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Plans for the Storage Ring and Detection Apparatus at DESY

by

K. Steffen

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Invited talk to be given at the
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Contents:

Introduction

The DESY electron-positron double storage ring, which was first proposed in 1966, is now starting its second year of construction and is planned to be completed in 1973. The project has been described in our 1967 proposal[1] and at the Yerevan accelerator conference last fall[2]. Instead of repeating this description here in full, I shall only summarize the main features before going into some more special aspects which have been recently discussed. In the second part of this talk I will describe the general experimental facilities and the planning and development of detection apparatus,relying mainly on the information gathered from the colleagues who are actively involved in this work[3].

Main features of the storage ring

The double storage ring was initially planned to have an energy of 3 BeV at a bending field of 8.1 KG. Meanwhile, all bending and focusing magnets have been designed for an energy of 4.5 BeV and will be equipped with power supplies corresponding to this energy. However, the initial total rf power of 1.5 MW will only suffice to carry two beams of 2 x 300 mA to an energy of 3.5 BeV. The later addition of another 500 kW would allow to hold 2 x 400 mA at 4 BeV. The final energy as permitted by the magnet system can only be reached by eventually installing superconducting rf cavities. With these, a current of about 2 x 280 mA can be expected at 4.5 BeV.

The design current is 2 x 6 Amperes at 1.5 BeV and 2 x 0.9A at 3 BeV, resulting in a design luminosity of 10^{33} cm^{-2} sec^{-1} at 1.5 BeV and of 10^{32} $cm^{-2}sec^{-1}$ at 3 Bev.

The storage ring will be located on the DESY site near the new 400 MeV electron-positron linac about 100 m away from the synchrotron (Fig.1). It has an oval shape, with diameters of about 120 m and 60 m, respectively. The two rings are mounted vertically on top of each other at a spacing of 80 cm, and the two beams intersect in two opposite points at a vertical crossing angle of about 23 mrad. Injection can be done at energies up to 2 BeV from the synchrotron or, mainly for test purposes, at 400 MeV directly from the new linac.

The power emitted as synchrotron radiation is 550 kW per beam at 3 GeV and maximum current. It is supplied by a 500 MHz radiofrequency system consisting of three 250 kW klystron transmitters per beam. Each transmitter feeds 4 cylindrical single cavities. The input couplers to the cavities are matched to have zero reflexion at maximum energy and beam current. At other values of current and energy, part of the power will be reflected and absorbed in water loads.

Dynamic control of rf system

In order to have practicable and stable operating conditions of the beam loaded rf system, the cavities as seen from the transmitter must be operated as a real or capacitive load. Therefore, the inductive load introduced by the beam current must be compensated by detuning the cavities to the capacitive side. The tune shift required for this compensation is proportional to the ratio of beam current divided by the rf voltage per revolution as seen by the synchronous particle, i.e. the voltage needed for restoring radiation losses. Since this voltage goes with the fourth power of energy, very large tune shifts are needed at small energies.

On the other side, the tune shift that can actually be realized is limited. We originally planned to install in each cavity a moveable plunger which would allow a maximum tune shift of 1.6 MHz. With this system, it would then be necessary at lower energies to increase the beam voltage per cavity by operating with a reduced number of cavities per ring, having the others completely detuned. Fig. 2 shows as a function of energy the maximum beam current that could be held with one, four and twelve operative cavities, respectively, at maximum tune shift. The situation demonstrated by these curves is not satisfactory since it would be extremely difficult to switch from twelve to only one operative cavity without loosing the beam.

Therefore, instead of the plunger with its limited tuning range, we now plan to use a position-controlled, retractable drift tube for cavity tuning. This would easily give a tuning range of 20-60 MHz without distorting the rf field. The upper curve in Fig.2 shows the maximum beam current as limited by the rf system for a tuning range of 56 MHz. In addition, the dashed curve indicates the incoherent beam-beam space charge limit. The current limitation by Touschek effect at low energies is not shown here.

We plan to use two different modes of dynamic rf system control, distinguishing between injection and operation of the storage ring. At injection we will start with a rather large capacitive over-detuning and thus have a small initial impedance and beam loading. The transmitter power will be set at its constant final value, and the cavity voltage will be measured and held constant in phase and amplitude by a dynamic control system. This system compares the amplitude with a reference value given by the control computer and, after each injection burst, moves the tuning drift tube to compensate for the induced amplitude change. At the same time, the phase of the cavity voltage is compared with the phase of the drive signal coming from the synchrotron and is controlled by a phase shifter at the entrance of the transmitter. As the stored current approaches its maximum value, the loaded cavity approaches resonant operation.

When resonance is reached, the dynamic control system locks onto the second control mode and now keeps the loaded cavity on resonance by controlling the cavity phase via regulating the position of the tuning drift tube. The amplitude of the cavity is now held at a reference value by regulating transmitter power. This mode of control will be used during energy variation and during steady operation of the storage ring.

Additional 50 MHz rf system

Following a suggestion by M.Sands[4)], it is being investigated whether an extra rf system of lower frequency, say 50 MHz, should be added to the storage ring. It would serve to test the dependence of beam performance on the harmonic number.It would also allow to rebunch the beam without significant particle loss into every tenth bucket by changing continuously from 500 MHz to 50 MHz operation and then back to 500 MHz. Such bunch population will be needed at high energies, where it allows to overcome the strong decrease of luminosity with energy due to natural beam size. The rebunching process has been analyzed in detail; an efficiency of about 90% was found when using a 250 kW/50 MHz system in each ring[5)].

A third aspect of an added lower frequency rf system is the possibility to shift the synchrotron frequency of bunches with respect to each other, which may be required to avoid the instabilities due to coherent phase oscillations. Finally, the system offers a significant increase of beam power at higher energies, when only every tenth bunch is populated.

Some features of beam optics

The magnet ring structure is shown in Fig.3. There are four identical quadrants, each composed of three magnet periods in the curved part, a short straight section for injection and a long straight section for beam interaction, vertical beam separation and radiofrequency acceleration. At interaction point, the beam has a very thin waist and - correspondingly - a large divergence which leads to a large beam cross section in the adjacent large aperture quadrupole doublet. This is expressed by the amplitude function β, which is proportional to the square of the beam envelope and has - in horizontal and vertical direction - a value of 10 cm at interaction points and of about 10 m and 25 m, respectively, in the normal ring structure. In the large aperture quadrupole doublet, however, its value rises to 90 and 700 m, respectively, for the horizontal and vertical coordinate.

It is this very large β-value which causes special difficulties and demands special attention in a storage ring with low-β insertion. Since the effect of bending and focusing field distortions and of momentum deviation on the beam optics is proportional to the amplitude function, the large β-value makes the machine very sensitive in several respects.

A statistical misalignment of the large quadrupole doublets by 0.1 mm would move the closed orbit at this point by 10 cm. Thus, a structural support with high long-term stability independent of load motions in the experimental hall is required for these quadrupoles and, in addition, a beam measuring and steering control system.

A relative change of focusing strength of 10^{-4} in the four large quadrupole doublets will change the ν-value of the machine, i.e. the number of betatron oscillations per turn, by $\Delta\nu_v = 0.01$.

Therefore, the strength of these quadrupoles as compared to the field in the main bending magnets must be kept constant within a relative accuracy of 10^{-4}. We plan to achieve this by powering the large quadrupoles electrically in series with the main bending magnets. They will have an additional 20% excitation coil which is separately powered and will be used for variation of optics and for a controlled tracking correction, if required.

The third severe consequence of the large β-value is a large chromaticity of the ring, i.e. a dependance of ν-value on energy which is much stronger than in usual machines. Our chromaticity, defined as ν-shift per 100% momentum deviation, is

$$\Delta\nu_h / \frac{\Delta p}{p} = -22 \quad \text{for the horizontal and}$$

$$\Delta\nu_v / \frac{\Delta p}{p} = -80 \quad \text{for the vertical coordinate.}$$

This means that, after injecting with 0.5% momentum spread, we would have a spread in the vertical ν-value of $\Delta\nu_v = \mp 0.4$. This is, of course much too large to be tolerated and has to be counteracted by sextupoles.

The effectiveness of such sextupoles is proportional to the product of the amplitude function times the dispersion at the point where they are located. In order to control the chromaticity independently in each coordinate, one must have two sets of sextupoles, located at points with different values of the above product. In the curved parts of our ring structure, which are the only regions with non-vanishing horizontal dispersion, sextupole positions of only moderate effectiveness are available, leading to rather excessive sextupole strengths. We have therefore tried to install a sextupole correction in the long straights, making use of the vertical dispersion and the large vertical amplitude function in this region. However, a separate large aperture sextupole or a sextupole field superimposed on the large quadrupoles would not work here, since they would be traversed by both beams and would have opposite effect on these.

Fortunately, another solution offered itself: As part of the system for the vertical beam separation, we have planned next to the large quadrupole doublet a long, low field, thin current-sheet septum magnet. It is easy to contour the poles of this magnet such that a constant sextupole field is imposed on each beam, which has the right strength and polarity to essentially cancel the vertical chromaticity. Adjustments and compensation of horizontal chromaticity can then be done by sextupoles in the curved part of the ring.

Other optical features of interest in the DESY ring are the variation of ν-values, the incoherent control of vertical beam size and the continuous control of damping distribution between horizontal betatron oscillation and synchrotron oscillation.

When varying the horizontal and vertical ν-value, the optical setting in the curved ring part and in the vicinity of the interaction points stays unaltered, and only the quadrupole matching between these regions is being varied. This requires the adjustment of 4 matching quadrupoles in the rf section and of 3 matching quadrupoles in the injection straight section. Fig.4 shows the region of ν_h-ν_v-values that can be covered this way.

The incoherent control of vertical beam size works as follows: Normally, the optics of the long straight section up to and including the vertical beam separation is matched to have zero vertical dispersion in the remaining part of the ring, i.e. the long straights are made nondispersive. This gives minimum vertical beam size as determined by coupling. When this matching is slightly varied, the vertical dispersion will continue around the ring through the main bending magnets and will cause there an excitation of vertical betatron oscillations by synchrotron radiation. We have calculated that we can in this way vary the beam height within a region covering a factor of about 10.

The continuous control of damping distribution between the horizontal and the longitudinal mode of oscillation can be done in two ways. The first method consists in slightly shifting the frequency of the rf system, which causes a shift in closed orbit position. The corresponding shift in the damping decrement of synchrotron oscillations is proportional to the product of the closed orbit shift times the dispersion times the square of the quadrupole strength, integrated around the ring. Since the sum of longitudinal and horizontal damping decrements is a constant, the damping of horizontal betatron oscillations will change in the opposite direction by the same amount. In order to double the horizontal damping or make it vanish, we will need a frequency shift of about ±100 kHz, leading to a maximum closed orbit shift of about ±2 cm.

The second method uses the same principle. However, the required closed orbit shift is here done as a beam bump in the vicinity of the injection straight sections. The bump is shown in Fig.5, together with the horizontal dispersion in this region. A maximum closed orbit amplitude of 2 cm will change the horizontal damping by almost the same amount as obtained by an rf frequency shift of 100 kHz.

Before I am going to describe now the plans for experimental facilities and detection apparatus, I shall briefly mention two developments at DESY which may be of general interest.

Scattering of electrons on synchrotron radiation

Due to the orbit curvature in the bending magnets, electrons may be scattered on the synchrotron radiation emitted by electrons of the same bunch. This effect has been analyzed and was found to impose a sharp limit on the stored beam current at high energy and particle density. In the DESY storage ring at an energy of 3 GeV, a current of 0.9A and a bunch population number of 16, for example, the beam lifetime due to this effect will be 6 hours[6].

Measurement of bunch length

The second development concerns the measurement of bunch length which, in our case, calls for an unconventional method since the bunches will only be about 100 psec long. We intend to use an optical sampling method incorporating a mode-locked laser as an ultrashort sampling pulse generator which is gating a Kerr-cell[7]. A schematic drawing of the arrangement is shown in Fig.6. The synchrotron light falls on a photo-diode after passing the Kerr-cell which is placed between crossed polarizers and is "opened" by the 5 psec-pulses of the laser. The distance between laser pulses is chosen slightly different from the 2 nsec bunch distance such that the sampling pulse slowly moves over the entire bunch. A test of a mode-locked Nd-glass laser gating a nitrobenzol Kerr-cell has been performed, simulating the synchrotron light by a continuous laser beam. Fig. 7 shows the light pulse as seen by a slow photodiode when the Nd-glass laser is fired. (The time scale is 100 μsec per bin).

General Experimental Facilities

I shall now come to describing the general experimental facilities.
The high bay connecting the 2 interaction points is 24,5 m wide and 86 m long and is served by a 40/5 t crane with a lifting height of 10 m above floor level. The free space between the large aperture quadrupole doublets facing the interaction point is 5 m long. The doublets are supported from concrete tunnel stubs reaching into the high bay.
In view of the very sensitive aligment of the doublets, the tunnel stubs are water temperature stabilised and rest on independent long pile foundations, thus being decoupled from crane and load motions in the hall. The clearance between adjacent tunnel stubs is 7.2 m.

At interaction region I, which is intended for varying experimental setups, the side walls of the tunnel stubs are composed of concrete blocks resting on the hall floor and can be removed, if required, in order to "view" the interaction point at an angle as small as permitted by the width of the quadrupole doublet, which is 13.5^{o}. In this case, the"viewing length" as limited by the walls of the hall is 12.5 m. At the outer side of the ring, all heavy building structures have been avoided in the sector between -23.5^{o} and $+23.5^{o}$ against the beam, and a "viewing length" of about 40 m can be made available in this region.

The height of the interaction points above the general hall floor level is 1.70 m. In their immediate vicinity, however, the floor is lowered by 2.8 m, giving a "viewing length" of 4.5 m from underneath. At interaction region I, the floor hole has an area of 8 by 8 m^2, centered around the interaction point, and will normally be covered by a steel structure.

At interaction region II, the floor hole is much bigger, covering an area of 10 by 26 m^2 and extending far toward the center of the high bay. This interaction region is intended for a large magnetic detector with 4π- geometry. Not knowing what the final dimensions of this detector as resulting from future physics, technology and cost considerations will be, we have tentatively conceived a maximum detector magnet compatible with the height and length of the interaction region and have designed the building geometry and foundation to fit it. This fictitious detector would have a cylindrical field volume 5,6 m in diameter and 4,3 m long in a superconducting solenoid which is surrounded by a 2500 t steel yoke of 8,5 m outer diameter and a length of 7 m. The detector would be supported on rails and could either be moved out of the beam toward the center of the high bay or splitted and moved in halves toward both sides. The bottom of the large floor hole, therefore, has a strong concrete foundation which is independent of the building.- There is room for a cryogenic plant extending from the hall into the adjoining laboratory building. - Since, at interaction region II, we expect to have a magnetic detector permanently installed, the side walls of the tunnel stubs need not be removable here and will be made solid.

The experimental counting rooms as well as the control room for the storage ring will be in the 3rd floor of the laboratory building running along the east side of the high bay. They will have direct view and short cable connection toward both interaction regions. The rooms will have air conditioning and double flooring for cables.

1,40 m Magnetic Detector

As a first prototype of a magnetic detector with large solid angle, a system with a cylindrical field volume of 1.40 m diameter and 1.15 m length is at present being developed at DESY. The magnet comprising a 20 KG superconducting solenoid, a 120 t steel yoke and a cryogenic supply system has been ordered half a year ago with an industrial firm and will be delivered at the end of this year. The coil is wound of a copper stabilized multicore twisted niobium-titanium conductor and is cooled by liquid helium at a temperature of $4.5^{o}K$. The refrigerator has a cooling capacity of about 90 W at $4.5^{o}K$.

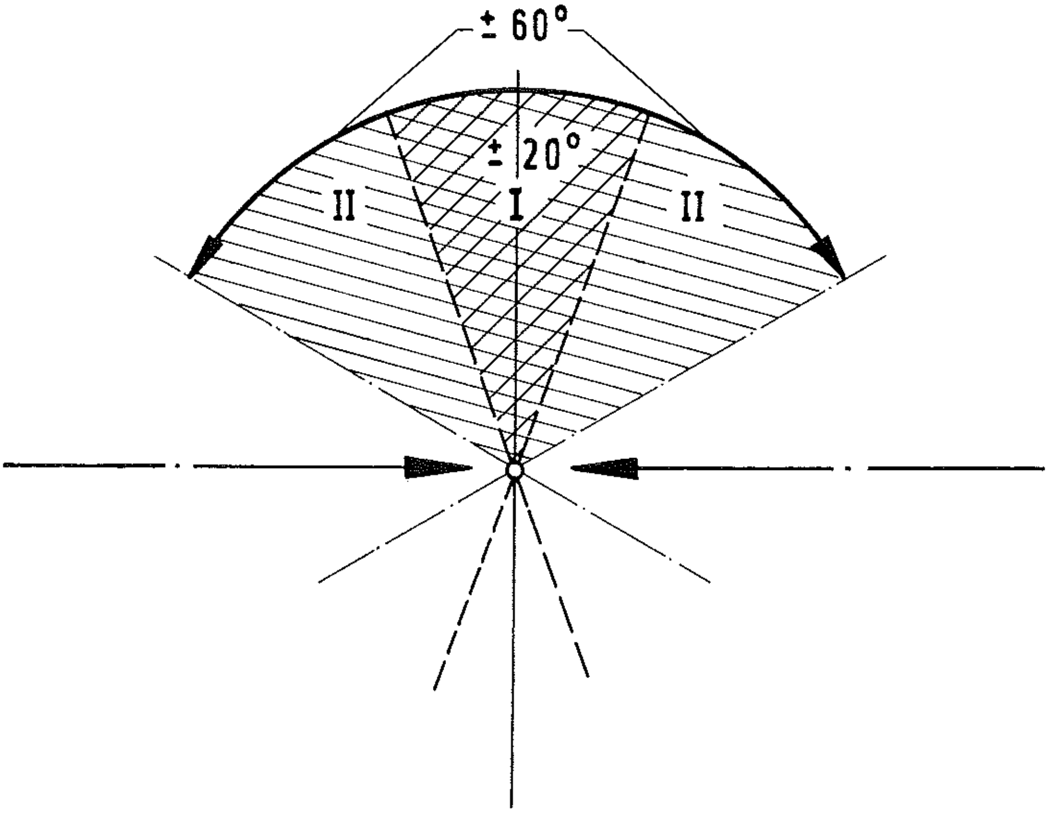
A model of the magnet is shown in Fig.8. The two half yokes slide on a common ground plate and can be retracted to give access to the field volume. Fig.9 shows the magnet cross sections. Side yokes and ground plate are slotted for insertion of muon counters. The interacting beams will be in a thin stainless steel vacuum chamber of initially 8 cm diameter which may be increased, if required, for reduction of background. In order to prevent beam distortion by the detector field, two coil versions are being considered.

The first version (A) is a superconducting shielding solenoid of 25 cm inner diameter which extends over the full length of the detector. It will be built of intrinsically stable twisted filament Nb-Ti wire. The coil including the cryostat will have a thickness of less than 5 cm and less than one radiation length. It will consist of 3 coils with two individual current settings for optimum field compensation along the beams. For technological reasons we started work on this version (A) although it is not the best for the analysis of some reactions. Its main disadvantage is the nuclear interaction and scattering of particles in the shielding coil.

The second version (B) avoids this disadvantage and will be worked out as an alternative. It consists of two compensating superconducting solenoids which are displaced toward the ends of the detector and leave a free gap in the center.

The interaction point will be surrounded by a trigger system which, in case of version (A), fills the cylindrical field-free space between the beam pipe and the shielding coil. This system will discriminate against undesired events and, at the same time, will determine the initial conditions of the particle trajectories. After passing the shielding coil, momentum analysis of the trajectories is done in the main field region. With a field of 20 KG, a minimum track length of 50 cm and 3 sets of wire chambers having a resolution of $\pm$ 1 mm, the expected momentum resolution is $\frac{\Delta p}{p} = 5\% \cdot p$ (GeV). For electrons, the inner coil helps to reject them. Adding a thin lead ring to make up a total of 2.5 radiation lengths, only one electron out of 10^4 will lose less than 20% of its energy there.

The central trigger or track recognition system as a crucial part of the experimental setup deserves some special attention. Regarding the particles emitted from the interaction point and distinguishing between two regions of emission angle, region I being confined between $\pm 20^o$ against the median detector plane and region II between $\pm 60^o$, we expect the following numbers of events per second at a luminosity of $10^{33} cm^{-2} sec^{-1}$:



final state	region I (±20°) [ev/sec]	region II (±60°) [ev/sec]
$e^+ + e^-$	$56/E^2$ [GeV]	$2000/E^2$ [GeV]
$\gamma\gamma$	$20/E^2$ [GeV]	
$\mu\mu$	$5/E^2$ [GeV]	
multibody		maybe $20/E^2$ [GeV]
background (gas bremsstrahlung)		$10^3 - 10^4/E^2$ [GeV] (not from I.P.!)

In view of these numbers, the trigger system should discriminate against background particles and against the elastic scattering events in region II while maintaining those in region I as well as all other rare events.

The trigger system proposed to serve this purpose is about 50 cm long and consists of the following two counter assemblies:

The 1^{st} counter assembly consists of

A cylindrical array of e.g. 2 x 6 plastic scintillation counters or eventually Charpak chambers with transverse wires which are supported from both ends of the trigger system and partly overlap in its central part. These counters define the angular region II, i.e. $\pm 60^{\circ}$ against the median detector plane, by single count, while the angular region I of $\pm 20^{\circ}$ is defined by coincidences between two overlapping counters.

The 2^{nd} counter assembly consists of

A set of two concentric cylindrical Charpak chambers. By observing coincidences between wires of the inner chamber and several wires of the outer chamber lying on or near the same radius vector, a "track" can be recognized as coming from the immediate vicinity of the beam axis (e.g. ± 6 mm). In addition, the wire logic will tell whether 2 tracks are "coplanar".

Using this counter system, an event is likely to be a good one if it simultaneously satisfies the following two criteria:

1) There are 2 or more "tracks" coming from the axis
2) There are <u>not</u> 2 "coplanar tracks" except in region I ($\pm 20^{\circ}$)

Criterion 1) strongly reduces the gas scattering and cosmic ray background, while criterion 2) eliminates the undesired elastic scattering events. - About 300 wires are needed in the cylindrical Charpak chambers, and the fast logic required for recognition of good events will fill a small rack only.

If necessary, a cylindrical Charpak chamber at a radius of about 70 cm could be added to the trigger system. Being at the outer side of the main field region, this chamber would provide a better rejection against machine background particles since these would not, in general, have enough transverse momentum to pass the 20kGauss region.

The wire chambers for momentum analysis in the field region will be triggered by the track recognition system. Either Charpak chambers or spark chambers with capacitive readout will be used, and prototypes for both types of chambers are being developed and tested at DESY. A total of 10 000 - 30 000 wires will be required for momentum measurement. In order to avoid ambiguities, three different wire orientations will be employed. The wires parallel to the beam axis will probably be held in cylindrical chambers, while the wires with oblique orientation will be mounted in plane chambers which are assembled around the axis in a hexagonal symmetry. The precision frame for holding the chambers will also have this sixfold symmetry. It will be held at the ends by a supporting structure which leaves free access to three of the chamber sectors without disassembly. The supporting structure at the other end is rotated by 60° such that the other three chamber sectors are freely accessible from that side. The logic connected to each wire of the Charpak chambers consists of an amplifier, a pulse shaper giving a ~ 60ns pulse for fast logic a one-shot with pulse shaper giving a pulse delayed by 400ns, an And-gate for triggering and a flip-flop for computer readout. The resolution will be about 100 ns. The price per wire for chamber, cable and logic is about 50 DM at present and can probably not be reduced below about 30 DM.

A cheaper solution is offered by spark chambers with capacitive readout. They allow a denser wire spacing (one instead of two millimeters) but have the disadvantage that their memory time is as large as 1 μs.

For the μ-Meson detection system embedded in the slotted steel yoke, scintillators or another 10 000 - 30 000 wires are needed. In the latter case it is intended, however, to use there a simpler and cheaper type of Charpak chamber.

It is planned to have the 1.40 m magnetic detector system operable by about the end of 1971. It can then, after appropriate running-in and testing, be applied in an experiment at the DESY synchrotron or at one of the existing storage ring facilities before being used for first-generation experiments at the DESY storage ring, starting in 1974. The experience gained in this development will, at some time, help to decide whether a larger second generation magnetic detector should be built and what its features should be.

Luminosity Monitors

After having tested the validity of QED, the best luminosity monitoring reactions will probably be the muon pair production and the elastic electron-positron scattering observed in region I of the magnetic detector at production angles between 70 and 110 degrees. Provision will also be made to measure the elastic scattering at about 3° by installing special vacuum chamber windows and counters at the ends of the interaction straight section in front of the large aperture quadrupole doublets.

Windows for viewing the interaction point at zero degrees are planned at a distance of 15 m, just behind the vertical septum magnet.

Single bremsstrahlung can be detected there, but only at smaller luminosities. At luminosities near $10^{33}cm^{-2}sec^{-1}$ a shower counter would be saturated, but with some precautions the total current in the photomultiplier could be used as a luminosity monitor.- The double bremsstrahlung will, at these luminosities, be completely swamped in the background arising from single bremsstrahlung chance coincidences.

Additional windows, so-called "tagging windows" will be provided in the optical structure around the interaction region for the detection of electrons emerging from single bremsstrahlung events. These electrons, having lost a certain fraction of their energy, are momentum analysed by the quadrupole and bending fields. Fig.10 shows the trajectories of forward electrons having retained between 20 and 90 percent of their initial momentum. There will be tagging windows in the center of the large aperture doublet, in the auxiliary septum magnet and behind the main septum magnet, which will accept electrons in narrow momentum bands around 20%, 35%, 45%, 80% and 85% of the initial momentum, respectively. It is the main advantage of this monitor system that it only depends on the magnetic fields and not on γ-counter thresholds. At luminosities near 10^{33} $cm^{-2}sec^{-1}$, the so-called "tagging electrons" as well as the $\approx 0^{o}$ photons coming from single bremsstrahlung will only contain a small contamination of gas bremsstrahlung.

The tagging windows can also be used for detecting electrons from the so-called Kessler-reactions or γγ-scattering. In these reactions, electron and positron emerge at about 0^{o}. The cross section is expected to be of the order of $10^{-33}cm^{2}$ independent of energy.

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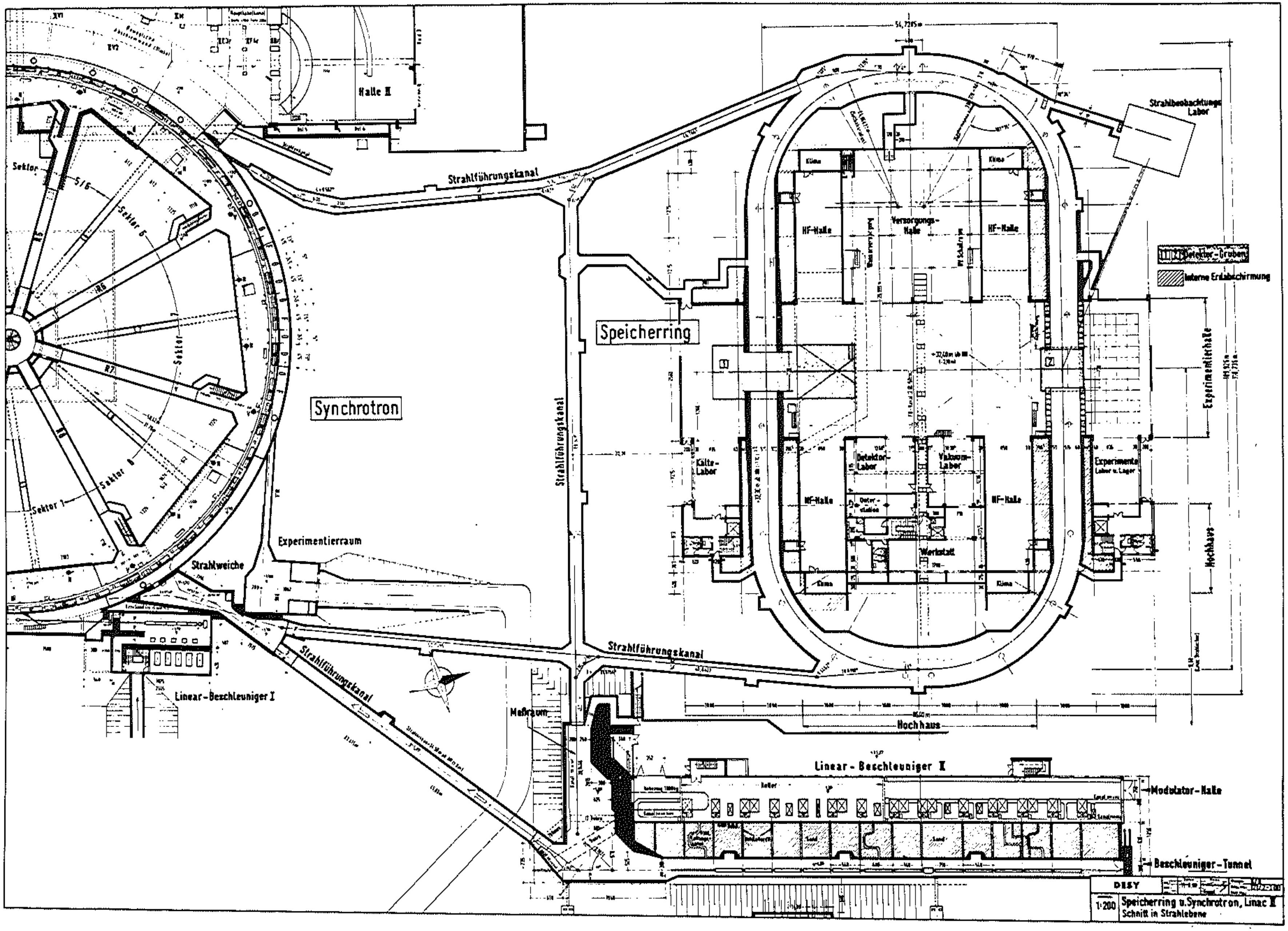
List of Figures



Synchrotron
Speicherring
Strahlführungskanal
Strahlführungskanal
Strahlführungskanal
Strahlführungskanal
Halle II
Experimentierraum
Strahlweiche
Linear-Beschleuniger I
Linear-Beschleuniger II
Meßraum
Modulator-Halle
Beschleuniger-Tunnel
Strahlbeobachtungs Labor
Versorgungs-Halle
HF-Halle
HF-Halle
HF-Halle
HF-Halle
Detektor-Labor
Vakuum-Labor
Kälte-Labor
Experimente Labor u. Lager
Werkstatt
Experimentierhalle
Hochhaus
Hochhaus
Detektor-Gruben
Interne Erdabschirmung
Sektor 5/6
Sektor 8
Sektor 1
DESY
1:200
Speicherring u. Synchrotron, Linac II
Schnitt in Strahlebene

Fig. 1

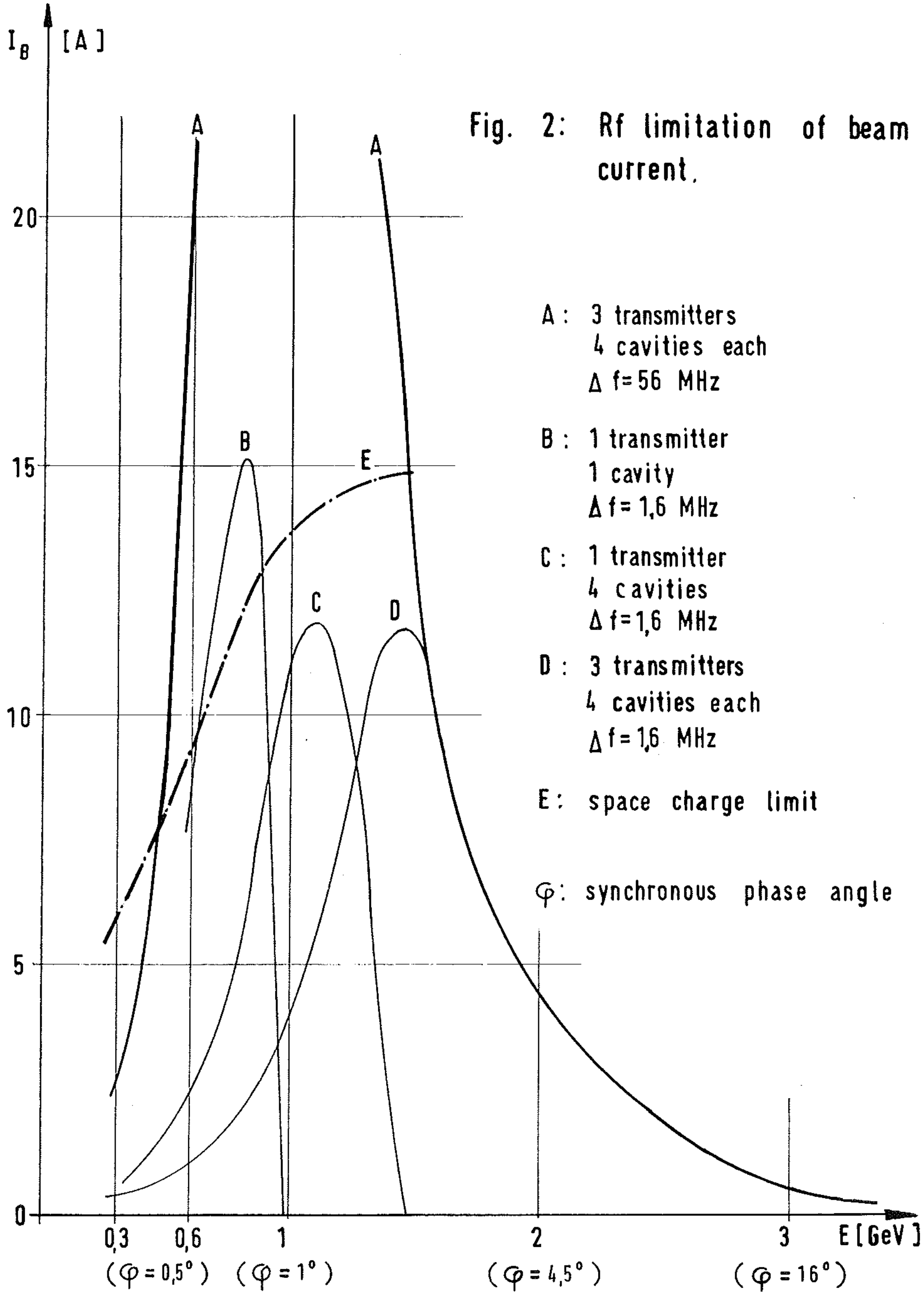


Fig. 2: Rf limitation of beam current.

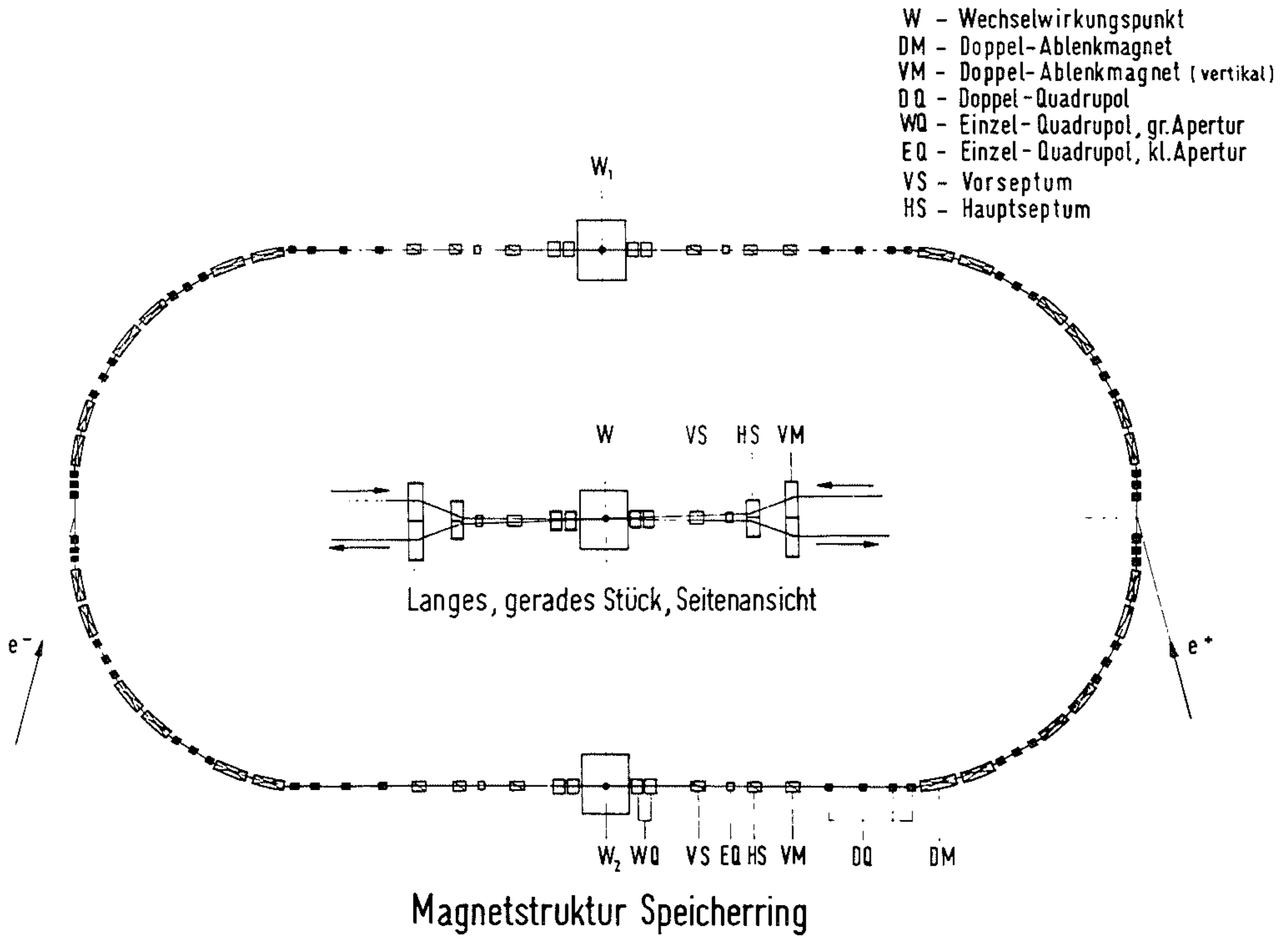

W - Wechselwirkungspunkt
DM - Doppel-Ablenkmagnet
VM - Doppel-Ablenkmagnet (vertikal)
DQ - Doppel-Quadrupol
WQ - Einzel-Quadrupol, gr. Apertur
EQ - Einzel-Quadrupol, kl. Apertur
VS - Vorseptum
HS - Hauptseptum
W1
W
VS
HS
VM
Langes, gerades Stück, Seitenansicht
e−
e+
W2
WQ
VS
EQ
HS
VM
DQ
DM
Magnetstruktur Speicherring

Fig. 3

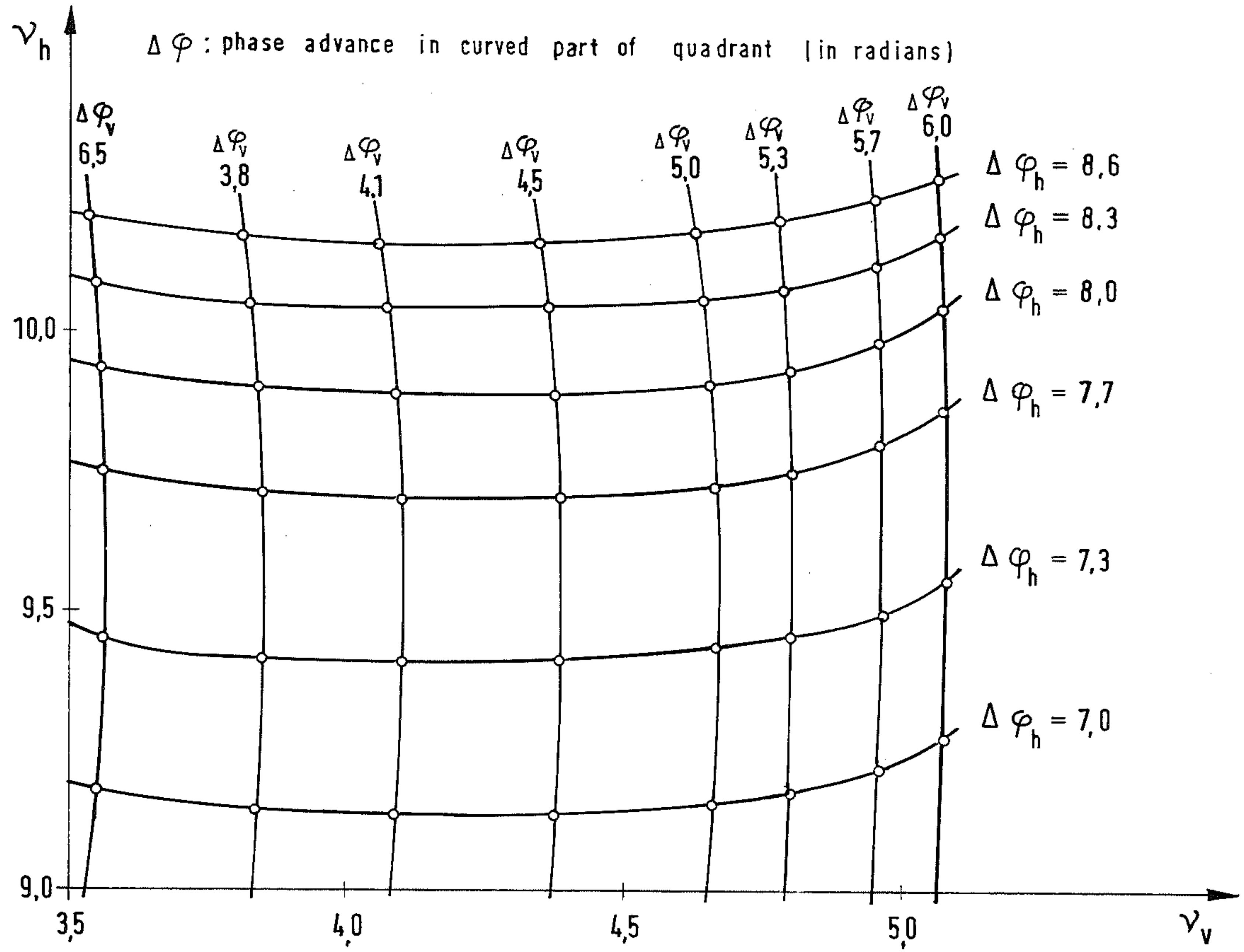
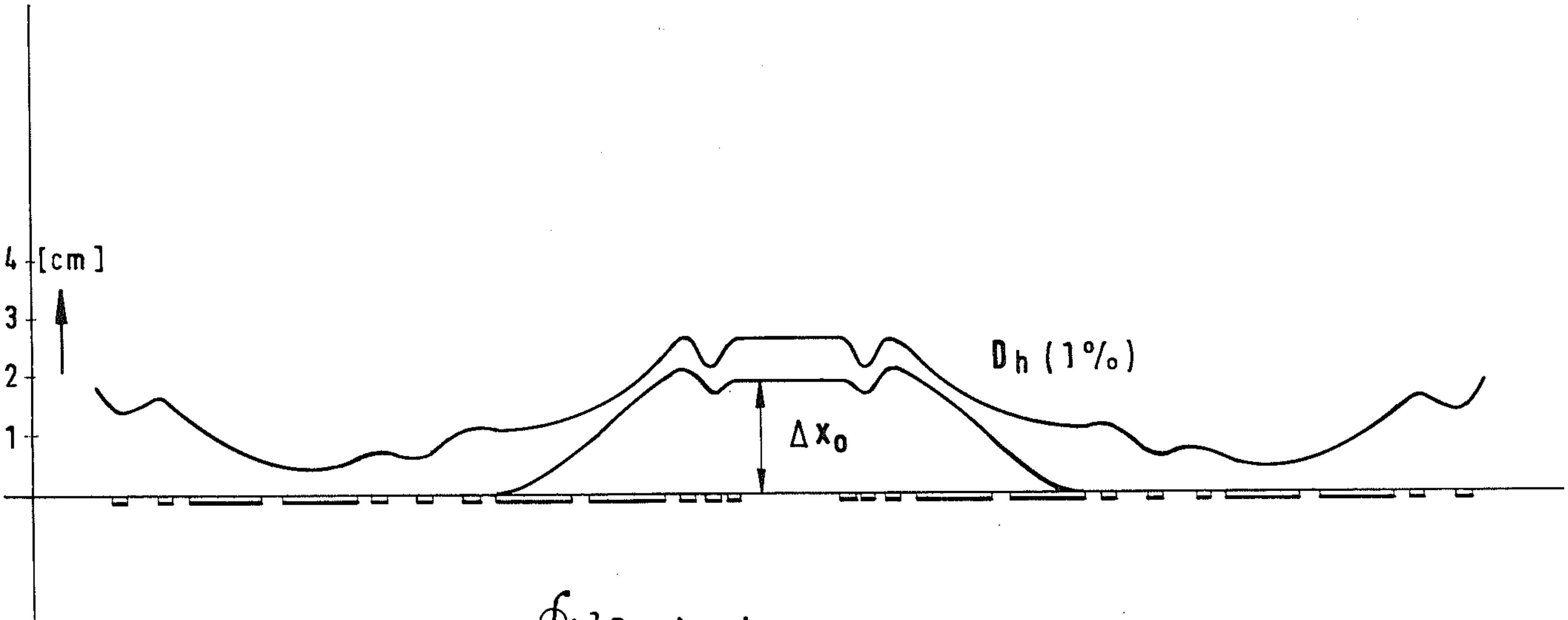


Fig. 4: Range for variation of ν -values



$$\Delta \alpha_{syn} = - \frac{\varepsilon_0}{E_0} \frac{\oint k^2 D_h \, \Delta x \, ds}{\oint \frac{1}{\rho^2} \, ds}$$

Fig. 5: Beam bump for variation of damping distribution

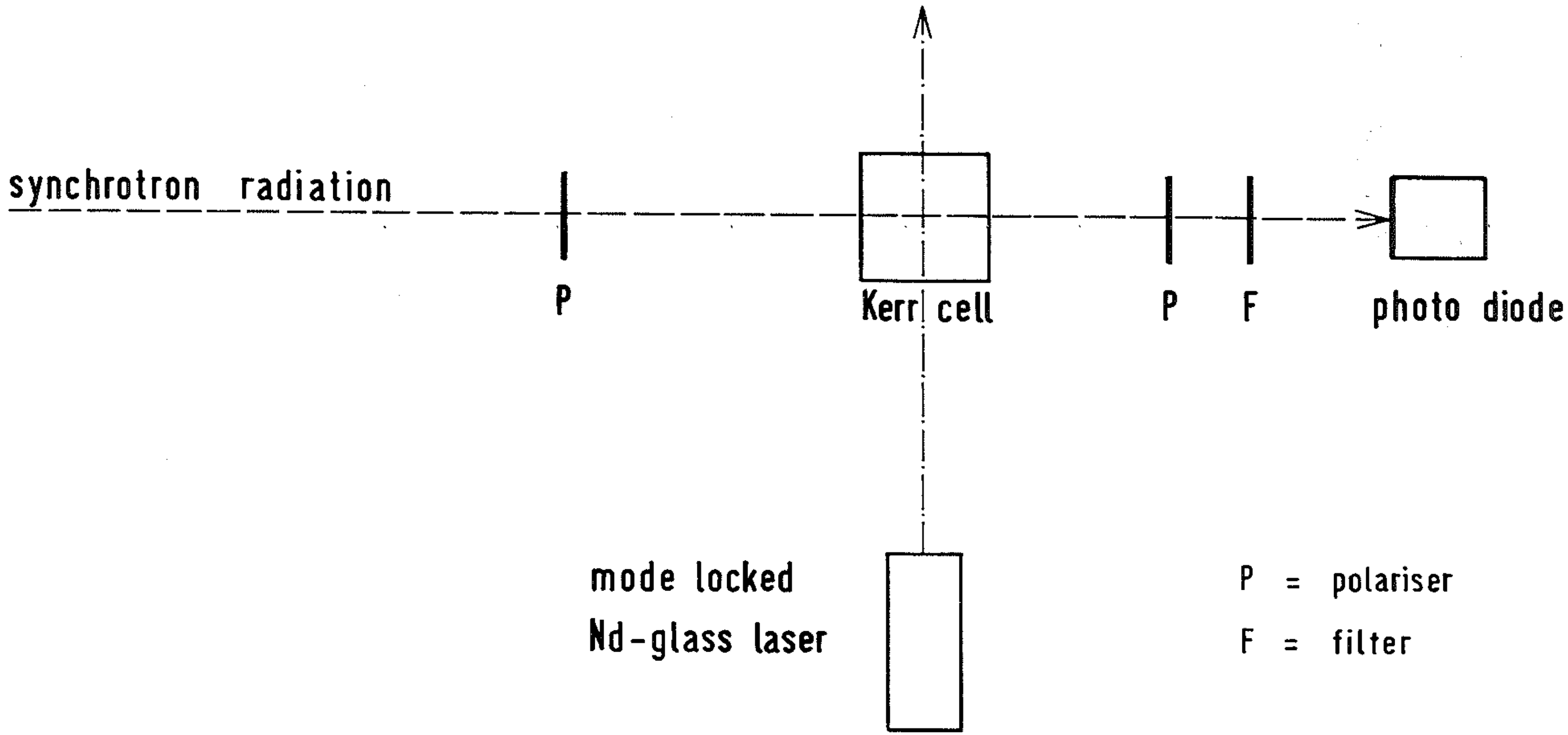


Fig. 6: Scheme for measurement of bunch length

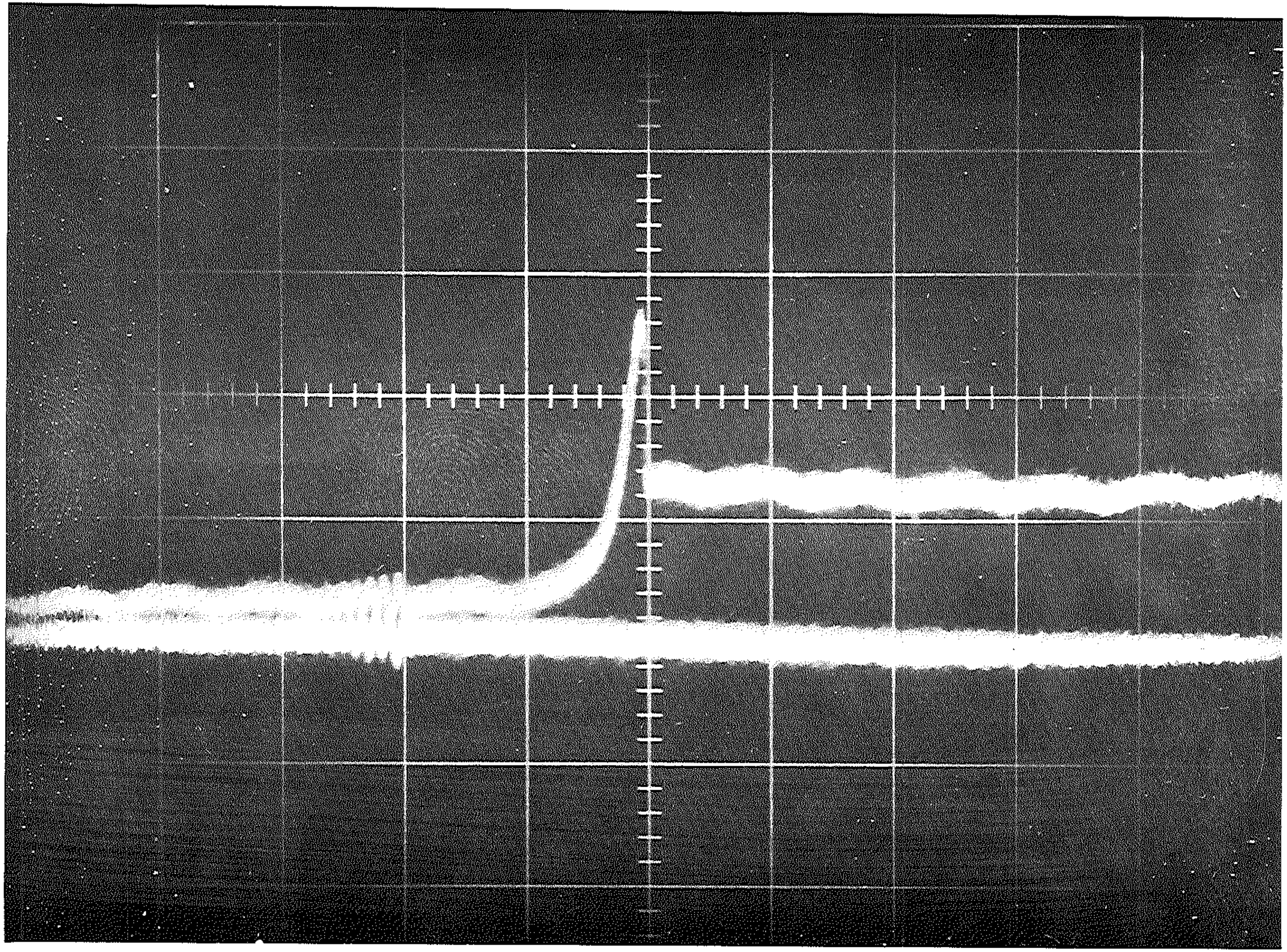


Fig. 7

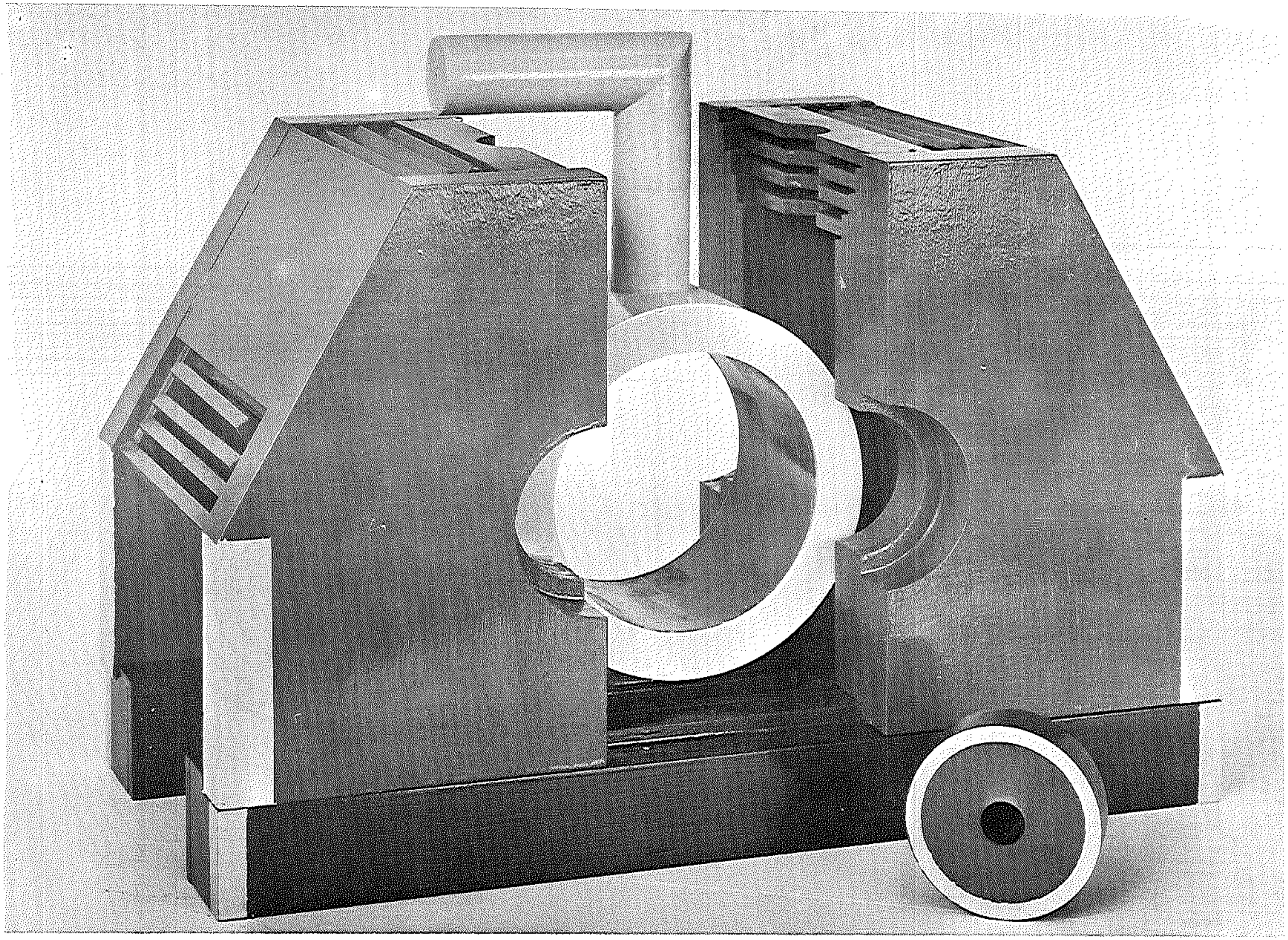
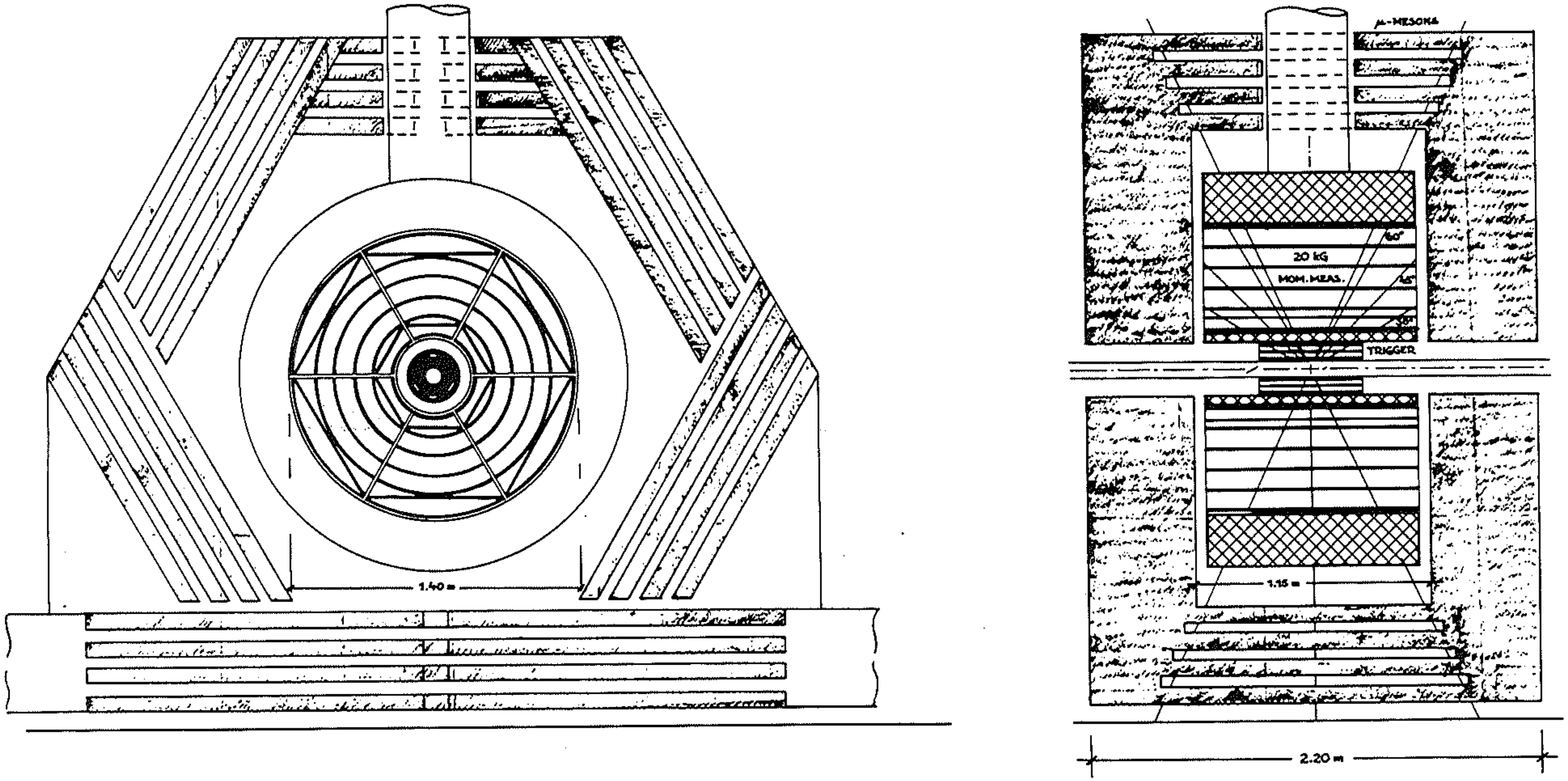


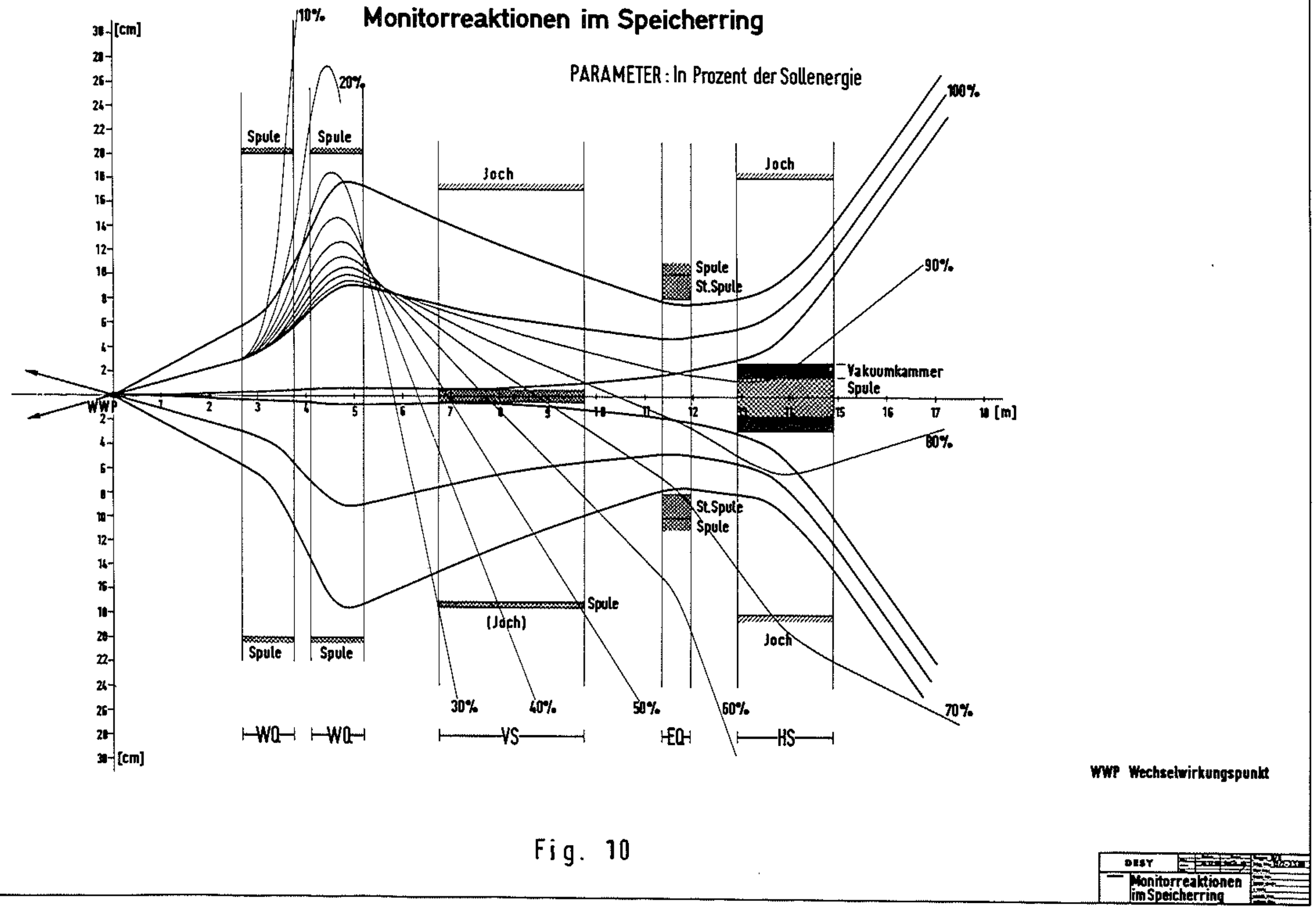
Fig. 8



SMALL DETECTOR - JAN. 1970 VERSION.

DESY F39.

Fig. 9



Monitorreaktionen im Speicherring
PARAMETER: In Prozent der Sollenergie
[cm]
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Spule
Joch
St.Spule
(Joch)
Vakuumkammer
Spule
WWP
[m]
WQ
VS
EQ
HS
WWP Wechselwirkungspunkt
DESY
Monitorreaktionen im Speicherring

Fig. 10