LHC Commissioning – how to get organised

1. Introduction

The following concentrates on commissioning the LHC machine with beam. The detailed organisation for the technical services, the LHC injectors and the LHC cryogenics are not discussed. It is understood that these activities will require several people on shift in the control room.

The overall picture is to have a central team of people driving the LHC beam commissioning, whose main thrust is to press on with the agreed program. This team works 24/7, and hence is composed of shift workers and associated supervision.

This team must have considerable and effective support from both Accelerator Physics and Equipment Specialists. This support is a major enterprise, and will need to be organised effectively.

2. Commissioning strategy

Several phases are foreseen for commissioning the LHC over the first 2 years or so:

1. Establish colliding beams with 43 low intensity bunches and no crossing angle or squeeze
2. Push some or all of bunch intensity, number of bunches, squeeze
3. Move to 75ns and use this to learn multi-bunch operation
4. Move to 25ns operation, up to the intensity limitation dictated by the phase I collimators and the partial installation of the beam dump dilution kickers.

The outline of the first and second phases is summarised in the following table.

	Phase	
1	First turn	Ring 2; Ring1. Commission injection, thread beam around first turn, commission relevant beam instrumentation.
2	Circulating beam	Ring2; Ring 1. Capture, adjustment of key beam parameters
3	450 GeV - Preliminary system commissioning	
4	450 GeV - Detailed measurement program	Increase current, machine protection, transverse damper, aperture, optics.
5	450 GeV - two beams	Pilots → higher intensity. Separation bumps, BLMs, crosstalk
6	Switch to nominal cycle	
7	Snapback – single beam,	Ring 2, ring 1
8	Ramp - single beams	Single beam, ring 2; ring1. Stop in ramp. Commission beam dump, machine protection in ramp, ring 2.
9	Single beam at physics energy	Ring 2, ring1 (± separation bump). Measurements.
10	Two beams to physics energy Collide pilots. Unsqueezed.	Collide procedure - first pass.
11	Physics. Unsqueezed.	Experiments on. Increase to 43 on 43
12	Commission squeeze	Single beam partially through squeeze, etc.
13	Physics with partially squeezed beams. No crossing angle.	

3. Organisation

For the long-term exploitation of the LHC, a team of EICs and Operators are foreseen in the AB/OP staff plan. However, the EICs and Operators will not be able to run the machine until it has been commissioned and procedures established. This is the job of the commissioning team.

We foresee a team of experienced engineers and physicists who all have a broad knowledge of the LHC and the commissioning plan.

In order to push through the commissioning plan, we feel that a scheduled presence of an experienced engineer/physicist is essential.

On the other hand we feel that longer term supervision is also needed.

The different roles and 'qualifications' needed are detailed below.

4. Machine Coordinator (3 or 4 needed)

Role: Take overall responsibility for the LHC machine for a period of 1 week:

- Implementation of the LHC commissioning program
- Supervising and directing the shift crews
- Ensuring the necessary follow up is done
- Chairing daily commissioning meetings
- Reporting progress and problems to the wider community
- Not (necessarily) a hands-on activity

Qualification: Experienced accelerator physicist. Must have a thorough knowledge of the LHC and the commissioning plan. Must have a wide knowledge of the supporting equipment groups. Experience of doing a similar job would be a clear advantage.

5. Shift workers (≥ 7 needed per post) on the LHC machine

5.1. Engineer in Charge (EIC) Long term (years)

Role: To run the LHC machine during an 8 hour shift:

- Under the guidance of the LHC Machine Coordinator
- Take overall responsibility for the LHC from the CCC
- Drive the machine through the regular operational cycle
- Establish procedures for future operation
- Assist the LHC Commissioner

Qualification: Physicist or Engineer. Expect to draw on staff with experience as EIC on other machines, or who have worked on LHC construction projects. We should aim to hire a pool of scientists with a wide range of specialties, each of which brings their own ideas on how to improve operations. Must be prepared to perform this role for 4 or 5 years, before moving on to other things (maybe Machine Supervisor).

5.2. Commissioner — Year 1, maybe Year 2

Role: To execute the LHC commissioning program during an 8 hour shift:

- Under the direction of the LHC Machine Coordinator
- Hands-on work on the machine
- Make the necessary beam measurements and implement corrections
- Obviously in close collaboration with the EIC
- Not obliged to stay in CCC (for example if there is no beam) but should be scheduled

Qualification: Experienced accelerator physicist. Must have a good knowledge of the LHC machine and physics. Must be committed to doing this until the LHC operation becomes routine enough to leave to the EIC (1 or 2 years).

5.3. Control Room Operator — Long term (years)

Role: to assist the EIC.

Qualification: Experienced accelerator operator. Good knowledge of the LHC machine. Expect to draw on staff with experience of LHC hardware commissioning, LHC magnetic measurements or LHC applications software.

6. Accelerator Physics and Equipment Support

All accelerator systems will need to be commissioned, first during hardware commissioning and later with beam. Once a system has been made to run, it will need frequent expert support to make it continue to work. While responsibility for the performance of any accelerator system rests clearly with the group(s) concerned, in some cases it would prove extremely useful to have personnel directly concerned with machine operation also involved.

We will need a pool of accelerator physicists ready to push through particular phases of the commissioning program and to pick up on the inevitable surprises that will crop up along the way. Although not shift work, must be committed to doing this until the LHC operation becomes routine. We will also need accelerator physicists responsible for specific aspects, or 'beam-based systems'.

7. LARP

In the present US-LARP proposal, resources are allocated for "Beam Commissioning and Accelerator Physics" activities from 2004 onwards, rising to significant numbers by 2007. In the discussions to date, we have made the point that the US-LARP commitment has to be made with long-term individual commitments of around 12 months, and that US staff should come to perform a specific role in the beam commissioning work. It has also been clearly said that CERN has to maintain sufficient expertise, particularly on shift, to ensure long-term exploitation of the machine.

With this in mind, we feel that a very limited number of US-LARP resources could participate in the shift rota. Rather, they would be best suited to the accelerator physics and equipment group support activities.

8. Accelerator systems and responsibilities

	System	Equipment group	AB / OP / LARP / other
Needed pre beam	Control system	B.Frammery	
	Applications software	M.Lamont	F. Schmidt
	Accelerator technical services	P.Sollander	
	Vacuum technical service	M.Jimenez	
	Cryogenics	L.Serio	
	Access	P.Ninin	G.Roy
	Cold magnets	L.Rossi	
	Warm magnets	K.K.Mess	
	Transfer line magnetic elements	B. Goddard, V. Mertens	H. Burkhardt, T. Risselada
	Magnet circuits and power converters	F.Bordry	F. Schmidt
	Injection elements • Kicker • Septa	V. Mertens • J. U. • J. B.	H. Burkhardt, T. Risselada
	Reference magnet system	L.Bottura	M.Lamont, S. Fartoukh
	Power Interlock System (PIC)	B.Puccio	
	Quench Protection and Energy Extraction (QPS)	K.H.Mess	
Needed for beam	Radio protection	D.Forkel-Wirth	R. Assmann
	Beam instrumentation • Screens • BCT • BPM, trajectory and orbit correction • BLM - • PLL for Q, Q', coupling • Profile monitors • Luminosity monitors -	H.Schmickler • X • X • X X • X X • X • X • X X	 • H. Burkhardt • Y • J.Wenninger W. Herr • B. Jeanneret S. Gilardoni • S. Fartoukh • S. Gilardoni • R. Assmann F. Zimmermann
	Beam in the injectors		G. Ardunini, M. Martini
	SPS extraction, transfer, injection and first turn	V.Mertens J.Uythoven	H.Burkhardt T.Risselada W. Herr
	Orbit feedback system	J. Wenninger	W. Herr
	Collimation system and halo cleaning	R.Assmann	H. Braun (ions)
	Protection devices other than collimator (TCDQ etc)	B. Goddard	H. Burkhardt
	Vacuum conditions during operation and electron cloud	M.Jimenez	F. Zimmermann
	Multi turn losses and BIS dependability		R.Assmann R.Schmidt
	Clean Beam Extraction	B.Goddard	
	Filling efficiency and flat bottom conditions		R.Assmann
	Ramp and squeeze losses and overall quality		R.Assmann
	RF systems and longitudinal beam dynamics	T.Linnecar O.Brunner P.Baudrigen	F. Ruggiero
	Transverse feedback	W.Hofle	E. Metral
	Schottky		E. Metral, F. Zimmermann

	Optics		O.Bruning S. Fartoukh T.Risselada M. Giovannozzi W. Herr
	Mechanical Aperture		J.B.Jeanneret
	Machine Impedance and collective instabilities		F. Ruggiero, E. Metral, F. Zimmermann
	Dynamic Aperture		W. Herr, F. Schmidt, F. Zimmermann
	Lattice corrector powering		S. Fartoukh, F. Schmidt
	Triplet corrector powering		S.Farthouk, F. Schmidt
	Lifetimes		J.Jowett, F. Zimmermann
	Beam crossing and separation schemes		W. Herr, F. Zimmermann
	Collisions and luminosity steering		W. Herr, R. Assmann
	Experimental solenoids and compensations		W. Herr
	Experimental equipment (Roman pots, velo)		W. Herr, H. Burkhardt
	Experimental conditions		
	Ions		S. Giulardoni, J.Jowett C.Carli S.Maury