



LHC Injectors Upgrade

New PS working point knobs in LSA

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Acknowledgements:

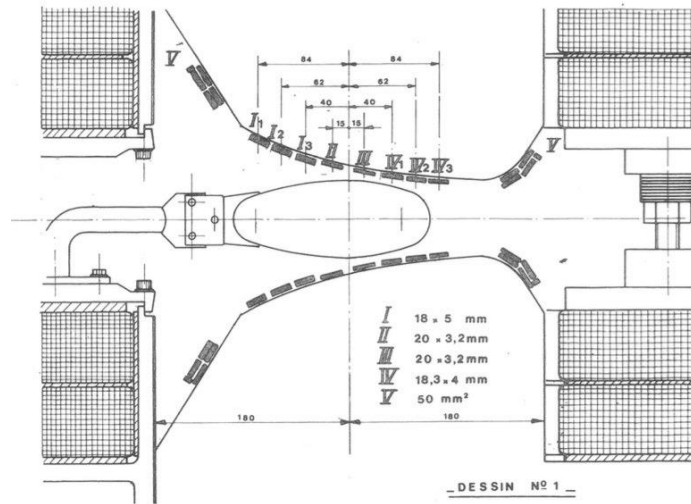
H. Bartosik, D. Cotte, D. Jacquet, V. Kain, E. Piselli, F. Tecker, B. Vandonpe



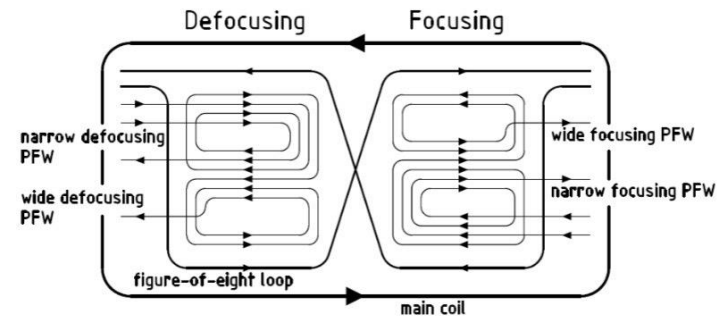
Pole Face Windings

- **Auxiliary circuits mounted on the poles of the PS main magnets**
 - Tune and chromaticity control at momentum > 3.5 GeV/c
 - Depending on the operational configuration → introduction of highly non-linear field

Pole shape



Different PFW circuits



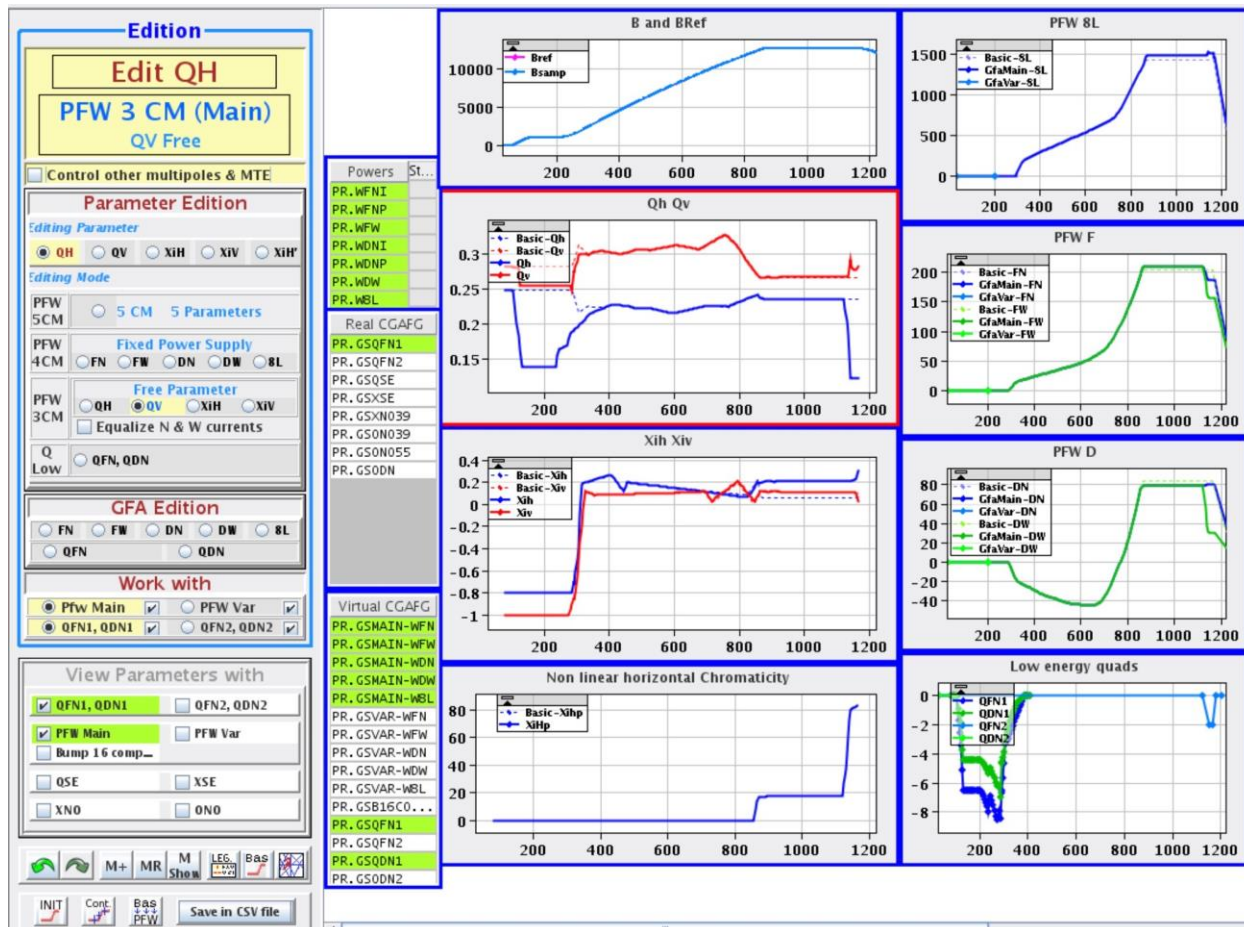
- **Operational use based on measured response matrix**

$$\begin{pmatrix} \Delta Q_x \\ \Delta Q_y \\ \Delta \xi_x \\ \Delta \xi_y \\ \Delta Q''_{x,y} \end{pmatrix} = \begin{pmatrix} a_{11} & a_{12} & a_{13} & a_{14} & a_{15} \\ a_{21} & a_{22} & a_{23} & a_{24} & a_{25} \\ a_{31} & a_{32} & a_{33} & a_{34} & a_{35} \\ a_{41} & a_{42} & a_{43} & a_{44} & a_{45} \\ \cancel{a_{51}} & \cancel{a_{52}} & \cancel{a_{53}} & \cancel{a_{54}} & \cancel{a_{55}} \end{pmatrix} \begin{pmatrix} \Delta I_{FN} \\ \Delta I_{FW} \\ \Delta I_{DN} \\ \Delta I_{DW} \\ \cancel{\Delta I_{F8L}} \end{pmatrix}$$



Current working point control application

- Developed by B. Vandore
- Extremely versatile but complex tool
- Allows tune and chromaticity control using various configurations of PFW and Low Energy Quadrupoles





Future prospect

- **Homogenization of the approaches in the different machines**
 - Simplifies the life of operators and MD users at the same time
- **Using the LSA-approach**
 - Change of settings to be programmed using single, generic application
 - Application supported by CO
- **Difficulty of PFW**
 - Non-linear elements creating quadrupolar, sextupolar and octupolar effect at the same time
 - Classical relation between physical parameter – gradient – current not available
- **Different approach**
 - Implementation of the complete response matrix in LSA
 - Equivalent approach to the implementation in the working point application



LSA implementation

The screenshot shows the 'Settings Management' application interface. At the top, there is a menu bar with 'File', 'Applications', 'Search', and 'Help'. Below the menu bar is a toolbar with various icons and a dropdown menu showing 'RBA: cpsop'. The main window is titled 'Settings Management x' and contains a 'Source' list on the left, a 'Parameter Group' list in the middle, and a 'Property' and 'Parameter' list on the right. The 'Source' list includes various LHC components like MD8, MD4, LHCINDIV, EAST1, ION2, LHC3, LHC2, LHC4, MD1, ION1, ION3, LHCPROBE, MD7, MD6, MD5, MD3, SFTPRO2, MD2, and ION4. The 'Parameter Group' list includes BLM, CHROMATICITY, CORRECTORS H, CORRECTORS K(DHZOC), CORRECTORS K(H&V), CORRECTORS V, KICKERS, MOMENTUM, PFW, QUAD DEFOC, QUAD FOC, QUAD SKEW, RF, TIMING, TUNE, and -NONE. The 'Property' list includes PSBEAM/Q and PSBEAM/QPRIME. The 'Parameter' list includes PSBEAM/QH_PFW, PSBEAM/QPH_PFW, PSBEAM/QPV_PFW, and PSBEAM/QV_PFW.

Below the main window is a 'Parameter Hierarchy' window. It has a 'Hierarchies' dropdown set to 'DEFAULT' and a 'Description of colors' section with 'Current' (purple), 'Dependent' (green), and 'Source' (blue) buttons. The hierarchy diagram shows a tree structure starting with 'PSBEAM/QH_PFW' at the top. It branches into two 'PR.CSVAR.-WDN/SettingAmplitudes' nodes. Each of these branches into two 'PR.WDN/REF.TABLE#FUNCTION' nodes. Each of these four branches into two 'PR.WFN/REF.TABLE#FUNCTION' nodes. Each of these eight branches into two 'PR.WFN/MEAS.ACQ_DELAY#value' nodes. The nodes are color-coded: 'PSBEAM/QH_PFW' is purple, 'PR.CSVAR.-WDN/SettingAmplitudes' is green, 'PR.WDN/REF.TABLE#FUNCTION' is blue, 'PR.WFN/REF.TABLE#FUNCTION' is green, and 'PR.WFN/MEAS.ACQ_DELAY#value' is blue.

At the bottom of the 'Parameter Hierarchy' window, there is an 'Available actions' section with two bullet points:

- Right-click the box with parameter to show details about parameter or parameter type
- Right-click the arrow to show details about the make rule

A 'Close' button is located at the bottom right of the 'Parameter Hierarchy' window.

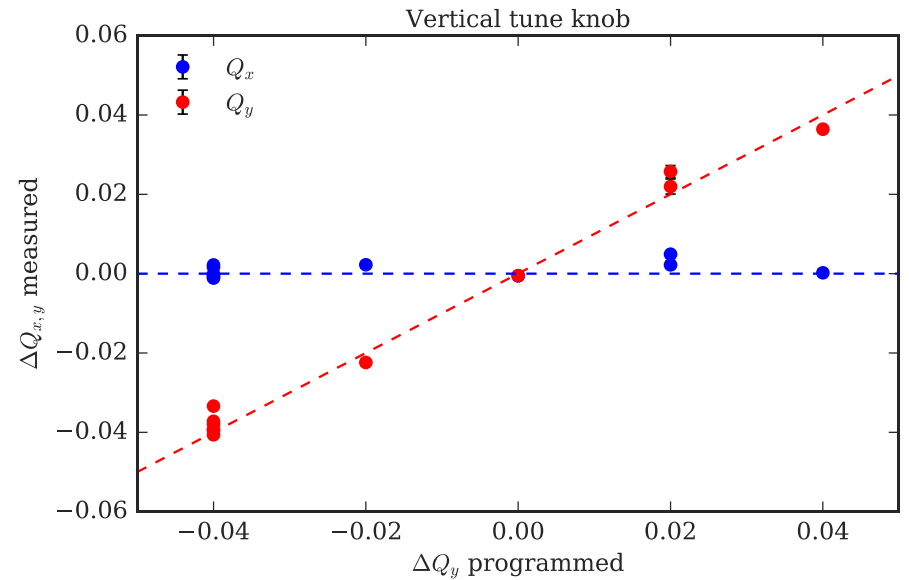
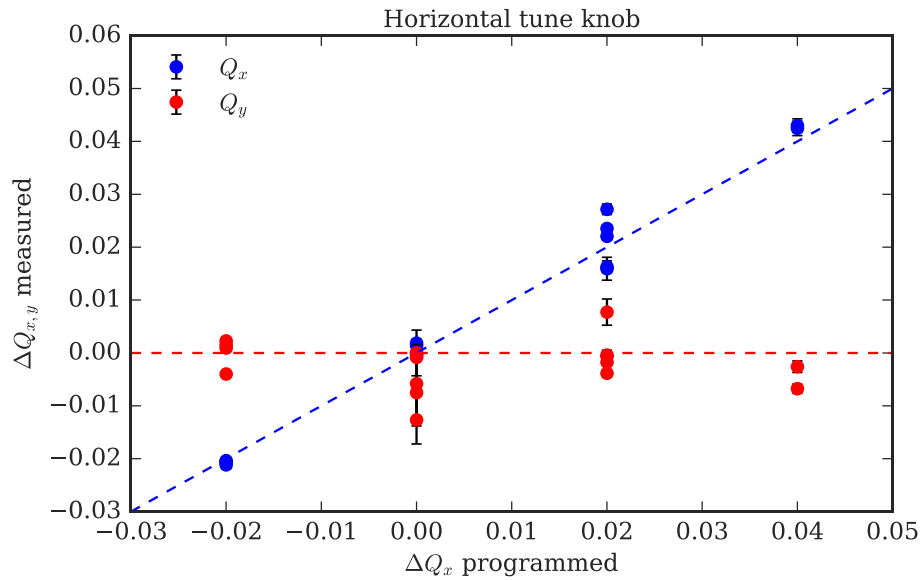
- Knobs are interlinked → generation of all 4 knobs required to allow trimming





First MD results – tune measurements

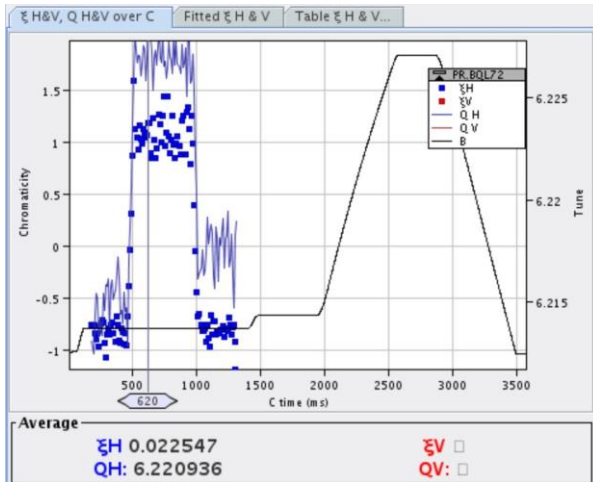
- Tune measurement follows well the programmed values





First MD results – chromaticity measurements

- Same is true for the chromaticity knobs



Settings Management x

Source	Parameter Group	Property	Parameter
MD-1	BLM	PSBEAM/QPRIME	PSBEAM/QPH_PFW
EAST1	CHROMATICITY		PSBEAM/QPV_PFW
ION2	CORRECTORS H		
MD3	CORRECTORS K(DHZO)		
LHC3	CORRECTORS K(H&V)		
MD5	CORRECTORS V		
MD1			
LHC4			

Trim Settings

Copy

Compare

Generate

Generate Settings

Acquire / Drive

Setting Part: Value Target Correction Time Base: Cycle Beamprocess Injection

PSBEAM/QPH_PFW

Graph Table

Zero Settings

Trim Cancel last trim Apply Trim



Summary and outlook

- **Knobs appear to behave as expected, but further verification required**
- **At the moment used as MD tool only**
 - One has still to be careful to avoid conflicts when trimming on I-level
- **Additional knobs for F8L and LEQ almost ready to be used**
- **Tests with new chromaticity sextupoles foreseen as well**
- **Knobs will allow the implementation of additional features**
 - AutoQ/Q'
 - Slow tune feedback for MTE
 - Further automatization of MD studies
 - ...



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Thank you for your attention!

