Outline

• Strategy
• Planning
• Status
• Lessons (being) learned
The main purpose of the testing activities is to verify that the systems and components meet their requirements and operational goals, i.e. they are verification and validation activities.
Strategy: Pragmatic approach

• Centralize coordination to get some consistency, but give teams agency to use the appropriate practices for themselves.
  – We try to minimize disruptions to ongoing work.

• It is better to adopt a good-enough approach quickly than a perfect one eventually, but it will nonetheless require an effort from everybody to adopt it.
  – It is challenging with the available resources.
Planning: Priorities

- **Realistic time allocation** in the ITC plan
  - Add and link detailed activities in JIRA
- **Milestones** linked between JIRA & P6
- **Key dependencies**
  - Links to other Accelerator systems and other divisions (CF, ICS...)
  - Correct Gateways/Reviews (TRR, SRR...)
- **Additional support**
  - Identify relevant Permits (internal, SSM...)
  - Ensure Safety Measures (RAMS, WSCP...)
Status: Procedures

• Use of ESS procedures to coordinate plans:
  – Handbook for Engineering Management, ESS-0092276
    • Graphical Workflow, ESS-0093443
  – Procedure for Prepare for Installation and Installation, ESS-0102864
  – Procedure for Test, Verification and Commissioning, ESS-0102865
  – Handbook for System Verification, ESS-0117128
  – Accelerator System Verification Plan, ESS-0005458
Status: Verification Plans

- BCM verification plan
- LEBT EMU verification plan
- DPL verification plan
- LEBT NPM verification plan
- LEBT FC verification plan
- HIPOT Testing for vacuum cables
- Gamma Blockers Verification Plan
- RSMS Test Procedures
- …
## Status: Planned activities (NC Linac)

<table>
<thead>
<tr>
<th>System</th>
<th>Local tests</th>
<th>Integrated tests</th>
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<tbody>
<tr>
<td>RFQ Cooling Water</td>
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<td>PLC comm. w/ controls, Closed loop test (dry run)</td>
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<tr>
<td>RFQ Vacuum</td>
<td>Leak tests</td>
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<tr>
<td>RFQ EMR</td>
<td>RFQ tuning</td>
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<tr>
<td>RFQ</td>
<td></td>
<td>Test comm. w/ LLRF</td>
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<tr>
<td>MEBT Cooling Water</td>
<td>Manifold inst.</td>
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<tr>
<td>MEBT Vacuum</td>
<td>Leak tests</td>
<td>Integrated tests</td>
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<tr>
<td>MEBT EMR</td>
<td>Buncher tuning</td>
<td>Controls tests, Tuner comm. w/ LLRF, RF conditioning</td>
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<tr>
<td>MEBT Bilbao rack equipment</td>
<td>Local tests</td>
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<tr>
<td>MEBT Beam Instrumentation</td>
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<td>Tests w/o beam (x9)</td>
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<tr>
<td>MEBT Magnets</td>
<td></td>
<td>Integrated tests</td>
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<tr>
<td>MEBT Chopper</td>
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<td>Integrated tests</td>
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<tr>
<td>MEBT MPS</td>
<td>Tests</td>
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<tr>
<td>MEBT</td>
<td></td>
<td>Dry run</td>
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<tr>
<td>DTL EMR</td>
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<td>RF conditioning 1, 2-4, 5</td>
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<tr>
<td>DTL</td>
<td>Local HW tests: 1, 2, 3, 4, 5</td>
<td>Dry run: 1, 2, 3, 4, 5, HW verification w/ beam</td>
</tr>
</tbody>
</table>
ISrc & LEBT Testing and Commissioning
Lessons Learned

• Session held 2018/10/12
• Worked well:
  – PSS is working great
  – Weekly meeting to organise the SRR was very useful
  – Vacuum documentation was excellent from the controls point of view
  – Good team building experience
  – Great support from technicians and Area Coordinators
• To be improved:
  – Changing conditions lead to need for re-testing
  – **FAT documentation** lacking
  – **Sequence** of tests (PSS...) needs to be more explicit
  – Management disconnect, lack of engagement
  – **Quality inspections** for all installations, make no assumptions
  – **Verification plans** missing (sometimes), and they should also include integration tests
  – Cramming activities to meet “arbitrary” deadlines leads to inefficiencies
  – Infrastructure plan still under development, coordination needed
  – **TRR was too weak**
• Suggestions:
  – Clear checklists
  – Clarify the **safety responsibility** during testing
  – Balance the paperwork vs hands-on work
  – SRR ≠ Beam RR, minimalistic and focused on safety
  – **Dry runs**
• Report in preparation
Testing-related learned lessons from other projects

- Lessons learned in different topics:
  - Leadership
  - Planning
  - Communication
  - Documentation
  - Control systems

- Collected from the proceedings of several conferences, as well as during the workshop held on Tuesday:
  - NuMI Lessons to Learn, S. Childress, Fermilab, 29 Sep 2008
  - Overview and Lessons Learned of the Jefferson Lab Cryomodule Production for the CEBAF 12 GeV Upgrade, North American PAC 29 September–04 October 2013 (WEZAA2)
  - The Spallation Neutron Source Beam Commissioning and Initial Operations, ORNL/TM-2015/321
  - ProtoDUNE - lesson learned, D. Mladenov CERN EP/NU, LBNF Cryostat final design review, SURF 21-22 August 2017
  - MAX IV Laboratory, Milestones and Lessons Learned Vincent Hardion on behalf of KITS Group, MAXIV ICALEPCS 2015
  - MAXIV STATUS, KITS MAXIV, 29th Tango meeting, Krakow
  - Workshop on Testing and Commissioning, ESS, Lund, 16 Oct 2018 (link)
    - Diamond Commissioning, Mark Heron
    - SNS Commissioning, Mike Plum
    - RF commissioning at XFEL, Julien Branlard
Testing-related learned lessons from other projects

• Leadership
  – “While our reviews are essential, many times they do not go into enough depth to really find many more subtle but major problems. For any challenging technical project, it is essential to have broad based lead technical experience at a decision making level.”
  – “Better/Faster way to resolve disputes, or ideally avoid them altogether.”
  – “Changing an established organisation is extremely difficult.”
Testing-related learned lessons from other projects

- **Planning**
  - “Some tests fail, allow for plenty of **time** for testing.”
  - “More time to evaluate/trade-off installation/operation impacts.”
  - “**Integrate** detailed schedule of activities including **resources** and **interdependencies** (Civil, beam transport, cryogenics, high power-rf, instrumentation, controls & safety)”
  - “Early operation of the frontend at SNS provided an opportunity for **integrated tests** of most of the basic accelerator systems, e.g. the control system, timing, machine protection, RF, vacuum and high level software.”
  - “Be prepared to take out installed equipment (storage, maintenance, documentation, testing, training, etc).”
  - “Commissioning a large accelerator facility necessitates **parallel Hardware and Beam commissioning**.”
  - “**Parallelising** activities has **limits**.”
  - “**Deep system test** of each device, from hardware to the synoptic (‘fully operational for the commissioning).”
  - “Large part of the project was spent on the **subsystems tests** (SST): the goal was to deliver the system ready for the commissioning with the fewest experienced defects. The SST helped to discover the discrepancy in the connection chain. For example the steering and the protection system of every single magnet has been all tested from the power supply to the report of the correct field of the magnet on the synoptic GUI.”
  - “**Expect surprises**: even the best checklist won’t catch everything.”
  - “Start tests as **soon** as the kit is ready for test, not to some arbitrary schedule.”
Testing-related learned lessons from other projects

- Communication
  - “Diligent communication between all relevant stakeholders is essential to deliver an optimal solution”
  - “Good communication & cross functional coordination is critical to success”
  - “Group should have established a rapport with safety officers.”
  - “Have an Electronic Log Book system up and running from day one”
  - “Tools will never solve any organisational communication issue”
  - “Operators working with and learning from other groups is invaluable experience and proves immensely helpful back in the control room”
  - “Accelerator scientists in the control room makes operators better: Questions are answered, issues are approached together, learning happens”
Testing-related learned lessons from other projects

• Documentation
  – “Procedure documentation, operation training, and testing are time consuming but essential.”
  – “Configuration Management: define the source and format of information.”
  – “A calibration plan should be developed.”
  – “Information gathered early is vital. Document as you go along”
  – “Design and follow checklists”
Testing-related learned lessons from other projects

• Control systems
  – “Software needs to be ready before beam commissioning, and should be tested in advance.”
  – “All subsystem had to include the Control System in their test suites. The tests included the access to the functionalities but also the performance and the quality of the responses. The improvement in the configuration management allowed a very fast reconfiguration without regression for all the different subsystems.”
Summary

• Short term goals:
  – Identify missing activities and V&V plans
  – Update the JIRA plan with milestones linked to Primavera

• Medium term goals:
  – Help producing the missing documentation
  – Support the preparation of TRRs and SRRs
  – Organise dry runs

• Long term goals:
  – Make sure the commissioning team gets the hardware they need, reliably tested and on time
Thank you for your attention
Commissioning vs Beam Commissioning

- In the context of the Handbook for Engineering Management, “Commissioning” is used for the Verification and Validation phase of all systems, independently of the use of the proton beam.

- To show to that the systems are ready from a safety point of view to start “Beam Commissioning” part of the accelerator, 5 separate Safety Readiness Reviews (SRR) will be held.

<table>
<thead>
<tr>
<th>ISrc+LEBT</th>
<th>RFQ+MEBT+DTL1</th>
<th>DTL2+DTL3+DTL4</th>
<th>DTL5+Spk+MBL+HBL+HEBT+DmpL</th>
<th>A2T</th>
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<tbody>
<tr>
<td>SRR1</td>
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<td>SRR2</td>
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<tr>
<td>SRR5</td>
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</tbody>
</table>
Status: Planned activities (NC Linac)

- **Testing milestones relating to other projects** (TO DO)
  - Summary of planned activities
  - Inigo Alonso
  - To 2020-Oct-01
  - Milestone

- **RFQ cooling system ready** (TO DO)
  - Janet Schmidt
  - To 2020-Mar-08
  - Milestone

- **LLRF input signal to SKID controls available** (TO DO)
  - Anders J Johansson
  - To 2020-Mar-08
  - Milestone

- **RFQ controls operational - milestone for ICS** (TO DO)
  - Thomas Fay
  - To 2020-Mar-08
  - Milestone

- **MEBT racks powered up and handed over** (TO DO)
  - Olle Lagerblad
  - To 2020-Apr-26
  - Milestone

- **DTL cooling system operational - milestone** (TO DO)
  - Joao Paulo Martins
  - To 2020-May-10
  - Milestone

- **DTL4 control system operational** (TO DO)
  - Thomas Fay
  - To 2020-May-27
  - Milestone

- **PS1 ready for operation - milestone to tick off when PS1** (TO DO)
  - Morten Rostrup For
e
  - To 2020-Jul-01
  - Milestone

- **DTL1 control system operational** (TO DO)
  - Thomas Fay
  - To 2020-Jul-08
  - Milestone

- **RF system for RFQ and DTL1 operational - This is a milestone** (TO DO)
  - Morten Rostrup For
e
  - To 2020-Jul-12
  - Milestone

- **MEBT RF system operational - This is a milestone for the PS1** (TO DO)
  - Morten Rostrup For
e
  - To 2020-Jul-12
  - Milestone

- **SSM licence released for cavity conditioning** (TO DO)
  - Thomas Fay
  - To 2020-Sep-13
  - Milestone

- **DTL3 control system operational** (TO DO)
  - Thomas Fay
  - To 2020-Nov-22
  - Milestone

- **RF system for DTL2 - DTL5 ready** (TO DO)
  - Morten Rostrup For
e
  - To 2020-Jan-03
  - Milestone

- **DTL2 control system operational** (TO DO)
  - Thomas Fay
  - To 2020-Jan-06
  - Milestone

- **DTL5 control system operational** (TO DO)
  - Thomas Fay
  - To 2020-Aug-17
  - Milestone

- **PS for DTL5 operation ready - a milestone like NCLIN-493** (TO DO)
  - Morten Rostrup For
e
  - To 2020-Oct-31
  - Milestone

- **MEBT cooling system operational - milestone** (TO DO)
  - Anton Lundmark
  - To 2020-May-10
  - Milestone

- **DTL4 Beam Stop Installation** (TO DO)
  - Thomas Shea
  - To 2020-May-30
  - Milestone

- **Temporary Shielding Installation** (TO DO)
  - Hakån Danared
  - To 2020-May-31
  - Milestone

- **Partial PSS 1 Validation by ICS (Iscr, LEBT, RFQ, DTL1)** (TO DO)
  - Stuart Birch
  - To 2020-Feb-14
  - Milestone

- **Safety Readiness Review (SRR2) - ISrc - DTL1** (TO DO)
  - Edgar Sargsyan
  - To 2019-Nov-01
  - Milestone

- **SRR preparation - Prepare according to ESS-0123901** (TO DO)
  - Edgar Sargsyan
  - To 2020-Jan-31
  - Milestone

- **Safety Readiness Review (SRR3) - Front End + DTL1,2,3,4** (TO DO)
  - Edgar Sargsyan
  - To 2020-Jun-20
  - Milestone

- **SRR preparation - Prepare according to ESS-0123901** (TO DO)
  - Edgar Sargsyan
  - To 2020-Jul-20
  - Milestone

- **ISrc - DTL1 Beam Commissioning** (TO DO)
  - Ryoichi Miyamoto
  - To 2020-Jan-06
  - Milestone

- **ISrc - DTL4 Beam Commissioning** (TO DO)
  - Ryoichi Miyamoto
  - To 2020-Mar-27
  - Milestone

- **DTL4 Beam Stop Removal** (TO DO)
  - Thomas Shea
  - To 2020-Jul-24
  - Milestone

- **Temporary Shielding Removal** (TO DO)
  - Hakån Danared
  - To 2020-Jul-24
  - Milestone
Requirements Engineering

• Quality: “Conformance to requirements”
• Good requirements engineering practices are a prerequisite to deliver systems that fulfil the Operations needs