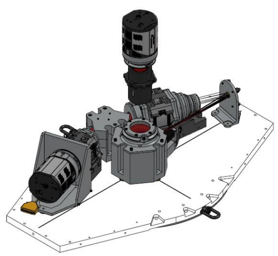
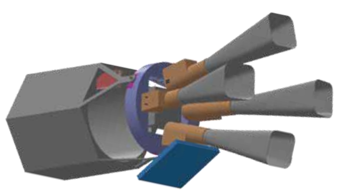
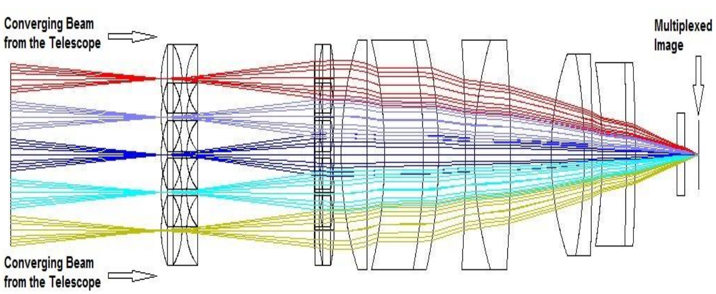
Weizmann Astrophysics: Instrumentation





Sagi Ben-Ami
Ilan Ramon fellow

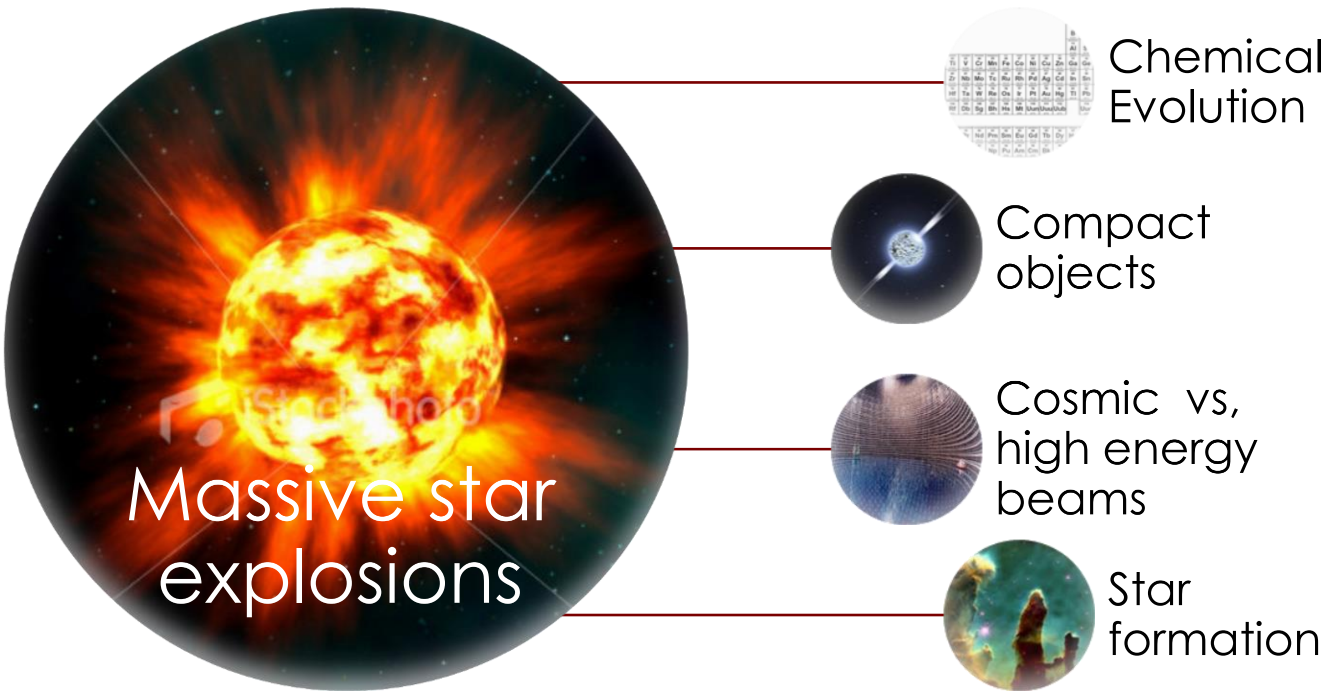
WEIZMANN INSTITUTE OF SCIENCE



i-CORE
Israeli Centers of Research Excellence

TAU
Dec 18, 2013

We are mainly investigating: Massive Star Explosions



- Currently poorly understood…

(Some of) The questions

- The standard picture: a spherical model.

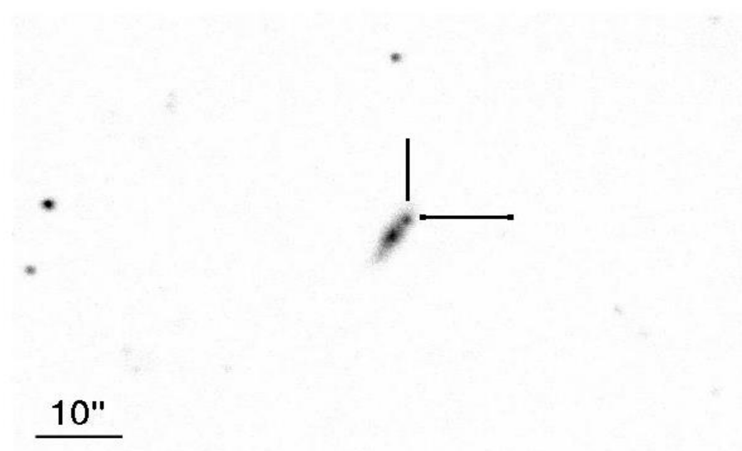
Massive star → Core Collapse → Proto-neutron star → Shock wave → Explosion

Massive star	Core Collapse	Proto-neutron star	Shock wave	Explosion
What progenitors?	Only mechanism ?	Neutron star ? Black Hole ?	Energy Mediated by v?	Gamma-ray bursts (GRBs)?

➢ **How can we find and classify these (and other types) of transients more efficiently?**

How do we find explosive transients?

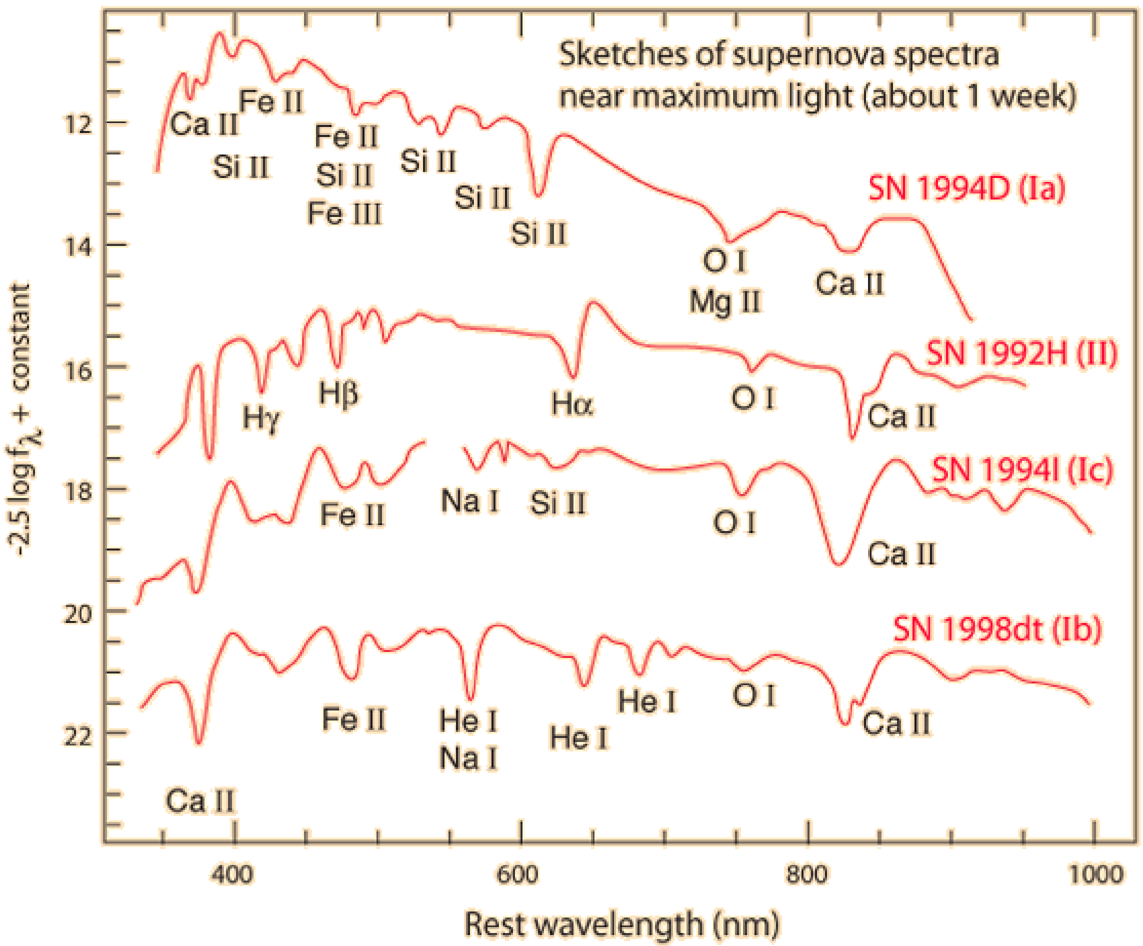
PALOMAR TRANSIENT FACTORY



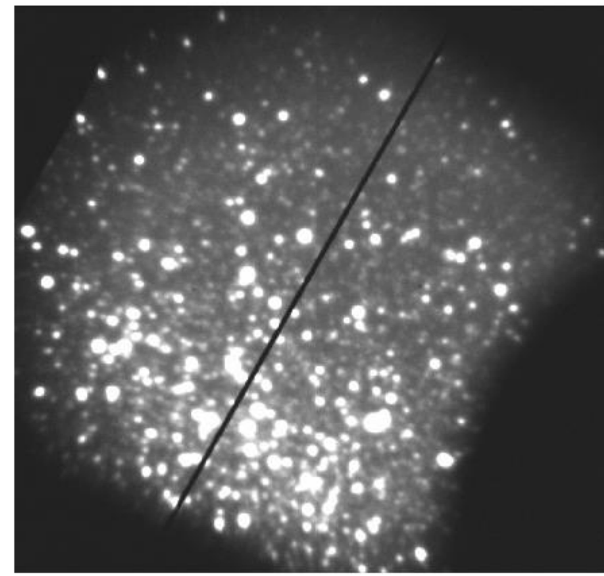
PTF – Results

- More than 2000 **classified** SNe in ~4 years.

PALOMAR TRANSIENT FACTORY

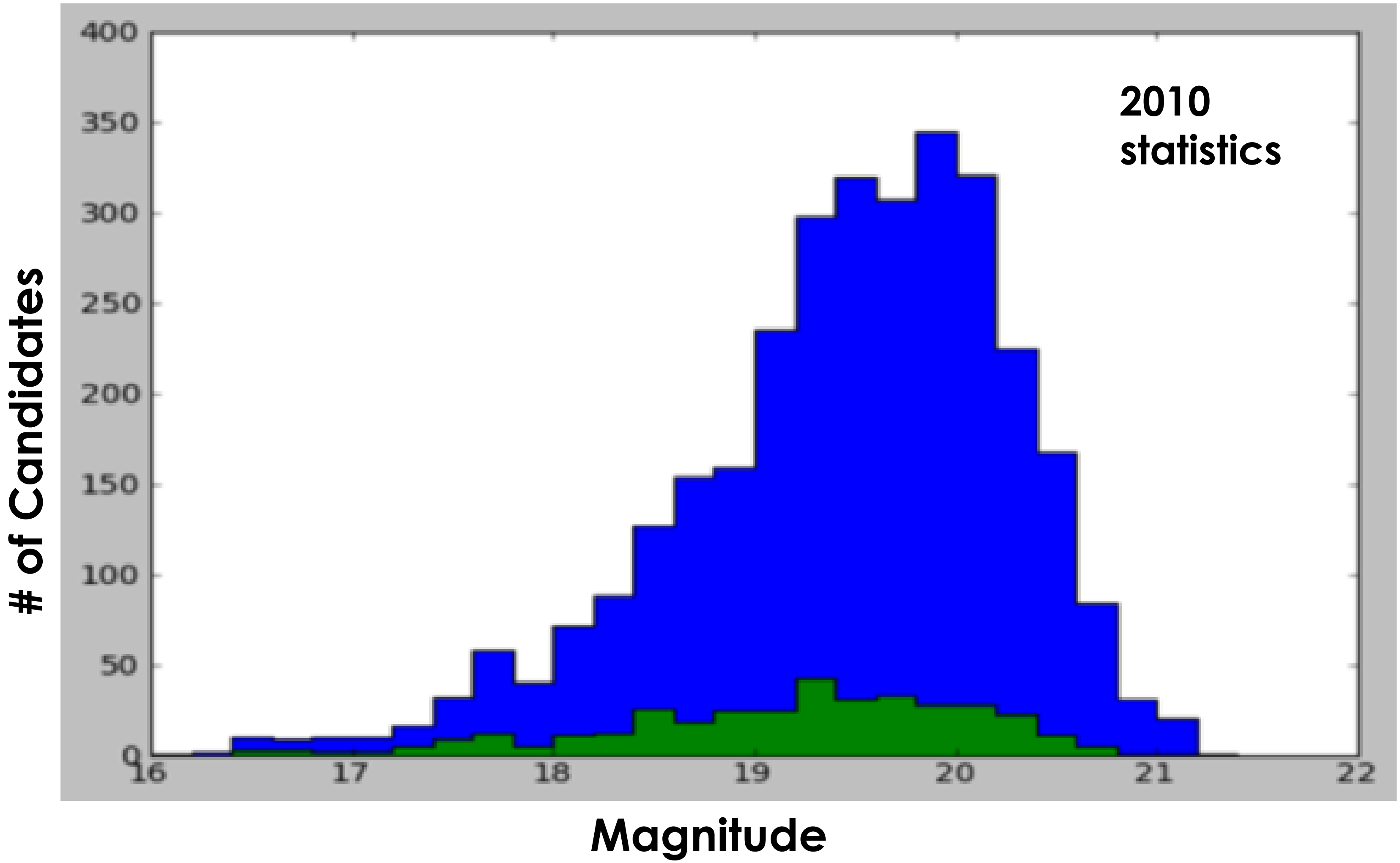


Sketches of spectra from Carroll & Ostlie, data attributed to Thomas Matheson of National Optical Astronomy Observatory.

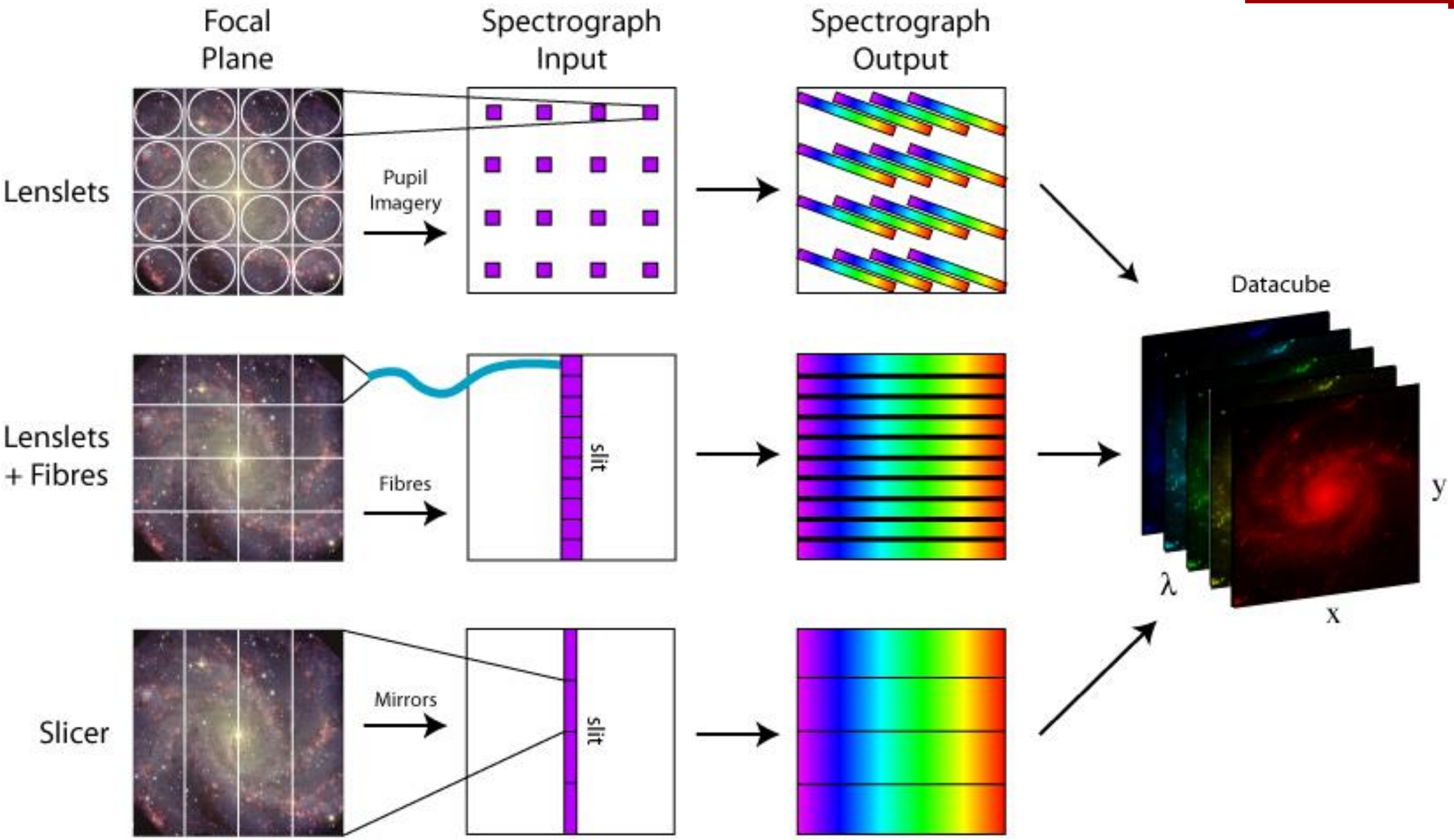


PTF – Keeping up the pace.

PALOMAR TRANSIENT FACTORY

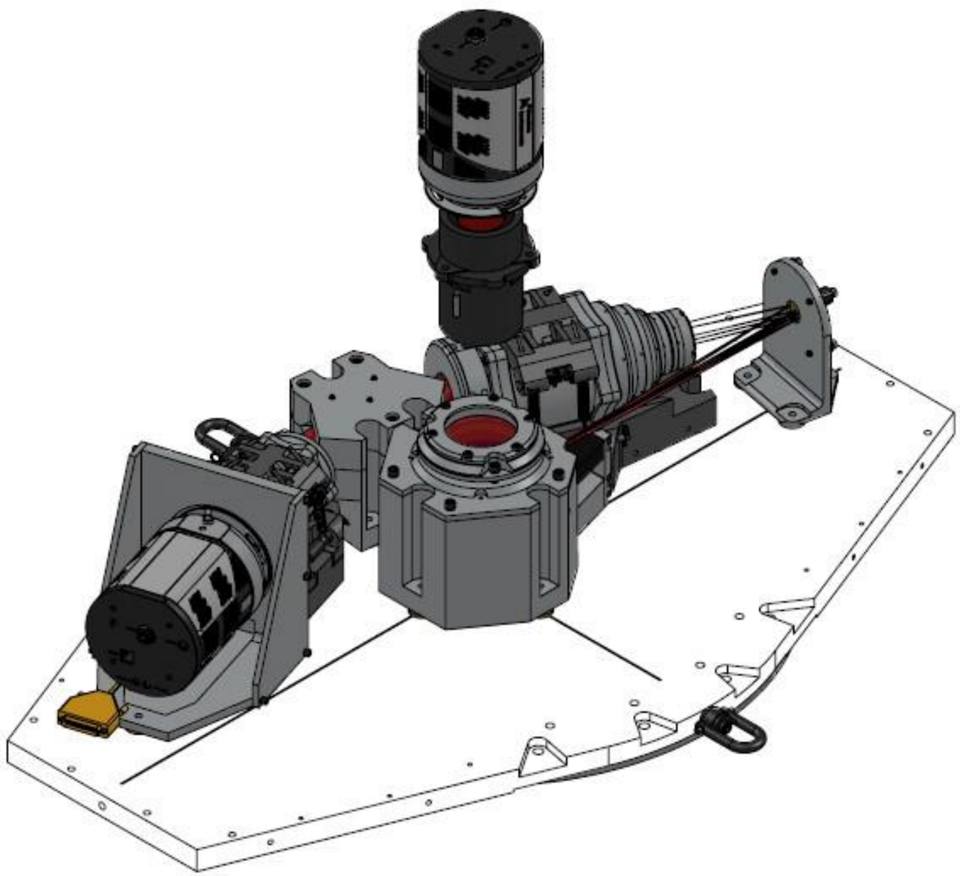


Integral Field Spectroscopy



SEDM – Spectral Energy Distribution Machine

- An Integral Field Spectrograph built from the bottom up to classify transients.
- Mounted on the Palomar 60'' telescope.
- First light June 2013.



PI: Nick Konidaris
PS: Robert Quimby

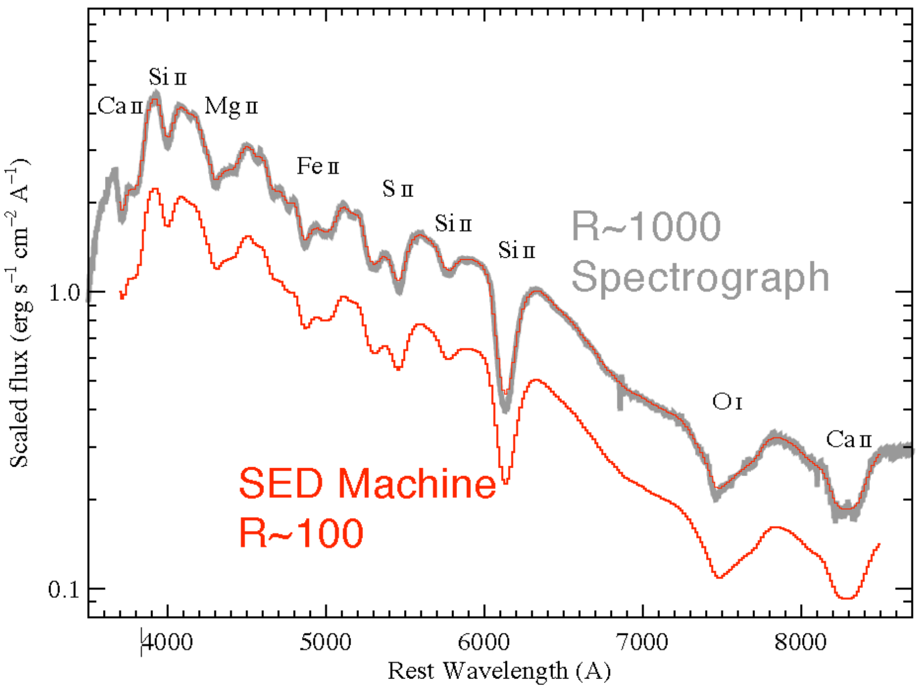
Optical Design: Nick Konidaris, SBA.

Optomechanics: Nick Konidaris, SBA.

Construction, Commissioning: Nick Konidaris, Robert Quimby, SBA.

SEDM – scientific requirements

- Spectral resolution R~100
- A spectral coverage of 370-850nm.
- A large active area.
- Spectrophotometric precision of 5%.
- High efficiency.



SEDM – Usage Overview

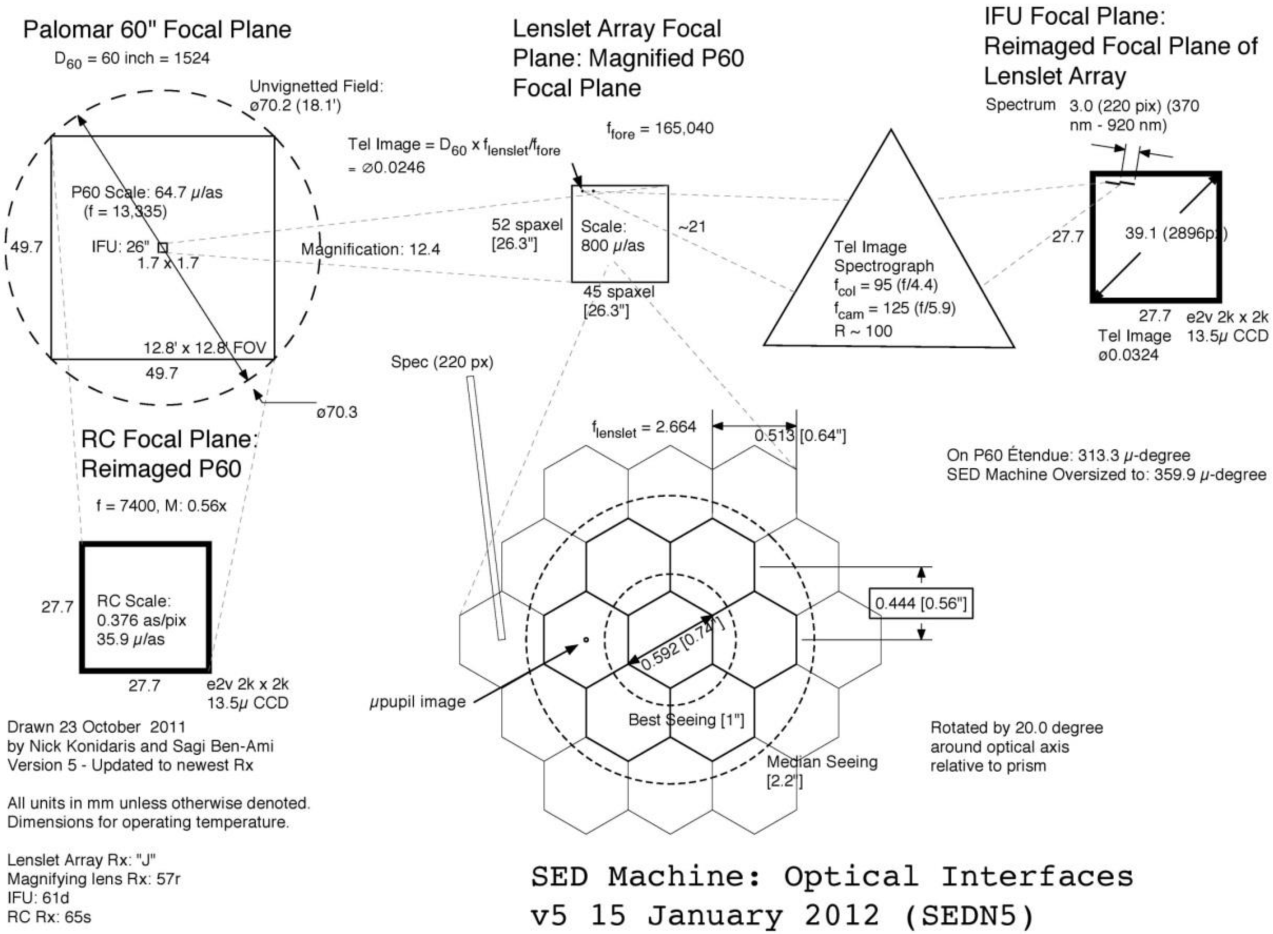
- Robotic telescope – Automatic instrument
- 18 candidate transients per night.

  → ~5,000 transients per year.

- Spectrophotometric calibration using a 4-band imager.
- Imaging capability in parallel.

Low Budget* + *one truck…

SEDM – scientific requirements



- 52×45 hexagonal lenses➔26.3''×26.3'' FoV.
- 4-band imager (*ugri*) 12.5'×12.5' FoV

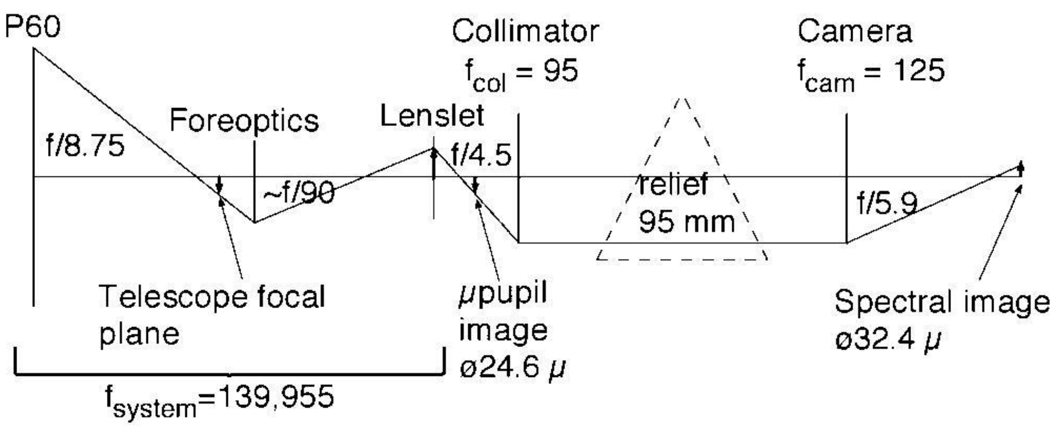
SEDM – Spectrograph channel

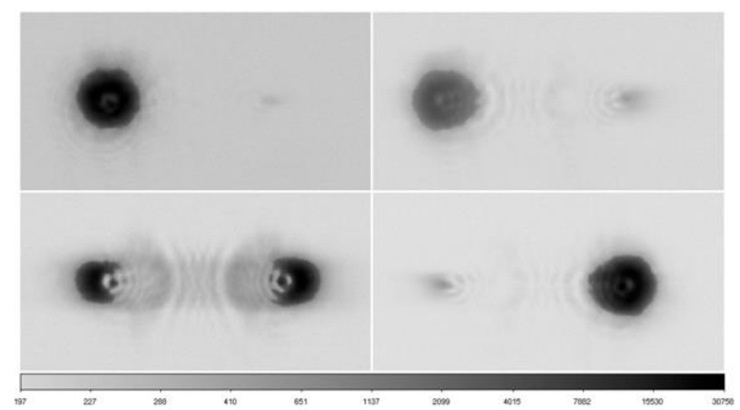
- The IFS is divided to three parts:

i. A magnifier/expander.

ii. A lenslet array produces a set of telescope pupil images.

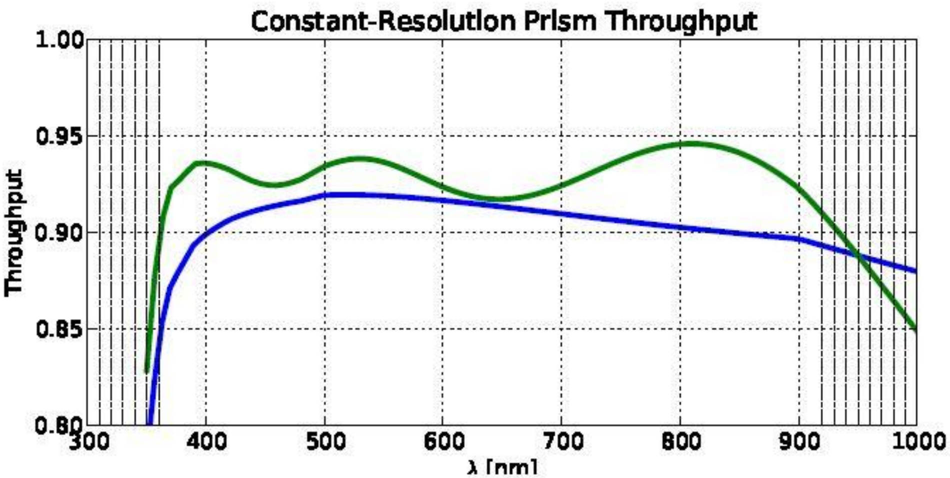
iii. A constant resolution spectrograph.

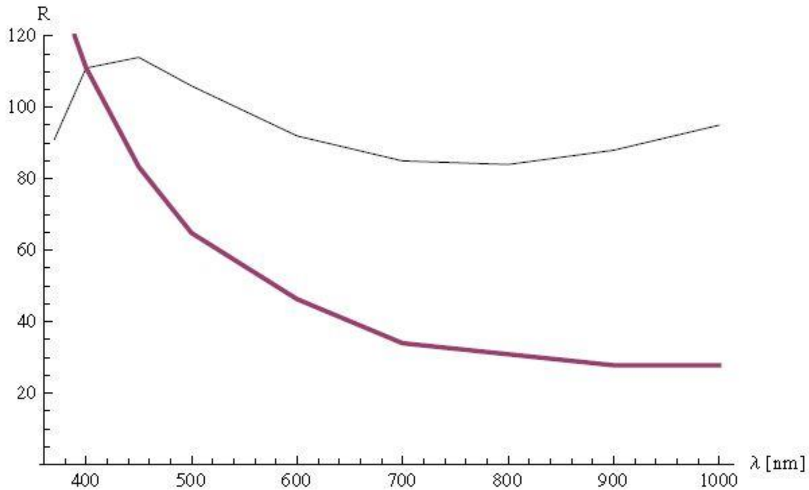


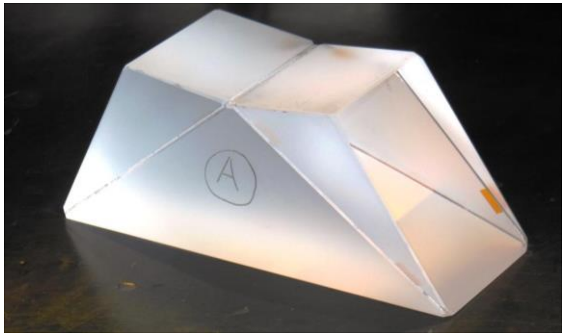


SEDM – Triple prism

- A novel triple-prism (CaF2, BSL7Y, PBM2Y).
- The prisms are cemented together, achieving a constant resolution of R~100.







SEDM – Photometric Channel.

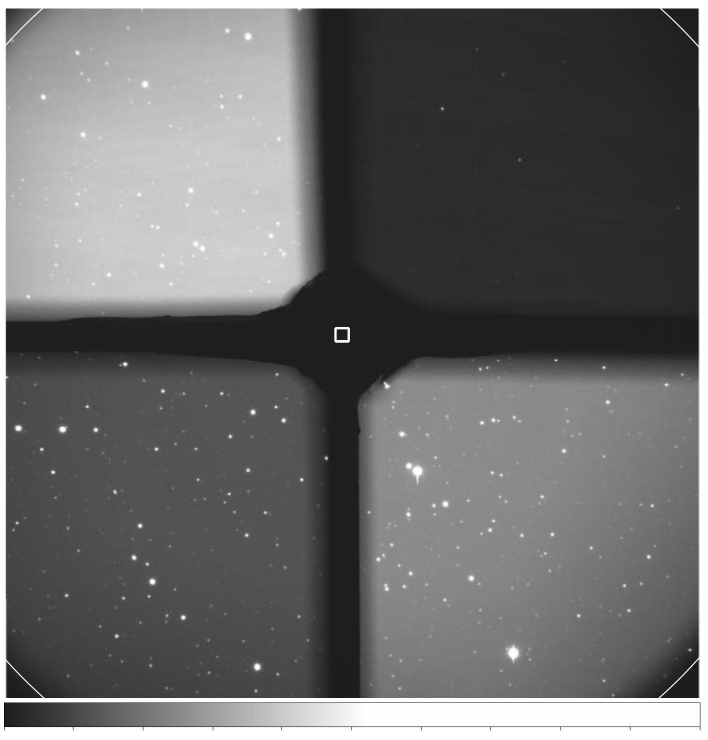
$f/4.8 \quad f = 89.7\,mm$

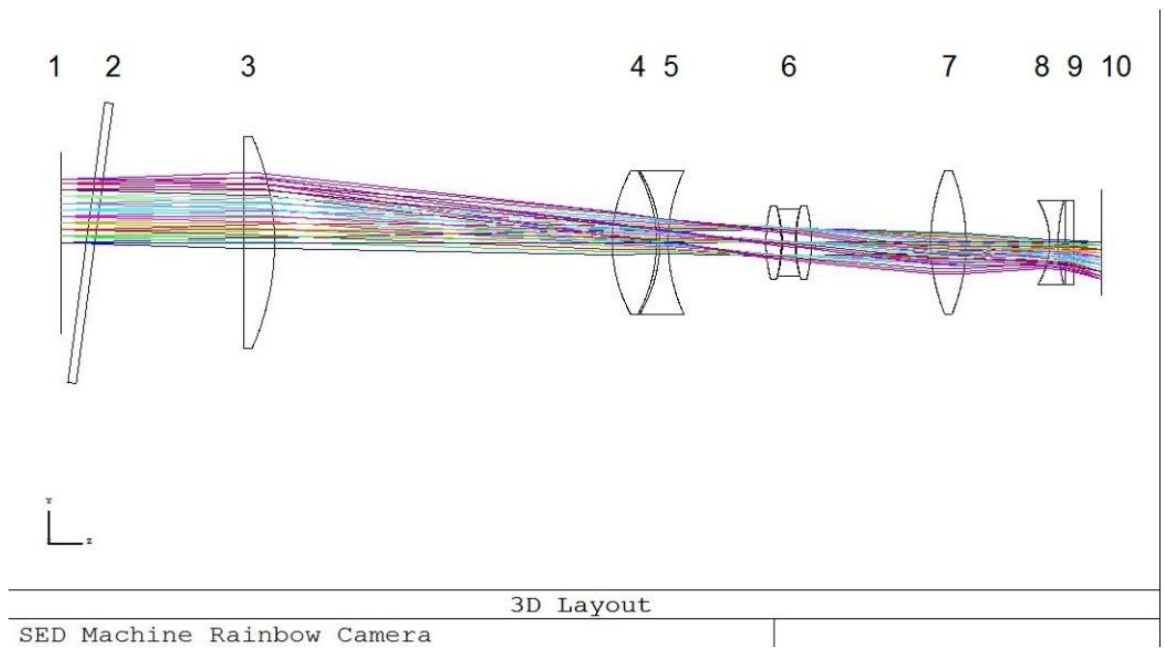
$39.5\,mm / arc\,sec$

$u = 0.65''/\,pixel \quad g = 0.51''/\,pixel$

$r,i = 0.6''/\,pixel$

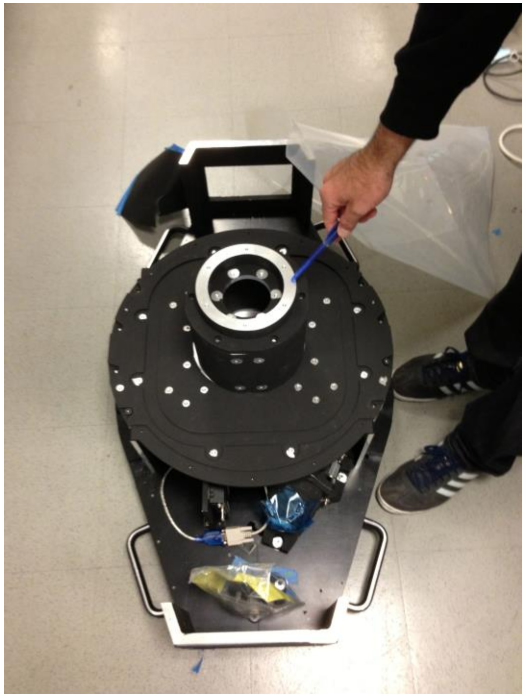
A low-cost system: 7 out of the 9 optical elements are off-the-shelf elements from EO/Thorlabs.



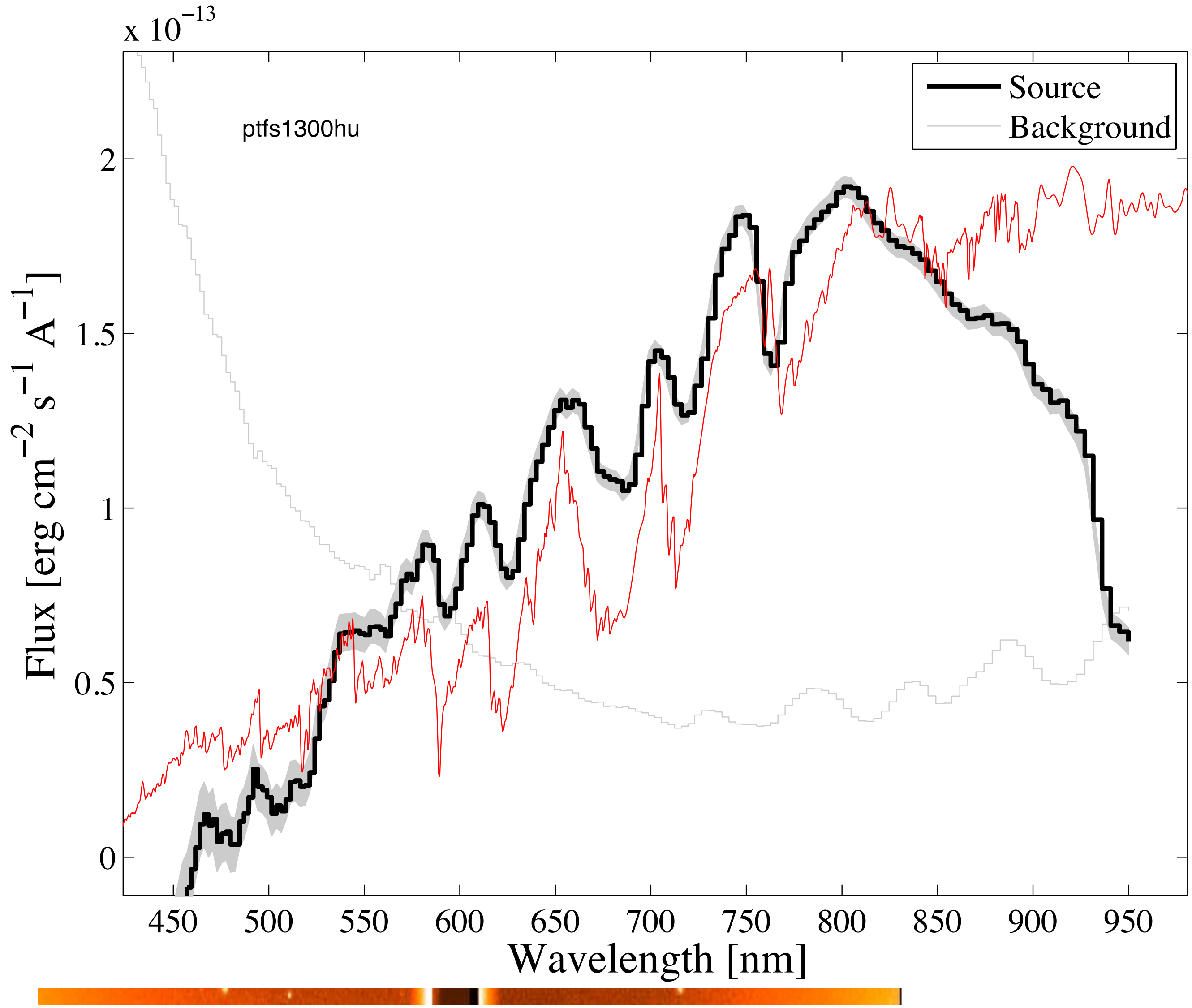


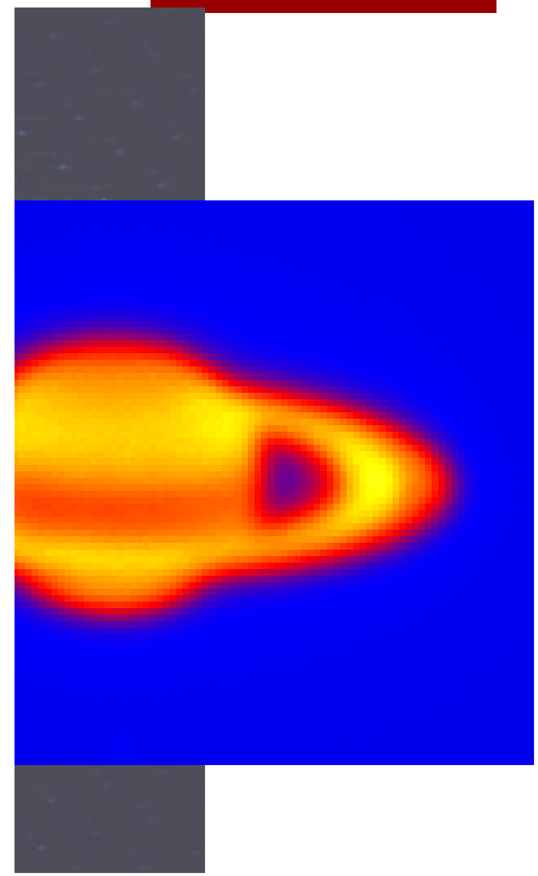
SEDM – Beyond optics

- Structure coated with Acktar “Black magic”.
- RC and IFU are focused on the same plane.
- RC – Delrin+Al6061 structure compensate thermal changes in f.
- IFU – Focused with a flexure stage.
- Detectors – Off the shelf PI PIXIS 2k×2k cameras.
- Water cooled.
- DRP – Matlab (Dr. Eran Ofek).

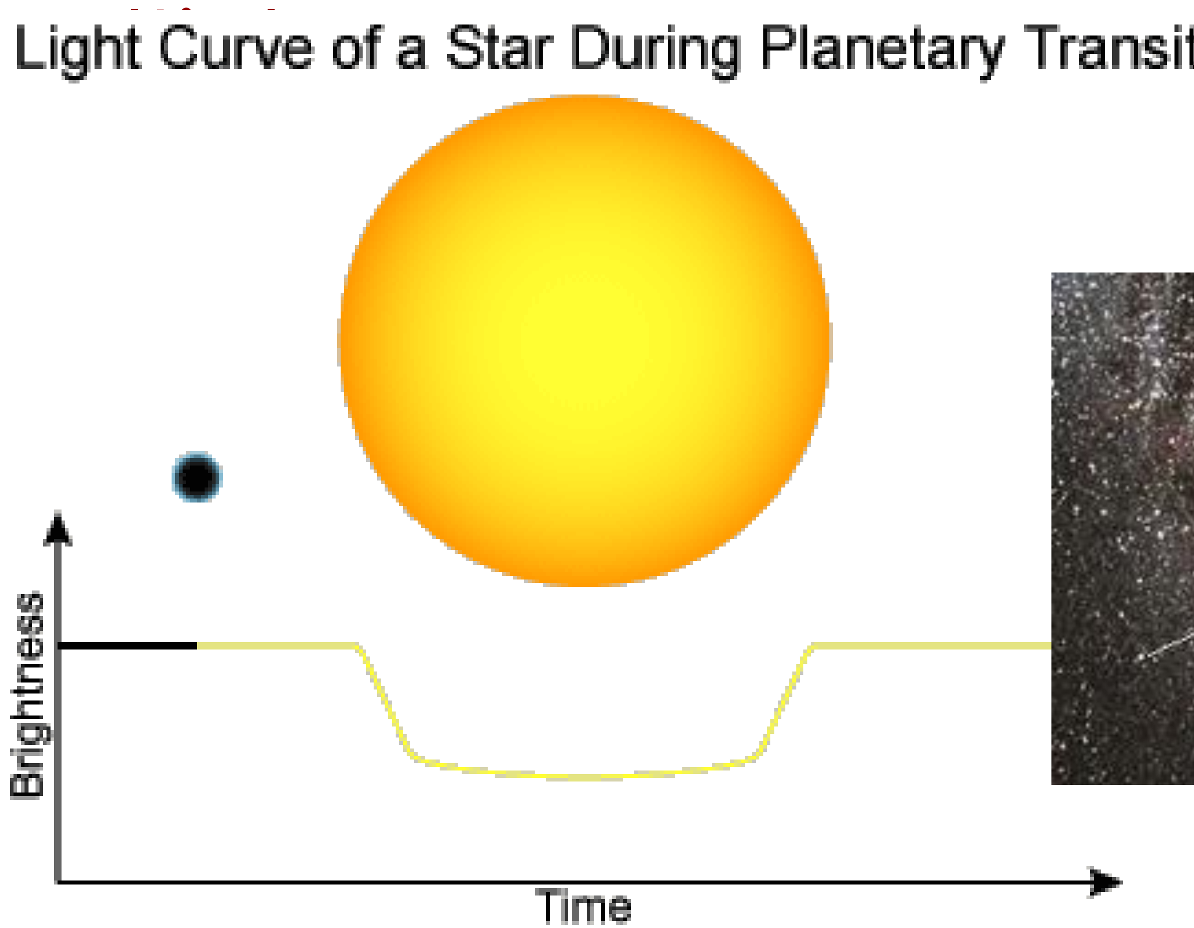


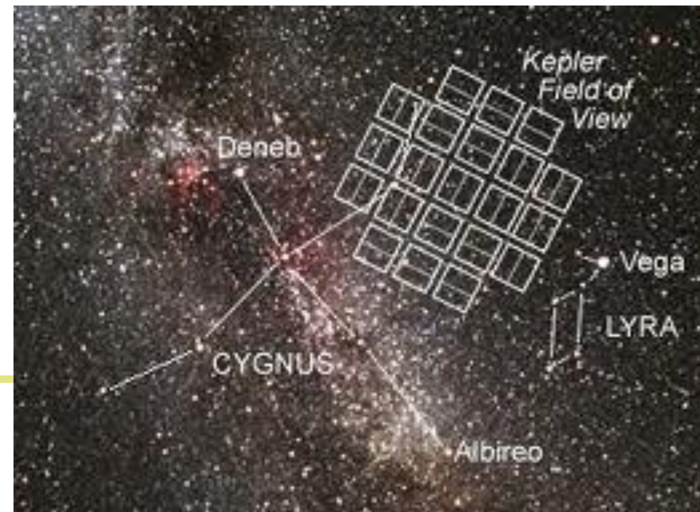
SEDM – The movie





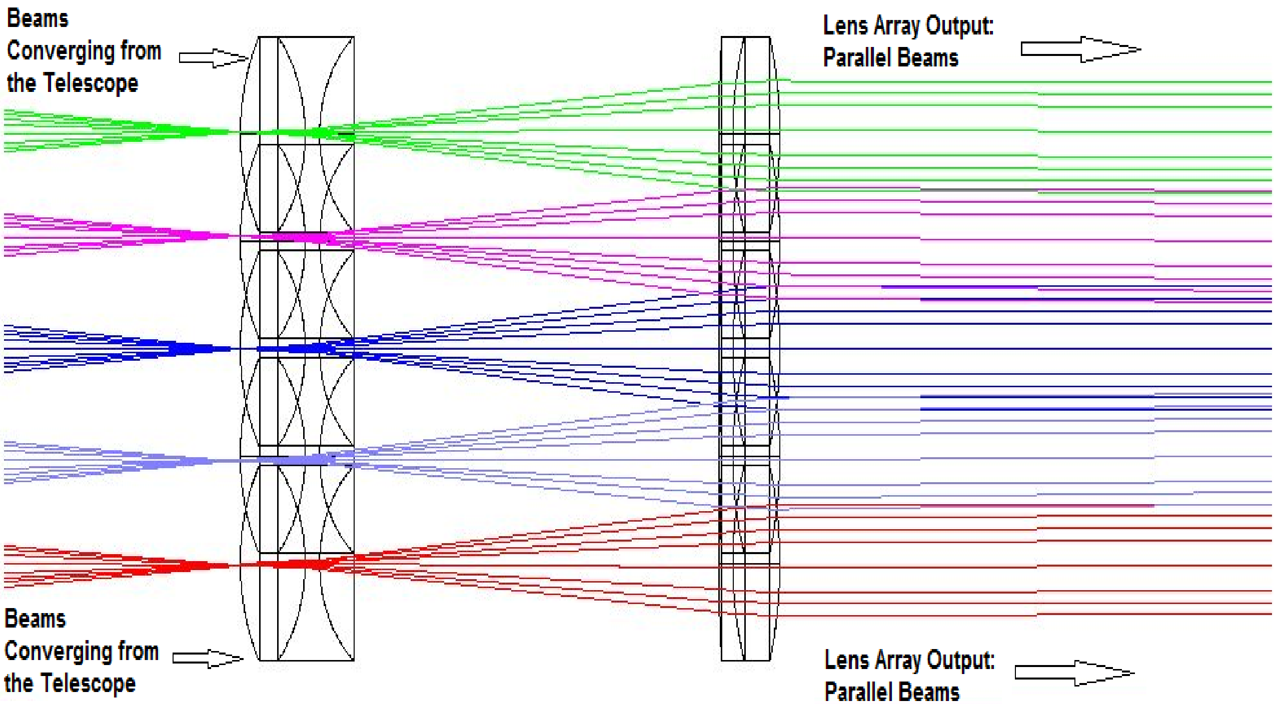
Weizmann Astronomical

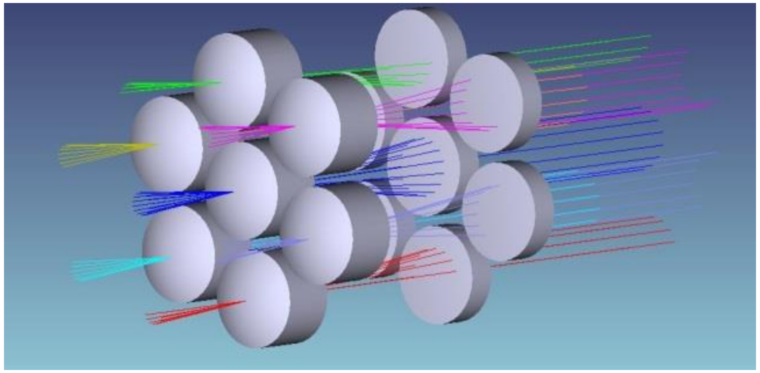




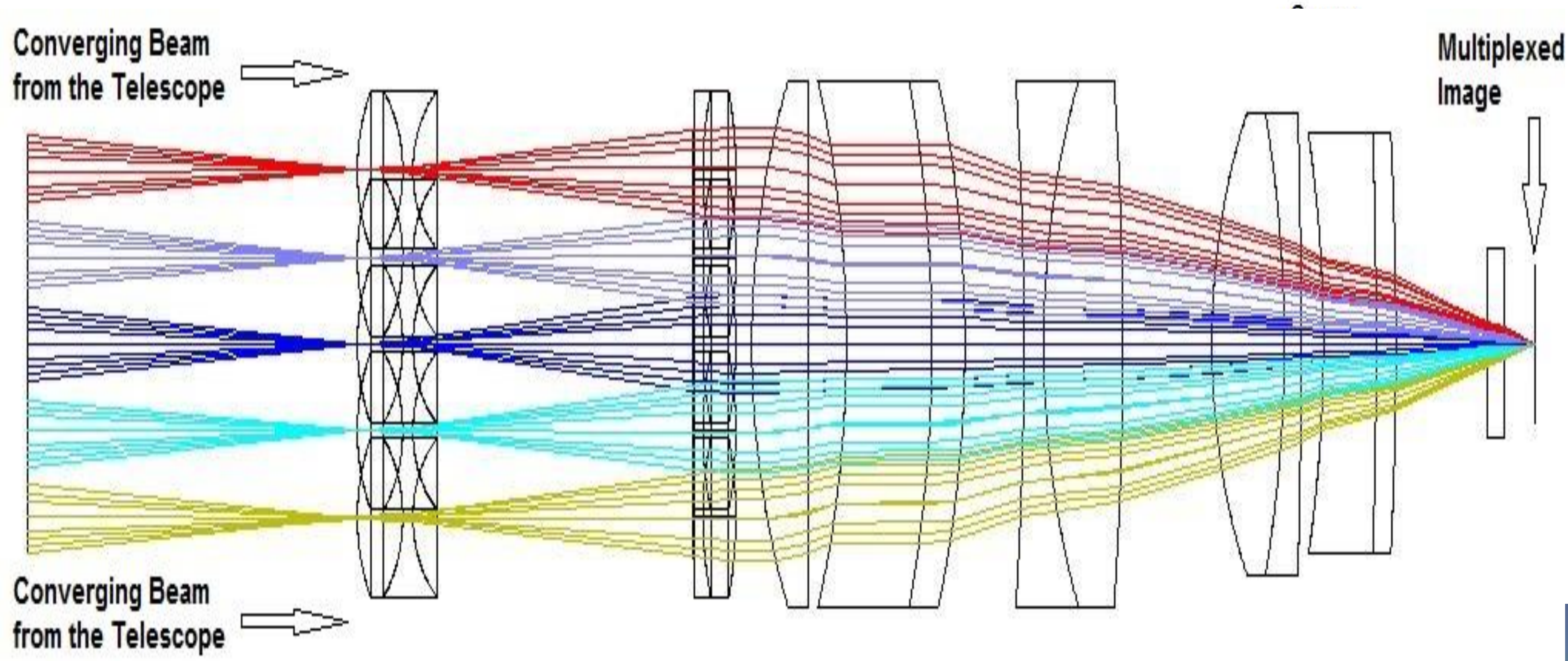
- Example: Exoplanets through the transient method.

WAM – collimator array



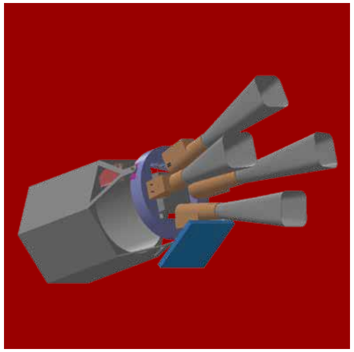


WAM- CAMERA



Status: Fabrication of optical elements completed.
Mechanical parts are fabricated at the WI workshop
Assembly in the lab starts in two weeks.

ULTRASAT – Ultraviolet Transient Astronomy Satellite

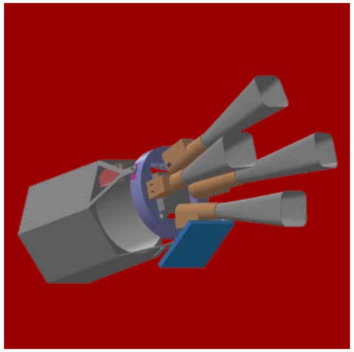


A proposed space mission to undertake the first high-cadence wide-field UV time-domain survey,

Gamma Ray Burst (GRB) Geometry – Identify > 10 GRB UV afterglows per year and a similar number of orphan GRB afterglows.

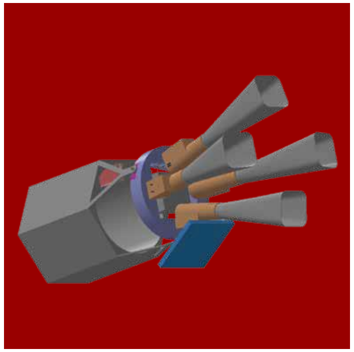
A rich legacy data set for studies of active galaxies, stellar variability, and the host stars of exoplanets.

ULTRASAT – Ultraviolet Transient Astronomy Satellite

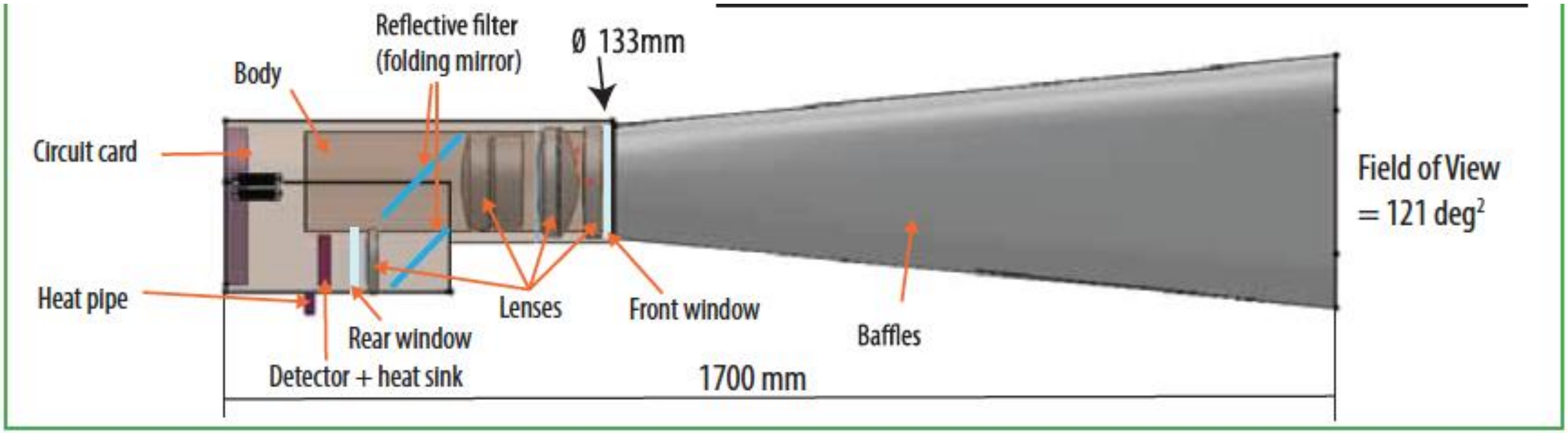


- 484 squared degrees field of view (FoV), and 5σ limiting magnitude of 21 (AB).
- Nearly continuous communication of the ULTRASAT data to the ground,
- Real-time processing ➔ alerts on new transients typically within 1hour from image capture.
- A sun-synchronous orbit, with the telescopes looking at the anti-sun direction.

Optical design and detectors

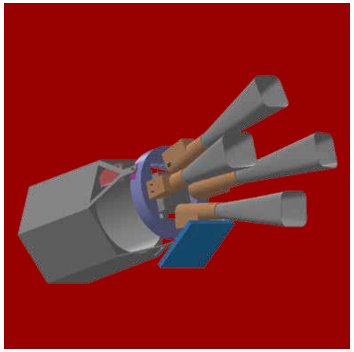


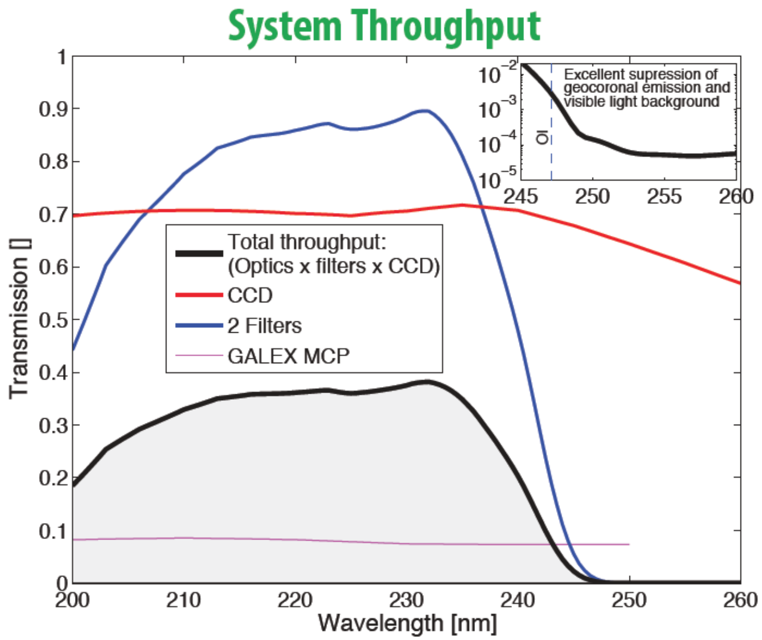
- 4 telescopes, each with a 11° × 11° FoV and a plate scale of 19.2''/pixel.
- Current design implements a simple double gaussian lens. Two reflective systems determine the bandpass.
- A 4K × 4K δ−doped p-channel CCDs.
- On-chip binning to create a 2K × 2K 30μm pixel array.

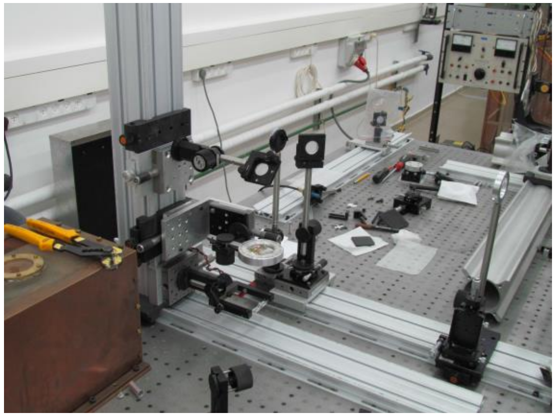


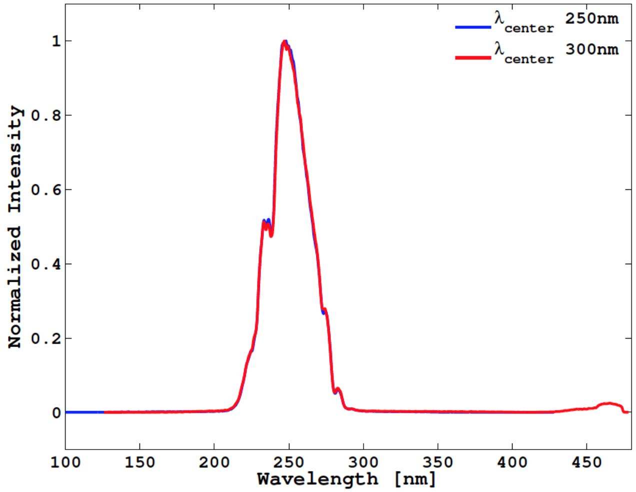
Throughput

- Polarization dependent reflecting filters (JDSU) tested at the WI.
- All optical elements are made from CaF2 and Fused Silica.

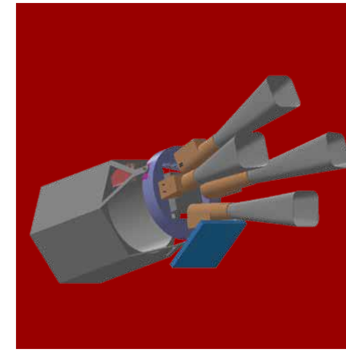






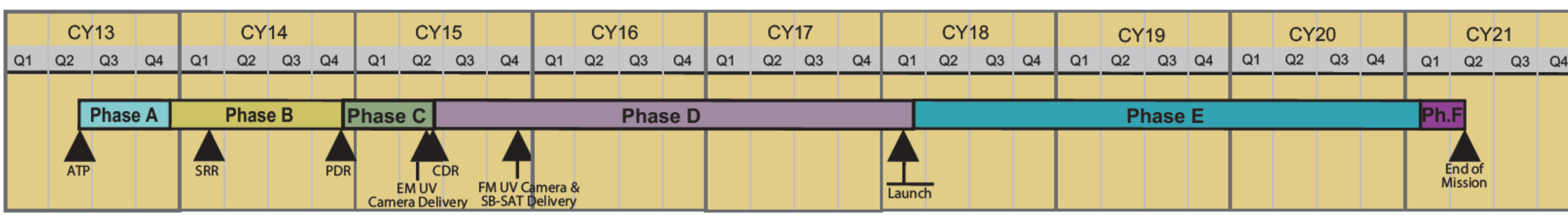


ULTRASAT - in the near future



- We will measure the index of refraction for CaF2 and FS at operating conditions to allow optimization of the optical design.
- Investigate other optical designs.
- advance the δ−doped p-channel CCDs from their current TRL number (5) to an higher one.
- Get support and funds.

Schedule -1



Summary

- We have started an intense instrumentation activity at the Weizmann Institute in the past 3 years.
- We are gaining experience and collaborating with leading institutes from around the world.
- A fully equipped lab is being built at the accelerator tower.
- It is our vision that by developing novel instrumentation at relatively low cost, the Israeli astrophysics community will be able to join leading collaborations around the globe.
- The future looks bright….