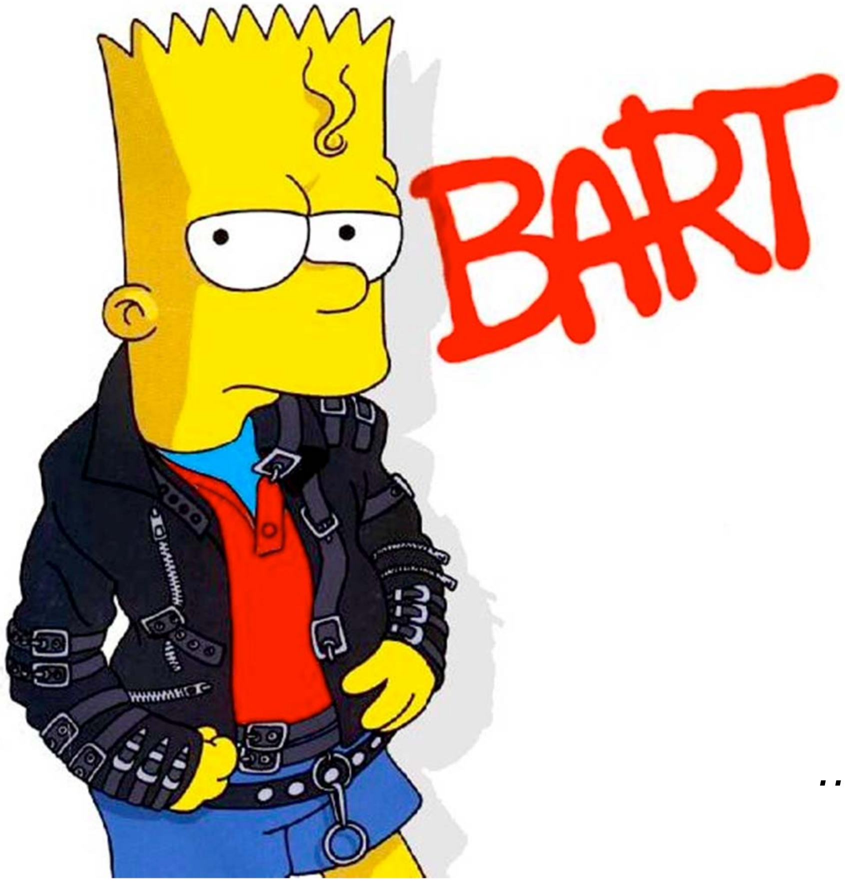


Big Ass Radio Telescope!

… or the Mega Dish Array

Simple Concept…

- Building large structures *may* be an easier means to manifest a large space-based collecting area for radio astronomy than building an equivalent number of dipoles. This is due to limitations of power and data transport requirements for the latter.

Design Requirements for BART/MDA

- Operational from 250 kHz to 30 MHz (Primary science is > 3 MHz)

- Collecting area of ~10^7 m^2

- Consists of X dishes of diameter Y with X and Y to be eventually determined by feasibility study and cost equation

- Initial concept is 10 x 10^6 m^2 dishes, i.e. dishes of diameter 1.1 km *[likely to be larger N of smaller aperture]*

- Antennas will be placed in a configuration with maximum baselines of 300-1000 km

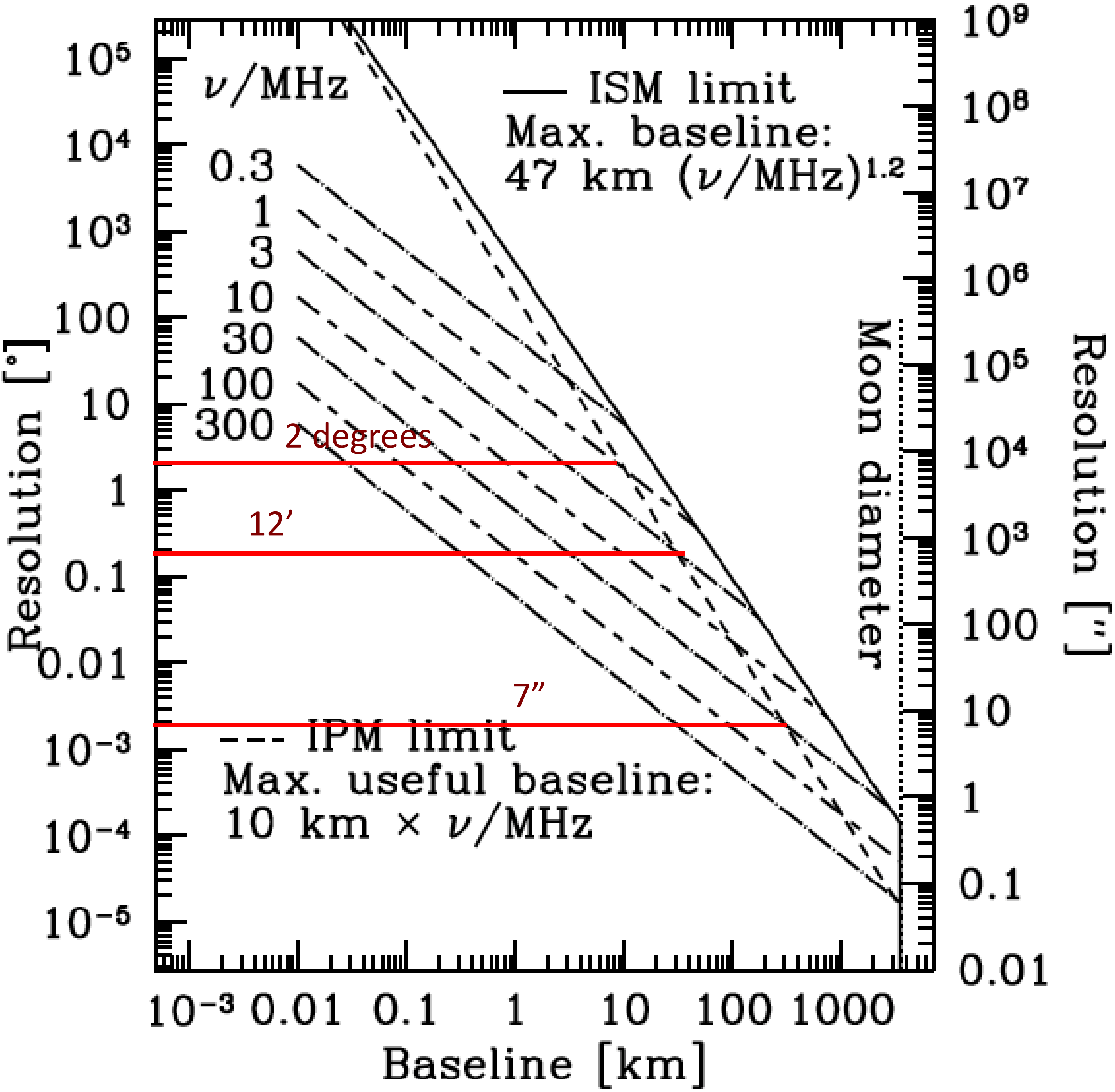
- Resolution will be ~2-7 arcseconds at the top of the band (limited by IMP/ISM scatter broadening)

- Thermal noise - 1-σ RMS in 1 hr at 30 MHz is **5 µJy** (best), 30 µJy (average) **[Jupiter average at 5 pc], [Jupiter active at 15 pc] Game-changing instrument for high-z HI studies and pretty much all of astronomy (and SETI)**

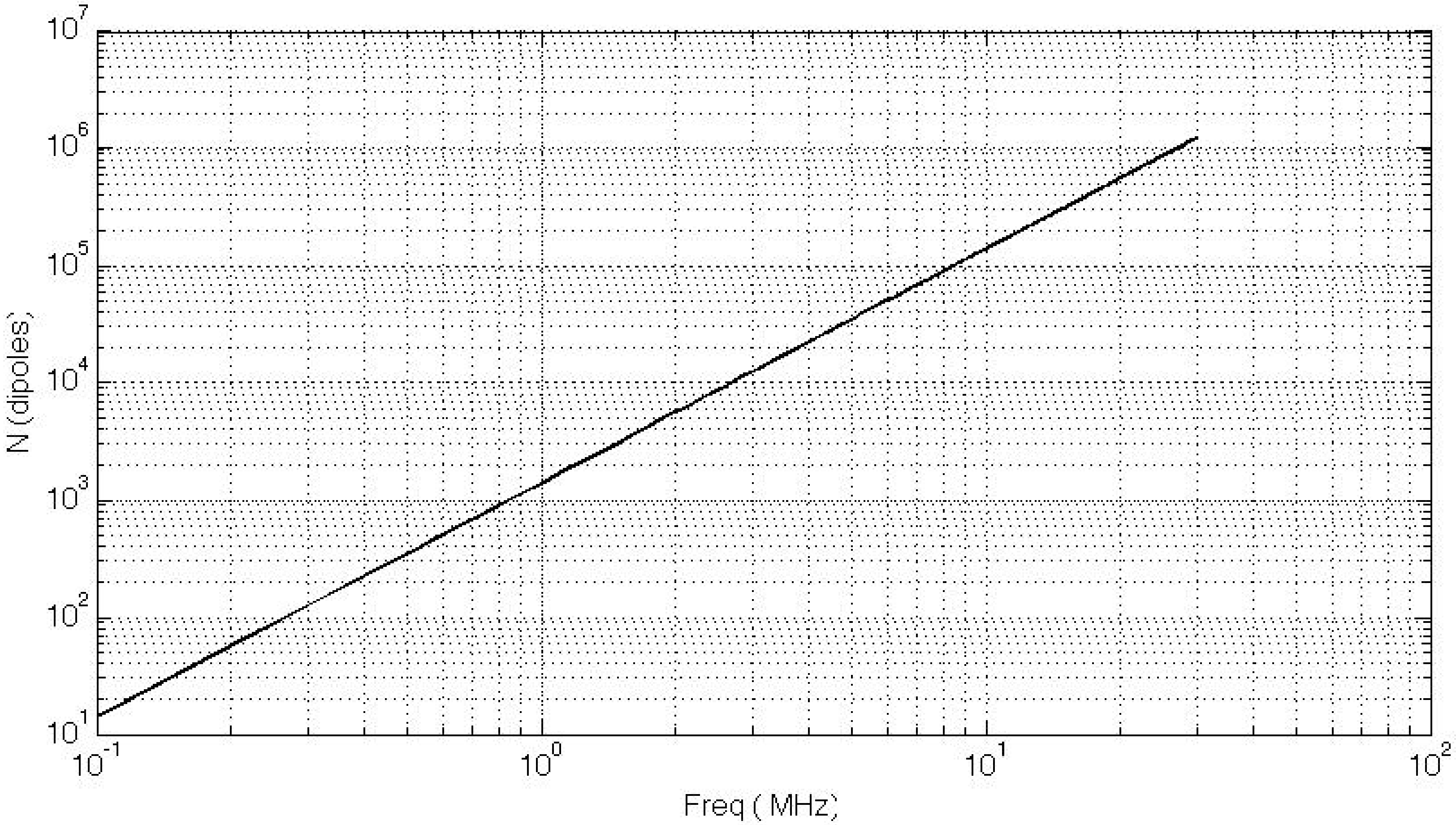
- Thermal noise - 1-σ RMS in 1 hr at 10 MHz is 100 µJy (best), 500 µJy (average)

- Thermal noise – 1-σ RMS in 1 hr at 3 MHz is 5 mJy

- Thermal noise – 1-σ RMS in 1 hr at 1 MHz is 20 mJy


ν/MHz
0.3
1
3
10
30
100
300
ISM limit
Max. baseline:
47 km (ν/MHz)^1.2
IPM limit
Max. useful baseline:
10 km × ν/MHz
Moon diameter
2 degrees
12’
7”
Resolution [°]
Resolution ["]
Baseline [km]
10^5
10^4
10^3
100
10
1
0.1
0.01
10^-3
10^-4
10^-5
10^9
10^8
10^7
10^6
10^5
10^4
10^3
100
10
1
0.1
0.01
10^-3
0.01
0.1
1
10
100
1000

- Number of dipoles to produce equivalent collecting area of BART/MDA (10^7 m^2) as a function of frequency. Does not take into account variations in sky temp or impact of short dipole, i.e. length >> λ, both of which are λ-dependent but favor dish array



- The choice of large dishes vs dipoles largely trades off mechanical challenges vs data challenges

Data Requirements

- Possible to heterodyne the data, but lose bandwidth. May be favorable for the dipole data.

- Assuming direct digitization there are 3 (or more) options…
  - 1) send raw data samples
  - 2) send post filter-bank data
  - 3) send correlated visibility data

- Nyquist Sample maximum frequency (60 Msps for 30 MHz)

- Dynamic range of 10^{10} needed! 20-bit sampler

- Raw sampler data rate per antenna is 1.2 Gbps [Each dipole would have the same sampler data rate!]

- An FPGA filter bank at each antenna can be used to reduce data rate depending on acceptable number of bits -> 300 Mbps for 5 bit samples

- Correlated visibility data – (N*(N-1))/2 * 600 kbps (30,000 channels dumped at 1 sec) * 4 -> much too large

Mechanical Requirements

- Max reflector size -> limits maximum λ
- Type of reflector -> dish vs orange-peel antenna vs? etc.?
- Need mesh density of ~0.2 λ (Transmission losses) –> limits minimum wavelength
- Need RMS surface accuracy of ~1/16 λ -> limits minimum wavelength
- Weight? -> limits minimum wavelength
- Receiver isolation?
- Survey sky through Earth-rotation, moon-rotation, precession?

Trade offs of BART/MDA compared to equivalent dipole array

- Dipoles are mechanically easy. Large dishes in space are an unproven concept!
- Total data rate of dish array is of order ~ Gbps vs ~Pbps for the dipole array
- Enormous sensitivity on each dish baseline makes calibration feasible
- How do you phase a dipole separated by 1000 kilometers (via space-based beam-former) without a priori knowledge of the impact of the IPM on delays at each antenna. Tiered beam-forming may be a solution?
- Tsys of the dish array will improve in cold parts of the sky at high frequencies. Not an advantage below 3 MHz
- What is the impact of resistive losses when the dipole is << λ
- Lots of other questions….