A textbook example of magnetic flux emergence leading to EBs, UV bursts, surges and EUV signatures

I. Cabello[1,2], D. Nóbrega-Siverio[1, 2, 3, 4], S. Bose[5, 6, 3, 4], L. H. M. Rouppe van der Voort[3, 4], V. M. J. Henriques[3, 4], and F. Moreno-Insertis[1,2]

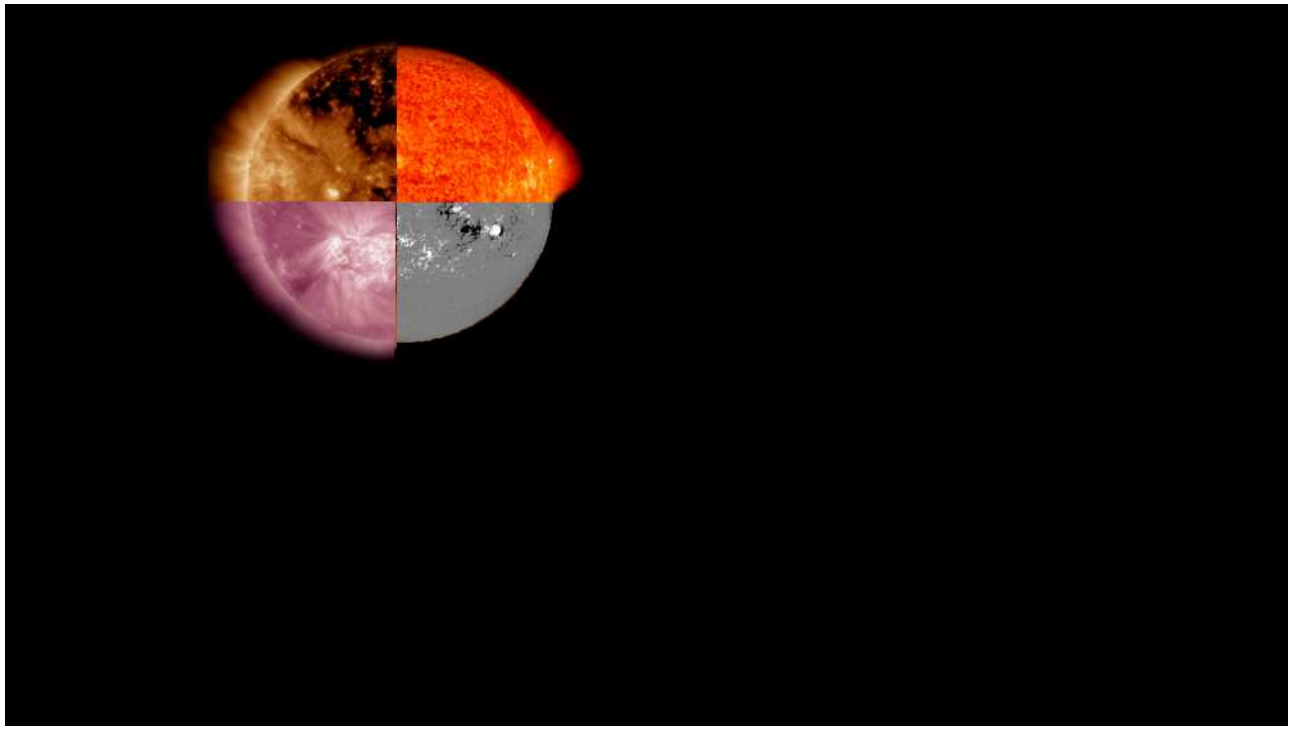
1. Instituto de Astrofísica de Canarias, E-38205 La Laguna, Tenerife, Spain.
2. Universidad de La Laguna, Dept. Astrofísica, E-38206 La Laguna, Tenerife, Spain
3. Rosseland Centre for Solar Physics, University of Oslo, PO Box 1029 Blindern, 0315 Oslo, Norway.
4. Institute of Theoretical Astrophysics, University of Oslo, PO Box 1029 Blindern, 0315 Oslo, Norway.
5. Lockheed Martin Solar and Astrophysics Laboratory, Palo Alto, CA 94304, USA
6. Bay Area Environmental Research Institute, NASA Research Park, Moffett Field, CA 94035, USA

Email: icabello@iac.es

Hinode-15 / IRIS-12, 19-22 September 2022

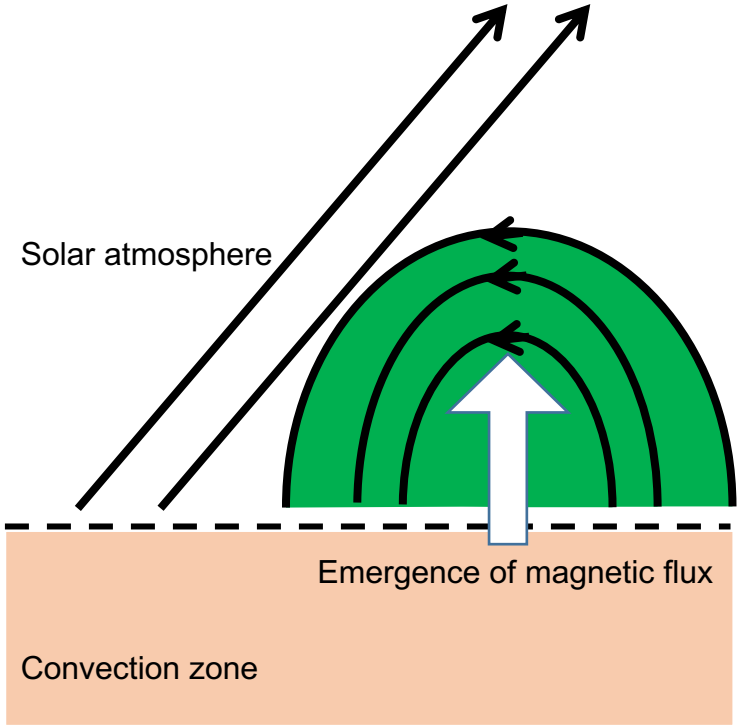
Introduction

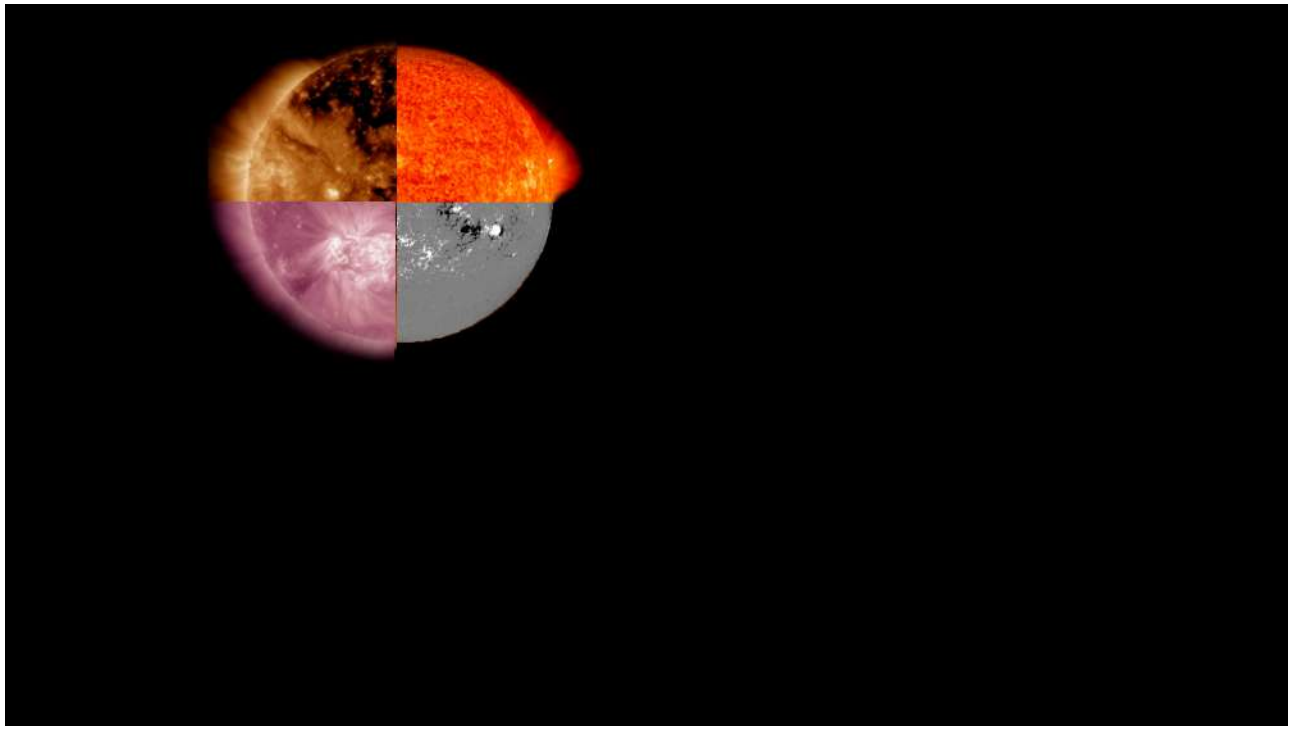
- The Sun shows a **wide variety of eruptive and ejective phenomena,** that are key to **understanding the solar atmosphere.**



Introduction

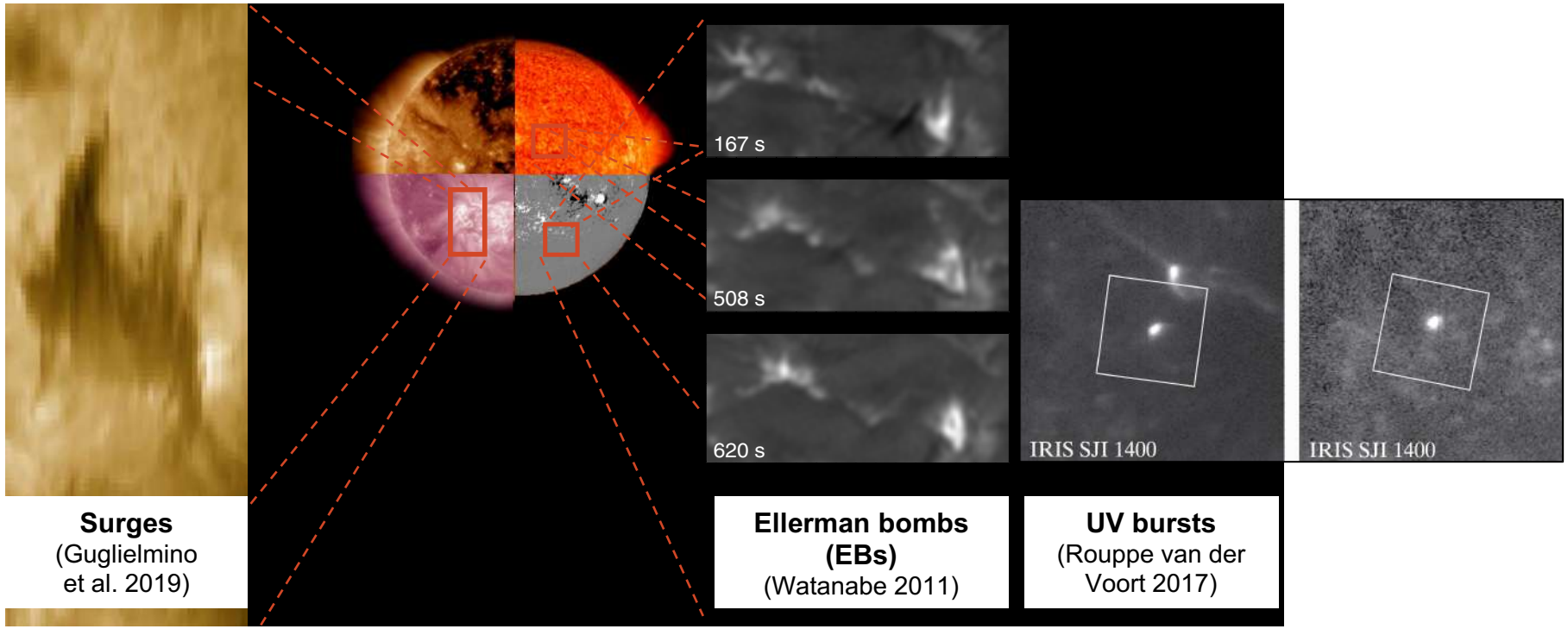
- Of special interest are those resulting from the **interaction** between the **emerging and pre-existing magnetic field**.





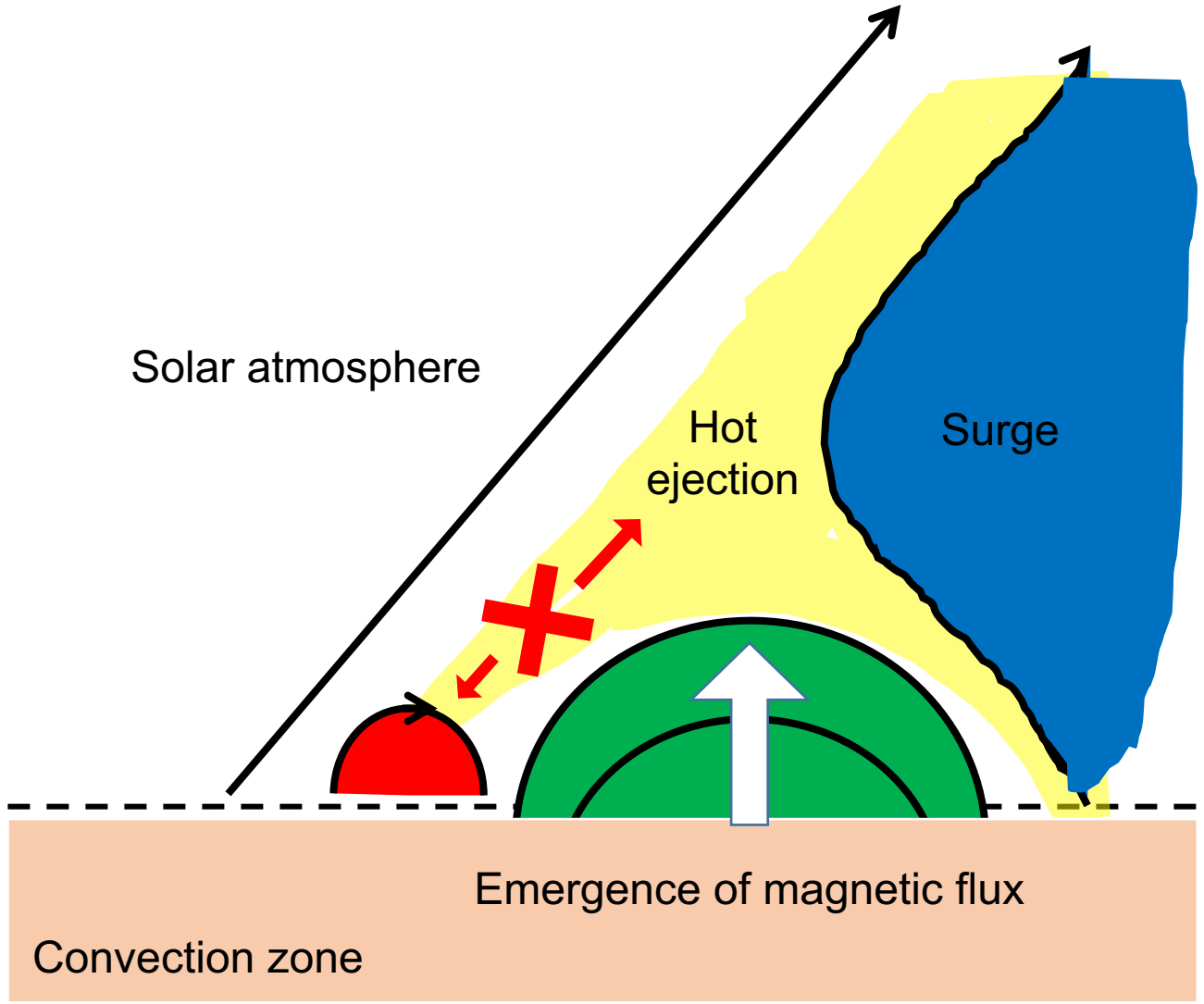
Introduction

- This work focuses on **small-scale** eruptive phenomena related to ephemeral flux emergence regions:
  - EBs
  - UV bursts
  - Surges



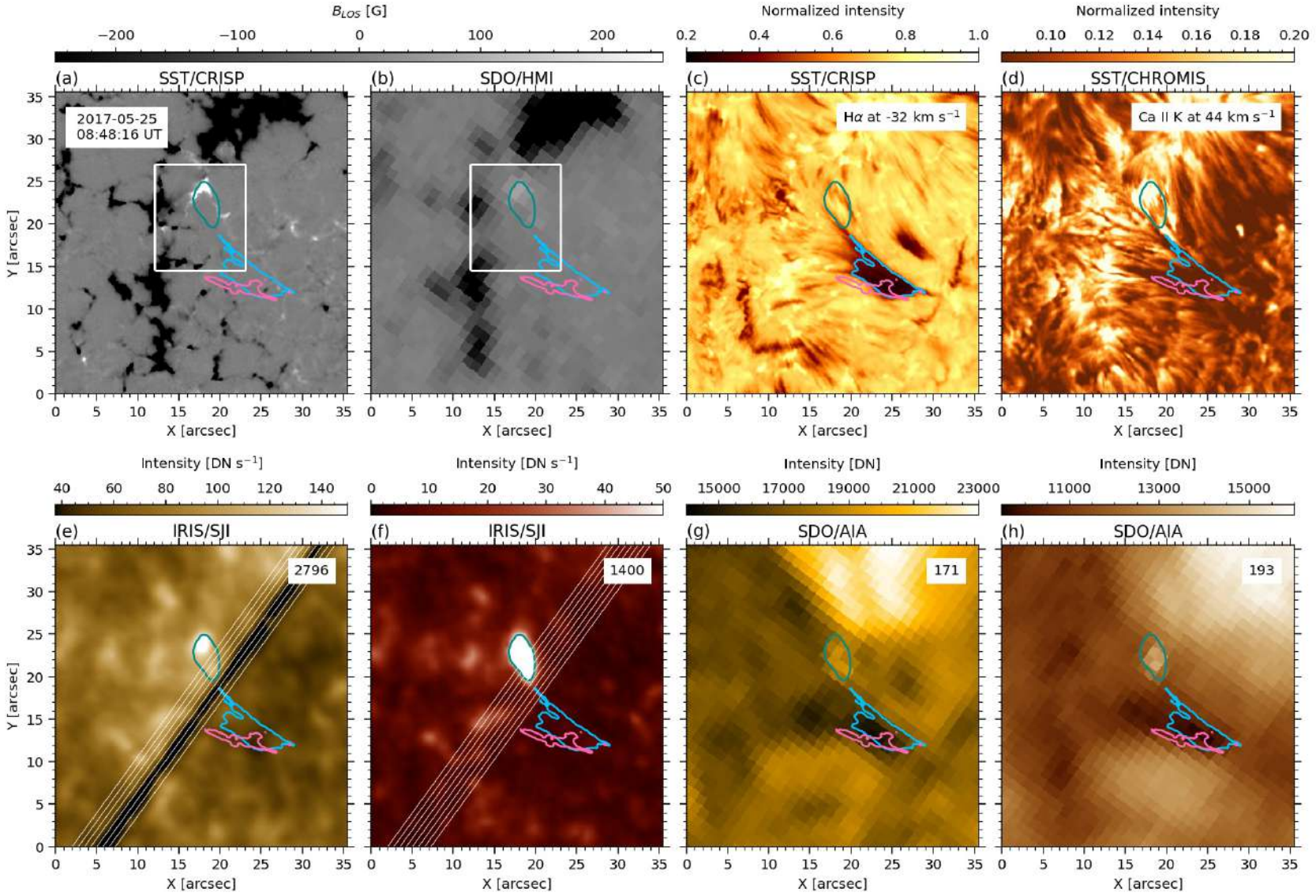
Introduction

- Getting a full perspective of the magnetic flux emergence **process** and the subsequent dynamic related events is complicated since it requires **multi-wavelength observations** that cover the different solar atmospheric layers.



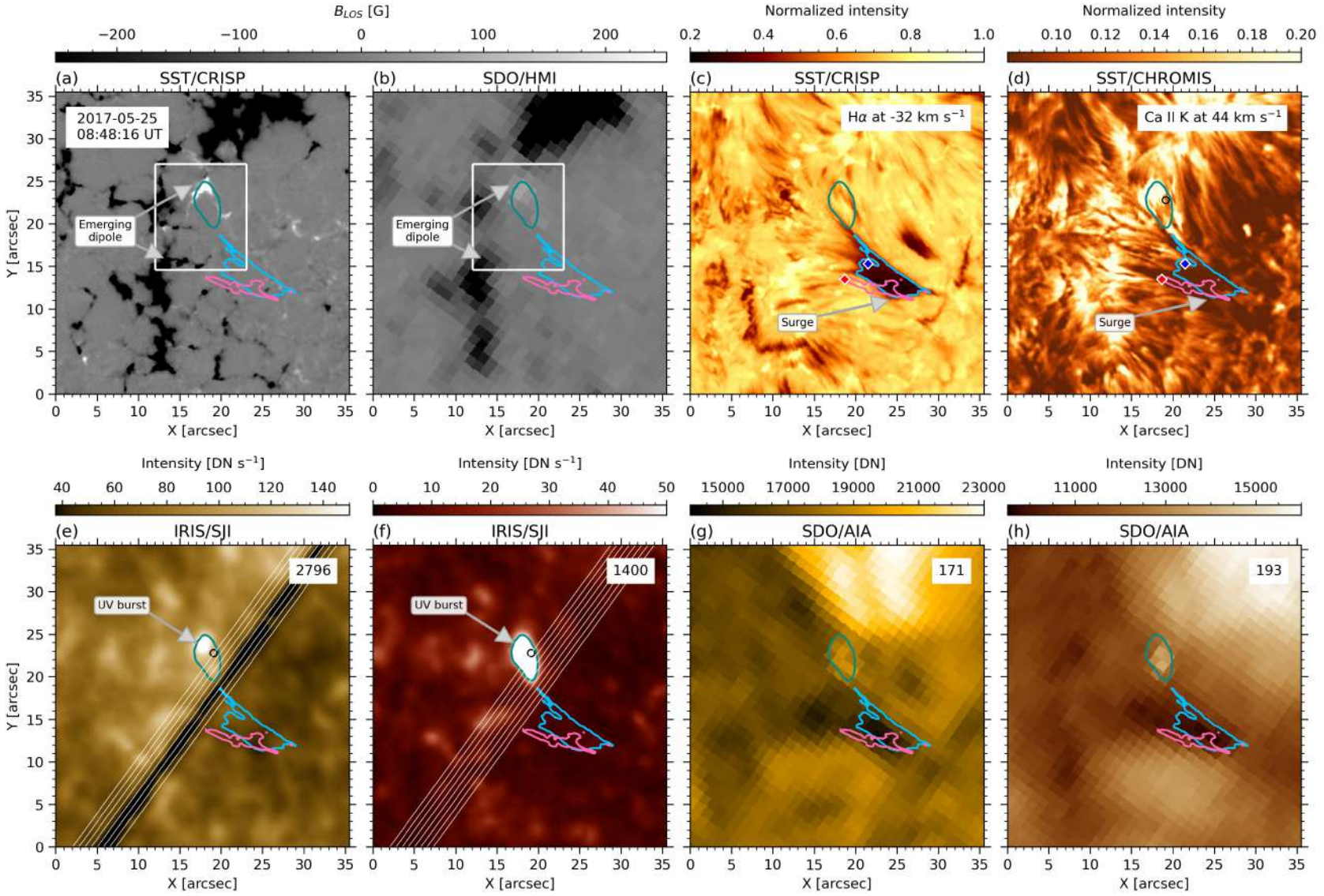
Context

- We have used **coordinated observations** from:
  - **SST (CRISP & CHROMIS):** mag, Hα, Ca II K
  - **SDO (HMI & AIA):** mag, 171 Å, 193 Å
  - **IRIS (SJI):** 2796 Å, 1400 Å



Context

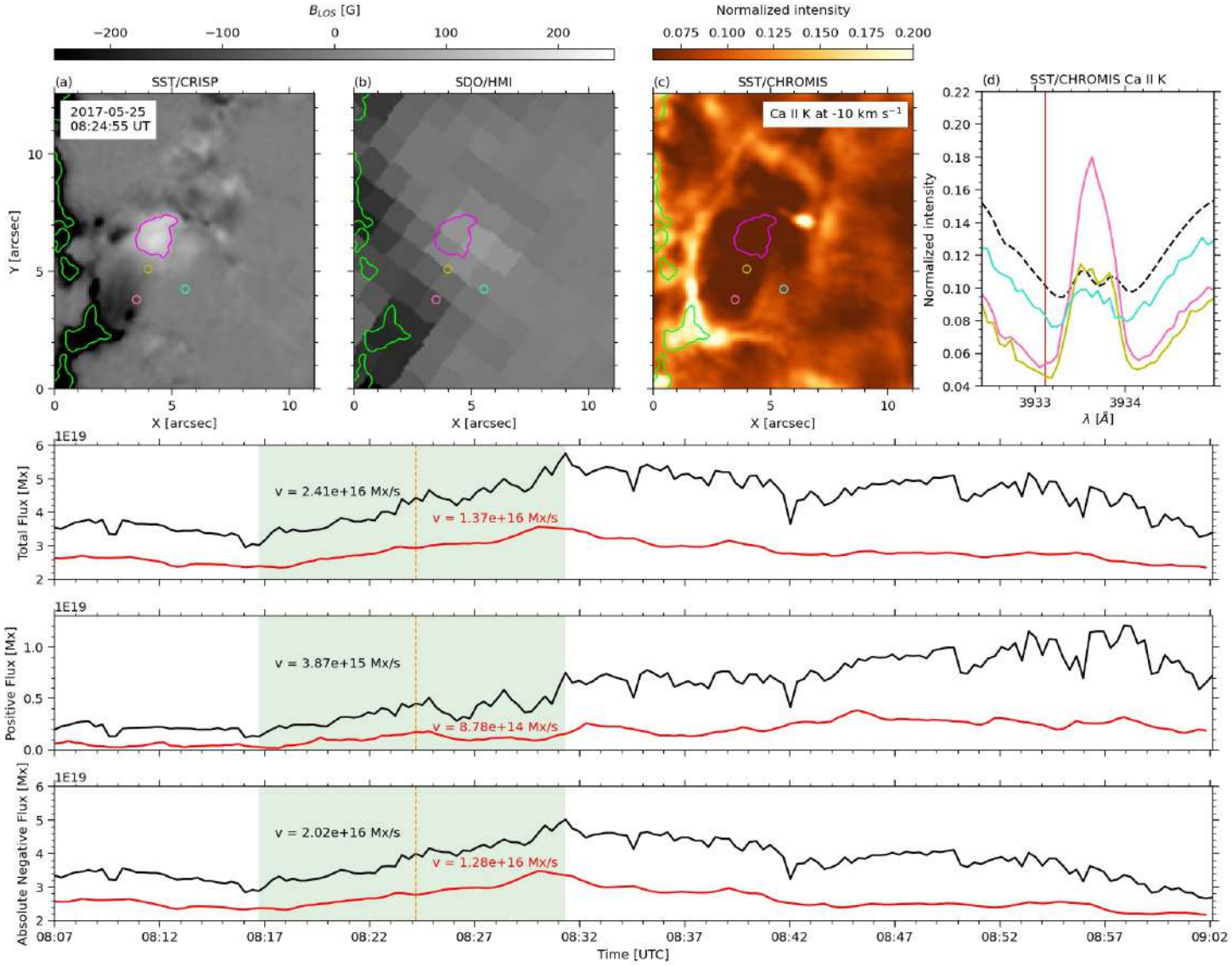
- We present a **small-scale flux emergence episode** leading to **EBs**, **UV bursts**, **surges** and **EUV** signatures.
- We analyze the evolution and relationship among phenomena from the photosphere up to the corona related to the **same event**:
  - Different λ: different layers
  - Magnetic fluxes: connection with the process
  - Ca II K data in different spectral positions: EB, surges
  - Also spectral analysis in Hα, Mg II h&k, Si IV, C II lines



Magnetic flux emergence

Magnetograms:

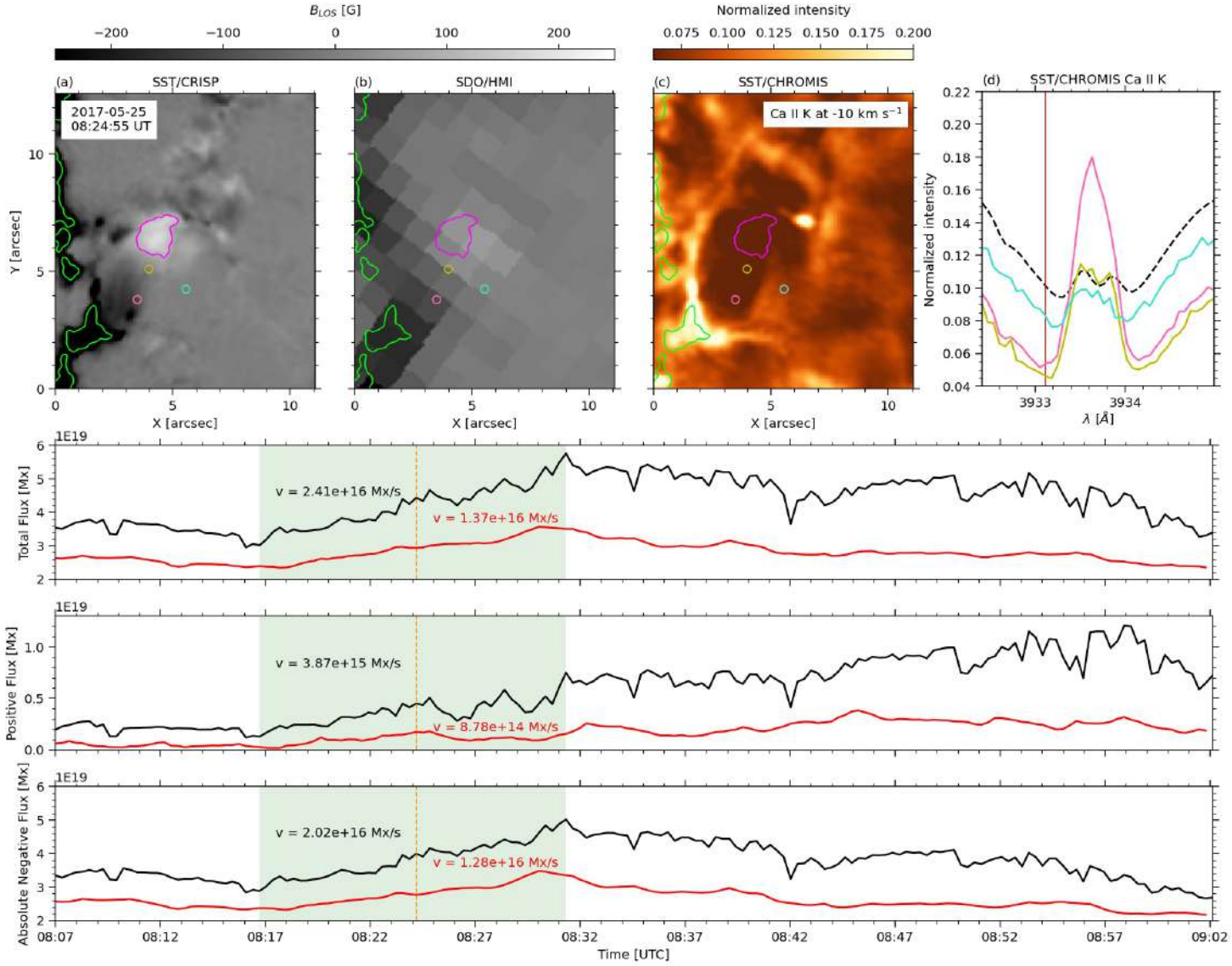
- This small-scale flux emergence is visible in SST/CRISP data and **barely discernible from SDO/HMI** observations.
- **SDO/HMI** data lead to an **underestimation of magnetic fluxes** in comparison with SST/CRISP data.
- Around 14 minutes of increasing flux.



Magnetic flux emergence

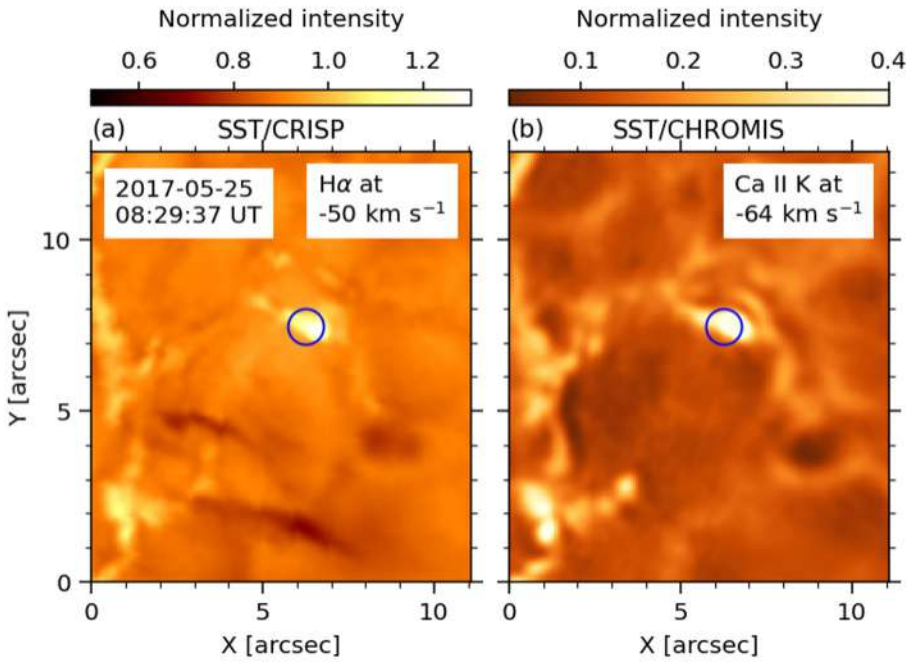
Ca II K data:

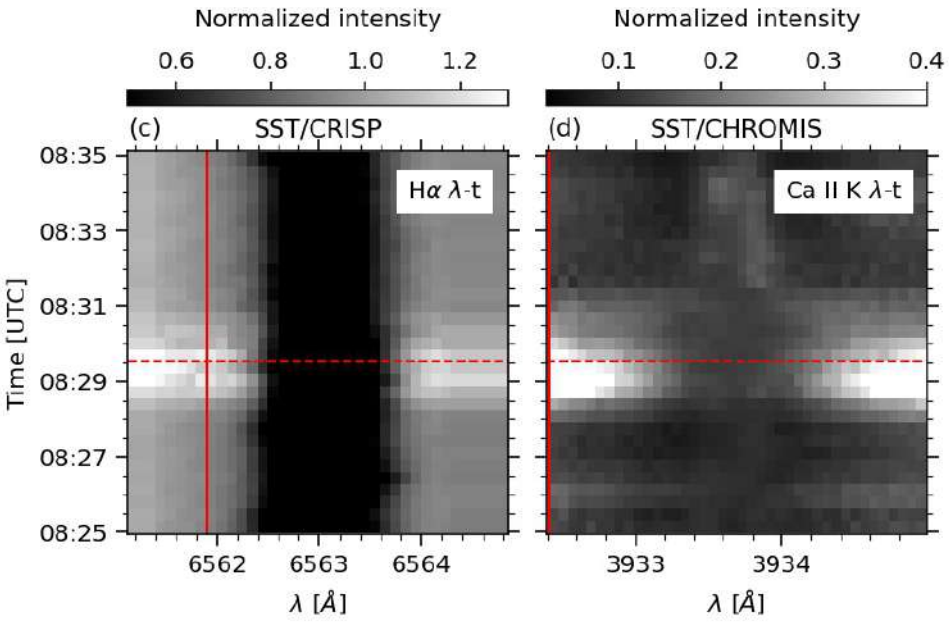
- The flux emergence is observed as a **dark bubble** in the Ca II K map
  - Ca II H: Vargas Domínguez et al. 2012, Kontogiannis et al. 2020
  - Ca 8542 Å: Ortiz et al. 2014
- Intensity decreases in the locations affected by the bubble.

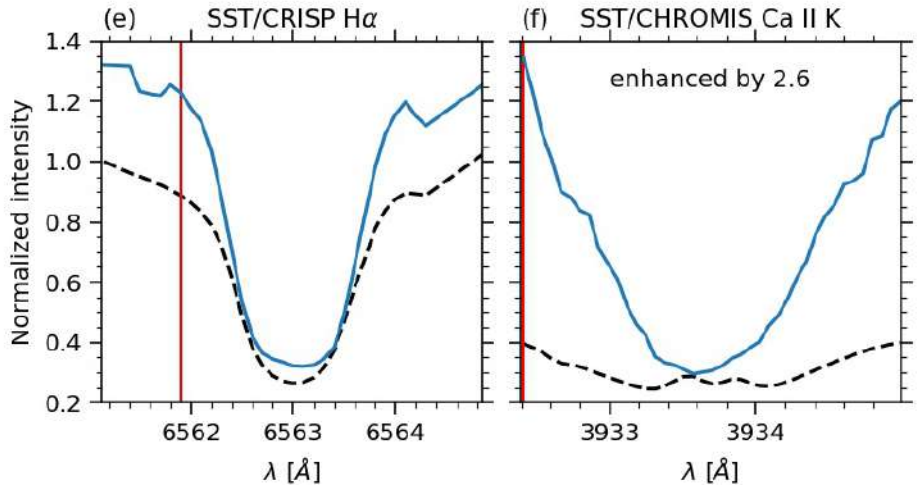


Ellerman bomb

- We clearly detect the characteristic **EB** spectral profile in the wings of **Hα**, which matches with bright **Ca II K** wings and brightenings in **Hα**, **Ca II K** and SDO/AIA **1600** Å and **1700** (UV) images.



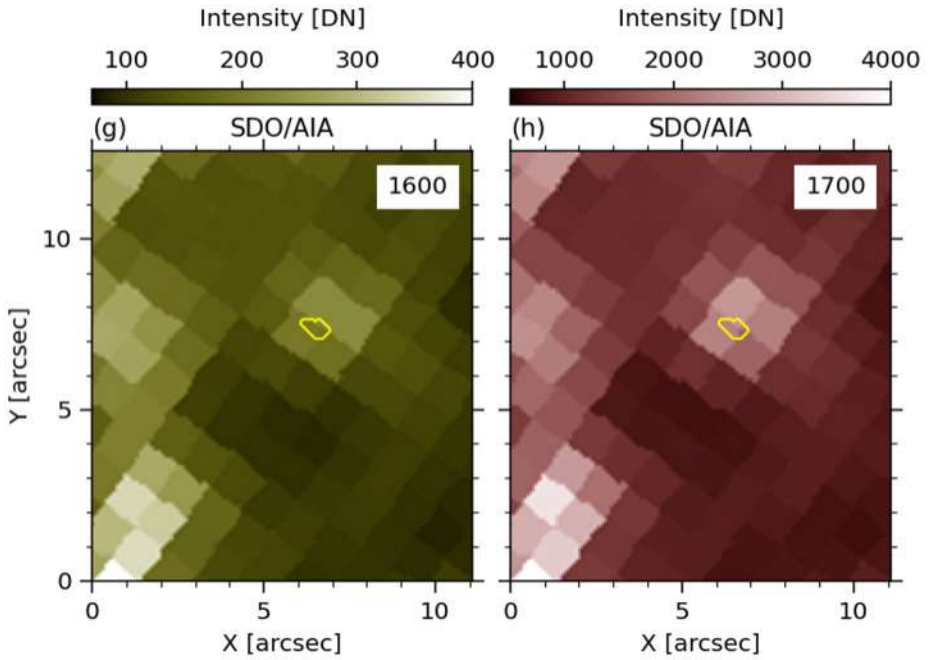




Major axis	1”.2 - 1”.7
Lifetime	~ 59 s

Ellerman bomb

- We clearly detect the characteristic **EB** spectral profile at the wings of **Hα**, which matches with bright **Ca II K** wings and brightenings in **Hα**, **Ca II K** and SDO/AIA **1600** Å and **1700** Å (UV) images.

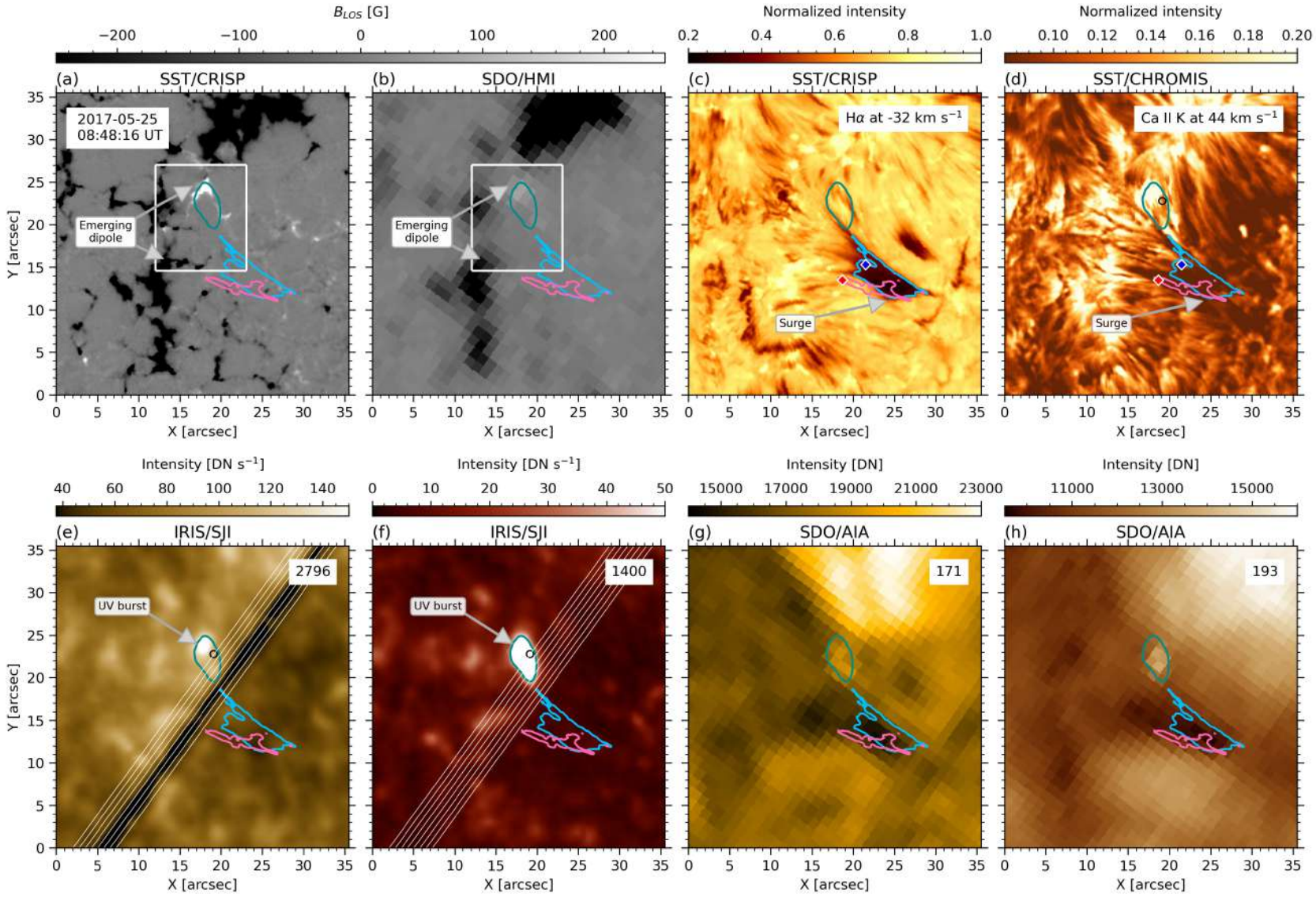


(in accordance with Rutten et al. 2013, Vissers et al. 2019)

UV burst

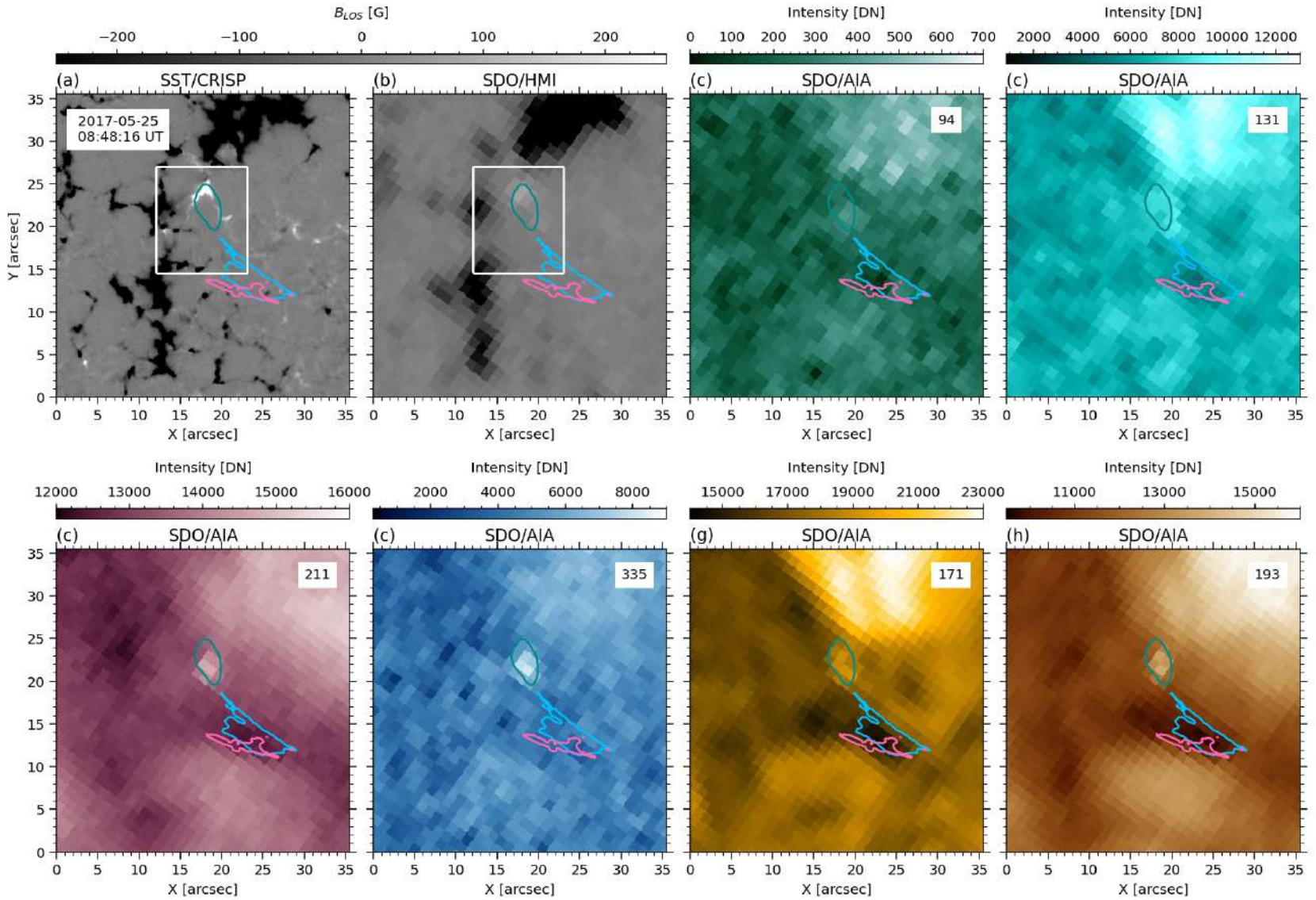
- Observable in IRIS/SJI **2796** Å and **1400** Å with counterparts in **Hα**, **Ca II K** and all the SDO/AIA hot channels.
- At the same location of the EB (Hansteen et al. 2019)

$Bright_{max}$/stddev(FOV)	23.2
Length	5”.5
Lifetime	> 22 m



UV burst

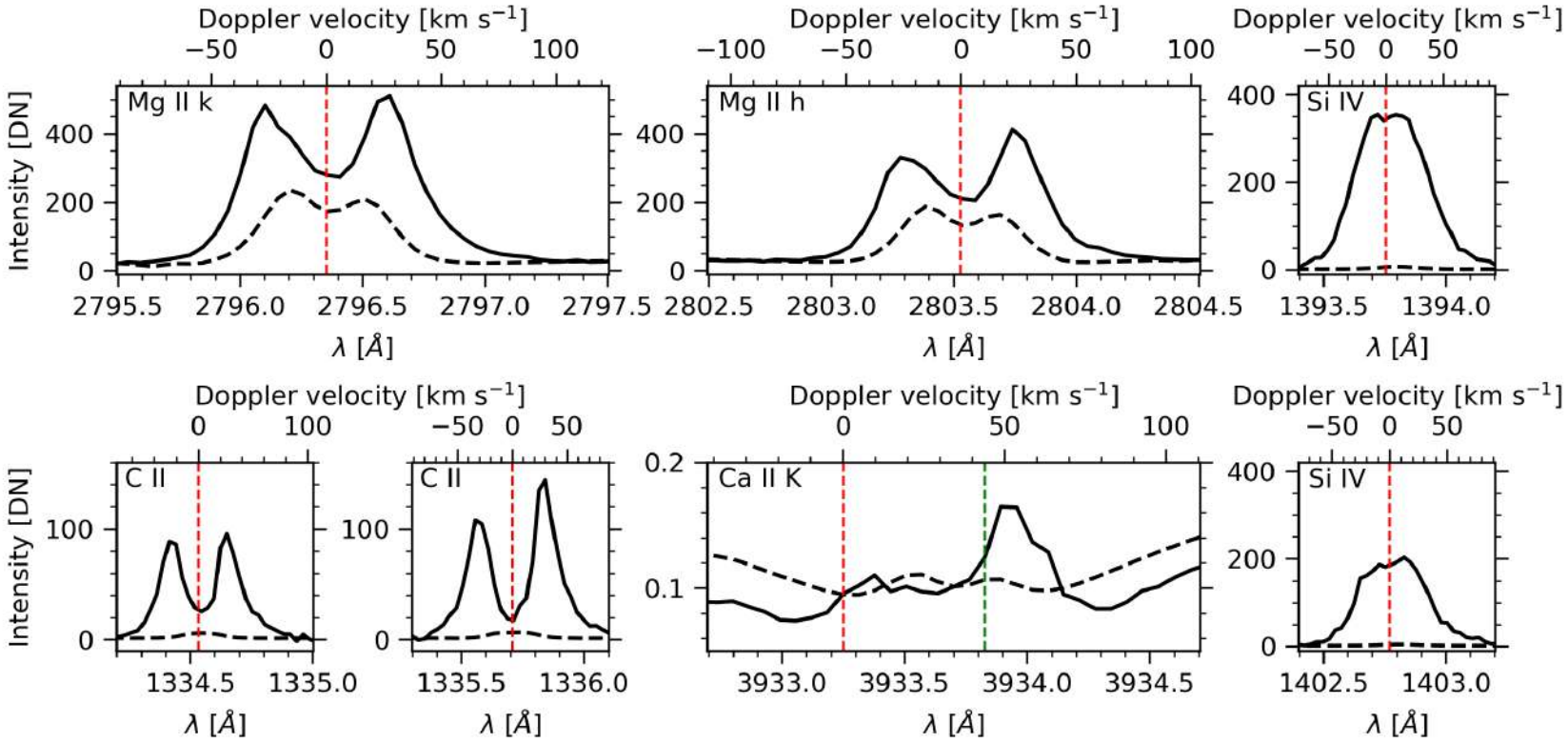
- Observable in IRIS/SJI **2796** Å and **1400** Å with counterparts in **Hα**, **Ca II K** and all the SDO/AIA hot channels.



UV burst

Typical characteristics:

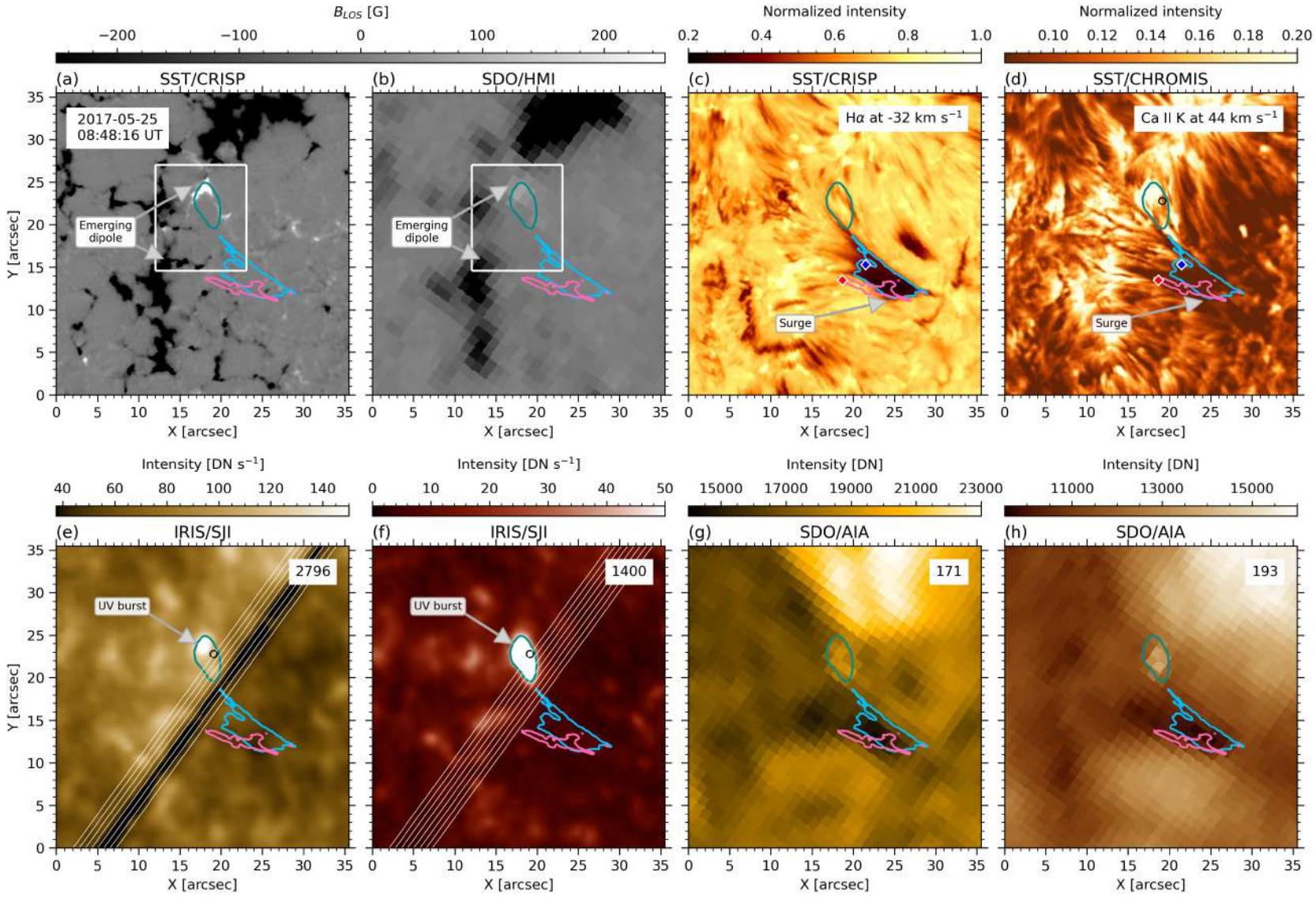
- **Mg II k, Mg II h, Si IV, C II** lines are **highly broadened and enhanced** with factors around 2-2, 51-65, 16-22.
- **Non-Gaussian Si IV profiles** and **Ca II K** line displays **triangular-shapes**, associated to possible **plasmoids** (Rouppe van der Voort et al. 2017).



Surge

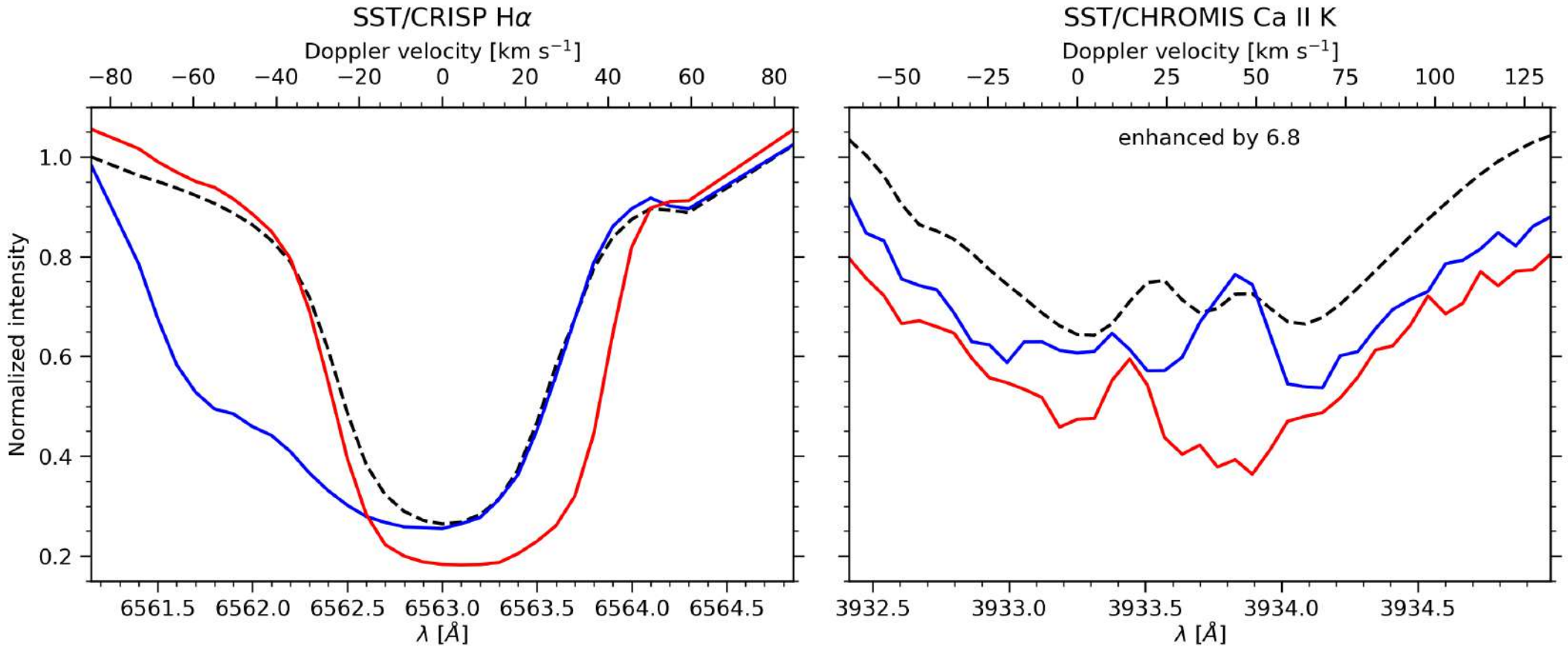
- Observable as a dark structure in **Hα**, **Ca II K** and SDO/AIA **171** Å and **193** Å.
- Cotemporal with the UV burst.

Projected velocity	25.6 km s^{-1}
Length	18”.5
Lifetime	> 24 m



Surge

The evolution of a typical surge consists of a rising and a decay phases. We show rising and falling material for the same moment in both Hα and Ca II K lines.



Summary and conclusions

- Thanks to **multi-wavelength** and **coordinated observations**, we present a textbook example of **magnetic flux emergence,** analysed from **images and spectral data**, that leads to a **variety of phenomena in all solar layers** related to the **same event**, which are:
  - an **EB** in SST Hα and Ca II K and counterparts in SDO/AIA 1600 Å and 1700 Å
  - a **UV burst** in IRIS/SJI 2796 Å and 1400 Å with bright counterparts in SST Hα and Ca II K and all the SDO/AIA hot channels
  - a **surge** in SST Hα and Ca II K with dark counterparts in SDO/AIA 171 Å and 193 Å
- **HMI** may **miss** many **small-scale** magnetic flux emergence episodes in comparison with high-resolution magnetograms from SST (see also Gošic et al. 2021).
- **Ca II K** exhibits **dark bubbles**.

Thanks for your attention