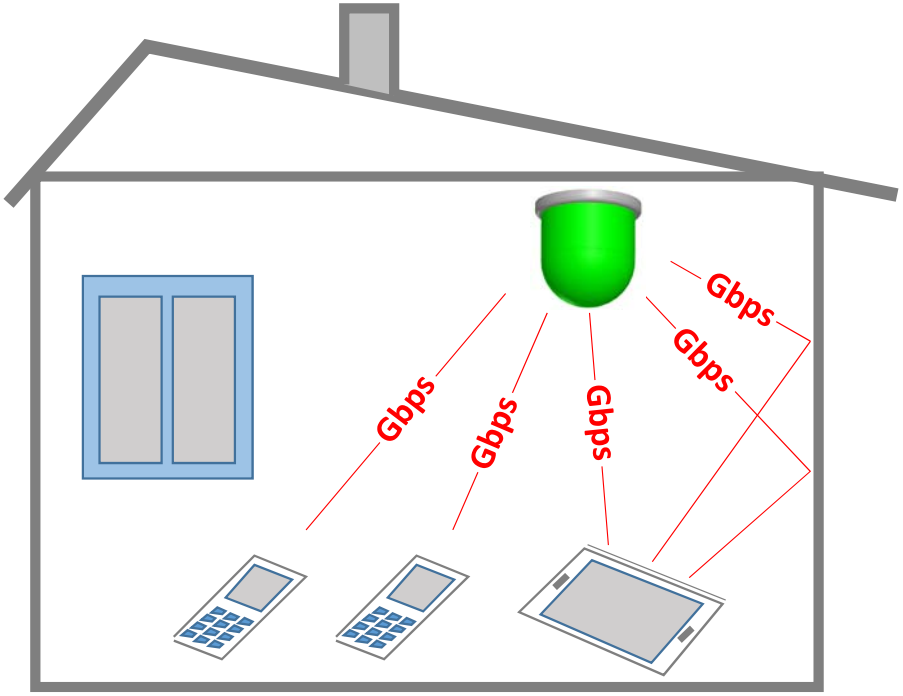
Radio Bulb

JAN HESSELBARTH ET AL.

➢ a millimeter-wave high-directivity multi-beam hotspot with wide-sector coverage



150 cm^3

150 GHz

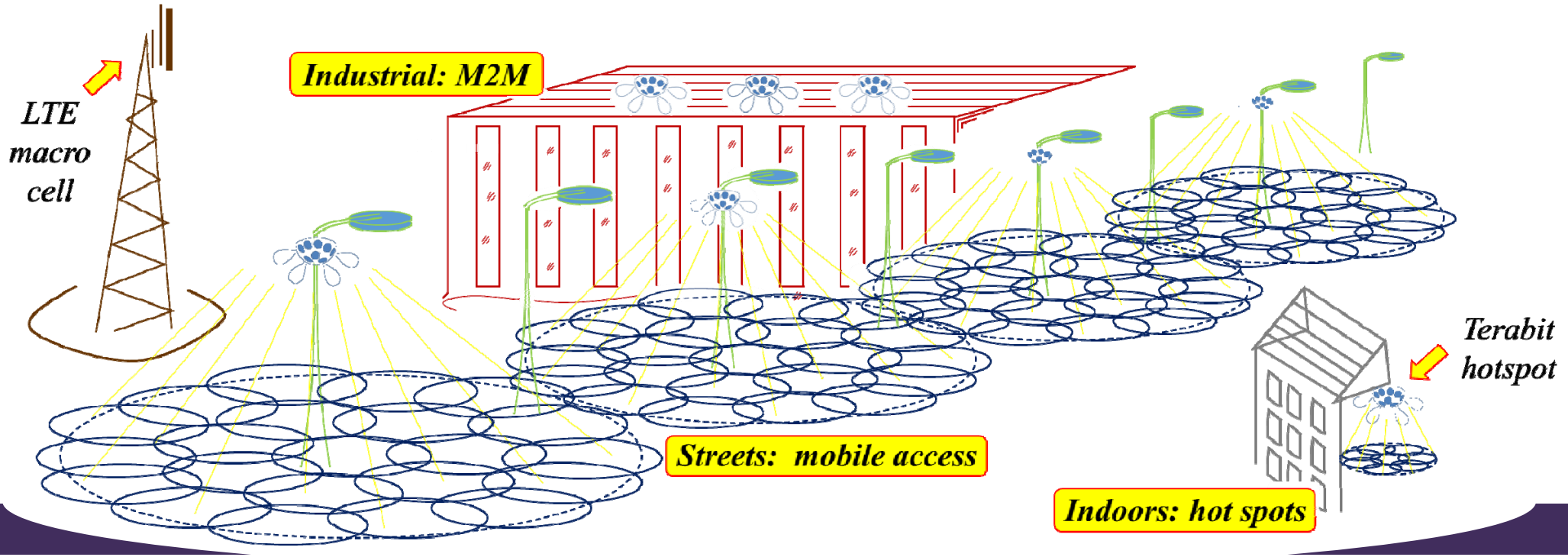
150 m range

150 degrees coverage

New: A wireless hotspot with Tbps throughput and 10 Gbps per-user data rate

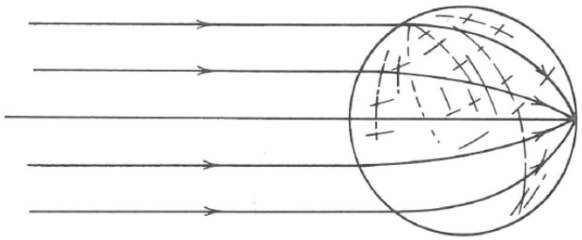
Growing demand for wireless speed and capacity

- how to provide (cost effectively!) multi-Gbps (per user!) data-rate to the mobile(!) user with a reasonably dense (70m…100m cell radius) small cell network ???



Existing standards and techniques are insufficient

- LTE, WiGig (802.11ad): low per-user data-rate, short range ☹
- millimeter-wave links: high-directivity antennas needed for range
- adaptive, high-directivity, multi-beam antenna: focal plane array
  - transceivers placed in focal plane of parabolic mirror or lens
  - narrow sector coverage as focusing deteriorates fast at angles off axis ☹
- wide-sector coverage possible with gradient-index lens:
  - for 2D: steering in azimuth only ☹
  - for 3D: „Luneburg“ lens,
    severe problems at mm-waves ☹



[Luneburg, 1944]

Mobile mm-wave access is a must in the not-so-distant future: antenna is the bottleneck

Problems to be solved

- „Luneburg“ lens foci are on spherical surface ☹
- gradient-index lens material (and technology) which is homogeneous down to 100µm scale is unknown ☹
- impossible to couple many (~1000) transceiver circuit chips to the lens at the locations of foci ☹

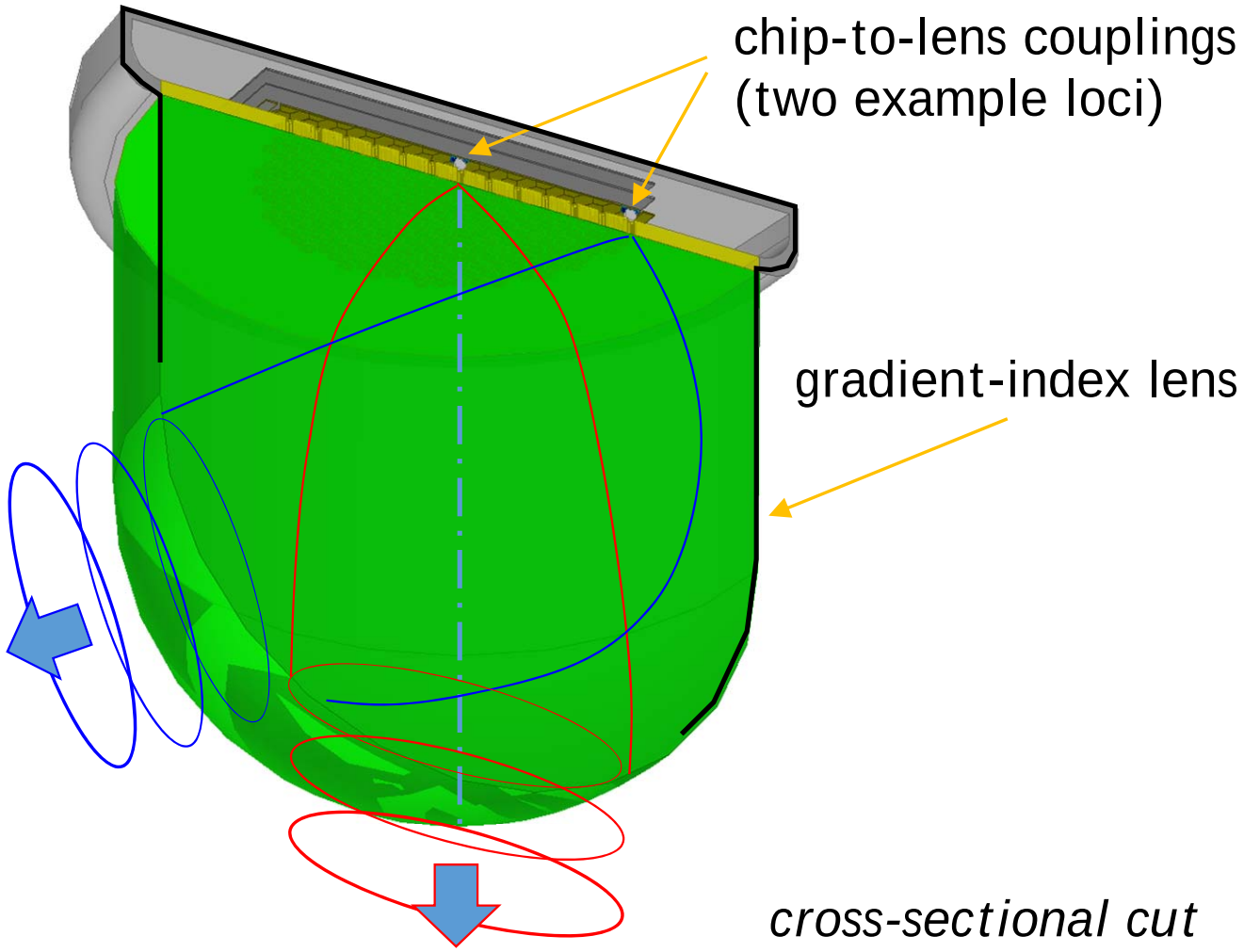
- new „morphed“ version of the Luneburg lens with all foci on a plane ✓
- new: high-homogeneity gradient-index lens made from polymer filled with ceramic powder and hollow glass bubbles ✓
- new chip-to-lens coupling from anywhere on a chip allows for many (e.g., 1000) couplings on a single large integrated circuit ✓

3 problems to be solved: focal plane for Luneburg-like lens, lens homogeneity, chip-to-lens coupling

Radio Bulb — Concept

- several (out of many) beams can be „active“ at any point in time

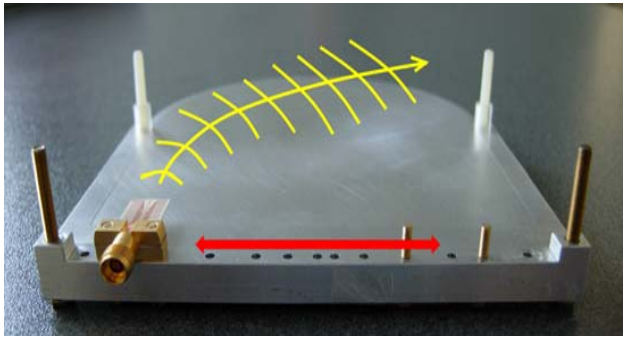
- dimensioning example:
  1000 beams
  32 dBi directivity
  ±75° sector
  150 GHz
  diameter 50 mm
  height 60 mm

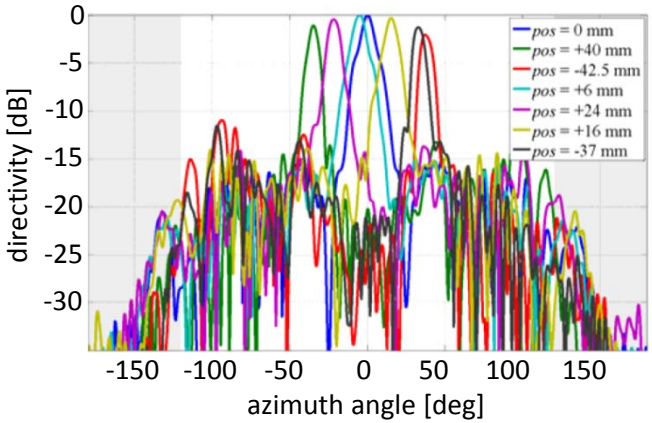


New enabling techniques will let the Radio Bulb hotspot become reality

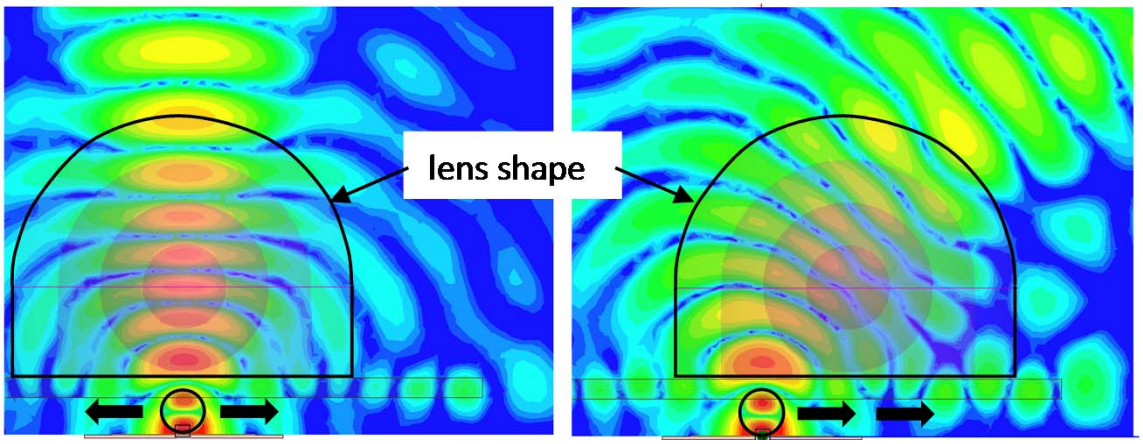
First steps (1/2)

- 2D „morphed“ Luneburg lens with focal line: 30 GHz measurements





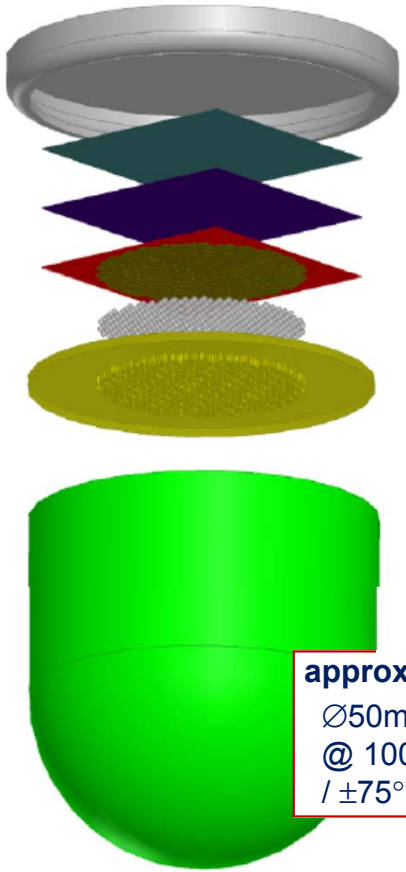
- 3D „morphed“ Luneburg lens with focal plane: simplified simulation



Proof-of-concept experiments were successful

Radio Bulb — Summary

- the need for mobile data-rate and cell throughput is growing fast
- no other approach than the proposed concept can offer in an economically viable way data-rates of many Gbps simultaneously to many users, resulting in a base station throughput of 100s of Gbps
- the proposed new concepts of high-directivity beam switching, gradient-index lens, and off-chip coupling by means of dielectric resonating spheres outcompete all alternative solutions



More than "10x Innovation Potential" in cell throughput, hotspot size, energy consumption, cost