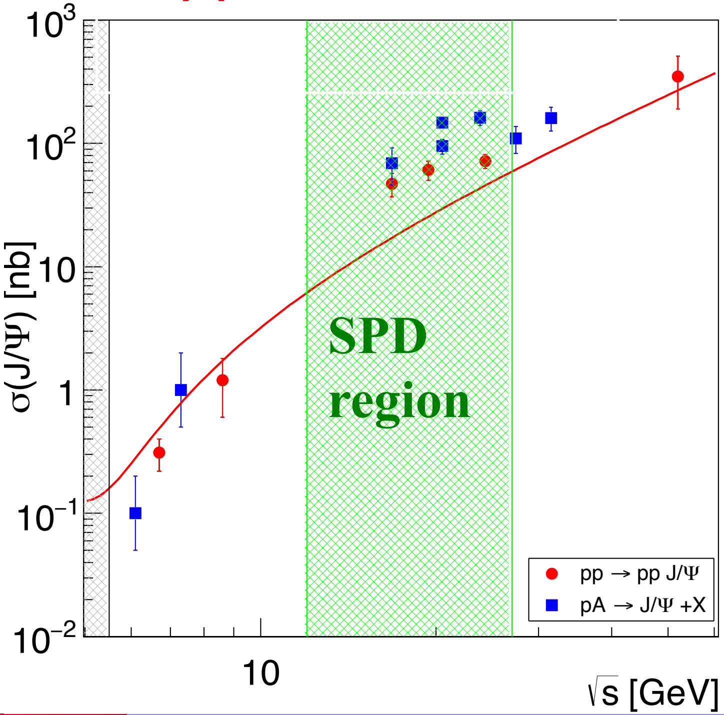
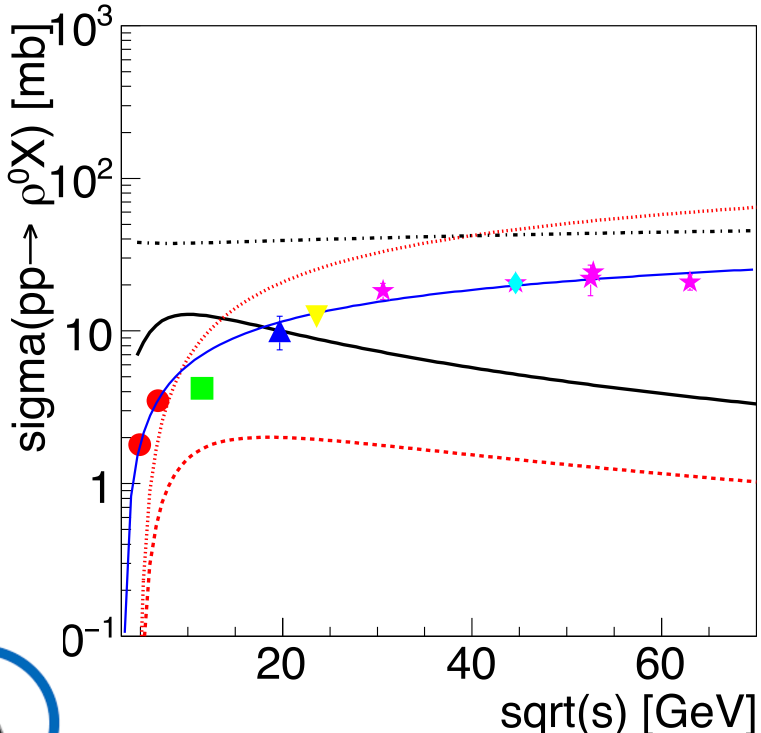
Suggestions for NICA-SPD physics

J/Ψ production
in *pp* collisions



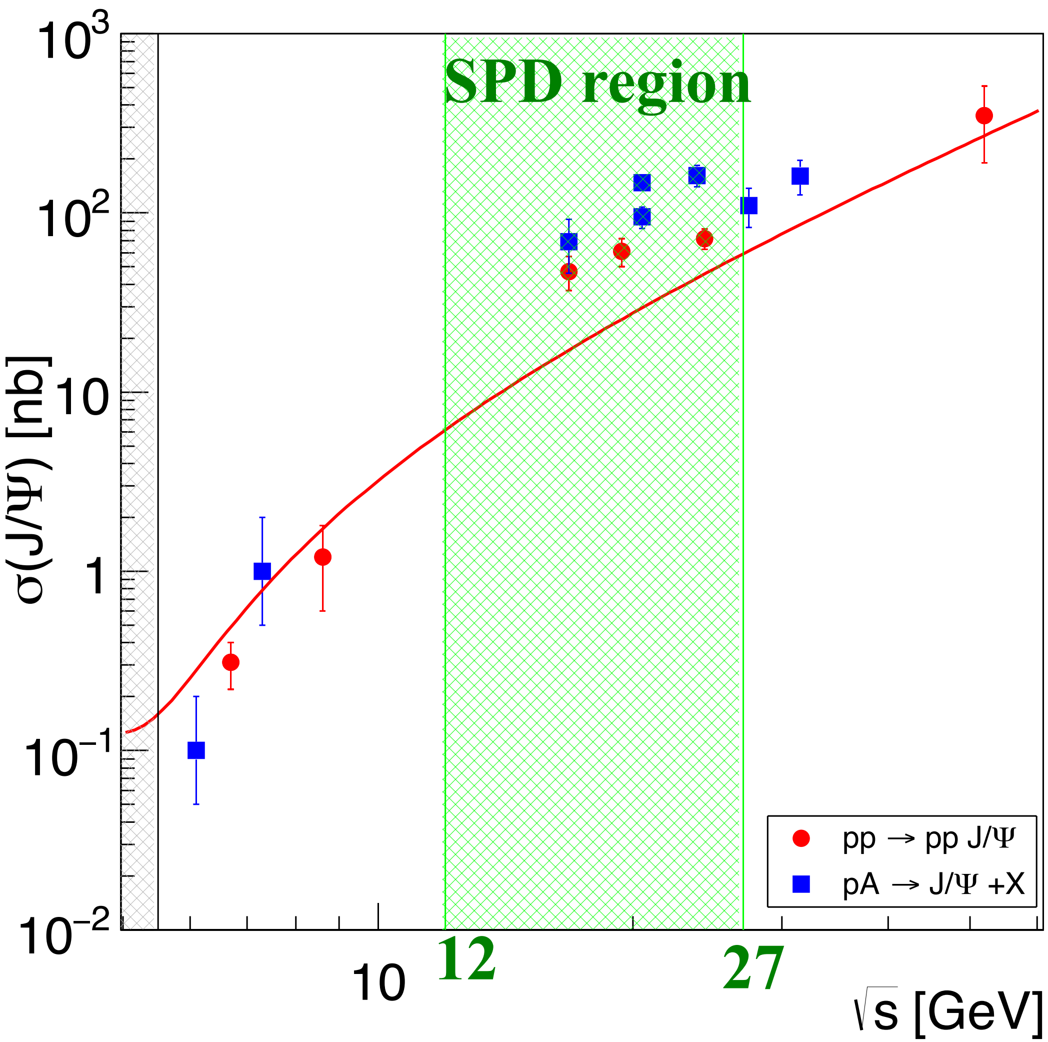
JOINT INSTITUTE FOR NUCLEAR RESEARCH

NICA



Backward vector meson
production
and possibility of
neutron beams

J/Ψ production



R. Vogt. Phys. Rept., 310, 197 (1999).

1) Hard process at parton level
2) Formation of $c\bar{c}$ pairs (not pre-existing in the proton)
3) Hadronization of cc pairs into J/Ψ
4) FSI

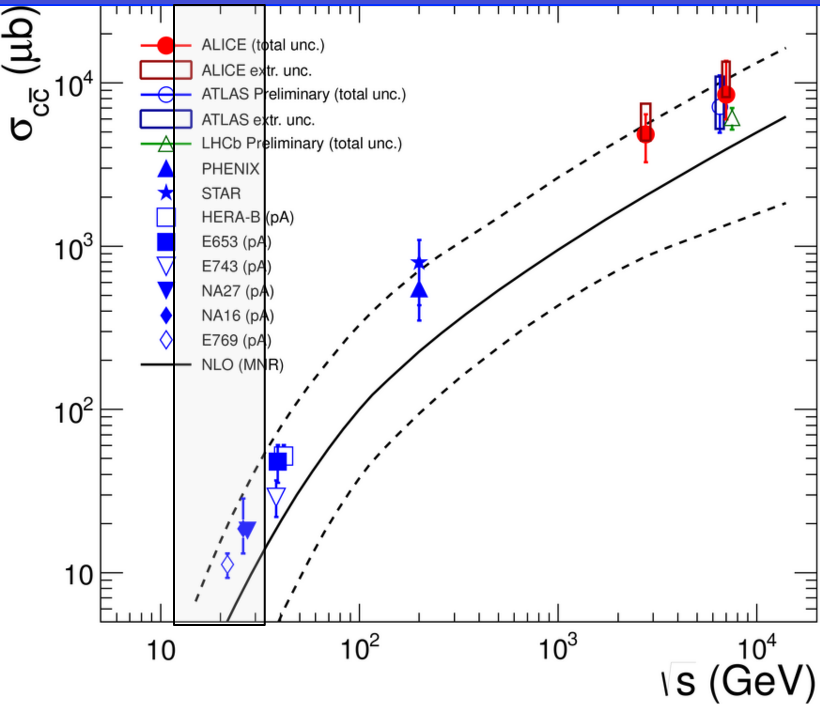
1) Effective proton size: $r_c \approx 1/m_c$
2) Large isotopic effects :

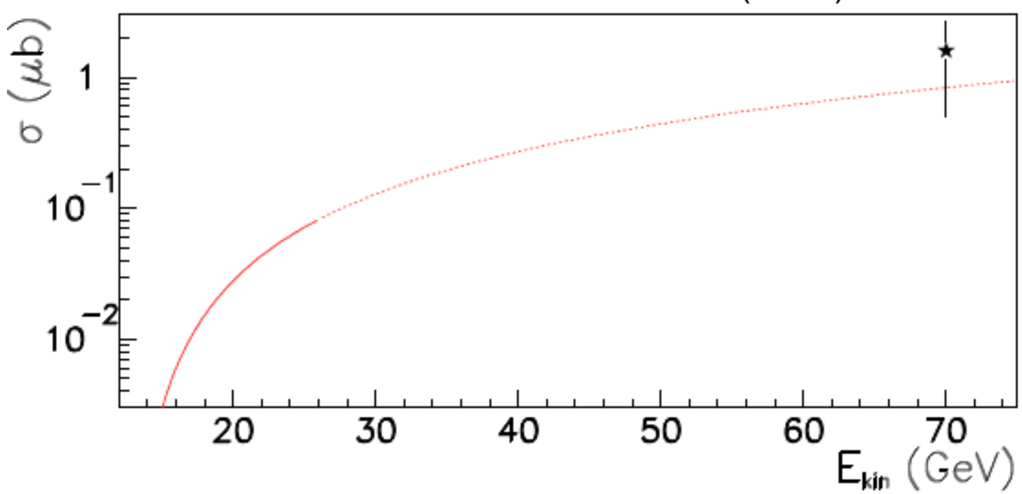
$$\sigma_{np} >> \sigma_{pp}$$

3) Polarization phenomena

M.P. Rekalo, E.T.-G.. New J. Phys., 4,68(2002).

Open Charm: $N+N \to N+\overline{D}+\Lambda_c\ (\Sigma_c)$

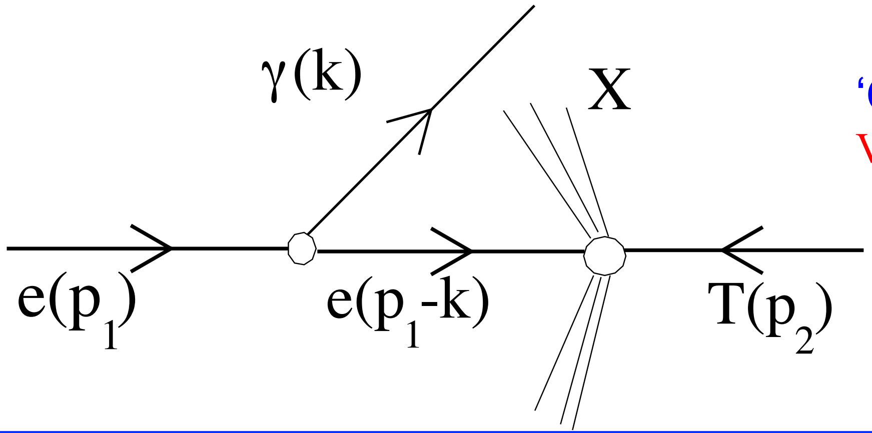




- Cross sections ≈ μb
- Dynamics of charm creation in NN, NA, AA-collisions
- Spin and isospin effects
- Analogy with strangeness production: interaction
  $N\Lambda_s$ $N\Lambda_c$
- Information on
  - -scattering length,
  - -effective radius,
  - -hadronic form factors …

M.P. Rekalo, E.T.-G.. Eur. Phys. J. A16, 575 (2003).

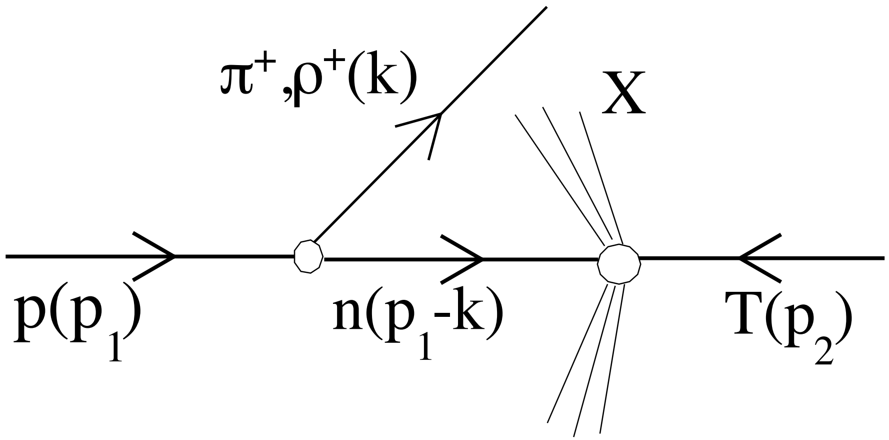
Backward light meson in pp or pA



'Quasi real electron method'

V.N. Baier, V. S. Fadin, V.M. Katkov (1973)

Extension of the *QED quasi real electron method* mechanism to light meson emission in pp or pA collisions

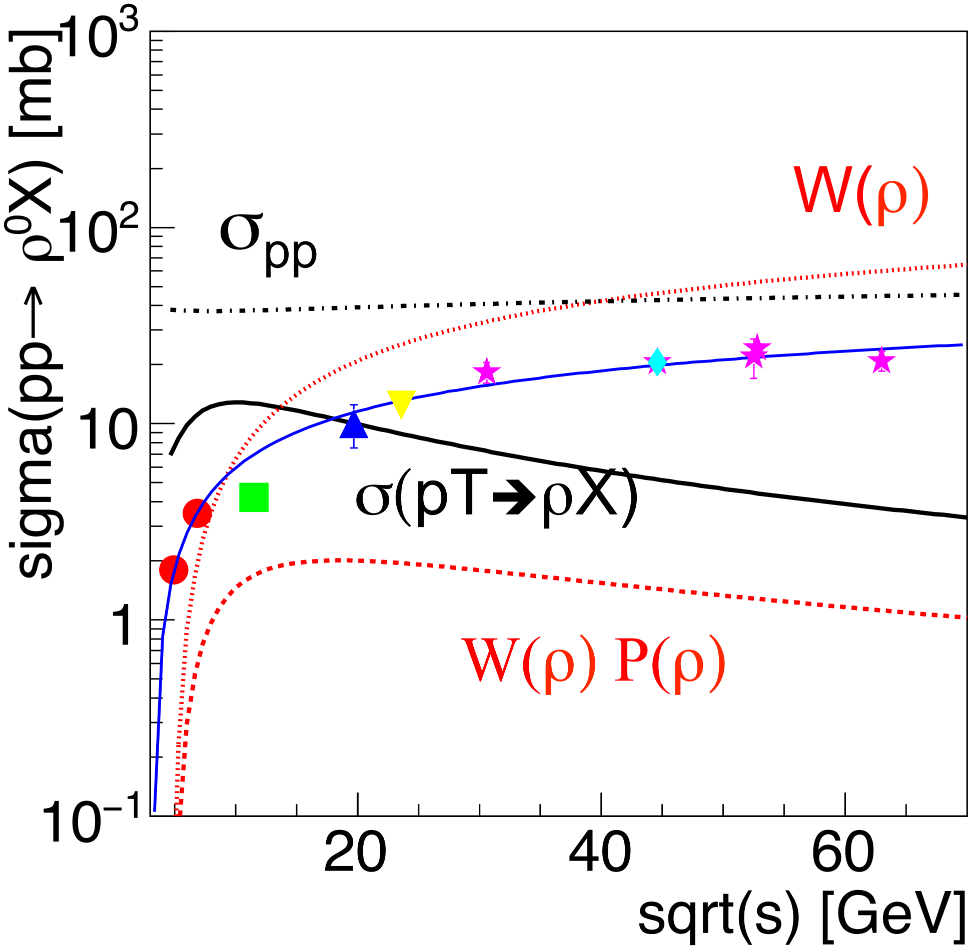


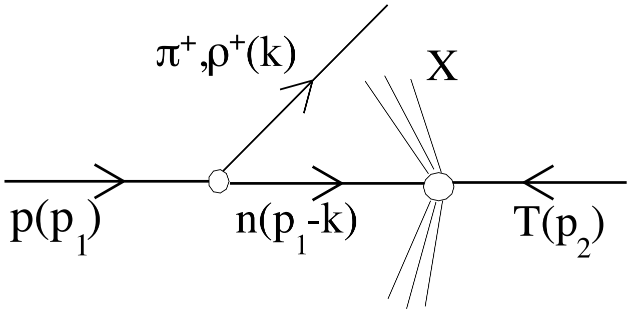
- Collinear emission probability has logarithmic enhancement
- Factorization of the cross section

Production of neutron beams?

E.A. Kuraev et al., Phys. Elem. Part and At. Nuclei 12 (2015) 1

Producing a neutron beam?





From the factorization hypothesis

$$\sigma^{nT\to X}(\bar{x}s) = \frac{d\sigma^{pT\to h^+X}/dx}{dW_+(x)/dx}$$

$\sigma(s) = 0.38 \log^2(s^2) - 2.1$

M.G. Albrow et al., Nuclear Physics B155 (1979) 39-51

Polarimetry of high energy proton beams

PHYSICAL REVIEW C **84**, 015212 (2011)

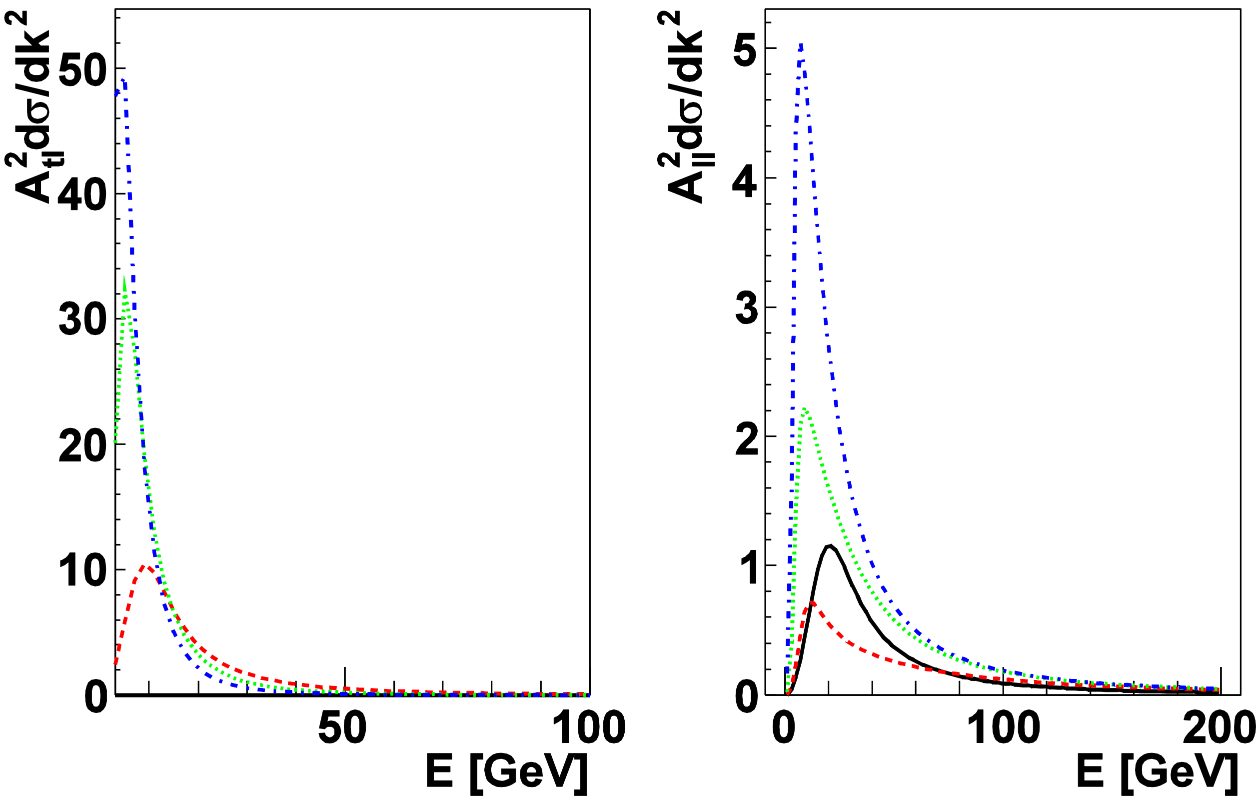
Polarization effects in elastic proton-electron scattering

G. I. Gakh,[1] A. Dbeyssi,[2] D. Marchand,[2] E. Tomasi-Gustafsson,[2,*] and V. V. Bytev[3]

Figure of Merit

$$\mathcal{F}^2(\theta_p) = \epsilon(\theta_p) A_{ij}^2(\theta_p), \quad \epsilon(\theta_p) = N_f(\theta_p)/N_i$$

$$\left(\frac{\Delta P(\theta_p)}{P}\right)^2 = \frac{2}{N_i(\theta_p)\mathcal{F}^2(\theta_p)P^2} = \frac{2}{Lt_m(d\sigma/d\Omega)d\Omega A_{ij}^2(\theta_p)P^2},$$



$\vec{p} + \vec{e} \to p + e$

$\theta_e = 30$ mrad

$\theta_e = 10$ mrad

$\theta_e = 0$

$\theta_e = 50$ mrad

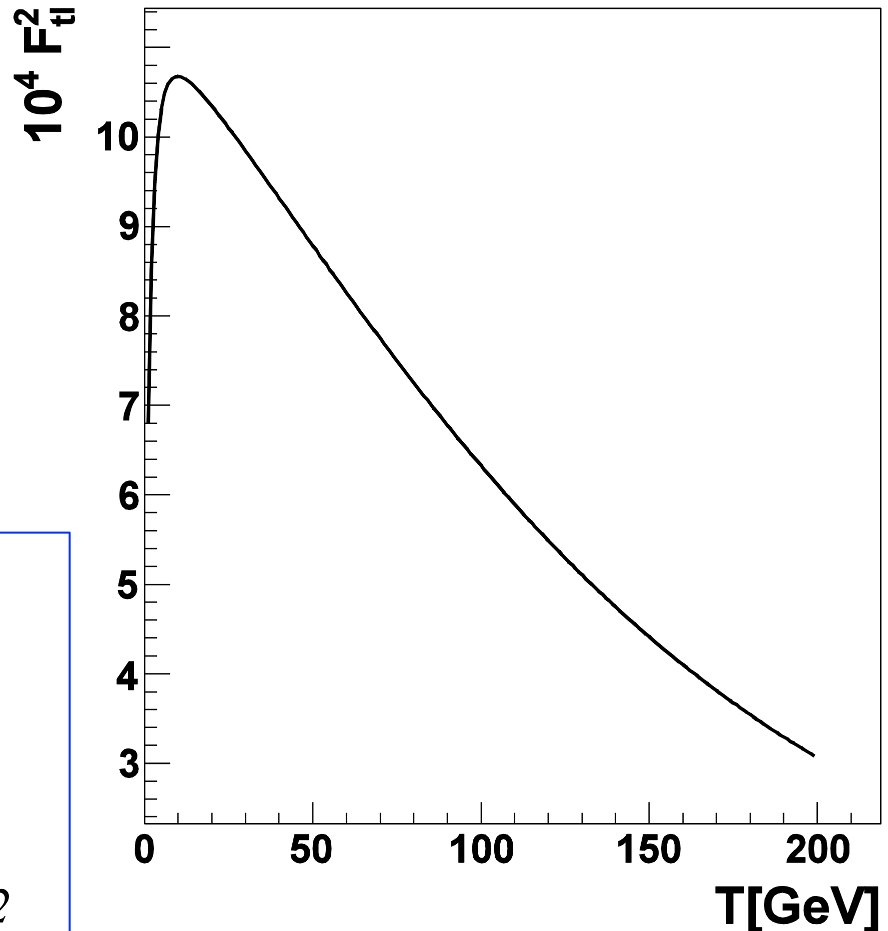
Polarimetry

Polarized beam on polarized target

$$F^2 = \int \frac{d\sigma}{dk^2} A_{ij}^2(k^2)\mathrm{d}k^2$$

F^2 Max at $E \sim 10$ GeV
$L = 10^{32}$ cm^{-2}s^{-1}

N beam $= 6 \times 10^{17}$ p s^{-1}
N target $= 2 \times 10^{14}$ atomes/cm^2
$\Delta P = 1\%$ in $t = 3$m



$N+N \to N+N+V,\ V=\rho,\omega,\phi,\ J/\Psi\ldots$

General Considerations for threshold production
(the threshold region may be quite wide : $q < m_c$)

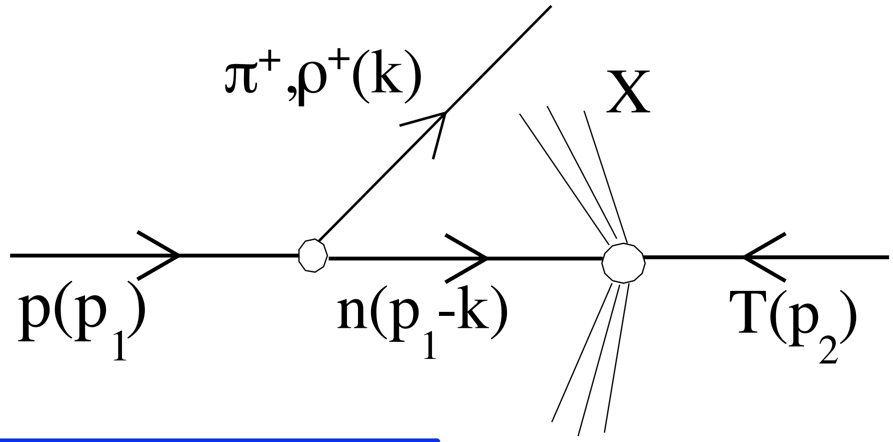
$$S_i = 1,\ \ell_i = 1\ \to\ j^P = 1^- \to S_f = 0,$$
$$\mathcal{M}(\mathrm{pp}) = 2 f_{10} [\tilde{\chi}_2 \sigma_y \vec{\sigma} \cdot (\vec{U}^* \times \hat{\vec{k}}) \chi_1]\,(\chi_4^\dagger \sigma_y\, \tilde{\chi}_3^\dagger),$$

$$S_i = 1, \ell_i = 1 \to j^P = 1^- \to S_f = 0,$$
$$S_i = 0, \ell_i = 1 \to j^P = 1^- \to S_f = 1,$$
$$\mathcal{M}(\mathrm{np}) = f_{10}[\tilde{\chi}_2 \sigma_y \vec{\sigma} \cdot (\vec{U}^* \times \hat{\vec{k}}) \chi_1](\chi_4^\dagger \sigma_y\, \tilde{\chi}_3^\dagger) + f_{01}(\tilde{\chi}_2\, \sigma_y \chi_1)[\chi_4^\dagger \vec{\sigma} \cdot (\vec{U}^* \times \hat{\vec{k}}) \sigma_y \tilde{\chi}_3^\dagger],$$

The dynamical information is contained in the amplitudes that are different for the different vector mesons

M.P. Rekalo, E.T.-G.. New J. Phys., 4,68(2002).

p+T → n+T+ h^+



The matrix element:

$$\mathcal{M}^{pT}_{h_+}(p_1,p_2)) = \mathcal{M}_{nT}(p_1-k,p_2)\mathcal{T}^{pn}_{h_+}(p_1,p_1-k),$$

The matrix element for the subprocess :

$$\mathcal{T}^{pn}_{\pi}(p_1,p_1-k) = \frac{g}{m_h^2-2p_1k}\bar{u}_n(p_1-k)\gamma_5 u_p(p_1),$$

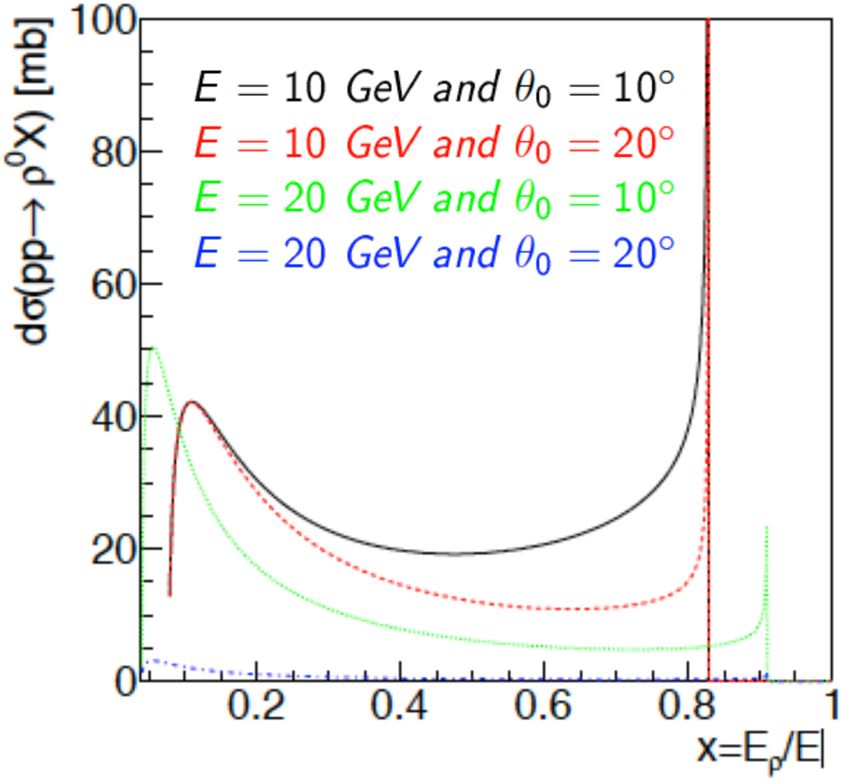
$$\mathcal{T}^{pn}_{\rho}(p_1,p_1-k) = \frac{g}{m_h^2-2p_1k}\bar{u}_n(p_1-k)\hat{\epsilon} u_p(p_1),$$

p → n+π

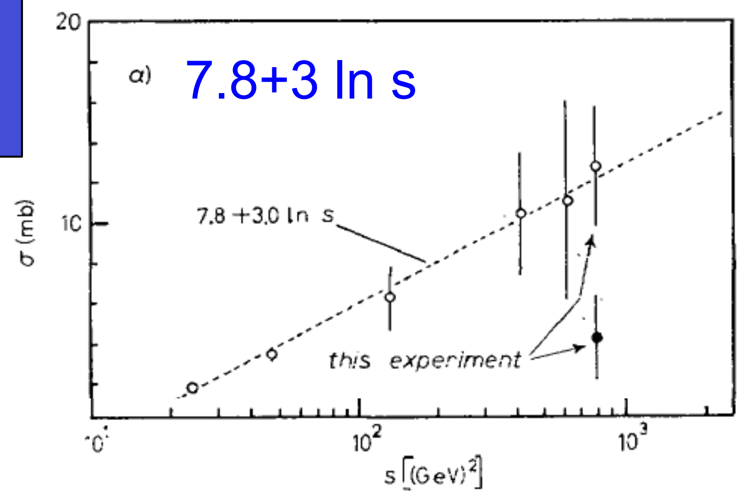
p → n+ρ

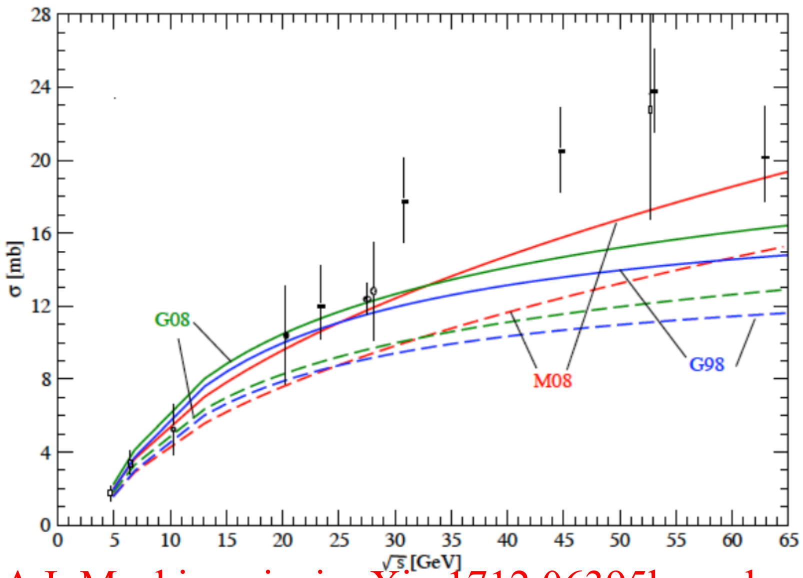
Two pion production from $pp \to \rho^0 X$

$$d\sigma^{p\bar{p}\to\rho^0 X} = 2\frac{dW_\rho(x)}{dx}\sigma^{p\bar{p}\to\rho^0 X}(\bar{x}s)\times P_\rho,$$



A. Suzuki et al., Lett. N. Cim. 24,13 (1979)





A.I. Machiavariani arXiv:1712.06395hep-ph