

Document to check feasibility of the experiment for CLEAR (The CERN Linear Electron Accelerator for Research)

Global requirements for a feasible experiment:

- Only fixed target experiments are possible. It is not possible to bring two beams into collision
- It is also possible to use radioactive materials or large (more than 1 kg) amounts of flammable materials as a target.
- The experimental area has a size of 1x1 m. All detectors must be placed inside that area
- It must be possible to perform the experiment in less than 10 days (maximum duration of the beam time). Beam is available for 12 hours per day.
- Access to the experimental area is possible on weekdays but limited to 2-3 accesses per day.
- The purpose of the experiment can be the observation of an effect in particle physics, the test of a new detector or creative combination of art and science.
- The experiment must be at a level that allows very skilled high school students to at least roughly understand its details and the physics formulas that it depends on.
- CERN prefers experiments that provide immediate feedback via electronic or optical sensors. The students will analyze the data and decide in real-time on the next steps to take (e.g. modifications of the setup or the beam parameters). Experiments that are based on the irradiation of samples and the off-line analysis of these samples in remote laboratories are permitted but discouraged.

Parameters of the beam:

- The beam is provided by the CLEAR facility of CERN. It is a pure electron beam.
- The beam's momentum ranges from 50 to 220 MeV/c and can be selected by the user
- Bunch charge: 0.01 - 1.5 nC
- Normalized emittances: 3 μm for 0.05 nC per bunch, 20 μm for 0.4 nC per bunch (in both planes)
- Bunch length: $\sim 100 \mu\text{m}$ - 1.2 mm
- Relative energy spread: $< 0.2 \%$ rms ($< 1 \text{ MeV FWHM}$)
- Repetition rate: 0.8 - 10 Hz
- Number of micro-bunches in train: 1 - 150
- Micro-bunch spacing: 1.5 or 3.0 GHz
- It is possible to attenuate the beam such that only one electron is delivered (on average) per bunch

List of available detectors:

- 1) Scintillators
- 2) Lead glass calorimeters
- 3) Neutron dose meters (WENDI)
- 4) YAG screens and CCD/CMOS cameras
- 5) TimePix3 and Katherine read-out system

Details about the detectors:

1) Scintillators

- Number of detectors available: 3
- Size: 10 x 10 cm
- Material: EJ200
- Read-out: PMT
- Efficiency: ~95%
- Limitation: Can only be used with a low intensity beam

2) Lead glass calorimeters

- Number of detectors available: 3
- Cross section: 10 x 10 cm
- Length: 37 cm
- Sensor: PMT
- Material: lead glass
- Resolution: $\sigma E / E = 0.02\% + 6.3\% / \sqrt{E}$
- Read out with: QDC
- Limitation: Can only be used with a low intensity beam

3) Neutron dose meters (WENDI)

- Number of detectors: 1
- Measured quantity: neutron dose (sievert)

4) YAG screens and CCD/CMOS cameras

- Beam interacts with YAG screen and produces visible light
- CCD/CMOS camera looks at the YAG screen and records the optical effects

5) TimePix3 and Katherine box

- The TimePix3 is a pixel sensor (256 × 256 pixels with a 55 μm pitch). It can detect the time of arrival of a particle. In addition, a (Time over Threshold measurement for charge / energy deposition is possible. For particles with an energy of 3-20 keV it works like a calorimeter.

6) Detector prototypes

- It is possible to install detector prototypes in the experimental area and to test their reaction to the beam. These detectors must not require very expensive materials (budget limit: USD 2000) for their construction.

Details about the data acquisition system:

- For creating a trigger signal all common types of NIM modules are available. This includes discriminators and coincidences. The NIM electronics modules have a time resolution of at least 5 nano seconds.
- For the digitization of analog signals, charge digitizer (QDC) and time digitizer (TDC) are available. There are also modules that can count signals. There are no ADCs available.
- The data acquisition system can record up to 2000 events per second