Accelerator Beam Transfer group report March April May 2016

Brennan Goddard

Thanks to Malika Meddahi, Etienne Carlier, Jan Borburgh, Laurent Ducimetiere, Tony Fowler, Lucie Mainoli and all ABT group members for their input and slides
Staff changes in next 12 months

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Septa
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M. ATANASOV
B. BALHAN
C. BAUD
P. BLAISE
R. BONTHOND
M. HOURICAN
T. MASSON
B. PINGET
A. PROST

CPE LD
CPD LD
CPC LD

Plus 5 LDs expiring mid 2017: of which 4 are FLEX/PROJ posts!
TE-ABT Manpower

• Recent departures
  – Internal mobility: Jan UYTHOVEN (to MPE)
  – Resignation: Jose ABELLEIRA FERNANDEZ (Fellow)

• Recent new Arrivals
  – Vincenzo FORTE (ABT-BTP Fellow)
  – Kim ABDOUN-CARIME (ABT-EC VIA)
  – Luis FERNANDEZ FERNANDEZ (ABT-FPS Fellow)
  – Vasilis VLACHODIMITROPOULOS (ABT-FPS Fellow)
  – Alejandro SANZ ULL (ABT-SE Doctoral Student)

• Present open posts
  – TE-ABT-BTP-2016-LD (Accelerator Physicist) – replaces J. Uythoven
  – TE-ABT-EC-2016-LD (Technical Engineer (Electronics)) – MKD generator CONS
  – TE-ABT-FPS-2016-LD (Higher Technician Electromechanical) – core M&O
Still only 3/54 Female Staff (3/18 in cat II) (12/79 with Fellows, TTE etc.)
2015 Operation and YETS
LHC 25 ns downtime 2015: ~55 h ABT
PS Kickers: YETS

- Renovation of CT-RSG kicker generator - 3rd operational switch tank and spare on-going
- Improved safety in CT-zone (Displaced AUG, installed flashers)
Significant workload for Sephta section. Following elements exchanged:

- PE.SMHI6 (end of lifetime)
- PE.SEH31 (end of lifetime)
- PI.SMH42 (end of lifetime)
- ZS2 (unscheduled, failure of motorisation)
- ZS4 (planned, damaged during 2015 run)

New LEIR extraction coil prepared for installation prior to LEIR start (done)
**SEPTA: ZS**

**Mechanical failure of ZS anode support**

Aperture limit diagnosed by BE/OP (-15 mm)

• Localised with ABT and BI to ZS1/2 junction
• Decision to open vacuum made 8th April
• MP removed, inspection showed damaged ZS
• Exchange on 13th April (TS) – 18h extra for LHC
• ZS now being HV conditioned, between LHC
• Analysis of older tank(s) to make
• Kicker magnets reconfigured, short-circuit termination;
• One magnet removed;
• One magnet now with reduced length of serigraphy
  ⇒ expect reduced power deposition with 25ns beam

• Pulse generator and controls greatly simplified.
YETS – MKE4 Reconfiguration (LIU)

Ready for operation (beam extracted 18/3 to TT40 TED)

ECA4 Past Configuration

ECA4 Actual Configuration

GEN 1
- Removed

GEN 2
- In operation

GEN 3
- In spare

GEN 4
- Disconnected

GEN 5
- Disconnected

Finished...
Re-commissioned with beam OK. Factor 2 less heating on new MKE4 with improved serigraphy
CONSolidation
LHC-LBDS kickers CONS (and HL-LHC)

- Upgrade of GTO stack with reduced E-field: prototype assembly ongoing
- Upgrade of trigger transformer design to speed up GTO commutation: ready to be tested
- Modification of MKD side panels to reduce dust penetration inside sensitive: in preparation
- Modification of assembly and cleaning procedures: done
- Reinforcement of sparking surveillance: in preparation
CONS – Restart of AD Horn Test Bench

AD horn test bench
- Pulse generators
  - Replace ignitrons by solid-state switches and free-wheeling diode [Validation test done]
  - 6 cubicles to modify (capacitors, new safety equipment, new wiring) [10/2016]
- Infrastructure
  - Power cables routing under false floor [Done - 02/2016]
  - Preparing floor in B195 for installation [01/2017]
- Controls [12/2016]
  - New interlocks for solid-state switches [12/2016]
  - Modified trigger system [06/2016]
- Installation of test-bench in B195 [03/2017]
- Testing & debugging [04/2017]

Challenging...
New interlock required for protection of solid-state switches

Schematic of new AD horn circuit
(500 kA max current)
CONS – Capacitor Chargers

LHC Injection kicker

Mechanical view of the new power supplies

<table>
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<td>Delivery of the design report</td>
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<tr>
<td>Week 28</td>
<td>Delivery of pre-series power supply</td>
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<tr>
<td>Week 40</td>
<td>Delivery of series power supply</td>
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Ready for installation during EYETS16-17

ISOLDE / HIE-Isolde

Planning

Before July  
Technical specification and specification committee (depending of the MD results)

3 firms qualified for this IT after MS

21/3/2016  TE-ABT Group report

Ongoing...
LIU project
LIU PSB – New BI-DIS

- Full size prototype PFN, now in final housing
- Thermal performance tests starting soon.
LIU PS – 2GeV injection

• 105 ns rise time specification: KFA45 in permanent Short-Circuit configuration.

• Requires reduction of flat top ripple:
  • Feasibility study done.
  • Waveform measurements done during YETS to evaluate various improvements.
  • Analysis and detailed technical design ongoing
  • Aim at deployment in EYETS
PSB H- inj – Foil Exchange Mechanism

Foil changer

membrane potentiometer

Micro switches

On track
Septa LIU-PSB

On track for readiness deadline (equipment for end 2016).
- BISMV stacks assembled. Preparing electrical and hydraulic connections.
- 2 prototypes of PSB BSW injection bumpers assembled and being tested.
- Part procurement for PSB recombination septa ongoing.
Septa LIU-PS/SPS

Progress on items OK.
• PS injection septa design work ongoing. Preparing eddy current septum prototype.
• ZS upgrade: 1st (partly upgraded) tank installed during YETS.
• ZS interconnect design concept finished. Detailed design ongoing.
• TPSG6 concept frozen; detailed design to be started.
• TPSG4 concept being reviewed, planning to use additional spoiler (TPSC4).

On track...concerns about ZS CONS needed
LIU-PSB – BI.DIS Generator Control

Status

• Prototype BI.DIS10 controls completed
• 7 TECHNIX 10kV-1A power supplies delivered
• Improved IGBT protection and triggering
• Pulsed power system near completion (PFN & Magnet)
• Thermal studies & reliability runs to start shortly
• Fast interlock system (first tests planned for April 2016)
• Review of logical connection to BIS ongoing (1 channel Vs. 4 channels)

Planning:

• Generator switchover strategy finalised
• Final rack topology in BCER
• Engineering specification near completion
• DIC in preparation
• Series production will be launched in Q3-2016
LIU-PSB – BI.KSW Pulsed Generator

KSW 400A pulsed generator prototype
- Power circuit tested alone
- Control circuit tested alone
- Capacitor charger prototype tested alone (some optimization still needed)
- Testing of everything together started
- EMC optimisation ongoing

Controls
- Fast digital control signals tested
- Analogue signal tested
- PROFINET communication under test
- Setting management and calibration mechanism under study

Still to be made:
- 40A low current generator (Prototype under construction)
- Internal low-voltage power supplies
- Final versions of some circuit boards (a few things to be corrected or improved)

On track but challenging
Ready for production in Q3-2016

21/3/2016
LIU-SPS – SBDS Reliability Analysis

- Full RAMS analysis of actual system completed
- Weakest sub-systems identified
- Study of possible configuration for new system after relocation in LSS5 ongoing

FMEA: Risk Priorities

- Fault Tree Analysis: results for test time 2007-2015

Risk Priority Number

- On track...
  - Study done in close collaboration with TE-MPE
LIU-SPS – Triggering System for MKDV 2Ω PFN

Power Trigger Module (PTM)
- Manufactured and under verification
- Performance in pulsed current generation confirmed
- Modifications being carried out prior to design review

Next steps
- Reduction of parallel IGBTs using SPS reliability data
- Evaluation of max operating voltage regarding R2E
- Design of Power Trigger Controller card.

One GTO triggering performance test bench
SPS-MKP R&D for beam screening

- Important for SPS longitudinal impedance and instabilities (need x2)
- Evaluation of a serigraphed inlay
- Serigraphy gives reduced power loss by ~70% for an MKP-L
- No solution yet compatible with aperture, vacuum, rise-time and HV

Measurement: no serigraphy
Measurement: serigraphed inlay
Prediction: serigraphed inlay

Still in R&D phase
ELENA project
AD kicker Platform displacement

- System fully operational in new B. 393
- AD commissioning on time
- HV switches fully refurbished
- ELENA generators ready

21/3/2016
TE-ABT Group report
Installed ABT Equipment:
• Septum
• Ion-switch + electrostatic quadrupole in LNS line
• 2 extraction kickers

Status of ABT equipment production:
• Electrostatic quadrupoles (ZQNA): Production completed (64 units)
• Fast deflectors (ZDFA): Vacuum chambers completed (7 units)
• Static deflectors (ZDS): Production started (10 units, Phase-2 installation)

Installation baseline:
• Jan 2015 – June 2016: Infrastructure, H-source line, AD injection line, Main ring, Extraction line
• July 2016 – Dec 2016: Hardware and beam commissioning
• Sep 2016: Decision on transfer line installation
• Dec 2016 – Oct 2017 or LS2: Transfer lines to experiments

Commissioning of LNS line with 100 keV H- beam on 11.03.2016

All elements operate at nominal parameters with excellent stability.
100 keV H- beam extracted from source; beam bent to ELENA injection line by the ion-switch; beam focused with quadrupole Doublet; beam steered by H/V correctors
ELENA injection kicker

- Last bake-out before tests
- Assembly in clean room
ELENA - Fast Deflectors

- High voltage generator prototype tested on fast deflector
  Rising/falling edges within 1us to 0.2% at flattop.
- TE-ABT have taken the responsibility of all the EISb on fast deflectors (instead of static bends due to TE-EPC power converter design issue).
  EIS interface card validated, still to test with GS-ASE-AC.
- Developed a high bandwidth HV fast pickup
  Wil also use for BI.DIS design and CLIC inductive ladder
  To put on Open Hardware repository for others.
- Two extraction fast deflectors tanks installed in ELENA ring
- PXI controller to be validated and tested.
- On-site installation of the control of two extraction FD and commissioning foreseen for end June.

On time... but challenging (dependencies)

Positive/negative pulses @ 6.5kV
<1u rising/falling edges
ELENA ring with ABT equipment

1st series of quadrupoles successfully tested in lab (electrical + vacuum).
AWAKE project
• Installation of proton beam line almost completed (some diagnostics missing, to be installed end of April together with related vacuum survey)

• Plasma cell in tunnel, last components (ends for continuous flow of Rb and irises) installed end June.

• HW commissioning of p+ line scheduled for May-June 2016. At present no delay!

• Proton beam commissioning will start after completion of plasma cell installation: July 2016.

• e-beam line: components being ordered, on track for installation in 2017.
HL-LHC project
HL-LHC WP 14 activities – Injection and LBDS

- **TDIS**: Design (STI) completed by Q3 2016. LS2 installation
- **MKI**: numerous improvements being studied, if needed
- **TCDS**: Advance from LS3? One additional tank: ongoing studies
- **TCDQ** *(not in baseline)*: Ongoing studies
  - Mechanical issue if opens during $\beta$ squeeze (ATS optics)
  - BETS upgrade to allow movement in squeeze ($\beta^*$ interlock).
- **TDE** *(not in baseline)*: Ongoing studies (new TDE material or additional dilution MKBs)
- **MKD**: Power trigger consolidation (LS2), Re-trigger and controls consolidation (presently LS3)

On track but still lots of decisions needed about scope
FCC study
**FCC studies**

**TL from a superconducting SPS (1.5 TeV) to FCC**

**TL from LHC P8 to FCC with 8 T dipoles**

**FCC insertion with two extractions mirrored in 4 km**

**FCC dilution concept: using overfocussing from SC quadrupole to reduce horizontal kick strength and vertical aperture**
FCC injection & dump studies

HEB extraction and FCC injection:
- Fellow on inductive adder for FCC injection kicker generator
- Basic design choices evaluated
- Selection and tests of components started

FCC dump extraction:
- Segmentation of dump system studied
  - Very beneficial in terms of requirements for switches and magnets
  - Would allow for one kicker erratically firing (if 1 sigma oscillation acceptable)
FCC septa related activities

- PhD student on Septa related activities started February 2016.
- Septa topology inventory in progress.
- Collaboration with Wigner institute (H) just signed.
- 2 T Lambertson topology being studied first
- Exciting new concepts for SC septa (flux shield)
Other activities
Inductive Adder for CLIC

- New mechanical and electrical design of prototype, 20-layer, 12.5 kV, 250 A, 0.05% stability inductive adder
- Core materials evaluated - Finemet FT-3L cores procured
- New PCB design and layout allowing for significantly higher current
- High synergy with CONS/OP and FCC
New 60 kV ISOLDE Target Modulator

60 kV modulator HT pulsing specifications
• Recovery times to +/-1V with a 1ms recovery time.
• Maximum voltage overshoot < 0.2%
• Tested successfully with neutron converter target in ISOLDE

Test in a simulated environment

New modulator 30kV recovery signal measured with simulated target
Laser triggering of semiconductor switches

- Studies and lab tests on high power laser triggering of semiconductor switch arrays

Electronics case studies

- Need collaboration with universities for “non-COTS” electronics projects
- Example: very low impedance measurement in pulsed environment (AD Horn pulser)

Machine learning (Artificial Intelligence)

- Aim to develop SW agent to monitor logging data to find non-linear cause-effect relations, and detect anomalies that indicate degraded equipment.
- Possible collaboration with KUL (University of Leuven) is being investigated
Topical concerns
• **SPS activation: YETS showed that ZS upgrade will be a challenge:**
  • Time consuming & high dose (Σ 6 mSv) - remote handling useful, but slow
  • Efforts needed from EN/HE and OP/ABT to improve situation.

• **Storage of radioactive equipment:**
  • in blg 955: insufficient space available to properly store the MS
  • In blg 151: will be too small after LS2
  • Not easy to store temporarily radioactive equipment during winter stops

• **ABT resources for R&D:**
  • Only a few threads are active
  • Still too limited with M&O, PROJ and CONS commitments
  • Still have policy of ‘everyone does a bit of everything’. To review?

• **Still need decision on CT vs MTE:**
  • Otherwise de facto we will keep all equipment running...extra cost/manpower

• **End of lifetime for some ‘mature’ equipment types?**
  • Recent ZS failures, LEIR extraction septum failures, PS extraction septum failures
  • Big impact on project work for small septum team
  • Wider concerns about need for more extensive CONS – to evaluate