Development of advanced neutron detectors at FLNP

Motivation:

• Increase of a neutron source flux by an order of magnitude is a serious challenge

• Advanced detector systems can increase the efficiency of an experiment by a factor of 100

• There is no reliable and affordable supplier of modern neutron detectors

• Practically all neutron centers are developing neutron detectors for themselves

Gas-filled detectors

Infrastructure

Figure1: gas-filling system

Figure 2: vacuum furnace (*Vacu Heat 17 L (200 C°)*), water purifying system (*Purelab Option – S7 (7,5 l/h)*) and ultrasonic bath (*ИЛ100-5 (39x37x14 cm)*)

Infrastructure

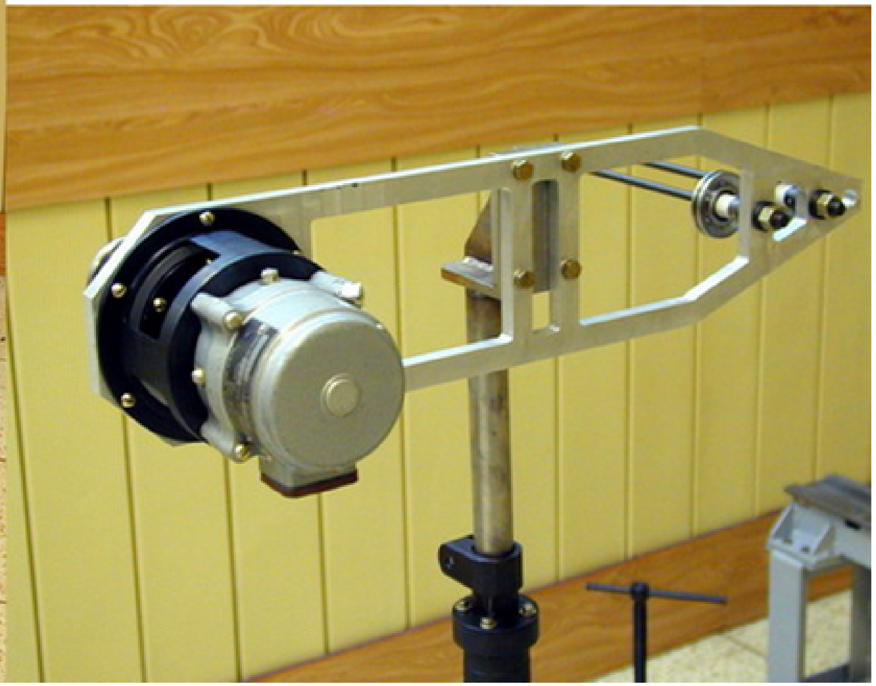

Figure 3: winding stand for wire planes manufacturing.
(Microscope *Leica S4E* is used for precision and quality control)

Infrastructure (clean room)

Gas-filled detectors

Infrastructure (clean room)

Infrastructure (clean room)

Clean Box inside CR

MSGC with “virtual” cathode

Microstrip chambers achieve high precision and high count rate by emulating the field structure of multiwire chambers using a sequence of alternating anode and cathode strips on an insulating support. Using photolithography instead of physical wires, the distance between sensitive elements can be reduced to a fraction of a millimetre.

To increase the detection efficiency of a detector one needs to increase an operating voltage. But at high gains parasitic ionisation can result in a discharge between strips and ruin delicate instrumentation.

MSGC with “virtual” cathode

“Virtual Cathode Chamber” is not subjected to the possibility of discharges between anodes and cathodes, thus avoiding one of the most dangerous problems met with standard micro-strip chambers.

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NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH Section A

The virtual cathode chamber

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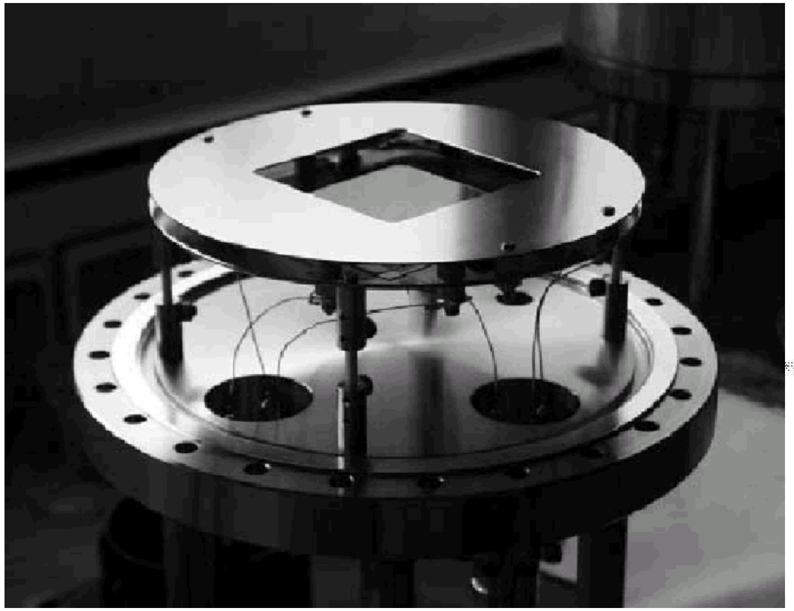
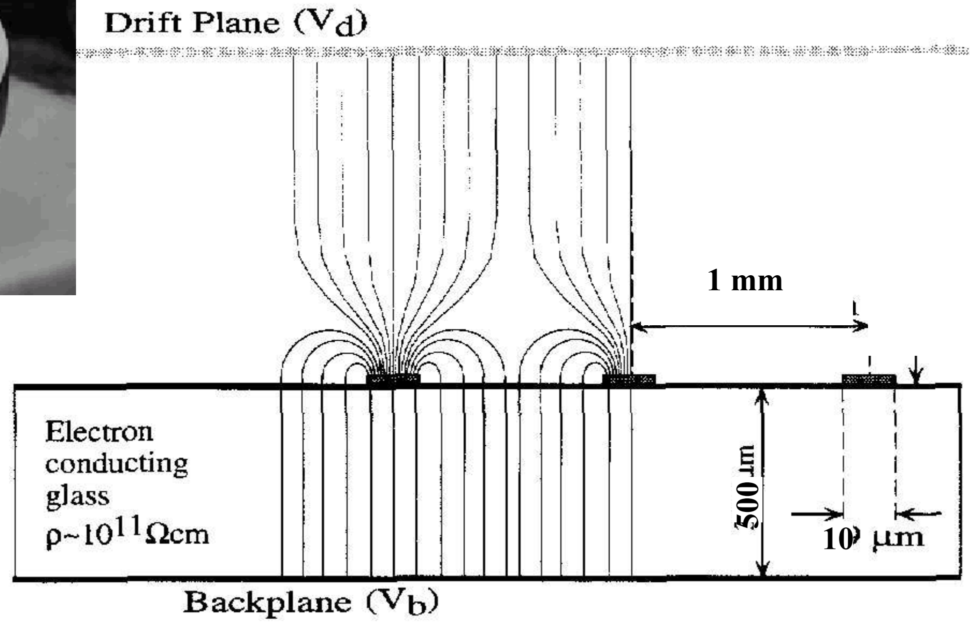
MSGC with “virtual” cathode



Bidim80 developed at ILL, reproduced at FLNP.

Two microstrip plates produced at IPM (RAS) are working successfully at ILL

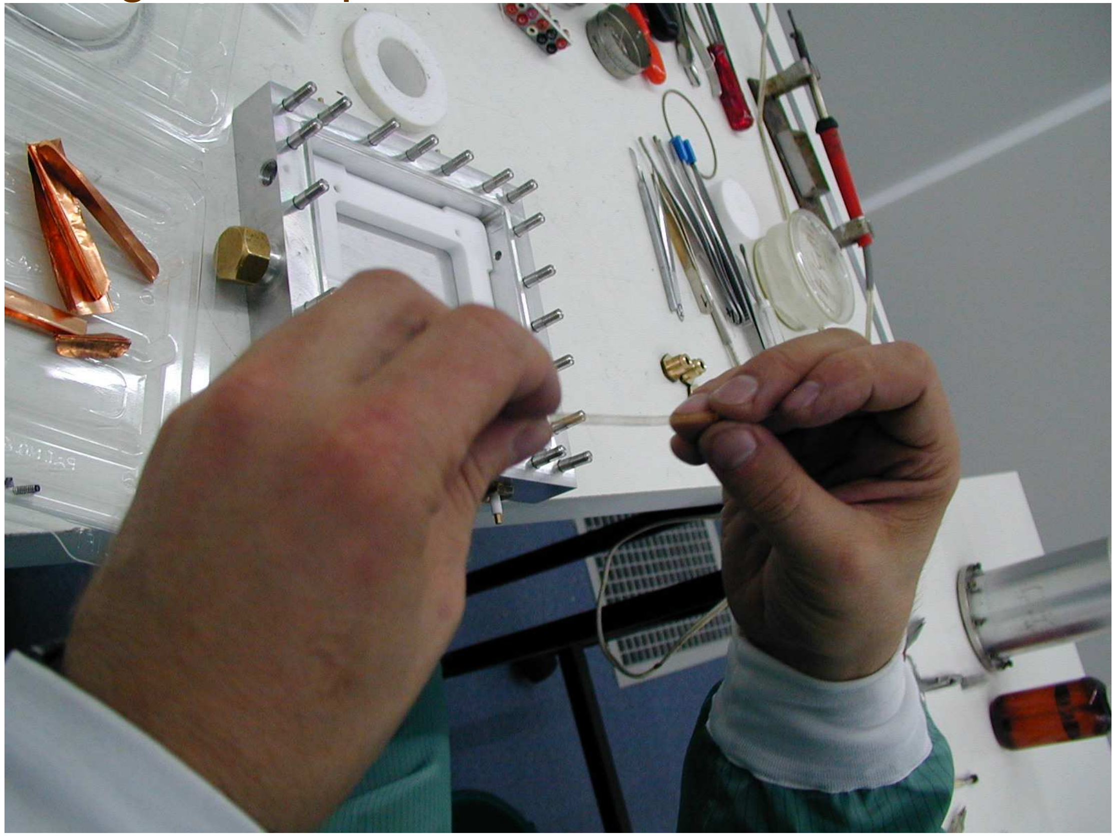


5×5 inches, Schott S8900 glass 0.5 mm thick. The sensitive area 80×80 mm². Strips are made of chromium, 1500µm..

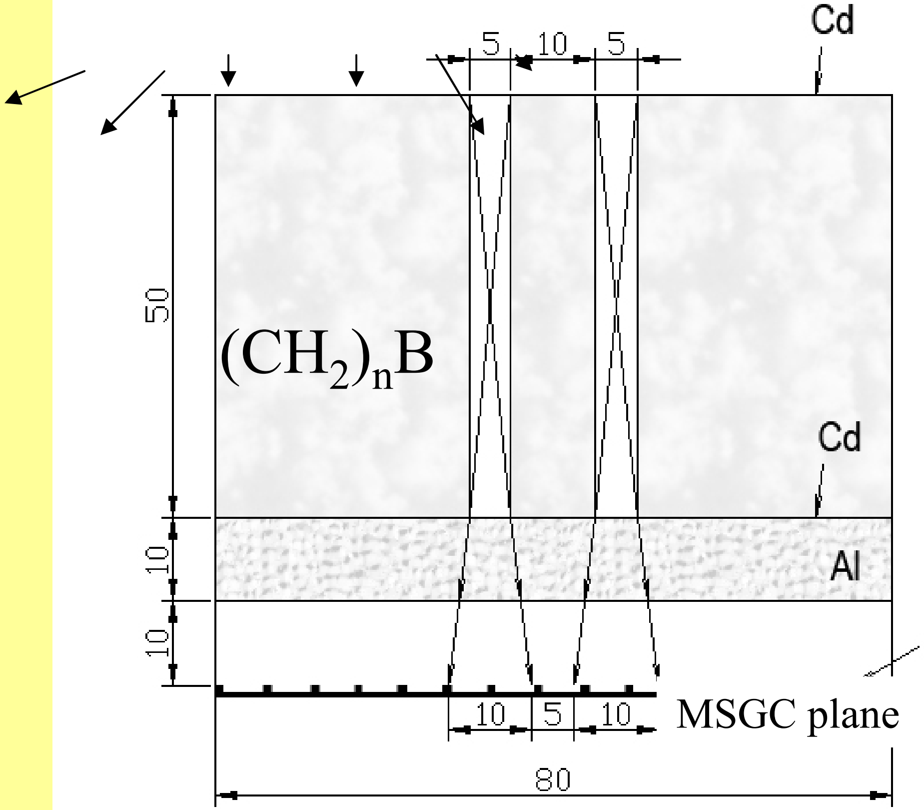
Front side anodes 10µm wide with a pitch 1mm, inter-connected together by a resistive line of 5kΩ. Back side cathodes 900µm wide are orthogonal to the anode structure and also interconnected by a resistive line of 5kΩ.

MSGC with “virtual” cathode

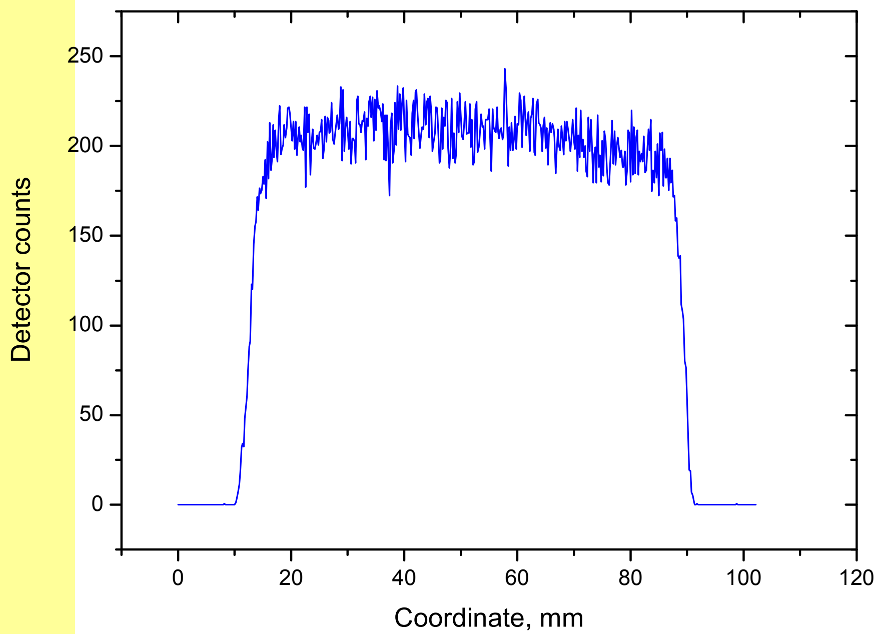
The detector box was modified in comparison with the original ILL design to adapt the detector for future modifications.

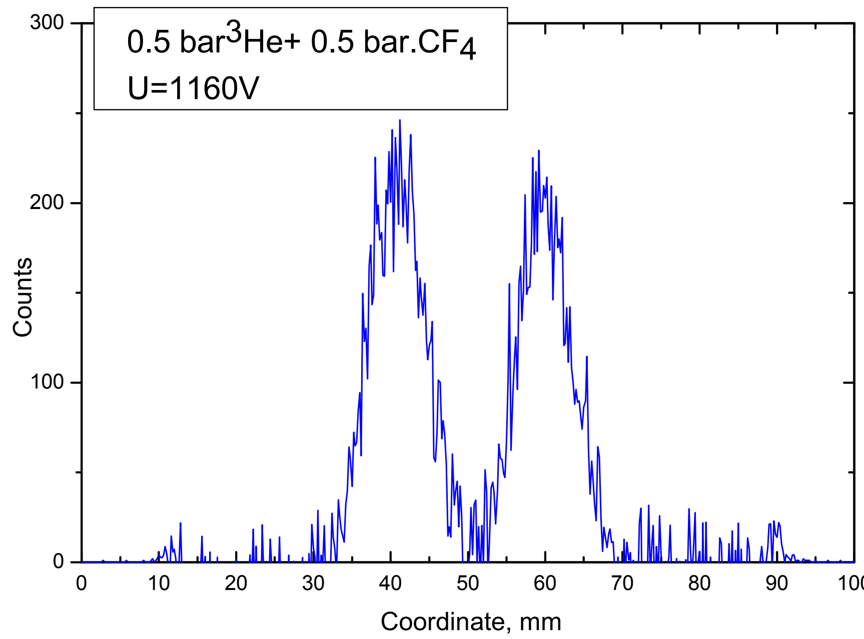


MSGC with “virtual” cathode: test with ^{252}Cf source



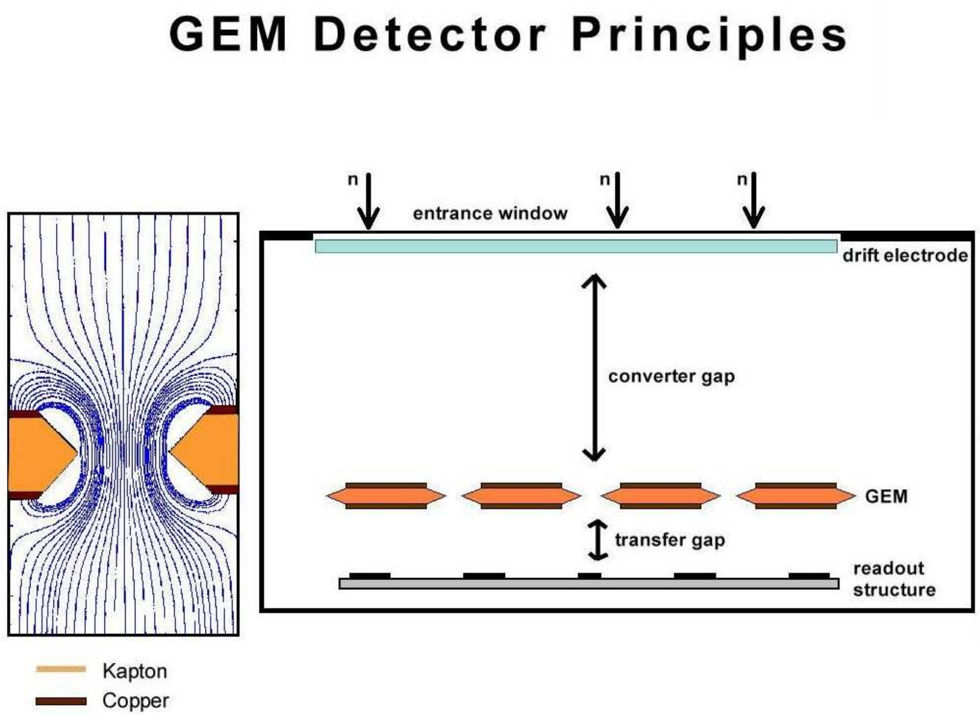
MSGC with "virtual" cathode: test with ^{252}Cf source

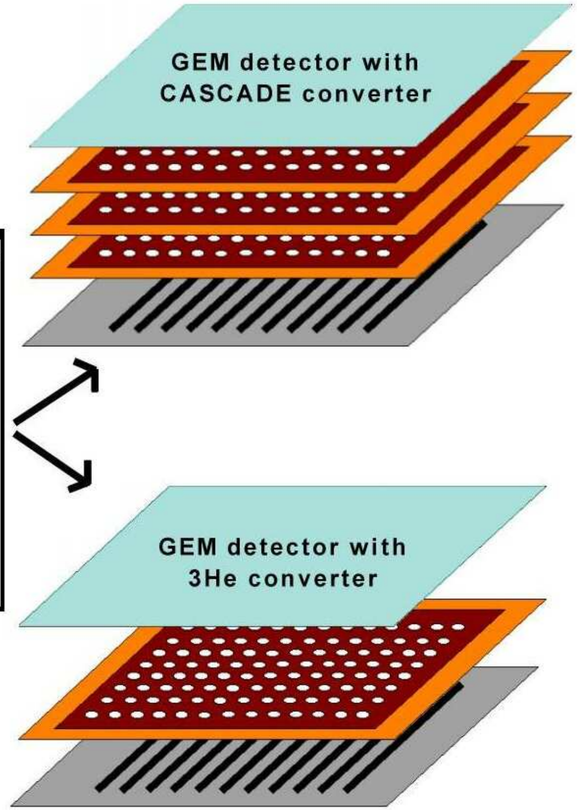




At working pressure detector will be tested at IBR-2 this September-October

GEM: gas electron multiplier





GEM uses a thin sheet of plastic (50 µm thick) coated with metal on both sides and chemically pierced by a regular array of holes a fraction of a millimeter across and apart.

Applying a voltage across the GEM, the resulting high electric field in the holes makes an avalanche of ions and electrons pour through each. The electrons are collected by a pick-up electrode with x- and y-readout

Specifications of a Position Sensitive Monitor Detector

Description:

The detector described is a **2D-position sensitive in-beam monitor** detector to be used at the FRM-II neutron research facility. It shall be used at different neutron scattering instruments to control the position and intensity of the incoming neutron beam. The detector shall be fully operational by the end of 2005 including readout electronics.

Specifications of a Position Sensitive Monitor Detector

Design Specification:

Type:	Multiwire Proportional Chamber
Active area:	$A = 100 \times 100\ mm^2$
Dimensions:	as small as possible
Monitor thickness	$d < 20$ mm
Position resolution	$\Delta x \approx 4$ mm
(FWHM)	$\Delta y \approx 4$ mm
anode wires:	∅ = 10 µm; material W(Re-doped) / Au-plated
cathode wires:	∅ = 30 µm; material W(Re-doped) / Au-plated
anode pitch	1 mm
cathode pitch	2 mm
Stopping gas	has to be investigated. Candidates are CF_4, Ar or eventually C_2F_6, C_3F_8 , C_4F_{10}

Specifications of a Position Sensitive Monitor Detector

Design Specification:

Neutron converter:	^3He, N_2
Sensitivity for thermal neutrons	$S_{th} = 10^{-3} – 10^{-6}$
Range of neutron wavelength	λ = 0.4 Å – 12 Å
Neutron flux	$f = 10^4 – 10^8$ n/s·cm^2
Detector count rate	R = 1 kHz – 50 kHz

Position Determination:

cathode x	delay line
cathode y	delay line
anode	trigger

Specifications of a Position Sensitive Monitor Detector

Desc

wPlatfo

Input s … NODE”

Data pr

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TDC … multihit mode)

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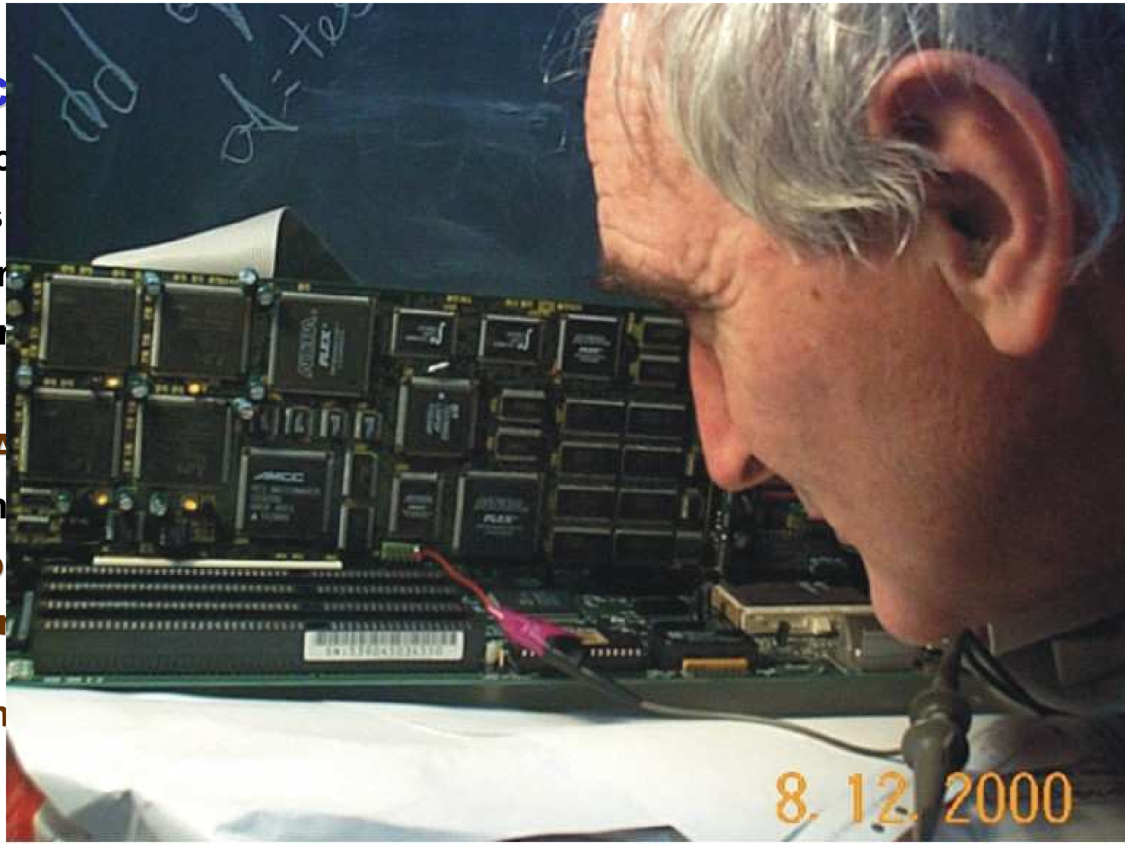
Data th

Possib … e time-channel width)

Concur

Built-in



Dr. Levchanovsky is adjusting and testing the DAQ board

Specifications of a Position Sensitive Monitor Detector

Description of Read-Out Scheme (cont.):

TDC **Acam F1 (8 channel, 150ps resolution, multihit mode)**

Flash ADC (40MHz) for the analog "ANODE" pulse height spectra accumulation

Data throughput **1-2 Mevents / sec**

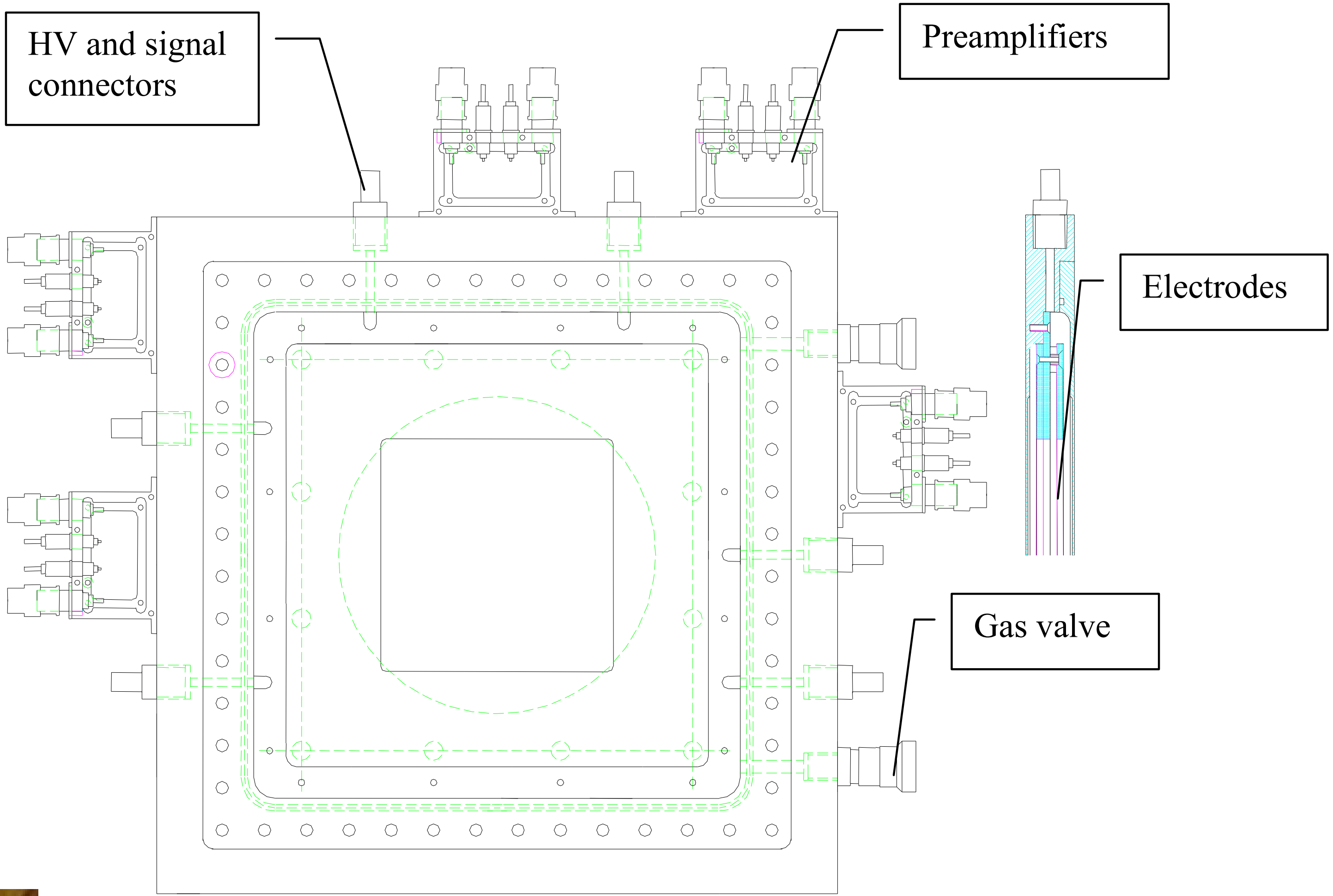
Possibility to work with TOF spectrometers (TOF mode, programmable time-channel width)

Built-in test generator

Concurrent list and histogramming mode of data accumulation

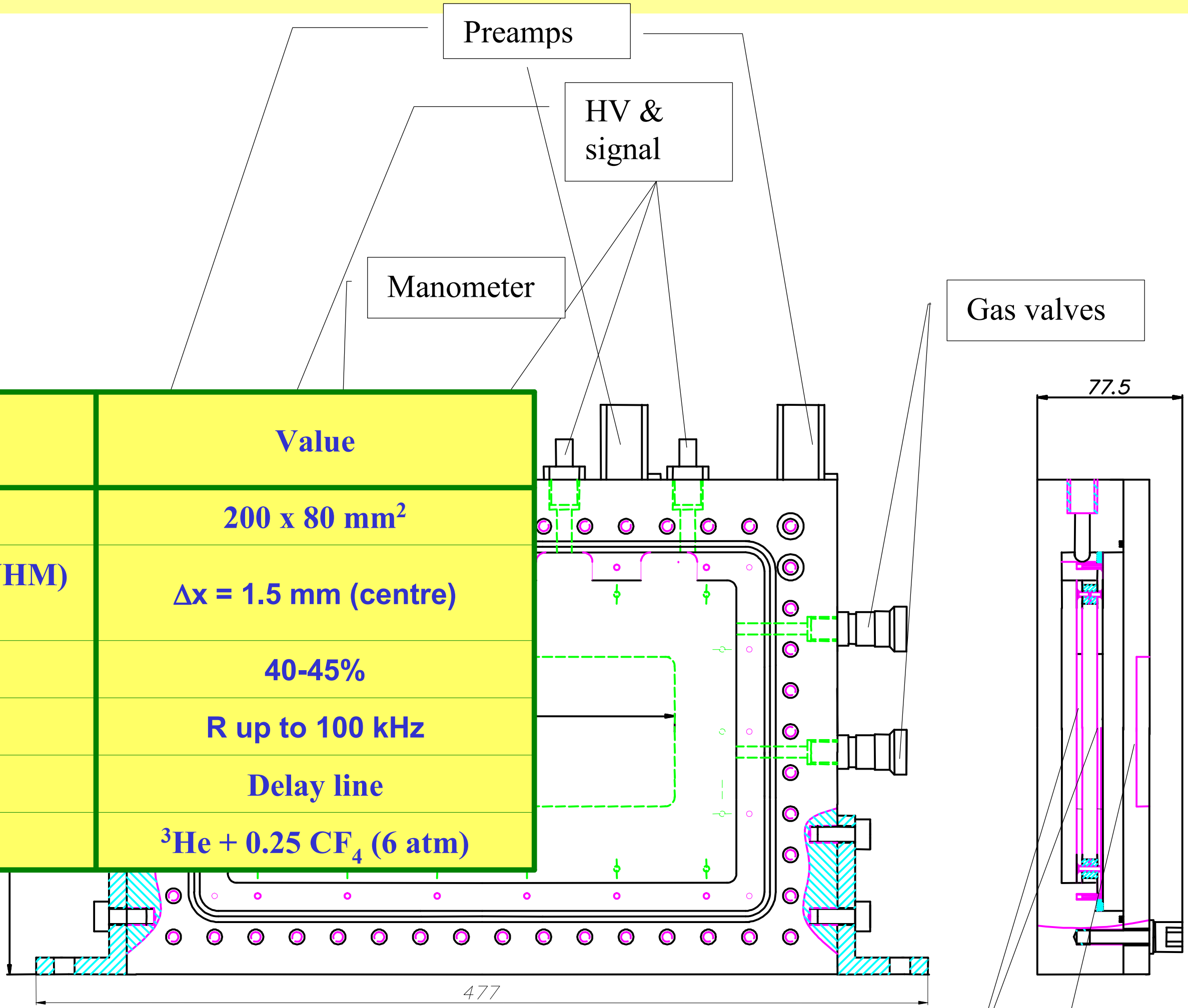
Master/slave mode for system extension (common signals: REF_CLK, CHOP_CYC, RUN, VETO, etc

Position sensitive monitor detector



One-dimensional PSD

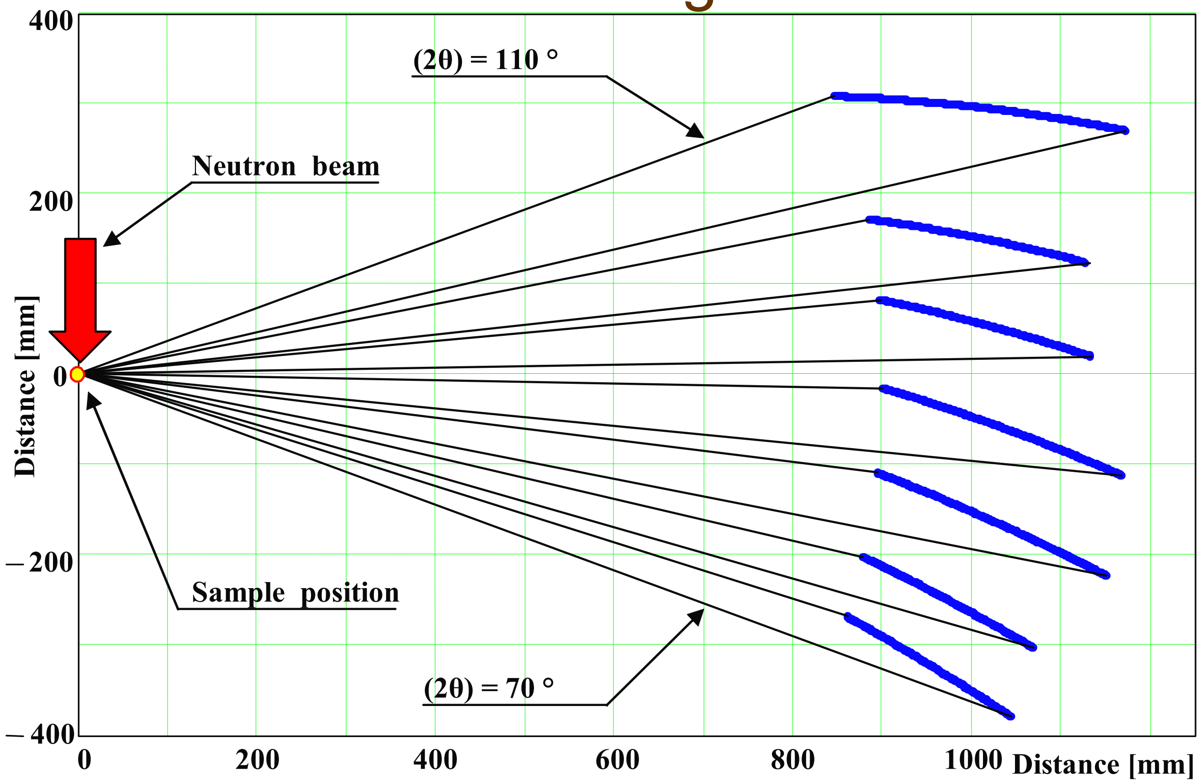
Parameter	Value
Aperture	200 x 80 mm^2
Position resolution (FWHM)	Δx = 1.5 mm (centre)
Efficiency (1 Å)	40-45%
Detector count rate	R up to 100 kHz
Readout	Delay line
Gas mixture	^{3}He + 0.25 CF_4 (6 atm)



Other Directions

- GEM structures on H-free supports in collaboration with PI (Heidelberg) and IPM (N.Novgorod)
- Precise spacers for MWPC and microstrip Si detectors in collaboration with IPM
- Design and development of the MWPC with individual readout
- 2D MWPC with delay line readout and 1,5 mm resolution
- Advanced scintillation detectors

Scintillation Detectors with combined Electron-Geometry Focusing

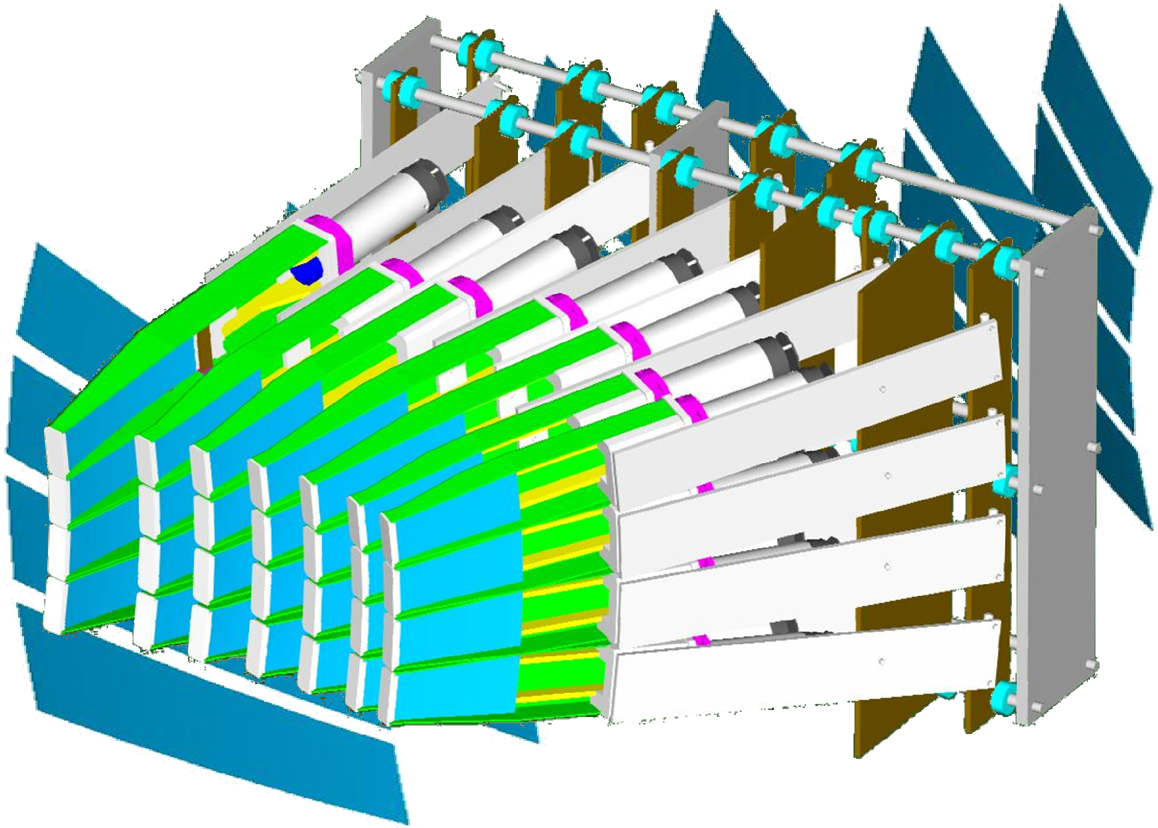


TFS calculated by the combined electron-geometry focusing method for the 90-degree detector bank of Fourier strain diffractometer

Scintillation detectors

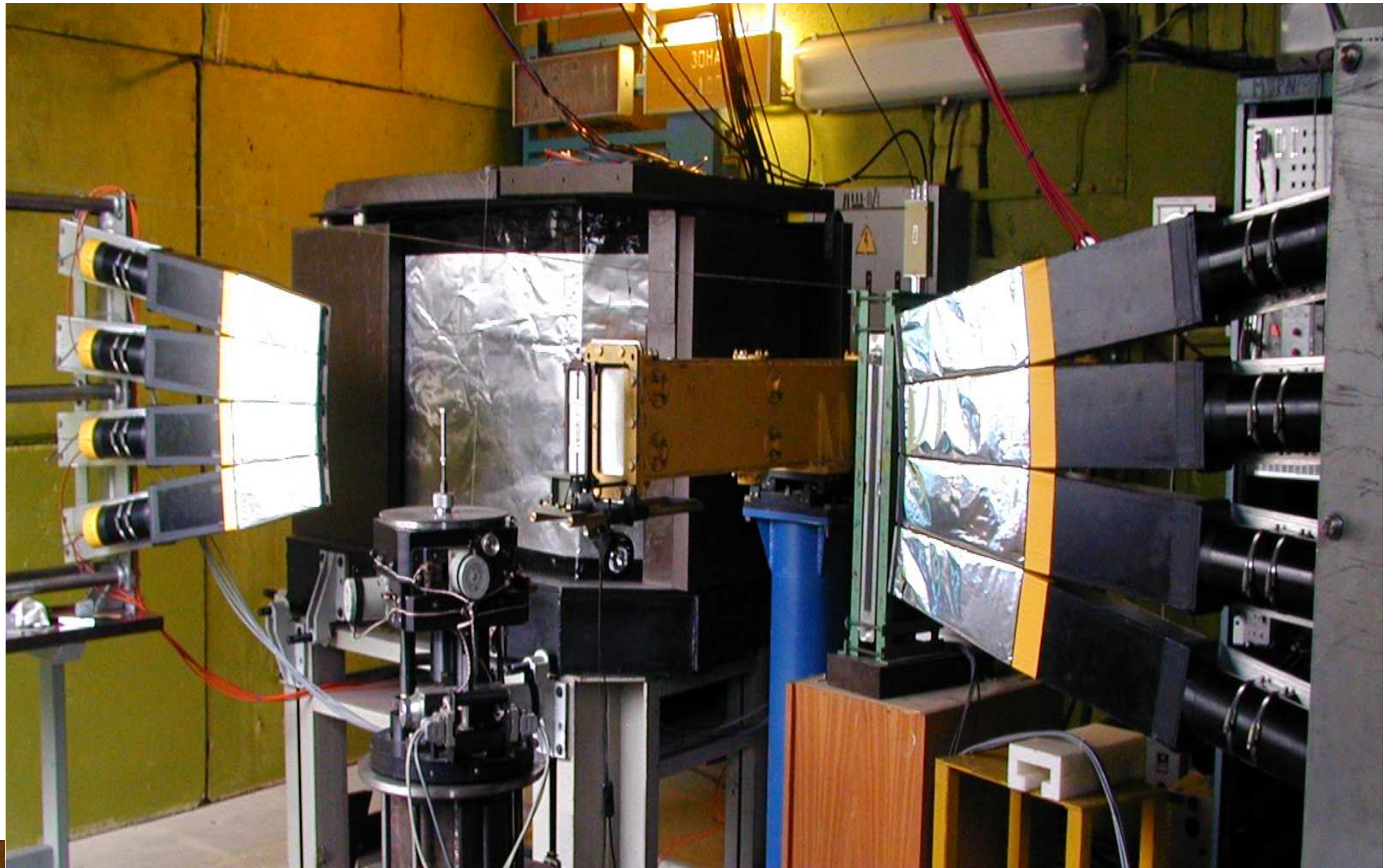
3-d model of detector design of TFS with cylindrical fragments

Umbrella-like approximation



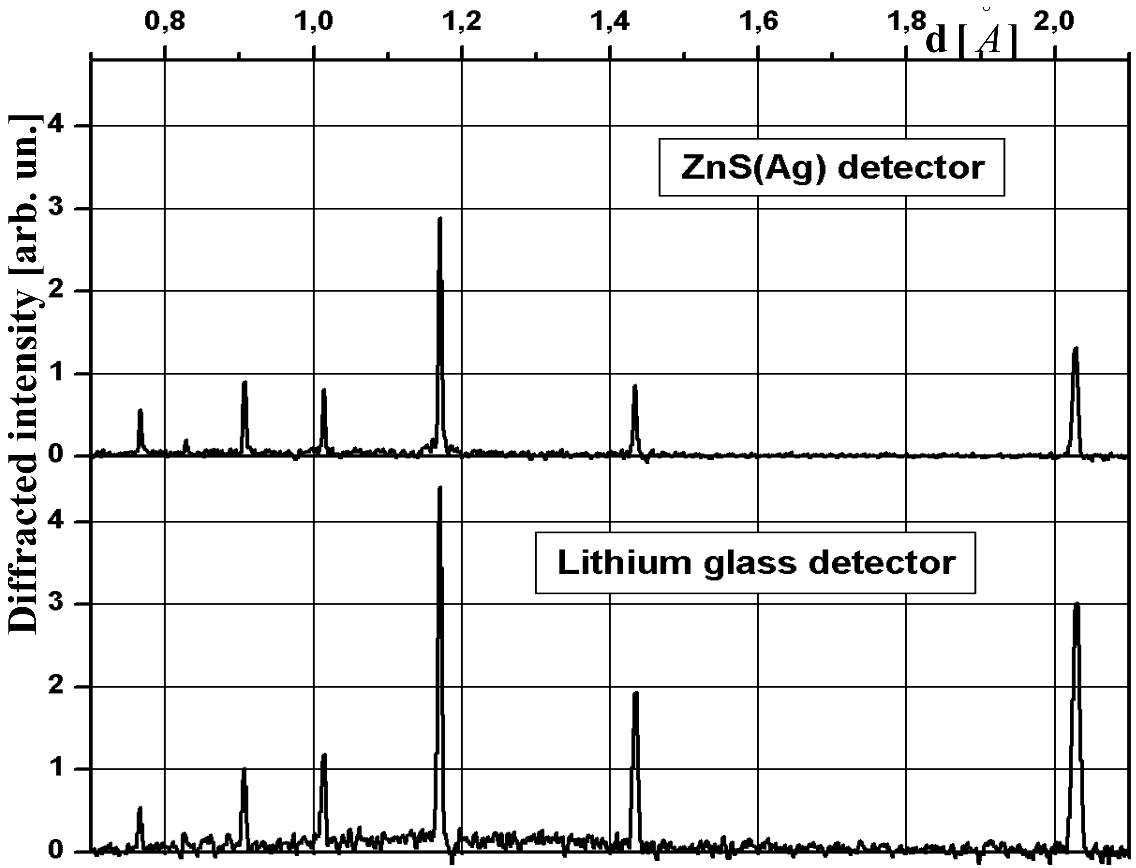
Scintillation detectors

The first detector stacks on Fourier stress diffractometer



Scintillation detectors

Diffraction intensity patterns for 1 mm lithium glass detector and 0.42 mm thick ZnS(Ag)/6LiF screen



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