Thermal Structure of Supra-arcade Downflows and Flare Plasma Sheets

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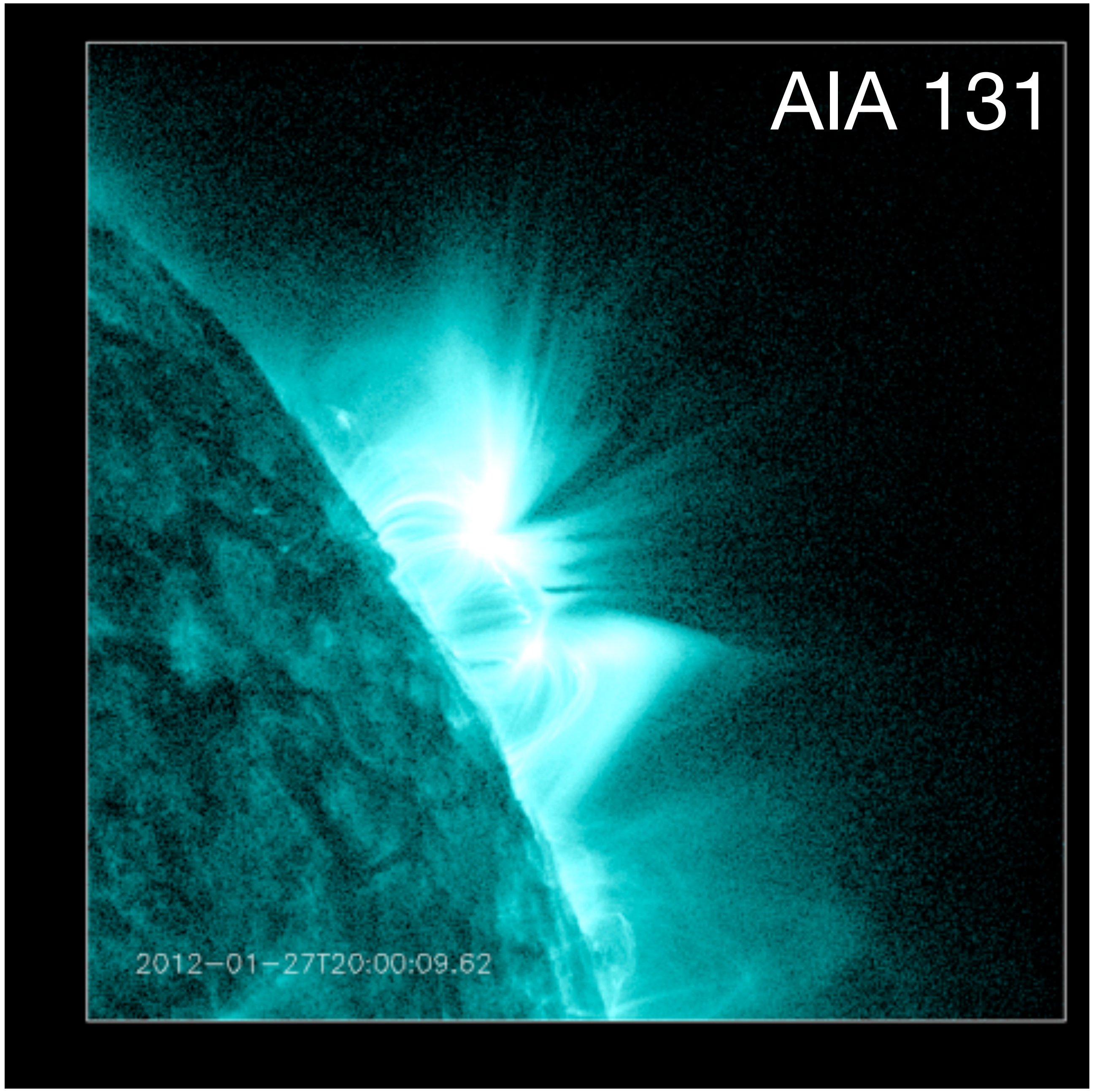
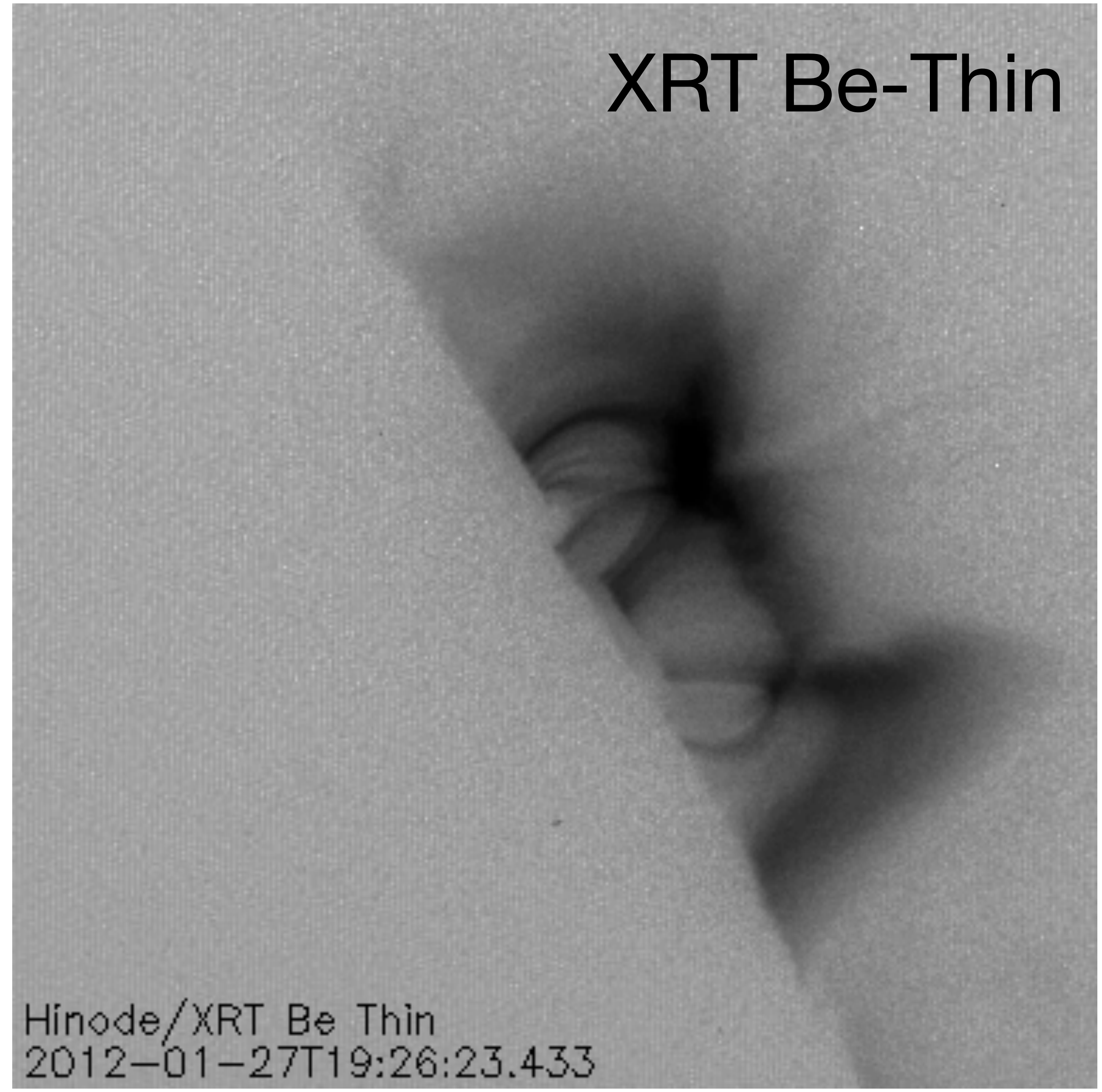
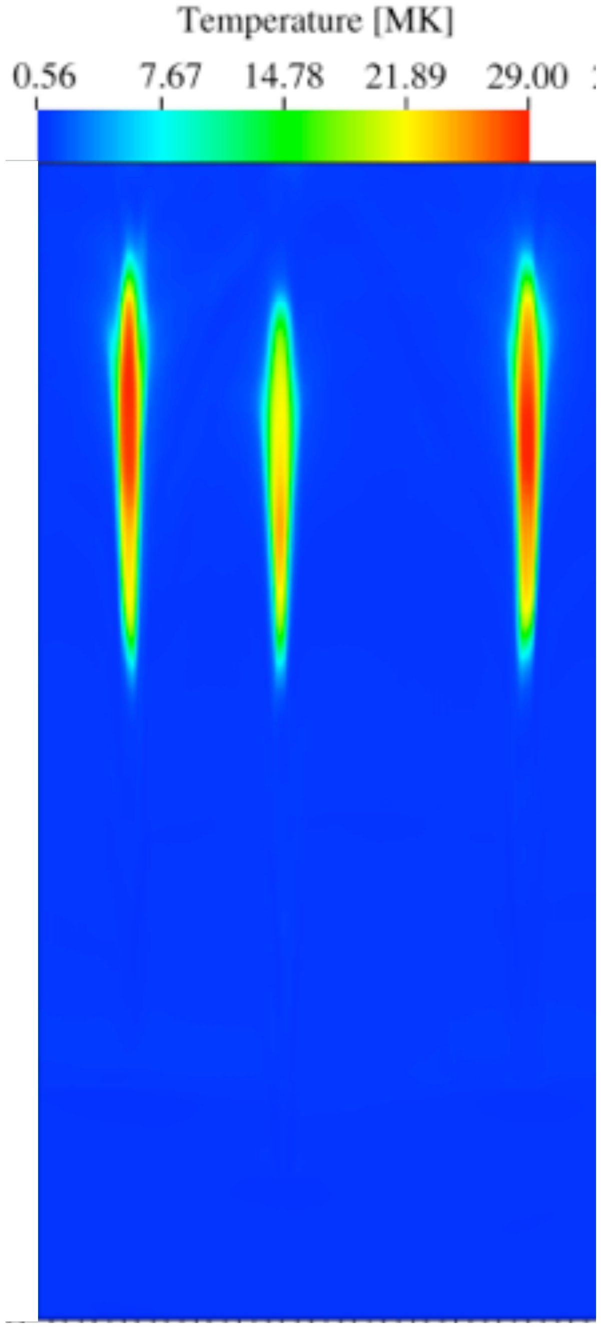
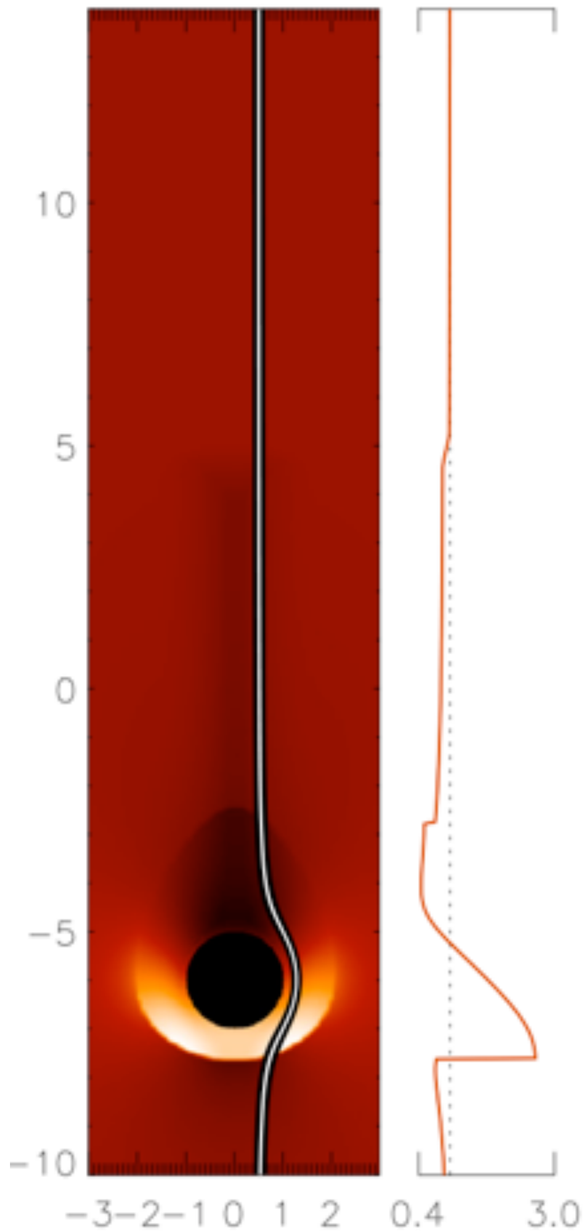




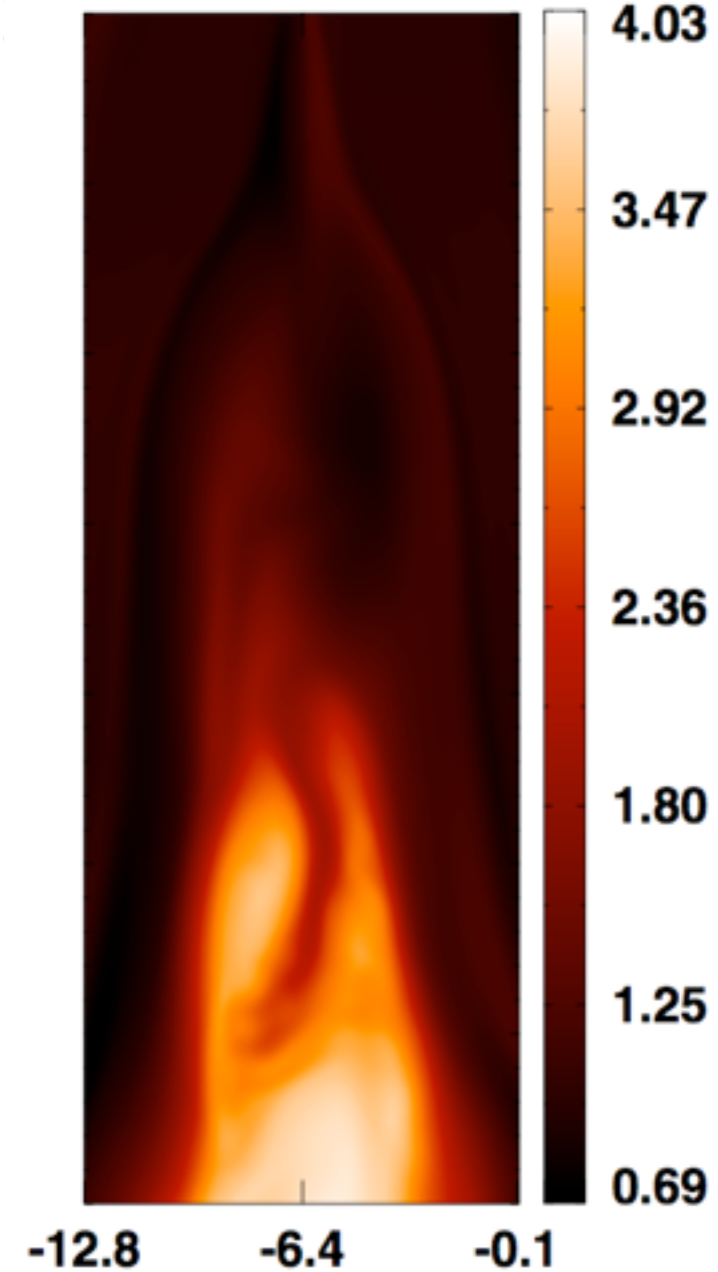
GOES X1.7 flare on 2012-01-27 18:37 UT



Pressure pulse + MHD wave
Cécere et al, 2012



Peristaltic pumping
R. Scott et al, 2013



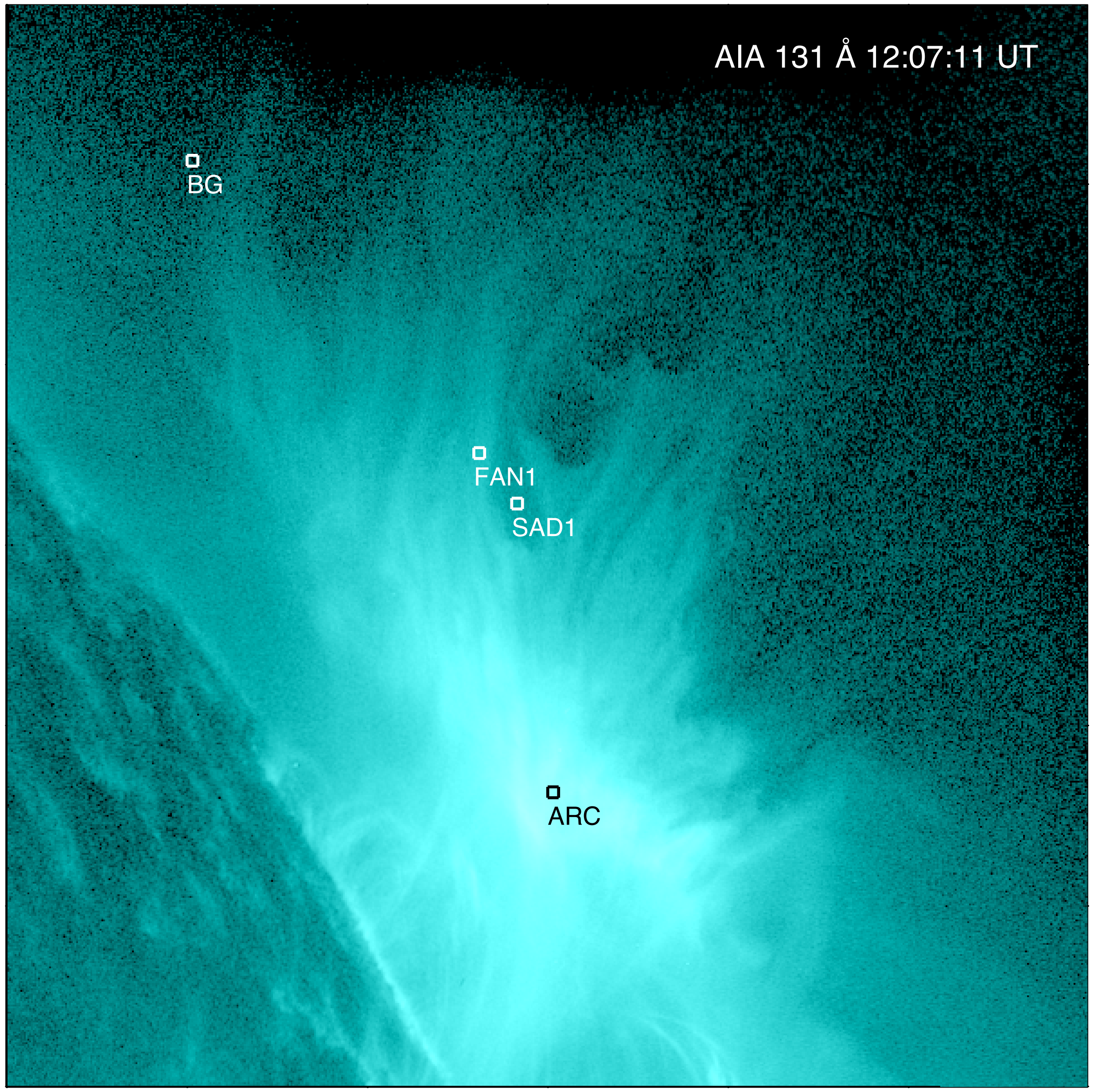
Reconnection outflows
P. Cassak et al, 2013

SADs much hotter than fan

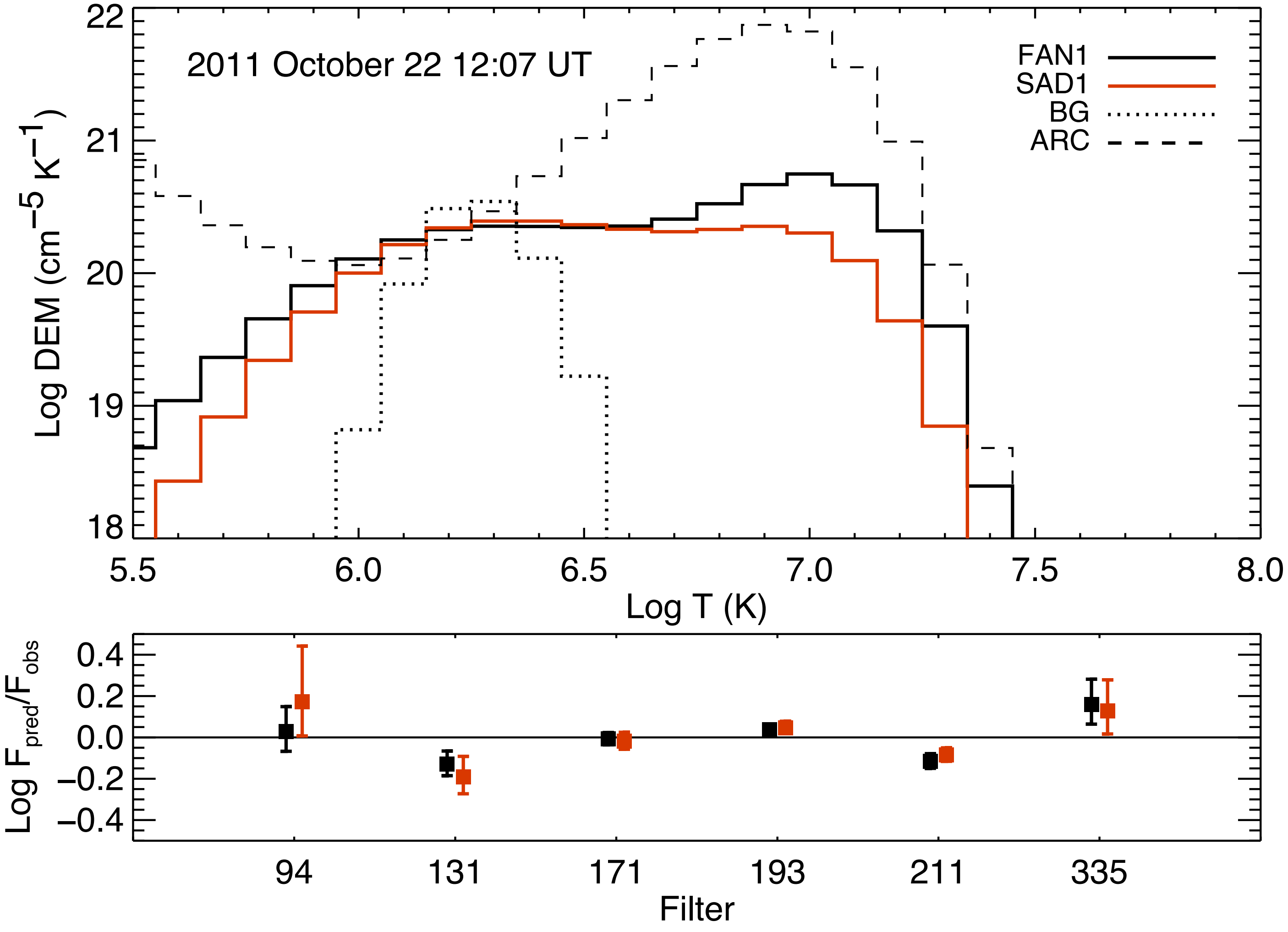
SADs a little cooler than fan (?)

SADs a little cooler than fan (?)

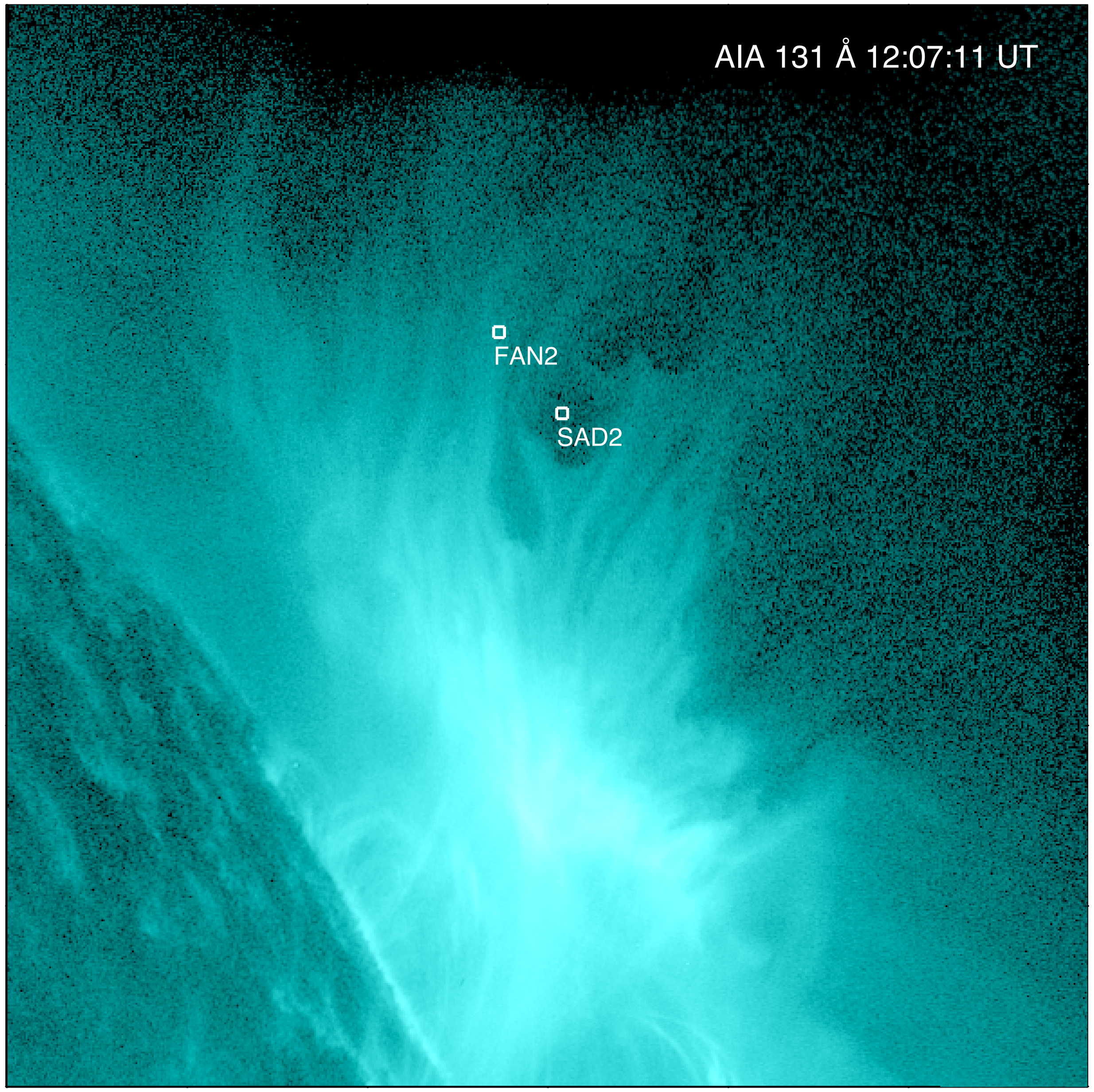
SAD models

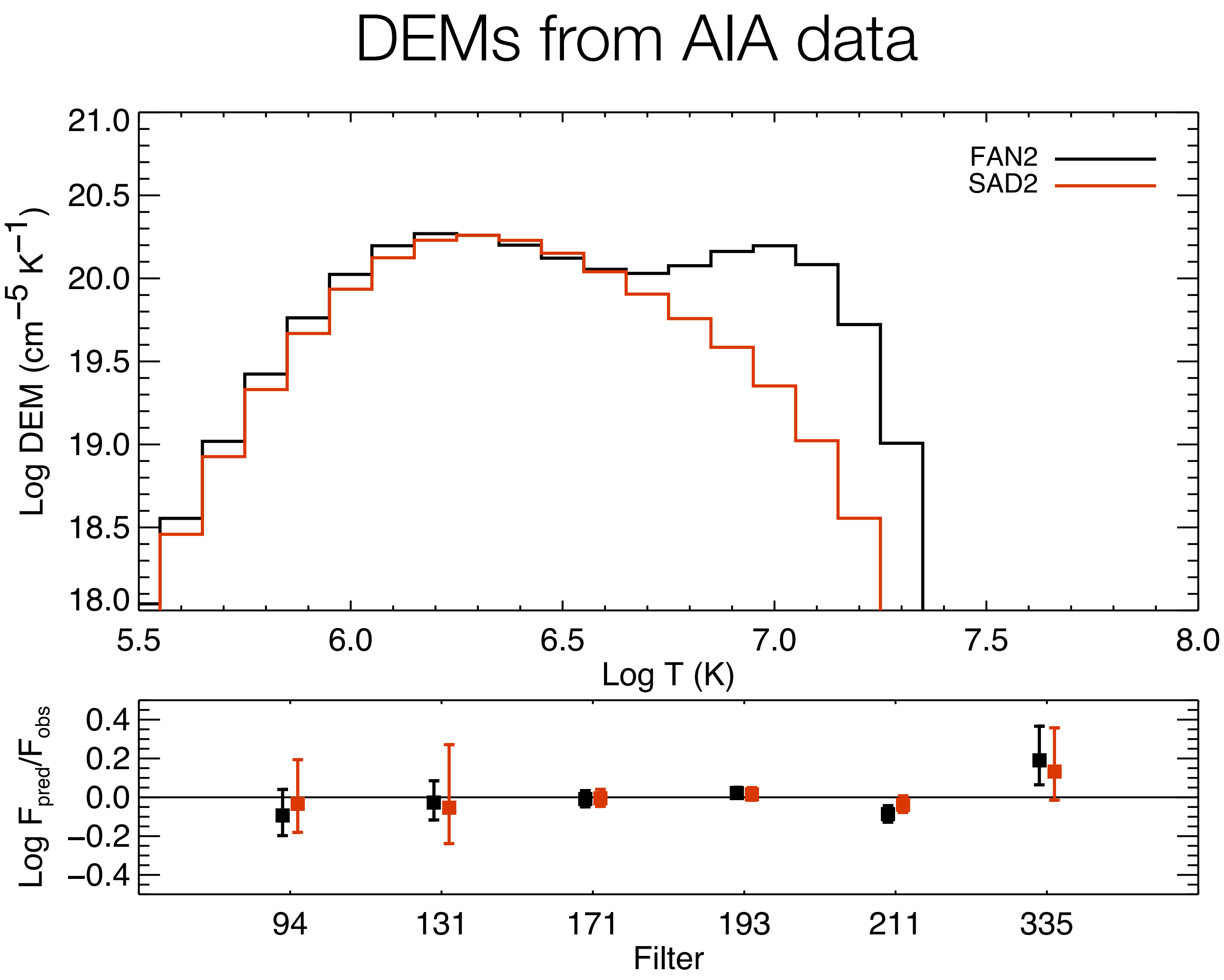


DEMs from AIA data

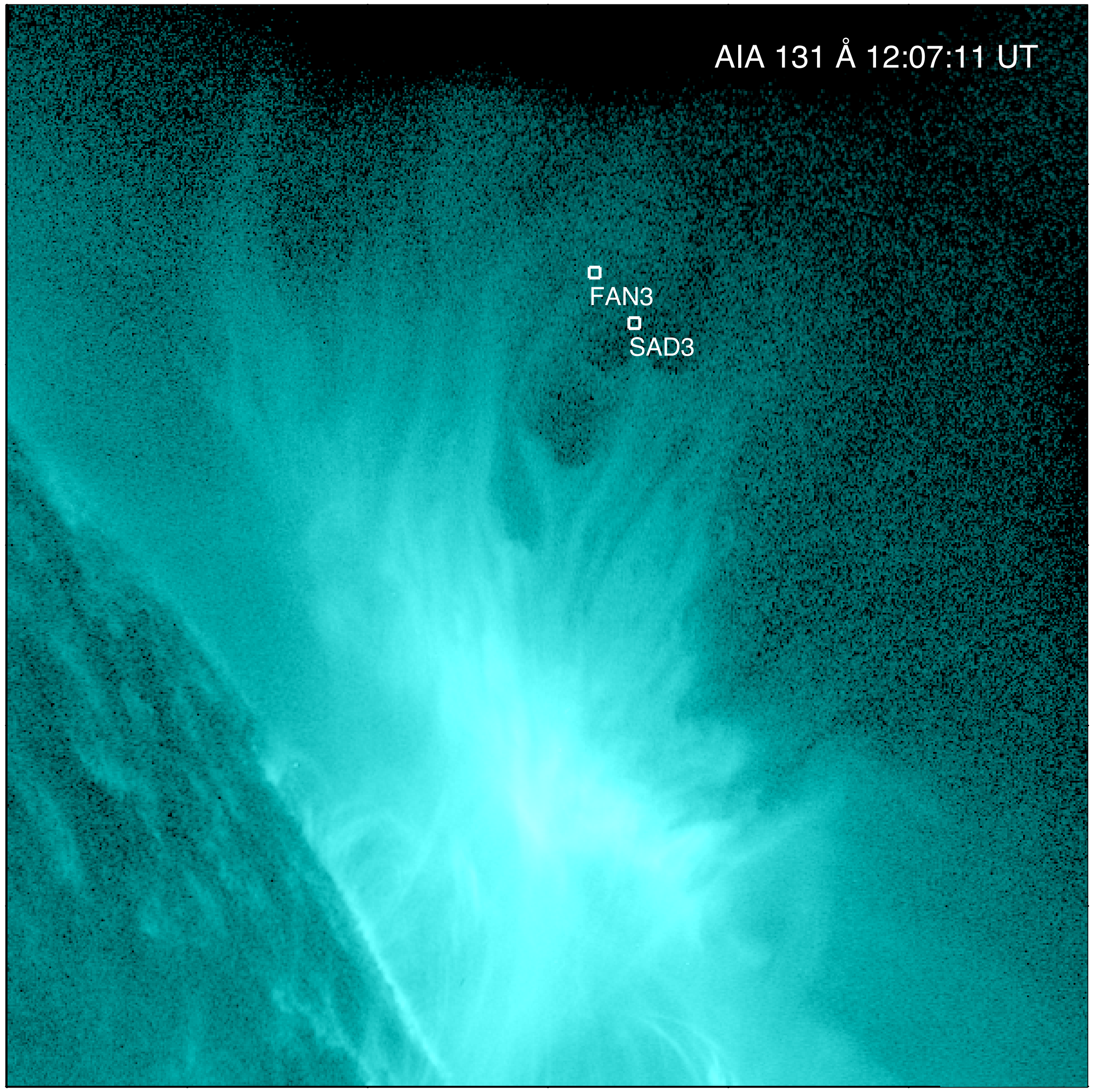


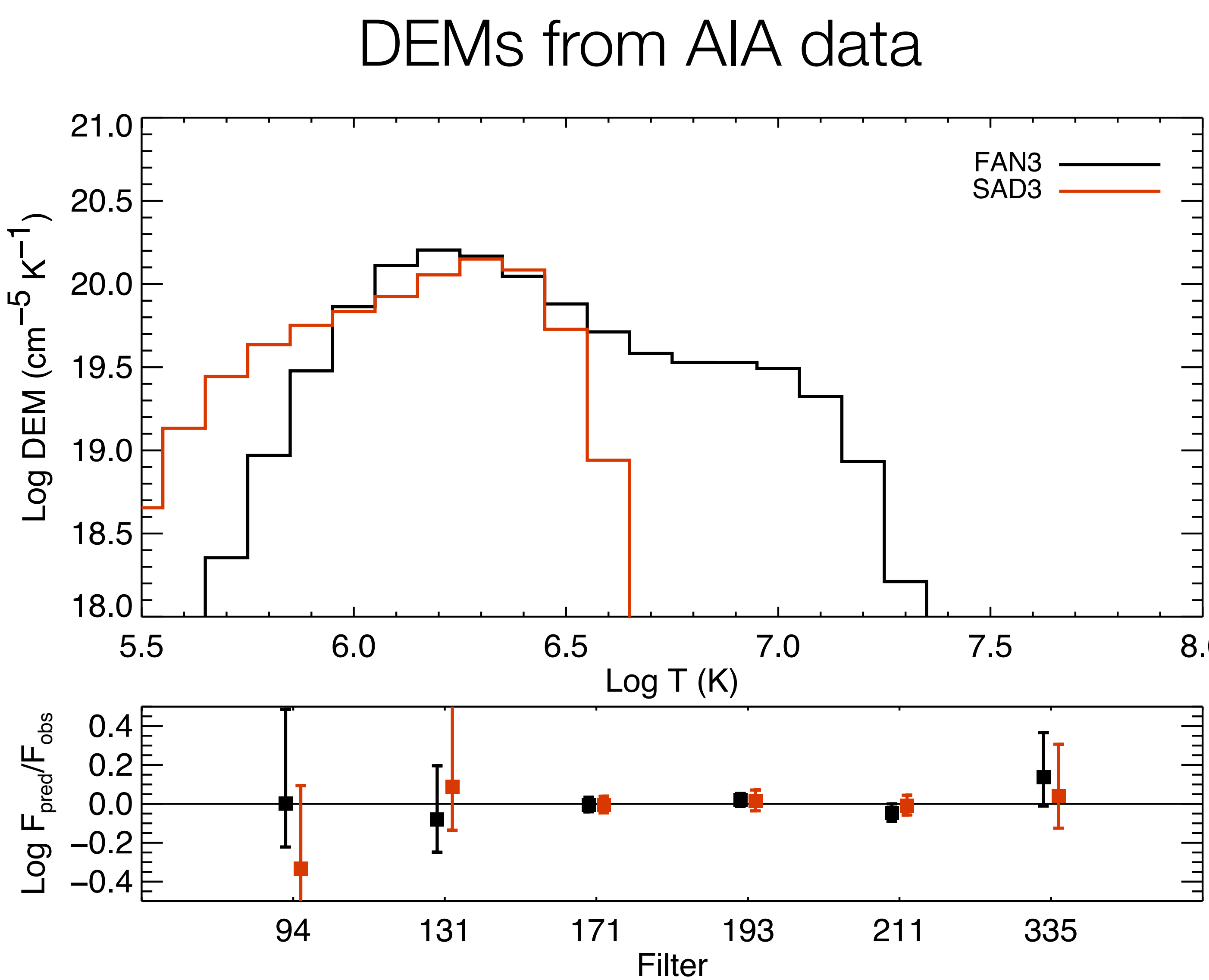
22-Oct-2011 flare



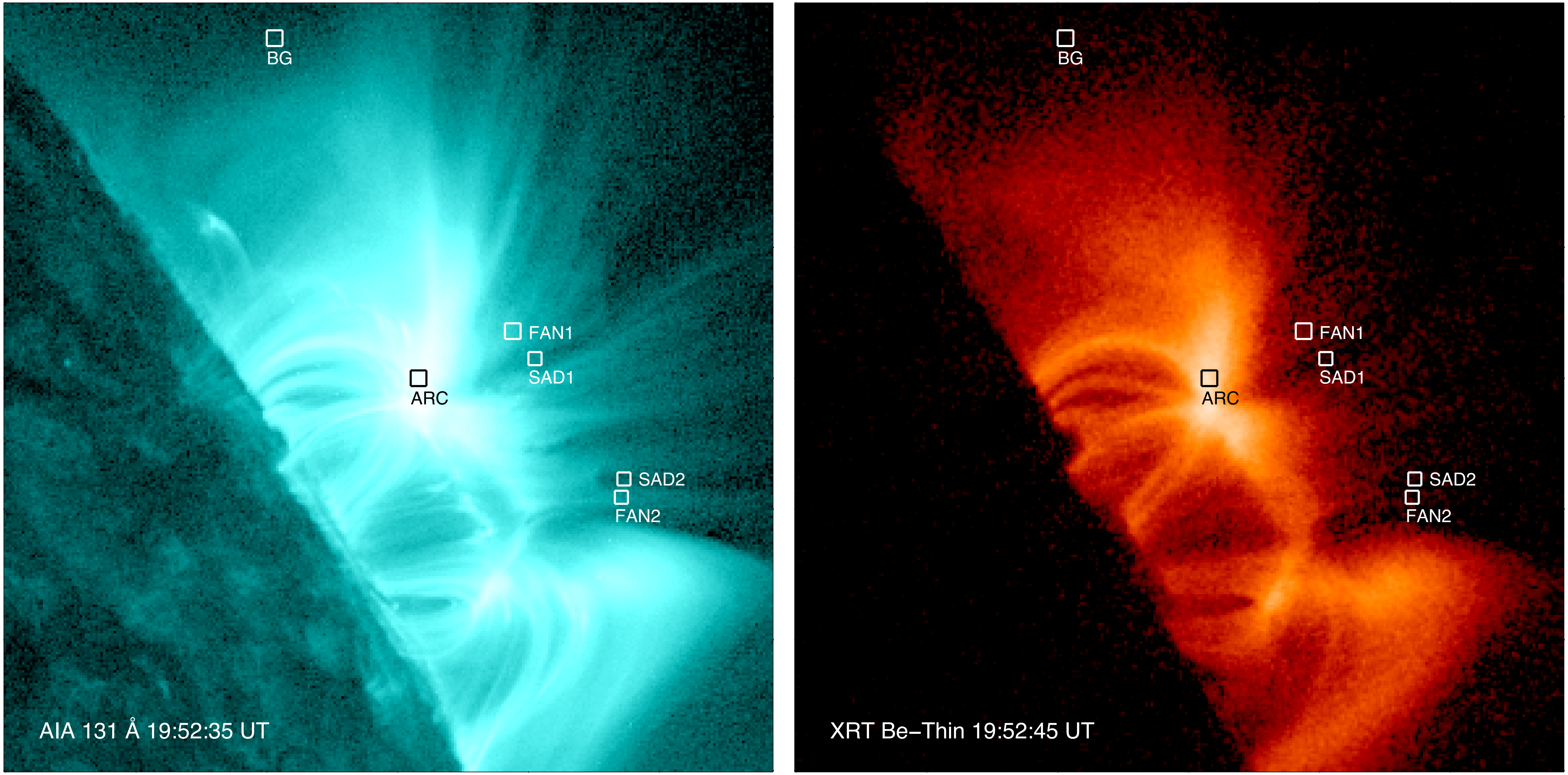


22-Oct-2011 flare



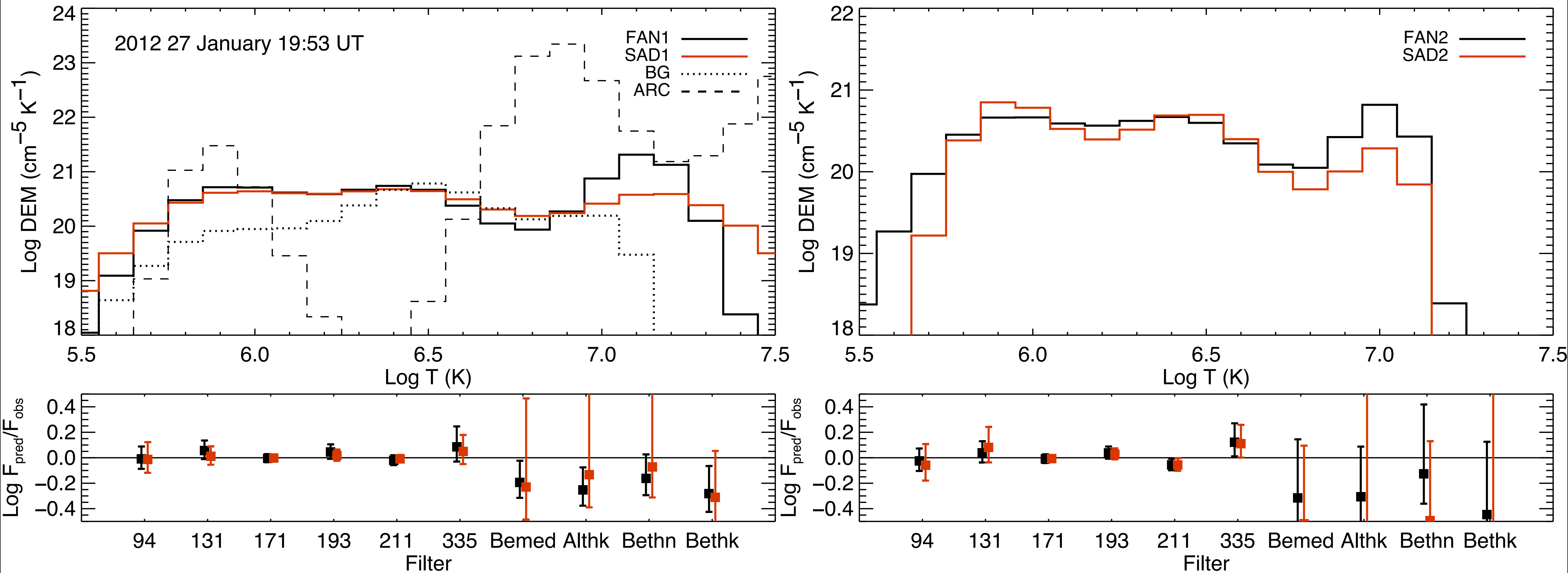


22-Oct-2011 flare



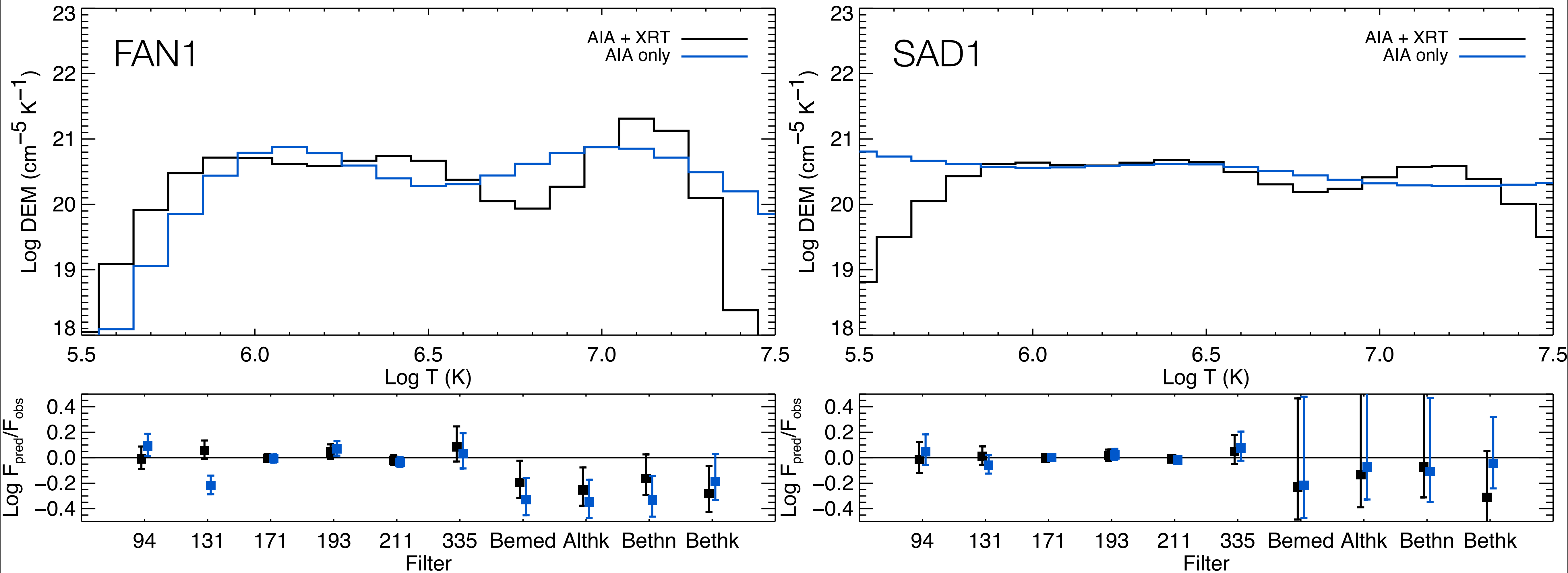
27-Jan-2012 flare

DEMs from AIA & XRT data

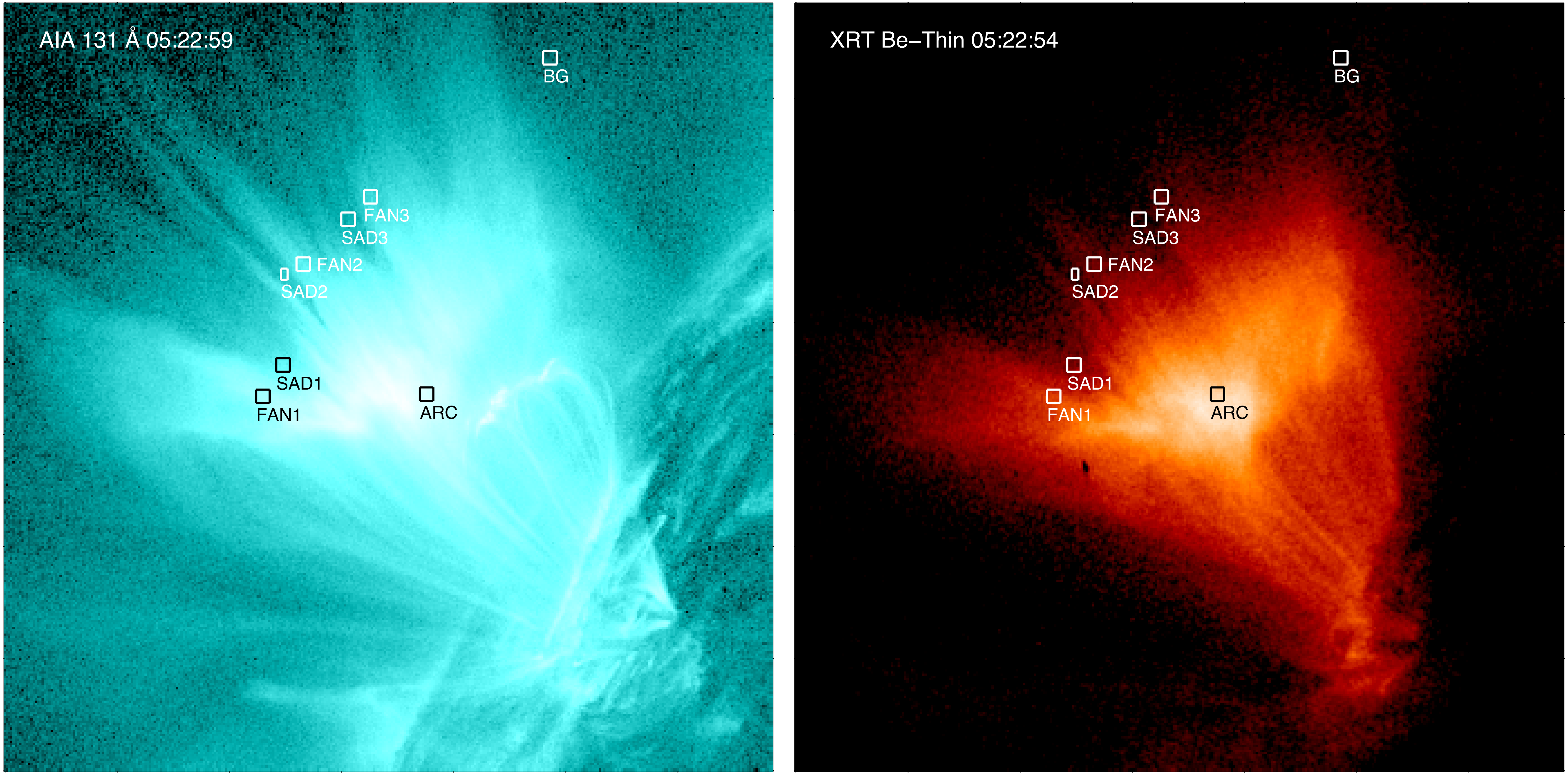


27-Jan-2012 flare

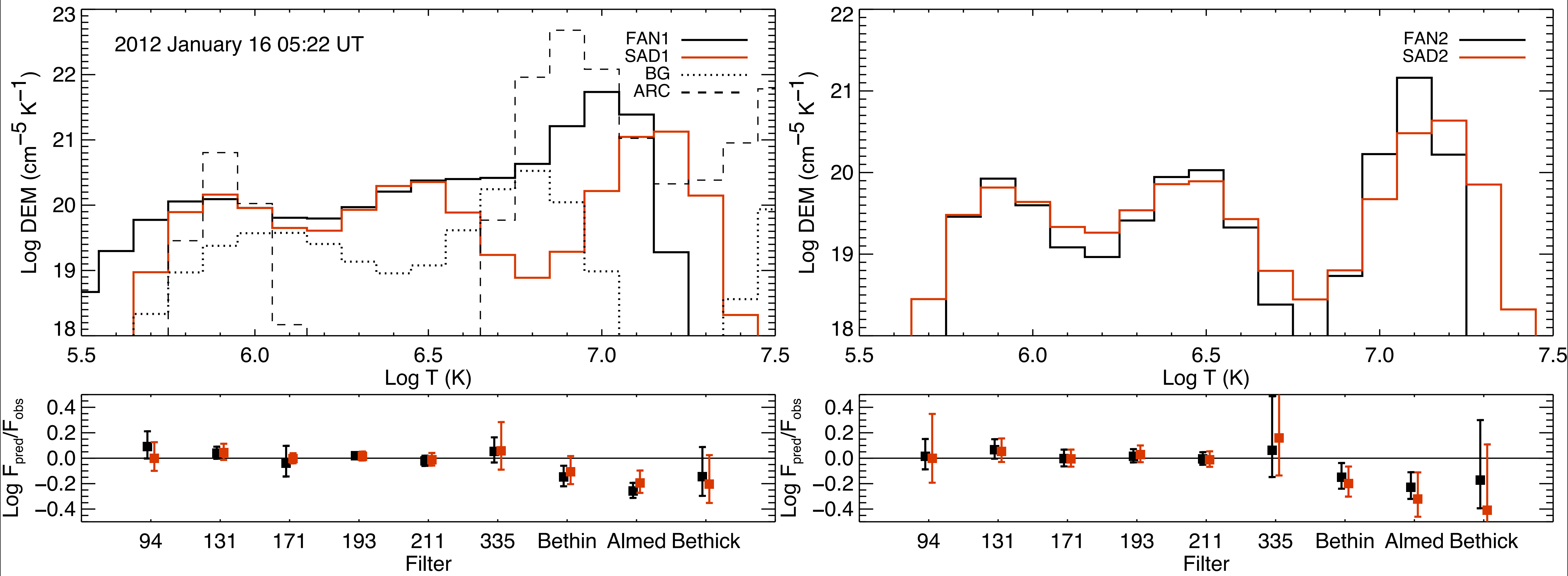
Advantages of including XRT data in DEMs

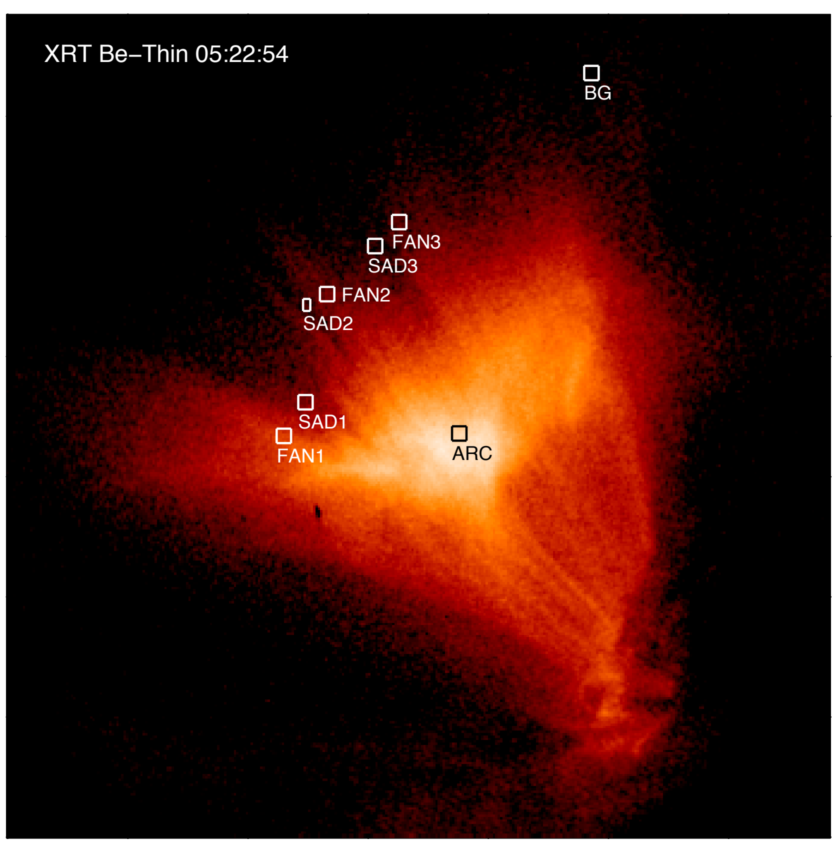


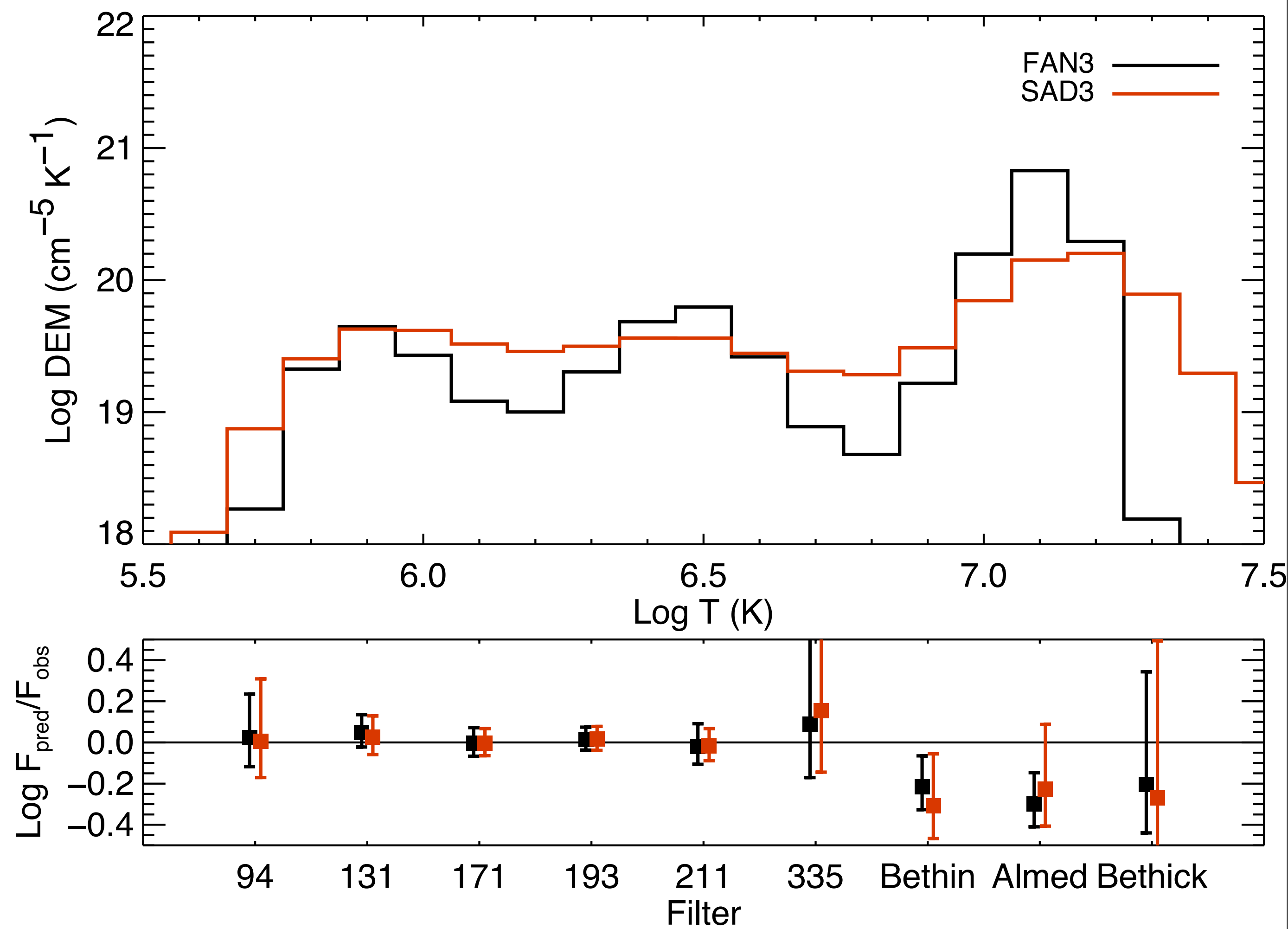
27-Jan-2012 flare



16-Jan-2012 flare



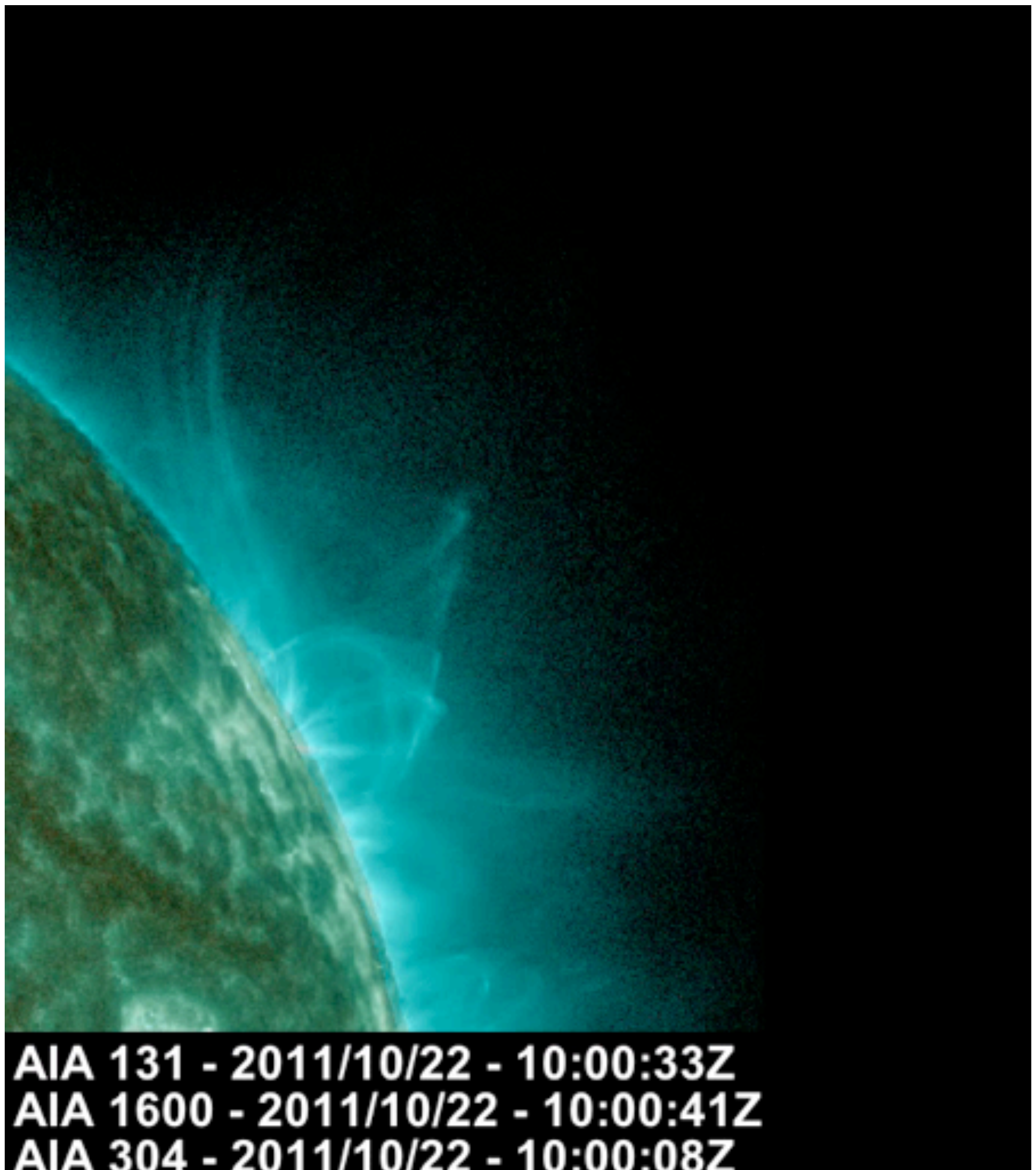


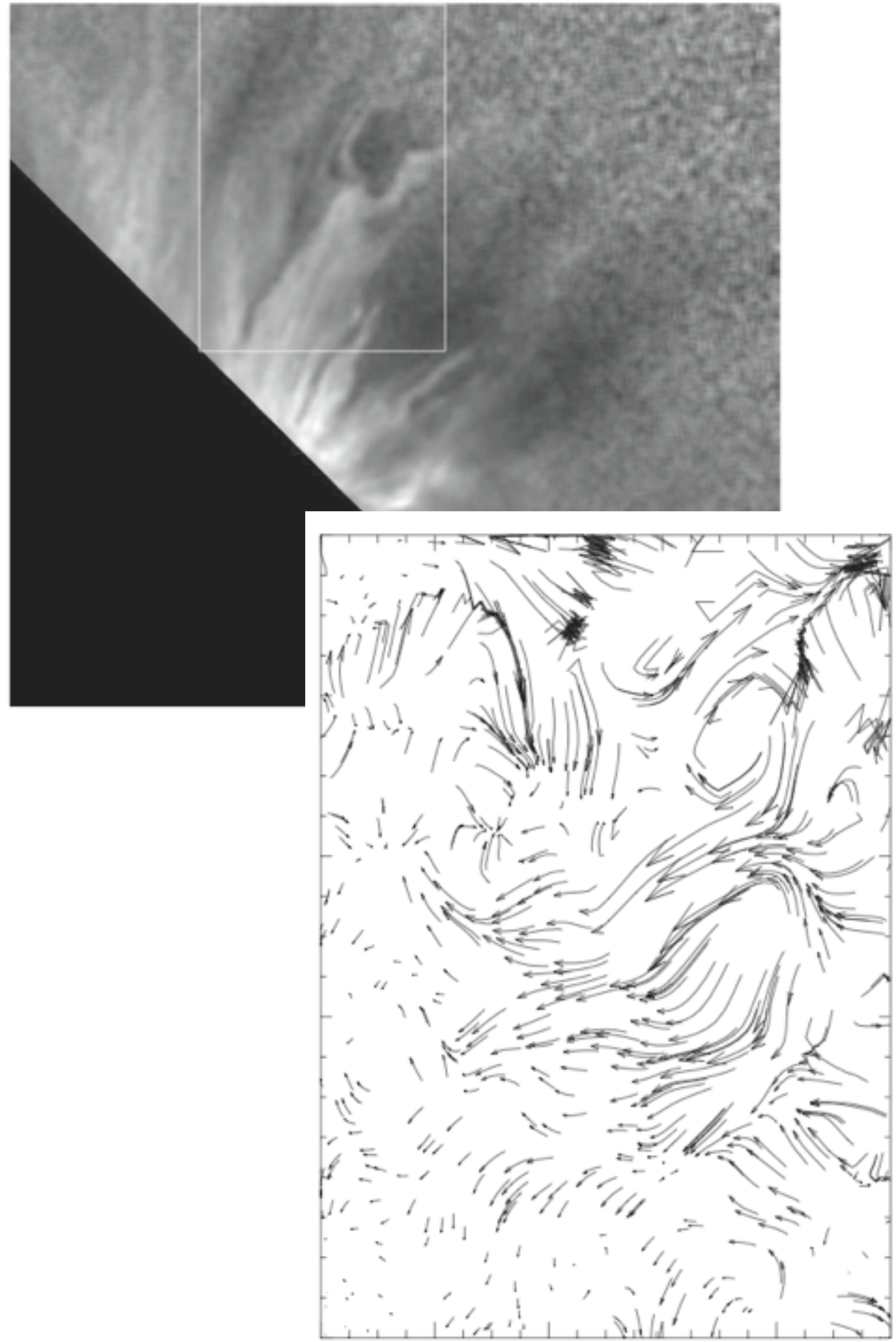


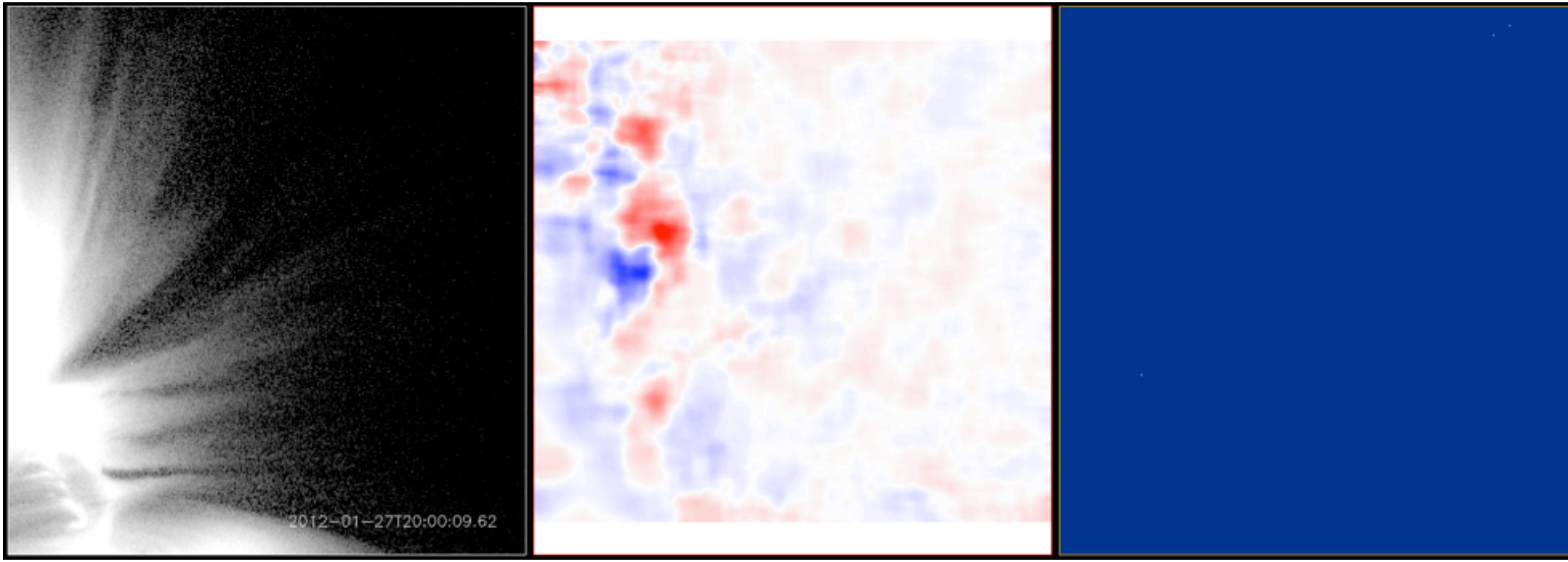
16-Jan-2012 flare

Is heating related to turbulent dynamics?

- See McKenzie, ApJ, 2013







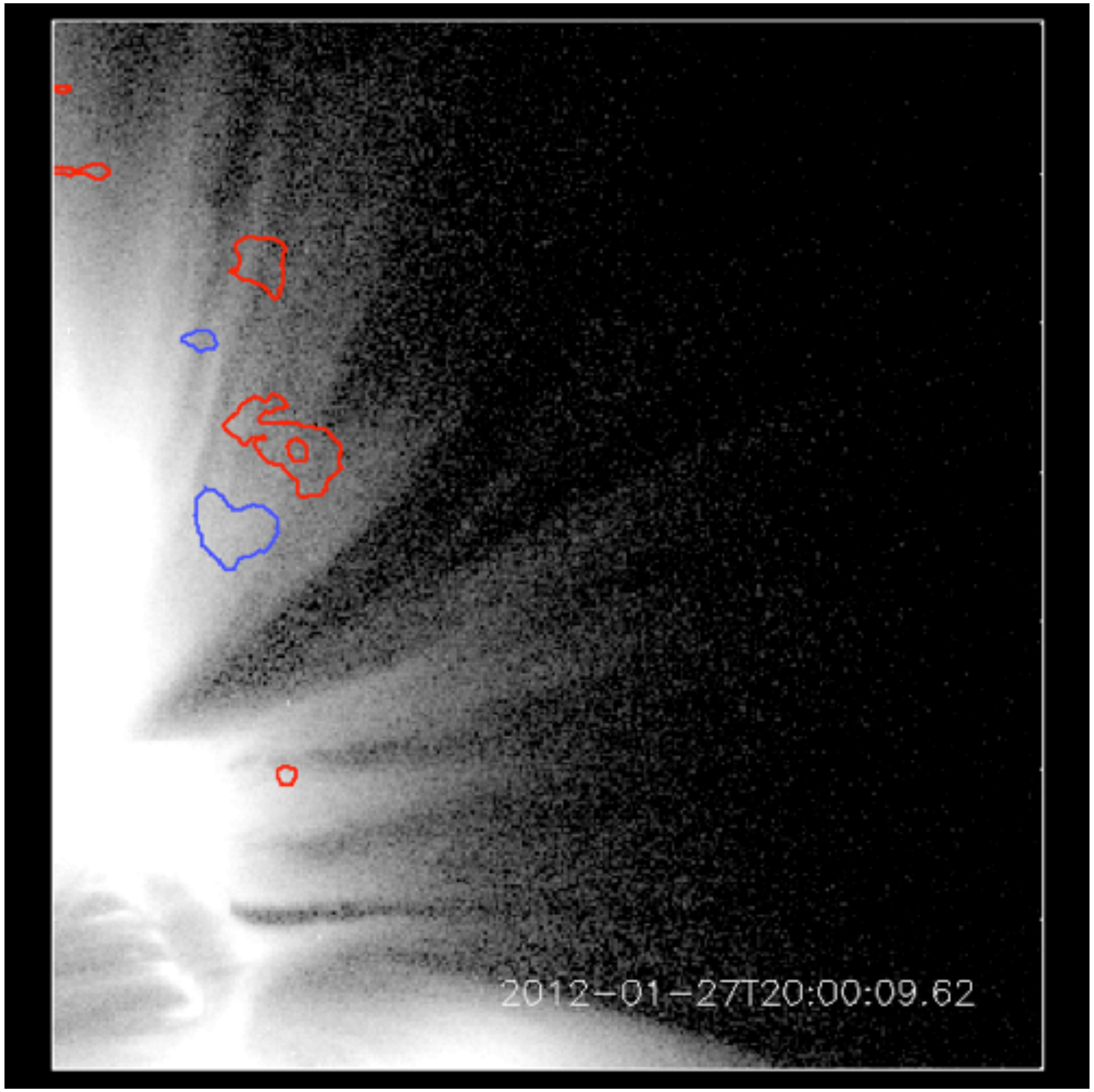
131 Å intensity

$T \; \nabla \cdot \mathbf{v}$

(adiabatic heating)

Temp difference

EM weighted T and $\nabla \cdot \mathbf{v}$



Red contours - expansion
Blue contours - compression

Purple contours - cooling
Gold contours - heating

EM weighted T and $T\nabla \cdot v$

T $\nabla \cdot v$

Temp difference (MK)

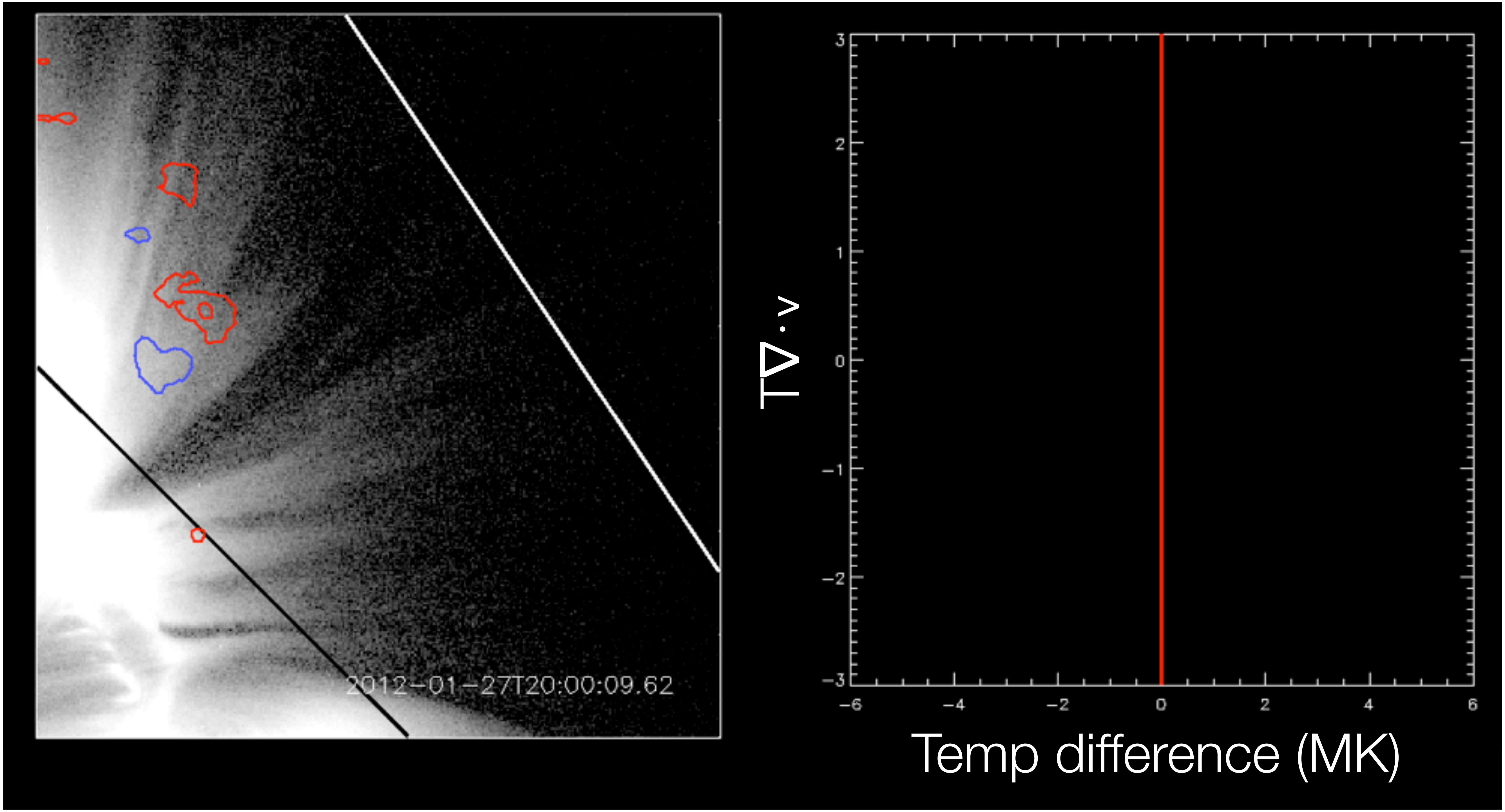
Red contours - expansion

Blue contours - compression

Purple contours - cooling

Gold contours - heating

EM weighted T and $\nabla \cdot v$



Red contours - expansion

Blue contours - compression

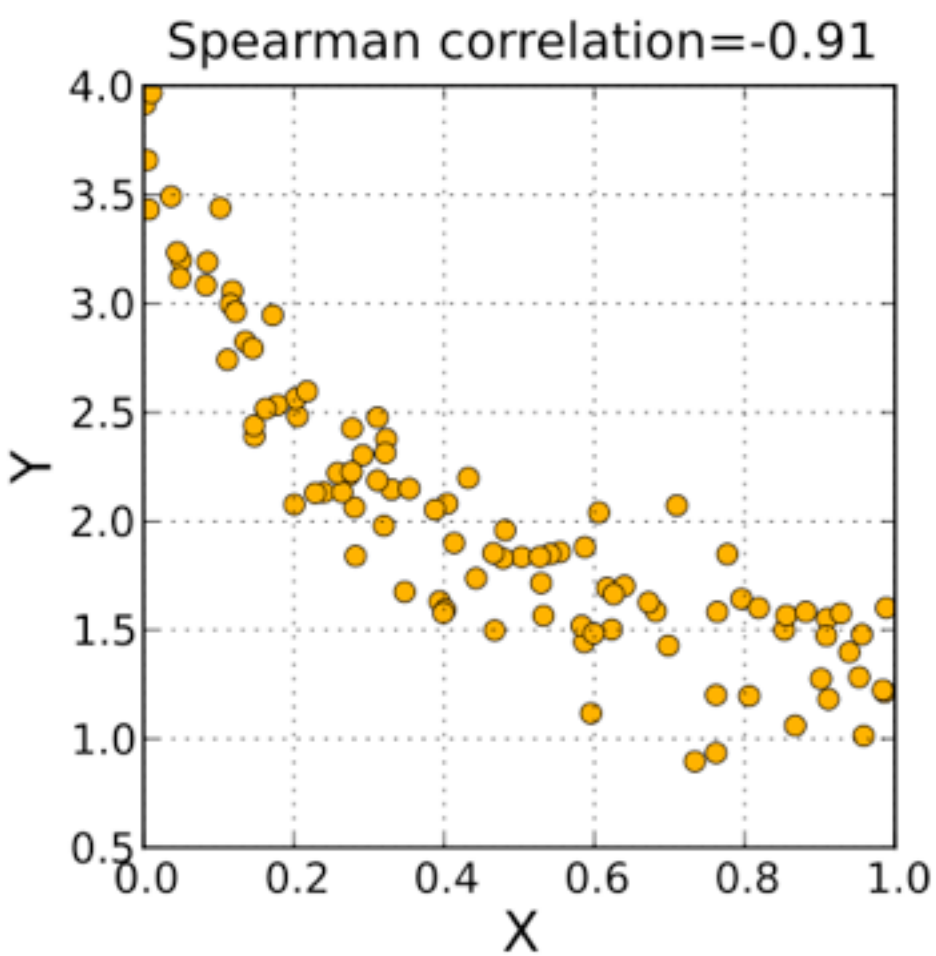
Purple contours - cooling

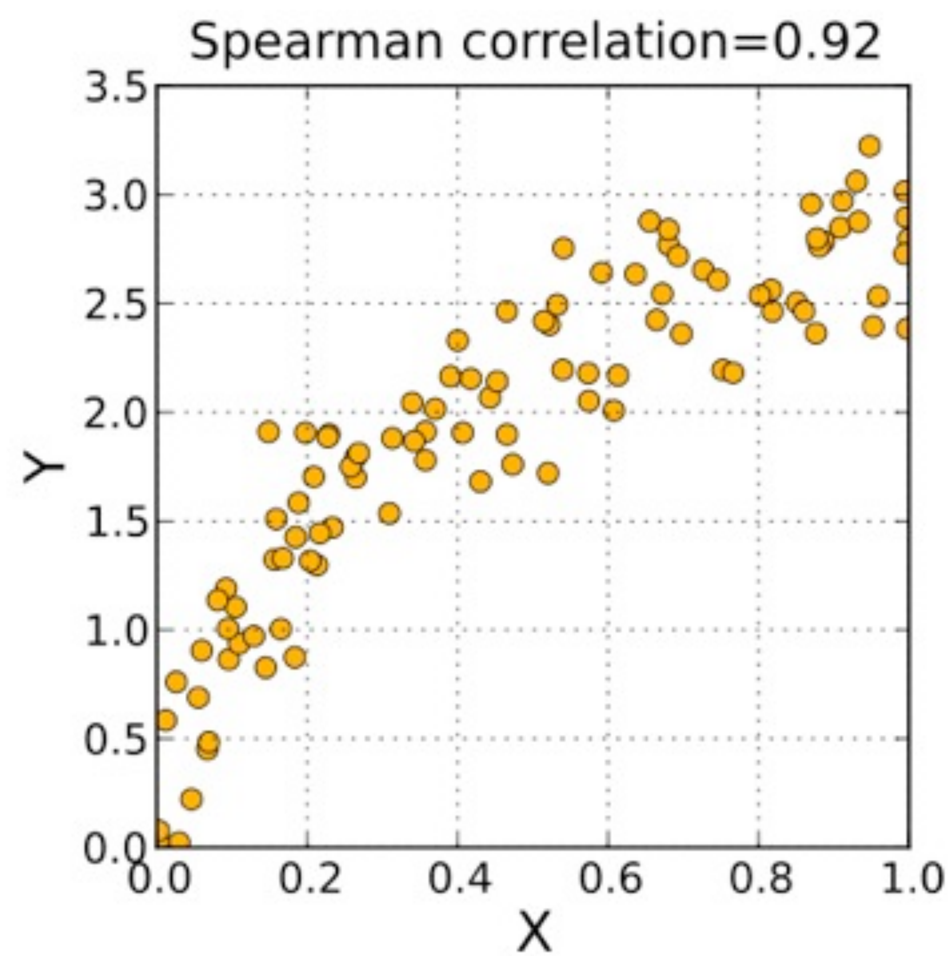
Gold contours - heating

EM weighted T and $\nabla \cdot v$

Rank-order correlation

- Spearman’s rank-order correlation is a nonparametric correlation used to test for a monotonic relationship between two variables.
- “Chance probability” (P_c) is the likelihood that the same number of points would line up with this correlation purely by random chance. Confidence of the correlation is $1-P_c$

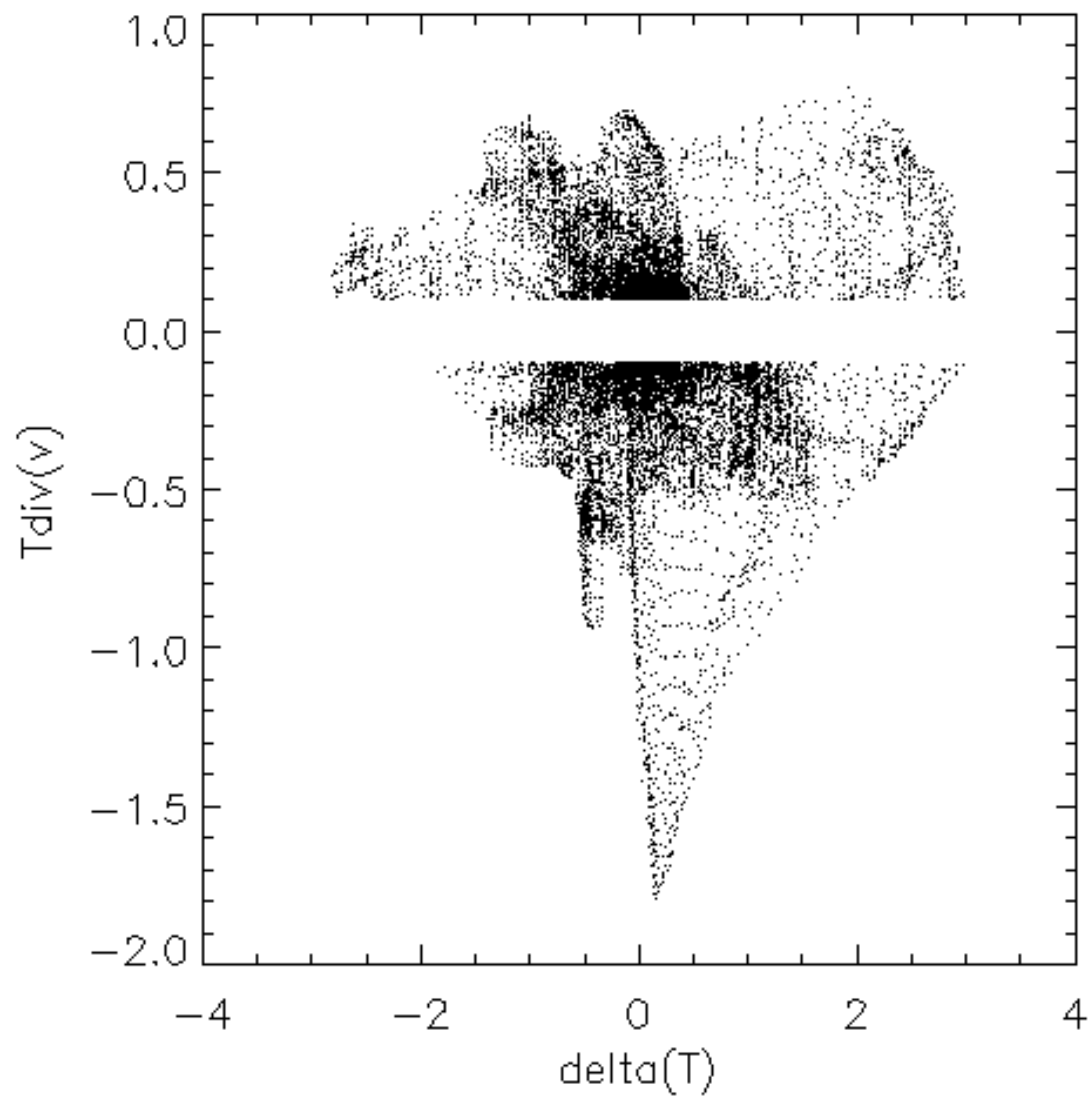




Images courtesy of http://en.wikipedia.org/wiki/Spearman's_rank_correlation_coefficient

Rank order for adiabatic heating

- Adiabatic heating would be consistent with a negative correlation
- Only used points where $|(T\nabla\cdot v)| > 0.1$.
- First example (right): 2012-01-27, 20:05:21
- Spearman corr. coeff = -0.15, Chance probability (P_C) < 0.01% (i.e. 99.99% confidence).



Rank-order for 26 snapshots

Timestep	Sprmn C	P_c	Timestep	Sprmn C	P_c	Timestep	Sprmn C	P_c
0	NaN	NaN	9	-0.045	0%	18	-0.156	0%
1	0.228	0%	10	-0.022	0.39%	19	-0.130	0%
2	0.152	0%	11	-0.184	0%	20	-0.126	0%
3	0.092	0%	12	-0.167	0%	21	-0.106	0%
4	0.011	8.7%	13	-0.153	0%	22	-0.019	0.81%
5	-0.016	2.2%	14	-0.148	0%	23	0.042	0%
6	-0.027	0.03%	15	-0.245	0%	24	0.128	0%
7	-0.068	0%	16	-0.224	0%	25	0.195	0%
8	-0.026	0.04%	17	-0.187	0%			

P_c of 0% indicates chance probability was less than 0.01% (i.e. confidence > 99.99%)

Conclusions

- Determining the temperature in the SADs is important for understanding the mechanism that creates them.
- DEMs indicate that plasma in SAD lanes is not significantly hotter than surrounding fan plasma, and is sometimes cooler or the same temperature.
- Preliminary analysis of adiabatic cooling and heating events is promising, but more analysis needs to be done. Also, velocity shear events are being examined.
- New XRT flare catalog! http://xrt.cfa.harvard.edu/flare_catalog/index.html


Photo credit: Loraine Lundquist
Thank you!