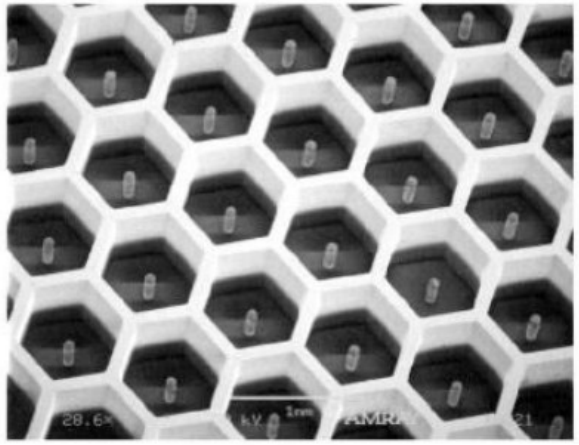
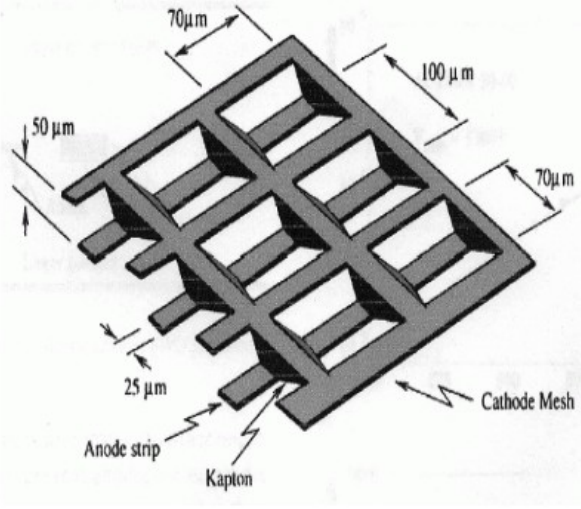
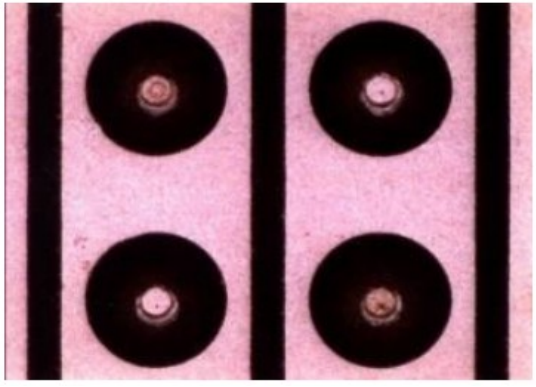
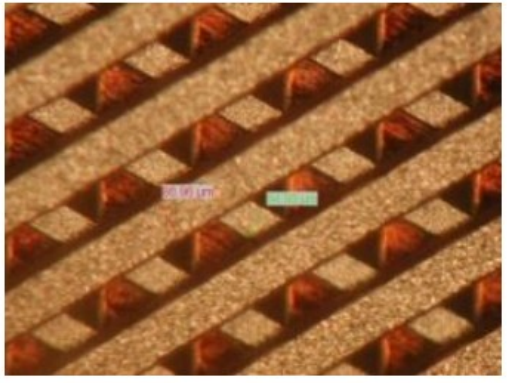




Application of Micropattern Detectors from High-Energy Physics for Neutron Detection

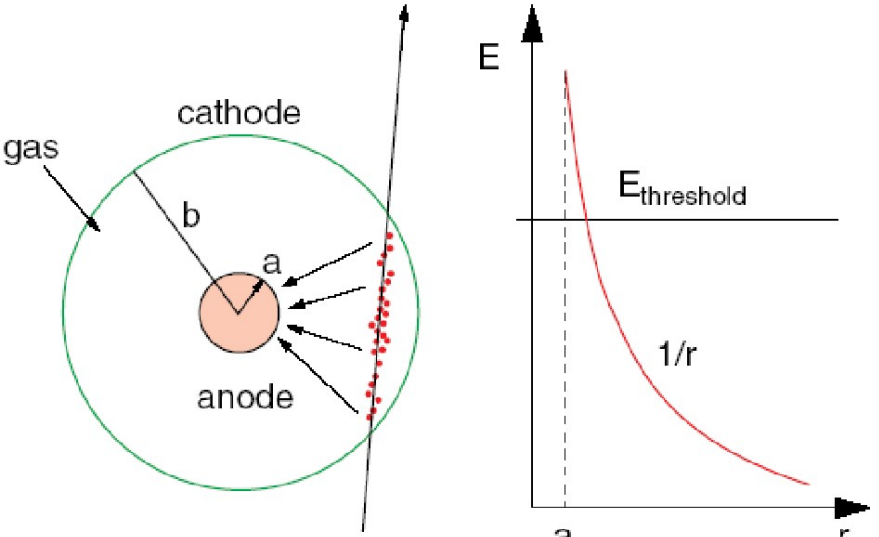




Vitalii Bautin, Temur Enik
LHEP, JINR

ISINN-31, May 2025
Dongguan, China

Field Configurations



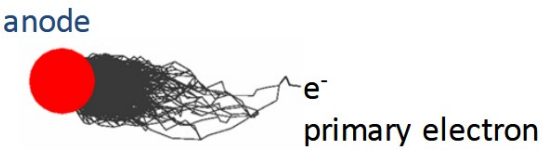
Electrons liberated by ionization drift towards the anode wire.

Electrical field close to the wire (typical wire Ø ~few tens of mm) is sufficiently high for electrons (above 10 kV/cm) to gain enough energy to ionize further → avalanche – exponential increase of number of electron ion pairs.

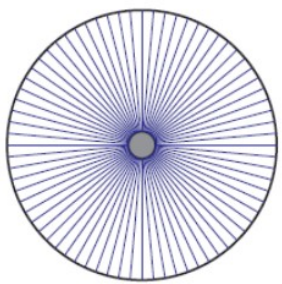
$$E(r) = \frac{CV_0}{2\pi\varepsilon_0} \cdot \frac{1}{r}$$

$$V(r) = \frac{CV_0}{2\pi\varepsilon_0} \cdot \ln\frac{r}{a}$$

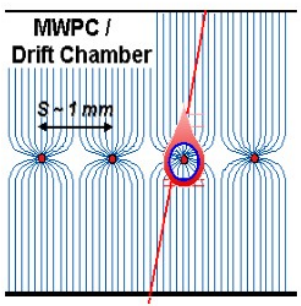
C – capacitance/unit length



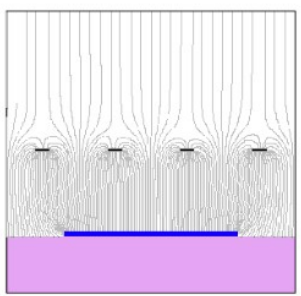
Cylindrical geometry is not the only one able to generate strong electric field:



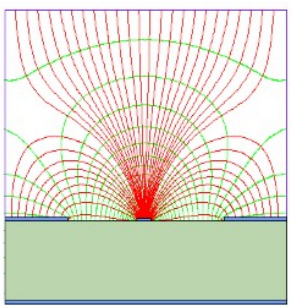
wire



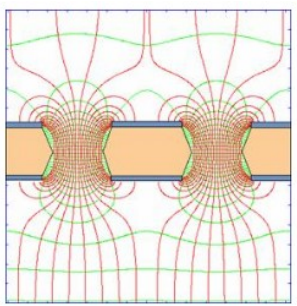
mwpc



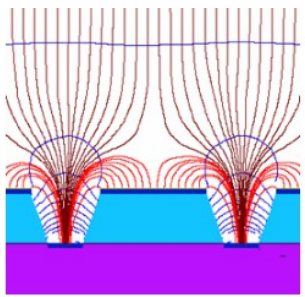
parallel plate



strip

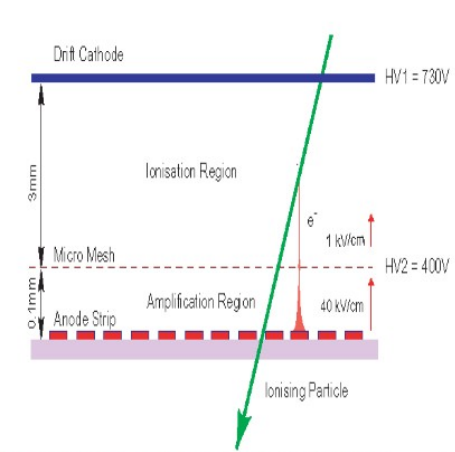


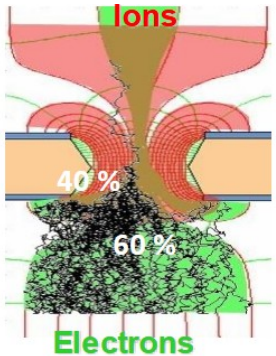
hole

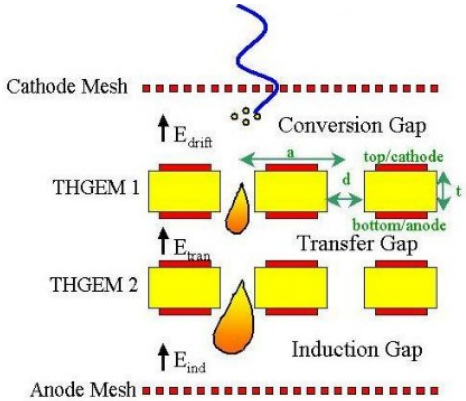


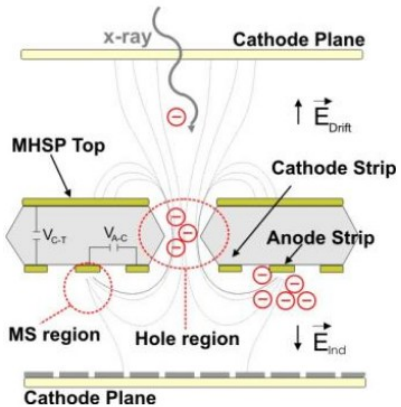
groove/well

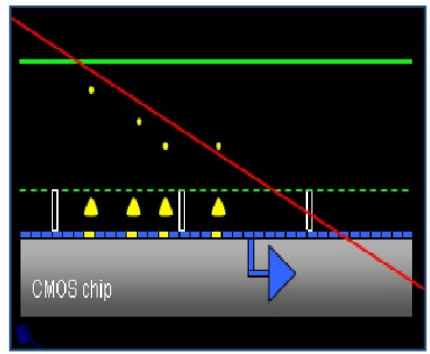
Current Trends in Micro-Pattern Gas Detectors

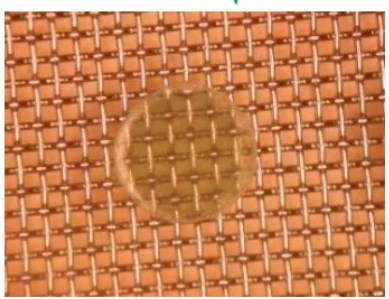




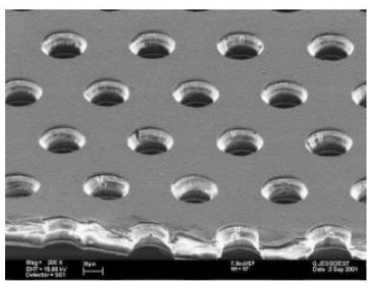




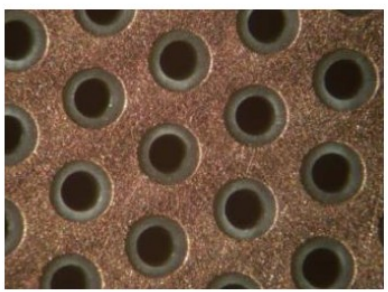




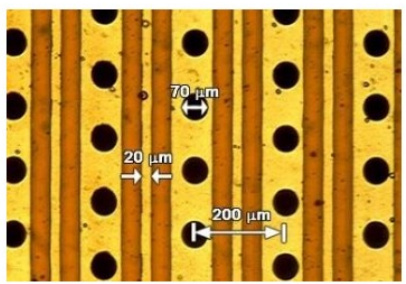
Micromegas



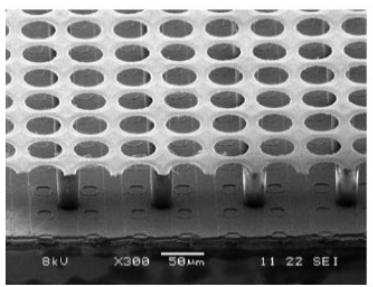
GEM



THGEM

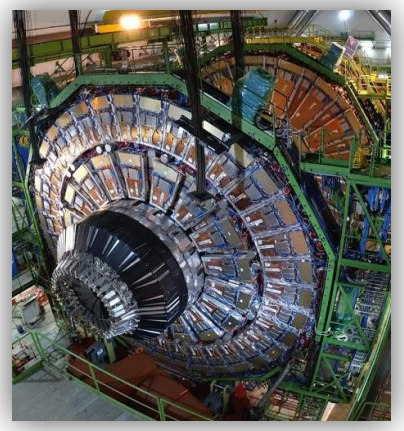


MHSP

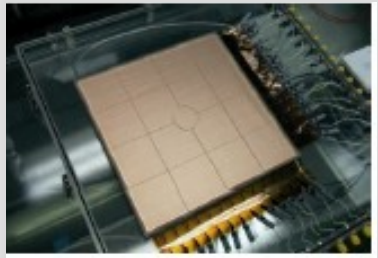


Ingrid

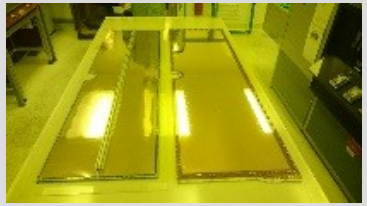
Examples of MPGD activities



GEM :

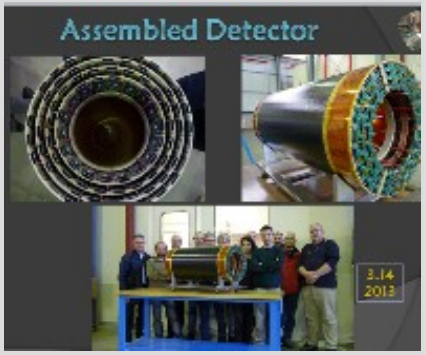


Compass
CMS GEM GE1/1
ALICE TPC GEM
CBM GEM for Fair
BM@N (Baryonic Matter at the Nuclotron Dubna)
Low material budget detectors (Hampton university)
Kloe
Totem
LHC-B
Phoenix TPC (Brookhaven)
SBS tracker (Jefferson Lab)
Etc…

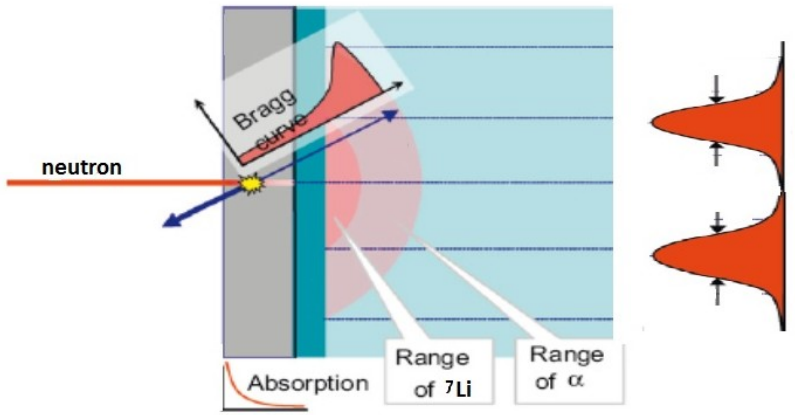


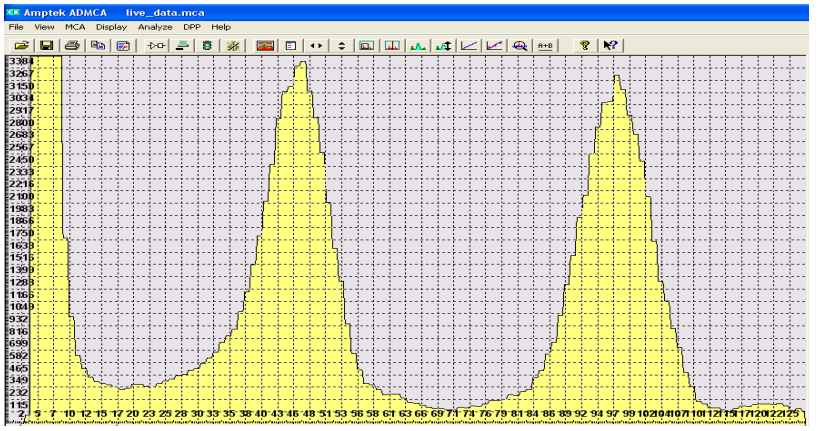
Micromegas

ILC Calorimeter
Minos TPC
T2K
ATLAS NSW
Cast
Panda X uBulk detectors
TrexDM uBulk detectors
TPC's for Nuclear physics
Beam for School
T2K upgrade
Clas12
Scanpyramid
Etc…



Neutron detector development

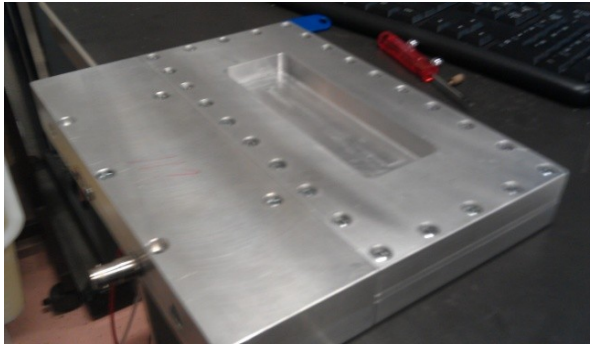




$^{10}B + n \xrightarrow{93.7\%} \alpha(1.47MeV) + {}^{7}Li(0.84Mev) + \gamma(0.48MeV)$

$\xrightarrow{6.3\%} \alpha(1.78MeV) + {}^{7}Li(1.01MeV)$

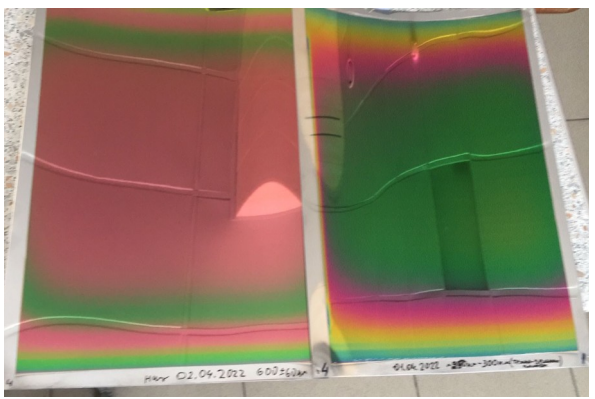
$\sigma_a = 3835$ barn



Neutron detector:

- MWPC, A-C gap h=6mm, wire step S=3 mm, anode wire D=20 µm
- B10 convertor thickness - h=0.1 µm, sensitive area: 144x48 mm2
- Ar/CO2, 70:30, gas flashing or filling up to dP=3 Bar
- HV=(300-1500) V

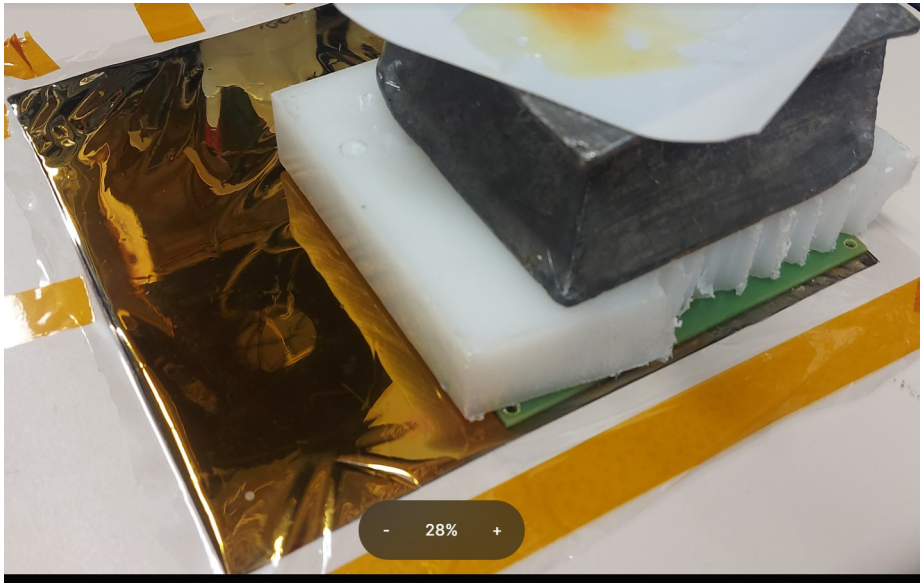
Facility for Coating in FLNP



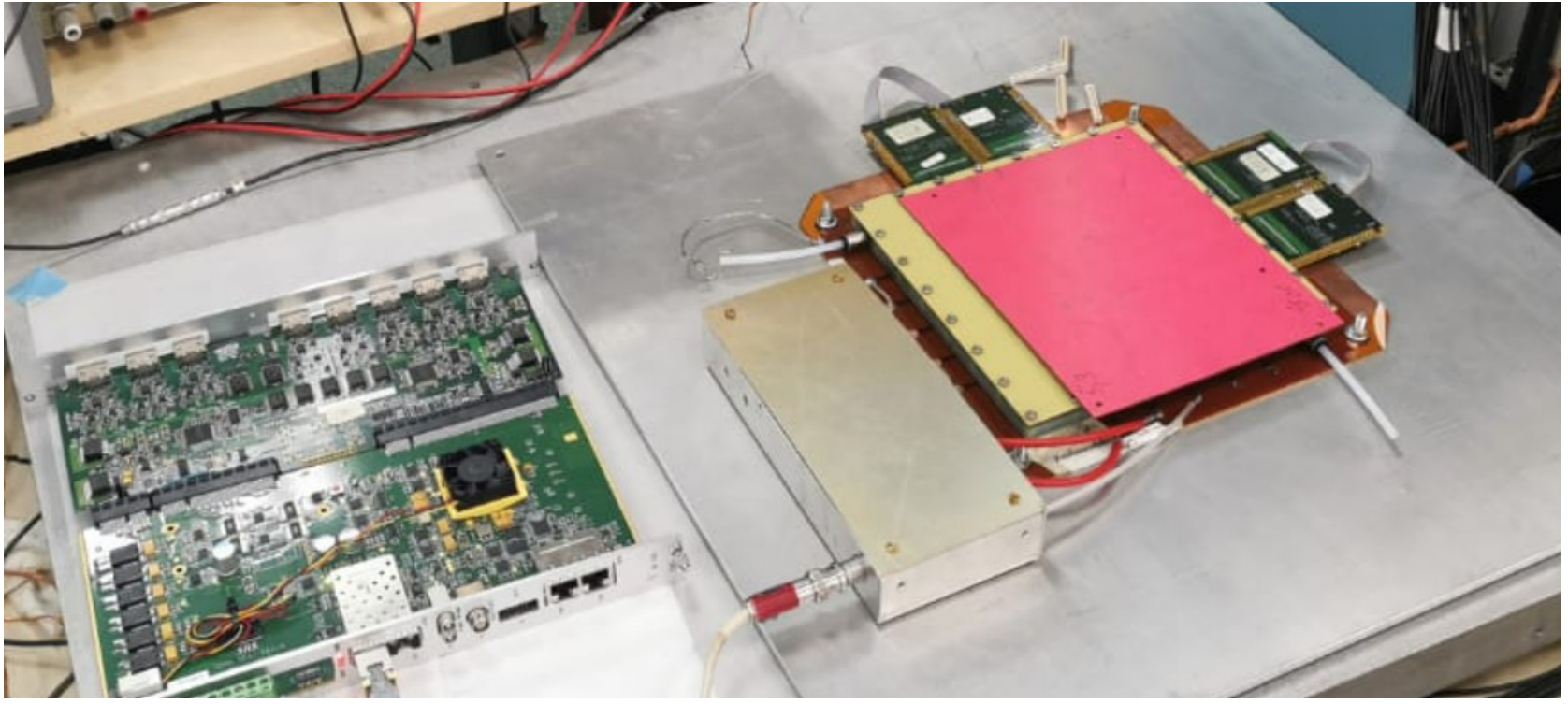
We propose use of B4C windows for the standard RD51 detectors in order to provide widely available neutron detectors

Replacement of the detector entrance window with a film with a coating B4C at JINR

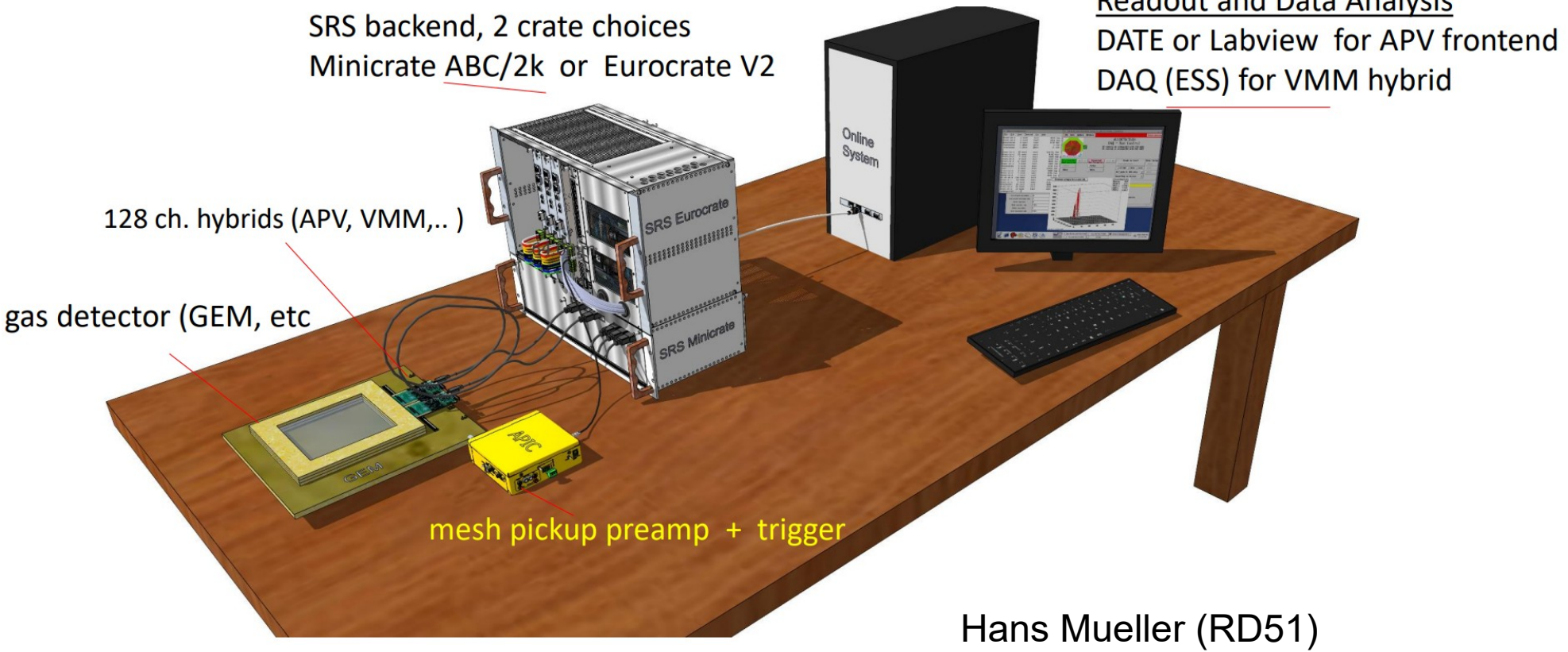
thickness of the coating is about 60 nm



Detector and Reading System



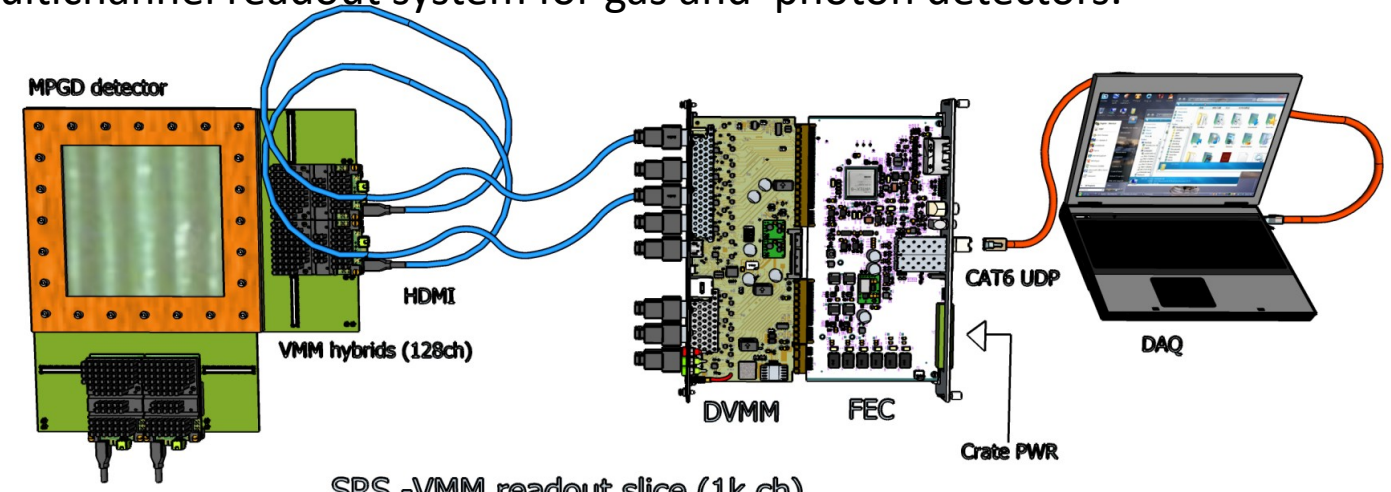
Modern readout solutions – SRS+VMM3a hybrid by RD51 (CERN)



Hans Mueller (RD51)

Scalable Readout System(SRS)

SRS with VMM frontend, so far implemented as a triggerless, scalable multichannel readout system for gas and photon detectors.

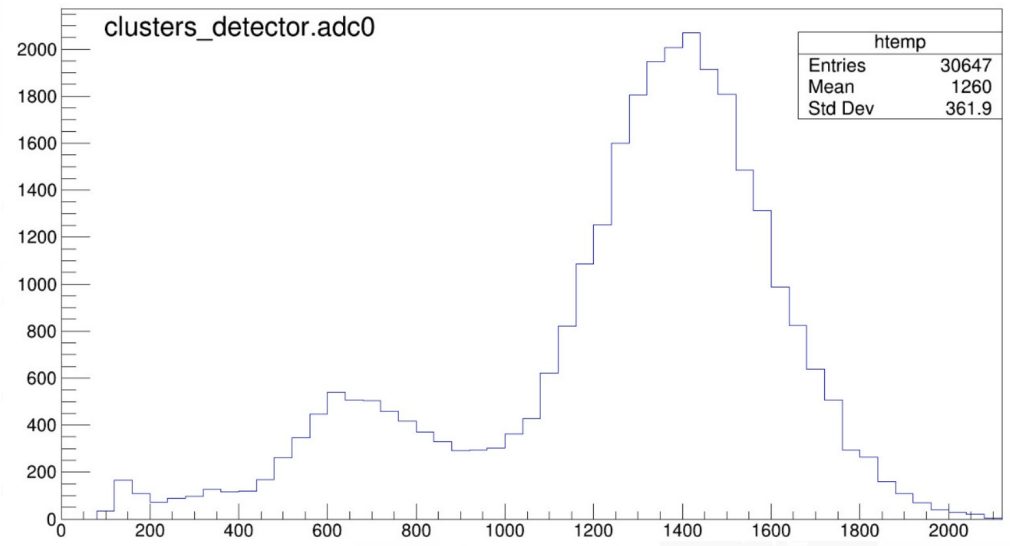


SRS -VMM readout slice (1k ch)

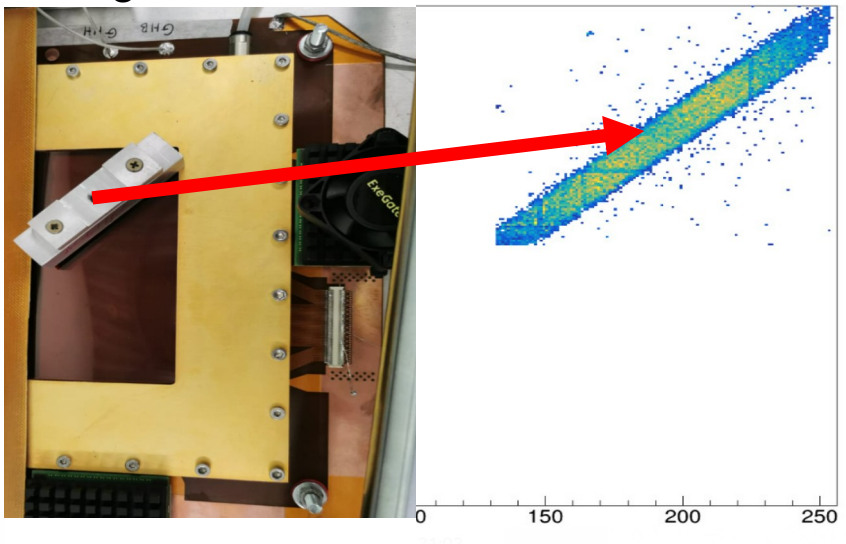
- 1 FEC for 8 VMM hybrids / 1024 detector channels connected via HMDI AD cables to DVMM.
- 2 FEC's with CTF (common clock) for 16 hybrids , 2048 ch.
- DVMM cards with octal HDMI connector including 70 W power for 16 VMM hybrids.
- Power / housing for 2 FECs and CTF via 1 Minicrate (not shown).
- 1 GB Ethernet /UDP uplink from FEC to Network via SFP+ jack
- ESS DAQ Software with Vmm Controls installed under Linux.

Testing basic configuration (standard tripleGEM+VMM3a hybrid+SRS) with 55Fe

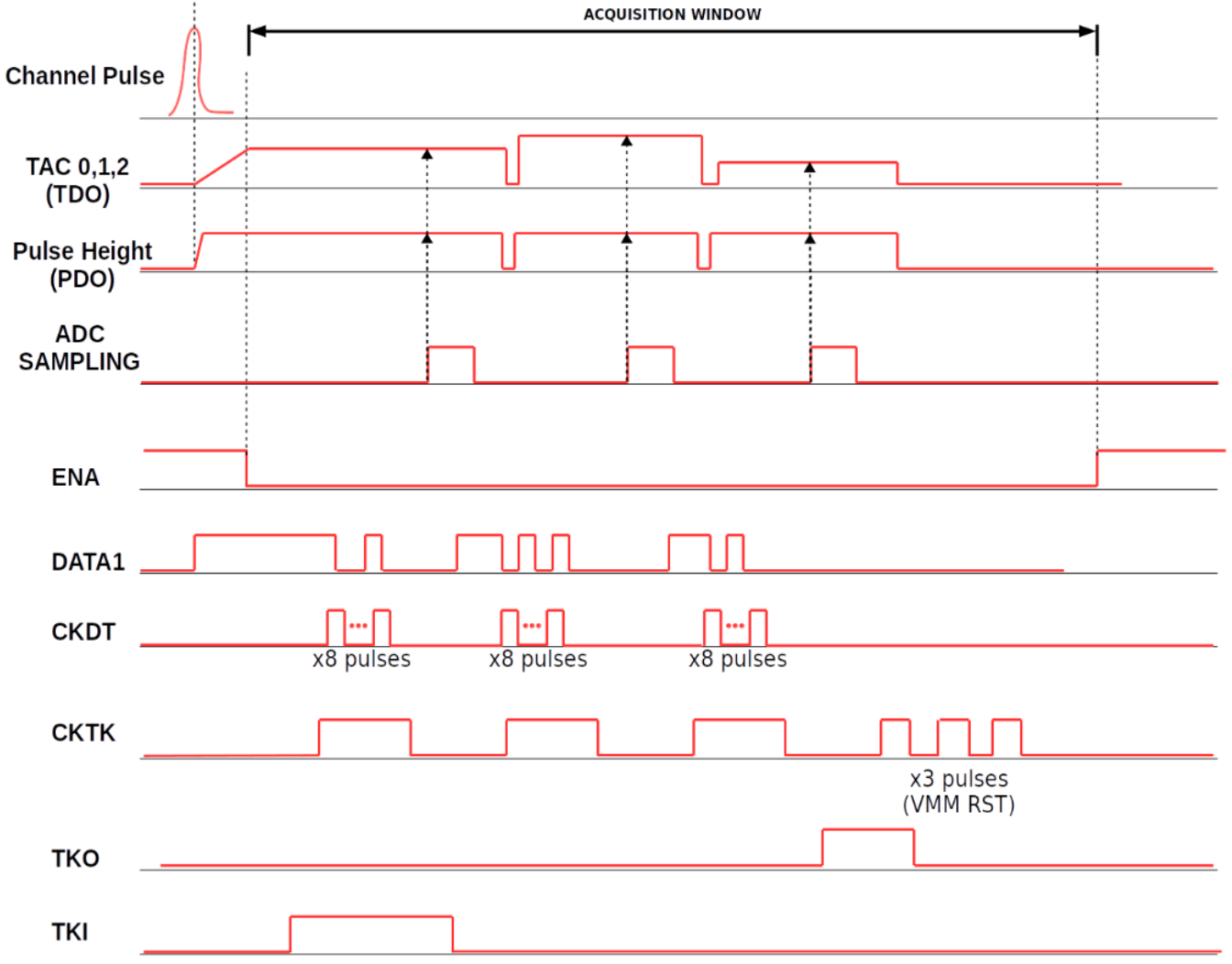
Amplitude spectrum of 5.9 keV ^{55}Fe



Coordinate distribution of illumination through a slit aluminum collimator

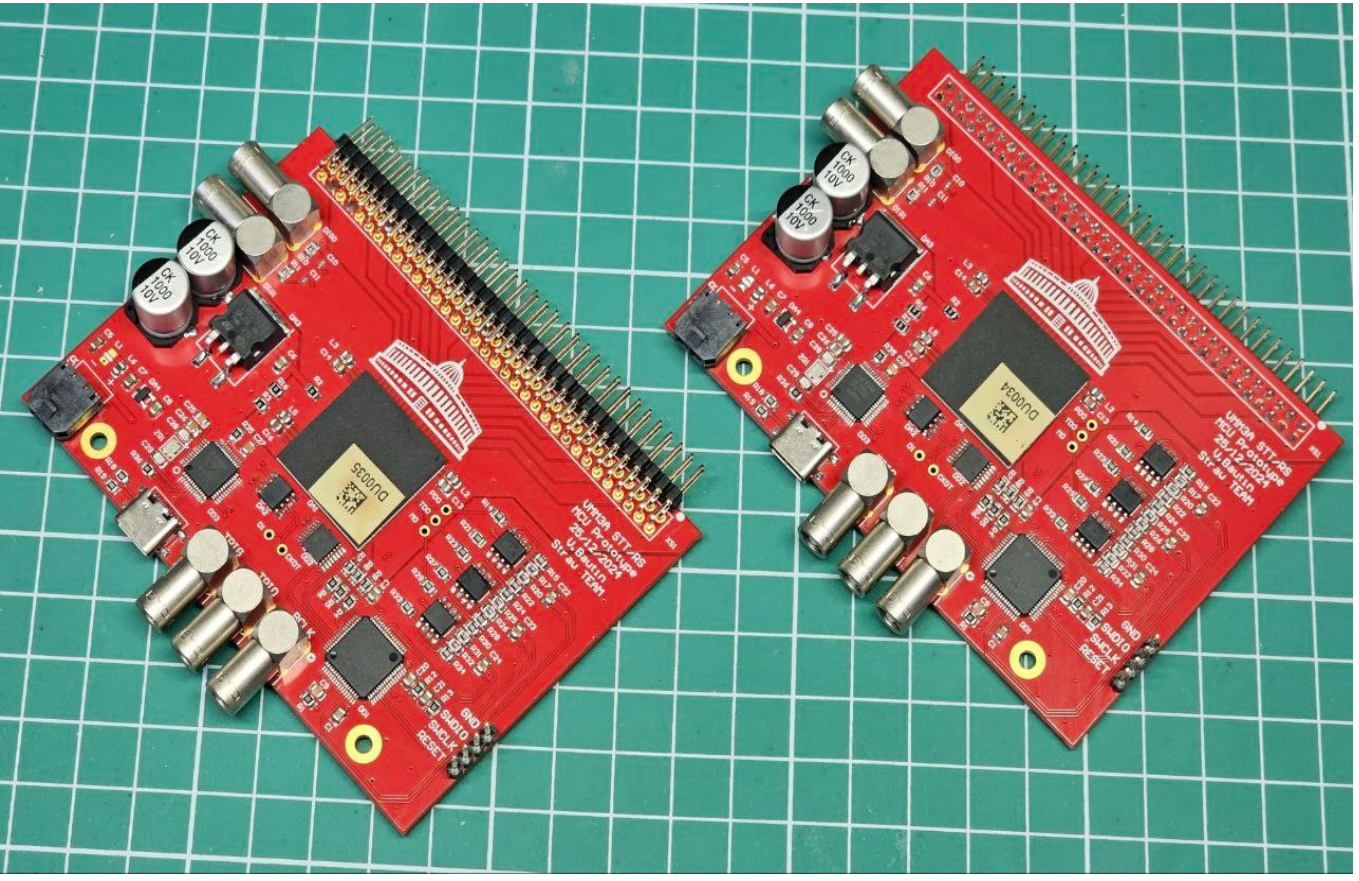


VMM3 with External ADC



- Once the process is complete the **ASIC can be switched readout phase**. The first set of amplitude and time voltages is made available at the **analog outputs**. The **address of the channel is serialised** and made available at the digital output using **six data clocks**.

VMM3A FEB designed



New VMM3a board designed in JINR

External **12-bit ADC**

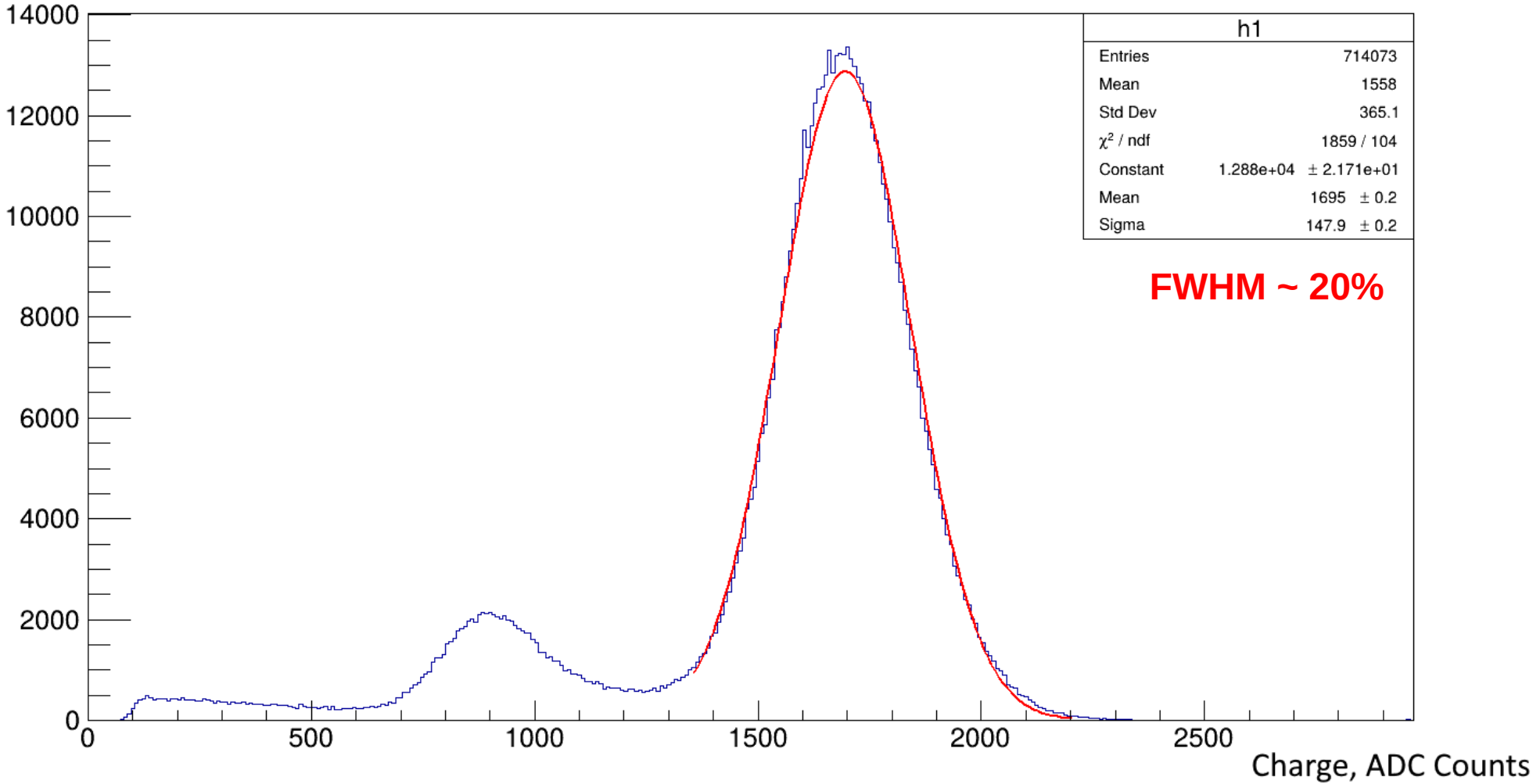
Better charge and time resolution

Lower power consumption

Limited hitrate

Next **FBGA**-based design ongoing

Fe55 Source, Ar/CO2 70:30 Mixture



Conclusion

- We proved that existing MPGD upgraded with B4C windows can be used as neutron detectors
- RD51 Collaboration (CERN) develops and provides standardized solutions for small-area gaseous detectors of ionizing radiation
- We propose use of B4C windows for the standard RD51 detectors in order to provide efficient and widely available thermal neutron detectors