# RDBE-G / R2DBE-G /DBEv5 Setup and Operations

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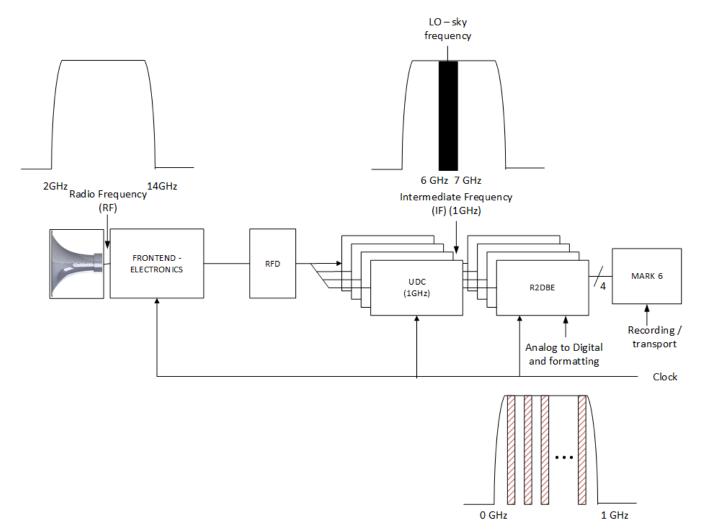


#### **Overview**

- Role of Haystack Digital Backends (DBEs)
- History of Haystack DBEs
- Capabilities
- State of operations
- Next steps
- General operational questions



#### **Role of Digital Backend (DBE)**





# **DBE Systems**

- VGOS systems consist of:
  - 1 DBE / band for both polarizations
    - 4 DBE's per signal chain
  - A Backend (BE) computer
- The DBEs are embedded systems
- BE computer
  - NFS mount computer for all DBE's
  - OS is Debian Stretch (EoL)
  - OS updated to Ubuntu
    - Expect the next 2 months it will be released for stations



# **Digital Backend**

- Receives two Intermediate Frequencies (IFs)
  - Horizontal and vertical polarization
  - Up to 1.5GHz of bandwidth from Up Down Converter
    - Based on filter installed
- Converts IF from analog to digital domain
- Filters the data thru poly phase filter bank
- Packetizes the data in VDIF format
  - With a timestamp
    - Integer second and frame count of when the data was received
  - Thread ID
- Transmit the packet over 10G Ethernet
  - IPv4/UDP/VTP



# **History of Haystack DBE's**

System	Input IF BW	Personality	Data Rates	Usage	VGOS Compliant
Vers. 1 – Ibob	512 MHz	DDC (Casper)	2 Gbps (real)	Astronomy	No
Vers. 2 - RDBE-H*	512 MHz	DDC / PFB (VHDL)	2   4 Gbps (Real)	Astronomy / Geodesy	No
Vers. 3 - RDBE-G	512 MHz	PFB (Casper)	2   4 Gbps (complex)	Geodesy	No
Vers. 4 - R2DBE-G	2 GHz	PFB (Casper)	2   4   8 Gbps (complex)	Geodesy	Yes
Vers. 5 – DBEv5	2.5 GHz	PFB (Casper) / ?	2  4   8   Gbps	Geodesy	Yes

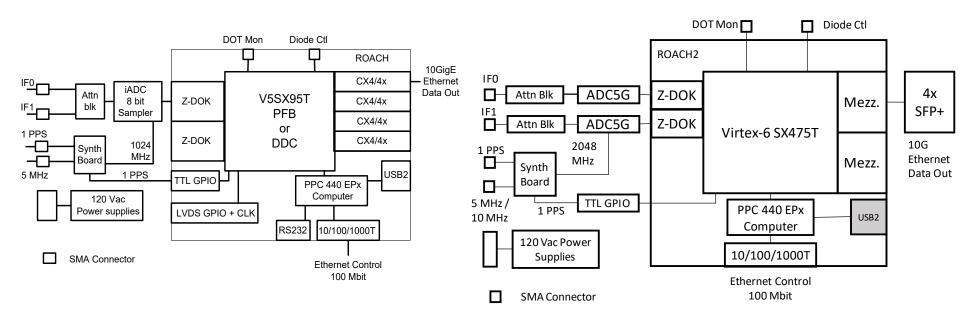
\* Joint project NRAO / Haystack



#### Block Diagram(s)

#### RDBE-G Block Diagram (Version 3)

#### R2DBE-G Block Diagram (Version 4)





#### **Overview**

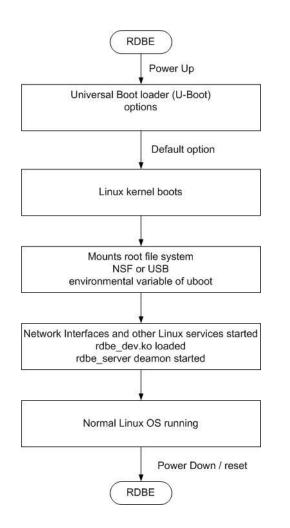
- RDBE-G was the 3<sup>rd</sup> Generation DBE system (Roach1 based unobtainium)
  - Emerged from a joint NRAO / MHO collaboration (Version 2)
  - Case, LCD display, attenuation, synthesizer board
  - CX4 10G Ethernet
- R2DBE-G is a 4<sup>th</sup> generation DBE (Roach2 based)
  - Leveraged from SAO's EHT system
    - ADC card initialization routine
  - Mezzanine board allows specification of 10G interface (SFP+)

System	Input IF BW	Output Channels <sup>1</sup>	Data Rates	Boot Options	VGOS Compliant
RDBE-G	512 MHz	16   32	2   4 Gbps (complex)	NFS, USB, SDRAM	No
R2DBE-G	2 GHz	16   32   64	2   4   8 Gbps (complex)	NFS	Yes

Note 1: Configuration of ½ the output channels per polarization for the total number of output channels



#### Bootup





#### • U-Boot options

- Environment variables defining what the boot loader will execute
  - location of the kernel in flash (address)
  - location of the root file system
    - USB
    - NFS
    - SDRAM
    - bootp
  - Network configuration
    - Static
    - Dynamic
- Details are beyond the scope of this talk
  - Detail documentation available if needed

# **Boot Up**

- RDBE
  - Boots from NFS, USB, SDRAM, bootp
  - rdbe\_server loads and configures the FPGA personality
- R2DBE
  - *Must* boot from NFS
  - katcp used to load personality and calibrate FPGA
    - Performed manually at present
    - Automated configuration is being developed
  - Load the personality and configure
    - Channel selection



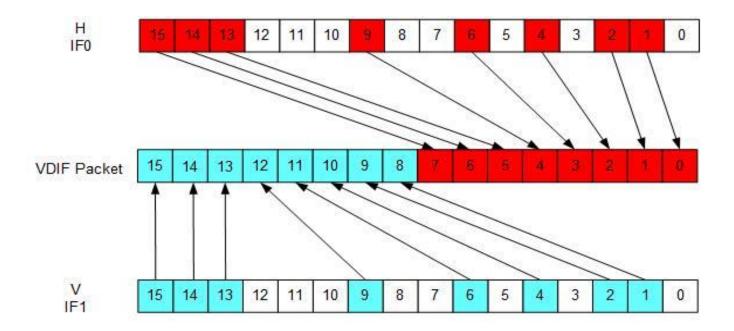
# **Operational Features**

- RDBE-G is a standalone system that boots into a known operation configuration
  - Communication to the outside world is enabled
  - NTP daemon started
  - FPGA loaded
  - Persistent configuration for:
    - Interfaces (10G, network stack)
    - VDIF headers are configured
  - DOT time is synchronized
  - Data is enabled
- PCFS configures
  - Channels and other observation dependent parameters
  - Enables multicast



#### **Legacy or RDBE-G Channel Output Configuration**

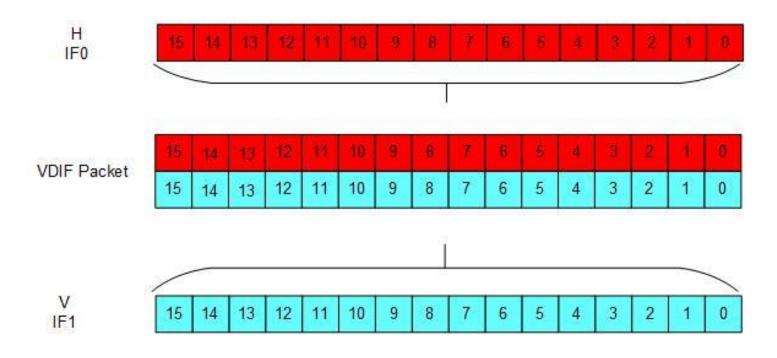
- 16 channels total / IF
- 2 Gbps data rate / DBE resulting in 8 Gbps aggregate per scan (4 DBE's)





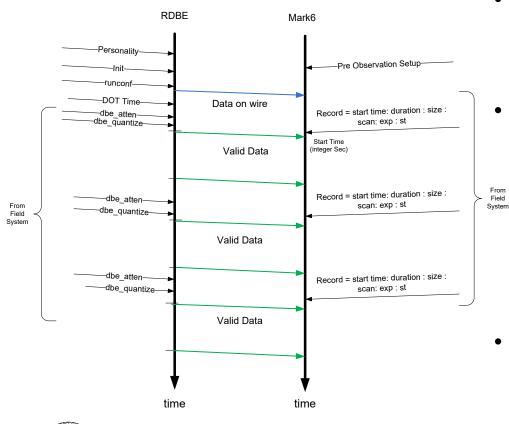
# Legacy 32 RDBE-G Channel Configuration

- Disabling channel select results in all channels selected
  - 16 channels total / IF
  - 4 Gbps data / RDBE-G resulting in 16 Gbps per scan





#### **RDBE-G Operation command / control flow**



- Loading the FPGA personality
  - Located where the root file system is mounted
  - /home/roach/personalities
- Initialization
  - Setting the FPGA registers
  - Setting the DOT time
    - system time
    - manually
  - Quantization
    - Formats the filter bank channels at 2 bits / sample
  - Monitoring capabilities
- Set for normal operations
  - Transmitting data out CX4 interface
  - Status / etc.

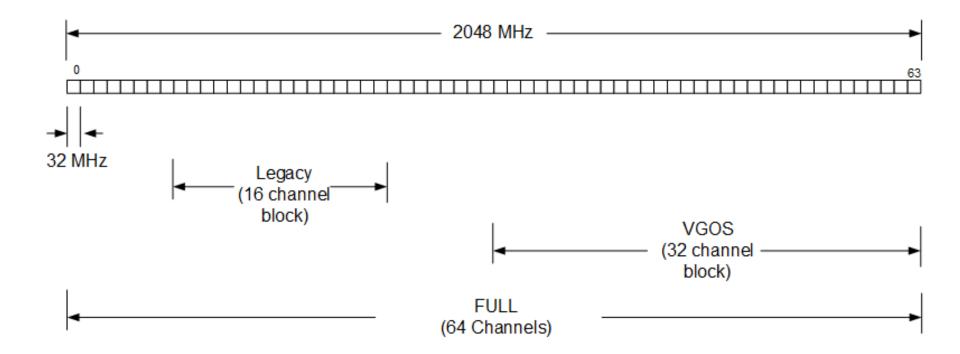


# **Operational Features**

- R2DBE-G
  - Communication to the outside world is enabled
  - NTP daemon started
  - Requires user interaction (a script executed)
    - Loading personality
    - Synchronization of the ADC's
    - Persistent configuration 10G interface and VDIF headers
  - PCFS configures
    - Channels and other observation dependent parameters
    - Enables multicast
  - All commands related to channel information return full 64 channels for IF
- VSI-S software interface to system
  - RDBE-G Command set -> 3.0
  - R2DBE-G Command set -> 1.1.1



#### **R2DBE-G Channel Configuration**





### **R2DBE Firmware**

- •1 Personality type (FPGA code)
  - Polyphase filter bank
    - Input is two 2048MHz BW IFs
    - Output selects 16/32/64 of 128 possible 32-MHz channels (2Gbps/4Gbps/8Gbps)
    - Output is a 8224 byte VDIF data format
    - Complex Data
      - Standard 32 byte header
    - eVLBI VTP protocol available



#### **Channel Selection Configuration**

4	Assignment of channels to VDIF packet by polarization in RDBE & R2DBE																	
H IFO		15	14	13	12	11	10	9	8	8 7 6 5 4 3 2 1 0		RDBE-G						
	IFU	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	R2DBE-G
													$\left  \right\rangle$					
VDIF	packet	15	14	13	12	11	10	9	8	7	6	5	4	З	2	1	0	
		Î	T	Ī														
v	IF1	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	R2DBE-G
<b>`</b>		15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	RDBE-G



Band D     Freq (MH:)     Freq (MH:)     (MH:)     Freq (MH:)     (MH:)<		Start Sky	Stop Sky	1st LO Freq	LO1 Synth	netLO					
MGO RDEE     102004     106804     311724     7773.1     9672.4       Westford RZDEE     102004     11208.4     32172.4     8003.1     9672.4       MGO RDEE (F filter 522-1038 MHz & ADC sampling at 024 MHz)     WF RZDEE (F filter 512-1336 MHz & ADC sampling at 4096 MHz       Ferg (MHz)     Son Sky     RDBE Storn IF (LSS) MHz     RDE Store Storn IF (LSS) MHz     RDE Storn IF (LSS) MHz <th>Band D</th> <th></th> <th></th> <th></th> <th>-</th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th>	Band D				-						
Westford R2DEE     12020-4     1120.8     3217.2     8903.1     9672.4     Wr R2DE     More The Second Se		ricq (iiiiz)	ricq (milz)	(11112)	ricq (itiliz)	(					
Westford R2DEE     12020-4     1120.8     3217.2     8903.1     9672.4     Wr R2DE     More The Second Se	MGO PDBE	10200 4	10680.4	31172 4	7793 1	9672.4					
MGO RDE (F filter 522-108 MHz & ADC sampling at 1024 MHz)     WF R2DE (F filter 512-155 MHz& ADC sampling at 4096 MHz     MUR R2DE (F filter 512-155 MHz& ADC sampling at 4096 MHz       IF     Stort Sty     Stop Sty     RDE Stort II     RDE Stort II     RDE FPB (ISB) MHz     R2DE Stort III     R2DE Stort IIII     R2DE Stort III     R2DE Stort III     R2DE Stort III     R2DE Stort III     R2DE Stort IIII     R2DE Stort IIIIII     R2DE Stort IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII											
IF     Start Sky Freq (MHz)     Stop Sky Freq (MHz)     RDBE Stort IF (LSB) MHz     RDBE Stort IF (LSB) MHz     RDBE Stort IF (LSB) MHz     RDBE Stort IF (LSB) MHz     R2DBE Stort IF (LSB) MHz     R2DBE Stort IF (LSB) MHz     R2DBE PFB Stort Sky Freq (MHz)     Stort Sky Freq (MHz)     Stort Sky (MHz)       H pol     0     10080.4     10080.4     10024     1008     0     10048     32     10680.4     10016.4       0     100643.4     10051.6.4     0754.4     944     2     944     2976     300     10661.6.4     10564.4       0     10552.4     10520.4     880     4     880     912     28     10552.4     10552.4       0     10520.4     10485.4     846     754     784     816     25     10456.4     10456.4       0     10456.4     10442.4     774     752     6     752     774     24     10424.4     10444.4       0     10392.4     10392.4     752     750     9     720     752     23     10392.4     10424.4     10444.4 <	Westiona R2DDL	10200.4	11200.4	52172.4	0045.1	5072.4					
IF     Start Sky Freq (MHz)     Stop Sky Freq (MHz)     RDBE Stort IF (LSB) MHz     RDBE Stort IF (LSB) MHz     RDBE Stort IF (LSB) MHz     RDBE Stort IF (LSB) MHz     R2DBE Stort IF (LSB) MHz     R2DBE Stort IF (LSB) MHz     R2DBE PFB Stort Sky Freq (MHz)     Stort Sky Freq (MHz)     Stort Sky (MHz)       H pol     0     10080.4     10080.4     10024     1008     0     10048     32     10680.4     10016.4       0     100643.4     10051.6.4     0754.4     944     2     944     2976     300     10661.6.4     10564.4       0     10552.4     10520.4     880     4     880     912     28     10552.4     10552.4       0     10520.4     10485.4     846     754     784     816     25     10456.4     10456.4       0     10456.4     10442.4     774     752     6     752     774     24     10424.4     10444.4       0     10392.4     10392.4     752     750     9     720     752     23     10392.4     10424.4     10444.4 <			(IE filter 528-	1008 MH7 & AF	C compling at 1	024 MHz)	WER2DRE (II	E filtor 512-1	536 MH78 A	DC sampling	at 4096 MHz)
IF     Stor Sky Freq (MHz)     Stor Sky Freq (MHz)     RDBE stor II (LSB) MHz     Channel (LSB) MHz     Stop III (LSB) MHz     Stop IIII (LSB) MHz     Stop IIII (LSB) MHz     Stop IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII		NIGO KODE	. (ir inter 520-		ve sampling at 1	024 10112)	WT K2DDE (II	mer Jiz-i	550 Will20 A	DC samping	at 4050 Will2)
IP     Freq (MHz)     Freq (MHz)     (LSB) MHz     Channel Select     Solor IF     Optional USB) MHz     Solor IF     Optional USB)     Optional USB) <thoptional< td=""><td></td><td>Charles Class</td><td>Charles Charl</td><td></td><td></td><td>RDBE PFB</td><td></td><td>R2DBE</td><td>R2DBE PFB</td><td>Chart Class</td><td>Charles Class Free</td></thoptional<>		Charles Class	Charles Charl			RDBE PFB		R2DBE	R2DBE PFB	Chart Class	Charles Class Free
Hor     Select     User     Select     User     Select     User     Select     User     User       0     10680.4     10668.4     10668.4     1008     276     1     276     1008     33     10648.4     10668.4       0     10648.4     10581.4     976     39     1051.6     10680.4     1052.4     10580.4     10580.4     10552.4     10580.4     10552.4     10580.4     10552.4     10580.4     10552.4     10580.4     10552.4     10580.4     10552.4     10580.4     10552.4     10488.4     10560.4     10580.4     10580.4     10580.4     10580.4     10580.4     10580.4     10580.4     10580.4     10580.4     10580.4     10580.4     10580.4     10680.	IF					Channel		Stop IF	Channel		
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$		Freq (IVIHZ)	Freq (IVIHZ)	(LSB) IVIHZ	(LSB) IVIHZ	Select	IF (USB) MHZ	(USB) MHz	Select	Freq (IVIHZ)	(IVIHZ)
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	H pol 0	10696.4	10680.4	1024	1008	0	1008	1040	32	10680.4	10712.4
0   10648.4   10616.4   10584.4   944   912   3   914   976   30   10616.4   10684.   10656.   10584.4   10582.4   912   880   44   880   912   28   10582.4   10482.4   10482.4   10482.4   10482.4   10482.4   10482.4   10482.4   10482.4   10482.4   10482.4   10482.4   10482.4   10382.4   10382.4   10382.4   10382.4   10382.4   10382.4   10382.4   10282.4   10						1					
0   10616.4   10584.4   1944   912   3   912   944   29   1058.4   10552.4     0   10552.4   10552.4   1052.0.4   1058.0.4   10552.0   10552.0.4   10552.0.4   10552.0.4   10552.0.4   10552.0.4   10552.0.4   10552.0.4   10552.0.4   10552.0.4   10552.0.4   10552.0.4   10552.0.4   10552.0.4   10552.0.4   10552.0.4   10552.0.4   10552.0.4   10552.0.4   10552.0.4   1052.0.4   10456.4   10456.4   1052.0.4   1042.0.4						2					
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$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$											10520.4
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	C	10488.4	10456.4	816	784	7	784	816	25	10456.4	10488.4
0   10392.4   10360.4   720   668   10   668   720   22   10360.4   10392     0   10328.4   10328.4   656   621   1656   668   21   10328.4   10392     0   10238.4   10296.4   624   522   13   592   624   19   10296.4   10296.4     0   10264.4   10223.4   500   550   14   560   592   18   10238.4   10200.4   10232.4     0   10224.4   10200.4   560   528   15   528   560   17   10200.4   10232.4     TH-pol RDE Channel 0 & corresponding R2DE channel 32 are not used due to RDBE FPBr0 being only halfband     MOR ORDE (IF filter 528-108 MHz & ADC sampling at 324 MHz)   Vf R2DE (IF filter 512-153 CMHz & ADC sampling at 324 MHz)   Vf R2DE (IF filter 512-153 CMHz & ADC sampling at 324 MHz)   Vf R2DE (IF filter 512-153 CMHz & ADC sampling at 324 MHz)   Vf R2DE (IF filter 512-153 CMHz & ADC sampling at 324 MHz)   Vf R2DE (IF filter 512-153 CMHz & ADC sampling at 324 MHz)   Vf R2DE (IF filter 512-153 CMHz & ADC sampling at 324 MHz)   Vf R2DE (IF filter 512-153 CMHz & ADC sampling at 324 MHz)   Vf R2DE IF filter 512-153 CMHz & ADC sampling at 324 MHz)<	C	10456.4	10424.4	784	752	8	752	784	24	10424.4	10456.4
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	C	10424.4	10392.4	752	720	9	720	752	23	10392.4	10424.4
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	C	10392.4	10360.4	720	688	10	688	720	22	10360.4	10392.4
0   10264.4   10264.4   624   592   13   592   624   19   10264.4   10296.4     0   10232.4   10232.4   592   560   14   560   592   18   10232.4   10200.4   10232.4     The 3 channels selected for VGOS correlation are accented by color     The 3 chancels selected for VGOS correlation are accented by color     MGO RDEE (IF filter 528-1008 MHz & ADC sampling at 124 MHz)   Wf R2DEE (IF filter 512-1536 MHz& ADC sampling at 4096 MHz     Start Sky Freq (MHz)   Stop Sky Freq (MHz)   RDBE start IF (LSB) MHz   RDBE stop IF (LSB) MHz   RDBE stop IF (LSB) MHz   R2DE Start Stop IF (USB) MHz   R2DE Start Sky Stop IF (USB) MHz   Start Sky Stop Sky Freq (MHz)   Start Sky Freq (MHz)   Stort Sky Freq (MHz)   Stop Sky Freq (MHz)   R0BE start IF (LSB) MHz   R2DE Start Stop IF   R2DE Start Stop IF   R2DE Start Stop IF   R2DE Start Sky Stop Sky Freq (MHz)   Stop Sky Freq (MHz	C	10360.4	10328.4	688	656	11	656	688	21	10328.4	10360.4
0   10264.4   10232.4   502   560   14   560   592   18   10232.4   10264.4     0   10232.4   10200.4   560   528   15   528   560   17   10200.4   10232.4     THE of RDBE Channel 0.8: corresponding R2DBE channel 32 are not used use to RDBE PFBHO being only halfband     MGO RDBE (IF filter 528.1008 MHz & ADC sampling at 1024 MHz)   Wf R2DBE (IF filter 521.553 MHz& ADC sampling at 1024 MHz)   Wf R2DBE (IF filter 521.553 MHz& ADC sampling at 1024 MHz)   Wf R2DBE (IF filter 521.553 MHz& ADC sampling at 1024 MHz)   Wf R2DBE (IF filter 521.553 MHz& ADC sampling at 1024 MHz)   Kop Sky   Freq (MHz)   Freq (MHz)   RDBE Start IF   RDBE Star IF   RDBE FFE   R2DBE Star   R2DBE Star   Start Sky   Start Sky   Star Sky   MKp Sky   RDBE Star IF   RDBE Star IF   RDBE Star IF   Fig. (USB) MHz   Start Sky	C	10328.4	10296.4	656	624	12	624	656	20	10296.4	10328.4
0   10232.4   10200.4   560   528   15   528   560   17   10200.4   10232.4     Interplay of the selected for VGOS correlation are accented by color     *H-pol ROBE (IF filter 528-1008 MHz & ADC sampling at 1024 MHz)   Wf R2DBE (IF filter 512-158 MHz & DC sampling at 4096 MHz     MGO ROBE   (IF filter 528-1008 MHz & ADC sampling at 1024 MHz)   Wf R2DBE (IF filter 512-158 MHz & DC sampling at 4096 MHz     IF   Start Sky Freq (MHz)   Stop Sky Freq (MHz)   RDBE Stort IF (LSB) MHz   RDBE Stop IF (LSB) MHz   R2DBE Start IF (USB) MHz   R2DBE Start (USB) MHz   R2DBE Start (USB) MHz   R2DBE Start (USB) MHz   R2DBE Start IF (USB) MHz   R2DBE Start (LSB) MHz   R2DBE Start (USB) MHz   R2DBE Start IF (USB) M	C	10296.4	10264.4	624	592	13	592	624	19	10264.4	10296.4
The 8 channels selected for VGOS correlation are accented by color       *H-pol RDBE Channel 0.8 corresponding R2DBE channel 32 are not used due to RDBE PFB#0 being only halfbain       MGO RDBE (IF filter 528-1008 MHz & ADC sampling at 1024 MHz)     Wf R2DBE (IF filter 512-1536 MHz& ADC sampling at 4096 MHz       Start Sky     Stor Sky     RDBE Start IF     RDBE Stor IF     RDBE Stor IF     R2DBE Start     R2DBE Start     R2DBE Start     Stor Sky     Start Sky     Stor Sky     Freq (MHz)     Stor Sky     RDBE Start IF     RDBE Stor IF     RDBE Stor IF     R2DBE Start     R2DBE Start     R2DBE Start     Stor Sky     Start Sky     Stor Sky <t< td=""><td>C</td><td>10264.4</td><td>10232.4</td><td>592</td><td>560</td><td>14</td><td>560</td><td>592</td><td>18</td><td>10232.4</td><td>10264.4</td></t<>	C	10264.4	10232.4	592	560	14	560	592	18	10232.4	10264.4
"H-pol RDBE Channel 0.8 corresponding R2DBE channel 32 are not used due to RDBE PFB/D being only halfbard     MGO RDBE (IF filter 528-1008 MHz & ADC sampling at 1024 MHz)   V R2DBE (IF filter 512-15-36 MHz&ADC sampling at 4096 MHz     IF   Start Sky Freq (MHz)   Stop Sky Freq (MHz)   RDBE Start IF (LSB) MHz   RDBE Stop IF (LSB) MHz<	C	10232.4	10200.4	560	528	15	528	560	17	10200.4	10232.4
MGO RDBE (IF filter 528-1008 MHz & ADC sampling at 1024 MHz)   Wf R2DBE (IF filter 512-136 MHz& ADC sampling at 4096 MHz     IF   Start Sky   Stop Sky   RDBE Start If   RDBE Start I(LSB) MHz   RDBE Start I(LSB) MHz   RDBE Start IF			Th	e 8 channels se	lected for VGOS	correlation a	re accented by	color			
IF   Start Sky Freq (MHz)   Stop Sky Freq (MHz)   RDBE Start IF (LSB) MHz   RDE Start IF (LSB) MHz   RDE Start IF (LSB) MHz   RDE Start IF (LSB) MHz   RDE Start IF (LSB)		*H-pol RDE	BE Channel 0 8	corresponding	R2DBE channel	32 are not us	ed due to RDB	E PFB#0 bein	g only halfba	nd	
IF     Stop Sky Freq (MHz)     Stop Sky Freq (MHz)     RDBE Start IP (LSB) MHz     RDBE Stor IF (LSB) MHz     R2DBE Start F(USB) MHz     Stop IF (USB) MHz     Channel Select     Start Sky Freq (MHz)		MGO RDBE	IF filter 528-	1008 MHz & Al	OC sampling at 1	.024 MHz)	Wf R2DBE (II	F filter 512-1	536 MHz& A	DC sampling	at 4096 MHz)
IF     Stop Sky Freq (MHz)     Stop Sky Freq (MHz)     RDBE Start IP (LSB) MHz     RDBE Stor IF (LSB) MHz     R2DBE Start F(USB) MHz     Stop IF (USB) MHz     Channel Select     Start Sky Freq (MHz)								02005	02005 050		
Freq (MHz)     Freq (MHz)     (LSB) MHz     (LSB) MHz     Select     IF (USB) MHz     (USB) MHz     Select     Freq (MHz)     (MHz) <td>15</td> <td>Start Sky</td> <td>Stop Sky</td> <td>RDBE Start IF</td> <td>RDBE Stop IF</td> <td></td> <td>R2DBE Start</td> <td></td> <td></td> <td>Start Sky</td> <td>Stop Sky Fre</td>	15	Start Sky	Stop Sky	RDBE Start IF	RDBE Stop IF		R2DBE Start			Start Sky	Stop Sky Fre
V pol   1   10696.4   10680.4   1024   1008   0   1008   1040   96   10680.4   10712     1   10680.4   10648.4   1008   976   1   976   1008   95   10648.4   10669.4     1   10648.4   10616.4   976   944   2   944   976   94   10616.4   10648.4     1   10616.4   10584.4   944   912   3   912   944   93   10584.4   10616.4   10648.4     1   10552.4   1052.4   912   880   4   880   912   92   10552.4   10584.4     1   10552.4   1052.0.4   880   848   5   848   880   91   1052.0.4   10552.4     1   10520.4   10488.4   848   816   6   816   848   90   10488.4   10550.4   10552.4     1   10520.4   10488.4   848   816   6   816   848   90   10488.4   10550.4   10552.4     1	IF	Freq (MHz)	Freq (MHz)	(LSB) MHz	(LSB) MHz		IF (USB) MHz			Freq (MHz)	(MHz)
1   10680.4   10648.4   1008   976   1   976   1008   95   10648.4   10680.4     1   10648.4   10616.4   976   944   2   944   976   94   10616.4   10648.4     1   10616.4   10584.4   912   3   912   944   93   10584.4   10616.4     1   10584.4   10552.4   912   880   4   880   912   92   10552.4   10584.4     1   10552.4   10520.4   880   848   5   848   880   91   10520.4   10520.4     1   10520.4   10488.4   848   816   6   816   848   90   10488.4   10520.4     1   10426.4   10424.4   784   752   8   752   784   88   10424.4   10456.4     1   10424.4   10392.4   752   720   9   720   752   87   10392.4   10424.4     1   10324.4   10360.4   720   688   10266.4						Select		(USB) MHZ	Select		
1   10648.4   10616.4   976   944   2   944   976   94   10616.4   10648.4     1   10616.4   10584.4   944   912   3   912   944   93   10584.4   10616.4     1   10584.4   10552.4   912   880   4   880   912   92   10552.4   10584.4     1   10552.4   10552.4   912   880   4   880   912   92   10552.4   10584.4     1   10552.4   10520.4   880   848   5   848   80   91   10520.4   10584.4     1   10520.4   10488.4   848   816   6   816   848   91   10520.4   10520.4     1   10488.4   10456.4   816   784   7   784   816   89   10456.4   10488.4     1   10456.4   10424.4   752   720   9   720   752   87   10392.4   10424.4   10456.4     1   10426.4   10328.4   688 <td< td=""><td>V pol 1</td><td></td><td></td><td></td><td></td><td></td><td></td><td>· · ·</td><td></td><td></td><td></td></td<>	V pol 1							· · ·			
1   10616.4   10584.4   944   912   3   912   944   93   10584.4   10616.4     1   10584.4   10552.4   912   880   4   880   912   92   10520.4   10584.4     1   10552.4   10520.4   880   848   5   848   880   91   10520.4   10520.4   10520.4     1   10520.4   10488.4   848   816   6   816   848   90   10488.4   10552.4   10520.4     1   10520.4   10488.4   848   816   6   816   848   90   10488.4   10552.4   10520.4   10552.4     1   10420.4   10488.4   848   816   6   816   848   90   10488.4   10052.4   10456.4   10488.4   10052.4   10488.4   100456.4   10488.4   100456.4   10488.4   10042.4   10424.4   10456.4   10424.4   10424.4   10424.4   10424.4   10424.4   10424.4   10424.4   10424.4   10424.4   10424.4   10424.4	-	10696.4	10680.4	1024	1008	0	1008	1040	96	10680.4	10712.4
1   10584.4   10552.4   912   880   4   880   912   92   10552.4   10584.4     1   10552.4   10520.4   880   848   5   848   880   91   10520.4   10552.4     1   10520.4   10520.4   880   848   5   848   880   91   10520.4   10552.4     1   10520.4   10488.4   848   816   6   816   848   90   10488.4   10550.4     1   10488.4   10456.4   816   784   7   784   816   89   10448.4   10488.4     1   10456.4   10424.4   784   752   8   752   784   88   10424.4   10486.4     1   10424.4   10392.4   752   720   9   720   752   87   10392.4   10424.4     1   10392.4   10360.4   720   688   10   688   720   86   10360.4   10392.4     1   10392.4   10264.4   688   656   1	1										1
1   10552.4   10520.4   880   848   5   848   880   91   10520.4   10520.4     1   10520.4   10488.4   848   816   6   816   848   90   10488.4   10520.4     1   10488.4   10456.4   816   784   7   784   816   89   10456.4   10488.4     1   10456.4   10424.4   784   752   8   752   784   88   10424.4   10456.4     1   10424.4   10392.4   752   720   9   720   752   87   10392.4   10424.4     1   10320.4   10360.4   720   688   100   688   720   86   10360.4   10392.4     1   10360.4   10328.4   688   656   11   656   688   85   10328.4   10360.4     1   10328.4   10296.4   624   592   13   592   624   83   10264.4   10296.4     1   10264.4   10224.4   592   50 <td< td=""><td></td><td>10680.4</td><td>10648.4</td><td>1008</td><td>976</td><td>1</td><td>976</td><td>1008</td><td>95</td><td>10648.4</td><td>10712.4 10680.4 10648.4</td></td<>		10680.4	10648.4	1008	976	1	976	1008	95	10648.4	10712.4 10680.4 10648.4
1   10520.4   10488.4   848   816   6   816   848   90   10488.4   10520.4     1   10488.4   10456.4   816   784   7   784   816   89   10456.4   10488.4     1   10456.4   10424.4   784   752   8   752   784   88   10424.4   10456.4     1   10424.4   10392.4   10392.4   752   720   9   720   752   87   10392.4   10424.4     1   10424.4   10392.4   752   720   9   720   752   87   10392.4   10424.4     1   10392.4   10360.4   720   688   10   688   720   86   10360.4   10392.4     1   10360.4   10328.4   688   656   11   656   688   85   10328.4   10360.4     1   10328.4   10264.4   624   592   13   592   624   83   10264.4   10296.4     1   10264.4   10224.4   592	1	10680.4 10648.4	10648.4 10616.4	1008 976	976 944	1 2	976 944	1008 976	95 94	10648.4 10616.4	10680.4
1   10488.4   10456.4   816   784   7   784   816   89   10456.4   10488.4     1   10456.4   10424.4   784   752   8   752   784   88   10424.4   10456.4     1   10424.4   10392.4   752   720   9   720   752   87   10392.4   10424.4     1   10392.4   10392.4   10392.4   700   688   700   86   10392.4   10424.4     1   10392.4   10392.4   10380.4   720   688   100   688   700   86   10360.4   10392.4     1   10360.4   10328.4   688   656   11   656   688   85   10380.4   10390.4     1   10328.4   10264.4   624   592   13   592   624   83   10264.4   10296.4     1   10264.4   10224.4   592   560   14   560   81   10204.4   10296.4     1   10232.4   10202.4   592   528   560 <td>1 1</td> <td>10680.4 10648.4 10616.4</td> <td>10648.4 10616.4 10584.4</td> <td>1008 976 944</td> <td>976 944 912</td> <td>1 2 3</td> <td>976 944 912</td> <td>1008 976 944</td> <td>95 94 93</td> <td>10648.4 10616.4 10584.4</td> <td>10680.4 10648.4 10616.4</td>	1 1	10680.4 10648.4 10616.4	10648.4 10616.4 10584.4	1008 976 944	976 944 912	1 2 3	976 944 912	1008 976 944	95 94 93	10648.4 10616.4 10584.4	10680.4 10648.4 10616.4
1   10456.4   10424.4   784   752   8   752   784   88   10424.4   10456.4     1   10424.4   10392.4   752   720   9   720   752   87   10392.4   10424.4     1   10392.4   10360.4   720   688   10   688   720   86   10360.4   10392.4     1   10360.4   10360.4   10320.4   688   6656   11   656   688   85   10328.4   10360.4   10392.4     1   10328.4   10296.4   656   624   12   624   656   84   10296.4   10328.4   10328.4     1   10296.4   10264.4   624   592   13   592   624   83   10264.4   10296.4     1   10264.4   10232.4   592   560   14   560   592   82   10232.4   10264.4     1   10232.4   10202.4   560   528   560   81   10202.4   10232.4     1   10232.4   10202.4   5	1 1 1	10680.4 10648.4 10616.4 10584.4	10648.4 10616.4 10584.4 10552.4	1008 976 944 912	976 944 912 880	1 2 3 4	976 944 912 880	1008 976 944 912	95 94 93 92	10648.4 10616.4 10584.4 10552.4	10680.4 10648.4
1   10424.4   10392.4   752   720   9   720   752   87   10392.4   10424.4     1   10392.4   10360.4   720   688   10   688   720   86   10360.4   10392.4     1   10360.4   10328.4   688   656   11   656   688   85   10328.4   10360.4     1   10328.4   10296.4   656   624   12   624   656   84   10296.4   10328.8     1   10296.4   10264.4   624   592   13   592   624   83   10264.4   10296.4     1   10264.4   10232.4   592   560   14   560   592   82   10232.4   10264.4     1   10232.4   10200.4   560   528   15   528   560   81   10200.4   10232.4	1 1 1 1	10680.4 10648.4 10616.4 10584.4 10552.4	10648.4 10616.4 10584.4 10552.4 10520.4	1008 976 944 912 880	976 944 912 880 848	1 2 3 4 5	976 944 912 880 848	1008 976 944 912 880	95 94 93 92 91	10648.4 10616.4 10584.4 10552.4 10520.4	10680. 10648. 10616. 10584.
1   10392.4   10360.4   720   688   10   688   720   86   10360.4   10392.4     1   10360.4   10328.4   688   656   11   656   688   85   10328.4   10360.4     1   10328.4   10296.4   656   624   12   624   656   84   10296.4   10328.4     1   10296.4   10264.4   624   592   13   592   624   83   10264.4   10296.4     1   10264.4   10232.4   592   560   14   560   592   82   10232.4   10264.4     1   10232.4   10200.4   560   528   15   528   560   81   10200.4   10232.4         10232.4   10200.4   10232.4        5528   560   81   10200.4   10232.4         5528   560   81   10200.4   10232.4 <td>1 1 1 1 1</td> <td>10680.4 10648.4 10616.4 10584.4 10552.4 10520.4</td> <td>10648.4 10616.4 10584.4 10552.4 10520.4 10488.4</td> <td>1008 976 944 912 880 848</td> <td>976 944 912 880 848 816 784</td> <td>1 2 3 4 5 6 7</td> <td>976 944 912 880 848 816 784</td> <td>1008 976 944 912 880 848</td> <td>95 94 93 92 91 90</td> <td>10648.4 10616.4 10584.4 10552.4 10520.4 10488.4</td> <td>10680. 10648. 10616. 10584. 10552. 10552.</td>	1 1 1 1 1	10680.4 10648.4 10616.4 10584.4 10552.4 10520.4	10648.4 10616.4 10584.4 10552.4 10520.4 10488.4	1008 976 944 912 880 848	976 944 912 880 848 816 784	1 2 3 4 5 6 7	976 944 912 880 848 816 784	1008 976 944 912 880 848	95 94 93 92 91 90	10648.4 10616.4 10584.4 10552.4 10520.4 10488.4	10680. 10648. 10616. 10584. 10552. 10552.
1   10360.4   10328.4   688   656   11   656   688   85   10328.4   10360.4     1   10328.4   10296.4   656   624   12   624   656   84   10296.4   10328.4   10296.4	1 1 1 1 1 1 1 1	10680.4 10648.4 10516.4 10552.4 10552.4 10520.4 10488.4 10456.4	10648.4 10616.4 10584.4 10552.4 10520.4 10488.4 10456.4 10424.4	1008 976 944 912 880 848 816 784	976 944 912 880 848 816 784 752	1 2 3 4 5 6 7 8	976 944 912 880 848 816 784 752	1008 976 944 912 880 848 816 784	95 94 93 92 91 90 89 88	10648.4 10616.4 10584.4 10552.4 10520.4 10488.4 10456.4 10424.4	10680. 10648. 10616. 10584. 10552. 10552. 10520. 10488.
1     10328.4     10296.4     656     624     12     624     656     84     10296.4     10328.4       1     10296.4     10264.4     624     592     13     592     624     83     10264.4     10296.4       1     10264.4     10232.4     592     560     14     560     592     82     10232.4     10264.4       1     10232.4     10200.4     560     528     15     528     560     81     10200.4     10232.4	1 1 1 1 1 1 1 1 1 1 1	10680.4 10648.4 10616.4 10552.4 10552.4 10520.4 10488.4 10456.4 10424.4	10648.4 10616.4 10584.4 10552.4 10520.4 10488.4 10456.4 10424.4	1008 976 944 912 880 848 816 784	976 944 912 880 848 816 784 752	1 2 3 4 5 6 7 8	976 944 912 880 848 816 784 752 720	1008 976 944 912 880 848 816 784	95 94 93 92 91 90 89 88	10648.4 10616.4 10584.4 10552.4 10520.4 10488.4 10456.4 10424.4	10680. 10648. 10616. 10584. 10552. 10520. 10520. 10488. 10456.
1   10296.4   10264.4   624   592   13   592   624   83   10264.4   10296.4     1   10264.4   10232.4   592   560   14   560   592   82   10232.4   10264.4     1   10232.4   10200.4   560   528   15   528   560   81   10200.4   10232.4     The 8 channels selected for VGOS correlation are accented by color	1 1 1 1 1 1 1 1 1 1 1	10680.4 10648.4 10548.4 10552.4 10520.4 10488.4 10456.4 10456.4 10424.4	10648.4 10616.4 10584.4 10552.4 10520.4 10488.4 10488.4 10456.4 10424.4 10392.4	1008 976 944 912 880 848 816 784 752	976 944 912 880 848 816 784 752 720	1 2 3 4 5 6 7 7 8 9	976 944 912 880 848 816 784 752 720	1008 976 944 912 880 848 816 784 752	95 94 93 92 91 90 89 88 88 87	10648.4 10616.4 10584.4 10552.4 10520.4 10488.4 10456.4 10456.4 10424.4	10680. 10648. 10616. 10584. 10552. 10520. 10488. 10456. 10424.
1     10264.4     10232.4     592     560     14     560     592     82     10232.4     10264.4       1     10232.4     10200.4     560     528     15     528     560     81     10200.4     10232.4       The 8 channels selected for VGOS correlation are accented by color	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	10680.4 10648.4 10616.4 10582.4 10552.4 10520.4 10488.4 10456.4 10424.4 10392.4 10360.4	10648.4 10616.4 10584.4 10552.4 10488.4 10488.4 10456.4 10449.4 10392.4 10360.4	1008 976 944 912 880 848 816 784 752 720	976 944 912 880 848 816 784 752 720 688	1 2 3 4 5 6 7 7 8 9 9 10	976 944 912 880 880 848 816 784 752 720 688 656	1008 976 944 912 880 848 816 784 752 720	95 94 93 92 91 90 89 88 88 87 88	10648.4 10616.4 10584.4 10552.4 10520.4 10488.4 10456.4 104456.4 10392.4 10392.4	10680. 10648. 10616. 10584. 10552. 10520. 10488. 10456. 10424. 10392.
1     10232.4     10200.4     560     528     15     528     560     81     10200.4     10232.4       The 8 channels selected for VGOS correlation are accented by color	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	10680.4 10648.4 10516.4 10552.4 10552.4 10488.4 10456.4 10424.4 10392.4 10392.4 10360.4	10648.4 10616.4 10584.4 10552.4 10520.4 10488.4 10456.4 10426.4 10392.4 10360.4	1008 976 944 912 880 848 816 784 752 720 688 656	976 944 912 880 848 816 784 752 720 688 656 654	1 2 3 4 5 6 7 7 8 9 10 11 11 12	976 944 912 880 848 816 784 752 720 688 656 624	1008 976 944 912 880 848 816 784 772 720 688	95 94 93 92 91 90 89 88 87 88 87 86 85 85 84	10648.4 10616.4 10584.4 10552.4 10520.4 10488.4 10456.4 10424.4 10392.4 10360.4	10680. 10648. 10548. 10584. 10552. 10520. 10488. 10456. 10424. 10392. 10360.
The 8 channels selected for VGOS correlation are accented by color	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	10680.4 10648.4 10516.4 10552.4 10552.4 10488.4 10456.4 10424.4 10392.4 10392.4 10360.4	10648.4 10584.4 10584.4 10552.4 10520.4 10488.4 10456.4 10424.4 10392.4 10360.4 10328.4	1008 976 944 912 880 848 816 784 752 720 688 656	976 944 912 880 848 816 784 752 720 688 656 654	1 2 3 4 5 6 7 7 8 9 10 10 11 12 13	976 944 912 880 848 816 784 752 720 688 656 624 592	1008 976 944 912 880 848 816 784 752 720 688 656	95 94 93 92 91 90 89 88 88 87 86 85 85 84 83	10648.4 10516.4 10584.4 10552.4 10520.4 10488.4 10456.4 10424.4 10392.4 10360.4 10328.4 10296.4	10680. 10648. 10554. 10552. 10520. 10488. 10456. 10424. 10392. 10360.
	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	10680.4 10648.4 10584.4 10584.4 10552.4 10488.4 10456.4 10456.4 10392.4 10392.4 10360.4 10328.4 10296.4	10648.4 10616.4 10584.4 10552.4 10488.4 10456.4 10449.4 10392.4 10360.4 10328.4 10296.4 1026.4	1008 976 944 912 880 848 816 784 752 720 688 656 656 624	976 944 912 880 848 816 784 752 720 688 656 624 592 560	1 2 3 4 5 6 7 8 9 10 10 11 12 13 14	976 944 912 880 848 816 784 752 720 688 656 624 592 560	1008 976 944 912 880 848 816 784 752 720 688 656 656 652 592	95 94 93 92 91 90 89 88 88 87 86 85 85 84 83	10648.4 10616.4 10584.4 10552.4 10520.4 10488.4 10456.4 10424.4 10392.4 10392.4 10360.4 10326.4 10296.4	10680. 10648. 10616. 10584. 10552. 10520. 10488. 10424. 10392. 10360. 10328. 10296.
*V-pol RDBE Channels 0 & corresponding R2DBE channel 96 are not used due to RDBE PFB#0 being only halfband	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	10680.4 10648.4 10584.4 10584.4 10552.4 10488.4 10456.4 10456.4 10392.4 10392.4 10360.4 10328.4 10296.4	10648.4 10616.4 10584.4 10552.4 10488.4 10456.4 10492.4 10392.4 10360.4 10328.4 10296.4 10296.4 10232.4	1008 976 944 912 880 848 816 784 752 720 688 656 624 592 560	976 944 912 880 848 816 784 752 720 688 656 656 624 592 550 528	1 2 3 4 5 6 7 7 8 9 9 10 11 12 13 14 15	976 944 912 880 848 816 784 752 720 688 656 624 556 528	1008 976 944 912 880 848 816 784 720 688 656 624 592 560	95 94 93 92 91 90 89 88 88 87 86 85 84 85 84 83 82	10648.4 10616.4 10552.4 10552.4 10488.4 10456.4 10449.4 10392.4 10360.4 10328.4 10296.4 10264.4	10680. 10648. 10564. 10552. 10520. 10488. 10456. 10424. 10392. 10360. 10328. 10296.
	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	10680.4 10648.4 10616.4 10584.4 10552.4 10520.4 10488.4 10488.4 10424.4 10390.4 10360.4 10360.4 10228.4	10648.4 10616.4 10584.4 10552.4 10452.4 10488.4 10488.4 10488.4 10424.4 10392.4 10360.4 10328.4 10296.4 10296.4 10264.4 10232.4	1008 976 944 912 880 848 816 784 752 720 688 656 624 592 560 e 8 channels se	976 944 912 880 848 816 784 752 720 688 656 656 624 592 508 528 8 lected for VGOS	1 2 3 4 5 6 7 7 8 9 10 11 11 12 13 14 15 correlation a	976 944 912 880 848 752 720 688 656 624 592 560 528 re accented by	1008 976 944 912 880 848 816 784 752 720 688 656 624 592 560 color	95 94 93 92 91 90 89 88 87 86 85 85 84 83 82 81	10648.4 10616.4 10552.4 10552.4 10456.4 10488.4 10456.4 10424.4 10392.4 10360.4 10328.4 10296.4 10264.4 10232.4 10200.4	10680. 10648. 10616. 10584. 10552.



## **R2DBE-G Software Updates**

- Originally the R2DBE-G was not backward compatible
  - 64 channel information / IF
  - Limited resources resulted in support not available for:
    - Pointing (Tsys)
    - Multicast processing
- New FPGA personality (under test)
  - dbe4t\_2025\_Mar\_30\_1622.bof
    - Tsys update how it is generated (the number of bits)
  - Fringe test with GGAO completed
  - Executed for Vo5120 observing session
    - Waiting for correlation report of session



### **R2DBE-G Software Updates**

- New rdbe\_server code
  - Version 3.2 (SVN 10190)
    - Update for tsys
    - Multicast updated
- Requires new version (10.3 or 10.4 ) of FS
  - Provides SEFD for all 4 bands
  - Pointing check
  - Testing required for full release in discussions with Ed Himwich
- R2DBE documentation and release package under construction
  - Release date Mid June 2025



# **Monitoring Capabilities**

# 1pps monitoring

- Multcast monitoring data broadcast 1 per second (1pps)
- dbe\_1pps\_mon = <enable> : <multicast IP address> : <port>;
- Use r2dbe\_mon.py on a system attached to same network to receive multicast data
  - Working with PCFS for processing information
- Tsys monitoring
  - System temperature measurement all 64 channels / pol
  - On power / off power of the receive chain
  - tsys data is summed every second
- Raw Capture Mode Removed from R2DBE



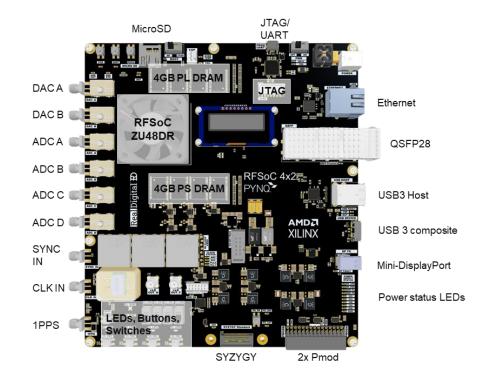
#### **R2DBE multicast monitoring**

#### R2DBE Monitor svn 10261 239.0.2.29 20020 192.52.63.54 : 50 : 10078256 : Sun Apr 27 : 2025-117-15-30-56 IF0 mu 0.02 sigma 23.74 IF1 mu 2.18 sigma 23.57 pcal freq 4600000.023842 pps offset -8e-09 gps offset 1e-04 puise car in pulse cal li 2.0 15 0.5 0.5 -0.5 -1.0 з z -1-2 -1 -3 500 1000 1500 2000 2500 3000 3500 4000 4500 500 1000 1500 2000 2500 3000 3500 4000 4500 puise carriero puipe carificinia 11.11 A Antificial Statement Infine σ. uioue pini ii o uioue pini ii ± з Loyo II V LOYO II II



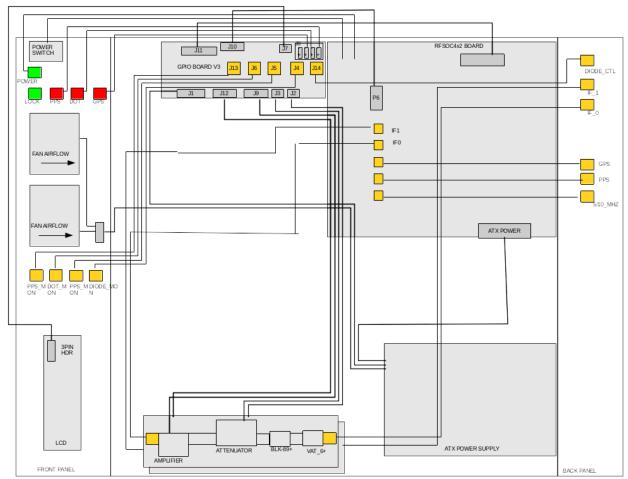
### **Next steps - DBE Version 5**

- DBEv5 was developed to be a drop-in replacement for DBEv4 (R2DBE)
- Based on the RF system on a chip (RFSoC) 4x2 chip set
- Utilizes a ported:
  - R2DBE FPGA personality
  - rdbe\_server
- Requires 100Gbps / 10Gbps network switch between existing Mark6's





#### **DBEv5 Layout**





# DBEv5 (cont)

- Engineering prototype built
  - On display at the front with V3 (RDBE) / V4 (R2DBE) / V5
  - Single RFSOC / chassis
    - Can update to 2 per chassis
- Expanded FPGA features expected
  - To support other NASA programs
- Will work with Digicom for release to general public
  - Date and Cost TBD



# Questions on presentation or operational problems?

Thank you

