693 GHz Poloidal High-k Scattering System for NSTX-U

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The high-k scattering system will measure electron scale density fluctuations by collective Thomson scattering for NSTX-U. An overmoded corrugated waveguide will deliver a 693 GHz probe beam at bay G. A system of remote control mirrors will steer and focus the beam waist at the desired scattering volume. Scattered signals will be detected by a 4 channel receiver at bay L. Signals are then down converted to 880 MHz by quasioptical sub-harmonic mixers. The data collected will aid in understanding ETG modes and anomalous transport.

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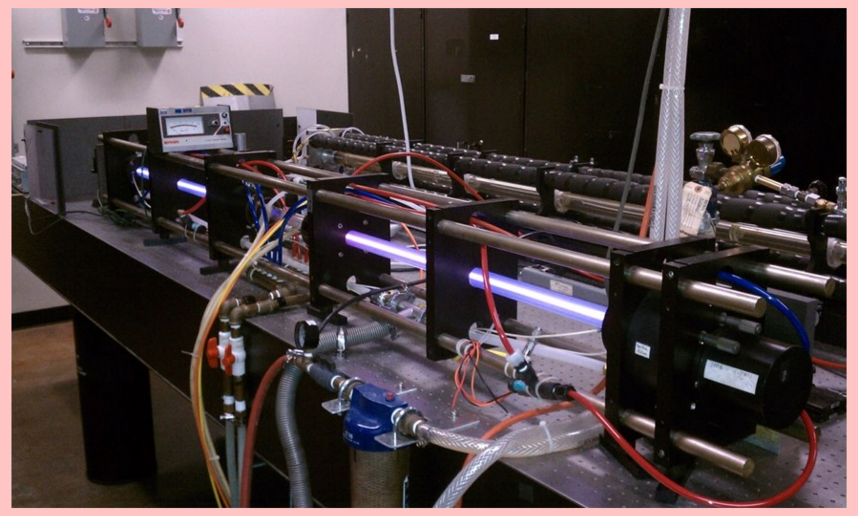
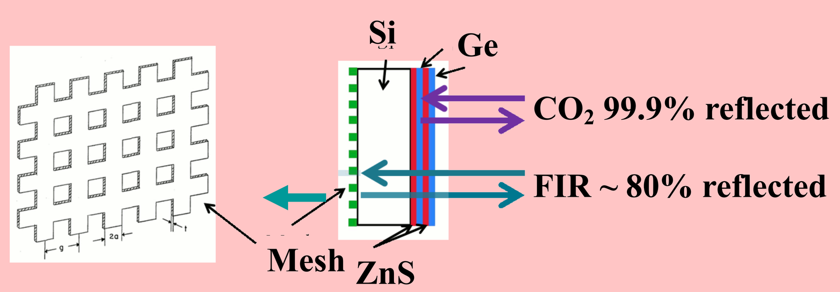
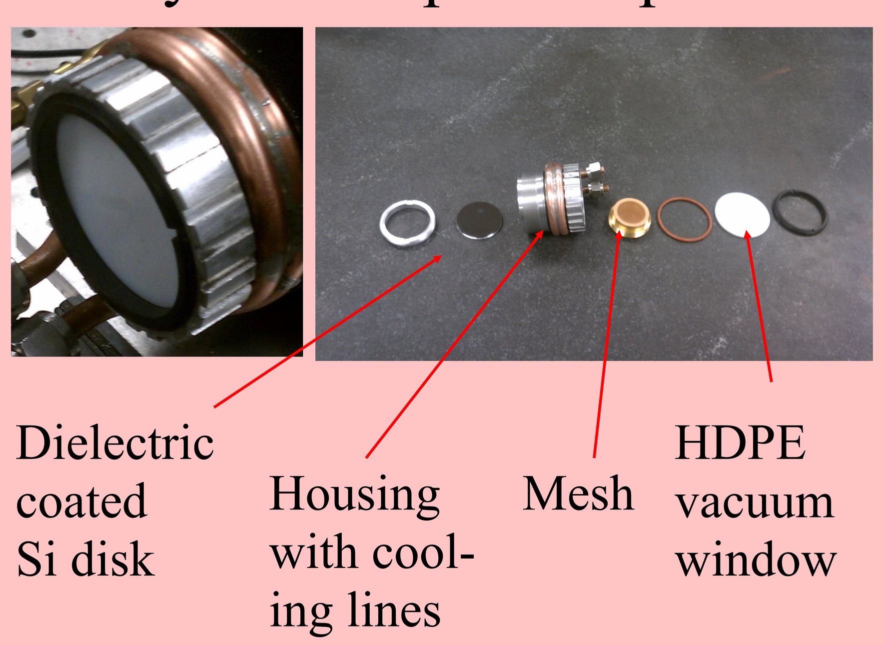
FIR Laser System



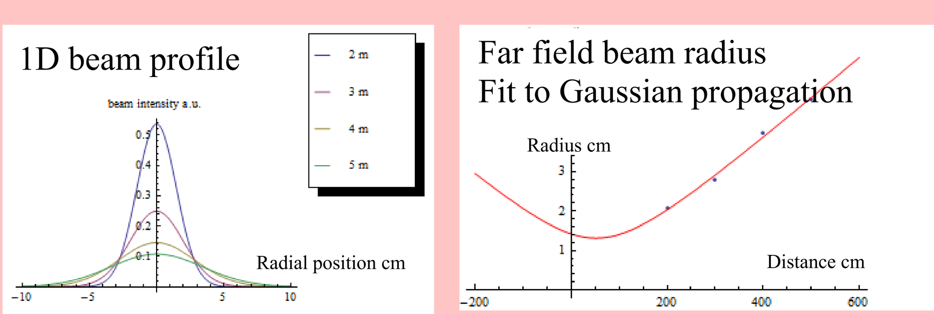
100+ W CO_2 pump laser
50 mW FIR laser
-Formic Acid
-432 μm



Hybrid Output Coupler

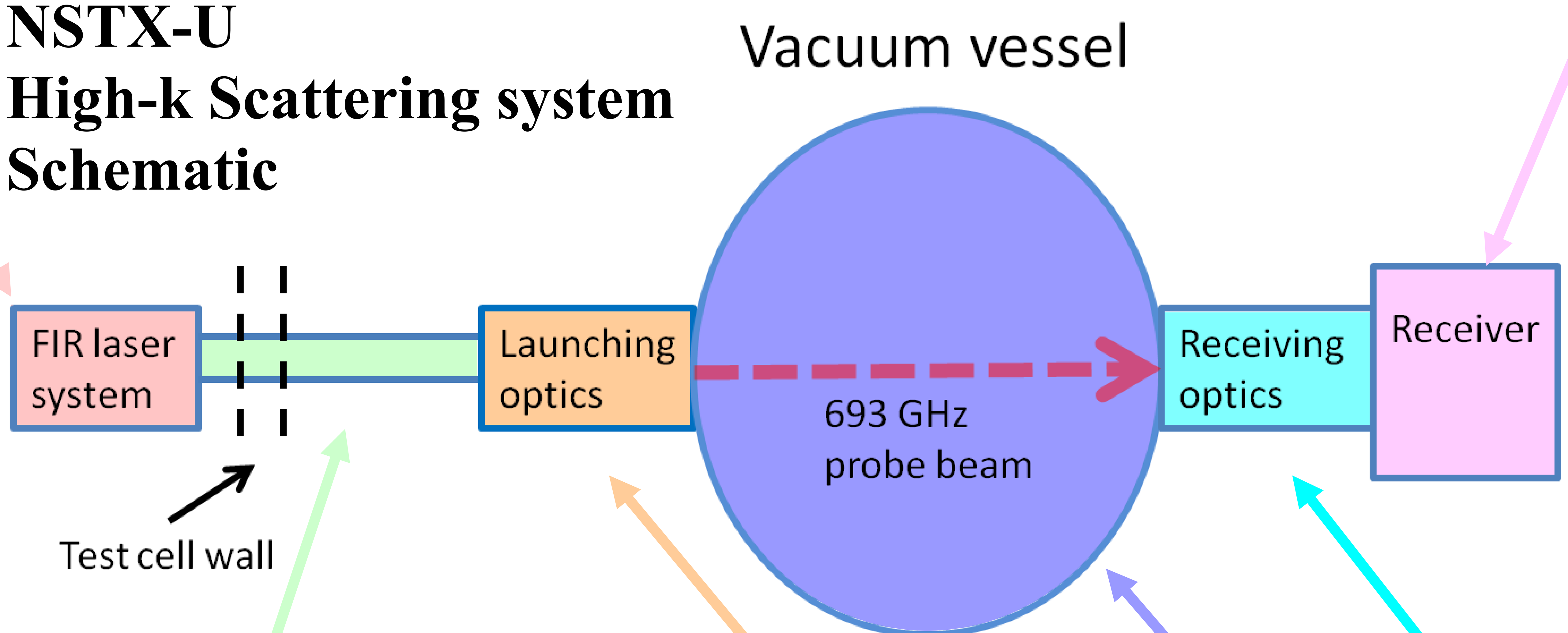


Far Field Beam Profile



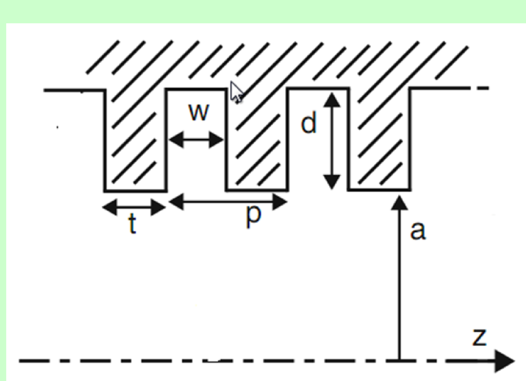
Beam waist: 1.3 cm radius at 52 cm from laser output

NSTX-U High-k Scattering system Schematic

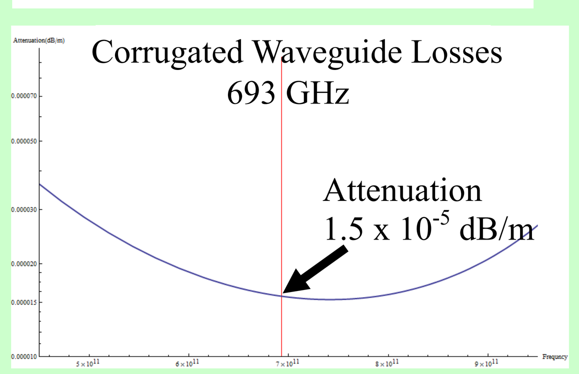


Corrugated Waveguide

Up to 50 m of transmission line is needed to deliver the probe beam to the vacuum vessel. Overmoded, corrugated waveguide will provide very low attenuation.

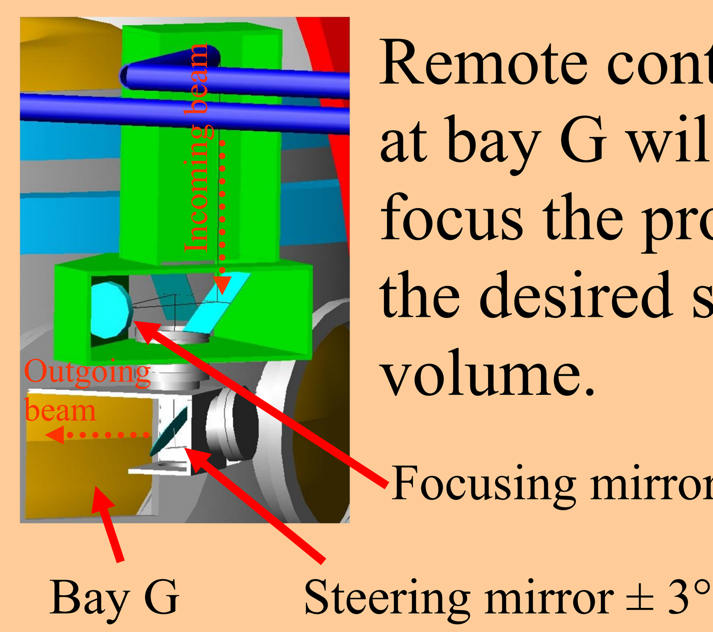


Period 188 μm
Depth 127 μm
Width 112 μm



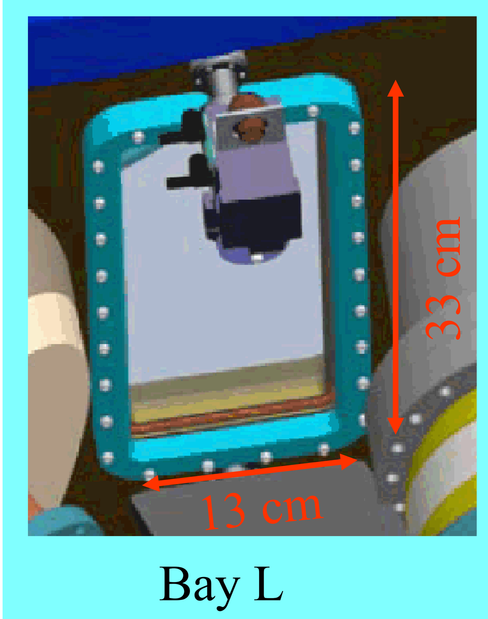
Simulations predict losses of 1.5 x 10^{-5} dB/m at 693 GHz. Actual losses will be higher due to fabrication errors and misalignments.

Launching Optics



Remote control mirrors at bay G will steer and focus the probe beam to the desired scattering volume.

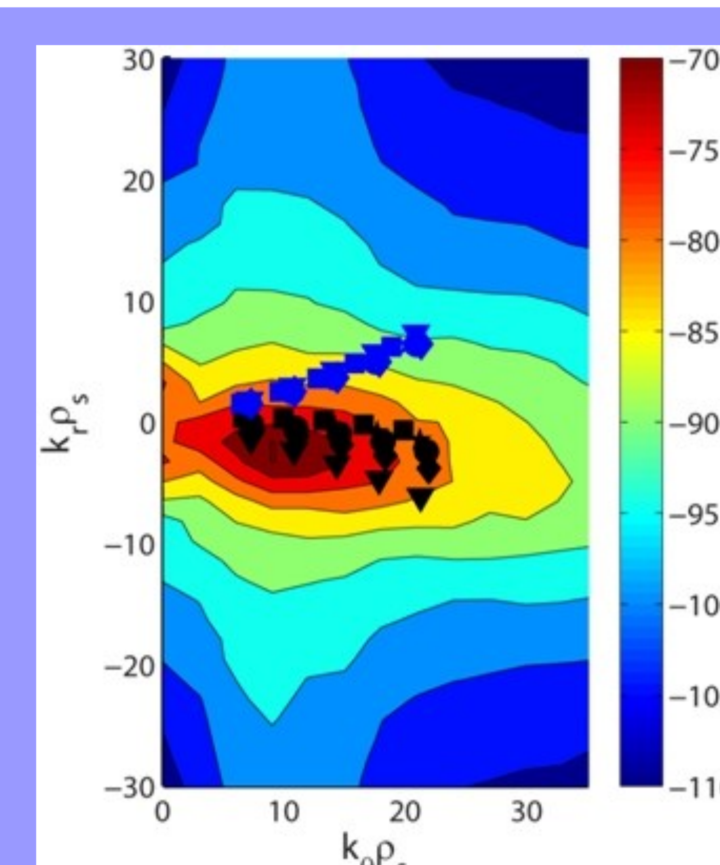
Receiving Optics



Receiving optics at Bay L will allow an array of receiving channels to measure k_θ scattering angles up to 15°.

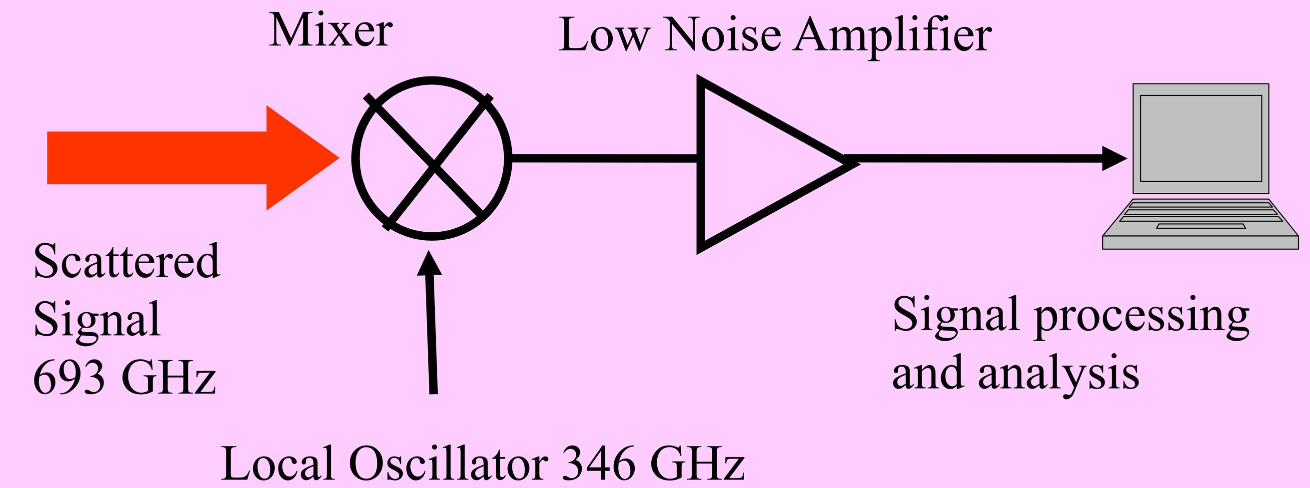
High-k Coverage

Predicted k_θ wavenumber coverage is from 5 to 25 cm^{-1}, thereby targeting the ETG mode peak, as shown here by computer simulation.

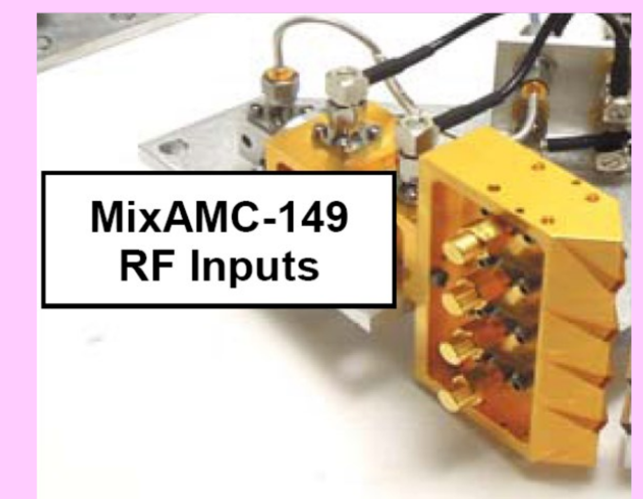


Receiver

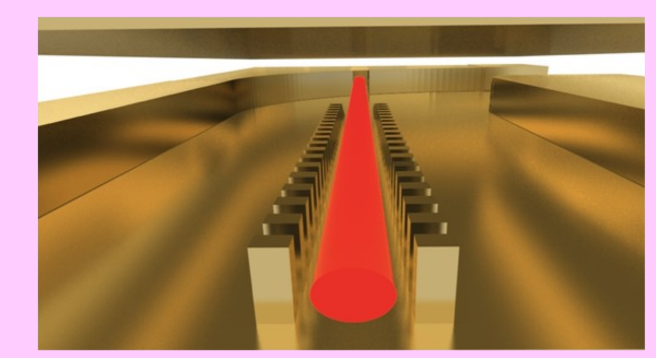
Four channel receiver will down convert signals to ~1 GHz via subharmonic quasioptical mixers.



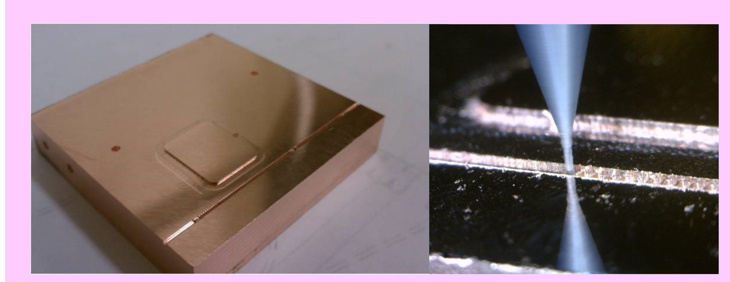
UC Davis is exploring options to develop mixers with nanomachining technology.



Example 4 x 1 mixer array from Virginia Diodes.



Local oscillator power can be delivered from a 346 GHz, 1 W backward wave oscillator (BWO), currently under development by UCD in collaboration with Lancaster University and Beijing Vacuum Electronics Research Institute. Nanomilling technology will facilitate BWO and mixer fabrication.



Previously nanomachined traveling wave tube (TWT) circuit block. 220 GHz TWT with 60 GHz bandwidth, 250 micron tooling shown. UC Davis's experience with these similar components provide confidence in fabricating ~700 GHz circuits with < 1 μm tolerance, and surface finishes better than 40 nm R_a.