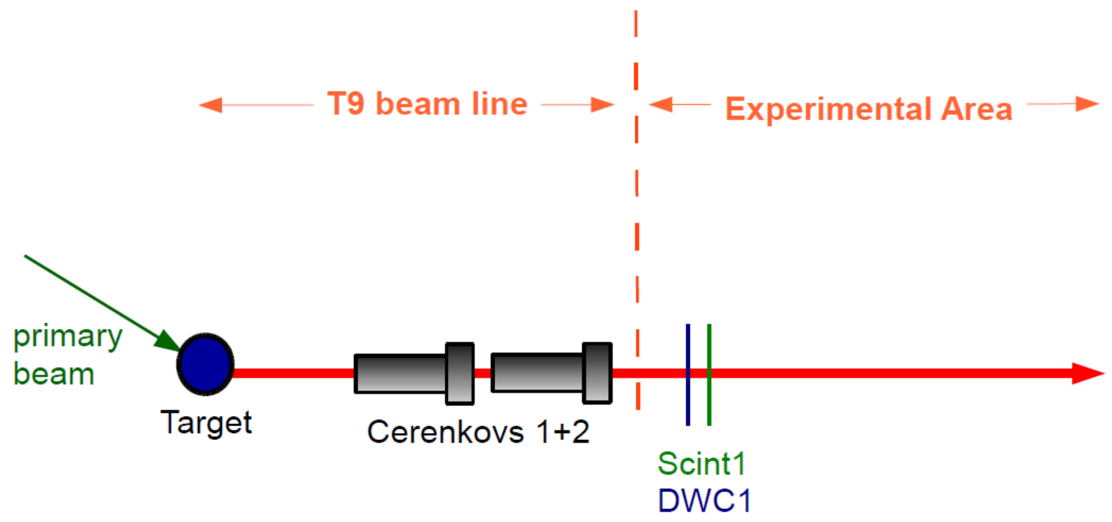
Information about the T9 beam line and experimental facilities

The incoming proton beam from the PS accelerator impinges on the North target and thus produces the particles for the T9 beam line. The collisions of the protons with the target can provide a variety of particles, such as electrons, positrons, muons, pions, kaons and (anti-)protons. The T9 beam line, used for the experiment is therefore a mixed hadron and electron beam and can transport either positively or negatively charged particles with momenta between 0.5 GeV and 10 GeV. The beam is delivered uniformly in time over a burst of 0.4 seconds. Depending on scheduling, such a burst is provided typically once or twice per 15 seconds. The maximum particle rate per burst of 10^6 is achieved for a 10 GeV/c positive beam, but drops for lower energies. For negative beams the rates are typically lower, meaning the bursts contain fewer particles. The beam travels approximately 55m before it enters the experimental area.
The experiment will take place in an area of about 5 m by 12 m, containing a number of detectors, which are fixed, along with devices that can be changed or added. They are used to measure and analyse the properties of the beam and its composition. All available apparatus are listed in this document. Additionally it is possible to install devices that are brought by your team in the experimental area. However please note, that CERN cannot guarantee the installation of the suggested devices. Each request has to be reviewed individually. The installation of combustible material (e.g. wood) is not possible for safety reasons.

The fixed setup of the beam line

(for explanations, see below)



Target

The primary beam, coming from the PS accelerator impinges on a target before it enters the secondary T9 beam line area. There are different target heads available, allowing different electron components of the beam. The core of the target is always light material (aluminium or beryllium). In some targets a tungsten plate enhances the electron content of the beam.

Scintillator counter (Scint)

A scintillator counter consists of a scintillator coupled to a sensitive photomultiplier. Scintillation is the light produced when charged particles pass through certain materials, such as certain plastics with specific additives. The scintillation light can be detected by photomultipliers. The photomultiplier tube transforms the incoming light emitted by the scintillator into an electrical signal and amplifies it. One scintillator counter is part of the fixed setup of the beam line. Two additional scintillators are readily available for installation in the experiment. You can for example measure the time it takes the particles to travel from one scintillator to another or simply count the arriving particles.

Delay Wire Chamber (DWC)

This tracking device is an evolution of the multiwire proportional chamber (MWPC), developed at CERN by Georges Charpak. Where the MWPC detects the position of a charged particle by indicating which wire was closest to the particle position, the delay wire chamber improves the position resolution by also measuring the time between the particle passage and delay of the chamber signal which is measured via a delay line. The delay measures the distance between the particle and the wire. Position resolutions of 100 to 200 microns can be achieved. However, the chamber can only measure one particle inside a certain time window. One DWC is part of the fixed setup of the beam line. Two additional DWCs can easily be installed for the experiment, if required.

Cherenkov counter

Nothing is faster than the speed of light in vacuum. However in other media, such as certain gasses, the velocity of particles can exceed the velocity of light in that medium. If that’s the case, the particles emit so called Cherenkov light. By adjusting the pressure of the gas, the velocity threshold of the particles emitting Cherenkov light can be chosen. Since the momentum of all traversing particles is preselected, the different velocities can be assigned to different particle masses and thus different types of particles. Electrons will in practice always emit light in any gas, contrary to the other particles. Depending on the choice of gas, in a given energy range, a discrimination between electrons, pions and heavier particles (mostly kaons or protons) may be possible.

Two Cherenkov counters are part of the fixed setup, each consisting of a Cherenkov threshold selector and a photomultiplier. Additional to the pressure of the gas, you can choose between certain gasses like carbon dioxide, helium, argon and nitrogen, according to what particles you would like to detect. If you choose not to use the Cherenkov counter in your experiment, it will remain on the beam but can be emptied, so that it won't interfere with the properties of the beam.

Optional additional devices

Six-plane pixel telescope

This tracking detector is used to measure and record the path of the beam particles very precisely. It is built out of six planes of silicon pixel sensors similar to the cameras sitting in our mobile phones. Each sensor plane is segmented into small pixels comparable in size to ½ a human hair, which allow the exact location of where the particle hits the sensor to be determined. Just as light leaves a signal in the camera, particles leave a signal in the silicon pixel sensors. Through combining the hits of the six planes, you can calculate the precise path of the particle on its journey.

The telescope can either be used as a tracking detector itself or as a tool to test another tracking detector. In figure 1 the telescope planes are blue while the tested detector is red. After calculating the path of the particles through the six planes of the telescope, the comparison to the location the red plane claims to have measured, will show how precise the tested detector works.

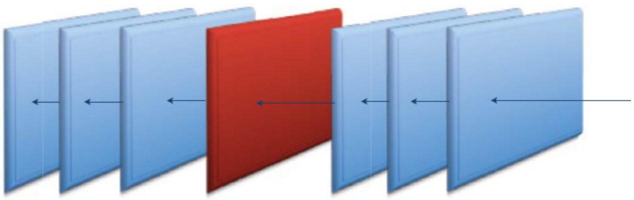


Figure 1 (Image: DESY)

Lead Crystal Calorimeter

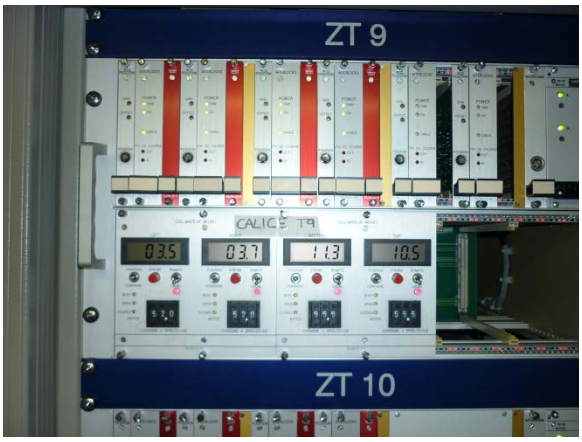
A calorimeter is a detector that measures the energies and positions of impinging particles. An electron hitting the calorimeter for example will produce a fully contained electromagnetic shower thus depositing all its energy in the calorimeter and therefore allowing a very precise measurement of its energy. Although heavier particles produce a signal as well, the energy deposition is much smaller than for electrons. By measuring the deposited energy, signals induced by electrons can be distinguished from those induced by muons, pions, kaons and protons. Although sometimes used as a position detector, the determination of a particle's position is less precise.

Four-layer straw detector

This tracking detector is made of many metal-coated tubes, called "straws" at ground potential filled with some specific gas. In the middle of each straw a very thin metal wire is stretched and put at a high positive voltage. Whenever a charged particle traverses the straw, the gas is ionised and the electrons will be attracted by the positive wire, where they will leave a signal. The number of the wire as well as the drift time (a measure for the distance) from the particle passage to the signal arrival time will provide a precise position measurement. Four layers will allow a precise measurement of the passage of the charged particles.

Collimator

A collimator is a tool to filter the beam of particles. There are two collimators in the T9 beam line. The horizontal collimator changes the width of the momentum distribution of the beam depending on its opening. Thus it rejects particles that have either a higher or lower momentum than a pre-determined range. The vertical collimator on the other hand filters particles according to their initial angle on leaving the target. Any particle with a larger angle than selected is rejected.



Halo counter

The halo counter is a special set of scintillator counters that have a hole around the beam passage. Its purpose is to identify particles that are too far away from the beam axis. While a collimator filters the beam by rejecting particles with a larger angle immediately, the halo counter identifies them and thus makes it possible to chose to either reject them or flag them. That's useful e.g. for flagging particles, that interacted with a certain absorber and underwent scattering.

Absorbers

An absorber is a plate of material that absorbs a fraction of the particles in the beam or degrades the momentum of particles of a specific type. Typical absorber materials are lead or tungsten, but other lighter materials can also be used (e.g. polyethylene). By using a lead absorber, electrons will lose a large amount of their energy in the lead whereas most of the hadrons cross the absorber essentially unobstructed. The electrons that have interacted with the absorber can then be flagged with a halo counter (see above).

Muon Filter

A muon filter is a special absorber in the form of a massive iron block. It will be installed by crane if needed. All particles of the beam travelling through the iron are absorbed completely, except of the muons. By installing a detector such as a scintillator counter behind the muon filter, the muon content of the beam can be detected.

MNP17 Magnet

CERN's large, polarity-changeable, horizontal dipole magnet has a maximum field of 0.96 T over a length of 52cm. The gap height is 30 cm and the useful aperture width is 1m. The field can be varied by adjusting the current. This magnet can be installed inside the experimental area on request in order to determine the momentum of the particles.

Bending magnets

Bending magnets are used in the beam line not only to guide the particles in a certain direction but also to choose the particles' energies (between 0,5 GeV and 10GeV) by defining the magnet currents accordingly.

Quadrupole magnets

Quadrupole magnets are used to control the beam size and to focus or defocus the particles in the beam line. Their role is similar to the role of lenses in your camera. However, contrary to an optical lense, a quadrupole will focus the beam in one plane, but defocus the beam in the other plane. That means a horizontally focussing quadrupole defocusses vertically and vice versa.