National Synchrotron Radiation Research Center

Commissioning Experience of SCRF Systems for the Taiwan Light Source

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Outline

1. Review of the SRF Project at TLS/NSRRC (1997-2005)

2. The SRF Operational Experience in last two years (2005-2006)

Decision Making in 97'-98'

- Double the photon flux of the synchrotron light by increasing the beam current;
- Keep the synchrotron light even more stable at a higher beam current;

- The solution:
  - SRF module is free of coupled-bunch instabilities by beam-cavity interaction via cavity's higher-order modes;

- The concern:
  - Highly reliable operation of SRF module is a challenge!

The SRF Project at TLS/NSRRC (1997-2005)

- Project initialed in winter, 1997;

- Approved in summer, 1999;
- Budget available from 2000 in 4 years;
- Commissioning originally scheduled for summer, 2003, and completed in end of 2004 owing to production problem of SRF module;
- Spare SRF module available in summer of 2005;

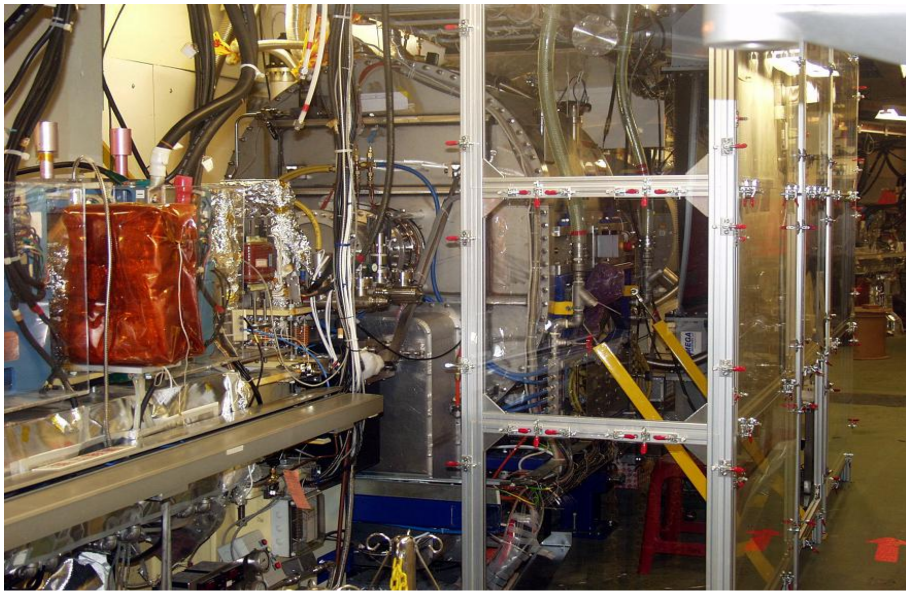
- Routine operation since beginning of 2005:
  - ✓ Routine operation at 300 mA in top-run mode;
  - ✓ Long-term reliable test runs at 400 mA in top-up mode;
  - – Routine operation at 360 mA to be started;

- Project goals achieved:
  - ✓ in terms of light source flux in winter, 2005;
  - ✓ in terms of maximum beam current in Sep., 2006;

Selections of Sub-systems

- **SRF modules:**
  - ✓ **Cornell design;**
  - – KEKB design (decision open for next machine) ;
- **Cryogenic plant:**
  - ✓ **Turbine machine (same for next machine);**
  - – piston machine;
- **RF transmitter:**
  - – Switching HVPS (proposed for next machine);
  - ✓ **Corwbar HVPS - In-house assembly;**
- **Low-level RF system:**
  - ✓ **Analog LLRF – Modifying the LLRF of PEP-I design;**
  - – Analog I/Q LLRF (based line for next machine);
  - – Digital LLRF (aggressive option);
- **SRF diagnostics system:**
  - ✓ **High speed scopes;**
  - ✓ **Fast transient recorders (32 channels);**
  - ✓ **Low speed archive system;**

The SRF Modules – S1 & S2



S1

S2

The spare one was assembled first.
We had a very difficult time during production of the SRF module S2, but we learned a lot from this SRF module.

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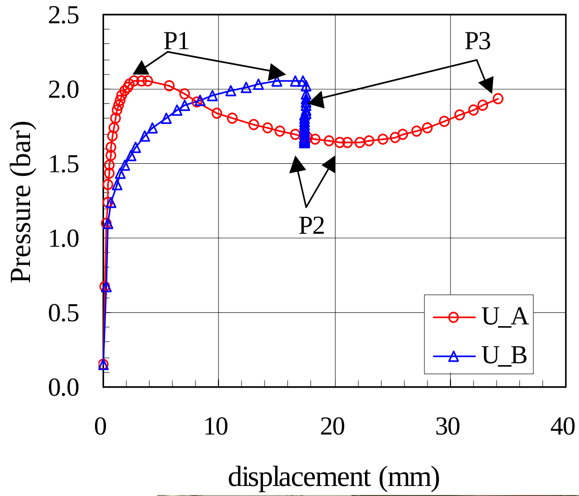
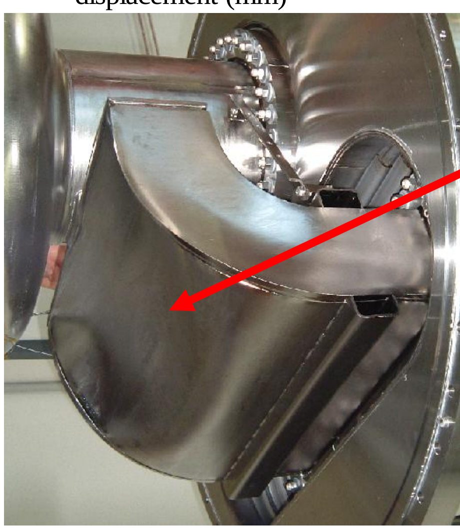
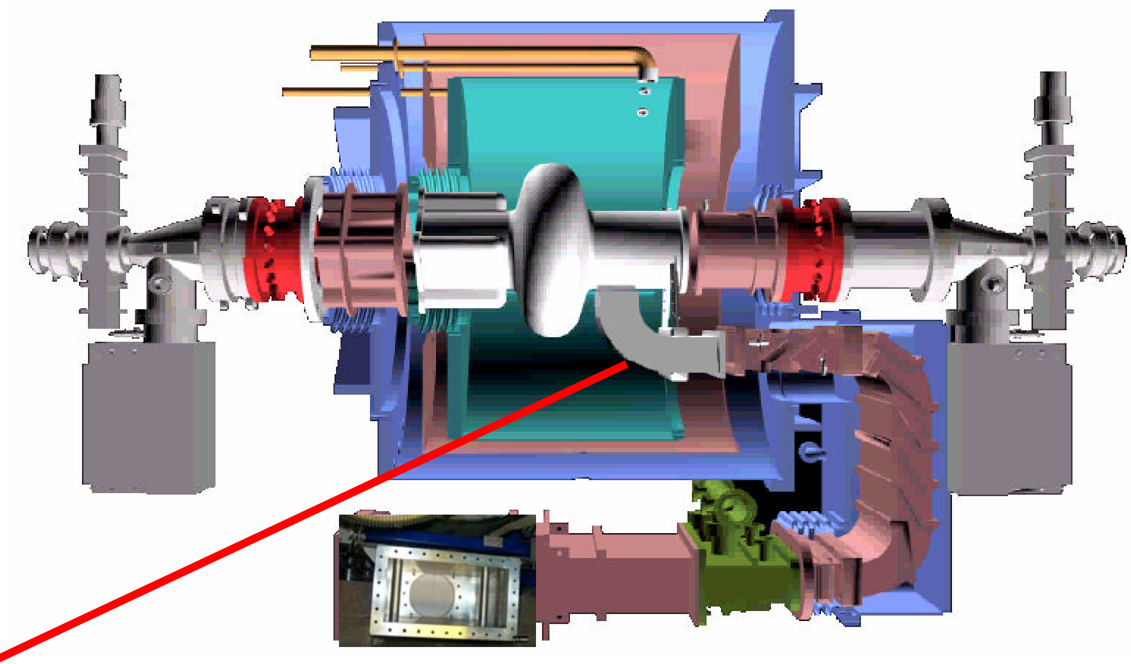
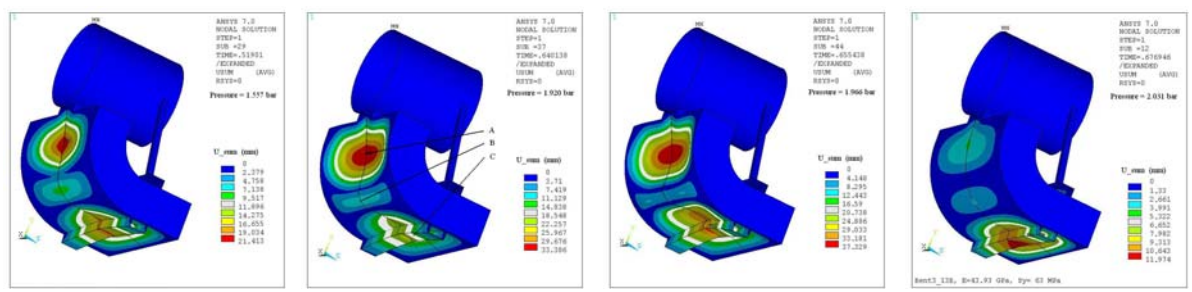
Buckling of Nb Waveguide of the SRF Module S2

- Under a gas pressure test up to 1.8 bara in 20 min. at warm









1.557 bara 1.920 bara 1.966 bara 2.031 bara

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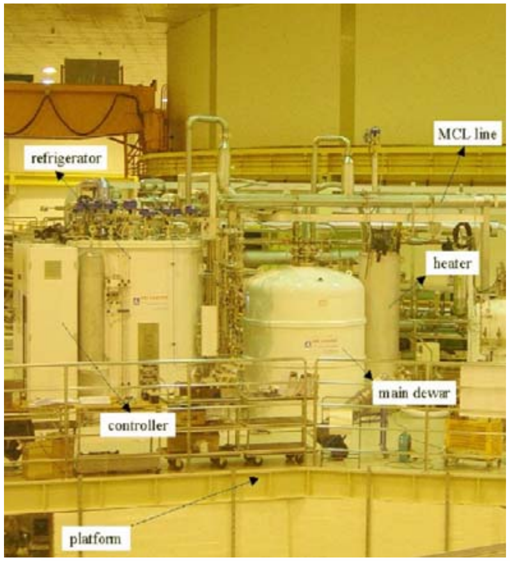
LHe Cryogenic Plant for SRF Operation

- ***Requirements:***
  - long term continuous operation
  - vibration free
  - fast cool down capacity
  - high redundancy
  - energy saving and load matching
  - easy operation
  - SRF operating LHe pressure as low as possible

- ***Solution:***
  - turbine machine
  - large helium inventory (2000 liter main dewar)
  - capacity safety factor of 1.5
  - frequency driver
  - fully automatic control
  - Cold box located to the SRF module as close as possible



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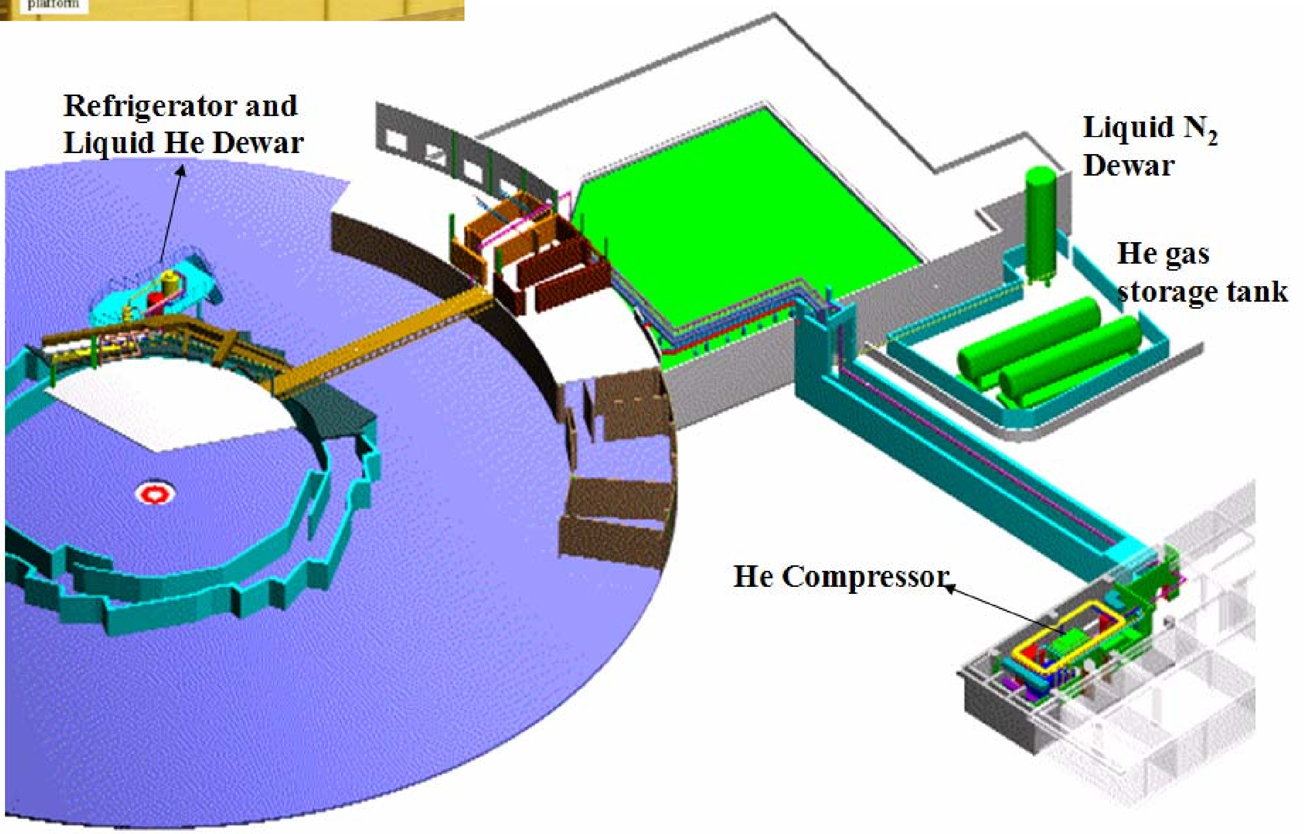

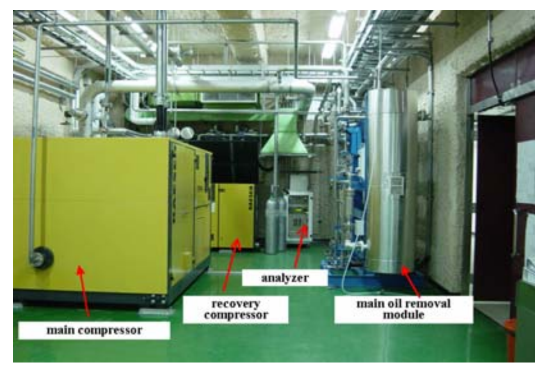

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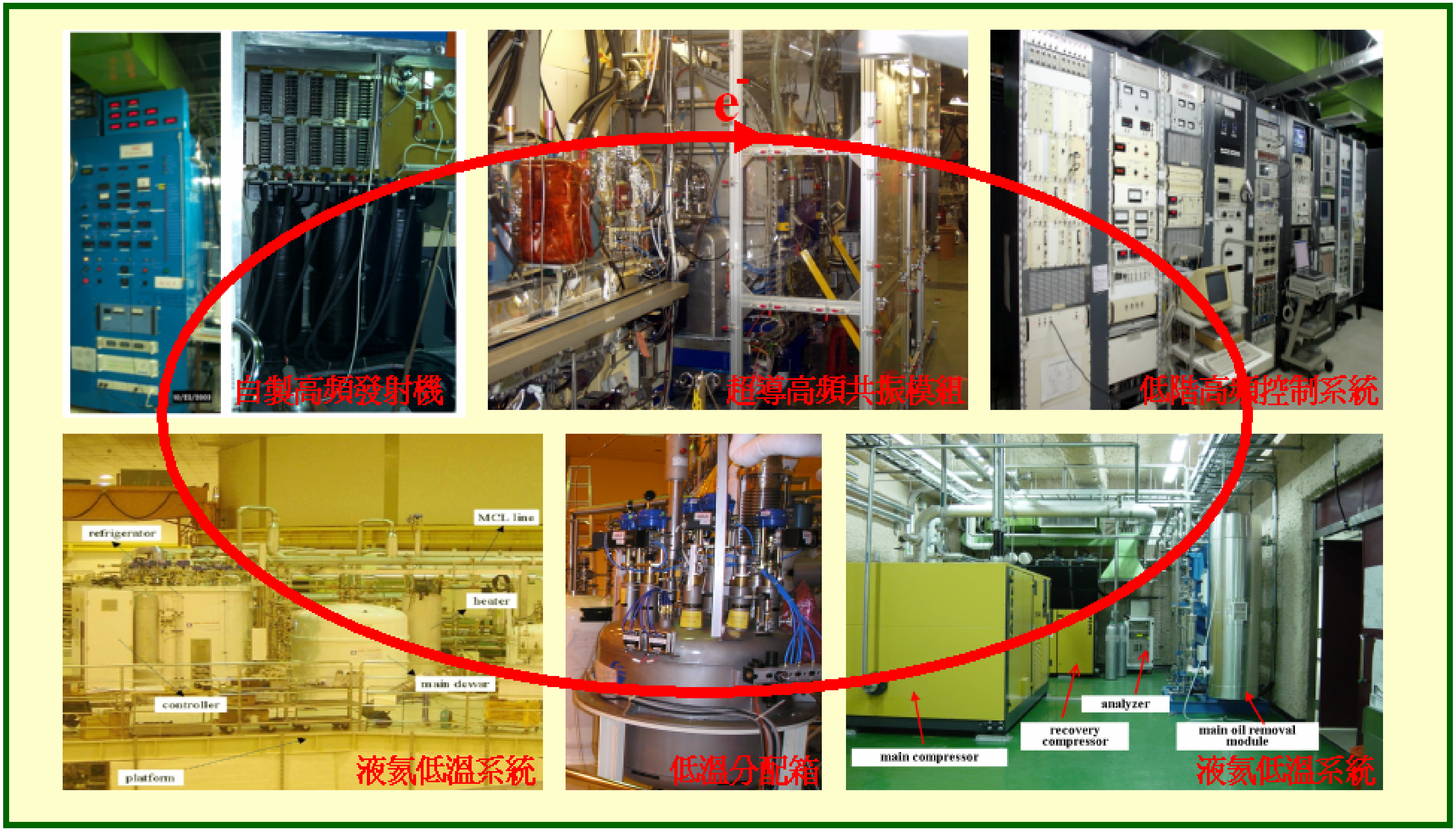
System Integrations



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Machine Performance with SRF Module

- Excellent HOM damping;
- Top-up mode at 300 mA in routine operation;
- Maximum beam current up to 400 mA verified;

- Transverse feedback is required to stabilize the residual instabilities;
- Extra benefit from the longitudinal feedback (I0 fluctuations of 0.06% available);

- **Intensive manpower required for the SRF operation – not to make mistake!**

Fluctuations of Synchrotron Light $\Delta I_0/I_0$ for the TLS Using the SRF Module as Accelerating Cavity

SRF Operational Experience

- **What we experienced…**
  - ✓ **LLRF's feedback loops become unstable due to heavy beam loading…**
  - ✓ **False alarm of window arcing…**
  - X Microphonics is no more a problem after using micro-stepping controller for tuner loop;
  - – Vacuum spikes observed sometimes during rf start-up at 0.9-1.1 MV (Multipacting around the coupling tongue?);

- **What we never experienced…**
  - X Real quench or field emission (rf gap voltage < 1.6 MV);
  - X Vacuum burst due to hydrogen desorption (cavity vacuum better than 0.7 nTorr);

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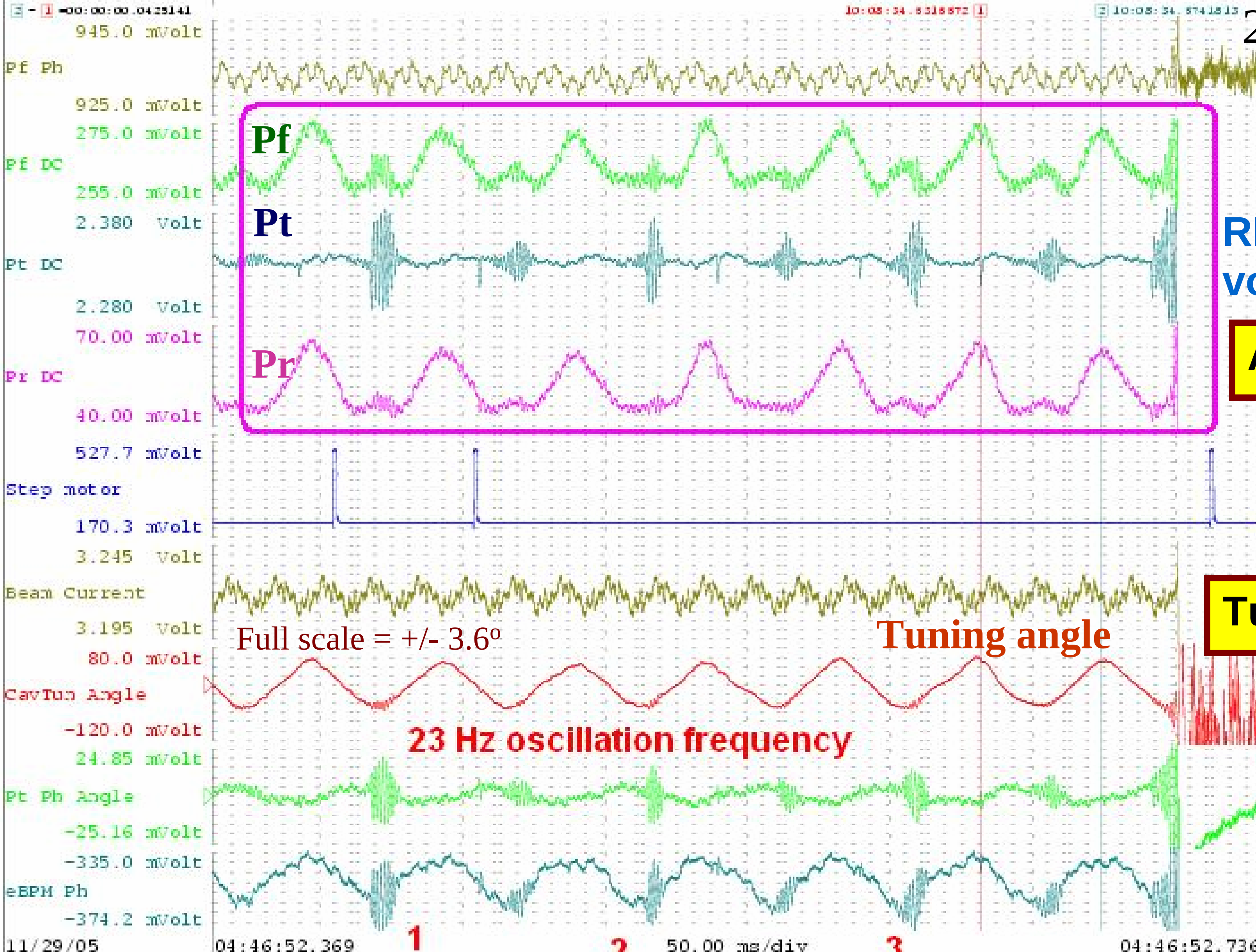
Ringing of RF Gap Voltage under Heavy Beam Loading

287 mA

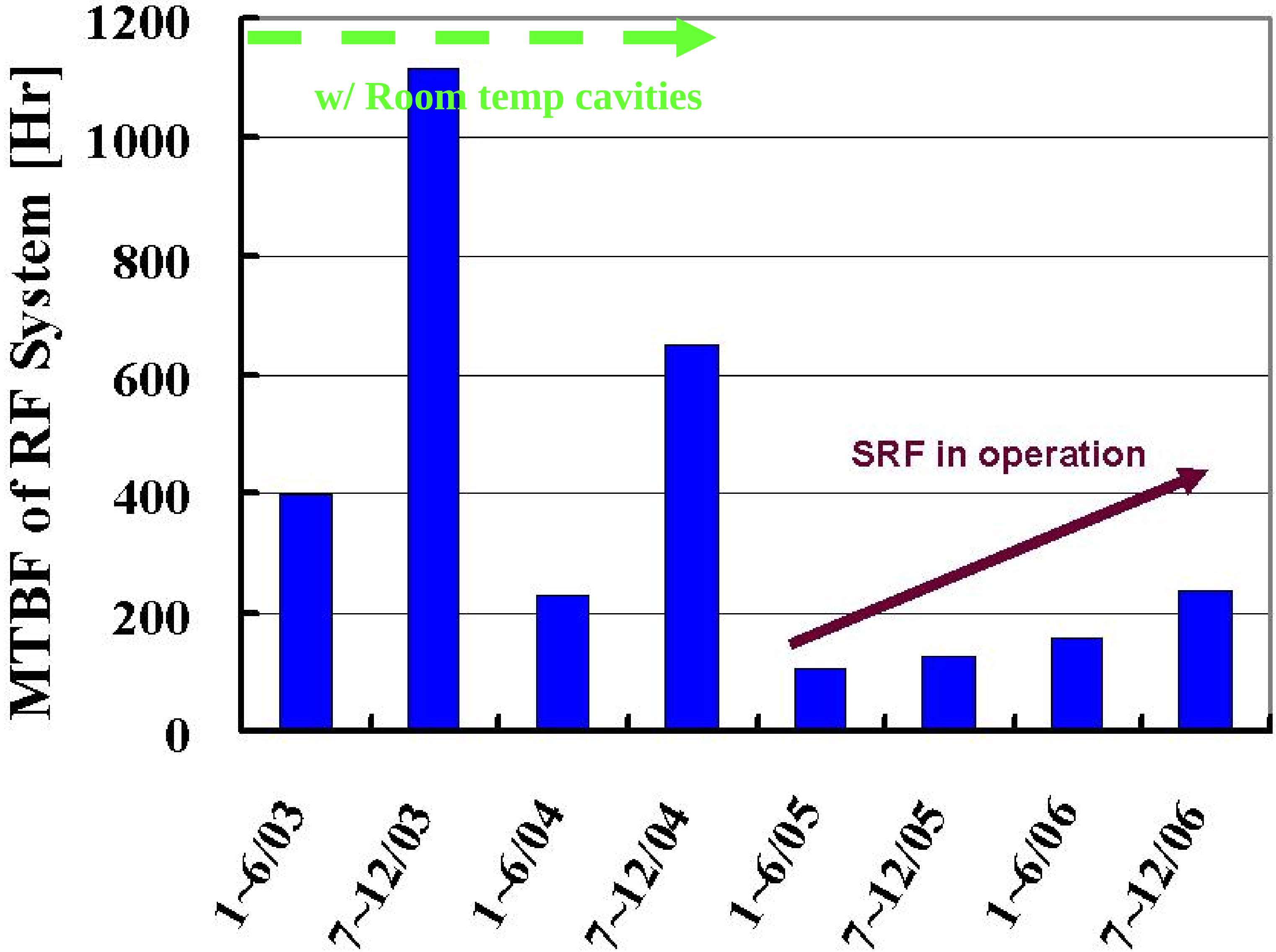


RF Gap voltage

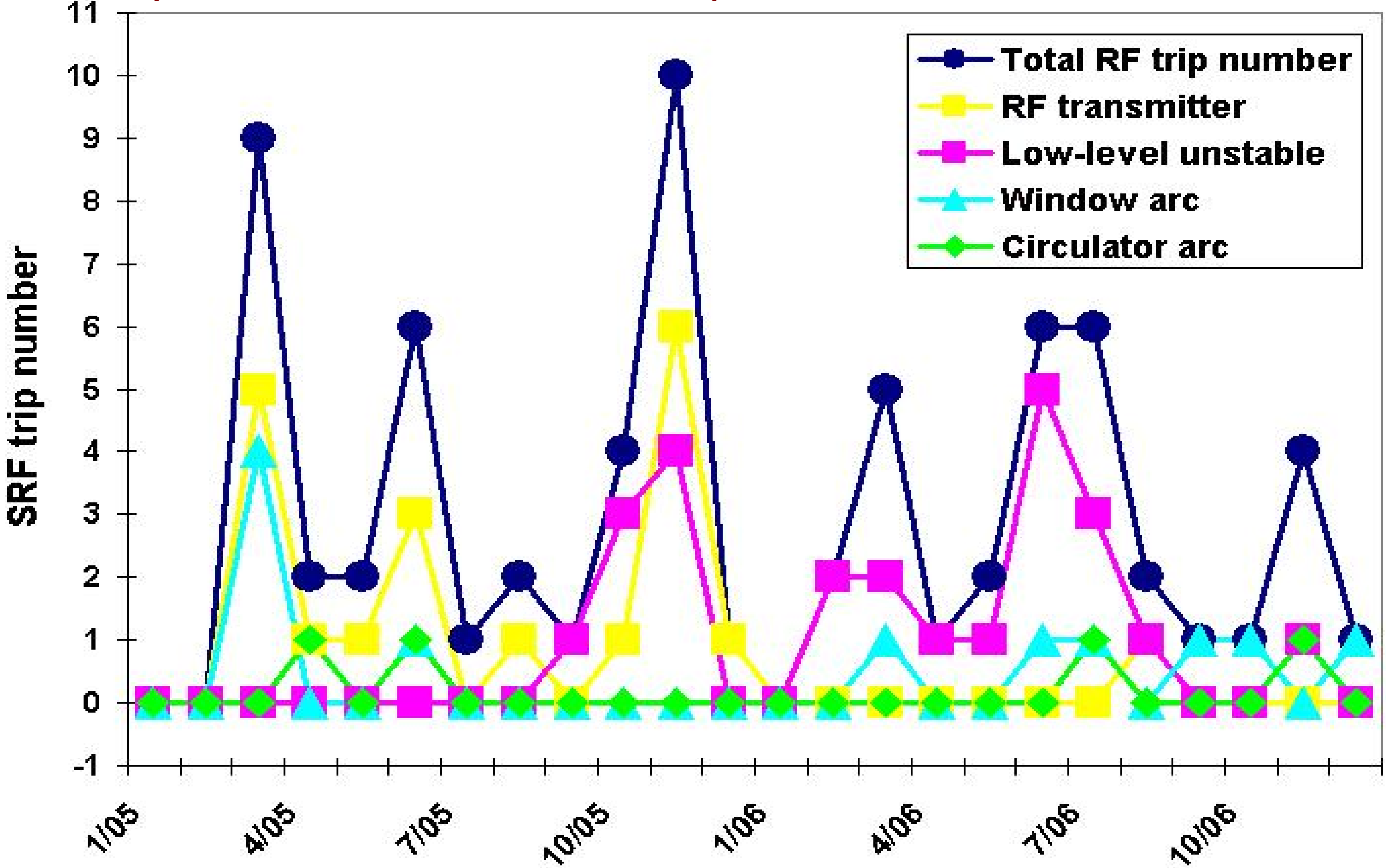
Amp loop

Tuner loop

Mean Time between Failures of the Complete RF System with SRF Module as Accelerating Cavity since 2005



Trip Statistics of RF System with SRF Module



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Conclusions

Thank you for your attention!