STRATEGY FOR MACHINE DEVELOPMENT STUDIES IN 2009

E. Métral (for MSWG)

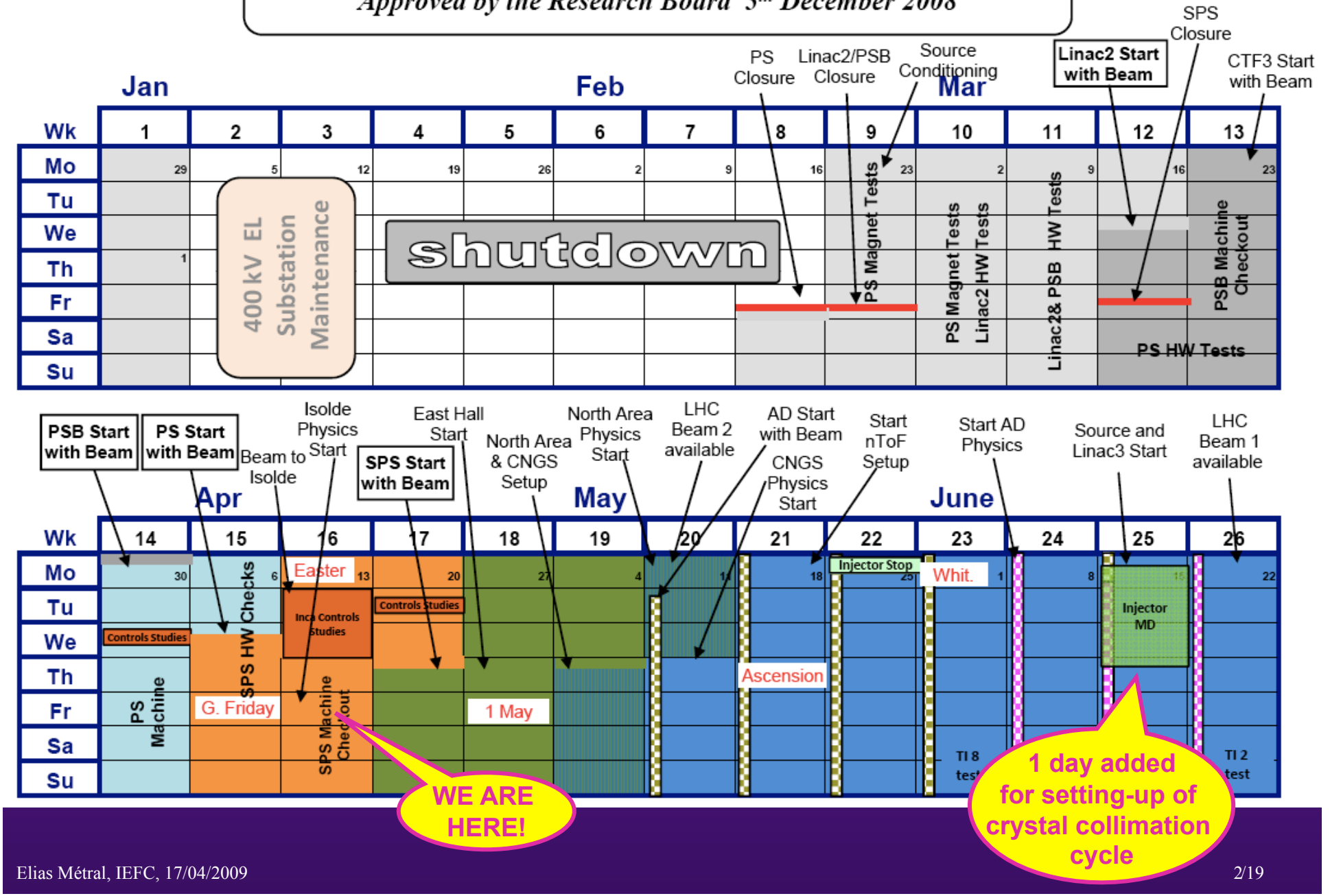
- **BOUNDARY CONDITIONS**
  - LHC beam tests and LHC beam commissioning
  - Readiness of and plans for injectors in 2009 (see also https://espace.cern.ch/acc-tec-sector/Chamonix/Chamx2009/papers/EM_9_04.pdf)
  - SPS ion beam commissioning
  - MTE commissioning
  - CNGS (3.1E19 pot required in 2009 vs. 1.78E19 pot delivered in 2008)
  - UA9 (CRYSTAL) collimation experiment
- **USE OF THE SPS CYCLES IN THE DIFFERENT LONG MDS**
- **MD WEB PAGE**

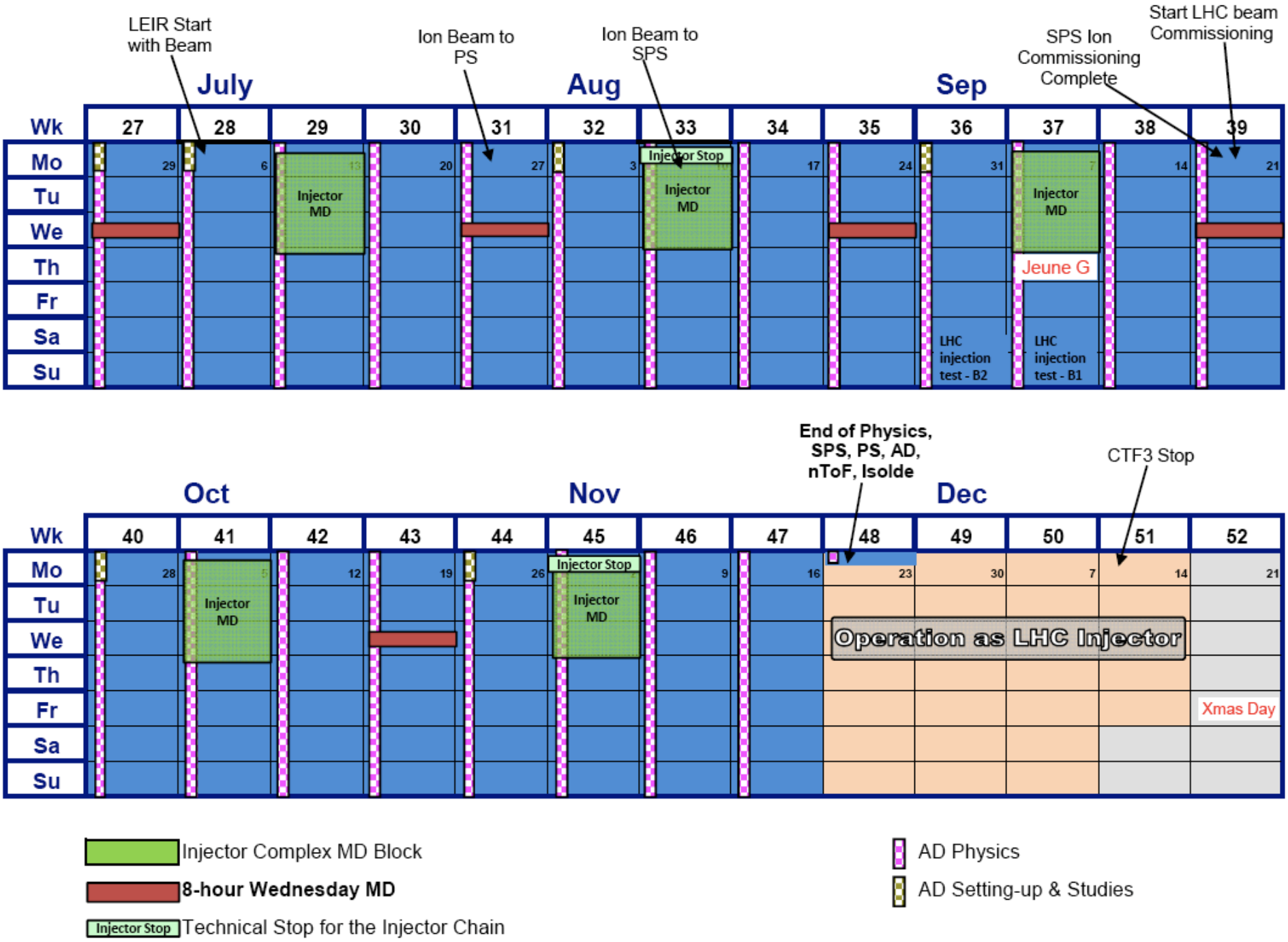
pc

1/3/2009
V3.3

2009 Injector Accelerator Schedule

Approved by the Research Board 5th December 2008




LEIR Start with Beam
Ion Beam to PS
Ion Beam to SPS
SPS Ion Commissioning Complete
Start LHC beam Commissioning
July
Aug
Sep
Oct
Nov
Dec
Wk
27 28 29 30 31 32 33 34 35 36 37 38 39
40 41 42 43 44 45 46 47 48 49 50 51 52
Mo
Tu
We
Th
Fr
Sa
Su
Injector MD
Injector Stop
Jeune G
LHC injection test - B2
LHC injection test - B1
End of Physics, SPS, PS, AD, nToF, Isolde
CTF3 Stop
Operation as LHC Injector
Xmas Day
Injector Complex MD Block
8-hour Wednesday MD
Injector Stop
Technical Stop for the Injector Chain
AD Physics
AD Setting-up & Studies

LHC BEAM TESTS AND LHC BEAM COMMISSIONING

- **LHC BEAM TESTS**
  - TI8 test → Week 23 (only PILOT)
  - TI2 test → Week 26 (PILOT and LHC25 with 12* to 72 bunches ready)
  - LHC injection test – B2 → Week 36
  - LHC injection test – B1 → Week 37

- **LHC BEAM COMMISSIONING**
  - ≥ 21/09/09
  - A Long Injector MD block might be cancelled due to LHC start-up (as last year)

** In the PS the radial loop has been identified as the first (low) intensity limitation at around 1.4E11 p/p total intensity, i.e. 12 bunches with 1.2E10 p/b (H. Damerau, APC, 26/09/08)*

→ Should we plan MDs to study lower intensities? What about LHC50&75?

READINESS OF AND PLANS FOR INJECTORS FOR 2009 (1/7)

- **DONE IN 2008**
  - Rephasing SPS-LHC
  - Low intensity probe beam: 2E9 p/b (instead of 5E9) ➔ Done in the PS with longitudinal shaving at the start of the ramp (Possibility to scan from 2E9 to 5E9 p/b with only 1 Timing)
  - LHC25 and LHC75 beams with intermediate intensities (down to 1/10 for LHC25)
  - Controlled transverse emittance blow-up in SPS
  - LHC50 = LHC25 ½ (No user in the PSB)
    - Small transverse emittances (~1-1.5 μm at 450 GeV/c)
    - Issues with SPS interlocks (outgassing) for intensities > 80% of the nominal one: ZS ion trap and MKDV1
  - Production of the LHC75(50) in 1 batch (instead of 2) into PS ➔ Promising results

  ➔ A particular attention was paid to low-intensity beams (with good reproducibility) to be ready for the LHC's (first) requests

READINESS OF AND PLANS FOR INJECTORS FOR 2009 (2/7)

- **TO BE DONE IN 2009**
  - **Production of the LHC75 in 1 batch (instead of 2) into PS**
    - **MDs are planned asap to check all open issues in detail**
    - **Once it is OK it should become the baseline (after approval by relevant committee) ➔ Could liberate a user in PSB for LHC50 (otherwise, as LHC50 is a variant of LHC25 we could also rename LHC25 as LHC50 and archive LHC25 as well as all its variants!)**
  - **Production of the LHC50/25 in 1 batch (instead of 2) into PS**
    - **PS injection plateau has to be increased by ~ 40 ms for longitudinal blow-up before 3-splitting**
    - **MDs are planned (right after LHC75) for it and study trans. emittance conservation vs. intensity**
  - **Compatibility low-intensity / high-intensity beams in the PS**
    - **MDs were done in 2008 and it is followed up ➔ Should be OK this year (an automatic tuner for the 40 MHz RF cavities is needed to replaced the manual one)**
    - **No MDs foreseen at the moment but will be followed up**

READINESS OF AND PLANS FOR INJECTORS FOR 2009 (3/7)

- Check MKDV1, which was changed during the 2008/2009 shutdown, with both LHC25 (➔ week 25) and LHC50 (➔ week 41)

- SPS matching monitor ➔ Under discussion
  - 1 matching monitor installed in the SPS as a prototype for the LHC (BMO.51997, at 0 dispersion): OTR screen, fast acquisition system, CCD camera not shielded from radiation → Need an access to install / remove it
  - Turn by turn beam profiles @ inj. (first ~ 100 turns)
  - MDs done in 2007
    - ✓ Dispersion mismatch and high chromaticities
    - ✓ Not Gaussian profiles
    - ✓ Rapid filamentation
    - ✓ Development of a coherent motion
  - MDs done in 2008
    - ✓ Measurements with the correct optics ➔ Beam is matched
    - ✓ Introduce mismatch and measure it ➔ Could not be done (pb with the camera)
    - ✓ Go to high chromaticity + See effects on beam shape (to reproduce condition of 2007) ➔ Could not be done

READINESS OF AND PLANS FOR INJECTORS FOR 2009 (4/7)

- LHC long cycle in the PS in case of pb with the motor/generator
  - MDs done in 2008
    - ✓ LHC beam of ~ nominal intensity in the 5 BP cycle with double injection and 3-splitting, accelerated with H21 without losses to the flat top and extracted regularly to D3
    - ✓ The transverse emittances at extraction were almost nominal
    - ✓ High energy gymnastics (2-splittings and bunch rotation) could not be done due to an upper limit of 3600 ms in a very generic class of timings (PTIM-V)
  - MDs are planned in 2009 to finalize the study (POPS will not be available before 2011)

- ecloud studies to see effect of the 3 (graphite) coated MBB magnets in SPS LSS5 + others + to scrub the machine
  - MDs have been planned to study the evolution of the ecloud build-up during the year ➔ The 1st Long Injector MD block will be used for ecloud studies and scrub the machine

READINESS OF AND PLANS FOR INJECTORS FOR 2009 (5/7)

- Study the nominal LHC25 in the PS as it was observed at the limit of longitudinal stability in 2008 (for the 1st time? Due to the 3 MTE kickers installed in 2008?)
  - See H.Damerau's talk at APC held on 27/03/08
  - Longitudinal coupled-bunch instability after transition and at flat-top (coupled-bunch feedback too strong ➔ A programmable gain is needed)
  - Measurement of the longitudinal impedance of the MTE kickers (http://accelconf.web.cern.ch/AccelConf/e06/PAPERS/THPCH059.PDF and http://ps-impedance.web.cern.ch/ps-impedance/MTE_Kickers/MTEKickerResonances_03-04-09.ppt)
  - MDs are planned in the PS (if this instability is still there) to try and stabilize the beam using double-harmonic RF 10/20 MHz

- New requests from ALICE (discussions with W. Herr)
  - Reminder: With LHC25, 39 batches of 72 bunches = 2808 bunches should be sent to the LHC. With LHC50, 39 batches of 36 bunches = 1404 bunches
  - The new request is 37 (or 38) batches of 36 bunches (LHC50) and 2 (or 1) batches with bunch spacings > 100 ns (and multiple of 50 ns) and with ~ 1/3 or ½ of nominal bunch intensity

READINESS OF AND PLANS FOR INJECTORS FOR 2009 (6/7)

- Answers (after discussions with PS RF experts, H. Damerau and S. Hancock):
  - ✓ It is OK with 2 bunches spaced by 1050 ns. Already done and it is just a matter of supercyle (LHCINDIV with only 2 PSB rings)
  - ✓ It should be OK with 12 bunches spaced by 150 ns, but needs some work and cannot be done this year as the MD program is already full (but no major problem is anticipated there). The idea would be to inject 6 bunches from PSB on h7, then do a rebucketing from h7 to h14 at low energy (instead of triple splitting), accelerate on h14 and then do only 1 splitting a top energy to end up with 12 bunches. Therefore, it is very similar to 75 ns beam which is also accelerated on h14
  - ✓ With 6 bunches spaced by 300 ns, it should not be much work compared to 12 bunches, but there might be a certain intensity limit which still has to be found experimentally
  - ✓ However this cannot be done in 2009 as the MD program is full and it is scheduled for 2010. Furthermore, these beams will profit from all the MDs scheduled this year, in particular with the 1-batch injection in the PS

READINESS OF AND PLANS FOR INJECTORS FOR 2009 (7/7)

- Study the transverse emittances evolution in the SPS at 450 GeV/c with the ~ nominal LHC25 vs. transverse emittances in the PSB
  - It was said in the past that the limit at PSB extraction should be 2.5 μm
  - What happens if the transverse emittances at PSB extraction are 3, 3.5 or 4 μm?
  - MDs planned during the year (as there is also a request to study a controlled transverse emittance blow-up in the PSB)

- Study the effect of broken PFW(s) in the PS
  - Some simulations are being performed
  - A dedicated MD might be needed at the end of the run ➔ A slot is already planned during the last Long Injector MD of week 45

SPS ION BEAM COMMISSIONING

- **EARLY BEAM**: Several weeks of setting-up and MD time are necessary to make a first LHC ion run possible (~ end of September)

- **NOMINAL BEAM**
  - PS HW needs rebuilding, testing, setting up
  - Alternative filling schemes (to minimize IBS and SC) need to be tested in SPS

- **Studies on the desorption of cryogenic targets in LINAC3**
  - For warm surfaces, most of the studies were done in the past and most of the answers given
  - However, cold surfaces are nearly unstudied using high-energy ions ➔ Studies important for LHC and SIS100 at GSI
  - Could be done between week 39 (foreseen stop) and week 41

- *No ions in rings since November 2007 ➔ Recommissioning needed (controls, RF, power supplies, etc.)*

MTE COMMISSIONING

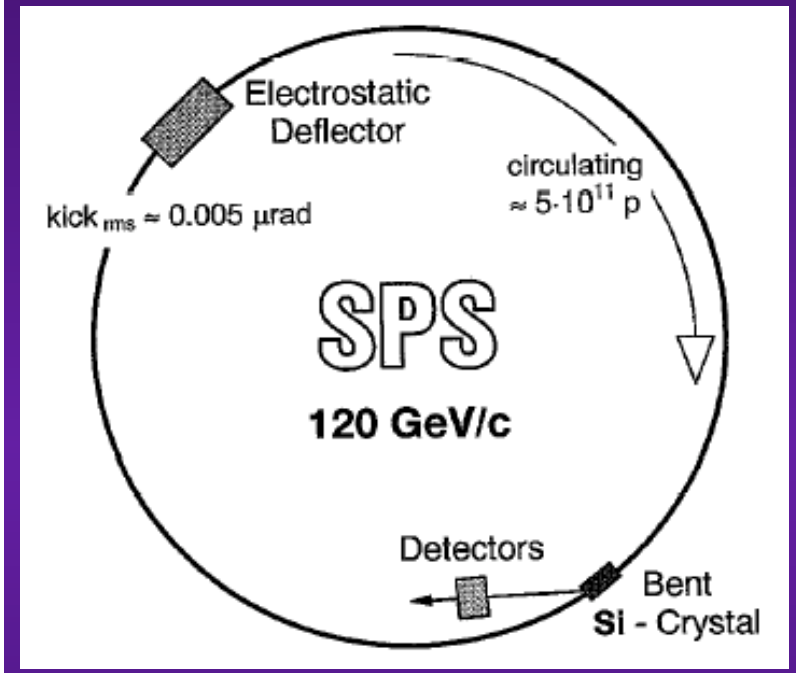
- A debunched beam will be used in the SPS in 2009
- During weeks 21 to 24 there will be no MD segment in the SPS supercycle ➔ Either LHCFAST will be used (to prepare the Ti8 tests of week 23, the 1st Long Injector MD of week 24 and the TI2 tests of week 26) or MTE for commissioning
- This was followed up in 2008 at every APC meeting and it will be followed up in 2009 by MSWG

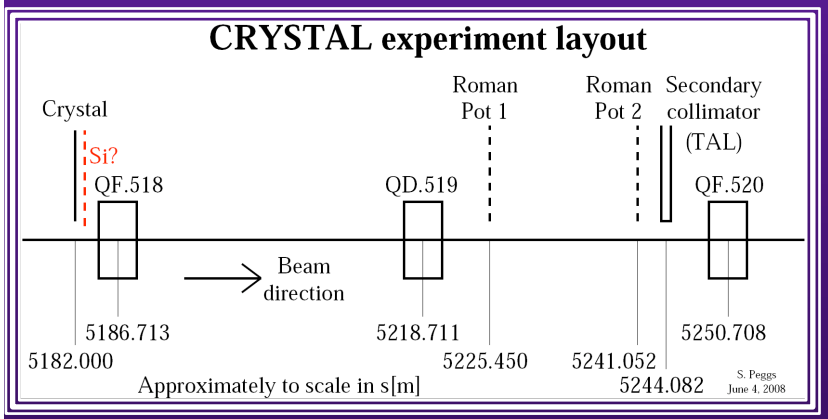
CNGS (3.1E19 pot required in 2009 vs. 1.78E19 pot delivered in 2008)

- The beam intensity was limited to ~ 4-4.2E13 p/b in the SPS in 2008 due to RF power
- ppm in SPS → Being implemented → We should have more flexibility for operation & MDs
- Reduction of the losses → PS radiation issue of Route Goward: 50% irradiation from CT extraction (~ 0% with MTE) + 50% directly from beam injection → MDs foreseen to continue studies on beam losses at PS injection + general follow up of losses by MSWG (APC before)
- Check acceptance in the SPS after several findings during the 2008/2009 shutdown
  - Dipole 30950 → A ball bearing (which belonged to a coil which is inserted into the vacuum chamber of the SPS dipoles) was found
  - ZS5 → Deformation observed on the ion trap (probably due to the successive bake-outs and beam-induced heating), which could explain a vertical aperture limitation (46 mm → 40 mm)

UA9 (CRYSTAL) COLLIMATION EXPERIMENTS (1/3)

- **Only 1 energy was chosen for all the coasts needed in 2009**
  ➔ 120 GeV/c





Goals:

- **Demonstrate loss localization**
- **Measure channeling and collimation efficiency**
- **Measure the single particle dynamics (later ?)**

Courtesy of W. Scandale

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2009 Injector Accelerator Schedule

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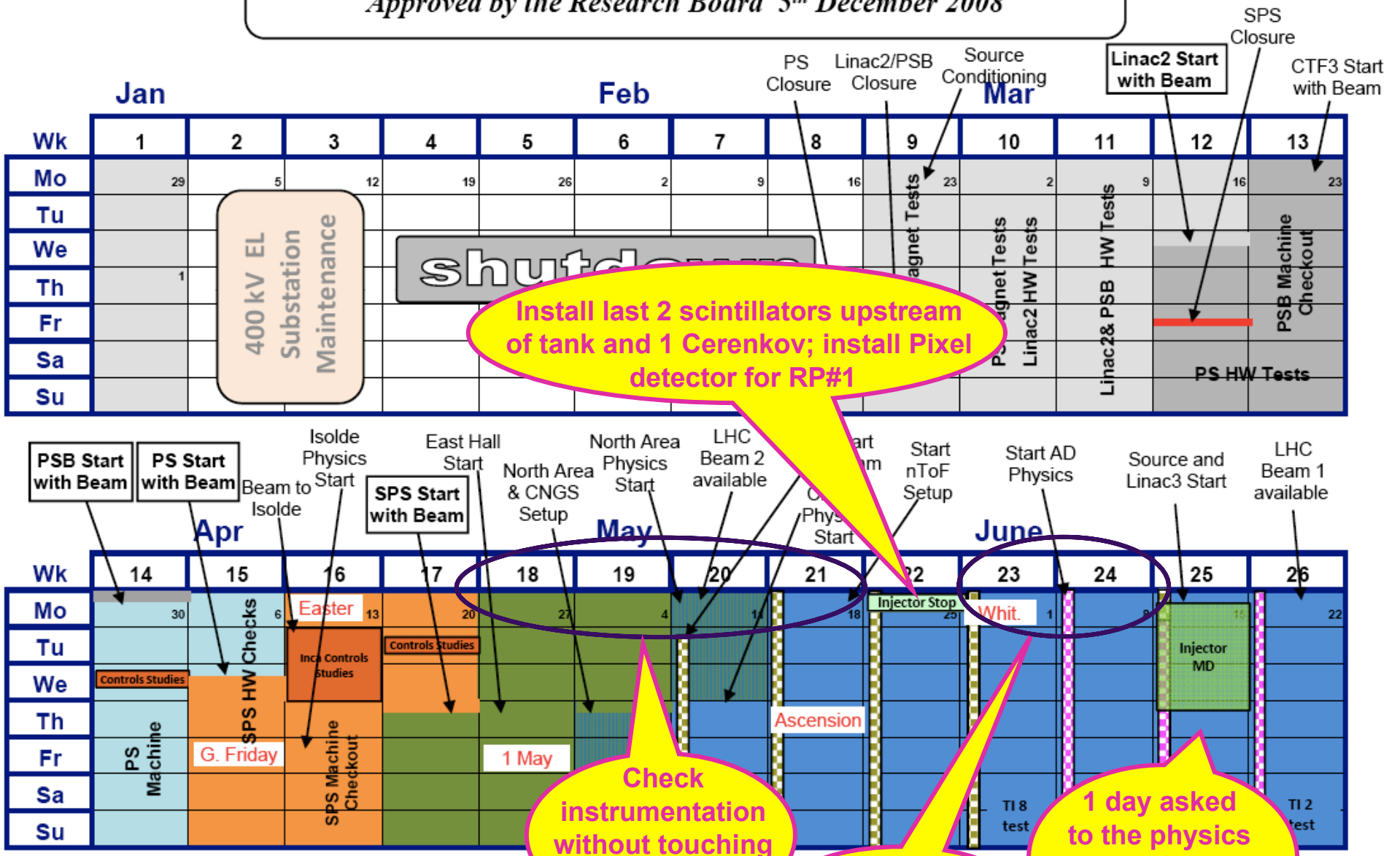

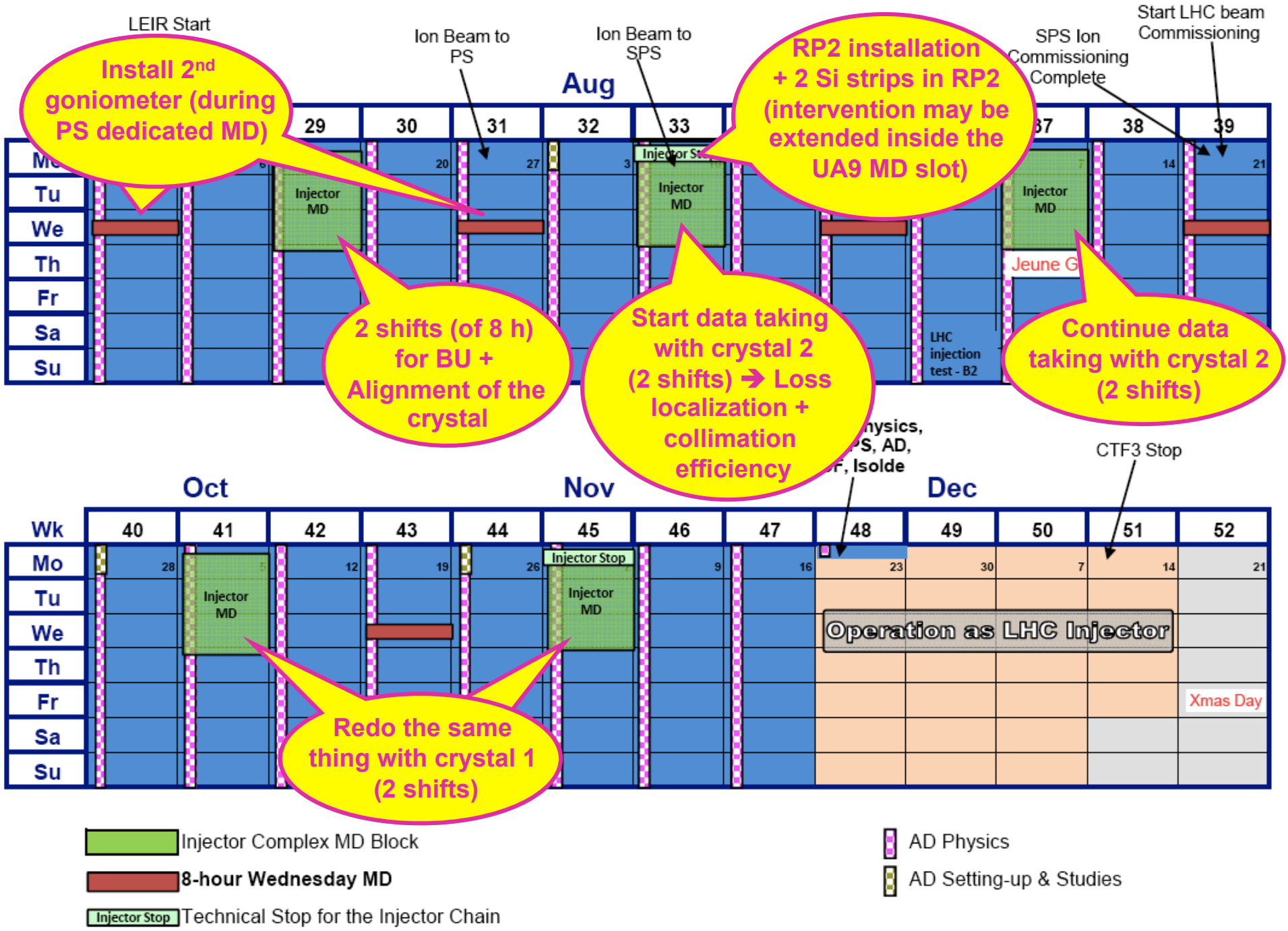
LEIR Start
Ion Beam to PS
Ion Beam to SPS
SPS Ion Commissioning Complete
Start LHC beam Commissioning
Aug
Wk
29
30
31
32
33
37
38
39
Mo
Tu
We
Th
Fr
Sa
Su
Injector MD
Jeune G
LHC injection test - B2
Install 2nd goniometer (during PS dedicated MD)
RP2 installation + 2 Si strips in RP2 (intervention may be extended inside the UA9 MD slot)
2 shifts (of 8 h) for BU + Alignment of the crystal
Start data taking with crystal 2 (2 shifts) ➔ Loss localization + collimation efficiency
Continue data taking with crystal 2 (2 shifts)
Oct
Nov
Dec
CTF3 Stop
40
41
42
43
44
45
46
47
48
49
50
51
52
Injector Stop
Operation as LHC Injector
Xmas Day
Redo the same thing with crystal 1 (2 shifts)
Injector Complex MD Block
8-hour Wednesday MD
Technical Stop for the Injector Chain
AD Physics
AD Setting-up & Studies

USE OF THE SPS CYCLES IN THE DIFFERENT LONG MDs

- W25 (96 h): LHC nom. 450 GeV/c (72 h) + 120 GeV/c coast (24 h)
- W29 (72 h): 120 GeV/c coast
- W33 (64 h): 120 GeV/c coast + ion cycle (to check HW etc.)
- W37 (72 h): 120 GeV/c coast + ion cycle + LHC nom. 450 GeV/c
- W41 (72 h): 120 GeV/c coast + LHC nom. 450 GeV/c
- W45 (64 h): 120 GeV/c coast + LHC nom. 450 GeV/c

MD WEB PAGE

- https://ab-mgt-md-users.web.cern.ch/ab-mgt-md-users/