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DEPARTMENT OF EXPEREMENTAL
NUCLEAR PHYSICS AND COSMOPHYSICS

MULTILAYER FILM SHIELDS FOR THE PROTECTION OF PMT FROM CONSTANT MAGNETIC FIELDS

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Multilayer film screens.

The shielding characteristics of different types of screens.

Shielding of PMTs by different screens.

Conclusions.

MULTILAYER SCREENS

First publications:

Rucker A W **1894** Phil. Mag. 37 95-130. (*Theor.)*
Esmarch W **1912a.** Ann. Phys., Lpz 39 1540-1552 and **1912b.** Ann. Phys., Lpz 39 1553-1566. (*Exper.)*

Advantages of multilayer screens were demonstrated in comparison with solid ones.

Real application of multilayer screens started significantly later, when high intensity magnetic fields and elements sensitive to magnetic fields started to use in physical experiments

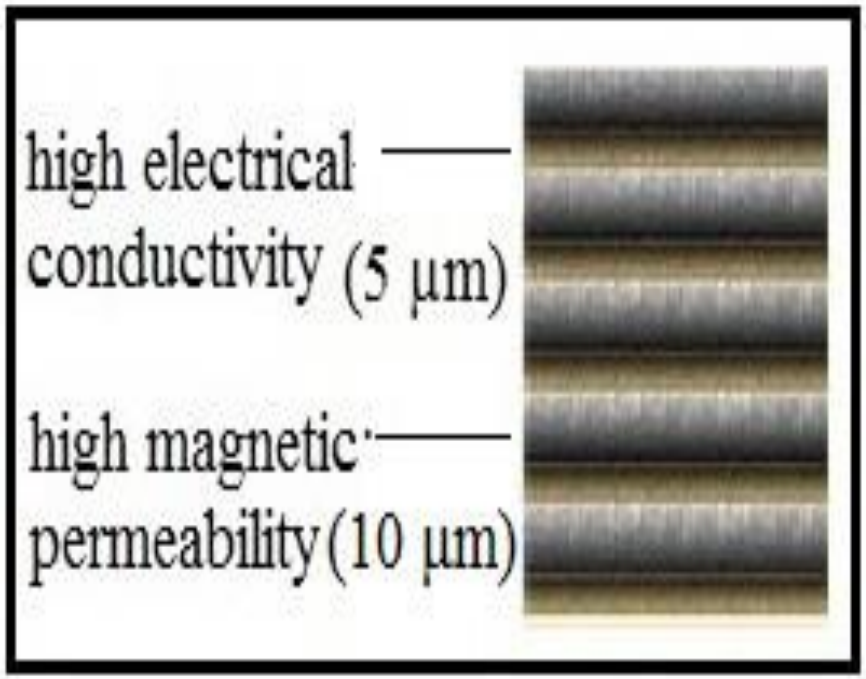
MULTILAYER FILM SCREENS

Multilayer film shields (MFS), manufactured by the galvanic electrodeposition, were created at:
- Scientific and Practical Center for Materials of National Academy of Science of Belarus and
- National Research Nuclear University MEPhI.

S.S. Grabchikov, L.B. Sosnovskaya and T.E. Sharapov, **Multilayer electromagnetic shield** // Patent RB, № 11843 on 01.28.2009.

V.V. Dmitrenko, A.G. Batishchev, S.S. Grabchikov and et al. **Multilayer shield to protect the photomultiplier tubes and the method of its application** // Patent for an invention, RB № 2474890 on 10.02.2013.

ELECTRODEPOSITED MULTILAYER FILM SHIELD.



Structure of the multilayer film shield (MFS).

Electrical: Au, Ag, Cu.

Magnetic: Fe (20-22%)-Ni (78-80%)

$\mu_0 = (1\text{-}3)*10^3$, $\mu_{max} = (1\text{-}5)*10^4$

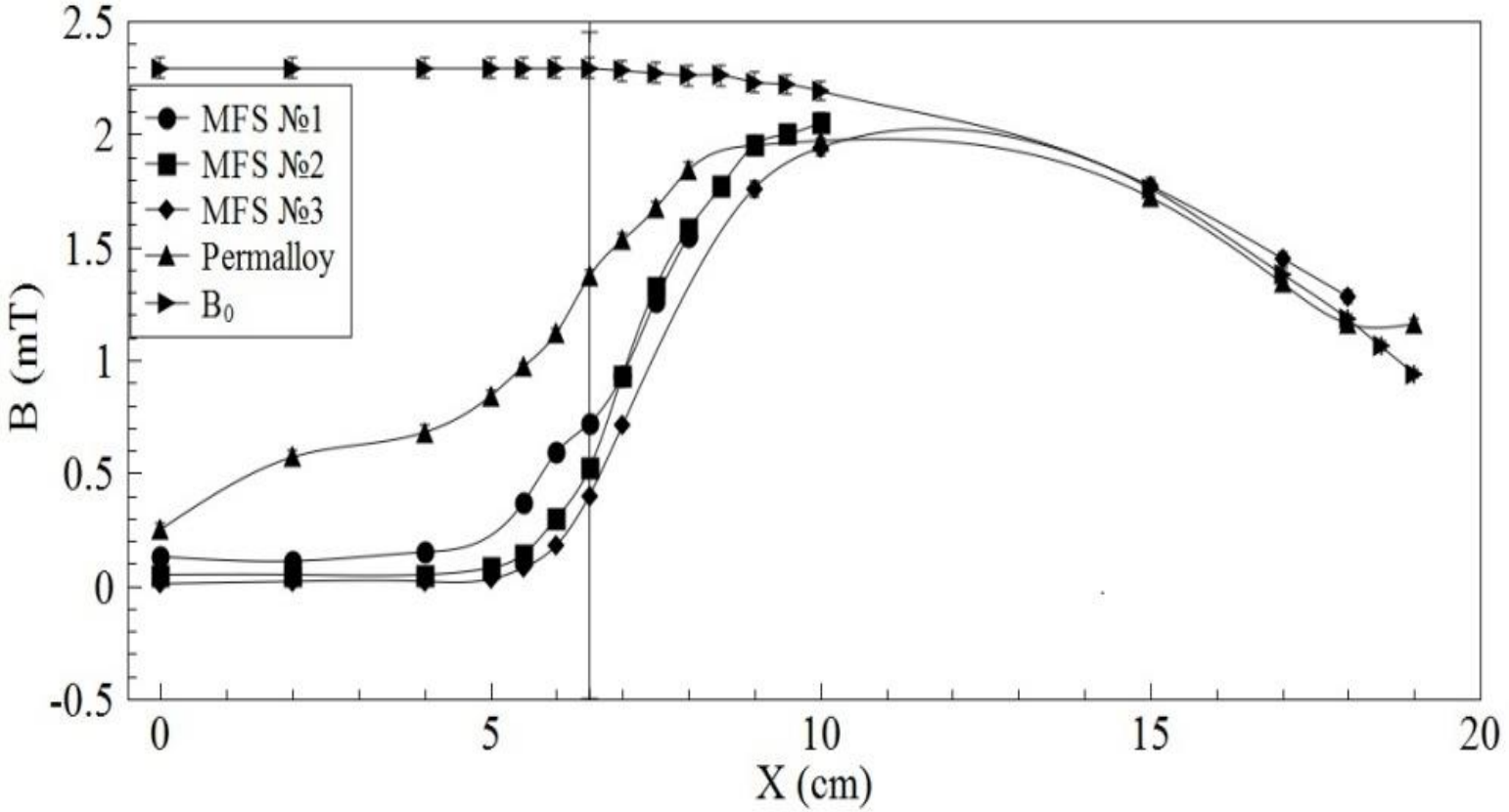
PMT-85 housing, covered with the electromagnetic shield based on multilayer film structures (above) and without electromagnetic shield (below).

CHARACTERISTICS OF SAMPLE SHIELDS

Sample shield	Magnetic layer thickness (µm)	Total number of magnetic layers	Total thickness of magnetic layers (µm)	Cu layer thickness (µm)	Total number of Cu layers	Total thickness of Cu layers (µm)	Total shield thickness (µm)
MFS-1	150	3	450	5	2	10	460
MFS -2	45	10	450	5	9	45	495
MFS -3	10	45	450	5	44	220	670
Permalloy	100	5	500	N/A	N/A	N/A	500

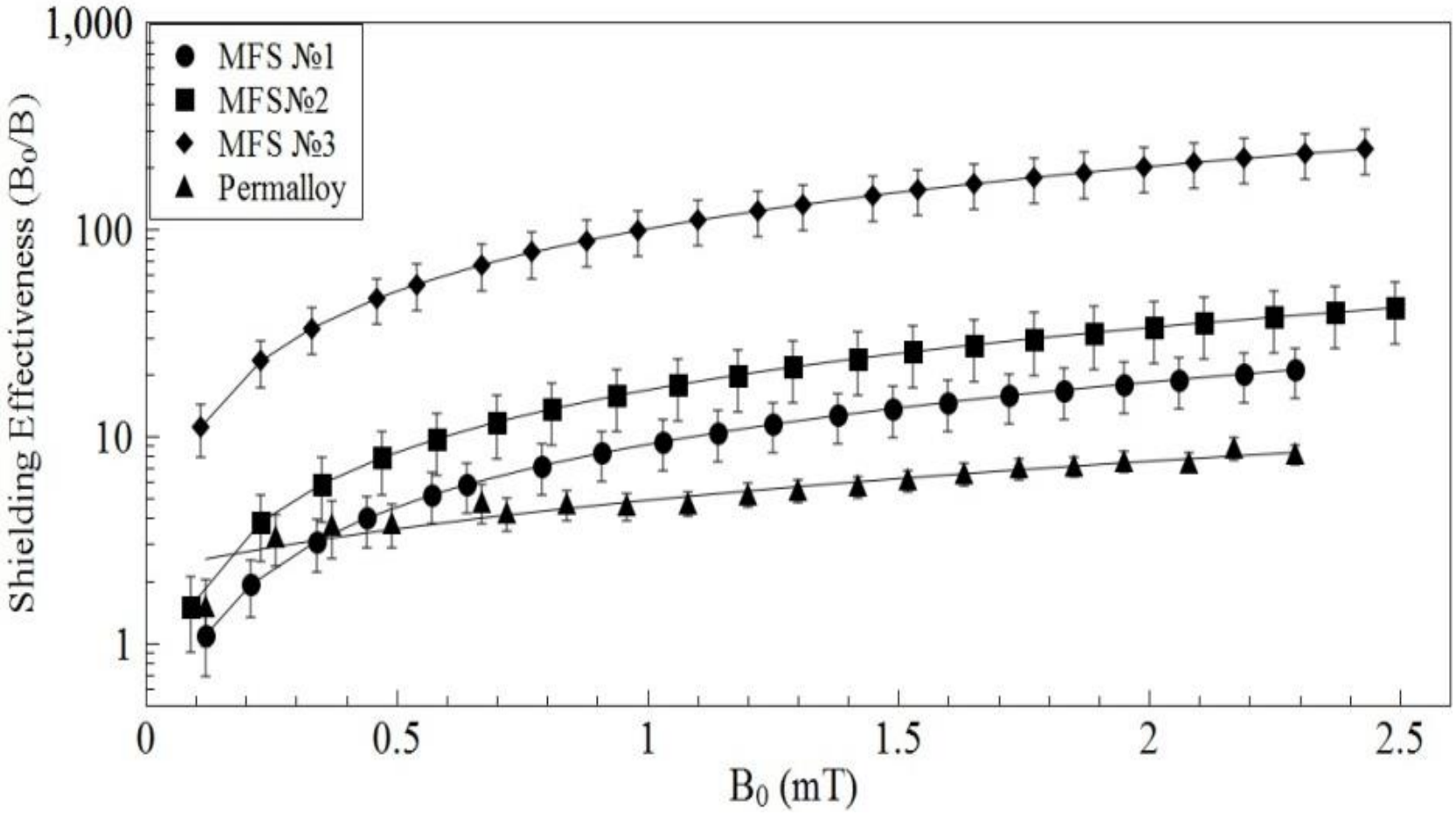
THE EXPERIMENTAL SETUP FOR STUDY OF MAGNETIC SHIELDS

THE SHIELDING EFFECT OF MAGNETIC SCREENS



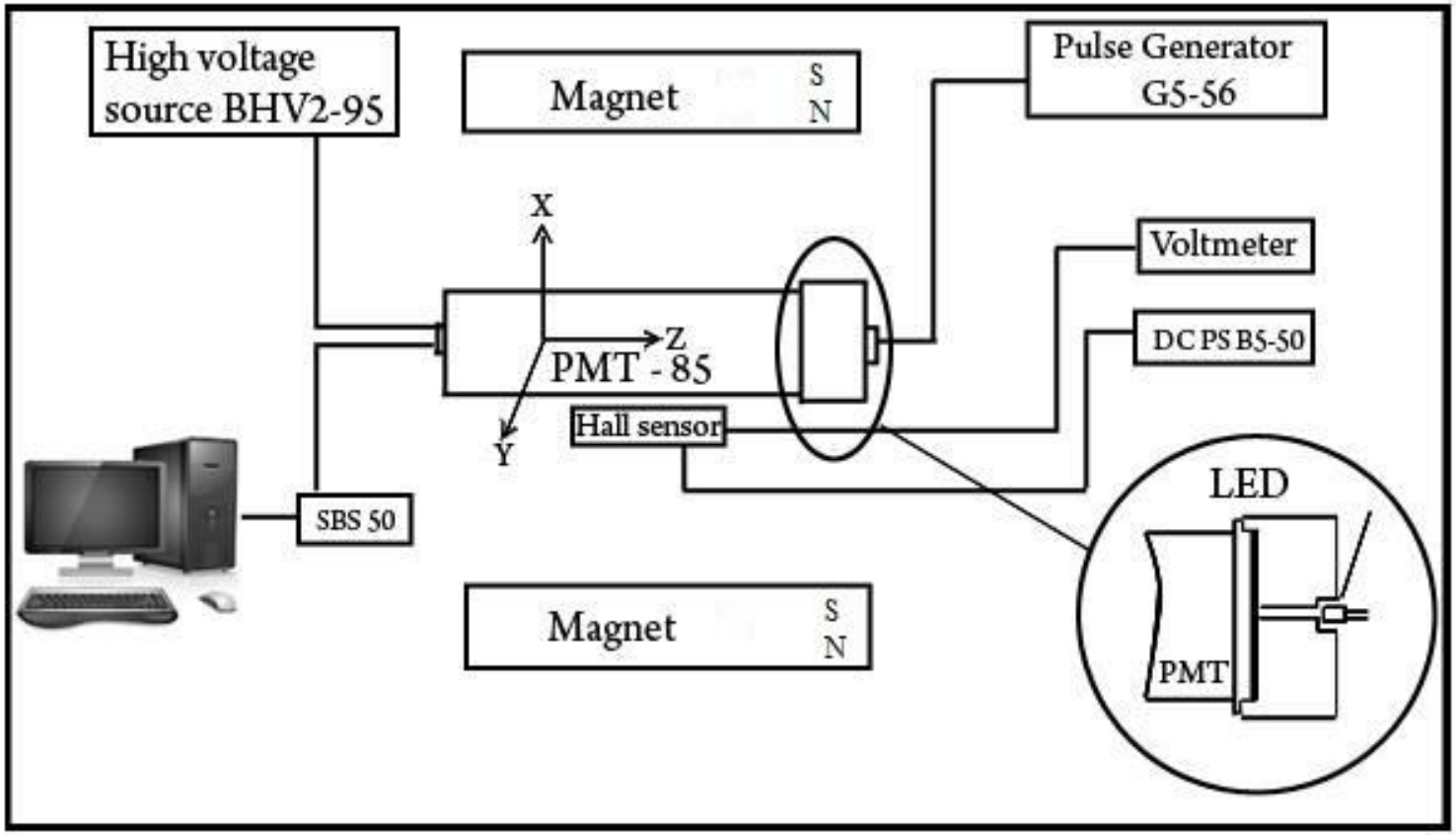
The distribution of the magnetic field along the longitudinal axis of the various shield's types. 0 on the horizontal axis corresponds to the middle of the longitudinal size of the shield. The vertical line is the end of the cylindrical shield. The magnetic field (B_0) is directed perpendicular to a longitudinal axis of the shield.

THE SHIELDING EFFECT OF MAGNETIC SCREENS



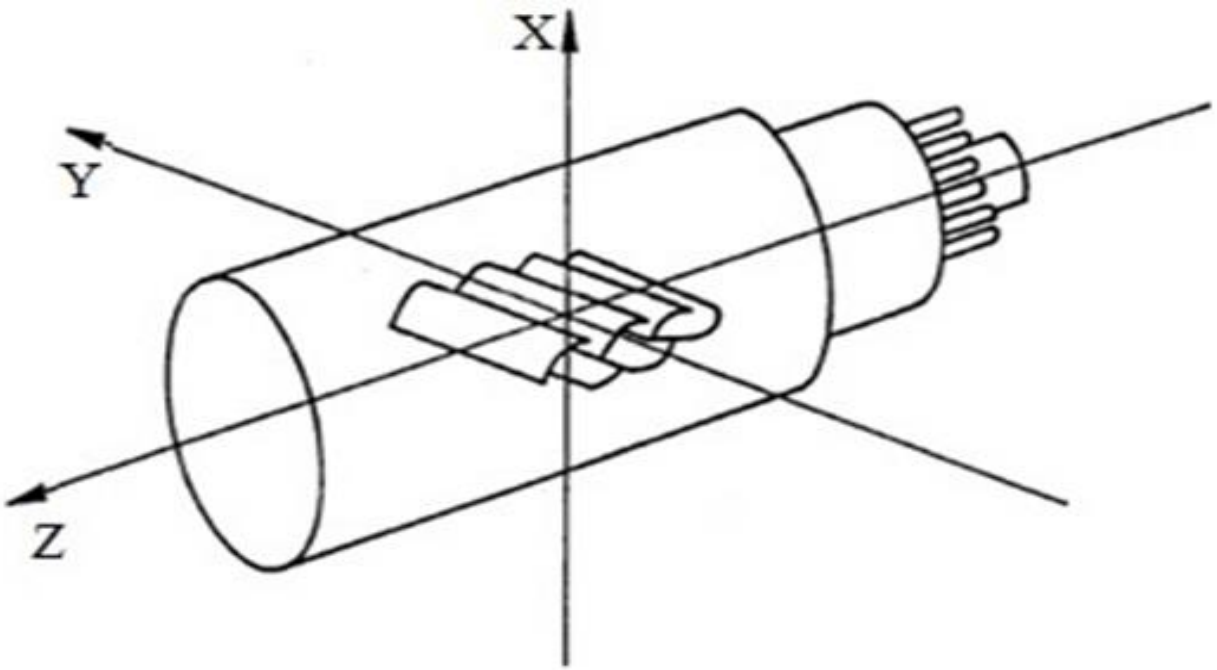
Shielding effectiveness of various shield's types (in the middle of the shield) depending on the value of the external magnetic field directed perpendicular to the longitudinal axis of the shield.

PROTECTION OF PMT BY MAGNETIC SHIELDS OF DIFFERENT TYPES



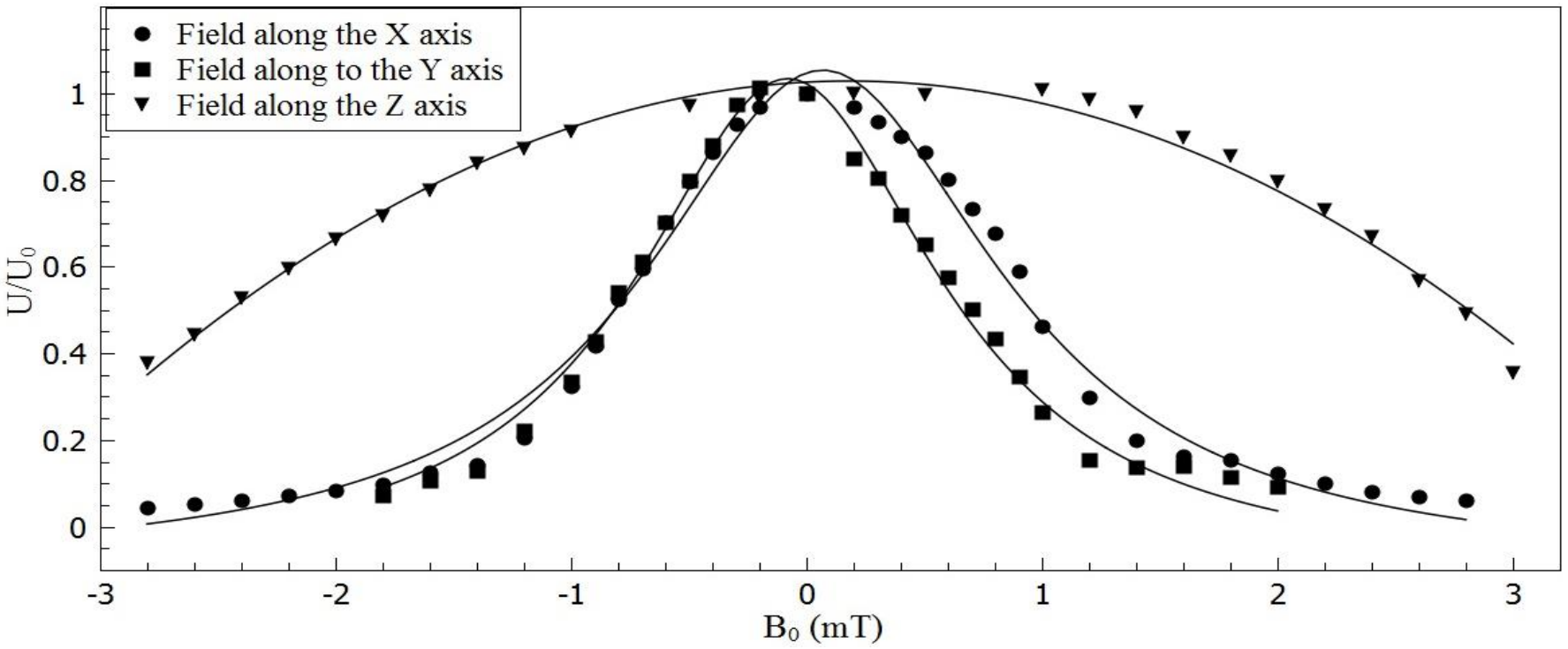
The scheme of experimental setup for the study of the screening effectiveness of PMT by different magnetic shields.

PROTECTION OF PMT BY MAGNETIC SHIELDS OF DIFFERENT TYPES



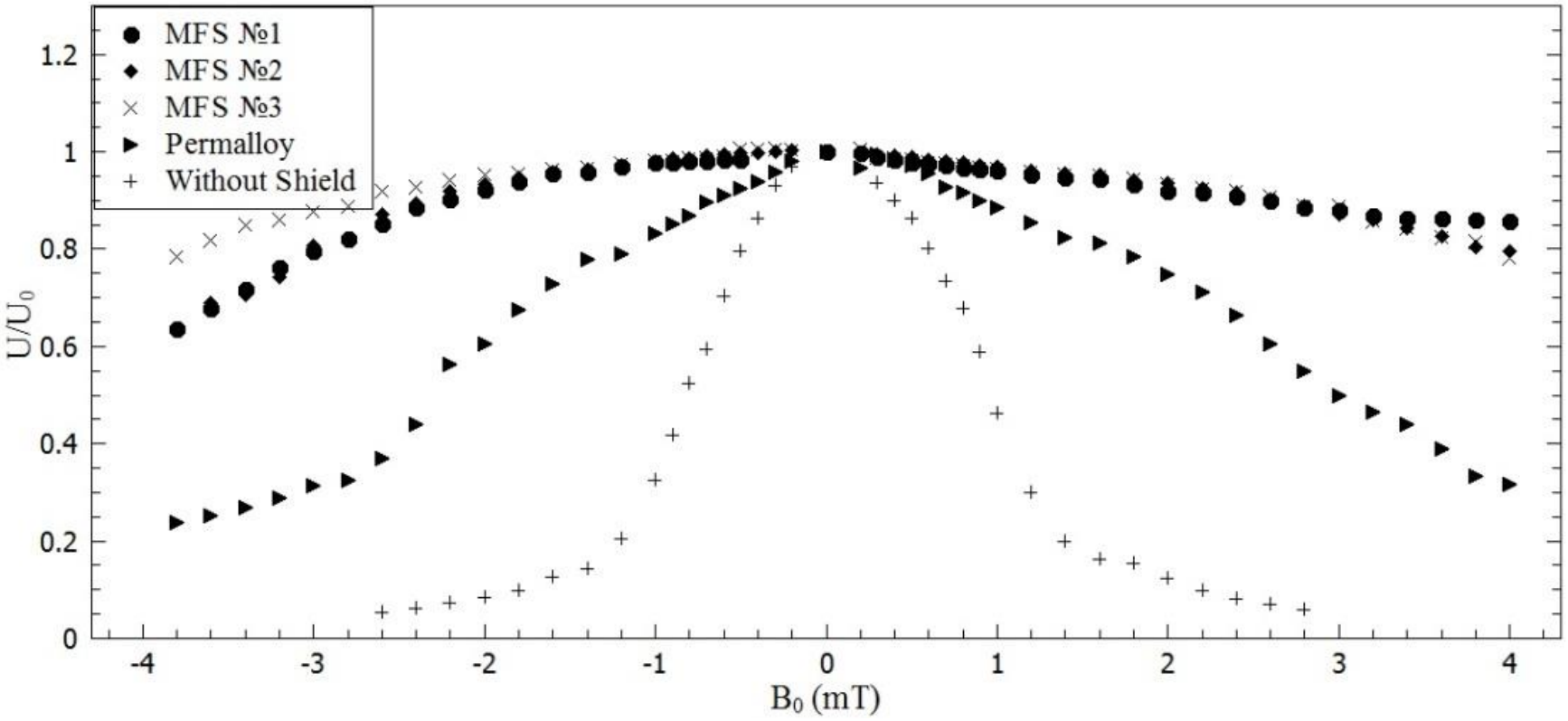
Coordinate system of the photomultiplier tube.

PROTECTION OF PMT BY MAGNETIC SHIELDS OF DIFFERENT TYPES



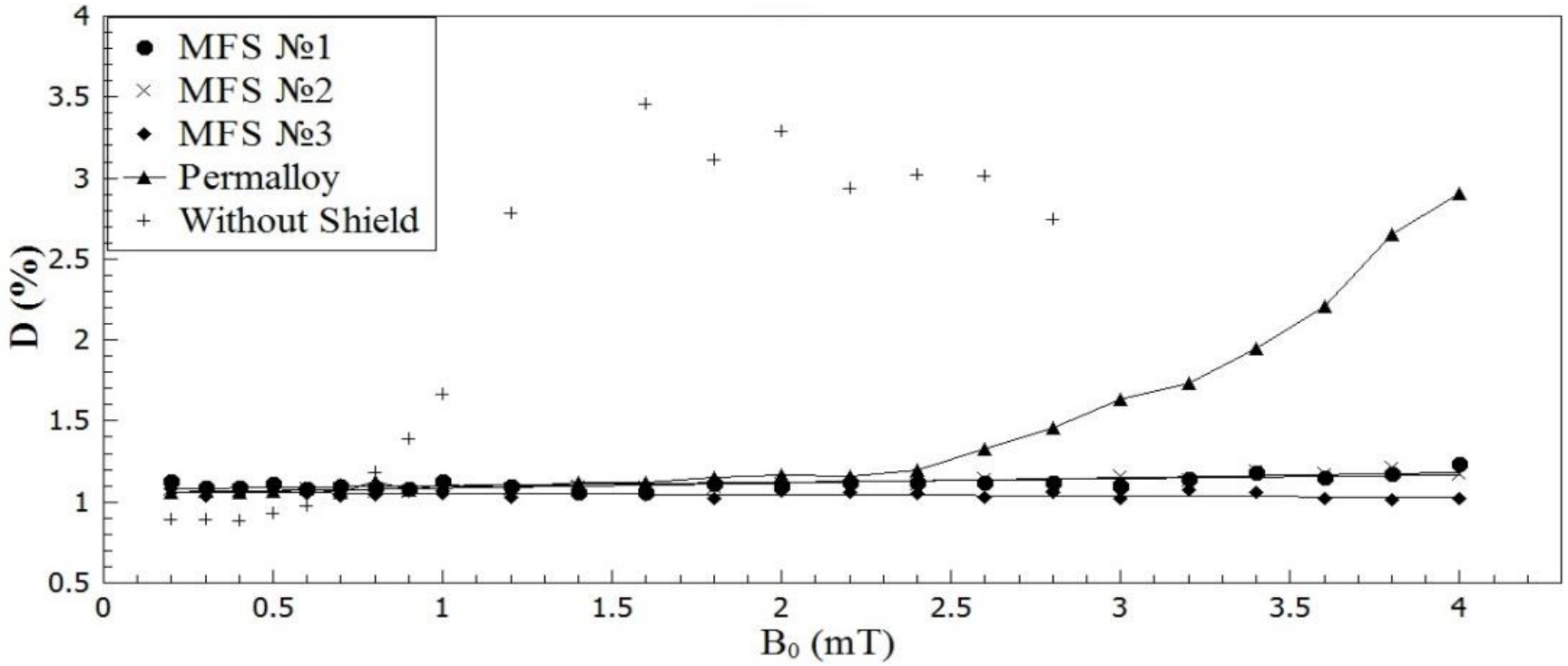
Dependence of the relative amplitude of the output signal of an unshielded PMT-85 on the magnetic field along the axes (X, Y) and parallel to the axis (Z).

PROTECTION OF PMT BY MAGNETIC SHIELDS OF DIFFERENT TYPES



The relative amplitude of the PMT-85 output signal, for different types of shields, depending on the external magnetic field in the direction of the magnetic field perpendicular to the shield.

PROTECTION OF PMT BY MAGNETIC SHIELDS OF DIFFERENT TYPES



Dependence of the amplitude resolution of PMT-85 pulses on the induction of magnetic field without shield and also with shields of permalloy and MFS № 1 - № 3, with direction of the magnetic field perpendicular to the Z axis.

MULTILAYER FILM SCREENS ADVANTAGES

Advantages of multilayer film screens formed by electrolytic deposition in comparison with traditional multilayer permalloy foil shields:

- higher shielding effectiveness at the same total thickness of the magnetically soft material.

- possibility to screen units with complex configuration.

- possibility to industrially manufactured.

- reasonable cost in case of industrial production.

PROPOSAL

Designed and manufactured optimized multilayer films screens based on electrolytic deposition technology for experiment SHiP.

To start this process we need the following information:

- types of PMT, which will be used in experiment SHiP (real samples are preferable).

- the intensity of the residual magnetic fields at the location of the PMTs.

- approximate total number of PMT in experiment SHiP.

Application of commercially manufactured FMS will reduce the time required for installation of experimental equipment, and possibly financial costs!

THANK YOU FOR ATTENTION