# ECLOUD in PS2, PS+, SPS+: update Feb. 2007

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# Summary

- Results for ecloud build-up in LHC injector upgrades (PS2, PS+, SPS, SPS+,…)
  - Bunch spacings $t_b$=**12.5**, **25**, **50** and **75** ns
  - Obtained with code POSINST
  - Only in a dipole bending magnet, during 1st injected batch

- Initial results (PPT file) were presented by MF at LUMI06
  - Coarse integration time step (**Δt=0.1-0.3 ns**) for expediency
- Present (new) results have **Δt=0.02-0.07** ns
  - These are now published in the LUMI06 proceedings (see also http://mafurman.lbl.gov/LBNL-61925.pdf)

- Basic conclusion:
  - New results much more favorable vis-à-vis heat load (roughly speaking, factor 5-20, depending on the case)
  - Caveat: time step Δt=0.02-0.07 ns believed to be adequate, but not methodically checked

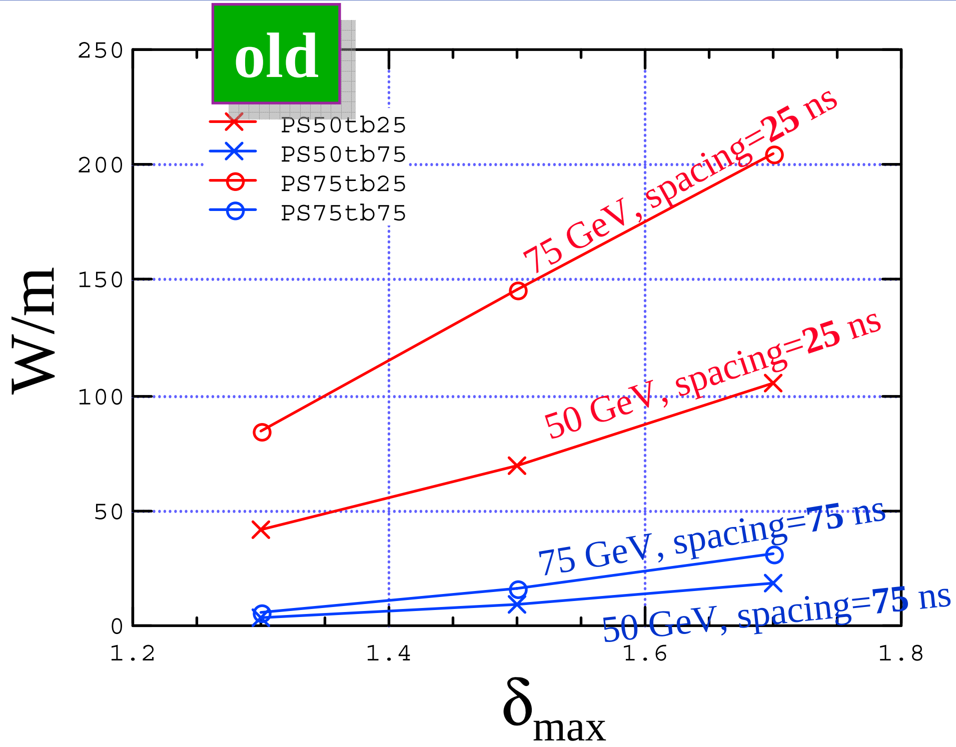
# Input parameter table

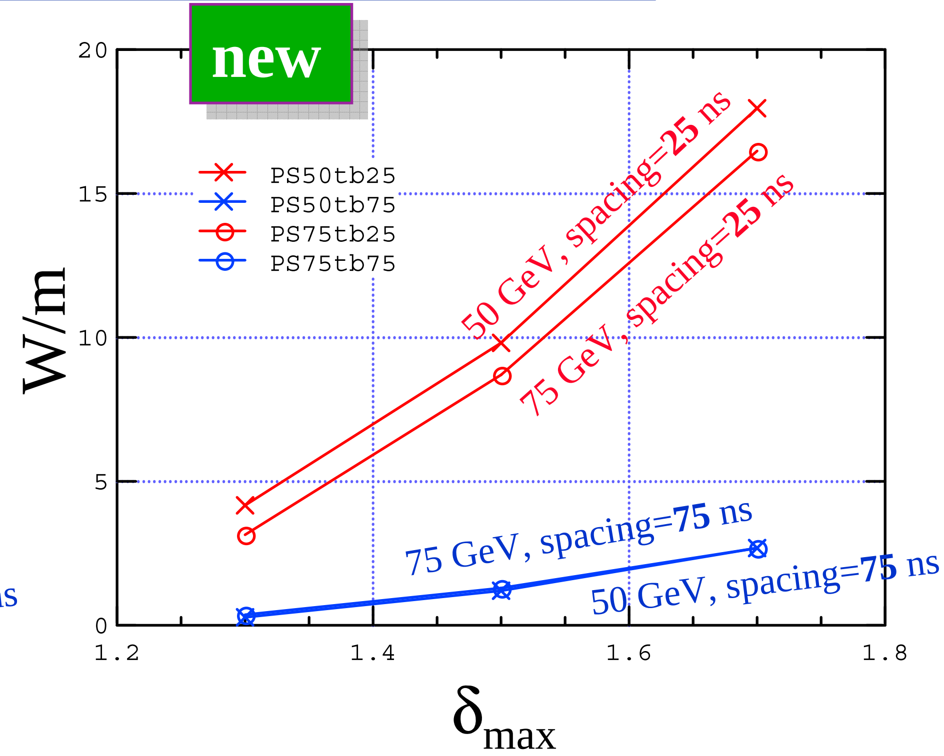
**(from LBNL-61925, based on FZ's "psplusetcparameters" and "lhcupgradeparameters")**

| Case | Our notation | $E_b$ GeV | $B$ T | $(a,b)$ cm | $N_b$ $10^{11}$ | $t_b$ ns | $(\sigma_x,\sigma_y)$ mm | $\sigma_z$ cm | profile ... |
|---|---|---|---|---|---|---|---|---|---|
| PS2, 50 GeV extr. | PS50tb12p5 | 50 | 1.8 | $(8,4)$ | 2 | 12.5 | $(1,0.9)$ | 57.3 | gauss. |
| | PS50tb25 | 50 | 1.8 | $(8,4)$ | 4 | 25 | $(1,0.9)$ | 93.5 | gauss. |
| | PS50tb50 | 50 | 1.8 | $(8,4)$ | 5.4 | 50 | $(1,0.9)$ | 104 | flat |
| | PS50tb75 | 50 | 1.8 | $(8,4)$ | 6.6 | 75 | $(1,0.9)$ | 104 | flat |
| PS+, 75 GeV extr. | PS75tb12p5 | 75 | 2.7 | $(8,4)$ | 2 | 12.5 | $(0.8,0.8)$ | 50.5 | gauss. |
| | PS75tb25 | 75 | 2.7 | $(8,4)$ | 4 | 25 | $(0.8,0.8)$ | 83.5 | gauss. |
| | PS75tb50 | 75 | 2.7 | $(8,4)$ | 5.4 | 50 | $(0.8,0.8)$ | 92.3 | flat |
| | PS75tb75 | 75 | 2.7 | $(8,4)$ | 6.6 | 75 | $(0.8,0.8)$ | 92.3 | flat |
| SPS, 50 GeV inj. | SPS50tb12p5 | 50 | 0.225 | $(7,2.2)$ | 1.9 | 12.5 | $(3.1,1.6)$ | 14.3 | gauss. |
| | SPS50tb25 | 50 | 0.225 | $(7,2.2)$ | 3.8 | 25 | $(2.8,1.6)$ | 23.4 | gauss. |
| | SPS50tb50 | 50 | 0.225 | $(7,2.2)$ | 5.2 | 50 | $(3,1.6)$ | 26.1 | flat |
| | SPS50tb75 | 50 | 0.225 | $(7,2.2)$ | 6.4 | 75 | $(3,1.6)$ | 26.1 | flat |
| SPS, 75 GeV inj. | SPS75tb12p5 | 75 | 0.337 | $(7,2.2)$ | 1.9 | 12.5 | $(2.4,1.3)$ | 12.6 | gauss. |
| | SPS75tb25 | 75 | 0.337 | $(7,2.2)$ | 3.8 | 25 | $(2.1,1.3)$ | 20.9 | gauss. |
| | SPS75tb50 | 75 | 0.337 | $(7,2.2)$ | 5.2 | 50 | $(2.3,1.3)$ | 23.1 | flat |
| | SPS75tb75 | 75 | 0.337 | $(7,2.2)$ | 6.4 | 75 | $(2.3,1.3)$ | 23.1 | flat |
| SPS, 450 GeV extr. | SPS450tb12p5 | 450 | 2.025 | $(7,2.2)$ | 1.9 | 12.5 | $(1.2,0.9)$ | 12 | gauss. |
| | SPS450tb25 | 450 | 2.025 | $(7,2.2)$ | 3.8 | 25 | $(1,0.5)$ | 12 | gauss. |
| | SPS450tb50 | 450 | 2.025 | $(7,2.2)$ | 5.2 | 50 | $(1,0.5)$ | 15 | flat |
| | SPS450tb75 | 450 | 2.025 | $(7,2.2)$ | 6.4 | 75 | $(1,0.5)$ | 15 | flat |
| SPS+, 1 TeV extr. | SPS1000tb12p5 | 1000 | 4.5 | $(6,2)$ | 1.8 | 12.5 | $(0.5,0.4)$ | 12 | gauss. |
| | SPS1000tb25 | 1000 | 4.5 | $(6,2)$ | 3.6 | 25 | $(0.6,0.4)$ | 12 | gauss. |
| | SPS1000tb50 | 1000 | 4.5 | $(6,2)$ | 5.1 | 50 | $(0.5,0.4)$ | 15 | flat |
| | SPS1000tb75 | 1000 | 4.5 | $(6,2)$ | 6.2 | 75 | $(0.5,0.4)$ | 15 | flat |
| SPS+a, 50 GeV inj. | SPSpa50tb12p5 | 50 | 0.225 | $(6,2)$ | 1.9 | 12.5 | $(3.1,1.6)$ | 14.3 | gauss. |
| | SPSpa50tb25 | 50 | 0.225 | $(6,2)$ | 3.8 | 25 | $(2.8,1.6)$ | 23.4 | gauss. |
| | SPSpa50tb50 | 50 | 0.225 | $(6,2)$ | 5.2 | 50 | $(3,1.6)$ | 26.1 | flat |
| | SPSpa50tb75 | 50 | 0.225 | $(6,2)$ | 6.4 | 75 | $(3,1.6)$ | 26.1 | flat |
| SPS+b, 75 GeV inj. | SPSpb75tb12p5 | 75 | 0.337 | $(6,2)$ | 1.9 | 12.5 | $(2.4,1.3)$ | 12.6 | gauss. |
| | SPSpb75tb25 | 75 | 0.337 | $(6,2)$ | 3.8 | 25 | $(2.1,1.3)$ | 20.9 | gauss. |
| | SPSpb75tb50 | 75 | 0.337 | $(6,2)$ | 5.2 | 50 | $(2.3,1.3)$ | 23.1 | flat |
| | SPSpb75tb75 | 75 | 0.337 | $(6,2)$ | 6.4 | 75 | $(2.3,1.3)$ | 23.1 | flat |

# Sample old vs. new results:

## heat load for PS2 and PS+




- Old: MF talk at LUMI06
  - 21 kicks/bunch, or $\Delta t=(6\text{-}7)\times 10^{-10}$ s
- New: MF paper in LUMI06 proceedings (LBNL-61925)
  - 201-251 kicks/bunch, or $\Delta t=(5.5\text{-}6.7)\times 10^{-11}$ s

# Sample new results: heat load vs. $\delta_{max}$

**(PS, $E_b$=50 or 75 GeV; SPS, $E_b$=75 GeV; $t_b$=25, 50, 75 ns)**

LARP

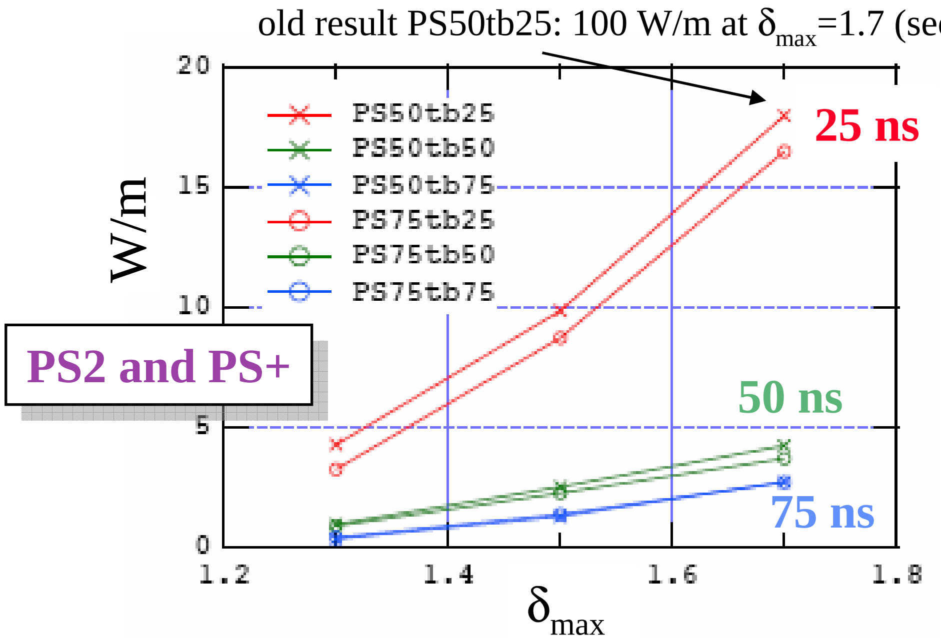



Figure 4: Simulated PS ecloud heat load vs. $\delta_{max}$ for cases PS50 and PS75 (PS2 and PS+ in "psplusetcparameters," respectively).

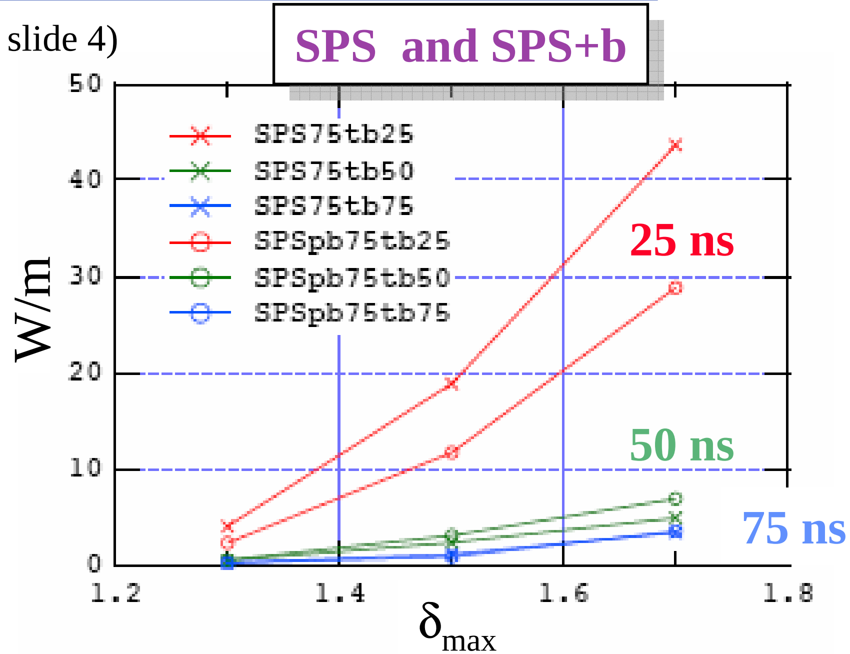



Figure 7: Simulated SPS ecloud heat load vs. $\delta_{max}$ for cases SPS75 and SPSpb75. The only difference between the calculation for these two cases is the transverse chamber size (see text).

- Generally, $t_b$=50 and 75 ns is much more favorable than 25 ns
  - — But 75 ns not significantly better than 50 ns
- SPS ~x2 higher heat load for same $E_b$, $N_b$ and $t_b$ than PS probably owing to smaller $\sigma_z$ and smaller chamber size

# Sample new results: Cu vs. St.St.

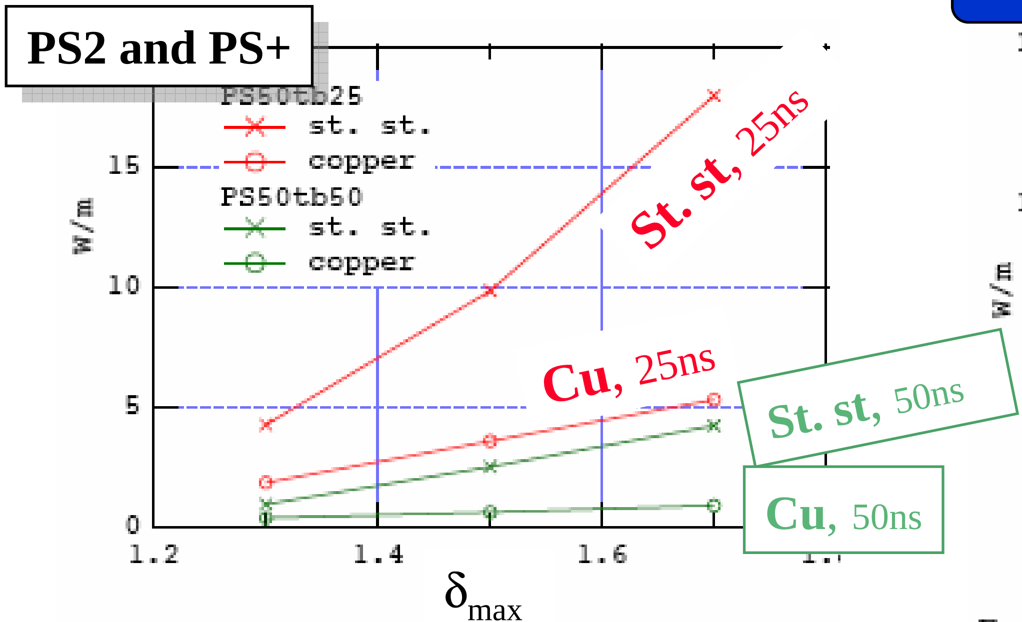



Figure 5: Simulated PS ecloud heat load vs. $\delta_{max}$ for case PS50, for copper and stainless steel chamber. The only difference in the calculation for the two cases is the secondary emission energy spectrum of the two metals.

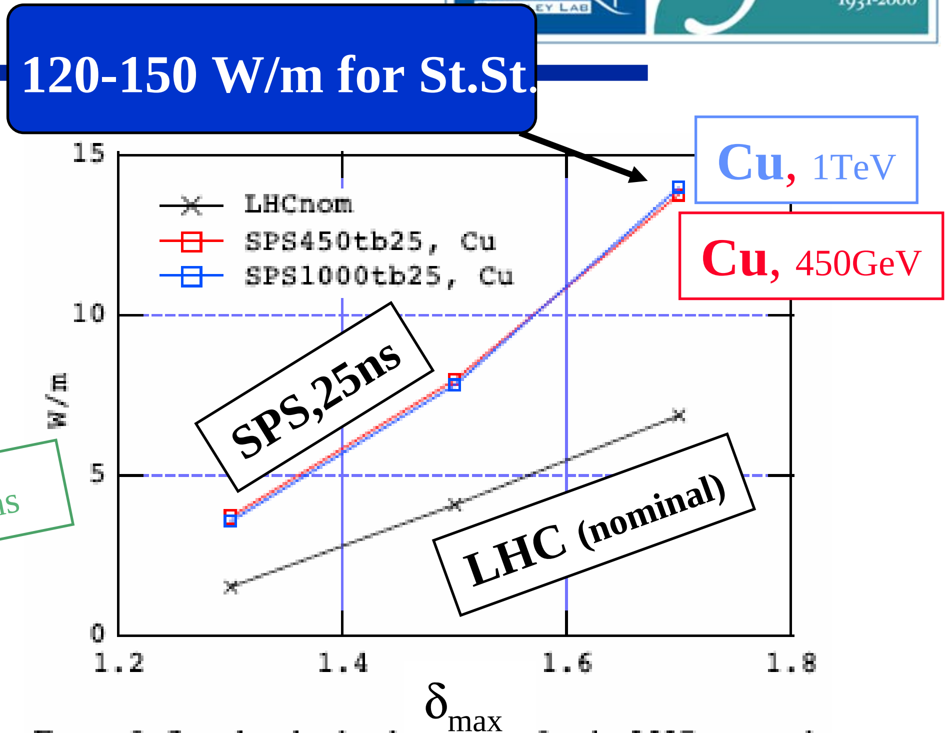



Figure 9: Simulated ecloud heat load for the LHC nominal case and for the SPS+ at $E_b = 450$ and 1,000 GeV vs. $\delta_{max}$ assuming a SEY model for copper. The bunch spacing is $t_b = 25$ ns in all cases (LHC results taken from Fig. 2).

- Copper much more favorable than St.St.
  - Owing to smaller rediffused component in SE energy spectrum
  - Subtle mechanism; explained in detail in Sec. IV-B of http://prst-ab.aps.org/pdf/PRSTAB/v9/i3/e034403
- Caveat: Cu and StSt emission parameters need to be re-measured to confirm this!

# Conclusions

- Heat load depends inversely with $t_b$
  - — $t_b$=75 ns is best, closely followed by 50 ns
  - — $t_b$=50 ns much better than 25 ns
  - — $t_b$=12.5 ns is terrible
- Cu (or Cu-coated) chamber much better than St.St.
  - — But this conclusion is based on a particular set of measurements of the SE energy spectrum
  - — Re-measure energy spectrum in order to verify this conclusion
- Not much difference in heat load between gaussian vs. flat long. profile for the LHC, at least for $t_b$=50 ns
- Not much difference between PS2 and PS+, nor between SPS50 and SPS+a50, except at high $\delta_{max}$ for $t_b$=25 ns
- This investigation is limited to heat load in the dipole bends
- I feel much more comfortable about the relative rankings than about the absolute values of the heat load