
High Power CW RF Sources for Booster and Ring in SSRF

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Outline

1. Status of Klystrons
2. Some Trips or problems
3. upgrades

Four Sets of CW Klystron Type Transmitters in SSRF

	NO0	NO1	NO2	NO3
Location	Booster	Ring	Ring	Ring
Klystron Type(Thales)	TH2161	TH2161B	TH2161B	TH2161B
Serial No	616002	161010	161012	161015(161013 before Oct,17)
Delivery time	2000	2007	2007	2009(2007)
Max Power(kW)	180	300	300	300
Power mode now(kW)	130	220	220	220
Used Power now(kW)	60(pulse)	145	145	145
Fil Time(h)	81000	75000	71300	3700
HVPS Time(h)	79000	73000	69000	3600
PSU(Ampegon)	46kV/7.5A	55kV/12A	55kV/12A	55kV/12A
PSM modules	68	86	86	86

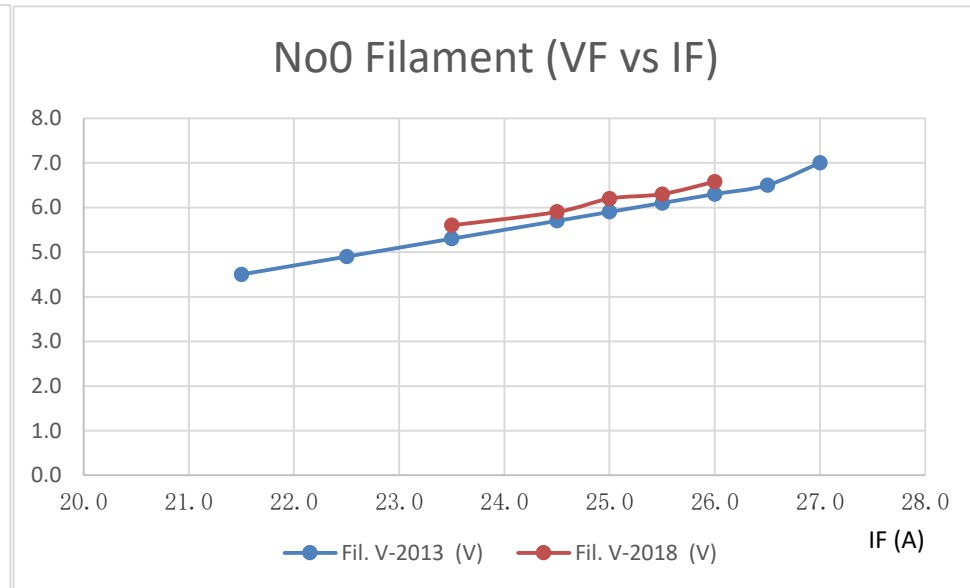
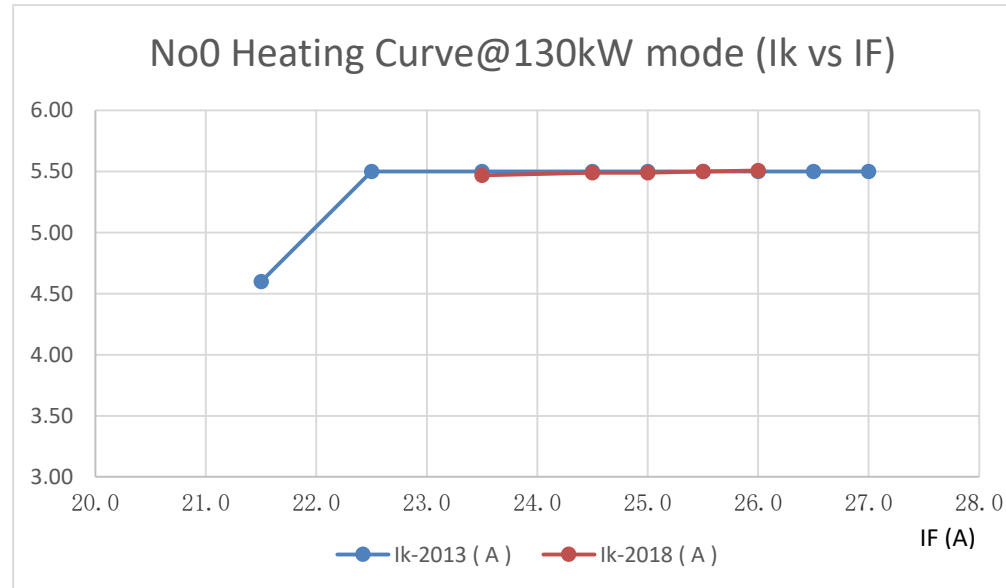


Three 300kW transmitters in Ring for three SRF cavities



one 180kW transmitters in Booster for two 5-cell NC cavities

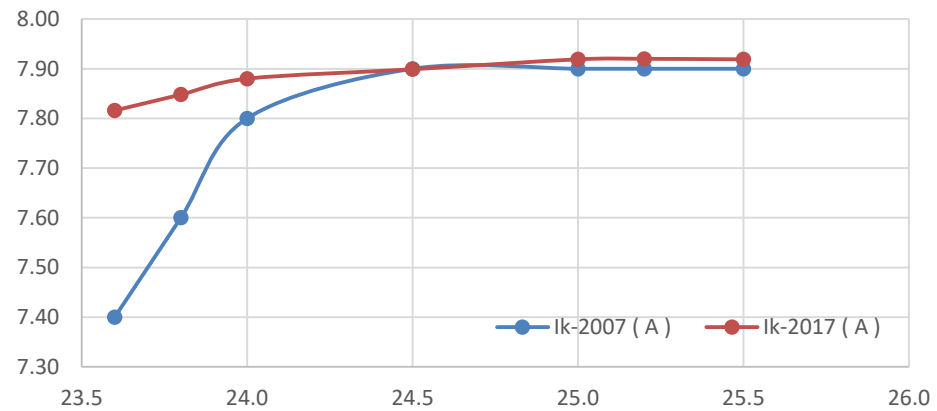
Heating Curves-No0



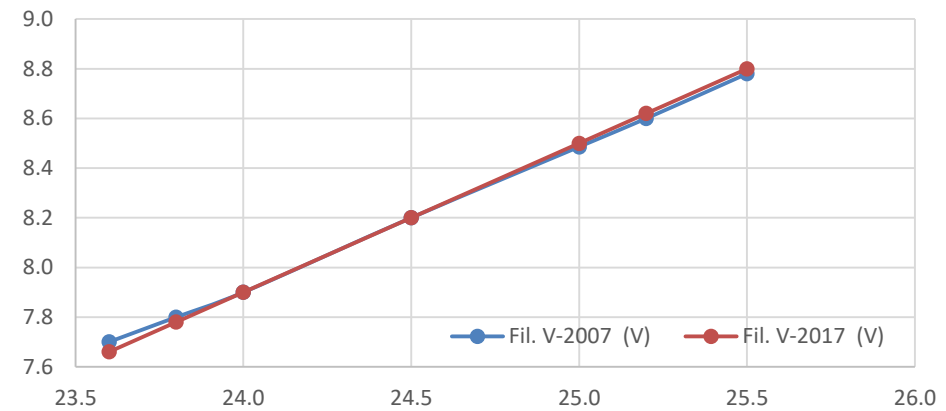
- Cathode not degraded;
- Filament a little thinner.

Heating Curves-No1

No1 Heating Curve@220kW mode (Ik vs IF)



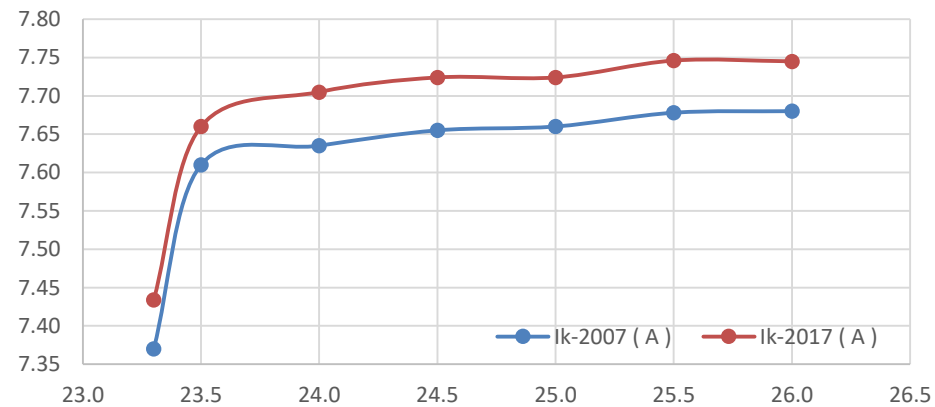
No1 Filament (VF vs IF)



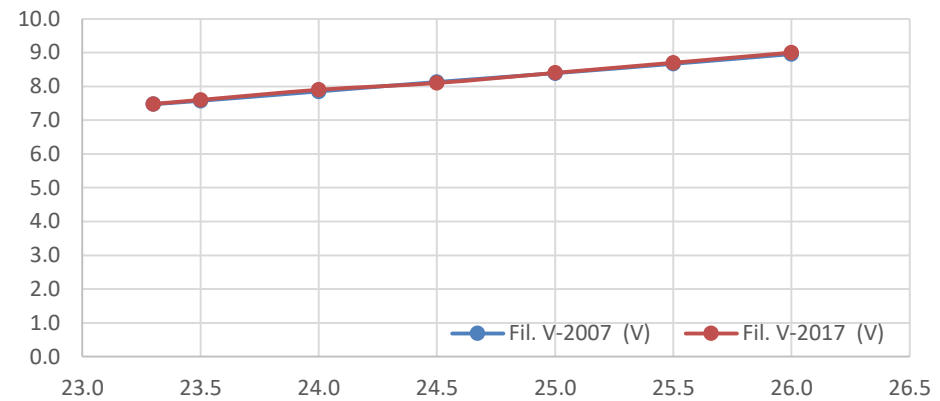
- Cathode and filament not degraded;

Heating Curves-No2

No2 Heating Curve@220kW mode (Ik vs IF)

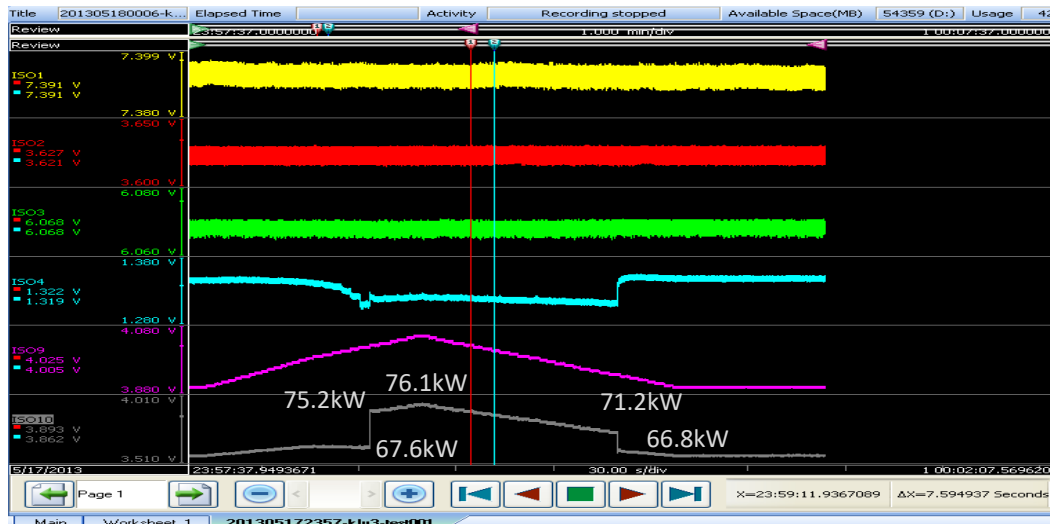


No2 Filament (VF vs IF)



- Cathode and filament not degraded;

Gain Jump of Original No3 Klystron

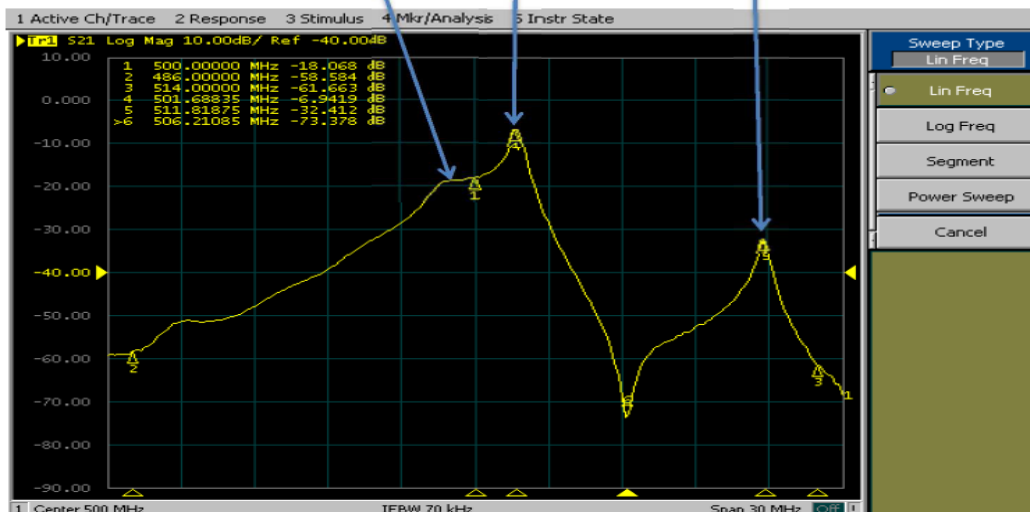


- The gain jump around 67~76kW of old No3 klystron start from 2010;
- Retune of the cavities of the klystron only make the gain jump power point changed a little;

Au départ : 499,5 MHz
Mesuré sur site : 498,5 MHz
Cavité 1

501,95 MHz
501,69 MHz
Cavité 2

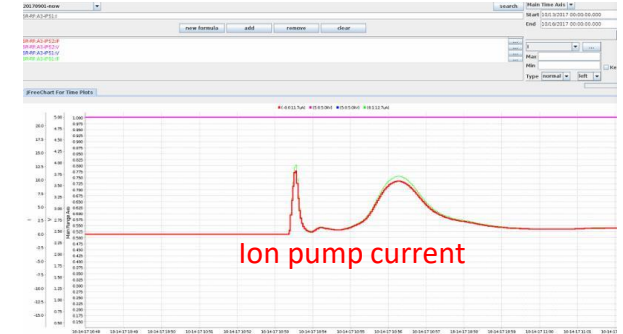
511,4 MHz
511,82 MHz
Cavité 4



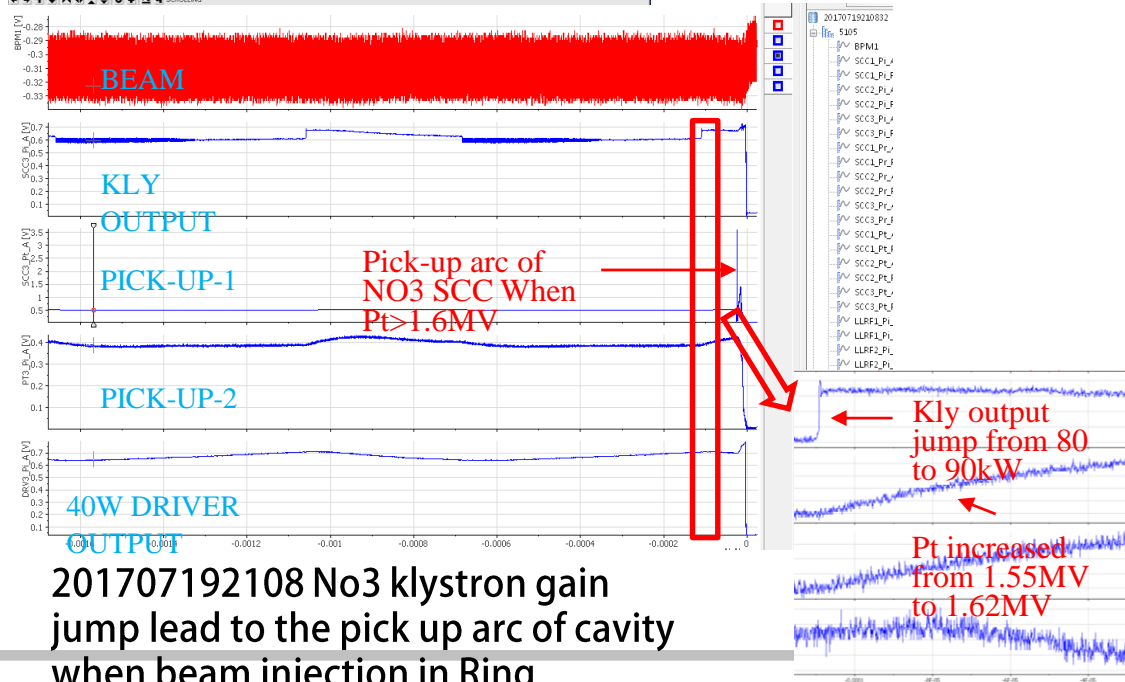
Gain Jump of Original No3 Klystron



Gain jump of original No3 klystron



20171013~15 3days high voltage condition on new No3 klystron

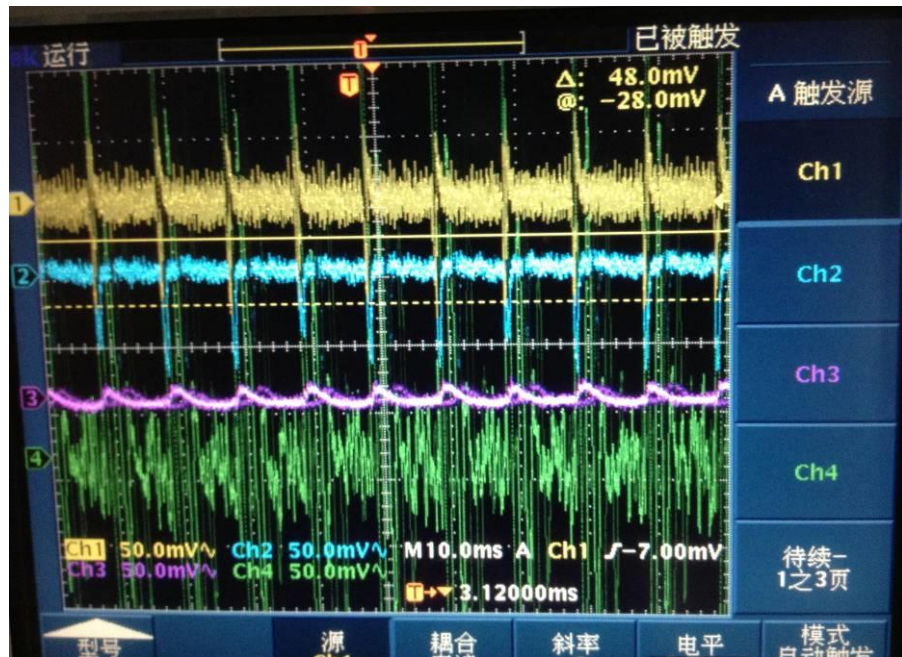


201707192108 No3 klystron gain jump lead to the pick up arc of cavity when beam injection in Ring

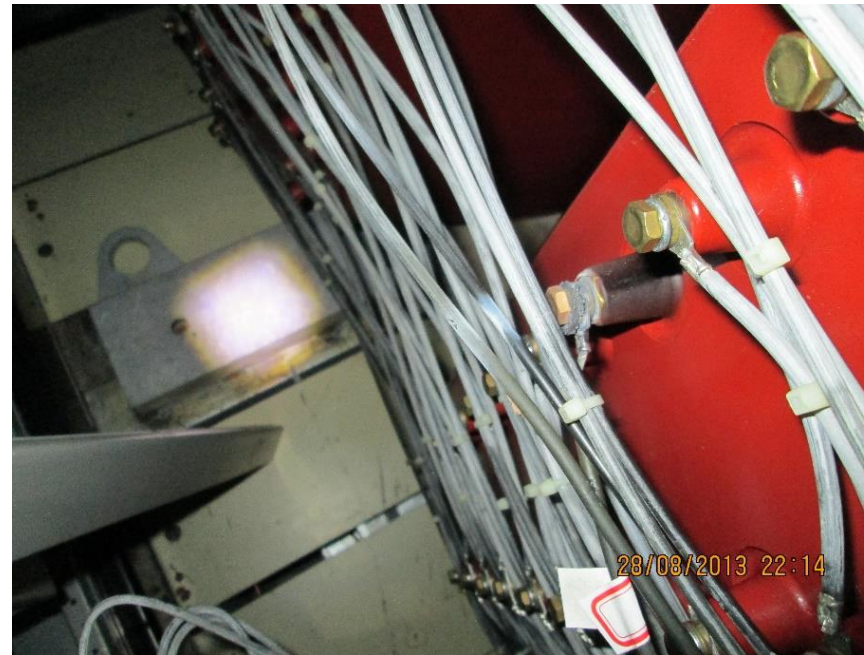
20171013 new No3 Klystron

- 20161129 80kW to 90kW jump was observed in pulse condition. This jump lead to cavity's pick-up arc at 201707192108 ;
- The check or test of this old klystron in Thales will cost ~50,000 EUR, without not any maintenance guarantee.

100Hz Noise on Forward Power



201303280820#3KLY 100Hz noise
AC coupling, 1M input resistor.
Ch1-HVPS:I、Ch2-HVPS:V、Ch3-FIL:I、Ch4-CO1:Pki



- A burn connect of No71 module lead to the 100Hz noise;
- 100Hz noise always comes from one abnormal module.

Transformer Current Interlock from PSU0



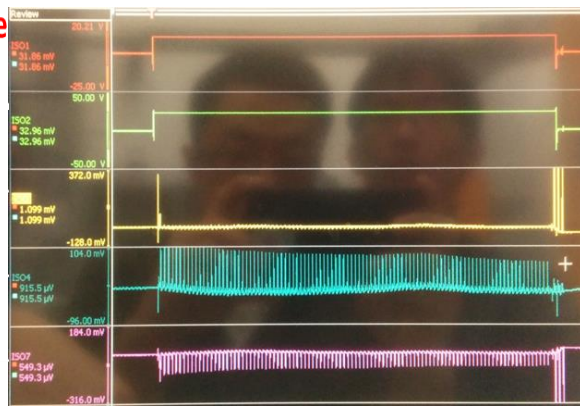
- During normal running(MOD Voltage On), sometimes (2016/02/25,2016/02/27)Transformer over current trip from P2(measuring the 3 phase current of T2).
- Frequently happen if try to close the step-start(AUX ON->Standby).Most from P2(L1,L2,I>>), one time from P1(L1,I>>)

24V to close the KM10 and 11

Current-T2-L1

Current-T2-L2

Current-T2-L3



- During test there is a serious trip.
- **P1 shows ~2000A when trip!**
- We can't turn on the KSU anyway.

- Set the time relay for step-start P10 to 0.5S(original 0.5S, and 2S from 2015/03/31) from comment of Ampegon engineer
- We can close the step-start without any problem

Isolated Transformer Spark-over

- Isolated transformer spark-over often lead to damage of many cards!
- After 2013, a new type domestic isolated transformer was adopted, the tolerant voltage is 100kV.

Trips From Humidity



dryer on HV feedthroug for Ion pumps



Some trips happened from high humidity:

- Discharge from HV feedthrough for Ion pumps
- Spark from HV power supply of klystron
- Damaged relay contacts of PSU0 in Booster

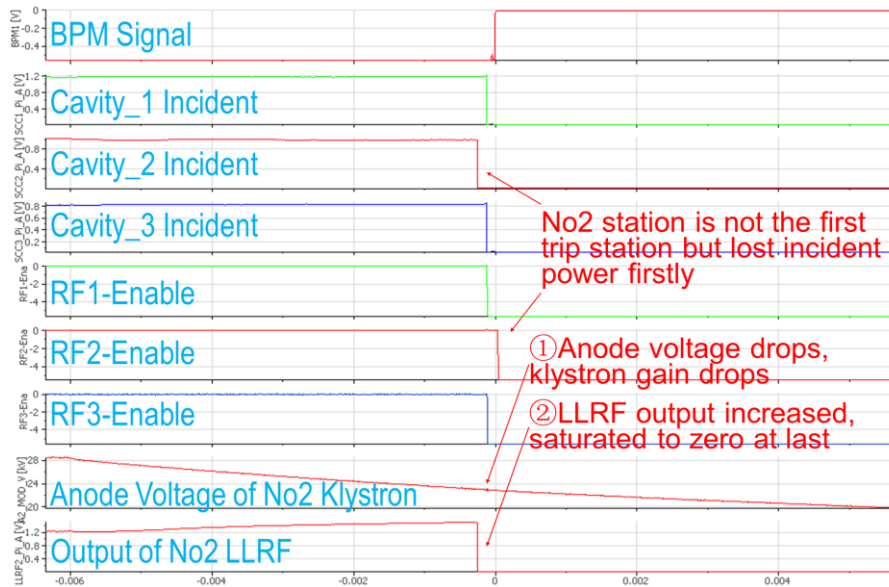
Solutions:

- Add dryer surrounding the HV feedthroughs;
- Turn on the fan inside the HV klystron power supply during machine shutting down;
- RF hall Isolating and extra dehumidifiers make the humidity of RF hall decreased from 65% to 55% during raining season.



Extra dehumidifiers were adopted in RF hall

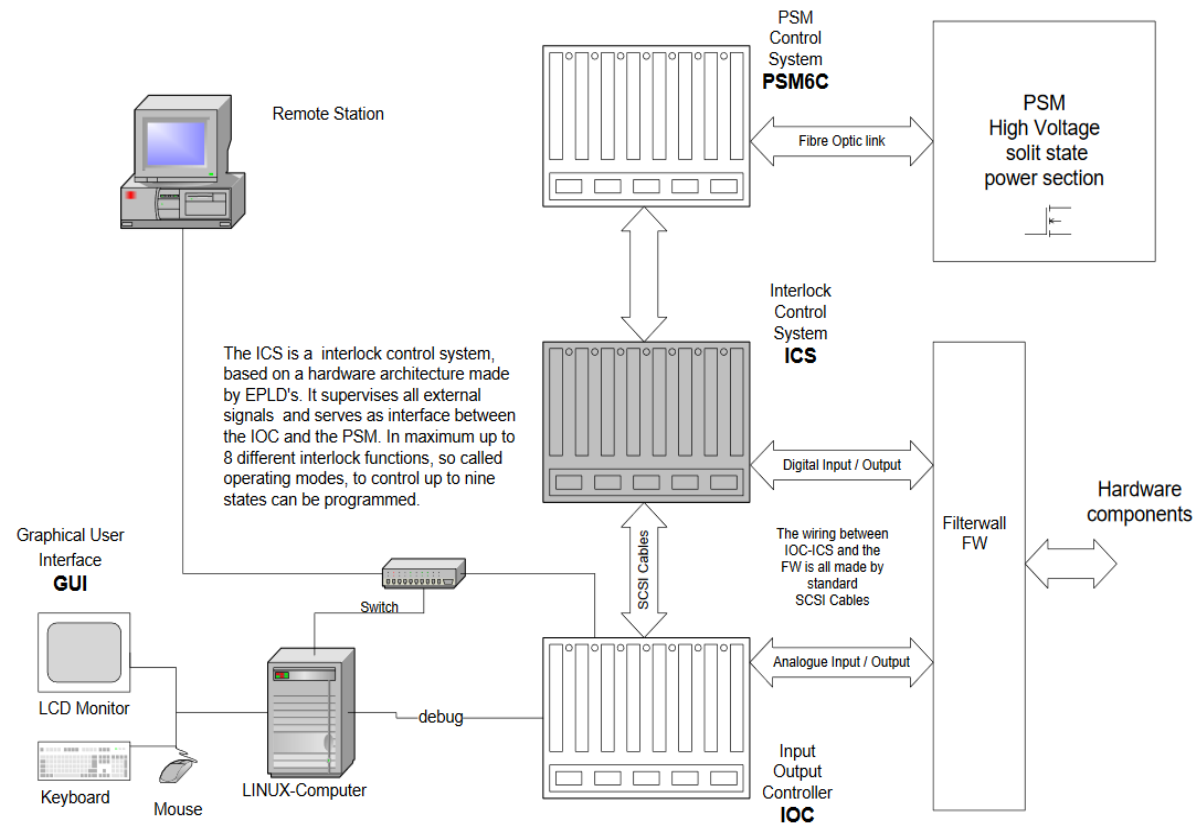
Trips from Auxiliary Powers



201510162026 trip. Anode voltage drop lead to beam dump

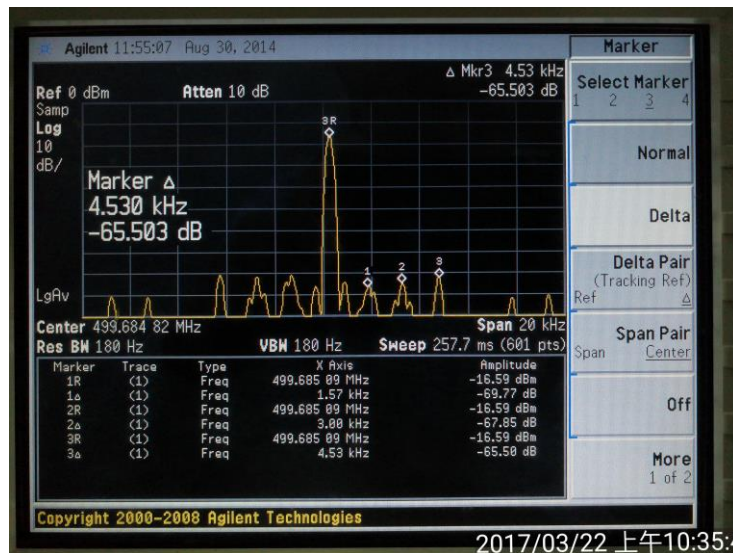
- There are many auxiliary power failures, focus power, 24V power, filament power, anode power, ion pump power etc;
- Now we exchange them periodically.

Upgrade of No0 PSU



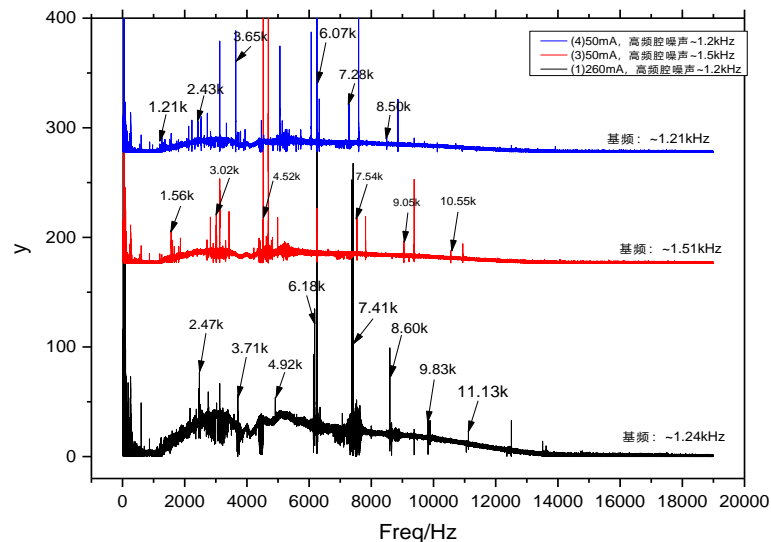
- The PSU0 was delivered in 2000, and was a very old version;
- Upgrade the control system means Booster and Ring can share the same spare parts;
- The upgraded parts include: PSMC, ICS, IOC, and EPICS.

Upgrade of the PSMC of No1~3 PSU



Noise on cavity field without beam

- The low frequency noise was suspected from RF PWM;
- On 2016 Summer, we upgraded the PSMC in ring, which make the PWM frequency adjustable.
- The light noise was verified from PWM of the PSUs.



Noise on light spectrum of IR beam line with different RF PWM frequency

Conclusion

- After more than 70,000 hours running, 3 of 4 high power CW klystrons work well and keep health;
- The old No3 klystron was exchanged because of big gain jump;
- 100 Hz noise always come from one abnormal PSM module;
- Humidity is a enemy for the transmitters especially for all high voltage powers;
- We exchange auxiliary power periodically;
- We upgraded the control system of PSU0 to make all the PSUs can share the same spare parts;
- The PSMC of PSU1~3 was upgraded to make the PWM frequency adjustable.

Thanks for attention!