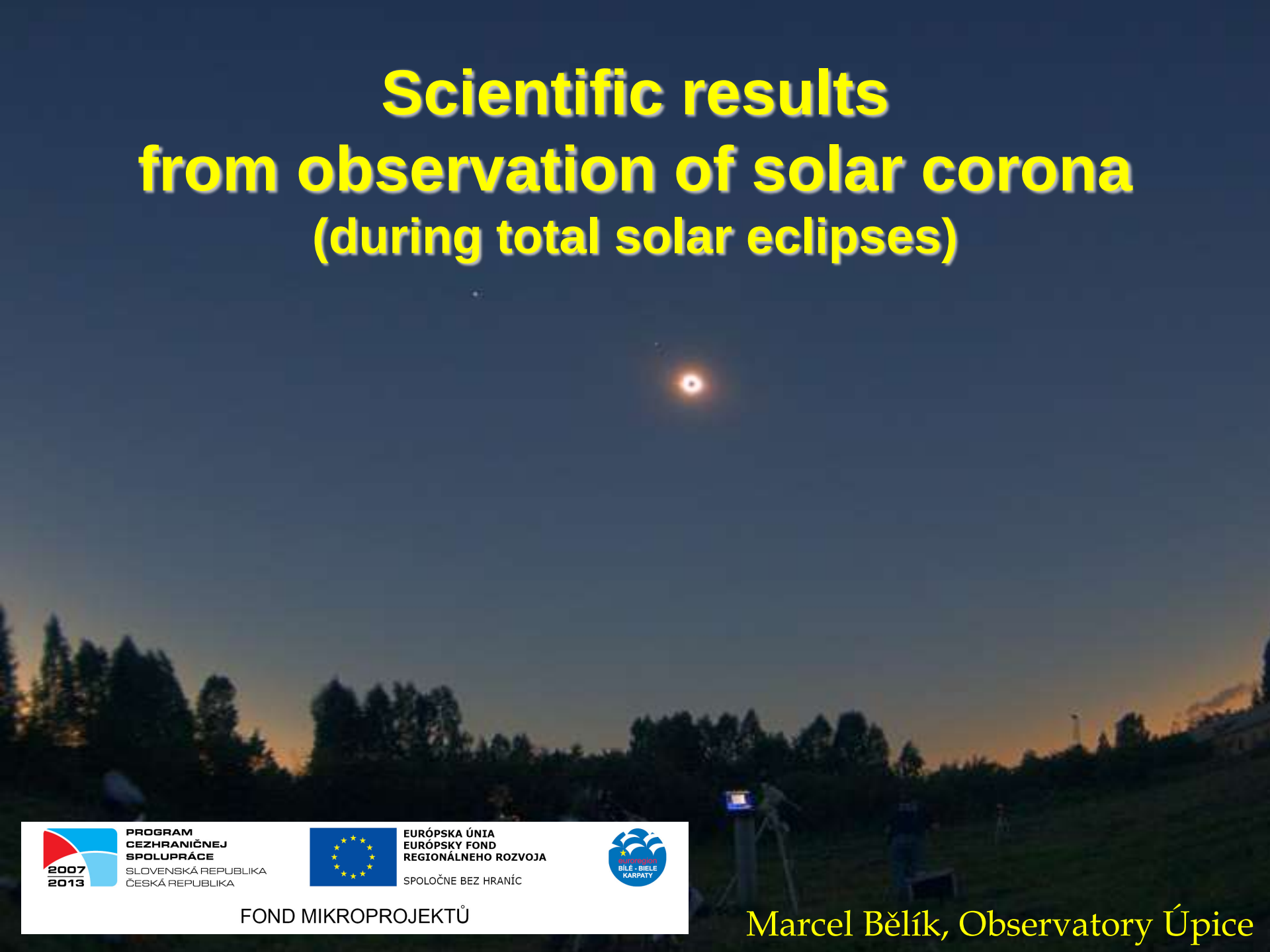
Scientific results from observation of solar corona
(during total solar eclipses)



PROGRAM CEZHRANIČNEJ SPOLUPRÁCE
2007 2013
SLOVENSKÁ REPUBLIKA
ČESKÁ REPUBLIKA

EURÓPSKA ÚNIA
EURÓPSKY FOND REGIONÁLNEHO ROZVOJA
SPOLOČNE BEZ HRANÍC

FOND MIKROPROJEKTŮ

Marcel Bělík, Observatory Úpice

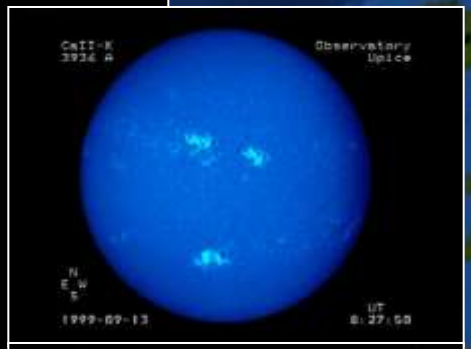
Solar Eclipse Conference 2007 (SEC 2007)
Griffith observatory, Los Angeles, USA

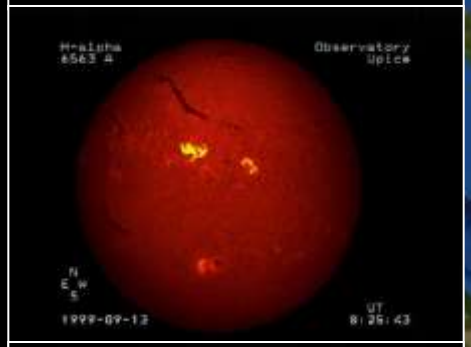
Vojto Rušin:

„… there exists the physics of solar corona before and after 2001…“

Observatory Úpice, Czech Republic

www.obsupice.cz





Observatory Úpice and TSE

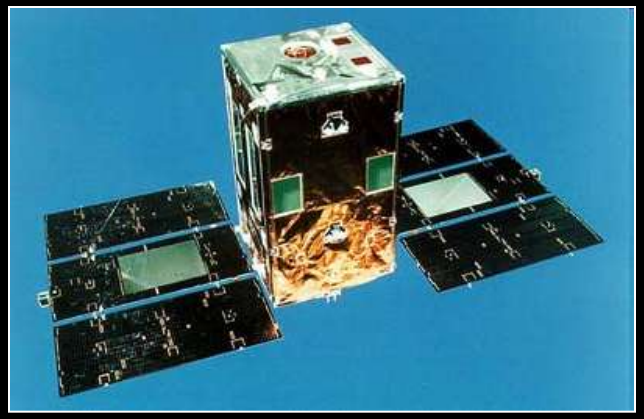
Total Solar Eclipse 1998

Total solar eclipse in the past:

Unique possibility to study solar atmosphere - corona

Space-born solar telescopes:

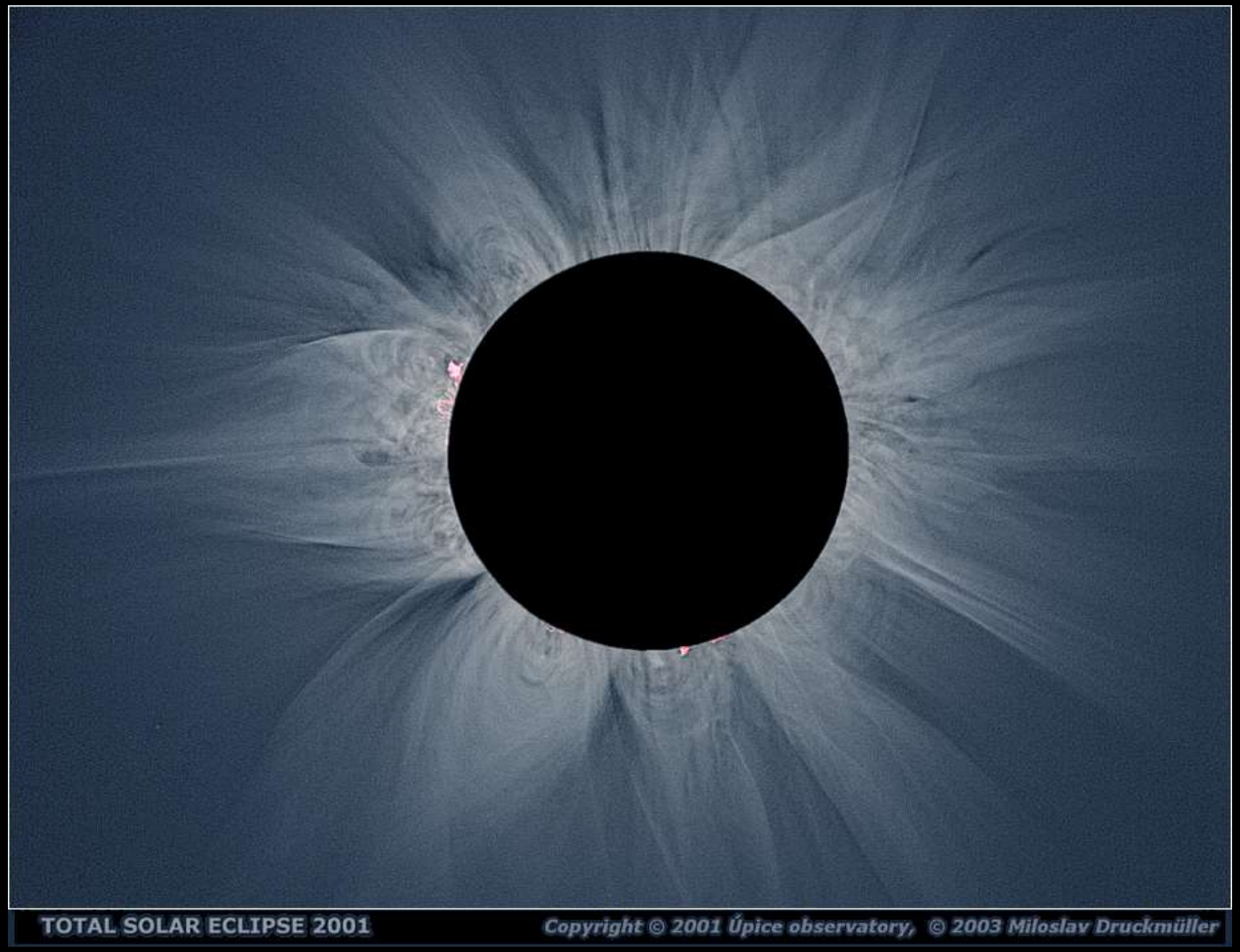
Temporary diminishing of TSE interest



Skylab, SOHO, Yohkoh, …….

Turn of millennium:

Renewal of TSE interest

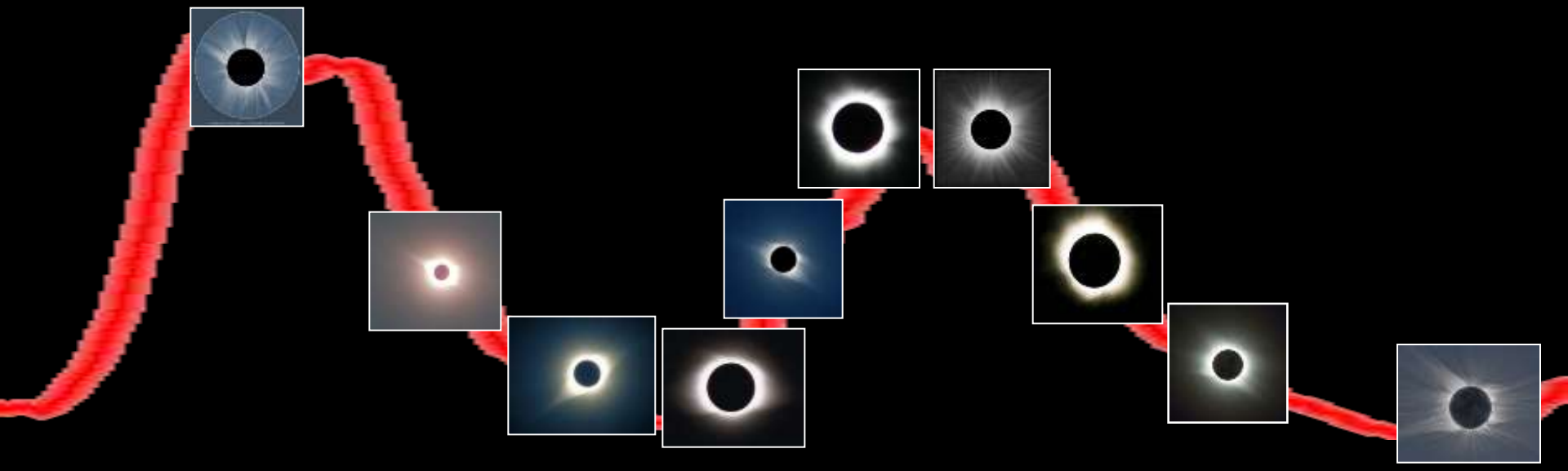


Role of the Úpice observatory:

Úpice Observatory plays an important role in this renewal

21 years of TSE´s:

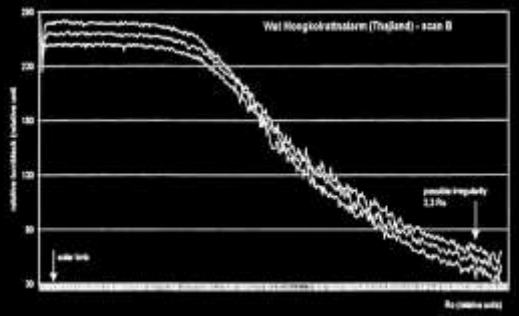
1. 1990 - Czukotka
2. 1994 – Brazil
3. 1995 – India
4. 1997 – Siberia
5. 1998 – Venezuela
6. 1999 – France, Hungary, Romania
7. 2001 – Angola
8. 2002 – South Africa (JAR)
9. 2006 – Egypt, Turkey
10. 2009 – China
11. 2010 – Argentina
12. ……



1990 2000 2010

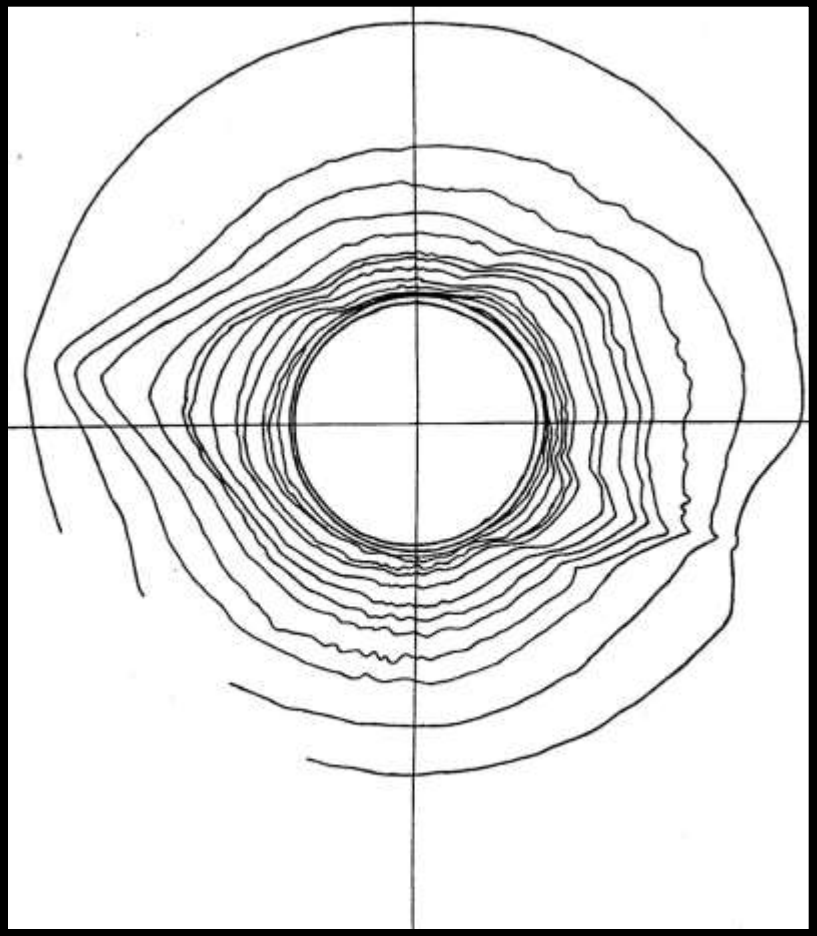
1990 – 2001 – collection of experiences

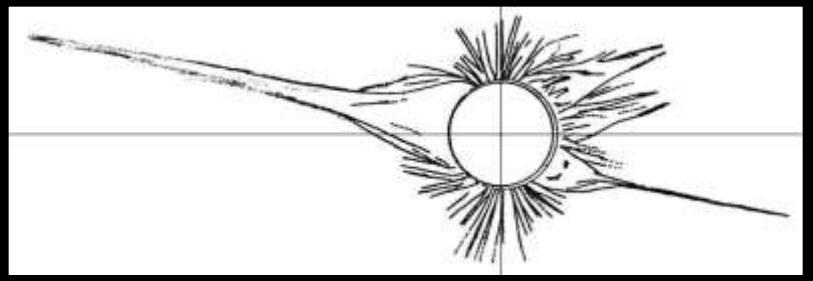
Big and heavy telescopes and mounts
„Classical“ B&W or colour slide films
„Standard“ photo-cameras
„Classical“ processing of pictures
„Standard“ results (ellipticity, structures, …)
First steps to the „digital“ age (getting and processing of data)
First attempt to detect dynamic of coronal structures (different observation places)

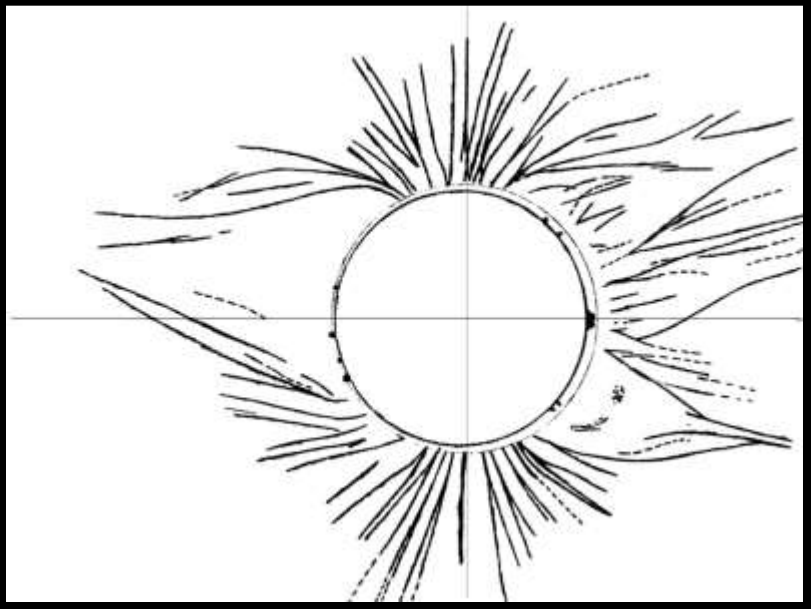


1990 - 1999:

„classical“ processing of images





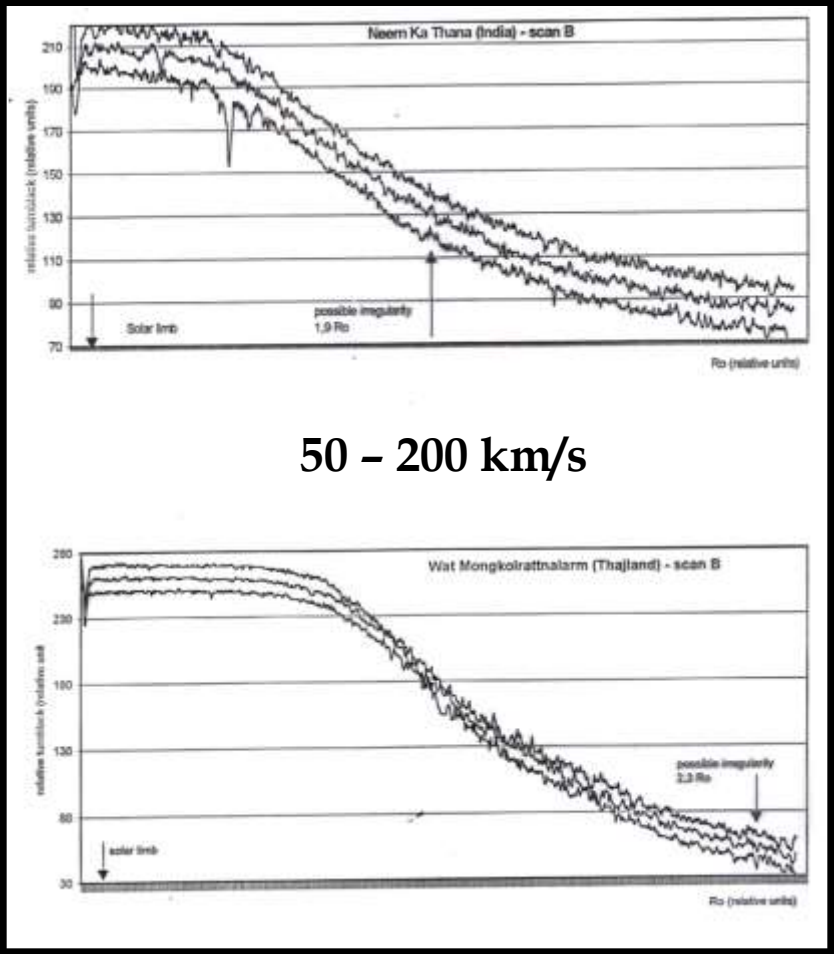


Shape of corona (isophoties, ellipticity), structures,

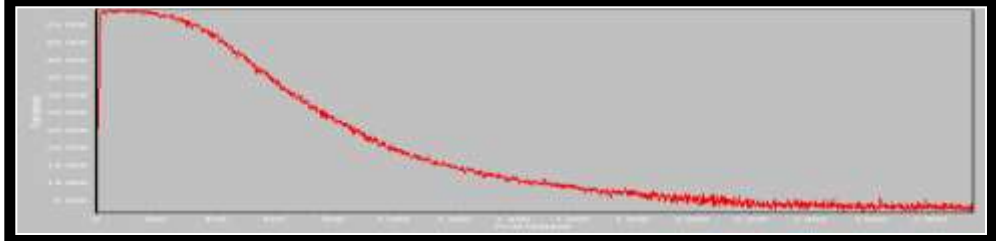
…….

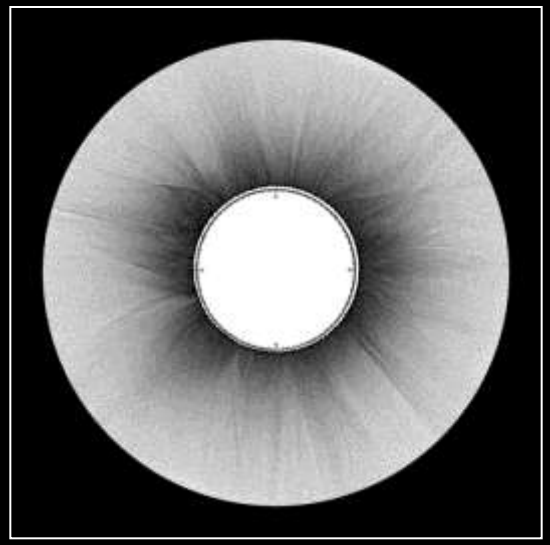
1990 - 1999:

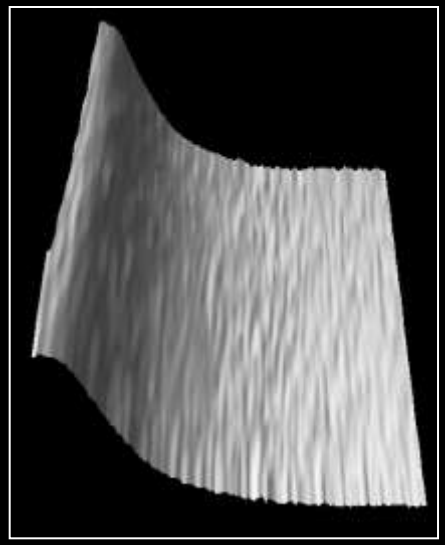
„new “ tendencies of eclipse processing



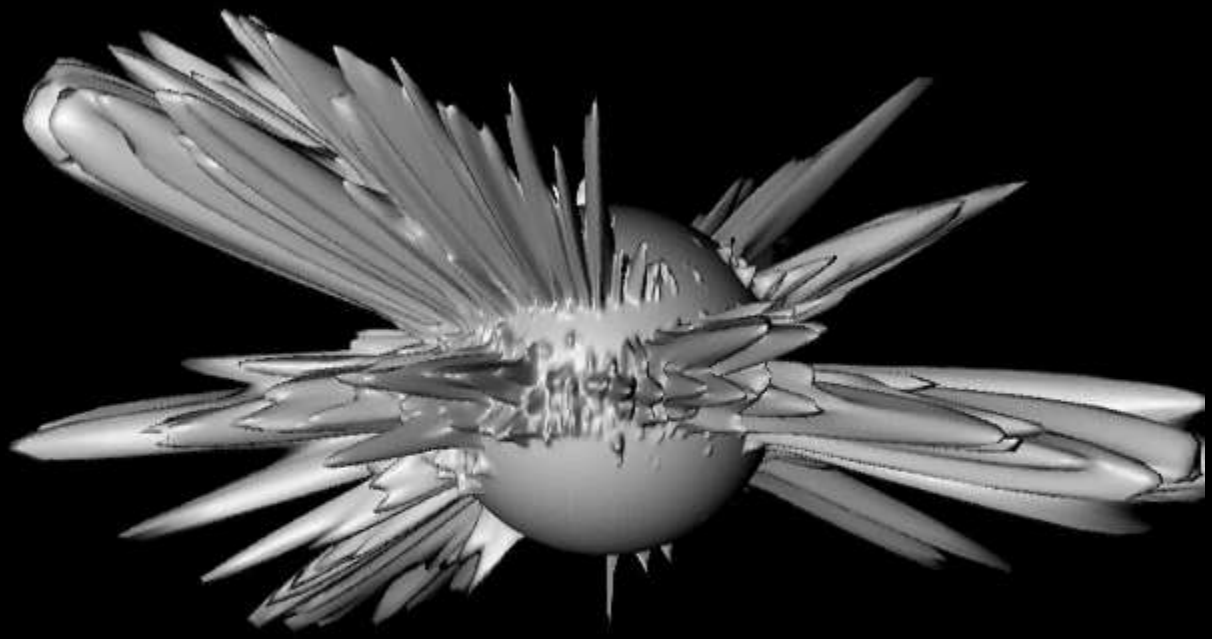
50 – 200 km/s





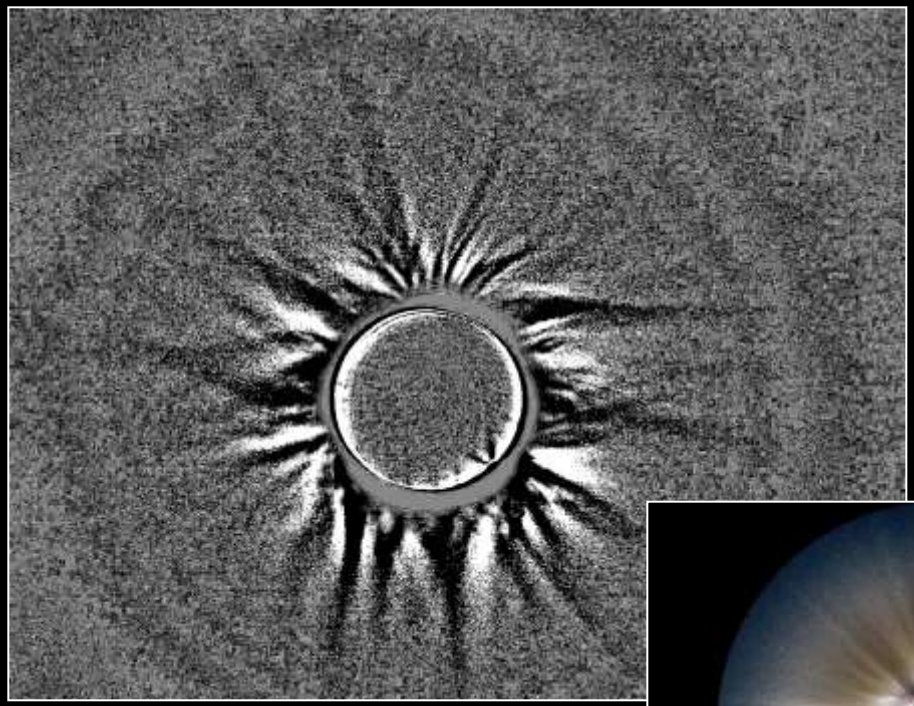


Comparison of observation from different places
Large and small scale dynamic of coronal structures



1999 – 2001:

„new “ tendencies of eclipse photography



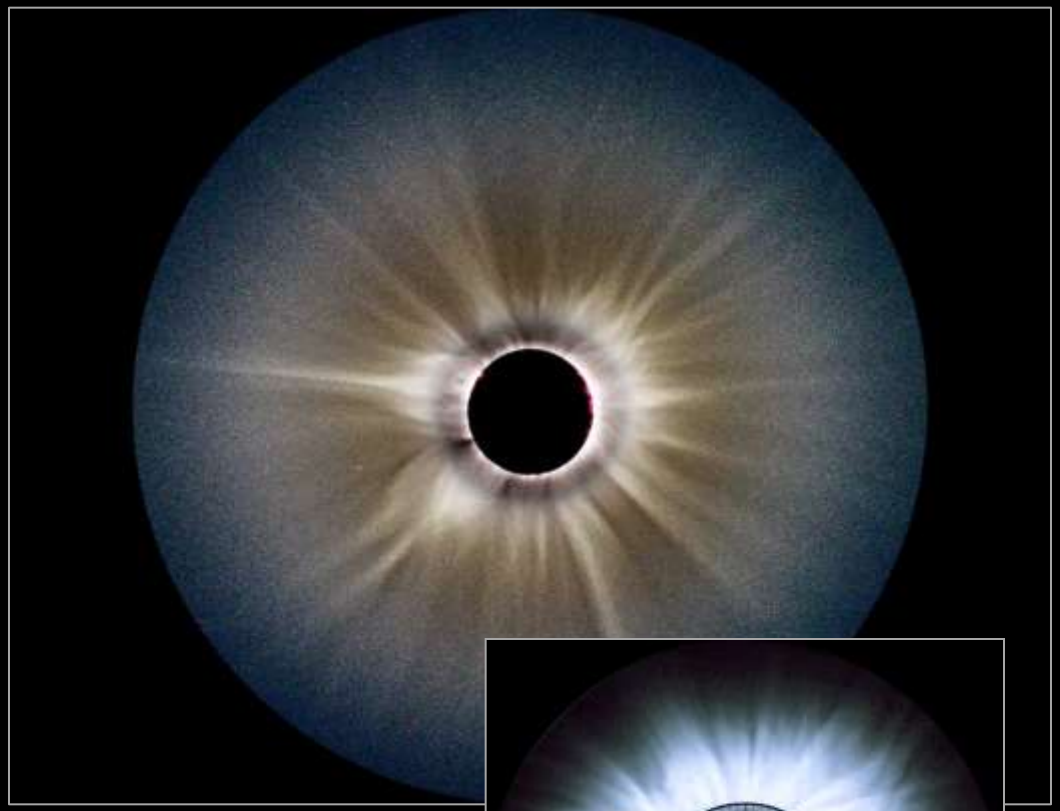
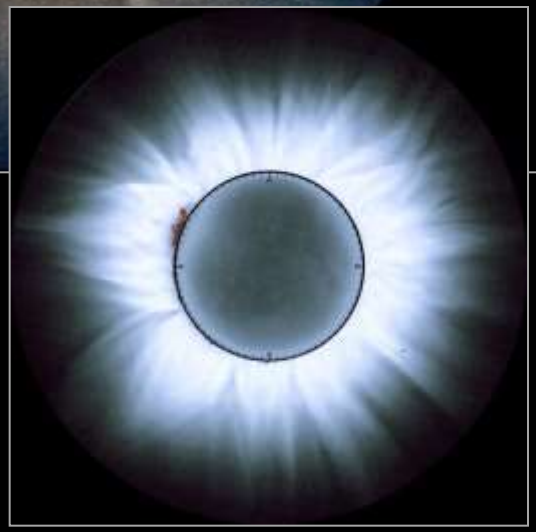
Technical inovation, exposition planning,
using of digital technique

Digital „radial filter“








PROJEKT M2V

Collecting of experiences and development of observing techniques 1990 - 1999

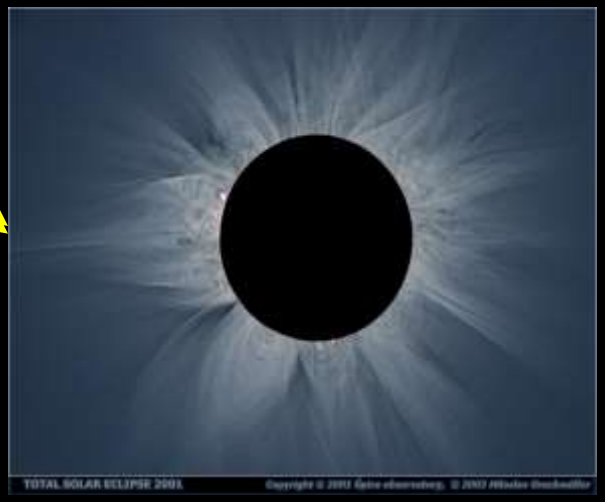
New ASAHI Pentax

New telescope 100/1875 mm (VOD Turnov)

Excelent meteorological conditions

Cooperation with VUT Brno num. processing (prof. Druckmüller)

2001 ANGOLA

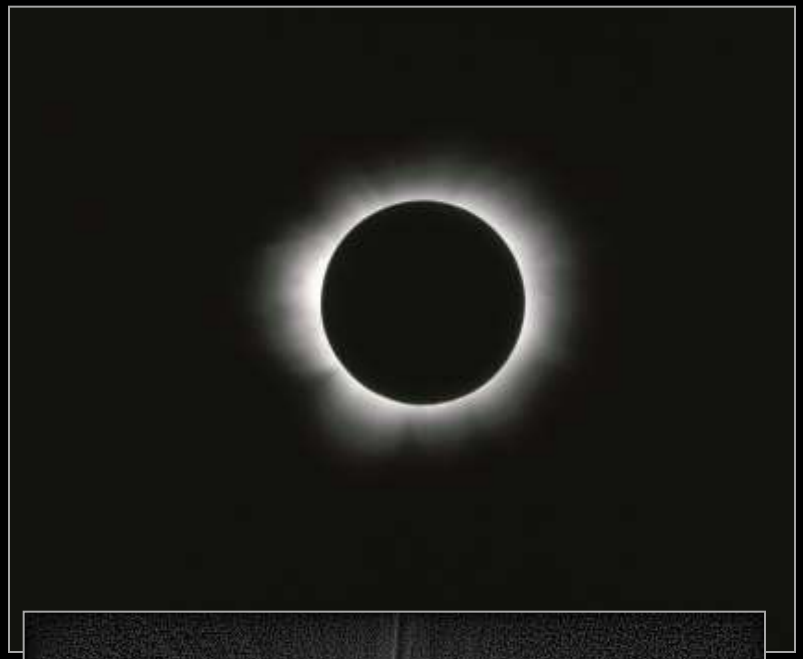


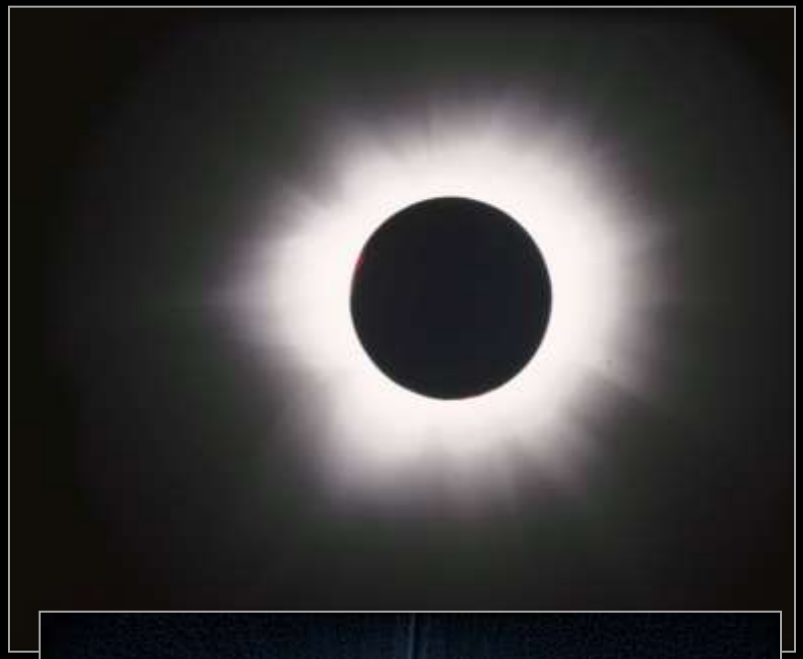
Vizualizace detailů

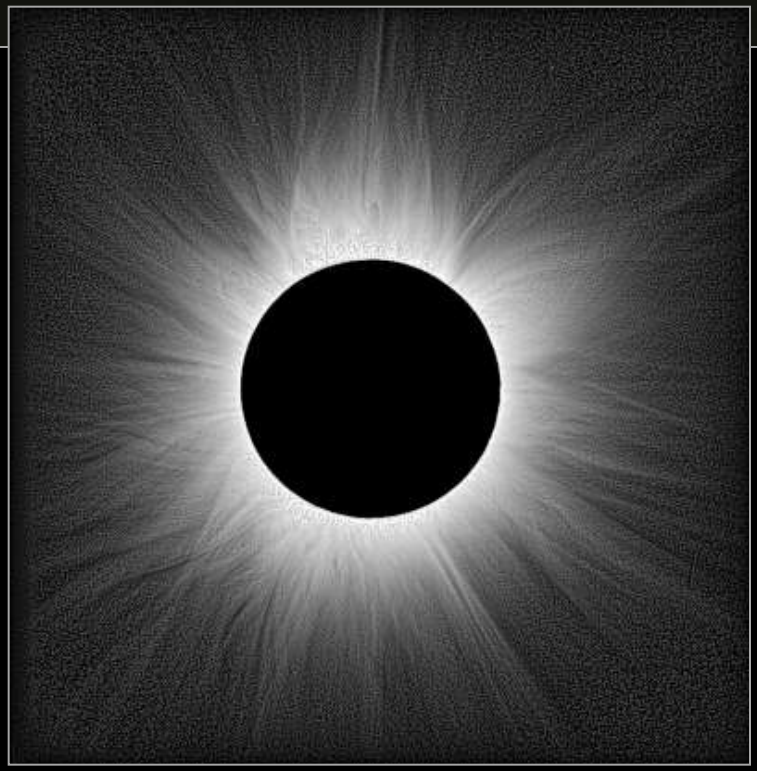
Matematické numerické metody, které upravují algoritmus zpracování vzhledem k lokálním vlastnostem obrazu podobně jako lidské oko se nazývají

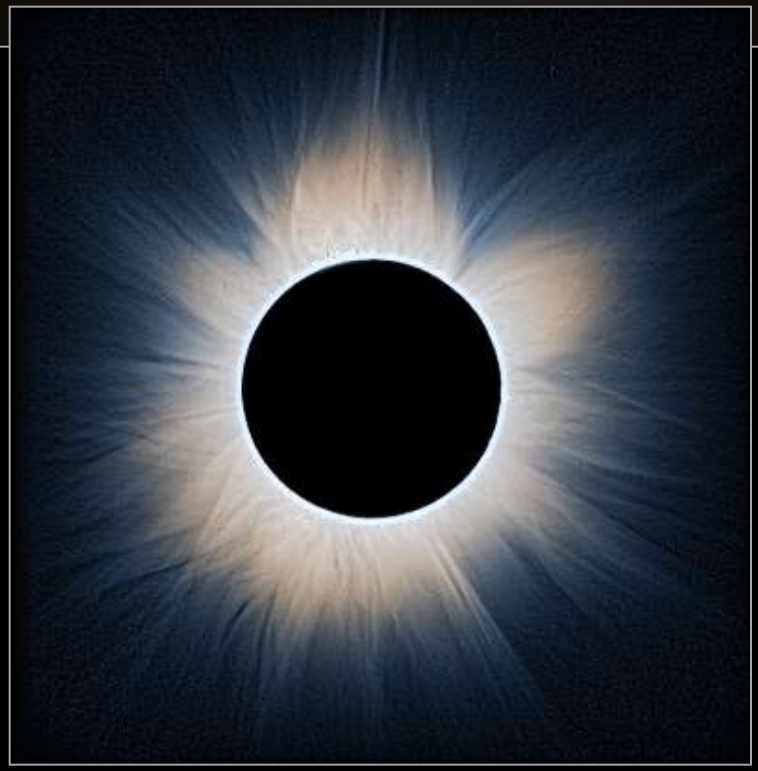
adaptivní filtry

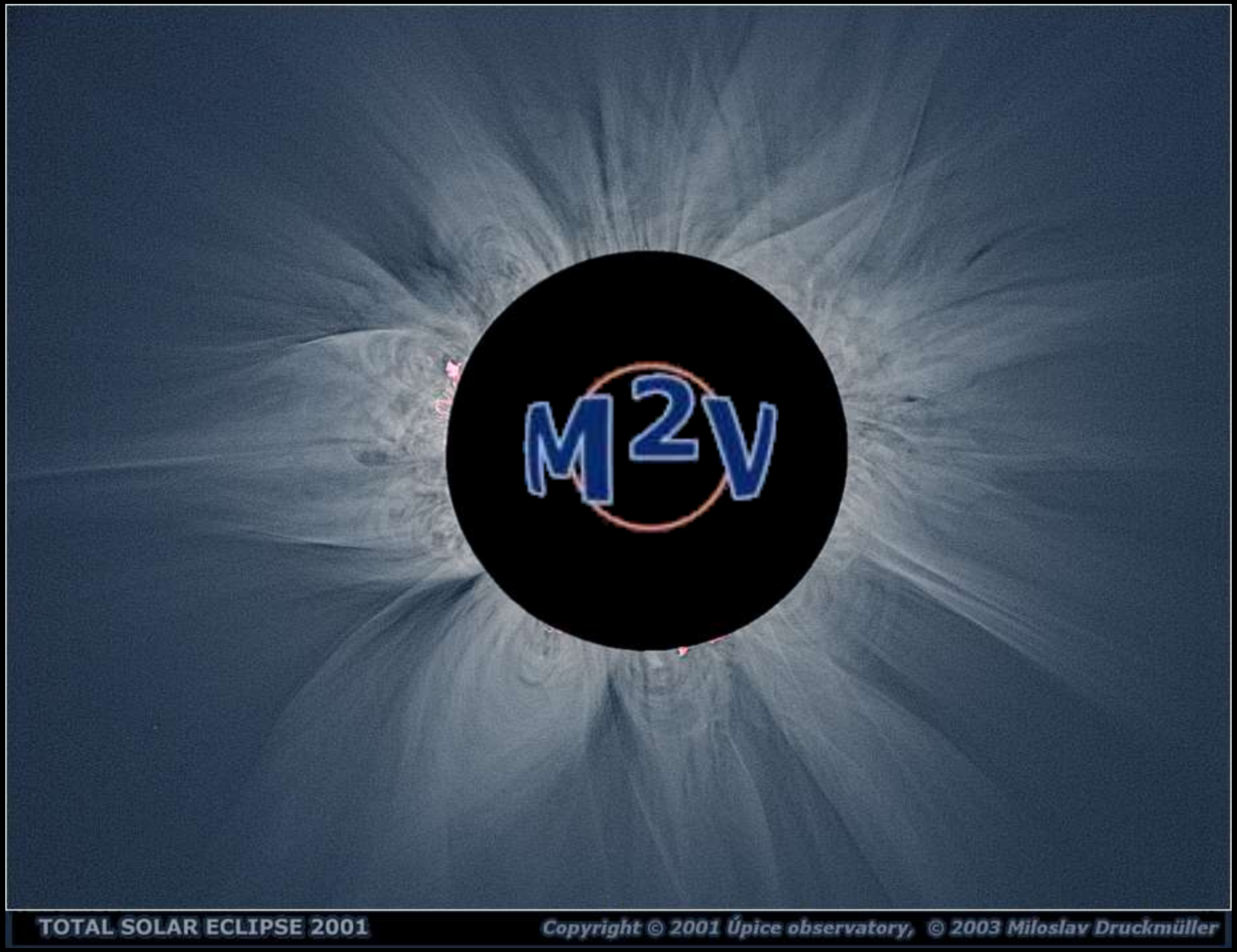
Tyto metody upravují vlastnosti zpracovávaného pixelu na základě histogramu blízkého okolí, jehož tvar je navíc závislý na vlastnostech tohoto okolí. Celý proces je následně kontrolován na překročení nastavených parametrů zpracování obrazu tak, aby nedocházelo k degradaci obrazu či tvorbě artefaktů.





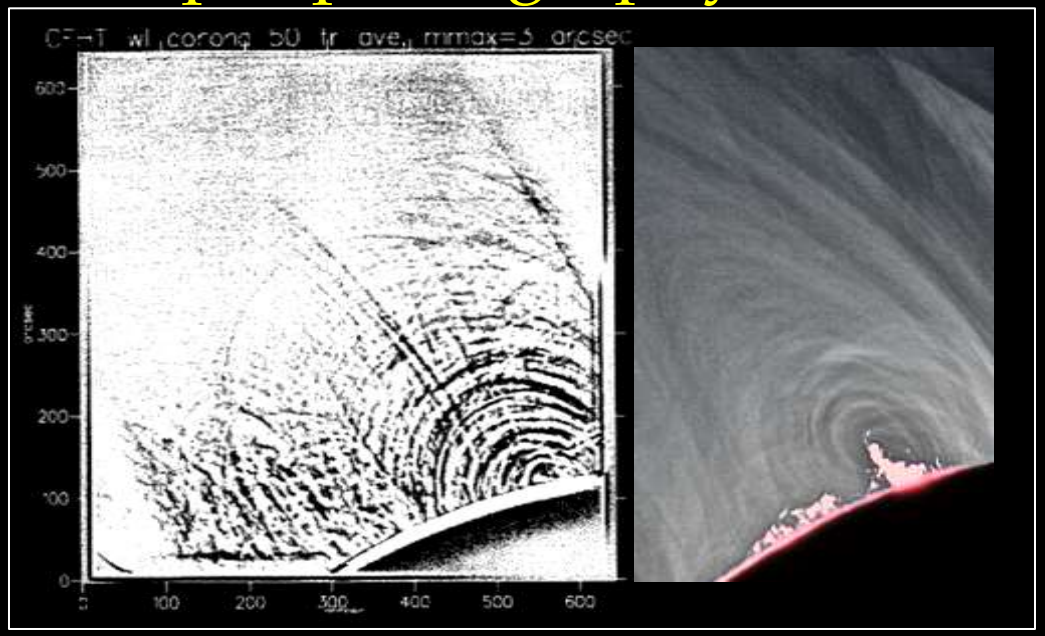





M2V
TOTAL SOLAR ECLIPSE 2001
Copyright © 2001 Úpice observatory, © 2003 Miloslav Druckmüller

2001 – end of next millenium:

„new “ tendencies of eclipse photography and processing



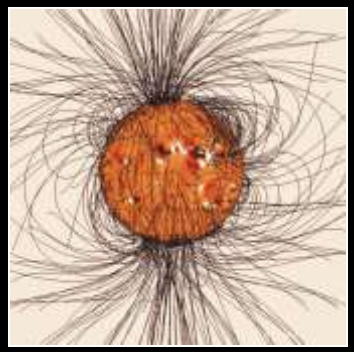
Canada-French-Hawaii telescope (CFHT) diameter 3,6 m Mauna Kea (1991)

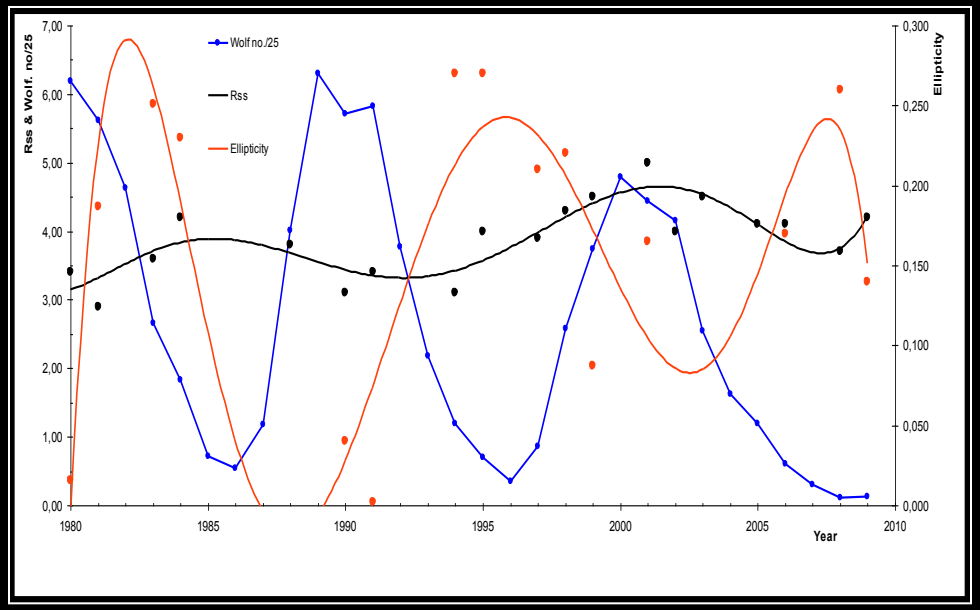
2001 – now – using of experiences

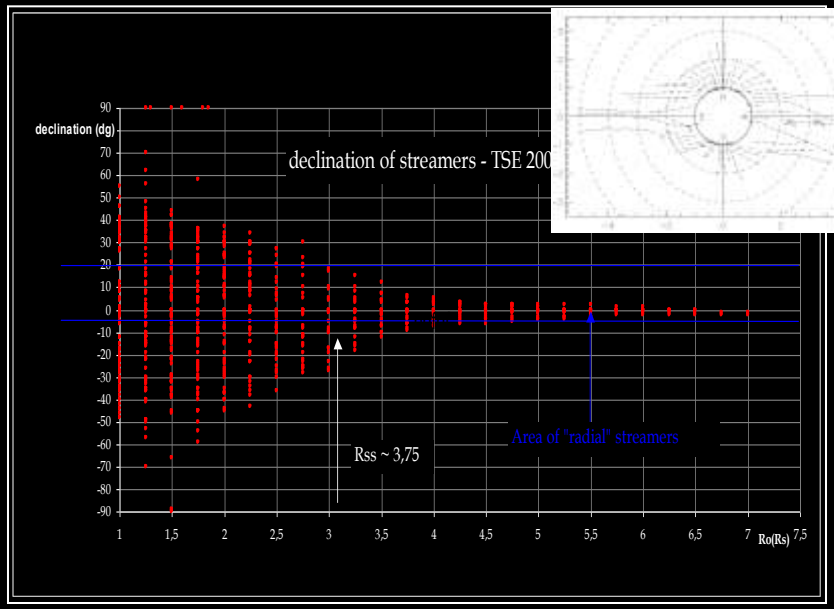
More transportable and quality mounts and optics
Digital cameras (included chips of 40 x 50 mm), controled by computer. New numerical methods of image processing.
„New“ results (very faint coronal structures, dynamic of them in very faint ranges, best determination of closed structures, …)
First steps to the absolute photometry (calibrated by stars)
New experiences in „digital“ age

„New“ value of source surface radius and its development of during solar cycles

The source surface radius presents one of the boundary condition in the modeling of solar coronal magnetic field. Its value affect the shape of the computed coronal magnetic structures. The pictures of solar corona obtained during total solar eclipses and processed by special numerical method, show very faint structures, extended to the several solar radii. Under the assumption that these structures represent a real magnetic situation in the corona, a value of the source surface radius can be estimated through the analysis of their shapes.







The average value of R_{ss} determined from 30 year period was R_{ss} ~ 3,9 and the maximum measured value was R_{ss} ~ 5,0. Moreover, the source surface radius show periodical tendency during described period of time.

Total solar eclipses observed on the long baseline allow us to obtain the pictures of white-light solar corona with the long temporal distance.

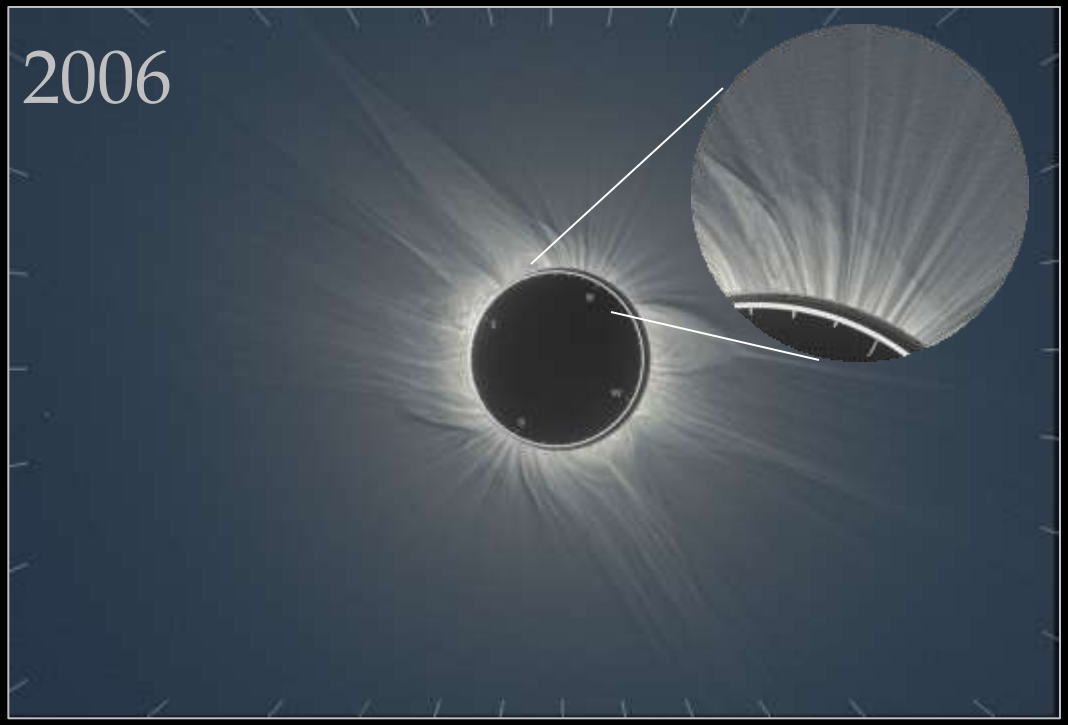
New numerical methods of coronal picture processing allow the visualization of very faint coronal structures and it enable to compare their position in corona with very high accuracy.

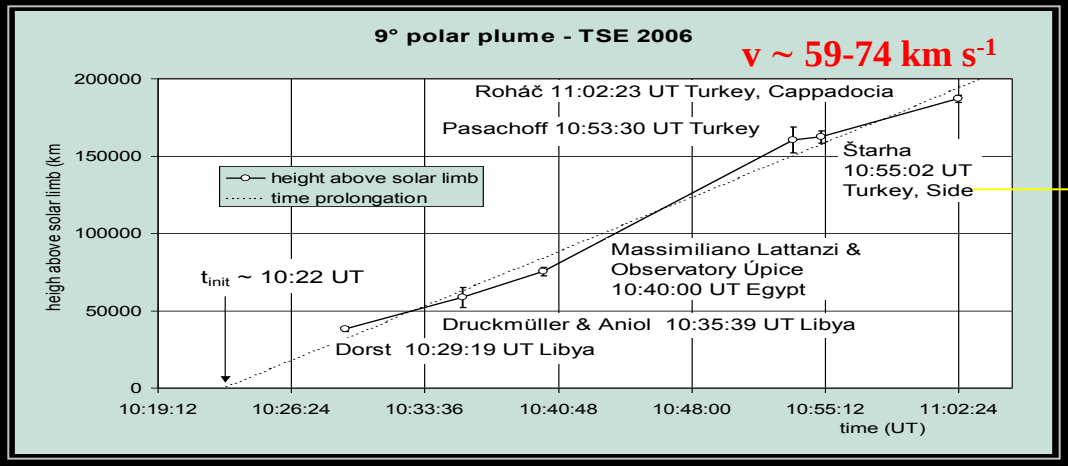
We can detect the moving of these faint structures by comparing of pictures obtained on the different places during the same total solar eclipse.

Such pictures are very well usable for study of disturbance propagation dynamic observed in polar plumes, for example.

$\mathrm{d}T = 2947$ s

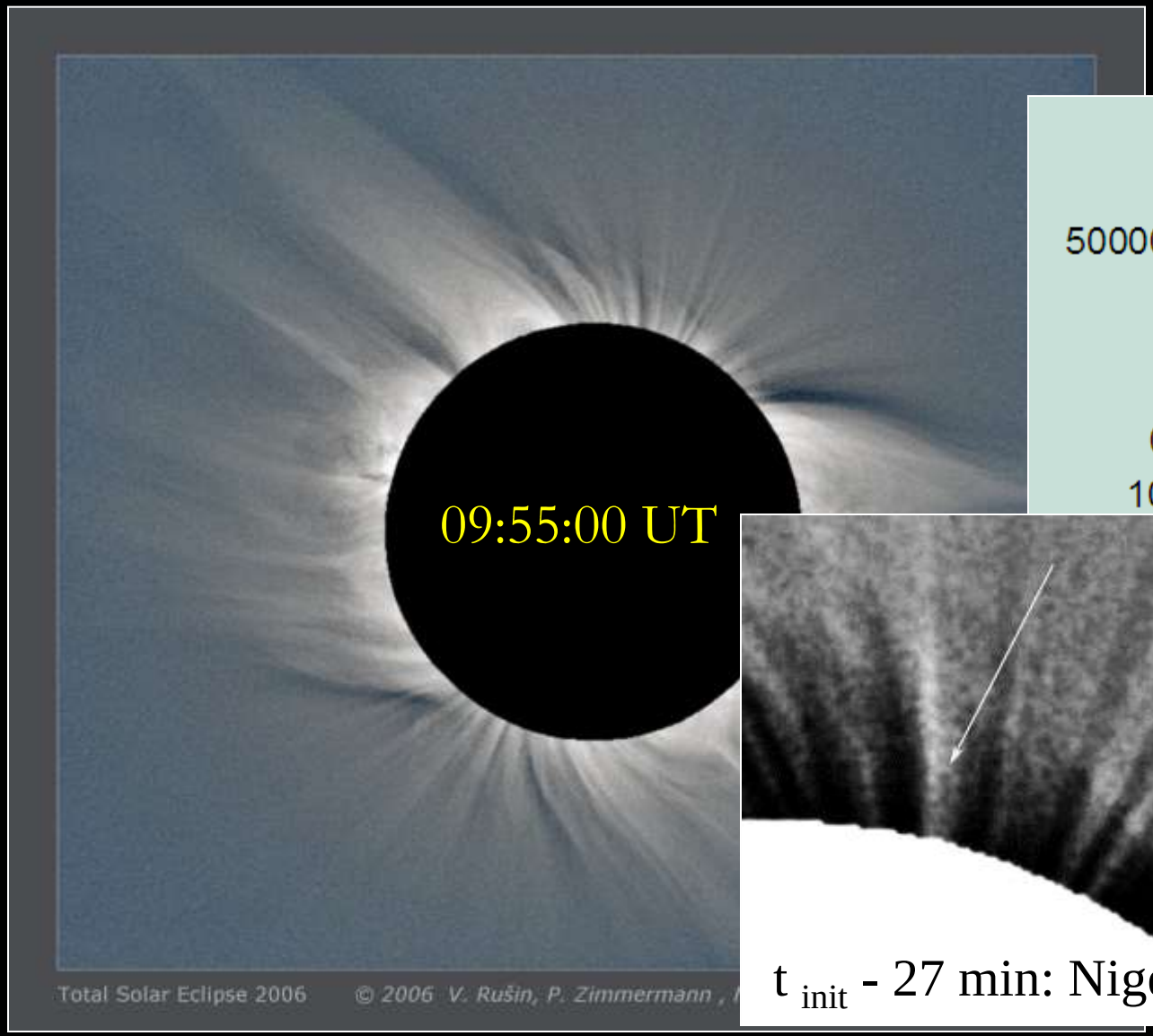
Dynamic of polar plumes

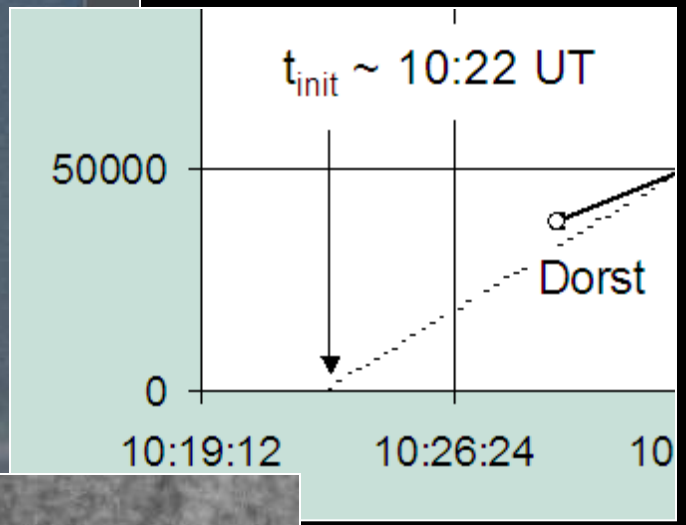




PASACHOFF, J.; RUŠIN, V.; DRUCKMÜLLER, M.; DRUCKMÜLLEROVÁ, H.; BĚLÍK, M.; SANIGA, M.; MINAROVJECH, M.; MARKOVÁ, E.; BABCOCK, B.; SOUZA, S.; LEVITT, J.: **Tolar Plume Brightening During the 2006 March 29 Total Eclipse**, ASTROPHYSICAL JOURNAL, Vol.682, (2008), No.1, pp.638-643, ISSN 0004-637X, Chicago

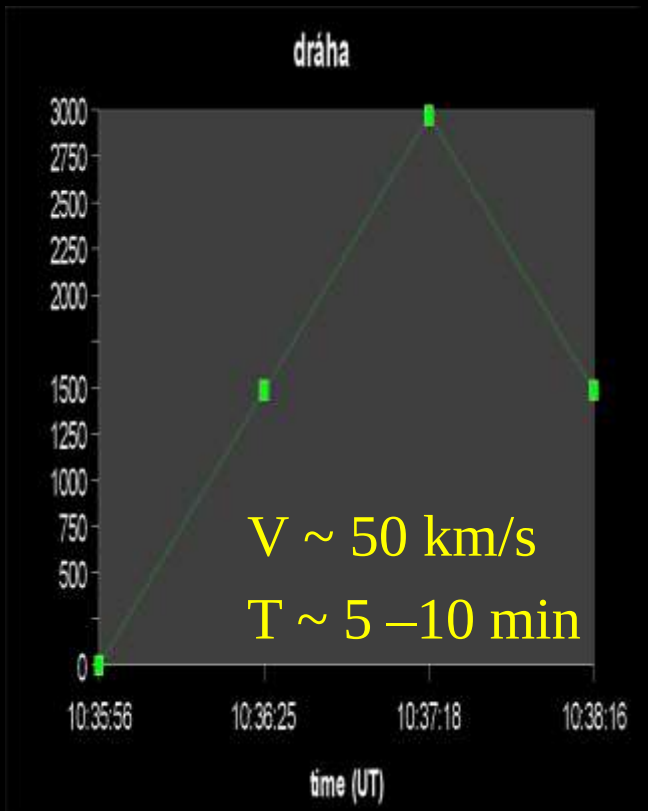
Dynamic of polar plumes



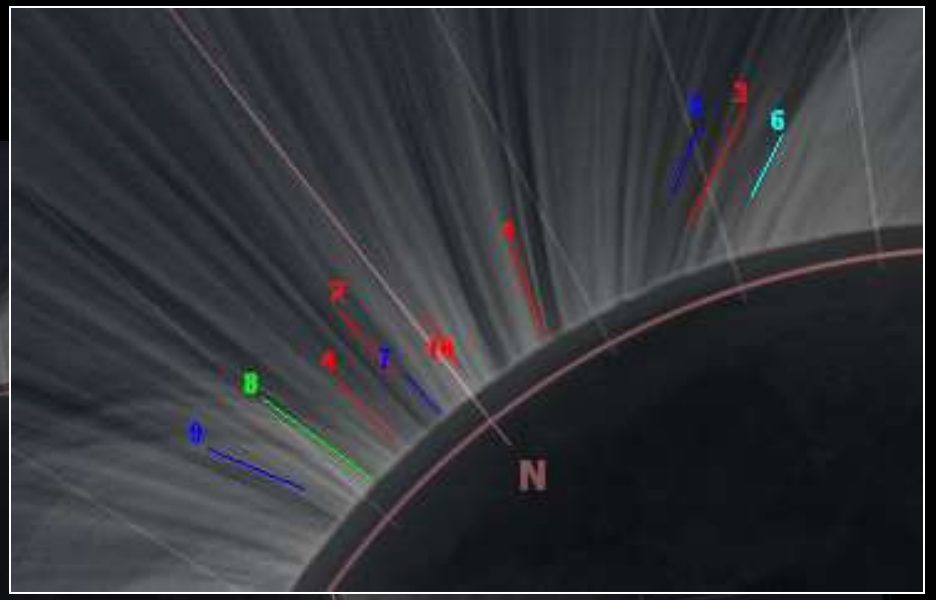


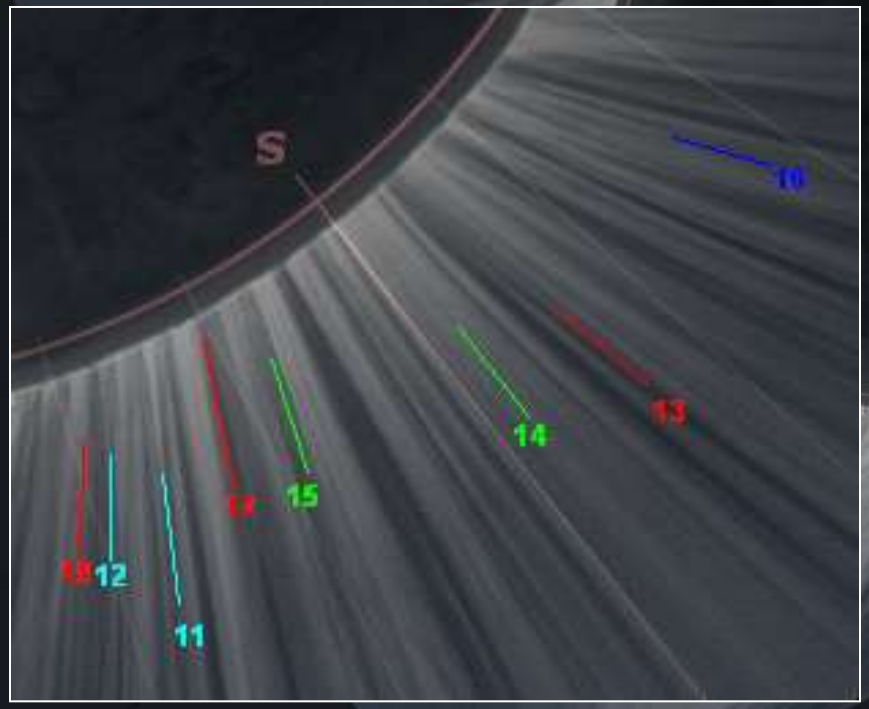
„Macrospicule“
at t_{init}-27min

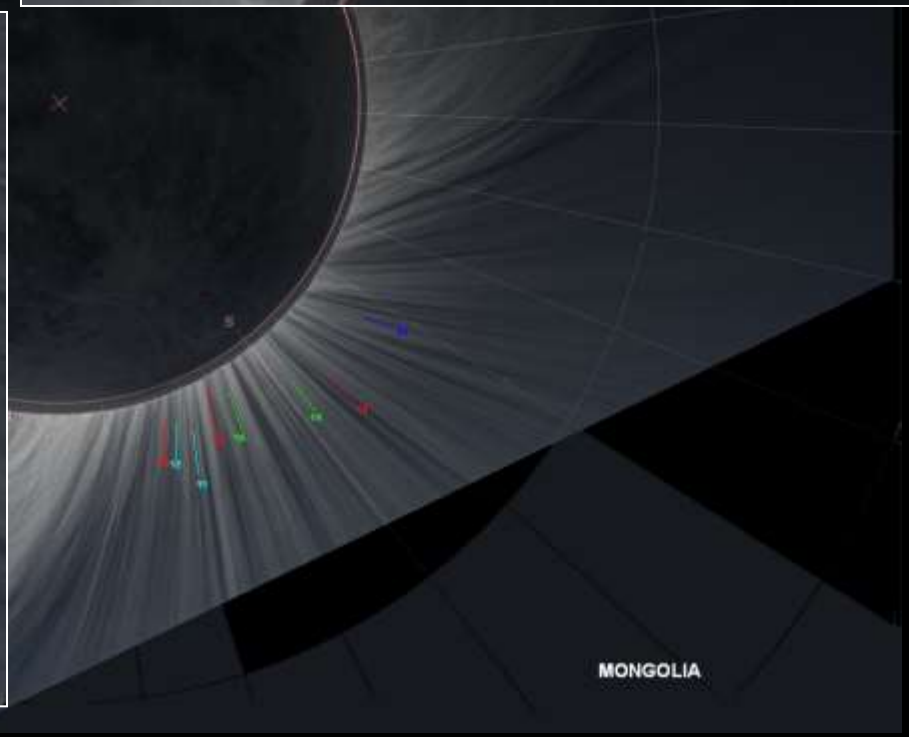
Dynamic of polar plumes



TSE 2008
WL polar plumes



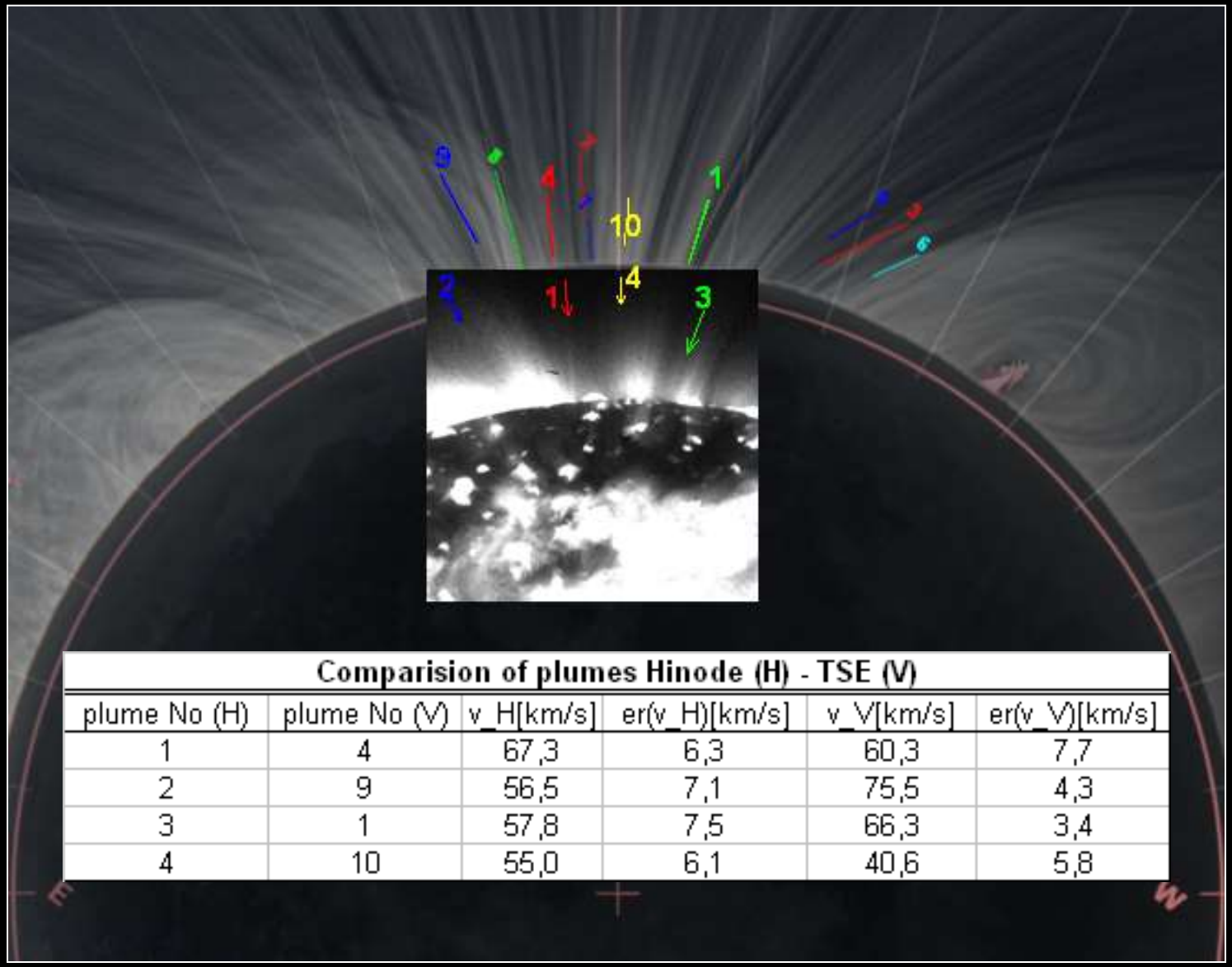




TSE 2008 - WL polar plumes

PLUME NUMBER	Speer [km/s]	Speed Error [km/s]	Type	Comments
1	66,3	3,4	N	
2	64,5	7,3	N	
3	62,8	6,1	N	
4	60,3	7,7	N	
5	51	13	N	?
6	33,3	2,0	N	?
7	40,5	2,4	N	?
8	74,1	5,0	N	
9	75,5	4,3	N	
10	40,6	5,8	N	?
11	89	27	S	
12	68,6	5,3	S	
13	66,5	8,3	S	
14	76,8	7,6	S	
15	75,2	7,0	S	
16	64,6	8,5	S	
17	87	11	S	?
18	56	11	S	

TSE 2008 - white-light & HINODE



Comparision of plumes Hinode (H) - TSE (V)					
plume No (H)	plume No (V)	v_H[km/s]	er(v_H)[km/s]	v_V[km/s]	er(v_V)[km/s]
1	4	67,3	6,3	60,3	7,7
2	9	56,5	7,1	75,5	4,3
3	1	57,8	7,5	66,3	3,4
4	10	55,0	6,1	40,6	5,8

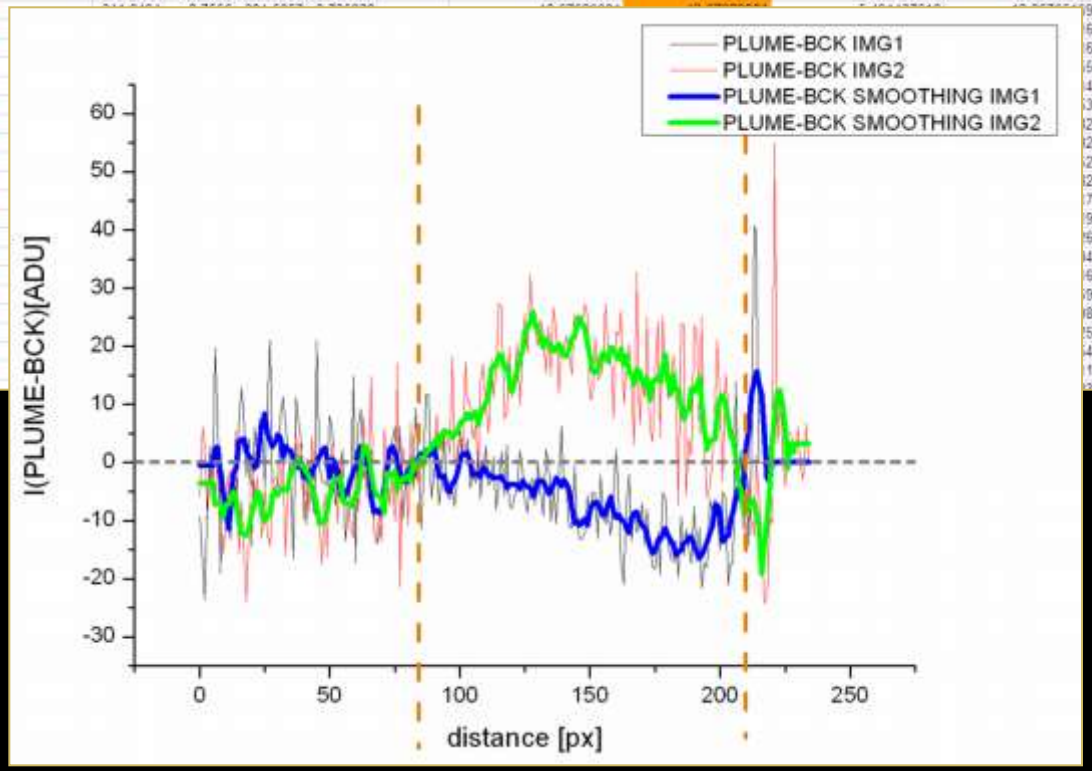
	px	km	
Solar radius	328.0349561	696740	
ΔSolar radius	0.593160367	110	

The time difference[s]	1147

	X	Y
Central point	1036	600

	PLUM1				PLUM2				PLUM3		
	px	km	km/s		px	km	km/s		px	km	km
AVERAGE	35.87625273	76091.11	66,33924	AVERAGE	34.90708	74035.57	64,54713756	AVERAGE	33.94091132	71986.38184	62
ERROR	1.749821668	3860.874	3,366063	ERROR	3.905093	8428.017	7,347878619	ERROR	3.240378365	7014.172636	6,
ERROR[%]	4.877381374	5.074014	5,074014	ERROR[%	11.18711	11.38374	11,38374047	ERROR[%]	9.54711656	9.743749369	9,

Measuer	Novosybirsk		Mongolia		Distance				Difference of far	Difference of far	Δ[Difference of far]	Δ[Difference of far][%]
Plume 1	x	y	x	y	N	ΔN	M	ΔM				
1	857	309	846	273	342.6981	2.754611	379.2005	2.737338	36.5023568	36.5023568	5.49194933	15.04546504
2	857	309	845	274	342.6981	2.754611	378.8469	2.739893	36.14881691	36.14881691	5.494503814	15.19967812
3	857	310	845	274	341.8494	2.7556	378.8469	2.739893	35.99755275	35.99755275	5.49549237	14.86366453
4	857	310	845	276	341.8494	2.7556	382.2944	2.736111	40.44500714	40.44500714	5.491710845	13.57821702
5	857	309	845	273	342.6981	2.754611	379.7078	2.736948	37.0096645	37.0096645	5.493559324	14.84368045
6	859	309	845	273	341.646	2.751386	379.7078	2.736948	38.06176674	38.06176674	5.490334151	14.42480111
7	857	310	846	275	341.8494	2.7556	377.4772	2.739239	35.62776959	35.62776959	5.494838182	15.42290816
8	857	310	844	268								
9	857	310	846	275								
10	857	310	846	276								
11	858	310	847	274								
12	857	309	846	276								
13	857	310	845	274								
14	858	310	846	274								
15	857	310	847	275								
16	857	310	846	276								
17	858	310	846	275								
18	857	309	844	273								
19	858	309	848	276								
20	857	310	848	275								
21	857	309	845	275								
22	857	310	846	275								
23	857	310	845	275								
24	858	310	847	275								
25	857	311	846	273								
26	857	309	845	275								
27	856	310	847	277								

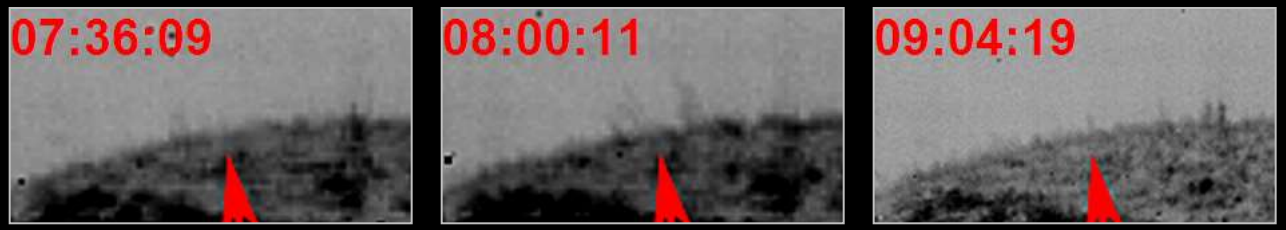


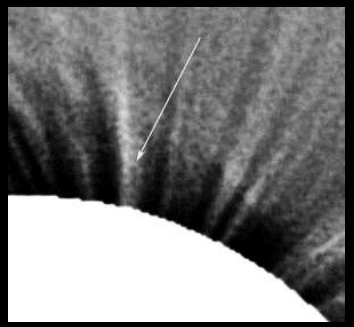
„Statistic“ of observed plumes

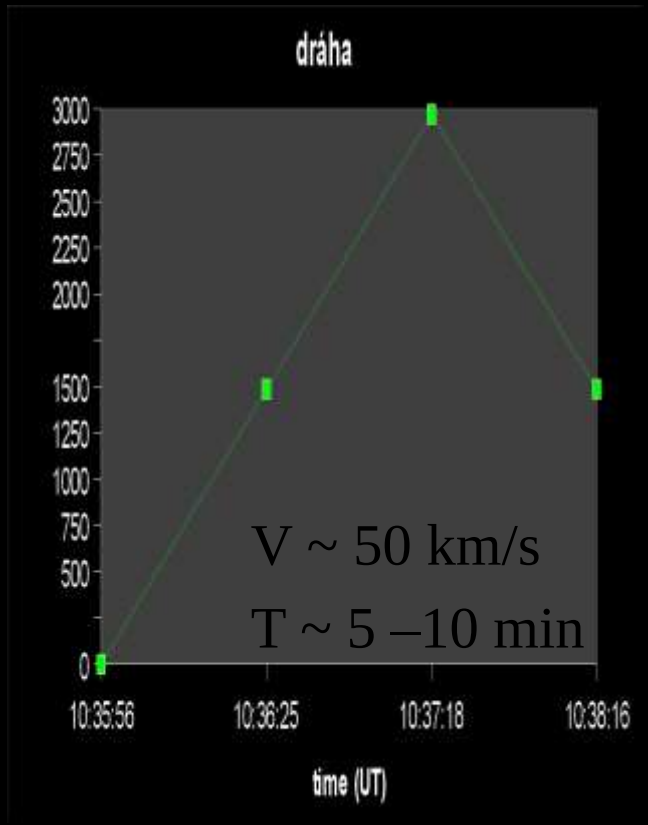
Plume location	average speed [km.s^{-1}]	minimal speed [km.s^{-1}]	maximal speed [km.s^{-1}]
both regions	67	32	146
north region	68	33	146
south region	66	32	90

There were analyzed 3 plumes on 2006, 18 plumes in 2008, 14 plumes in 2009 and 8 plumes in 2010 total solar eclipse pictures. There is perceptible an unexpected amount of dynamic plumes observed during the 2006 total solar eclipse and smaller amount of them during 2010 eclipse in opposite to the observed amount of plumes exhibited some dynamic. The reason of this disproportion is not known now. We suppose that it is because of less quality of primary data (eclipse pictures). On the other hand we could not exclude the possibility of some dependence of plume dynamic on solar cycle, because the 2008 and 2009 total solar eclipse occurred during the minimum of solar activity. The 2006 and 2010 total solar eclipse occurred during declining and growing phase of this cycle.

Release mechanisms – eruptive spicule or macrospicule





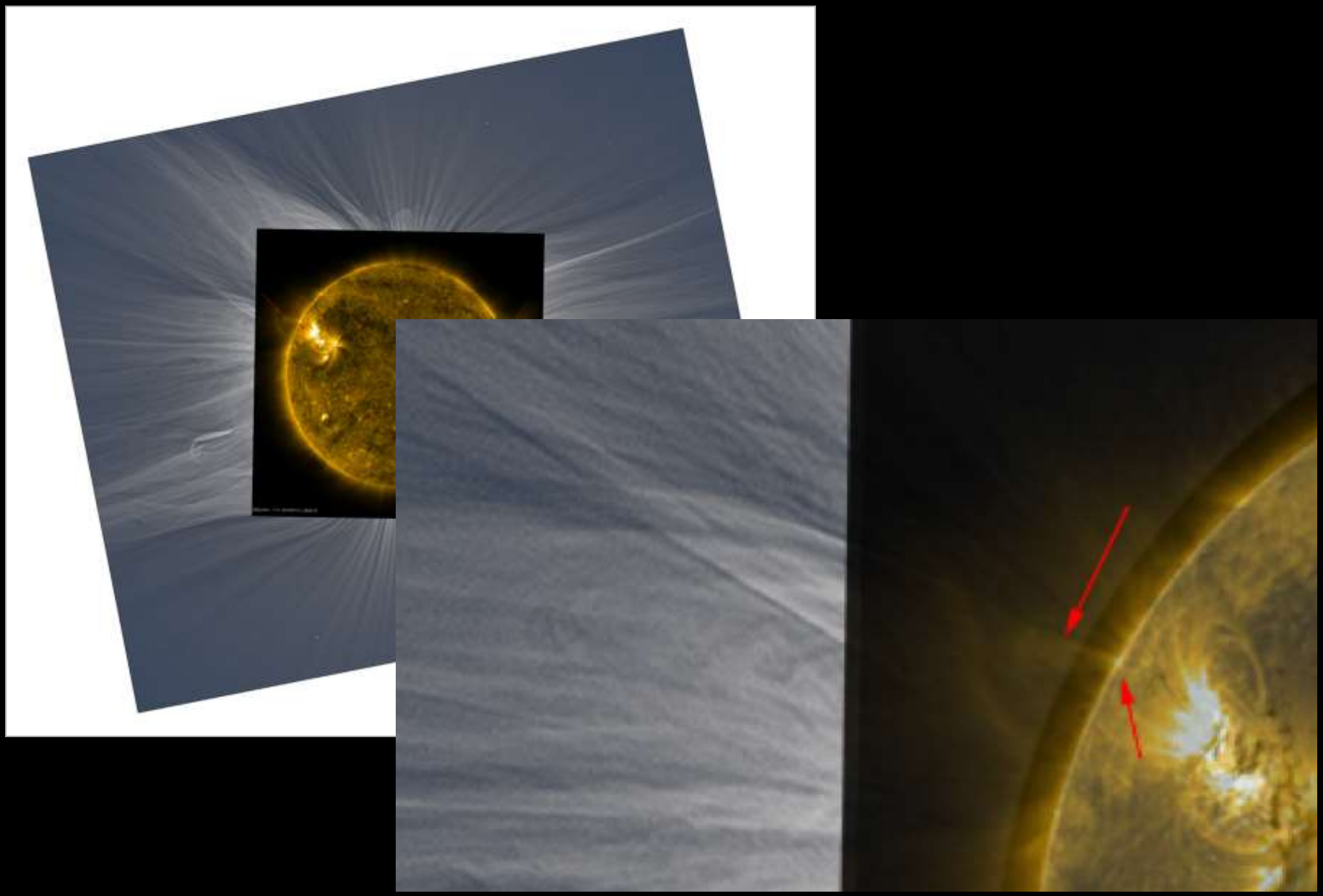


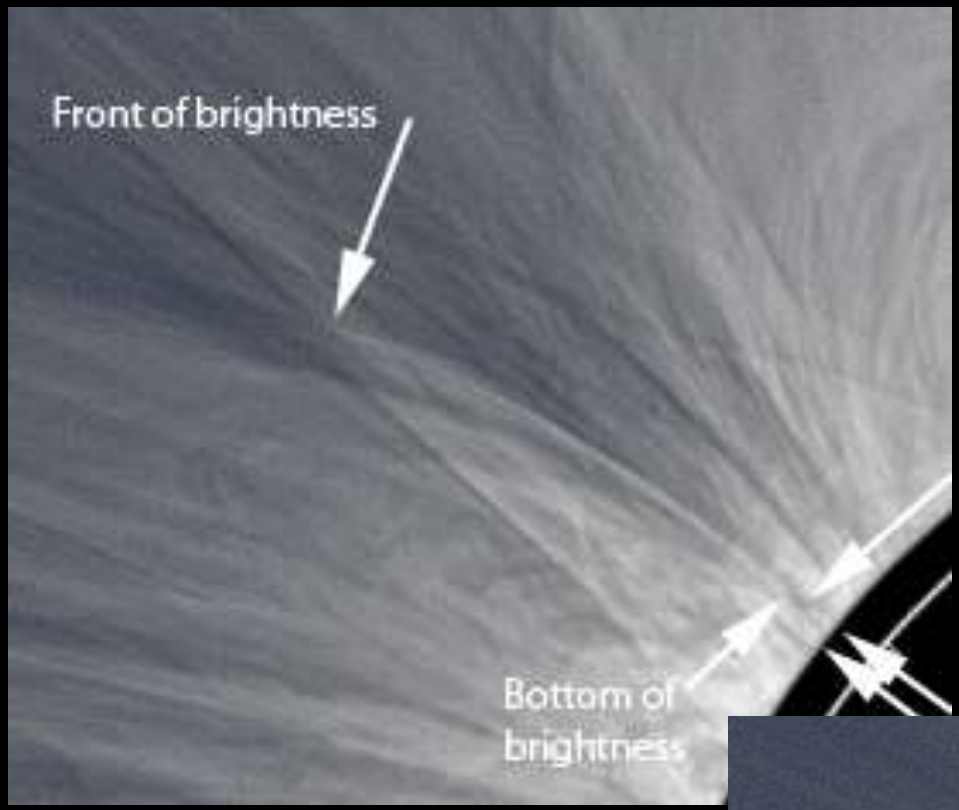
These data, presented in this paper, well correspond for example with the data from spectroscopic measurements from SOHO/SUMER that at the heights of 1.05 -1.35 solar radii the plume velocities are in excess of 60 km/s and are approximately constant throughout this height region (Gabriel, Bely-Dubay, and Lemaire, 2003).

Following the analysis done in this paper and in according with our knowledge about the plumes, spicules and macrospicules characteristics ((Yamauchi et al., 2005) for example) we would like to formulate the assumption, that observed dynamic in polar plumes should be in good correspondence with the spicule and the macrospicule erupting activity on their foots base.

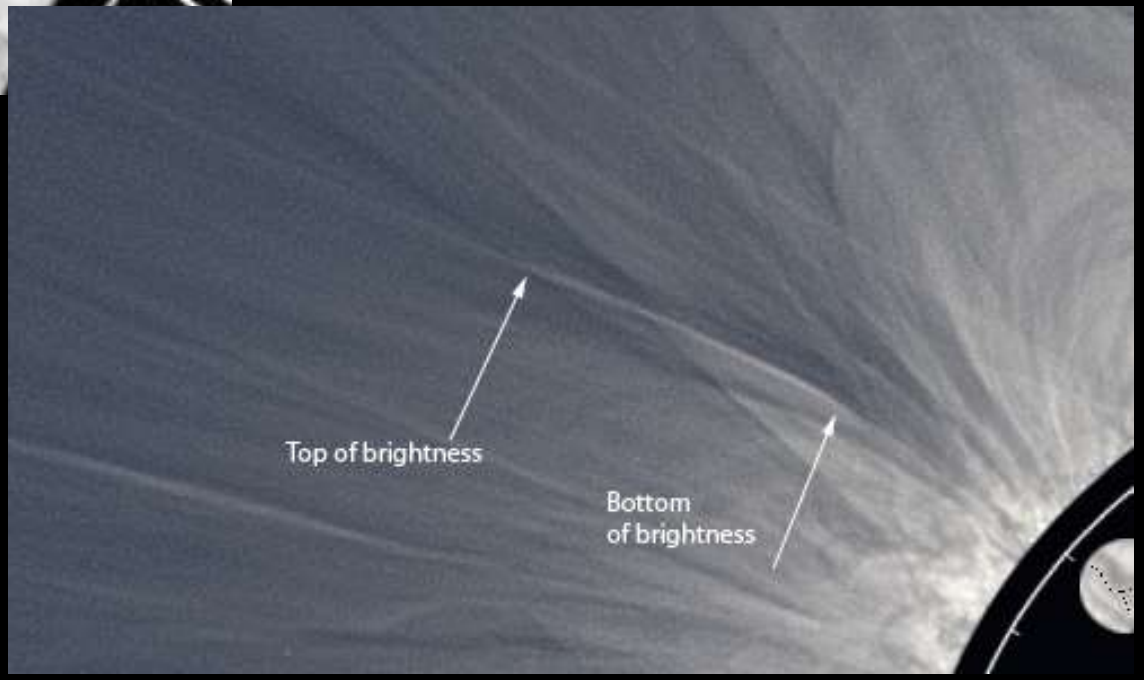
The observed speeds, presented in this paper, corresponds very well the data obtained by DePontieu and others based on the SOT observations of spicules. The second type of spicules, reported in the paper (DePontieu et al., 2007), is very dynamic. The authors measured the speed of sending material through the chromosphere order 50-150 km/s. Similar results are described in the work of Karovska and Habbal (Karovska and Habbal, 1994). In our previous studies of polar plumes during observed during 2006 total solar eclipse we described not only the dynamic outow (Pasacho et al., 2008), but also the twisting moving of the plume (Belik et al., 2008). The twisting speed of the plume v 50 km/s well correspond with the dynamic properties of dynamic macrospicules (Parenti, Bromage, and Bromage, 2002).

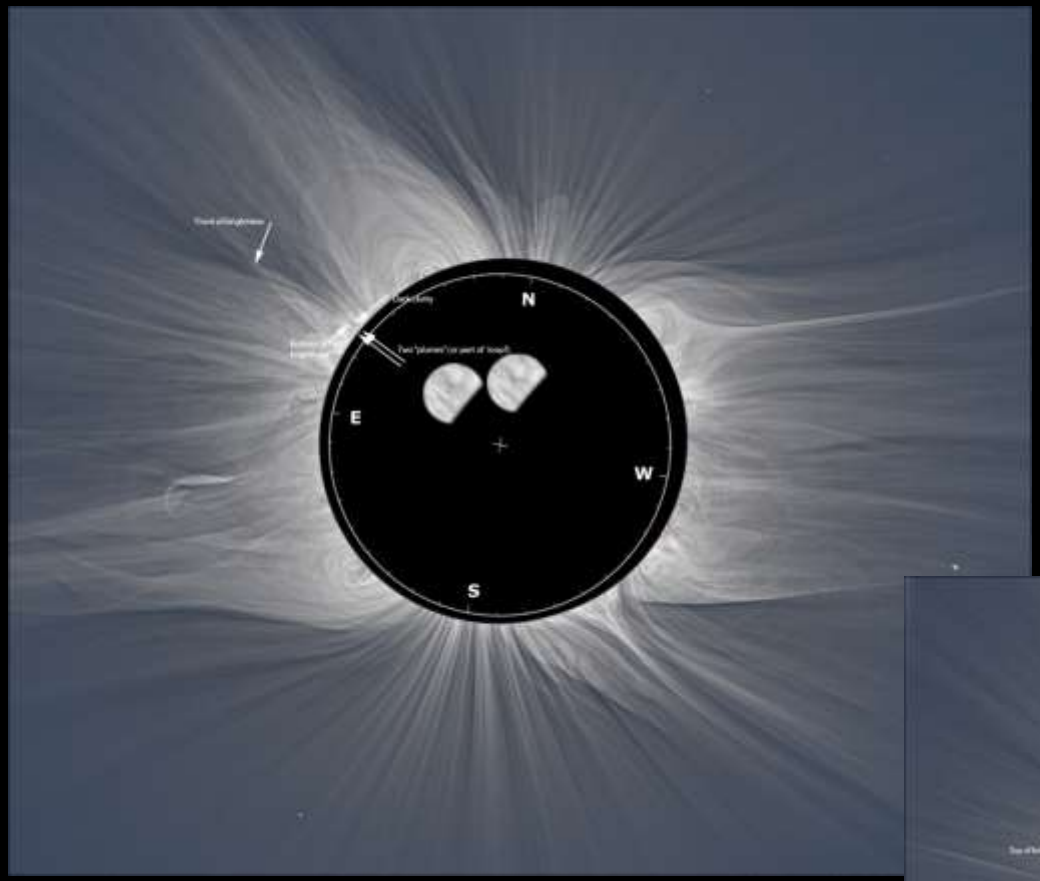
Low-altitude plumes

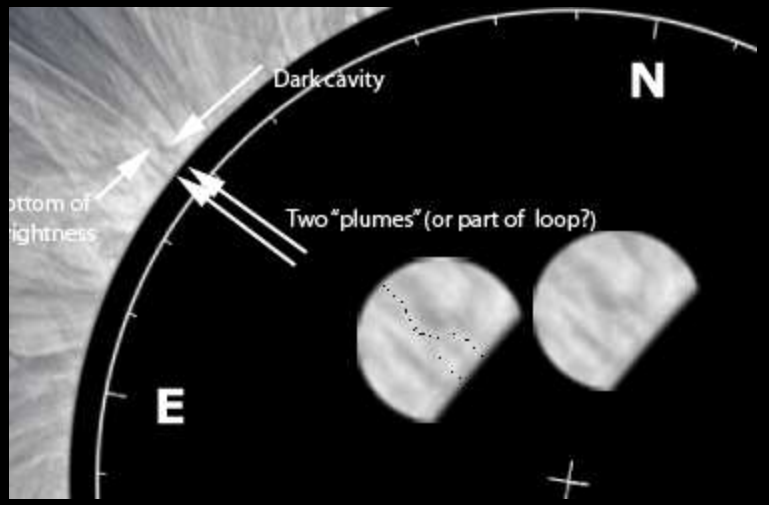


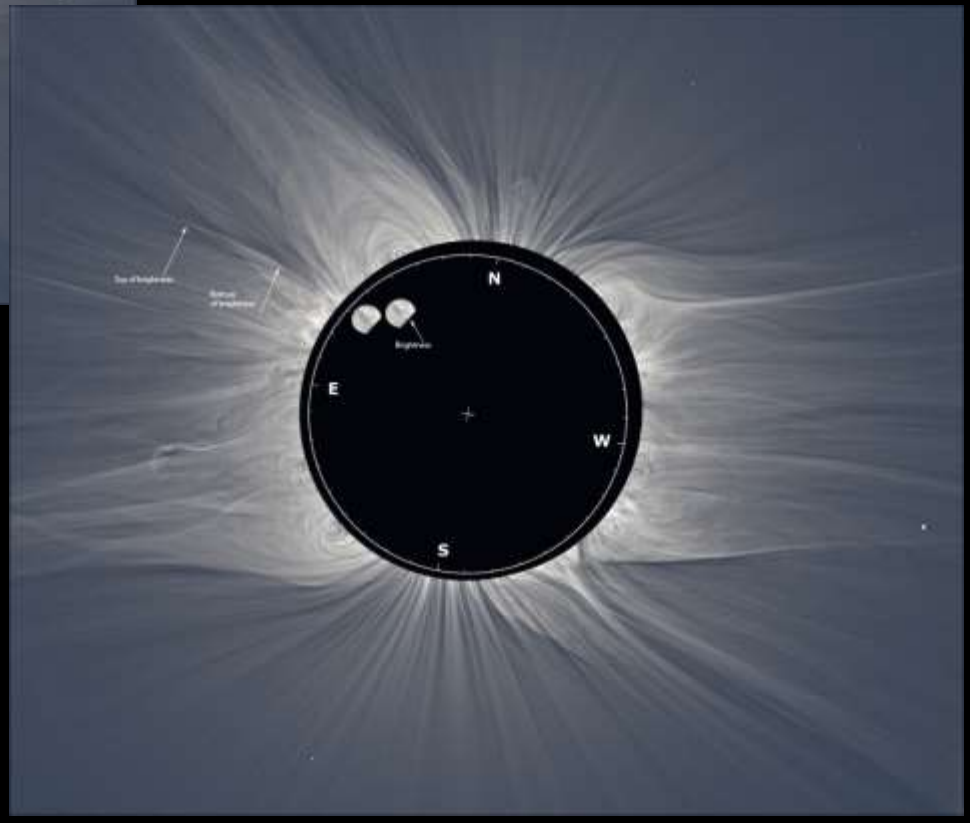

Front of brightness
Bottom of brightness

v 50 km/s


Top of brightness
Bottom of brightness


N
E
W
S


Dark cavity
N
ttom of
ightness
Two "plumes" (or part of loop?)
E


N
E
W
S

Outer corona and its connection with the „zodiacal light“

Absolute photometry of corona


THANK YOU FOR YOUR ATTENTION