VSTpol: the first large survey telescope for optical polarimetry

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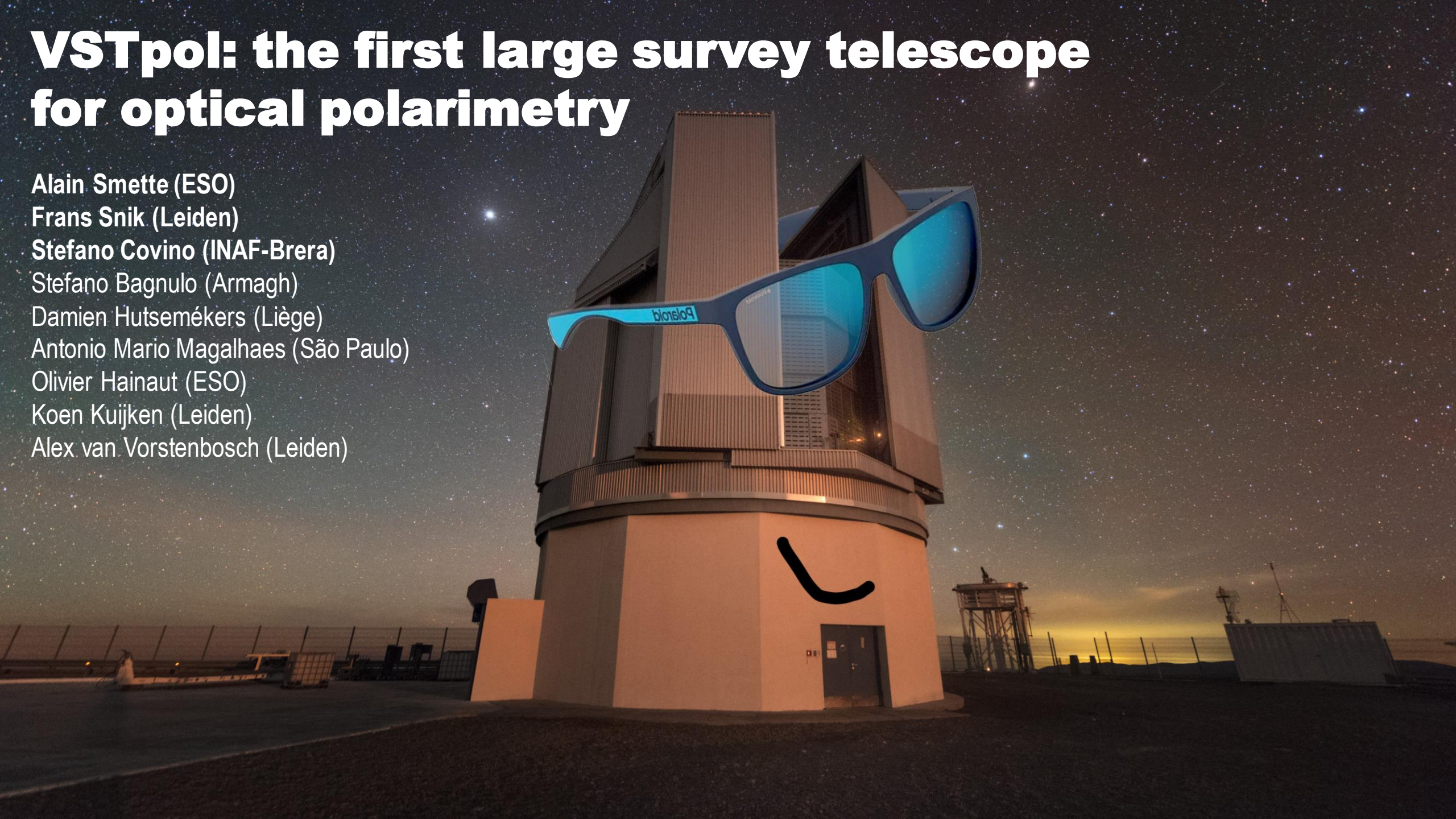
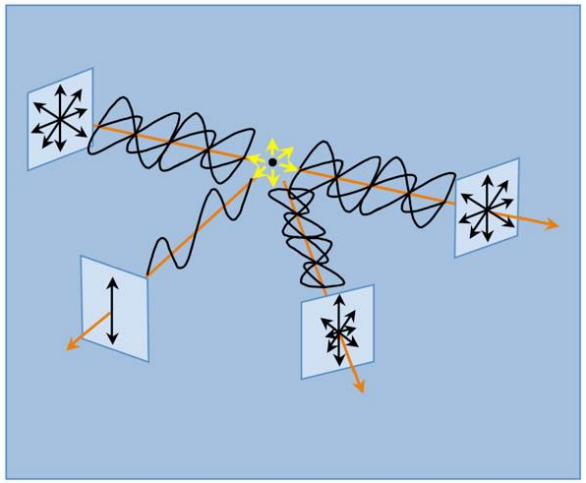


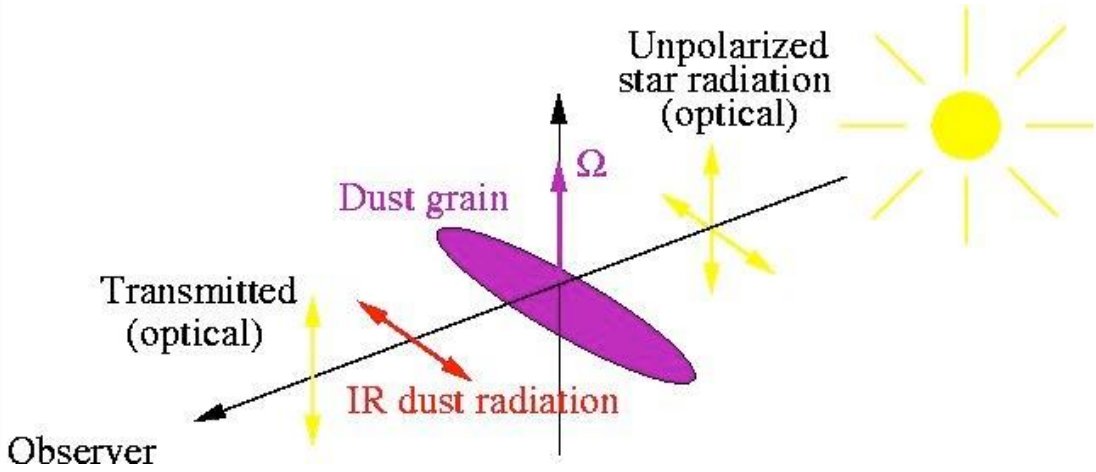
Why polarimetry?

Polarization is produced when symmetry is broken

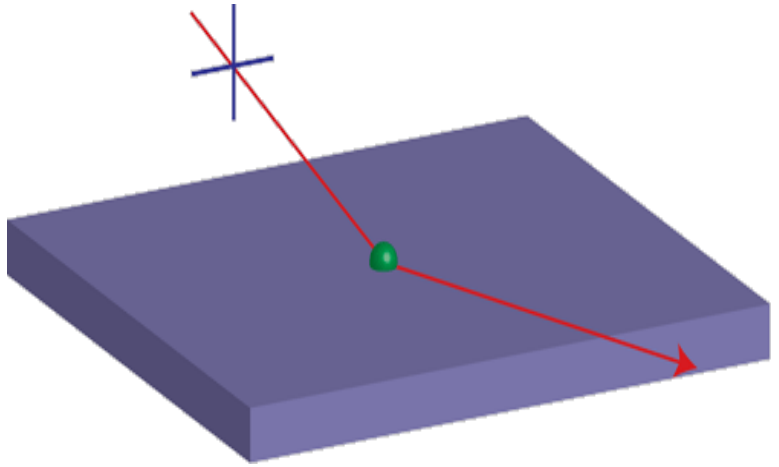
- in a radiative source, or
- between the source and the observer



Electron scattering



Dust scattering/absorption



Surface scattering

Optical/polarimetric support for CTA

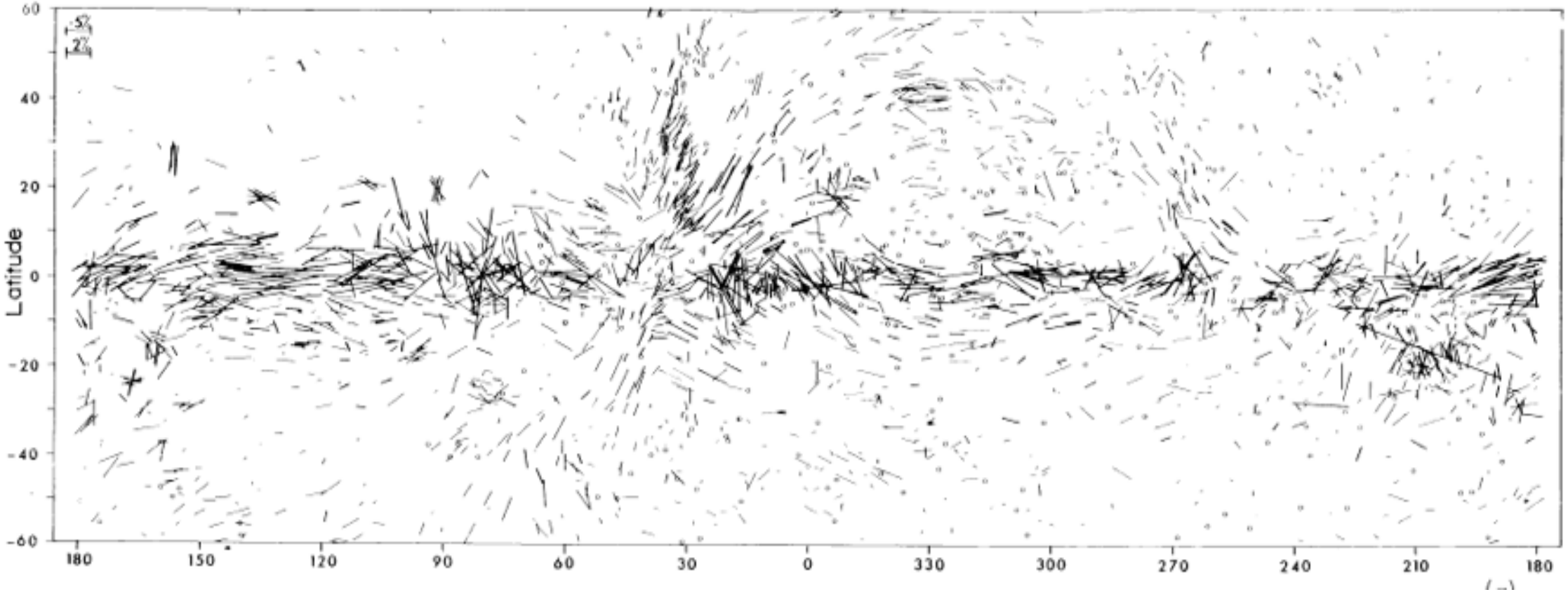
	CTA OST requirements	*VSTpol estimated performance*
Limiting magnitude (photometry)	~ 20	~ 22.9 – 24.8 for ugri
Limiting magnitude (polarimetry)	~ 17 *	~ 20
Polarimetric sensitivity and accuracy	0.5 – 1%	36 min at V~16 for 0.16% sensitivity
Field of view	5' x 5'	1° x 1°
Cadence	Intra-night	Possible, depends on time allocation
Repointing speed	Better than 2'	(30+(separation in deg)/1.5) seconds

Rapid Response Mode: start observation
6 to 8 min after trigger

- AGN and all cosmic "accelerators"
- Transients (GRBs...)
- VHE binary systems

** Markoff et al. (2018)*
Critical Assessment of Optical Support Needs for CTA Science and Consensus Proposal

Optical starlight polarization: 3D galactic magnetic field



O(3,000h): correlation with accurate Gaia parallaxes: 3D mapping of the magnetic field of MW, LMC, SMC + correlation with Planck

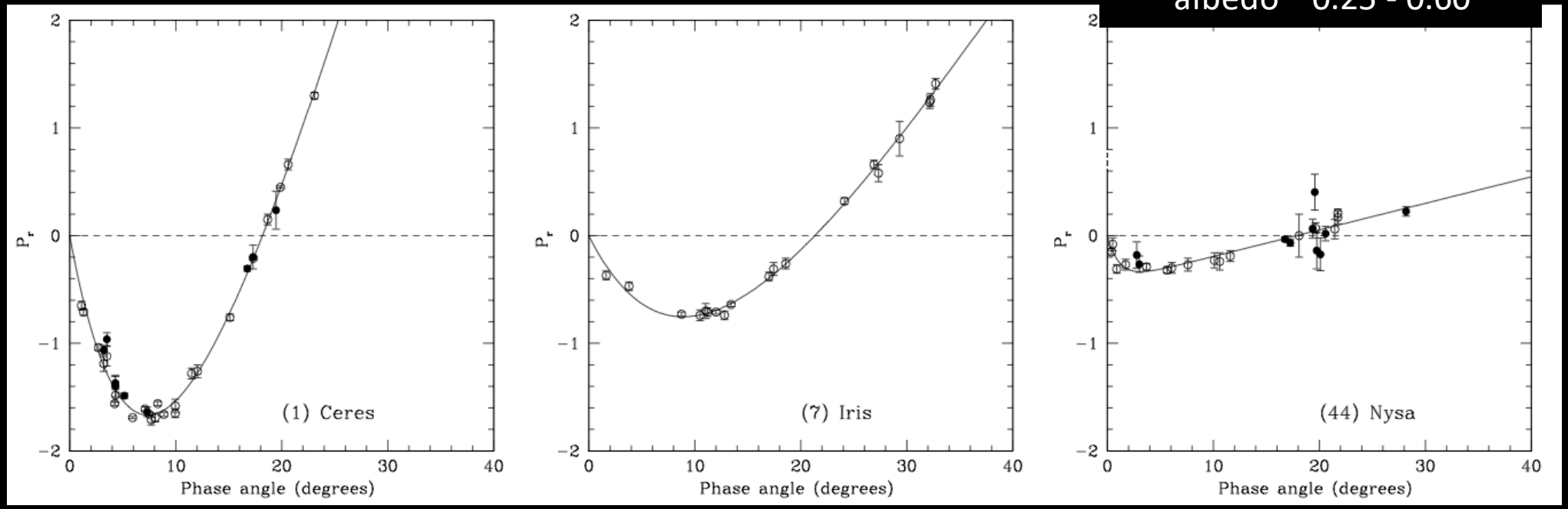
Classification of asteroids

S- and C-type asteroids can be classified through their polarization properties

C-type (carbonaceous)
low-albedo (0.03-0.10)

S-type (silicaeous)
albedo ~ 0.1 - 0.2

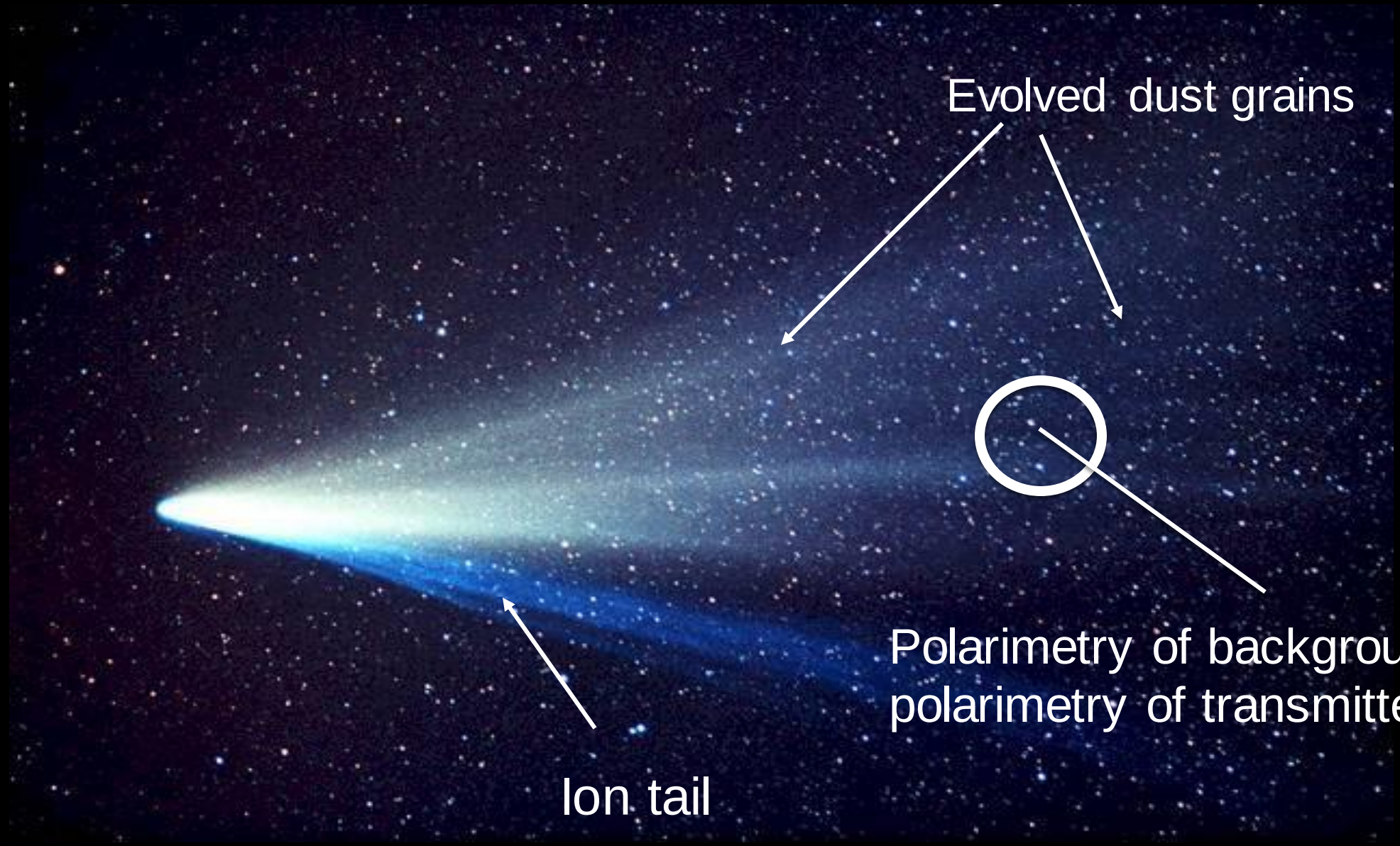
E-type (enstatite achondrite)
albedo ~ 0.25 - 0.60



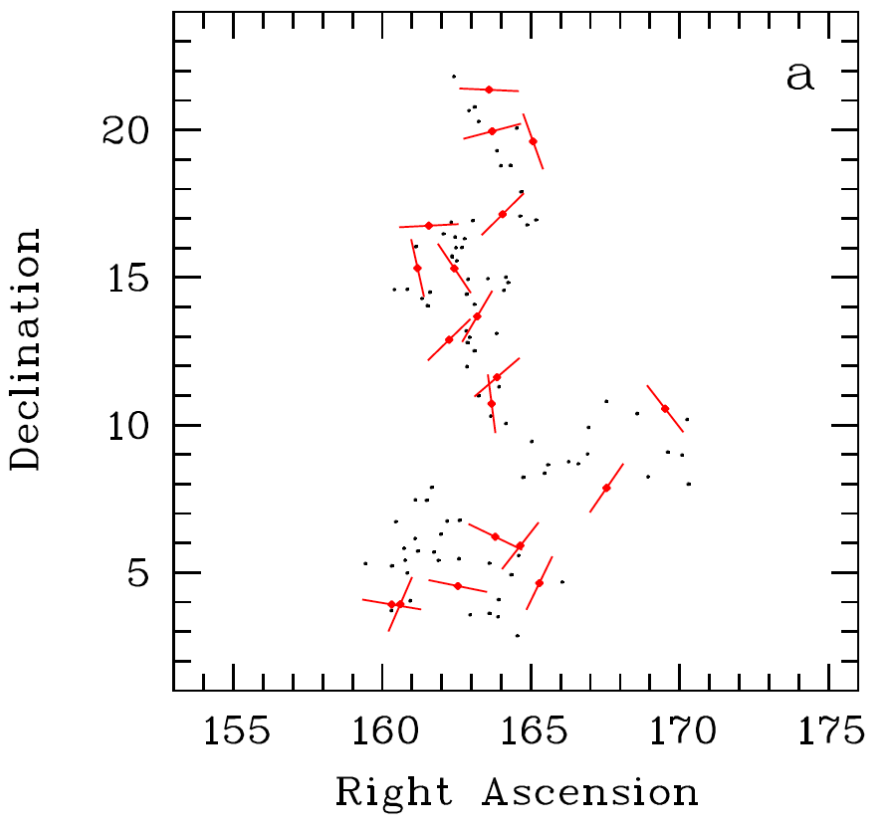
Bagnulo (2018)

O(10,000h) VSTpol survey of the ecliptic increases by a factor of ~ 10 the number of V< 20 asteroids with polarimetric measurements

Comets: dust grain evolution



Orientation of AGN polarization axis

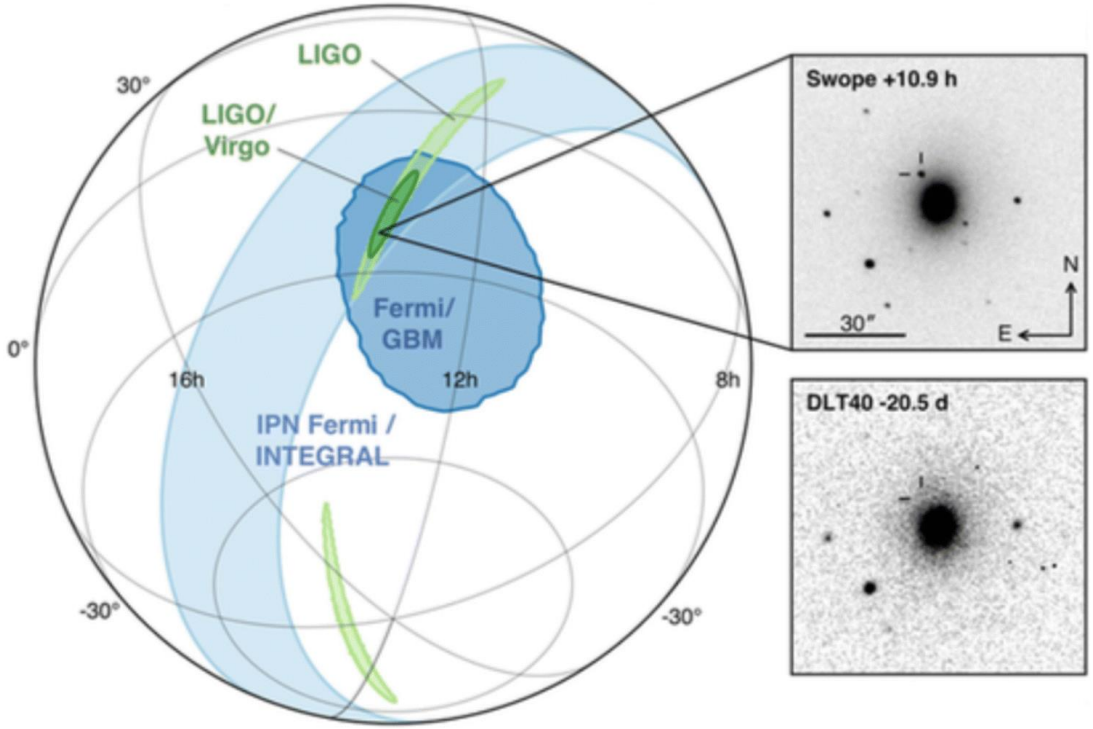


Hutsemékers et al. (2014)

- Directions of AGN morphological axes - as probed by measurements of polarisation position angle **-show structures from 100 Mpc to ~ 500 Mpc**
- **Alignment with the large scale structure**
- O(6,000h): polarization for 20,000 QSOs down to sensitivity ~ 0.3%
- VST would be 20 times more efficient than EFOSC/FORS2

GW electromagnetic counterparts

- GW localizations for good S/N events will be even better than 10°
- Early-time (hr) kilonova polarisation is a powerful and unique diagnostics.
- Only a large FoV polarimeter could make these observations feasible.
- Unique science!



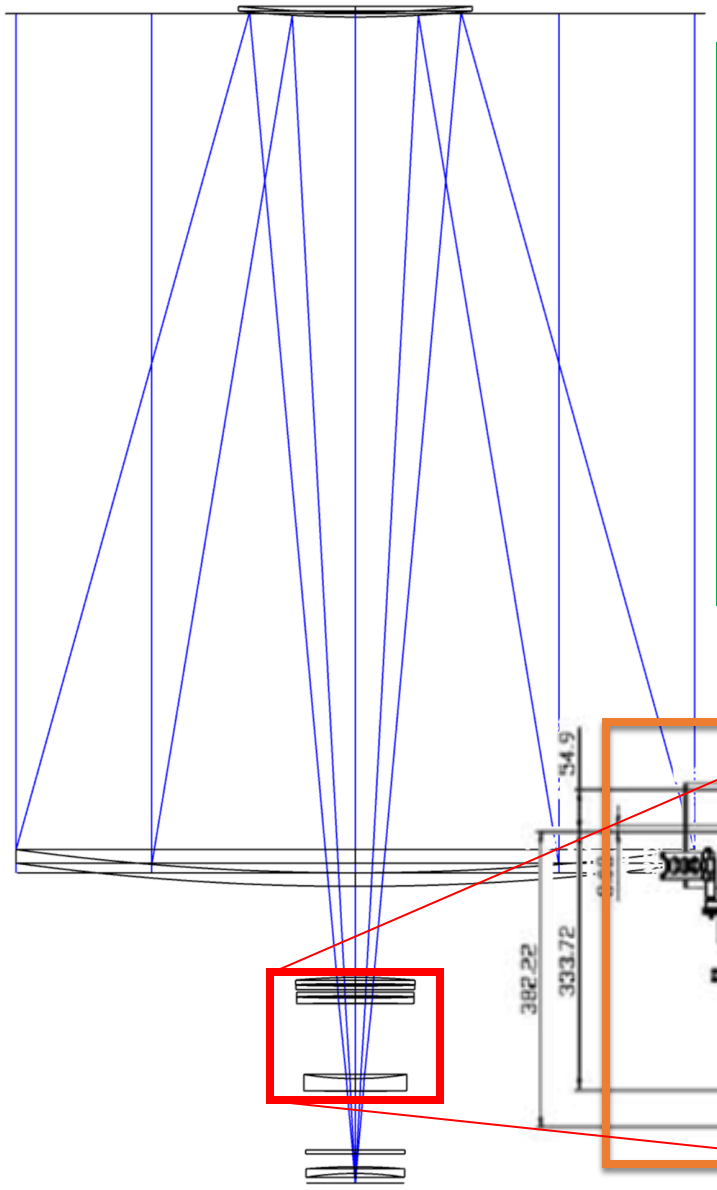
This is true for any rapid transient without (yet) accurate localization

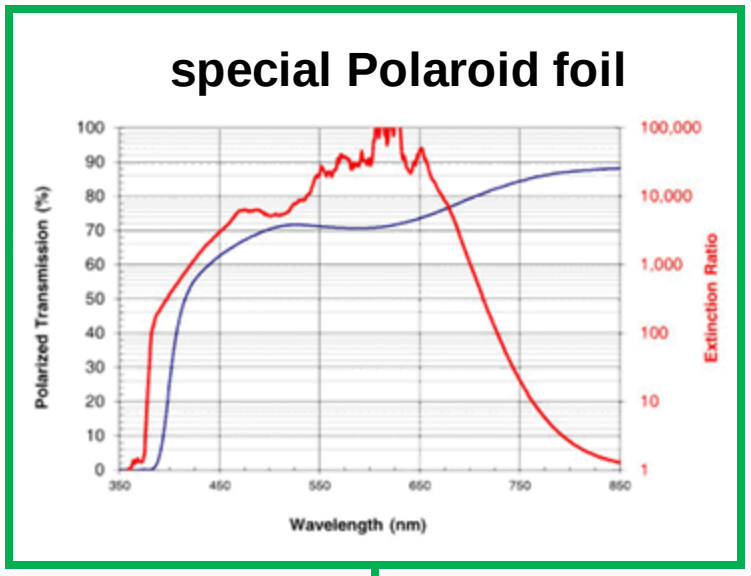
Many other science cases for VSTpol

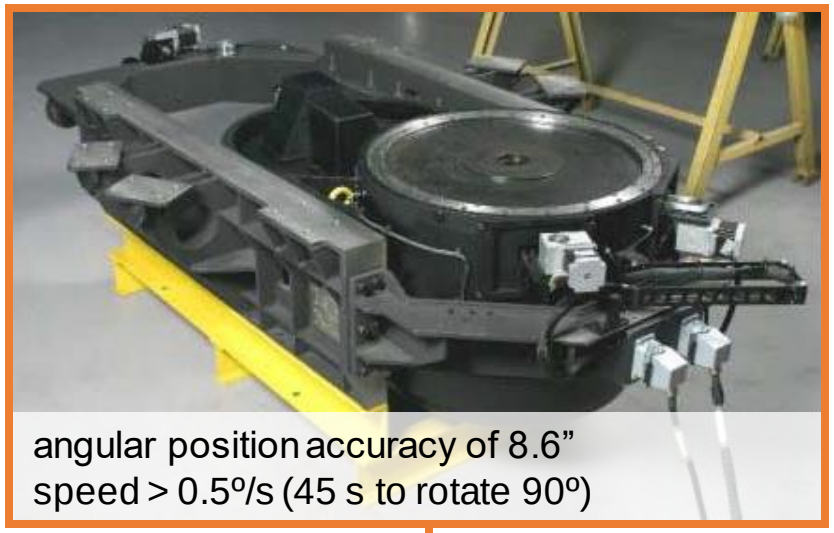
- the Moon and planets
- Kordylewski clouds & Earth Trojans
- zodiacal light
- atmospheric structure of brown dwarfs
- "dark" clouds, low-mass star forming regions, HII regions
- planetary nebulae
- stars with disks (e.g., Herbig AeBe)
- white dwarfs
- SN afterglows
- light echoes
- weak gravitational lensing

Huge discovery space!

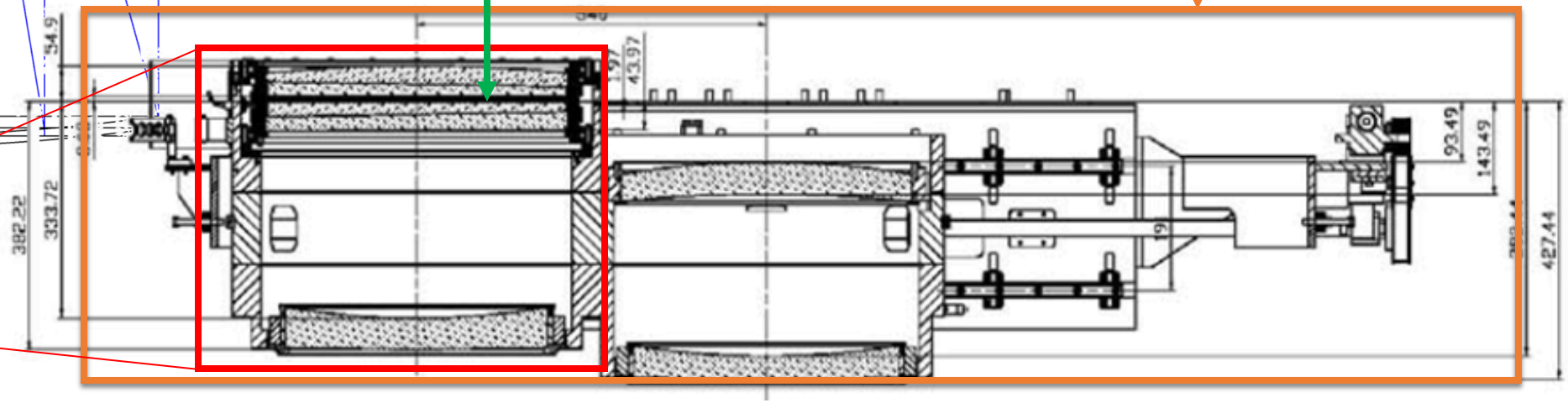
Polarimetric implementation







angular position accuracy of 8.6”
speed > 0.5º/s (45 s to rotate 90º)



Polarimetric implementation

polarimetric sensitivity

Single-beam implementation is susceptible to temporal variations (seeing, sky transparency, Starlink trails, etc.).

polarimetric accuracy

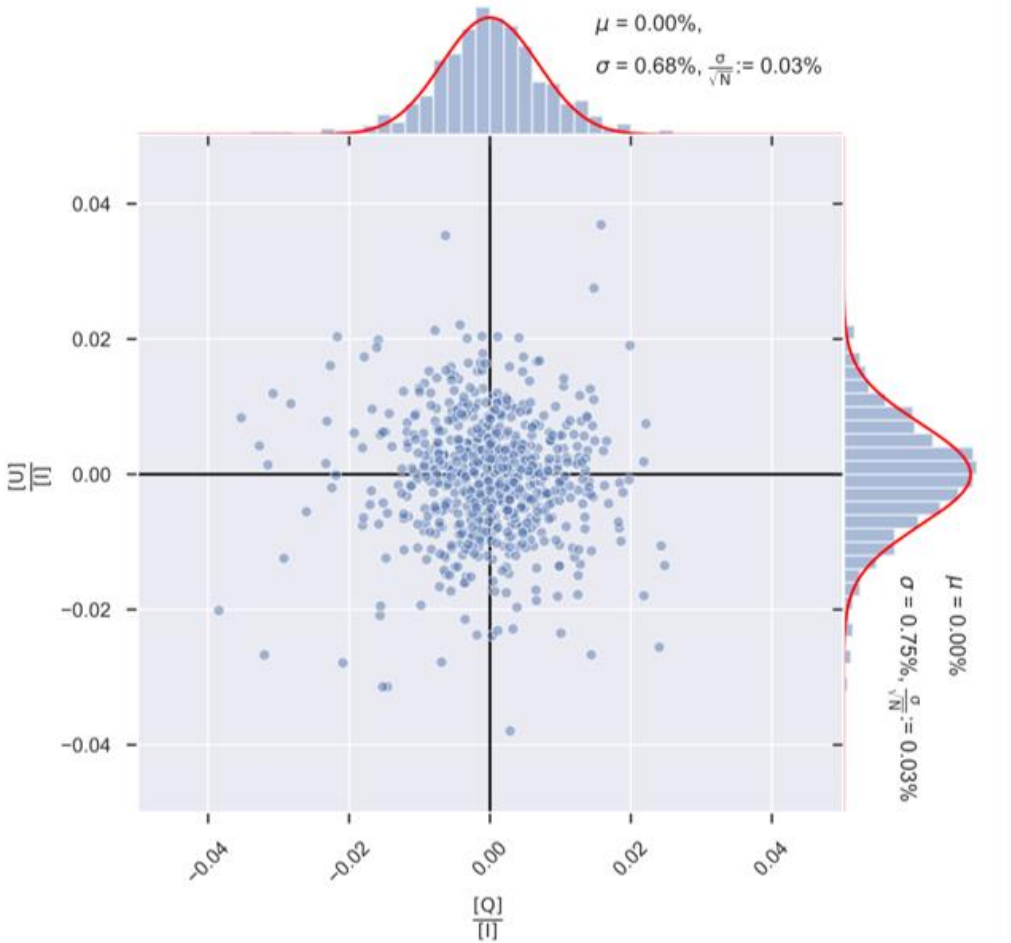
Lenses before the polarizer induce polarization, and can convert source polarization into unmeasurable circular polarization.
Both as a function of field position and wavelength.

However, many unpolarized stars in the field can help correct for these effects!

Polarimetric implementation

polarimetric sensitivity

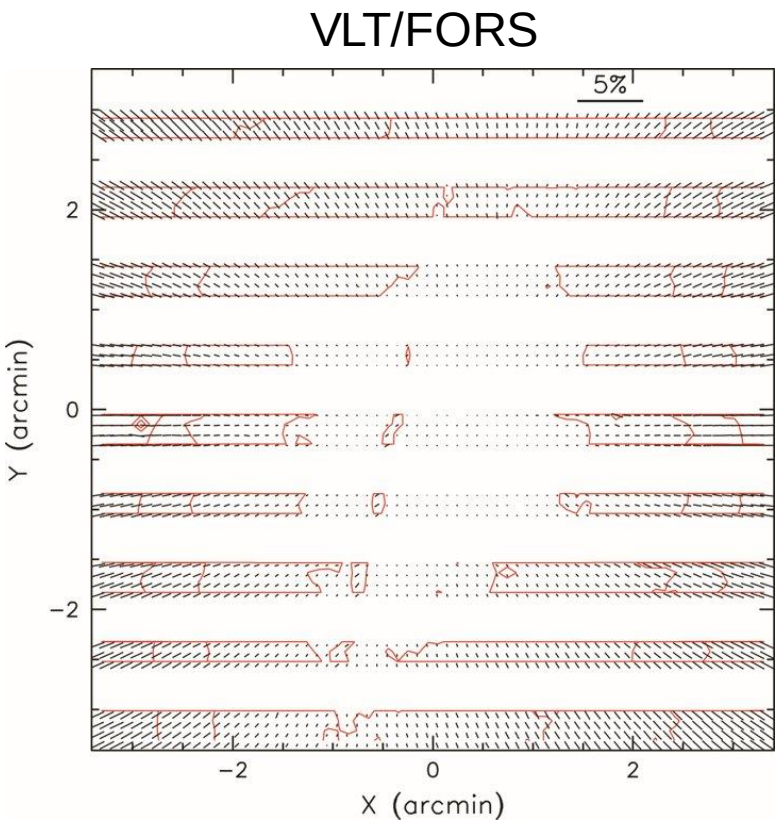
~0.1% for 30 min V=16



A. van Vorstenbosch MSc thesis, Leiden

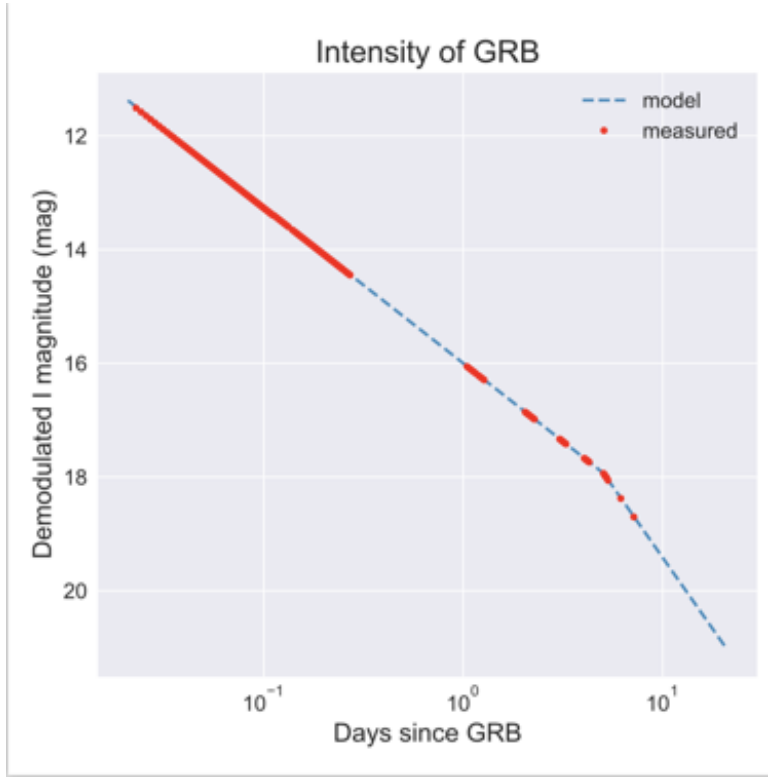
polarimetric accuracy

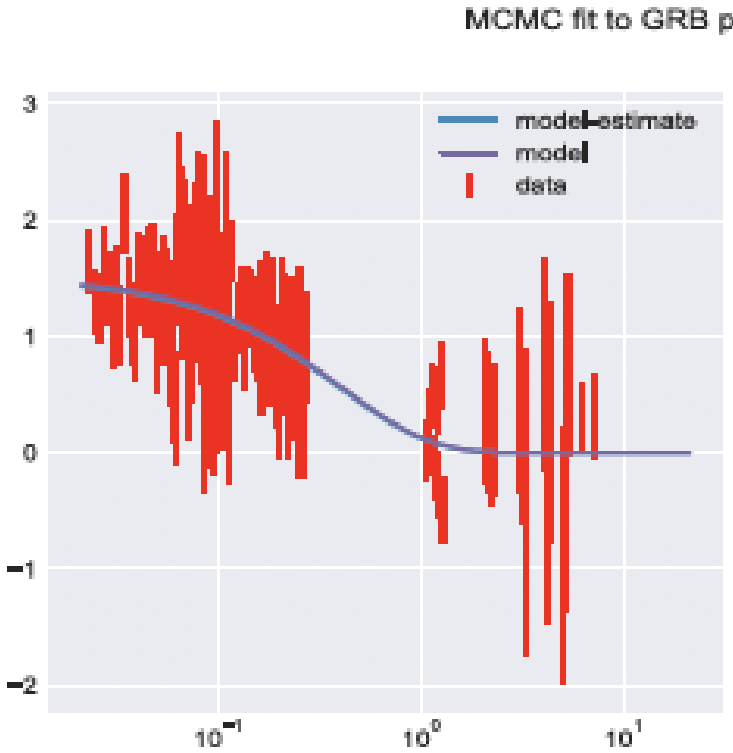
~0.1%

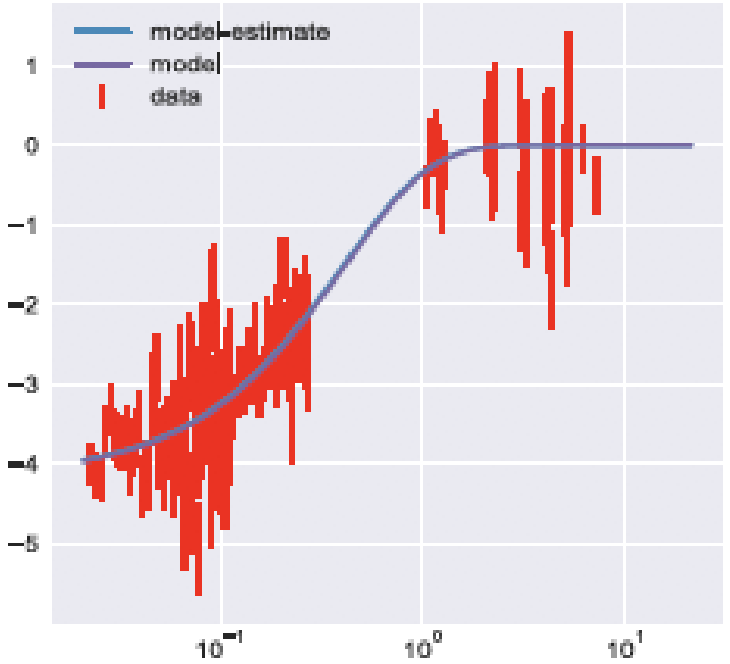


Patat & Romaniello (2006)

Performance simulation: GRB afterglow







VSTpol: the first large survey telescope for optical polarimetry

- **unique instrument**, with no competitor
  - polarimeter
  - 2.6-m telescope x large FoV
  - maintains current capabilities
- **perfect timing**
- **cost-effective**
- **strengthens Italian community**
  - CTA
  - for transients
  - for asteroids
  - Planck
  - Rubin (LSST) follow-up

Other polarimetric surveys

Project	Telescope & diameter	FoV [deg^2]	(area* FoV) * T/#exp [m^2 * deg^2]	Polarimetric optics	Sensitivity	Status
SOUTH POL	1 m telescope	4	2.2/4 = 0.55	dual-beam polarimeter	For V=16, 0.16% in 2400s	1m tel. : project. Polarimeter is commiss. on 84cm tel.
MOPTOP (RINGO3's successor)	Liverpool @ La Palma: 2 m (shared with other instruments)	0.014	0.044/4 = 0.011	dual-beam polarimeter	For V=16: ~0.1% in 2000s	Commissioning?
RoboPol	Skinakas observatory (Crete): 1.3 m (shared with other instruments)	0.045	0.060	4-channel polarimeter	for R= 16 0.25% in ~ 1200s	Operational
PASIPHAE	Skinakas observatory (Crete), 1.3 m South African astron. obs., 1 m (shared with other instruments?)	0.25	0.33 0.20	4-channel polarimeter	For R=16.4 0.2% in 900s 1440 s	Project
VST pol	VST (Paranal), 2.6m (dedicated telescope, shared time with normal imaging?)	1	5.3*0.5/3 = 0.88	single-beam polarizer	For V=16, ~0.1% in 1800s	Proposal