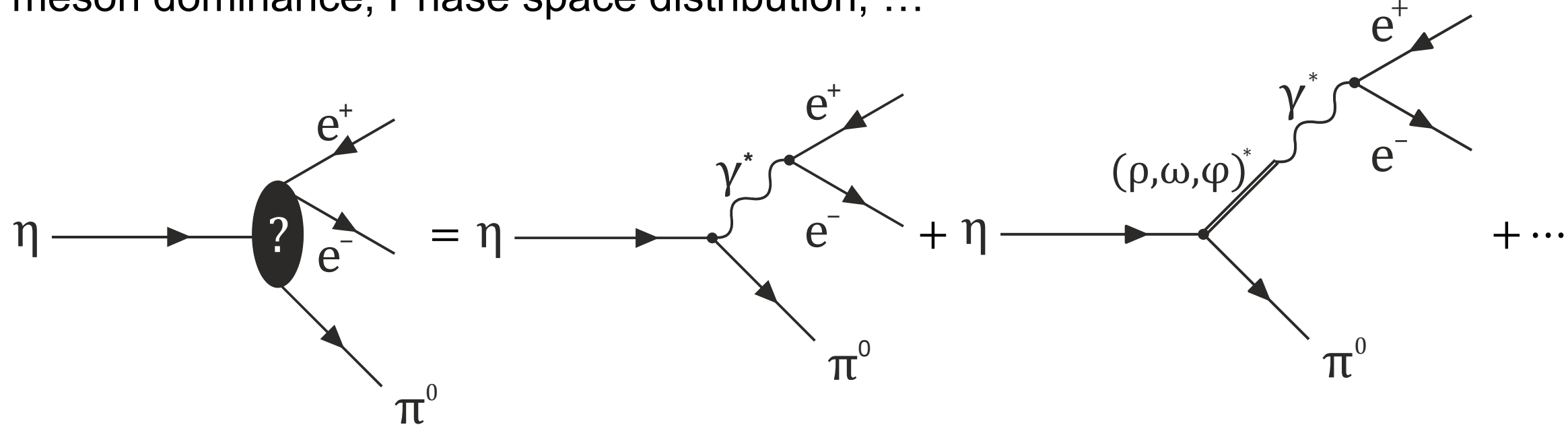


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Analysis of the C-violating Decay $\eta \rightarrow \pi^0 + \gamma^* \rightarrow \pi^0 + e^+ + e^-$ with WASA-at-COSY

Motivation

- Decay $\eta \rightarrow \pi^0 + \gamma^* \rightarrow \pi^0 + e^+ + e^-$ is forbidden since it violates the C -parity conservation
- Current upper limit assuming a phase space distribution:
 - $BR(\eta \rightarrow \pi^0 + e^+ + e^-) < 4 \cdot 10^{-5}$ [1]
- Aim: Lowering the existing upper limit by high statistics measurements at WASA-at-COSY to test the C -parity conservation with increased sensitivity
- Different model assumptions relevant for the analysis: Decay via a virtual photon, Vector meson dominance, Phase space distribution, ...



[1] K. Nakamura et al.: Review of Particle Physics. Journal of Physics G: Nuclear and Particle Physics, 37(075021):186, 2010

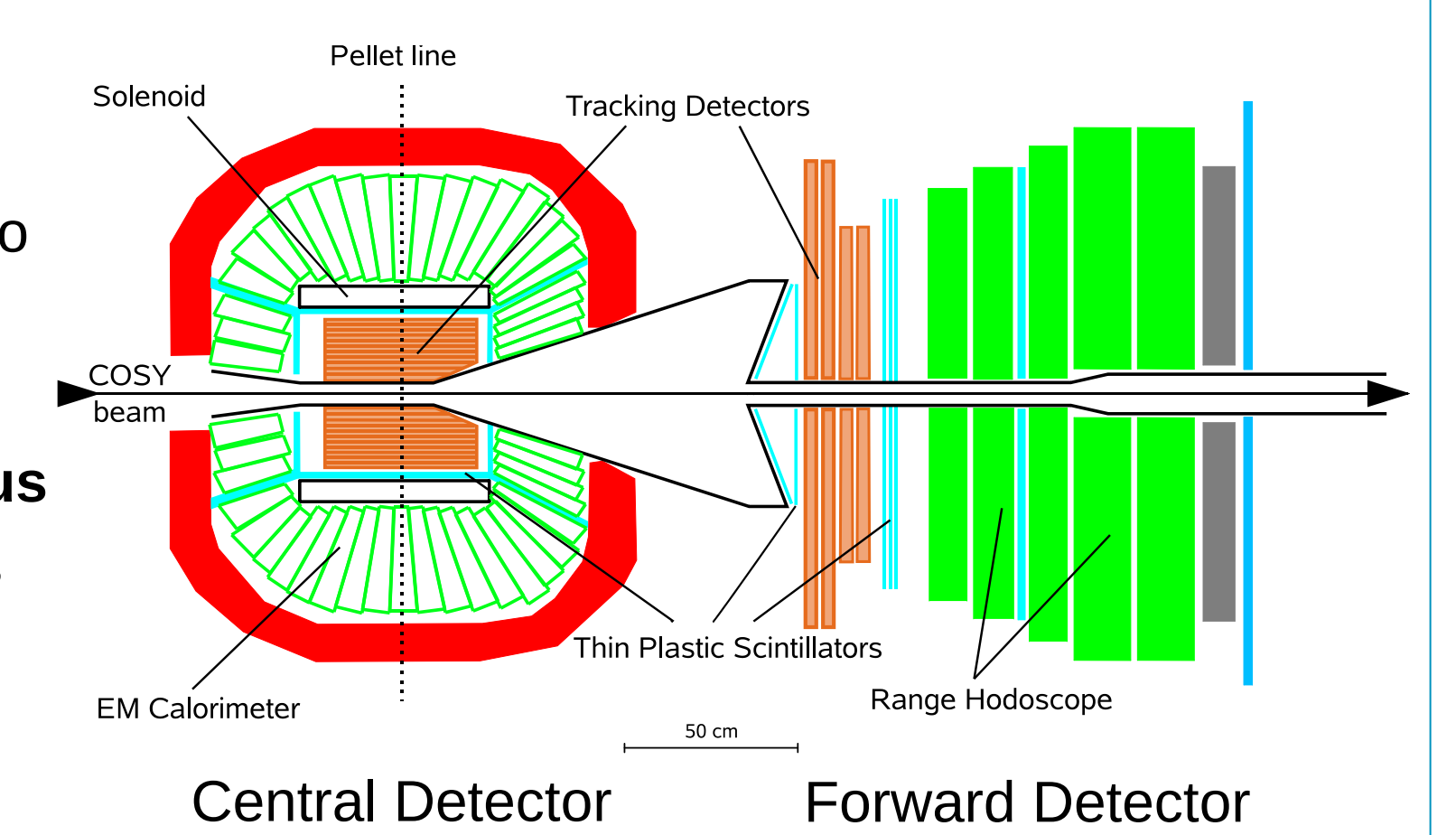
Experiment

COSY – Cooler Synchrotron

- Provides an (un)polarized proton or deuterium beam with momentum up to 3.7 GeV/c [2]

WASA – Wide Angle Shower Apparatus

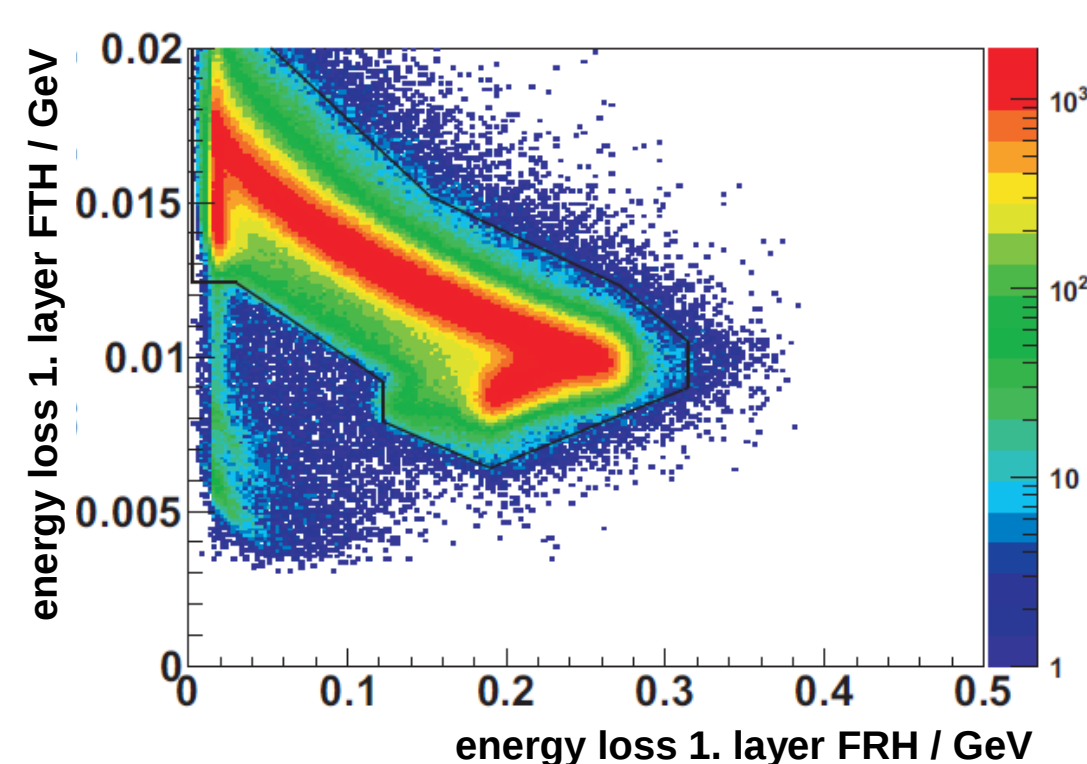
- Frozen hydrogen or deuterium pellets as an internal target
- The central part can detect neutral as well as charged particles with a near 4π -acceptance
- The forward detector is used for detecting charged particles like protons, deuterons and He nuclei [3]



[2] R. Maier, Nucl. Instrum. Meth., doi:10.1016/S0168-9002(97)00324-0
[3] H.-H. Adam et al. (WASA-at-COSY Collaboration), arXiv:nucl-ex/0411038

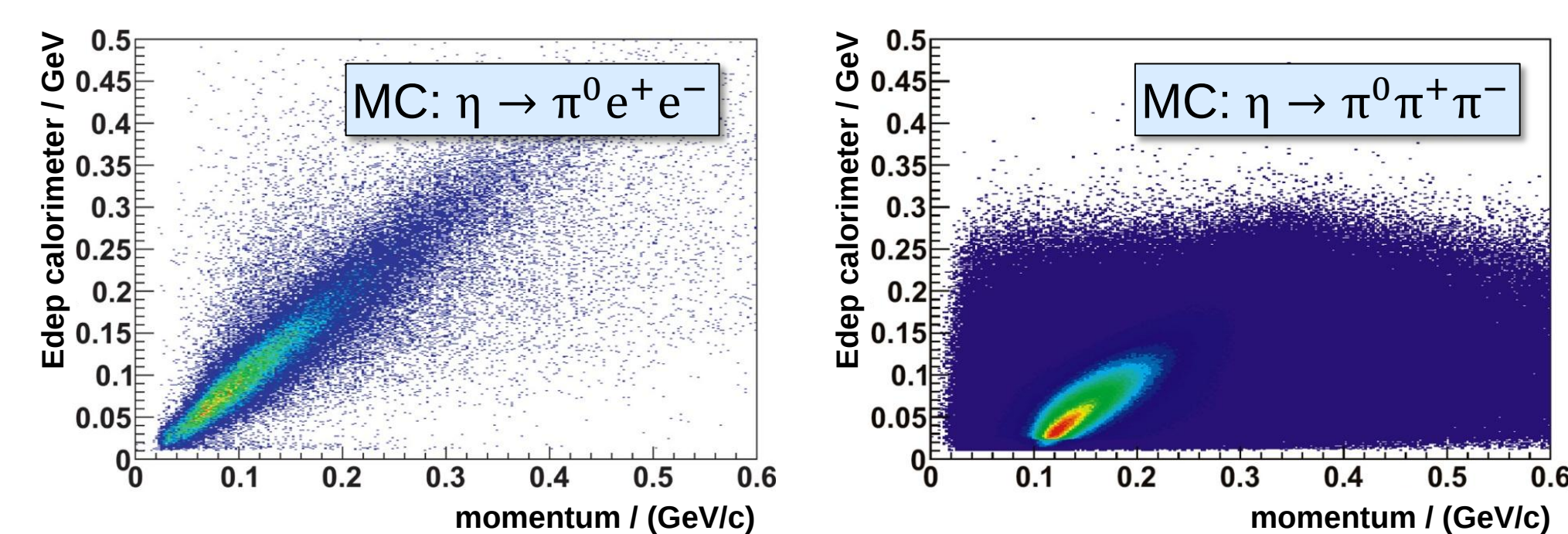
Analysis

- $\sim 30 \cdot 10^6$ $p + d \rightarrow {}^3\text{He} + \eta$ events on disc from two beam times:
 - 2008: $\sim 10 \cdot 10^6$ η -events
 - 2009: $\sim 20 \cdot 10^6$ η -events
- Preselection on $p + d \rightarrow {}^3\text{He} + X$ events via ${}^3\text{He}$ identification in ΔE - E plot (energy loss in Forward Trigger Hodoscope versus energy loss in Forward Range Hodoscope)

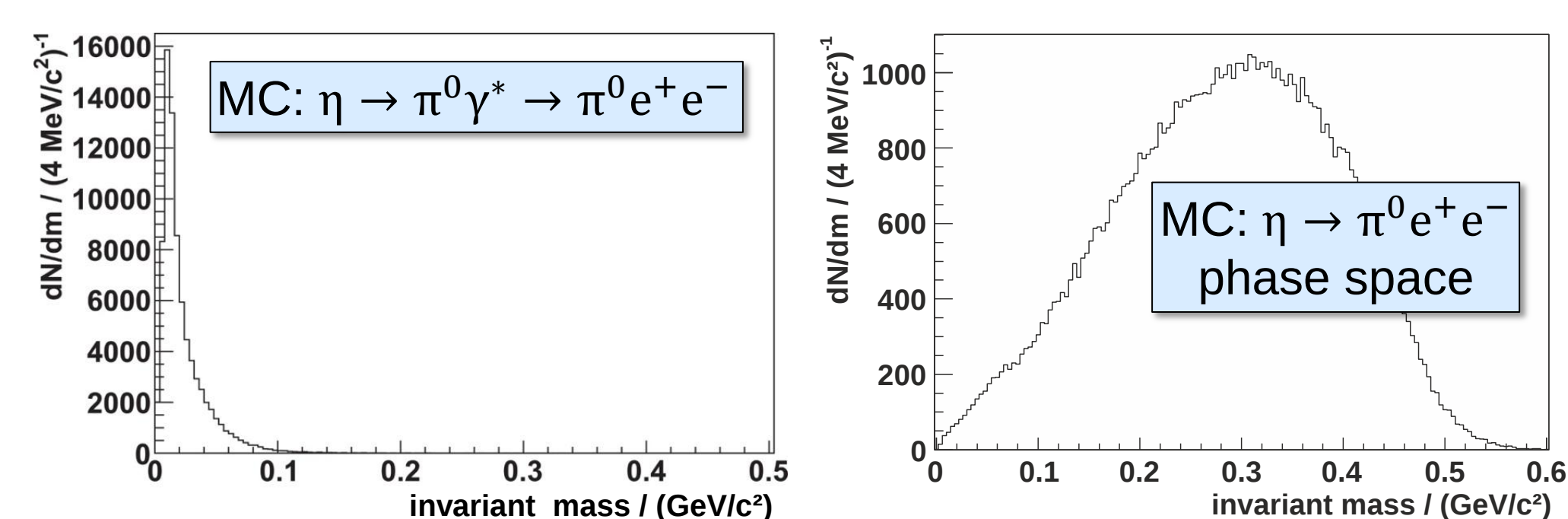


- Preselection on the signature of the decay $\eta \rightarrow \pi^0 + e^+ + e^- \rightarrow \gamma + \gamma + e^+ + e^-$:
 - 2 neutral particles in central detector (2γ)
 - 1 positively and 1 negatively charged particle in central detector (e^+, e^-)

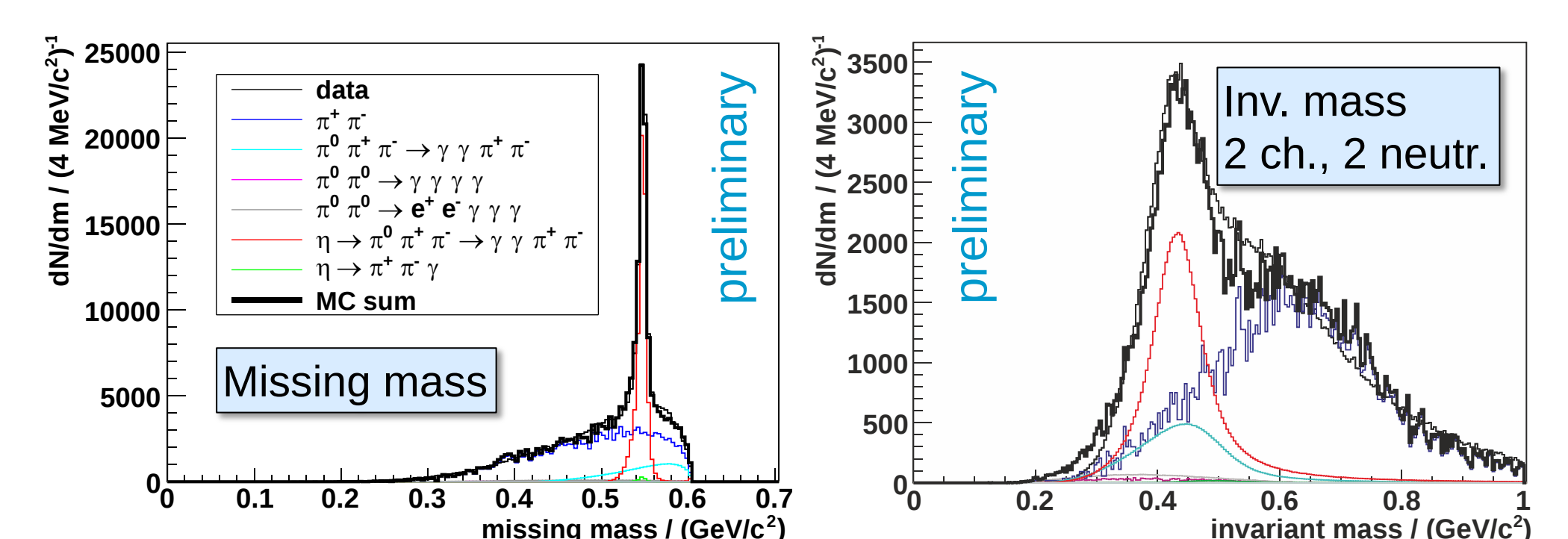
- Determination of further selection conditions by simulating all possible background reactions like direct (multi-)pion production and other η -decay channels
- Discrimination of electrons and pions by energy versus momentum correlation



- Invariant mass distribution of the lepton pair is model dependent



- Fitting of the measured data (2008) with a Monte Carlo cocktail using the same fit parameters for all differential spectra
 - Result: Accurate description of the observed data



- Determination of the optimal selection conditions via an evaluation function for all cuts:

$$G = S_R \frac{S_R}{B_R}$$

S_R : relative signal
 B_R : relative background

- Use Monte Carlo data and vary cuts to find the maximum of the evaluation function G

Preliminary Results

- 2008 data analyzed by A. Winnemöller, PhD thesis "Analyse des verbotenen η -Meson Zerfalls $\eta \rightarrow \pi^0 + e^+ + e^-$ am Experimentaufbau WASA-at-COSY", 2011:
 - Overall detection efficiency: After applying the optimal set of cuts 9920 out of 10^6 simulated $\eta \rightarrow \pi^0 + \gamma^* \rightarrow \gamma + \gamma + e^+ + e^-$ events remain
 - According to simulations the signal to background ratio is $1/1.7 \cdot 10^6$ and only one background event is expected to pass all cuts
 - Experiment: After applying all cuts on the measured data one out of $1.7 \cdot 10^8$ events remains

Outlook

- Analysis of $\sim 20 \cdot 10^6$ $p + d \rightarrow {}^3\text{He} + \eta$ events from 2009 in progress
- Decay model independent analysis
- Significantly more $p + p \rightarrow p + p + \eta$ events on tape for analysis
- ➔ New, model independent upper limit for the branching ratio of the η -decay channel $\eta \rightarrow \pi^0 + e^+ + e^-$ can be achieved