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Trieste – Italy.

STATUS OF THE SOLEIL RF SYSTEM

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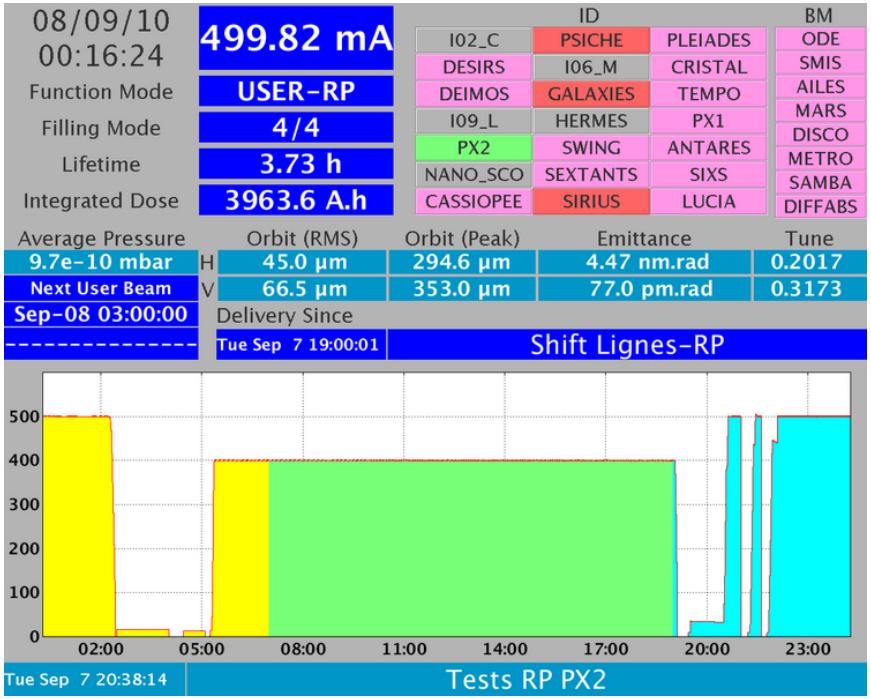
- SOLEIL Operation September 2009-September 2010
- Booster RF operation
- Storage ring RF operation
- New frequency Tuner
- RF AMPLIFIER operation and R & D
- Summary and conclusion

SOLEIL Operation Sept.2009/ Sept.2010



300 mA Top-up until November 2009

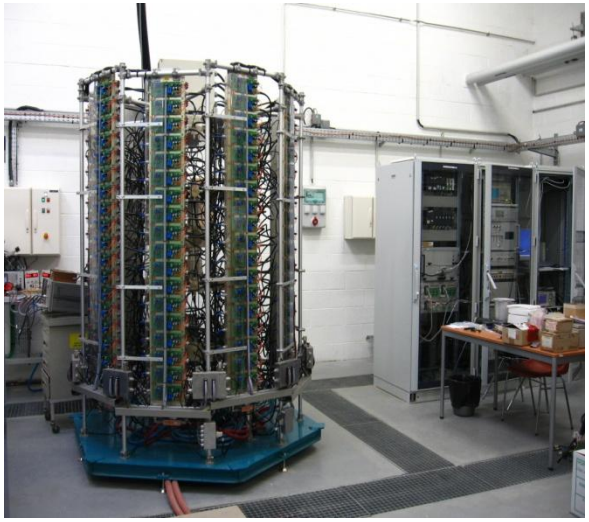
400 mA Top up standard operation for users since November 2009

Other available users modes :

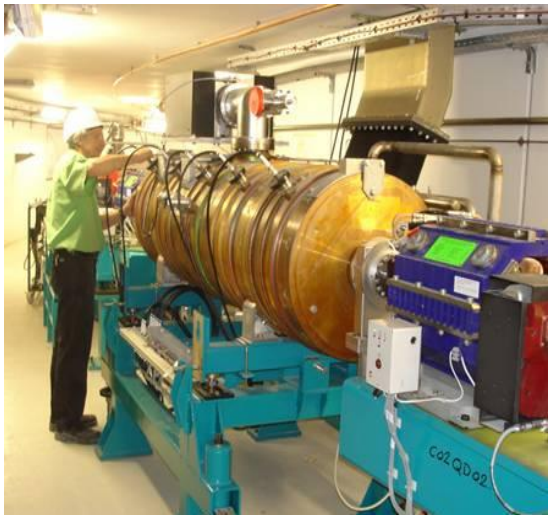
- **400 mA Hybrid Top-Up**
- **80 mA 8 Bunches Top-Up**
- **10 mA Single Bunch Top-Up**

500 mA Top-Up validated beginning of 2010, used for machine R&D and Radioprotection test (for users beginning of 2011)

Booster RF



35 kW solid state amplifier & LLRF

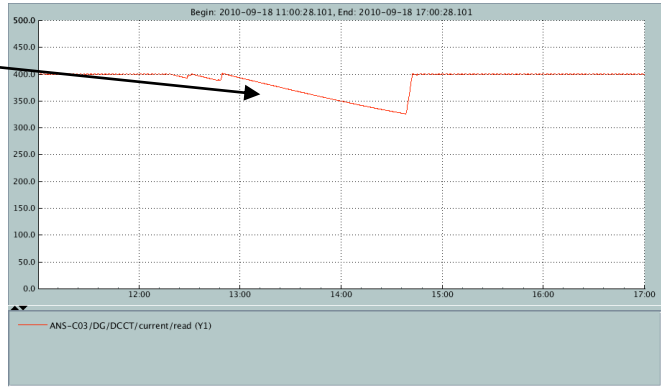


5-cell LEP type cavity

From Sept. 09 until Sept. 2010 ~ 5000 running hours

- **Short Top-up interruption but no beam loss caused by RF booster interlock card fault**
- **Amplifier : no failure at all**

> 20000 hours operation over 5 years, no real problem

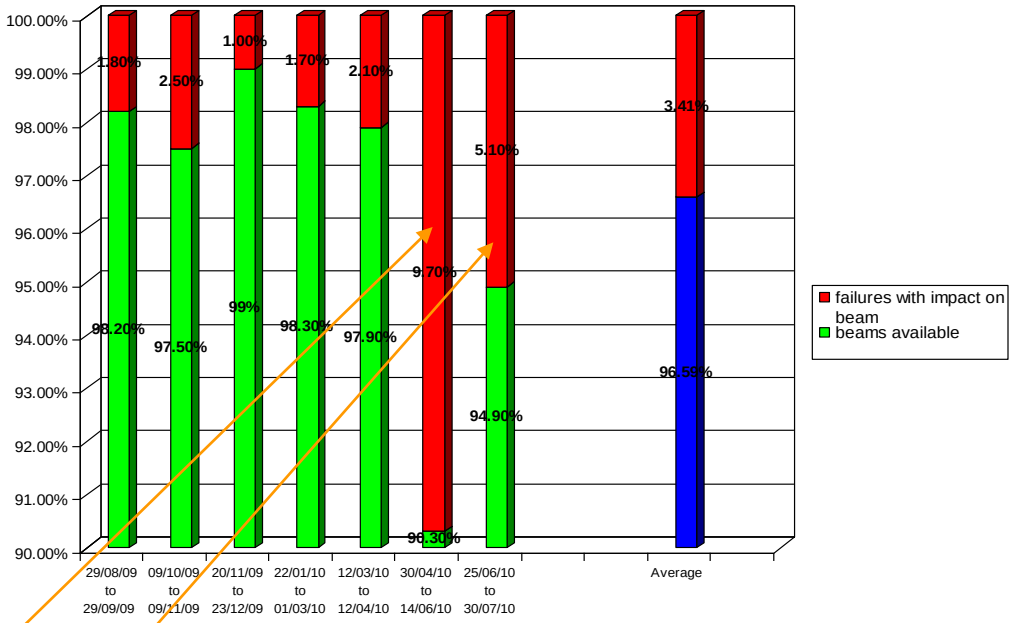


Storage ring RF

- 580 kW (500 mA) & 4 MV @ 352 MHz
- 2 cryomodules, each containing a pair of single-cell s.c. cavities
- Each cavity powered by a 180 kW solid state amplifier
- Both CM supplied with LHe (4.5 K) from a single cryo-plant

Storage ring operation

Beam availability during the users and RP sessions



Beam time availability of ~ 96% , 98% before may 2010

Two main RF cryogenic failures impacted beam in 2010

- **Breakdown of compressor PLC CPU board ~60 hours of beam downtime failure during week end + day off, spare board not compatible and spare station under installation.**
- **Electrical power interruption during the spare compressor test (lost helium) ~ 6 hours of beam downtime**

RF Cryogenic System

Install of spare compressor station with separate utilities.

- **Redundancy in operation (losses of utilities (electric, water) → few hours restart)**
- **Maintenance transparency**

Operational since June 2010

New Tuner Version

1) Standard screw-nut assembly replaced by *planetary roller screw*

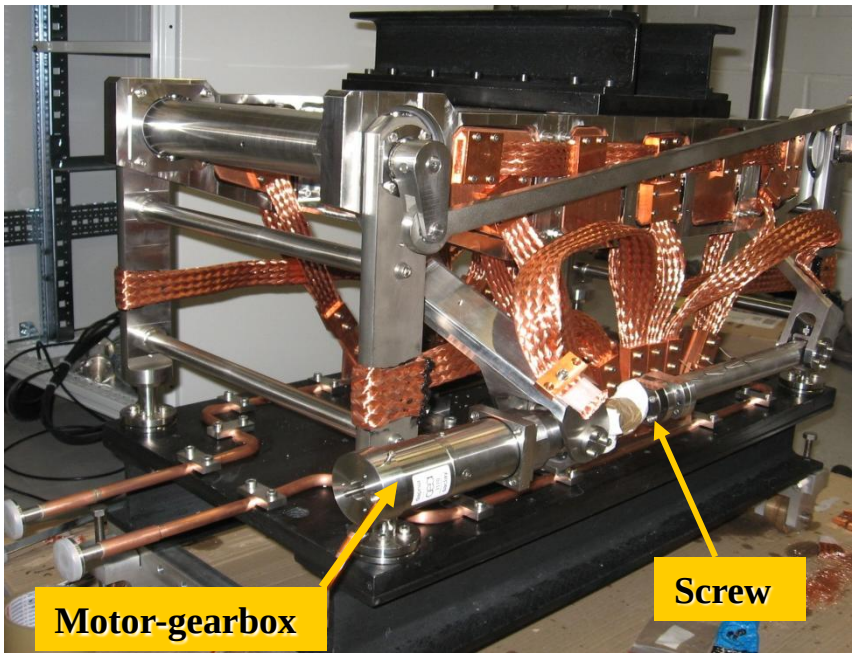
2) Stepper motor + harmonic drive gear box

Stepper motor with planetary gear box

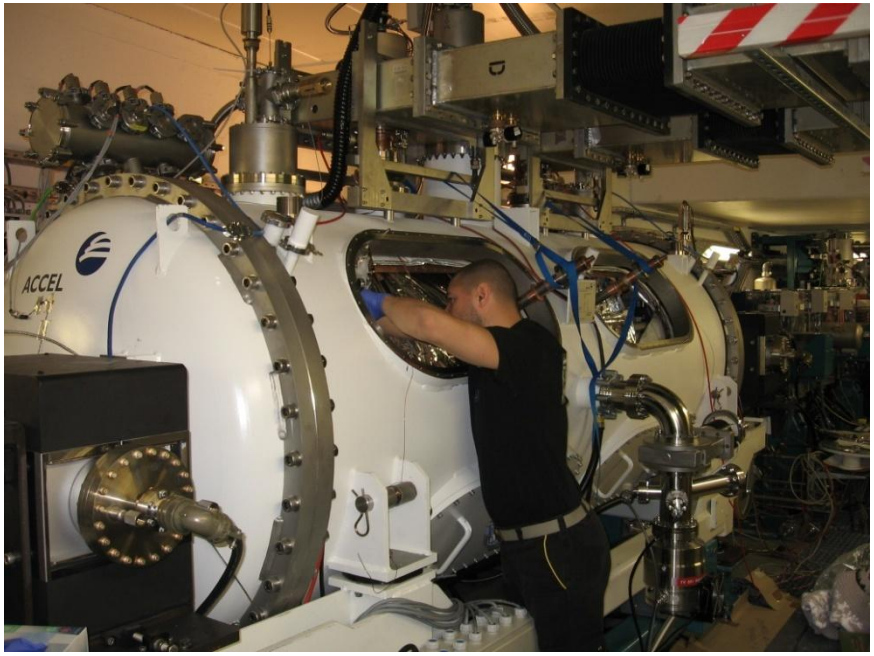
→ Less friction
→ More robust

→ Longer lifetime

Prototype was successfully tested on a test bench @ cold in CryHolab at CEA
→20 years of SOLEIL operation



Installation of New Tuner



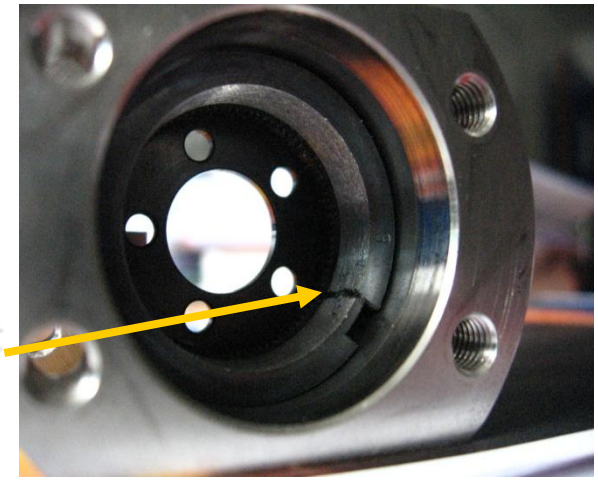
Installation of the new cold tuning system for cavity 3&4 during summer shut down (August 2009)
Installation of the new cold tuning system for cavity 1&2 during winter shut down (January 2010)

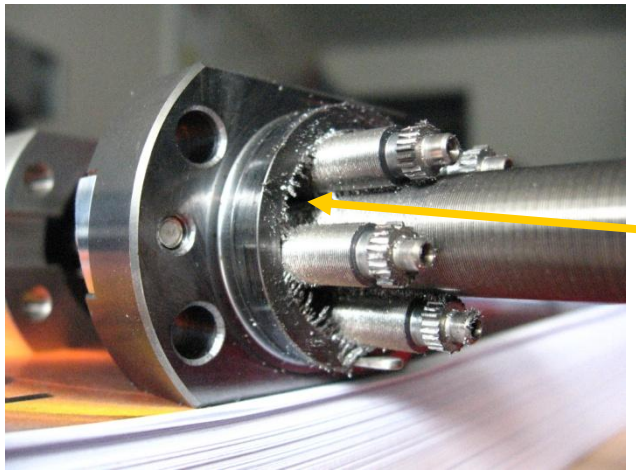
Tuner Screw Damages

In may 2010, the tuner of cavity 4 showed signs of malfunctioning

Before full sticking, use of the backup mode at fixed tuning and variable voltage until next shut down

Open Cryomodule 2 and investinvestigation during the summer shut down 2010

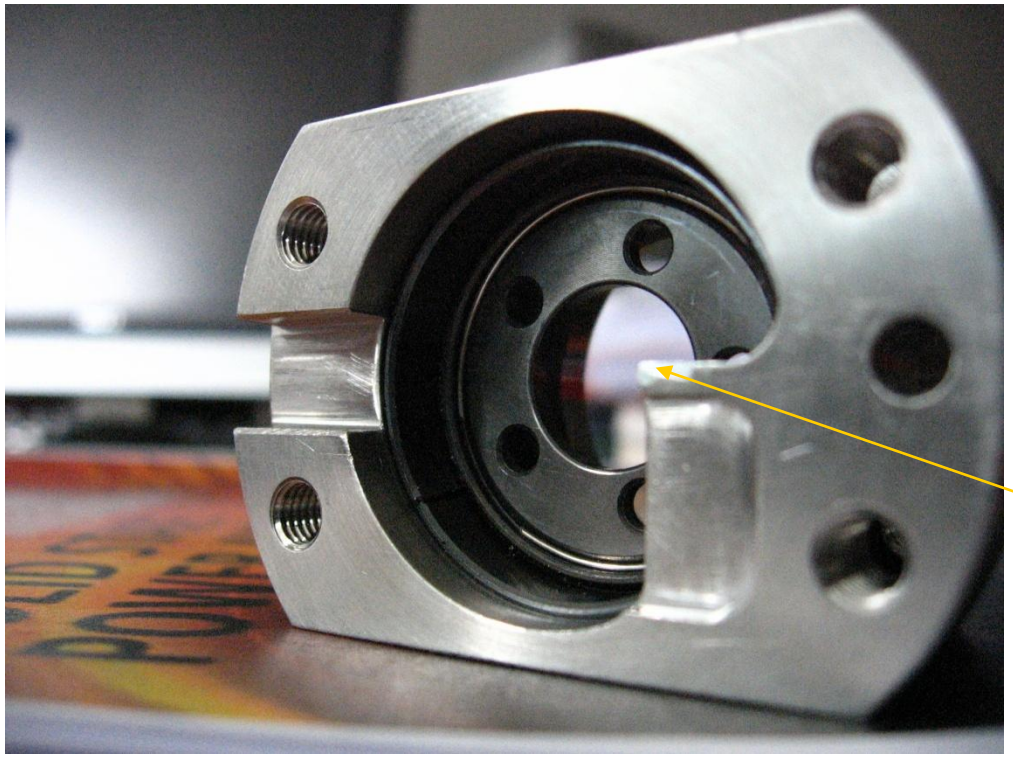




The friction between the nut and satellites screw caused the blocking of the system

Tuner Screw Damages

Mechanical stop which prevents the cavity from plastic deformation



→ Double mistake

- During the preliminary test at warm, without operational soft interlock system, we probably hit the mechanical stop.
- Mechanical stop not correctly settled → abnormal stress

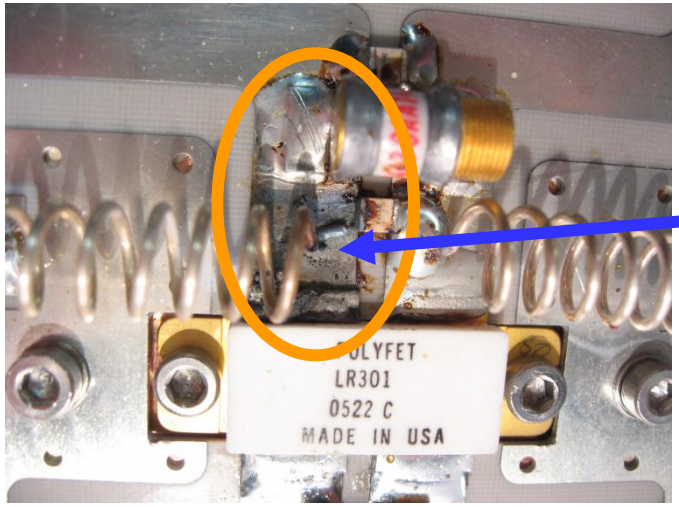
→ The inspection of the cav 3 system didn't show any sign of problem and the other tuners on CM1 are still working well

Amplifier Performance

→ ≈ 20000 hours running, and ≈ 100% operational availability

→ Modules failure rate ~ 3,5% per year (AMP 2,3,4~ 2% and AMP1 : 6%)

→2 failures types :
- Transistor failure
- Soldering thermal fatigue



Thermal Fatigue Failure After working for 20000 hrs

About 80% of them can be repaired (preventive repair maintenance on T2 and T3 during the shut down of the last summer)

None of these failures has impacted the operation (modularity & redundancy).

RF AMPLIFIER UPGRADE

SOLEIL SYNCHROTRON

- **Development a new module with 6th generation LDMOS (50V), much more robust + thermal stress strongly reduced → longer MTBF.**

- **Working point has been optimised for 46V @ 330W (G=21, η =72%)**

P (W)	Gain (dB)	Idc1 (A)	Idc2 (A)	Idc (A)	Phase ( )	S11 (dB)	Po (W)	E (%)
330	20,82	4,8	5,10	9,92	-127,0	-50,0	456,3	72,3
315	21,20	4,70	4,90	9,60	-126,7	-51,0	441,6	71,3
300	21,48	4,58	4,72	9,30	-126,3	-51,7	427,8	70,1
250	21,95	4,18	4,21	8,39	-126,0	-43,7	385,9	64,8
200	22,10	3,75	3,74	7,49	-126,7	-39,0	344,5	58,0
150	22,14	3,25	3,2	6,47	-128,0	-36,0	297,6	50,4

- **Replace progressively the actual modules with LR301 by new ones with BLF574 transistor (typically 1 tower/year)**

- **The choice of this solution will minimize the modifications**

- **Option for higher power (380W) @ 50V**

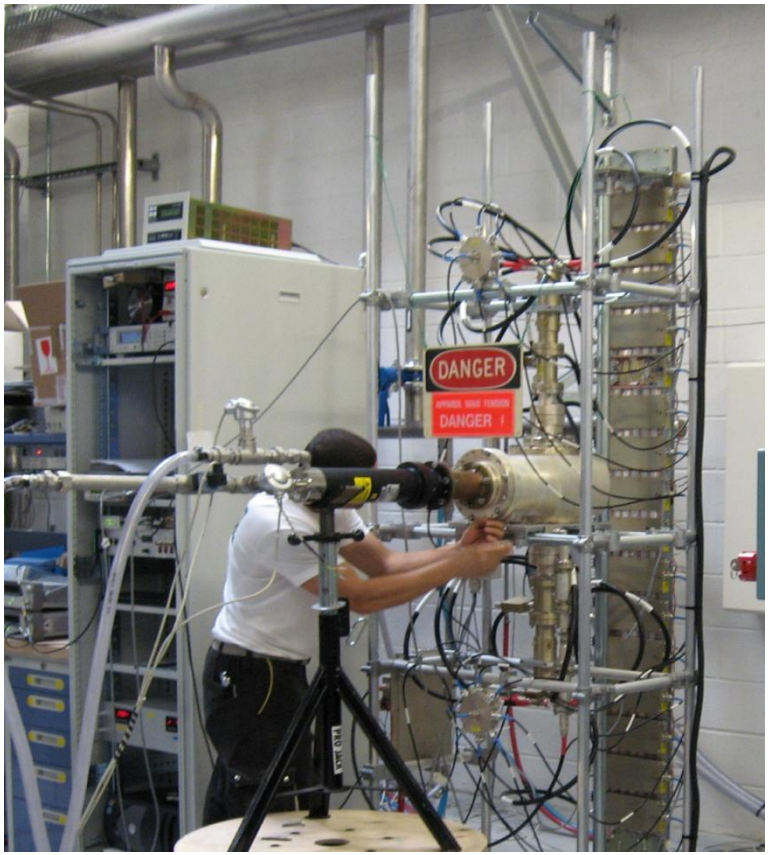
RF AMPLIFIER R & D

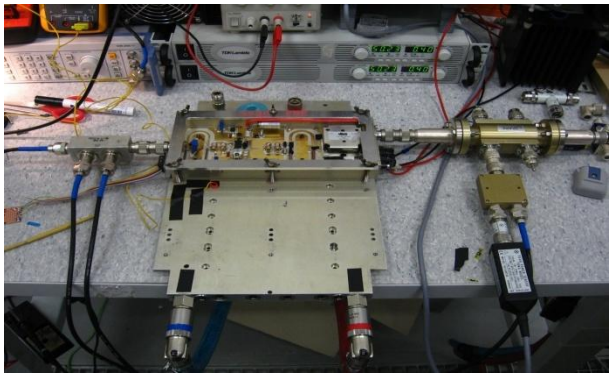
New generation modules developed at SOLEIL for different projects and collaborations.

Frequency	Output Power	Gain (1 dB)	Efficiency	projects
MHz	**W**	**dB**	**%**	
476	400	20	69	LNLS
352	700	20.5	73	ESRF
500	700	18	67	SESAME
88	1000	26	87	

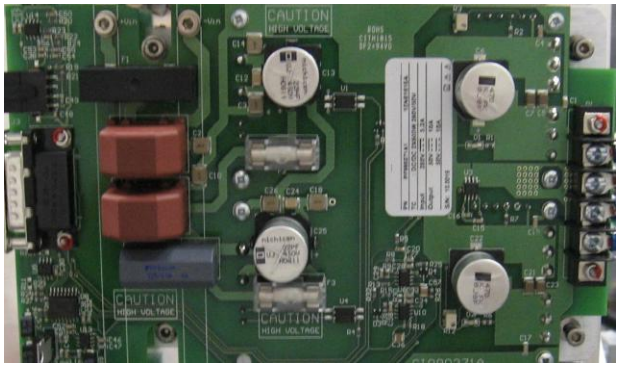
Possibility of designing modules of intermediate frequency such 100 MHz (Astrid) 200 MHz (CERN) and up to L band (1.3-1.5 GHz)

ESRF Project





700 W module



DC/DC 50V/1200W

Transfer of technology agreement concluded with ELTA-AREVA

→ ESRF contract for 7 amplifiers of 150 kW (14 towers of 75 kW)

- **Module validated → P = 700 W, G > 20 dB, η > 70% @ 350 MHz**
- **Integration test and validation for one unity of 10kW combination of 16 modules"**
- **75 kW tower → next year**

LNLS Collaboration

2 amplifiers of 50 kW with RF modules of 400 W @ 476MHz were successfully tested.

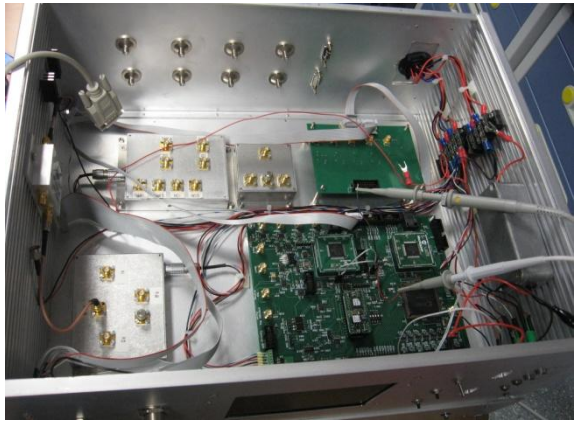
AVRIL 2010 , "SOLEIL – LNLS team in Campinas BRAZIL"

Other R & D

Area test with high power voltage, water and spare BOOSTER Cavity

→ LLRF and amplifier test

→ Conditioning the spare BOOSTER cavity (ready to be installed, if necessary)



New digital LLRF BOOSTER
(R. Sreedharan presentation)

Summary & conclusions

- For the BO RF, no operation problem at all
- For SR RF , after 4 years of running, the operational experience proved to be fully satisfactory, but in 2010 significant downtime due to 2 long cryogenics failures
- Installation of a spare He compressor station
- Confirm the good reliability of the new CM frequency tuners
- Upgrade of the power couplers (collab. with CERN & ESRF), able to store 500mA with one Cryomodule (→ redundancy)
- Progressive replace of the actual modules by the new generation (1 tour/year) → increase MTBF
- Continue the development of LLRF for Booster and Storage ring and others projects.