NUCLÉAIRE & PARTICULES

LPSC GRENOBLE | MODANE

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GRENOBLE INP UGA

WADAPT

WIRELESS ALLOWING DATA AND POWER TRANSMISSION★

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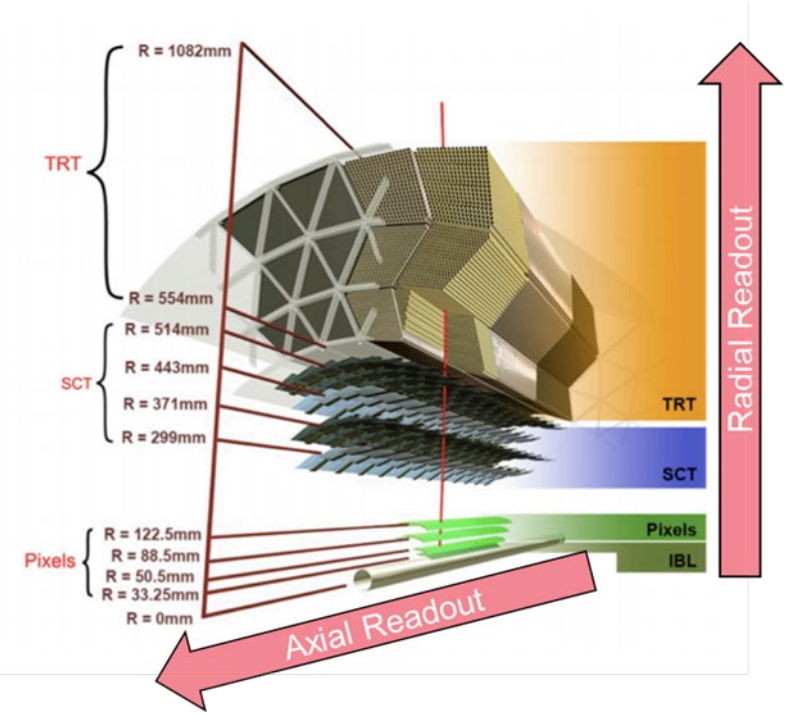
Some slides courtesy of Cédric Dehos, CEA Léti

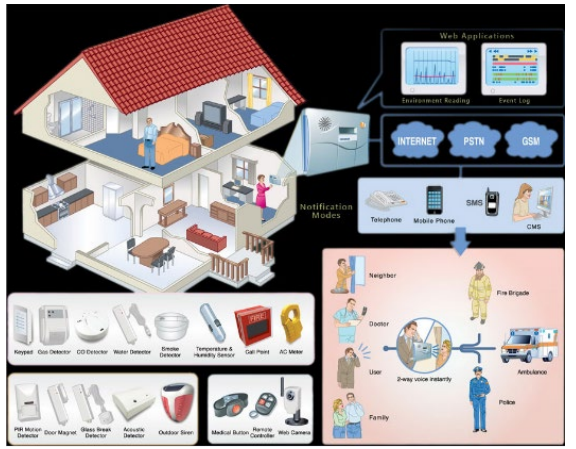
MOTIVATION

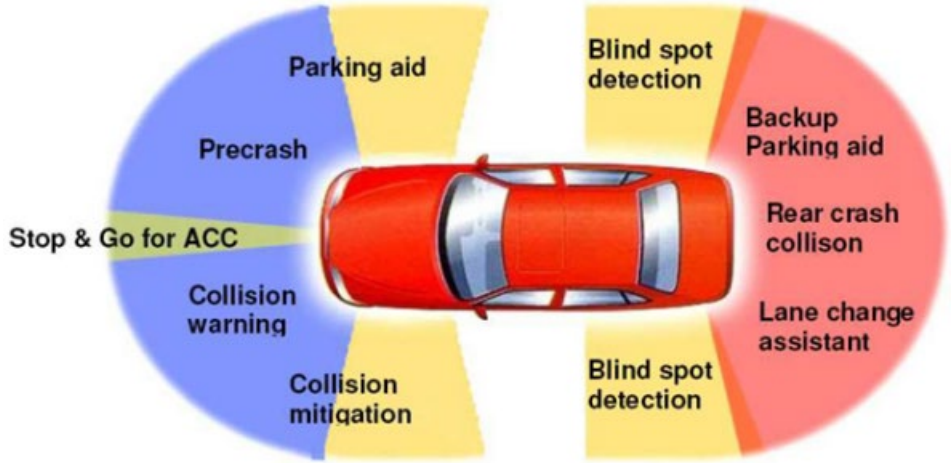
- Cables
  - Create multiple scattering and nuclear interactions, dead-zone areas
  - Impact on the installation and the operation
  - Axial readout induces important latencies
- Wireless
  - Minimize material budget of cables/connectors
    - Reducing the radiation length of massive services in region between Barrel and Disks
  - Direct communication between layers (radial readout)
  - More flexible transceiver placement
  - Point-to-Multipoint links, interlayer intelligence
  - Data follows event topology enabling fast triggering



WIRELESS DATA TRANSMISSION: APPLICATIONS

- A huge number of applications
  - Radio astronomy
  - Innovative Health Care
  - Military and space
  - Cellular Infrastructure, 5G small cell
  - Automotive Radar
  - Home automation
  - Imaging and security





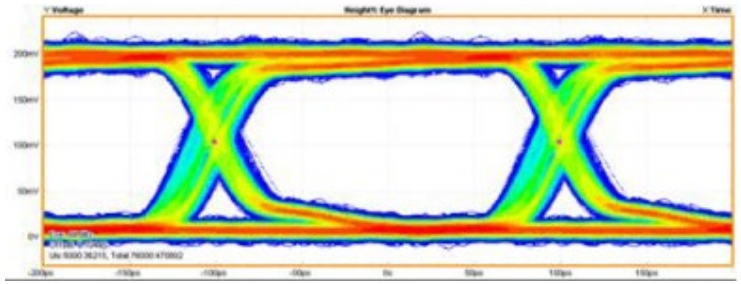
THE HEP COMMUNITY IS NOT AN EXCEPTION

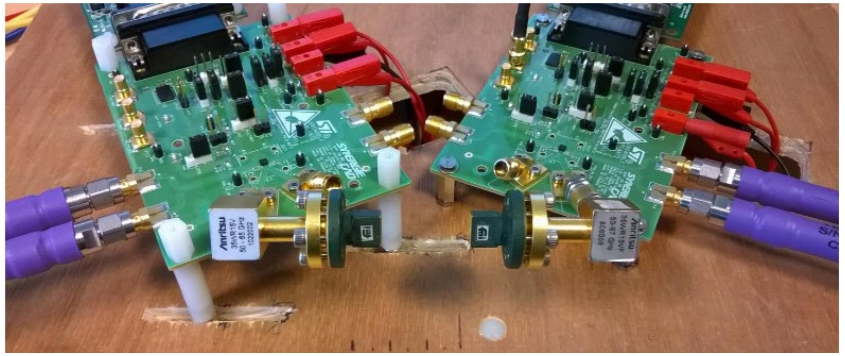
WIRELESS DATA TRANSMISSION: MILLIMETER WAVE

- 1-10mm wavelength
  - Short wavelength
  - High level of integration, compact antenna scheme
  - System in package integration
- 30-300GHz carrier frequency
- Compatible with low cost CMOS
  - Passives in Back End Of Line
  - High quality factor >28nm node
- Wireless Data Transfer using the 60 GHz band
  - Unlicensed Spectrum
  - Can send Gigabits/s of data over short distance

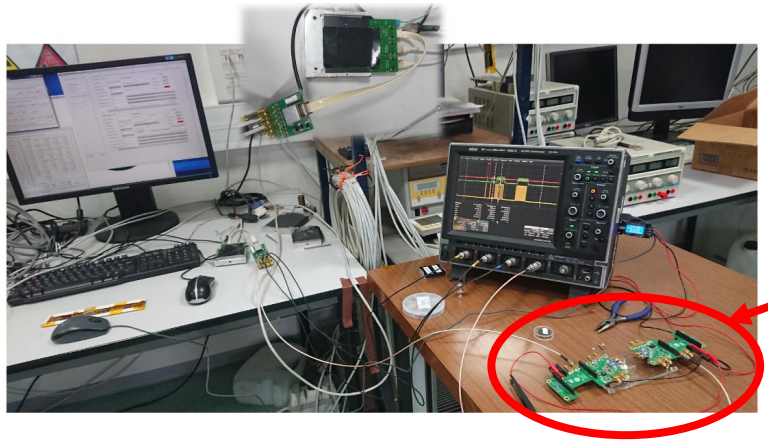
WIRELESS DATA TRANSMISSION: FEASIBILITY STUDIES

- CEA Léti
  - 60GHz Tx-RX package on test board
  - 3cm range



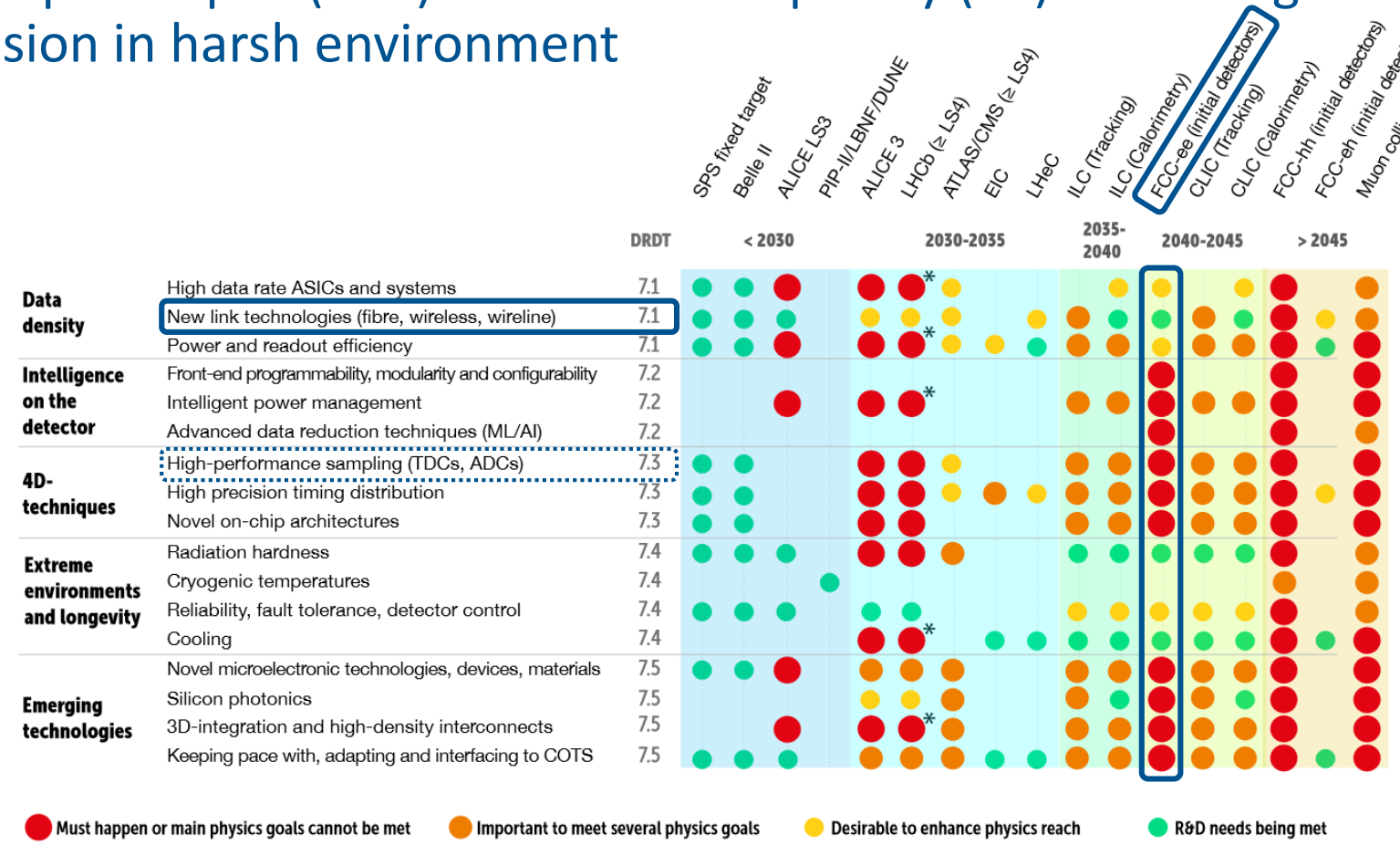


- Interfacing with 3M Pixel Detectors (IPHC Strasbourg)
  - ST60 Application Board

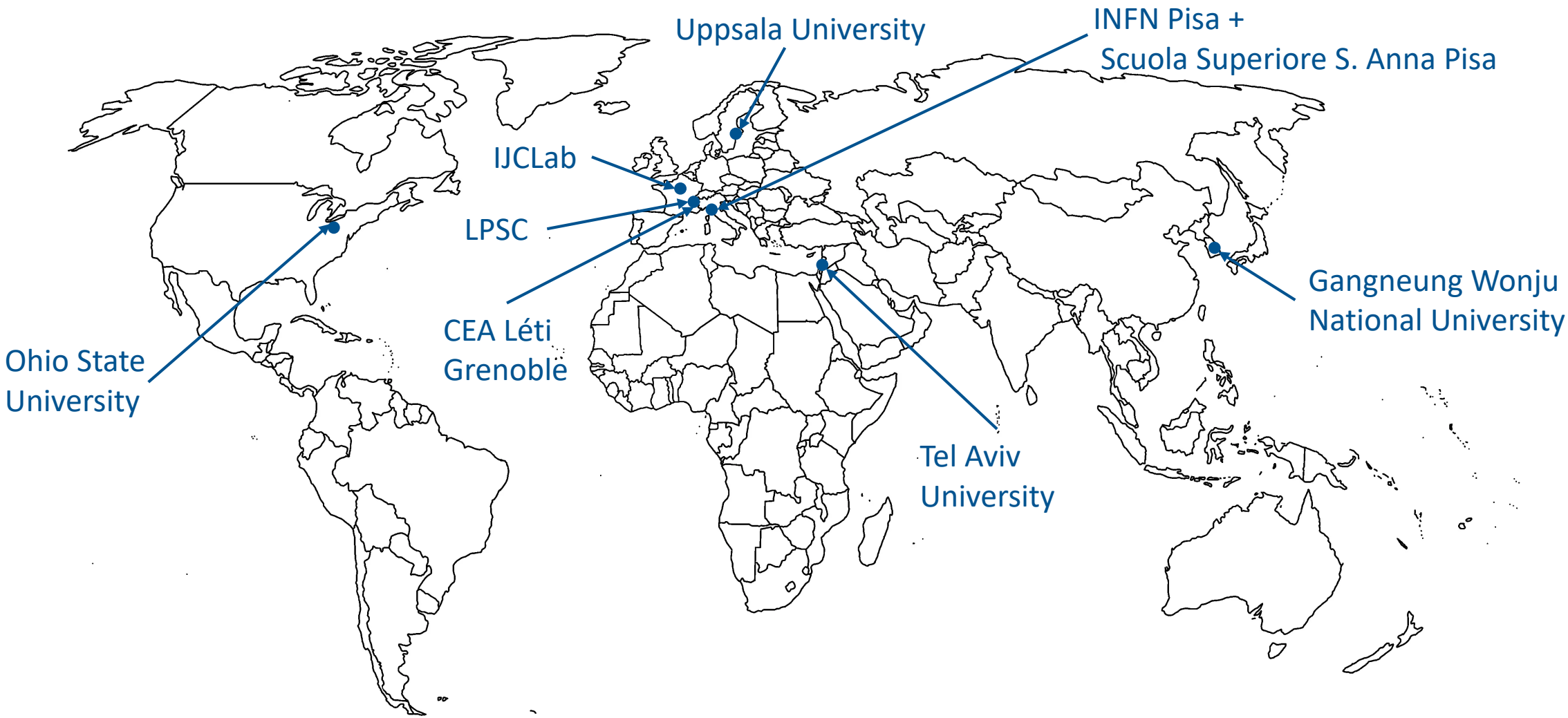


CONTEXT

- Wireless technologies proposed as key « New link technologies » to ECFA roadmap
- Wireless Free Space Optic (FSO) and Radio Frequency (RF) technologies for high density data transmission in harsh environment

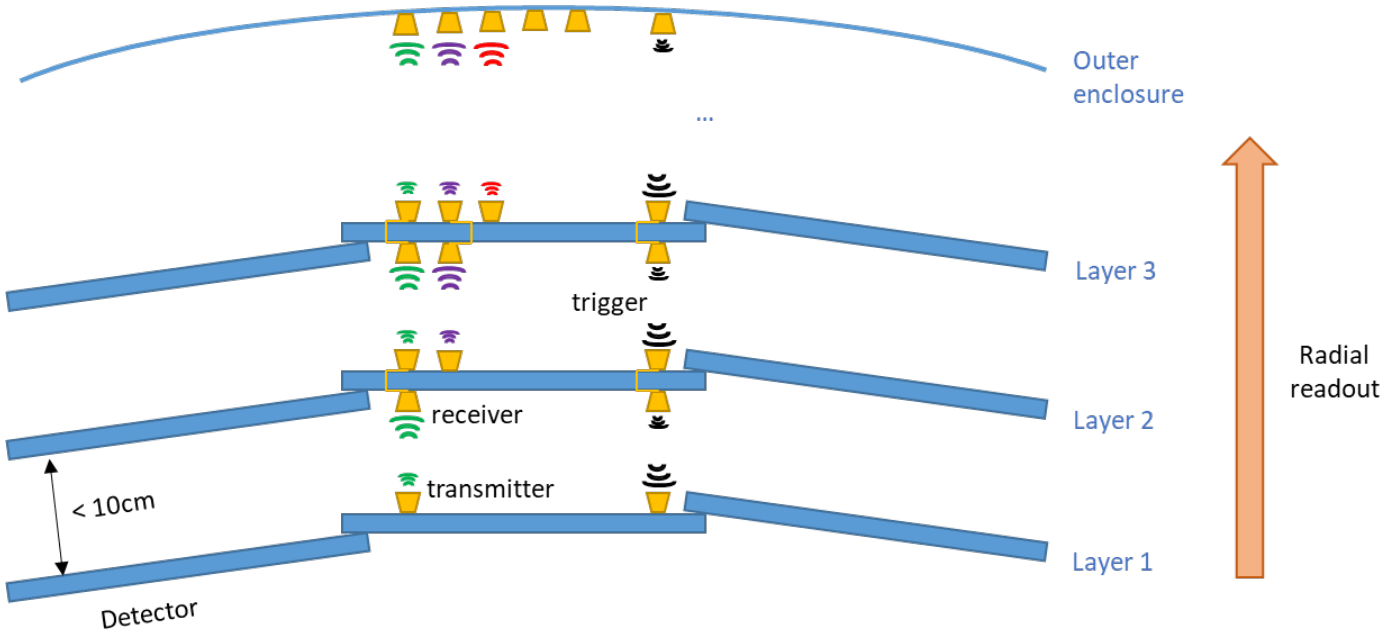


PARTICIPANTS



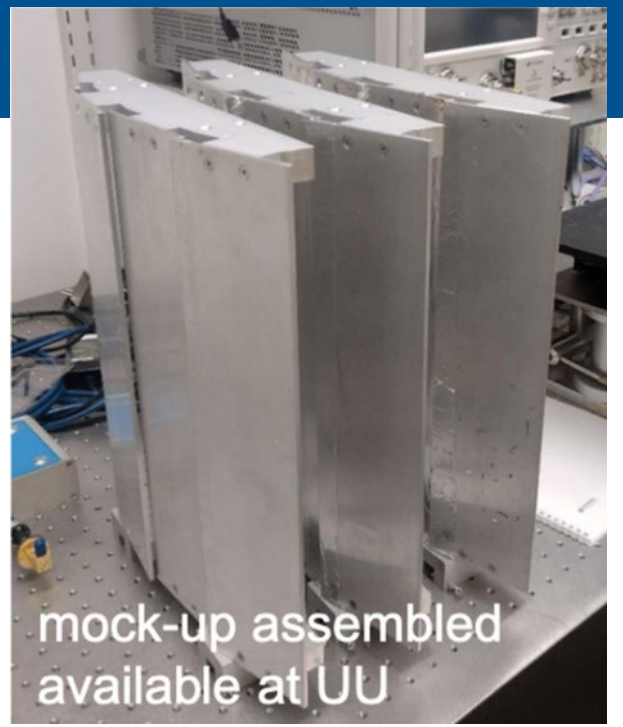
PROPOSED APPROACH

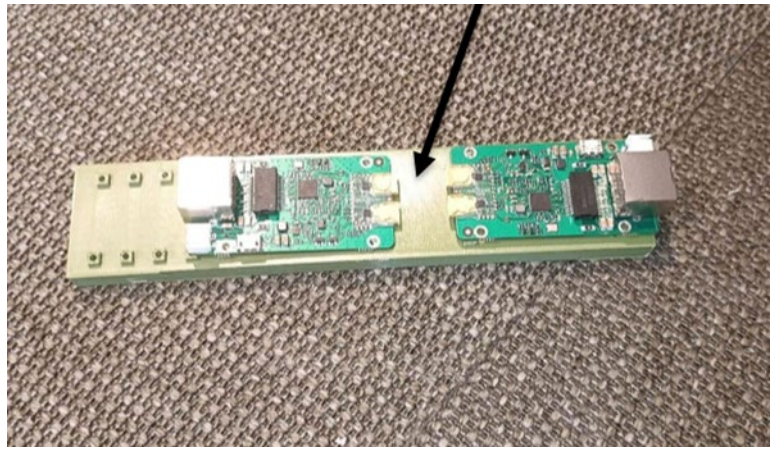
- Multi-hop data transmission between inner detector layers
  - Directive and short range transmission using millimeter wave RF or Free Space Optic
  - Use of non-coherent modulation scheme (OOK, ASK, PAM), up to 10Gbps per link
  - Compatibility with wired standards (modulation, QoS), and high energy efficiency



CURRENT WORK (1)

- Aidainnova WP13 (Blue Sky)
  - **Uppsala Univ.**, Tel Aviv Univ., Gangneung-Wonju Univ.
  - Study of components and antennas integration
  - Full link demonstrator(s) from 1 tile to 2 and 3 tiles
    1 Gbps per layer -> 3 Gbps at the outer enclosure
  - Use and integrate **commercially available components**
  - Study the performance of the system
    (data rate, bit error rate, modulation schemes, usage of bandwidth, crosstalk in repeater, etc.)





SK202 Board

CURRENT WORK (2)

- LPSC internal project
  - Design of an integrated multi-channel readout electronics to be interfaced with the wireless data transmission module
    - ADC block (DRD 7.3)
    - 8b/10b encoding
  - 3 years Engineering through apprenticeship (CNRS fund)

Fatah Rarbi, Brice Gogué-Meunier, Olivier Rossetto, CAO Group

ROADMAP AND PROPOSED WORK PLAN

- Millimeter integrated circuit, packaging and antenna design
- Proof of concept demonstrator with commercial products
- Design of custom Millimeter Wave Integrated Circuit
- Design of an integrated multi-channel readout electronics
- Realize and test a FSO system solution for a FCC-ee tracker
- Exploration of wireless power transmission

THANK YOU FOR YOUR ATTENTION

BACK UP

Roadmap and proposed work plan

WP1. ***Readout system level definition****, including new link technologies (T0-T0+6m)*

- Objectives: reduction of cable mass, power consumption, more network flexibility, improved overall bandwidths and data rates, increasing the network synchronization, taking into account the environmental constrains of HEP
- CEA-Leti, extra experts from readout system, RF, FSO, Silicon Photonics to be involved.

WP2. **System level analysis**, signal integrity (T0+3-T0+9m)

- Objectives: assess the key performances of the proposed network, give global specifications for the different components, building of a system level simulator to evaluate the signal integrity in a multi-hop scenario with interferers from cross talks, throughout the different nodes of the network
- CEA-Leti

WP3. Millimeter integrated **circuit, packaging and antenna** development (T0+6-T0+9m)

- Objectives: Use the system analysis and signal integrity simulator to define the millimeter wave integrated circuit architecture and its components, the type of chip assembly, the packaging and antenna scheme
- Uppsala University

WP4. Proof of concept **demonstrator** with commercial products (24m)

- Objectives: a proof of concept by building and interconnecting a three (or four) layer silicon detector, based on commercial ICs (with reduced performance) and custom on board antennas. This mock-up of a central tracker will be equipped with the transceiver chip in BGA package. This will allow studying the added noise and data transmission quality (impact on eye diagram, Jitter, Bit Error Rate) over the different layers. The setup will be interfaced with detectors to check the readout capabilities while using multi-hop wireless link. Eventually a multilink scenario will be considered to check if the isolation between channels is sufficient for the considered application. This would bring us closer to the full-scale implementation and would help specify and integrate the future wireless systems in detectors at future colliders
- Uppsala Univ., Gangneung-Wonju Univ., TAU

Roadmap and proposed work plan

WP5. Design of **custom Millimeter Wave Integrated Circuit** (T0+12-T0+36m)

- Objectives: design of a dedicated radiation hardened millimeter-wave transceiver IP in advanced technology node, to be integrated either as a companion chip or as an IP within the silicon trackers. The transceiver shall reach high energy efficiency, while providing enough margin and robustness to operate during a long period in harsh environment
- CEA-Leti, Ohio State University

WP6. Design of an integrated **multi-channel readout electronics** (T0-T0+36m)

- Objectives: design of an integrated multi-channel readout electronics in 65nm or 28 nm CMOS technology (TSMC) for detectors with a capacitance of 10pF to be interfaced to the multi gigabit wireless data transmission module
- LPSC

WP7 Dissemination, training on RF/mmw technologies (T0-T0+36m)

- Objectives: organization of workshop and training on RF/mmw technologies. The training will use the proof-of-concept demonstrator to feel the physical behavior of the wireless propagation
- Institutes: CEA-Leti, INFN-Pisa, Scuola Superiore S. Anna di Pisa

WP8. Realize and test a **FSO system solution** for a FCC-ee tracker (T0-T0+36m)

- Objectives: maximum data rate as a function of distance, signal integrity and latency, material budget and power reduction compared to a plastic fiber solution
- INFN-Pisa (F. Palla), Scuola Superiore S. Anna di Pisa

WP9. Exploration of wireless power transmission (T0-T0+36m)

- Objectives: selection of power transmission means, building of demonstrators
- Tel-Aviv University