LFR status

- Ground segment software **(status)**
- k-coefficients **(SCM 'new' alignment)**
- Spectrograms of FFT data (**overview**)

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LFR ground segment software (1)

- **Last version of lfr-calbut (0.6.2.1) was integrated to ROC pipeline**. This integration leads to several modifications of the software. These modifications were reported in a new version of the user guide **(not yet delivered)**.

- **Some checks need to be done for ASM**. Indeed, ASM obtained by ROC differ from test data.

LFR ground segment software (2)

Products:

Calibration tables (RCT)

- Produced calibration tables for BIAS, SCM (and VHF).

Waveforms products (CWF, SWF)

- L1 to L1R pipeline is operational. It produces :

- CWF in SBM1, SBM2 and SURV mode.
- SWF in SURV mode.

LFR ground segment software (3)

Products:

Spectral products (Averaged Spectral Matrices)

- L1 to L2 pipeline is operational. It produces ASM in SURV mode.

  Some problems were encountered for large file. It should be solve with our new development machine.

Spectral products (Basic Parameters)

- L1 to L2 pipeline is developed. It produces BP1 and BP2 in SBM1, SBM2 and SURV mode.

  We are waiting for LESIA inputs to fully validate these products.

LFR ground segment software (4)

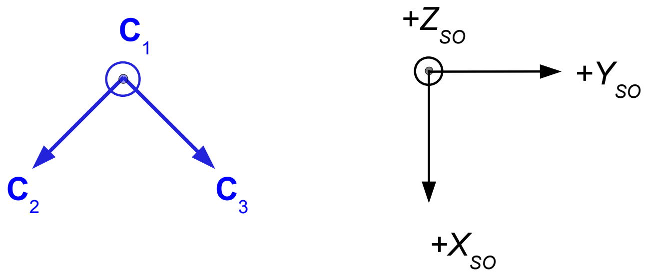
Open issues:

How to know which calibration tables to use to perform our calibrations ?

- It was proposed in Kiruna to centralize these information in a dictionary
- Recently, the BIAS team proposed to other teams its method. Should (Could) every teams implement it?

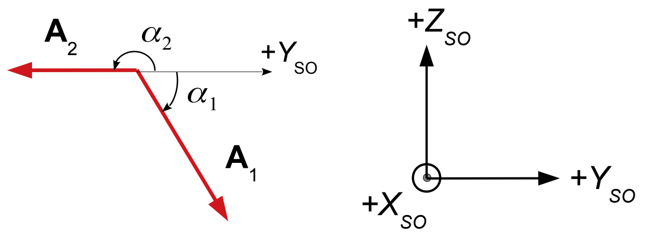
LFR k-coefficients and geometry

- These coefficients if correctly set would allow to correlate on-board the electric and magnetic signals for an estimate of :
  1) the (radial) ***X_{SO}*-component of the Poynting flux**;
  2) the **phase velocity** of plane waves.

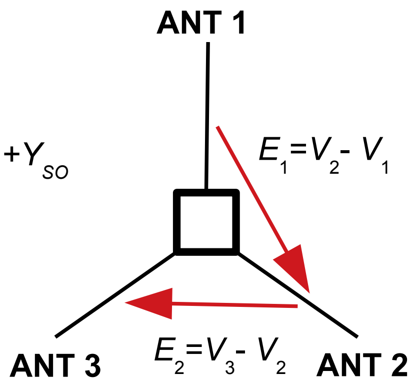


$$B_1(\omega) = [\mathbf{B}(\omega)\cdot\hat{\mathbf{e}}_{X_M}] \times C_1(\omega) = \mathbf{B}(\omega)\cdot\mathbf{C}_1(\omega)$$
$$B_2(\omega) = [\mathbf{B}(\omega)\cdot\hat{\mathbf{e}}_{Y_M}] \times C_2(\omega) = \mathbf{B}(\omega)\cdot\mathbf{C}_2(\omega)$$
$$B_3(\omega) = [\mathbf{B}(\omega)\cdot\hat{\mathbf{e}}_{Z_M}] \times C_3(\omega) = \mathbf{B}(\omega)\cdot\mathbf{C}_3(\omega)$$

$$\overline{\mathbf{A}}_M = [\mathbf{C}_1, \mathbf{C}_2, \mathbf{C}_3] = \begin{bmatrix} C_{X1} & C_{X2} & C_{X3} \\ C_{Y1} & C_{Y2} & C_{Y3} \\ C_{Z1} & C_{Z2} & C_{Z3} \end{bmatrix}_{SO} \simeq \begin{bmatrix} 0 & C_1 \cos\alpha_M & -C_1 \sin\alpha_M \\ 0 & C_1 \sin\alpha_M & C_1 \cos\alpha_M \\ C_1 & 0 & 0 \end{bmatrix}_{SO}$$

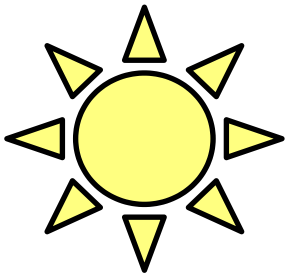


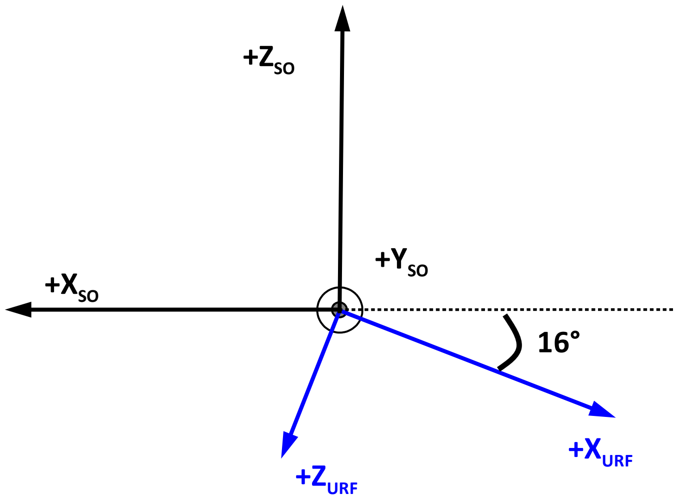
$$E_1(\omega) = [\mathbf{E}(\omega)\cdot\hat{\mathbf{e}}_1] \times A_1(\omega) = \mathbf{E}(\omega)\cdot\mathbf{A}_1(\omega)$$
$$E_2(\omega) = [\mathbf{E}(\omega)\cdot\hat{\mathbf{e}}_2] \times A_2(\omega) = \mathbf{E}(\omega)\cdot\mathbf{A}_2(\omega)$$



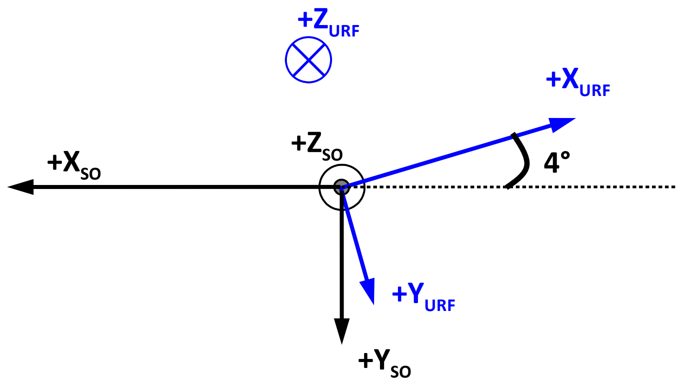
$$\overline{\mathbf{A}}_E = [\mathbf{A}_1, \mathbf{A}_2] = \begin{bmatrix} A_{X1} & A_{X2} \\ A_{Y1} & A_{Y2} \\ A_{Z1} & A_{Z1} \end{bmatrix}_{SO} \simeq \begin{bmatrix} 0 & 0 \\ A_1 \cos\alpha_1 & A_2 \cos\alpha_2 \\ A_1 \sin\alpha_1 & A_2 \sin\alpha_2 \end{bmatrix}_{SO}$$

Current SCM alignment

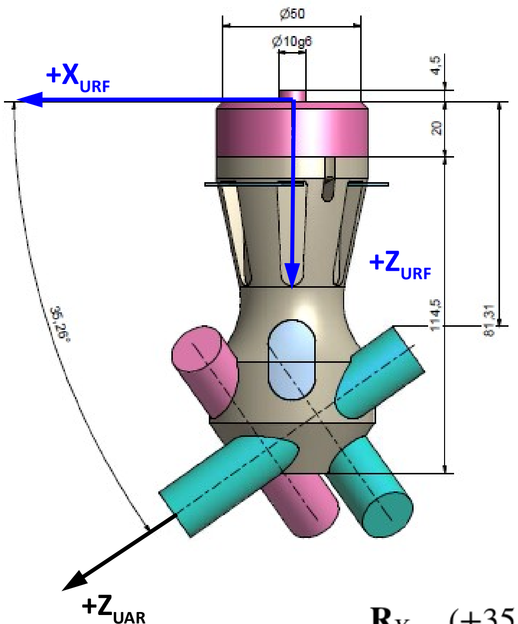


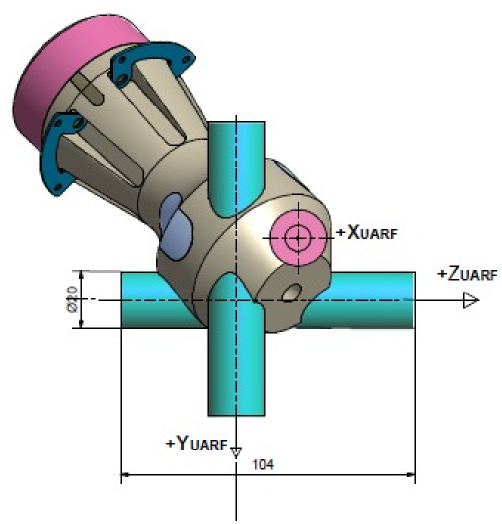


View from the "side"



View from the "top"





Transformation matrix from UARF to SO coordinate system

X_{UARF}	Y_{UARF}	Z_{UARF}
0.184872	0.279701	-0.942119
0.733859	-0.676909	-0.056959
-0.653661	-0.680852	-0.330403

SO

$$\mathbf{R}_{Y_{URF}}(+35.26°) \cdot \mathbf{Z}_{UARF} = \mathbf{X}_{URF}$$
$$\mathbf{R}_{X_{URF}}(+45°) \cdot \mathbf{R}_{Y_{URF}}(+35.26°) \cdot \mathbf{X}_{UARF} = \mathbf{Z}_{URF}$$
$$\mathbf{R}_{X_{URF}}(+45°) \cdot \mathbf{R}_{Y_{URF}}(+35.26°) \cdot \mathbf{Y}_{UARF} = -\mathbf{Y}_{URF}$$

X_{SO}-component of the Poynting flux

[BP1 set 6]

$$\langle S_X \rangle = \langle (\mathbf{E} \times \mathbf{B^*})_X \rangle = \langle E_Y B_Z^* \rangle - \langle E_Z B_Y^* \rangle$$

$$\simeq \left\langle (+A_2 \sin\alpha_2 E_1 - A_1 \sin\alpha_1 E_2) \frac{1}{A_1 A_2 \sin(\alpha_2 - \alpha_1)} \frac{B_1^*}{C_1^*} \right\rangle -$$

$$\left\langle (-A_2 \cos\alpha_2 E_1 + A_1 \cos\alpha_1 E_2) \frac{1}{A_1 A_2 \sin(\alpha_2 - \alpha_1)} \frac{\sin\alpha_M B_2^* + \cos\alpha_M B_3^*}{C_1^*} \right\rangle$$

$$= (+A_2 \sin\alpha_2 S_{41} - A_1 \sin\alpha_1 S_{51} + A_2 \cos\alpha_2 \sin\alpha_M S_{42} + A_2 \cos\alpha_2 \cos\alpha_M S_{43}$$

$$- A_1 \cos\alpha_1 \sin\alpha_M S_{52} - A_1 \cos\alpha_1 \cos\alpha_M S_{53}) \frac{1}{A_1 A_2 \sin(\alpha_2 - \alpha_1)} \frac{1}{C_1^*}$$

$$= \frac{\cos\alpha_2 \cos\alpha_M}{\sin(\alpha_2 - \alpha_1)} \left(\frac{\tan\alpha_2}{\cos\alpha_M} S_{41} + \tan\alpha_M S_{42} + S_{43} - \frac{A_1}{A_2} \frac{\cos\alpha_1}{\cos\alpha_2} \tan\alpha_M S_{52} - \right.$$

$$\left. \frac{A_1}{A_2} \frac{\cos\alpha_1}{\cos\alpha_2} S_{53} - \frac{A_1}{A_2} \frac{\sin\alpha_1}{\cos\alpha_2} \frac{1}{\cos\alpha_M} S_{51} \right) \frac{1}{A_1 C_1^*}$$

New determination of the k-coefficients seems possible for taking into account the new antenna alignment ...

Phase velocity of plane waves

[BP1 set 7]

$$\mathbf{n}\times\mathbf{E} = \frac{\omega}{k}\mathbf{B} \;\longrightarrow\; (\mathbf{n}\times\mathbf{E})\cdot\hat{\mathbf{e}}_{X_{SO}} B_X^* = \frac{\omega}{k} B_X B_X^* = (n_Y E_Z - n_Z E_Y) B_X^*$$

$$\longrightarrow\; v_\varphi = \frac{\omega}{k} = \frac{n_Y\langle E_Z B_X^*\rangle - n_Z\langle E_Y B_X^*\rangle}{\langle B_X B_X^*\rangle} \qquad \begin{cases} n_Y = \sin\alpha_M n_2 + \cos\alpha_M n_3 \\ n_Z = n_1 \end{cases}$$

$$v_\varphi \simeq \Bigg[n_Y \Big\langle (-A_2\cos\alpha_2 E_1 + A_1\cos\alpha_1 E_2)\frac{1}{A_1 A_2 \sin(\alpha_2-\alpha_1)}(\cos\alpha_M B_2^* - \sin\alpha_M B_3^*)\frac{1}{C_1^*}\Big\rangle - n_Z \Big\langle (+A_2\sin\alpha_2 E_1 - A_1\sin\alpha_1 E_2)\frac{1}{A_1 A_2\sin(\alpha_2-\alpha_1)}(\cos\alpha_M B_2^* - \sin\alpha_M B_3^*)\frac{1}{C_1^*}\Big\rangle \Bigg] \Big/$$

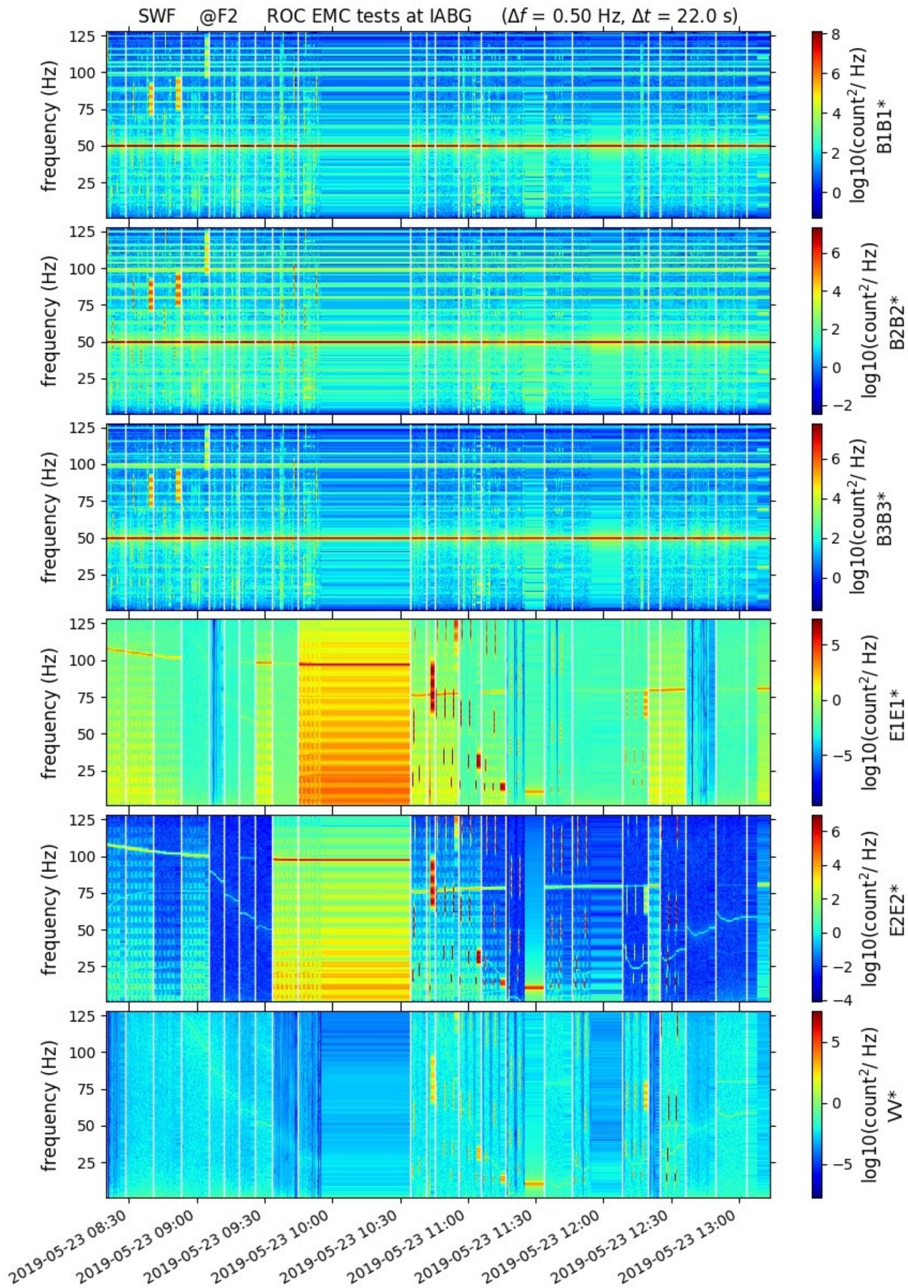
$$\Big[\big(\cos\alpha_M^2\langle B_2 B_2^*\rangle + \sin\alpha_M^2\langle B_3 B_3^*\rangle - 2\sin\alpha_M\cos\alpha_M \Re[\langle B_2 B_3^*\rangle]\big)\frac{1}{C_1 C_1^*}\Big]$$

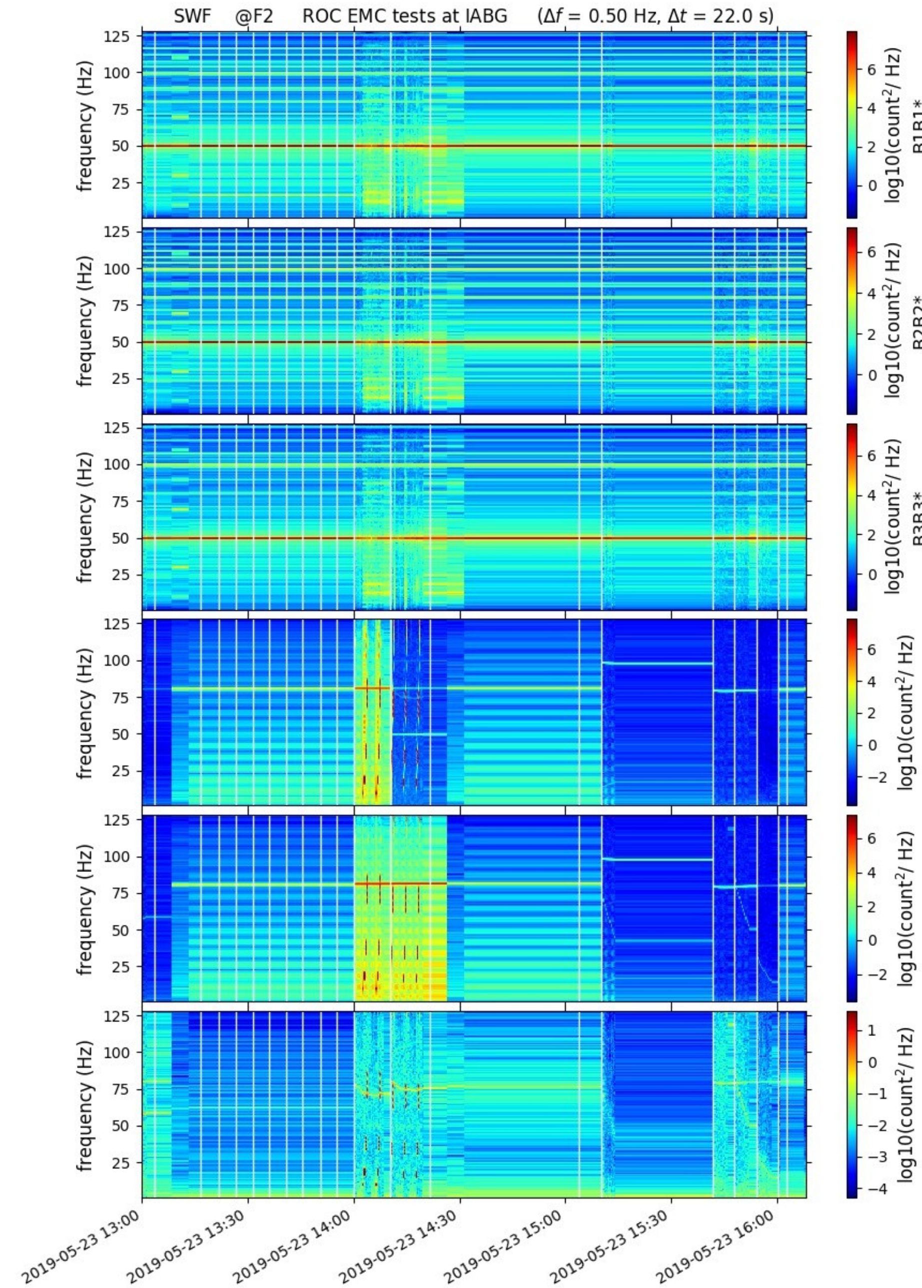
$$= \frac{-\cos\alpha_2\cos\alpha_M}{\sin(\alpha_2-\alpha_1)}\frac{C_1}{A_1} \times \Bigg[n_Y\Big(S_{42} - \frac{A_1}{A_2}\frac{\cos\alpha_1}{\cos\alpha_2}S_{52} - \tan\alpha_M S_{43} + \frac{A_1}{A_2}\frac{\cos\alpha_1}{\cos\alpha_2}\tan\alpha_M S_{53}\Big) - n_Z\Big(\tan\alpha_2 S_{42} - \frac{A_1}{A_2}\frac{\sin\alpha_1}{\cos\alpha_2}S_{52} - \tan\alpha_2\tan\alpha_M S_{43} + \frac{A_1}{A_2}\frac{\sin\alpha_1}{\cos\alpha_2}\tan\alpha_M S_{53}\Big)\Bigg] \Big/$$

$$\big[\cos\alpha_M^2 S_{22} + \sin\alpha_M^2 S_{33} - 2\sin\alpha_M\cos\alpha_M \Re[S_{23}]\big]$$

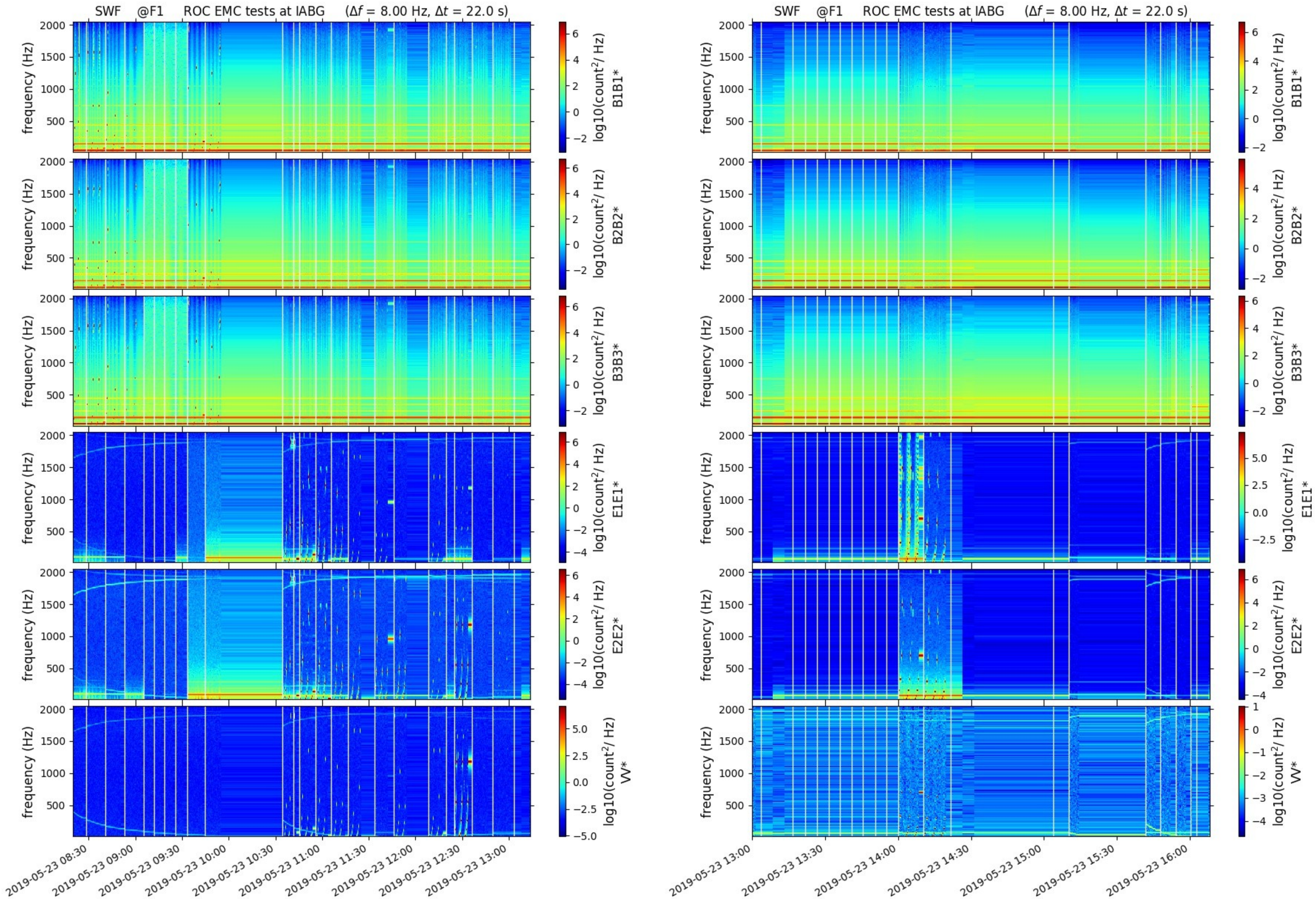
Seems not possible here ...

FFT overview (@F2 = 256Hz)

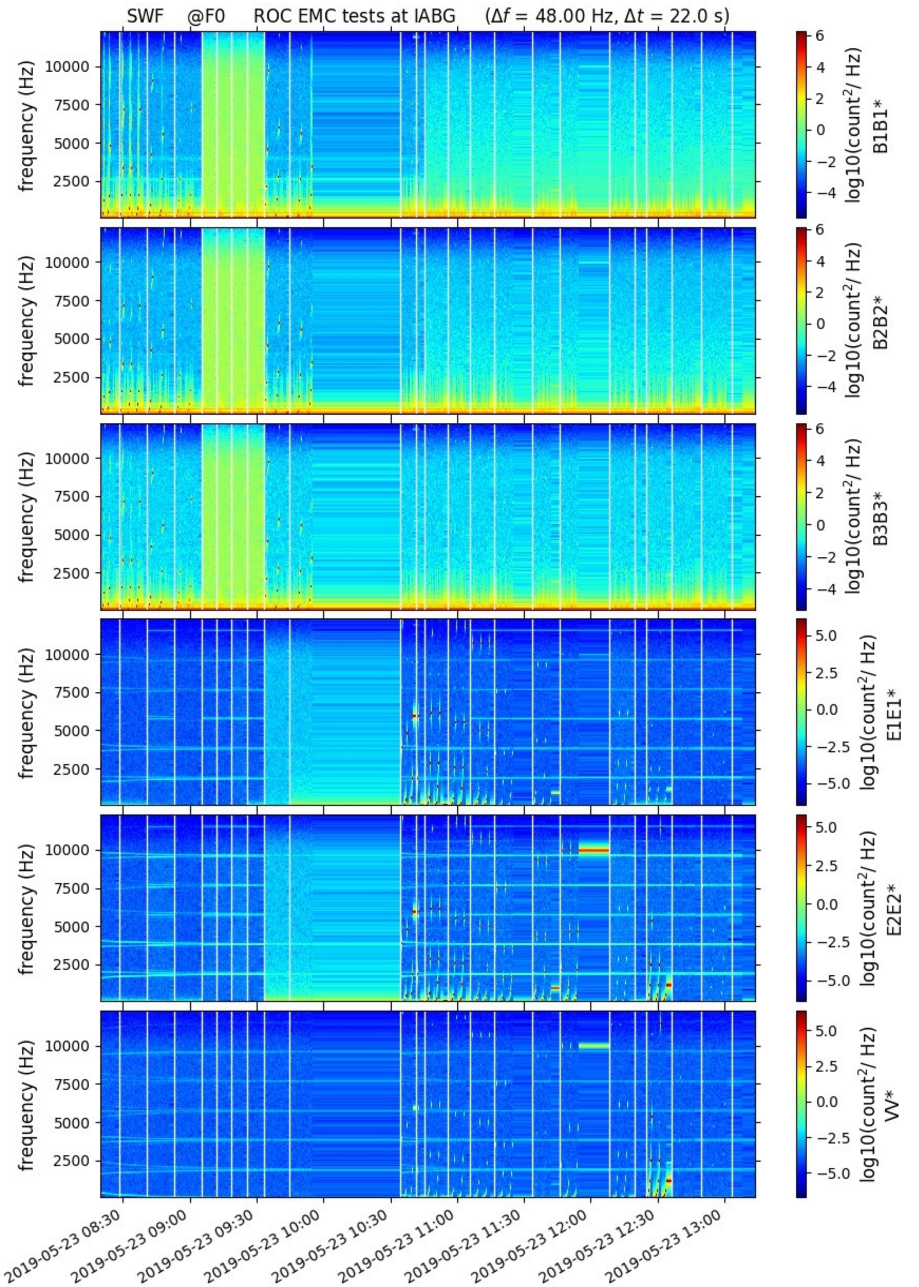


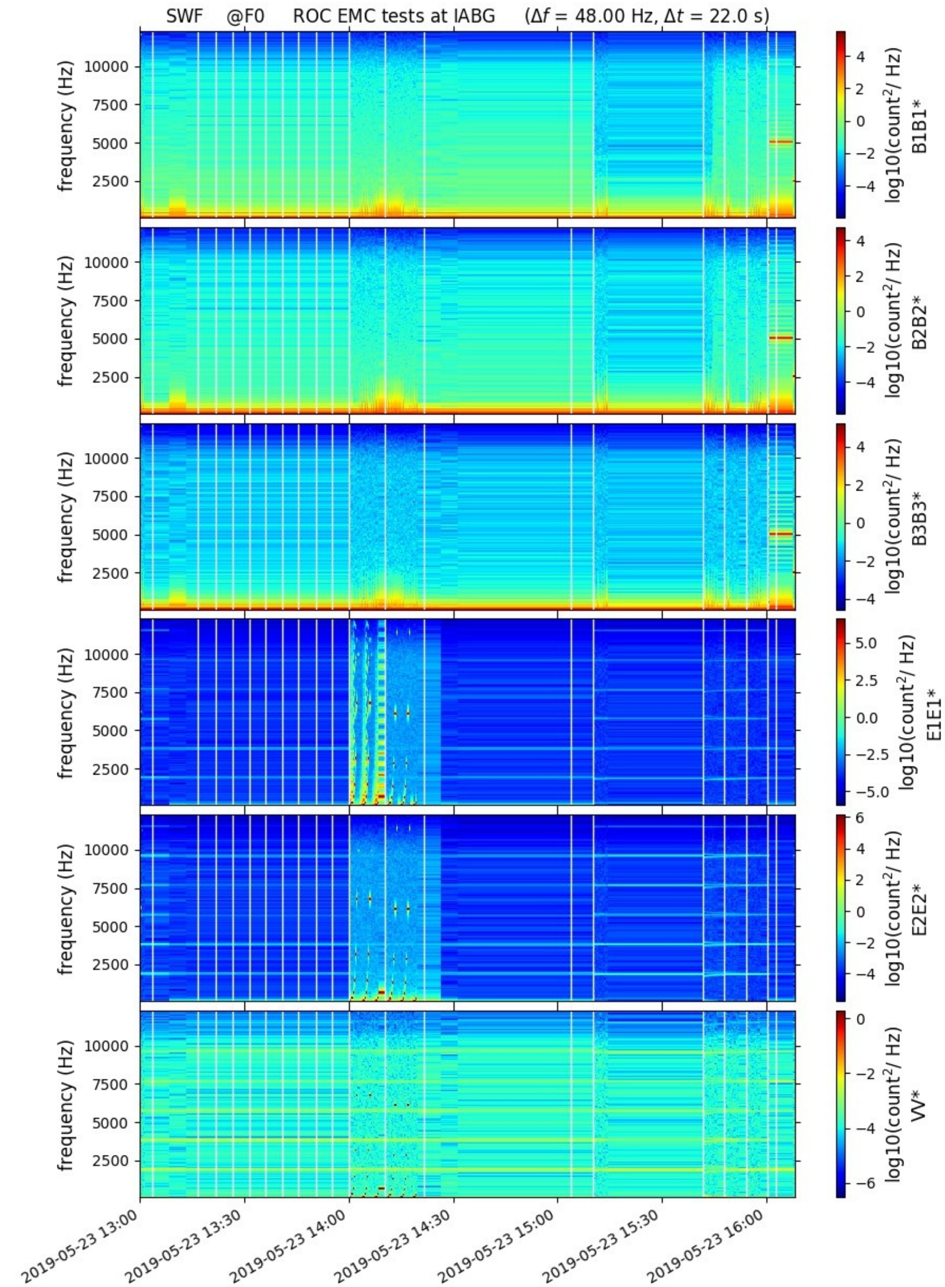


FFT overview (@F1 = 4096Hz)



FFT overview (@F0 = 24576Hz)

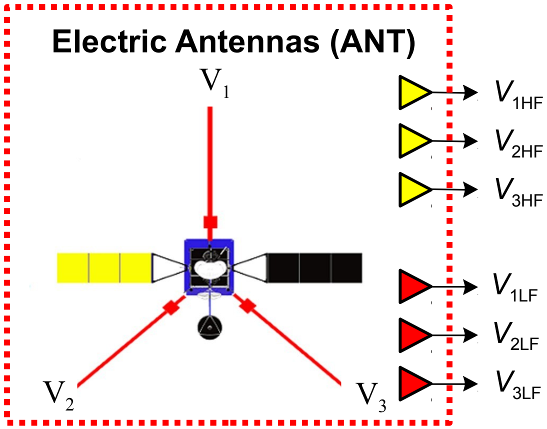


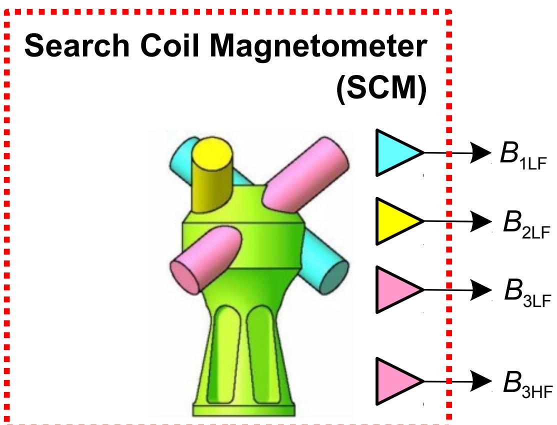


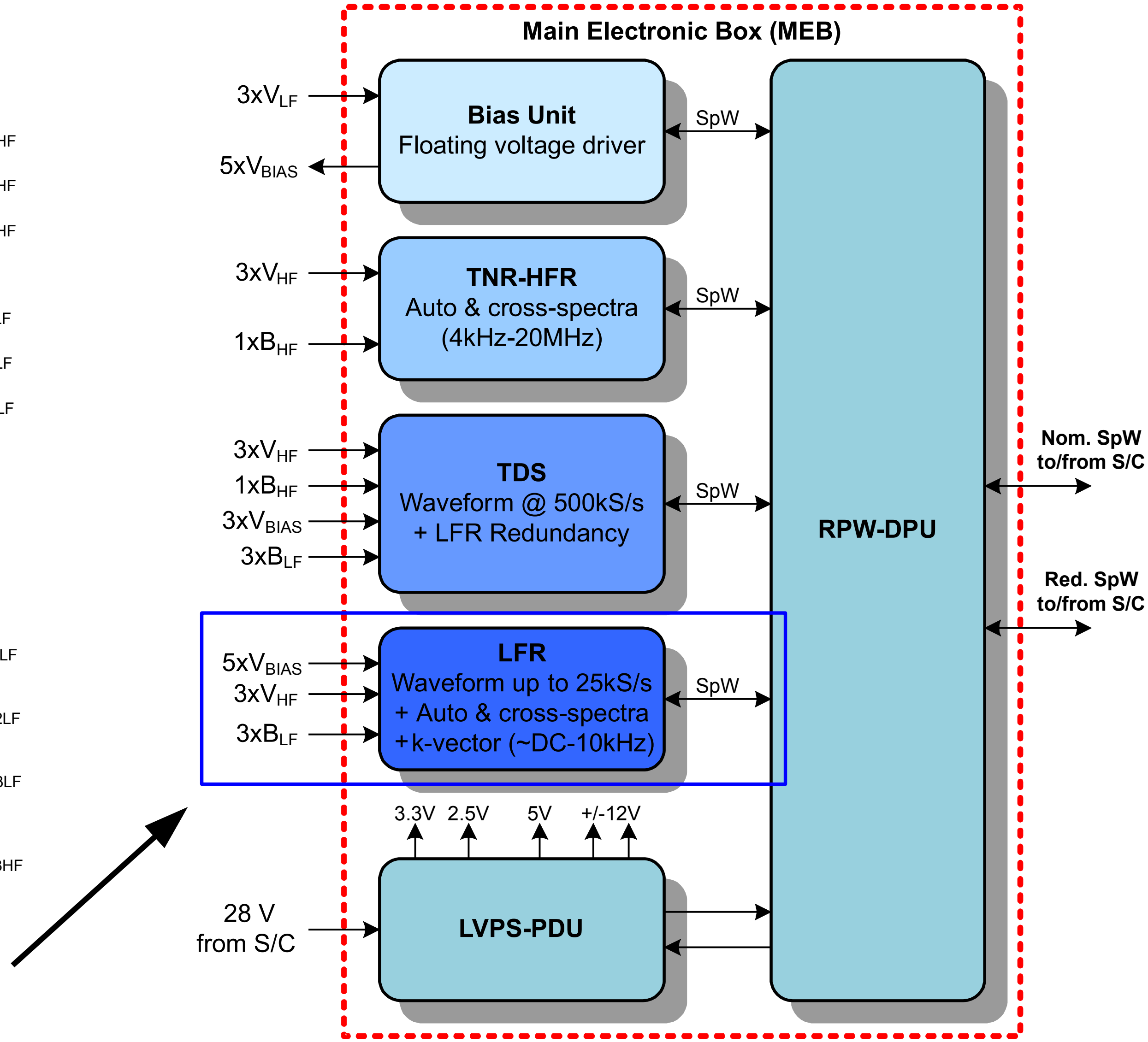
Additional slides

RPW Instrument Overview

*Will allow the characterization of the electric and magnetic fields associated to the dynamics of the near-Sun heliosphere **from near DC up to 20 MHz***

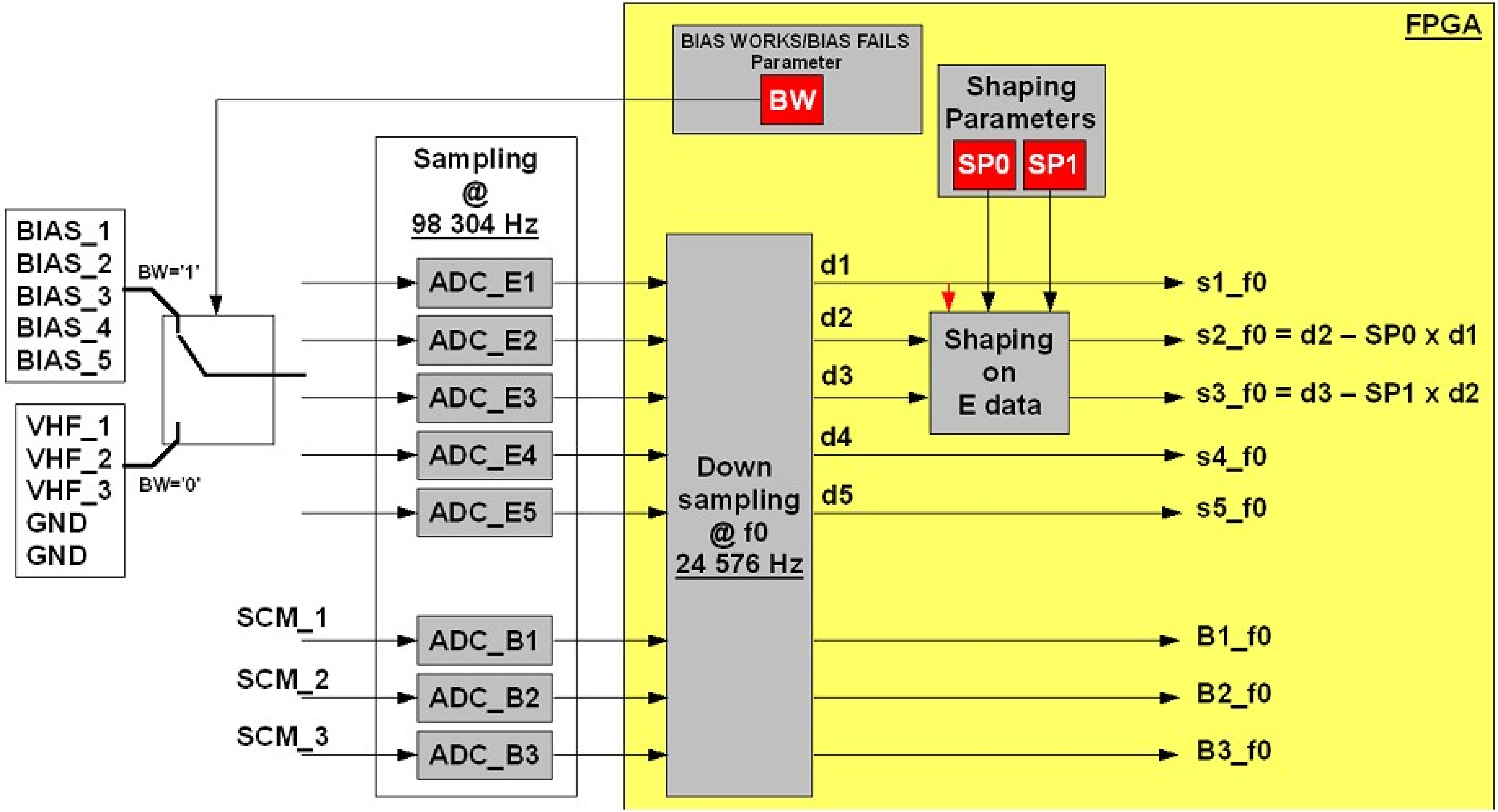




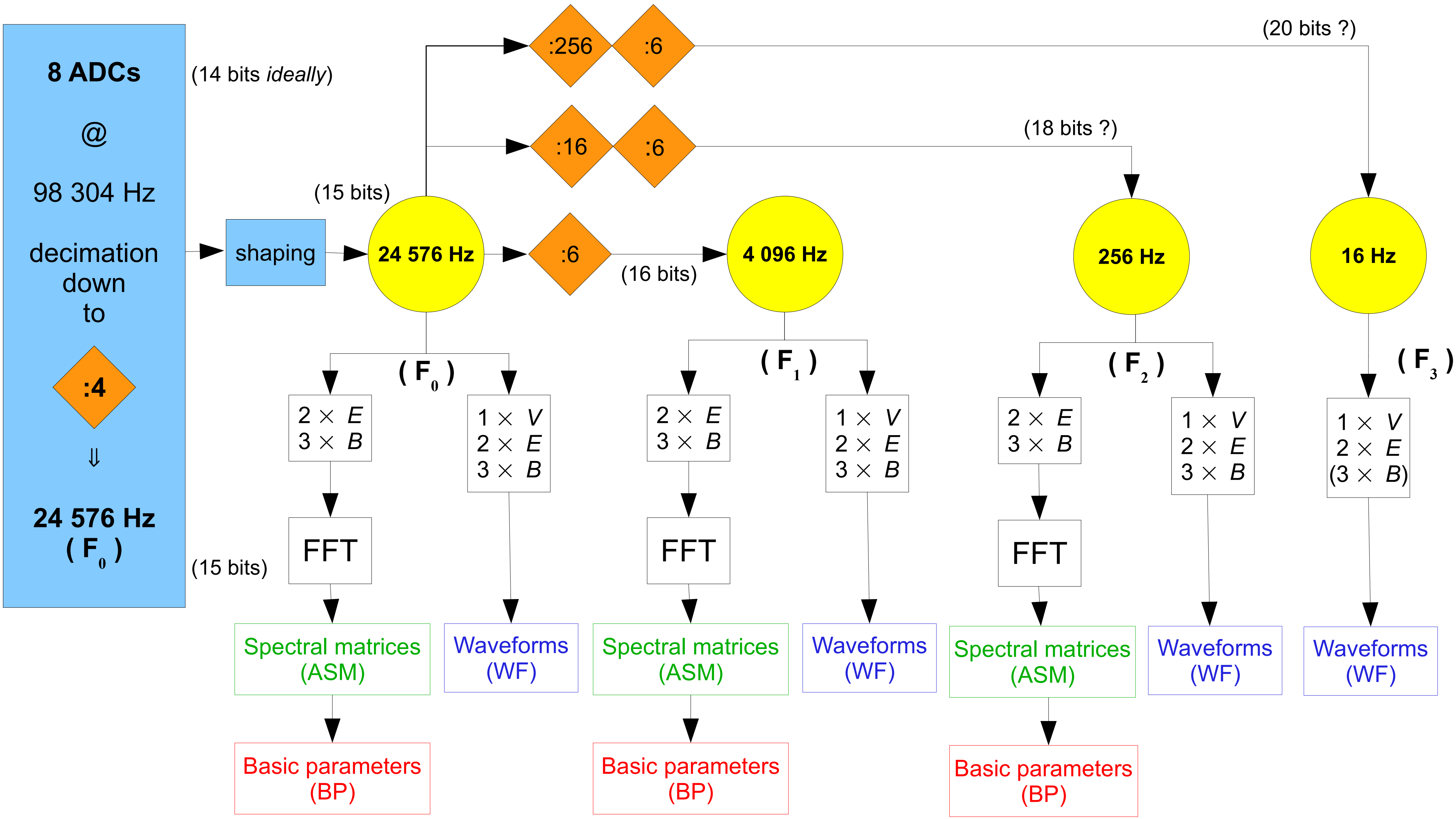


Low Frequency Receiver

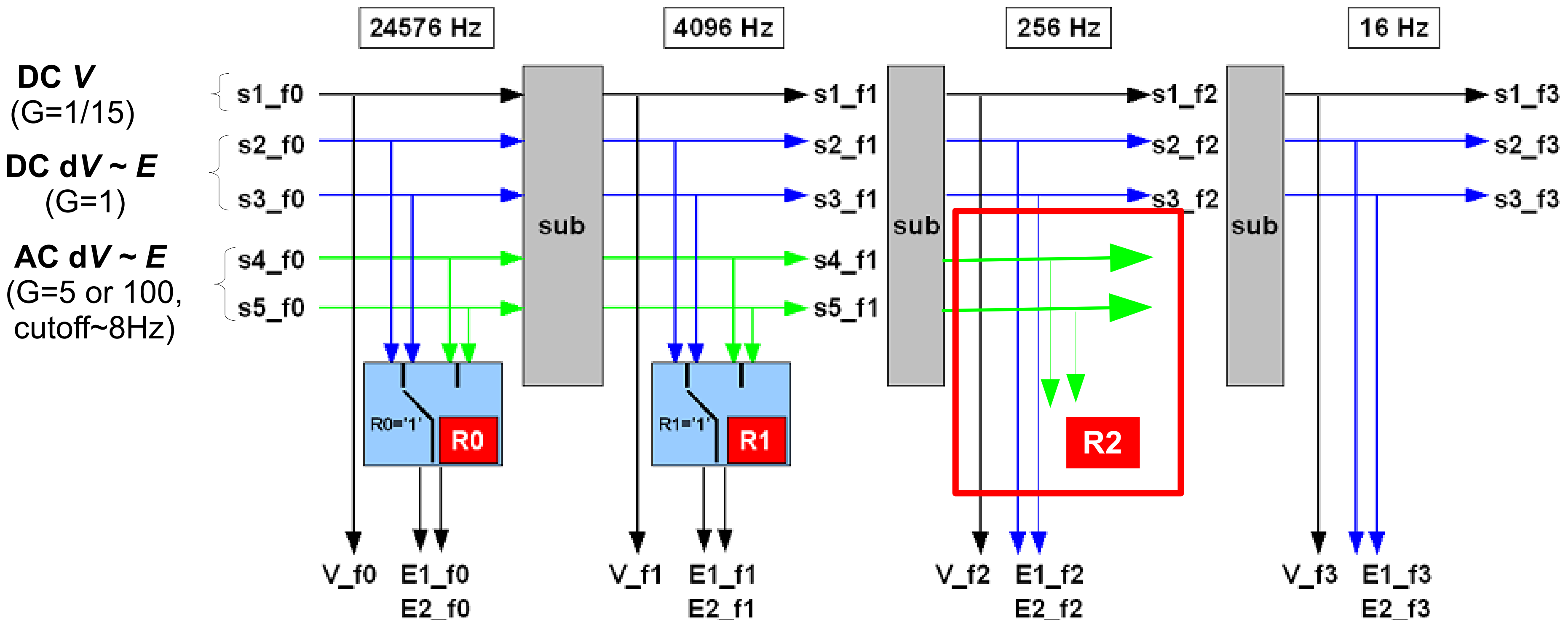
LFR 11 analogue inputs



LFR Decimation and Processing Strategy



BIAS 5 analog inputs and the R-parameters



BIAS configuration

BIAS_WORKS								
BIAS_1	BIAS_2	BIAS_3	BIAS_4	BIAS_5				
V1_DC	V12_DC	V23_DC	V12_AC	V23_AC	standard	SCM_1	SCM_2	SCM_3
V2_DC	V3_DC	V23_DC	V12_AC	V23_AC	probe 1 fails	SCM_1	SCM_2	SCM_3
V1_DC	V3_DC	V13_DC	V13_AC	V23_AC	probe 2 fails	SCM_1	SCM_2	SCM_3
V1_DC	V2_DC	V12_DC	V12_AC	V23_AC	probe 3 fails	SCM_1	SCM_2	SCM_3
V1_DC	V2_DC	V3_DC	V12_AC	V23_AC	offsets saturate V12	SCM_1	SCM_2	SCM_3
BIAS_FAILS								
VHF_1	VHF_2	VHF_3	GND	GND		SCM_1	SCM_2	SCM_3
↓	↓	↓	↓	↓		↓	↓	↓
ADC_ E1	ADC_E2	ADC_E3	ADC_E4	ADC_E5		ADC_B1	ADC_B2	ADC_B3

Current set of Basic Parameters

"Instantaneous" 5 x 5 spectral matrix
(256 FFT points)

$$\mathbf{SM}\left(\omega_j^{(m)}\right)=\begin{bmatrix} B_1B_1^* & B_1B_2^* & B_1B_3^* & B_1E_1^* & B_1E_2^* \\ cc & B_2B_2^* & B_2B_3^* & B_2E_1^* & B_2E_2^* \\ cc & cc & B_3B_3^* & B_3E_1^* & B_3E_2^* \\ cc & cc & cc & E_1E_1^* & E_1E_2^* \\ cc & cc & cc & cc & E_2E_2^* \end{bmatrix}$$

Time Averaged Spectral Matrix (ASM)

$$\mathbf{ASM}\left(\omega_j^{(m)}\right)=\frac{1}{N_{SM}^{(m)}}\sum_{k=1}^{N_{SM}^{(m)}}\mathbf{SM}_k\left(\omega_j^{(m)}\right)=\langle\mathbf{SM}\rangle_{time}$$

***Frequency* average ...**

$$\mathbf{S}\left(\omega_j^{(m)}\right)=\langle\mathbf{ASM}\rangle_{frequency}$$

... before computations of the BPs (i.e. wave parameters)

Mono-**k** assumption :

	BP1 set 1:	Power spectrum of the magnetic field (***B***)
	BP1 set 2:	Power spectrum of the electric field (***E***)
(Means, JGR, 1972) {	BP1 set 3:	Wave normal vector (from ***B***)
	BP1 set 4:	Wave ellipticity estimator (from ***B***)
(Samson & Olson, GJRA, 1980) {	BP1 set 5:	Wave planarity estimator (from ***B***)
	BP1 set 6:	X_{SO}(radial)-component of the Poynting vector
$\mathbf{n}\times\mathbf{E}=\frac{\omega}{k}\mathbf{B}$ →	BP1 set 7:	Phase velocity estimator
	BP2 set 1:	Autocorrelations
$\frac{S_{ij}}{\sqrt{S_{ii}S_{jj}}}$ →	BP2 set 2:	Normalized cross correlations

LFR Spectral Frequencies

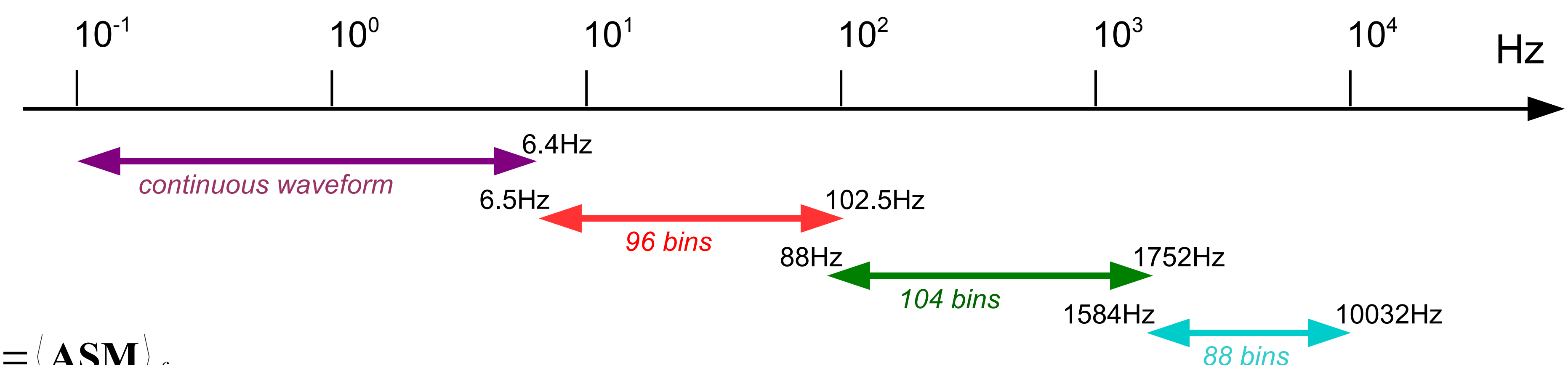
(1) Depending on the frequency channel, **selection** of 96, 104 or 88 consecutive **frequency bins** among 128 (N_{FFT} = 256) of the *time* averaged spectral matrices.

(2) Then, the ASMs are averaged over packets of N_{freq} (8 or 4) consecutive bins :

$$\Delta f^{(m)} = \frac{f_m}{N_{FFT}} \times N_{freq}$$

$$N_{freq} = 8$$

f_3 = 16 Hz	=>	waveform	[DC, 8Hz]		f_3 / 2.5 = 6.4 Hz
f_2 = 256 Hz	=>	12 frequencies	[6.5Hz, 102.5Hz]	$\Delta f^{(2)}$ = 8 Hz	f_2 / 2.5 = 102.4 Hz
f_1 = 4096 Hz	=>	13 frequencies	[88Hz, 1752Hz]	$\Delta f^{(1)}$ = 128 Hz	f_1 / 2.5 = 1638.4 Hz
f_0 = 24576 Hz	=>	11 frequencies	[1584Hz, 10032Hz]	$\Delta f^{(0)}$ = 768 Hz	f_0 / 2.5 = 9830.4 Hz

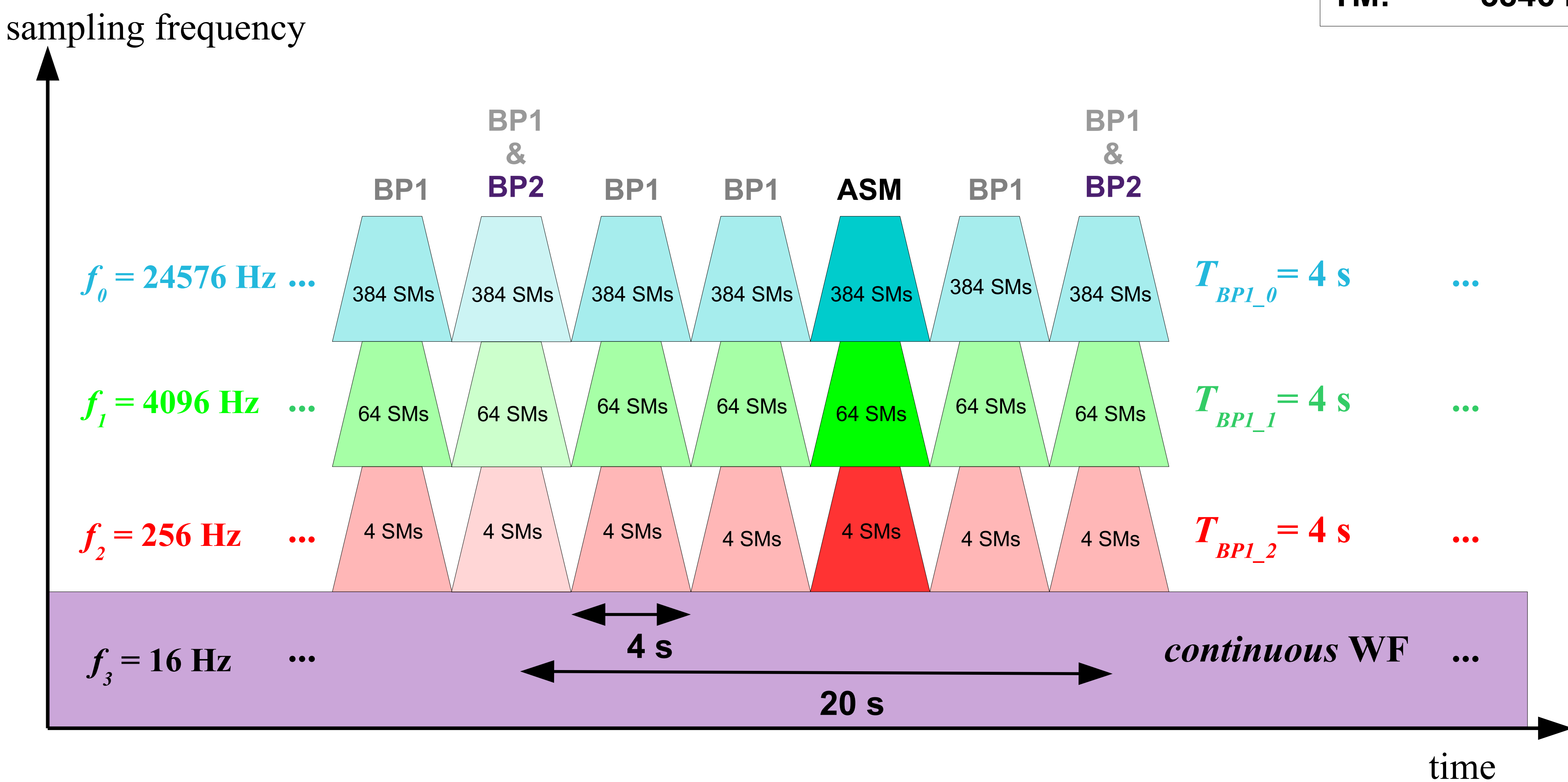


$$\mathbf{S} = \langle \mathbf{ASM} \rangle_{frequency}$$

LFR Normal Mode (1)

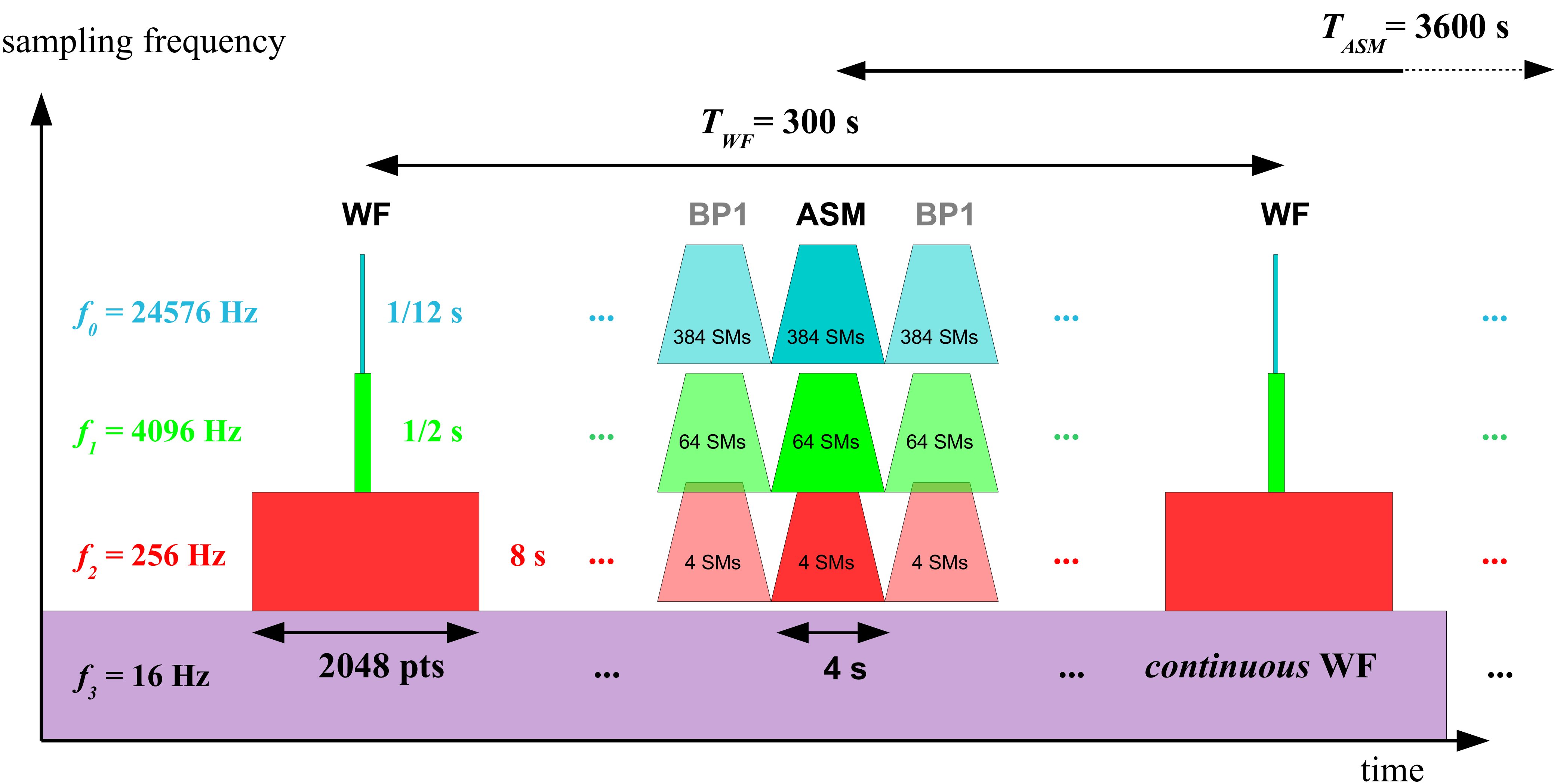
BP:	1080 bps
WF:	2734 bps
ASM:	32 bps
TM:	3846 bps

Basic Parameters



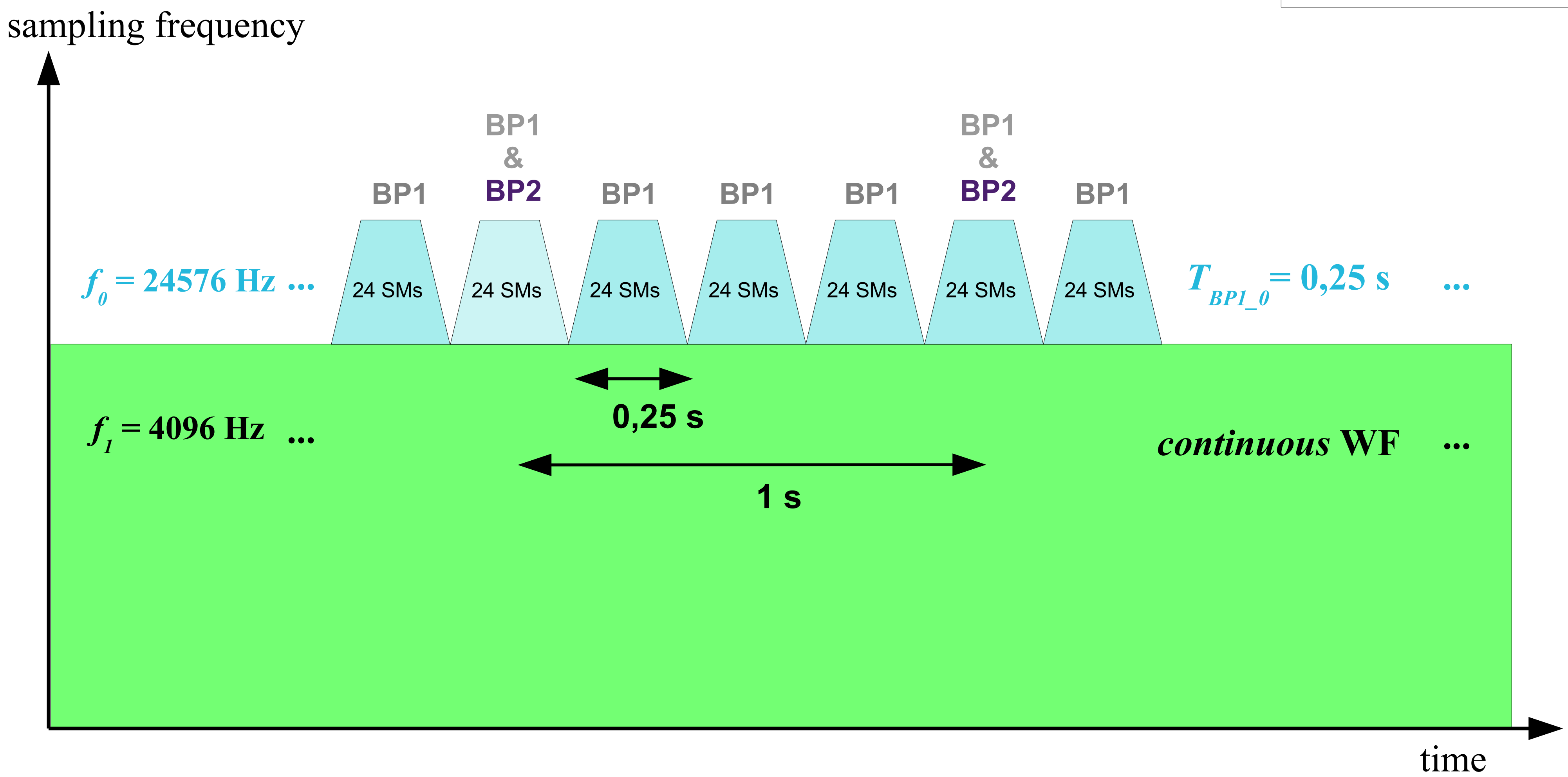
LFR Normal Mode (2)

WaveForms & Averaged Spectral Matrices



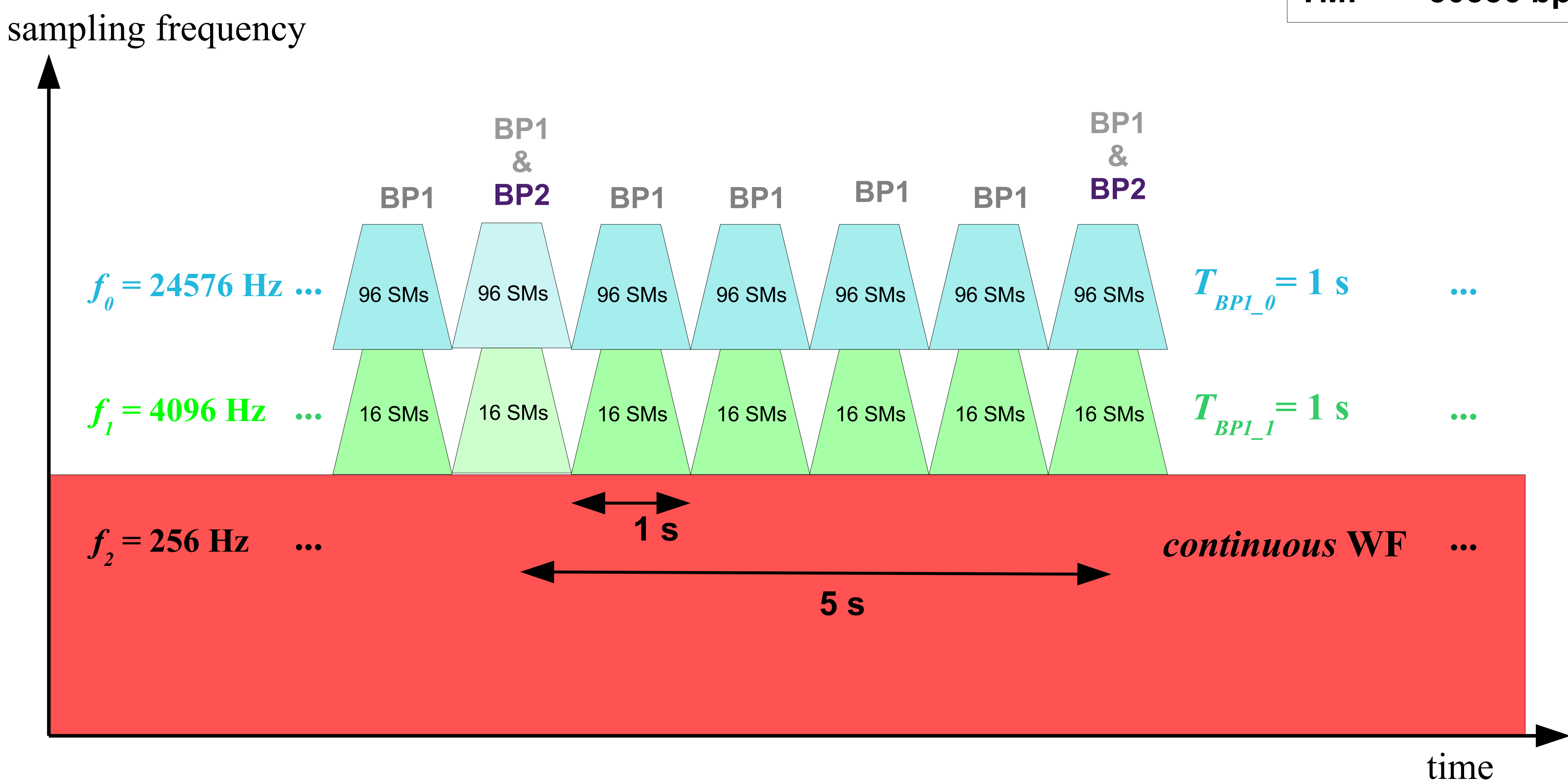
LFR Selected Burst Mode 1

BP:	12672 bps
WF:	393216 bps
ASM:	0 bps
TM:	405888 bps



LFR Selected Burst Mode 2

BP:	5760 bps
WF:	24576 bps
ASM:	0 bps
TM:	30336 bps



LFR block diagram