LAMOST-HiRes

LangZhong - June 20, 2006

LAMOST-HiRes

A Fiber-Fed High Resolution Echelle Spectrograph for LAMOST

Outline (1)

- Project general preconditions
  - Participants
  - Xinglong seeing conditions
  - One arm, one camera design
- Scientific preconditions
  - Stability (long co-added integration time)
  - Resolution
  - Wavelength coverage

Outline (2)

- HiRes spectrograph design
  - FOCES-like geometry – New camera
  - Spectral coverage
  - Optical properties of HiRes
- Focal plane device
  - Telescopic device
  - Pickup optics and fiber feed
- Observation strategy
- Summary and next steps

Frank GRUPP: Science

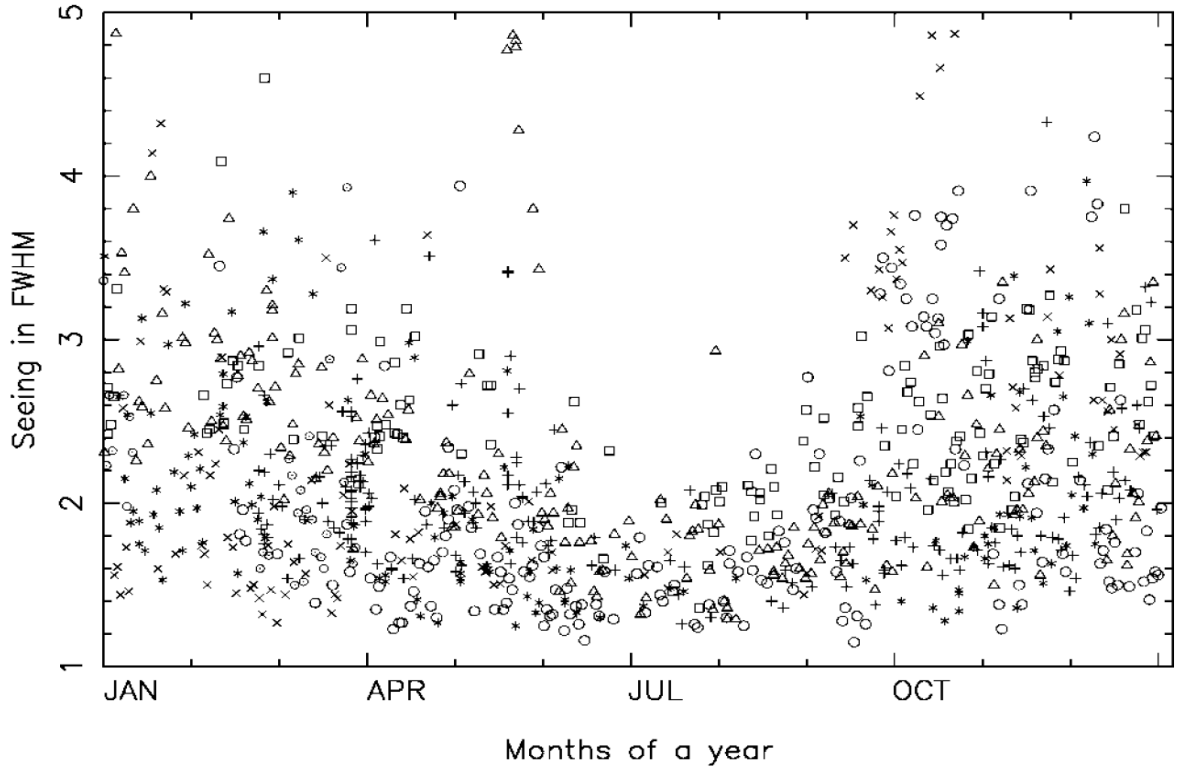
- MAFAGS-OS opacity sampling model atmosphere code
  - Spectroscopic stellar parameters of:
    - Open cluster main-sequence stars
    - Metal poor stars
  - LTE & Non-LTE element abundances
- Properties of optical fibers
  - VIRUS project at HET
  - “Fiber-noise”

General: Participants

- NAOC/Beijing: Prof. ZHAO Gang (science driver)
- USM/Munich: Prof. Thomas GEHREN (sci. driv.)
- USM/Munich: Frank GRUPP (PI, optical design)
- LAMOST/Beijing: LAMOST-Team (project structure, CCD-camera, on-site construction)
- NIAOT/Nanjing: Prof. ZHU and team (opto-mechanical design and construction, manufacturing)

General: Xinglong seeing (1)

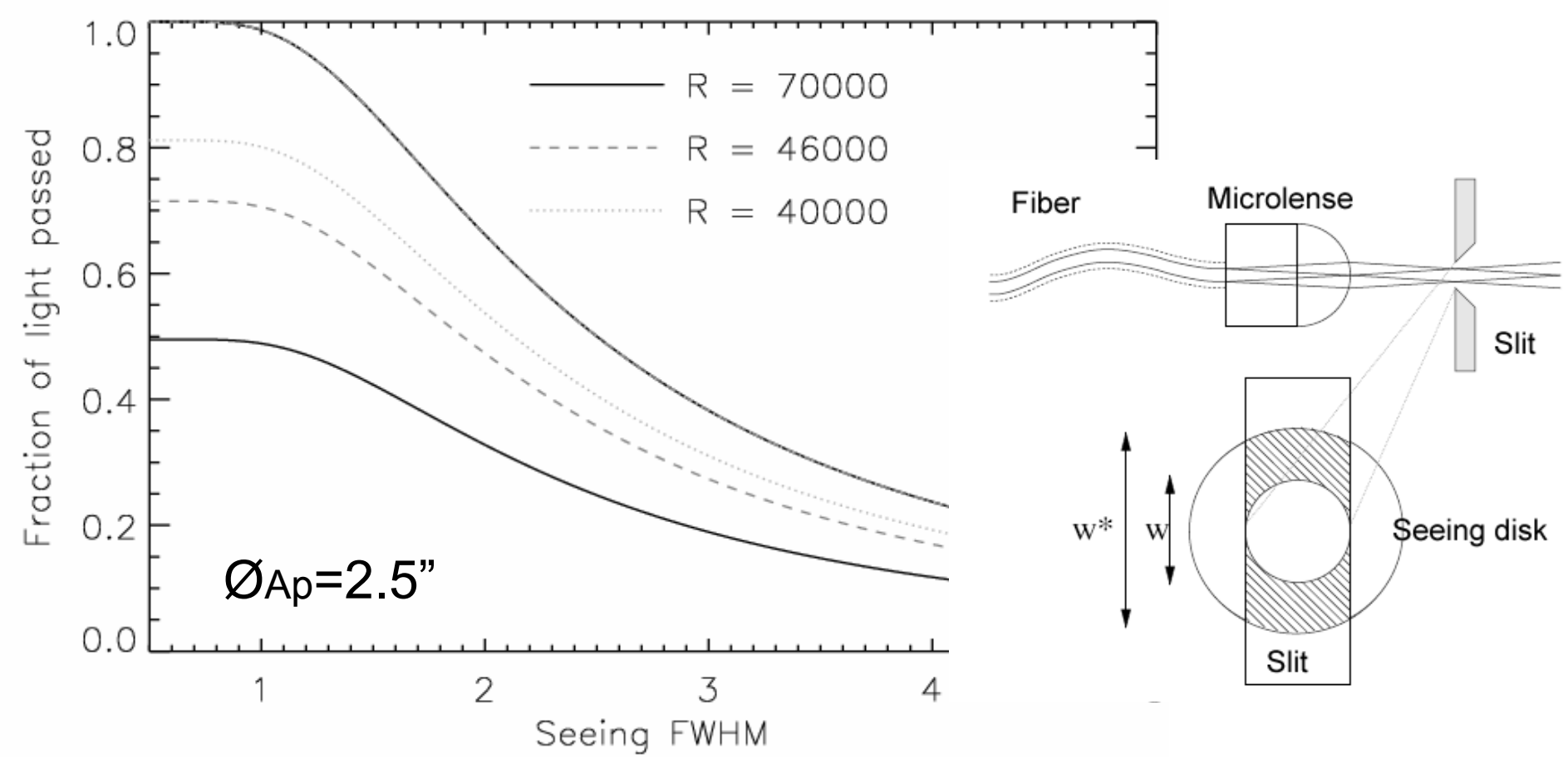
Liu et al. 2003



- BATC survey → Seeing ofthen > 2”
- New measurements will be done (DIMM)

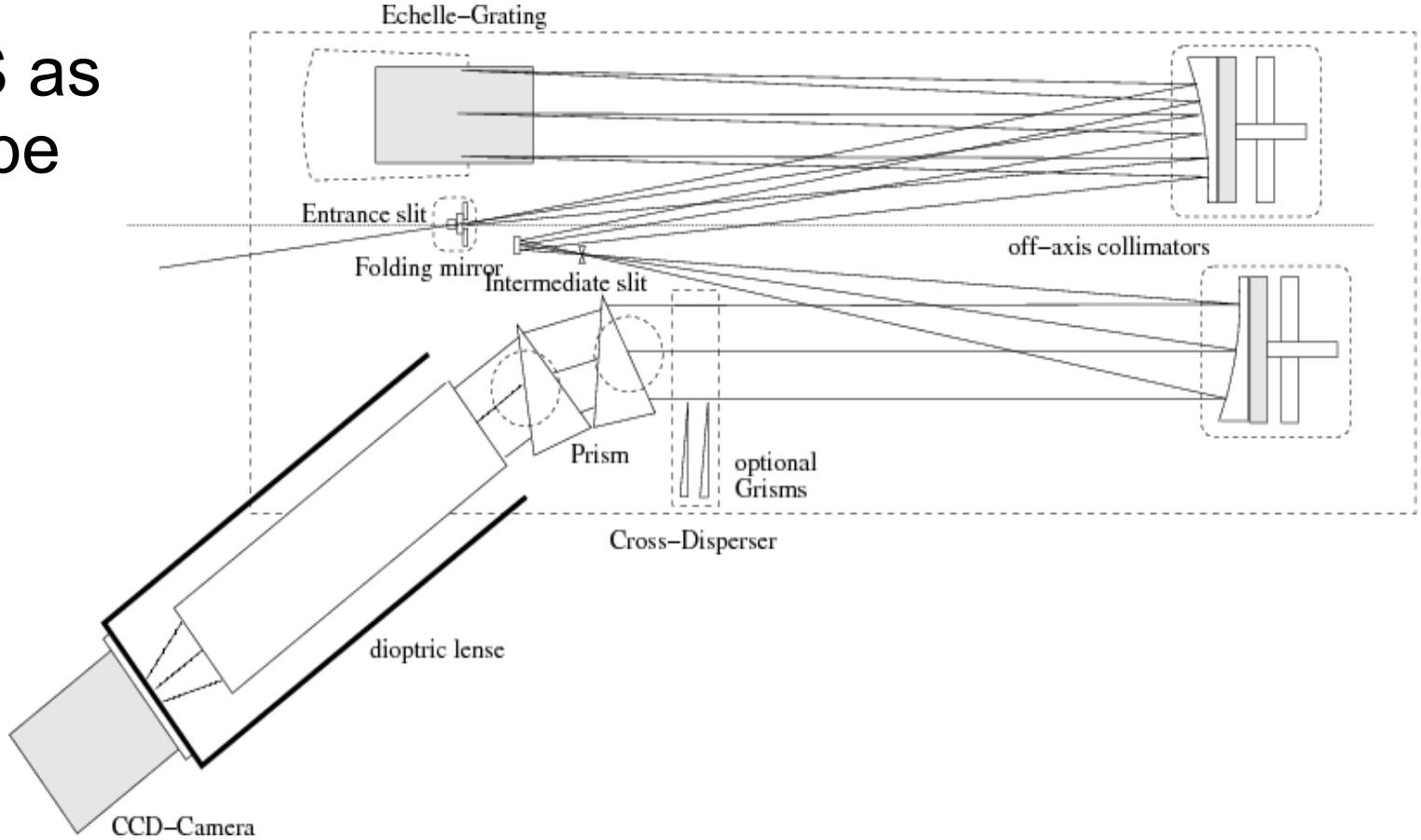
General: Xinglong seeing (2)

- Large seeing → large slit losses
  → image slicer → reduced λ coverage



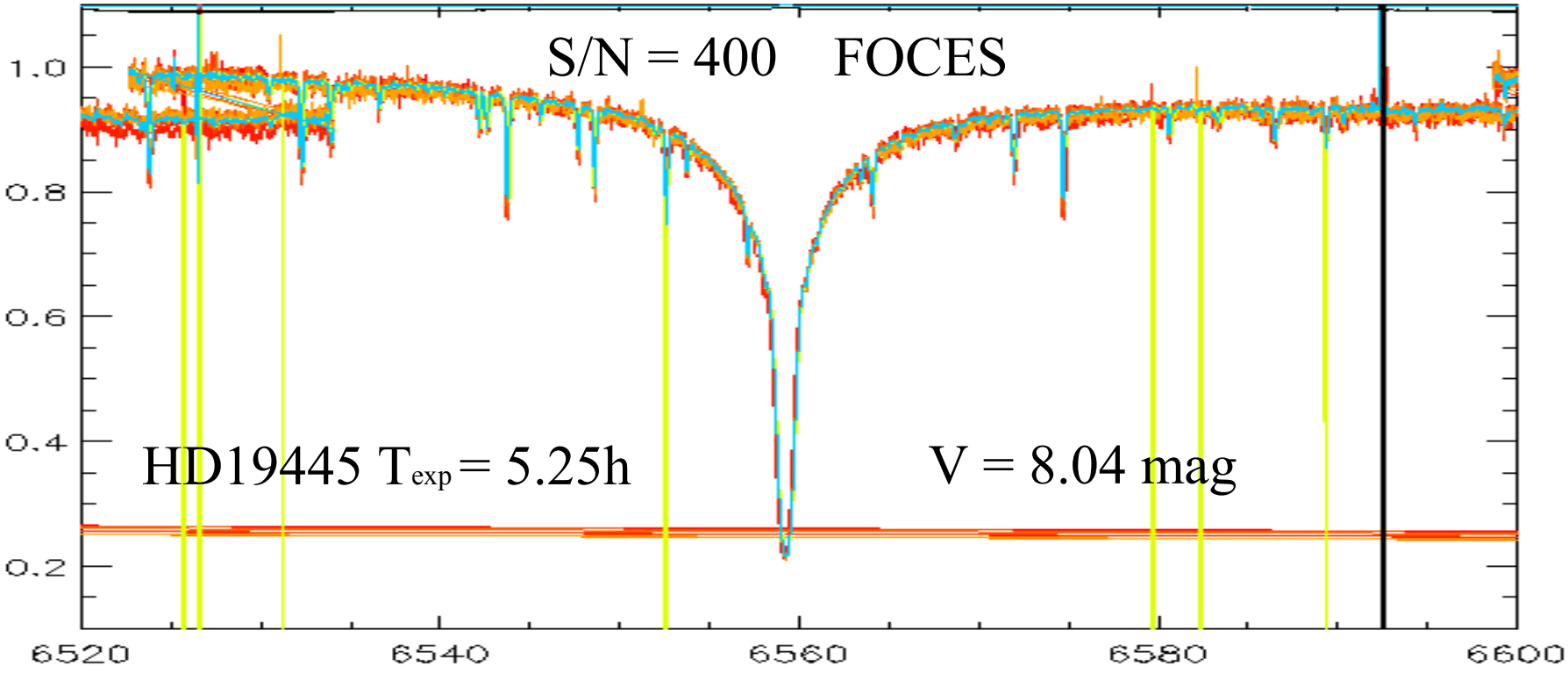
General: Design preconditions

- One arm, one camera design
  - Keep costs reasonable
  - FOCES as prototype



Science: Stability

- High stability of spectrum “on the CCD”
  - Allows for long (multi-exposure) integration times
  - Very demanding in mechanical & thermal stability



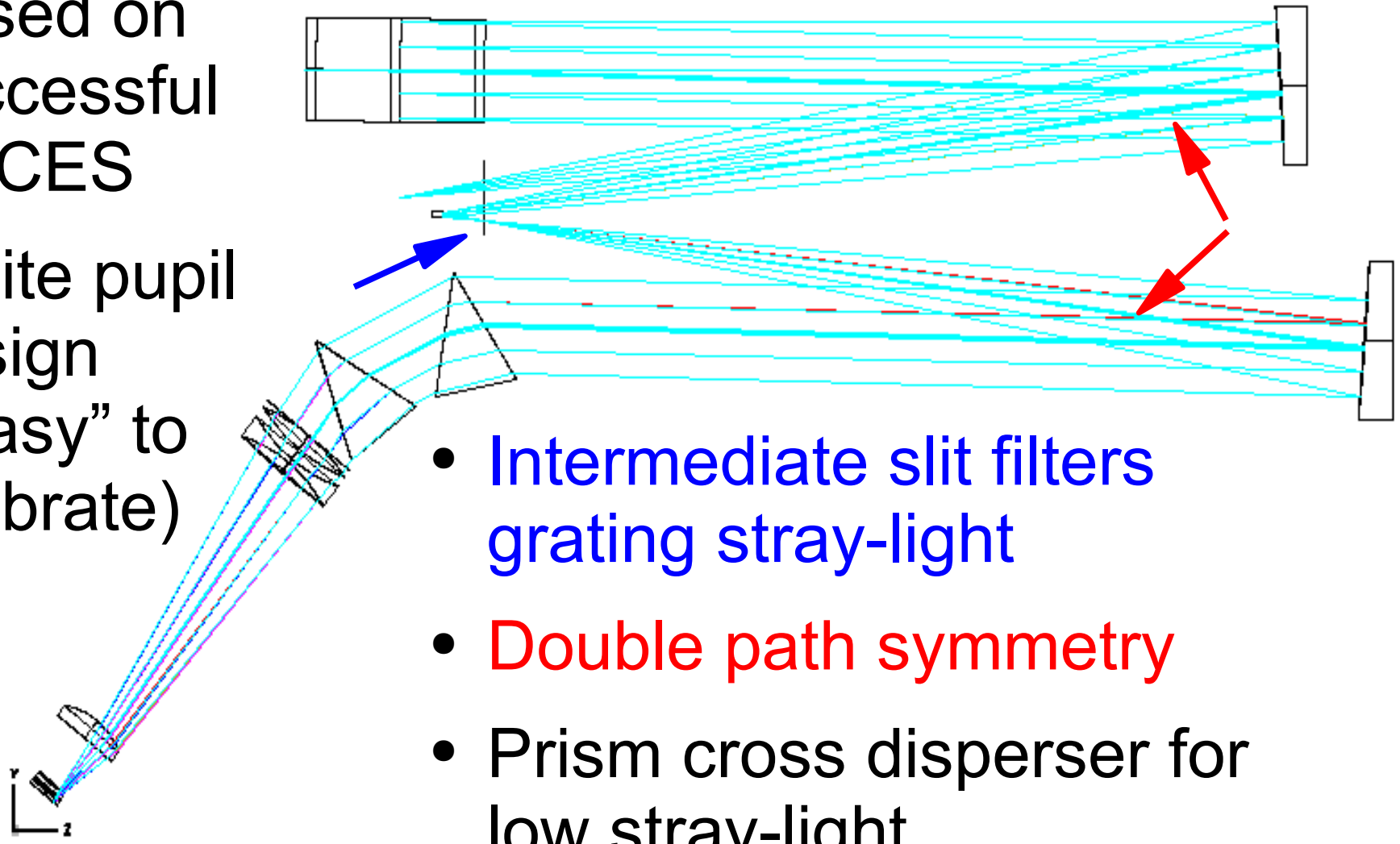
Science: Resolution & λ-coverage

- Resolution: 40000-70000
- Wavelength coverage
  - Ca H&K lines (3800 Å)
  - Mg B lines (5200 Å)
  - Balmer lines (6560,4860,4340,4100 Å)
  - O triplet (7780 Å)
  - ... ...

  → 3800 – 9000 Å

HiRes: Optical layout (1)

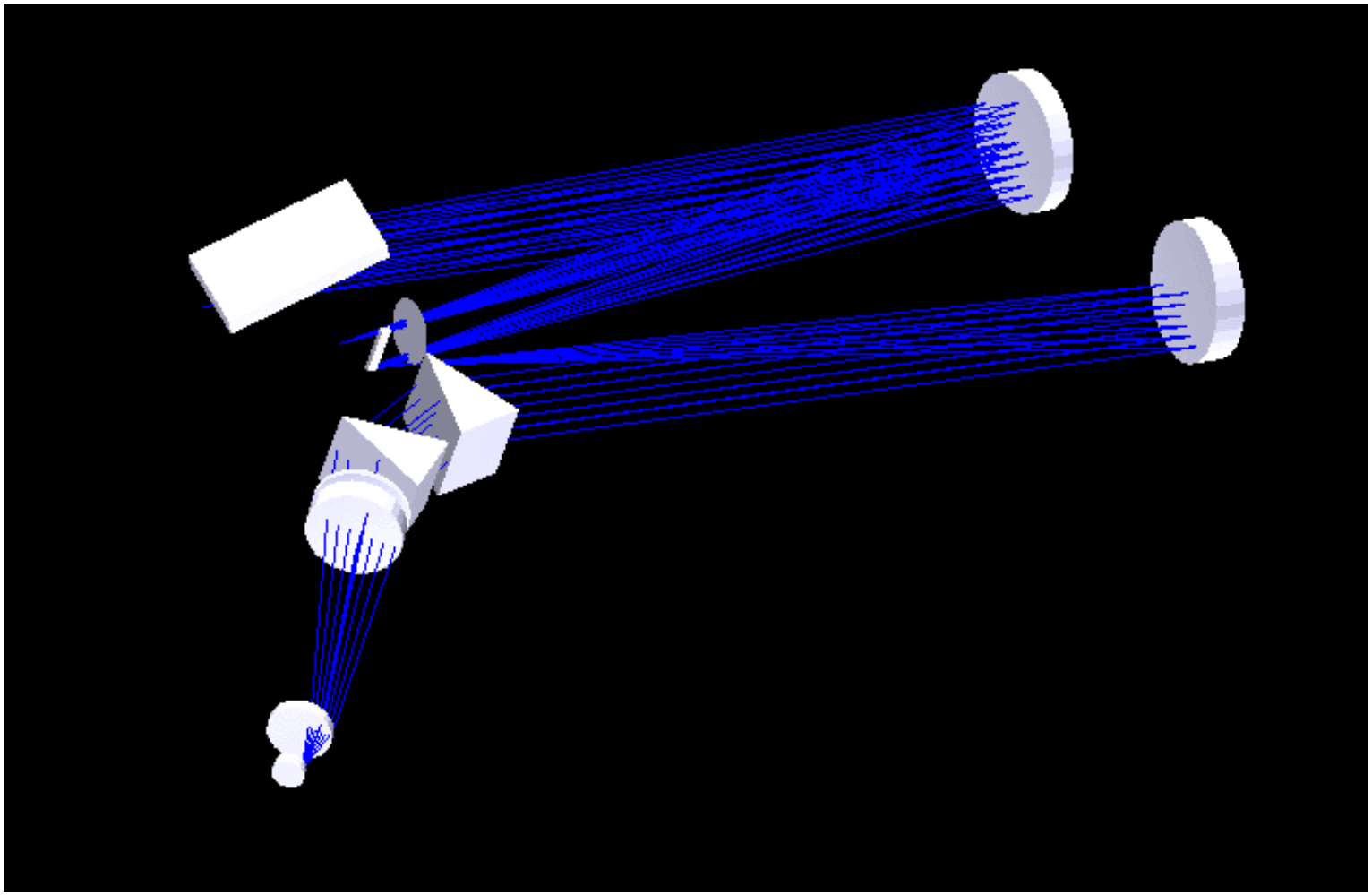
- Based on successful FOCES
- White pupil design (“easy” to calibrate)



- Intermediate slit filters grating stray-light
- Double path symmetry
- Prism cross disperser for low stray-light

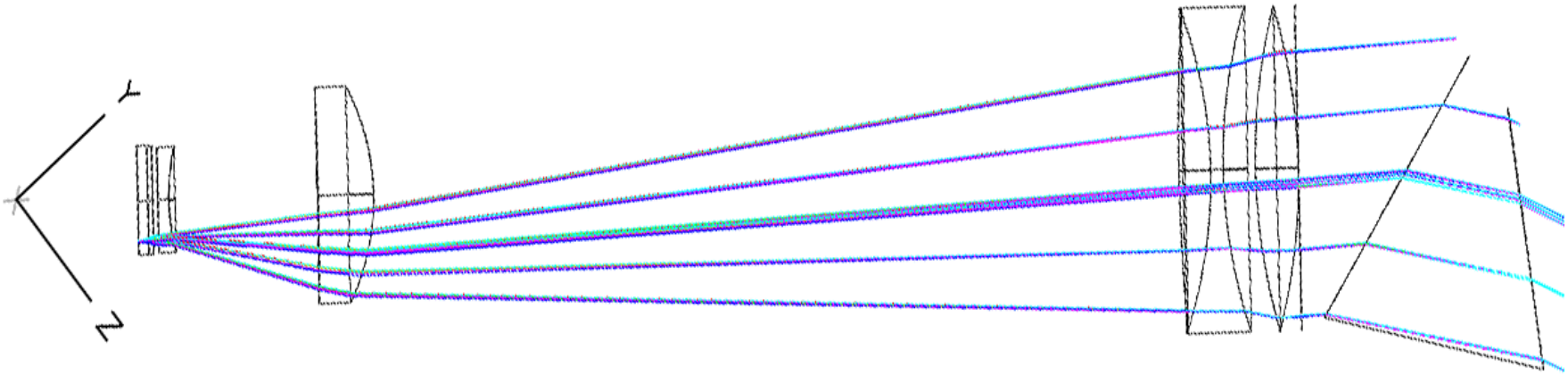
HiRes: Optical layout (2)

- Another view...



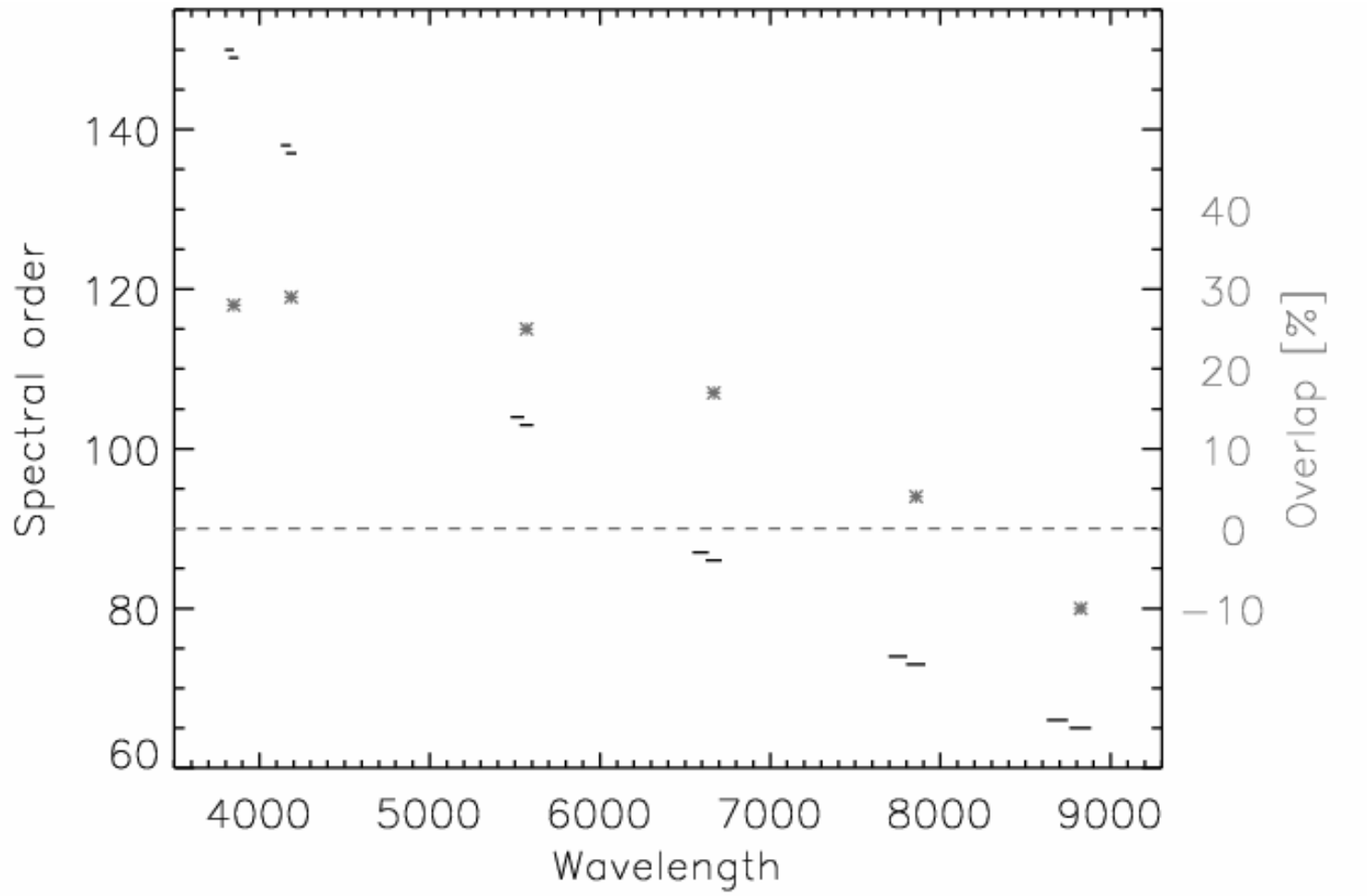
HiRes: Optical layout (3)

- Differences compared with FOCES
  - Using Chinese glasses → new camera design
  - Higher resolution 60000 → 70000
  - Completely different focal plane device



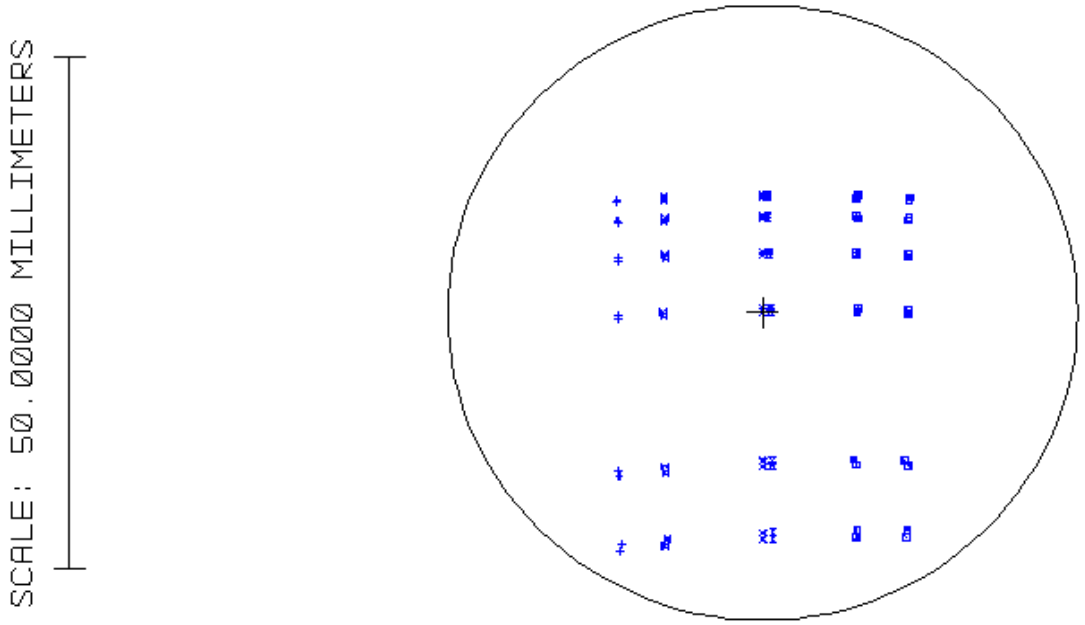
HiRes: Spectral coverage (1)

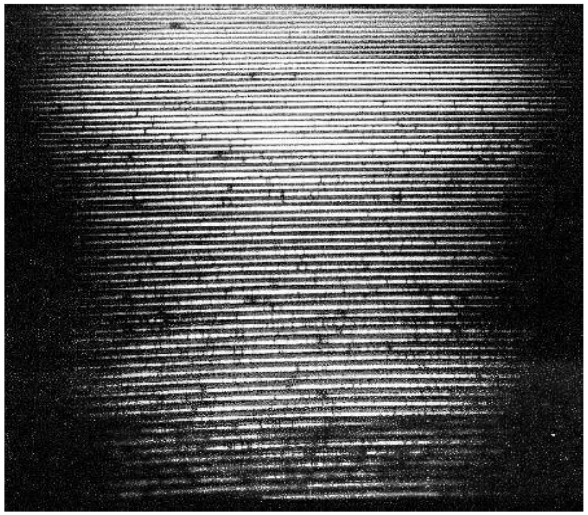
- Orders overlap from 3800 up to ≈8300 Å



HiRes: Image on CCD

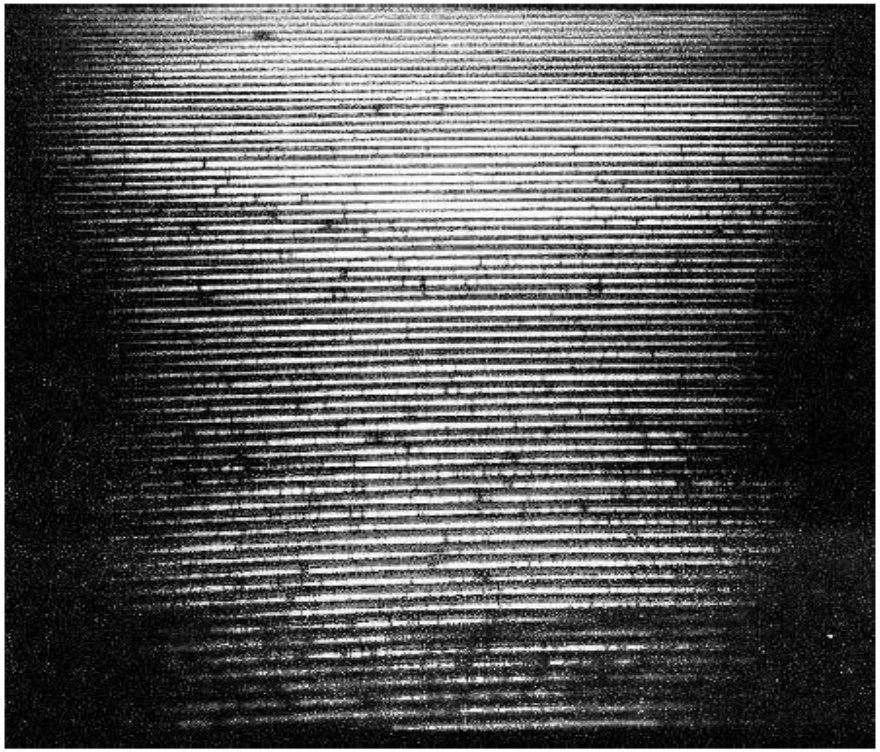
- d(image) ≈ 54mm
- 4k-12µ diagonal ≈ 68mm





HiRes: Spectral coverage (2)

- BUT: Orders getting very close together in the red
- Limits spectral coverage! → Two operational modes.



red

blue

HiRes: Configurations (1)

- Sliced and unsliced fiber-end
  - Wavelength coverage and range
  - Throughput
- Slitwidth
  - Resolution
  - Througput
- Extra cross disperser
  - Wavelength coverage and range

HiRes: Configurations (2)

- Configuration changes need to be automatic
  - Manual interaction is slow and dangerous
- Selecting a configuration:
  - There is no such thing as a ***universal spectrograph***
  - Observations need to be carefully planned to get best spectra possible
  - Seeing largely influences the spectrographs configuration

Focal plane device: General (1)

- There is already “some-thing” in the LAMOST focal plane
- This something is > 6m heigh and 1.8m broad
- It carries 4000 fibers to LowRes spectrographs
- Shack-Hartmann sensor in the middle needed for mirror alignment

Focal plane device: General (2)

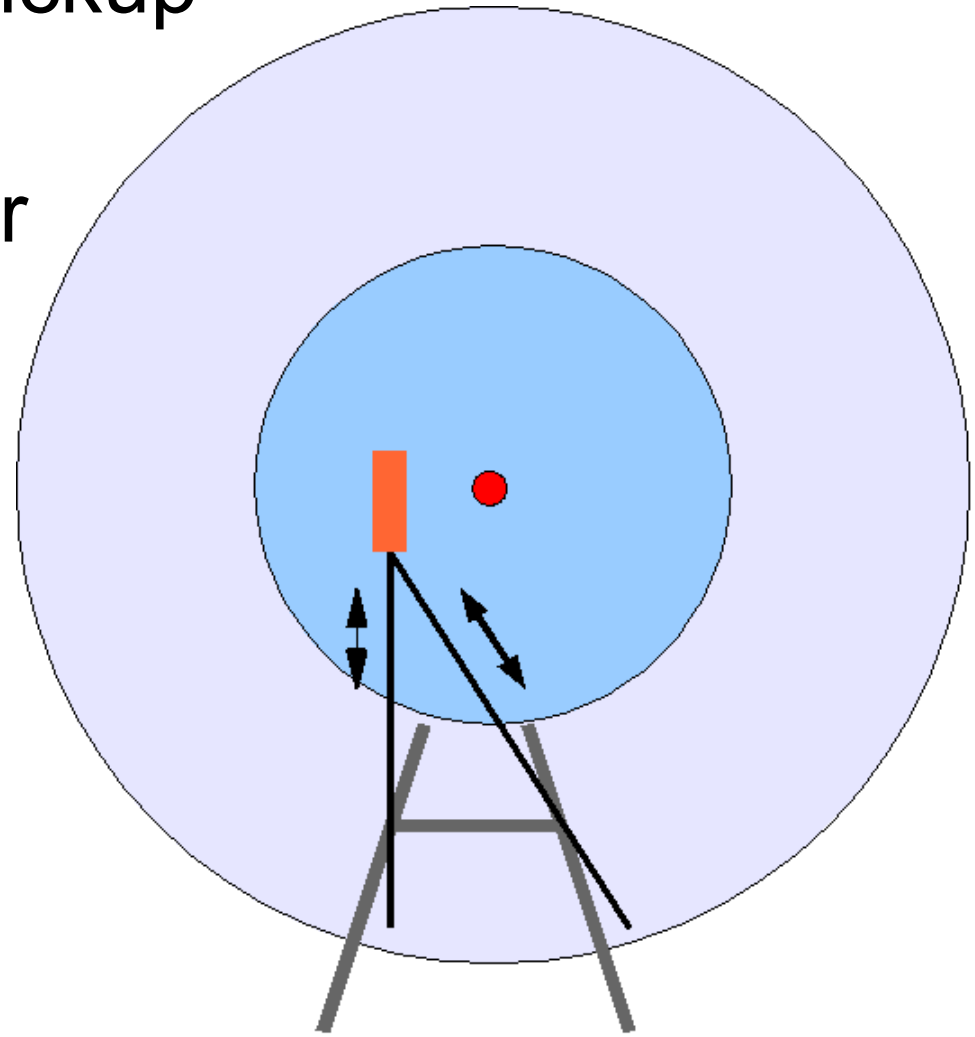
HiRes:

- Co-operates with normal LAMOST-Survey mode
- Total / partly blocks approx 7-10% of the LowRes fibers
  - Blocked fibers can be predicted
  - Footprint of pickup optics on LowRes focal plane will be minimized.

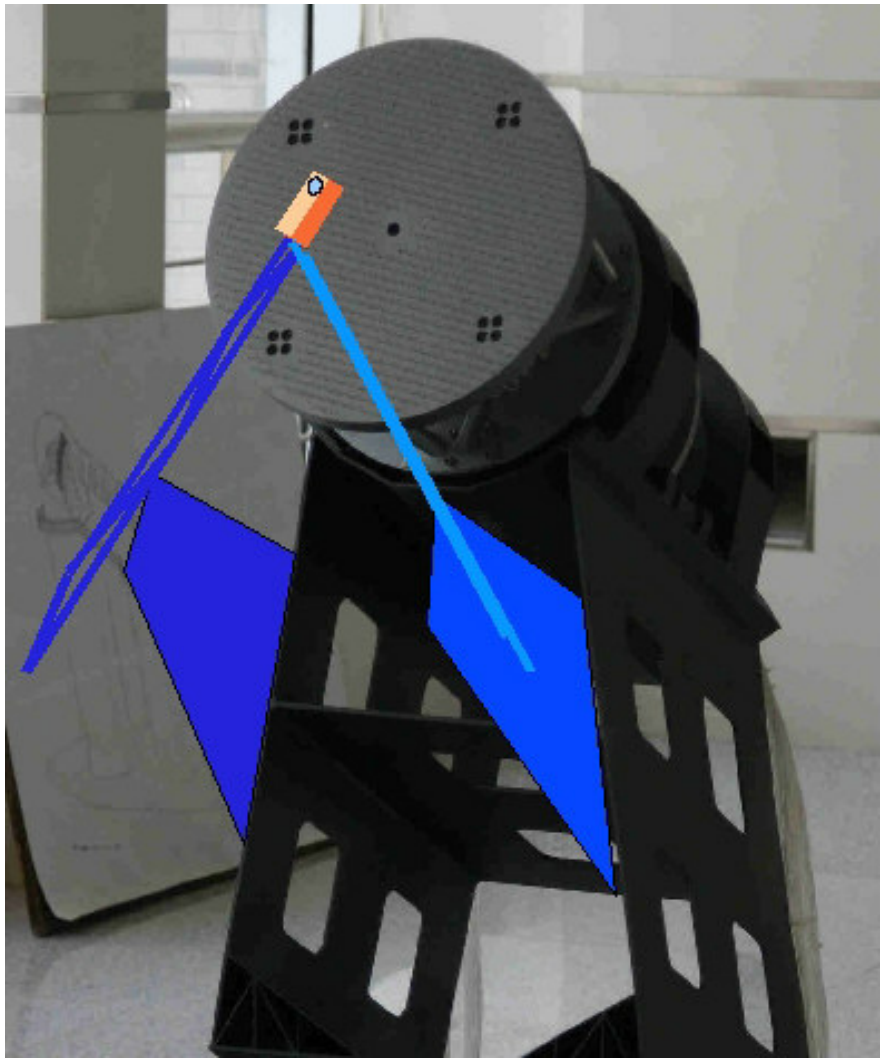
→ Survey can go on during HiRes observations

Pickup optics: Mechanical design (1)

- Movable arms get the pickup optics in place
- Shack-Hartmann sensor is kept free all the time
- Active optics can continue mirror control



Pickup optics: Mechanical design (2)



HiRes: Expected performance...

- Strongly depends on seeing conditions!!!
- A very preliminary estimate, based on the well known FOCES performance at very good seeing:
  - R=40000 S/N=100 1h → 12 mag
  - R=70000 S/N=100 1h → 11 mag
- But remember: Integration time can be very long with an opto-meachnically stable instrument... 10 hours or even longer ...

Possible observation strategy

- HiRes observations in parallel to LRS survey
  - 7-10% of LRS fibers blocked
  - Observation only if seeing is better than given threshold
    - Depending on object brightness
    - Depending on resolution

Only what can be done - will be done

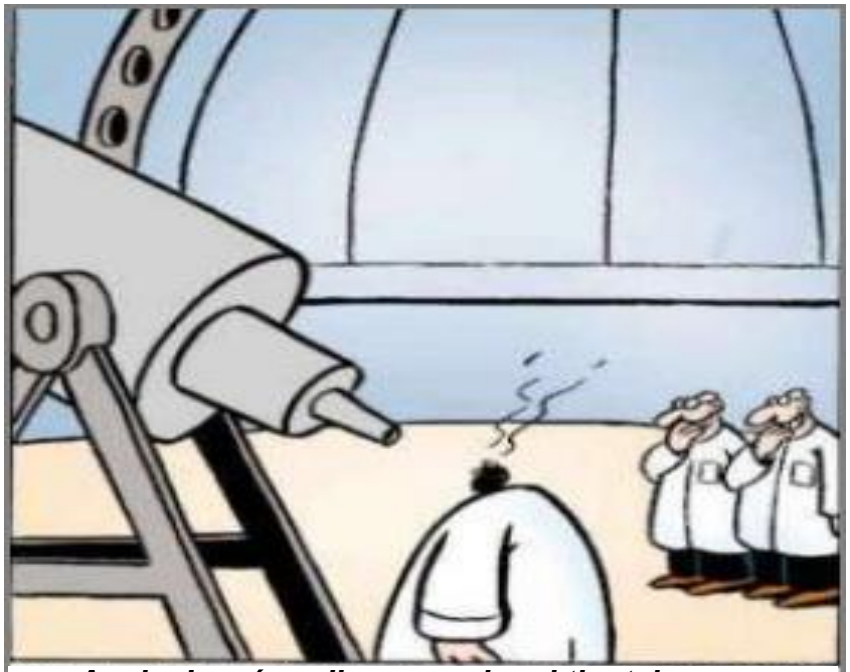
- HiRes configuration changes without manual interaction.
  - Quick changes
  - Requires (semi-)automatic alignment procedure

HiRes: Summery

- HiRes basic spectrograph design ready
  - R=70000, λ=3800-9000Å
- Seeing conditions give strong boundary conditions to design
  - Better seeing statistics needed
  - Observations have to be carefully planned
  - Spectrograph alignment has to be (semi-) automatic

HiRes: Next steps

- Final design and manufacturing
- www.grupp-astro.de/publications/langzhong.pdf



Again Jone´s colleagues aimed the telescope sneaky at the sun ...

Thank you for your time and dedication!