



4th FCC / DRD France Workshop, Strasbourg (Nov.22-24/2023)

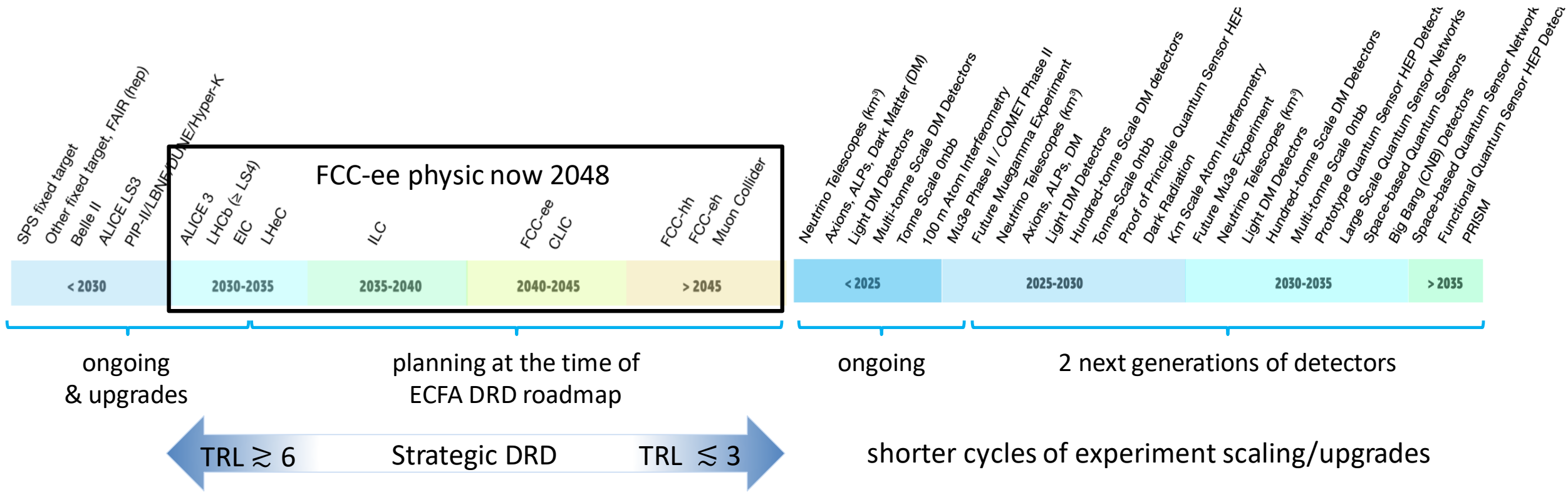
Highlights of French interests in the new DRD collaborations at CERN

D. Contardo IP2I

Context of HEP projects for Detector Research & Development

large accelerators

small accelerators, nuclear reactors, cosmic rays



Strategic DRD programs evolve with technical success and increase of TRL*
 DRD proposal consider a first phase of about 3-4 year, eg timescale for LS4*

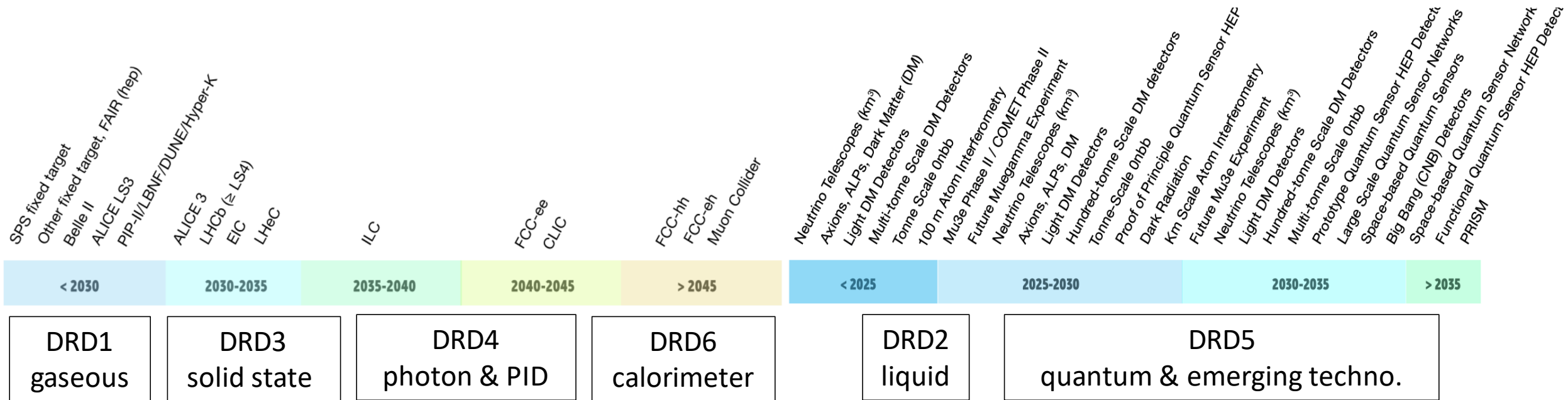
* *Technology Readiness Level defined by NASA, low TRL < 3 also often referred as "blue sky", TRL > 6 are experiment specific R&D*

** *Planning of projects is for physics start, end of strategic R&D should consider specific project engineering, construction, and installation time*

DRDs areas defined in the [ECFA detector roadmap](#)

Large accelerators - long cycles

small accelerators, nuclear reactors, cosmic rays
- shorter cycles experiment scaling/upgrades

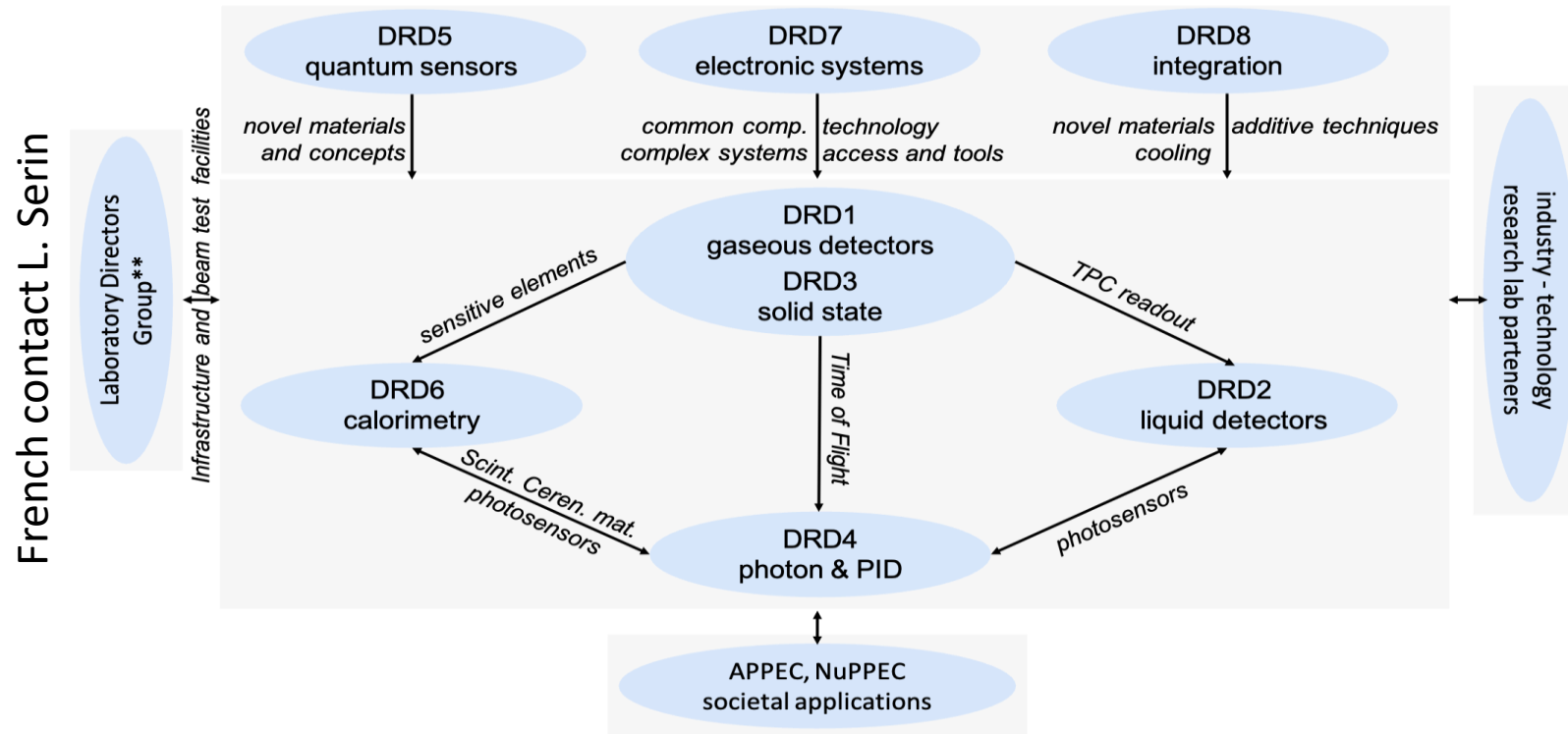


DRD7 electronics and on-detector processing - DRD8 integration - DRD9 training and career

Relative match between the DRD areas and the two types of strategic projects also considering technology versus detector systems

Broad brush links between DRDs and with external partners

DRDs can provide technologies to others and/or share developments of similar components with different performance or operation conditions
can involve participation cross-DRD on a same topic (naturally true for transverse DRD7)



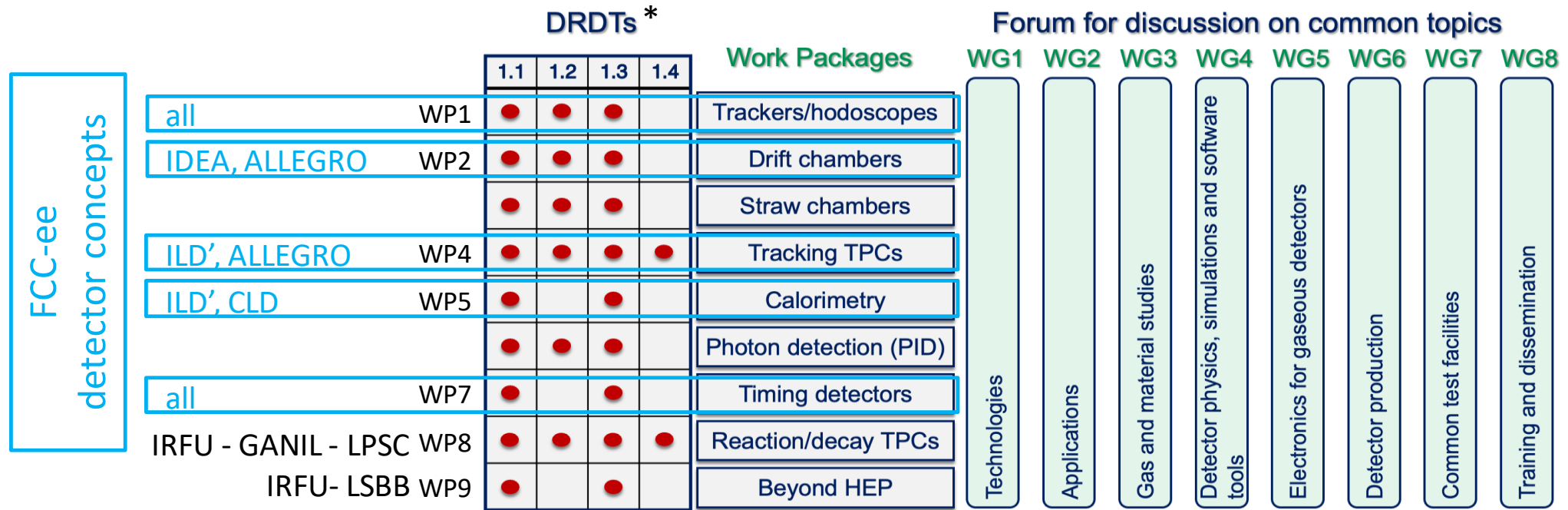
So far DRD1/2/3/4/6 proposals under scrutiny of [DRDC](#)* (see L. Serin)
DRD7 provided an interim document with proposal target during summer also for DRD5
DRD8 being investigated [community meeting 6 Dec.](#), DRD9 new forum being form

DRD proposals content

- Scientific program cover about TRL 3 to 6 and consider other DRD programs
 - breakdown in Work Packages with Deliverables due to achieve Research Goals/Tasks Milestones
 - Planning is focused on first R&D period of 3 - 4 years
 - stepping stones earlier strategic programs
 - iterations toward longer term goals: new technologies - new materials - ultimate radiation tolerance
 - Human resources and funding
 - in public document
 - list of institutes willing to contribute to various WPs
 - estimate of human and funding resources required to achieve the WP goals
 - sums of expected resources
 - confidential to DRDC to evaluate feasibility of the programs
 - current level of human and funding resources expected to be available/prolongated
 - new resources being requested to achieve the strategic scope
 - preliminary breakdown of resources per Funding Agency
- Basis to establish Funding Agency MoU commitments to DRD WP deliverables (see L. Serin)

French institute interests per DRD
reported as they appear in the proposals Work Packages

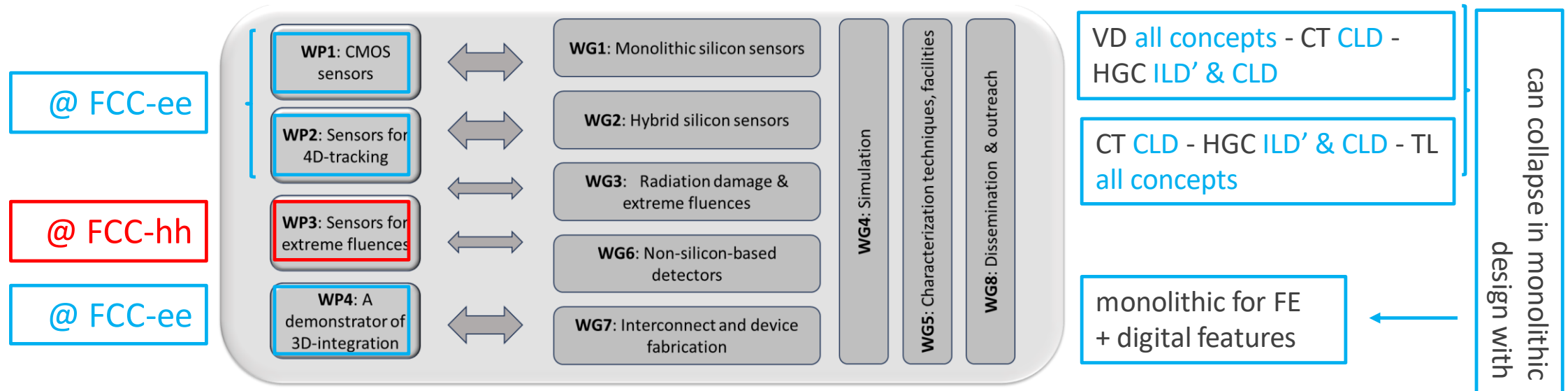
DRD1: Gaseous Detectors



- WP1 : Micromegas at IRFU large size, high rates... (see F. Janneau)
- WP2 : Drift Chamber light wires, drift cell design and weaving procedures at IJCLab, Ganil, LPSC (see N. de Filippis)
- WP4 : Time Projection Chamber IBF studies and electronics for MicroMegas readout at IRFU (see D. Jeans)
- WP6 : RPCs large size multigap and FE with <100 ps precision at IP2I and Omega (see I. Laktineh)
- WP5 : ToF with MicroMegas Picosec project at IRFU (see A. Kallitsopoulou)

* Detector Research and Development Themes defined in the [ECFA detector roadmap](#)

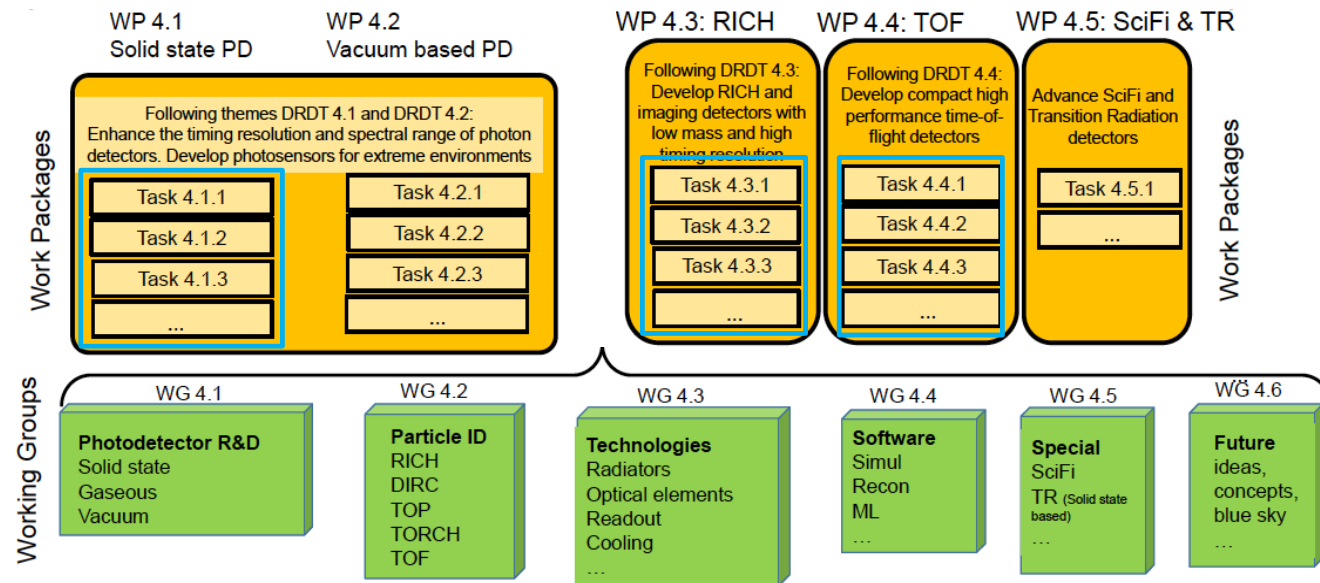
DRD3: Solid State Detectors



- WP1 : TJ 65 (180) nm (small electrode design) at APC, CPPM, IPHC, IP2I, LPNHE (see A. Besson); LFoundry 150 nm (large electrode design) at IRFU (see P. Schwemling)
- WP2 : LGAD at IJCLab , Omega, LPNHE
- WP3 : WBG at LPSC, Diamond and Silicon at LPSC, IJCLab; Silicon at APC, IRFU and LPNHE (HL-LHC and FCC-hh)
- WP4 : in house interconnect. at CPPM, IJCLab; wafer to wafer interconnect. for MCMOS at IP2I, all interconnection techniques at LPNHE, mechanics & cooling at CPPM, LPNHE (see M. Winter)

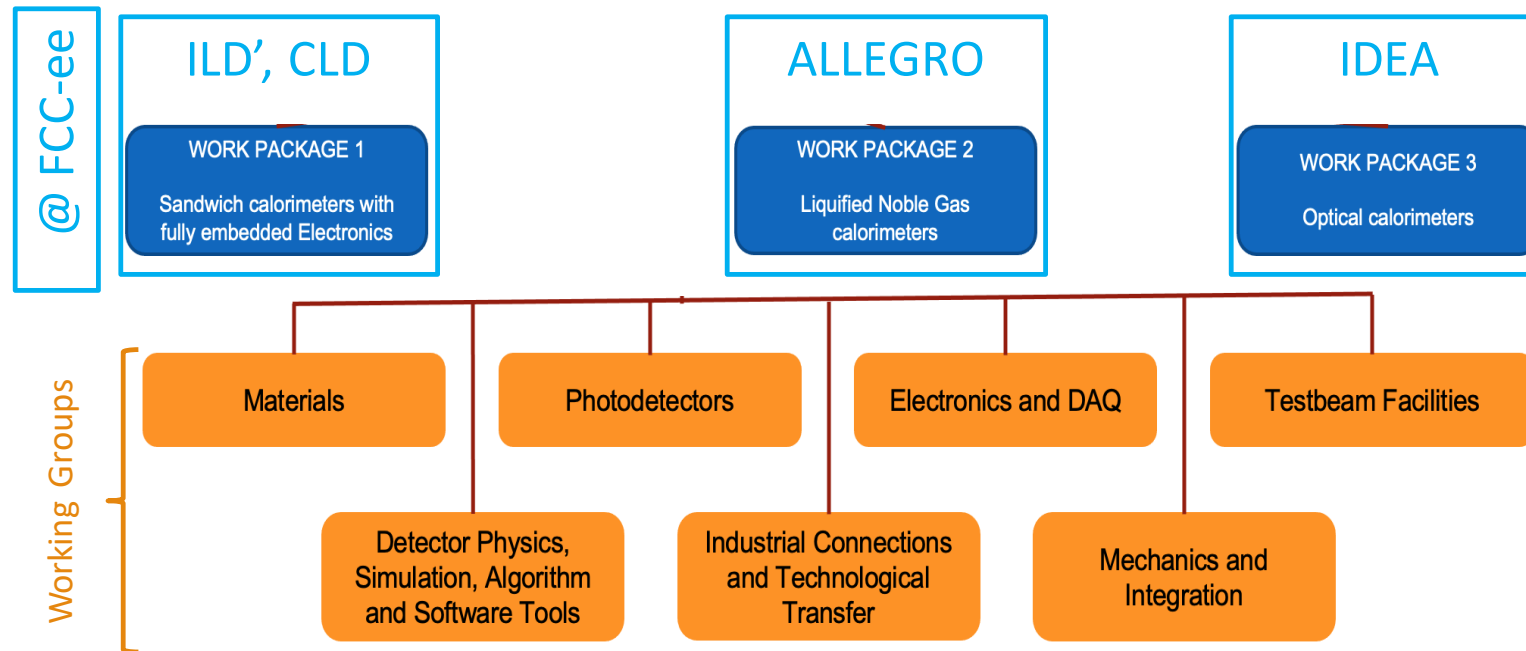
DRD4: Photon detectors and PID

@ FCC-ee : synergies for solid state photodetectors (SiPM/SPAD) for calorimetry in IDEA, ILD', CLD, for ARC in ILD', CLD and optical ToF TL (in all concepts)



- WP 4.5.1 : radiation hard scintillating fibers at LPC
- WP 4.2.1/4.2.2/4.2.3. : PICMIC nano-PMT photodetector concept at IP2I (low TRL in WG6)
- WP 4.3.1/4.4.1/4.4.2 : new radiators materials & components, coupling to single photon SiPM for ToF TL at CPPM
- WG 4.1/4.4/4 : IRFU interest not yet assigned to WPs

DRD6: Calorimetry



WP1 : .1.1 SiW-ECAL at IJCLab, LLR, LPNHE, Omega, (DMLAB) (see V. Boudry); .2.1 AHCAL at Omega;
.2.3 T-SDHCAL at IP2I, Omega (see I. Laktineh)

WP2 : at IJCLab, APC, CPPM, LPNHE, Omega (see N. Morange)

WP3 : .2.1 GRAiNITA at IJCLAB, LPC-CF (see M. Schune); .2.2 SpaCal spider at IJCLab, IP2I, LPC-Caen, LPC-CF

WG materials : at CPPM, IJCLab, ILM, IP2I, IRFU (see S. Gascon)

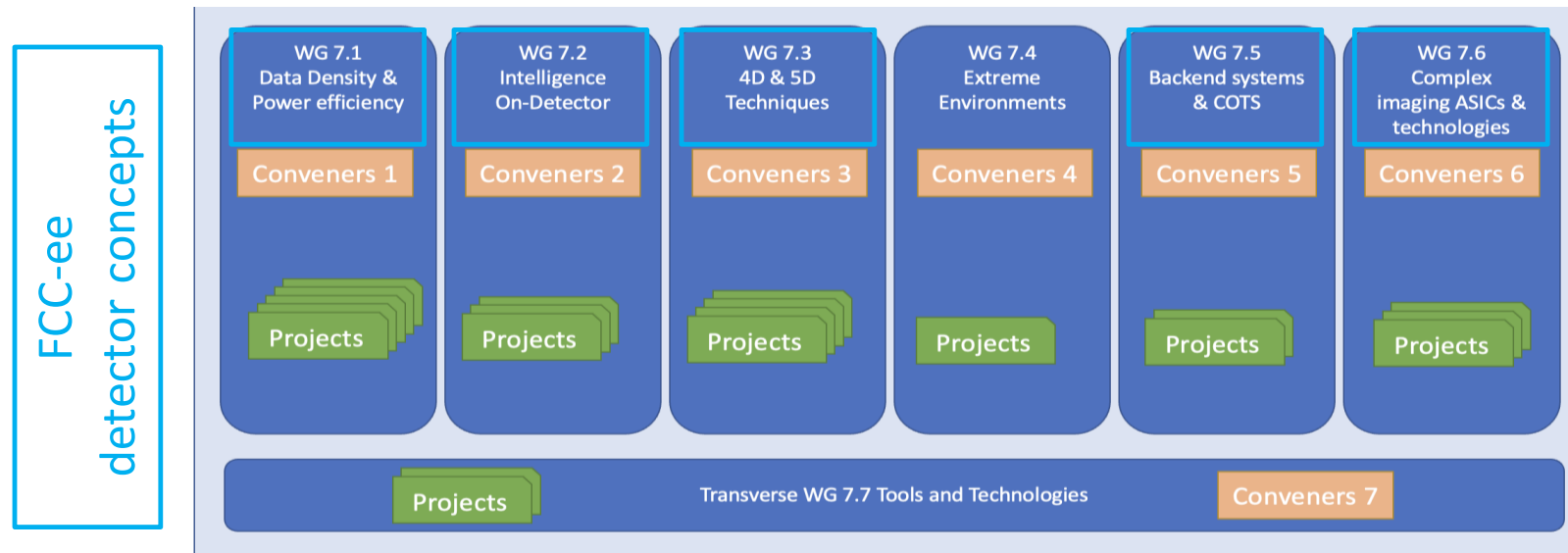
WG PhotoDetectors : at IRFU, IJCLab

WG Electronics and DAQ : at Omega, IRFU

WG Detector Physics... : at Univ. Clermont Auvergne

DRD7: Electronic systems

improve and develop further common standards, methodologies, and IP blocks
provide facilities and tools for R&D in the community, with long-term continuity
support development of complex ASICs in other DRDs



- WP7.1.c : wireless Allowing Data and Power Transmission (WADAPT) at IRFU (LETI), LPSC (see F.E Rarbi)
- WP7.2 : .? at LP2I and IPHC
- WP7.3.a : high performance TDC and ADC blocks at ultralow power at CPPM, IP2I, IRFU, Omega*
- WP7.3 : .b1 data driven calibration at LPC; .b2 clock distribution techniques at CPPM, .? LPSC
- WP7.4 : .b radiation tolerance of advanced CMOS nodes; .c cooling at CPPM
- WP7.5 : .b no back-end at CPPM, .c generic backend (TBC)
- WP7.6 : common access to .a techno. and IP (IPHC, IP2I, CPPM); .b 3D and advanced integration IP2I

preliminary interim doc.

* ADC in MCMOS at APC not (yet) included in WP7.3a, White Rabbit clock distribution at IJCLab not (yet) included in WP7.3

French institute interests per DRD
reported as they can enter FCC detector concepts*

DRD interest links to FCC-ee CLD⁺ (w/ PID) concept

APC, CPPM, IJCLab, IPHC, IP2I, IRFU, LLR, LPNHE, Omega

Muon hodoscope (HCAL?)

DRD1 - WP1 : Micromegas at IRFU

Sandwich calorimeter
with fully embedded electronics

DRD6 - WP1 (DRD1- WP6) : AHCAL at Omega;
T-SDHCAL at IP2I, Omega

SiW-ECAL at IJCLab, LLR, LPNHE, Omega

Timing Layer DRD1 - WP5 : Picosec at IRFU

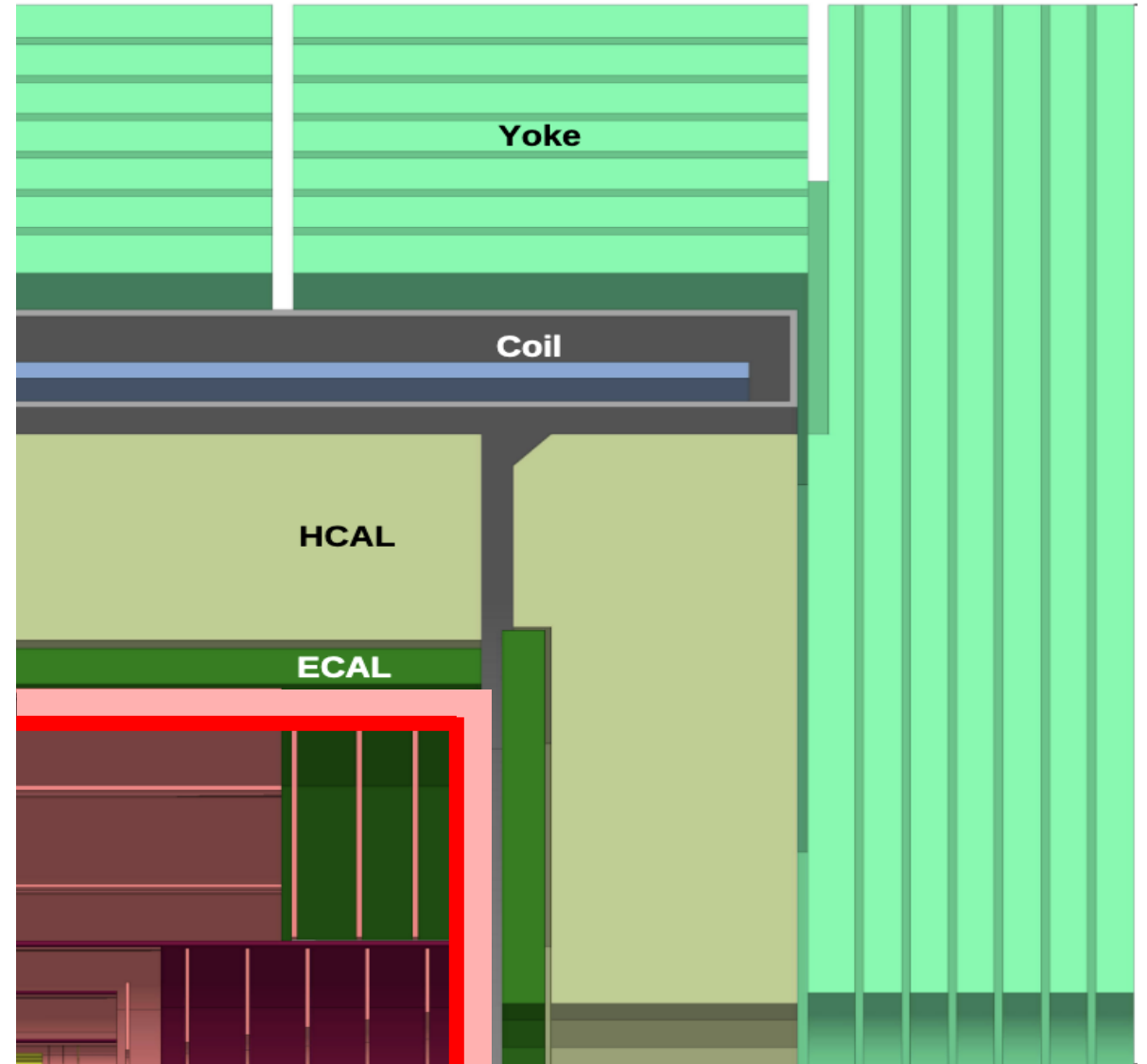
DRD1 - WP1 : MCMOS at APC, AMU, CPPM, IPHC, IP2I, IRFU

DRD3 - WP2 : LGAD at AMU, LPNHE

DRD4 - WP4.2 : nano MCP at IP2I; WP4.3 : materials at CPPM

Tracking (ECAL?)

DRD3 - WP1 : Monolithic CMOS
at APC, CPPM, IPHC, IP2I, LPNHE, IRFU



DRD links to FCC-ee ILD' concept

APC, CPPM, IJCLab, IPHC, IP2I, IRFU, LLR, LPNHE, Omega

Muon hodoscope (HCAL?)

DRD1 - WP1 : MicroMegas at IRFU

Sandwich calorimeter
with fully embedded electronics

DRD6 - WP1 : AHCAL at Omega;

T-SDHCAL at IP2I, Omega also DRD1 - WP6

SiW-ECAL at IJCLab, LLR, LPNHE, Omega

Timing Layer DRD1 - WP5 : Picosec at IRFU

DRD1 - WP1 : MCMOS at APC, AMU, CPPM, IPHC, IP2I, IRFU

DRD3 - WP2 : LGAD at AMU, LPNHE

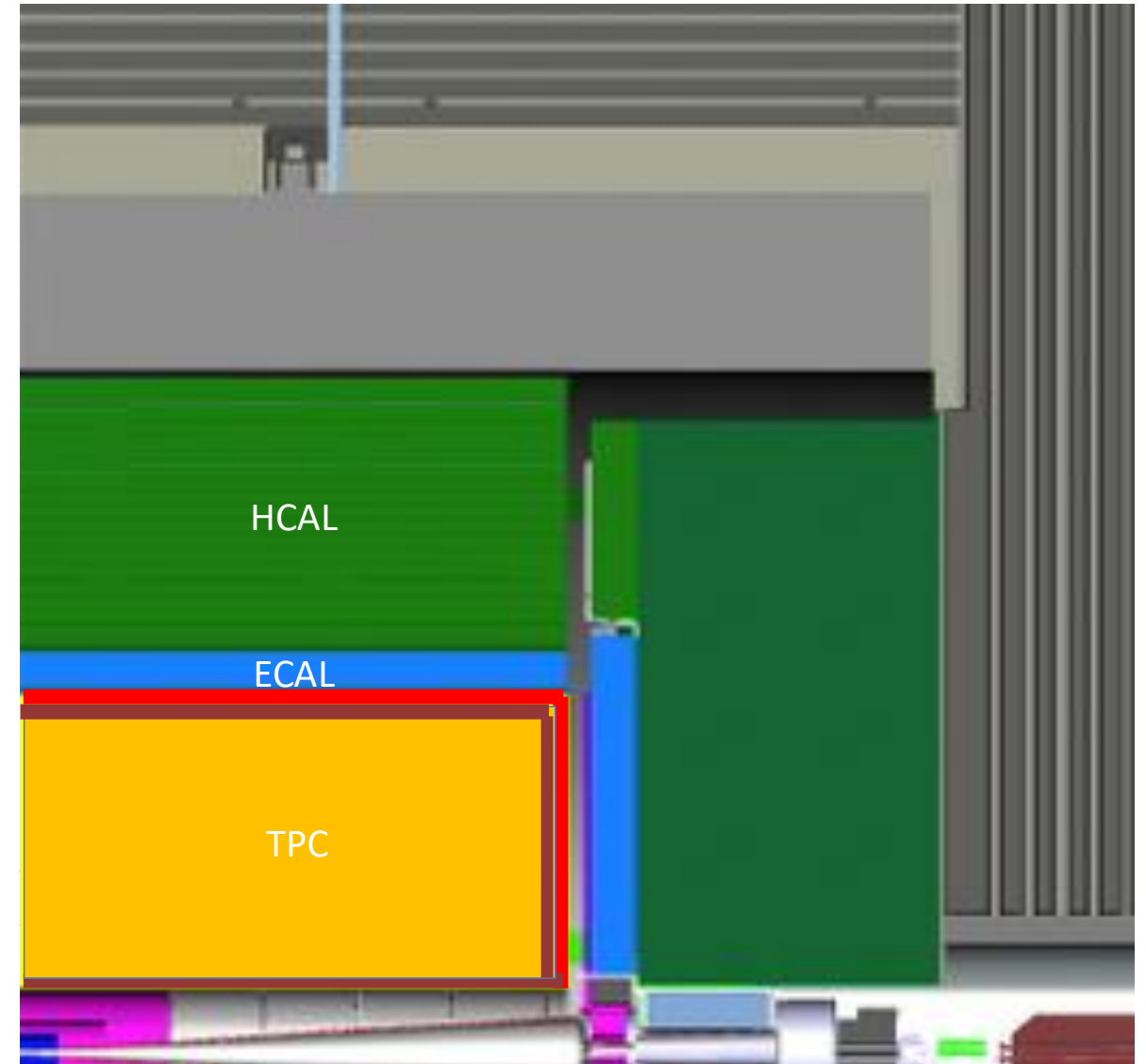
DRD4 - WP4.2 : nano MCP at IP2I; WP4.3 : materials at CPPM

Time Projection Chambers

DRD1 – WP4: IBF & MicroMegas readout at IRFU

VD - Wrapper – (ECAL?)

DRD3 - WP1 : Monolithic CMOS
at APC, CPPM, IPHC, IP2I, LPNHE



DRD interest links to FCC-ee ALLEGRO concept

APC, CPPM, IJCLab, IPHC, IP2I, IRFU, LPNHE, LPSC, Omega

Muon Tagger

DRD1 - WP1 : Micromegas at IRFU

Liquid Noble Gas DRD6 - WP2 :
at IJCLab, APC, CPPM, LPNHE, Omega

Timing Layer DRD1 - WP5 : Picosec at IRFU

DRD1 - WP1 : MCMOS at APC, AMU, CPPM, IPHC, IP2I, IRFU

DRD3 - WP2 : LGAD at AMU, LPNHE

DRD4 - WP4.2 : nano MCP at IP2I; WP4.3 : materials at CPPM

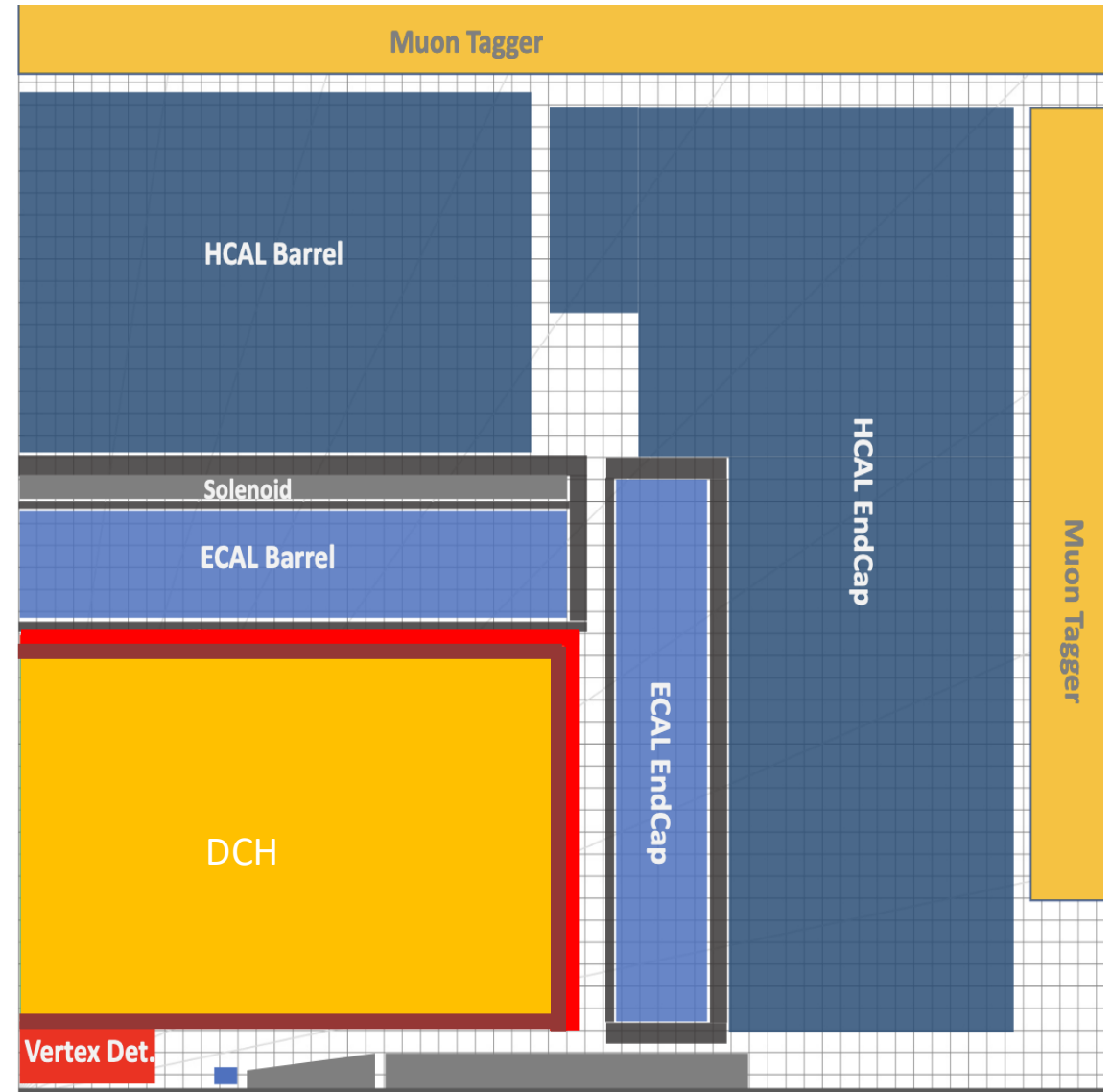
Drift or Time Projection Chamber

DRD1 - WP4: TPC IBF & MicroMegas readout at IRFU

DRD1 - WP4: DCH light wires & weaving at IJCLab, Ganil, LPSC

VD - Wrapper

DRD3 - WP1 : Monolithic CMOS
at APC, CPPM, IPHC, IP2I, LPNHE, IRFU



DRD interest links to FCC-ee IDEA⁺ w/ crystal ECAL concept

APC, CPPM, IJCLab, IPHC, IP2I, IRFU, LPNHE, LPSC

Muon Tagger

DRD1 - WP1 : Micromegas at IRFU

ECAL

DRD6 - WP3 : GRAiNITA at IJCLAB, LPC-CF

DRD6 - WG materials : at CPPM, IJCLab, ILM, IP2I, IRFU

DRD6 - WG Photodetectors : at IRFU, IJCLab

Timing Layer with crystals

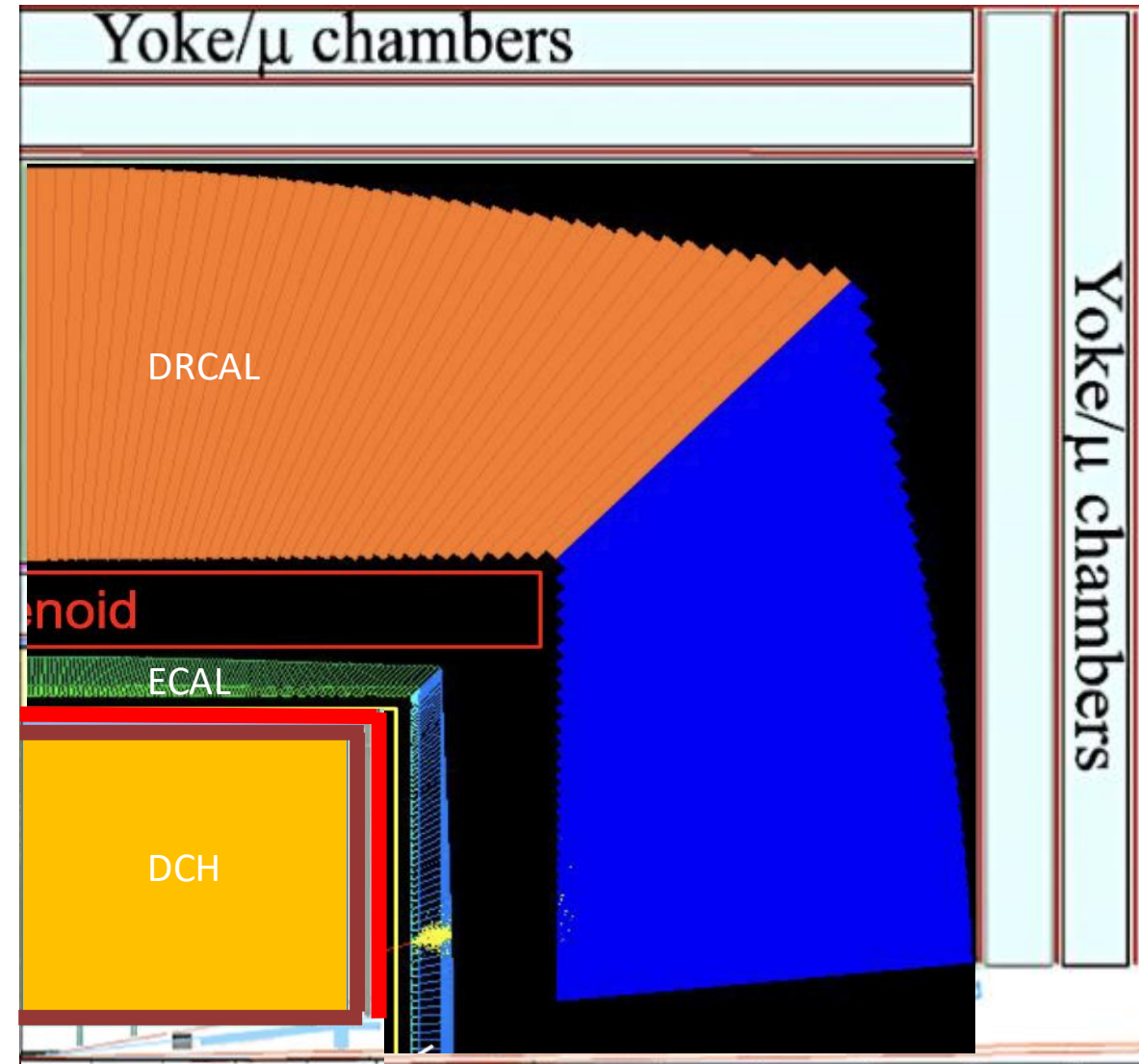
DRD4 - WP4.2 : nano MCP at IP2I; WP4.3 : materials at CPPM ?

Drift Chamber

DRD1 - WP4: DCH light wires & weaving at IJCLab, Ganil, LPSC

VD, Wrapper

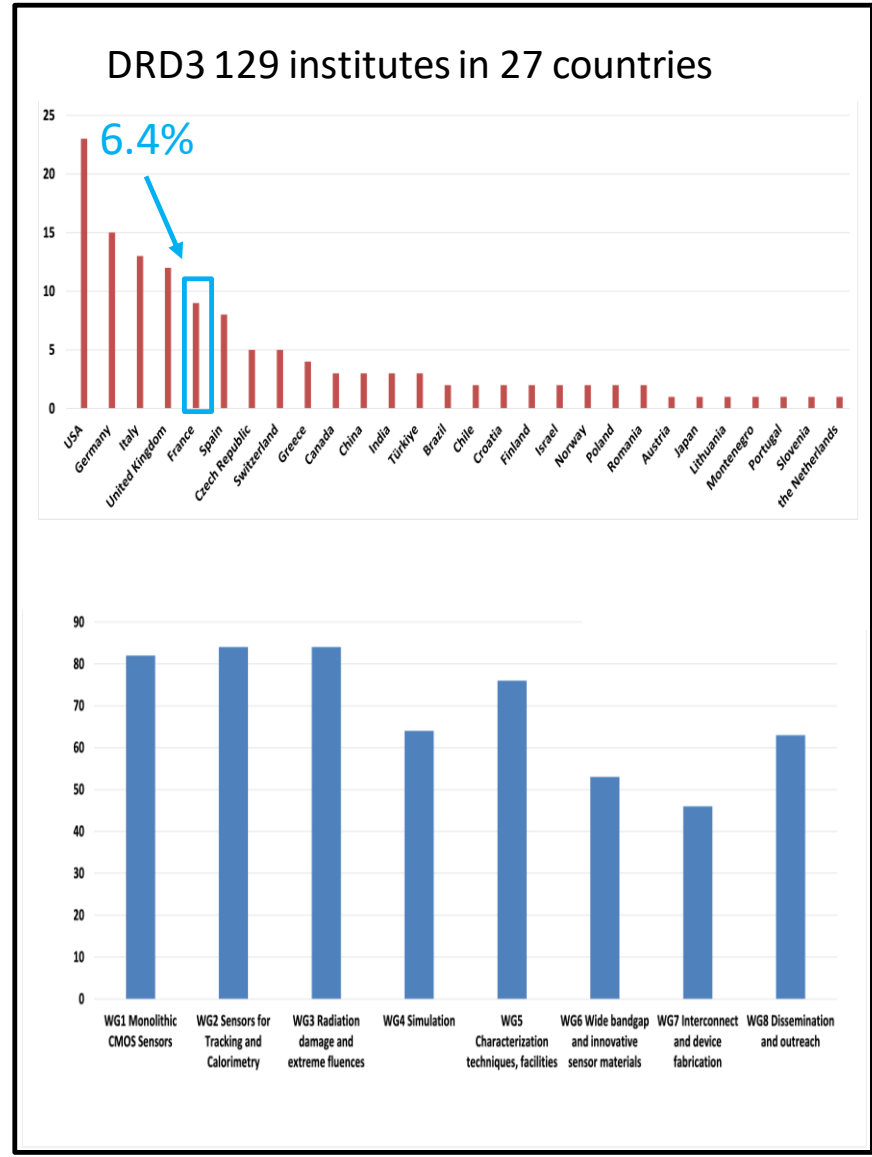
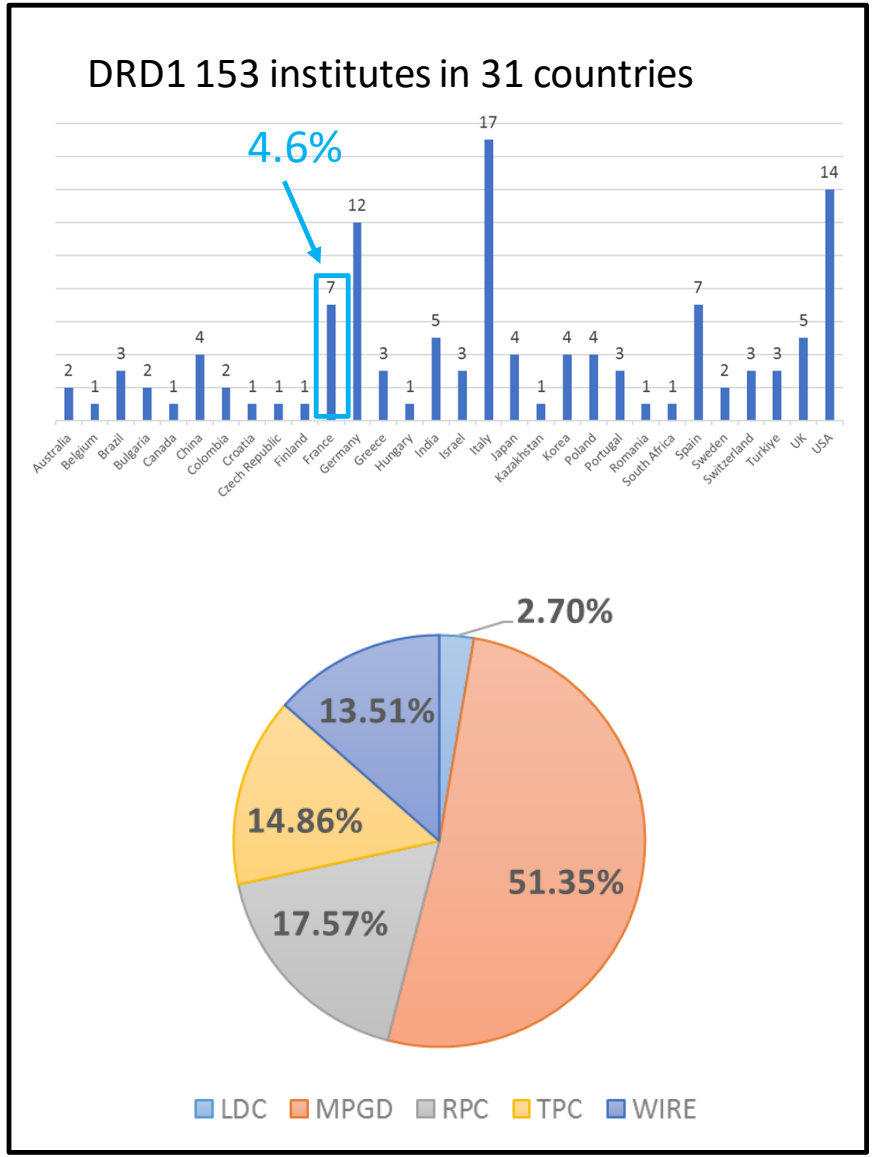
DRD3 - WP1 : Monolithic CMOS
at APC, CPPM, IPHC, IP2I, LPNHE, IRFU



French institute interests per DRD as a function of systems for FCC-ee

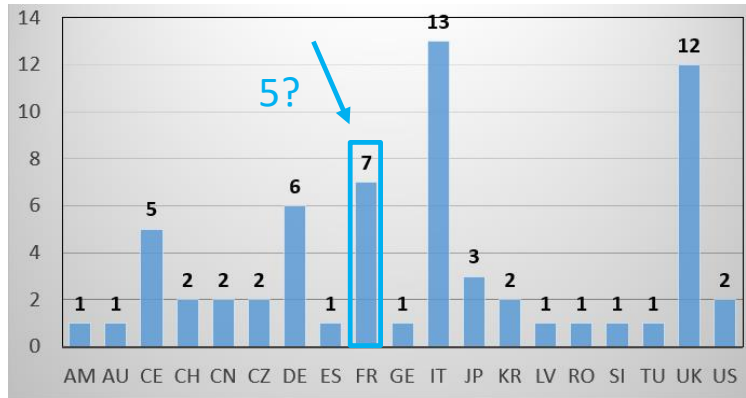
- Muon hodoscope/tagger
 - Micromegas at IRFU, (RPC experience at IP2I but no specific project)
- Sampling calorimetry with fully embedded electronics
 - ECAL at IJCLab, LLR, LPNHE; HCAL at IP2I, electronique at Omega
- NLG calorimetry
 - ECAL at APC, CPPM, IJCLAB, LPNHE, Omega
- Optical calorimetry
 - ECAL GRAiNita at IJCLAB, LPC-CF, Crystals at IP2I
- Timing Layers
 - MicroMegas IRFU, LGAD LPNHE, MCMOS IPHC, IP2I, CPPM, optical CPPM, IP2I
- Tracking
 - DCH IJCLab, Ganil, LPSC; TPC IRFU; MCMOS CPPM, IPHC, IP2I, LPNHE

France in context of international contributions and interests

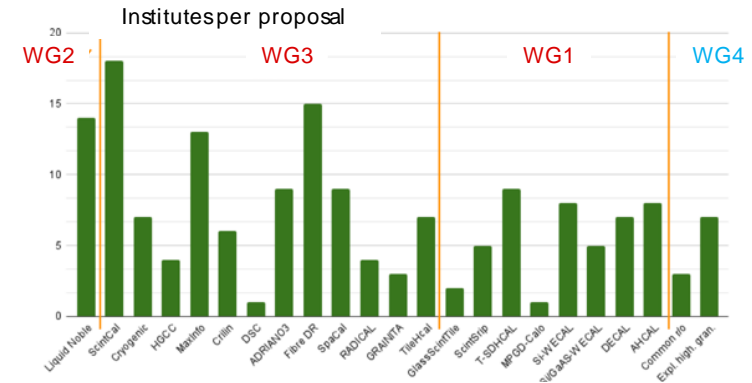
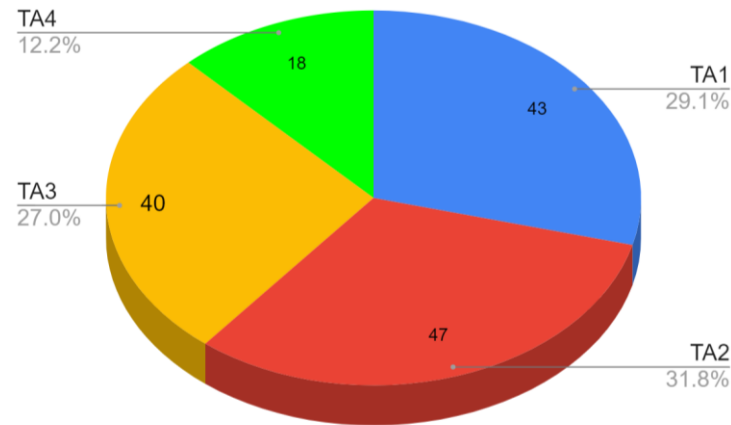
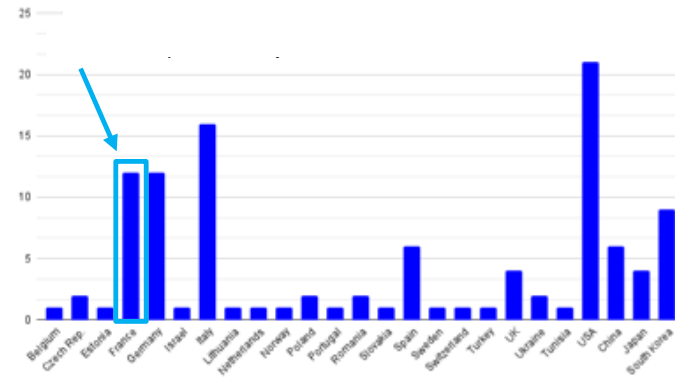


France in context of international contributions and interests

DRD4 74 institutes in 19 countries



DRD6 131 institutes in 29 countries



French contributions to DRD implementation teams

- DRD1 : G. Charles (IJCLab), M. Gouzevitch, I. Laktineh (IP2I), E. Ferrer Ribas, M. Titov, P. Colas, F. Jeanneau (IRFU)
- DRD2 : D. Franco (APC)
- DRD3 : G. Calderini (LPNHE)
- DRD4 : I. Laktineh (IP2I)
- DRD6 : N. Morange, I. Laktineh (IP2I), R. Poeschl (LLR), C. de la Taille (Omega),
- DRD7 : J. Baudot (IPHC)

Outlook

- Several proposed French contributions to DRDs
 - some associated to specific detector concepts at FCC-ee*
 - typically DCH, TPC, Calorimetry
 - some for systems not directly attached to a detector concepts
 - typically PID ToF layers with LGAD, MicroMegas
 - some not yet assigned to a system and that can appear in all or specific concepts
 - typically MCMOS (for VD, Central Tracking, Calorimetry, possibly w/ precision timing)
 - some with possible intermediate targets in LS4 (or similar timescale ex. Belle-2) :
 - typically MCMOS and LGADs
- All labs have DRD interests that can enter different FCC-ee detector concepts
- Next steps
 - DRD approval by DRDC (see L. Serin)
 - collaboration will soon form, important to be involved in the key contribution areas
 - French R&D projects
 - no time in the preparation phase to consider synergies and contributions to common deliverables within and across DRDs - more discussion can happen now considering international context and MoU preparation
 - framework for allocation of resources see A. Lucotte
 - How to integrate DRD interests in FCC-ee detector Lol in 2025
 - discussion this evening

Further information

French interests in DRD WPs per institute (FCC-ee only) (1)

- APC
 - DRD3 - WP1 : MCMOS VD, CT/Wrapper (TL?) - [all concepts](#), ECAL - [ILD',CLD](#)
 - DRD6 - WP2 : NLG-ECAL - [ALLEGRO](#)
- CPPM - AMU
 - DRD3 - WP1 / DRD 7.3 : MCMOS VD, CT/Wrapper (TL?) - [all concepts](#), ECAL - [ILD',CLD](#)
 - DRD3 - WP2 : LGAD TL - [all concepts](#), ECAL - [ILD',CLD](#)
 - DRD3 - WP4 / DRD 7.6 : interconnection - [all concepts](#)
 - DRD4 - WP4.2 : material optical TL - [all concepts \(IDEA\)](#)
 - DRD6 - WP2 : NLG-ECAL - [ALLEGRO](#)
 - DRD 7.5 : no back-end - [all concepts](#)
- IJCLab
 - DRD1 - WP2 : Drift Chamber at IJCLab, Ganil, LPSC - [IDEA](#), [ALLEGRO](#)
 - DRD6 - WP1 : SiW-ECAL - [ILD', CLD](#)
 - DRD6 - WP2 : NLG-ECAL - [ALLEGRO](#)
 - DRD6 – WP3 : GRAiNITA - [IDEA'](#)
- IPHC
 - DRD3 - WP1 / DRD 7.6 : MCMOS VD, CT/Wrapper (TL?) - [all concepts](#), ECAL - [ILD',CLD](#)
 - DRD7 – WP7.2 : Intelligence On-Detector ? - [all concepts](#)

French interests in DRD WPs per institute (FCC-ee only) (2)

- IP2I
 - DRD1 - WP6 / DRD6 – WP1 : RPC T-SDHCAL - [ILD', CLD](#); (RPC muon hodoscope/tagger - [all concepts](#) ?)
 - DRD3 - WP1 / DRD7.3-7.6 : MCMOS VD, CT/Wrapper(TL?) - [all concepts](#); ECAL - [ILD', CLD](#)
 - DRD3 - WP4 / DRD 7.6 : interconnection [all concepts](#)
 - DRD4 - WP4.2 : nano-MCP optical TL - [all concepts \(IDEA\)](#)
- IRFU
 - DRD1 - WP1 : Micromegas large size, high rates – muon hodoscope/tagger - [all concepts](#), HCAL - [ILD', CLD](#)
 - DRD1 - WP4 : Time Projection Chambers IBF with electronics for MicroMegas readout - [ILD', ALLEGRO](#)
 - DRD1 - WP5 / DRD 7.3 : Timing Layer with MicroMegas - [all concepts](#)
 - DRD3 - WP1 / DRD 7.3 : MCMOS VD, CT/Wrapper (TL?) - [all concepts](#), ECAL - [ILD', CLD](#)
 - DRD7 – WP7.1 : Wireless Data Transmission And Powering – [all concepts](#)
- LLR
 - DRD6 - WP1 : SiW-ECAL - [ILD', CLD](#)
- LPC-CF
 - DRD6 - WP2 : GRAiNITA - [IDEA'](#), (precision timing electronics for LHCb SpaCal)
- LPSC
 - DRD7 – WP7.1 : Wireless Data Transmission And Powering - [all concepts](#)

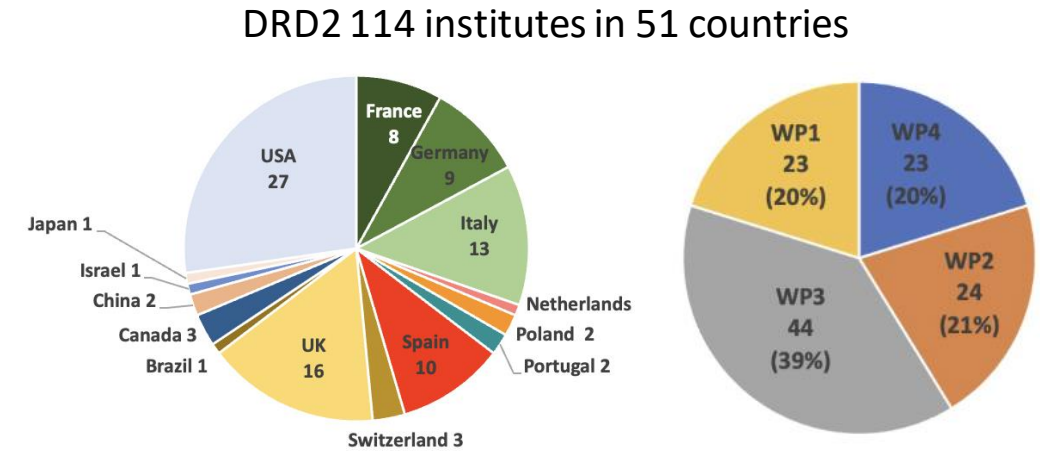
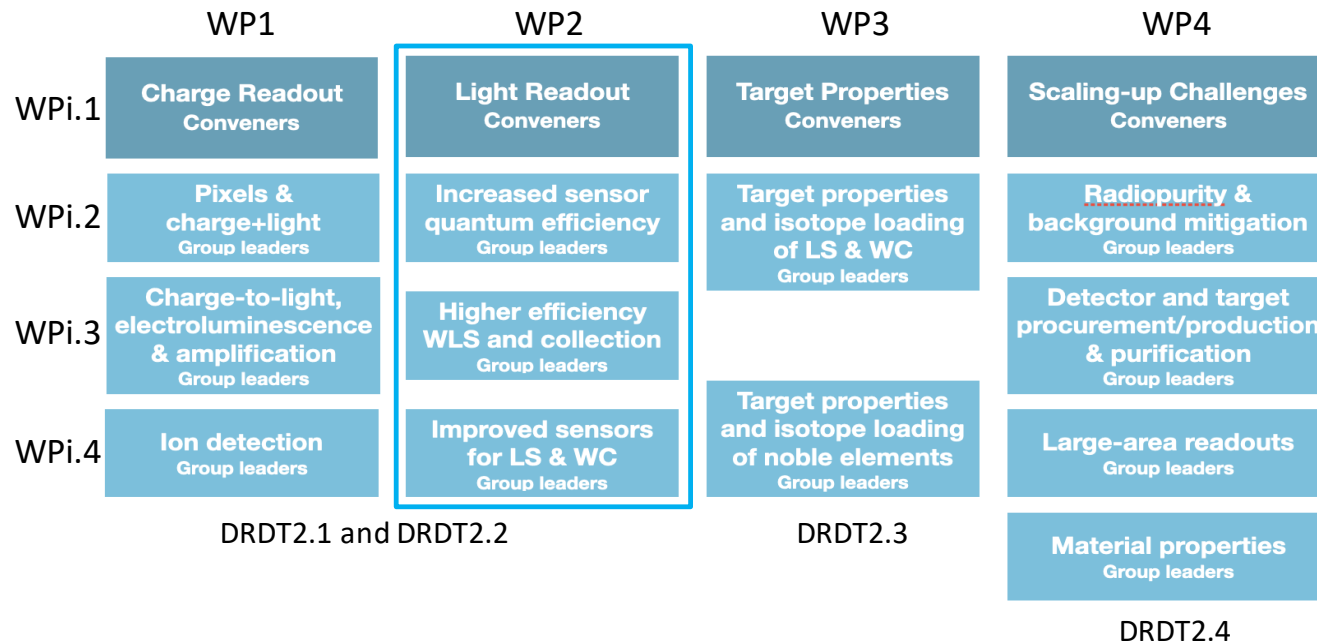
French interests in DRD WPs per institute (FCC-ee only) (3)

- LI2P
 - DRD6 - WP2 : GRAiNITA - **IDEA'**, (precision timing electronics for LHCb SpaCal)
 - DRD7 – WP7.2 : Intelligence On-Detector ? - **all concepts**
- LPNHE
 - DRD3 - WP1 : MCMOS VD, CT/Wrapper(TL?) -**all concepts**; ECAL - **ILD', CLD**
 - DRD3 - WP4 / DRD7.6: interconnection - **all concepts**
 - DRD6 - WP1 : SiW-ECAL - **ILD', CLD**
 - DRD6 - WP2 : NLG-ECAL - **ALLEGRO**
- Omega :
 - DRD6 - WP1 / DRD7.3 : SiWECAL, RPC TSDHCAL, AHCAL - **ILD', CLD**
 - DRD6 - WP2 : NLG-ECAL - **ALLEGRO**

DRD2: Liquid Detectors

Water Cerenkov, Noble Liquids, Liquid Scintillators for DM, Neutrino & rare process (ex. $0\nu\beta\beta$)

@ FCC-ee : synergies for photodetectors (SiPM/SPAD) with DRD4 (RICH PID) and DRD6; and for cryogenic operation of readout with DRD6 and DRD7



- WP1.2 (TA3.2) : double phase TPC XELAB at LPNHE – characterization of charge amplification & scalability
- WP3.1 : opaque scintillator TPC LiquidO at IJCLab
- WP3.2 : microphysics of NL liquids, characterize and model of light emission and transport at APC
- WP4.1 : radio assay and material fabrication and selection at CPPM
- WP4.3 : large area readout at LLR, Omega, IRFU (ILANCE)

no direct links to FCC-ee in this contributions

DRD5: Quantum sensors and emerging technologies

sensors with high sensitivity and precision, nano/meta/heterogenous materials enabling new experimental concepts, so far applications in EDM, DM, neutrino, $0\nu\beta\beta$ searches, fundamental forces, ...

TA1	Clocks and clock networks
TA2	Kinetic detectors
TA3	Spin-based sensors Superconducting sensors
TA4	Optomechanical sensors
TA5	Atoms/molecules/ions Atom interferometry
TA6	Metamaterials, 0/1/2D-materials Quantum materials

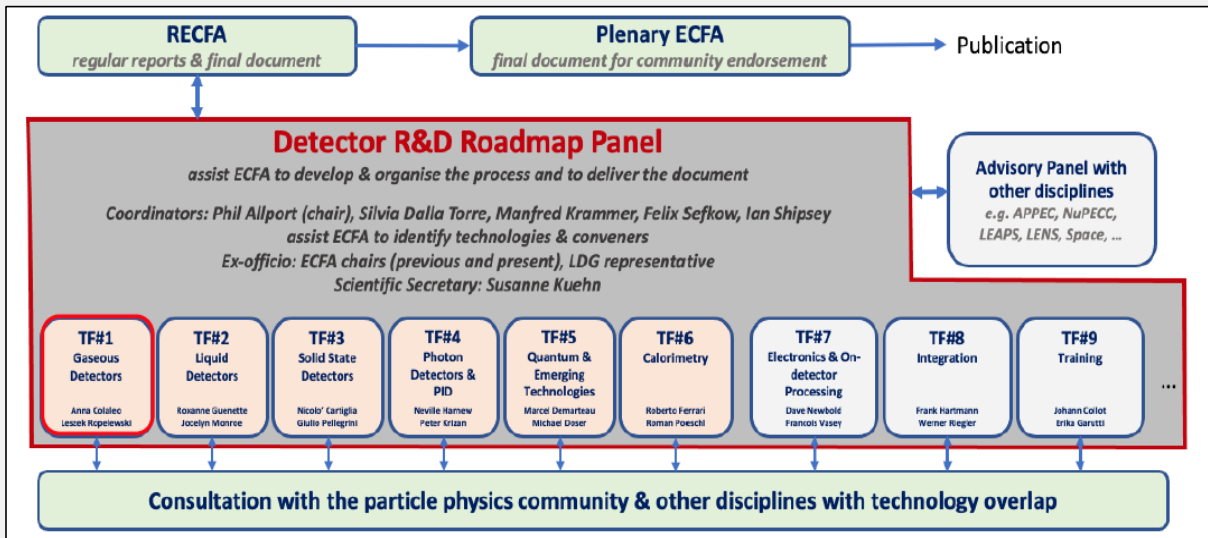
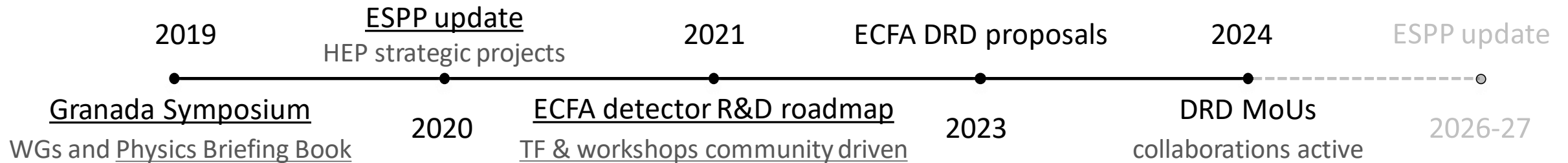
@ FCC-ee :

- WP1 : atomic, nuclear & molecular systems in trap & beam, TA1 and TA5 (TA4)
- WP2 : quantum materials, TA2, TA3, TA4, TA6
- WP3 : large ensembles of quantum sensors (multi-modal)
- WP4 : scaled-up “quantum for HEP”, (TA2), TA3, (TA4),TA5
- WP5 : quantum techniques for sensing, TA1-5
- WP6 : networking, training, shared expertise and infrastructure (all TAs)

Opening window for new detector concepts?

40 institutes in 15 countries, 25 proposed contributions - French interests (IML Univ. Lyon in TA6) ?

Steps toward a long term detector R&D program



10 Global Recommendations
 GSR4: international coordination & organization of R&D activities
 GSR6: establish long term strategic funding program

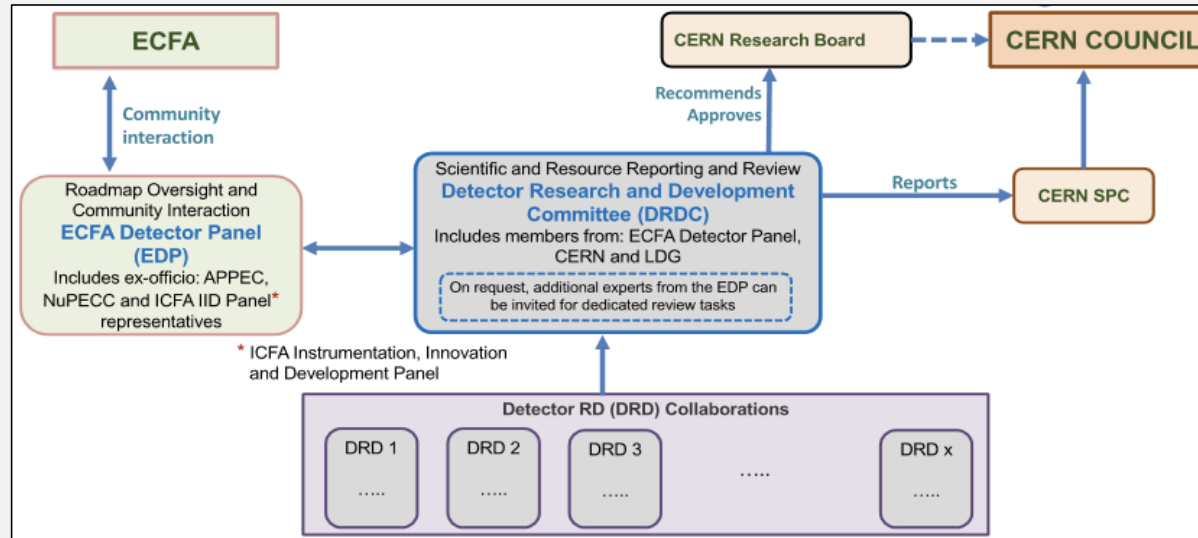
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 Form international DRD collaborations
 hosted at CERN ([CERN/SPC/1190](https://cern.ch/spc/1190))

Framework for DRD collaborations

similar to general conditions for execution of experiments at CERN
with a dedicated Detector R&D review Committee and MoU with Funding Agencies

Co-chairs:	Phil Allport (Birmingham) Didier Contardo (IP2I Lyon)
Scientific secretary:	Doris Eckstein (DESY)
Gaseous Detectors:	Silvia Dalla Torre (Torino)
Liquid Detectors:	Inés Gil Botella (CIEMAT, Madrid)
Solid State Detectors:	Doris Eckstein (DESY) Phil Allport (Birmingham)
PID & Photon Detectors:	Roger Forty (CERN)
Quantum and emerging Technologies.:	Steven Hoekstra (Groningen)
Calorimetry:	Laurent Serin (IJCLab)
Electronics:	Valerio Re (Bergamo)
Ex Officio:	Karl Jakobs (ECFA Chair) Ian Shipsey (ICFA Detector Panel)
Observer for APPEC	Aldo Ianni (INFN, LNGS)
Observer for NuPECC	Eugenio Nappi (INFN, Unit of Bari)

ECFA Detector Panel



BERGAUER, Thomas	HEPHY, Vienna, Chairperson
Members	
BENTVELSEN, Stan	NIKHEF
BRESSLER, Shikma	Weizmann Institute of Science
BUDKER, Dmitry	Helmholtz Institute Mainz and Johannes Gutenberg
FORTY, Roger	CERN
GEMME, Claudia	INFN and University, Genoa
GIL BOTELLA, Ines	CIEMAT
MERKEL, Petra	Fermilab
PESARESI, Mark	Imperial College
SERIN, Laurent	IJCLab - Laboratoire de physique des 2 infinis
Ex-officio	ECFA Detector Panel (EDP) Chair

DRDC membership

EDP provides input on DRD proposals to the DRDC* in terms of roadmap priorities
it follows up achievements and evolution from experiment concept groups for update of the roadmap

* through its co-chairs, appointed members in the DRDC or via topic-specific experts in the conduct of the DRDC reviews