



JAGIELLONIAN UNIVERSITY
IN KRAKOW



SOLARIS
NATIONAL SYNCHROTRON
RADIATION CENTRE

Status of SOLARIS

Paweł Borowiec
On behalf of Solaris Team

- 1. Timeline**
- 2. Injector**
- 3. Storage ring**

Winter shutdown 14.12.2015-15.02.2016

Landau installation

Summer shutdown 25.07-26.08.2016

Regular maintenance

Few days stops for interventions.

One week needed for parameters stabilization of the machine after shutdown.

12.2015 RF team was reduced to 2 members but 2 persons will begin this December.

Energy out of the gun 2.62MeV.

1st stripline chopper

- 500MHz RF modulation of beam, signal improvement on storage ring BPMs at low current

2nd stripline chopper

- HV switches has been installed, no significant improvement on bunch shape yet

Thermal insulation of SLED cavities.

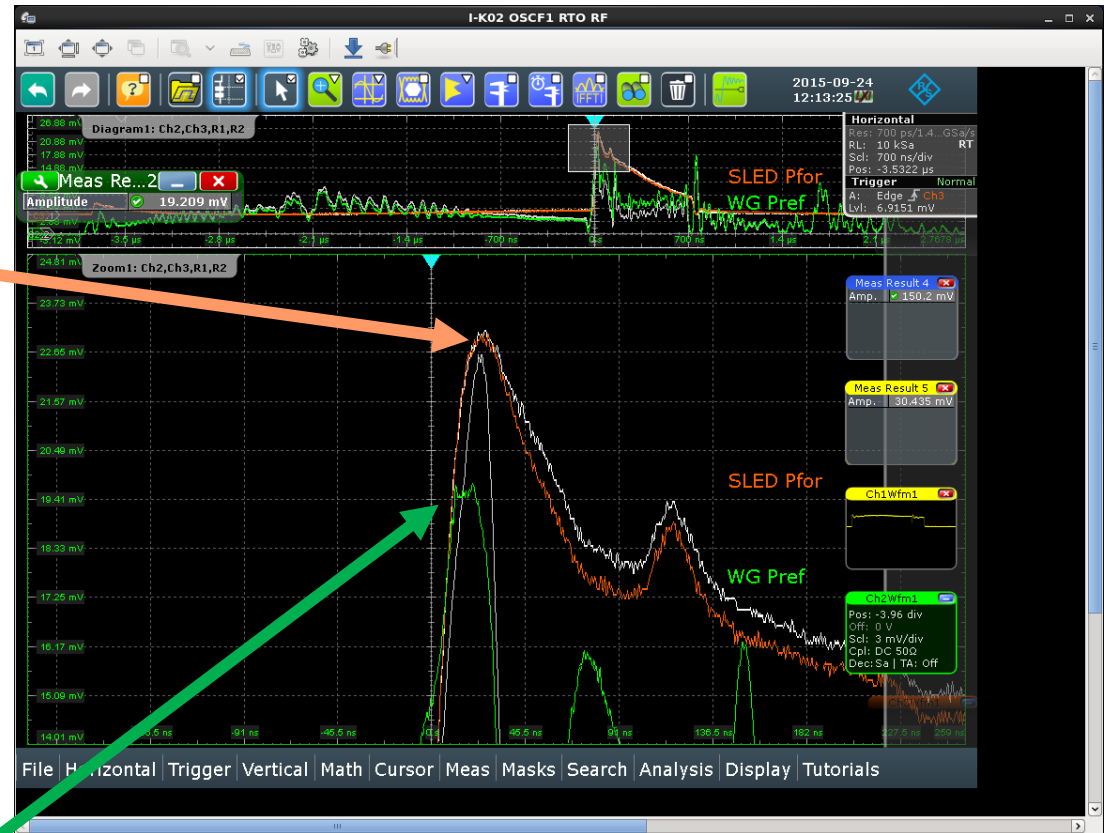
Permanent conditioning of waveguides and accelerating structures in automatic mode.

Energy out of the injector 525MeV. Energy is fixed during last year for storage ring commissioning.

Shortening of RF pulse based on Max IV experience:

- Filling time of SLED from 3,75 μs to 3,3 μs
- Filling time of accelerating structure from 0,75 μs to 0,7 μs

No significant beam energy loss



lower reflected RF power,
less stress for klystrons

White traces show values at previous settings

Modulators working time after 2 years:

	Standby Time [h]	HV Time [h]	TriggerTime [h]
I-K00	1039	953	1241
I-K01	1166	407	5571
I-K02	1116	431	5900
I-K03	1205	718	5214

I-K02 was the test modulator during RF startup.

Milestones:

09.06.2016

Injection of 540mA, which was tried to ramp to full energy.

Unfortunately, the vacuum trip in 100MHz cavities appeared during ramping at 970MeV(480mA) and beam dump.

Later during the day injection of 438mA which was ramped to 1.5 GeV (408mA).

The beam was circulating for 20min at full energy, but after that the vacuum trip has appeared on cavities which interlocked the transmitters and dump the beam.

27.06.2016

Injection of 596.5 mA. After that beam was dump due to vacuum trips in the 100MHz cavity No.1

Investigation shown leak in ceramic window for pick-up in both main cavities

Ceramics have been exchanged but maximum allowed beam current is 370mA injected.

New type of pick-up without ceramic will be installed.

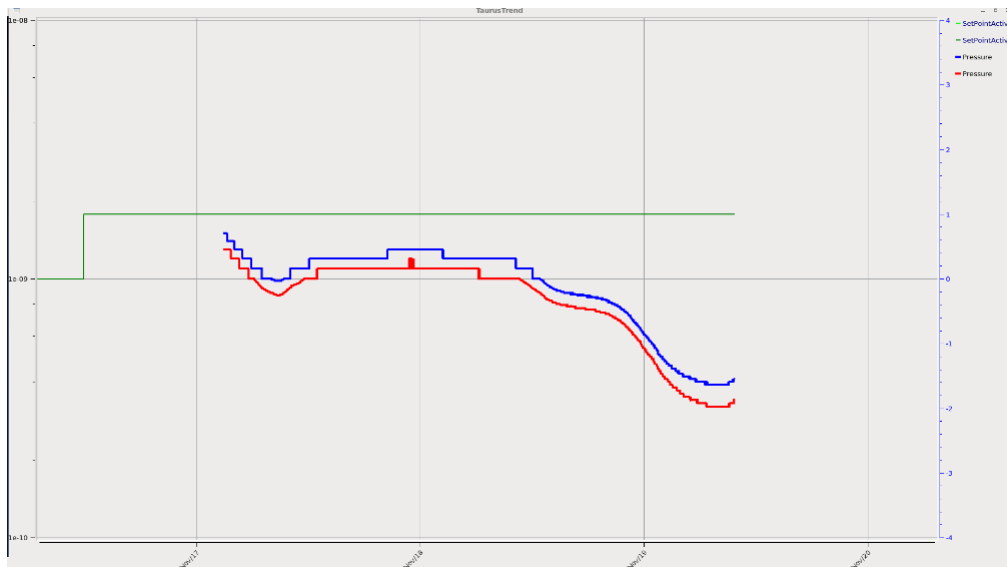
Delivered to Solaris but not installed in first stage of commissioning.

- Easier start-up of Storage Ring

07.2015 Baked out

11.2015 Conditioning at 50W only because no test-stand available @ Solaris

- Power coupler borrowed from Max IV
- 50W @ 300MHz RF power, monitoring of Pfor and Pref
- Without cooling, without tuning of cavity
- Manual reflected RF power optimisation (frequency change of signal generator)
- Vacuum interlock,
- No radiation has been observed, no shielding required



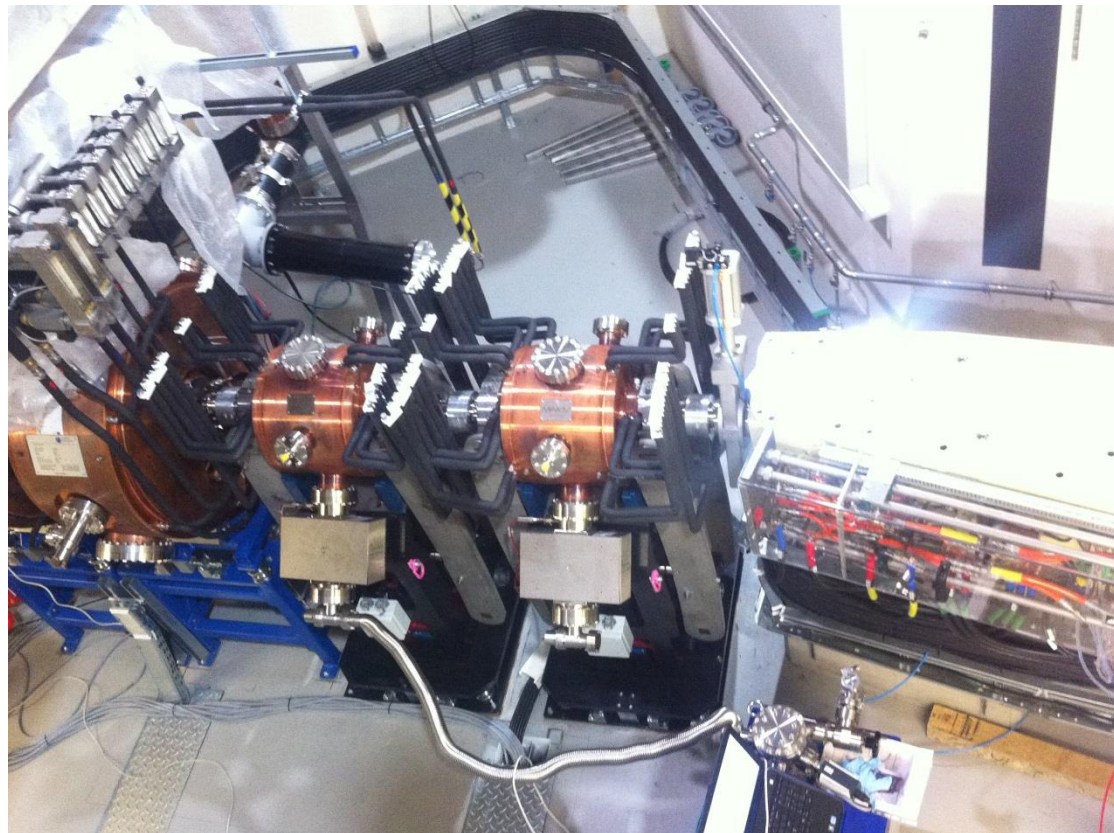
Tuning range set from 299,4MHz to 300,4MHz

Some troubles with tuning mechanism:

- **New alignment of worm gear**
- **Greasing**
- **Sensitive adjustment of limit switches**

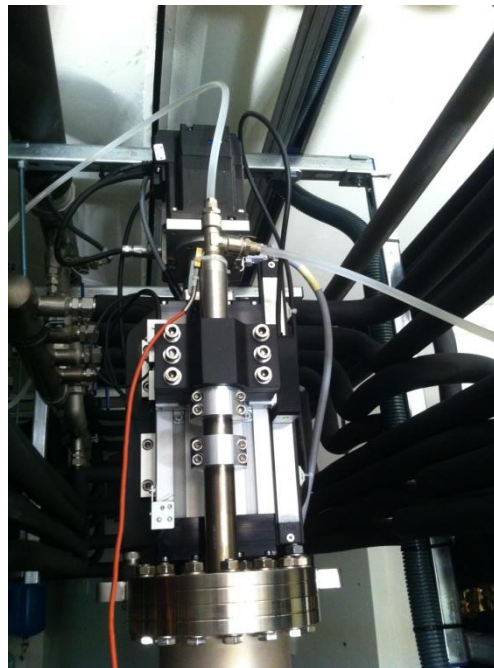
Second pick-up installed for transmission measurement.

12.2016 installed in storage ring



According to simulation* and Max III ring operation the possibility of additional detuning of Landau is necessary during injection and ramping.

- Detuning up to 600kHz in 4 minutes
- Possibility to shift HOM (ev. no needs of extra HOM dampers)
- Installed on CF100 top port of cavity
- Range of movement 80mm
- Step size 0,1mm, encoder included
- Water cooled copper part
- PLC controlled, integrated in TANGO

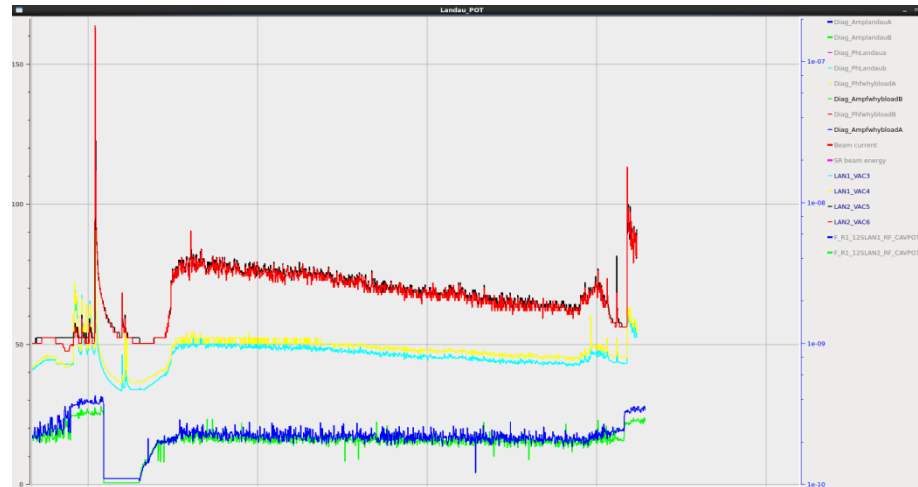


*Designed by MeasLine, Poland,
based on Max IV concept*

* Åke Andersson, „Special considerations taken for the SOLARIS 300 MHz Landau cavities, concerning the beam accumulation, beam energy ramping and user operation in decaying beam mode.”

At the beginning not possible to move plunger even by 0,1mm at few mA of beam current @ 1,5GeV, immediately pressure increase and beam dump. Very slow progress till summer shutdown.

Landau cavities with plungers have been installed together at the same time in storage ring. Since Landau cavities have not been conditioned with high RF power, it is not clear what is a source of outgassing.

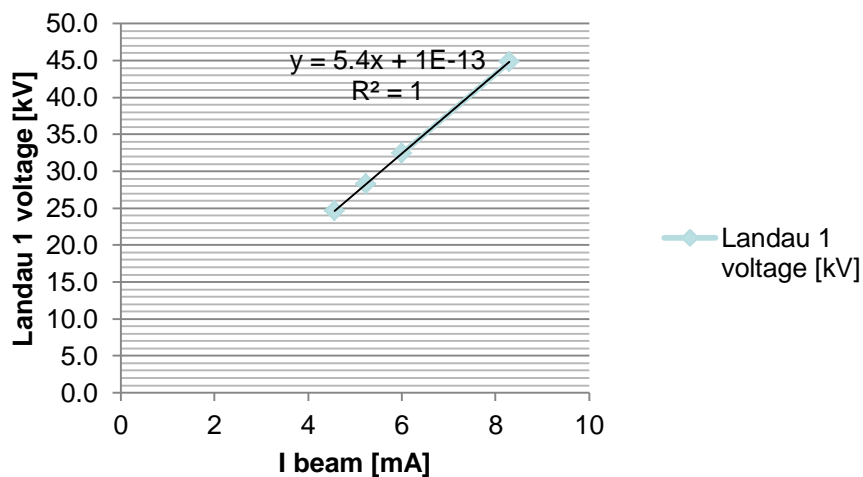


New conditioning strategy: ramping is paused when pressure is close to 1e-8mbar.

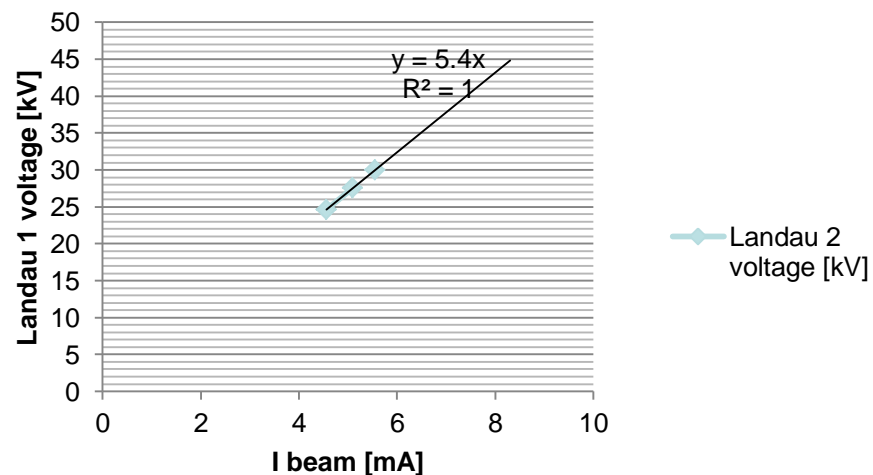
Recent status: full range movement of plunger with ramped 130mA of beam.

Landau cavity tuned to 3rd harmonic, plunger retracted.
Low current in storage ring.

Landau 1 voltage vs. beam current



Landau 2 voltage vs. beam current



HOM measurement of 100MHz and Landau cavities performed according to simulations *

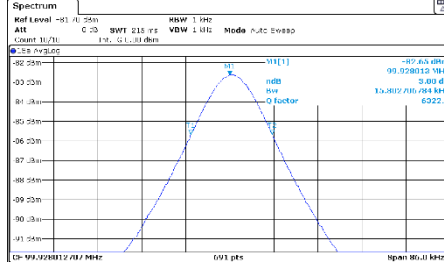
Identification of frequency and quality factor of HOM modes in cavities installed in storage ring.

Transmission measurements with spectrum analyzer equipped with tracking generator.
Frequency range from 99MHz (299MHz for Landau) to 1,5GHz
Measured at 30°C, 40°C, 50°C

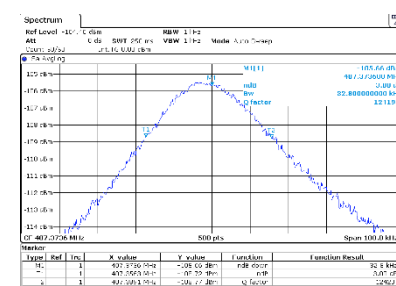
45 modes for 100MHz cavities
13 modes for Landau cavities

Data for further analysis by beam physicist.

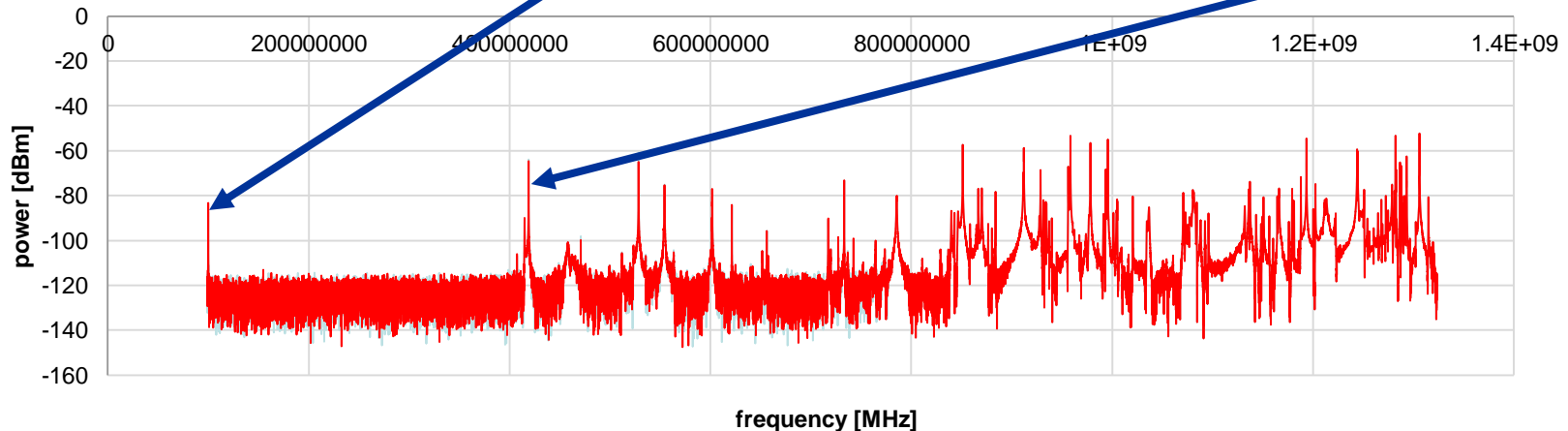
Fundamental frequency 99,92MHz



First HOM 407,37MHz



HOM in main cavity

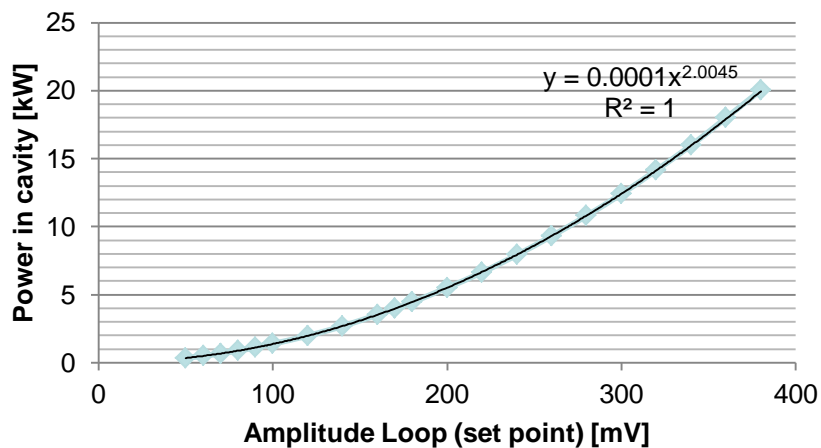


* Jonas Björklund Svensson, Master's Thesis „Characterization of Higher Order Modes in the MAX IV Active 100 MHz Cavities”

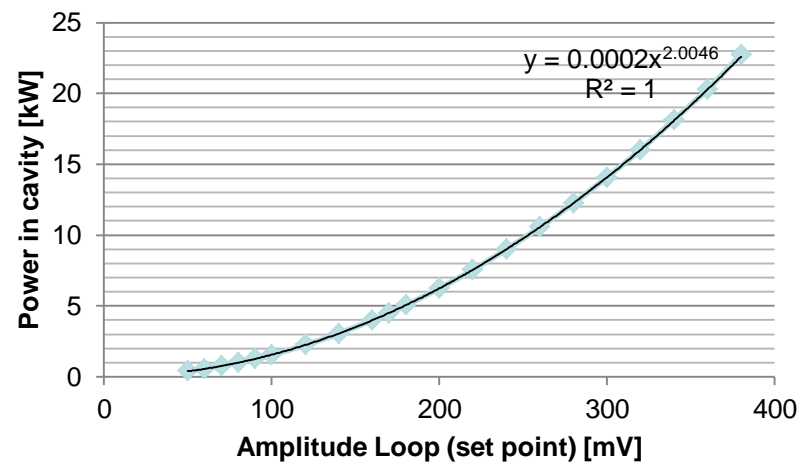
Characterization of RF power in system versus LLRF settings. Performed up to 25kW.
Formulas will be implemented in TANGO control system

Due to often intervention on pick-up's (leak search), calibration had to be repeated.

RF power in CAV1 [kW]

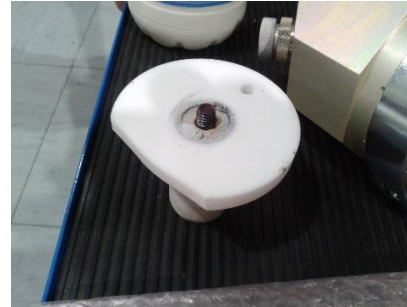


RF power in CAV2 [kW]



Rhode & Schwarz transmitters, modularity make operation possible even with some issues:

- Overheating of 3 1/8" elbow, wrong inner spacer assembly



- Cooling pumps of transmitters didn't start (internal R&S control system via CAN bus), thermal interlock (no flow switch) switched off whole transmitter but permanent problem with one module (out of 12).
2 visits in service 10'2015-01'2016, twice received as good
06'2016 problem appeared again, module replaced for new one

RF input connector mechanical problem.



100MHz cavities

- Stacked tuner mechanism, no grease in tapered roller bearings. Exchanged for new ones in both cavities.
- Leakage up to $1.0e-7$ mbar*l/s at ceramic of pick-up (already 4 pieces), even after one discharge in the cavity. They will be replaced for pick-ups loop without ceramic (Max IV concept), manufacturing by Research Instruments under warranty.



Ceramic – vacuum side, 30x

Metal inclusions



Crack

Rhode & Schwarz signal generator SMA100A (Master Oscillator for linac)

- Synchronization error on 10MHz reference, repaired under warranty

Activities:

**Fully operational LLRF, integration of missing high level software,
Chopper start-up for gun system,
Landau setup for bunch lengthening,
Bunch length measurement together with diagnostic team but no diagnostic beamline,
New electronics for reflected power interlock of klystrons in linac,
HOM filters for 100MHz cavities,
Setting-up of spare parts stock, critical for RF system operation**

I WOULD LIKE TO EXPRESS SPECIAL THANKS TO

MAX IV TEAM for sharing their knowledge and time

ANGELA SALOM for support with LLRF

Virtual tour of SOLARIS: <http://synchrotron.wkraj.pl/?EN#>



Thank you for your attention