RF and Data Processing Towards Tbps – Challenges and Opportunities on the way to 6G

Aarno Pärssinen

Professor Radio Engineering

aarno.parssinen@oulu.fi

Three Technology Visions

1. Densified network and edge computing mandate need for ultra high speed connectivity without capacity bottlenecks
2. Radar, imaging and sensing benefit from THz in increased bandwidth and propagation properties of different media

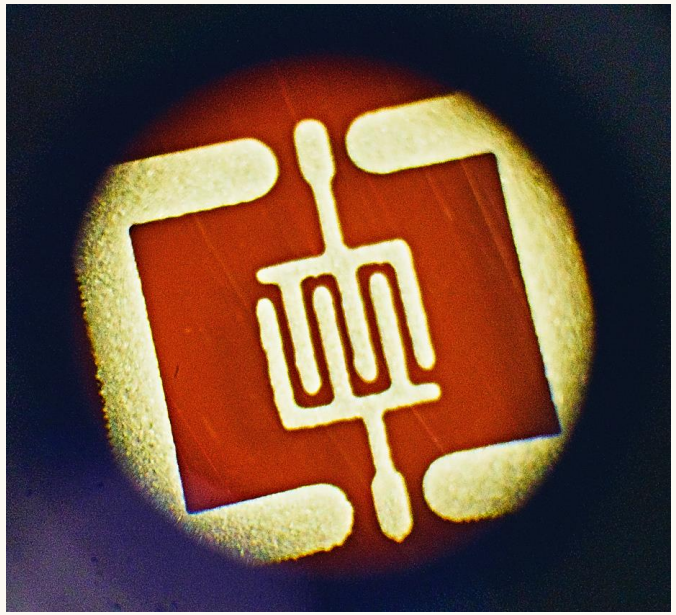
Consequences 1&2:

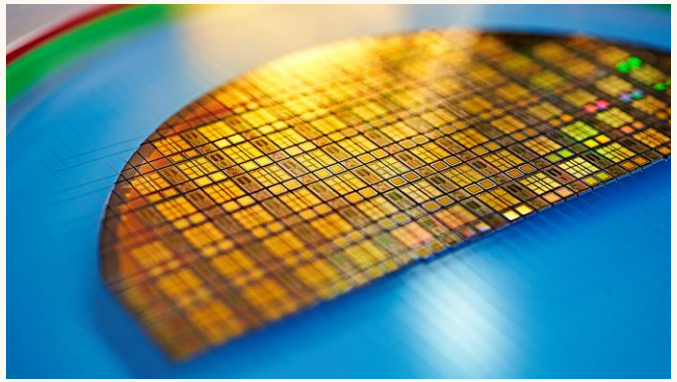
- Bandwidth of tens of GHz for rate and precision
- RF frequencies 0.1…1 THz

3. Utilize the opportunity of reduced physical dimensions radios in new form factors and surfaces

No free lunch available – Meeting physical boundaries

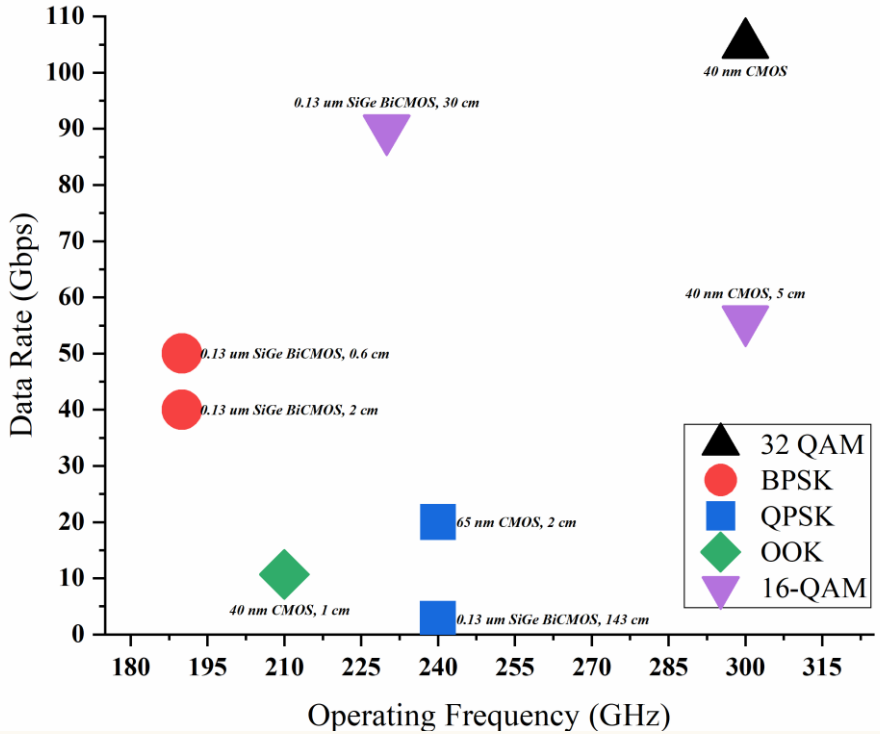
- Affordable HW technologies are key to conquer the new frequency region
- Transistor speed will become an issue towards THz
- Generating power and avoid material and interconnect losses is an extreme challenge
- Precision in manufacturing
- Antenna elements scale down and phased arrays beyond 5G era are a must even in short range

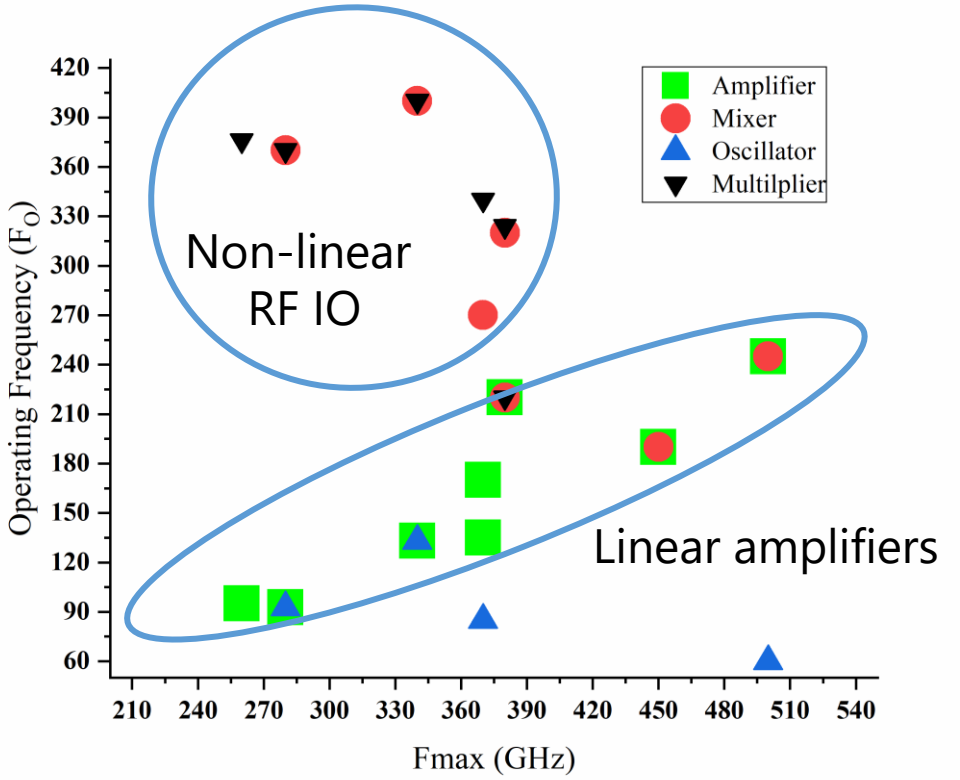




Technical challenges towards THz

- Data rate and transistor f_{max} vs. operating frequency

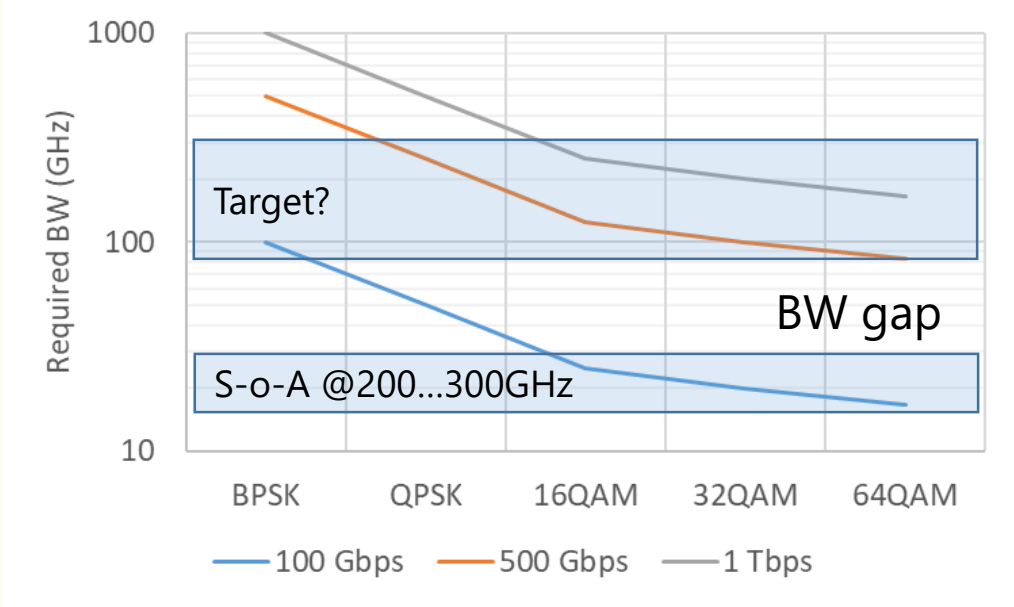


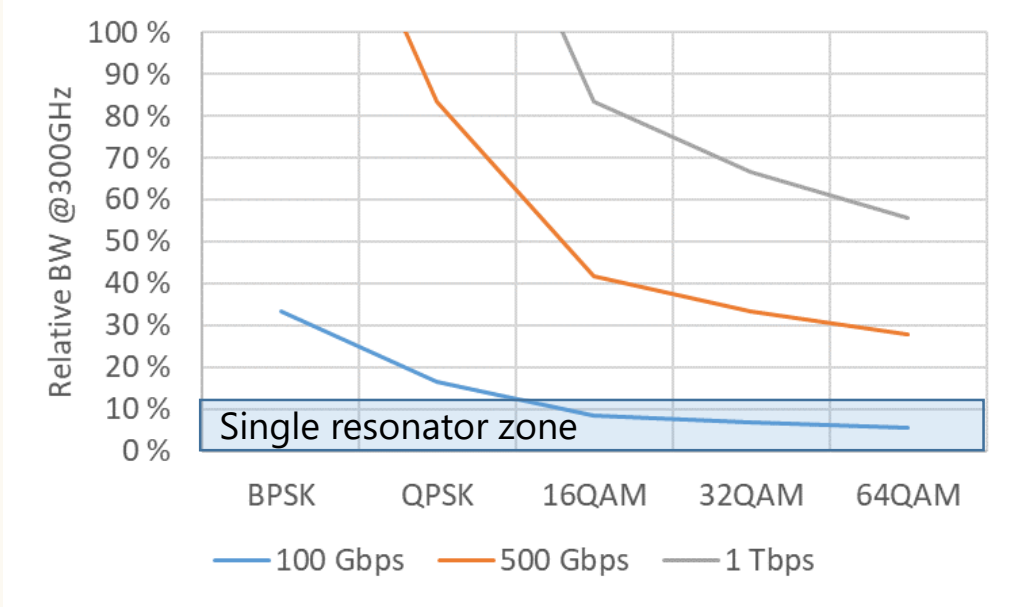


HOW ABOUT RANGE?

Feasibility of Tbps ?

- **Required channel BW's 170…250GHz using 16…64QAM (without network capacity improvements from spatial and mMIMO gains)**
- **Relative BW @300GHz exceeds 50% while S-o-A ~10%**
- **Multiple frequency carriers and transformer based design !**
- **Practical single user data rates in networks are often 0.1…0.2x peak data rate of the link**

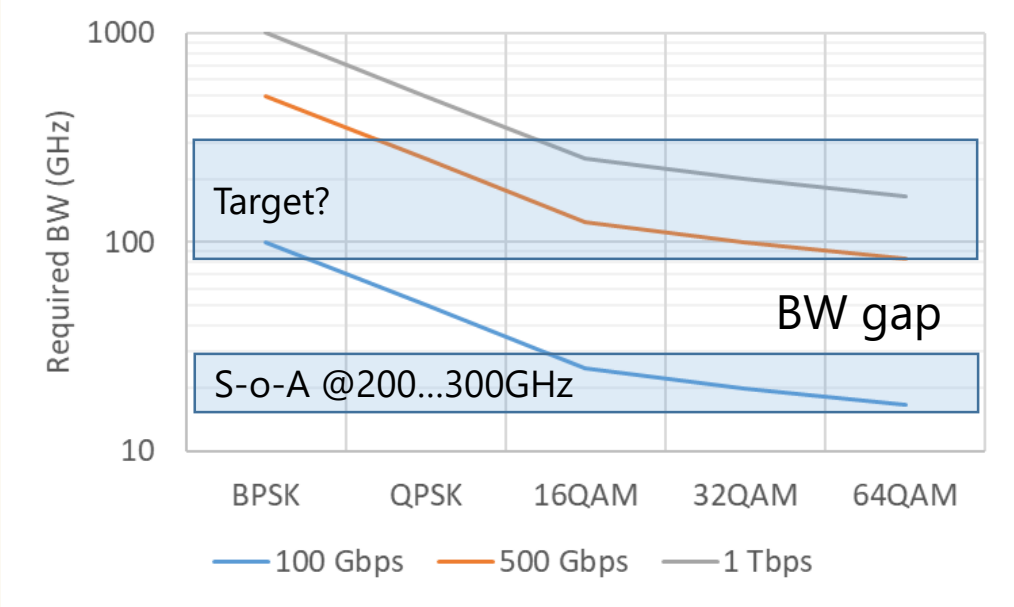


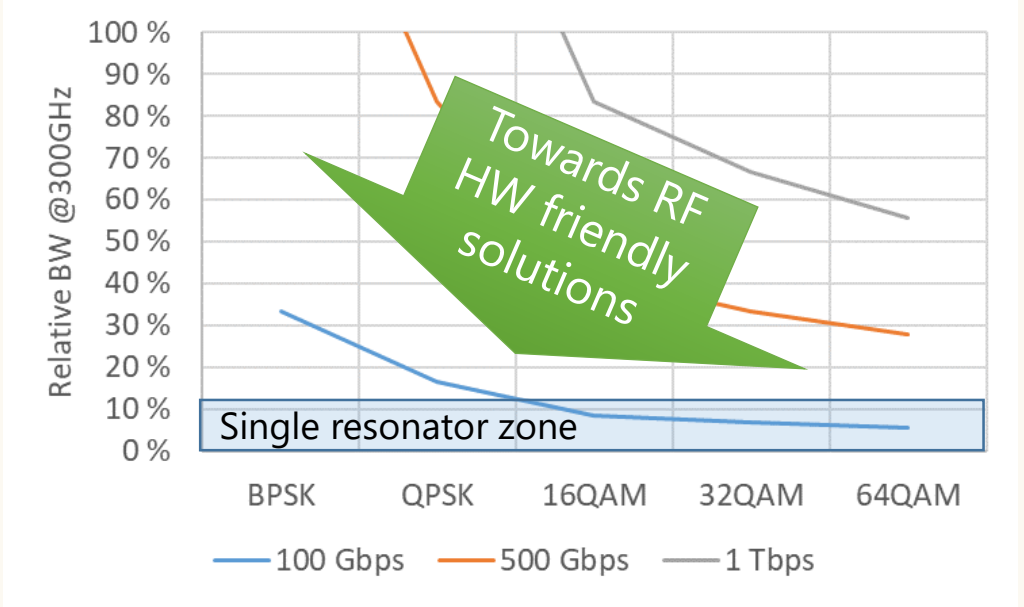


Feasibility of Tbps ?

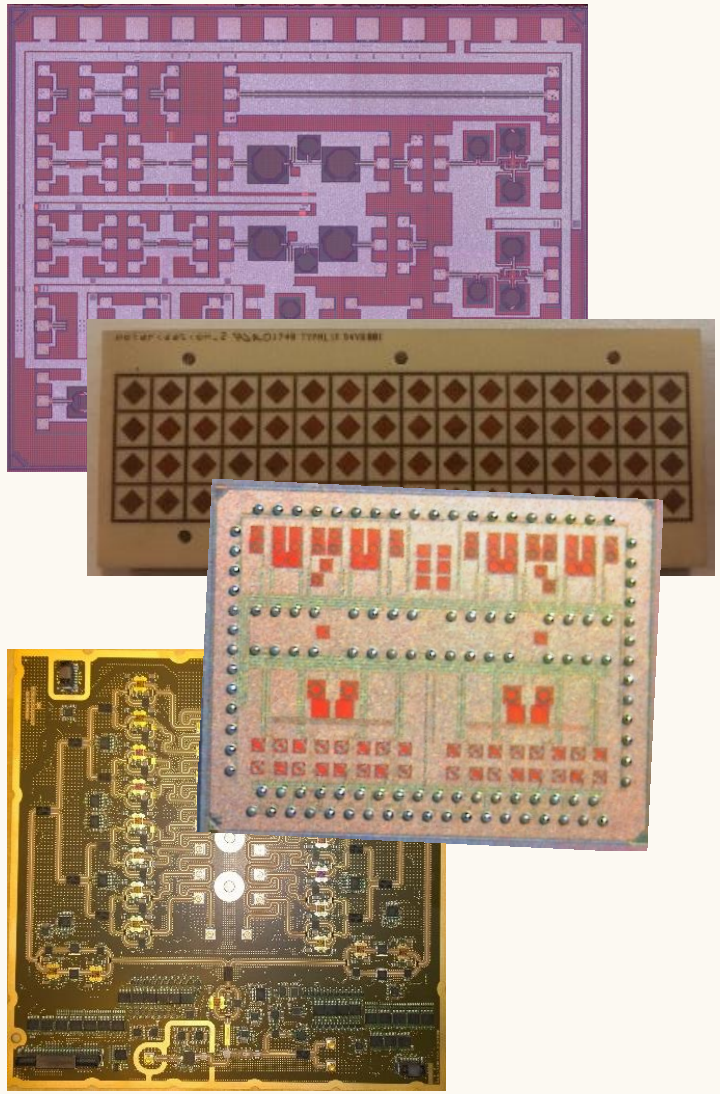
- **Required channel BW's 170…250GHz using 16…64QAM (without network capacity improvem**
- **Relative BW @300GHz exce**
- **Multiple frequency carriers**
- **Practical single user data rat data rate of the link**

6…>>30x multi-user gains needed for 1Tbps network capacity @300GHz carrier and 30GHz channel BW depending on the waveform





Devices and Circuits for Comms and Sensing



- Focus in HW is on key enabling technologies for 6G from materials to transceivers and sensing at THz range (0.1THz onwards)
- Approach from systems to HW and back
- Silicon based transceiver design from blocks to systems
- Integration, scalability and performance of antenna arrays including challenge of wideband modulation
- New technologies and materials beyond IC core
- Build on the top of 5G experience, investing in THz to meet the goals