KSP Status Report

Solar Physics and Space Weather with LOFAR

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Management Structure

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	Dr. Bartosz Dabrowski	Univ. Olsztyn	Poland
	Dr. Richard Fallows	ASTRON	Netherlands
	Dr. Peter Gallagher	Trinity College Dublin	Ireland
	Dr. Alain Kerdraon	Obs. de Paris-Meudon	France
	Dr. Alexander Konovalenko	Institute of Radio Astronomy	Ukraine
	Dr. Jasmina Magdalenic	Royal Obs. of Belgium	Belgium
	Dr. Alec McKinnon	Univ. Glasgow	UK
	Prof. Dr. Helmut Rucker	IWF Graz	Austria
	Prof. Dr. Bo Thide	Univ. Uppsala	Sweden
(project manager)	Dr. Christian Vocks	AIP	Germany
ordinary members	Dr. Jens Berdermann	DLR Neustrelitz	Germany
	Frank Breitling	AIP	Germany
	Eoin Carley	Trinity College Dublin	Ireland
	Dr. Harry Enke	AIP	Germany
	Dr. Norbert Jakowski	DLR Neustrelitz	Germany
	Dr. Eduard Kontar	Univ. Glasgow	UK
	Prof. Dr. Andrzej Krankowski	Univ. Olsztyn	Poland
	Dr. Christophe Marqué	Royal Obs. of Belgium	Belgium
	Diana Morosan	Trinity College Dublin	Ireland
	Dr. Jürgen Rendtel	AIP	Germany
	Dr. Hamish Reid	Univ. Glasgow	UK
	Pietro Zucca	Trinity College Dublin	Ireland
associated memb.	Dr. Philippa Browning	Univ. Manchester	UK
	Prof. Dr. Carsten Denker	AIP	Germany
	Dr. Lyndsay Fletcher	Univ. Glasgow	UK
	Prof. Dr. Arnold Hanslmeier	Univ. Graz	Austria
	Dr. Matthias Hoeft	Thür. LSW Tautenburg	Germany
	Dr. Karl-Ludwig Klein	Obs. de Paris-Meudon	France
	Dr. Hanna Rothkaehl	SRC Warsaw	Poland
	Dr. Astrid Veronig	Univ. Graz	Austria
	Dr. Alexander Warmuth	AIP	Germany

32 members
of
10 countries

Funding

- by German government:
  - D-LOFAR III
    230 k€ for 3 years (Frank Breitling)
    07/2014 – 06/2017
- by Irish government:
  - Diana Morosan
  - Pietro Zucca
- by UK government:
  - Hamish Reid
- by AIP – operation costs:
  - ≈ 80 k€ for ASTRON
  - ≈ 35 k€ for costs
  - ≈ 15 k€ data link
  - ≈ **120 k€ in total per year**

– 1 staff position (Christian Vocks LOFAR scientist at AIP)

KSP Workshops

1st workshop in Potsdam	Oct. 5/6, 2006
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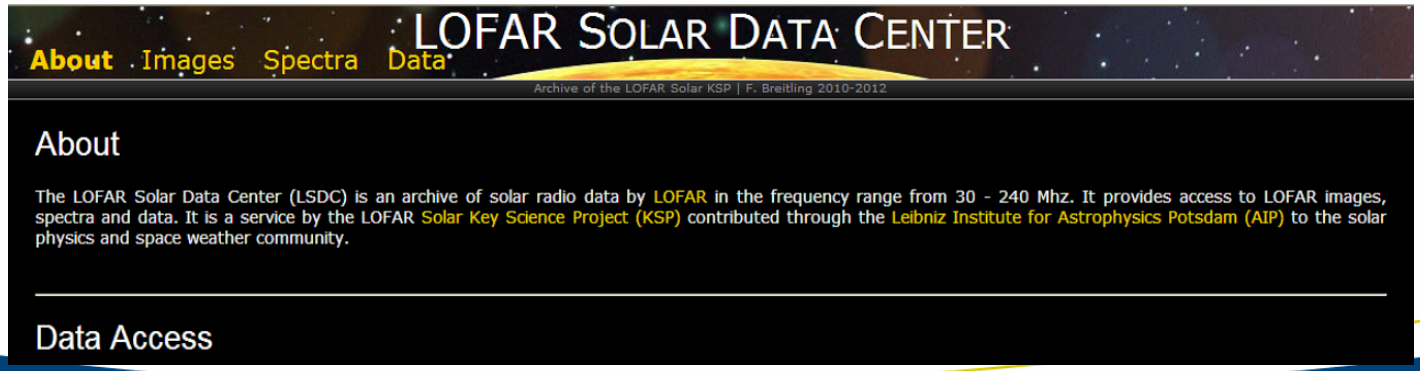
8th workshop in Dwingeloo	May 6-7, 2014
9th workshop in Brussels	May 26/27, 2015
10th workshop in Glasgow	Oct./Nov.(?), 2016

http://www.aip.de/groups/osra/german/de_lofar.html

Results of 2015/16

- development of the ***solar imaging pipeline***
- simultaneous ***dynamic radio spectra*** from imaging data
- studying fast electron propagation *(Mann et al. in rev. proc.)*
- studying of S bursts *(Morosan et al.: 2015, A&A 580, 65)*
- studying quiet Sun (radial density profiles above coronal holes)
  (→ talk by C. Vocks at LOFAR Science Meeting *(Vocks et al.: 2016, A&A in prep.)*)
- studying of the ionospheric influences *(Fallows et al.: 2016, ApJ in rev. proc.)*
- submission of proposals (for C 5 & 6)
- establishment of the ***LOFAR Solar Data Center*** (LSDC) at AIP: *http://lsdc.aip.de*



Proposals for Cycle 6

LC6_001: Monitoring Scintillations above LOFAR (PI: R. Fallows)

LC6_002: Interferometric Imaging Observations of the Sun with LOFAR

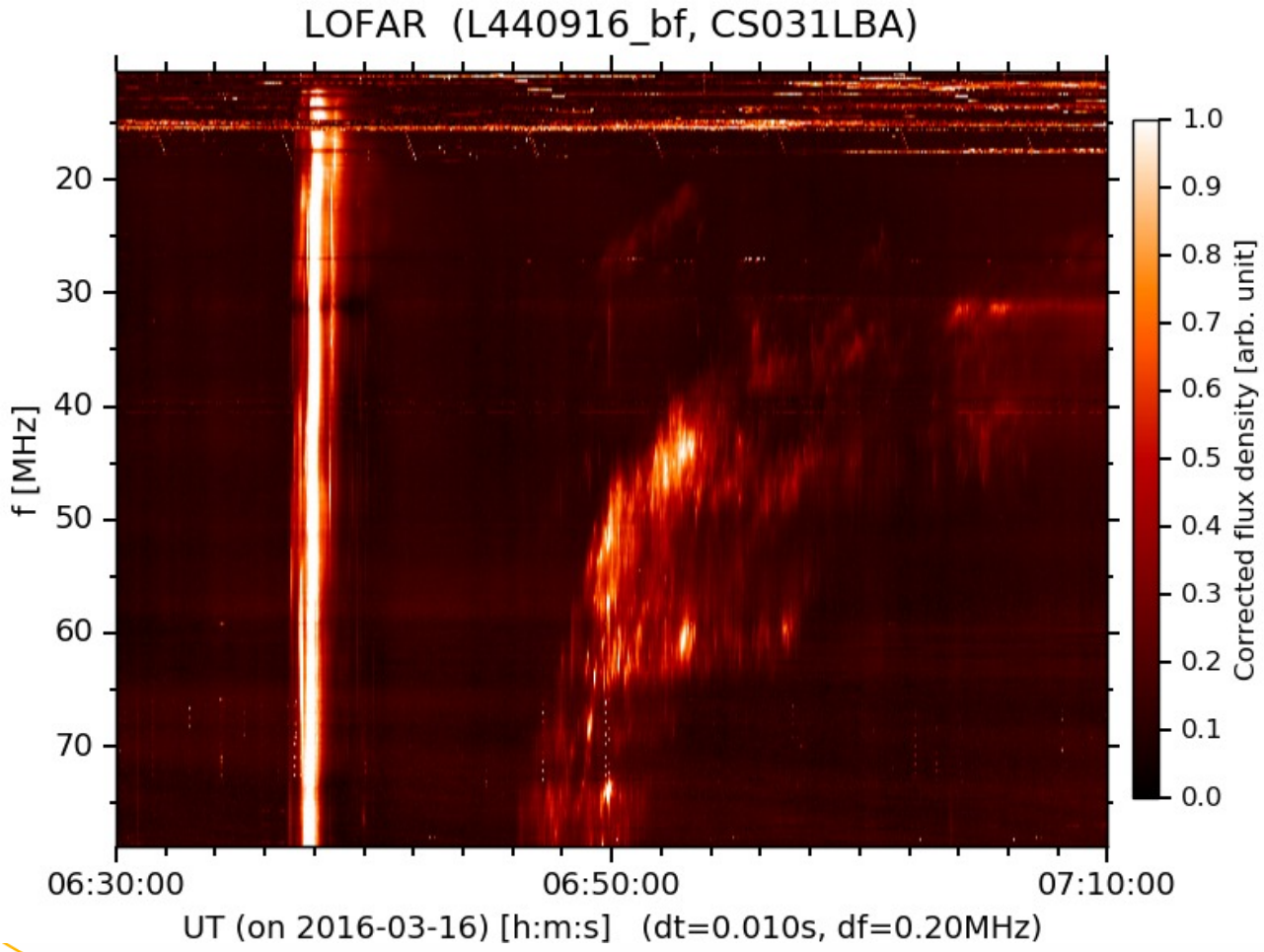
(PI: G. Mann, C. Vocks, M. Bisi, P. Gallagher, A. Kerdraon, J. Magdalenic, A. Mac Kinnon, H. Rucker, B. Thide, A. Konovalenko, C. Marque, E. Kontar, B. Dabrowski, A. Krankowski, H. Reid)

(common proposal of solar KSP)

scientific topics

- electron acceleration at coronal shocks
- probing the density of the high corona and near interplanetary space with type III bursts
- studying the nature of noise storms
- studying of the nature of S bursts
- radio signatures of CME launch and propagation
- backup plan: Structure of the quiet solar corona

Recent Solar Observations with LOFAR



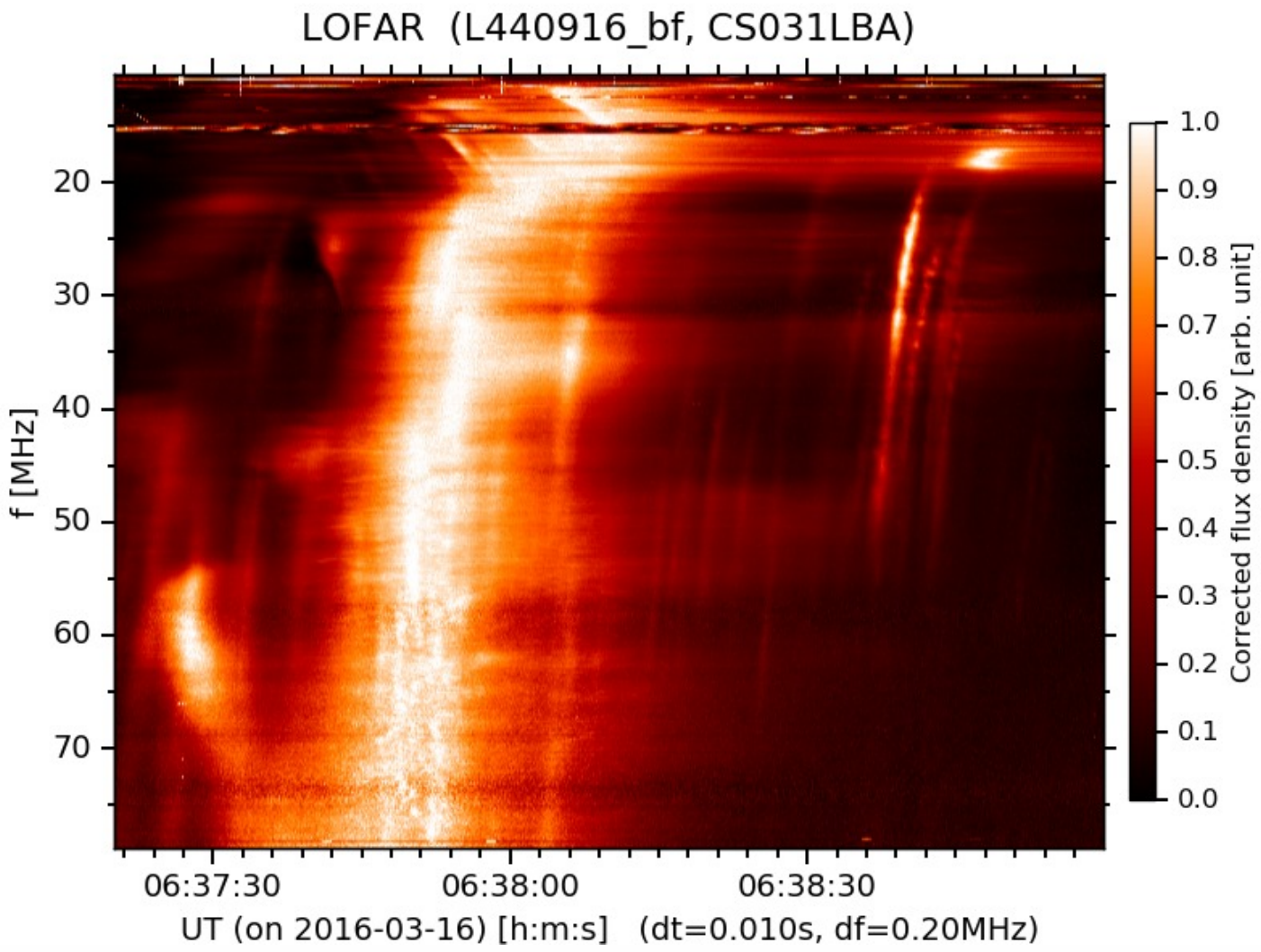
– type III burst
– type II burst

covering a large range of the corona

80 MHz → 1.42 R_S
10 MHz → 2.52 R_S
(see Mann et al., 1999)

note: $r_c = 6.9\ R_S$
→ f > 10 MHz is in the range of the hydrostatic corona

Type III Burst I



Type III Burst II

- type III burst – radio signature of an electron beam travelling along magnetic field lines through the corona *(see Wild et al., 1950)*

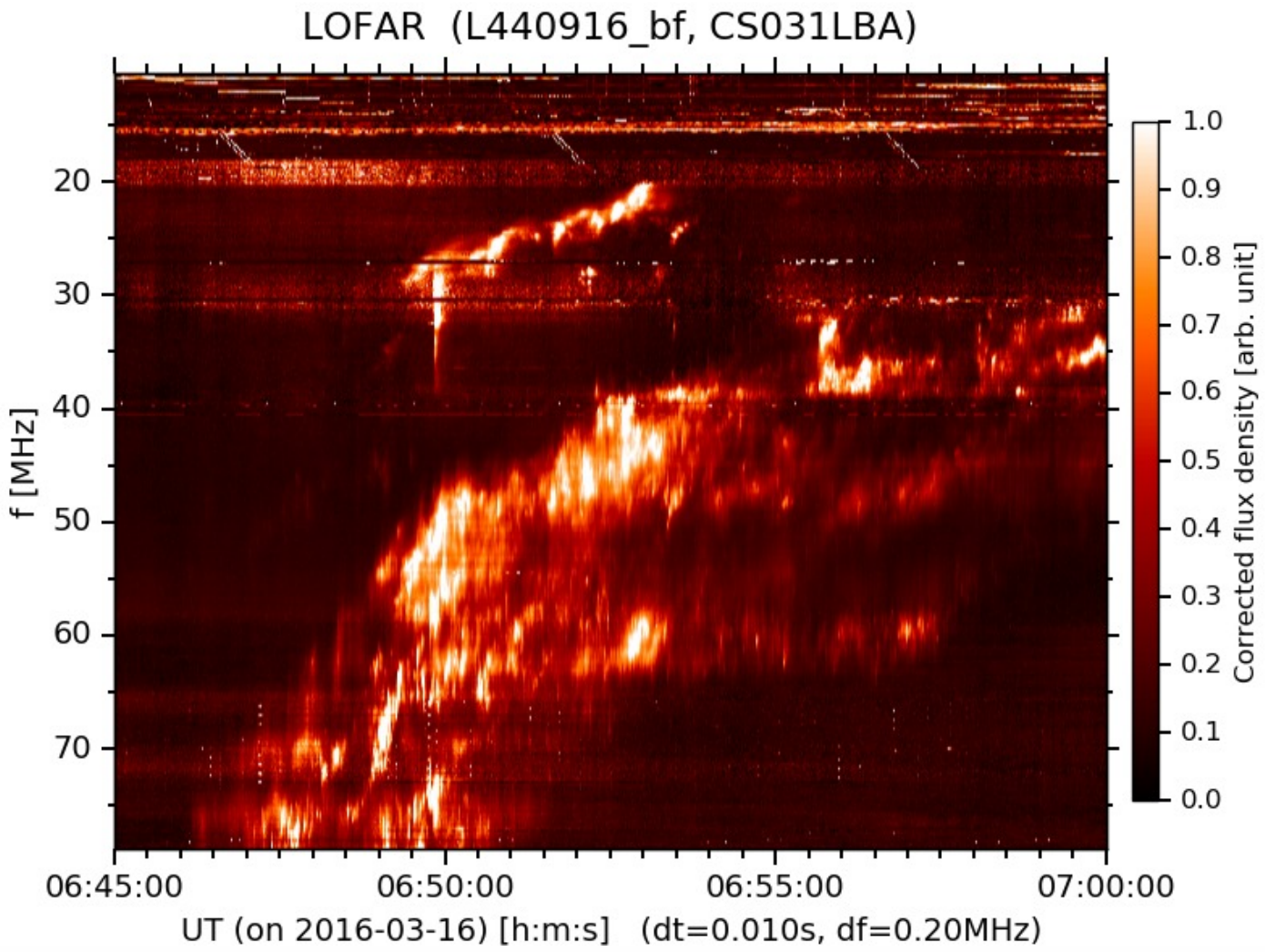
- type III burst at 06:38:36 UT

f MHz	Δ l mm	t s	r 10^6 km	v km/s
50	12.5	6.098	1.106	
40	14.5	7.073	1.166	61,538
30	17.5	8.537	1.253	59,426
20	22.5	10.976	1.401	60,680

The type III burst is generated by a nearly mono-energetic electron beam.

(velocity = 60,500 km/s = 0.2 c; ≈ 10 keV)

Type II Burst I



Type II Burst II

- type II radio burst – radio signature of a shock wave travelling through the corona

  (see e.g. Mann, 1995)

- fundamental-harmonic structure

  at 06:57 UT: F: 15 MHz
  1 H: ≈ 30 MHz
  2 H: ≈ 45 MHz
  4 H: ≈ 60 MHz

- drift of fundamental lane:

  start: 06:49:30 UT at 27 MHz
  end: 06:53:00 UT at 20 MHz

  → drift rate: - 0.033 MHz/s
  (cf. Mann, 1995)
  mean velocity: 533 km/s

- Alfvén speed (at 23.5 MHz) = 467 km/s
  - $r = 1.338 \cdot 10^6$ km
  - $N_e = 6.851 \cdot 106$ cm-3
  - B = 0.56 G

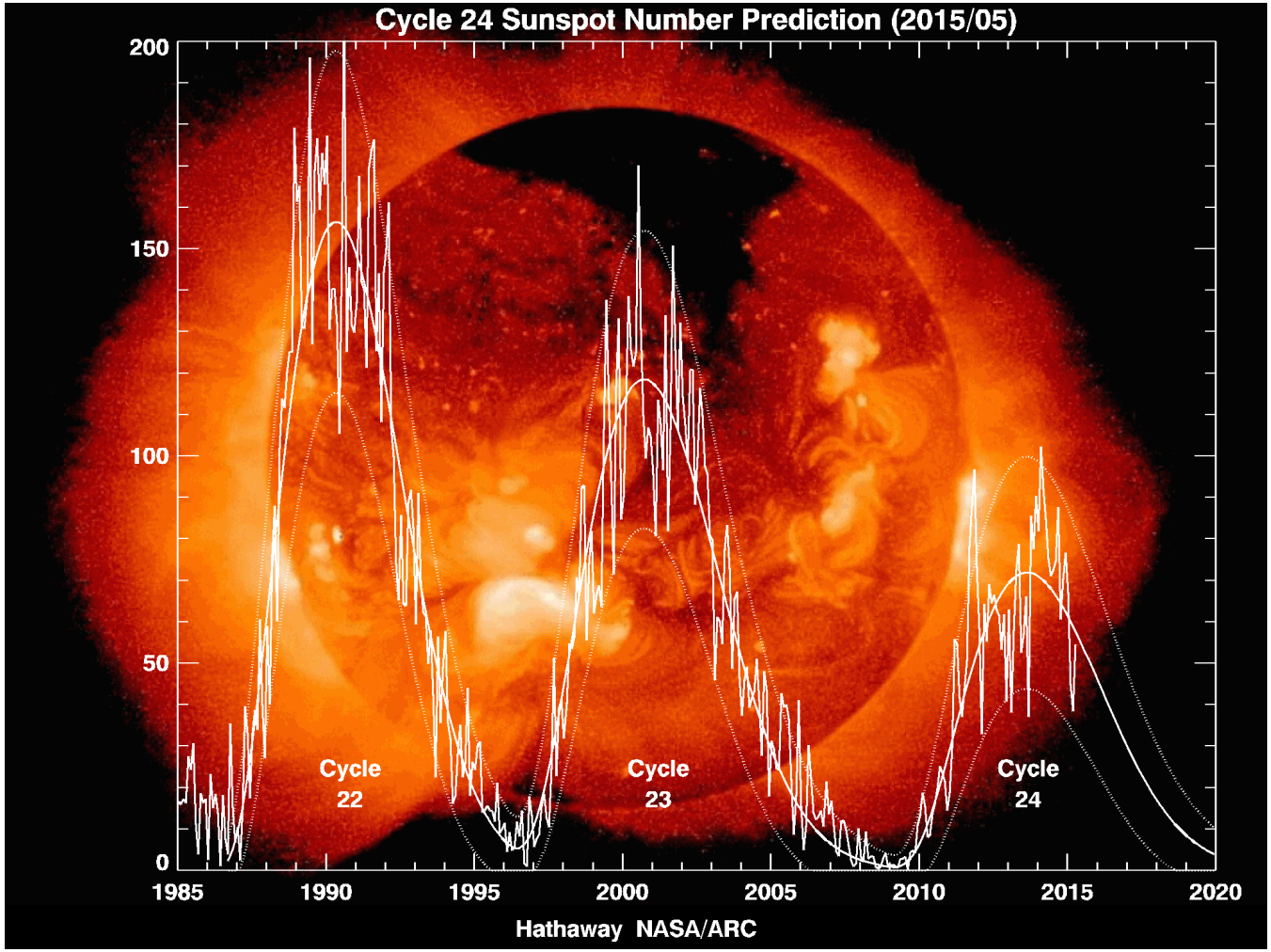
  → Alfvén-Mach number 1.14
  (typical for type II related shocks)

Problems Which Should be Discussed

- LOFAR observations of the Sun
  - The Sun is a special target !!!
    - regularly observations of the Sun by spacecraft Hinode, RHESSI, and SDO
    - We must wait up to the Sun provides us an event, which we can scientificly study.

    → A long Term Proposal would be important for the solar KSP.
  - external triggering (→ solar activity, e.g.: www.solarmonitor.org)
    - alert time to ASTRON (3 days or 1 hour) ???
    - Could a single LOFAR station be used only for solar observations i.e. as a spectrometer ?

Solar Activity



Thank you for your attention!

This work was done
in collaboration
with the solar KSP and
LOFAR/ASTRON team