Relative production of the ϕ vector meson in heavy ion collisions

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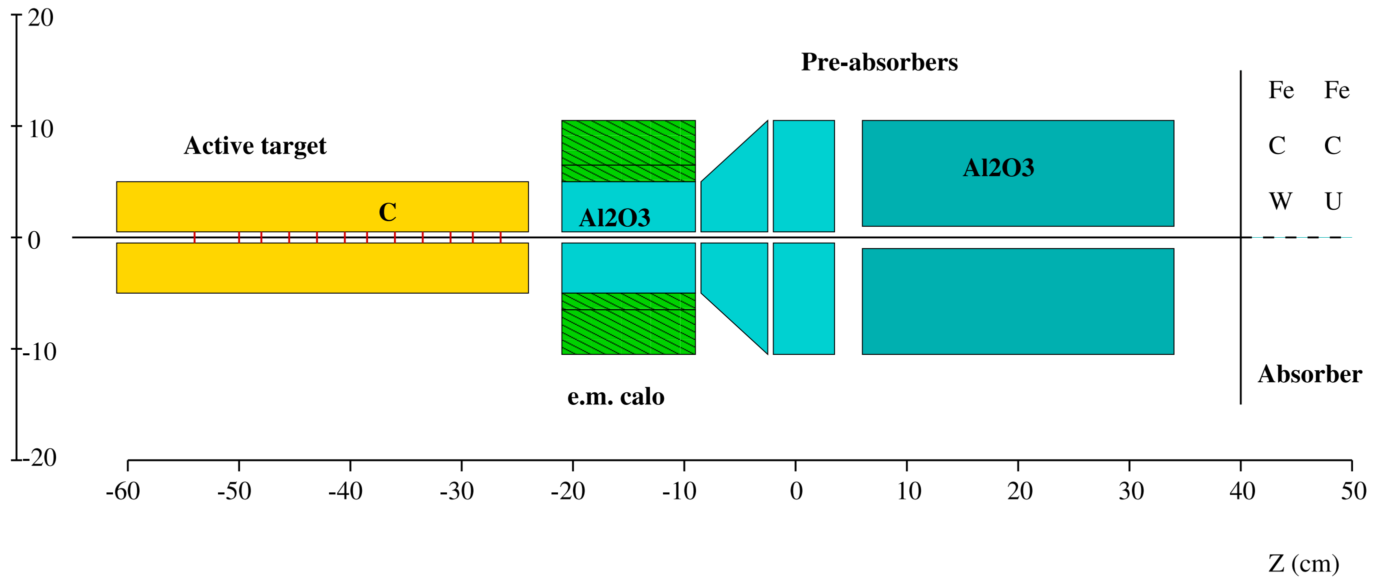
For the NA50 Collaboration

- Experimental Apparatus: NA38/NA50
- Systems: p-W, S-S, S-Cu, S-U at 200 A GeV/c
  Pb-Pb at 158 A GeV/c
- Method of analysis
- Cross-sections: $\sigma_{\rho+\omega}$ and σ_ϕ in p_T bins;
  A dependence
- Ratios $\phi/(\rho+\omega)$ as function of p_T and E_T
- Temperatures for $\rho+\omega$ and ϕ
- Conclusions

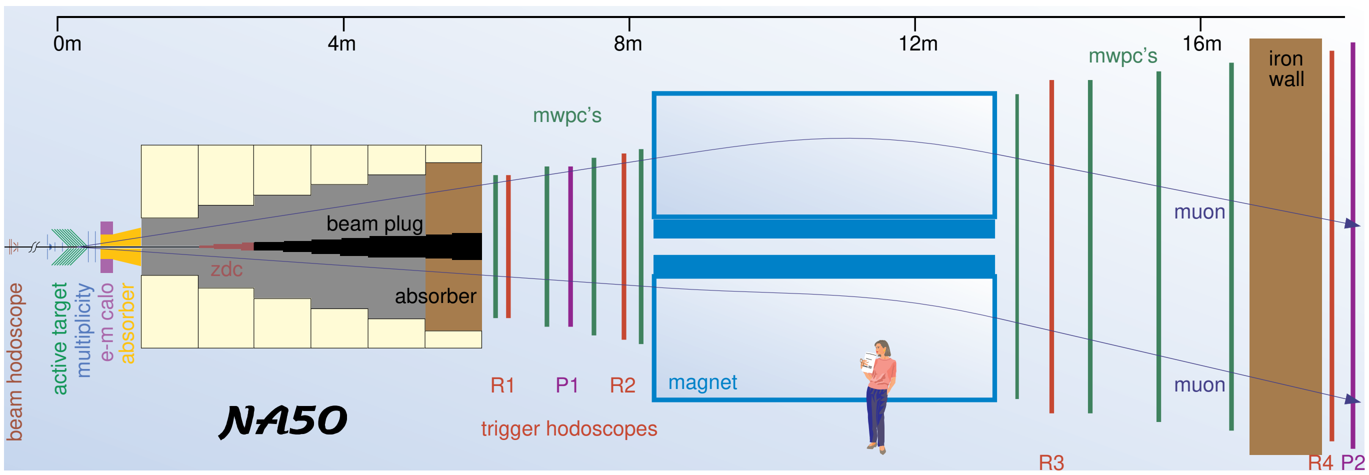
Experimental Apparatus

NA38: S-S, S-Cu, S-U

Set-up Φ: Target region



NA50: Pb-Pb



Statistics

Systems p-W, S-S, S-Cu, S-U (NA38): 200 A GeV/c beam

System Pb-Pb (NA50): 158 A GeV/c beam

Events	Recorded on tape	After recons. & cuts	L (b^{-1})
p-W	4.5×10^5	8.1×10^4	$(1.89 \pm 0.05)\cdot 10^{11}$
S-S	1.2×10^6	3.4×10^4	$(8.81 \pm 0.77)\cdot 10^{9}$
S-Cu	1.4×10^6	7.7×10^4	$(6.18 \pm 0.34)\cdot 10^{9}$
S-U	9.2×10^6	8.8×10^5	$(1.40 \pm 0.03)\cdot 10^{10}$
Pb-Pb	—	—	$(4.00 \pm 0.00)\cdot 10^{12}$

Kinematical domain

→ $0.25 \leq M_{\mu\mu} \leq 2.5$ GeV/c^2 (≤ 2.0 GeV/c^2 for Pb-Pb)

→ $0. \leq Y_{\mu\mu}^{CM} \leq 1.$

→ $-0.5 \leq cos\theta_{CS} \leq 0.5$

→ $\forall\ \phi_{CS}$

Background subtraction according to:

$$N_{signal}^{+-} = N^{+-} - 2\sqrt{N^{++}N^{--}}|_{-} - 2\sqrt{N^{++}N^{--}}|_{+}$$

Method

- Muon tracks are reconstructed. Quality and kinematical cuts are applied.
- Background subtraction is performed.

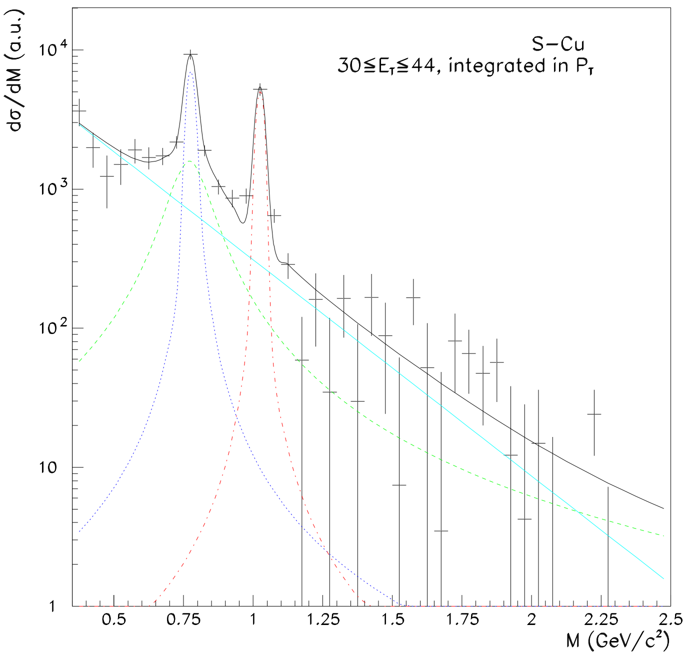
  ϕ Signal/background : 0.2 - 2.2 (S-S)
  0.2 - 2.6 (S-Cu)
  0.2 - 2.3 (S-U)
  $\approx$ 0.4 (Pb-Pb)

- Acceptance and smearing are calculated using a Monte-Carlo method with 3 Breit-Wigners (ρ, ω and ϕ) and a continuum coming from Dalitz and open charm decays and Drell-Yan as input.

  Experimental mass spectra in $P_{T\mu\mu}$ regions are corrected for acceptance and smearing.

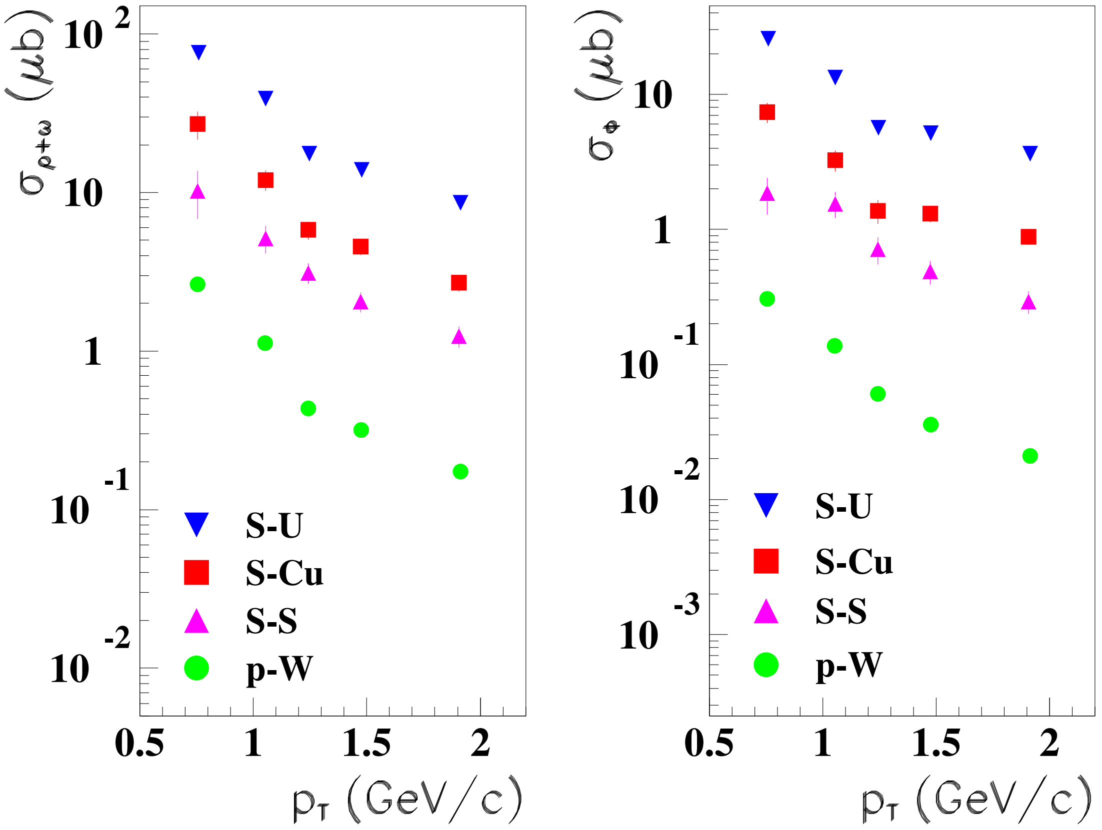
- Mass spectra are fitted with function accounting for all known contributions:

$$F \;=\; P_1\ BW^{\rho} + P_2\ BW^{\omega} + P_3\ BW^{\phi} + P_4\ exp(-P_5 M_{\mu\mu})$$



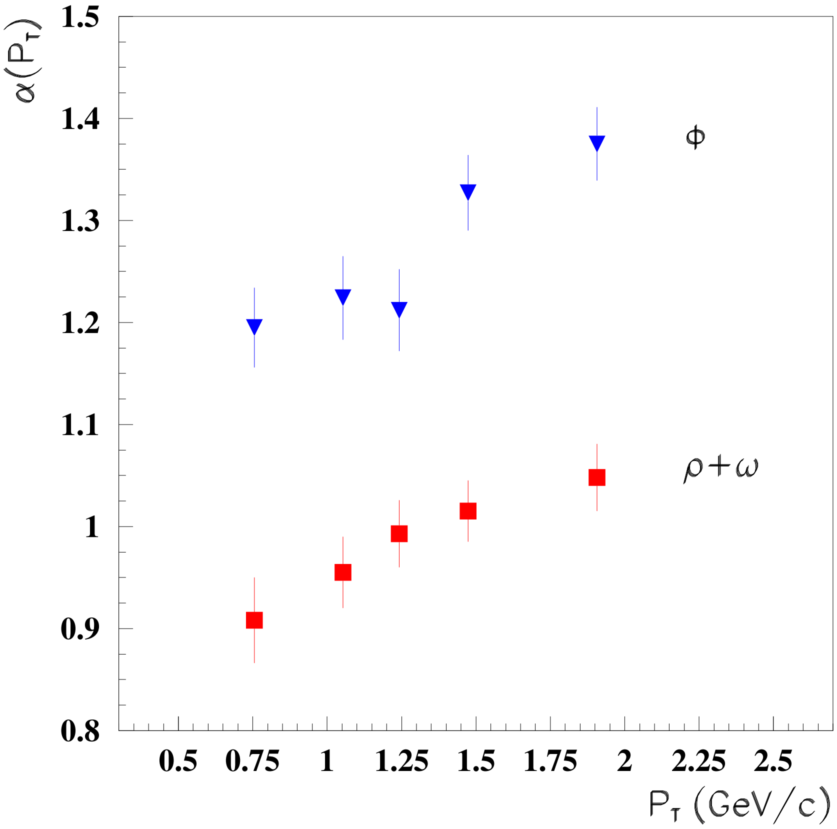
Cross-sections

$$\frac{d\sigma}{dM_{\mu\mu}} = \frac{1}{L}\,\frac{dN^{sgn}}{dM_{\mu\mu}}\,\frac{1}{\prod \epsilon_i}$$



A dependence

$$\sigma = \sigma_o \ (A \cdot B)^{\alpha}$$

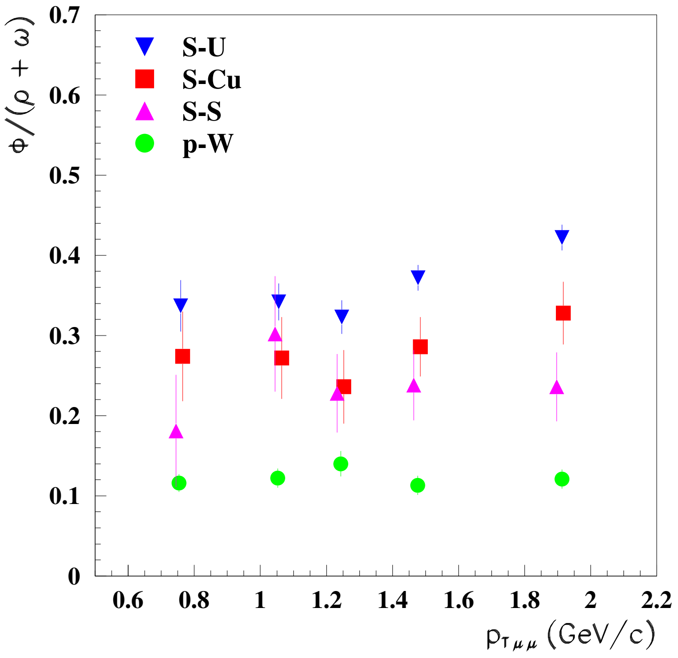


- $\alpha_{\rho+\omega}$ around 1. as expected.
- Superproduction of ϕ ($\alpha_\phi > 1.$).
- Cronin Effect observed for both resonances.

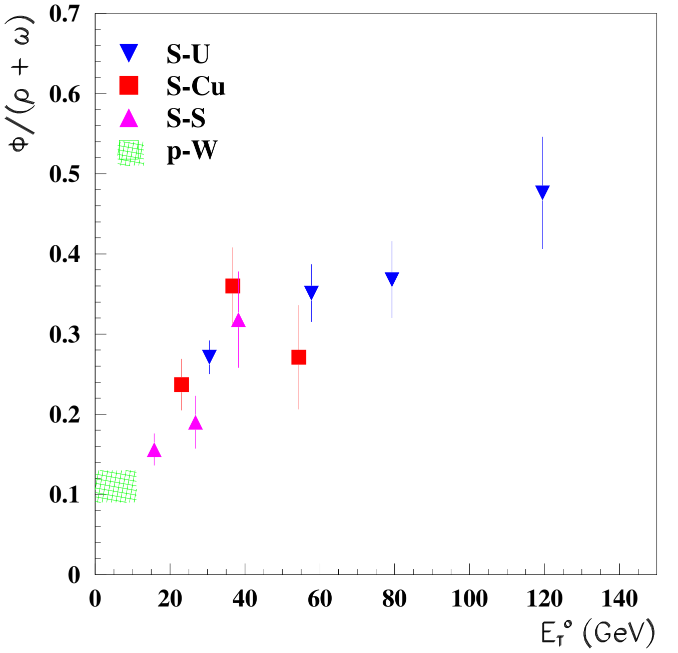
$$\alpha_{\rho+\omega} = 0.927 \pm 0.034$$

$$\alpha_\phi = 1.226 \pm 0.030$$

$\frac{\phi}{\rho+\omega}$ production

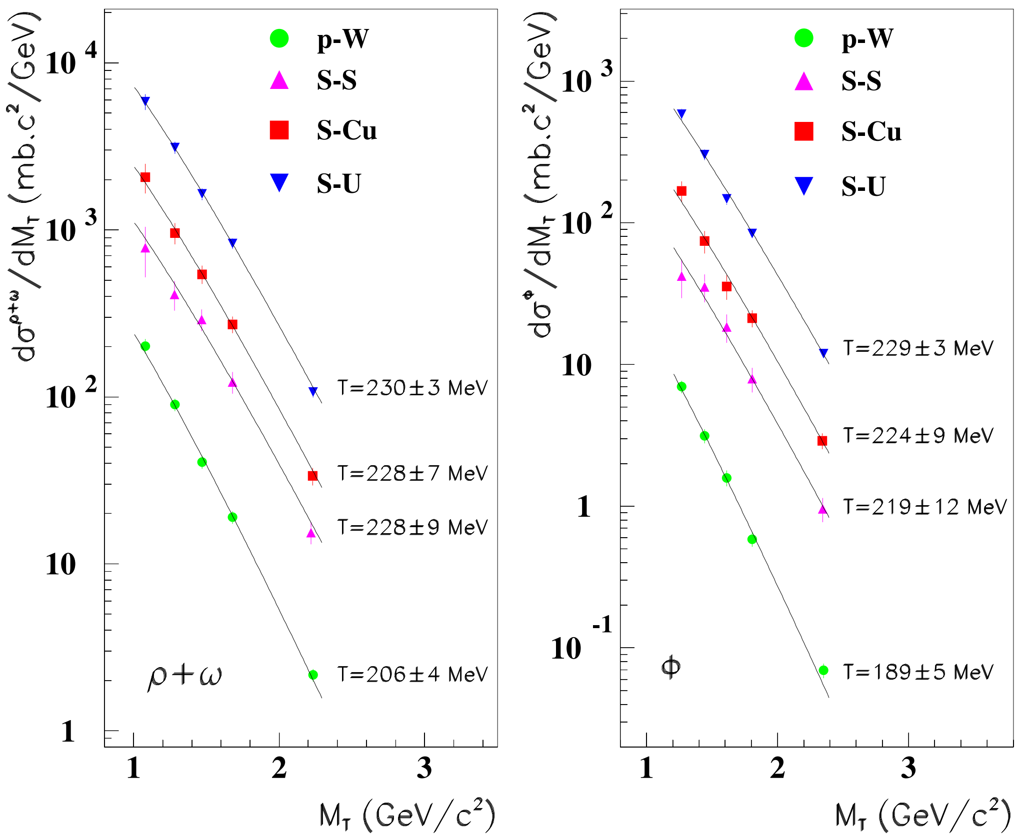


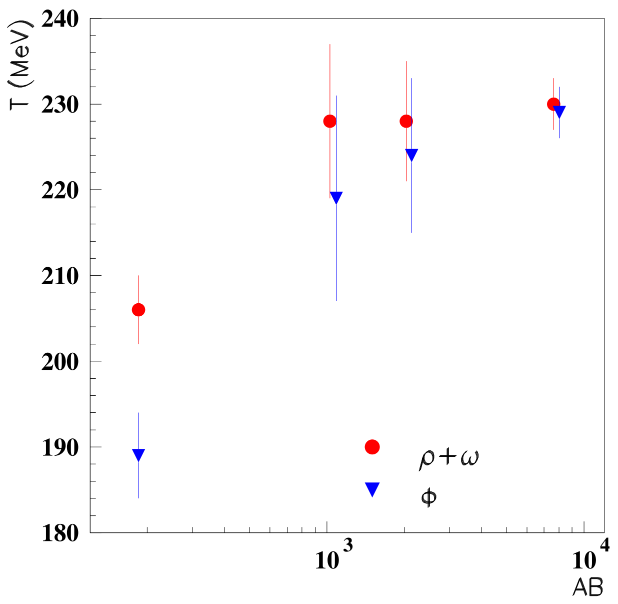
No dependence as function of $p_{T\mu\mu}$.



The ratio increases both with AB and centrality.

Inverse slopes: $\frac{d\sigma}{dM_T} \propto M_T^{3/2}\, e^{-M_T/T}$





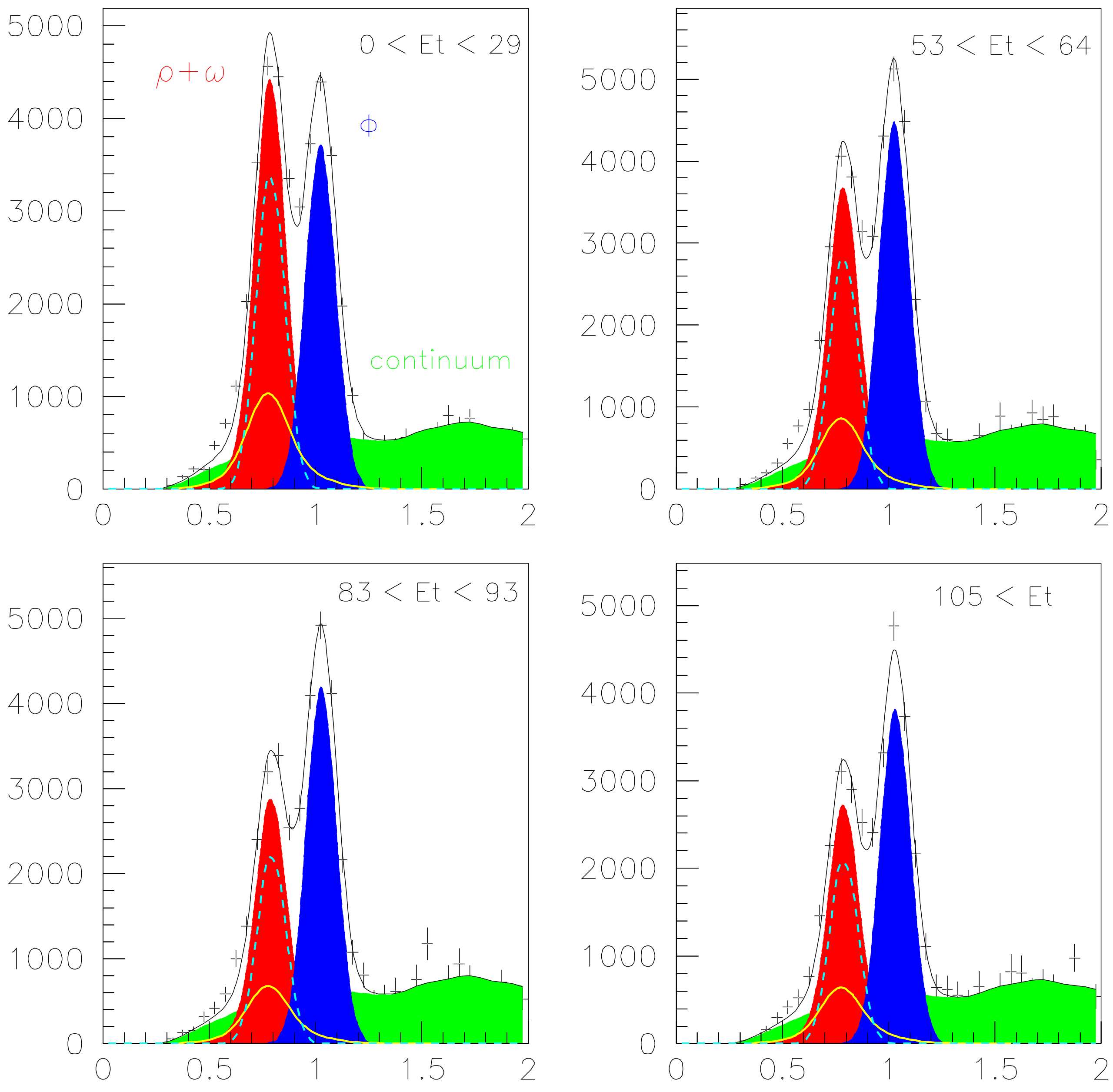
Slight increase of T with the system mass number

Pb-Pb 1996 results

NA50 set-up is specially adapted to ψ studies. In the low mass region, there is only significant acceptance for $M_T \geq 1.5$ GeV/c^2.

Different method of analysis for the Pb-Pb data - simulated resonances and continuum are smeared. Experimental data are fitted with the obtained smeared function.

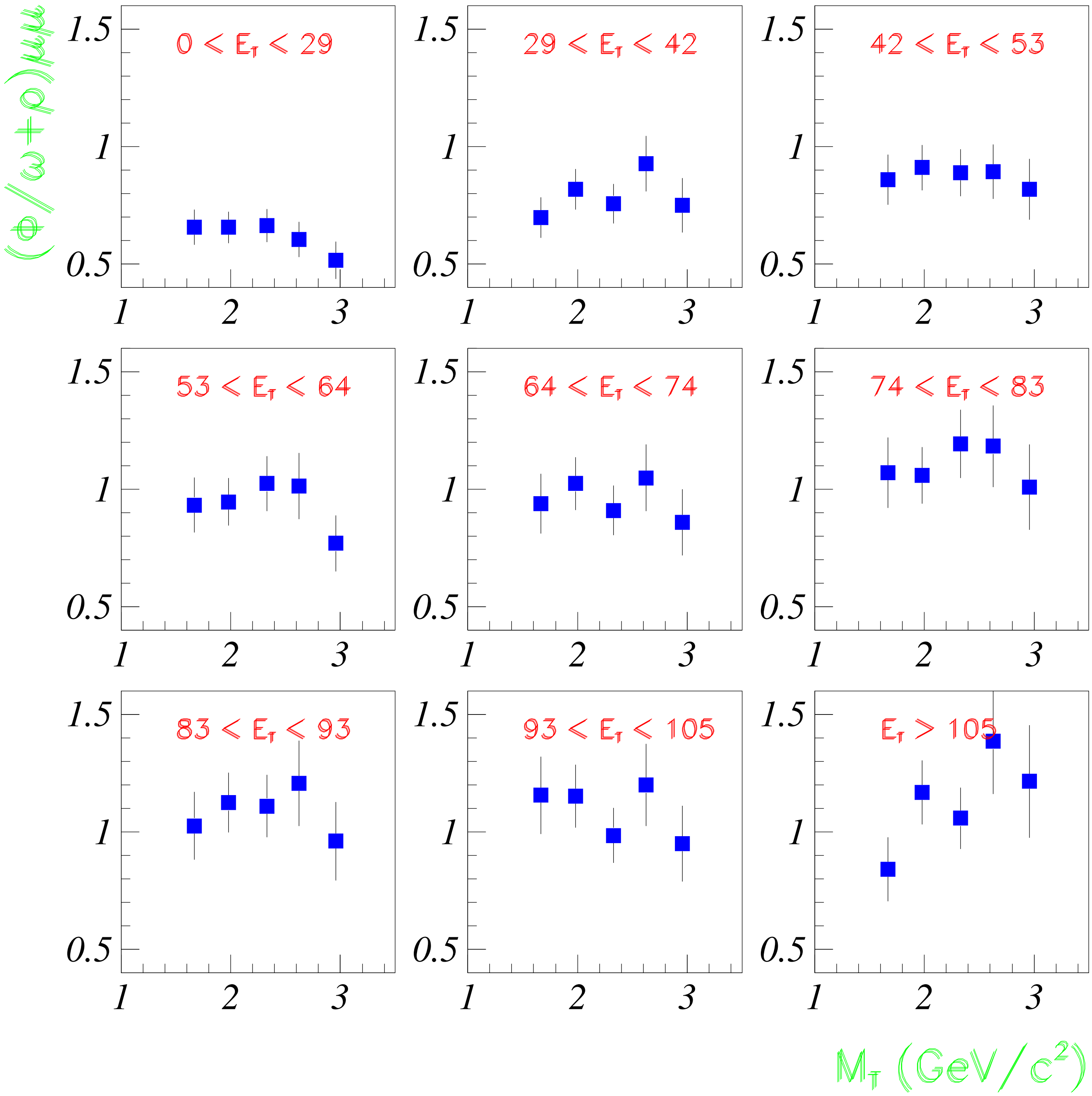
dN/dM$_{\mu\mu}$ versus M$_{\mu\mu}$ (GeV/c^2)



$\rightarrow \sim$ 130000 experimental ϕ's reconstructed

$\frac{\phi}{\rho+\omega}$ as function of M_T, in different E_T regions

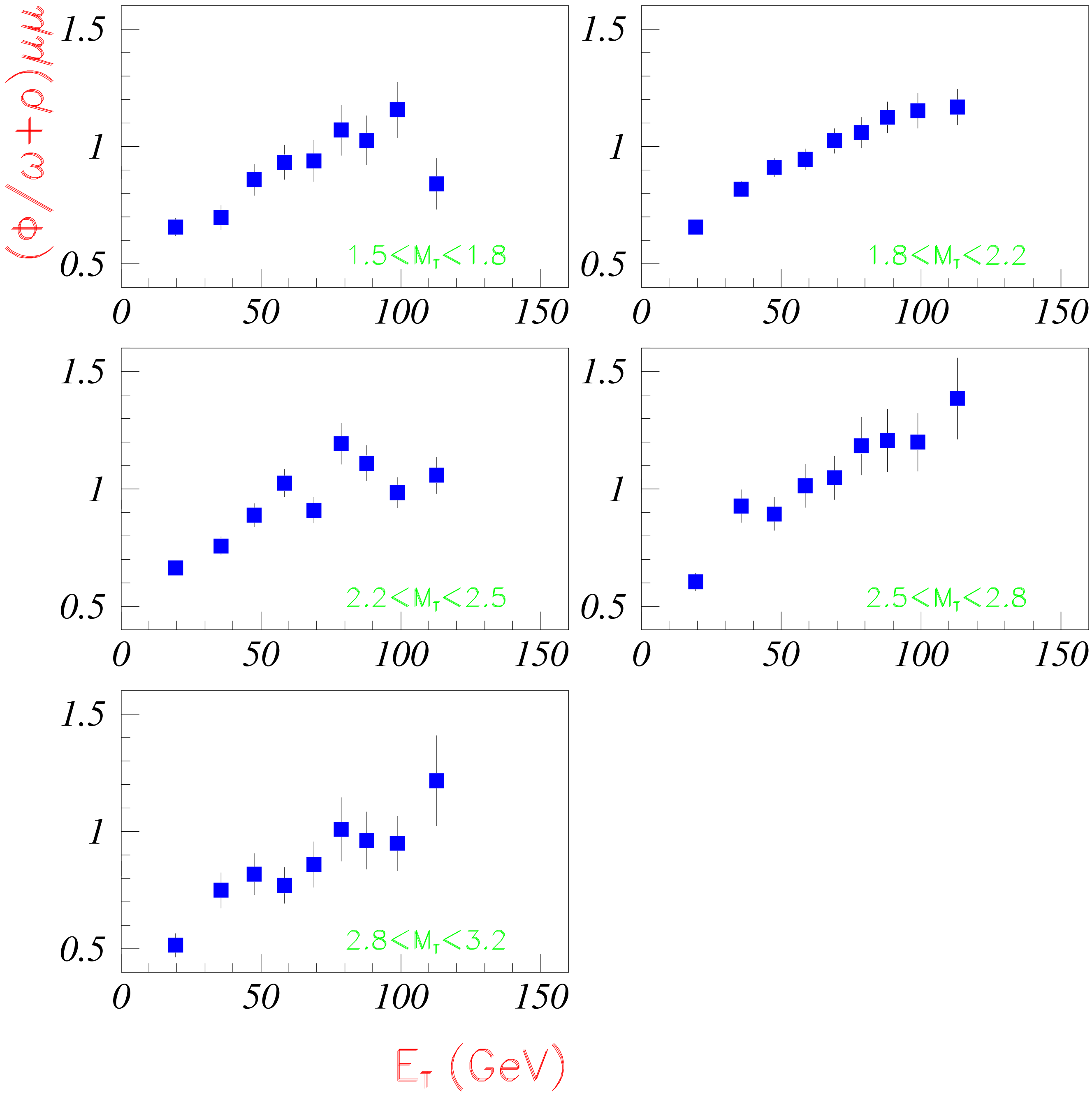
Pb-Pb 1996



No dependence with M_T is seen.

$\frac{\phi}{\rho+\omega}$ as function of E_T, in different M_T regions

Pb-Pb 1996

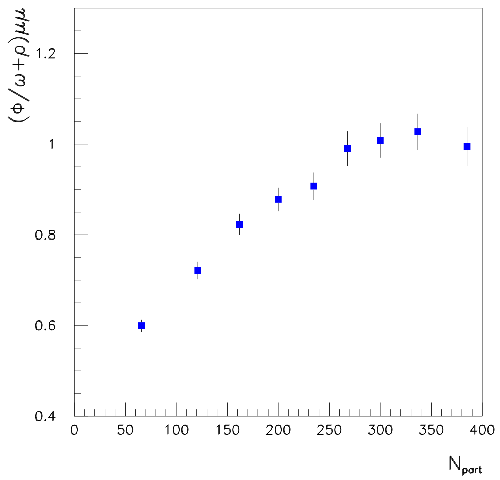


The ratio increases with E_T by a factor ≈ 2.

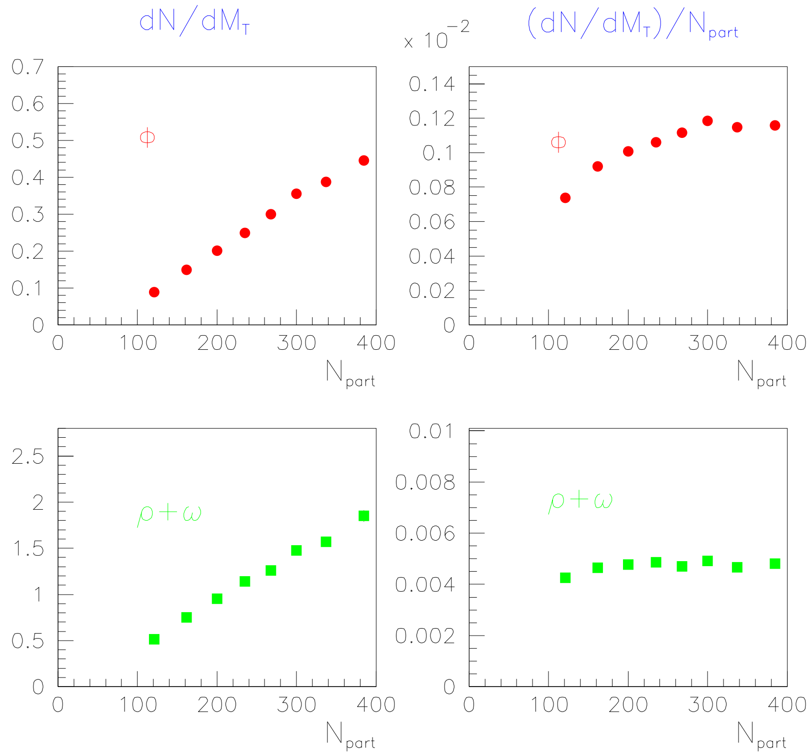
Pb-Pb 1996, $M_T > 1.5$ GeV/c^2

N_{part} = Number of participant nucleons in the collision

$\phi/(\rho+\omega)$ as function of N_{part}



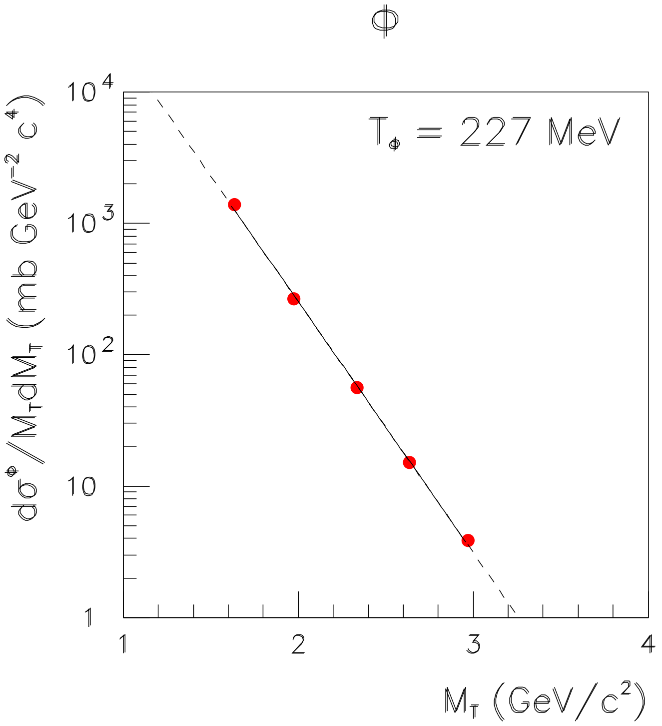
Multiplicities (=produced particles per collision) and multiplicities per participant for ϕ and $\rho+\omega$:

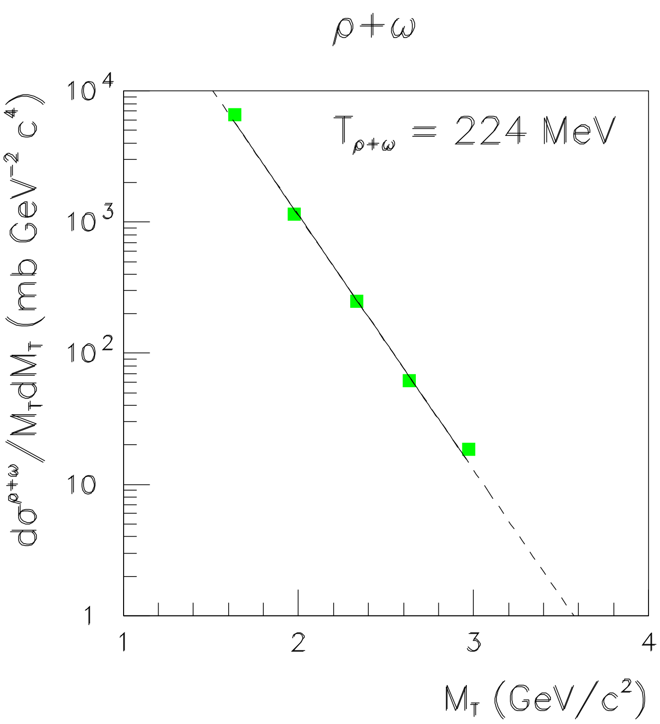


No dependence of the $\rho+\omega$ multiplicity/N_{part} with N_{part} is seen, while ϕ exhibits a stronger increase.

Inverse slopes for Pb-Pb 1996

Using fit function $\frac{d\sigma}{dM_T} \propto M_T \; exp(-M_T/T)$:





$T_{\rho+\omega} = 224 \pm 10$ MeV and $T_\phi = 227 \pm 10$ MeV

Using fit function $\frac{d\sigma}{dM_T} \propto M_T^{3/2} \; exp(-M_T/T)$:

$T_{\rho+\omega} = 213 \pm 10$ MeV and $T_\phi = 216 \pm 10$ MeV

Conclusions

- The cross-sections $\sigma_{\rho+\omega}$ and σ_{ϕ} were extracted for the following systems: p-W, S-S, S-Cu, S-U and Pb-Pb.

- Cronin effect is observed, and from the power law A dependence of the cross-section a superproduction of ϕ is seen. $\alpha_{\rho+\omega} = 0.927 \pm 0.034$ and $\alpha_{\phi} = 1.226 \pm 0.030$.

- The ratio $\phi/(\rho+\omega)$ shows no dependence with p_T (or M_T) for none of the systems.

- The ratio increases with the centrality of the collisions, for all the systems. For Pb-Pb this increase is by a factor $\sim$ 2 .

- Resonance multiplicities per participant are measured only in Pb-Pb. For ϕ they increase with N_{part}, while for $\rho+\omega$ they remain constant.

- Inverse slopes obtained for $\rho+\omega$ and ϕ are the same, within the error bars. The parameter T increases for both resonances when going from proton to sulphur induced collisions. There seems to be a saturation already within the sulphur systems. T parameters obtained for Pb-Pb are slightly lower than the sulphur ones.