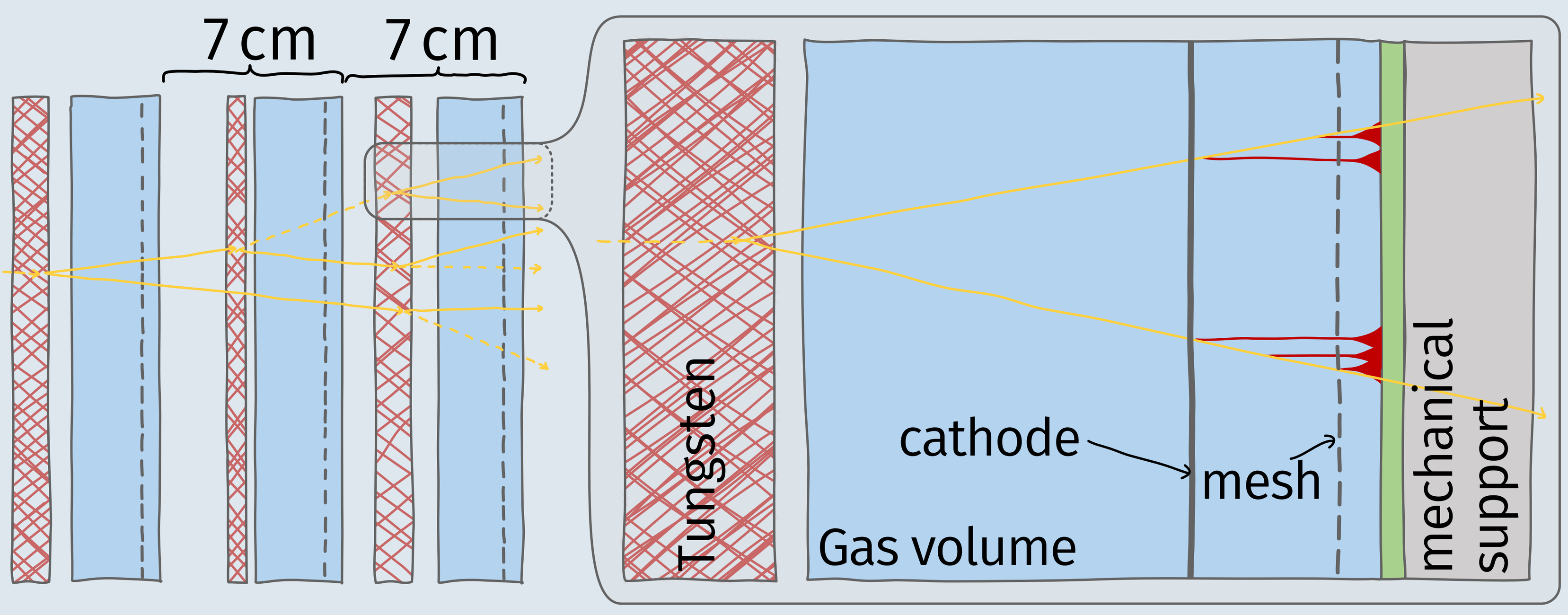
Detection of collinear high energetic di-photon signatures with Micromegas Detectors

Introduction

- significant interest in weakly interacting, light particles in recent years, e.g. axions [1]
- when produced at high energies, may decay in two collinear photons [2]
- dominant background: single high-energetic photons
- standard calorimeter not able to differentiate the two
- **aim:** discriminate between high-energetic single and collinear di-photon events
- **potential solution:** use simple and compact pre-shower detector based on Micromegas detectors

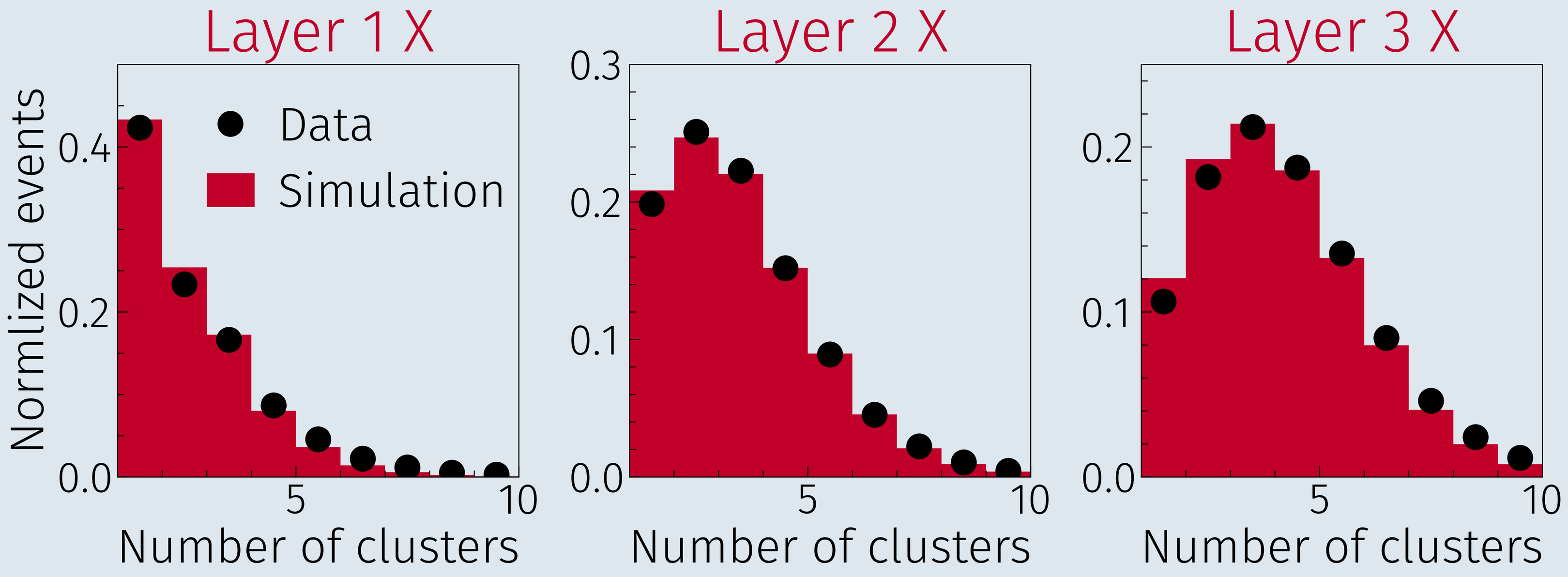
Detector Design



- **cheap and compact detector**: 230 mm depth
- three layers of absorber and active detectors
- 3/6 mm thick tungsten plates as absorber material
- 2D resistive bulk Micromegas with an active area of $10 \times 10\,\mathrm{cm}^2$ with 360 strips in each layer
- initial tests with 855.1 MeV electron beam at MAMI

Simulation

- uses `Geant4` and simplified charge simulation based on charge distributions extracted from test beam data
- charge added to strips around gas interaction with scaled charge distribution
- gain factors tuned and simulation setup verified with test beam data to match charges and cluster number
- high energetic photon samples simulated with photon energies of 100 GeV to 7 TeV and di-photon distances of 0 to 2 mm

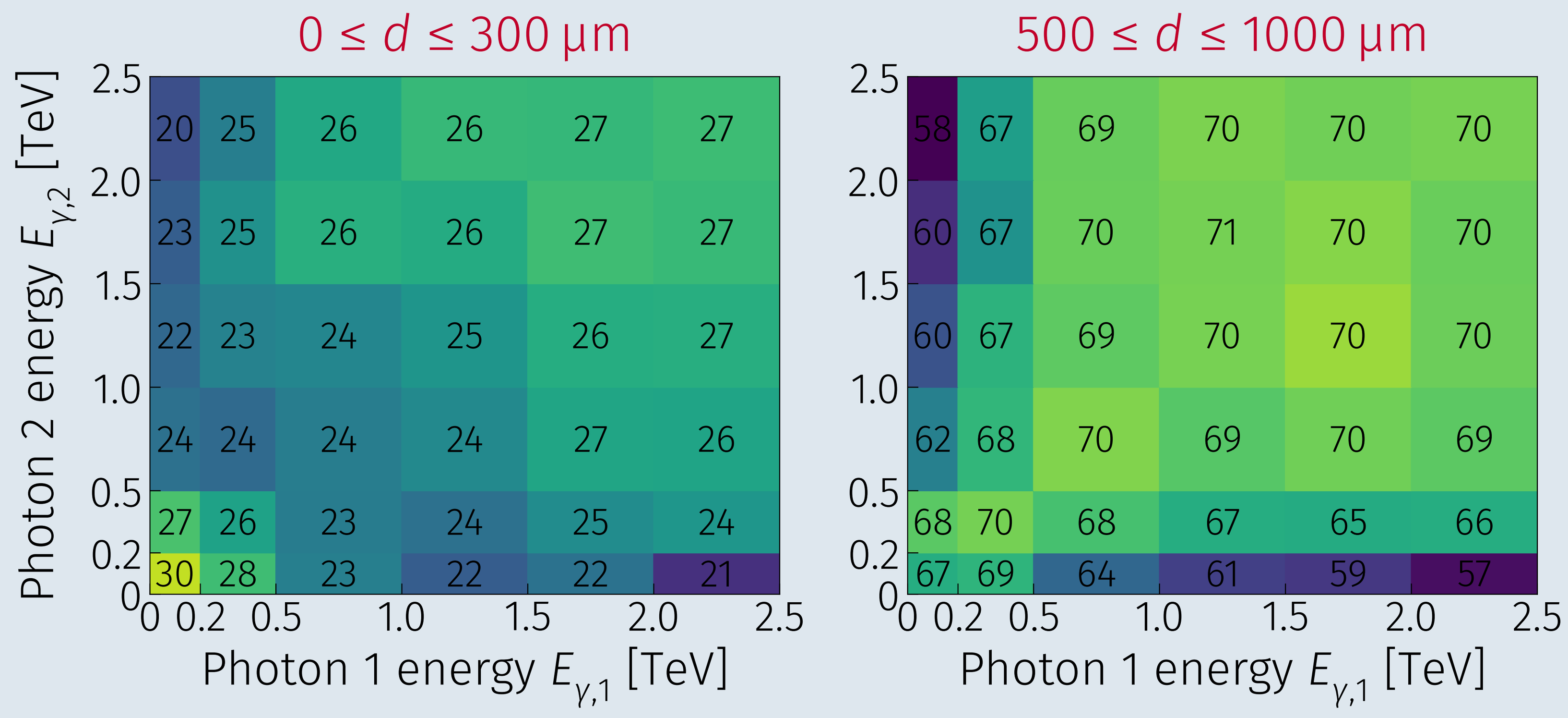


Di-photon identification

- energy deposits and spatial distribution are different between single and di-photon events
- use neural networks to classify events with charges on each strip and total event energy as the inputs
- energy smeared to reflect resolution of $10\,\%/\sqrt{E}$
- network architecture contains 1D convolution with charges followed by dense layers after concatenating with the energy information
- single output neuron with range of 0 (single photon) and 1 (di-photon)
- trained on ≈ 10 million events

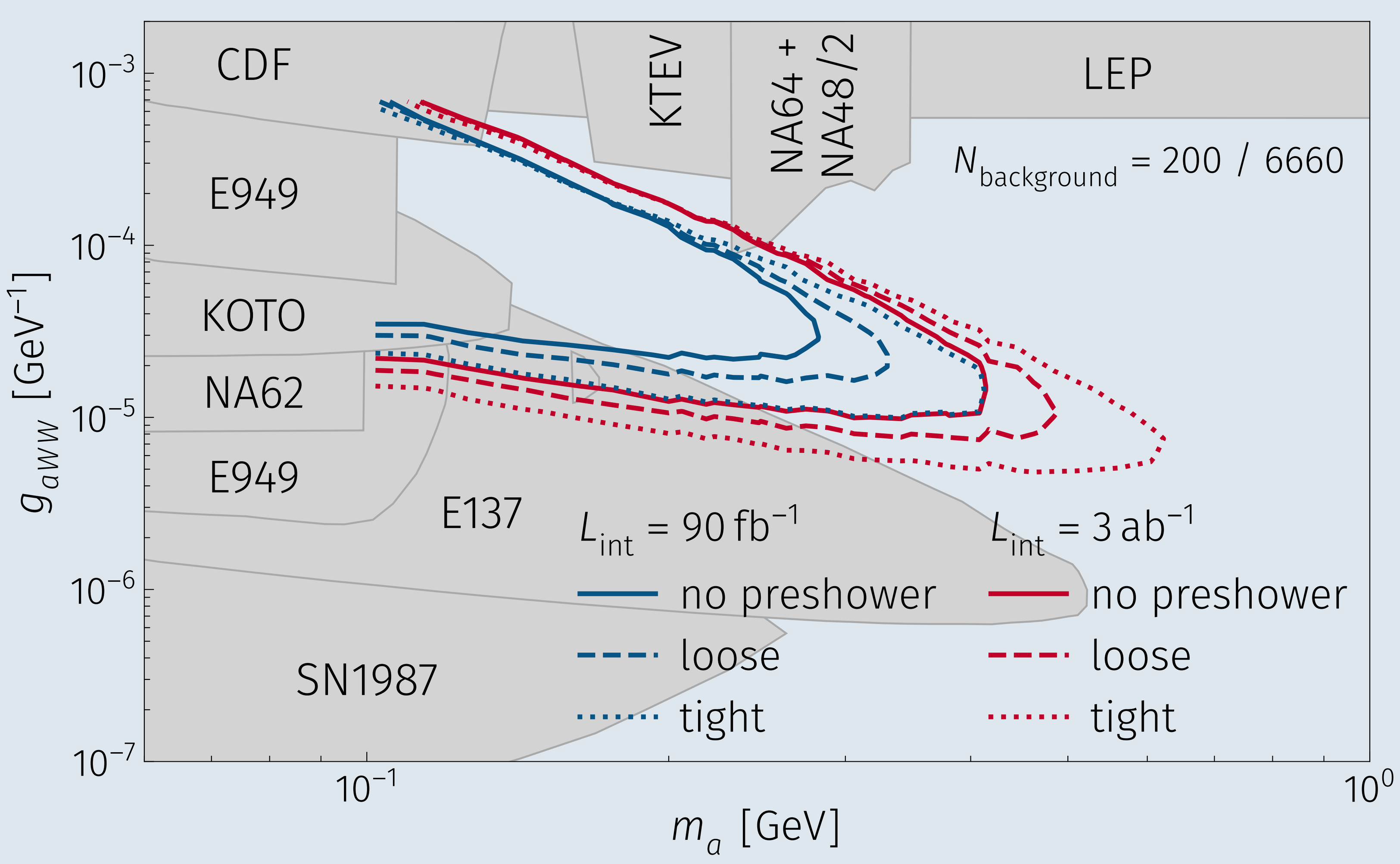
Results

- performance evaluated with simulated samples
- efficiencies at 90 % background rejection for different diphoton separations



Applications in ALP search experiments

- estimated the performance of the pre-shower detector for the FASER experiment [3]
- based on the event yield 1452 different combinations for ALP mass m_a and coupling g_{aWW}
- considering two working points: loose (90 %) and tight (99.5 % background rejection)



[1] S. Weinberg. "A New Light Boson?" In: *Phys.Rev.Lett.* 40 (1978), p. 223.
[2] J. L. Feng et al. "Axionlike Particles at FASER: The LHC as a Photon Beam Dump". In: *Phys. Rev. D* 98.5 (Sept. 18, 2018), p. 055021.
[3] FASER Collaboration. *FASER: ForwArd Search ExpeRiment at the LHC.* Jan. 2019. arXiv: `1901.04468`.

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Friedemann Neuhaus, Elisa Ruiz-Choliz, Matthias Schott
Institute for Physics, University of Mainz
JOHANNES GUTENBERG UNIVERSITÄT MAINZ