Design and parameters of the fiber optics multilayer scintillating spectrometer at the JINR Nuclotron internal target

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History

In the last some years for registration and energy measurements of the charged pions in nuclear physics experiments have received application a method of repeated energy losses measurement at passage of a particle thru the multilayered detector [1,2].

1. J.Julien et al., Z.Phys. A 347(1994)181.

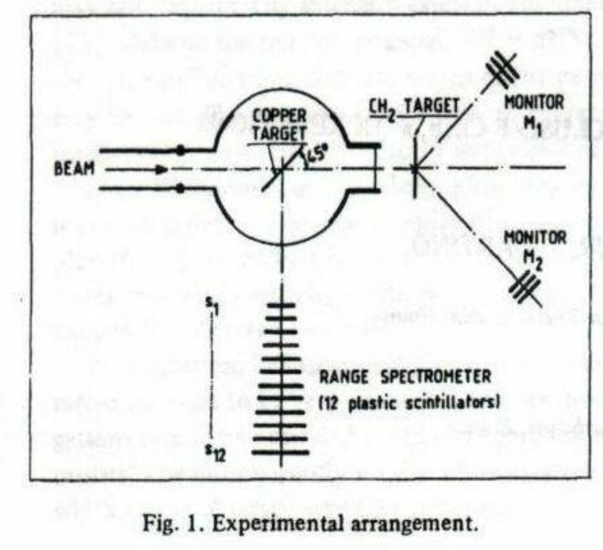
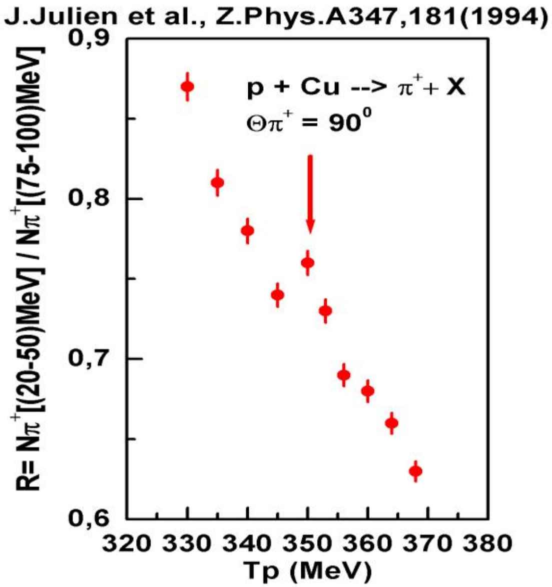


Fig. 1. Experimental arrangement.

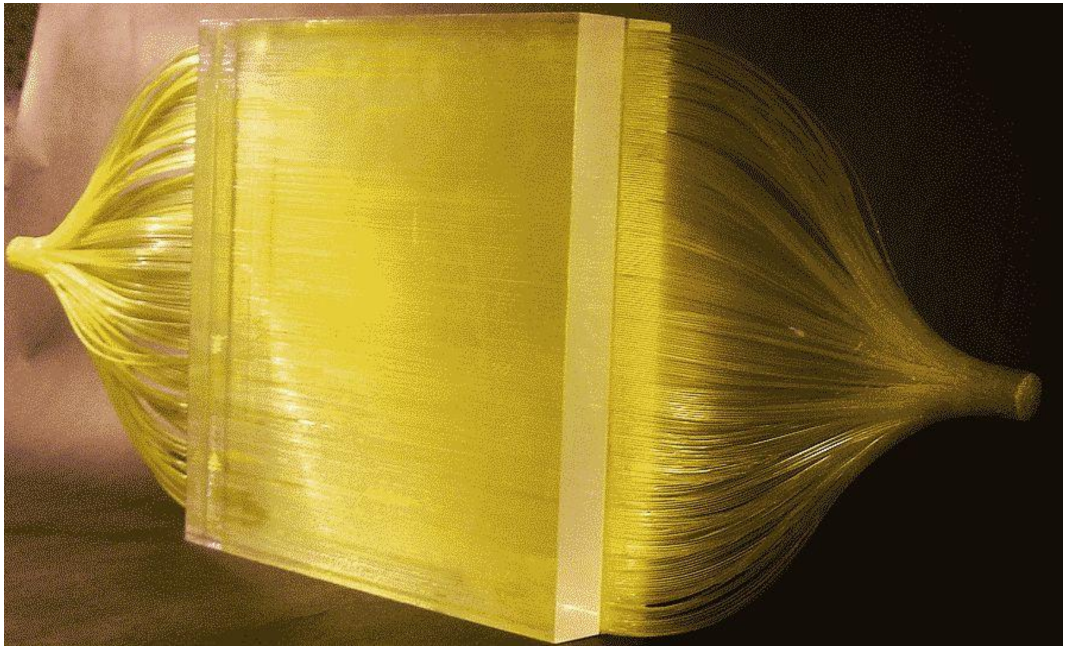


2. A.I. Reshetin et al., RAS INR Annual Report, Moscow, 1997

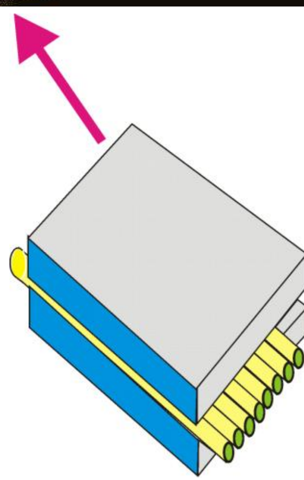
In both these experiments were applied standard type scintillation detectors made by a standard technique - scintillating plate - an optical light guide - the photoelectronic multiplier.

What is new?

We have developed and applied an ideology of detector plates based on the use of optical light reradiating fibres.

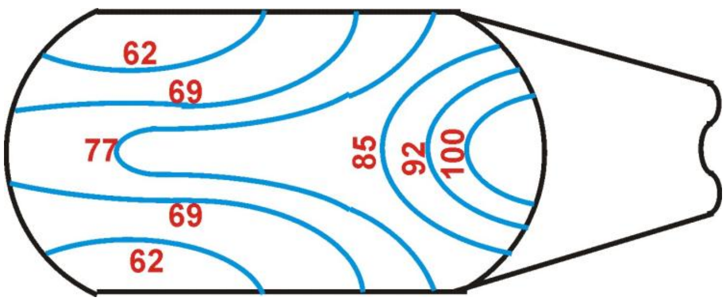


The filaments are pasted in one stratum in parallel one another by silicone glue between two scintillator slices on the polystyrene base with the component p-terfenil and POPOP with a thickness of each slice 10 or 20 mm. Outside a slice a filaments are going in a bundle, are pasted in a hub for strengthening on the PMT entering window , the end faces them will be cuted off and are polished.



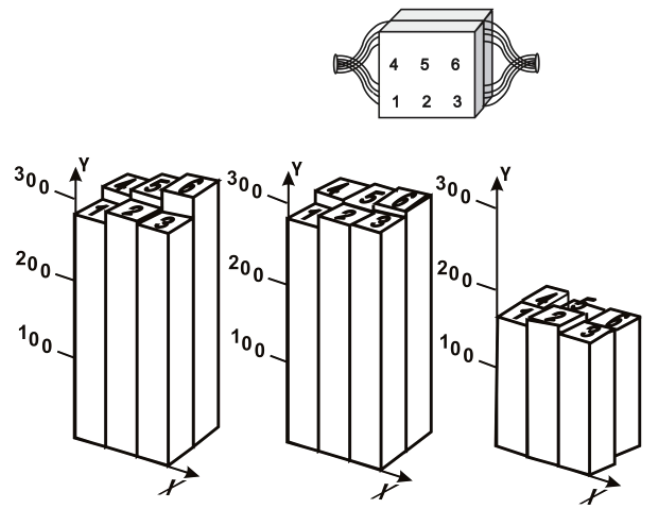
Comparison of the standard counter and plate with optical fibres

Standard type scintillation detector
A.V. Vlasov et al., ITEP-54, 1985
155x125x10 mm, rel. light yield %



Our detector

The spatial uniformity for “fiber-optics” scint. detector 200x200 mm
η>95%



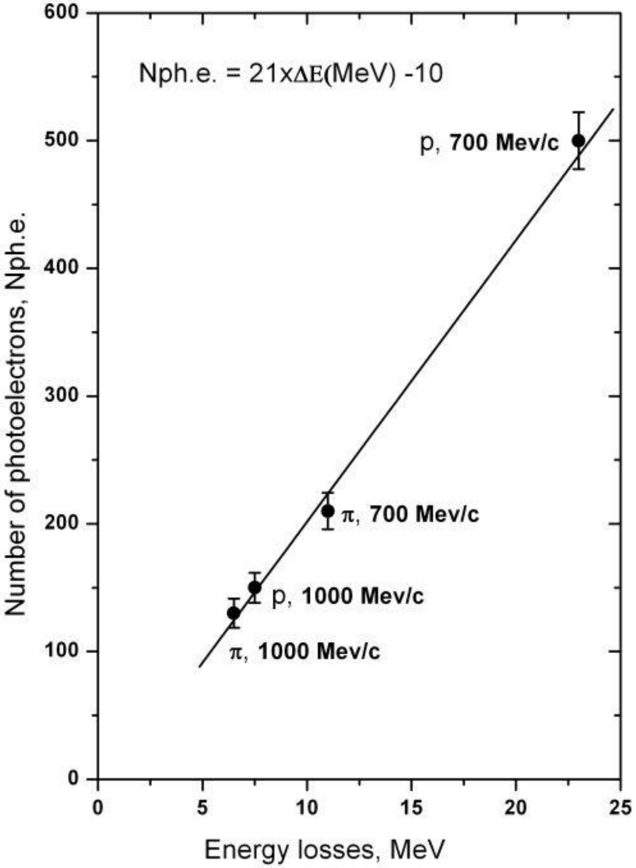
A) d=40 mm B) d=40 mm C) d=20 mm

The use of light reradiating optical fibres for transfer light on entrance PMT window improves uniformity of light collecting from a surface of the detector in 5 - 7 times.

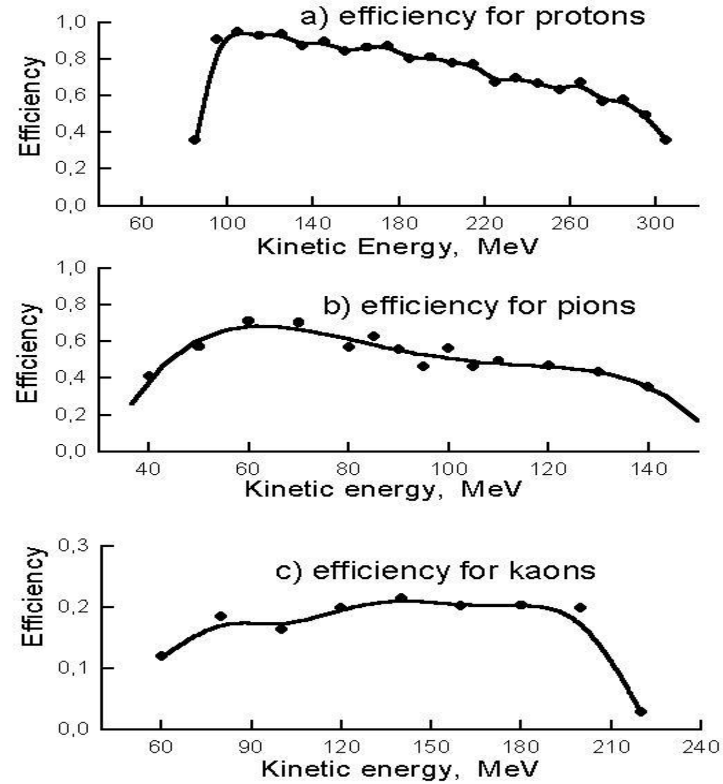
However thus in a full internal reflection mode inside fibres volume gets about 10 % of photons.

Detector parameters

Light output (number of photoelectrons)



Energy measured range

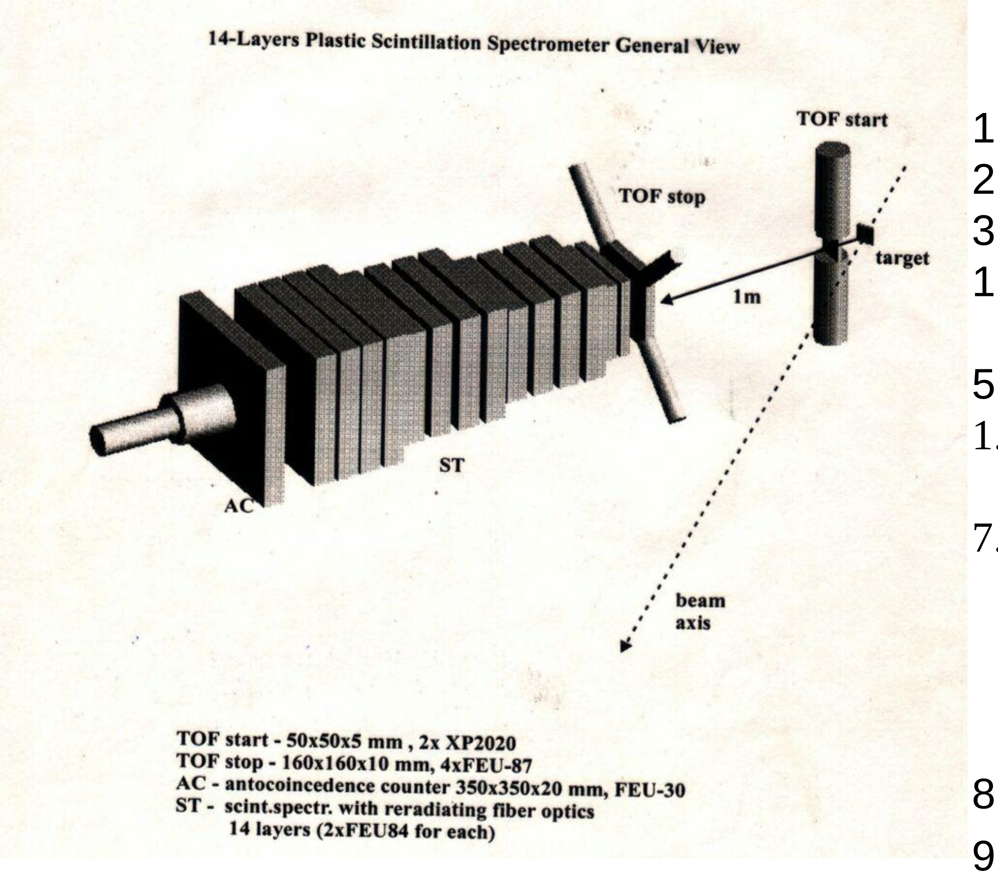


The interval of a measurement of an energy positive and negative pions is in the range of energies 40 - 150 MeV, K+ - mesons in a range 60 - 280 MeV, protons in a range 80 - 320 MeV.

The use of a method of repeated ionization losses measurements allows us to allocate events pure ionization braking of particles in detector material from cases nonelastic interactions of pions.

Efficiency of a spectrometer thus is shown in figure on the right.

The main scheme of the apparatus

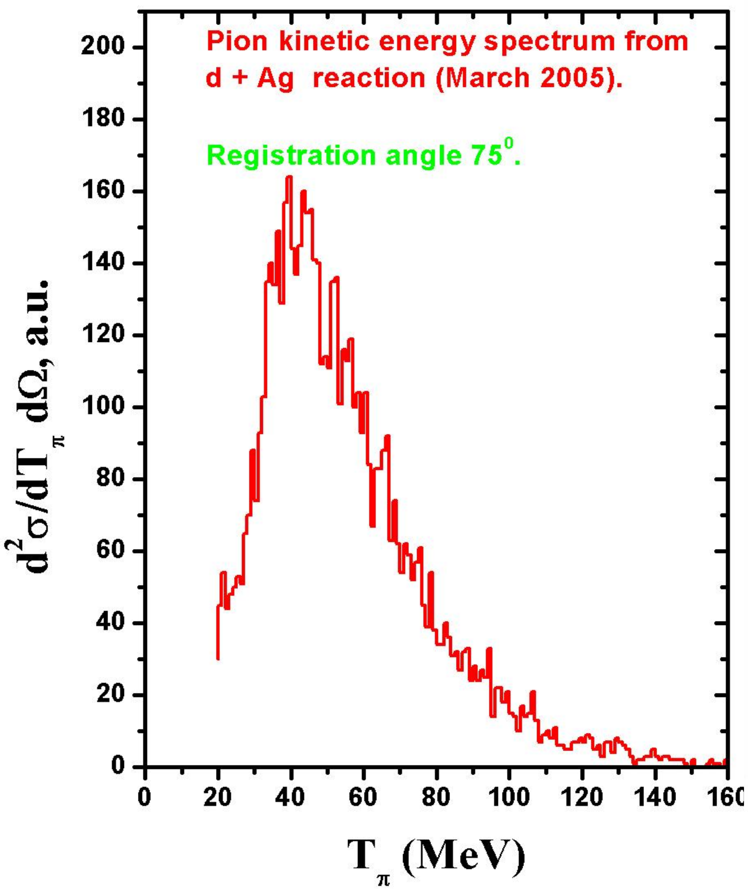


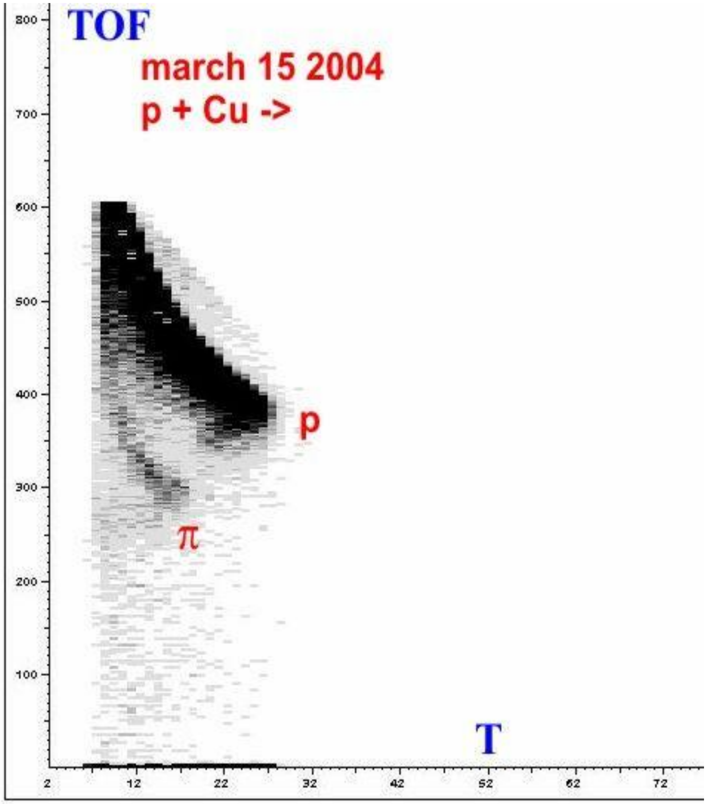
1. Number of plates: 14
2. Plates dimensions: 160 to 270 mm
3. Plates thickness: 20 to 40 mm
1.Structure: 2 polystyrene scintillators glued together plastic fiber optics wires
5. Light yield: $N_{ph.e.} = 21*\Delta E(MeV)-10$
1.Uniformity of the light collection over the area: $>$ 95%
7. Particle energy interval:
   - $\pi\pm$: 40 - 150 MeV
   - K+ : 80 - 280 MeV
   - p : 70 - 320 MeV
   - d : 150 - 600 MeV
8. Energy resolution: $<$ 5% (FWHM)
9. TOF resolution: $\cong$200 ps (σ)

An error about 12% for energy loss measurement at one plate allows one to determine the energy of a charged particle at the 3-4 % accuracy and particle type with error probability at a level of 10-4 (including TOF measurements).
Antocoincidence detector AC, installed on an exit of a spectrometer, serves for restriction of an effective interval of energies of charged particles up to area of a full absorption of ionization lossies in material of a spectrometer.

The example of the kinetic energy spectrum for charged pions at the accelerator beam

The example of the two – dimensional spectrum





On right Figure an example the obtained two-dimensional spectrum " a kinetic energy - time of flight" for secondary particles under an angle 73 deg concerning direction of a beam is shown.
On Figure separation of particles on masses in two-dimensional plot is clearly visible, that allows to carry out the separate analysis mesons spectra in a deuteron - nuclear interactions.

The common view on the spectrometer without cover

One can see the scintillation plates with fibers, photomultipliers and voltage dividers.

Conclusions:

- The high-performance spectrometer for the detection of charged particles has been constructed and successfully tested on the cosmic muons and particle beams of the LHE JINR accelerators complex.
- The Monte - Carlo calculation and calibration tests have demonstrated that a high-performance instrument exists now. Its capabilities open up numerous areas of research for abnormal pion production on the Nuclotron internal target.

Acknowledgements

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