With significant contributions from H. Damerau and M. Morvillo
The PS high level RF system

Issues in the PS longitudinal phase space

Implications for the hardware

The high level RF upgrade program (possible options)

What is already in the pipeline

Concluding remarks
PS high level RF systems - overview

- 10 MHz system
- 13/20 MHz system
- 40 MHz system
- 80 MHz system
- 200 MHz system
The 10 MHz system

- Ferrite loaded cavity
- Freq range 2.8 – 10 MHz
- 2 RF gaps / cavity
- 20 kV / cavity

Built in 1975, upgraded in 1988

RF amplifier adopting:
3 x YL1056 tubes in the feedback stage;
1 x RS1084 in the final stage.
Housed in the cavity base.
The 13/20 MHz system

Ferrite loaded cavity
Frequencies 13 or 20 MHz
2 RF gaps / cavity
20 kV / cavity peak
*Built in 2002*

Driver amplifier
Especially designed to slide in the gallery
The 40 MHz system

Vacuum reentrant cavity
Frequency 40 MHz
1 RF gap / cavity
300 kV / cavity
Built in 1996
The 80 MHz system

Vacuum reentrant cavity
Frequency 80 MHz
1 RF gap / cavity
300 kV / cavity

Built in 1997
The 200 MHz system

Pill-box cavity
Frequency 200 MHz
1 RF gap / cavity
6 cavities
50 kV / cavity
Built in 1979

Amplifiers and HV power supplies partially renovated in 2005
The PS Longitudinal phase space – CBI & TBL

LHC25, LHC50ns

For more details see S. Hancock’s presentation, this LIU Event.
Possible remedies to PS longitudinal limitations

Main longitudinal limitations:

1. Coupled-bunch instabilities during acceleration and on flat-top
   → New coupled-bunch feedback: based on 1-turn delay electronics
   → Longitudinal kickers: 10 MHz RF cavities or dedicated wide-band cavity?
   → Impedance reduction of all cavities, especially 2.8 – 10 MHz

2. Transient beam loading during bunch splitting manipulations
   → Distributed issue: all RF systems for bunch splittings concerned
   → 10 MHz: new 1-turn delay feedback, new feedback amplifier or completely new amplifier?
   → 20 MHz: 1-turn delay feedback
   → 40 MHz: 1-turn delay feedback, new feedback amplifier?
   → 80 MHz: 1-turn delay feedback, new feedback amplifier, fast ferrite tuner?

Some ideas for hardware developments

New 1-turn delay feedback around all systems would be beneficial for both CBI and TBL.

A dedicated wide band RF system using magnetic alloy rings in the resonator may result very effective in fighting CBI.

Prototype for PSBC04 RF cavity.
See M. Paoluzzi’s presentation, this LIU Event.

LEIR RF system operational since 2004, built in collaboration with KEK.
A new 1-turn delay feedback around the 10 MHz system is already in the pipeline.

If possible, an increase of the amplifier fast feedback beyond the present 26 dB could significantly reduce further the cavity impedance seen by the circulating beam.
10 MHz developments – feedback increase
limitations from the present architecture

Test performed in 2001 to replace the pre-driver stage with a solid state amplifier.
10 MHz developments – second gap relay installed in 2011

Both gap relays close

Only one relay closes

With one gap relay closed and 8/10 cavities parked at h=6.5 the result is much more impressive.
40/80 MHz developments – feedback increase

Long cable length from the cavity to the feedback amplifier and back to the final amplifier (120 ns) is a limit to push the feedback beyond the present performance (43 dB).

A second limitation comes from the HV power supplies, already limiting the present performance of the system in the presence of high beam loading or cavity detuning.
Mechanical gap relay cannot be used in a pulse to pulse operation to reduce the cavity impedance seen by the beam (pneumatic actuator).

By parking the cavities at an intermediate frequency (250 kHz off resonance) 2 to 4 dB could be gained in impedance reduction.

Use perpendicularly biased ferrites to build a fast tuner.

By parking the cavities at an intermediate frequency (250 kHz off resonance) 2 to 4 dB could be gained in impedance reduction.
### Some planning and what is already in the pipeline

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Concluding remarks

- The final choice among the possible optional developments will depend on experimental results from MD studies and operational decisions;

- A prioritized list of interventions will be decided soon, depending on impact, available resources and possibility of success;

- Aspects related to the maintenance of equipment and to the application of the ALARA principle will be a relevant factor in the decision process;

- The R&D program will be anyway strongly dependent on available resources and on manpower, in particular.
THANK YOU FOR YOUR ATTENTION!

LHC Injectors Upgrade