MAX IV subsystem commissioning

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Overview

- Subsystem tests
  - Magnet SST
  - Vacuum SST
  - RF SST
- Main difficulties

Subsystem tests

Subsystem tests

- Subsystem test policy was that each subsystem owner/responsible should plan and perform their tests, preparing written test descriptions and test protocols.
- Testing was defined as part of the installation, but the work to drive the testing landed with the project management rather than installation management
- Series of meetings were held with subsystem owners for the project management to follow up on the progress and be able to coordinate/plan
- Personell Safety System testing handled completely by safety group (not covered by the subsystem tests described here)

Subsystem tests

In the rear view mirror:

- **Test responsible person had the technical expertise by definition.** Most owners were deeply involved in the R&D phase for the systems (LLRF, cavities, NEG-coated chambers)
- **Uneven quality of the testing between groups**. Experience with documenting test procedures, writing test protocols, etc. was dependent on the background/training/mentality of the owner in question.
- **No-one had testing as a full-time job or primary responsibility.** Owners usually also involved in design, R&D, procurement and installation. Project management occasionally occupied with fire-fighting, restricting ability to follow-up.
  - Consequence was that not all subsystem owners managed to produce the test descriptions and protocols, especially when they were hit by delays in other phases
  - Subsystems lacking well-defined test instructions suffered double, as it proved difficult to delegate the actual testing to others. For those that did have those, the operators assisted in the testing (particularly the magnet SST).

For future projects, will bring in people experienced with quality assurance and testing…

Magnet SST

- **Installation checks:**
  - Standard measurements (isolation checks, cable numbers, etc.) done by electricians (external) and protocols scanned
  - Installation inspections done by the installation coordinators (external consultants from ÅF) and protocols scanned
- **SST phases, performed by achromat:**
  - **Phase 1: Power supply and MPS.**
    - Covered PLC I/O and function tests, including interlock notification and reset via the TANGO system (PANICGUI, Jive). Verified power supply could provide low current (1A).
  - **Phase 2: TANGO integration.**
    - Configuration and automated tests of high-level devices (circuit+magnet), interfaces (synoptic, state-grid), archiving.
    - No issues were discovered for the configuration, which was done automatically from data in two main EXCEL documents.
  - **Phase 3: Field and magnet tests**
    - Required approved cooling installation due to full-current test
    - Included full-current test, temperature increase test, calibration curve data verification, field polarity check w. Hall-probe.
    - Interfaces from phase 2 used to control the magnets and operators involved in tests → feedback to control group
- **Global circuit tests**
  - Global circuits (dipoles, PFS, octupoles) use large DANFYSIK power supplies. First use at high power had to be during SAT, but not possible before the load was ready (i.e. all magnets installed) → SAT at end of installation → required slight adjustment of SST phases.
  - PLC I/O done earlier achromat by achromat, function and low current shortly before SAT.

Testing turned up some surprises. A few blocked cooling water circuits detected through insulation test! No flow → standing water → means not de-ionized...

Vacuum SST

- **SST phases, performed by achromat:**
  - **PLC I/O**
    - Bulk of test time
    - Verification of signals from gauges, valves
  - **PLC function tests**
    - Partially automated in order to reduce time
    - PANICGUI available to verify interlocks were properly displayed in TANGO
  - **Human-Machine Interface (HMI) tests**
    - Synoptic ready
    - VACCA configuration not completed in time for the tests

RF SST

In effect performed during early commissioning, as there were significant delays during the installation phase

Main difficulties, pt. 1

- **RF Cavity Conditioning:**
  - Main and harmonic cavities conditioned ahead of time at MAX-lab conditioning station to avoid length conditioning at MAX IV site. Throughput proved an issue in order to keep installation time table. Simultaneous de-commissioning of MAX-lab caused several issues.
  - Post-installation, further conditioning proved necessary to reach high power.
  - Cavity in achr. 19 sprang a leak and had to be removed.
- **RF System commissioning (LLRF, shunt groups):**
  - Delays in development and installation resulted in very limited SST on the installation. As a result, stability issues and spurious interlocks plagued the system early on and disrupted commissioning efforts.
  - Policy with grounding was to do basic installation and then reinforce where and when needed. Grounding reinforcement now underway for the R3 RF rooms after tests in the 1.5 GeV ring. This has contributed to the stability issues.

Main difficulties, pt. 2

- **Diagnostic System Commissioning:**
  - Libera Brilliance+ BPM electronics: numerous childhood issues due to new development for the event receiver (MRF timing system compatibility), TANGO implementation was only lab-tested. As a result early commissioning period was dominated by bug-hunting (which also turned up firmware bug for automatic gain control).
- **Kicker Magnet PS failure:**
  - No SST phase was scheduled, as complete test of system (including control system integration with TANGO devices, cables, magnet load) done during the SAT. PS failure appeared after a period of operation. Required test would have been non-stop pulsing for some weeks – would have been incompatible with the time plan.
- **Gun Klystron Failures:**
  - thermionic gun used for storage ring injection is a single-point-of-failure.
- **Long Radiation Surveys:**
  - mandated by SSM permit. Impact partially self-inflicted (?). Lesson was learned for 1.5 GeV ring

Main difficulties, pt. 3

- **Cooling System Failures:**
  - declining water flow in circuits for vacuum chambers and main power supplies (DIP, DIPM, etc.) mandating periodic adjustments. Appeared gradually and was made worse after filter installations (which added oxygen to the water). Still an issue today, though it is managed by periodic adjustments; additional nitrogen bubbling stations are in the pipeline but lead time is long. Power supply issues resolved after removing constriction where CuO2 accumulated. Unlikely to have been caught in advance by a test procedure.
- **Control System Commissioning:**
  - development pipeline throughput was too low. At commissioning start a significant amount of GUIs, high-level TANGO-devices were missing. Commissioning workaround was control via low-level devices and remote-desktop control of scopes
  - Final interfaces in many cases not ready in time for the subsystem tests, which were then done with low-level interfaces only. This then ate up commissioning time.
- **PS Failures:**
  - Apart from the expectation that power supplies fail in greater numbers early on (bathtub curve), known systematic issues from the linac commissioning had persisted (non-functional remote reset of Delta PS interlocks being one example). In addition, the above cooling issues impacted on the power supply uptime.