

# Operations Review 2007 of the LHC Injector Chain

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with the help of:

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.....and many other colleagues....

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# Topics:

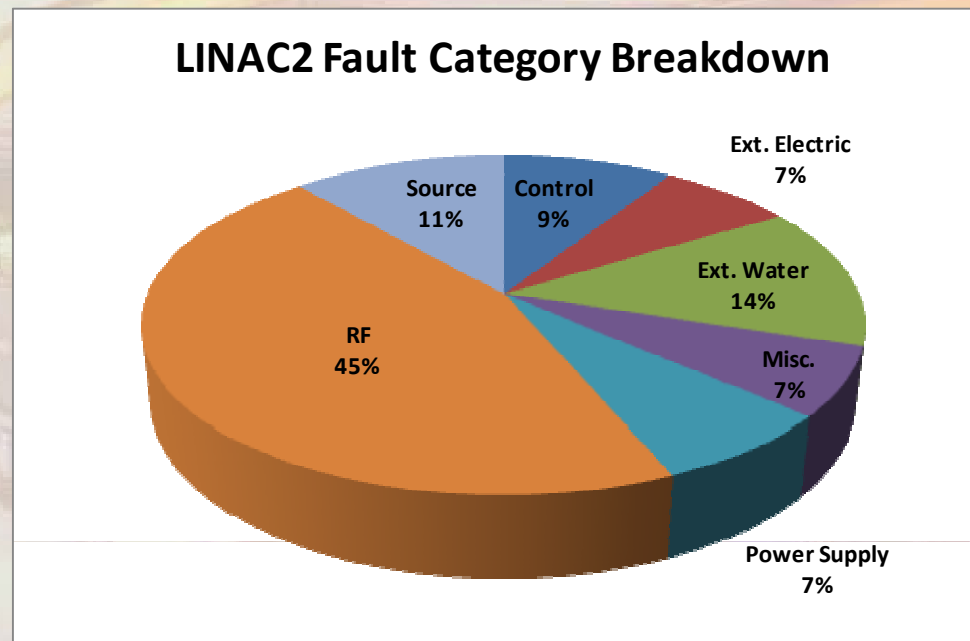
- # Machine performance in some numbers
- # Machine issues: solved, pending or to be discussed
- # Machine highlights and successes.
- # Support request
- # Conclusions
- # Remark:
  - Many topics in this presentation will be dealt with in more detail by some of our colleagues during these ATC-ABOC days.

# Boundary Conditions

- # The LHC injector chain machines considered are LINAC2, PS Booster, PS, SPS.
- # The up/down time figures are extracted from the e-logbook and are as precise as they are entered.
- # Beam availability calculations take into account the performance of the upstream machine(s).
- # The figures do not take into account when the beams were produced, but in a degraded mode.
- # The figures do not take into account the down time when it was decided to remove the cycle from the super cycle in case of a long break down.
- # A detailed AB/OP report on the 2007 machine performance and statistics will be published soon.

# LINAC 2 performance in figure

# LINAC2 ran **5044 hours** with a **98.7% up time**.



# Overall an **excellent LINAC2 up time !**



# LINAC 2 issues

(1)

## # RF related issues:

- **Water cooling leak on RF amplifiers.** Old tubing will be replaced this shut down.
- **RF tuner on RFQ blocked** for several weeks, resulting in reduced intensity. Was repaired during technical stop. **All other tuners will be inspected** this shut down

## # Black dust from air-conditioning ducts:

- Lasting already for **2 runs** due to **unclean heat exchanger**.
- Reason for very **high source flash-over rate**.
- **Broke source equipment** and caused ~13 hours of down time.
- *Talk in this session by Serge Deleval.*

# LINAC 2 issues

(2)

## # Controls:

- **WorkingSets** under **Java console manager** do not always report **coherent information** and freezes sometimes.
  - E.g. Equipments reported to be off with external faults, were working perfectly.
- There is also a **general impression** that the **Java** system is **slower, less reliable** and does not offer any new functionalities over the X-motif system it replaces.
- **CO** propose **improvements to solve** some of **these issues**.
- Will the **X-motif system** remain **available** in 2008 and later?
- *Talks in session 3 controls issues by Eugenia Hatziangeli*

# LINAC 2 highlights

- # Vacuum leak on tanks successfully mitigated by 2<sup>nd</sup>ary vacuum system.
  - No vacuum faults in 2007.
  - TS/CV will provide proposal to reduce temperature oscillations in 2008.
- # All the "town water" cooled systems have been moved to demineralised water.
  - The condensation, which was causing corrosion, has gone.

# PSB performance in figures

(1)

## # ISOLDE beam availability:

- GPS: 98% (of 1784 hours)
- HRS: 98% (of 1942 hours)
- Staggered beam: 95% (of 493 hours)

## # SPS production beams availability:

- Fixed target beam: 97% (of 4322 hours)
- CNGS beam: 96% (of 508 hours)

## # PS production beams availability :

- East Area north branch: 97% (of 1813 hours)
- East Area T8 DIRAC: 96% (of 3223 hours)
- East Area T7 irradiation: 97% (of 3275 hours)
- AD: 96% (of 3285 hours)
- MERIT: ~ 97% (of 769 hours)



# PSB performance in figures (2)

## # LHC type beams availability:

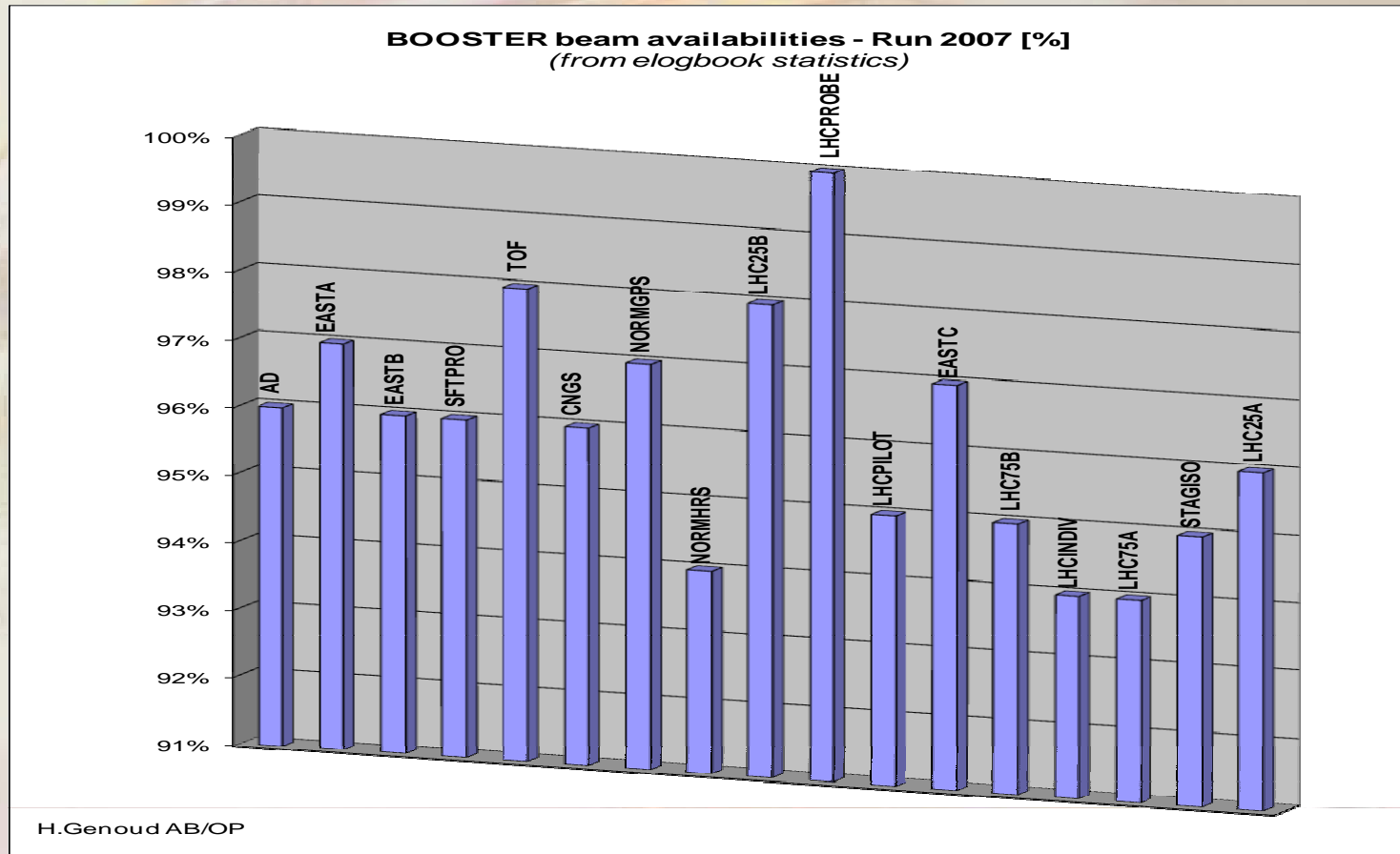
- LHC25: ~ 97% (of 892 hours)
- LHC75: ~ 92% (of 106 hours)
- LHCPILOT: 94% (of 446 hours)
- LHCPROBE: 98% (of 35 hours)
- LHCINDIV: 94% (of 286 hours)

## # Other MD beams (few among many):

- MD1 (for MTE): 99% (of 185 hours)
- MD2 (for various MD's): 96% (of 123 hours)
- MD3 (for high intensity setting-up): 98% (of 240 hours)

# Very good PS Booster beam availability of ~ 96% !

# PSB performance in figures (3)



# Very good PS Booster beam availability of ~ 96% !

# PSB issues

(1)

- # **LINAC2 to PSB trajectory** troublesome following problems with **quadruple ppm power supplies**.
  - Possible solution is being worked on.
- # **Archiving was troublesome** over a major part of the year.
  - **Problems solved now**, all beams are archived for the next run.
- # **Fast wire scanner problems**.
  - **2 out of 8 devices broken**.
  - **Vacuum valve** will be added during shutdown to **ease repair**.
  - **New electronics will be tested** on ring 1 in 2008.
  - Main emittance instrument for LHC type beams → **High priority**.
- # **Tune measurement**:
  - Was not working for major part of the run, but started **working towards the end of the run**.
  - **Modifications and implementation on all rings** for 2008 **agreed with BI**.

# PSB issues

(2)

## # Ejection transformers gave repeatedly erratic readings:

- Relatively many interventions on old electronics for which are no spares.
- Important for operation (loss minimization) and intensity statistics.
- Can electronics be replaced ??
- *Talk in session 6 by Jocelyn Tan.*

## # Beam intensity limitation due to transverse instability:

- Concerns mainly ring 4.
- During last milliseconds of the cycle (extraction bump).
- HW response time problem. (Beam Offset Signal Suppression)
- Successful test with a solution were made during last days of the run.
- The solution will be available early in the 2008 run.
- *Note being published by A. Blas and Co.*



# PSB issues

(3)

## # Beam intensity (H1) is limited by the C04 cavity:

- Limitations are analyzed (beam loading @ low voltage).
- MD done, working point of amplifier was changed, which improved the situation
- However, this working point cannot be maintained for cooling reasons.
- An operational solution is proposed and will be tried in 2008.
- Note (with this free of charge solution) is being published by A. Blas and Co.
- If this is not satisfactory then a strategy for a solution needs to be defined.

# PSB highlights

- # **Smooth and very quick start-up** within the three scheduled days.
  - New **MPS regulation** was **working well** from day 1.
  - One day lost due to **instrumentation problems**.
  - **Increased temperature of some bus bars** observed at start-up and surveyed throughout the year → **Follow-up !**
- # **All LHC type beams** in the PSB were **produced with nominal specifications**.
  - Some MD time is needed to ensure the correct production of the LHC 25 ns and 75 ns beams over a large intensity range.
- # **High intensity** was pushed to **3.8E13 ppp**.
- # **Change of control** for **BTY.BVT101** and **BTY.BHZ301** improved **stability** of ISOLDE beam on target.

# PS performance in figures

(1)

## # SPS production beams availability:

- Fixed target beam: 92% (of 3856 hours)
- CNGS beam: 93% (of 347 hours)

## # PS production beams availability:

- East Area north branch: 94% (of 1689 hours)
- East Area T8 DIRAC: 93% (of 3084 hours)
- East Area T7 irradiation: 91% (of 3401 hours)
- AD: 92% (of 3680 hours)
- MERIT: ~ 95% (of 262 hours)

## # LHC type beams availability:

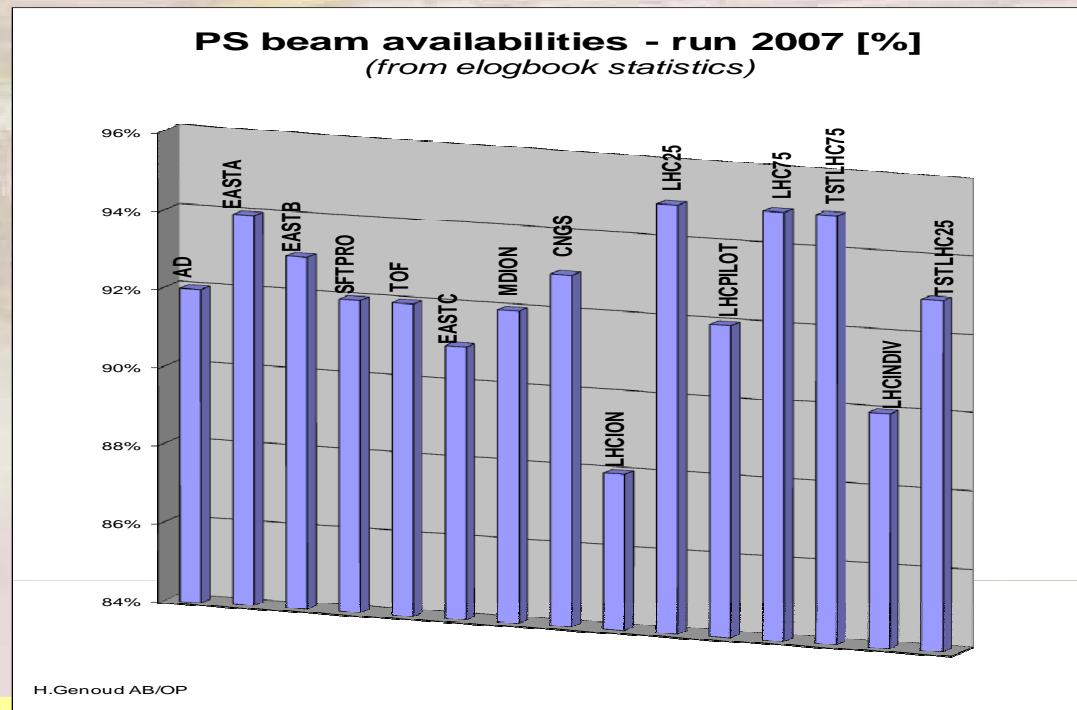
- LHC25: ~ 94 % (of 801 hours)
- LHC75: ~ 95% (of 116 hours)
- LHCPILOT: 92% (of 224 hours)
- LHCINDIV: 90% (of 62 hours)
- LHCION: 87% (of 569 hours)

# PS performance in figures

(2)

## # Other MD beams (few among many):

- MD1 (for MTE): 100% (of 8 hours)
- MD2 (for MTE): 92% (of 95 hours)
- MDION: 92% (of 104 hours)



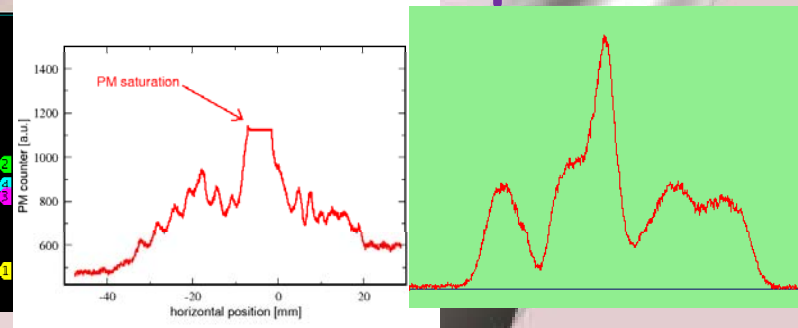
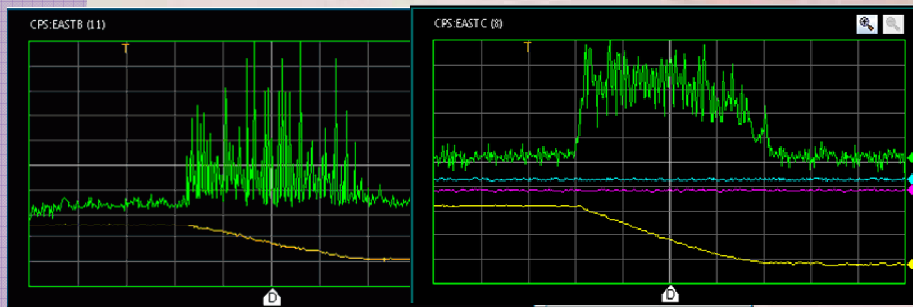
# Good PS beam availability of ~ 93% !



# PS issues

(1)

- # **New 5-Current Mode PFW power converters**
  - Initially fast commissioning on operational beams, but followed by period of problems.
  - Many back and forth switching between new and old power converters.
  - DIRAC was hampered by the large ripple on the SE spill.
  - MTE islands could not be recovered.
  - 26 July: The major problems were solved, only minor issues remained and two presentations were given at ATC of 24 August 2007.
- # **New installations should be tested in parallel and commissioned and validated in dedicated periods.**



# PS issues

(1)

## # Tune Measurement

- Worked part of the year and often only for beam with small radial displacement.
- Situation towards the end of the run improved considerably.
- Requested modifications and implementation strategy are discussed and agreed with BI for the 2008 run.

## # Following the PFW and Tune measurement problems :

- Non-linear chromaticity measurements could not be finished.
- PFW matrices are incomplete.
- Therefore the PS is in a not too good shape for tune and chromaticity control.
  - MTE MD's seriously hampered.
  - More difficulties to provide stable high intensity beams with low losses.
  - Some additional LHC beam transverse emittance blow up around transition.

# PS issues

(2)

## # Electro-Statics Septum Cables

- Last 2 meter is changed every shutdown.
- SEH23 (East Area SE) lasted for the whole run.
- SEH31 (CT extraction to SPS) broke 3 times last year, mainly during CNGS run.
- New production of same type of cable was used and only had a life time in the machine of about 2 to 3 weeks.
- Run was finished successfully with an old cable.
- Interventions become longer due increasing radiation levels following CNGS operation.
- This will become a non-issues when MTE will be operational.
- *Talk in session 6 by Jan Borburgh.*

## # MERIT installation work had an impact on the beam production in TT2.

- How will this be handled for nTOF (re-)installation ?
- *Talk in session 2 by Markus Brugger.*

# PS issues

(2)

## # Vacuum

- In **May a leaking feed-through** on an ion pump was found.
- The reason was a corroded feed-through.
- What is the **status of the other feed-through's** ?
- *Talk in this session by Pierre Strubin.*
  
- The **internal dump 48**, which is a mechanical device moving often, started **leaking** towards the end of the run.
- The dump was **renovated in 2006**.
- Is this an **incident or** are there **life-time issues** on the internal dumps ?



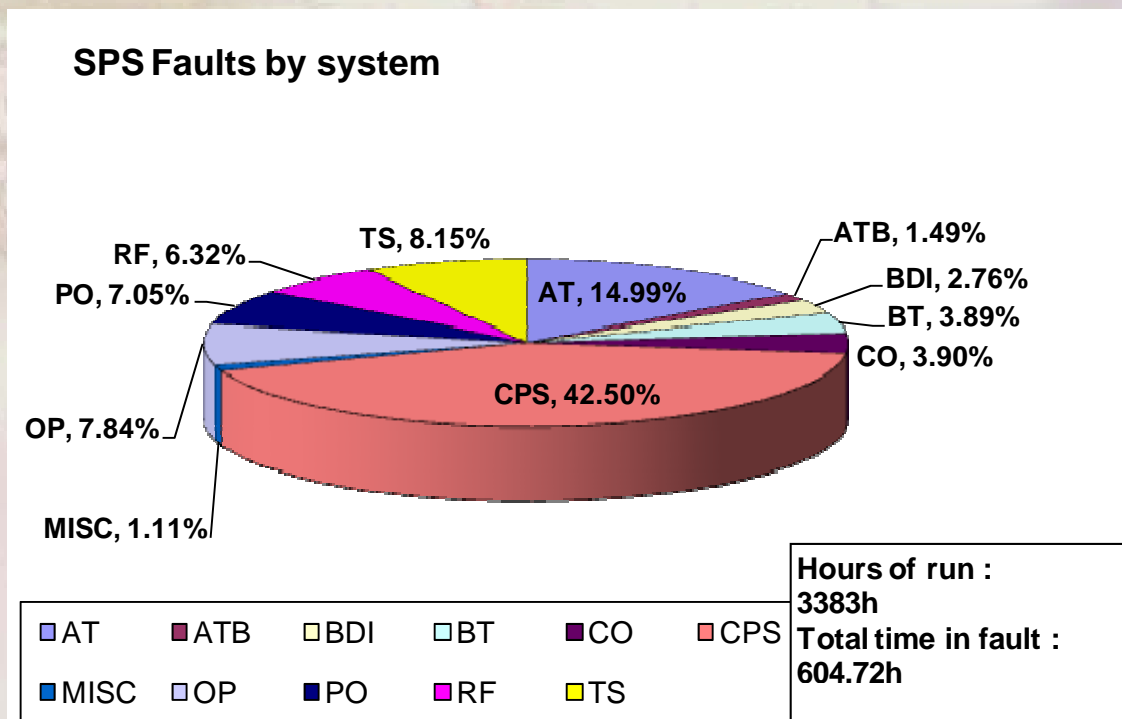
# PS highlights

- # The **CT loss displacement** scheme was implemented and **works well**.
  - ▣ **Radiation levels** below PS bridge **reduced** and **increased in SS74**.
  - ▣ *Talk in session 2 by Simone Gilardoni.*
- # All **required MERIT beam configurations** (even more) were **delivered**.
- # New **PFW power supplies work well** and reliable now.
  - ▣ Some additional improvement foreseen for next run.
- # **New triplet power converters** for transition jump worked very well from day 1.
- # Main magnet renovation scheme well advanced, **no main magnet related breakdowns**.

# SPS performance in figures

# The **SPS** has produced a **record number of different beams/configurations**.

# Overall a **good SPS beam availability** of **~ 82%!**



# SPS issues

(1)

## # Electricity:

- Many **18 KV cables** breakdowns.
- During major part of the run **no spare cable to BA4**.
- What is the **present spare situation** ?
- What is the **strategy to reduce** the number of **breakdowns** ?
- *Next talk by Serge Deleval*

## # Compensator:

- **Overheating** when SPS is not pulsing (mainly in summer).
- Why not **switch off the compensator** when SPS is not pulsing ?
- Will the **2<sup>nd</sup> compensator** (spare) be **operational in 2008** ?
- *Next talk by Serge Deleval.*

## # RF:

- **Transmitter problems** over the whole year, but **worse** after start-up with ion MD's (large frequency sweep).
- This **did not cause beam stop**, but degraded beam operation.
- **Being worked on**, what is the status ?

# SPS issues

(1)

## # Magnets:

- Several magnets (ring, transfer lines and experimental areas) were changed following leaks.
- In the ring the manifold repair campaign now covers ~ 1/3 of the machine.
- About 80 hours were lost due to leaks of magnets close to target boxes.
- *Talks in this session by Pierre Strubin.*

## # CNGS:

- Run started successfully, but stopped early due to the influence of radiation on the ventilation system electronics.
- *Talk in session 2 by Edda Gschwendtner.*



# SPS highlights

(1)

- # The **fixed target** beam was delivered with **high intensity** to the **North Area**.
  - **Highest intensity** per spill ever.
  - Nominal and **double length spills**.
  - Integrated  $11.12 \times 10^{18}$  protons, which is **95% more** than in 2006 ( $5.71 \times 10^{18}$ )
- # **CNGS** successfully received  **$8.3 \times 10^{17}$  protons on target** until ventilation problems arose.
- # **Frequent super cycle changes** beneficial for physics.
- # The **extraction tests** in TI2 and TI8 were **very successful**.
- # **LSA** became **more stable and reliable**.
  - **Cycle management** now much better under control.
  - **Tune and chromaticity predictions** are **more precise** following trim experience on different cycles.

# SPS highlights

(2)

## # Extraction without tune-split:

- Successfully operated at the end of the run.
- 2008 start-up will be without tune-split.
- Q-split equipment remains available in case.....

## # The Pb ions MD's were successful:

- Injected, accelerated and non-synchronized extracted.
- End of run with very low intensity due to PS vacuum leak.

# Support

- # The **recent consolidation** projects make the **machines** operate **more efficiently** and **reliable**.
- # The **good beam availability** and machines up times are not only thanks to the hardware, but **mainly to all the people that make the systems work**.
- # The **LHC commissioning** will require a **enormous effort** and will therefore attract **all** the **support** necessary, which is fully justified.
- # However,  
**The support for the injectors, that increased last year, should not reduce again.**

# Conclusions

- # The **2008 beam availability** in all machines was **high**.
- # **Consolidation** contributed to this **success**.
- # Nevertheless there are **still several problem areas** that cause worries and need **to be tackled**.
  - # 18 KV cables, etc...
- # **New installations** should be **tested in parallel** and **commissioned** and validated in **dedicated periods**.
  - # MTE, New MPS regulation, PS SW renovation, BBQ, etc...
- # The **list of issues is not exhaustive** and all **additional information** is very **welcome**.
- # During the shut down many of the issues are being worked on and will be ready for the next run !!!

The 2007 run was the final rehearsal for next year's  
"Grand Première"

Let's make it work together !!!