



THE PICOSEC MC-NET PROJECT



Overview of the PicoSEC Project

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Aim of project



PicoSEC-MCNet Project :

Pico-second Silicon photomultiplier-Electronics- & Cystal research-Marie-Curie-Network

A **multi-site Network** to provide **training to young researchers** in a multidisciplinary R&D project geared to develop a new class of ultra-fast photon detectors in Positron Emission Tomography (PET) and high energy physics (HEP).





PicoSEC : A Multisite Network



11 Partners from 6 different European countries: 7 academia and 4 companies



Host Institutes	Scientist in charge
European Organization for Nuclear Research (CERN) Coordinator Switzerland	E. Auffray
Technical University TU-Delft (TU-Delft) The Netherlands	E. Charbon
Stiftung Deutsches Electronen-Synchrotron (DESY) Germany	E. Garutti
Fibercryst SAS, Villeurbanne France	D. Perrodin
Ruprecht-Karls-Universität Heidelberg (UHEI) Germany	H.C. Schultz-Coulon
Kloé SA/Montpellier France	P. Coudray
Laboratório de Instrumentação e Física Experimental de Partículas (LIP) Portugal	J. Varela
University Milano Bicocca (UNIMIB) Italy	M. Paganoni
Technische Universität München (TUM) Germany	N. Navab
STMicroelectronics S.r.l. Italy	P. G. Fallica
SurgicEye GmbH München Germany	T. Wendler



PicoSEC : A training program

15 scheduled network training events :

4 workshops, 7 scientific trainings,

4 management and administration + local trainings



	Main training events & conferences	WP	Lead Institution	Project Month
WS1 V1	Workshop on Intraoperative Imaging and Navigation Solutions – from basic research to medical product; Visit of the Nuclear Medicine Department of the university hospital “Klinikum rechts der Isar”.	1-5	TUM & SurgicEye	M12
WS2 V2	Workshop on medical instrumentation Visit of “Heidelberger Ionenstrahl Therapie” (HIT)	1-5	UHEI	M22
WS3 V3	Workshop on detectors for High Energy Physics; Visit of CERN	1-5	CERN, UNIMIB	M36
WS4	Network workshop on PicoSEC-MCNet results	1-5	All	M48
Specialized S & T training				
L1	Short courses on crystals and scintillators	1	CERN, Fibercryst	M4
L2	Short courses on laser lithography and diffractive optics	1	Kloé	M6
L3	Short courses on quantum detection, single-photon imaging, SiPMs, SPADs	2	TU-Delft	M11
L4	Short course on semiconductor devices, design and manufacturing	2	ST-I	M15
L5	SiPM-School with Hands-On	2	DESY	M18
L6	Short course on PET electronics and data acquisition	3	LIP	M24
L7	Short course on image processing	5	TUM, SurgicEye	M38
Management & Administration				
L8	Certification of medical products, Intellectual Property Rights (IPR), clinical studies, marketing and sales	1-5	TUM & SurgicEye	M12
L9	Lecture on management	1-5	ST-I	M30
L10	The route to market: how innovation moves from laboratory to product.	1-5	Fibercryst & Kloé	M33
L11	Intellectual Property Rights (IPR)	1-5	CERN	M36



PicoSEC : For young researchers

22 job opportunities : 18 Early Stage Researchers, 4 Experienced Researchers



Fellow type & number	Individual Research Project (IRP) Title	Link with WPs	Host Institution	Fellow months
ESR1	Understanding and improving light production, light transport, light collection in scintillators;	1	CERN	36
ESR2	Evaluation of scintillator timing performance with different SiPM types (analog and digital)	2	CERN	36
ESR3	Development and optimization of a matrix assembly for PET detector: crystal coating and assembly, coupling of optical component and photodetectors	4	CERN	36
ER1	Concept, realization and optimization of a crystal fiber matrix prototype for calorimetry in HEP and evaluation of its performance in test beam	4	CERN	24
ESR4	Design of time-to-digital converter (TDC) arrays; readout of individual single-photon detecting pixels based on SPADs;	2	TU-Delft	36
ESR5	Design of single-photon detector arrays (SPADs) in CMOS; event-driven column readout or on-chip data reorganization;	2	TU-Delft	36
ESR6	Development of front-end electronics for fast SiPM readout	3	DESY	36
ESR7	Use of SiPMs for fast timing in highly granular calorimeters;	4	DESY	36
ESR8	Micro-pulling-down growth of shaped single crystals, quality and efficiency improvement of this technique.	1	Fibercryst	36



PicoSEC : For young researchers



Fellow type & number	Individual Research Project (IRP) Title	Link with WPs	Host Institution	Fellow months
ESR10	Design, construction and test of a TOF-PET prototype	4	UHEI	36
ER2	Design & characterization of ASIC for fast SiPM readout	3	UHEI	24
ER3	Research on & test of combined Scint./SiPM systems	4	UHEI	24
ESR11	Fabrication of optical coupling microstructures via laser direct writing	1	Kloé	36
ER4	Test and assembly of optical coupling microstructures realised by laser direct writing	1	Kloé	24
ESR12	Design and characterization of TOF ASIC	3	LIP	36
ESR13	Development of high-performance DAQ for PET	3	LIP	36
ESR14	Characterization and optimization of scintillating crystals for applications to medical imaging and future detectors for high energy physics.	1	UNIMIB	36
ESR15	Characterization of several types of SiPM	2	UNIMIB	36
ESR16	Advanced tracking and navigation for endoscopy	5	TUM	36
ESR17	Design of a SiPM for Time of Flight-PET	2	ST-I	36
ESR18	Image Reconstruction using Tracked Flexible Detectors	5	SurgicEye	36



PicoSEC : Mobility



Each student will spend at least 3 months in partner institutes

Fellow ID	Host	Seconded to:	Research/training topics during secondment	Planned start date of secondment	Planned end date of secondment
ESR1	CERN	Kloé	Learn optical coupling and the concept of coupling optics;	M6	M9
ESR2	CERN	TU-Delft	Learn SiPM SPAD readout	M9	M12
ESR3	CERN	Kloé	Learn optical coupling and the concept of coupling optics;	M12	M15
ER1	CERN	Fibercryst	Learn crystal growth techniques and industrial aspects;	M20	M23
ESR4	TU-Delft	ST-I	Learn SiPM design and prod. in industry	M18	M21
ESR5	TU-Delft	LIP	Learn data processing	M27	M33
ESR6	DESY	LIP	Learn ASIC design	M12	M15
ESR7	DESY	UHEI	Learn PET detector integration	M24	M27
ESR8	Fibercryst	CERN	Learn scint. characterization, light transport & collection, interfacing with SiPM	M24	M27
ESR9	UHEI	LIP	Learn DAQ systems	M12	M15
ESR10	UHEI	DESY	Learn fast calorimetry	M6	M9
ER2	UHEI	TU-Delft	Learn SPAD developments & readout	M12	M15
ER3	UHEI	CERN	Learn optical coupling and test beam facilities	M36	M39
ESR11	Kloé	CERN	Learn scintillators characterisation, light transport and collection, interfacing with SiPM	M15	M18
ER4	Kloé	CERN	Learn scintillators characterisation, light transport and collection, interfacing with SiPM	M18	M21
ESR12	LIP	TU-Delft	Learn SPAD readout	M6	M9
ESR13	LIP	UHEI	Learn PET detector integration	M21	M24
ESR14	UNIMIB	SurgicEye	Image reconstruction, clinical integration, regulatory issues in medical device development	M30	M33
ESR15	UNIMIB	ST-I	Learn equipment for SiPM devices' design and production	M12	M15
ESR16	TUM	UHEI/ UNIMIB	Learn simulation of light transport in scintillators and SiPM response/ image reconstruction in PEM	M20/M30	M23/M33
ESR17	ST-I	UNIMIB	Learn scintillators, their characterization, light transport and collection, interfacing	M21	M27



PicoSEC : Scientific Program



- **The core activity of PICOSEC is detector developments for**
 - TOF-PET applications with fast time resolution (200ps) in close relation with the FP7-EndoTOFPET project from detector components to image reconstruction;
 - Calorimetry in particle physics experiments: HLLHC, ILC, CLIC.
- **Fields of activity**
 - Scintillators and optics for fast timing;
 - Photodetectors, particularly silicon photomultipliers (SiPMs) and SiPM derivatives;
 - Electronics and data acquisition systems;
 - Detector integration and prototyping;
 - Endoscopic instrumentation;
 - Calorimetry in high energy physics;
 - Tracking and image reconstruction (hardware and software).
- **Work organised in 5 WPs**



PicoSEC : Work packages



- **WP1 : Scintillators & optics for fast timing** : [CERN](#), [Milano](#), [Fiberocryst](#), [Kloé](#)
 - Develop and optimize scintillators and optical systems such that the light loss from the scintillating medium to the photodetector becomes a minimum.
 - Produce and evaluate the best optical components for use in fast, high time resolution, photodetectors for high energy physics and medical imaging (TOF-PET) aiming to achieve a coincidence time resolution of less than 200ps FWHM.
 - Identification of the most appropriate scintillator material and optimization of scintillator production parameters in terms of shape, optical quality, doping and cost.
 - Improvement of light transport in and light extraction from the scintillator.
 - Design, production and characterization of the light-coupling system for the most efficient light transfer between the crystals and the photodetector.
- **WP2 : Photodetectors for fast timing** : [Delft](#), [CERN](#), [Milano](#), [ST-Microelectronics](#)
 - Develop a special SiPM chip (SPAD array) with high spectral sensitivity (centered around 400-500nm) and ultrafast response time where each SPAD is read out individually yielding a time resolution of <100ps FWHM, measured on chip;
 - Design pixel geometries for matching the crystal fiber matrix with the SPAD array;
 - Evaluate the timing performance of devices with laser-excited fibers and/or other techniques;
 - Evaluate standard SiPMs for use in TOF-PET in terms of time resolution



PicoSEC : Work packages



- **WP3 : Electronics & Data Acquisition** : [LIP](#), [DESY](#), [UHEI](#)
 - Acquire base knowledge in electronics for signal processing and data acquisition in PET and calorimeter detectors.
 - Design and test prototypes of ASICs for time and energy measurement of radiation pulses detected with scintillators and SiPMs.
 - Design and evaluation of high-performance DAQ system prototypes for TOF-PET and calorimetry.
- **WP4 : Detector Integration & Prototyping** : [UHEI](#), [DESY](#), [CERN](#)
 - Build and test combined scintillator/SiPM systems including readout and data acquisition.
 - Test of timing response and performance of the combined systems w.r.t applications in TOF-PET and fast calorimeter systems.
 - Build demonstrator prototypes for the endoscopic TOF-PET probe and calorimetry with fast scintillator-based detectors and SiPM readout
- **WP5: Image Reconstruction, Tracking/Navigation, Hardware & Software** : [TUM](#), [SurgicEye](#)
 - Provide tracking solutions for flexible endoscopy and endoscopic imaging devices, and evaluate their robustness and accuracy.
 - Based on tracking and imaging data, reconstruct volumes of interest from flexible endoscopic detectors.
 - For orientation, guidance to specific regions of interest, and, where appropriate, through specific scanning protocols, provide navigation solutions.



PicoSEC : Milestones



Scientific Milestones



List of milestones (selected milestones)				
WP	N°	Milestone	Lead beneficiary	Month
1	M1.1	Choice of material done	CERN (1)	M12
1	M1.2	Choice of optical coupling	CERN (1)	M12
1	M1.3	Setups for measurements ready	CERN (1)	M21
1	M1.4	Report on measurements	CERN (1)	M36
2	M2.1	Test setup SiPM characterization ready	TU-Delft (2)	M15
2	M2.2	Report on tests commercial SiPMs	TU-Delft (2)	M30
2	M2.3	Report on SPADs	TU-Delft (2)	M36
3	M3.1	Chip design for foundry ready	LIP (7)	M12
3	M3.2	Chips delivered	LIP (7)	M24
3	M3.3	Report on chip evaluation	LIP (7)	M36
3	M3.4	Design of DAQ for TOF PET	LIP (7)	M24
3	M3.5	Report on DAQ for TOF-PET	LIP (7)	M36
3	M3.6	Design of DAQ for calorimetry	LIP (7)	M24
3	M3.7	Report on DAQ for calorimetry	LIP (7)	M 36
4	M4.1	Setup for combined scintillator/SiPM	UHEI (5)	M28
4	M4.2	Report on combined test	UHEI (5)	M36
4	M4.3	Prototypes ready for testing	UHEI (5)	M42
4	M4.4	Report on performance of prototypes	UHEI (5)	M48
5	M5.1	Report on prototype simulation	TUM (9)	M36
5	M5.2	Report on image reconstruction from simulated data	TUM (9)	M48
5	M5.3	Report on clinical scenario, available data, required tracking accuracy	TUM (9)	M24
5	M5.4	Tracking system ready for testing	TUM (9)	M42



PicoSEC : Milestones

Training, Outreach, Management Milestones



List of milestones (selected milestones)				
WP	N°	Milestone	Lead beneficiary	Month
6	M6.1	1st year's training events accomplished	CERN (1)	M12
6	M6.2	2nd year's training events accomplished	CERN (1)	M24
6	M6.3	3rd year's training events accomplished	CERN (1)	M36
6	M6.4	4th year's training events accomplished	CERN (1)	M48
7	M7.1	Kick-off meeting	CERN (1)	M3
7	M7.2n	annual internal meetings	CERN (1)	M12, 24, 36
7	M7.3	Recruitment of trainees finished	CERN (1)	M19
7	M7.4	Mid term review	CERN (1)	M22
7	M7.5	Network closure meeting	CERN (1)	M48
8	M8.1	1 st year's dissemination & outreach events accomplished	CERN (1)	M12
8	M8.2	2 nd year's dissemination & outreach events accomplished	CERN (1)	M24
8	M8.3	3 rd year's dissemination & outreach events accomplished	CERN (1)	M36
8	M8.4	4 th year's dissemination & outreach events accomplished	CERN (1)	M48



PicoSEC : Management



Today, we need:
to elect :
Chair of the Supervisory Board
and to nominate :
the Deputy Coordinator,
the Training Coordinator.



Status of Recruitment



- All applications are centralised in the ERT system at CERN.
CERN checks the eligibility of all applicants.
- All posts have been published on the PicoSEC website, CERN's ERT pages, Euroaxess and several other networks.
- Deadline extended until January 31.
- **At this time: < 5 applications/per post → Need more advertising**
- Recruitment between February & March in each institute:
Most of the students could start beginning of April/May.
- Propose to have a "Student Welcome" event during the first Network training in Lyon on scintillators in Spring 2012 (mid-June)
- **All ESRs have to be recruited before end of October 2012 (end of 1st year of the project)**



Training



- **Individual training (specific for each student):**
 - Research program;
 - Local training in each institute;
 - Participation in specific courses and/ or conferences.
- **Training organized by the network**
 - All PicoSEC network students should participate;
 - Open also to students not being members of the PicoSEC network.

Communication



- PicoSEC Logo:



PICO-SECOND SILICON
PHOTOMULTIPLIER-ELECTRONICS
& CRYSTAL RESEARCH



- PicoSEC public web site : <http://www.cern.ch/picosec>
- Indico zone (private, need to register on indico):
<http://indico.cern.ch/categoryDisplay.py?categId=3893>
- Mailing lists : picosec-members@cern.ch, picosec-SB@cern.ch, picosec-EC@cern.ch



Outreach & Dissemination



Dissemination

Publications in scientific journals;

Presentations at conferences and workshops;

Important to mention the project in all published documents.

Outreach

Project website,

Brochure,

Articles in information bulletins of participating partners, or webpages,

Pro-active participation in outreach events for the general public.

All students are expected to participate in all outreach activities.



Objectives of today's meeting



- **Introduce project participants**
- **Setting up project management and organization**
- **Preparation of a project plan**
 - Recruitment
 - Training
 - Milestones, objectives, and deliverables



THE PICOSEC MC-NET PROJECT



Welcome to the PicoSEC project!

**Wish you a successful
collaboration!**

