How to keep the SPS running for another 25 years

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General remarks :

- lots of information collected
- Review system by system, many slides, some with much detail as known….
  - Vacuum, RF, Magnets, Kickers & septa, Beam Instrumentation, Interlocks, Cooling & Ventilation, Electricity, Power Convertors, Cabling, Handling, Dumps, RP, Tunnel Infrastructure etc….

Vacuum

- A report is in preparation for the injector chain
- First “estimate”
  - Operation to 2022 replace 50-70% of system hardware
  - Operation to 2035 replace 100%
- SPS
  - Spares (windows in target areas?)
  - TIDVG upgrade
  - MKE?
- Any major consolidation campaign (ABT, MSC, RF etc…) would involve a lot of vacuum activity

Vacuum (M. Jimenez)

	Proton Chain									Ion chain	
	LINAC2	PSB		PS		TT2		SPS	TI2/TI8	LINAC3	LEIR
Reference dates	2016	2022	2035	2022	2035	2022	2035	2035	2035	2035	2035
Vacuum Instrumentation											
High pressure gauges (Pirani)	C (30%)	C (70%)	R	C (70%)	R	C (70%)	R	R	R	R	R
Low pressure gauges (Penning)	C (30%)	C (70%)	R	C (70%)	R	C (70%)	R	R	R	R	R
UHV pressure gauges (Bayard-Alpert)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	C (70%)
Pressiostats	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	R	R	N.A.	N.A.
Residual Gas Analyser	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	R
Vacuum Pumps											
Turbomolecular pumps (fixed)	C (30%)	R	R	R	R	R	R	R	N.A.	R	N.A.
Oil-sealed primary pumps	N.A.	R	R	R	R	R	R	R	N.A.	R	N.A.
Dry primary pumps	C (30%)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
NEG cartridges	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	R
Ion pumps	R (5)	C (70%)	R	C (70%)	R	C (70%)	R	R	R	R	R
Sublimation pumps	N.A.	R	R	R	R	R	R	N.A.	N.A.	N.A.	R
NEG coated vacuum chambers	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	R (20%)
Vacuum Valves											
Sector Valves	C (30%)	C (70%)	R	C (70%)	R	C (70%)	R	R	R	R	R
Roughing Valves	C (30%)	C (70%)	R	C (70%)	R	C (70%)	R	R	R	R	R
Fast-closing Valves	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	R	N.A.	N.A.	N.A.
Vacuum Controls and Power Supplies											
Vacuum Controls	N.A.	C (70%)	R	C (70%)	R	C (70%)	R	R	R	R	R
Power Supplies	N.A.	R(VPS)	R(VPS)	R(VPS)	R(VPS)	N.A.	C	R	R	R	R
Miscellaneous											
Turbomolecular pumps (mobile)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	R (16)	N.A.	N.A.	N.A.
Leak detectors	N.A.	N.A.	N.A.	R (10 u)	R (10 u)	R (10 u)	R (10 u)	R (5)	N.A.	N.A.	N.A.
Venting systems	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	R (5)	N.A.	N.A.	N.A.

2010 -> 2016 = 6y	scaling C = 25% -> 30% (not linear with time)
2010 -> 2022 = 12y	scaling C = 50% -> 70% (not linear with time)
2010 -> 2035 = 25 y	R = 100%

RF (Erk Jensen)

- In addition to the usual annual maintenance activities, the following items will require a consolidation for the next 20/25 years, considering we keep the present RF configuration:
- - spare couplers TWC200;
- - spare couplers TWC800;
- - spare tetrodes (budget ~ 1 MCHF/year);
- - Siemens and Philips amplifiers: replacement of RS2004 and YL1530 tetrodes by new diacrodes; replacement of RS2004 drivers by RS2058 drivers (major projects).

- **This does not include the major upgrades needed to increase intensity**

Magnets (EDMS no: 1057909)

- The magnets replacement programme (replacing 10-12 weakest magnets every year) must continue
  - 2 year LHC runs??
- Maintain a vigorous maintenance plan
  - Dielectric tests, endoscopic inspections, inter-turn testing, water hoses, maintain a healthy stock of spare coils and magnets
- Specific concerns
  - Water erosion, inter-turn shorts & fatigue of pole shim bolts
  - Study of water erosion problems
  - Good supply of spare coils
  - Replace pole shim bolts as part of the maintenance plan

Beam transfer systems (Full table)

- Replace septa HV generators, diluter
- LSS4&6 new fast pulsed magnets
- Spare MKDV/H magnets
- Replace timing systems
- Buy Thyratrons for 25 years of operation (single supplier)

- Some of this is included in present Consolidation programs

- General remarks
  - for the septa equipment; consolidate the TPST (protection shield for thin septum magnets in LSS2) which turns out to be insufficiently rigid.
  - For the kickers, the usual maintenance activities, combined with the consolidation project already integrated in the White Book, will allow a normal operation for the next 20/25 years.
  - cable replacement campaigns : most probably in LSS1 (2010/2011 shutdown) and LSS2; possibly in LSS4 and LSS6 as well, but it is still hard to see what the radiation damage will be once the LHC is in full operation.

BT (1)

SPS	MST LSS2	Septum	Magnet	SE		
			Motorisation	SE	Initiate potentiometer replacement program	
			Electronics & Controls	EC		
SPS	MSE LSS2	Septum	Magnet	SE		
			Motorisation	SE	Initiate potentiometer replacement program	
			Electronics & Controls	EC		
SPS	ZS LSS2	Septum	Deflector	SE		
			Motorisation	SE	Consolidate motorisation	
			Generator	EC	Replace 25 years old HV generator	Consolidation program required
			Electronics & Controls	EC	Implement earth-plane in LSS2	LSS2 ion trap earthing circuit to be reviewed (next LSS2 re-cabling campaign)
			3M station hardware	SE		
SPS	TPSN	Diluter	Diluter	SE	Redesign and rebuild diluter	Mechanically very unstable
			Electronics & Controls	EC		
SPS	TPSG4	Diluter	Diluter	SE	Build additional spare	
			Electronics & Controls	EC		
SPS	TPSG6	Diluter	Diluter	SE	Build additional spare	
			Electronics & Controls	EC		
SPS	MP	Septum	Pumping Module	SE	Build additional spare(s)	Only 3 spares for > 20 installed
SPS	MST LSS4 and LSS6	Septum	Magnet	SE	Design & build a fast pulsed magnet extraction	Will significantly reduce power consumption and cooling requirements
			Motorisation	SE	Initiate potentiometer replacement program	
			Electronics & Controls	EC		
SPS	MSE LSS4 and LSS6	Septum	Magnet	SE	Design & build a fast pulsed magnet extraction	Will significantly reduce power consumption and cooling requirements
			Motorisation	SE	Initiate potentiometer replacement program	
			Electronics & Controls	EC		
SPS	MKP	Kicker	Magnets	FPS	Rotate spares and refurbish magnets	+ Reduction of system impedance to increase the reliability ?
			Entrance box & TMR	FPS	Refurbish and recable TMRs	
			Transmission lines	FPS	Change HV cables every 10-15 years	
			PFNs & HV switches	FPS		Thyratron upgrade starting in 2010 from approved consolidation
			RCPS	FPS	Build new safety switch, change capa bank	
			Electronics & Controls	EC	Consolidate timing system (G64 eradication), Pulse-to-pulse regulation, IPOC, Fast Interlock	

BT (3)

SPS	MKDV	Kicker	Magnets	FPS	Rotate spares and refurbish magnets	
			Entrance box & TMR	FPS	Refurbish and recable TMRs	
			Transmission lines	FPS		
			PFNs & HV switches	FPS		New equipment from approved consolidation
			Electronics & Controls	EC		New equipment from approved consolidation
SPS	MKDH	Kicker	Magnets	FPS	Build a spare	
			Entrance boxes	FPS	Build a spare	
			Transmission lines	FPS		
			Generators	FPS	Build new safety switch, change capa bank	
			Electronics & Controls	EC	Renew controls & electronics equipment, build new electrical distribution	
SPS	MKE4	Kicker	Magnets	FPS		Rotation of magnets done in impedance reduction program
			Entrance box & TMR	FPS	Change ceramic capacitors in matching boxes, refurbish and recable TMR's	
			Transmission lines	FPS		
			PFNs & HV switches	FPS	Reduce number of generators after CNGS stops, add active dump switches	Will improve reliability
			RCPS	FPS	Build new safety switch, change capa bank	
			Electronics & Controls	EC	Consolidate timing system (G64 eradication)	
SPS	MKE6	Kicker	Magnets	FPS		Rotation of magnets done in impedance reduction program
			Entrance box & TMR	FPS		
			Transmission lines	FPS		
			PFNs & HV switches	FPS	Add an active dump switch	
			RCPS	FPS	Build new safety switch, change capa bank	
			Electronics & Controls	EC	Add interlocking (dump switches)	
SPS	MKQH/V	Kicker	Magnets	FPS	Rebuild the MKQH magnet	Voltage limitation
			Entrance box & TMR	FPS	Refurbish and recable TMRs	
			Transmission lines	FPS		
			PFNs & HV switches	FPS		
			RCPS	FPS	Build 2 new RCPS (instead of 4 now), new safety switch, change capa bank	
			Electronics & Controls	EC	Consolidate timing system (G64 eradication), Thyratron heater, HV Power supplies	
SPS	Thyratron	Kicker	Thyratron	FPS	Buy and store thyratrons for 20-25 years	Single source supplier - could disappear

Beam Instrumentation

- "Normal" replacement/upgrade of hardware will continue
  - Wire scanners
    - New fast BWS prototype developed for installation from 2014, for PS SPS & LHC
  - BLMs
    - New system for PSB in 2013 (LINAC4)
    - PS and SPS afterwards
  - Beam position & trajectory systems
    - SPS replacement planned for 2013

Electricity (EN/EL)

- Existing Consolidation (44MCHf)
  - Covers 18kV substations, loops etc.

- Other items include
  - Replace 2 400/18kV transformers (8MCHf)
  - Replace SMB 18kV cable network (7MCHf)
  - Replace all TGBT switchboards (7MCHf)
  - Replace 40/72 18/4kV transformers (2.3MCHf)
  - Cable replacement in tunnel (40MCHf)
  - Remove unused cables (30MCHf)

EN/EL details: F Duval

- Low voltage items (below) will be 60 years old and don't comply anymore with safety rules & standards. 100% of them are considered in the estimation. Mitigation have to be discussed….!
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- Upgrade works:
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- 2 of the 3 400/18kV power transformers: roughly **8MCHF**
- Those transformers are 37years old and will be 62 years old in 2035…
- SMB 18kV cable network (38km)was not included in the today consolidation plan despite of the same bad shape as the 18kv loop cable network. **7MCHF**
- All TGBT switchboards (40 pieces) installed in 1972-75 will be 60 years old in 2035… **7MCHF**
- All Power boxes "coffret force" (170 pieces) have to be changed; those are already 35 years old and built partially with plastic.. **0,75MCHF**
- 18/0,4kV transformers replacement of 40 of 72 transformers **2,3MCHF**
- All LV Power cables will be partially changed **17MCHF**
- All safety lighting system **1,4MCHF**
- All toolings and removal for LV Items **1,3MCHF**
- Control cables are partially part of a continuous renovation program and will not be considered but le remaining part has to be changed once before 2035 **40MCHF**
- A huge quantity of unused cables were/are abandoned in cable trays despite of continuous warning from our part, cable renovation as per previous items is not possible without removing unused cables from full cable trays and some cable trays update and renovation works have to be done **30MCHF**
- Supervision and control has to be updated following all renovation works **0,35MCHF**
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Power Converters

- MPS (dipoles & quadrupole converters) renovation is underway
  - 2010 -14 (7MCHf)
- AuxPS and LHC transfer lines recently upgraded/installed
- annual maintenance not sufficient, a true consolidation over 10-15 yrs of several millions (G. Le Godec)
- Two static VAR Compensators (BEQ2 & 3) will require replacement after 20 years operation (2022 & 2027)
  - The spare SVC, BEQ1, “will reach the end of it’s lifetime soon and will be dismantled” …. Spare?
- North area power converters will need replacing or renovation

Power Converters SPS + Areas some general details + example of age/nos. in N.Area..

Machine/Complexe	Budget (CHF)
TT2	4150000
SPS_Aux_TT10_TT40_TT60	2700000
SPS_COD	2150500
SPS_MAINS	6700000
TI2_TI8	1000000
East Zone	2800000
North_zone_TT20	3700000
Total (CHF)	*23200500*

Model	Quantity	Designation	Technical Ref	Last upgrade	Unit Cost (KCHF)	Total Cost (KCHF)	Comment	Next upgrade
C11-MIB	64	C11-MIB [±250A, ±100V]	Y.GAILLARD	>30 ans	37	2368	New	2015
R11-BBC	110	R11-BBC [±500A, ±150V]	Y.GAILLARD	>30 ans	62	6820	New	2015
R12-BBC	40	R12-BBC [±500A, ±300V]	Y.GAILLARD	>30 ans	77	3080	New	2015
R21-BBC	45	R21-BBC [±1000A, ±300V]	Y.GAILLARD	>30 ans	49	2205	Renovation	2015
R22-BBC	62	R22-BBC [±1500A, ±250V]	Y.GAILLARD	>30 ans	59	3658	Renovation	2015
R31-SIE	8	R31-SIE [±2500A, ±355V]	Y.GAILLARD	>30 ans	89	712	Renovation	2015
D21-BBC	43	D21-BBC [±1500A, ±200V]	Y.GAILLARD	>30 ans	39	1677	Renovation	2015
D31-SIE	5	D31-SIE [±2500A, ±285V]	Y.GAILLARD	>30 ans	54	270	Renovation	2015
Total	**377**					**20790**		

Access and safety systems

- SPS: PPS replacement is planned to start in 2012 - 2015/6?
  - Current “obsolete” system will be maintained as necessary
- Safety & Fire alarm systems will be maintained as long as necessary
  - Renovation???

Interlocks

- BIC is already in operation for SPS machine and transfer lines
- The WIC is deployed for SPS transfer lines only
  - TT40, TT41, TT60, TI2 & TI8
  - Main ring magnet interlocks have never been renovated, could be replaced with WIC (800kCHf)

Dumps, collimators..

- Beam stoppers - Standard maintenance
- SPS
  - Scrapers: planned for consolidation
  - TIDVG Improved spare under constructions

- Experimental area equipment, target stations, collimators etc also need urgent maintenance
  - Some work is included in existing consolidation 2011 & 2012

Cooling & Ventilation

- In addition to the usual annual maintenance interventions General consolidation is necessary
  - reliability reasons, in order to reduce operation down-time,
  - reduce costs due to increasing repetition of breakdowns
  - difficulty to obtain spare parts (piping consolidation SPS, replacement of SPS tunnel safety valves, North area cooling tower and its rejected water (CO2 injection), …).
- The absence of a modern PLC based control system prevents (CCC) remote monitoring
  - only general alarms exist
- Safety concerns
    - the presence of asbestos
    - the new Legionella legislation (Fr, 2004)
    - noise levels outside the legislation (SPS discharge water pumps,
    - replacement of non-conform pressure vessels SPS, firefighting circuits, …);

2. SU Work needed in the SPS Complex for the next 25 Years

Anneau SPS	Frequency	Duration	Unit cost	Nr	Total cost
1 Annual tilt and altimetric control on quadrupoles	Every year	2 wks	SFr. 20 000.00	25	SFr. 500 000.00
2 Annual alignment correction on main magnets and maintenance on others	Every year	1 to 6 wks	SFr. 15 000.00	25	SFr. 375 000.00
3 Global smoothing of all components in all directions	Every 6-7 years	4 months	SFr. 145 000.00	3	SFr. 435 000.00
				Total	SFr. 1 310 000.00
TT10					
1 Annual altimetric control on floor points	Every year	2 days	SFr. 2 500.00	25	SFr. 62 500.00
2 Global smoothing of all components in all directions	Every 6-7 years	2 months	SFr. 30 000.00	3	SFr. 90 000.00
				Total	SFr. 62 500.00
TT20 / TDC2					
1 Annual altimetric control on floor points	Every year (TT20) & 2 years (TDC2)	3 days	SFr. 3 500.00	18	SFr. 63 000.00
2 Global smoothing of all components in all directions	Every 6-7 years	2.5 months	SFr. 40 000.00	3	SFr. 120 000.00
				Total	SFr. 63 000.00
TT60 / TI2					
1 Annual tilt and altimetric control on quadrupoles	Every 2 years	2 wks	SFr. 16 000.00	12	SFr. 192 000.00
2 Global smoothing of all components in all directions	Every 6-7 years	2.5 months	SFr. 40 000.00	3	SFr. 120 000.00
				Total	SFr. 192 000.00
TI8					
1 Annual tilt and altimetric control on quadrupoles	Almost every year	2 wks	SFr. 16 000.00	20	SFr. 320 000.00
2 planimetric control on quadrupoles and local smoothing correction on quadrupoles and other components (due to tunnel instability)	Almost every 2-3 years	1 month	SFr. 15 000.00	8	SFr. 120 000.00
3 Global smoothing of all components in all directions	Every 6-7 years	2.5 months	SFr. 40 000.00	3	SFr. 120 000.00
				Total	SFr. 320 000.00
TT41 (CNGS)					
1 Annual tilt and altimetric control on quadrupoles	Almost every year	2 wks	SFr. 16 000.00	20	SFr. 320 000.00
2 planimetric control on quadrupoles and local smoothing correction on quadrupoles and other components (due to tunnel instability)	Almost every 2-3 years	1 month	SFr. 15 000.00	6	SFr. 90 000.00
3 Global smoothing of all components in all directions	Every 6-7 years	2.5 months	SFr. 40 000.00	3	SFr. 120 000.00
				Total	SFr. 320 000.00
				TOTAL	**SFr. 2 267 500.00**

Other systems

- Cranes, lifts, handling equipment are in the existing Consolidation plan
- SC/RP radiation monitoring - Ramses deployment is in the existing Consolidation plan
- Tunnel Infrastructure under study - Civil Engineering

Additional SPS Upgrades will also come within 25 years.....

- The work to be done for an SPS upgrade is still a matter of study – by the SPS-upgrade working group, to be presented in June 2011 for possible commissioning in 2017 - and cannot be dealt now.
- a summary of the work of this committee in its chairperson's presentation is :
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- http://indico.cern.ch/getFile.py/access?contribId=2&sessionId=0&resId=1&materialId=slides&confId=42645
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- Some hypotheses are already being focused: these include coating of all dipole vacuum chambers, modification of injection kickers, RF system, beam dump system, collimation, beam diagnostics.

spares

Conclusions
(S.Baird – Chamonix 2010)

- This is just a start
  - Some BUT DEFINITELY NOT ALL of these activities are included in current Consolidation programs.

- Strong and vigorous maintenance programs are very important