Leibniz-Institut für
Astrophysik Potsdam

Automatic Extraction of Polar Crown Filaments Using Machine Learning Techniques

AG 2020

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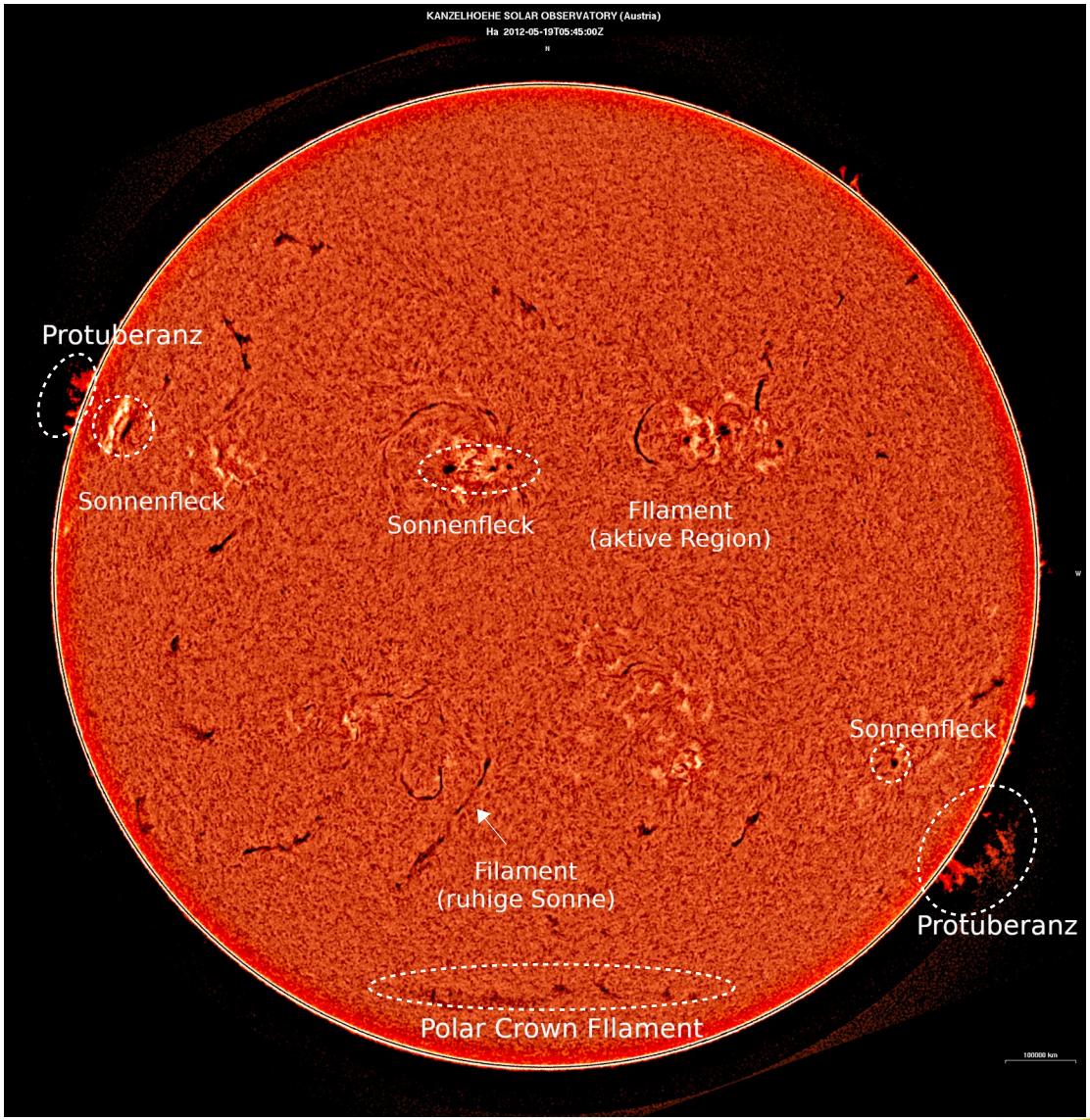
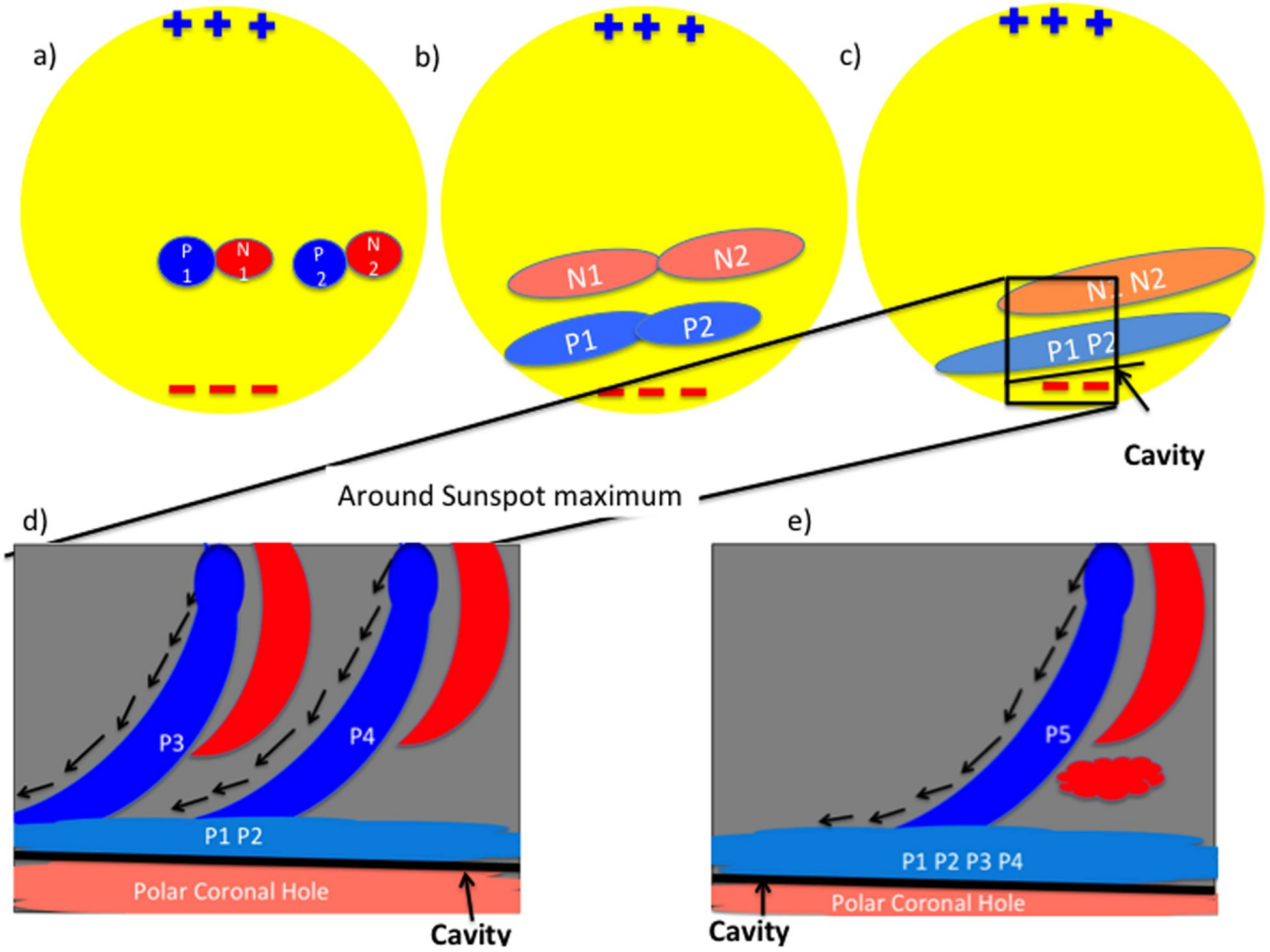
The Sun in Hα – the Chromosphere



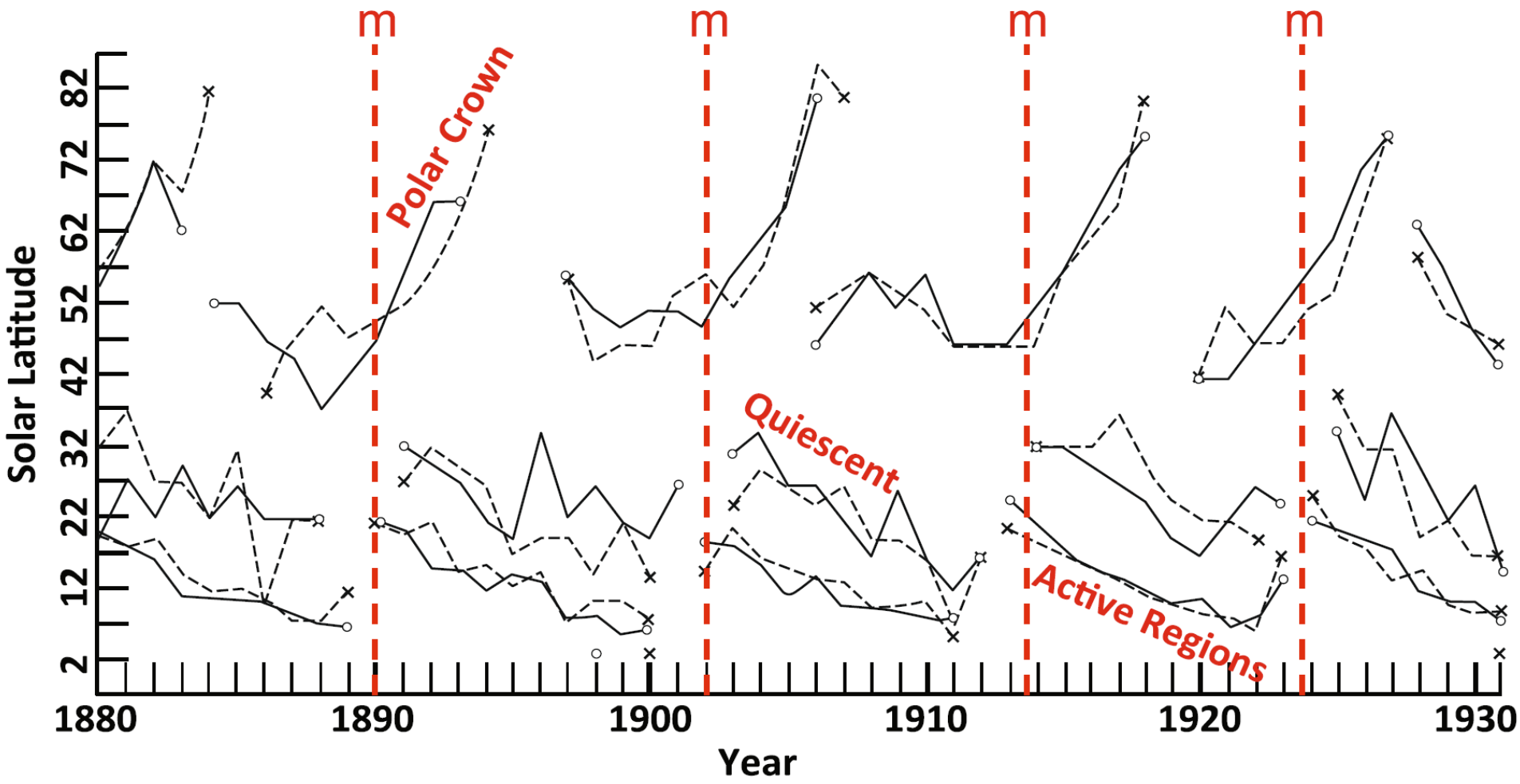
http://cesar.kso.ac.at/

Cyclic behavior of polar crown filaments: “Rush to the Pole”



Karna et al. (2017), ApJ 835, 135

Cyclic behavior of polar crown filaments: “Rush to the Pole”



Cliver (2014), Space Sci. Rev. 186, 169

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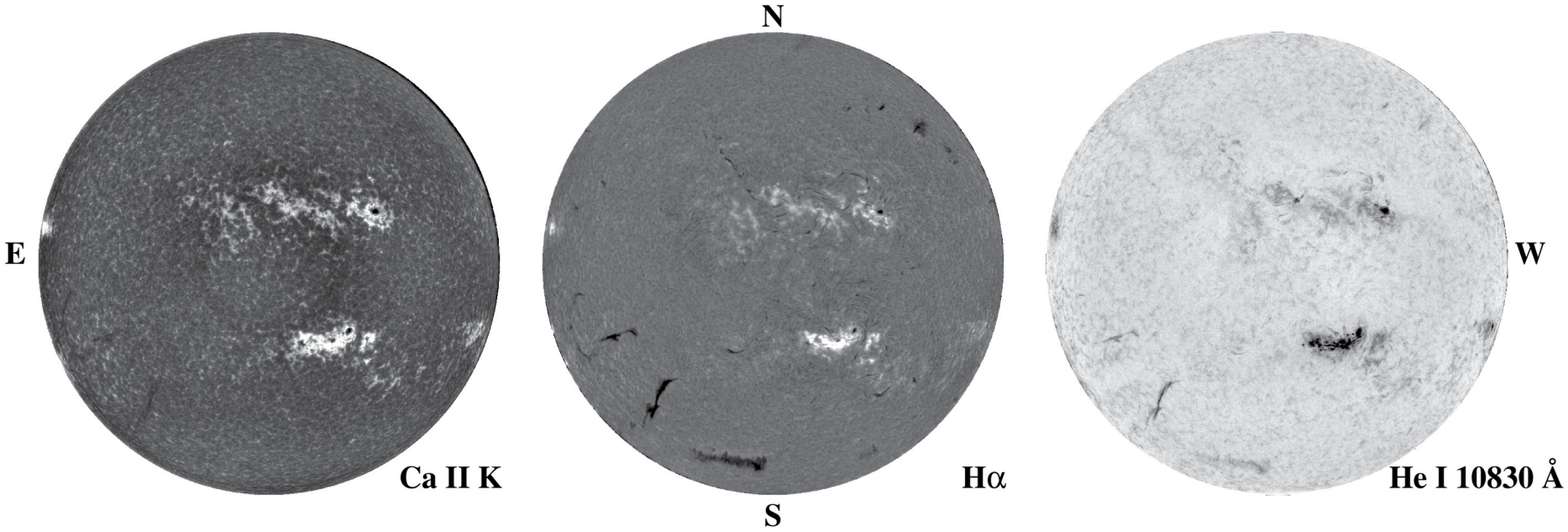
Filament analysis from full-disk Hα data

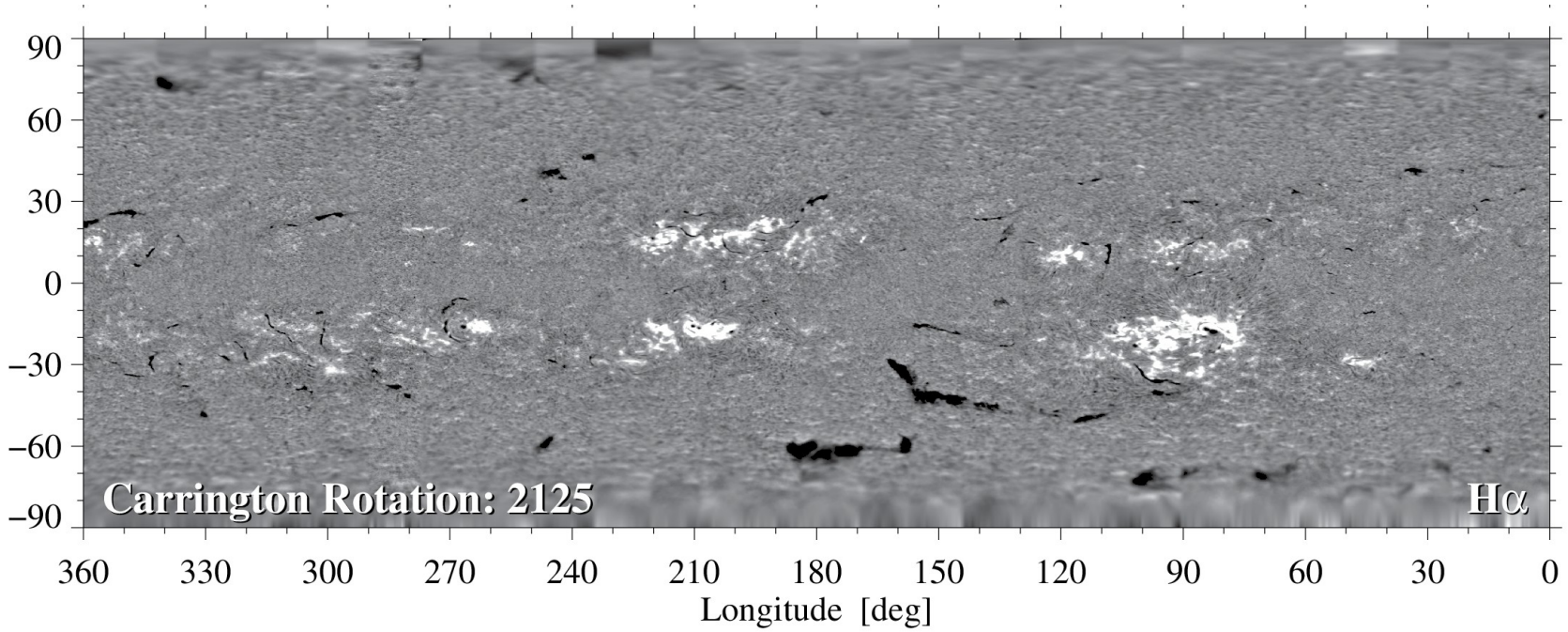
Solar Telescopes on Tenerife, Spain

Chromospheric Telescope: The Chromosphere in three different Wavelengths

- 10-cm aperture
- Lyot Filter
- Observations every 3 min in three chromospheric wavelengths

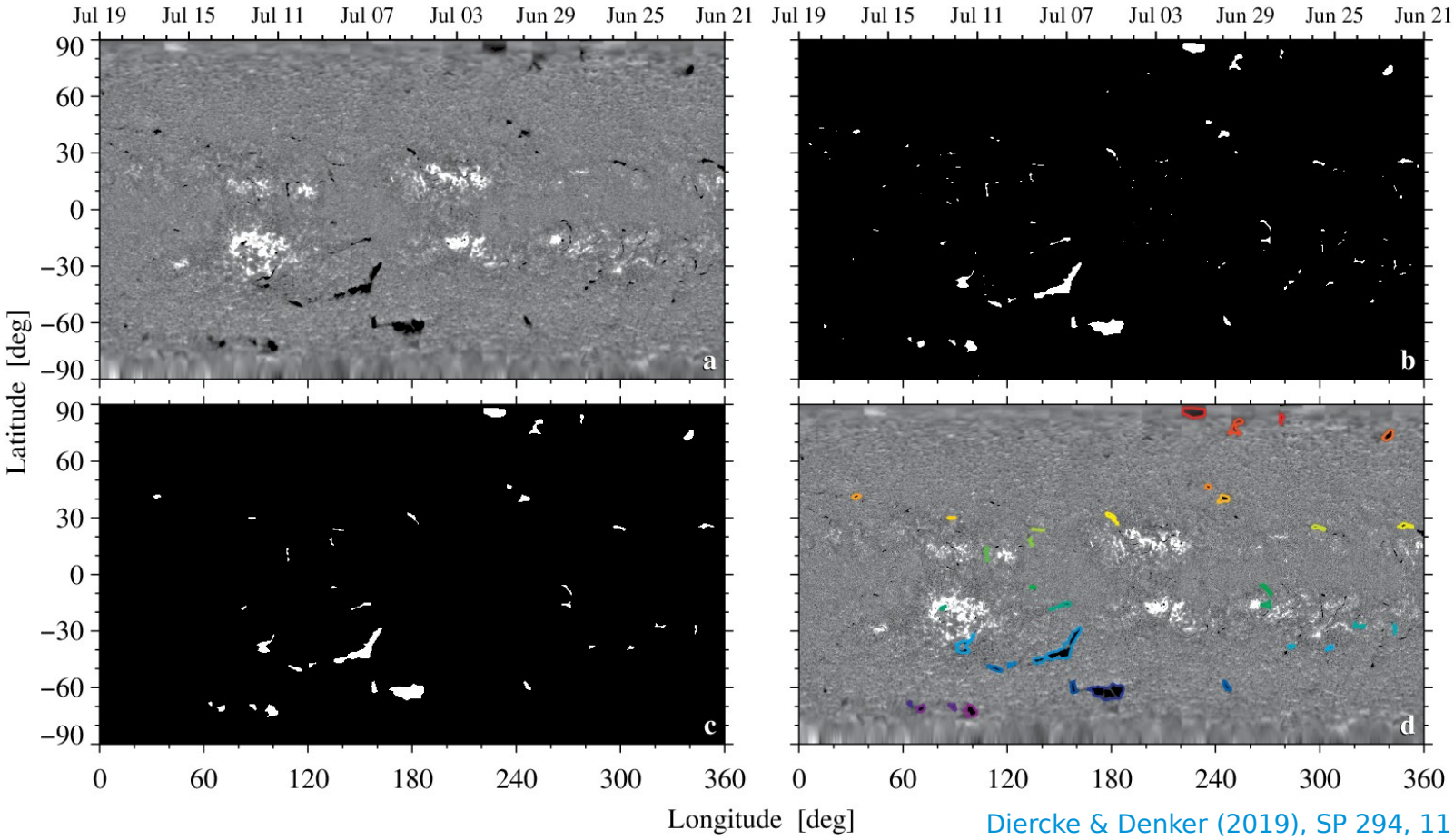


Synoptic Maps of Filaments



- ChroTel observations between 2012 – 2018: 962 observing days
- Covering 90 Carrington rotation periods
  - Create synoptic maps
  - Extract filament data with morphological image processing

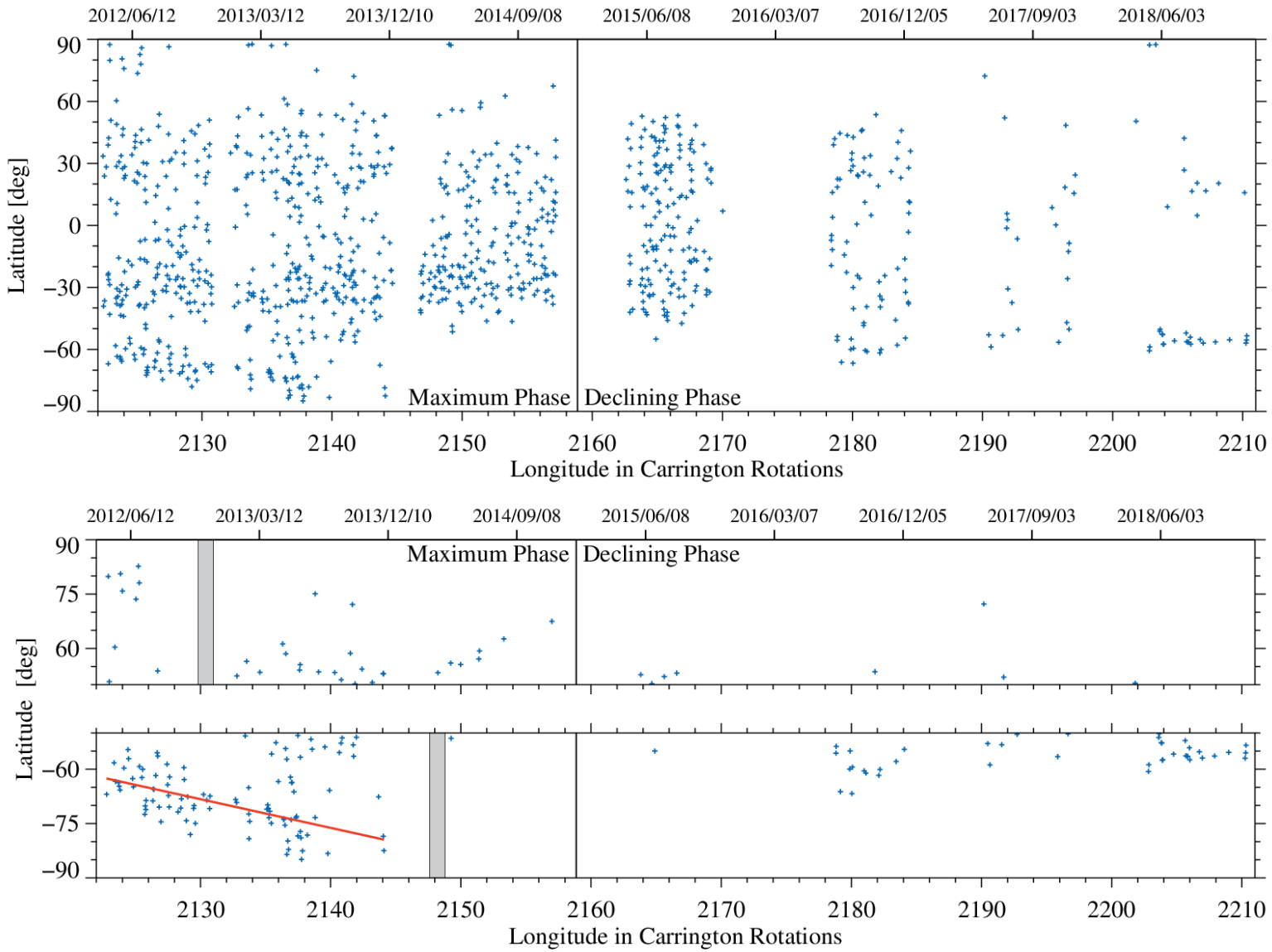
Filament Extraction with Morphological Image Processing



Diercke & Denker (2019), SP 294, 11

- Extraction of filaments data
  - Perona-Malik filter
  - Morphological Closing
  - Blob analysis
- Problems with the extraction
  - No simple exclusion of sunspots
  - Exclusion of small scale filaments

Filament Extraction with Morphological Image Processing



Diercke & Denker (2019), SP 294, 11

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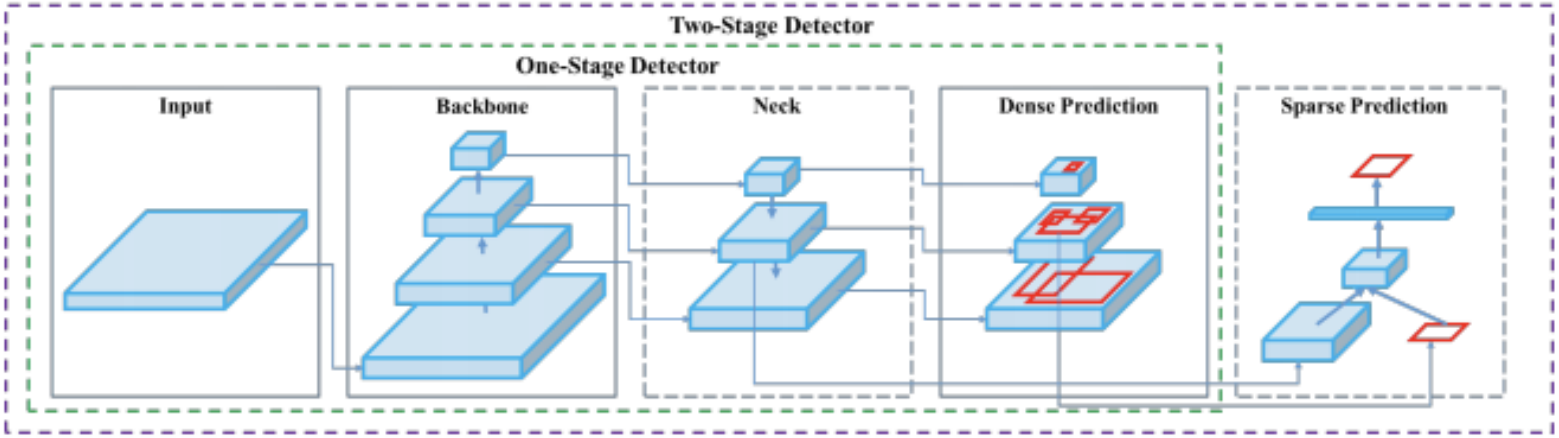
Improvement of filament detection with deep neural networks

Filament detection with YOLOv5

Tests with YOLO (You look only once)

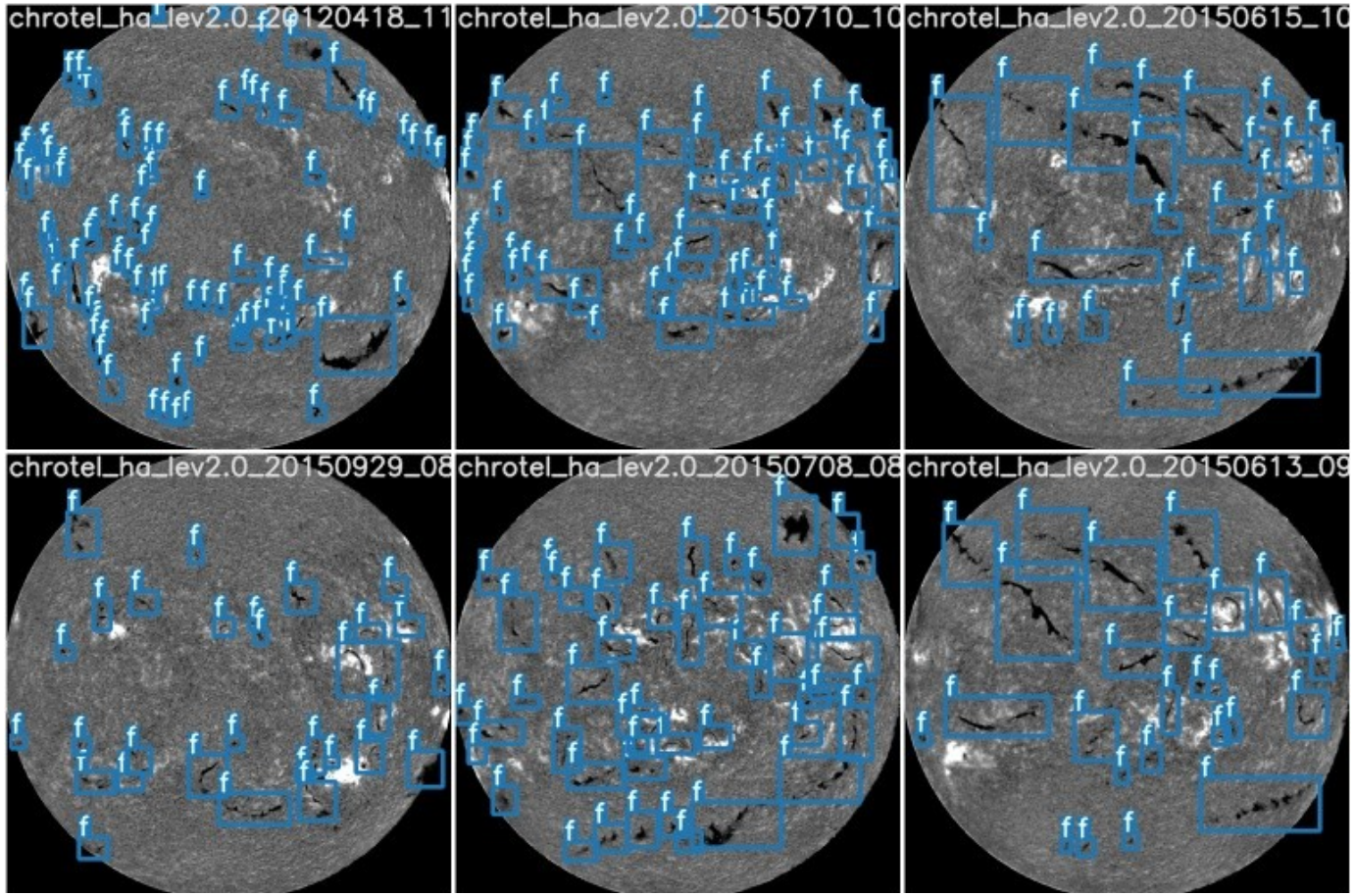
- Yolov5: https://github.com/ultralytics/yolov5
- Backbone: convolutional neural network to extract important features - Cross Stage Partial Network (CSPNet)
- Neck: series of layers to mix and combine image features
- Head: box and class prediction



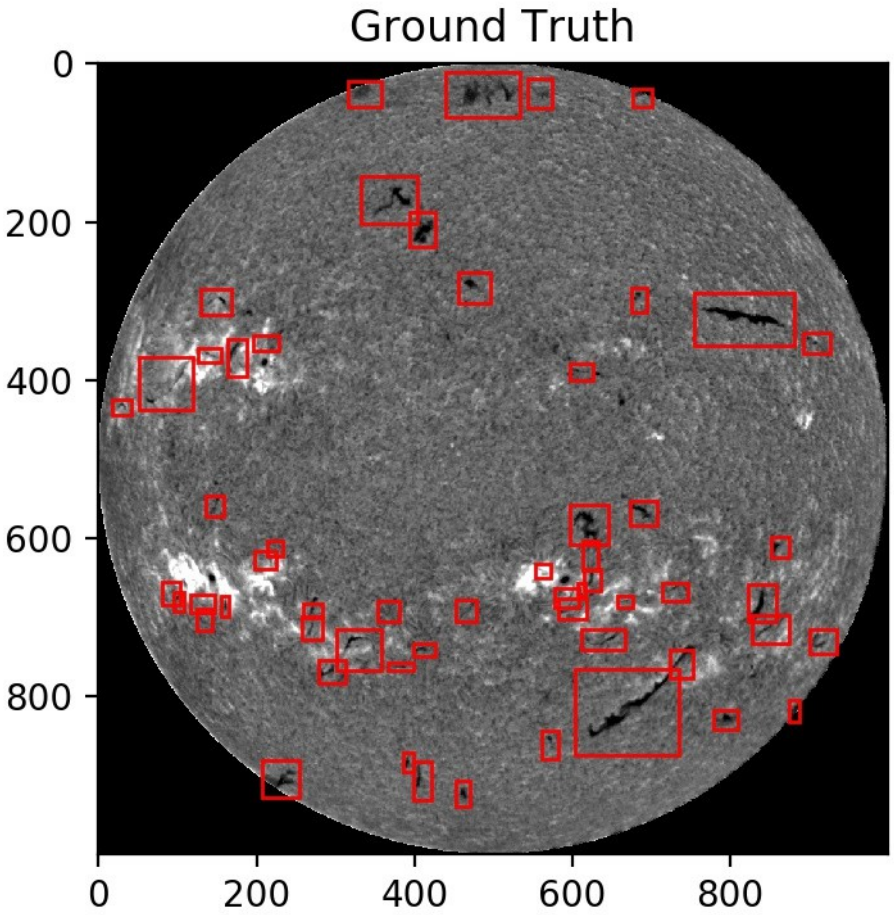
Bochkovskiy et al. 2020

Filament detection with Yolov5

- ChroTel observations between 2012 – 2018: 962 observing days
- Labeling of the data set manually

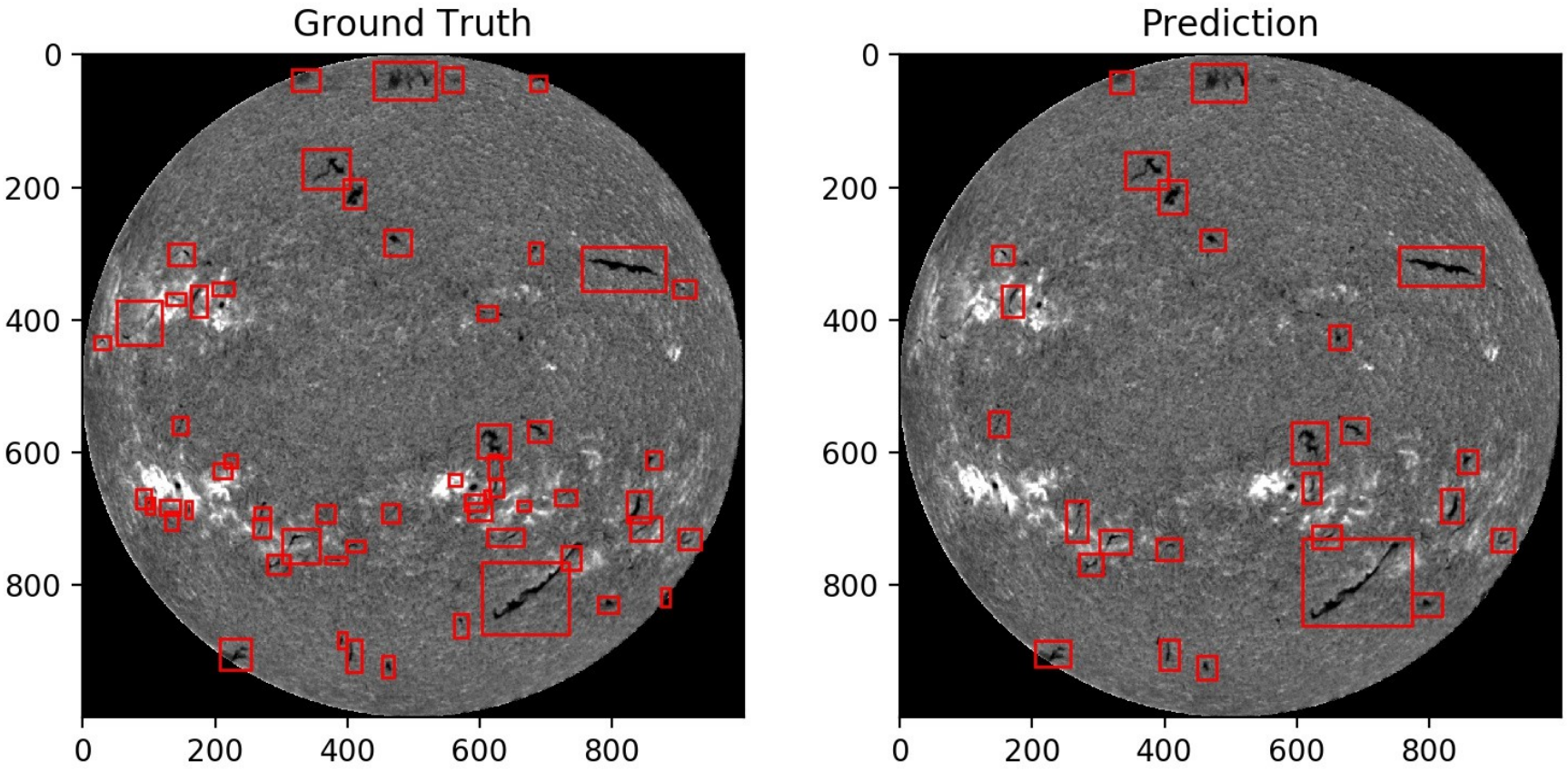


Filament detection with YOLOv5 – Baseline: Training without weights



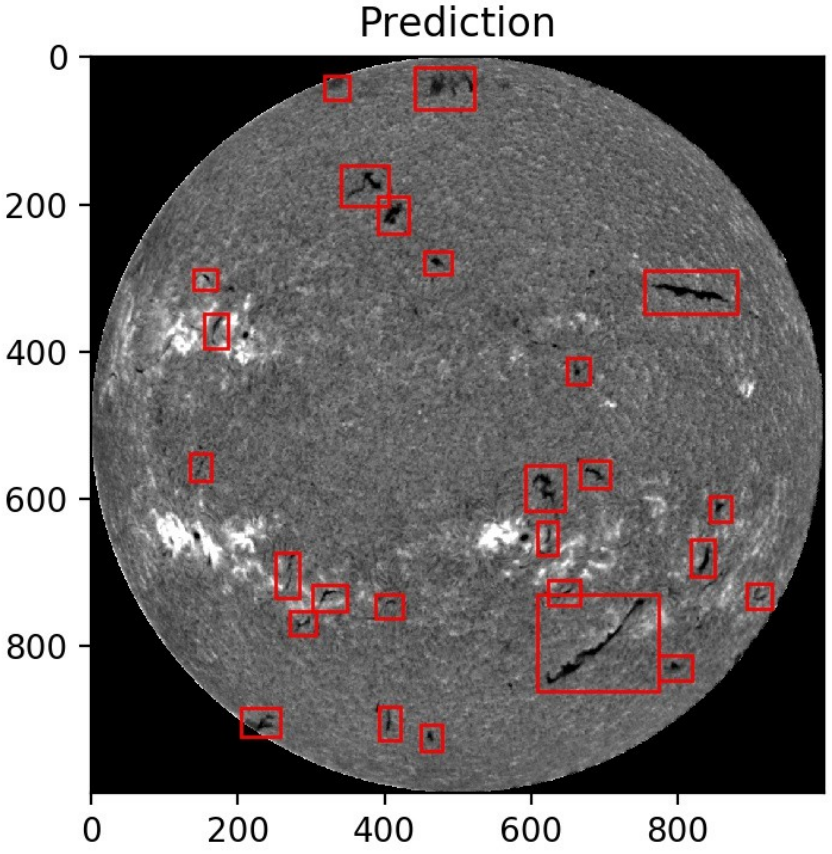
- Training set [70% / 680 images]
- Validation set [10/85]
- Test set [20/190]
- Epochs: 60
- Batches: 8
- Image Size: 512 pixel
- 284 layers
- 25 min for training on GeForce RTX 2080 Ti (11 GB Memory)

Filament detection with YOLOv5 – Baseline: Training without weights

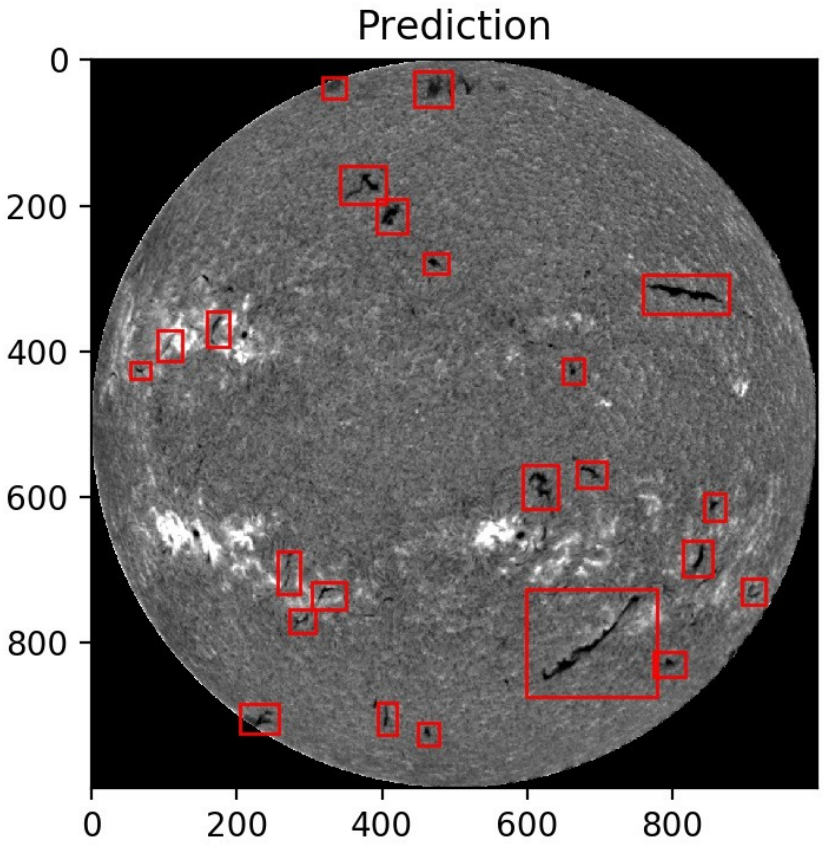


- Image Size: 512 pixel
- 8 ms for detection on test set

Filament detection with YOLOv5 – Baseline: Comparison with weights



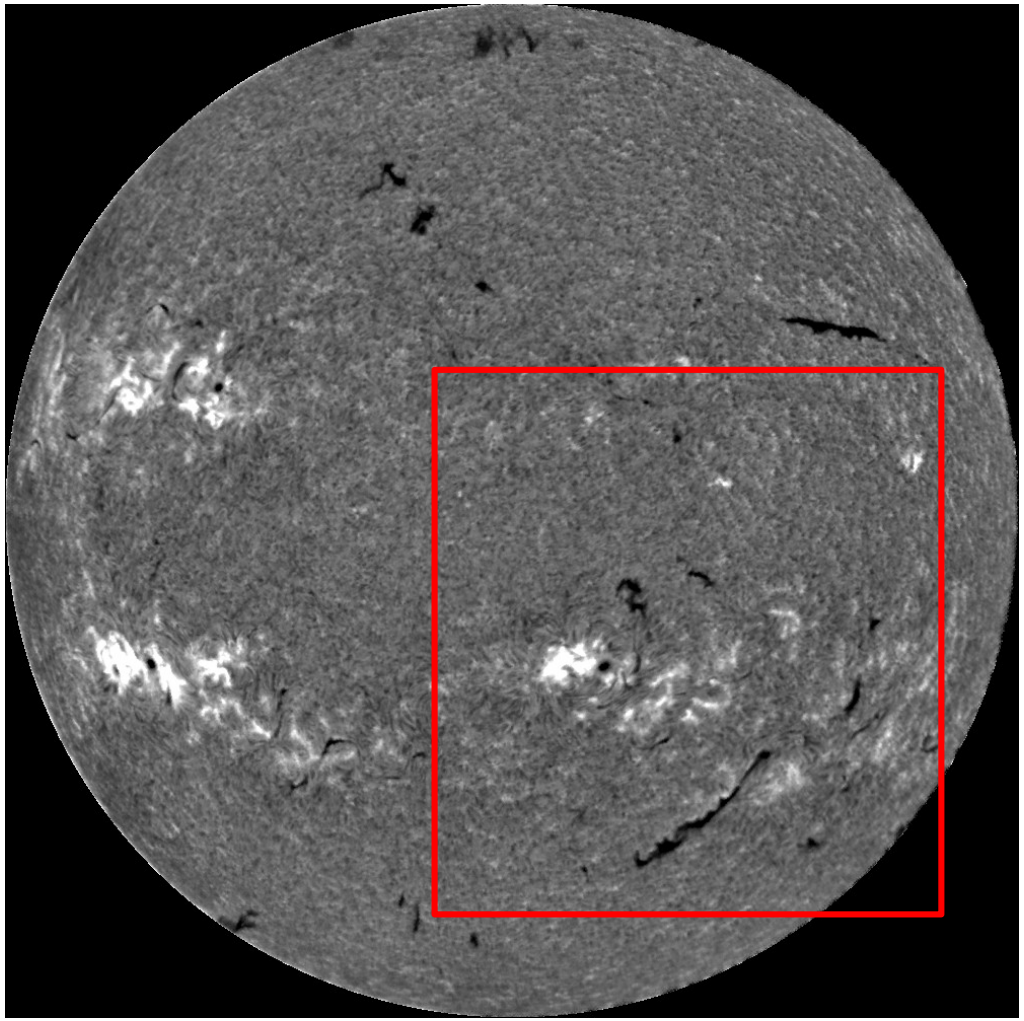
without weights



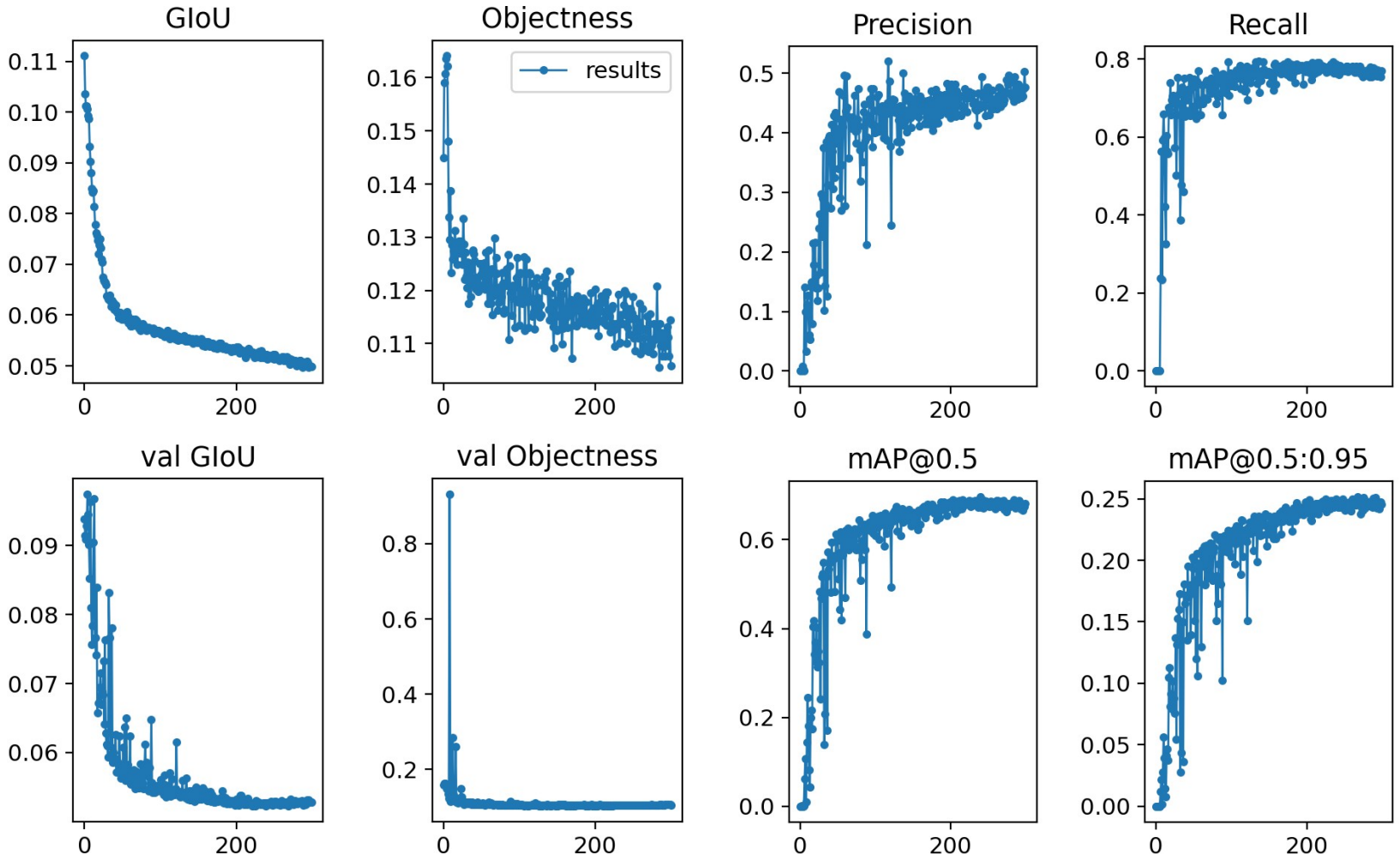
with weights

Filament detection with YOLOv5 – Dividing images into patches

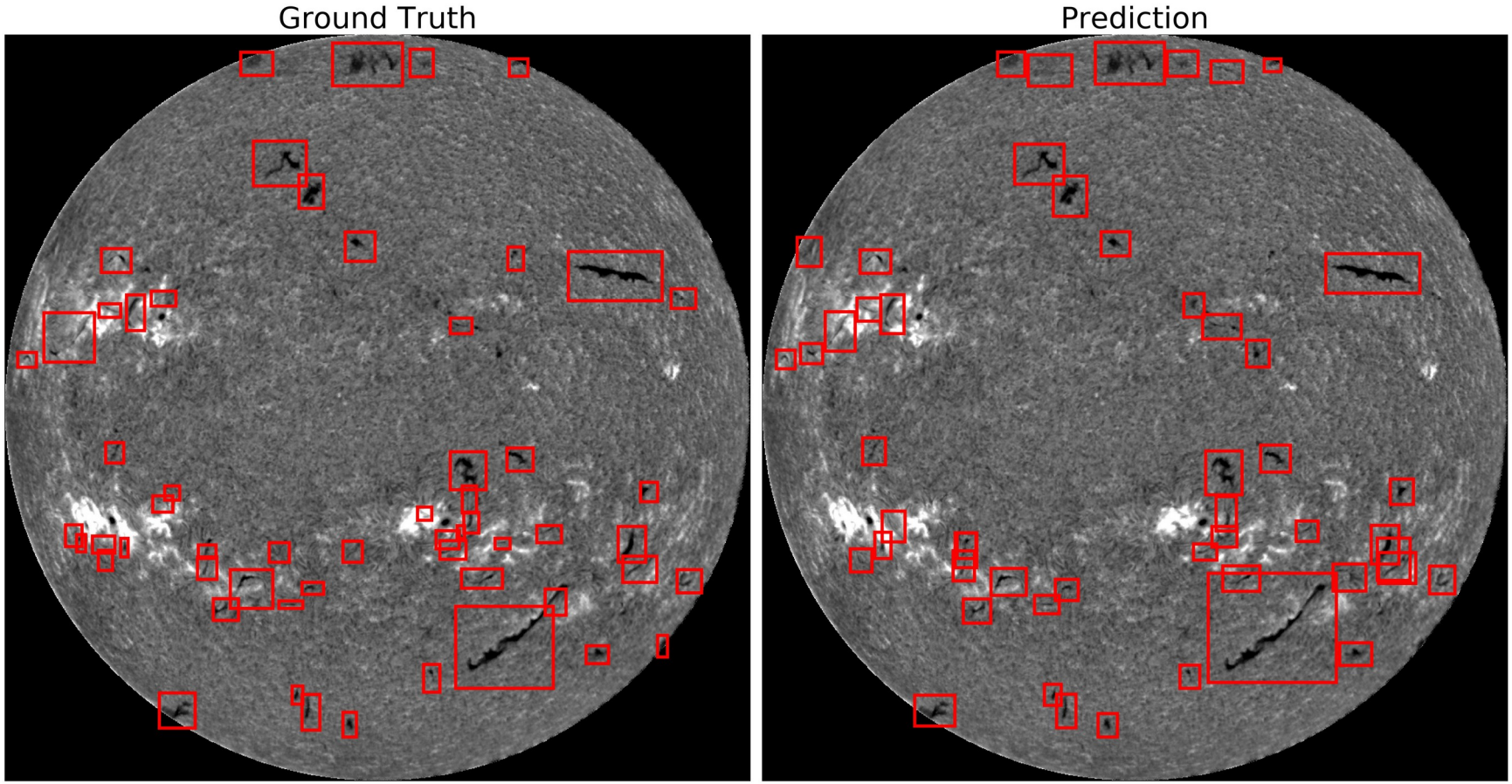
- Image Size: 1024 pixel
- Patch size: 512 pixels
- Random selected start point for patch
- Epochs: 300
- Batches: 16
- 2h training



Filament detection with YOLOv5 – Dividing images into patches: Evaluation



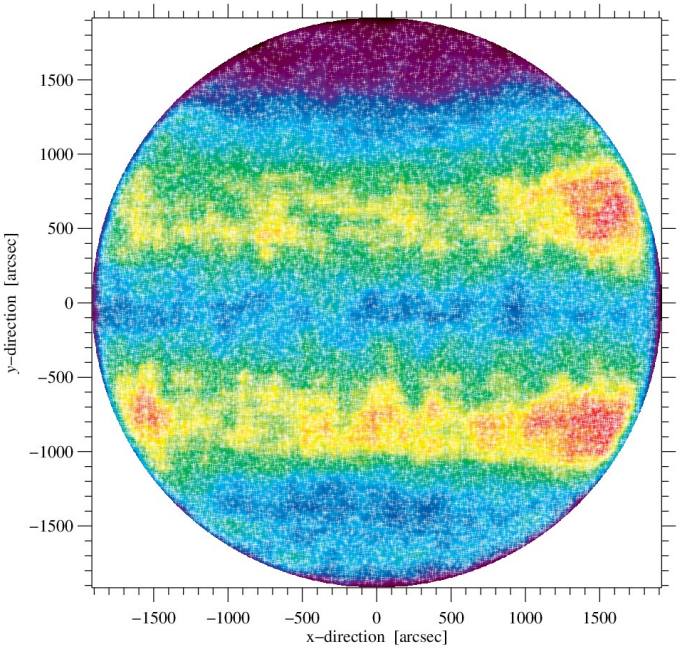
Filament detection with YOLOv5 – Dividing images into patches: Test set



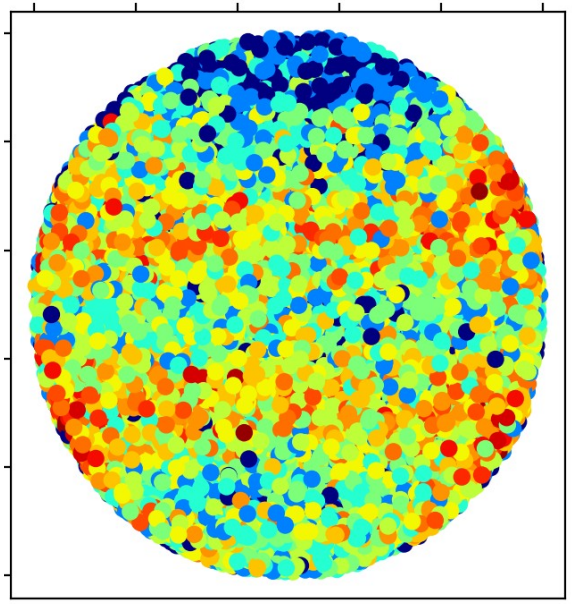
- Image size: 1024 pixel
- Confidence: 0.3
- Test set: 32 ms

Filament detection with YOLOv5 – Dividing images into patches: Bounding boxes

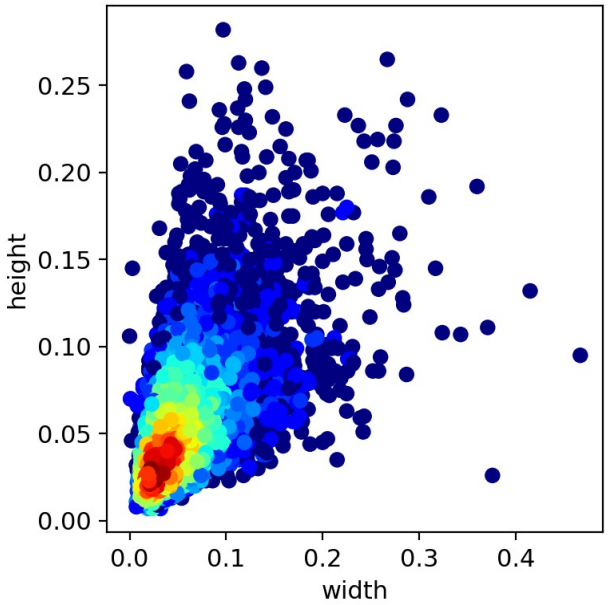
Input bounding boxes



Output bounding boxes



Size of bounding boxes



Conclusion and future work

- ChroTel observations between 2012 – 2018: 962 observing days
- Already very good detection of filaments
- Exclusion of sunspots possible
- Yolov5 on Kanzelhöhe Solar Observatory (KSO) full-disk Hα data
- Use ChroTel and KSO for training
- Segmentation
- Repeat statistical filament study

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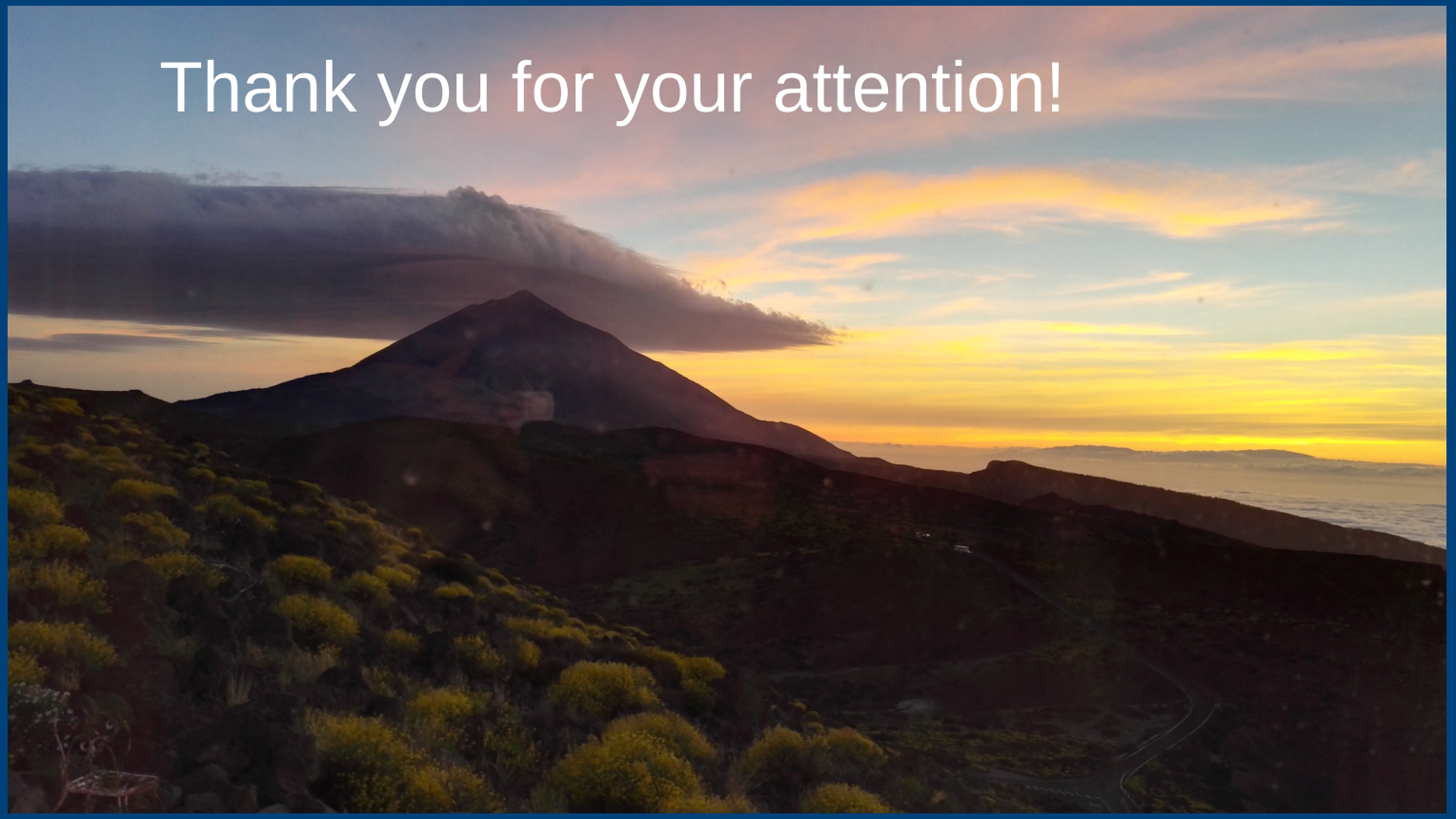

www.aip.de