

# Fault Tree

Kay Kasemir, March 2007



06-000576a1am



OAK RIDGE NATIONAL LABORATORY  
U. S. DEPARTMENT OF ENERGY

# SNS LLRF Main Screen

**DTL 5 Control** 04/03/07 12:08:35

Main Ctrl FdFwd Diag Diag IIQ ResCtrl Time Sched IOC Hardw. Fault Log

**Amplitudes**

**Phases**

**Settings**

Amplitude: 0 to 1, value: 0.584, Ramp Goal: 0.584

Cav. [MV/m] Fwd. [kW] Refl. [kW]: 19.50 1478.9 21.6

FCM Field HOM B [W] Ampl. Error: 0.584 15.6 -0.00

Cavity Field Phase: -200 to 200, value: 117, 116.9

Loop: Closed, Adaptive Feed Fwd. Freeze, Freq. Offset: 0.00 kHz, No Warmup

Idle Ramp Kill RF Stopped

...manual... ...manual or on errors

**Ramp**

Ramp cavity amplitude to: 92.0 % of goal, i.e. 0.537

while power is below: 2000.0 kW, stepping: 0.00500

every: 3.0 sec, With good vac., accelerate: 2.0 time

Check cav. rise after stepping: 4 times

...when done... ...manual or when amplitude reduced... ...auto-matically...

**Status**

Operation: Status, Res.Err.: 0.98 kHz, FCM, ...Limit: 6.00 kHz, HPM, Power: 1478.95 kW, MPS, ...Limit: 2400.00 kW, Chatter, HPRF: HPRF OK, RCCS, RF Load: 21.948 kW

**Tune**

Wait for Reson. Error to stay below... for at last...: 5.00 kHz, 30 sec

Duration: 30 sec

**Vacuum**

Wait for vacuum to get below: 3.2e-07

9.9e-07

Kill RF Forward Reflected Cavity

**RF Pulse**

Width: 1000.0 us, Rate: 15 Hz, Duty Cyc.: 1.50 %, ...Limit: 4.10 %

Phase Shift: -150 us, Beam RF: Off, Always On

Closing... Closed Loop: 0.1 min

Regulation Err. Limit: 0.29 %, 6.25 %

Trip RF? No

04/03/07 12:04:19 -- Booted --

04/03/07 12:04:19

04/03/07 12:05:14 Ramp Paused, Vacuum Excursion

04/03/07 12:05:19 Ramp Paused, Vacuum Excursion

04/03/07 12:07:51 Closed Loop



# SNS LLRF Main Screen

**DTL 5 Control** 04/03/07 12:08:35

**Amplitudes**

**Phases**

**Settings**

Amplitude: 0.584

Ramp Goal: 0.584

Cav. [MV/m] Fwd. [kW] Refl. [kW]: 19.50 1478.9 21.6

FCM Field HOM B [W] Ampl. Error: 0.584 15.6 -0.00

Cavity Field Phase: 117 116.9

Loop: Closed

Adaptive Feed Fwd. Freq. Offset: 0.00 kHz

Res.Err.: 0.98 kHz

FCM: [Green]

HPM: [Green]

MPS: [Green]

Chatter: [Green]

RCCS: [Green]

Power: 1478.95 kW

HPRF: HPRF OK

RF Load: 21.948 kW

**Control Panel:** Idle Ramp Kill RF Stopped

**Ramp Section:** Ramp cavity amplitude to 92.0% of goal, i.e. 0.537 while power is below 2000.0 kW, stepping 0.00500 every 3.0 sec. With good vac., accelerate 2.0 time. Check cav. rise after stepping 4 times.

**Tune Section:** Wait for Reson. Error to stay below... 5.00 kHz for at last... 30 sec. Duration: 30 sec.

**Vacuum Section:** Wait for vacuum 3.2e-07 to get below: 9.9e-07

**Status Panel:** Closing... Closed Loop 0.1 min. Regulation Err. Limit 0.29% 6.25%. Trip RF? No

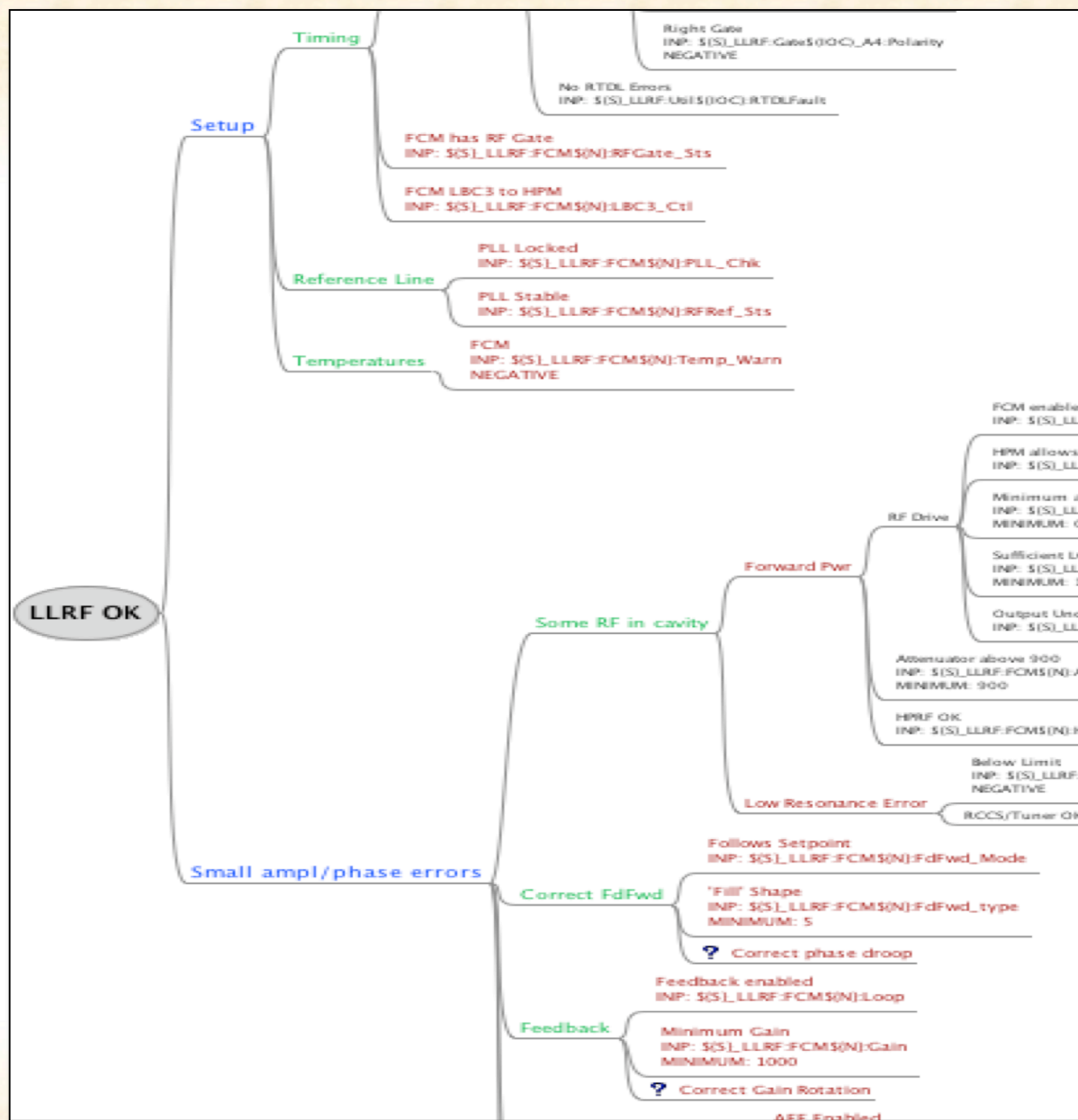
**Log:**

- 04/03/07 12:04:19 -- Booted --
- 04/03/07 12:04:19
- 04/03/07 12:05:14 Ramp Paused, Vacuum Excursion
- 04/03/07 12:05:19 Ramp Paused, Vacuum Excursion
- 04/03/07 12:07:51 Closed Loop



# "Fault Tree"

- Shows consequences of faults, respectively conditions for proper operation
- Create graphically with "FreeMind", a free Java "Mind Mapping" tool
- Basis to discuss, document, understand subsystem dependencies

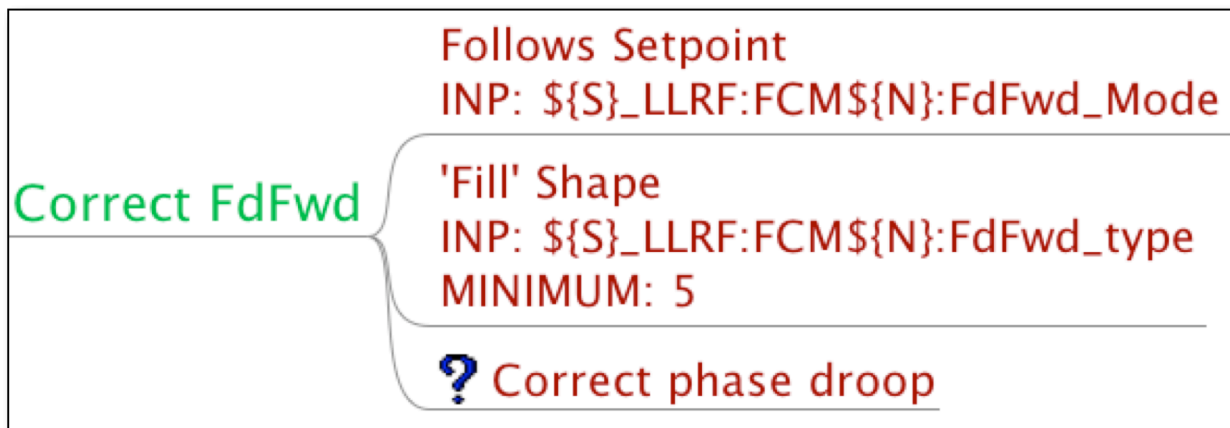


OAK RIDGE NATIONAL LABORATORY  
U. S. DEPARTMENT OF ENERGY



## Detail..

- **Some conditions directly match PVs**
  - INP: ....
- **Some conditions easily compute from PVs**
  - NEGATIVE, MINIMUM: 5, ABS\_MINIMUM: 10
- **Some are unclear**
  - No PV nor recipe beyond "Expert tries some values".
  - Still: At least you know that you don't know.



## Turn this into software?

- **Script converts FreeMind config (XML) into a simpler "Fault Tree" config (XML)**
  - Not locked to FreeMind
- **Other scripts create EPICS database (mostly calc records) and EDM screen**
  - Thanks: Rolf Keitel/TRIUMF, perl edl lib

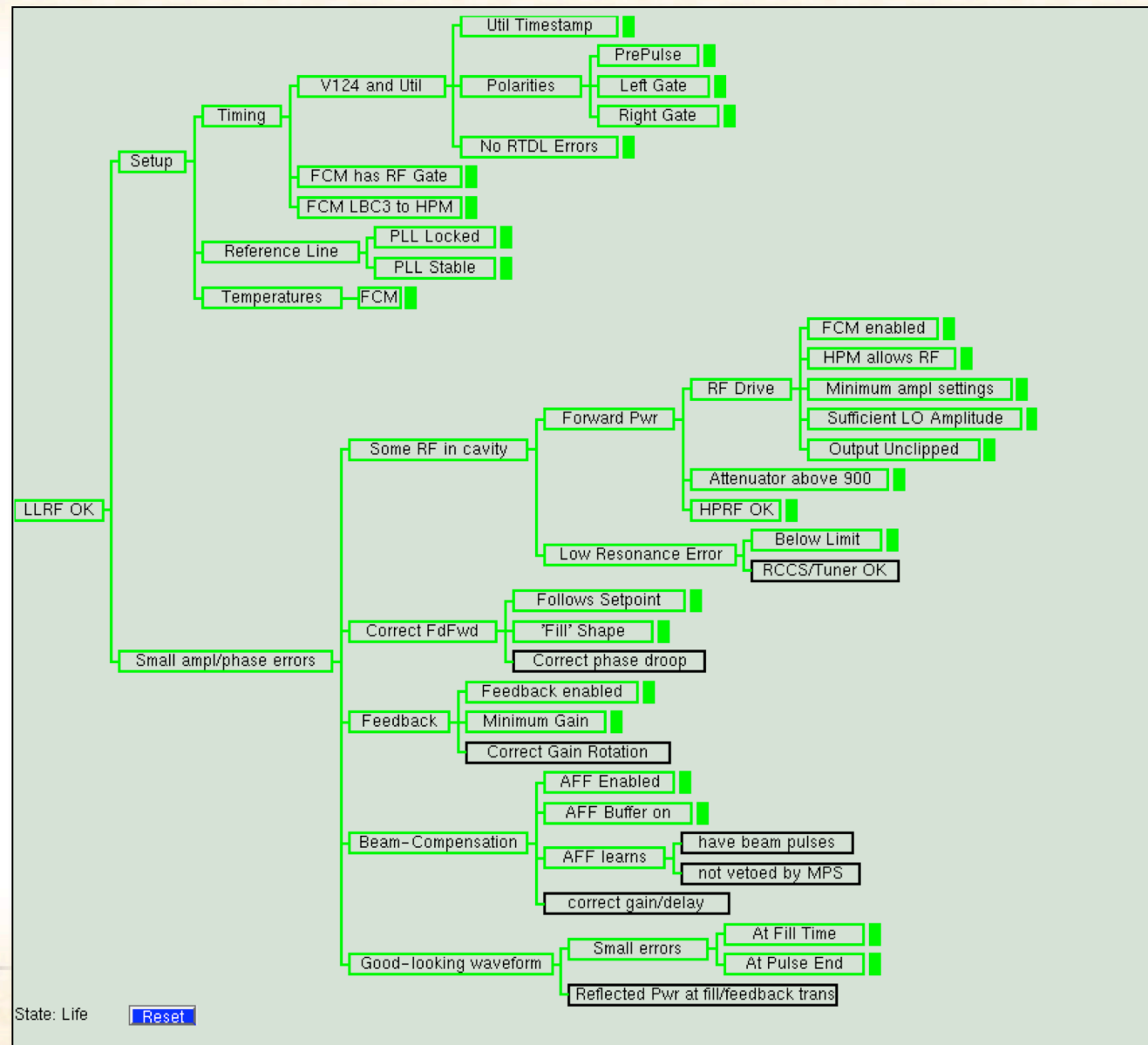


**OAK RIDGE NATIONAL LABORATORY**  
**U. S. DEPARTMENT OF ENERGY**



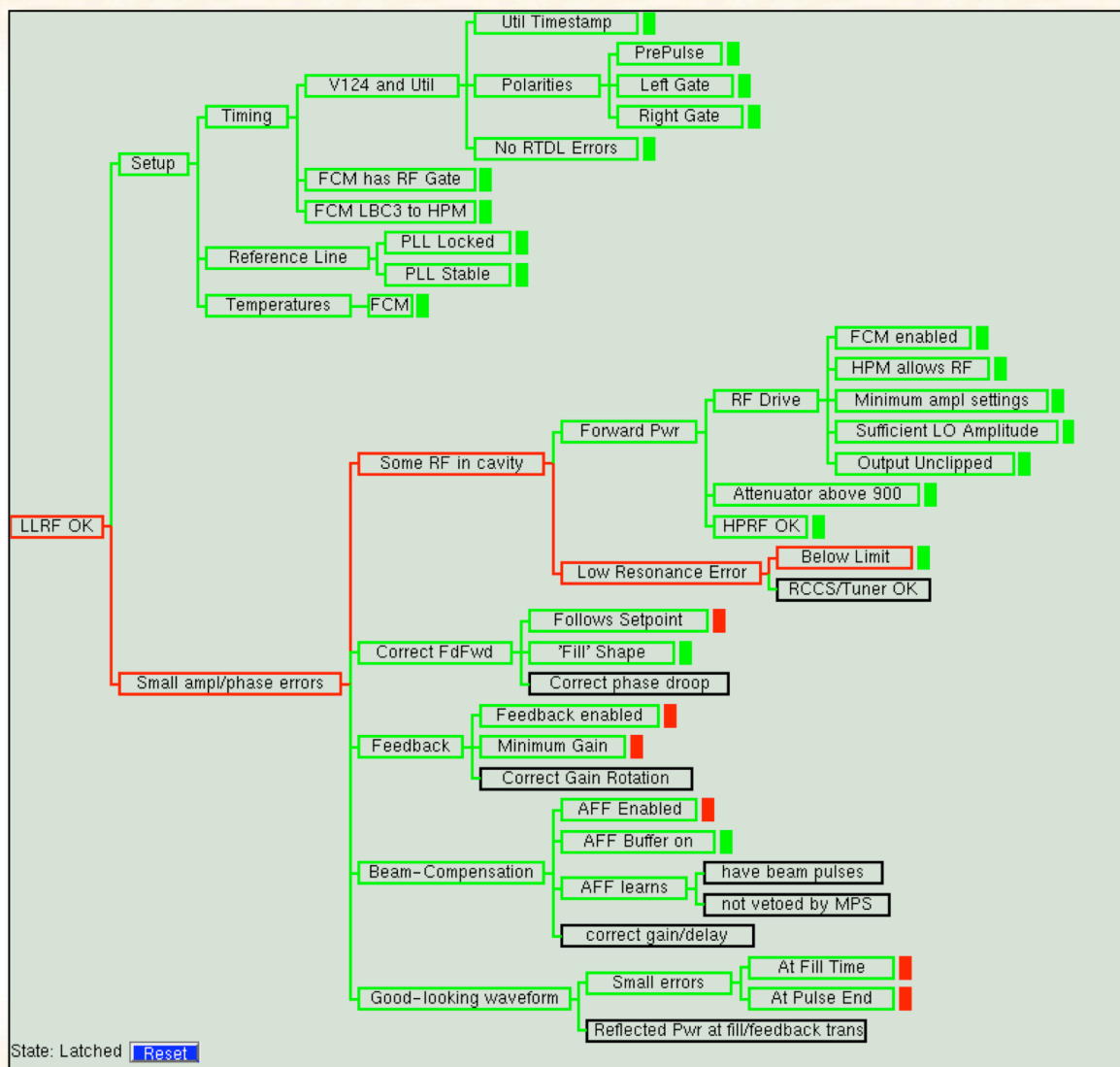
# Live Fault Tree

- Logic and OPI generated from Mind Map



# Latches on First Fault

- **Example:**  
**Resonance Error was too high**
  - Consequences: Loop opened,
  - Feedback disabled, ...
- **Lead nodes continue to reflect 'current' state**
- **Resets when all faults clear. Manual unlatch to update tree for current faults.**





# Summary

- **FaultTree type view of system useful in general**
- **Database & screens**
  - real nice to have
  - Hardly any added work
- **"First Fault" display sometimes useful**
  - .. but driven by "CP" links, so depending on races with other database logic, the true "first fault" is not always obvious.
- **No "alarm handler" with logging, overrides, acknowledgement, phone dialer, ...**



**OAK RIDGE NATIONAL LABORATORY**  
**U. S. DEPARTMENT OF ENERGY**

