8. Site and Conventional Facilities

The CANDLE synchrotron radiation facility will be located in the north-eastern part of Yerevan, capital of Armenia, at the site previously reserved for the creation of the Polytechnic Complex. Of the total available land of 70 Hectares, 20 Hectares has been allocated for the CANDLE facility and its attendant infrastructure. The general plan view of the site is shown in Fig.8.1. The site is in immediate proximity to the railway and regional highway. The most important nearby objects are: the city Botanical Garden, the Life Science International Center, Institute of Stones and Silicates and the Branch of the Yerevan State University. The site is flat and is located at the distance of about 4 km from the city Center being easy accessible by the urban transport.

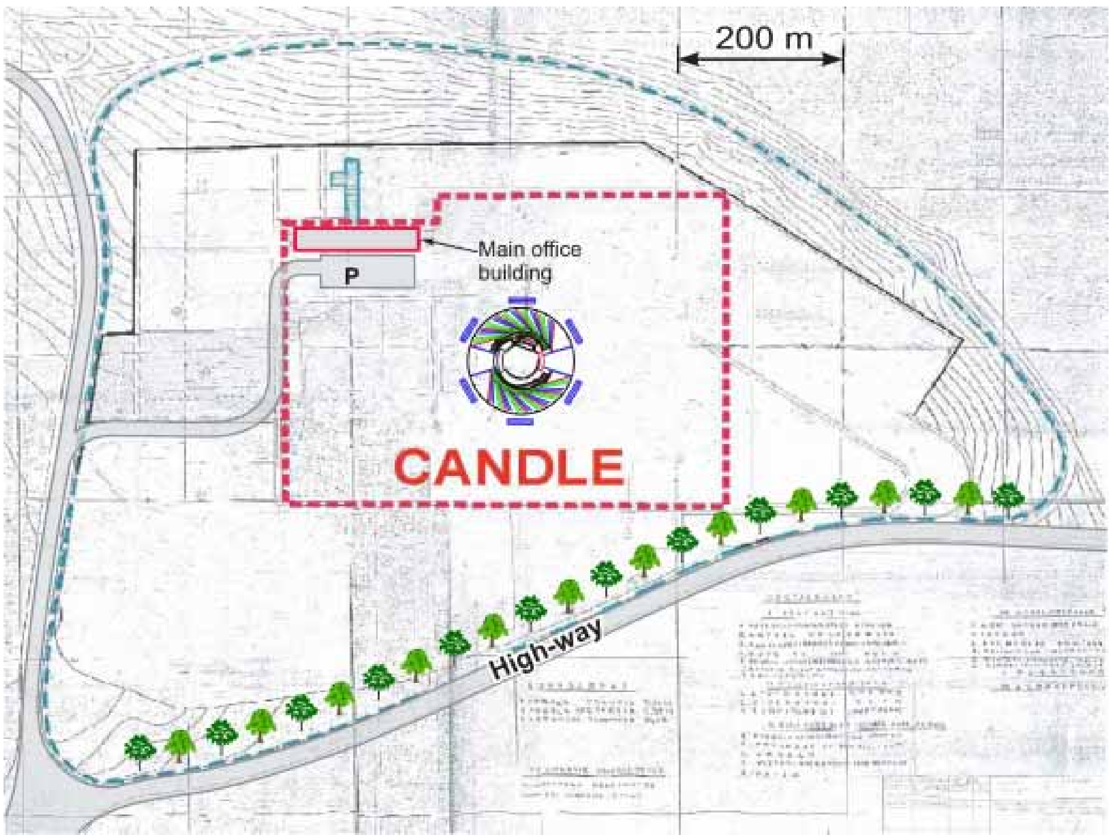

Fig. 8.1 CANDLE site planview

The site presently contains two buildings, the lower of which is three-floor office building (Fig. 8.2), which has been assigned to CANDLE, and where the major activity on the machine design and the prototyping program will be conducted curing the initial stages of the project. The total available space of the building is 3500 m^2.

Fig. 8.2 Front Building – the CANDLE office and laboratory building.

The main additional conventional facilities to be built to house and maintain the CANDLE synchrotron radiation facility include

- Accelerator Building
- Electrical Power station
- Cooling Tower
- Pumping station

In considering the suitability of the site, number of environmental factors need to be considered together with the main requirements related to stability issues. These assessments dictate site selection, building design and the civil engineering. The instability issues are divided in time scale into long (months to year), medium (hours to day) and short (fraction of second to minutes) periods of time (Table 8.1).

Table 8.1 Instability issues.

Movement	**Long term**	**Medium term**	**Short term**
Time scale	Months to year	Hours to day	Sub-sec. to minutes
Source	Seasonal temperature variation Seismic motion Ground settlement	Temperature changes Environmental noise Heavy machinery	Power supply Booster cycling Vibrations
Effects	Building /ground expansion /shrinking Tectonic motion Tidal motion	Drift of magnet supports, vacuum chamber, magnets, mirrors	ID gap drift Magnet vibrations, BPM vibrations, Orbit distortion

The requirements upon suppression of instabilities form the basis approaches to consideration of the CANDLE facility site, civil engineering and accelerator building design.

Listed below are some of the requirements.

- Proper choice of site and distance from environmental noise.
- Detail study of the geological structure
- A very stable base for floors of accelerator tunnel and experimental halls.
- Separation of floor and roof supports bases.
- The damping of the ground vibrations.
- Separation of the accelerator and experimental halls from movable structures.
- Isolation of mechanical pumps/compressors by vibration attenuating materials.
- Regulation and control of temperature.
- Homogeneous and regulated air-conditioning in accelerator&experimental halls.
- Usage of vibration attenuation materials in magnet and beamline support system.

The building design should provide the feasibility for:

- Easy access to accelerator tunnel.
- Preparation rooms close to experimental stations.
- Easy access to beamlines and experimental stations.
- User-friendly environment.

8.1 Summary of Geological Analysis

The geologic analysis of the site, currently allocated for CANDLE construction, was performed in years 84-86 as part of the Polytechnic Complex design study. From the geomorphologic point of view the territory is located at the border of the Avan plain, which separates the Arabkir-Khanaker and Nork lava plateaus. Morphologically and geologically, the 70 Hectares site consists of two parts: the Arabkir-Khanaker plate with about 8.6^o east slope (A) and the flat Avan plain with about a 1.7^o south slope (CANDLE site). The geological structure of the territory is formed by Neogenic, fourth age basalt lavas of lake-alluvial and eluvia-diluvia formations. The site geological structure is composed of the following geologic-lithologic varieties (Fig. 8.1.1):

- Humus and alluvial soils layer – to 0.5-1m.
- Effusive red-to-black tuffs layer (βQ)– to 4-5m.
- Clay, sand and large pebbles-boulder compositions ground ($I - dQ$)– to 20-22m.
- Basalt layer (βN_2)- to 90-100m. The depth of basalts' surface is 20-25m.
- Under the basalts (from 120-130m) there are saliferous clays.

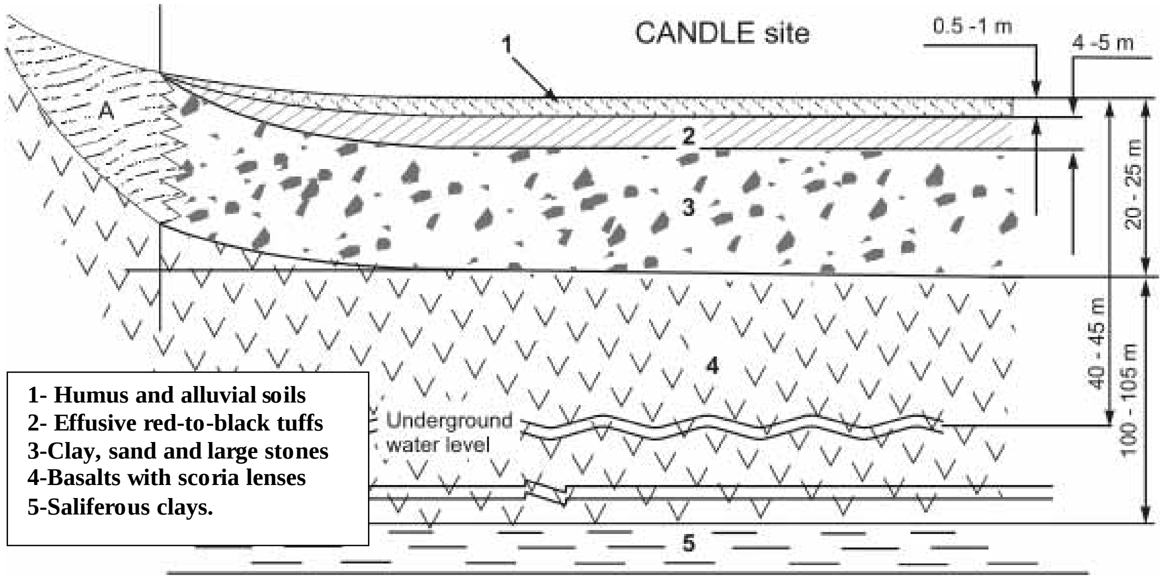

Fig. 8.1.1 Geological structure of the ground at the CANDLE site.

The level of underground water (subterranean waters) is at a depth of 40-45 m. Divided basalts are considered as a water-bearing horizon, and the clays placed underneath – as water-resistant layer. Yerevan is in the 3rd seismic zone (according to the seismic norms of RA). By the seismic characterizations, the soils of the territory belong to: I class – basalts and tuffs, II class – large boulders, II -III class – sand and clay soils.

The physical-geological occurrences (landslides, karsts, fallings, etc.) are absent in the territory. The engineering-geological conditions of the territory are conditionally favorable. Detailed engineering-geological measurements and surveys of the CANDLE site will be performed at the accelerator building design stage. The site will be the subject of intensive study with the aim to determine the soil properties, geological and geophysical conditions in particular those regarding the presence of slow motions over long periods and ability to propagate or damp tremor arising from either natural (important) or human sources. The results of this study will be summarized in a special Report. After that the master plan, requirements and specifications of the Main Building and other facilities will be designed.

8.2 Building

The main building of the complex needs to be designed with environmental stability being one of the most important requirements to be satisfied. Of these the most important are probably seismic stability and temperature stability. The major sources of these factors are the sun's radiant energy and the geologic seismic activities. Other important problems include personnel protection against radiation and personnel access to the accelerator. Finally, there is the need to optimize the usage of the beam lines, incorporating consideration of the features of the accelerator complex itself.

The ways needed to cope with these problems has been the source of a great deal of discussion within the CANDLE collaboration and has resulted in a number of decisions upon which the building design has been based.

The CANDLE main building complex functionally are divided into few parts

- Accelerator tunnel that houses the booster synchrotron and the storage ring.
- The linear accelerator hall located in the inner space of the tunnel.
- Experimental halls surrounding the storage ring.
- Preparation rooms attached close to experimental stations.
- Internal region of the ring for assembly and to house powers supplies.
- Control Room interior to accelerator tunnel.

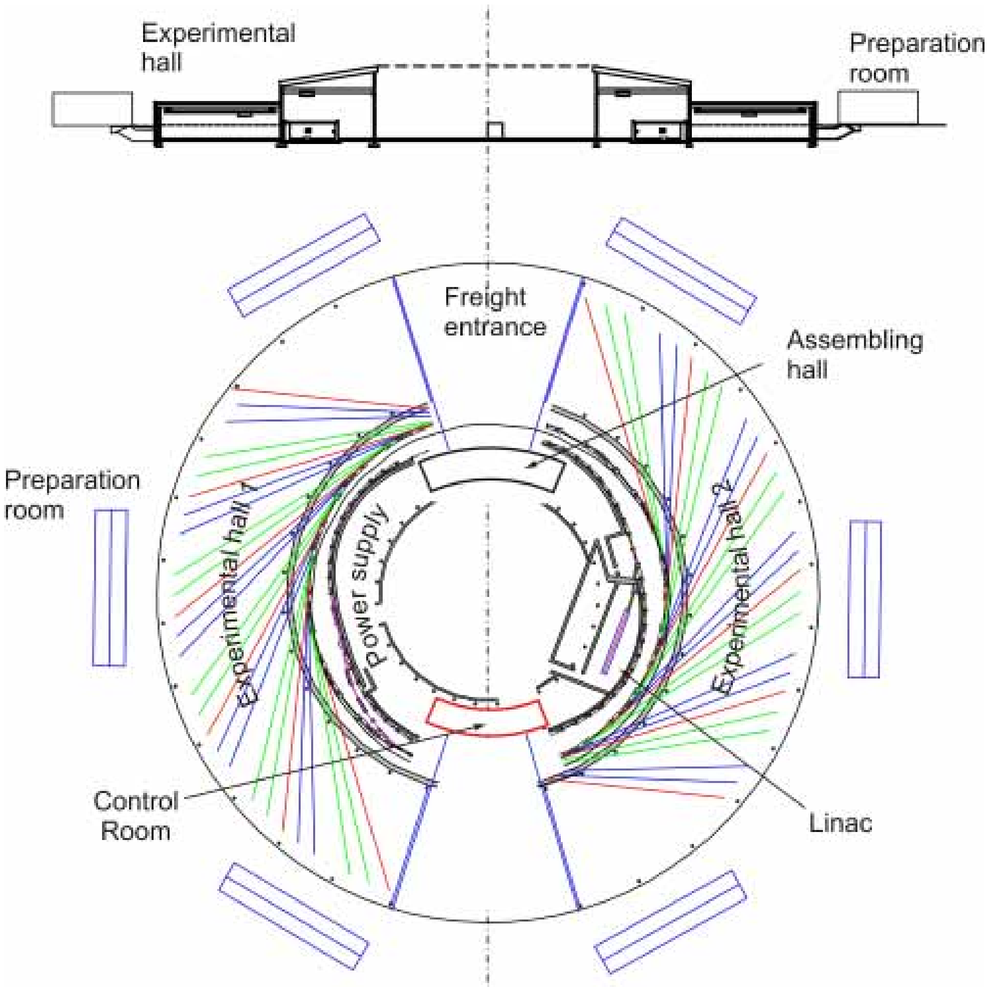

Fig. 8.2.1 The main building layout.

The basic approaches to building consideration include:

- Easy accessibility to all the functional parts of the building.
- Hermetic tunnel with high degree of temperature control.
- Experimental halls of adequate size to house experiments.
- Flexibility and ease in equipment transportation and installation.
- User-friendly environment.
- A very stable whole base for accelerator and experimental halls.
- Cost saving construction.

The preliminary layout of the building is given in Fig. 8.2.1. The central part of the building, which devoted to accelerators installation, power supplies and pre-assembling area has two accesses: main - for personnel, auxiliary - for equipment transportation. These entrances are located at the surface level (about 3 m from the building floor). Power supply and pre-assembling area is located at the inner space of the accelerator building.

Accelerator tunnel. We begin by noting that our design for the booster-storage ring arrangement places the two rings in close proximity to each other. This quite naturally leads to the decision to place both accelerators within the same tunnel. This single tunnel has advantages from many points of view including the following:

- Ease of transferring beam between two machines.
- Economy of providing power and water, and signals from and to external facilities.
- Economy and ease of shielding accelerators from radiation.
- Development of a common environment for the two accelerators with concurrent regulation of temperature to a high degree of accuracy.
- With a single, wide tunnel, the problem of bringing in components, positioning, and removing are made easier. Adequate space for utilities as well as air conditioning is also available.

We have decided, therefore, to build an essentially hermetic tunnel with poured concrete walls. Since beam lines will always emerge from fixed components in the storage ring lattice, we can plan for their emergence through the shielding wall in the wall design by having openings, which will be plugged when not in use.
Air conditioning ducts will provide for cooling and the maintenance of the tunnel's temperature to ±0.1ºC. Utilities and cables will be attached to the inner radius wall and pass through the inner wall to an area where power supplies and utility distribution devices will be placed. The walls and ceilings of the tunnel will be thermally insulated as well. Space will be provided within the outer radius of the tunnel to incorporate the devices for the first stage of the experimental beam lines including slits, collimators, beam pipes, etc.
Accelerator tunnel will house the booster synchrotron and the main storage ring (Fig. 8.2.2). The tunnel is distinguished by shielding walls of 1 m thickness and covered by the ordinary concrete roof. The inner width of the tunnel varies between 2.5 m (bend part of booster synchrotron) and 4.5 m (straight part of booster synchrotron), the tunnel height is 3 m. The booster synchrotron ring is mounted on the supports fastened to the inner shielding wall of the tunnel, similar to the SLS design. The cable trays, located from the outside of the inner walls provide all the necessary electrical and communication supplies for the rings operation. The air conditioning and cooling water access also served through the tunnels internal wall. (Fig.8.2.2). The tunnel will have two accesses from the pre-assembling area and for personnel entrance.

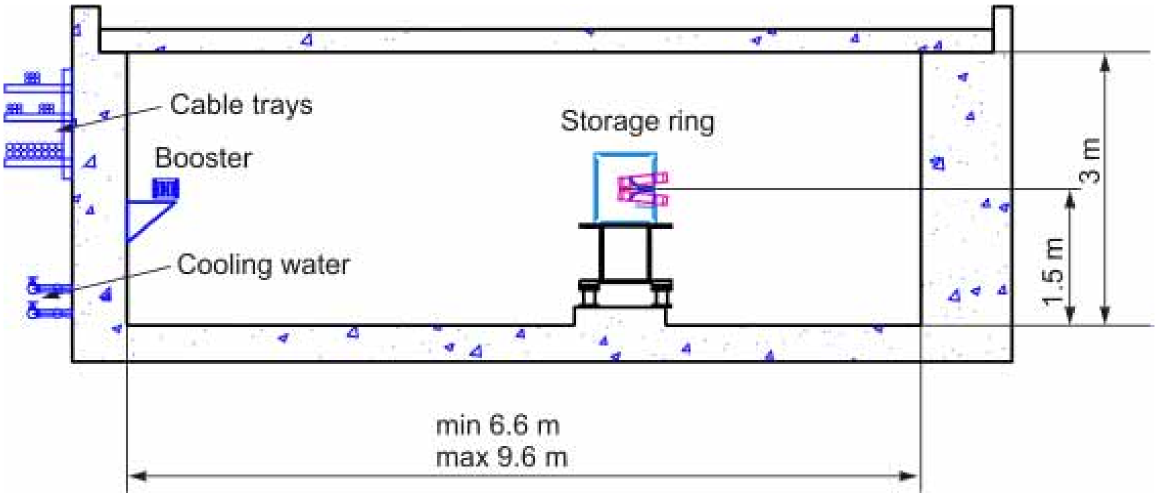

Fig. 8.2.2 Accelerator tunnel and utilities.

Experimental Halls. The experimental hall has been divided into two separate halls to reflect the fact that four straight sections will be required for RF cavities, insertion devices and beam injection. Their locations are chosen to naturally result in two experimental halls with space between for easy access to the accelerator complex from outside (see Fig. 8.4). Major components can be brought within a few meters of the tunnel by truck and then transported via a tunnel underneath the accelerator tunnel or an external crane to an assembly area located exterior to the accelerator tunnel inner wall.

The features of the experimental hall include the following:

- The floor will be re-inforced concrete about 35 cm thick since the loads they will be required to support will be generally be very small. The floor will be mechanically isolated from the rest of the building.
- A 3 tons crane will provide for movement of devices within the hall.
- The roof of the building will be supported by 2 m high girders spanning a distance of 24 m. The roof will be thermally insulated with aluminum backed perlite sheets to reduce heat conduction into the building.
- Columns to support the girders will nave a foundation separate and mechanically isolated from the foundation for the floor of the experimental halls.

The facility has two experimental halls, A and B that house more than 90% of the available synchrotron radiation beamlines. The height of the halls is 6 m and the wide is 24 m that provide the necessary spacing for the equipments, the flexibility for additional beamlines installation as well as the accessibility and user-friendly environment. The total area of the experimental halls is 6400 m^2 (2×3200 m^2). Each experimental hall is equipped by crane of 3 T load fastened under the roof. The regulated air conditioning will provide the temperature stabilization to $\pm$ 0.1^o C. The experimental halls will be added by corresponding preparation rooms at outer diameter with direct access to experimental stations.

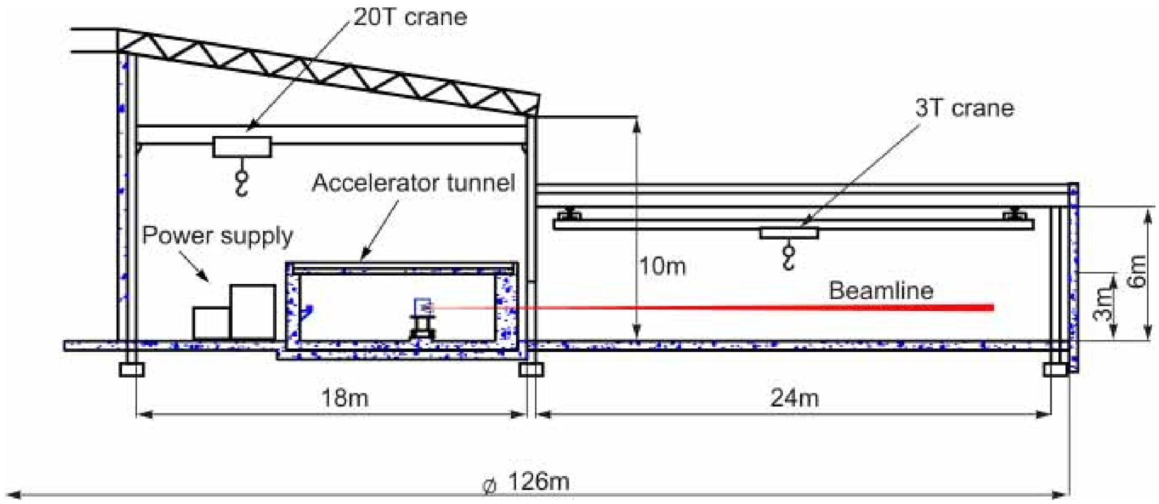

Fig. 8.2.3 The Accelerator and Experimental halls.

Base. For stability requirements and cost saving purpose the basement of the tunnel as well as the building is located 3 m below the earth surface. The base is whole plate from reinforced concrete of 600 mm thickness that lies on a fine quartz sand (river sand) layer of 0.5 m thickness (Fig. 8.2.4). The sand layer serves as a damper of oscillations. It is based upon well proven technology for long term instability cures that has been successfully adopted for the Armenian Nuclear reactor. Previously to floor construction, the sand layer is compacted a water volume. To isolate effects upon the floor originating from constructions loads and movements, building supports are separated from the base and have separate foundations that reach the main solid ground layer.

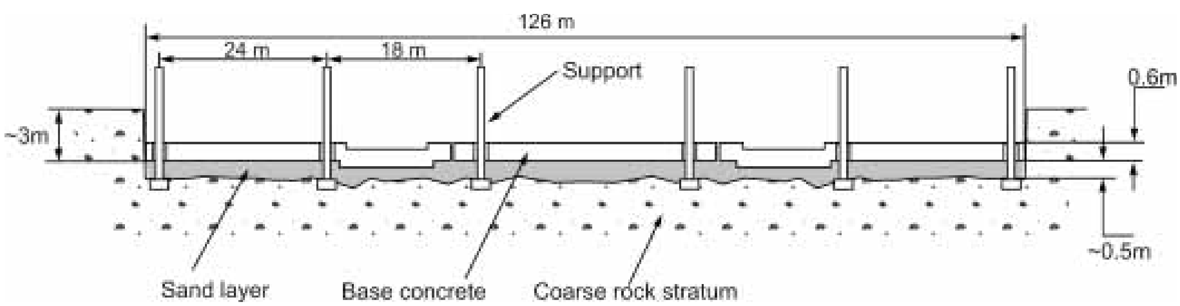

Fig. 8.2.4 The building base construction approach.

Assembly, Storage and Control Area. The area inside of the ring and adjacent to the accelerator tunnel has been designed to serve several purposes. Initially, it will be an assembly and test area for components of the accelerators such as magnets, vacuum chambers, and RF components. From this area, components will be transferred to the accelerator tunnel with electric carts where they will be installed.

Later, the area will be used to house the control room for the accelerators and beam lines and to house the power supplies and control equipment for the accelerators. A 10 ton crane will be used to move heavy components within the region.

Access to the region will be provided by two short tunnels diametrically placed at 180º from each other going from the regions between the two halls to the assembly area.

Elevators and or cranes will lift the components between the floor and access tunnel locations. Power, water and cables will run the length of the tunnels and connect outside facilities such as power substations and water cooling plant to distribution panels which supply the accelerator complex.
Before completion of construction, a portion of the area will be converted into a central room for the accelerator complex.
User facilities and offices will reside in the CANDLE office building which has an area of 6900 m^2 and contains approximately 75 offices. The experimental halls are expected to be within 200 m of the office building. The general view of the CANDLE building is given in Fig.8.2.5.

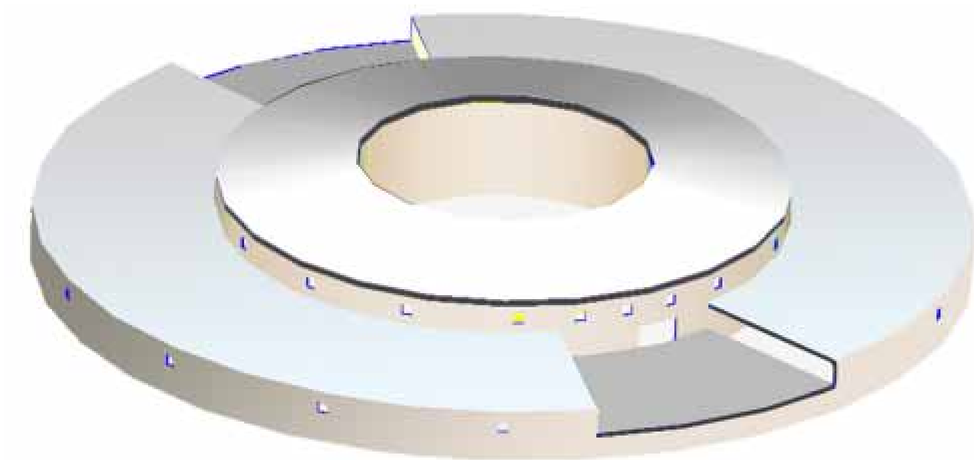

Fig. 8.2.5 General view of CANDLE building.

8.3 Infrastructure

The infrastructure must provide the general electrical powering, water cooling, as well the air cooling and conditioning.

Electrical Power.
The total power consumption is equal of 8.1 MW (see Table 8.3.1). The 10 MVA installed power will be provided by a 110 kV sub-station located near the Main Building.

Table 8.3.1

Components	Power (MW)
Magnets	2.0
RF	2.0
Vacuum Pumps and Water Pumps	0.2
LINAC	0.3
Other Devices	0.6
Accelerator (Subtotal)	5.1
Experimental Beam lines	1.0
Air Conditioning	1.0
Other (Lighting, Low Voltage power, etc)	1.0
TOTAL	8.1
INSTALLED (MVA)	10.0

To provide for a backup capability of 100%, we plan to have a double-transformer high voltage sub-station. The 110 kV voltage is carried to the area of the sub-station via two independent overhead power transmission lines. Two reducing oil transformers, each with a power output of 10 MVA power will be mounted in the sub-station .
The 110 kV voltage is reduced to 10 kV with these transformers and is then fed to switches of the distributing device, which is also mounted in the high voltage sub-station. Thus, the high voltage sub-station consists of two power transformers (each of 10 MVA), two high voltage switches and a distributive device. The 10 kV voltage is carried to the power building, located near the main building via a raceway. Five reducing transformers, each with a capacity of 1600 kVA will be mounted in an energy building. By means of these transformers, the 10 kV voltage is reduced to 380/220V and is distributed along the territory of the complex through a complete distributing device. Voltage tapping is carried out to provide the power needs of the other necessary technical services.10 kV cables are led from the 35 kV sub-station to supply devices of the RF system. The power necessary to supply devices of the control system is provided by two transformers, each of 80 kVA.
They will be also mounted in the power building. By means of these transformers, the 380/220 V voltage is reduced to 220/127 V. The general outline of CANDLE electrical powering is schematically given in Fig. 8.3.1.

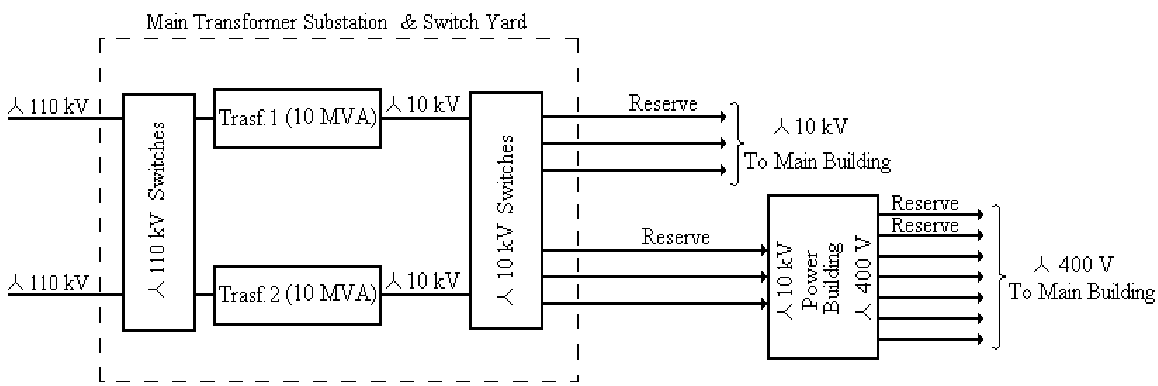

Fig. 8.3.1 CANDLE Electrical Powering General Outline

The lighting protection will be provided by 3 towers located around the CANDLE.
The ground circuit has three major tasks: personnel safety and equipment protection; as well electronics noise reduction. The personnel safety ground conductors must be sized according to " Safety Standards and Operational Regulations of Electric Installations of Republic of Armenia".

Water cooling. Air.
More then 90% of the load power must be cooled by a water-cooling system. This system consists of two circuits, the first of which includes the general cooling plant (including water-cooling towers) of 8000 kW capacity which will be mounted outside of the Main Building and is shown in Fig. 8.3.2.

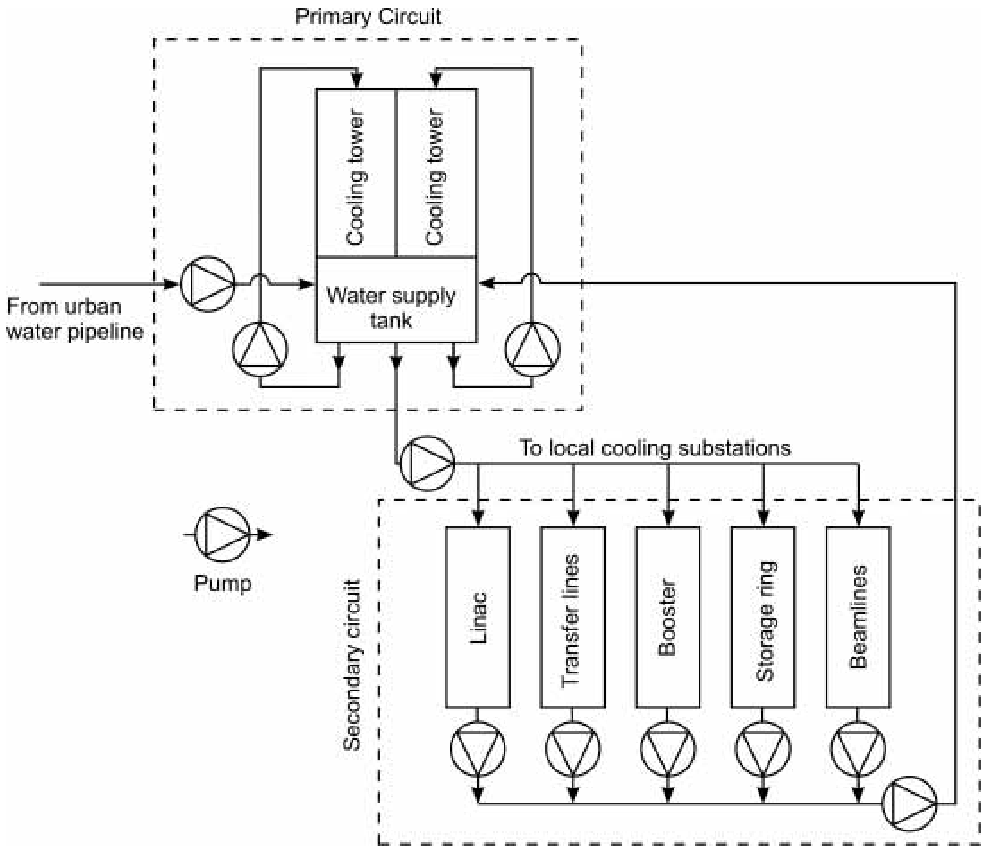

Fig. 8.3.2 CANDLE Water-Cooling General Outline

The secondary circuits – for temperature-controlled, deionized, high conductance (1 μS/cm) water – must include the local reservoirs and water heat exchangers. These circuits will be installed in the Main Building. Two different internal sub-circuits should be provided: one for the cooling of the vacuum absorbers, magnets (25-35°C) and another for cooling the RF cavities (40-70°C). Furthermore a filtered water circuit will be needed for standard applications at the accelerators and users labs.

The 10% of the load power will be vented by an air-cooling and conditioning central plant will be installed outside of the Main Building.