



Four years of operation of the VATLY radio telescope: A summary of main results

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(on behalf of VATLY)

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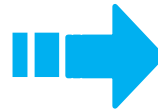
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Introduction

High energy cosmic rays

- Collaboration with the Pierre Auger Observatory in Argentina.



Radio astronomy

- Collaboration with French institutes.
- Using 2.6 m radio telescope at home.



- Radio astronomy, with recent developments in the millimetric and submillimetric domain, is at the forefront of current research → observations made from major international observatories.
- For training students at home, it is much better adapted to the Vietnamese tropical sky than optical astronomy, for which observations are very rarely possible.

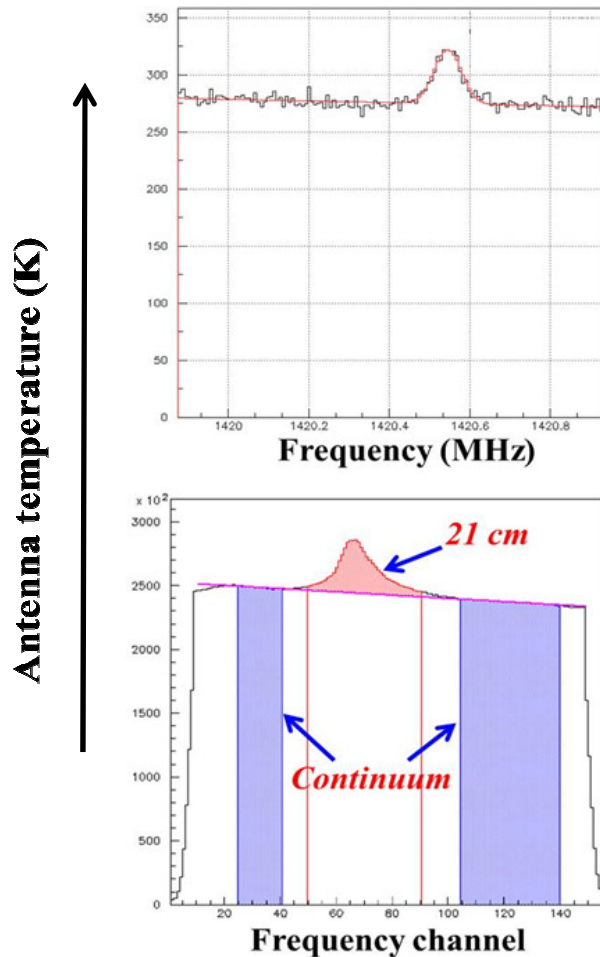
The VATLY radio telescope and its performance

- Mobile parabolic dish, 2.6 m in diameter
- Operated at frequencies between 1400 MHz to 1440 MHz
- Pointing accuracy of 0.22° in $\alpha \times \cos(h)$ and 0.11° in h (α : azimuth and h : elevation)

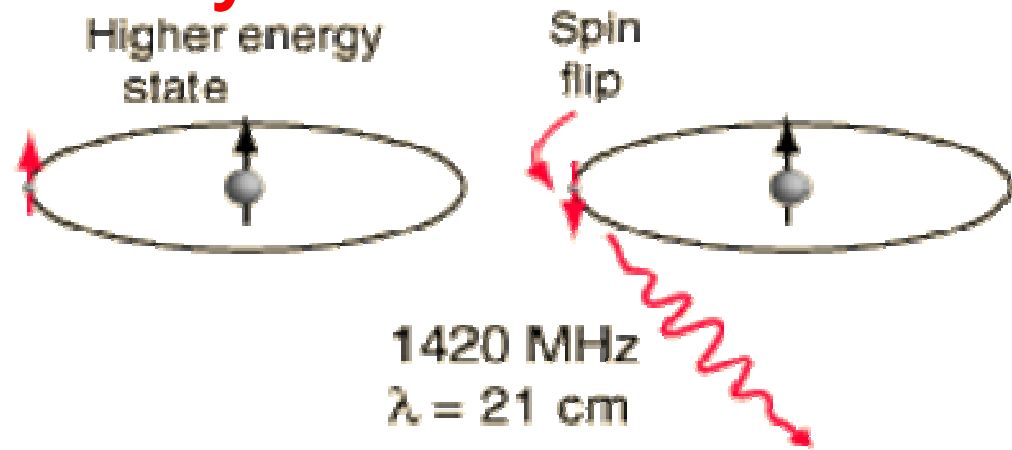


- The angular aperture of the main lobe (the “beam”) is well described by a Gaussian having a σ of 2.3°
- Antenna efficiency factor is 65% meaning a conversion factor of 1.25 ± 0.09 K/kJy.
- The sensitivity of the instrument has been evaluated at the level of a few 100 Jy.

The HI line and its map in the Milky Way



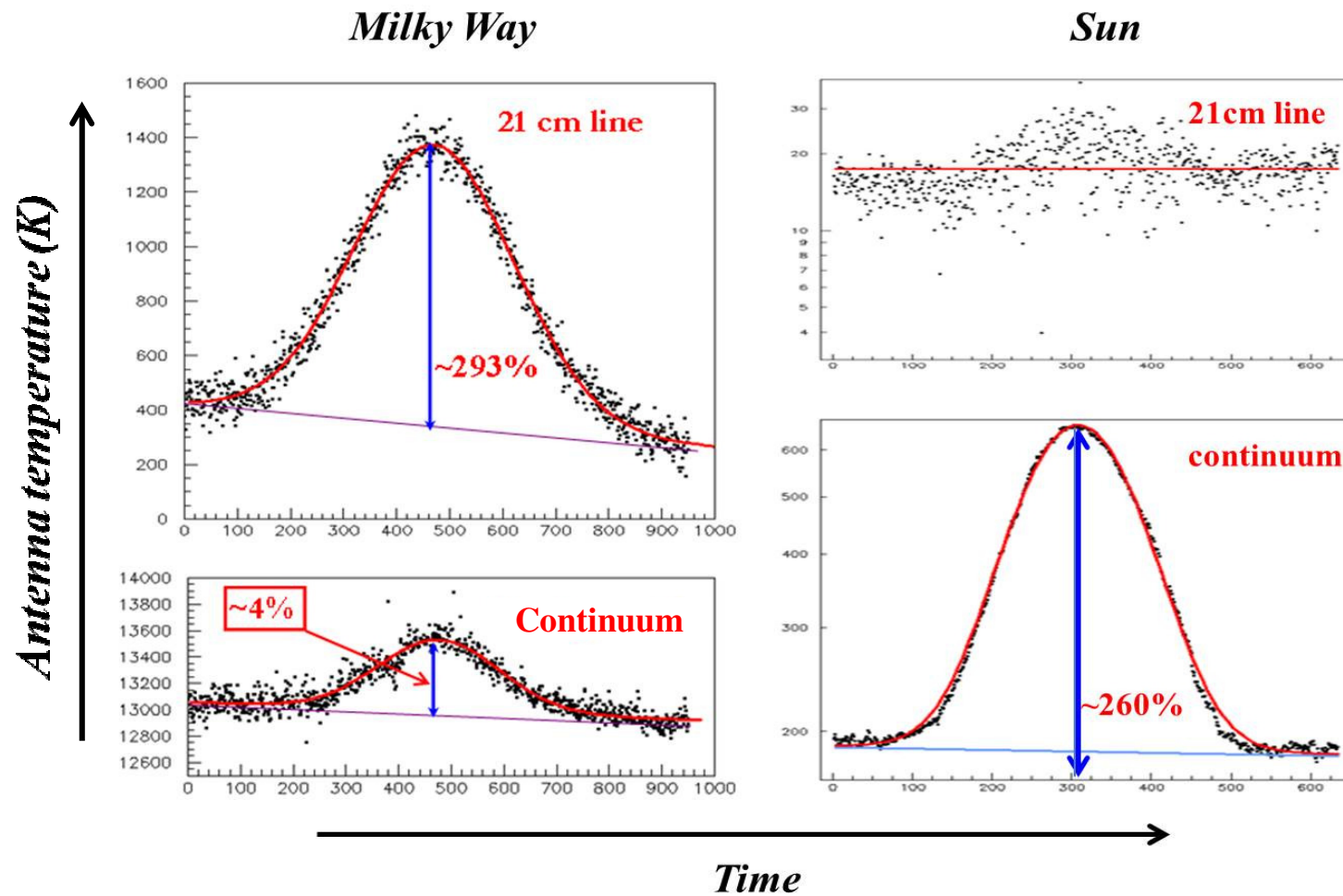
Way



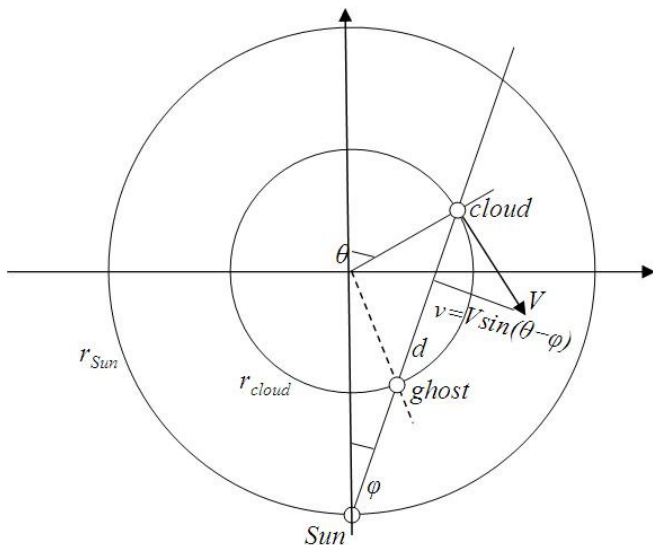
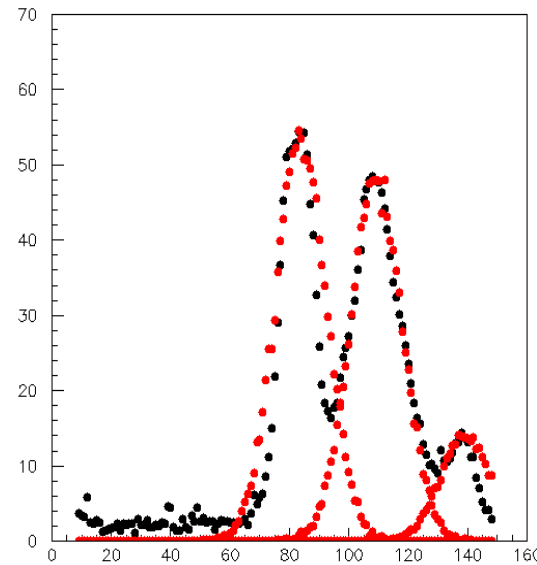
- The HI line, is associated with the hyperfine transition of the hydrogen ground state.
- The continuum signals the presence of ionized matter and is associated with thermal or “free-free” (bremsstrahlung)

emission, including synchrotron radiation from free relativistic electrons accelerated in the interstellar magnetic field.

Galaxies such as ours contain many HI clouds and the 21 cm signal of the disk of the Milky Way is particularly strong. On the contrary, the Sun emits exclusively in the continuum.

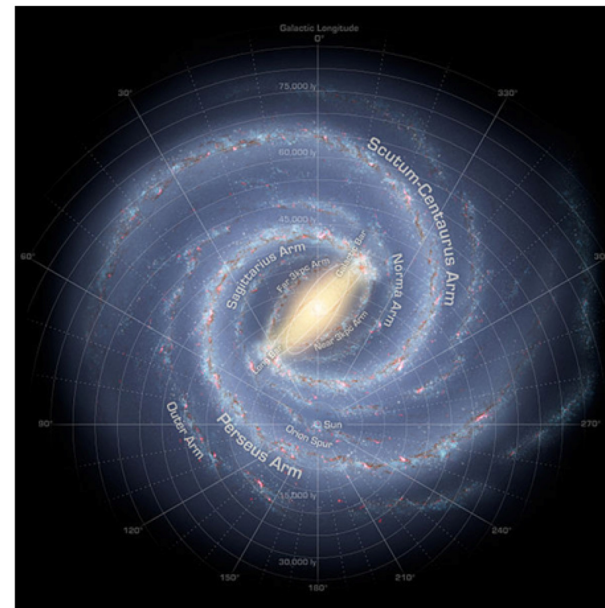
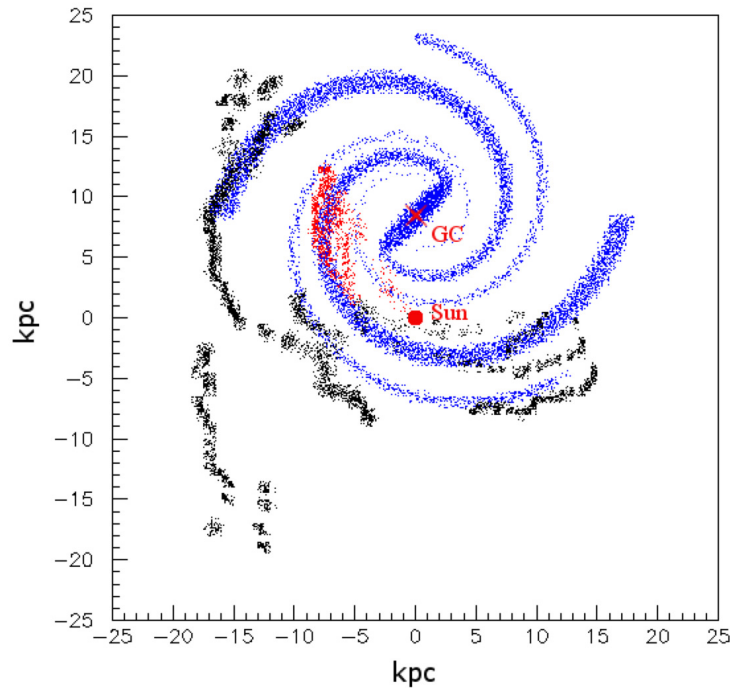


- Velocity Doppler spectra have been collected along the disk of the Milky Way over three quarters of the galactic longitude.
- They have been reduced into peaks associated with different clouds of atomic hydrogen and show clear evidence for differential rotation.



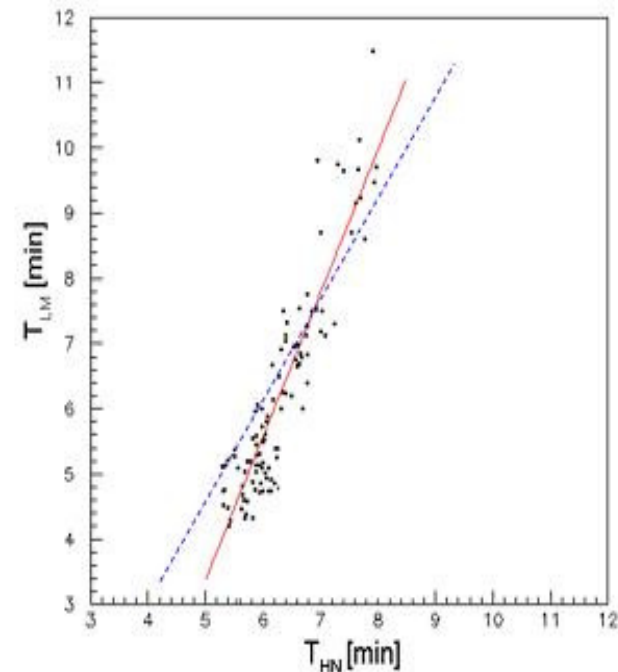
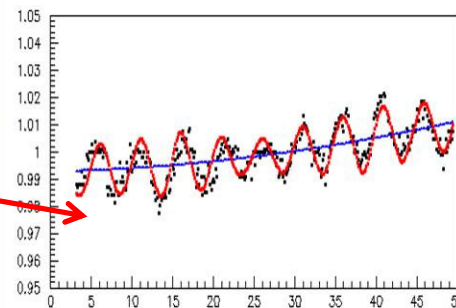
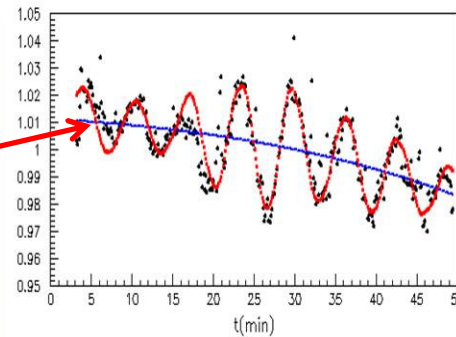
- Given a differential rotation curve, these measurements allow for drawing a map of atomic hydrogen in the Milky Way disk up to an occasional twofold ambiguity.

Good agreement between our result and Spitzer Space Telescope in the infrared is achieved with the known rotation curve that implies the existence of a dark matter halo.

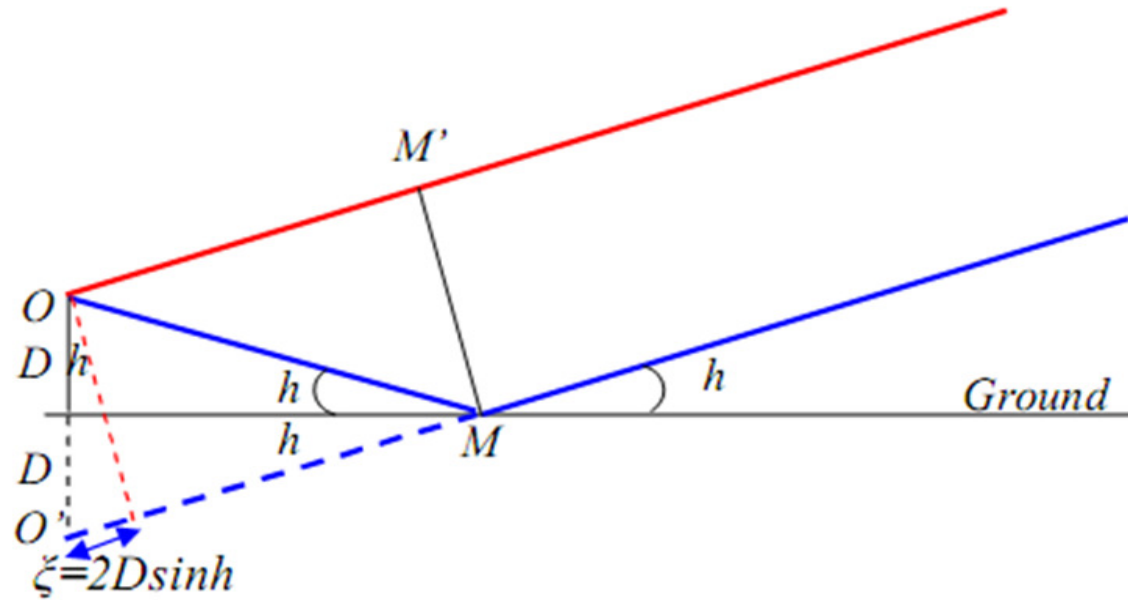


The Sun

- We compared our observations (2012) with those of Learmonth Solar Observatory in Australia (same longitude, opposite latitude).
- Simultaneous oscillations with amplitudes at the percent level and periods of a few minutes display correlated periods.

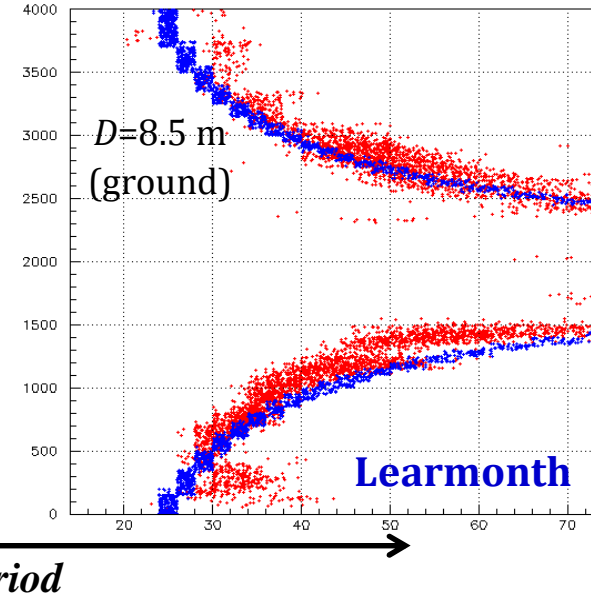
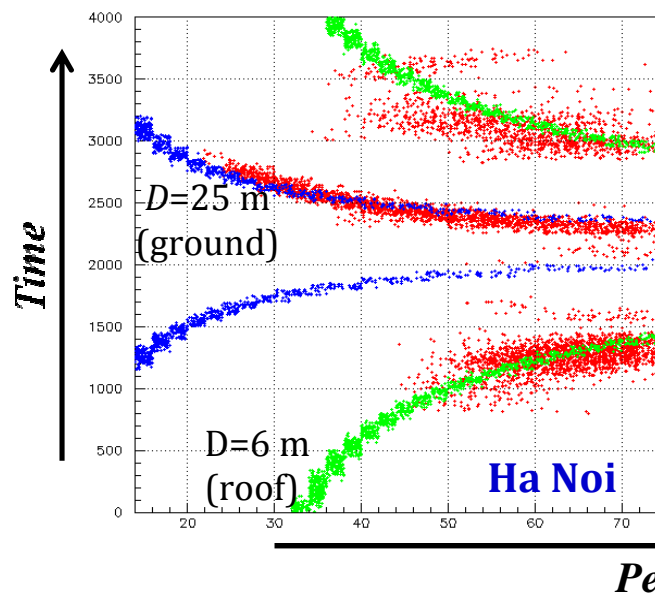


New data were then collected in 2013 and separate analyses were performed of the Ha Noi and Learmonth oscillations, no longer requiring simultaneity.

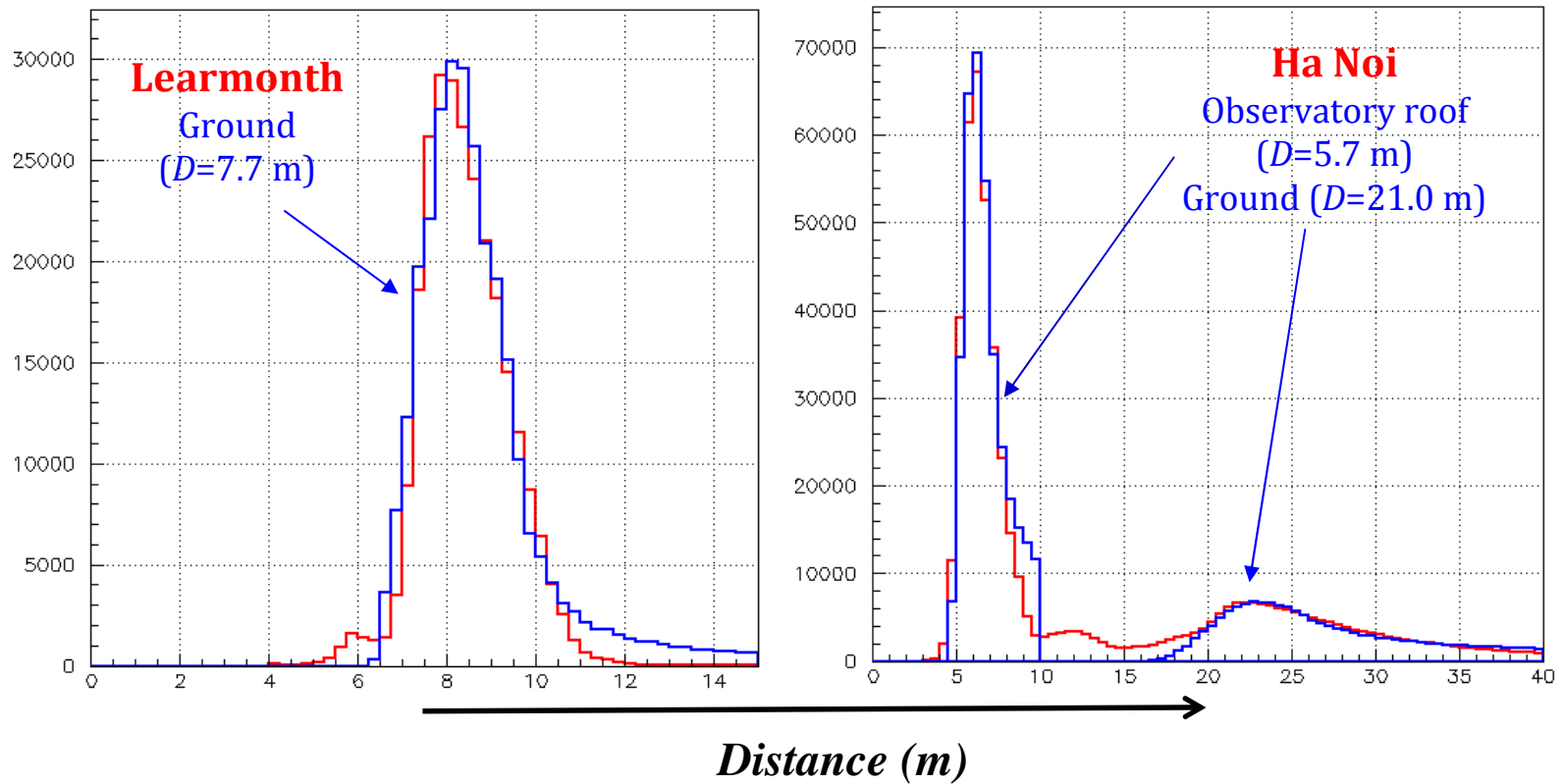


$$T = \frac{\lambda}{|d\xi/dt|}$$

Distributions of time versus period using sensible selection criteria display very clear patterns and follow the same trend as expected from specular reflection on ground.



The measurements of the period of oscillation provide independent evaluations of the altitude D of the antenna above the ground.



- In addition, Solar flares have been studied and compared with observations at Learmonth and other observatories at frequencies from radio to X-ray.
- Radio sources at the limit of sensitivity of the instrument, such as the Crab and the Moon, have been observed over long periods.
- Very accurate studies of the response of the instrument have revealed a number of corrections at the permil level.

Publications

- [1] **N.V. Hiep et al.**, *The VATLY radio telescope*, Comm. Phys. Vietnam 22/4 (2012) 365;
- [2] **N.V. Hiep et al.**, 2013, *Mapping atomic hydrogen in the disk of the Milky Way*, Comm. Phys. Vietnam. Vol.23, No 2 (2013), 107-119.
- [3] **N.V. Hiep et al.**, *Radio Observation of Solar-Activity-Related mHz Oscillations*, Sol. Phys. 289, 3 (2014), 939-950.
- [4] **N.V. Hiep**, *Observation of the 21 cm sky using the VATLY radio telescope*, Master thesis, presented at Vietnam Institute of Physics, 2013.
- [5] **P.N. Diep et al.**, *Correlated Oscillations Due to Similar Multipath Effects Seen in Two Widely Separated Radio Telescopes*, 31, e029 doi:10.1017/pasa.2014.24.
- [6] **N.T. Phuong et al.**, *The VATLY radio telescope: performance study*, accepted for publication in Comm. Phys. Vietnam.
- [7] **B.V. Tuan**, *A study of the six major solar flares recently detected from Hanoi and Learmonth at 1415 MHz compare with other frequencies* & **N.H. Phuong Thanh**, *A study of 34 solar flares detected by Hanoi and Learmonth telescope at 1415 MHz between 2012 and 2014*, summer Master internship, presented at University of Science and Technology of Hanoi, September, 2014.

Conclusion

- **The VATLY radio telescope has proven to be an excellent training tool and has produced a large number of valuable publications for a rather small investment cost. We shall continue to use it on top of the VNSC building to train students.**
- **We are deeply indebted to the Learmonth Solar Observatory staff, who are making their data available to the public, and particularly to Dr Owen Giersch for having kindly and patiently answered many of our questions. We are grateful to Dr Alain Maestrini, Dr Pierre Lesaffre and Dr Alan Rogers for useful comments. We acknowledge financial support from the Vietnam National Foundation for Science and Technology Development (NAFOSTED) under grant number 103.08-2012.34, the Institute for Nuclear Science and Technology, the World Laboratory, the Odon Vallet Foundation and the Rencontres du Vietnam.**

Thank you for your attention !