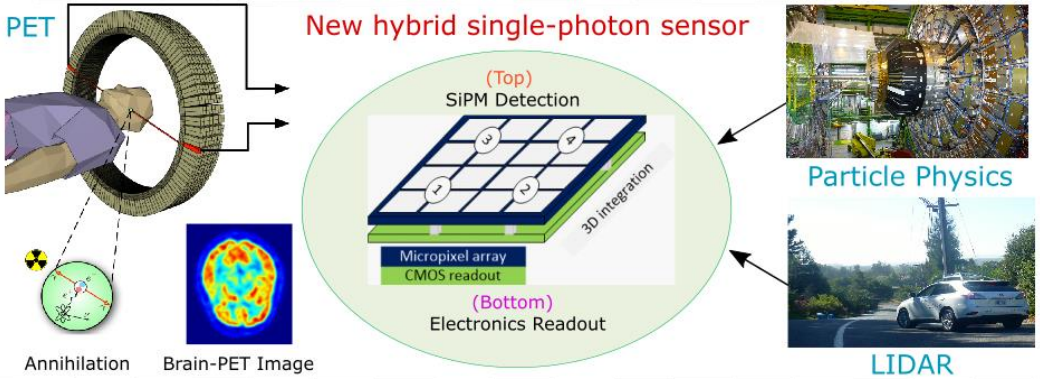
FastICPix

Integrated Signal Processing for a New Generation of Active Hybrid Single Photon Sensors with Picosecond Time Resolution (Collaboration U. Barcelona-CERN)

Essence:

- Cover large detector areas with time resolution ~10ps
- Smart combination of signals in pixels, Scalable
- Hybrid between Analog and Digital SiPMs
- Other sensors possible (MCPs)
- Highly configurable technological platform (sensors / applications)



Studies:

Sensor simulation, Analog Front-End study, On chip Clock Distribution and Time-To-Digital Converter (TDC)

Current status of progress:

~60% of deliverables completed so far

~65% of budget (100 kEUR) spent so far

Any remaining uncertainties w.r.t planned deliverables: No

Using students (PhD/MSc/BSc) in the project?

Yes: 5 PhD students: 2 CERN, 2 U. Barcelona, 1 CNM-IMSE (4 months)

Team of Challenge Based Innovation students

Any interactions with other funded ATTRACT projects so far?

CERN group E. Auffray (Photoquant, Scintiglass) (competences in scintillator materials and device characterization), Fondazione Bruno Kessler (Photoquant) group A. Gola (Competences on SiPM design and fabrication) (informal contacts for exploring Phase II common application)

If your project were to be selected for ATTRACT Phase 2:

How would your technology scale up to become an industrial product/system?

Phase I: Concept feasibility study

Phase II: Detector implementation. Building blocks: Sensor/ASIC/Interconnects.

Technology Readiness Level ~7 (system prototype demonstration in operating environment)

With who you would need to partner for this to happen? (No names, just profiles of type of organizations)

Scintillator material experts

SiPM manufacturer

Advisory board with companies and experts from industry

Have you already discussed this with KT Group?

FastICPix is the natural continuation of the FastIC project (KT funded project)

FastIC we are building a demonstrator prototype, together with CERN KT, for an ASIC to readout fast detectors to be used in different applications

What applications will you demonstrate with value for science, industry and society? (Examples)

Science: High Energy Physics

PET (Positron Emission Tomography) (10ps CTR implies 10-fold increase in sensitivity i.e. reduction of dose, scan time and cost), LIDAR, Applications in Biology

Additional slides

Technology Readiness Level (TRL)

Minimum TRL for SME Instrument proposals: 6

- TRL 1 – basic principles observed
- TRL 2 – technology concept formulated
- TRL 3 – experimental proof of concept
- TRL 4 – technology validated in lab
- TRL 5 – technology validated in relevant environment
- TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
- TRL 7 – system prototype demonstration in operational environment
- TRL 8 – system complete and qualified
- TRL 9 – actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

The fastIC project

SiPMs, MCPs, PMTs	NINO (0.25µm, 2004)	HPTDC (0.25µm, 25ps (8ch); 100ps (32ch) bin)
Advanced SiPMs, MCPs, PMTs	FastIC (65nm, 2020)	picoTDC (65nm, 3ps (64ch); 12ps (64ch) bin, 2019)

FastIC addresses limitations from NINO: mainly linearity of the energy measurement and power consumption

Highly configurable: Singled ended / differential and summation of 4 single-ended channels (+/-) to explore benefits of segmentation of detector areas

~25 ps r.m.s. Jitter (electronics) (wirebonded 3x3 mm2 SiPM) + Linear energy measurement (~2.5 % error) up to 20 mA peak (6mW single ended channel)

Started in April 2017 as a collaboration between CERN (KT funded) and University of Barcelona (ICCUB)
Submission prototype (8 SE channels) Q1-Q2 2020 (layout scalable). Larger chip (32/64 channels) Q4 2020

Team: CERN: M. Campbell, R. Ballabriga, J.M. Fernandez
ICCUB: D. Gascon, S. Gomez, R. Manera, J. Mauricio, A. Sanmukh

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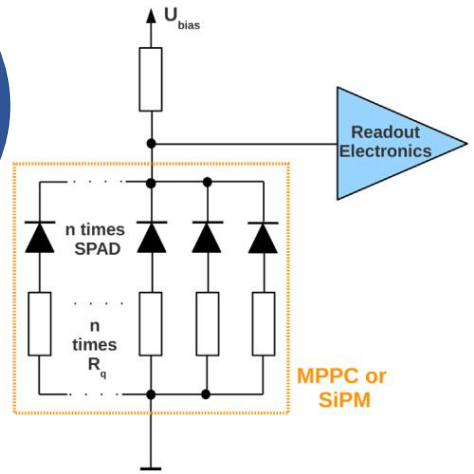
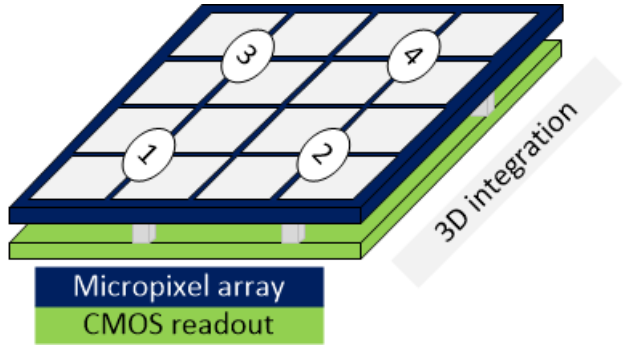
CERN

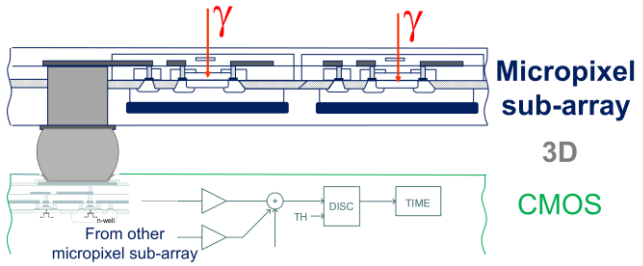
FastICPix: Integrated Signal Processing for Hybrid Single Photon Sensors with Picosecond Time Resolution (Attract phase I)

ANALOG SiPM

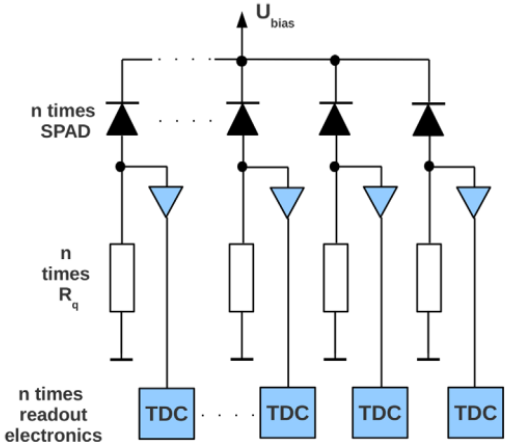


hybrid detector





DIGITAL SiPM



Analog SiPM

- Signals are summed
- Sensor process optimized for photo detection (high PDE, low DCR)
- Large interconnection parasitics

Digital SiPM

- TDC per SPAD
- Commercial CMOS process
- Large power consumption

Groups of SPADs summed, sensor process is optimized for detection, small parasitics, optimized consumption
12 month project:
Started May 2019, ends May 2020
J. M. Fernandez: Front-end study, N. Egidos: Clock Distribution Network, F. Bandi: TDC design