CENTRE FOR WIRELESS INNOVATION

Liquid crystal antennas for Earth Observation

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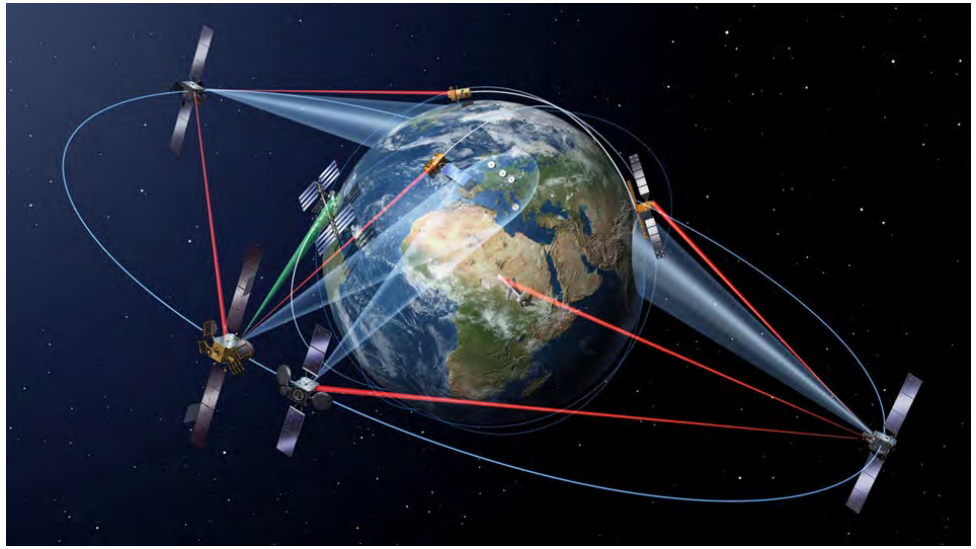
Outline

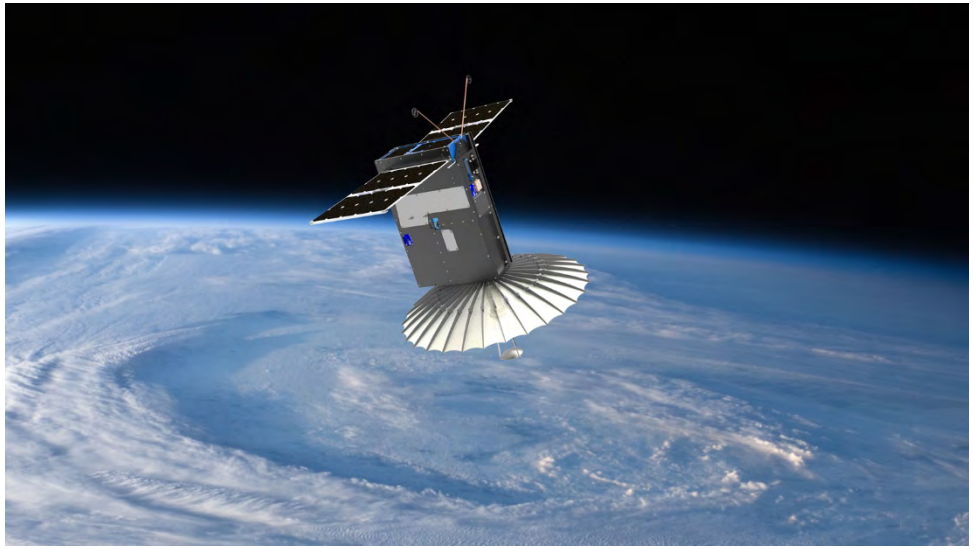
- Antennas for space applications
- Space antenna types
- Liquid crystal technology
- LC antenna demonstrators
- LC antenna for Earth observation
- Future work

Antennas for space applications

High data rate wireless communications:

Mobile and wireless networks, sensing





Satellite technology:

Earth observation, broadcasting, internet and mobile

Mainly: microwave, mm-wave, THz

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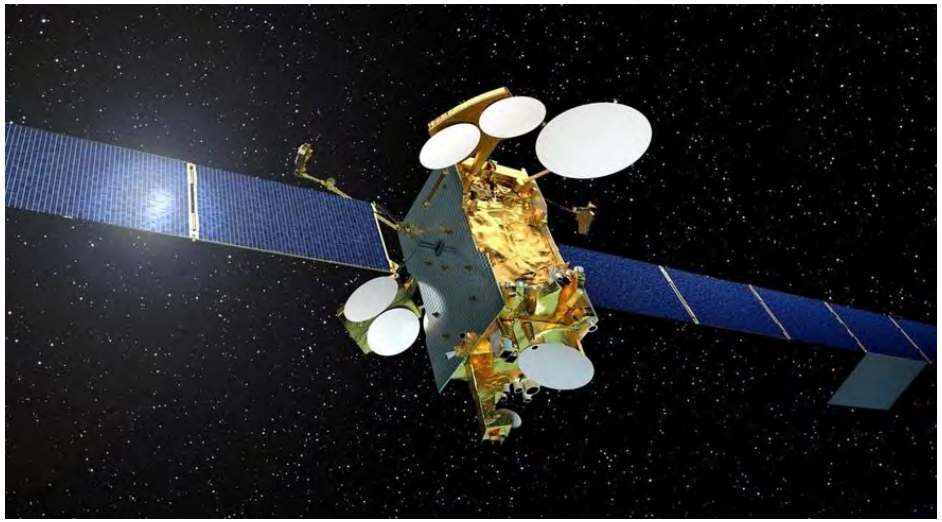
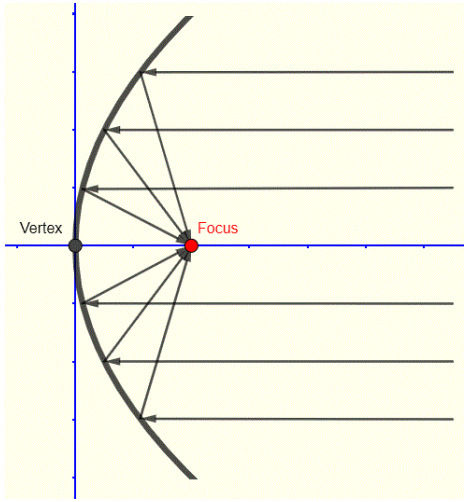
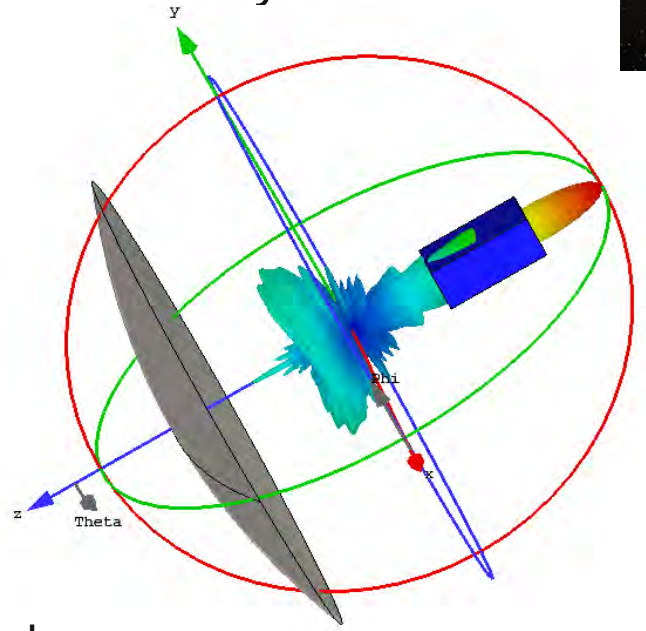
Antennas for space

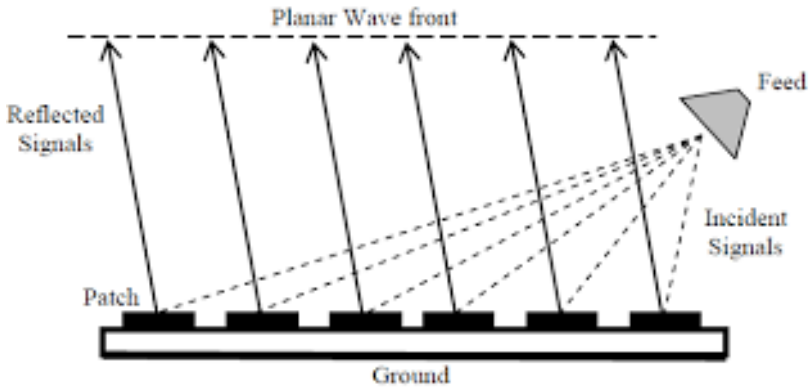
Reflector antennas manifest higher efficiency
Parabolic dishes – low loss, high gain, mechanical steering
Reflectarray - flat, can be reconfigured for complex beam shape, can be steered electronically







Parabolic dishes



Reflectarray

Why Liquid Crystals ?

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- **Why liquid crystals are most useful for applications >100 GHz**

- **Thin tuneable LC film(<100µm) means:**
  - * Low voltage electronic control – easy to bias
  - * Faster switching speed
  - * **Not limited in frequency**
  - * Device architecture and construction similar to optical LC displays
  - * Low weight, power consumption and cost

Theory of Operation

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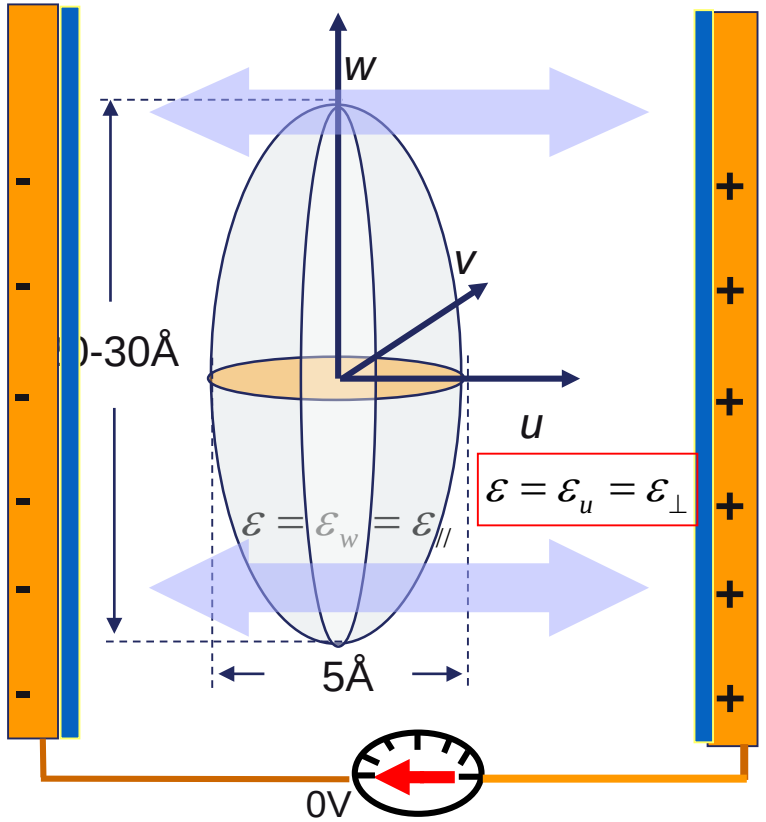
Single Molecule of Liquid Crystal:

1. Rod like physical shape.
2. Anisotropic microstructure leads to dielectric anisotropy.
3. Dipole like feature can be aligned by polyimide layer
4. Molecule can be orientated by DC field and rotated back when V=0.



$$\vec{D} = \varepsilon \cdot \vec{E} = \begin{pmatrix} \varepsilon_u & 0 & 0 \\ 0 & \varepsilon_v & 0 \\ 0 & 0 & \varepsilon_w \end{pmatrix} \cdot \vec{E}$$

Theory of Operation

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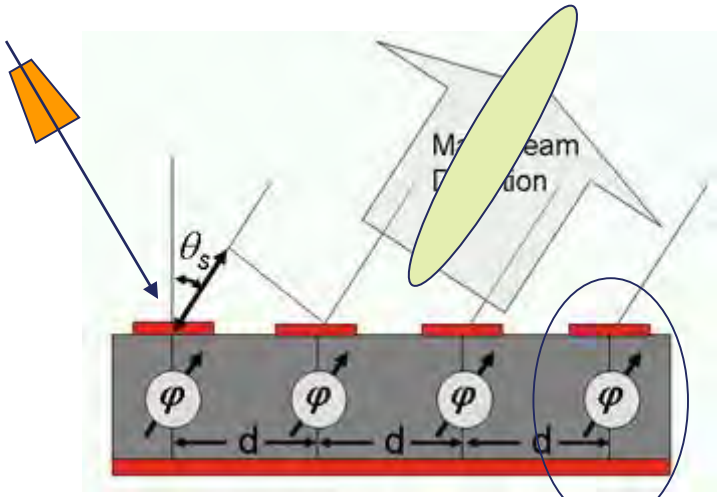
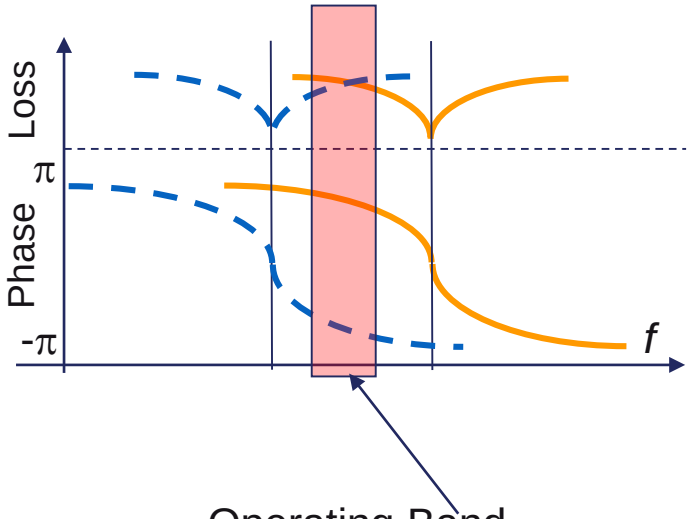
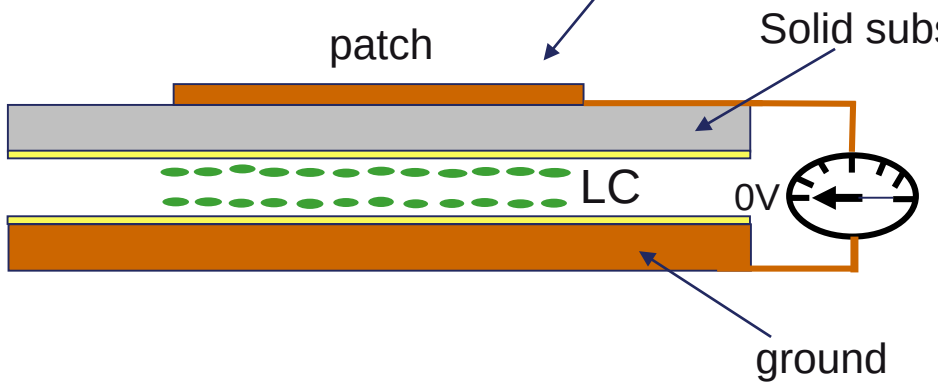
Voltage controlled permittivity of Liquid Crystal can be exploited to produce a phase agile reflectarray cell







V=0, $\varepsilon=\varepsilon_{\perp}$, $\tan\delta=\tan\delta_{\perp}$

$V=V_{max}$, $\varepsilon=\varepsilon_{//}$, $\tan\delta=\tan\delta_{//}$

$$\Delta\varepsilon_{eff} = \varepsilon_{//} - \varepsilon_{\perp}$$

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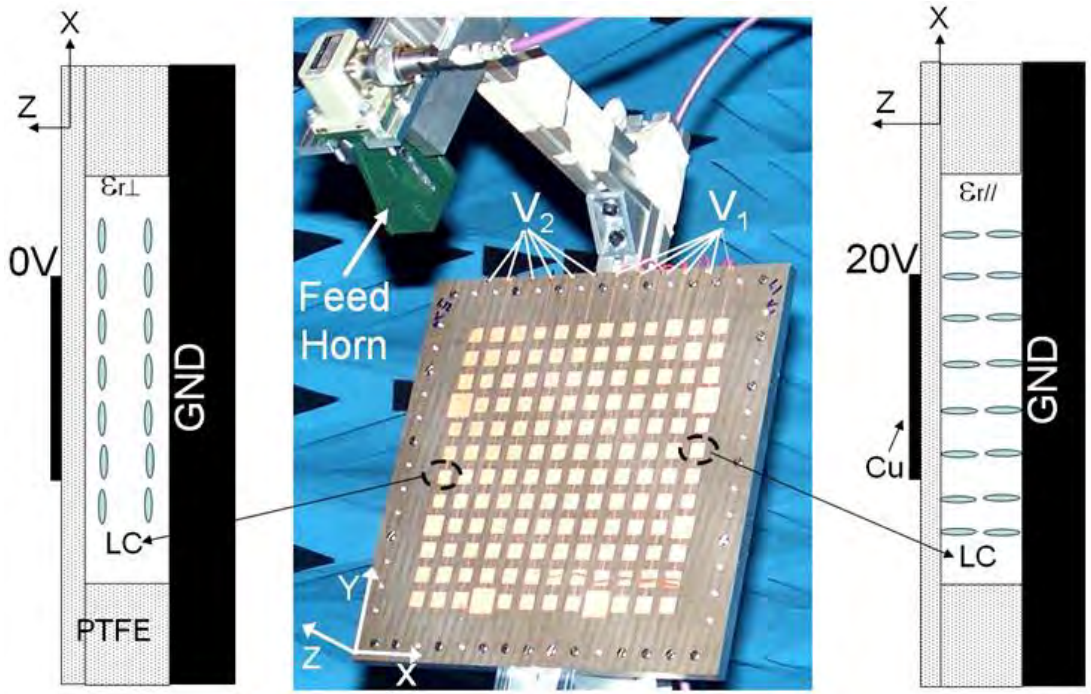
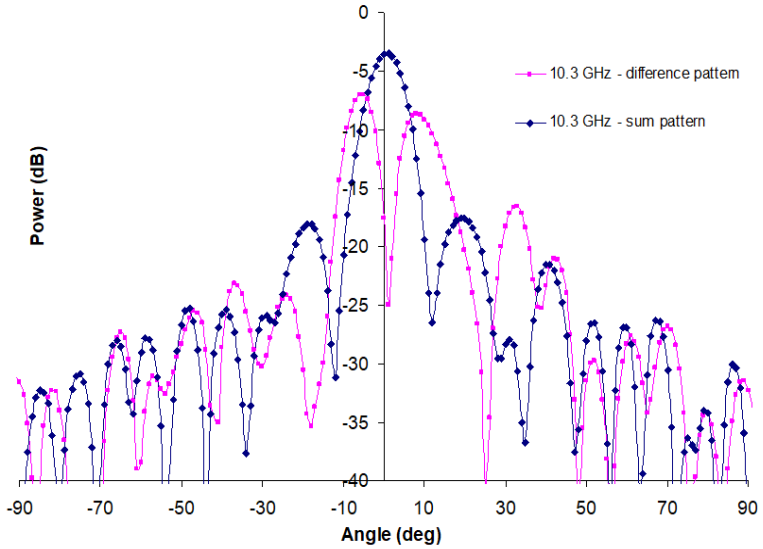
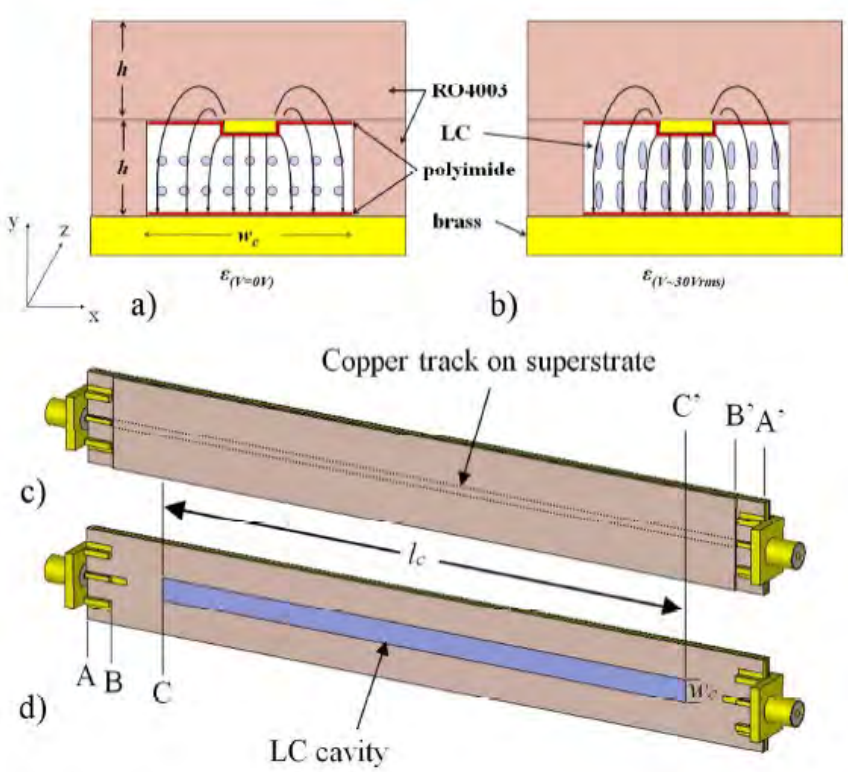
Liquid crystal antennas demonstrators



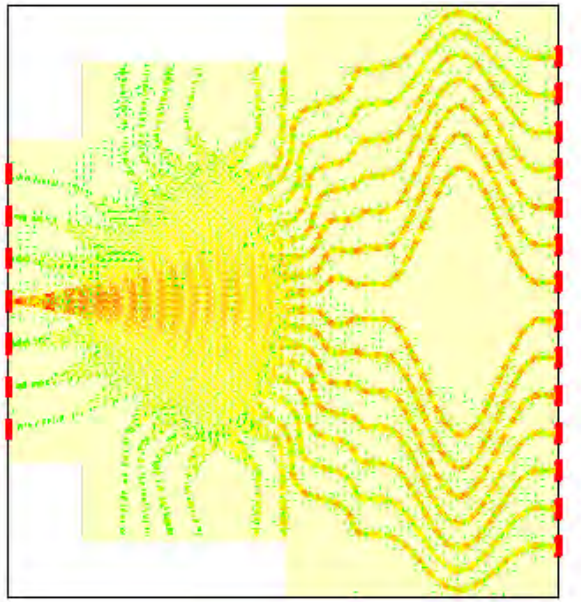


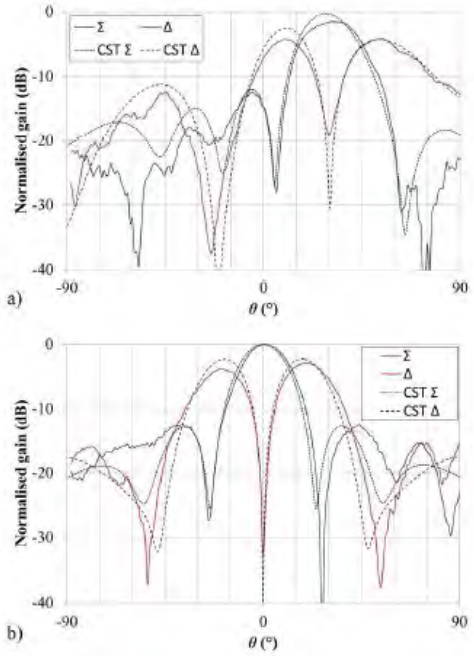
X-band reflectarray

Liquid crystal antennas demonstrators



LC phase shifter





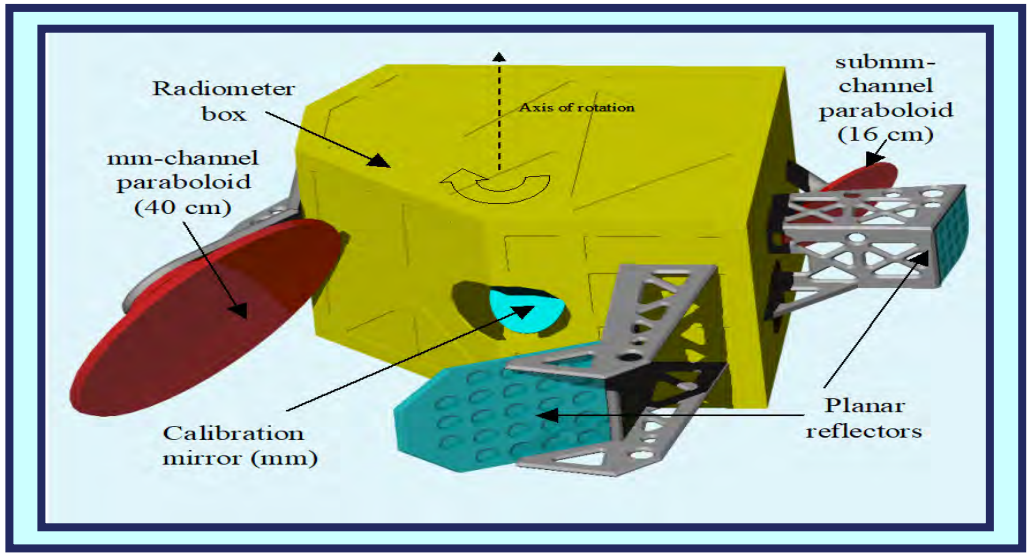
Rotman lens

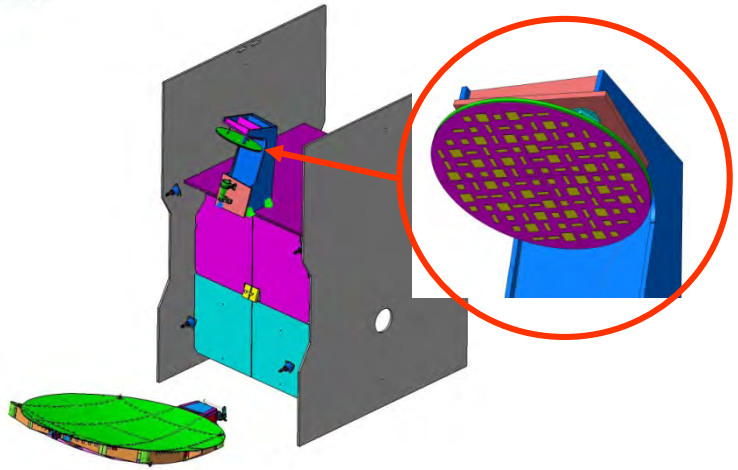
Spaceborne Radiometers

Radiometer on satellite platforms measuring emissions from the Earth's atmosphere

Radiation

- CO 345 GHz
- H_2O 325 GHz
- Ozone 300 GHz





•Mechanical system on the left scans the atmosphere and can be replaced by electronic scanning system with tunable subreflector on the right

Electronically Tunable Reflectarray

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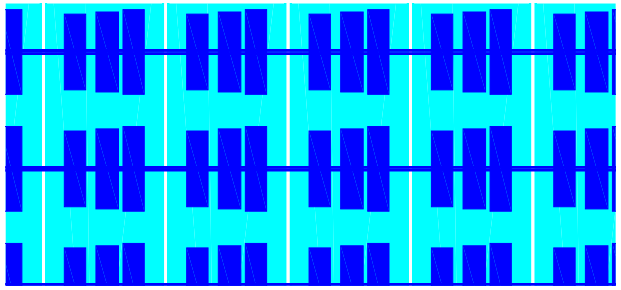
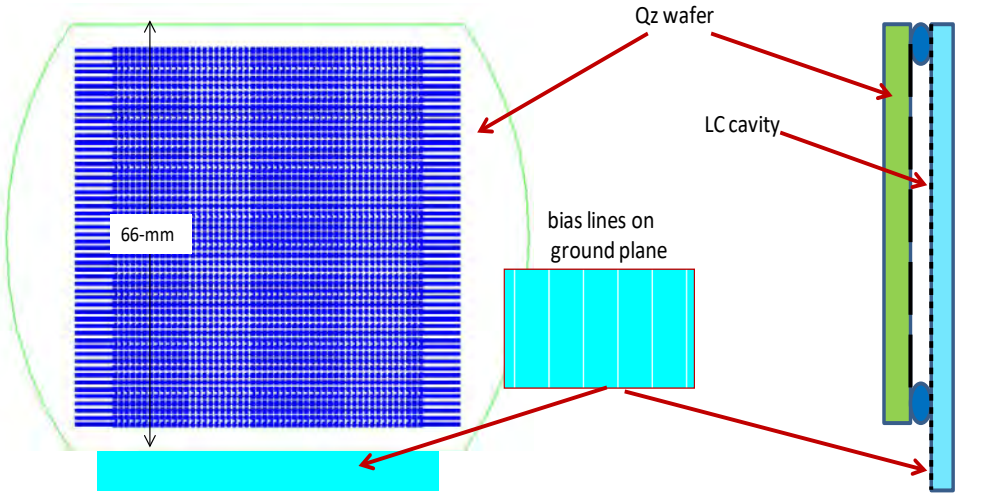
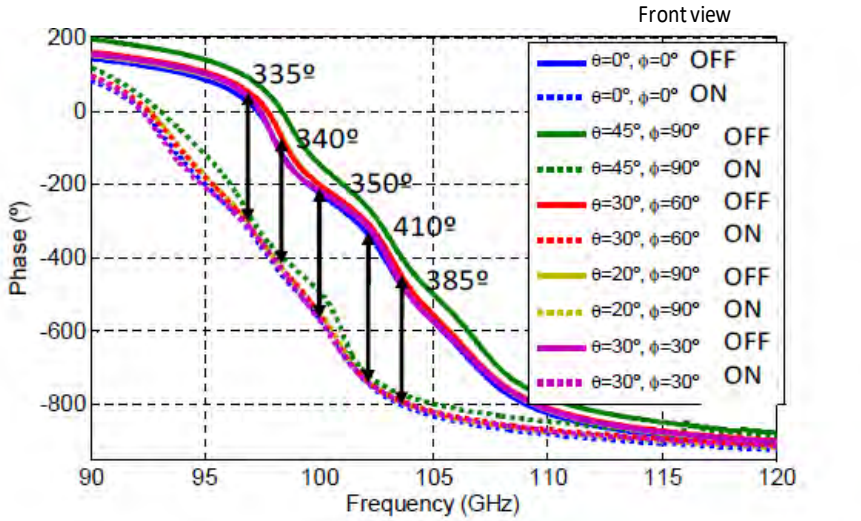




Electronically Tunable
LC Reflectarray Subreflector



GT3-23001 - 80μm

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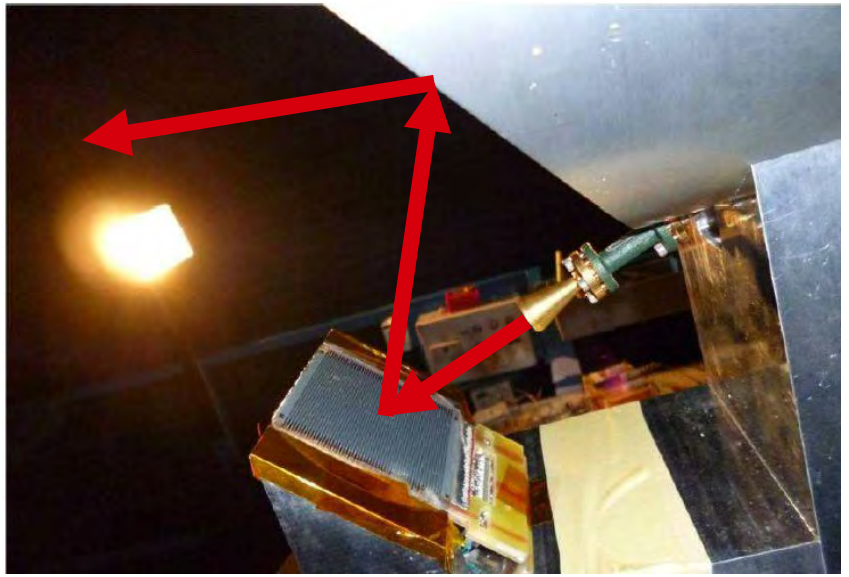
Electronically Tunable Reflectarray



Full setup with Electronically Tunable LC Reflectarray Subreflector

Electronically Tunable Reflectarray

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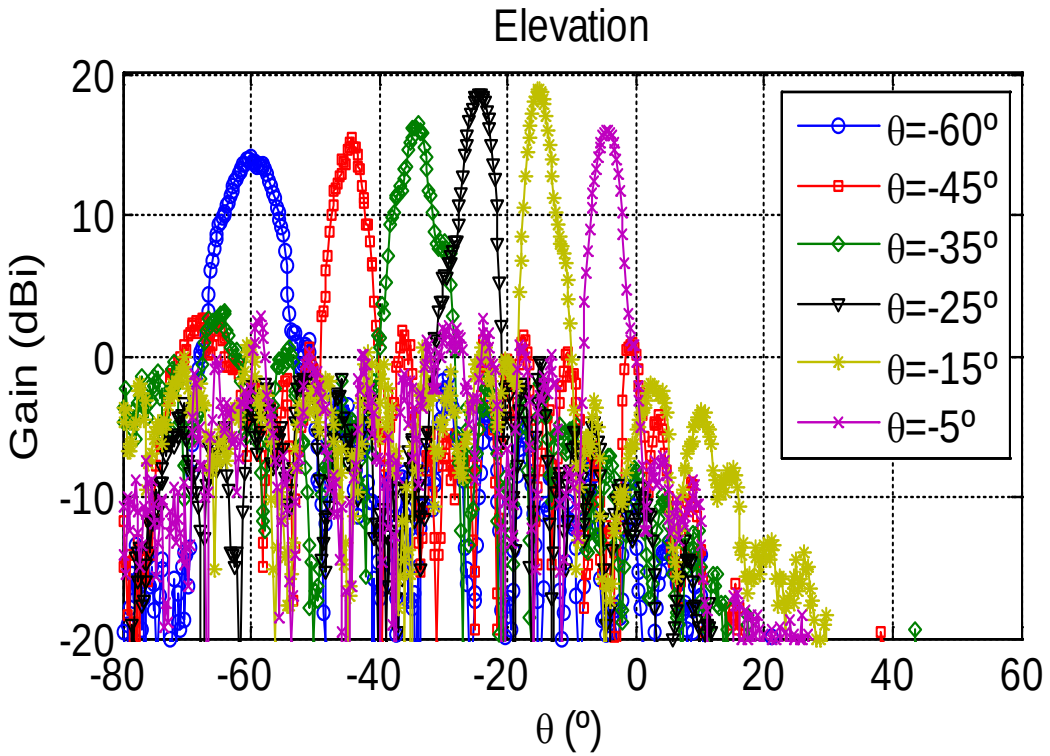
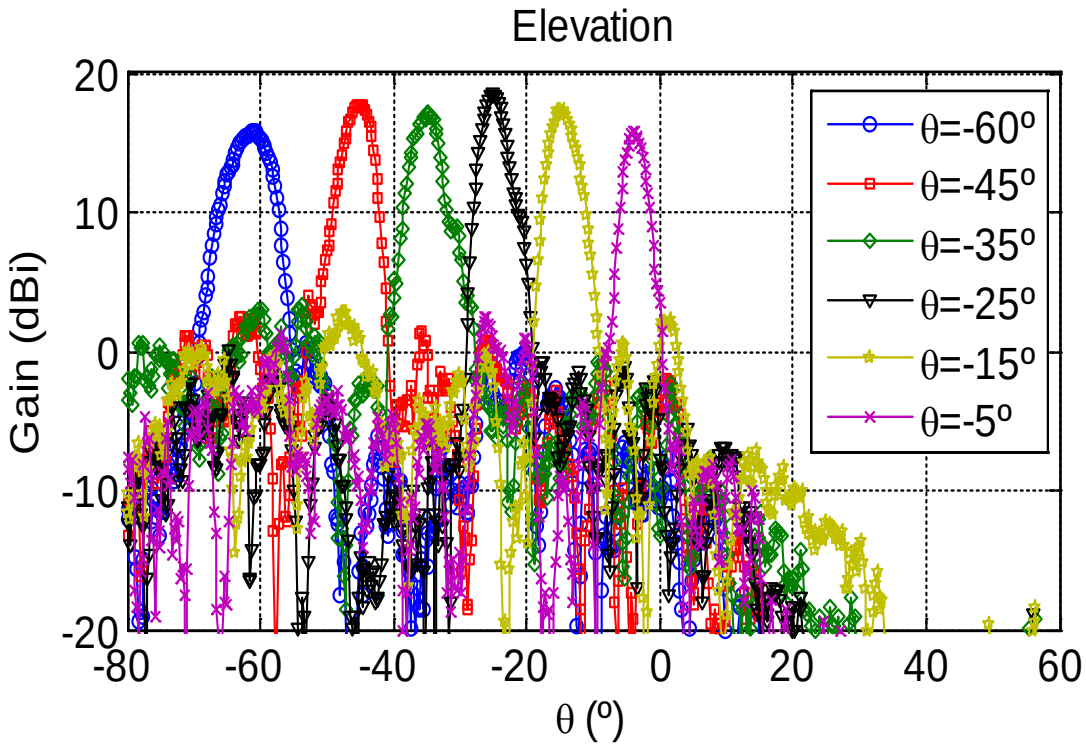


100 GHz



104 GHz

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Future work

- Antennas for space applications with new generation of LC materials
- Combination of metasurface antennas with LC
- Exploring collaborations within GSTP programme
- Deployable NanoSat LC antennas