Spin alignment and OZI rule violation in exlusive ω and ϕ production in pp collisions at COMPASS

HK61.8 DPG Frühjahrstagung Dresden

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on behalf of the COMPASS collaboration

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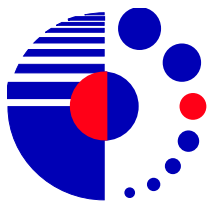

bmb+f - Förderschwerpunkt
COMPASS
Großgeräte der physikalischen Grundlagenforschung

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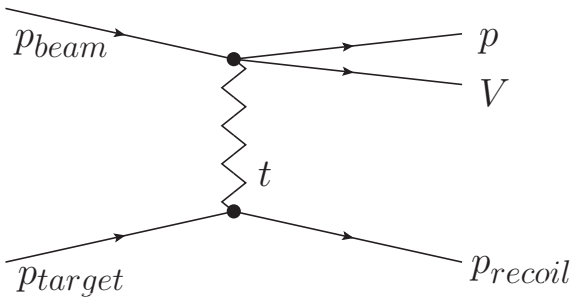
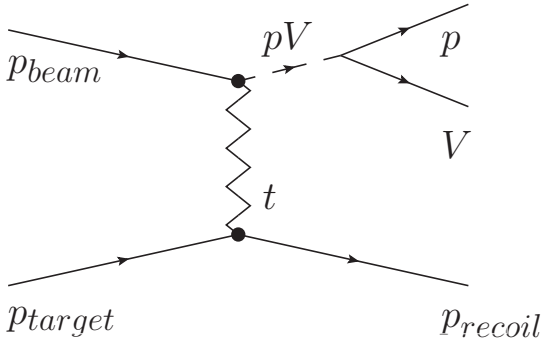
Production mechanisms

At medium beam energies, $\mathcal{O}(100\,\mathrm{GeV})$:

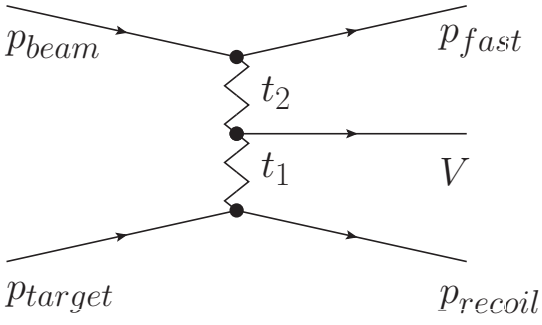
non-resonant



resonant (diffractive)



central



Try to understand interplay by studying strangeness transfer in well-understood vector meson production ("strangeness chemistry"):

- $\phi(1020)$ is close to pure $s\bar{s}$ state
- $\omega(782)$ is close to pure $u\bar{u}/d\bar{d}$ state

OZI rule

Idea: study empirical model (corrected for non-ideal mixing)

Okubo-**Z**weig-**I**izuka rule: processes with disconnected quark lines suppressed

prediction for $\phi(1020)$ to $\omega(782)$ production ratios:

$$\sigma(pp \to \phi X)/\sigma(pp \to \omega X) \simeq \tan^2(\theta - \theta_0) \simeq 4.2 \cdot 10^{-3}$$

Violation of ratio hints at flavour-neutral exchange processes

Study at COMPASS:
Compare $\phi(1020) \longrightarrow K^+K^-$ to $\omega(782) \longrightarrow \pi^+\pi^-\pi^0$ production
Necessary to measure full kinematics of all involved particles (exclusive events)

Event selection

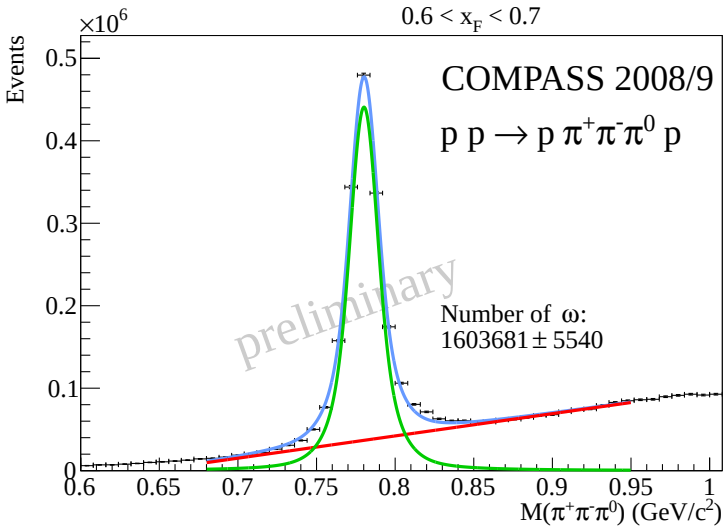
Restriction to similar, well-known phase space for both ω and ϕ by cuts on

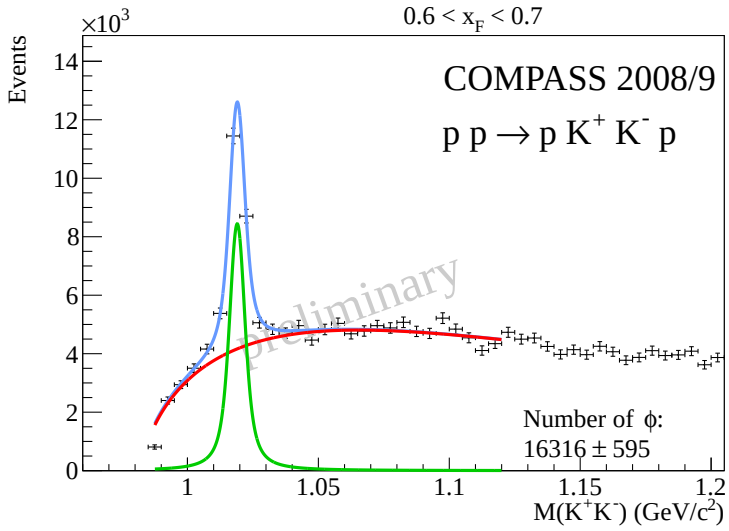
- longitudinal momentum share (x_F)
- momentum transfer (t')
- mass of pV system (M_{pV})

Method:

1. Monte-Carlo simulation of apparatus acceptance, 3D correction in t', x_F and M_{pV}
2. fit acceptance corrected invariant mass distributions in x_F bins $\Rightarrow$ yields
3. correct for branching $\Rightarrow$ corrected yields
4. calculate $R = \frac{\text{Number of } \phi}{\text{Number of } \omega}$

Preliminary Results $R_{\phi/\omega}$





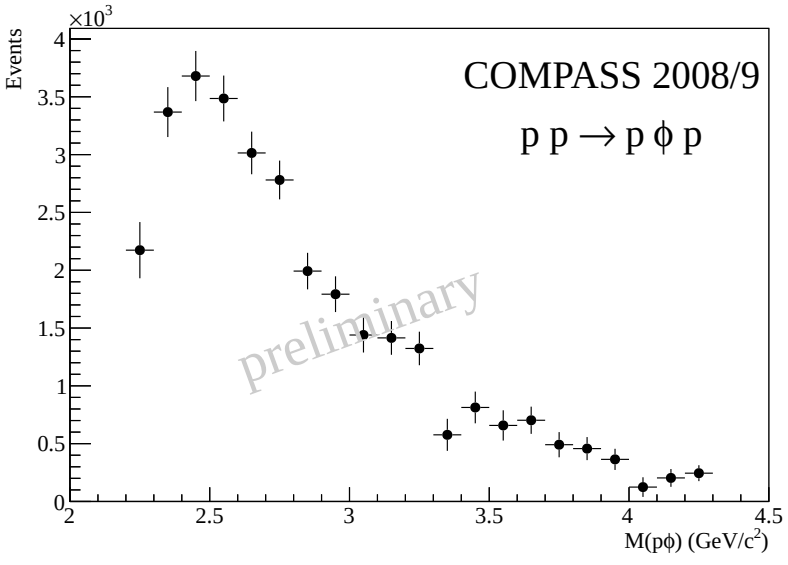
Differential cross section ratio $R_{\phi/\omega}(x_F)$ (*preliminary*):

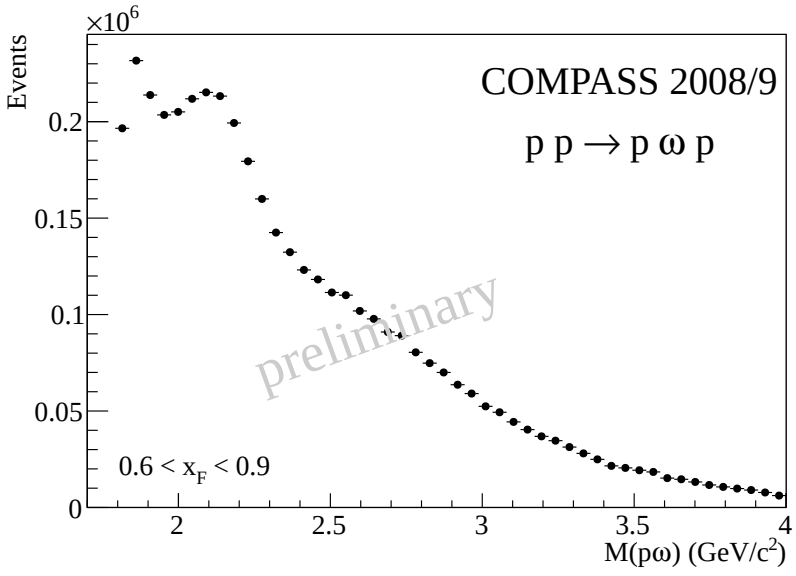
x_F	$R_{\phi/\omega}$	*OZI violation factor*
0.6-0.7	0.019	4.5 ± 0.6
0.7-0.8	0.017	4.0 ± 0.5
0.8-0.9	0.012	2.9 ± 0.4

Role of Resonances

What is the reason for the violation?

Investigate mass of pV system:





$p\phi$: phase-space-like, no structures

$p\omega$: resonances

Preliminary Results $R_{\phi/\omega}$ - II

Restrict measurement to region without visible structures, but still compare to ϕ within in the same phase space!

$\Rightarrow$ cut on vector meson momentum p_V, independent of mass differences

	$p_V > 1.0$ (GeV/c)		$p_V > 1.4$ (GeV/c)	
x_F	$R_{\phi/\omega}$	*OZI viol.*	$R_{\phi/\omega}$	*OZI viol.*
0.6-0.7	0.032	7.6 ± 1.0		
0.7-0.8	0.038	9.0 ± 1.1	0.033	7.9 ± 1.1
0.8-0.9	0.019	4.5 ± 0.6	0.032	7.6 ± 1.0

preliminary!

Differential cross sections: angular dependencies

Spin alignment of vector mesons is a handle to distinguish production mechanisms, cross section linearly parameterised[2] in terms of spin density matrix element ρ_{00}

$$d\sigma/d\cos\theta \propto N(1-\rho_{00}+(3\rho_{00}-1)\cos^2\theta)$$

Spin density matrix has representation depending on reference frame, *e.g.* helicity frame:

- with forward system R (*e.g.* pϕ), $\hat{z} = |\vec{\mathrm{R}}|$ in CM(V) system
- analyser to define angles:
  1. $\vec{n} = \vec{\mathrm{K}}^+$ or $\vec{\mathrm{K}}^-$ for ϕ
  2. $\vec{n} = \vec{\pi}^+ \times \vec{\pi}^-$ for ω

N.B.: $\rho_{00} = 0$ long. alignment, $\rho_{00} = 0.33$ arbitrary alignment, $\rho_{00} = 1$ transverse alignment

[2] K. Schilling, P. Seyboth and G. Wolf, Nucl. Phys. B 15 (1969) 397

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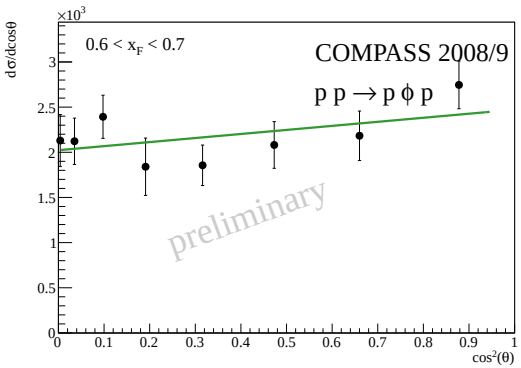
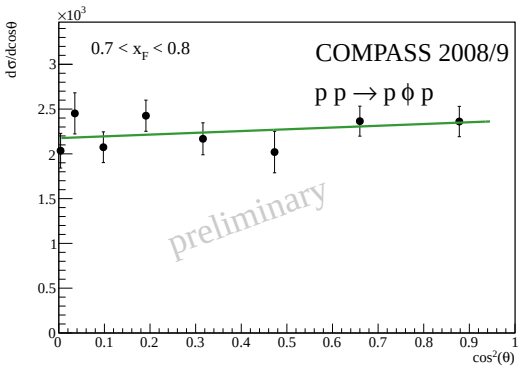
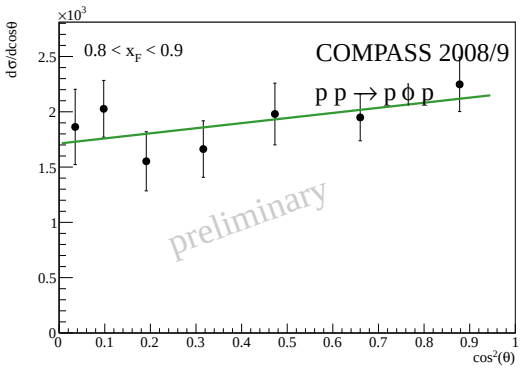


$\rho_{00} = 0.38 \pm 0.03$



$\rho_{00} = 0.35 \pm 0.02$



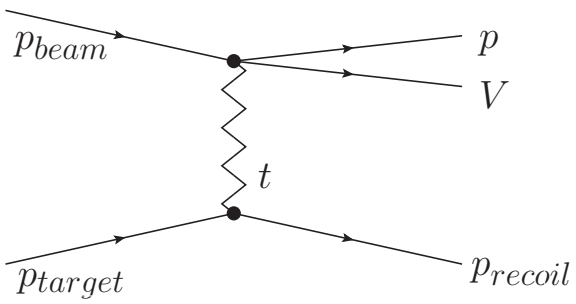
$\rho_{00} = 0.39 \pm 0.04$

preliminary!

[2] K. Schilling, P. Seyboth and G. Wolf, Nucl. Phys. B 15 (1969) 397

Two-particle exchanges

non-resonant



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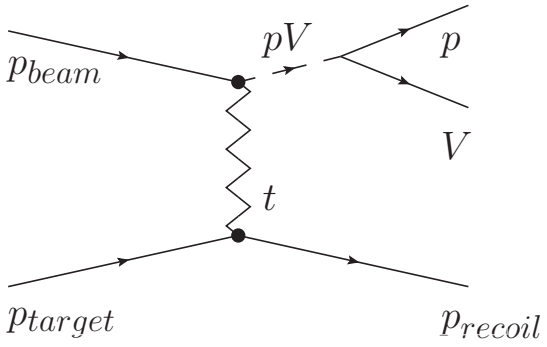
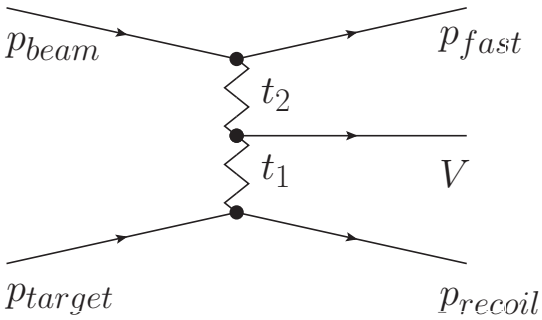


central



Define new reference axis along momentum transfer $\vec{p}_{beam} - \vec{p}$, sensitive to central mechanisms / two particle exchanges

Reaction	x_F	ρ_{00}	Uncertainty
$pp \to pp\phi$	0.6-0.7	0.51	0.03
$pp \to pp\phi$	0.7-0.8	0.58	0.02
$pp \to pp\phi$	0.8-0.9	0.67	0.04

preliminary!

Summary and Outlook

Study of production mechanisms at medium energies via

1. OZI rule violation / production ratio $R(\phi/\omega)$
2. spin alignment

Results:

- found OZI violation of factor 3-4, low violation due to resonances
- OZI violation universally 8 when visible $p\omega$ resonances excluded (interestingly, also for low energy measurements near threshold!)
- weak alignment of ϕ mesons, no obvious structures in $p\phi$ mass spectrum
- observe strong (transverse) alignment for ϕ with respect to exchange particle direction

Outlook:

- not shown: ω alignment results
- Publication in preparation