Lunar Energetic Astro-Particle Experiment (LEAP)

Exploring the High Energy Cutoff of the Universe

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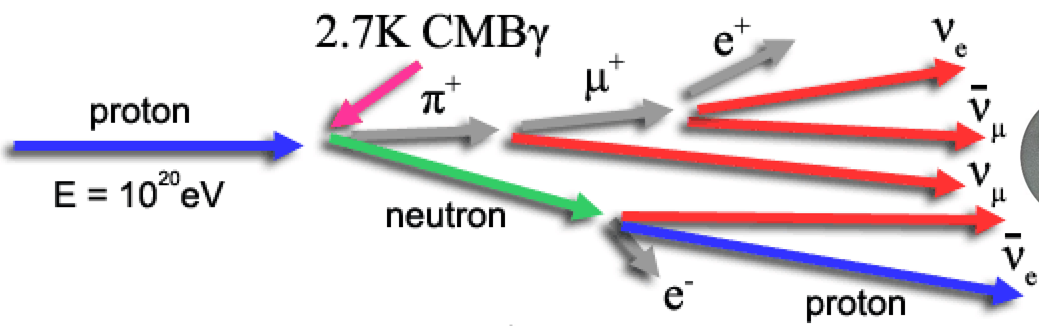
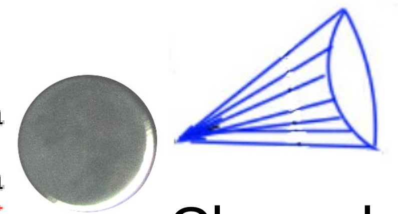
The GZK Process

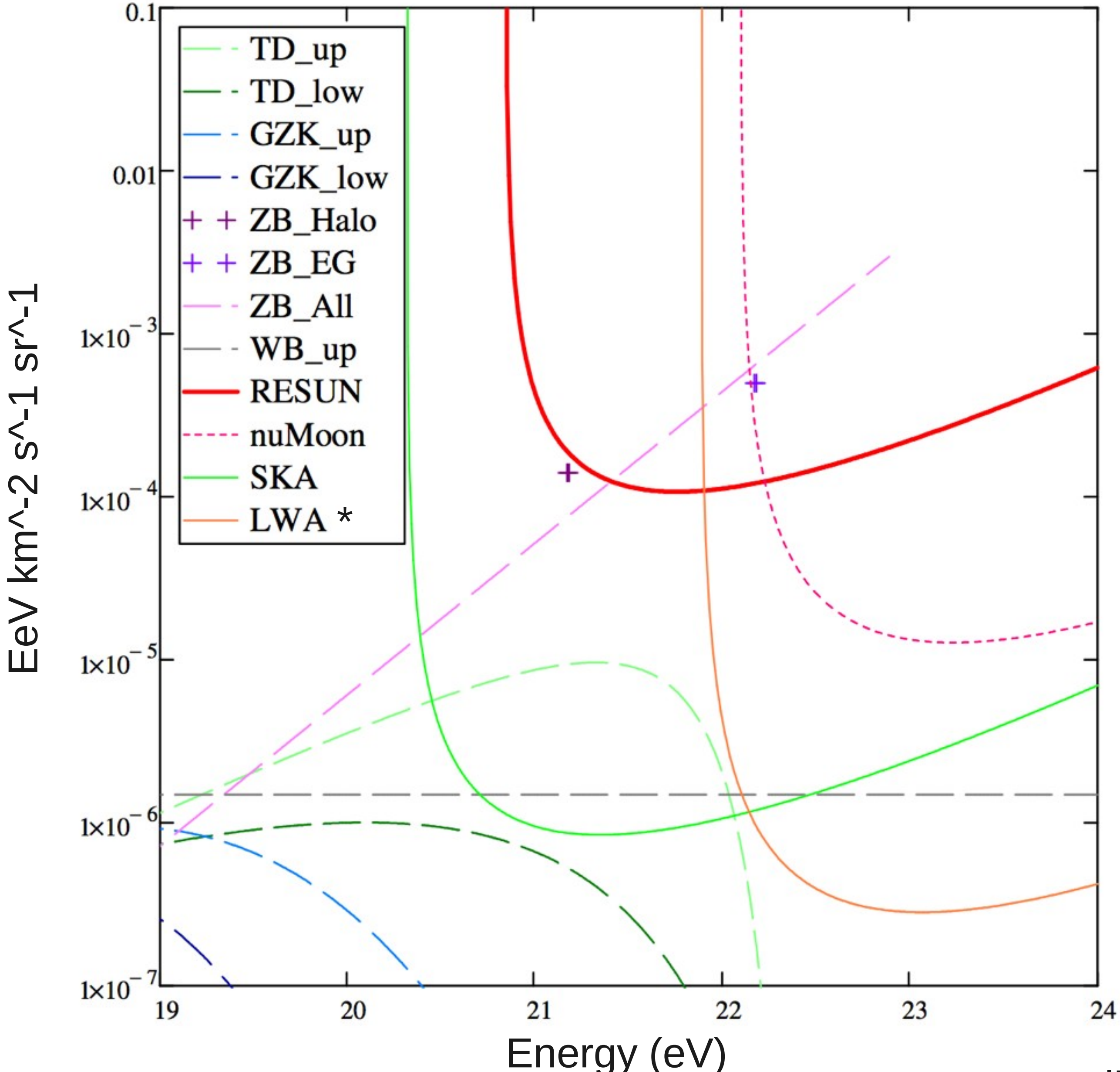


$$p + \gamma \rightarrow \Delta^* \rightarrow n + \pi^+$$

The Askaryan Impulse

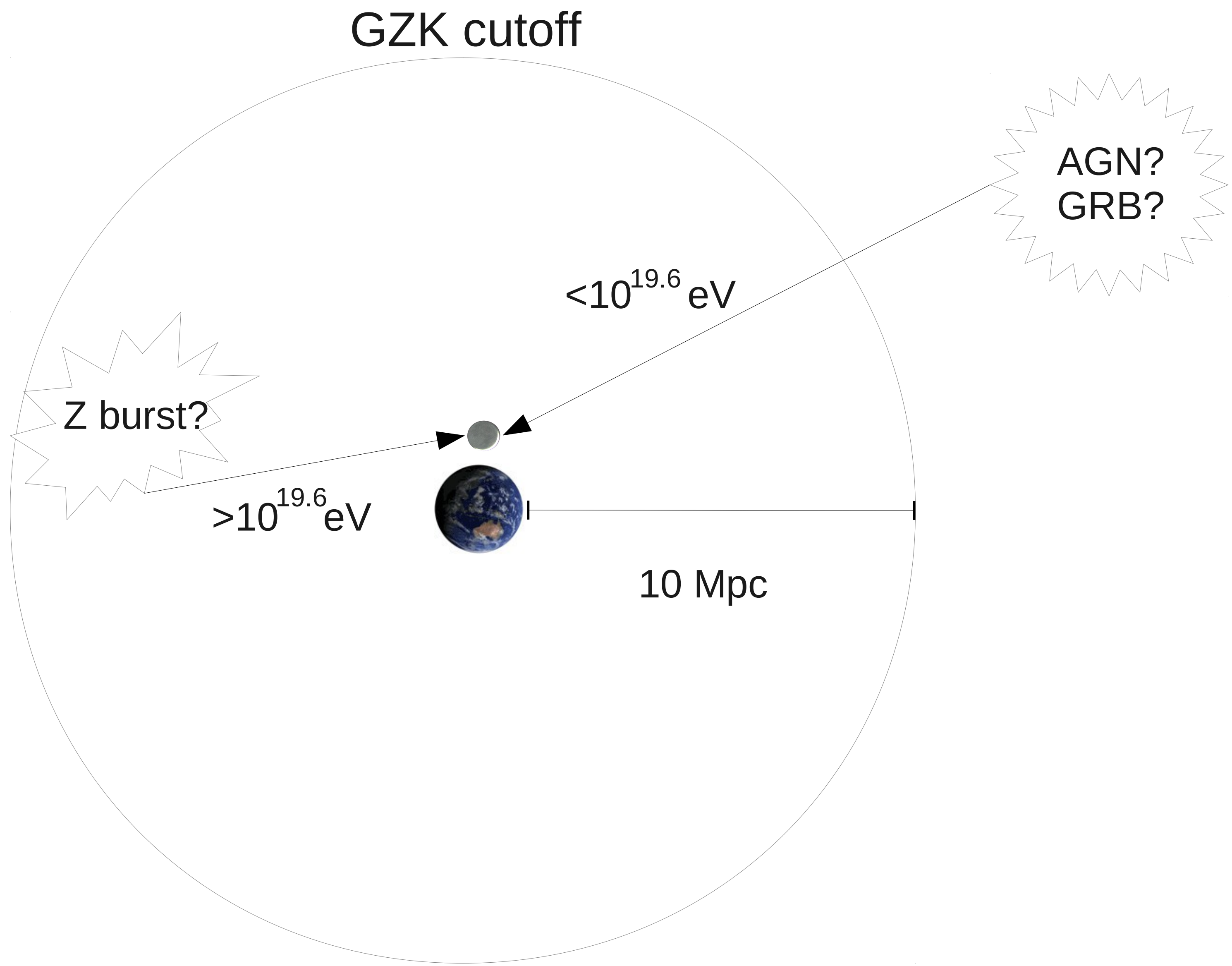


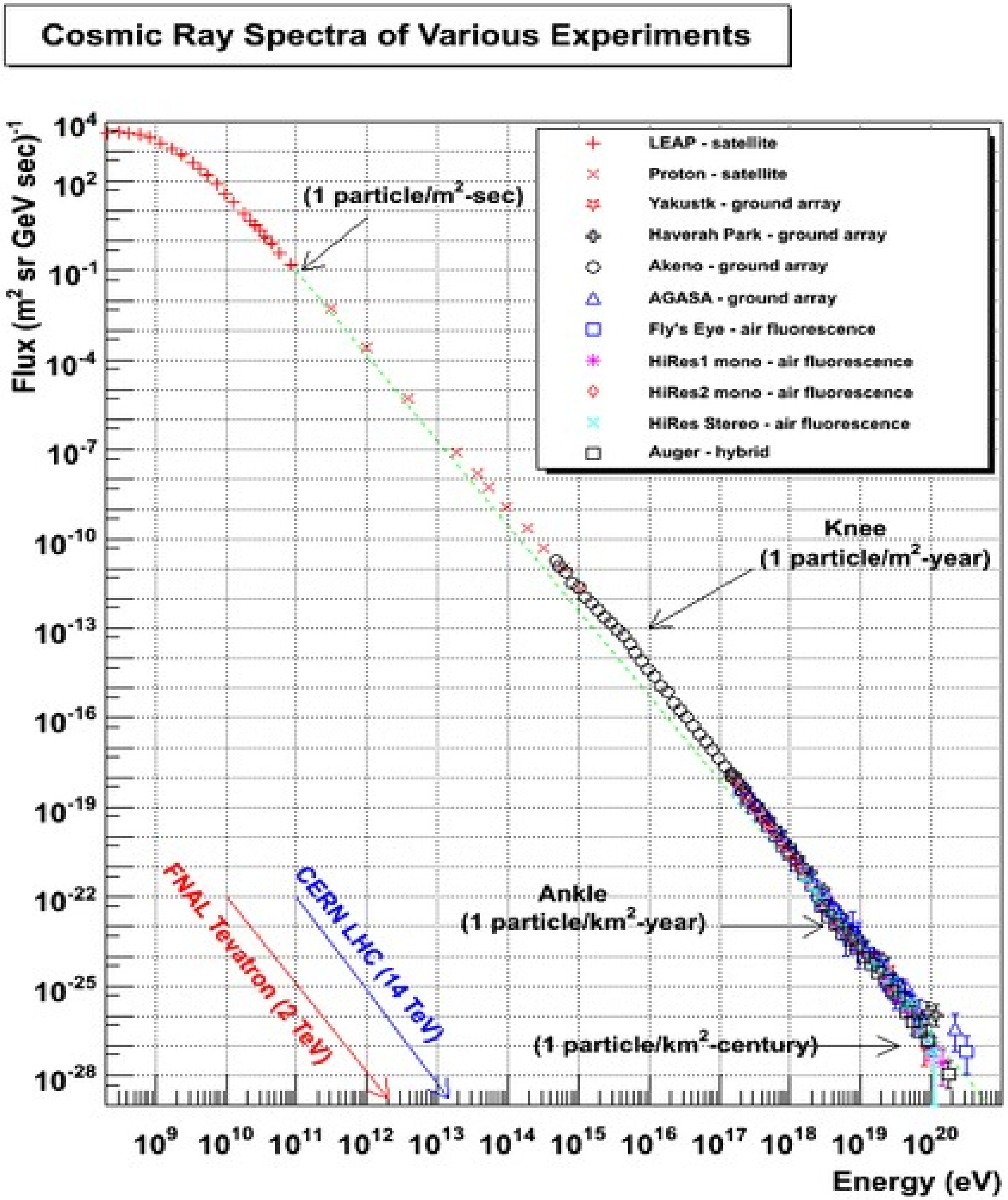
Cherenkov cone



*Preliminary result

Ted Jaeger


GZK cutoff
AGN?
GRB?
<10^19.6 eV
Z burst?
>10^19.6 eV
10 Mpc



Hanlon W (University of Utah)

GLUE

Target frequency
1000 Mhz

NuMoon

Target frequency
110-190 MHz

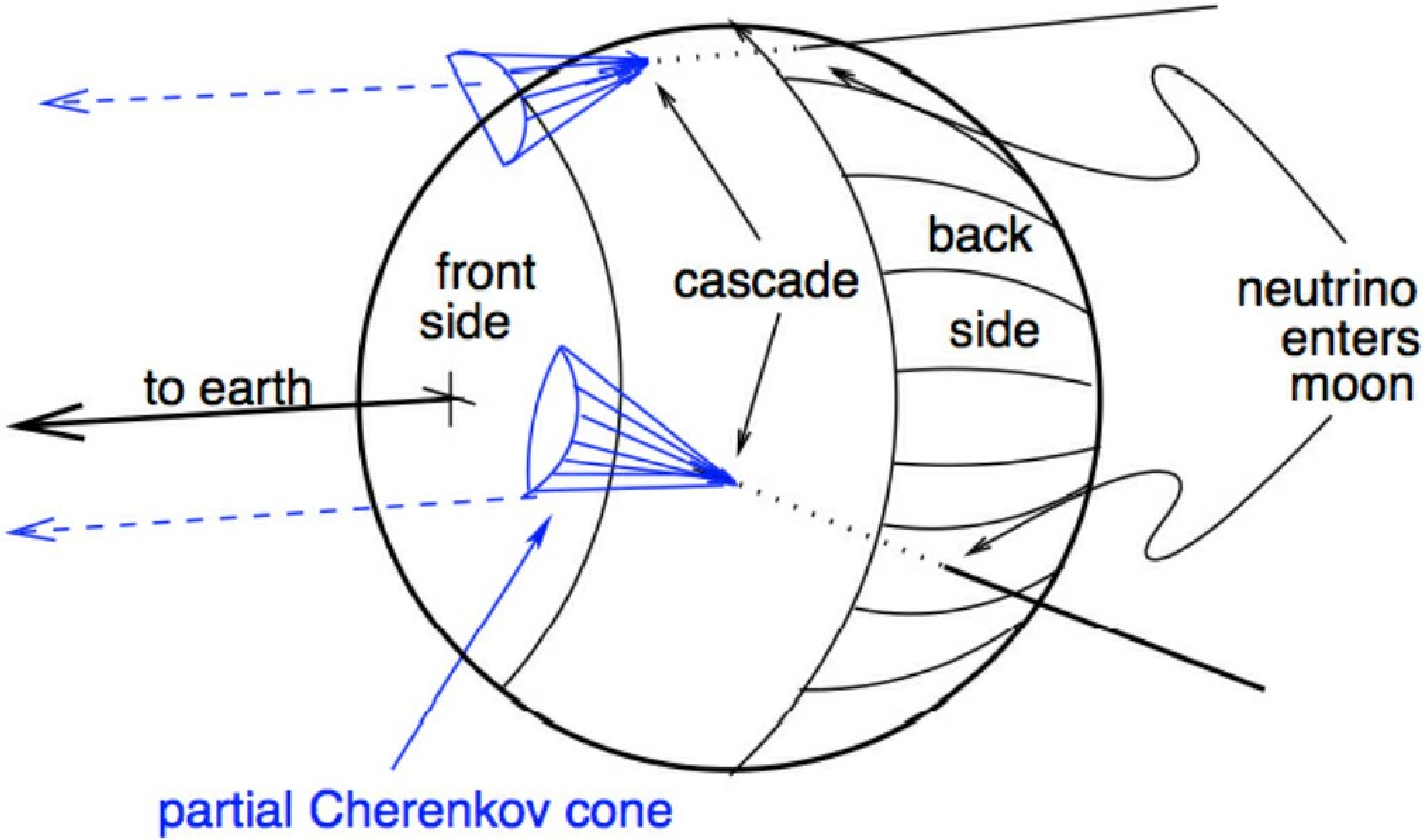
LEAP
Target frequency: 48-88 MHz
DRX observations, tracking the moon

Two beams in the high frequency band pointed at the moon

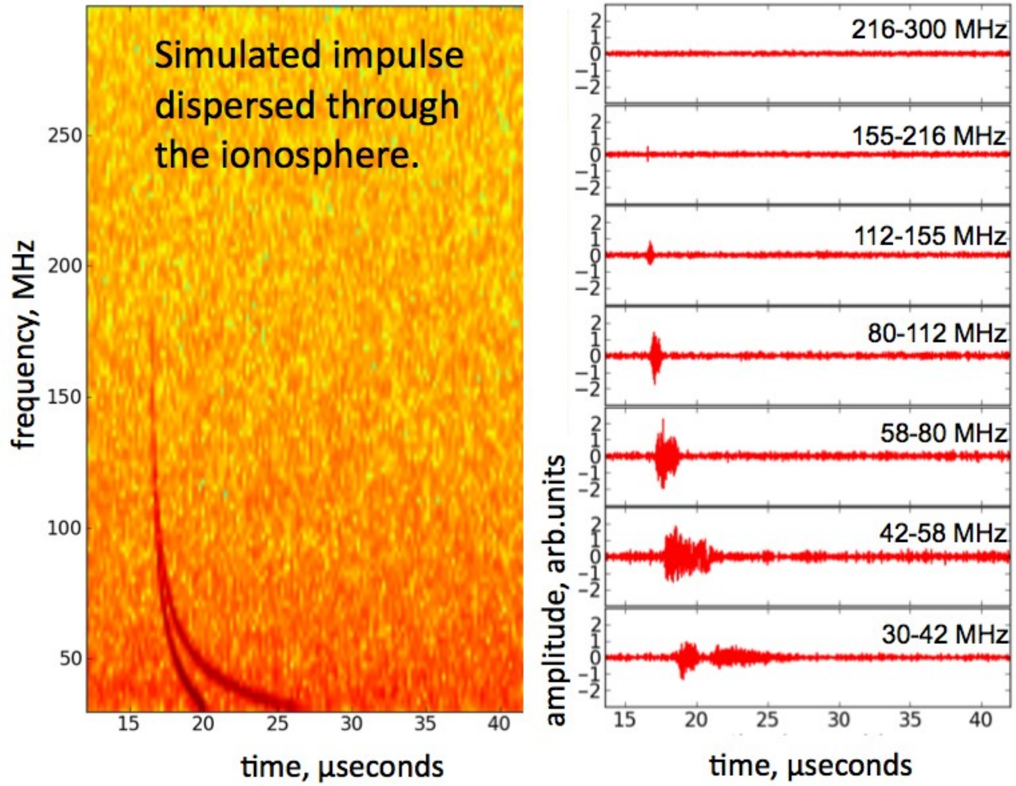
Two beams in the low frequency band pointed off the moon

Off-angle determined by beam width at min. elevation angle of moon during observations

On and off moon observations, looking for impulsive events



P W Gorham (JPL)



Propagation of radio pulses through the ionosphere produces frequency dependent delays resulting in dispersion. The delay t at a given frequency f is given by

$$\tau(f) = \alpha TEC \frac{1}{f^2} \pm \alpha TEC \frac{2m_e}{c} \frac{\hat{\mathbf{k}} \cdot \mathbf{B}}{f^3} + \ldots$$

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where alpha = 1.3445 ⇥ 109 Hz/TECU. The total electron content (TEC) of the ionosphere is the column density of electrons in the path between the source and the observer and is given in TEC units (TECU) with 1 TECU = 1016 electrons / m2 . The ± sign corresponds to each circular polarization component of the electromagnetic wave with direction of propagation k in the presence of the geo-magnetic field vector B. The constants m sub e and c are the electron mass and speed of light respectively.

The LEAP Experiment Procedure:

1.) Plan ephemeris
2.) Gain calibration observation, correction
3.) Observation
4.) Perform Avg Power Spectrum to find RFI
5.) Filter terrestrial RFI to match expected galactic background.
6.) Cross correlate simulated neutrino events with filtered “raw” data.
7.) Compare cross-correlated search to search with de-dispersion algorithm
8.) Produce time or frame bounds for potential neutrino events for further analysis.

Nighttime Lunar Elevation

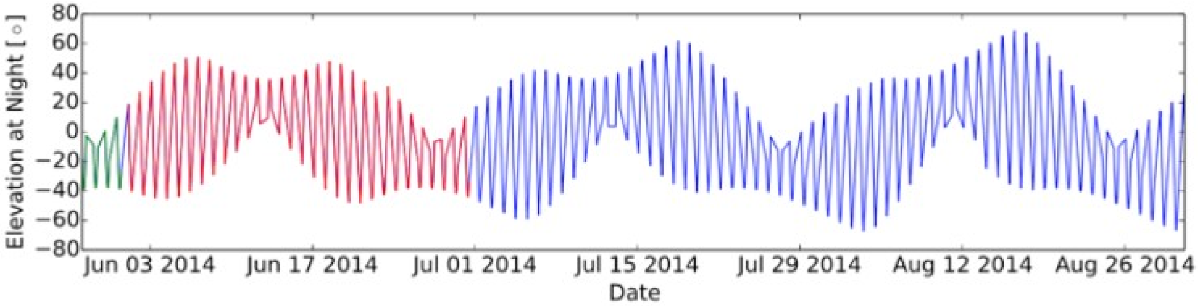
- Peak declination steadily rises throughout summer.

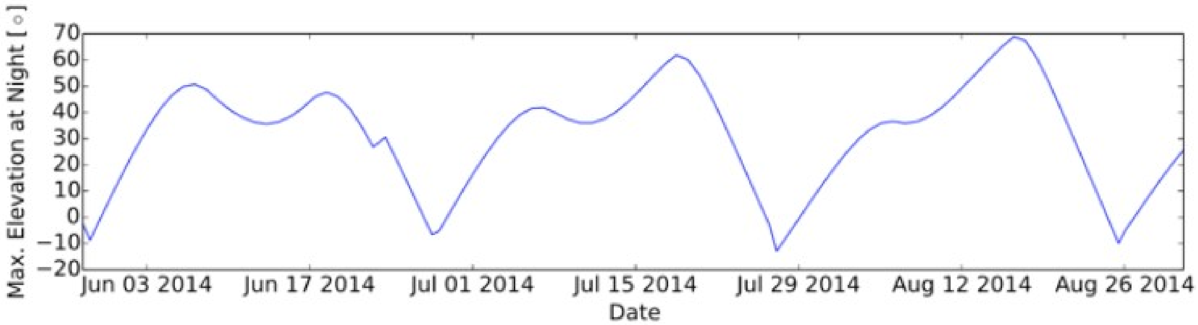
- Peak times:

June 18,
UTC 12:00 MDT 6:00

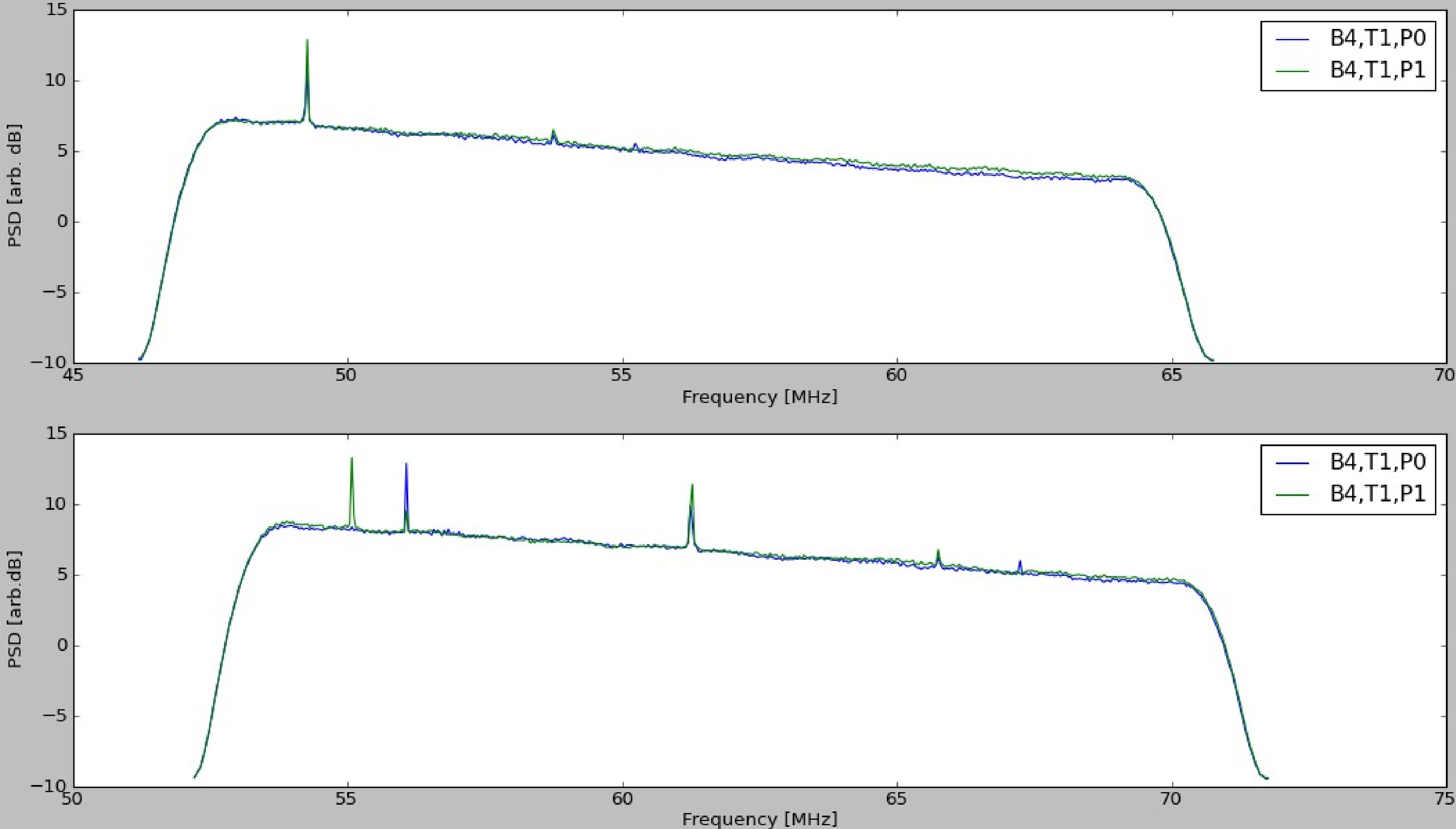
July 17,
UTC 12:00, MDT 6:00

August 16,
UTC 12:00, MDT 6:00

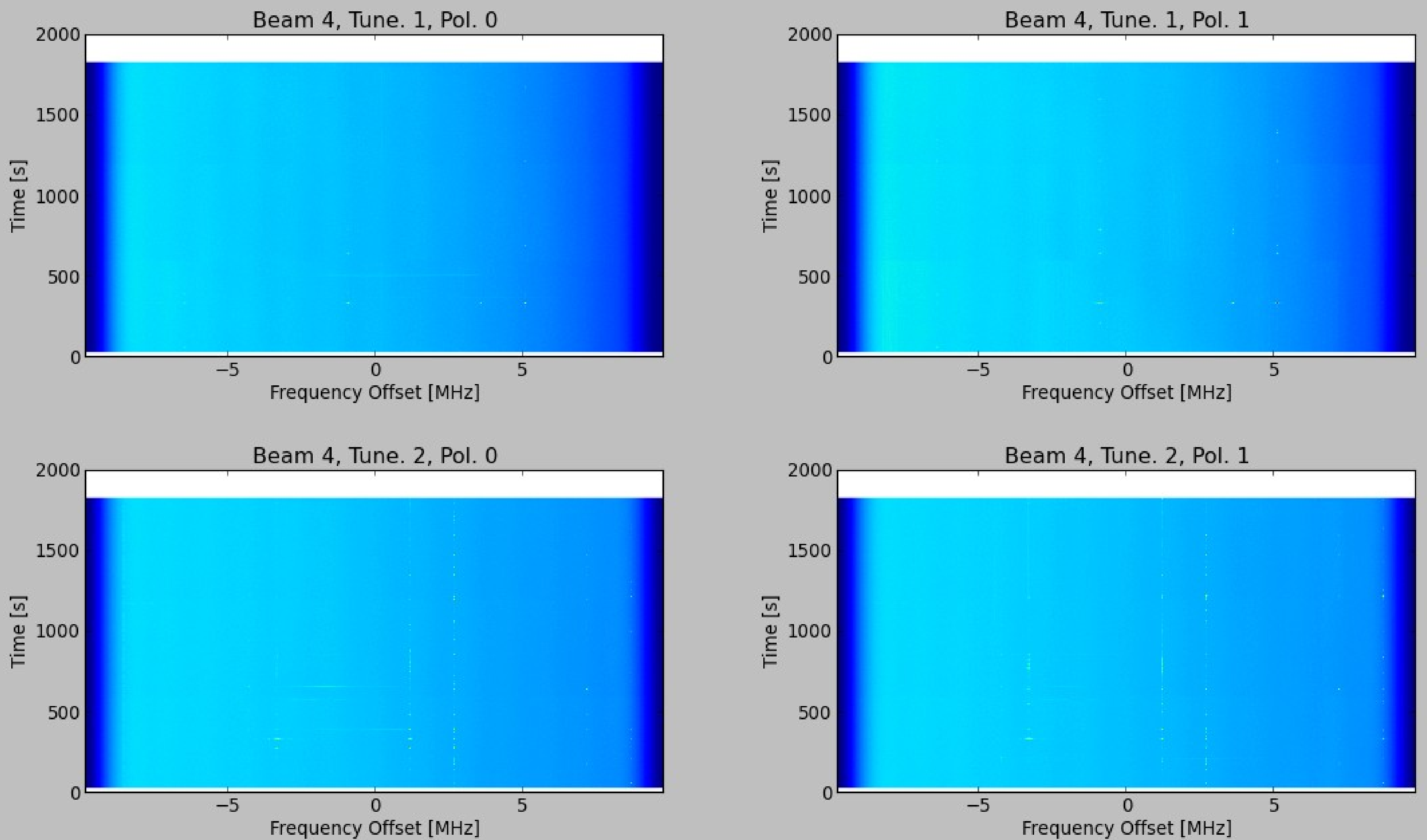




	4/30/2014	5/1/2014	5/2/2014	6/18/2014	7/17/2014	8/16/2014
Elevation Angle Min	71.9	54.8	46.0	40.8	56.9	63.8
Elevation Angle Max	72.9	63.2	55.8	47.7	58.4	68.9
Rising / Setting	Rising & Setting	Setting	Rising	Rising	Rising	Rising
Off-Angle	6 deg	8 deg	10 deg	12 deg	8 deg	7 deg
LST Min	14:00	17:00	13:00	4:00	5:00	5:00
LST Max	15:00	18:00	14:00	5:00	6:00	6:00
UTC Min	20:00	23:00	19:00	10:00	11:00	11:00
UTC Max	21:00	24:00	20:00	11:00	12:00	12:00

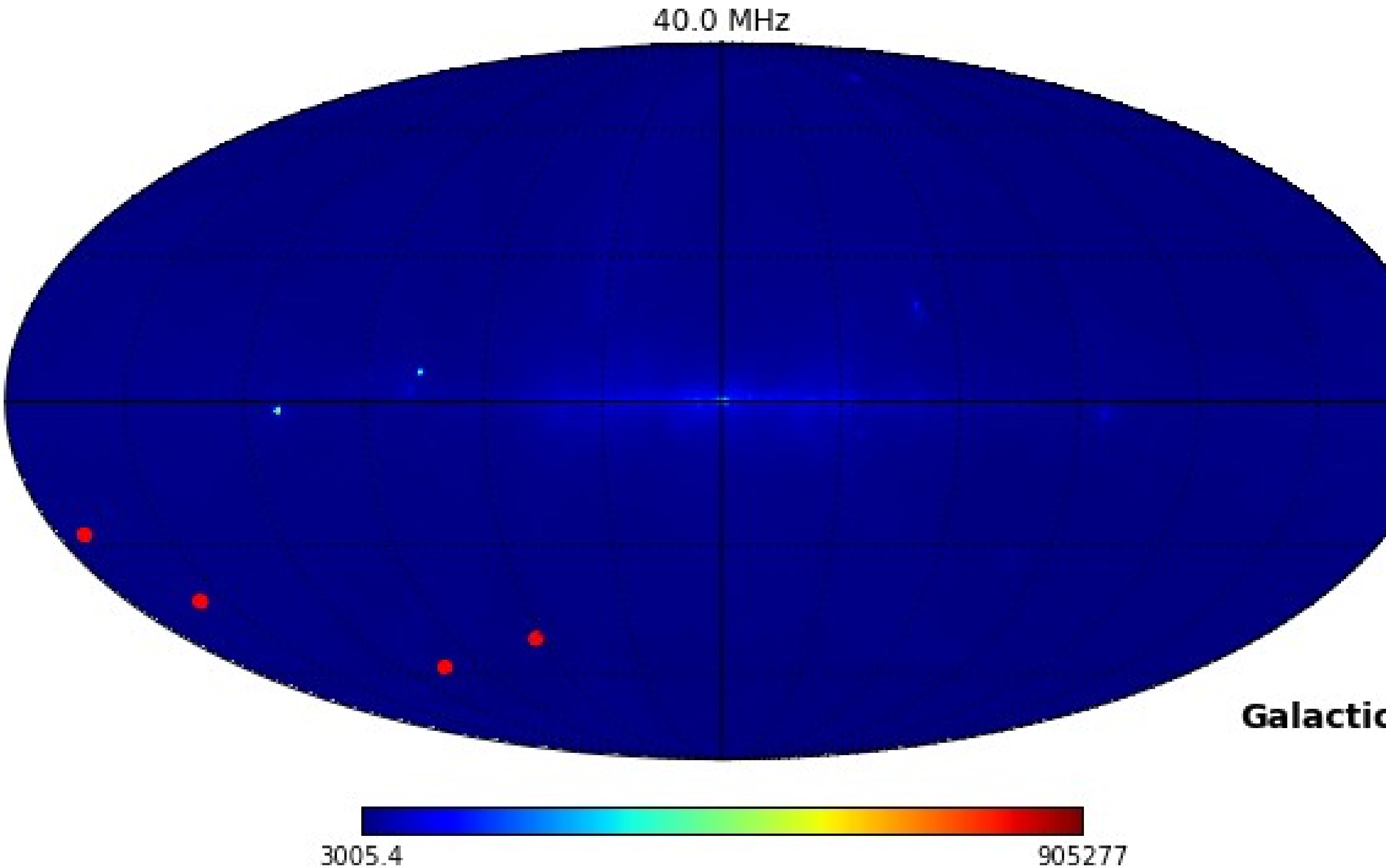


Average Power Spectrum



Spectrogram Waterfall from RAW data

Note: Galactic background shown for 40 MHz, where galactic noise will be highest



A. de Oliveira-Costa et al.
"A model of diffuse Galactic radio emission from 10MHz to 100 GHz"
Monthly Notices of the Royal Astronomical Society, 388, 247-260, (2008)

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