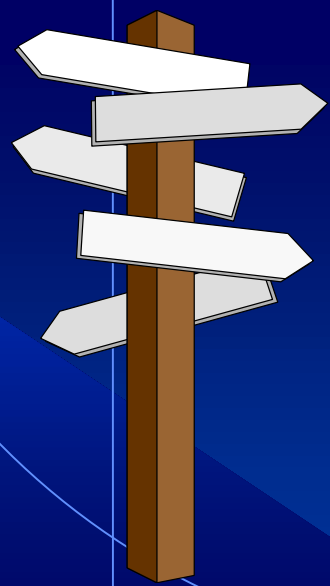
The ESRF Radio-frequency Data Logging System for Failure Analysis



Jean-Luc REVOL

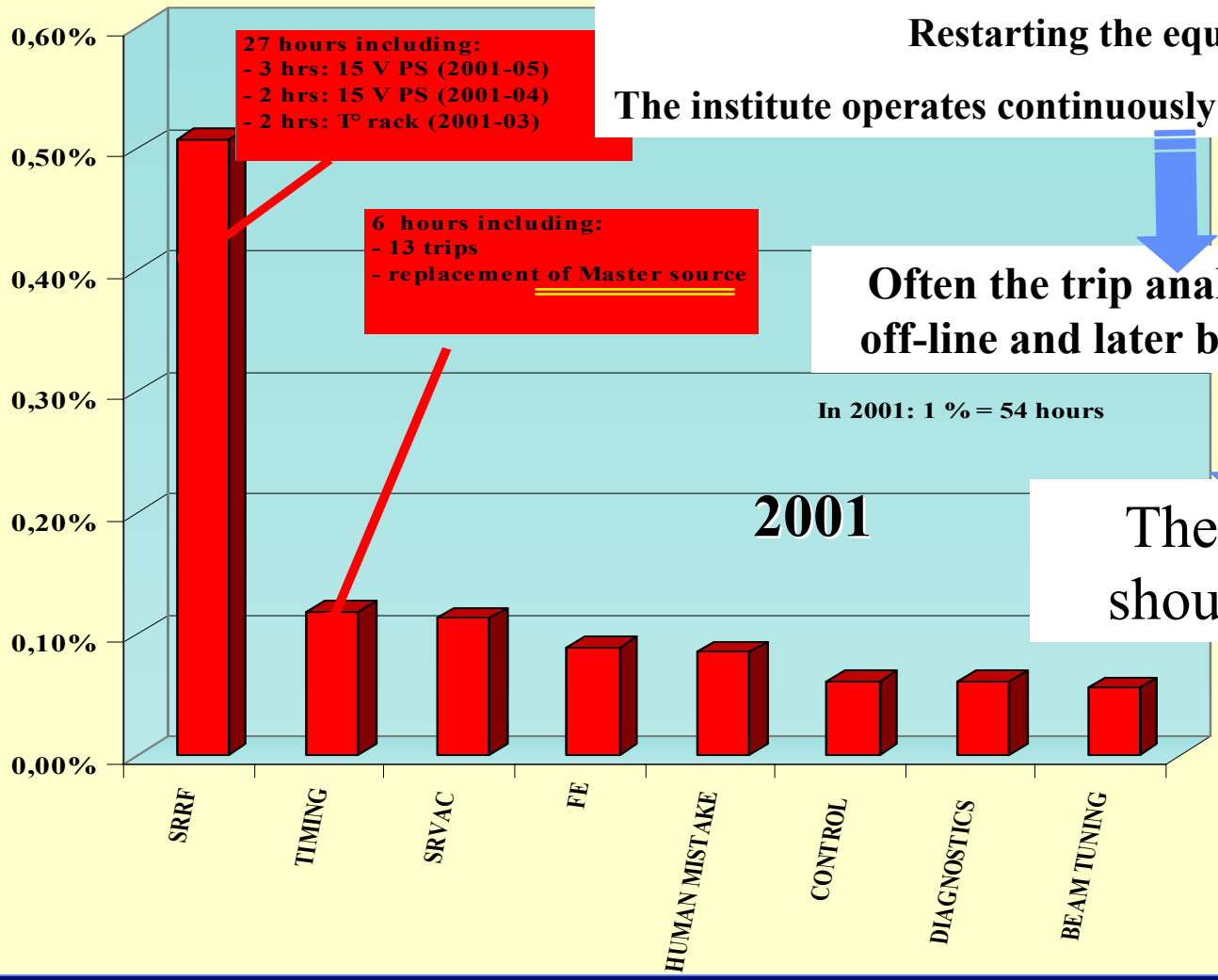
Machine Division

European Synchrotron Radiation Facility

Accelerator Reliability Workshop

4-6 February 2002

Impact of the RF time lost / equipment



First objective after a beam loss:

Restarting the equipment!!

The institute operates continuously:

Often the trip analysis is made off-line and later by the expert!

The information should not be lost

Two Objectives

Why was the RF faulty?

Which equipment is faulty?

What is the first detected fault?

Sometimes we should go deeper in the analysis

What is the initial source ?

Why has the beam been lost?

It is not the RF!

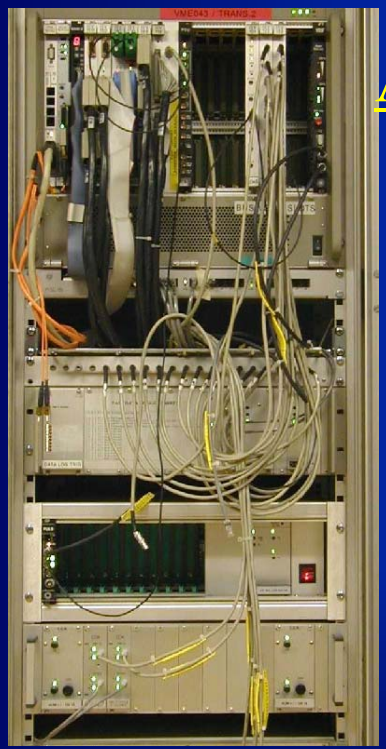
It could come from another source

It is the RF!

Strategy

Initial experience:

The initial industrial RF system already had some data logging potential, but the fault logger did not have the appropriate time stamp and the analog logger was too slow. Oscilloscopes were often needed!!

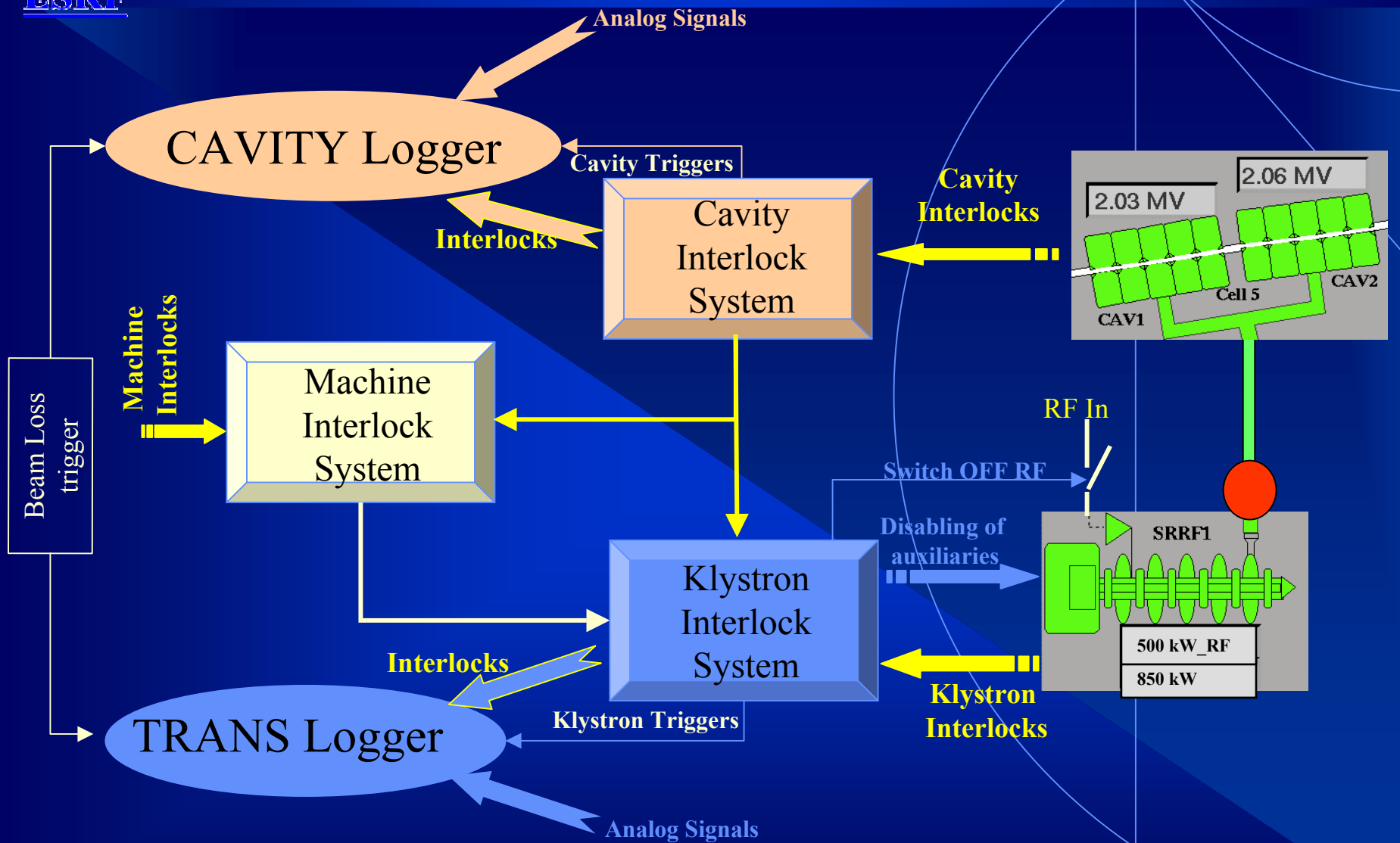


At the same time as the RF upgrade:

The data logging function was developed in parallel with the control of the devices and was fully integrated in the object oriented design.

The interlock system constitutes the foundation of the logger.

Interlock system and data logging



Stored information

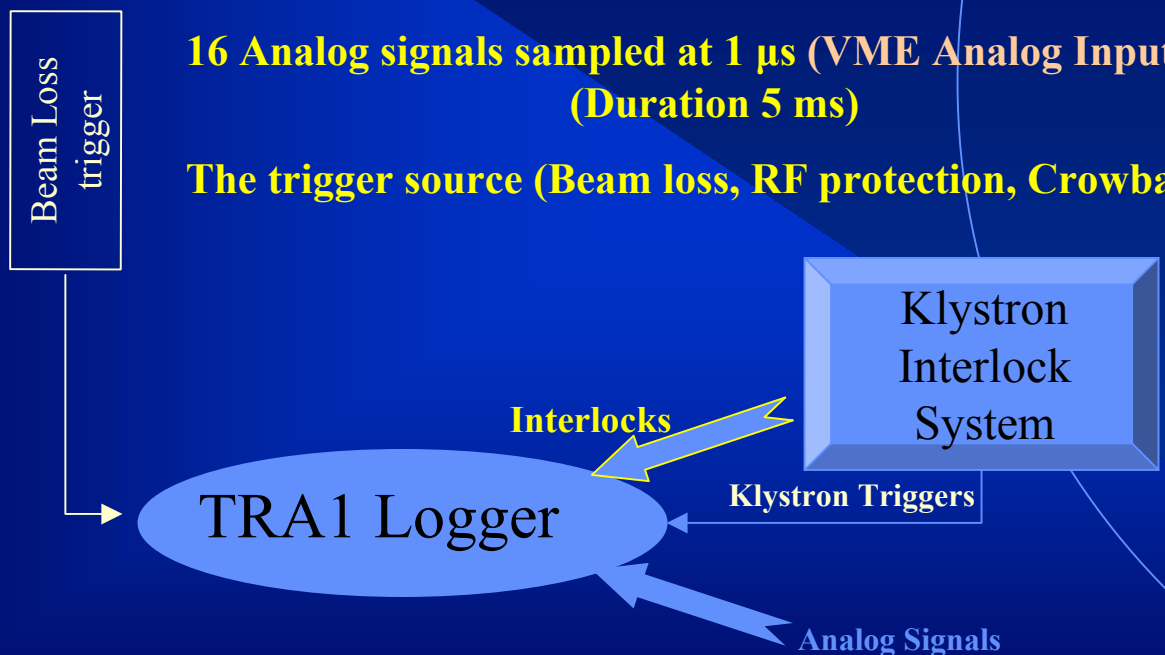
For each beam loss or RF trip, automatic storage in a dedicated directory of :

First Fault & Interlock History (PLC and Hardwired Interlock System)

All analog signals sampled at 120 ms (VME Analog Input acquisition) (Duration 30 sec)

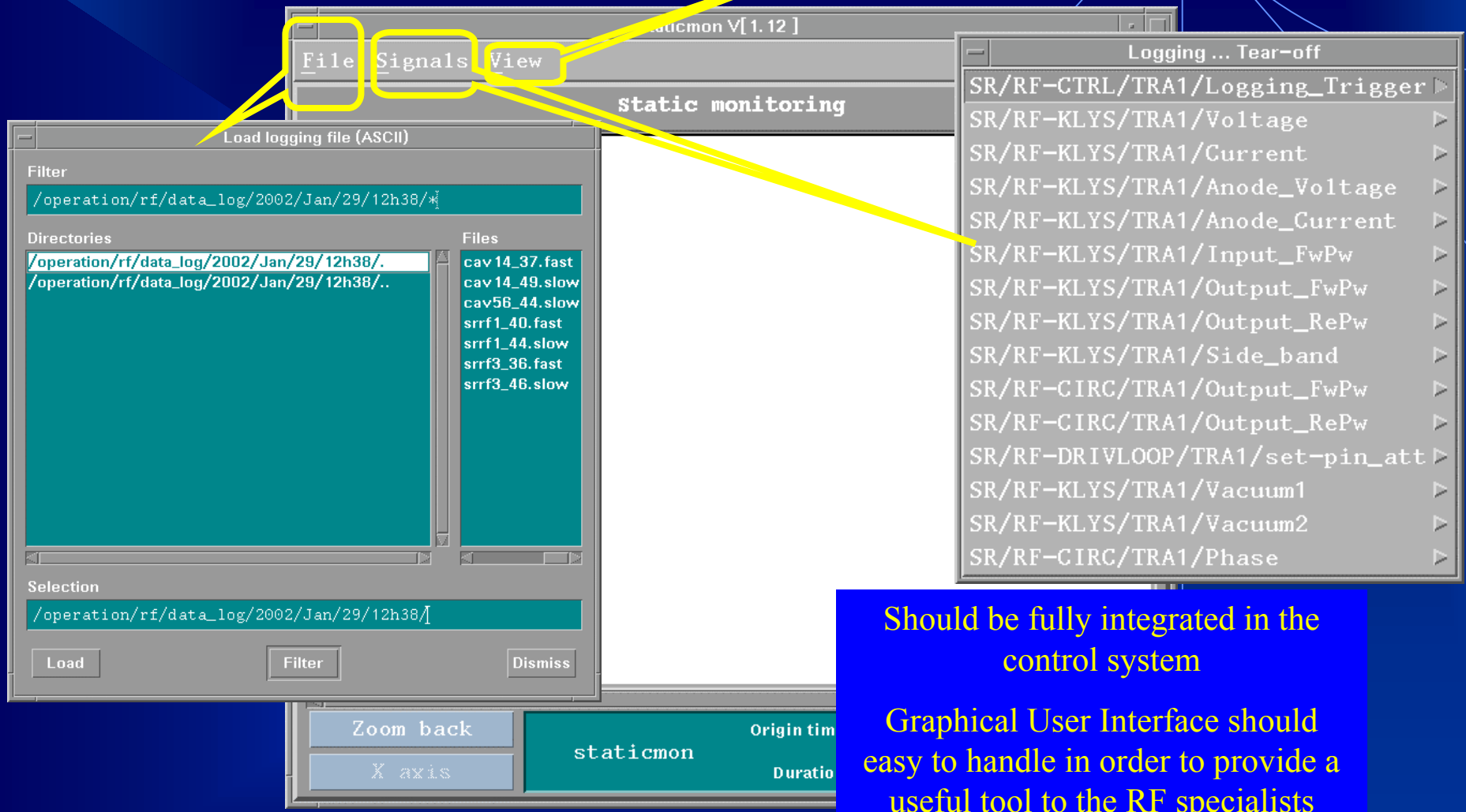
16 Analog signals sampled at 1 µs (VME Analog Input acquisition) (Duration 5 ms)

The trigger source (Beam loss, RF protection, Crowbar)



Analysis tools

Graphic manipulation tool (Scale, colours…)



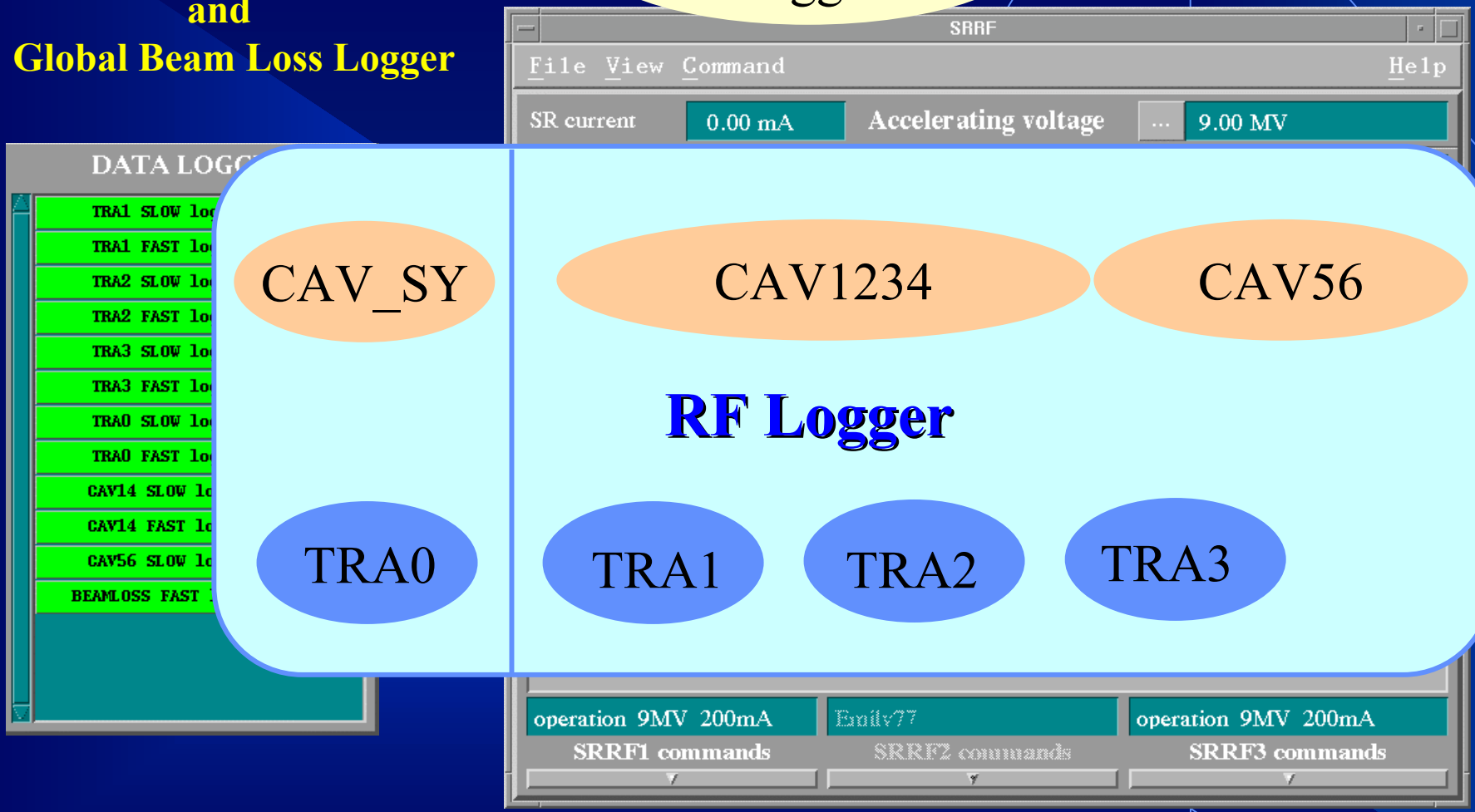
Should be fully integrated in the control system

Graphical User Interface should easy to handle in order to provide a useful tool to the RF specialists

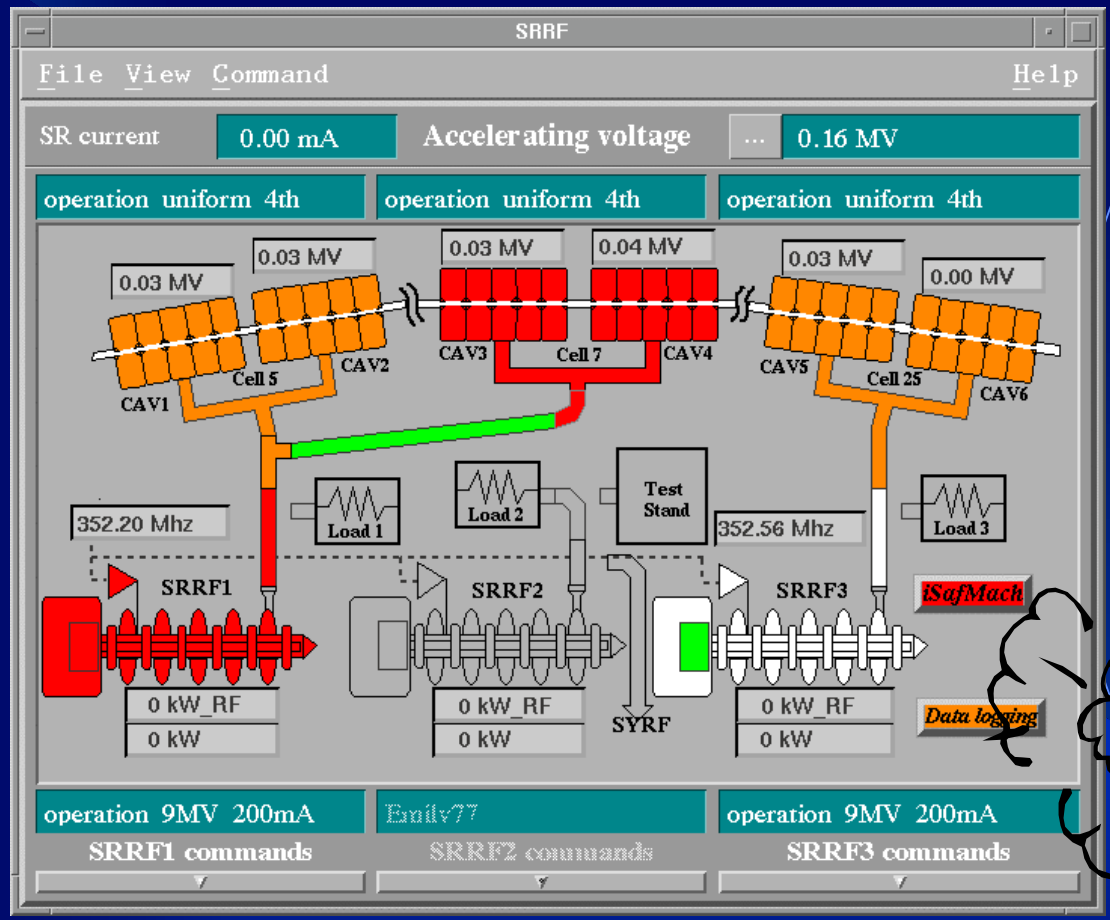
General RF Data Logging Structure

8 Independent RF loggers and 1 Global Beam Loss Logger

Beam Loss Logger

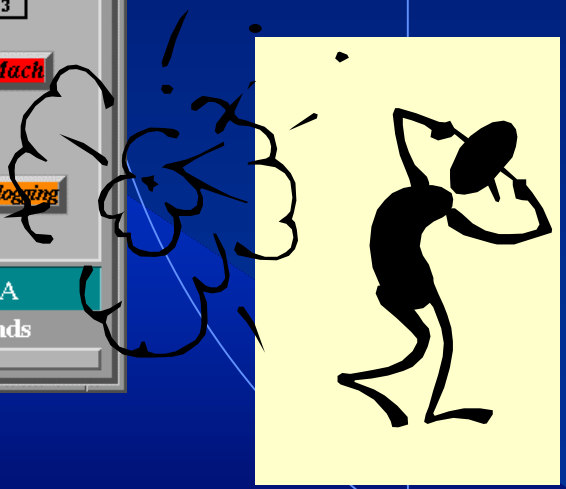


Example of the analysis of a RF trip

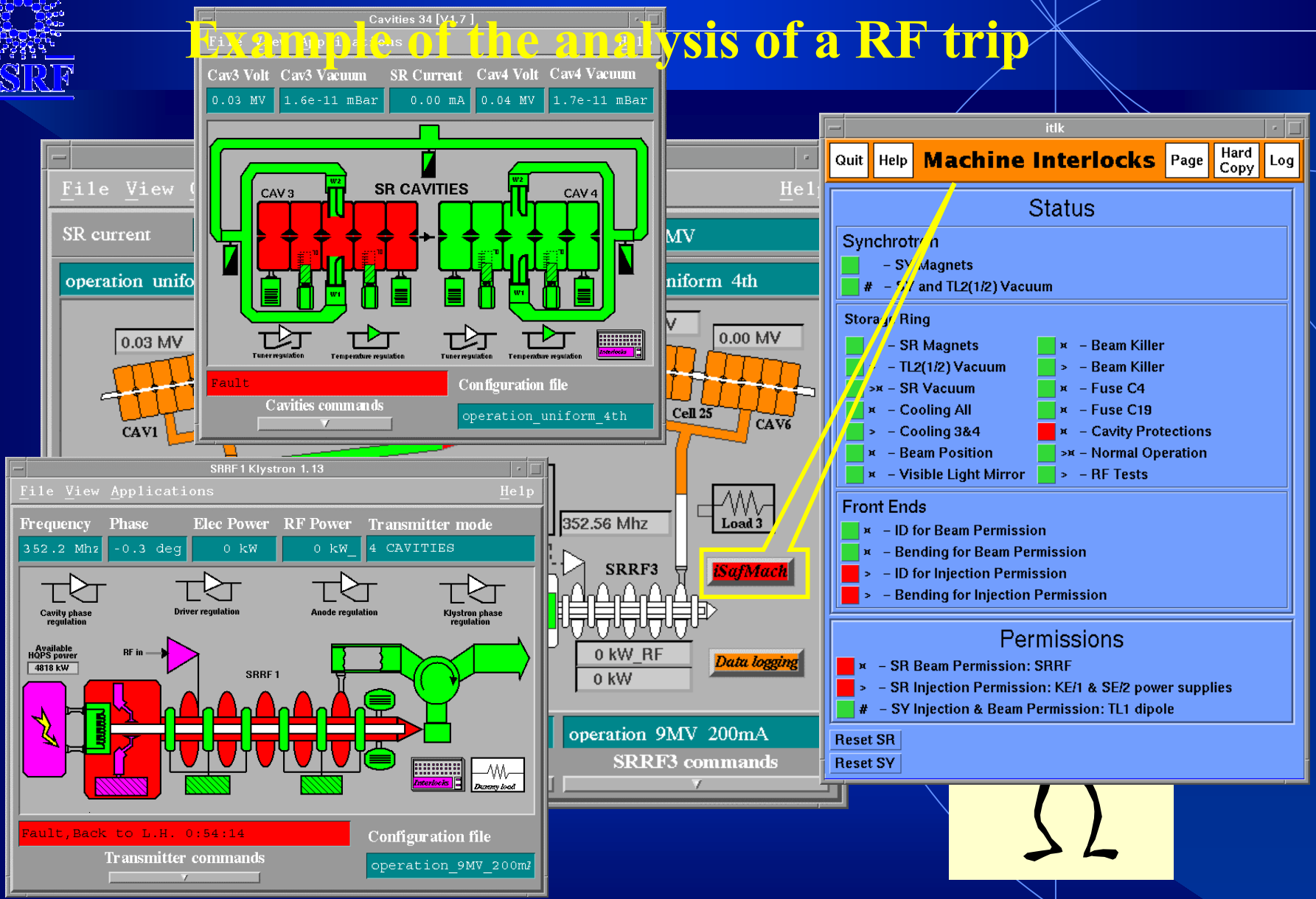


Seen from the CTRM

Beam is lost
Cav34 is faulty
TRA1 is faulty
Machine Interlock is faulty



Example of the analysis of a RF trip



Information given by the analysis of the first fault logging

Cavity 34 first fault:
Cavity 3 field amplitude too high

```
-----------------------------------------
sr/rf-cav/cav3:Fault

-----------------------------------------
PLC status :
State : One or more active interlocks.
Fault History :
Cycle Front : signal name
 0    : sr/rf-cav/cav3/f-voltage
      Cavity 3: Field amplitude too high
 0    : sr/rf-ctrl/cav14/set-rf_disable_cav_34
      none
 1    : sr/rf-cav/cav3/f-voltage
      Cavity 3: Field amplitude too high
 0    : sr/rf-ctrl/cav14/f-rf_disable_cav34_plc
      none
```

Transmitter 1 first fault:
RF trip requested by cavity 34

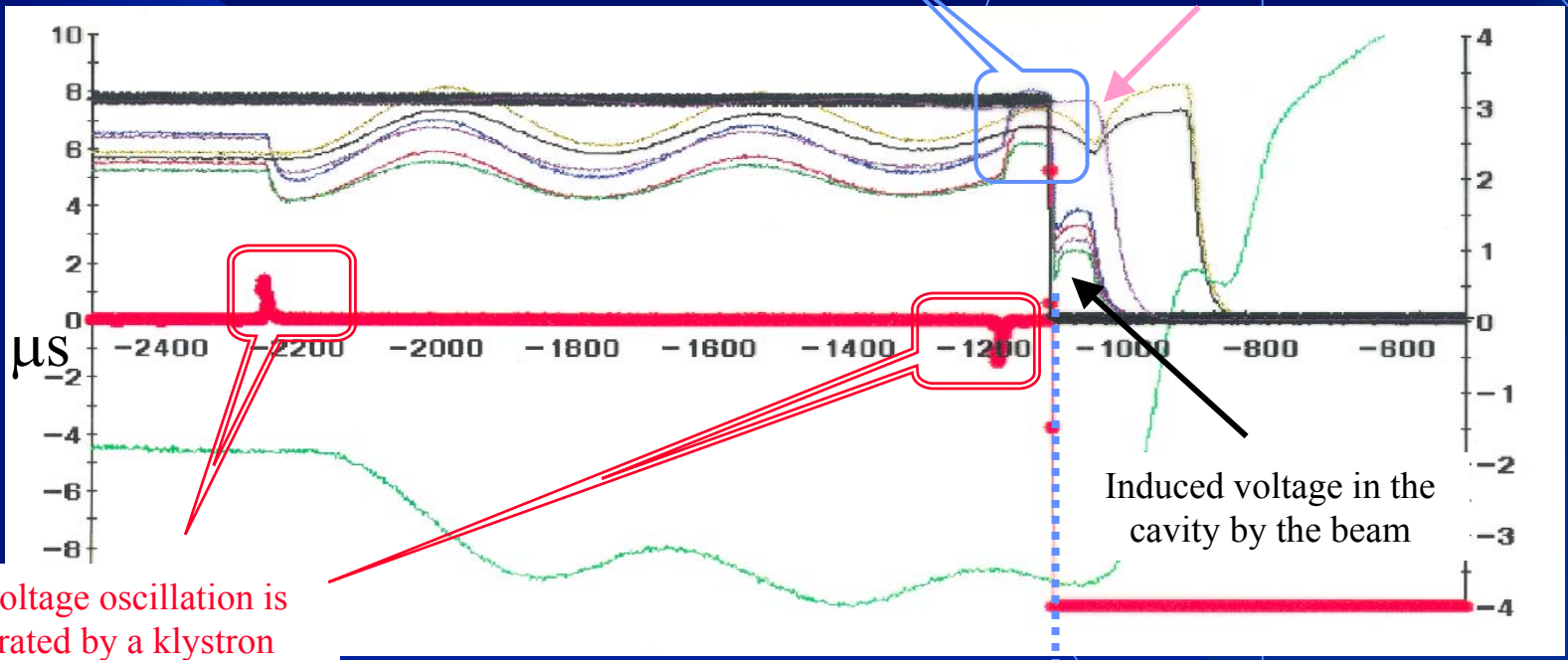
```
-----------------------------------------
Sub device states:
sr/rf-klys/tra1:Fault
-----------------------------------------
PLC status :
State : One or more active interlocks.
Fault History :
   Cycle Front : signal name
1.)  0  0   : sr/rf-ctrl/tra1/f-pinsw_cavity_34
            none
2.)  0  0   : sr/rf-driv/tra1/set-disable
            Driver  externally disabled
3.)  0  0   : sr/rf-ctrl/tra1/set-rf_disable_trans
            Pin switch transmitter  requested by the PLC
4.)  0  0   : sr/rf-anod/tra1/set-disable
            Modulating Anode  externally disabled
5.)  2  0   : sr/rf-ctrl/tra1/f-safety_machine
            Safety machine  protection requested by the machine interlock
6.)  3  0   : sr/rf-hvps/tra1/set-disable
            HVPS externally disabled
7.)  4  0   : sr/rf-ctrl/tra1/f-rf_disable_trans
            RF Disabled request by PLC acknowledged  for Trans HIS
```

Information given by the analysis of the fast data logging system.

RF is guilty!! It was a phase measurement problem!

Cavity 1,2,3,4,5,6 Voltages increase

Beam Lost

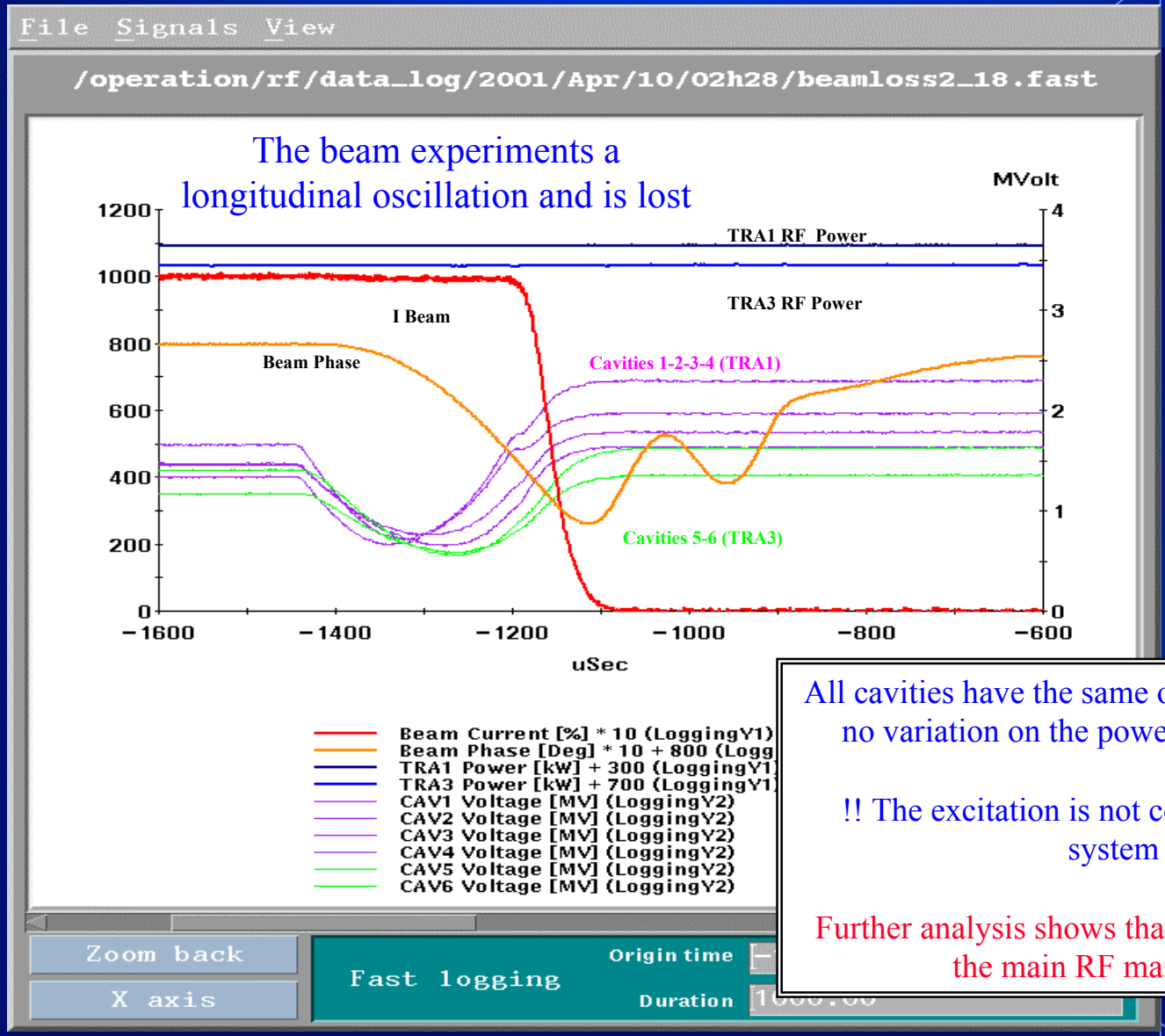


Induced voltage in the cavity by the beam

The voltage oscillation is generated by a klystron phase glitch

Detection of the peak voltage and TRA1 RF switch OFF

Another case of data logging: SRRF not guilty !!

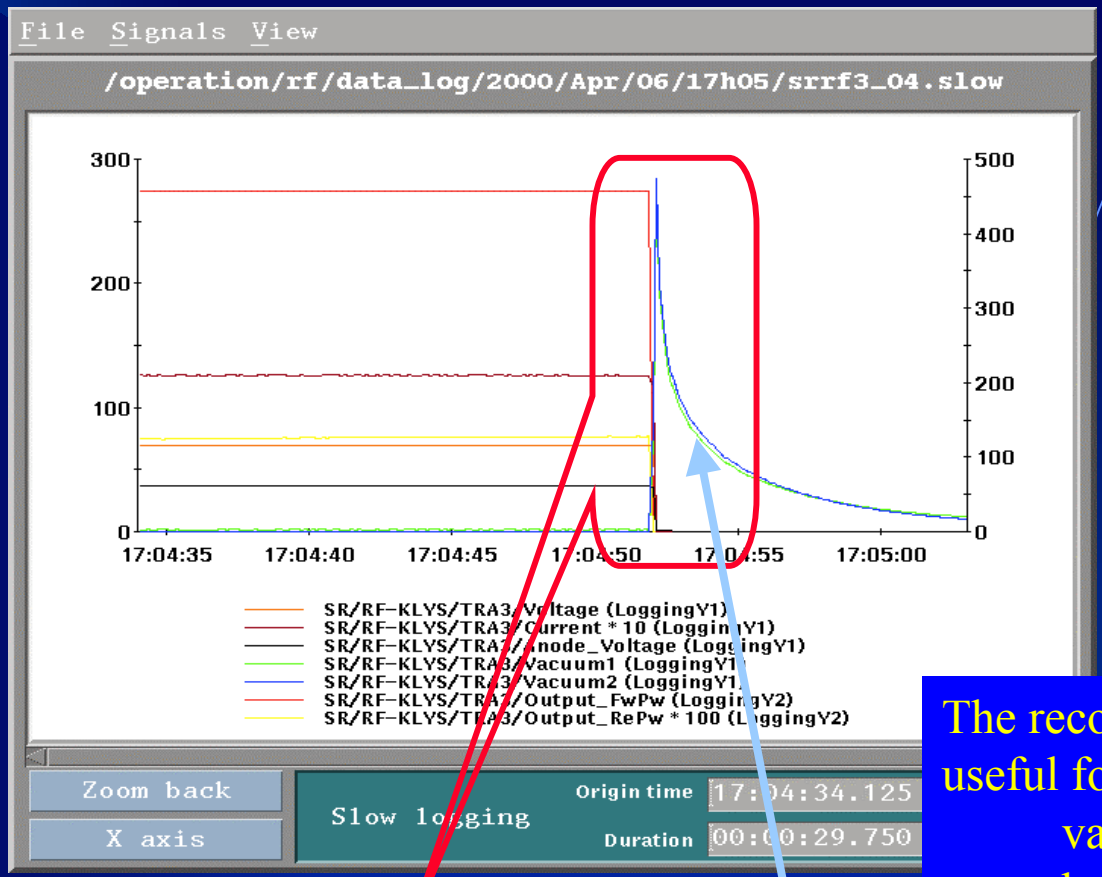


All cavities have the same oscillation and there is no variation on the power and on the phase.

!! The excitation is not coming from the RF system !!

Further analysis shows that is was coming from the main RF master source

The slow analog signal logging



Storage of the evolution of all analog signals at 8Hz during 30 sec

The recording of slow analog signals is useful for the analysis of:

vacuum events,

behaviour of loops

or switching ON/OFF sequences.

Example: Switching OFF of the RF transmitter due to an **out gassing in the klystron tube**.

The ESRF historical data base (HDB)

Data source

Data collector

OS9,UNIX,NT
VME
C

Device server

Hardware access
fbus, serial line,...

Polling frequency and conditions could be configured by the users (Periodic mode or data change mode)

Data Storage

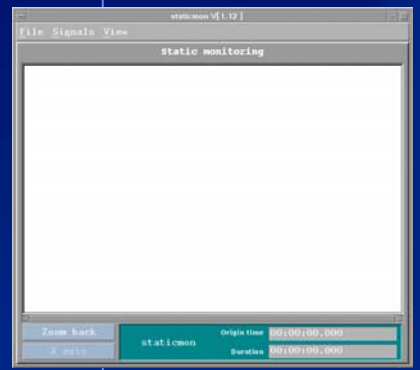
HDB Filler

More than 6000 signals
50 Gbytes

1 Year Data available on line
Transfer then on DLT Tapes

Data extraction

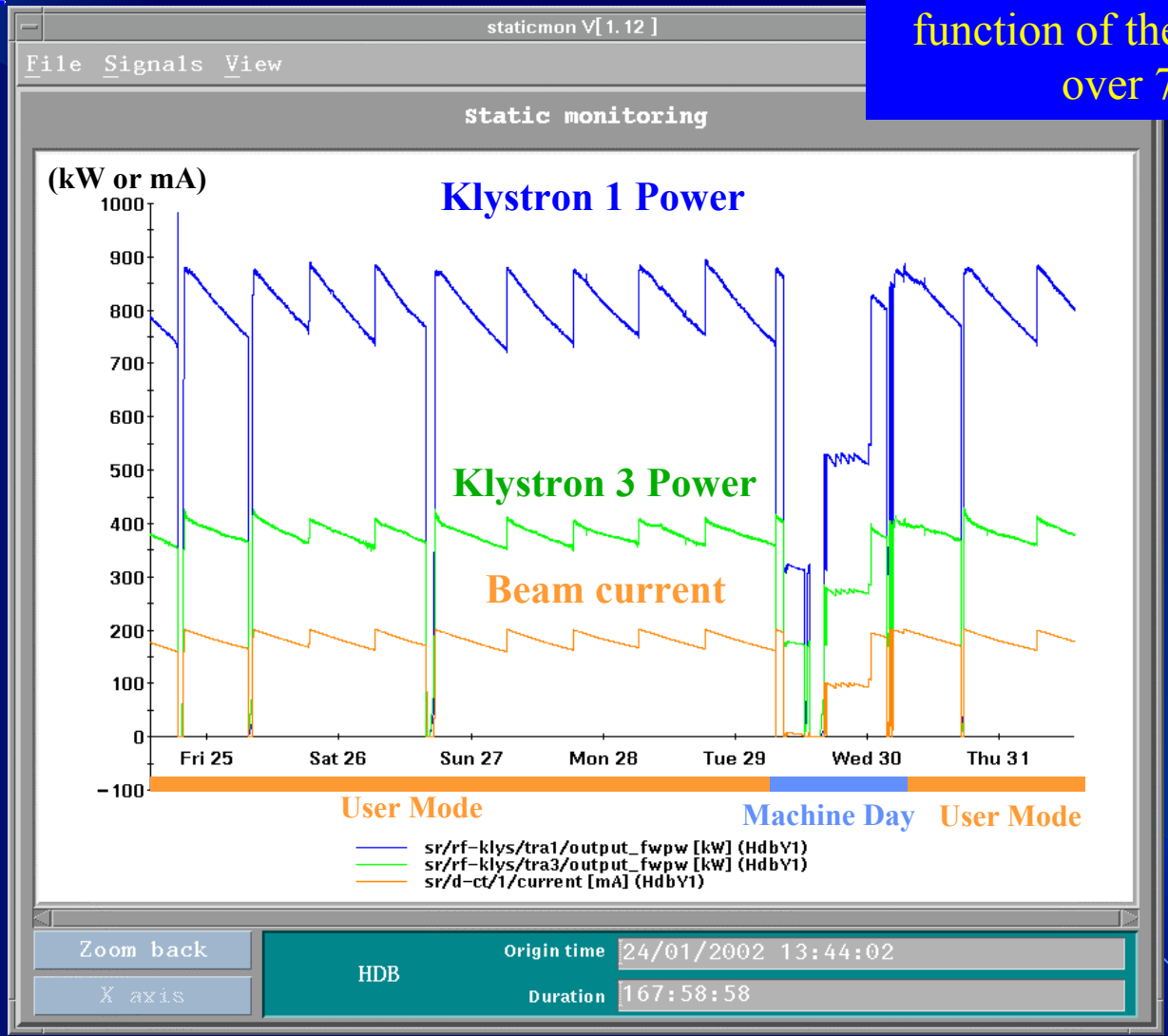
Analog signals
Device status



Standard GUI

HDB example 1

Evolution of the RF power as a function of the beam current over 7 Days

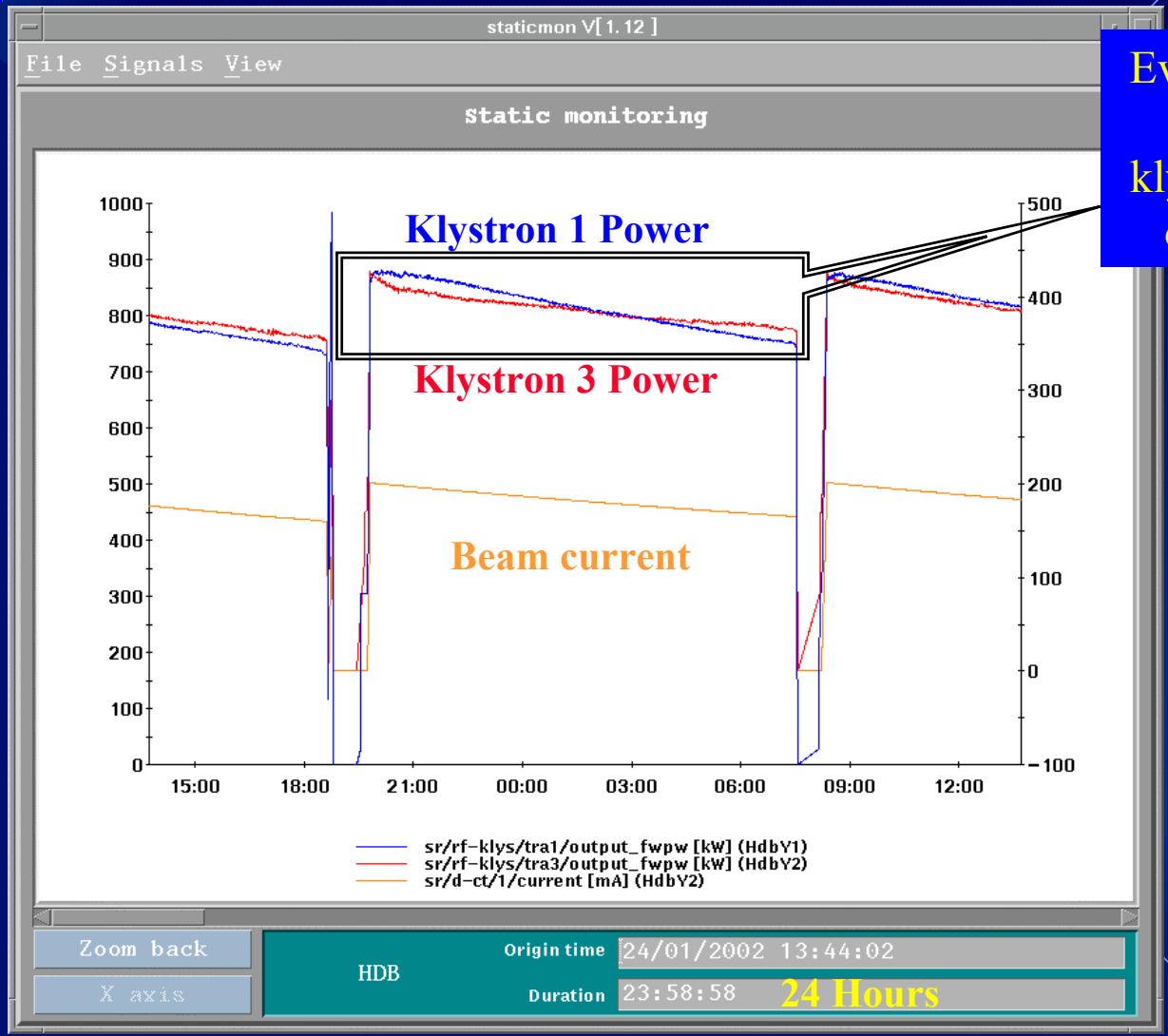


Klystron1
drives cavity 1,2,3,4

and

Klystron3
drives cavity 5,6

HDB example 1 (zoomed)



Evolution of the power balance between klystron1 and kystron2 over a beam decay.

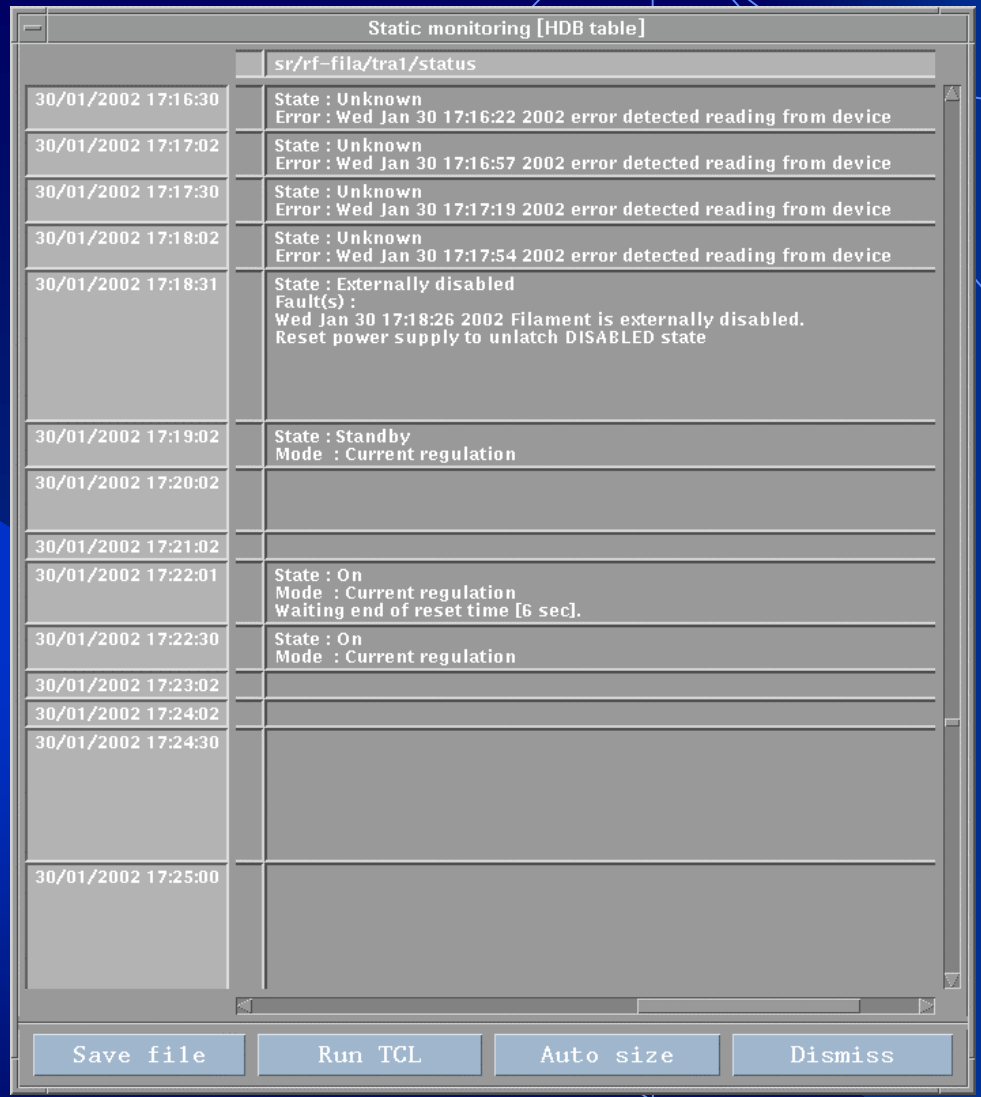
Klystron power not evolving in parallel.

No clear explanation.

HDB Example 3 (Device state)

The state of a device is stored every hour or immediately if there is a modification.

==> very useful for the tracking of failures, warnings or control problems.



Conclusion

- Data logging possibilities should be fully integrated at the design stage.
- Graphical User Interface should be identical for data logging analysis and on-line monitoring.
- First fault and history of fault should be logged without ambiguity.
- Analog logging should cover the range from 1μs to 1 year!!
- Data Logging is costly (money and manpower) but worthwhile for maintenance and reliability.
- Data Logging must be reliable

Many thanks to all colleagues who participated in the development of this system and to all those who helped me to prepare this talk.