Ultimate Low Light-Level Sensor Development

This project received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no 713171

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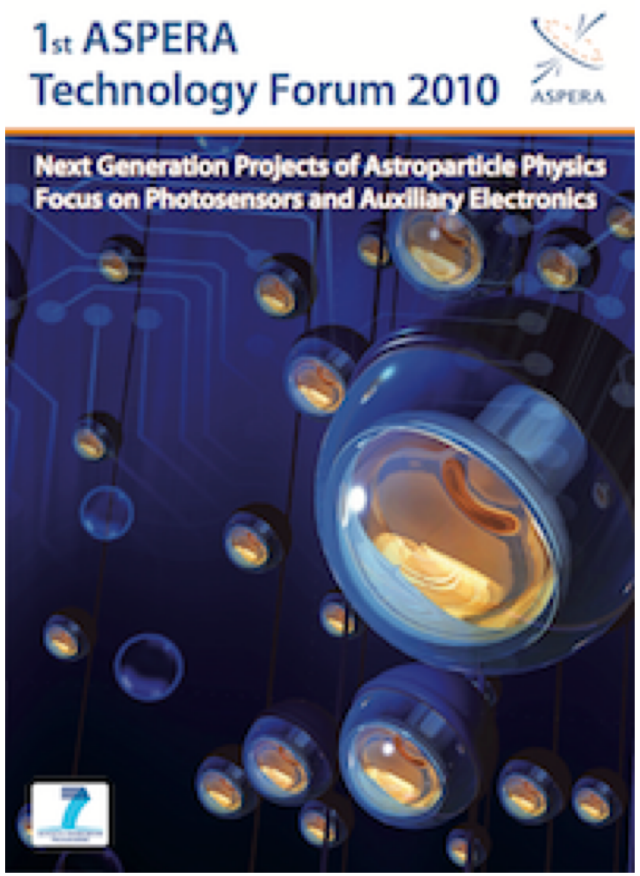
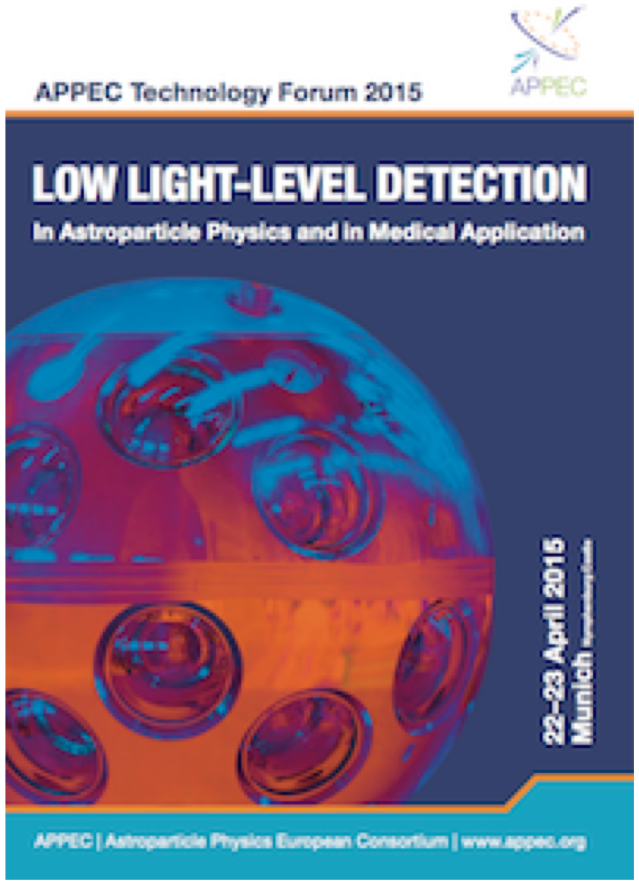
Single Photon Detection Workshop at ALBA/ Spain

SENSE – Background

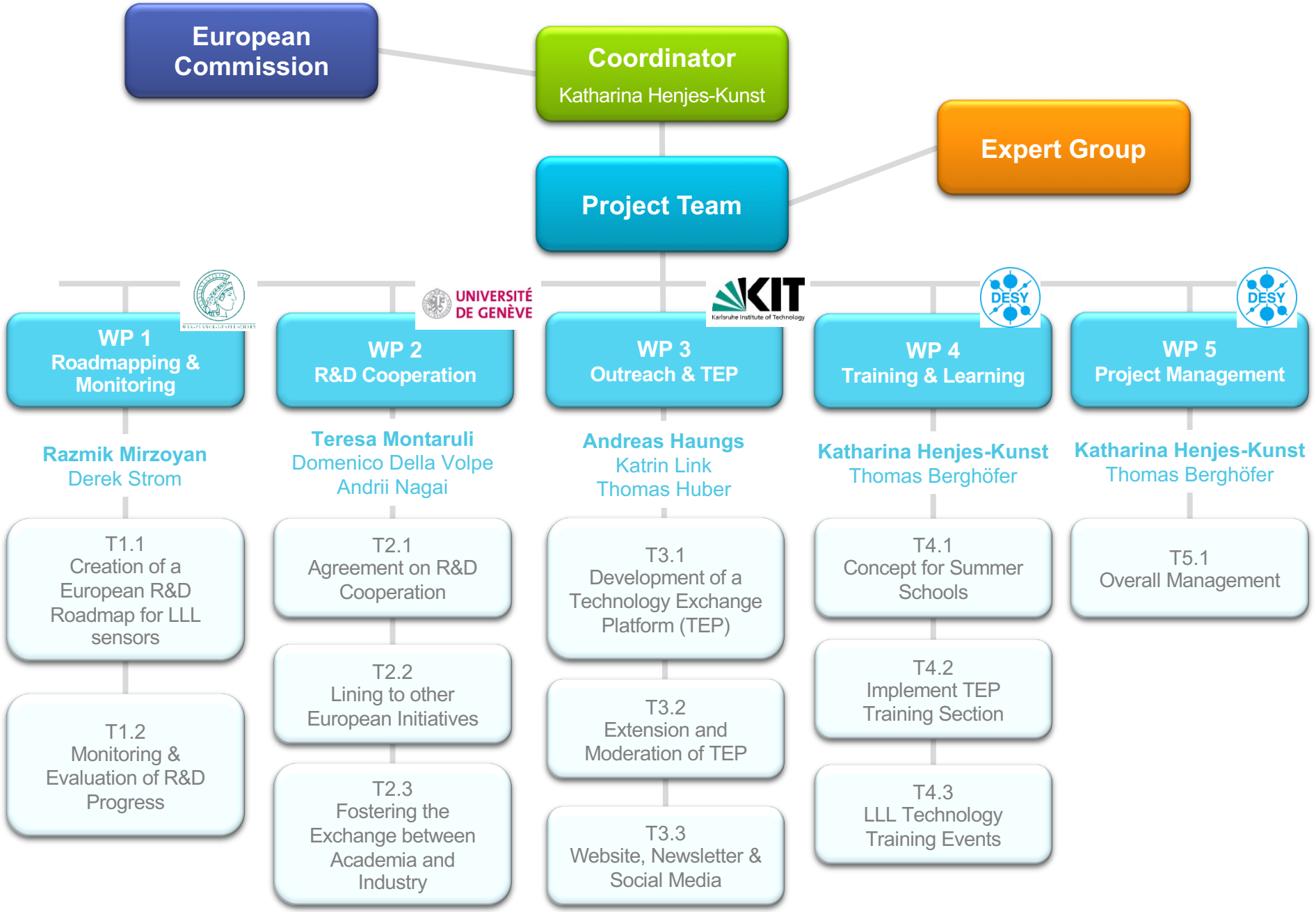
- SENSE is a European Commission Horizon 2020 Coordination and Support Action (FET-OPEN) aiming to coordinate research and development efforts in academia and industry in low light level sensoring
- Started in September 2016 for three years → successful midterm review with EC in November 2017
- Experience from ASPERA and APPEC technology fora
  - ➢ coordination of European research groups concerned with low light-level sensors is currently missing
  - ➢ representatives from academia and industry pointed out that developments could be made faster when one or a small number of labs could take the lead of these activities

SENSE – Background





- Focus on one technological challenge common to different scientific fields
- Invitation of scientists and companies
- Talks, open discussions and interdisciplinary exchange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Coordinator
Katharina Henjes-Kunst
Expert Group
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WP 2
R&D Cooperation
WP 3
Outreach & TEP
WP 4
Training & Learning
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T1.1 Creation of a European R&D Roadmap for LLL sensors
T1.2 Monitoring & Evaluation of R&D Progress
T2.1 Agreement on R&D Cooperation
T2.2 Lining to other European Initiatives
T2.3 Fostering the Exchange between Academia and Industry
T3.1 Development of a Technology Exchange Platform (TEP)
T3.2 Extension and Moderation of TEP
T3.3 Website, Newsletter & Social Media
T4.1 Concept for Summer Schools
T4.2 Implement TEP Training Section
T4.3 LLL Technology Training Events
T5.1 Overall Management

SENSE – Expert Group

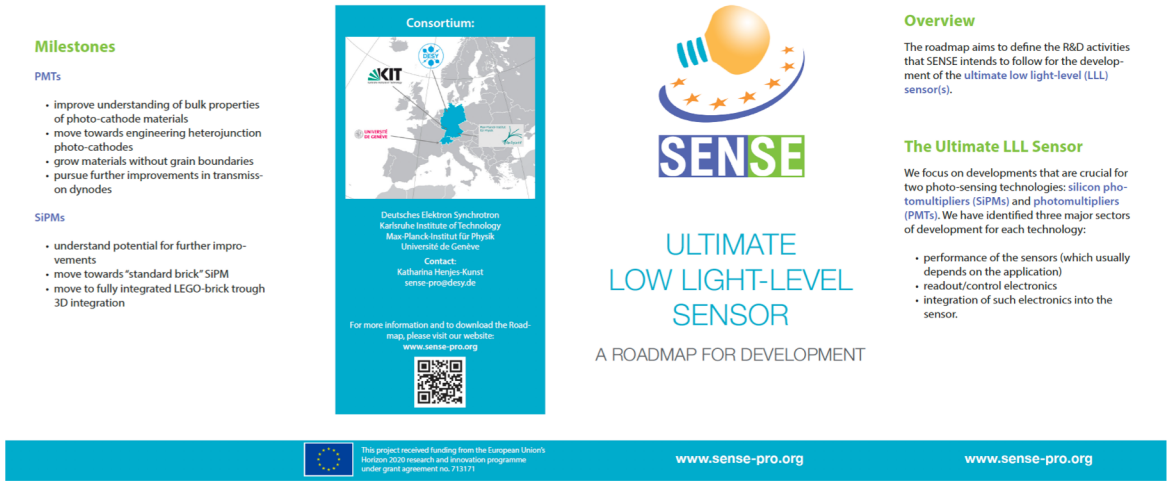
- the Experts Group (EG) comprises first-rate developers in the field of low light-level sensors, representatives of major research projects requiring low light-level sensors
- they act as an advisory panel to the project:

  - **Razmik Mirzoyan, MPI for Physics, Germany, (head of experts group)**
  - Sergey Vinogradov, Lebedev Physical Institute, Russia
  - Elena Popova, MEPHI, Russia
  - Klaus Attenkoffer, ALBA Synchrotron, Spain
  - Bayarto Lubsandorzhiev, INR of the Russian Academy of Sciences, Russia
  - Samo Korpar, Jožef Stefan Institute, Slowenia
  - Peter Krizan, Jožef Stefan Institute, Slowenia
  - Osvaldo Catalano, INAF, Italy
  - Claudio Piemonte, Broadcom, Germany
  - John Smedley, Los Alamos National Lab, US
  - Stefan Schönert, Technische Unversität München, Germany
  - Eric Delagnes, CEA, France
  - Nicoleta Dinu-Jaeger, CNRS Artemis, France
  - Giovanni Bonanno, INAF, Italy
  - David Gascon, ICCUB, Spain
  - Wei Shen, University of Heidelberg, Germany
  - Hiro Tajima, University of Nagoya, Japan

SENSE – WP 1

- aim: roadmap incorporating all R&D activities necessary for the development of (the) ultimate LLL sensor(s)
- final version of roadmap should be available until October on website process

https://www.sense-pro.org/documents/roadmap



Milestones

PMTs

- improve understanding of bulk properties of photo-cathode materials
- move towards engineering heterojunction photo-cathodes
- grow materials without grain boundaries
- pursue further improvements in transmission dynodes

SiPMs

- understand potential for further improvements
- move towards "standard brick" SiPM
- move to fully integrated LEGO-brick trough 3D integration

Consortium:

Deutsches Elektron Synchrotron
Karlsruhe Institute of Technology
Max-Planck-Institut für Physik
Université de Genève

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For more information and to download the Roadmap, please visit our website:
www.sense-pro.org

SENSE

ULTIMATE
LOW LIGHT-LEVEL
SENSOR

A ROADMAP FOR DEVELOPMENT

Overview

The roadmap aims to define the R&D activities that SENSE intends to follow for the development of the ultimate low light-level (LLL) sensor(s).

The Ultimate LLL Sensor

We focus on developments that are crucial for two photo-sensing technologies: silicon photomultipliers (SiPMs) and photomultipliers (PMTs). We have identified three major sectors of development for each technology:

- performance of the sensors (which usually depends on the application)
- readout/control electronics
- integration of such electronics into the sensor.

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SENSE – WP 1

- Steps afterwards:
  - recommendations list
  - monitoring and evaluation of the progress, coordination of the efforts

    ➔ Further collaborations e.g. Solid-state photomultiplier handbook with ICASiPM‘s groups
- Final steps:
  - recommendation to EC by October 2019 (final review)

SENSE – WP 2: Tasks

2.1 Agreement on R&D cooperation between research groups and industry for advancing LLL sensors

- Minimizing the duplication of efforts given the limited funds for innovation;
- Encouraging the formation of **Consortia** between research Institutions and Industrial partners ;
- Negotiation between research institutes and industries to optimize costs of developments capable of satisfying ‘common needs’;
- Offering a **platform for testing devices**;
- Offering a **platform for disseminating knowledge on developments;**
- Develop a sensors database with “*quality factor*”.

2.2 Linking to other European initiatives

- Provide information on the R&D activities followed by SENSE through the web page (WB3), phone calls of the working group and with EG;

2.3 Fostering the exchange between academia and industry

- Organization of Technology Forum: https://indico.cern.ch/event/688729/overview

SENSE – WP 3

- **WP3:** Website (https://www.sense-pro.org) and newsletter online/ active
- SENSE @ several upcoming workshops/ conferences: NSSMIC 2018, VCI 2019 ...,

  several other workshops already done, first two SENSE publications
- Calendar with LLL-related events and workshops online
- Forum: place for technical discussions with experts, after signing up

SENSE – WP 4

- **Technology training sessions** during summer schools in summer 2018 (MAGIC, TESHEP) and

  Training event in summer 2019

- **SENSE Detector Mini School**

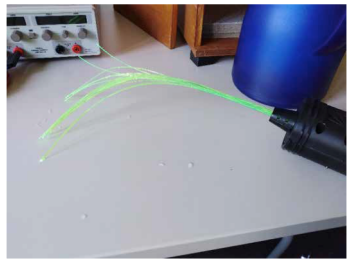
- **Material will be prepared for website**

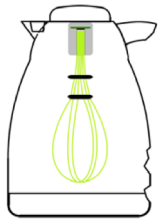
  ➔ Animation SiPM vs PMTs

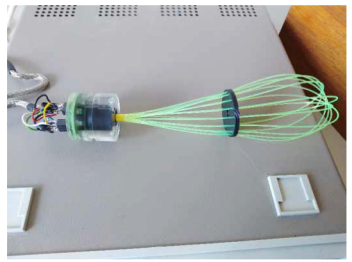
SENSE – WP 4 – Show case experiment

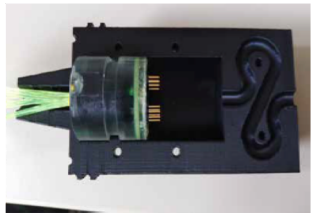
Measurement of cosmic muons with thermos flask used as water cherenkov detector

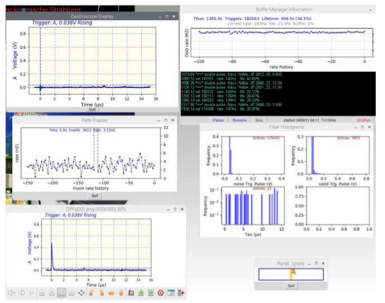
Optical fibers in water → Frontend-board with SiPM → Readout-Board → DAQ/ Picoscope → Software











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SENSE – Discussion on the roadmap

- What is missing in the roadmap?
- What is the demand or motivation coming from application side to do certain R&D steps for SiPMs, PMTs or other types of photosensors?
- Who can do what or is already working on what?
- Where comes industry into play?
- Where can we team up and join activities?
- How and when to monitor progress (e.g. next Light workshop?)?
- What kind of coordination is necessary?
- To whom shall the roadmap be sent/presented?

CONCLUSION

- Why engange in coordination, I want to develop...
  - Many similar developments in parallel
  - Money and personell intensive
- Coordination is needed
- Needs more working power
- Has to be spread over all dicsiplines, in all experiments...
- Needs endurance – the first three years were the starting point

Thank you!

Please visit *sense-pro.org* for the latest news and the SENSE Forum for latest discussions and stay in contact with us

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