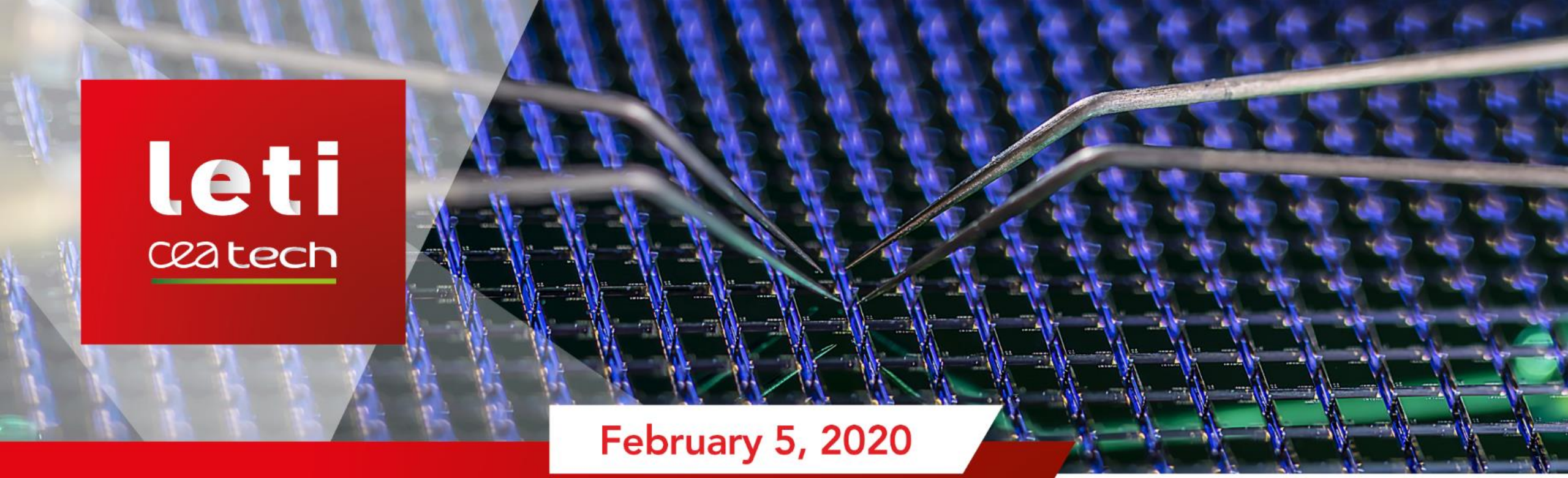


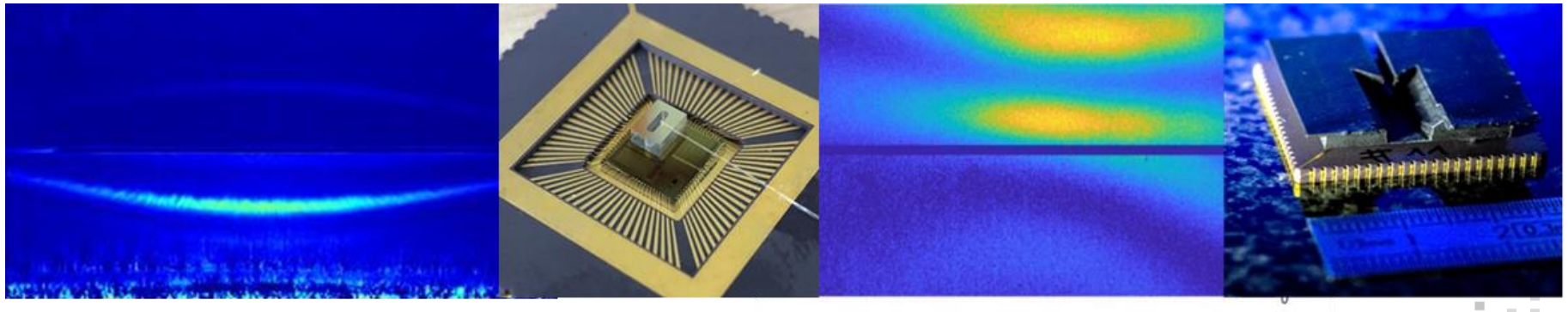
leti
cea tech

February 5, 2020

Leti Photonics Workshop

W-Hotel, San Francisco

SPIE. PHOTONICS WEST



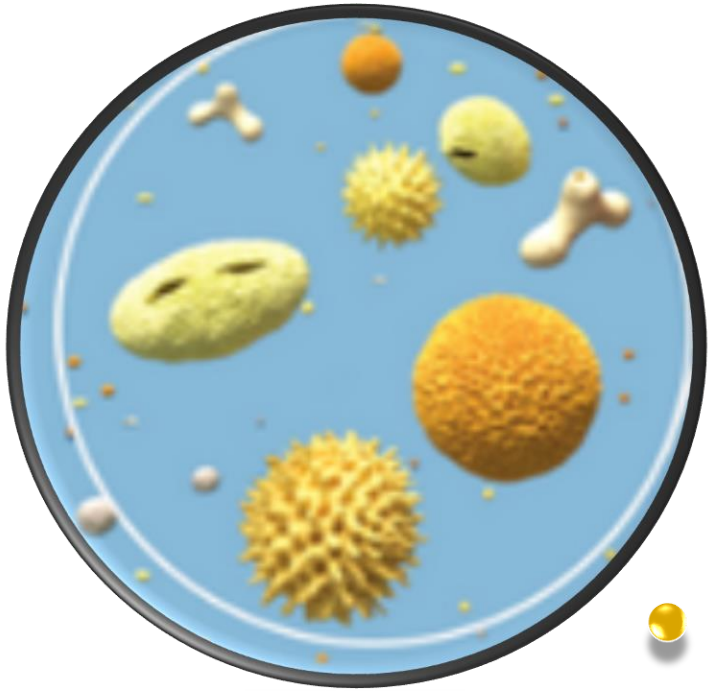
NEW MINIATURE SENSORS OF PARTICULATE MATTER USING ANGULAR SPECTRAL IMAGING

5th Leti Workshop San Francisco| Duraffourg Laurent | 5/06/2020
CEA-Leti's photonics sensors lab manager

PARTICULATES OF MATTER? MIXTURE OF AIR BORNE PARTICLES

PM_{10}: Coarse particulates
Dust, pollen, mold…

$2.5\mu m < d < 10\ \mu m$
→ Enter lung



$PM_{2.5}$: Fine particulates
Oil smokes, organic compounds, metals, oxides

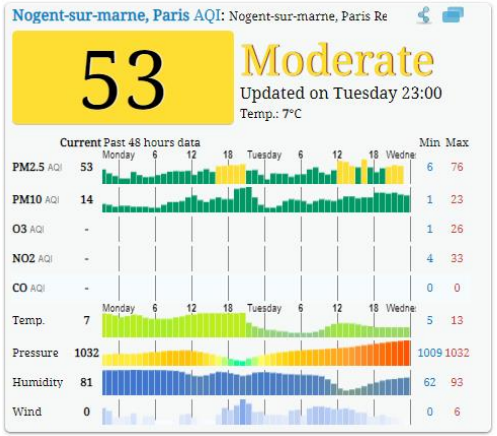
$d < 2.5\ \mu m$
→ Enter into deep lung tissues

$PM_{0.1}$: Ultra fine particulate
Soot, organic compounds, metals

$d < 0.1\mu m$
→ Human body penetration, pass into blood stream, human cell disturbance

Natural particulates & particulates due to human activities

APPLICATION FIELDS & PLAYERS



Credit: eLichens

Bulky, high perf.

Aerodynamic Particle Sizer (APS)

Honeywell
HPMA115S0-XXX

Nova Fitness
SDS011

PLANTOWER
PMS 7003

SENSIRION
SPS30

Huge number of players!

Optical sensors

Portable, low perf.

BEYOND CURRENT SENSORS: POWERING THE LORENZ-MIE THEORY

- Detection of PM2.5
- Resolution: 10µg/m^3
- Footprint: 4 x 4 x 3mm^3
- Measurement time : 10s

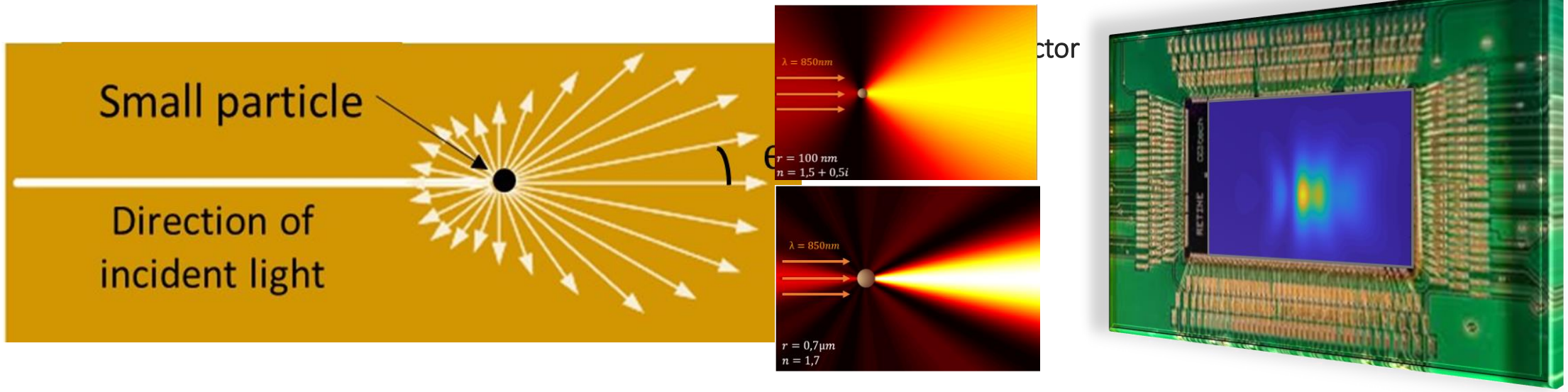
+

Real time PM identification
- **diameter distribution**
- **classification / nature**

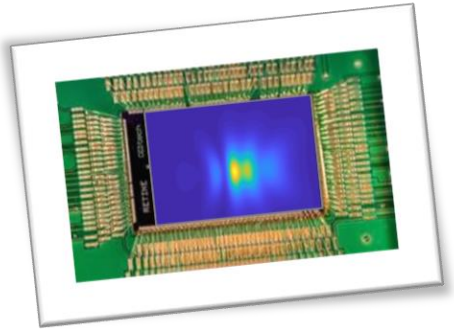
PM0.1 (100nm)

CMOS image sensor

Overall angular scattering pattern → Index / size

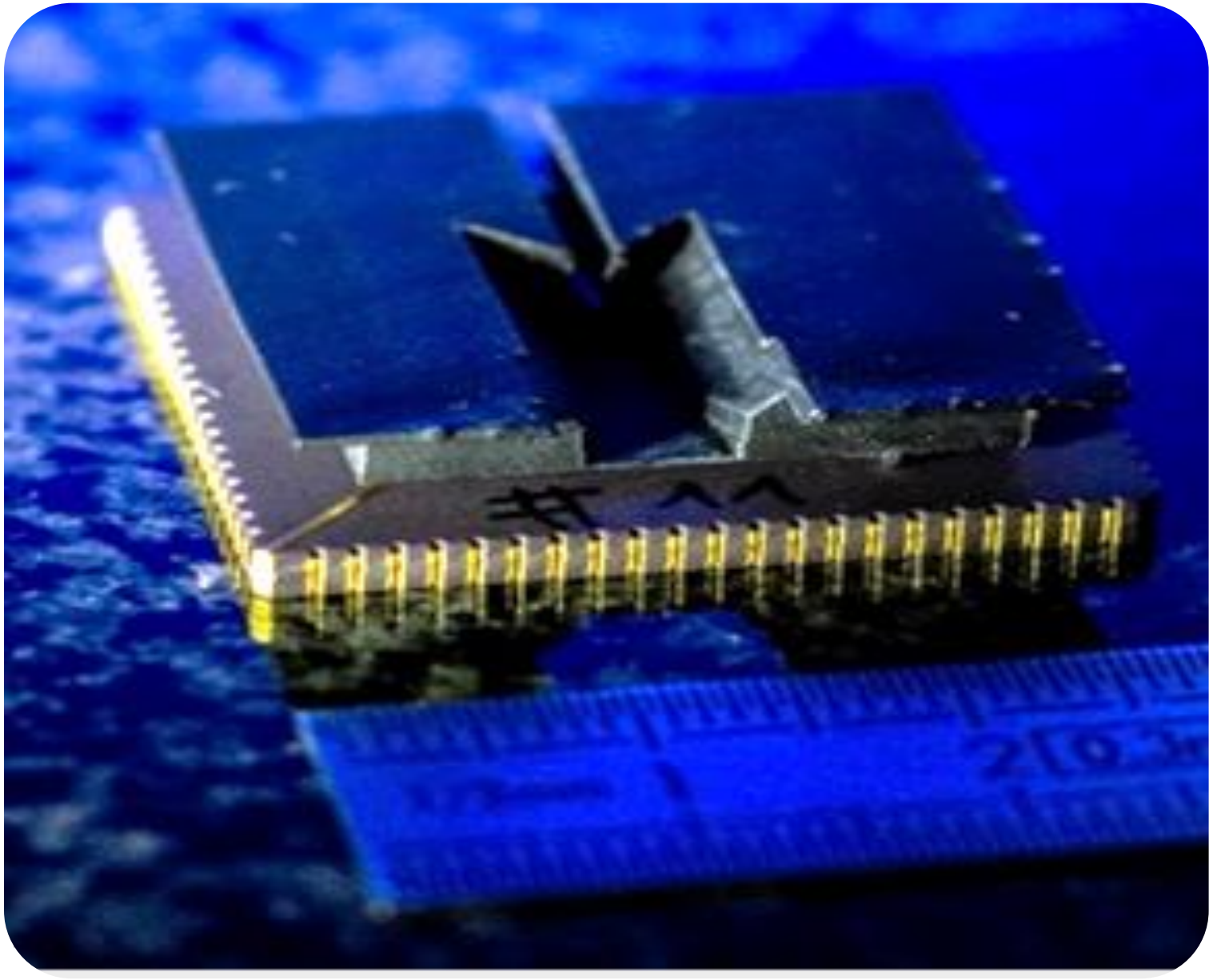


IN PRACTICE

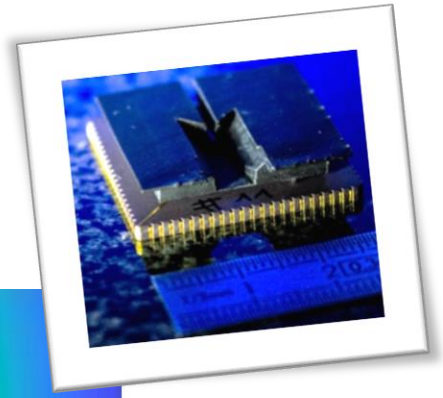


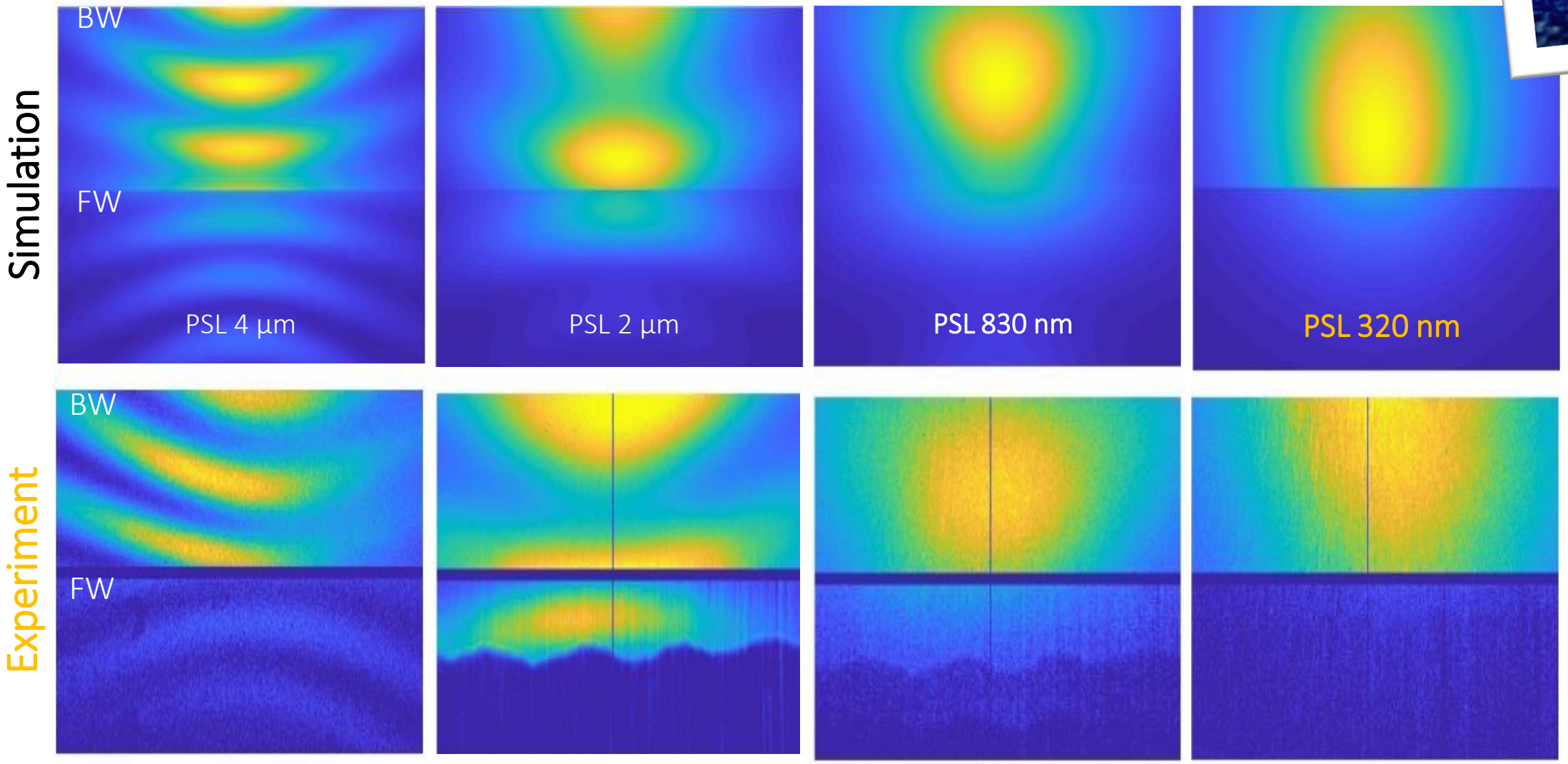
Optical fibe

Holed retinas



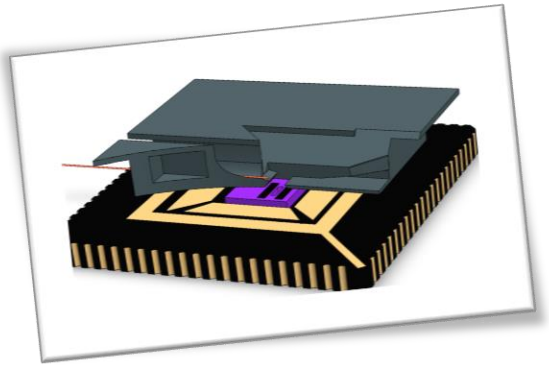
HOW LOOKS A TYPICAL MEASUREMENT?





PSL : Polystyrene Latex Sphere

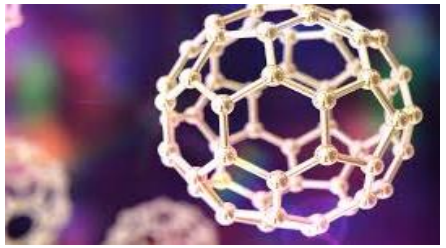
CONCLUDING REMARKS



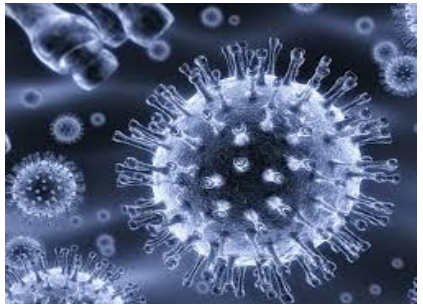
- ✓ Detection of single particles demonstrated for diameters 5µm down to 300nm
  - Particulate counting (as done with bulky analysis system / APS)
  - Low flow rate (for a resolution comparable to commercial device)
- ✓ Real time diameter identification
- ✓ Towards nanoparticles (300nm)

PERSPECTIVES

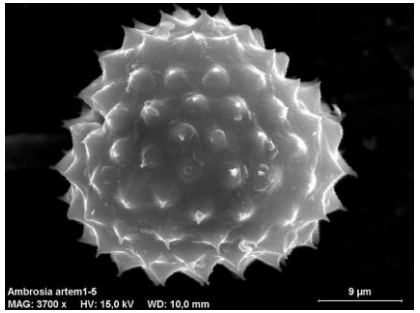
- Experiments
  - Demonstration of a PM classification



nanoparticles ≤ 100nm



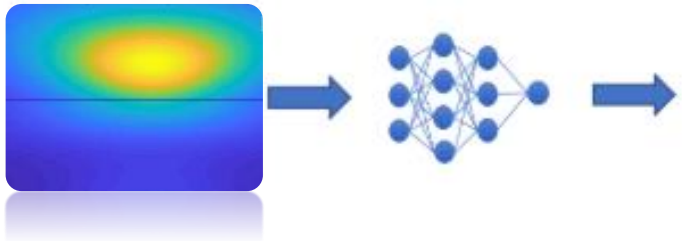
Big virus - 100nm



Ambrosia

- Hardware
  - Toward 100nm PM & smaller
  - Toward large PM: pollen?

- Software
  - Machine learning



- PM1
- Soot
- Organic compounds

- **Publications**
  - G Jobert, M Fournier, P Barritault, S Boutami, J Auger, A Maillard, J Michelot, P Lienhard, S Nicoletti, L Duraffourg, A Miniaturized Optical Sensor for Fire Smoke Detection, 2019/6/23, 2019 20th International Conference on Solid-State Sensors, Actuators and Microsystems & Eurosensors XXXIII (TRANSDUCERS & EUROSENSORS XXXIII), 1144-1149

  - @PW2020:
    - A miniaturized optical sensor for particulate matter counting and classification
    - Millimeter-sized particle sensor using a wide FoV monolithic lens assembly for light scattering analysis in Fourier domain

- **Patents**
  - Particle Detector and Method for producing such a detector, Sergio Nicoletti, US2013/0120749 A1
  - Optical Detector of particles, Salim Boutami, Sergio Nicoletti, 2018WO-EP51890

  - on-going patents
    - Détecteur Optique de Particules, Salim Boutami, Mathieu Dupoy, Jean-Marc Fedeli (DD17433 HB)
    - Détecteur Optique de particules, Gabriel Jobert (DD18825 HB)
    - Détecteur Optique de particules, Gabriel Jobert (DD19082 HB)
    - Détecteur Optique de particules, Gabriel Jobert, Salim Boutami, Maryse Fournier, Christian Seassal (DD19907 HB)
    - Détecteur multi-particules, Gabriel Jobert, Pierre Barritault, Maryse Fournier (DD19480 HB)

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Thank you for your attention

See Leti's demontrators at booth 857A France Pavilion (South Hall)

And welcome in Grenoble in June >>

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