Narodowe Centrum Badań i Rozwoju

TECHTRA
TECHNOLOGY TRANSFER AGENCY

Gas Electron Multipliers
@
TTA Techtra

PIOTR BIELÓWKA

Prezentacja promująca Projekt
Modularne Detektory GEM (MGEM)
Nr POIR.04.01.02-00-0080/17

Projekt współfinansowany przez Narodowe Centrum Badań i Rozwoju wybrany w ramach programu Program Operacyjny Inteligentny Rozwój w Konkursie nr 1 - 4.1.2/2017_RANB.

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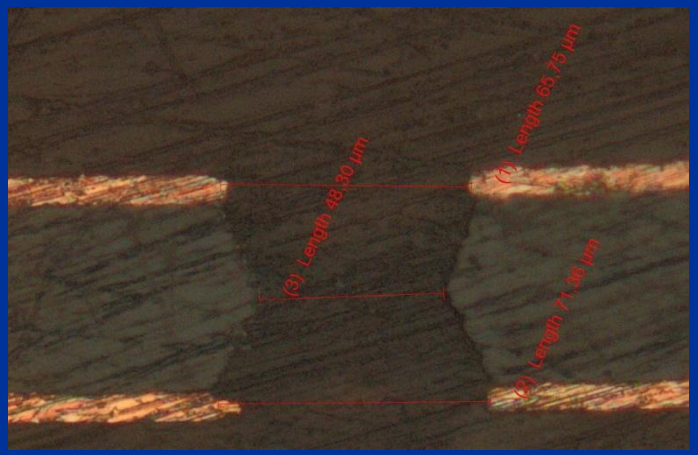
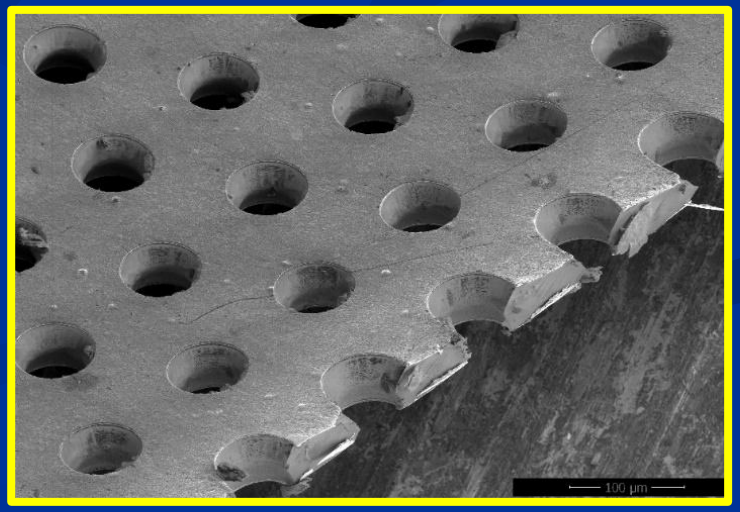
GEM detectors are an extension of the concept of multi-wire chambers developed by Georges Charpak (Nobel Prise winner in 1992)

G.Charpak, F. Sauli, J. Santiard @CERN

Fabio Sauli inventor of GEM technology





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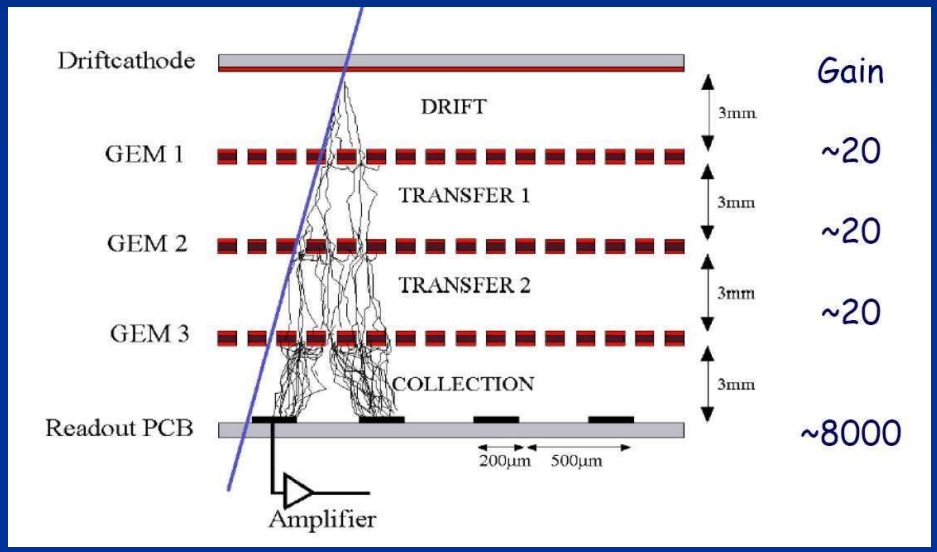
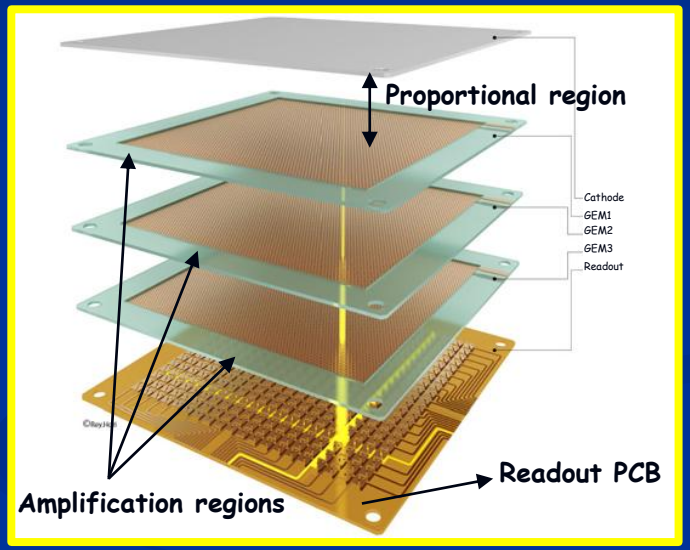
- GEM detectors typically consist of a stack of foils, each operated at ca. 500V difference placed a drift cathode and a readout anode.





- GEM detectors offer excellent spatial, temporal and energy resolution at costs much lower than solid-state ones.
- GEM detectors tolerate extremely high radiation levels.

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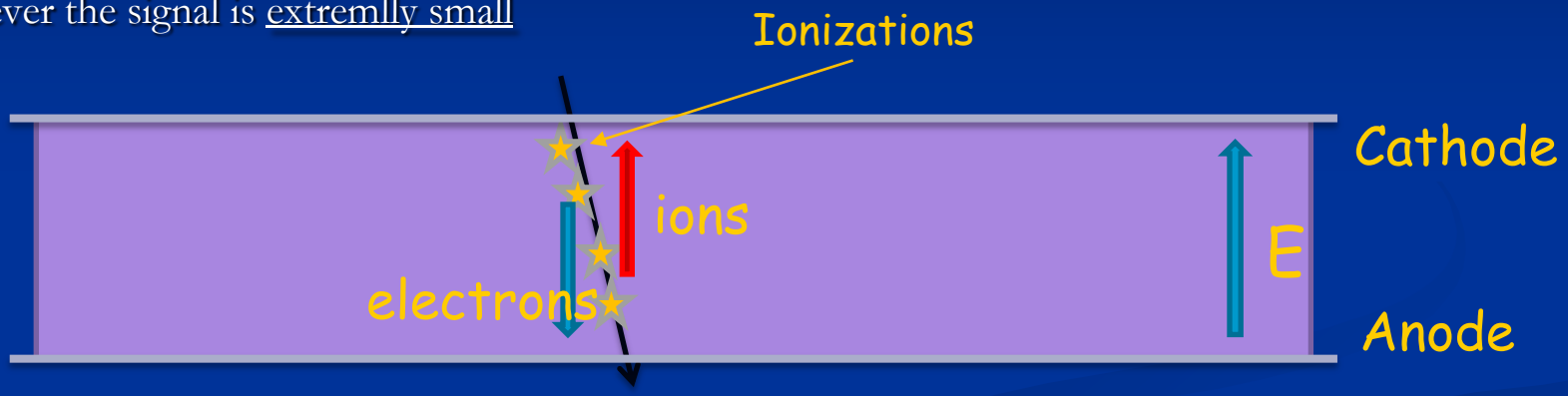
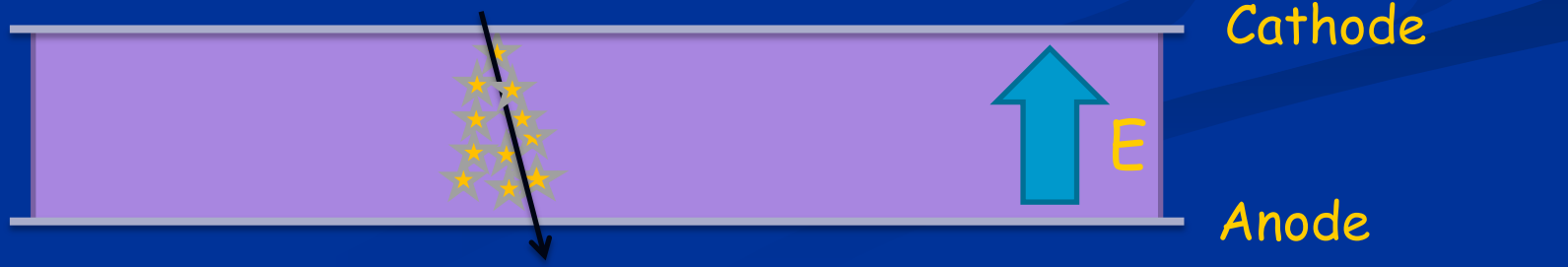
Proportional region

- When electrical field is applied to the gas we can collect the electrons to anode
- However the signal is extremlly small



Amplification regions

- Applying a large electric field allows us to create avalanche secondary ionization in the gas
- The signal is large, but we the magnitude depends on avalanche length – no proportionality to energy loss!



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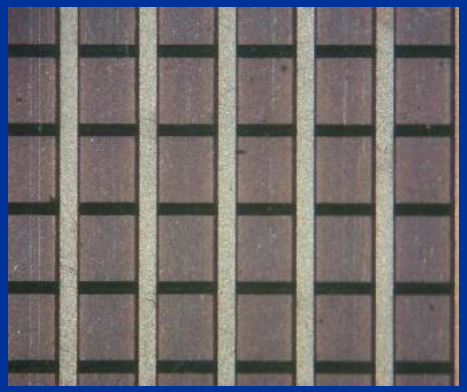
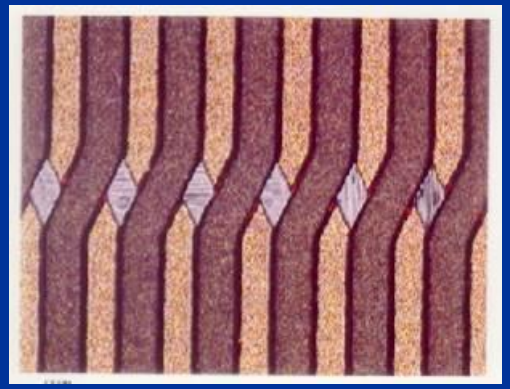
Readout PCB

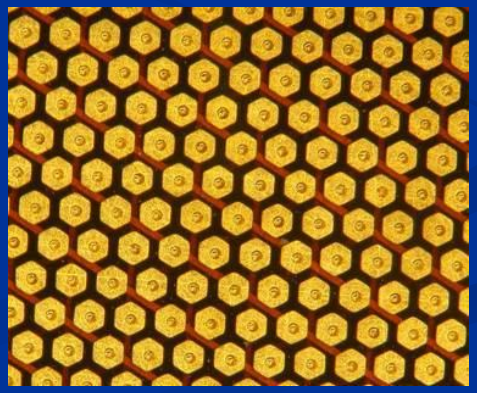
GEMs and Micromegas decouple the readout geometry from charge collection and amplification. Thus readout is not limited to parallel strips/wires.



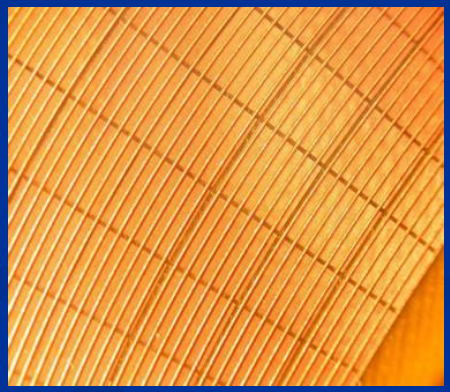
Cartesian,
Compass, LHCb



Small Angle



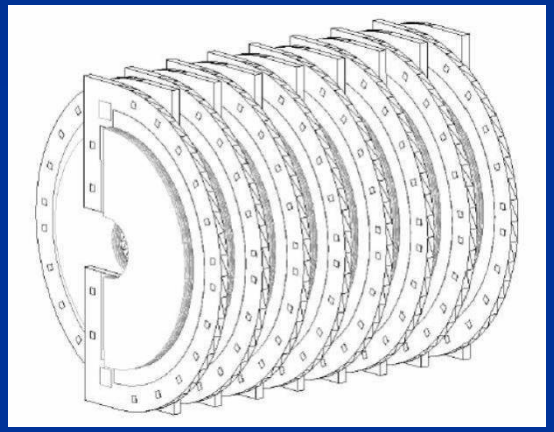
Haxagonal pads, MICE



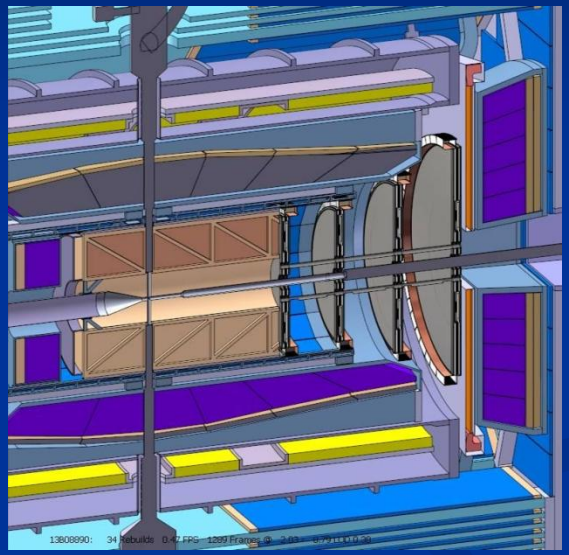
Mixed, TOTEM

GEMs in HEP experiments

- Several HEP experiments use or will use GEM detectors, e.g.:

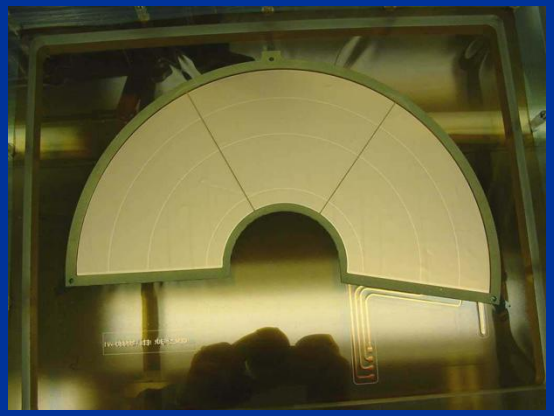


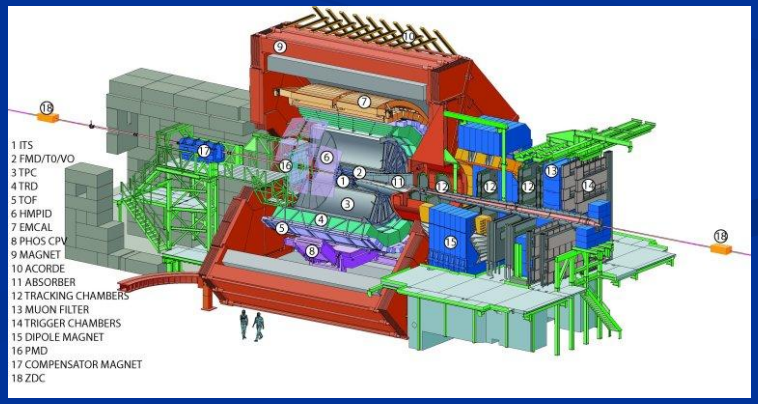
TOTEM T2 telescope



Target spectrometer PANDA

The CMS TPC





The ALICE TPC

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2002: Implementation of GEM technology into Techtra company.


ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE
CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

AGREEMENT K1564/TT/TS/P1/02/01

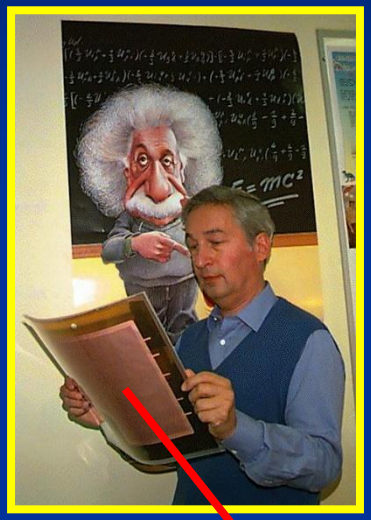
LICENSE AGREEMENT

ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE
CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

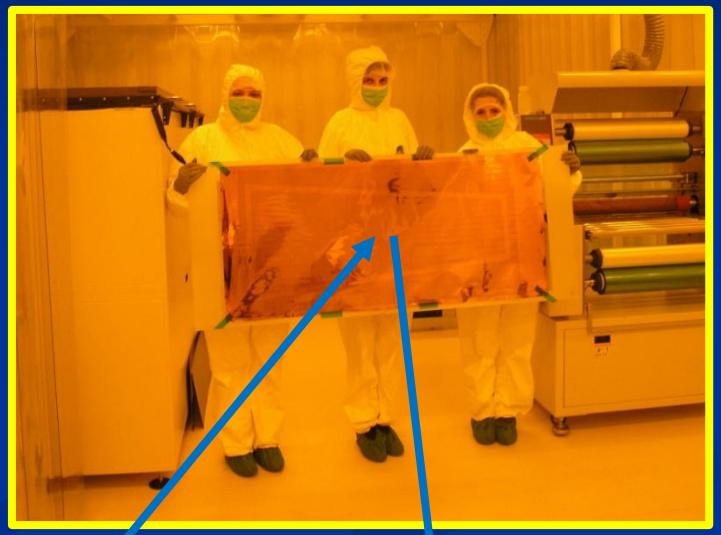
AGREEMENT K 922/ETT

LICENCE AGREEMENT FOR MICROVIA TECHNOLOGY

Licensee: Technology Transfer Agency Techtra Ltd.



Fabio Sauli, CERN


Techtra prototypes of CMS foils.


Compact Muon Solenoid, CERN

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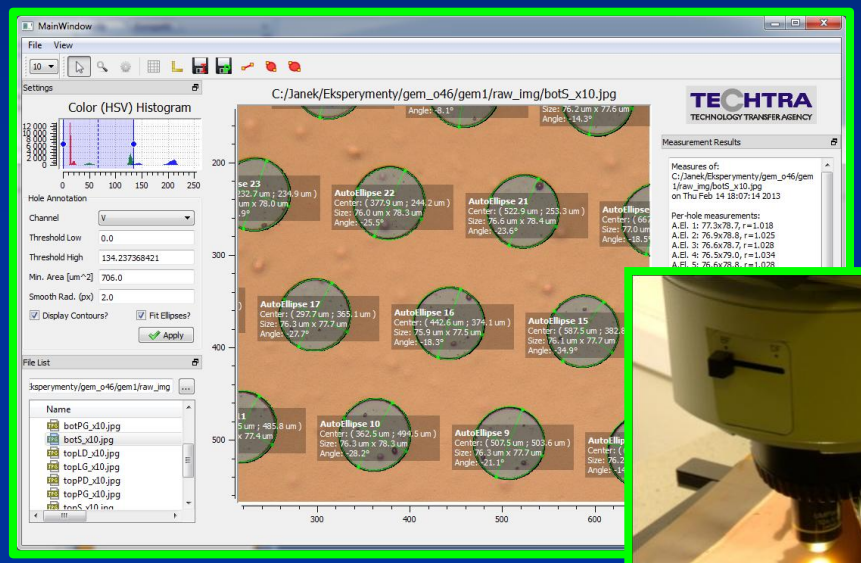
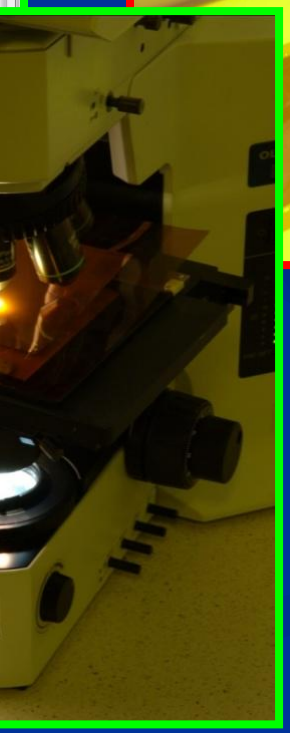
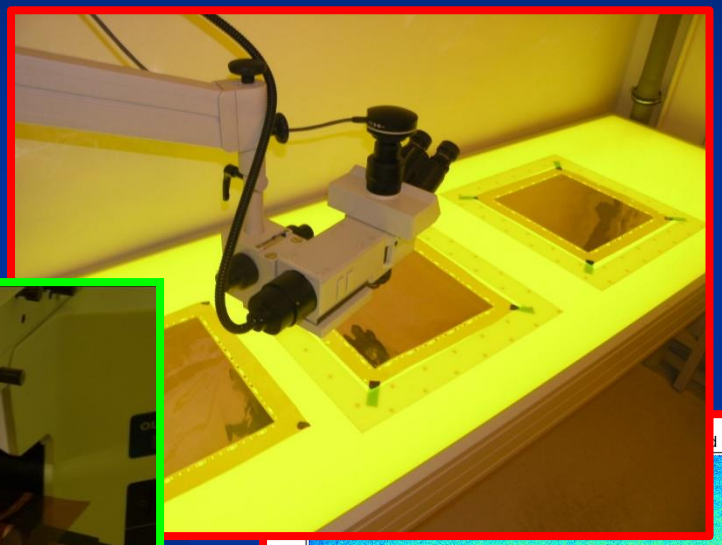
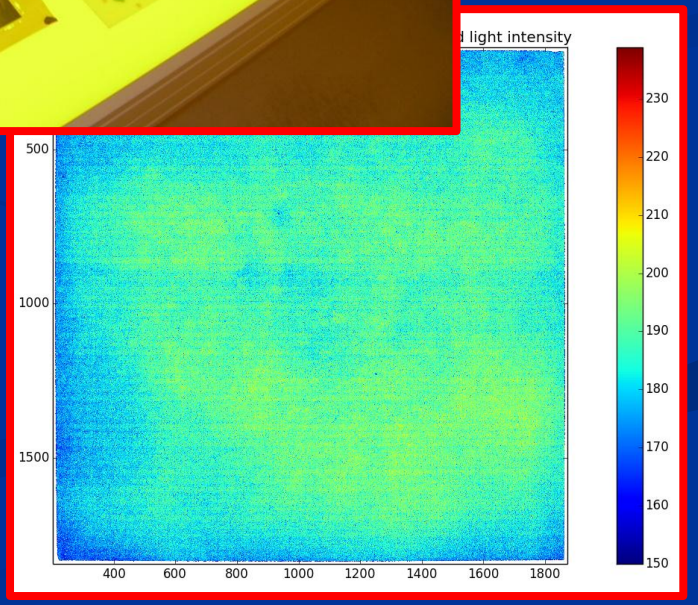
Quolity control: optical scaning



Spot test







Global test

There are about half a million holes in the 100cm2 area.

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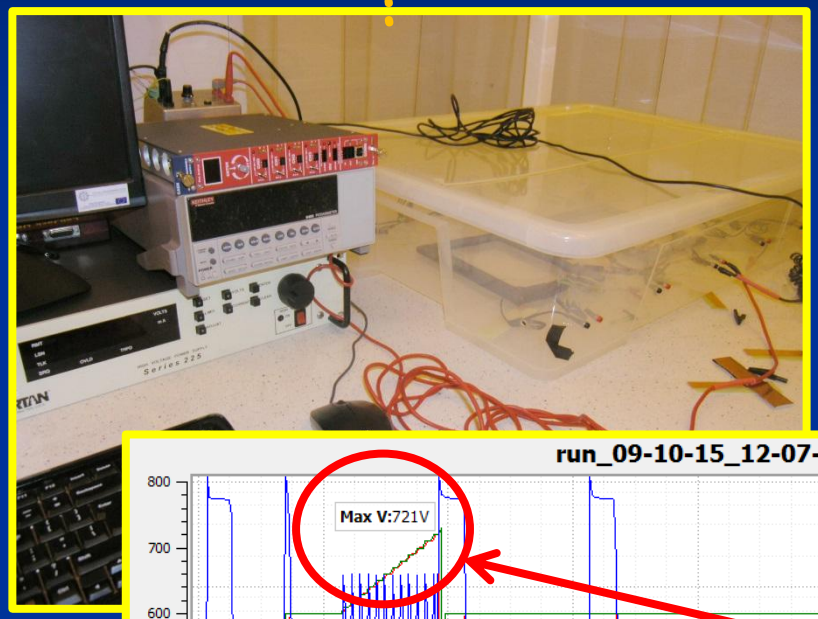
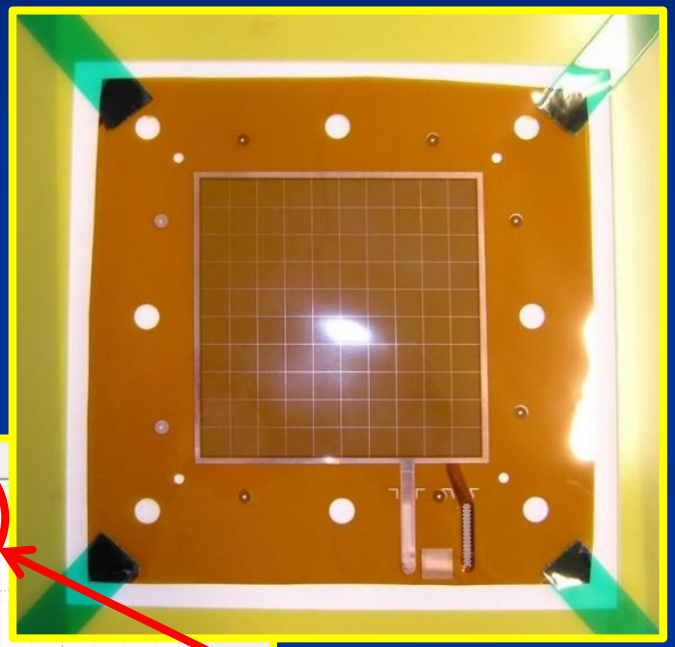
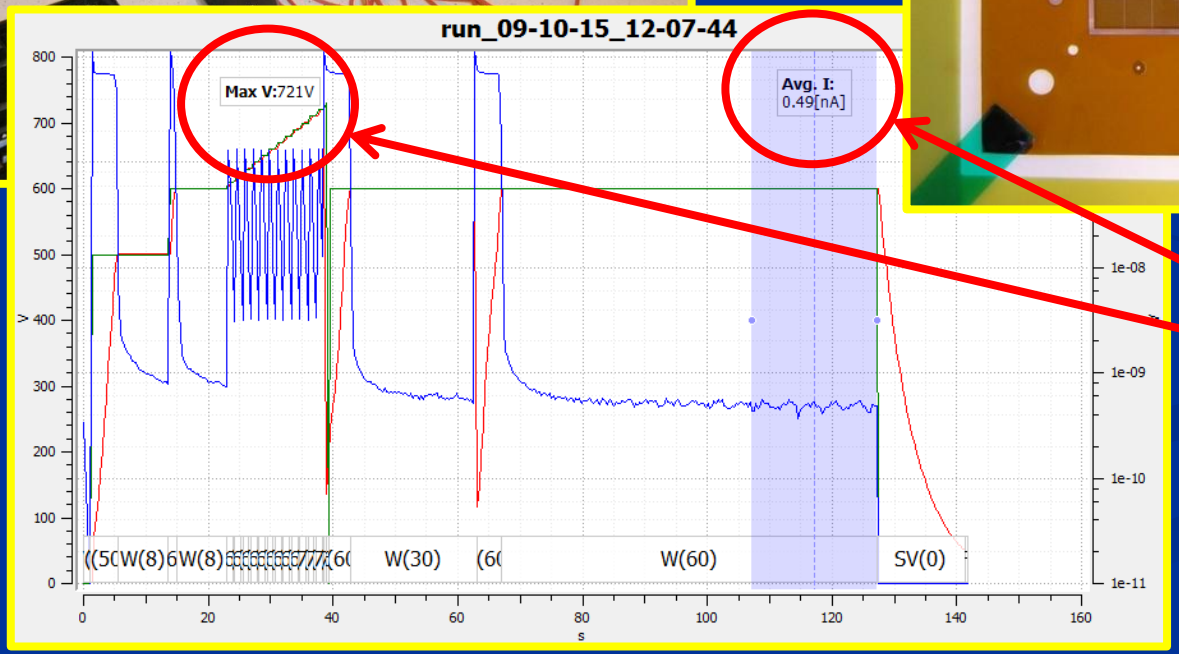
Quolity control: electrical testscaning







Leakage current meeds to be below 1nA @100cm2 @600V @30 %HR

Wrocławski Park Technologiczny

Dedicated laboratory for GEM production

GEM foils 100x100mm2

Copper etching machine

PCB developer

Cleanroom: ISO7

UV exposure unit

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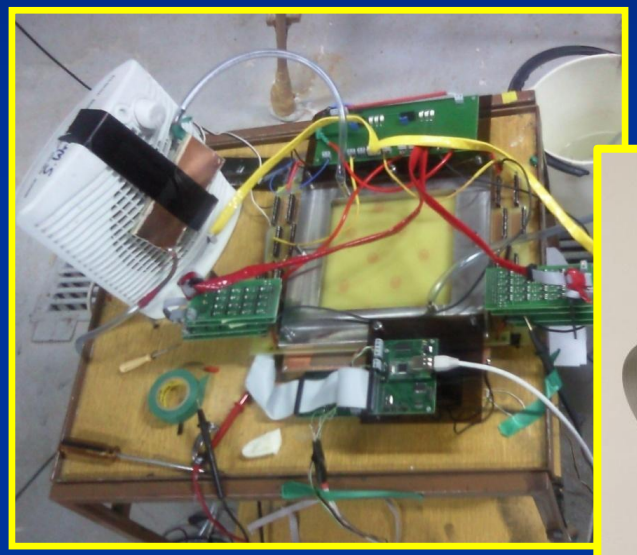
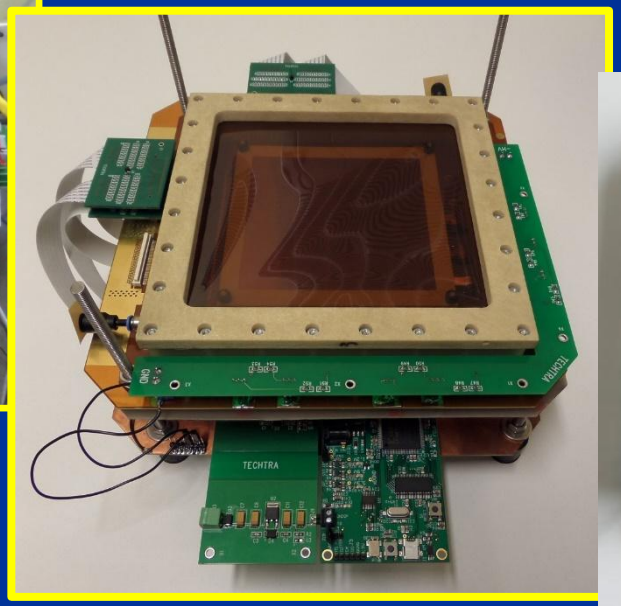
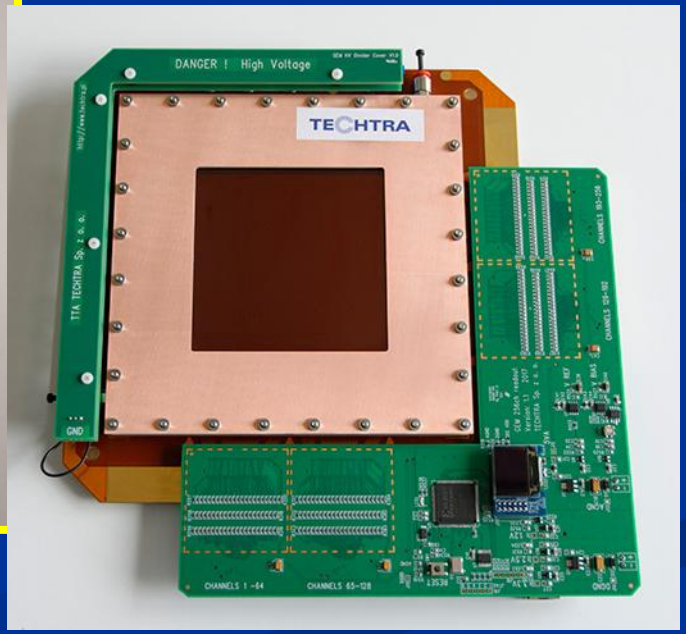
GEM detectors produced and offered by Techtra



„proof of concept"
Techtra



Operational prototype,
Techtra



Final version of GEM
detector, Techtra

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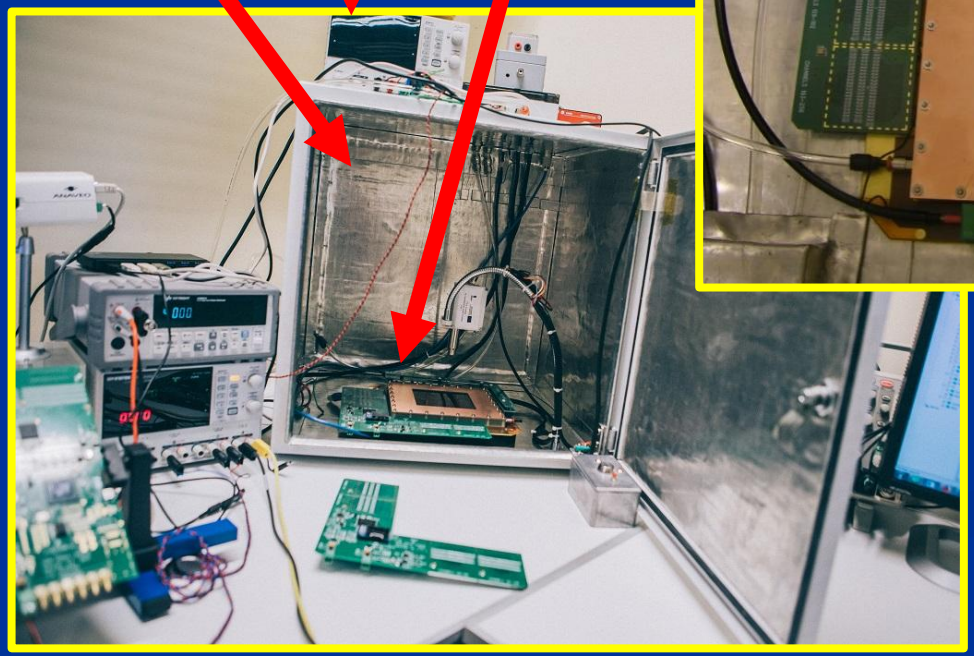
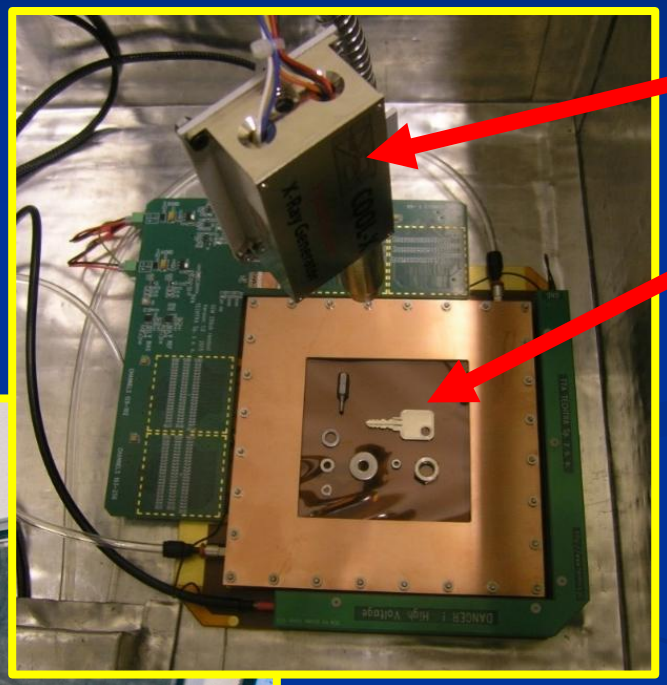
GEM detectors measurement setup

LV and HV power supply

Lead covered encolusure

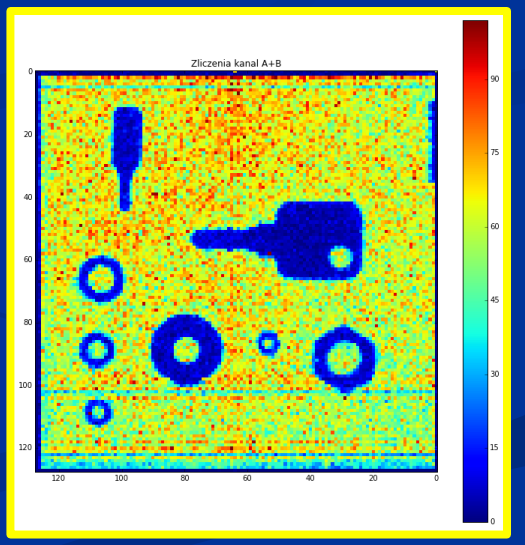
Techtra GEM detector





X-ray source

Metal elements placed onto detector



Radiograph made with Cool-X Amptec miniature X-ray generator

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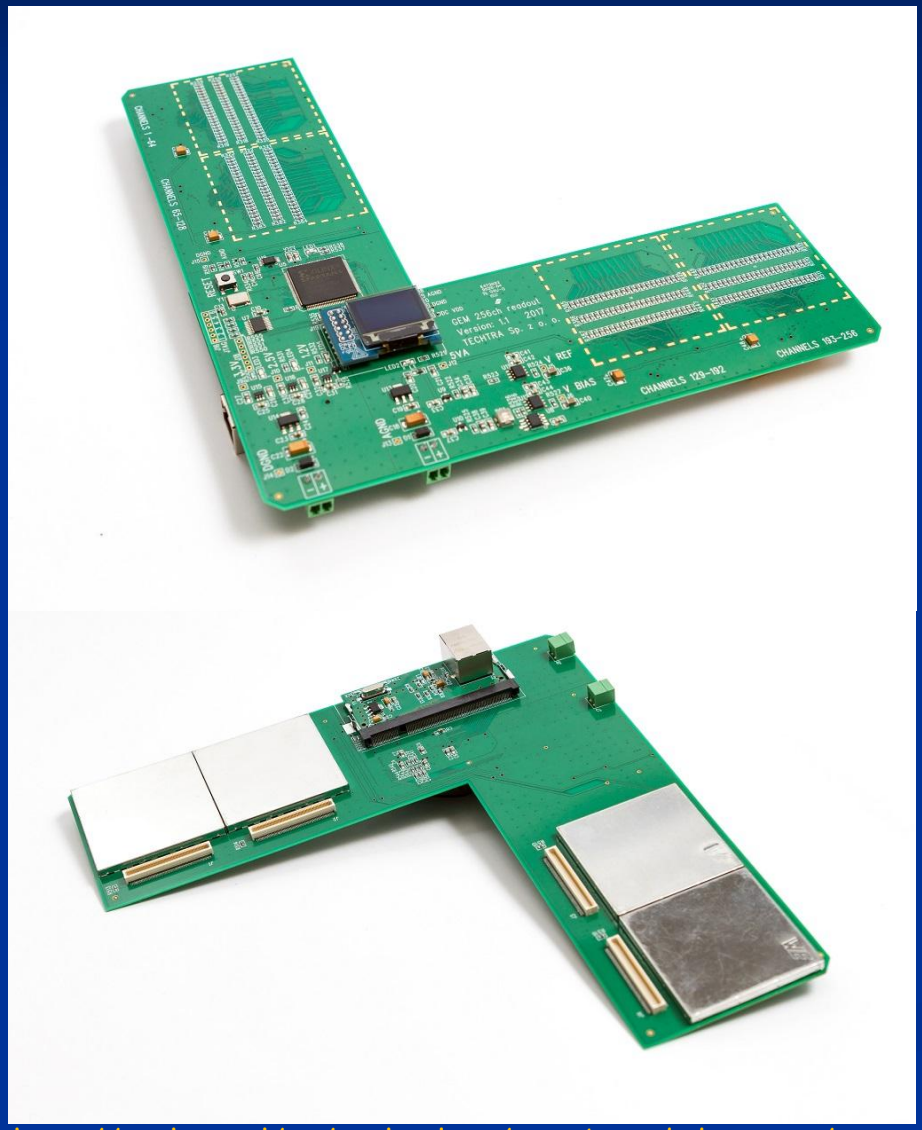

GEM detector V1.1

- Designed and validated,
- A few detectors are already delivered to clients,
- Channels: 128 x 128 strips,
- For 10x10 cm detector kit,
- Sampling rate of 6,25 kHz,
- ADC resolution 20-bit,
- Minimal ADC range – 6,25 pC,
- 100 Mbit Ethernet communication,
- Connects directly onto detector readout plate,
- Noise level: about 1 fC peak-to-peak disconected from strip readout,
- With strip readout connected noise increases 3 Times,

http://techtra.pl/en/technology/gem-based-detector/

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GEM detector V2.0

- Design is based on experiences gathered from DAQ V1.1 detector project,
- Sampling rate is increased from 6,25 kHz to 17 kHz
- As the new DAQ is much faster, we can use higher count-rate X-ray source,
- ADC resolution is also improved from 20-bit to 24-bit,
- Minimal ADC range – 6,25 pC,
- 100Mbit Ethernet communication,
- 100Mbit communication is too slow for huge amount of data from new DAQ ☹,
- We introduced digital triggering and data procesing inside FPGA,
- To measure noise performance and to validate the detector we have integrated digital phosphor function.

http://techtra.pl/en/technology/gem-based-detector/

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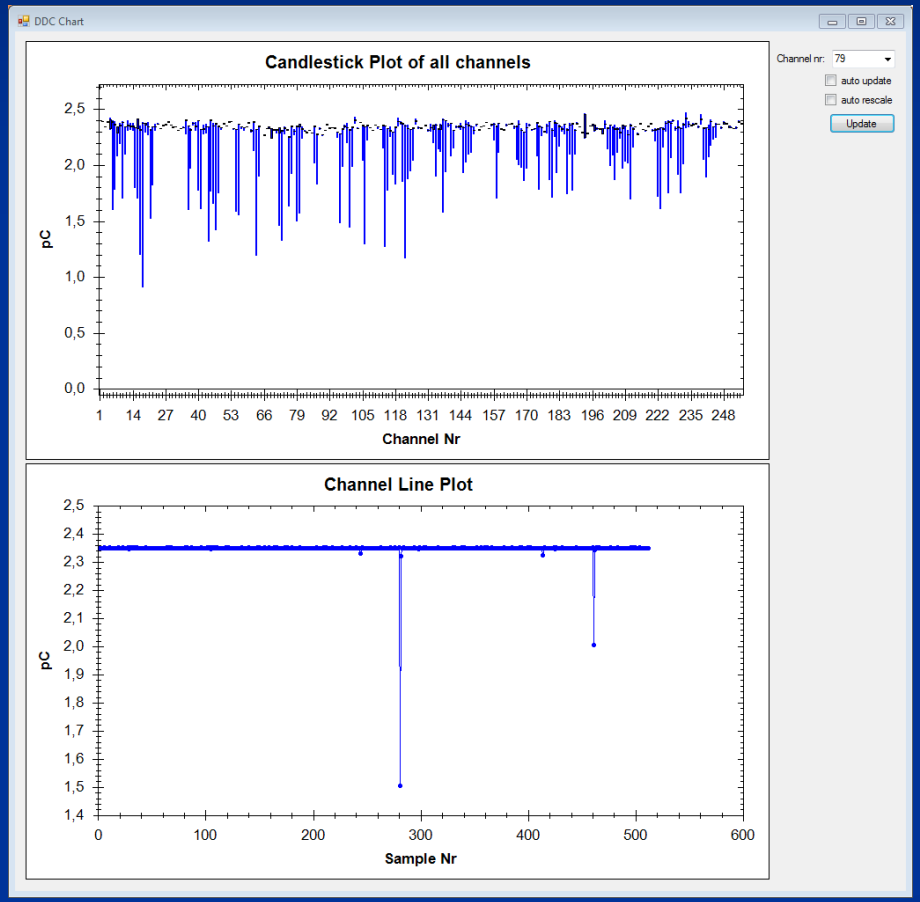
GEM detector data acquisition software - visualization



- Data from detector are transmitted in packages of 512 samples from each of 256 channels,
- We use candlestick plot to show average values and min-max values spread for each channels on one plot (based on 512 samples),
- On candlestick plot we can see on which channels we have detected events and how many such channels we have,
- On channel line plot we can see all of 512 samples from 1 chosen channel - something like oscilloscope.

http://techtra.pl/en/technology/gem-based-detector/

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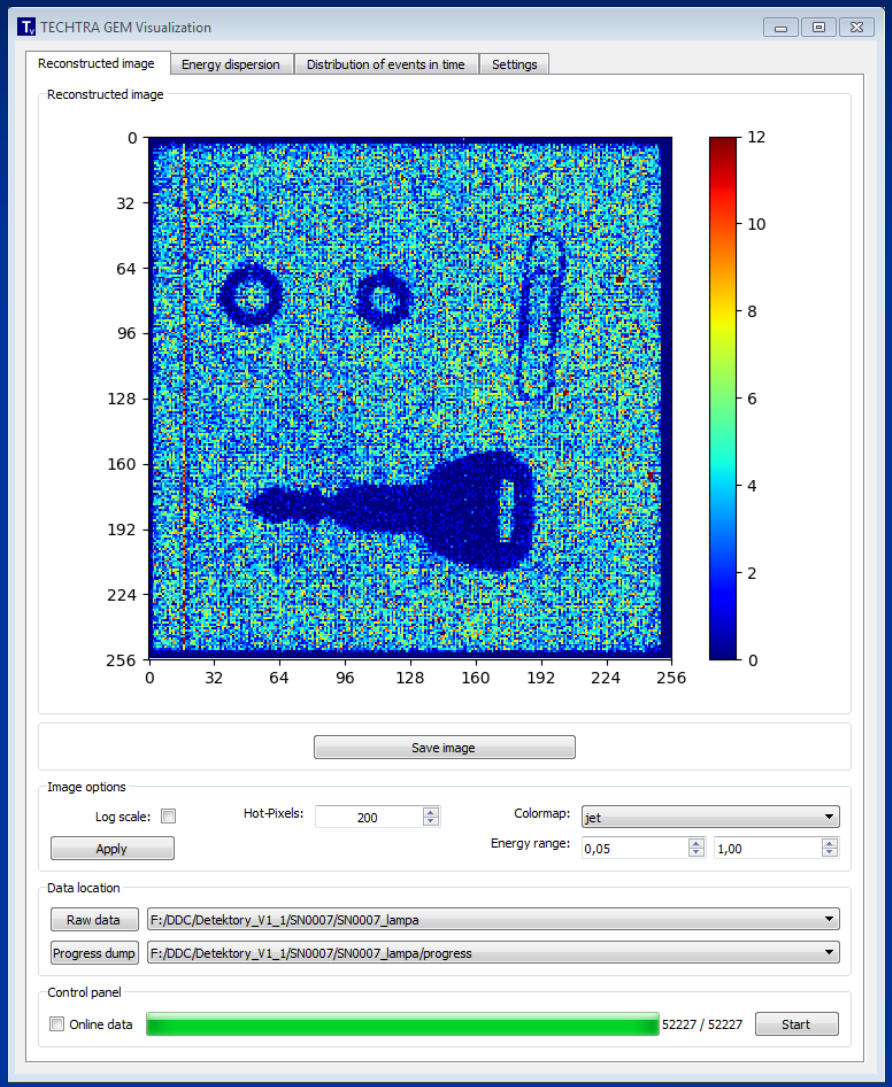

GEM detector data visualization software

- Designed specially for our detector DAQ,
- Application performs **DIGITAL TRIGGERing** function on raw data,
- User can change triggering parameters to see the difference in results on the same raw data,
- Software automatically recognizes peaks correspond to events and reconstructs their position on the 2D map,
- User can see the image reconstruction progres on-live during data acquisition,

http://techtra.pl/en/technology/gem-based-detector/

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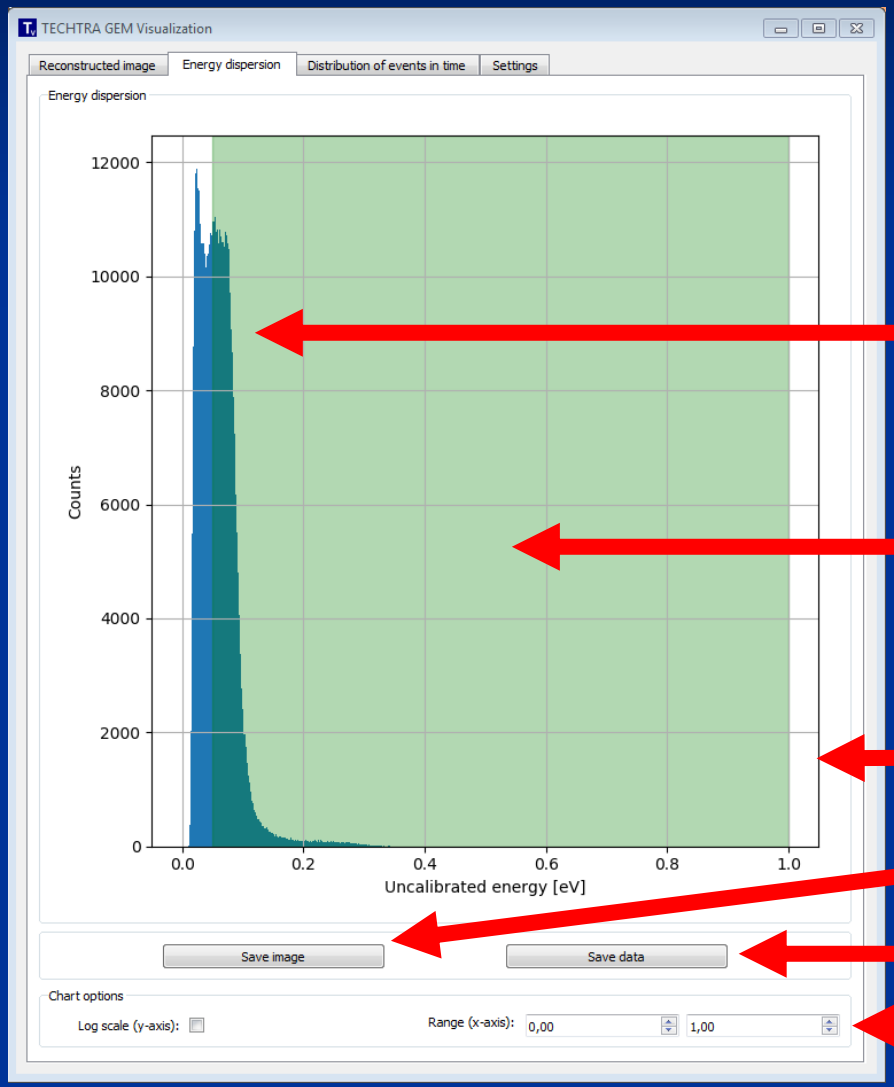

GEM detector data visualization software - energy spectra of events

Energy spectra of detected events

Visual indication of filter energy bandwith – user can check which part of signal will be used in 2D reconstruction

Chart with scales

Image file save button

Output data save buton, txt file

Energy range selector

http://techtra.pl/en/technology/gem-based-detector/

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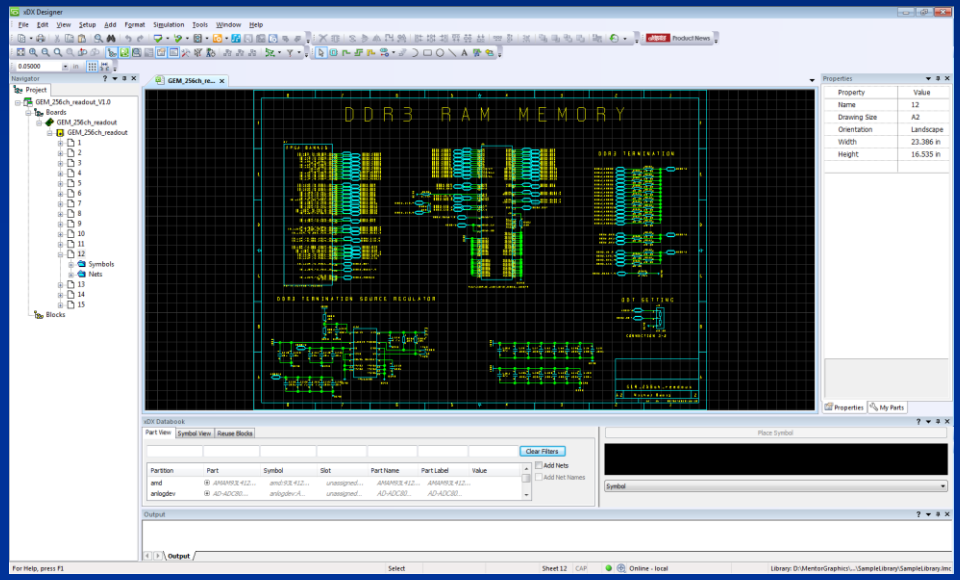
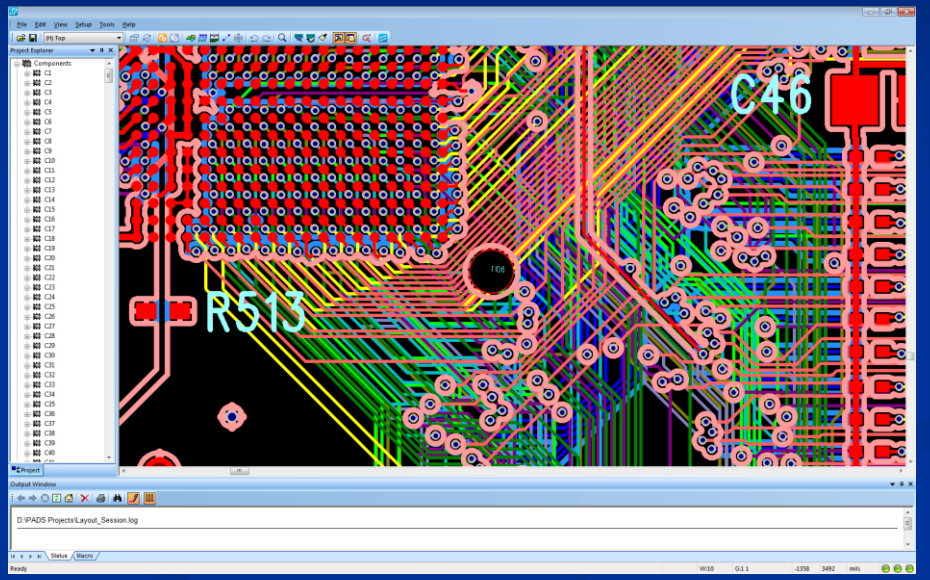
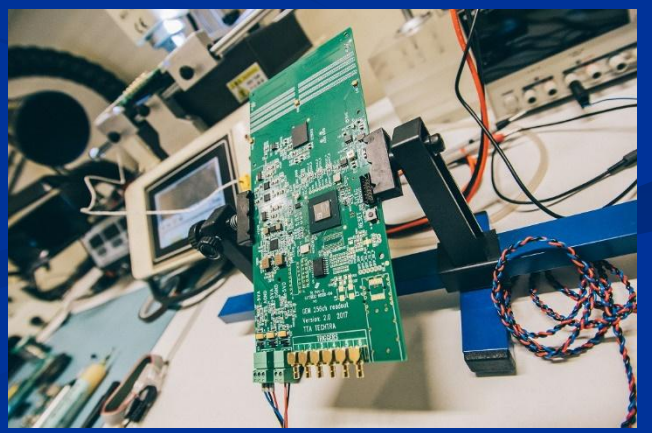
Measurement electronics designing and prototyping





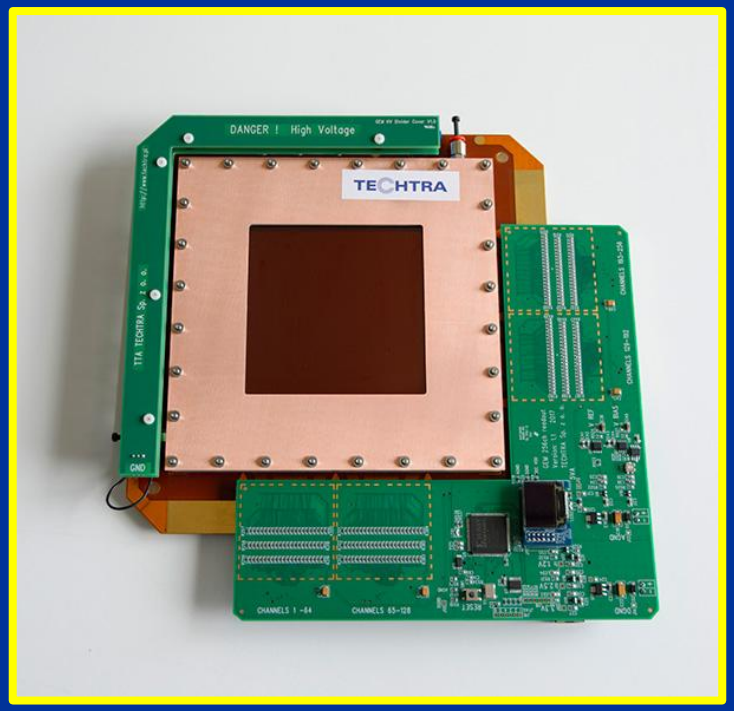


http://techtra.pl/en/technology/electronics-design/

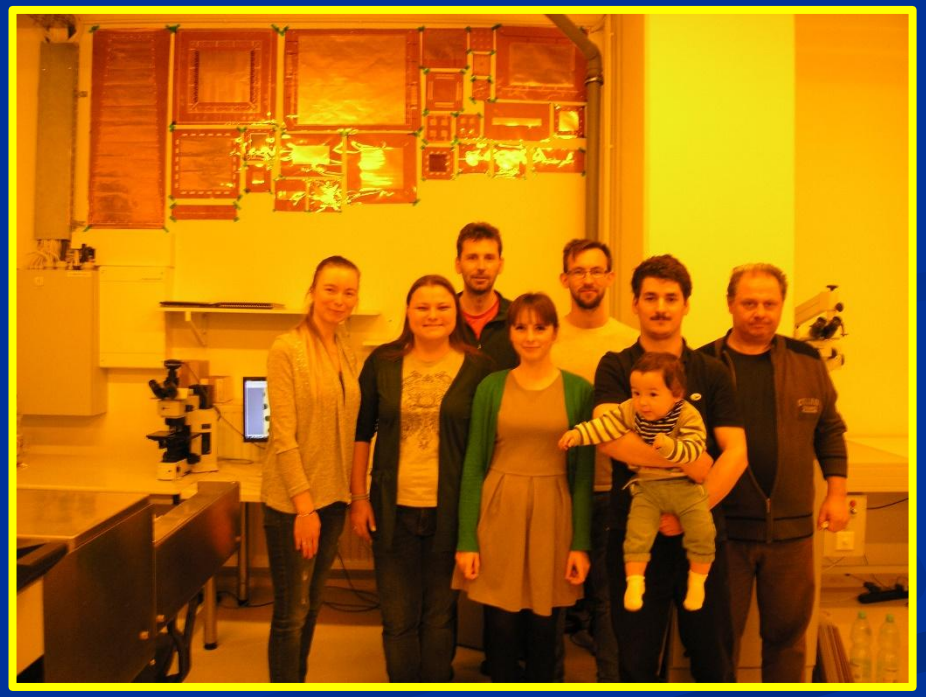
Our Core GEM-team

European Funds
Smart Growth

EUROPEAN UNION
EUROPEAN REGIONAL
DEVELOPMENT FUND



GEM detector, Techtra



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