

Operational Scenarios for 2008

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What is running in 2008

Isolde:

- * Similar level of requests to 2007 (was 480 in 2007)
- * Radioactive air issues have to be resolved to lift the limitation on the GPS
- * High level of REX and RFQ usage.

East Hall:

- * All 3 branches will be used at some point, Dirac, Irradiations, Cloud, Tests Beams
- * Special test for LHC CMS and LHCb Velo (Fast extraction)

AD:

- * Similar request as 2007 – around 20 weeks operation.
- * Request to go back to 8 hour shifts (2007 mostly 12h)

nToF:

- * Possibility of operation with the new target towards the end of the year (October?)

North Area:

- * Still very active for LHC test beams. Plus Compass, NA61, NA62 NA63 etc.



CNGS:

- * Consolidation and shielding after the test run in 2007 ...
- * First Production Year – very hungry for protons!

What else is Running in 2008

CTF3

- * Passive operation of the CTF3-PETS during nights and weekends
- * Full CTF3 Commissioning and Operation Locally at other times

Linac3:

- * Commissioning of the new 18GHz source (4weeks)
- * Running the beam down Linac3 (few weeks)
- * All operations done in the local control rooms.

LHC : See later

What is Not Running in 2008

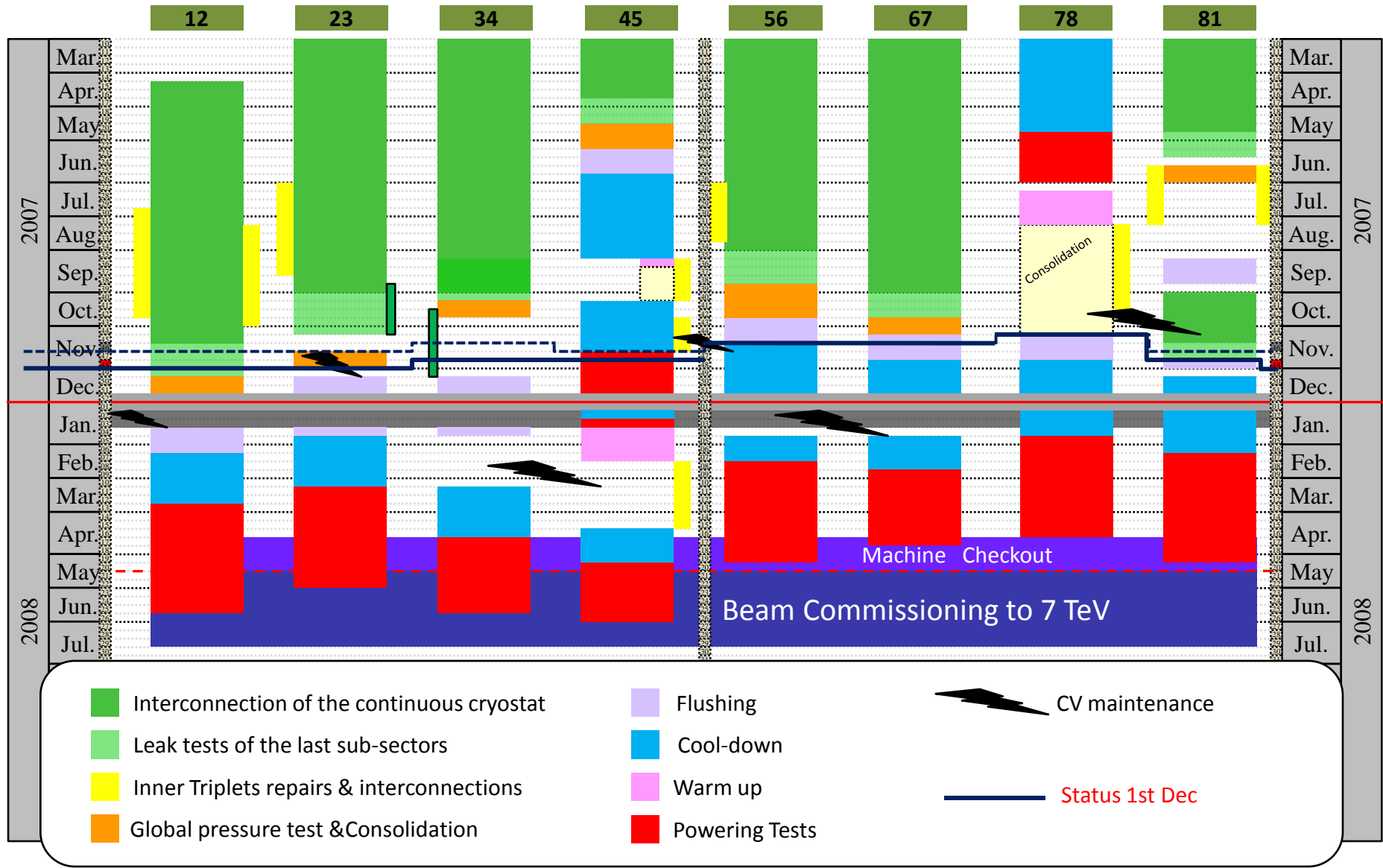
LEIR:

- * No Ions in the injector chain in 2008.

Merit:

- * Possible request for a new run
- * Cannot realistically be done if nTof is to run (Interference with SPS/LHC Operation)

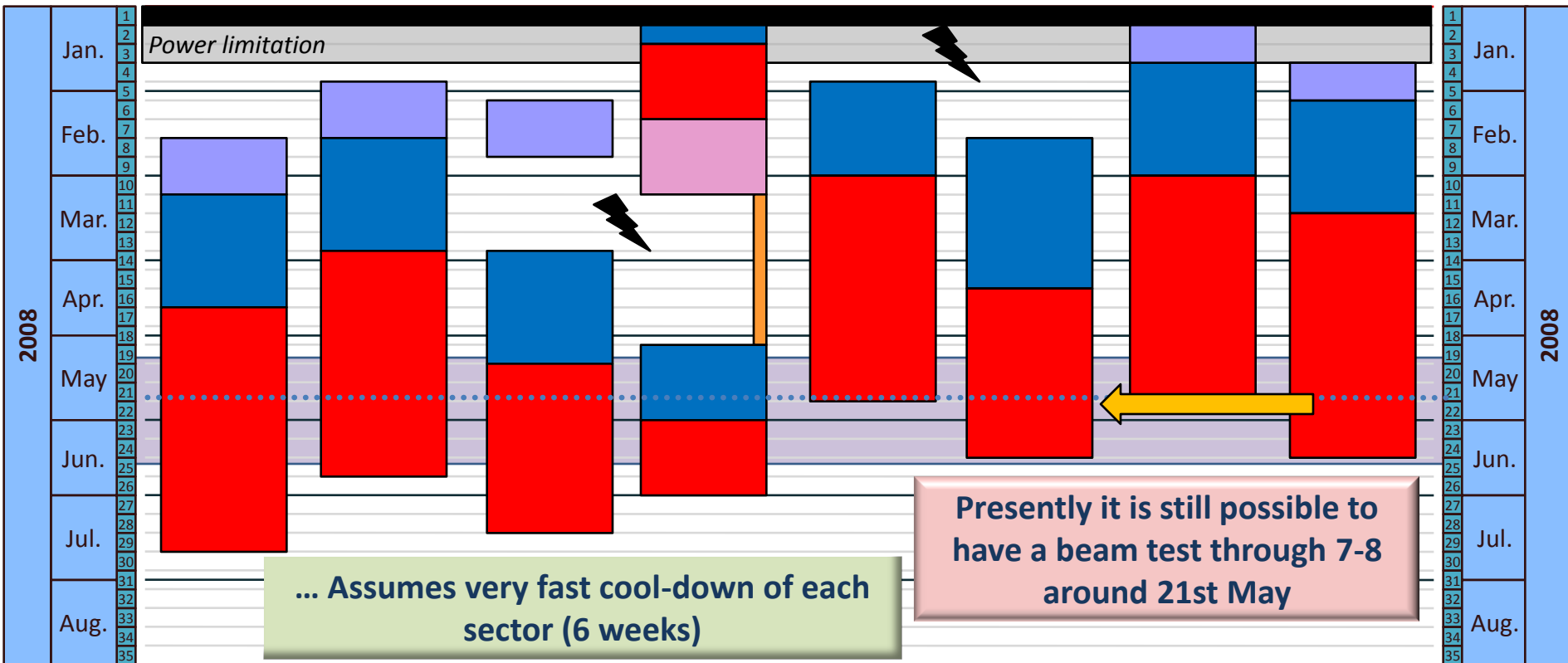
LHC Schedule ... October



LHC Schedule, Week 03

K. Foraz TS-IC-PL

12 23 34 45 56 67 78 81



- Flushing
- Cool-down
- Inner triplet interconnect
- Warm up
- Powering Tests
- CV maintenance

In addition ...
 The possibility of circulating beam during June/July has not been excluded (once the last sector is cold ...)

Now HWC in 6 sectors in parallel at the same time as starting the injector complex with beam ...

Constraints on Making the 2008 Schedule

Sufficient time during the 2007-2008 shutdown to complete the Activities ...

- Installation of the multi-turn extraction equipment (12 weeks)
- Continuation of the PS magnet renovation project (8 magnet units)
- Continuation of the SPS magnet consolidation with the repair of 80 magnets
- Normal Shutdown activities for the existing complex
- CNGS work – which has now become a heavy item!

The LHC

- The schedule must be compatible with LHC taking beam from the 21st May
- Throughout the year LHC beam available 'on request'
 - ↪ Initially 'pilot' type beams
 - ↪ Later low intensity Physics beams
- Possible extension of the 2008 run as LHC injector only



Machine Developments and Studies

- Time needed to commission and perfect the MTE as well as many studies for LHC

**LHC Has the highest priority at CERN – But CNGS Must work ...
therefore priority is not much lower!**

Startup

Original Plan

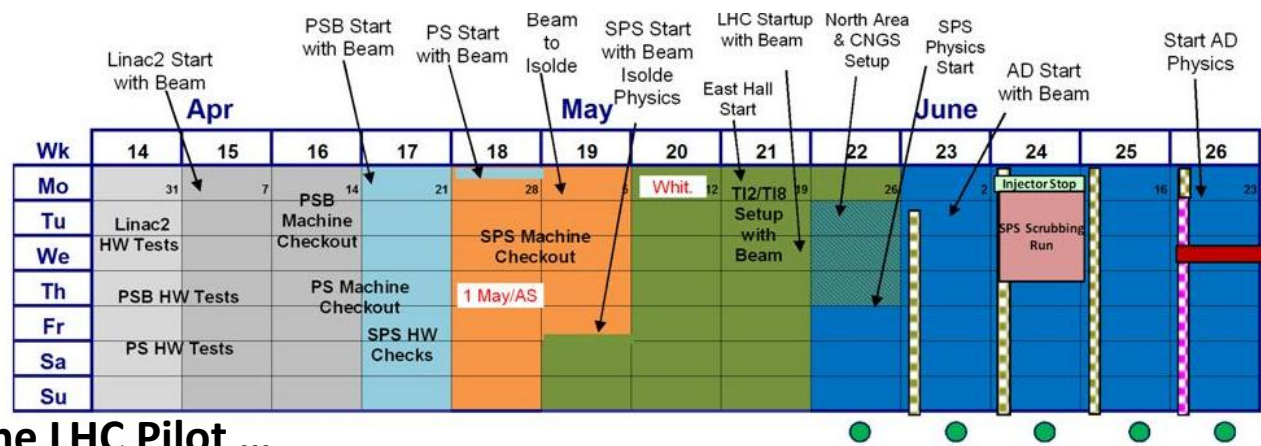
- Start each machine with the LHC Pilot ...
- ... Make it operational for the next machine
- Then go back and start work on the physics beams.

LHC can now not manage a circulating beam in May

- But can make a beam test (sector test) – possibly in early June.
- The injector chain must therefore still be ready with the LHC pilot quite early

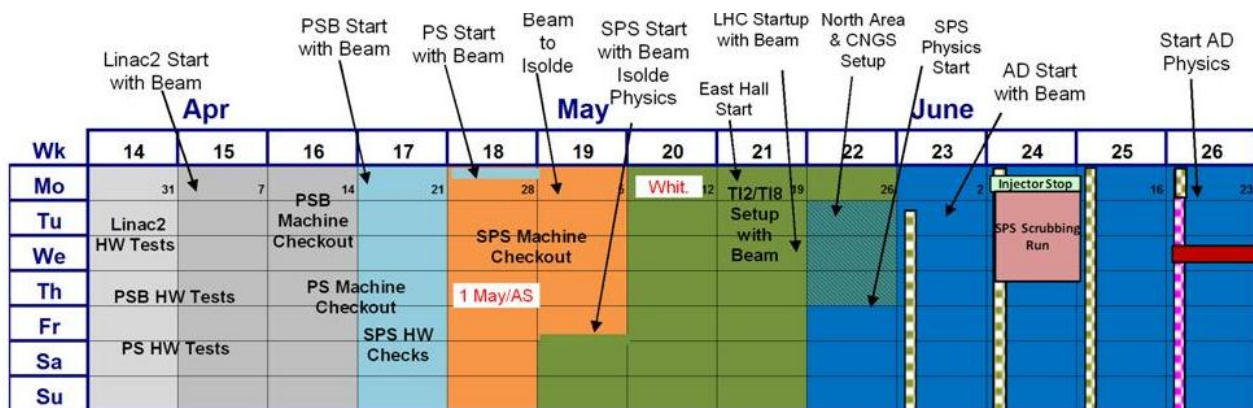
Most likely scenario is that we will start the machines with an 'easier' beam

- Allows the machines to start up following their standard plan
- Probably easier for the measurement and re-alignment campaigns that will be made in PSB, PS and SPS this year (e.g. references)
- SFTPRO/CNGS is the most likely beam and anyway the 2nd priority beam
- In this case the LHC pilot will be set-up immediately afterwards
- Other beams follow as needed for the schedule



The decision here can be made just before beam operation starts on the basis of the state of readiness of the LHC

Starting the Physics Programmes



Isolde: 5th May
East Hall: 19th May
LHC: 21st May
North Area: 30th May
CNGS: 30th May
AD Beam: 3rd June
AD Physics: 23rd June

Can Physics be advanced If LHC does not need beam on May 21st?

- Not significantly since the whole startup is very tight anyway. With little slack in case of problems.
- The alignment campaigns will be more annoying once physics operation has begin ...
- Possibility of advancing the start of AD by a few days.

In addition, even if LHC ring is not ready there will be a strong push to re-start the two transfer lines - and complete the commissioning programmes that were interrupted/cancelled last year.

- ❖ TI 8 Has not seen beam since 2004!
 - ↪ Requests for beam in 2006/2007 could not be met
- ❖ TI 2 had only 1 day of commissioning work in 2007
 - ↪ With a temporary dump upstream of the TED
 - ↪ Strong restrictions on the beam intensity

Will just require closing LHC point 2 and point 8 +LHCb +Alice

We need at least some of this doing before LHC starts demanding beam

Studies and MD's I

Changed the concept this year back to blocks of time (as it used to be ...)

- Hope to improve the efficiency for physics fewer breaks and less time lost starting and recovering from MD's - But time has to be allocated in the block for this ...
- Six MD Blocks in total
 - 3 are complete 72 hours (3-days)
 - 3 are 64 hours (MD begins after an 8 hour technical stop.
- The need for compatibility with LHC can be looked at as each block is planned.
- A 7th Block has been penciled in during the period at the end of the year when only LHC is operating.
- Special Wednesday MD's for MTE ...

Parasitic MD time will be needed throughout the year

- Plan again the idea of a weekday, daytime block in the supercycle for parasitic MDs in the complex.

Scrubbing Run

- Presently 1, 3-day block dedicated to SPS scrubbing.

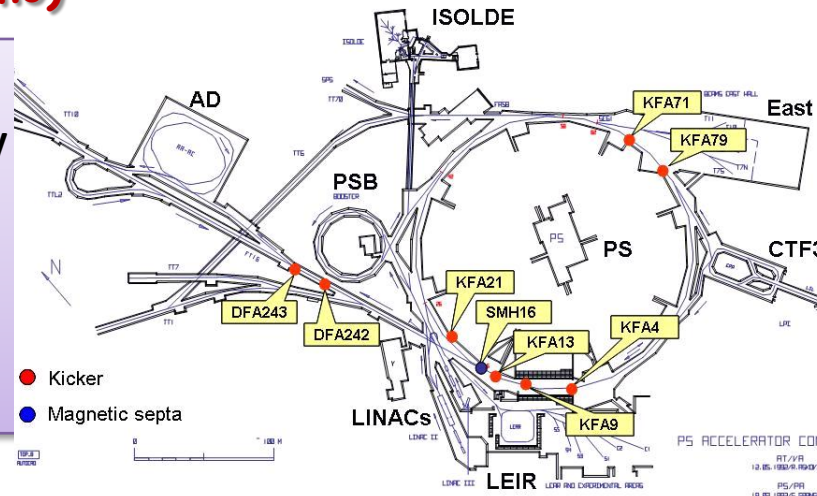
This year will be a test of this way of doing MD's with specific worries about the availability of experts
We better get used to it because LHC will probably follow the same route ...

Studies II : Commissioning MTE

(Stolen from Massimo)

May-June : (Kickers not yet ready)

- Set-up the operational cycle for MTE with low intensity
- Commission the new slow bump
- Non-linear Q' measurements
- Set-up splitting
- Move to multi-bunch, high intensities.
- Dedicated hardware checks of kickers ...

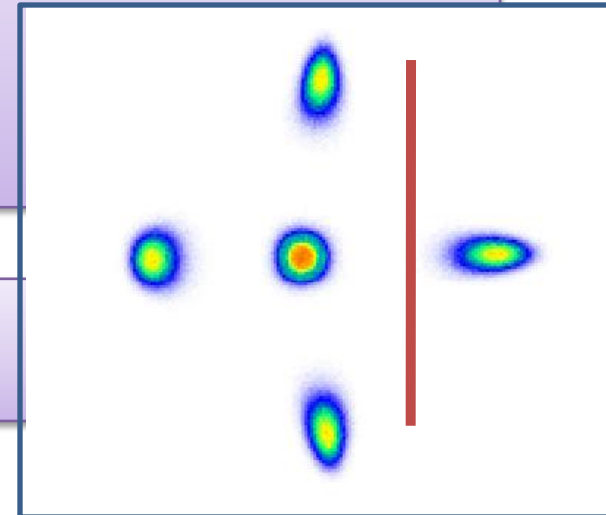


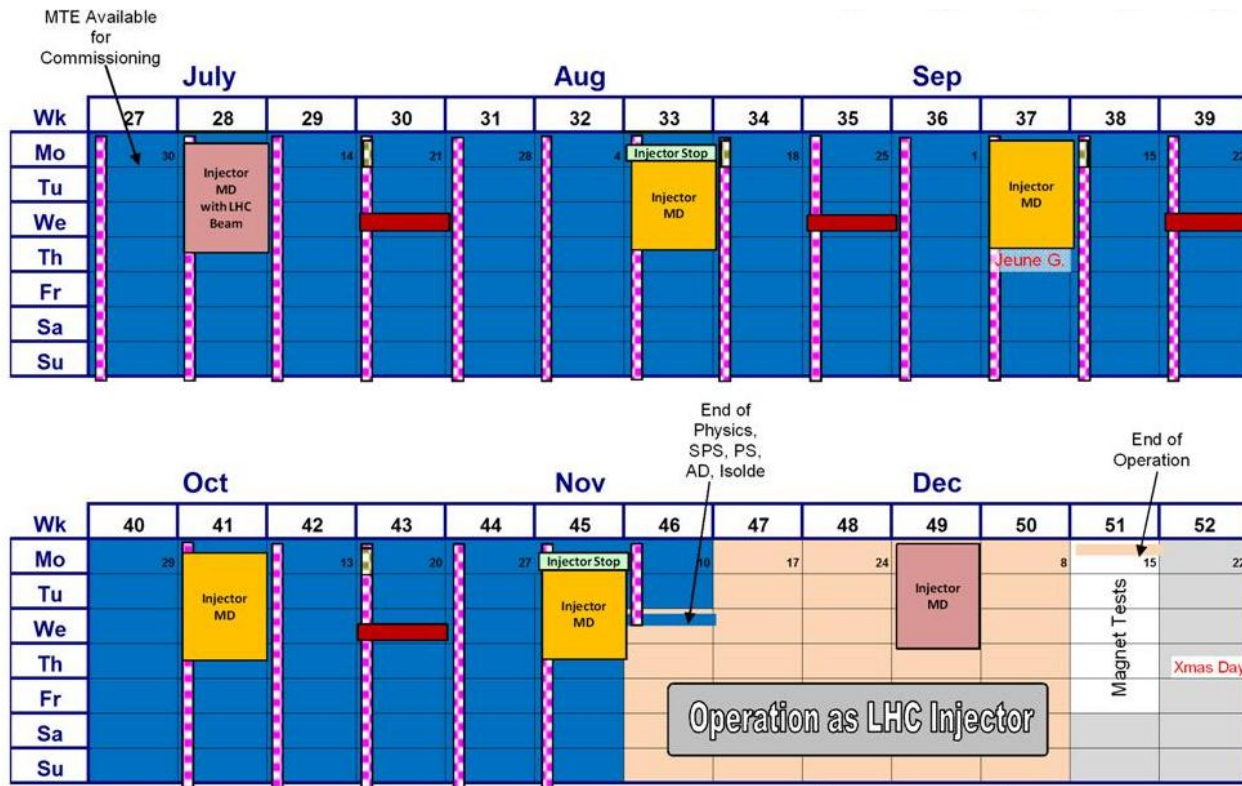
From July: (Kickers Available for Extraction)

- Some additional Dedicated time (Wednesday slots) specified in the Schedule
- Commission kickers and fast bump with beam extraction to D3
 - ↪ Start with Single bunch no splitting etc ...
 - ↪ Move to multi-bunch etc.
- Commission full transfer into the SPS
 - ↪ Including full optics check and matching.

From August:

- Put MTE into normal operation ...





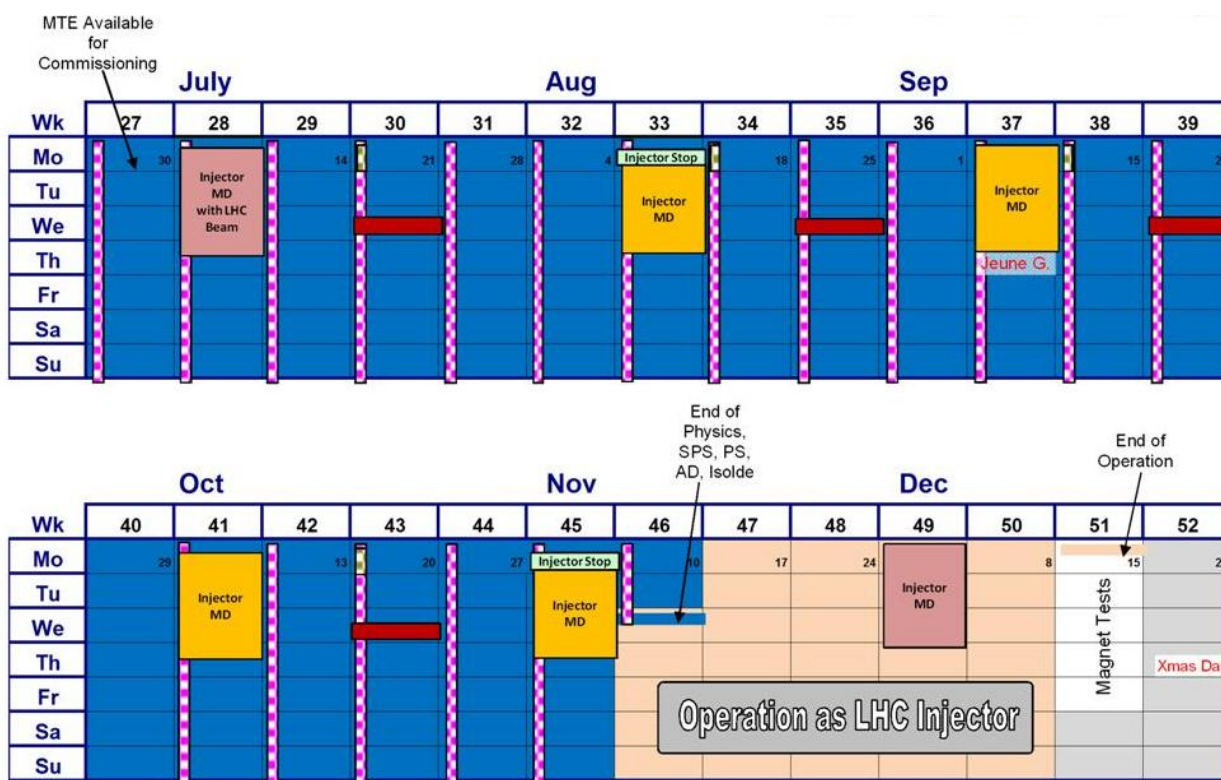
2008: End of the Year

Injector Physics Operation Scheduled to end on 12th November

Operation as LHC injector *MIGHT* continue until just before Christmas

- The schedule presently is very tentative and cannot really be decided until close to the time
- LHC beam is relatively clean
 - ↪ Low intensities
 - ↪ Only used when needed
 - ↪ No major impact on radiation cool-down of the complex
 - ↪ The MD block tentatively shown would also have to use low intensities ...

2008: End of the Year



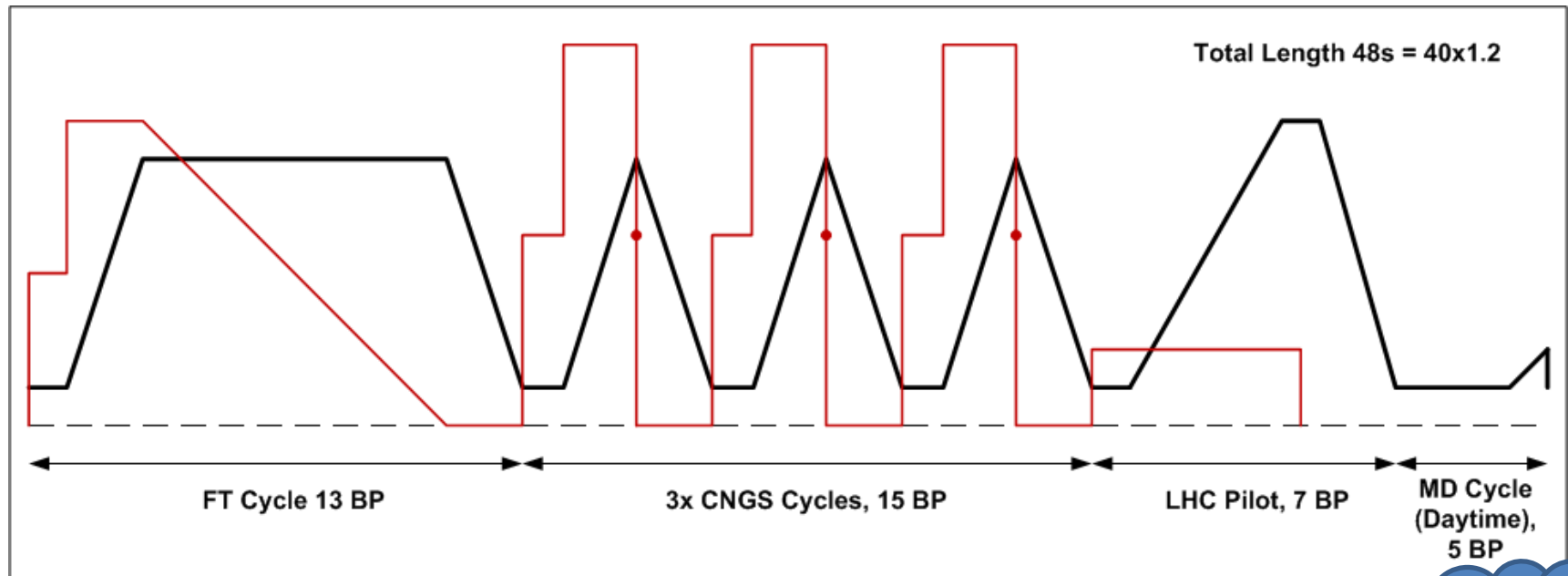
- Annual magnet tests etc can (probably) be slotted in during periods when the LHC does not need beam
- The schedule shows a few days to close the machines down before the Christmas break
 - ↪ This is almost certainly too short for the LHC
 - ↪ Running through Christmas cannot be excluded – but is probably rather unlikely.

The period at the end of the year should be treated as tentative.

- It will have to be revised in the late summer/autumn depending on the reality on the ground
- If the Injectors run for the LHC, requests to extend the Physics runs of the various facilities cannot be excluded ... but would impact strongly on activities during the 2008/2009 shutdown.

SPS Supercycles for 2008 - I

During the initial commissioning phase of the LHC – (first couple of months of circulating beam) LHC will require mainly single bunch pilots on a fairly regular basis (no physics fills)



Weekday daytimes (60h/wk):

Nights and weekends (108 h/wk):

Run complete supercycle

Supercycle without MD segment

Beam available to LHC whenever it needs it ...

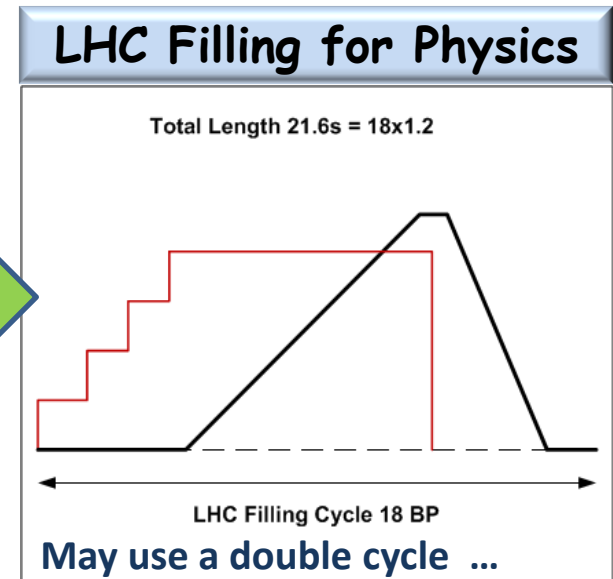
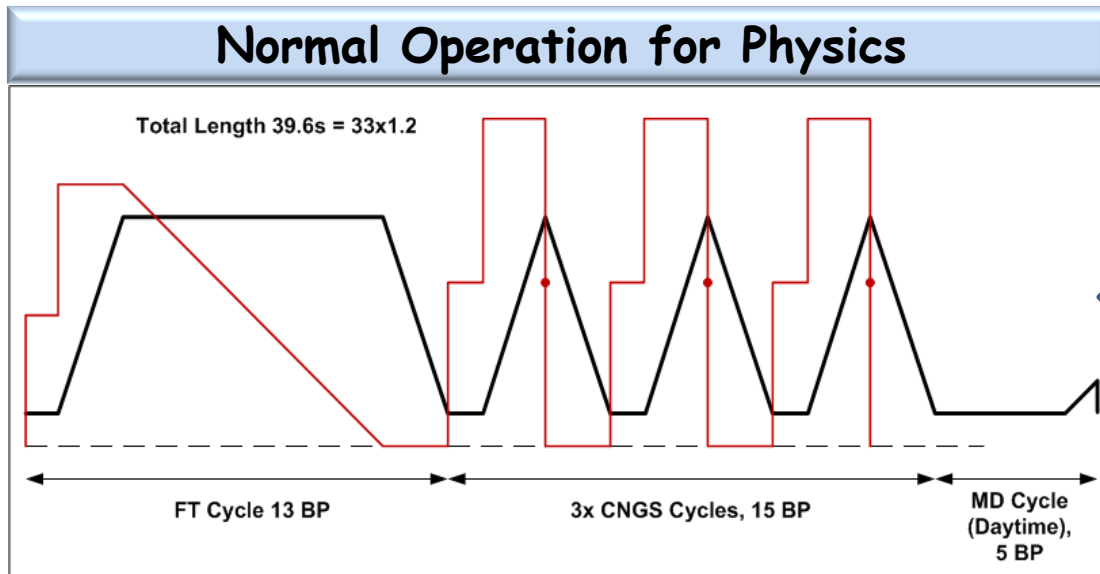
If LHC does not require beam for a substantial period (days), move to corresponding Supercycles without the LHC pilot ... (20% increase in flux)

N.B. The LHC cycle will an operational beam and not be there for SPS MD's.

SPS Supercycles for 2008 - II

Later in the year, LHC will (hopefully) be doing a bit of Physics

- ↪ Initially with 43x43 operation, later 156x156
- ↪ Possible tests of other beams
- ↪ All these will use the same type of dedicated LHC filling cycle.



The amount of time needed is not easy to quantify in the early phase of LHC operation

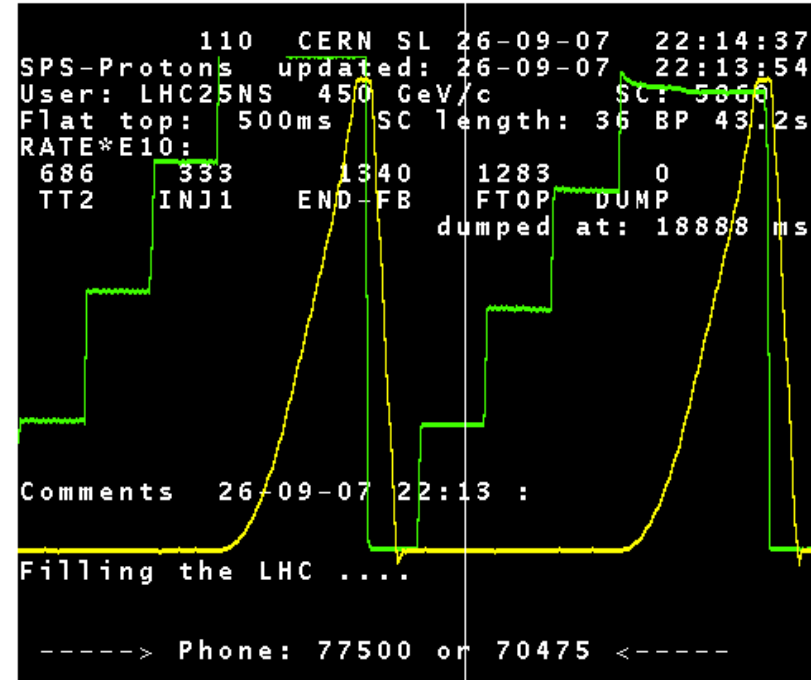
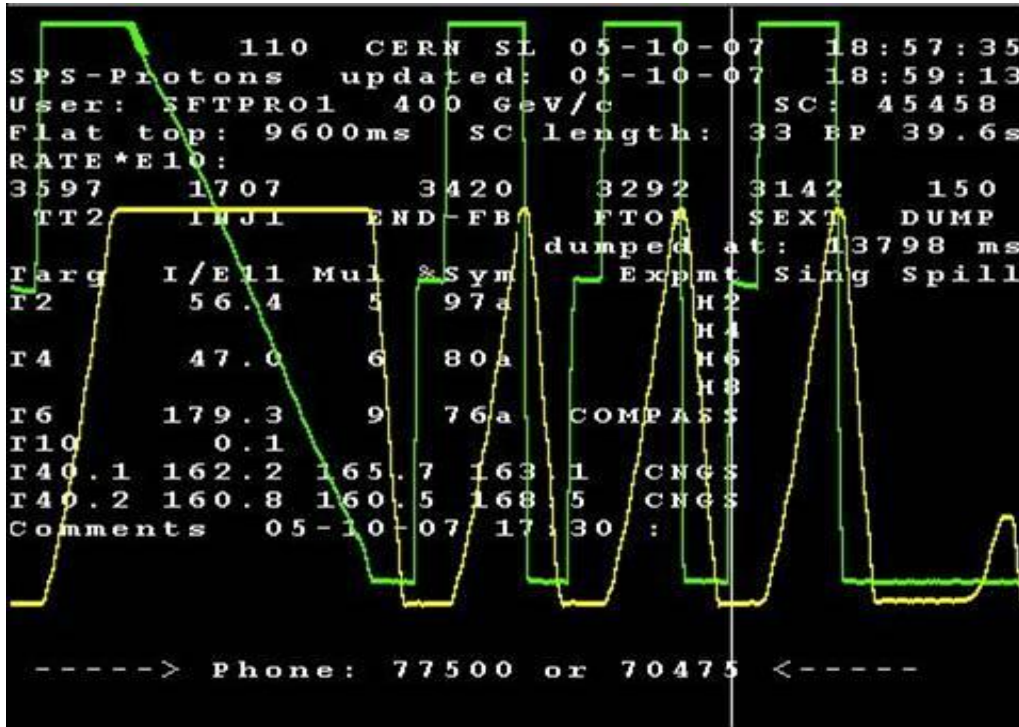
- ↪ Assume LHC fills 3x per day and 1.5 hours needed to fill ...
- ↪ This includes cycle switching and LHC injection setup time
- ↪ Gives 19% of the scheduled time to LHC filling.

Therefore very comparable with the earlier dedicated filling period.

SPS Supercycles

None of this is new

We have been routinely operating a similar supercycle during 2007 ...



... and even tried filling the LHC.

Expected Performances (SPS) in 2008

Based on $4.5E^{+13}$ protons/cycle to CNGS and $3.2E^{+13}$ to North Area (146 days)
 In all cases SPS Takes around 30% of the available cycles

With LHC Pilot always available	BP	Length /sec	Operating Hours /week	Machine Efficiency /%	CNGS/ year	FT /year
Daytime Cycle (MD)	40	48	60	80	3.1E ⁺¹⁹	0.74E ⁺¹⁹
Night/Weekend Cycle	35	42	108			

With no LHC Operation	BP	Length /sec	Operating Hours /week	Machine Efficiency /%	CNGS/ year	FT /year
Daytime Cycle (MD)	33	39.6	60	80	3.8E ⁺¹⁹	0.91E ⁺¹⁹
Night/Weekend Cycle	28	33.6	108			

The reality will be somewhere between (we hope!)
But CNGS Request $4.5 \times 10^{+19}$

The LHC Beam Zoo Specifications (LHC-OP-ES-0002)

LHC Beam type	SPS extraction				PS extr.	PSB extraction	
	intensity per bunch [$\times 10^{11}$]	$\epsilon_{rms, norm.}$ [μm]	$\epsilon_{longit.}$ [eVs]	N ^o .of bunches	N ^o . of bunches	bunches (rings)	intensity per bunch [$\times 10^{11}$]
25 ns physics	0.2–1.15	≤ 3.5	≤ 0.8	1-4 \times 72	72	6 (4+2)	2.4-13.8
75 ns physics	0.2–1.15	≤ 3.5	≤ 0.8	1-4 \times 24	24	6 (4+2)	0.8-4.6
Indiv. physics	0.2–1.15	≤ 3.5	≤ 0.8	1, 4 or 16	1 or 4	1 or 4	0.2-1.15
25 ns intermediate	0.2–1.15	≤ 3.5	≤ 0.8	12	12	1	2.4–13.8
75 ns intermediate	0.2–1.15	≤ 3.5	≤ 0.8	4	4	1	0.8-4.6
Indiv. Intermediate	0.2–1.15	≤ 3.5	≤ 0.8	1	1	1	0.2-1.15
Pilot beam	0.05	≤ 3.5	≤ 0.8	1	1	1	0.05
Probe beam	0.05–0.2	≤ 1.0	≤ 0.3	1	1	1	0.05–0.2

At LHC Injection

Pilot Beam : 1 Bunch, 5×10^9 , Nominal Emittance of $3.5 \mu m$.

Probe Beam : 1 Bunch, 5×10^9 , Minimum Emittance of around $1 \mu m$

Individual Physics Beam : From 1 Bunch, 2×10^{10}
to 16 Bunch, 1.15×10^{11}

Used for 43x43
& 156x156
Physics

What Beams Will LHC Need in 2008?

Type	N ^o . Bunches /PS Batch	Intensity [x10 ⁺¹⁰]	Emittance [μm]	
Pilot	1	0.5	3.5	Will always be needed
Probe	1	0.5	1.0	Will we use this?
Intermediate Physics	1	0.5 – 10	3.5	For 43x43 Physics (note lowest intensity)
Intermediate Physics	4	0.5 – 10	3.5	For 156x156 Physics (note lowest intensity)
75ns/25ns	24/72	1.0 – 3.0	3.5	Some Studies might begin

Note the specific requirement
this year for very low intensity
'Physics' beams
c.f. Specifications

LHC will need a subset of beams in 2008

- Generally at low intensity
- But with nominal emittance
- The probe beam might be used for studies (but after injecting a pilot).

Emittance ($3.5\mu\text{m}$)

- As a general rule (for 2008 ...) LHC will want low intensities with the nominal emittance
- Eventually will want variable intensity per bunch (over a range of a factor 20) with a constant nominal emittance
- Later still smaller emittances might be requested ...
- It does need a highly reproducible beam – with the nominal emittance.

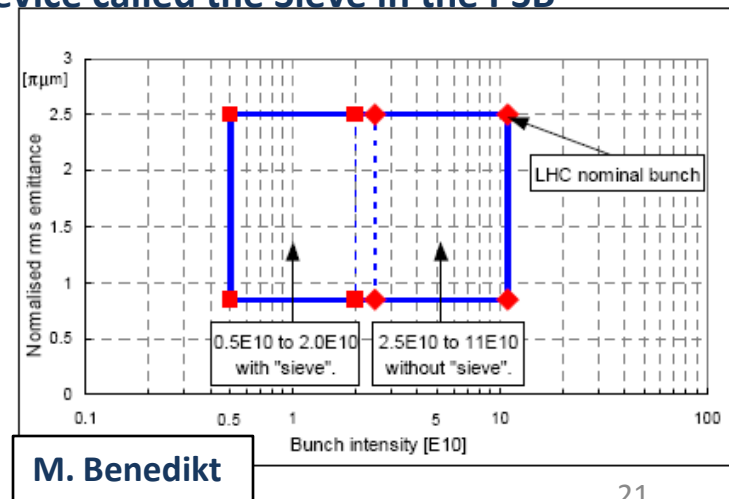
The injector Chain therefore needs a very robust 'dial-a-beam' system

Two methods under study:

- Allow the pre-injectors (notably PSB) to generate a low intensity, low emittance beam (low intensities by shaving, or injecting fewer turns and use a controlled blow-up (in the SPS) to set the emittance.
- Request the PSB to control Intensity and emittance correctly and transport this through the other machines. This requires the use of a mechanical device called the Sieve in the PSB injection line

Both schemes might be needed –
but the sieve is not presently an operational
device

- ↪ There is no spare
- ↪ Studies are ongoing ...



Dealing with Major Problems/Breakdowns

The Electrical Distribution System is the basis for the whole technical infrastructure of CERN

- ★ Failures here can impact on widely different parts of the complex.
- ★ Other services can also provoke major breakdowns (CV, access, safety systems etc).

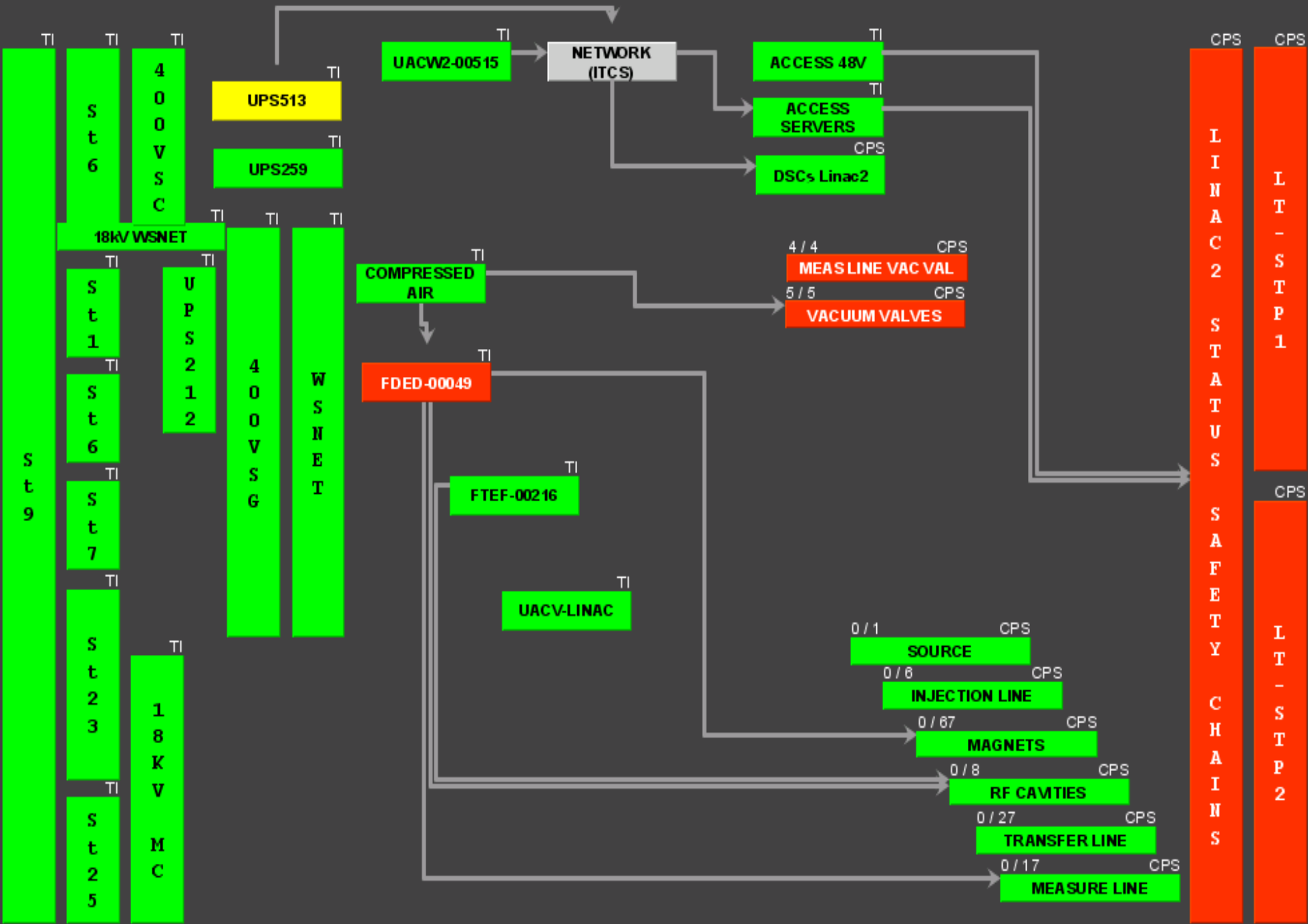
After the power fails many other systems stop working and require intervention to restart them

- ★ The TI Team are therefore faced with a flood of alarms and phone calls and must sort and prioritize the responses
- ★ Each Service has a limited amount of resources in terms of Standby and Expert teams
- ★ The use of these resources must be organized to optimize the restart of the complex
 - ↪ ... don't start work on the user equipment until the services are stable ...

AB/OP-TI have the means to look at the dependencies within a facility (GTPM) for many cases (BUT NOT ALL):

- ↪ What is needed at each stage to progress
- ↪ What is blocking progress,
- ↪ Where intervention teams are not presently required and can be used elsewhere

LINAC-2



Priority list during shutdown 2007-2008

For prioritization of interventions after a major breakdown

- 1. Safety System..... Flood Pumps, Safety PLCs, Level 3 Equipment
- 2. Environmental Protection.. Water Quality, Radiation
- 3. Computer Centre..... Cooling, Ventilation, Power
- 4. LHC P4..... Cryogenics
- 5. LHC P8..... Cryogenics
- 6. LHC P6..... Cryogenics
- 7. Atlas..... LHC Experiments (Cryogenic)
- 8. CMS LHC Experiments (Cryogenic)
- 9. CTF3..... Machine
- 10. LHC P2..... Cryogenics
- 11. LHCb LHC Experiments (non Cryogenic)
- 12. Alice..... LHC Experiments (non Cryogenic)
- 13. SM18..... Cryogenics
- 14. Ion injector chain..... Linac3 and LEIR
- 15. Accelerator Backbone..... Linac2, PSB, PS, SPS
- 16. Experimental Areas ISOLDE, North Area, East Hall, CNGS
- 17. AD..... Machine and Areas
- 18. CAST
- 19. SMI2

	Always high priority
	Schedule driven priority
	Always low priority

Overall Prioritization

Presently set-up by AB/OP with our best knowledge of the current situation.

Used in Major incidents – but also in the case where a choice has to be made for where to intervene first

Updated a few times per year (shutdown vs. operation period)

During the coming year(s) this list is likely to be very dynamic

AB/OP does not have all the information needed to properly prioritize all facilities ...

... or even a consistent view of all facilities in terms of the detail of what is there

CERN-wide Panel for Intervention Prioritization

- Representatives from each department covering all major facilities
- Meeting regularly to set and review the overall priorities
- Harmonize the level of detail in each facility - and prioritize within a facility where possible
- Output coordinated by AB/OP and transmitted to the TI team.

Composition: Representatives from:

- AB:** Accelerator backbone (Linac2, PSB,PS,SPS,LHC), Ions (Linac3, LEIR), Others (AD, Isolde, CTF3, Experimental areas), CCC, AB-installations
- AT:** CERN-wide Cryogenics, AT-Installations
- IT:** Computer Centre , IT-Infrastructure
- PH:** LHC Experiments, non-LHC experiments and areas (Isolde, NA, East, AD...), Non-beam PH installations and experiments (Cast)
- TS:** Safety, access and primary services, General CERN site

First Meeting is next week

ABOC

It is not (presently) planned to have the ABOC cover the operation of the LHC

- ↪ We already have enough to cover
- ↪ LHC would tend to dominate too much

Instead the chairman will probably give a brief resume of the news from LHC during the weekly ABOC meeting ...

- ↪ Needed in any case since the LHC request for beam will impact on the performance for other facilities
- ↪ The statistics will need to reflect LHC request from the start

In addition one (or more) representatives from the injector complex will need to report in the LHC Users meetings and whatever other meetings are set-up to cover LHC operation ...

Similar situation for the ATC ...

- ↪ The present mandate covers the operational machines – except the LHC.

Not sure about the APC

Conclusions

2008 Is going to be an interesting year (aren't they all!)

↪ ... and we will have to be flexible ...

↪ The end of the year is especially uncertain for the injector complex

However, we should be able to run in such a way that the operation of the other facilities is not seriously perturbed by what's happening in the LHC.

The flexible use of the supercycle in 2007 will have to continue and be refined further to optimize the protons delivered to ALL users

↪ Daytime and night/weekend changes to add/take away the MD cycle.

↪ Addition and removal of the LHC cycle as required.

The blocks of MD time should be more efficient for Physics ...

↪ But it remains to be seen if it is better for the studies teams

↪ Some changes to when the MD blocks occur might be needed

There will be too few protons to meet all the requests in 2008

↪ ... a general problem for the future

Conclusions II

There will be too few protons to meet all the requests in 2008

This will be a general problem for the future

Long term strategy

to re-build the CERN complex for LHC (benefits for everyone)

Short term strategy

optimize operation as much as possible improve efficiency,

Otherwise

work longer, shorter shutdowns

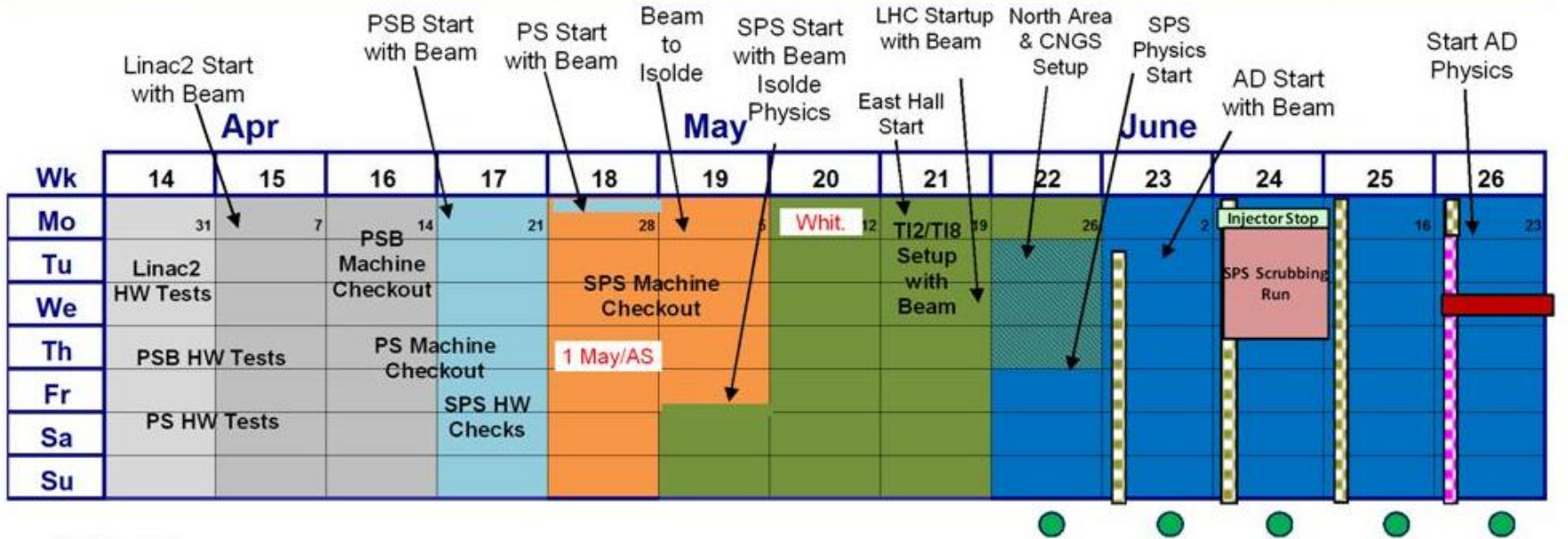
increase intensity ...

... risk problems with equipment breakdowns

Additional Slides

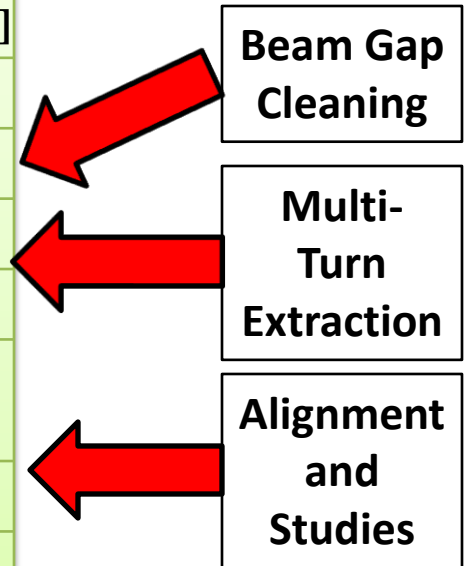
2008 Injector Accelerator Schedule

Approved by Research Board 28th November 2007



The "Cost" of the High intensity Beam

	Intensity [10 ¹³ p/cycle]	Loss [10 ¹³ p/cycle]	Loss energy range [GeV]
Protons on Target	4.8		
Extraction from SPS	4.83	~0.03	399.1
SPS Injection & Acceleration	5.2	~0.4	13.1-22
PS transfer to SPS	5.8=2x2.9	0.6	13.1
PS injection and Acceleration	6.1=2x3.1	0.3	1.4-5.0
PSB transfer to PS	6.4=2x3.2	0.3	1.4
PSB Injection & Acceleration	15=2x7.5	8.6	0.05-0.15
Acceleration in Linac 2	16.4=2x8.2	1.4	0.001-0.05

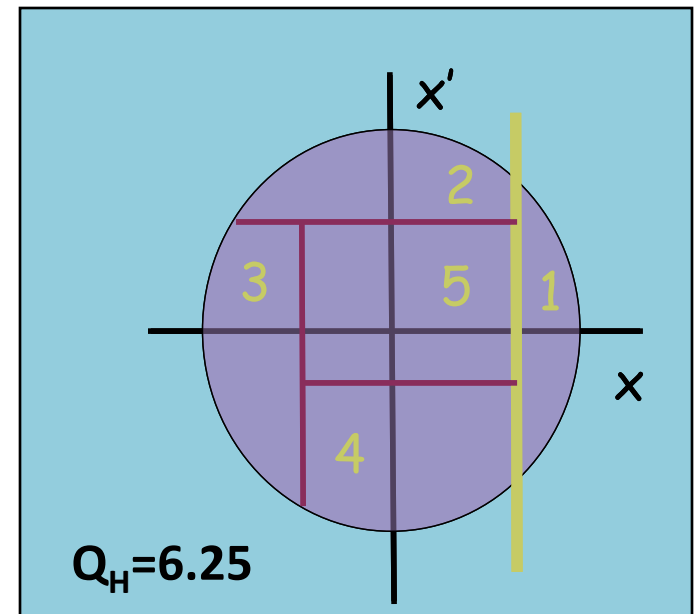
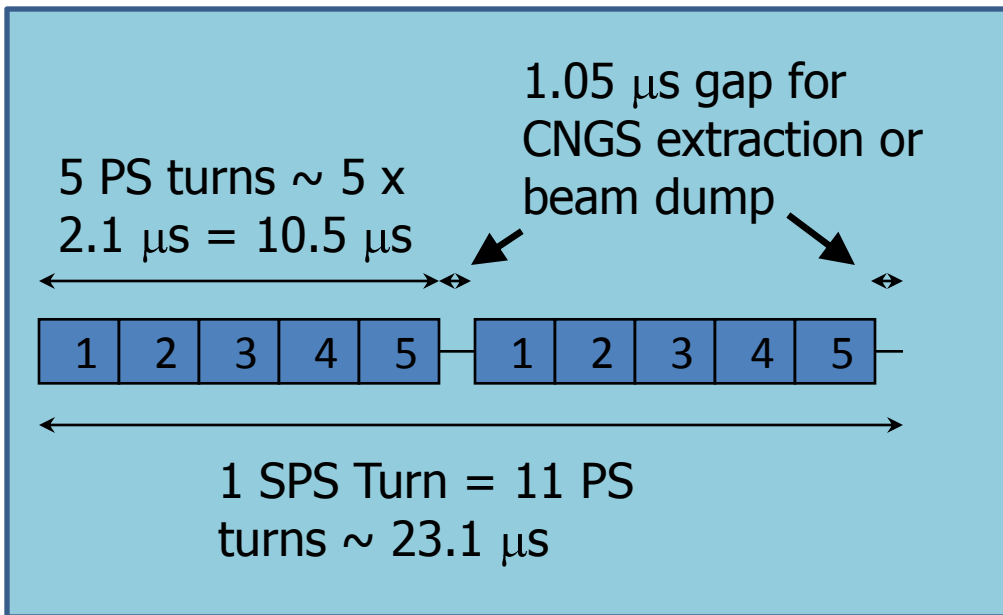


**Most losses are at low energy – phase painting the beam at PSB injection
But the losses at PS extraction and SPS injection give the greatest radiological impact.**

Losses at SPS extraction if the beam gap is not clean are also significant...

Present CT Transfer (PS to SPS)

- SPS Circumference = $11 \times$ PS Circumference
- 2 consecutive injections (1.2s) each filling 5/11 of the SPS circumference by transverse slicing of the PS beam in the H-plane by means of a thin electrostatic septum
- Fast bumpers to extract each turn – including the last



Inherent losses of around 10-12% due to the thickness of the septum and the large trajectory excursions around the machine.

Beyond 2008

What are the prospects for later years?

	Gain (Approx!!)	Comment
Run Longer	20% (4 weeks running)	Less consolidation – PS Magnet reconstruction, SPS magnet repair etc ... Impact on machine efficiency!
Improve LHC filling	5%?	Marginal gain unless LHC filling is much worse than assumed.
Change Ratio of FT to CNGS Beam		Approval of Scientific committees Needed since the other physics community would get correspondingly less.
a) Shorter Fixed-Target Flat top	10%	
b) Additional CNGS Cycle(s) in the Supercycle	n x 18%	
Increase the Intensity per cycle	10% ?	MTE should help via fewer losses. 5.2×10^{13} achieved (briefly) in 2004. Losses through the chain lead to higher radiation with impact on repair and shutdown works

All options have drawbacks and the number of protons available for ALL CERN users will continue to be an issue.