LHC quench limit with adjusted collimator jaws

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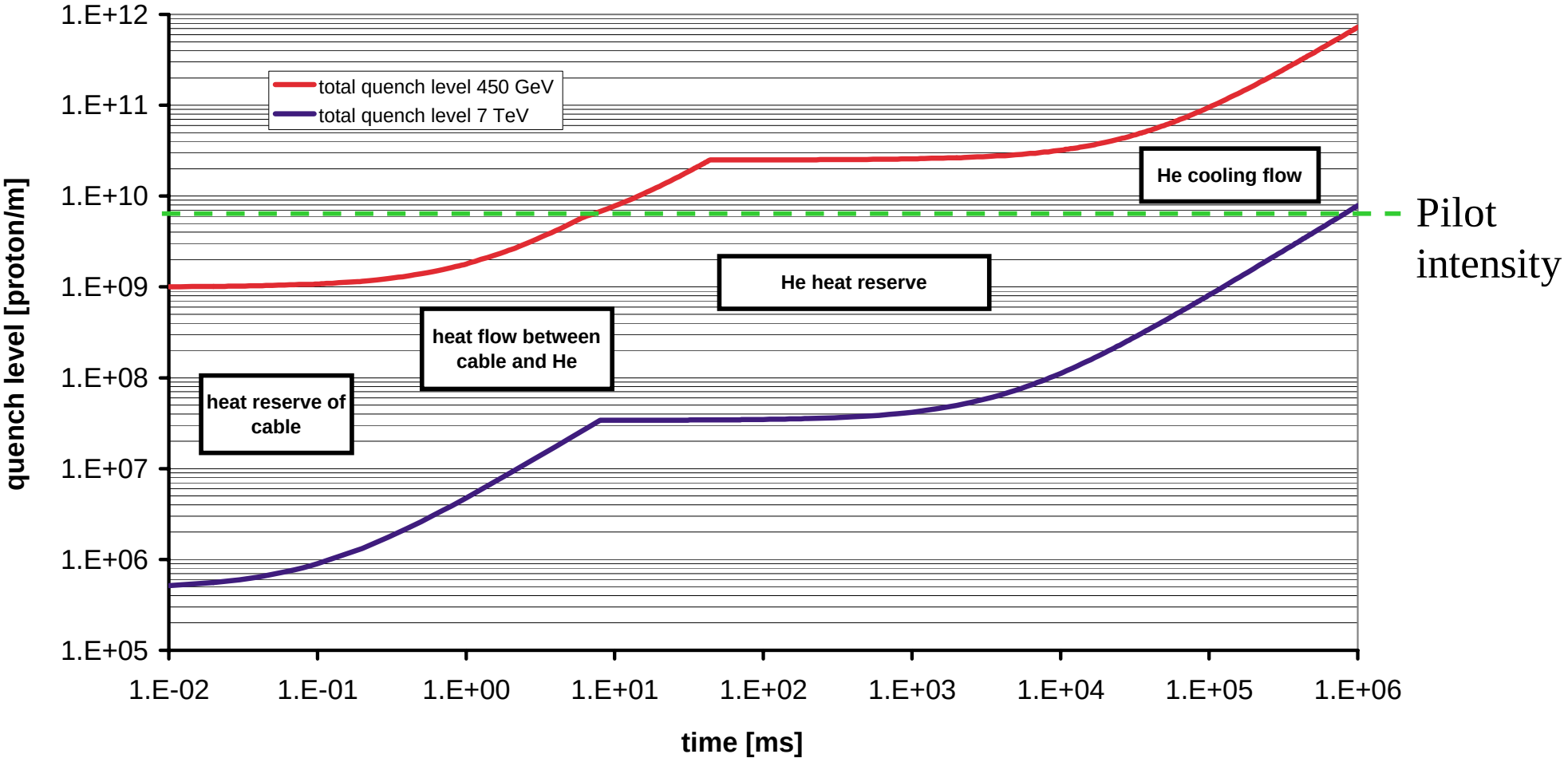
Quench limits at injection

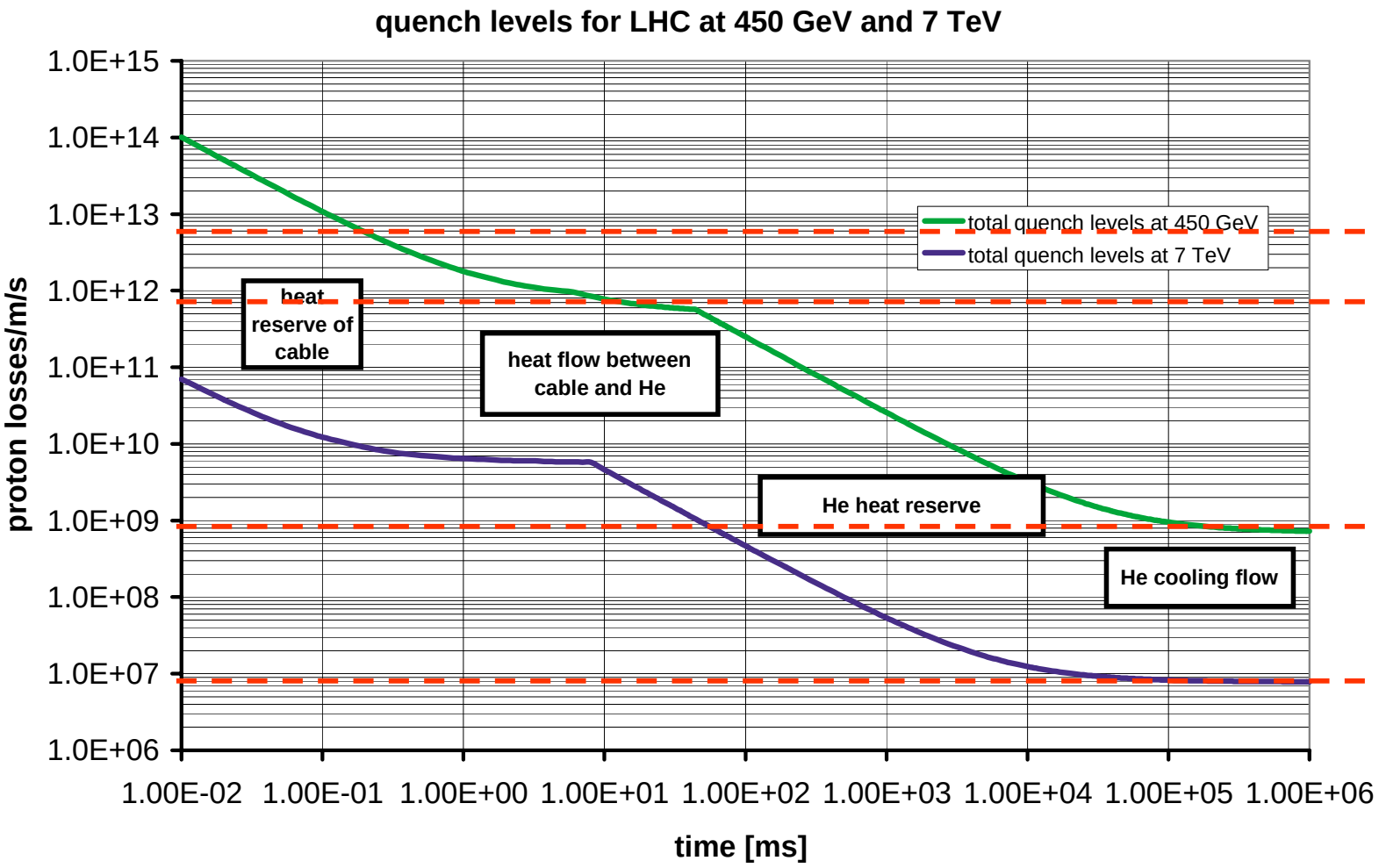
Reference: J.B. Jeanneret et al, LHC Project Report 44. B. Dehning, E. Gschwendtner.



Pilot with 5e9 p does not quench if losses are diluted over ~ 5 m.

Without collimation and dilution

$$(\Delta N/\Delta t) = N_0 / \tau$$



Loss rates for 1 min lifetime

Nominal beam

Nominal batch

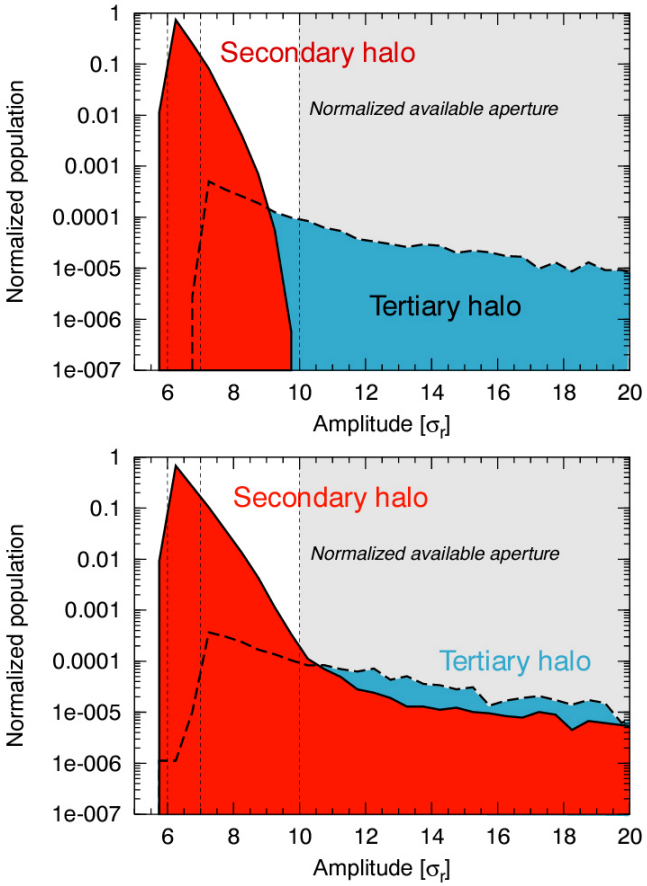
$3 \cdot 10^{10}$ p

Pilot

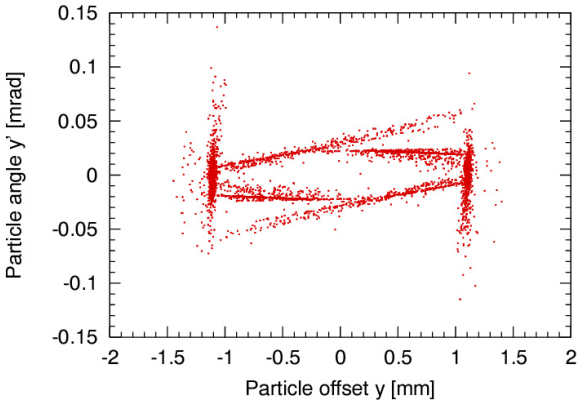
B. Dehning, E. Gschwendtner.

Reminder

$$\text{Collimation inefficiency} = \frac{\text{Number of protons above } 10\,\sigma}{\text{Number of protons hitting the collimator at } 6\,\sigma}$$



Phase space tertiary halo:



Not all protons above 10 σ are lost in the same place:

Local inefficiency [1/m]:

Integrate halos above 10σ

Divide by dilution length (~ 50 m)

Collimation efficiency

Ideal design: 10^{-3}
Dilution length: 50 m
Local cleaning inefficiency: $2 \cdot 10^{-5}$

Tolerances for each 50% increase in inefficiency (preliminary):

Transient changes

Error	Tolerance
Orbit	$0.6\ \sigma$
Beta beat	8%
Longitudinal angle	50 μrad
$\Delta L/L$ (prim)	75%
Surface flatness (prim)	10 μm
$\Delta L/L$ (sec)	20%
Surface flatness (sec)	25 μm
Setting accuracy (prim)	-1.0/+0.5 σ
Setting accuracy (sec)	$\geq \pm 0.5\ \sigma$

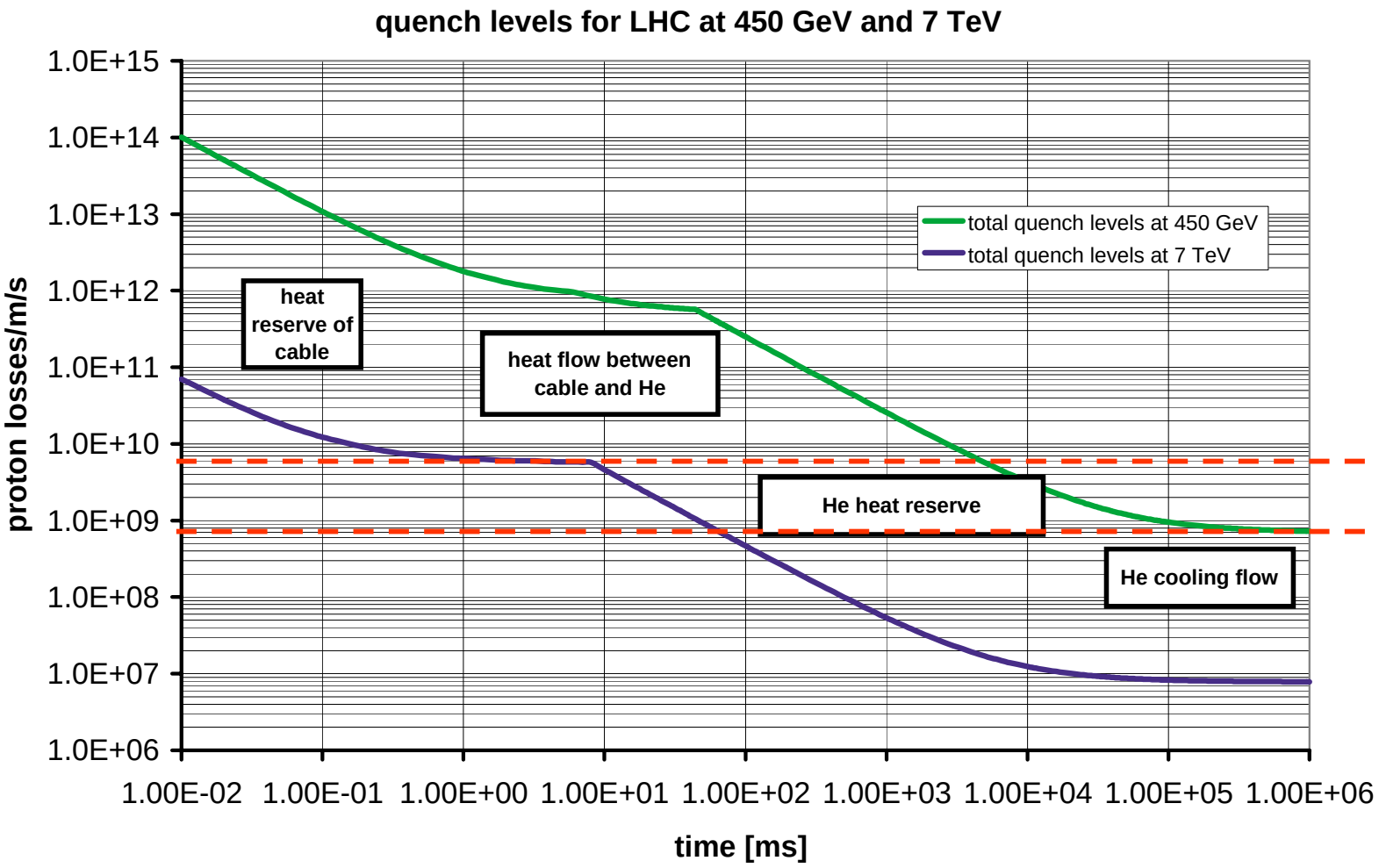
Preliminary estimates:

Combined effect can make tolerances more severe!

Estimate:

Loose factor 10, dilution 10 m
Local cleaning inefficiency 10^{-3}

With collimation and dilution



Local loss rates for 1 min lifetime

Nominal beam

Nominal batch

B. Dehning, E. Gschwendtner.

Conclusion

1 turn loss of pilot bunch:

Pilot ($5 \cdot 10^9$ p) is above fast transient quench limit at injection.

No quench if losses are distributed over 5-10 m.

Consider 1 min beam lifetime:

Without collimation and dilution: up to $3 \cdot 10^{10}$ p

Roughly set collimation: nominal LHC batch
(assume factor 50 loss in local cleaning inefficiency)

All depends on assumptions on efficiency and beam lifetime!

Note: Efficiency must be optimized to top energy requirement before ramp!