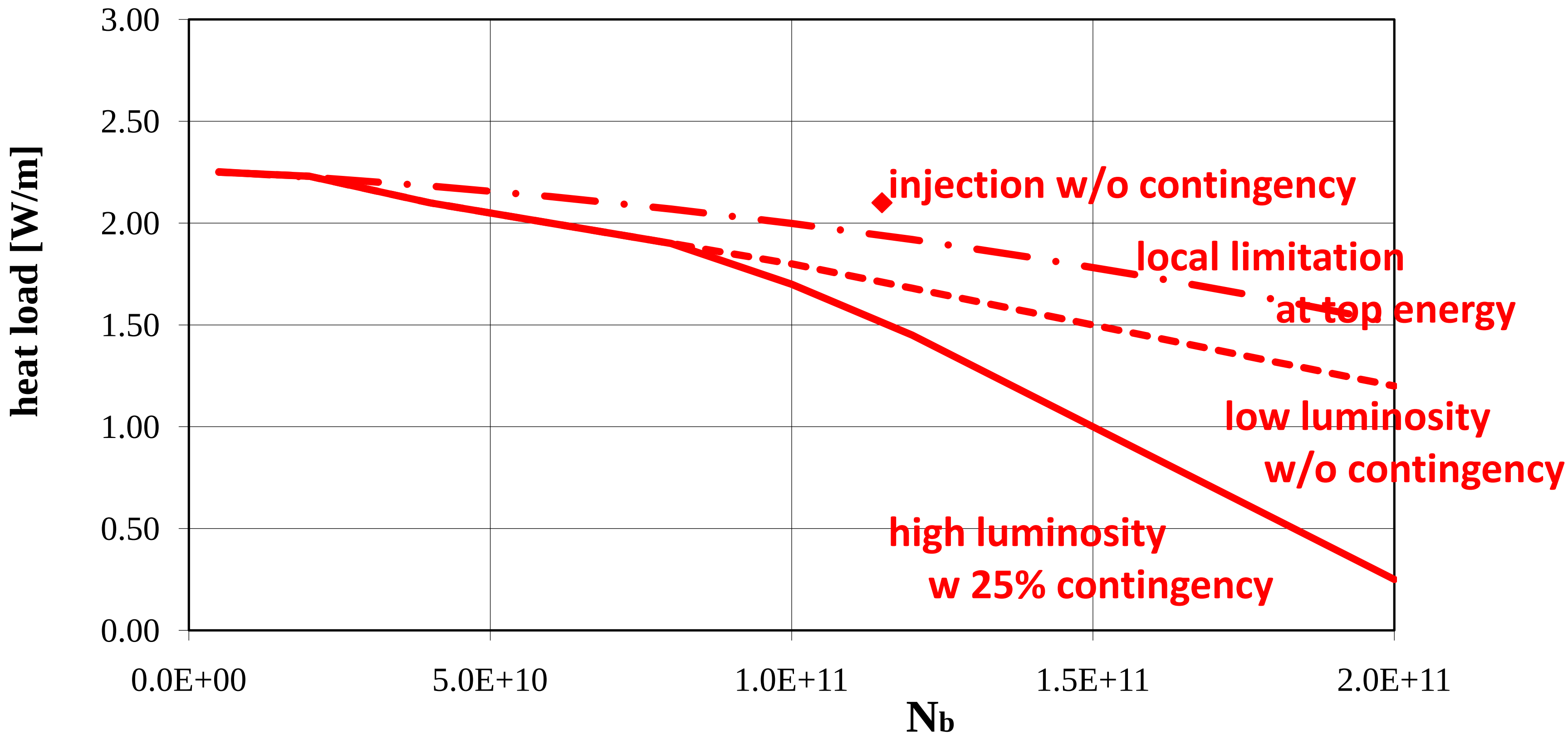
impact on e-cloud heat load of wrongly-oriented beam screens

Frank Zimmermann

21 January 2009

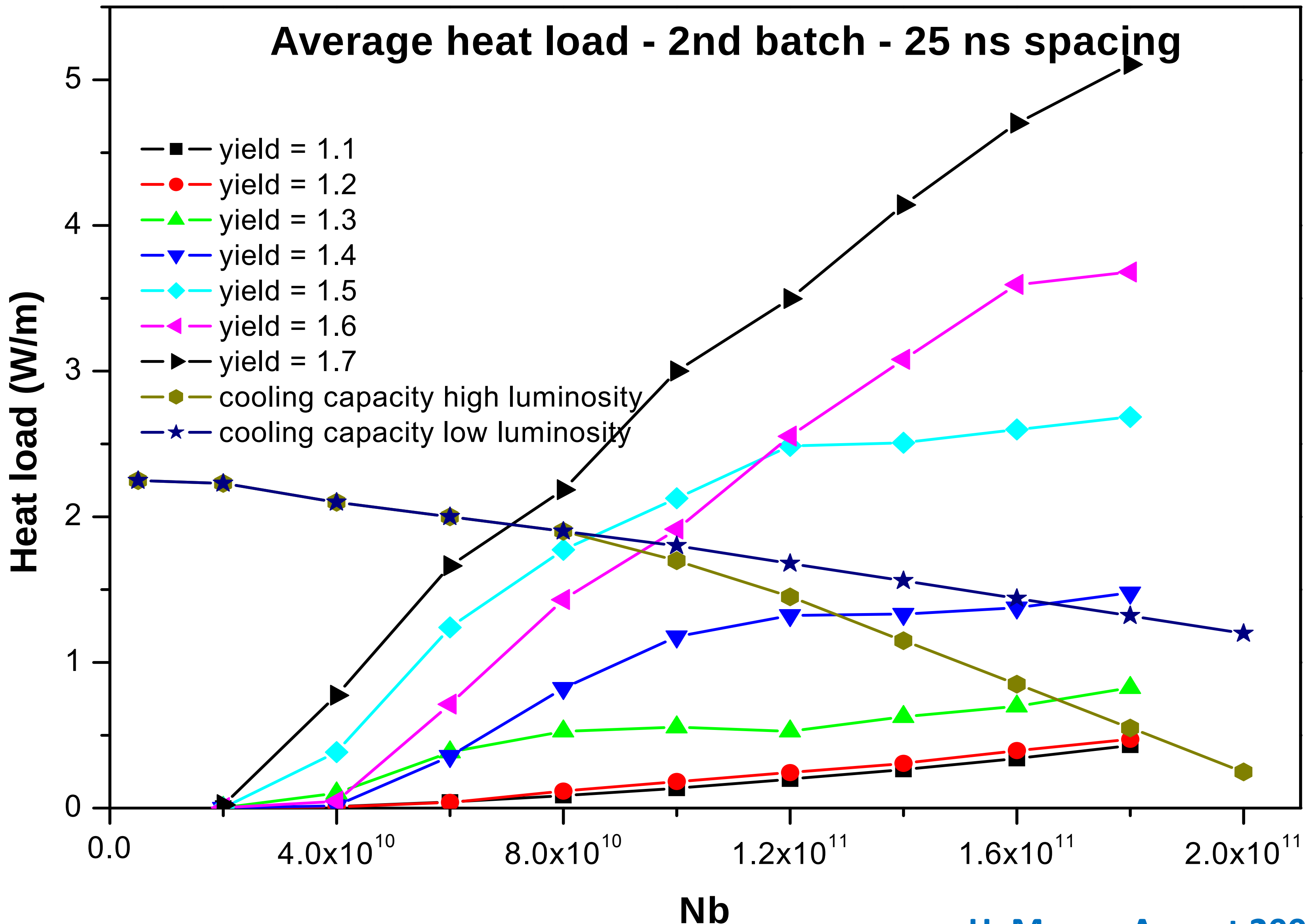
local & global cooling limits

L. Tavian, B. Jeanneret, F.Z., 2005

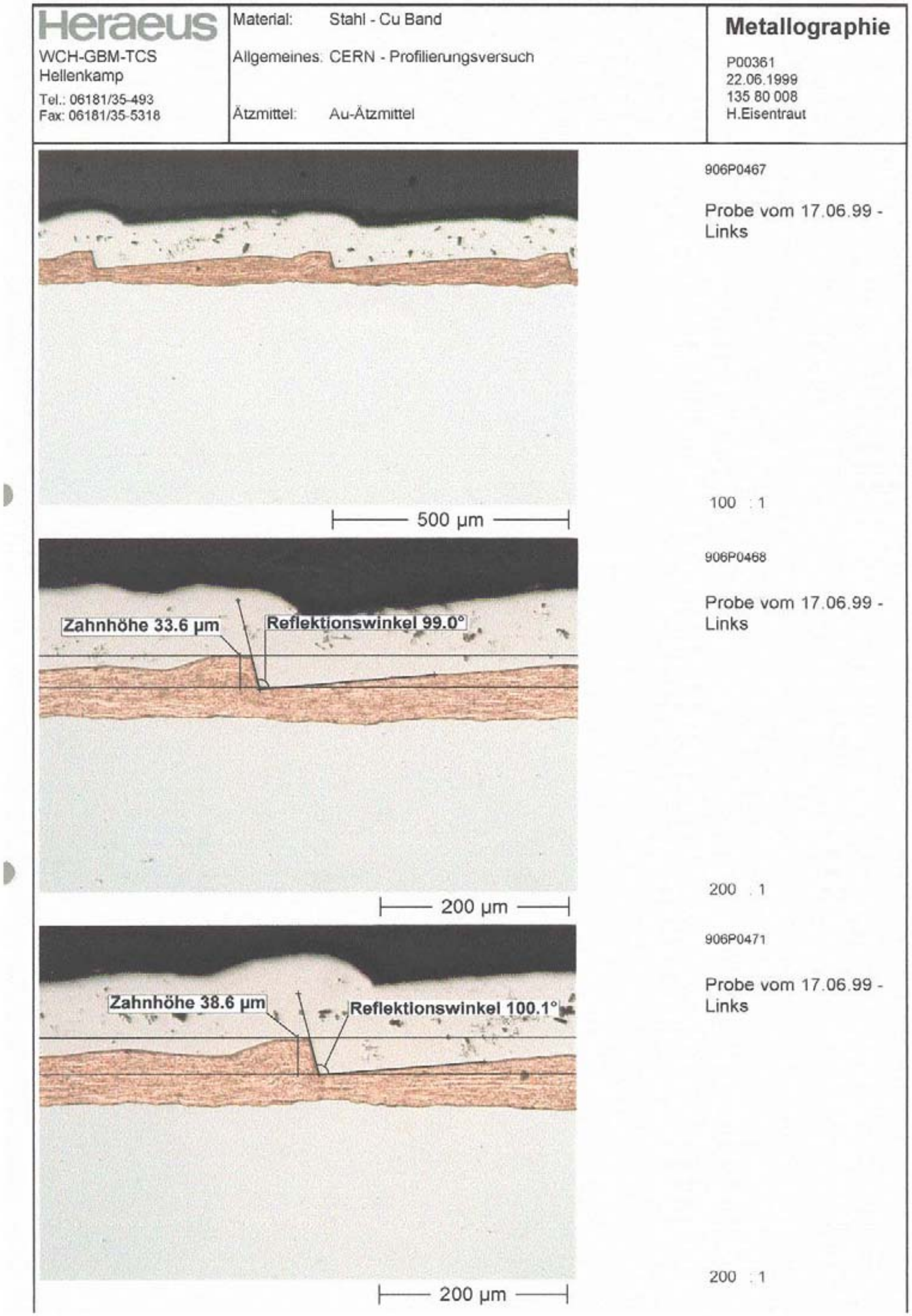


if only a small number of magnets is concerned, the local limit will be more relevant

predicted heat load & average arc cooling capacity vs bunch intensity



H. Maury, August 2008



LHC “sawtooth” chamber

perpendicular photon impact → reduced photoemission yield

effect of sawtooth on photo-electron yield & photon reflection

V. Baglin, I. Collins, O. Grobner, "Photoelectron Yield and Photon Reflectivity from Candidate LHC Vacuum Chamber Materials with Implications to the Vacuum Chamber Design", LHC Project Report 206, 1998

Table 1. Forward scattering photon reflection R and photoelectron yields per absorbed photon, Y^*, of the studied materials under different surface conditioning, irradiated by 45 eV and 194 eV critical energy synchrotron radiation.

Surface	Status	45 eV R (%)	45 eV Y* (e/ph)	194 eV R (%)	194 eV Y* (e/ph)
Cu co-lam.	as-received	80.9	0.114	77.0	0.318
	air baked	21.7	0.096	18.2	0.180
Cu elect.	as-received	5.0	0.084	6.9	0.078
Cu sawtooth	as-received	1.8	0.053	-	-
	150°C, 9h	1.3	0.053	1.2	0.052
	150°C, 24h	1.3	0.040	1.2	0.040

measurements at CERN EPA, 1998

V.V. Anashin, I.R. Collins, R.V. Dostovalov, N.V. Fedorov, O. Grobner, A.A. Krasnov, O.B. Malyshev, E.E. Pyata, "Magnetic and Electric Field Effects on the Photoelectron Emission from Prototype LHC Beam Screen Material", LHC Project Report 373, 2001

Table 3: A summary of the measured reflectivities and photoelectron yields per absorbed photon. The critical energy at which the measurements were made is also indicated.

Sample	Critical Energy E_c (eV)	Forward Scattered Reflection R_e (by current)	Forward Scattered Reflection R_W (by power)	Diffuse Reflectivity R_{dif}	Photon Adsorption R_1	$\frac{R_{dif}}{R_1 + R_{dif}}$	Y (electron/photon)
Smooth surface	20	0.67	—	0.04	0.29	0.13	0.03
Saw-tooth surface	49	0.035	—	0.22	0.74	0.23	0.049
	246	0.026	0.03	0.185	0.79	0.19	0.063

measurements at BINP VEPP-2M, 2001

sawtooth eliminates 70-80 % forward scattering, but introduces 20% diffuse scattering

effect of sawtooth on photon reflection (& energy distribution)

R. Cimino, V. Baglin, I.R. Collins, A. Giglia, N. Mahne, S. Nannarone, L. Pasquali, M. Pedio, "Photon Reflectivity Distributions from the LHC Beam Screen and their Implications on the Arc Beam Vacuum System", LHC Project Report 668, 2004

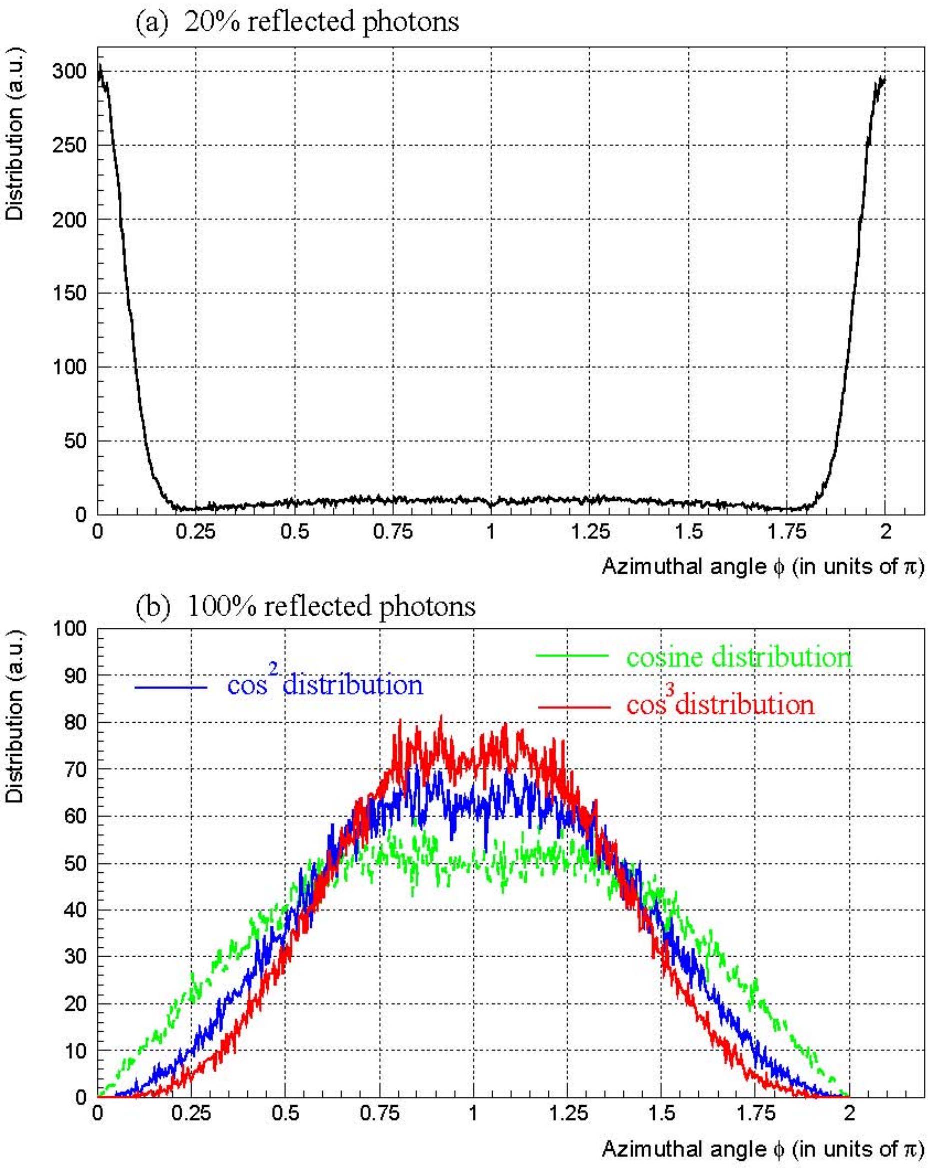
measurements at ELETTRA, 2003

	Flat sample	Saw-tooth sample
Forward scattering	80 %	4 %
Back scattering	0 %	2 %
Diffused	2 %	4 %
Total	82 %	10 %

only 4% diffuse scattering – why?

Table 1: Measured values of the forward scattering, back scattering and diffused light expressed in percentage of the incoming light.

angular distribution of emitted photoelectrons with sawtooth chamber, assumed in the simulation

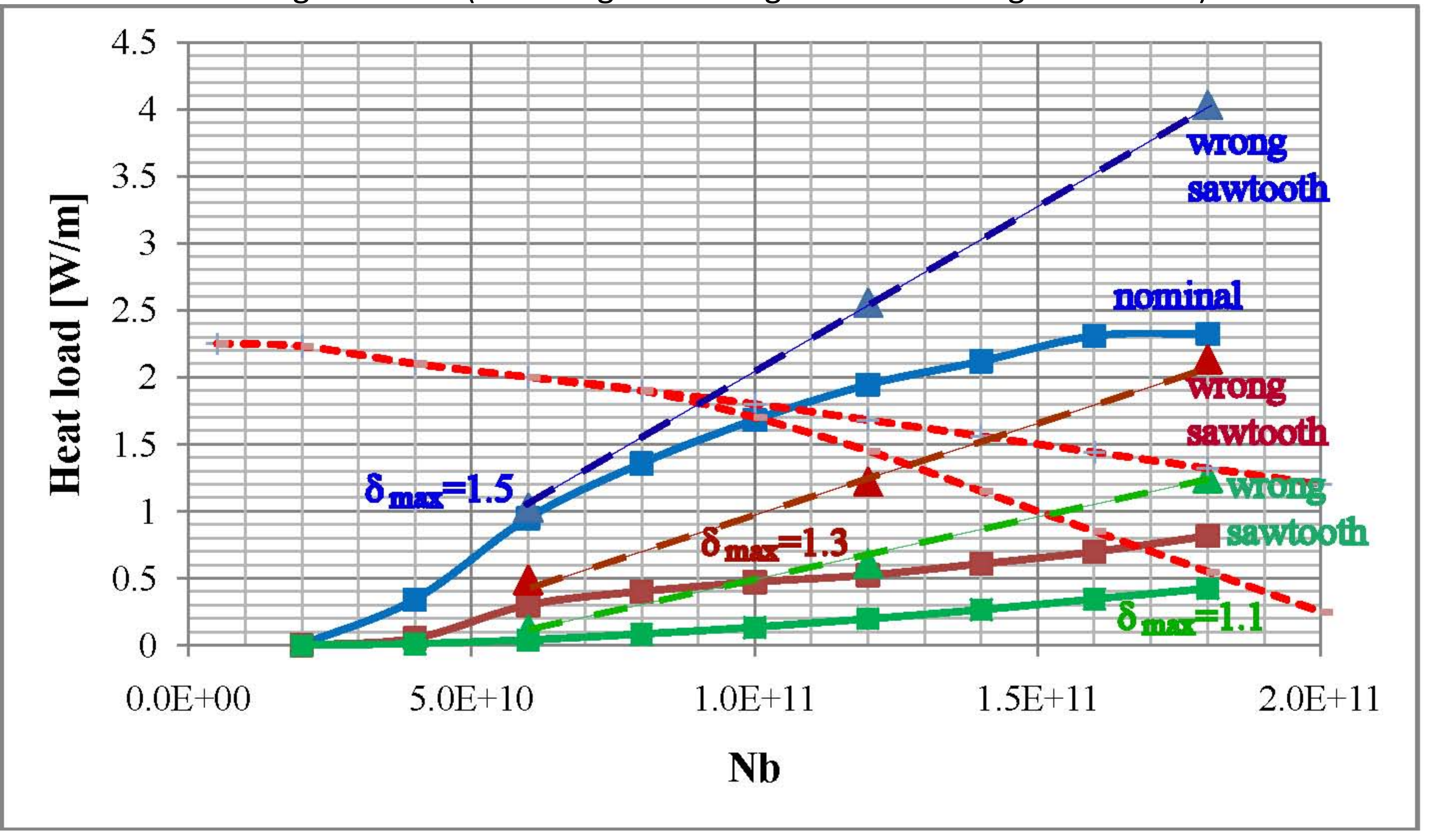


wrongly-oriented sawtooth chamber

- no measurement available
- perhaps plausible to assume both ~20% diffusive scattering and 60-70% forward scattering
- to be conservative take $\cos^2$ distribution with 100% reflection
- also take 3 times larger photoelectron yield (rough estimate from CERN EPA data)

how much does the heat load change?

compute heat load in dipole w and w/o sawtooth and then scale arc heat load starting from Humberto's result global limit (assuming all arc magnets have wrong orientation)

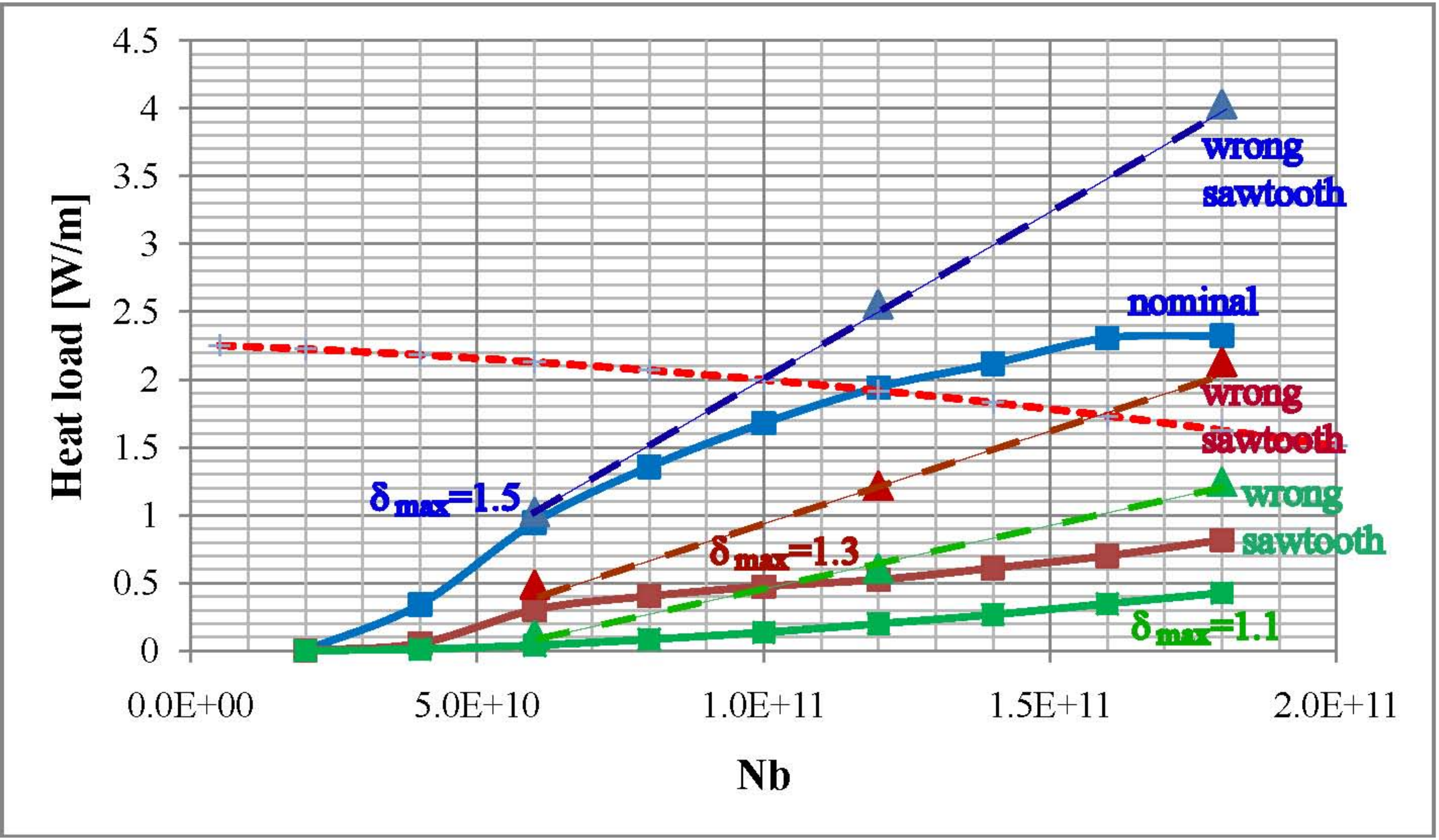


for δ_{max}=1.5: N_{max}~$10^{11}\rightarrow 9\text{x}10^{10}$

for δ_{max}=1.3: N_{max}~$1.6\text{x}10^{11}\rightarrow 1.2\text{x}10^{11}$

for δ_{max}=1.1: N_{max}~$1.8\text{x}10^{11}\rightarrow 1.5\text{x}10^{11}$

local limit (assuming all magnets in 1 half cell have wrong orientation)



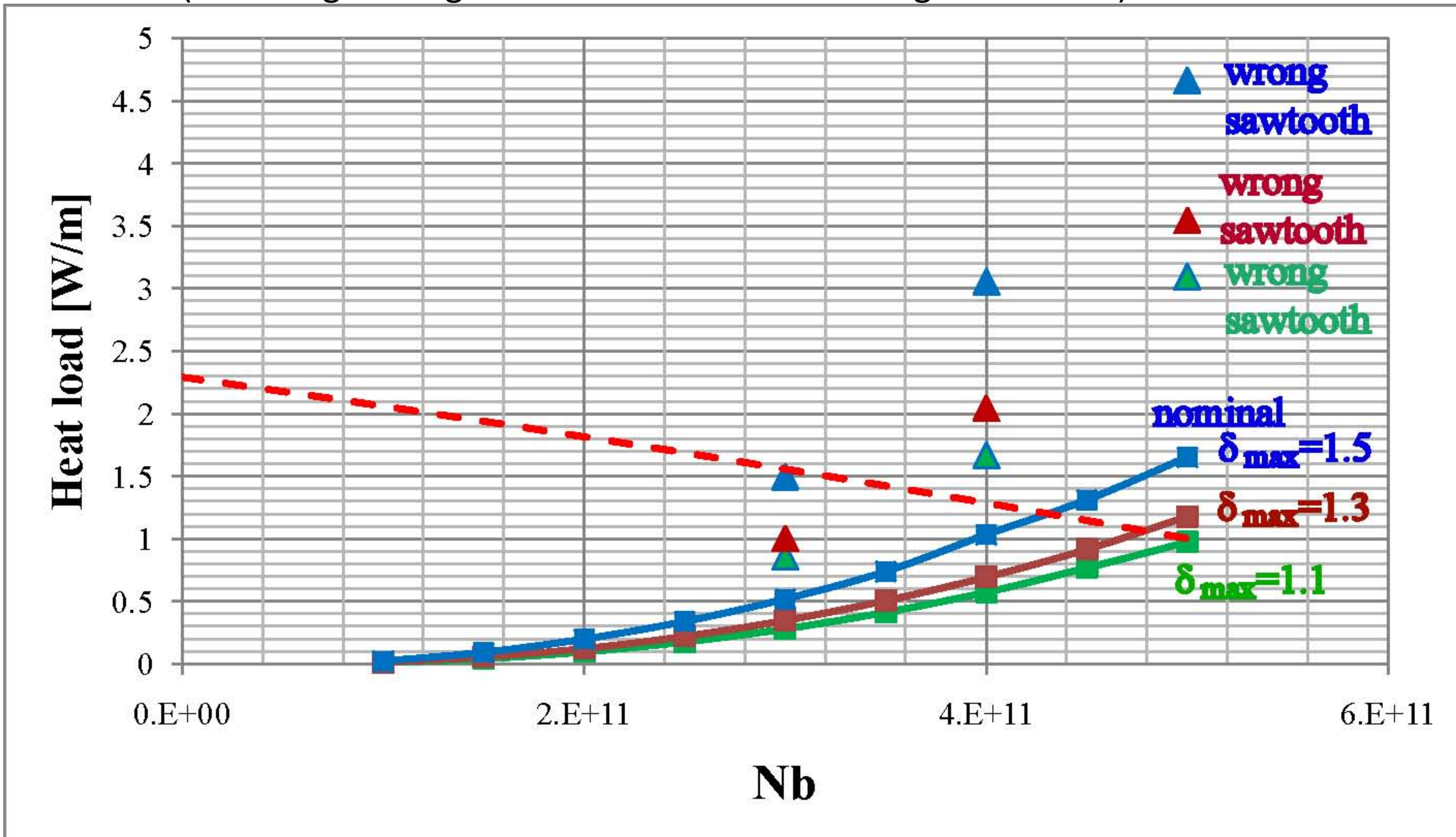
for δ_{max}=1.5: N_{max}~$1.2 \times 10^{11} \rightarrow 1.0 \times 10^{11}$

for δ_{max}=1.3: N_{max} $>2 \times 10^{11} \rightarrow 1.6 \times 10^{11}$

for δ_{max}=1.1: N_{max} $>>2 \times 10^{11} \rightarrow 2.0 \times 10^{11}$

50–ns flat-bunch upgrade scenario (LPA)

local limit (assuming all magnets in 1 half cell have wrong orientation)



for δ_{max}=1.5: N_{max} ~4.3x10^{11}→3.0x10^{11}

for δ_{max}=1.3: N_{max} ~4.8x10^{11}→3.4x10^{11}

for δ_{max}=1.1: N_{max} ~5.0x10^{11}→3.6x10^{11}

warning: I did not recover Humberto's results here; nevertheless I scaled from them

conclusions

- photon data are incomplete and inconsistent
- there is an impact on the local heat load, especially for the upgrade ; effect is 10-30% at most
- no more than one dipole per half cell (local cooling loop) should be installed with wrong beam-screen orientation if possible