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DIRAC (I191) PRELIMINARY OPTICS IN EAST HALL

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Introduction

After the first contacts with people of what is now the DIRAC collaboration, we proposed to use the present ZT7 area for housing the experiment when it will be approved.

This location has been selected with due attention to the required beam characteristics and the physical space requirement of the proposed experiment. Another constraint was to limit the impact of this installation on other already running facilities.

More information on the general working of this complex can be found in Ref. 1.

The ZT7 test area uses the PS slow extraction channel SE61 and shares the beam between two targets, north and south. The extracted beam is common to both lines e17 and e17s and is split in the vertical plane by a special septum magnet which controls the beams intensity ratio.

This experimental area is located in the PS East Hall (building 157) and the required transformations should not impair the continued smooth running of the three others test zones (ZT9, ZT10 and ZT11) fed from the north target.

Proposed layout

It is shown on Fig. 1. The ZT7 experimental area has enough space to physically hold the DIRAC experiment as proposed, taking the required additional shielding into account.

The main constraint is to bring the primary proton beam to the experimental focus, with more bending power than now available, due to the increased rigidity of the 24 GeV/c beam with respect to the maximum of 10 GeV/c for the existing secondary ZT7 beam line.

More elements are obviously needed in order to control the focus location and size as well as to make small vertical and horizontal adjustments.

The shielding requirements have been estimated in collaboration with the TIS division. The amount of required material, installation time, cost and required resources have been analyzed by the PS/PA/IN section (Ref. 2.).

SE61 characteristics

Slow extraction is available from PS "B cycles" of 2.4s duration with the following beam characteristics:

- One or two B cycles per PS super cycle of 14.4s, usually one unless negotiated and possible.
- One single beam is extracted from the machine and split with a special magnet in two branches, the bent one going to the south target would be reassigned to I191; the undeflected part going to

the north target serving ZT9, ZT10 and ZT11 test areas as usual. The extracted beam is shared between the two channels, their relative intensities being set by adjusting the splitting magnet and/or the beam parameters at its location.

- Nominal momentum is 24 GeV/c
- Spill length is usually 350ms, maximum spill length being just over 400ms, the useful flat-top does not allow more, once the needed beam manipulations are considered.
- The primary beam intensity is limited to $2.0*10^{11}$ p/spill per target, due to radiation safety constraints in the downstream part of the hall. Higher intensities will probably require additional shielding on all test lines as well as for I191.
  It can be reduced either by reducing the ejected beam intensity (other users allowing) or modification of the splitting ratio. However very asymmetric sharing usually implies increased sensitivity to input emittance changes and instabilities. Acceptable beam behaviour can be guaranteed up to an intensity ratio of about 1/5.
- There is a mean momentum change during extraction, inherent in the extraction mechanism. The mean beam momentum increases by about 0.3% along the spill. This can be compensated for with the help of properly located programmed magnet(s).
- The instantaneous momentum spread is close to 0.08% (2σ) and cannot be compensated for.
- The intensity vary during the spill, say ~20% as better resolution is not usually required. Less variation is deemed possible. This may requires some MD time in order to assess what is possible.
- For computation purposes, later in this note, vertical and horizontal beam emittances are both taken to be 2.0π.mm.mrad (2σ values).

DIRAC requirements

1. Get H and V focus with controllable spot size at their target location (range [2 .. 6] mm at specified emittances).
2. Ability to move the target up to 2m upstream while satisfying the previous constraints.
3. Low beam induced noise in the vertical plane in order to avoid degradation and/or false triggering of silicon detectors located off-axis (2 m downstream, edge is 2.5^0 above the beam).
4. Intensity variable between $2*10^{10}$ and $2.0*10^{11}$ p/spill (typical around $4*10^{10}$) in the longest possible spill time (~400ms). The instantaneous intensity should not vary more than 5%.
5. Stability of the beam center of gravity at the target location in the order of 1mm or better, inside the spill and from spill to spill.
6. Low back scattering noise from the beam catcher.

Proposed optics

Its general layout is shown on Fig 1. It consists of two quadrupole doublets separated by a string of dipoles. Some corrections elements have been added to get proper control of the beam position, statically as well as dynamically.

- *Main transport mechanism :*

The first doublet mostly contains the beam in the beam pipe but is also used in conjunction with the last one in order to fulfil the optical constraints at the target.

The dipole string bends the beam and can make some slight position adjustments. It has to be located the more upstream as possible to minimize the bending power required (148 mrad).

The last doublet, with the help of the first one will bring the beam on target with the required properties. Its location, spacing and optics function have been chosen such as to minimize the dispersion at the focus. Given the geometrical and variability constraints, it has not been possible to find a solution with zero dispersion at the focus, valid in all the range.

The selected solution allows a variation of β^* in the range [2 .. 20] m in both planes independently in the full depth of field while minimizing the residual dispersion at the focus as well as the displacement of the zero dispersion point where the horizontal corrector has to be placed (see fig. 2).

Simple optical considerations indicate that the minimum beam noise on the silicon detectors is obtained when the vertical β^* is set equal to the distance separating the vertical focus from the detector. Positioning of the horizontal corrector was made under this condition.

- *Correcting elements :*

A small, programmable, horizontal bend has been placed at a location of zero dispersion in order to cancel the beam sweep during the spill (driven by the residual dispersion or any time dependent cause). It can also be used to finely tune the horizontal mean position; in conjunction with one of the main bends, both angle and position may be controlled.

A small vertical bend was also added, at the proper location, to adjust the vertical position. The angle in the vertical plane can not be controlled.

- *Line tuning monitors :*

The screen MTV08 can be displaced at the location shown. This will allow a crude tuning of the line, before the final focus.

Some additional diagnostic should be available at or close to the final focus to fine tune the beam where it is needed. Beam profile and time structure information within the spill would be very useful. Discussion on the type of device is ongoing.

Most magnets and quadrupoles are recovered from the present ZT7 line, two are coming from our own stock. All are available as are the needed power supplies.

Beam tails

As indicated, the DIRAC experiment will be sensitive to the beam distribution far from the core. Preliminary measurements have been done last June (results are on fig. 3) on a primary beam tuned such as to be close to the required focus conditions. Those measurements have been done using radiation dosimeter, with the help of the TIS commission (Ref. 3).

More precise measurements were planned last fall but could not be done due to the very tight schedule of the East Area at that time. It will be done at machine start-up this year, measuring the beam profile in the vertical plane using a scintillator set-up (absolute flux, far away from the beam center).

Conclusions

A satisfactory solution has been found to match the optical requirements of the I191 proposal. The proposed solution only uses available components and could be used a such. Slight optimization is still possible if a restricted range of tuning is selected. Two questions need some more investigation and are currently under scrutiny, namely the beam profile density in the tails and the beam intensity modulation during the spill.

References

[1] Secondary beams for tests in the PS East Experimental Area, PS/PA Note 93-21.

[2] Zone experimentale Est, Experience I191 (DIRAC project), PS/PA Note Installation 93-10.

[3] Private communication, M. Tavlet, TIS.

Figures

Distribution

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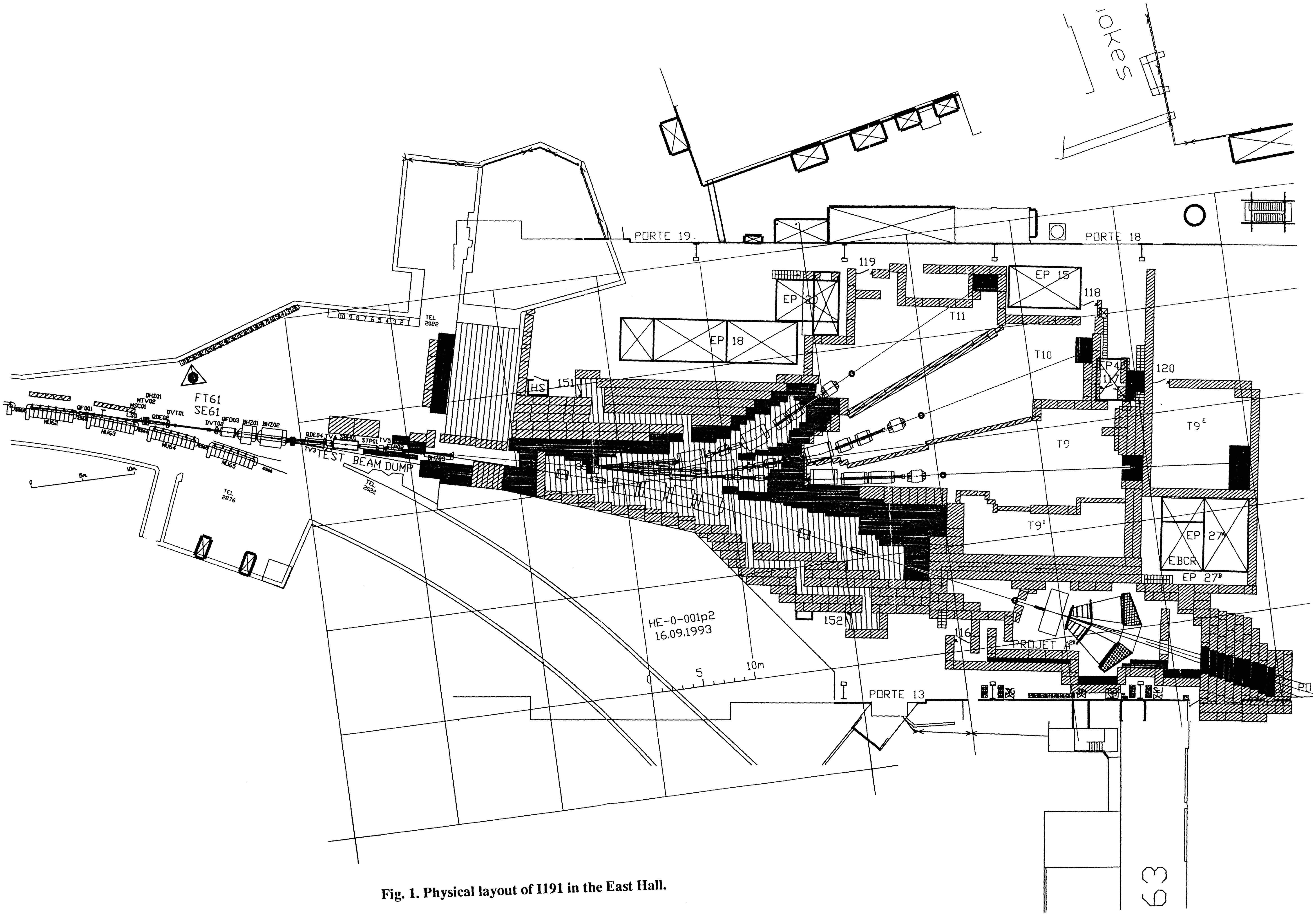

Fig. 1. Physical layout of I191 in the East Hall.

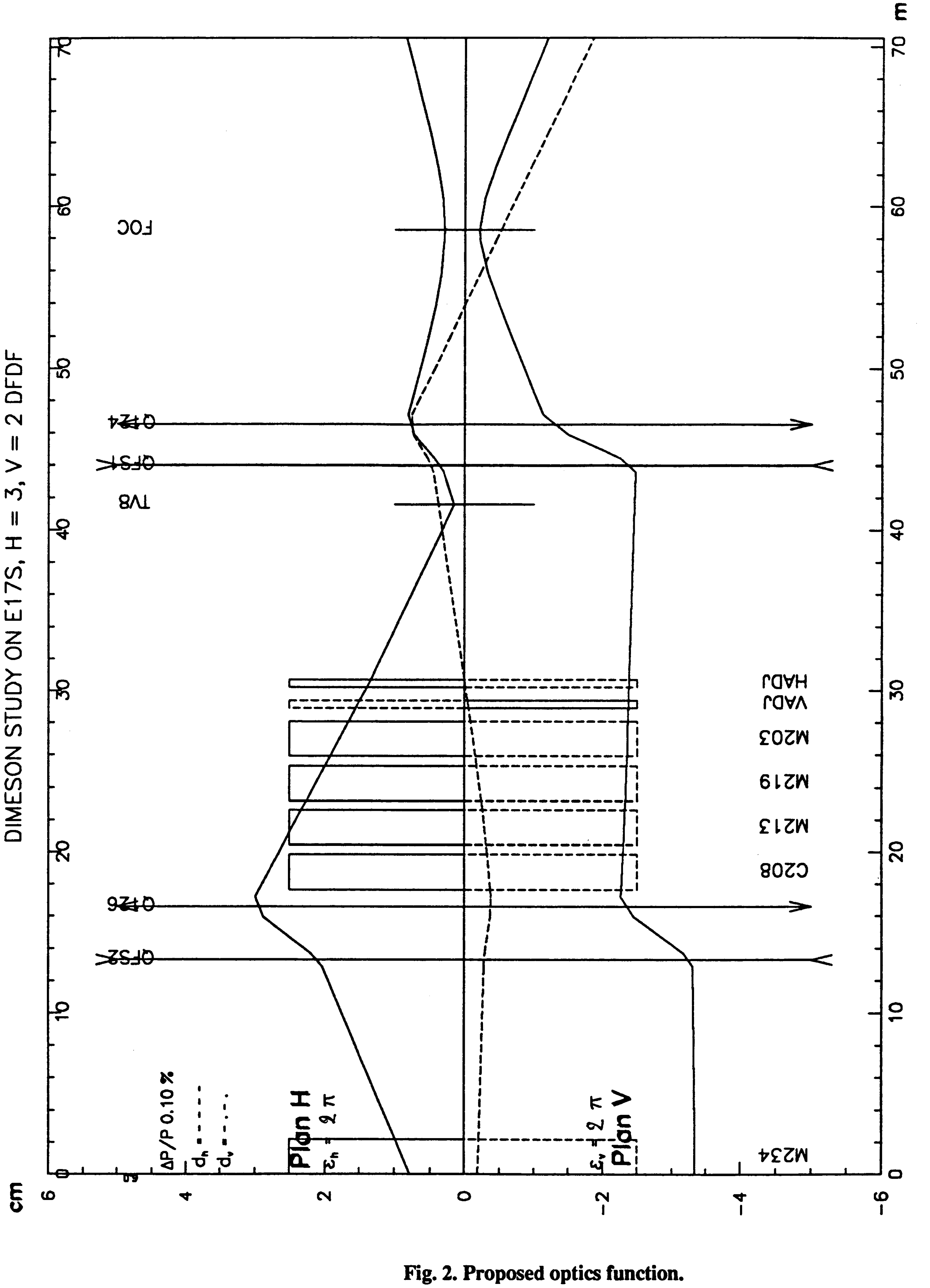

Fig. 2. Proposed optics function.

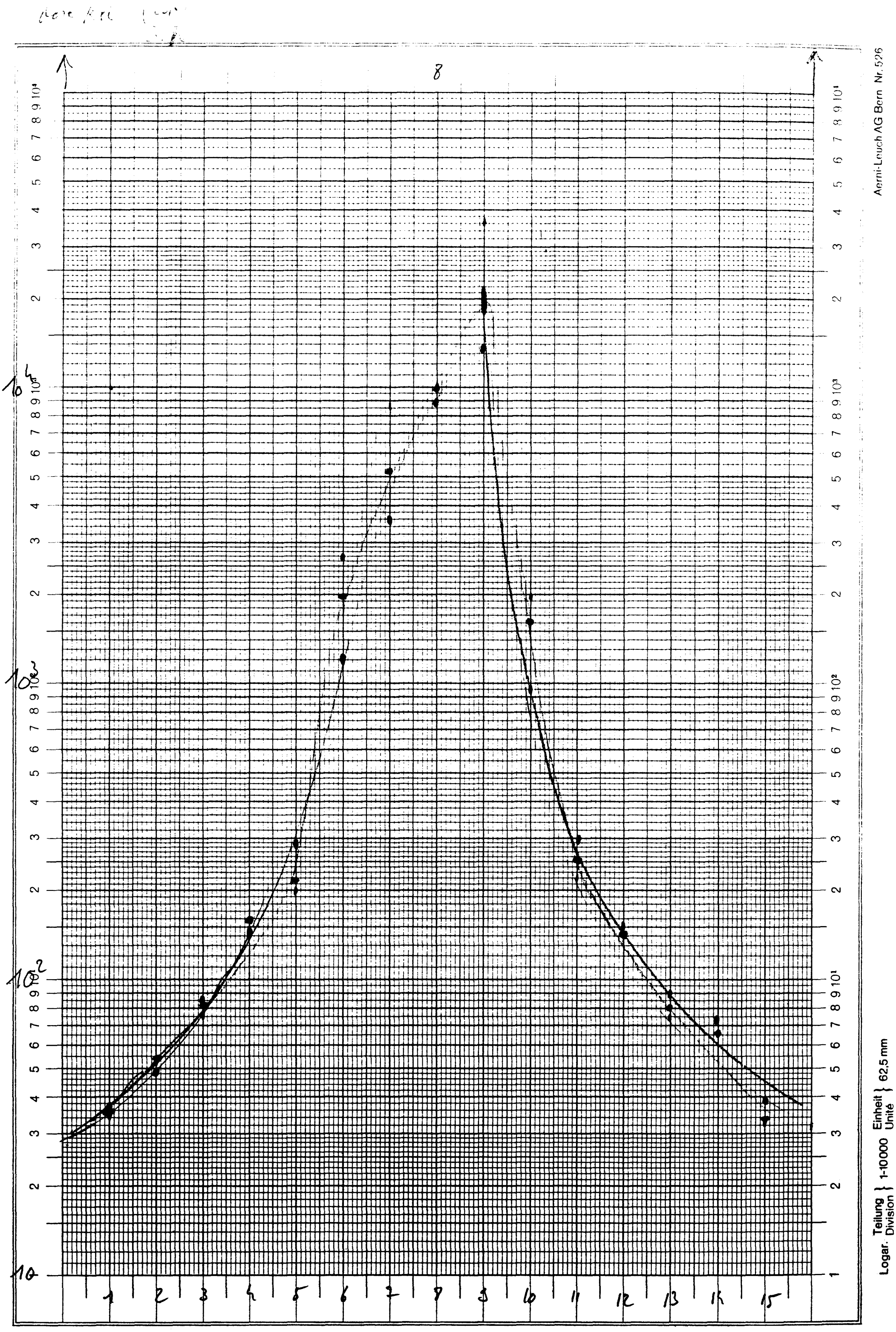

Fig. 3. Beam profile results, dosimeter step = 4 mm, 1.5*10^{14} protons.