V.Efremenko
ITEP, Moscow

Forward Neutron Calorimeter

for H1 Experiment at DESY

DESY (Hamburg) - ITEP (Moscow) - MPI(Heidelberg)

CALOR-2000
IX International Conference on Calorimetry in Particle Physics
Annecy, France, October 9-14, 2000

The Introduction

The Forward Neutron Calorimeter (FNC) was installed into H1 experiment in 1996.
The purpose is to measure the energy and angles of fast neutrons from reaction

$$ep \Rightarrow enX$$

In 1998, the FNC was upgraded by a small preshower sub-detector, which improved significantly the energy and space resolution. The preshower also allows to separate neutrons from electro-magnetic showers. After several years of working, the response of the FNC degradaded significantly.
In 1999 the decision was taken to replace the FNC with the new calorimeter.

The design parameters:

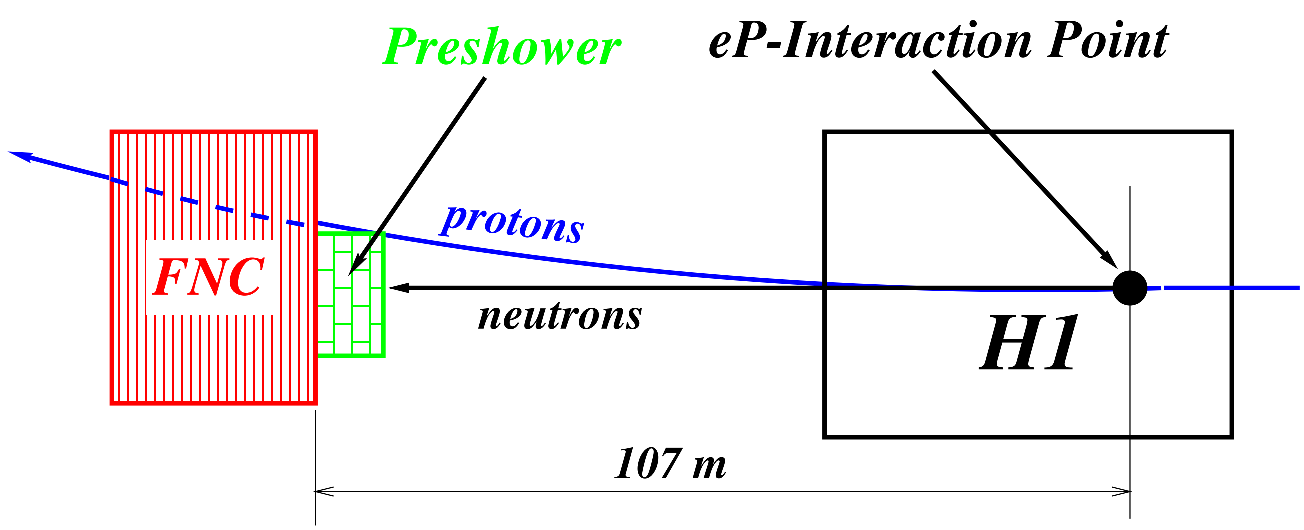
- **Neutron energy range** $100 \div 900 GeV$
- **Energy resolution** $\sim 50\%/\sqrt{E}$
- **Angle acceptance** $\leq 0.6 mRad$
- **Space resolution** $\sim 5cm/\sqrt{E}$
- **Space resolution with the preshower** $\sim 2mm$
- **Fiducial volume:**
  length 200 cm; height 60 cm; width 60 cm

The Design and Construction

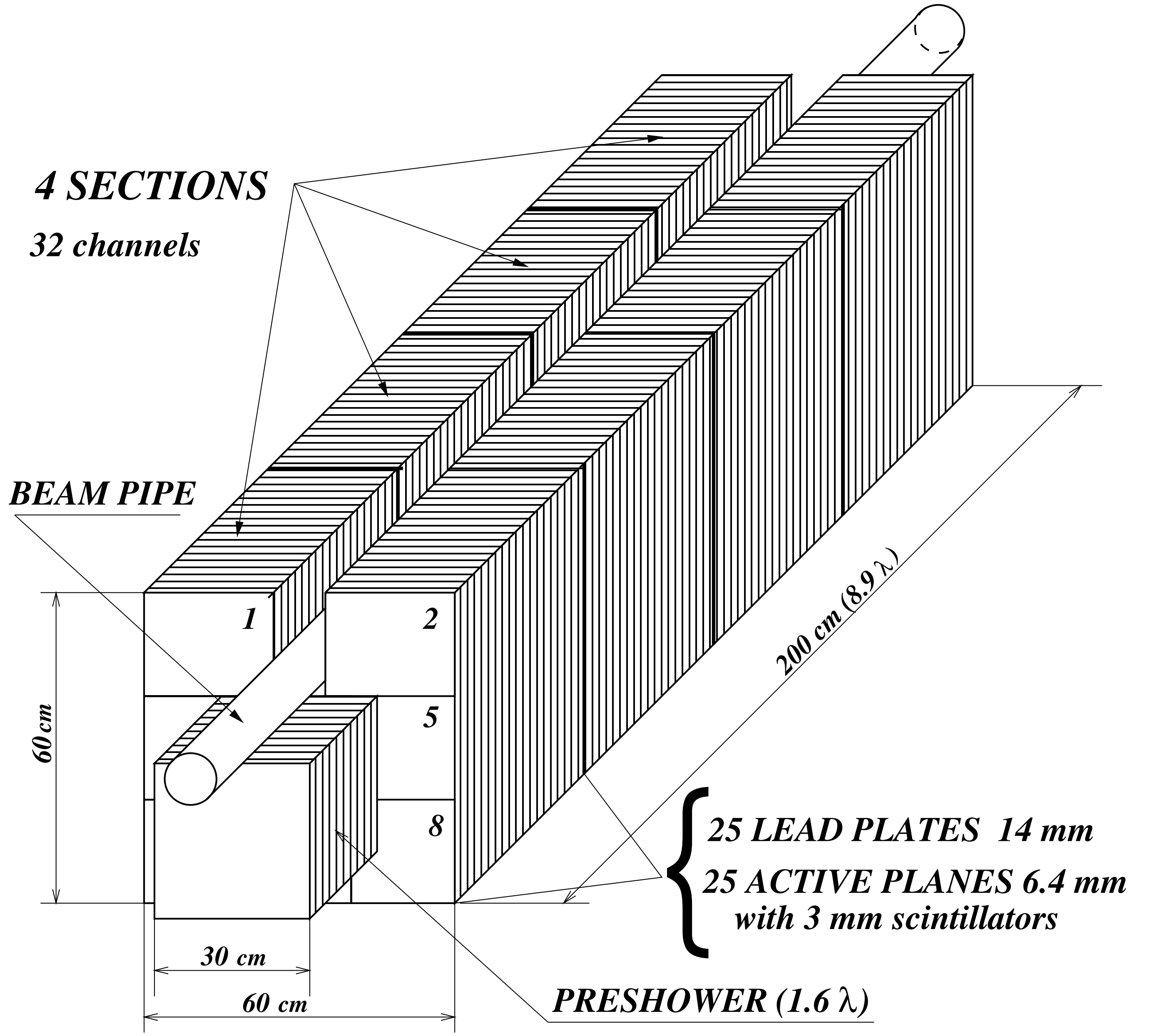
- **The physical calculations and design have been done by DESY-MPI-ITEP group in 1999.**
- **The construction was done in 1999 - 2000 in Moscow.**

- **The tests were done at proton and electron beams**
  - **in April at ITEP (8 Gev)**
  - **in June-July at CERN (120 - 350 GeV)**
- **The installation into HERA tunnel is planned for February, 2001**

Here the details of the design and the preliminary results of the beam tests are presented.

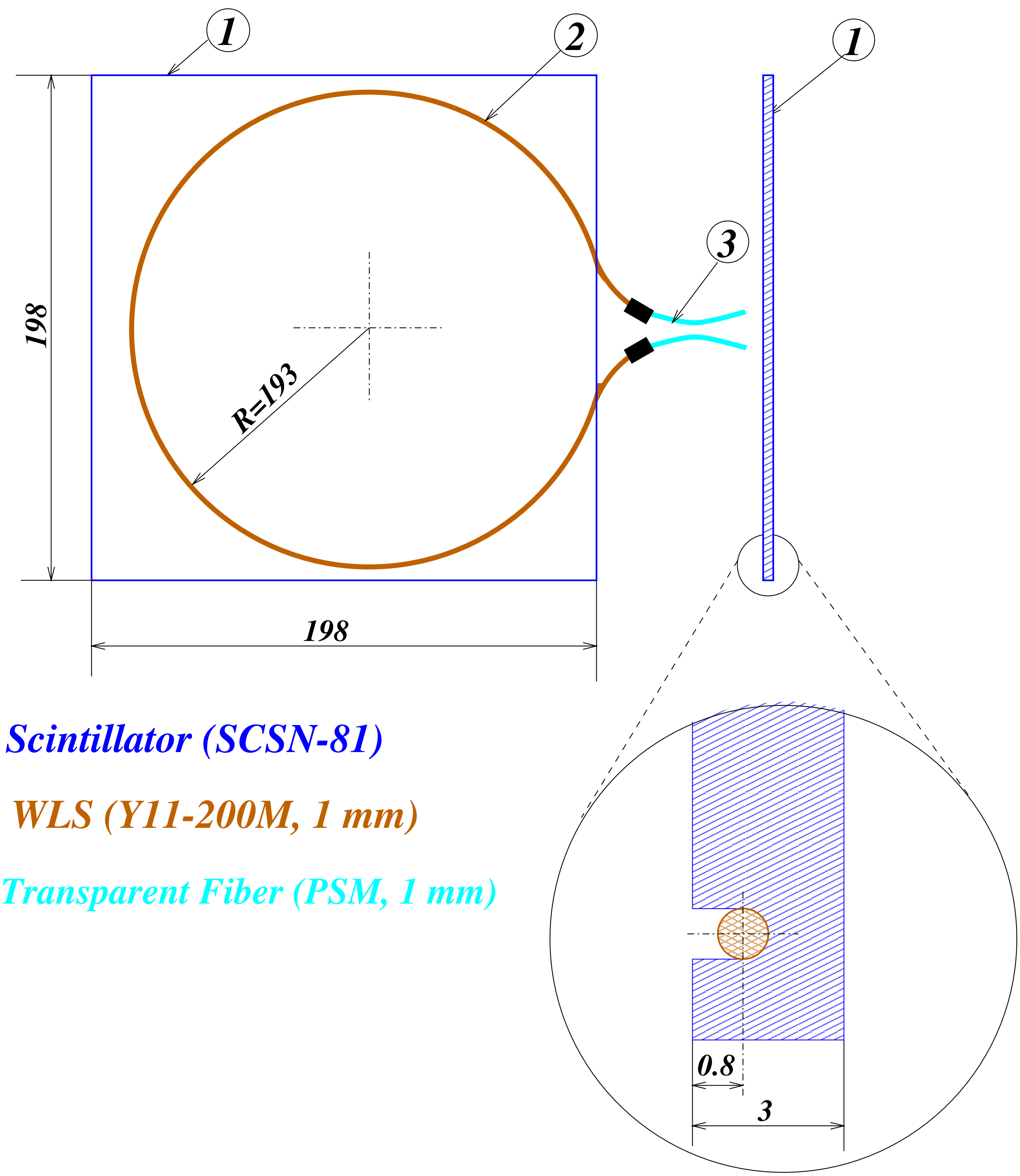


General View



1 section – 8 towers, 1 tower – 25 scintillators

Scintillators



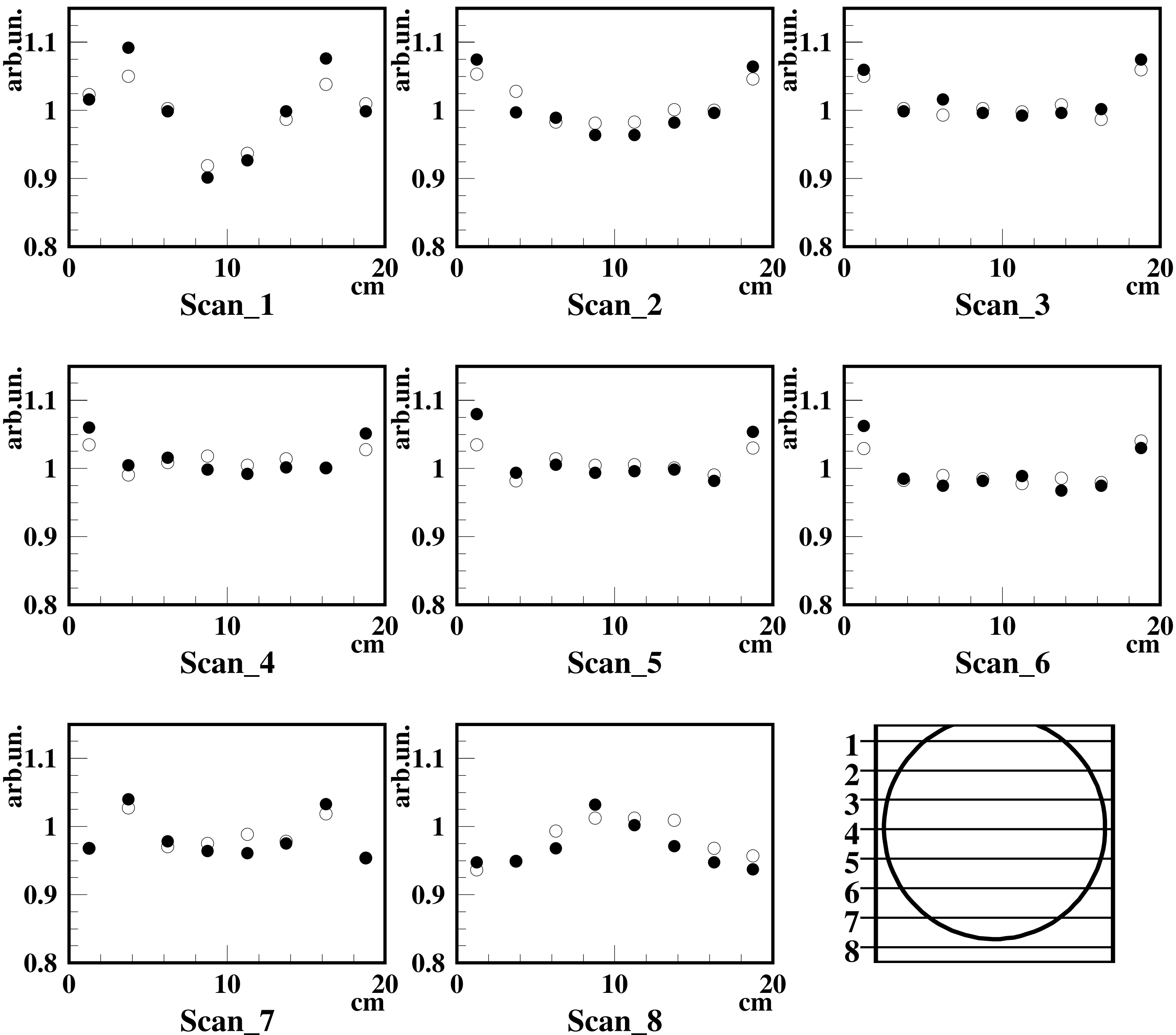
1 *Scintillator (SCSN-81)*

2 *WLS (Y11-200M, 1 mm)*

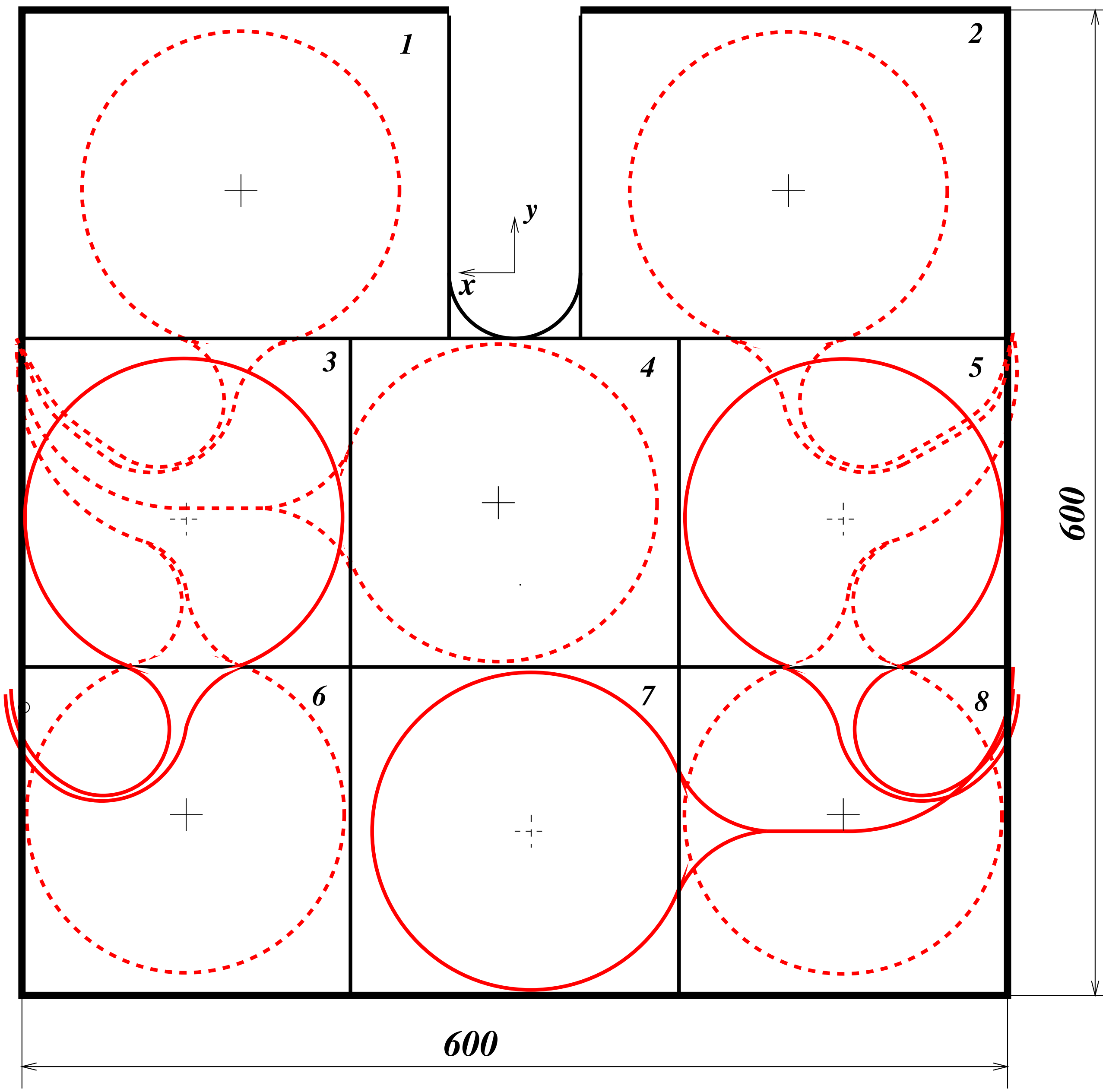
3 *Transparent Fiber (PSM, 1 mm)*

Horizontal scan of a scintillator with 25 mm step

Comparison of r/a source scan (black circle) and Monte-Carlo simulation (open circle)

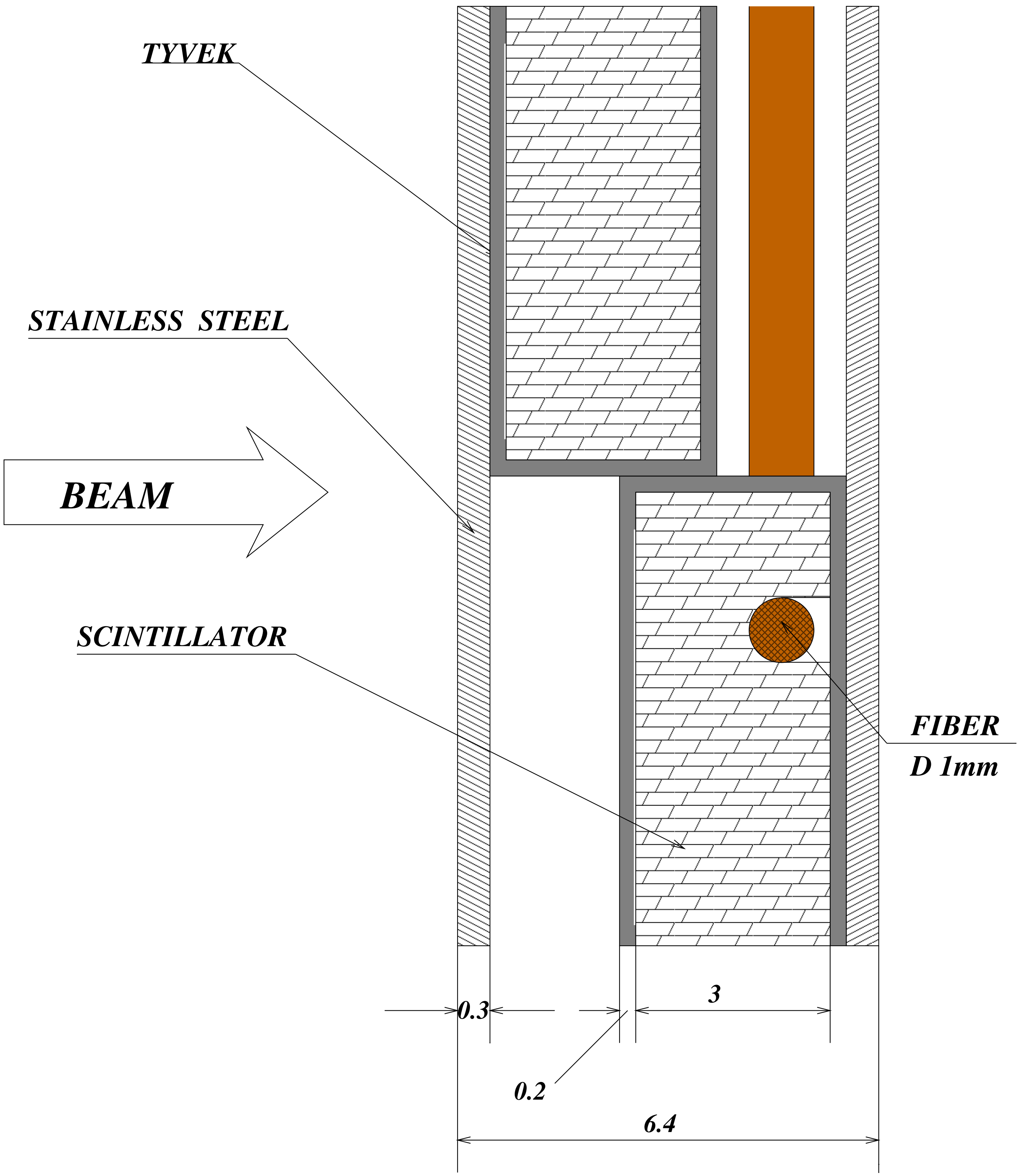


Active Board

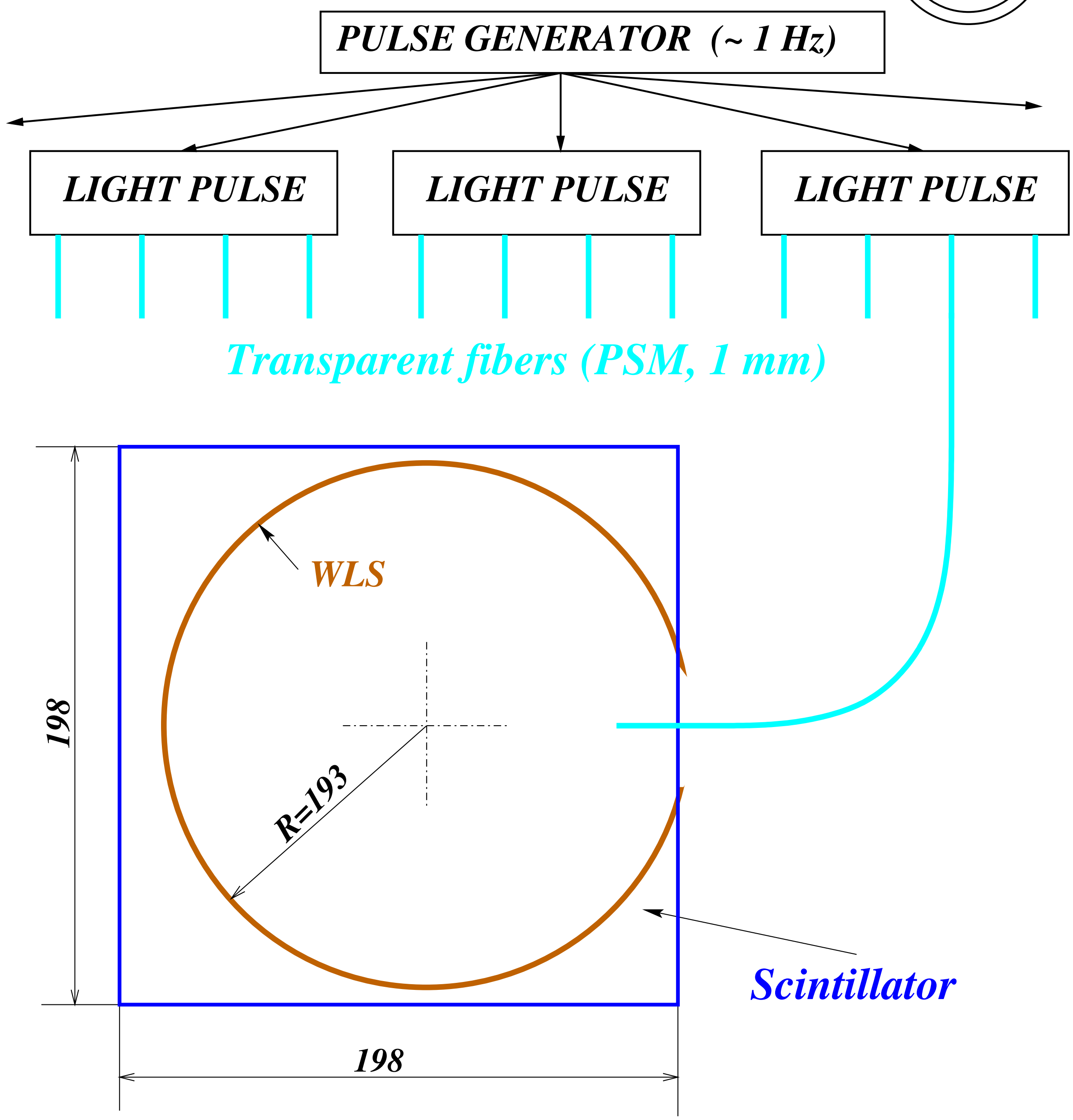


Layout of scintillators and fibers

X-section of Active Board



Monitor Systems



Two independent monitor systems:

1. **Light pulses are injected into 20% of all scintillators;**
2. **Light pulses are transferred to all PMT.**

The FNC Structure

The structure of the main FNC calorimeter

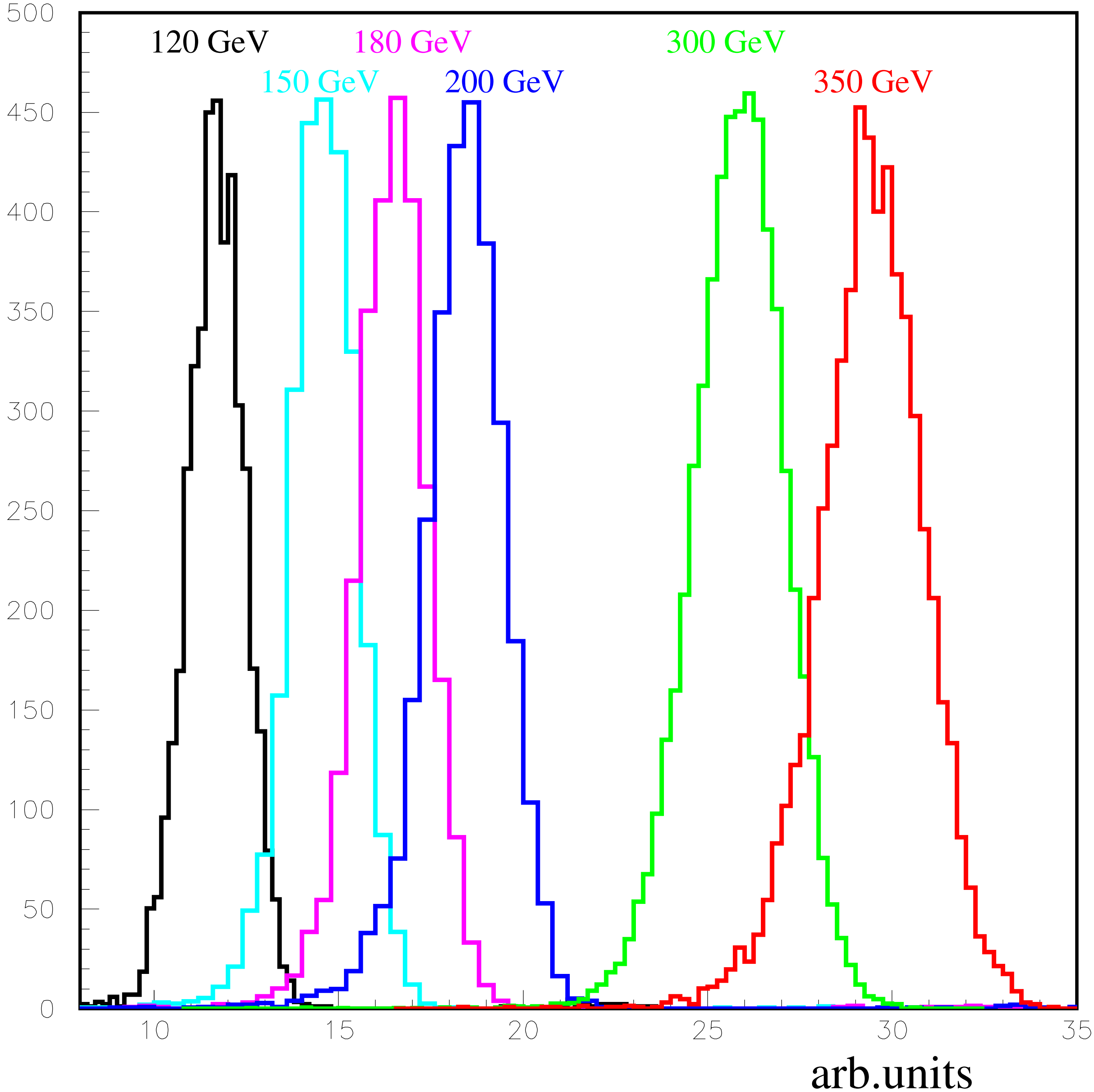
Material	Depth (mm)	Nuclear interaction lengths λ_I
PbSb4	14 $\times$ 100	8.20
scintillator	3.0 $\times$ 100	0.34
Tyvek paper	0.3 $\times$ 100	0.00
steel	0.6 $\times$ 100	0.36
air	2.0 $\times$ 100	0.00
total	2000	8.9

The structure of the Preshower

Material	Depth (mm)	Nuclear interaction lengths λ_I
e/m part		
PbSb4	7.5 $\times$ 12	0.52
scintillator	2.6 $\times$ 13	0.04
Tyvek paper	0.3 $\times$ 12	0.00
air	1.2 $\times$ 12	0.00
total e/m part	142	0.56
hadron part		
PbSb4	14. $\times$ 12	0.98
scintillator	5.2 $\times$ 12	0.07
Tyvek paper	0.3 $\times$ 12	0.00
air	0.6 $\times$ 12	0.00
total hadr.part	251	1.05
total	393	1.6

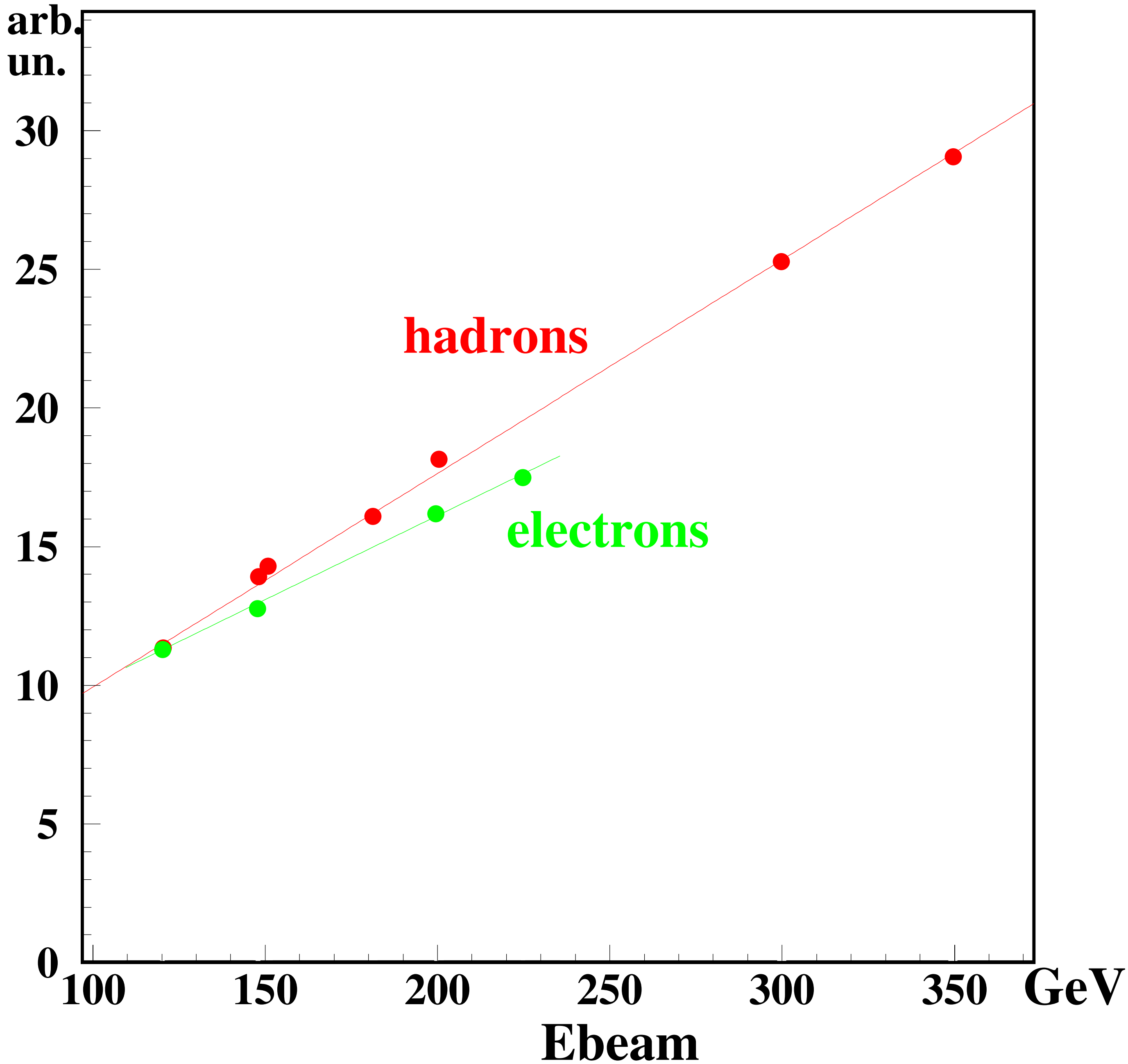
The FNC response

June - July, 2000 CERN hadron beam tests at SPS

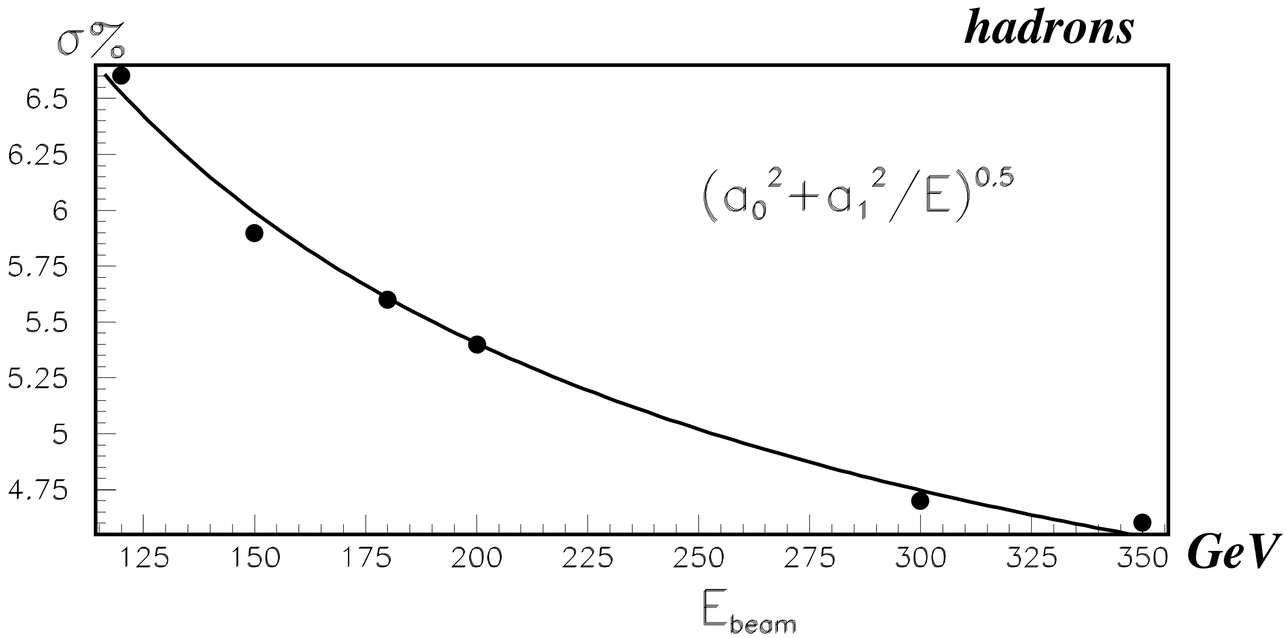


The Energy Dependence

All measurements were done with preshower.



The FNC Resolution



June-July CERN test at energy of hadron beams 120 - 350 GeV

$$\frac{\sigma}{E} = \sqrt{\left(\frac{a_0}{E}\right)^2 + a_1^2}$$

$$a_0 = 60\% \qquad a_1 = 3\%$$

$$(\textit{Monte-Carlo estimate } a_0 \sim 50\%)$$

The results for the electrons at energy 120 - 225 GeV are

$$a_0 = 30\% \qquad a_1 = 2\%$$

Summary

- **Forward Neutron Calorimeter is completed**
- **CERN test-beam calibration data are taken, very preliminary results:**
  $\sigma(E)/E \sim 60\%/\sqrt{E} + 3\%$ **(hadrons),**
  $\sigma(E)/E \sim 30\%/\sqrt{E} + 2\%$ **(electrons)**
- **New FADC (12 bit) are at present developed and will be used in the new FNC-DAQ.**
- **FNC installation in HERA tunnel is planned in February 2001.**

Acknowledgements

We are grateful to all ITEP technicians and engineers, who participated in FNC construction, assembling and tests.

Successful test and calibration runs at CERN were not possible without the help of DESY and H1 staff.

Many thanks to CERN staff for providing us the good beams and good working conditions. We thank Ch.Kukovka-Erich from CERN Users Office for solving many of our problems.

We are especially grateful to M.Haguenauer, K.Elsener, P. Grafstrom for the help in organization of runs at CERN and good beams.

We thank the Ecole Polytechnique group for the readiness to sacrifice a part of their beam time.