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## Some technical features of the spectrometer

The main spectrometric unit being composed of the Euro-bin with the power supply and containing nuclear, transducer control, digital control and auxiliary boards is the autonomous Mössbauer and  $\gamma$ -ray spectrometer. It is totally remotely controlled from the attached computer except of a few jumpers and trimmers one needs to touch only during general configuration rebuilding or testing. This computer is necessary for setting spectrometer and reading results but not for spectra collecting. There is only one switch on the front panel – the lock switch preventing from unintentional parameter change during experiment pending. Data are stored with all control parameters and hence, it is easy to come back to the previous settings.

A short “excursion” over the spectrometer blocks is described below. Please run the attached programme **MS.EXE** now (see page 9 for details). As the hardware is not actually connected you will get alerts like “timeout” – ignore them. The file **MS.HDW** (see page 9 for details) should be present in the folder you are using to run this programme from. This is a text file describing some hardware properties.

## There are two **standard heads**

available, i.e., a **proportional detector head** and a **scintillation detector head** both containing internal pre-amplifiers and high voltage supplies (remotely controlled). Hence, there are none high voltage cables. A proportional head including proportional detector is shown in Fig. 1 in typical room temperature geometry together with the standard bench, absorber holder and a transducer mounted on the bench holder. A scintillation head equipped with a standard crystal is shown in Fig. 2.



Fig. 1. Basic set-up of the spectrometer with the proportional detector.



Fig. 2. Scintillation head with the bench holder.

Additionally, raw pulses could be accepted from the external detector, e.g. some Si detector or CEMS detector, but they should have their own high voltage supplies and pre-amplifiers. In the case of the optically coupled semi-conductor detector its reset pulse is accepted by the nuclear board to avoid collecting undefined pulses during the reset phase of the pre-amplifier.

## The **nuclear block**

contains all features of the  $\gamma$ -ray spectrometer. Run programme **MS.EXE** (see page 9 for details) and open *Settings. Set\_Analogue\_Block* dialogue to see its structure. We hope most of the parameters are self-explainable. You can select the proprietary *inputA* for our heads with high voltage control or general purpose BNC *inputB*. You can connect an oscilloscope to the test BNC port and select the point you observe the signal at. *TriggerLevel* and *...capture delays* are trimmers to improve the analysis efficiency. *Signal* and *Trigger* pulses go to a single channel analyser (SCA) and analogue to digital converter (ADC) integrated within this block as well.

## The **digital block**

is responsible for a communication with the PC and a general control of the spectrometer. General *Counter&Timers* are also located there – open please *Settings. General\_Counter&Timers* window to see them. We hope they are self-explainable as well. A *Switch* is the EMERGENCY SWITCH capable to stop data collecting under unusual circumstances. Its hardware is located on the auxiliary board.

However the most important parts of this block are four 4096-channels, 32-bit long arrays of counters. Two of them are for the  $\gamma$ -ray spectra collection: coincidence and anti-coincidence (within and outside of the SCA window). A direct spectrum is the sum of them, of course. The third array of counters collects Mössbauer data, and the fourth is used to collect the laser calibration data, but they may be also redirected to collect pulses from the external sources via inputs on the auxiliary board. **Hence, they are separate, independent arrays of counters and all four spectra are collected simultaneously.** Open please *Settings. Clear\_run/stop* to see the control you have over these counters. Multi-scaler counters start/stop synchronically with the transducer cycle. You may observe the current count rate opening the *Settings. Ms\_Pulses/sec* dialogue.

The useable range for each type of the  $\gamma$ -ray spectrum amounts to about 3800 channels due to the averaging procedure using 256 last channels.

At present the spectrometer communicates with the PC via a special ISA card and such a way of communication is quite sufficient. However, a new communication interface is planned due to the fact that the ISA standard becomes obsolete. It is going to be the Ethernet link with the TCP/IP protocol.

To see the main functions of the **transducer control block**

open please *Settings. Set\_Vibrator*. We hope the parameters there are self-explainable, too. The driving coil of the transducer may be biased with the bi-directional *Bias current*. In a horizontal position it cancels a slight misalignment shift from a central position, while in a vertical position it compensates weight of the transducer coils and a sample fastened to it. The voltage proportional to coils position can be observed via the BNC port, as the transducer is equipped with the appropriate optical position sensor. Other two BNC ports are for monitoring of the *Velocity* and *Error(x200)*. *Updating speed* command is used to set hardware limit on the rate the appropriate parameter is changing in order to avoid sudden strikes of the driving currents that wouldn't be healthy to the delicate transducer.

The velocity reference file contains 8192 points per cycle at 12-bit precision. A reference function could be generated here or downloaded from the external file. This file may be generated by one of the MOSGRAF programmes containing a large set of algorithms to generate and optimize various reference functions.

## The **auxiliary block**

has alternate inputs to both multi-scaler arrays of counters and outputs for START and ADVANCE signals of the transducer cycle. The EMERGENCY SWITCH input is also located there - a change of its state may be programmed to stop the data collecting. This block is also equipped with the 8-bit DAC directly programmed from the PC that could control some external device like furnace driver.

All connectors are located in the front panel of the main spectrometric unit as shown in Fig. 3.

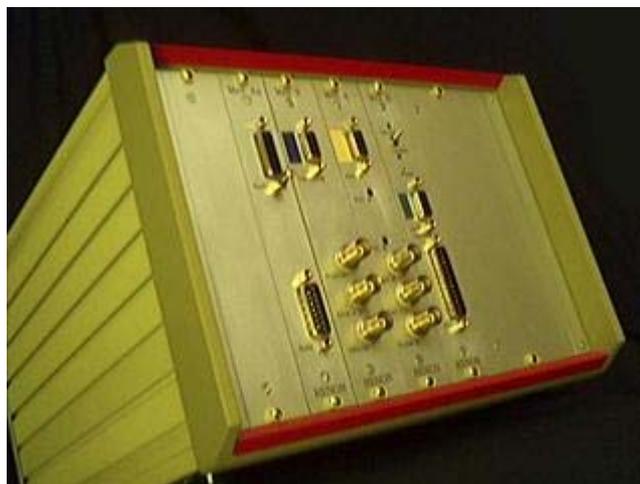


Fig. 3. Front panel of the main spectrometric unit. Boards (from right): digital, nuclear, transducer and auxiliary.

## Bin and power supply

While the four blocks described above are inserted into the bin there are three slots still empty to be used for additional function blocks.

The spectrometer's power supply is designed to co-operate with a regular, maintenance free, 24-volt lead battery working as a power buffer. Just add the proper battery charger and you are going to get high quality (as working *on-line*) Uninterrupted Power Supply. Two 12V/7Ah batteries allow typically configured spectrometer to work for about 10 hours without connection to the power line.

## The transducer

is designed in such a way to be able to operate in the horizontal or vertical geometry. A central tube is hollow with a clear bore having diameter of 8 mm. Hence one can use this transducer with the synchrotron beam. It is equipped with the lead collimator having clear bore with the diameter of 20 mm. A special ring allows for easy mounting of the heavy collimator without risking mechanical damage. The outer diameter of the transducer is 120 mm. A transducer contains position sensor allowing checking and compensating the constant shift (with the *Bias current* – see above). A laser velocity-calibrator could be attached directly to the back end of the transducer, while the reflective corner prism could be attached just behind the source (a laser beam goes along the hollow central tube). Such a design provides the most accurate measurement of the source velocity. A standard source mount is equipped with the M4 male thread.

The transducer is rather a delicate instrument - so it is difficult to characterize it with just a few unconditional parameters. The maximum load of the transducer is about 150 gms regardless of the geometry - less than 60 gms is recommended. The free path is  $\pm 3$  mm – less than  $\pm 1$  mm is recommended. Repetition frequencies giving the best results fall within the range: 1 to 20 Hz.

Available velocity ranges vary from about  $\pm 0.5$  mm/s to about  $\pm 150$  mm/s. A quality of motion depends on the above parameters. It was never worse than 0.06% (as the ratio of the error to the maximum), but usually it is at least twice better.

For highly optimized conditions the error signal becomes so small to trust it so we have tried a special test. A difficult test this transducer passed was performed by using it for the Mössbauer holography (Jagiellonian University, Cracow), where one requires a constant velocity to be kept to within about 0.1% of the natural iron line width at the velocity of the outermost line of the metallic iron or hematite. There are none discernible oscillations in the signal under such conditions. We cannot guarantee such a quality under all circumstances, but two transducers were tested that way and both behaved similarly.

Round-corner reference functions generated by the software help to achieve transducer's calm motion. MOSGRAF allows to generate such functions and to perform a harmonic analysis of them as shown in Fig. 4.

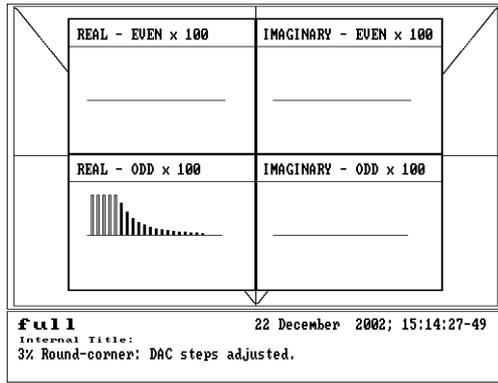


Fig. 4. Typical round-corner reference function with harmonics shown.

A transducer attached to the standard bench holder is shown in Fig. 5, while Fig. 6 shows the front end of the transducer.



Fig. 5. Transducer on the standard bench holder.



Fig. 6. Front end of the transducer. See, the hollow central tube.

A design of the transducer allows for easy mounting in the vertical geometry cryostat.

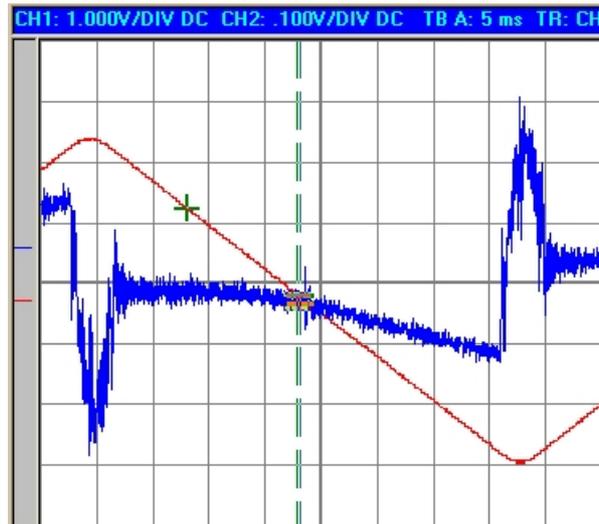


Fig. 7. Transducer velocity (ch1 – red 1 V/div) and 200 x Error (ch2 – blue 0.1 V/div) at: load 45 gms, 13 Hz, 63 mm/s.

Fig. 7 shows round-corner triangular velocity of the transducer and the corresponding velocity error at 13 Hz repetition frequency and for a velocity range  $\pm 63$  mm/s. Simple calculation gives the error to be  $\pm 0.02\%$  of the velocity. As it sounds too good, please read about another quality test above.

## A laser velocity calibrator

could measure absolute value of the velocity in each channel within the range for a maximum velocity being 0.5 till 1000 mm/s. A special optical design and a complete mechanical integration make it almost insensitive to the external vibrations. The phase averaging is achieved via the random mode switching mechanism, but it is planned to equip it with the phase averaging system (at no extra cost). A device has to be aligned only once upon mounting. An easy access to the alignment worm screws is provided. In the case a transducer is enclosed in the cryostat a tilted optical window has to be provided, as the velocity-calibrator should not be operated in the air pressure lower than corresponding to the altitude of about 3000 m above the sea level. Typical calibration data are shown in Fig. 8.

Note please, that upon having folded data and leaving odd number of channels one can have as many as 2047 data points per Mössbauer spectrum. The upper left corner of Fig. 8 shows residual noise of the calibration data. On the other hand, a raw signal from the interferometer is shown in Fig. 9 as seen on the digital oscilloscope near the turning point of the transducer (null velocity). A large depth of modulation assures high quality of the calibration data.

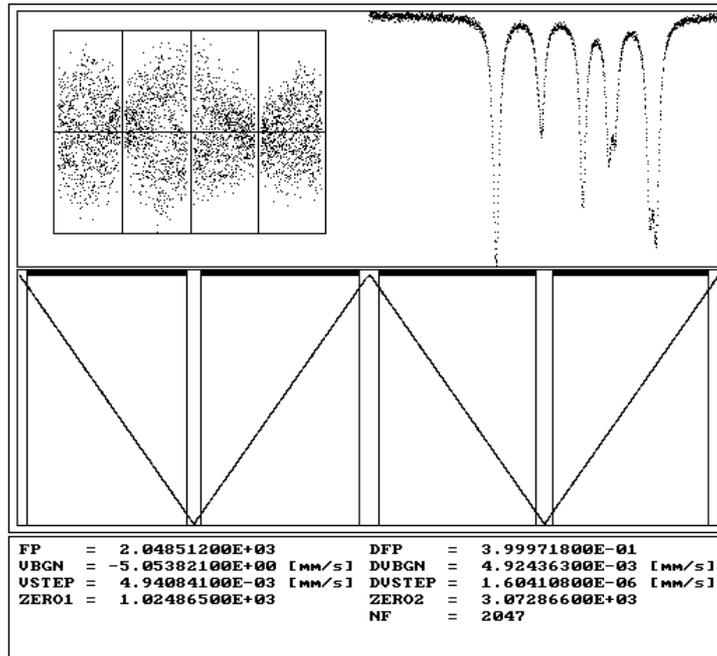


Fig. 8. Typical laser calibration data with the folded Mössbauer data.

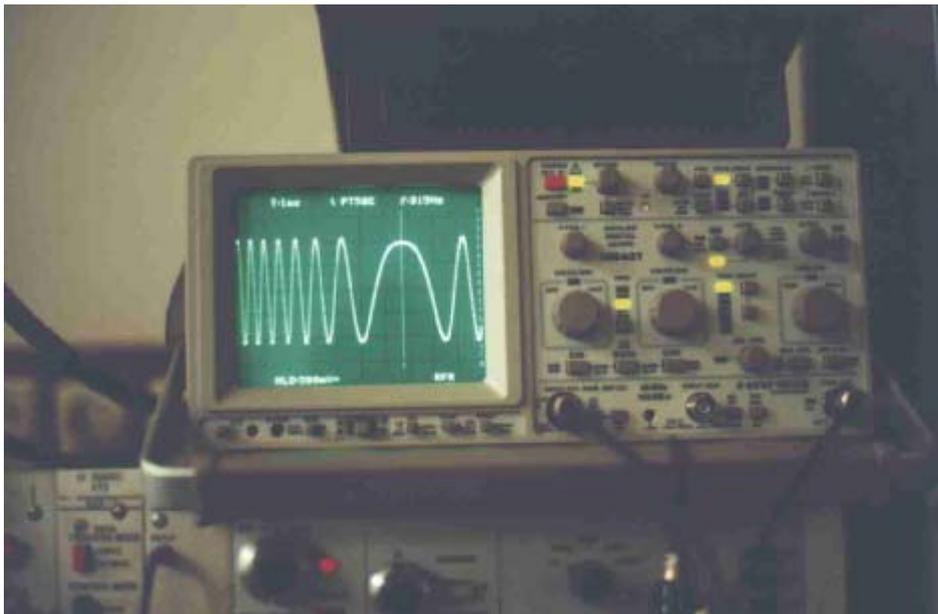


Fig. 9. Raw signal from the laser interferometer near the turning point.

A general view of the spectrometer (without laser velocity-calibrator) is shown in Fig. 10. A digital oscilloscope shown is the external device.

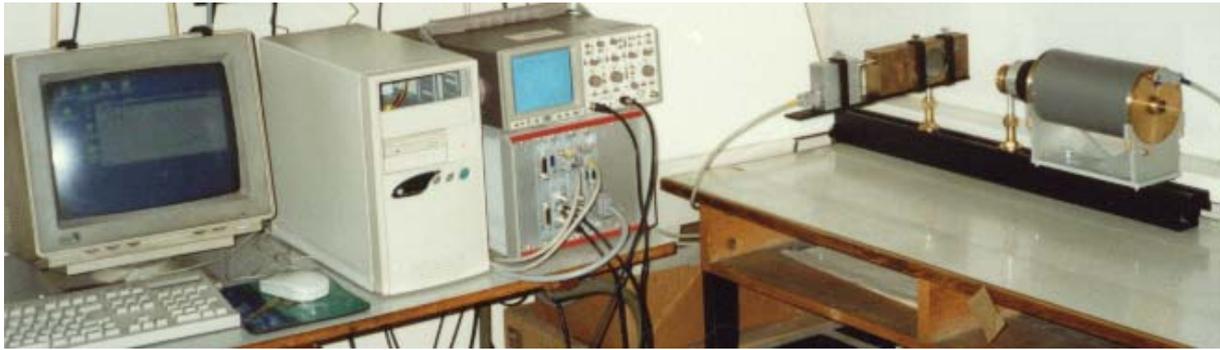


Fig. 10. A general view of the spectrometer.

## The **MS.EXE** programme

allows for setting of the spectrometer, reading the results and saving them on a disk. The saved data are accompanied by the current spectrometer settings and a comment one can add and edit. One can also read this data from a disk and load accompanying settings into the spectrometer. Exception is a reference function, which one has to set manually as mentioned above. Use cursors to check a counter value at a particular channel. To recall cursors press *Measure Data*, to move them use mouse after pressing left or right mouse key depending upon the cursor. We attach this programme with some data patterns. The file **MS.HDW** (see [page 9 for details](#)) must be present in the folder used to run this programme from. This is a text file describing some hardware parameters. *There is a bug: sometimes after loading a file the window is blank. Then resize the window just by dragging its corner.* This version will not work under Windows NT, 2000 or XP. It is designed for Windows 95/98 as it uses ISA link to the spectrometer. This obstacle is going to disappear upon having implemented TCP/IP link.

## Data processing software

is delivered together with the source files. Hence, one can modify respective programmes when necessary. It is a huge collection of interconnected programmes being able to process the majority of Mössbauer data from the first principles. There are many programming tools enclosed as well as auxiliary programmes e.g. to process  $\gamma$ -ray spectra and reference functions. All the calibration and data folding programmes are enclosed. A control panel of the MOSGRAF is shown in Fig. 11. Note please, that some icons lead to the sub-systems rather than to single programmes. MOSGRAF is fully compatible with data formats of the spectrometer driver.

MOSGRAF could be run under variety of the operational systems, but we recommend Windows 98 SE or newer edition of the Microsoft Windows e.g. Windows XP. The work is getting more and more comfortable with the increasing speed of the processor and the increasing amount of the RAM installed. Actually, a standard edition is optimized for a Pentium II or higher processor, and 128 MB of RAM allows for running comfortably all programmes. A 3-key mouse assures more comfortable work than any 2-key mouse as well as a colour monitor being unnecessary gives more comfort. Printouts are designed for a variety of printers, and we recommend either printers compatible with the HP LaserJet series or HP InkJet series – either network printers or local CENTRONICS LPT printers could be used.



Fig. 11. MOSGRAF control panel.

**Attached DATA.ZIP archive contains the following files:**

- MS.EXE           current version of the spectrometer driver
- MS.HDW         example of the factory hardware setting file with comments
- MS.ICO           external icon to be attached eventually to the MS.EXE
- SCINT.MS         $\gamma$ -ray spectrum obtained with the help of the standard scintillation head
- RHODIUM.MS     Fe/Rh spectrum obtained at very low velocity: scintillation head
- FENORM.MS      Fe-foil spectrum: proportional detector head
- HOLO.MS         CEMS “spectrum” of the enriched Fe-metal film – see below
- REF03.REF       example of the round-corner triangular reference function – see below

CEMS data were obtained at a constant velocity set on the steepest outer slope of the outermost hyperfine line – holographic arrangement.

The reference function is compatible with the hardware requirements. It has been generated with 3% of the rounded part.

One can retrieve DATA.ZIP file, unpack it into any desired folder, and run the programme MS.EXE as described above. You can try to retrieve the above file from:

- [www.elektron.ap.krakow.pl/data.zip](http://www.elektron.ap.krakow.pl/data.zip) ,
- [www.cyf-kr.edu.pl/~sfrueben/data.zip](http://www.cyf-kr.edu.pl/~sfrueben/data.zip) or
- [www.ap.krakow.pl/psm/data.zip](http://www.ap.krakow.pl/psm/data.zip)

*Details of the equipment and software described above may change without further notice due to the constant development of the equipment and related software. Ask please, about current status and further details prior to placing order.*