Optical follow-up observations of Fermi LAT blazars and NOT

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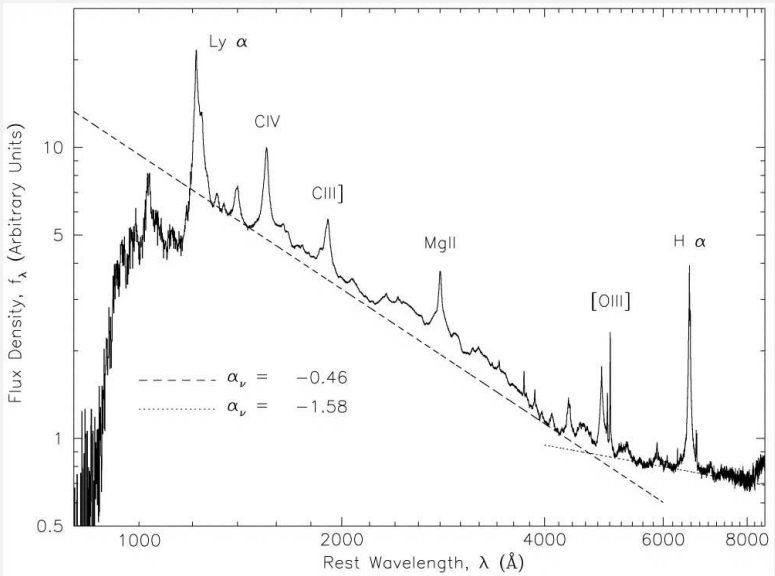
Topics, definitions

- Fermi: NASA γ-ray space telescope
- The Large Area Telescope (LAT) 20 MeV –300 GeV, the whole sky scanned in every three hours
- Blazar (Flat Spectrum Radio Quasar, BL Lac objects)
- Gaia follow ups
- NOT, Nordic Optical Telescope

Image Credit: Brian Krog

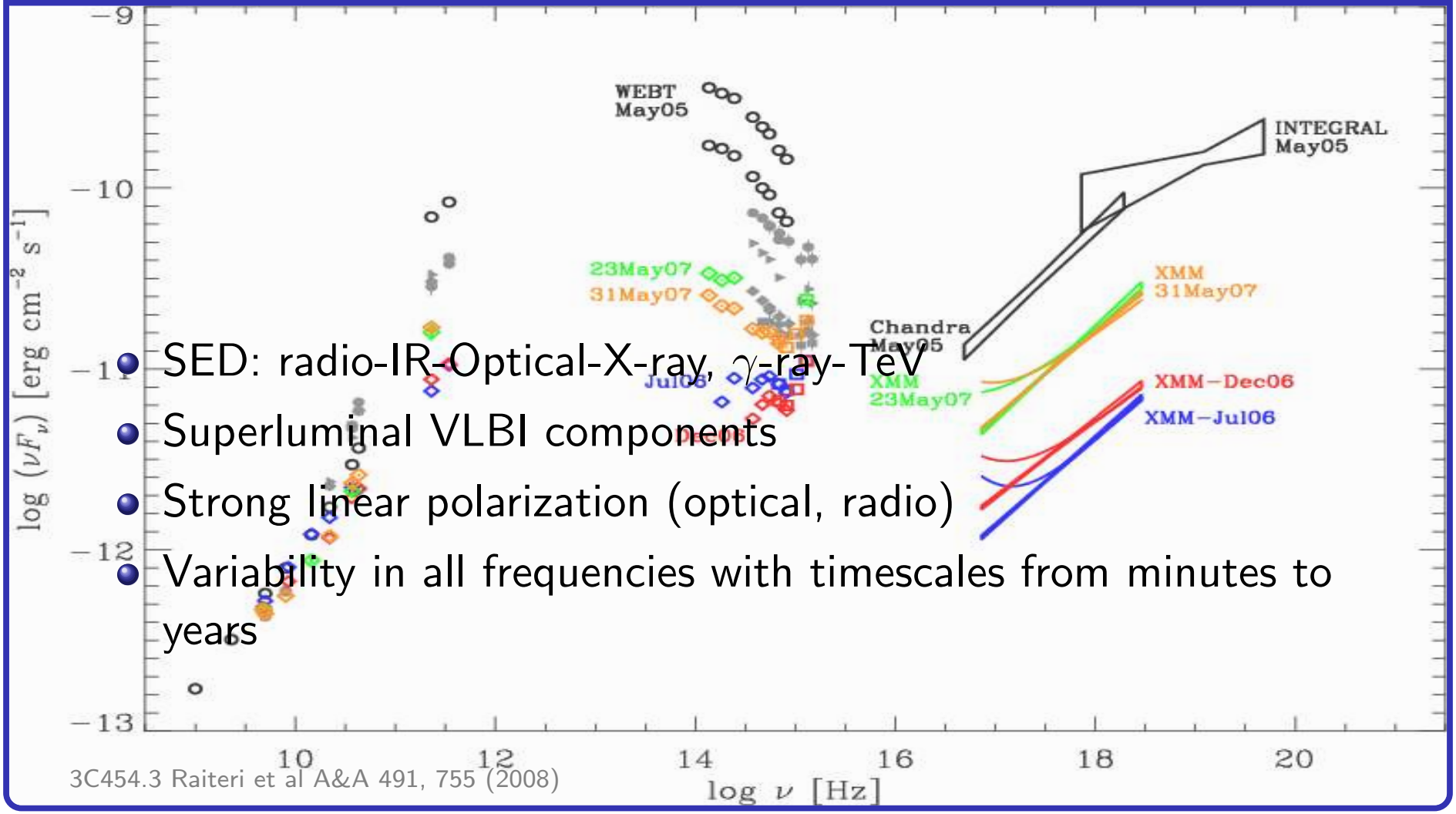
Intro, γ-AGN (blazar), observed stuff

- AGN with broad permitted lines (FSRQ) or lineless objects (BL Lac objects)



SDSS FSRQ composite spectrum (Vanden Berk et al, 2001, AJ 122, 5490

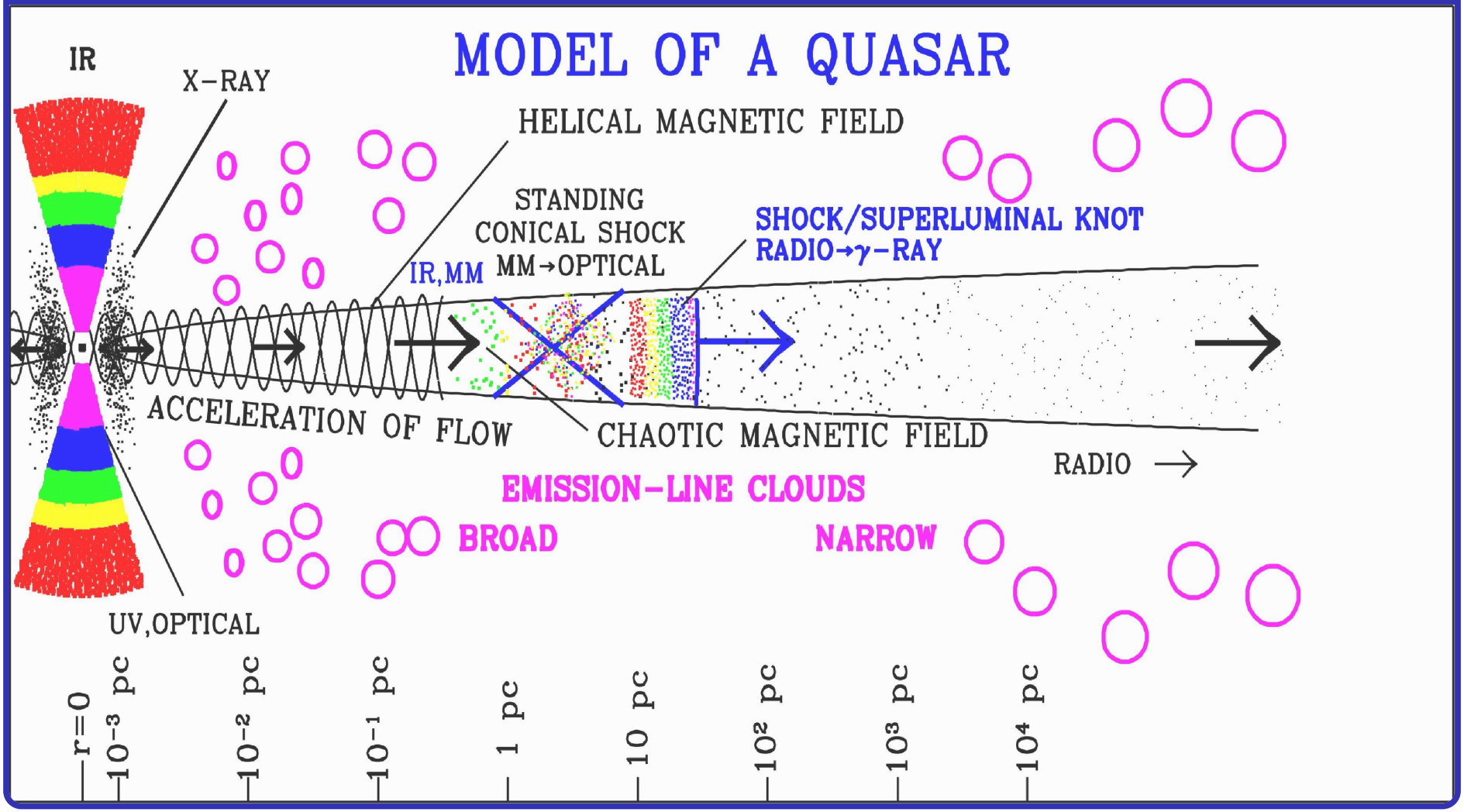
SED variability



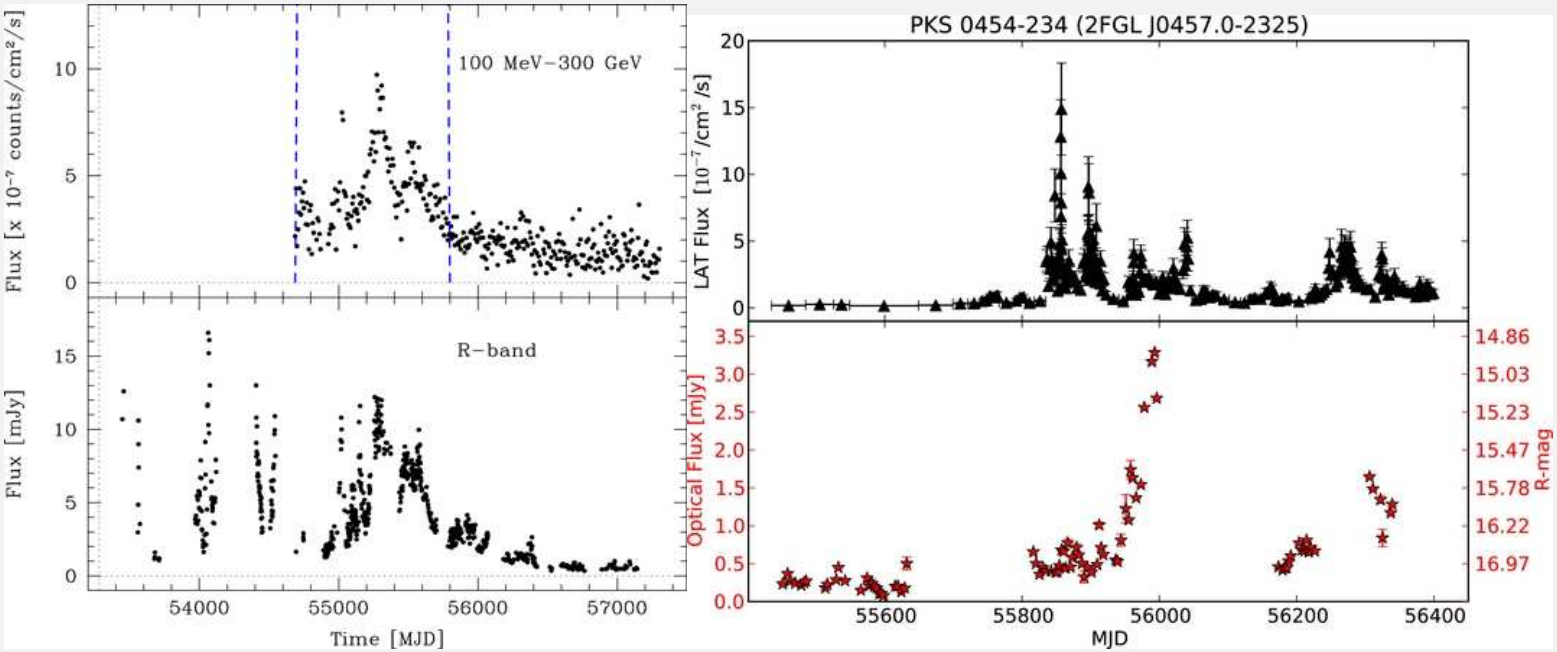
3C454.3 Raiteri et al A&A 491, 755 (2008)

- SED: radio-IR-Optical-X-ray, γ-ray-TeV
- Superluminal VLBI components
- Strong linear polarization (optical, radio)
- Variability in all frequencies with timescales from minutes to years

Marscher model, https://www.bu.edu/blazars/



blazars, optical–γ-correlation



left: PKS0537–441, Sandrinelli et al. ApJ, 820, 20 (2016), right: PKS045-234, Cohen et al. ApJ, 797, 137 (2014)

- Optical and γ-ray are often correlated, but not always
- Typical LAT blazar R$\sim$18mag

Our work & Gaia

- On average two LAT events per day, only a small fraction with Astronomer's Telegram (Roopesh Ojha private communication)
  - Example ATel #10905 CGRaBS J0809+5341 γ-ray flare ATel #10916 optical activity r=17.88, vs *SDSSr*=19.711
- TANAMI (Tracking Active Galactic Nuclei with Austral Milliarcsecond Interferometry), VLBI core programme targeting the parsec-scale structures of southern blazars, two frequencies: 8.4GHz and 22GHz. Monitoring every $\sim$4 months with a typical angular resolution of 1.5 x 0.7 mas.
- Gaia
  - Optical baseline magnitudes
  - Alert modest simultaneous optical + γ activity
  - Better understanding of radio–optical-γ correlations

NOT

- La Palma Canary islands
- 2.56m alt-az telescope
- Altitude 2382 m
- About 100 refereed publications per year
- "Normal" programme, one semester, visitor/service mode, typically one to five nights
- Large programme, two to six semesters
- Fast Track progamme, maximum 4 hours
  - Fee for non-Nordic PI: 1670 Euro per night, assuming an average of 10 hr per full night.
- Flexible scheduling
  - Target of Opportunity (immediate reaction)
  - "Soft" Target of Opportunity (reaction on the next service night)
  - Monitoring programmes, monthly, weekly daily visits

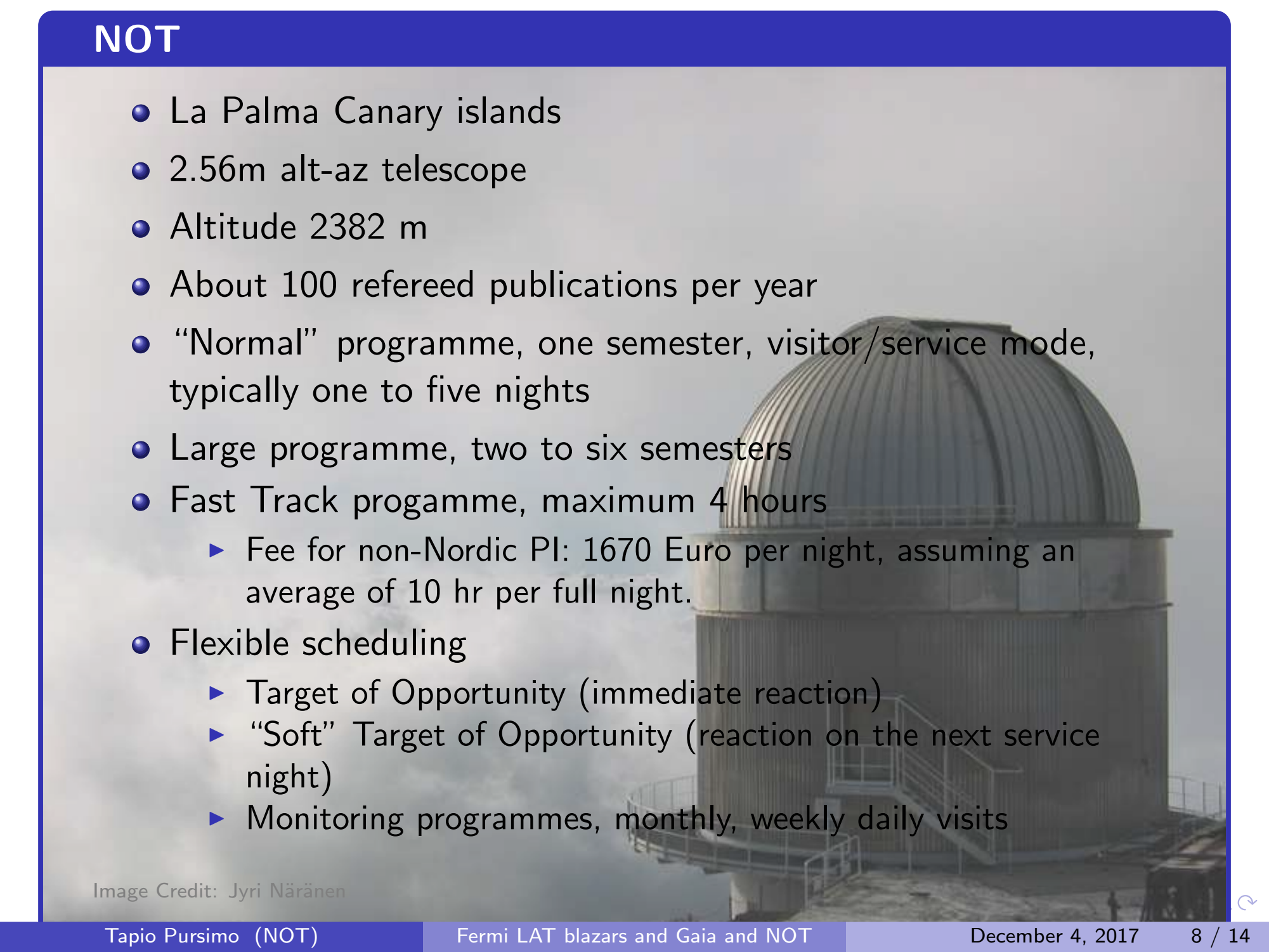
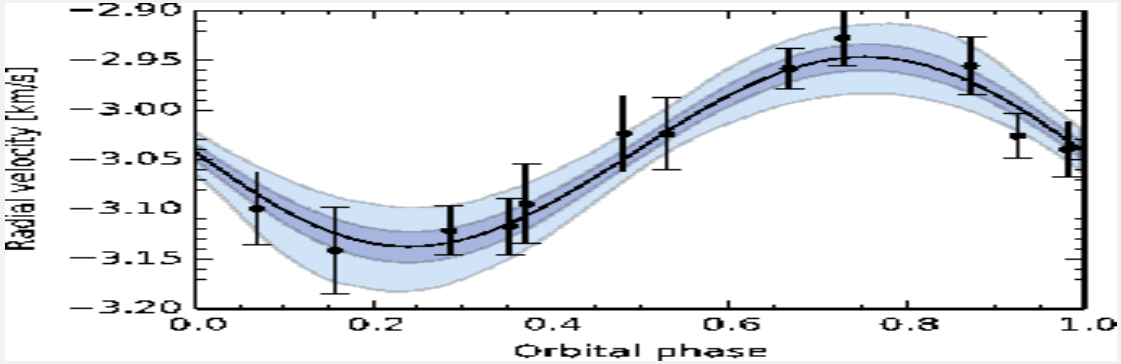


Image Credit: Jyri Näränen

NOT instruments: ALFOSC

- Detector: e2v, FoV 7.3′ square, no fringes, CCD QE 90% from 4000 to 7000Å
- Observing modes: imaging, spectroscopy, polarimetry
  - Imaging: three filter wheels, 19 slots
  - Filter set: Bessell, SDSS, Strömgren, many narrow band filters
  - Grism wheel: 8 slots, 20 grisms available, R=200-2000
  - Polarimetry for non-crowded fields, with clacite + rotating retarder plate, imaging polarimetry and spectropolarimetry
- Expected count rates
  - Photometry:
    - ★ R=20mag, Sky: Gray, S/N∼100 in 6 min
  - Long slit spectroscopy :
    - ★ R=18mag, gr#4, R=360, Sky: Gray, S/N∼20 in 9 min
  - Imaging polarimetry:
    - ★ R=16 mag, Sky: Gray, polarimetry accuracy 0.3% in one minute

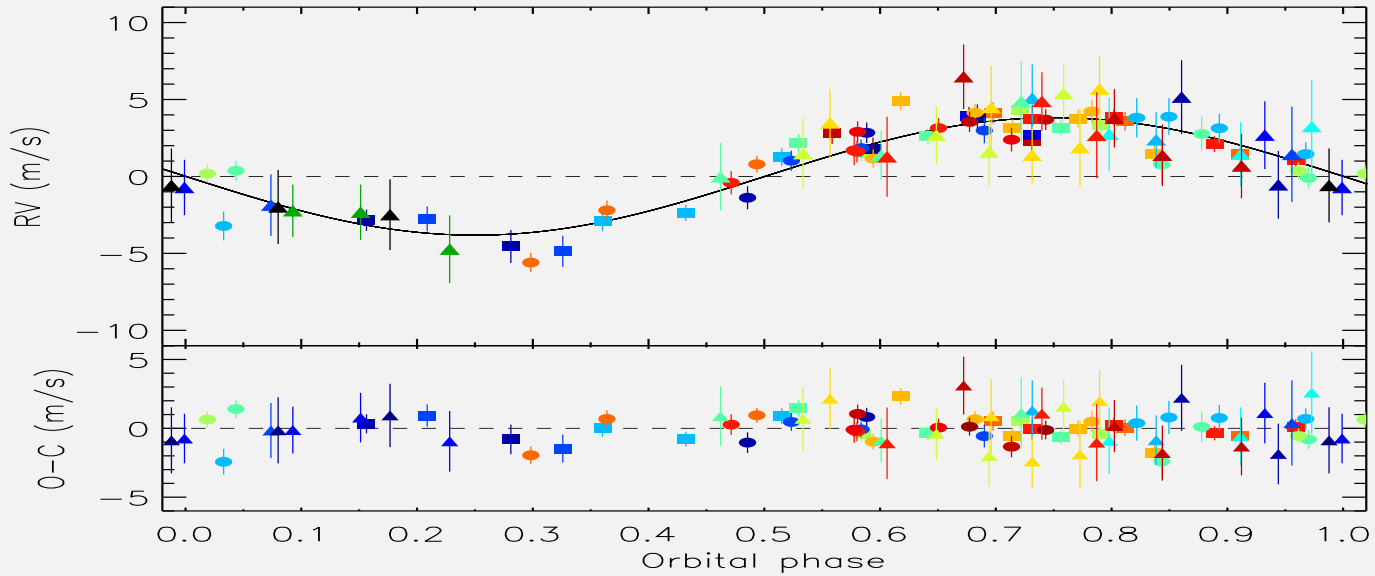
FIES, FIbre-fed Echelle Spectrograph



Kepler-423b, g=14.7, r=14.2, period 2.7 days, Gandolfi et al. A&A 576, A11 (2015)

- A high degree of mechanical and thermal stability
- Always available
- Resolution: 65000, 25000 and (45000)
- Wavelength coverage 3640 – 9100(high res), 8700 (low res) Å
- Velocity zero-point accuracy
  - 15 m/s or better, ThAr spectrum before and after
  - 500 m/s or better, using day time calibrations

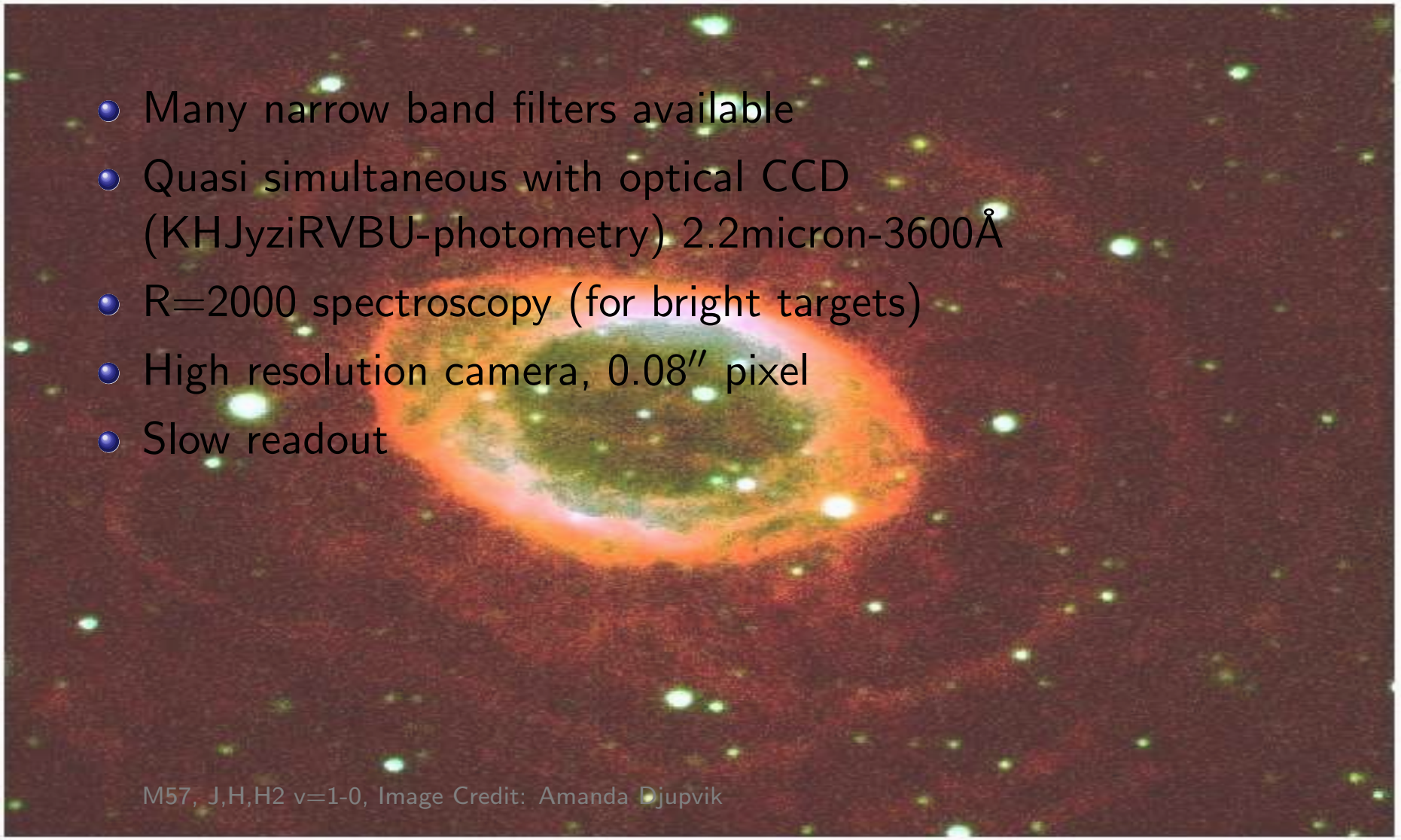
FIES, FIbre-fed Echelle Spectrograph



HD 3167, V=8.9 mag, period 0.96 days, Gandolfi et al. AJ 154, 123 (2017)

- S/N $\sim$ 60
  - High res: R=10.5 in 30 minutes
  - Low res: R=11.5 in 30 minutes
- S/N $\sim$ 200
  - High res: R=7.9 in 30 minutes
  - Low res: R=8.9 in 30 minutes

NOTCam NIR imager spectrograph



- Many narrow band filters available
- Quasi simultaneous with optical CCD (KHJyziRVBU-photometry) 2.2micron-3600Å
- R=2000 spectroscopy (for bright targets)
- High resolution camera, 0.08″ pixel
- Slow readout

M57, J,H,H2 v=1-0, Image Credit: Amanda Djupvik

The science time

- Nordic countries 75%
  - Joint TNG- NOT
    $\Rightarrow$20 nights at NOT open for Italian proposals
  - OPTICON up to $\sim$15% of the Nordic time
- Spanish 20%
- IAC-Nordic 5%
- FastTrack programme:fee for non-Nordic PI: 1670 Euros per night, assuming an average of 10 hr per full night.
- Buy a night $\sim$5000-6000 Euros

Semesters: 1.4-30.9 & 1.10-31.3

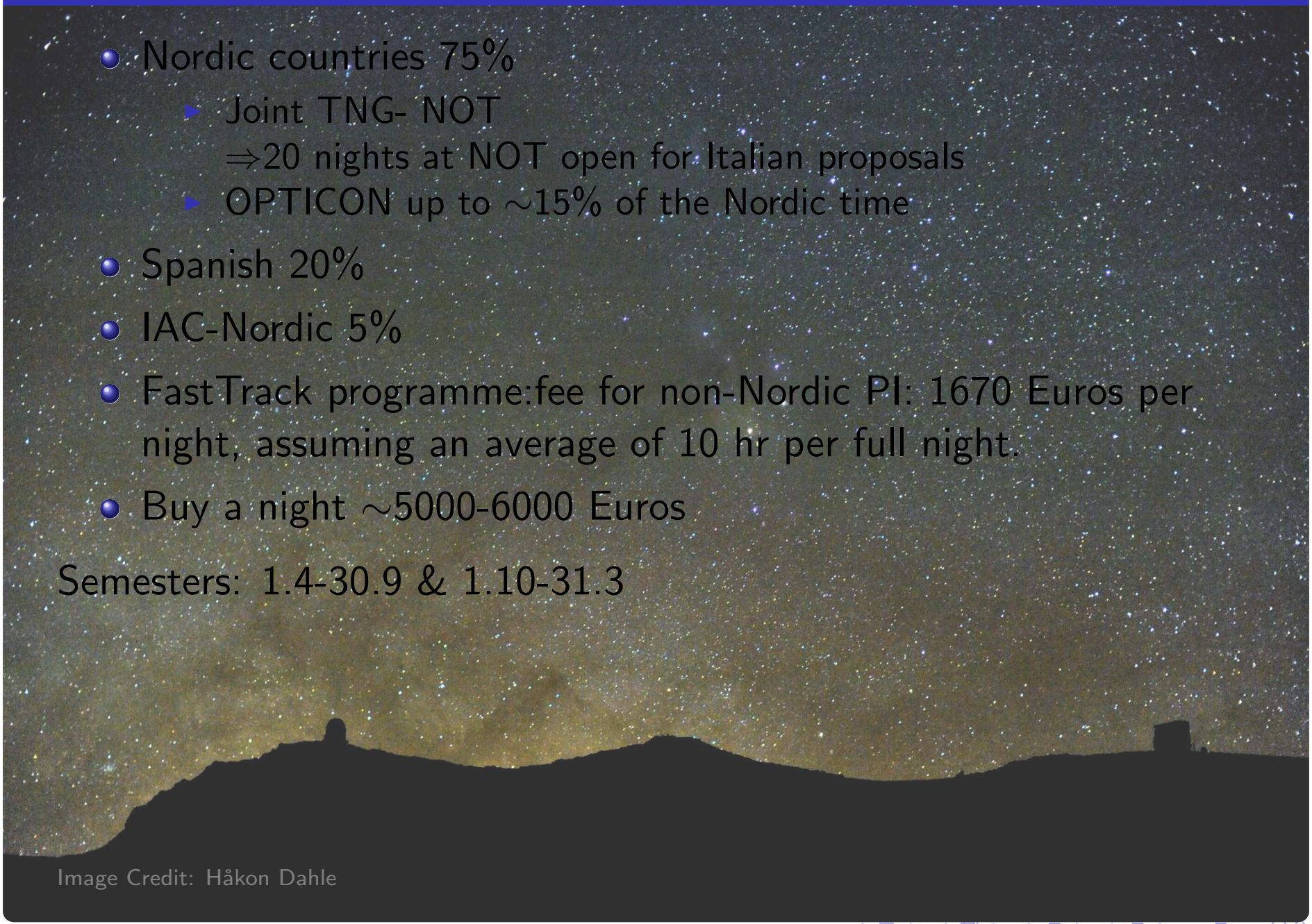


Image Credit: Håkon Dahle


Thank You!
Image Credit: Håkon Dahle