

## WATER PURIFICATION PLANT

The water used in the Cherenkov light detectors is ultra-pure: it has been purified to extraordinarily strict specifications, with the highest levels of purity for all types of contaminants, including organic and inorganic compounds, dissolved and particulate matter, volatile and non-volatile species, reactive and inert substances, and dissolved gases.

A schematic of the water purification plant at the Pierre Auger Observatory is shown in Figure 1. The water is transported to the site of the Observatory's Cherenkov detectors in stainless steel tanks, and the filling of the detectors is carried out under safety measures to avoid contamination.

Each Cherenkov detector contains 12,000 liters of ultra-pure water, which remains unchanged for decades.

## PURIFICATION PROCESS

### 1. PRE-TREATMENT

- The water required for the plant is drawn from a nearby well and stored in a cistern. To optimize water production costs, water from the well is combined with mains water in the cistern.
- The water stored in the cistern is chlorinated to remove microorganisms. It then passes through two filter cylinders: the multimedia filter, consisting of sand and anthracite, reduces the turbidity of the water; while the softening filter selectively removes the hardness of the water by exchanging  $\text{Ca}^{++}$  and  $\text{Mg}^{++}$  ions for  $\text{Na}^{+}$ .
- Subsequently, the water passes through a chlorine reducer, sodium thiosulphate, which neutralizes the free chlorine, crucial to prevent damage to the osmosis membranes. An anti-scalant is added to prevent ion deposition on the membranes and prolong their lifetime.
- Finally, the water passes through a system of two  $20\ \mu\text{m}$  filters and two  $5\ \mu\text{m}$  filters, which retain microparticles and mix the previously dosed solutions.

## PIERRE AUGER HYPER PURE WATER PLANT

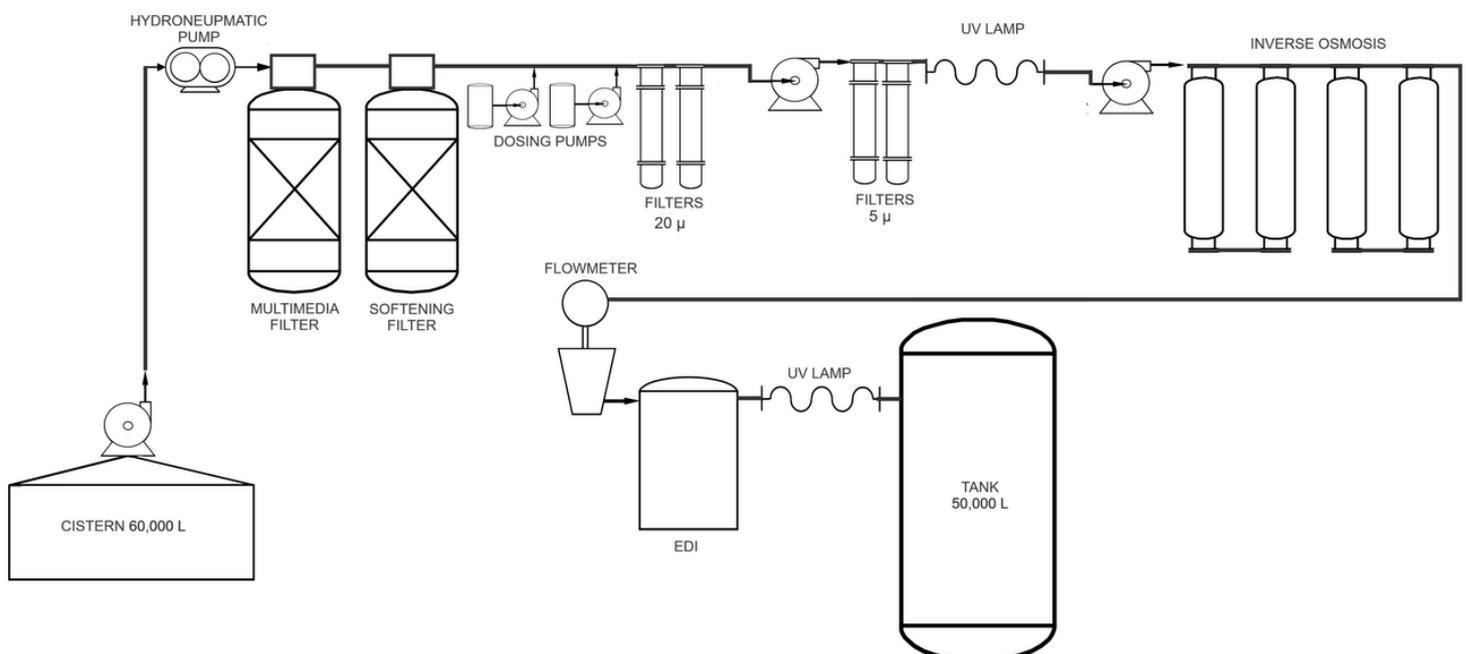


FIGURE 1. SCHEMATIC OF THE AUGER OBSERVATORY WATER PURIFICATION PLANT. (CREDIT: JOSÉ ESCALONA, PIERRE AUGER OBSERVATORY).

## 2. REVERSE OSMOSIS

Reverse osmosis uses two sets of three semi-permeable membranes each, arranged in parallel to remove dissolved ions.

A high-pressure pump is used to force water through membranes with small pores, which retain dissolved ions and other solutes on the feed side. Some of the water along with the rejected contaminants is sent to a drain to prevent build-up on the membranes. The recovery, i.e. the ratio of filtered water to rejected water, is 50-60 %, which is high compared to other purification methods. However, this method prevents the accumulation of concentrated contaminants. The conductivity in the water is about  $8 \mu\text{S}/\text{cm}$ , compared to  $1\,560 \mu\text{S}/\text{cm}$  in the water before treatment.

A conductivity of  $8 \mu\text{S}/\text{cm}$  in the purified water indicates that the process removed most of the dissolved ions and other contaminants, reflecting a high degree of purity. This value is not the final conductivity of the ultra-pure water, but an indicator of the effectiveness of the method.

## 3. ELECTRODEIONIZATION (EDI)

After reverse osmosis, a 185 nm UV lamp decomposes organic molecules into  $\text{CO}_2$  and  $\text{H}_2\text{O}$ . Then, in the EDI module, there are electrodes of opposite polarity and ion exchange cells with membranes. These membranes in the EDI retain ions and the resin is regenerated through water hydrolysis, removing contaminants that are attracted by the electrodes and discarded in the concentrate chamber (D), while in the dilution chamber (C), ultra-pure water is obtained.

## 4. STORAGE AND RECIRCULATION

The produced water is stored in a 50 000-liter fiberglass tank (Fig. 2) near the plant. This tank is connected to a recirculation system with two pumps and two mixed-bed ion exchange filters. Although they do not produce water with the same purity as EDI, they help to maintain water quality during storage.

## 5. AUTOMATIZATION

The water plant operates automatically through a computerized system that monitors all key production parameters. If any sensor detects values out of the set range, the plant stops automatically and triggers an alarm signal.



FIGURE 2. AUGER OBSERVATORY WATER PURIFICATION PLANT STORAGE TANK.