Instrumental developments and scientific programs at Istituto Ricerche Solari Locarno (IRSOL)

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IRSOL

- IRSOL = Istituto Ricerche Solari Locarno
- Observatory specialized in polarimetry

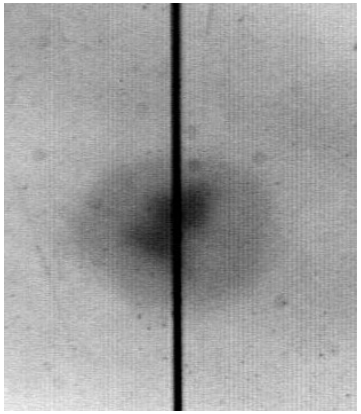
Outline

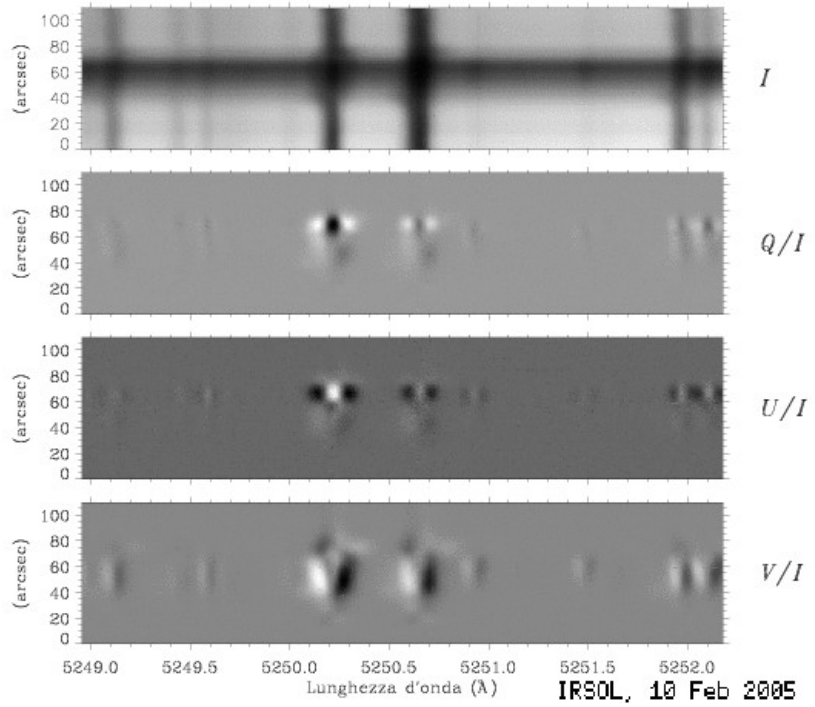
- Scientific interest of polarimetry
- (old) Instrumentation (ZIMPOL, ...)
- List of some scientific results
- New instrumentation
  - Fabry- Perot filter system
  - Adaptive optics
- Future projects
- Conclusion

Polarimetry

- Polarimetry allows to get information about the magnetic fields

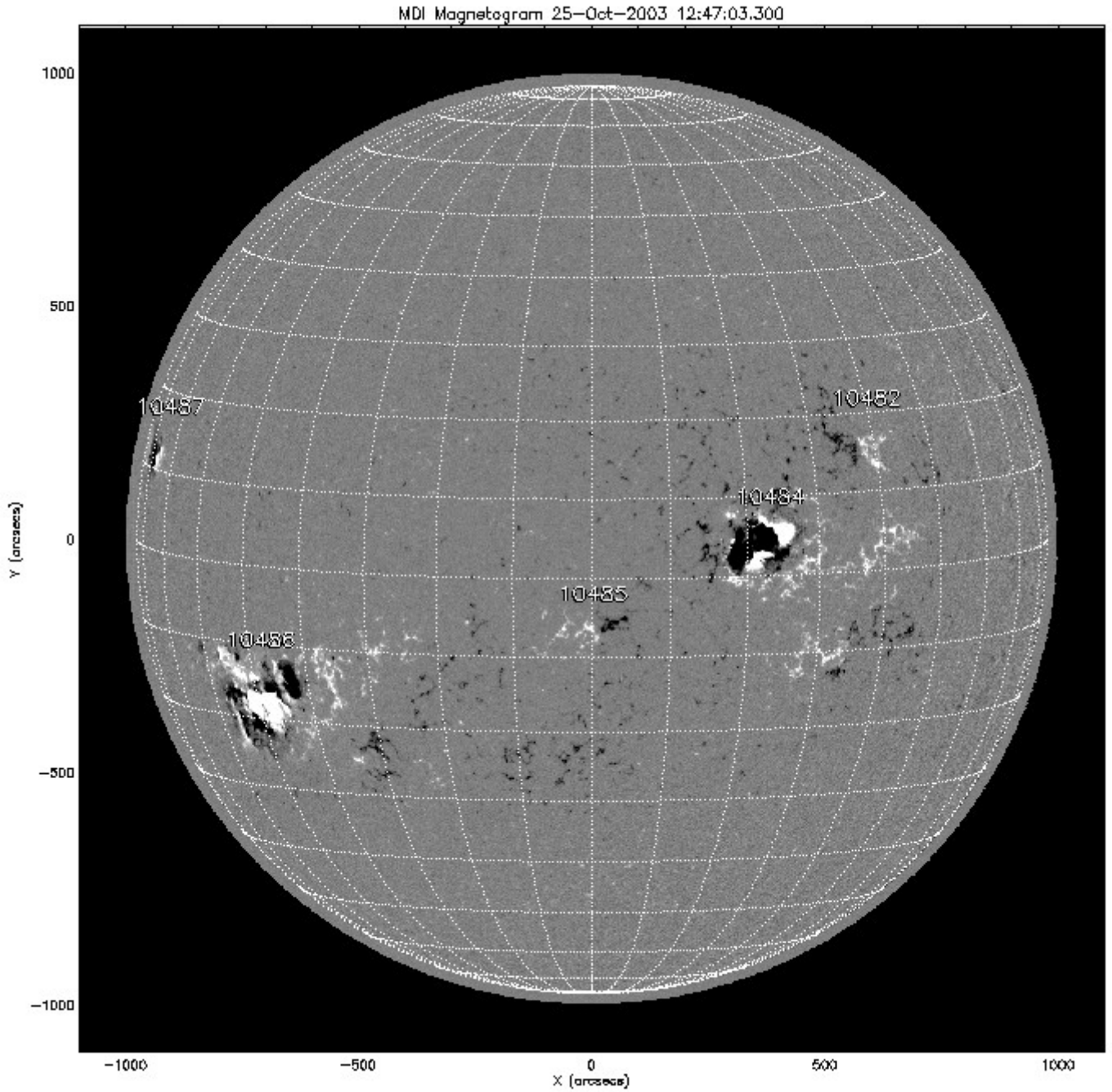
Zeeman effect:





Polarization signals: ~ 20 %

Zeeman effect allows to get the tridimensional information of strong oriented magnetic fields.

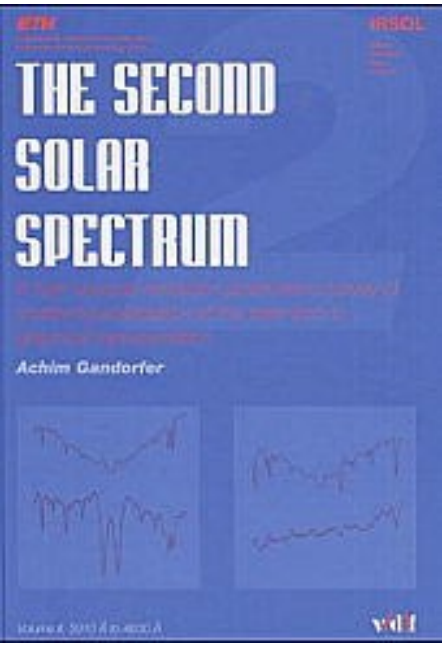

MDI Magnetogram 25-Oct-2003 12:47:03.300
10487
10452
10484
10455
10456
1000
500
0
−500
−1000
Y (arcsecs)
−1000
−500
0
500
1000
X (arcsecs)

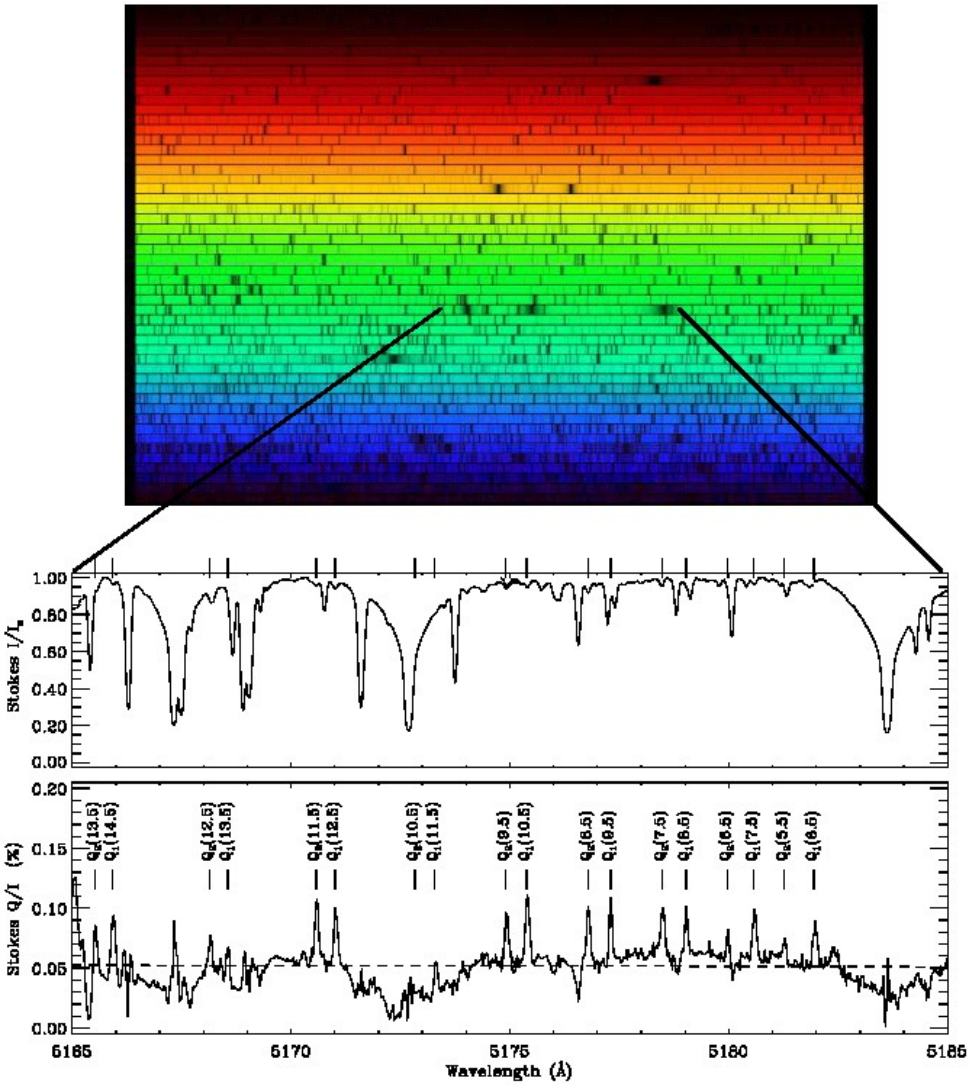
Scattering polarization and the Hanle effect

- The improvement in the polarimetric accuracy (at 10^{-4} level or better) allows interesting measurements of scattering polarization (mainly) near the limb
- Scattering polarization profiles in spectral lines are influenced also by weak and mixed-polarity magnetic fields through the Hanle Effect (which mainly manifests itself as depolarization and ev. a rotation of plane of polarization)
- Powerful tool to get information about magnetic fields that are weak or/and tangled on scales below the spatial resolution (to which Zeeman is blind)

Second solar spectrum

First two volumes of
Gandorfer's Atlas obtained
at IRSOL (2000, 2002)



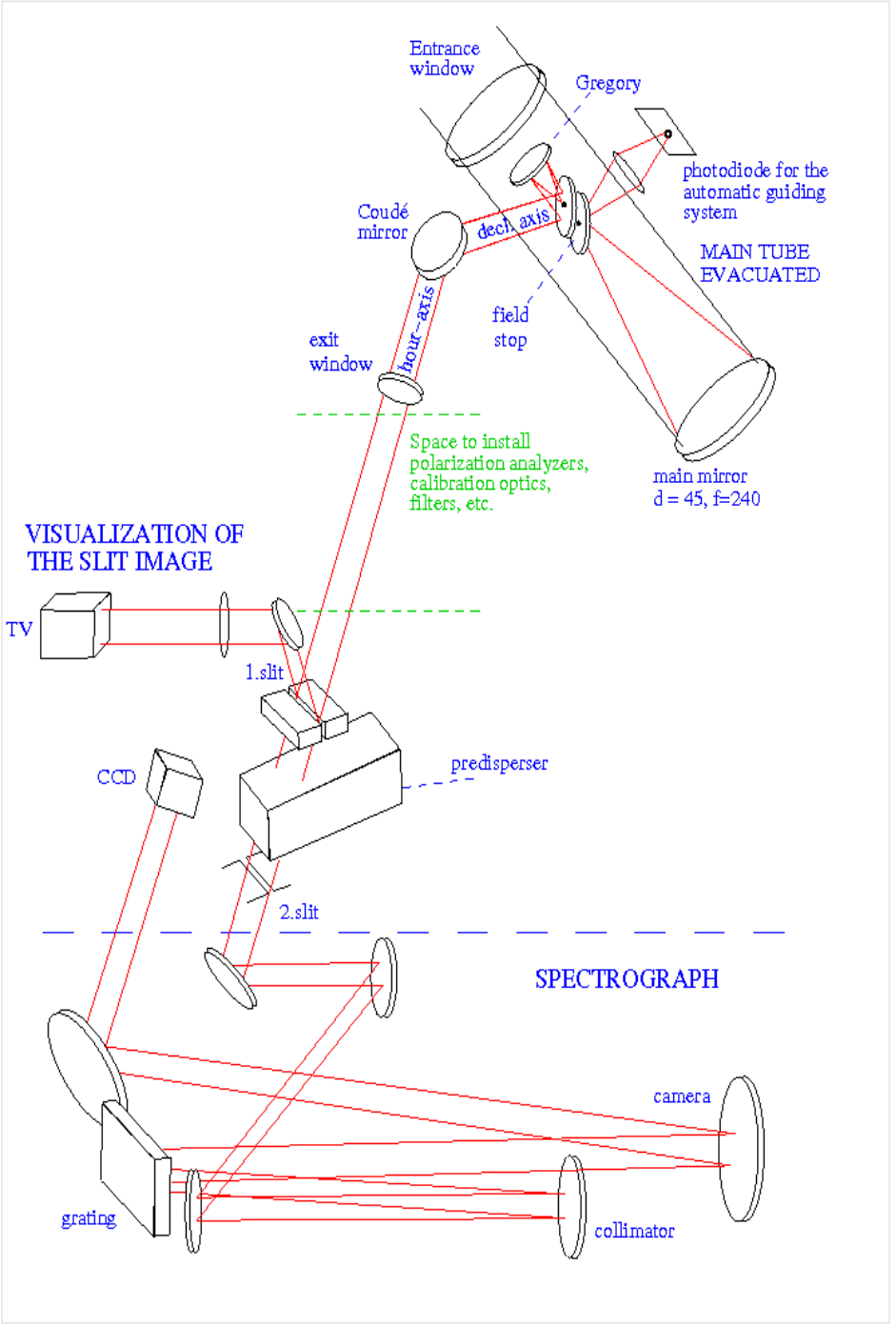


The IRSOL instrumentation

Telescope

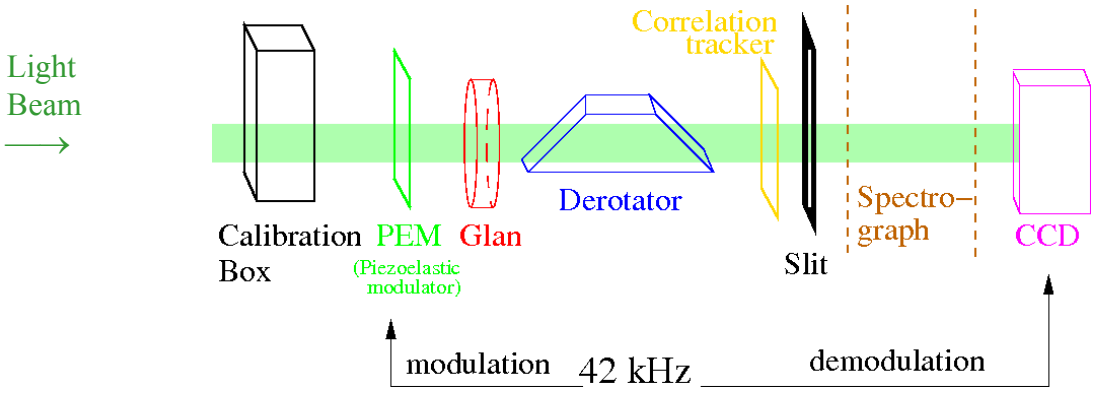
- **Telescope:** Gregory - Coudé, evacuated
  - Diameter of primary mirror: 45 cm
  - Total focal length: 25 m
- **Spectrograph:** Czerny - Turner
  - focal length: 10 m
  - grating 18 cm × 36 cm
  - 300 lines / mm
  - blaze 63°

Telescope layout



ZIMPOL polarimeter

- ZIMPOL2-polarimeter ***(Zurich Imaging Polarimeter,*** developed at ETH-Zurich) allows precise full Stokes measurements free form seeing induced spurious effects (modulation 42 kHz).
- Polarimetric accuracy depends primarily on photon statistics. 10^{-5} level can be reached with long exposure time.



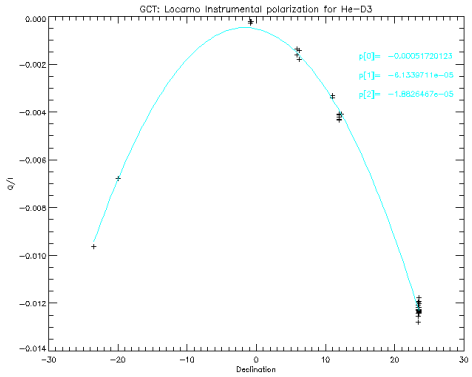
ZIMPOL 2 - setup

Advantages of GCT + ZIMPOL

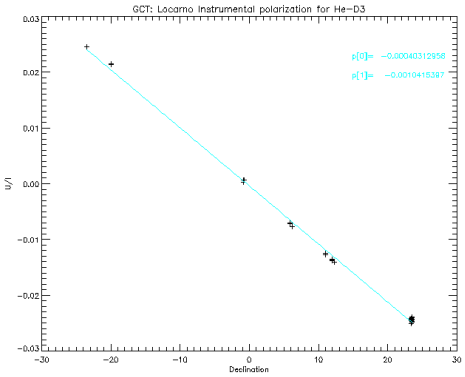
- Very good polarimetric and spectral accuracy
- Large amount of observing time available:
  - Flexibility, fast reaction to particular solar events
  - Good for monitoring or for projects requiring long observation time
  - Good for testing and development of new instrumentation
- Instrumental polarization is small and almost constant over one day of observations (easy to correct – depends on declination only)

Crosstalks

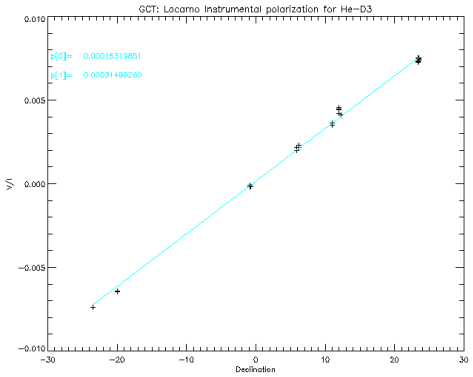
I → Q



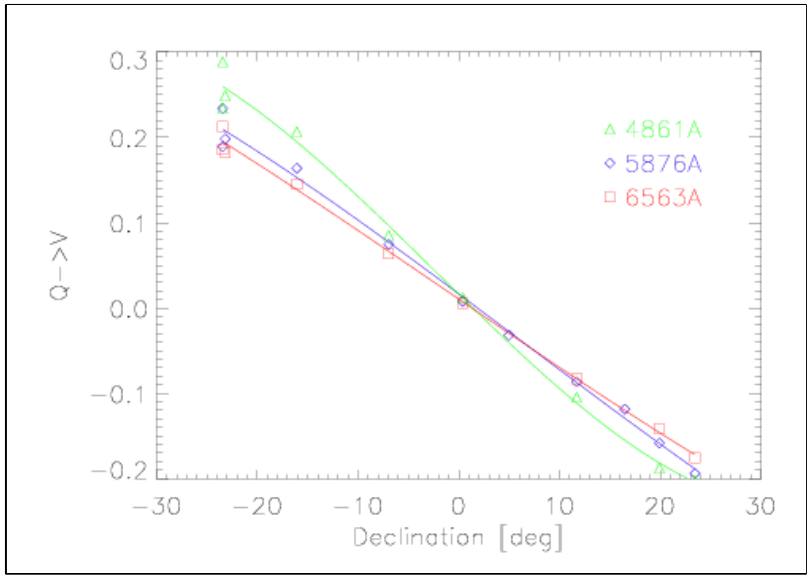
I → U



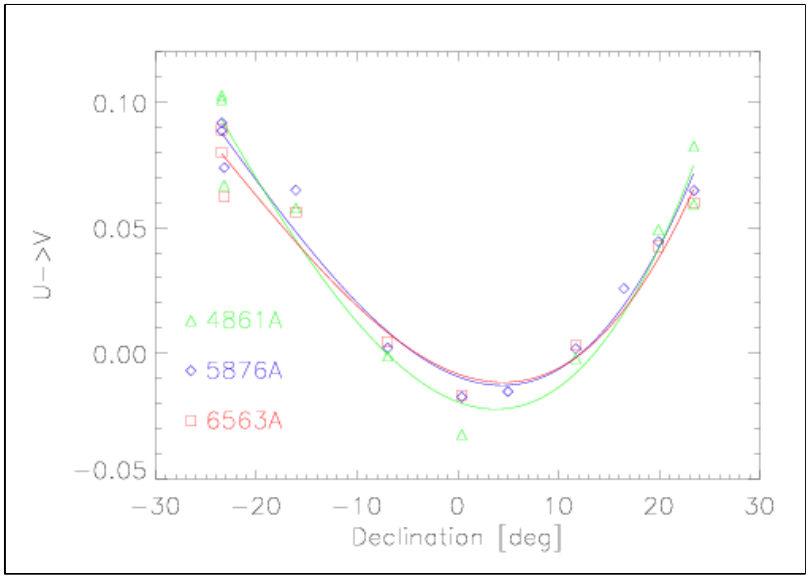
I → V



Q → V



U → V



Examples of results obtained at IRSOL

- Hanle effect measured in the quiet chromosphere (Bianda et al., 1998)
- 2 Volumes of "Second Solar Spectrum Atlas" (Gandorfer, 2000/2002)
- Determination of novel constraints on impact polarization in solar flares (Bianda et al., 2005)
- Discovery of vast amount of hidden magnetismus in the solar photosphere (Trujillo Bueno et al.- Stenflo, Nature 2004)
- Measurements of polarization in molecular lines (e.g. Berdyugina et al. 2006 ; Asensio Ramos et al. 2004)
- Measurements of full Stokes profiles in prominences in Hα, He-D_3 and H β (Ramelli et al., 2005)
- He-D_3 full Stokes spectropolarimetric measurements in spicules (Ramelli et al., 2005)

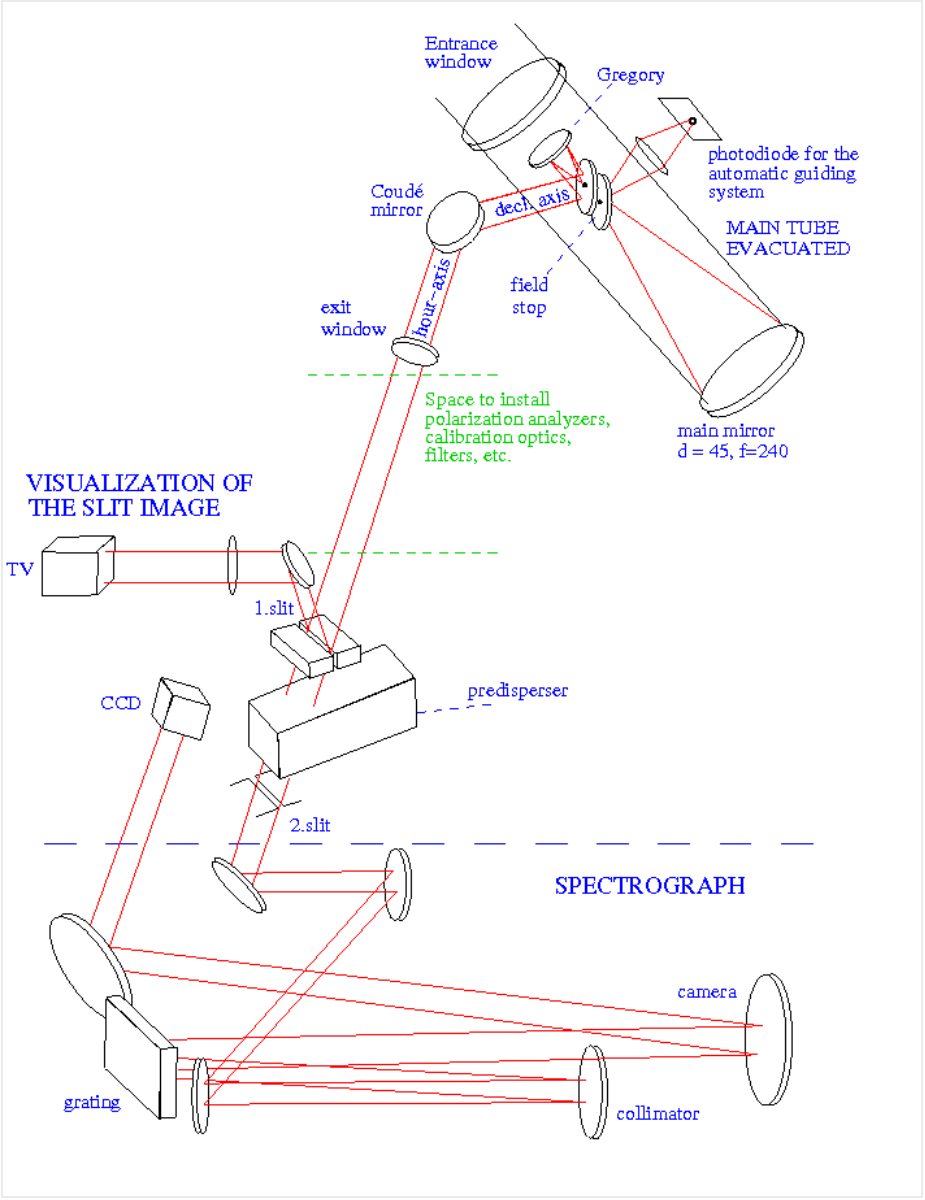
New instrumentation

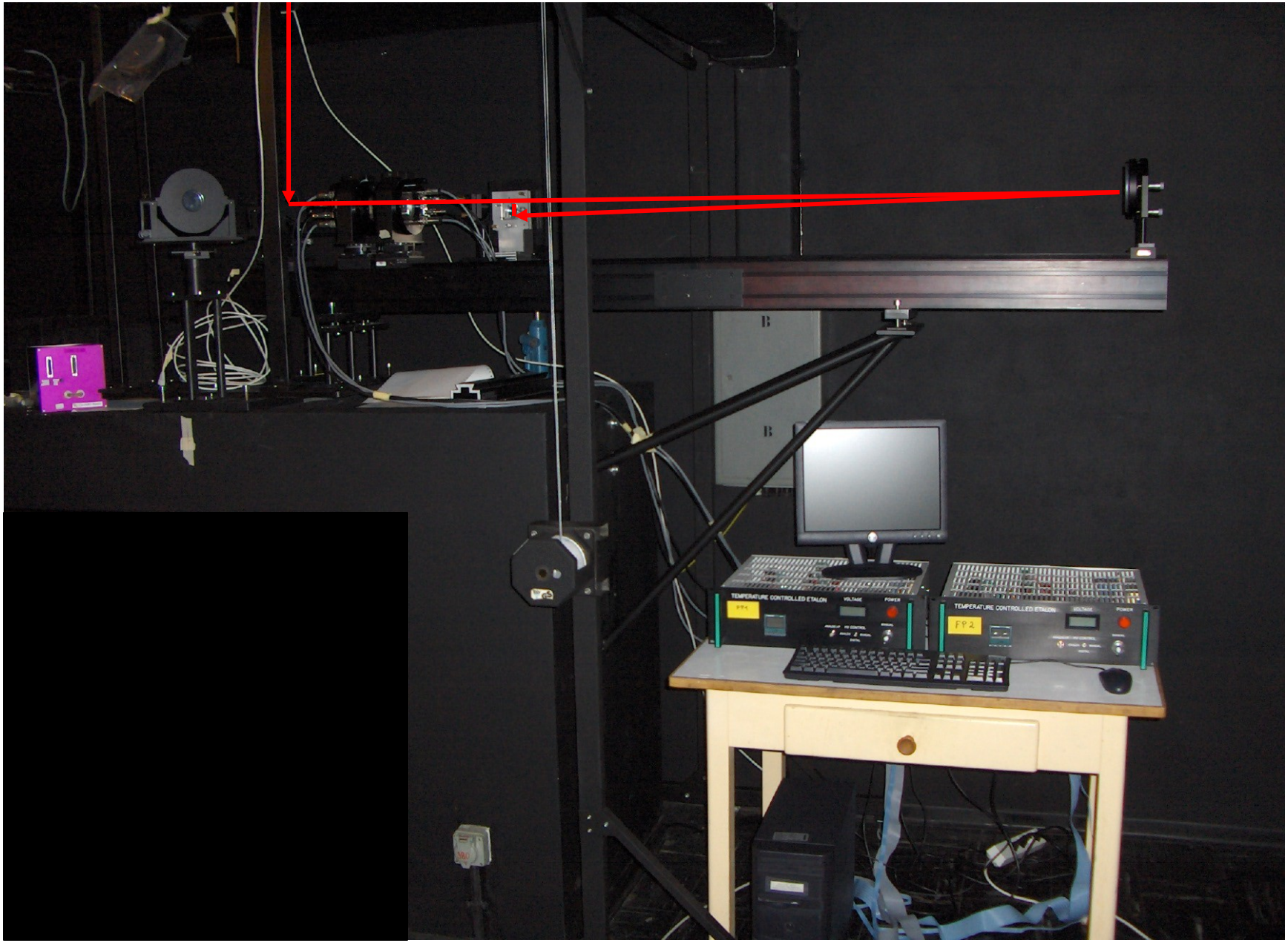
- Fast tunable narrow band filter system

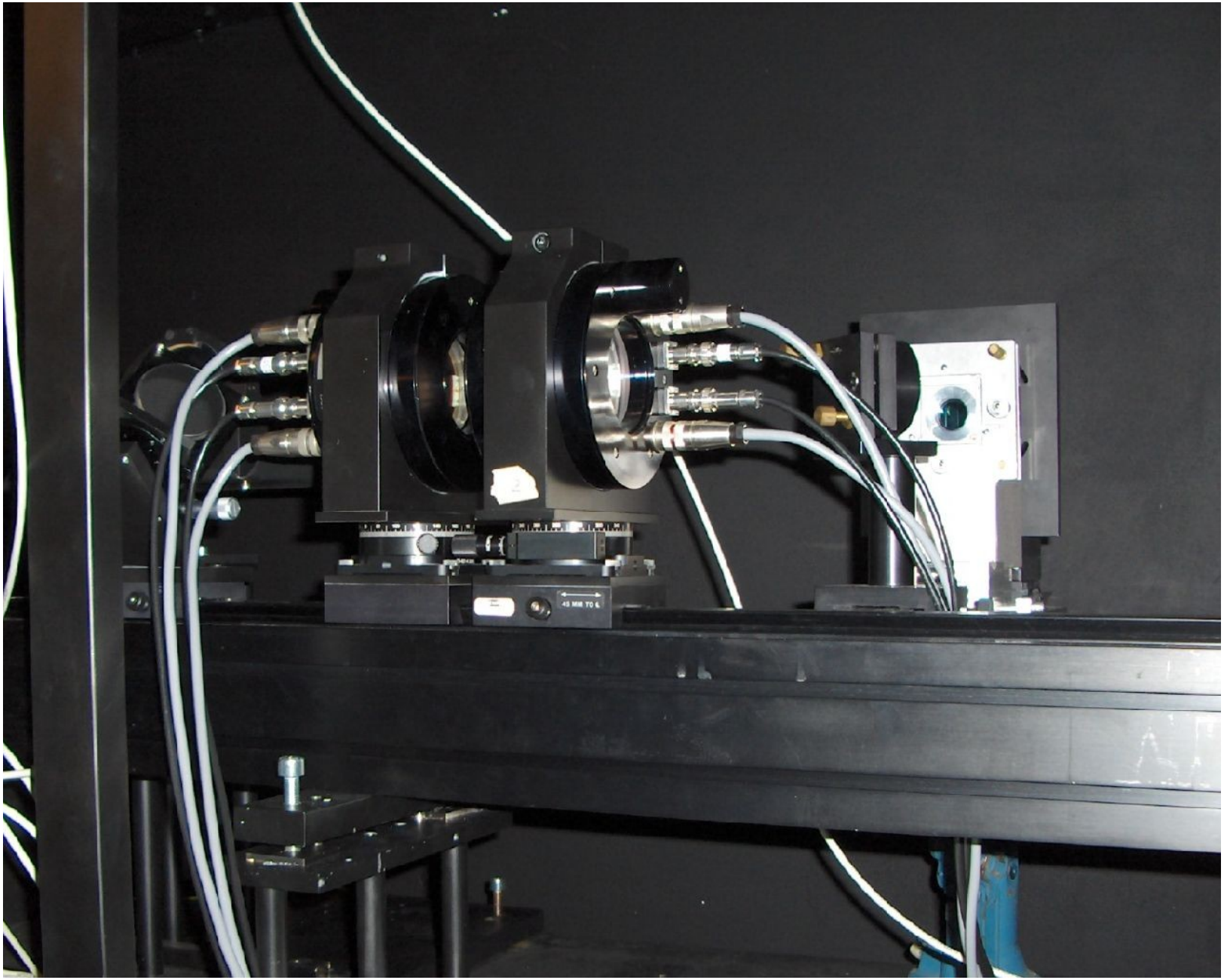
  → monochromatic imaging

  - two lithium niobate Fabry–Perot etalons
  - Bandwidth ~ 30 mA

- AO system




TEMPERATURE CONTROLLED ETALON
FP1
VOLTAGE
POWER
TEMPERATURE CONTROLLED ETALON
FP2
VOLTAGE
POWER



Ramelli:

ple of FP recording in the Ca I 4227 A line

Ramelli:

One of the first observations in the \ion{Ca}{i} prefilter range with the collimated setup at IRSOL. Active region (NOAA 10905) close to the west limb on August 31. \textbf{Upper right:} scan with the FP filter (solid line). As comparison, the corresponding spectrum from \citet{gandorfer02} is overplotted (dashed line).
\textbf{Lower right:} Q/I from \citet{gandorfer02} for a limb distance of $\mu=0.1$.
\textbf{Left:} Series of Stokes images recorded with ZIMPOL at the two spectral positions indicated by the vertical lines in the scan. The greyscale for Stokes Q/I and V/I is 2\%. To enhance the contrast, the limb darkening has been removed in the Stokes I images.

(limb darkening removed)

```
@Book{gandorfer02,
   author = {{Gandorfer}, A.},
    title = "{The Second Solar Spectrum: A high spectral resolution
polarimetric survey of scattering polarization at the solar limb in
graphical representation. Volume II: 3910 {\AA} to 4630 {\AA}}",
  publisher = {VdF},
     year = 2002,
 address = {Zurich}
}
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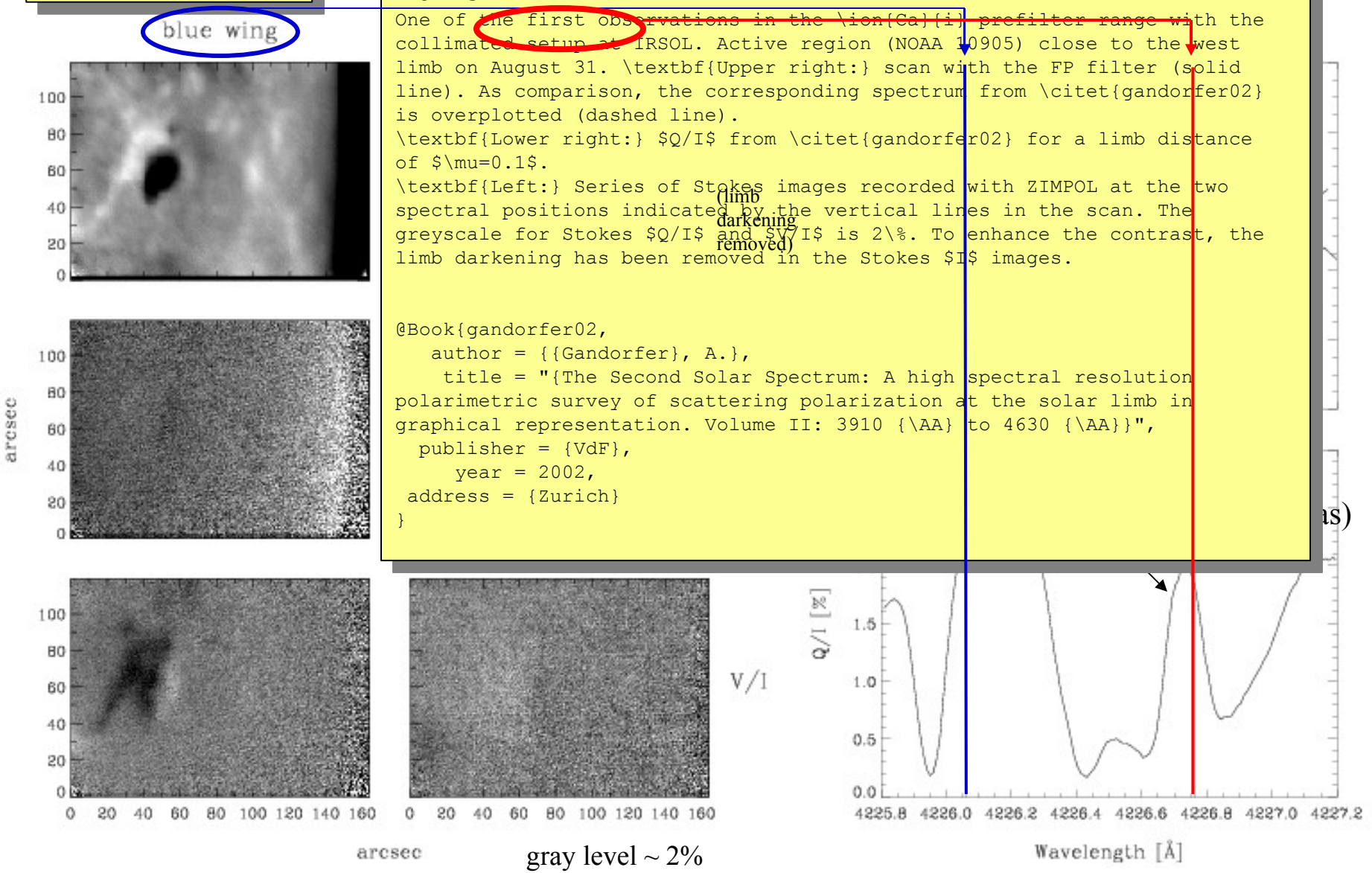
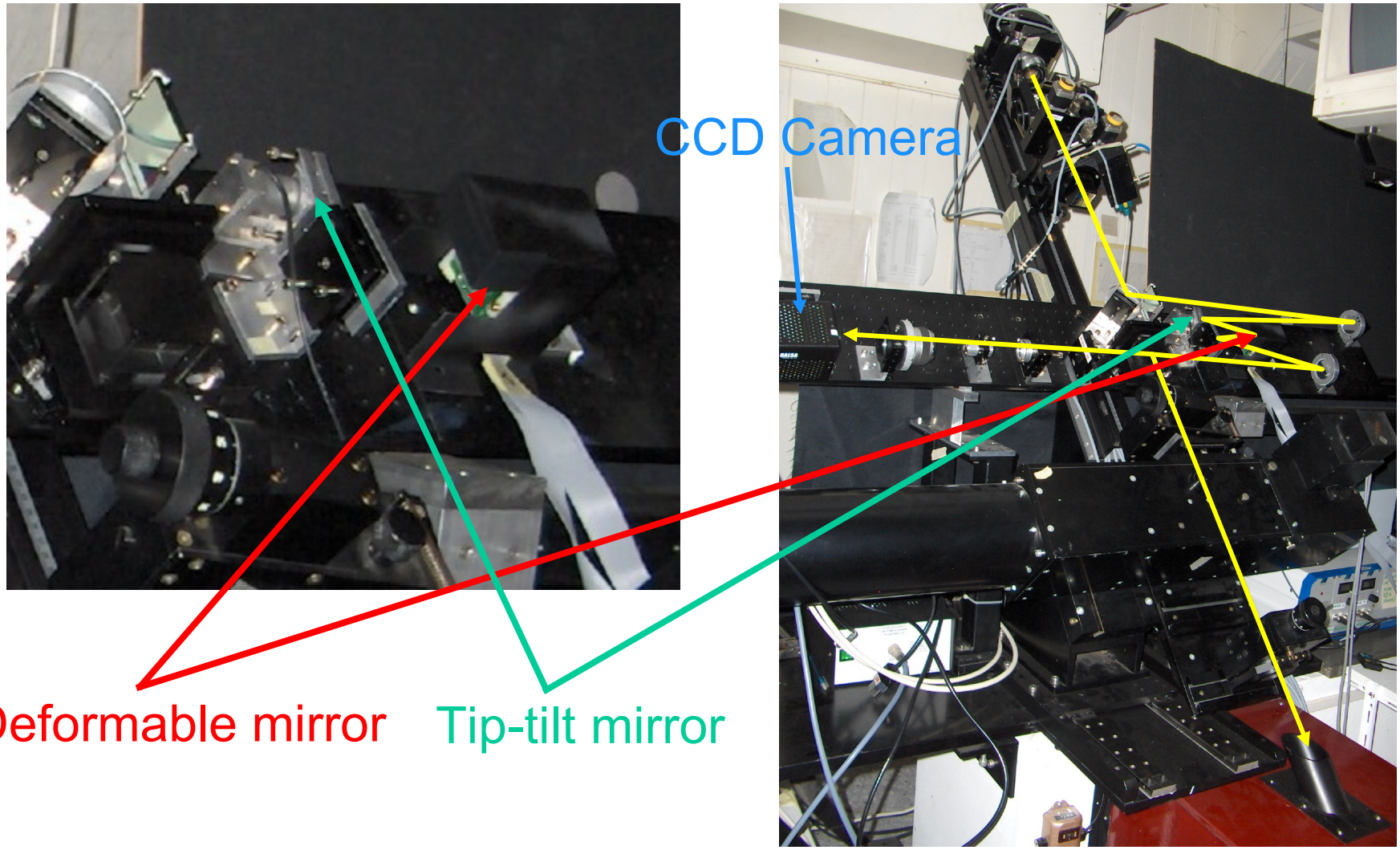


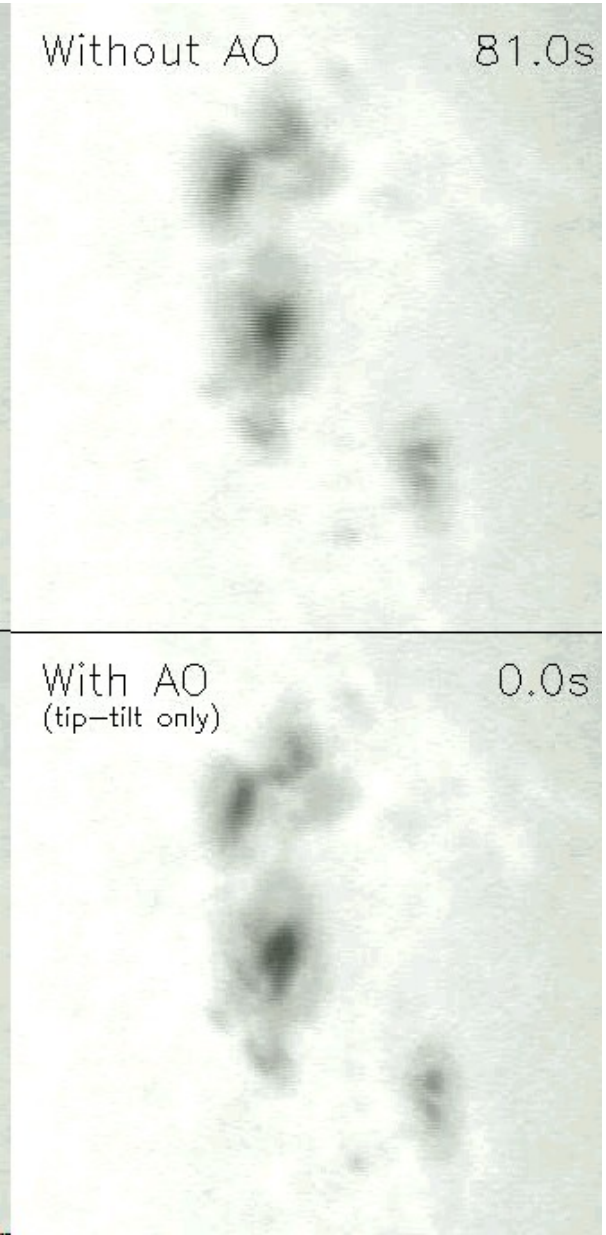
31 August 2006

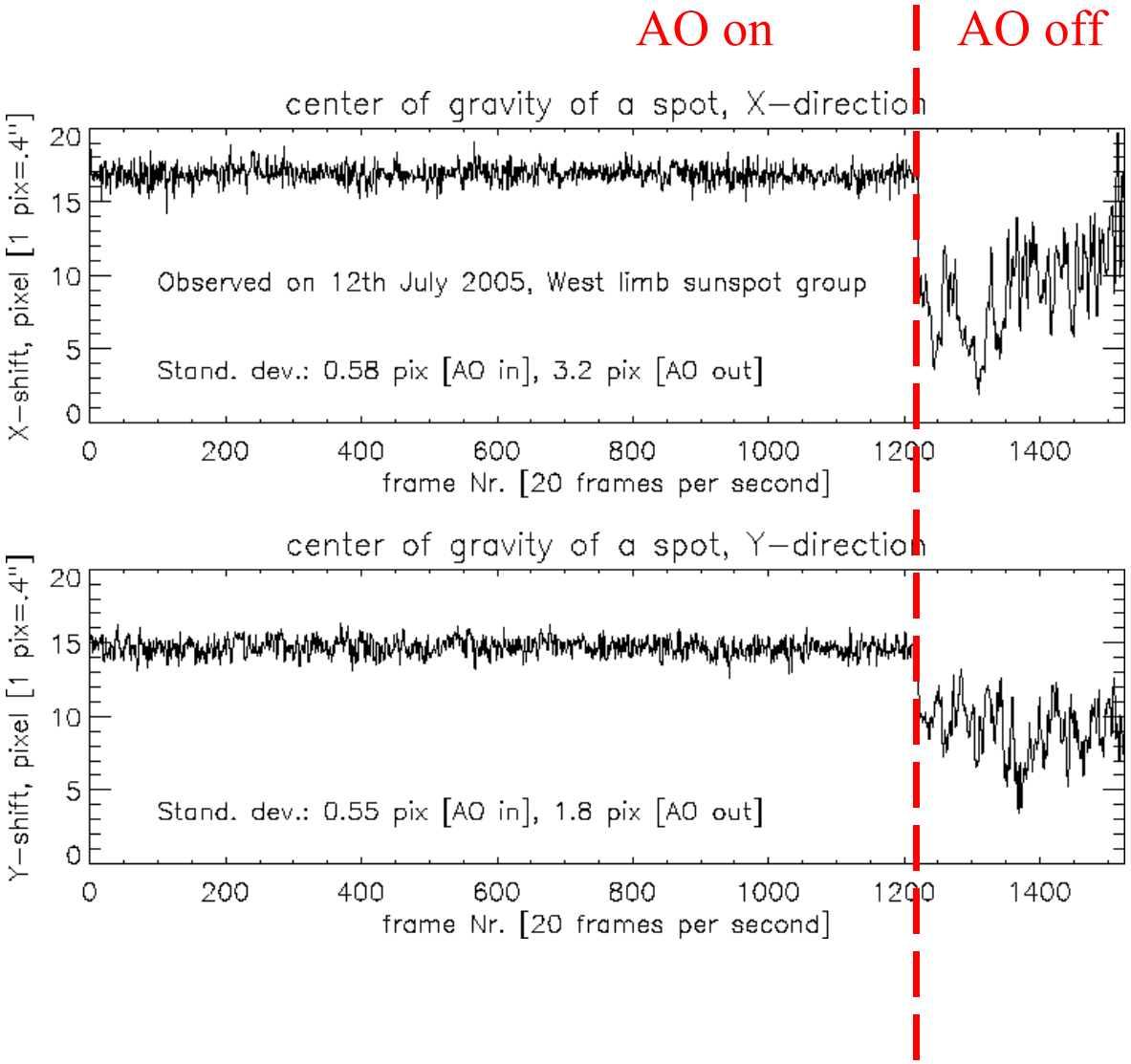
(A. Feller, PhD thesis, 2007)

Adaptive optics



First results from AO





Future research at IRSOL

- Different observing programs on solar magnetism and polarimetry (with FP or spectrograph)
- Synoptic type programs (eg. Variations of the Hanle-effect signatures with respect to heliographic latitude and solar cycle phase)
- Coordinated type programs with other observatories
  - Simultaneous observations of solar features with complementary sets of instruments
  - Supporting type observations that complement the science of another project

2 meter Telescope?

- We are thinking about a 2 meter telescope in order to get more photons, and thus to allow to achieve better measurement accuracies and to better exploit the potentialities of our instrumentation (specially the Fabry Perot).

- The project is now at an early feasibility study stage

Conclusion

- Thanks to the IRSOL telescope, spectrograph + ZIMPOL and the new instrumentation (AO and Fabry Perot) interesting research projects in polarimetry and solar magnetism will continue in Locarno.
- A larger telescope would help to better exploit the potentialities of the available instrumentation (2 meters?)
- We are open to new collaborations.