Electronics for Wakefield Monitor

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Wake Field Monitor == Structure BPM

- In addition to the wanted longitudinal accelerating mode, accelerating structures tend to have unwanted transverse dipole modes which are kicked up by off-centre beams.
- These modes need to be damped to prevent their interference with later bunches.
- Some part of these modes can also be coupled out and measured to give information on beam position relative to the electrical centre of the structure.

WFM in CLIC

- To preserve luminosity in CLIC accelerating structures need to be aligned to 5 µm.
- This will be achieved by measuring structure misalignment via wake field monitors, followed by structure alignment via micro-movers.

Electronics requirement in CLIC

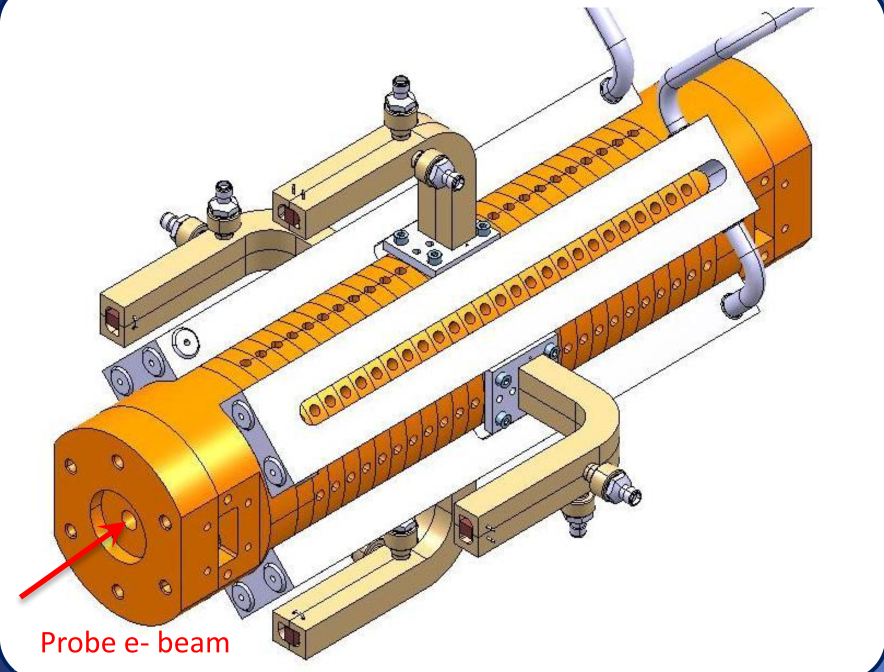
- Frequency: 18 GHz (possible 26 GHz)
- Accuracy: 5 μm
- Resolution: 5 μm
- Range: ±2 mm (?)
- Factor 400 in Voltage → 52 dB dynamic range
- Cheap! There are 144k accelerating structures to equip…

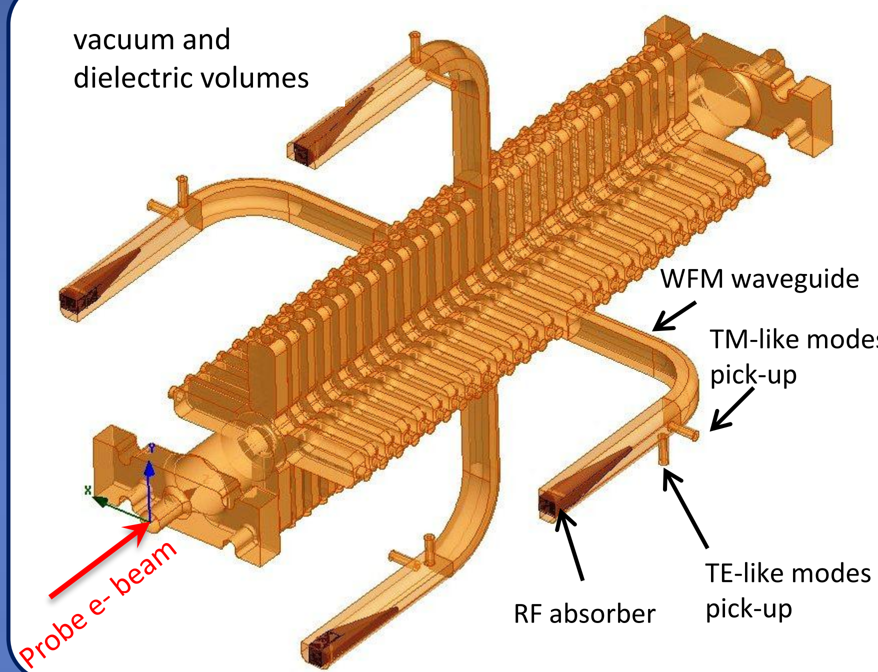
Implications of CLIC requirements

- Simple rather than sophisticated
- 1 readout per pulse, average information only
- Only magnitude, not direction information
  - At the moment we are not sure to have a global, phase stable reference for CLIC
  - We cannot use a Local Oscillator and reference to the beam RF at 12 GHz because of incompatibility with the 18 GHz Wake Field mode.
  - Would need a monopole mode pickup at 2, 6, or 18 GHz.

TD24-WFM accelerating structure design

(Franck PEAUGER – CEA SACLAY, LCWS11 – Grenada, 29th September 2011)



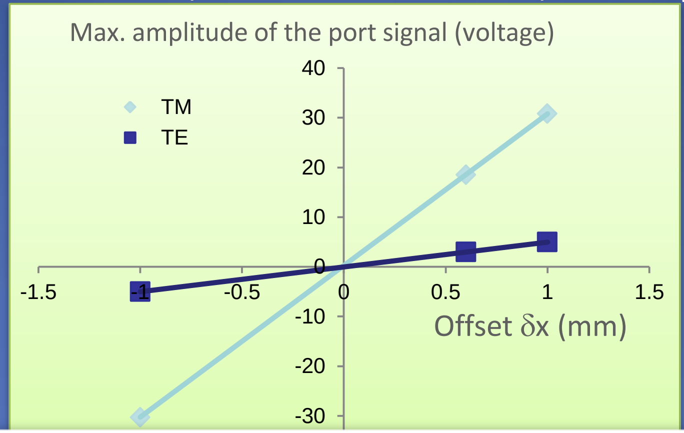


- TD24 structure (CERN design)
  - 24 cells + 2 matching cells + high power couplers separeted from the cells
  - No rf absorbers in the damped waveguides
  - Diamond machining and diffusion bonding of the disks
  - Tuning studs in every cell
- WFM = 90 deg waveguide bend + pick-ups + rf absorber
  - Implemented on the middle cell
  - Screwed on the structure with special feature to ensure good electrical contact
- Cooling circuit
  - Brazed on the structure

Linearity and power range

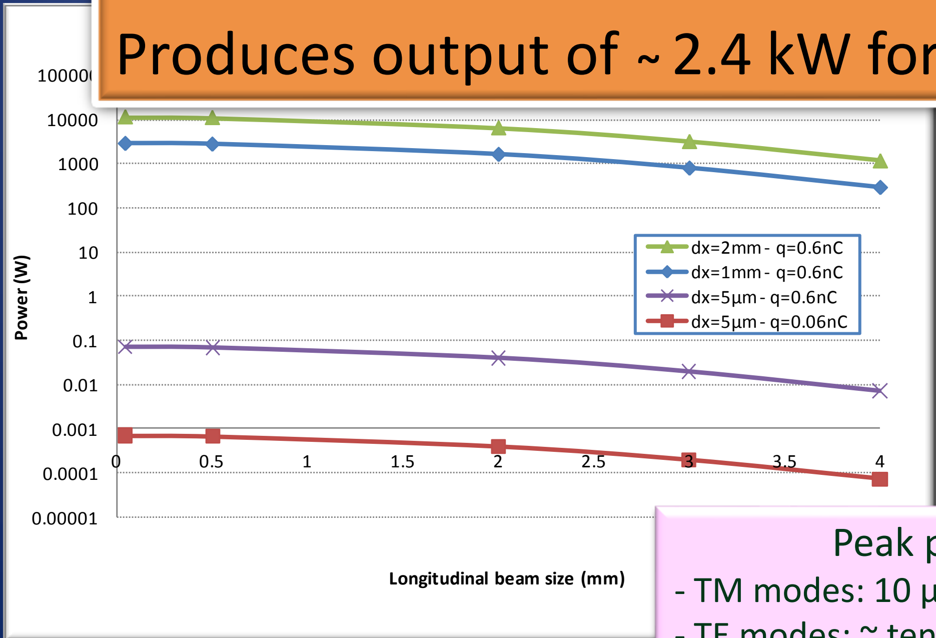
DITANET

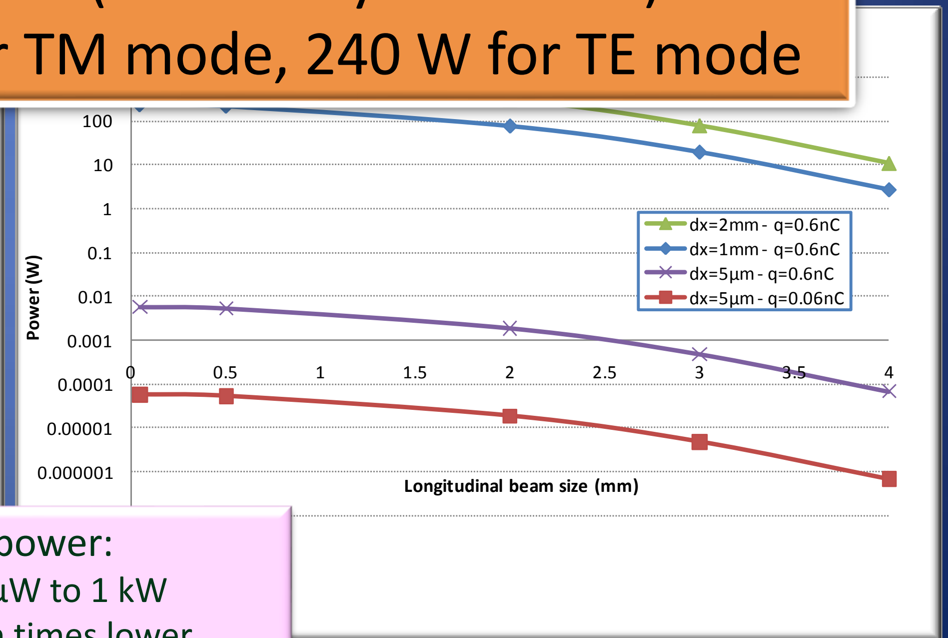
(Franck PEAUGER – CEA SACLAY, LCWS11 – Grenada, 29th September 2011)



Absolute maximum offset: ~ 3 mm (Limited by Iris radius)

Produces output of ~ 2.4 kW for TM mode, 240 W for TE mode



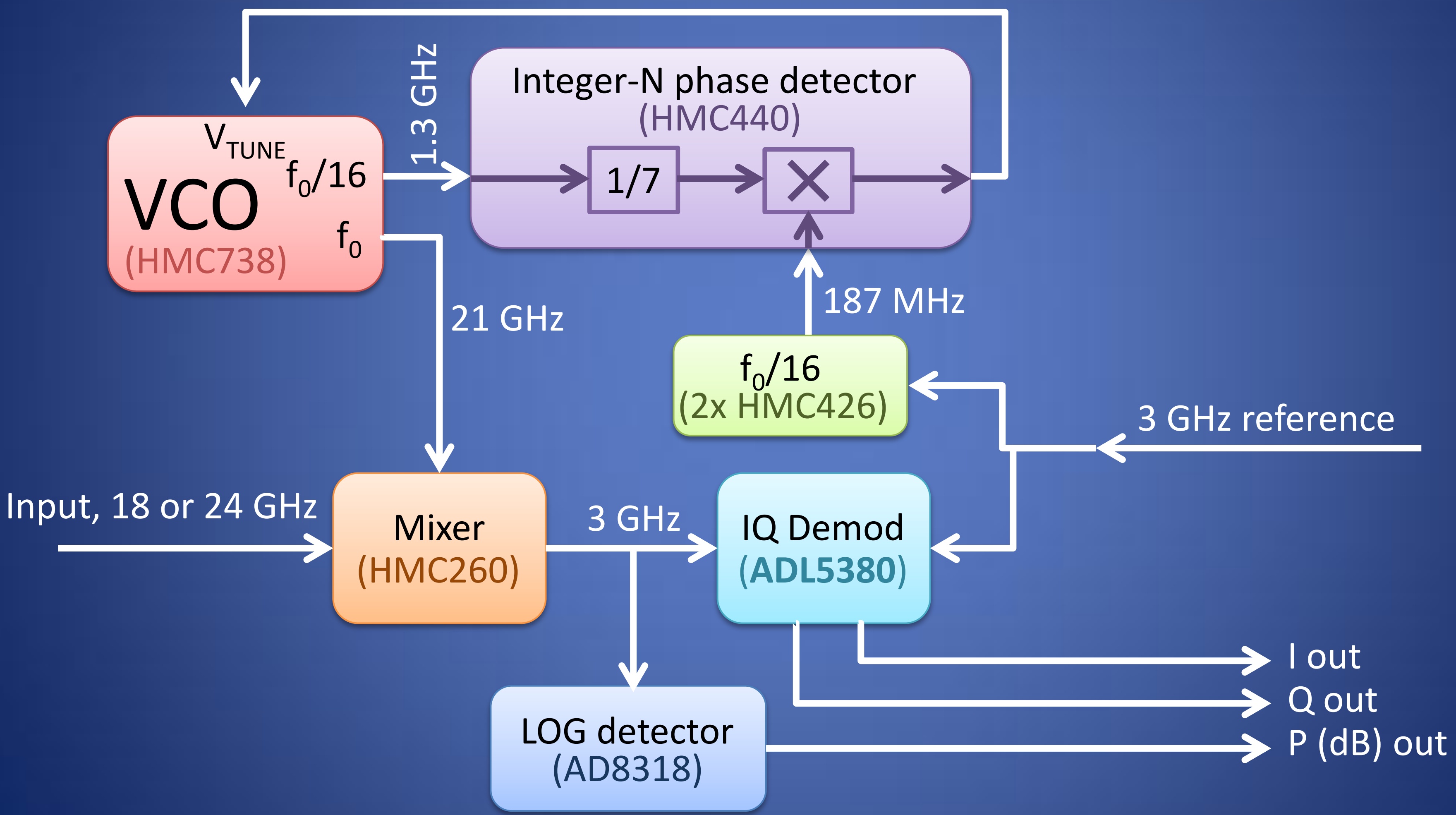


Peak power:
- TM modes: 10 µW to 1 kW
- TE modes: ~ ten times lower

WFM Electronics for qualifying structure prototypes to be installed in CTF3

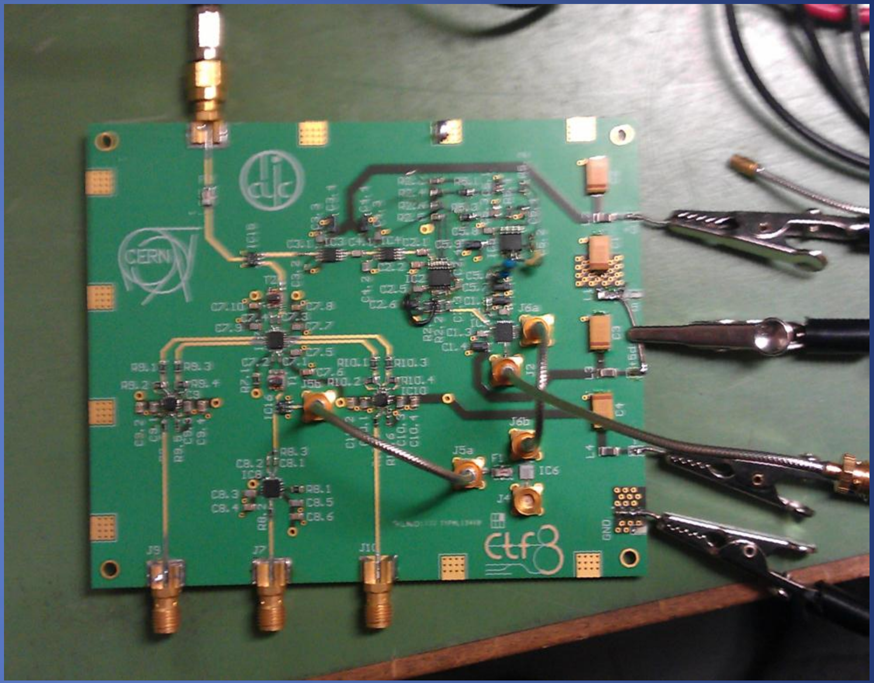
- Would like to have both phase and amplitude information for TM mode (18 GHz) and TE mode (24 GHz) signals.
- Phase stable reference distribution exists at 3 GHz.
- Can use one single board for both frequencies if LO for first down-mixing stage is 21 GHz.
- Generated IF at 3 GHz is detected with IQ demodulators for phase and amplitude information, and with logarithmic power detectors for large dynamic range

Electronics Block diagram



PCB prototype

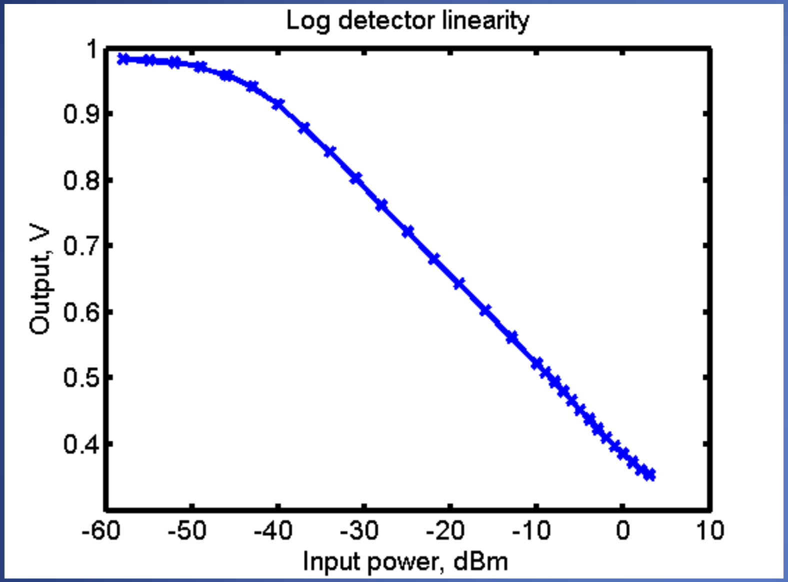
- RF laminate: RO4350B 0,25mm thickness
- Prototype designed with some connections via RF connectors (SMP) to be jumpered with small semi-rigid cables.



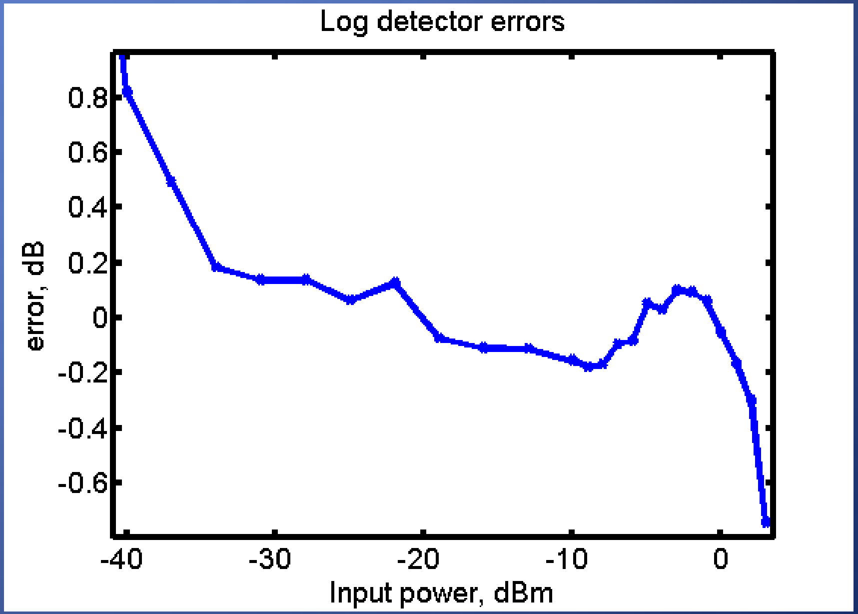
PCB prototype measurements

- Measurements only at 18 GHz for now. (24 GHz source was unavailable)
- Input reflections on SMP connectors are terrible. Between 4 and 6 dB…
- Is it the connectors themselves, or a problematic connection to the board?
- Nevertheless, output response is not completely horrible.
- Still, looking to improve input matching in future versions.

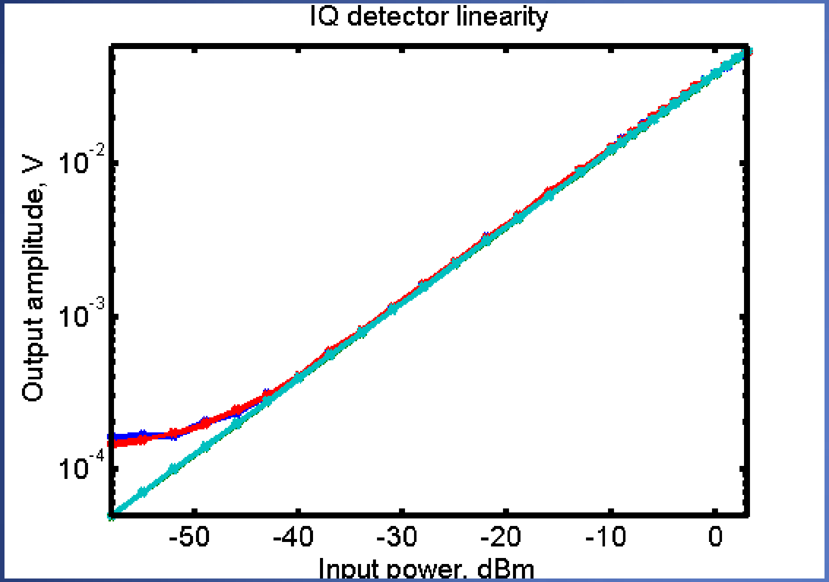
Log detector linearity



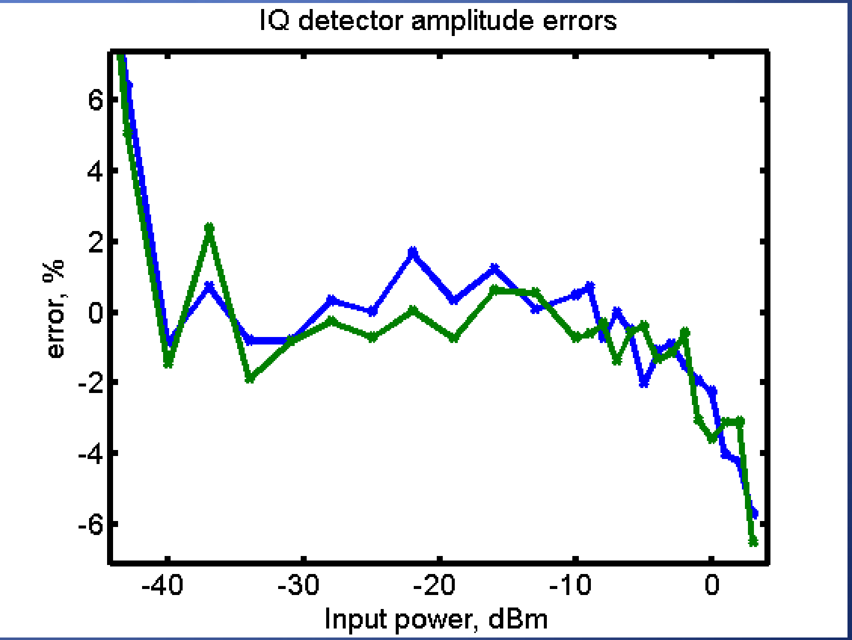
Quite linear from around 3 dBm to -40 dBm. Useful range a bit wider

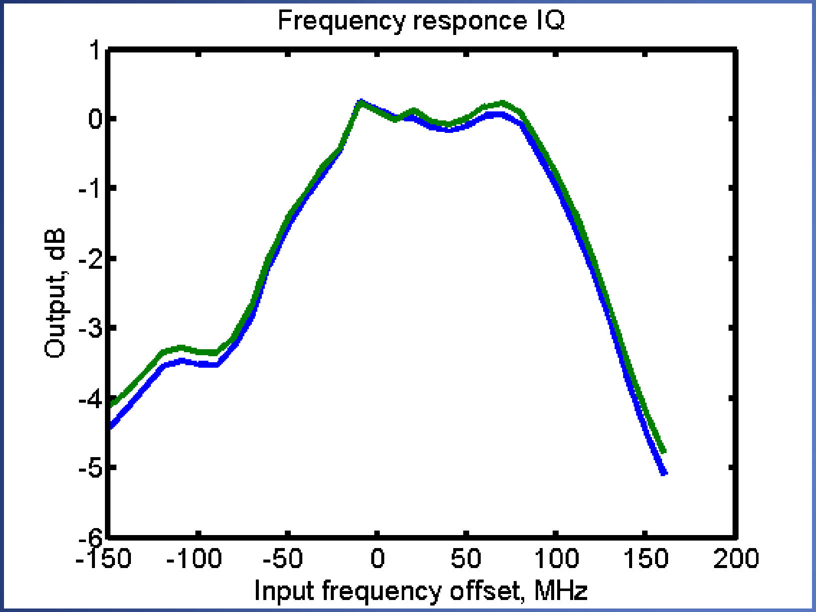


IQ detector linearity



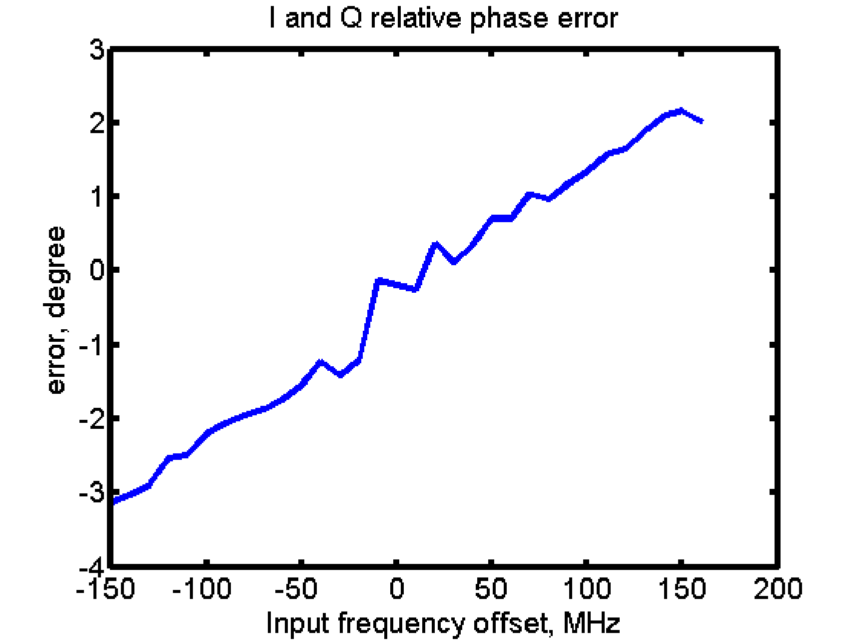
About the same range as the LOG detectors





Phase balance between I and Q is very good. The constant slope phase curve suggest a path-length error on the order of 50 ps

Frequency response on the low offset side is terrible.



12 GHz reference for phase at 18 GHz?

$$V_{LO} = \sin(\omega_{6G} t + \varphi_0)$$

$$V_{LO2} = \sin(2\omega_{6G} t + 2\varphi_0)$$

$$V_{Beam} = \cos(2\omega_{6G} t)$$

$$V_{LO3} = \sin(3\omega_{6G} t + 3\varphi_0)$$

$$V_{WFM} = \sin(3\omega_{6G} t + 3\varphi_{WFM})$$

$$V_{LO2} \times V_{Beam} = \frac{1}{2}\left(\sin(2\varphi_0) + \sin(4\omega_{6G} t + 2\varphi_0)\right)$$

$$V_{LO3} \times V_{WFM} = \frac{1}{2}\left(\sin(3\varphi_0 - \varphi_{WFM}) + \sin(6\omega_{6G} t + 3\varphi_0 + \varphi_{WFM})\right)$$

$$\varphi_0 = \varphi + \pi$$

$$2\varphi_0 = 2\varphi + 2\pi = 2\varphi$$

$$3\varphi_0 = 3\varphi + 3\pi = 3\varphi + \pi$$