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CONCEPTUAL PROJECT OF THE BARREL AND END-CAP ELECTROMAGNETIC CALORIMETERS OF THE ALICE

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Abstract

A conceptual integration project of the Barrel (BARC) and Near End-Cap (NEC) electromagnetic calorimeters as well as the photon spectrometer (PHOS) are presented. The design of the BARC and NEC calorimetres is based on a novel sandwich-type BAYAN technology. The PHOS detector is designed of new heavy crystals. A conception of the joint mechanical support for BARC, PHOS and NEC detectors is proposed and developed.

Introduction

The large area EM calorimeters, BARC and NEC, extend essentially physics performaces of the ALICE experiment [2] in central and peripheral ion collisions. Particulary a study of the azimuth fluctuations of particle fluxes will be possible in the central ion collisions as well as a study of the coherent two-photon processes in the peripheral collisions, see [1].

A conceptual project of the BARrel (BARC) and Near End-Cap (NEC) electromagnetic calorimeters is based on a novel sandwich-type BAYAN technology which is rapidly progressing now in IHEP (Protvino) [3, 4].

The PHOS detector is designed of new heavy crystals, details see elsewhere $PbWO_4$ [5, 6].

The aim of the present note is the conceptual design of BARC and NEC calorimerers as well as the conception of the joint mechanical support for the BARC, PHOS and NEC calorimeters inside the L3 magnet. The following requirements in the BARC, NEC and the PHOS designs were taken into account:

- common main mechanical support of BARC, PHOS and NEC;
- a possibility of BARC assembly after the start of LHC;
- the symmetrical position with respect to LHC beam axis;
- the simplicity of assembling, a free accessto the electronics of the any tower in a case of repaired;
- job in magnetic field;
- maximum distance between front surface of detectors and beam crossing point;

1 Barrel electromagnetic calorimeter

The parameters of common calorimeters support:

diameter of the inner support	9100 mm
material	honeycomb (aluminium)
radiation thikness	0.2 X_0 (0.25 X_0)
weight of the inner support	10 t (14 t)
inner diameter of the main support	10500 mm
weight of the main support	160 t

The parameters of BARC detector are :

inner diameter	9240 mm
thikness	408 mm
radiation thikness	17.5 X_0
weight	412 t
tilt angle	15°
weight of scintillator	71 t
weight of lead	296 t
number of towers	21100
fibers	860 km
scintillator thikness	1 mm
absorber thikness	0.5 mm (0.3 mm Pb, 2×0.1 Fe)
tower size	100×100 mm^2
number of section per φ	48
weight of half section	4.29 t
number of towers in half section	222(6×37)

The parameters of PHOS detector are :

Inner diameter	9800 mm
thikness	215 mm
radiation thikness	24 X_0
material	$PbWO_4$
weight	50 t
tilt angle	2.86°
number of crystals	50400
per φ	300
per θ	168
crystal size	20×20 mm^2
number of section per φ	10
weight of half section	2.5 t
number of towers in half section	2520(30×84)

The parameters of NEC detector are :

outer diameter	9240 mm
inner diameter	2580 mm
thikness	550 mm
radiation thikness	23.5 X_0
weight	175 t
weight of scintillator	23 t
weight of lead	130 t
number of towers	7000
fibers	410 km
scintillator thikness	1 mm
absorber thikness	0.5 mm (0.3 mm Pb, 2×0.1 Fe)
tower size	100×100 mm^2
number of section per φ	48
weight of half section	4.29 t
number of towers in half section	222(6×37)

2 Cost estimate

2.1 The common calorimeters support

Inner support tube

rolled aluminium 22.5kSf
  type .... D16T (Russian)
  weight 7.5t (3Sf/kg)
  square .... $183m^2$
machining .... 45kSf(Russie 40Sf/day)
assembly .... 30kSf(CERN 100Sf/day)
SUBTOTAL 97.5kSf

Main support tube

stainless steel 288kSf
  type .... 12X18H10T (Russian)
  weight 160t (1.8Sf/kg)
  square .... $450m^2$
machining .... 864kSf(Russie 40Sf/day)
rails 67kSf
  type .... 12X18H10T (Russian)
  weight 37t (1.8Sf/kg)
  length 1150m
machining .... 106kSf(Russie 40Sf/day)
assembly .... 525kSf(CERN 100Sf/day)
SUBTOTAL 1850kSf

TOTAL 1947.5kSf

2.2 Barrel Calorimeter

scintillator 400kSf
  material .... polystyrene
  dopants .... 1.5%PT+0.01%POPOP
  weight .... 63 t(6.3Sf/kg)
  number 2632700
  square .... 60000 m^2
production of plates 1200kSf
SUBTOTAL .... 1600kSf(27Sf/m^2,25Sf/kg

Inner diameter	9800 mm
thikness	215 mm
radiation thikness	24 X_0
material	$PbWO_4$
weight	50 t
tilt angle	2.86°
number of crystals	50400
per φ	300
per θ	168
crystal size	20×20 mm^2
number of section per φ	10
weight of half section	2.5 t
number of towers in half section	2520(30×84)

The parameters of NEC detector are :

outer diameter	9240 mm
inner diameter	2580 mm
thikness	550 mm
radiation thikness	23.5 X_0
weight	175 t
weight of scintillator	23 t
weight of lead	130 t
number of towers	7000
fibers	410 km
scintillator thikness	1 mm
absorber thikness	0.5 mm (0.3 mm Pb, 2×0.1 Fe)
tower size	100×100 mm^2
number of section per φ	48
weight of half section	4.29 t
number of towers in half section	222(6×37)

fibers	555kSf
type	Y11(KURARAY)
length	790km(0.7Sf/m)
number	1316350
evaporing mirror	110kSf(Russie 40Sf/day)
SUBTOTAL	665kSf(0.84Sf/m,0.5Sf/piece)
paper	240kSf
type	Tyvek(Dupont)
square	120000m^2(2Sf/m^2)
wraping of plates	520kSf
SUBTOTAL	760kSf(0.57Sf/piece
lead	410kSf
type	C1(Russie)
weight	205 t(2Sf/kg)
square	60000 m^2
stainless steel	170kSf
type	12X18H10T(Russie)
weight	94 t(1.8Sf/kg)
square	120000 m^2
machining of absorber plates	1160kSf
number	38400
SUBTOTAL	1740kSf(45.3Sf/piece,5.8Sf/kg)
outer support of sectors	108kSf
weight	60 t(1.8Sf/kg)
material	stainless steel
type	12X18H10T(Russie)
machining	220kSf
inner support of sectors	18kSf
weight	5.8 t(3Sf/kg)
material	aluninium
type	D16T(Russie)
machining	36kSf
SUBTOTAL	382kSf(4kSf/sector)
assembly of sectors	864kSf(9kSf/sector)
TOTAL (detector)	**6011kSf**
phototetrodes (R2149,HAMAMATSU)	1963kSf
phototriodes (Novosibirsk)	589kSf
Si photodiodes	589kSf
amplifiers (Zelenograd)	196kSf
ADC	196kSf
cables	430kSf
length	392km(1.1Sf/m)
TOTAL (read out)	**2785kSf(1411kSf)**
TOTAL	**8796kSf**(7422kSf)

2.3 End-cap Calorimeter

scintillator	156kSf
material	polystyrene
dopants	1.5%PT+0.01%POPOP
weight	24.8 t(6.3Sf/kg)
number plates	924000
square	24100 m^2
production of plates	468kSf
SUBTOTAL	624kSf(27Sf/m^2,25Sf/kg
fibers	226kSf
type	Y11(KURARAY)
length	323km(0.7Sf/m)
number	462000
evaporing mirror	45kSf(Russie 40Sf/day)
SUBTOTAL	271kSf(0.84Sf/m,0.5Sf/piece
paper	96kSf
type	Tyvek(Dupont)
square	48200m^2(2Sf/m^2)
wraping of plates	208kSf
SUBTOTAL	304kSf(0.66Sf/piece)
lead	164kSf
type	C1(Russie)
weight	82 t(2Sf/kg)
square	24100 m^2
stainless steel	68kSf
type	12X18H10T(Russie)
weight	38 t(1.8Sf/kg)
square	48200 m^2
machining of absorber plates	464kSf
SUBTOTAL	696kSf(5.8Sf/kg)
assemble	272kSf
TOTAL (detector)	**2167kSf**
phototetrodes (HAMAMATSU)	720kSf
phototriodes (Novosibirsk)	210kSf
Si photodiodes	210kSf
amplifiers (Zelenograd)	72kSf
ADC	72kSf
TOTAL (half NEC)	**3031kSf**(2521kSf)
TOTAL	**6062kSf**(5042kSf)

3 Radiation Doses in the Barrel Calorimeter (BARC) and Photon Spectrometer (PHOS)

HIJING code was used to simulate Pb-Pb collisions at a center-of-mass energy of 5.5 TeV/nucleon to provide a primary source of radiation for further energy deposition calculations. To simulate the particles transport in the ALICE detector and the energy deposition in BARC, MARS [7] Monte-Carlo code was used. The conical absorber at 1.5 m downstream the interaction point(IP) was taken into account in the geometry calculations. The results show that the longitudinal dependence of energy deposition in BARC is practically uniform. The radial dependence of the energy deposition in BARC is presented in a Table.

R, cm	460-470	470-480	480-490	490-500
E, (GeV/g)/event	7.0×10^{-6}	4.8×10^{-6}	3.5×10^{-6}	2.6×10^{-6}

So the dose per average event is estimated as 1.1×10^{-10} rad or 1.1×10^{-12} Gy.

Same numbers can be used to estimate radiation doses in PHOS.

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[1] S.A.Sadovsky. ALICE/93 - 07 Internal note/PHYS, Geneva, 1993; S.A.Sadovsky. ALICE/95 - 30 Internal note/PHYS, Geneva, 1995.

[2] ALICE LoI, CERN/LHCC 93 - 16, Geneva, 1993.

[3] A.V. Inyakin et al., ALICE/93 - 26, CERN, Geneva, 1993. Preprint IHEP 93 - 157, Protvino, 1993.

[4] A.V. Dolgopolov et al., ALICE/94 - 09, CERN, Geneva, 1994. Preprint IHEP 94 - 67, Protvino, 1994.

[5] V.G. Baryshevsky et al., Nucl. Instrum. Methods A322 (1992) 231.

[6] O.V.Buyanov et al., Proc. IVth Int. Conf. on Calorimetry in High Energy Physics, Isola d'Elba, 1993, p.292. O.V.Buyanov et al., Nucl. Instrum. Methods A349 (1994) 62.

[7] I.S. Baishev, I.A. Kurochkin, N.V. Mokhov.

Extension of the MARS10 Code System Possibilities. Preprint IHEP 91-118, Protvino, 1991.

4 Conceptual project.

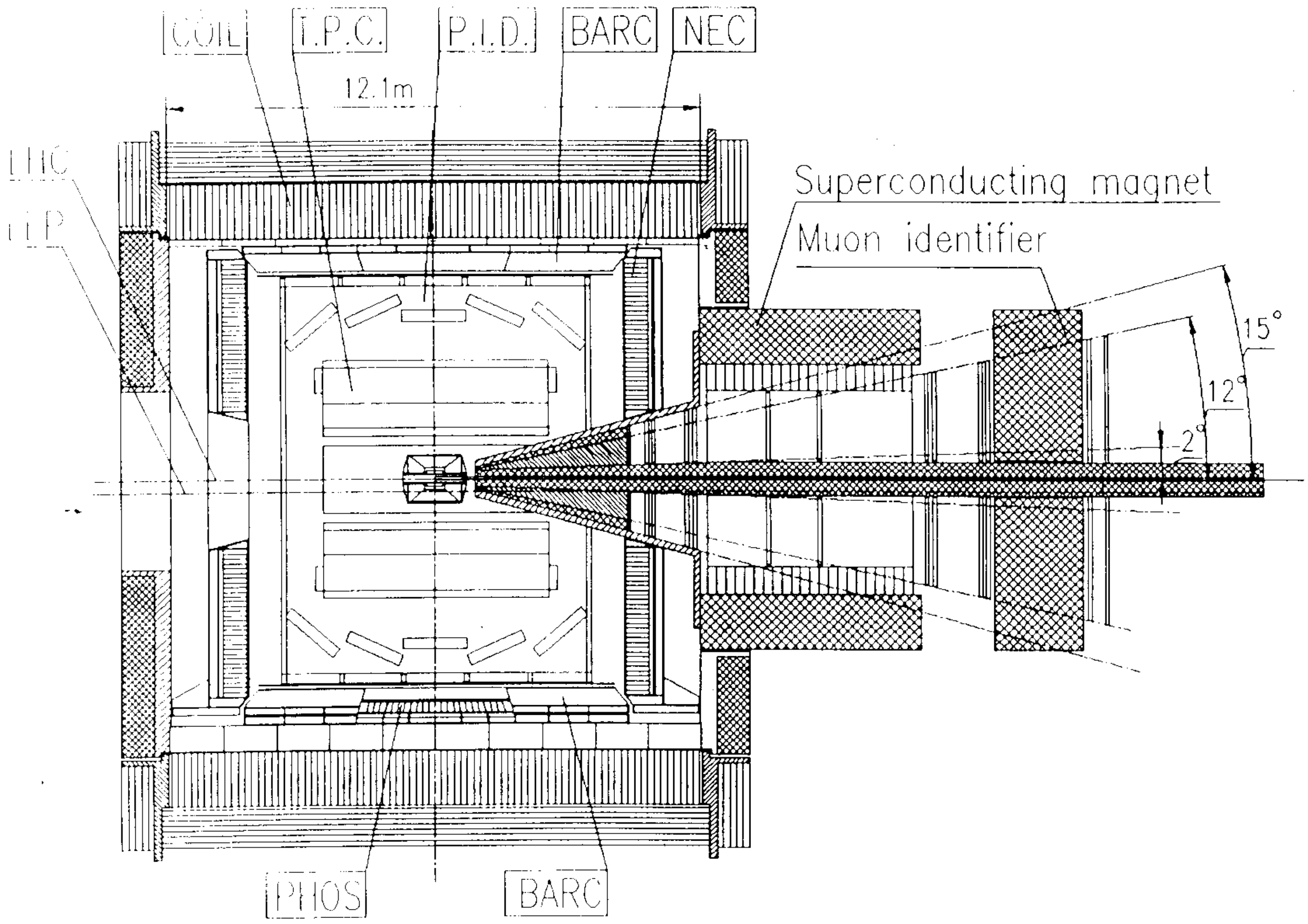

Fig.1.1.Longitudinal view of the ALICE.

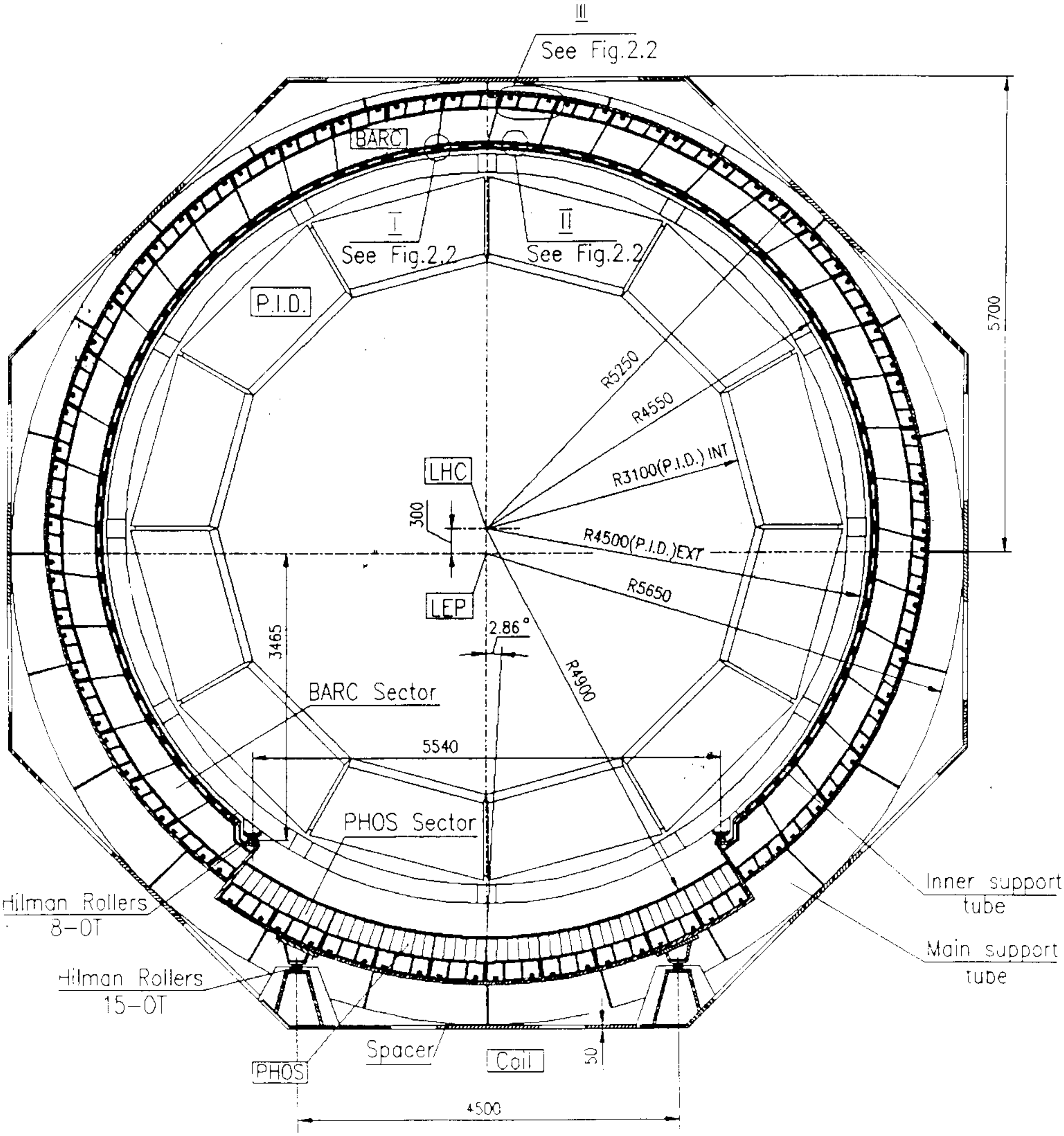

Fig.2.1 Lateral View of the ALICE

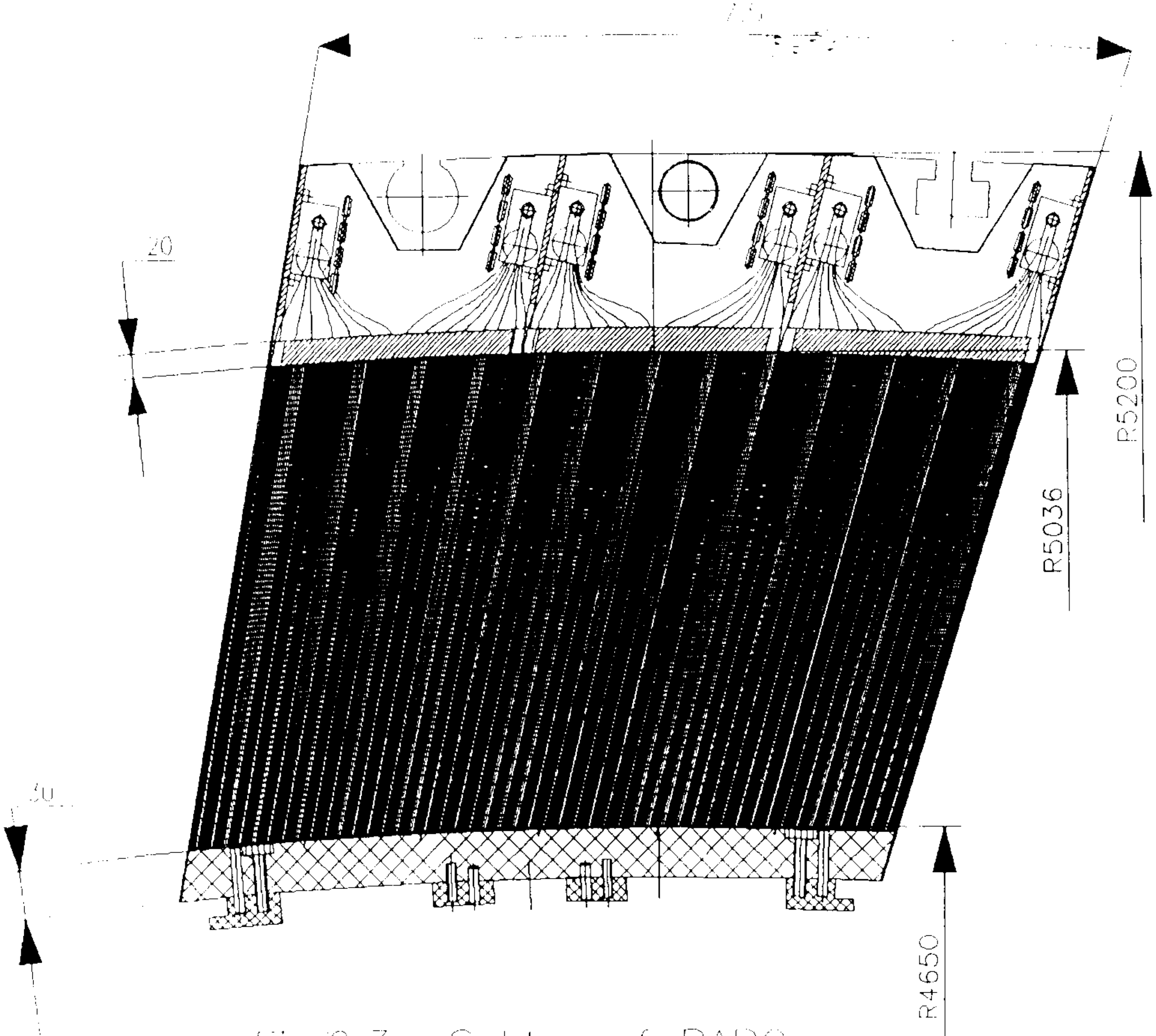

Fig.2.3 Sektor of BARC

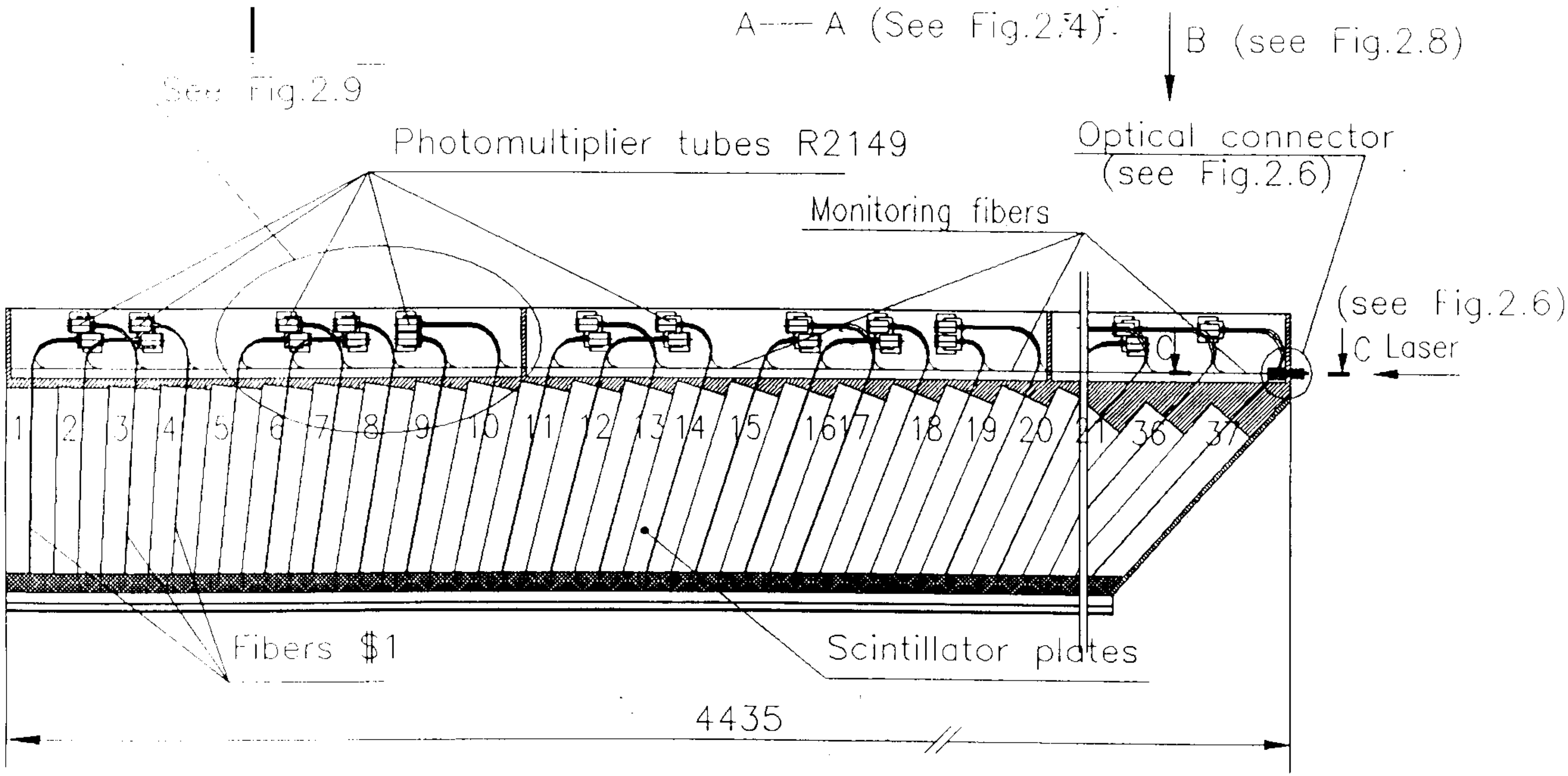

Fig.2.5 Sektor of BARC

B (See Fig.2.5)

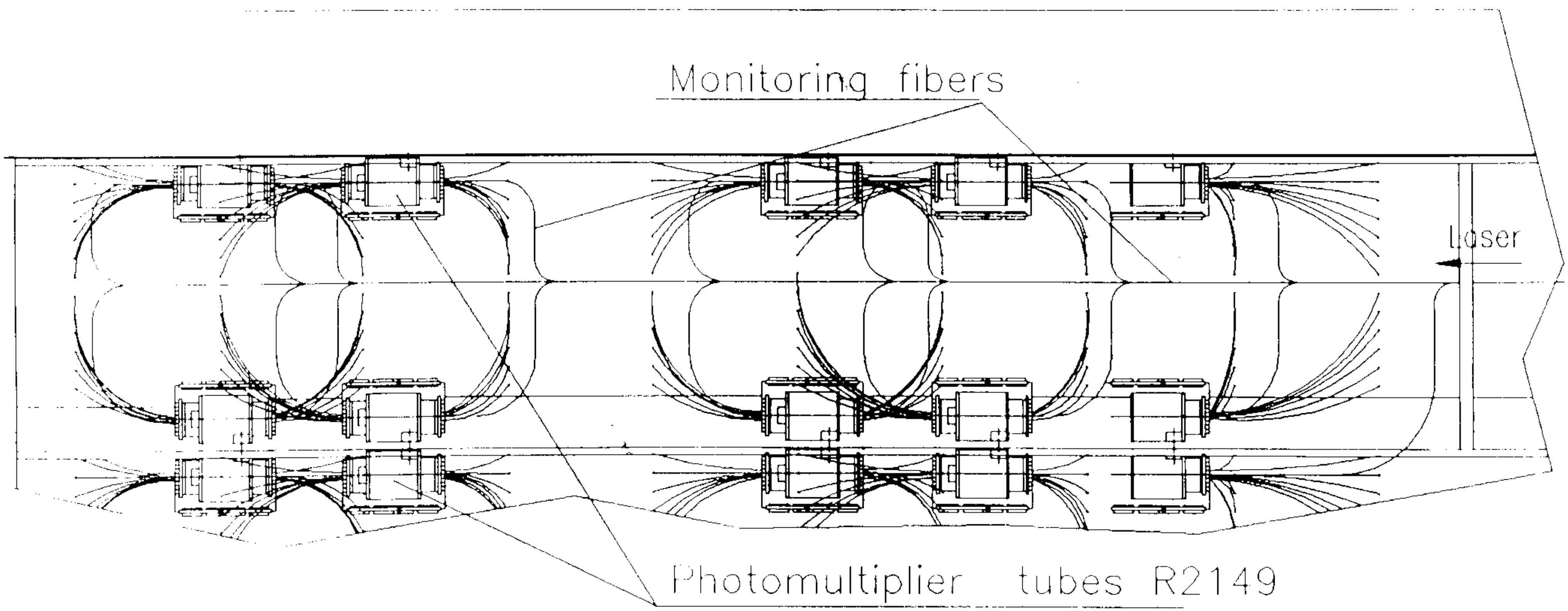

Fig.2.8

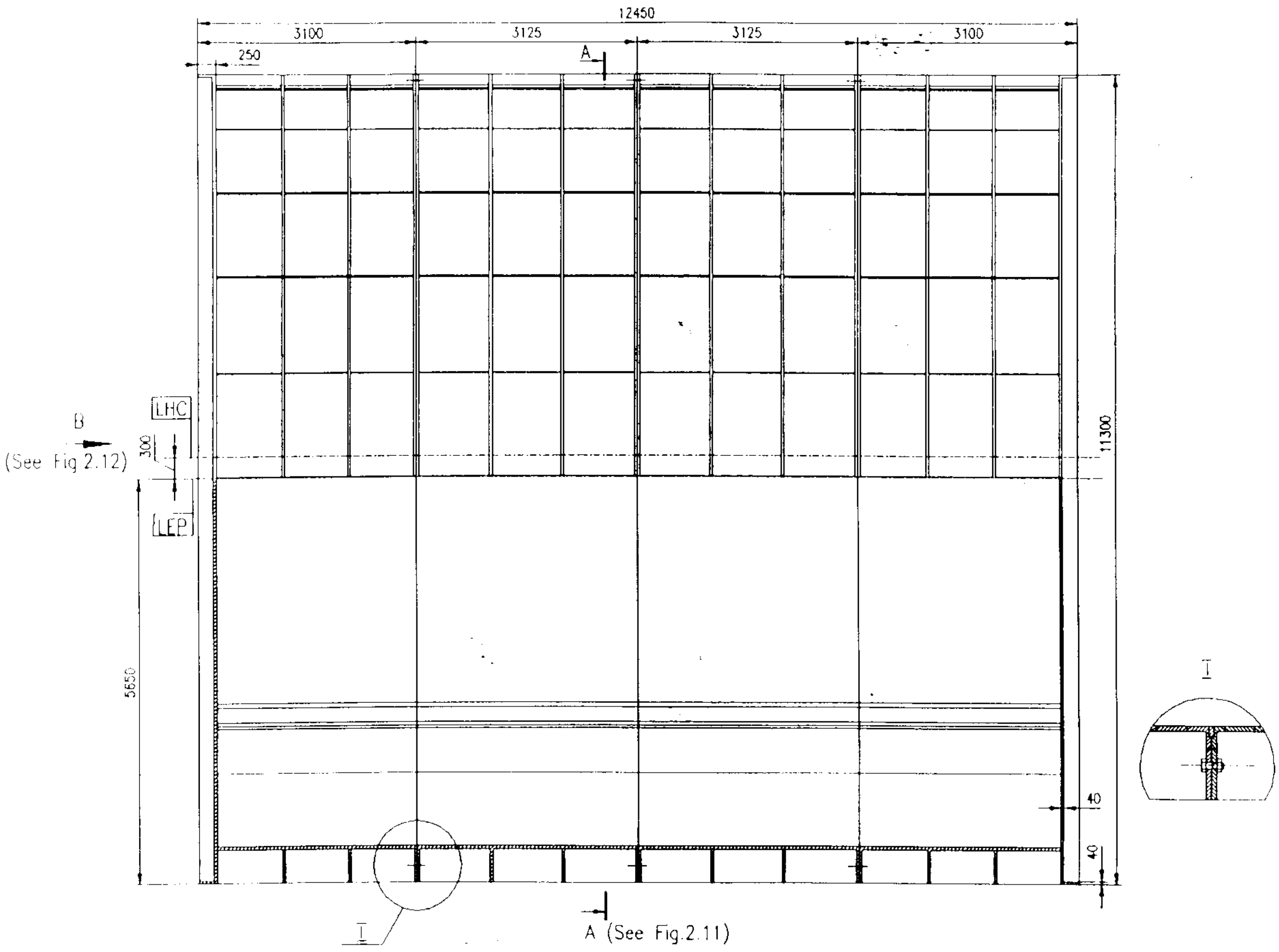

Fig.2.10 Main support tube.

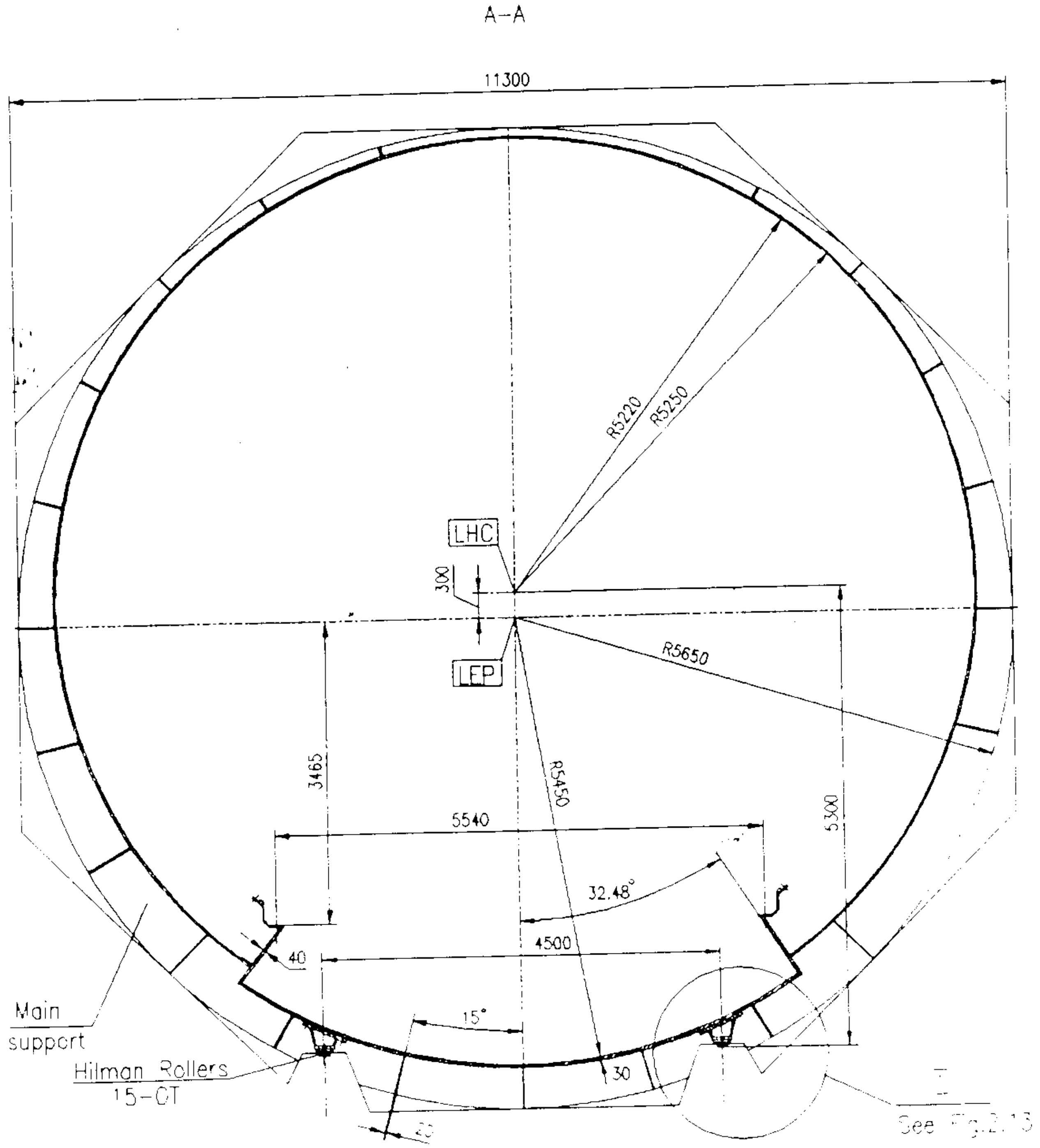

Fig.2.11 (See Fig.2.10) Main support tube

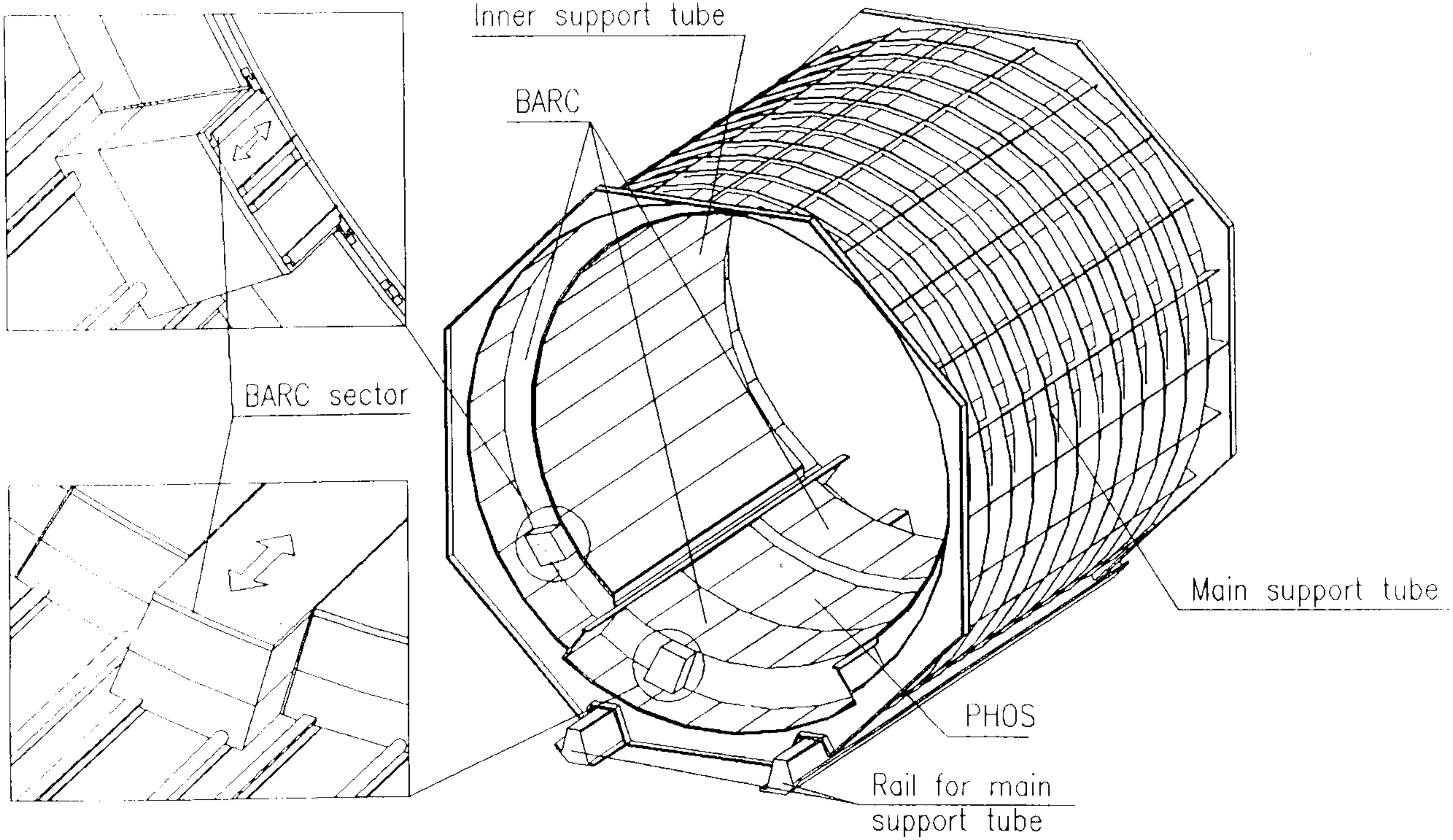
Inner support tube
BARC
BARC sector
Main support tube
PHOS
Rail for main support tube

Fig. 2.17

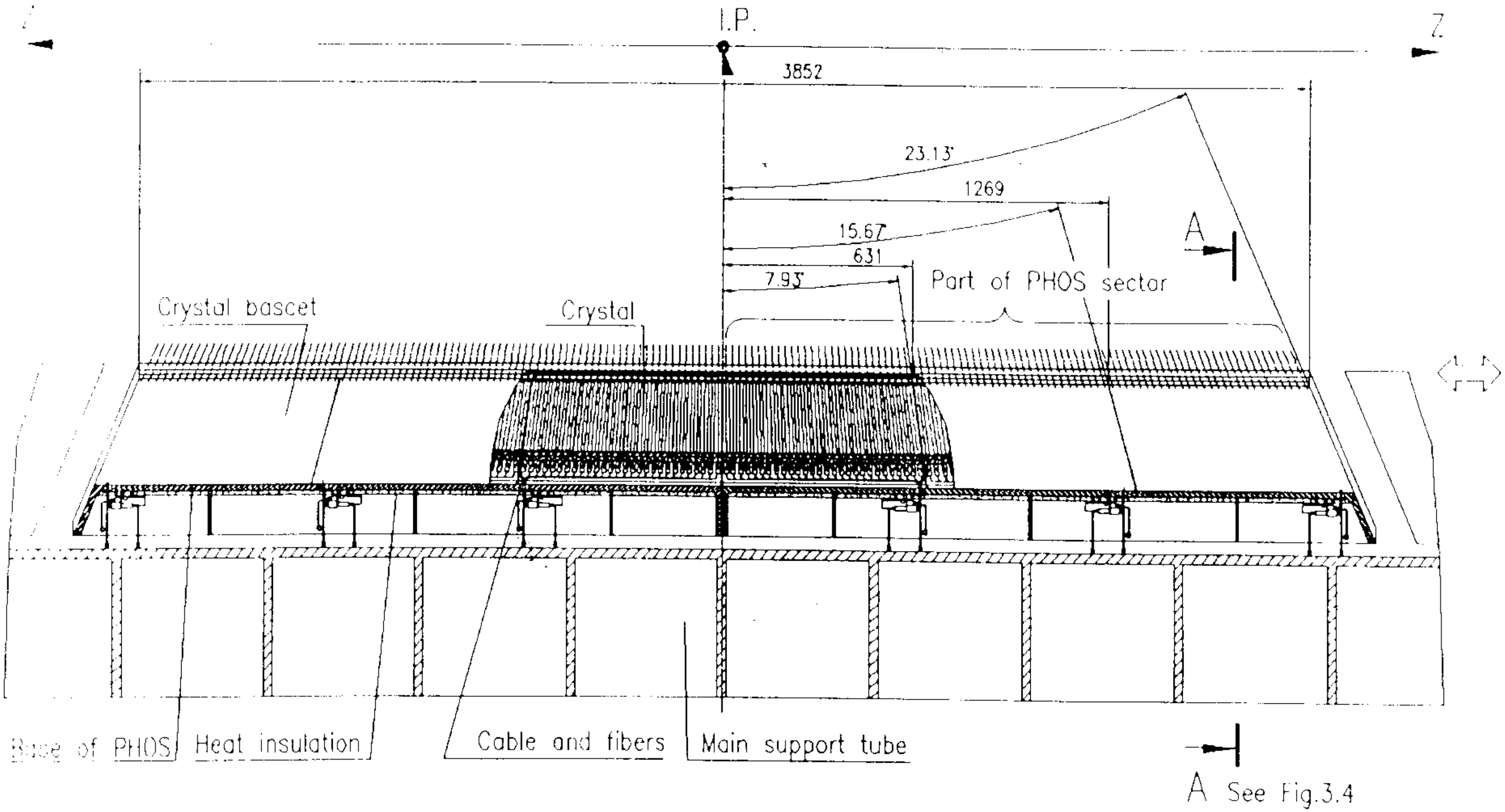

Fig.3.3 Scheme of Photon spectrometer.

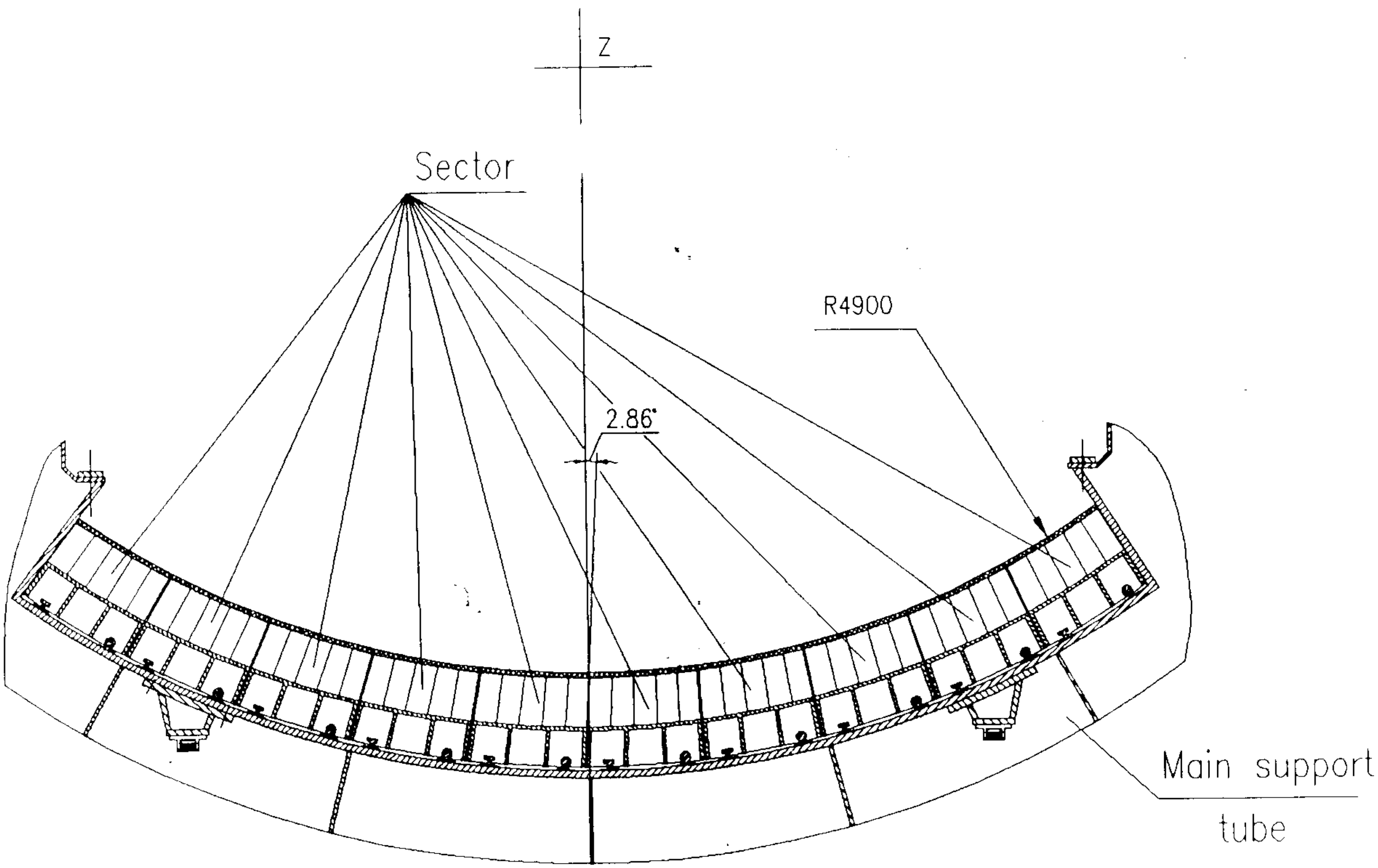

Fig.3.4 Cross section of PHOS (A–A see Fig.3.3)

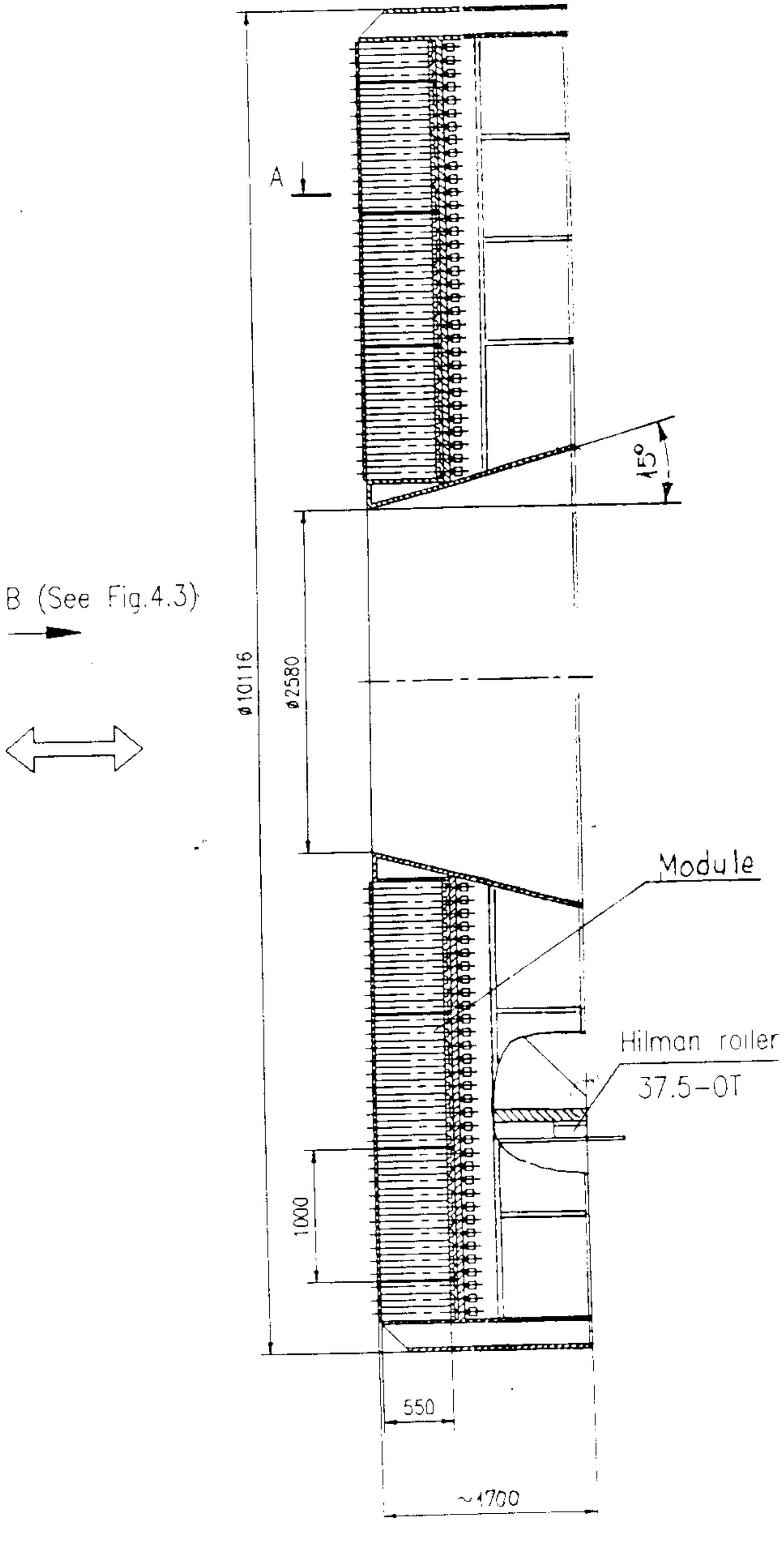

Fig.4.1 NEC detector

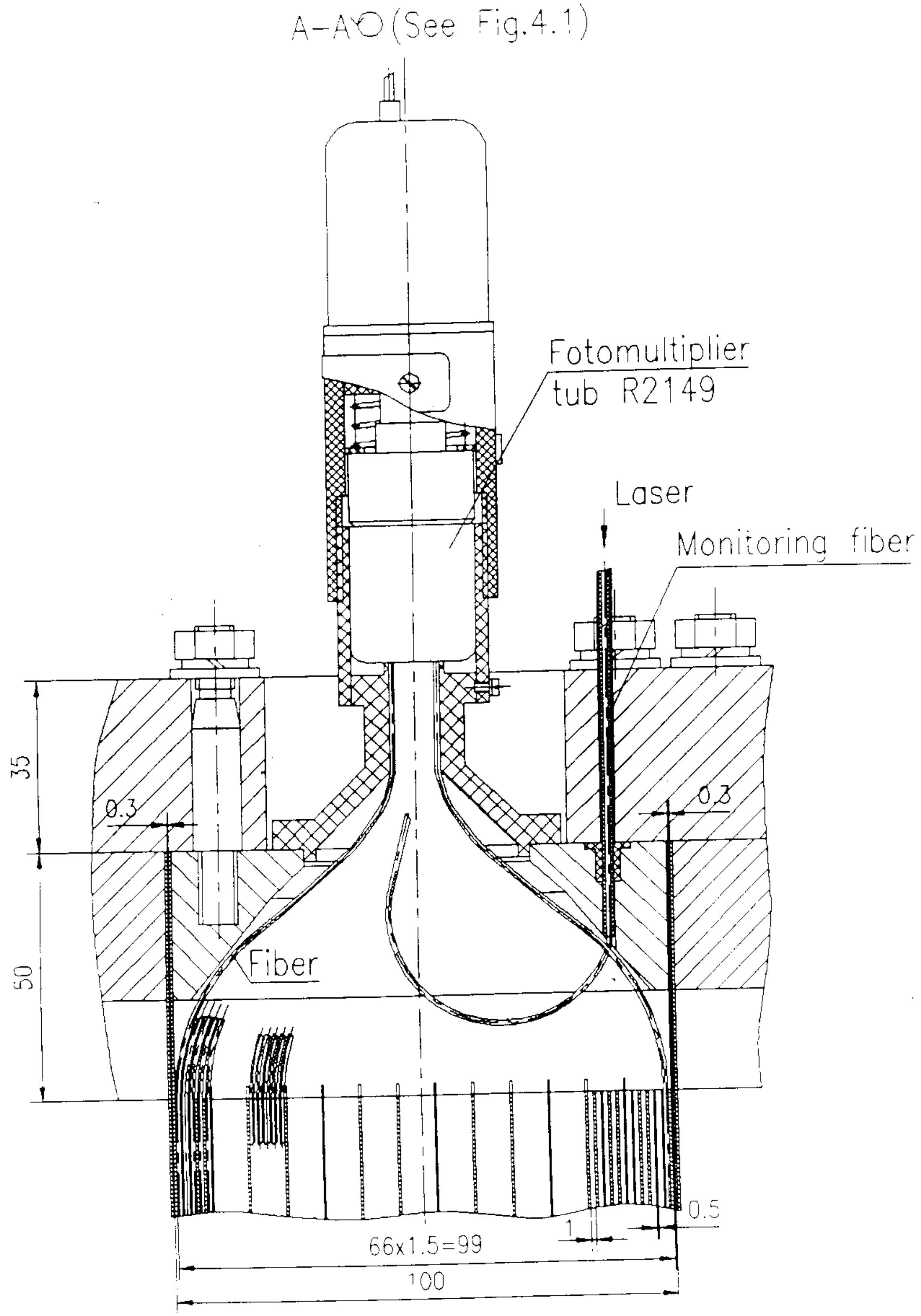
A–A (See Fig.4.1)
Fotomultiplier
tub R2149
Laser
Monitoring fiber
35
50
0.3
0.3
Fiber
0.5
1
66x1.5=99
100

Fig.4.2.

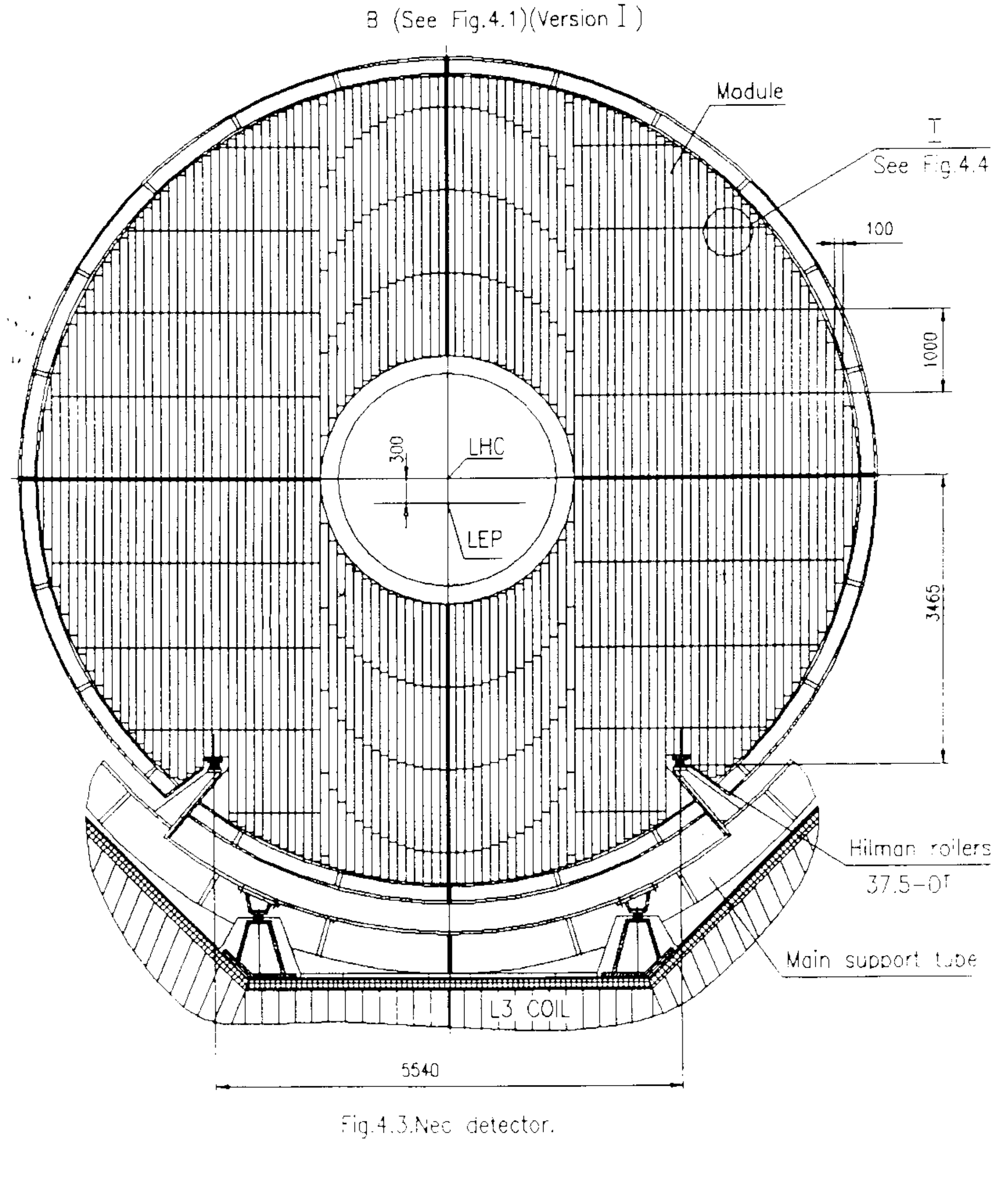

Fig.4.3.Nec detector.

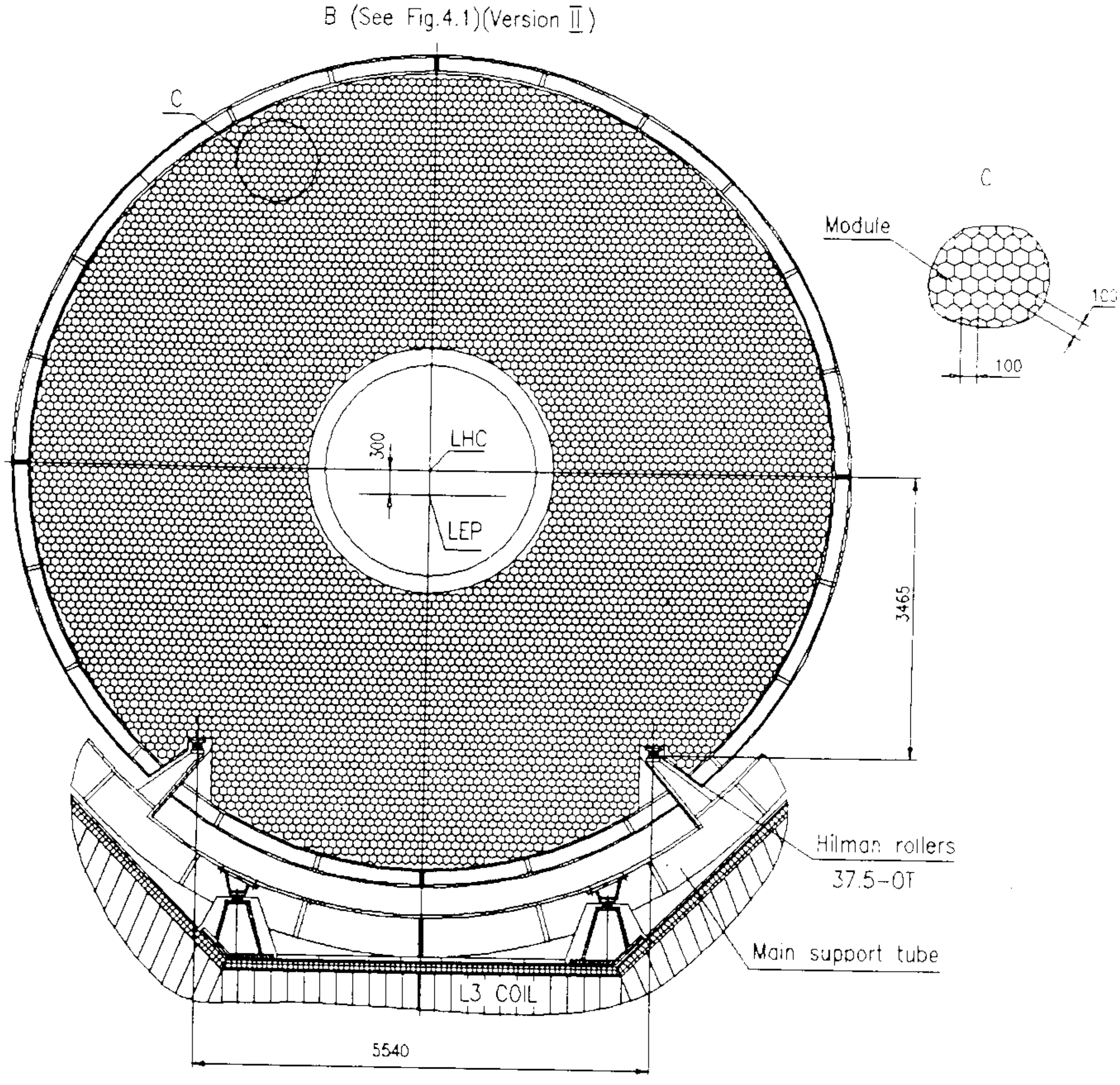

Fig.4.5.Nec detector.