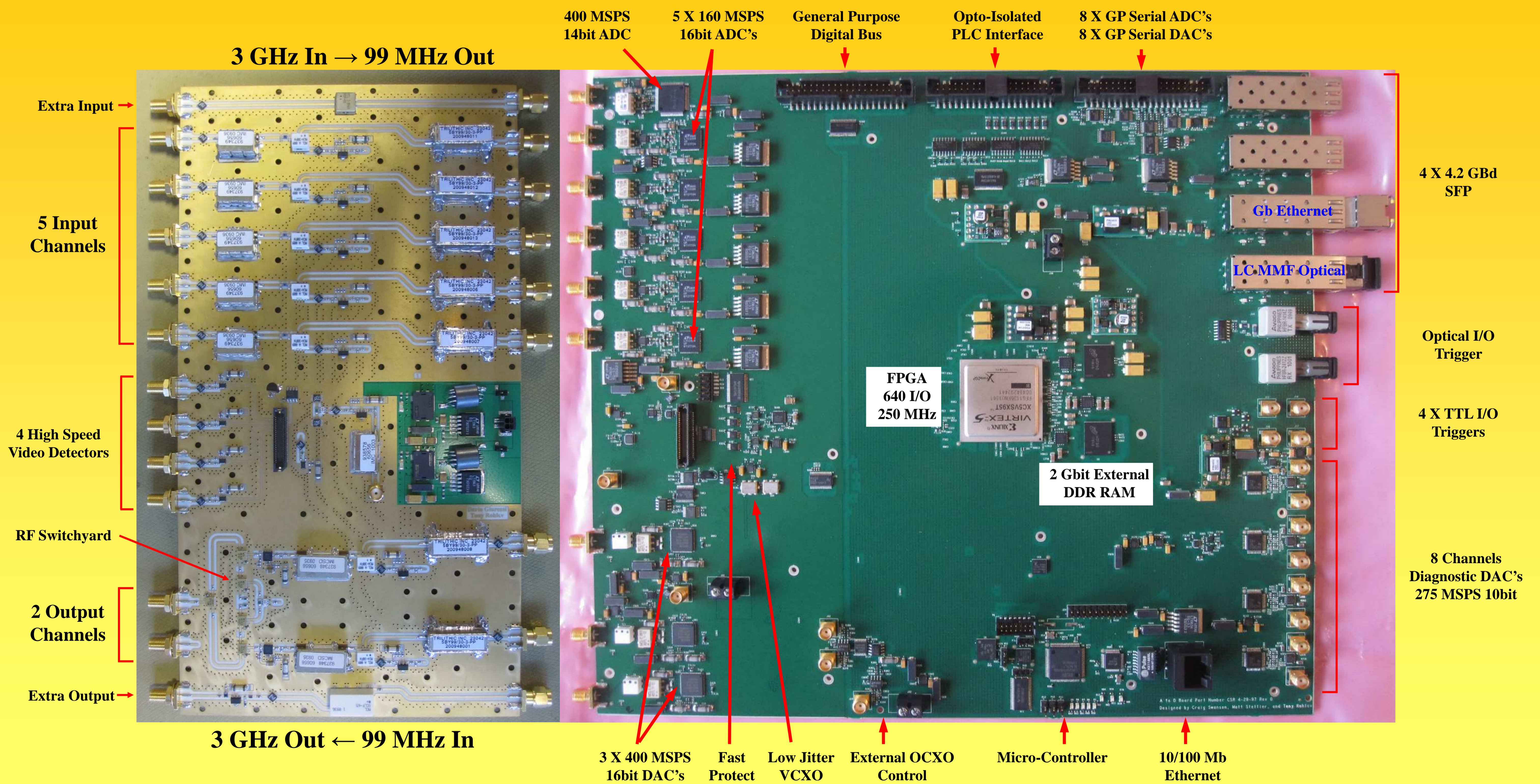


Abstract

The LLRF system developed for the FERMI@Elettra 4th generation FEL had to meet cavity amplitude and phase control requirements of 0.1%, 0.1° for a 4 μs 50 Hz RF pulse at 3 GHz. The system described below meets these requirements with a single-sample (no averaging) acquisition accuracy of 0.017°, 0.029% and an open-loop 3 GHz RF output with 0.024°, 0.042% RMS noise. This hardware performance coupled with a large high-performance FPGA sets the stage for novel firmware techniques such as active cable calibration, a single-pulse klystron loop, active distortion cancellation, and adaptive learning. With the combination of low noise hardware and innovative firmware we have been able to exceed the required performance specifications (see Poster “LLRF Performance Results in Fermi@Elettra”).

The FERMI Low Level RF Control System



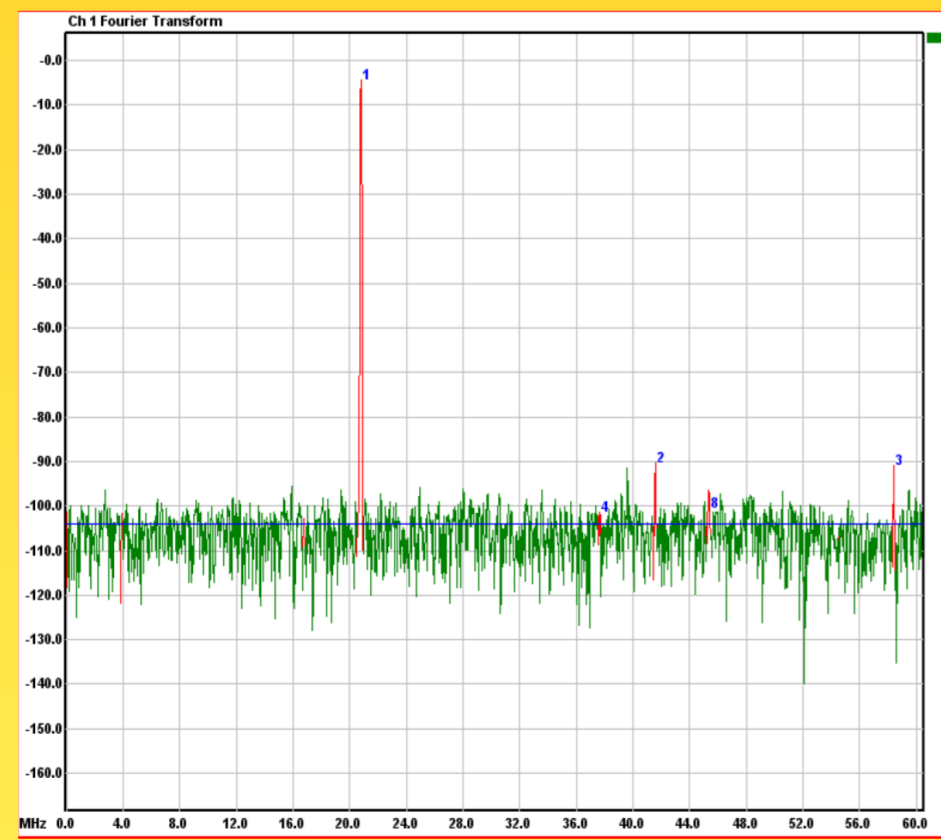
Experimental Results

Input Channels

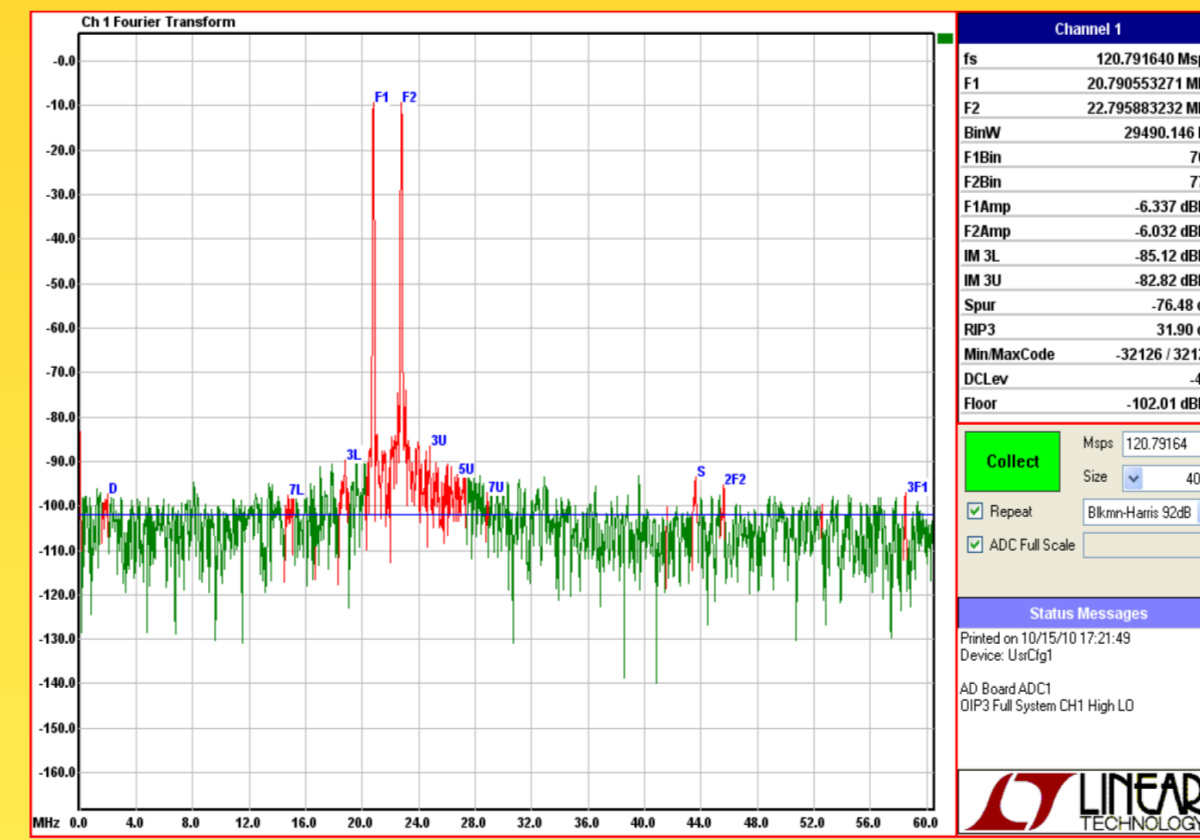
- 0.0005° added noise in RF down conversion (0.013° with OCXO LO)
- VSWR < 1.12:1 @ 3 GHz (-25 dB return loss) on all channels
- RF board measured OIP3 > 35 dBm
- RF board Input Channel-to-Channel Isolation > 86 dB
- Digital acquisition with 0.024°, 0.042% noise (derived from FFT)
- 3rd harmonic distortion < -82 dBFS
- Digital board Channel-to-Channel Isolation > 95 dB

IN / OUT	1	2	3	4	5
1	-	-90	-111	-106	-101
2	-87	-	-89	-100	-108
3	-112	-91	-	-86	-96
4	-105	-104	-87	-	-87
5	-109	-104	-104	-95	-

RF Board Channel-to-Channel Isolation
 3 GHz In, 99 MHz Out



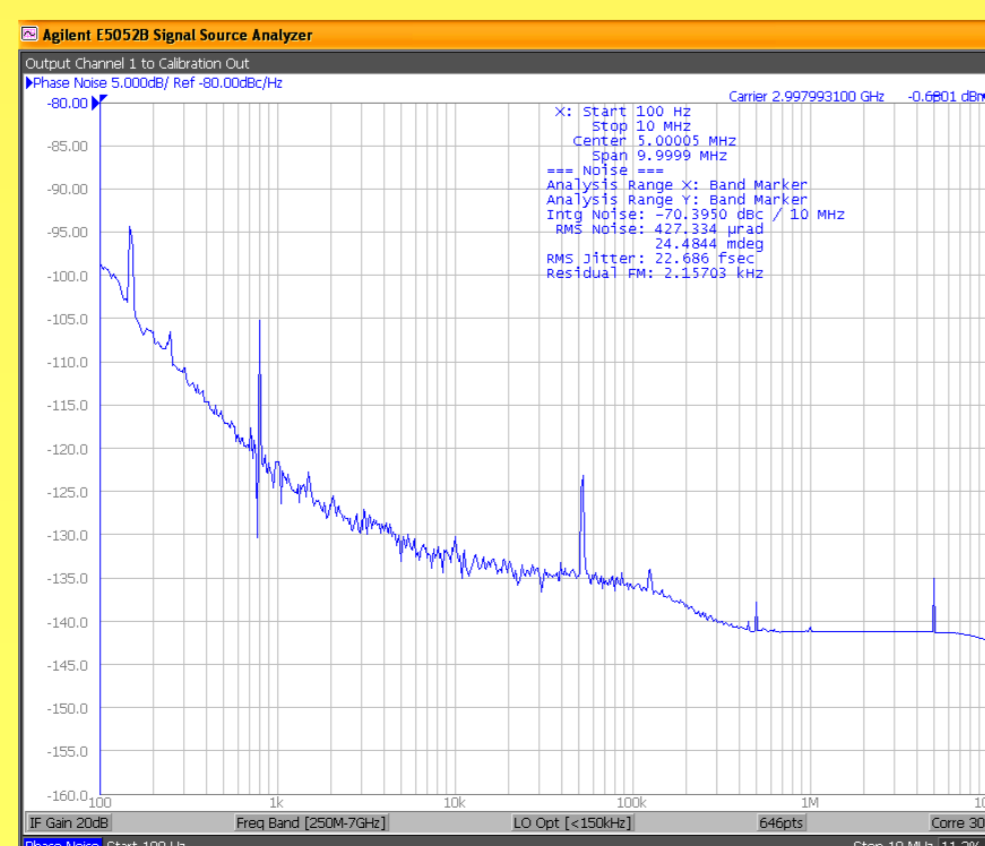
ADC Acquisition 99 MHz In



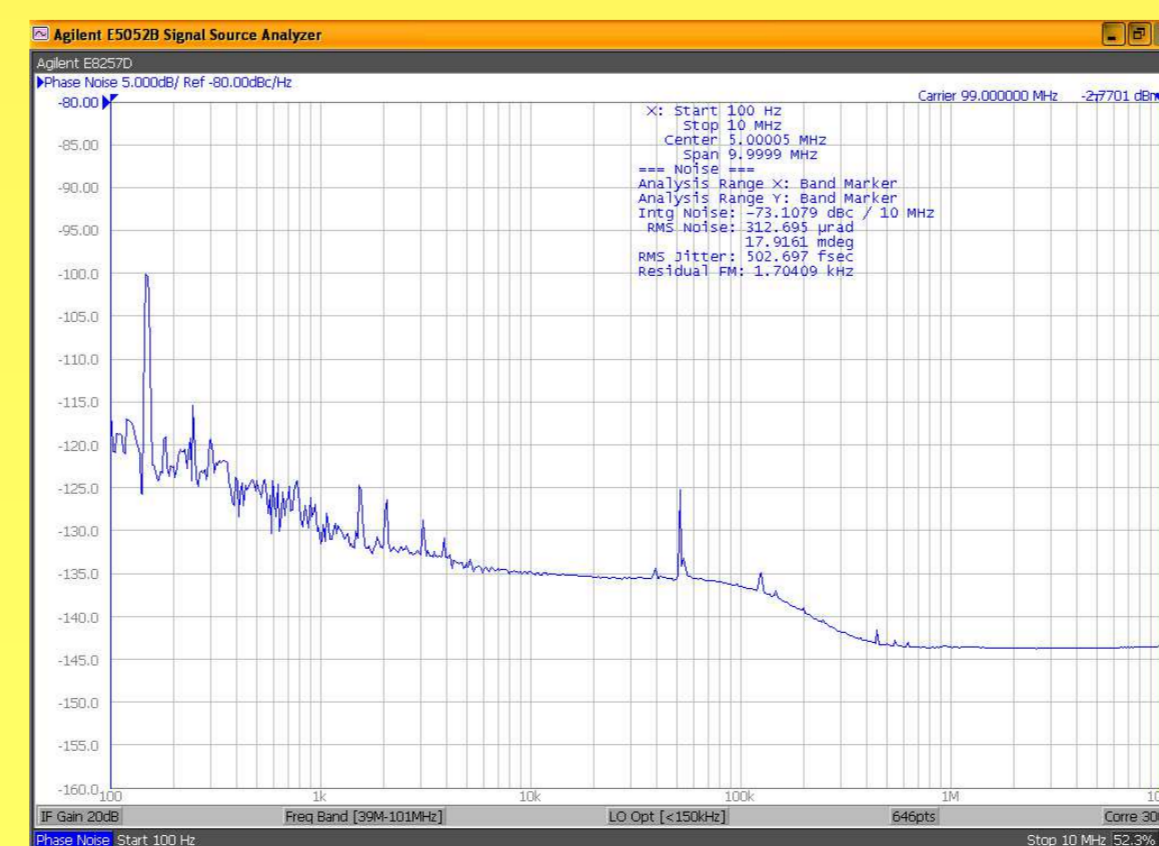
ADC 2-Tone Distortion

Output Channels

- 0.0025° added noise in RF up conversion (0.013° with OCXO LO)
- RF board output Channel-to-Channel Isolation > 75 dB
- DAC output: 0.018°, 0.031% noise RMS @ 99 MHz
- RF board output: 0.024°, 0.042% noise RMS @ 3 GHz

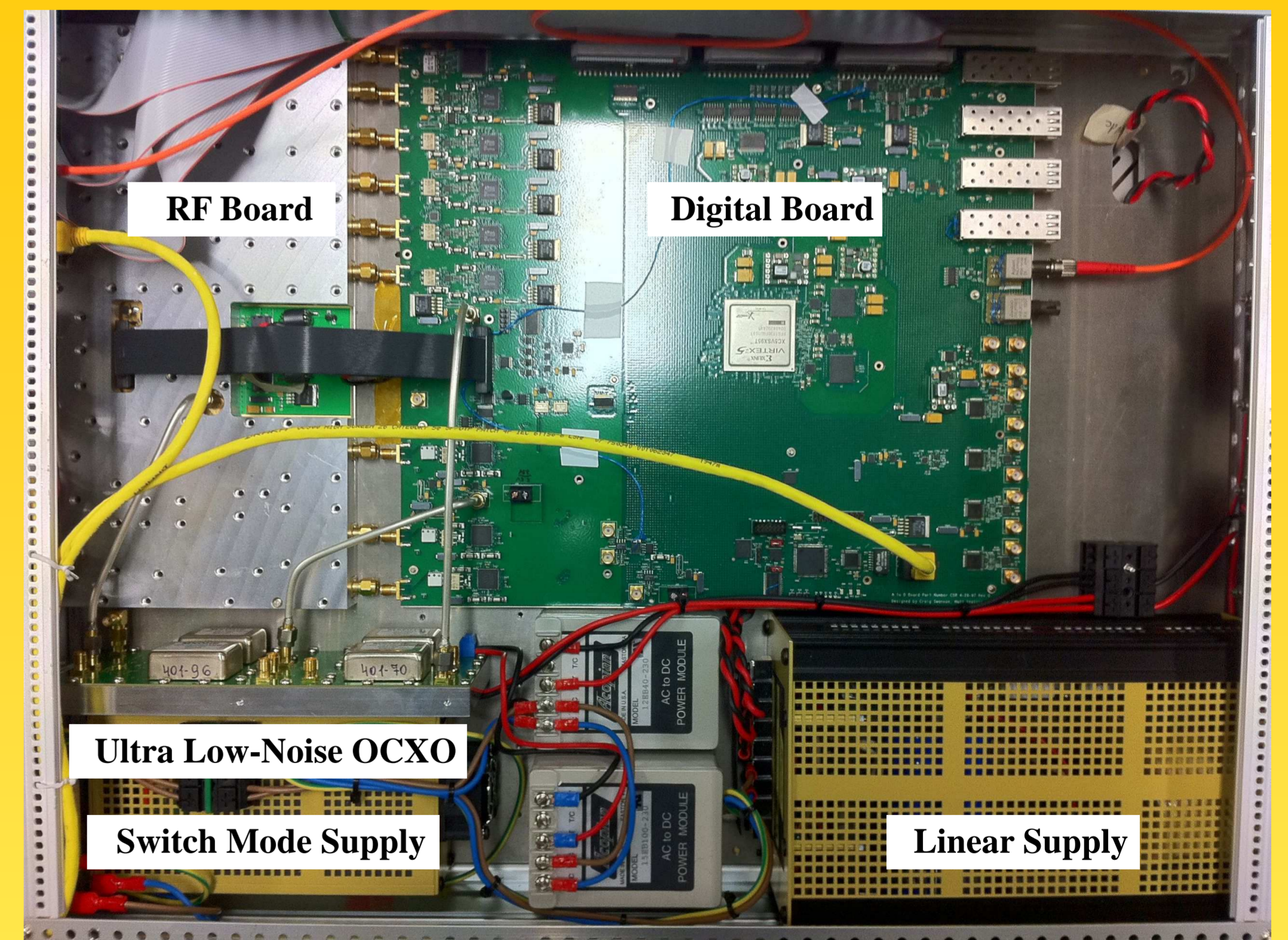


RF Output 3 GHz



DAC Output 99 MHz

The Chassis



Assembled Cost ~ 13k € (\$17k)

The Team

