6.4 OPTICS AND MAGNET OF THE HYDROGEN BUBBLE CHAMBER "MIRABELLE"

M. Gensollen

Centre d'Etudes Nucléaires, Saclay.

The magnetic field applied to the Bubble Chamber is horizontal with an intensity of 20 Kilogauss. It is generated by a classical C shape electromagnet (Fig 5). The power consomption is of 11 MW (660v 16 600 A). The iron core weighs 1150 T and its outer dimensions are 5.3 x 6.2 x 5 m.

The coils are made of aluminium. They weigh 30 tons each and are 4 meters high, 8 meters long and 0.85 meters thick. The spacing is 90 cm. They are placed in leak-proof containers in which nitrogen is continnously circulated under slight overpressure, in order to isolate the electrical circuits from the outside air.

Each coil contains 140 turns and is divided into 5 indentical double-pancakes, each of them being separately vacuum-impregnated with araldite.

The conductor is an aluminium tube of rectangular cross section 64 mm x 77mm with a circular hole of 33 mm in diameter for cooling water circulation. Aluminium was chosen mainly for reliability reasons; such a conductor can be supplied in continuous lengths of 250 m which correspond to the length of one single pancake, and thus awoids the presence of joints inside the winding. Whilst with a copper conductor; there would have been about 50 joints inside each pancake.

In order to eliminate thermal stress on the conductor, the coils are left free to expand when heated. This is achieved by feeding the cold water on to the inside turn of the pancake and by placing mylar spacers between turns in the circular ends of the coils.

The only stresses experienced by the conductor are due to the electromagnetic forces and are limited to 3 kg/mm2, which are quite acceptable with aluminium.

The design of the magnet and the checking of the various characteristics are being carried out on a 1/25 scale model. This model has been equipped with superconducting coils in order to reach the desired current density. It is being tested at present time and it will be used for predetermining, the map of the magnetic field in the useful volume of the chamber and for optimising the shape of the hole pieces with respect to field homogeneity. The variations of the field are expected to be lower than 7% on the axis of the chamber and 5% in a transversal cross-section.

"MIRABELLE" Optics

I - OPTICS

Lens system consists of two parts (fig 1). A cold part of fish-eye type made up of a single spheric window and of a parabolic lens which reduces the field from 110° to 10°. A room temperature part rectifies the aberrations of the parabol and carries the image out of the magnet, the whole system is 2.5 m long.

Between these two parts a plane window made of quartz isolates the optics vacuum which is surronded by a stainless steel vessel.

Two floating screens made of stainless steel reduce radiance bewteen the cold and the room-temperature parts.

Scotchilte system is used for illumination. Flash tubes which are installed at the outer side of the vacuum tank illuminate the inner face of the parabolic lens through a separate optical system.

The use of the parabolic lens allows a demagnification of 15, which permits a good utilisation of scotchlite (average scattering angle bewteen flash and entrance pupil equal 1/3°).
Nevertheless this arrangement brings up ghost images, which are eliminated by a set of masks located where intermediate images are formed.

The utilisation of the parabolic lens for illumination leads to a field decreasing in terms of cosinus of incident angle, due to the pupil dilatation, whose surface increase in terms of 1/cos3.

II - PROTOTYPE

A prototype has been designed:

lenght	: 1 meter
field aperture	: 110°
focal	: - 18 m
aperture	: f/12
focal depth	: 1 meter
distorsion	: 1.5% at 50°

Caracteristic curves are shown in Fig 2,3,4. Flash power is 600 Joules under 10 KW distributed into six flashs. But optical system of the flash accepts only 1 per cent of the emitted flux.

Its cold face has been tested in liquid hydrogen (and under a pressure of 15 Kg/cm2), in a cryostat and this experiment has given satisfactory results relative to the mechanical way of fixing spherical window.

We have checked in laboratory the expected performance of this prototype in air, results on stigmatism, chromatism, distorsion are those waited by calculations.

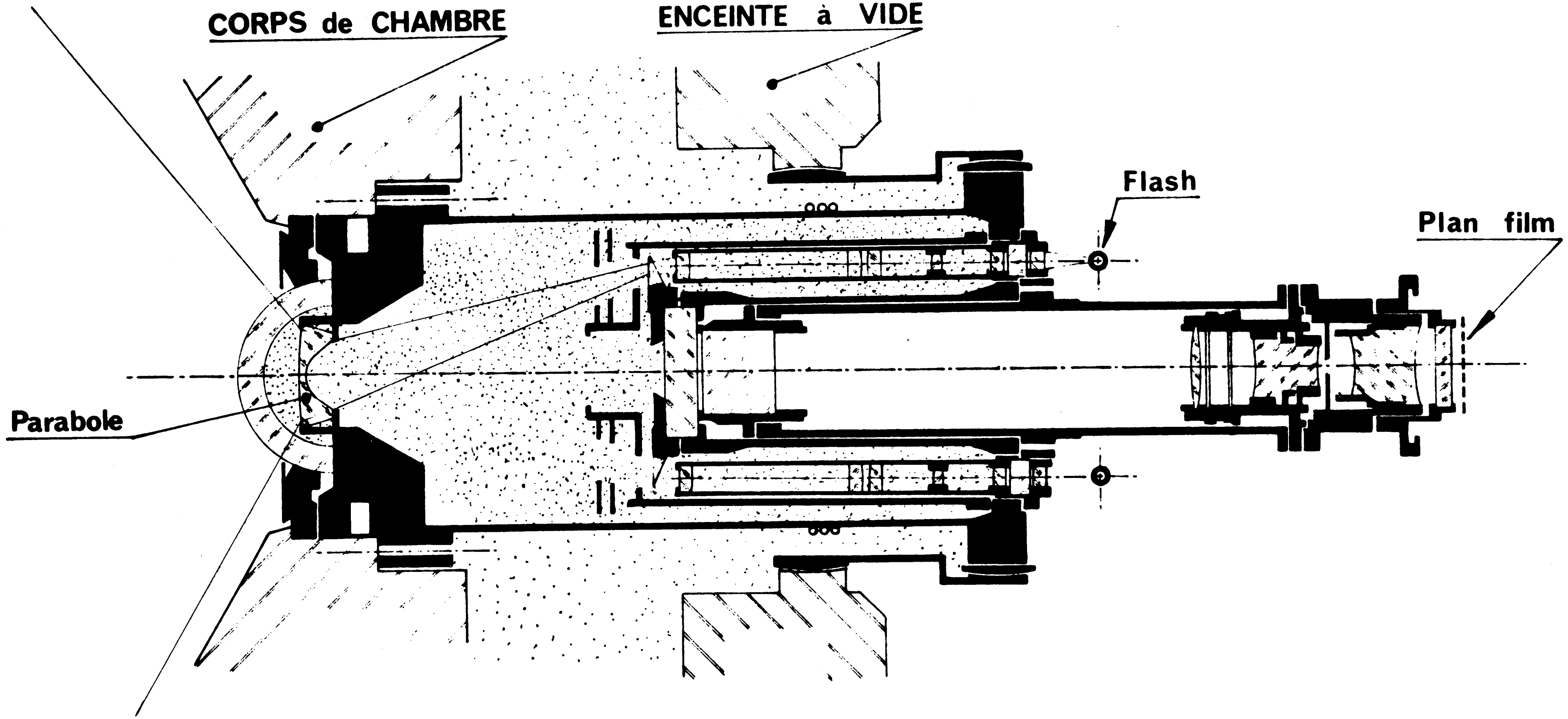
Resolving power measured with a grating was 100 line/mm on the axis.

III - THE CAMERAS

The actually proposed number of objectives is eight, on two horizontal rows whose basis are 70 cm horizontally and 50 cm verticaly. Optical axis are parallel, giving an easy scanning.

Photographied volume is 6 m3 compared to the 8 m3 volume of the chamber body.

Dispersion of camera permits selecting the best cople of cameras in front of the tracks to be measured, and minimize the light path in hydrogen (maximum 2 meters).
Camera studed at present time will be two or four, by grouping pictures on the same film.



PROTOTYPE de L'OPTIQUE MIRABELLE

Fig. 1

Aberration sphérique de la pupille d'entrée

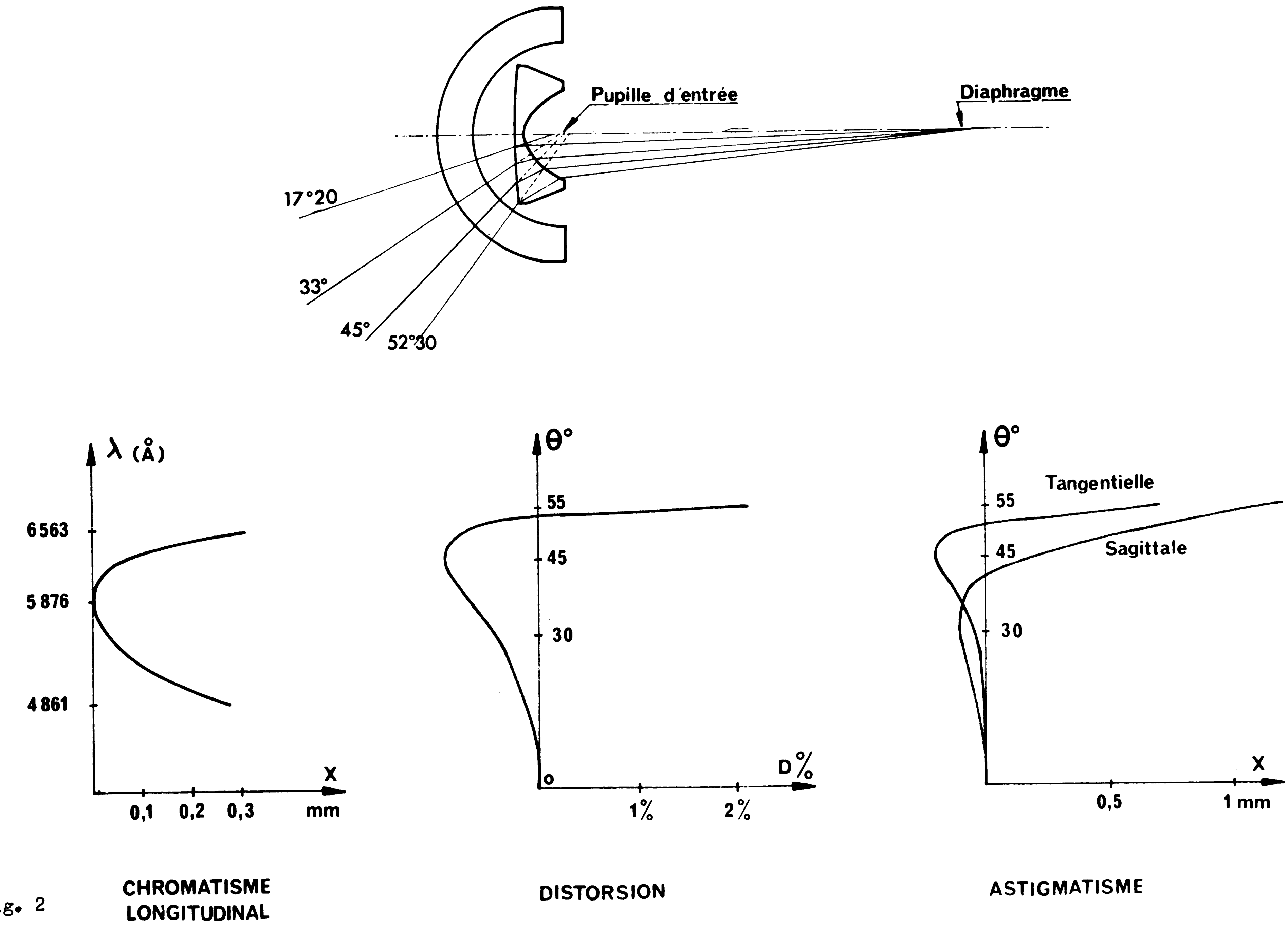


Fig. 2

SURFACES D' ONDE

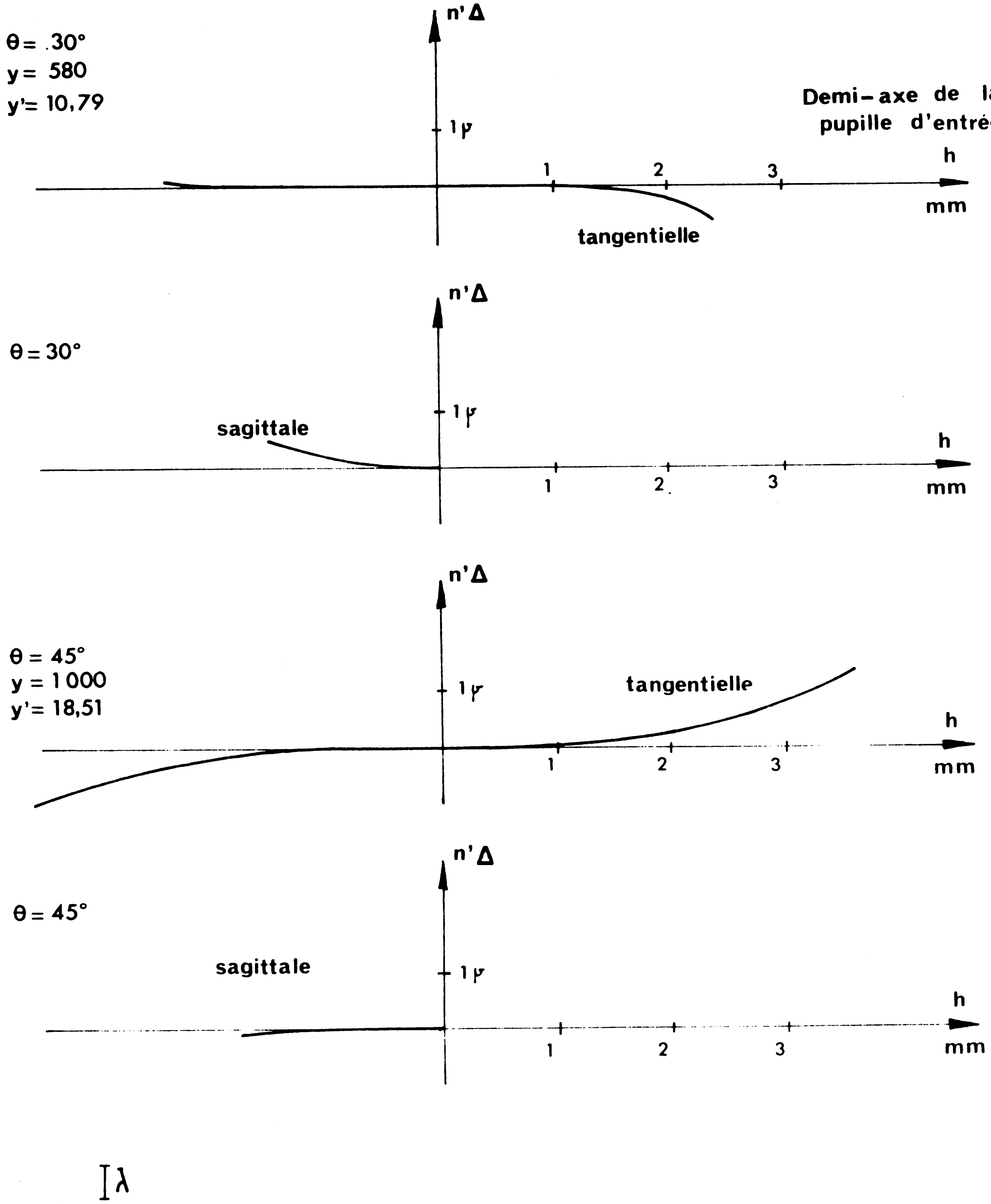
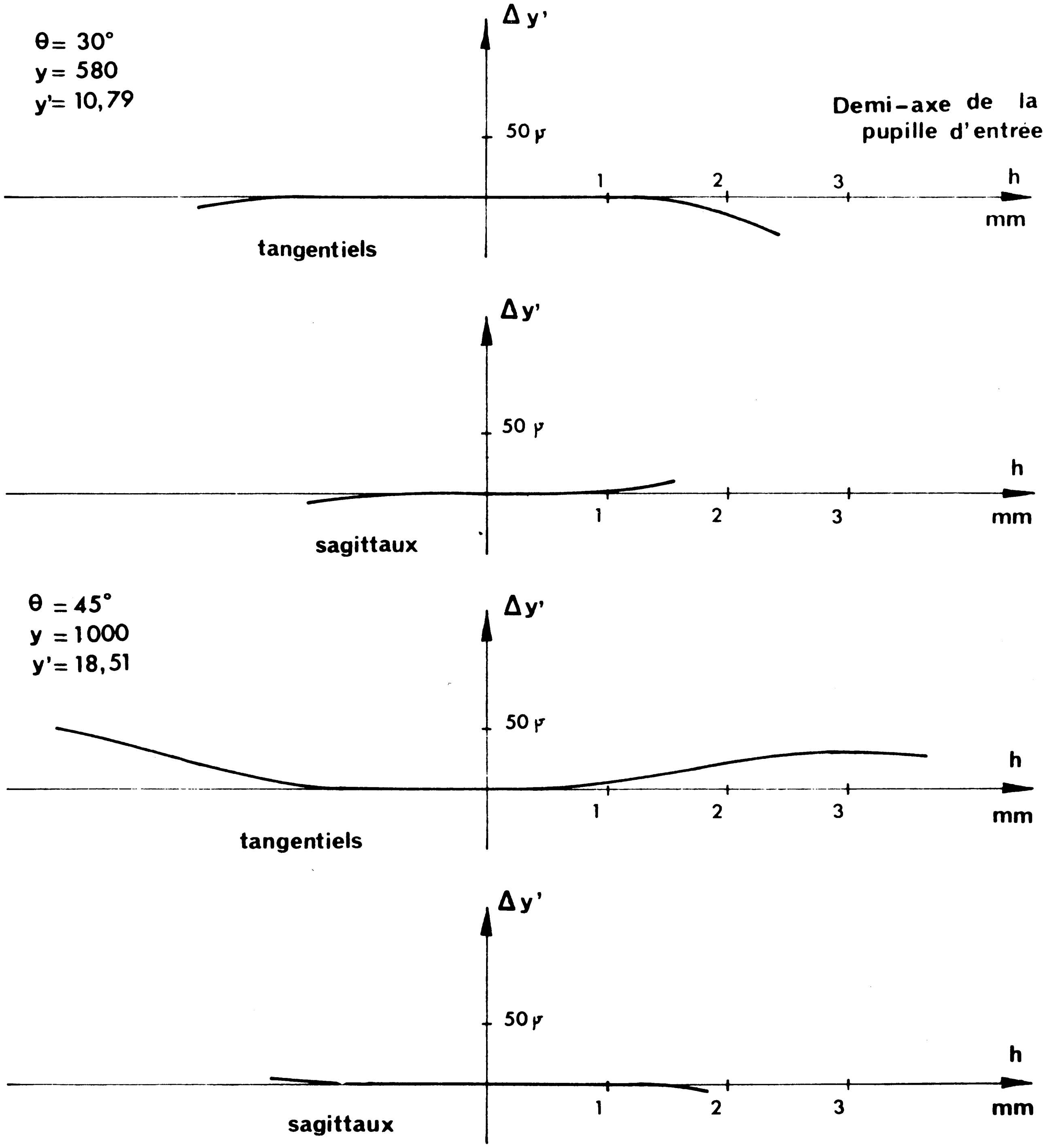


Fig. 3

RAYONS



θ= 30°
y= 580
y'= 10,79
Δ y'
50 μ
Demi-axe de la pupille d'entrée
1
2
3
h
mm
tangentiels
Δ y'
50 μ
h
1
2
3
mm
sagittaux
θ = 45°
y = 1000
y'= 18,51
Δ y'
50 μ
h
1
2
3
mm
tangentiels
Δ y'
50 μ
h
1
2
3
mm
sagittaux

Fig. 4

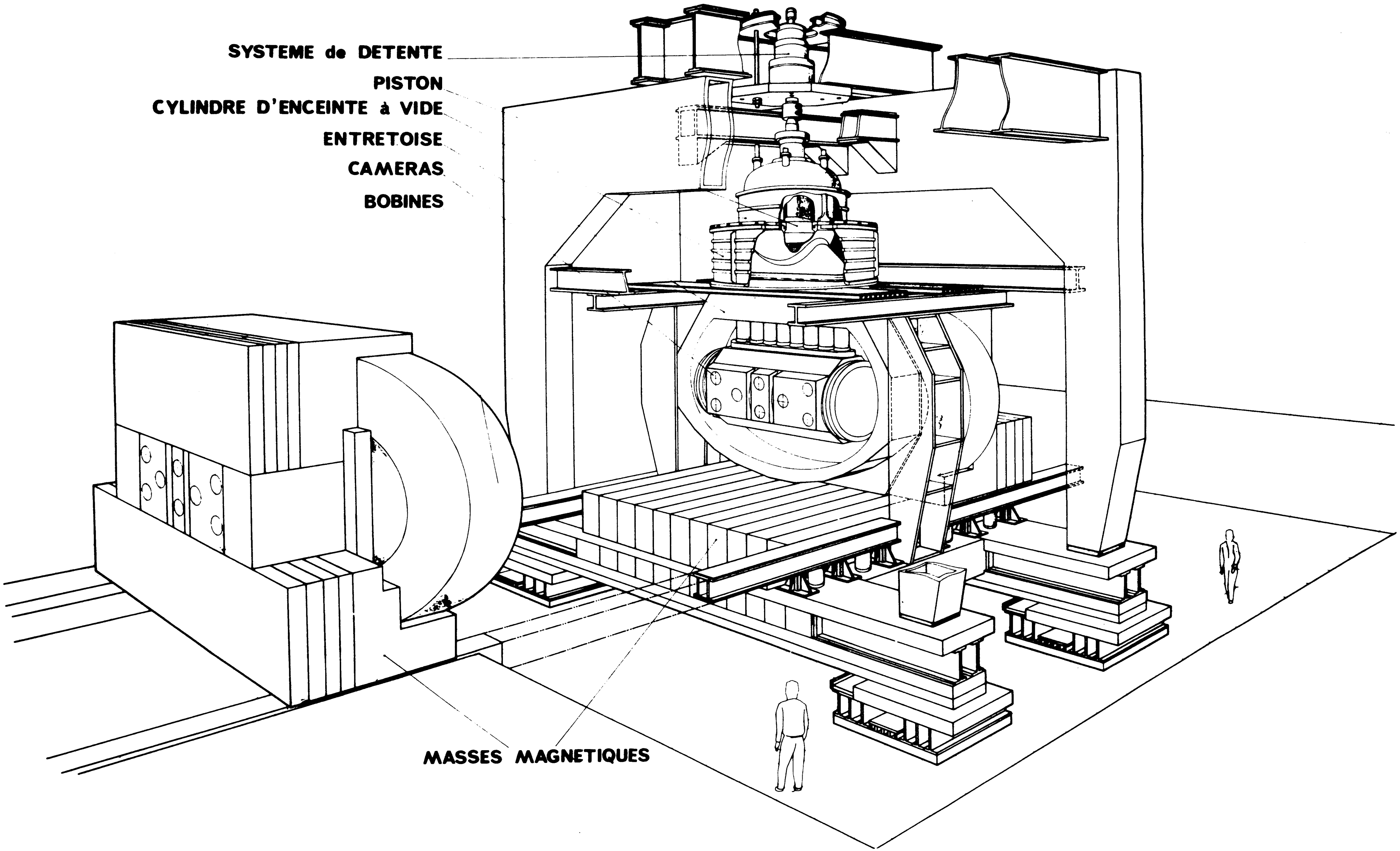

SYSTEME de DETENTE
PISTON
CYLINDRE D'ENCEINTE à VIDE
ENTRETOISE
CAMERAS
BOBINES
MASSES MAGNETIQUES

Fig. 5