



Apertif system overview

Emanuela Orru' Head of Apertif Telescope Operations

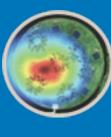


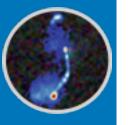


Netherlands Institute for Radio Astronomy



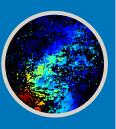










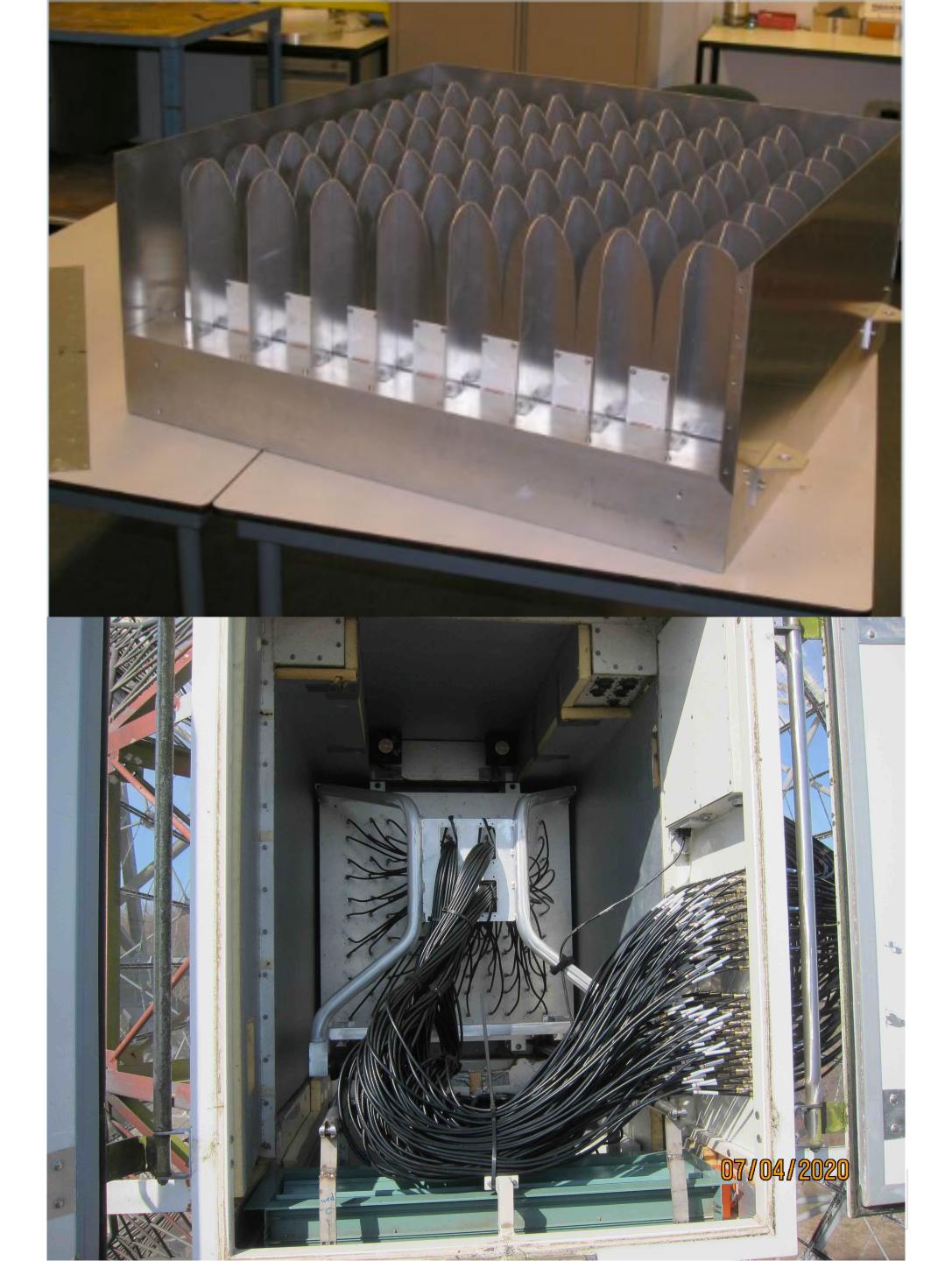


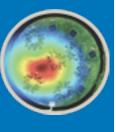
Phased Array Feed

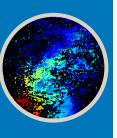
(PAF) system installed on 12 (WSRT) dishes

PAF consists of 121 electrically connected Vivaldi antennas with integrated LNA (low noise amplifiers),

60 of which measure X polarised signal and 61 of them recording Y polarised emission.





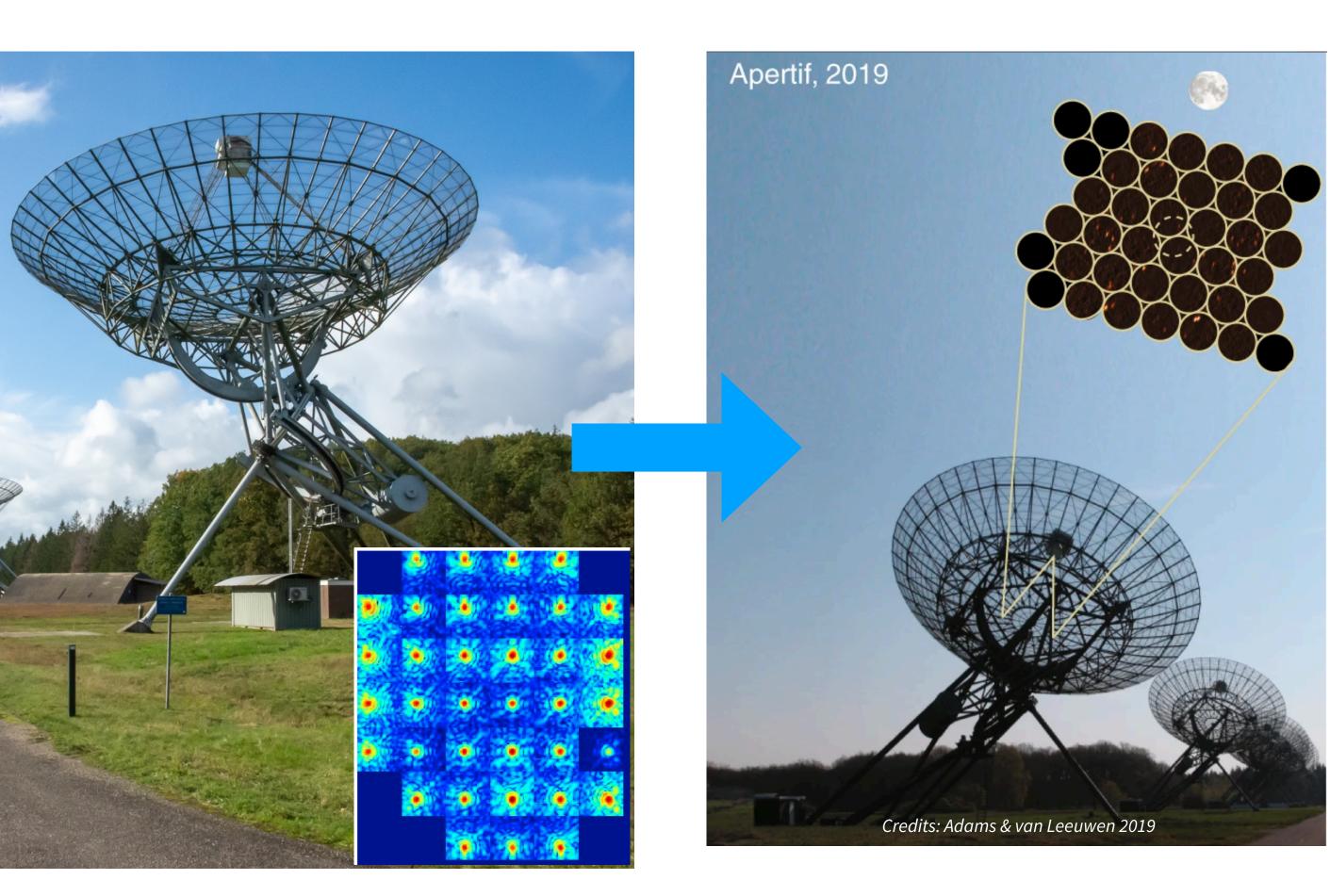


Apertif: wide Bandwidth and FOV

Operational since July 1st 2019

Frequency range 1130 -1750 MHz

40 digital beams formed with an instantaneous bandwidth of 300 MHz.

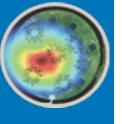


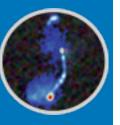
...a perfect survey instrument



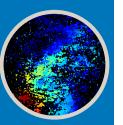


Image credits: A. Corstanje, F. Sweijen, C. Van Eck, P. Zucca



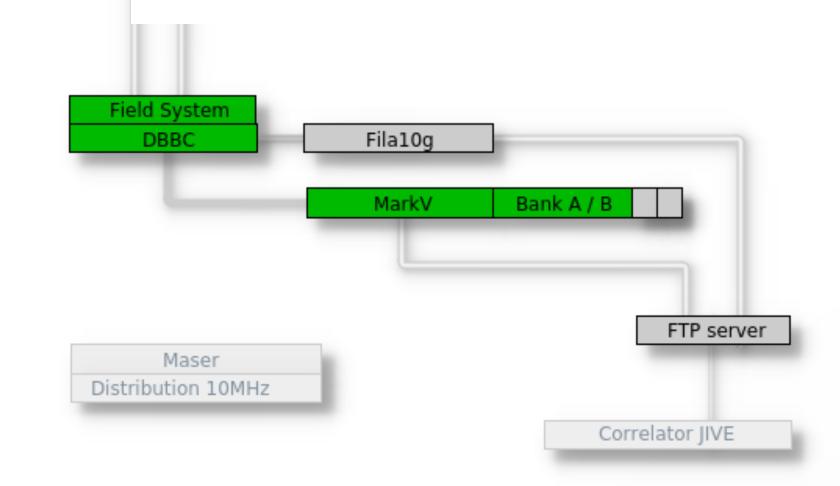


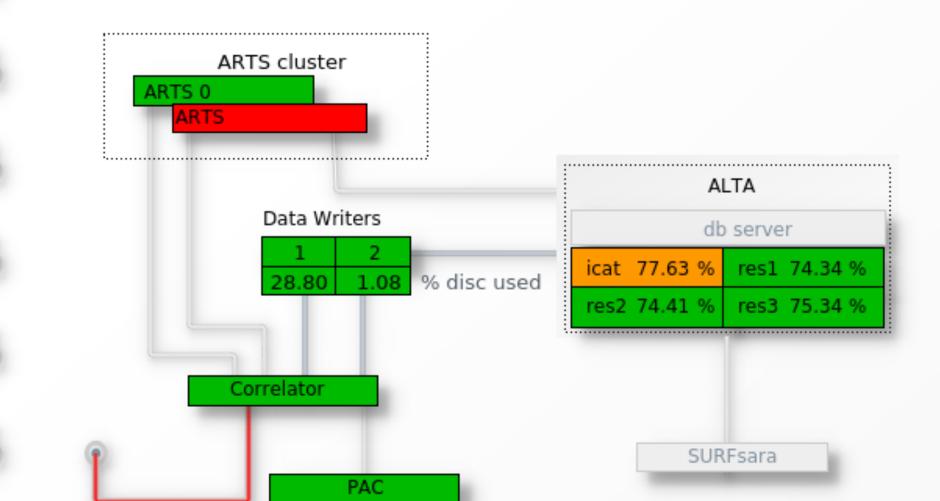




		GPS antenna	GPS receiver	Delay counter
tracking	onPos MFFE	4 (21cm)		
RT1	onPos			
ready	MFFE	7 (6cm)		
RT2		DCU	LCU	Uniboard BF
tracking	onPos NS	LOG		PAC
	0 LNA			
RT3 tracking	onPos NS		LCU	Uniboard BF PAC
tracking	onPos NS 1 LNA			PAC
RT4	_	DCU	LCU	Uniboard BF
tracking	onPos NS	LOG		PAC
	0 LNA	P		
RT5		DCU	LCU	Uniboard BF
tracking	onPos NS 1 LNA	LOG		PAC
				Units and Dr.
 RT6 tracking 	onPos NS		LCU	Uniboard BF PAC
	3 LNA			
RT7		DCU	LCU	Uniboard BF
tracking	onPos NS	LOG	_	PAC
	1 LNA			
RT8 tracking	onPos NS		LCU	Uniboard BF PAC
	0 LNA			
RT9		DCU	LCU	Uniboard BF
tracking	onPos NS	LOG		PAC
	0 LNA			
RTA ready	onPos NS		LCU	Uniboard BF
Teauy	2 LNA			PAC
RTB		DCU	LCU	Uniboard BF
ready	onPos NS	LOG		PAC
	1 LNA			
RTC	apper NC		LCU	Uniboard BF
ready	onPos NS 4 LNA	LOG		PAC
RTD		DCU	LCU	Uniboard BF
ready	onPos NS	LOG	200	PAC
	1 LNA			

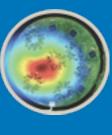
Monitoring

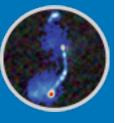




Control Heartbeats											
۷	VinCC	Bridg	je								
		_	_								
Co	rrelat	or Coi	ntrol								
De	lay Co	mpens	ation								
RT2	RT3	RT4	RT5								
RT6	RT7	RT8	RT9								
RTA	RTB	RTC	RTD								
	Signal	Contro	el								
RT2	RT3	RT4	RT5								
RT6	RT7	RT8	RT9								
RTA	RTB	RTC	RTD								
fil	WSRT	json ag	ges								
W	srt_me	eteo_i	nfo								
W	srt_se	nsor_i	info								
dis	shctl										
Fie	eldsys	tem									
AT	DB ol	os info	D								
M	FE in	fo									

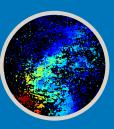
Control Heartbeats											
V	VinCC	Bridg	je								
-		_	_								
Co	rrelat	or Coi	ntrol								
De	lay Co	mpens	ation								
RT2	RT3										
RT6	RT7	RT8	RT9								
RTA	RTB	RTC	RTD								
-	Signal	Contro)								
RT2	RT3	RT4	RT5								
RT6	RT7	RT8	RT9								
RTA	RTB	RTC	RTD								
fill	WSRT	json ag	ges								
WS	srt_me	eteo_i	nfo								
WS	srt_se	nsor_i	info								
dis	shctl										
Fie	eldsys	tem									
AT	DB ol	os info	b								
M	FFE in	fo									





6th LOFAR Data School





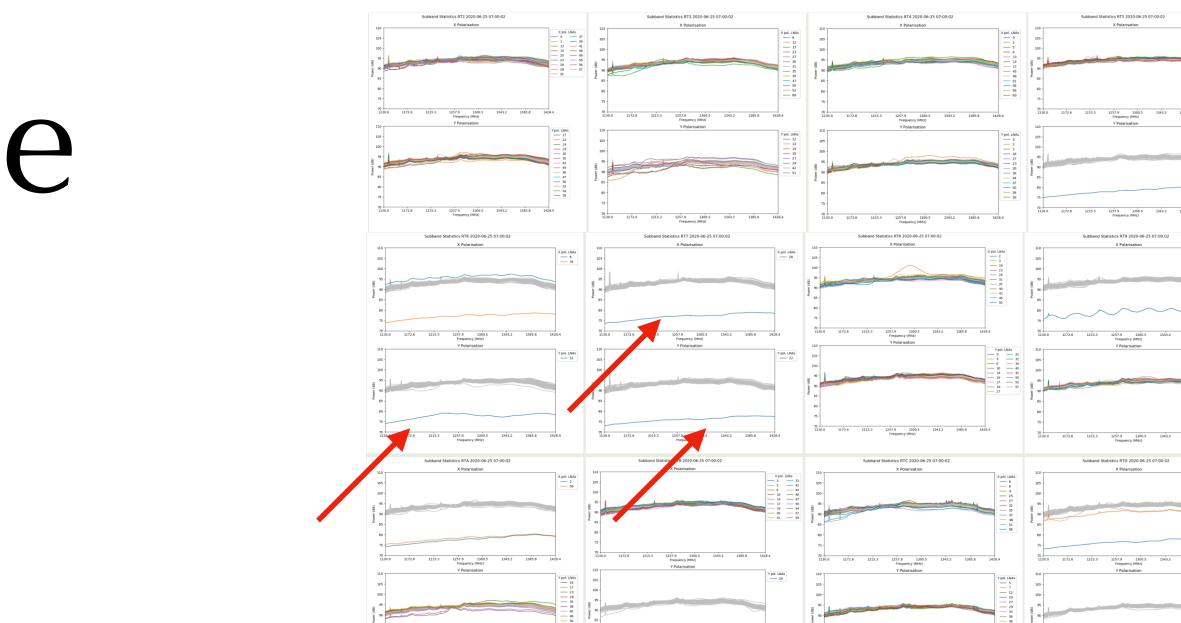
PAF maintenance

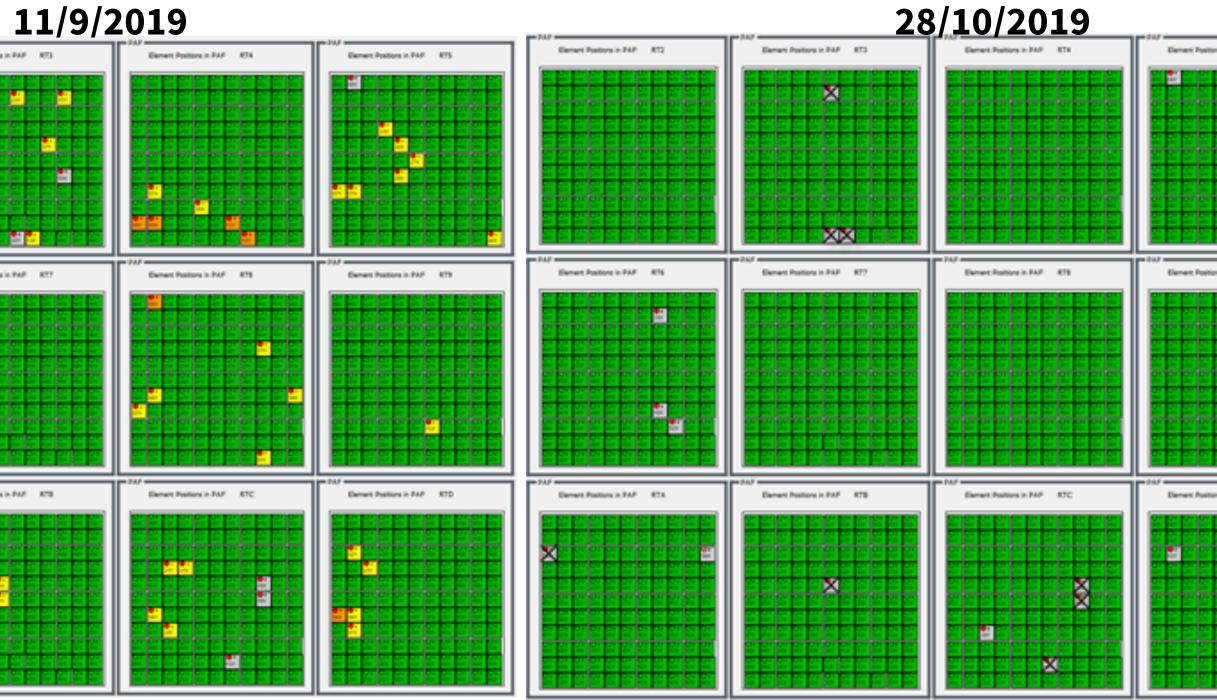
Malfunctioning elements have big effects in the data quality.

Monitor 121 antenna element 's health of each PAF

Replacing individual PAF elements involves a significant effort. It is performed in campaigns



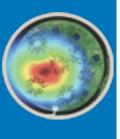




mage creates its constantes is strength, c. ran ces, i. zuce

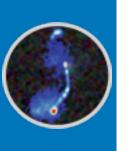
	X pol. LNAs 7 35 10 36 11 37 16 40 25 41 29 55 31
3365.8 342	Y pol. LNAs
1385.8 142	X pol. LNAs
1385.8	Ypol. LNAs
1385.8	
	X pol. LNA4
1385.8	4428.4
	Y pol. LNAs
1395.8	1428.4

iore i	n Pad		KTS.				1
F	E.	E	2	E	E		il
E	E.	E	1	E.	E	E.	
1	21			-	-	-	I
2	21	Ē	12		2		I
Ē	14	E	12	127	1	1	1
E	1		5	1		1	ll
Ē	-					-	I
2	2	E	2	1	Ē	2	1
2	2		55	2	2		
					_	=	4
-			879				
E	E.			E	2		ıl
Ē	2		2	27	2		I
E	E	E	E.	E	E	Ľ.	1
	100		51 51 5	51 51 5	51 51 5	11	
20 21 21 21		21 21 22 21	51 51 53 51	51 51 51 51			
51 51 51 51 51			51 51 55 58 51	54 54 54 54 54	<u> </u>	10.00	
20.201.20	1 21 21 21	1 21 21 21	15151	51 51 51	1 51 51 51		
50 50 50 50		2 24 24 24 24 24	3 51 51 53	54 54 54 54	1 51 51 51		
51 51 51 51	2 52 54 52 54 54	2 24 24 24 24 24	4 51 52 52 52	54 54 54 54	4 54 54 54 54		
51 51 51 51	2 52 54 52 54 54	2 24 24 24 24 24 24	4 51 52 52 52	54 54 54 54	4 54 54 54 54		
51 51 51 51	2 52 54 52 54 54	2 24 24 24 24 24 24 24 24	4 51 52 52 52	54 54 54 54 54 54	4 54 54 54 54		
51 51 51 51	3 52 54 52 54 53 53 54	2 24 24 24 24 24 24 24 24	4 51 52 52 52 52	54 54 54 54 54 54	4 54 54 54 54		
51 51 51 51	3 52 54 52 54 53 53 54	2 24 24 24 24 24 24 24 24	4 51 52 52 52 52	54 54 54 54 54 54	4 54 54 54 54		
50 50 50 50	3 52 54 52 54 53 53 54	2 24 24 24 24 24 24 24 24	4 51 52 52 52 52	54 54 54 54 54 54	4 54 54 54 54		



PAF calibration

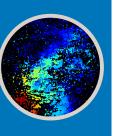
Average Weight Amplitude over PAF



Average Weight Amplitude over PAF 20191119T164508 - RT4 - CBM2

		X00	Y00	X11	Y11	X22	Y22	X33	Y33	X44	Y44	X55
	4 -	Y01	X01	Y12	X12	Y23	X23	Y34	X34	Y45	X45	Y55
		X02	Y02	X13	Y13	X24	Y24	X35	Y35	X46	Y46	X56
	2 -	Y03	X03	Y14	X14	Y25	X25	Y36	X36	Y47	X47	Y56
		X04	Y04	X15	Y15	X26	Y26	X37	Y37	X48	Y48	X57
y pos	0 -	Y05	X05	Y16	X16	Y27	X27	Y38	X38	Y49	X49	Y57
		X06	Y06	X17	Y17	X28	Y28	X39	Y39	X50	Y50	X58
	-2 -	Y07	X07	Y18	X18	Y29	X29	Y40	X40	Y51	X51	Y58
		X08	Y08	X19	Y19	X30	Y30	X41	Y41	X52	Y52	X59
	-4 -	Y09	X09	Y20	X20	Y31	X31	Y42	X42	Y53	X53	Y59
		X10	Y10	X21	Y21	X32	Y32	X43	Y43	X54	Y54	X60
	I		-4		-2		0		2		4	



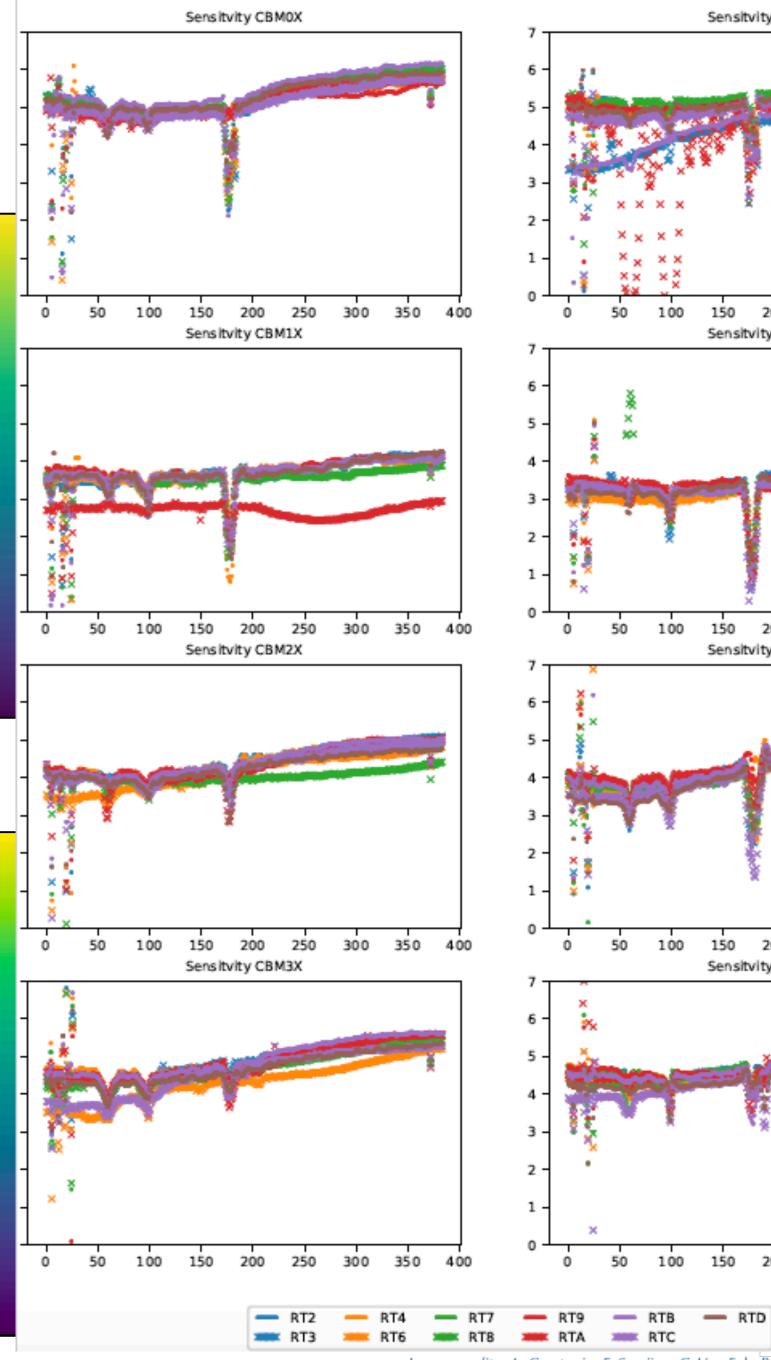


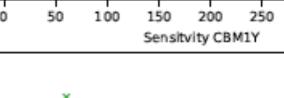
			X00	Y00	X11	Y11
		4 -	Y01	X01	Y12	X12
			X02	Y02	X13	Y13
		2 -	Y03	X03	Y14	X14
			X04	Y04	X15	Y15
- 8000	y pos	0 -	Y05	X05	Y16	X16
- 7000			X06	Y06	X17	Y17
		-2 -	Y07	X07	Y18	X18
- 6000 (. 			X08	Y08	X19	Y19
- 5000 ^{eii}		-4 -	Y09	X09	Y20	X20
 000 0005 Weight Amplitude (linear)			X10	Y10	X21	Y21
- 4000 <u>H</u>				-4		-2
t An				-		erag
- 3000 ti				20)191	015
- 2000 [♥]			X00		X11	Y11
2000		4 -	Y01	X01	Y12	X12
- 1000			X02		X13	Y13
		2 -		X03	Y14	X14

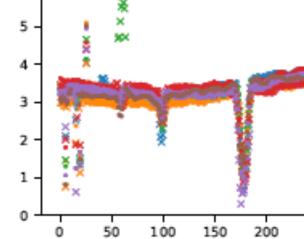
		X00	Y00	X11	Y11	X22	Y22	X33	Y33	X44	Y44	X55
	4 -	Y01	X01	Y12	X12	Y23	X23	Y34	X34	Y45	X45	Y55
		X02		X13	Y13	X24	Y24	X35	Y35	X46	Y46	X56
	2 -		X03	Y14	X14	Y25	X25	Y36	X36	Y47	X47	Y56
		X04	Y04	X15	Y15	X26	Y26	X37	Y37	X48	Y48	X57
y pos	0 -		X05	Y16	X16	Y27	X27	Y38	X38	Y49	X49	Y57
		X06		X17	Y17	X28	Y28	X39	Y39	X50	Y50	X58
-	-2 -	Y07	X07	Y18	X18	Y29	X29	Y40	X40	Y51	X51	Y58
		X08		X19	Y19	X30		X41	Y41	X52	Y52	X59
-	-4 -		X09	Y20	X20	Y31	X31	Y42	X42		X53	Y59
		X10	Y10	X21	Y21	X32	Y32	X43	Y43	X54	Y54	X60
			-4		-2		0		2		4	

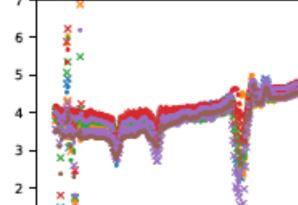


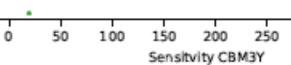
ge Weight Amplitude over PAF 5T213010 - RT4 - CBM15











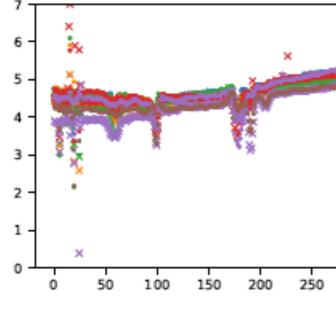
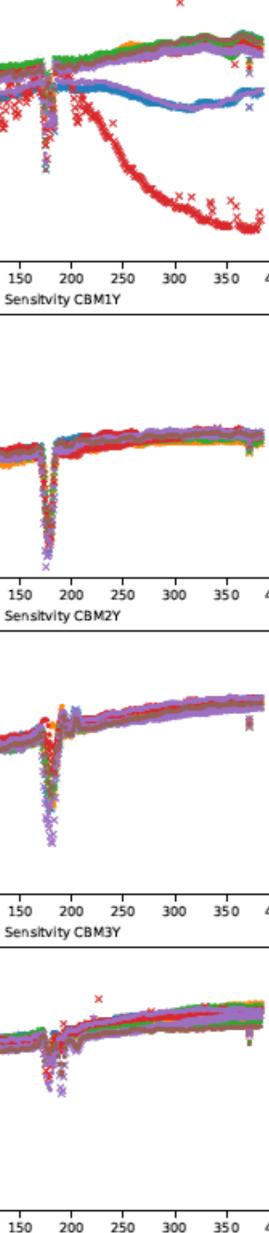


Image credits: A. Corstanje, F. Sweijen, C. Van Eck, P. Zucca

x pos

Sensitvity (BMOY
--------------	------



- - ----

350

QUESTION?

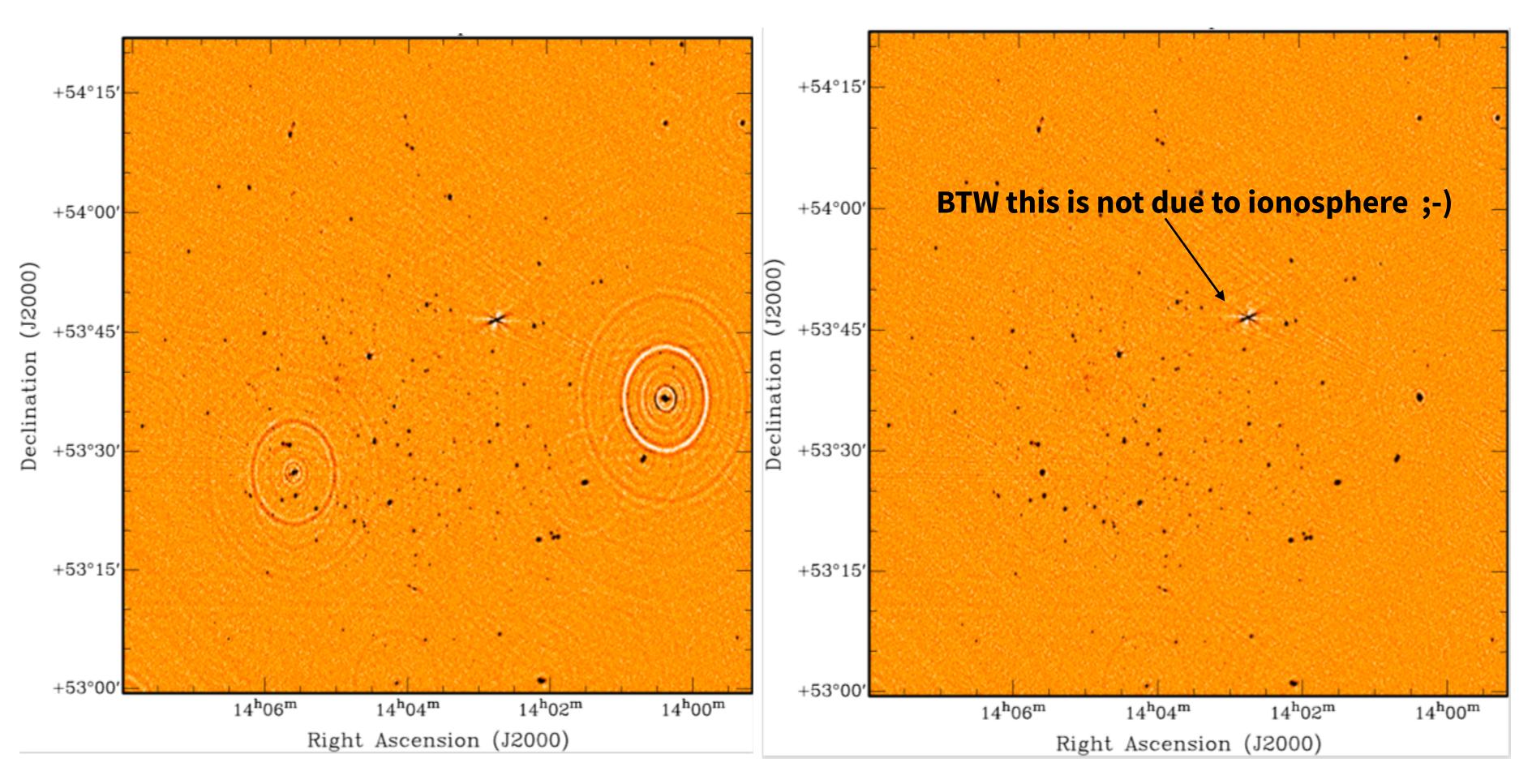
What would you expect to be the effect of broken/ malfunctioning PAF elements?

1. The mechanical stability of the PAF would be compromised 2.Loss of sensitivity on correlated and tied array beam data **3.Direction dependent errors in imaging** ock synchronization would be lost



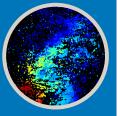


- LOFAR are caused by the ionosphere & variable beam
- In Apertif they caused by variable beam of a particular compound beam.
- On top of that there is also the loss of sensitivity the is reflected on BF observation as well as in imaging.



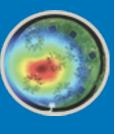


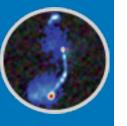




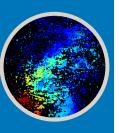
DDEs & sensitivity loss











Apertif Long Term Archive

- ALTA makes use of two systems to store the data:
- an online disk cluster located in Dwingeloo where science ready data products are stored and immediately available.
- The tape system at SURFsara (long term) storage or "cold storage") where visibilities and time series are stored. These can be retrieved contacting the ASTRON <u>Helpdesk</u>.

Apertif Long Term Archive

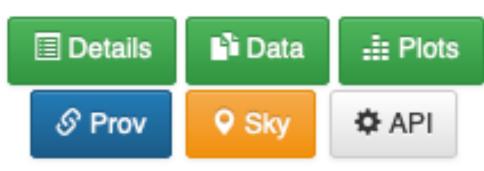


SVC_2019_Imaging



190411042

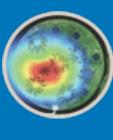
S1415+36



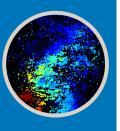


...and now Science with Apertif







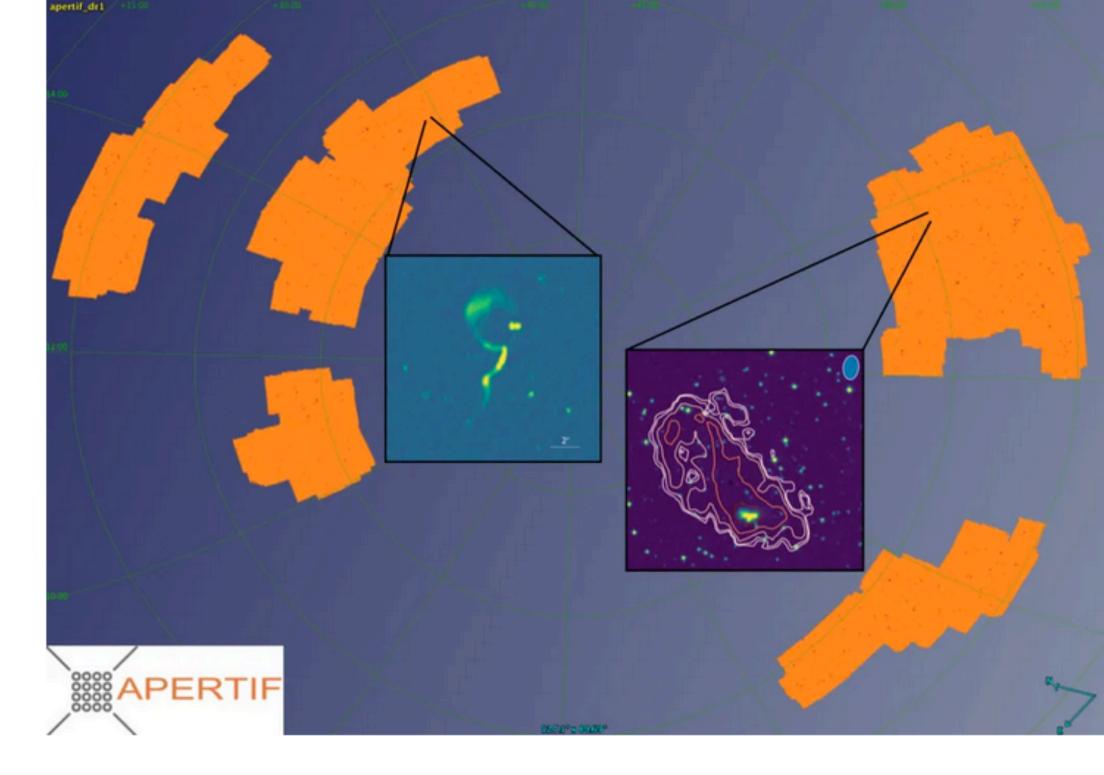


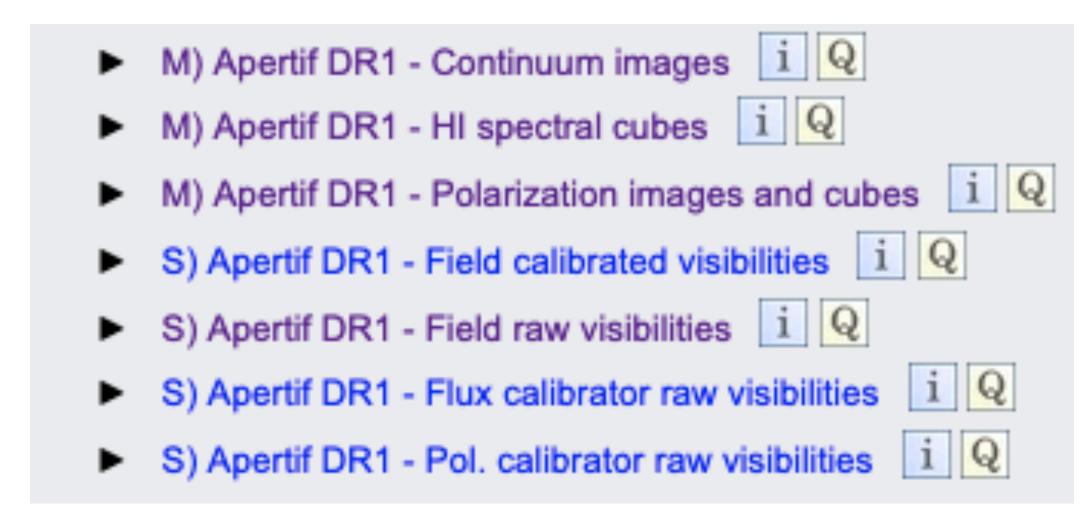
DATA release and VO

- Apertif imaging DR1 is in <u>vo.astron.nl</u>
- Documentation <u>apertif-dr1-documentation</u> & Adams et al. in prep.
- Directly retrievable: Continuum images, HI spectral cubes and Polarization images and cubes.
- Visibilities upon request via <u>SDC-Helpdesk</u>
- Only beams that passed validation have been released.

ARTS DR1 is coming soon. Stay tuned!

To help us improve the data access services we appreciate your feedback, which can be provided at <u>https://forms.gle/wecdDsttuYjHF8W66</u>.

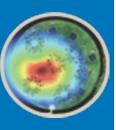




AST(RON



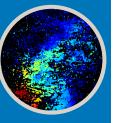




Data access described how to find the data.







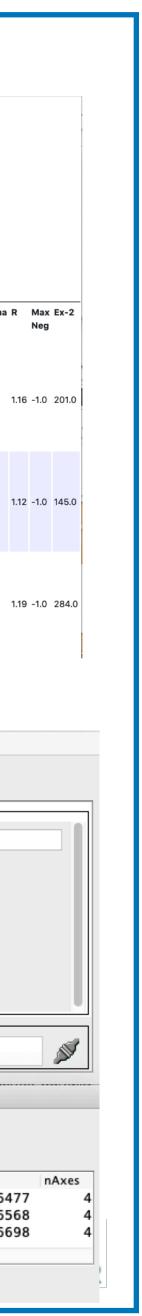
Directly	on	vo@astron.nl
1		

Position [deg]	ICRS Position, RA,DEC, or Simbad object (e.g., 234.234,-32.45)
Field size [deg]	0.5 Size in decimal degrees (e.g., 0.2 or 1,0.1)
Intersection type	 Image overlaps Rol Image covers Rol Rol covers image The given position is shown on image Relation of image and specified Region of Interest.
Field Name	
Obsld	Name of the field. Matches also partial input (e.g. m1403+5324 or 1403+5324). Observation id
Beam number	Beam number
Max distance from the center [deg]	0.75 Maximum distance to the center of the images
Table	Sort by _r O ASC C Limit to 100 C items.
Output format	HTML OMORE Output fields
	Go
	& ADQL query

TOPCAT via samp

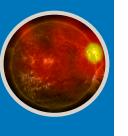
M)	Δn	orti	fD	R	1.	. Co	ntini	uum	image	20														
Parar • Fie • Ma • Ou	met eld size ax dista itput fo	ers	m the o nage/fi	cente				um	image	50														
Resu Matched:	3		iek Die	•																				
Send via Dist [arcmin]	Field		Ctr. RA [deg]	Ct De			max. y Freque [MHz]	# ncy chan	Obs. da nels	te	Obsid	Beam	Product key	Туре	File size [byte]	Passed validation	Scales [deg/pix]	Instrument	Related products		P. DID	Sigma in	a Sigma out	R
0.30	s224	5+2904	341.8	6 28	.07 [/]	1280.0	1430.0	1	2020-00	8-25T03:57:16Z	200624213	5	image_mf_01.fits	image/fits	36.1MiB	True	[0.00111111, 0.00111111]	Apertif	dimeta	200624213_AP_B005	ivo://astron.nl , /~?APERTIF_DR1 /200624213_AP_B005 /image_mf_01.fits	59.7	51.4	1.16
27.78	s224	5+2904	342.1	2 28	1.47 ·	1280.0	1430.0	1	2020-00	6-25T03:58:35Z	Z 200624213	12	image_mf_01.fits	image/fits	36.1MiB	True	[0.00111111, 0.00111111]	Apertif	dimeta	200624213_AP_B012	ivo://astron.nl /~?APERTIF_DR1 /200624213_AP_B012 /image_mf_01.fits	50.4	45.2	1.12
27.95	s224	5+2904	341.5	9 28	.47 ·	1280.0	1430.0	1	2020-00	3-25T04:00:27Z	2 200624213	11		image/fits	36.1MiB	True	[0.00111111, 0.00111111]	Apertif	dimeta	200624213_AP_B011	ivo://astron.nl /~?APERTIF_DR1 /200624213_AP_B011 /image_mf_02.fits	51.9	43.7	1.19
) A	<u>الا</u>						Σ 1				image_mf_02.fits				f (<i>x</i>							
Table .: DaC							Curre	L C Sor	ocation: Name: Rows: olumns: rt Order:	DaCHS r samp:Da0 DaCHS re 3 42	CHS rest sult	ult	\$											

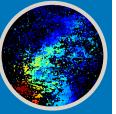
			Row Subset: Activation Actions: 1	All 🗘								
			SAMP Messages: Cli						Clients: 💿 👹 🔲			
	44 / 409	96 M]		<u> </u>			
0					٦	TOPCAT(1): Ta	ble Browser					
		P ×										
abl	e Browser for	1: DaCHS res	ult									
	_r	accref			mime	accsize	centerAlpha	centerDelta	imageTitle	instld	dateObs	
L	0.301772	https://vo.as	tron.nl/getproduct/APERTI	F_DR1/20	image/fits	37895040	341.85672	28.06588	200624213_AP_B005	Apertif	59025.164	
2	27.778	https://vo.as	tron.nl/getproduct/APERTI	F_DR1/20	image/fits	37883520	342.12447	28.4701	200624213_AP_B012	Apertif	59025.165	
3	27.9506	https://vo.as	tron.nl/getproduct/APERTI	F_DR1/20	image/fits	37883520	341.59207	28.47166	200624213_AP_B011	Apertif	59025.166	

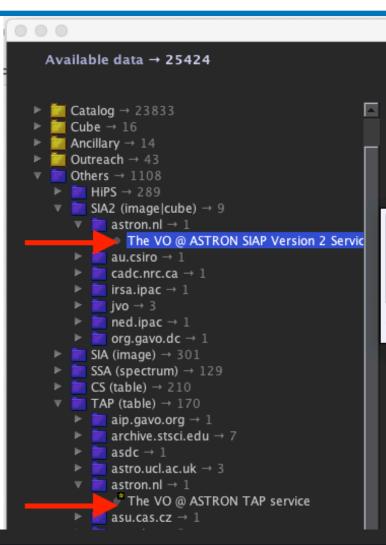


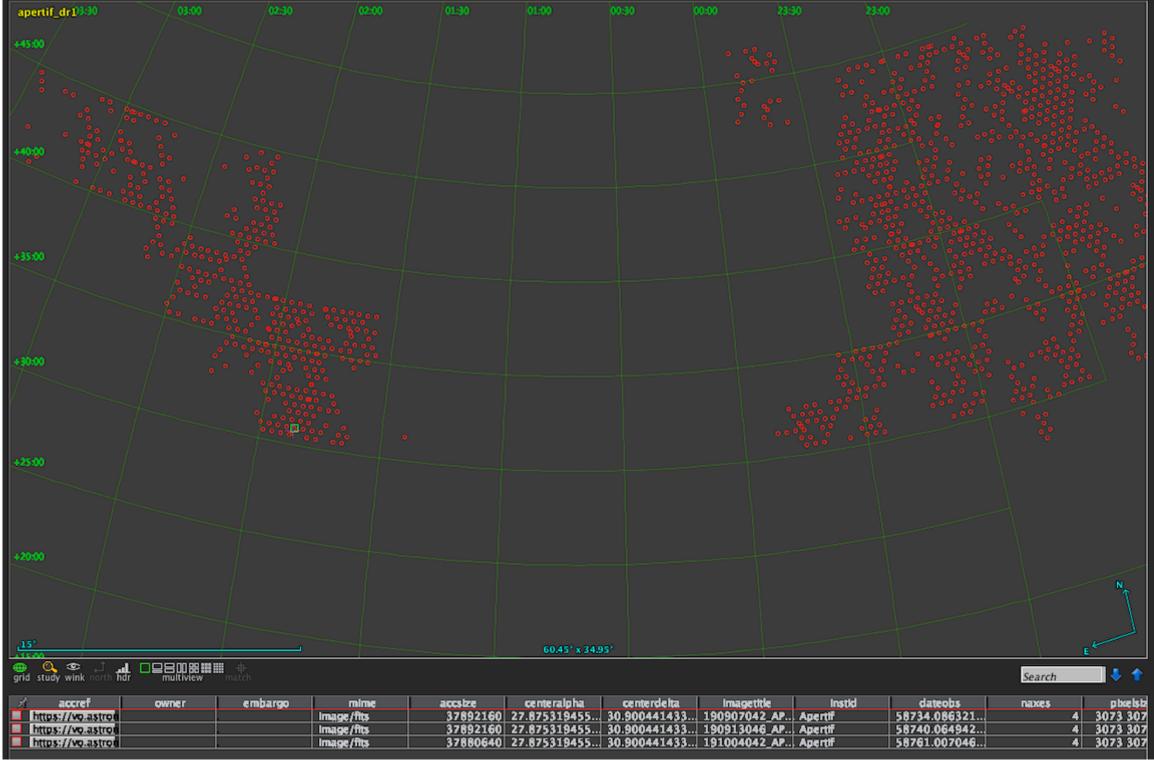


	Graphics Joins Windows	VO Interop Help VO Cone Search	
	🗄 🗒 🕥 Σ 🗱 [
ble List	Current Table Properties -		
DaCHS result	Label: DaC	-	
	Location: samp		
	Name: DaCH	Virgo-Millennium Simulation Query	
	Rows: 3 Columns: 42	BaSTI Data Loader	
	Sort Order: 合	Data Loader	
	Row Subset: All	I 🛛 💥 CDS Upload X-Match	
	Activation Actions: 1 / 8	Multicone	
		Multiple SIA	
		R Multiple SSA	
45 / 400C M	SAMP Messages:	0	Clients: 🖲 🌺 🔲
45 / 4096 M	messages.		
Metadata	Select	Service Use Service Resume Jo	
Find:		Service Schema	● Table ● Columns ○ FKeys Hints
🗸 Name 🗌	Descrip Or	Name:	
	TAD (27)	apertif_dr1	
ASTRON VC		Tables:	
	tif_dr1.beam_cubes	8 Description:	
	tif_dr1.calibrated_visibilitie	Description: Apertif Imaging Data fr	rom the data release 1
	tif_dr1.continuum_images	· ·	
	tif_dr1.flux_cal_visibilities		
	tif_dr1.pol_cal_visibilities		
	tif_dr1.pol_cubes		
	tif_dr1.raw_visibilities tif_dr1.spectral_cubes		
v hetdex (
	ex.hetdex_images		
	ay ima main		
Service Capab		0	
Query Languag	je: ADQL-2.0 ≎ N	Max Rows: 20000 (default) 🗘 Up	ploads: 20Mb
ADQL Text			
Mode: Sync	hronous 🗘		💻 📺 🧷 🥱 🌈 🖭 🔤 🛕 📎
		1	
SELECT TOP	1000 * FROM apertif_dr	1.continuum image	
SELECT TOT	tooo w mon aper err_ar.	In conteindum_image	_
Examples			Info 🗷









ALADIN

DSS PanSTARRS SDSS 2MASS GALEX Gaia Simbad NED +



Image credits: A. Corstanje, F. Sweijen, C. Van Eck, P. Zucca

LOFAR



