



# Status of the SPL study


R. Garoby – 30/06/2010

**Fourth SPL Collaboration Meeting jointly with ESS  
30 June - 2 July 2010 / Lund**

# OUTLINE

- 1. Past context and recent changes**
- 2. New plans for the SPL R & D**
- 3. Progress since Nov. 2009**
- 4. Near future...**

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# History...

End 2006 and beginning of 2007: preparation of a roadmap and workplan towards the LHC luminosity upgrade (“White paper”)

- Luminosity depends directly upon  $\beta^*$  and beam **brightness**  $N/\varepsilon^*$

$$L \propto \frac{1}{\beta^*} \frac{N_b}{\varepsilon_{X,Y}} \cdot N_b \cdot k_b$$

$N_b$  : number of protons/bunch

$\varepsilon_{X,Y}$  : normalized transverse emittances

$k_b$  : number of bunches per ring

- Brightness is defined at low energy in the **injectors**

$$\Delta Q_{SC} \propto \frac{N_b}{\varepsilon_{X,Y}} \cdot \frac{R}{\beta\gamma^2}$$

$N_b$  : number of protons/bunch

$\varepsilon_{X,Y}$  : normalized transverse emittances

$R$  : mean radius of the accelerator

$\beta\gamma$  : classical relativistic parameters

# History (cont.)...

19/09/2008:  
LHC splice  
“incident”

Oct.2008 –  
Oct.2009: LHC  
repair

CHAMONIX 2010  
Workshop  
+  
New CERN  
Scientific Strategy

- December 2007: CERN Council approval of “White paper”, consisting in upgrading the **high luminosity IRs** (“IR upgrade phase 1”) and the **injectors** (“Linac4” + study of LP-SPL & PS2)
- January 2008: official start of the LP-SPL study
- December 2008: 1<sup>st</sup> SPL collaboration meeting
- May 2009: 2<sup>nd</sup> SPL collaboration meeting
- June 2009: increased LP-SPL budget in Medium Term Plan 2010-2014
- Nov. 2009: 3<sup>rd</sup> SPL collaboration meeting
- 15 June 2010: Proposal for new Medium Term Plan 2011-2015 submitted to the CERN Council

# Arguments for the new scientific strategy

- **LHC:**

- Delayed start-up
- Slower progress of performance than initially foreseen
- Need for more work & resources to reach nominal performance
- More worries on capability to operate beyond ultimate beam characteristics

- **New injectors:**

- Realistic planning: availability in 2020-2022

⇒ **need to invest for consolidating the existing accelerators**

- Uncertain SPS potential



⇒ **Interest for investigating the possibility to minimize cost by “simply” upgrading PSB and PS**

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# New plans for the SPL R & D

**Considering the present context (pending CERN Council decision for implementation) the CERN management has recommended:**

- No construction of LP-SPL and PS2.
- Termination of studies to allow for the LP-SPL and PS2 to remain as possible fall-back solutions.
- **Continuation of SPL R & D for high beam power in view of potential use in a neutrino facility.**
- Increase of the PSB to PS transfer energy.
- Consolidation and upgrade of PSB, PS and SPS. } **Completion in ~2015**



# HP-SPL wrt LP-SPL

- Upgrade of infrastructure (cooling water, electricity, cryogenics etc.)
- Replacement of klystron power supplies,
- Addition of 5 high  $\beta$  cryomodules to accelerate up to 5 GeV ( $\pi$  production for  $\nu$  Factory)?

## Beam characteristics of the main options

	Option 1	Option 2
Energy (GeV)	2.5 or 5	2.5 and 5
Beam power (MW)	2.25 MW (2.5 GeV) <u>or</u> 4.5 MW (5 GeV)	5 MW (2.5 GeV) <u>and</u> 4 MW (5 GeV)
Rep. frequency (Hz)	50	50
Protons/pulse ( $\times 10^{14}$ )	1.1	2 (2.5 GeV) + 1 (5 GeV)
Av. Pulse current (mA)	20	40
Pulse duration (ms)	0.9	1 (2.5 GeV) + 0.4 (5 GeV)

Faster rep. rate  
 $\Rightarrow$  new power supplies, more cooling etc.

$2 \times$  beam current  $\Rightarrow 2 \times$  nb. of klystrons etc .



# R & D for high power SPL

(in continuity with the work previously done for the LP-SPL)

## Motivation

- Preserve potential for some alternative physics programmes (Neutrinos, RIB)
- Preserve possibility of new injectors at long term
- Update CERN competences in superconducting RF

## Description

- Focused on high beam power
- R & D only (no work on integration / civil engineering / environmental impact)

## Main objectives

- End 2010-2011: ~simultaneously with the PS2 CDR): LP-SPL CDR
- First half of 2013: high power test of 4 sc cavities in a short horizontal cryostat
- First half of 2015: high power test of 8 sc cavities in a prototype full size cryomodule
- Beyond 2015:
  - if a project proposal has to be prepared: integration, safety, civil engineering environmental impact study...
  - if R & D continues: Nb coating on Cu,  $\beta=0.65$  cavities, rings for a neutrino facility, target and target area, other needs of a neutrino facility...

# R & D subjects until 2015

(in continuity with the work previously done for the LP-SPL)

Partly  
addressed in  
sLHC-PP

- R & D towards a high duty cycle H<sup>-</sup> source (continued after end of SLHC-PP)

Treated in  
sLHC-PP

- Study of the optimum high power RF architecture for a high power SPL

Partly  
addressed in  
"EuCARD"

- Design, construction and test of superconducting RF cavities (704 MHz – 5 cells –  $\beta=1$ )

Partly supported  
by French "in-  
kind" contrib.

- Development of high power RF coupler, HOM damper and adaptation of tuner

With ESS  
support

- Upgrade of the SM18 test place [2 K cooling + pulsed RF source at 704 MHz (1 MW @ 50 Hz )]
- Pulsed high power RF tests of contiguous cavities in a common cryostat
- Design, construction and test a high power klystron modulator
- Design, construction and test of a prototype cryomodule equipped with 8  $\beta=1$  cavities



# Planning for cavities and cryomodule

	2011				2012				2013				2014				2015			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
SM18 - 2K Cryogenics			V cryo.					X												
SM18 modulator								1												2
SM18 - 704 MHz High Power RF								X												
High Power RF couplers	4			>4								>8								
Superconducting cavities				>4								>8								
Assembled string of 4 cavities						X														
Horiz. test cryostat (4 cav.)						X														
Equipped horiz. test cryostat								X												
High power RF tests in test cryo.									X											
Assembled string of 8 cavities														X						
8 cavities cryomodule														X						
Equipped cryomodule																X				
High power RF tests in full CM																		X		

From industry (ESS)

CERN design

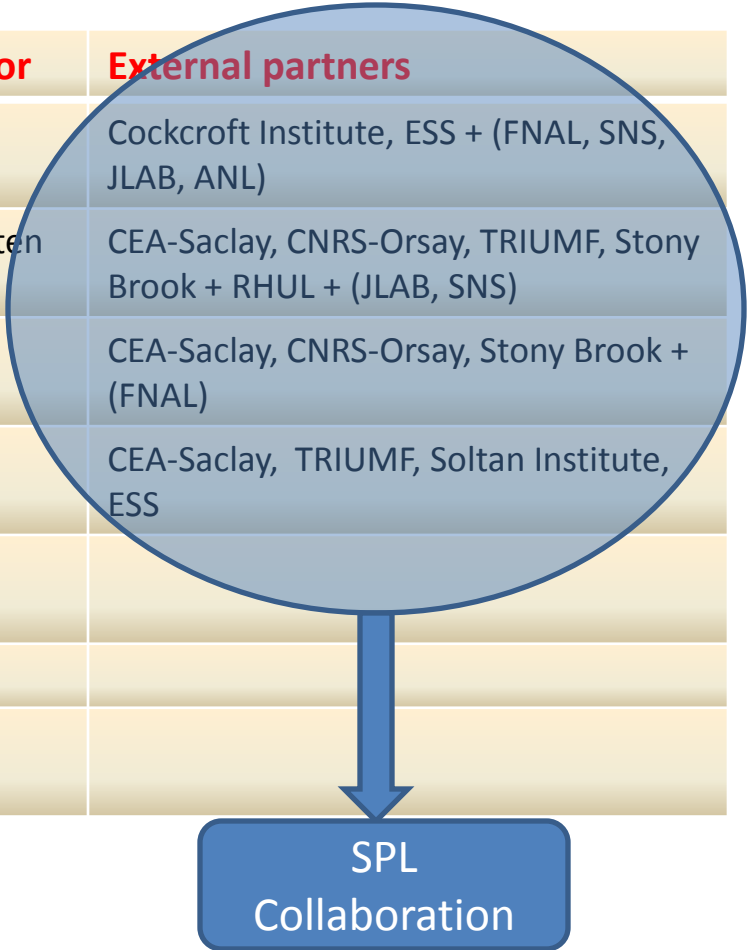
~ in-phase with ESS design update

# Organization

Study leader: R. Garoby

Working  
Groups

	Coordinator	External partners
RF hardware (low level & high power)	E. Ciapala	Cockcroft Institute, ESS + (FNAL, SNS, JLAB, ANL)
Cavities (structures & auxiliary equipment)	W. Weingarten	CEA-Saclay, CNRS-Orsay, TRIUMF, Stony Brook + RHUL + (JLAB, SNS)
Cryomodule (cryostat & cryogenics)	V. Parma	CEA-Saclay, CNRS-Orsay, Stony Brook + (FNAL)
Beam dynamics (beam parameters)	A. Lombardi	CEA-Saclay, TRIUMF, Soltan Institute, ESS
Architecture (layout & geometry, extraction, transfer)	F. Gerigk	
Surface treatment and vacuum	S. Calatroni	
Mechanical design and construction	O. Capatina	



- [SPL documentation](https://edms.cern.ch/nav/SLHC-000008) in EDMS [ <https://edms.cern.ch/nav/SLHC-000008> ]
- [SPL meetings](http://indico.cern.ch/categoryDisplay.py?categId=1893) in Indico [ <http://indico.cern.ch/categoryDisplay.py?categId=1893> ]



# Requested CERN resources

		2010	2011	2012	2013	2014	2015	TOTAL 2010-2015	COMMENTS
Management (travels and visitors)	FTE	1	1	1	1	1	1	6	
	kCHF	60	50	50	50	50	50	310	
Fellows and students	FTE				0	0	0	0	
	kCHF				120	120	120	360	3 years fellow
Optics design and beam dynamics	FTE	0.2	0.2	0.2	0.2	0.2	0.2	1.2	
	kCHF	0	0	120	120	120	120	480	4 years fellow
SLHC-PP [CNI in FP7] (H- source and RF field stabilization)	FTE	2	0.8	0	0	0	0	2.8	
	kCHF	600	180	0	0	0	0	780	
Cryomodule devt. (CERN)	FTE	0.7	0.9	1.9	2.5	2.8	2.8	11.6	
	kCHF	250	360	580	540	660	260	2650	11 years fellow
SC cavities technology	FTE	0.75	0.75	0	0	0	0	1.5	
	kCHF	200	50	0	0	0	0	250	
Radio protection study	FTE	0.2	0.2	0.2	0.2	0.2	0.2	1.2	
	kCHF	60	60					120	1 year fellow
Niobium & other raw materials procurement	FTE							0	
	kCHF	280	280					560	
Upgrade of workshop equipment (HPWR stations)	FTE	0.5						0.5	Assumes 12 months of Technical Student or ESS engineer
	kCHF	200						200	
High Power RF couplers (2 types , 8 in total)	FTE	0.5	0.5	0.5	0.5			2	
	kCHF	350	100	200	300			950	
Fabrication of cavities with HOM couplers + upgrade of EB welding	FTE	0.3	1.2	2.1	1.3	0.8	0.4	6.1	
	kCHF	350	890	340	200			1780	2.5 years fellow
Processing & measurement of sc cavities / assembly, commissioning and tests of cavities	FTE	0.8	1.2	1.2	1.2	1.2		5.6	Assumes availability of Doctoral student
	kCHF	20	30	50	80	60		240	
Upgrade of clean room equipment and auxiliary systems in SM18	FTE	2.5	2.5	2	2	2		11	
	kCHF	100	1050	580	50	30	0	1810	
Upgrade of cryogenics in SM18	FTE	0.1	0.2	0.1				0.4	
	kCHF	348	720	172				1240	2 years fellow
Clean room assembly	FTE			1	1	1.5	0.5	4	
	kCHF			150	100	300	50	600	
High power amplifier and 704 MHz RF hardware procurement / commissioning and testing of cavities in	FTE	0.6	1.6	1.9	2.1	1.6	2.1	9.9	
	kCHF	100	720	1120	320	170	220	2650	5 years fellow
Modulator design and construction	FTE	0.3	3.4	6.3	4.8	1.3		16.1	
	kCHF	45	270	535	385	140		1375	4 years fellow
<b>OVERALL TOTAL (CERN)</b>	FTE	<b>10.5</b>	<b>14.5</b>	<b>18.4</b>	<b>16.8</b>	<b>12.6</b>	<b>7.2</b>	<b>79.9</b>	
	kCHF	<b>2963</b>	<b>4760</b>	<b>3897</b>	<b>2265</b>	<b>1650</b>	<b>820</b>	<b>16355</b>	
<b>Additional work package for the continuation of the R &amp; D for a high duty factor H- source</b>									
H- ion source prototype design/construction and test	FTE		1.2	2.4	2.4	2.4	2.4	11	
	kCHF		309	498	618	618	618	2660	8 years fellow
<b>TOTAL (CERN) with H- source devt</b>	FTE	<b>10.5</b>	<b>15.7</b>	<b>20.8</b>	<b>19.2</b>	<b>15.0</b>	<b>9.6</b>	<b>90.9</b>	
	kCHF	<b>2963</b>	<b>5069</b>	<b>4395</b>	<b>2883</b>	<b>2268</b>	<b>1438</b>	<b>19015</b>	

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# Linac4 Civil Engineering



Accelerator tunnel

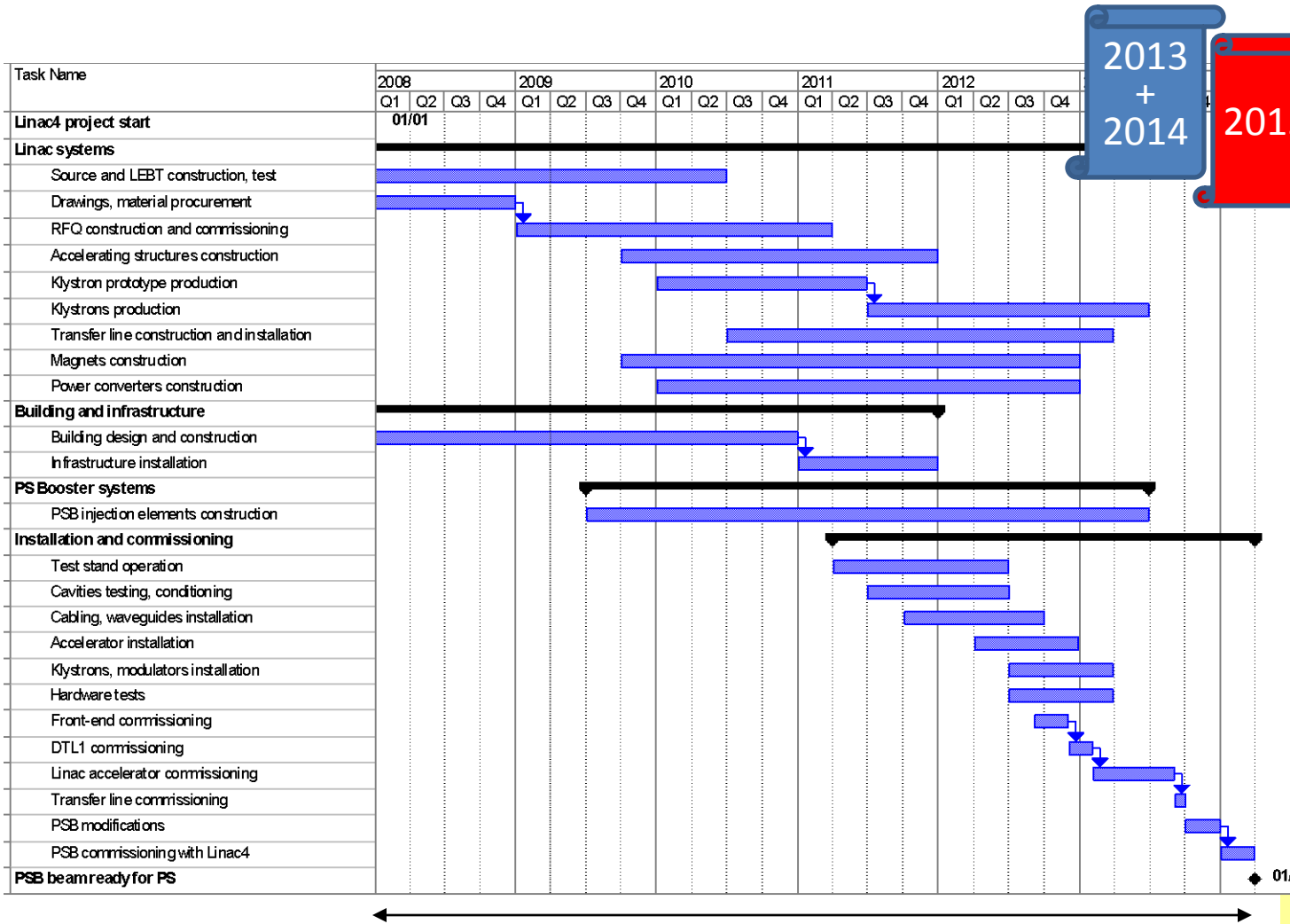
Equipment hall



Fial words



# Linac4 planning



2013  
+  
2014  
2015

## Milestones

- End CE works: December 2010
- Infrastructure: 2011
- Installation: 2011-2012
- Commissioning: 2012 till 2014
- Modifications PSB: shut-down 2014/15
- **Operation: Spring 2015**

project duration: ~ 7 years



# Activity since Nov. 2009

- + **Active participation to the preparation of the new CERN MTP...**
- ⇒ **Redefinition of the workplan and French in-kind contribution**
- + **Work within WGs** [e.g. video-conferences of WG2 ([~1/ month](#)), technical discussions, contributions to conferences and workshops, visits, etc.]
- + **Technical Workshops:**
  - 21 January 2010: [RF needs for SPL sc cavities tests](#)
  - 16-17 March 2010: [Review of SPL RF high power couplers](#)
- + **First public seminar:**
  - 18 February 2010: <http://indico.cern.ch/conferenceDisplay.py?confId=81116>
- + **Collaboration Meeting:**
  - End July 2010: [4th SPL Collaboration Meeting](#)
- + **Coordination** ([~2 meetings/month](#))
- **Freeze on preparation of collaboration documents, pending firm decision on CERN commitment to the SPL R & D...**

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# Next 12 months

**... provided that the HP-SPL R & D is supported at the expected level within the future MTP:**

- Extension of the study to a full proton driver for a neutrino factory
- Optimization & cost estimate of full proton driver (contribution to the IDS-NF)

# Next 12 months

## ... concerning the SPL itself (non-exhaustive list):

- Order of Niobium and construction of cavities in industry
- Start of upgrade of cryogenics and overall infrastructure in SM18
- Specification & order of klystron modulator from industry (ESS)
- Cryomodule specification meeting (Sept. 2010) + design review (Nov. 2010) + beginning of construction (IN2P3)
- Specification & construction of tuners and He tanks (CEA)
- 5<sup>th</sup> SPL Collaboration Meeting (Nov. 2010)
- LP-SPL CDR (jointly with PS2) (Beginning of 2011)
- Construction & test of High power RF couplers + Review (March 2011)
- Test of single cell sc cavity



**THANK YOU FOR  
YOUR  
ATTENTION!**