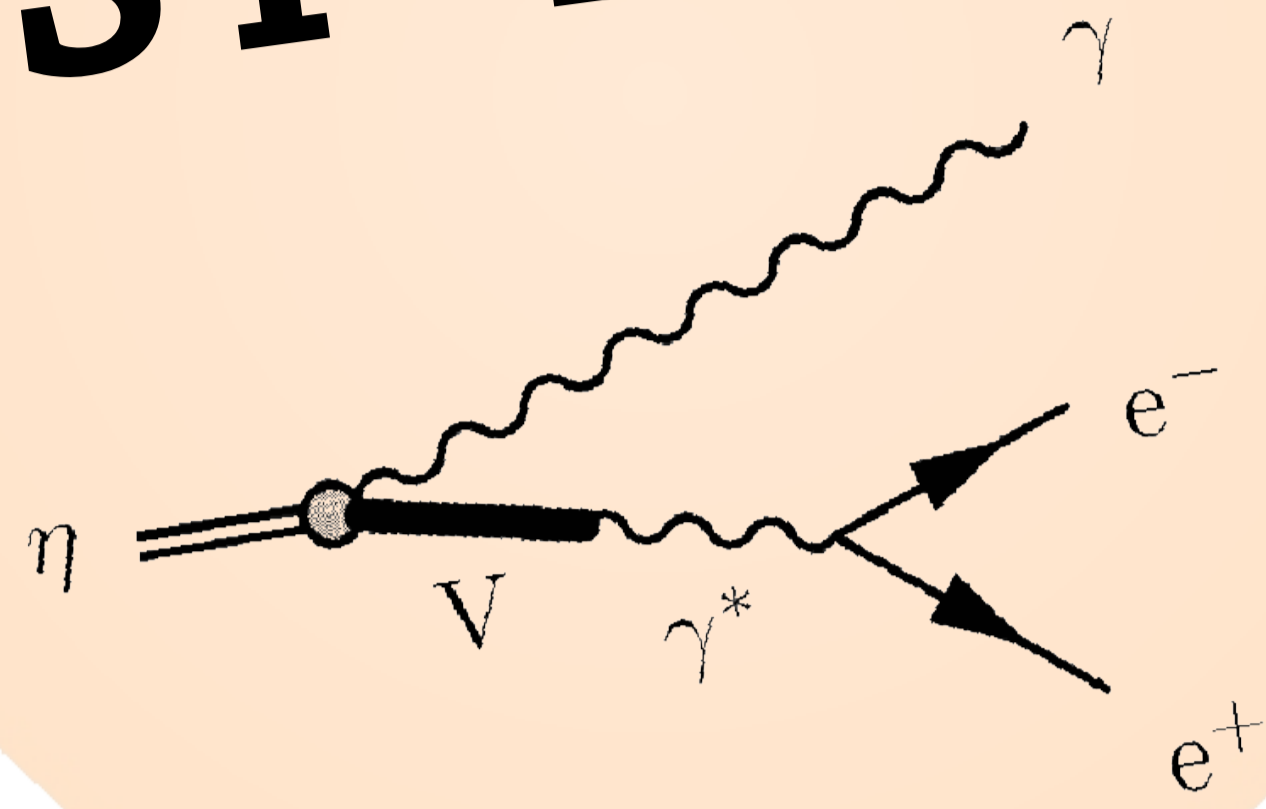


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Study of the $\eta \rightarrow e^+e^-\gamma$ Decay using WASA-at-COSY Detector System



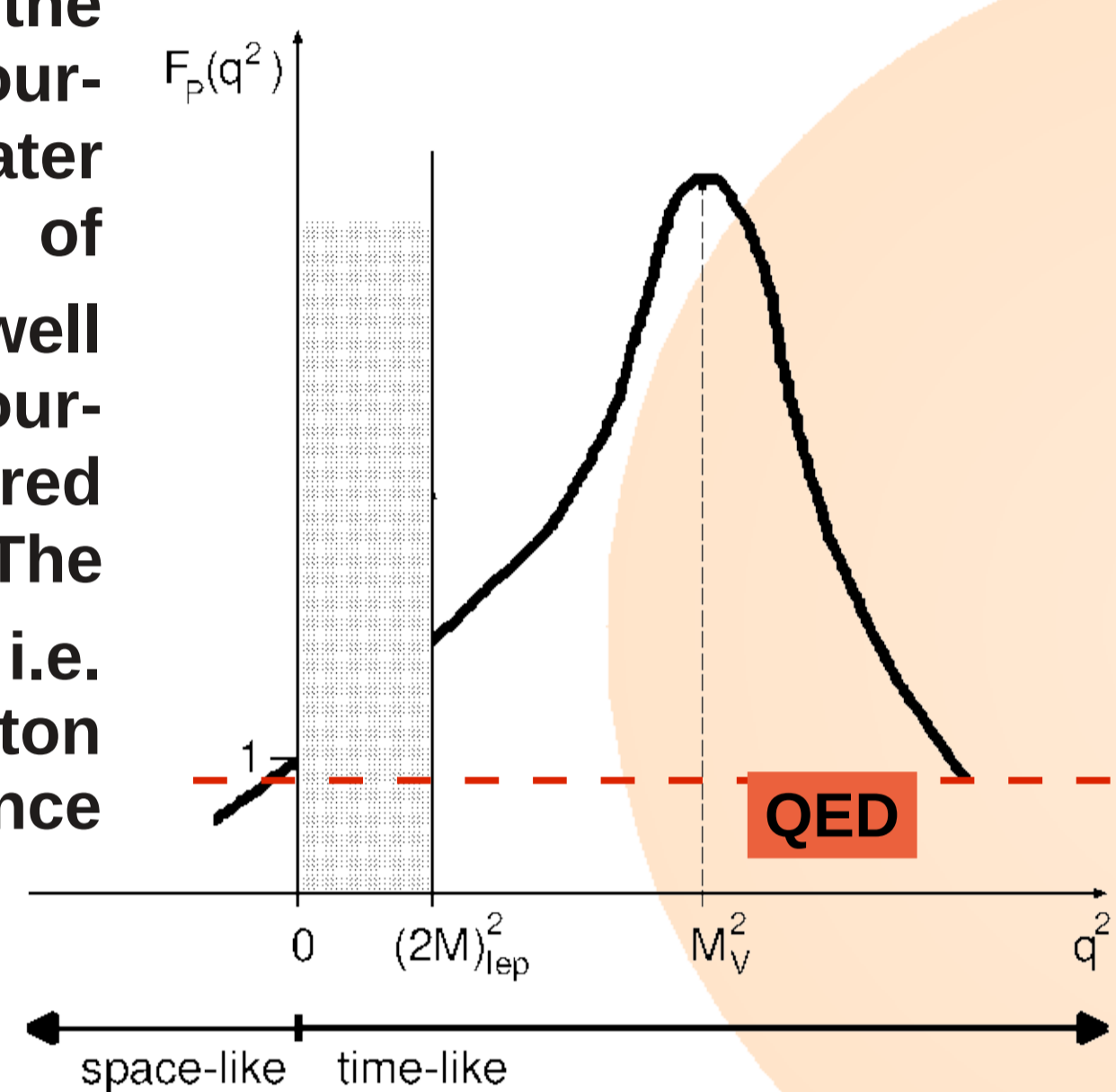
30% of available p - d data collected by the WASA detector has been studied. The analysis led to the reconstruction of 525 of $\eta \rightarrow e^+e^-\gamma$ events.

$$\frac{d\Gamma_{\eta \rightarrow e^+e^-\gamma}}{dq^2} = \left[\frac{d\Gamma}{dq^2} \right]_{\text{pointlike}} |F(q^2)|^2$$

Vector Meson Dominance Model

Photon fluctuates between electromagnetic and hadronic $q\bar{q}$ state of the same quantum numbers. This state corresponds to a vector meson, V .

Study of the electromagnetic transition form factor in $A \rightarrow B^*\Gamma$ decays is limited to the time-like region, where the squared four-momentum of the virtual photon, q^2 is greater than $(2M)^2$. In this case the mechanism of photon-hadron interaction is especially well pronounced since the squared four-momentum, q^2 , approaches the squared mass of the vector meson ($q^2 \approx M_V^2$). The virtual meson reaches its mass shell, i.e. becomes real and then decays to a lepton pair. It results in a strong resonance enhancement of the form factor of a meson. Then, at $q^2 > M_V^2$, the form factor begins to diminish [Lan85].



$$F(q^2) = \frac{1}{\sum_V g_{V\eta\gamma}/g_{V\gamma}} \sum_V \frac{g_{V\eta\gamma}}{g_{V\gamma}} \frac{M_V^2}{M_V^2 - q^2 - iM_V\Gamma_V(q^2)} \approx \frac{1}{1 - q^2/M_V^2}$$

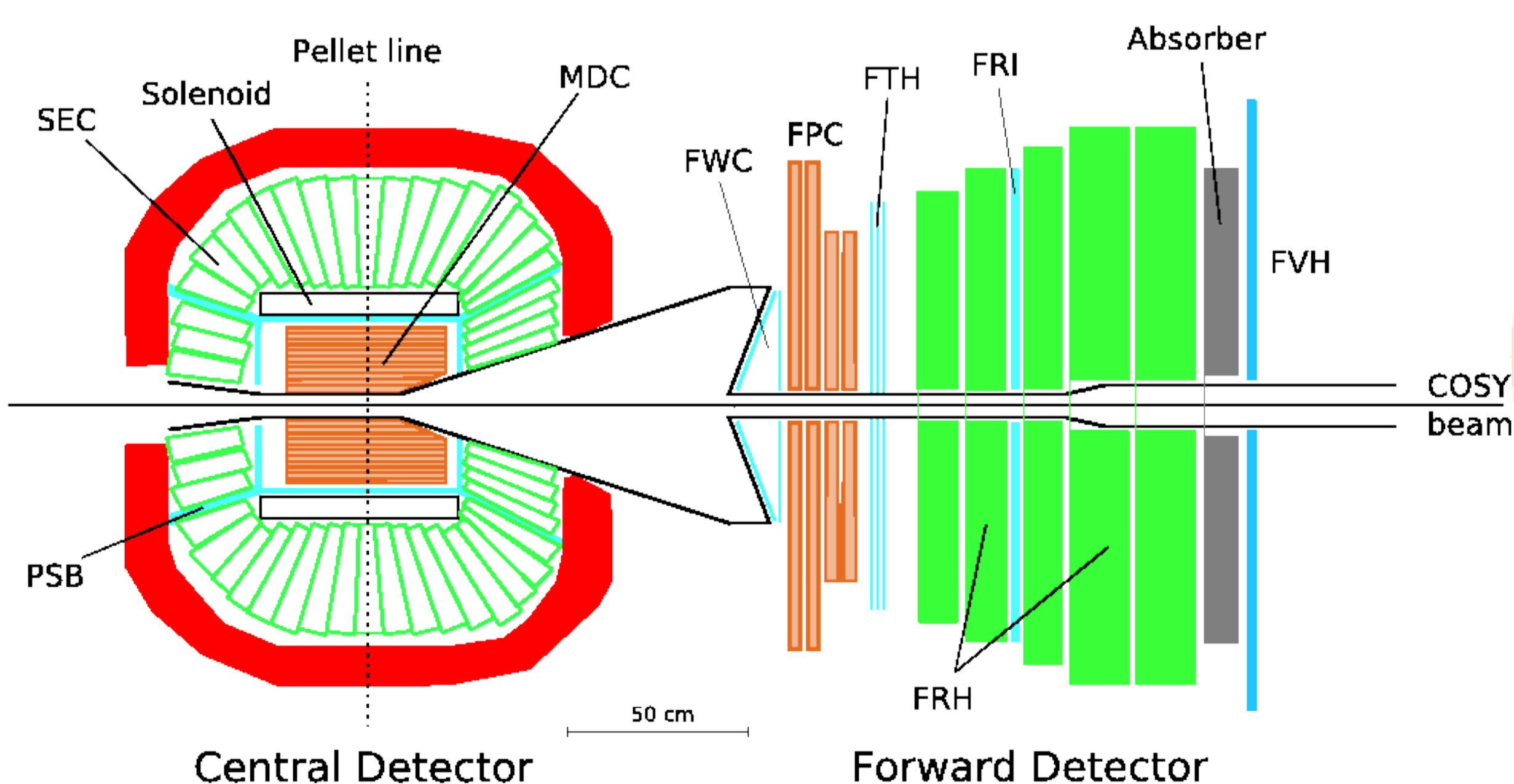
V denotes ρ, ω and ϕ vector mesons with couplings to the photon ($g_{V\gamma}$) and to the $\eta\gamma$ ($g_{V\eta\gamma}$), and the $\Gamma_V(q^2)$ corresponds to the total vector meson width.

the slope parameter of the form factor is related to the particle's mean quadratic charge radius

$$F(q^2) = \int d^3r \rho(r) e^{-iqr} \approx 1 - q^2 \frac{\langle r^2 \rangle}{6} + \dots$$

Study of the transition form factors is a tool used to gain insight into the structure of pseudoscalar meson and provides test of different models of meson's decay.

The Experimental Setup



The WASA-at-COSY detector is located in the Research Center Jülich in Germany at the COSY accelerator.



The Measurement

The proton-deuteron collision data were taken at the turn of October and November 2008 for the beam momentum of 1.7 GeV/c².

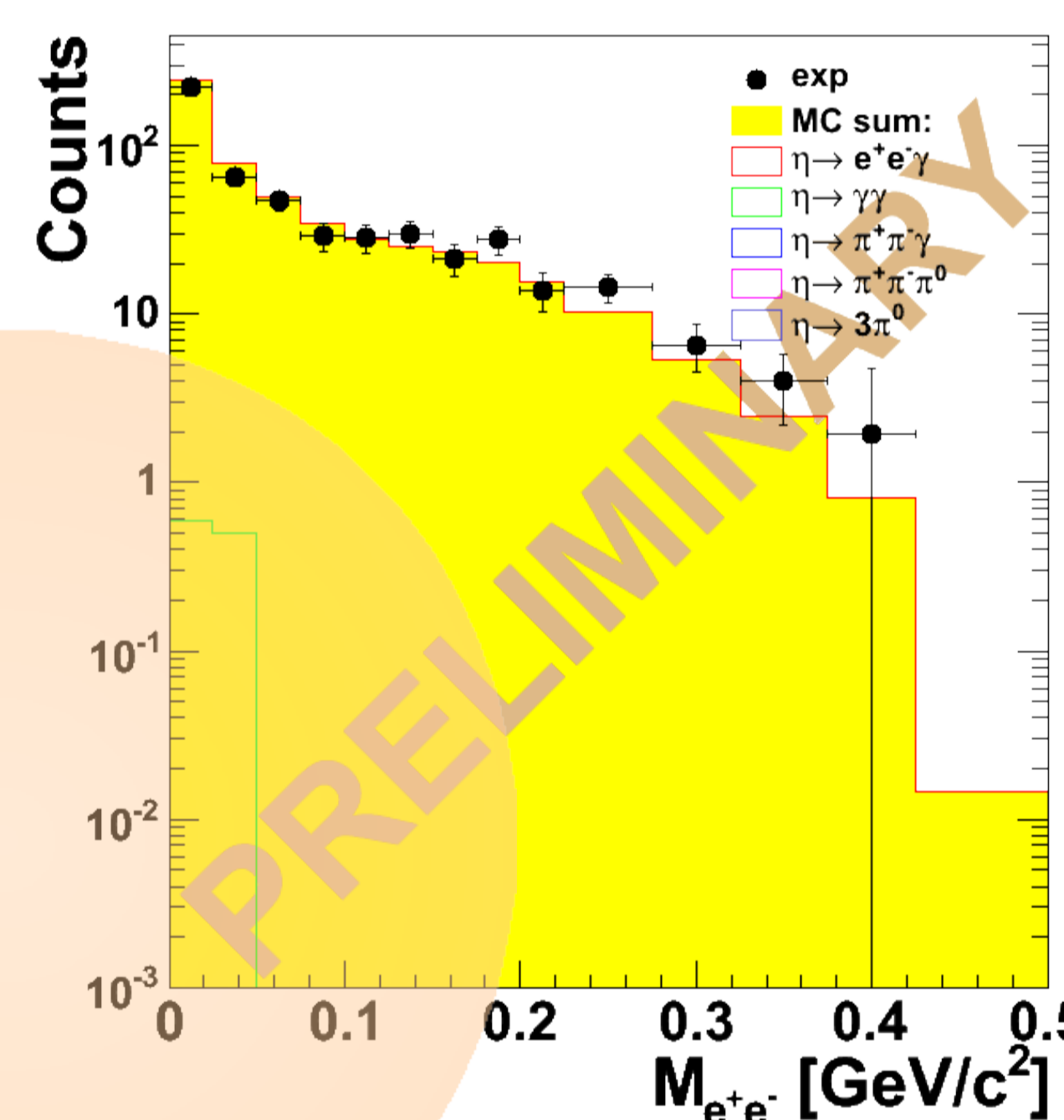
All particles have been measured explicitly, taking advantage of the large acceptance of the WASA 4 π detector. Helium ions were registered using the forward part of the detector while the central detector's part was used to measure leptons and photons (in the calorimeter).

Particles' charge was determined based on the magnetic field provided by the superconducting solenoid surrounding the drift chamber of the Central Detector.

Analysis

The analysis aims at reconstructing as many as possible of the $\eta \rightarrow e^+e^-\gamma$ decay events and, at the same time, minimizing the amount of events produced in another processes.

There are two types of background to eliminate. The one coming from pion production is subtracted from the signal using the spectrum of the missing mass for the $pd \rightarrow {}^3\text{He}X$ reaction. The second one, consisting of events of unwanted η decays, is suppressed using carefully matched kinematic constraints [Hod12].



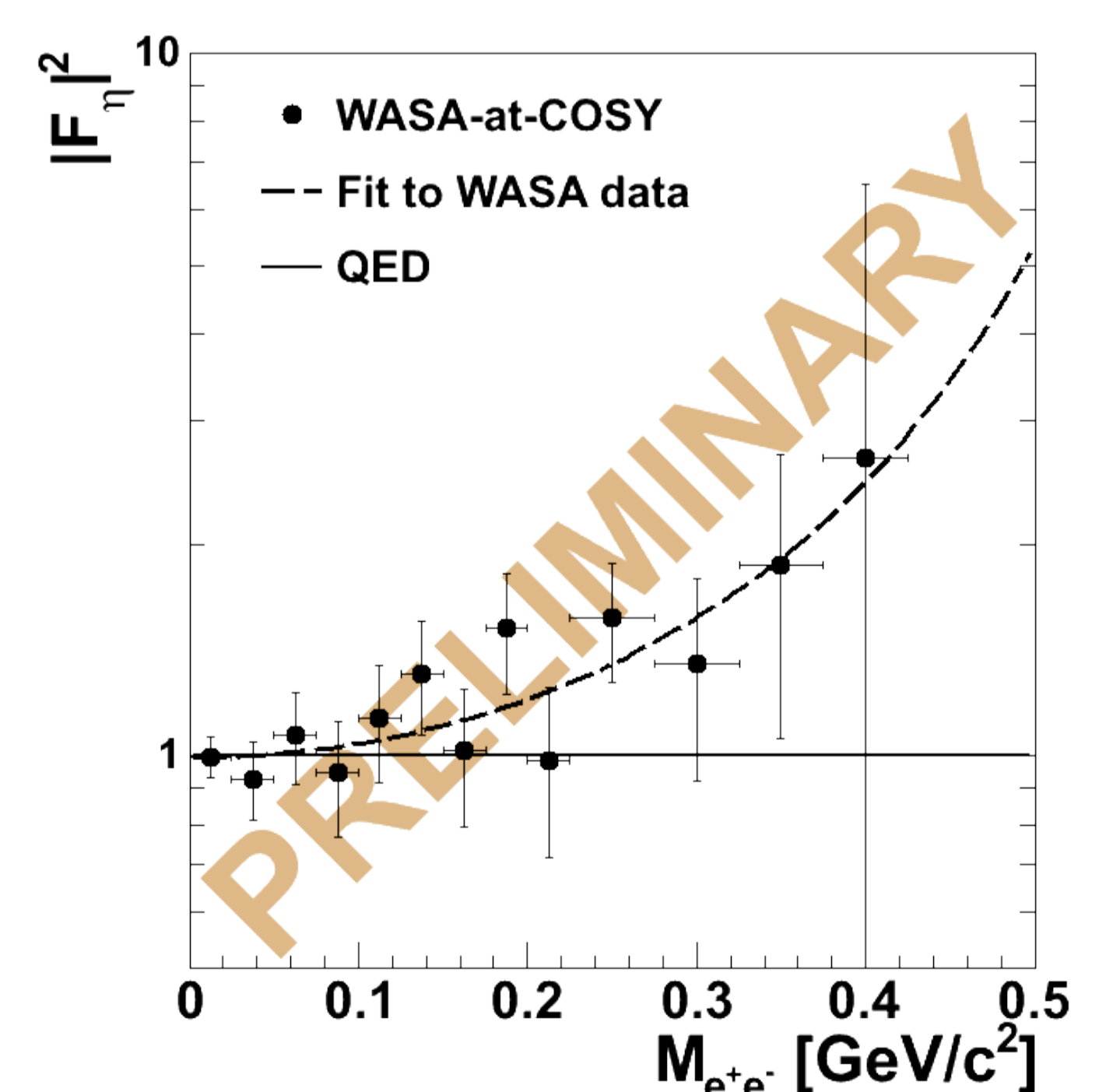
The analysis performed so far allowed for the extraction of 525 ± 26 events of the single Dalitz decay, up to the mass of e^+e^- pairs equal to $0.425 \text{ GeV}/c^2$.

The contribution to the background of the main η decay channels is shown in the adjoining figure. Our studies show that kinematic conditions used to suppress the amount of not wanted η decay channels contaminating the signal region is very efficient. The final contribution of this background is neglected.

The transition form factor squared shown as a function of the invariant mass of e^+e^- pairs corresponds to the ratio of the experimentally obtained distribution of the e^+e^- mass to the model prediction in which the transition form factor is constant in q and equals one.

Observed growth of the transition form factor squared with the e^+e^- mass confirms the not point-like structure of the η meson.

The slope parameter of the structure function provides the knowledge of the mean size of the transition region.



Outlook

Based on the results of studies made so far, we expect to obtain in the near future the biggest sample of $\eta \rightarrow e^+e^-\gamma$ events, where all particles have been measured explicitly.

Furthermore, investigations on this subject are carrying out in proton-proton collisions at WASA-at-COSY, where nearly 10^9 of η mesons have been produced already.

Bibliography

- [Lan85] L. G. Landsberg, Phys. Rept. 128, 301–376 (1985)
- [Hod12] M. Hodana, PhD thesis, Jagiellonian University, Poland, arXiv:1203.5756v1 (2012)