



ESS BILBAO

Scintillation detector capabilities

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ESS Bilbao

- Official **representation of Spain** in the **ESS ERIC**.
- **Coordination** of the Spanish **in-kind** contributions to **ESS ERIC**
- **Connection** to the **Spanish industry**
- **56 professionals** working in research, engineering and administration



Outline

- Overview of activities about detectors in ESS Bilbao
- SCIENTIFICA activities and capabilities
- SCIENTIFICA prototype
- Checks on the prototype
- SCIENTIFICA offer of off-the-shelf detectors for
HEIMDAL
- Possible developments for HEIMDAL

Detector development: proposed in-kind contribution

Identification of the best technology for neutron detection based on **scintillators** for applications in **diffractometry**

1) Evaluation of the mature technologies:

- ZnS(Ag) coupled with PMTs by clear fibers with coincidence encoding
- ^6Li -glass Anger cameras
- ZnS(Ag) coupled with PMTs by WLS fibers with coincidence encoding
- ZnS(Ag) coupled with SiPMs by WLS fibers

2) Evaluation of the feasibility of visualization of single events of neutron detection in scintillators by silicon sensors

3) Direct coupling of scintillators to SiPMs (or with a short light guide)

ESS Bilbao activities

I. Research line about coupling scintillators to silicon sensors

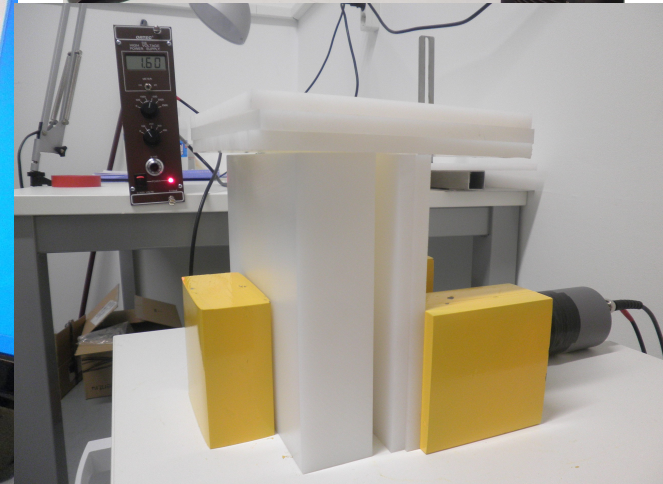
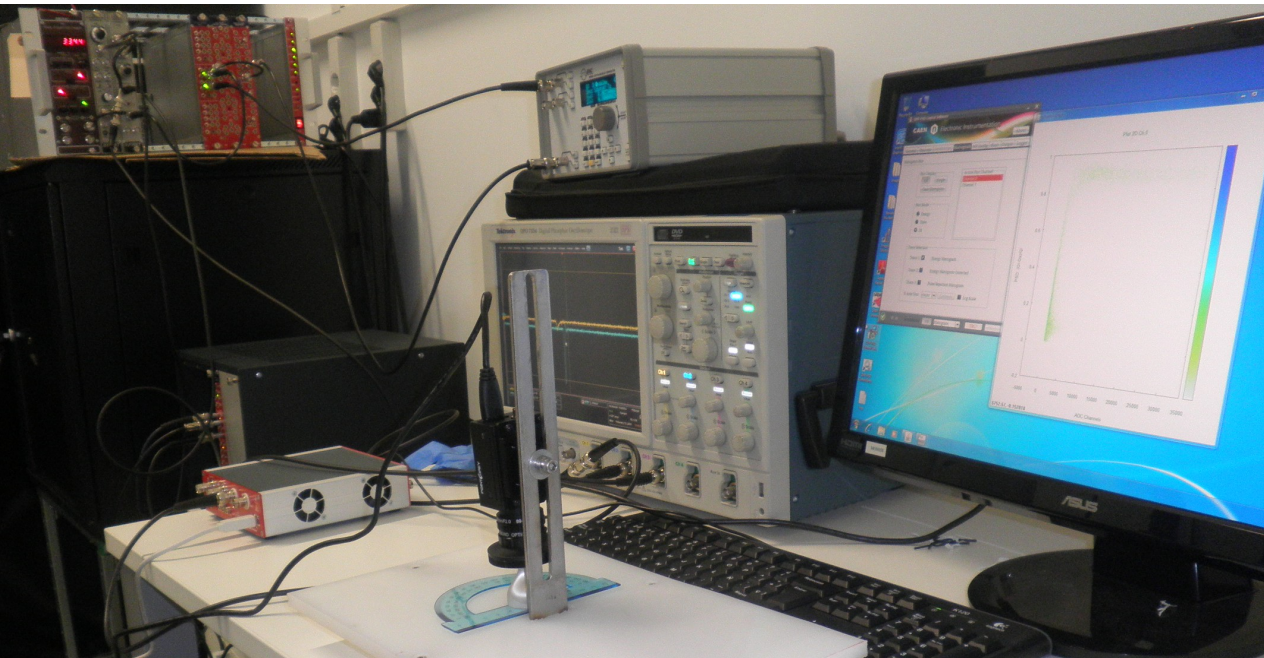
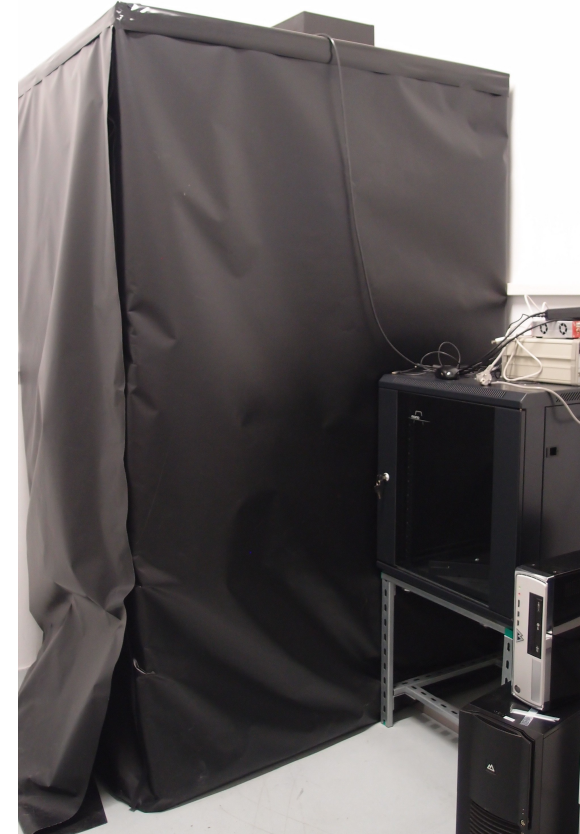
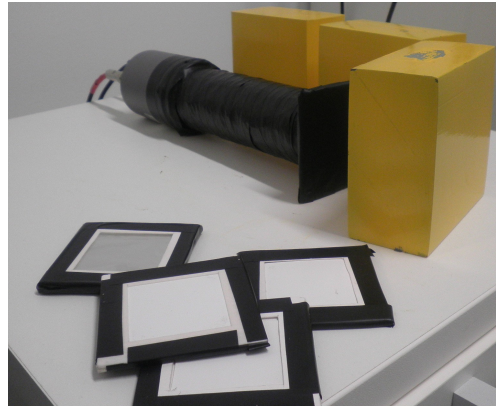
- (a) Highly pixilated detectors: camera sensors
- (b) Commercial SiPM arrays

II. Partnership with SCIENTIFICA

- (a) Assessing properties of their detectors
- (b) Collaboration for technology improvements

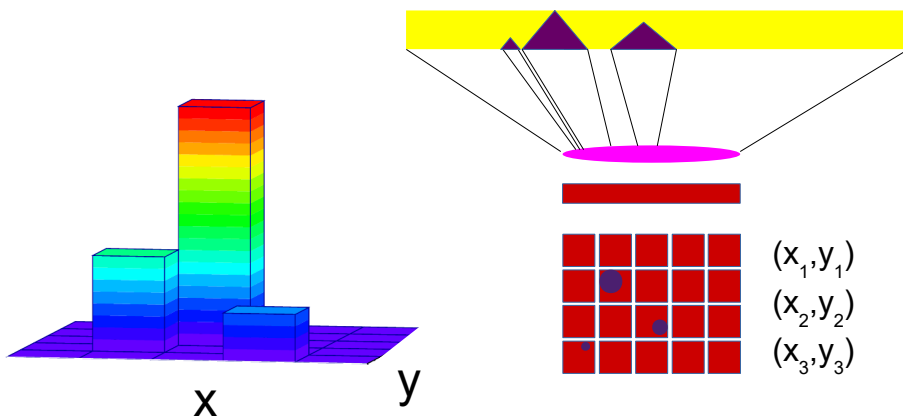
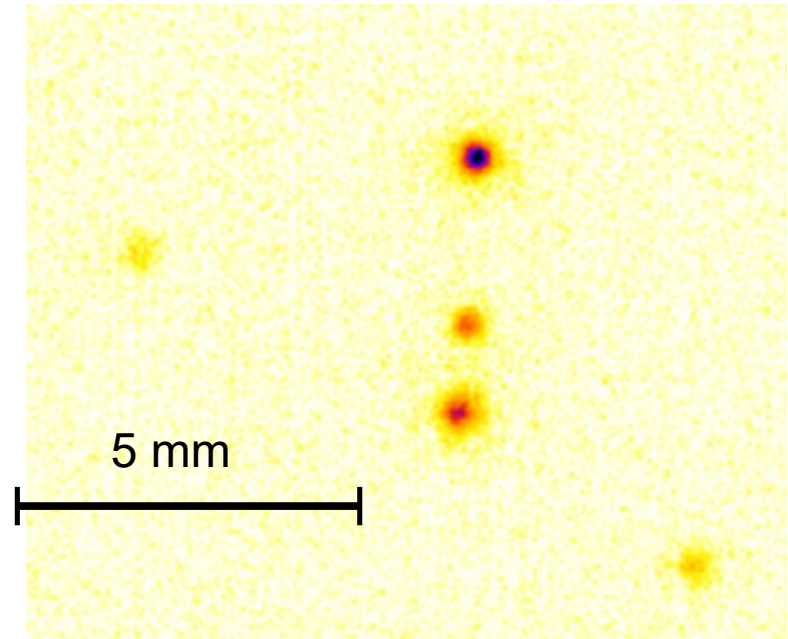
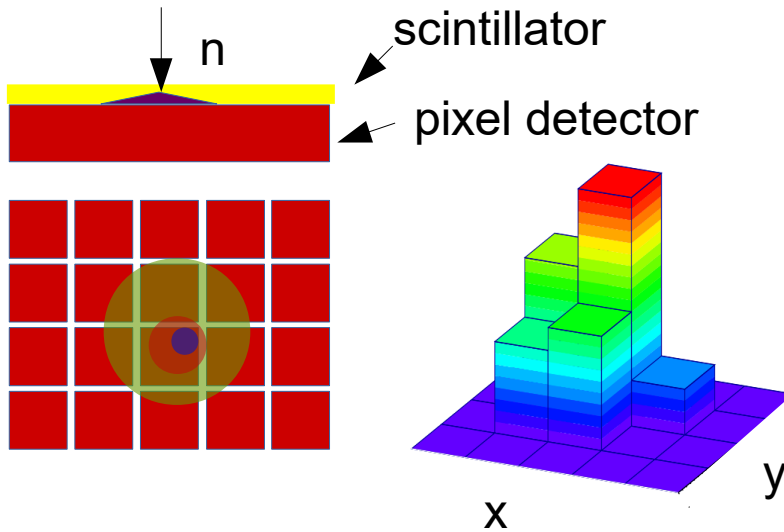
ESS Bilbao detector laboratory

- ✓ Selection of scintillators:
 - ZnS(Ag), ZnS(Cu,Au,Al)
 - ^6Li glass: GS20, KG2
- ✓ ^{252}Cf source 7.8 kBq on 01.12.2015
 - 6 MeV alphas
 - soft gammas
 - neutron fission spectrum
- ✓ Dark room
- ✓ Electronics for n/ γ discrimination of PMT pulses



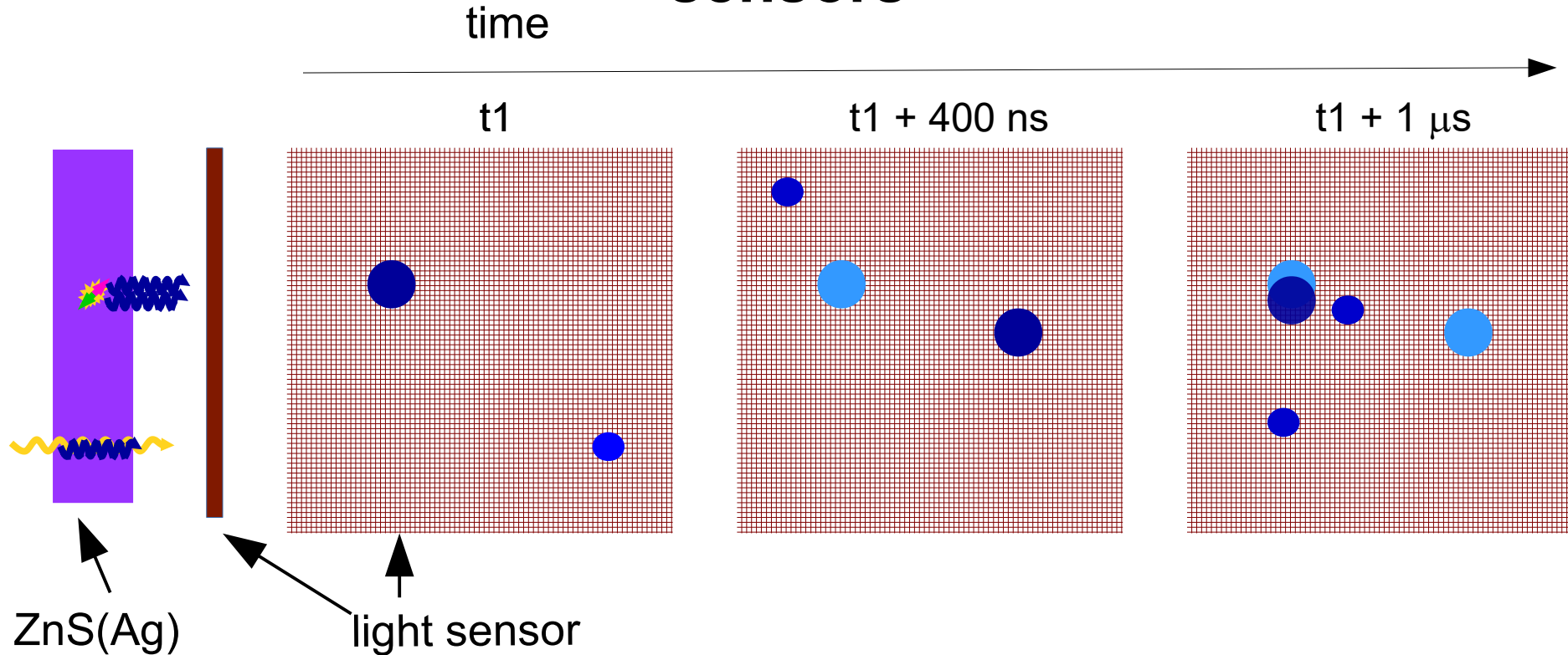
Visualisation through highly pixelated silicon sensors

Neutron detection in ZnS(Ag) intensified by MCPs and viewed by a 200 fps camera



B W Miller et al. Nucl. Instr. Meth. A , 767, 2014

Dead time and n/γ discrimination in pixelated sensors



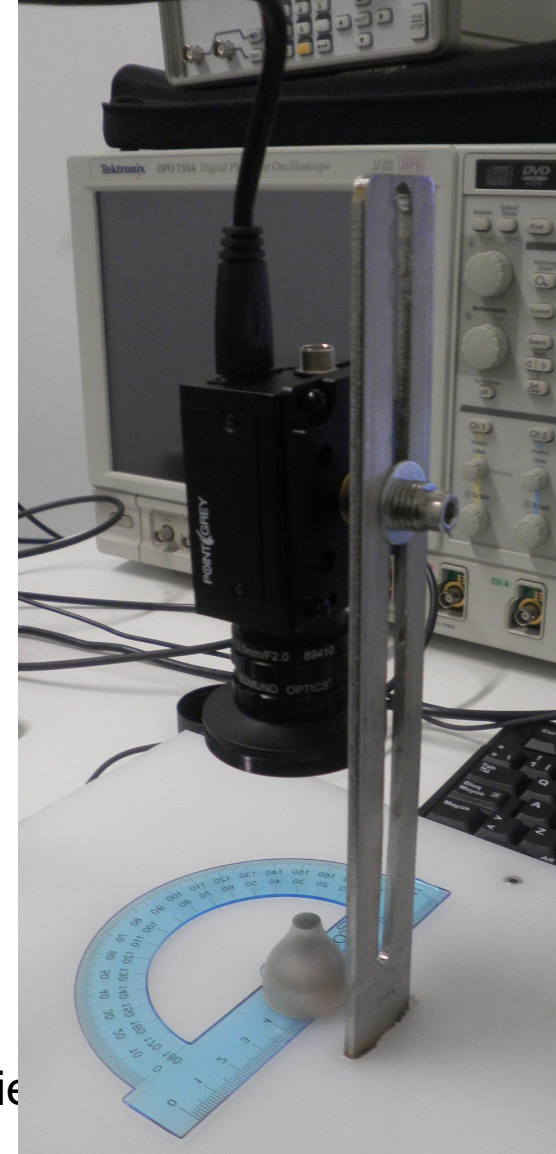
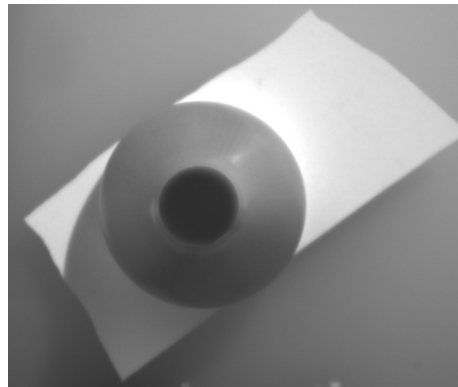
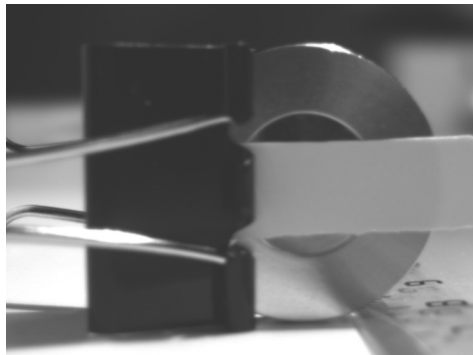
Pixelated light sensors in the market:

- Camera sensors (μm pixels, slow if cheap)
- SiPM arrays (mm pixels, single pixel comparable to a PMT)

Optical tests

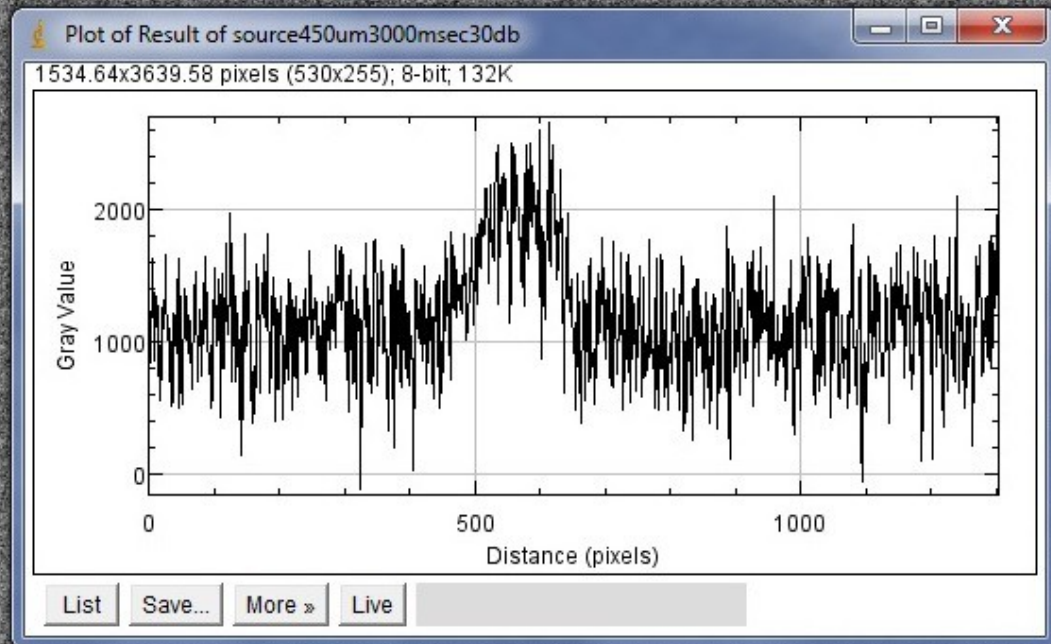
Visualisation of 6 MeV alphas in 250 μm ZnS(Ag) 2:1 by Scintacor

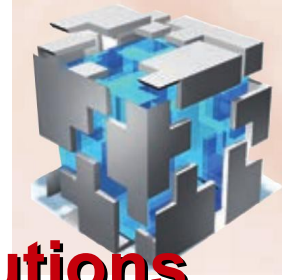
- ✓ Point Grey camera mounting a Sony IMX252 121 fps
- ✓ Optics:
 - Focal length 8 mm, working distance 8 cm
 - Focal length 3.5 mm, working distance 0 mm
 - FOT 3:1



Scintillation light: 8 mm lens

2048x1536 pixels; 32-bit; 12MB





Spin-off of AVS (Added Value engineering Solutions s.l.u.) specialised in precision mechanics, electronics-signal processing and composite materials

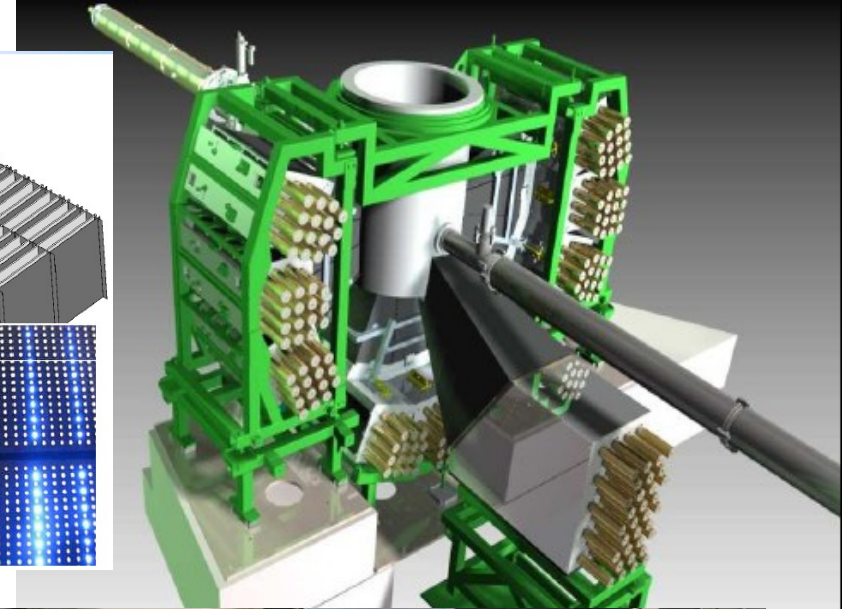
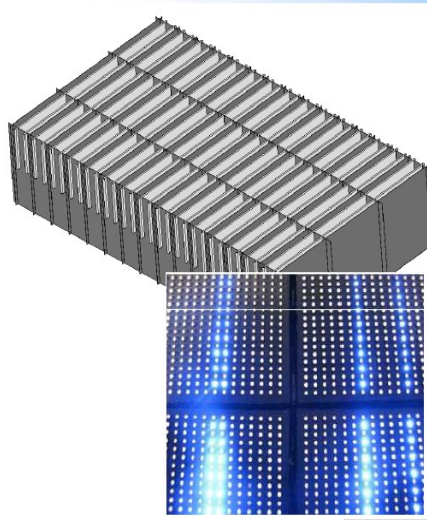
- Supplier of the detector modules of the **ISIS instrument PEARL**
- It inherits from the mother company expertise in mechatronics, **high precision positioning systems in UHV**, engineering design and mechanical systems



Activities connected to the PEARL upgrade

- **General coordination** of the project: specification definition, funding bodies, scientist-engineer-manufacturer
- **Technical coordination of the project:** specification definition in collaboration with the scientist and engineering groups, mechanical design and coordination tasks in the facility
- **Detector manufacturing:**
 - 90 Degree Detectors: 9 modules for the 3 banks
 - Forward Scattering Detectors: 1 module for the Low Angle Forward Scattering detector bank
 - Backscattering Detectors: 3 modules for 1 bank
 - Detector electronics, DAE, PMTs, cabling and power supply
 - Detector Support Frame: Detectors, tank and rest of the elements metallic support structure
- **Shielding:** Blockhouse Expansion, Shielding Blocks, detector shielding and Wax Tanks (Concrete blocks, steel blocks, Borated Polythene wax tanks)
- **Instrument area flooring**
- **Flight Tube**
- **Collimating Jaws**

Images from the PEARL project



14/03/16

ESS Bilbao: Scintillation

Additional projects (AVS and SCIENTIFICA)

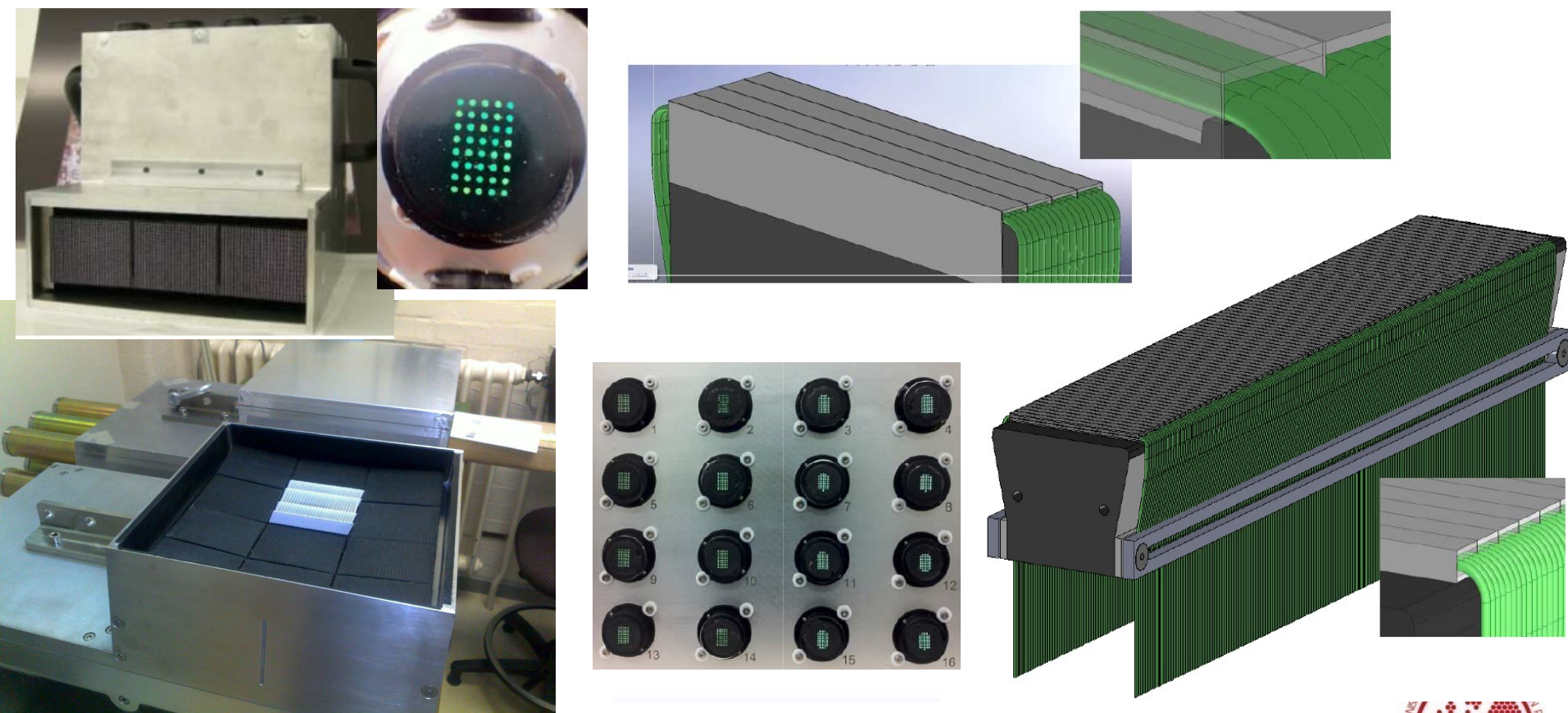
- **Target Station 2** at ISIS (UK). **Neutron premoderator** design and manufacturing
- **LET** instrument at ISIS (UK). **Detector columns** design and manufacturing
- **POLARIS** instrument at ISIS (UK). Instrument upgrade. **Vacuum tank** and **collimator** design and manufacturing
- **XTREMED** instrument at ILL (FR). Technical feasibility study of the instrument.
- **H24 neutron guide** at ILL (FR). Feasibility Study for the Upgrade
- **H5 neutron guide** at ILL (FR). Feasibility Study for the Upgrade
- **IN16B** instrument at ILL (FR). Novel **carbon fibre** extended large angle backscattering analyser **structures**, design and manufacturing
- **NEAT** instrument at HZB (DE). Instrument upgrade **project management** and vacuum tank design and manufacturing
- **THALES** Instrument at ILL (FR). Instrument upgrade design and manufacturing and commissioning: monochromator **shielding**, casemate shielding, **optical guide changer, chopper selector, Heussler analyzer**
- **CHIPIR** Instrument at ISIS (UK). **Beam collimator** design and manufacturing
- **ZOOM** Instrument at ISIS (UK). **Optical guide changer**, design and manufacturing
- **SAXS** Instrument at ESRF (FR). Largest Small Angle Scattering Instrument (33m long): design manufacturing and commissioning of the vacuum tank and the **detector carriage**

SCIENTIFICA prototype

Commercial detector with fibre encoding and GUI, mounting

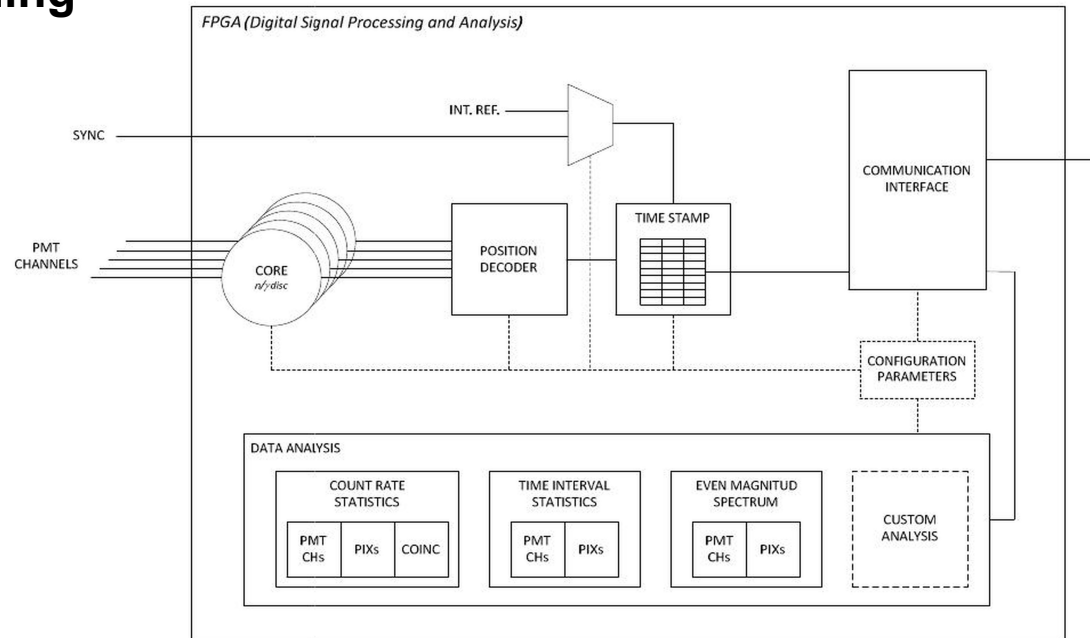
- PEARL pixels (clear fibres) and/or the HEIMDAL pixel size
- WLSF pixels (in order of definition)

→ Evaluation of the performances and characterisation



A closer look to the prototype

- Event discrimination:
 - Noise filter with **adjustable processing time window** and discrimination threshold
- **Selectable coincidence encoding**
- Configurable time stamp
- GUI for detector control and different available communication platforms
- On-screen output:
 - (a) Count rate statistics per PMT, pixel, coincidences
 - (b) Photons per neutron
 - (c) Time between two consecutive events
 - (d) 2D PMT light collection plot



Planned tests

- **Neutron detection efficiency**
Au activation at reactors and/or sources (R2D2 beam line Kjeller reactor, UPV/EHU University of the Basque Country or commercial facility)
- **Gamma sensitivity** (UPV/EHU University of the Basque Country or commercial facility)
- **Time resolution**
- **Read out noise**
- **Dinamic range**
- **Dead time and rate capability**
- **Multicounts** occurrence (simulated photon pulses)

SCIENTIFICA offer of off-the-shelf detectors

In the framework of a Spanish in-kind contribution to HEIMDAL

- 3 m² areal coverage , pixel size 3 x 60 mm²
- ZnS/⁶LiF in Venetian design, clear fibre, single anode PMTs (PEARL)
- Signal processing via FPGA

Features

- Pixels/Channel: **26** ~ **1278 channels; 16,6K pixels**
- Homogeneous dual pixel coding
- Detection specifications:
 - Native channel maximum count rate: **20.000 cps (50 µsecs between events)**
 - Maximum count rate in a uniform neutron source at full area: **427,4 cps/cm²**
- **One FPGA electronics box** per detector module, in charge of:
 - Neutron/gamma discrimination
 - Event decoding
 - Time stamping
- **One data cable** per detector module and **optimized (reduced) number of HV channels**



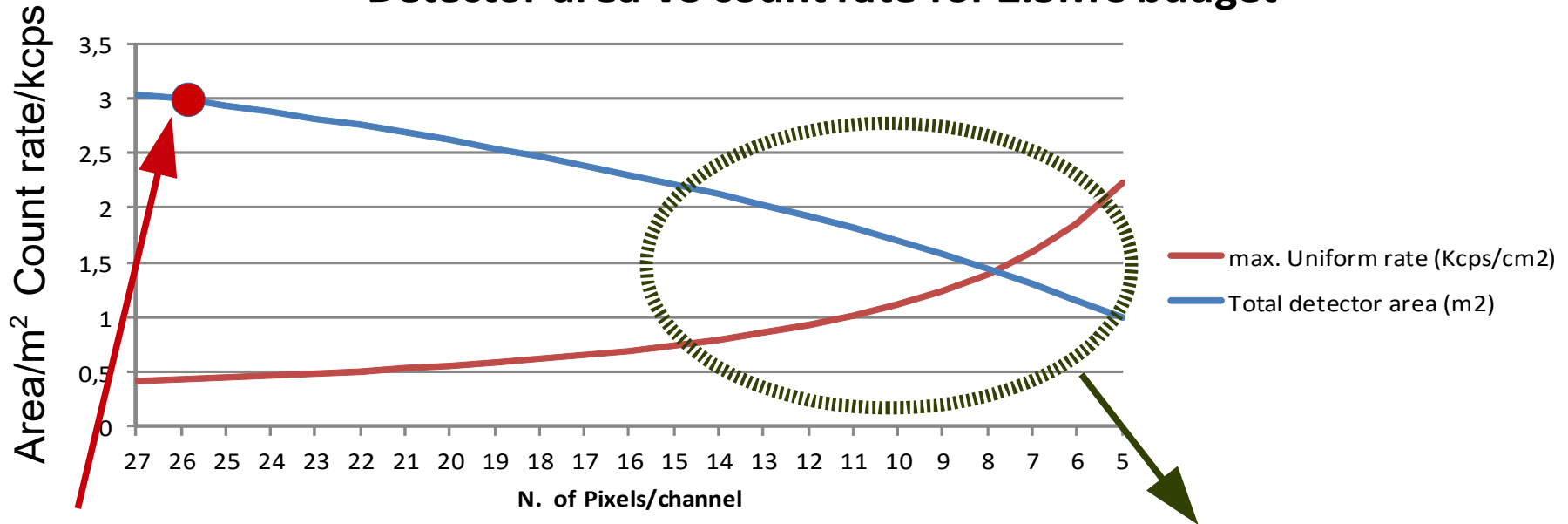
Description of the supply included on 2.5 M€

- **Project engineering** (requirement collection, tasks coordination...)
- **Detector mechanical design:**
 - Detector Modularity definition (module size, shape, ...)
 - Detector's features (shielding, ...)
 - Support frames, alignment system design, ...
 - Detector's integration (interface with the rest of the instrument)
 - Other design requirements
- **Detector manufacturing**
 - Detector modules
 - PMTs assemblies (channels)
 - Discriminator and DAE electronics
- **Power supply:** HV power supply and other power sources are included
- **Delivery**
- **Support** in the commissioning phase

Exercise: increasing the count rate

Count rate can rise significantly reducing the number of pixels/channel

Detector area VS count rate for 2.5M€ budget



The presented offer

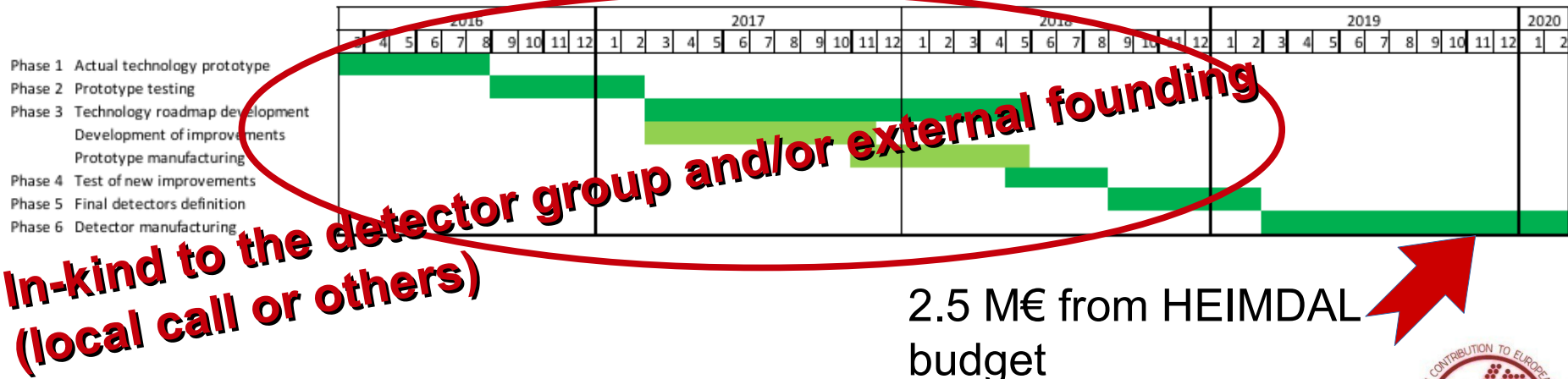
**High number of PMTs per module.
Possible solutions: smaller area
PMTS, MaPMTs, SiPMs**

Detector development possibilities for HEIMDAL

- In-kind Spanish contribution SCIENTIFICA - ESS Bilbao
- ESS Bilbao can contribute both with its infrastructures and two scientists

A possibility for a SCIENTIFICA-ESS Bilbao contribution

- PEARL type configuration, HEIMDAL pixel size on clear fibres development of suitable encoding (this option can take advantage of the already commissioned prototype)
- Development of different pixels and optical collection with in a new prototype



Summary

- ✓ Overview of the possibilities of Spanish in-kind contributions
- ✓ Description of the capability of the Basque company SCIENTIFICA
- ✓ Details about the started contract between ESS-Bilbao and SCIENTIFICA
- ✓ SCIENTIFICA off-the-shelf offer for HEIMDAL
- ✓ Possibilities of detector developments by ESS Bilbao and SCIENTIFICA