MAIER-LEIBNITZ-LABORATORIUM TANDEM OPERATION AND EXPERIMENTS

L. Beck, Maier-Leibnitz-Laboratorium, Am Coulombwall 6, Garching, Germany

Abstract

The Tandem accelerator of the Maier-Leibnitz-Laboratorium (MLL), the former "Beschleunigerlabor der LMU und TU München" was running very reliable during the last years. The status of the Tandem accelerator will be presented and some technical problems of the past years of operation will be discussed.

The MAFF project (Munich Accelerator for Fission Fragments) was suspended due to missing funding. MAFF was planned to be the successor of the Tandem accelerator. In the next years the Tandem accelerator will be useful for experiments in the framework of the two clusters of excellence "Origin and Structure of the Universe" and MAP (Munich Centre for Advanced Photonics). The Tandem ion beams are applied for experiments in the field of nuclear astrophysics, AMS with astrophysical implication, for irradiation of cells, tissue and finally animals for cancer therapy studies.

STRUCTURE OF THE MLL

The former "Beschleunigerlabor der Ludwig-Maximilians Universität und der Technischen Universität München" has since July 2008 now officially the name "Maier-Leibnitz-Laboratorium (MLL)". The person Heinz Maier-Leibnitz is associated with the old research reactor FRM. This reactor started its operation in 1957 until it was shut down in 2000. The research field of Heinz Maier-Leibnitz was nuclear physics and especially the physics with neutrons. In the framework of the MLL physicists of both Munich universities and the Universität der Bundeswehr (University of armed forces) are in close collaboration in the field of nuclear and particle physics. The Ultra Cold Neutrons (UCN) working group is developing a new source for UCN which will be installed at the new research reactor FRM-II in the next years. This new source promises a much higher neutron density as all now existing sources. The last year was the first full year in which the MLL groups have performed most of their work with the additional support of the clusters of excellence "Origin and Structure of the Universe" and "Munich Centre for Advanced Photonics (MAP)". In the MAP cluster the use of laser beams for cooling, production and acceleration of ions or electrons is one of the main research fields. Both clusters are also performing a lot of experiments at the Tandem accelerator. Some of these experiments are presented later.

TANDEM OPERATION

In 2008 the tandem accelerator (MP-8 from HVEC) was running 6600 hours for experiments. For maintenance each week 6-8 hours were scheduled but not used always. In Table 1 the beam on target time in the past years is shown. With an average of 7000 h the operation of the accelerator was very reliable.

Table 1: Beam on Target

Year	Beam on target [h]
2008	6600
2007	7000
2006	6800
2005	7000
2004	7200
2003	7600
2002	7200
2001	6600

Fig. 1 shows the operating statistics for 2008 in detail. In July and August we had a 3 week routine maintenance period for cleaning the whole machine and check of all components. The maximum terminal voltages for experimental use were all the year around 13 MV as is shown in Fig. 2. The accelerated ions range from hydrogen to heavy ions like gold. The light ions (partially polarized) are mostly used for nuclear physics experiments and the heavy gold ions for material analysis with ERDA. The distribution of beam time to the different ions is shown in Table 2.

Table 2: Beam Time in percent of total available Beam Time for 2008 (The isotopes marked with an * were measured with AMS studies. The ion source for polarized protons and deuterons delivered about 70% of all protons and deuterons in a running time of about 800h)

Ion	%	Ion	%
1H	14.4	36Cl*	0.9
2H	2.5	41Ca*	2.2
3He	0.7	53Mn*	2.9
4He	5.0	58Ni	2.3
7Li	0.9	59Ni*	0.9
11B	5.2	63Ni*	1.8
12C	4.3	127I	23.4
16O	9.0	197Au	12.4
26Al*	0.9	Others	10.0

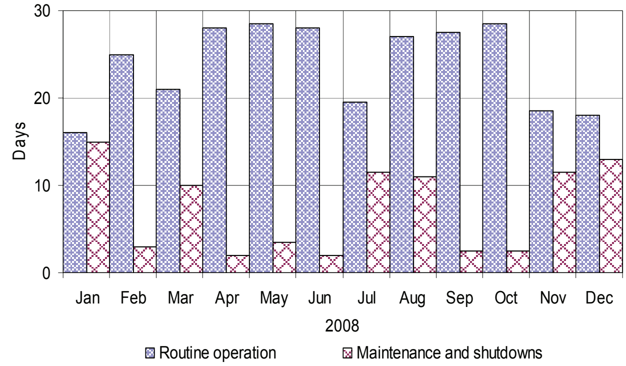

Figure 1: Operation statistics.

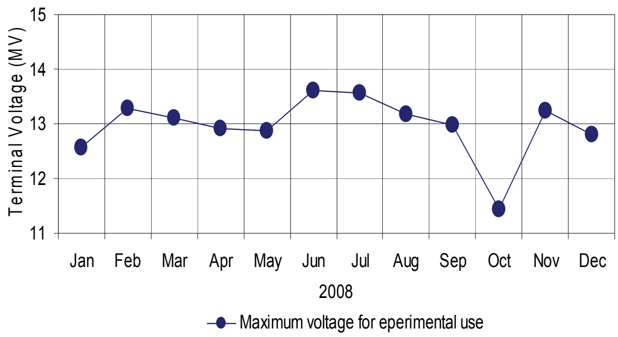

Figure 2: Terminal voltage.

Replacement of Charging Chains

In April 2009 the set of 3 charging chains at the high energy (HE) side was replaced. These chains were running since September 1990. With an average running time of 7000 h per year they reach about 130 000 h of total operation time. In the past years all chains reached operation times of 100 000 h or more. Unexpectedly we had also to replace the chains at the low energy (LE) side in May 2009 after 24 000 h of operation.. These chains were installed in August 2005. With these chains we had a problem which never before occurred. The spacers in each link of the chain became very brittle and many of them were broken. It is probably a problem with the material of the spacers. In 1993 NEC changed the material from originally nylon to delrin (polyoxymethylene). The chains we installed in 2005 were purchase 1998 as spare chains for the tandem accelerator in Heidelberg. The new chains (purchased in 2005) we have installed have also delrin spacers with purple colour. We hope that this problem will not occur here. Inside our tank delrin was used for example for high voltage feedthroughs or gearwheels. The material also became brittle after a few years. Maybe there is a problem when using delrin in a dry SF6 atmosphere. NEC assumes the reason for the problem in the SF6 break down products, but it also may be caused by the missing humidity. NEC will investigate the problematic spacers in their laboratory.

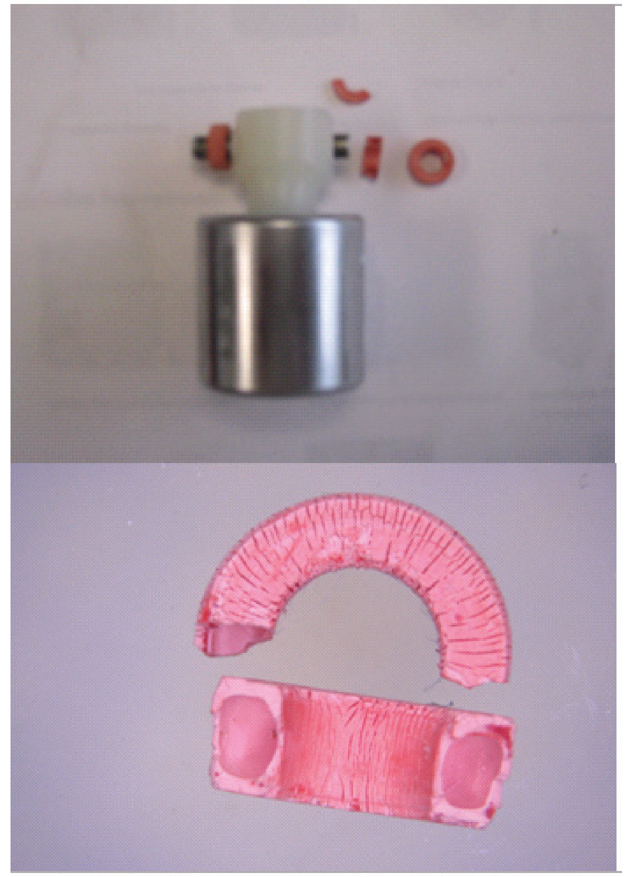

Figure 3: Chain link and spacer.

Repair of a Quadrupole Lens

The ion beam since a long time seemed to leave the accelerator with an angle in y-direction. Therefore a steering magnet was used for y-correction. But last year the problem became worsened. A correction was not possible anymore. First there was the suspicion that there is something wrong with the beam optics in the accelerating tubes which would have been fatal. But the reason for the problem was the quadrupole doublet lens located close to the exit of the accelerator. The magnetic field of one pole was significantly lower than at the other three poles. In this incorrect field of the quadrupole lens the beam was deflected in y-direction. All four coils of one doublet were replaced. There is bad experience in the SNEAP-community with replacement of only the defective coil. Replacement coils with nominally the same number of turns produced significantly different fields than the original ones. Although we do not understand why a coil with supposedly the same number of turns should produce a different field, we decided that we had to use them in sets of 4 in a quad singlet rather than replace just one. The set of four spare coils we have gotten from the tandem accelerator in Heidelberg. What was the reason for failure? The resistance of all four coils was about 0.4Ω. But a measurement of the inductance showed a significant difference between the coils. The good coils had $800\ \mu H$ but the bad one only $150\ \mu H$. The

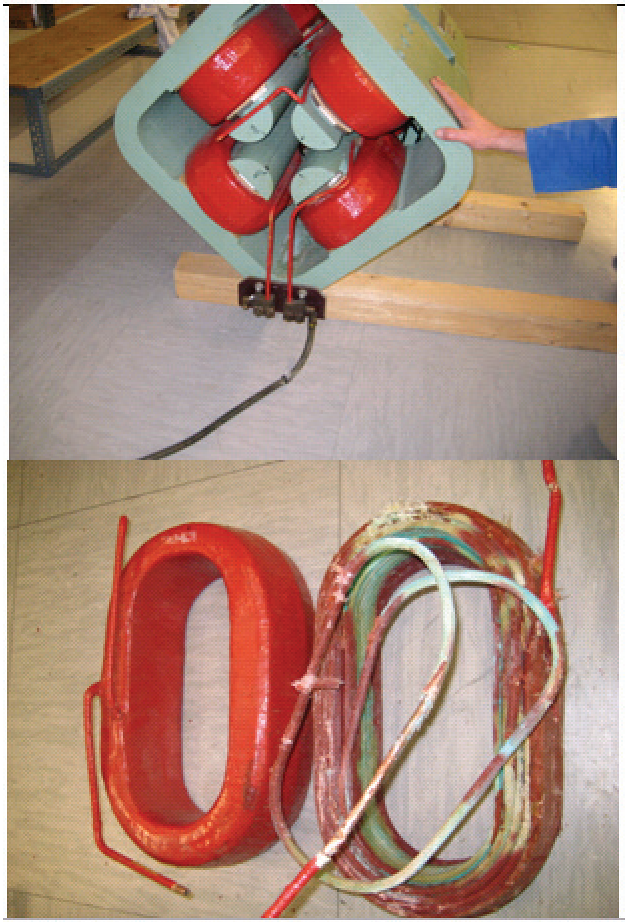

Figure 4: Quadrupole lens at the exit of the accelerator and the defective coil.

reason was found when opening this coil. Inside we found the coil filled with water and a lot of corrosion products of copper. This mixture of water and corrosion products was certainly highly conductive and produced a kind of short circuit in the coil.

With the new coils the beam is perfectly horizontal after the lens and no steering is necessary anymore.

Storage of Idle Wheels

We had in the past years a problem with our spare idle wheels. The rubber like material of the wheels showed a consistency like chewing gum, not elastic as rubber. The problem here is the moisture of the air. Therefore we now store the spare idle wheels at both ends inside the accelerator in dry SF6 atmosphere. Our experience in the past three years shows that the problem vanished.

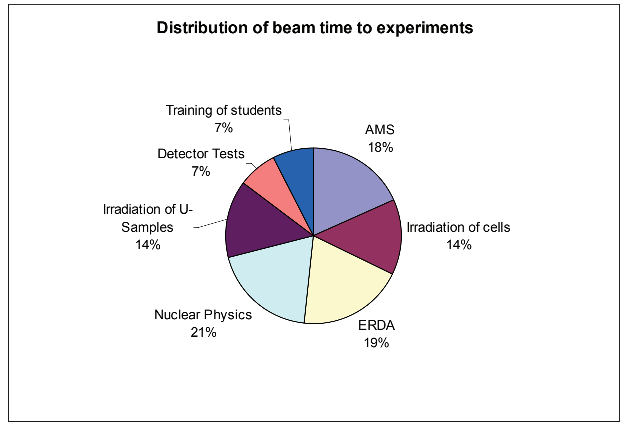

Figure 6: Distribution of beam time to experiments.

EXPERIMENTS

When the Tandem accelerator started in 1970 almost all experiments were in the field of fundamental nuclear physics. But with the years the methods used in the beginning for nuclear physics led to a lot of applications for example in AMS or materials analysis with ERDA.

Today only 21 percent of beamtime are in the field of nuclear physics. Many of these experiments have astrophysical relevance and were performed in the excellence cluster Origin and Structure of the Universe. A project in the MAP cluster is the irradiation of living cells with single ions. These experiments were carried out with the microbeam facility called SNAKE. The laboratory can offer some 20 experimental places. The instrument most frequently used is the magnetic spectrograph Q3D. About 22% of available beam time was there. The experiments here are in the field of high resolution nuclear spectroscopy and material analysis with ERDA. About 18% account for the gas filled analysing magnet GAMS. The microprobe SNAKE accounts for 13% of beamtime. Especially in the last year the irradiation of Uranium-samples demanded about 14% of available beam time. The goal of these studies is the development of a new reactor fuel element with lower enrichment for the research reactor FRM-II. More information about the experiments can be found in the annual report of the laboratory (http://www.bl.physik.uni-muenchen.de/mll-jb.html).

Future perspective of the Tandem Accelerator

In the next years a high demand for beam time at the Tandem accelerator is expected. Many groups of very different fields will use the versatile experimental places at the beam lines.