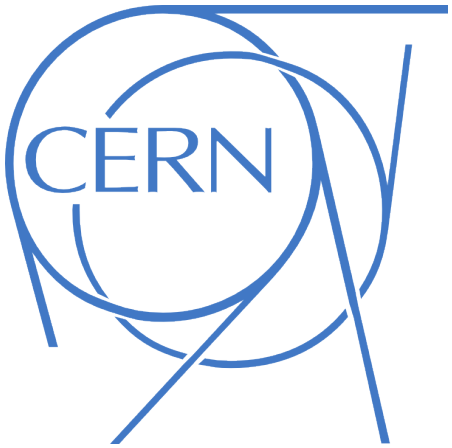
High performance beam monitors

Presented by
Giuseppe Gorini



Do unicorns exist?

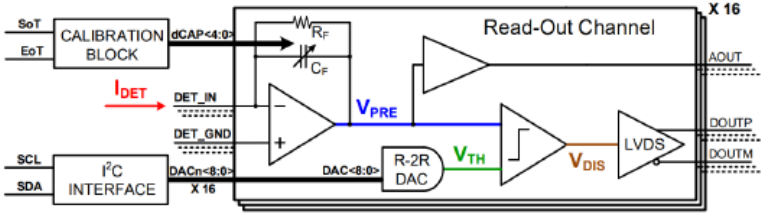
Space/time resolution, transmission…

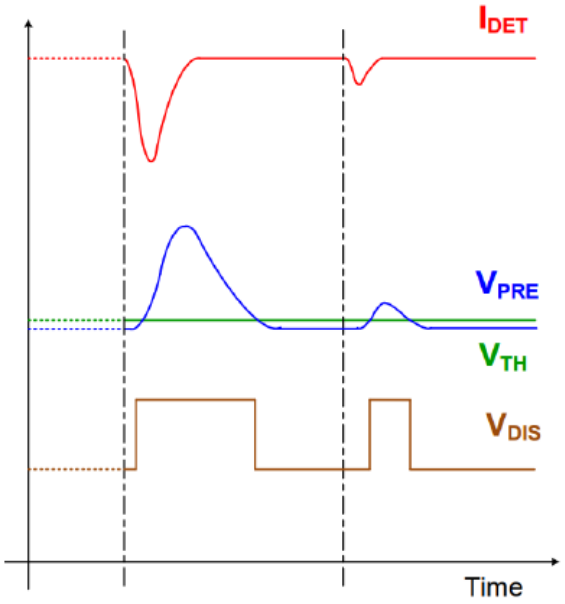
Motivation

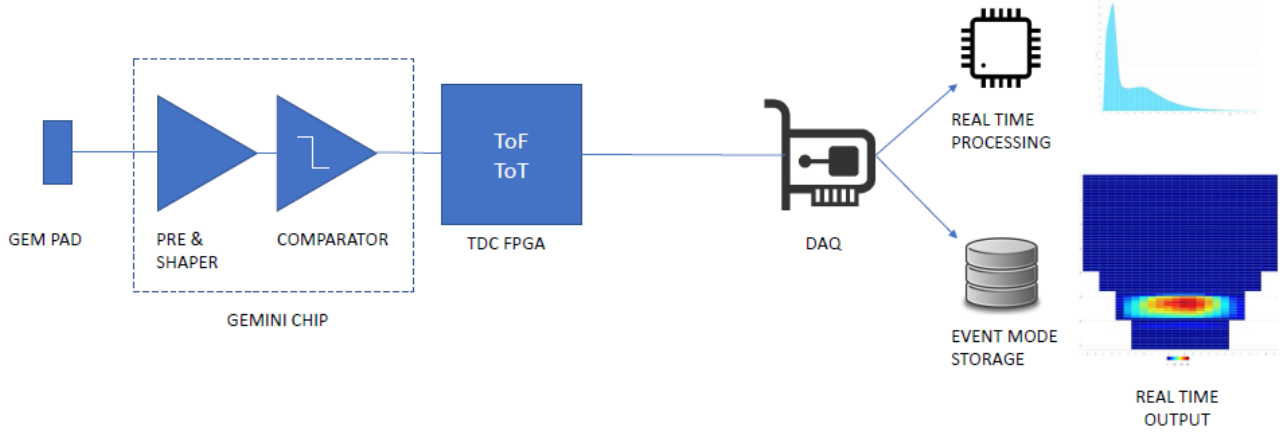
- Experience in Gas Electron Multiplier (GEM) detectors
- Used to build detectors for fast and thermal neutrons: nGEM, bGEM, BAND-GEM…
- FPGA-based data readout developed around new ASIC chip GEMINI
- Develop beam monitors based on the technology at hand?
- Choice of performance/cost

GEMINI CHIP

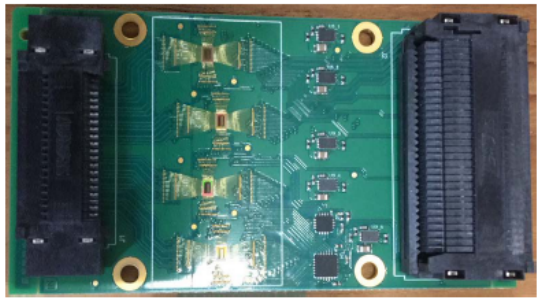
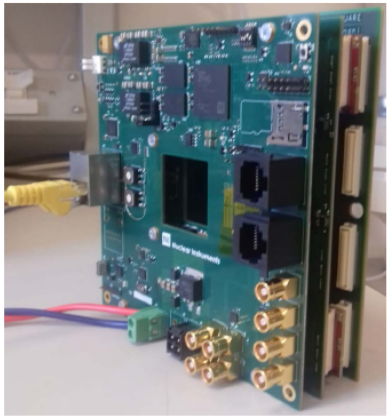
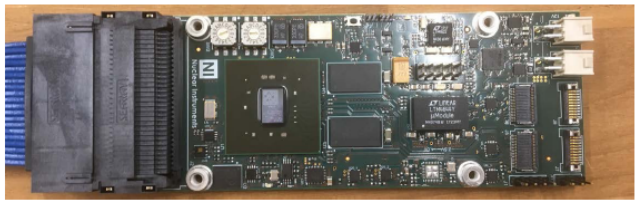
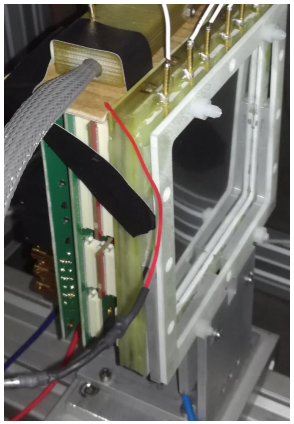
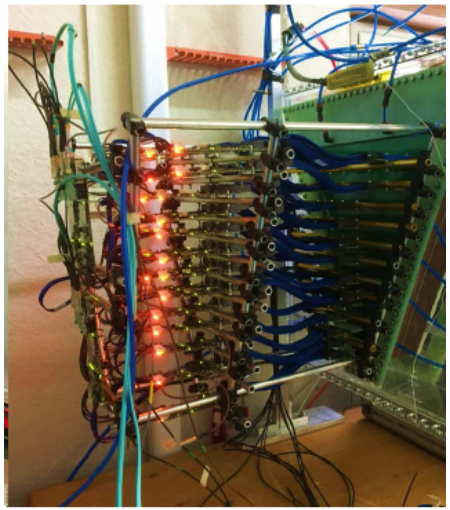
- Realized within a INFN-UNIMIB collaboration
- ASIC chip with Time Over Threshold information
- 16 channels
- First working version end of 2017
- Different hybrid cards
  - 16D – 16 channels – 1 chip
  - 32D – 32 channels – 2 chips
  - 64D – 64 channels – 4 chips
- The DAQ systems for all the different cards has been realized and successfully tested
- Currently used for neutron and X-Ray detection



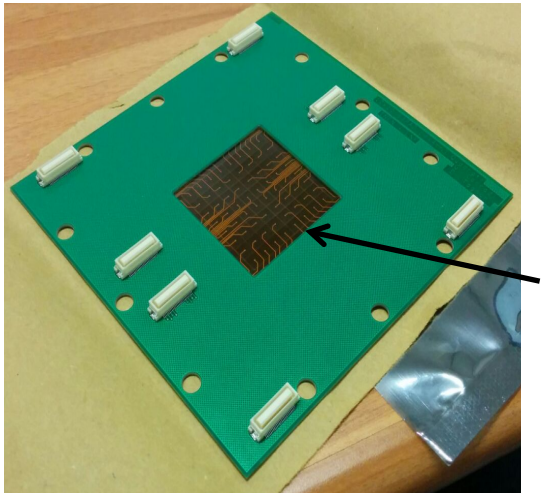




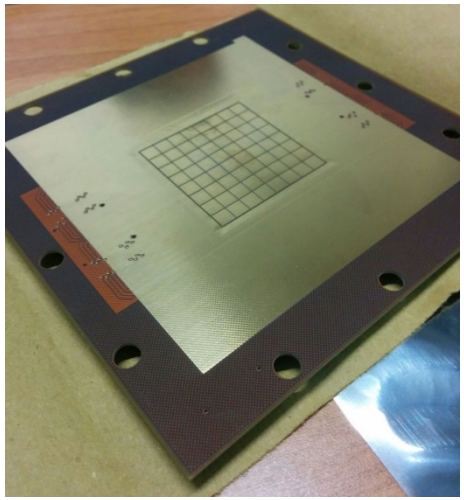
GEMINI 32D and 64D cards

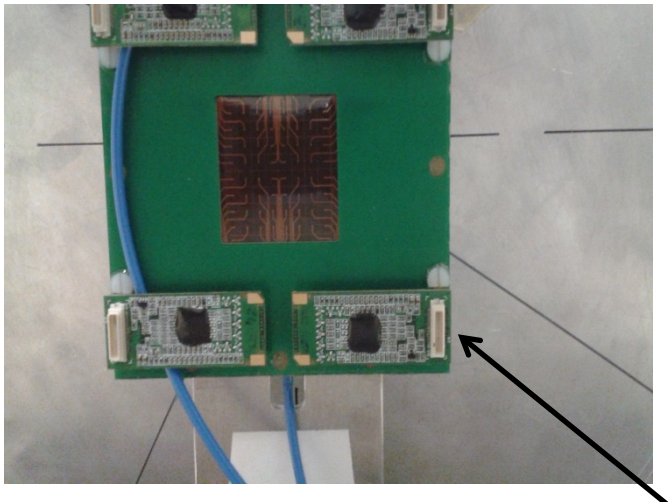
32D			64D	
Parallel mount		*Card*		*Hortogonal mount*
1 FPGA for all 256 channels Compact		*FPGA*		*Each card has its FPGA*
Mounted on board Fixed number of channels		*Full system*		*Expandable and fully customizable system. Possibility to read-out a large number of channels*

Low Mass Beam Monitor

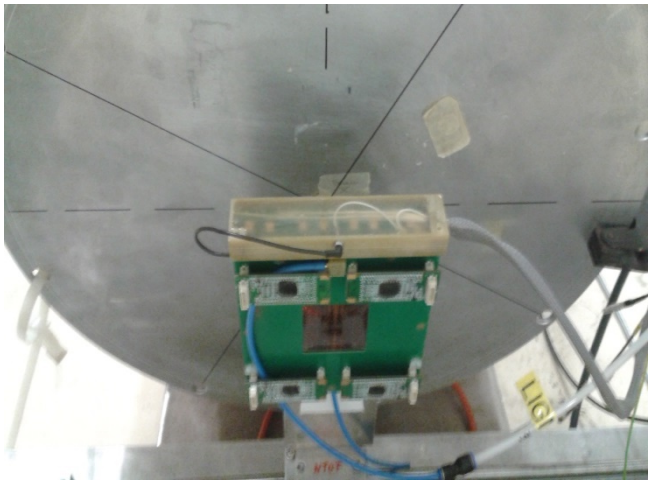


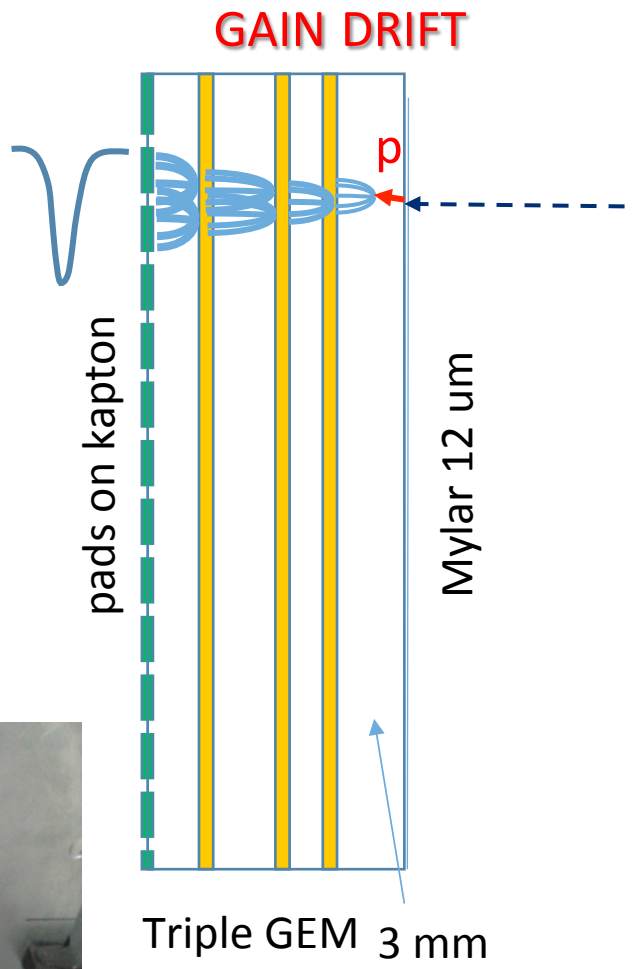
Kapton Pads





Electronics out of the beam



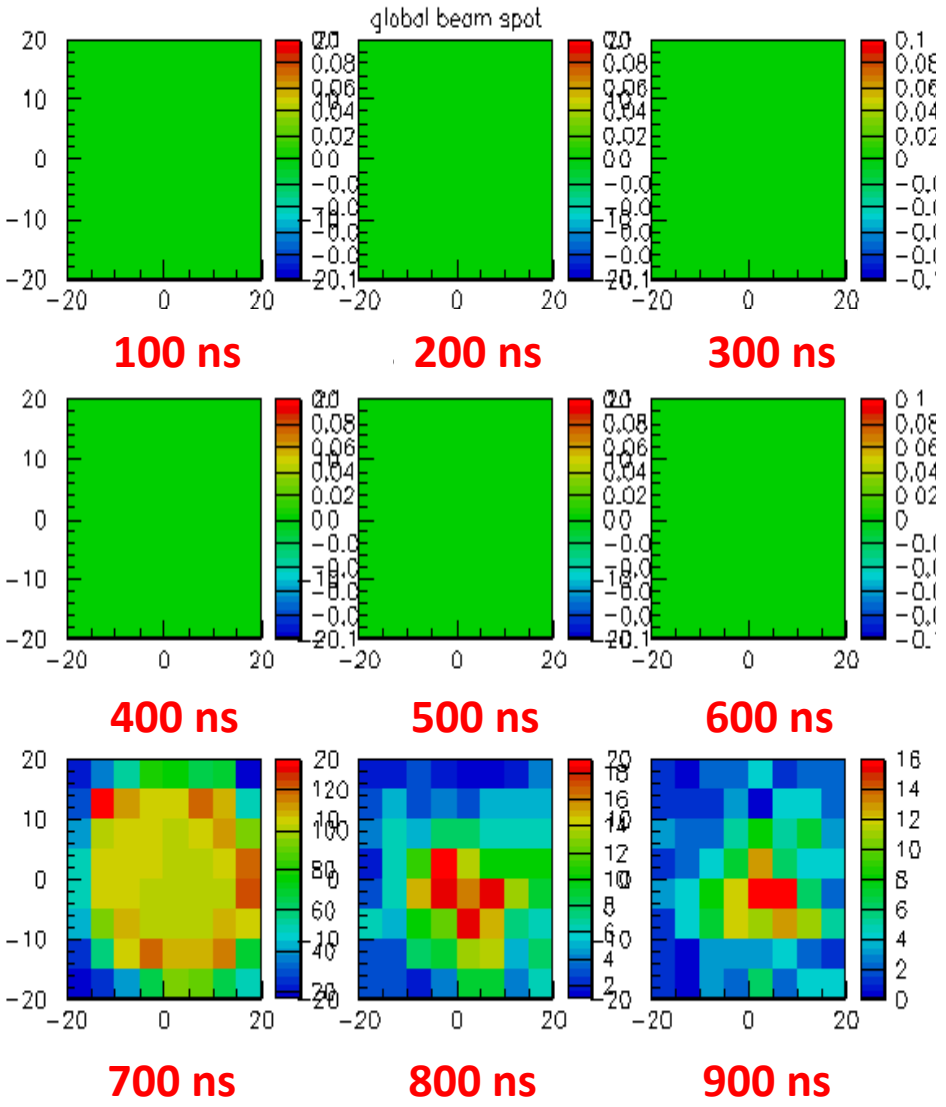


Low Material Budget

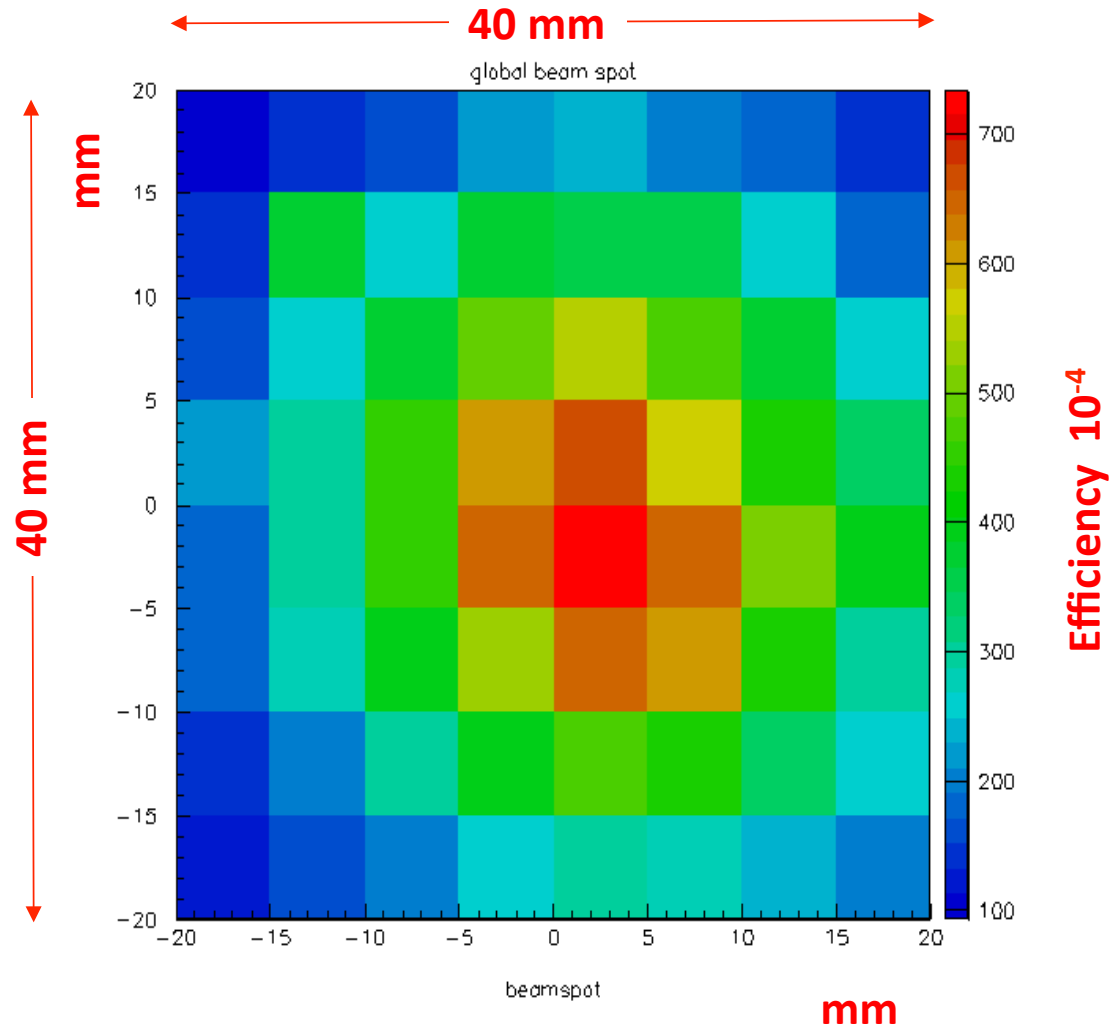
Beam monitor: nTOF gamma flash

The GEM detector with his FPGA based acquisition is able to measure the flux of particle in time slice of 100 ns starting from the CERN-PS trigger.

After 700 ns the gamma flash appear



Beam Monitor: nTOF fast neutron map



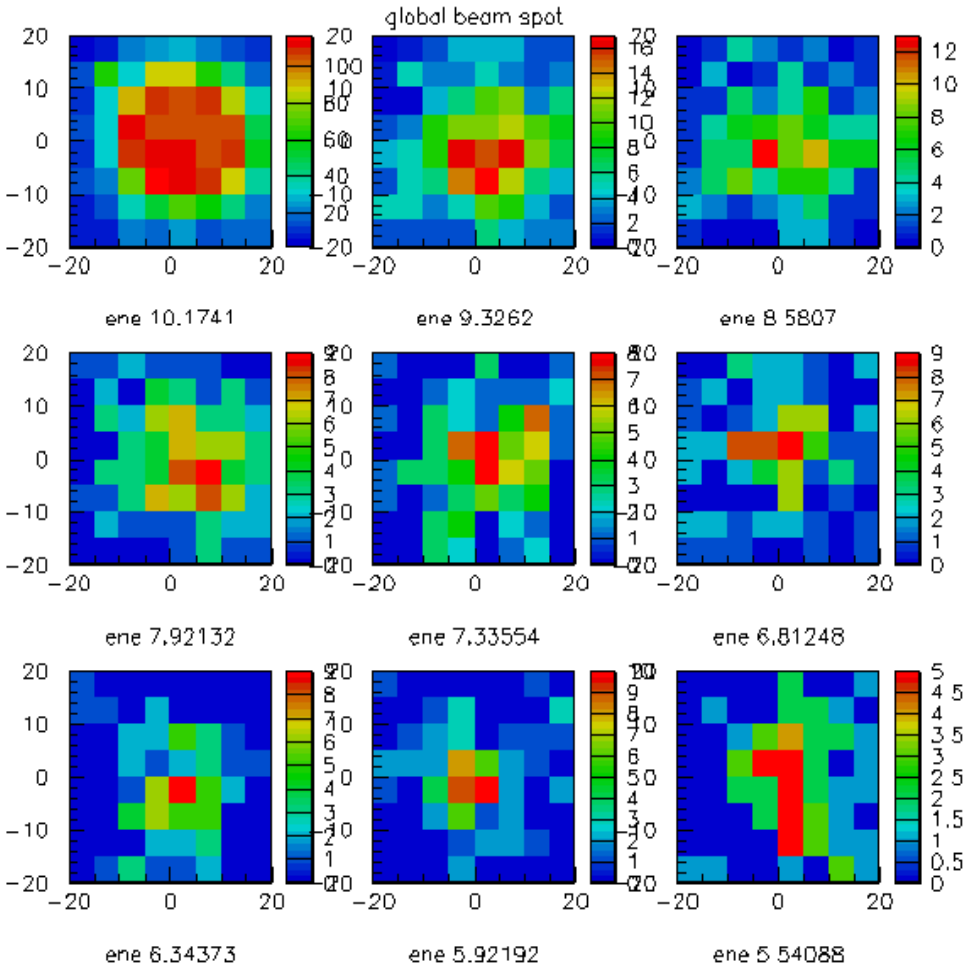
Beam Monitor: nTOF beam spot vs E_n

The FPGA based program is able to create the pictures of the beam spot in the different energy ranges

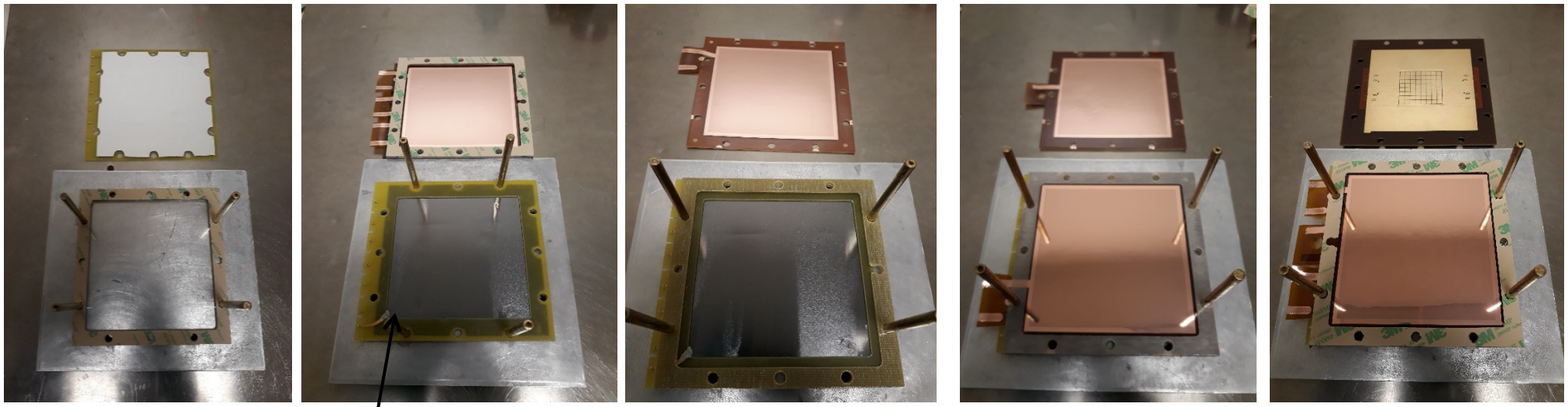
Here the 9 energy slices ranging from 10 to 5 Mev

At the peak neutron flux the detector is not saturated

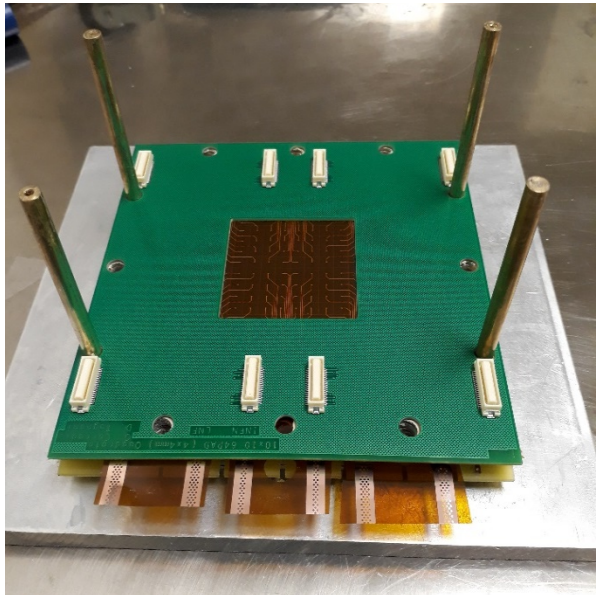
20 min acquistion time



Coming up:
Low mass thermal neutron beam monitor



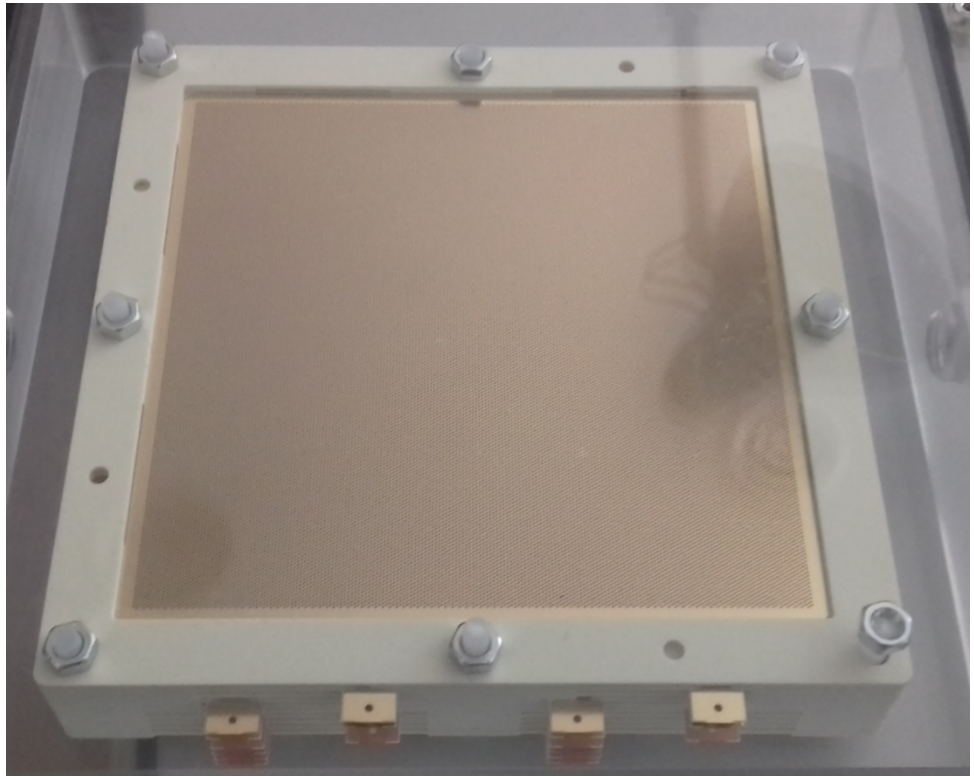
1 µm natB4C deposited on 35 µm Al foil (as cathode)

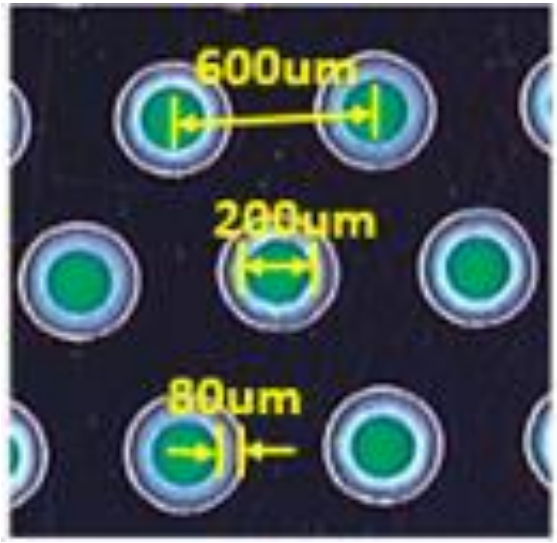


Kapton Pads
Readout by
GEMINI 16D

To be tested in the coming months

A new technology: Al_2O_3 "Thick GEM"

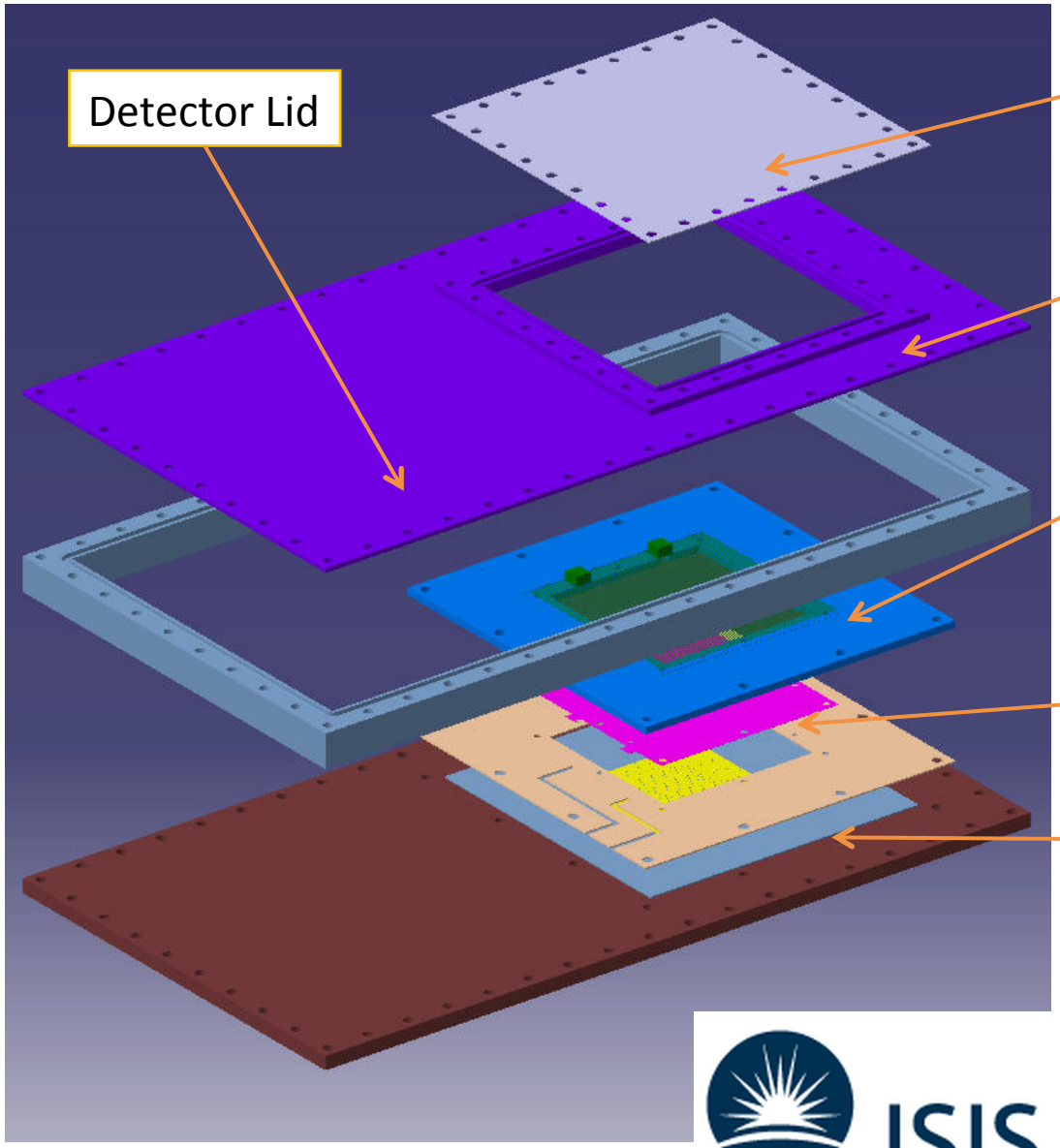




- Industrial development for CNSN
- THGEM realized in Alumina with thickness of 200 µm
- Non Hygroscopic
- Low outgassing → realize sealed (without gas flow) detectors

SNS 中国散裂中子源 China Spallation Neutron Source

Coming up: High performance Al_2O_3 monitor



Detector entrance window (Al 1mm thick)

Al Box with o-ring (on both sides)

Detector cathode (Al foil coated with B4C)

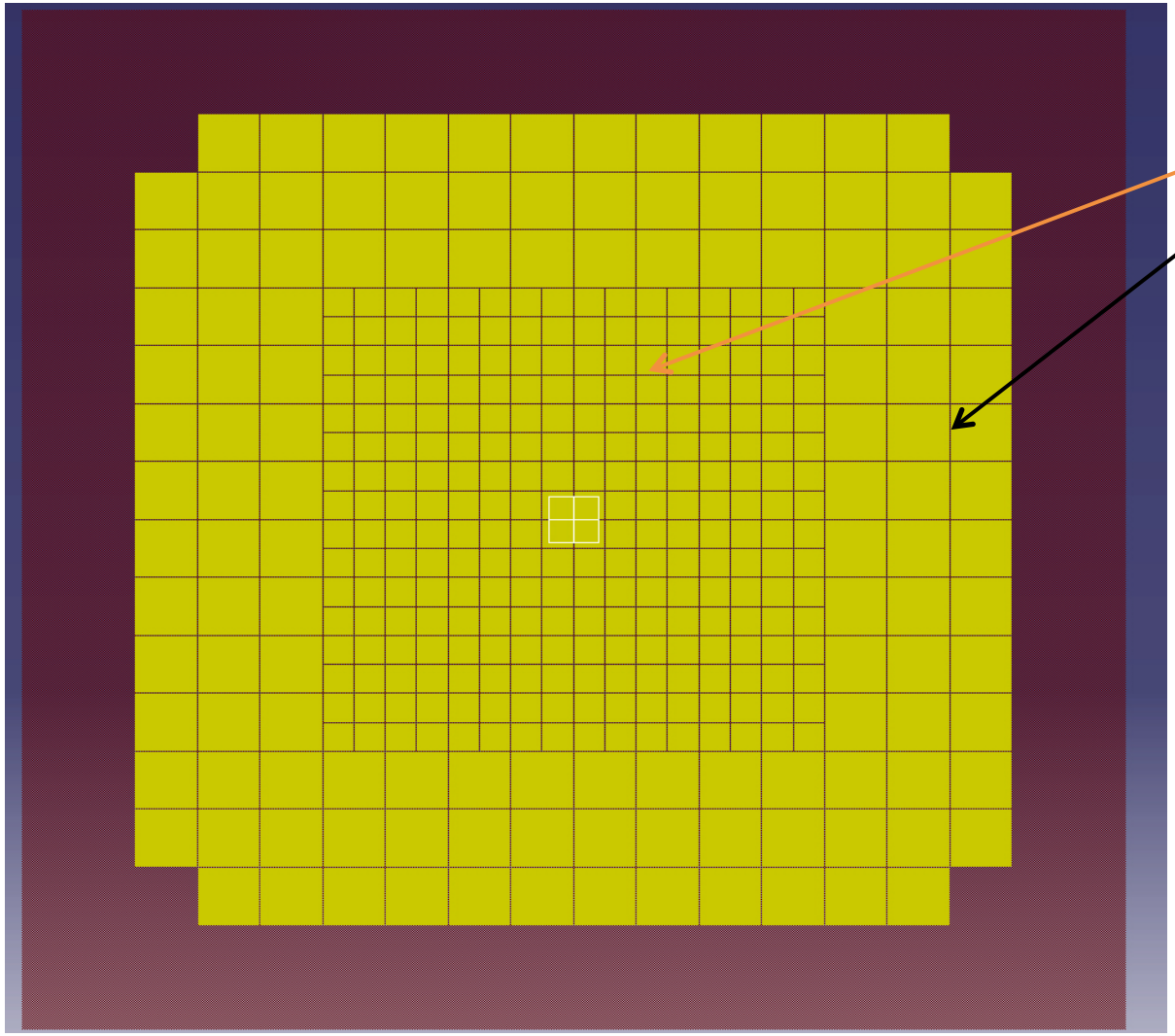
THGEM with its frame
or
Triple GEM stack

Detector Anode

Also: read-out the bottom electrode of the last GEM/THGEM in order to have a single-channel information and to reconstruct TOF spectra

ISIS

High performance Al_2O_3 monitor - pads



- 256 channels 3x3 mm^2
- 128 channels 6x6 mm^2

A total of 384 channels will be read using six 64D GEMINI cards.

The anode is composed by a multi-layer board made of Al2O3 (1 mm thick).

To be tested before summer

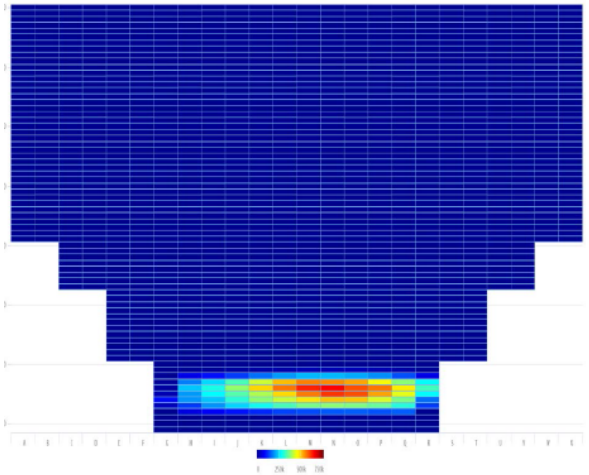
Beam attenuation, efficiency

	Cathode	Amplification	Anode	Efficiency (1.8 Å)	Attenuation (1.8 Å)
Triple GEM + Kapton Pads	Al plate 25 µm thick + 0.1 µm B_4C *Scatt. neutrons (Al) 0.01%*	Triple GEM *Scatt. Neutrons 0.3%*	50 µm of Kapton *Scatt. Neutrons 0.4%*	≈0.06%	≈0.8%
Triple GEM +Al_2O_3 Pads (High Performance)	Al plate 25 µm thick + 0.1 µm B_4C *Scatt. neutrons (Al) 0.01%*	Triple GEM *Scatt. Neutrons 0.3%*	1 mm of Al_2O_3 *Scatt. neutrons 0.3%*	≈0.06%	≈0.65%
Single THGEM +Al_2O_3 Pads (High Performance)	Al plate 25 µm thick + 0.1 µm B_4C *Scatt. neutrons (Al) 0.01%*	Al_2O_3 200 µm thick *Scatt. Neutrons 0.05%*	1 mm of Al_2O_3 *Scatt. neutrons 0.3%*	≈0.06%	≈0.4%

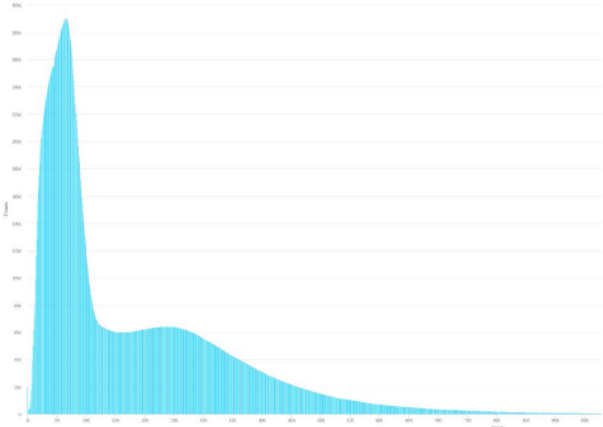
Performance

- ✓ Time resolution of about 1 ns can be reached both in TOF and TOT
- ✓ Spatial resolution depends on the number and size of pads e.g:
  10x10 cm2 active area
  Max n of pads = 1024
  Size about 3 mm x 3 mm
- ✓ *The spatial resolution can be improved with respect to pad dimension using TOT information*

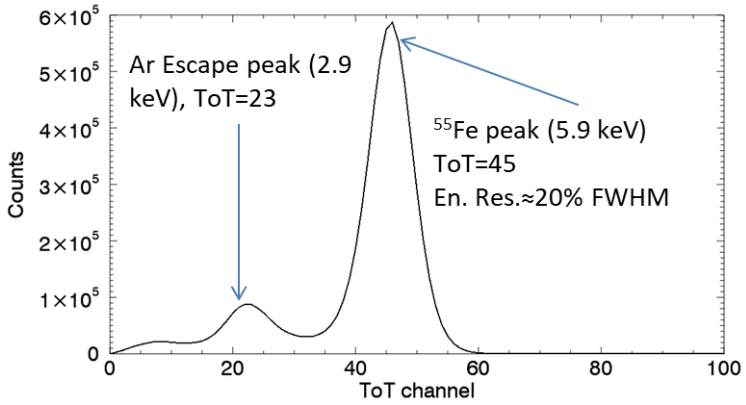
Online beam profile reconstruction



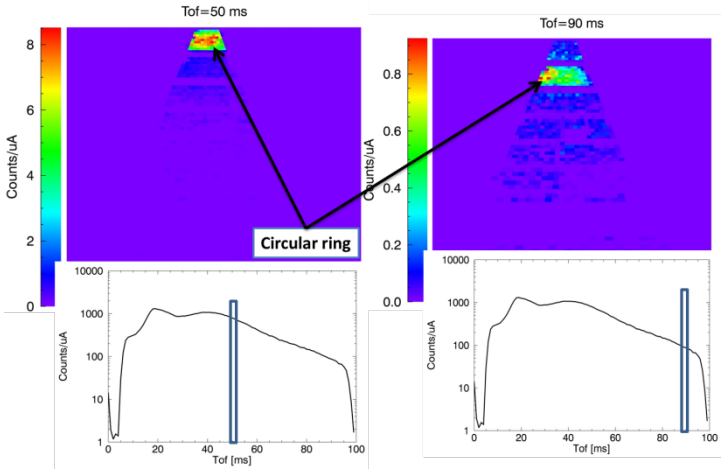
TOF spectrum reconstruction



TOT spectrum reconstruction



Profile reconstruction for different TOF slices



Summary

- Low mass neutron beam monitors: <0.5% attenuation
- Fast neutron low mass beam monitor successfully realized and tested
- Thermal neutron beam monitor built, will be tested soon
  - 64 channels, based on GEMINI 16D
- New beam monitors equipped with GEMINI (32D and 64D boards) electronics
  - Finer spatial resolution (TOT information) and/or larger area
- In progress: Realization of a sealable detector
  - Use low-outgassing materials as detector components (e.g Al_2O_3 instead of Kapton)

Thank you