σ

$$J_i$$

$$A_{ij}$$

S

u, v

1

$$\widetilde{V}_{ijk}$$

i

j

k

V_{ij}

$$\widetilde{V}_{ijk} = g_i(t) g_j^*(t) b_{ijk}(t) V_{ij}(u_k(t), v_k(t)) + noiseterm$$

$$u_k(t)$$

$$v_k(t)$$

ij

t

$g_i(t)$

$$b_{ijk}(t)$$

P_a

$\delta\nu$

T_a

$$P_a = kT_a \delta\nu$$

$$e^{-\tau_{atm}}$$

η_f

T_a^*

$$T_a^* = \frac{(1 + g_{im})}{\eta_f} e^{\tau_{atm}} T_a$$

$$(1 + g_{im})$$

g_{im}

T_b

I_ν

$$T_b = \frac{c^2}{2k\nu^2} I_\nu$$

S_ν

$$T_a^* = \frac{\eta_a A}{2k} S_\nu = \frac{1}{J} S_\nu$$

$$J = \frac{2k}{\eta_a A}$$

$$T_{noise} = T_{bg} + T_{sky} + T_{spill} + T_{rec}$$

T_{bg}

T_{sky}

$$T_{spill}$$

T_{rec}

4π

T_{atm}

τ_{atm}

T_{sky}

$$\eta_f(1 - e^{-\tau_{atm}})T_{atm}$$

$$T_{spill}$$

$$(1 - \eta_f)T_{ground}$$

T_{sys}

$$T_{noise}$$

$$T_{sys} = \frac{1 + g_{im}}{\eta_f} e^{\tau_{atm}} T_{noise}$$

δt

n

A

ηa

η_q

η_p

$$\sigma = \frac{1}{\eta_q \eta_p} \frac{\sqrt{2}k}{\eta_a A} \frac{T_{sys}}{\sqrt{\delta\nu\delta t}}$$

$$\sigma = \frac{1}{\eta_q \eta_p} \frac{2k}{\eta_a A} \frac{T_{sys}}{\sqrt{n(n-1)\delta\nu\delta t}}$$

$$W_{ij}$$

10^6

2

10^{-3}

$$W_{ij} = \frac{1}{\sigma_{ij}^2}$$

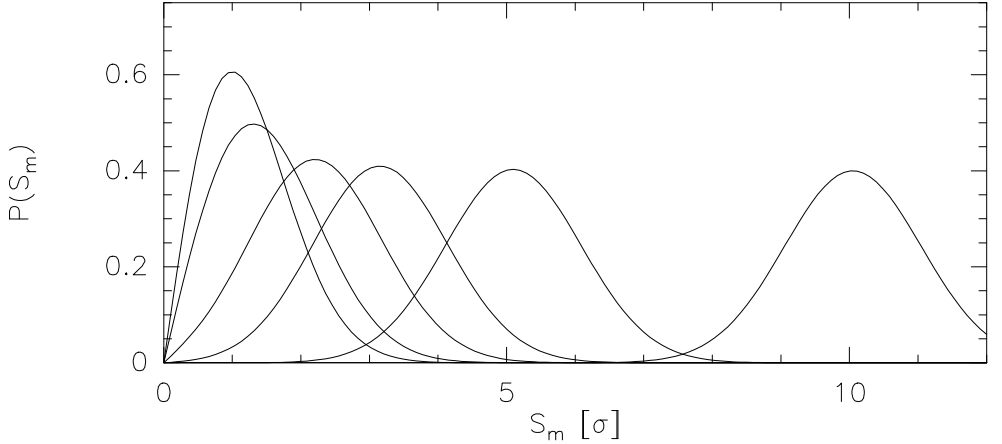
$$V_{ij}(t) = a_{ij}(t)e^{i\varphi_{ij}(t)}$$

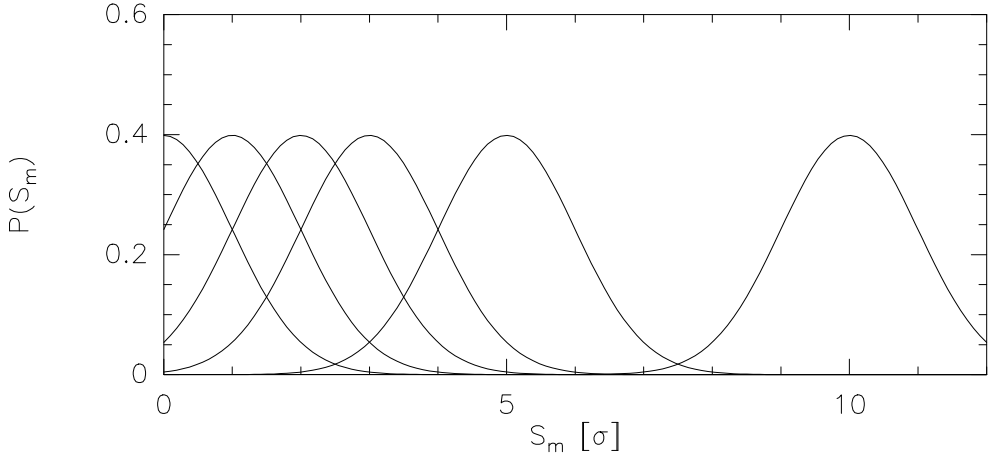
$$\widetilde{\varphi}_{ij} + \widetilde{\varphi}_{jk} - \widetilde{\varphi}_{ik}$$

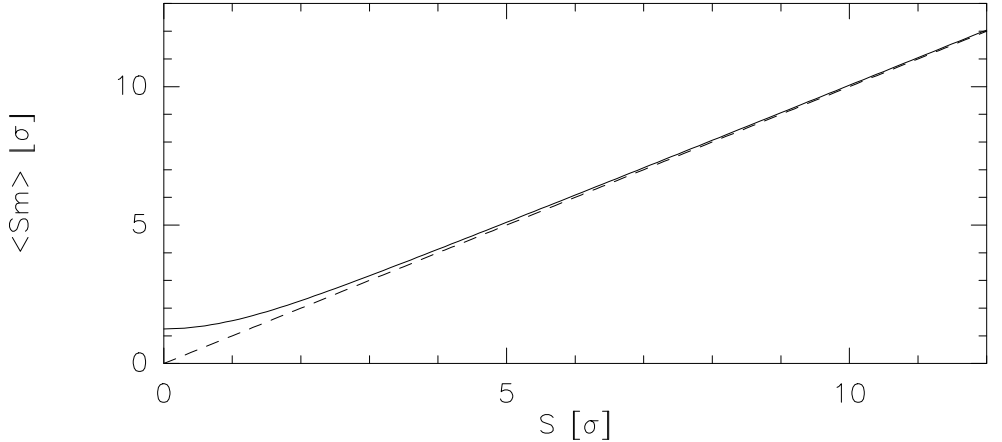
$$\varphi_{ij} + \varphi_{jk} - \varphi_{ik}$$

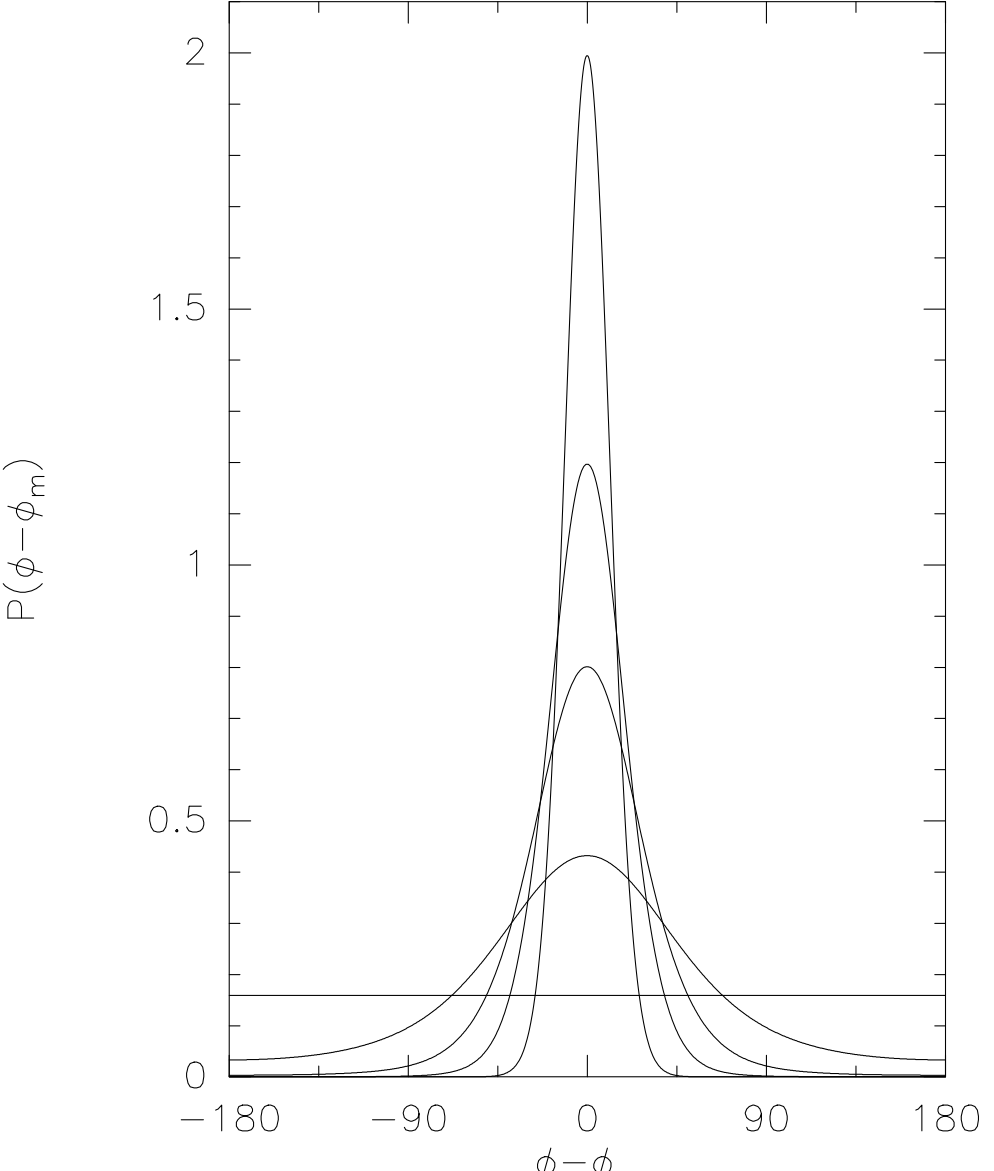
$$\frac{\widetilde{a}_{ij}\widetilde{a}_{kl}}{\widetilde{a}_{ik}\widetilde{a}_{jl}}$$

$$\frac{a_{ij}a_{kl}}{a_{ik}a_{jl}}$$


0.6
0.4
0.2
0
P(S_m)
0
5
10
S_m [σ]


0.6
0.4
0.2
0
P(S_m)
0
5
10
S_m [σ]


10
5
0
<Sm> [σ]
0
5
10
S [σ]


2
1.5
1
0.5
0
−180
−90
0
90
180
$\phi-\phi_m$
$P(\phi-\phi_m)$

ϕ

$$e^{-\phi^2/2}$$

$$G_{ij}(t) = g_i(t) \cdot g_j^*(t)$$

$$\widetilde{V_{ij}} = g_i \cdot g_j^* S$$

$$\widetilde{\varphi}_{ij} = \phi_j - \phi_i$$

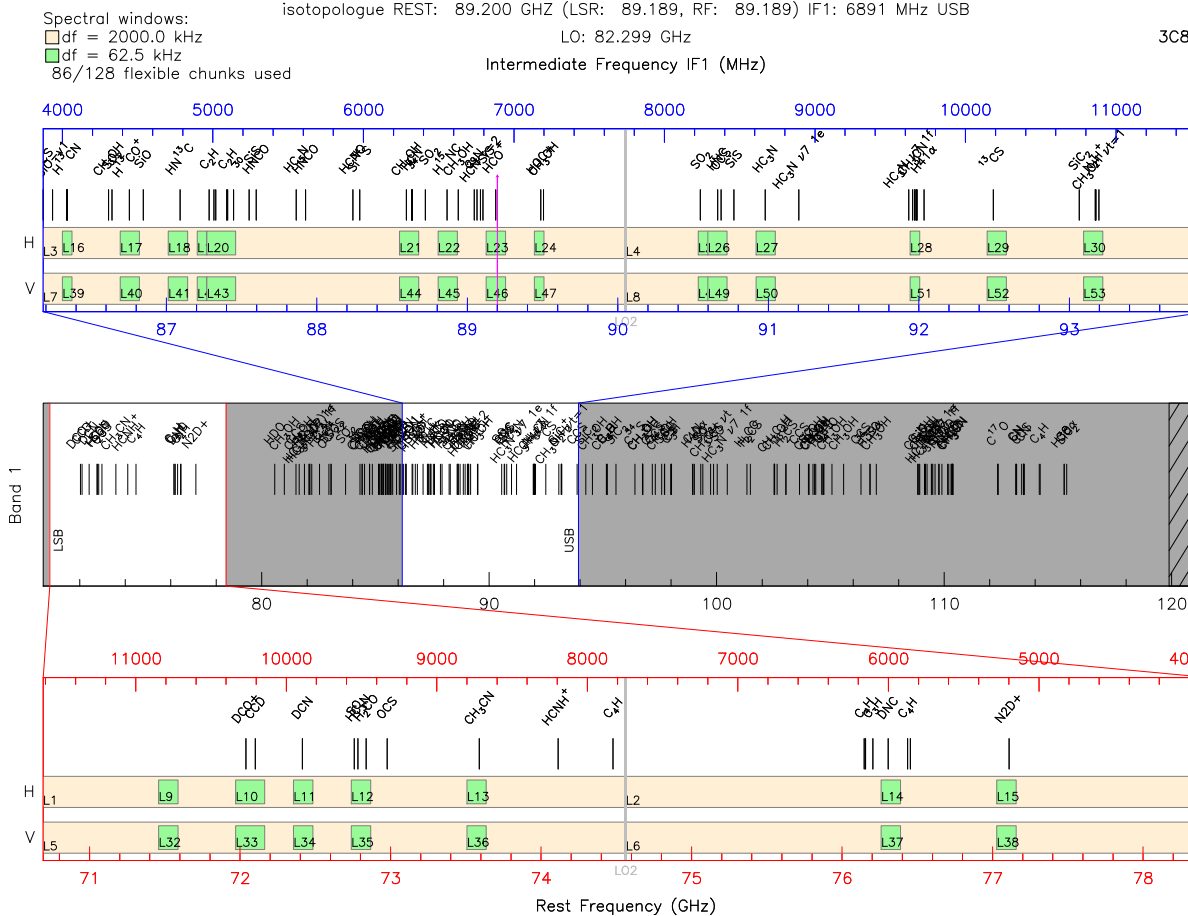
$$\widetilde{a}_{ij} = a_i \cdot a_j \cdot S$$

$n + 2$

$$(spectralwindow, sideband, baseline)$$

$$(channel, sideband, baseline)$$

$channel$


Spectral windows:
df = 2000.0 kHz
df = 62.5 kHz
86/128 flexible chunks used
isotopologue REST: 89.200 GHZ (LSR: 89.189, RF: 89.189) IF1: 6891 MHz USB
LO: 82.299 GHz
3C8
Intermediate Frequency IF1 (MHz)
4000
5000
6000
7000
8000
9000
10000
11000
H
V
L3
L16
L17
L18
L20
L21
L22
L23
L24
L4
L26
L27
L28
L29
L30
L7
L39
L40
L41
L43
L44
L45
L46
L47
L8
L49
L50
L51
L52
L53
87
88
89
90
91
92
93
LO2
Band 1
LSB
USB
80
90
100
110
120
11000
10000
9000
8000
7000
6000
5000
DCN
OCS
CH3CN
HCNH+
C4H
N2D+
L1
L9
L10
L11
L12
L13
L2
L14
L15
L5
L32
L33
L34
L35
L36
L6
L37
L38
71
72
73
74
75
76
77
78
Rest Frequency (GHz)

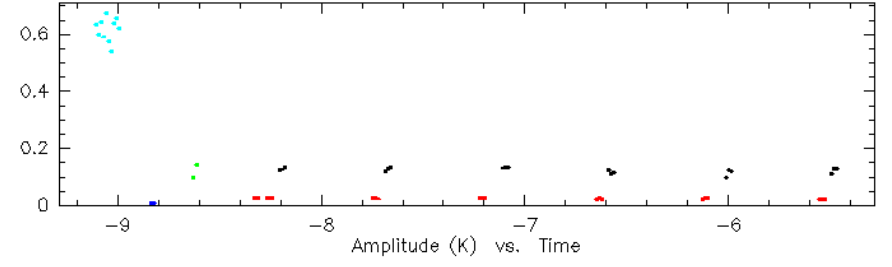
4

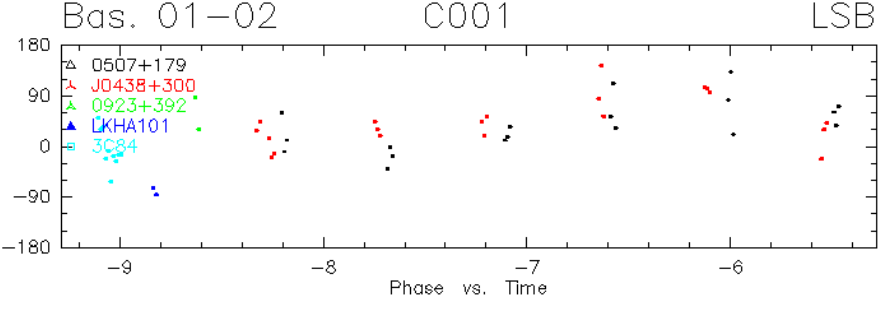
RF: Uncal.
Am: Abs.
Ph: Abs.

CLIC – 06–NOV–2019 13:30:29 – pietu@pietu.iram.fr E03W12N11W20E16E68W09 7ant–Special
D17IC001 isotopologue 89.200GHz B1 Q0() Q0()
(17 6322 P CORR)–(373 6602 P CORR) 19–APR–2018 14:53–18:31

Scan Avg.
HORIZONTAL pol.

1 Bas. 01–02 2 C001 3 LSB





$$A_{ij}(t)$$

$1/S$

$$\sqrt{J_i * J_j}$$

$$A_{ij}(t)/\sqrt{J_i * J_j}$$

$$B_{,ijk}$$

b_{ik}

$$B_{ijk} = b_{ik} b^*_{jk}$$

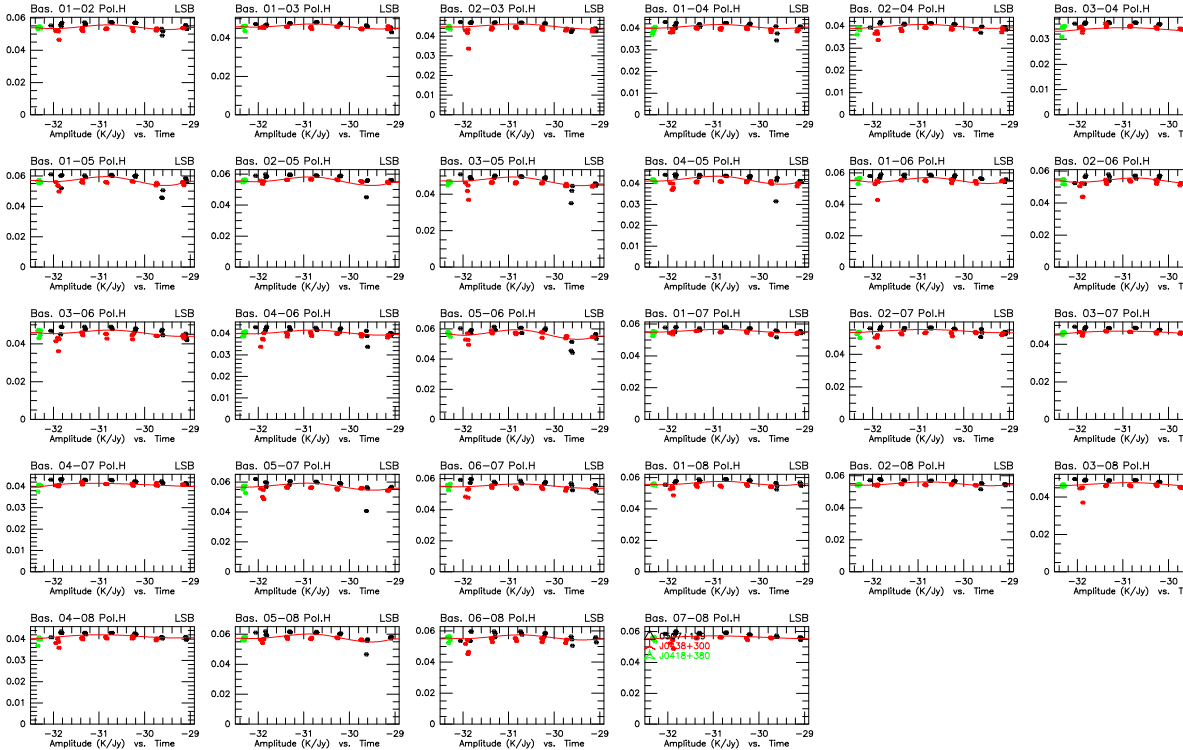
α

$$G_{ij}(t)$$

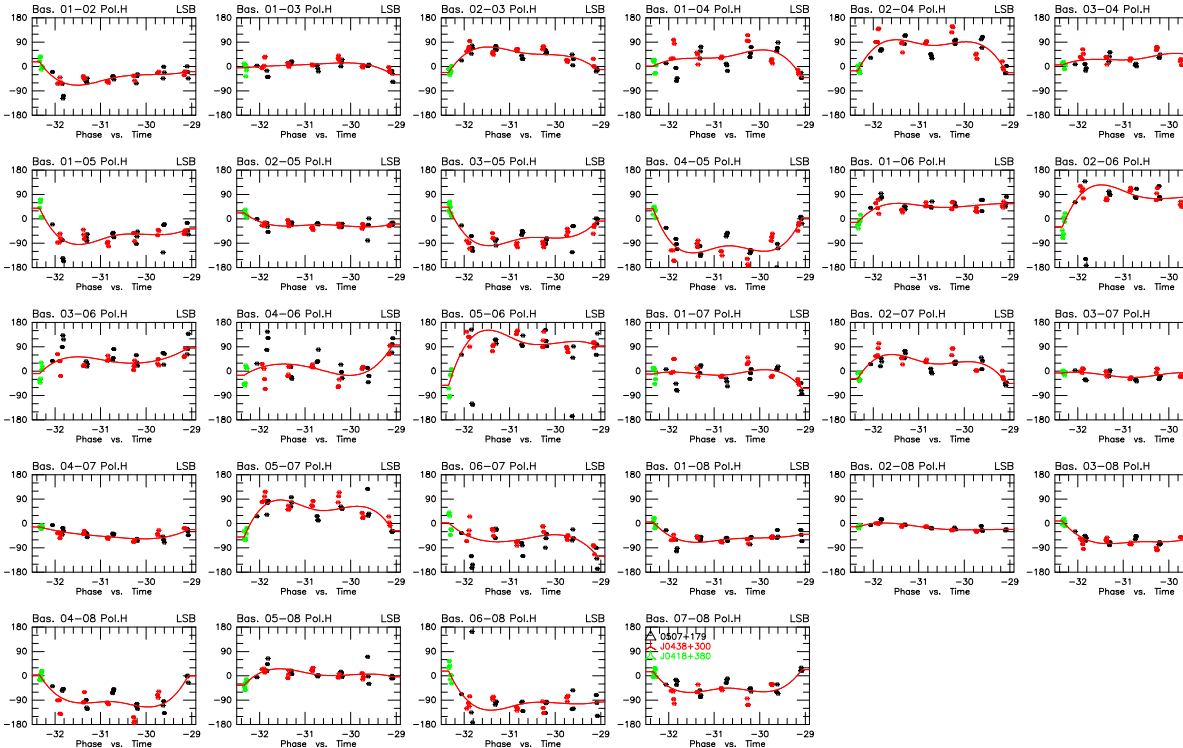
$g_i(t)$

$$G_{ij}(t) = g_i(t) g_j^*(t)$$

RF: Uncal. CLIC – 07–NOV–2019 14:06:07 – pietu@pietu.iram.fr E03W12N11N29W20E16N20W09 9C–E10 Scan
Am: Scaled D17IC001 isotopologue 89.200GHz B1 Q0() Q0() HORIZONTAL
Ph: Abs. (21 4716 P CORR)–(352 4985 P CORR) 18–APR–2018 15:39–18:55



RF: Uncal. CLIC – 07–NOV–2019 14:04:27 – pietu@pietu.iram.fr E03W12N11N29W20E16N20W09 9C–E10 Scan
Am: Abs. D17IC001 isotopologue 89.200GHz B1 Q0() Q0() HORIZONTAL
Ph: Abs. (21 4716 P CORR)–(352 4985 P CORR) 18–APR–2018 15:39–18:55



$$\widetilde{A}_{ij} = a_i a_j \left(I + Q\cos(2\chi) + U\sin(2\chi)\right)$$

χ

$$I, Q, U, V$$

$$P = \frac{\sqrt{Q^2+U^2}}{I}$$

$$\Delta\tau$$

$$\phi = \pm 2\pi \Delta\tau \nu_{IF1}$$

$$\frac{\pi}{2}$$

$$P_{sky}$$

$$P_{hot}$$

T_{hot}

$$(T_{hot} + T_{rec}) \times \frac{P_{sky}}{P_{hot}} - T_{rec} = \eta_f \times Airmass \times \tau_{zenith} + (1 - \eta_f) \times T_{ground}$$

$$\tau_g = \frac{\mathbf{b}.\mathbf{s}}{c}$$

$$\mathbf{b} = (X_{ij}, Y_{ij}, Z_{ij})$$

$$\mathbf{s} = (\cos h \cos \delta, -\sin h \cos \delta, \sin \delta)$$

$$\phi_{ijk}$$

$$2\pi\tau_g\nu_{RF}$$

$$\frac{2\pi}{\lambda}\mathbf{b}.\mathbf{s}$$

$$\frac{2\pi}{\lambda_k}\left(X_{ij}\cos h\cos\delta - Y_{ij}\sin h\cos\delta + Z_{ij}\sin\delta\right)$$

$$\cos(El)$$

$$> 2d^2/\lambda$$

130

30−sep−2019−holo−r1

RF: Fr.(B) *CLIC − 19−NOV−2019 10:01:36 − pietu@pietu.iram.fr − Ant 10 − N05N13W12W09E10E04W05N02N09*

Am: Rel.(B) 3C454.3 9D scans 6011 to 6085 30−SEP−2019 23:23UT El: 56.00

Ph: Rel.(B)

rms Pha.

01−09 4.82
02−09 3.75
03−09 14.35
04−09 13.36
05−09 10.87
06−09 10.26
07−09 11.02
08−09 8.17

Edge taper = 19.05x 16.49 dB − offset X= −0.39 Y= −0.13 m

Focus offsets (X,Y,Z) = −0.71 −1.40 0.12 mm; Astigmatism = 20.4 μm (52.0deg.)

Phase rms (unweighted)= 0.101 (weighted)= 0.097 radians

Surface rms (unweighted)= 33.63 − (weighted)= 31.09 μm

η_A(82.000 GHz) = 0.737; η_A(230.0 GHz) = 0.692; η_A(345.0 GHz) = 0.632

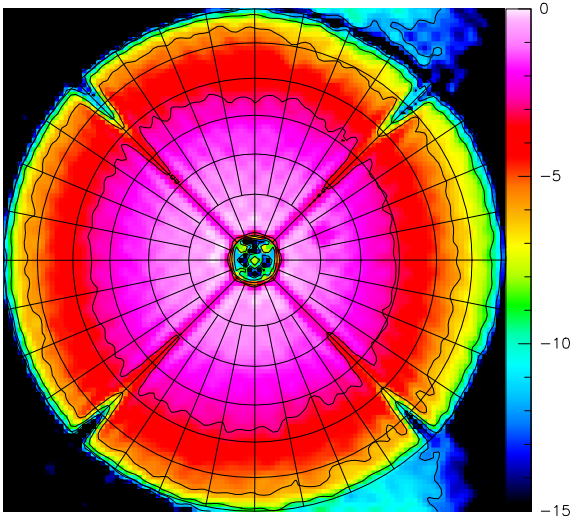
S/T(82.000 GHz)= 21.179 Jy/K; S/T(230GHz)= 22.573 Jy/K; S/T(345 GHz)= 24.720 Jy/K

η_I=0.744 $-\eta_S$=0.862 $-\eta_P$(82.000 GHz)=0.991 $-\eta_P$(230 GHz)=0.930 $-\eta_P$(345 GHz)=0.849

Rms/ring: 27.6 29.3 26.5 33.4 31.0 37.8

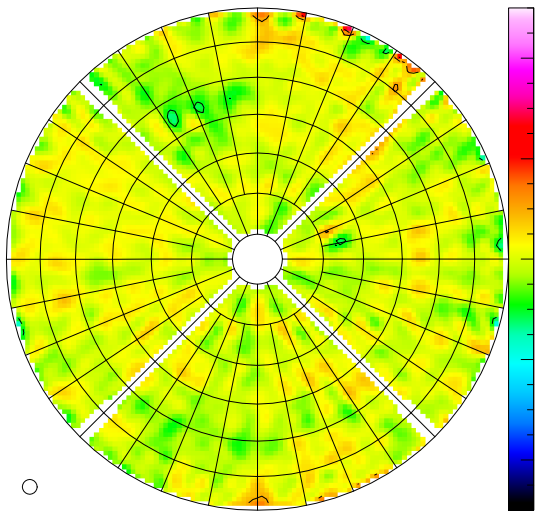
Amplitude (back view)

−15.000 to 0.000 by 3.000



Normal errors (back view)

−500.000 to 500.000 by 100.000



(ξ, η)

$$r = \sqrt{\xi^2 + \eta^2}$$

f

$$\phi_1(\xi, \eta)$$

a

$$\phi_2(\xi, \eta)$$

$b\xi$

$$\phi_3(\xi, \eta)$$

$c\eta$

$$\phi_4(\xi, \eta)$$

$$\delta z \left(1 - \frac{1 - \frac{r^2}{4f^2}}{\sqrt{\frac{r^2}{f^2} + (1 - \frac{r^2}{4f^2})^2}} \right)$$

$$\phi_5(\xi, \eta)$$

$$\delta x \frac{\xi}{f} \left(1 - \frac{1}{\sqrt{\frac{r^2}{f^2} + \left(1 - \frac{r^2}{4f^2}\right)^2}} \right)$$

$$\phi_6(\xi, \eta)$$

$$\delta y \frac{\eta}{f} \left(1 - \frac{1}{\sqrt{\frac{r^2}{f^2} + \left(1 - \frac{r^2}{4f^2}\right)^2}} \right)$$

$$\phi_7(\xi, \eta)$$

$$a_+ \frac{\xi^2 - \eta^2}{2f^2}$$

$$\phi_8(\xi, \eta)$$

$$a \times \frac{2\xi\eta}{2f^2}$$

a

b

C

δx

δy

δz

a_+

$a_{\times}$

○

ψ_a

$$\psi_a = \frac{\arctan\left(a_\times, a_+\right)}{2}$$

η_A

η_I

η_A

$$\frac{\left|\int_A A(\xi,\eta)\exp(i\phi(\xi,\eta))d\xi d\eta\right|^2}{\pi r^2 \int_A A(\xi,\eta)^2 d\xi d\eta}$$

η_I

$$\frac{\left|\int_A A(\xi,\eta)\,d\xi\,d\eta\right|^2}{\pi r^2\int_A A(\xi,\eta)^2\,d\xi\,d\eta}$$

$$J = \frac{2k}{\eta_{\mathrm{A}} \pi r^2}$$

$$\delta p = \delta\phi \times \frac{\lambda}{4\pi} \times \sqrt{1 + \frac{r^2}{4f^2}}$$

$$\phi_j - \phi_i$$

ϕ_i

τ_g

$$\frac{\mathbf{b.s}}{c}$$

$$\frac{1}{c}\left(X_{ij}\cos h\cos\delta - Y_{ij}\sin h\cos\delta + Z_{ij}\sin\delta\right)$$

$$F_{rest}^{ref}$$

v

$$F_{IF}^{ref}$$

$$F_{rest}$$

$$F_{topo}$$

$$F_{topo} = F_{rest}\left(1 + \delta - \frac{v}{c}\right)$$

δ

$$F_{IF} = \pm(F_{topo} - F_{LO1})$$

$$F_{IF} = \pm \left(F_{rest} \left(1 + \delta - \frac{v}{c} \right) - F_{LO1} \right)$$

$$F_{LO1} = F_{rest}^{ref}\left(1 + \delta - \frac{v}{c}\right) \mp F_{IF}^{ref}$$

$$F_{LO1}$$

$$F_{IF}(j,k)$$

$$(k - i_{IF}(j)) * \delta F_{topo} + F^0_{IF}(j)$$

$$F_{rest}(j, k)$$

$$(k - i_{rest}(j)) * \delta F_{rest} + F^0_{rest}(j)$$

$$\delta F_{topo}$$

$$\delta F_{topo} = \delta F_{rest} \left(1 + \delta - \frac{v}{c}\right)$$

n_{ch}

$$i_{IF}$$

$$F^0_{IF}$$

i_{ref}

$$F^0_{rest}$$

$$\delta F_{rest}$$

P

T

K_p

$$P = K_p T$$

K_c

$$\widetilde{A}_{ij} = K_p T_{ij}$$

$$T_{ij}$$

$$P_{hot}$$

$$K_p \left(T_{hot} + T_{rec}\right)$$

P_{cold}

$$K_p \left(T_{cold} + T_{rec}\right)$$

$$P_{sky}$$

$$K_p \left(T_{sky} + T_{spill} + T_{rec} + T_a\right)$$

C_{ii}

$$K_c\left(T_{sky} + T_{spill} + T_{rec} + T_a\right)$$

$$|C_{ij}|$$

$$K_c T_a$$

$$|C_{ij}|$$

C_{ii}

$$T_{sky} + T_{spill} + T_{rec}$$

$$T_{rec} = \frac{P_{cold}T_{hot} - P_{hot}T_{cold}}{P_{hot} - P_{cold}}$$

$$T_{sky} = (T_{hot} + T_{rec}) \frac{P_{sky}}{P_{hot}} - T_{rec} - T_{spill}$$

T_{emi}

$$T_{emi} = \frac{T_{sky}}{\eta_f}$$

$$T^{atm}_{emi,s}$$

$$T^{atm}_{emi,i}$$

$\tau_{atm,s}$

$\tau_{atm,i}$

$$T_{emi} - \frac{T_{emi,s}^{atm} + g_{im} T_{emi,i}^{atm}}{1 + g_{im}}$$

$$T_{sys,s}$$

$$T_{sys,i}$$

$$T_{sys,s} = \frac{e^{\tau_s}\left(T_{hot} - T_{sky} - T_{spill}\right)\left(1 + g_{im}\right)}{\eta_f} \frac{P_{sky}}{P_{hot} - P_{sky}}$$

$$T_{sys,i} = \frac{e^{\tau_i}\left(T_{hot} - T_{sky} - T_{spill}\right)\left(1 + \frac{1}{g_{im}}\right)}{\eta_f} \frac{P_{sky}}{P_{hot} - P_{sky}}$$

$$T_{sky} + T_{spill} = (1 - \eta_f) \left(\frac{T_{emi,s}^{atm} + g_{im} T_{emi,i}^{atm}}{1 + g_{im}} \right) + \eta_f T_{ground}$$

$$C_{ijk}$$

$$T_{ijk}$$

$$T_{ijk} = \frac{C_{ijk}}{\sqrt{C_{iik}C_{jjk}}}\sqrt{T_{sys}(i)T_{sys}(j)}$$

K_c

T_{cal}

T_i

ν_1

ν_2

ν_3

ν^2

$$T_{triple} = \frac{1 - \left(\frac{\nu_1}{\nu_2}\right)^2}{1 - \left(\frac{\nu_2}{\nu_3}\right)^2} \left(T_2 - T_3 \left(\frac{\nu_2}{\nu_3}\right)^2\right) - \left(T_1 - T_2 \left(\frac{\nu_1}{\nu_2}\right)^2\right)$$

(u, v)