

OVERVIEW OF THE MDs IN 2007

E. Métral

- ◆ **3 types of Machine Developments (MDs)**
 - In parallel with physics (working days from 08:00 to 18:00)
 - PS and SPS “Wednesday” MDs (08:00 - 16:00, usually on We’s)
 - SPS Long MD (24 h, normally from 08:00 to 08:00)
- ◆ **Distribution of the dedicated MD sessions in 2007 is available on the web in the accelerator schedule:** <http://ab-div.web.cern.ch/ab-div/Schedules/schedule2007.pdf>
- ◆ **Form available on the web** (http://ab-mgt-md-users.web.cern.ch/ab-mgt-md-users/MD_request_form_last.htm) **to submit MD requests**

2007 Accelerator Schedule

Approved by the Research Board 29th November 2006

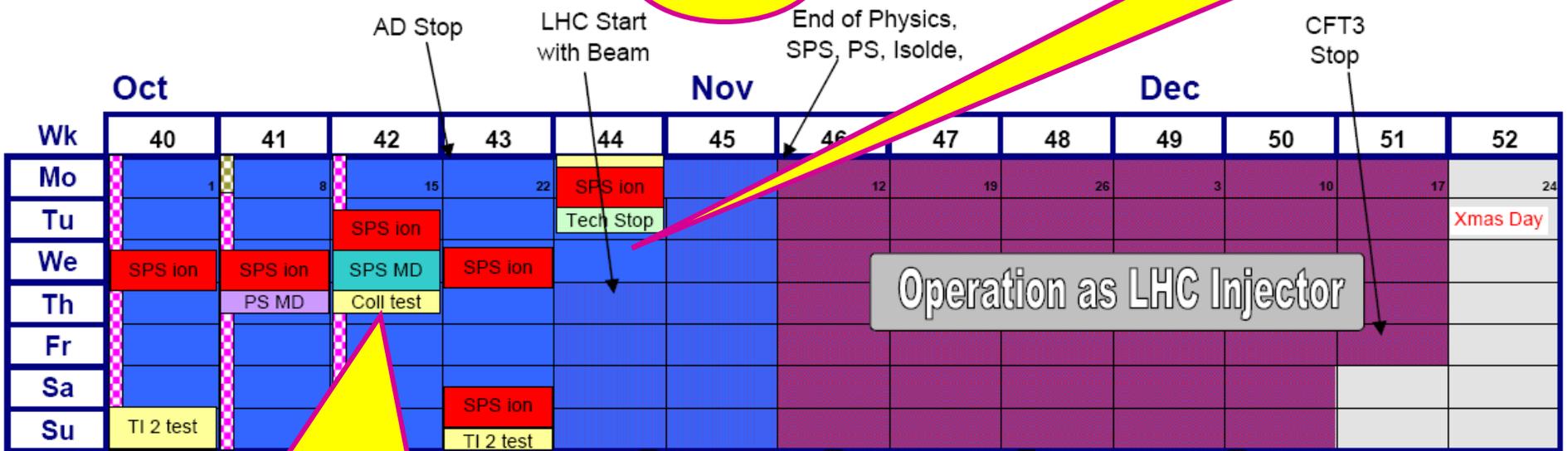
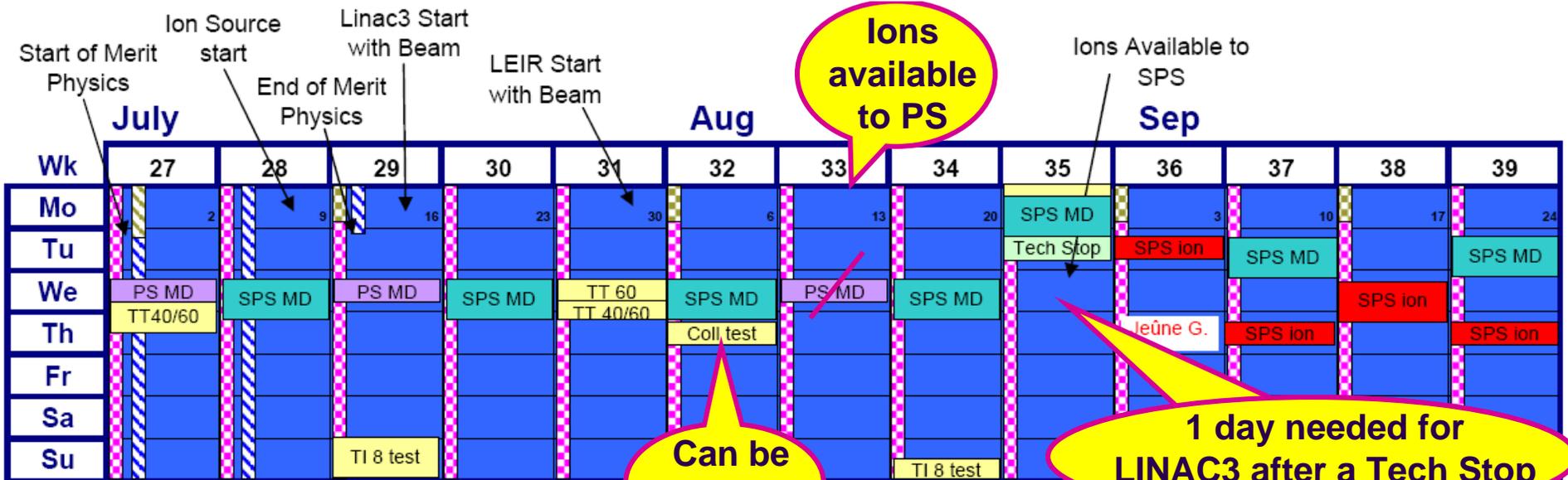
	Jan				Feb				Mar				
Wk	1	2	3	4	5	6	7	8	9	10	11	12	13
Mo	1	8	15	22	29	5	12	19	26	5	12	19	26
Tu											Linac2 HW Tests		PSB Machine Checkout
We											PSB HW Tests		
Th					shutdown								
Fr													
Sa											PS Magnet Tests		PS HW Tests
Su													

CFT3 Start
CPS Closure
Beam in Linac2
SPS Closure

	Apr			May			June						
Wk	14	15	16	17	18	19	20	21	22	23	24	25	26
Mo	PSB 2	Easter 9	16	23	30	7	14	21	Whit 28	Tech Stop	11	18	25
Tu	Machine Checkout				1 May								
We		PS Machine Checkout											SPS MD
Th	PS HW Tests								PS MD		PS MD		
Fr	G.Friday												
Sa	SPS Power Tests		SPS DSO Checks		SPS Machine Checkout								
Su													

PAC07

PS MD of W33 ⇒ During SPS realignment



Will be used to prepare the slow extraction for the crystal collimation

PS MD	Dedicated PS MD	Weeks with AD Physics
SPS MD	Dedicated SPS Proton MD	AD Setting up
SPS ion	Dedicated SPS Ion MD	Weeks with Merit (nToF11) Physics
TI 2 Test	Special Dedicated Test	Merit Setting up
SPS Scrubbing Run		

3/39

OUTLINE

- ◆ **SPS scrubbing run**
- ◆ **TT40/60 and TI2/8 tests**
- ◆ **SPS commissioning with the Early LHC Ion Beam**
- ◆ **Main studies**
 - **LINAC2&3**
 - **PSB**
 - **PS**
 - **SPS**
- ◆ **Summary of the required beams**
- ◆ **Summary of the required SPS cycles**
- ◆ **Use of the SPS cycles in the different Long MDs**
- ◆ **Instrumentation needed**
- ◆ **Organization**

**See G. Arduini's talk
at LTC (25/10/06)**

TT40/60 AND T12/8 TESTS (1/2)

⇒ **Not in the MDs list, but we have to be sure that the required beam is ready!**

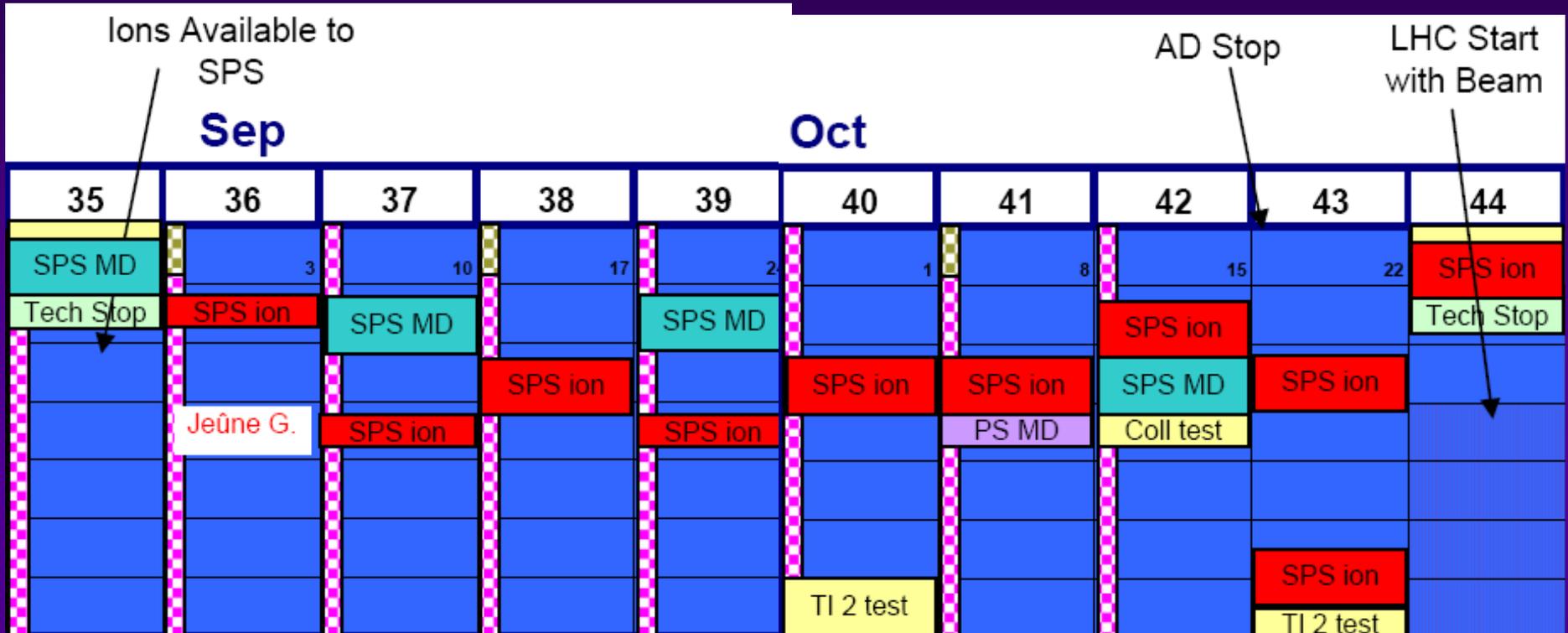
- ◆ **W27: TT40/60 (Interleaved extractions, low intensity ⇒ Pilot and up to 12 bunches)**
- ◆ **W29: T18 (Low intensity ⇒ Pilot and up to 12 bunches)**
- ◆ **W31: TT40/60 (Interleaved extractions, high intensity ⇒ Up to 4 batches of 72 bunches)**
- ◆ **W34: T18 (High intensity ⇒ Up to 4 batches of 72 bunches)**
- ◆ **W40: T12 (Low intensity ⇒ Pilot and up to 12 bunches)**
- ◆ **W43: T12 (High intensity ⇒ Up to 4 batches of 72 bunches)**

⇒ **The LHC pilot bunch has to be ready in the SPS for W27 on July 4**

TT40/60 AND TI2/8 TESTS (2/2)

- ◆ Email from J. Uythoven (13/04/07): **The details of the TI8 tests of this year remain to be determined... For W34 we presently foresee operation with 4 x 72 bunches of 1/3 of nominal intensity and 1 x 72 bunches with nominal intensity. For the TI2 tests this has not been discussed in detail, but it is likely to be similar to the TI8 tests**
- ◆ In the summary notes of the coordination meeting of TI8 Beam Tests 2007 on 16/04/07: **It is thought to be more efficient to move the beam tests from the Saturdays 12:00 to the Sundays 12:00 ⇒ Advantages that the beams can be prepared during the day time and there is more radiation cool down time before the access to be given to the zone (Monday morning). A request will be made to the ABOC to make this change to the accelerator schedule**

SPS COMMISSIONING WITH THE EARLY LHC ION BEAM (1/4)



Main aims (*with decreasing priority*) - **Contact person: Django**

- ◆ **Produce the Early Ion LHC beam Pb^{82+} at the exit of the SPS (TT40/60)**
 - Up to 4 x 1 bunches with $N_{\text{bunch}} = 9 \times 10^7$ ions, $\varepsilon_{H(V)}^* = 1.2 \mu\text{m}$, $\varepsilon_L = 0.28 \text{ eV.s/u}$
 - Extraction momentum: 177.4 GeV/c/u, bunch spacing: 1350 ns
 - Reduced injection plateau (7.2 s) and “fast” ramp

SPS COMMISSIONING WITH THE EARLY LHC ION BEAM (2/4)

⇒ Re-phasing and synchronisation with LHC might be postponed to 2008 as well as the extraction with several bunches to TT40/60 (see W. Hofle's talk at I-LHC meeting, 29/03/07). Note that interleaved CNGS and ions extractions are not possible (re-cabling needed, ~ 2 h)

- ◆ Investigate space charge and IBS at injection momentum in coast (in order to rule out the need for the installation of 100 MHz cavities in the SPS and the bunchlet scheme in the PS)
- ◆ Study the collimation of Pb^{82+} ions in the SPS with LSS5 LHC prototype collimator ⇒ Verify the physical model used in the simulation of the collimation efficiency (according to this model, at present, ion collimation limits the total intensity to ~ half the nominal) ⇒ W42
- ◆ Start investigations on possible means to enhance collimation efficiency for ions with crystals ⇒ W43

⇒ **Total need:** 24 dedicated shifts (1 shift = 8 hours) + 10 parallel shifts

SPS COMMISSIONING WITH THE EARLY LHC ION BEAM (3/4)

◆ Work for the ions in the PS

■ Setting-up (W33 and 34)

- Sensitivity of the radial PU \Rightarrow Has an impact on the early beam
- Lower intermediate plateau (0.17 T instead of 0.31 T) \Rightarrow Has no impact on the early beam
- Commissioning of low-beta in TT2 with new power supplies (the current in QFO205 was not sufficient last year)

■ MDs (starting in W35, i.e. 27/08)

- 5 sessions of 8 h
- Parasitic to all normal operation, but there is a risk of conflict - particularly in the beginning - between nominal and early beams
- Control of the relative phasing between the different harmonic components of the 10 MHz system
- Local oscillators \Rightarrow It should be possible to minimize the complexity of the nominal beam control
- Several more MDS to finish the nominal beam

SPS COMMISSIONING WITH THE EARLY LHC ION BEAM (4/4)

- ◆ **LEIR to PS matching – Contact person: C. Carli**
 - 2 dedicated **MDs** of 4 h
 - Early LHC ion beam needed \Rightarrow W41

MDs in LINAC2 (A. Lombardi)

- ◆ **Steering and control of the losses in the line LT-LTB**
 - 4 h
 - Parallel
- ◆ **Study the effect of dispersion / space charge / buncher voltage on the emittance at the PSB**
 - 4 h
 - Dedicated
- ◆ **Test the automatic beam steering procedure that they are developing for PATH**
 - 4 h
 - Parallel

MDs in LINAC3 (D. Kuchler & E. Mahner)

- ◆ **Heavy-ion-induced desorption experiments with warm and cold targets**
⇒ Continue to run LINAC3 as main user from W44 until W50

MDs in PSB (1/2)

- ◆ Space charge **studies at 160 MeV; parallel** (M. Chanel)
- ◆ **Performance with acceleration with decreased $B\dot{\theta}$ at low energy; parallel**; Study the impact of staying longer with large space charge tune shifts (which will be the case with LINAC4) on the performance (C. Carli)
- ◆ **Some** further work on the early LHC beams; parallel (K. Hanke)
- ◆ **Some** work on the 25ns and 75ns LHC beams; parallel (K. Hanke)
- ◆ Set-up of the beam for MERIT; parallel; quite demanding **and will require one or more cycles** during June (K. Hanke) \Rightarrow Problems of cycles should be discussed with the physics coordinator
- ◆ **Continue** measurements with the wire scanners; parallel (K. Hanke)

MDs in PSB (2/2)

- ◆ Ejection synchronisation studies **by the RF group (digital beam control...)**: 1 PSB cycle for the last week of June and the first week of July; parallel; **Partly the MD can be done using a free PSB ring of the EAST user \Rightarrow In this case it will be transparent (M.E. Angoletta). Another week in ~ September might also be needed**
- ◆ Flat bunches **created** in the PSB **to** reduce the space charge tune spread at PS injection **on the nominal LHC beam (C. Carli & E. Métral)**

Dedicated PS MD (1/4)

◆ 5-CM for the PFWs

- **Contact person: R. Steerenberg**
- **3 dedicated MDs (W19 instead of W33, 22 and 24) and then parallel**
- **TSTPS beam**

**We will try and schedule
this PS MD the day of realignment
in the SPS**

**⇒ Only 3 dedicated PS MDs remain (in W27, 29 and 41) for
the following studies**

Dedicated PS MD (2/4)

- ◆ Commissioning of a delayed MHS clock for groups of 10 MHz cavities
 - **Contact person:** M. Schokker & J.-L. Vallet
 - **2 shifts \Rightarrow No AD and LHC-type beams**
 - **TSTLHC, $1.2 \cdot 10^{11}$ p/b**
 - **HW requirement: New delay module (Ready for begin. of May)**

- ◆ Fast switching between LHC-type beams
 - **Contact person:** S. Hancock
 - **2 shifts \Rightarrow No LHC-type beams**
 - **TSTLHC / LHC, $0.2 - 1.2 \cdot 10^{11}$ p/b**
 - **HW requirement: New delay module for H84 phase loop (Ready for begin. of May)**

Dedicated PS MD (3/4)

- ◆ Investigation of 10 MHz cavity trips due to coupled-bunch feedback
 - **Contact person: H. Damereau**
 - **1 shift**
 - **LHC, Max. p/b**
- ◆ 75ns LHC variant
 - **Contact person: S. Hancock**
 - **2 shifts**
 - **MDRF / MDSPS, $1.2 \cdot 10^{11}$ p/b**
 - **HW requirement: PA.GSPC20 (Ready)**

Dedicated PS MD (4/4)

- ◆ **Bunch rotation with two 40 MHz voltage steps at extraction of the LHC beam**
 - **Contact person: S. Hancock**
 - **1 shift**
 - **LHC, $1.2 \cdot 10^{11}$ p/b**
 - **HW requirement: Fast digital oscilloscope with large memory for WCM03 (No pb)**
- ◆ **Beam-based voltage calibration of the 200 MHz system**
 - **Contact person: H. Damereau**
 - **Dedicated**

APC action \Rightarrow Will we remove another 2 cavities at the end of the 2007 run?

Parallel PS MD (1/4)

- ◆ Optics measurements on AD beam with QKE58 on and off
 - **Contact person:** E. Benedetto
 - **AD, low intensity**
- ◆ TT2 (dispersion) matching after QKE58 removal
 - **Contact person:** E. Benedetto
 - **LHC-type**

Parallel PS MD (2/4)

◆ Test LHC cycle and beam for run without motor-generator set

- **Contact person:** R. Steerenberg
- **Dedicated beam (e.g. MDSPS)**

Reminder: No spare until ~ 2010!

◆ CT Loss displacement tests

- **Contact person:** S. Gilardoni
- **SFTPRO or CNGS**

◆ MTE related MD's

- **Contact person:** S. Gilardoni
- **MD1 in PSB and MD2 in PS**

⇒ **PSB will need ~ 1 day to prepare the pencil beam and ~ 1/2 day to prepare the high-intensity one. The high-intensity beam should be prepared just after the scrubbing run (W25)**

A bunch with ~ $3e12$ p/b (i.e. ~ half required high intensity) and large horizontal emittance should be available asap

Parallel PS MD (3/4)

◆ Loss reduction around transition using triplet unbalancing

- **Contact person: S. Gilardoni**
- **AD**

Edgar et al. installed all the HW for ecloud measurements in SS98 (Clearing electrode in an antechamber
⇒ No aperture restriction, fast, i.e. ~100ms, gauge, and dipolar field until 100 Gauss using a C-magnet + windings around)

◆ LHC high energy instability

- **E-cloud measurements**
 - **Contact person: E. Mahner**
- **Other measurements**
 - **Contact person: R. Steerenberg**

⇒ Possible PS scrubbing run in the future?

◆ Transverse damper studies / commissioning

- **Contact person: A. Blas**
- **LHC nom. but with lower intensity on the 26 GeV/c flat-top**

Parallel PS MD (4/4)

- ◆ **BBQ tune measurements**
 - **Contact person: M .Gasior?**
 - **All (operational) beams**
- ◆ **Beam Break Up measurements at transition**
 - **Contact person: E. Métral**
 - **TOF-like (MTE)**

Long MDs in SPS (1/7)

- ◆ LHC beam with 25 ns bunch spacing
 - **Achieving nominal parameters**
 - **Contact person: T. Bohl**
 - **8 h \Rightarrow W26**
 - **SPS-LHC re-phasing on the flat top**
 - **First low (1/2) intensity and then nominal intensity**
 - **Contact person: P. Baudrenghien**
 - **4 \times 4 h**
 - **SPECIFIC dates for MDs: W30, 35, 37, 39**
 - **PS-SPS transfer optimisation (capture/flat-bottom losses)**
 - **Contact person: E. Shaposhnikova**
 - **8 h \Rightarrow W26**

Long MDs in SPS (2/7)

- ◆ LHC beam with 75 ns bunch spacing - to see results of RF settings in the PS on LHC beam quality at 450 GeV/c + some modifications made in the SPS (adapters...)
 - **Contact person:** T. Bohl
 - **8 h** \Rightarrow W39
- ◆ BBLR
 - **Contact person:** Frank Zimmermann
 - **(2 parallel MDs of 5 h at 26 GeV/c \Rightarrow W30)**
 - **4 h + 7 h at 55 GeV/c \Rightarrow W34 and W35**
- ◆ Matching monitor in the SPS
 - **Contact person:** Elena Benedetto
 - **2 shifts \Rightarrow W30 and 39**
 - **MESPS**

Long MDs in SPS (3/7)

◆ RF studies with coasts

- **Slow controlled longitudinal emittance blow-up (LHC test-bed) \Rightarrow 270 GeV/c, W28 (T. Bohl)**
- **Beam stability in double harmonic RF system (LHC upgrade test-bed) \Rightarrow 4 h, 270 GeV/c, W32 (E. Shaposhnikova)**
- **Bunch shape evolution (LHC upgrade test-bed) \Rightarrow 4 h, 270 GeV/c, W35, (E. Shaposhnikova)**

◆ Abort gap cleaning tests in view of LHC

- **Contact person: A. Koschik**
- **4 parallel MDs of 4 h on the SPS OP MD cycle + 1 dedicated MD of 8 h (LHC), 26 GeV/c coast, W32**

Long MDs in SPS (4/7)

- ◆ **Scraper commissioning**
 - **Contact person:** Helmut Burkhardt
 - **MD requirements similar to 2006, 270 GeV/c**
 - **Will be put at the end of some long MDs: W28, 32, 35, 37, 42**
- ◆ **Precise calibration of the beam energy at 450 GeV using protons and lead with the central frequency**
 - **Contact person:** Jorg Wenninger
 - **3 × 4-8 h**
 - **Ideally must be done by injecting first protons and then Lead on the same cycle ⇒ Should be done when the ions are ready (at 450 GeV/c) ⇒ W43 and 44**
- ◆ **Identify most robust filling scheme (48 vs 72 bunches) for first years of operation (action of the LHCCWG, 14/02/07)**
 - **Contact person:** SPS operation (OP training), W26 and 30

Long MDs in SPS (5/7)

- ◆ On-line modeling (for LHC) with MADX
 - **Contact person: Ilya Agapov**
 - **120 GeV/c (the 26 GeV/c flat-bottom will also be used)**
 - **$2 \times 4 \text{ h} + 8 \text{ h} \Rightarrow \text{W34 and 42}$**
- ◆ Study for the LHC BLM system \Rightarrow Contact person: Barbara Holzer
 - 3 sessions
 - **Before start-up 2 hours without beam. With the kicker magnets pulsing (injection kickers and dump kickers)**
 \Rightarrow To be done during the cold checkout
 - **$3 \times 2 \text{ h}$; "semi-parasitically". Beam on the TIDV internal SPS dump at all possible intensities (10^{10} to 10^{13}) \Rightarrow In the shadow...**
 - **$2 \times 4 \text{ h}$ at 270 GeV/c; LHC collimator installed inside the SPS \Rightarrow W37 and W42**

Long MDs in SPS (6/7)

◆ Q' measurements (for LHC)

- **Contact person:** Ralph Steinhagen
- **4 kinds of MDs**
 - **Q' measurements based on slow dp/p modulation and continuous Q tracking** $\Rightarrow 3 \times 8$ h, 26 or 270 GeV/c coast (3rd meas.)
 - **Indirect Q' through measuring the tune width** $\Rightarrow 3 \times 8$ h, 270 GeV/c (1st meas.)
 - **Kicked and continuous head-tail Q' measurements** $\Rightarrow 3 \times 4$ h, 270 GeV/c (2nd meas.)
 - **Hardware/Software tests of the tune (beam transfer function) measurement using the internal DAB fast chirp excitation** $\Rightarrow 3 \times 4$ h, 26 GeV/c scrubbing run

\Rightarrow W28, 32, 35, 37, 42 **at 270 GeV/c coast**

\Rightarrow W30 **and 34 at 26 GeV/c coast**

Long MDs in SPS (7/7)

- ◆ Effect of energy on the electron cloud fast instability
 - **Contact person:** Giovanni Rumolo
 - (37 GeV/c MD cycle **with 1 batch before the scrubbing run** \Rightarrow **The nominal LHC beam should be ready for W23 and this new cycle should be tested during the cold checkout**)
 - 120 GeV/c, **4h**, W34
- ◆ Beam lifetime studies (scan in transverse emittances)
 - **Contact person:** Giovanni Rumolo
 - 26 GeV/c coast, **4 h**, W26
- ◆ Study of the Montague resonance with unsplit and split tunes
 - **Contact person:** G. Arduini & E. Métral
 - (1 parallel session of 4 hours) + 1 dedicated of 4 hours (**Re-cabling to have the split tunes in the SPS**), W39
 - **MESPS beam**

Parallel MDs in SPS (1/3)

- ◆ **Single bunch \Rightarrow MESPS (should be prepared for W28)**
 - **Contact person: E. Shaposhnikova**
 - **Variable intensity with constant longitudinal parameters (quadrupole frequency shift as a function of intensity to monitor longitudinal impedance - less MKEs in 2007) \Rightarrow 2×8 h, 26 GeV/c, short bunches (3 ns) in W28 and 29**
- ◆ **Global impedance \Rightarrow MESPS**
 - **Contact person: Helmut Burkhardt**
 - **2×8 h after Elena (W28 and 29)**

Parallel MDs in SPS (2/3)

- ◆ **Fast vertical single-bunch instability at injection**
 - **Contact person:** Benoit Salvant
 - **MESPS \Rightarrow After Helmut (W28 and 29)**
 - **Scan in bunch intensity and record the transverse modes**
- ◆ **Calibration TT2-TT10-SPS pick-ups**
 - **Contact person:** Elena Benedetto
 - **8 h**
 - **MESPS \Rightarrow After Benoit (W28 and 29)**
 - **1-4 bunches, with bunch rotation**
- ◆ **Optics measurements MESPS beam with QKE58 on and off**
 - **Contact person:** Elena Benedetto
 - **8 h**
 - **MESPS \Rightarrow After Elena (W28 and 29)**
 - **1-4 bunches, no bunch rotation**

Parallel MDs in SPS (3/3)

- ◆ Study and measurements of BPM offsets in the TT10 transfer line
 - **Contact person:** Jorg Wenninger
 - **2 × 4 h**
 - **MESPS ⇒ After Elena (W29)**
- ◆ Systematic measurements of the horizontal and momentum aperture in the SPS
 - **Contact person:** Stefano Redaelli
 - **During the start-up, i.e. from W19 to 21**

Summary of the required beams

- ◆ **W23: Nominal LHC beam at SPS entrance**
- ◆ **W27: Pilot at SPS exit**
- ◆ **W28: Single-bunch (called MESPS in the past) in SPS at 26 GeV/c**
- ◆ **W39: 75 ns at SPS exit**

**Will become operational
this year (individual bunch
LHC beam LHCINDIV)**

Summary of the required SPS cycles (1/2)

◆ Scrubbing run

- 26 GeV/c coastable \Rightarrow Should be tested during the cold checkout

◆ SPS Long MDs

- LHC nominal 450 GeV/c
- 270 GeV/c coastable
- 120 GeV/c
- 55 GeV/c
- 37 GeV/c \Rightarrow Based on the SPS OP MD cycle below... and should be tested during the cold checkout

◆ SPS OP MD cycle (accepted by the physics coordinator) in parallel

- LHC pilot of 8.4 s (from 26 to 450 GeV/c) with a flat-top of 100 ms

Summary of the required SPS cycles (2/2)

In discussion

SPS super-cycles / 'pure' LHC

LHC nom. SC ~ 21+ s

- Flat bottom 26 GeV, 10.8 s, 4 injections
- Ramp ~ 8 s
- Flat top 450 GeV, 0.5 s

For the synchro

LHC pilot SC, 8.4 s, ~ same as 2006

- Flat bottom 26 GeV, 60 ms, 1 injection
- Ramp ~ 4.2 s
- Flat top 450 GeV, 0.5 s

FT of ~ 100 ms in fact
(power consumption)

LHC 270 GeV coastable, 28.8 s (or 2BPs shorter ?)

- Flat bottom 26 GeV, 10.8 s, 4 injections
- Ramp to 270 GeV ~ 5 s
- Interm. flat top 270 GeV, 2 s
- Ramp to 450 GeV (no beam !)

For the remnant field

LHC 120 GeV coastable, length ~ same as 270 GeV

- Flat bottom 26 GeV, 10.8 s, 4 injections
- Ramp to 120 GeV ~ 3 s
- Interm. flat top 120 GeV, 2 s
- Ramp to 450 GeV (no beam !)

LHC 55 GeV coastable ??, low intensity, length ~ 16 s ?

- Flat bottom 26 GeV, 60 ms, 1 injection
- Ramp to 55 GeV ~ 1.5 s
- Interm. flat top 55 GeV, 5 s
- Ramp to 450 GeV (no beam !)

Courtesy of J. Wenninger

Use of the SPS cycles in the different Long MDs

- ◆ W26: LHC nom + 26 GeV/c
- ◆ W28: 270
- ◆ W30: LHC nom + 26
- ◆ W32: 26 + 270
- ◆ W34: 26 + 55 + 120
- ◆ W35: LHC nom + 55 + 270
- ◆ W37: LHC nom + 270
- ◆ W39: LHC nom + 26
- ◆ W42: 120 + 270

Instrumentation needed

- ◆ SEM wires in the PS and “ralentisseur”
- ◆ SEMgrids in TT2, pick-ups in TT2 (if possible), emittance measurements in PS, bunch length + dp/p in PS, BLMs in PS
- ◆ Wire scanners (PSB-PS-SPS)
- ◆ Tune measurement
- ◆ Online visualization of lifetime, possibly scraper, BLMs in SPS
- ◆ Beam trajectory in TT2, TT10, SPS; OTR in TT2 and TT10
- ◆ Q-Meter, BBQ-Tunemeter, BCT, FBCT, RF instrumentation, Abort Gap Monitor (only useful at 450 GeV/c and may not be ready for this year...)
- ◆ TT10 couplers and SPS ring BPMs, LHC BPMs with turn-by-turn acquisition
- ◆ ...

Organization

- ◆ **Results and steering \Rightarrow APC**
- ◆ **Weekly beam requirements \Rightarrow ABOC**
- ◆ **Follow-up of the MDs to steer the programme accordingly \Rightarrow Send me few lines or words (I will create a web form for that)**
 - Did you have the required machine/beam conditions for your MD?
 - If not, what were the problems encountered?
 - Current results
 - Next step
 - New requirements?
- ◆ **Many thanks for the MD users' inputs and comments at our Informal Meeting (13/04/07)!**
- ◆ **Please, do not hesitate for any other comment/suggestion...**