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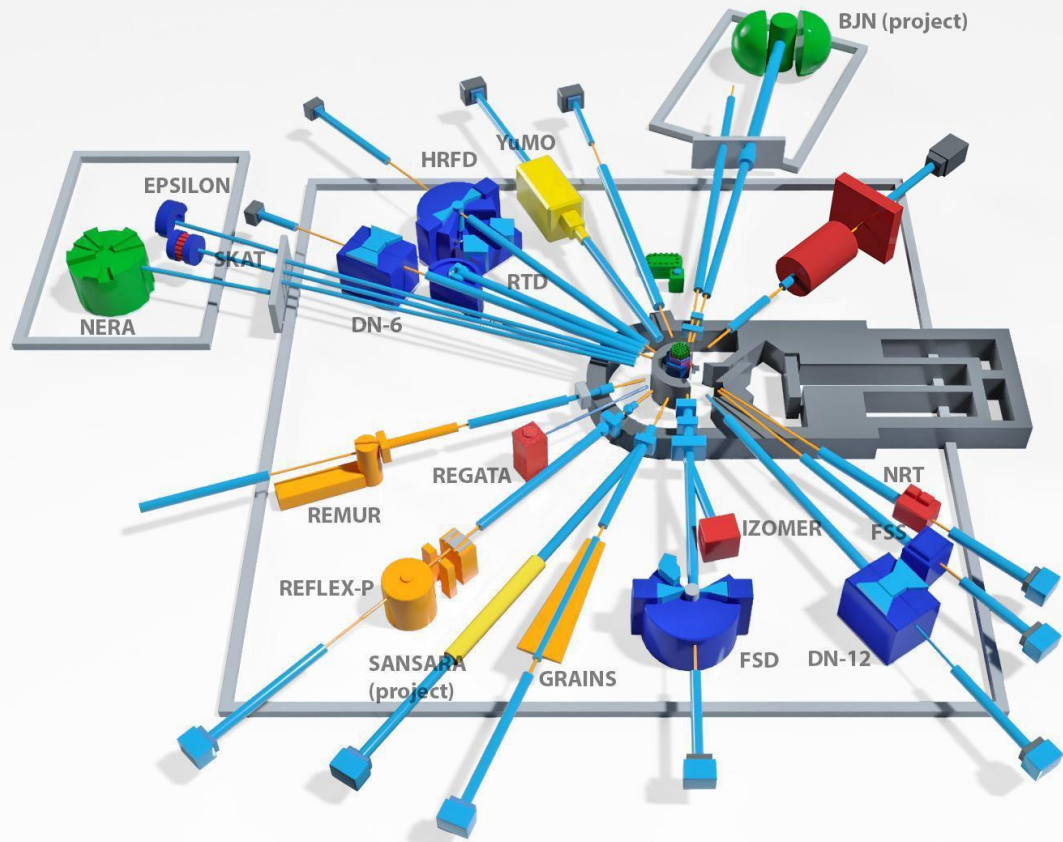


FRANK LABORATORY  
OF NEUTRON PHYSICS

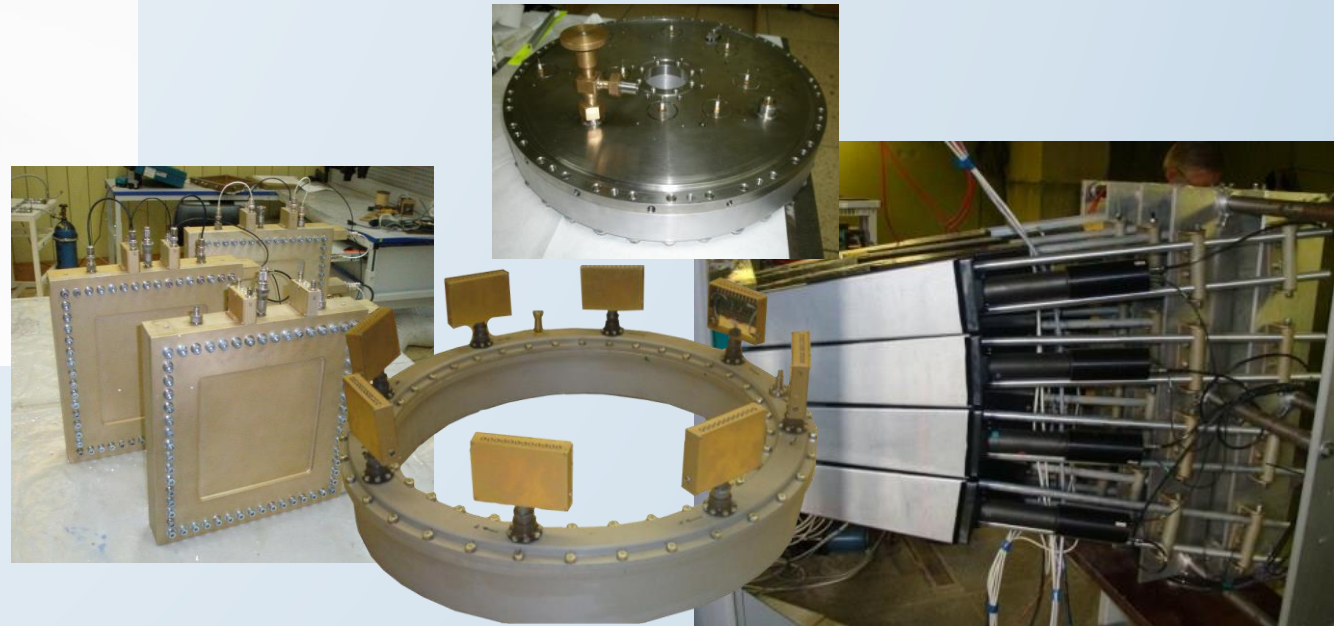
# **Data Acquisition and Accumulation Systems of the Spectrometers Complex at the IBR-2 Reactor**

*Speaker: Shvetsov V.V.  
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# Spectrometer complex on IBR-2M reactor



- 18 spectrometers operate at IBR-2;
- Various types of point, multielement and position sensitive neutron detectors;
- The time-of-flight method for measuring the energy of the detected neutrons;
- Unified DAQ systems based on MPD-240 and DeliDAQ modules for multielement and position sensitive neutron detectors;



CC B7 A2 F0 E9 AE C9 84 2B 6B 5E 0F 98 20 6C 70 07 FA 23 70  
 A3 55 A3 FC 1A 83 59 98 2B EE DF 70 9B 1C AA 52 D3 50 2A 3  
 02 CD 53 E2 76 51 53 FC 66 2C 04 53 D0 85 18 BA 83 32 03  
 BA BD EP 82 55 0A 01 01 01 01 01 01 01 01 01 01 01 01 01 01 01

# DAQ-systems of the IBR-2M Spectrometer complex

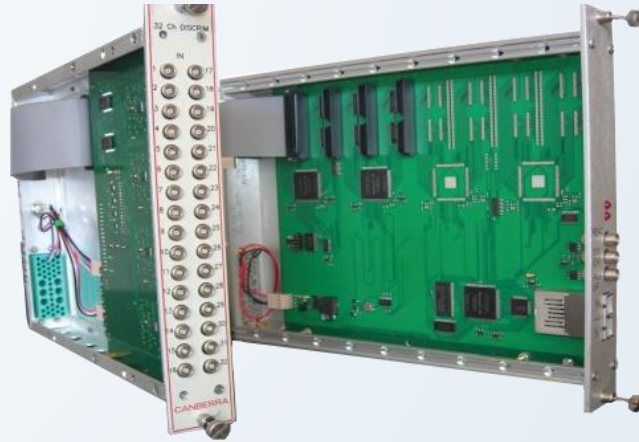
On our spectrometers the DAQ operation parameters are set by commands through the USB interface by software toolkit Sonix+ experiment management.



MPD-16



MPD-32



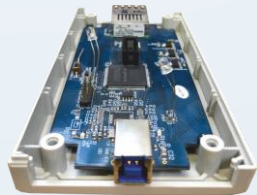
MPD-240 and 32-channel discriminator



FLINK USB 2.0



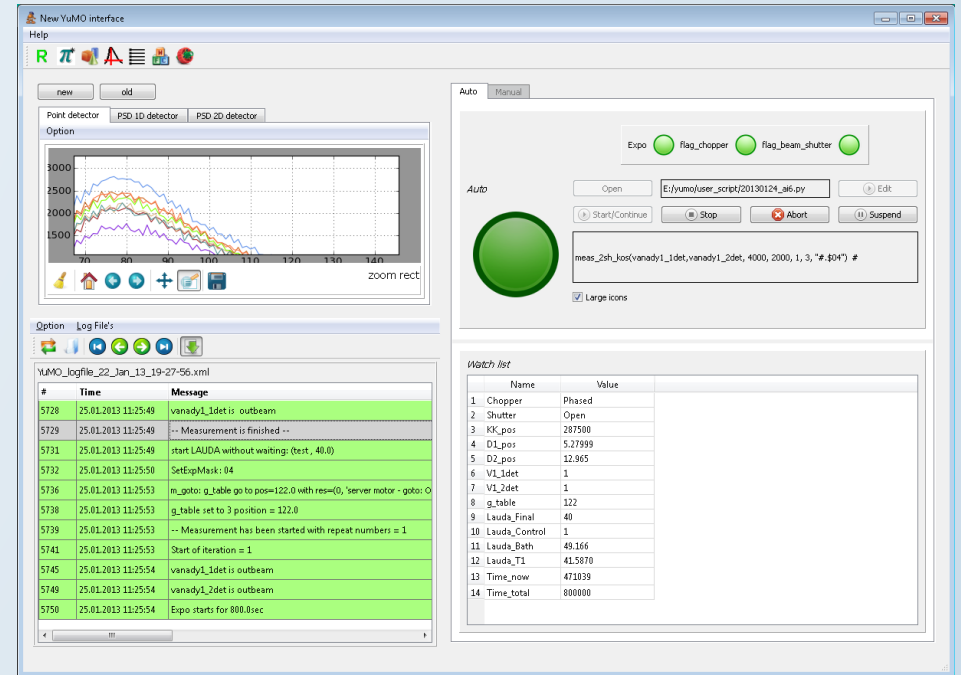
DeLiDAQ-1



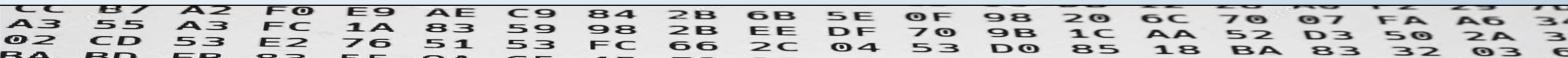
FLINK USB 3.0



DeLiDAQ-2D



Sonix+ user interface



## De-Li-DAQ-2D



*DeLiDAQ-2D module*

The main parameters of the DeLiDAQ-2D module:

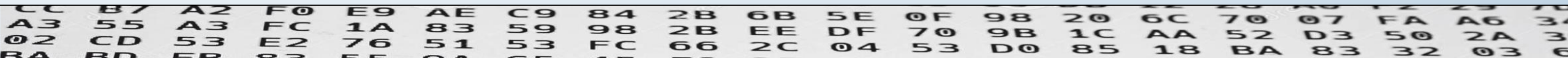
- DAQ system for MWPCs with delay line readout;
- Flexible configuration for 1D or 2D PSDs;
- TDC resolution – 80ps;
- Real time data filtering and event recognition;
- Maximum detection rate is 1 million events/sec;
- RAM memory of 1GB for accumulation 3D histogram;
- 2 monitor detector inputs;
- 3 events pile-up reconstruction (overlapping);
- neutron loss counters for dead time calculation;
- embedded test generator of detector signals;
- 1 Gb serial fiber optic interface;
- NIM standard module (+6V, 0.8A).

In the Research Department of the JINR Spectrometer Complex, digitizers from CAEN are becoming increasingly popular, so a comparative analysis of the characteristics of data acquisition systems De-Li-DAQ-1, De-Li-DAQ-2D and a system based on the N6730 digitizer manufactured by CAEN [6] was carried out, based on the results of which it is possible to optimize the choice of a particular system for a specific spectrometer.

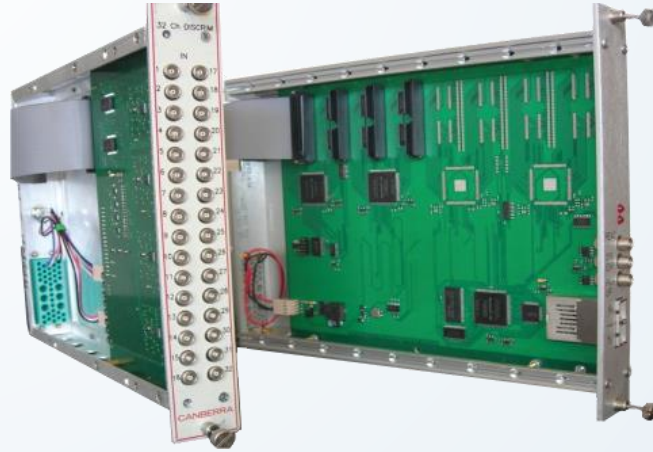


*DeLiDAQ-1 module*

The De-Li-DAQ-1 module was developed in cooperation with HZB, Berlin for readout of two-dimensional position-sensitive PSD. It is based on a TMS 320C6701 high-performance DSP, programmable logic arrays and connected to the computer via PCI. The module has 256 Mb of internal histogram memory and is capable of detection rates of up to  $10^5$  events/sec (in list mode—up to  $8 \times 10^5$  events/sec).



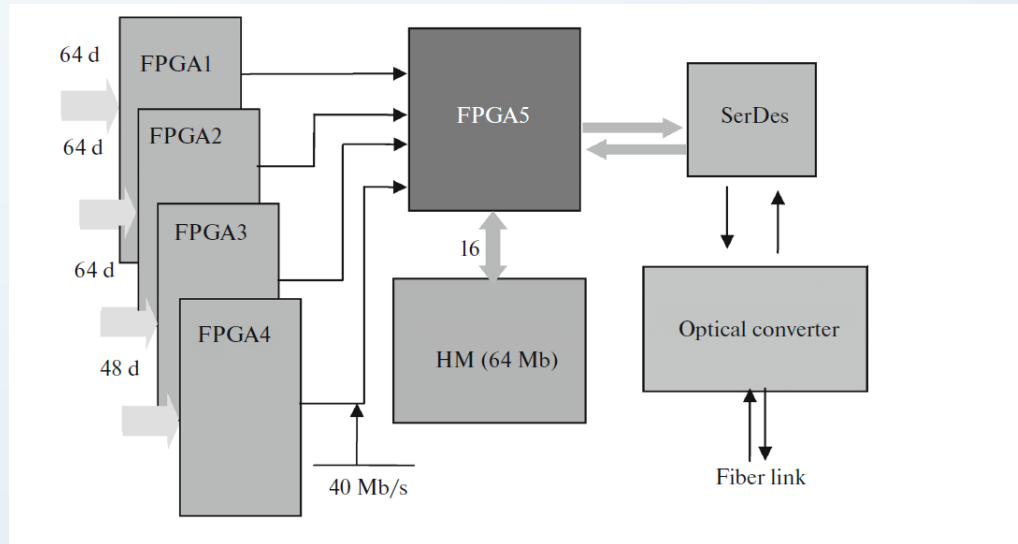
## MPD-240



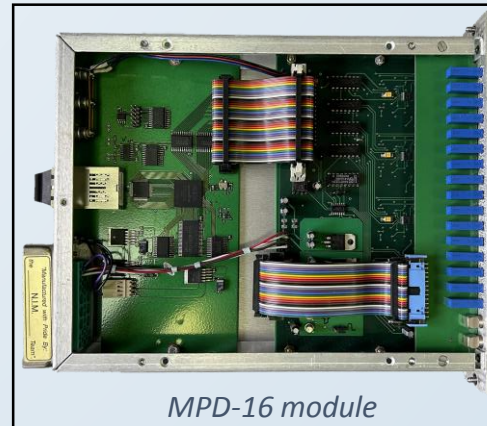
MPD-240 and 32-channel discriminator

The main parameters of the MPD-240 module:

- signal sampling frequency (detector signals, pick-up, reactor startup, etc.): programmable (up to 62.5 MHz);
- maximum number of detector elements: 240;
- maximum detection rate:  $8 \times 10^6$  events/sec;
- internal histogram memory: 64 Mb;
- detection delay with respect to reactor pulse; channel width and time window length of neutron detection are programmable (16 ns time quantum);
- data transmission between data acquisition electronics and USB 2.0 port of a computer through an interface module over serial fiber-optical connection (1.25 Gbit/sec data transmission speed, maximum distance from the computer of 100 m).



Architecture of the MPD-240 module

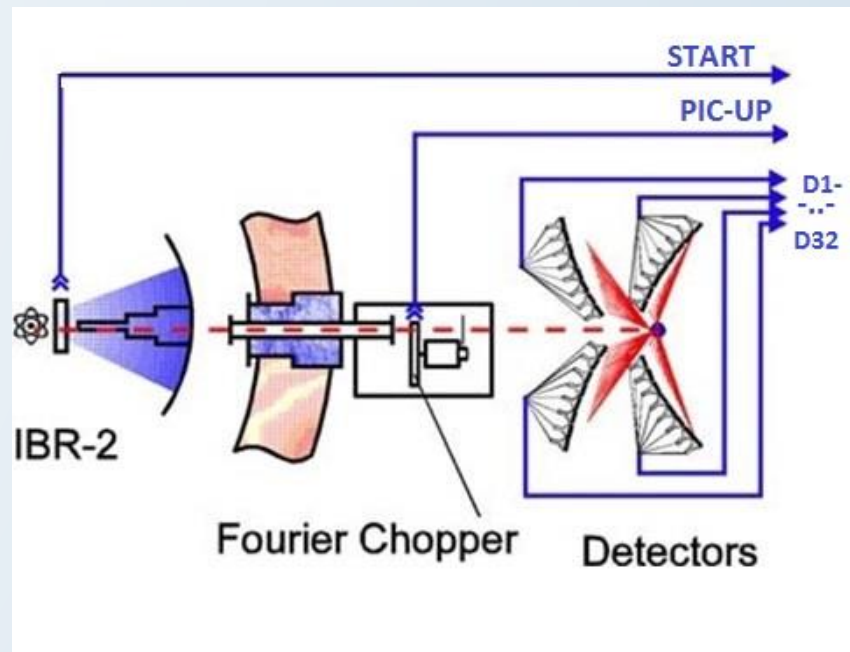
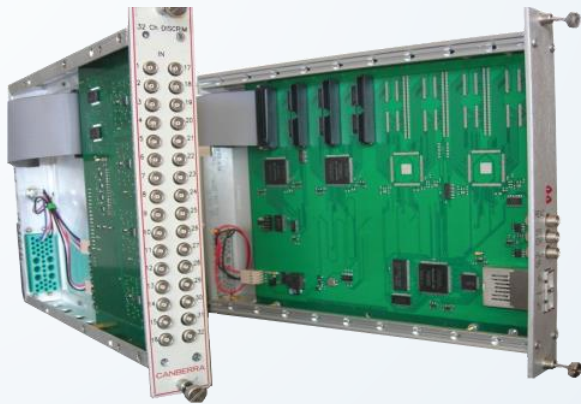


MPD-16 module

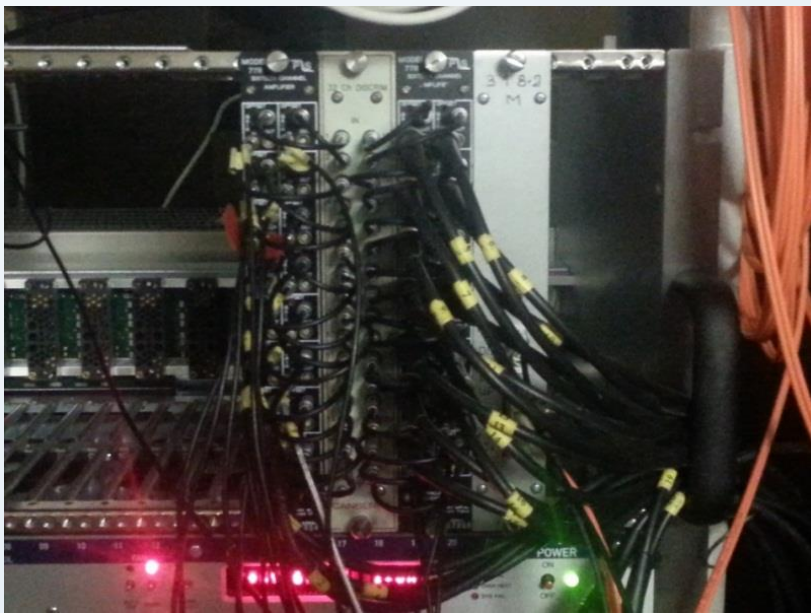
## MPD-16

The 16-channel MPD system was developed and manufactured under a contract with the Physicochemical Institute named after L.Ya. Karpova (Obninsk).

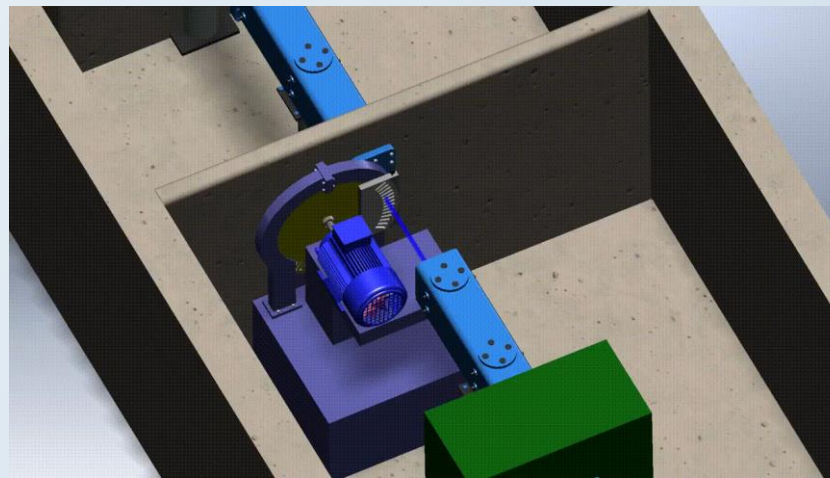
# MPD-240 DAQ on HRFD



Scheme of the old detector system on HRFD



MPD-240 DAQ on HRFD



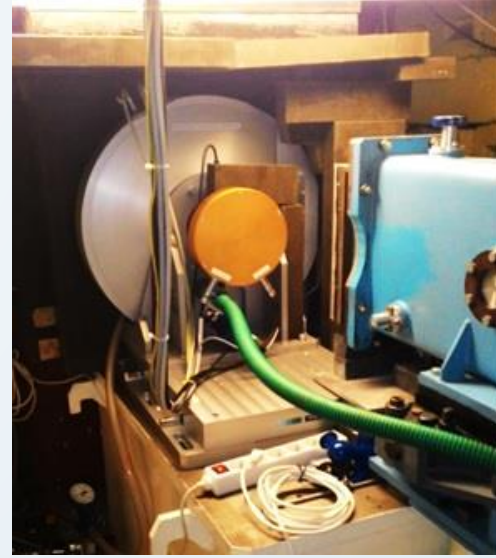
Fourie chopper on HRFD

CC B7 A2 F0 E9 AE C9 84 2B 6B 5E 0F 98 20 6C 70 07 FA 29 70  
 A3 55 A3 FC 1A 83 59 98 2B EE DF 70 9B 1C AA 52 03 2A 3  
 02 CD 53 E2 76 51 53 FC 66 2C 04 53 D0 85 18 BA 83 32 03 6  
 BA BD EP 83 55 CA 11 1E 25 40 12 23 7D

## Modernization of HRFD



*Curved mirror neutron guide*

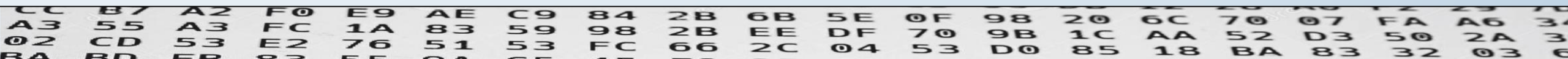


*Fourier chopper*

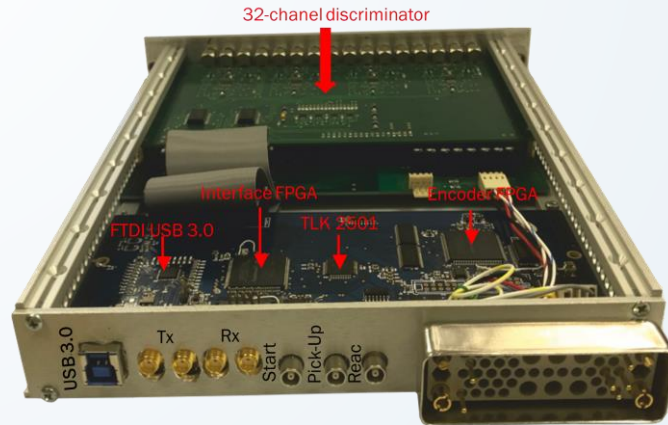


*Backscattering detectors*

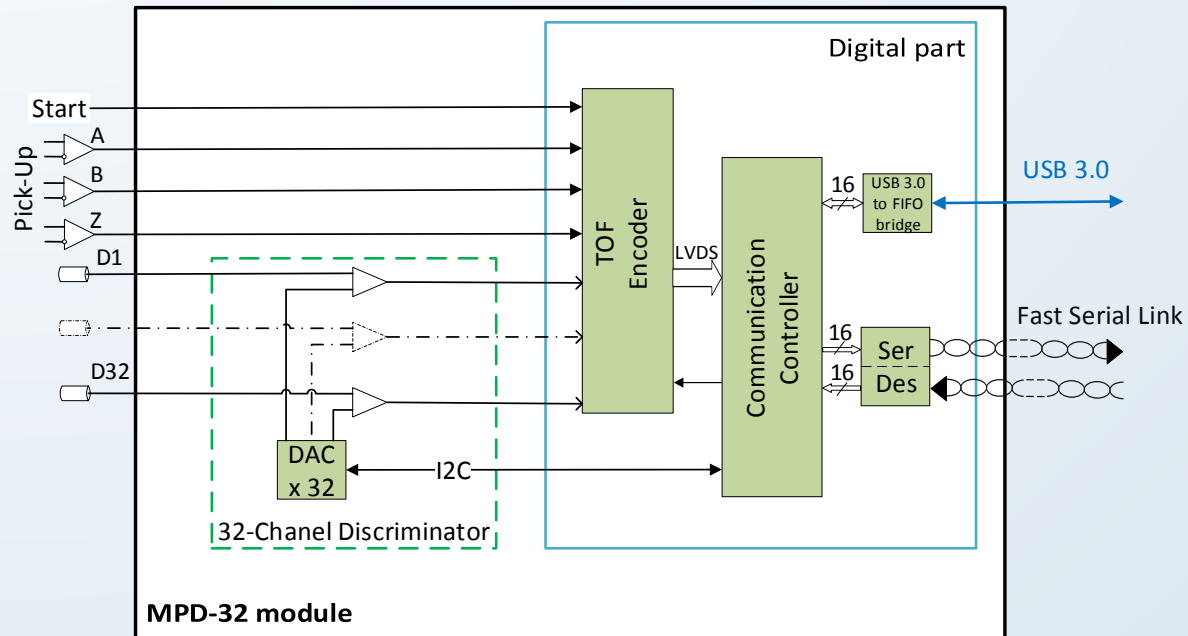
- The new detector covers the scattering angle interval  $2\theta = (133-175)^\circ$ ;
- The new neutron guide provides an increase in the neutron flux by a factor of 2–3;
- Upgraded Fourier chopper improves resolution



# MPD-32



MPD-32 module



MPD-32 module

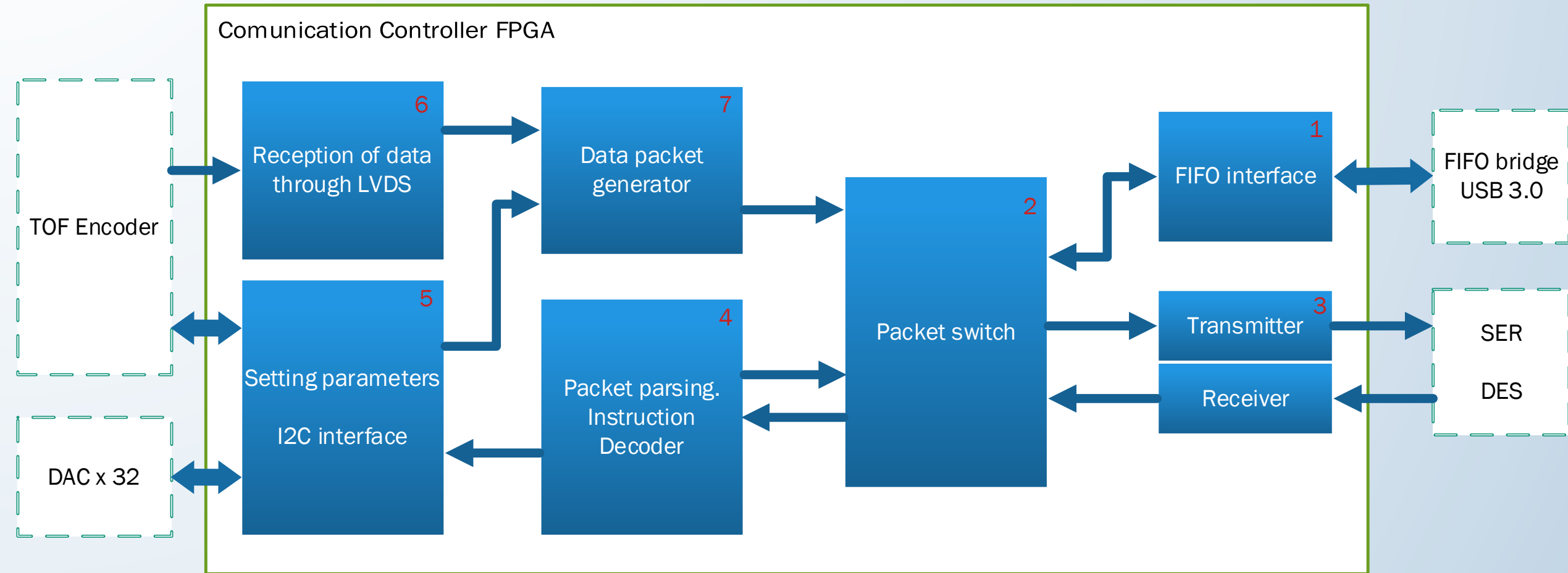
Schematic diagram of the MDP-32 module

Main features of DAQ based on MPD-32 modules:

1. MPD-32 allows you to organize the data acquisition system that meets the requirements of all types of multipoint detector systems of neutron spectrometers at the IBR-2M reactor;
2. Maximum number of detector elements  $i = 32$  for one MPD-32 in the system;
3. Maximum detection rate =  $3 \times 10^7$  events/s;
4. Frequency of time sampling = 62.5 MHz (16ns),  $\sim 1$ ppm;
5. Events are recorded in absolute time of experiment, max. exposure time =  $4.5 \times 10^6$  s (length of time counter = 48 b);
6. Registration of service signals with the same accuracy as that of detector elements: such as start of reactor, start / end of time window, end of exposure, etc.;
7. Registration of additional 6 external signals for example PICK-UP Fourier chopper signals on the HRFD diffractometer.



# Communication controller structure



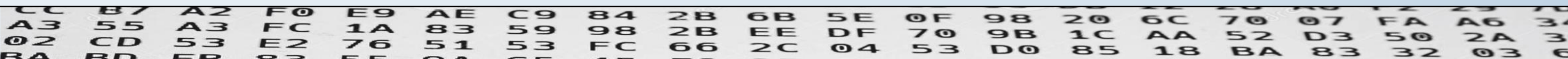
CC B7 A2 F0 E9 AE C9 84 2B 6B 5E 0F 98 20 6C 70 A0 12 29 70  
 A3 55 A3 FC 1A 83 59 98 2B EE DF 70 9B 1C AA 52 07 FA A6 34  
 02 CD 53 E2 76 51 53 FC 66 2C 04 53 D0 85 18 BA 83 32 03 3  
 BA BD EP 83 55 CA 01 01 01 01 01 01 01 01 01 01 01 01 01 01

## Structure of packet at the MPD-32 communication protocol

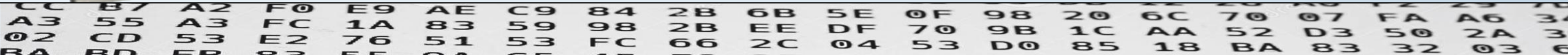
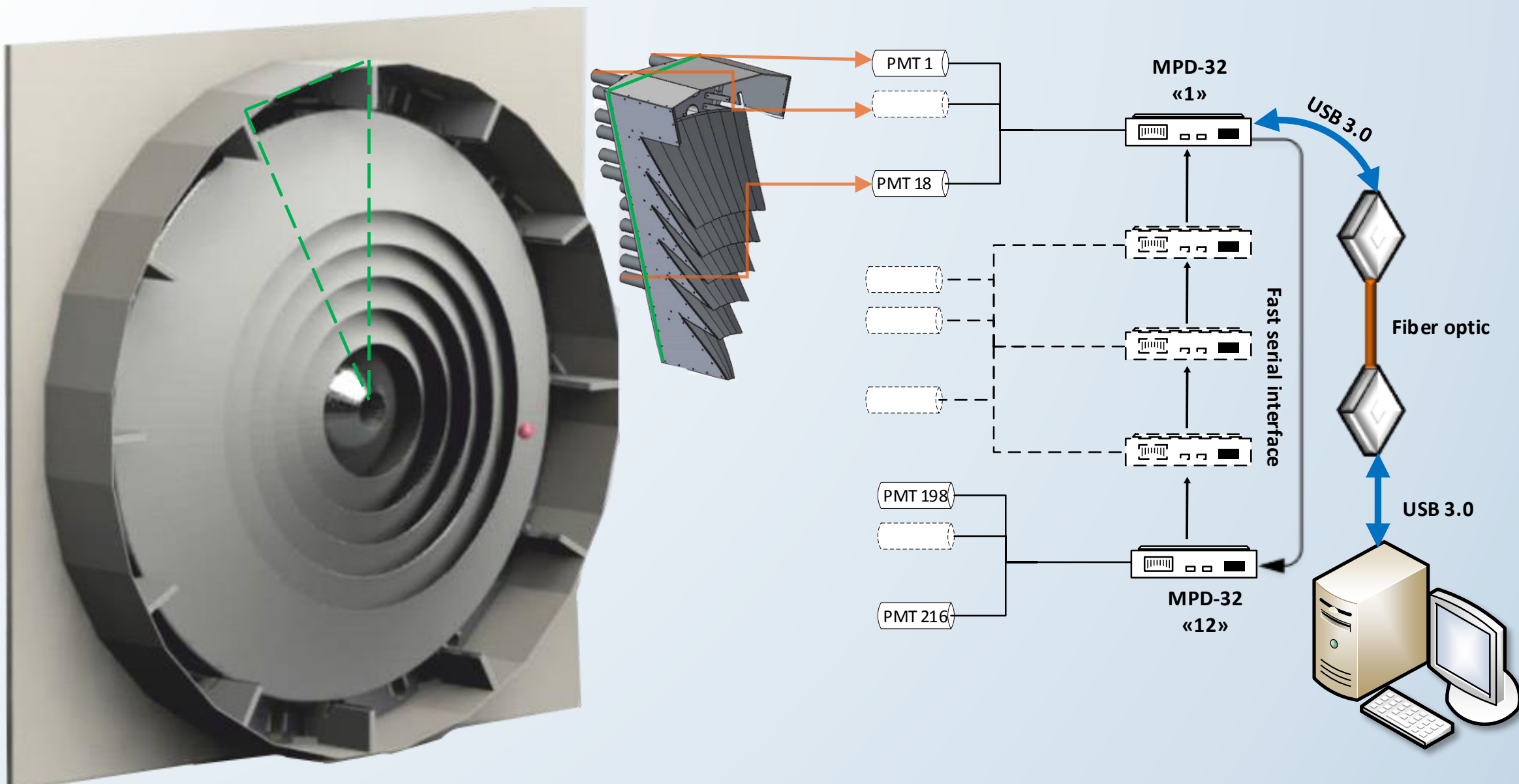
	Заголовок	Block address	Packet type	Length of the packet	Data	Check sum
Title	HEADER	ADDRESS	ID	LENGTH	DATA	CRC32
Length in bytes	6	2	2	2	0..512	4

Message packets are described by the following structure:

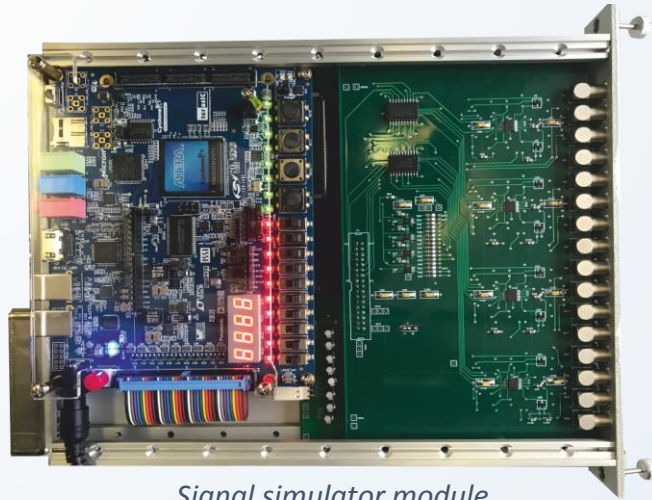
- **Header** as “4d 50 44 2d 33 32” == “MPD-32” - (6 bytes);
- **Block address** of the command sent from the server to the block or address of the block transmitting the data packet (2 bytes);
- **The packet type** corresponds to the command number in packets from the server, and in packets from MPD32 blocks it determines the type of data transmitted from the block to the server (2 bytes);
- **Packet length** in bytes starting from the header to the last byte of the packet including the CRC32 checksum (2 bytes);
- **Data** — field of transmitted data in a packet, the data structure is determined by the type of packet (0 ÷ 512 bytes, a multiple of 2 bytes);
- **CRC32 checksum** - packet checksum without 6 bytes of header (4 bytes);



# DAQ system for BSD based on MPD-32



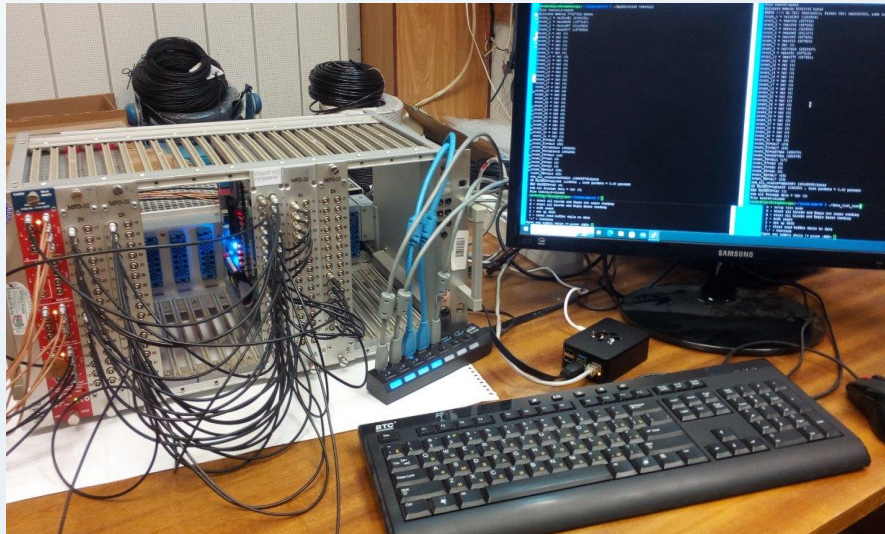
## Signal simulator for setting up and debugging data acquisition systems



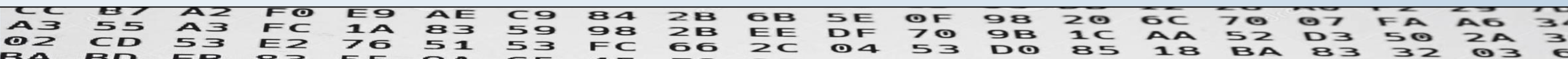
*Signal simulator module*

Main features of the DSS module:

- The number of output simulated detector signals: 32;
- Flexible configuration:
  - setting the variable frequency of the neutron chopper signal;
  - simulated start signal of the IBR-2M pulsed reactor;
  - the intensity level of pseudorandom noise;
  - background level of thermal neutrons;
  - intensity of the simulated spectrum of detector signals;
- Frequency range of the choper signal - 0~100 kHz;
- Maximum frequency of signals per detector channel – $8 \times 10^6$ ;
- The amplitude of the output signals -0.25 — -1 V;
- NIM standard module.

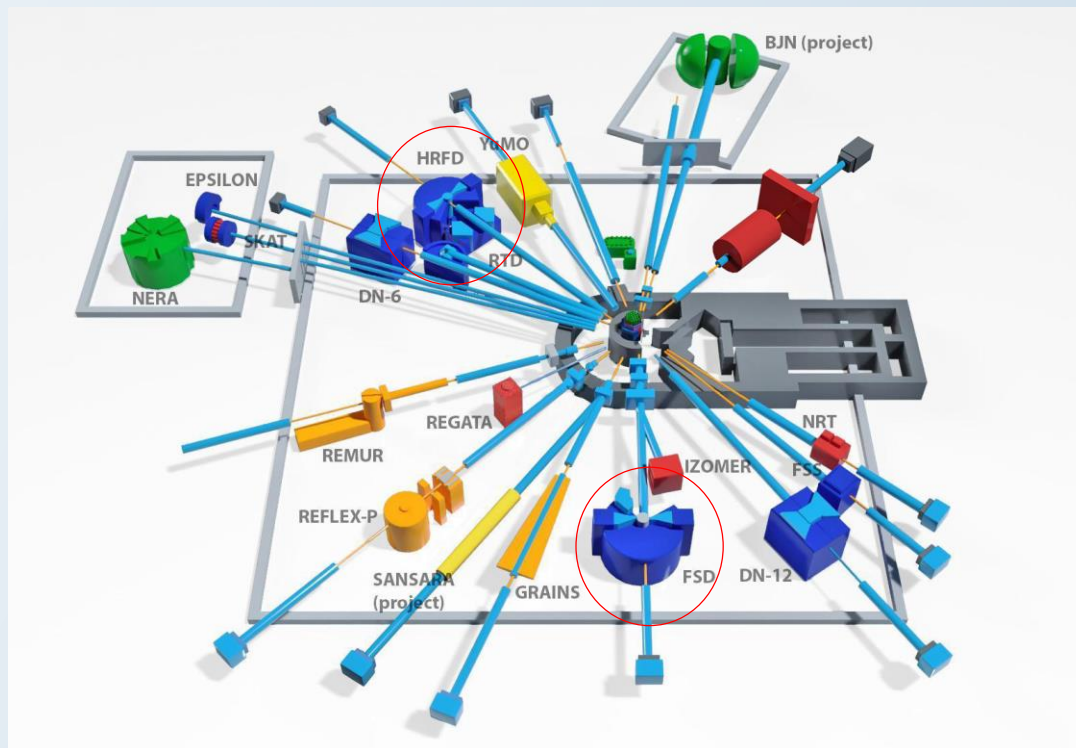


*Stend for debugging MPD-DAQ systems*

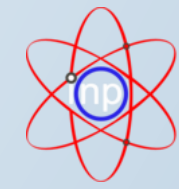


# Conclusion

No channel	Facility	DAQ-system	
1	KHOLHIDA		
2	DIN-2PI		
3			
4	YuMO	MPD-16	DeLiDAQ-1
5	HRFD	8 x MPD-32	DeLiDAQ-2D
6a	RTD	MPD-240	DeLiDAQ-1
6b	DN-6	MPD-240	
7a	EPSILON-SKAT	MPD-240	
7b	NERA	MPD-240	
8	REMUR	MPD-16	DeLiDAQ-2D
9	REFLEX	MPD-16	DeLiDAQ-1
10	GRAINS	MPD-16	DeLiDAQ-2D
11	FSD	MPD-32	
12	DN-12	MPD-240	
13	FSS	MPD-240	



Scientific center	DAQ-system		
«Scientific Research Institute of Physics and Chemistry of L. Karpov» (Obninsk, Russia)	MPD-16		
The National Research Center Kurchatov Institute (Moscow, Russia)	MPD-16	DeLiDAQ-1	DeLiDAQ-2D
The Institute of Metal Physics, Ural Branch of the Russian Academy of Sciences (Yekaterinburg, Russia)	MPD-240		
"Institute of Nuclear Physics" (Řež, Czech Republic)		5x DeLiDAQ-1	
The Institute of Nuclear Research of the Russian Academy of Sciences (Troitsk, Russia)		DeLiDAQ-1	DeLiDAQ-2D
"Institute of Nuclear Physics" (Almaty, Kazakhstan Republic)	MPD-16		





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