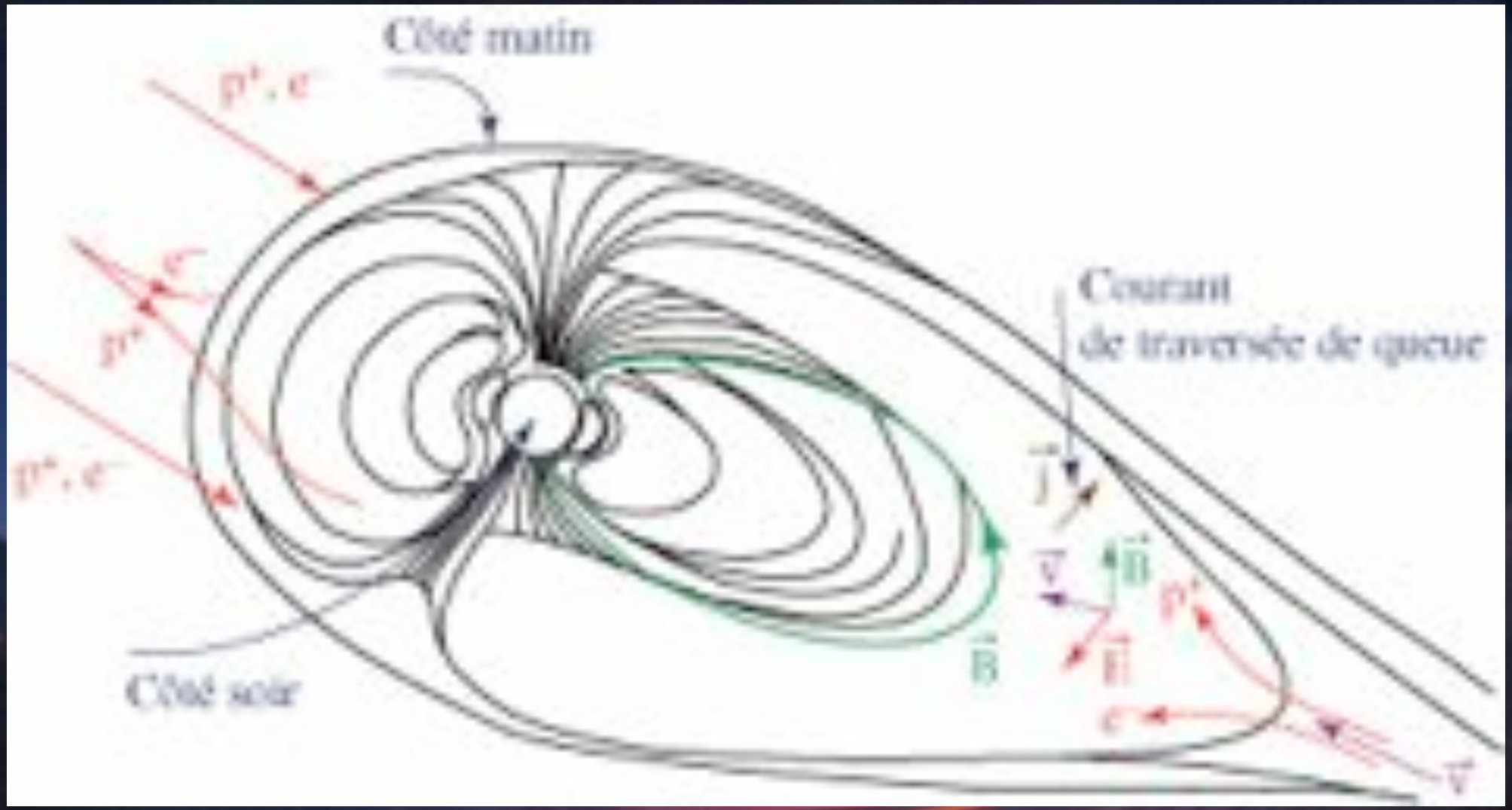
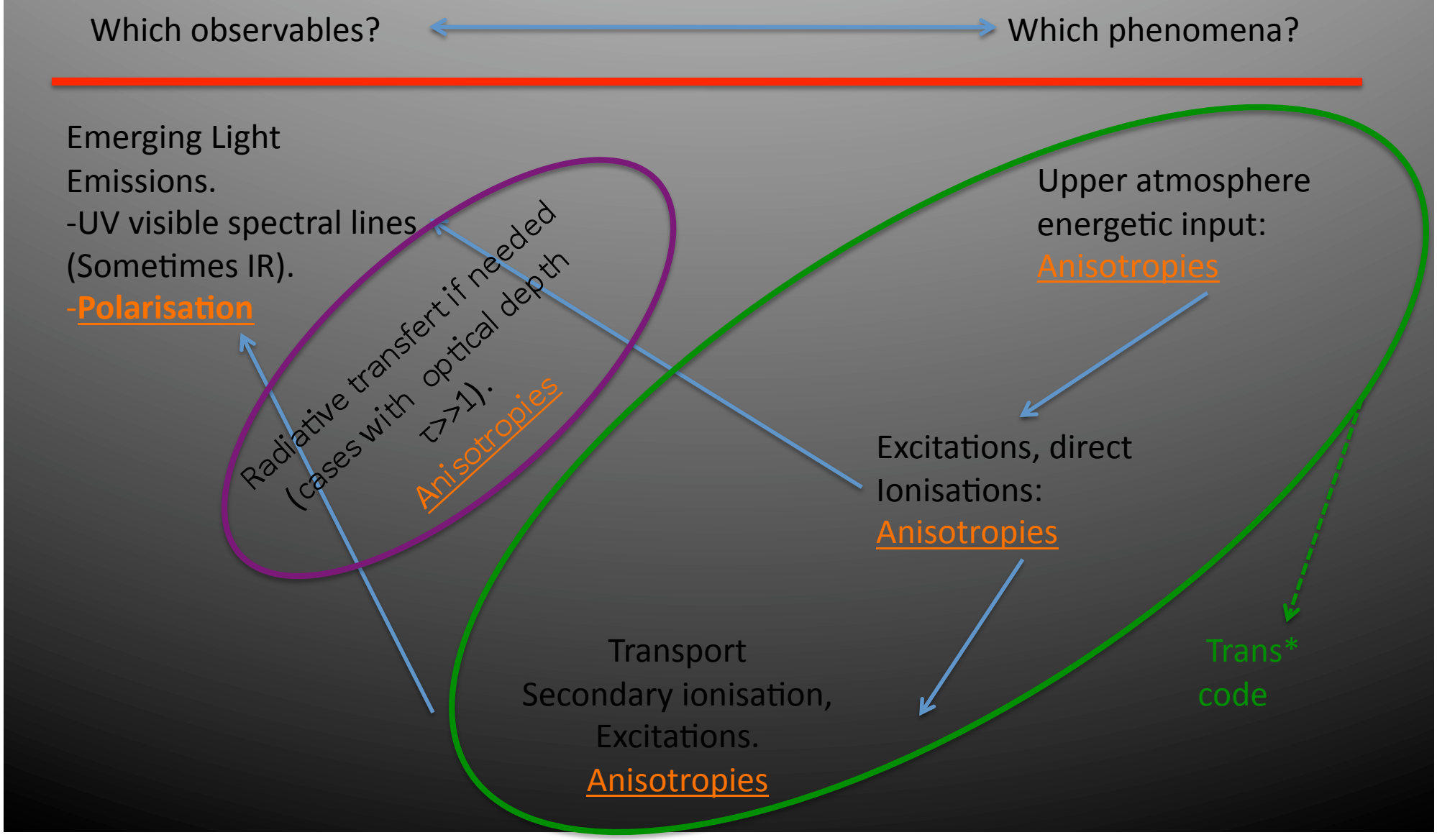
Polarisation of auroral emission lines : results, interpretation and perspectives.

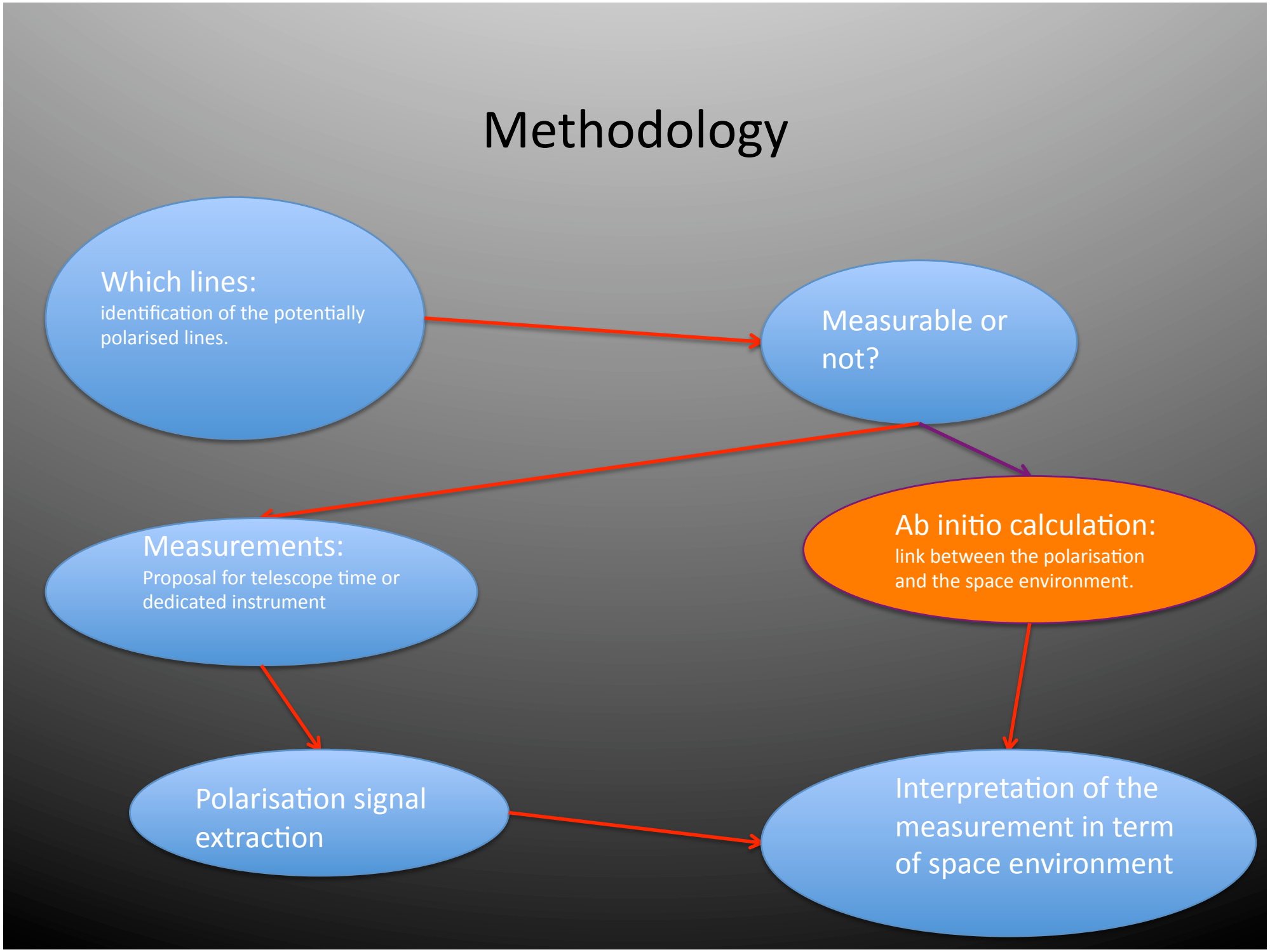
Barthélémy Mathieu (IPAG, France); Lilensten Jean (IPAG, FRANCE); Bommier Véronique (LESIA, FRANCE); Amblard Pierre-Olivier, (Gipsa Lab, FRANCE); Moen Joran (UiO, Norvège); Rothkaehl Hanna (Space Research Center, POLOGNE), Simon Wedlund Cyril, Lamy Hervé (Bira, Belgique); Chris Parkinson (University Michigan)


Côté matin
Courant
de traversée de queue
Côté soir

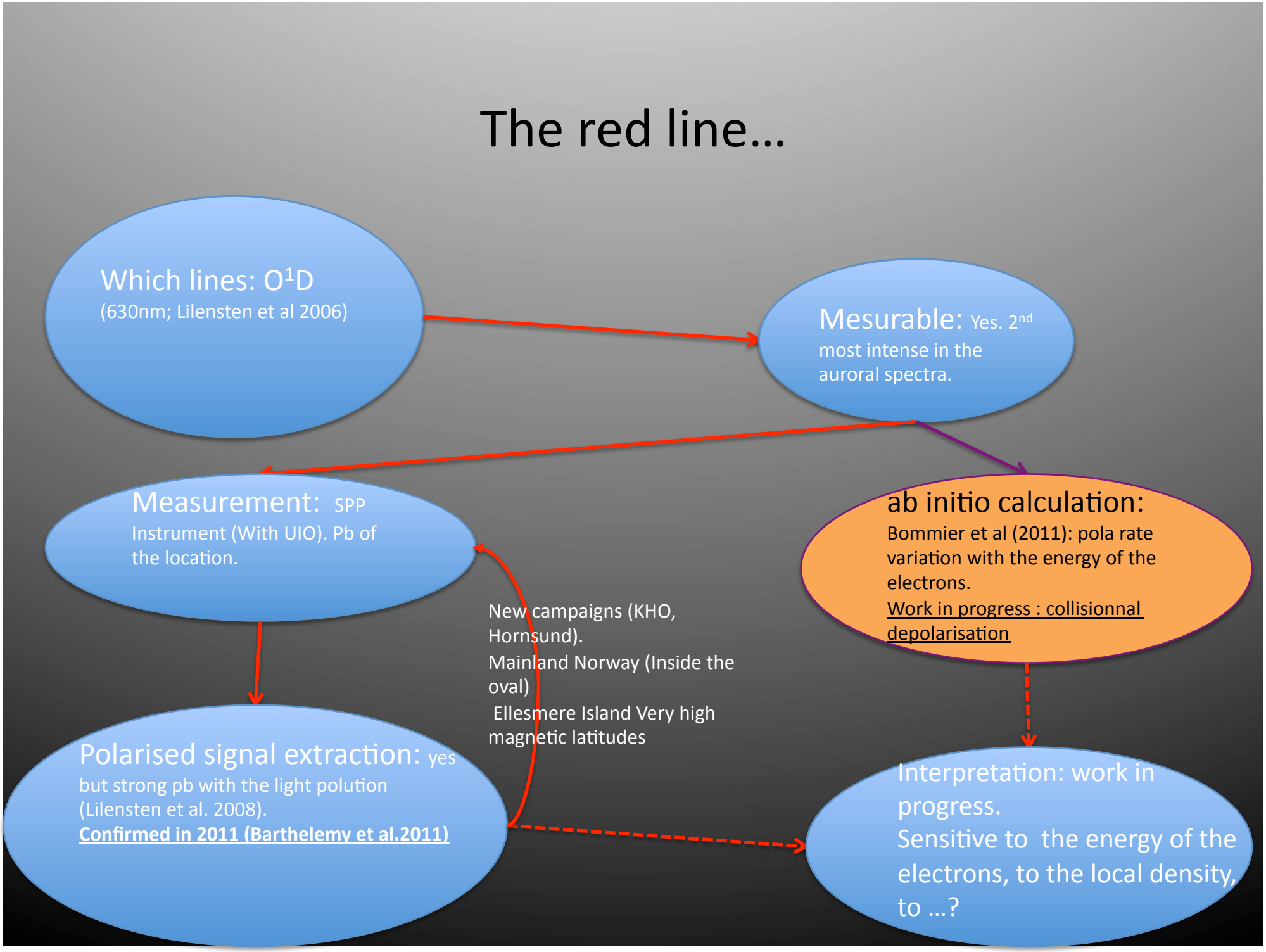
Why polarisation?



Methodology

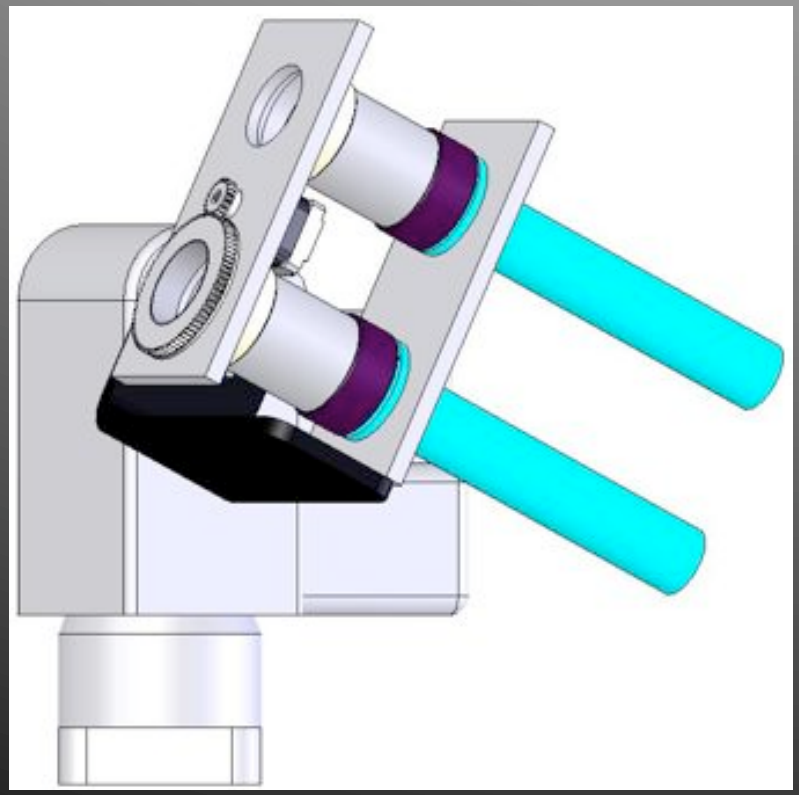


The red line…


Which lines: O^1D
(630nm; Lilensten et al 2006)
Mesurable: Yes. 2nd most intense in the auroral spectra.
Measurement: SPP Instrument (With UIO). Pb of the location.
ab initio calculation:
Bommier et al (2011): pola rate variation with the energy of the electrons.
Work in progress : collisionnal depolarisation
New campaigns (KHO, Hornsund).
Mainland Norway (Inside the oval)
Ellesmere Island Very high magnetic latitudes
Polarised signal extraction: yes but strong pb with the light polution (Lilensten et al. 2008).
Confirmed in 2011 (Barthelemy et al.2011)
Interpretation: work in progress.
Sensitive to the energy of the electrons, to the local density, to …?

SPP: technical details

- Photopolarimeter: SPP.



Steerable Polarization Photometer (SPP) built at Oslo University (UIO).

Channel 1: PM.

Red filter at 630 nm (FWHM 1 nm.

Rotating Analyser (T=4s)

Field of view 2°

Instrumental polarisation <0.9%; almost vertical.

Channel 2: Idem without analyser

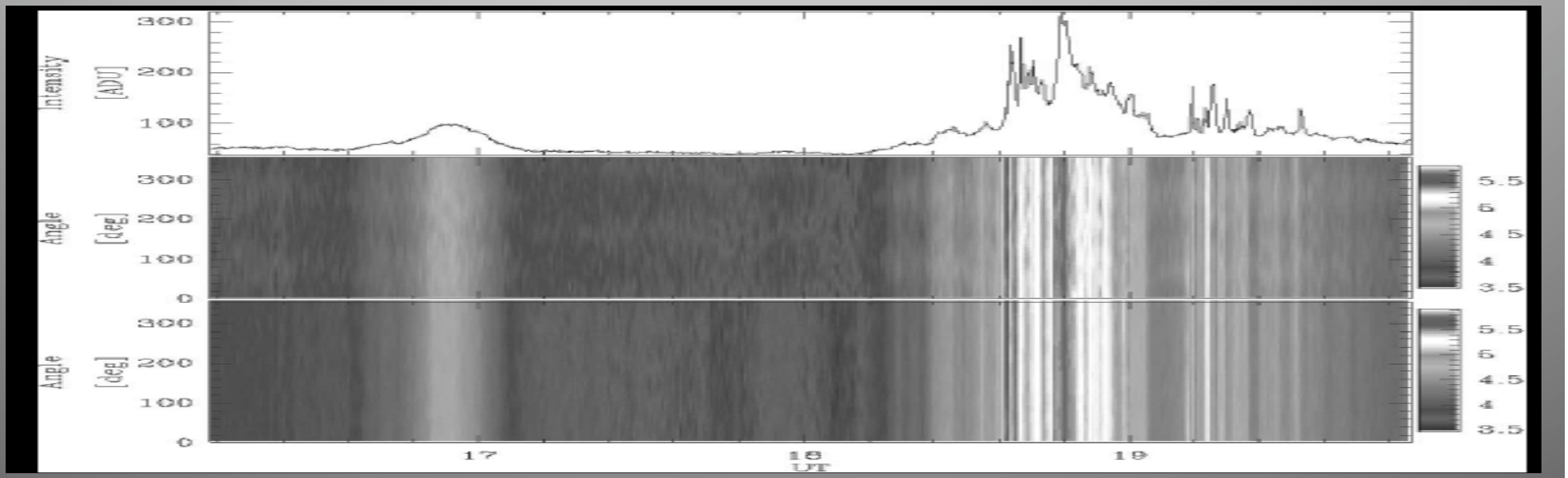
Data processing: 2 independant metohds…

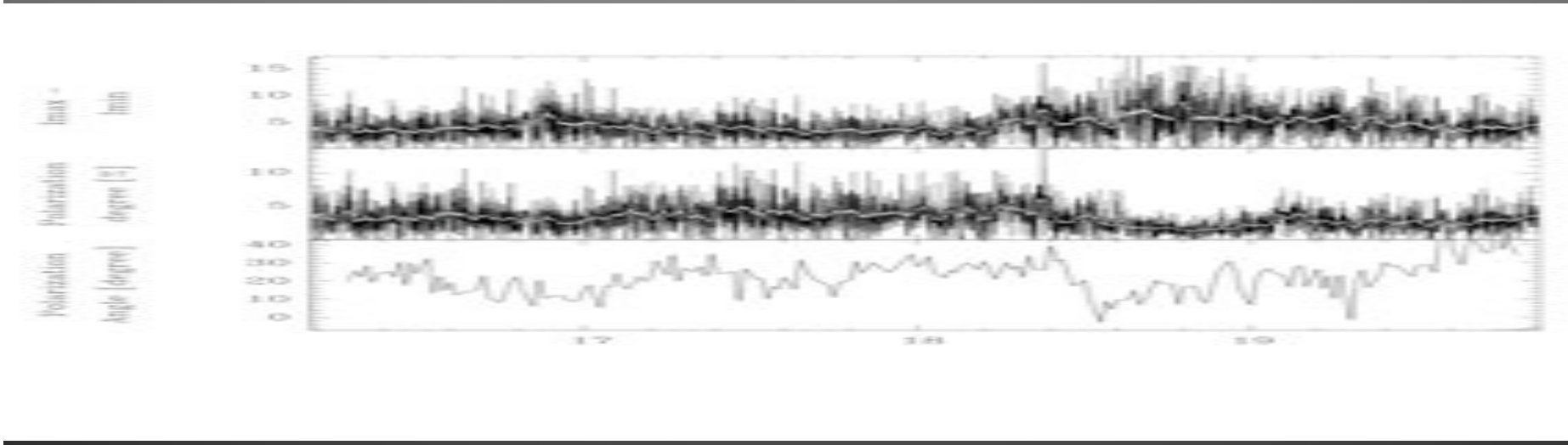
- FT processing: Automatic detection of the polarised signal
  - FFT of the signal, low bandpass filtering (1.5Hz)
  - Detection of a 0.5 Hz signal (In fact presence of a maximum between 0.4 and 0.6 Hz)
  - Comparison with pure noise signal and with the reference channel.
  - Parameters calculation by FFT-1 and fit of the result

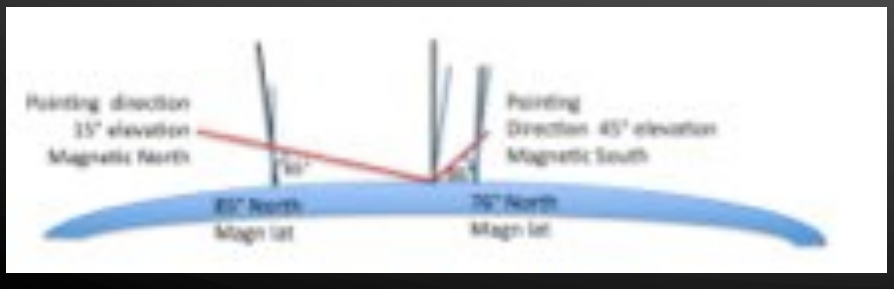
- Direct processing:
  - Mean over 1 min, Filter (Moving average over 5 or 7 points), Fit with a sine square function.
  - Calibration of the direction with references (Diffusion Rayleigh sza<108°)
  - Virtual noised data production with instrumental polarisation for comparison with the real data.

Discrimination between instrumental polarisation and auroral polarisation signal?

- Polarisation direction
  - But
  - Vertical polarisation signal expected
  - Instrumental polarisation also vertical.
    - Really complex to turn the instrument in real conditions.
- Noised data generator
  - Noise : $$Br = \frac{N_s\sqrt{\Delta T}}{\sqrt{N_s + 2(N_d)}}$$
  - Introduction of a virtual noised signal affected of the instrumental polarisation.
  - Data processing of this virtual signal
- Statistical check (Student test on the average) of difference between the real signal and the virtual one.







17 jan 2007 late afternoon. From Lilensten et al. 2008. GRL

- Existing polarisation caused by 2 processes (Pollution+ Aurora).

- Quantification (degree and direction) impossible due to the light pollution.

- **Not sufficient to extract usable data for space environment studies.**

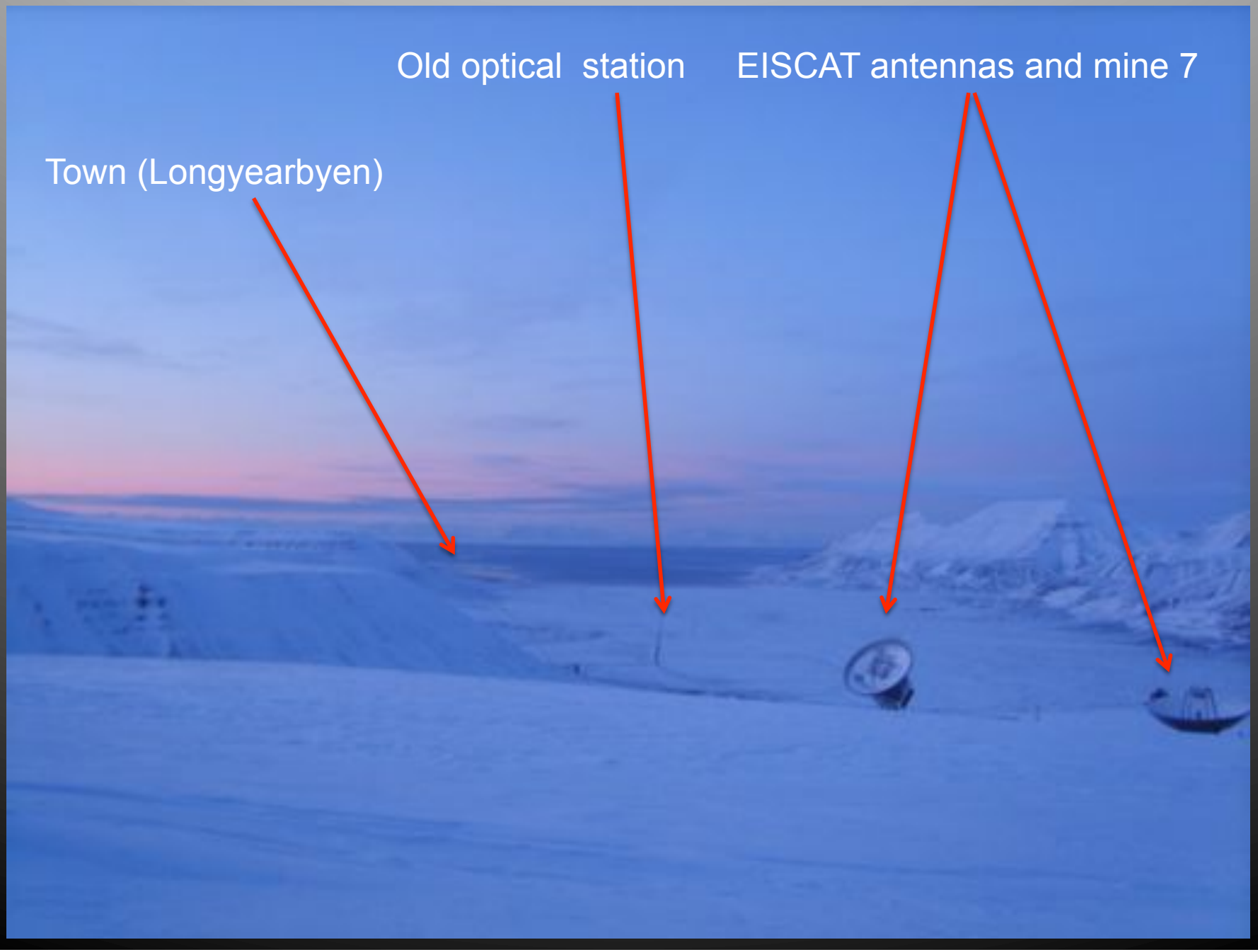
Coordinated campaigns ESR/polarlis (2007-2009)

•Campaign 2007 from 9 to 18 dec 2007 at KHO (new optical observatory). Still some light polution especially when looking in N or N-W directions.
•Campaign 2008: Instrument located in Ny Alesund. Large light polution…
•Campaign 2009: Very bad weather conditions. Still some light polution except during Zenith and South observations.

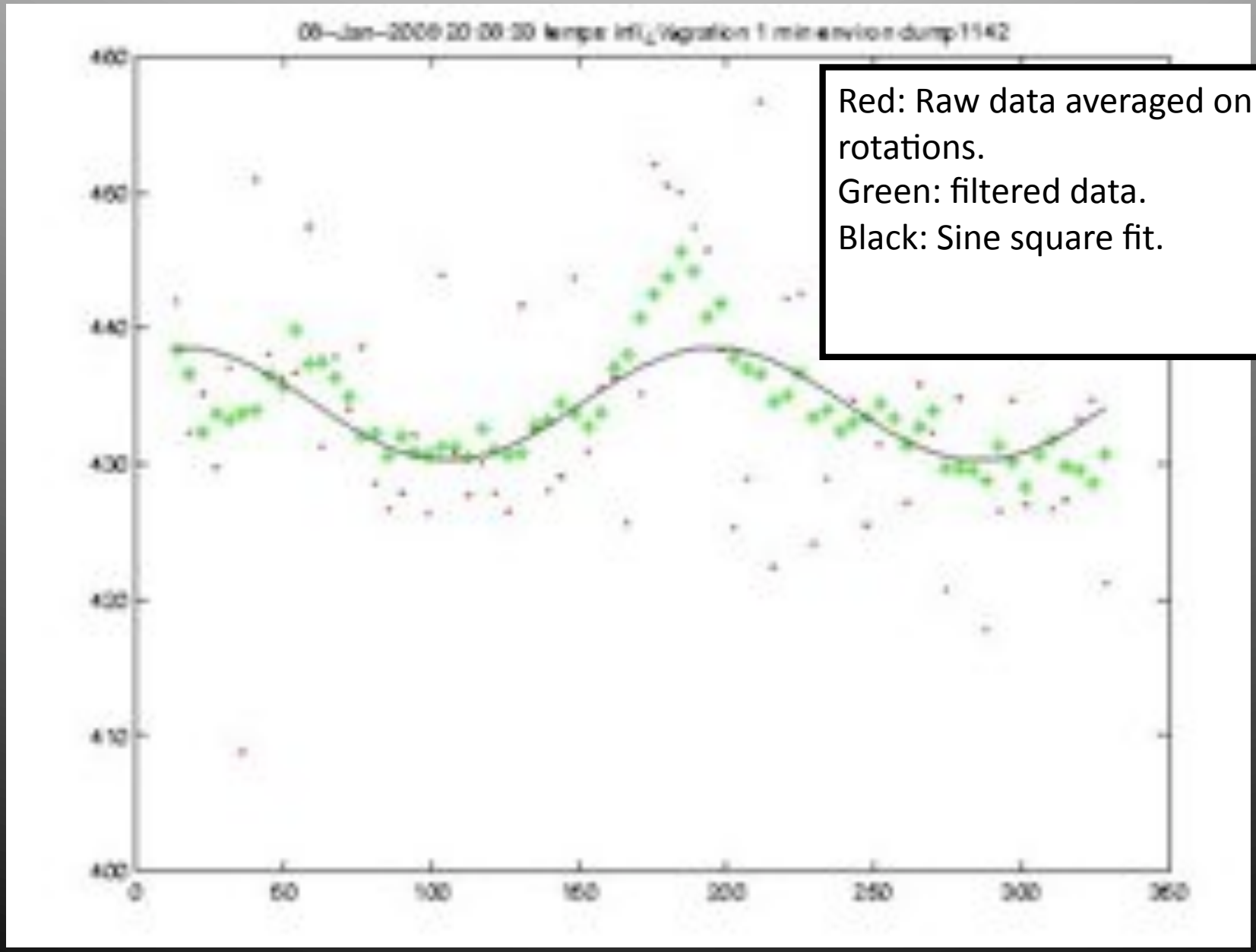
However:

•Confirmation of the first result
•Polarisation close to the vertical when looking to the North.
•But strong difficulties to get some calibrated data.
•**<u>Still difficult in term of space weather interpretation</u>**

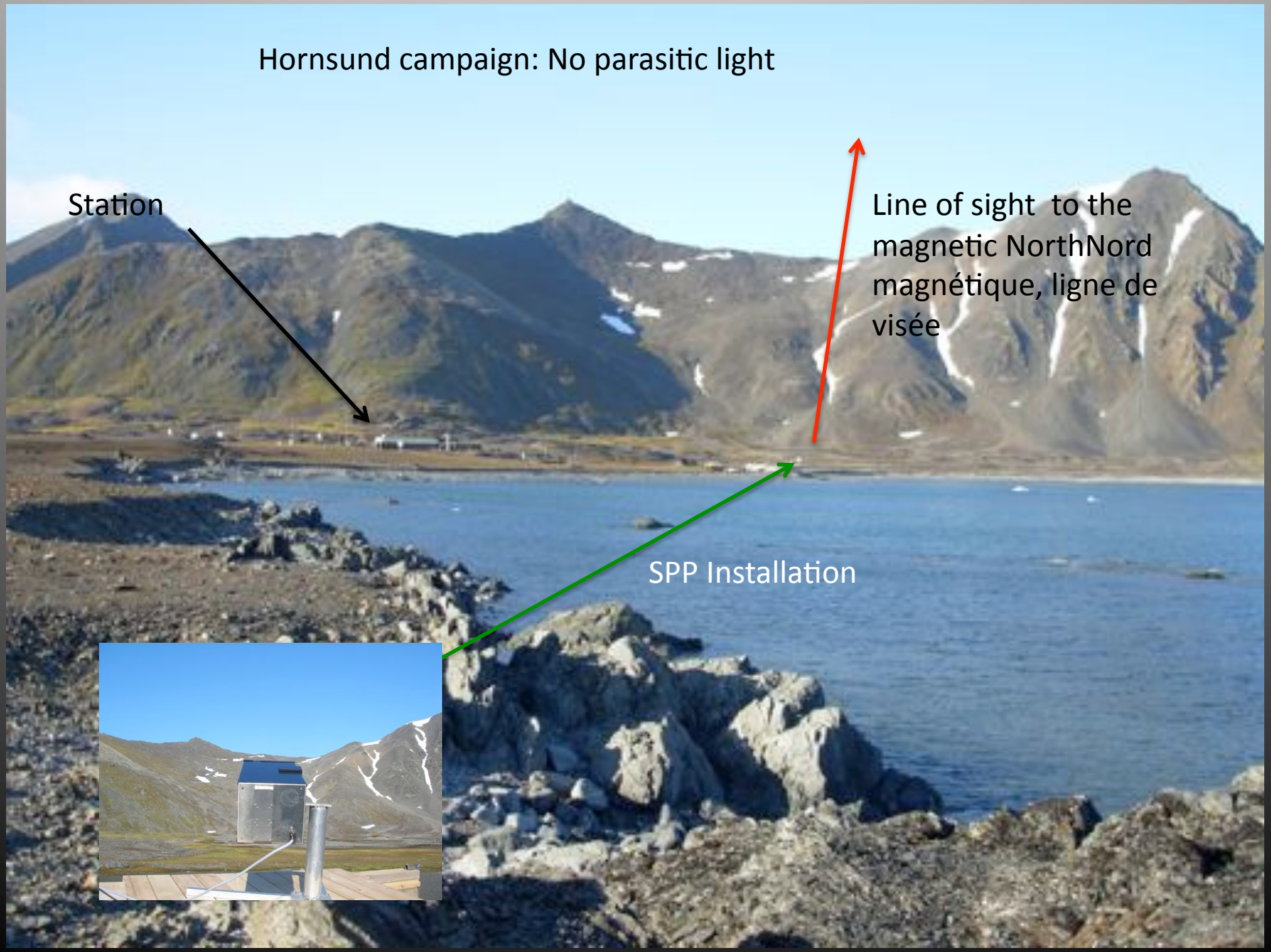
From the new optical station



Confirmation de la polarisation instrumentale (Zenith)
P=0.9%. Direction verticale après corrections



Red: Raw data averaged on 15 rotations.
Green: filtered data.
Black: Sine square fit.


Hornsund campaign: No parasitic light
Station
Line of sight to the magnetic NorthNord magnétique, ligne de visée
SPP Installation

Hornsund: results

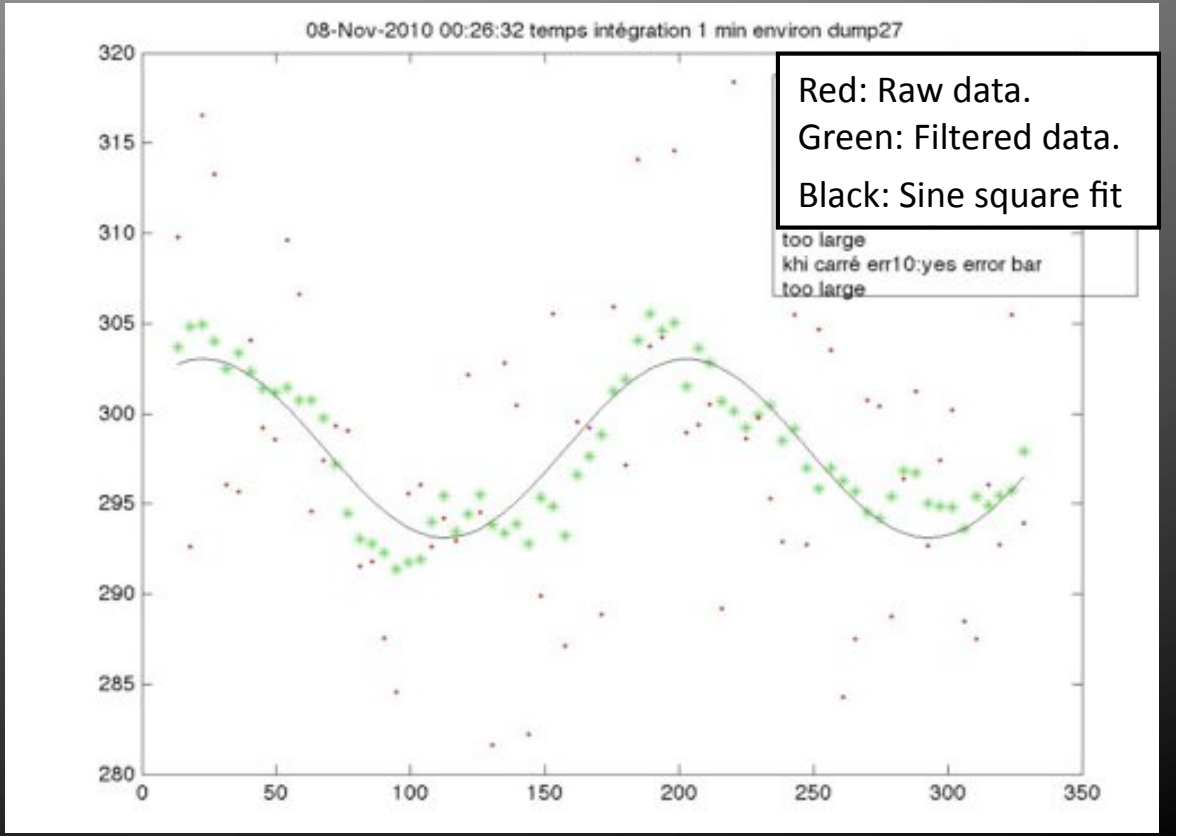
•2 month of data (Nov and Dec 2010)

but

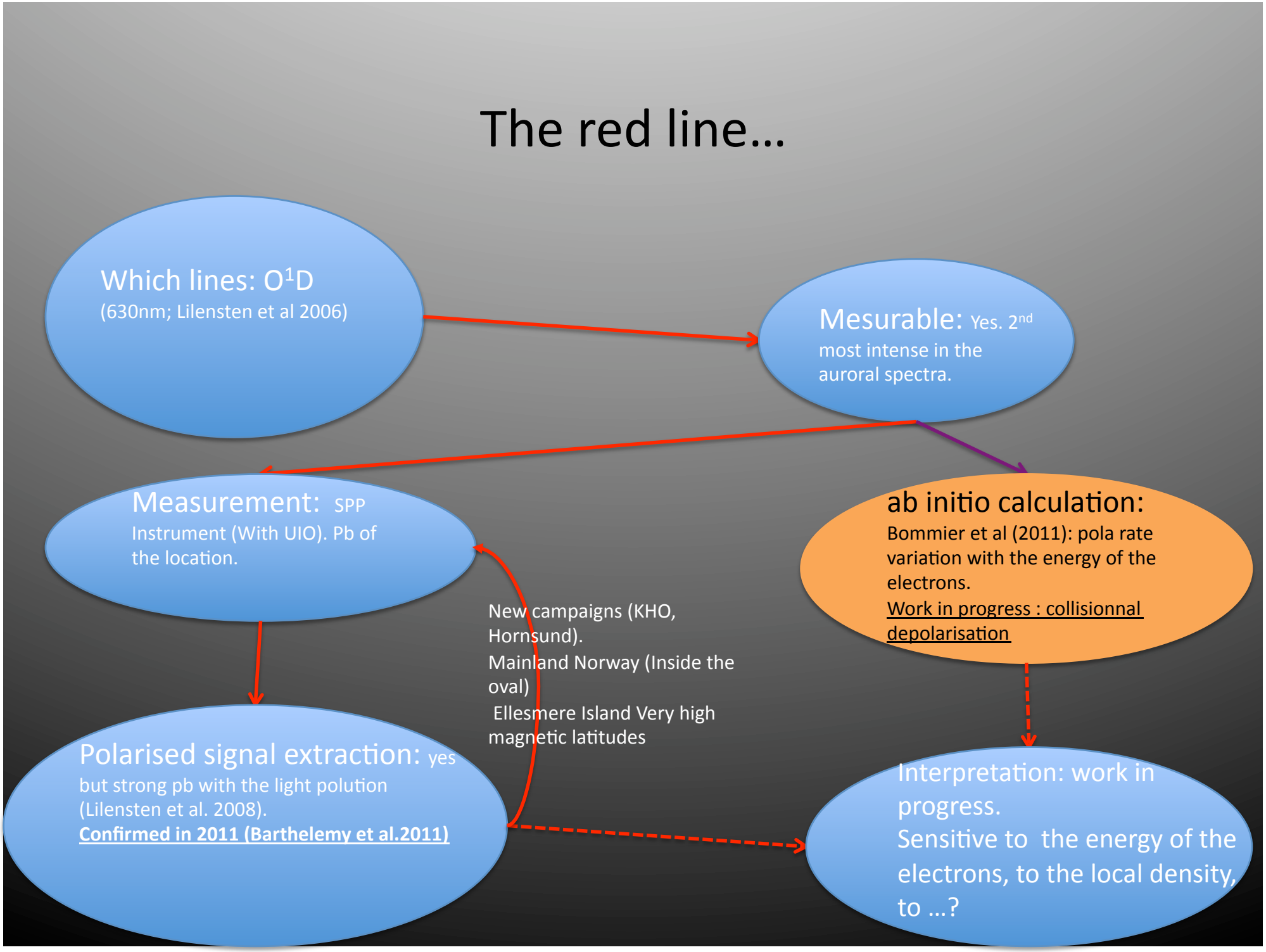
•Very constant solar activity 70<f10.7<85.

•Statistical correlation very difficult.
•Strong need for ab initio calculation results.

Data example (Hornsund)
P=1.67%; Direction <5° after correction.



The red line…


Which lines: O¹D
(630nm; Lilensten et al 2006)
Mesurable: Yes. 2nd most intense in the auroral spectra.
Measurement: SPP Instrument (With UIO). Pb of the location.
ab initio calculation:
Bommier et al (2011): pola rate variation with the energy of the electrons.
Work in progress : collisionnal depolarisation
New campaigns (KHO, Hornsund).
Mainland Norway (Inside the oval)
Ellesmere Island Very high magnetic latitudes
Polarised signal extraction: yes but strong pb with the light polution (Lilensten et al. 2008).
Confirmed in 2011 (Barthelemy et al.2011)
Interpretation: work in progress.
Sensitive to the energy of the electrons, to the local density, to …?

-Polarisation degree as a function of the particles energy.)

-Polarisation degree very stable around 17% (strong difference with the data)

-Direction // to B (coherent with the data)

-but

-Collisionnal Depolarisations

-Secondary electron role

- Work in progress (V. Bommier et al.), résultats espérés à l'EGU 2012.

"On voit le bout du tunnel…"

We are very close to a possible interpretation.

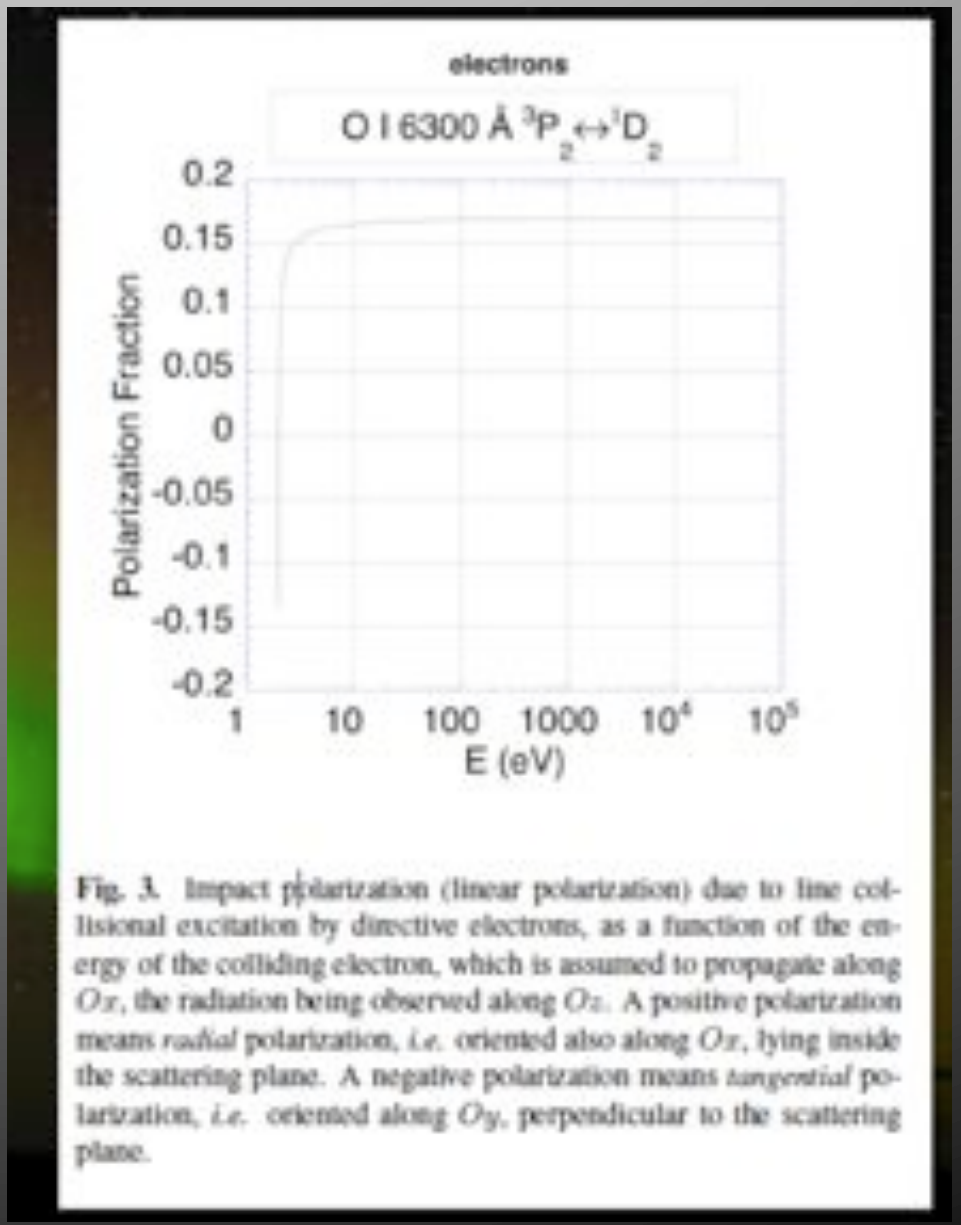
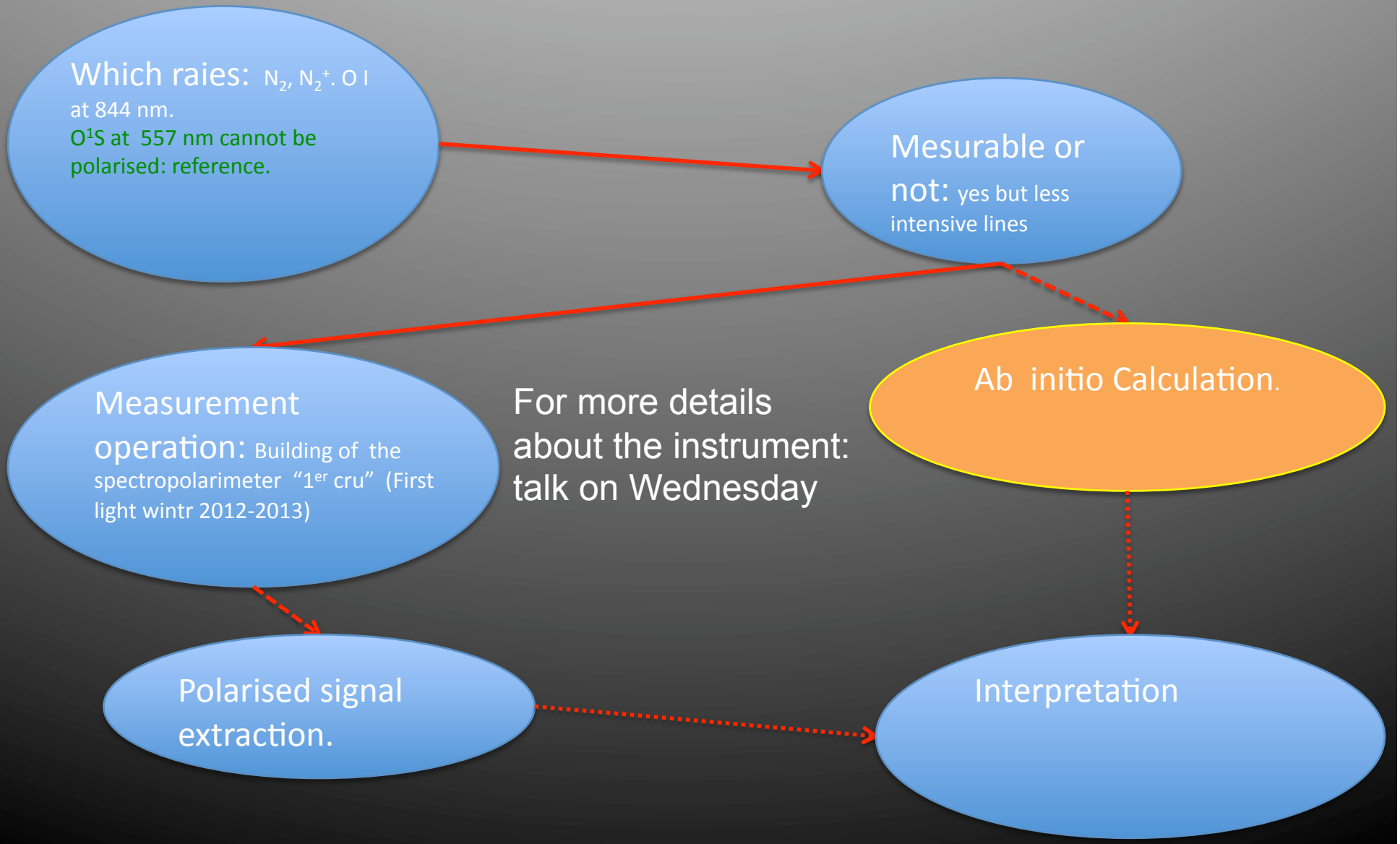
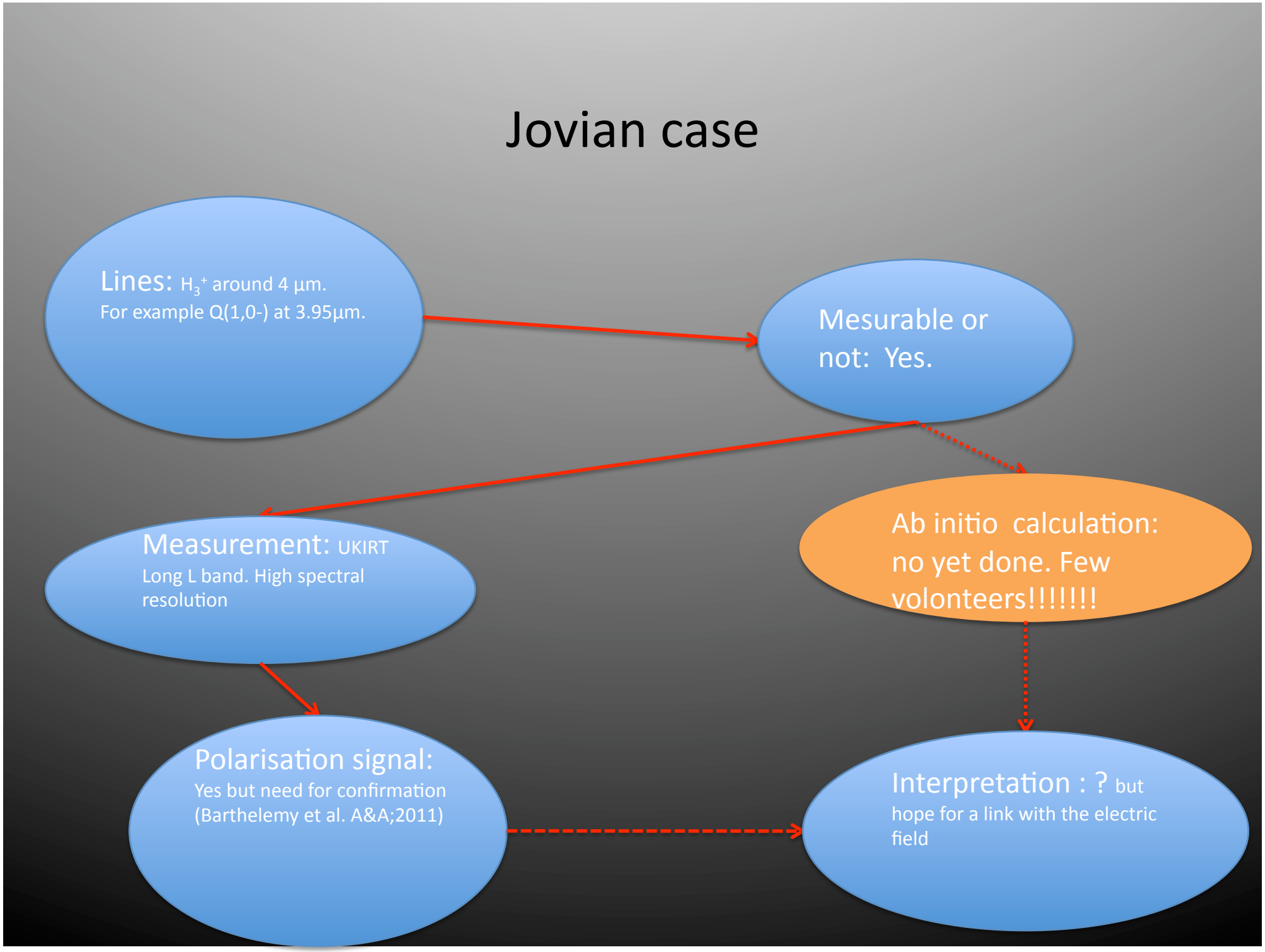


Fig. 3. Impact polarization (linear polarization) due to line collisional excitation by directive electrons, as a function of the energy of the colliding electron, which is assumed to propagate along Ox, the radiation being observed along Oz. A positive polarization means *radial* polarization, *i.e.* oriented also along Ox, lying inside the scattering plane. A negative polarization means *tangential* polarization, *i.e.* oriented along Oy, perpendicular to the scattering plane.

The polarisation : Other lines?



Jovian case


Lines: H_3^+ around 4 µm.
For example Q(1,0-) at 3.95µm.
Mesurable or not: Yes.
Measurement: UKIRT
Long L band. High spectral resolution
Ab initio calculation: no yet done. Few volonteers!!!!!!!
Polarisation signal:
Yes but need for confirmation (Barthelemy et al. A&A;2011)
Interpretation : ? but hope for a link with the electric field

Jovian Lyman α

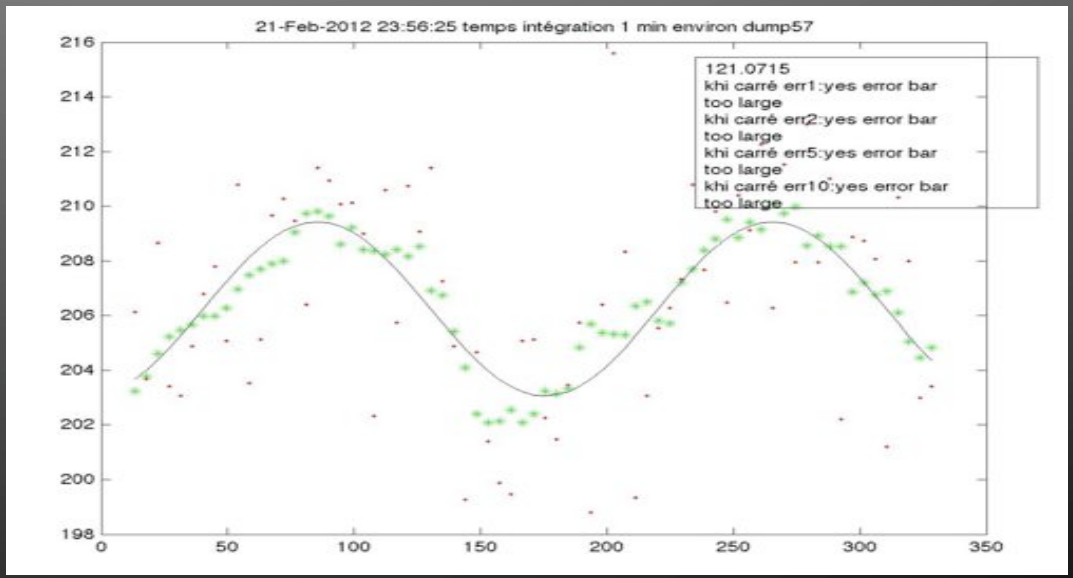
- Juice mission: selected by ESA
- Polarimeter on the UV visible instrument?
  - Difficult to achieve in the FUV
  - Pb of the moving pieces

Conclusions

- Red line
  - Polarisation confirmed
  - Direction coherent with ab initio calculation
  - In term of space weather: still need for ab initio results
  - A new campaign have been done in Feb 2012 with some activity (Kp=4-5)!!!
- Other lines:
  - "Premier cru":

  Winter 2012-2013.
  - And H_3^+ on Jupiter.

– To be continued….



Example of 2012 data: 21 feb 2012, 23h56Line of sight: magnetic W .P~1.5%