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SUBJECT	NAME	
Chalk Talk - Goals		
	DATE	REVISION DATE

21 Cm Goal: Measure Dark Energy expansion using BAO as a ~~standard~~ ruler

Achieve a DETF FoM of 250 (~4x DES) for an instrument cost of ~20M$

Technique: use Intensity mapping of Hydrogen hyperfine transition of 1.42 GHz.

Goals:

Redshift range	0.5 → 2.0
Angular resolution	15 arc-min
Survey Area	> 2.5 π steradians
	~ 25,000 square deg.
	~ 2×10^9 3-D pixels (100kHz res BW)
Sensitivity / Pixel	100 μK
* Survey Time	2 yrs 50% Duty factor

→ killer!!

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SUBJECT: Chalk Talk
Telescope resolution

NAME:
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$$\Delta\Theta = \frac{\lambda}{L}$$

for $\Delta\Theta = 15$ arc-min

$\lambda = .4m$ (750 MHz)

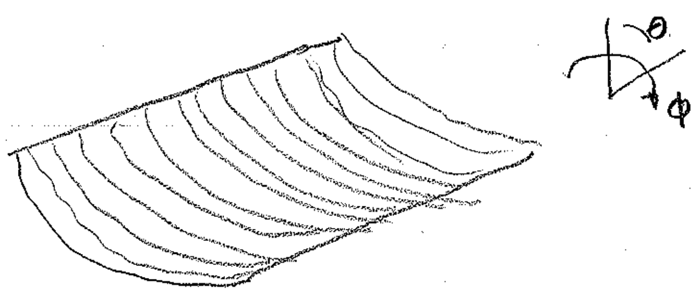
$L \approx 100\,m$

Consider a an antenna 100m x 100m
With one reciever (GBT)

$$\frac{\text{Signal}}{\text{Noise}} = \frac{S \cdot A}{K T_r} = S \cdot L^2$$

→ Takes forever to scan

Now consider slicing telescope into N sections
each with a reciever



Each reciever has an Area

$$A_r = L \cdot \frac{L}{N_R}$$

Each reciever has a beam width

$$\Delta\phi = \frac{\lambda}{L} \qquad \Delta\Theta_R = \frac{N\lambda}{L} \leftarrow \text{bigger}$$

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SUBJECT: Chalk Talk - Phased Array

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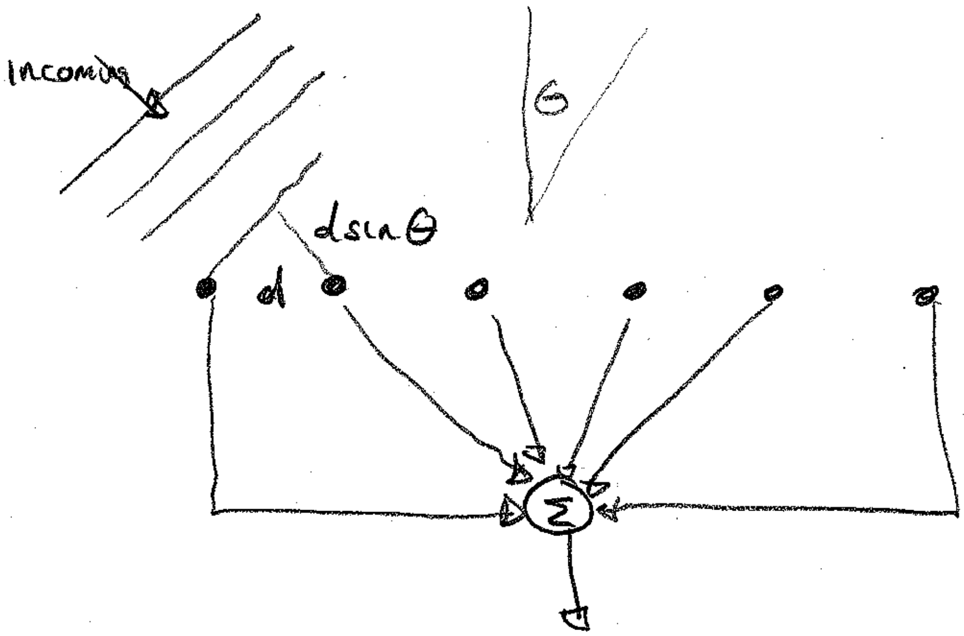
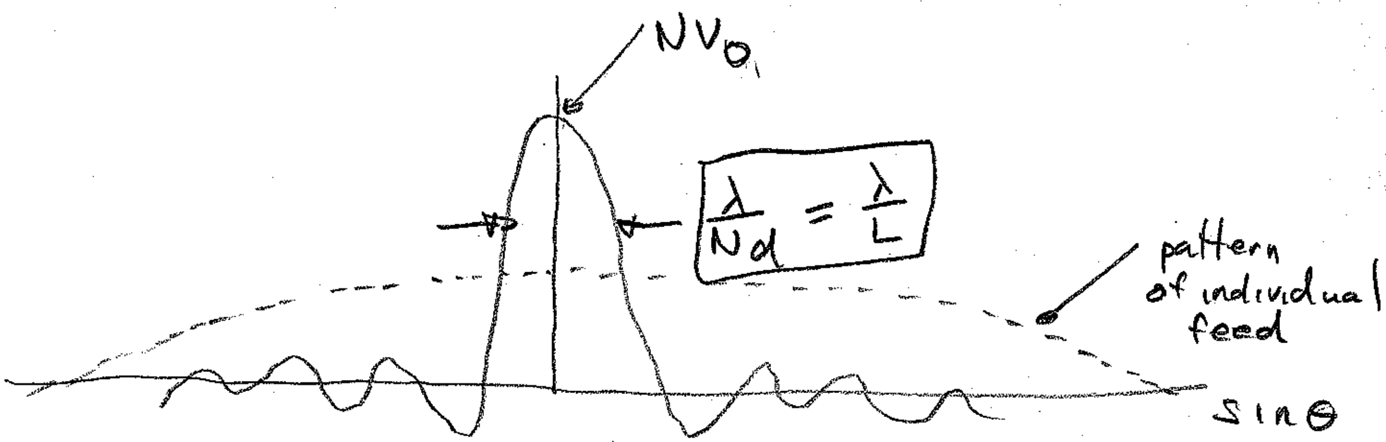
Add recievers Together in phase.



phase shift between feeds = $2\pi \frac{d}{\lambda} \sin\theta$

$$V(\theta) = \sum_n V_0 e^{-jn 2\pi \frac{d}{\lambda} \sin\theta}$$



$$\Delta\theta_{Array} = \frac{\lambda}{N d_f} = \frac{\lambda}{L}$$

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			4.

SUBJECT: Chalk Talk - Phased Array S/N

NAME:

DATE: REVISION DATE:

$$\text{Signal Array} = N_r^2 S \cdot L \cdot \frac{L}{N_r}$$

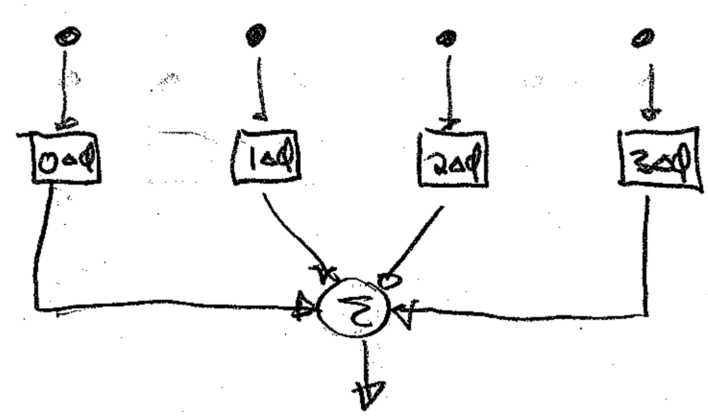
voltage adds in phase

$$\text{Noise Array} = N_R k T_r$$

noise is uncorrelated

$$\left.\frac{\text{Signal}}{\text{Noise}}\right|_{\text{array}} = \frac{S \cdot L \cdot L}{k T_r} = \text{Same as GBT}$$

What about adding an extra phase shift (or delay) between recievers



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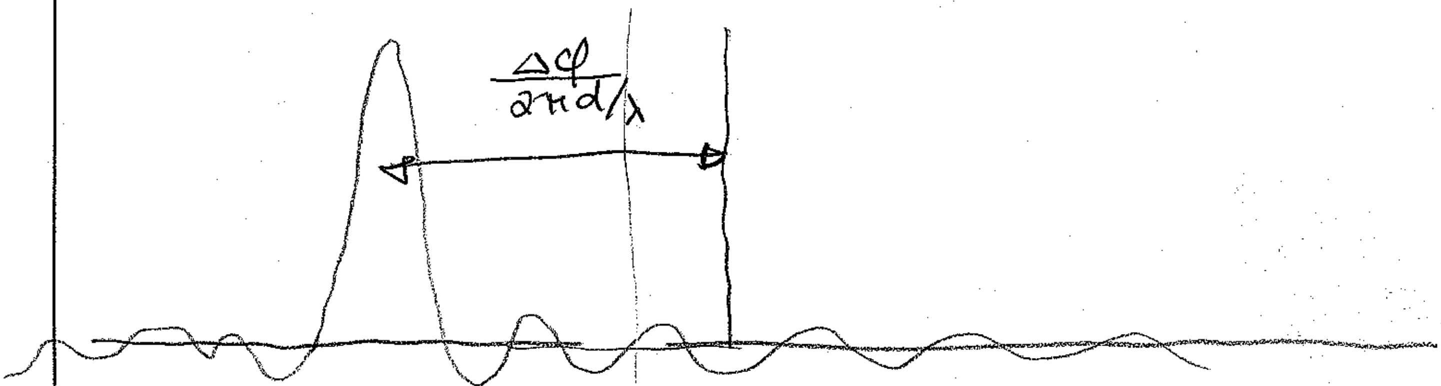
SUBJECT	NAME	
Chalk Talk - Multiple Beams	DATE	REVISION DATE

$$V_A(\theta,\phi) = \sum_n V_0 \, e^{-jn2\pi\frac{d}{\lambda}\sin\theta} \, e^{-jn\Delta\phi}$$



Since $\Delta\phi$ is just mathematical we can see the two beams at the same time!!

Because $\Delta\Theta_A = \frac{\lambda}{N d_e}$

There are only N "non-overlapping" beams

$$\Delta\phi_k = \frac{2\pi}{N} k$$

$$k = -\frac{N}{2} \dots \frac{N}{2}$$

This means we can see N beams on the sky at the same time

$$T_{survey} \propto \frac{1}{N_R}$$

$$V_k(\theta) = \sum_n V_0 e^{-j n \frac{2\pi d}{\lambda} \sin\theta} e^{-j \frac{2\pi n}{N} k}$$

$$V_{r_n} = V_0 e^{-j n \frac{2\pi d}{\lambda} \sin\theta}$$

$$V_k(\theta) = \sum_n V_{r_n} e^{-j \frac{2\pi n}{N} k}$$

$V_k(\theta)$ is just the spatial fourier transform of the recvrs.

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SUBJECT: Chalk Talk - New Technology

NAME

DATE | REVISION DATE

Old Idea!

1960 Vermillion River Telesope

New Technology - Cell phones & cheap computers.

Broad band low noise amplifiers for cellphones

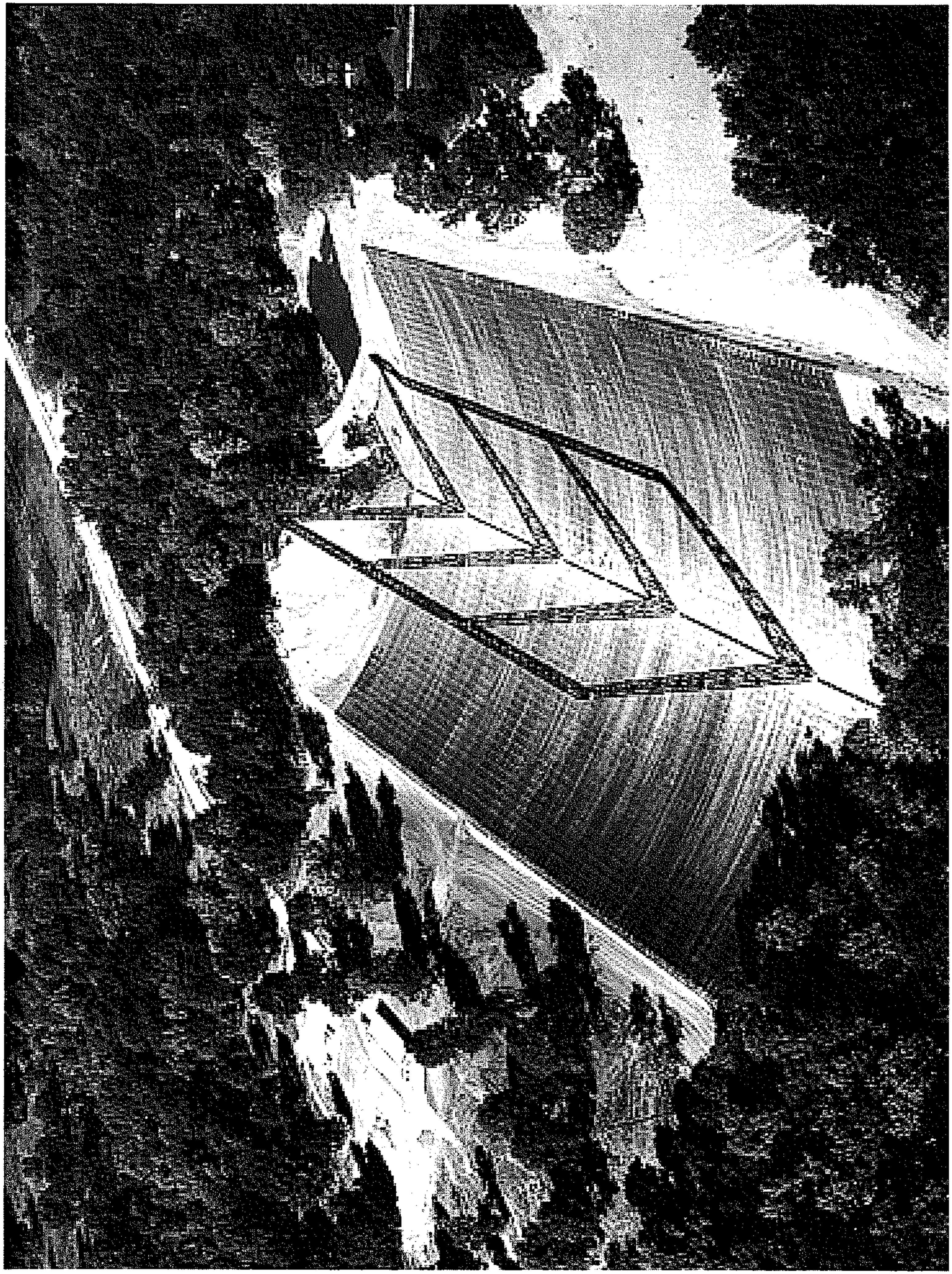
40K Noise Temp

10$ a piece

Beam Forming:

Either FPGA's or
GPU's

New Technology ⇒ We have the expertise!
Ground floor opportunity.



Surface Mount

Low Noise Amplifier

TAMP-960LN+

50Ω 824 to 960 MHz

CASE STYLE: JQ1382
PRICE: $9.95 ea. QTY (5-49)

+ RoHS compliant in accordance with EU Directive (2002/95/EC)

The +Suffix has been added in order to identify RoHS Compliance. See our web site for RoHS Compliance methodologies and qualifications.

Features

- Ultra low noise figure, 0.55 dB typ.
- High gain, 18 dB typ.
- Output power, up to +16.5 dBm typ.
- Low current consumption
- Excellent return loss
- Unconditionally stable

Applications

- Base transceiver station, tower mounted amplifier, repeater
- CDMA: 824 to 894 MHz
- GSM Rx: 880 to 915 MHz
- GSM Tx: 925 to 960 MHz
- General purpose low noise amplifier

Electrical Specifications at 25°C

Parameter	Condition (MHz)	Min.	Typ.	Max.	Units
Frequency Range		824		960	MHz
Noise Figure	824 - 960		0.55	0.80	dB
	824 - 894		0.60	0.80	
	880 - 915		0.55	0.70	
	925 - 960		0.55	0.70	
Gain	824 - 960	16.5	18.0		dB
	824 - 894	16.5	18.0		
	880 - 915	16.5	18.0		
	925 - 960	16.5	17.5		
Gain Flatness	824 - 960		± 0.6	± 1.2	dB
	824 - 894		± 0.4	± 0.8	
	880 - 915		± 0.2	± 0.4	
	925 - 960		± 0.2	± 0.4	
Output Power at 1dB compression	824 - 960	15.5	16.5		dBm
	824 - 894	15.5	16.5		
	880 - 915	15.5	16.5		
	925 - 960	15.5	16.5		
Output third order intercept point (OIP3)	824 - 960		30		dBm
	824 - 894		30		
	880 - 915		30		
	925 - 960		30		
Input VSWR	824 - 960		1.1		:1
	824 - 894		1.1		
	880 - 915		1.1		
	925 - 960		1.1		
Output VSWR	824 - 960		1.4		:1
	824 - 894		1.3		
	880 - 915		1.4		
	925 - 960		1.5		
DC Supply Voltage			5.0		V
Supply Current			40	45	mA

Pin Connections

RF IN	10
RF OUT	5
V+	7
GROUND	1,2,3,4,6,8,9,11

Maximum Ratings

Parameter	Ratings
Operating Temperature	-40°C to 85°C
Storage Temperature	-55°C to 100°C
Operating Voltage	5.5 V
Input RF Power (no damage)	+10 dBm
Power Consumption	250 mW

Permanent damage may occur if any of these limits are exceeded.

Mini-Circuits®
ISO 9001 ISO 14001 AS 9100 CERTIFIED
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661 The Design Engineers Search Engine Provides ACTUAL Data Instantly at minicircuits.com
IF/RF MICROWAVE COMPONENTS

For detailed performance specs & shopping online see web site

Notes: 1. Performance and quality attributes and conditions not expressly stated in this specification sheet are intended to be excluded and do not form a part of this specification sheet. 2. Electrical specifications and performance data contained herein are based on Mini-Circuit's applicable established test performance criteria and measurement instructions. 3. The parts covered by this specification sheet are subject to Mini-Circuits standard limited warranty and terms and conditions (collectively, "Standard Terms"); Purchasers of this part are entitled to the rights and benefits contained therein. For a full statement of the Standard Terms and the exclusive rights and remedies thereunder, please visit Mini-Circuits' website at www.minicircuits.com/MCLStore/terms.jsp.

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SUBJECT: Chalk Talk - 2D array Cost

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Survey Speed goes up with recievers

$$\frac{d}{\lambda} \approx .6$$

$$\lambda = .4\,m$$

$$L = 100\,m$$

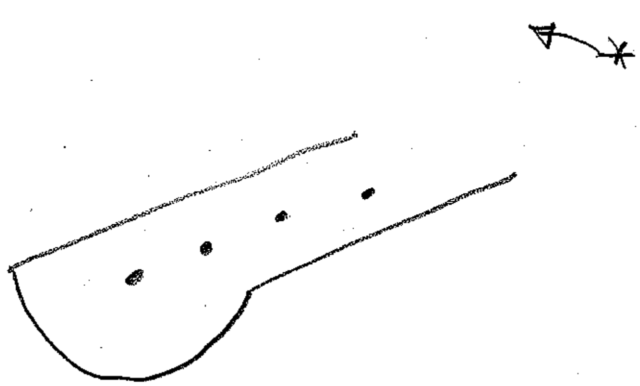
In one direction ≈ 400 recievers

In two directions $\approx 160{,}000$ recievers

Cost / reciever $\approx 3000\,\$$

$$\$3000 \times 160{,}000 = 480\,M\$ \;!!$$

Reduce cost (but increase survey time) by focussing in one direction



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SUBJECT: Chalk- Talk- Cylinders

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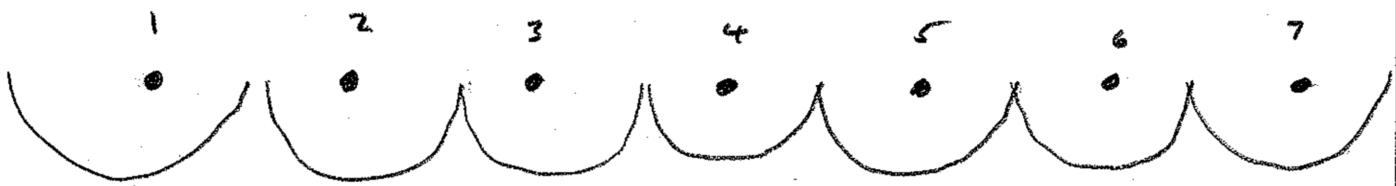
Reduce cost further by Drift scanning

*No moving parts

*Better stability

How Many Cylinders?

How to beam for between Cylinders?



Take an FFT beam from one cylinder and mult by another cylinder to make a "psuedo visibility"

$$\mathcal{V}_{12_K} (\quad V_{1_K} \cdot V_{2_K}^{*}$$

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SUBJECT	NAME	
Chalk Talk - Cylinder Visibility		
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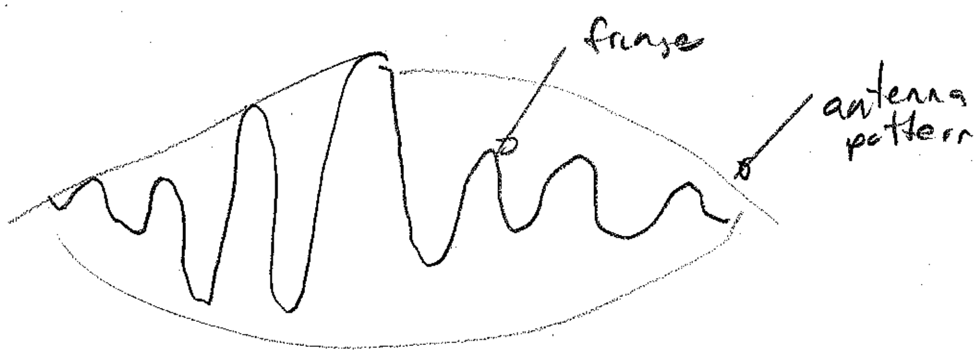
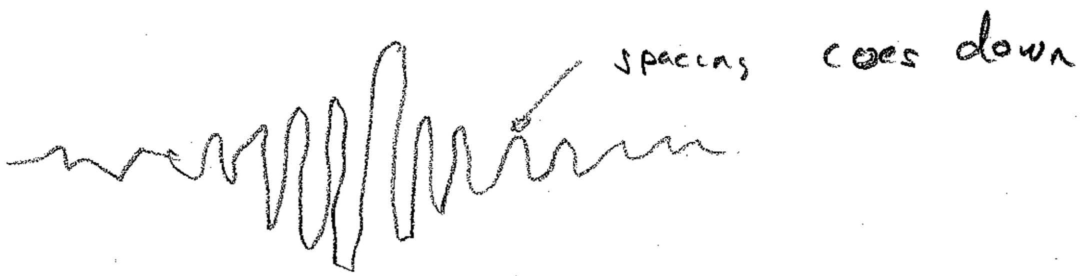
As a star passes over the cylinder



For a pair of cylinders twice as far apart



For a source that is a point function you need all the spatial sign-wave components.

A visibility can be thought of as spacial Fourier component of the source

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SUBJECT: Chalk Talk - Visibility Transform	NAME		DATE	REVISION DATE

For a cylinder The beam pattern Transverse to the cylinder is

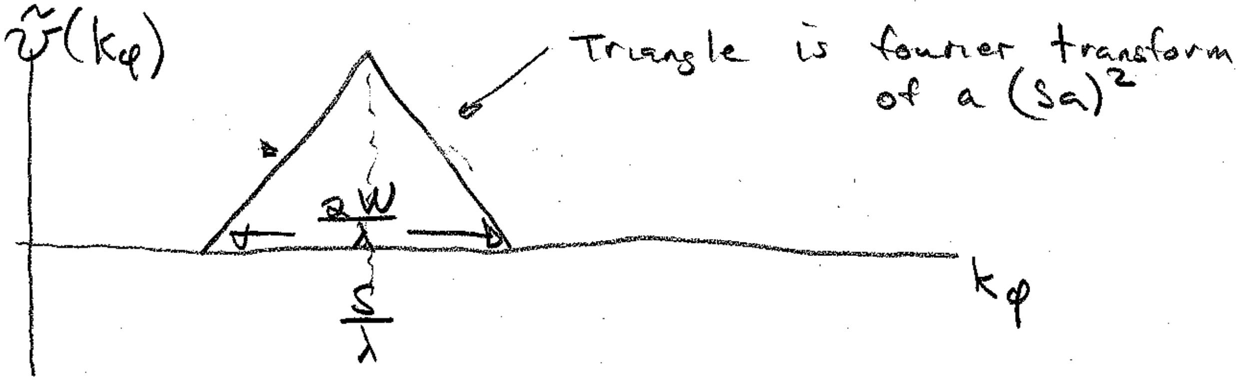
$$D(\phi) = Sa\left(\pi \frac{W}{\lambda} \phi\right)$$

cylinder width

For a pair of cylinders

$$v(\phi) = Sa\left(\pi \frac{W}{\lambda}\phi\right)^2 e^{j 2\pi \frac{s}{\lambda} \sin\phi}$$

$$\tilde{v}(k_\phi) = \int_{-\infty}^{\infty} v(\phi)\, e^{-j k_\phi \phi}\, d\phi$$



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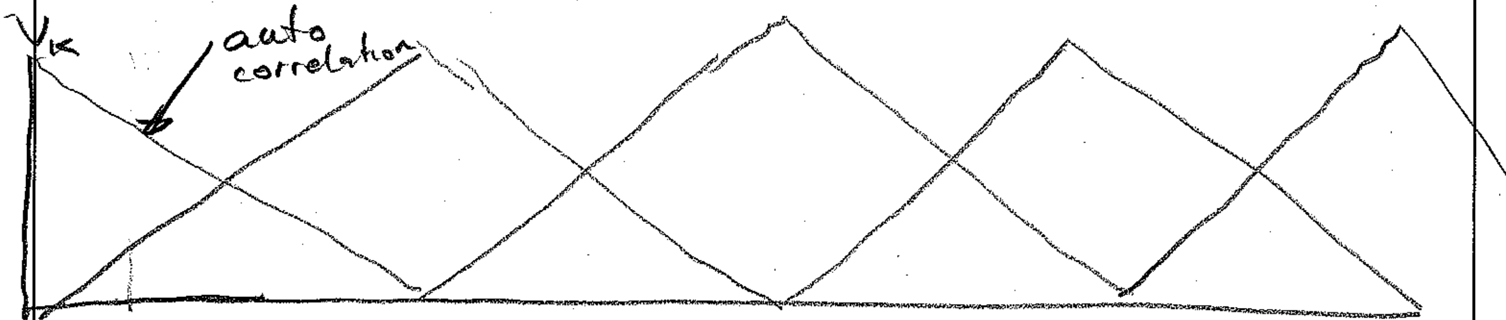
SUBJECT: Chalk Talk - baselines	NAME		DATE	REVISION DATE

Like to have an array of Cylinders so that



For example

1 2 3 4 5 6 7

⊙ ⊙ X X ⊙ X ⊙

For a coverage of 7 cylinders we need only 4 cylinders

$$N_{vis} = \frac{N(N-1)}{2} = \frac{4 \cdot 3}{2} = 6 \text{ baselines}$$

or 6 visibilities from 4 cylinders

To reach our goal 4 cylinders
20 m in width 100 m in length
5 M$ / Cylinder