


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



BINGO Telescope

University of São Paulo
Nicolli Soares
(F. Abdalla & C. Tello)



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**



**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

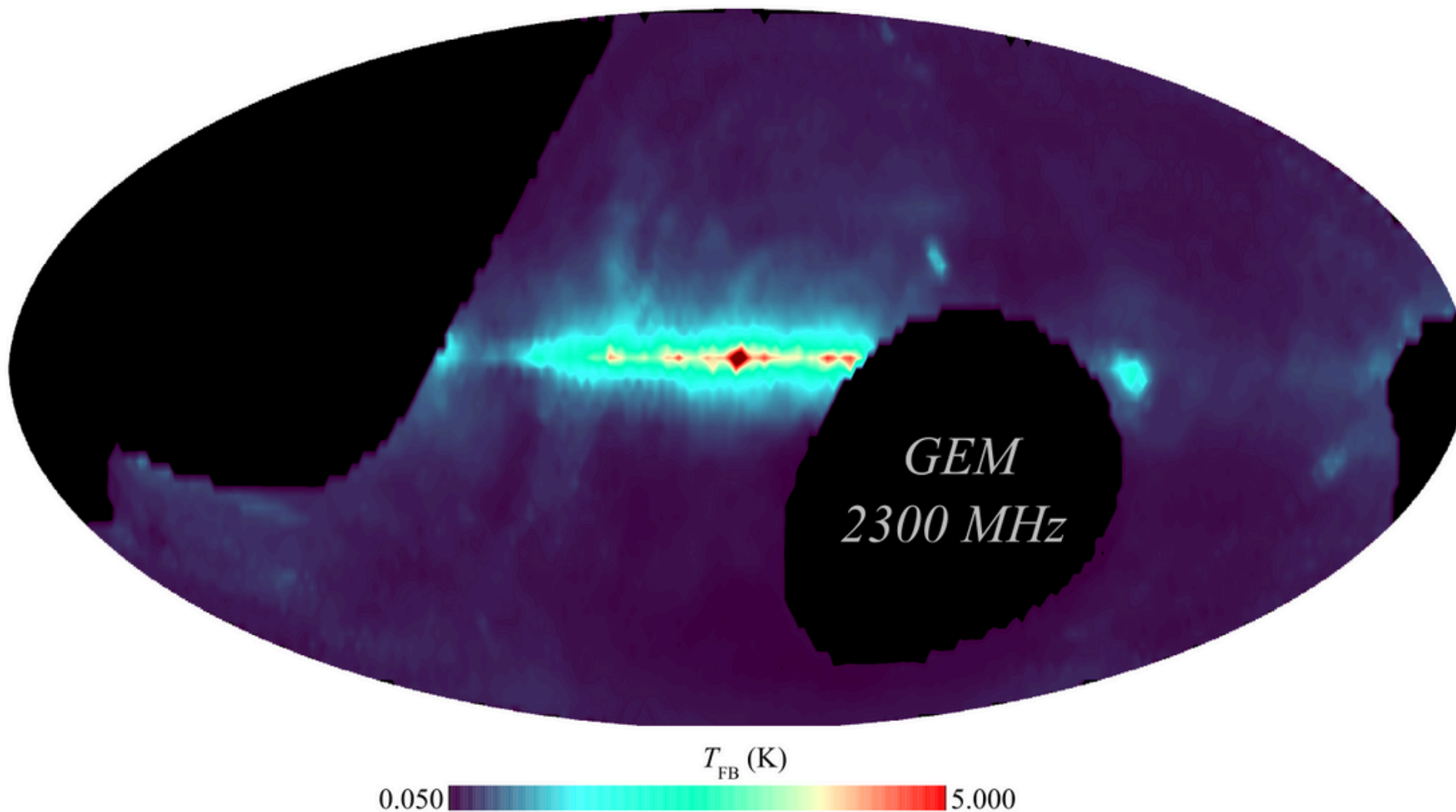
5.0

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

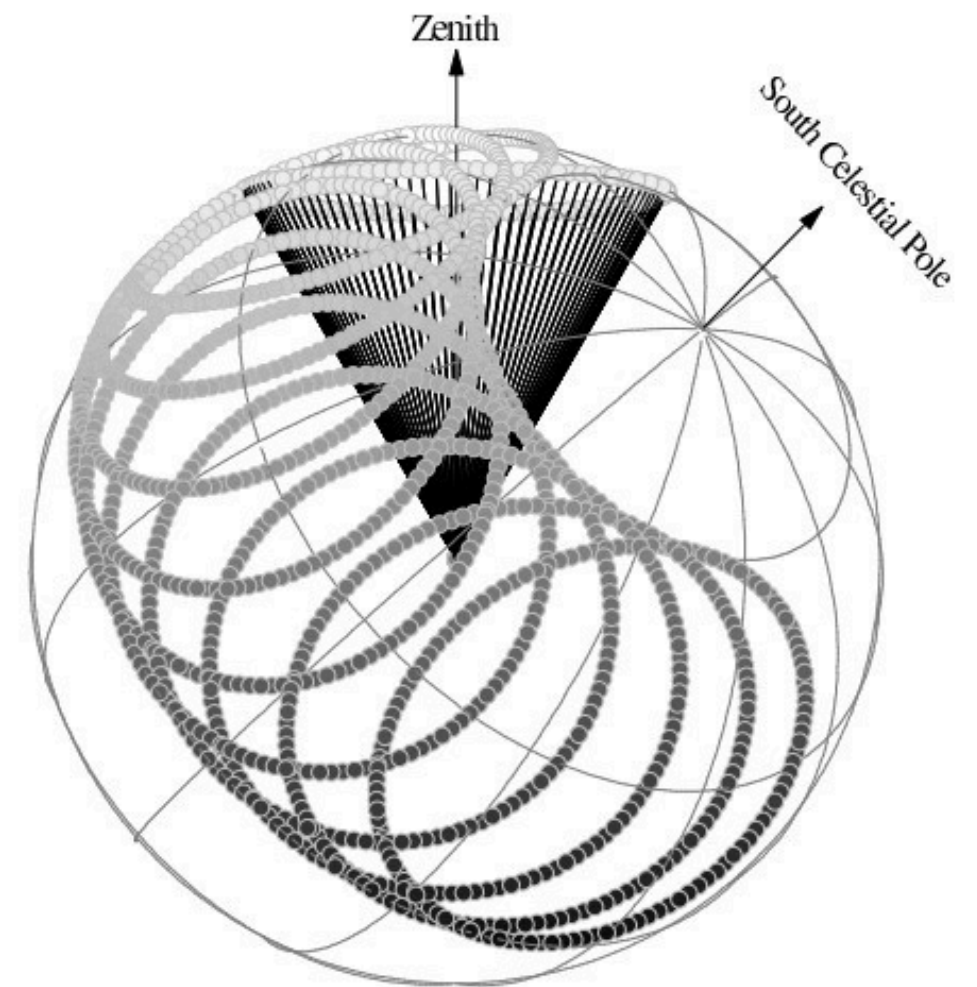
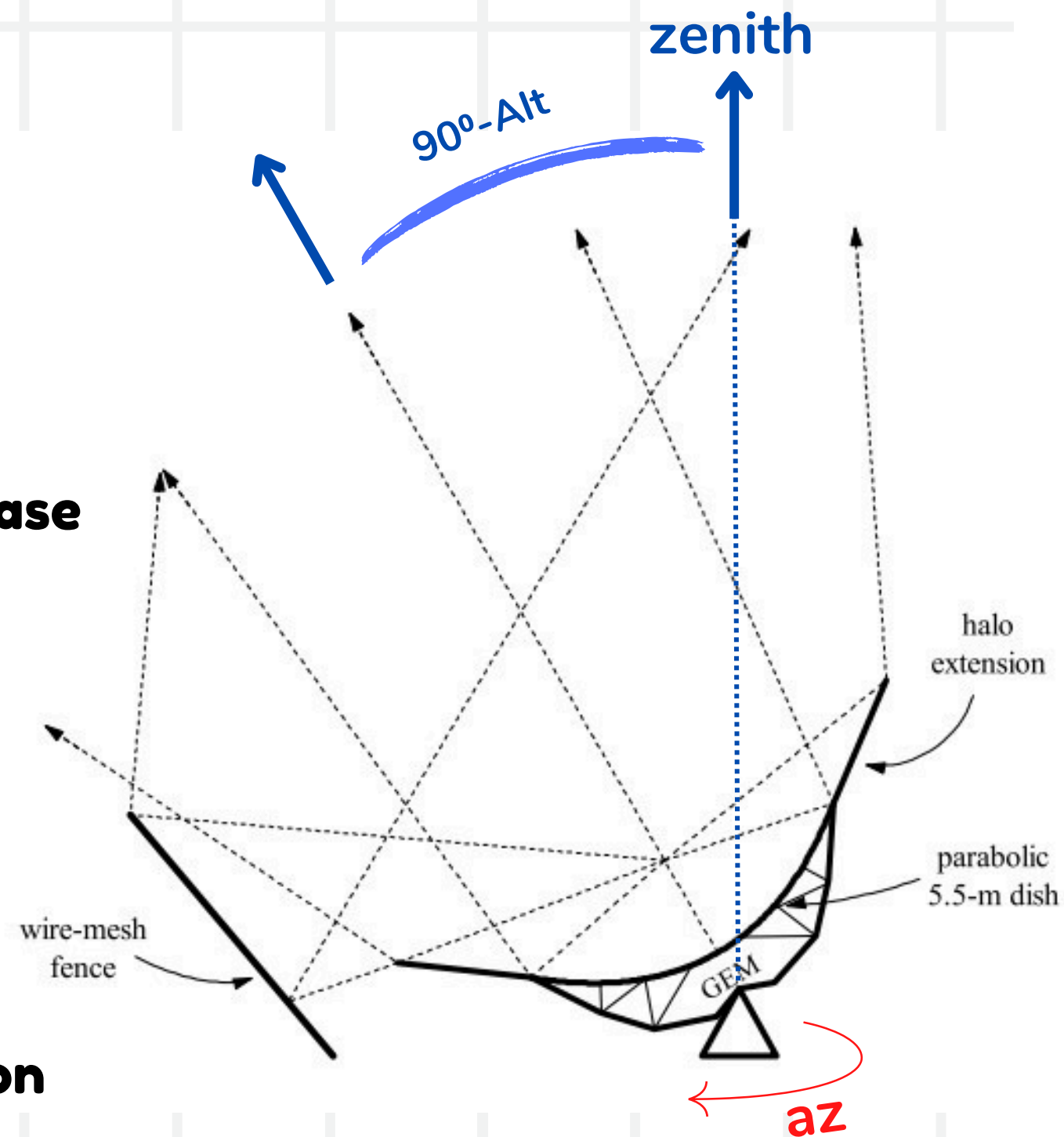


The 2.3 GHz continuum survey of the GEM
project -
C. Tello et al. (2013)

Description	Colombia	Brazil
Observational site	Villa de Leyva	Cachoeira Paulista
Longitude (WGS84)	$-73^{\circ}35'0.53''$	$-44^{\circ}59'54.34''$
Latitude (WGS84)	$+5^{\circ}37'7.84''$	$-22^{\circ}41'0.74''$
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 susceptibility (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 $HPBW$ ($^{\circ}$)	2.30 ± 0.13	2.31 ± 0.03
Vertical $HPBW$ ($^{\circ}$)	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

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**

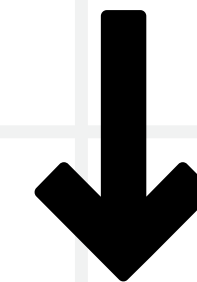


Observation strategy of GEM

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**

**ANALYSIS OF GEM
DATA**



**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

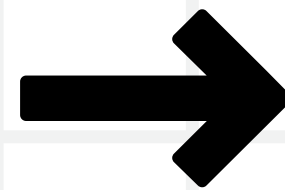
- Calibration of the rotation speed.
- Calibration of the **radiometer signal** to antenna temp. (V to K)
- Tight pointing (calibrates beam pattern using the Moon position)
- Sun ephemeris

STEP 3

- Removal RFI
- Removal ground effects

STEP 1 - GEM_2300_0

**INPUTS
(DIGITAL UNITS)**

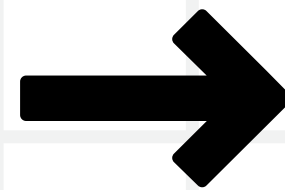


OUTPUT AT PHYSICAL UNITS

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

Time Synchronization

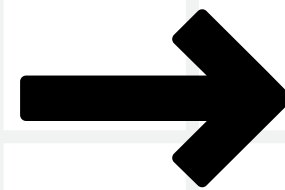
initial info used



records the time
(yr/m/d/hr/min/sec/ms)
of the file

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.)

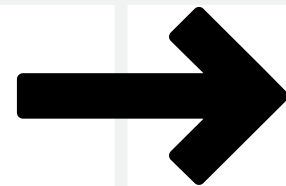


- Radiometer temperature sensors: T1, T2, T3, T4 (°C)
- Radiometer signal (Volts)
- Tns - Noise temperature (°C)
- Vns - Noise voltage (Volts)
- Heater Voltage (Volts)

STEP 2 - GEM_2300_1

INPUT

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



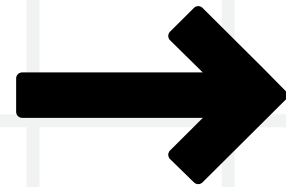
OUTPUT

- 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

