A quiet-Sun magnetic flux cancelation observed with GREGOR/IFU

Anjali J. Kaithakkal[1]

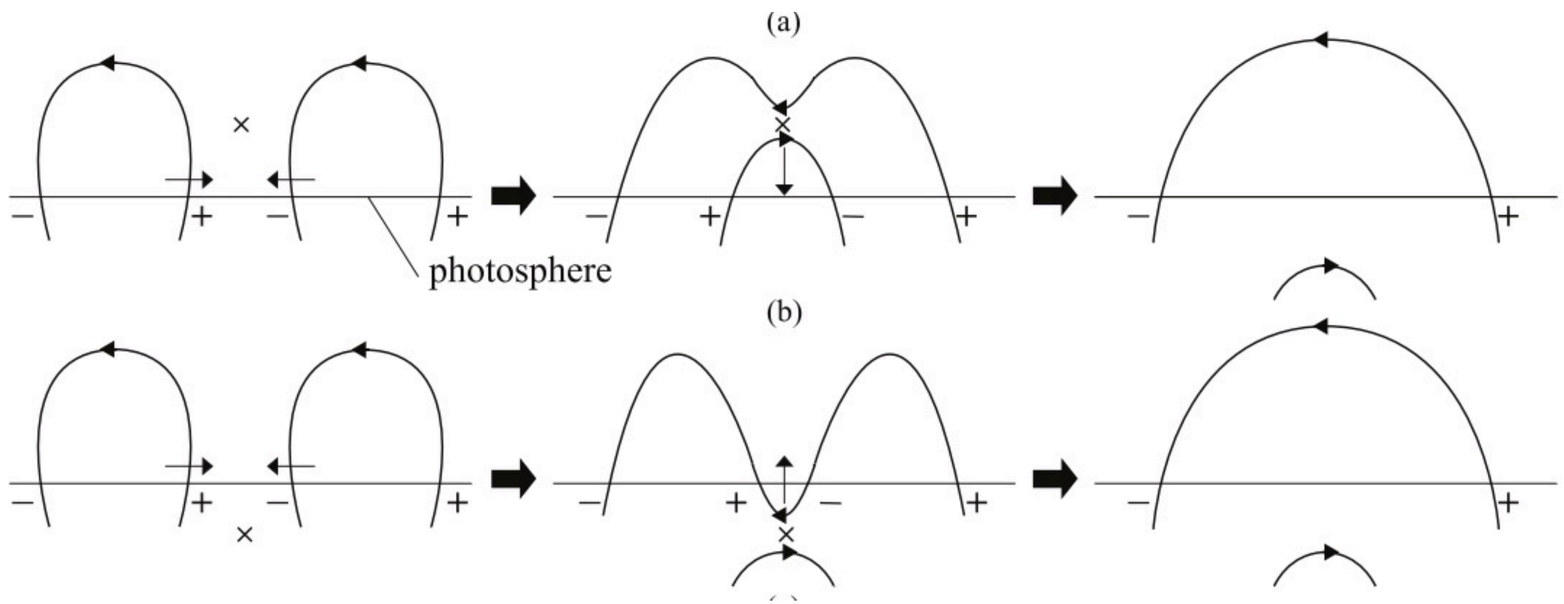
J. M. Borrero[1], C. Fischer[1], C. Dominguez-Tagle[2], and M. Collados[2]

1: Leibniz Institute for Solar Physics (KIS)

2: Instituto de Astrofísica de Canarias (IAC)

BACKGROUND

- In situ disappearance of magnetic flux due to collision of opposite-polarity magnetic elements (Martin et al. 1985)
  - occurs frequently in the active and quiet solar surface
  - pre-connected bipoles — submergence
  - unconnceted bipoles: (a) retraction of a Ω-shaped loop, or (b) emergence of a U-shaped loop (Zwaan 1987)



(a) Chae et al. 2004, Yang et al. 2009, Iida et al 2010

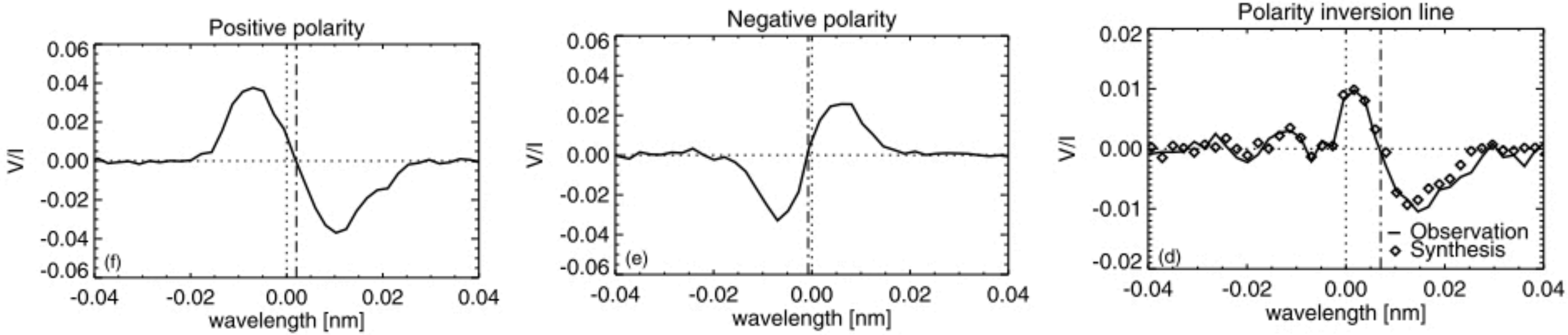
(b) van Driel-Gesztelyi et al. (2000), Yurchyshyn & Wang (2001), Bellot Rubio & Beck (2005)

BACKGROUND

- Kubo et al. 2014 — asymmetric Stokes V profiles at polarity inversion line (PIL) do not indicate flux removal

  — mixture of unresolved, opposite-polarity magnetic elements or the unresolved width of the PIL

$$V_{\mathrm{PIL}}^{\mathrm{syn}} = A \times V_{+}^{\mathrm{obs}} + B \times V_{-}^{\mathrm{obs}}$$



BACKGROUND

- Area asymmetry in Stokes V profile:
  - gradients in velocity and magnetic field along the LOS (e.g., Illing et al. 1975; Auer & Heasley 1978; Sanchez Almeida & Lites 1992; Solanki & Montavon 1993)

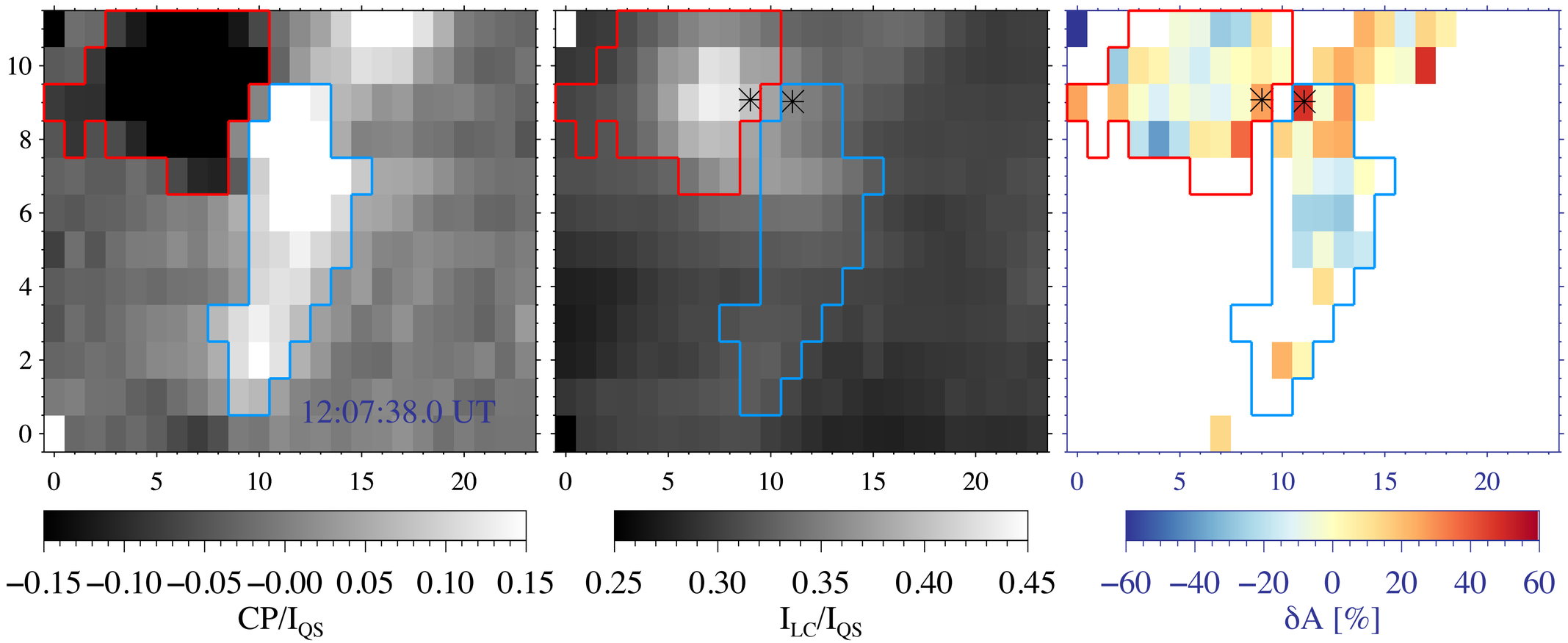
$$\delta A = \frac{\int_{\lambda_i}^{\lambda_f} V(\lambda)\, d\lambda}{\int_{\lambda_i}^{\lambda_f} |V(\lambda)|\, d\lambda}$$

- Question — Evolution of Stokes profiles during the cancelation?

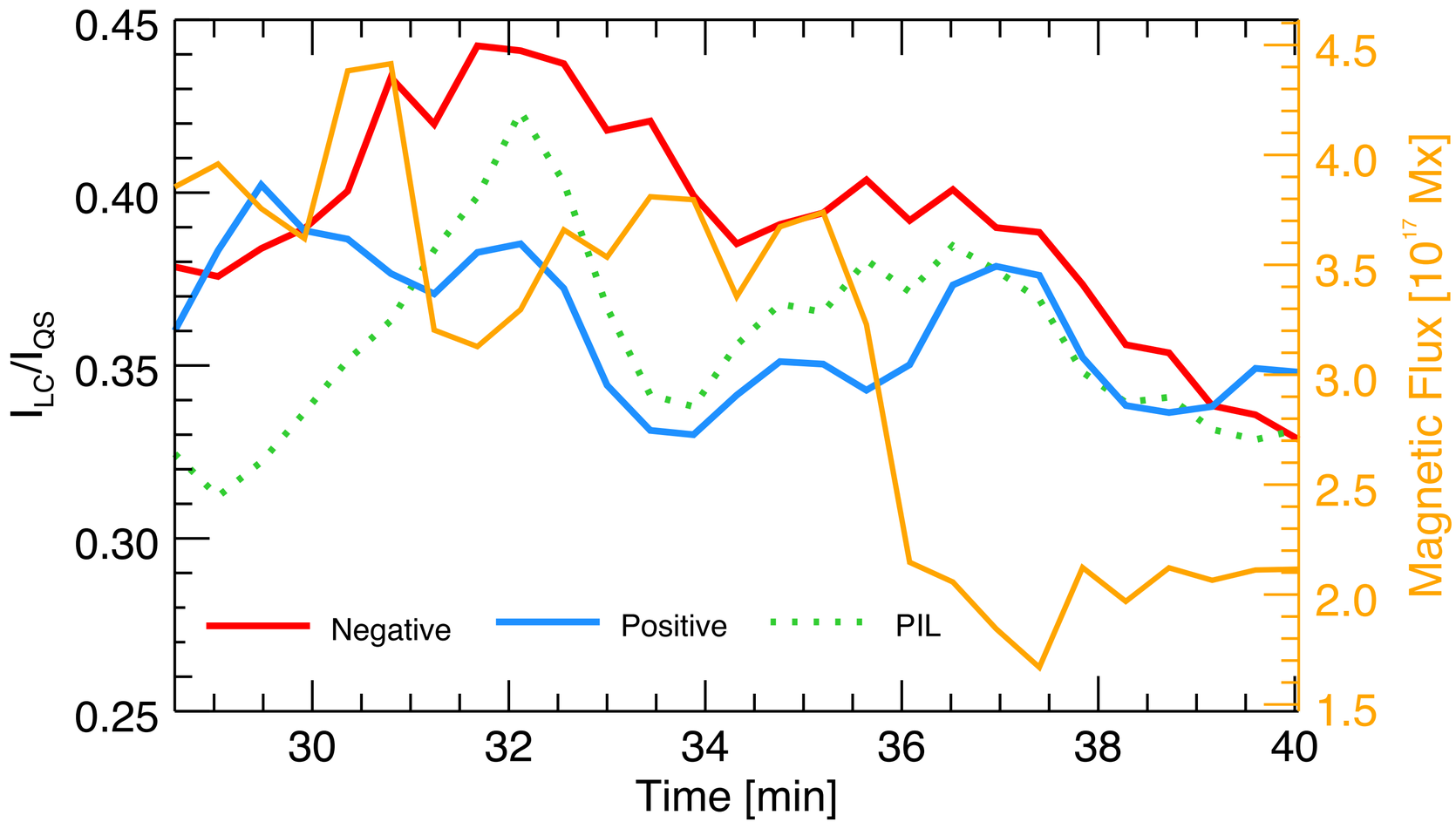
DATA

- GREGOR GRIS / IFU (Integral Field Unit) — Nov. 2 2018 11: 40 UT
- λ — Si I 10827.108 Å (Landé factor, g = 1.5)
- spectral sampling — 18 mA/pixel
- cadence — 26.4 sec
- FOV — 6″ x 6″ (mosaic of two tiles)
- disk centre quiet-Sun

RESULTS


12:07:38.0 UT
0
2
4
6
8
10
0
5
10
15
20
−0.15 −0.10 −0.05 −0.00 0.05 0.10 0.15
CP/I_QS
0.25 0.30 0.35 0.40 0.45
I_LC/I_QS
−60 −40 −20 0 20 40 60
δA [%]

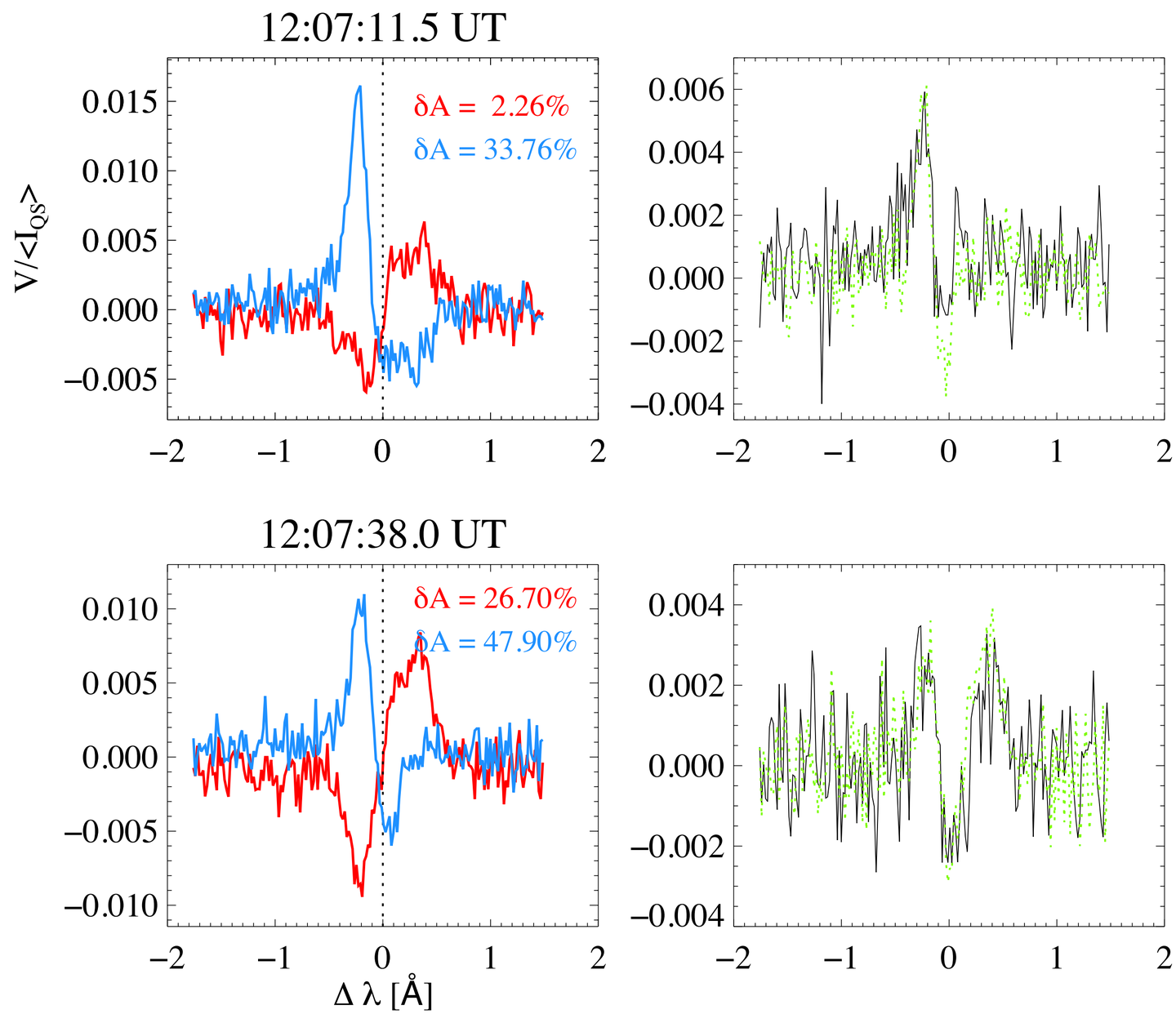
RESULTS



Magnetic flux decay rate —$1.6 * 10^{15}$Mx/s

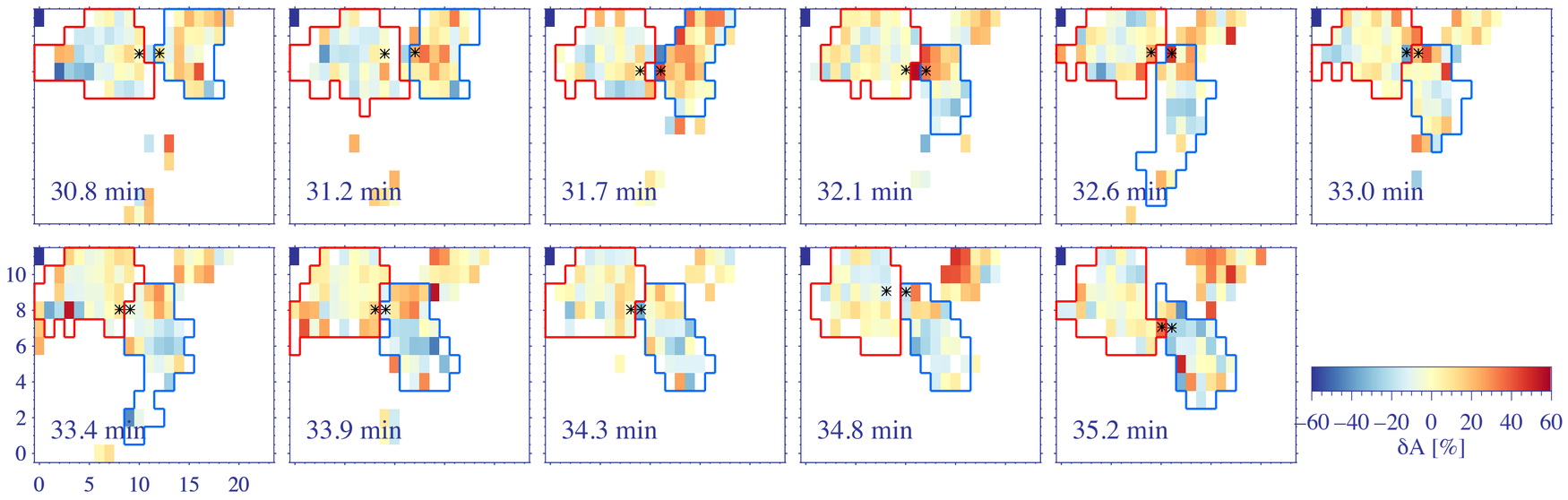
RESULTS

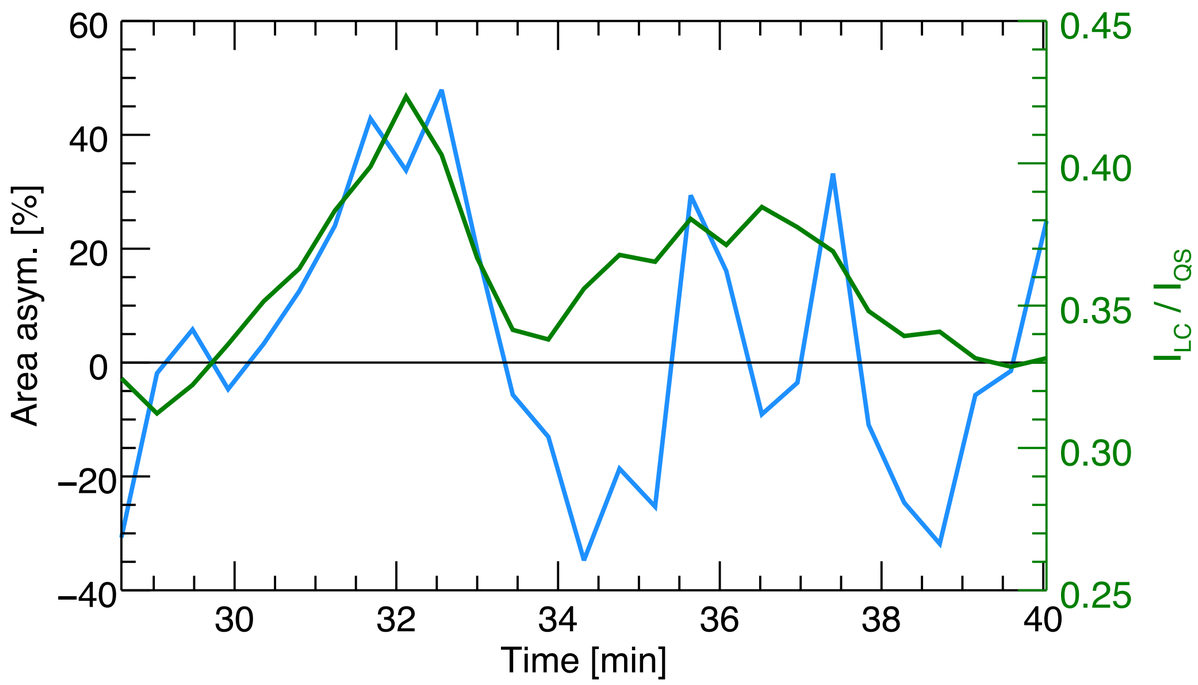
- Left — Stokes V profiles of border pixels of opposite polarity
  - Blue — positive polarity
  - Red — negative polarity
- Right — Stokes V profiles at PIL
  - Black — observed
  - Green — synthetic



RESULTS

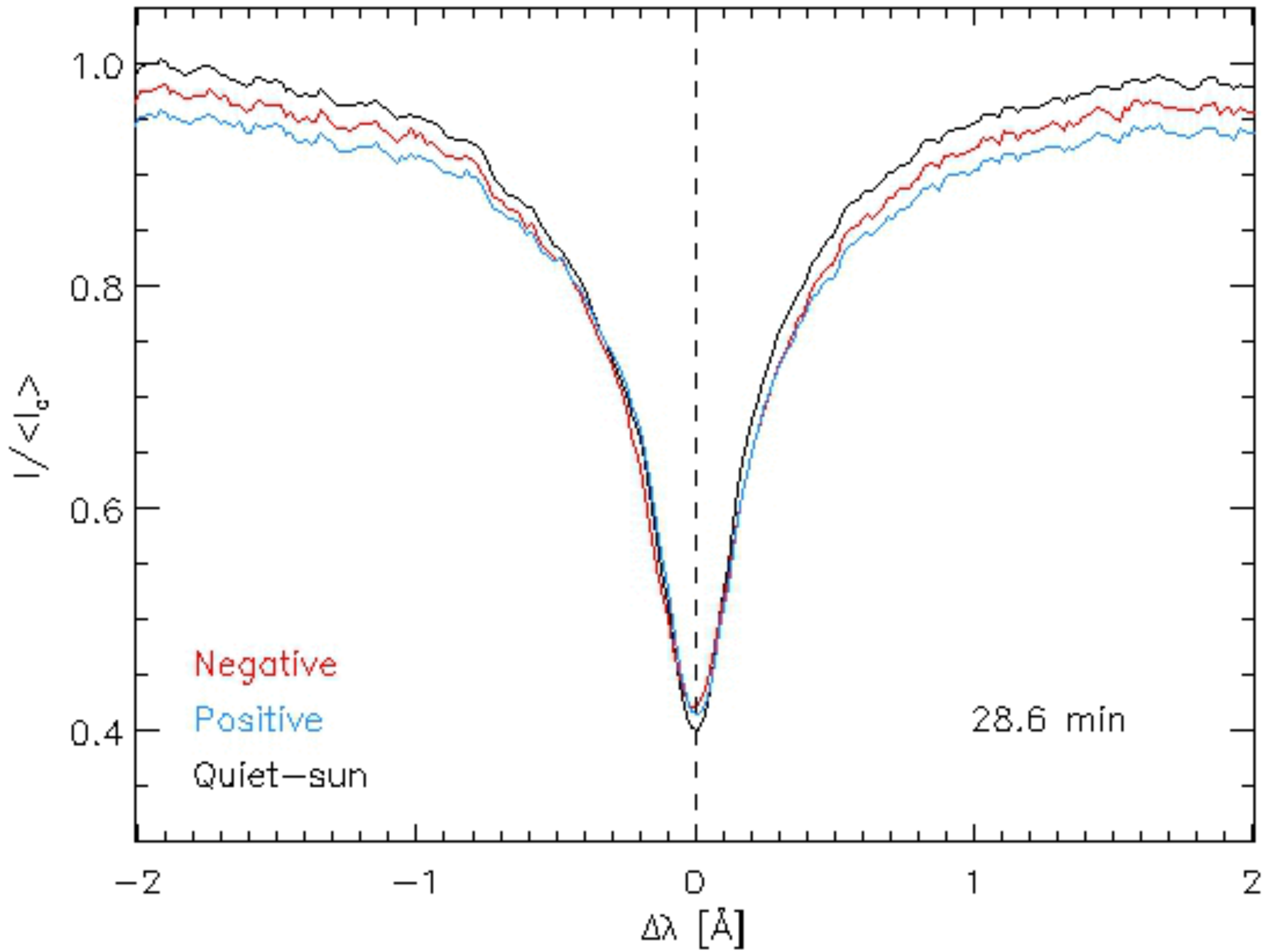
Stokes V area asymmetry with time at border pixels





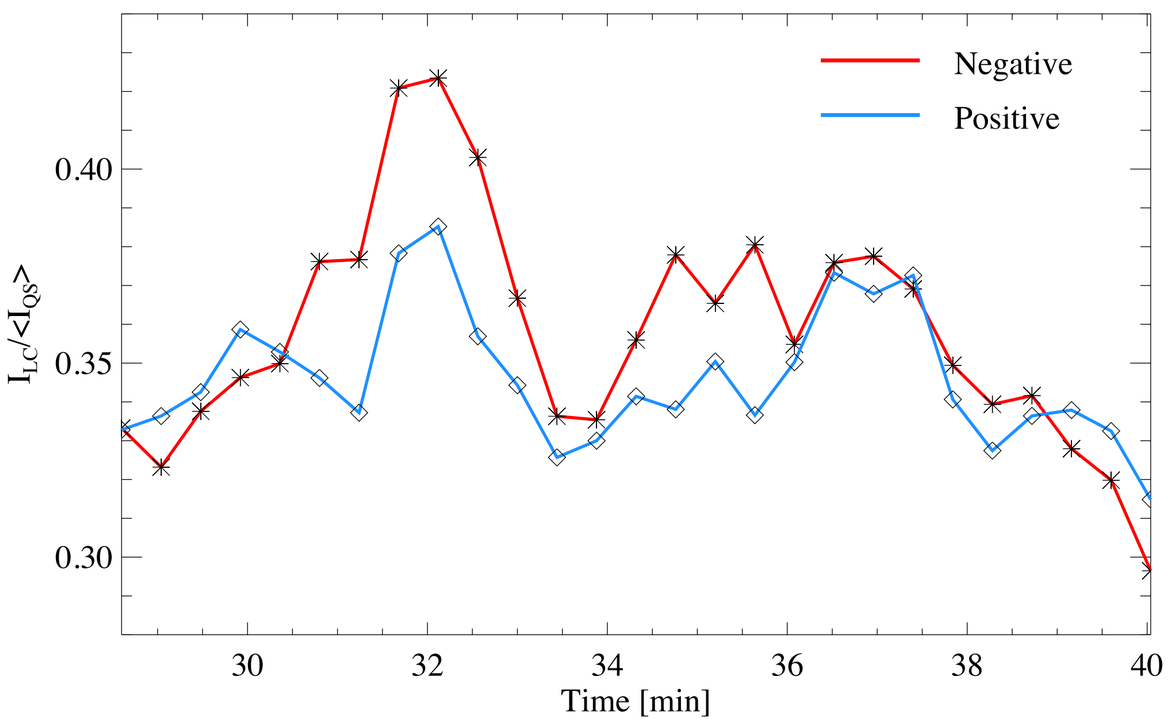
RESULTS

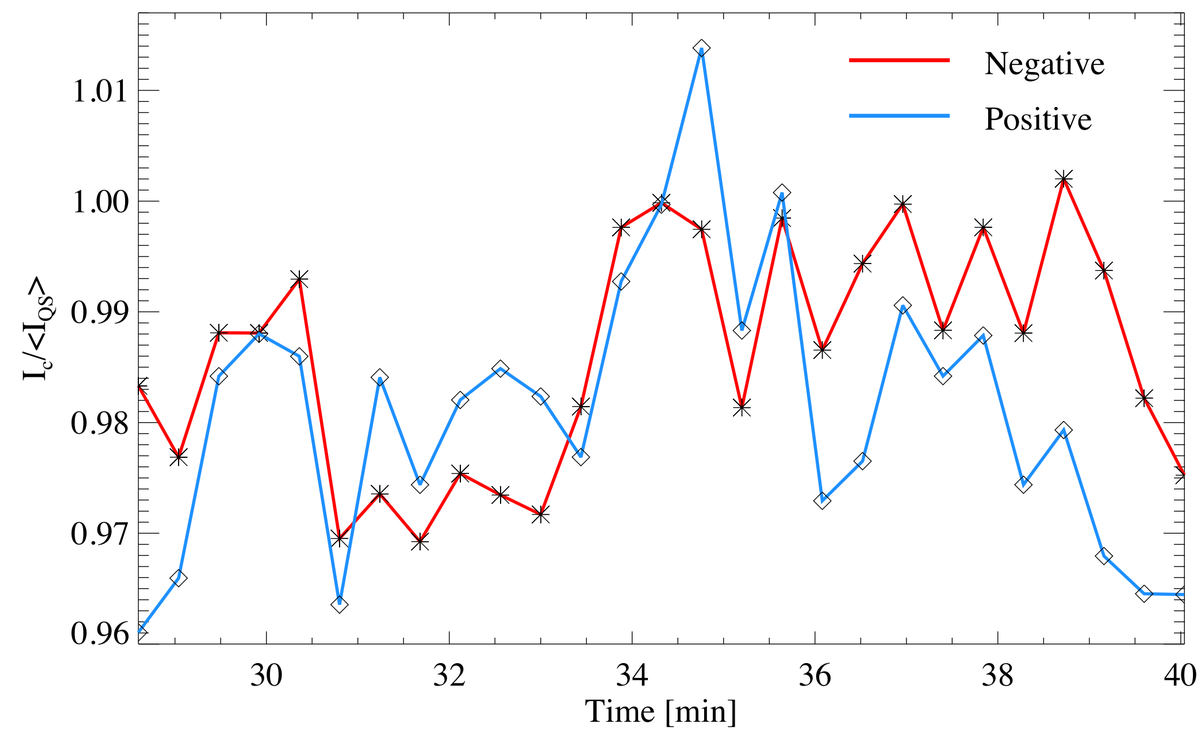
Evolution of the Stokes I profile of the border pixels



RESULTS

Variation of continuum and core intensity of the border pixels





- Energy travels down to the lower-photosphere — speed @ 3 km/s

RESULTS

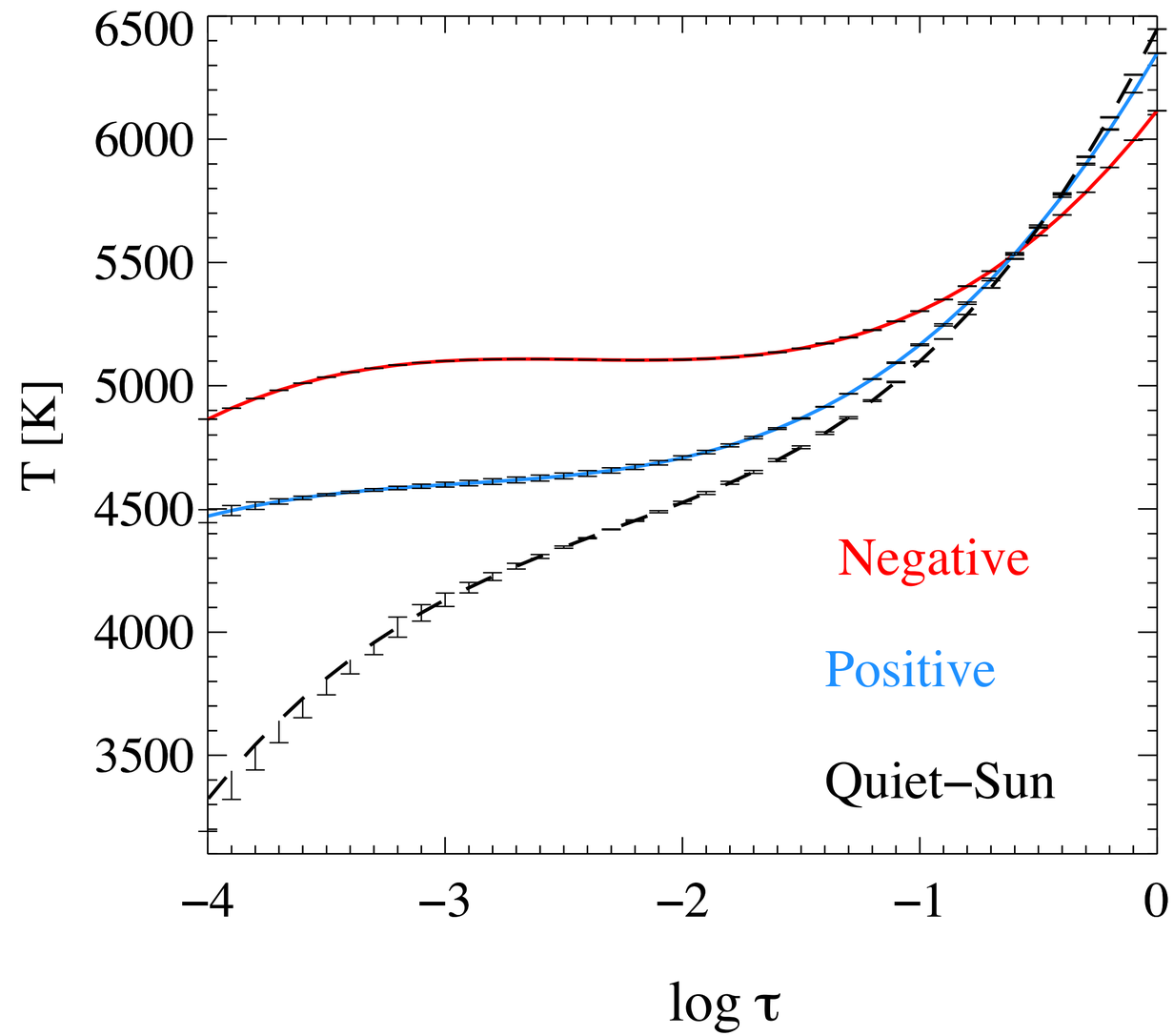
SIR inversion

- In LTE
- Single component atmosphere
- Four nodes in temperature
- Temperature rise corresponding to core enhancement,

  Negative polarity — 969 K,

  Positive polarity — 467 K,

  when compared to the quiet-Sun



SUMMARY

- Quiet-Sun disk centre small-scale flux cancelation
  - Preceded by reconnection
  - Systematic variation of Stokes V area asymmetry in the border pixels for one of the polarity
  - Sign reversal of area asymmetry
  - Heats up the entire atmosphere

Kaithakkal et al., submitted to A&A

OPEN QUESTIONS

- The sign flip in area asymmetry — magnetic field gradient or LOS velocity gradient
- Involvement of waves
- Significance of the resulting heating
- Statistical relevance

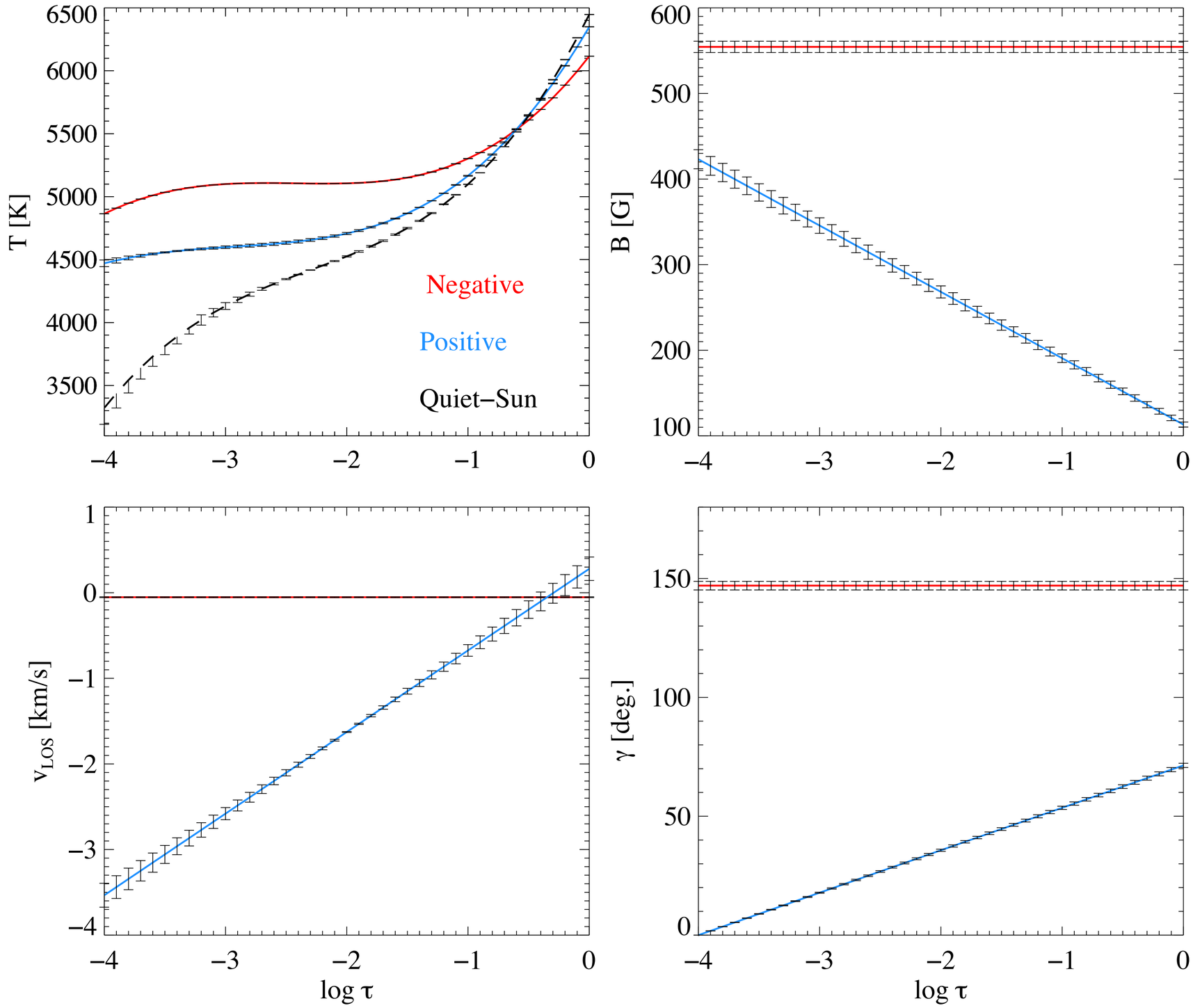
QUEST

- QUEST — QUiet-Sun Event Statistics

  — statistical analysis of quiet-Sun events using multi-wavelength data sets

http://www.leibniz-kis.de/en/projects/quest/

THANK YOU


T [K]
B [G]
v_{LOS} [km/s]
γ [deg.]
log τ
log τ
Negative
Positive
Quiet−Sun