# Academia and Industry Come Together
# 1st Industrial FAST Workshop
# Aachen Sep.'15

## Overview of possible Applications

Pedro Almeida
(IBEB- Universidade de Lisboa – PT)
Stefaan Tavernier
(Vrije Universiteit Brussel - BE),

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# Possible applications of FAST detection chains:

- High Energy Physics
- Medical Imaging
- Biological Imaging
- Spectroscopy
- Other Applications:
  - Security.
  - Industrial non-destructive quality control in production chains.
  - LIDAR applications.

# High Energy Physics:

- e.g. measure intact protons at high luminosity in the ATLAS and CMS/TOTEM experiments

SAMPIC: a readout chip for fast timing detectors in particle physics and medical imaging

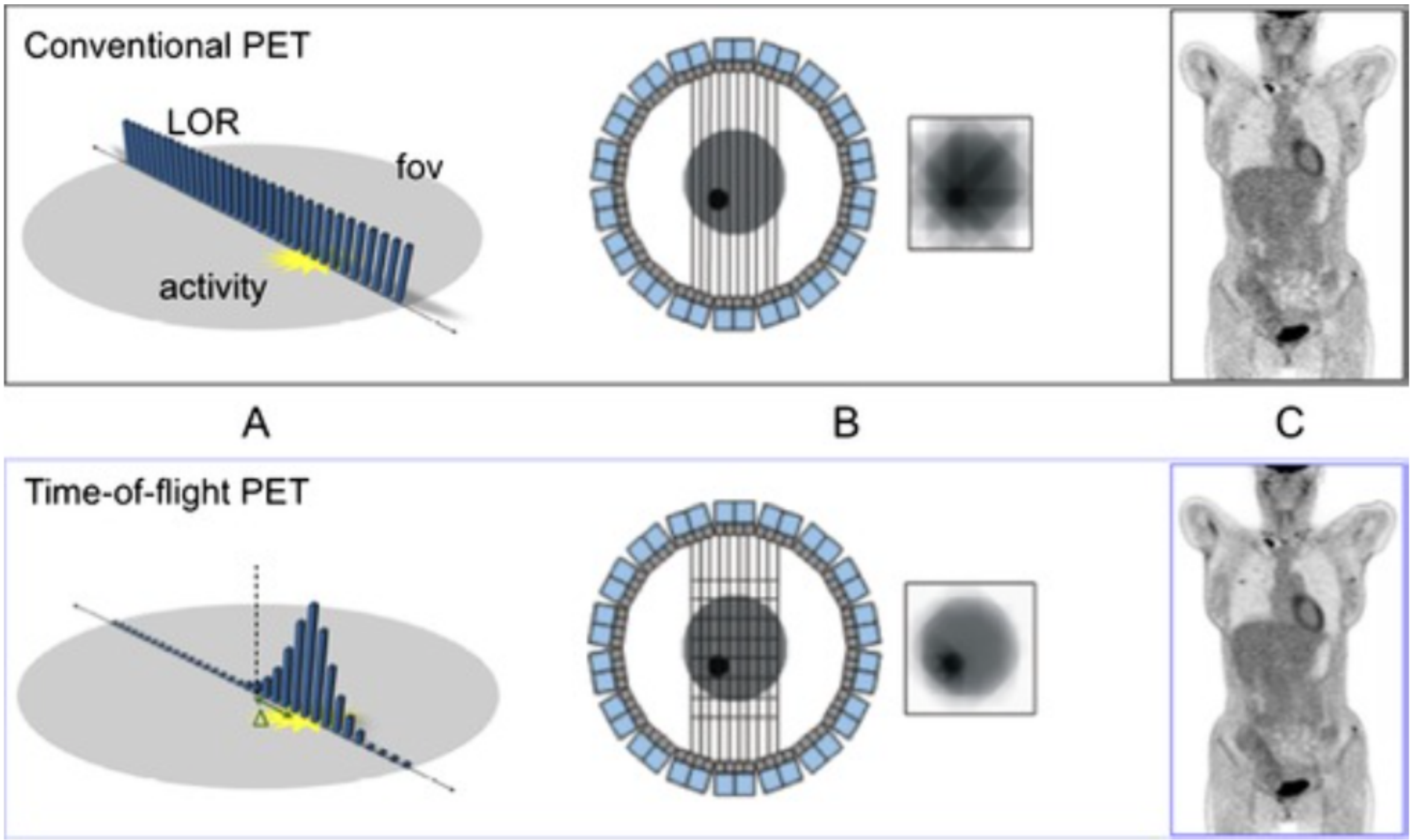

- Christophe Royon

IRFU/Service de Physique des Particules, CEA/Saclay, 91191 Gif-sur-Yvette cedex, France E-mail: christophe.royon@cern.ch

## Medical Imaging/Diagnostics:

– TOF PET
– Beta-Radio Luminesce Imaging (RLI)
– Cerenkov Imaging
– X-ray imaging

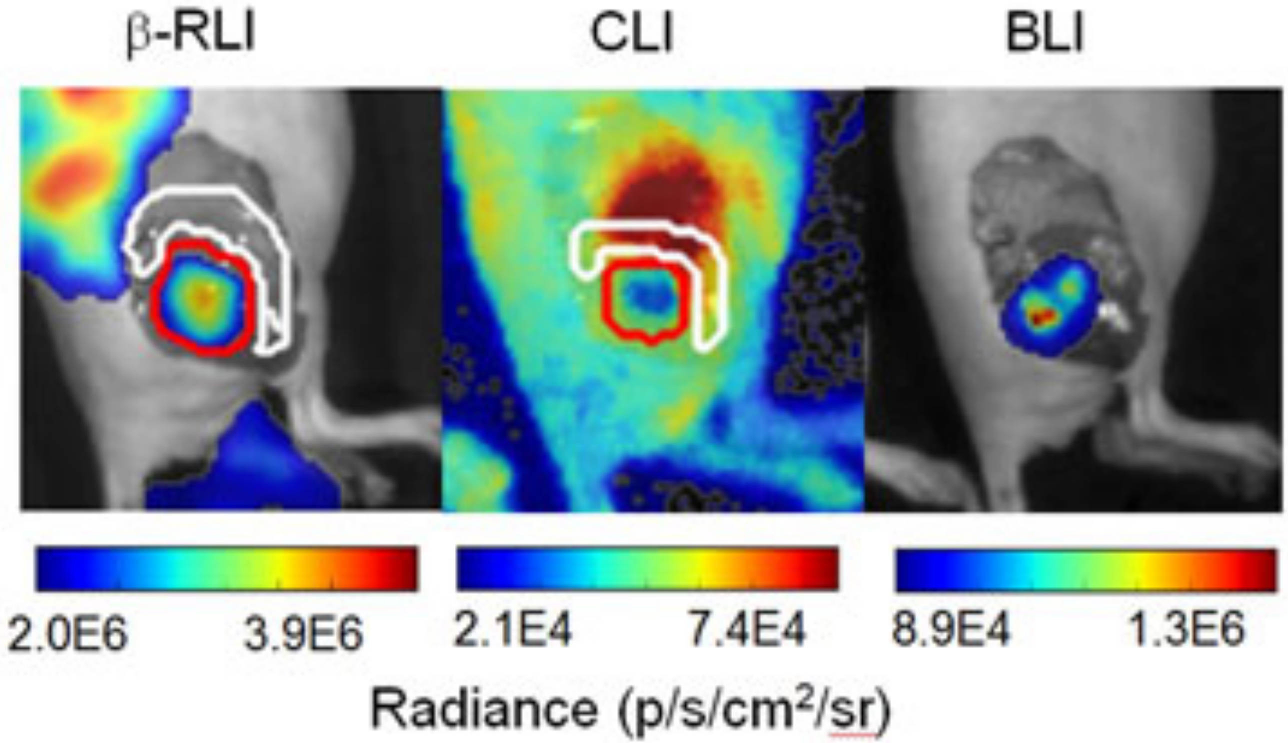
- **Medical Imaging/Diagnostics**
  - TOF-PET:




http://www.springerimages.com/

## Medical Imaging/Diagnostics

- Beta-RLI imaging

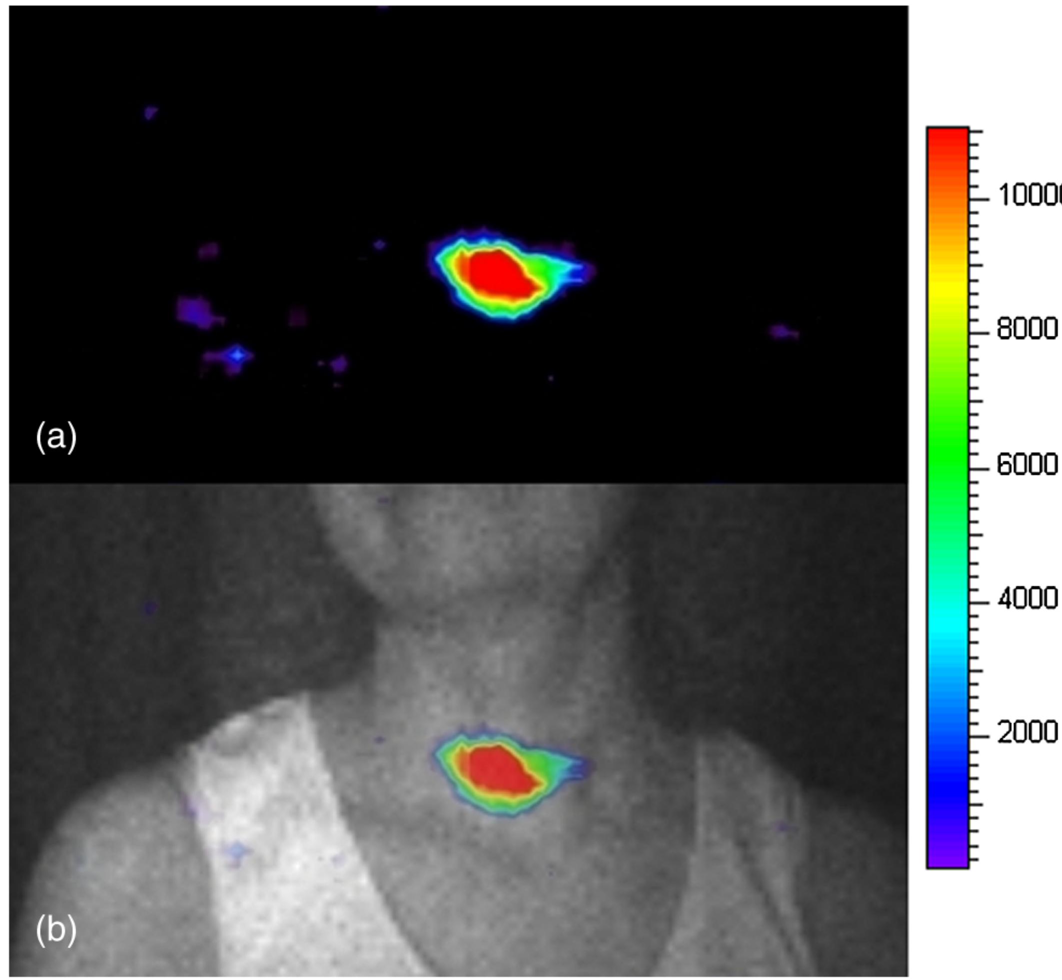



(*J. Nucl. Med.* **56** 1458).

# Medical Imaging/Diagnostics

- Cerenkov imaging

First human Cerenkography
*J. Biomed. Opt*. 18(2), 020502 (Jan 18, 2013). doi:10.1117/1.JBO.18.2.020502




- High Energy Cerenkov detector (CEA Saclay)

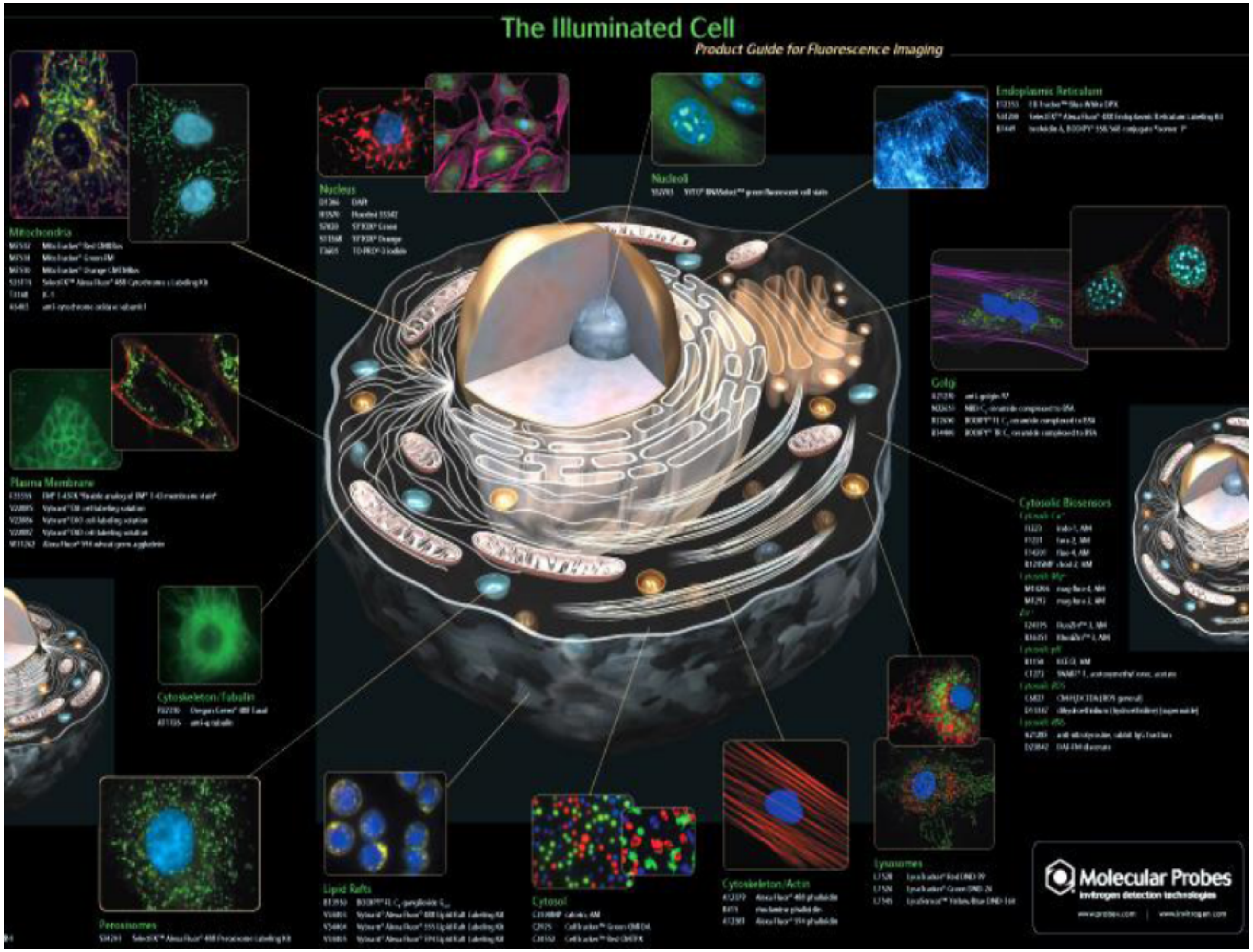
# Medical Imaging/Diagnostics

- X-ray imaging
  - Thin scintillators for ultrafast hard X-ray imaging

  *Proc. SPIE* 9504, Photon Counting Applications 2015, 95040N (May 6, 2015); doi:10.1117/12.2178420

  A multilayer thin-scintillator concept is described for ultrafast imaging. The individual layer thickness is determined by the spatial resolution and light attenuation length, the number of layers is determined by the overall efficiency. By coating the scintillators with a high quantum-efficiency photocathode, single X-ray photon detection can be achieved using fast scintillators with low light yield. The fast, efficient sensors, when combined with MCP and novel nanostructed electron amplification schemes, is a possible way towards **GHz hard X-ray cameras** for a few frames of images

# “Biological” Imaging

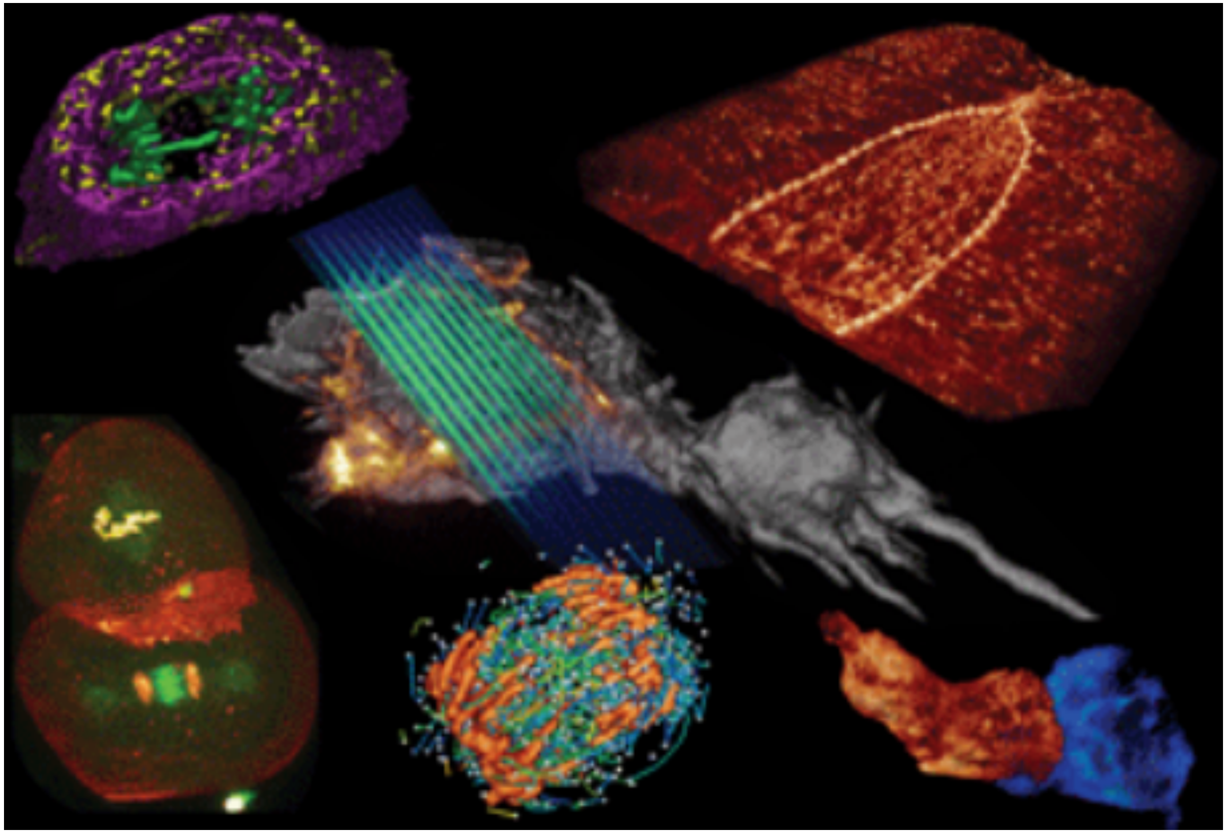


## “Biological” Imaging

- 3D imaging/Live imaging
- Radioluminescence Microscopy
- Multi-thread flow cytometry
- Time-gated optical tomography
- High throughput microscopy
- Other…(see presentation from IGC in Prague).

# “Biological” Imaging

- 3D imaging/Live imaging



[Lattice light-sheet microscopy]
Science 24 October 2014: Vol. 346 no. 6208
DOI: 10.1126/science.1257998

# “Biological” Imaging

- Radioluminescence microscopy

J Nucl Med 2013; 54:1841–1846

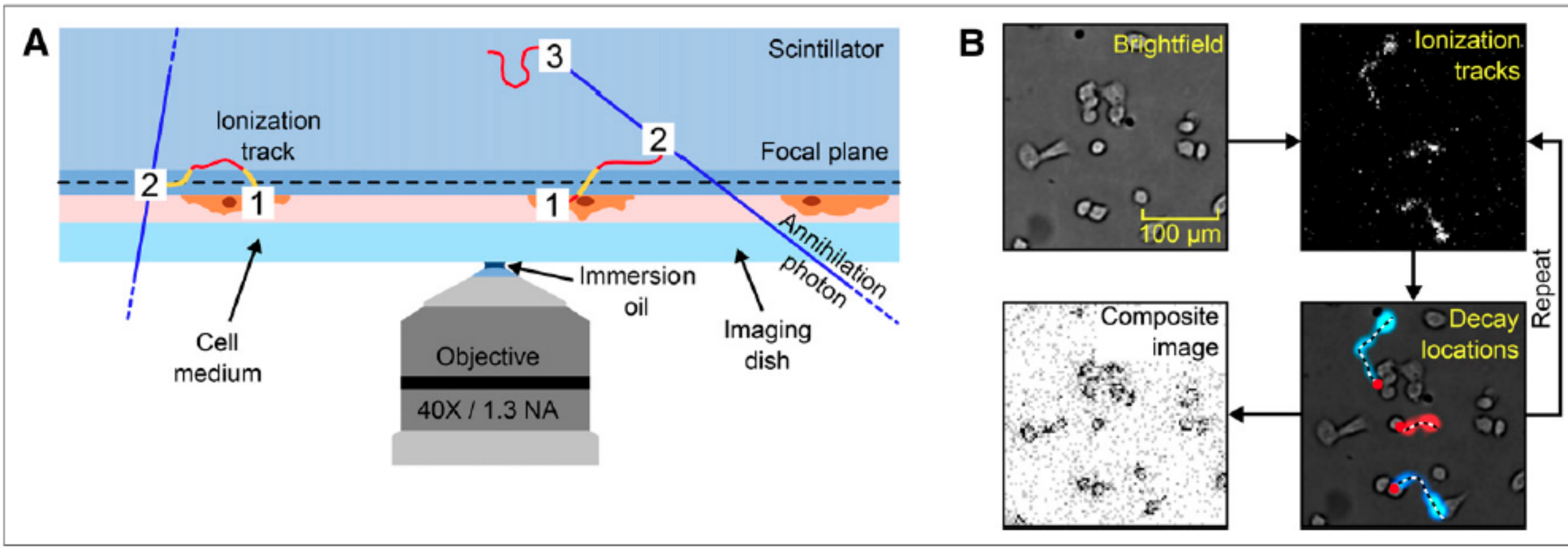
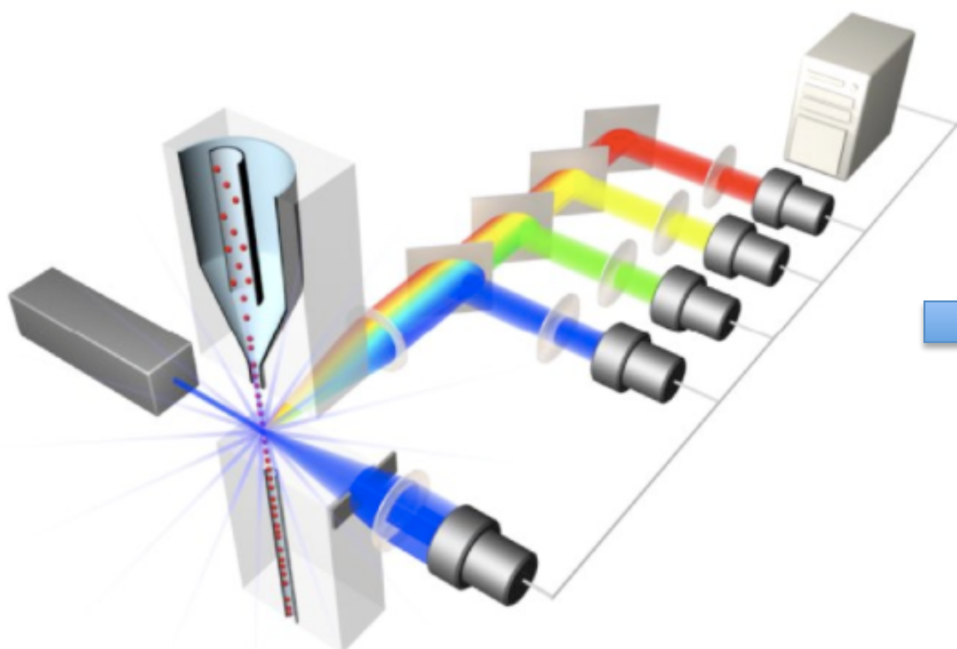



**FIGURE 1.** Radioluminescence microscopy using ORBIT. (A) Emission of positron from radiotracer bound to cell (*1*) is followed by positron-electron annihilation (*2*) and emission of 2 back-to-back 511-keV photons (blue lines), which may interact with electron in scintillator via Compton scatter or photoelectric absorption (*3*). Energetic charged particles (red lines) propagate through scintillator, producing light, which can be recorded by microscope. Because of shallow depth of field, system is sensitive only to events occurring near focal plane. (Drawing is not to scale: objective’s field of view is 1.2 mm). (B) To acquire radioluminescence image with ORBIT, bright-field micrograph is first acquired to delineate cell boundaries. Sequence of short image frames is then acquired with high gain to capture ionization tracks produced by energetic charged particles. Those frames are processed to extract decay locations, which are then aggregated into composite image. (Each decay location is represented as a dot). NA = numerical aperture.

# “Biological” Imaging

- Cell Sorting (can we do it faster ?).



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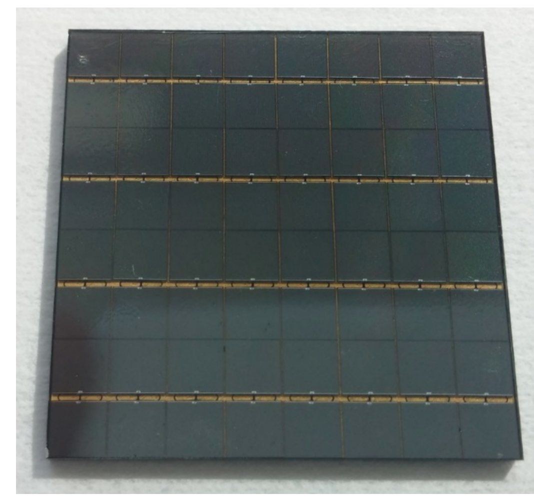
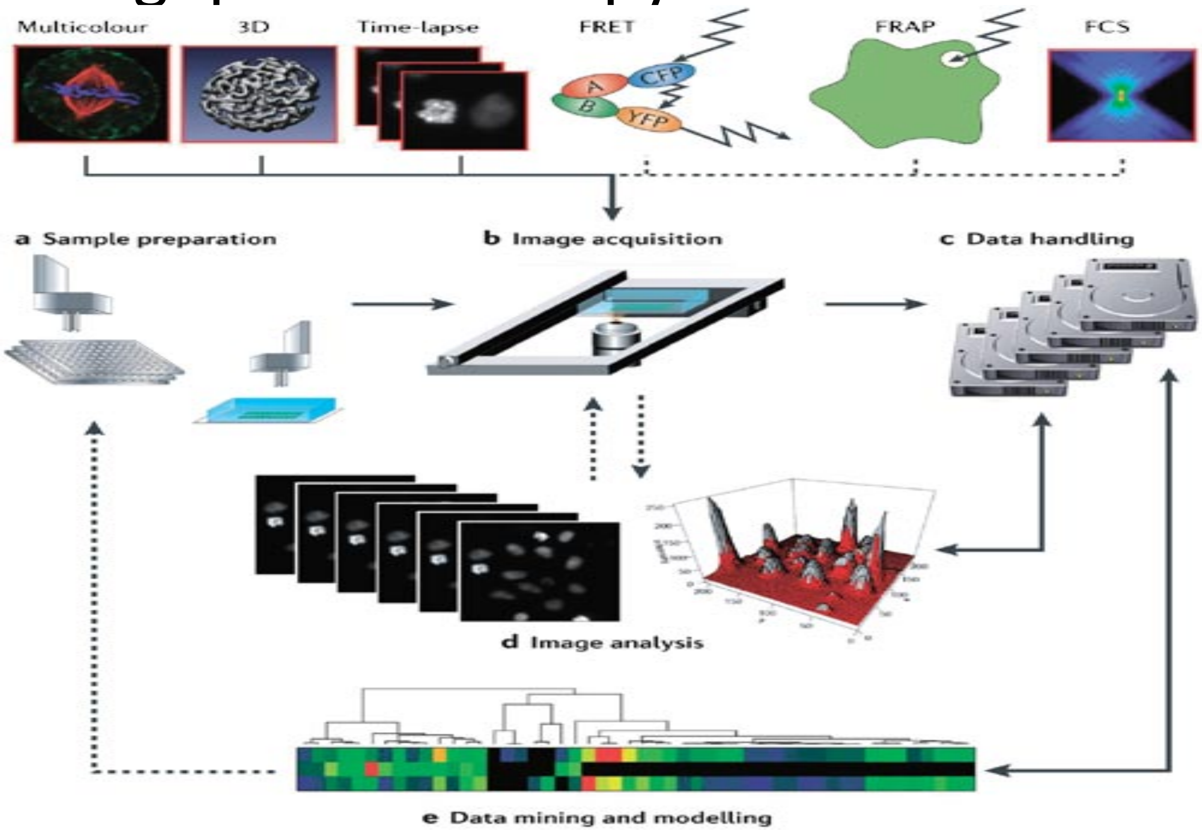


## “Biological” Imaging

- Time-gated optical tomography
  - Infrared spectroscopy.
  - FRET and FLIM.
  - 3D – fluorescence lifetime measurements.

# "Biological" Imaging

- High throughput microscopy





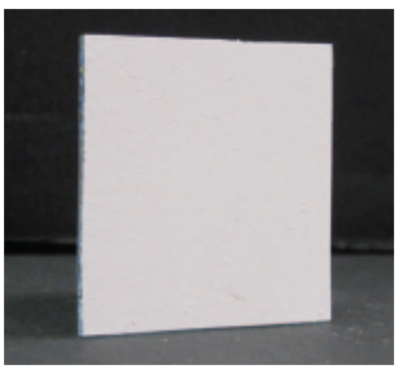

Pepperkok and Ellenberg *Nature Reviews Molecular Cell Biology* **7**, 690–695 (2006) | doi:10.1038/nrm1979

nature REVIEWS MOLECULAR CELL BIOLOGY

# Spectroscopy:

- Imaging mass spectroscopy and chemical reaction dynamics REVIEW OF SCIENTIFIC INSTRUMENTS **85**, 023306 (2014)

**"A fast microchannel plate-scintillator detector for velocity map imaging and imaging mass spectrometry" -** B. Winter et al – Chemistry Dep - Oxford



A P47 Scintillation screen

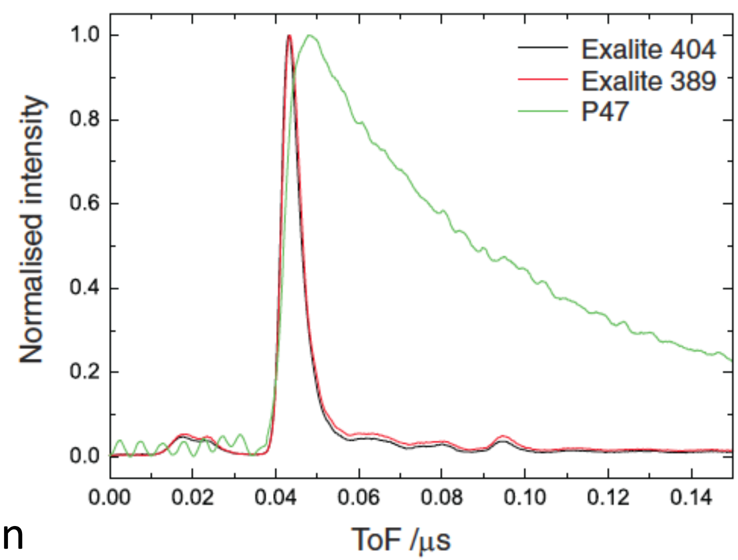
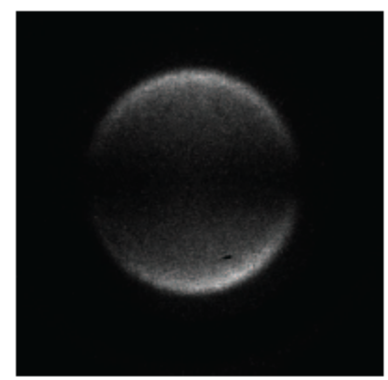



FIG. 3. Electron time-of-flight signal recorded for the Exalite 404, Exalite 389 and P47 screens.

A typical velocity-map ion image of the iodine fragment formed in the 245.2 nm photolysis of CH3I, recorded using a P47 phosphor screen



# Other Applications:

- Security:
  - Radioactvity detection
    - Detection of  fast neutrons for nuclear reactor safety.

- Industrial non-destructive quality control in production chains
  - Cavitation measurements during liquid flow using FAST X-ray imaging. **I. KHLIFA et al.** *(Arts et Métiers ParisTech).*
  - Automatic evaluation of cork quality for wine bottles using X-Rays

# Other Applications:

- LIDAR : “Light (LASER) Detection and Ranging”

Energies used: UV, Visible or Near Infrared.

- Pollution mapping (very low SNR).
- Cartography using satellites (Higher SNR).

Distance measurements precision dependent on how fast and sensitive are the detectors. Time-of-response limits accuracy on distance measurements (currently on the order of 1 meter for a distance of 100m).

Photodetectors are photomultipliers and Si-Photodiodes.

Uses of LIDAR

Real-time 3D scanning

# Tomorrow

## Meeting of COST FAST Workgroup 5 Applications

**Objective:**

The WG5 will assemble all partners with expertise in the various relevant research domains and experience in applications where FAST timing is important. One of its aims is to identify appropriate research and application domains for which they will also propose a list of requirements and application tradeoff to WGs 1,2, 3, 4. They shall work in close collaboration with the other WGs and commercial companies.

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# Whole-cell biosensors

The detection of very low light signals is still limited and remains a challenge in the design of compact photon counting systems.

- Rapid detection of small-volume samples at a low cost.
- Point-of-detection systems.