SLS RF operation report 2003

M. Pedrozzi, Jean-Yves Raguin

Paul Scherrer Institute, 5232 Villigen PSI, Switzerland

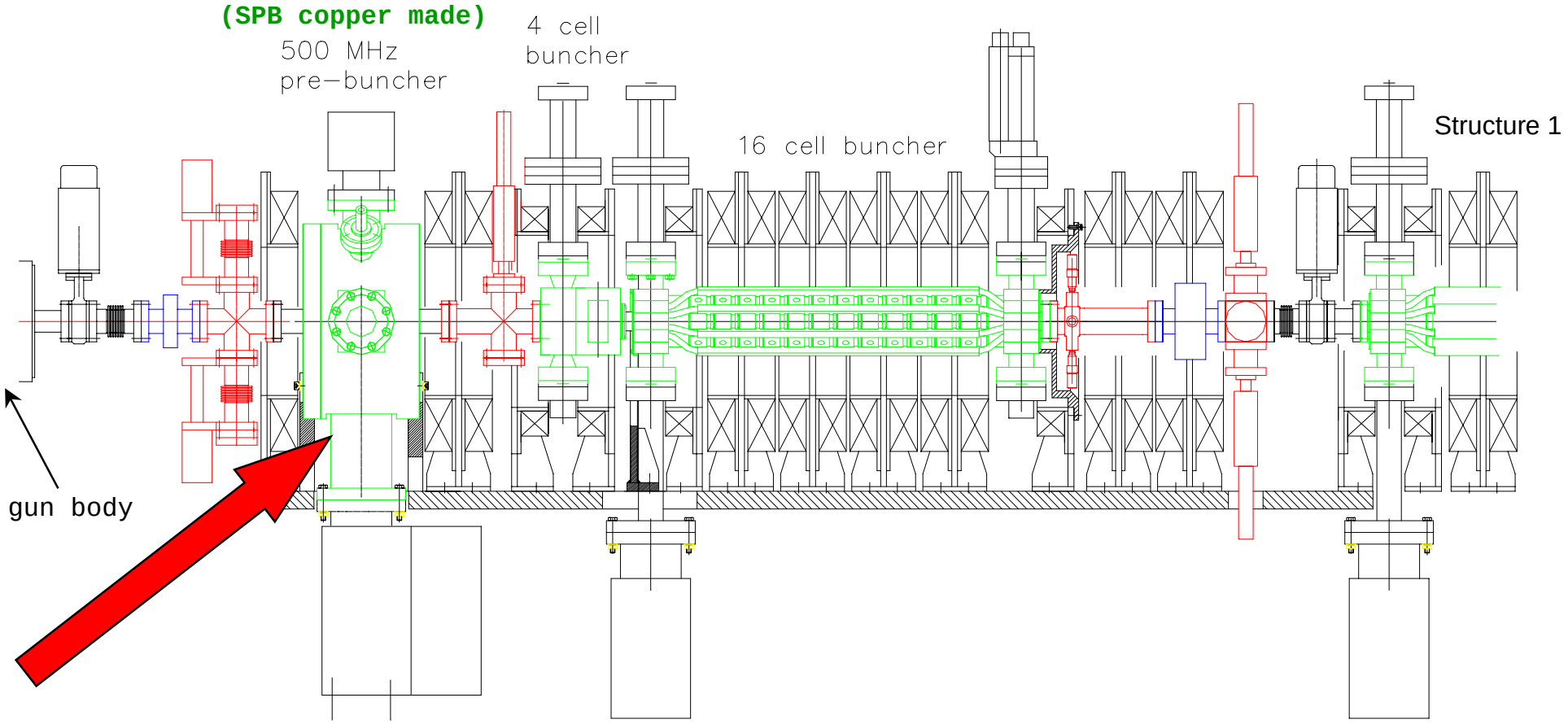
SUMMARY

• LINAC report

• SR Superconducting Third Harmonic system report

• SR 500 MHz system report

Linac Report (new 500 MHz Sub Harmonic Prebuncher)

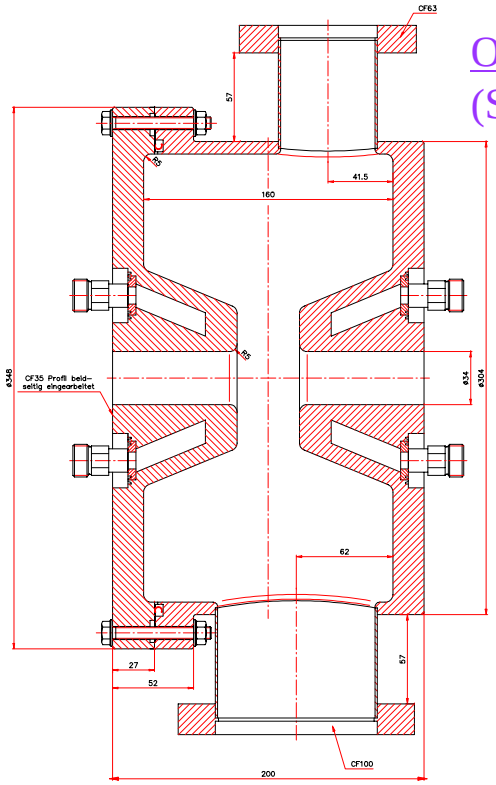


The 500 MHz SPB cavity is needed to achieve high transmission rate down to the booster and minimize the losses, especially in single bunch mode (1 nC, 1 ns at the gun).

Typically parameters: Unloaded Q~16000 - Input power ~400W

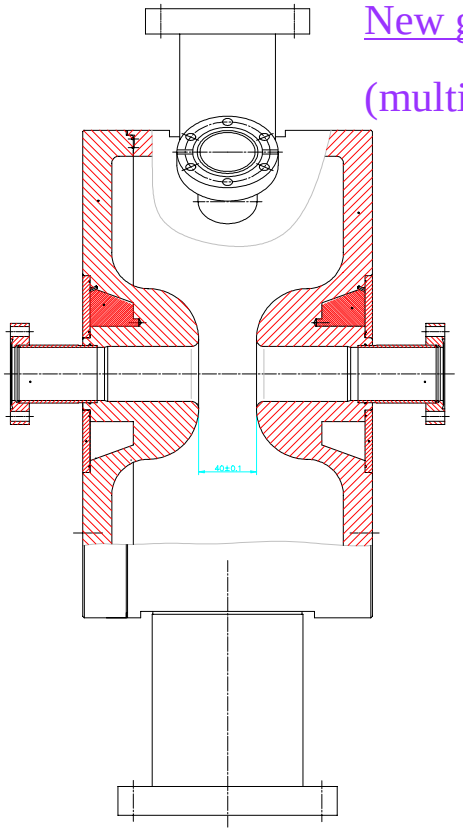
Linac Report (new 500 MHz Sub Harmonic Prebuncher)

Old geometry
(SBTF design)



New geometry

(multipactor simulations)



Motivation: suppress the strong multipactor activity observed in the old SPB cavity (See ESLS-RF 2000), which was perturbing the injection stability and the optimization.

Technical aspects: New shape optimized via multipactor simulations (University of Helsinki), the copper surface has been chemically cleaned in a clean room, similar to a superconducting cavity. No coating on the surface.

Installation: October 30, 2002.

Linac Report (new 500 MHz Sub Harmonic Prebuncher)

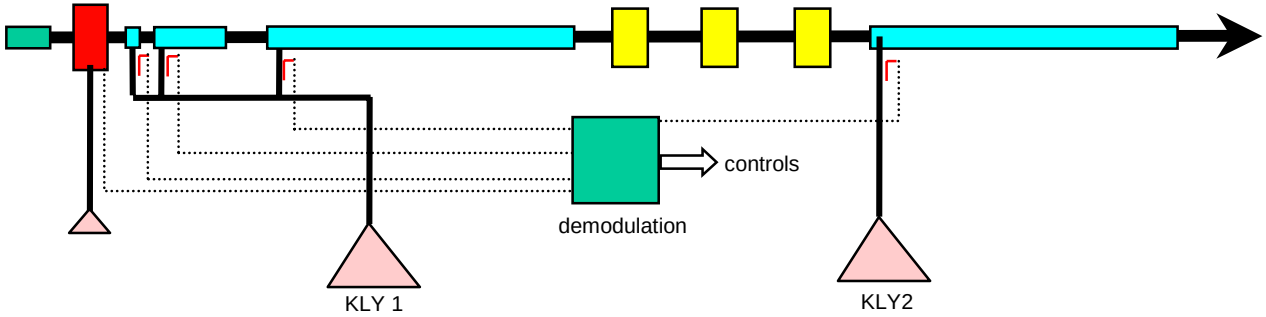
What we learned:

1) A coating of the "noses" with Aquadag (graphite colloid) didn't improve multipactor.
2) Technically a Titanium coating would be possible, but this require in-situ back out capabilities up to ~180 oC after venting the cavity.
3) The usual cleaning procedure after assembly is not enough (degreased and treated with light citric acid).
4) DUST IS A MAJOR PROBLEM. After a "special chemical treatment" (ACCEL receipt) the SPB has to dry in a clean area, the same for the coupler and the tuner.
5) To preserve the surface quality, the SPB must be pumped or ventilated slowly (20-50mBar/min) with pure, dry nitrogen. It is possible to let the SPB stay under nitrogen atmosphere for several days.
6) Conditioning capabilities are needed (high duty cycle), in our case cw 500W amplifier.

   - After installation (cavity on air), cw conditioning was needed to suppress multipactor.
   - Additional cw conditioning needed after 3 weeks, then after a couple of month.
   - Presently cw conditioning still useful ~twice a Year.

Linac Report (upgrades and major interventions)

1) Phase measurement of the 500 MHz and 3 GHz structures – SLS development (see Friday presentation).



2) Purchase of new klystron power driver (To be installed October 2003)

Supplier: Microwave Amplifier Ltd - 4 High Street – Nailsea, Bristol – BS48 1BT – UK
Frequency: 2.998GHz +/- 15MHz
Output: +56dBm (400W) minimum @ 10% duty cycle
Input: +6dBm
Pulse: 3-20 μs,
Rise time: 100 ns
Indicative price: 14050 GB/piece

3) Replacement of the klystron tank oil type, and tank revision.

old oil: ELTECK GK2 (Esso, not anymore in production)

new oil: DIALA B (Schell, same oil used at CERN)

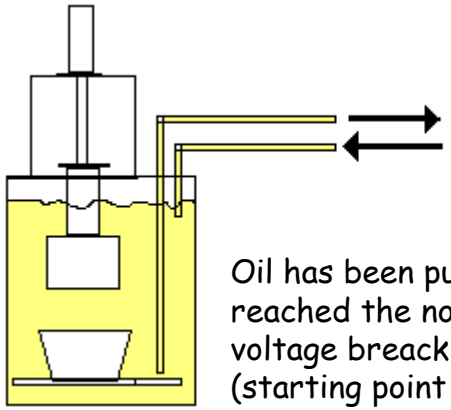
4) Installation of the TH2100 spare klystron before end of warranty

Linac Report (major interventions)

What we learned about the klystron tank oil?

1) The in situ oil regeneration (normal procedure for transformer) is here very risky.

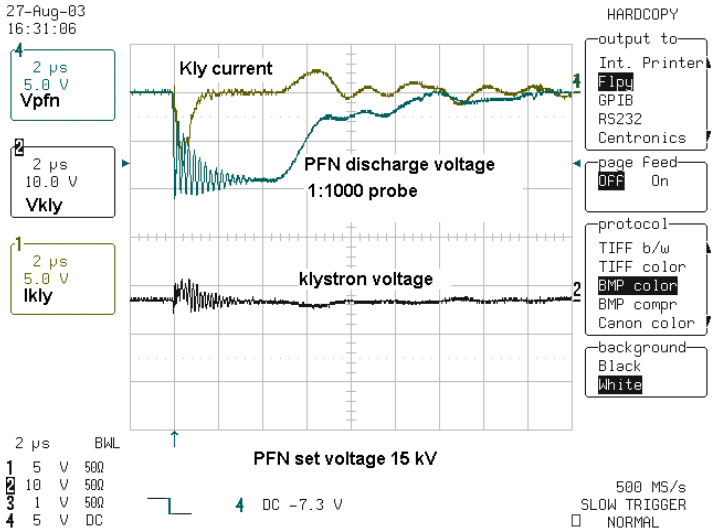
Since in principle there is no temperature sensitive components in the tank, and after discussion with CERN, we decided to try the in situ regeneration because our oil was not anymore in production.



80°C Oil circulation to purifier

Oil has been purified until we reached the nominal 75 kV high voltage breack down limit (starting point 25 kV !).

Results after purification !

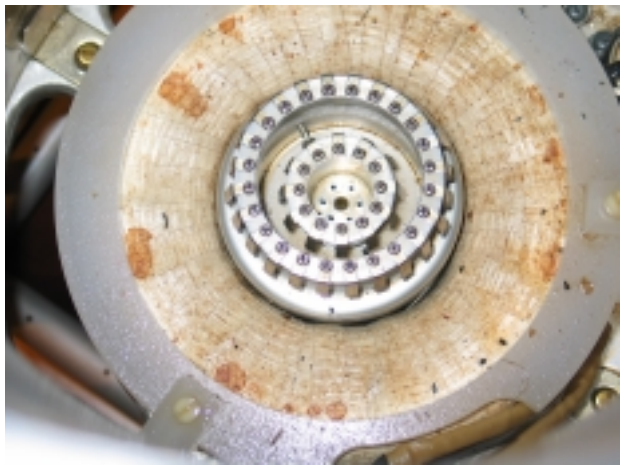


Consequence: We completely opened the tank and carefully inspected all components.

Linac Report (major interventions)

Everything was quite dirty and still an important amount of water was on the bottom of the tank, in the capacitive probe for the HV measurements, and in the cover containing the tri-axial cable connector.
The current and HV probe coaxial cable was damaged, probably because of the regeneration temperature.

Bottom support plate



Heater transformer

Current and HV probe coaxial cables

All components have been cleaned using alcohol.

New coaxial cables for current and voltage probes have been mounted

Tanks refilled with new fresh oil (DIALA B from Schell).

Tank inner components (already cleaned)

Linac Report (major interventions)

2) For safe operation would be a good idea to analyze the oil at least once every 6 months.

3) Once per Year inspect the tank components and replace the oil with fresh oil.

4) Oil should be regenerated only outside.

5) The klystron collector water connection are probably partially responsible of the oil water contamination (metallic conical fitting, very hard to get tight). We will modify the fitting to integrate an O-ring.

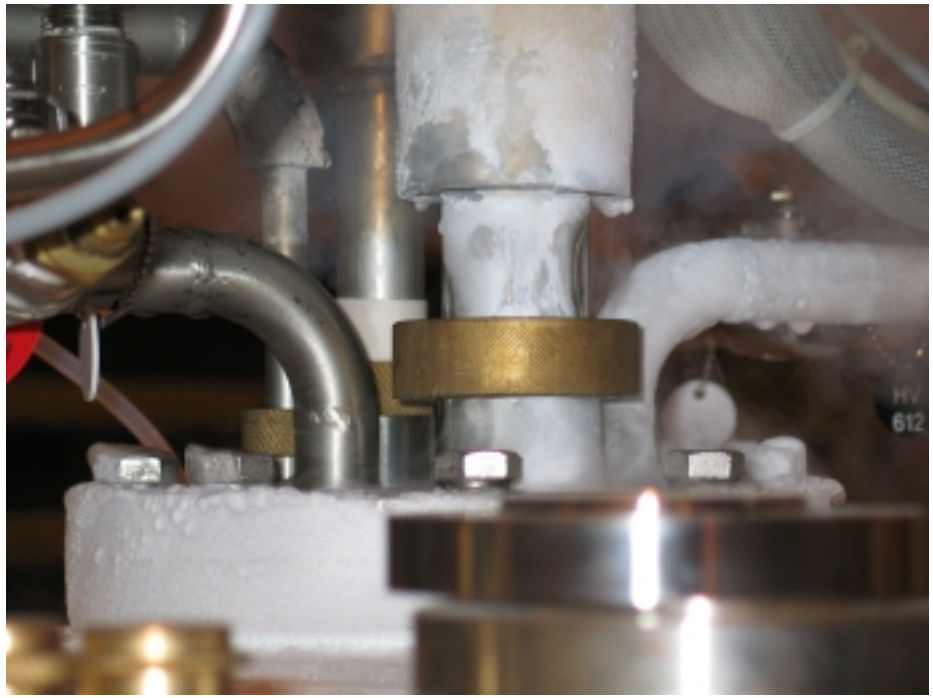
TH2100 collector

S3HC report

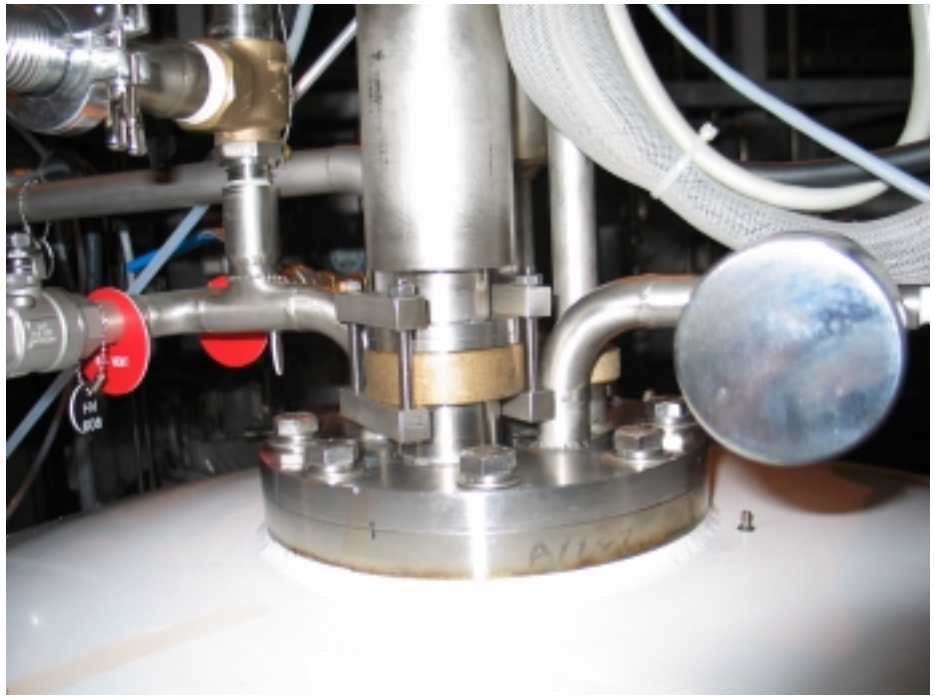
Major failures.

1) Summer: Leak of cold He gas from Dewar

   Cold Box / Dewar transfer line junction leaking probably due to the vibration induced by the insulation vacuum primary pump and/or the very high room temperature.



He leak on the Dewar



Junction consolidated with an Indium wire

S3HC report

Major failures.

2) September: **TURBINE 1 failure**

During normal operation, turbine 1 stops (under-speed interlock) and didn't restart.

The refrigerator is still covered by the warranty.

Both turbines replaced by PBS (První brněnská strojírna, Velká Bíteš, a. s., Aircraft Technique Division, Vlkovská 279, 594 12 Velká Bíteš , CZECH REPUBLIC)

Dark metallic dust observed on the bottom of turbine 1, as well as a small mechanical deformation of one pallet, No dust on turbine 2 (but some problems while restarting).

PBS is presently analyzing our turbines to understand the reason of the failure.

Possible explanations

Air Liquide first reaction:

Impurities in the Helium (PSI responsibility…, but unlikely)

Other possibility:

Vibration induced by the primary pump the isolation vacuum.

Design problem.

S3HC report

What we learned during operation?

1) Because of the stable top-up operation the cavity can be operated at fixed tune (good for tuning motors).

2) Due to external temperature changes (winter-summer) the main SR frequency can considerably change, the voltage should be consequently verified manually from time to time (this Year 5.5 kHz excursion at 500 MHz, 16.5 kHz at the third harmonic because of temperature stabilization problems during the hot season).

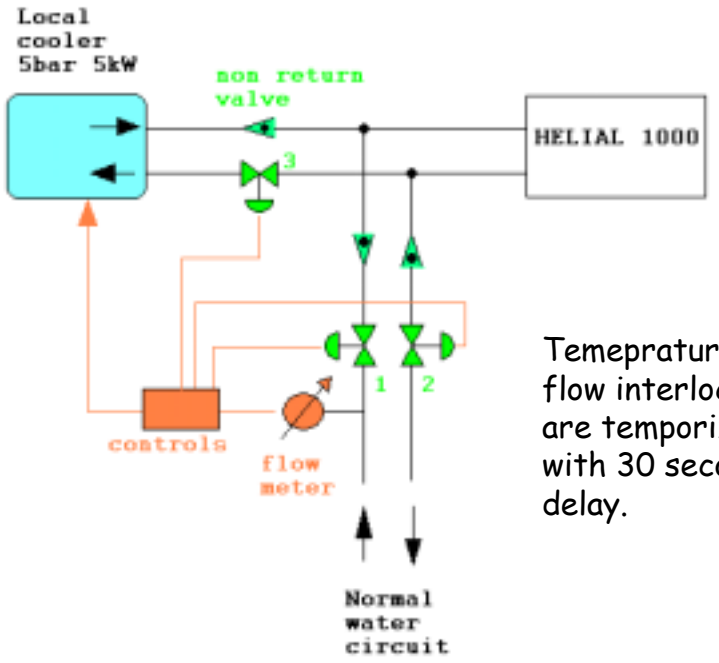
3) In the SLS the same tune (~ +65kHz) can be used to stable fill the machine up to 300 or 400 mA.

4) Stable operation at 400 mA has been well established (life time improvement ~2.2). No additional radiation losses with respect to 300 mA operation.

5) The cooling system for the refrigerator turbines should have a redundancy to overcome failures or to allow maintenance of the main cooling system. A complementary cooling rack will be mounted during the October shut down.

6) We should avoid all source of vibration on the cold box (primary pump of the isolation vacuum)

7) Spare turbines ready to be mounted are Probably a good investment.



Temeprature and flow interlocks are temporized with 30 seconds delay.

Storage Ring 500 MHz RF report

1) Test and operation on the SR of the new 500 MHz Thales klystron

	heater voltage	heater current	solenoid 1 voltage	solenoid 1 current	solenoid 2 voltage	solenoid 2 current	beam voltage	beam current	anode voltage	anode current	gun perveance	drive power	output power	gain	efficiency
	[V]	[A]	[V]	[A]	[V]	[A]	[kV]	[A]	[kV]	[mA]	[uA/Vexp 3/2]	[W]	[kW]	[dB]	[%]
THALES	6.8	26.3	86.6	9.7	96.1	9.7	45	7	26.5	0.1	1.62	12	181.4	41.8	57.8
EEV	13.94	24.62	137	9.34	74.7	8.2	45.3	6.24	25.66	1	1.52	17	180	39	63

less heater power

More beam power

- Same interfaces as for EEV klystron.
- Mounted on SR-RF plant 2 during the last week of August and stable operation during the last month.
- The possibility to buy a third spare klystron is presently investigated (~uncertainty about klystron suppliers).

2) Implementation of absolute encoders on the HOM frequency shifter (important for fine tuning of the HOM and cavity settings restore)

3) Stable operation at 400 mA tested during 8 hour shift.

4) SLS is investigating the possibility to build a complete RF test stand for klystron tests, components development, controls and LLE tests.