The Gustav Werner Cyclotron at TSL

- Frequency modulation mode up to 180 MeV protons.
- Isochronous mode protons can be accelerated in the range 25 to 100 MeV.
- Heavy ions up to ca 40 MeV/nucleon.
- Maximum average magnetic field: 1.75 Tesla.
- Extraction radius: 1150 mm.
- Proportional extraction in CW mode, where the accelerating voltage is sufficiently high: Regenerative extraction in PM mode.
- User controlled beam-sharing:
  - Primary user: Proton Therapy (The Uppsala Academical Hospital).
  - Secondary user: Irradiation of electronics.

Energy saving considerations

**Energy saving considerations: Advantages.**

**Phase 1.** A program (PutToSleep) is run which has the following actions: Cyclotron main magnet, RF powers supplies, extraction elements set to 0 A (0 V) – a practice followed already since several years ago.

**Phase 2.** Based on measurements made in Feb 2012 it was concluded that all beam elements also can be set to 0 A without influencing the beam transport’s repeatability. A simple cycling procedure is used to ensure repeatability of magnetic fields.

**Results.** Energy saving results are shown in the figures below.

**Investigation of magnetic field settle time for beam line parameters:** Initial test measurements.

**Set-up and procedure:** Measure beam position using therapy’s ionization chambers; positioning accuracy? Y-scale units correspond to 0.1 mm.

**Measurement 1 & 2:** All bending magnets set to 0 A; wait 10 minutes; set to the correct set value following a specific cycling procedure.

**Measurement 3:** All quadrupoles set to 0 A; wait 10 minutes; act directly to the correct set value (no cycling).

**Conclusions:** The beam position stabilizes to a sufficient accuracy level within 3 minutes.

New Camera System

**Background.** Instead of harps or scanners, fluorescent viewers are used to diagnose beam characteristics.

**Motivation for upgrade.**

1. Mostly Vidicon cameras are still in use. They are not replaceable and spare parts are difficult to find.
2. Replacing the old TSL-built multiplexing system.

**Solution.** Extensive tests of various CMOS and CCD cameras were done leading to the choice of Eyseo CCD cameras (Fig. 2) which will replace the Vidicon cameras currently in use.

The old mux system will be replaced by a video matrix switch. Eyseo will be used at some of the 21 viewer positions. Instead of harps or scanners, fluorescent viewers are used to diagnose beam characteristics.

**New construction.** Intending to keep the changes simple, the existing base (Fig. 2 (a)) of the ion source is kept.

Radial displacement of the ion source will be affected by transferring the necessary force via the X-Y table - see Fig. 2 (b).

Positoning of this plate is accomplished via a drive rod driven by a stepper motor well away from the cyclotron magnet.

**Fig. 1.** Layout of the new camera system.

**Fig. 2.** The Eyseo Ecological Standard CCTV camera.

**Fig. 3.** Adapting Vidicon camera to output a video signal instead of VHF.

**Table 1.** Beam time statistics 2011:

<table>
<thead>
<tr>
<th>Year</th>
<th>Beam Therapy</th>
<th>Beam Irradiation</th>
<th>Beam Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>1000 h</td>
<td>834 h</td>
<td>0 h</td>
</tr>
</tbody>
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**Fig. 2.** Energy consumption distribution for various parameters.

**Fig. 3.** Changing beam position due to settling of magnetic fields.

**Fig. 4.** Beam intensity stabilization at morning start-up.