Λ and $\bar{\Lambda}$ hyperon production by polarized muons at COMPASS

On behalf of the COMPASS Collaboration

V. Alexakhin

JINR, Dubna

Physics motiviations

- Target fragmentation region (TFR) $x_F < 0$
  - Ellis, Kharzeev, Kotzinian (Z.Physik C69 (1996) 467) predict negative longitudinal polarisation of Λ hyperons (within polarised nucleon intrinsic strangeness model)
- Current fragmentation region (CFR) $x_F > 0$
  - Study of the quark to baryon spin transfer processes $q \rightarrow \Lambda$
  - Λ spin structure
    NQM: $\Delta u^{\Lambda} = \Delta d^{\Lambda} = 0, \Delta s^{\Lambda} = 1$
    Burkardt and Jaffe (PRL **70**, (1993) 2537):
    $$g_1^{\Lambda} \Rightarrow \Delta u^{\Lambda} = \Delta d^{\Lambda} = -0.23, \Delta s^{\Lambda} = 0.58$$
  - Test of the strange quark-antiquark symmetry of the nucleon sea
    $s(x) \neq \bar{s}(x)$?
    $\Delta s(x) \neq \Delta \bar{s}(x)$?

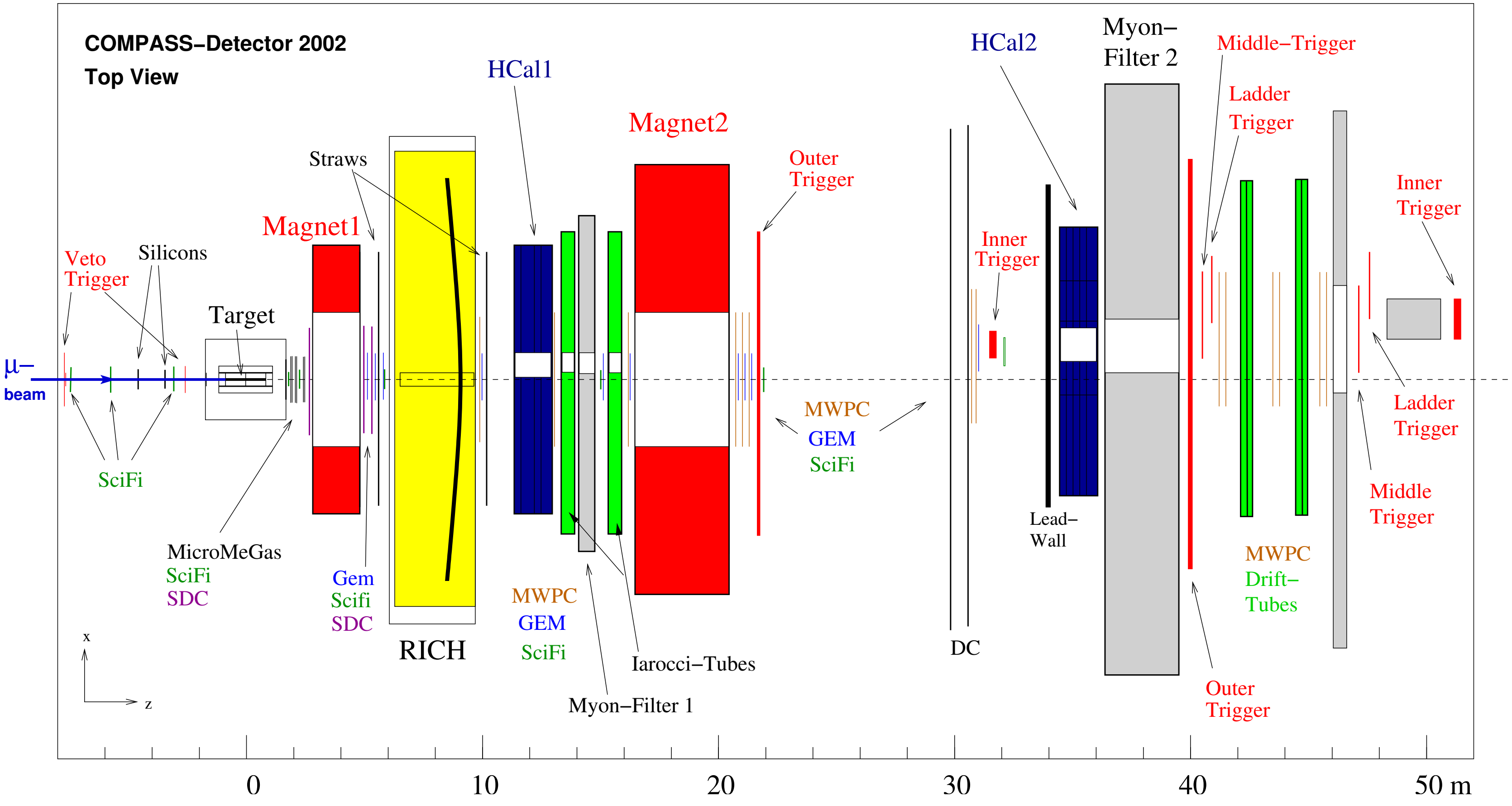
Theoretical summary

	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.*		$\oplus$		$\oplus$

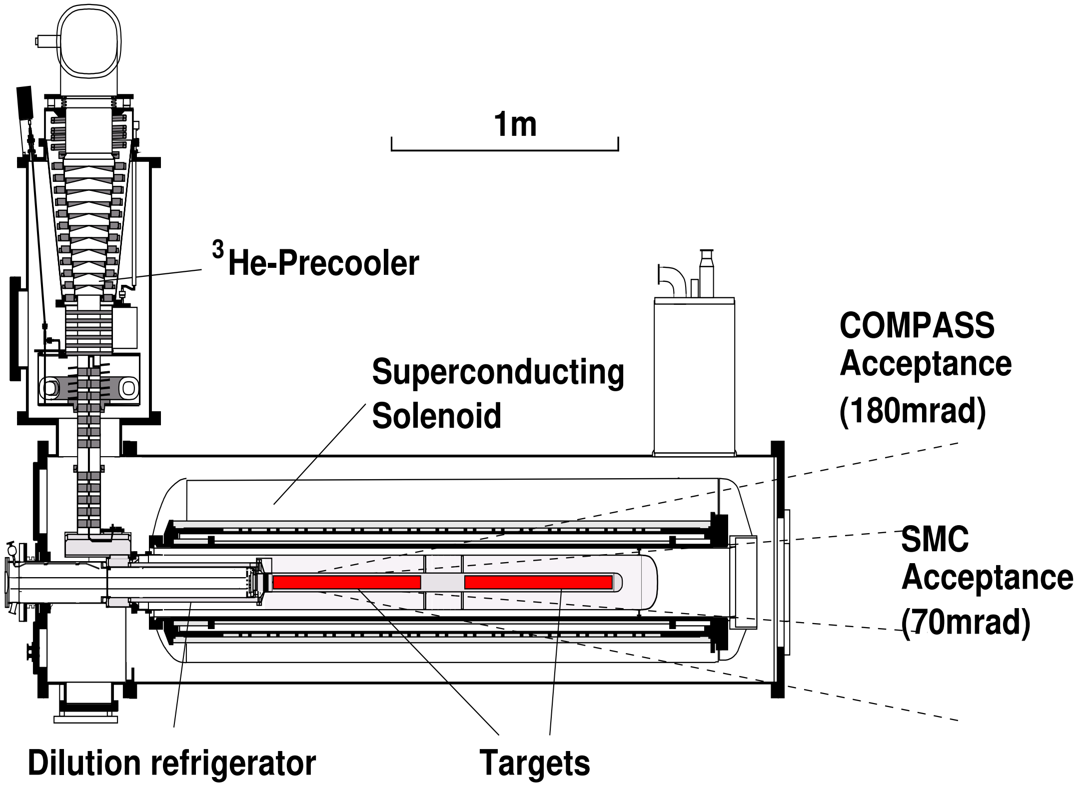
Experimental measurements of Λ polarisation

Reaction Exp.	$< E_b >$ (GeV)	Select.	N_Λ	P_Λ	$N_{\bar{\Lambda}}$	$P_{\bar{\Lambda}}$
$\bar{\nu_\mu} Ne$	40	$x_F < 0$	403	-0.63 ± 0.13		
WA59		$x_F > 0$	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

COMPASS experimental setup

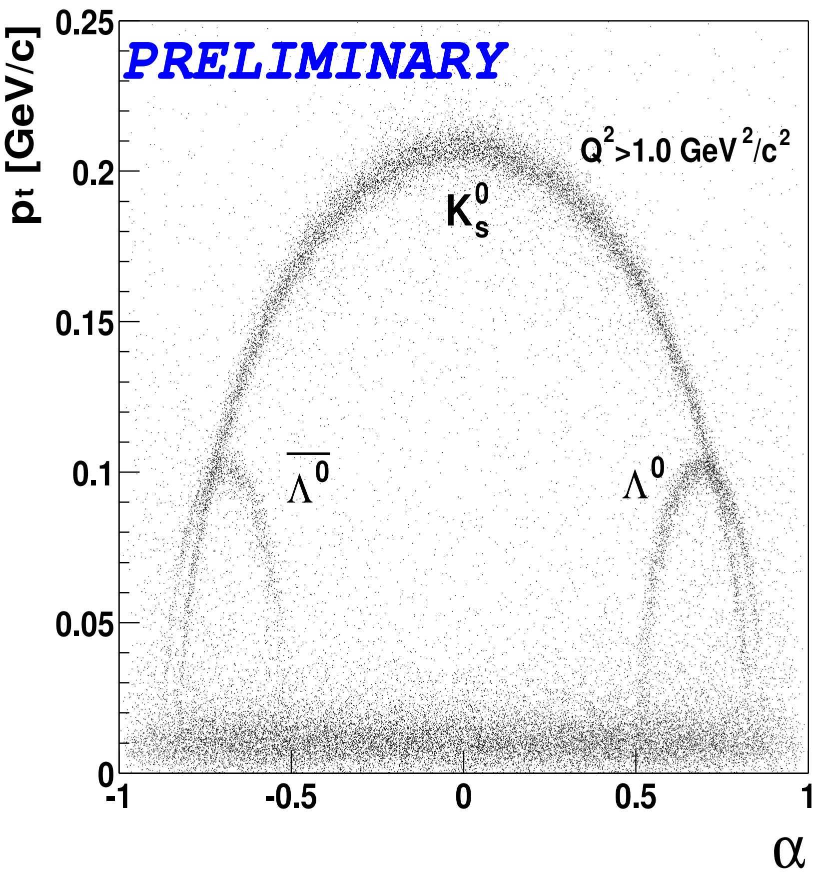


Polarised target



- Li^6D
- $P_T \approx 50\%$
- $f = 0.5$

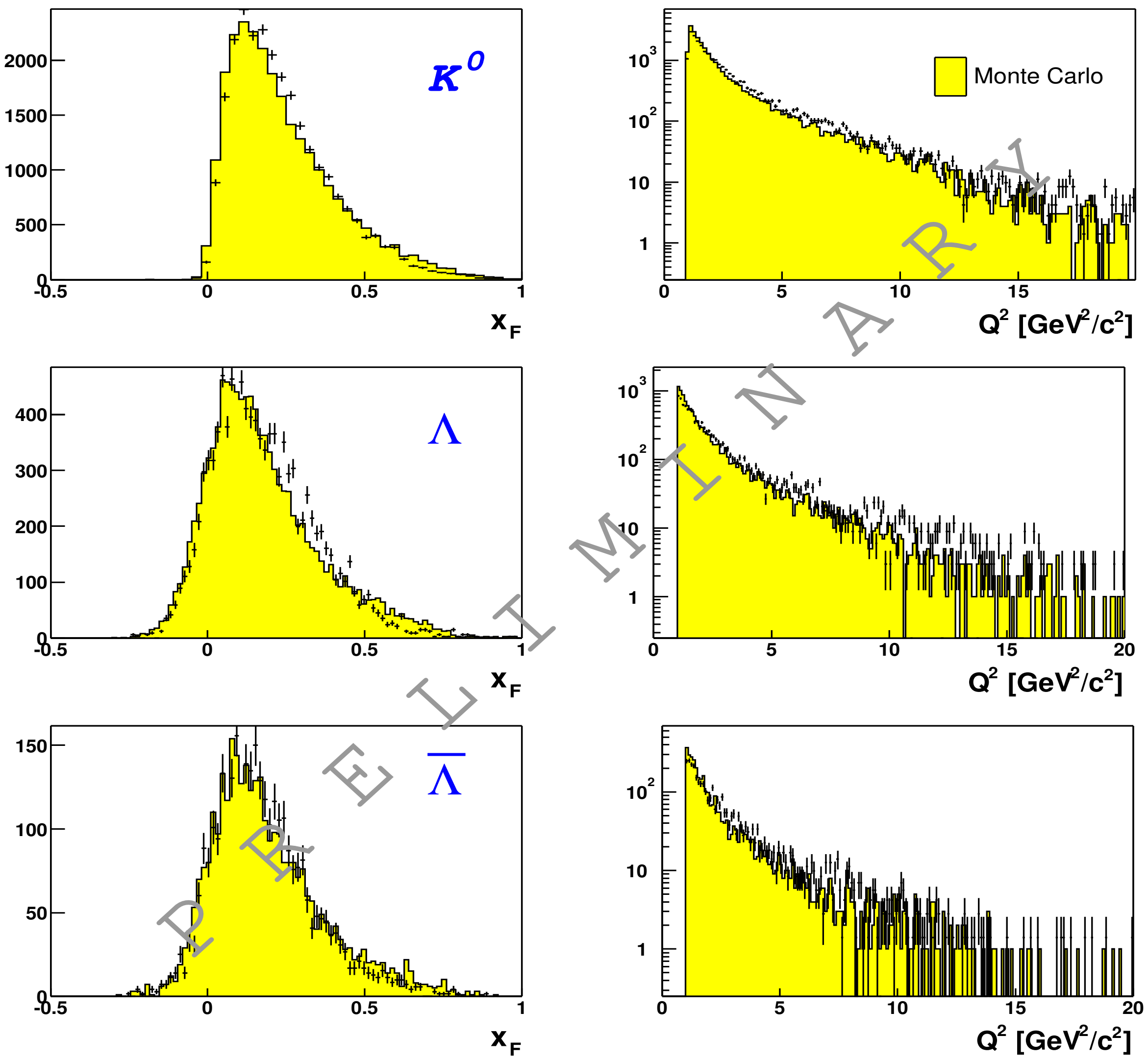
Selection cuts



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

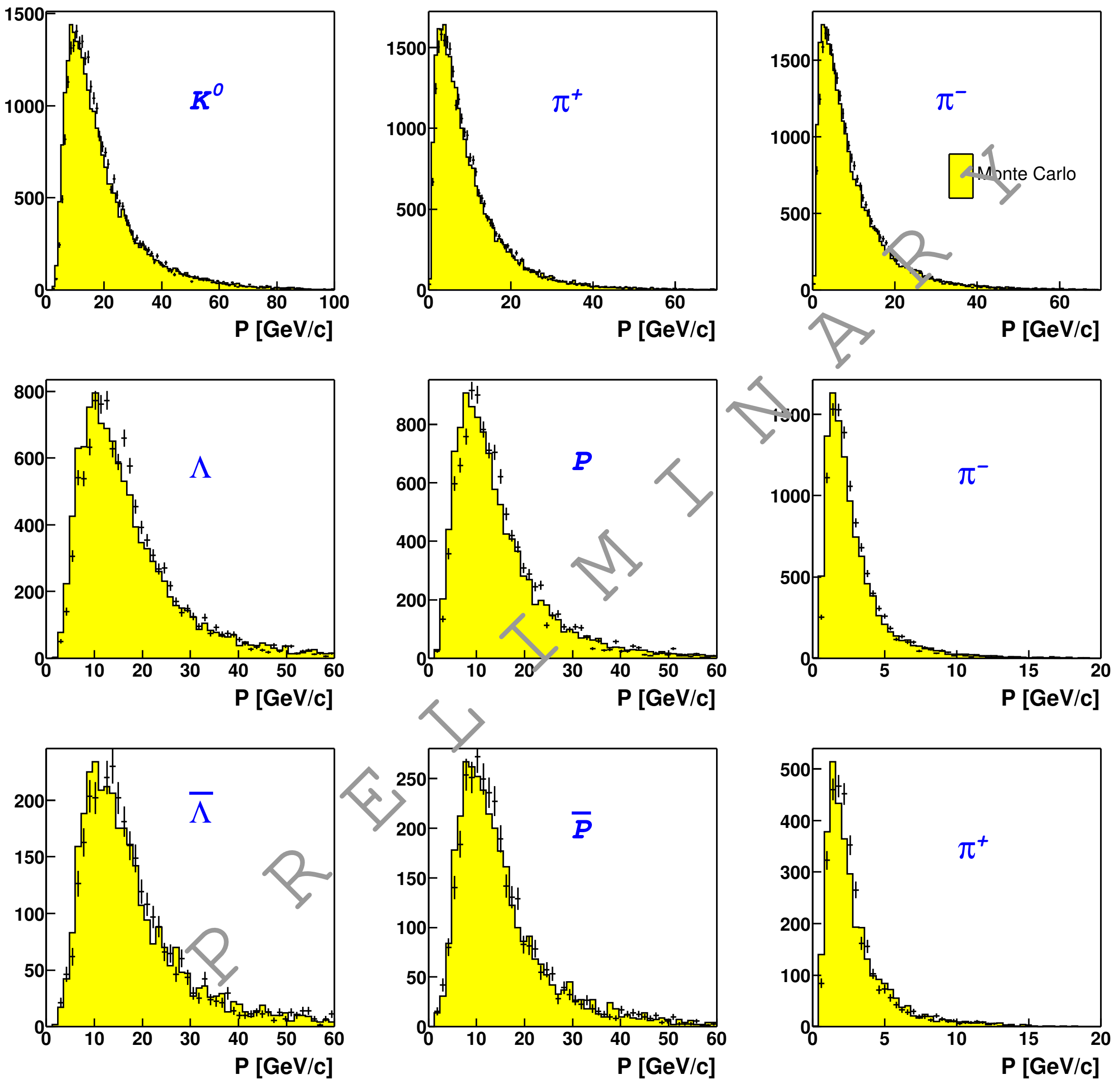
- Decay vertex (V^0) must be outside of the target.
- The angle between vector of V^0 momentum and vector between primary and V^0 vertices should be $\theta_{col} < 0.01$ rad.
- $p_t > 23$ MeV/c.
- $Q^2 > 1$, $0.2 < y < 0.9$

Kinematical characteristics



LEPTO 6.5.1 is used for event simulation.

Kinematical characteristics



Angular distributions

- $\Lambda(\bar{\Lambda})$ hyperon polarisation is measured via angular asymmetry of decay protons in $\Lambda \to p\pi^-$ ($\bar{\Lambda} \to \bar{p}\pi^+$) decays.

- Angular distribution of the decay protons in $\Lambda(\bar{\Lambda})$ rest frame is given by a formula:

$$\frac{dN}{d\cos\theta_i} = \frac{N}{2}\,(1 + \alpha P_i \cos\theta_i) \qquad (1)$$

  where i = x,y,z, coordinate system for each $\Lambda(\bar{\Lambda})$ hyperon $\mathbf{n} = (n_x, n_y, n_z)$, polarisation vector $\mathbf{P} = (P_x, P_y, P_z)$, $\cos\theta_i = \mathbf{n}_i \cdot \mathbf{k}$, $\mathbf{k}$ — unit vector of the direction of the positive decay particle (p for $\Lambda \to p\pi^-$).

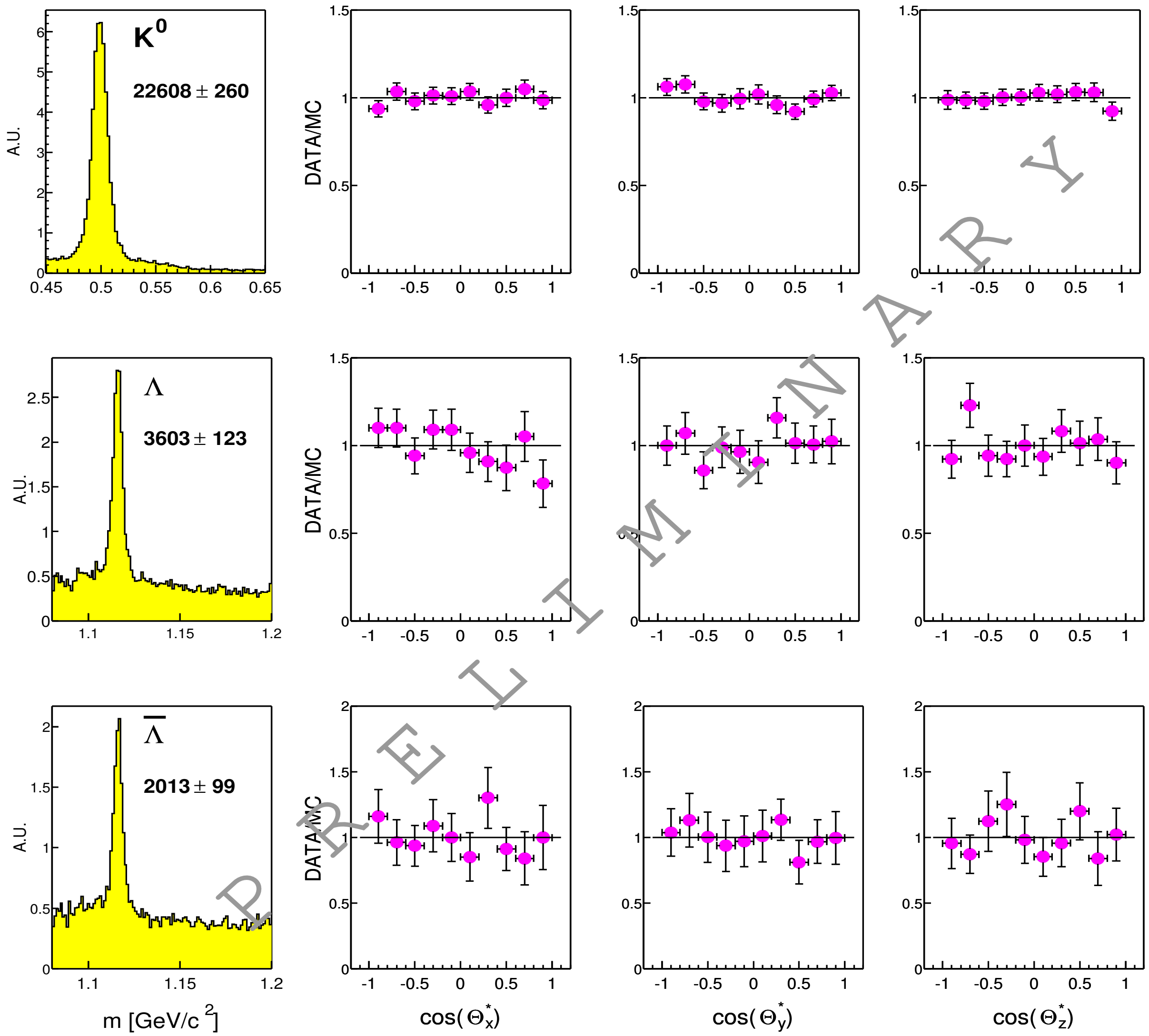
- "J"-system can be built using directions of virtual photon ($\mathbf{e}_\gamma$) and target nucleon ($\mathbf{e}_T$), all vectors are taken in the Λ rest frame.

  $\mathbf{n}_x = \mathbf{e}_\gamma$

  $\mathbf{n}_y = \mathbf{e}_\gamma \times \mathbf{e}_T / |\mathbf{e}_\gamma \times \mathbf{e}_T|$

  $\mathbf{n}_z = \mathbf{n}_x \times \mathbf{n}_y$

Angular distributions



1/6 of the 2002 statistics

Conclusion

- After processing of 1/6 of 2002 data statistics is about 3600 Λ and 2000 $\bar{\Lambda}$ with background subtraction and with cuts on $Q^2 > 1$, $0.2 < y < 0.9$.
- COMPASS 2002 data show good potential for Λ hyperon polarisation measurement.