Design considerations for automatic operation

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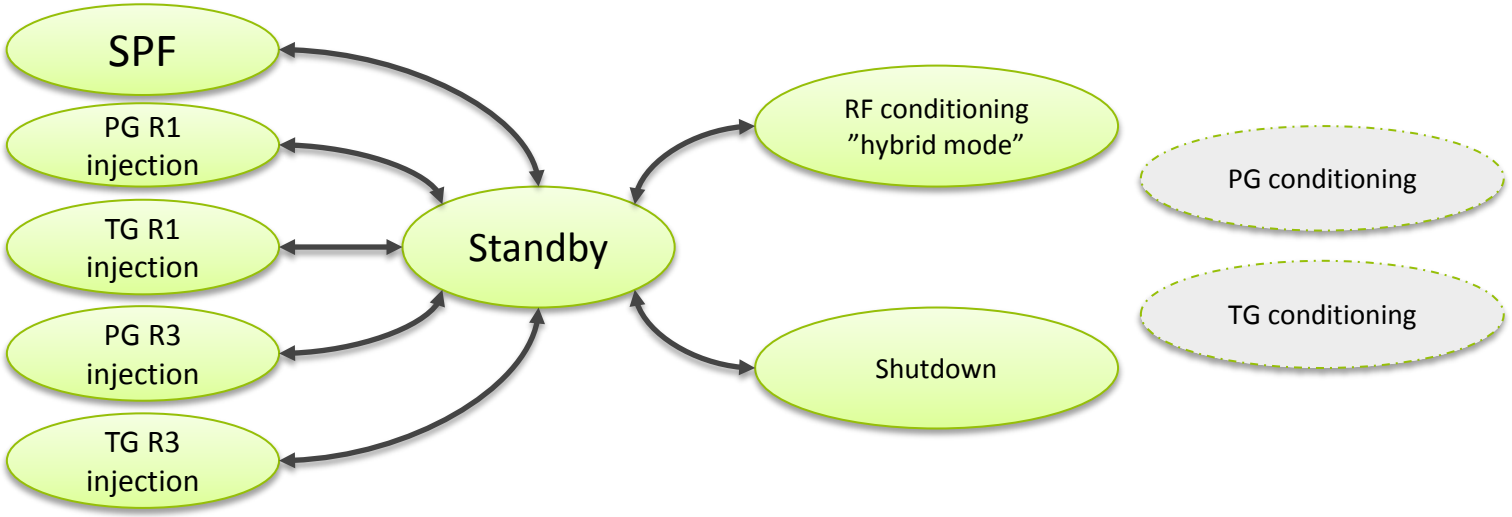
Outline

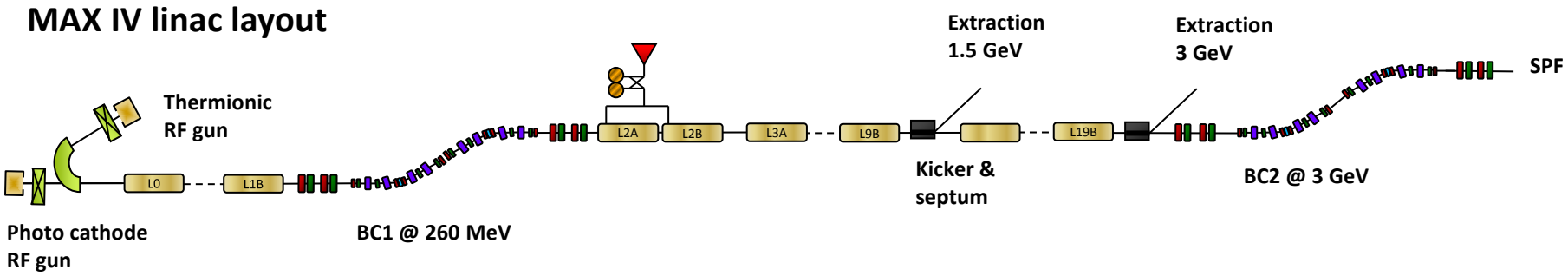
- States and state transitions
  - Linac
    - States
    - Feedbacks
    - Current automation
  - R3/R1
    - States
    - Feedbacks
    - Current automation
  - MPS and PSS
  - Snapshot system

Linac states, features



Standby: Mode with blocked/disabled beam, to allow machine changes in a safe way from PSS perspective.
Injection: Feedbacks active, non-compressed bunches, 10 Hz rep-rate, thermionic gun active.
SPF: 100 Hz rep-rate, compressed bunches, feedbacks active, photo-cathode gun.
”Hybrid mode” conditioning: No beam, 100 Hz to condition the SLEDs/RF structures, no RF to guns and L00.
Gun conditioning states: automation not foreseen
Shutdown: Well defined when going from standby. Maintenance and other activities then ”ruins” it. Diagnostic routines and tests needed to get back to it.

Linac states, feedbacks



Trajectory feedback:

- Position and angle stability critical for SPF, injection.
- Sextupole magnets in bunch compressors require good position stability

Energy feedback:

- Automatic compensation for loss of RF station
- Will require intelligent magnet optics tuning to compensate for particle E(s) profile changes

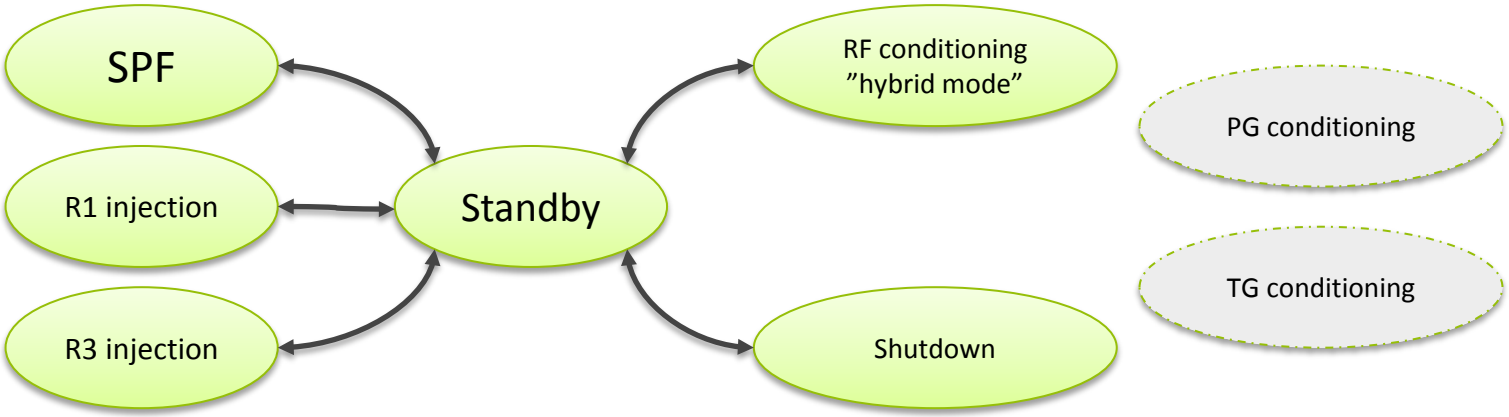
Bunch length feedback:

- Compression knob will be linac phasing → need to tightly integrate with energy feedback

Charge feedback:

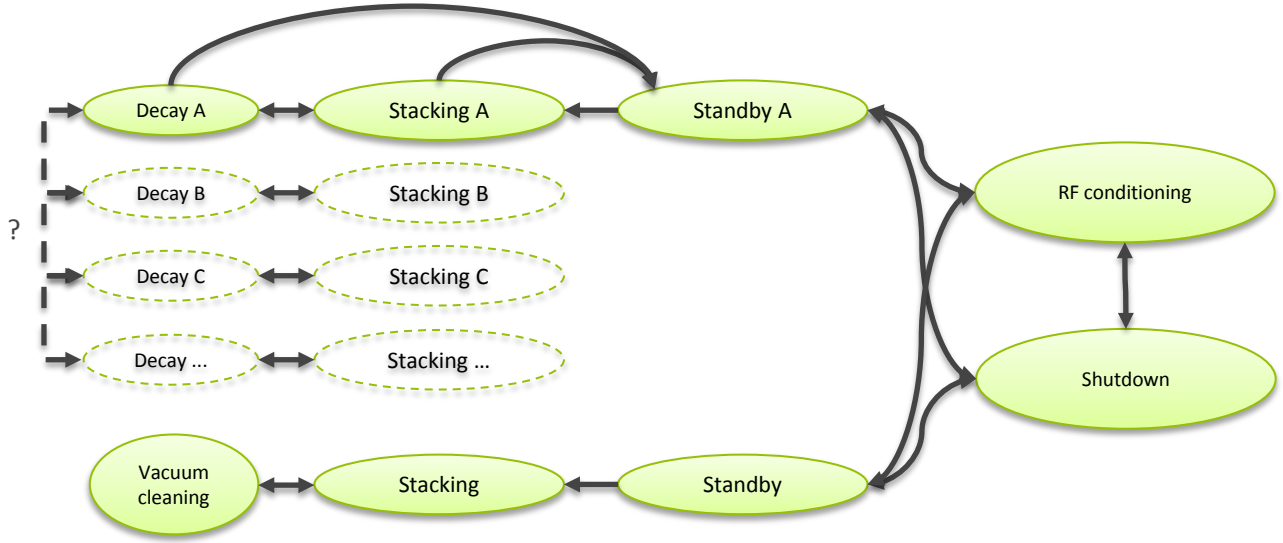
- Stabilization of charge exiting the gun

Linac state transitions, current automation



RF systems: Largely manually adjusted, handled by RF operator.
Feedbacks: Simple trajectory feedback being tested. Adjustment of golden trajectory upon state change will be needed.
Magnets: Snapshot functionality handled via Bensikin. Scripting capability for snapshots should be there but not tested by the operators/physicists yet.
Laser system: Laser system in TANGO but autonomous. If laser has been shut down significant manual intervention needed.
Timing system: Partially in TANGO, operated manually.

R3/R1 states, features



Standby: relevant magnet settings applied, RF on, valves open, IDs open (?), no beam
Stacking: active injection kicker. Once current is above certain limits, activate feedback on orbit/tune/coupling/bbb, allow closed IDs (?). MPS switches on orbit interlocks over 5 mA.
Decay: stored beam, no injection. Once current decreases below threshold, switch to stacking state.
RF conditioning: closed valves around RF cavities. RF power in relevant cavity.
Shutdown: magnet power supplies off, valves closed, RF power off

R3 feedbacks

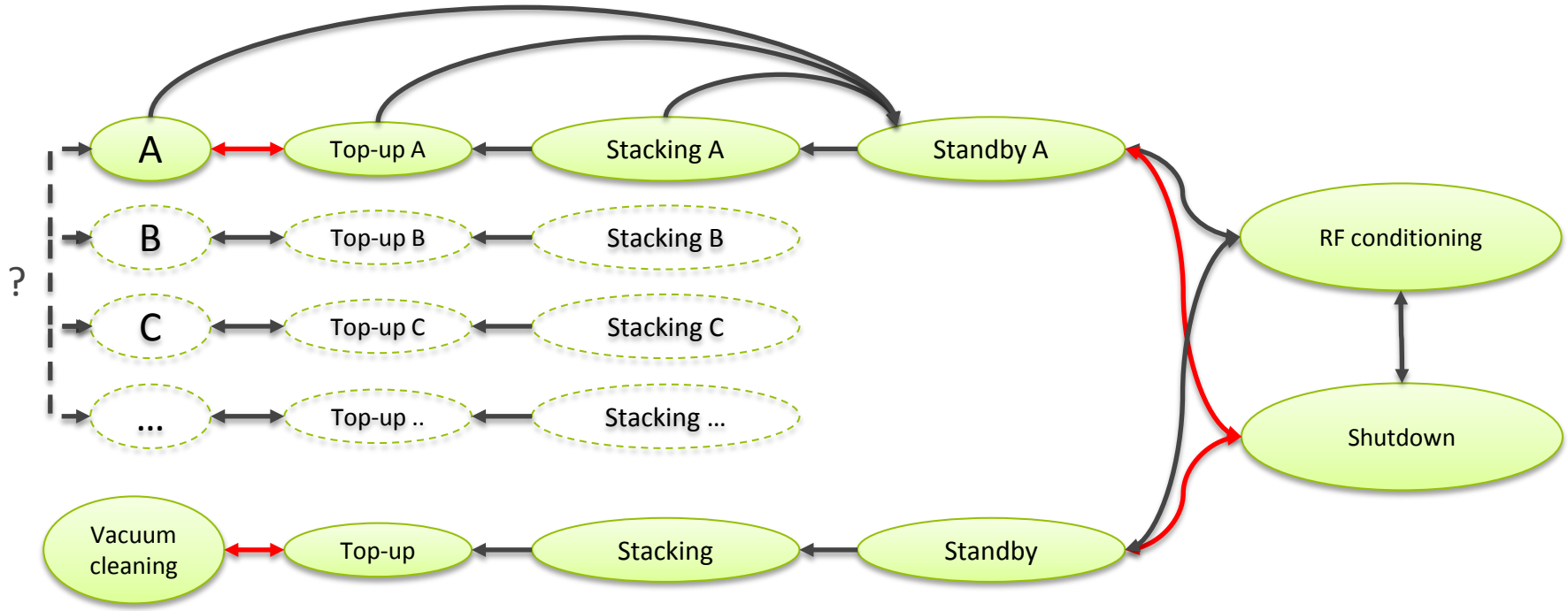
Correction system	Actuator	Monitor
Orbit feedback, slow	Slow correctors, 10H + 9V per achr. RF	200 BPMs, Libera Brilliance+ SA data stream (10 Hz)
Orbit feedback, fast	Fast correctors, 2H + 2V per achr.	200 BPMs, Libera Brilliance+ FA data stream (10 kHz)
Coupling feedback	Trim coils in skew mode	B320B diagnostic beamline (vis. SR) B302B diagnostic beamline (vis. SR)
Tune feedback	Global quad adj. (QF + PFS)	Tune measurement
Transverse Bunch-by-Bunch feedback	Stripline antenna	RF pickup
Filling pattern feedback	Injection event timing	Stripline antenna
ID optics compensation feed-forward	Local quadrupoles (QFE + QDE)	-
ID coupling compensation feed-forward	Local trim coils in skew mode	-

R3 state transitions, current automation

Sub-system automation level:

- **RF:**
  - auto start-up functionality feature available in LLRF system. Not fully in use
  - RF group still conditioning/tuning the RF system
- **Magnets:**
  - cycling functionality (TANGO)
  - Resistance monitoring (TANGO)
- **Vacuum:**
  - scripted routines written to manage valves (MATLAB – TANGO)
- **Timing:**
  - TANGO device to manage injection rep-rates, bucket selection, etc.
- **Diagnostics:**
  - Pinger/kicker tune measurement scripts available (MATLAB)
  - Orbit feedback running via MML (MATLAB)
  - Automation needed for diagnostic beam lines, spectrum analyzer

R3 state transitions, current automation



Transitions currently scripted in MATLAB / MML:

- *setmachineconfig.m* to get to a Standby state (RF currently excepted)
- *srshutdown.m* to get to Shutdown (RF currently excepted)
- *injecttraingui.m* to handle A <-> Top-up A (RF currently excepted)

MPS and PSS

Machine Protection System (MPS)

- Largely implemented in PLCs. Logic defined in functional descriptions reviewed by subsystem owners (vacuum). For fast interlocks the timing system is used.
- TANGO devices read/write PLC tags to integrate interlock monitoring/reset in the control system.
- Insertion Devices and front-ends belong to beamlines

Personnel Safety System (PSS)

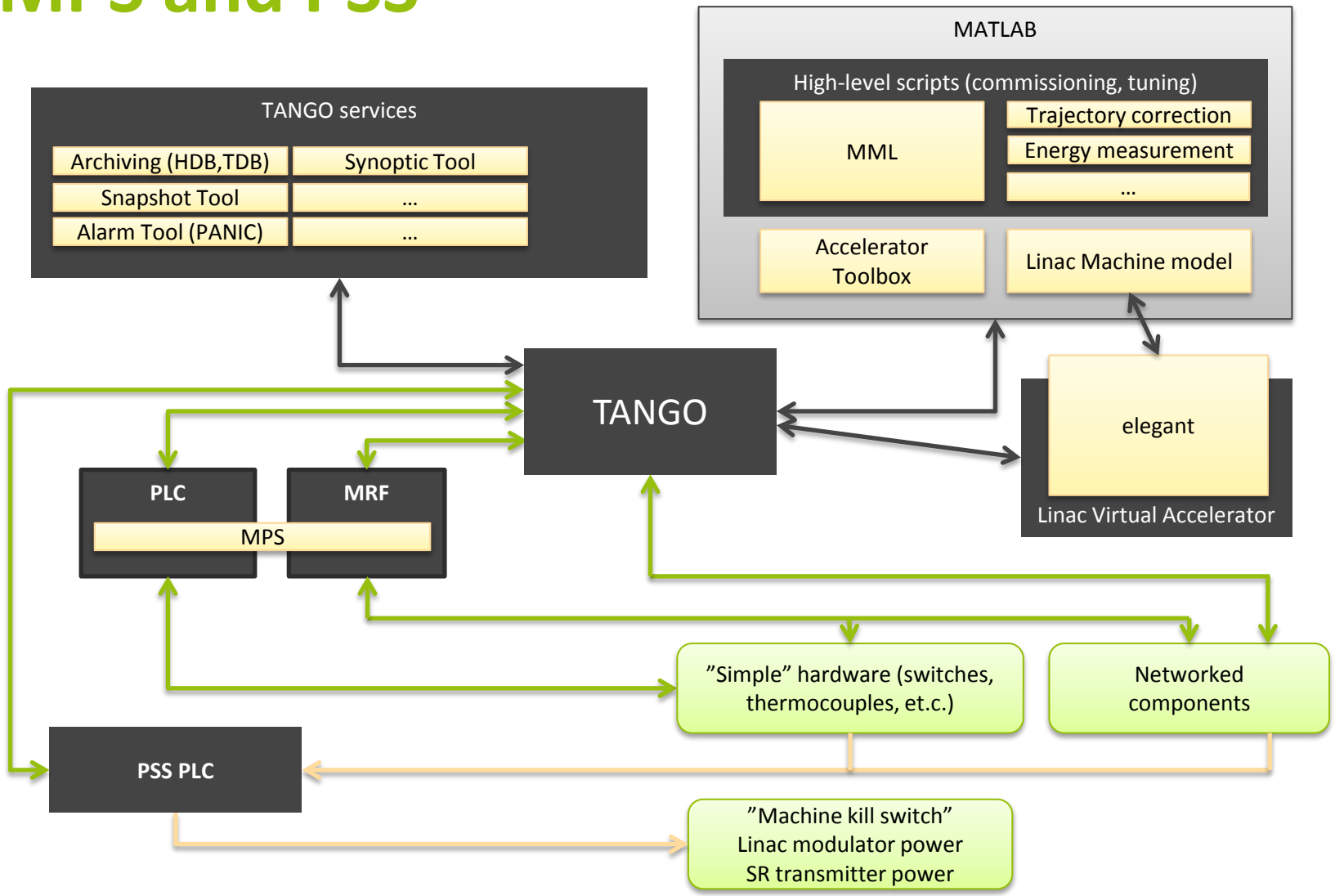
- Implemented in separate PLC system that lives on both green (machine) and blue (beamline) network
- Kills the beam if all conditions are not fulfilled (RF power cut)
- Machine/BL system can only monitor tags and request resets
- Code is comparatively static, as code changes must be extensively tested.

Watchdog (Radiation Safety)

- PyAlarm TANGO application that monitors the system to provide extra safety layer
- Has different states depending on the machine state.

Need to tailor state transitions to avoid triggering PSS / MPS conditions!

MPS and PSS


MATLAB
High-level scripts (commissioning, tuning)
MML
Trajectory correction
Energy measurement
...
Accelerator Toolbox
Linac Machine model
TANGO services
Archiving (HDB,TDB)
Synoptic Tool
Snapshot Tool
...
Alarm Tool (PANIC)
...
TANGO
elegant
Linac Virtual Accelerator
PLC
MRF
MPS
"Simple" hardware (switches, thermocouples, et.c.)
Networked components
PSS PLC
"Machine kill switch"
Linac modulator power
SR transmitter power

Setting a state, snapshot system

Two systems currently used:

- Bensikin TANGO application
  - Stores/loads attribute set points (current, phase, etc.) defined in a context (main linac, transfer lines, storage ring)
  - Used primarily for the linac. Covers power supplies, electronic phase shifters.
  - Contexts limited re. number of parameters
- MML machine configurations
  - Used for the storage ring. Currently saves/loads set points and monitor values for PS currents, trim coil relays, cavity phase references, main frequency.

Inclusion of all relevant parameters into a snapshot needed urgently!

Thank you for your attention!

THE END