TEMN – 31 March 2014

B. Goddard

on behalf of the ABT group

Outline:
The ABT group and its demographics
Highlights from LS1 work and projects
A few non-technical concerns (will not cover staffing or budget)

Previous report on 8th April 2013, https://edms.cern.ch/file/1279588

*#1 in the new “AV” calendar

All contributors are gratefully acknowledged – apologies for missing names
The **Accelerator Beam Transfer** group conceives, studies, designs and commissions **injection and extraction processes and systems** in the accelerator complex, beam transfer lines between accelerators up to primary targets and beam dump systems, including studies for future projects. The group is in charge of the **conception, design, development, construction, installation, exploitation and maintenance** of the injection and extraction related equipment:

- pulsed magnets with associated high voltage pulse generators and transmission lines;
- electrostatic and magnetic septa, including high voltage power supplies for electrostatic septa;
- electrostatic lenses and deflectors for low-energy beam transfer lines;
- protection devices
- associated equipment-level control systems and software.
54 staff members (still +2/-3 in 2014)
6 FELL, 1 TTE
1 VIA, 1 Ph.D.
3 COAS, 3 TECH
1 Admin assistant staff at 50% +1 temp
at 50% until ~05/14

Supported by FSU TE-05 and TE-08
Pictures: worth a thousand words?
Demographics

Professional class

- LD: 26%
- IC: 74%
- III: 61%
- IV: 6%

LD / IC

Age

- II: 33%
- III: 61%
- IV: 6%

Professional class

Demographics

Rather poor in terms of gender balance (2/54 staff, 6/71 total Female)

C. Cazenoves
LS1 highlights
LHC
MKI x 8, major upgrade
MKBV completion of system with last 4 magnets
TCDQ major upgrade from 2 x 3 m graphite absorbers to 3 x 3 m CfC
MKD/B x 22 + 20, complete overhaul of pulse generators (reliability, for 7 TeV)
MKD x 30, overhaul of magnet entry boxes (reliability)
MKQA x 2, improvement of AC dipole controls and electrical distribution
Controls for Inj. and LBDS, major improvements (safety (e.g. TSU layout/powering), reliability, diagnostics, follow BE-CO triggered HW/SW changes)

SPS
MKE, 1 magnet exchange (beam impedance reduction)
MKP x 4, MKDH x 2, MKDV x 2, remove/reinstall (ease exchange of irradiated cables)
MKP x 1, exchange (faster rise time, better diagnostics, beam impedance reduction)
MKP, replacement of irradiated HV cables
MKDV2, remove/repair/re-install (restore HV performance, beam impedance reduction)
MKDV charging power supplies, replace (reliability) and new controls
MKQH x 1, MKQV x 1, remove/work/re-install (beam impedance reduction)
MST/MSE x 11 (LSS2, 4, 6), exchange (end of useful life)
ZS x 2, exchange (anti-e-cloud measures, beam impedance reduction)
TPST LSS2, upgrade (mechanically more robust and better to align)
Irradiated cables in LSS1 (major follow-up and test/validation effort)
Controls for all systems, major improvements (reliability, diagnostics, BE-CO changes)
Huge planned program (ii)

**PS**
SMH16, exchange (not enough lifetime for Run 2)
SMH57, exchange (end of life)
SEH23, exchange (performance, reliability (replace oil in HV feedthrough by 3M liquid))
MTE/CT, renovate RSG switches (reliability), replace mineral oil by Ester oil (safety), controls: eradication of CAMAC, integration into InCA
TPS15, install (“dummy septum”, to support MTE operation)
Septa long HV cables x 4, replacement (retrieve broken, install new spare cables)

**PSB**
BE.SMH, remove/upgrade/re-install (reliability, compatible with 2 GeV)
BI.SMH, repair or exchange (small vacuum leak under He, would soon expect failure)
Kickers hydraulic group, replace (oil viscosity, reliability, diagnostics/handling)

**AD**
SMH5305-07, exchange (cooling circuit leaky and switched off)
KFI55/56, remove/upgrade/re-install (re-weld tanks to overcome vacuum prbs.)

**LEIR**

**ISOLDE**

**CTF3**

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**Plus:**
- inspections and basic maintenance of all systems
- subsequent repair of removed equipment, reconstitution of new spares
- resource-intensive HV conditioning and controls restart (parallel activities)
Increased workload due to unforeseen events:

- AD horn stripline failure
- MKD erratic triggering investigations
- ZS accidental venting, recovery and reconditioning
- MSE accidental venting, recovery
- MKB aluminium foil contamination
- SMH16 instrumentation
- Vacuum leaks on various elements
- Unplanned activities by other groups

Part and parcel of normal shutdown, but we need to be able to cope with this in our resource levels, especially with simultaneous project work
Major upgrade: LHC MKI kickers

All removed, being refurbished and replaced, with 4 new spares
Major upgrade: LHC MKI kickers

Scope:

- Inspect all magnets for traces of breakdowns, and repair as necessary (not required for many):
  - cause of excessive heating of old MKI8D fully understood (15 twisted screen wires).
- Streamline all kickers to identical hardware configuration (screening wires, relocated thermocouples, RF fingers, damping resistors, …).
- Equip all kickers with 2nd bypass tube, and vacuum valves on these as well.
- NEG coating of both Cu bypass tubes (can be used at either P2 or P8).
- Use new ceramic tubes with 24 screening wires.
- New step-out metal cylinder at the capacitively coupled end (modify metallisation).
- Even more thorough cleaning, to reduce number of dust particles.
- MKI interconnects: ion pump upgraded to include a NEG cartridge.
- NEG coating of all MKI interconnects and adjacent BTVSI and BPTX.
- Tried to increase emissivity of tanks by ion bombardment – unsuccessful so far.
- Potentially fit one (spare) MKI with (aC or Cr$_2$O$_3$) coated ceramic tube – discussions ongoing with industry.

Expected results:

- Less ferrite heating (reduced by factor 6 c.f. old MKI8D (for 1.6e11 ppb, 50 ns))
- Greater HV margin against breakdowns (40% reduction in E-field)
- Less e-cloud
- Fewer UFOs (MKI8D replaced in TS3/2012 showed factor 5 less)

Tight planning – resource intensive work and test period:

- 4 tanks installed to date (positions A & D at both Pt 2 & Pt 8 to allow closing of vacuum sectors).
- Last installation planned for Aug. 2014. 4 spares subsequently to be upgraded. On track.

Wim Weterings and team
LHC TSU upgrade to V3

**Improvements**

- No common mode coupling any more between redundant TSU
- New design compatible for operation either in LHC or in SPS
- Improved diagnostic functionalities
- New deployment to reduce dependability
- More robust design against EMC
- Hardware fully tested successfully
- Ongoing production of all boards
- Firmware needs to be tested with test bench

**Status:** Design finished. Hardware production ongoing.

**New TSU consists in 4 modules**

- **Main**: Basic Functionalities & Clients’ inputs
- **Mezzanine**: IPOC signals & TSU to TSU communication
- **Interface**: Ext trigger & OASIS signals
- **Backplane**: Transmission of signals from interface through VME to Main
New LHC TSU Test Bench

- Test Bench to validate hardware and software functionalities of the TSU before operational deployment in the LHC
- Automated system running predefined set of sequences of tests for normal and abnormal operational conditions

- The Test Bench is based on a PXI crate consisting of an embedded controller and several Arbitrary Waveform Generators running LabVIEW Real-Time
- Analyses all possible failure cases and records rules violations

Status: Test Bench is in its final development stage

Application V-Cycle approach to TSU project

Sundeep Kang
Upgrade of the 30 IPOC systems for the surveillance of the internal currents of the LBDS MKD HV generators and power trigger output currents

Production of electronic boards:
- 35x ‘Signal Level Adapter v2’:
  -> Upgrade for acquisition of 10 signals
- 35x ‘Trigger and IPOC Watchdog Interface’
  -> Interlock of MKD Generator if IPOC not OK

**Status:** DONE, production in test.

Addition of 3 digitisers (10 channels) per MKD Generator:
=> 10 signals acquired per generator

**Status:** All digitiser cards received.

2 Prototypes tested in Hall 867 (JU3 and JU4).

*Installation in UA63 and UA67: Week 15-2014*

Nicolas Magnin
LHC and SPS extraction protection

• LHC: TCDQ (beam 1 and beam 2) major upgrade, installing 3 new tanks of 3 m CfC and graphite for each beam
• SPS: MST/MSE exchanged 11 magnets (LSS2, 6), (end of useful life).
• SPS: TPST LSS2 new upgraded version installed (mechanically more robust, better to align).

Jan Borburgh, Bruno Balhan, Wim Weterings, Bernard Pinget, Miro Antanasov and teams
New SPS BETS for Beam Dump

- BETS LBDS hardware adapted to SBDS
  - Much faster machine cycles
  - No rearm needed, except for internal faults or tracking error
- HVPS reference signals through new BER card
  - One adjustable 0-10V output pro HVPS (3 for MKDV, 3 for MKDH)
  - PLCs would be too slow to generate references
  - FRAM stored transfer function with corruption detection
  - USB interface to modify transfer functions (on-site)
- New B Train Dump Interlock card
  - Generates an emergency dump request when the field in the main bending magnets decreases.

**Status:** Hardware & software ready for installation
SPS kicker impedance reduction

• Final serigraphed MKE kicker installed in LSS4
  – All 8 magnets now treated – program complete (took 12 years!)
  – MKE heating should no longer limit any LHC beams, including high-duty cycle scrubbing

Mike Barnes and team
PS septa

- PS: SMH16 (leak), SMH57 (lifetime) and SEH23 (upgrade oil to 3M) all exchanged, TPS15 installed (dummy septum) for MTE, long HV cables between blg. 359 and ring replaced.
- PSB: BI.SMH exchanged (leak), and repair preparation (de-contamination) started or removed unit.
- AD: SMH5305-07, replaced by spare, repair now ongoing in b867.
In order to establish a radial movement 2 induction motors control the blade. These motors operate independently so an angular position can be requested. The motors can be controlled with a 0.1 mm precision through a local HMI or a CCC knob. Position measurement is done with redundant linear potentiometers.

Installation in the PS

Local HMI and master PLC (Siemens S7-317F)

CCC remote control

Status: Hardware & software commissioning finished
- Electrical power distribution with protection and lockout point by equipment
- CAMAC replacement: Slow control based on PLC on PROFINET with new decentralized I/O station – ET200SP
- Interface and interlock system using the old electronics
- New thyatron heater power supplies with full monitoring
- New capacitor chargers for staircase kickers

**Status:** Hardware & software commissioning started

Christophe Boucly
• Eradication of last CAMAC hardware
• New timing fully implemented within generic TE-ABT Kicker Timing Software (KiTS) already used within SPS and LHC
  – BFA9 & 21 pedestal
  – BFA9 & 21 staircase
  – DFA242
  – DFA254 staircase
• Based on 1ns fine delay modules developed in the frame of CERN Open Hardware initiative
• Successfully integrated within FESA3
  – ELMA + MEN-A20
  – Linux SLC5-32bit
• Timing interlocking logic embedded within external PMC FPGA
• Integration within CCC generic knobs ongoing

**Status:** Hardware & software commissioning started
AD injection kickers KFI55 & 56

KFI 56 had a vacuum leak, → reparation + consolidation of KFI 55
Huge amount of preparation and work, coordination between several groups, FPS, Vacuum, RP, Transport and Main Workshop - works successfully completed early 2014

KFI 56 magnet modules, outside tank.

HV contacts

KFI 56 removal and re-installation

Reinforcement of welds on AD tanks, the weld diameter has doubled.

Luc Sermeus and team
Embedded functionalities integrated within PXI controller:

- Interlocking,
- Equipment state control,
- Thyratron drift stabilisation and protection,
- Short circuit detection in magnets and transmission lines,
- Pulsed signal acquisition, and
- Fine timing.

**Status:** Hardware commissioning ongoing
LIU and HL-LHC
LIU septa (PS, PSB and SPS)

BI.SMV: parts manufacturing ongoing

BI.BSW: magnetic field simulations being finalised
mechanical magnet design progressing well
first tests to braze coil prototype done

ZS: impedance measurements done
2 ZS tanks modified (extrusions for ion pumps)

Jan Borburgh, Bruno Balhan, Mike Hourican
Linac4 Pre-Chopper is a pulse electrostatic deflection system located in the Linac4 LEBT. It deflects the beam away from the RFQ input aperture by applying -20kV between plates (dump).

Pre-Chopper driver main functions:
- HV pulsed power supply control
- Timing pulses acquisitions & verifications
- BEHLKE HV switch triggering
- Pulsed signals acquisitions & analysis
- Interlocking logic
- Interface with machine protection (BIS)

Status: Operational

-20kV +/- 1% applied to load
LIU-PSB: New BI.DIS

- Integration within BCER started
- Power supply purchasing ongoing
  - DR in preparation
  - Technical specification
- IGBT’s driver card performance studies
- Design general controls based on PLC ongoing
  - Safety
  - Power distribution
- Design of fast controls based on PXI approach started
  - IGBT drift stabilization
  - IGBT protection
- Bi-polar considerations if p+ will be used.
- PFN studies, optimization of cells, performance, kicker rise time ongoing

**Status:** Development ongoing. Challenging!
• Conceptual design completed and issues with $H^0/H^-$ Dump have been solved.
• Inconel chambers for BI.BSW is now the baseline and BSW design in final stage.
• Dedicated vacuum sector valves to be installed and BSW1 convertors inside tunnel.
LIU-PSB H- injection

- Beam dynamic studies (ORBIT): define optimum way of painting injected particles uniformly in transverse space (4 kickers current modulation)
- Simulation results ➞ input for HW design specification

Kicker waveform as from simulations
LIU-PSB Stripping foil unit

- First stripping foil unit being built: blanc assembly of complete zone planned in 2016.
- Permanent stripping foil test stand will be installed in L4 in 2015 and a Half Sector Test is planned in 2016. Integration of BTV also completed.

Wim Weterings, Remy Noulibos
LIU-PSB KSW kicker magnets

BI.KSW magnets and structure manufactured and assembled
BI.KSW ceramic chambers under construction - issues with outsourced titanium coating
BI.KSW generators conceptual design of generator high current version concluded
Stage 1 and 3 under test with real magnet

BI.KSW half magnets + new ceramic chamber

BI.KSW generator

BI.KSW possible waveforms

Louis Feliciano, Gregor Grawer
Prototype built and tested in 2013

Next Steps

- Build stage 4 with power amplifier.
- Modify stage 2 for higher output voltage (2kV).
- Modify stage 3 for generation of waveforms as defined in December 2013.
- Build capacitor chargers.
- Build control circuit.
- Build new prototype for high current.
- Build prototype for low current.
- Define higher level control system.
- Define algorithm for automatic calibration of generators.

Status: Development ongoing. Challenging!
LIU-PS: 2 GeV injection line upgrade

- Optics of BTP transfer line fixed
- Injection scheme and system specifications defined
- BE.SMH @ 2 GeV design of upgraded electrical connection started.
- KFA10 spare kickers checking for 2 GeV compatibility (saturation, vacuum).
- MS being launched for 80 kV SF$_6$ filled cable (difficult to find suppliers)
LIU-SPS: technical reviews

- Reviews carried on throughout 2013 – last one less than a week ago on TCDI
- Project baseline now almost fully decided
  - Major remaining questions: aC coating or scrubbing? New external dump?
LIU-SPS: new beam dump studies

- Two options identified for external dump location, for high energy planned dumps

- 7 C-shaped bends (MBS) to branch off from TI8
- 1 QNL
- 5 H-bends
- 3 m thick shield

Malika Meddahi, Jose Abelleira, Francesco Velotti
Recommendation of LIU-SPS ion injection review to upgrade the MKP-system by adding a 100ns PFL generator.

- Simulation shows that PFL will allow for 100ns rise time (2-98%), 2% ripple (undershoot to be optimized).
- Flat top ~300ns (current request is for 2 bunches separated by 100ns).
- Fall time not critical as gap for extraction is bigger.

**Next steps:**
- Functional Specification
- Simplified test stand (MKP+PFL) to verify rise time performance
- Design of switch (between PFL and PFN)

Thomas Kramer, Jan Uythoven
**HL-LHC**

- **WP14**: Beam transfer and kickers
- **LS2** concentrate on injection system
  - **TDI**: New absorber materials and separation of absorbers in several tanks.
  - Possibly replace other injection absorbers (TCLIs)
  - **MKI**, Ongoing R&D for new ferrites and coated ceramic tube for low SEY.
- **LS3** accent will be on beam dump system
  - Simulations are about to start. **TCDS** likely to be exchanged.
  - Dilution system **MKB** upgrade may be needed

**Stresses in TDI**

**Energy density in hBN TDI**

Jan Uythoven
Projects - MedAustron
• Scope for ABT:
  – Electrostatic septa,
  – Magnetic septa,
  – Fast kicker magnets,
  – Injection kicker,
  – Dump kicker,
  – Chopper kickers,
  – Tune kickers

• All elements have been manufactured (at CERN and in industry) and tested. Various stages of installation/commissioning.

• CERN contribution successfully delivered, responsibility handed over to MA team upon relocation to Austria in August 2013

• Installation and commissioning being done by MA (still some CERN help).

Thomas Kramer, Jan Borburgh, Tony Fowler, Roger Barlow, Mike Hourican
MedAustron

Chopper and dump kickers prior to installation

Magnetic septa being measured in 867

Electrostatic septa in MedAustron

Magnetic septa in MedAustron

Thomas Kramer, Jan Borburgh, Tony Fowler, Roger Barlow, Mike Hourican
MedAustron – first beam!

• 1\textsuperscript{st} test with beam injected in synchrotron 24 March
• At least the injection septa work...

Screen shows 1\textsuperscript{st} beam injected (apparently)!
Other projects
CONSOLIDATION
ELENA
AWAKE
HL-LHC
HIE-ISOLDE
LAGUNA
CLIC
FCC
SHIP
300 kV EPR insulated cable manufactured on demand and successfully tested

SPS MS yoke construction, in house (after unsuccessful MS)
laminations punched
laminations insulated
Yoke press designed and built

Jan Borburgh and team
ELENA move kicker platform to B393

Status: On Critical Path

New Layout (Bat. 393)

New Building 393

- Renewal of Dump-switches starts April 2014
- Preparations for kicker displacement underway
- Kicker removal ~12/2014-01/2015
- Re-commissioning 04-05/2015

B393 also to house AD horn test bench (saved from demolished B174), after LS1 (test zone in B195 still needed for temporary tests).
Elena electrostatic beamlines

- Optics fixed, Component design finishing – procurement process starting. Becoming tight for June 2015

Wolfgang Bartmann, Dani Barna, Jan Uythoven, Ranko Ostojic
Proton beam

Minor modification of the existing p+ beam line (last ~80m) and re-use of existing components (magnets, diagnostics, power supplies, etc.)

Electron beam

- Strict geometric constraints
- Optics flexibility
- Preservation of beam quality as at the RF source
HIE-ISOLDE

- Beamline: optics and design finished, specifications done and component procurement launched. Remaining followup now fully handed over to core team.

- ABT involvement essentially limited to new target modulator, plus some occasional input on beamline

Stray field 5 Gauss, 0.3 MeV/u, X-stray field
- Conceptual design report required for Summer 2014
- ABT contributions cover extraction from SPS, new TLs to LAGUNA target, HP-PS beam transfer (TLs, 4 GeV H- injection, extraction)

400 GeV non-local extraction from SPS

Extraction from 75 GeV HP-PS

4 GeV H- injection to HP-PS

Wolfgang Bartmann, Francesco Velotti
Blue: dipole magnet
Orange: quadrupole

Purple: $4\sqrt{\varepsilon_x \beta_x}$
Pink: $4 \left( \sqrt{\varepsilon_x \beta_x + \eta \frac{\Delta p}{p}} \right)$

CLIC machine protection studies

R&D on prototype „inductive adder“, for damping rings (requiring extremely flat pulses to limit emittance blow-up).

Diode, charge, trigger and switch PCBs

5 layer prototype:

CLIC

J. Holma, Ph.D. student → COFUND fellow

Mike Barnes, Jani Holma, Rob Apsimon
• ABT scope includes beam transfer (50 TeV dump design…) and hadron injectors coordination

• First considerations starting to trickle out

Filling factor as function of kicker risetime

Reusing LHC as HEB – new IR5 optics

Wolfgang Bartmann
SHIP (aka HNL/SNOOPY)

- WG report required for early summer 2014…in progress
- Contribution to cover extraction from SPS, TT20 modifications, switching and new TL, dilution system

TL optics with large beta at W target

New MSSB

New laminated splitter/switch?

Need new MSSB magnets with Laminated yoke, and larger (symmetric) high-field region
General comments

• Restart of accelerators over holiday period is a concern – expert availability likely to be compromised (not just for ABT)

• Very close follow-up still needed of impact of parallel activities across accelerators during startup (time for power testing, controls restart).
  – Readiness of controls framework OK (but resources for FESA3 migration underestimated)
  – Clearly there were issues with planning of access system EIS tests

• Guidelines to setup collaboration with university welcome (alternative to Fellows)
  – Should be possible for development of software and hardware modules

• Still missing staff in some sections
  – Not a problem of competences (all required technical competences are well covered)
  – Due to high number of projects (with increasing complexity) to be executed concurrently
  – Need somehow to also free resources for key R&D topics (and not just for FCC)

• Space, becoming a serious issue – need to get 867bis (or other solution) moving
Conclusions and perspective

- Colossal LS1 upgrade and maintenance programme in full swing
  - Coming rapidly to end for injectors, beams back soon!
  - Still a lot remaining for LHC, with very heavy testing and reliability runs

- Work on approved projects continues
  - 2013 saw some increases and some decreases in expected scope of HW to be built
  - LIU added 100 ns ion injection kicker system, supressed new MKE extraction kickers
  - AWAKE and ELENA (soon) moving to procurement phase
  - HIE-ISOLDE involvement reduced (naturally)

- Studies and pre-studies continue at a similar or even higher level c.f. 4/13
  - SHIP starting up, LAGUNA winding up, requests from CENF have stopped

- Some pre-studies have rapidly moved to studies
  - In particular FCC (with an enormous possible scope and probably endless appetite for resources)

- An ever-widening range of activity (and of equipment to maintain)...

Interesting times, indeed!