ANALYSIS OF CALIBRATION AND PRE-PROCESSING OF GEM DATA AND ITS APPLICATION TO THE BINGO

BINGO Telescope

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OUTLINE

- Brief Contextualization
- The Galactic Emission Mapping project (GEM)
- GEM - Design & Observation
- Calibration and data processing - BINGO
- GEM - Data description and processing
- Step 1 - GEM_2300_0
- Step 2 - GEM_2300_1
- Step 2 - GEM_2300_2

BRIEF CONTEXTUALIZATION

COBE satellite results (1990's)

CMB mean & anisotropies

needs

Better description Foreground at > 100 MHz

Lack of full-sky map of (diffuse) Galactic emissions on large scales

- More than one frequency
- At the same (good) angular resolution
- At the same beam pattern
- Improve template parameters
- Control over scanning strategy as a systematic

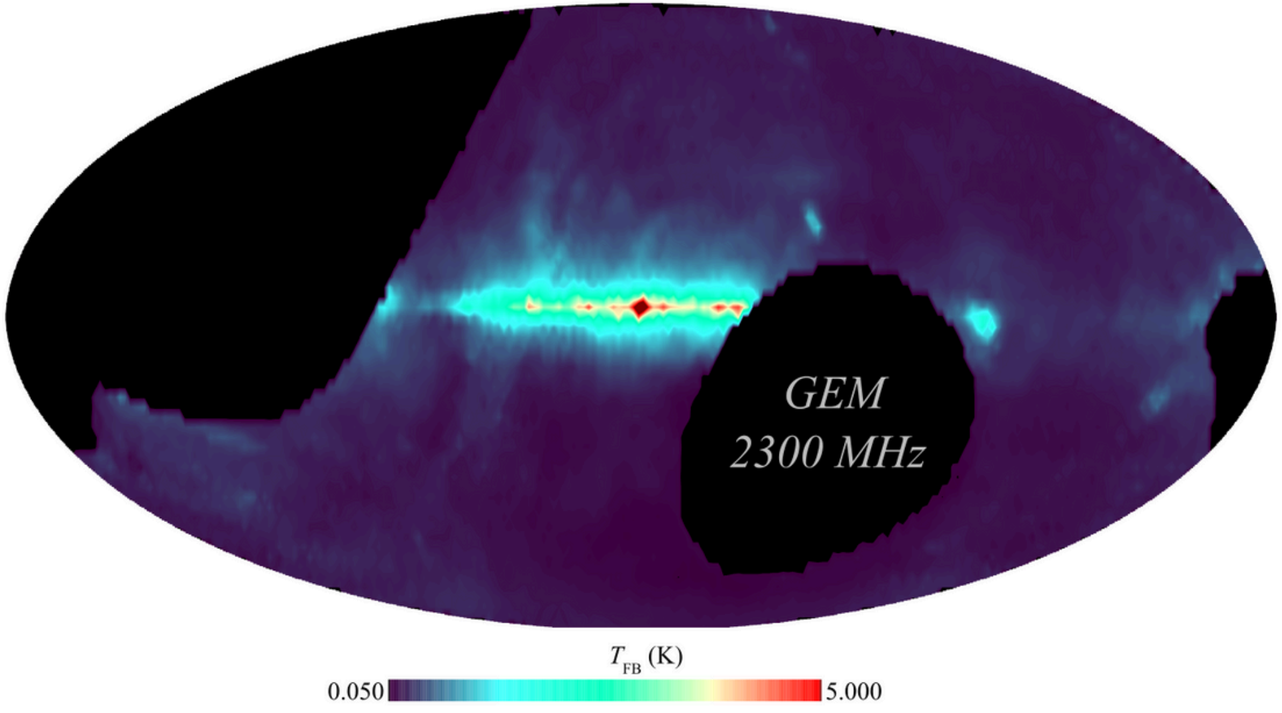
THE GALACTIC EMISSION MAPPING PROJECT - GEM

- Maps at (receivers)

0.408
1.465
2.3 **GHz**
5.0
10.0

- Improve foreground description through 5 freqs
- Portable telescope
- Possible in different countries at different latitudes
- Combination between telescope rotation (at fixed zenith) and Earth's rotation
- Double-shielded to minimize sidelobe pick-up
- Collab. Brazil, Colombia, USA, Italy, Portugal, and Spain

THE GALACTIC EMISSION MAPPING PROJECT - GEM



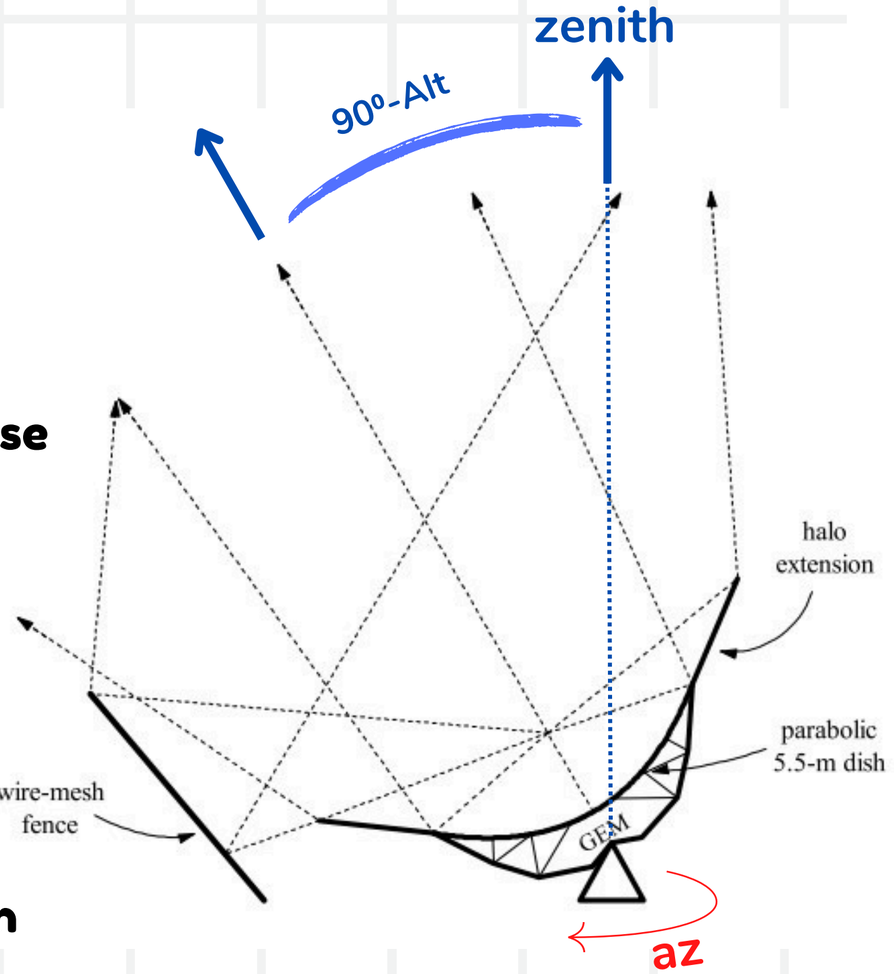
Description	Colombia	Brazil
Observational site	Villa de Leyva	Cachoeira Paulista
Longitude (WGS84)	−73°35′0.53″	−44°59′54.34′
Latitude (WGS84)	+5°37′7.84″	−22°41′0.74″
Altitude (m.a.s.l.)	2173	572
Observing runs	1995-Jun-1–18	1999-May-18–Jun-17 1999-Oct-11–26
Antenna mounting	altazimuthal	altazimuthal
Azimuth scanning speed (rpm)	0.99632 ± 0.00036	1.00290 ± 0.00063
Sky coverage (%)	46.3	46.8
Pointing accuracy	6′.84	5′.26
Center frequency (MHz)	2300	2300
Pre-detection BW (MHz)	100	100
Gain (K V^{-1})	54.675	50.928
Gain susceptability (K^{-1})	−0.02381 ± 0.00028	−0.02164 ± 0.00006
System temperature (K)	85.466	61.644
RMS sensitivity (mK)	11.42	8.24
RF plate T_{cal} (K)	310.572	308.031
Horizontal *HPBW* (°)	2.30 ± 0.13	2.31 ± 0.03
Vertical *HPBW* (°)	1.92 ± 0.18	1.82 ± 0.12
Beam efficiency (%)	75.0 ± 3.5	75.0 ± 3.5
Aperture efficiency (%)	38.0	39.9
PSS (Jy K^{-1})	306	291

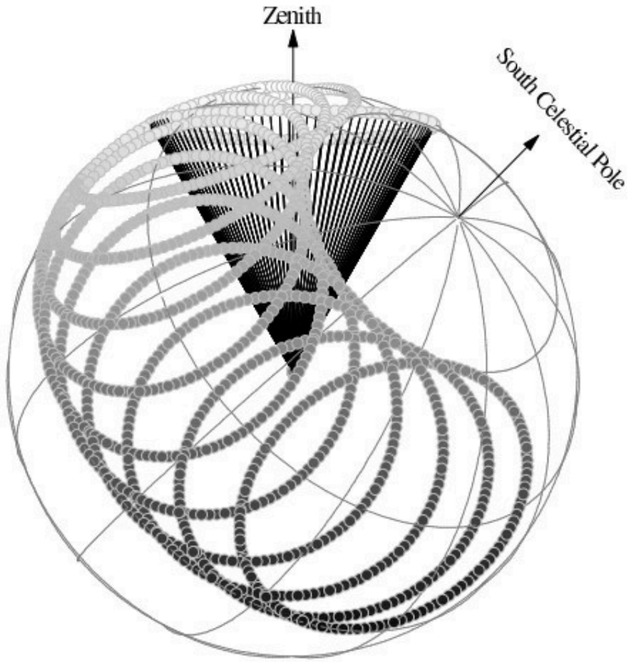
The 2.3 GHz continuum survey of the GEM project -
C. Tello et al. (2013)

GEM - DESIGN & OBSERVATION

- **5.5m diameter**
- **Extension 2.1m (halo extension)**
- **Parabolic Reflector**
  - Prime-focus mounted feed antenna
  - Cassegrain optics
- **Mounted over an alt-az rotating base**

- **Circularly scan the sky around the zenith at a rate of ~ 1 rpm**
- **1 rpm turns the scan insensible to atmospheric fluctuations**
- **Protections allow a ground rejection (<10 GHz). Minimum sidelobe pick-up**





Observation strategy of GEM

DATA CALIBRATION AND PRE-PROCESSING (BINGO)

- GEM will serve as an outrigger for BINGO
- Used to improve the pre-processing part
- Mainly to handle the foreground contamination
- Interaction with HIDE&SEEK

ANALISYS OF GEM DATA

BINGO

BINGO PIPELINE DATA PRE-PROCESSING

DATA DESCRIPTION AND PROCESSING

STEP 1

- Temporal synchronization of the raw data
- (First) Conversion of digital-physical units (V to K)

STEP 2

- Calibration of the rotation speed.
- Calibration of the radiometer signal to antenna temp. (V to K)
- Tight pointing (calibrates beam pattern using the Moon position)
- Sun ephemeris

STEP 3

- Removal RFI
- Removal ground effects

STEP 1 - GEM_2300_0

INPUTS
(DIGITAL UNITS)

OUTPUT AT PHYSICAL UNITS

- Frame count
- Time (s)
- Elevation (degree)
- Azimuth (degree)
- Radiometer temperature sensors:
  T1, T2, T3, T4 (°C)
- Radiometer signal (Volts)
- Tns - Noise temperature (°C)
- Vns - Noise voltage (Volts)
- Heater Voltage (Volts)

STEP 1 - GEM_2300_0

INPUTS (DIGITAL UNITS)

OUTPUT AT PHYSICAL UNITS

- Frame count
- Time (s)
- Elevation (degree)
- Azimuth (degree)

Time Synchronization

initial info used
↓
records the time (yr/m/d/hr/min/sec/ms) of the file

- Radiometer temperature sensors: T1, T2, T3, T4 (°C)
- Radiometer signal (Volts)
- Tns - Noise temperature (°C)
- Vns - Noise voltage (Volts)
- Heater Voltage (Volts)

STEP 1 - GEM_2300_0

INPUTS (DIGITAL UNITS)

OUTPUT AT PHYSICAL UNITS

- Frame count
- Time (s)
- Elevation (degree)
- Azimuth (degree)

Main factor in conversions

Digital-Physical units use a cte factor defined according to the data acquisition system (through an ADC multiplexer module.)

- Radiometer temperature sensors: T1, T2, T3, T4 (°C)
- Radiometer signal (Volts)
- Tns - Noise temperature (°C)
- Vns - Noise voltage (Volts)
- Heater Voltage (Volts)

STEP 2 - GEM_2300_1

INPUT

- Frame count
- Time (s)
- Azimuth (graus)

OUTPUT

- Average rotation speed of the plate (deg/sec)
- Average rotation period (s)
- Average angular distance per frame (deg/frame)
- Horizontal pointing for each frame in relation to azimuth position (degree)

STEP 2 - GEM_2300_2

INPUTS

- Frame count
- Time (s)
- Elevation (degree)
- Azimuth (degree)
- T1 (°C)
- Radiometer signal (Volts)
- T2 (°C)
- T4 (°C)
- Tns - noise temperature(°C)
- Vns - noise voltage (volts)

OUTPUT

- Frame count
- Time (s)
- Elevation (degree)
- Radiometer signal (K)
- Azimuth (degree)
- T2 (K)
- Background (K)
- Sun's horizontal coordinates (degree)
- Sun's angle (degree)

STEP 3 - IN PROCESSING

THE ANALYSIS OF STEP 3 WILL STILL BE CARRIED OUT

THANK YOU