Status and Plans of the SPL study

R. Garoby – 3/05/2012

2nd Open Collaboration meeting on
Superconducting Linacs for High Power Proton Beams
(SLHiPP-2)
May 3-4, 2012 Catania

OUTLINE

1. Resources and organization
2. Planning
3. Recent progress
4. Future…

Resources

- **R & D for a High Power SPL formally supported at CERN in view of multiple future potential applications**

⇒ **~1.7 MCHF and 6 FTEs / year**

- **Collaboration with ESS**

⇒ **Fellows and procurement of klystron modulator for SM18**

- **French in-kind contribution**

⇒ **Tuners, Helium tanks, use of Saclay 704 MHz high power test place…**

- **EC-supported programmes**
  - EuCARD (WP10)
    - ⇒ **Development and test of beta=1 (CEA) and beta=0.65 (IN2P3) 5 cells cavities**
  - CRISP (WP4)
    - ⇒ **Joint work with ESS and DESY**
    - ⇒ **EC-supported manpower for upgrading and exploiting the SM18 test place**
  - LAGUNA-LBNO
    - ⇒ **EC-supported fellow for studying proton drivers at CERN using LP- or HP-SPL**
- **DOE-supported programme**
  - BNL

⇒ **Development and test of a β=1 cavity**

Organization of the SPL R&D at CERN

Guideline

«Project-like» structure aimed at meeting the objectives of the HP-SPL R&D:

- **Building and testing a prototype cryomodule with 4 cavities**
- **Updating CERN infrastructure and competence in superconducting RF technology**
- **Preparing submission of future subjects of R&D [design and construction of a full-size cryomodule, high power RF sources, HIPIMS (High Power Impulse Magnetron Sputtering)…]**

Work Units

-Design, construction and test of the prototype cryomodule (Leader: V. Parma)

- Components: Cryomodule, Cavities, RF items (Couplers, tuners, …), cryogenics equipment…
- Assembly (with adequate tools): cavities string in clean room, inclusion in cryomodule
- Tests: cavities in vertical cryostat, assembled cryomodule in bunker.
- **Upgrade of the SM18 infrastructure (Leader: O. Brunner)**
- HP water rinsing system and upgraded clean roon
- Cryogenics for efficient operation at 2K
- High power RF at 704 MHz (klystron, modulator, high power distribution)
- Low Level RF and controls

-SC RF cavities technology (Leader: E. Ciapala)

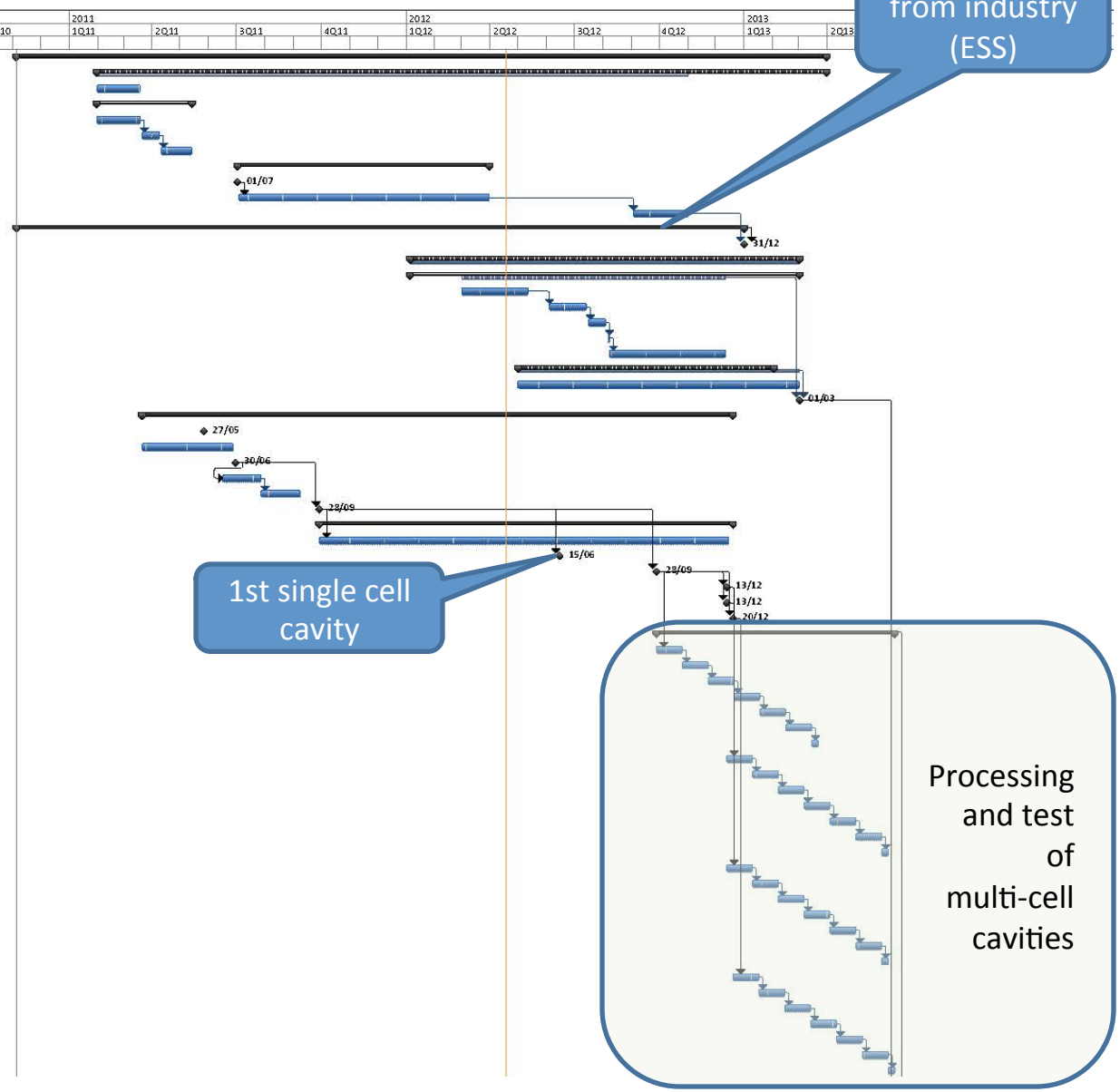
- Fabrication and processing
- Test, diagnostics and analysis

OUTLINE

1. Resources and organization
2. Planning
3. Recent progress
4. Future…

Planning of SPL R&D (1/2)

Task Name	Duration	Start	Finish
SM18 test infrastructure	**626 days**	**Fri 05/11/10**	**Sat 30/03/13**
Cryogenics distribution line	**566 days**	**Mon 31/01/11**	**Sat 30/03/13**
Cryoline specification	7 wks	Mon 31/01/11	Fri 18/03/11
Design	**75 days**	**Mon 31/01/11**	**Fri 13/05/11**
Cryoline design	7 wks	Mon 31/01/11	Fri 18/03/11
RF service Module design	3 wks	Mon 21/03/11	Fri 08/04/11
Auxilliary equipment	5 wks	Mon 11/04/11	Fri 13/05/11
Construction and procurement	**195 days**	**Fri 01/07/11**	**Fri 30/03/12**
Procurement of critical components	0 days	Fri 01/07/11	Fri 01/07/11
Construction and procurement	39 wks	Mon 04/07/11	Fri 30/03/12
Installation	**43 days**	**Mon 03/09/12**	**Wed 31/10/12**
RF infrastructure	**562 days**	**Fri 05/11/10**	**Mon 31/12/12**
SM18 test infrastructure ready	0 days	Mon 31/12/12	Mon 31/12/12
SM18 Clean Room	**302 days**	**Thu 05/01/12**	**Fri 01/03/13**
Clean Room upgrade	**302 days**	**Thu 05/01/12**	**Fri 01/03/13**
Tech. spec.	52 days	Thu 01/03/12	Fri 11/05/12
Call for tender	30 days	Mon 04/06/12	Fri 13/07/12
Assessment of offers	15 days	Mon 16/07/12	Fri 03/08/12
Signature of contract	1 day	Tue 07/08/12	Tue 07/08/12
Upgrade activity	18 wks	Wed 08/08/12	Tue 11/12/12
SPL specific tooling	**199 days**	**Tue 01/05/12**	**Fri 01/02/13**
Design & fabrication	219 days	Tue 01/05/12	Fri 01/03/13
SM18 Clean Room ready for SPL	0 days	Fri 01/03/13	Fri 01/03/13
Cavities production	**458 days**	**Mon 21/03/11**	**Thu 20/12/12**
Niobium delivery	0 days	Fri 27/05/11	Fri 27/05/11
Cavities design (incl. detailed design)	71 days	Mon 21/03/11	Mon 27/06/11
Cavities design validation	0 days	Thu 30/06/11	Thu 30/06/11
Tech. spec.	6 wks	Thu 16/06/11	Wed 27/07/11
Call for tender	6 wks	Thu 28/07/11	Wed 07/09/11
Signature of contract	0 days	Wed 28/09/11	Wed 28/09/11
Cavities production	**320 days**	**Thu 29/09/11**	**Thu 20/12/12**
Production	317 days	Thu 29/09/11	Fri 14/12/12
Delivery of monocell	0 days	Fri 15/06/12	Fri 15/06/12
Cavity 1	0 days	Fri 28/09/12	Fri 28/09/12
Cavity 2	0 days	Thu 13/12/12	Thu 13/12/12
Cavity 3	0 days	Thu 13/12/12	Thu 13/12/12
Cavity 4	0 days	Thu 20/12/12	Thu 20/12/12
Cavities processing/vertical testing (SM18)/dressing	**184 days**	**Fri 28/09/12**	**Wed 12/06/13**
Cavity 1 processing 1	4 wks	Fri 28/09/12	Thu 25/10/12
Cavity 1 testing 1	4 wks	Fri 26/10/12	Thu 22/11/12
Cavity 1 processing 2	4 wks	Fri 23/11/12	Thu 20/12/12
Cavity 1 testing 2	4 wks	Fri 21/12/12	Thu 17/01/13
Cavity 1 processing 3	4 wks	Fri 18/01/13	Thu 14/02/13
Cavity 1 testing 3 (final)	4 wks	Fri 15/02/13	Thu 14/03/13
Insertion of cavity 1 in helium vessel 1	1 wk	Fri 15/03/13	Thu 21/03/13
Cavity 2 processing 1	4 wks	Thu 13/12/12	Wed 09/01/13
Cavity 2 testing 1	4 wks	Thu 10/01/13	Wed 06/02/13
Cavity 2 processing 2	4 wks	Thu 07/02/13	Wed 06/03/13
Cavity 2 testing 2	4 wks	Thu 07/03/13	Wed 03/04/13
Cavity 2 processing 3	4 wks	Thu 04/04/13	Wed 01/05/13
Cavity 2 testing 3 (final)	4 wks	Thu 02/05/13	Wed 29/05/13
Insertion of cavity 2 in helium vessel 2	1 wk	Thu 30/05/13	Wed 05/06/13
Cavity 3 processing 1	4 wks	Thu 13/12/12	Wed 09/01/13
Cavity 3 testing 1	4 wks	Thu 10/01/13	Wed 06/02/13
Cavity 3 processing 2	4 wks	Thu 07/02/13	Wed 06/03/13
Cavity 3 testing 2	4 wks	Thu 07/03/13	Wed 03/04/13
Cavity 3 processing 3	4 wks	Thu 04/04/13	Wed 01/05/13
Cavity 3 testing 3 (final)	4 wks	Thu 02/05/13	Wed 29/05/13
Insertion of cavity 3 in helium vessel 3	1 wk	Thu 30/05/13	Wed 05/06/13
Cavity 4 processing 1	4 wks	Thu 20/12/12	Wed 16/01/13
Cavity 4 testing 1	4 wks	Thu 17/01/13	Wed 13/02/13
Cavity 4 processing 2	4 wks	Thu 14/02/13	Wed 13/03/13
Cavity 4 testing 2	4 wks	Thu 14/03/13	Wed 10/04/13
Cavity 4 processing 3	4 wks	Thu 11/04/13	Wed 08/05/13
Cavity 4 testing 3 (final)	4 wks	Thu 09/05/13	Wed 05/06/13
Insertion of cavity 4 in helium vessel 4	1 wk	Thu 06/06/13	Wed 12/06/13



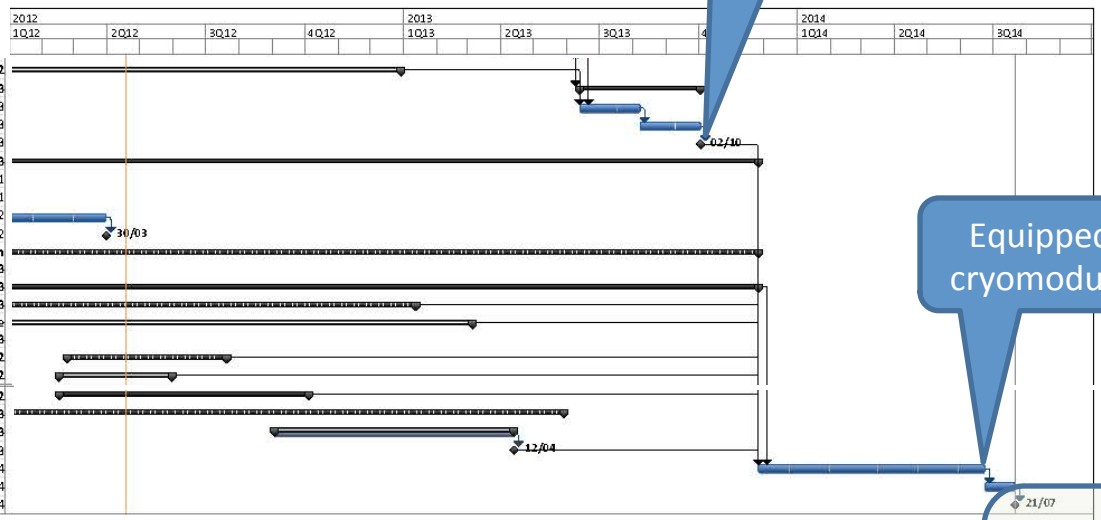
Modulator from industry (ESS)

1st single cell cavity

Processing and test of multi-cell cavities

Planning of SPL R&D (2/2)

Couplers	520 days	Mon 03/01/11	Fri 28/12/12	
Clean room assembly	80 days	Thu 13/06/13	Wed 02/10/13	
Cavities - coupler assembly	8 wks	Thu 13/06/13	Wed 07/08/13	
Assembly of string of 4 cavities	8 wks	Thu 08/08/13	Wed 02/10/13	
String of cavities rolls out of clean rom	0 days	Wed 02/10/13	Wed 02/10/13	
Cryomodule design & fabrication	700.88 days?	Mon 21/03/11	Mon 25/11/13	
Conceptual design	28 wks	Mon 21/03/11	Fri 30/09/11	
Conceptual design review	0 days	Fri 30/09/11	Fri 30/09/11	
Detailed design	26 wks	Mon 03/10/11	Fri 30/03/12	
Detailed design review	0 days	Fri 30/03/12	Fri 30/03/12	
Procurement of cryomodule components & assembly tooling	700.88 days?	Mon 21/03/11	Mon 25/11/13	
Vacuum vessel	700.88 days	Mon 21/03/11	Mon 25/11/13	
Thermal shield	475 days	Mon 21/03/11	Fri 11/01/13	
Cryogenics distribution (ph.separator, cryo lines, ...)	511.38 days	Mon 21/03/11	Tue 05/03/13	
Magnetic shielding	106.25 days?	Thu 23/02/12	Fri 20/07/12	
Instrumentation	74.88 days?	Thu 16/02/12	Wed 30/05/12	
Technical Service Module	165.63 days?	Thu 16/02/12	Thu 04/10/12	
Valve Box	572.63 days	Mon 21/03/11	Wed 29/05/13	
Cryomodule assembly tooling	8 mons	Mon 03/09/12	Fri 12/04/13	
Tooling ready for cryomodule assembly	0 days	Fri 12/04/13	Fri 12/04/13	
Cryomodule assembly	30 wks	Mon 25/11/13	Mon 23/06/14	
Cryomodule connection in RF bunker (SM18)	4 wks	Mon 23/06/14	Mon 21/07/14	
Start 1st cryomodule test campaign	0 days	Mon 21/07/14	Mon 21/07/14	



String cavities assembly

Equipped cryomodule

Test of cavities in cryomodule

OUTLINE

1. Resources and organization
2. Planning
3. Recent progress
4. Future…

Status of SPL R&D (1/2)

- Construction of 4 cavities in industry
  ⇒ **In progress (full delivery in 2012)**
- Construction of one additional cavity at CERN
  ⇒ **In progress (2012)**
- Test of single cell cavities from CEA and INFN
  ⇒ **In progress**
- Measurements and tests with dumbbell copper cavity
  ⇒ **Done**
- Upgrade of cryogenics and water rinsing facility in SM18
  ⇒ **Planned in 2012**
- Upgrade of clean room in SM18
  ⇒ **Planned in 2012-2013**
- 704 MHz klystron for SM18
  ⇒ **In fabrication (delivery in 2013)**
- Klystron modulator from industry (ESS)
  ⇒ **In fabrication**
- Preparation of 704 MHz RF components (Low Level and High Power) for SM18
  ⇒ **In progress**

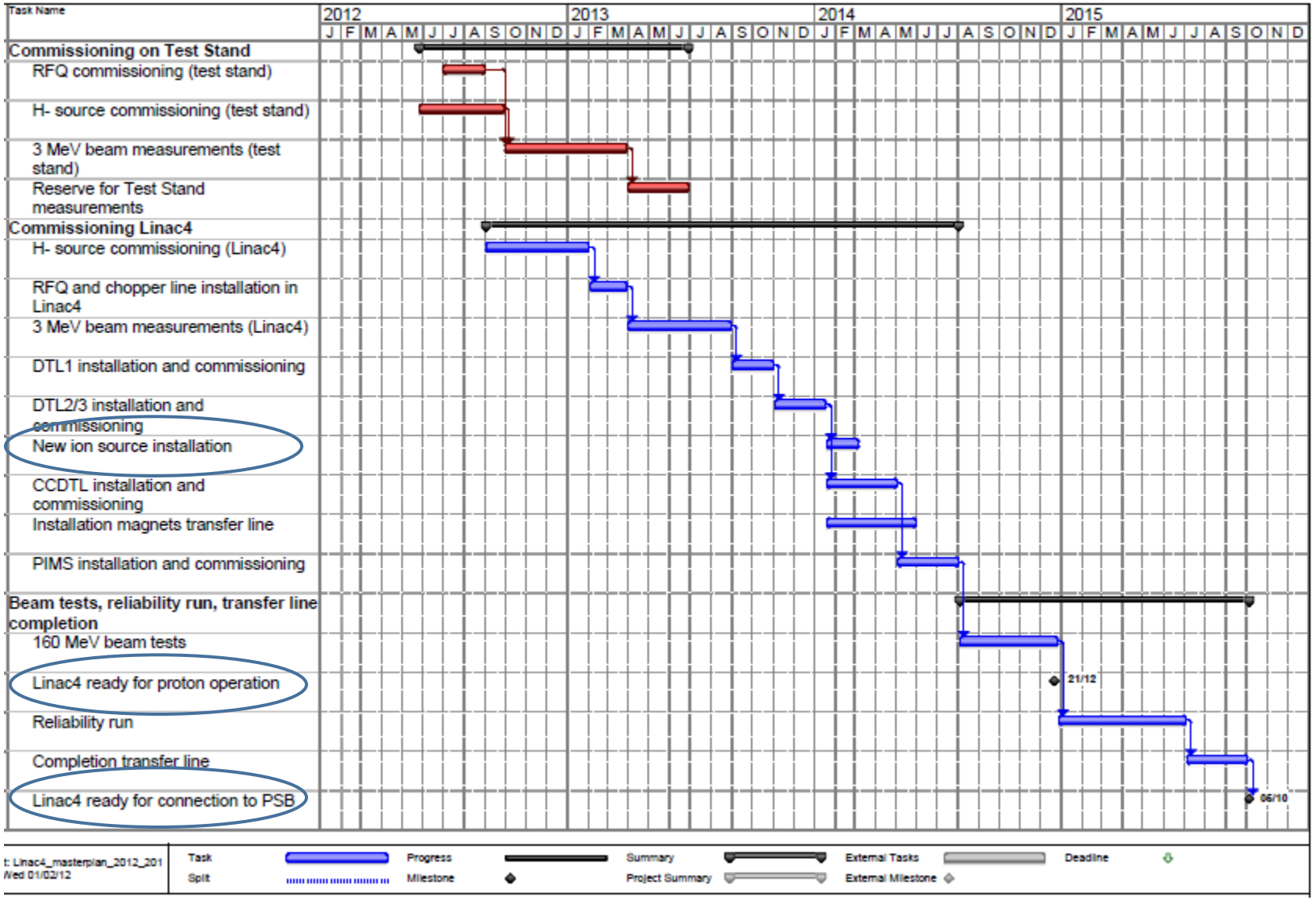
More details during this meeting

Status of SPL R&D (2/2)

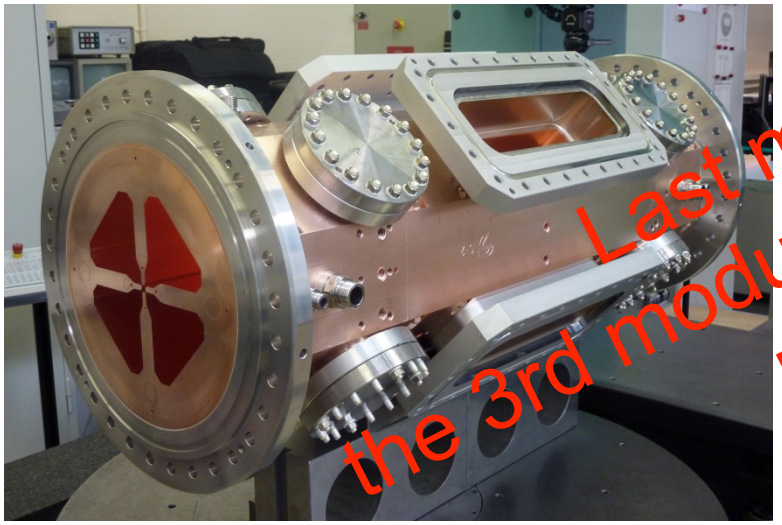
- Construction & test of High power RF couplers
  - ⇒ **Successful high power RF tests in Saclay, limited by heating (problem with Cu-platting)**
  - ⇒ **Correctly Cu-platted tubes available / New assembly planned in DESY**
  - ⇒ **Review delayed to the end of 2012**
- Specification & construction of tuners and He tanks (CEA)
  - ⇒ **Delayed**
- LP-SPL CDR (jointly with PS2)
  - ⇒ **Delayed to 2012…**
  - – Future meetings
  - ⇒ **No SLHiPP meeting at CERN in 2012**
  - ⇒ **9-14 September 2012: LINAC'12 Conference (Tel-Aviv)**
  - ⇒ **5-9 November 2012: TTC meeting (JLab)**
  - ⇒ **6-7 December 2012: "internal" meeting of contributors (CERN) (but external partners are welcome…)**

More details during this meeting

Linac4 (1/2)


Task Name
2012
2013
2014
2015
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
Commissioning on Test Stand
RFQ commissioning (test stand)
H- source commissioning (test stand)
3 MeV beam measurements (test stand)
Reserve for Test Stand measurements
Commissioning Linac4
H- source commissioning (Linac4)
RFQ and chopper line installation in Linac4
3 MeV beam measurements (Linac4)
DTL1 installation and commissioning
DTL2/3 installation and commissioning
New ion source installation
CCDTL installation and commissioning
Installation magnets transfer line
PIMS installation and commissioning
Beam tests, reliability run, transfer line completion
160 MeV beam tests
Linac4 ready for proton operation
21/12
Reliability run
Completion transfer line
Linac4 ready for connection to PSB
06/10
t: Linac4_masterplan_2012_201
Wed 01/02/12
Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline

Linac4 (2/2)



Last minute:
the 3rd module of the RFQ is ready!

Planning of connection to the PSB

ID	Task Name	M-1	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14
1	**LHC ion run**															
2	**PSB activities**															
3	PSB cooling															
4	PSB injection modifications															
5	**Linac4 activities**															
6	Linac2 shielding, BHZ20 conn.															
7	LBE,LBS modifications															
8	Transfer line commissioning															
9	**Start-up**															
10	PSB commissioning															
11	PS/SPS start-up															
12	**LHC proton run**															
13	**LHC stop: 6 months**															

Need 8 months / LHC stop of 6 months
Ready from 2015 (Linac4 must be already commissioned)
Likely starting date: at the end of 2016 («LS1.5») or 2018 (LS2)

HP-SPL cost estimate (1/2)

Cost estimate for the High Power SPL (HP-SPL)

sLHC-Project-Note-0037

F. Gerigk, CERN-BE-RF

Keywords: SPL, cost estimate

Abstract

This note gives a cost estimate for the construction of a 5 GeV, 4 MW High Power H^- Linac (SPL) on the CERN site.

1 Assumptions

This estimate is an extrapolation and update of a costing that was done in 2009 for the construction of a new LHC proton injector chain, consisting of a Low-Power SPL, PS2, and an upgrade of the SPS [1]. It is largely based on the basic parameters listed in Table 1 whose choice is detailed and motivated in [2].

Table 1: Parameters of the HP-SPL

Energy	5 GeV	
Beam power	4 MW	
Repetition rate	50 Hz	
Average pulse current	40 mA (20 mA)*	
Beam pulse length	0.4 ms (0.8 ms)*	
RF pulse length	0.8 ms (1.6 ms)*	
protons per pulse	$1 \cdot 10^{14}$	
Cavity bath temperature	2 K	
Cavity types	$\beta = 0.65$	$\beta = 1.0$
Number of klystrons	66	200
Cells per cavity	5	5
Cavities per cryo-module	3	8
Number of cavities	60	184
Re-buncher cavities	0	4
Spare cavities	6	12
Accelerating gradient	19.3 MV/m	25 MV/m
(R/Q)	275	566
Q in 10^9	6 (3)*	10 (5)*
Peak power per cavity	0.5 MW	1 MW

* worst case assumption for cryogenics design

HP-SPL cost estimate (2/2)

sLHC-Project-Note-0037

Item	Material cost (MCHF)
Civil Engineering (Tunnels and surface buildings)	105
Cryogenics (Cooling plant, cryo-line etc.)	29
RF cavities (including 2 more PIMS cavities in Linac4)	123
RF power systems (including 50 Hz upgrade of Linac4)	424
Magnets (conventional including transfer line to synchrotron)	13
Vacuum equipments	14
Controls, Safety & access, Cooling & Ventilation, Beam Instrumentation	99
TOTAL	**807**

Subject of a special ESS-SPL meeting on May 30 at CERN

OUTLINE

1. Resources and organization
2. Planning
3. Recent progress
4. Future…

Future (beyond what has been shown before)…

- **2012-2013:**

⇒ **contribution to the briefing book of the European Strategy Group [Chapter of a CERN document about accelerator R&D to be referenced by other documents (not necessarily from CERN) requiring the technology (neutrino facilities, EURISOL, LHeC, LEP-III…)]**

⇒ **Reactivation of studies for proton drivers in future neutrino facilities (in the context of LAGUNA-LBNO):**

  ⇒ **LP-SPL as injector of a 2 MW / 30-50 GeV synchrotron**

  ⇒ **HP-SPL with an accumulator as a 5 MW / 5 GeV proton source**

- **Branching point for defining the continuation of the R&D**

⇒ **Recommendations of the European Strategy Group at end 2012/beginning 2013**

⇒ **Updated Scientific Strategy of CERN: 2014?**

⇒ **Strong link with the ESS-SPL collaboration**

Key ingredients for continuation:

- Physics! Based on the results of LHC and of the on-going ν experiments.
- Strength / weaknesses of competing options (Linear collider …)
- Strength / weaknesses of the SPL-related applications (Proton drivers for ν facilities, Injectors for LHC-related future beyond HL-LHC, LHeC, LEP-III …)
- CERN strategy for sc RF technology
- Politics and collaborations…

THANK YOU FOR YOUR ATTENTION!