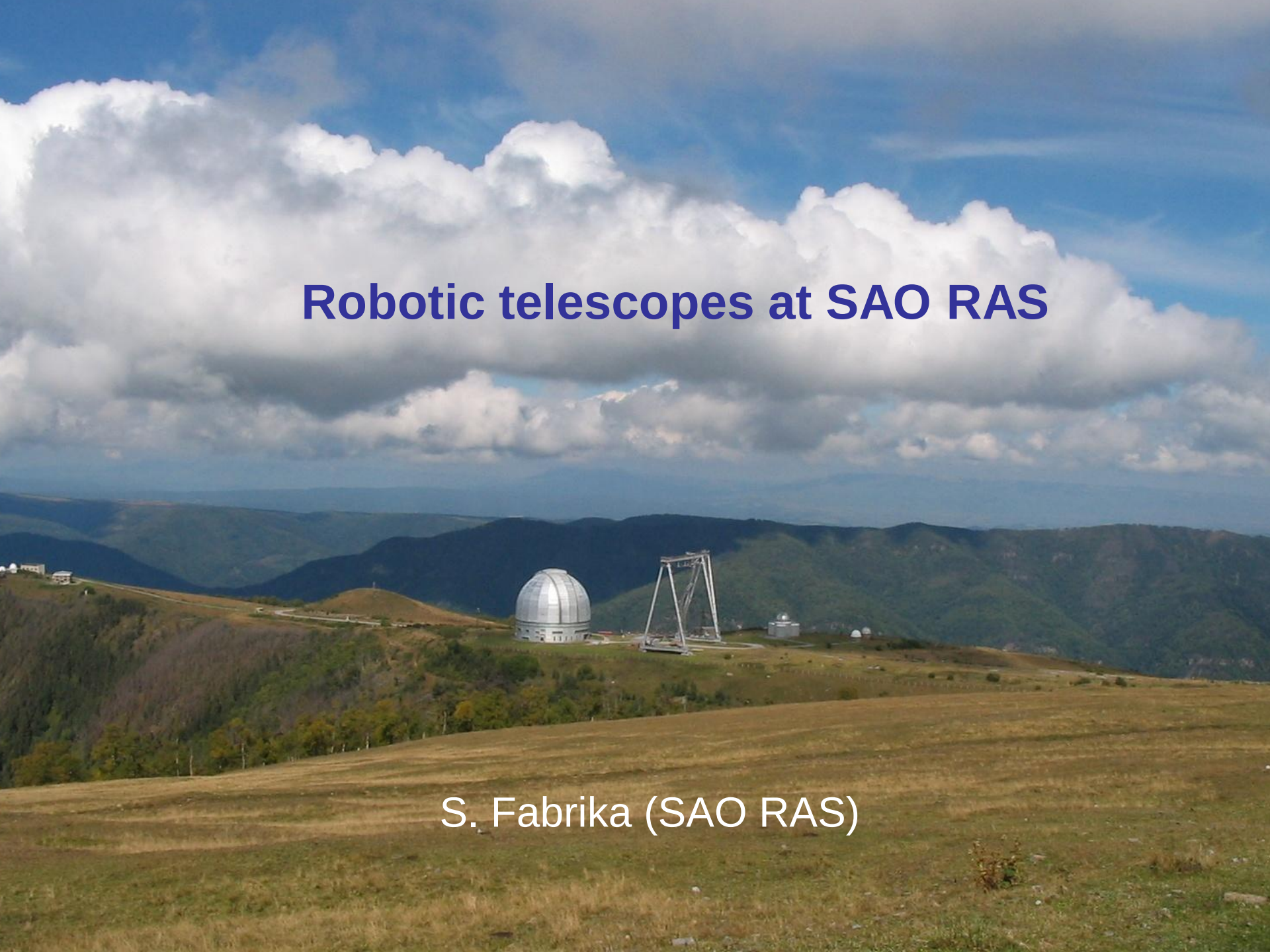


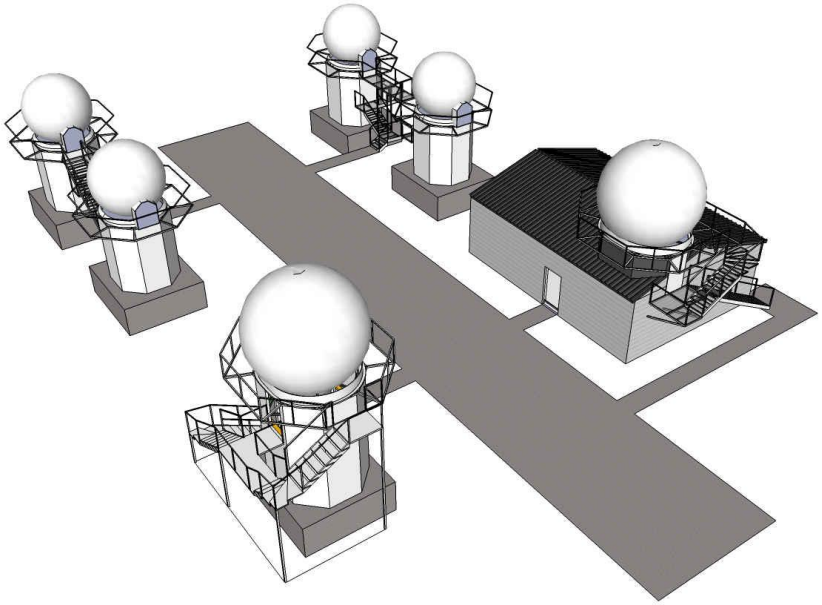
Robotic telescopes at SAO RAS

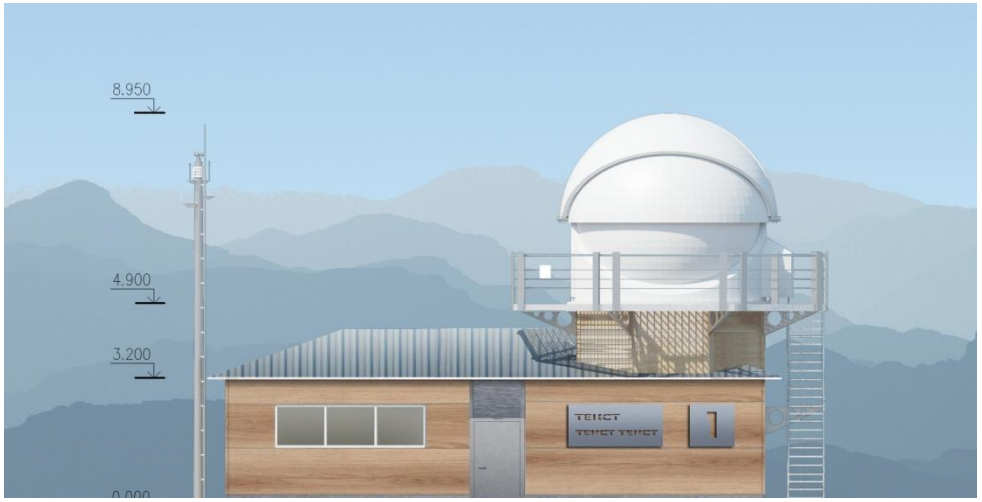
S. Fabrika (SAO RAS)

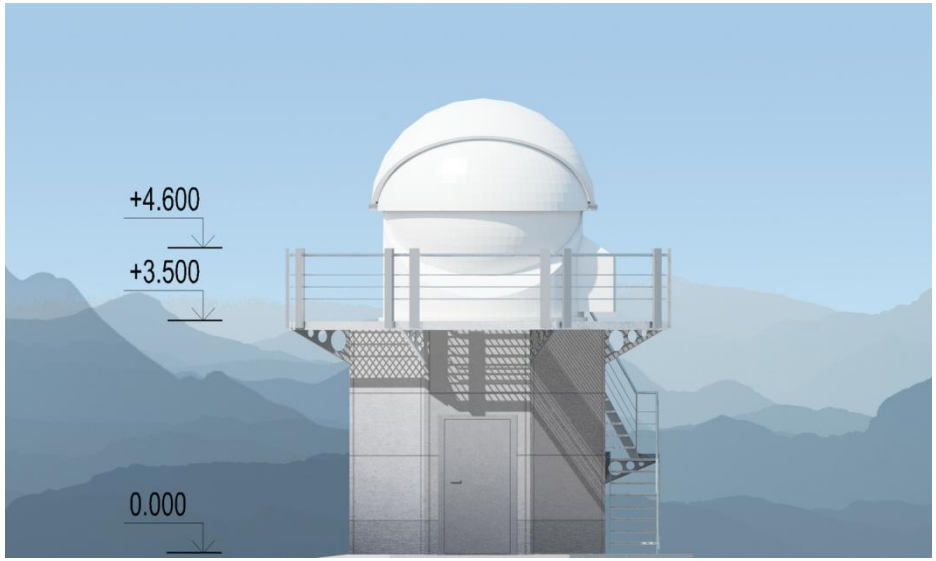
General view

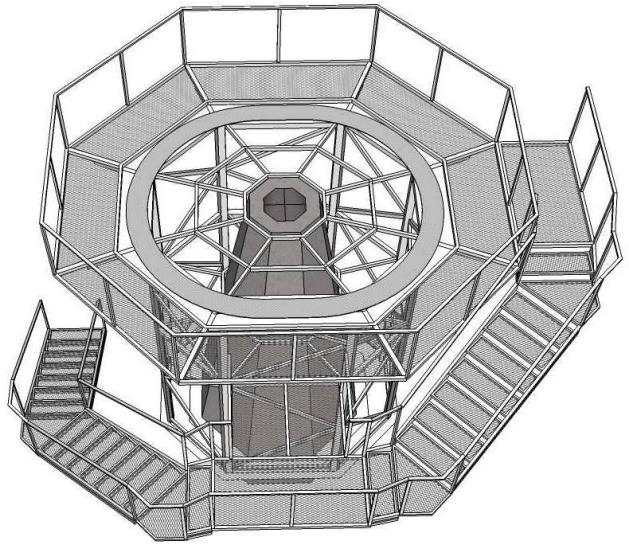
Conceptual plan

Court, observatory building, domes









Construction site and telescopes on 16.09.2017

October 10, 2017

Officiality (11.10.2017)

Six telescopes 0.5-m Ritchey-Chretien (“Astrosib”, Novosibirsk)

First 2 telescopes with tuneable foci

FOV (F/2.7 Prime Focus) 2° x 2°; FOV (F/8) 40’ x 40’

Others with F/8 only

Mounts for fast pointing (10 Micron Mount GM 4000 HPS)

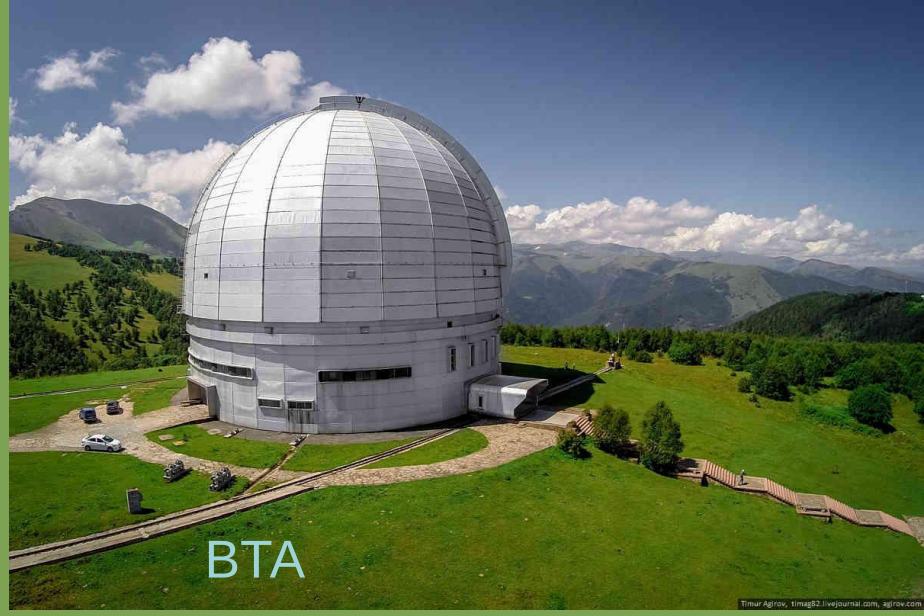
First 2 telescopes

Other mountings with (“Astrosib”, Novosibirsk)

CCD with electron cooling 4K x 4K, pixel size 9 μm

Broad filters

SDSS ugri и системы UBVRcIc with analyzers circular and linear polarization



Main goals is
a search signals from the space
gamma-ray bursts (GRB) and
fast radio transients (FRB)

Instantaneous transfer to the BTA (6-m) telescope

- GRBs with space Swift observatory:

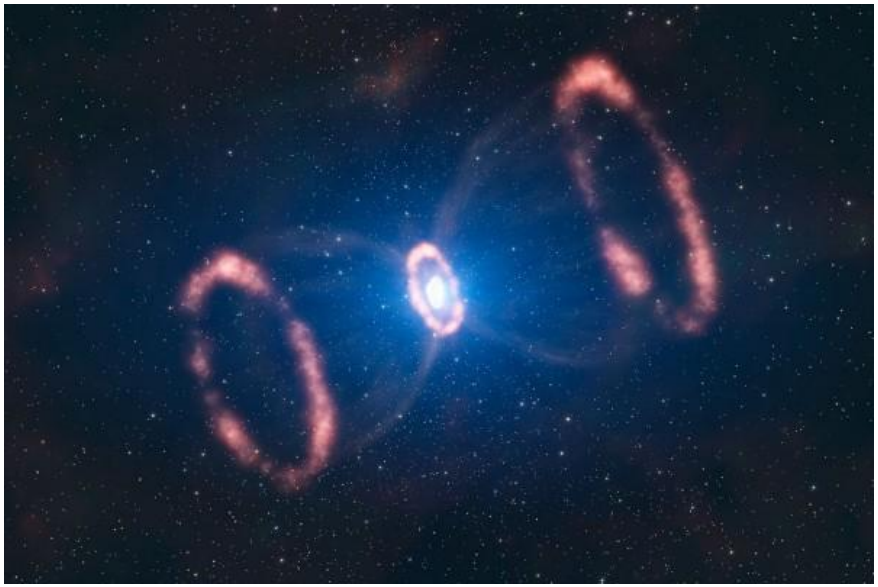
  small robotic telescopes (SRTs) find a signal in optical,
  transfer to the BTA for spectroscopy,
  SRTs continue observations (photometry, polarimetry, spectroscopy).
  In optical range the GRB may weaken on 5 mag for a few hours.

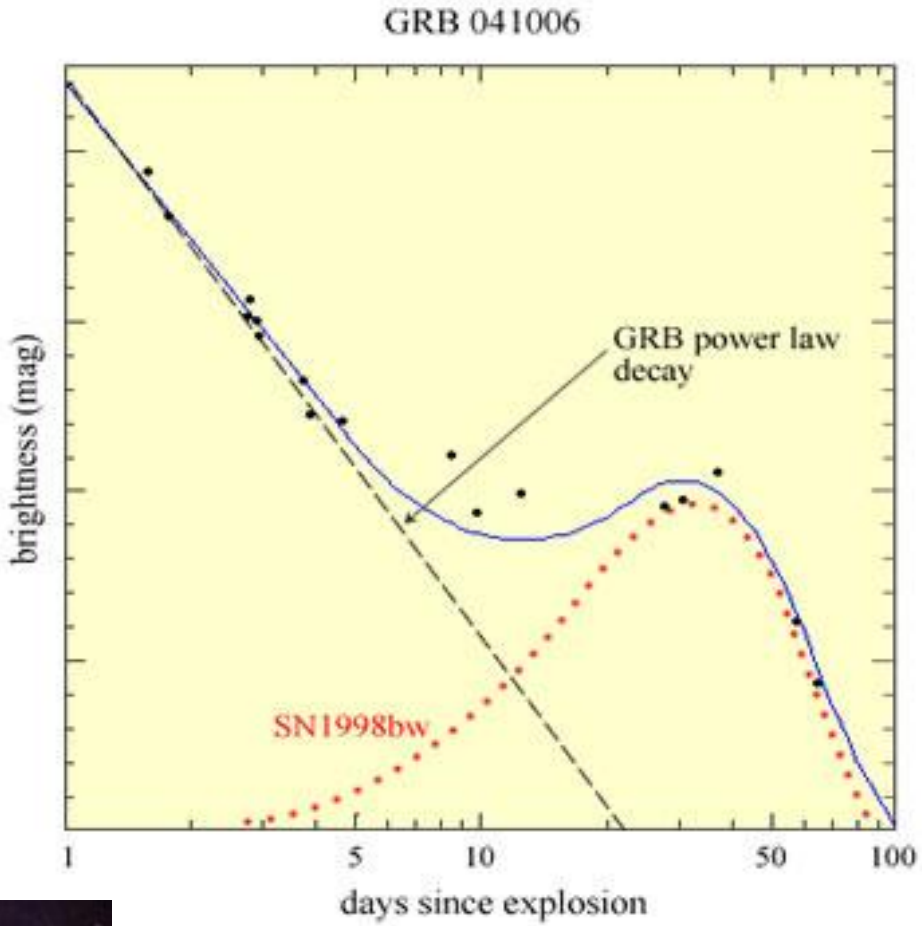
  For 20-years history there were found more than 4000 GRBs, several hundreds were found in optical, less than 100 spectra were obtained. One spectrum taken less than one hour, several others in a few hours, others with a big delay.

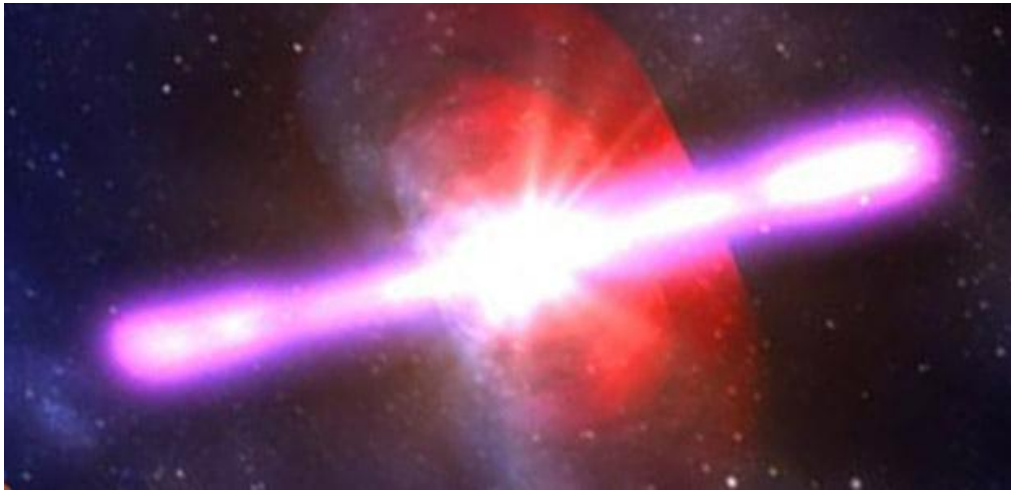
- FRBs from RATAN-600 :

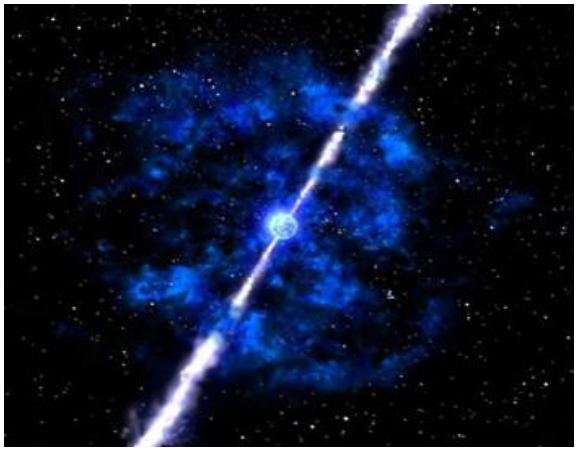
  a new project, with RATAN-600 we expect about 8 FRBs per year.
  Fast transfer from the radio telescope to SRTs in 2-3 minutes. If we keep one SRT in the same position as RATAN-600, we may find optical signal in the same moment. Transfer to the BTA for spectroscopy (if we find).
  There are 21 FRBs now, they appear as a several tens Jy with a width (FWHM) less than 10 ms. It is a luminosity of a bright QSO.

  For several years only 21 FRBs were detected, no one has been detected in optical (a delay of several days).

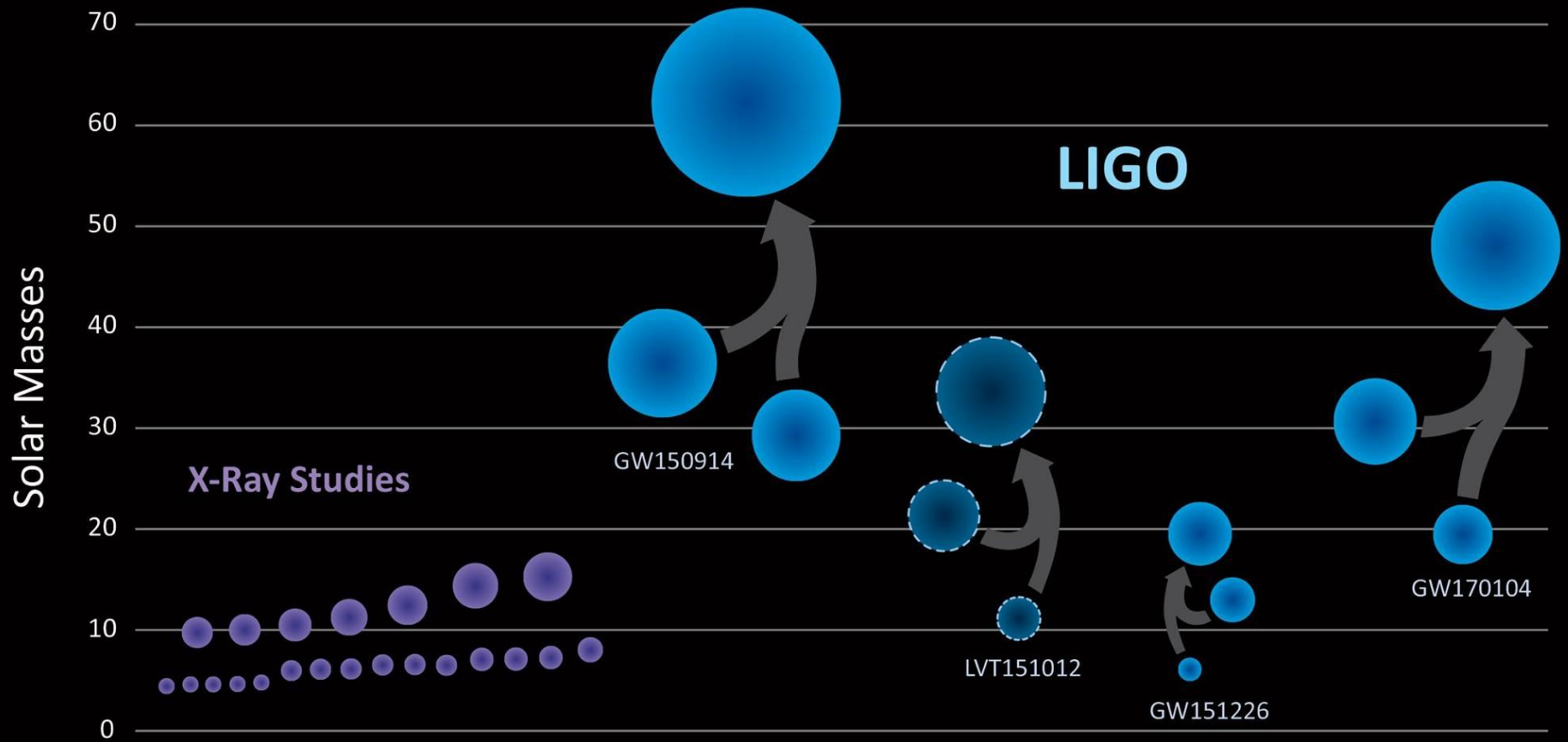



GRB 041006
brightness (mag)
GRB power law
decay
SN1998bw
1
5
10
50
100
days since explosion

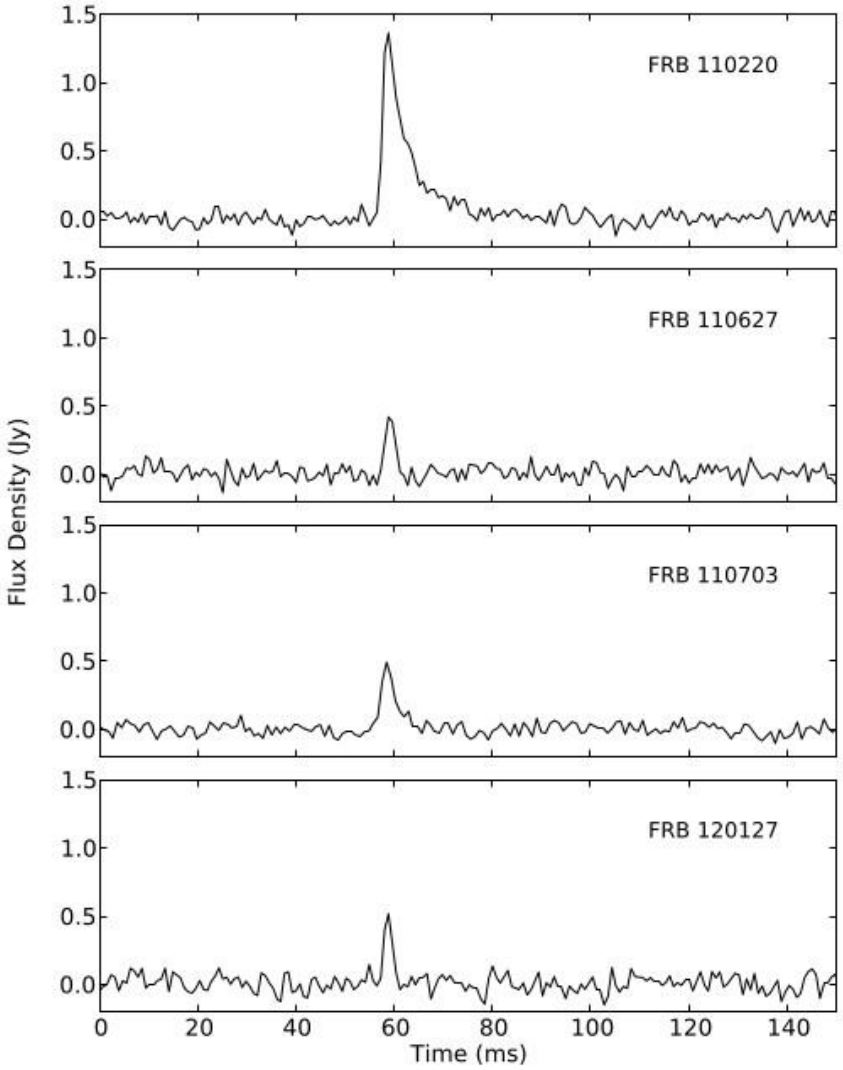




Black Holes of Known Mass



Parkes (1.38 GHz):



944

723

1104

553 DM pc cm^{-3}

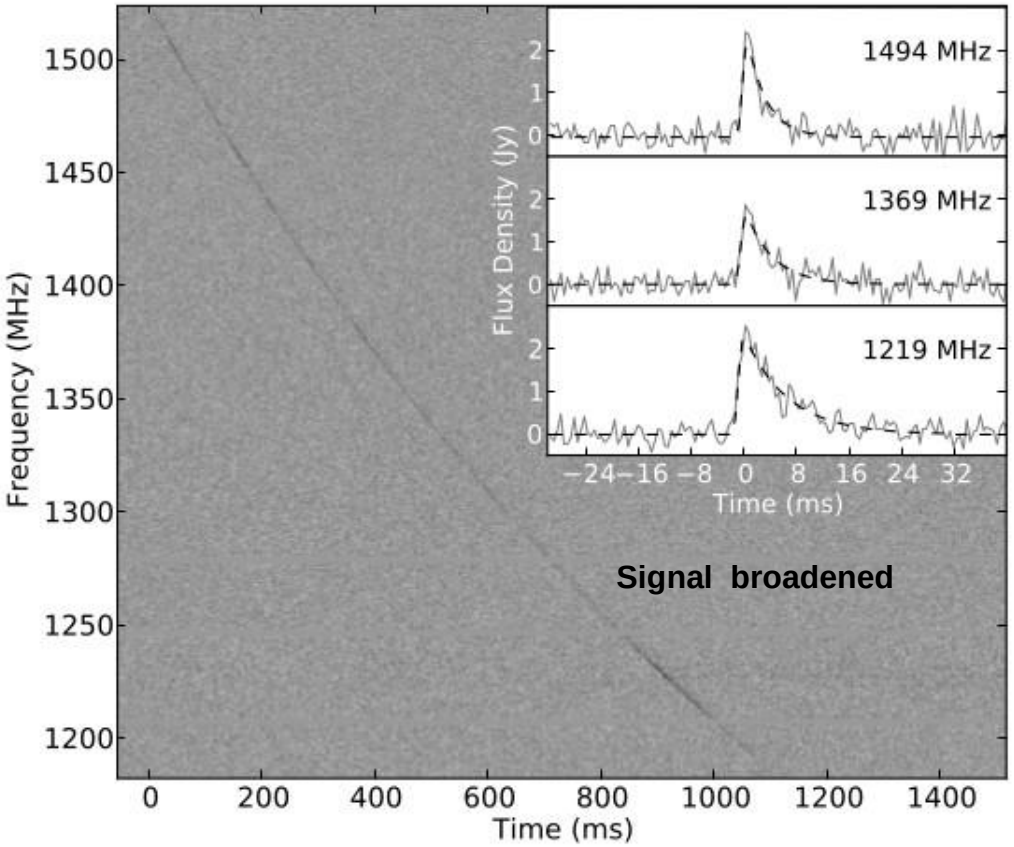
Thrompton+13

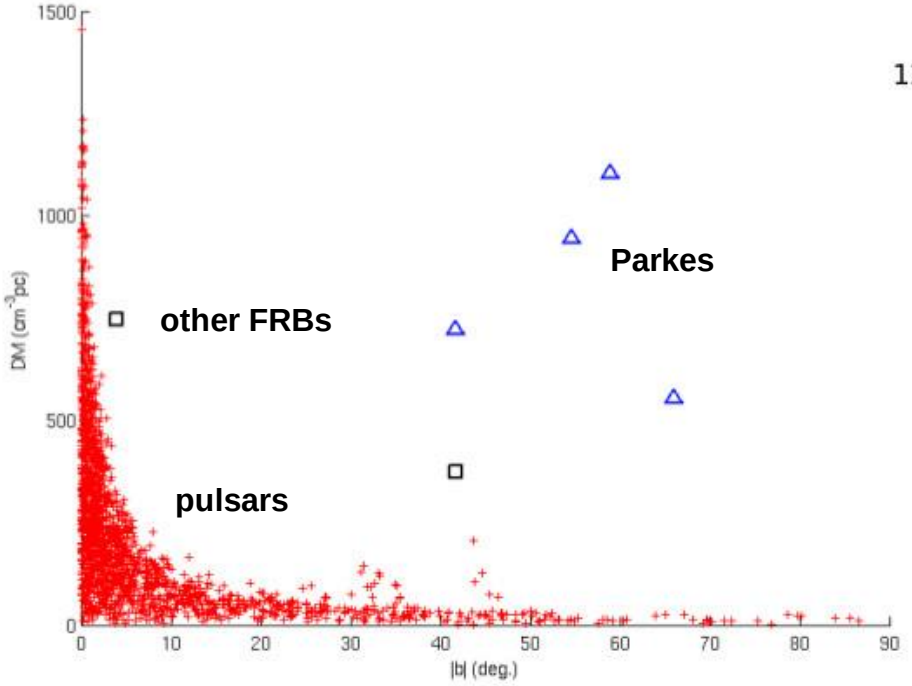
$\Delta T = 4.15\ 10^6\ (1/f_1^2 - 1/f_2^2)\ DM$

ΔT ms, f MHz, DM pc cm^{-3}

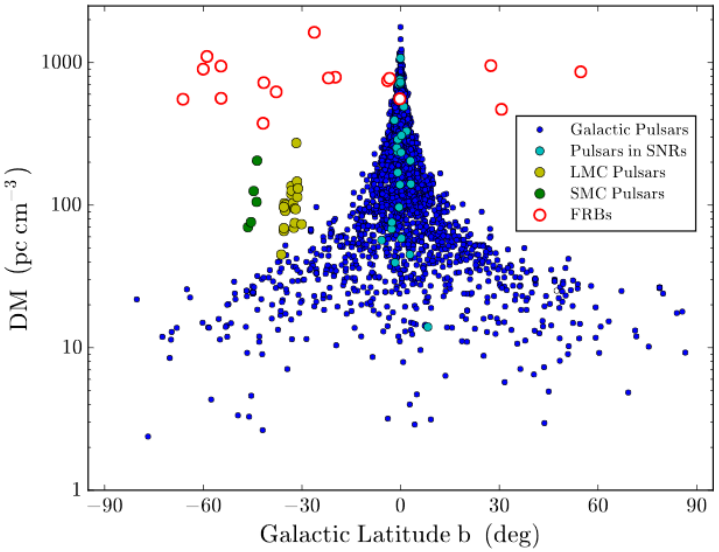
Parkes: 10000 FRBs / 4π day

More accurate estimate:
(Parkes: Keane, Petroff (2015):
2500 FRBs / 4π day



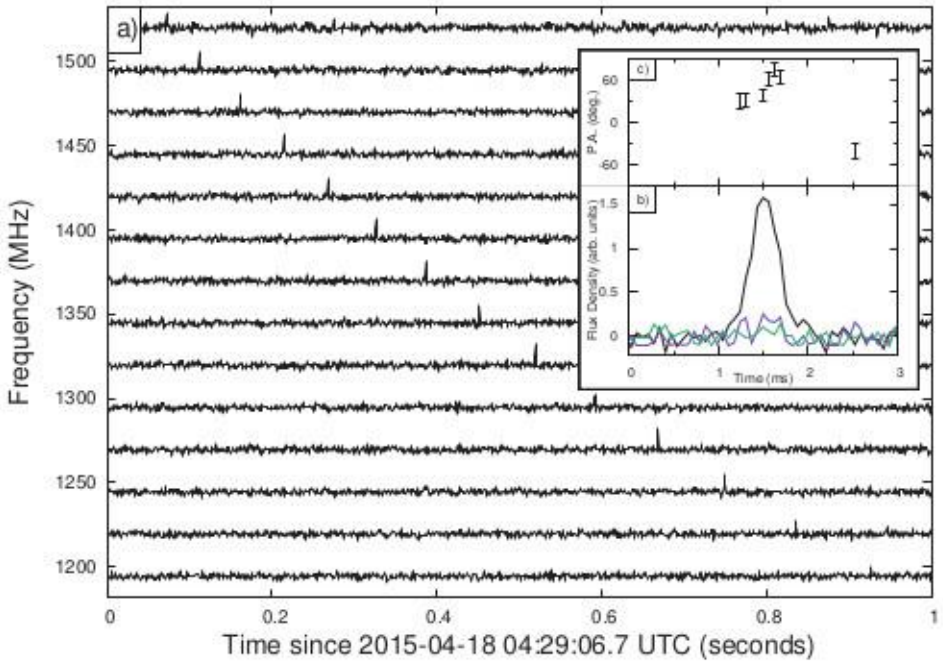


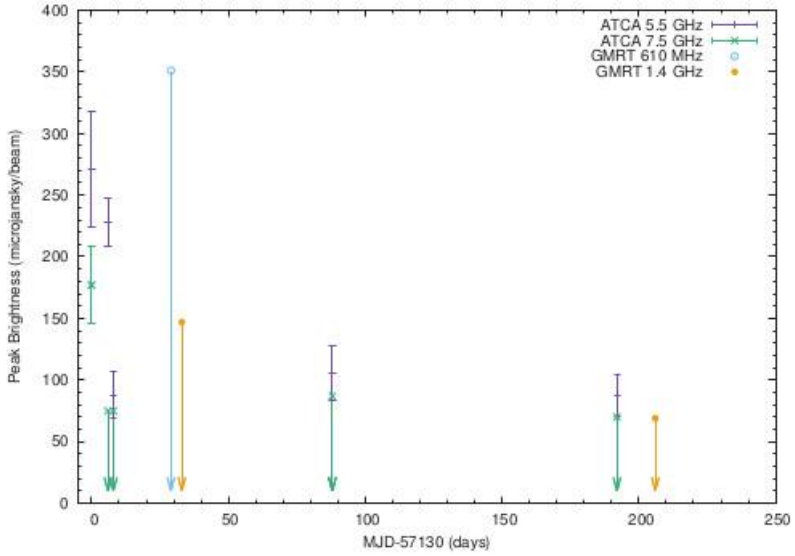
Thrompton+13

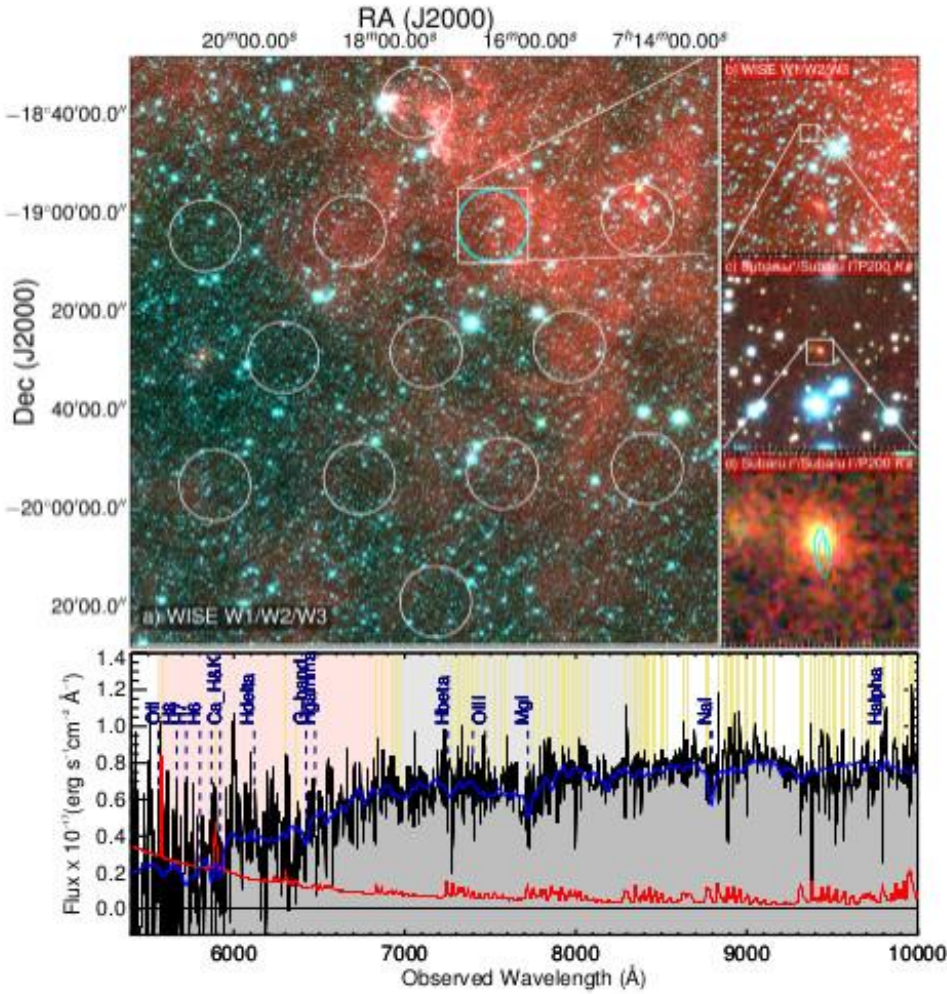


Cordes+16

Keane+16 (Parkes)



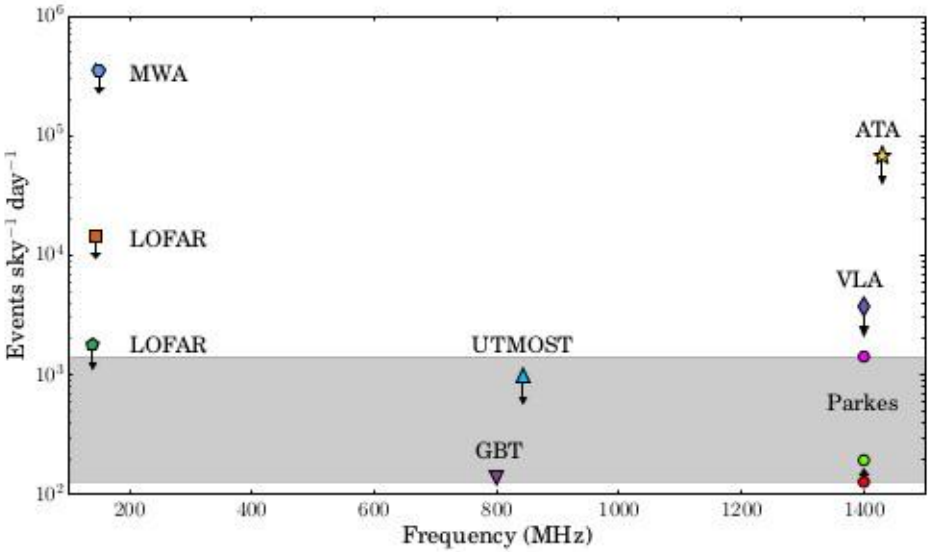




18.04.2015: FRB 150148 (DM776)

spectrum Subaru/FOCAS 18.04.2015
later: Keck, Swift, Palomar (empty)

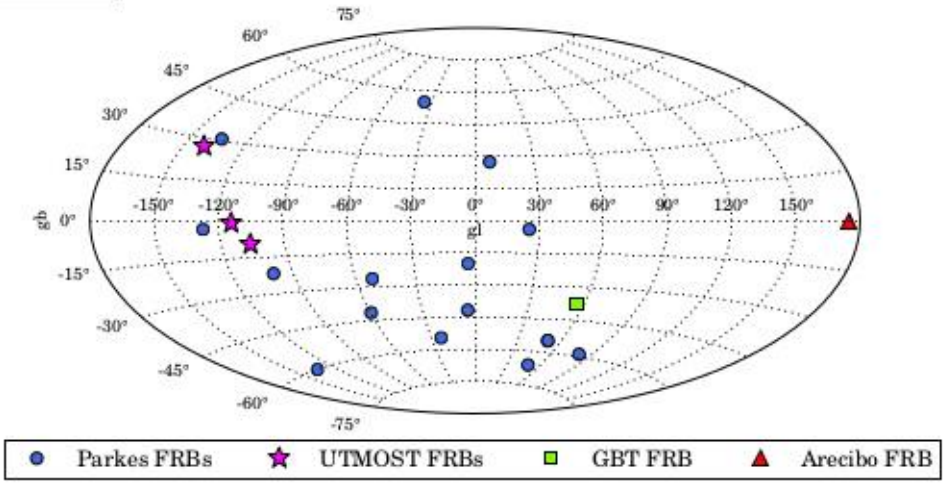
a – burst, b – intensity, curcular and linear polarization, c – position angle



- Upper limit of 48 events at 440 Jy ms at 1.4 GHz scaled to 11 Jy ms (Siemion et al. 2012)
- Rate of 10^4 events at ~3 Jy ms at 1.4 GHz scaled to 11 Jy ms (Thornton et al. 2013)
- Lower limit of 10^4 events above 0.6 Jy ms at 1.4 GHz scaled to 11 Jy ms (Thornton et al. 2013)
- Upper limit of 150 events at 71 Jy ms at 140 MHz scaled to 11 Jy ms (Coenen et al. 2014)
- Upper limit of 29 events at 310 Jy ms at 145 MHz scaled to 11 Jy ms (Karastergiou et al. 2015)
- Rate of 2500 events above 2 Jy ms at 1.4 GHz scaled to 11 Jy ms (Keane & Petroff. 2015)
- Upper limit of 7 x 10^4 events at 0.9 Jy ms at 1.4 GHz scaled to 11 Jy ms (Law et al. 2015)
- Rate of 5000 events above 1 Jy ms at 800 MHz scaled to 11 Jy ms (Masui et al. 2015)
- Upper limit of 700 events at 700 Jy ms at 150 MHz scaled to 11 Jy ms (Tingay et al. 2015)
- Upper limit of 10^3 events at 11 Jy ms at 843 MHz (This work)

Caleb+16, the UTMOST
(Molongo ObservatorySynthesis Telescope)

Caleb+17: 3 FRBs 843 MHz (DM 278-1165)
R > 11 Jy ms > 78 / 4π day
100 times higher than Parkes
(after recalculation)




Western sector

RATAN-6000 radio telescope

4.7 GHz – 3mK per 1 sec and for 1500 m^2 for 10 mJy per 1 sec or 1 Jy for 10 ms

FOV (one beam) 35’ x 1.5’: Western sector (24 hours) 2-10 FRB/year.

4 radiometers (already done) for focal line of secondary mirrow

Total band 4.4-5.0 GHz with 4 subbands (150 MHz) with microwave filters (Micran, Tomsk, Russia)

$\Delta T = 4.15\ 10^6\ (1/f_1^{\,2} - 1/f_2^{\,2})\ DM$, ($\Delta T$ ms, f MHz, DM pc cm^{-3})

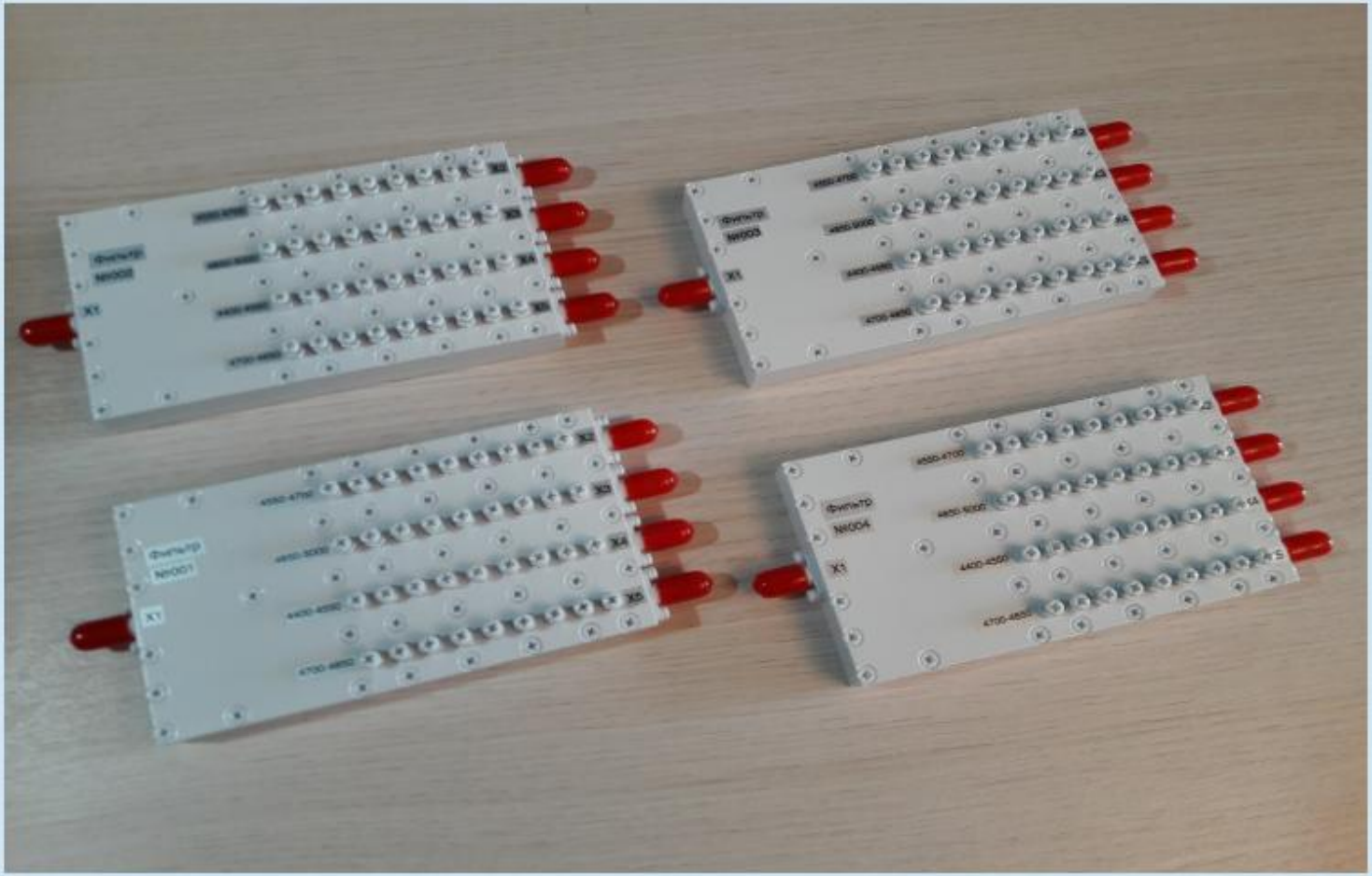
f_1 = 4475 МГц f_2 = 4625 МГц f_3 = 4775 МГц f_4 = 4925 МГц

0.0132 DM = 3.96 DM_{300}ms **0.120 DM = 3.60 DM_{300}ms** **0.0109 DM = 3.27 DM_{300}ms**

the delay between subbands

Scattering within subbands (dispersion) $8.3\ 10^6\ (\Delta f/f^3)DM = 1.92\ DM_{300}$ ms

Four-channel filters devide total 600 GHz band (4700 MHz) on the four 150 MHz.



Exoplanet search

First two telescopes have FOV 2 degrees, a star fits in one pixel

Others FOV 40', a star fits in 3 pixels (PSF photometry)

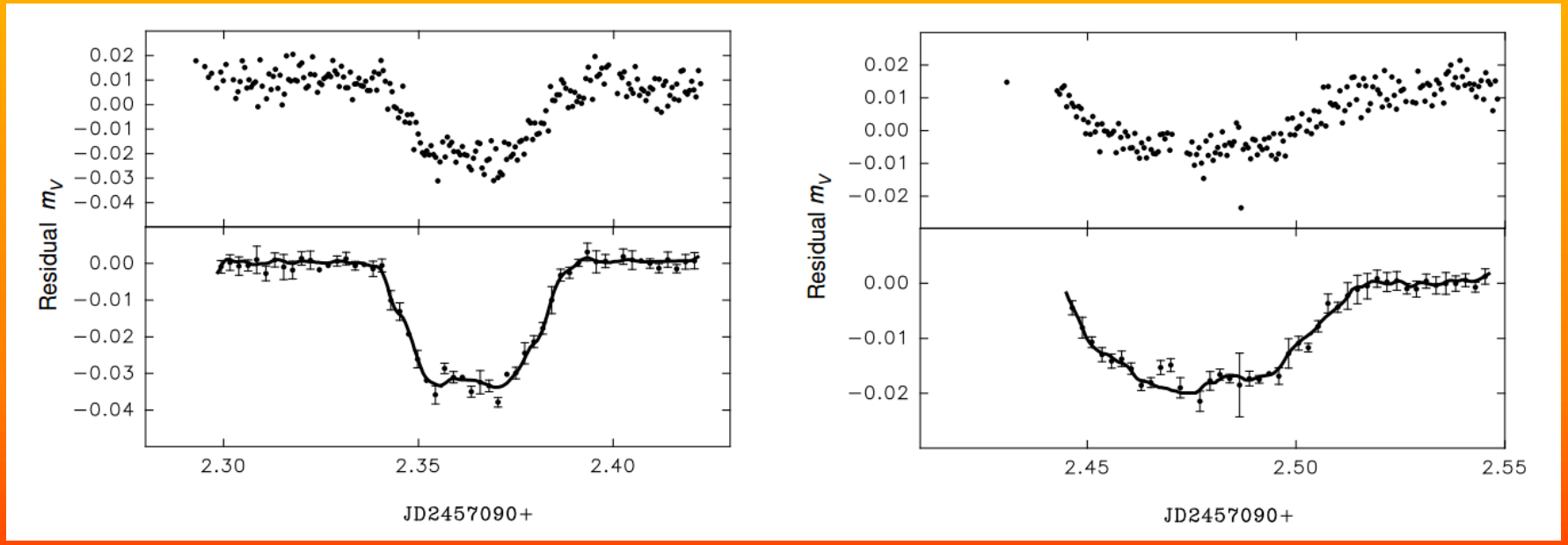
We may find potential exoplanet transits in 2^{o} and a more detail information in 40'

Accuracy of the photometry with 0.5-m telescope for 12 mag star is about 0.001 mag.

At present about 3500 exoplanets were discovered, about 100 in habitable zone, about 20 of them are Earth-like.

Research highligths for two years of the program.

Photometry with 1-m class telescopes



Observations for other astronomers:

Cataclismic variables, other variables, QSO/ANG, magnetic stars with spots, magnetic white dwars, Novae, Supernovae, space debrits.

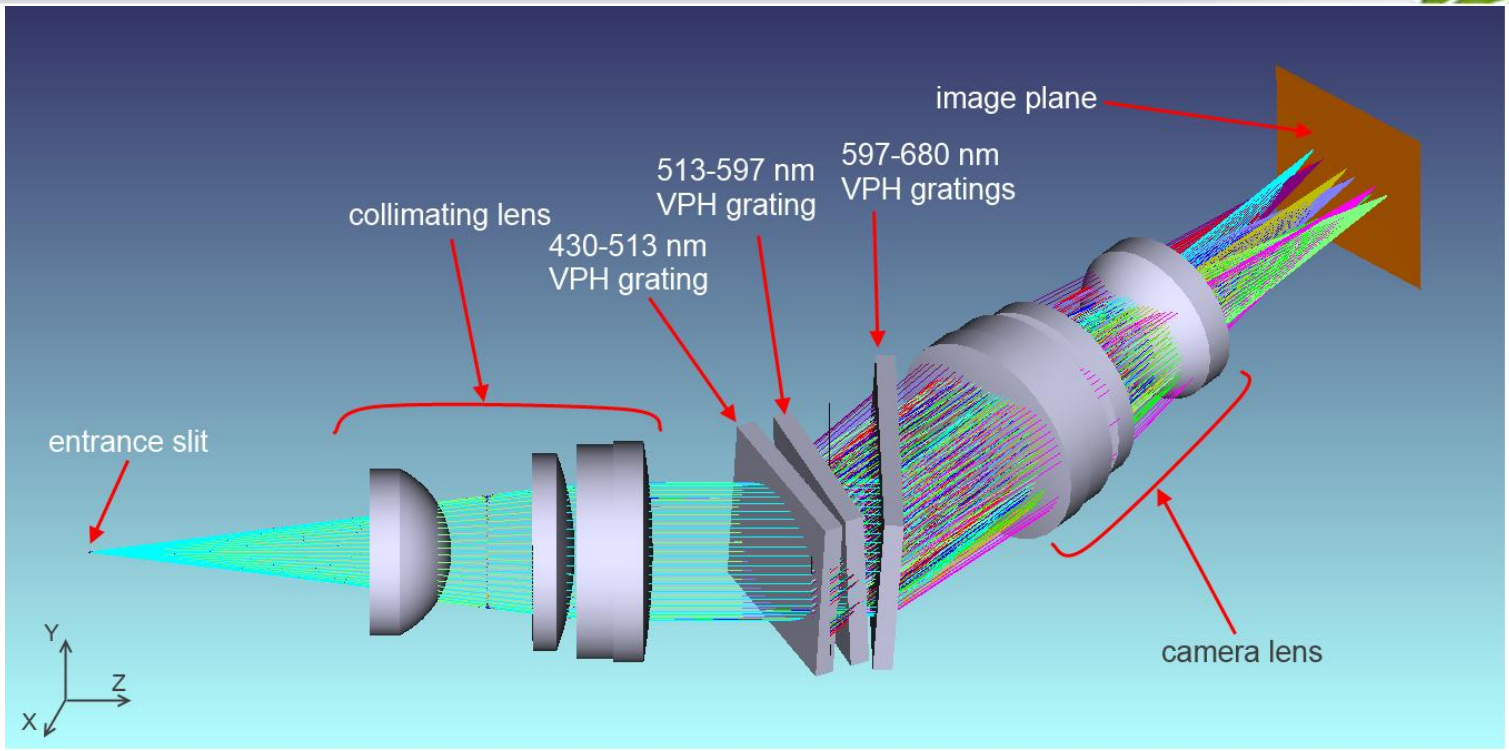
Educational project (foundation “Traektoria”):

preparing photometry and study of many targets –
exoplanets, variable stars, asteroids, comets, SNe (hunting);
classification of galaxies, meteors, asteroids, satellites (Zoo).
All the data will be public (YouTube, Facebook, Twitter).

Astro-tourist project (Northen Caucasus Resorts):

direct translation of all objects for tourists.

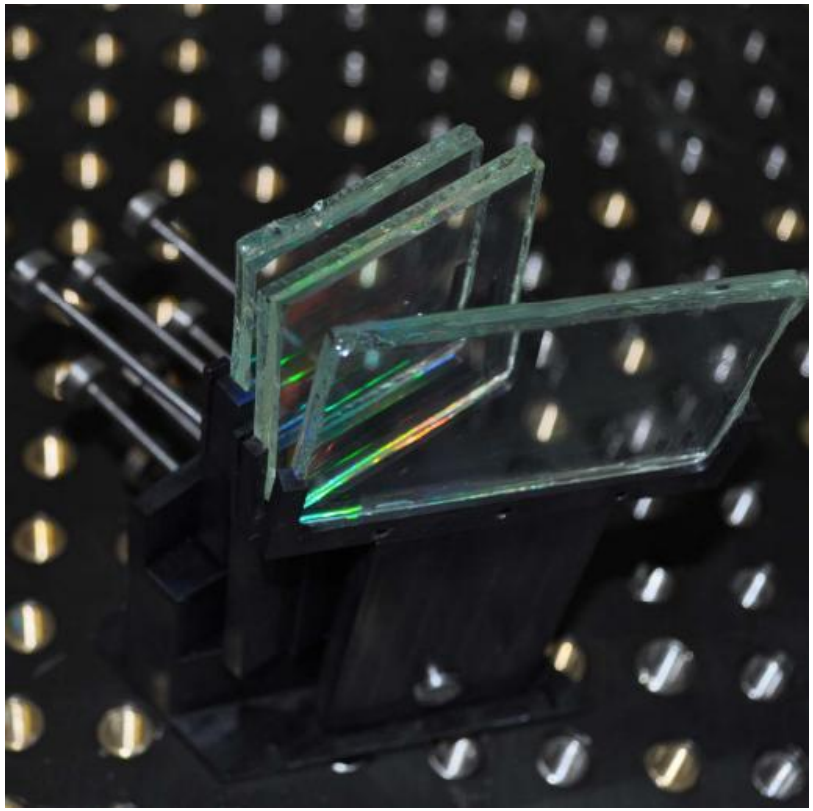
Lab prototype optical design



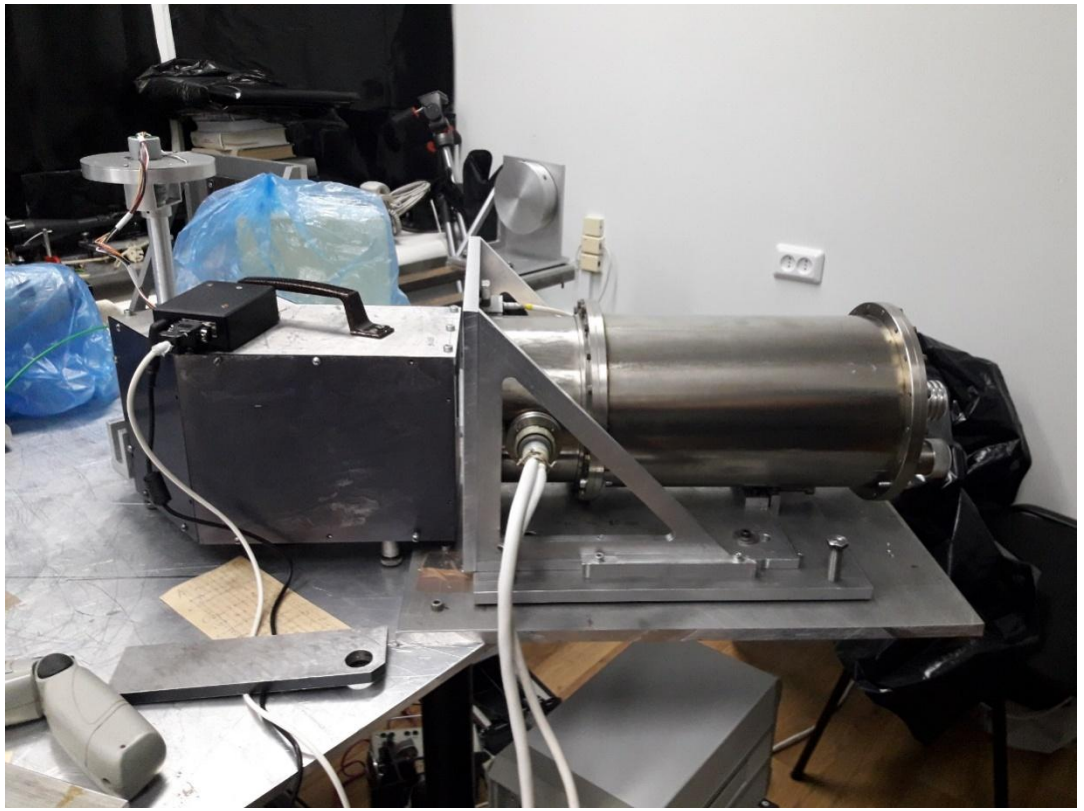
General view of the cascaded spectrograph optical scheme

Wavelength coverage	430-680 nm
Target spectral resolution	~1500-5000
Entrance slit	0.03x1 mm
Collimator&camera	Two identical commercial Tessar-type lenses 135 mm, F/4

Lab prototype assembly

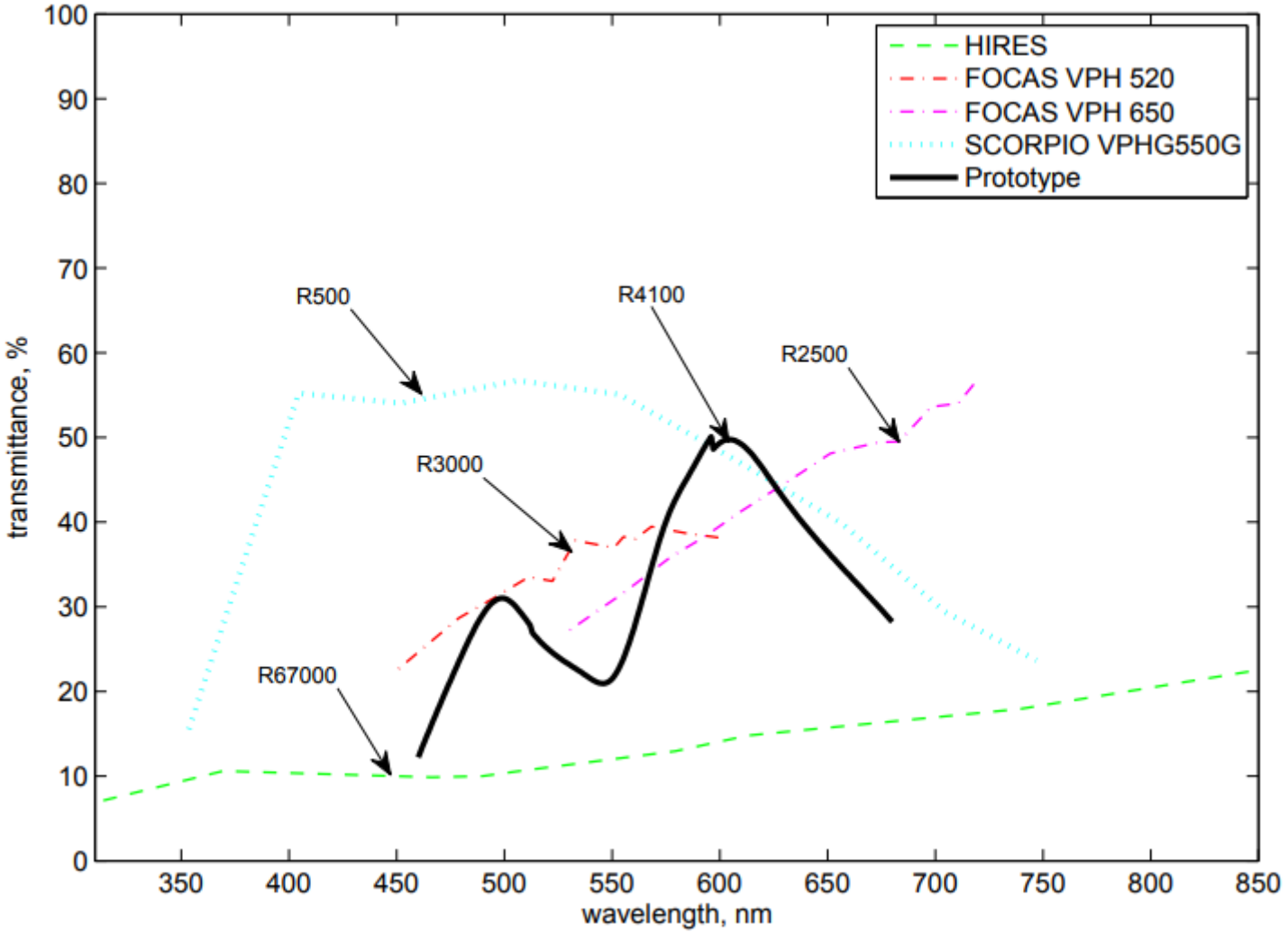


Assembled gratings unit.
From left to right: blue, green and red



Entire spectrographs prototype
with camera attached

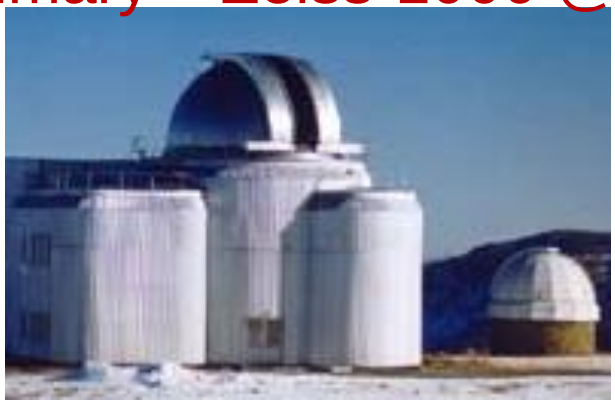
Experiments: throughput (II)



Prototype throughput in comparison with existing instruments

Prospective installation sites

Primary – Zeiss-1000 @ SAO RAS



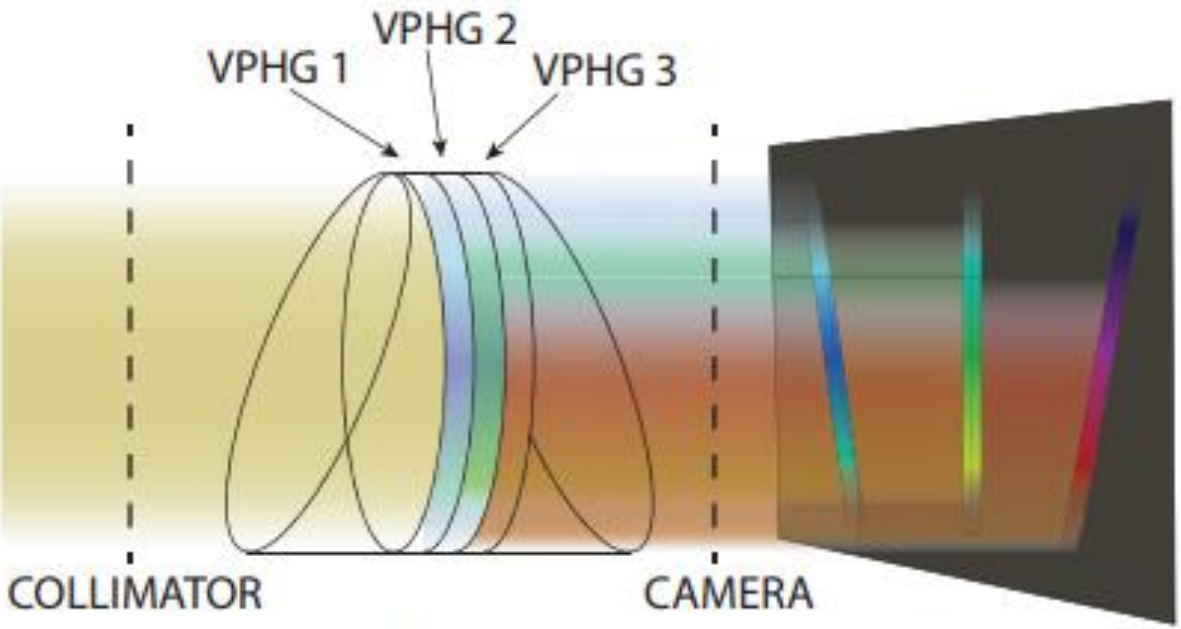
Main mirror diameter	1016 mm
Ritchey - Cretien system:	
Focal length	13.3 m
Nonvignetted field diameter	170 mm = 45 arcmin
Wavelength range	0.3 - 10 mkm
Angular resolution	0.8 arcsec
Tube weight	4.8 tons
Total weight	12 tons
Maximum weight @ Cassegrain focus	96 kg
The limiting stellar mag.	23.5

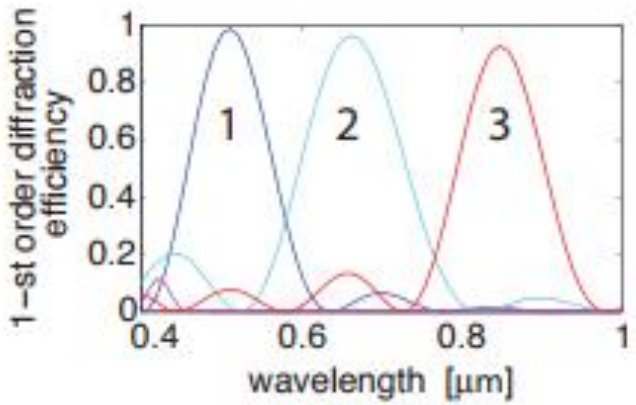
Prospective – BTA @ SAO RA

Main mirror diameter	6.05 m
Focal length	24 m
Light collecting area	25.1 sq.m
Wavelength range	0.3 - 10 mkm
Angular resolution	0.6 arcsec
Angular resolution	0.02 arcsec
Mass of the main mirror	42 tons
Total telescope mass	850 tons
Telescope height	42 m
Dome height	53 m

Other suggestions?

Generation 2: multiplexed design





The multiplexed design principle:

Top - Scheme of a possible application of a multiplexed device in GRISM mode.

Bottom - the possible uncombined efficiencies, peaked in different spectral ranges.

* A. Zanutta & M. Landoni, M. Riva, and A. Bianco (Brera Observatry, INAF)