

What needs to be automated

- **Procedure** (sequence of complex actions),
example: turn on rf
- **Application** (complex action or calculation),
example: adaptive feedforward
- **Algorithm** (calculation; signal_in => signal out);
example: measure cavity detuning
- **Function** (simple action); example: turn on/off rf switch
- **Signals and Parameters**

Elements of FSM

- Define
 - Superstates, Simple states (hierachy, parallelism, history)
 - Flows
 - Conditions
 - Events
 - Signals and Parameters

Types of Signals

Signals

- physical signals measured (analog and digital)
- physical signal calibrated (analog and digital)
- derived signals measured
- raw control signals
- derived control signals
- system parameters
- timing
- events
- warnings
- alarms
- llrf interlocks
- other subsystem interlocks

Procedures

- rf commissioning
 - Initial (first time)
 - Hardware/software diagnostic
 - Level adjustment (probe forward, reflected)
 - Calibrate gradient/forward/reflected power
 - Cavity tuning (few hundred kHz)
 - Operation with cavity simulator
 - Downconverter calibration with test signals
 - RF reference check
 - after long shutdown
 - Hardware/software diagnostic
 - Measurement chain check
 - Operation with cavity simulator
 - Low power check
 - Verify calibrations and operational parameters
 - after maintenance day
 - Hardware/software diagnostic

Procedures (Cnt'd)

- rf operation

1. Turn on relevant subsystems and set their parameters
2. set low power operation in open loop mode and verify signals
3. Turn-on feedback and optimize feedback parameters
4. Set-up for short beam pulses and operate with beam
5. Set-up for long beam pulses

• rf system maintenance

- Hardware/software diagnostic
- Operation with cavity simulator and signal integrity check
- Measure rf test signals and identify defect channels
- Measure maximum operable gradients

• rf system debugging and trouble shooting

- Measure rf test signals and identify defect channels

Procedures (Cnt'd)

- special procedures
 - coupler warm and cold conditioning
 - cavity conditioning
- control of Hrf related subsystems
 - master oscillator and frequency distribution
 - LO- oscillator generation
 - timing system (trigger, clocks)
 - klystron and modulator
 - Cryogenics
 - cavity, coupler and frequency tuner
 - machine protection

Applications

- Autotune (motor tuner)
- By-passing of cavities
- Adjust power levels waves
- Verify LO/clock signal integrity
- Adaptive feedforward
- System Identification
- Momentum Management

Algorithms

- Measure cavity detuning and load Q
- Measure loop phase and loop gain
- Calibrate gradient and phase, forward and reflected wave
- Measure klystron saturation curve
- Cavity field estimator
- RMS amplitude and phase measurement
- Calculate available gradient/current headroom