

### MEASUREMENT AND ANALYSIS OF SPS KICKER MAGNET HEATING AND OUTGASSING WITH DIFFERENT BUNCH SPACING G. Rumolo, CERN

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• Machine Development (MD) studies at the SPS have been carried out with trains of bunches spaced by 25 ns, 50 ns or 75 ns.

• For one of the SPS kicker magnets (MKDV2) the 75 ns bunch spacing resulted in considerable beam induced heating.

 $\rightarrow$  This is believed to be understood and will be explained.

• The MDs showed that 50 ns bunch spacing could result in a very rapid pressure rise in some kicker magnets (especially MKDV1) and thus cause an interlock.

 $\rightarrow$  Detailed measurements will be presented and discussed.





#### **The MKDV kickers**

## The MKDH + MKDV kickers are used to send the SPS beam onto an internal dump



<u>No transition pieces between the magnet and the vacuum</u> <u>tank are installed in the MKDV magnets</u>

No impedance reduction measures (like serigraphy) applied.

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#### SPS beam parameters during the Machine Development Studies

An overview view on the main beam parameters (at the MKDV) during the MD sessions in the SPS

	β <sub>x</sub> (m)	β <sub>y</sub> (m)
MKDV1	23.6	94.51
MKDV2	28.55	81.1

#### Beam sizes @ MKDV1

	25, 75 ns	50 ns
σ <sub>x</sub> @26 GeV/c	1.6 mm	0.9 mm
σ <sub>y</sub> @26 GeV/c	3.2 mm	1.8 mm
σ <sub>x</sub> @450 GeV/c	0.38 mm	0.22 mm
σ <sub>y</sub> @450 GeV/c	0.77 mm	0.44 mm

#### Bunch length $(1\sigma)$

	Injection (26 GeV/c)	Before ramp	450 GeV/c
25 ns	0.92 ns	(0.6 ns)	0.35 ns
<b>50 ns</b>	0.92 ns	0.6 ns	0.31 ns
75 ns	0.9 ns	(0.6 ns)	0.31 ns

\* The beam sizes are smaller at 50ns than at 25 and 75ns because the 50ns beam is produced with lower transverse emittances at the PSB ( $\sim$ 1 µm instead of 2.7 µm)



#### MKDV Temperature & Pressure on 12, 13 & 14<sup>th</sup> August 2008





#### **MKDV Pressure on 14/08/2008**, between 01:20hrs & 02:10hrs.

#### 1s resolution



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#### MKDV Pressure on 14/08/2008, between 05:00hrs & 07:00hrs.

#### 1s resolution



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#### Partial summary and comparison with other kickers

- MKDV1 & MKDV2 are affected by temperature increase with beams spaced by 75ns and pressure rise with beams spaced by 50ns
- Temperature increase is specially severe in MKDV2, whereas pressure rise is larger in MKDV1
- Other kickers also exhibit pressure rise with the 50ns spaced beams, but always over a factor of 2 below that observed in MKDV
  - $\rightarrow$  MKDH, MKQV, MKE6 show vacuum activity with 50ns beams
  - $\rightarrow$  MKQH, MKE4, MKP do not have pressure rise
  - $\rightarrow$  MKQH is sensitive to 75ns beams
- The temperature rise is observed to be specially low in the MKE kickers that are serigraphed. However, the MKEs exhibit significant pressure rise, irrespective of whether they are serigraphed, or not.

## **MKDV: Longitudinal Impedance**





#### MKDV1 Kicker: Vacuum, October 6<sup>th</sup> to 8th, 2008









## **MKDV Pressure Peak versus Bunch Intensity (4 batches)**

- 50ns bunch spacing;
- The instantaneous pressure rises in MKDV kickers shows a clear threshold effect with intensity.





# Electron cloud study for the MKD kickers

lectron cloud simulations were run with ECLOUD to understand whether the pressure rise in MKDV1 can be explained with electron cloud formation:

**KDV1** has the most electron cloud among the **MKD** magnets

f the  $\delta_{max}$ >1.7, both 25ns and 50ns bunch spacings cause electron cloud formation, but the 25ns appears more critical (~2-3 larger density).





Conclusions

- Temperature rise of MKDV2 with 75 ns bunch spacing, is believed to be attributable to impedance resonances coinciding with one or more beam spectral lines of significant current;
  - Measurements on MKDV1 show that the resonances are significantly attenuated by the use of transition pieces (see paper <u>TU6RFP076</u>)
  - It is planned to install transition pieces in MKDV2: this is expected to reduce the temperature rise with 75 ns bunch spacing.
- 50ns bunch spacing causes fast pressure rise (suspected surface effect, e.g. <u>electron cloud</u>) for most SPS kickers – but MKDV1 is most significant;
- Consistent with electron cloud, pressure rise is dependent upon:
  - Beam intensity
    - Number of batches
    - There is an intensity threshold at ~6x10<sup>10</sup> protons/bunch
  - Bunch sizes

Below However, both e-cloud monitors and simulations show higher ecloud build up with 25ns bunch spacing...



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9

## SPS Kickers: Vacuum, August <u>Is resolution</u> 14, 2008





<sup>10</sup> 





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