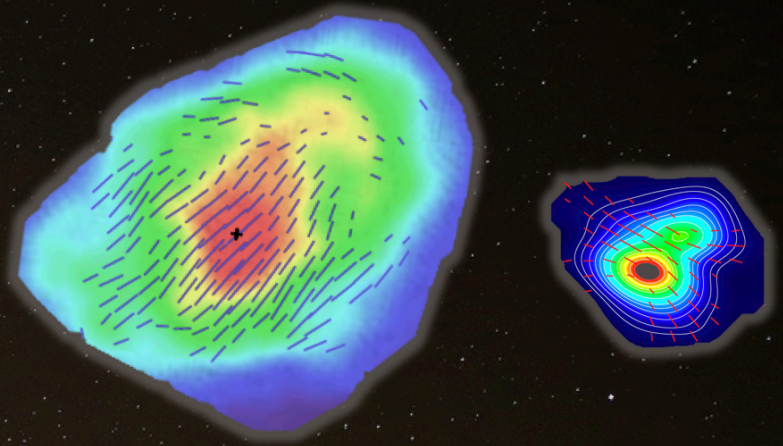
PRELIMINARY RESULTS FROM THE NIKA2-Pol COMMISSIONING: ANALYZING AND CORRECTING FOR INSTRUMENTAL POLARIZATION



Talk given by :
H. Ajeddig (CEA - AIM/DAp)

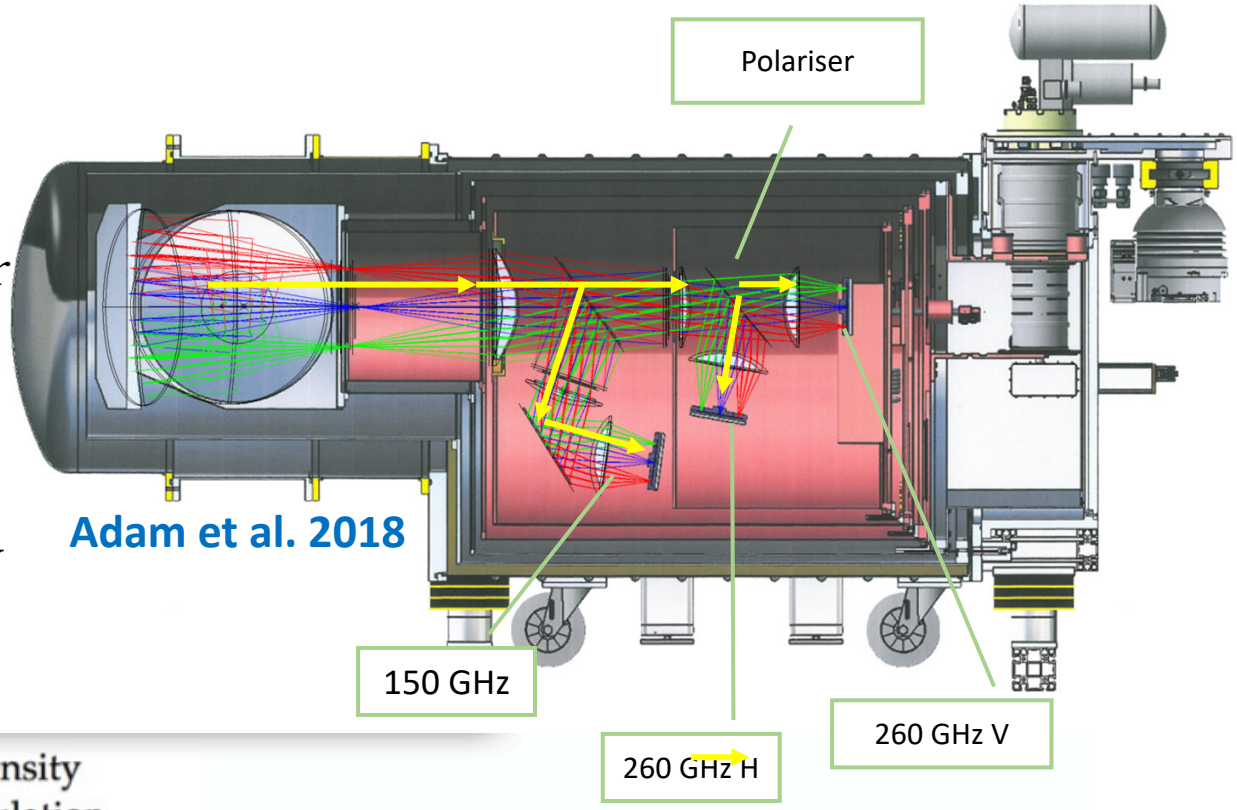
@B-FUN

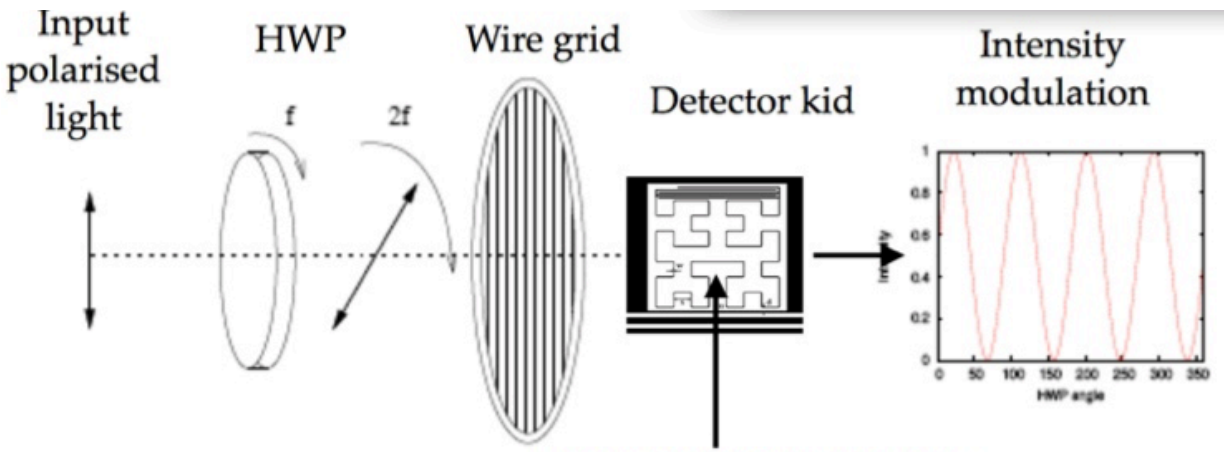
On behalf of NIKA2-Pol commissioning team :
Ph. André(AIM/DAP), A. Maury(AIM/DAP), N. Ponthieu(IPAG), A. Ritacco(IRAM), A. Andriansolo(IPAG),Y. Shimajiri(AIM/DAP)

NIKA2-Pol

- It maps the linear polarization at 260 GHz with two arrays allowing to detect both linear polarization components.

- Half-wave-plate: The modulated polarised signal is split into the two 260 GHz arrays by the 45-degree wire-grid polarizer.





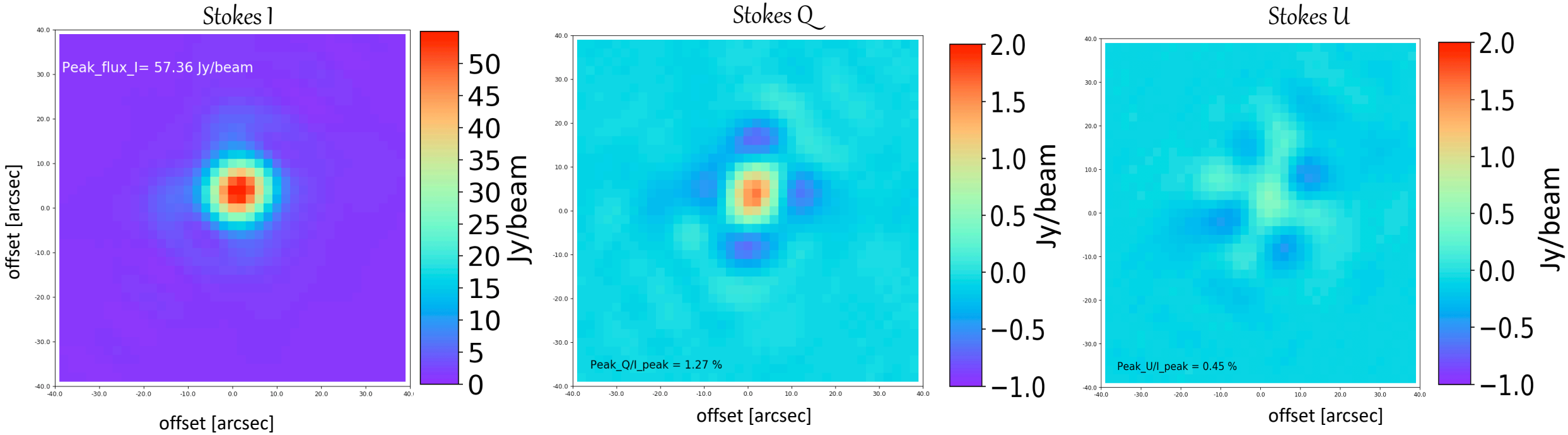
$$S = \frac{1}{2}(I + Qcos4\omega t + Usin4\omega t)$$

POLARISED SIGNAL MODULATED AT 4 TIMES THE ROTATIONAL FREQUENCY

Instrumental polarization : ‘ Intensity to polarization leakage pattern ’

Definition :

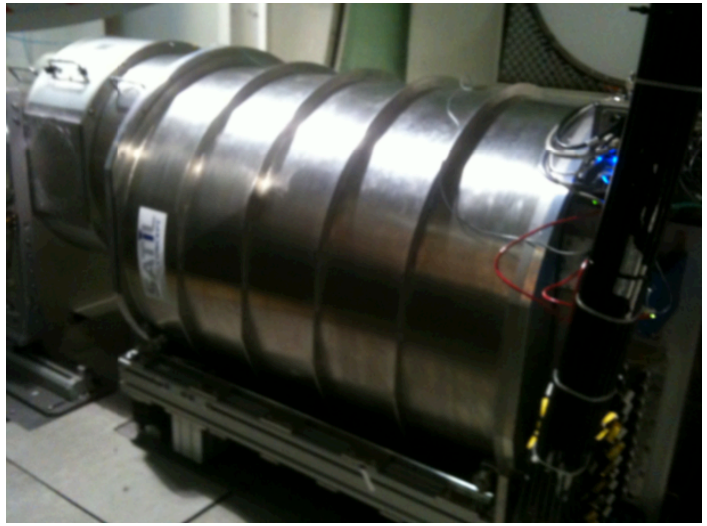
- Conversion of a fraction of the incident unpolarized total intensity into polarized emission
- Differs from one instrument to another
- Uncertain source of this **instrumental polarization**
- Example : Observing Uranus (unpolarized source) with NIKA2-Pol



NIKA2-Pol commissioning :

- One successful week of test observations in December 2018.
- Half-wave-plate synchronization.
- Tests of data reduction pipeline in polarization mode.
- Observation of unpolarized sources (e.g Uranus) to **characterize leakage** pattern of NIKA2-Pol.
- **Absolute calibrations** and testing the stability of polarization angle and degree as function of elvation, FWHM, opacity and other variables using quasars.
- Observing extended sources and beginning to test 1-2 scientific targets of the B-FUN large program.
- **Sensitivity and performance** of NIKA2-Pol.

IRAM 30m telescope



@NIKA2 image

Leakage pattern of NIKA2-Pol :

Selecting good scans

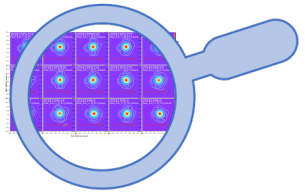
- Using Uranus and quasars maps to investigate the dependence of leakage on elevation.
- Using Uranus defocused beam maps to test the variation of the leakage pattern with focus

- Good atmospheric opacity (Tau_1.2mm < 0.2)
- Good FWHM <13'' (c.f NIKA2 resolution at 1mm 11.6'')
- Good HWP synchronization (to be sure we checked each scan)

Measuring the dependence of the leakage pattern on elevation

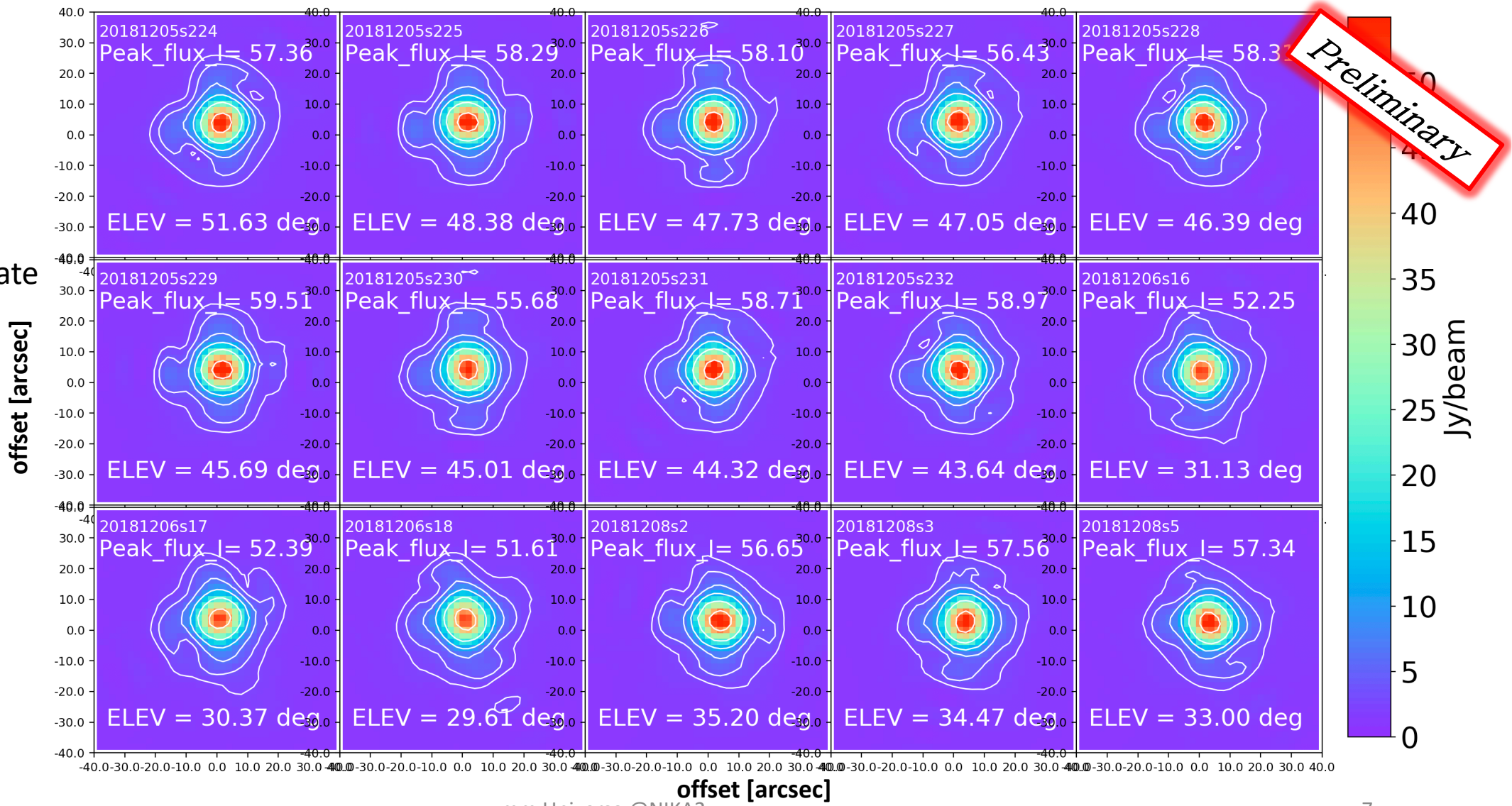
Using a series of Uranus(focused) maps observed at different elevations

Stokes I



Nasmyth coordinate

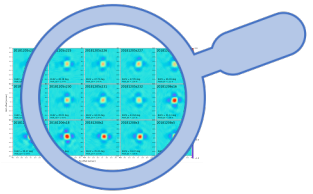
Stokes I images from Uranus focused map data



Measuring the dependence of the leakage pattern on elevation

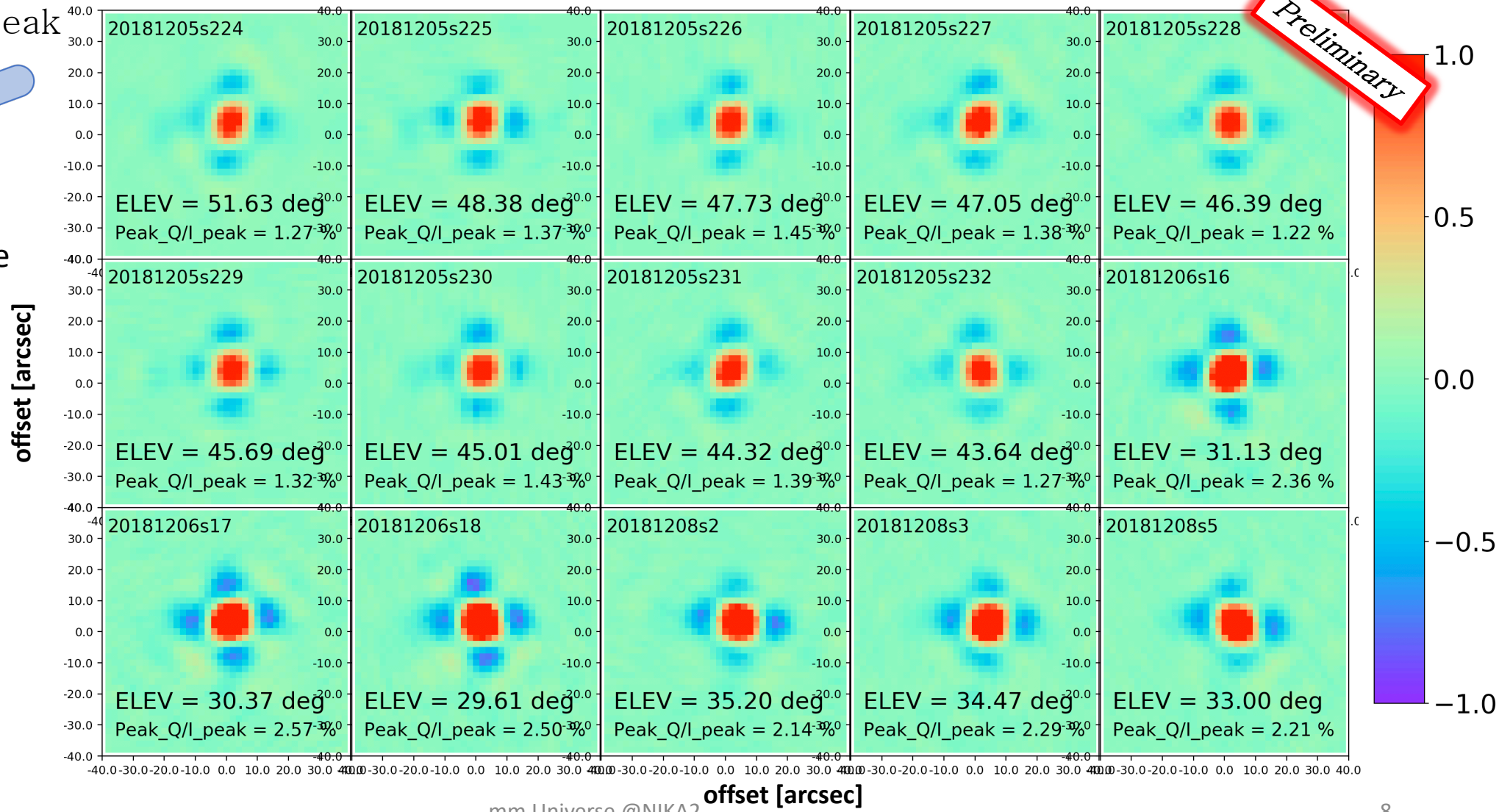
Using a series of Uranus(focused) maps observed at different elevations

Stokes Q over I peak



Nasmyth coordinate

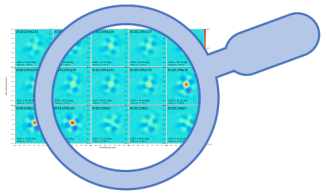
Normalized Stokes Q images (Q/I_peak) from Uranus focused map data



Measuring the dependence of the leakage pattern on elevation

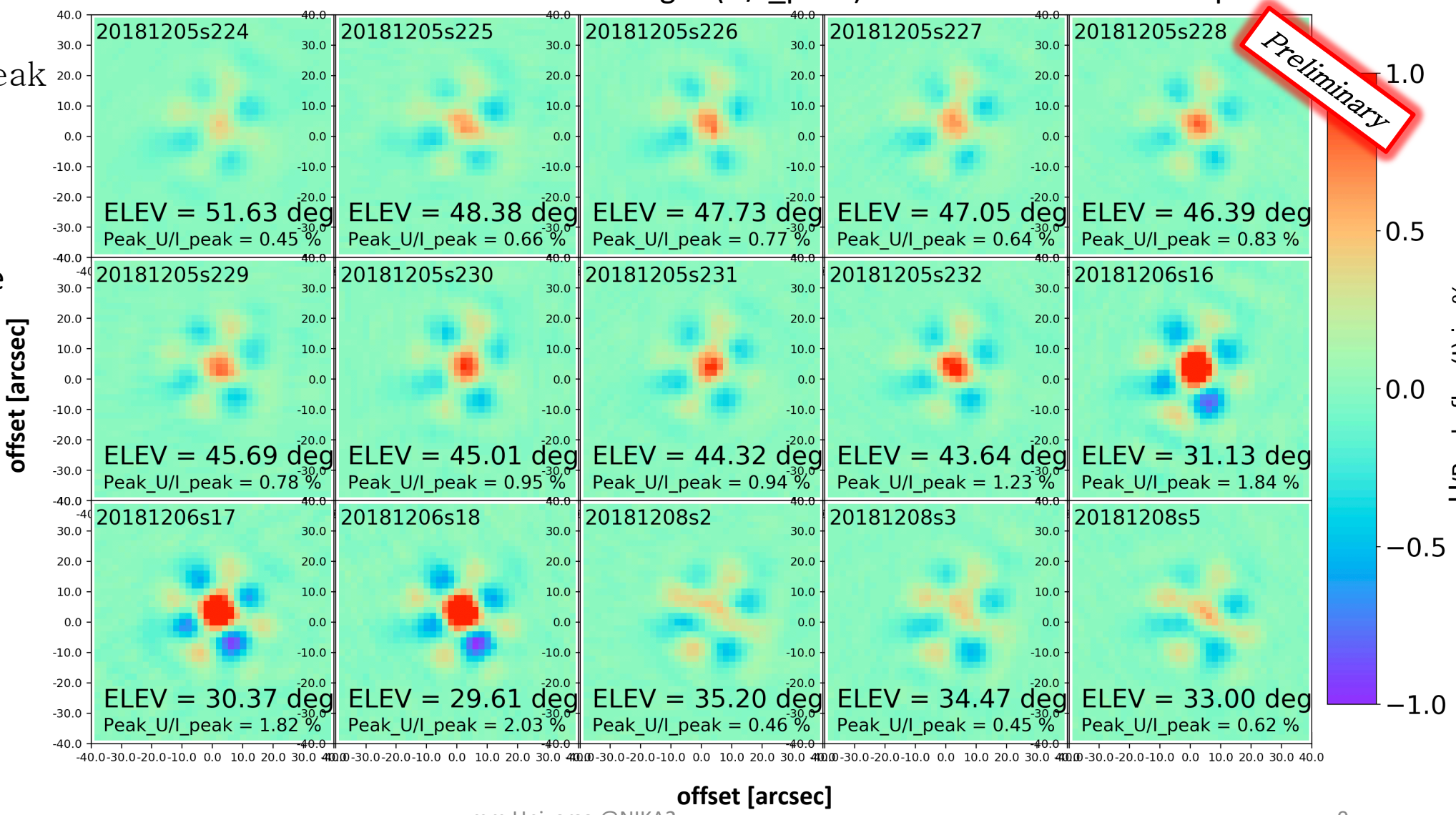
Using a series of Uranus(focused) maps observed at different elevations

Stokes U over I peak



Nasmyth coordinate

Normalized Stokes U images (U/I_peak) from Uranus focused map data



Investigating the dependence of the leakage pattern on focus

Using Uranus defocused beam maps

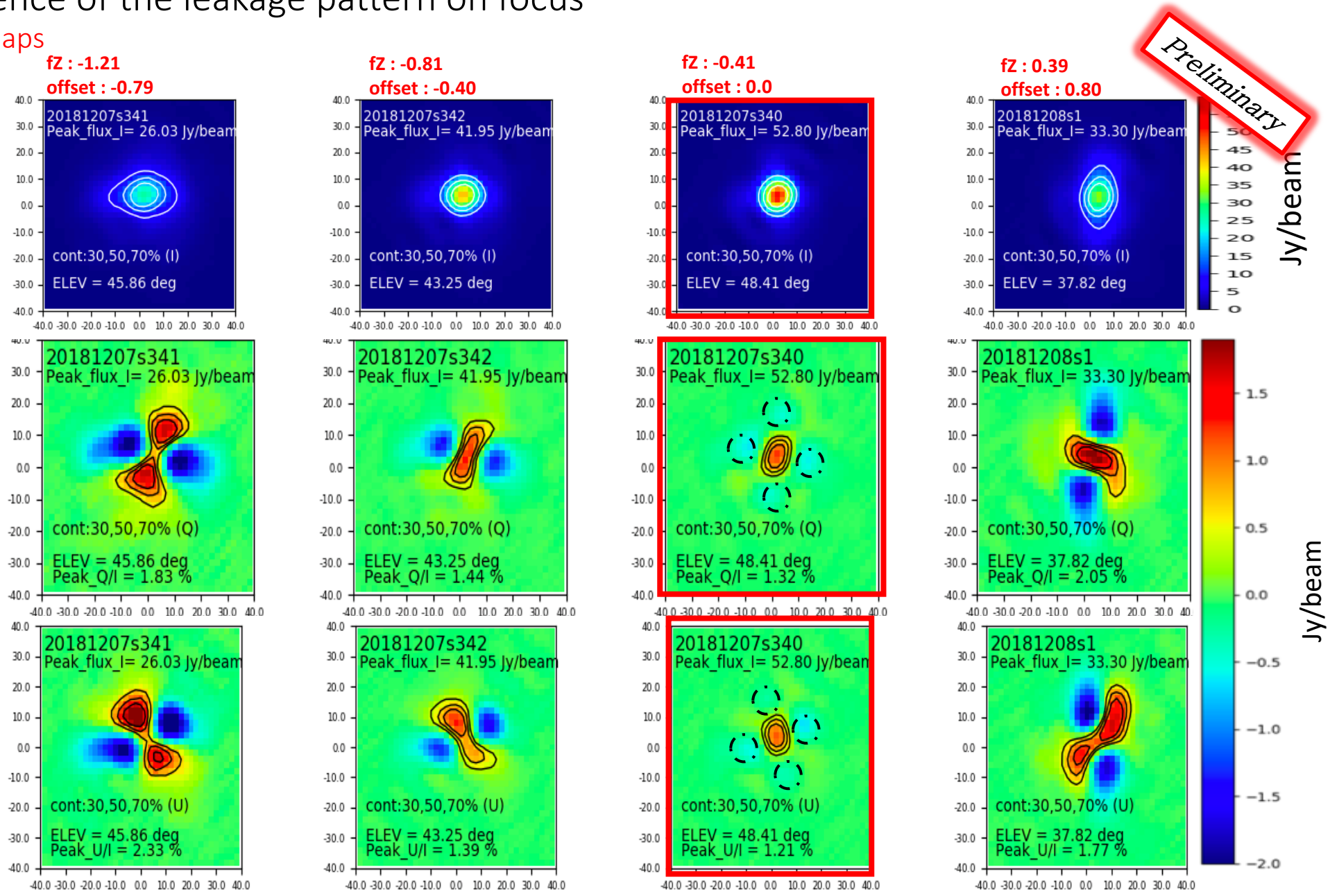
Nominal focus : −0.41 mm
Offset = Fz − nominal_focus

Stokes I

Nasmyth coordinate

Stokes Q

Stokes U

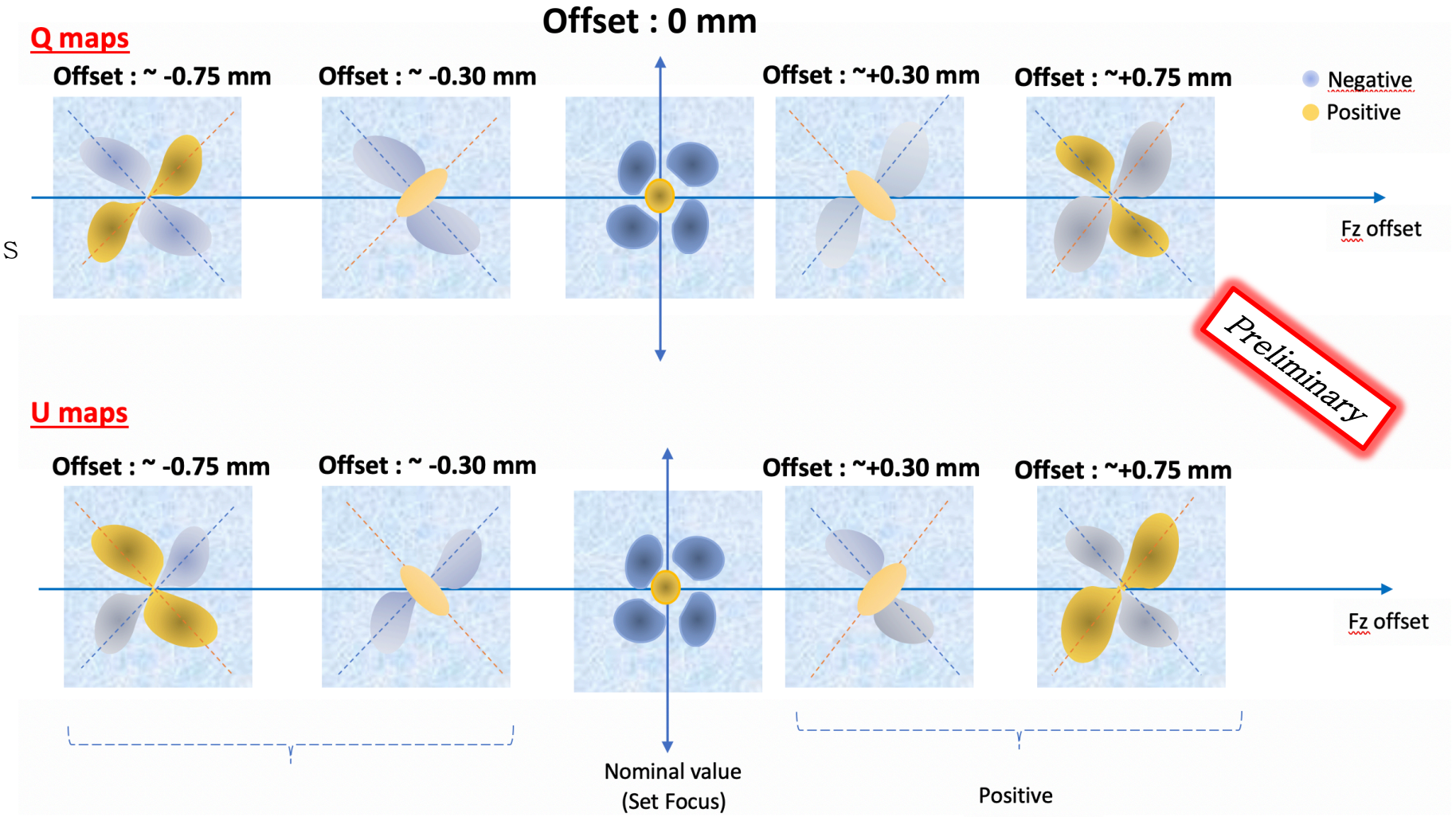


Investigating the dependence of the leakage pattern on focus

Using Uranus defocused beam maps

- Illustration of the leakage pattern of NIKA2-Pol depending on focus FZ using Uranus defocused beam maps

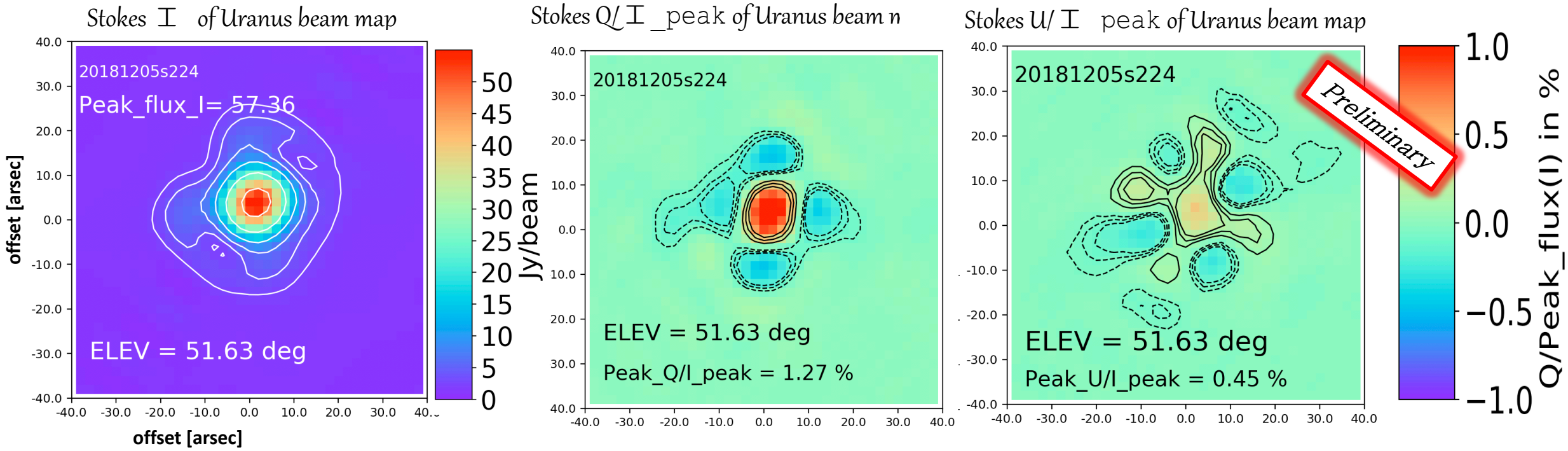
- An offset of ~0.15 mm from the nominal value (set focus) seems acceptable



Correcting for the leakage effect

Selecting a suitable leakage

- Selecting a suitable leakage pattern to correct for the leakage effect

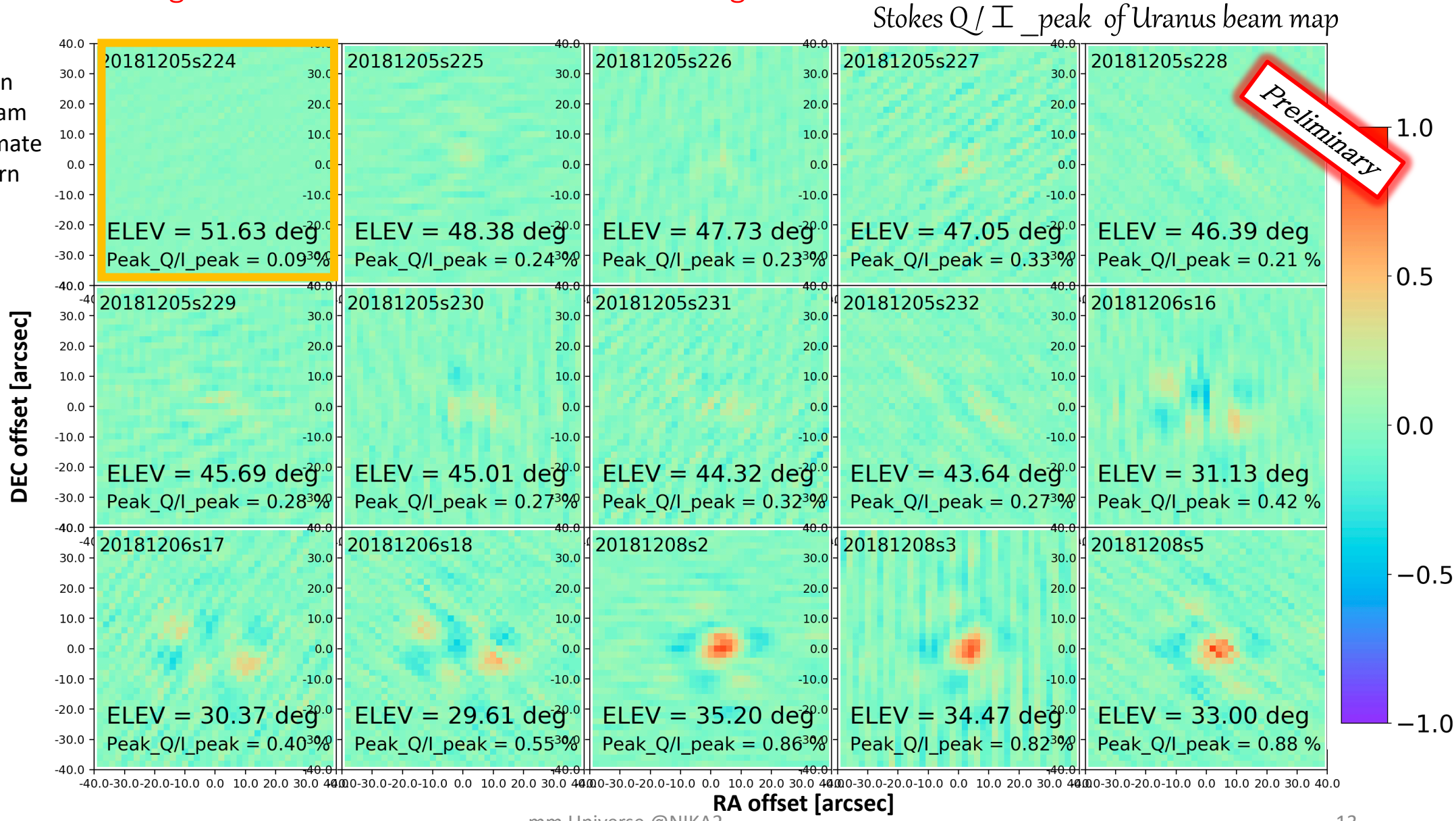


- Applying the correction using a single leakage pattern observed at given elevation (20181205s224)
- Applying the leakage correction to : (see Ritacco, Ponthieu, catalano et al. 2017)
  a) The beam map used to estimate the leakage pattern
  b) Uranus focused maps
  c) Quasars

Applying the leakage correction to Uranus focused maps :

Residual stokes Q images for Uranus focused data after leakage correction

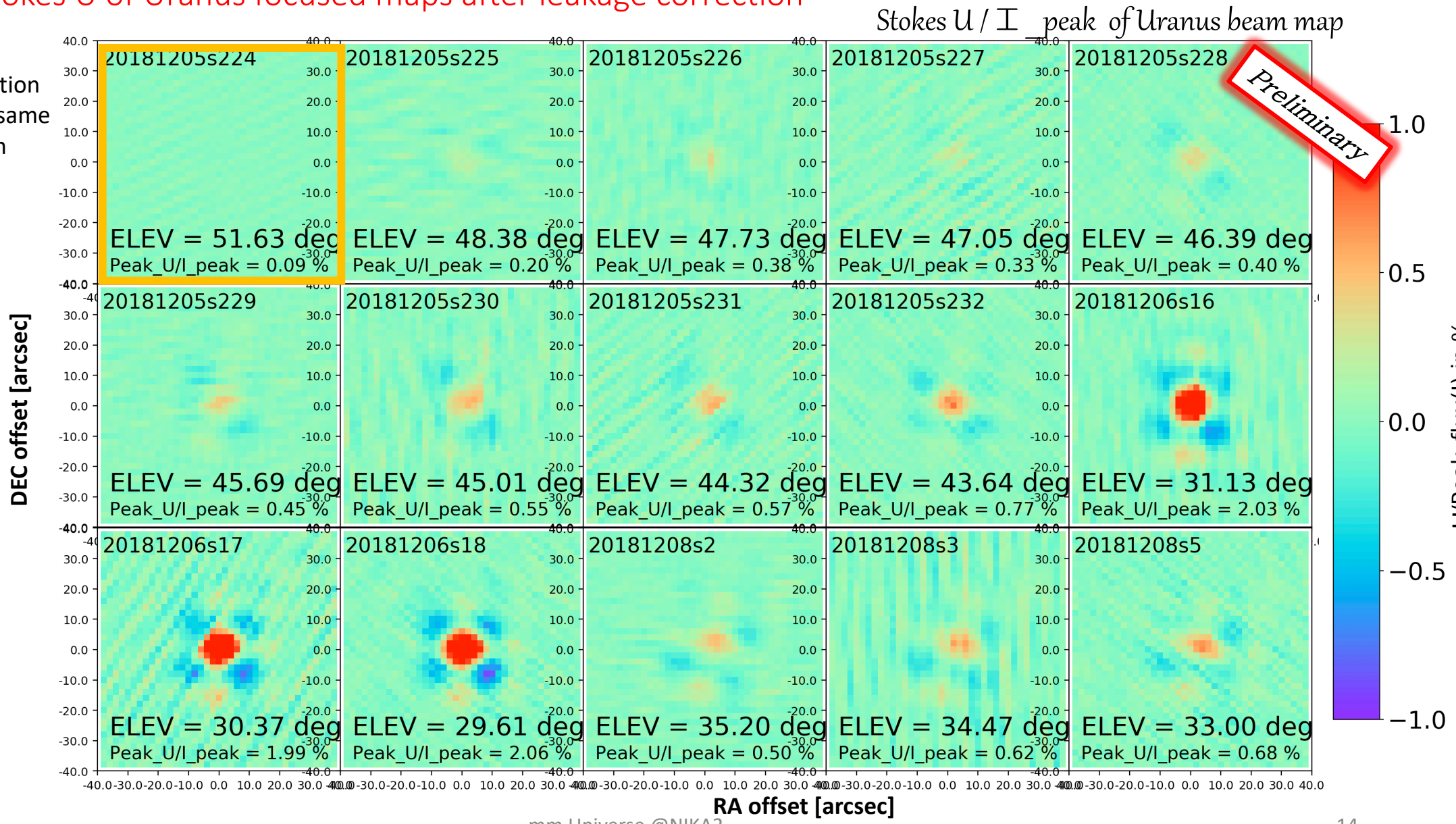
- Leakage correction applied to the beam map used to estimate the leakage pattern



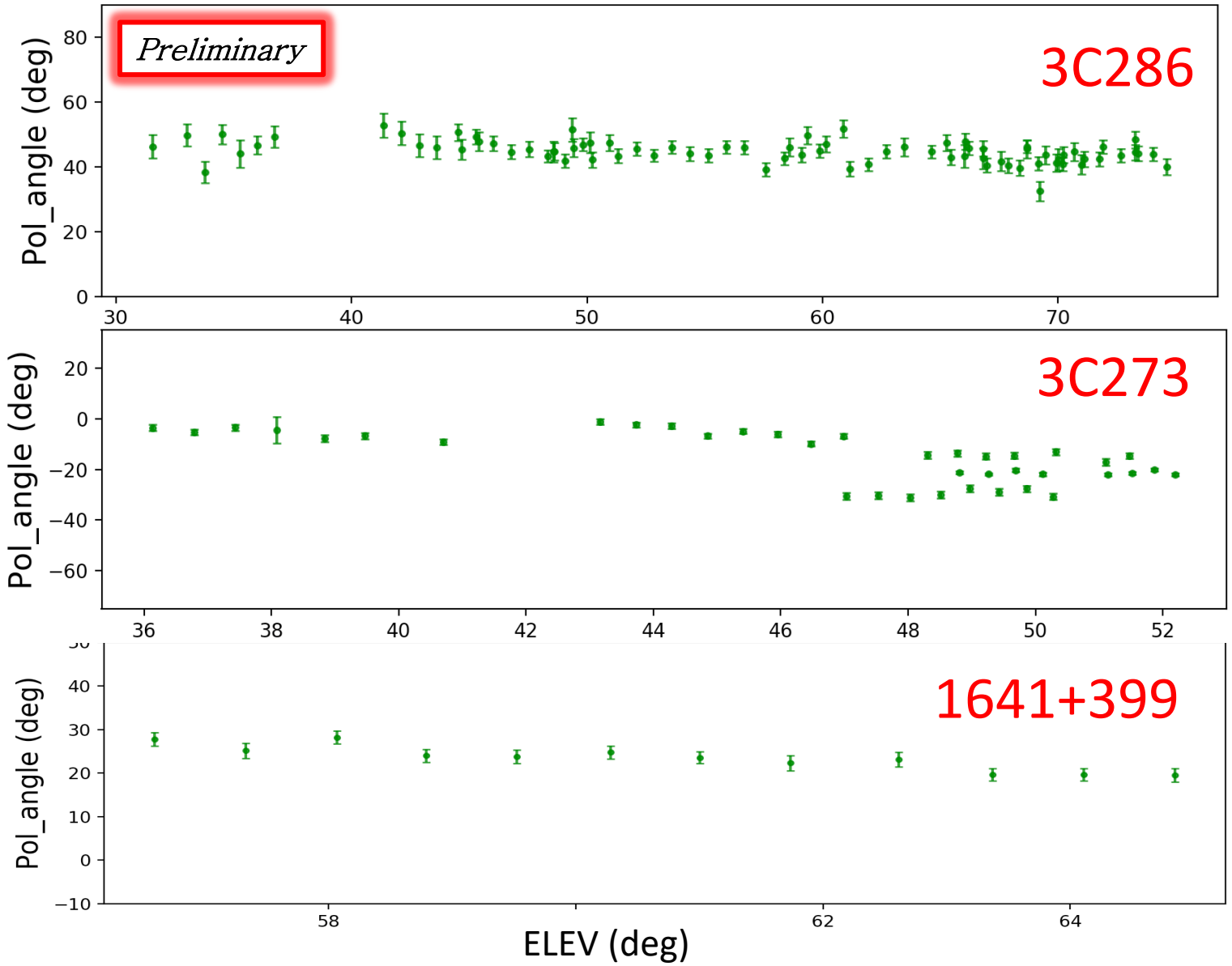
Applying leakage correction to Uranus focused maps :

Residual stokes U of Uranus focused maps after leakage correction

Leakage correction applied to the same leakage pattern



Analyzing the stability polarization angle and polarization fraction of quasars



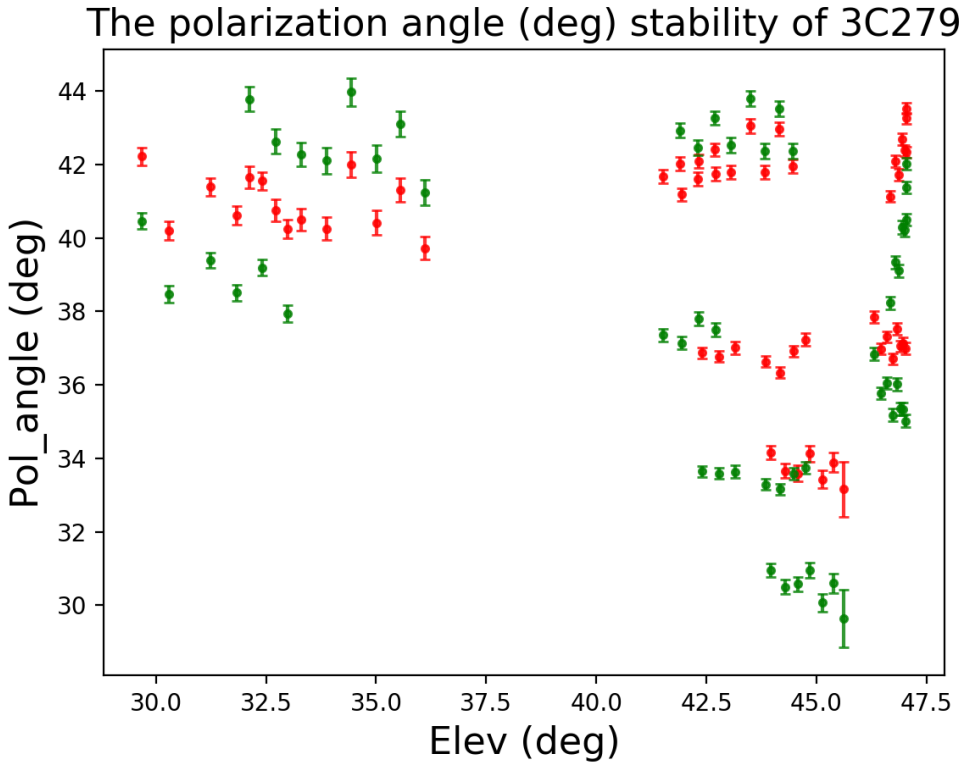
Weigthed mean(without leakage correction) :
44.3° ± 3.4°

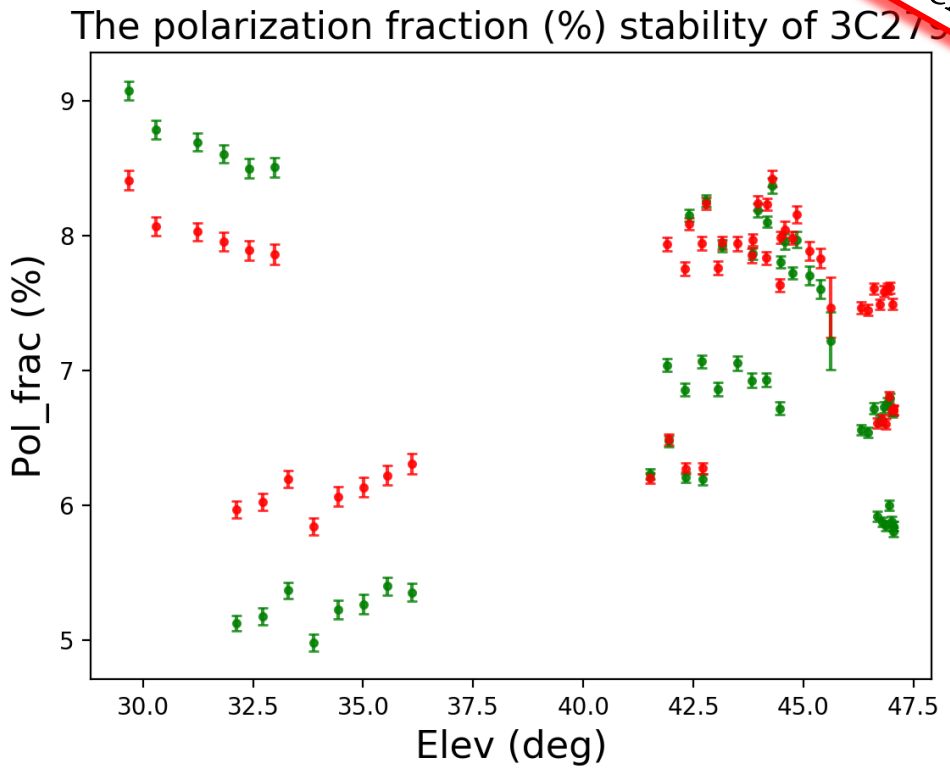
Weigthed mean(without leakage correction) :
-15.7° ± 10.4°

Weigthed mean(without leakage correction) :
22.0° ± 2.4°

Analyzing the stability of polarization angle and polarization fraction of quasars

Applying leakage correction to quasars **3C279** ,0923+392 , 2251+158, 3C273, 3C286





Preliminary

Weigthed mean(without leakage correction) : 37.5° ± 4.6°

Weigthed mean(with leakage correction) : 38.8° ± 3.0°

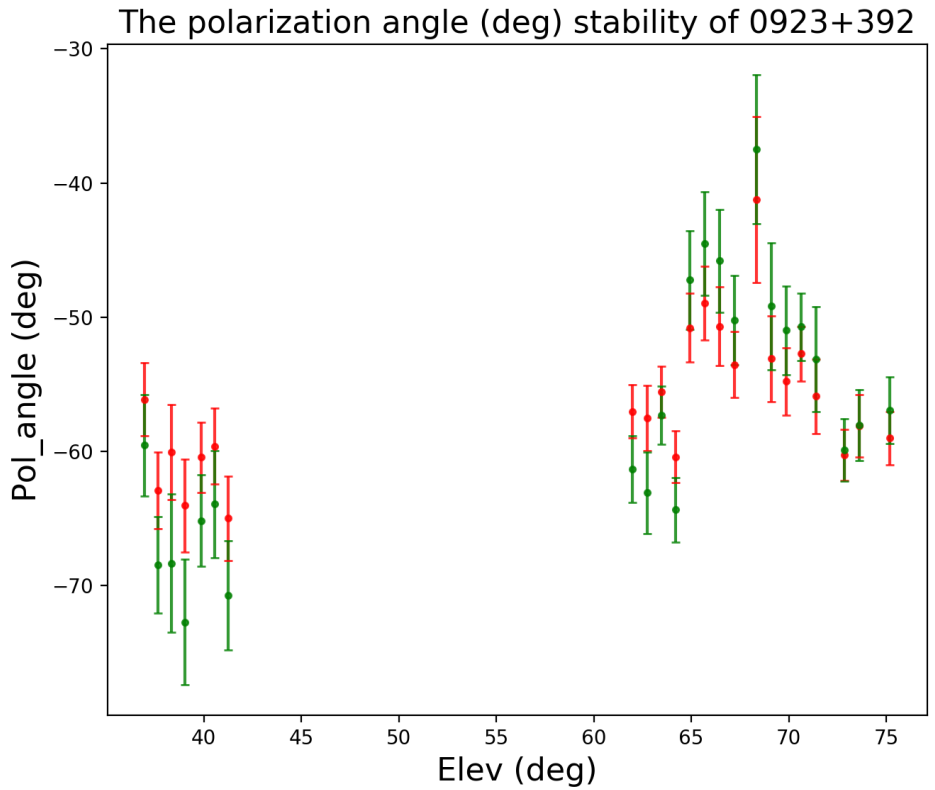
Weigthed mean(without leakage correction) : 6.9 ± 0.9 %

Weigthed mean(with leakage correction) : 7.5 ± 0.6 %

Analyzing the stability of polarization angle and polarization fraction of quasars

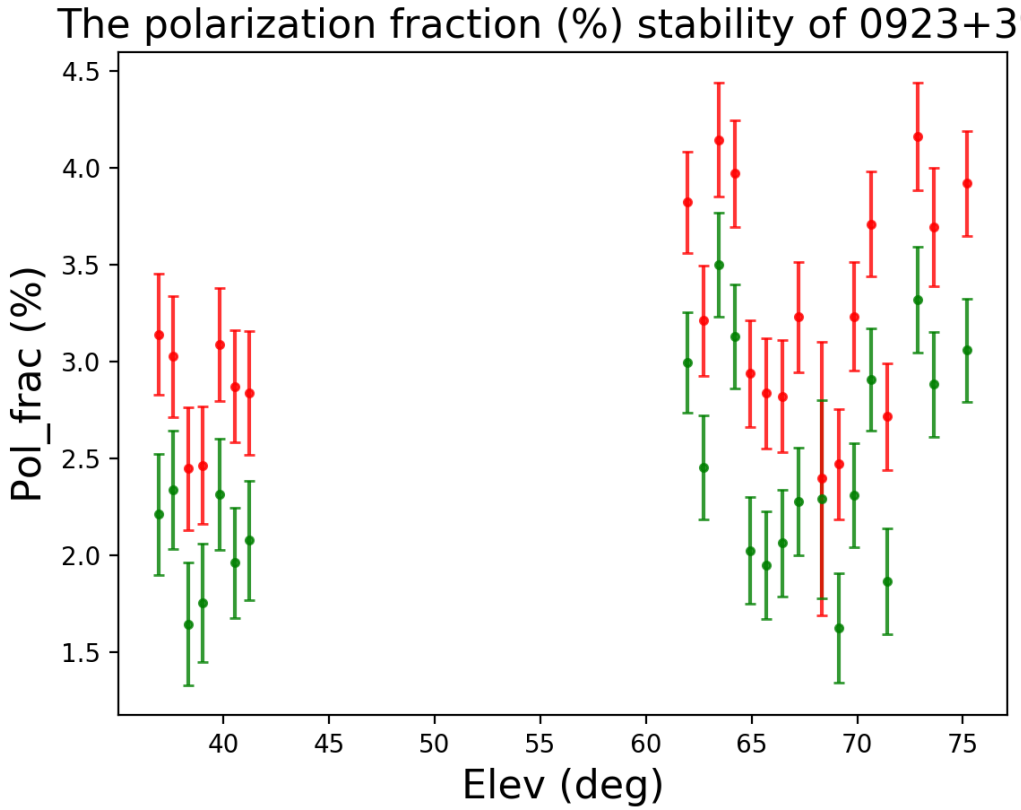
Applying leakage correction to quasars 3C279, 0923+392, 2251+158, 3C273, 3C286

Preliminary



Weigthed mean(without leakage correction) : -52.7° ± 8.1°

Weigthed mean(without leakage correction) : -54.0° ± 5.1°

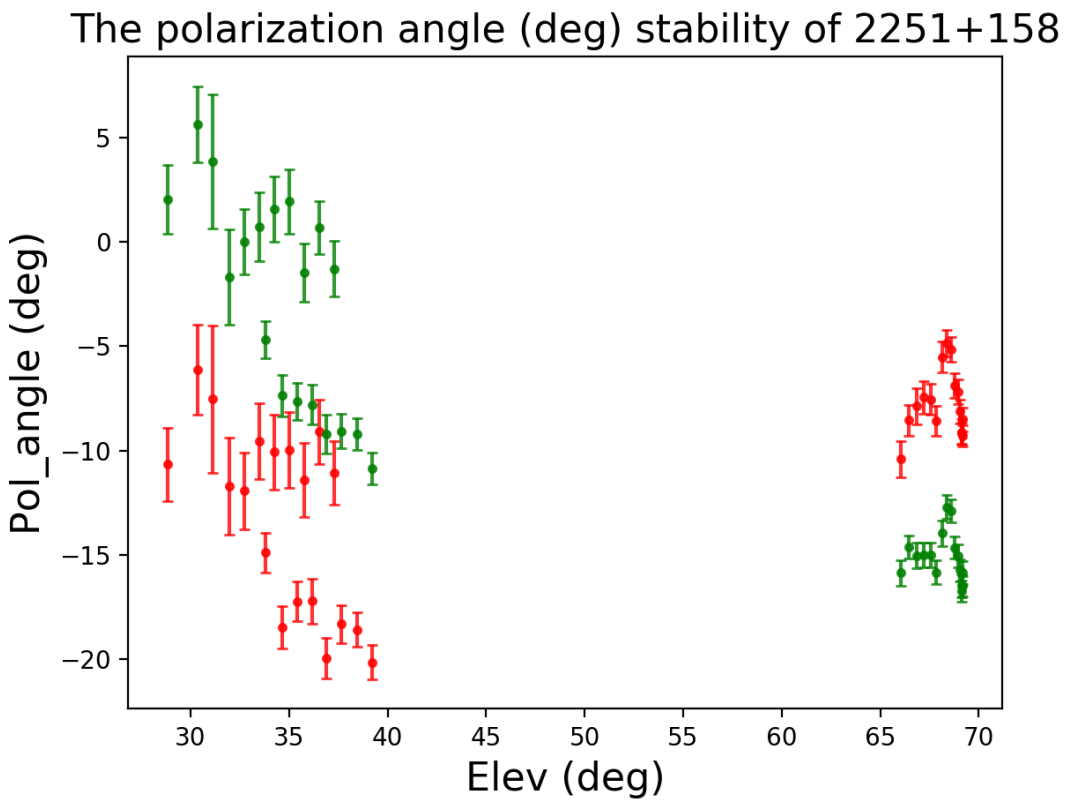


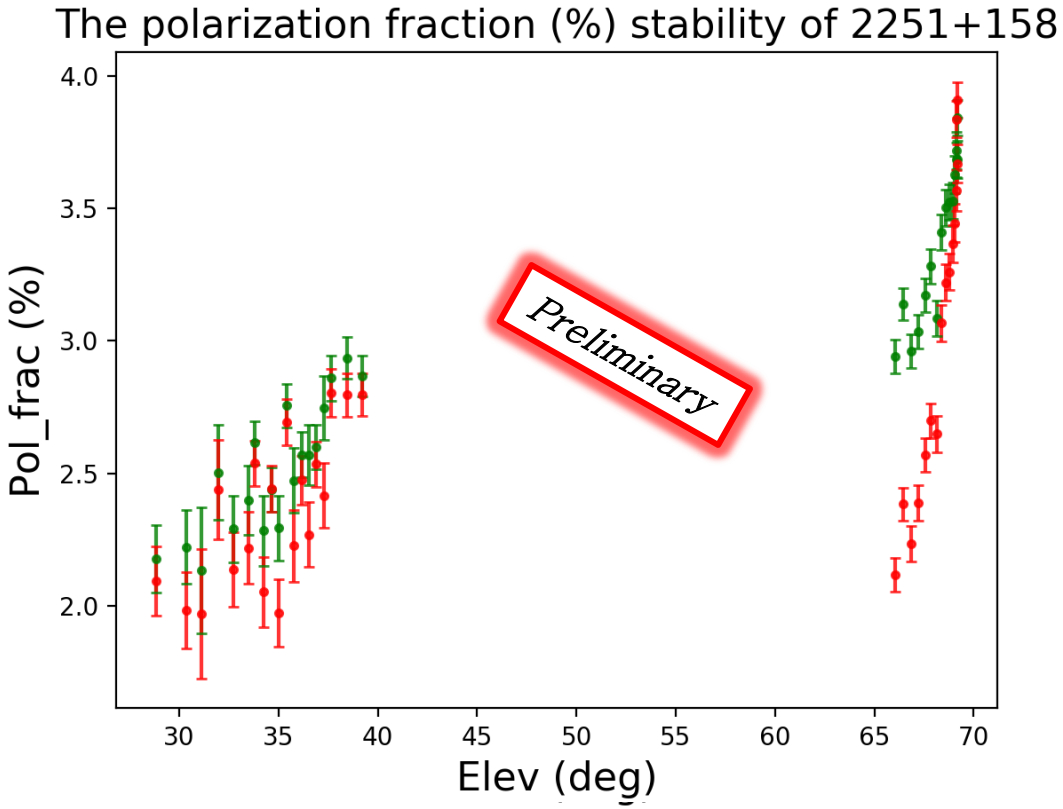
Weigthed mean(without leakage correction) : 2.3 ± 0.5 %

Weigthed mean(without leakage correction) : 3.1 ± 0.5 %

Analyzing the stability of polarization angle and polarization fraction of quasars

Applying leakage correction to quasars 3C279,0923+392, 2251+158, 3C273, 3C286





Weigthed mean(without leakage correction) : -10.6° ± 7.1°

Weigthed mean(with leakage correction) : -8.8° ± 2.8°

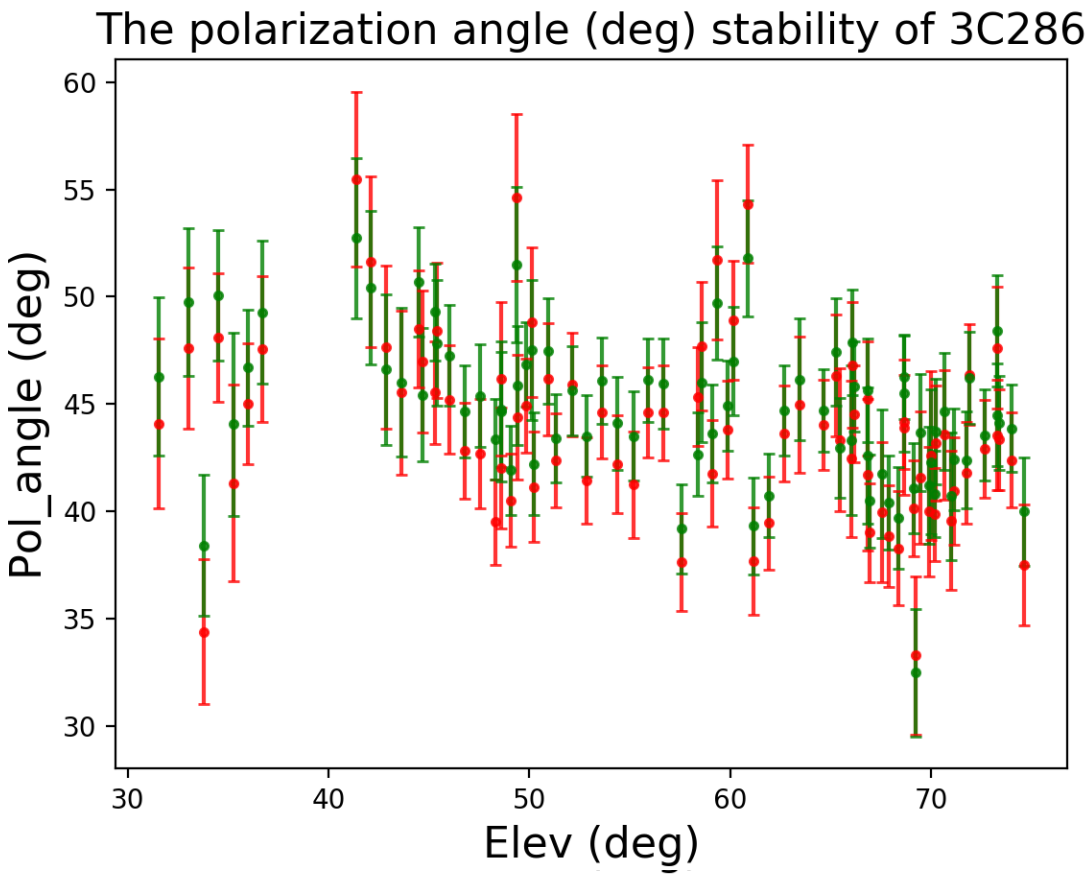
Weigthed mean(without leakage correction) : 3.0 ± 0.5 %

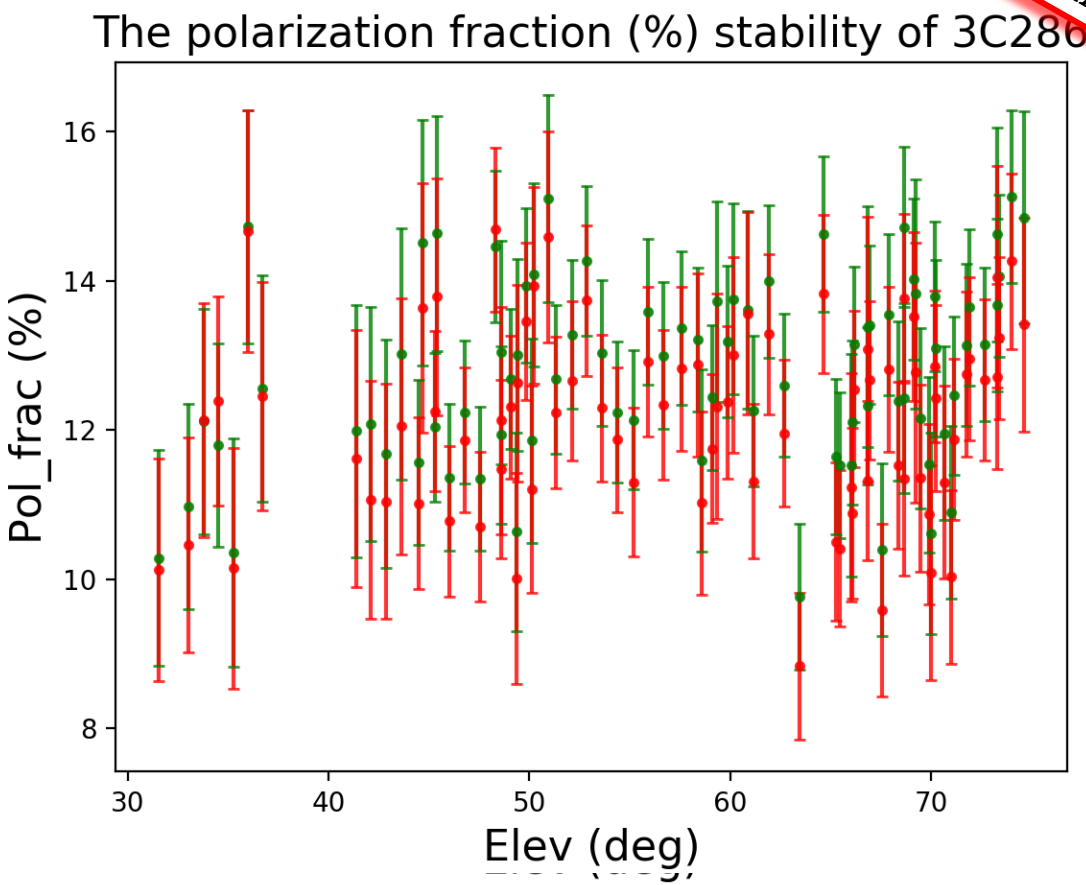
Weigthed mean(with leakage correction) : 2.17 ± 0.5 %

Analyzing the stability of polarization angle and polarization fraction of quasars

Applying leakage correction to quasars 3C279,0923+392, 2251+158, 3C286, 3C273

Preliminary





Weigthed mean(without leakage correction) : 44.3° ± 3.4°

Weigthed mean(with leakage correction) : 43.4° ± 3.9°

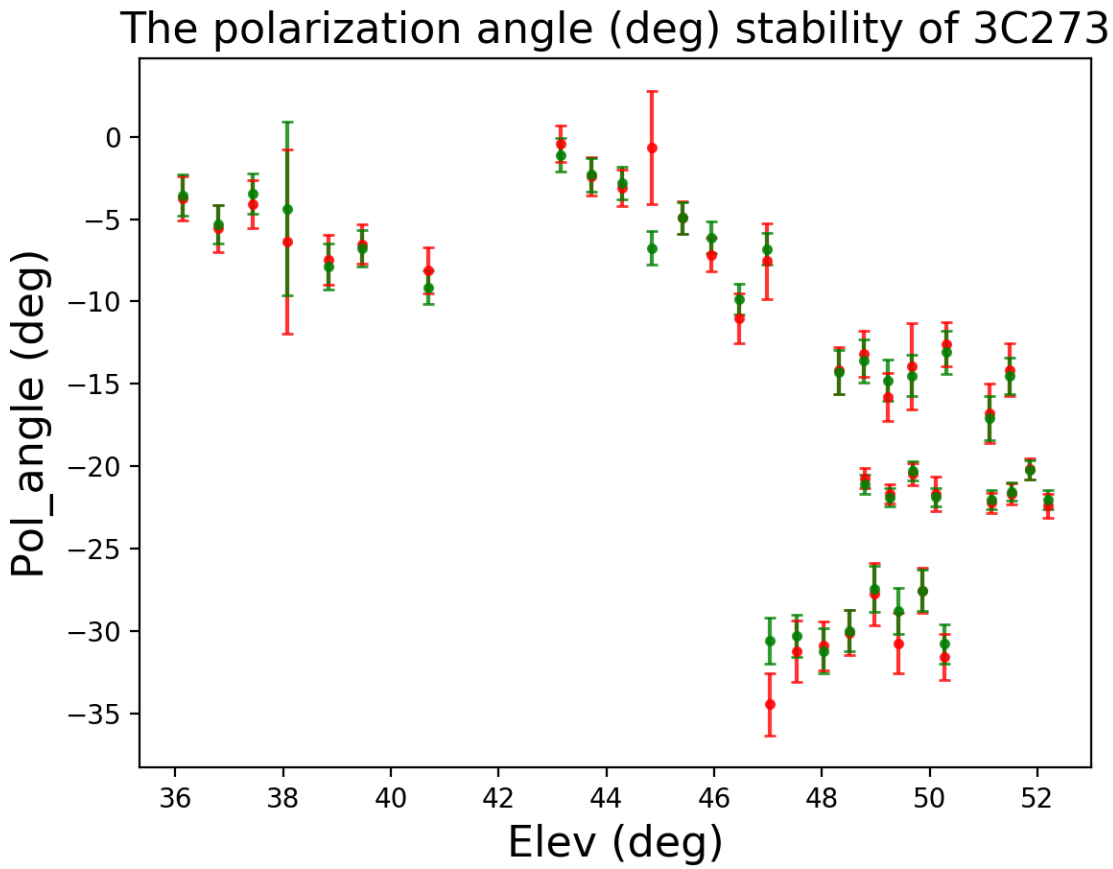
Weigthed mean(without leakage correction) : 12 .8 ± 1.2 %

Weigthed mean(with leakage correction) : 12.1 ± 1.2 %

Analyzing the stability of polarization angle and polarization fraction of quasars

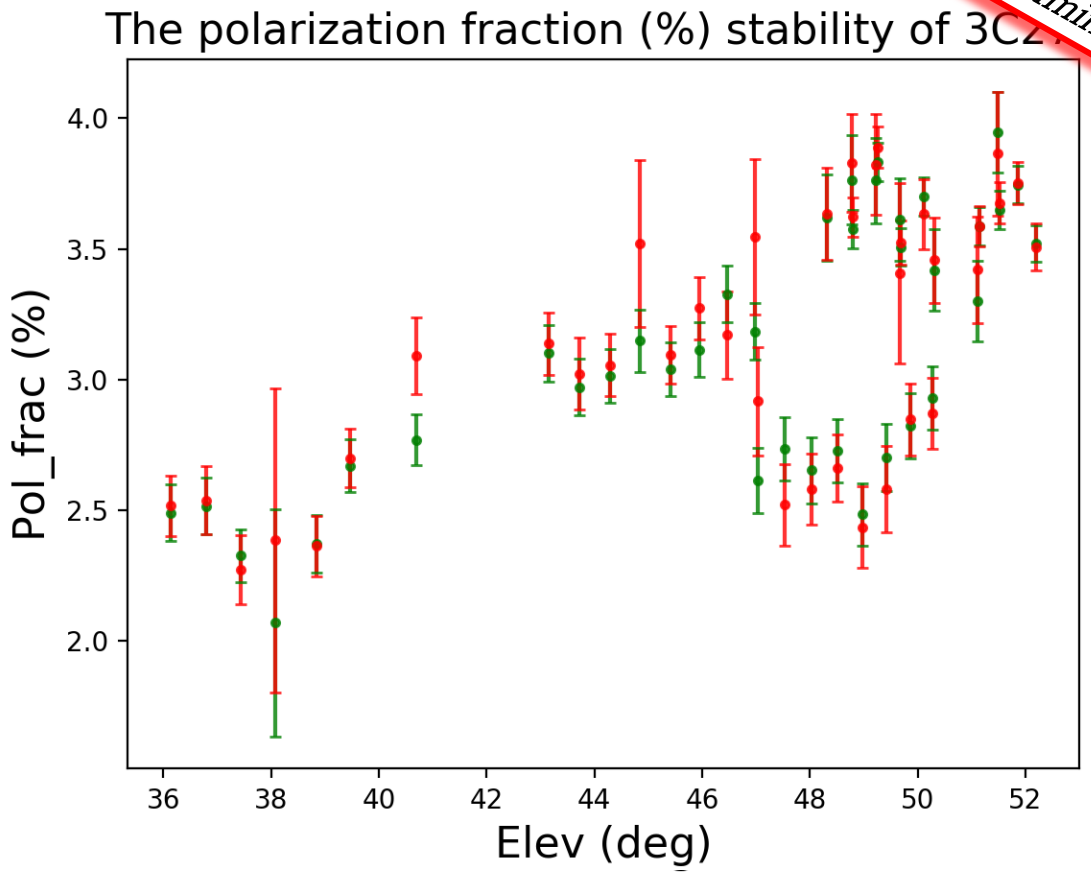
Applying leakage correction to quasars 3C279,0923+392,2251+158, 3C286, 3C273

Preliminary



Weigthed mean(without leakage correction) : -15.7° ± 10.4°

Weigthed mean(with leakage correction) : -15.7° ± 11.1°



Weigthed mean(without leakage correction) : 3.1 ± 0.4 %

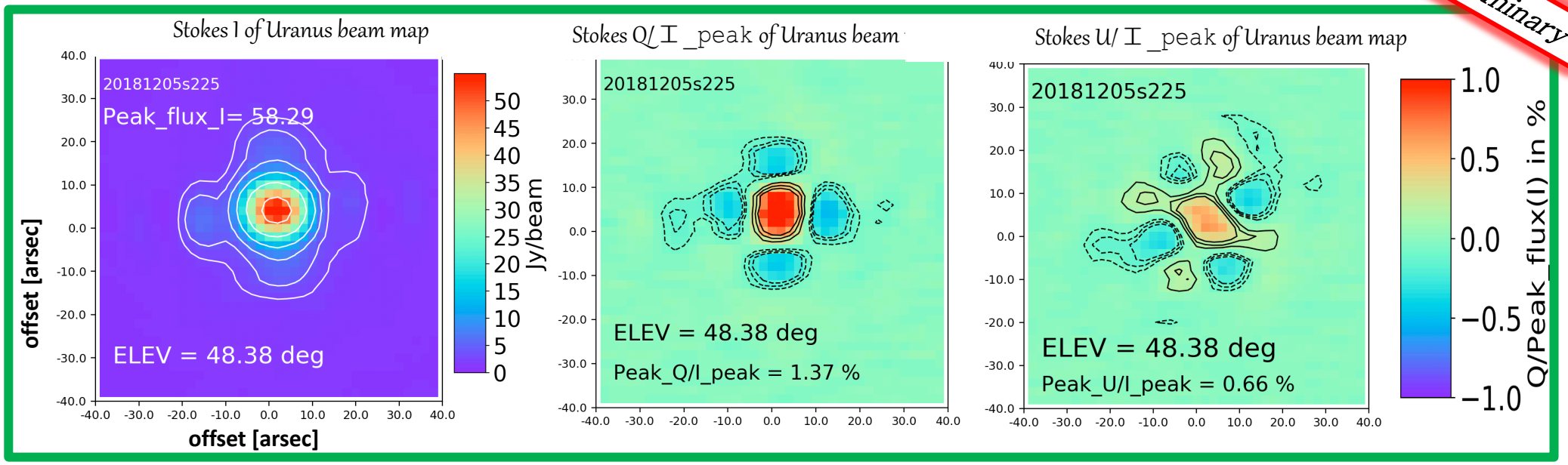
Weigthed mean(with leakage correction) : 3.1 ± 0.4 %

Analyzing the polarization angle and polarization degree of quasars

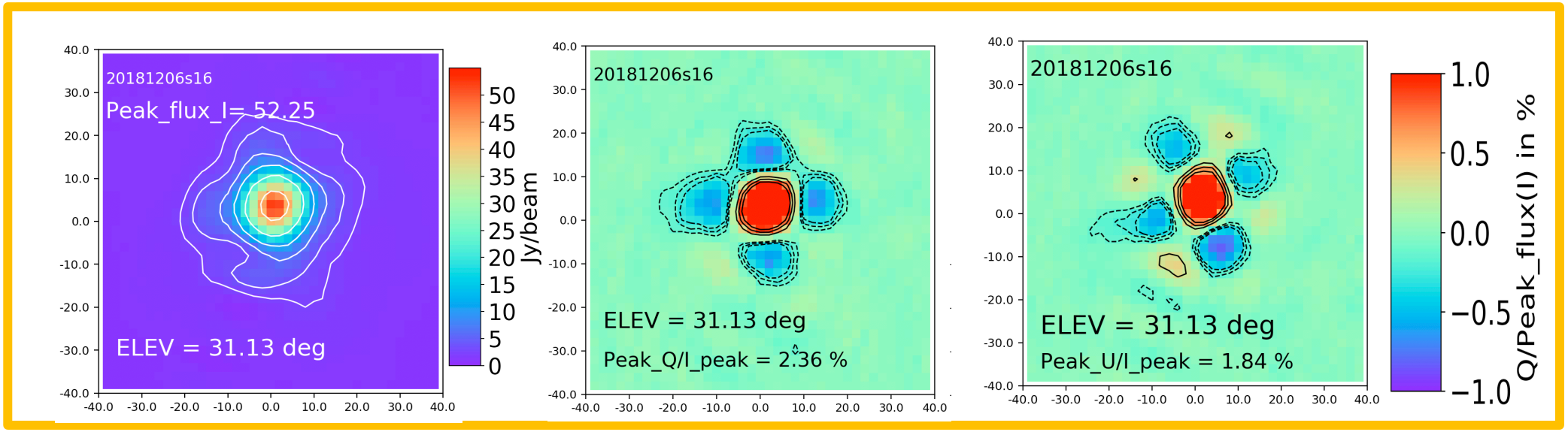
Correcting for the leakage effect using different leakage patterns at different ellevations

Preliminary

- For ELEV > 46 °

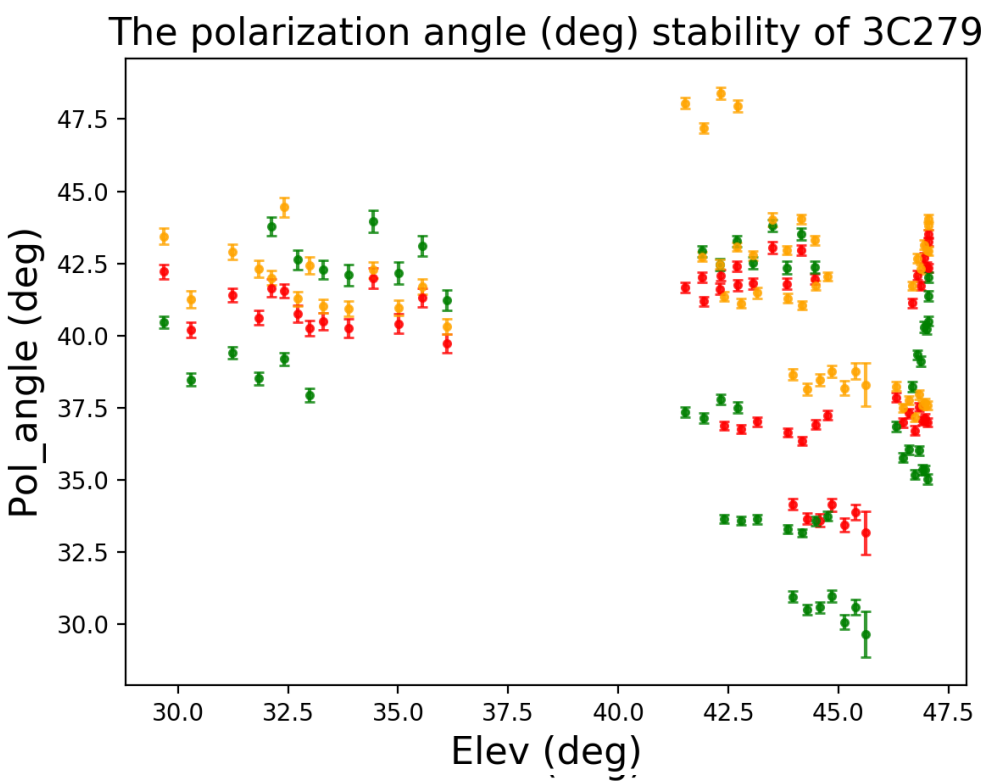


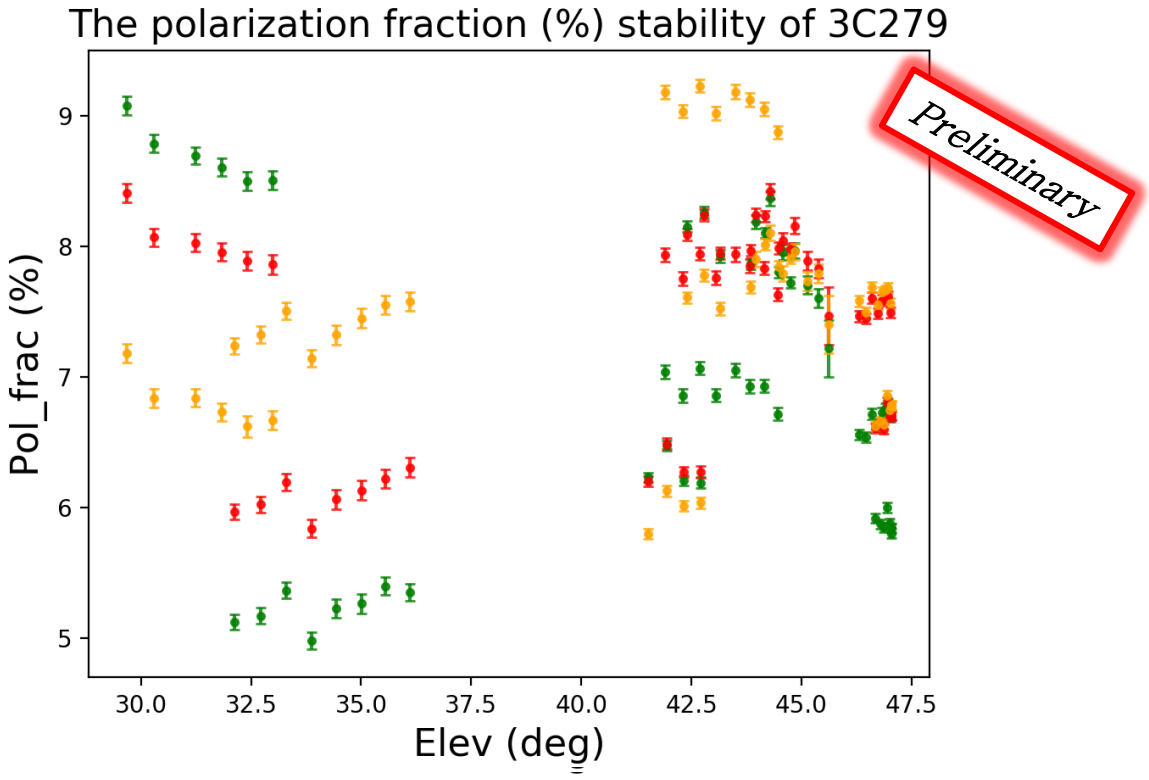
- For ELEV < 46 °



Analyzing the polarization angle and polarization degree of quasars

Applying leakage correction to quasars 3C279





Weigthed mean(without leakage correction): 37.5° ± 4.6°

Weigthed mean(with simple leakage correction) : 38.8° ± 3.0°

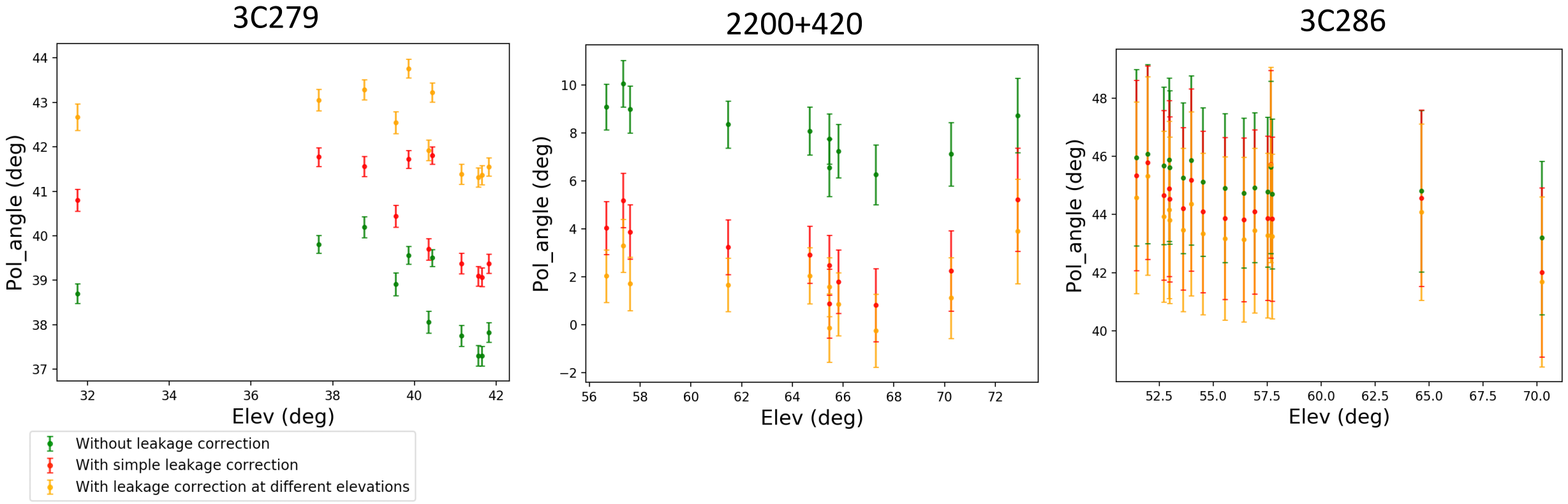
Weigthed mean(with different leakage correction) : 41.1° ± 2.4°

Weigthed mean(without leakage correction) : 6.9 ± 0.9 %

Weigthed mean(with simple leakage correction) : 7.5 ± 0.6 %

Weigthed mean(with different leakage correction) : 7.9 ± 0.8 %

Absolute calibration of NIKA2 polarization angles using quasars (comparison with XPOL)



Calibrator	NIKA2 *	NIKA2 **	NIKA2 ***	XPOL	Offset(NIKA2-XPOL)
3C286	45.1 ± 0.4	44.2 ± 0.5	43.6 ± 0.6	35.87 ± 0.02 (3mm)	9.77/7.27
3C279	38.2 ± 0.9	39.9 ± 0.9	42.0 ± 0.8	30.6 ± 4.1 (1mm)	7.6/11.4
2200+420	8.4 ± 1.0	3.3 ± 1.3	1.7 ± 0.9	14.8 ± 3.9 (1mm)	6.4/13.1

An offset of (7 ± 1 /11 ± 2) deg needs to be used for the absolute calibration of NIKA2-Pol angles

Preliminary conclusions

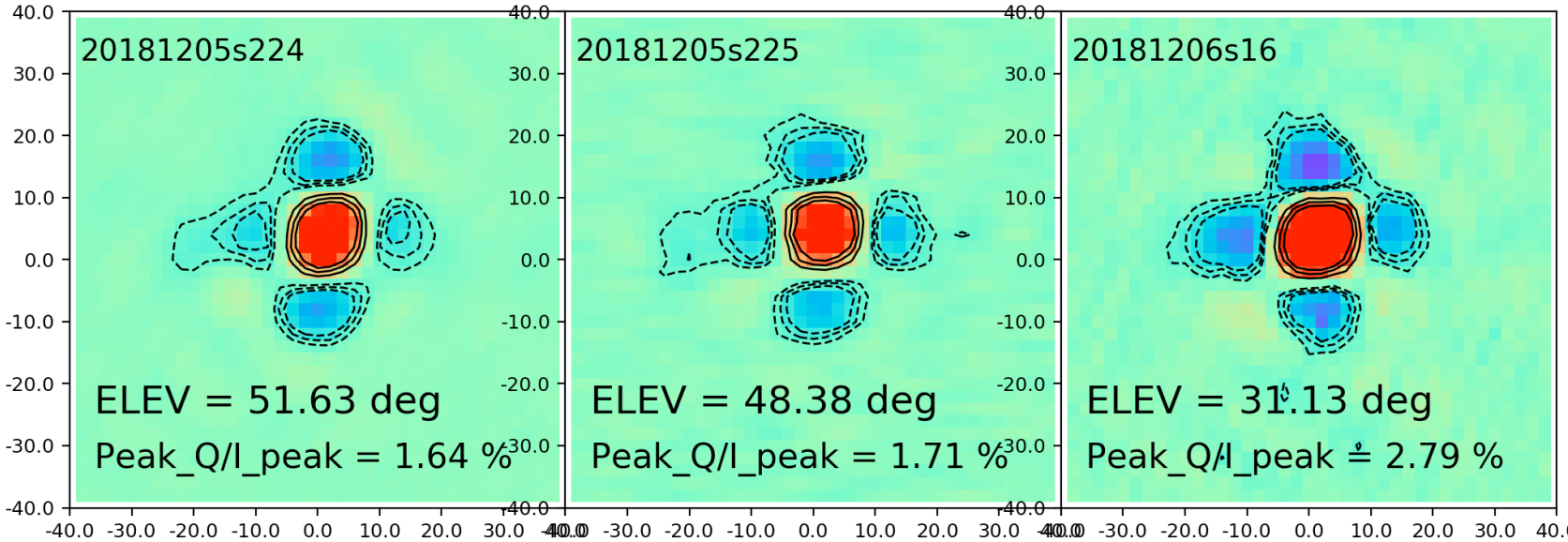
- NIKA2 pipeline has been succefully tested in polarization mode
- The instrumental polarization pattern of NIKA2-Pol depends on elevation
- Out of focus (**offset > 0.15**) observations are affected by more asymmetric and more intense leakage patterns
- A larger number of Uranus beam maps taken at different elevations would be needed to allow an optimum leakage correction.
- The absolute calibration of NIKA2-Pol polarization angles revealed an angular offset of about (**7° ± 1°/ 11° ± 2°**) from comparison with XPOL results

Thank you ...🙂

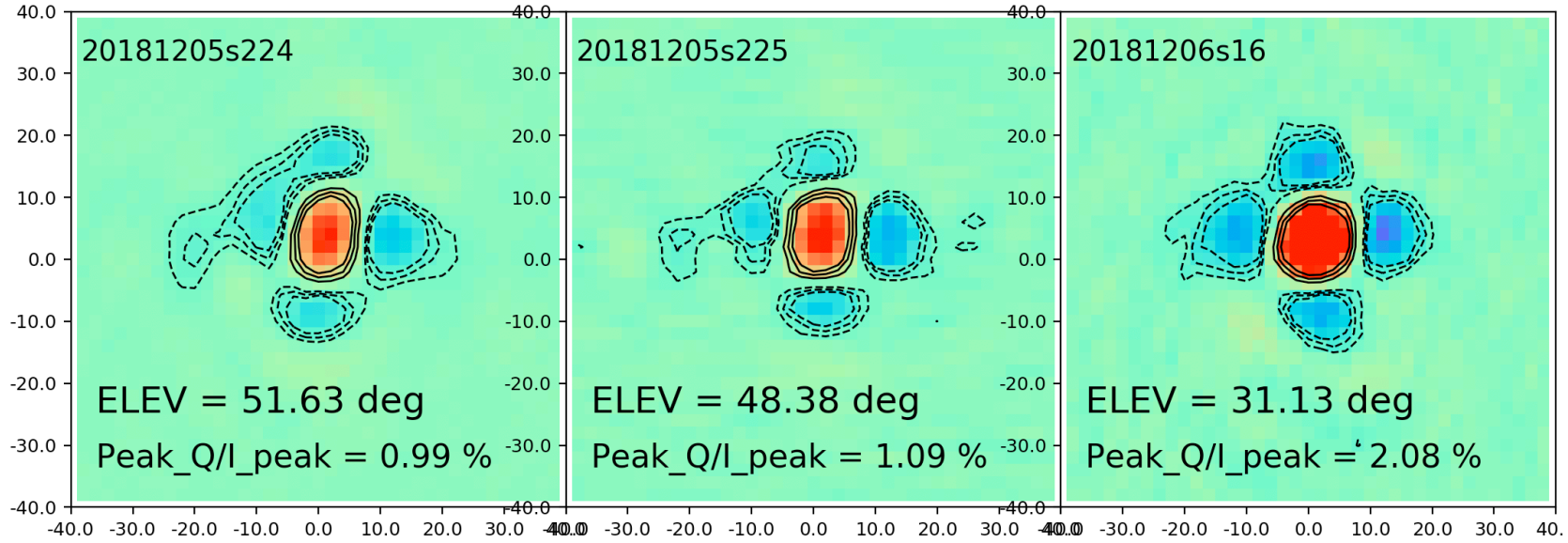
Testing the leakage pattern in different arrays

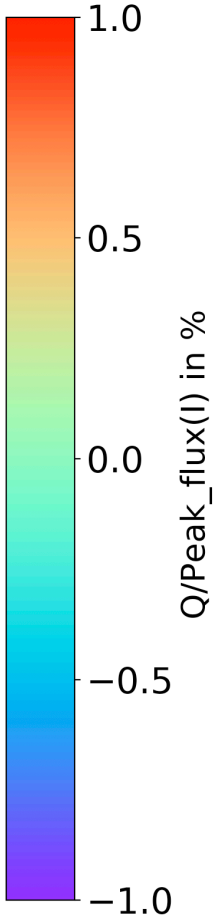
A1

Stokes Q/I _peak of Uranus focused beam maps



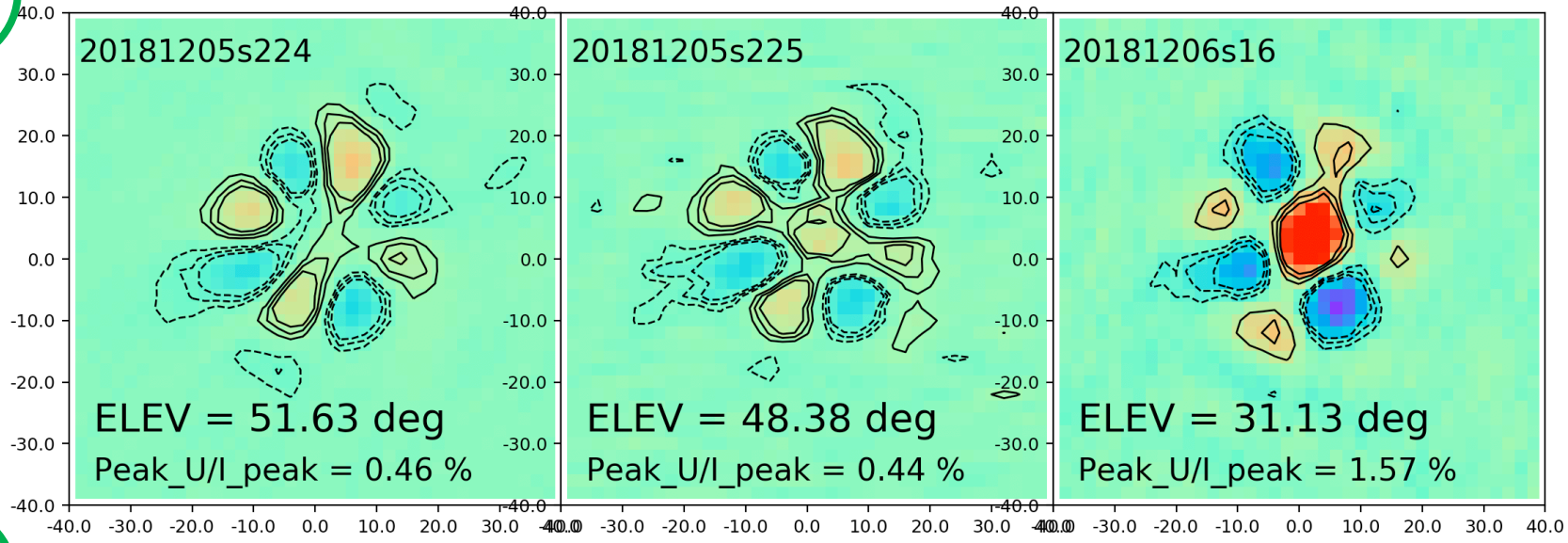
A3





Stokes U/I_peak of Uranus focused beam maps

A1



A3