Construction and characterization of a GEM prototype detector for MAGIX

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MAGIX Collaboration Meeting 2017

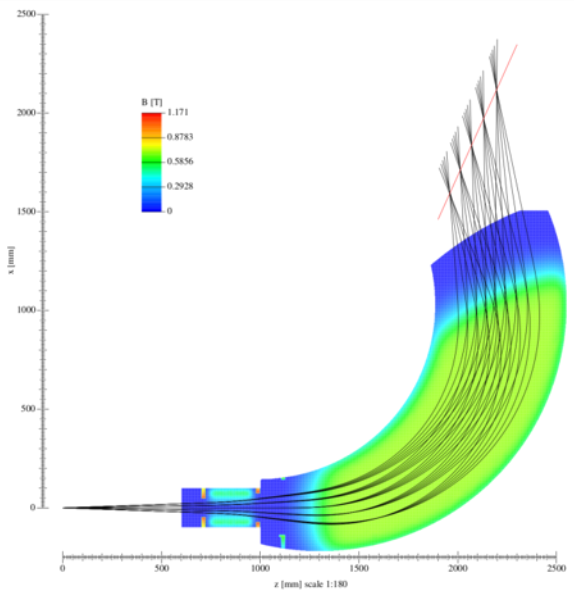
Outline

- detector challenges
- construction of a GEM prototype detector
- data acquisition
- laboratory measurements
- measurements in the electron beam of MAMI
- summary and outlook

Detector challenges

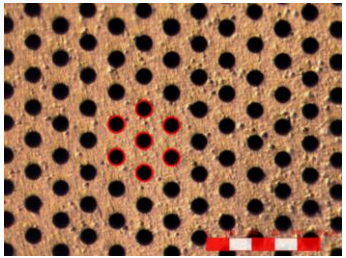
- precise detector system
  - active area: 1.20 x 0.30 m^2
  - spatial resolution < 50 µm
  - multiple points for track reconstruction
  - high rate capability O(1 MHz)

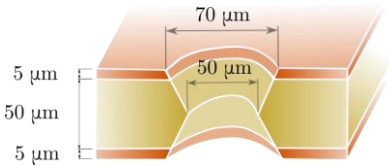
- alternative to drift chambers

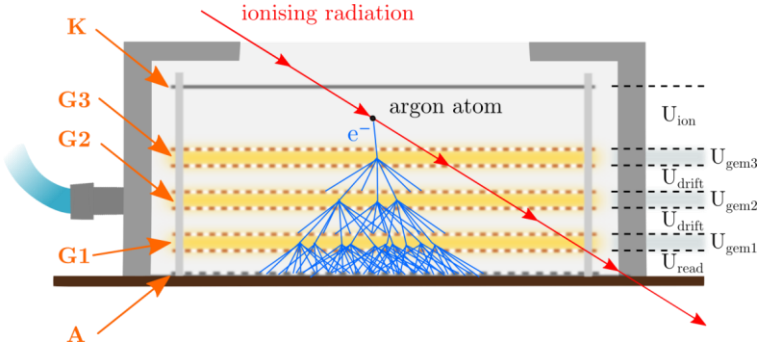


GEM detectors

- they satisfy this criteria
- GEM foils have a low radiation length as well



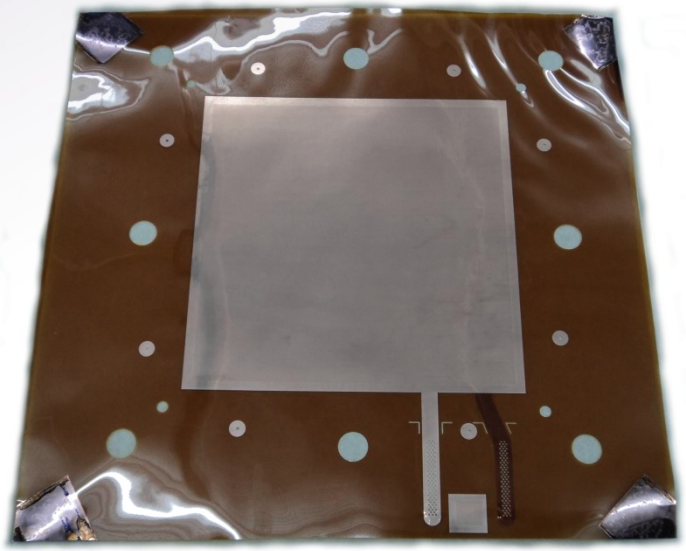




- high electric fields in the holes ➡ e^- avalanche

Construction of a GEM detector

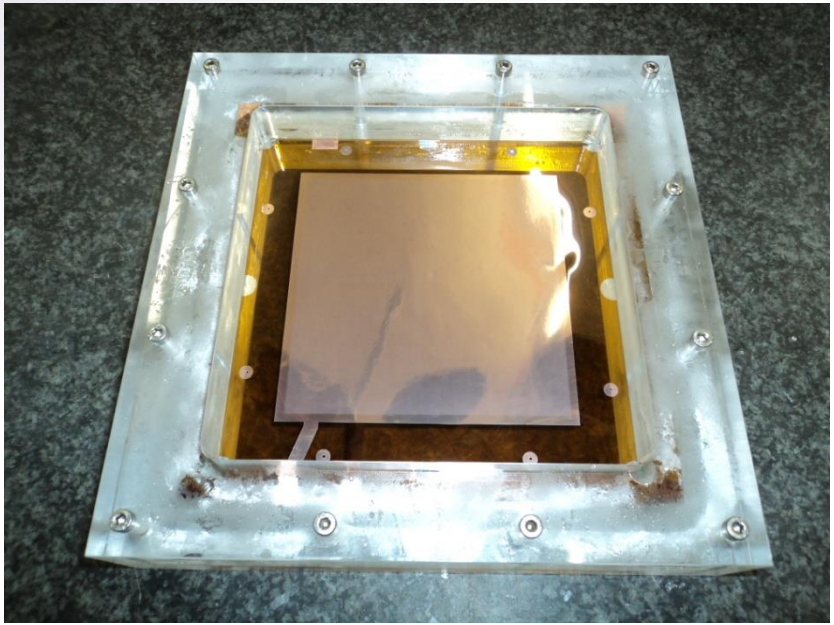
- stretching and framing the foils



- condition at delivery
- active area:
  10 x 10 cm^2
- electrical contacts
- leakage current
  < 10 nA @ 500 V

Construction of a GEM detector

- stretching and framing the foils

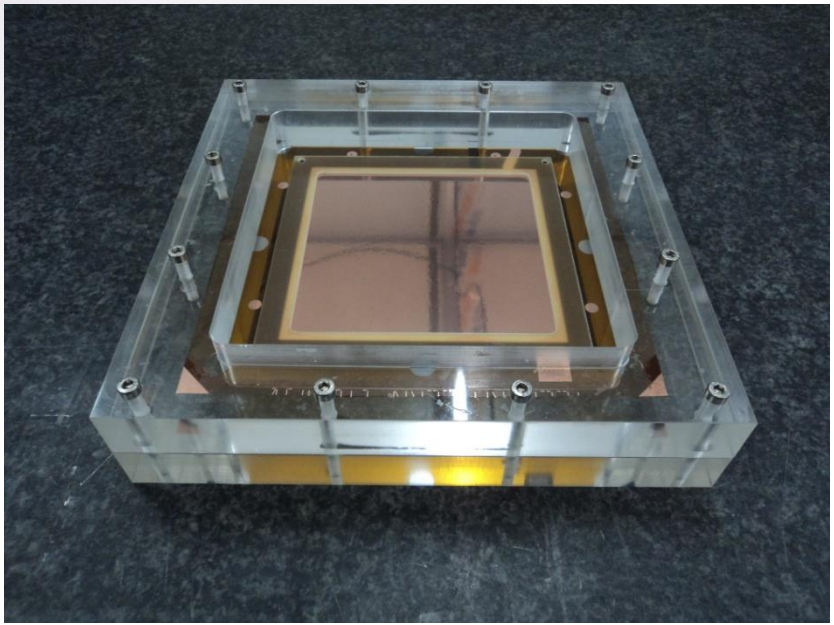


- coefficient of thermal expansion is different
- cooled frame for stretching
- laboratory oven

➡ stretching

Construction of a GEM detector

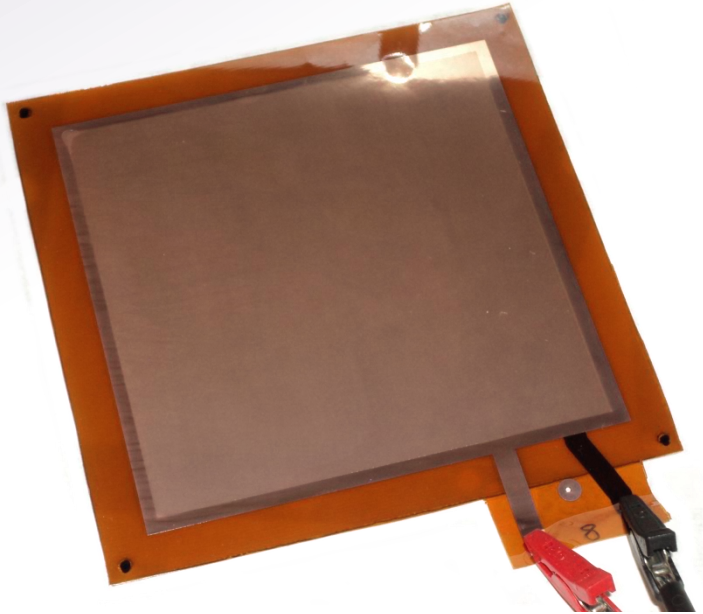
- stretching and framing the foils



- glue a fibreglass frame on the foil
- cures in the laboratory oven
- cut into shape
- check leakage current again

Construction of a GEM detector

- stretching and framing the foils



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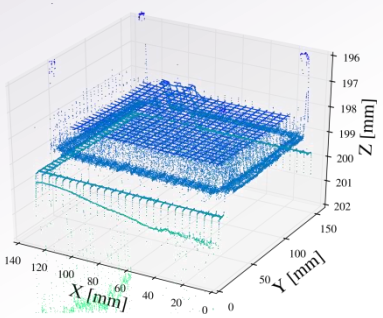
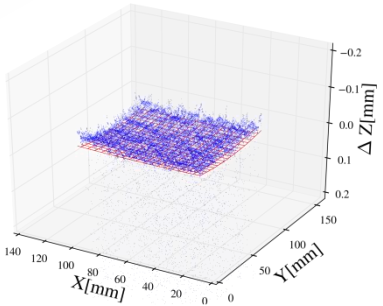
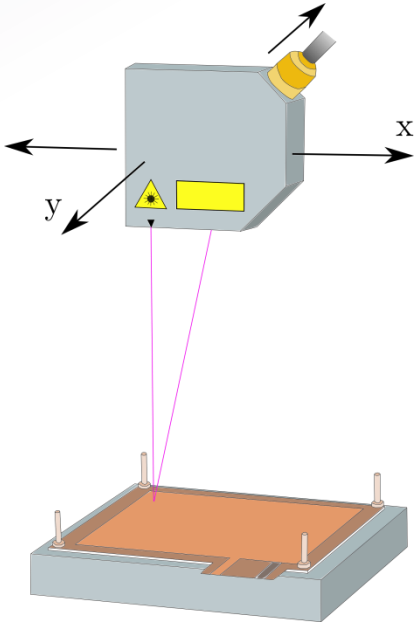
Construction of a GEM detector

- profile measurements of the foils



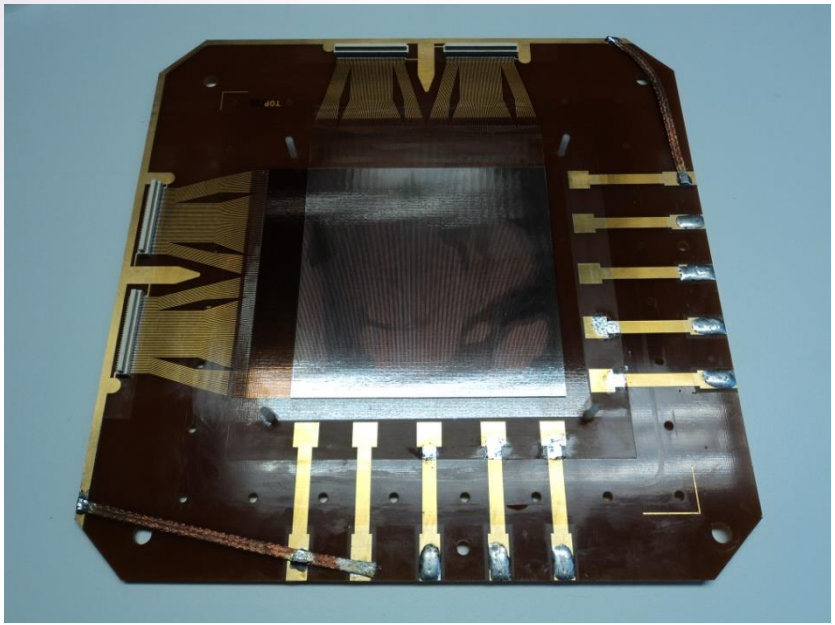




- evaluate the stretching procedure
- laser sensor
- plane table
- curvature much lower than for pre-framed ones

Construction of a GEM detector

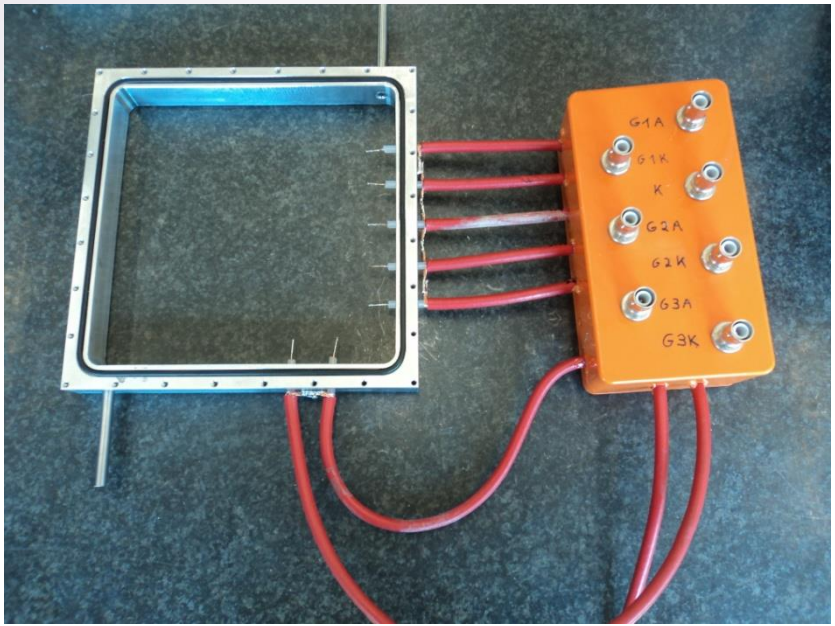
- additional detector components needed



- 512-channel readout board

Construction of a GEM detector

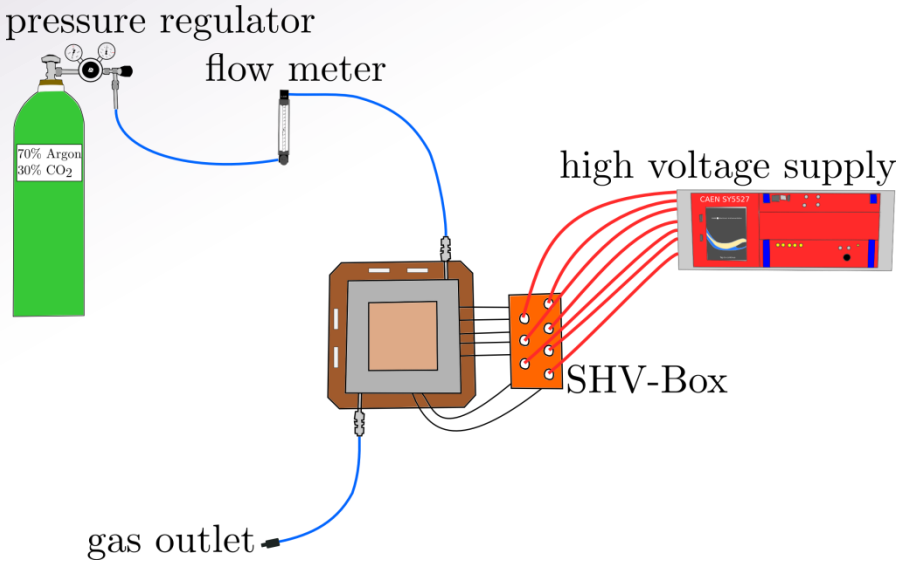
- additional detector components needed



- 512-channel readout board
- chamber (frame and cap)
- high voltage connection box

Construction of a GEM detector

- additional detector components needed



- 512-channel readout board
- chamber (frame and cap)
- high voltage connection box
- gas system

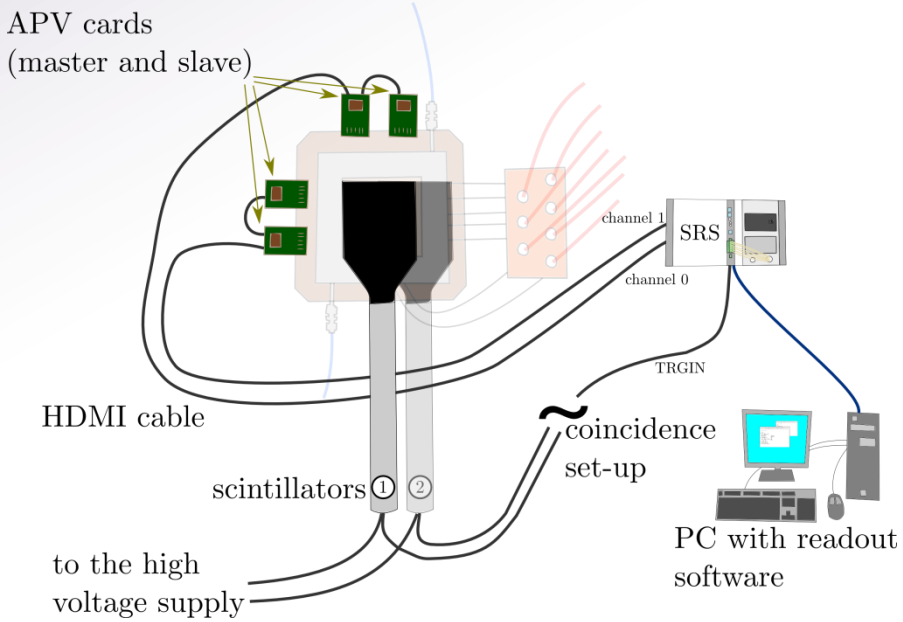
How to readout data?

- SRS (*Scalable Readout System*): data acquisition

- APV cards (128 channels each)

How to readout data?

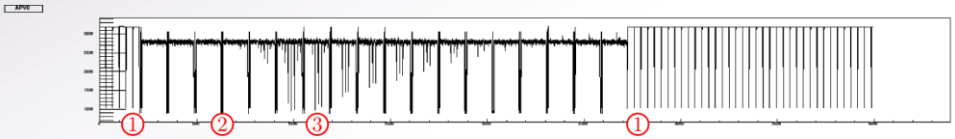
- SRS (*Scalable Readout System*): data acquisition



- APV cards (128 channels each)
- scintillators for trigger signal

How to readout data?

- SRS (*Scalable Readout System*): data acquisition

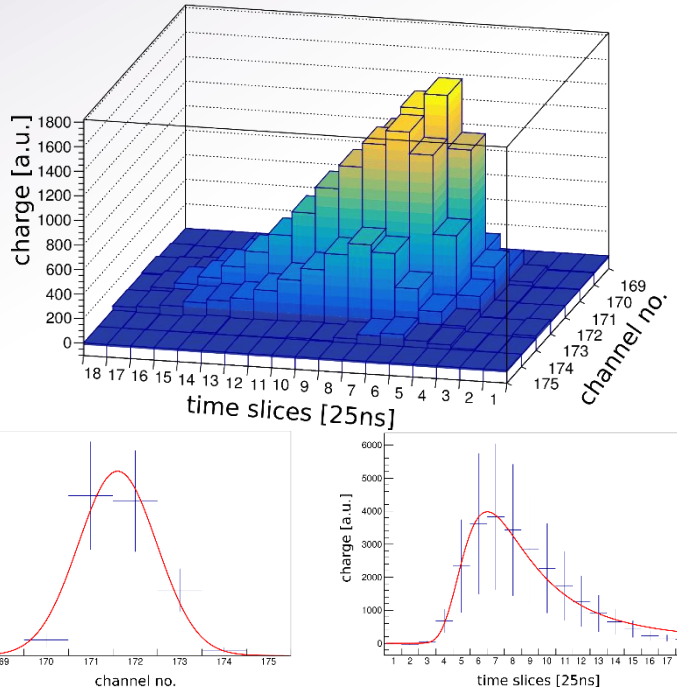


① synchronisation peaks
② separation of timing frames
③ signal in a timing frame

- APV cards (128 channels each)
- scintillators for trigger signal
- APV signals

How to readout data?

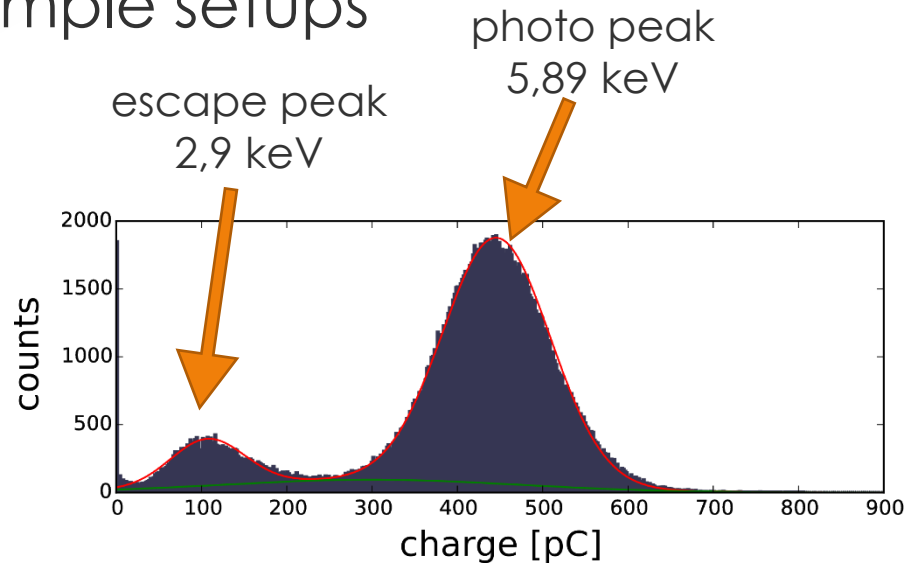
- SRS (*Scalable Readout System*): data acquisition



- APV cards (128 channels each)
- scintillators for trigger signal
- APV signals
- 1-d hit position
- hit time

Lab measurements

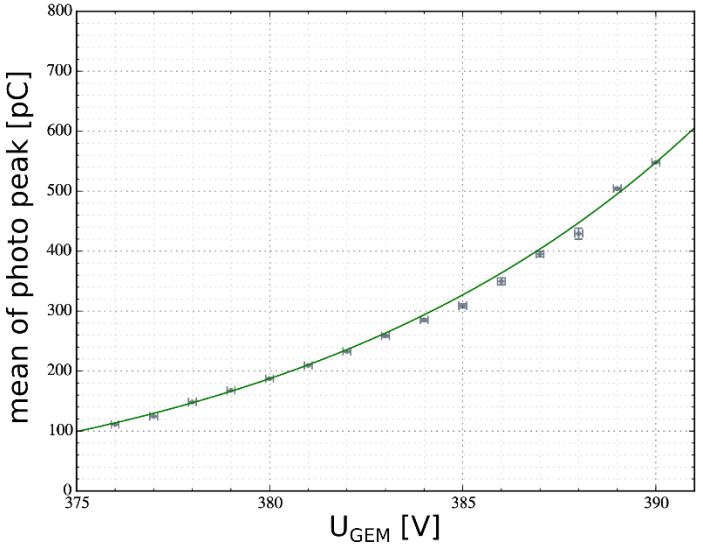
- basic tests with more simple setups
- energy resolution
  - ^{55}Fe-Spectra



FWHM: 16%

Lab measurements

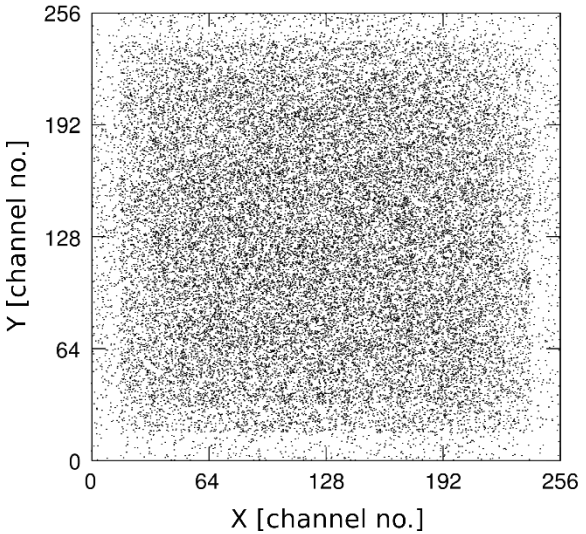
- basic tests with more simple setups
- energy resolution
  - ^{55}Fe-Spectra
- gain curve (vary U_{GEM})



Lab measurements

- basic tests with more simple setups
- energy resolution
  - ^{55}Fe-Spectra
- gain curve (vary U_{GEM})
- homogeneity test
  - cosmics
  - less events at the edges

    ➡ geometry of the setup



Lab measurements

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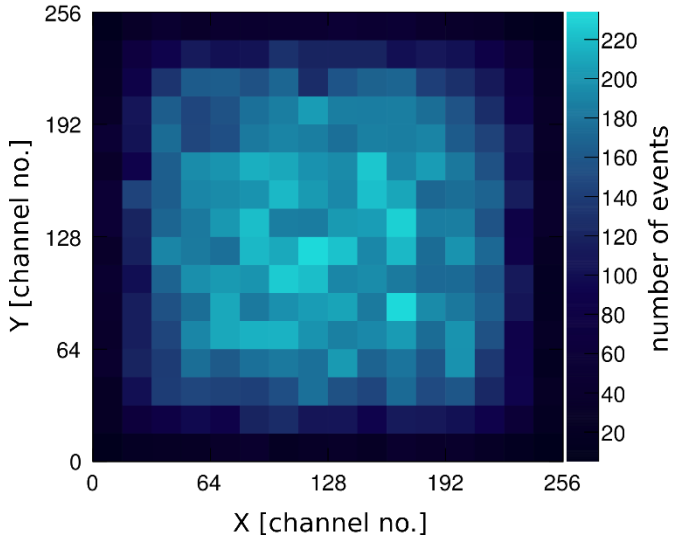
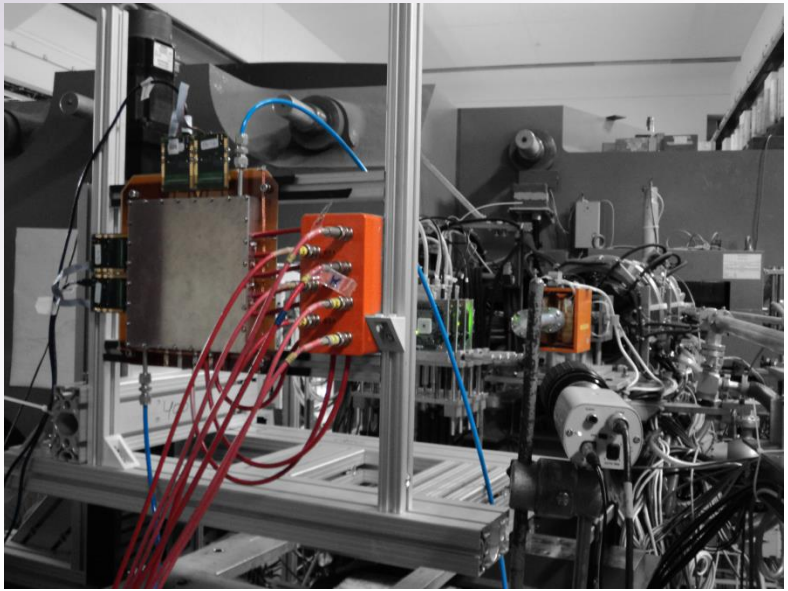
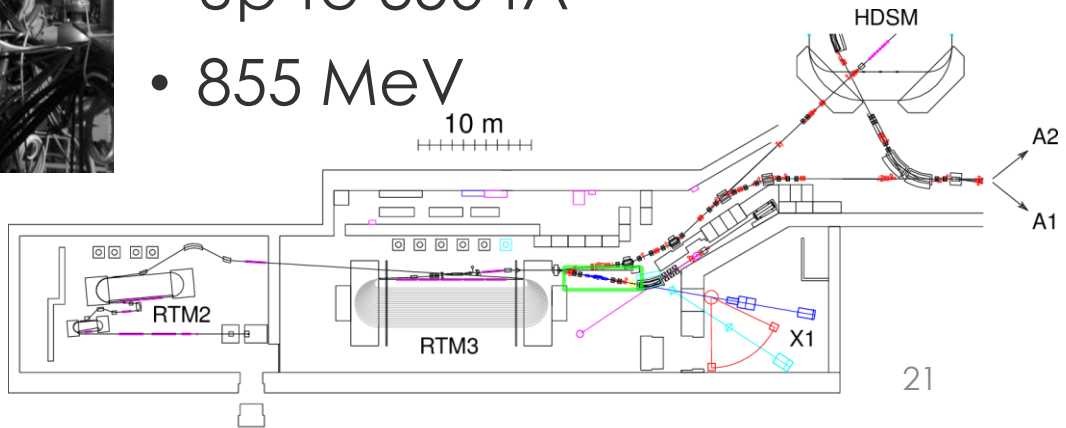


MAMI beam time @X1

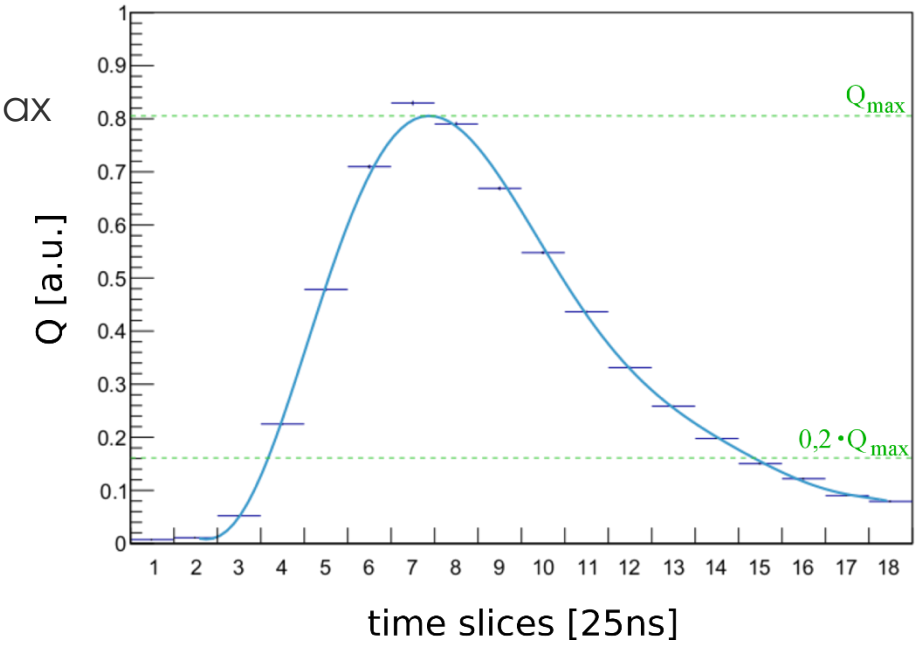


- 28/29th of June 2016
- behind HV-MAPS
- detector on xy-table, scintillators fixed
- up to 350 fA
- 855 MeV



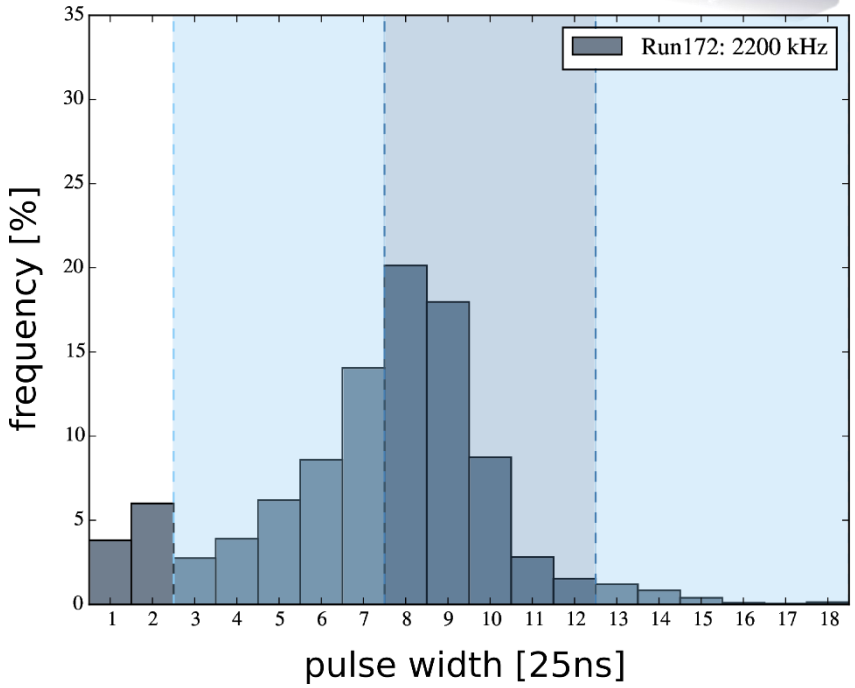
Filtering the raw data

- filter out the noise
- pulse width at 20% of Q_{max}

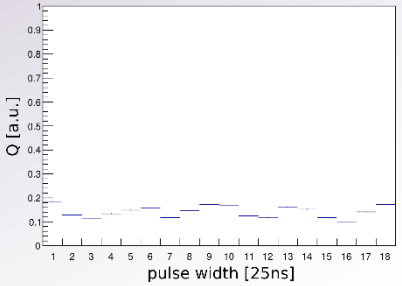


Filtering the raw data

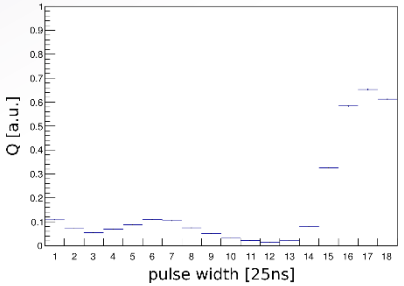
- filter out the noise
- pulse width at 20% of Q_{max}
- distribution of pulse widths [25 ns]



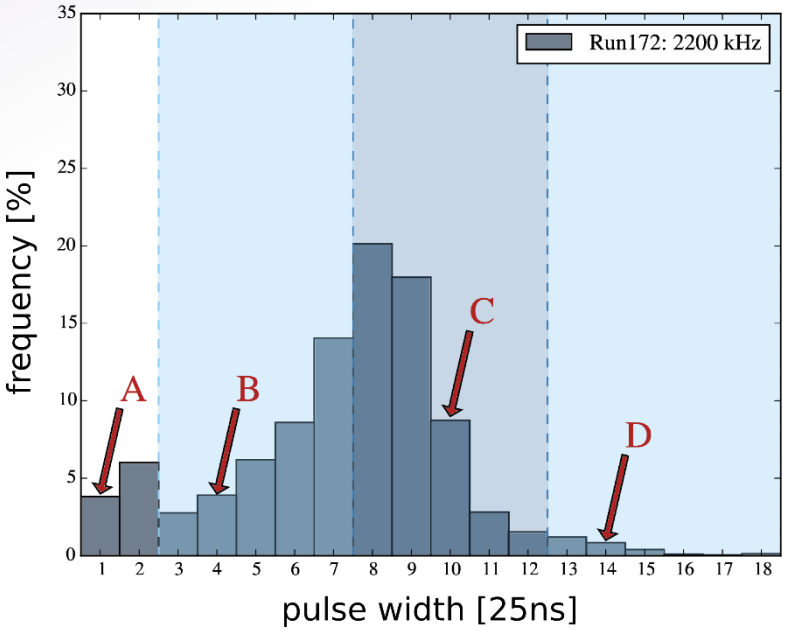
Filtering the raw data

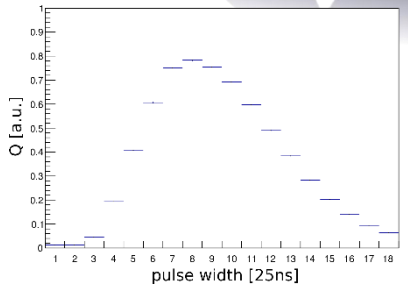


(A) width 1x25 ns

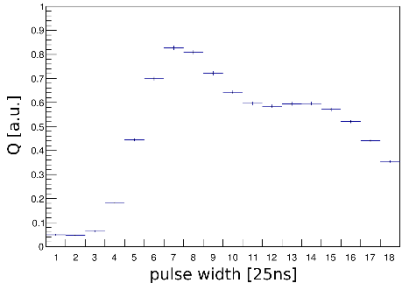


(B) width 4x25 ns





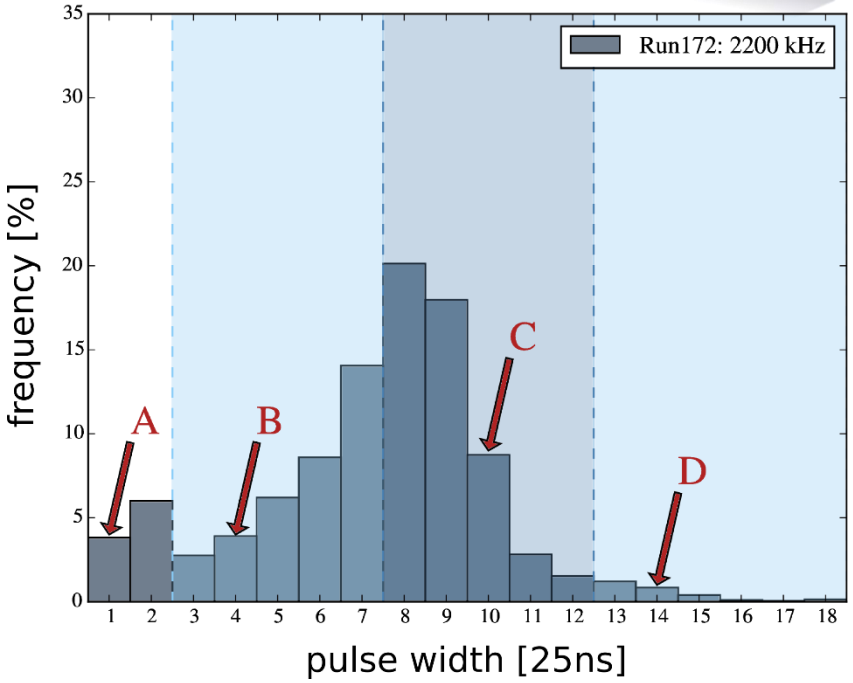
(C) width 10x25 ns



(D) width 14x25 ns

Filtering the raw data

- filter out the noise
- pulse width at 20% of Q_{max}
- distribution of pulse widths [25 ns]
- B+D: mainly double hits
- A: mainly noise
- second filter: charge



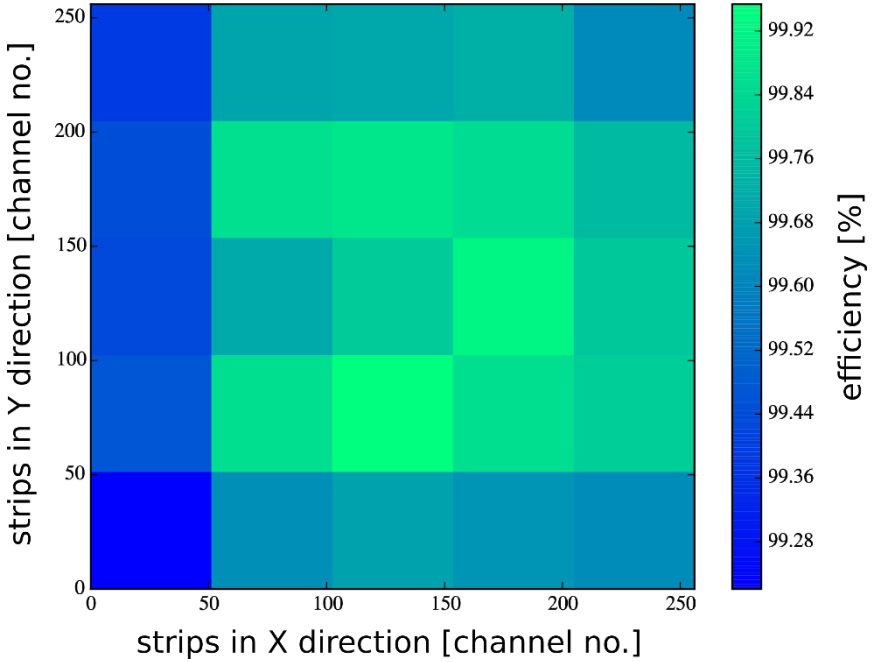
Results: High Rate Tests

- 6 series of measurement:
  0.5 - 2.2 MHz
- limited by trigger system
- electron detection at 1 MHz with efficiency >99.9%
- at maximum rate: efficiency >99.5%

➡ requirement full-filled

Results: XY-Scan

- 25 series of measurement:
  - 11.4 kHz, raster pitch 2 cm
- 9 measurements in the middle:
  - 99.85±0.04% efficiency
- lower efficiencies @ edges



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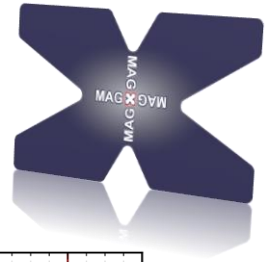
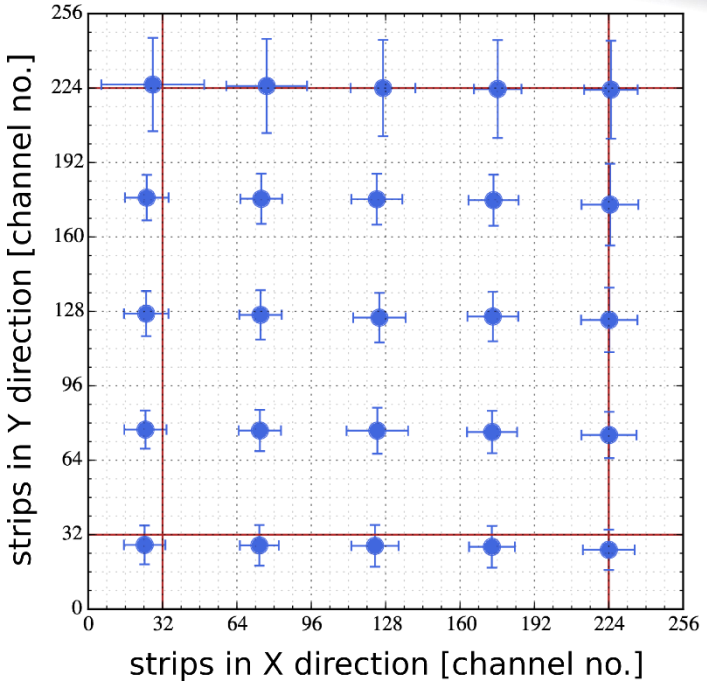


- 25 series of measurement:
  - 11.4 kHz, raster pitch 2 cm
- 9 measurements in the middle:
  - 99.85±0.04% efficiency
- lower efficiencies @ edges
- alignment of detector
  - shift in beamspot positions



Summary & Outlook

- stretching and framing procedure
- profile measurements ➡ uniform result
- readout data: 512 crossed copper stripes ➡ SRS
- filter data by pulse width
- high rate tests ➡ efficiency >99.9% @ 1 MHz
- XY-Scan ➡ 99.85±0.04% efficiency in the middle

Summary & Outlook

- go bigger
  - 30 x 30 cm^2 GEMs are ordered
  - same procedure (stretching, framing, …)
- go thinner
  - thinner GEMs are ordered (10x10 cm^2)
  - foil based readout (Master Thesis: Yasemin Schelhaas)

SFB 1044

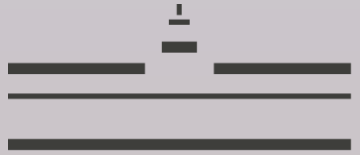
PRISMA

THANK YOU FOR YOUR ATTENTION!

Univerza v Ljubljani

Massachusetts Institute of Technology

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



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