Crab Cavity Technical Coordination WG
Kick-off meeting

Alick Macpherson
11 July 2012

5th Crab Cavity Workshop (14th-15th November)

Objectives of SPS Beam Test

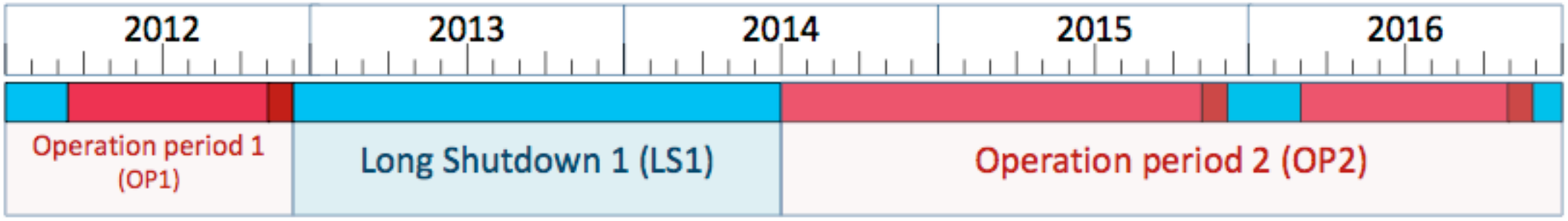
- Crab cavities in LHC: robust functioning through entire LHC cycle
  - no effect on LHC beam during injection, ramp and squeeze.
- RF structures yet to be realized will be used for the LHC crab crossing.
- **Prototype tests with hadron beams are a pre-requisite**
  - Identify potential risks and mitigations to ensure the safety of the accelerator.
- **An essential milestone is to test a crab cavity in the SPS**
  - Verify crabbing can be achieved in a proton machine: **no showstoppers**
  - **Key Issues: Crabbing, machine protection, cavity transparency**

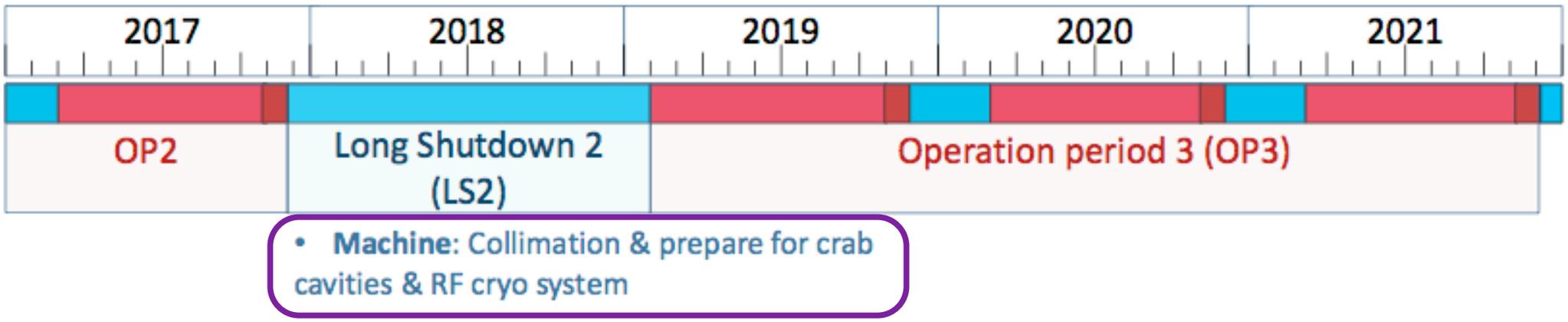
Crab Cavity Technical Coordination WG

Mandate of this working group

- **Prepare, organize, and run Crab Cavities beam tests in SPS.**
  - Coordinate infrastructure requirements for these beam tests
  - Handle the complete integration of these beam tests
  - Implement agreed validation program for Crab Cavity functionality @LHC
  - Identify common design and infrastructure elements that facilitate both the SPS tests and potential verification tests in LHC Pt 4
  - Set and maintain schedules for crab cavity beam tests
- **Provide relevant specifications [functional and technical]** that allow the LHC crab cavity project to proceed to a Technical Design Report and beyond.
- **Assess [in conjunction with Machine Protection] operational and machine safety risks** associated with crab cavity operation in LHC [&SPS]

Draft 10 years plan *(27/10/11)*





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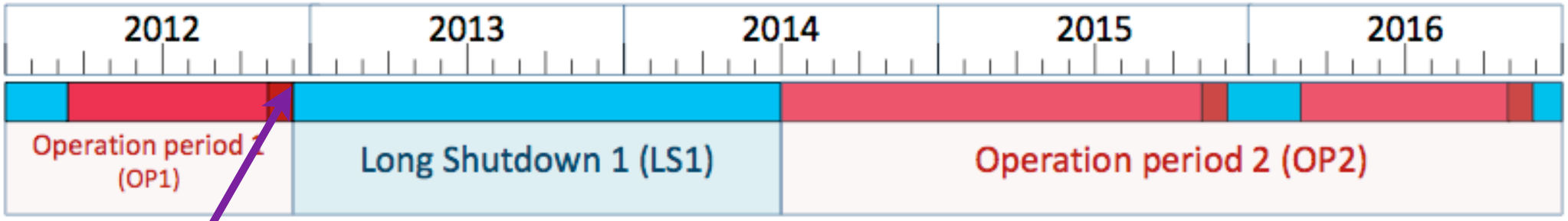
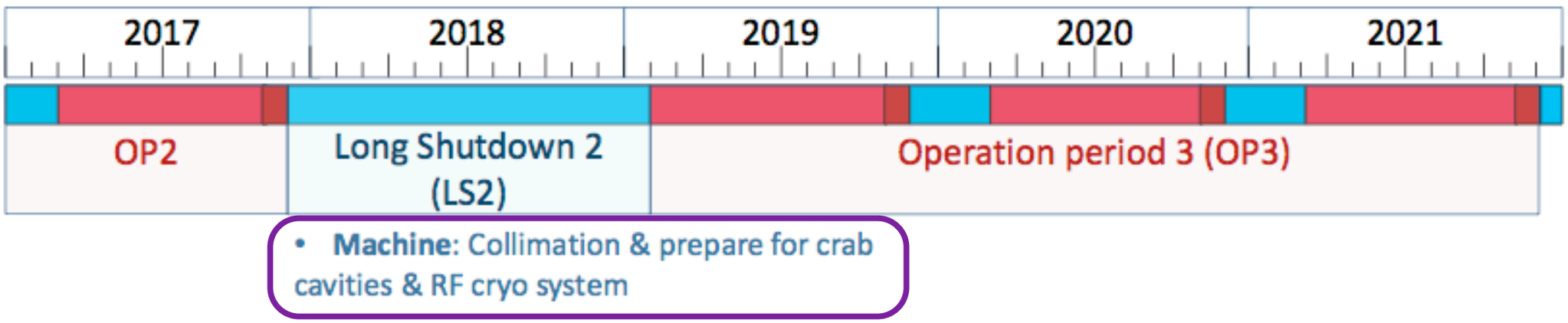


4.5 K TCF20 at SPS Pt 4



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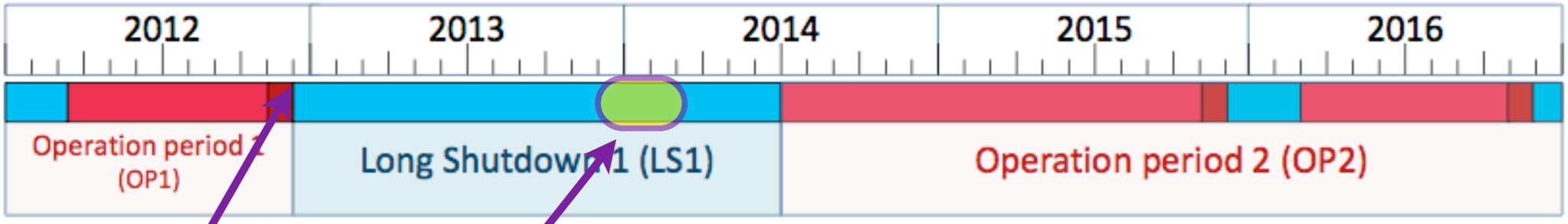

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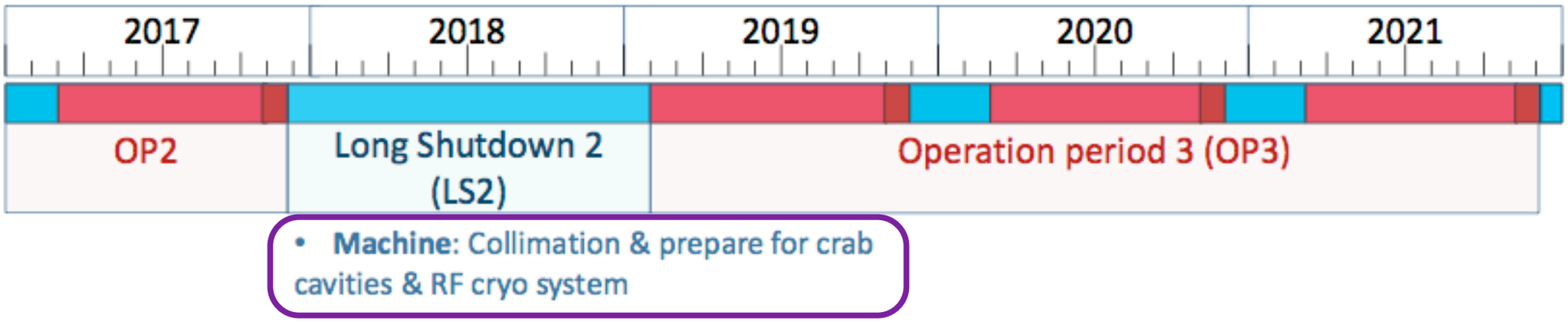
2K Subcooling at SPS Pt 4



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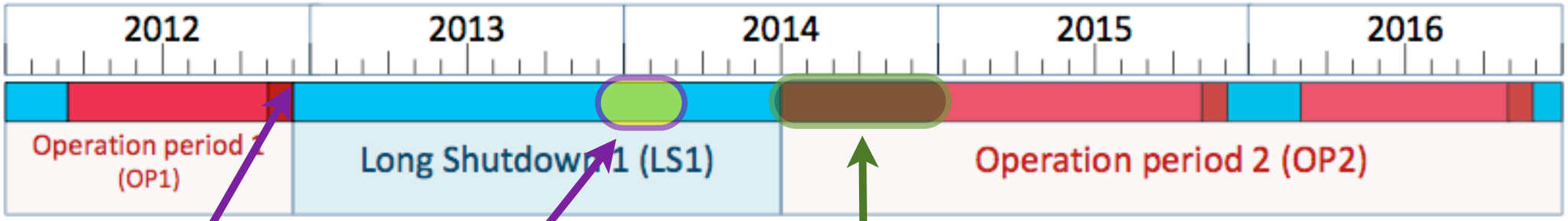

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COLDEX carbon coating tests foreseen

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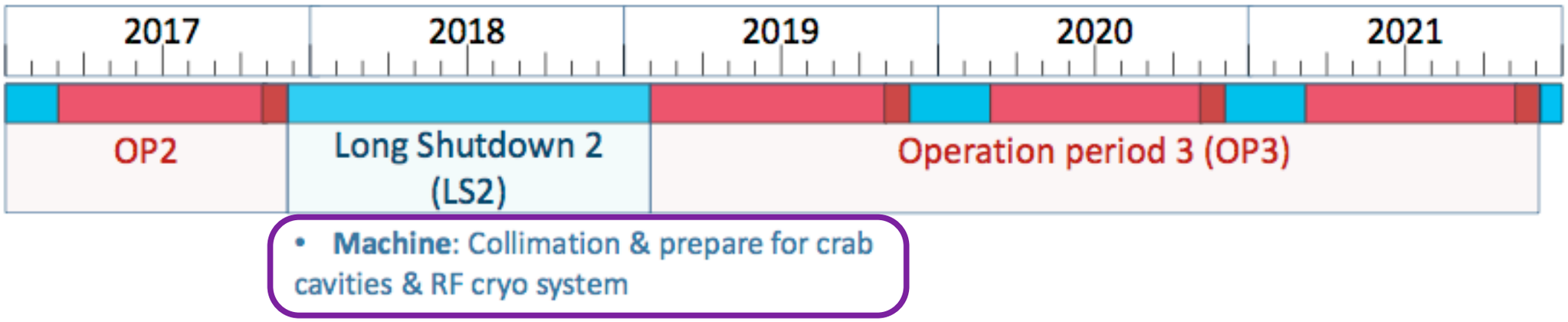

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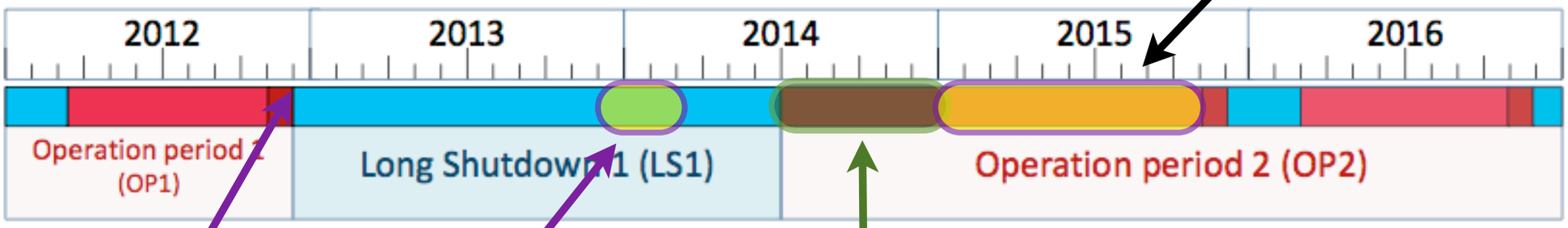

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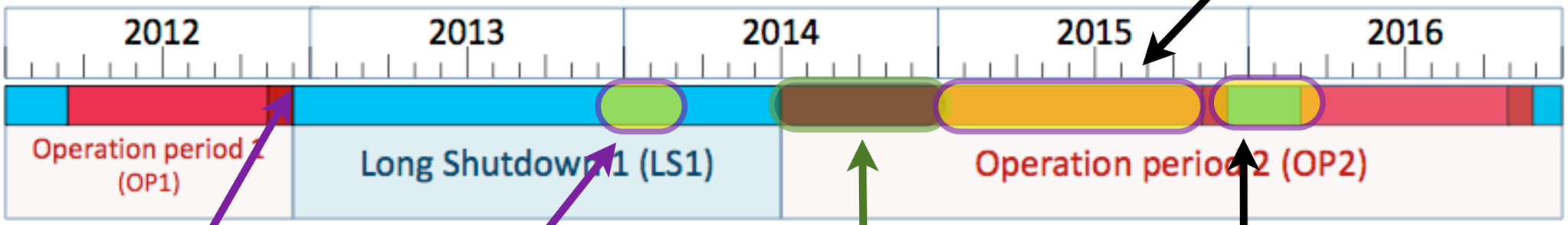

SM18 Tests

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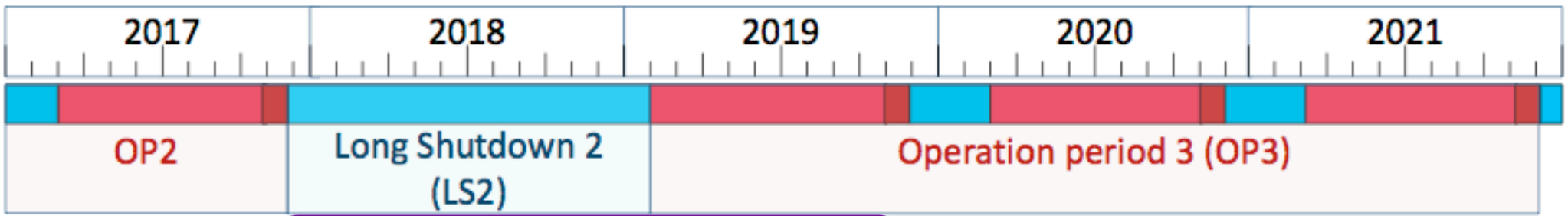
SPS: Crab Cavity Installation



- **Machine**: Collimation & prepare for crab cavities & RF cryo system

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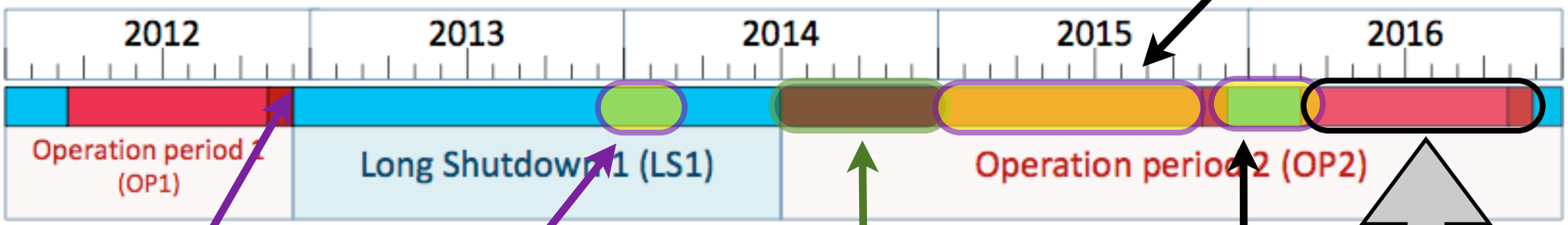

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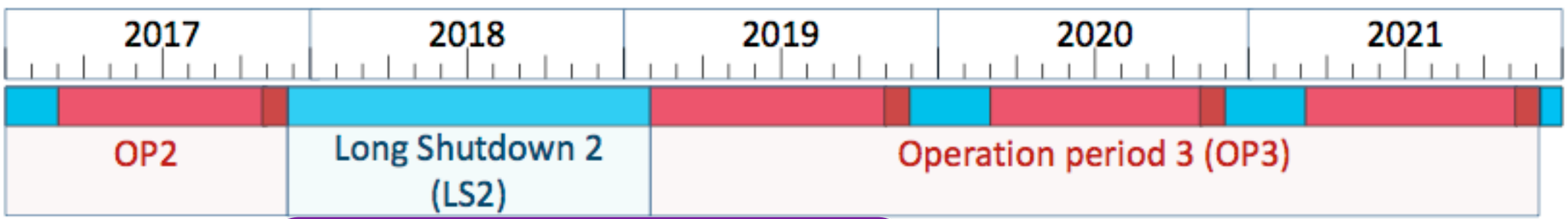

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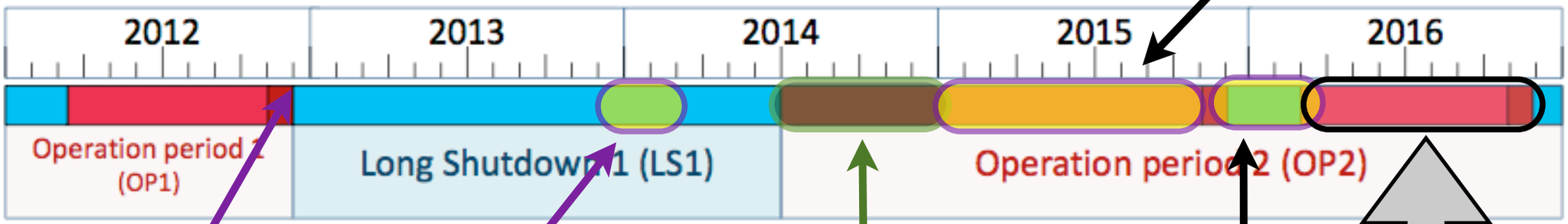

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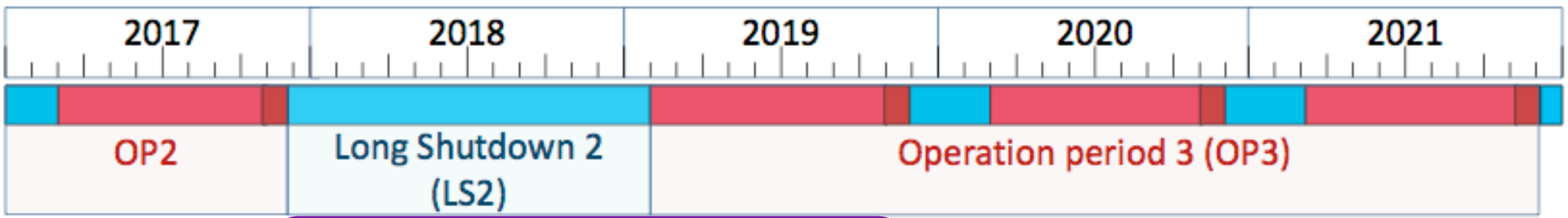

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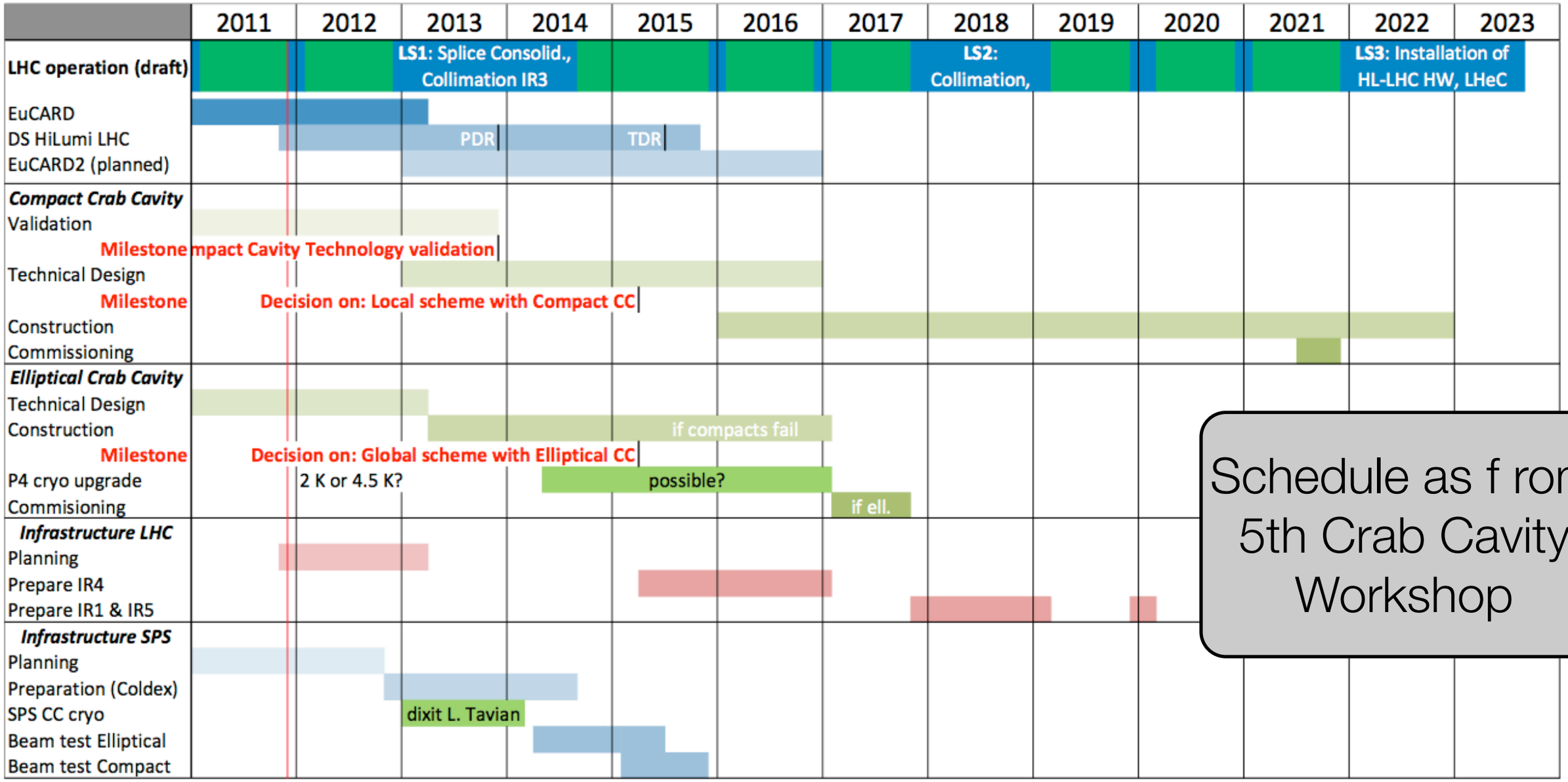
- Issues
  - COLDEX testing in 2014-2015
  - SPS Installation 2015-2016 Xmas break

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
LHC operation (draft)			**LS1: Splice Consolid., Collimation IR3**					**LS2: Collimation,**				**LS3: Installation of HL-LHC HW, LHeC**	
EuCARD													
DS HiLumi LHC			PDR		TDR								
EuCARD2 (planned)													
Compact Crab Cavity													
Validation													
Milestone	mpact Cavity Technology validation												
Technical Design													
Milestone	Decision on: Local scheme with Compact CC												
Construction													
Commissioning													
Elliptical Crab Cavity													
Technical Design													
Construction					if compacts fail								
Milestone	Decision on: Global scheme with Elliptical CC												
P4 cryo upgrade	2 K or 4.5 K?				possible?								
Commisioning							if ell.						
Infrastructure LHC													
Planning													
Prepare IR4													
Prepare IR1 & IR5													
Infrastructure SPS													
Planning													
Preparation (Coldex)													
SPS CC cryo			dixit L. Tavian										
Beam test Elliptical													
Beam test Compact													

Schedule as f rom 5th Crab Cavity Workshop



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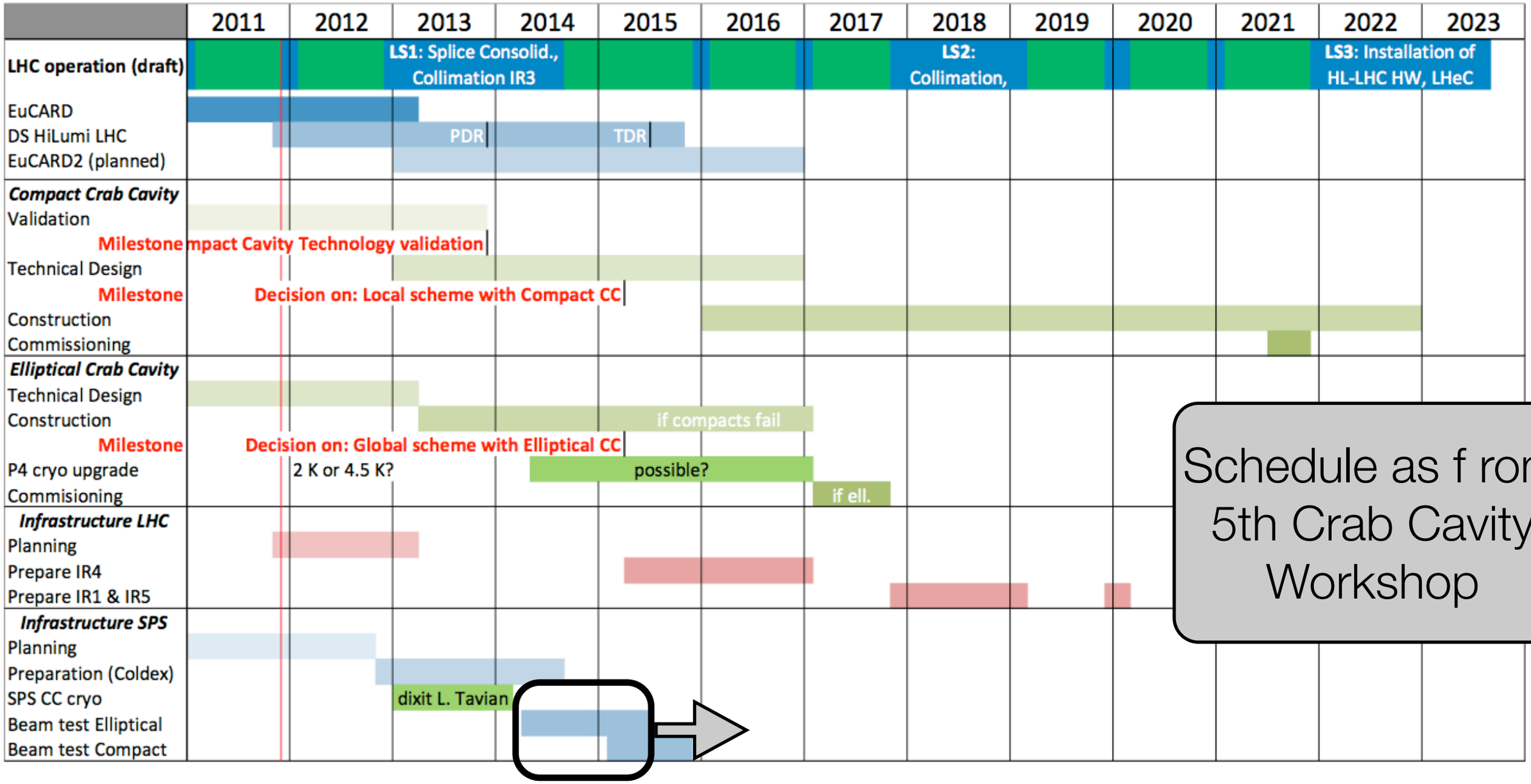
- 2015 not really feasible for SPS beam test
  - COLDEX till mid 2015. Removal time ~1.5 months => CC installation conflict
- **Possibility of installation independent of COLDEX**
  - Cryogenics: Must be close to SPS Pt 4
  - Vacuum: Requires new Y-Chamber.
    - Possibility of LHC compatible cryostat (420mm beam center separation)



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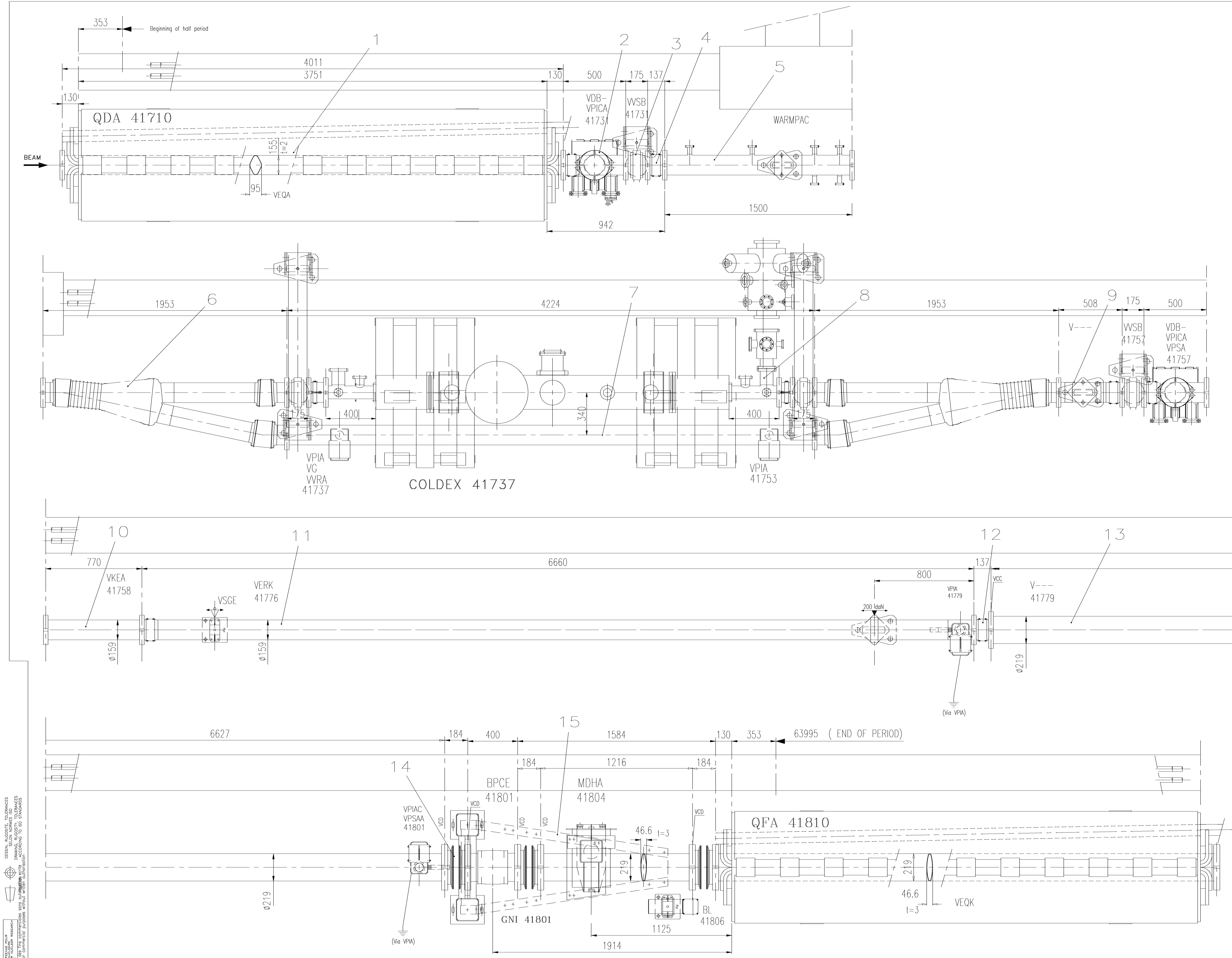

KEY TO SYMBOLS

Earthing point for vacuum chamber

DAMPING RESISTORS

Short without fixation

Short with fixation

Long without fixation

Long with fixation

Insulated quick disconnect joint (enamelled flange on side carrying pointer)

200daN Vacuum chamber support (capable of withstanding force of 200daN along beam axis)

Support (withstanding no force along the beam)

200daN Support insulated electrically from vacuum chamber

10 Maximum offset in flexible element

H 9 7 5 R Displacement of special elements

H= Horizontal displacement
V= Vertical displacement
Initial position (basic fixed displacement)
After running-in (max. additional fixed displacement)
In service (max. additional displacement)
Remote control in service

Example shows that maximum total horizontal displacement in service will be 9+7+5=21mm

NOTA: VPSA,VPRS and VGHA,VGHBare insulated from vacuum chamber and earthed separately

APERTURE OF THE VACUUM CHAMBER

42.3 156 t=2

Vacuum chamber cross section with external nominal dimensions under vacuum. t=wall thickness

SITUATION: QF 41410 | QD 41510 | QF 41610 | QDB 41710 | QFB 41810 | QD 41910 | QF 42010 | QD 42110 | QF 42210

Echelle: 10cm = 1m

QUANT.	DESCRIPTION	POS	MAT.	OBSERVATIONS	REF.CERN
1	GNI	15		SPSLGSSS0822	
1	VBDB	14		SPS8095000747	
1	V---	13		SPS	
1	VBBB	12		SPS8095003007	
1	VERK	11		SPS8095003024	
1	VKEA	10		SPSVCPEB0003	
1	V---	9		SPSVCPEB0007	
1	COLDEX	8			
1	V---	7		SPSVCPEB0003	
2	V---	6		SPSVCPEB0001	
1	WARMPAC	5			
1	VBBA	4		SPS8095003006	
1	VVSB	3		SPS8094007487	
1	VDB-	2		SPSVCPEB0070	
1	VEQA	1		SPS8094007092	

ENS/ASS | S.ENS/S.ASS

LAYOUT D'INSTALLATION MACHINES LEP-SPS

SPS LSS4
HALF PERIOD QDA 41710 – QFA 41810
SPS LSS4
DEMI PERIODE QDA 41710 – QFA 41810

ECHELLE SCALE 1:10

DES/DRA.	J. RAMILLON	1993-02-25
CONTROLLED	M. TIMMINS	2007-10-19
RELEASED	N. GILBERT	2007-10-24
APPROVED	-	-

SPS\LNINS0\LNINS028

REMPLACE/REPLACES

RELEASED BY PROJECT ENGINEER | AS BUILT | QAC – | SPSLNINS0028 | SIZE 0 | IND. F

IND.	DATE	NOM/NAME	ZONE	MODIFICATION
F	2007-10-11	J. RAMILLON		Change nomenclature
E	2006-05-15	J. RAMILLON		VERSION 2006
D	2001-06-26	J. RAMILLON		Mise a jour (Shut Down 2001)
C	1999-03-26	J. RAMILLON		MIS A JOUR
B	1998-03-06	J. RAMILLON		MIS A JOUR
A	1995-09-15	J. RAMILLON		–

ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE
EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH
GENEVE

DESSIN SUIVANT TOLERANCES SELON NORMES ISO
DRAWING FOLLOWING TOLERANCES ACCORDING TO ISO STANDARDS

People involved/contacted ....

Tobias Baer	Crab cavities/Machine Protection
Philippe Baudrenghien	RF low level
Krzysztof Brodzinski	Cryo
Rama Calaga	Crab Cavities
Paolo Chiggiato/ Vincent Baglin	Vacuum
Edmond Ciapala	RF
David McFarlane	Space and integration
Rhodri Jones	Beam Instrumentation
Alick Macpherson	Coordination
Elias Metral/Benoit Salvant	Beam dynamics/SPS
Eric Monteinos	RF power
Stefano Redaelli/Belen Salvachua	Collimation
Bruce Yee Rendon	Simulations
Joachim Tucmantel	Crab Cavities + RF
Rogelio Tomas	Optics issues
Frank Zimmermann	Crab Cavities+ measurements
Markus Zerlauth/Jorg Wenninger	Machine Protection

SPS BEAM TEST

CAVITY DESIGN

- SM18 Cavity Testing
- Needed: Review of functional specifications, design envelopes and performance parameters

CRYOSTAT

- Needed: Functional specification, and clarification of design and integration constraints

CRYOGENICS

- Refurbishment of TCF20 unit (4.5K System) ongoing, and capacity to be verified
- Sub-cooling unit (2K System) to beb done in 2013, then commissioning
- Needed: More details on beam test layout and dynamic heat load

VACUUM

- Possible conflict with COLDEX Installation
    - May need to construct new Y chamber
- Needed: inputs/constraints on vacuum conditions required from RF team
    - eg is differential pumping needed

SPS BEAM TEST - II

OPTICS

- low intensity LHC beams in SPS: determine hardware + measurement conditions
- Location: Initial proposal = COLDEX location. (small Horizontal beta-function)
  - Local optics knobs: β-functions knobs if CC voltage not OK for SPS energy (26-450 GeV)
  - Alternative locations: RF, cryogenic and other infrastructure constraints.
  - Needed: inputs/constraints for cavity functional specifications

IMPEDANCE AND INSTABILITIES

- Accurate knowledge of CC impedance and tolerances for HOM damping.
- SM18 + SPS tests: characterization CC impedance and damping to stay below instability thresholds.
- Needed: Input for layout constraints in SPS layout

LONG-RANGE BEAM-BEAM EFFECTS

- Effect of long-range beam-beam to be estimated using crabbed bunches and long-range beam-beam wires. Need to investigate the sensitivity at different tunes.

SPS BEAM TEST - III

RF NOISE, STABILITY AND CONTROLS

- Effect of RF noise on the beam emittance to be measured and understood.
- Definition of beam parameters: Tilt from crab cavity >= horizontal beam size
  - normalized emittance ~2 μm + E ~ 55 GeV/c or E > 120 GeV/c and I ~ $1x10^{10}$
  - SPS emittance growth of about 20%/hr in coast but need ~1%/hr
    - need to improve working point and or measurement process
- Parametric scan of RF noise amplitude and freq for evaluation of beam size evolution.
  - Aim: Establish final tolerances for the construction of the LHC crab cavities.

BEAM INSTRUMENTATION

- Most instrumentation in place or adaptable.
  - Exception: Streak camera to be developed .... could be ready for 2016
- Needed: understanding of what is required when.

SPS BEAM TEST - IV

COLLIMATION

- Proposal: Two collimators to be used [SLAC (not yet installed) + CERN (installed)]
  - Collimation in horizontal (crabbing plane).
  - Phase advance: SLAC -> almost no crabbing, CERN -> full crabbing
  - Collimation study: determine efficiency, beam losses + hierarchy.

MACHINE PROTECTION

- Issues due to fast voltage and phase failures; loss characteristics understood.
  - Induced RF trips studied to guarantee machine protection and to devise interlocks.

OPERATIONAL ASPECTS

- Cavity transparency in single-beam scenario: beam behaviour at “zero-voltage”
- beam loading and transient effects with and without RF feedback.
- Long term effects with crab cavities on coasting beams at various energies.

Next steps ...

- Identify/confirm participants
- define/review relevant inputs for cavity functional specification
- Draft functional specification for implementation of SPS Beam Test
  - Target date: end of year 2012
- Outline location and schedule for SPS Beam tests
  - seek preliminary endorsement
- Input from round table discussion ....

- Agree on next meeting time
  - Meetings to be managed via INDICO
  - WG website to be established