ANL/AOD/CP-103175

# Commissioning Of Experimental Enclosures ("Hutches") At The Advanced Photon Source - A to Z ALARA:

John Vacca, P. K. Job, A. Rauchas, A. Justus & V. R. Veluri
Argonne National Laboratory, Argonne, IL 60439)

**Introduction**: The Advanced Photon Source (APS), 7 GeV electron Storage Ring at the Argonne National Laboratory is designed to be a major national user facility providing high-brilliance x-ray beams. Fig. 1 shows a plan view of the APS. At completion, APS will have 35 bending magnet (BM) beamlines and 35 insertion device (ID) beamlines. A typical x-ray beamline at APS comprises of a front end (FE) that confines the beam; a first optics enclosure (FOE) which houses optics to filter and monochromatize the beam; and beam transports, additional optics, and the experiment stations. Fig 2. shows a section of the storage ring with the layout of the ID and BM beamlines and typical experiment stations. The first x-ray beam was delivered to an experiment station in 1995. Ever since, to date, over 120 experimental stations (hutches) have been commissioned and are receiving intense x-ray beams of varying energies for various experiments. This paper describes in some detail the steps involved in the process of commissioning experimental stations and the implementation of the ALARA at each step.

**Physical Dimensions & Typical Shielding of Hutches**:

To give a better feel for the reader, typical physical dimensions of the walls of the hutches are summarized below.

**Table 1. Physical Dimensions of the Walls of the Hutches**

| | Length | Width | Height |
|---|---|---|---|
| FOE | 9.1 m | 1.8 m | 3.4 m |
| Hutch | 3.7 m - 11 m | 3.7 m - 4.3 m | 4.3 - 6.1 m |

The recommended lead shielding thicknesses (Ipe et al., 1993) of the hutch walls depending on how the beam is derived ( Insertion Device or Bending Magnet) and the beam characteristics (White beam or Monochromatic beam) is summarized below.

**Table 2. Recommended Lead Shielding Thickness (White Beam Hutches)**

| | Insertion Device Beamline | Bending Magnet Beamline |
|---|---|---|
| Back Wall | 50 mm (+ 50 mm at center) | 12 mm (+12 mm at center) |
| Lateral Walls | 19 mm | 8 mm |
| Roof | 12 mm | 6 mm |
| **(Monochromatic Hutches)** | | |
| Back Wall | 12.5 mm | 7 mm |
| Front & Lateral Walls | 10 mm | 6 mm |
| Roof | 6 mm | 4 mm |



The lead shielding is snugly sandwiched between 3 mm of steel sheet on the outside and 2 mm on the inside.

**Pre-Commissioning Surveys:**

The pre-commissioning surveys are thoroughly done before an x-ray beam at a pre-selected current (about 20 mA) is stored in the storage ring. The visual check list includes, the verification of the front-end installation, the locations of stops and collimators inside the station, the doors, labyrinths, and seams ( See Figures 3 and 4). In addition, the labyrinths are checked for appropriate tags and seals. As appropriate, the Ozone monitor, air blowing system etc., are also checked for proper operation. The appropriate radiation scatterers (Tungsten block for bremsstrahlung and cooled Aluminum piece for white beam) are installed and aligned in the beam path. For monobeams, air becomes the scattering medium. The general radiation background around the entire area is established. A sufficiently large area surrounding the enclosure scheduled to receive the first x-ray beam is roped off as an exclusion area. The enclosed area is appropriately posted with visible signs. The health physics technicians obtain briefing prior to beam delivery. The number of people that could participate in the commissioning activities is restricted to a minimum. One can appreciate the importance of these pre-surveys and checks if one realizes that a highly collimated APS x-ray that strikes the first optical element as a concentrated beam could have a total power of 1 to 10 kW. At peak, this can be 300 watts per square millimeter, a power density that is greater than that of electron beam welders used to melt metal.

**Commissioning Activity Surveys:**

The actual commissioning activity of a hutch is a joint exercise comprising the technical personnel of several groups, such as the Collaborative Access Team (CAT) members who are the ultimate users of the beamline, the APS personnel, and the Health Physics personnel. The primary instruments used for the radiations survey are: (1) a GM Survey Meter such as a Pancake Probe which has a photon sensitivity as low as 6.0 keV and its ability to access into small crevices between the doors and seams. (2) A Pressurized Ion Chamber such as a Victoreen 450P for detecting and measuring photons above 25 keV with operating range extending down into 0.01 μGy levels (μR levels) of exposure. The Health Physics technicians are advised to have an immediate access to a Neutron Rem meter such as a Hankin's Sphere or Anderson-Braun (BF-3 probe) as necessary.

The Main Control Room (MCR) of APS is requested to provide a low current beam ($\leq$20 mA). With the x-ray beam delivered into the enclosure, radiation surveys are conducted. This radiation surveys are essentially meant to check the integrity of the experiment enclosure and identify any leakage through the seams, doors, specific interfaces, the labyrinths and the entry and exit ports. Although, the approved commissioning procedure ( Veluri et al, 2000) mandates the stoppage of survey work if the leakage radiation exposure measurement is >50 μGy per hour( 5mR per hour) the technicians are advised to record exposure levels as low as the instruments could detect. In addition, if 2.5 μGy per hour (0.25 mR per hour) exposure in accessible areas such as the sides of the walls, near doors, etc., and 25 μGy per hour (2.5 mR per hour) exposure at inaccessible areas such as roofs are agreed as acceptable minima for operations. The APS management is committed to certifying the hutches as permissible to receive x-ray beams for experiments only if the radiation levels are less than the acceptable limits measured with the state-of-the art- instrumentation available for the health physics technicians. As such, the technicians initially comb for leakage radiation with the GM Pancake probe and record any readings above the usual background (60 cpm) level. At higher count rates, the exposure rate is measured using the an Ion Chamber mentioned elsewhere, and recorded. The leakage areas are marked on the hutch drawings and if possible at the exact locations on the hutch itself. A Tungsten block (2 cm thick) is appropriately placed within the beam path to scatter the beam. This is to facilitate for bremsstrahlung scatter and the subsequent leakage. Again, the seams, labyrinths, doors and the interface of the doors with the walls are surveyed and the radiation exposure levels are appropriately documented. Next, a cooled Aluminum piece (5 mm thick) is appropriately placed within the beam path as a scatterer for white beams. Measurements are repeated at above. The leakage areas are mitigated with the addition of lead and the hutch is re-verified for the entry of the full beam at a later date. In the course of commissioning and certifying over 120 hutches, the leakage radiation exposure levels up to the following levels have been observed.

For some of the First Optics Enclosures (FOEs) levels ranging from 5 μGy per hour at the enclosure wall/experiment hall floor interface (marked as D in Fig. 3) wall to up to 200 μGy per hour at the exit ports ( marked as E in Fig. 3) were measured with the storage ring current at 20 mA. For hutches scheduled to receive white/mono beams, the exposure levels ranged from 5 μGy per hour at some locations marked as D in Fig. 4 and up to 35 μGy per hour at some locations marked as C in Fig.4. All these levels have been mitigated to near background levels by installing additional lead at the appropriate locations, before the hutches were certified to receive the full beams.

Once the hutch is certified to receive the x-ray beam as intended, the hutch is placed on a routine survey mode by the Health Physics Group and it receives routine check annually as per the approved procedure (Veluri et al, 1999).

**Conclusion**:

Evidently, one can see that at each step of the commissioning process of an experiment enclosure to receive full x-ray beam, how ALARA principles were invoked and implemented. To wit, the pre-commissioning check list, the choice of the lowest beam current in the storage ring, the levels of leakage radiation observed and mitigated to near background amply indicate the commitment of the Advanced Photon Source (APS) management to the implementation of ALARA to the fullest extent achievable.

**Acknowledgements**

The authors wish to thank the ANL-E, Health Physics Technicians assigned to the Advanced Photon Source facility and members of the Health Physics Instrumentation Group for their continued assistance.

This work was supported by the U.S. Department of Energy, Office of Basic Energy Sciences, under Contract W-31-109-ENG-38.

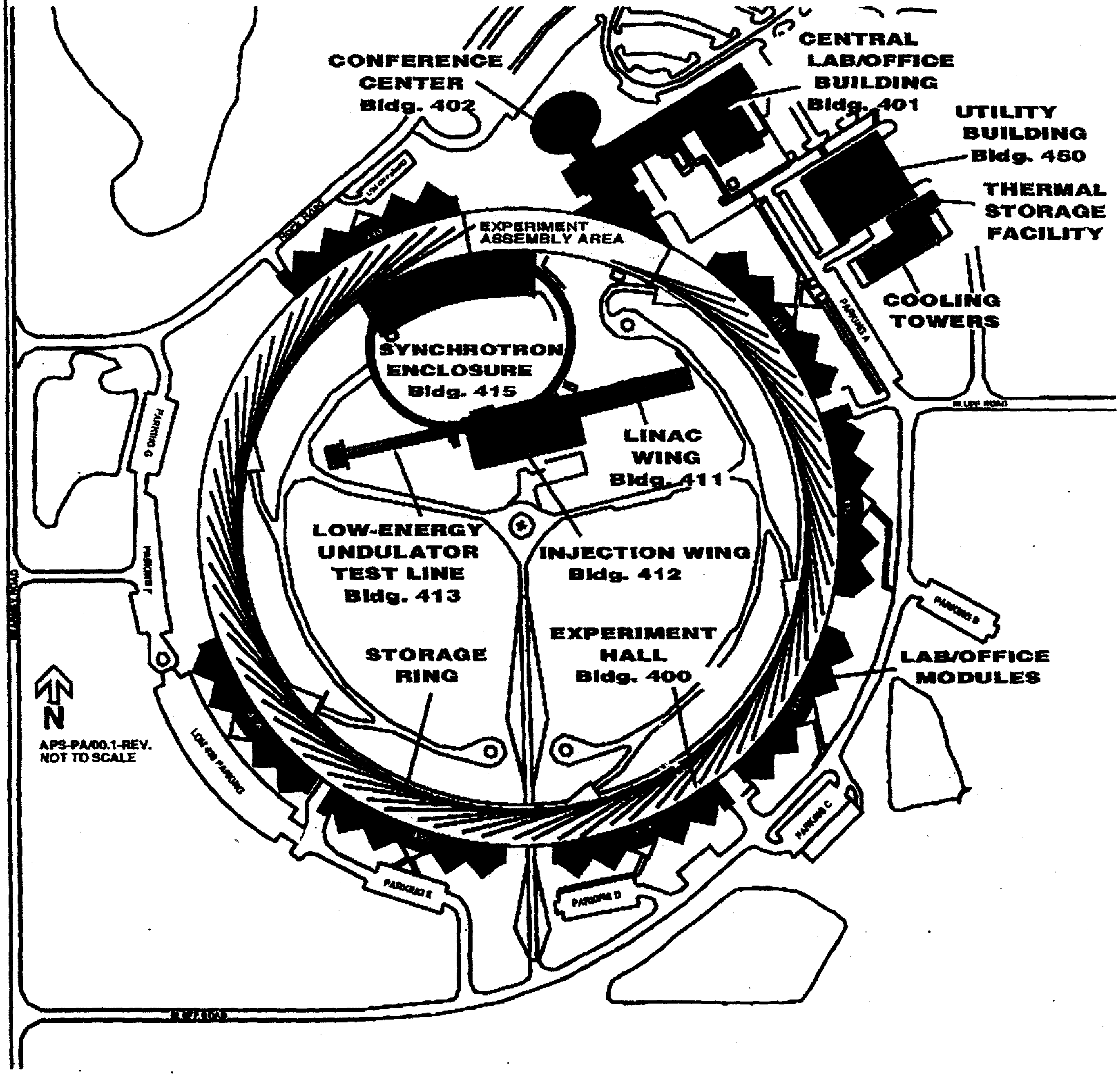
**References:**

Guide to Beamline Radiation Shielding Design at the Advanced Photon Source, N. Ipe, D. R. Haeffner, E. E. Alp, S. C. Davey, R. J. Dejus, U. Hahn, B. Lai, K. J. Randall, and D. Shu, Argonne National Laboratory, Argonne, Illinois 60439, ANL/APS/TB-7, November 1993.

Experimental Enclosure Routine Radiation Survey Procedure, V. Rao Veluri, J. Vacca, P. K. Job and A. Rauchas. Argonne National laboratory, Argonne, Illinois 60439. APS/XFD/ESH-PROC-002, Revision 01- April 20, 1999.

Experimental Enclosure Commissioning Radiation Survey Procedure, V. Rao Veluri, P. K. Job and A. Rauchas, Argonne National Laboratory, Argonne, Illinois 60439. APS/AOD/ESH-PROC -001 Revision 02- March 7, 2000.

Fig. 1 Plan View of the APS



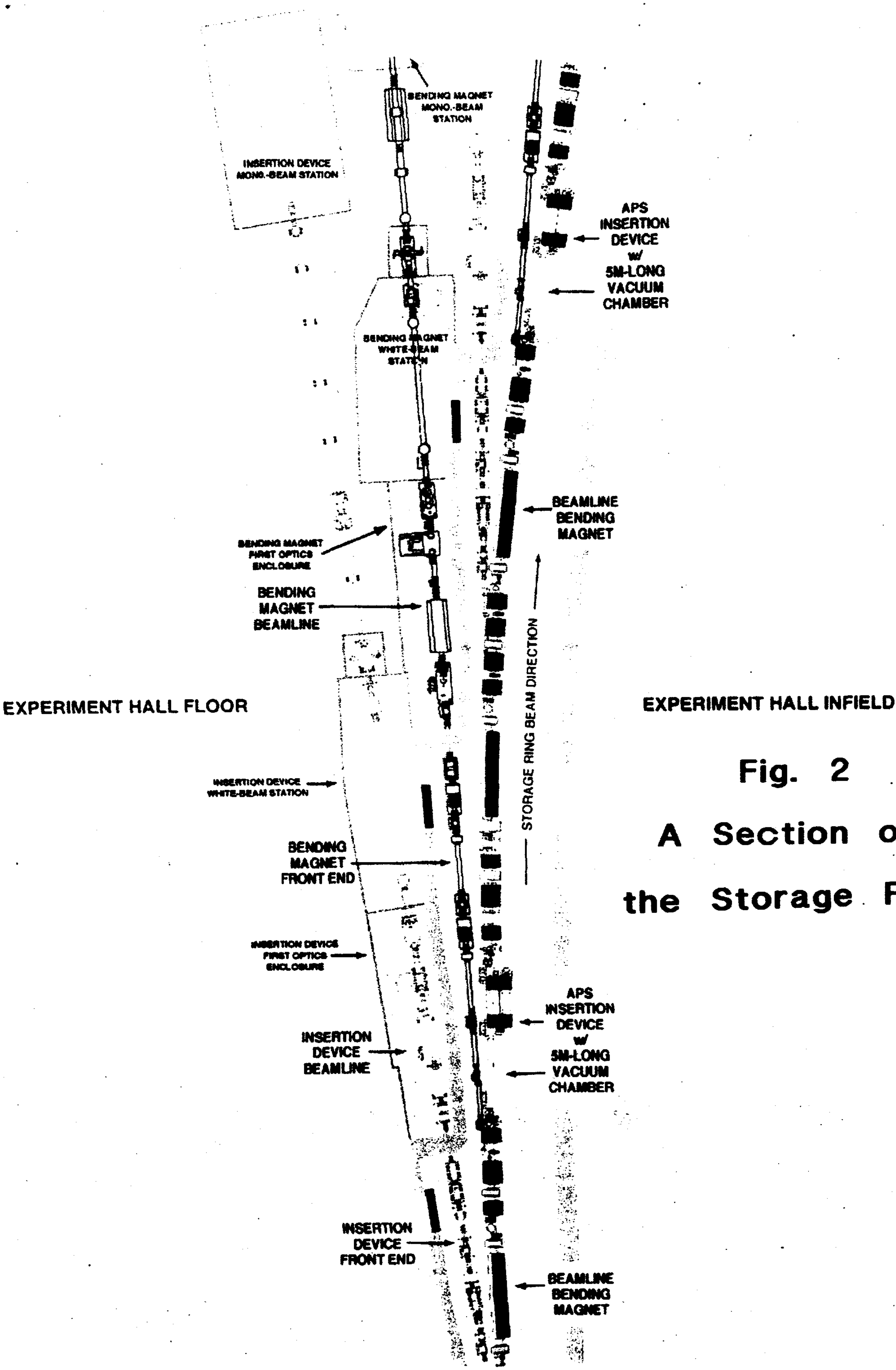
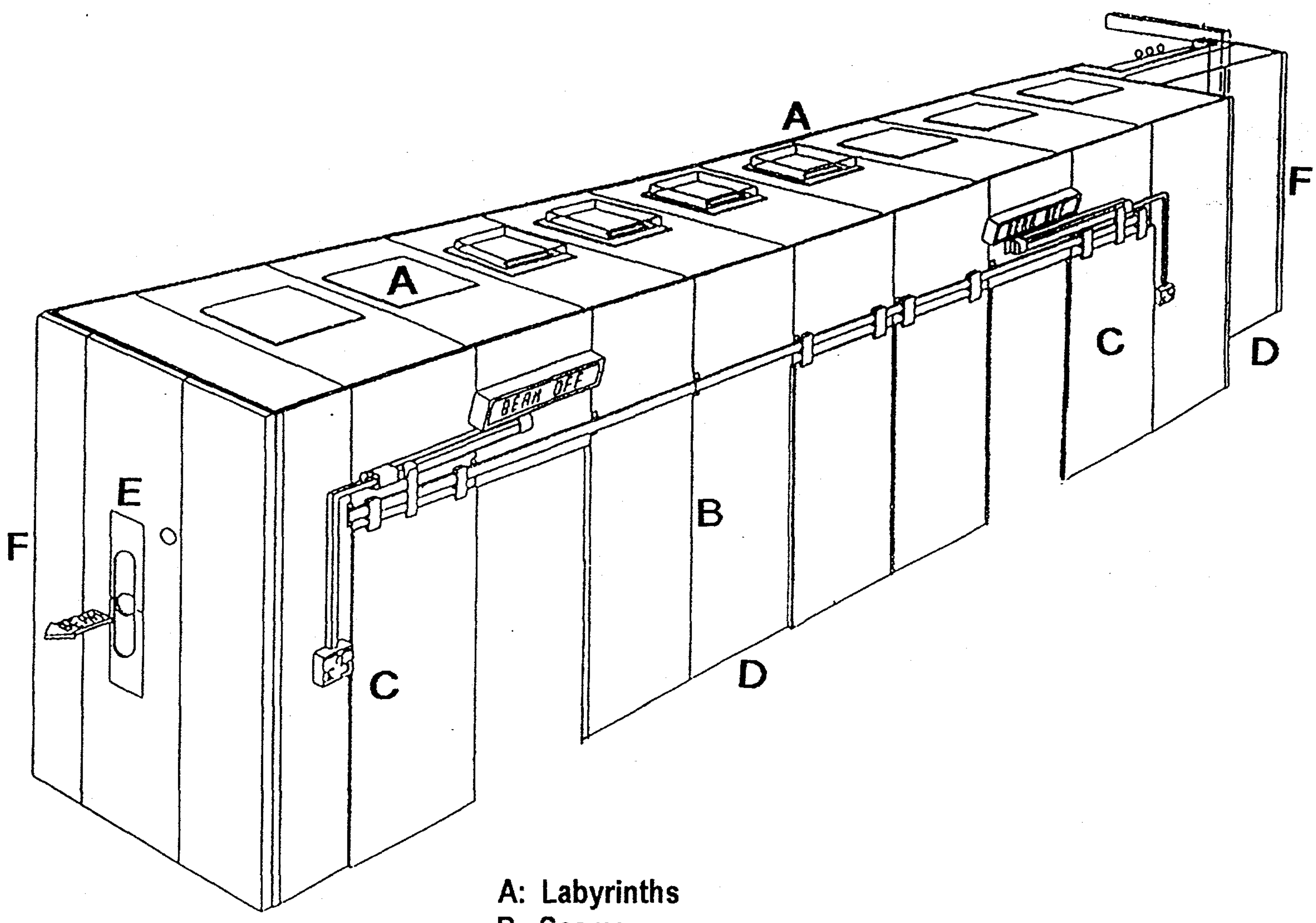



Fig. 2

A Section of the Storage Ring

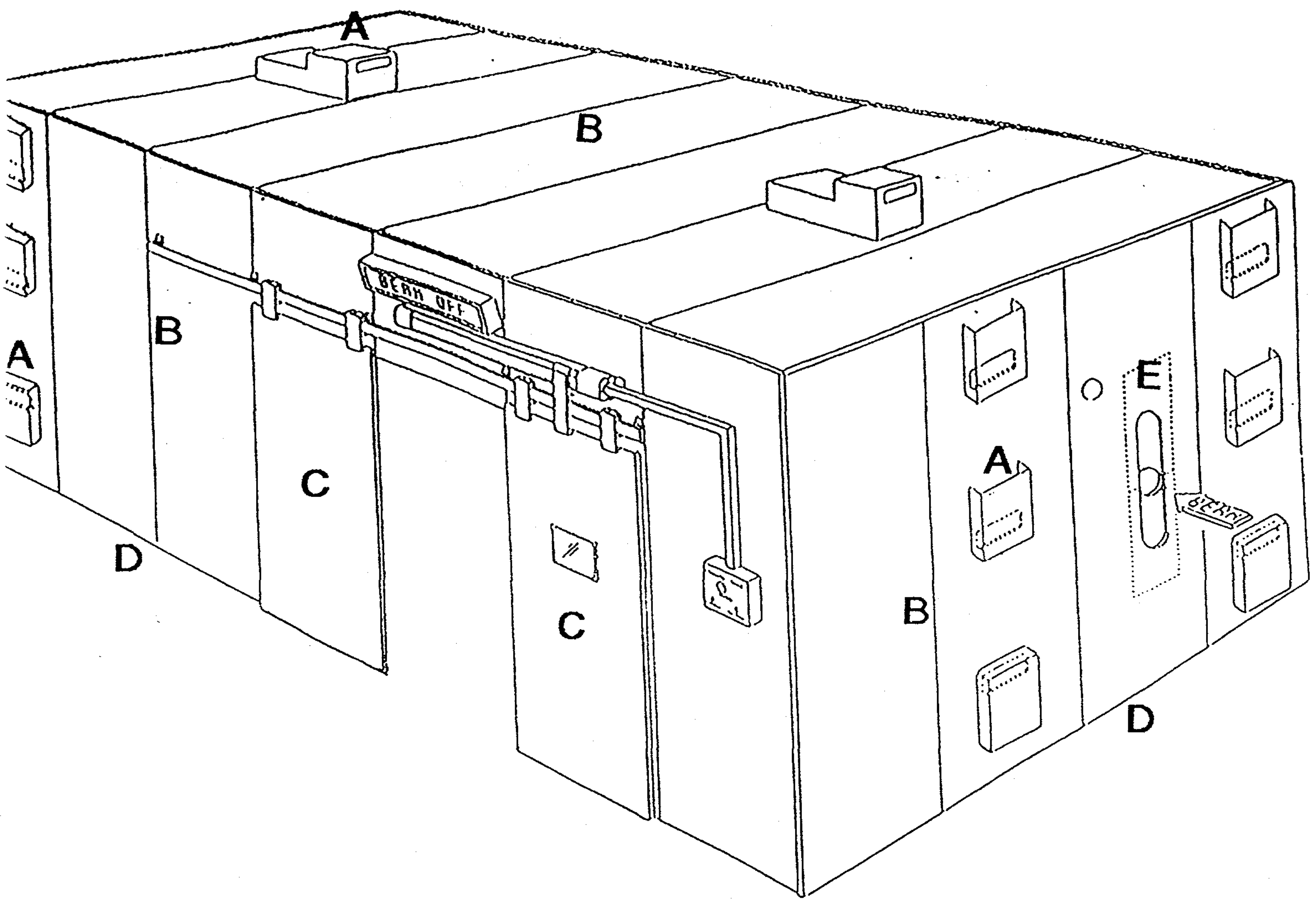
# TYPICAL FIRST OPTICS ENCLOSURE




A: Labyrinths
B: Seams
C: Doors
D: Enclosure Wall / Experimental Hall Floor Interface
E: Exit Port
F: Enclosure Wall / Storage Ring Ratchet Wall Interface

Fig. 3

# TYPICAL EXPERIMENTAL ENCLOSURE




A: Labyrinths
B: Seams
C: Doors
D: Enclosure Wall / Experimental Hall Floor Interface
E: Entrance / Exit Port

Fig. 4