

Science with the Cylinder Radio Telescope in Morocco



Presented at CRT-Ifrane
By Jeff Peterson CMU
17 June, 2009

CMU Cylinder Telescope Prototype



Outline

- Radio Astronomy
- 21-cm Baryon Oscillation Expt.
- The Cylinder Radio Telescope
- Superb Sites in Morocco

The Cylinder Radio Telescope Consortium

- Jeff Peterson (CMU)
- Kevin Bandura,
- Bruce Taylor
- Jim McGee
- Blake Conaugher
- Bruce McWilliams
- Uros Seljak (U. C Berkeley)
- Peter Timbie (U. Wisc.)
- Scott Dodelson (FNAL)
- John Marriner
- Chris Stoughton
- Hee Jong Seo
- Dave McGinnis
- Albert Stebbins
- Tzu-Ching Chang (IAA Taipei)
- Hassane Darhmouai (AUI)
- Ahmed Legrouri
- Khalid Loudiyi
- Khalil Chamcham (Oxford)
- Ue-LI Pen (CITA)
- Gojko Vojanovic
- Christophe Yeche (CEA)
- Christohpe Magneville
- Marc Monez
- Jean-Marc LeGoff
- 2 FTE engineer
- Reza Ansari (LAL)
- Jim Rich
- 2 FTE engineer
- Jon Bunton (CSIRO)

Carnegie Mellon



the David &
Lucile Packard
FOUNDATION

جامعة الأنوين
AL AKHAWAYN
UNIVERSITY

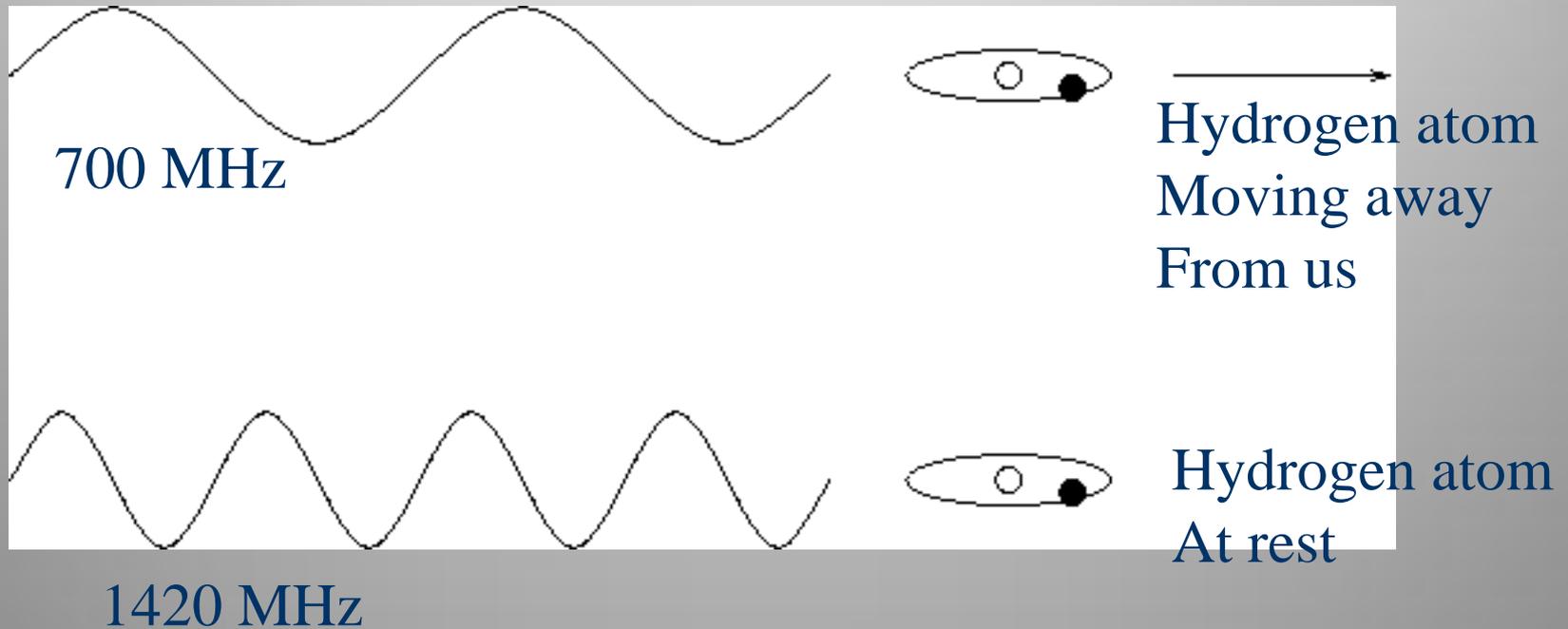
IN2P3
Institut National de Physique Nucléaire
et de Physique des Particules



 **CITA**
ICAT



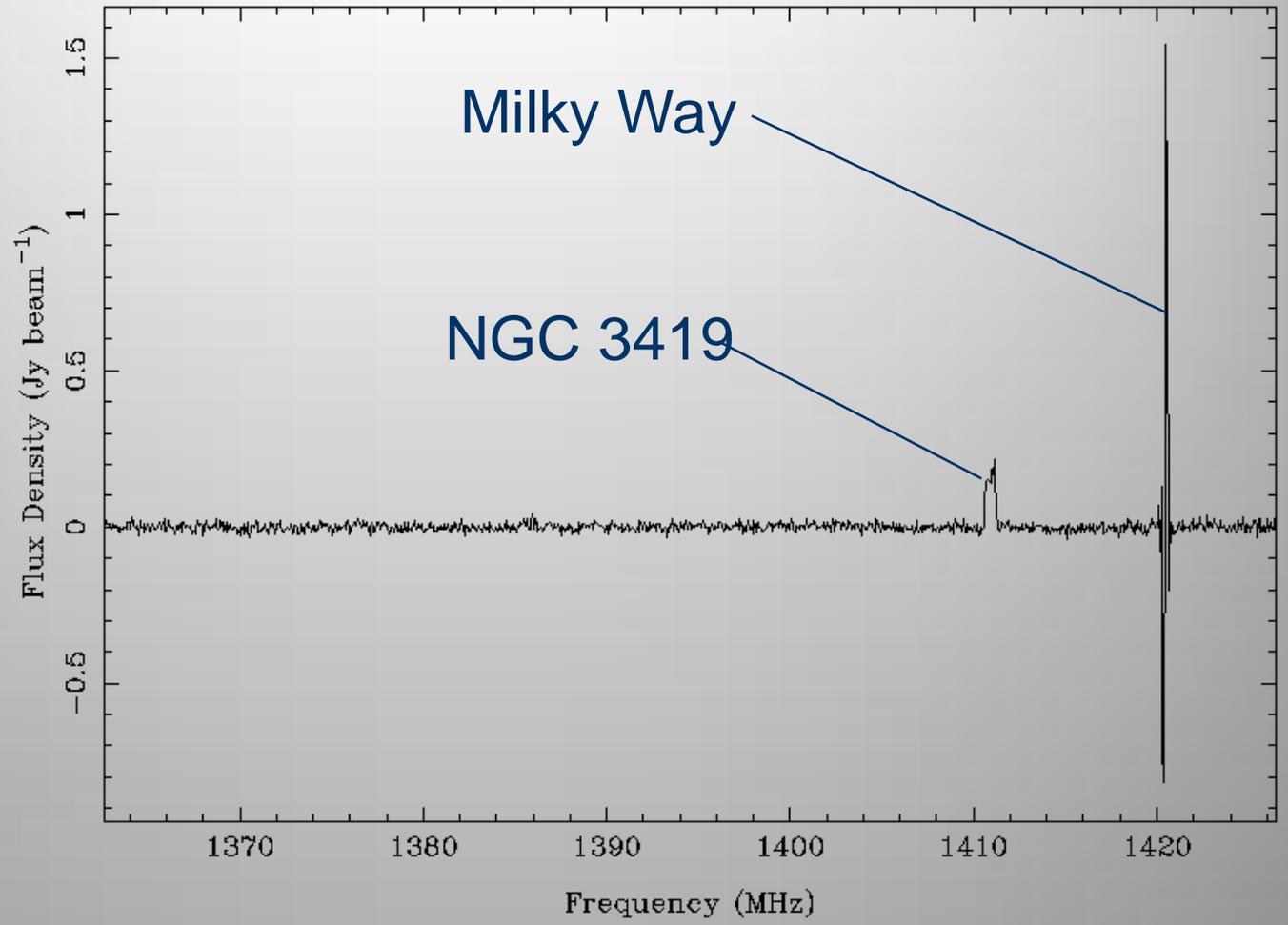
An object moving away from us is seen with **RED**shifted emission

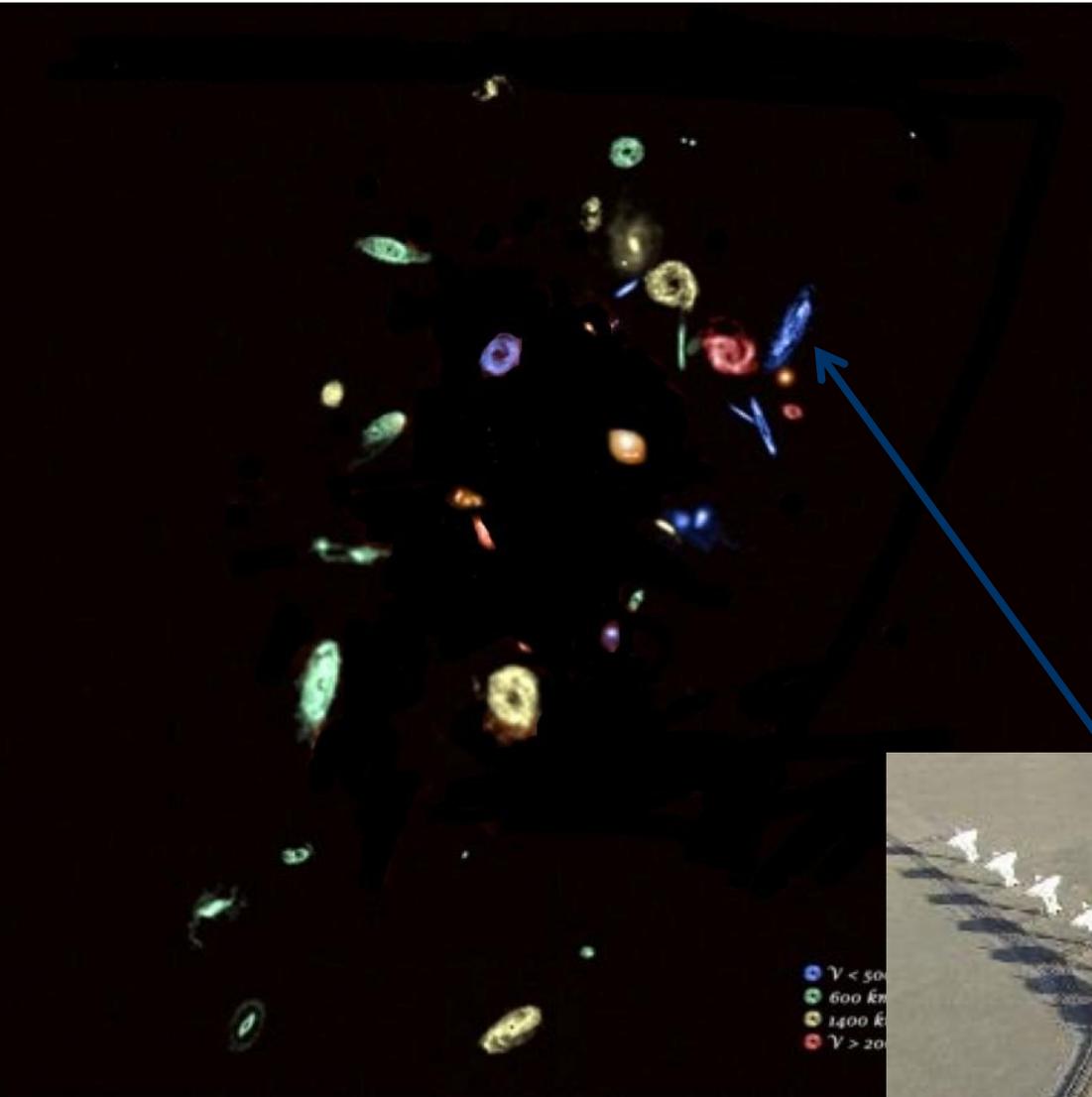


Object: H004
Requested: 10:04:00.00 -80:26:08.00
Actual : 10:03:37.95 -80:23:18.98
Equinox : J2000

HIPASS public data release - v1.2 May 13 2000 (south)

Data from Parkes Telescope



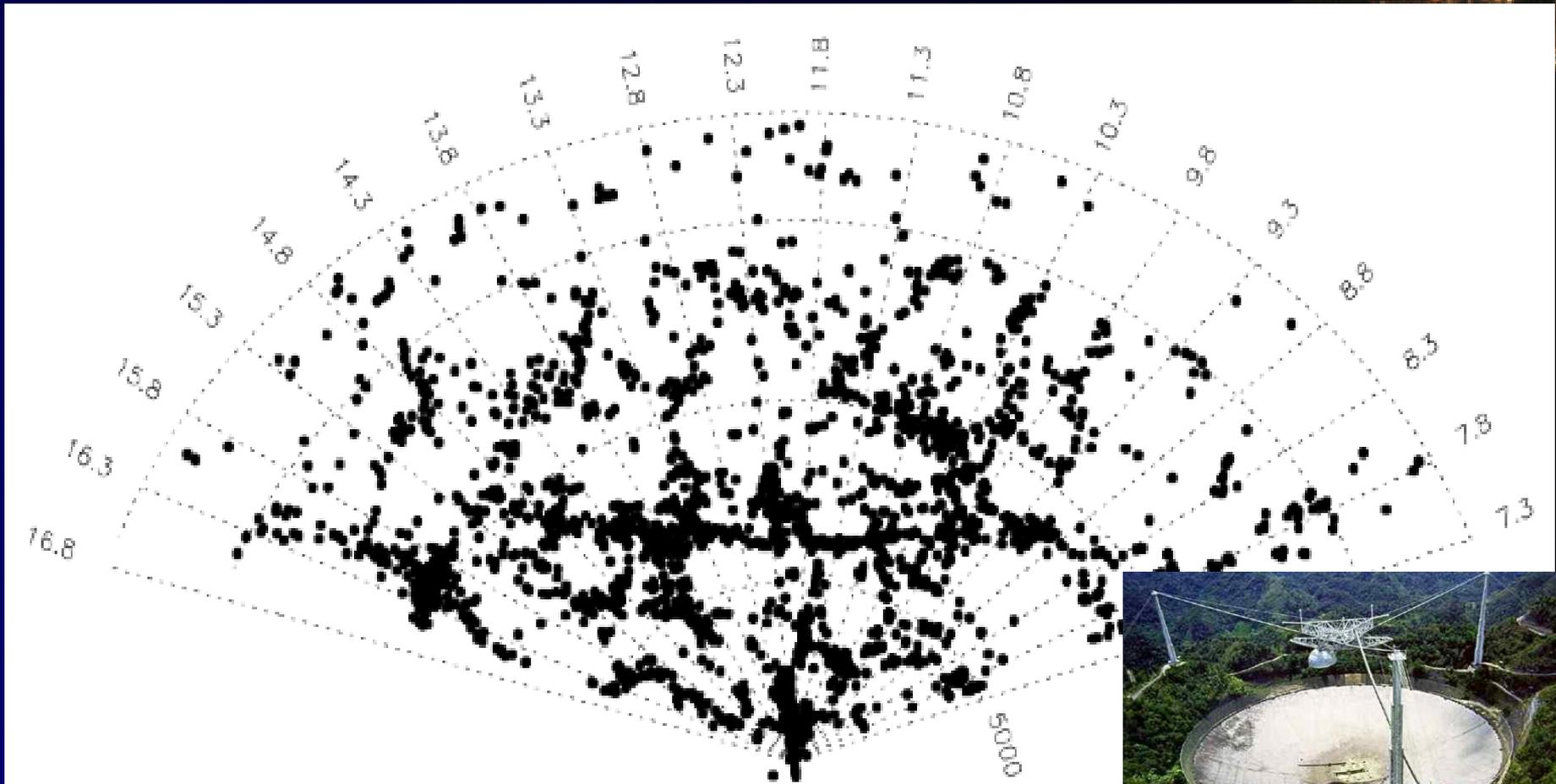


Very Large Array



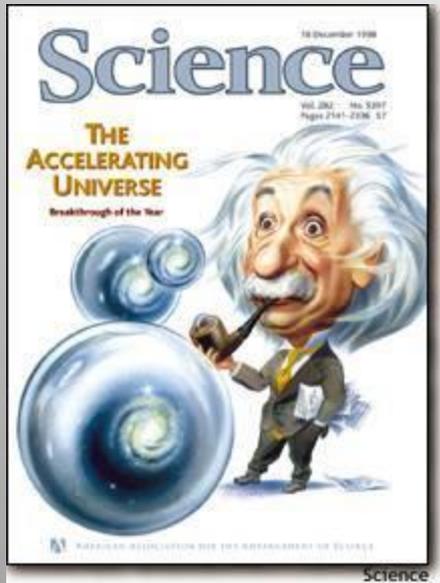
21 cm galaxy images,
Form the VIVA project.

Arecibo redshift survey



Large scale structure matches
optical surveys

The Accelerating Universe



1998: Accelerating Universe named “Breakthrough of the year”

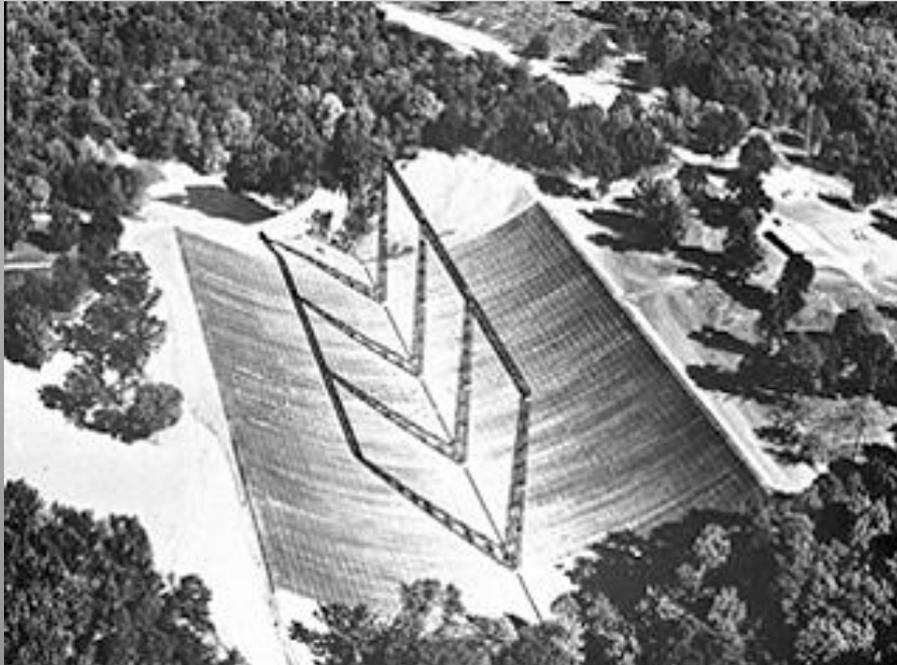
2005: Top of the list of 25 outstanding Science questions:
“What is the Universe made of?”

Science Goals

- Understand Dark Energy and the acceleration of the universe, using BAO technique.
- 21 cm BAO telescope will also allow study of
 - Ionization by the first stars.
 - Magnetic fields.
 - Time Domain Studies
 - SETI

Cylinder History

- Popular 1960-1980
- Lost favor with advent of cryogenically cooled pre-amplifiers.
- Room temp amplifiers with 20K noise temp now available.



Illinois 400 ft
Telescope
ca. 1960

CMU cylinders in operation:

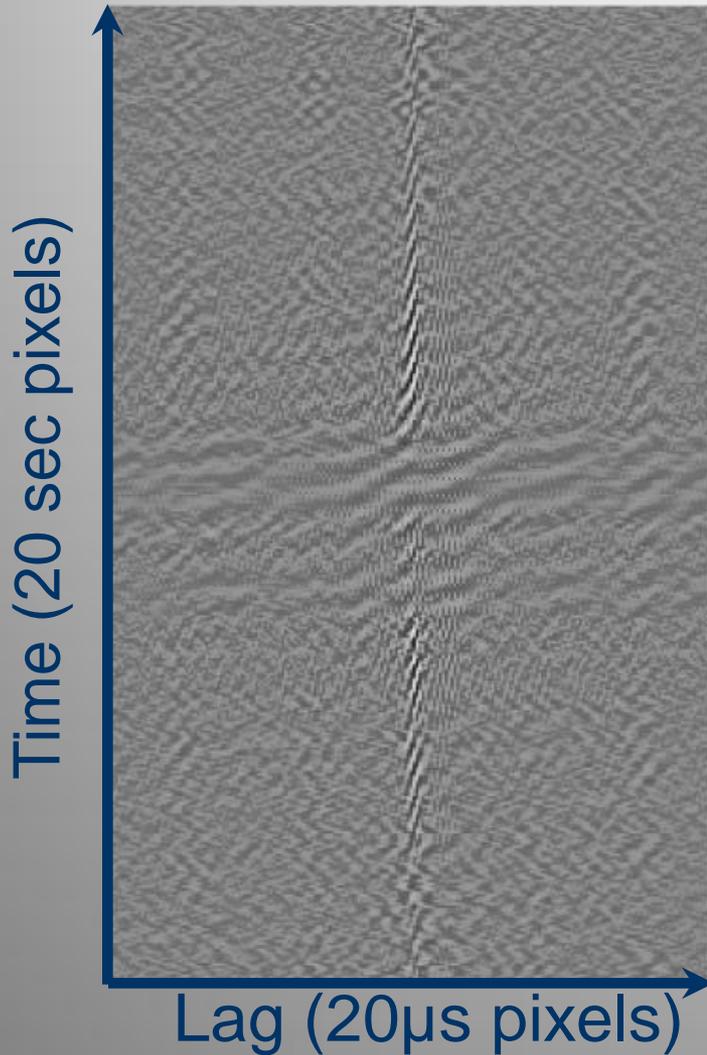
J. Peterson, K. Bandura, U-L Pen, K. Sigurdson





Preliminary Results

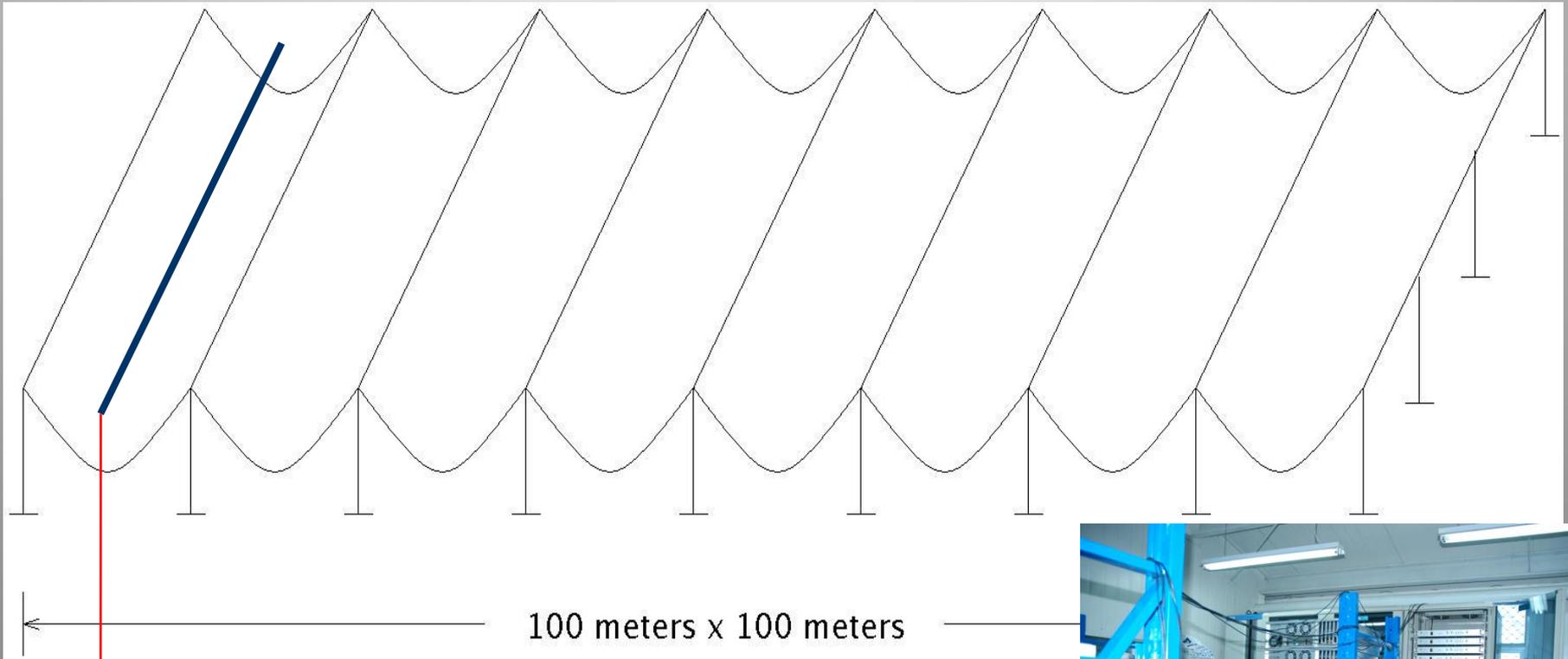
Sun



Cassiopeia A



CRT Layout



8192 signals



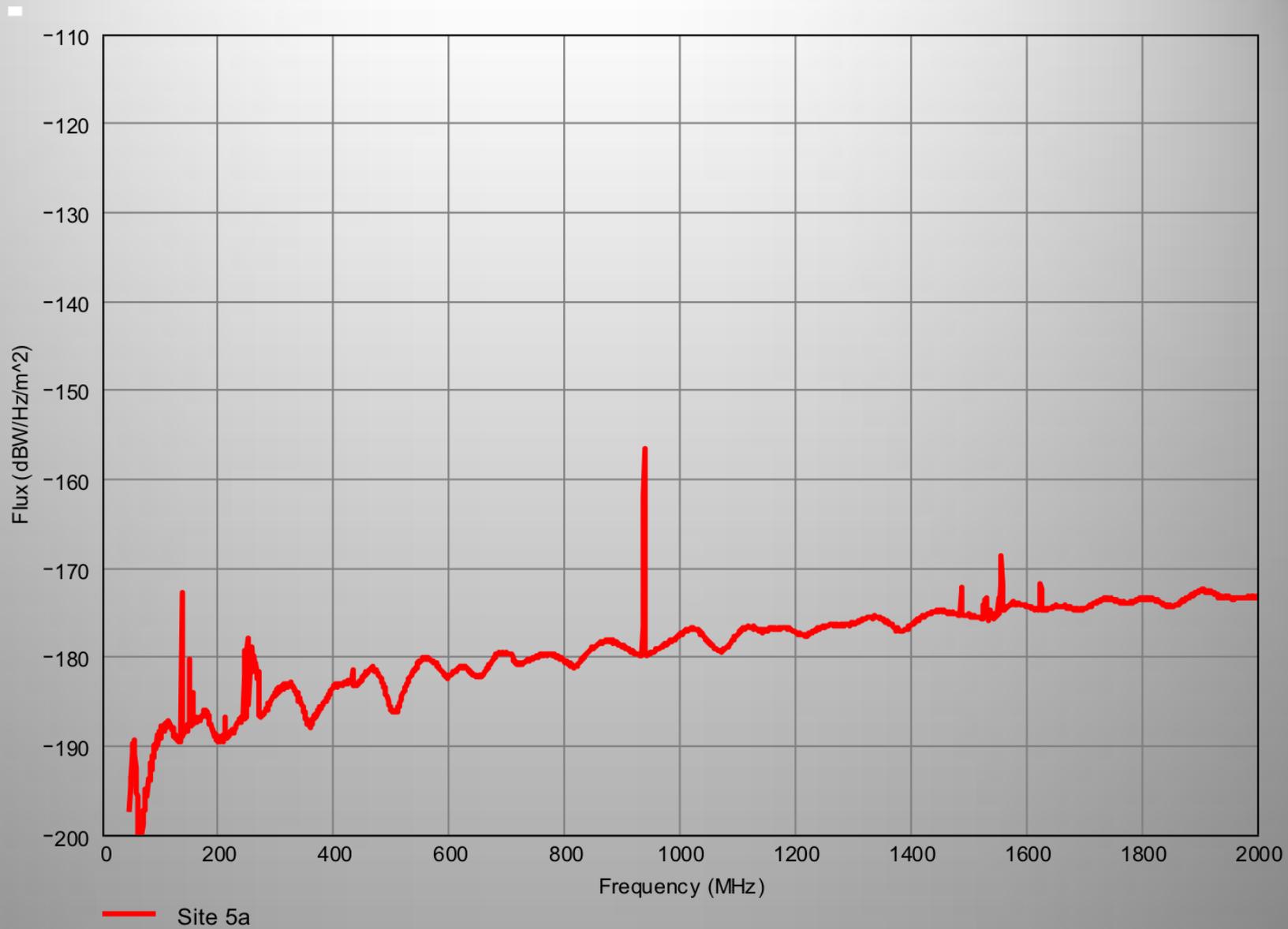
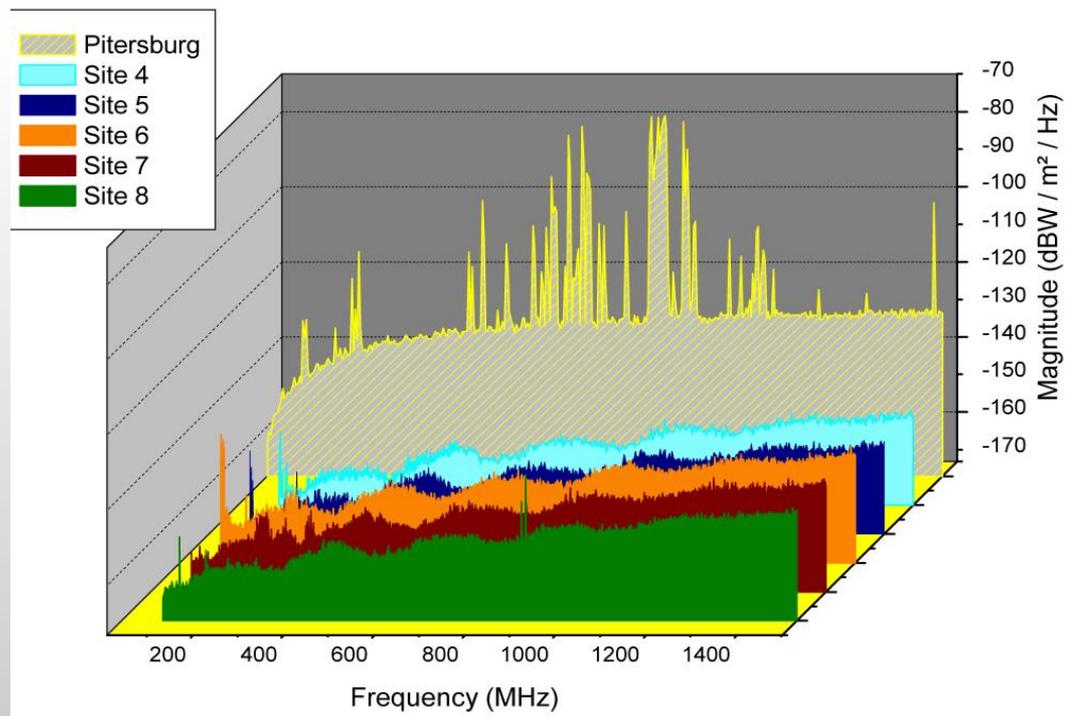


Figure 14. Discone measurements at Site 5a. The resolution bandwidth of the measurement is 25kHz.







Social Impact

-Pride: First Major Cosmology Facility in the Arab World

-Technical education at the Undergraduate and Graduate level

-Engage Young Students

-Use scientific methods to address questions that span all cultures

-Technology spin-offs: Adaptive cell phone networks. Data-Intensive computing.

Outreach Program

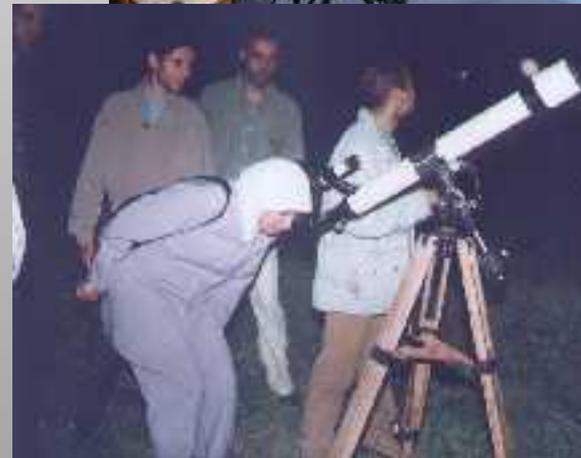
-Web based materials for teachers of students age 6-18 (Arabic, English, French)

-Involve local population in Support, beginning with Site Testing.

-Cosmology Lecture Series at Al Ahkawayn Univ.

-Organize at least one International Cosmology Conference in Morocco

-Student exchange program—initially CMU<>AUI



Challenges

- Synchrotron foregrounds: 10^3 times larger than signal
- Polarized leakage: instrumental calibration
- Man-made Radio Frequency Interference: narrow and broad-band
- Calibration: ionosphere (TEC, faraday rotation), instrument.

Al Akhawayn University in Ifrane, Morocco

State-Owned Moroccan University:

- Non-profit
- Financial and administrative autonomy
- North American educational system
- English, main medium of instruction



Mission

- Offer quality higher education in different fields of knowledge;
- Diversify branches of knowledge & adapt them to emerging needs;
- Participate in the mastery and application of new and advanced technologies;
- Carry out scientific and technological research in national and international fields related to the socio-economic development;
- Foster continuing education and knowledge development;
- Encourage human progress, and serve as an arena for cooperation and mutual understanding between peoples and civilizations.

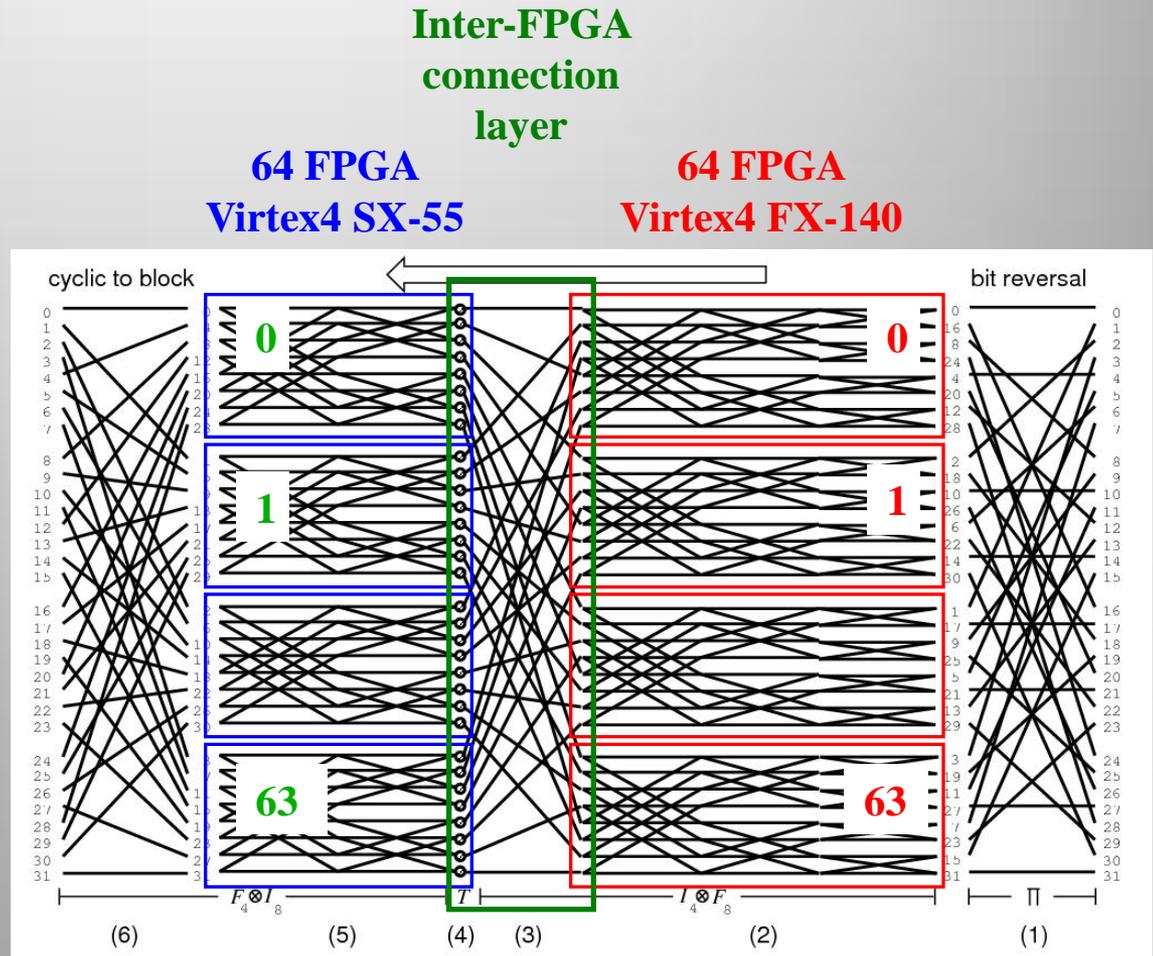


Impacts for Morocco and MENA Region

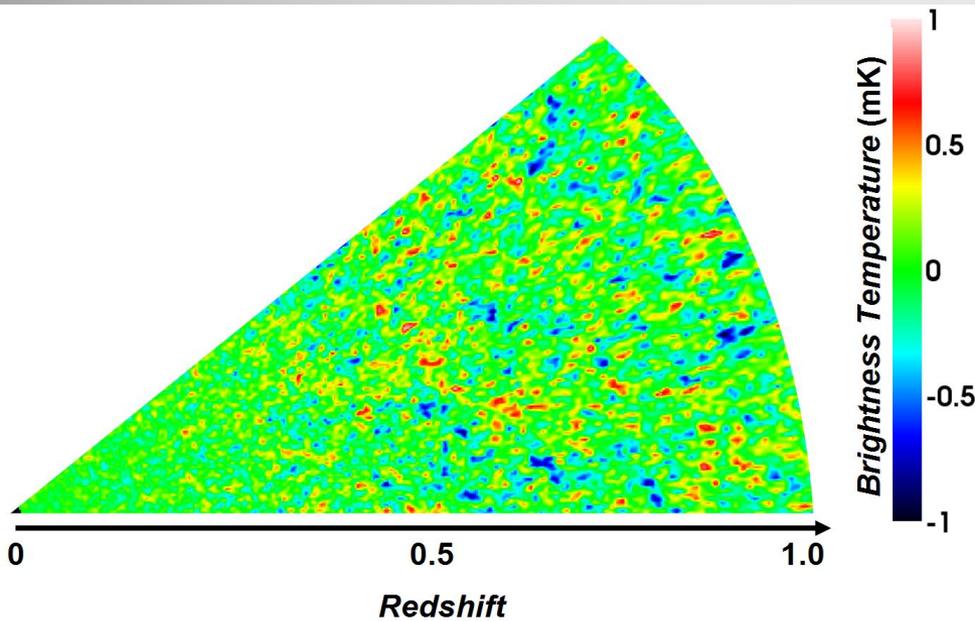
- **Development of Science and Technology**
- **Networking amongst scientists at national and regional levels**
- **Capacity building**
- **Collaboration with renown institutions at the international level (interfaith dialogue)**
- **Motivation of students for Science and Technology**
- **Stimulation of technical and research programs in universities**
- **New academic programs in astrophysics with partner institutions linked to the CRT.**
- **Development of innovative educational resources in astronomy for middle and high schools to support the science curricula (in Arabic)**
- **Science and technology outreach programs**
- **Social and economic development of Talsint, Morocco**
- **Morocco, as an international center for astronomy**

PetaFlop DSP technology: FPGAs

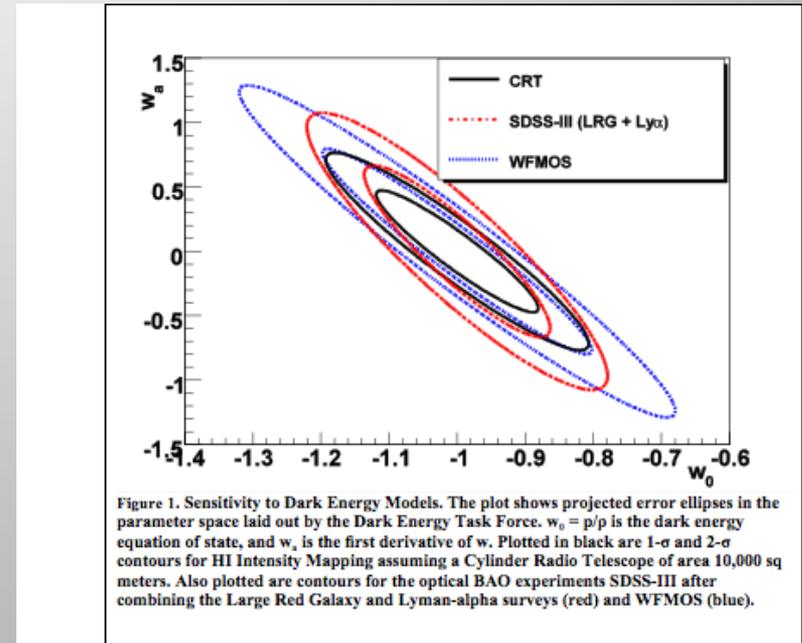
- **N=1024 FFT can be factorized into $N = 16 \cdot 64$; $p=64$ and $n=16$ and a 2-layer architecture can be employed (64 FPGAs/layer)**



Simulated Results

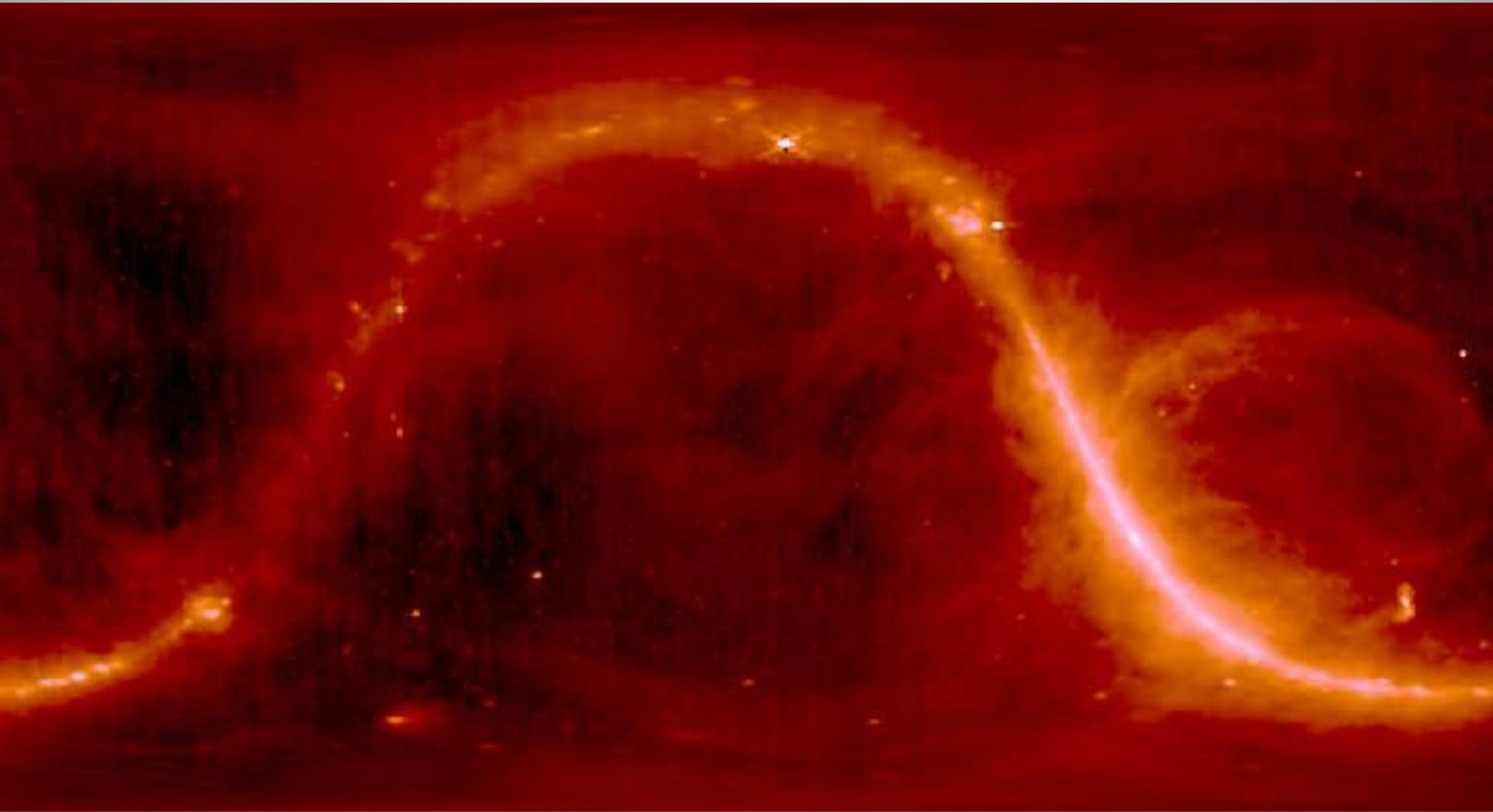


N. Gnedin



R. Ansari, etal

Foreground: Galactic Synchrotron



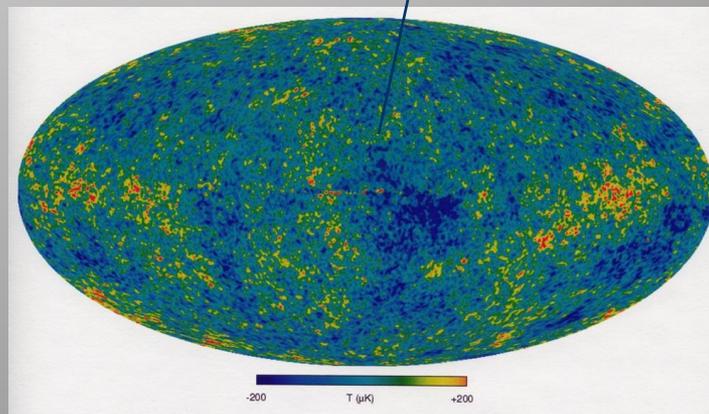
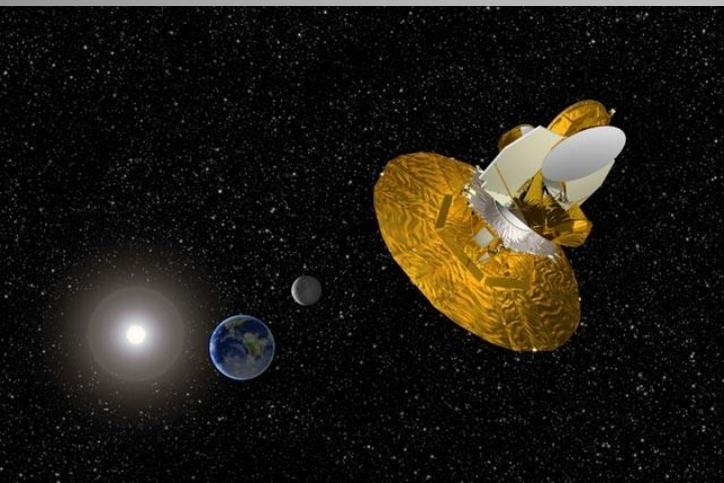
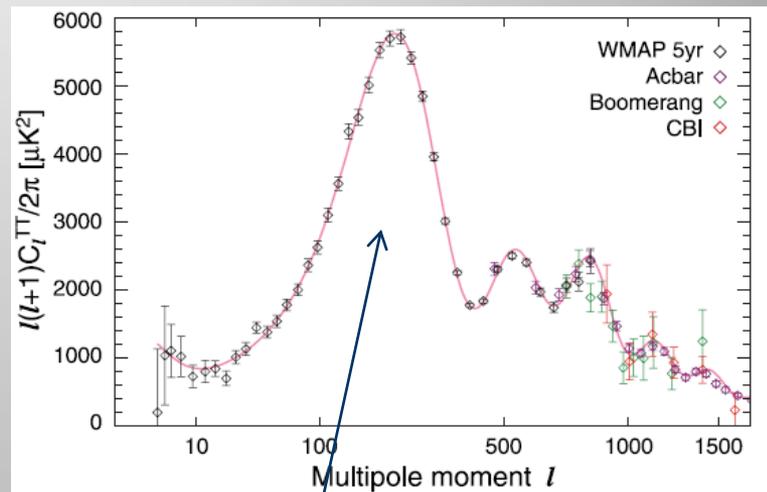
Haslam 408 MHz

Much brighter than signal, but very smooth spectral structure

Baryon Acoustic Oscillations – Dark Energy Probe

- CMB acoustic oscillations: imprinted standard ruler, 400 Mly.

WMAP5 and other, Nolita et al (2008)



Baryon Wiggles Detected by SDSS and 2df

