# Gain measurements of Chromium GEM foils

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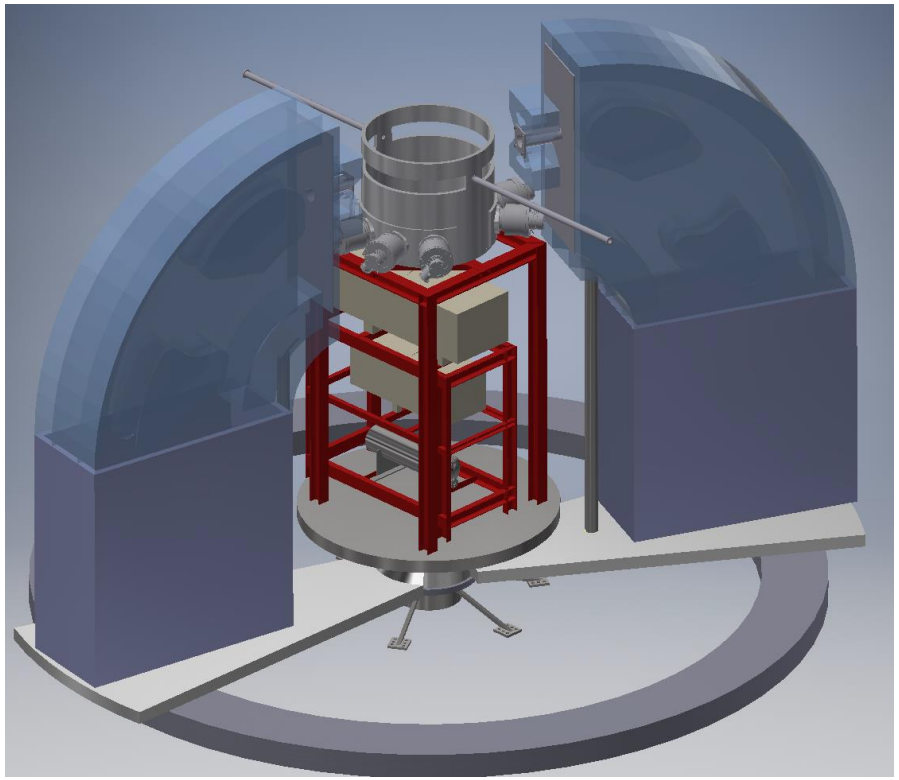
# Introduction

- **MESA** (**M**ainz **E**nergy-recovering **S**uperconducting **A**ccelerator):
  - New linear polarized electron accelerator being built at the Institute for Nuclear Physics in Mainz, Germany
  - Up to **105 MeV** @ **1 mA** (ERL mode)

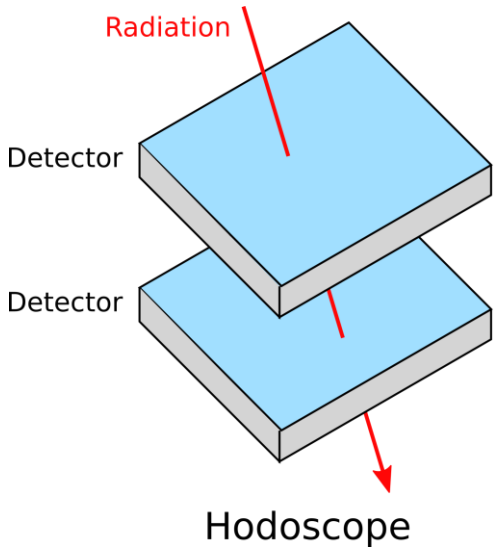
- **MAGIX** (**M**ES**A** **G**as **I**nternal target e**X**periment)
  - High precision physics including:
    - Search for the dark photon
    - Measurement of the proton radius
  - Internal windows-less gas target
  - Luminosity of **$10^{34}$ cm$^{-2}$ s$^{-1}$**
  - Magnet spectrometers to identify scattered particles
  - Focal plane detectors: **GEMs**



# Our interest in Chromium GEMs

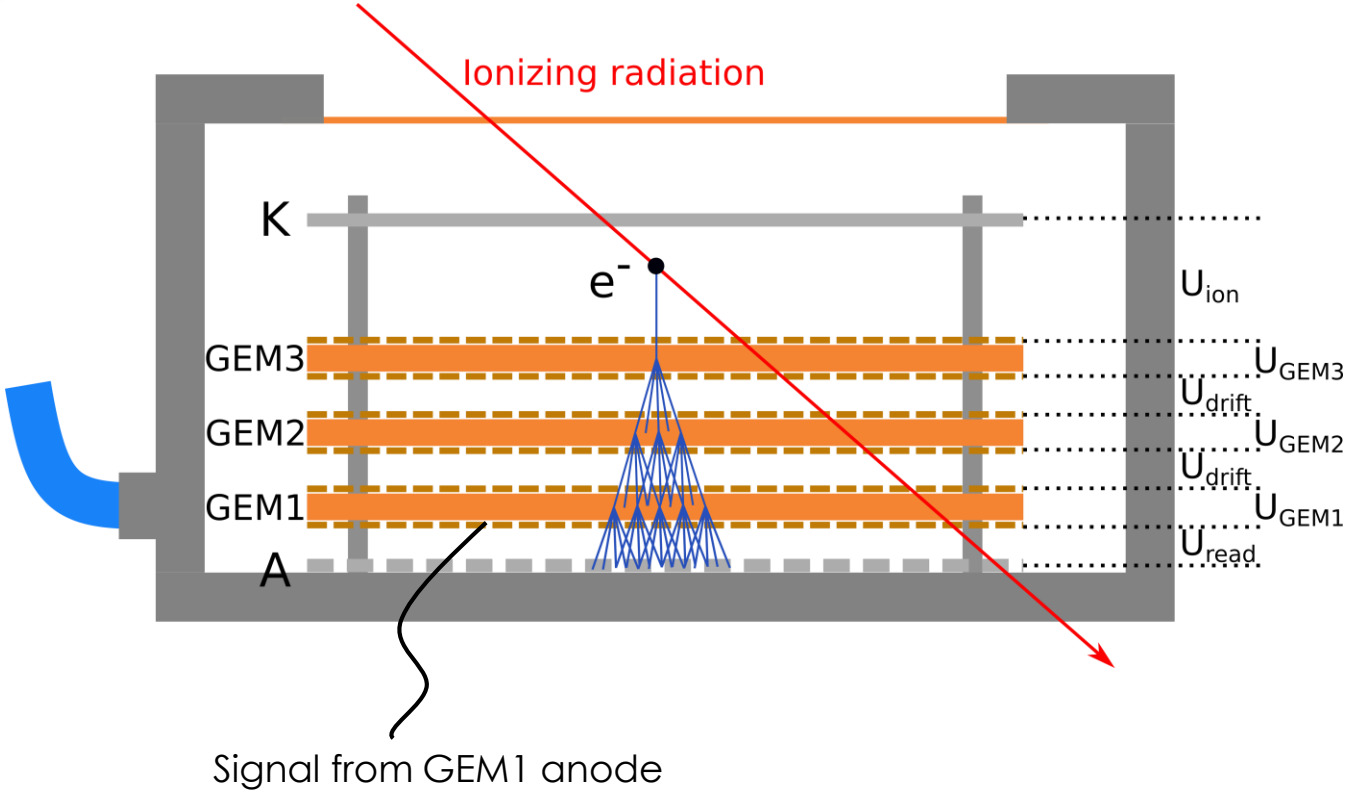

- Characterized Chromium GEMs to evaluate feasibility of GEM detectors in hodoscope mode for the MAGIX spectrometers

- Tested 10x10 $cm^2$ Chromium GEM foils
  - Conductive layer of 100 nm Cr (instead of 5 µm Cu)
  - Produced by CERN
  - Full Cr-GEMs and single sided Cr-GEMs with a regular copper side

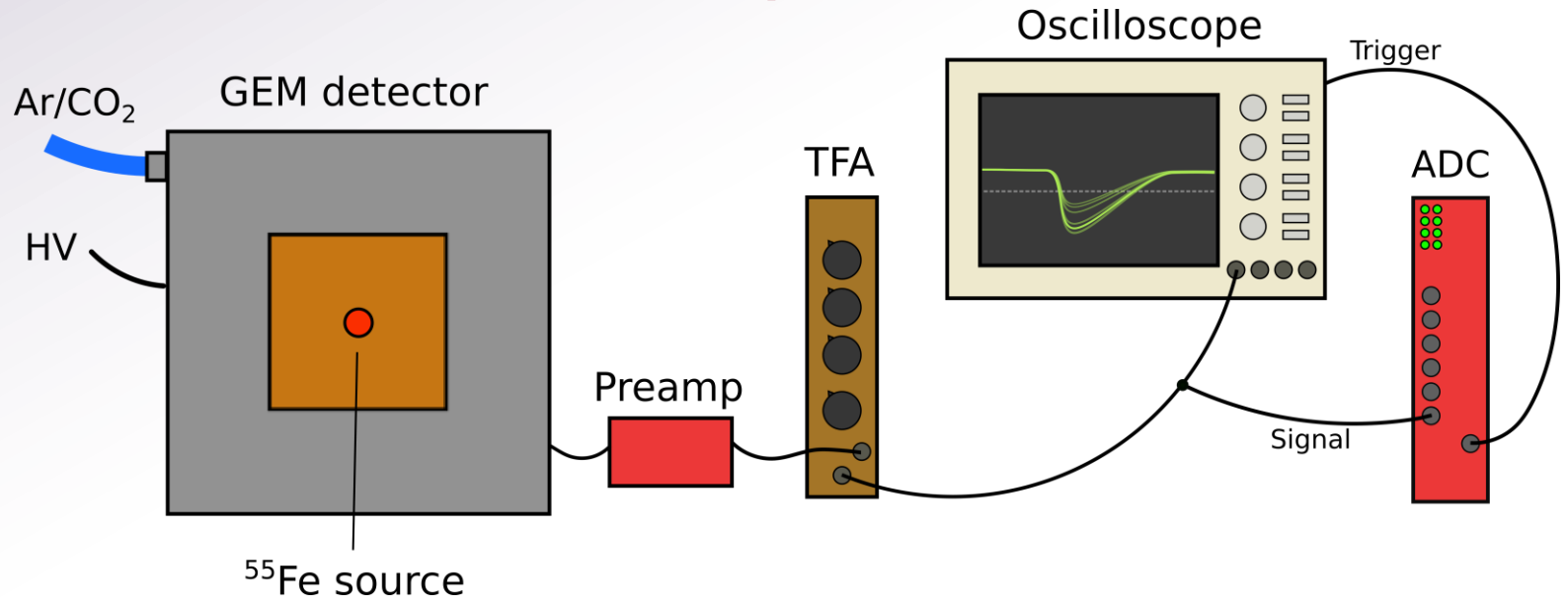


# GEM detector setup


- Triple GEM setup
- Default GEM voltage: 370 V
- Transfer fields: 200 V/mm
- Induction field: 400 V/mm
- Ionization gap: 5 mm
- Drift field: 100 V/mm
- Counting gas: 70% Ar, 30% $CO_2$
- Signal from GEM1 anode current

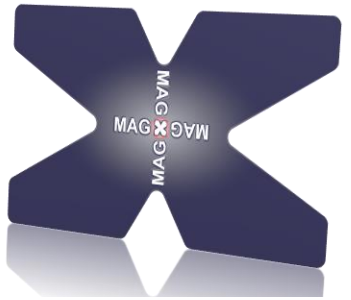


# Measurement setup




- $^{55}$FE source with photo energy of 5.9 keV in the center
- G1-current amplified and shaped, Trigger signal from oscilloscope
- Digitization of the signal with a peak sensitive ADC
- In addition: Signal from readout plane measured with APVs

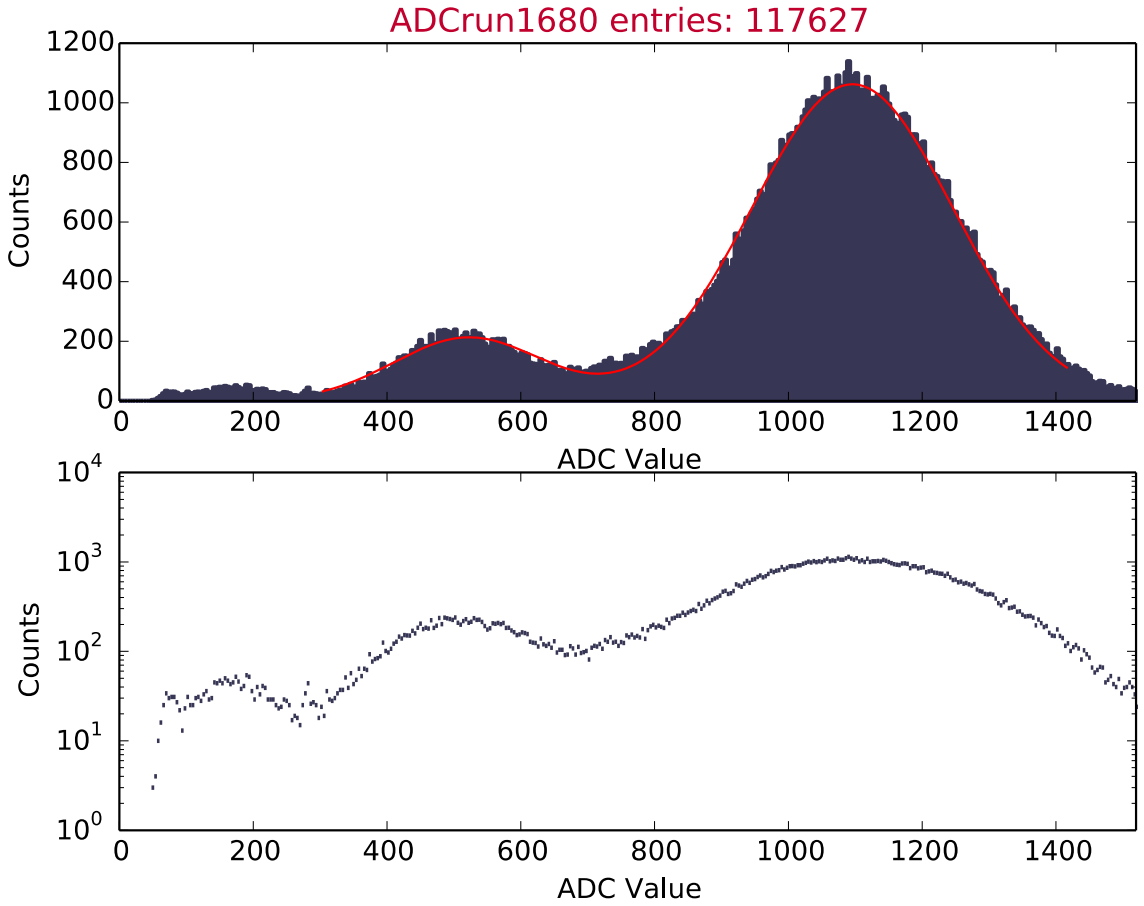
# $^{55}$Fe-spectra from the ADC




- Clear energy spectra
  - Photo peak at 5.9 keV
    - Energy resolution ≈ 14%
  - Escape peak at 3.2 keV

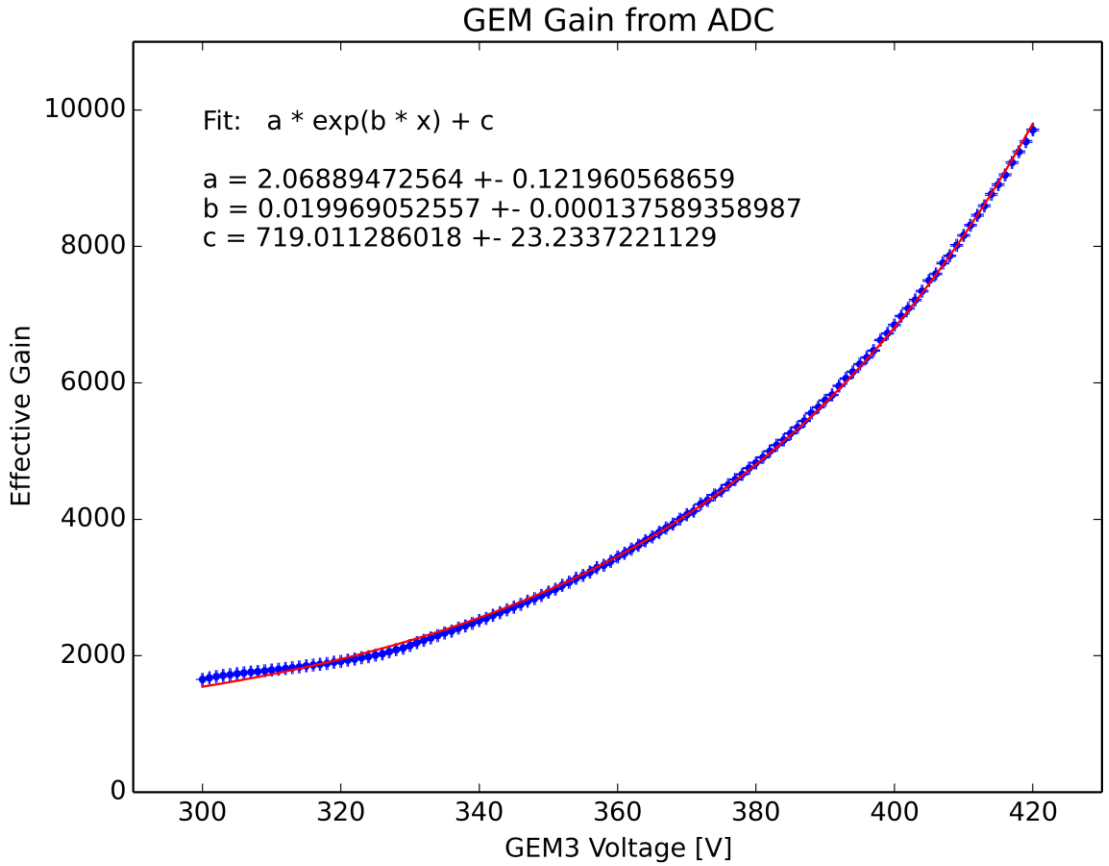
- **Effective Gain**:
  - $Q_{GEM1}/Q_{ionization}$
  - Setup calibrated with a test pulse generator

- Default setup (All GEMs @ 370 V):
  - Effective Gain ≈ 6840



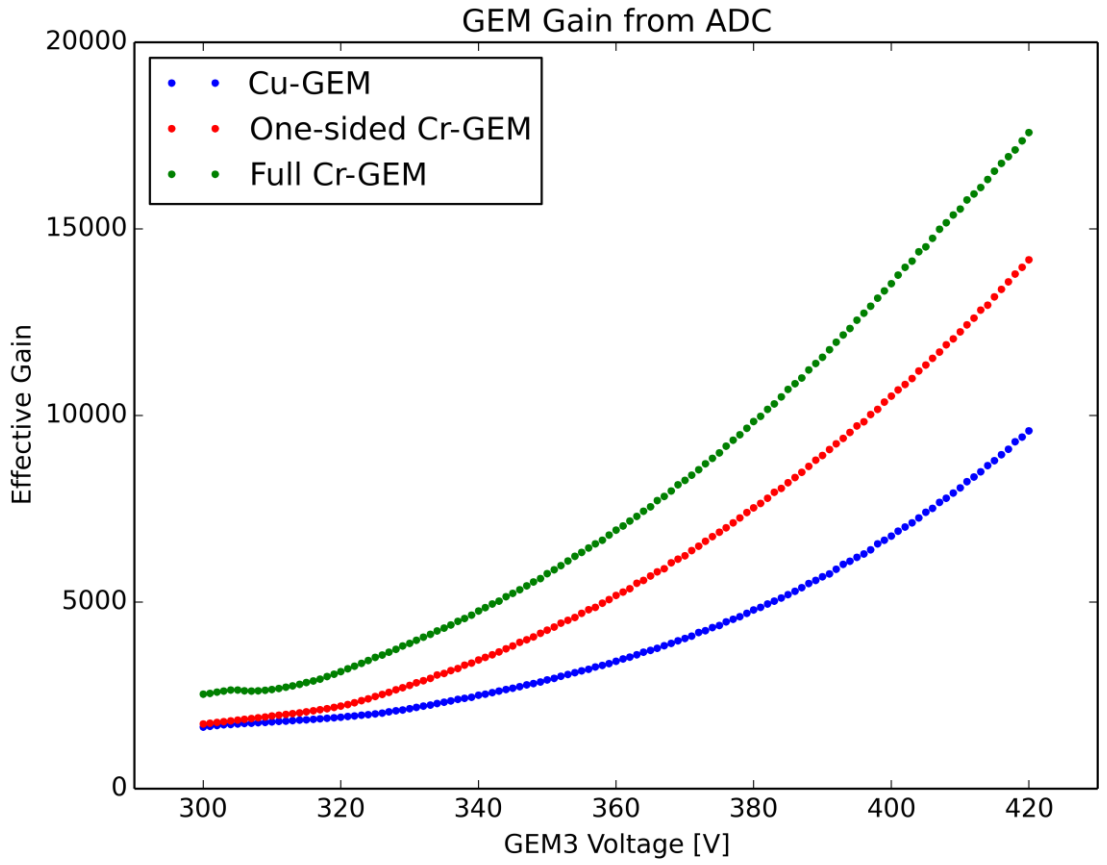
# Gain curve of copper GEMs (ADC)

- Acquired gain curve by variation of GEM3 voltage from 300 to 420 V
  - GEM1 and GEM2 constant at 370V
- Exponential rise
  - Eff. gain from ≈ 2000 – 10000

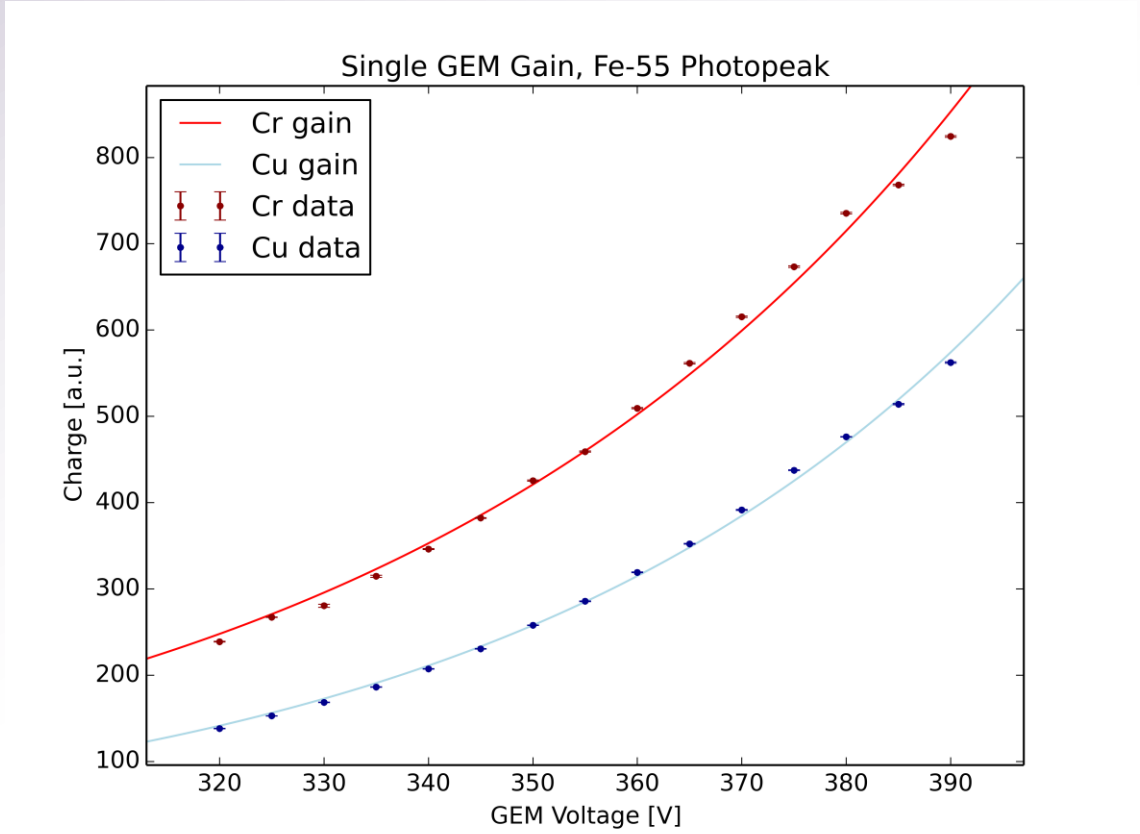


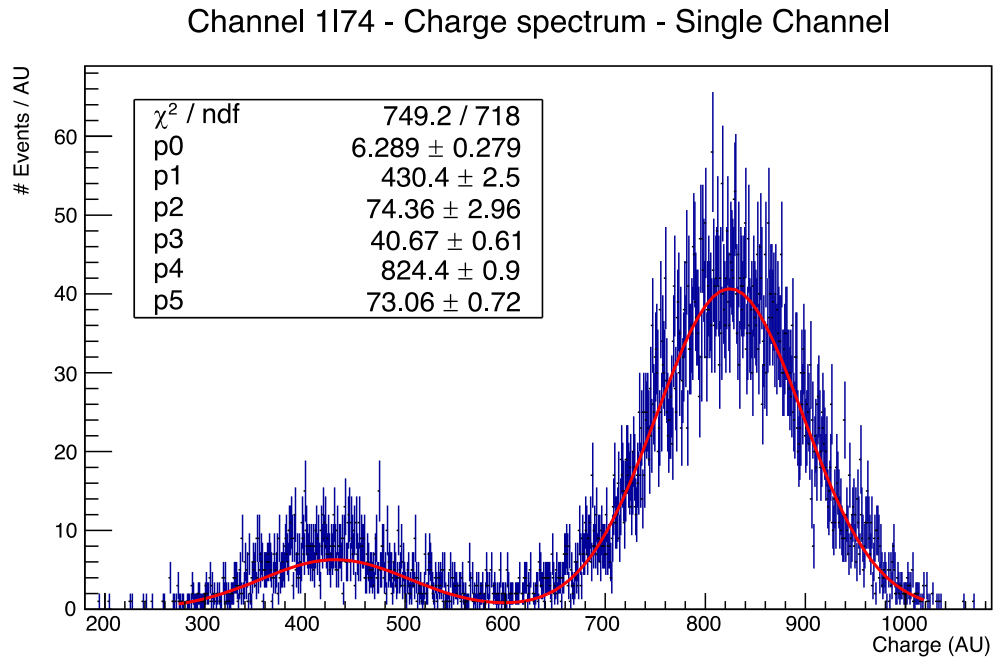
# Gain comparison for Cr GEMs (ADC)


- Cr-GEMs on G3 position
- Two types of chromium GEMs used
  - "One-sided" Cr-GEMs with one side made from copper (red)
  - Full Cr-GEM foil (green)
  - Cu-GEM gain in comparison (blue)
- Noticeable increase in gain over Cu-GEMs
- Stronger effect in Full Cr-GEM



# Confirmation from APV spectra

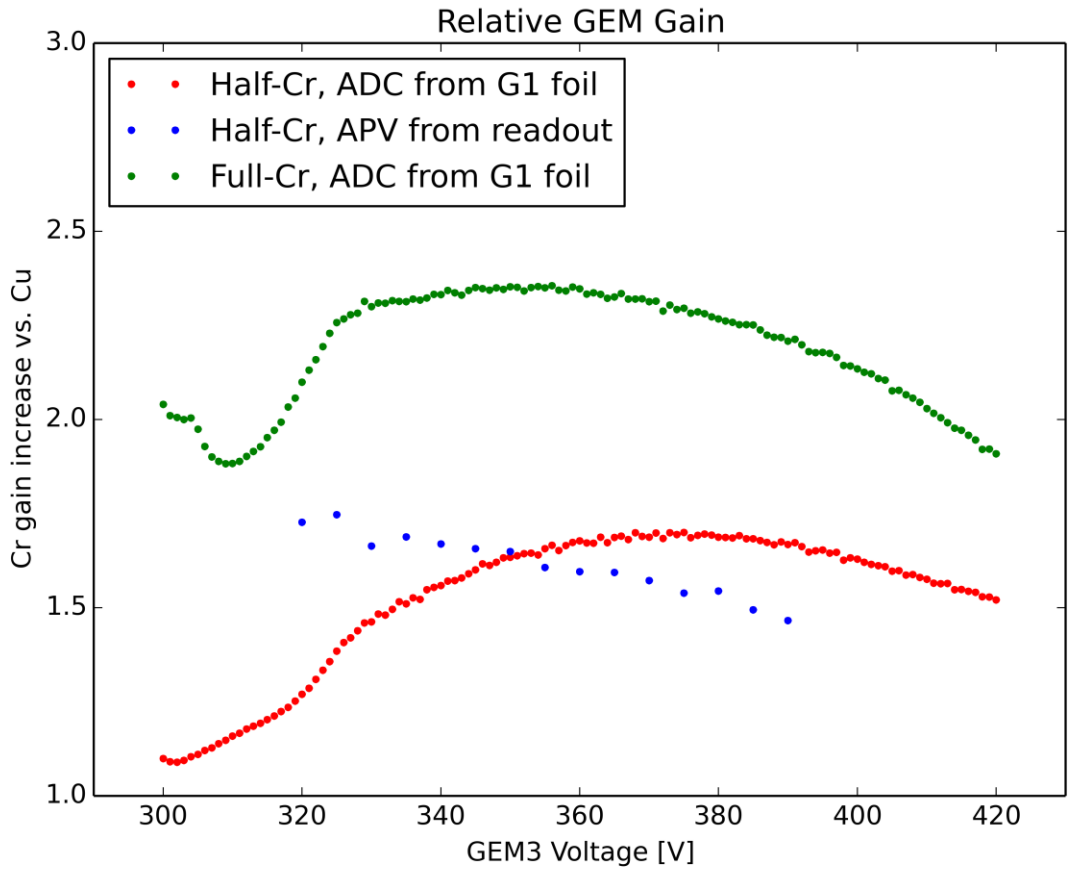



- Confirmed higher gain with measurements of the readout charge with APV-cards
- Only done for one-sided Cr GEM foils

# Relative Gain Cr vs Copper (ADC)

- Ratio of Cr-GEM to Cu-GEM gain
- Local maximum, lower for high voltages
- APV results from a different setup
  - Match the order of magnitude



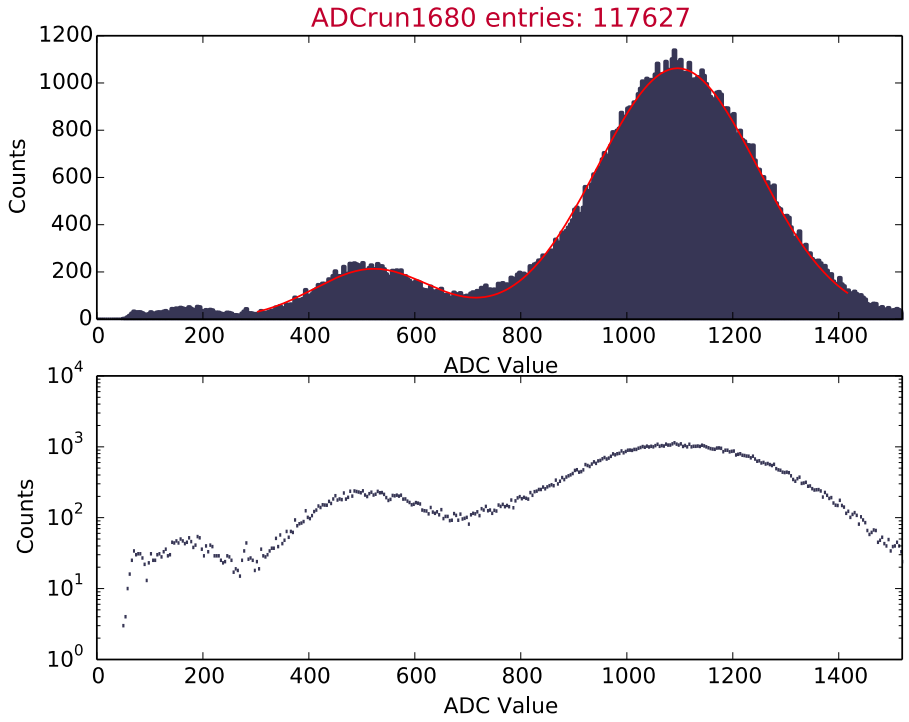
# Conclusion

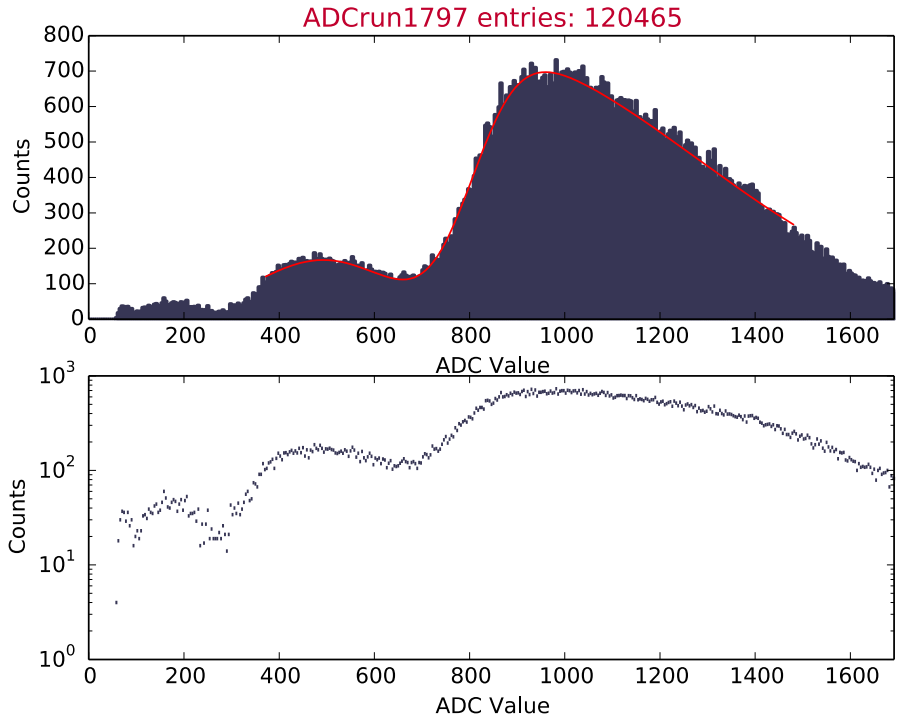

- Recorded spectra of $^{55}Fe$ to measure GEM detector gain
- Relevant increase of gain for single sided Cr GEM foils
- Double sided Cr GEM foil even higher than single sided Cr GEM
- Gain curves measured with the APV-cards from the readout plane confirmed these observations

# Outlook


- Continue systematic scanning for different positions of the Cr-GEM
- Compare multiple positions and different foils
- Redo the APV measurements
  - Check the relative gain curve
  - Check homogeneity
  - Compare GEM foil and readout signals
- Possible explanations for the higher gain?
  - Different charge up effects then in copper
  - Geometrical effects
  - Edge effects

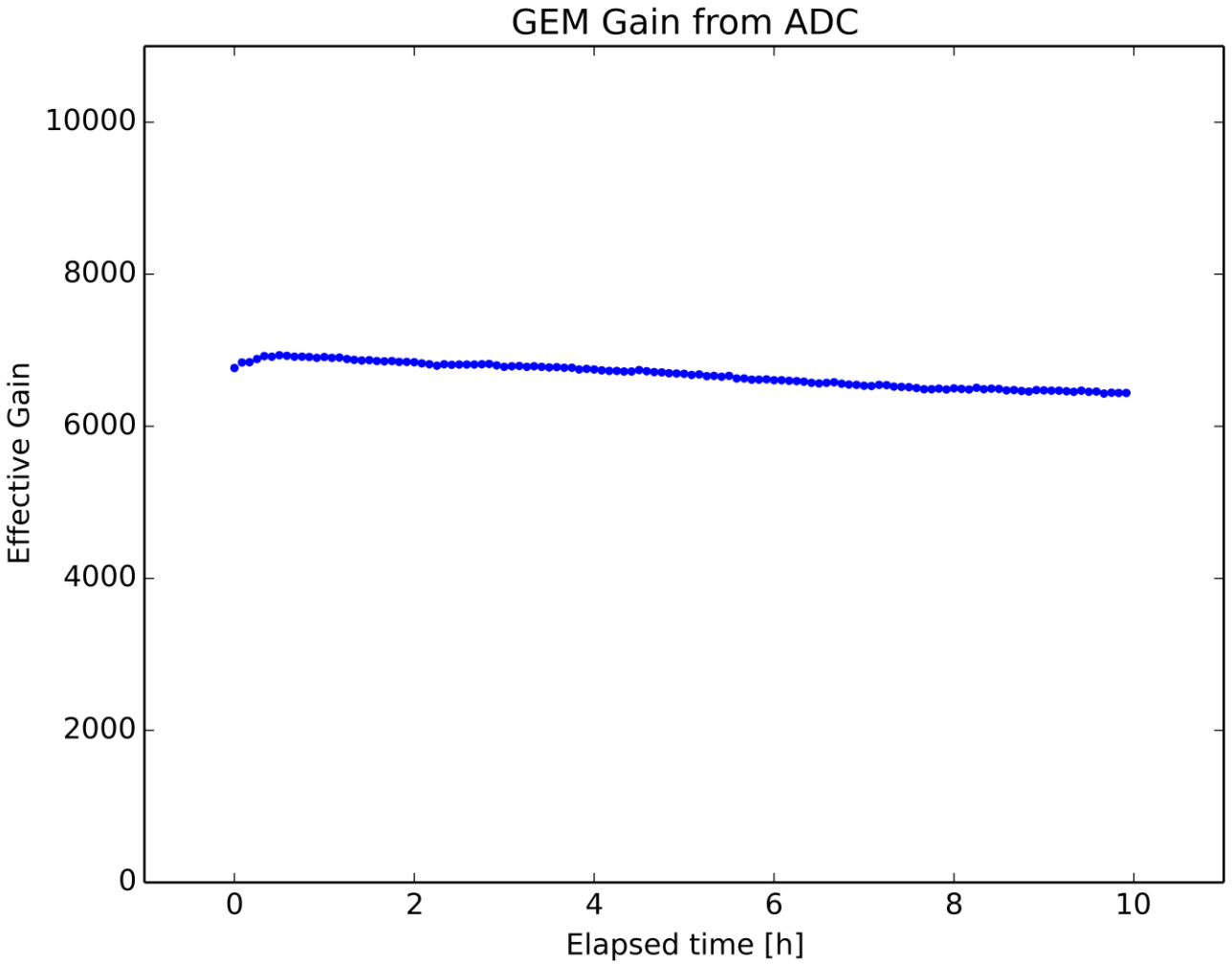
# An open question: Peak broadening at ADC spectra




- Charge up effects deform the Gaussian over time (~hours)
- Independent of GEM material
- Prevents us from analyzing the energy resolution from the ADC spectra

# Charge up




- 10 hours at constant GEM voltages (370 V)
- No significant shift in peak position
  - No influence in gain curves

SFB 1044

PRISMA

# THANK YOU FOR YOUR ATTENTION!

http://magix.kph.uni-mainz.de

Massachusetts Institute of Technology

University of Ljubljana

Westfälische Wilhelms-Universität Münster

Johannes Gutenberg Universität Mainz

JG|U

# Backup: Energy resolution


- **Energy resolution**: Ratio of photo peak width to mean
- APV measurements showed a better energy resolution for Cr GEM beyond the Cu-gain-range
- Peak broadening prevented us from further investigation