Nanoflare heating of coronal loops in an active region triggered by reconnecting current sheets

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Ioannina, Hel.A.S., Session 1, 07-09-2011

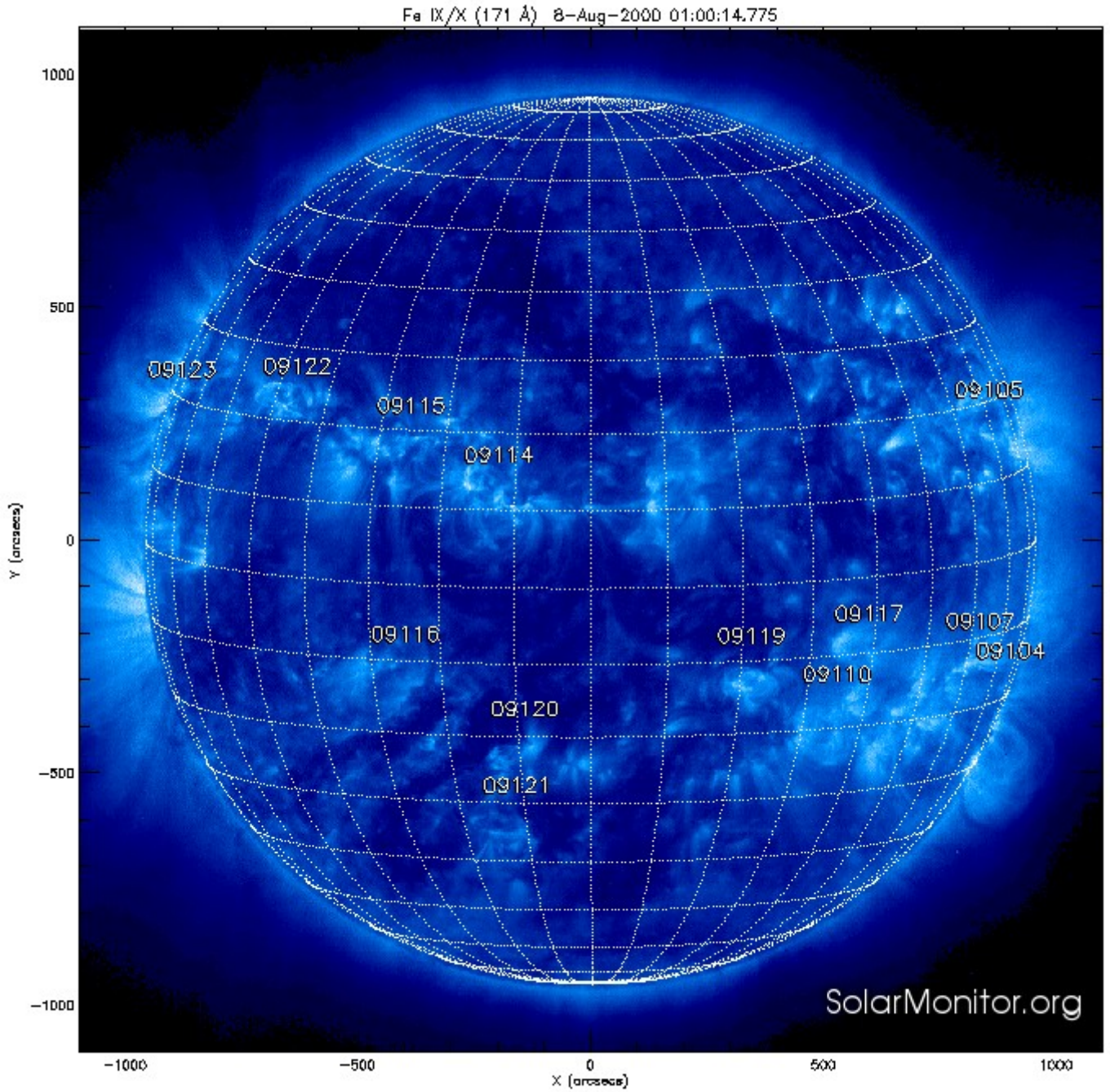
Nanoflares Energy=1.E-9 typical solar flares
cause of million Kelvins solar corona.

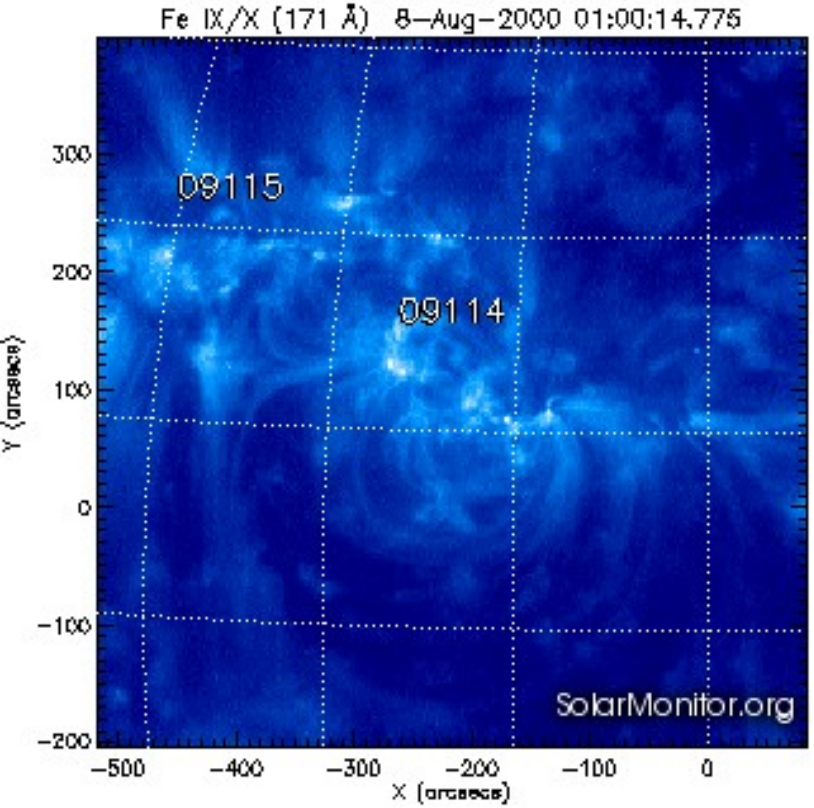
Coronal magnetic fields stressed due to photospheric motions develop **current sheets** (Parker 1972).

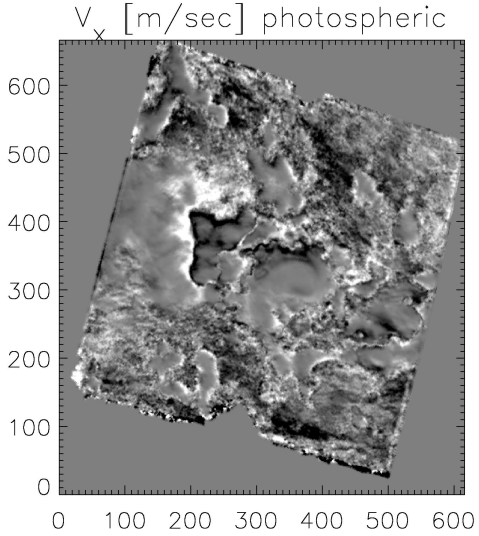
Magnetic field orientation changes by **14^0** across current sheet **and triggers magnetic energy release** (Parker 1988).

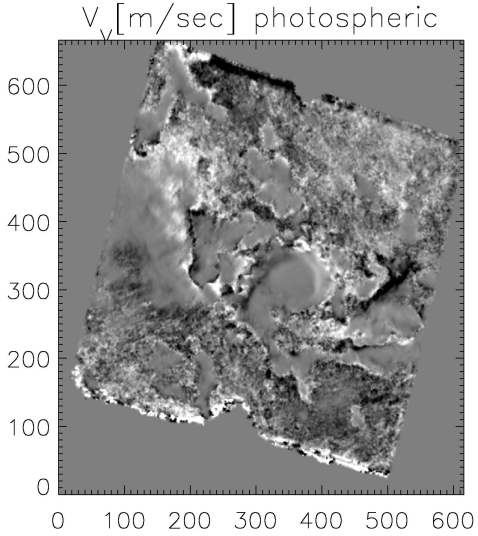
Our approach :

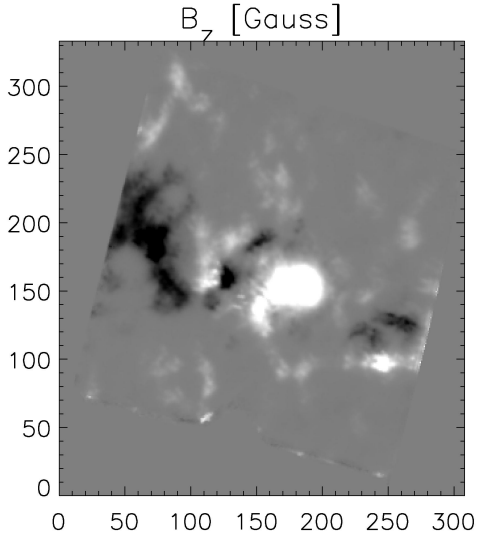
Scaling laws between **coronal loops** length and **particles' acceleration parameters.** Test if **heating** support **a coronal loop atmosphere** with hydrodynamic simulations.

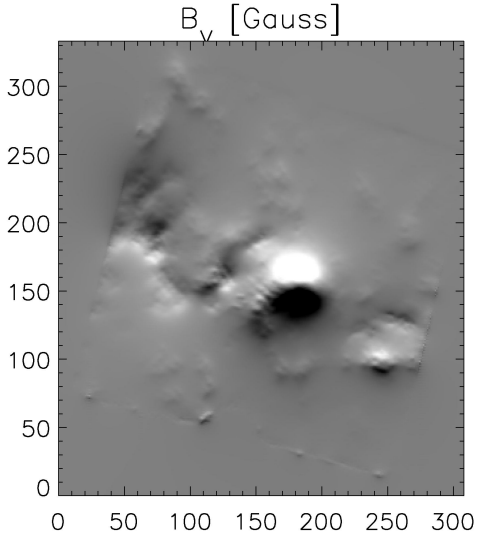

Fe IX/X (171 Å) 8-Aug-2000 01:00:14.775
09123
09122
09115
09114
09105
09116
09119
09117
09107
09104
09110
09120
09121
SolarMonitor.org
1000
500
0
−500
−1000
Y (arcsecs)
X (arcsecs)







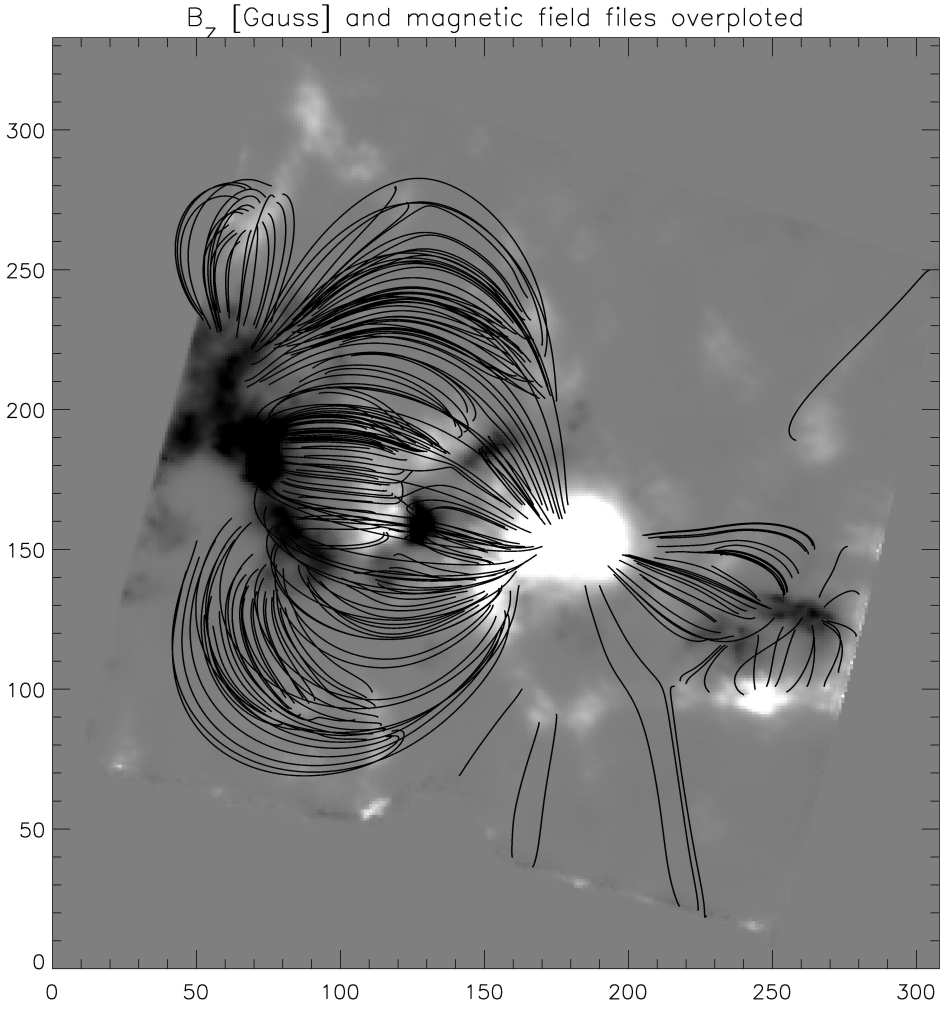




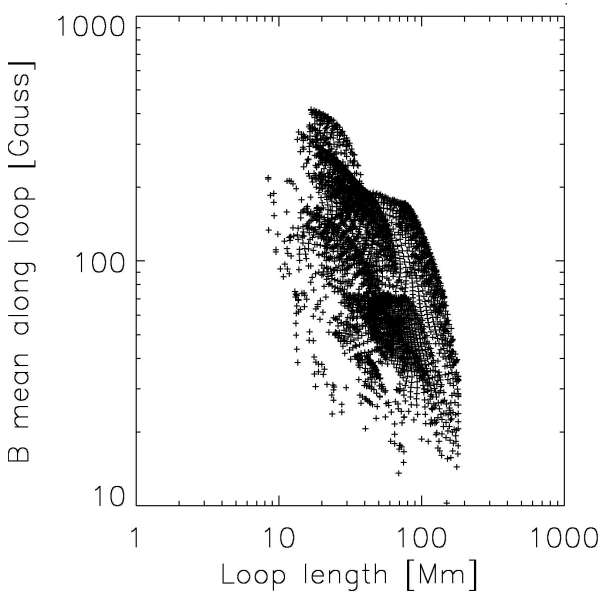
Imaging Vector Magnetograph.

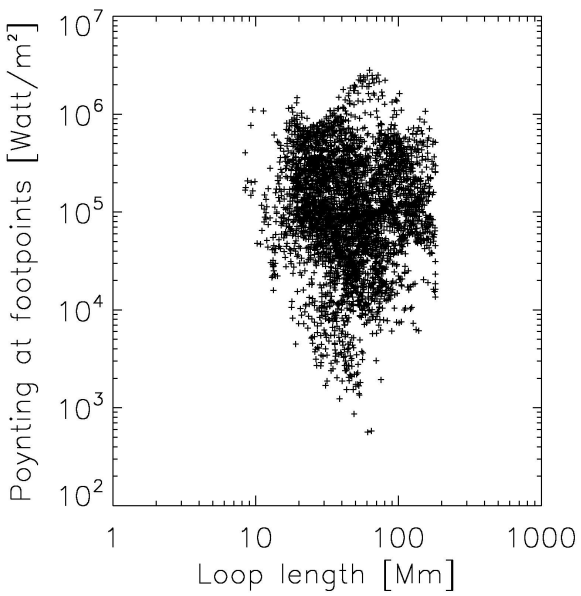
V photospheric computed with Minimum Structure Reconstruction

Georgoulis Labonte, 2006, ApJ



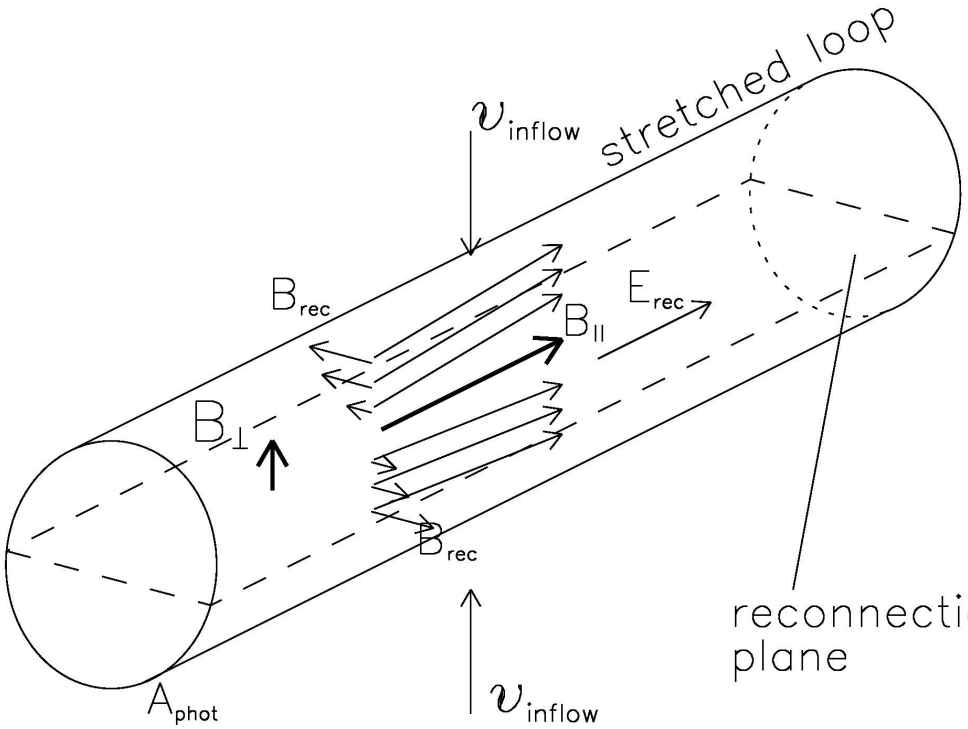
Potential magnetic field extrapolation (Alissandrakis 1981). Loops are closed magnetic field lines.

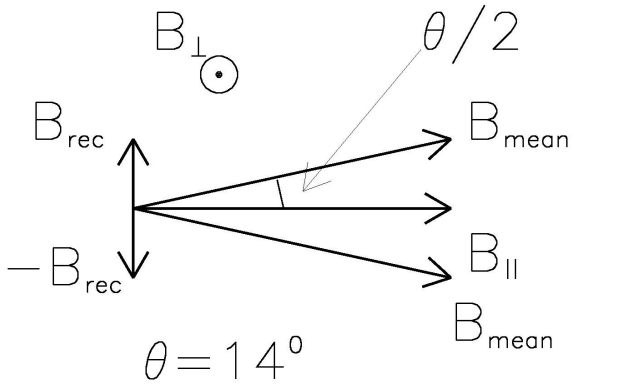




Poynting flux : $S_{phot} = (-V_{phot} \times Bz) \times B_{hor}$

$V_{phot,}$ Bz, B_{hor} from observations.





$\theta = 14^0$

$B_{rec} = B_{mean} \sin(\theta/2)$

$B_{||} = B_{mean} \cos(\theta/2)$

$\xi_{||} = B_{||}/B_{rec} = 8$

$$S_{rec}\, A_{rec} = S_{phot}\, A_{phot}$$

$$S_{rec} = V_{inflow}\, B^2_{rec}$$

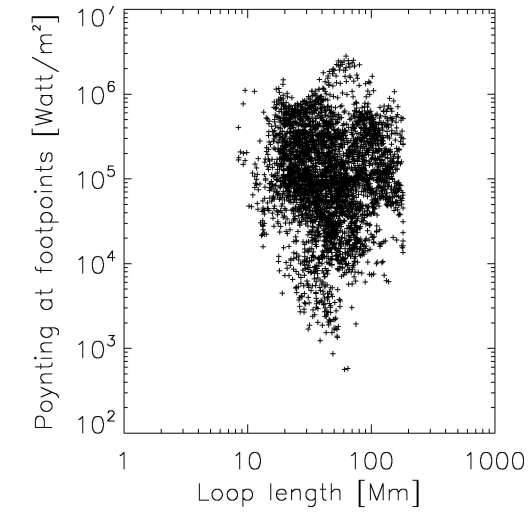
$$E_{rec} = -V_{inflow} \times B_{rec}$$

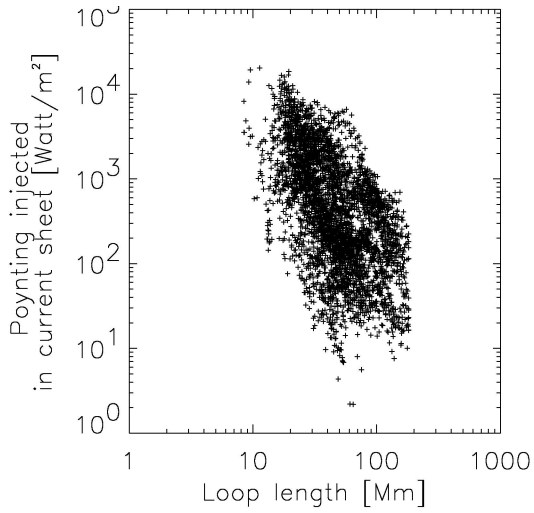
$$\mathbf{E_k = B_{||}\, E_{rec}\, a/B_{\perp}}$$

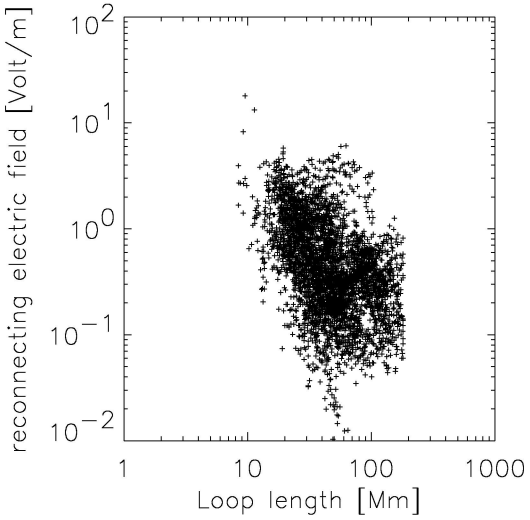
Litvinenko (1996), Efthymiopoulos et al (2005)

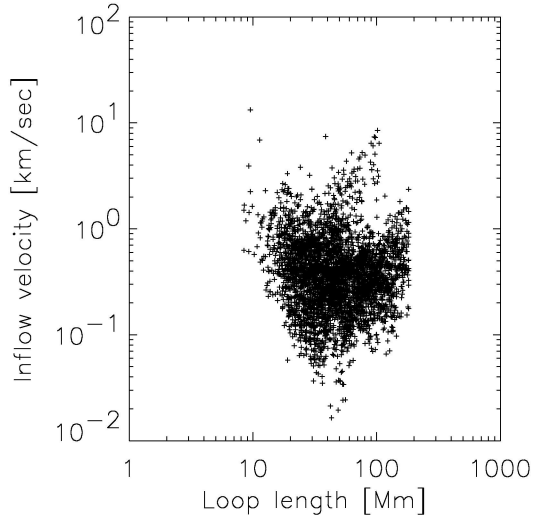
$$V_{inflow}\ \ B_{rec} = V_{alfven}\, B_{\perp}$$

Current sheet statistics









Loop atmospheres

Tmax=1.E6 Kelvin

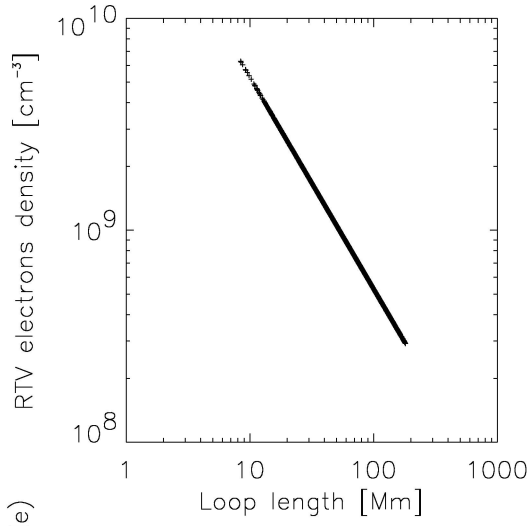
pressure ~ T^3/L
Rosner Tucker Vaiana (1978)

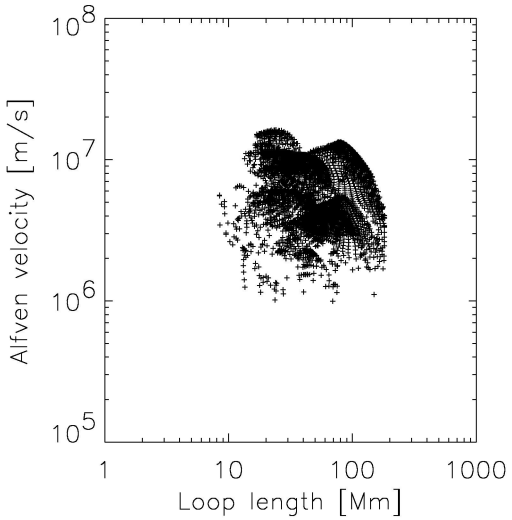
Collissionless reconnection with guide field

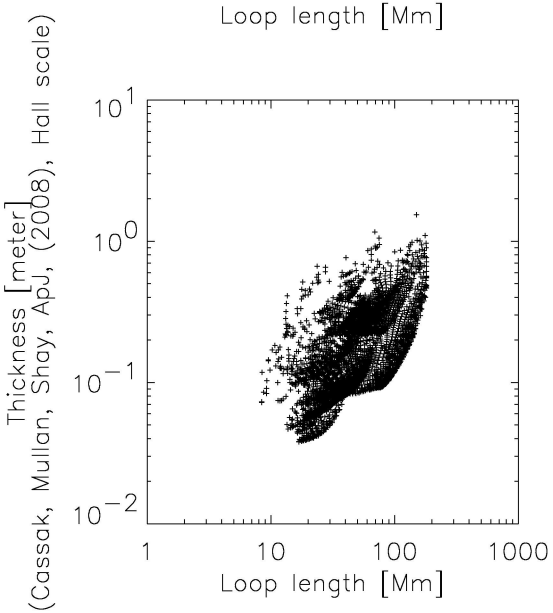
thickness :

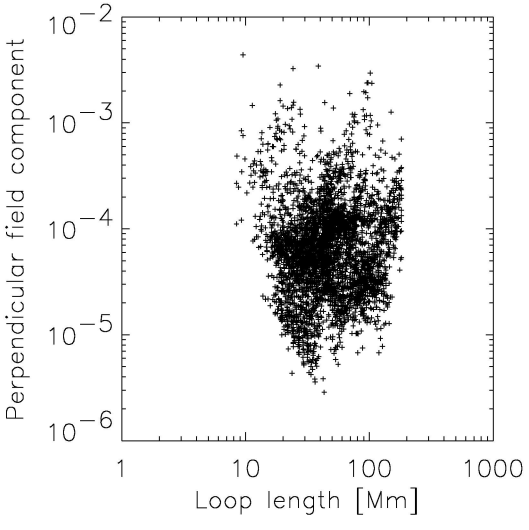
a~ sqrt(T)/B

Cassak, Mullan, Shay (2008)







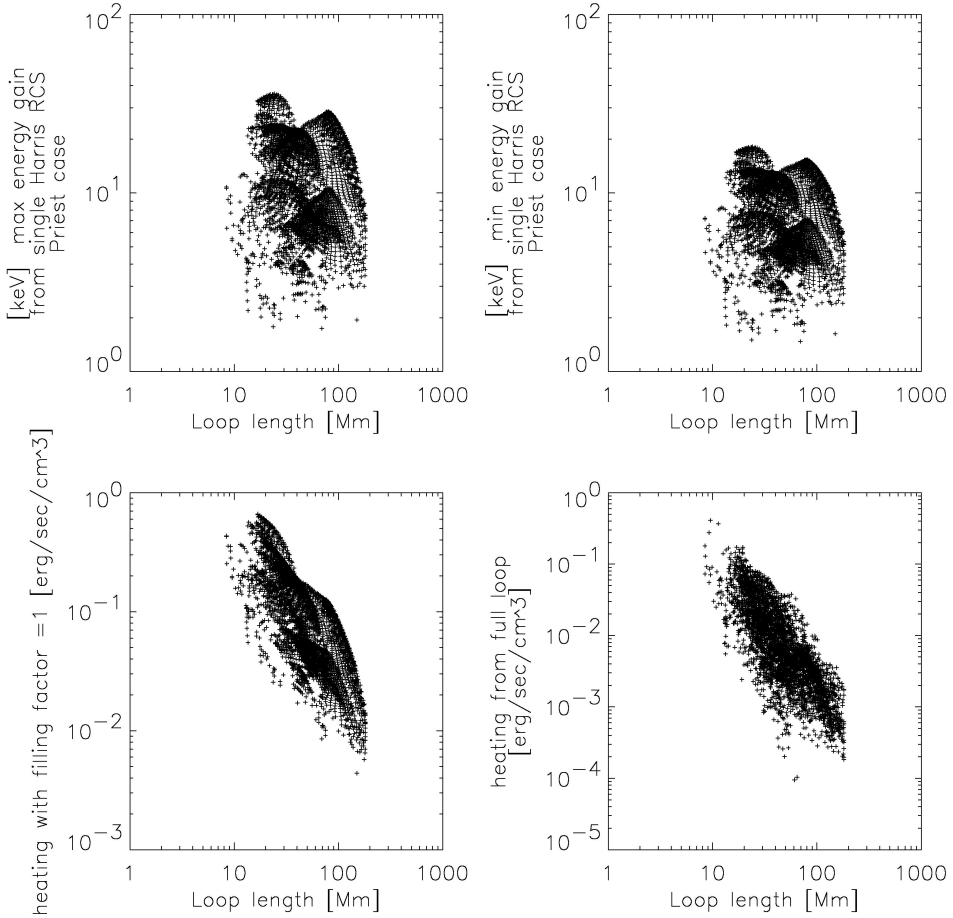


Kinetic energy and loop heating

$E_k = B_{||} E_{rec} a/B_{\perp}$

derived heating
$Q = E_k \; n_e$/time

time=250 sec
Dahlburg
Klimchuk, Antiochos, (2005)

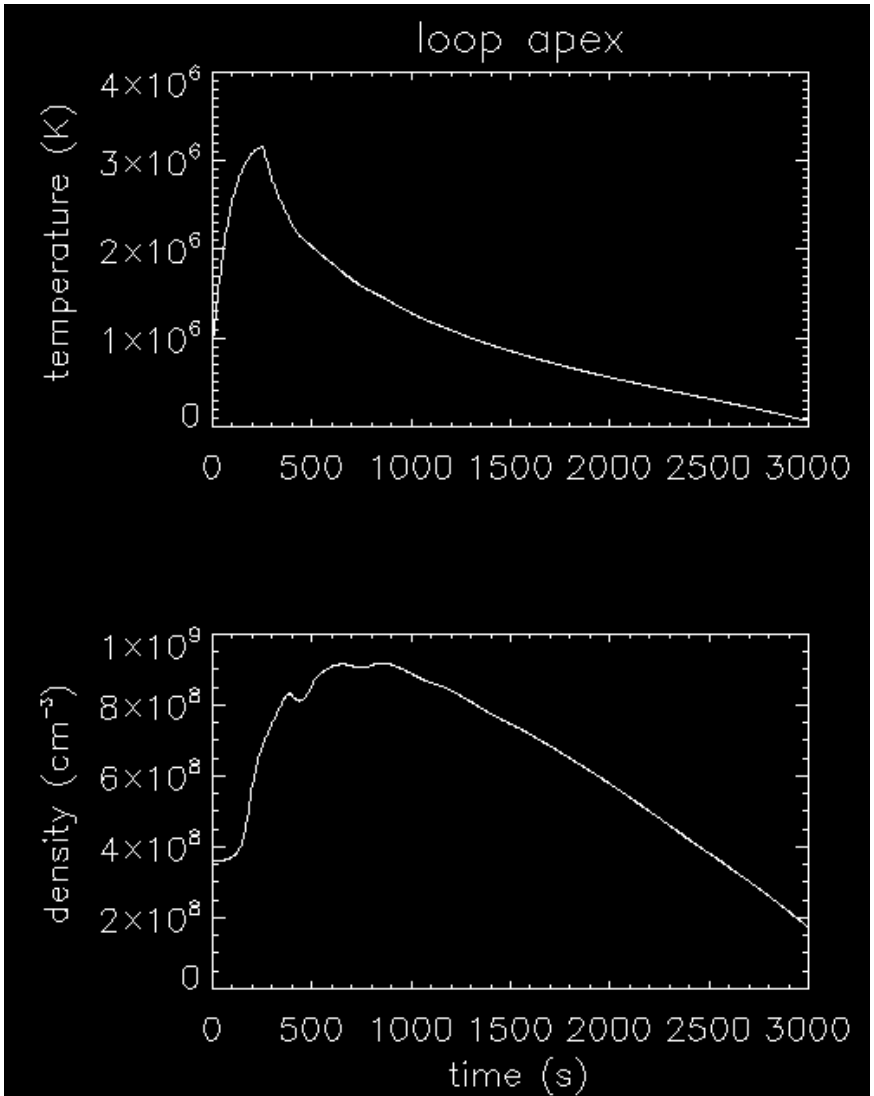


L = 100Mm

h = 0.02 erg/s/cm^3

1D time dependent hydro-dynamic equations

(Patsourakos, Klimchuk 2006)



Discussion and Conclusions

Particle acceleration in nanoflares :

electron max kinetic energy gain 2 to 30 keV

Electric field 0.03 to 7 Volt/m

heating 1.E-3 to 0.5 erg/s/cm^3

Enough to heat a 100Mm loop to T>10^6 K for 25 minutes