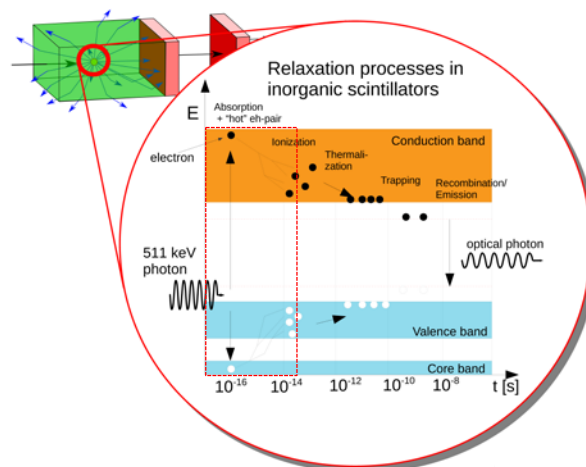


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Introduction

- Several improvements in PET scanners are needed to transform in-vivo molecular imaging into a standard tool for personalized medicine: reduce the radiation dose scan time and costs per patient.
- A way to achieve it is pushing time-of-flight *Coincidence Time Resolution (CTR)* to ~ 10 ps, enabling direct 3D imaging [1].
- Current PET technology based on scintillators has several limitations limiting CRT > 100 ps
- For sub-100 ps time resolution, mechanisms involving the production of prompt photons need to be considered [2]:
 - Photonic crystals offer attractive perspectives: higher light yield [3] and use of Cherenkov radiation [4]
- Prompt emission is weak (few photons) and in UV region
 - **New advances required in photodetector and FE aiming for an overall SPTR ~ 10 ps and enhanced UV sensitivity.**



S.E. Brunner, "Studies on the Cherenkov Effect for Improved Time Resolution of TOF-PET using digital SiPM" Based on: R. Williams et al., Rad. Meas. 33 (2001) p. 497.

The Idea/Concept

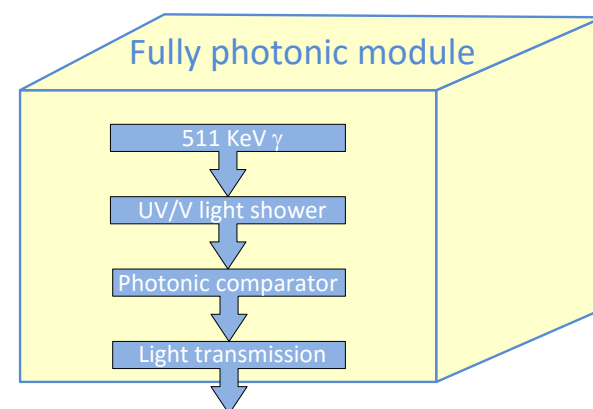
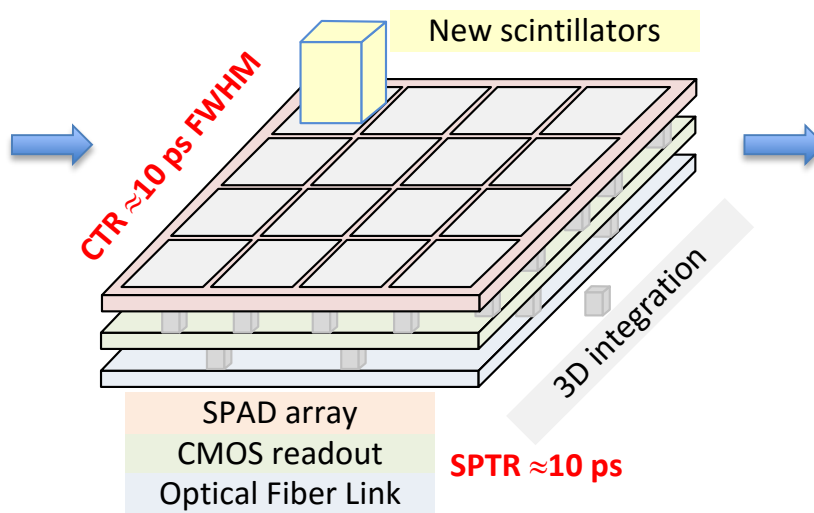
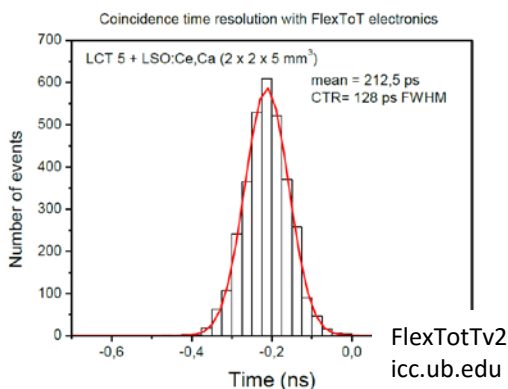
- "Digital" SPAD based sensor optimized for prompt light emission which provides the time of arrival of the n first impinging photons

- High quality process SPAD process [5]
- CMOS front end and readout electronics.
- Optical link integration
- Integration techniques: 3D, system on a chip and multi-chip-modules

- Fully photonic module
 - Detection [3]
 - Processing [6]: comparators [7]
 - Light transmission (optical fiber)
- Photonic crystals might be a promising alternative

State of the art

CRT ~ 100 ps // SPTR ~ 100 ps
LYSO + SiPM + ASIC



Potential Impact

Many technological challenges will be faced, but optical processing elements such as comparators are being developed [7]. This is an endeavour for the next 10 years and many new amazing possibilities will open for *high-luminosity colliders, such as HL-LHC or CLIC, with a bunch-crossing rate of 2 GHz*, as well as for **direct 3D PET in medical imaging**.

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- [7] C. Lu et al. "Chip-integrated ultrawide-band all-optical logic comparator in plasmonic circuits", Nature, 3869 (2014)