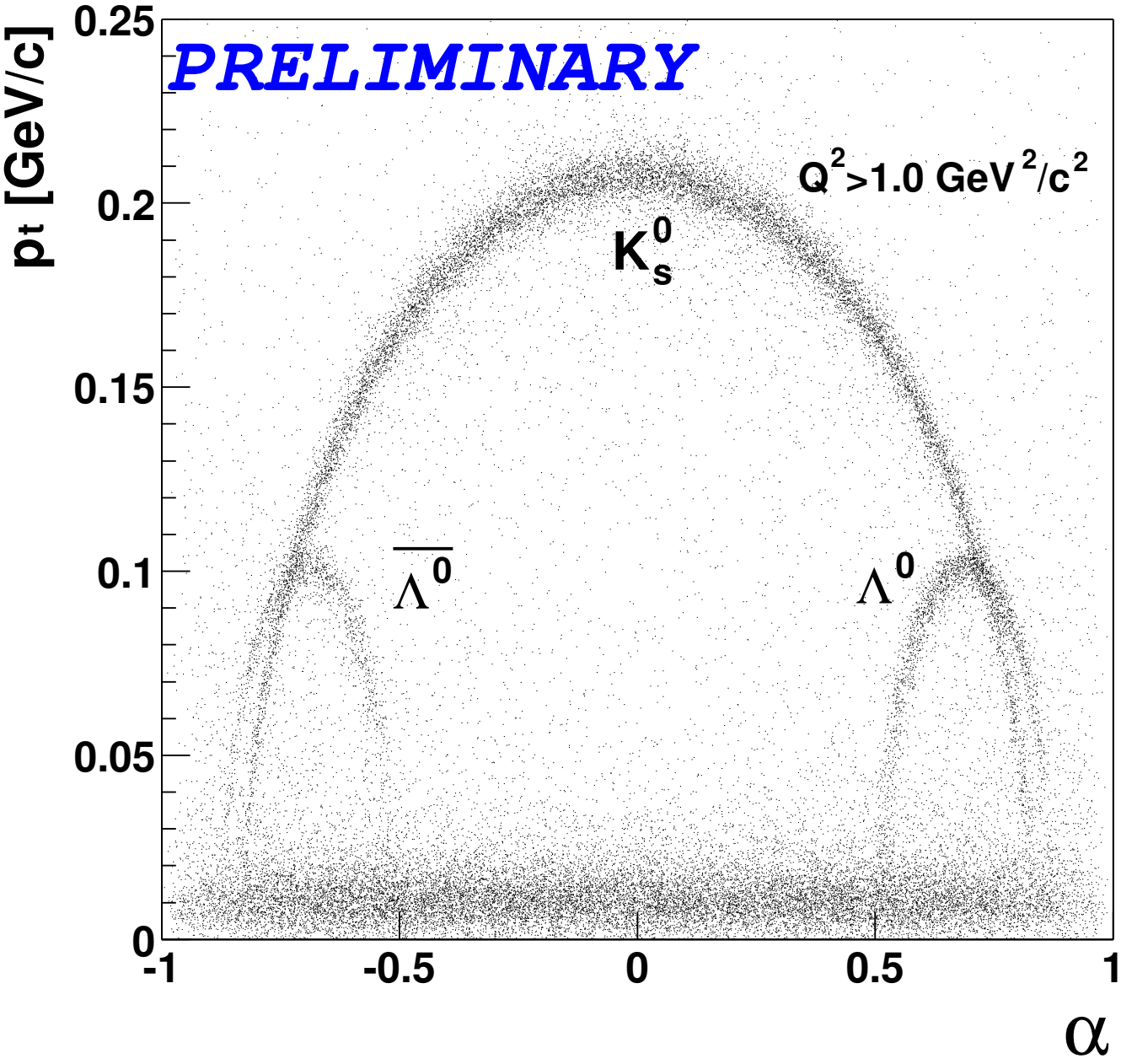
Overall cuts: $Q^2 > 1$ (GeV/c)^2, $0.2 < y < 0.9$

K^0, Λ^0 and $\overline{\Lambda^0}$ invariant mass distributions



- The decay vertex (V^0) must be outside of the target
- The angle between the V^0 momentum vector and the vector between the primary and decay vertices must be $\theta_{col} < 10$ mrad
- The transverse momentum of the decay particles wrt the V^0 momentum must be $p_T > 23$ MeV/c

Armenteros plot



$$\alpha = \frac{p_L^+ - p_L^-}{p_L^+ + p_L^-}$$

Extraction of the polarization

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- **Let's define:**

  $\mathbf{n}_{\gamma^*} \to$ direction of the **virtual photon** in the Λ^0 rest frame

  $\mathbf{n}_{p^*} \to$ direction of the **target nucleon** in the Λ^0 rest frame

  $$\mathbf{n}_x = \mathbf{n}_{\gamma^*}, \quad \mathbf{n}_y = \mathbf{n}_x \times \mathbf{n}_{p^*} / |\mathbf{n}_x \times \mathbf{n}_{p^*}|, \quad \mathbf{n}_z = \mathbf{n}_x \times \mathbf{n}_y$$

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- **The distribution of the positive decay particle in the** Λ^0 ($\overline{\Lambda^0}$) **rest frame is given by:**

  $$\frac{dN}{d\cos(\theta_i^*)} = \frac{N_0}{2}\left(1+(-)\alpha P_i \, \mathbf{n}_i \cdot \mathbf{k}\right) = \frac{N_0}{2}\left(1+(-)\alpha P_i \cos(\theta_i^*)\right),$$

  where $\mathbf{k}$ is the unit vector along the decay particle momentum and
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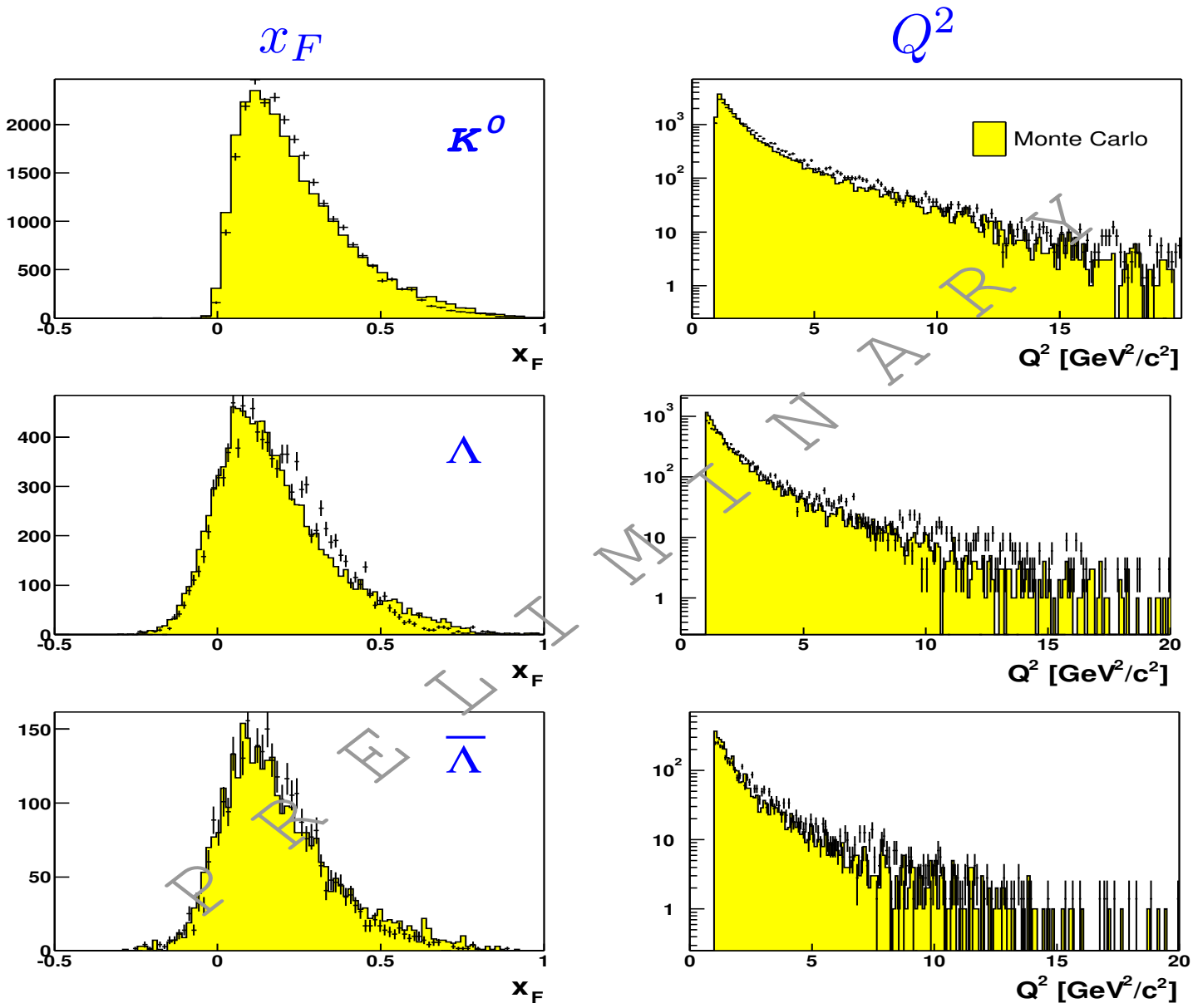
- **Correction of the apparatus acceptance from Monte Carlo simulation**

Lambda data vs MC



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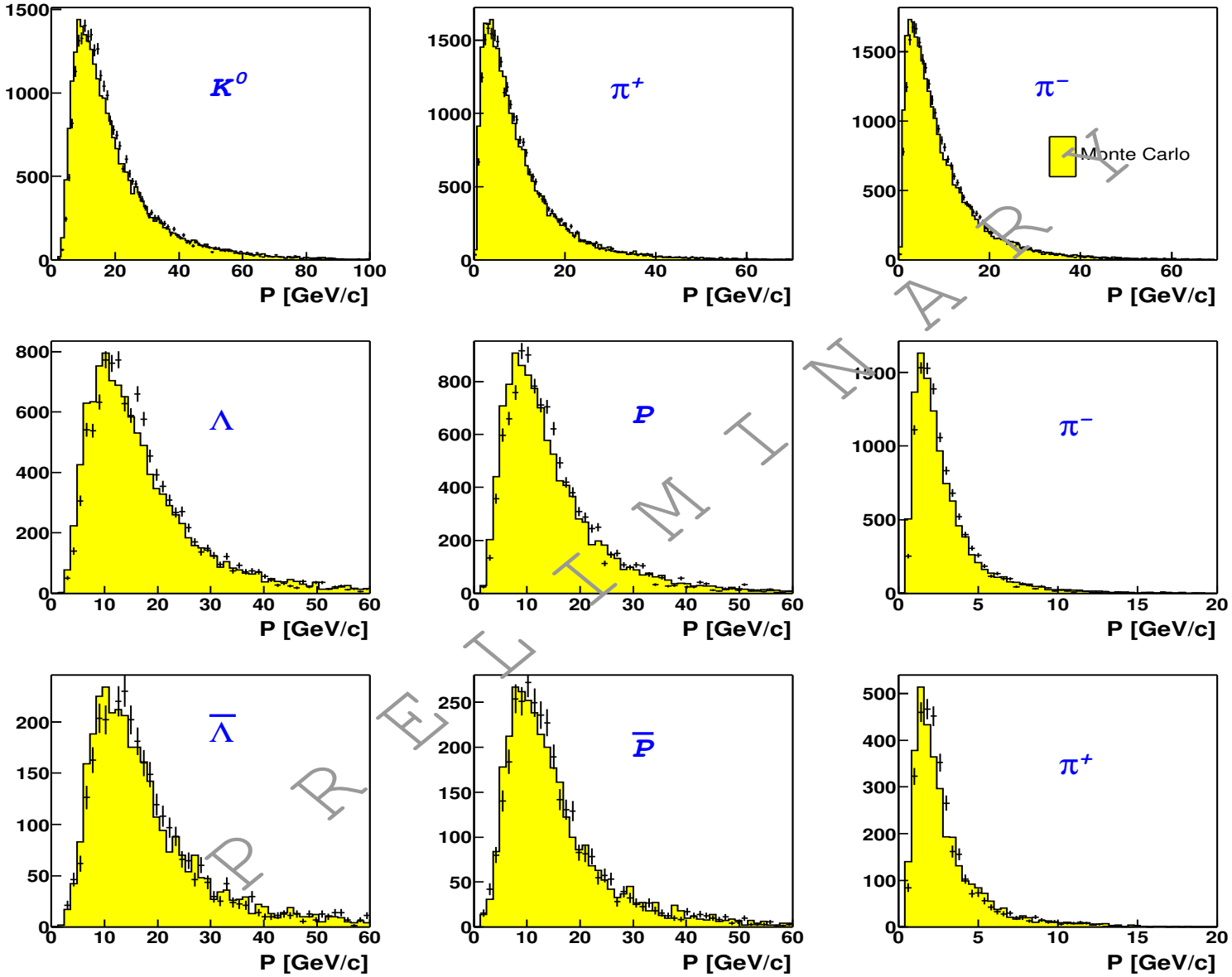
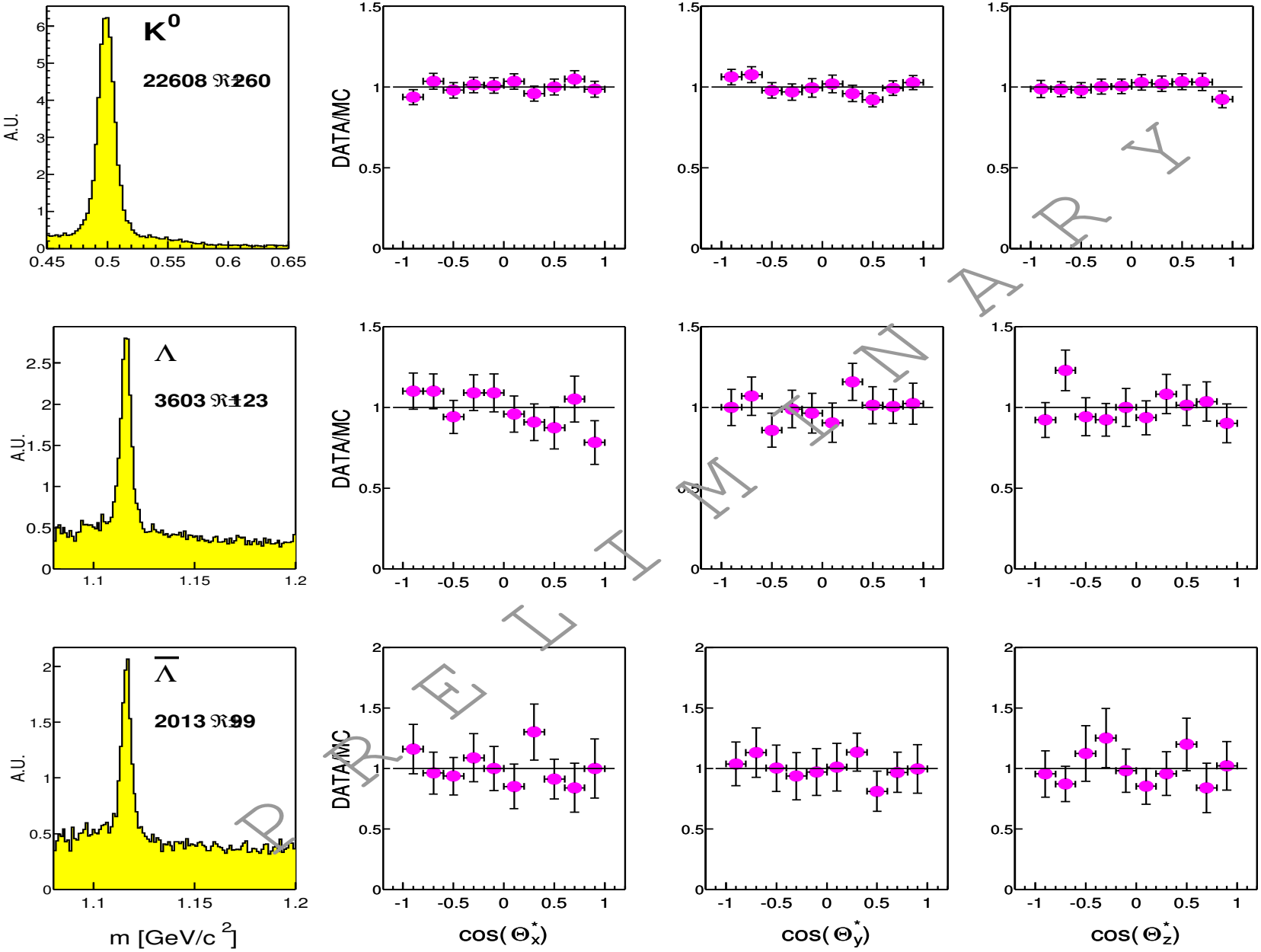


Corrected angular distributions



Summary and Outlook

- COMPASS is able to provide a large statistics of Λ^0 and $\overline{\Lambda^0}$ events:

  about 3600 Λ^0 and 2000 $\overline{\Lambda^0}$ events from the analysis of 1/6 of 2002 data ($Q^2 > 1,\ 0.2 < y < 0.9$)

- Analysis of the complete 2002 data (including transversity data) is in advanced stage

- Processing of 2003 data has already been started, expected statistics is at least comparable to 2002

- COMPASS 2002 data show good potential for the Λ^0 polarization measurement

Thank You