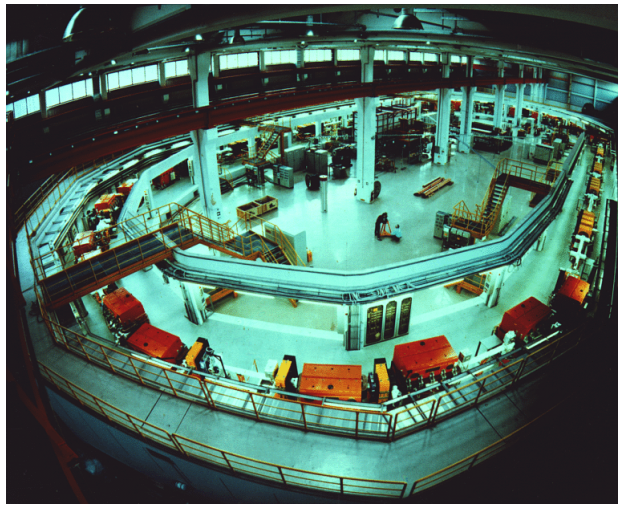
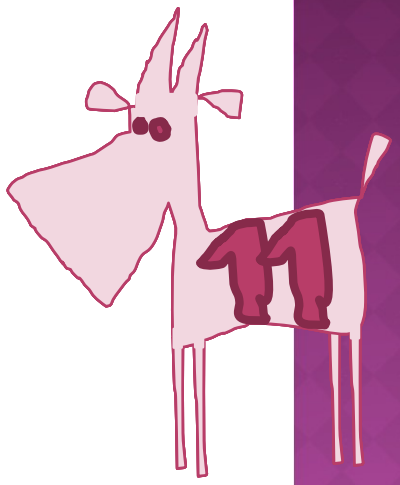
Isospin dependence of the η' meson production in nucleon-nucleon collisions

Joanna Przerwa for the COSY-11 collaboration

Jagellonian University & FZ - Juelich





motivation
experimental setup
analysis of the data
summary

mesons η and η′:

$$\eta = \cos\theta \cdot \eta_8 - \sin\theta \cdot \eta_1$$
$$\eta' = \sin\theta \cdot \eta_8 + \cos\theta \cdot \eta_1$$

mixing angle θ = -15.5°

$$\eta = 0.77 \frac{1}{\sqrt{2}}\left(u\bar{u} + d\bar{d}\right) - 0.63 s\bar{s}$$
$$\eta' = 0.63 \frac{1}{\sqrt{2}}\left(u\bar{u} + d\bar{d}\right) + 0.77 s\bar{s}$$

η mass = 547 MeV η′ mass = 958 MeV

Total cross section for η′ production 40 times smaller !

Anomausly high η′ appearance in the decays of B and D_s mesons

Eta and eta prime Decays where glue is or believed to be important

$$\frac{\Gamma(D_s^+ \to \eta' \rho^+)}{\Gamma(D_s \to \eta' e^+ \nu)} = 12.0 \pm 4.3 \qquad \frac{\Gamma(D_s^+ \to \eta \rho^+)}{\Gamma(D_s \to \eta e^+ \nu)} = 4.4 \pm 1.2$$

* $B^+ \to K^+ \eta' = (80 \pm 7) \cdot 10^{-6}$

* $B^+ \to K^+ \eta < 6.9 \cdot 10^{-6}$

observed BR do not agree with predictions which ignore the gluonic content of the η′

η′ is a good candidate to have a sizeable gluonium content

What is „gluonium" in the etaprime ?

Measurement of the pseudoscalar mixing angle and η' gluonium content with KLOE detector

The KLOE Collaboration

Abstract

We have measured the ratio $R_\phi = BR(\phi \to \eta'\gamma)/BR(\phi \to \eta\gamma)$ by looking for the radiative decays $\phi \to \eta'\gamma$ and $\phi \to \eta\gamma$ in the final states $\pi^+\pi^-$ 7 γ's and 7 γ's respectively, in a sample of $\sim 1.3 \cdot 10^9$ ϕ mesons produced at the Frascati ϕ-factory. We obtain $R_\phi = (4.77 \pm 0.09_{stat} \pm 0.19_{sys}) \cdot 10^{-3}$ from which we derive $BR(\phi \to \eta'\gamma) = (6.20 \pm 0.11_{stat} \pm 0.25_{sys}) \cdot 10^{-5}$. In the hypothesis of no gluonium content we extract the pseudoscalar mixing angle in the quark-flavor basis $\varphi_P = (41.4 \pm 0.3_{stat} \pm 0.7_{sys} \pm 0.6_{th})°$. Combining the value of R_ϕ with other constraints, we estimate the gluonium fractional content of η' meson as $Z^2 = 0.14 \pm 0.04$ and the mixing angle $\varphi_P = (39.7 \pm 0.7)°$.

On the gluon content of the η and η' mesons

Rafel Escribano

Grup de Física Teòrica and IFAE, Universitat Autònoma de Barcelona, E-08193 Bellaterra (Barcelona), Spain
E-mail: Rafel.Escribano@ifae.es

Jordi Nadal

Institut de Física d'Altes Energies, Universitat Autònoma de Barcelona, E-08193 Bellaterra (Barcelona), Spain
E-mail: jnadal@ifae.es

ABSTRACT: A phenomenological analysis of radiative $V \to P\gamma$ and $P \to V\gamma$ decays is performed with the purpose of determining the gluonic content of the η and η' wave functions. Our results show that within our model there is no evidence for a gluonium contribution in the η, $Z_\eta^2 = 0.00 \pm 0.12$, or the η', $Z_{\eta'}^2 = 0.04 \pm 0.09$. In terms of a mixing angle description this corresponds to $\phi_P = (41.4 \pm 1.3)°$ and $|\phi_{\eta' G}| = (12 \pm 13)°$. In addition, the η-η' mixing angle is found to be $\phi_P = (41.5 \pm 1.2)°$ if we don't allow for a gluonium component.

On the η' Gluonic Admixture

E. Kou *

Abstract

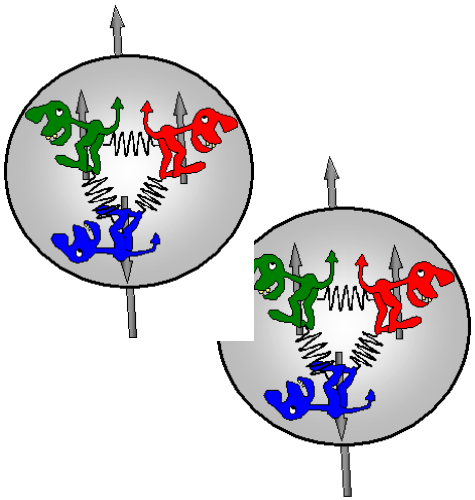
The η' which is an $SU(3)_F$ singlet state can contain a pure gluon component, gluonium. We examine this possibility by analysing all available experimental data. It is pointed out that the η' gluonic component may be as large as 26%. We also show that the amplitude for $J/\psi \to \eta'\gamma$ decay obtains a notable contribution from gluonium.

η′ production from isospin I = 0 and I = 1

$$pp \to pp\eta' \qquad pn \to pn\eta'$$

$\sigma_I = \sigma_{I=1}$ $\qquad$ $\sigma_I = ½\,(\sigma_{I=1} + \sigma_{I=0})$

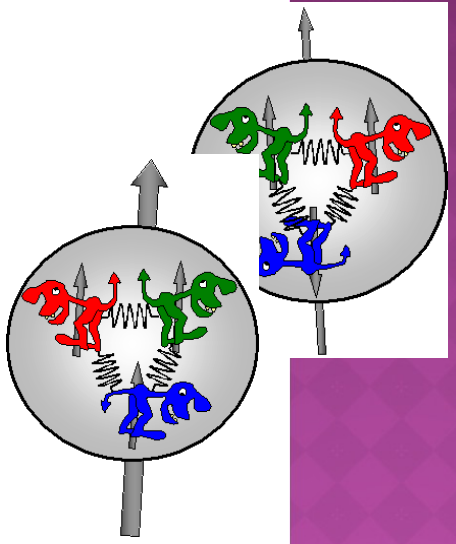
$$R_{\eta'} = \frac{\sigma(pn \to pn\eta')}{\sigma(pp \to pp\eta')} = ?$$



? $R_{\eta'} = 6.5$?

dominance of the isovector meson exchange

? $R_{\eta'} = 1$?



production via flavour-blind gluonic component

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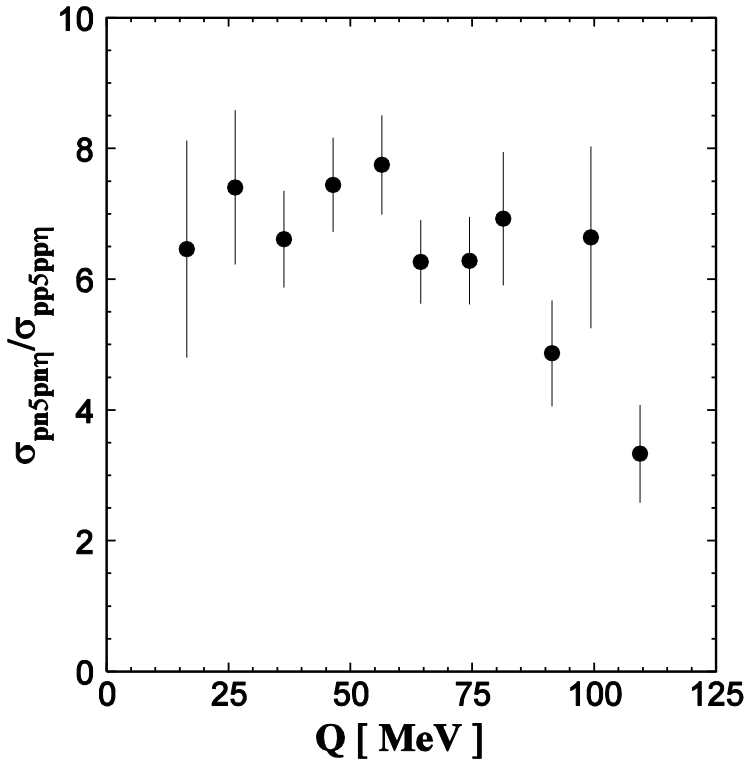
η production from isospin I = 0 and I = 1

H.Calén et al., Phys. Rev. C 65 (2002) 045210.



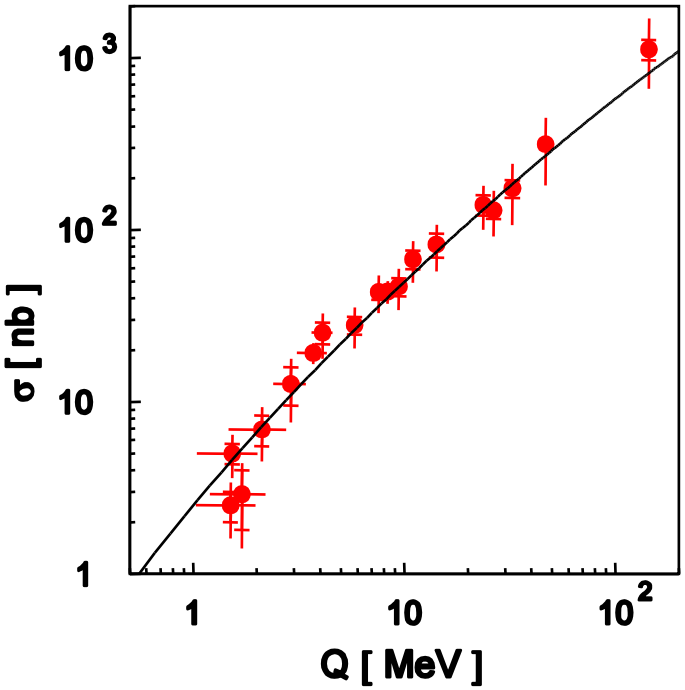
Will the observed ratio be different from 6.5?

- production mechanism of the η' meson in NN collisions
  - Isovector meson (π, ρ, ...) exchange ...
  - Gluonic excitation...
  - ???
- structure of the η' meson

$$\eta' = \alpha\,|\,qq\,\rangle + \beta\,|\mathrm{glue}\,\rangle$$

η′ production in proton – proton collisions

$\sigma_l = \sigma_{l=1}$



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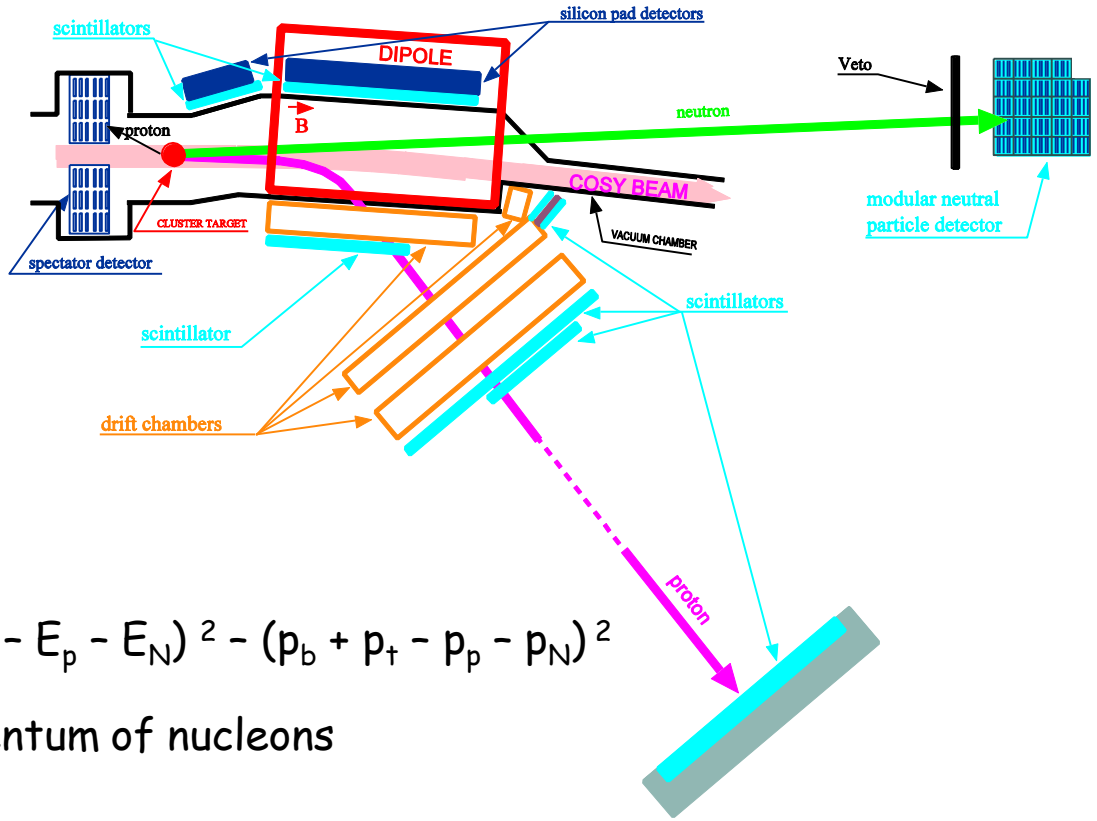
SPESIII: F. Hibou et al., Phys. Lett. ***B 438*** *(1998) 41.*
SATURNE: F. Balestra et al., Phys. Lett. ***B 491*** *(2000) 29.*

Experiment:
η' production in proton – neutron collisions

Pbeam = 3.35 GeV/c
deuteron target

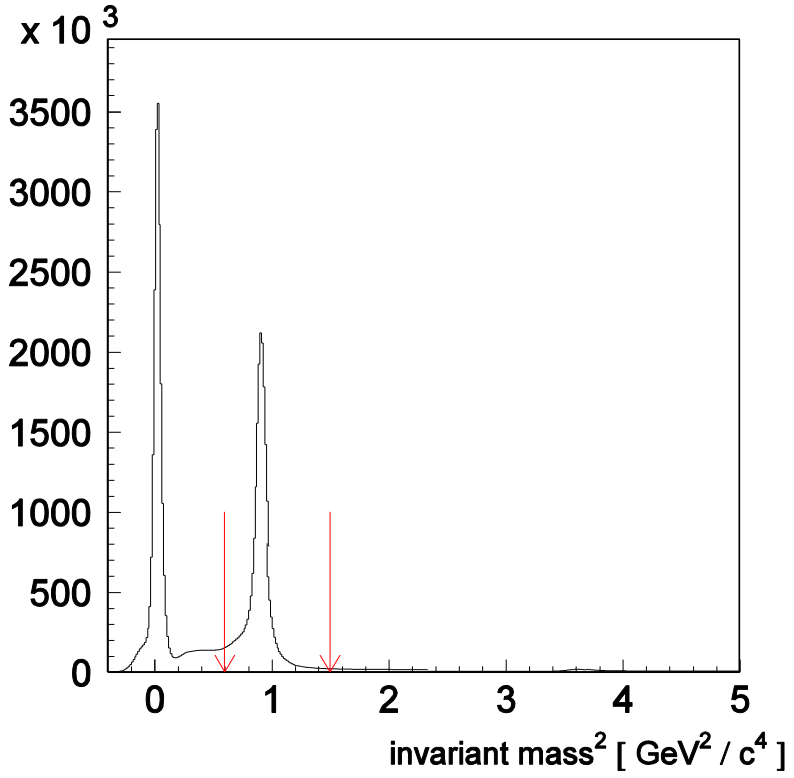


$$m_x^2 = E_x^2 - \mathbf{p}_x^2 = (E_b + E_t - E_p - E_N)^2 - (p_b + p_t - p_p - p_N)^2$$

E, p – energy and momentum of nucleons

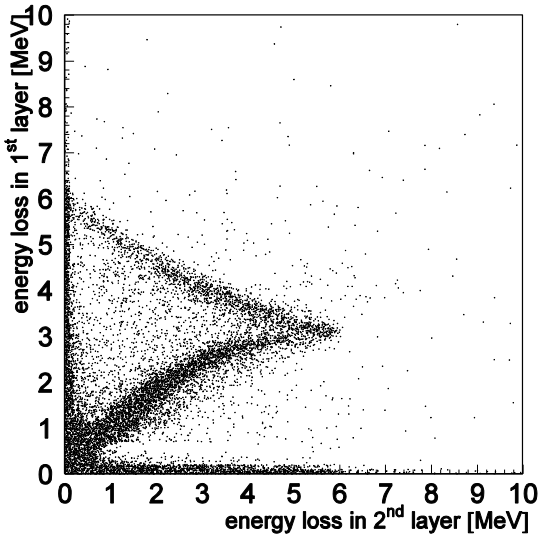
The momentum of both nucleons inside deuteron is measured for each event!!

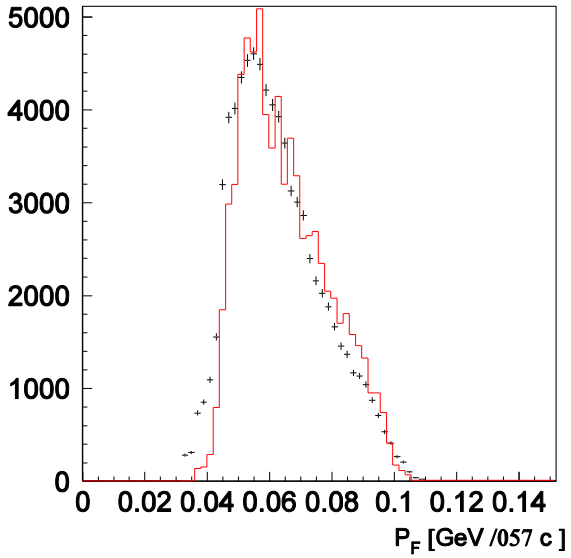
Proton identification
Momentum reconstruction in magnetic field + TOF



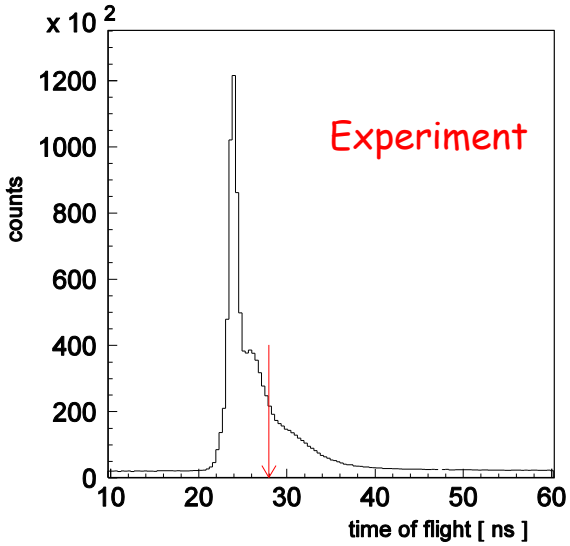
Proton spectator momentum reconstruction from hit position and energy loss

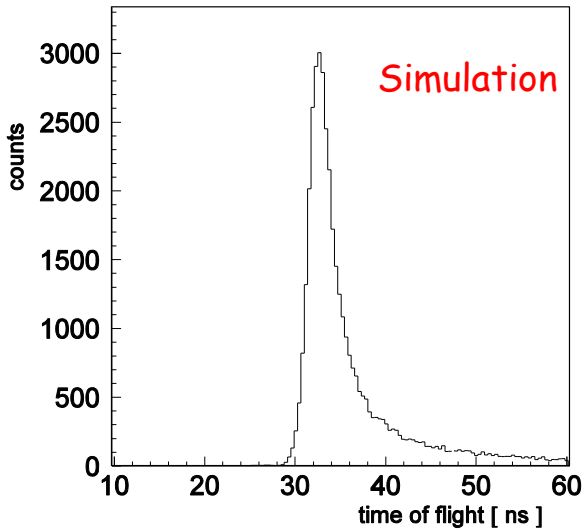
Spectator detector





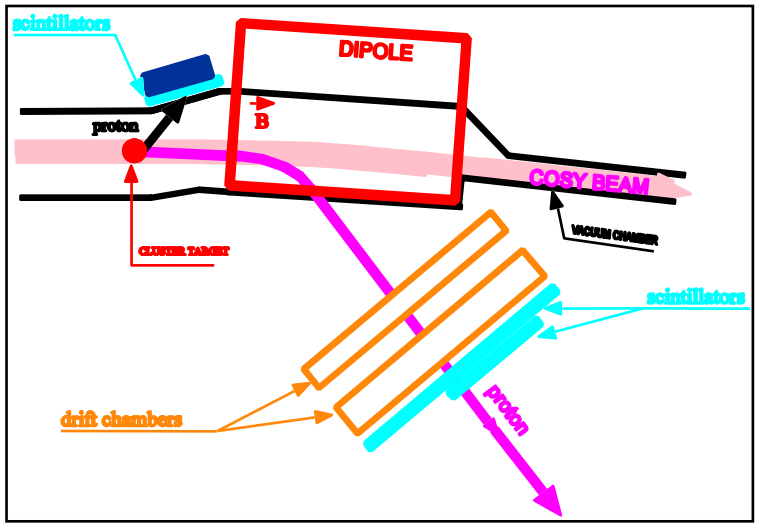
Neutron momentum reconstruction from TOF and hit position

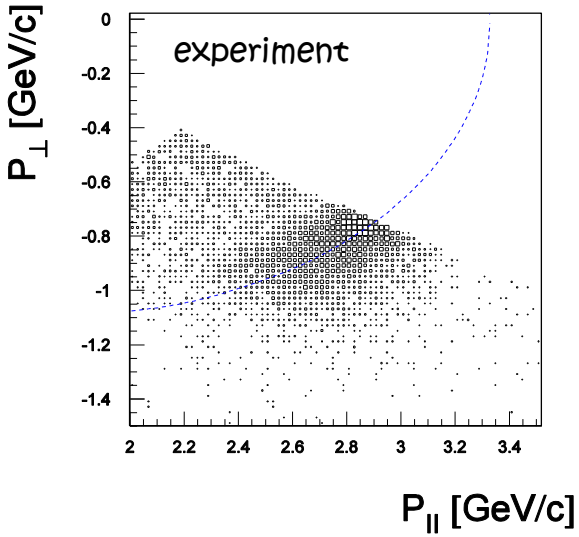


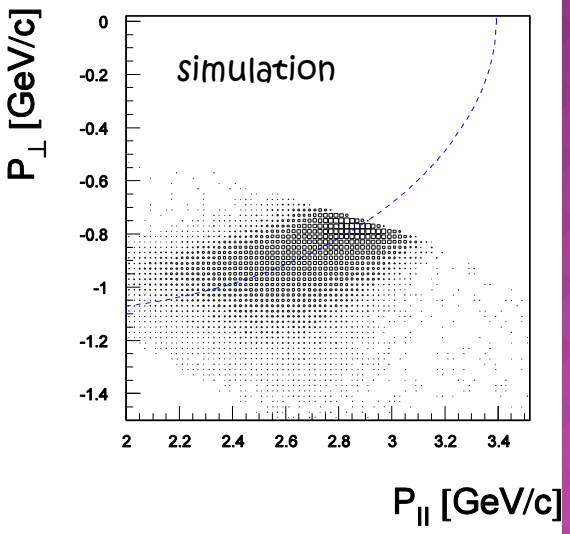


Luminosity determination

pp → pp (quasi-free)

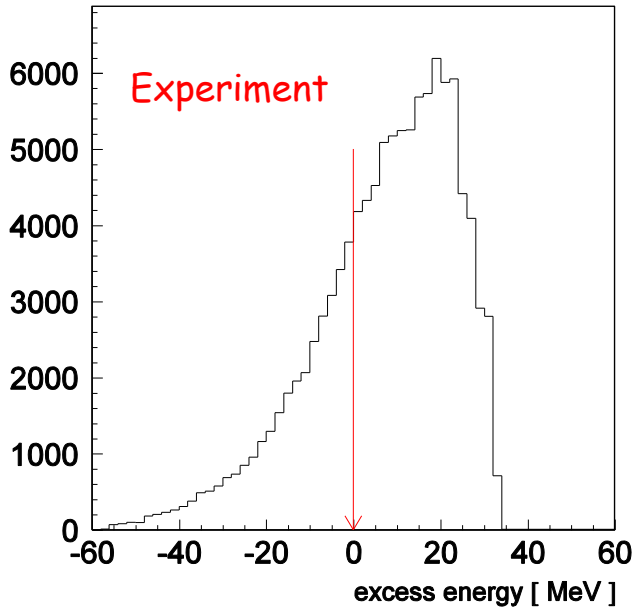


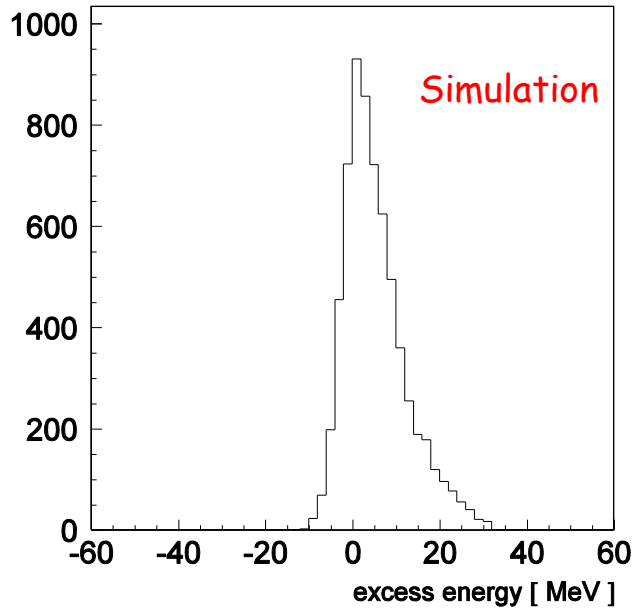




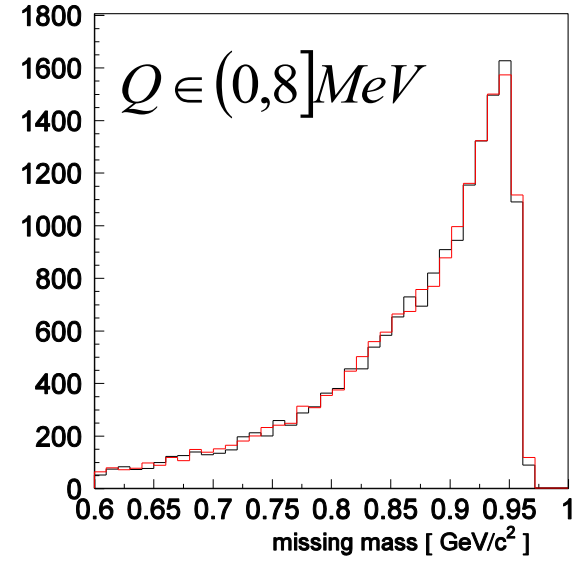
$$L = (4.77 \pm 0.06) \cdot 10^{36} cm^{-2}$$

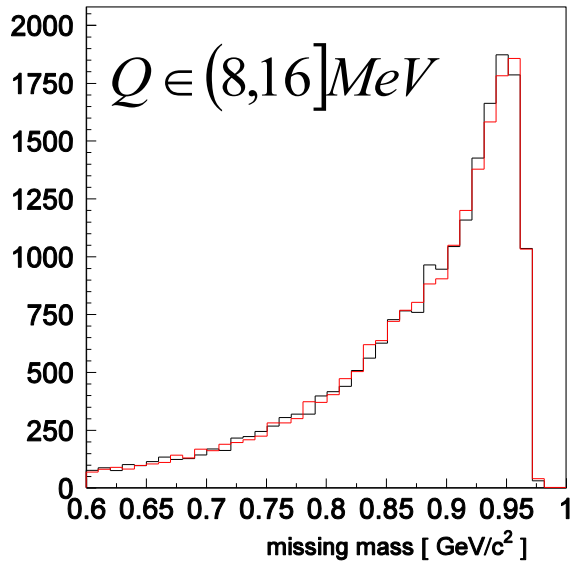
$$Q_{cm} = \sqrt{S} - m_p - m_n - m_{\eta'}$$

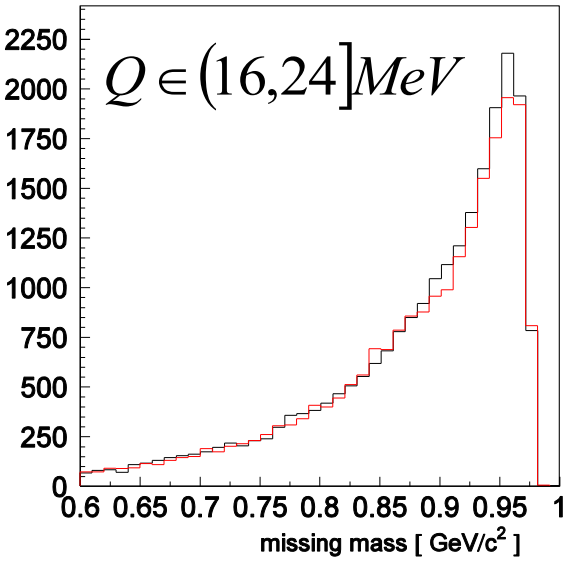


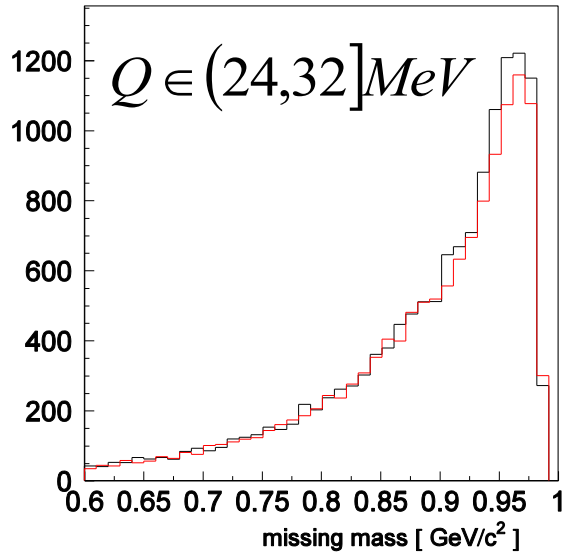


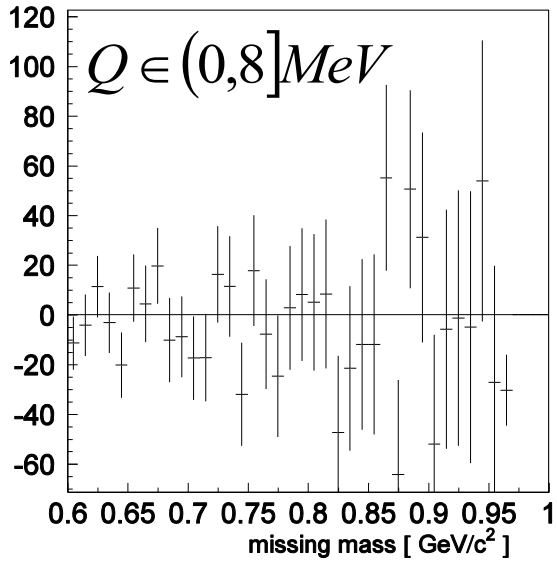
Background subtraction

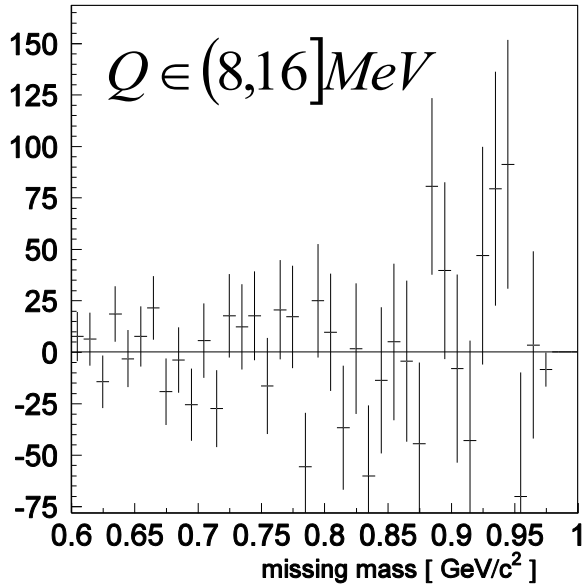












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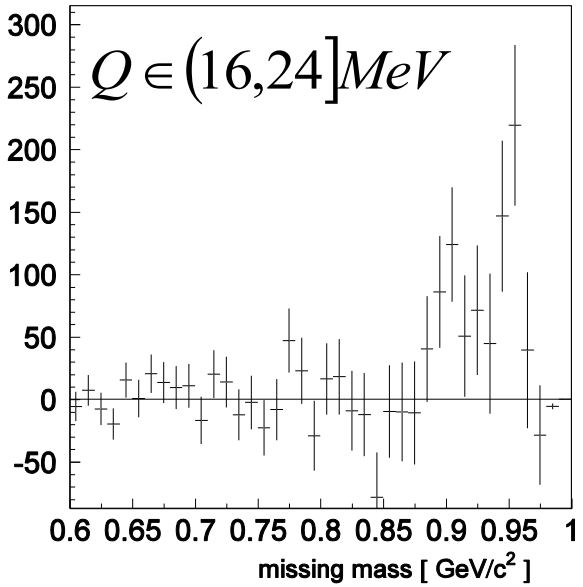

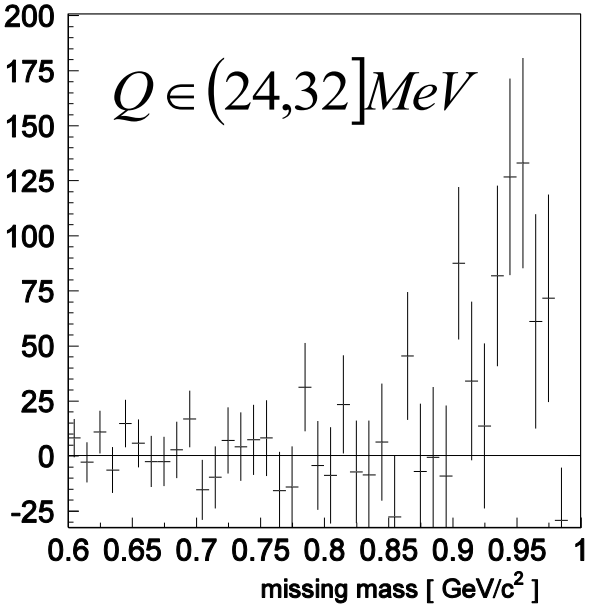

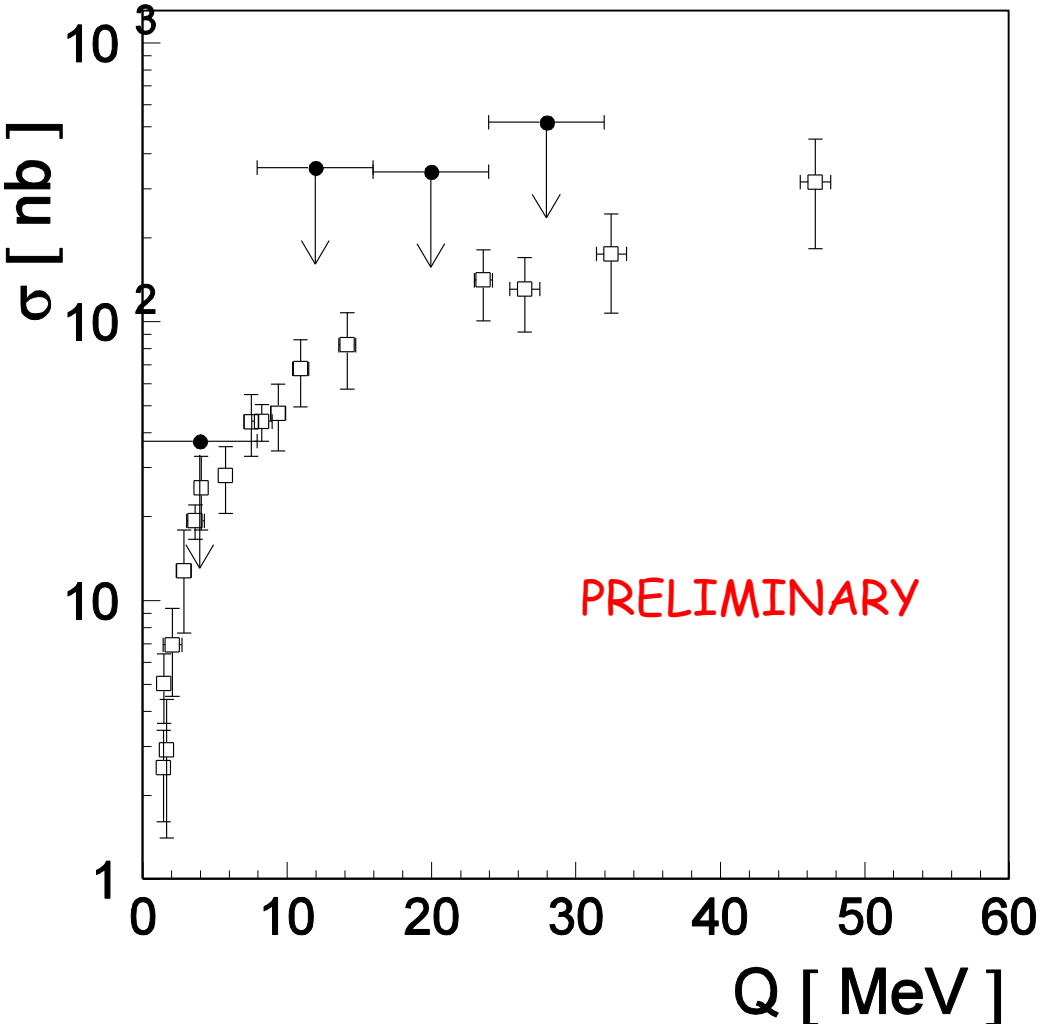
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10^3
10^2
10
1
0
10
20
30
40
50
60
Q [MeV]
PRELIMINARY