Charged and Neutral light meson pair production at PANDA

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Egle Tomasi-Gustafsson

CEA, IRFU, DPhN

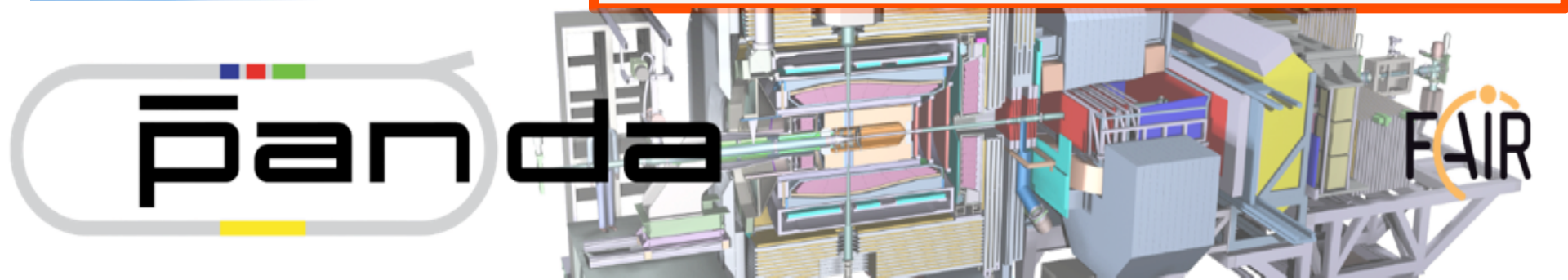
Université Paris-Saclay

France

Novosibirsk State University

*THE REAL SCIENCE

BINP



This work is object of WANG Ying PHD Thesis,
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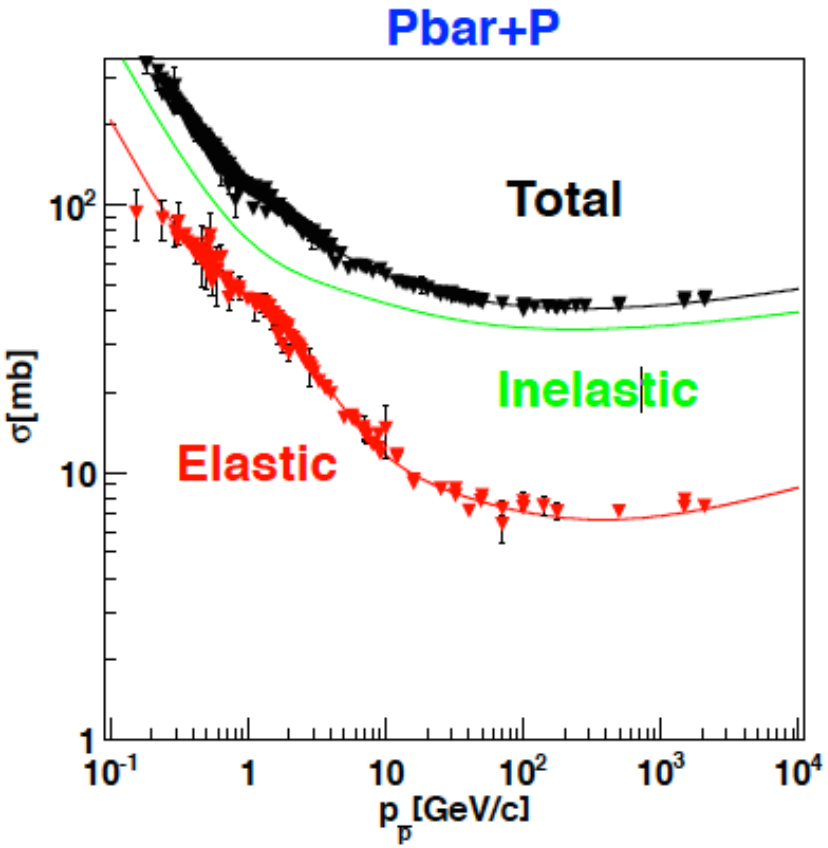
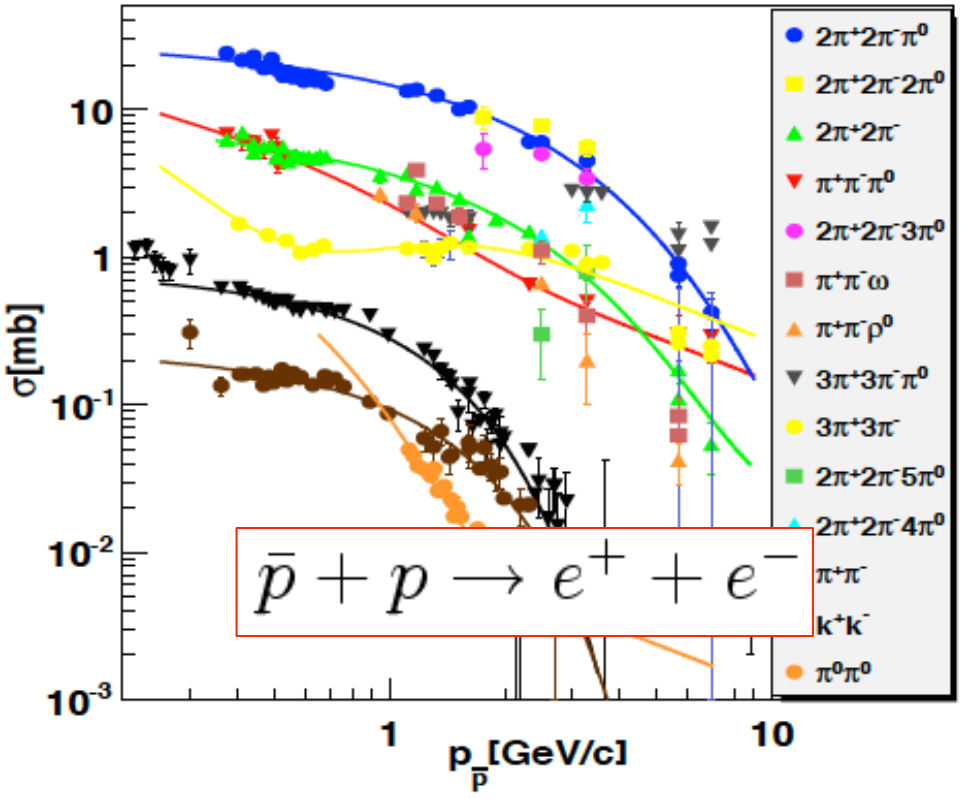
and it is published in:

Y. Wang, Yu. Bystritskiy, E.T-G,
PRC 95, 045202 (2017)

Y. Wang, Yu. Bystritskiy, A. Ahmadov, E.T-G,
PRC96, 025204 (2017)

Pbar p annihilation





5 pions at threshold

- two step production ρ,ω?
- statistical production
- dynamical QCD selection rules

Light meson pair production

1) Largest background for time-like form factor measurements

$$\bar{p} + p \rightarrow e^+ + e^-$$

2) Test of QCD dynamics: scaling ?
Large angle scattering

3) Pair particle production: signature of QGP?

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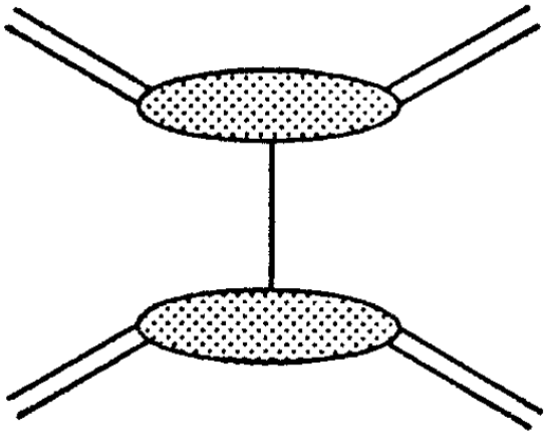
Volume 815, Issues 1–4, 1 January 2009, Pages 67-88

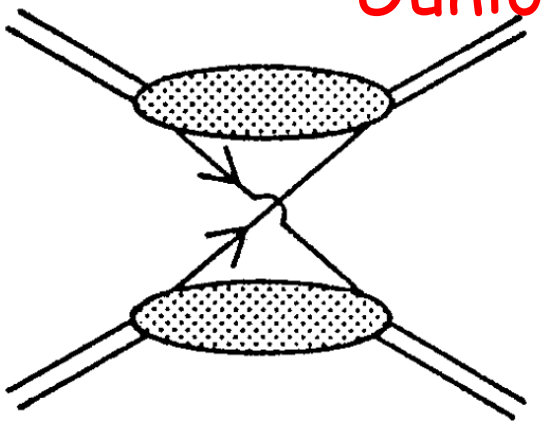
High strangeness production in antiproton annihilation at rest on few nucleon systems as a possible signature of quark deconfinement or QGP occurrence

G. Bendiscioli [a, b], T. Bressani [c], L. Lavezzi [a], A. Panzarasa [a, b], P. Salvini [b]

Constituent interchange model

Gunion 1973





$$B(\bar{p}p \to \pi^- \pi^+) \cong -\frac{N_B}{s^2}\left(\frac{\alpha}{t^2} + \frac{\beta}{u^2}\right)$$

$$s^2 \frac{d\sigma}{dt}(\bar{p}p \to \pi^- \pi^+) = \frac{\sigma_0(1-z^2)}{2s^6}\left[\alpha(1-z)^{-2} + \beta(1+z)^{-2}\right]^2$$

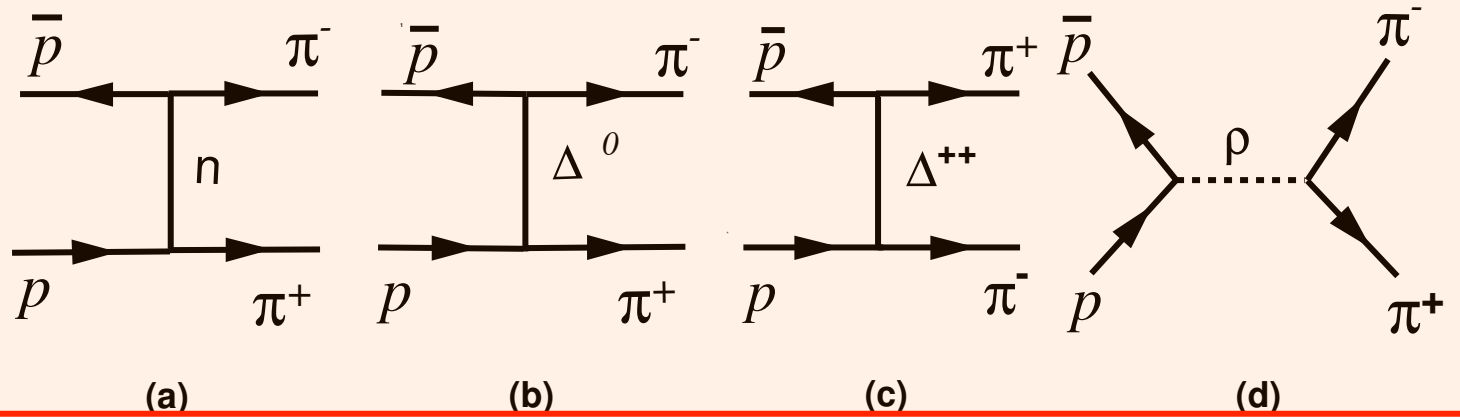
$\sigma \sim s^{-8}$

$z = \cos\theta$

Large angle scattering

Effective Lagrangian Model for $\pi^+ + \pi^-$

$$\mathcal{M} = \mathcal{M}_n + \mathcal{M}_{\Delta^0} + \mathcal{M}_{\Delta^{++}} + \mathcal{M}_\rho .$$

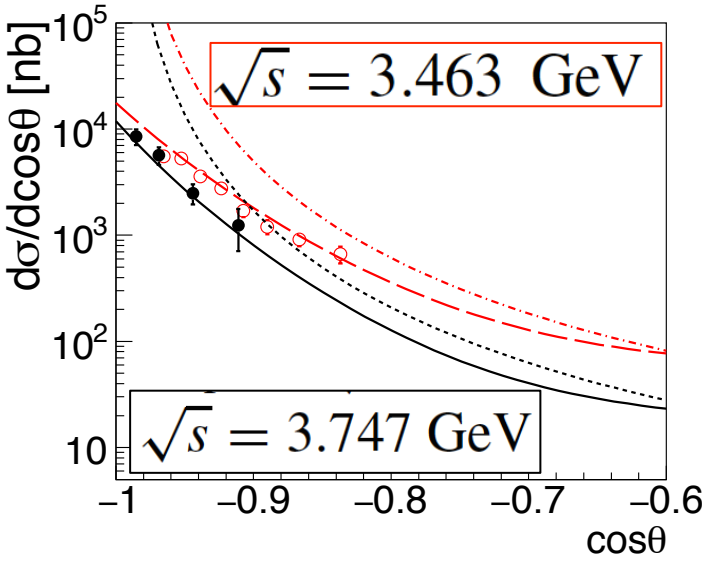


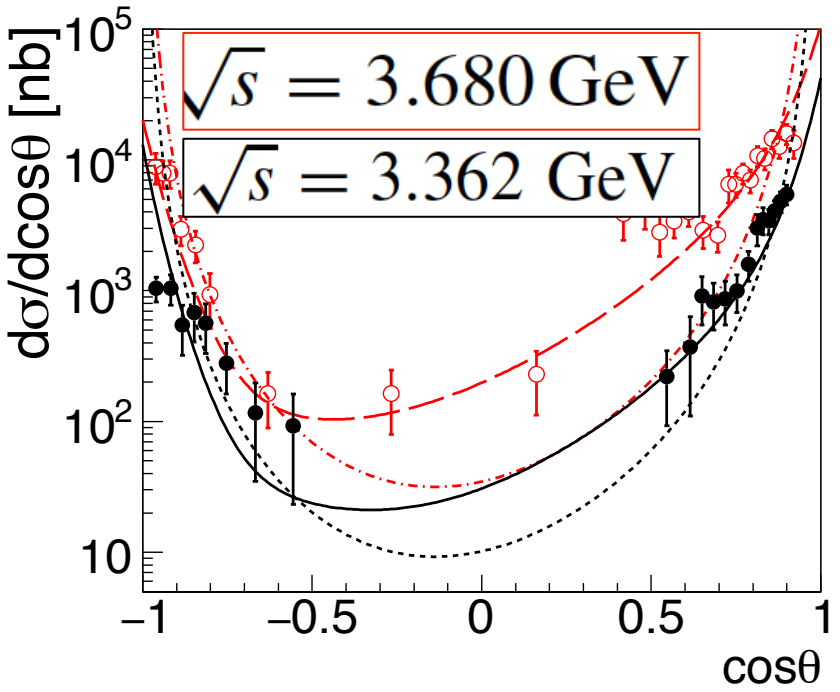
$$F_{N,\Delta}(x) = \frac{\mathcal{N}_{N,\Delta} M_0^4}{\left[\left(x - \Lambda^2_{N,\Delta}\right) \log \frac{(x-\Lambda^2_{N,\Delta})}{\Lambda^2_{\mathrm{QCD}}}\right]^2}, \quad x = s,t,u$$

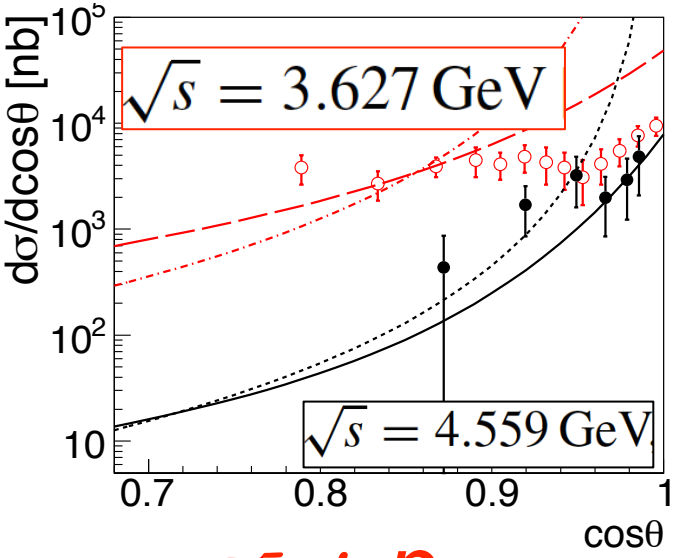
$$\widetilde{F}_{N,\Delta}(s,t) = F_{N,\Delta}(s) F_{N,\Delta}(t)$$

- Composite nature of the particles
- Resonance in intermediate state (pre-Regge regime)

Results for $\pi^+ + \pi^-$: angular distributions





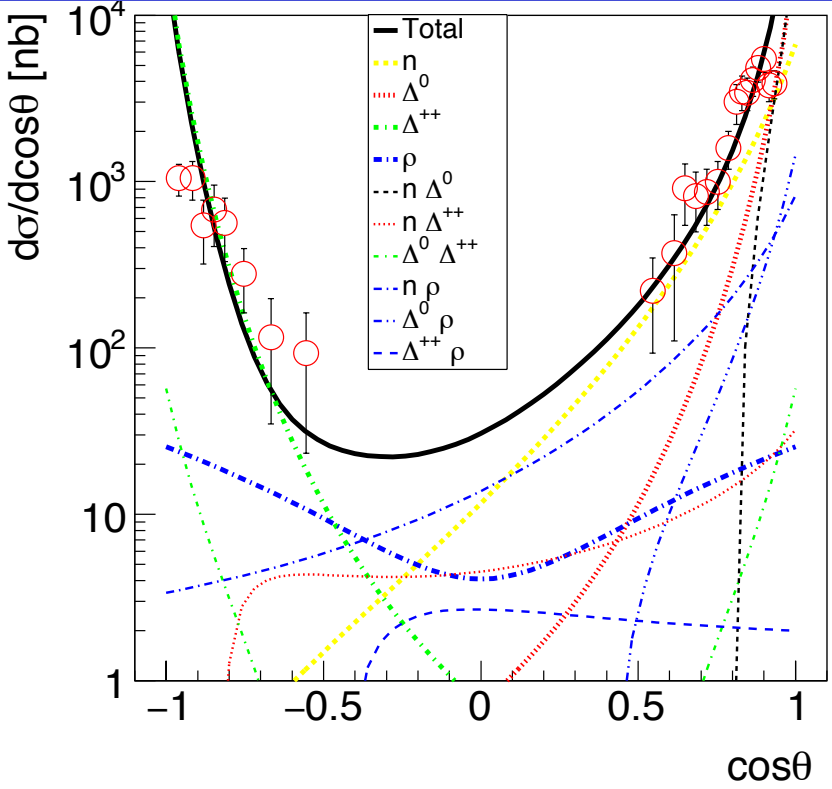


$\pi^- + p$

Constituent interchange ------
(Gunion 1973) .....

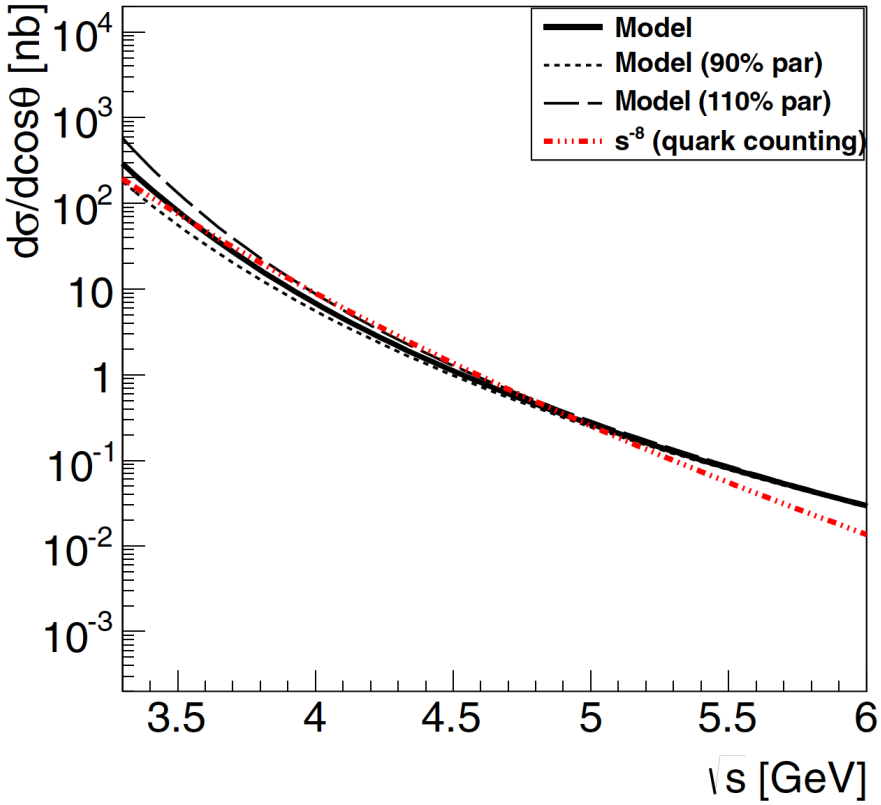
This work ———
(Wang 2017) .....

Results for $\pi^+ + \pi^-$



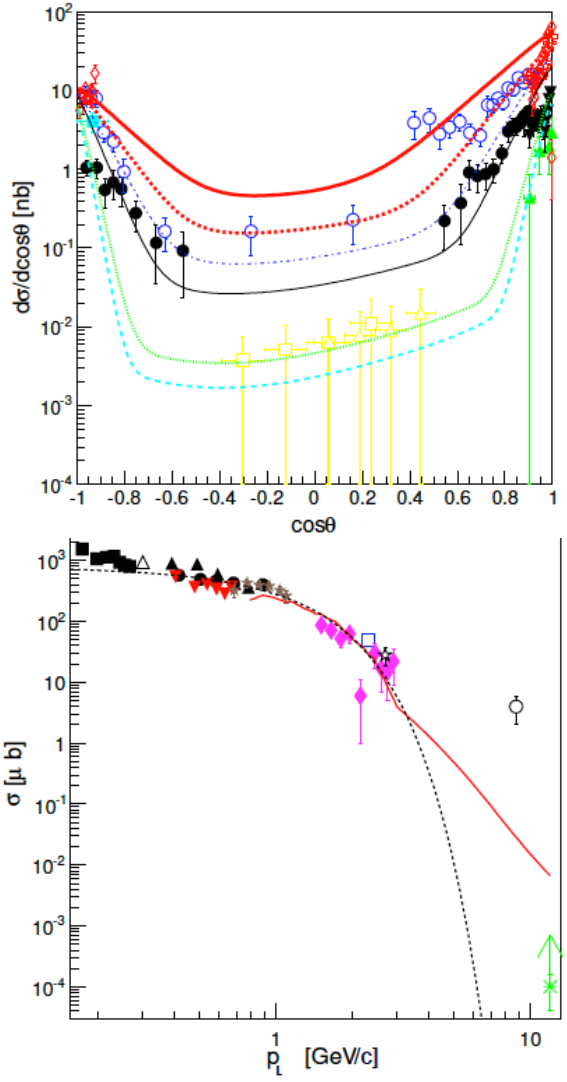
$$F_{N,\Delta}(x) = \frac{\mathcal{N}_{N,\Delta} M_0^4}{\left[\left(x - \Lambda^2_{N,\Delta}\right) \log \frac{(x-\Lambda^2_{N,\Delta})}{\Lambda^2_{\mathrm{QCD}}}\right]^2},$$

Parameter	Value
$\mathcal{N}_p$	0.361 ± 0.006
$\mathcal{N}_\Delta$	0.041 ± 0.003
Λ^2_p	2.25 ± 0.09
Λ^2_Δ	1.05 ± 0.04



Results for $\pi^+ + \pi^-$: total cross section

PandaRoot (generator Mainz)
Orsay model

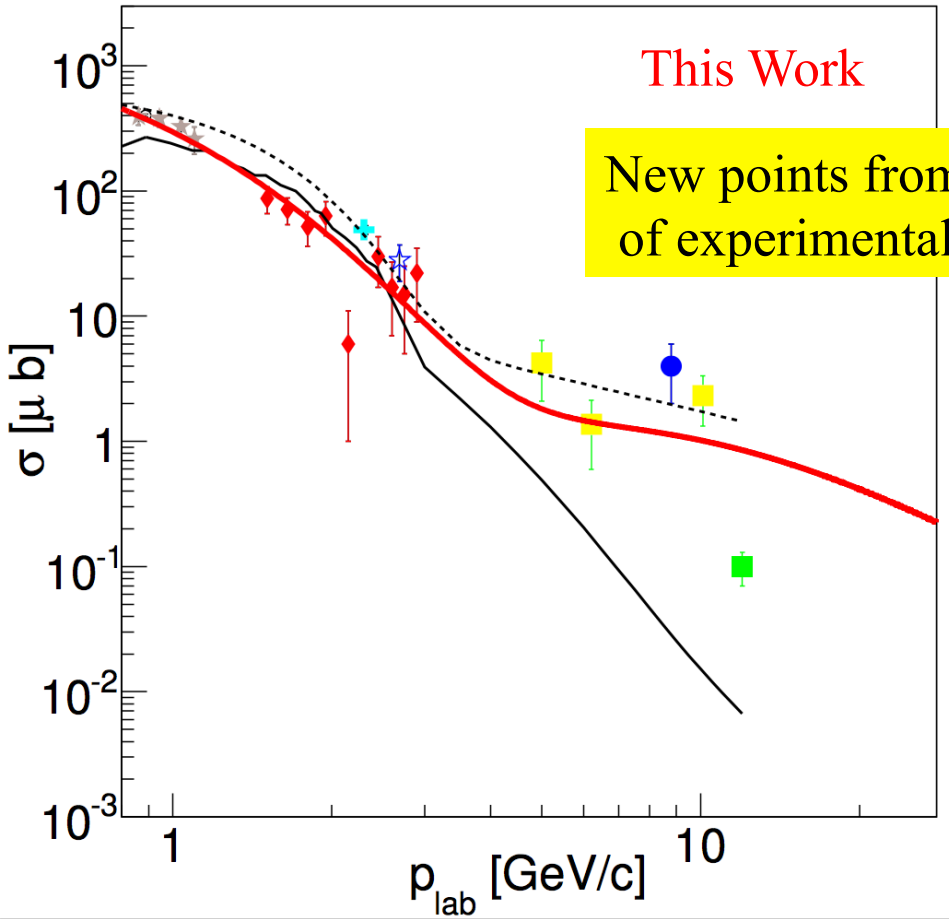


$$\sigma = a \cdot e^{-(b \cdot p_{lab} + c \cdot p_{lab}^2 + d)} + \frac{e}{p_{lab}}$$

A. Dbeyssi (PhD) modified

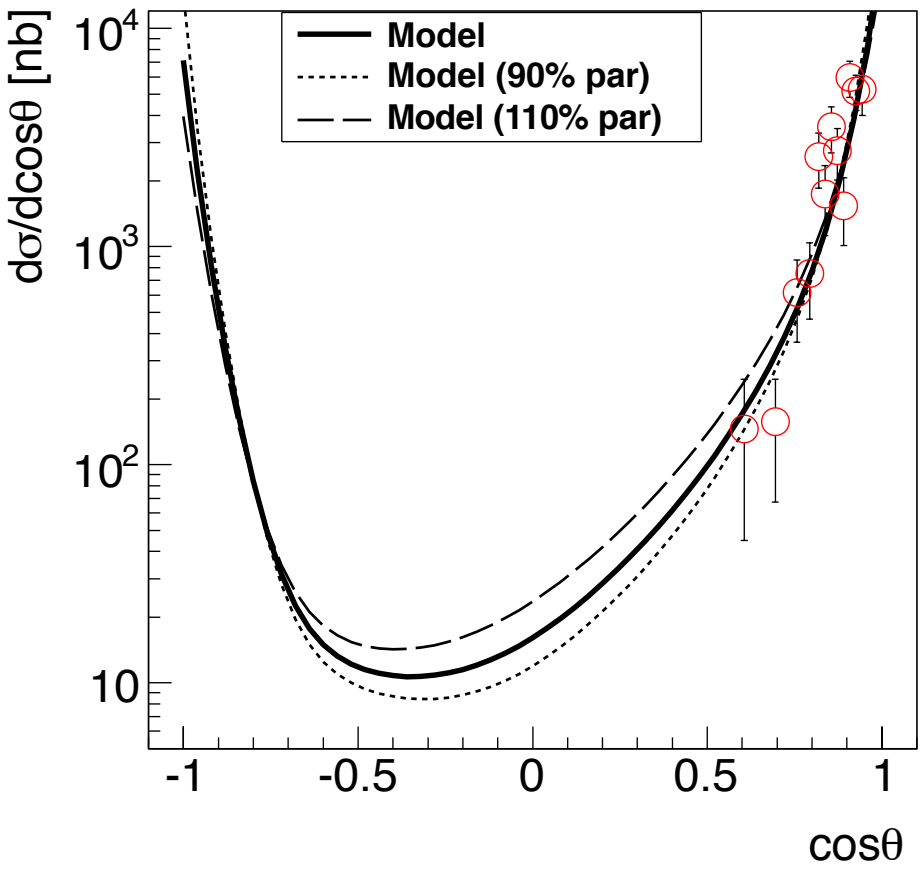
This Work

New points from integration of experimental data



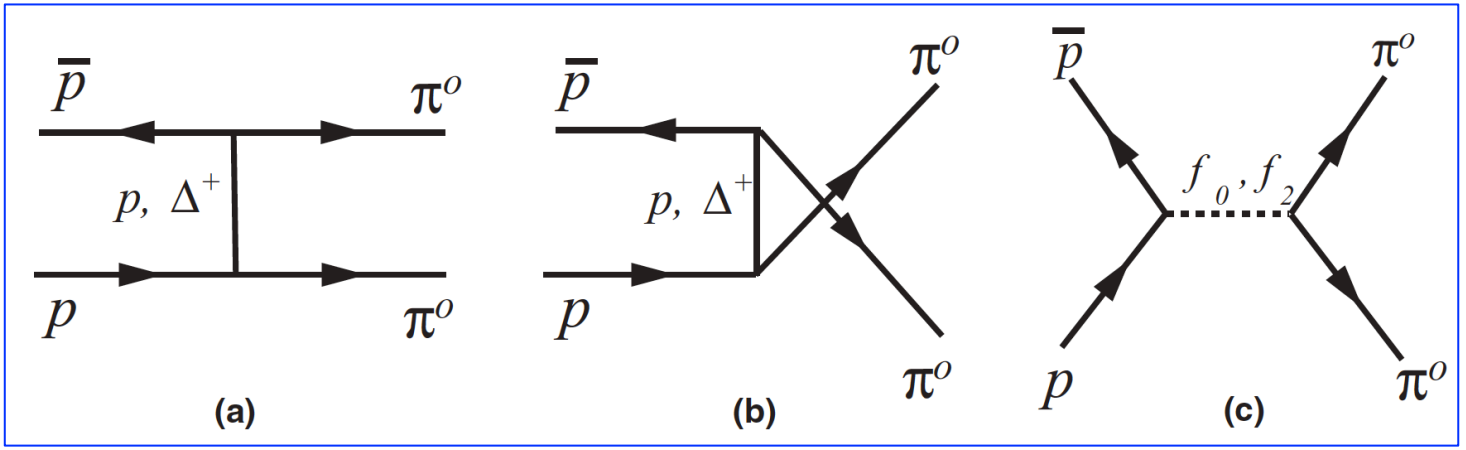
Results for $K^+ + K^-$: SU(3)

$$\sigma(\pi^-\pi^+) : \sigma(K^-K^+) = 1 : \frac{4\lambda}{3}, \quad \text{where } \lambda = 0.4.$$



$\sigma_{Tot}(3.680\ \text{GeV}) = 2.1 \pm 0.8\ \text{mb}$

Model for $\pi^0 + \pi^0$



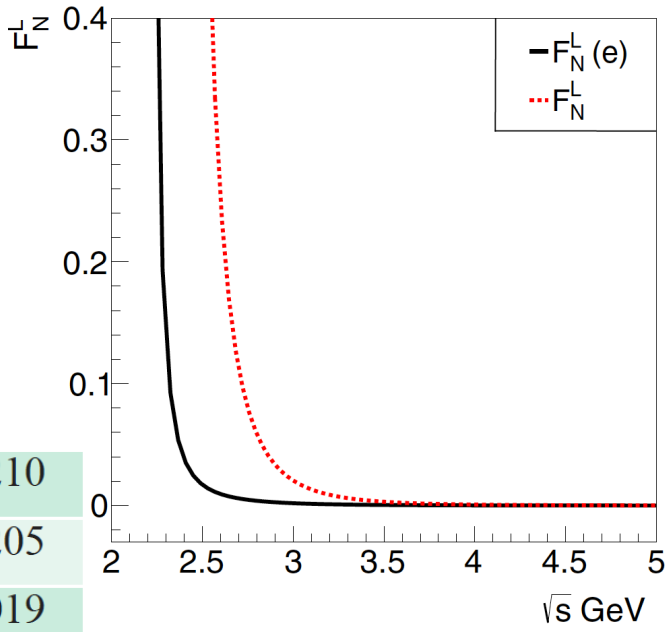
$$F^L_{N,\Delta}(x) = \frac{\mathcal{N}_{N,\Delta}\ M_0^4}{\left[\left(x - \Lambda^2_{N,\Delta}\right)\ln\frac{(x-\Lambda^2_{N,\Delta})}{\Lambda^2_{\rm QCD}}\right]^2}, \quad x = s,t,u,$$

$$M_0 = 3.86\ \text{GeV}, \quad \Lambda_{\rm QCD} = 0.3\ \text{GeV},$$

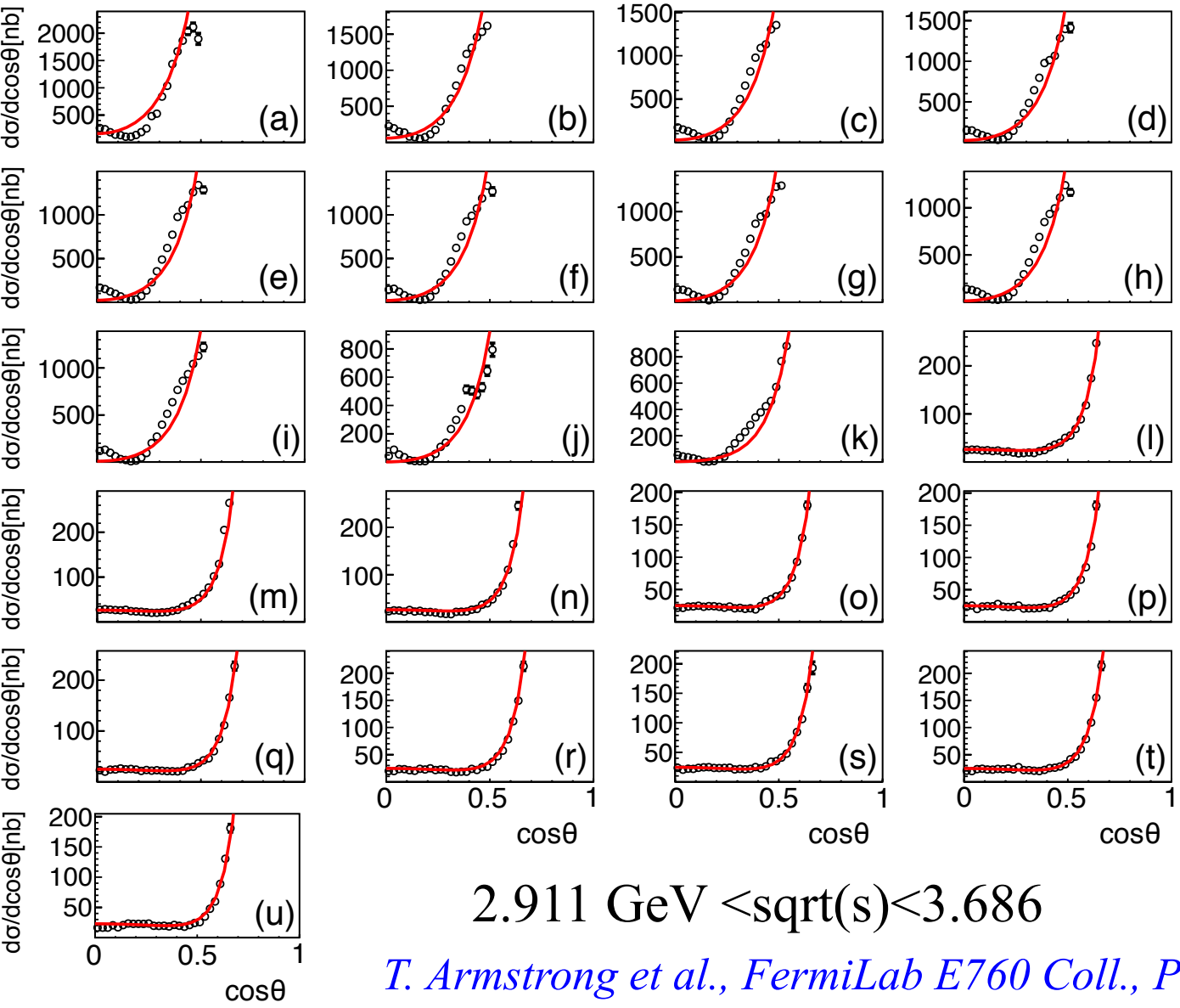
$$\mathcal{N}(s)_{p,\Delta} \rightarrow \mathcal{N}(s)_{p,\Delta} - e^{\frac{p^{\mathcal{N}}_{p,\Delta}(s)}{\sqrt{s}}},$$

$$\Lambda(s)^2_{p,\Delta} \rightarrow \Lambda(s)^2_{p,\Delta} - e^{\frac{p^{\Lambda}_{p,\Delta}(s)}{\sqrt{s}}}$$

$p^{\mathcal{N}}(N)$	-3,013	0,210
$p^{\mathcal{N}}(\Delta)$	-5,959	0,205
$p^{\Lambda}(N)$	4,047	0,019
$p^{\Lambda}(\Delta)$	3,141	0,002



Results for $\pi^0 + \pi^0$

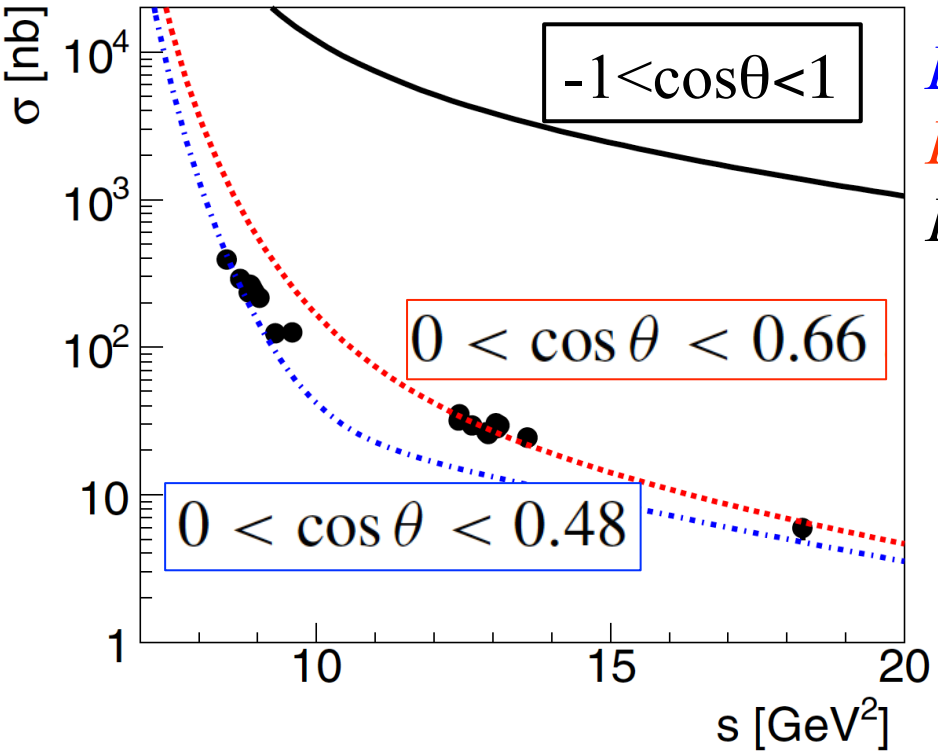


Bump at 90°

2.911 GeV <sqrt(s)<3.686

T. Armstrong et al., FermiLab E760 Coll., PRD 56, 2509 (1997)

Results for $\pi^0 + \pi^0$: integral cross section

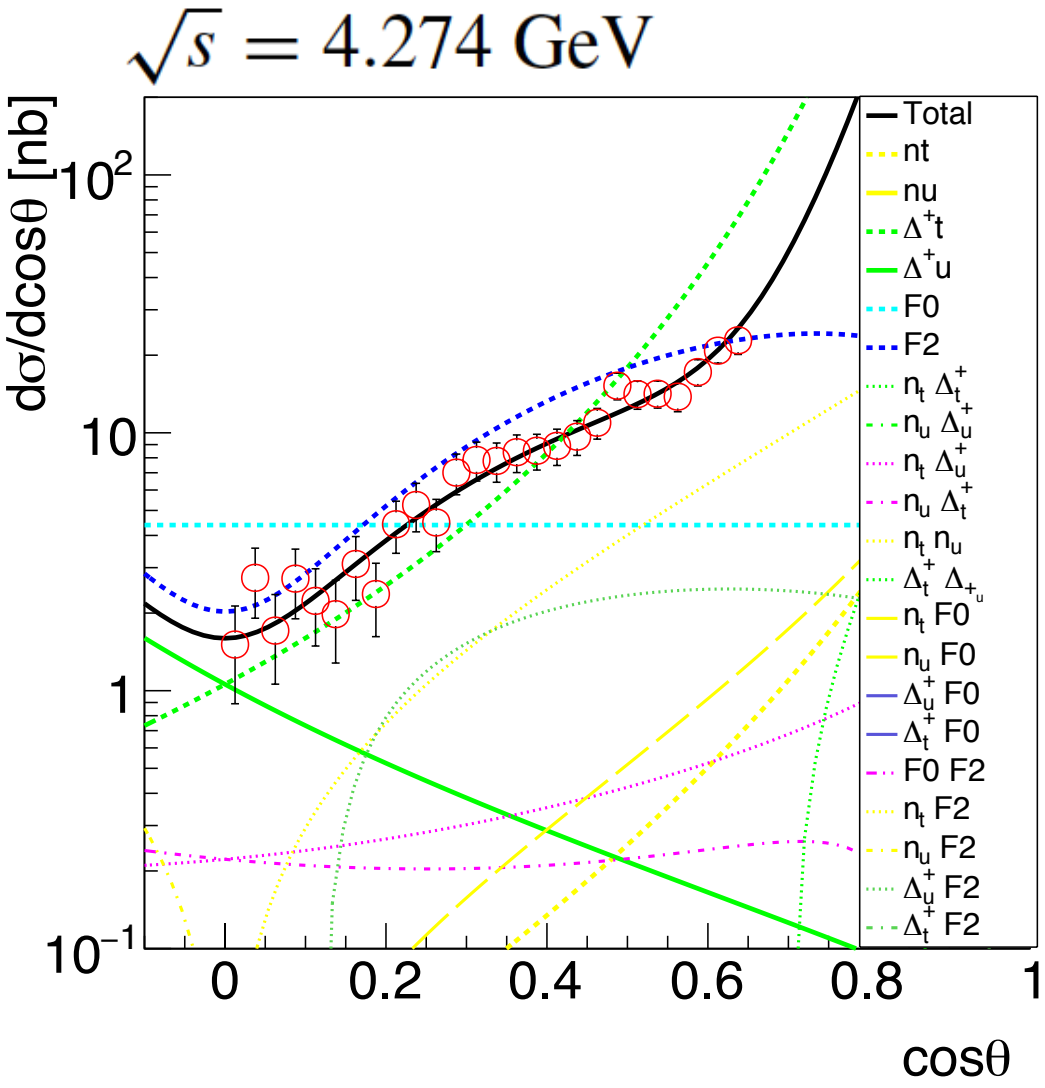


Low energy set

High energy set

Prediction for the total cross section

High energy set: $\pi^0 + \pi^0$



F_{f0}	0,870	0,014
F_{f2}	0,187	0,001
$\chi 2$/ndf	0,787	

F_0 meson

F_2 meson

From π^0 to η with SU(3) symmetry

η and π belong to the same pseudoscalar multiplet

$$\eta \approx (u\bar{u} + d\bar{d})/\sqrt{2} + s\bar{s}$$

$(u\bar{u} + d\bar{d})\sqrt{2}$

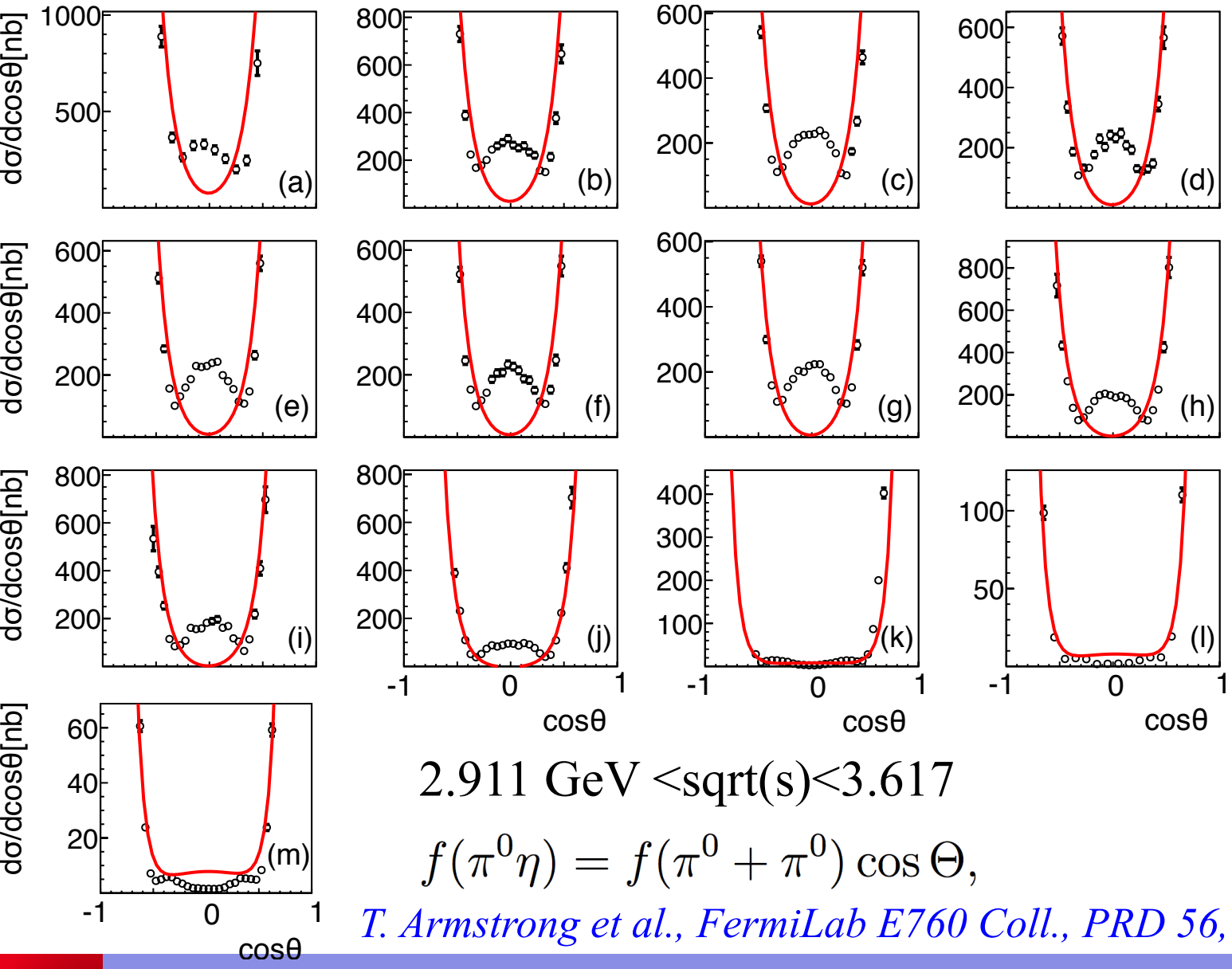
$$|q\bar{q}> = \cos\Theta|\eta> + \sin\Theta|\eta'>$$

$$|s\bar{s}> = -\sin\Theta|\eta> + \cos\Theta|\eta'>$$

Mixing angle Θ=45°

$$f(\pi^0\eta) = f(\pi^0 + \pi^0)\cos\Theta, \quad f(\eta\eta) = f(\pi^0 + \pi^0)\cos^2\Theta$$

Results for $\pi^0 + \eta$

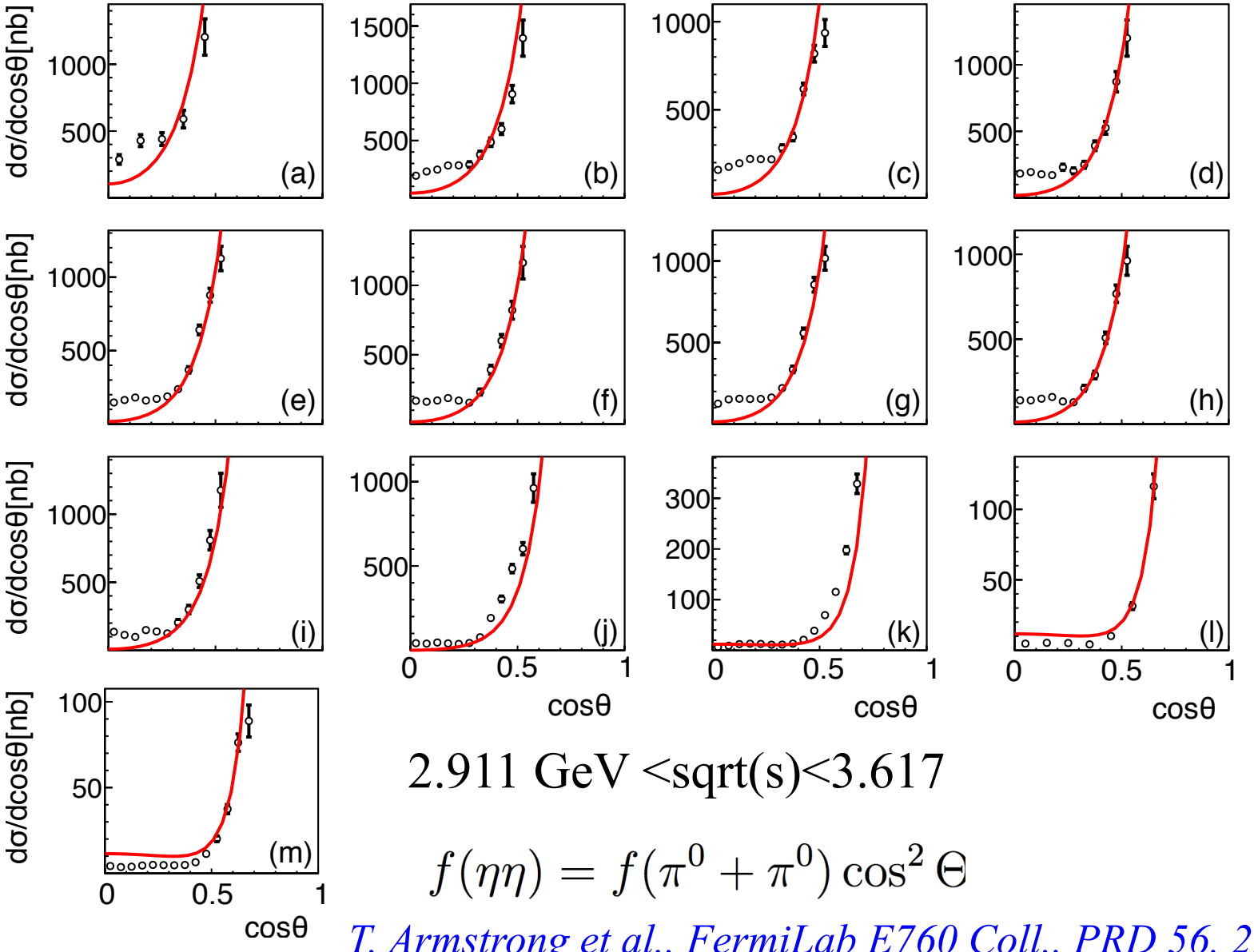


2.911 GeV <sqrt(s)<3.617

$$f(\pi^0\eta) = f(\pi^0 + \pi^0)\cos\Theta,$$

T. Armstrong et al., FermiLab E760 Coll., PRD 56, 2509 (1997)

Results for $\eta + \eta$



2.911 GeV <sqrt(s)<3.617

$$f(\eta\eta) = f(\pi^0 + \pi^0)\cos^2\Theta$$

T. Armstrong et al., FermiLab E760 Coll., PRD 56, 2509 (1997)

Conclusions

- We built a realistic model to calculate energy and angular dependence of the cross section for pbar p annihilation into light meson pairs
  - reproduce all existing data
  - solid predictions for PANDA kinematical range
  - useful for MonteCarlo
  - background calculations

Logarithmic form factors:
hint from matter creation from vacuum?

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