WRMISS - 9 Vienna, Austria, 8-10 September 2004

RESULTS OBTAINED WITH DB-8 AND LIULIN-ISS INSTRUMENTS DURING ICCHIBAN-5 SESSION AT THE NIRS, HIMAC

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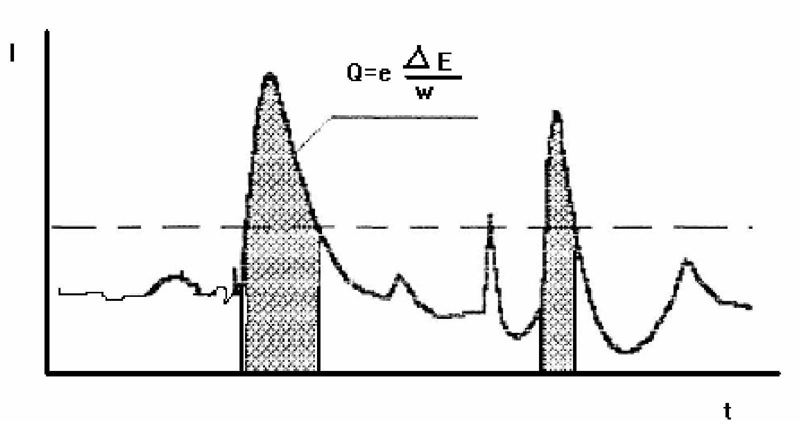
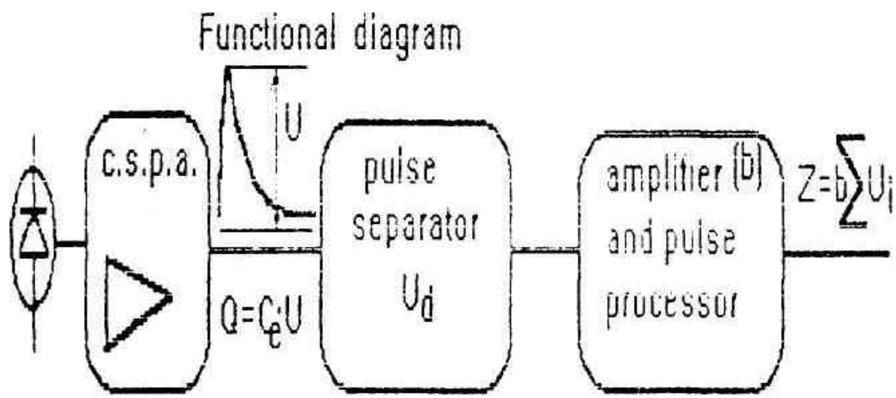
The dosimetric method of the Liulin-ISS and DB-8 device



The typical time dependence of: current in a semiconductor detector circuit



Block-diagram of an instrument employing the amplitude-pulse method for processing the semiconductor detector signals.

$$D = \frac{E}{m} = \frac{w_i \times \frac{q}{e}}{m} = \frac{w_i \times \Delta U \times C}{m \times e \times h} \times \sum K = V \times \sum K$$

where	**D**	**is the absorbed dose;**
	E	**is the energy absorbed by the sensitive volume**
	m	**is the sensitive volume mass;**
	w_i	**is the NP pair formation energy;**
	e	**is the electron's charge**
	q	**is the electric charge generated in the detector sensitive volume;**
	K	**is the analog-digital converter output signal;**
	?	**is the input capacitance of the detector-preamplifier system;**
	h	**overall multiplication factor of signal before the ADC;**
	DU	**is the quantization step of the ADC;**

The Experiment Schedule

- February 16, 2004 - **Liulin-ISS** jointly with **Liulin-4** experiment carried out by Dr. Uchihori.
- February 17, 2004 - **DB-8** jointly with **Liulin-ISS.**

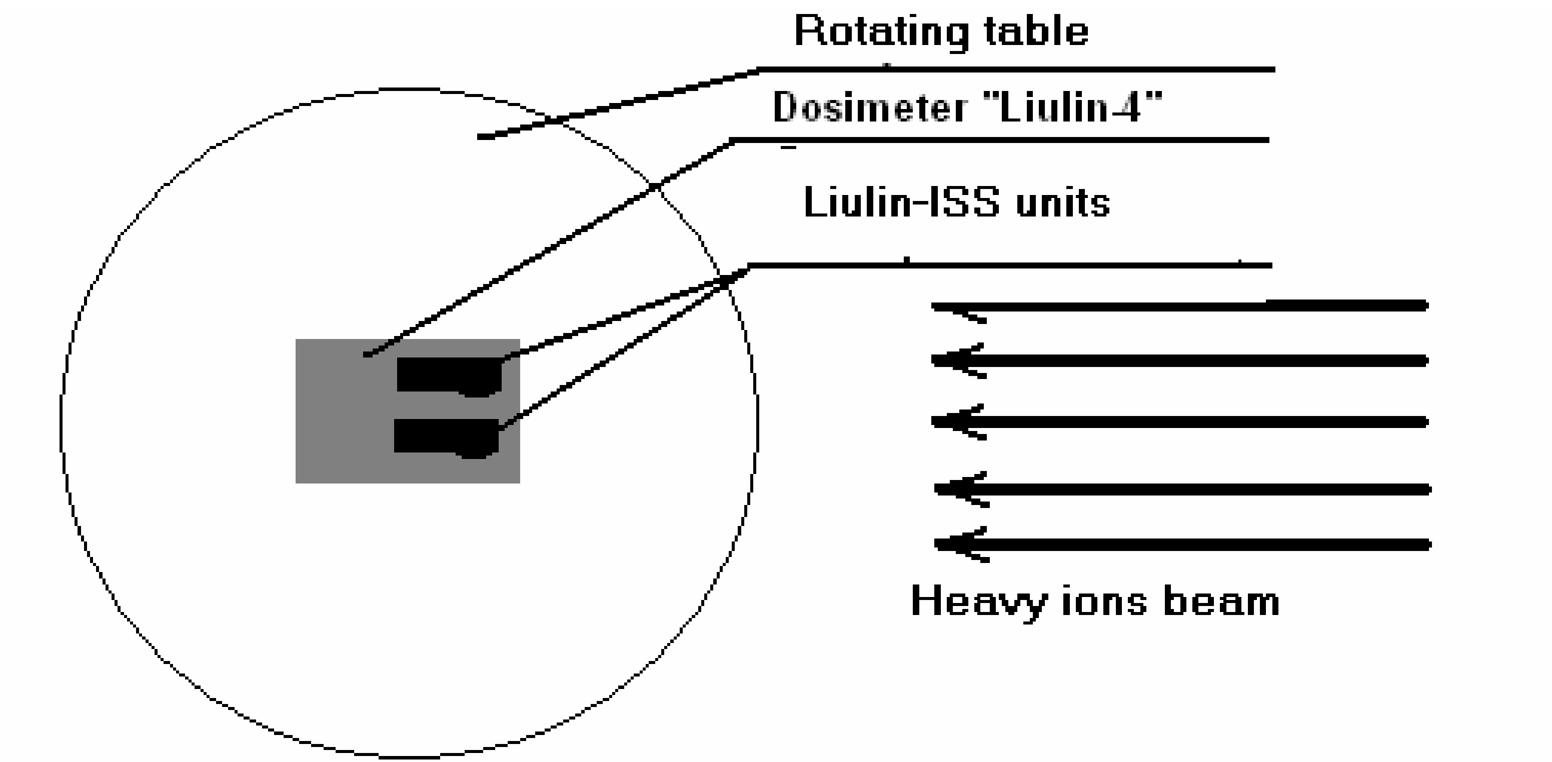
MDU of Liulin-ISS device

Detector side

Liulin–ISS device was designed in Solar-Terr. Influence Laboratory – BAS, Sofia Bulgaria. The device consists of 4 Mobile Dosimetry Units (MDU) and one Control and Interface Unit. MDU is a miniature spectrometer-dosimeter containing: one semiconductor detector, charge-sensitive preamplifier, ADC, microcontrollers, flash memory and battery.

LIULIN-ISS units

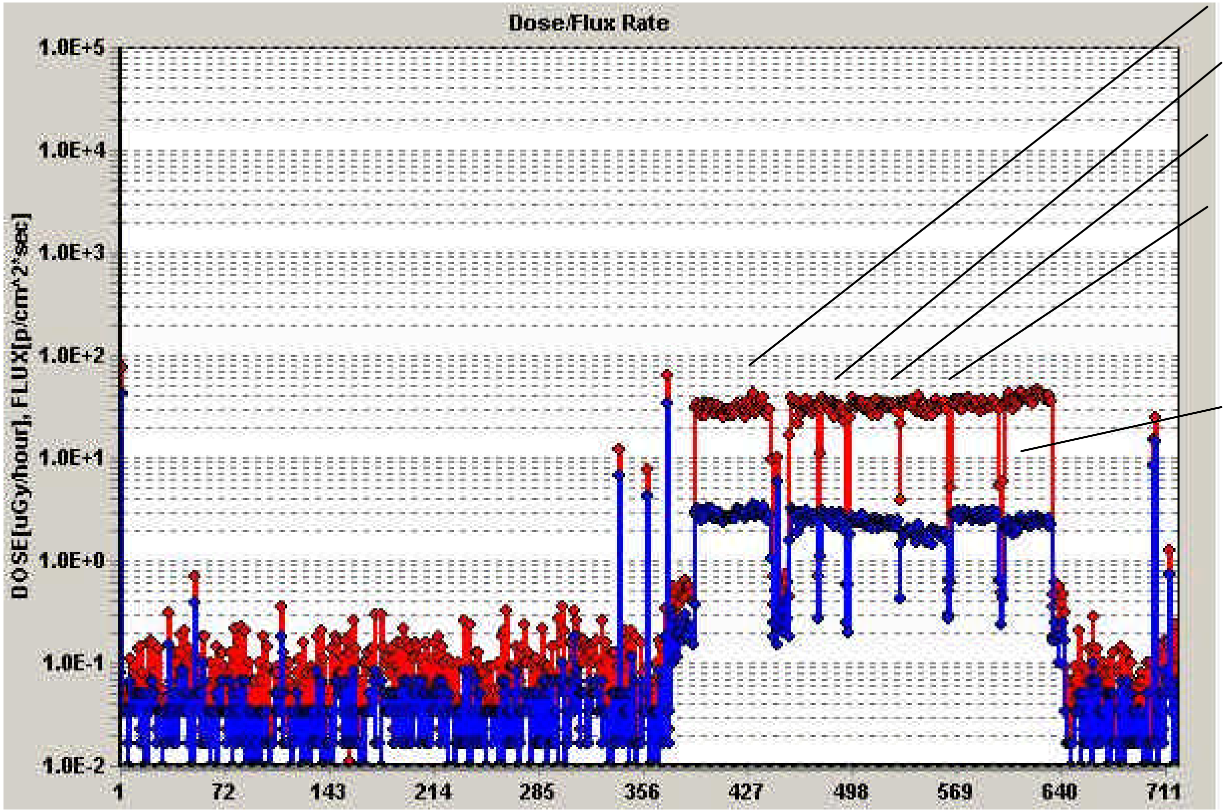
Allocation scheme of Liulin-ISS dosimeters



ИМБП

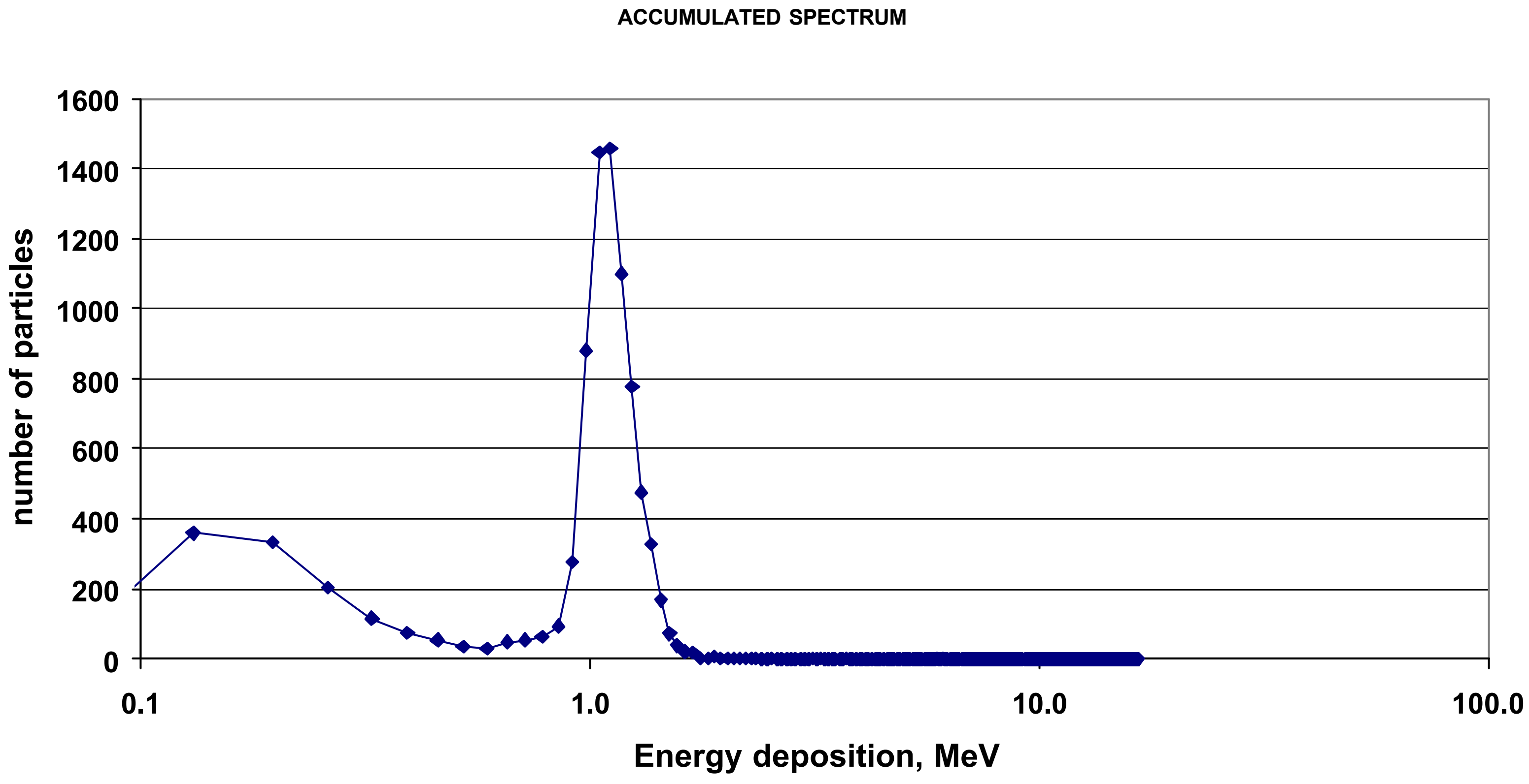
View of Liulin-ISS dosimeters placed together with the Liulin-4 dosimeter on the rotating table in the experimental hall of the HIMAC accelerator

Dose rate measured with the MDU



Beam inclined angle:
0 degree
30 degree
45 degree
60 degree
0 degree +
5 cm acryl
10 cm acryl

The energy deposition spectrum of the Liulin-ISS dosimeter (MDU #301) for February 16 session. Beam inclined angle 0 degree.



Method of the calibration coefficient estimation using the energy deposition spectrum

$$E = Ns \times \Delta E = dE/dX \times h$$

$$D = \frac{E}{m} = \frac{dE/dX \times h}{\rho \times h \times S} = \frac{dE/dX}{\rho \times S}$$

Where:

? - one particle average energy deposition in the detector

D – one particle dose in the detector.

Ns – analog-to-digital converter code value corresponding to the particle

D**?** – energetic equivalent of one quantum of analog-to-digital converter.

dE/dX – average ionization loss of incident particles.

h – thickness of the detector sensitive area.

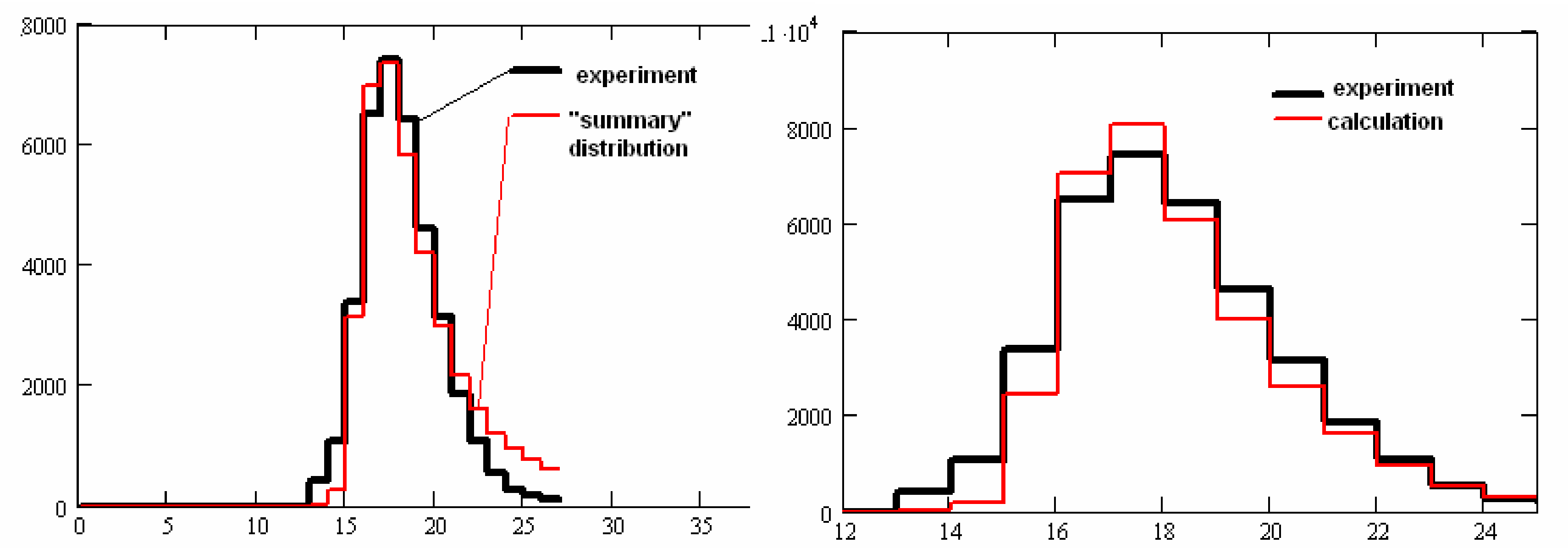
m – mass of the detector sensitive area.

S –the detector sensitive area.

r - matter density of the detector sensitive area.

$$K_D = \frac{D}{Ns} = \frac{dE/dX}{\rho \times S \times Ns}$$

Comparison of experimentally measured energy deposition spectrum with Landau and Vavilov distributions



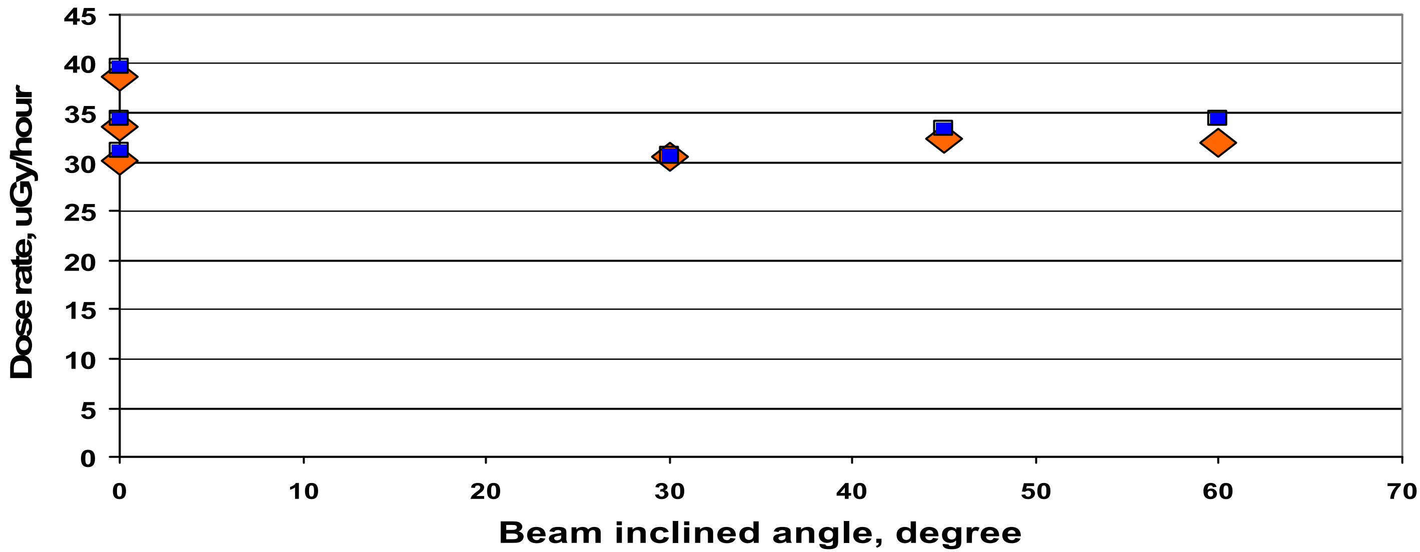
Two methods of **Ns** estimation have been compared:

- optimization parameters of Vavilov distribution;

- average value calculated by the formula **Ns** **=** S **(i*Ni)** **/** S **Ni – ½**

The calculations indicated that the difference doesn't exceed 3%.

Comparison of dose rate values calculated by Bulgarian program of the Liulin-ISS data handling and estimated by the energy deposition spectrum



Beam conditions		0	30	45	60	5 cm Acr	10 cm Ac
MDU #301	Calc. by Bulgarian programm	30.1	30.6	32.3	32.0	33.6	38.6
	Estimated by spectrum	31.3	30.7	33.4	34.7	34.6	39.9
MDU # 302	Calc. by Bulgarian programm	30.3	30.6	30.3	32.0	34.0	38.1
	Estimated by spectrum	31.1	30.2	31.6	33.9	34.6	39.9

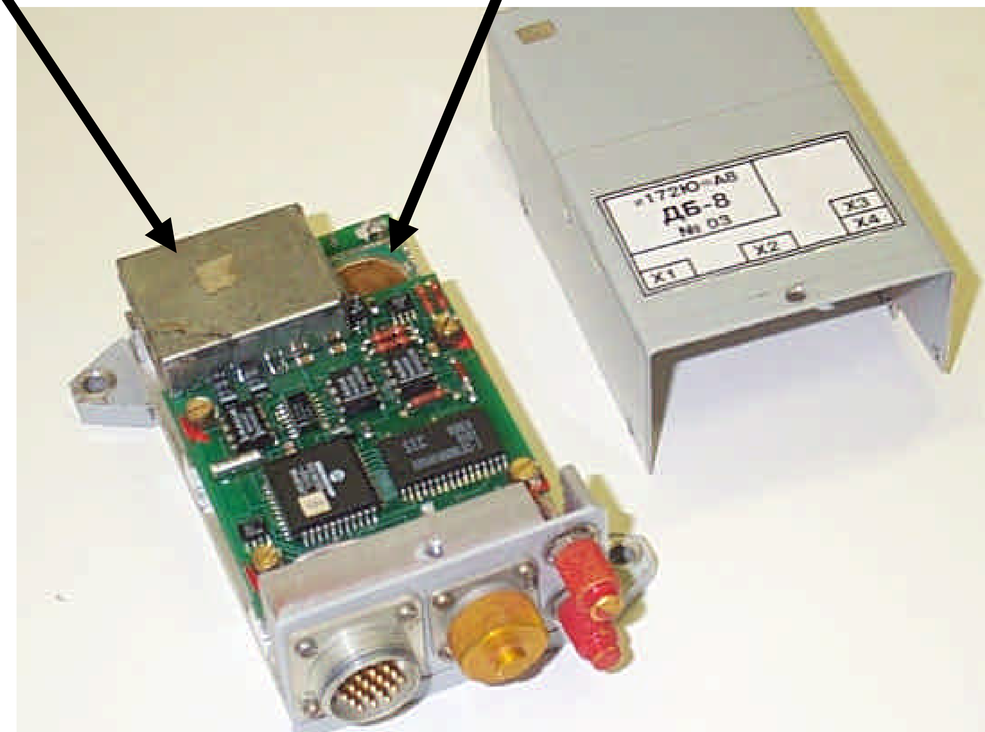
DB-8 unit

**All the DB-8 units are similar.
Each of them has 2 fully independent channels consisting of a semiconductor detector and electronic circuit.**

The sensitive component is a silicon semiconductor detector of 300 mm sensitive layer covering an area of 1 cm^2.

The DB-8 unit without cover

Shielded detector **Unshielded detector**

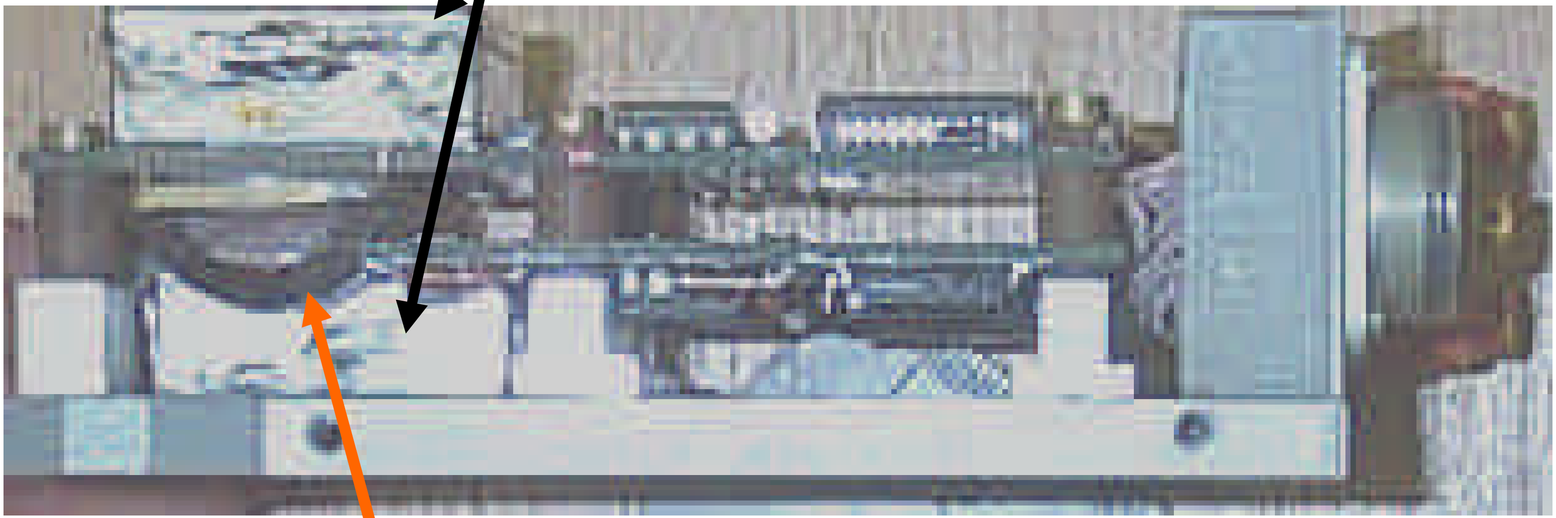


The difference between the two channels is that one of the detectors has an additional lead shielding. The shielding is a sphere surrounding the detector.

The sphere wall thickness is 3 g/cm^2 Pb

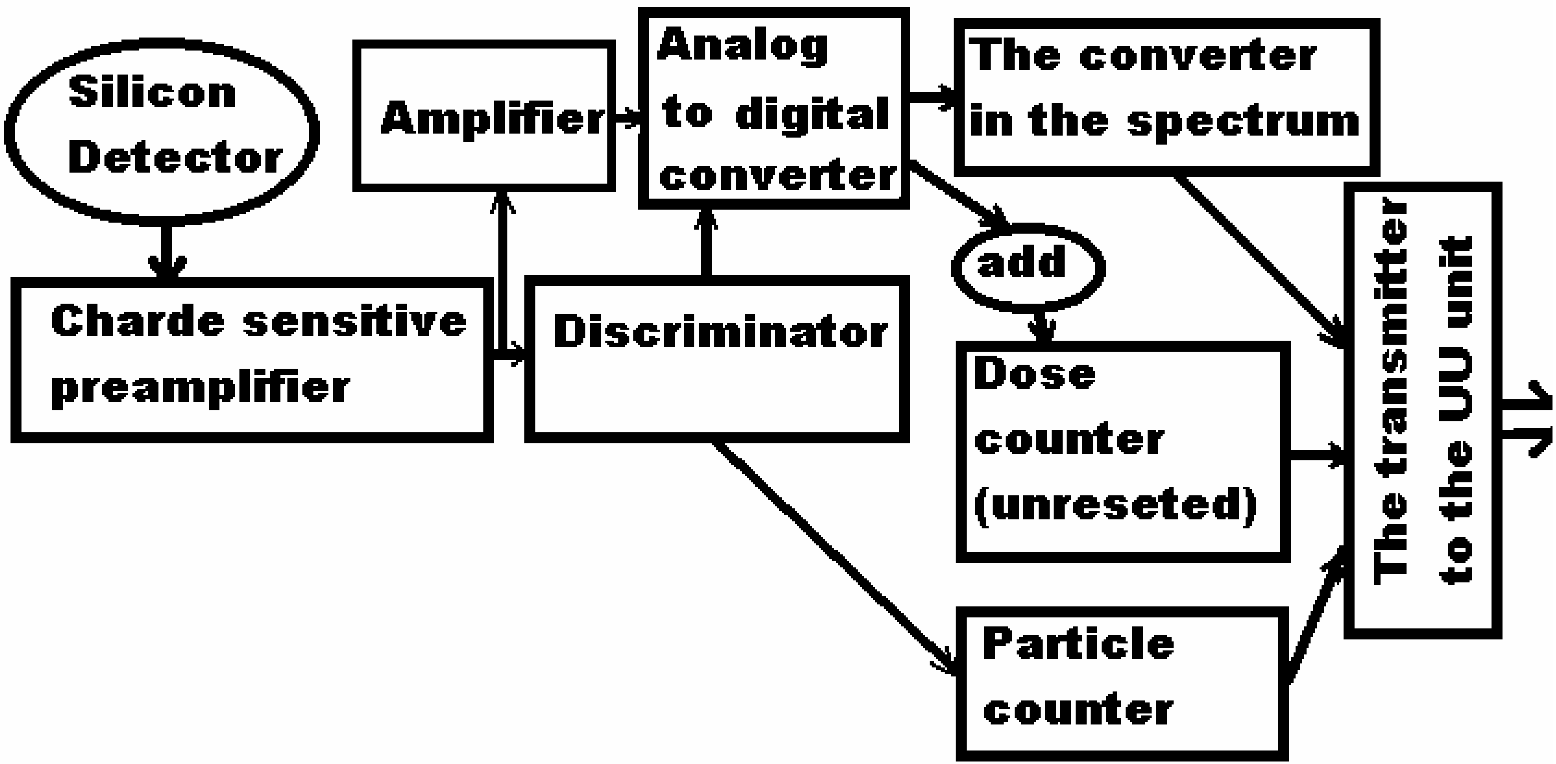
Each DB-8 unit consists of 2 independent dosimeters

Electromagnetic screens of detectors



The lead spherical shielding of 2.5 mm thickness that covers the detector

The flowchart of DB-8



If we neglect the system noise and round off errors then the absorbed dose is proportional to the sum of the ADC output signal.

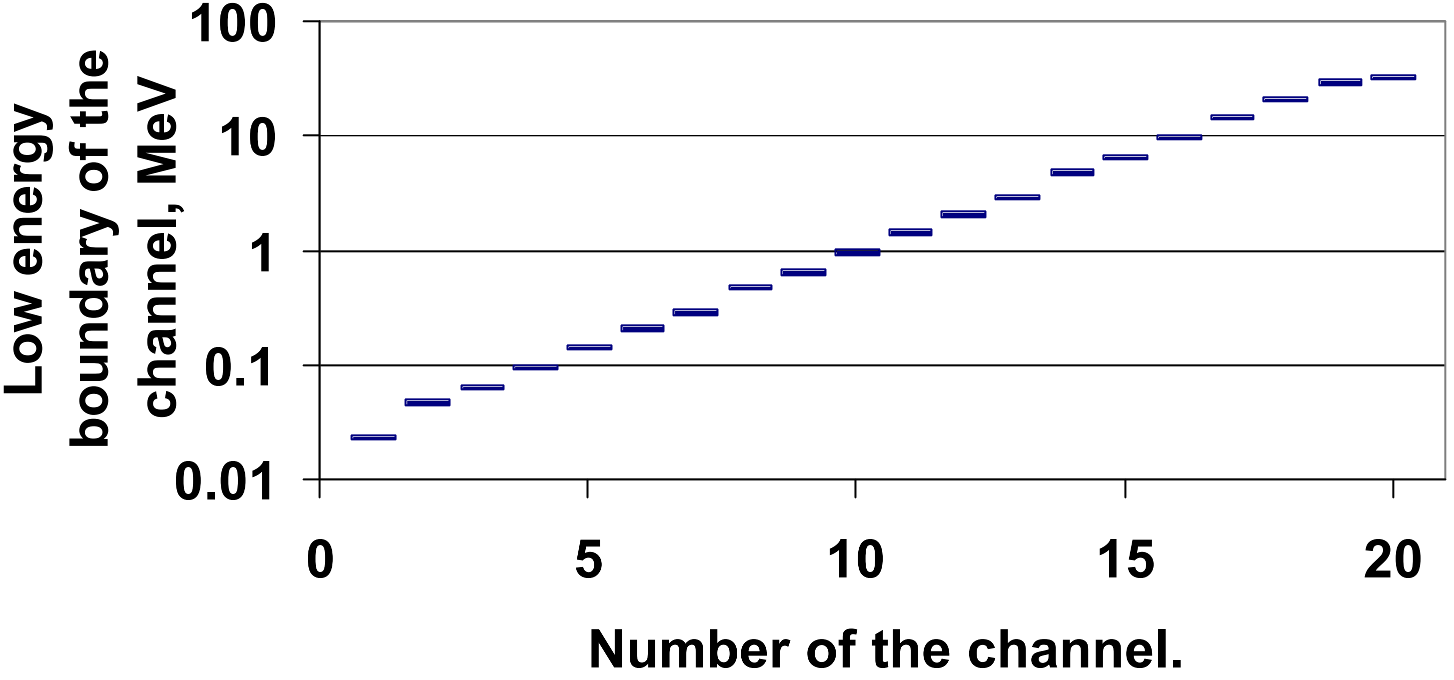
There are two ways to obtain the dose.

The first way, output signal from the ADC is added to the total dose counter. After power-up of the RMS this 32-bit counter resets and then accumulates signals until overflow after which the cycle loops.

The second way is based on summing up the number of particles in spectrum channels with respective weighting factors. This way allows increasing of the dynamical range of measurements based on the correction of the calculating errors caused by the dead time of the discriminator and ADC.

Dosimetric information obtained by these two ways is presented on the next slide.

Distribution of energy bordaries for the channels of the DB-8.



$$D = \frac{V}{1 - \frac{N_p \times t}{T}} \times \frac{N_p}{\sum_{j=1}^{19} n_j} \times \sum_{j=1}^{19} (u_j \bullet n_j)$$

where D is the absorbed dose;

V is calibrated factor

N_p is a number in the counter of particles

t is a dead time of the discriminator

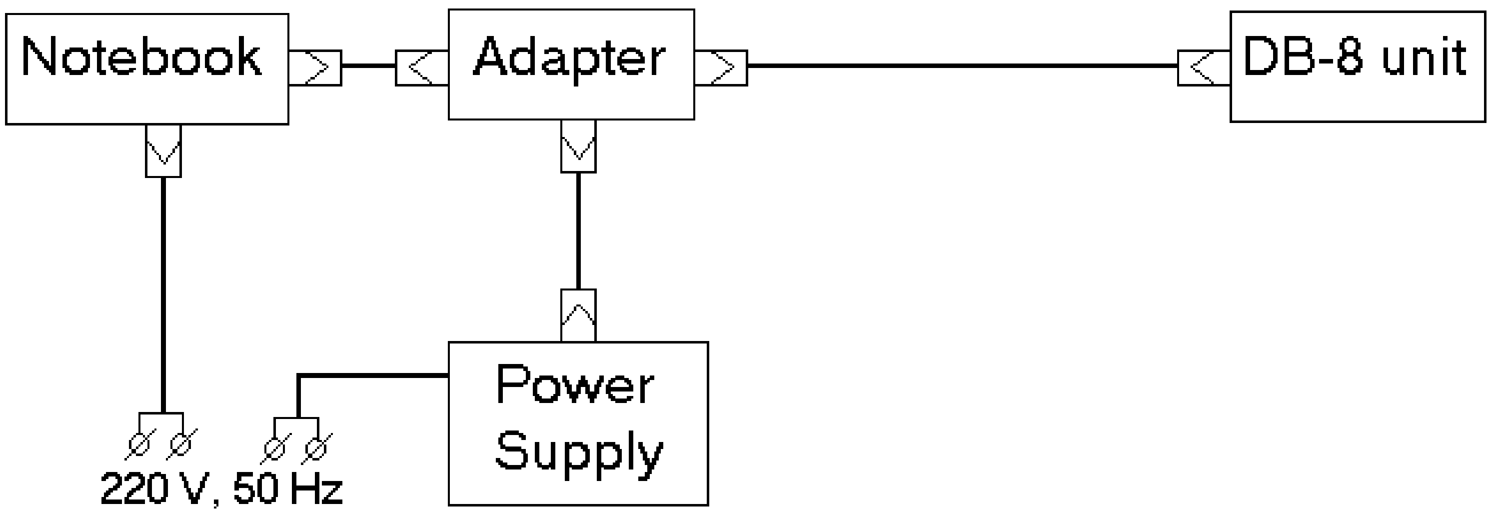
T is a duration of the interval of measurement

j is a number of spectrum channel

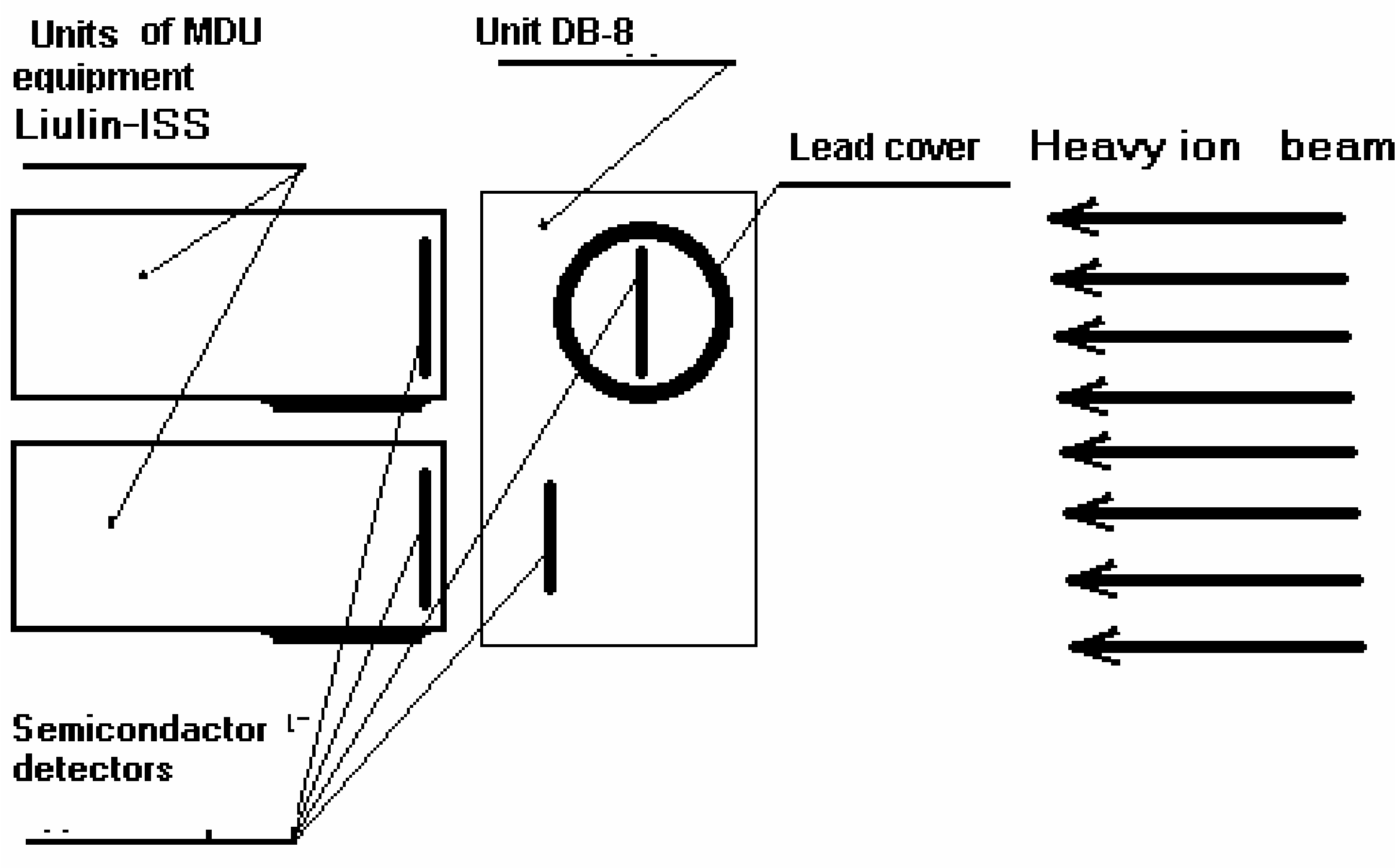
n_j is a number of counting in the channel j

u_j is the weighting coefficient for the channel j

Block-diagram of devices for DB-8 self-contained tests



The scheme of mutual location of the DB-8 unit and the Liulin-ISS dosimeters



The mutual location of the DB-8 unit and the Liulin-ISS dosimeters

Slip of peak in the Liulin-ISS energy deposition spectrum when behind the DB-8 unit

	Irradiation conditions		
	Value on Feb 16.	**Behind unshielded detector**	**Behind shielded detector**
Ns, MDU #301	**17.64**	**17.87**	**20.93**
Ns, MDU #302	**17.58**	**17.84**	**20.79**
Estimation of relative increasing of energy deposition behind DB-8 unit.		**1.014**	**1.18**
Per cent of relative increasing of energy deposition for DB-8 detectors.		**0.7 %**	**9 %**

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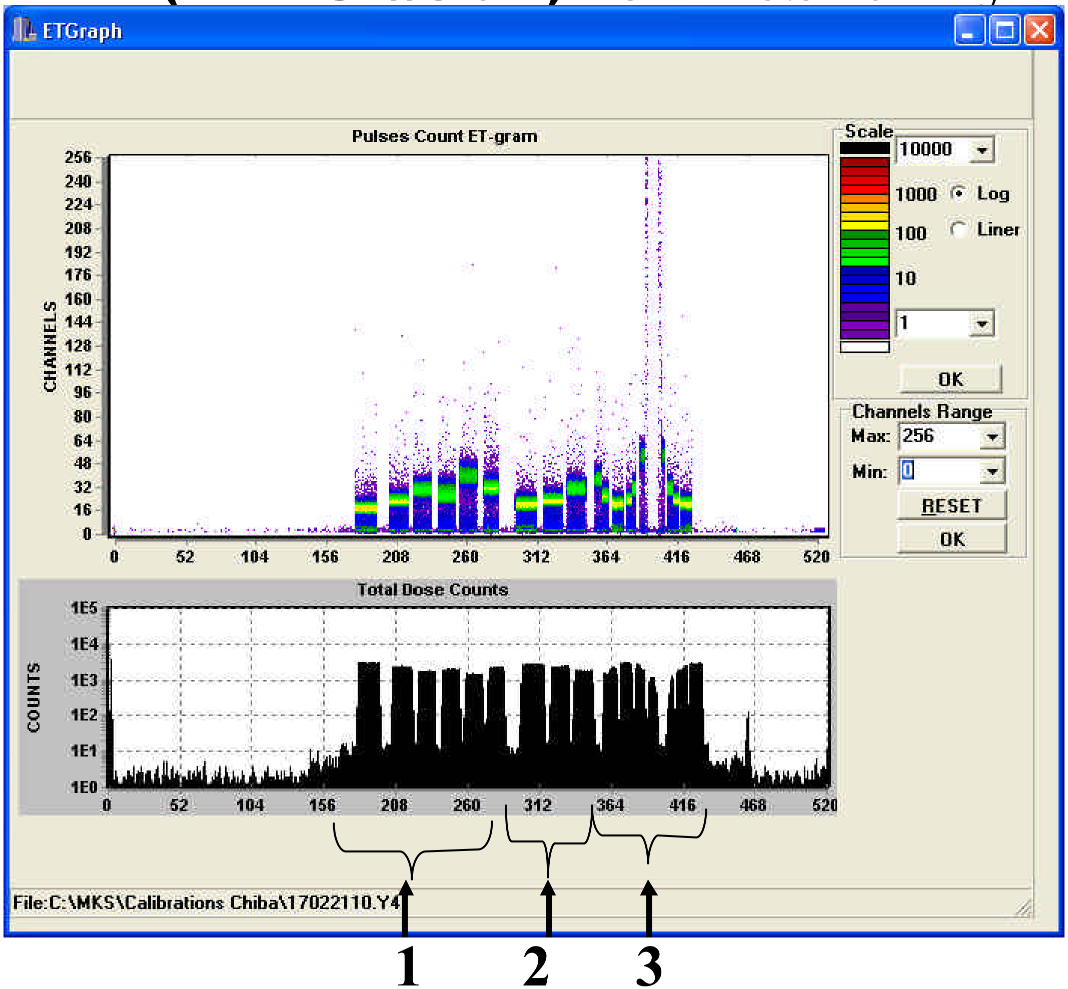
The results of the Liulin-ISS dosimeter (MDU #301) for February 17 session



1 – test mode, unshielded detector

2 – test mode, shielded detector

3 – operational mode, unshielded and shielded detectors

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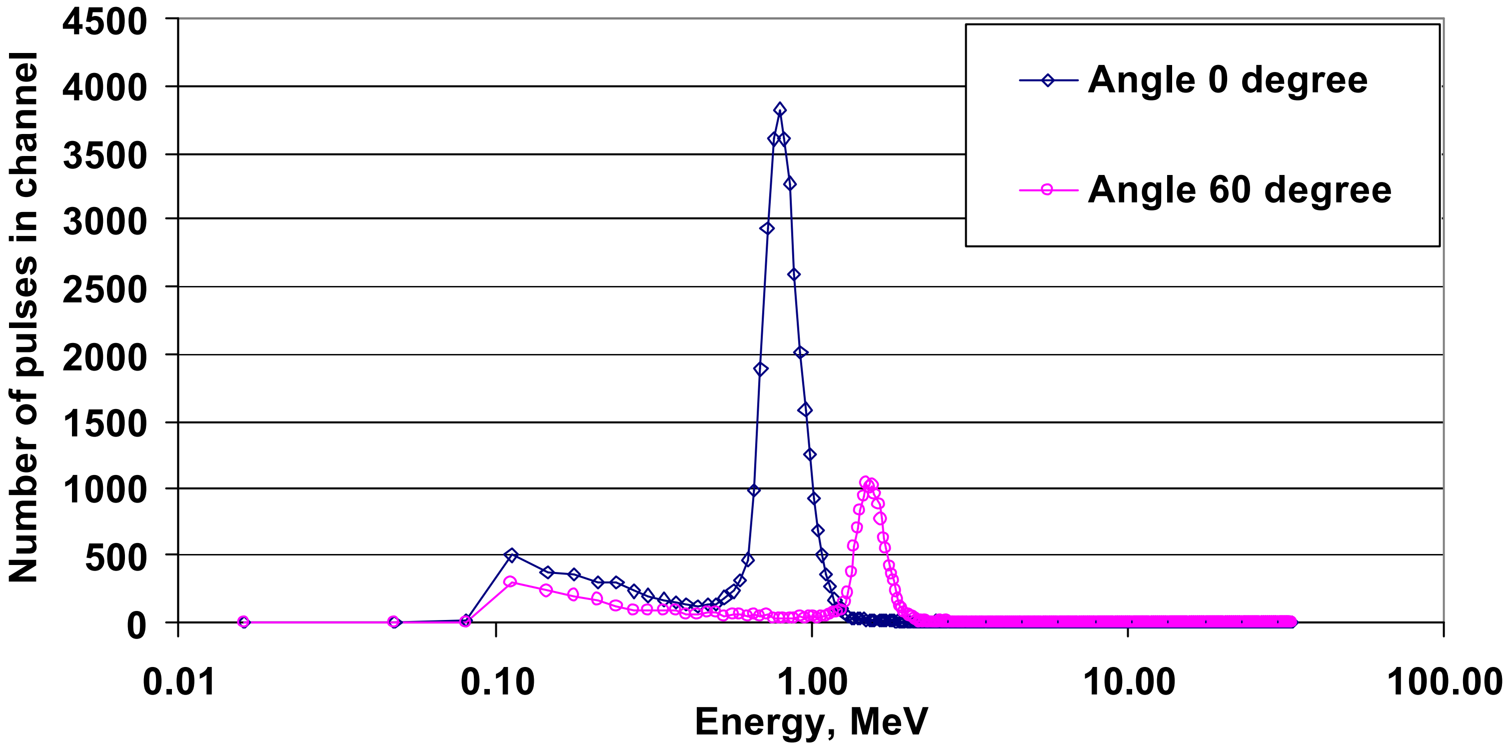
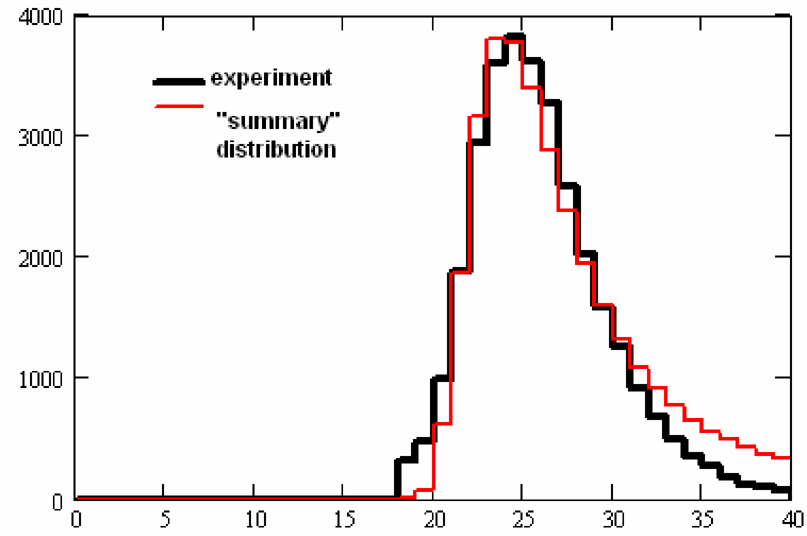
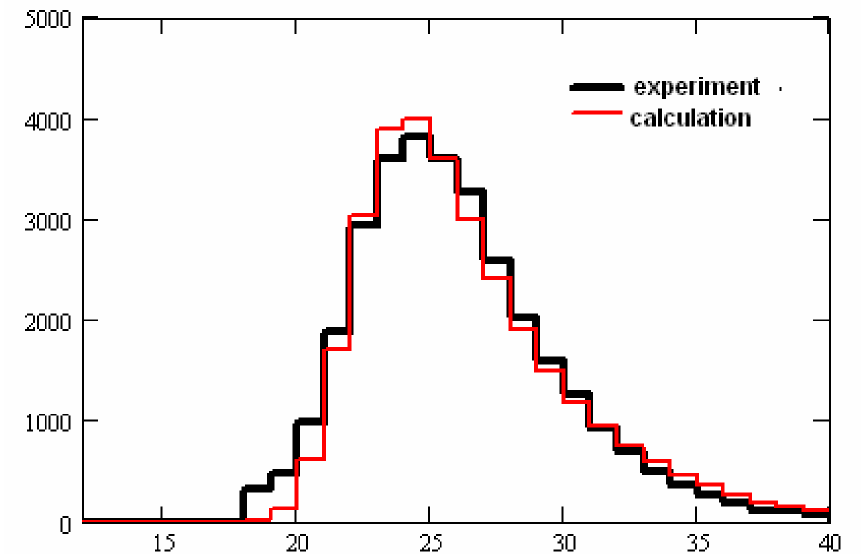
The energy deposition spectrum of the DB-8 unshielded detector for February 17 session. Beam inclined angle 0 and 60 degree.



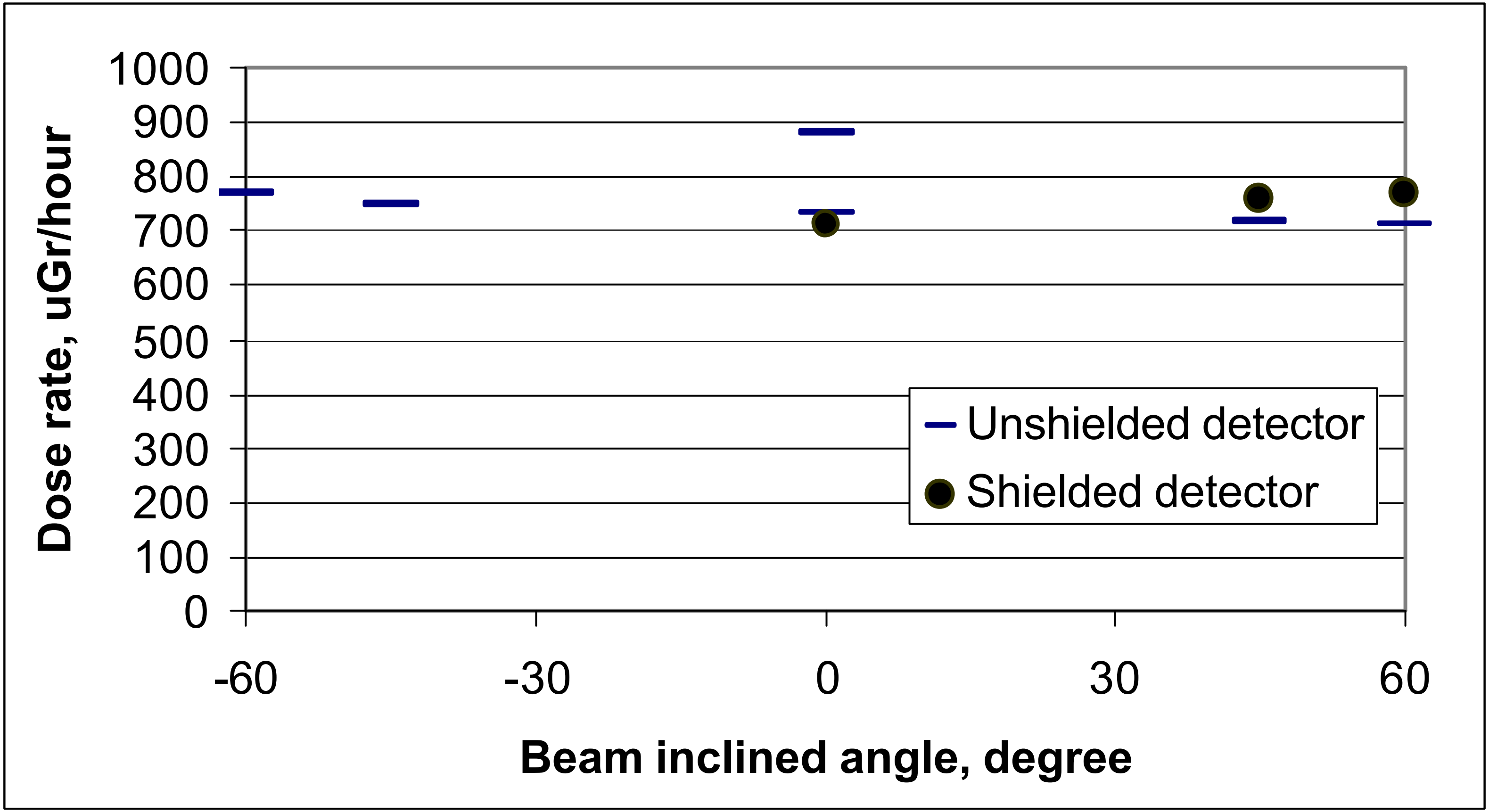
Comparison of the DB-8 measured energy deposition spectrum with Landau and Vavilov distributions





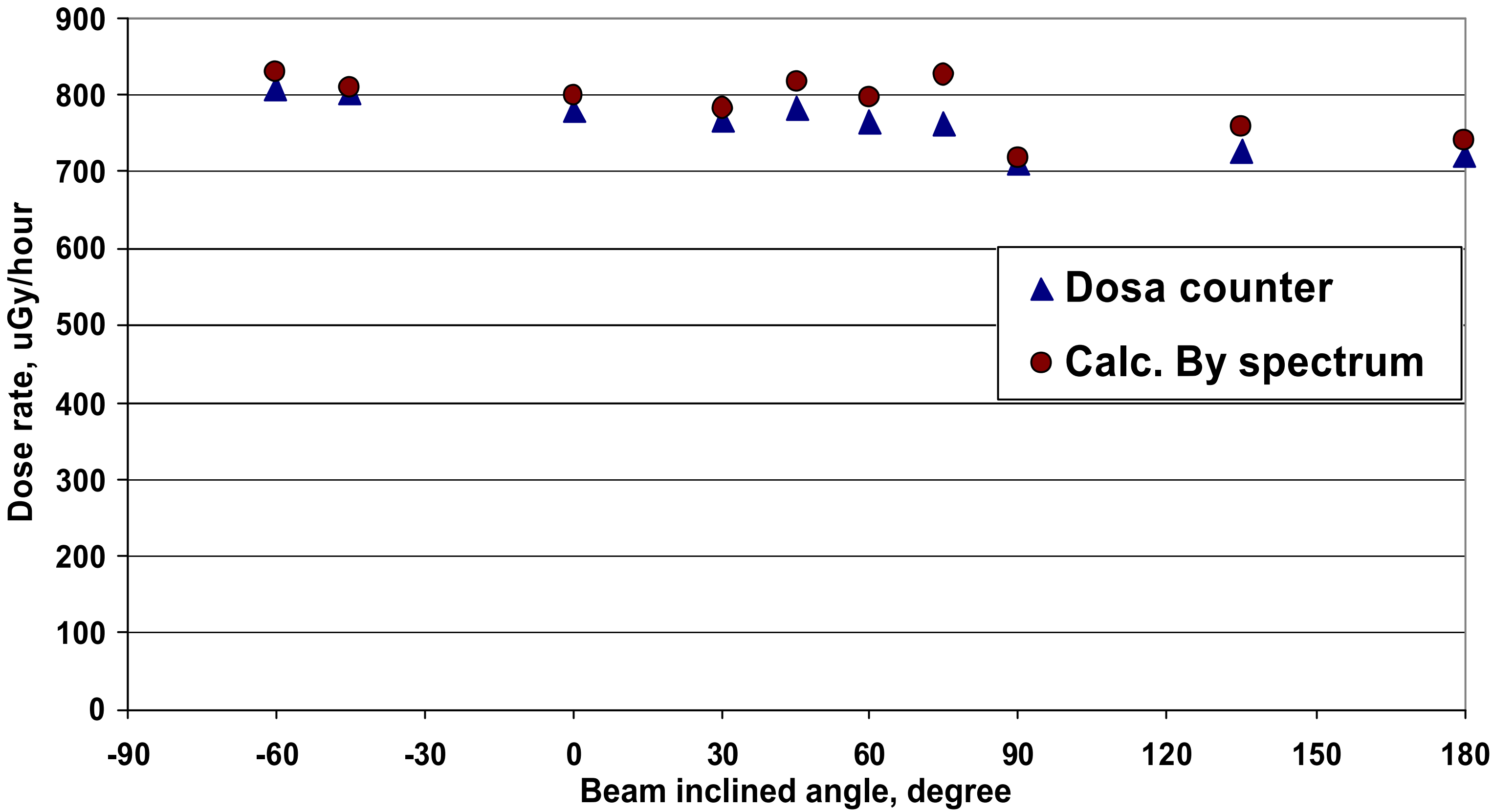
The results of approximation for the spectrum registered on February 17 with unshielded DB-8 detector at normal incident beam

Dose rate versus beam inclined angle. DB-8 test mode



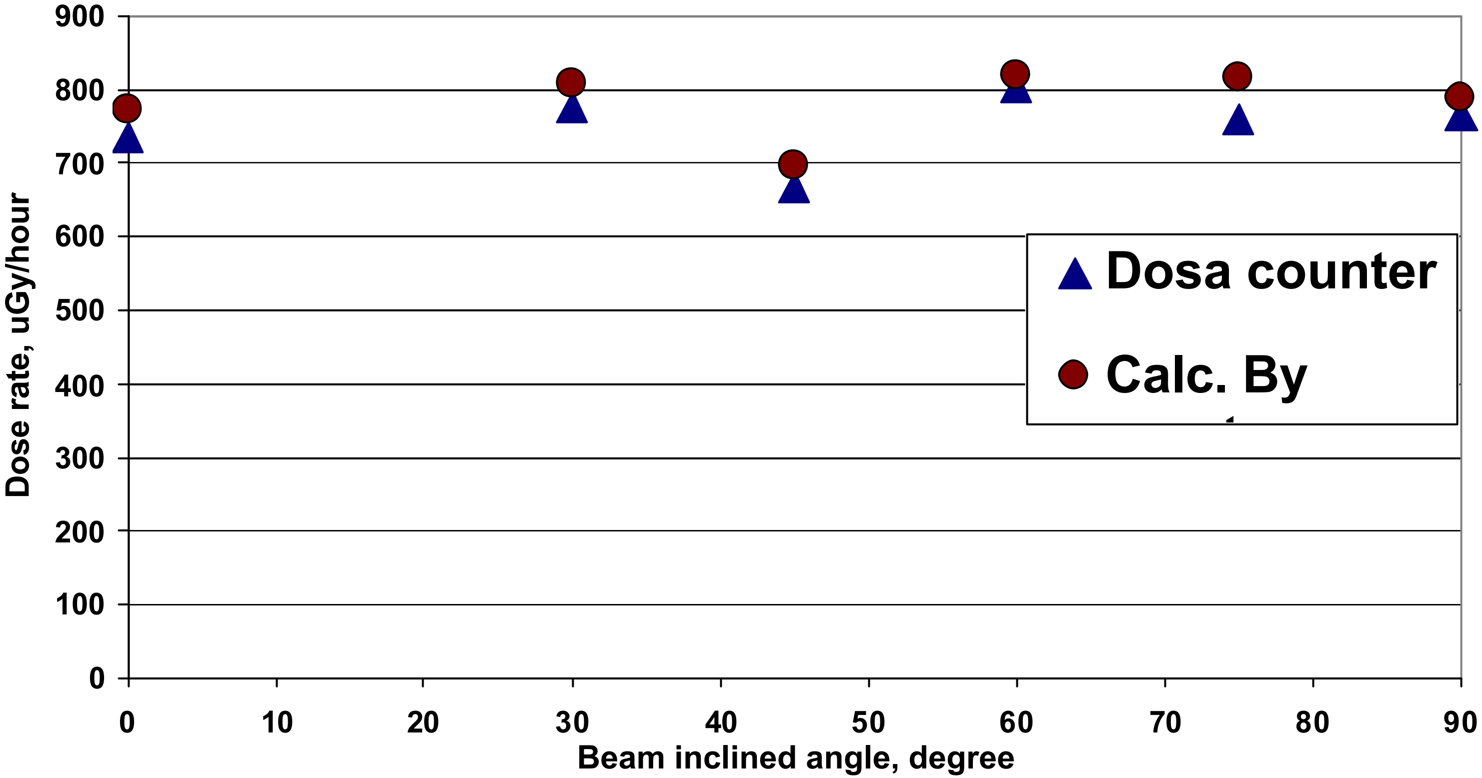
Dose rate versus beam inclined angle.

DB-8 operational mode, unshielded detector

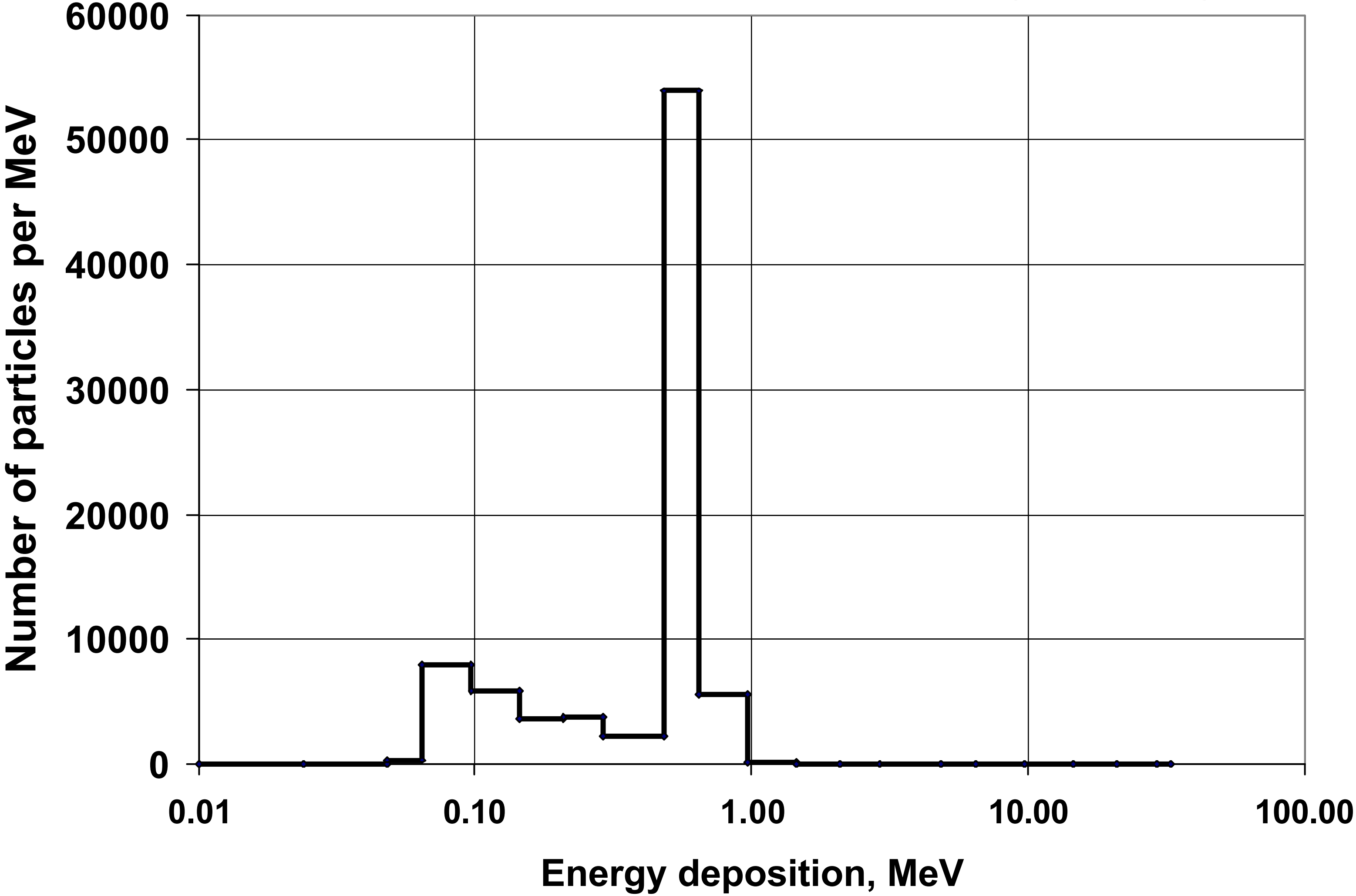


Dose rate versus beam inclined angle.

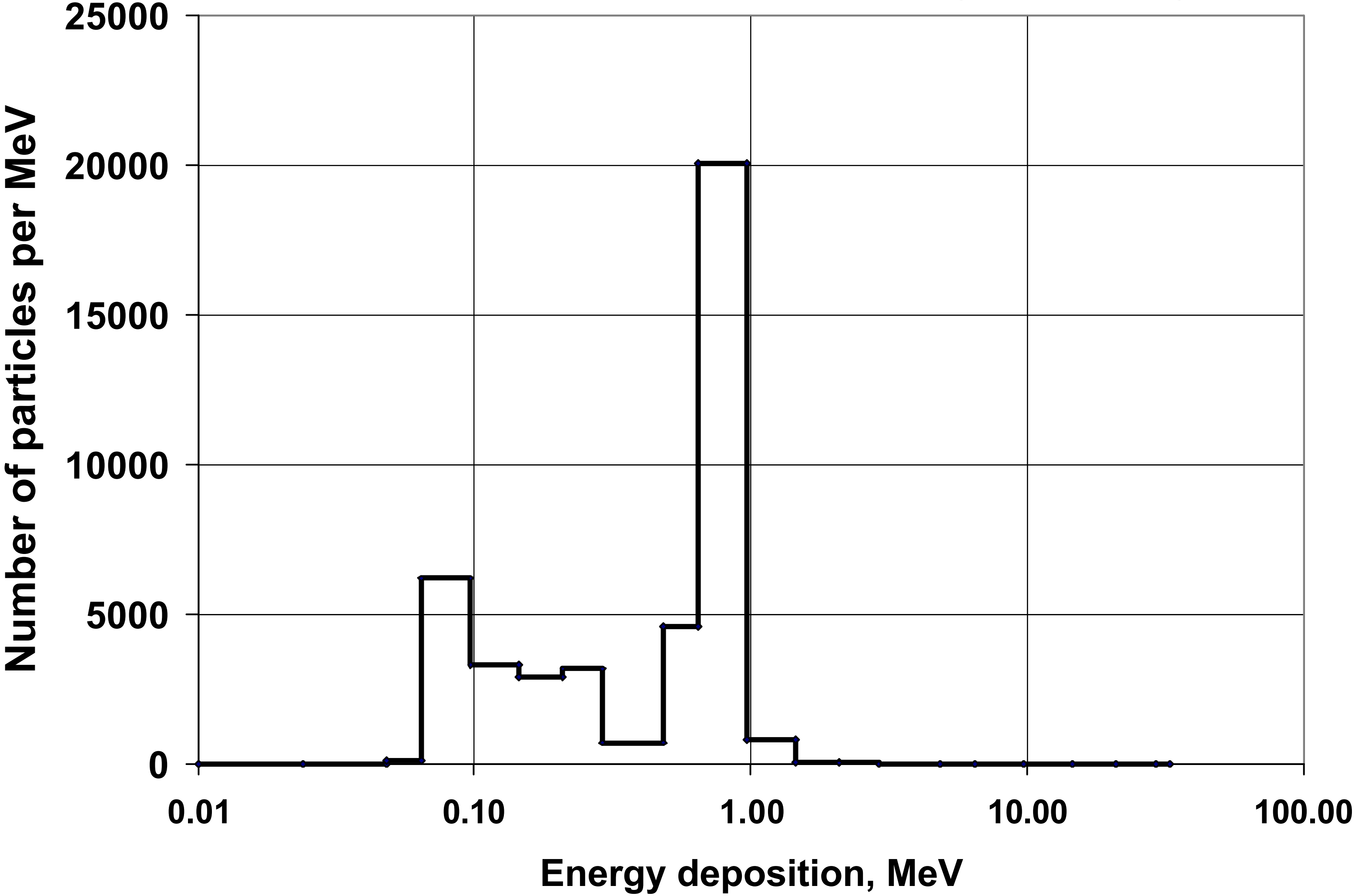
DB-8 operational mode, shielded detector



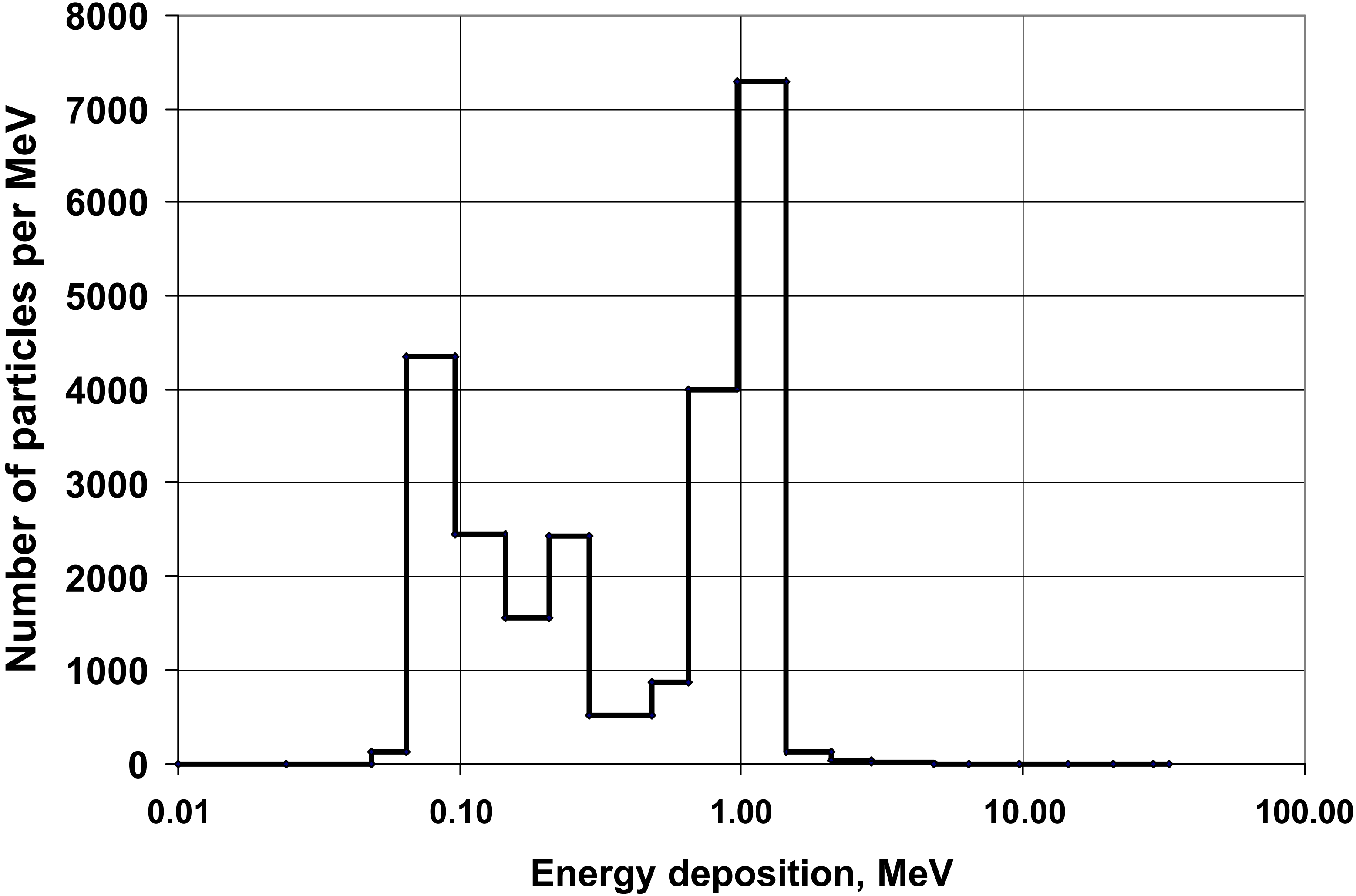
Energy deposition spectrum. DB-8 operational mode. Unshielded detector. Beam inclined angle 0 degree.



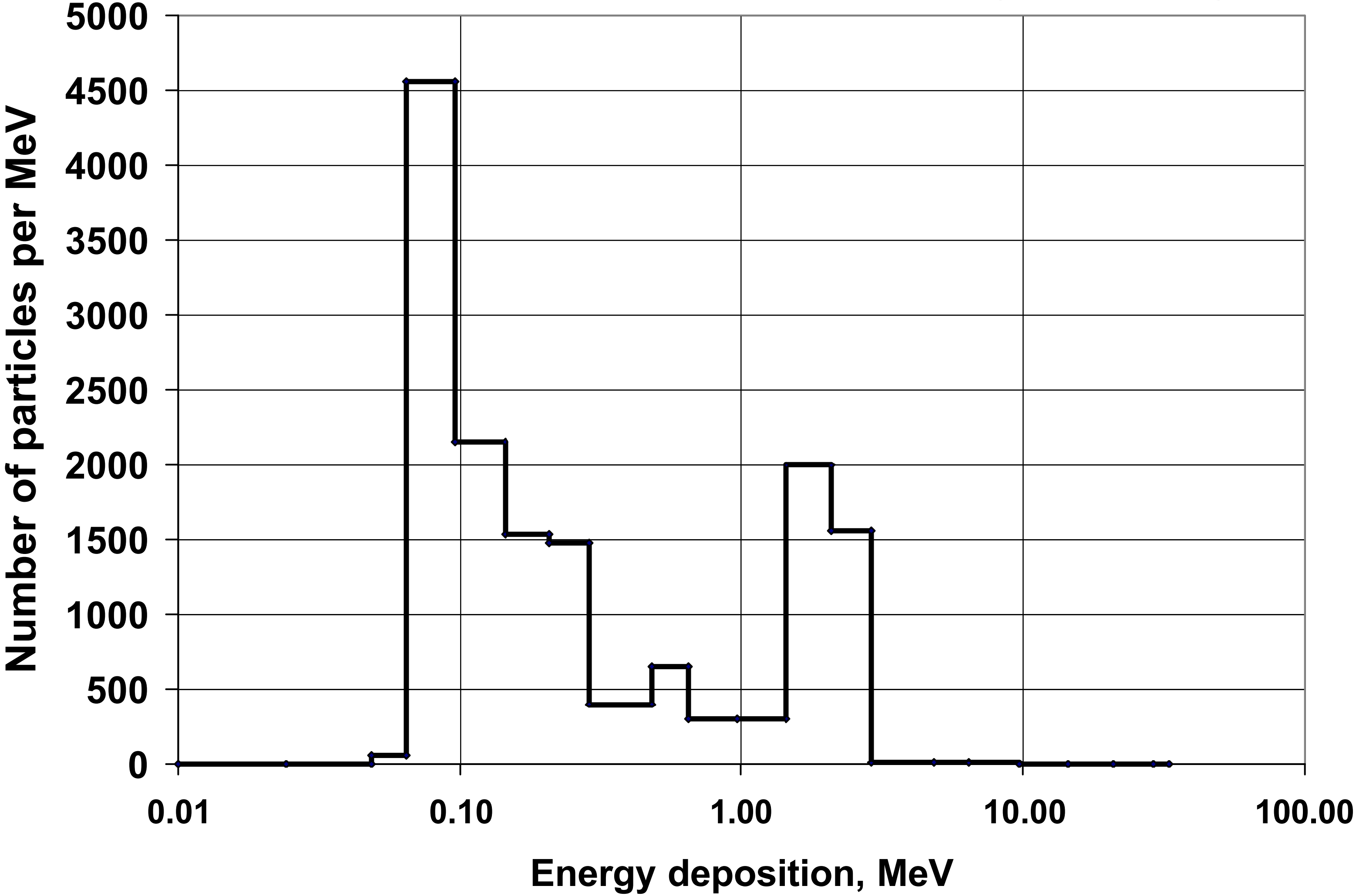
Energy deposition spectrum. DB-8 operational mode. Unshielded detector. Beam inclined angle 45 degree.



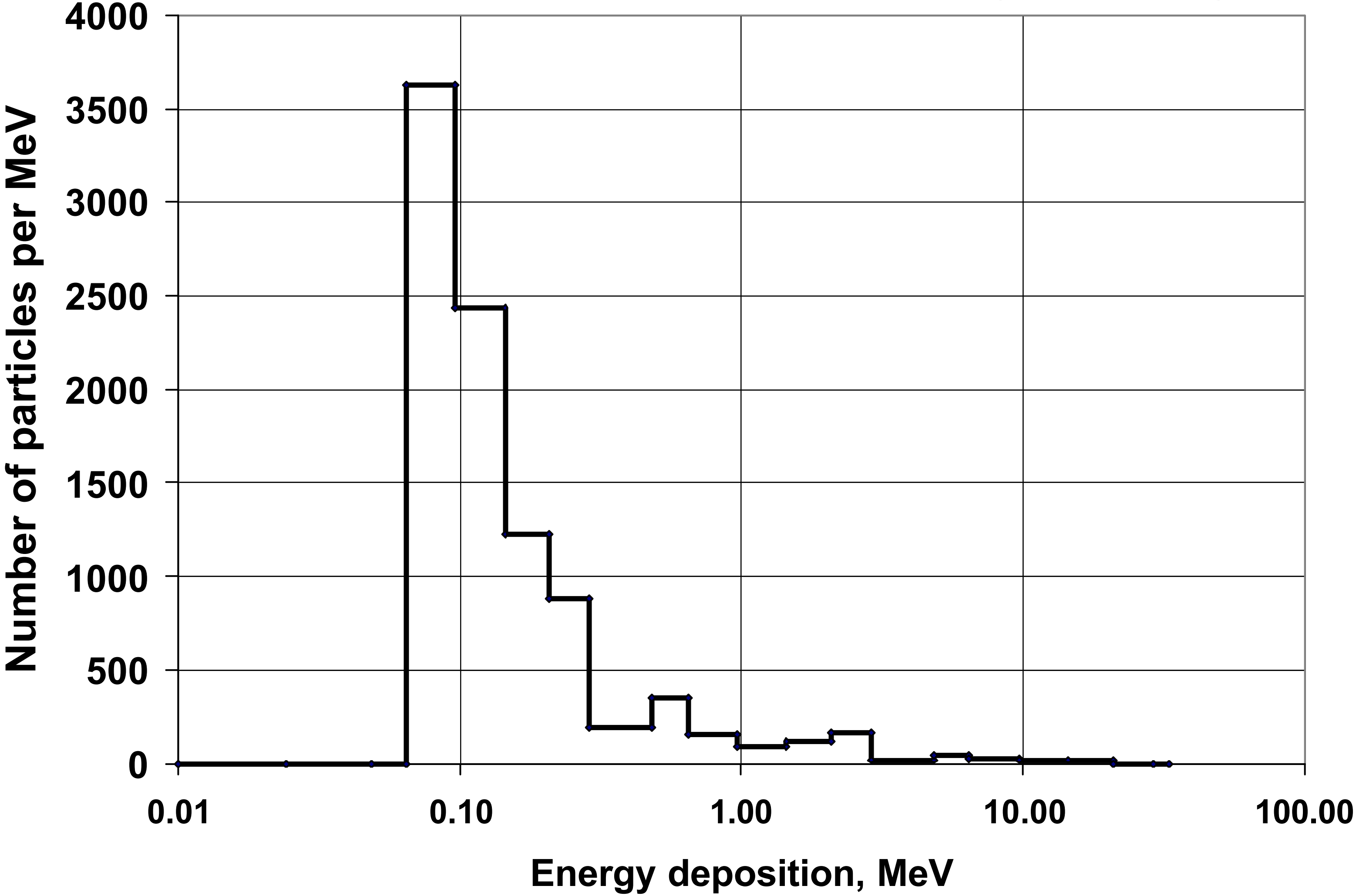
Energy deposition spectrum. DB-8 operational mode. Unshielded detector. Beam inclined angle 60 degree.



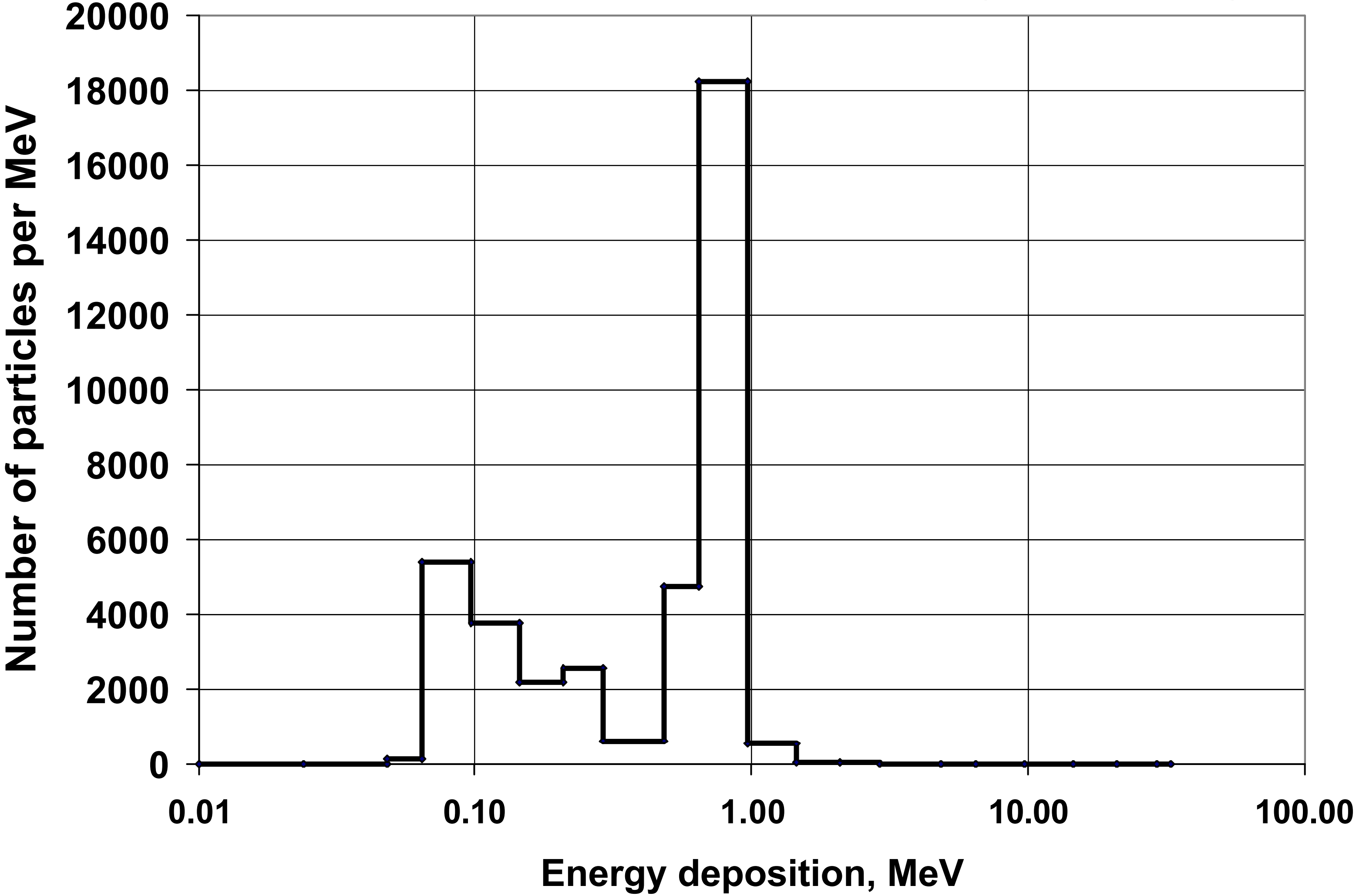
Energy deposition spectrum. DB-8 operational mode. Unshielded detector. Beam inclined angle 75 degree.



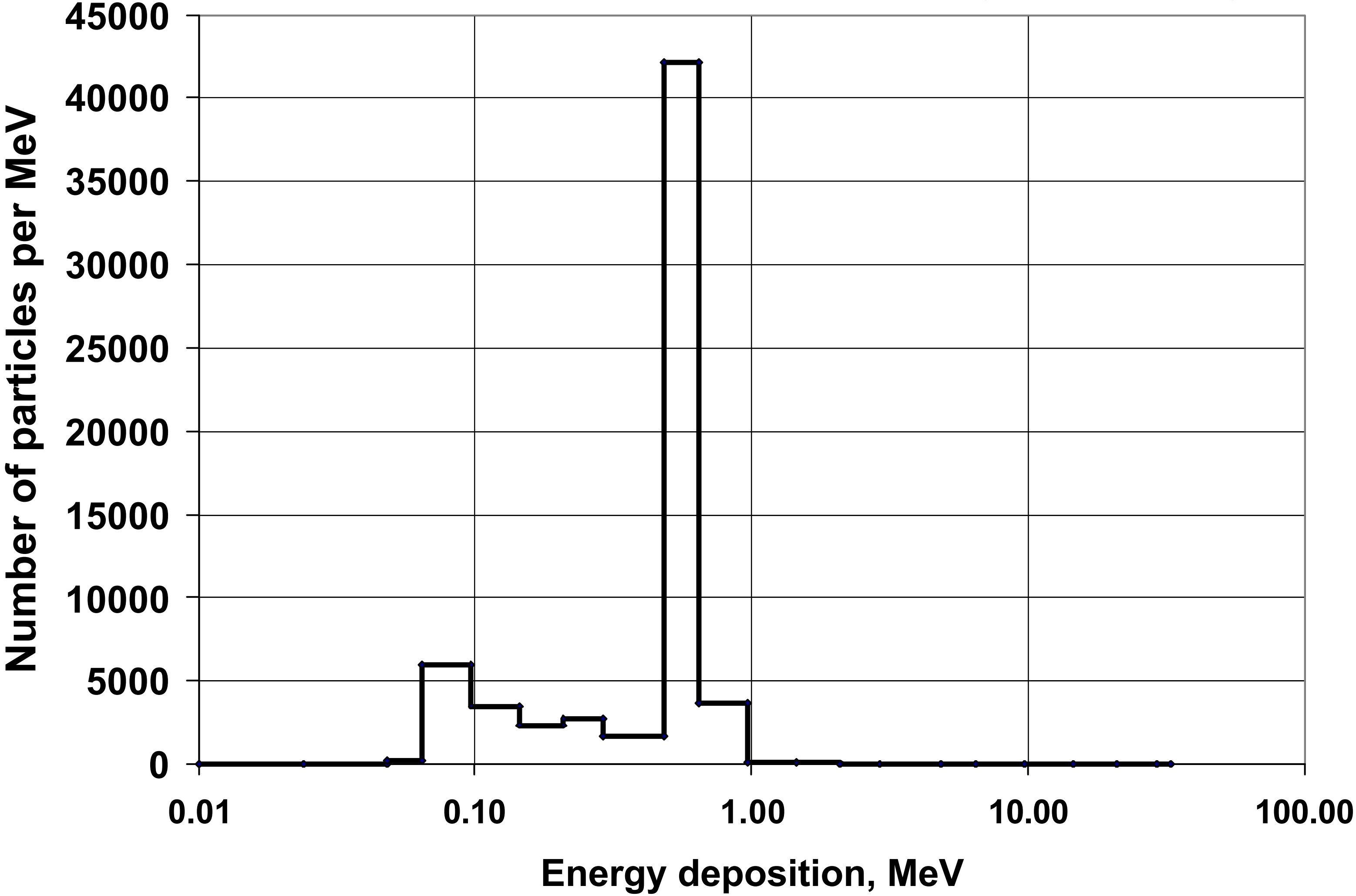
Energy deposition spectrum. DB-8 operational mode. Unshielded detector. Beam inclined angle 90 degree.



Energy deposition spectrum. DB-8 operational mode. Unshielded detector. Beam inclined angle 135 degree.



Energy deposition spectrum. DB-8 operational mode. Unshielded detector. Beam inclined angle 180 degree.



Conclusion

- **The ICCHIBAN-5 studies with DB-8 and Liulin-ISS silicon detector instruments were carried out in the 150 MeV helium ion beam in February 2004.**
- **The data analysis shows:**
  - dose rate and flux data measured with the DB-8 and Liulin-ISS are different one from the other not more than 15 – 20%.
  - No significant difference was noted between the dose rate registered with the DB-8 device in the testing and operational modes.
  - No significant dose rate changing was noted at different beam inclined angles. It indicates that, in this case, the detector dose sensitivity is close to isotropic.
- **The above results approve the possibility to use the LIULIN-ISS and DB-8 instruments for space radiation dosimetry applications.**

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