First results on η photoproduction on the neutron at GRAAL

GRAAL Collaboration

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- Introduction

- The GRAAL facility. Neutron detectors at GRAAL.

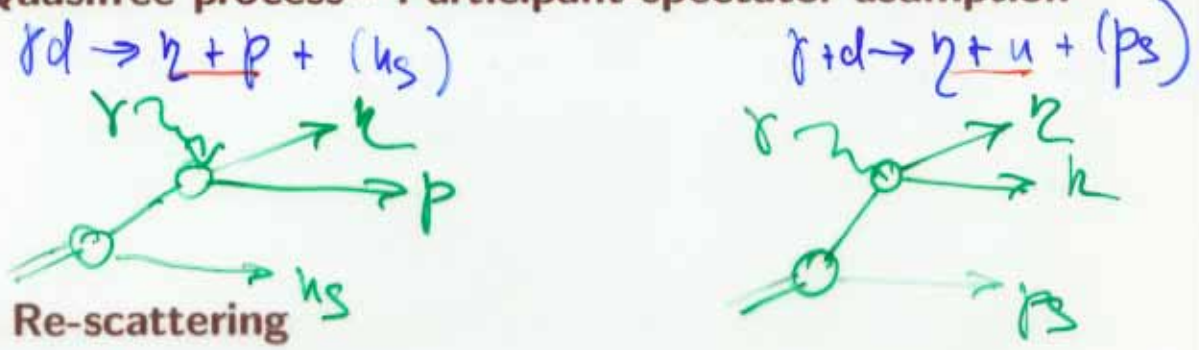
- Data analysis

- First outcome: Ratio $d\sigma_n/d\sigma_p$, Beam asymmetry Σ.

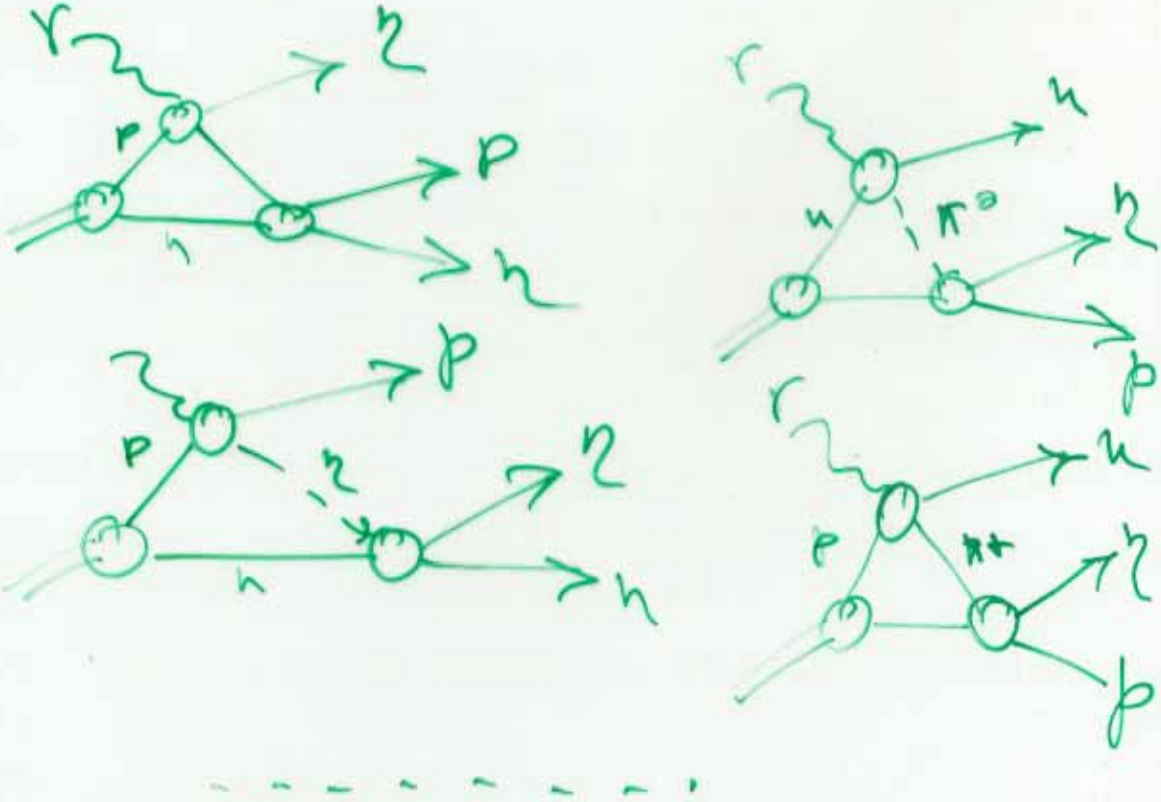
- Meson photoproduction on the neutron at GRAAL: Perspectivas.

No neutron targets → use of the deuteron or light nuclei.

Quasifree process - Participant-spectator asumption



- **Re-scattering**



- What is the role of re-scattering? (A.Lvov, Private Communication, Y.Zang and D.Halderson, Phys. Rev. C **45**. 563(1992) - few percents ; A.Fix and H.Arenhovel, Z.Phys. **A359**, 168(1997) - essential near threshold).

Present situation

Inclusive measurements: Detection of only η-meson $\rightarrow \sigma_{tot}$ on the deuteron.

Mainz-TAPS (B.Krusche et al., Phys. Lett. **358**(1995) 40; V.Heiny et al., Eur. Phys. J. **A6**(1999) 83; V.Heiny at al.,Eur. Phys. J. **A13**(2002)493 and references therein.)

Energy coverage from the threshold to 0.82 GeV

Impulse approximation: $\sigma_{tot} = \sigma_p^* + \sigma_n^*$,
where $\sigma^*(E_\gamma)$ is $\sigma_{freenucleon}(E_\gamma)$ folded with the momentum distribution of the bound nucleons.

Extraction of $\frac{\sigma_n}{\sigma_p}$ from the fit to the inclusive data: $\frac{\sigma_n}{\sigma_p} = \frac{2}{3}$

in the region of the $S_{11}(1535)$ resonance.

Exclusive measurements: Detection of η in coincidence with recoil neutron/proton, selection of the quasifree kinematics $\rightarrow$ direct measurements of $\frac{\sigma_n}{\sigma_p}$.

Mainz-TAPS (J.Weib et al., Nucl-ex/0210003;

V.Heiny et al.,Eur. Phys. J. **A6**(1999) 83):

$$\frac{\sigma_n}{\sigma_p} = 0.68 \pm 0.07$$

Bonn-Phoenix-Seneca (P.Hoffman-Rothe, PRL **78** 4697 (1997)).

Energy coverage from the threshold to 0.98 GeV.

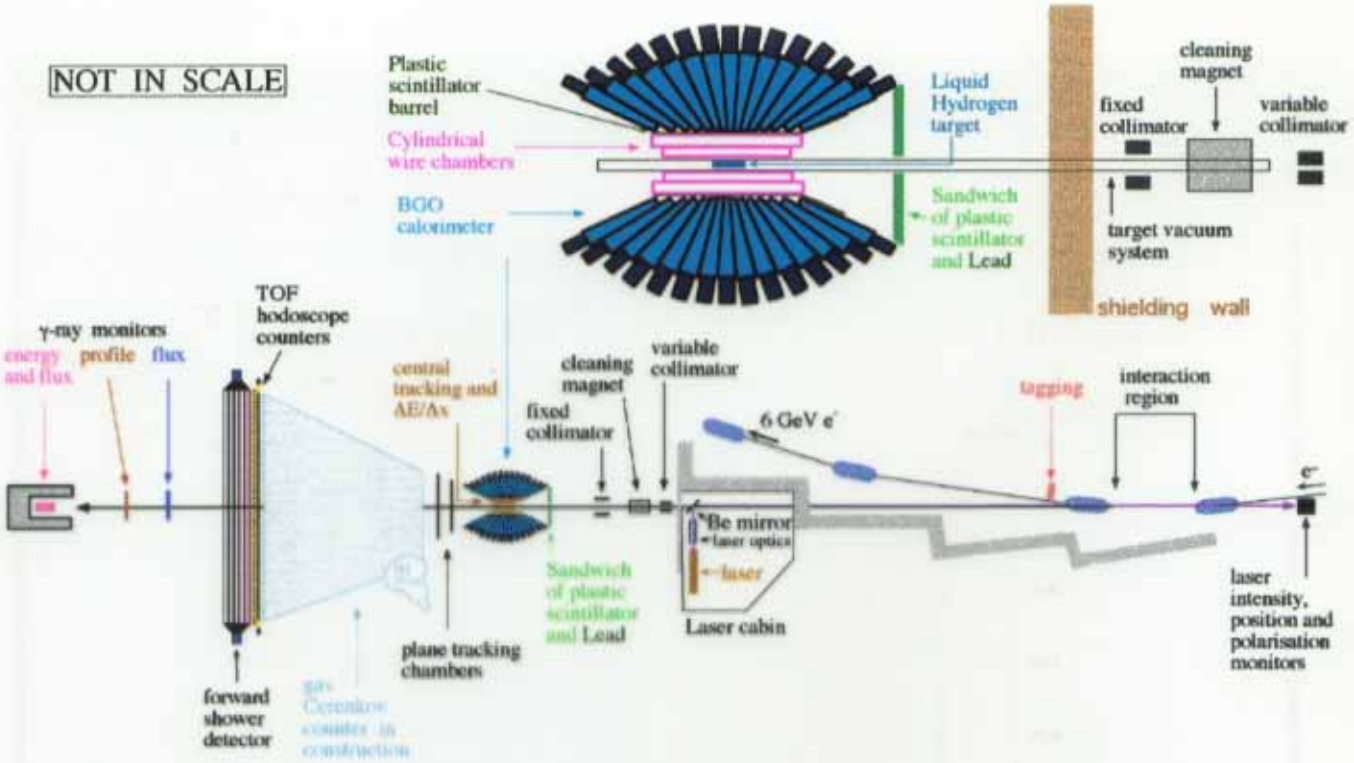
$$\frac{\sigma_n}{\sigma_p} = 0.68 \pm 0.06$$

$\frac{d\sigma_n}{d\sigma_p}$ at Θ_{cm} 134 and 154° (will be shown).

Summary

Experimental data: $\frac{\sigma_n}{\sigma_p} \sim \frac{2}{3}$ in the region of the $S_{11}(1535)$

Theory: Rise up of the neutron cross section above the $S_{11}(1535)$


NOT IN SCALE
Plastic scintillator barrel
Cylindrical wire chambers
BGO calorimeter
Liquid Hydrogen target
Sandwich of plastic scintillator and Lead
cleaning magnet
fixed collimator
variable collimator
target vacuum system
shielding wall
γ-ray monitors
energy
profile
flux
and flux
TOF hodoscope counters
central tracking and ΔE/Δx
cleaning magnet
variable collimator
fixed collimator
6 GeV e⁻
tagging
interaction region
e⁻
Be mirror
laser optics
laser
Laser cabin
Sandwich of plastic scintillator and Lead
plane tracking chambers
forward shower detector
laser intensity, position and polarisation monitors

Neutron detectors at GRAAL

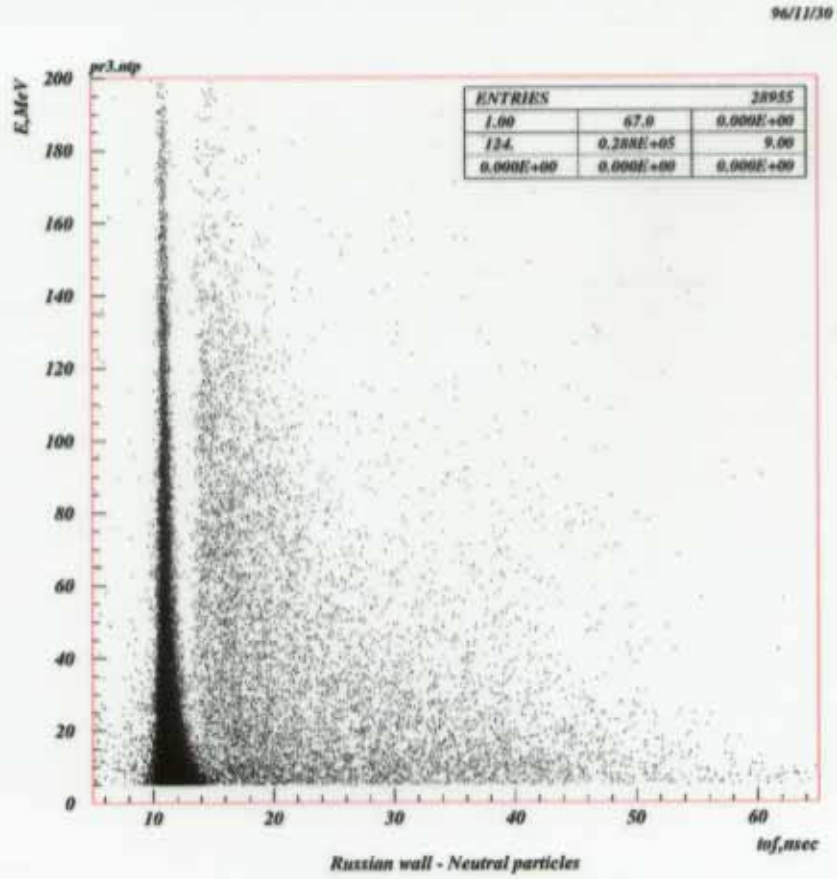
Russian Wall

Angular acceptance 1 - 25 °;

Neutron efficiency $22 - 25\%$;

Particle identification (photons, neutrons, protons, charged pions);

Angular resolution $2 - 3°$, TOF resolution 600 ps FWHM.



BGO crystal ball

Angular acceptance 25 - 155 °

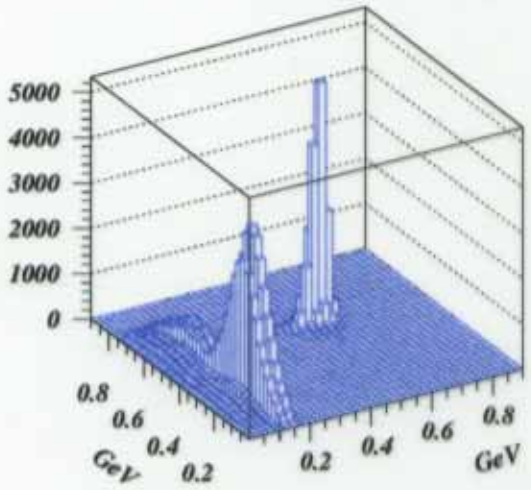
Neutron efficiency ~25% (?????)

Partial discrimination of neutrons from photons

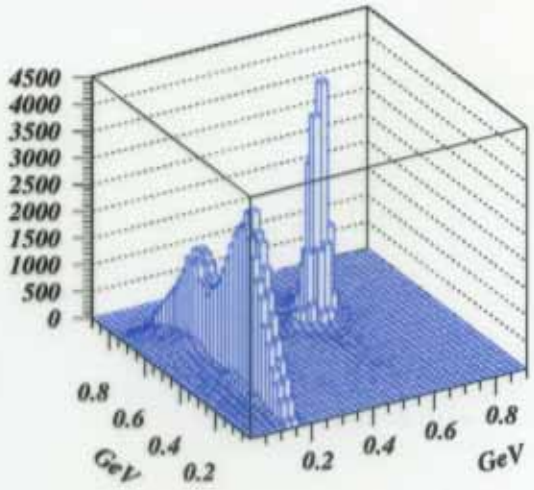
Angular resolution 6-8°

Eta on the neutron:

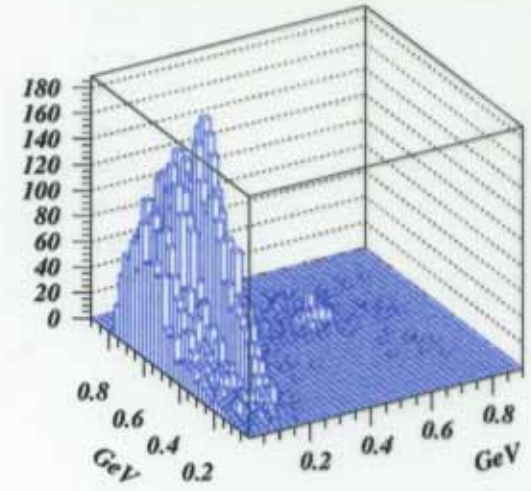
- Detection of the recoil neutrons in the Russian Wall or the BGO;
- Simultaneous measurements on the quasi-free neutron and the quasi- free proton bound in the deuteron target.



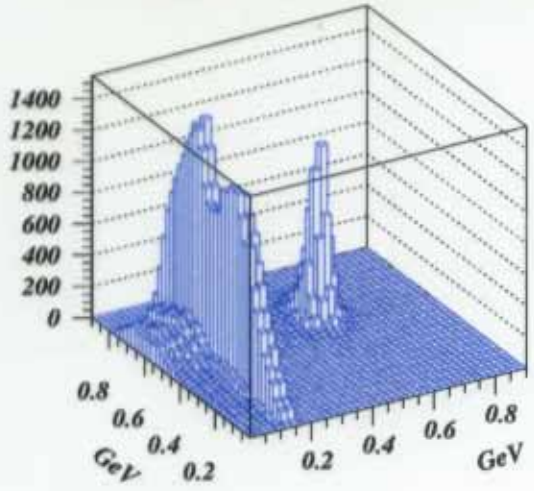
Recoil proton, proton target



Recoil proton, deuteron target



Recoil neutron, proton target



Recoil neutron, deuteron target

Shown on the plot is the missing mass calculated from the momentum of the recoil nucleon in the forward direction versus the invariant mass of two photons in the BGO.

Data analysis

Fisrt step: cut on the missing and invariant masses.

Second step: χ^2 minimization procedure.

Background subtraction from the distribution of the identification parameter

$$P_{\chi^2} = \sum \frac{(P_i^{meas} - P_i^{calc})^2}{\sigma_i^2}$$

Measured and calculated are energies, theta and phi angles of two photons and TOF, X,Y of the recoil nucleon.

Background subtraction from the distribution of the identification parameter

$$P_{ind} = \sum \frac{(P_i^{meas} - P_i^{calc})}{\sigma_i}$$

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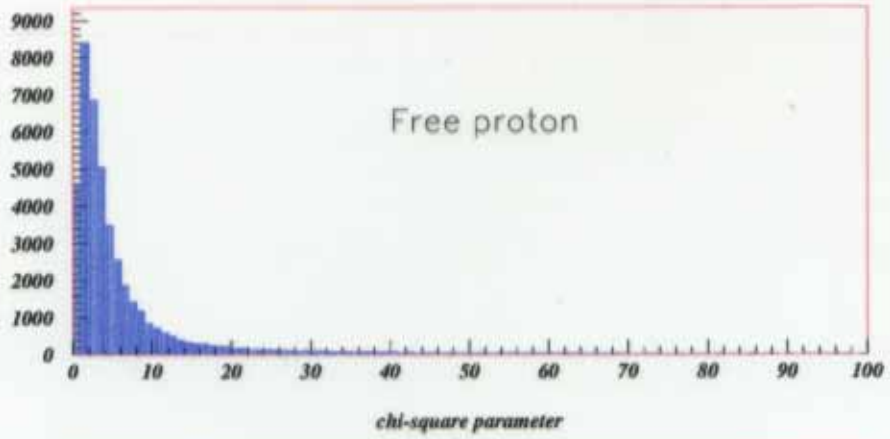
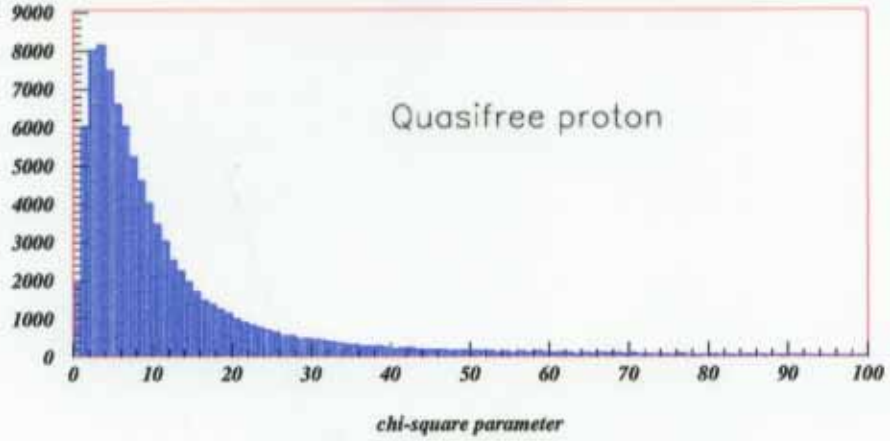
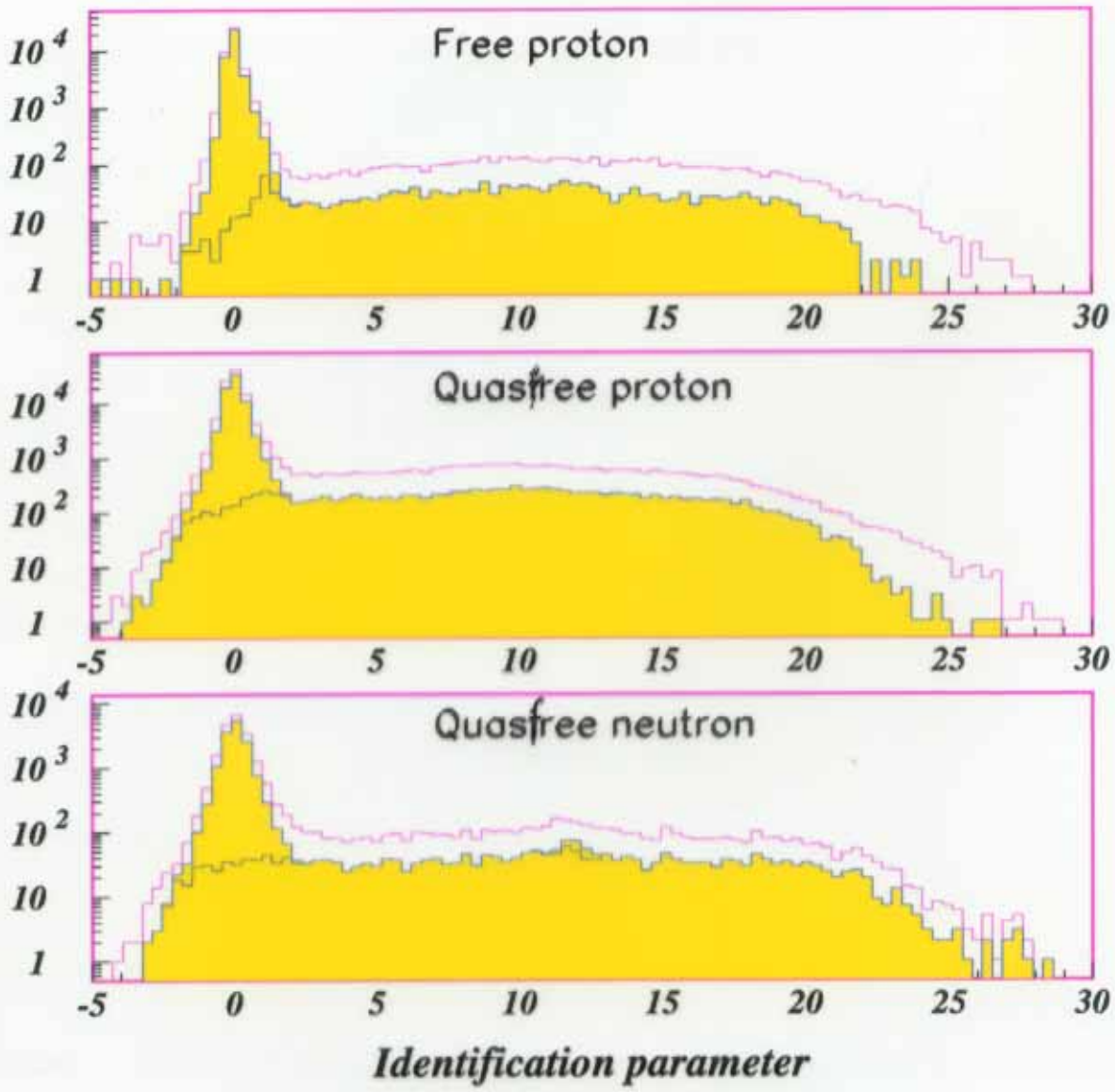




Data analysis



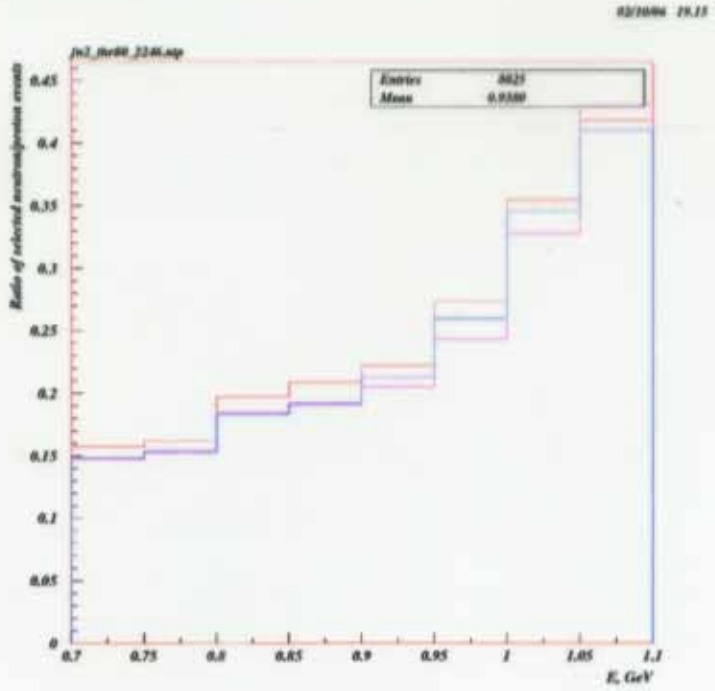
RW $\gamma p_{qfr} \rightarrow (\eta p)_{qfr} + n$ Detection of the (η p) pair corresponding to the quasifree(free) kinematics PLUS 1 neutron of 20-100 MeV energy in the Russian Wall.

Number of selected events:

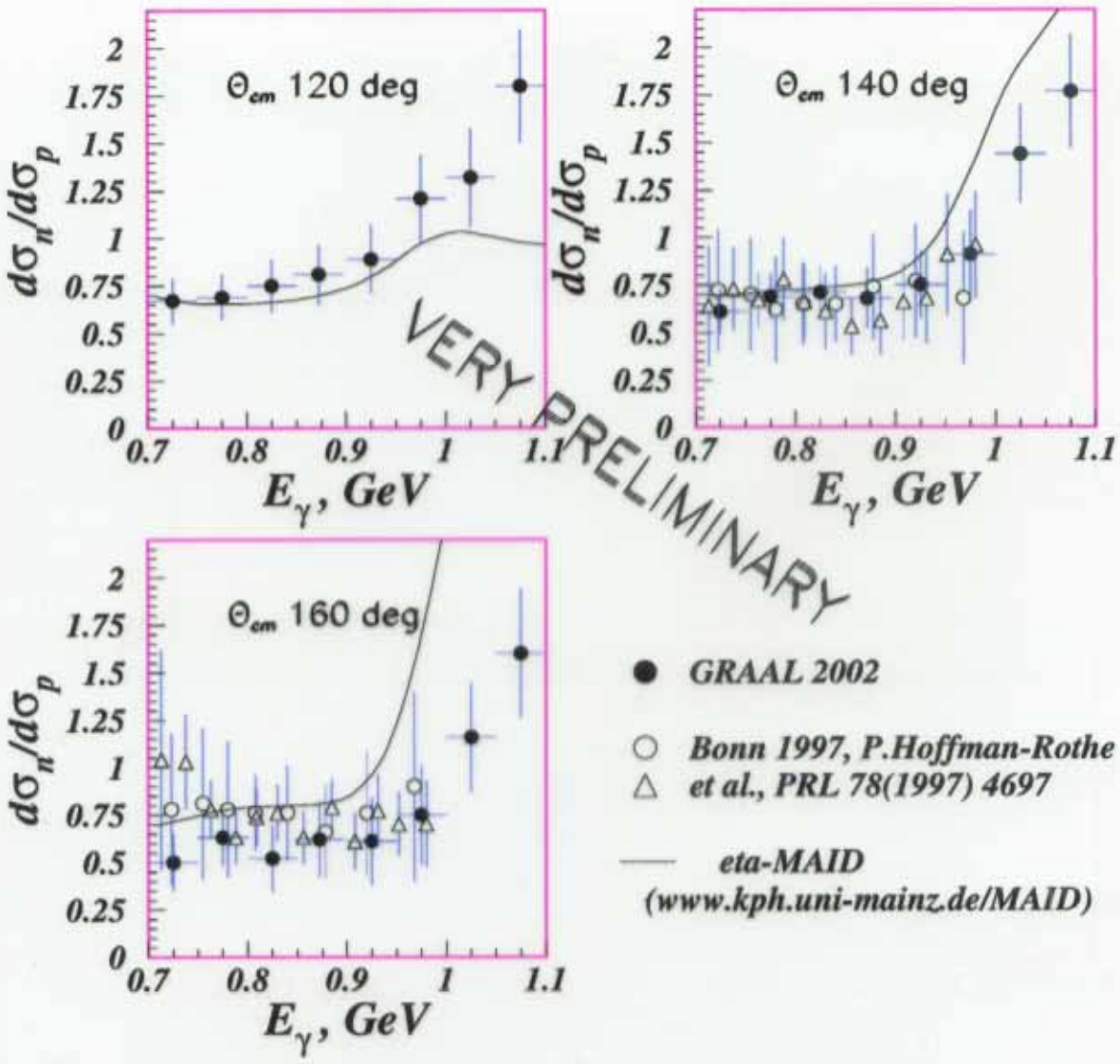
(η p) - 105796, (η p) + n - 74 ;

(for the free proton 45789 and 5 respectively)

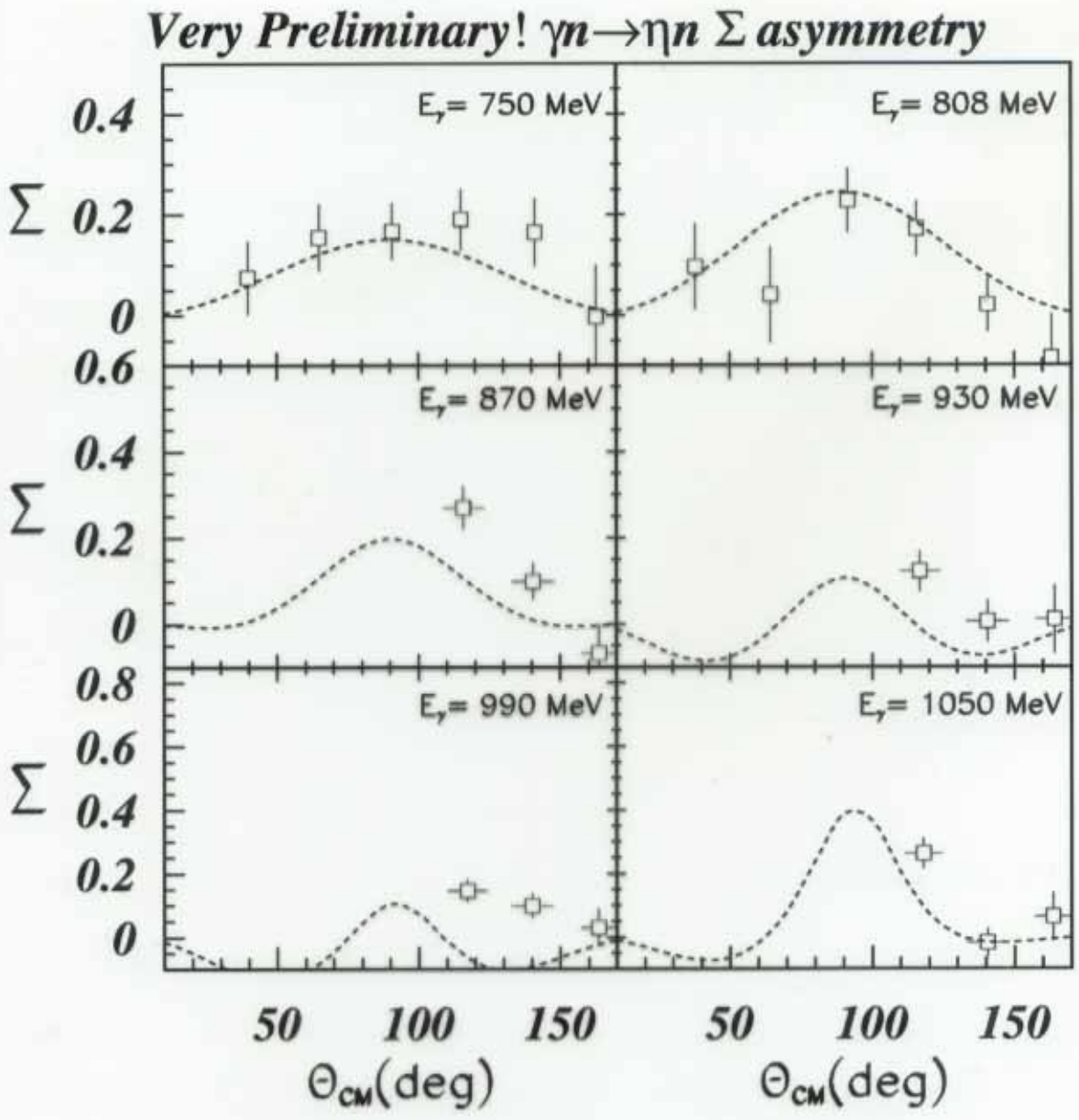
BGO Selection of two photons in the BGO above different limits of 5, 15 and 80 MeV. Selection of the (η N) pair corresponding to the quasifree kinematics PLUS any particle in the BGO below the threshold. Test of the ratio of selected neutron/proton events.



Neutron/proton ratio



Beam asymmetry Σ



Perspectivas at GRAAL

η photoproduction

- Strong reduction of systematic uncertanties
- Extention to the higher energies up to 1.5 GeV
- Detection of recoil neutrons in the BGO. Coverage of the wide angular range of 25-155°.

Other channels to be analysed:

$\gamma n \to \gamma n$

$\gamma n \to \pi N$

$\gamma n \to \pi\pi N$

$\gamma n \to \omega n$

Thanks

Many thanks to the Organizers.

Many thanks to Dominique Rebreyend, Jean-Paul Bocquet, Annick Lleres, and Igor Strakovsky for fruitful discussions and the assistance in preparation of this talk.