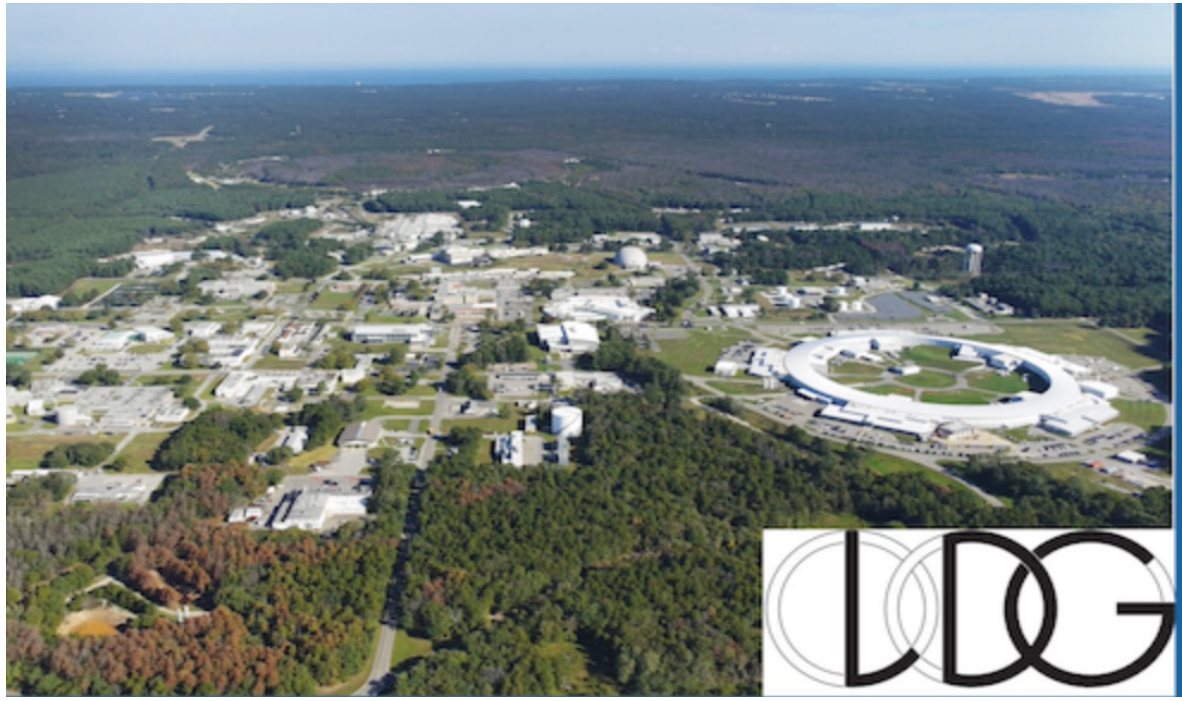


European Laboratory Directors Group Meeting and Accelerator R&D Workshop

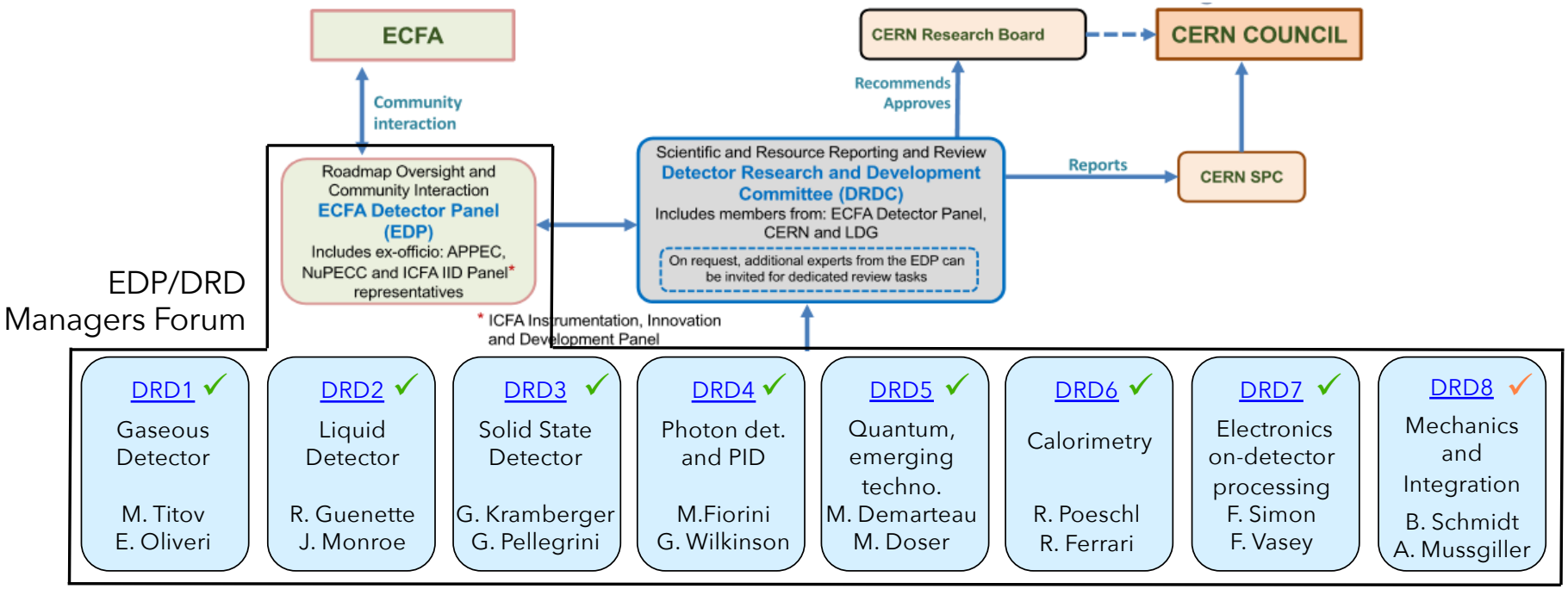
6–7 Jun 2024, Brookhaven National Laboratory

Detector R&D in Europe

D. Contardo IP2I-CNRS/N2P3

New DRD collaborations hosted at CERN (framework)

follows general conditions for execution of experiments at CERN



✓ approved by CERN RB*, ✓ DRD8 LoI submitted to DRDC, proposal aims end-2024

DRDC wep page and presentations of DRDs at open sessions

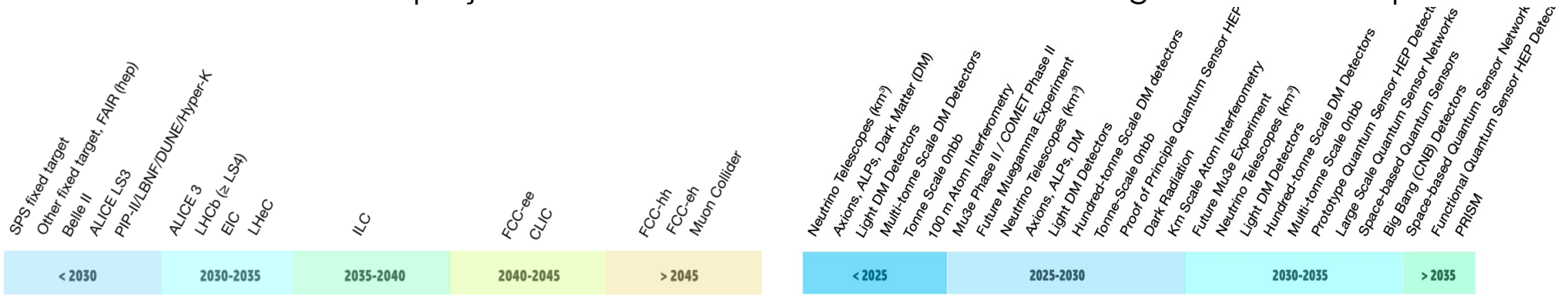
** approvals cover a period of three years – to be renewed*

DRDs address "strategic programs" identified in ECFA detector roadmap

covering 3 ≲ TRL ≲ 6 in between "blue sky" and "specific system engineering"

upgrades and future large accelerator projects

small accelerators, nuclear reactors, cosmic rays second and third generation of experiments



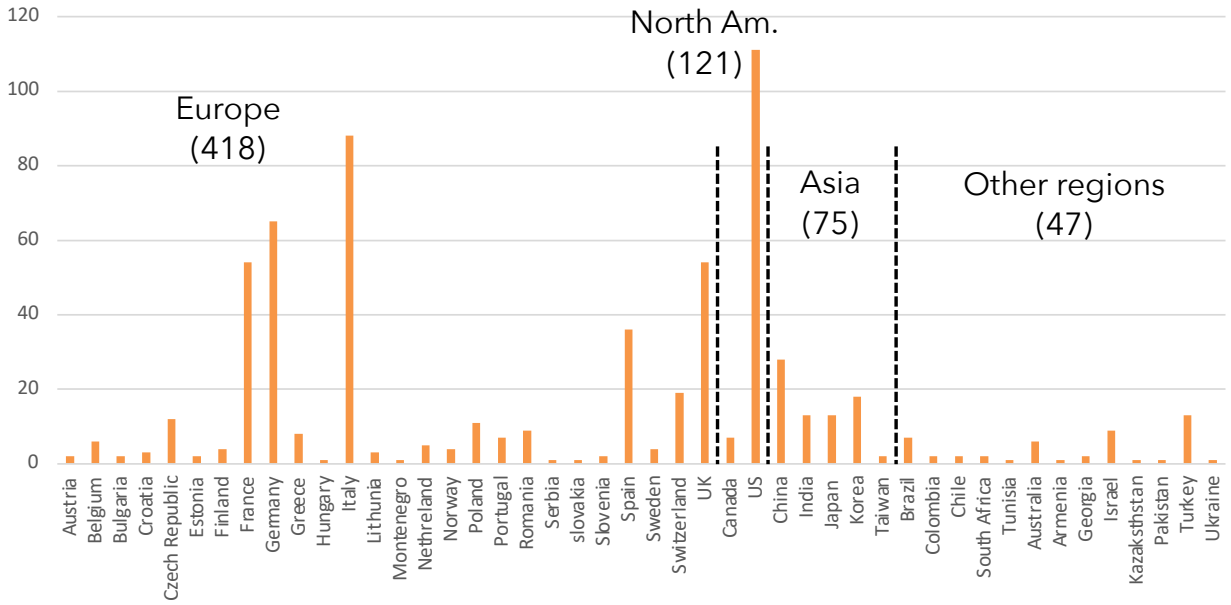
DRD1 gaseous	DRD3 solid state	DRD4 photon & PID	DRD6 calorimeter	DRD2 liquid	DRD5* quantum & emerging techno.

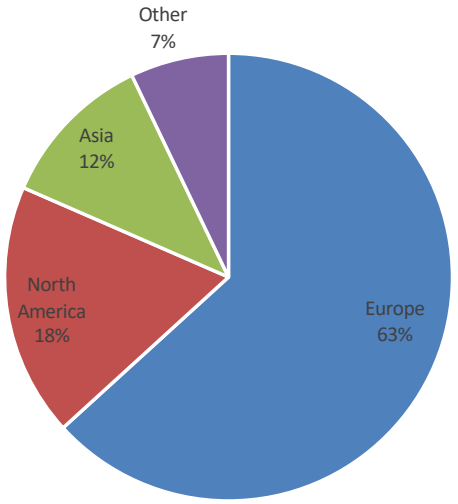
Transverse areas DRD7 electronics and on-detector processing - DRD8 mechanics and cooling

** DRD5 also transverse to other DRDs*

DRD international contributions

661 institute contributions in 46 countries
summed over DRD1, DRD2, DRD3, DRD4, DRD6 and DRD7*





Large participation for ambitiuous developments

available resources from initial estimates (bottom-up & w/o commitments)
seem to be on low side ≃ 2/3 & 1/2 for manpower & funding
some ramp-up expected with completion of current projects (HL-LHC upgrades…)

** several intstitutes contribute to more than one DRD (multiple counting), also some industrial or other partners outside HEP included*

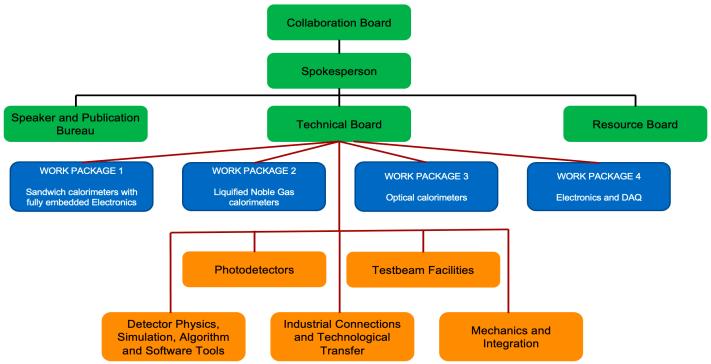
Progress of DRD collaborations implementation

- Most DRDs have established Collaboration Boards
  - endorsed organisation, SP team, WP/WG conveners
  - DRD2, DRD5, DRD7 still with interim managements
- WP/WG meetings started to establish collaborative work
  - consolidation of "deliverables" list and timeline; loaded with contributors and associated resource needs and availability

➢ Aim for MoU to be ready by end-2024
  - annexes will contain manpower and funding pledge associated to deliverables* and possibly a common fund**
    - expected to cover few years cycles with flexibility to close/open new lines within the cycles

➢ MoUs can be updated and will be vetted by FAs in a Finance Review Committee every year

typical organisation ex. DRD6



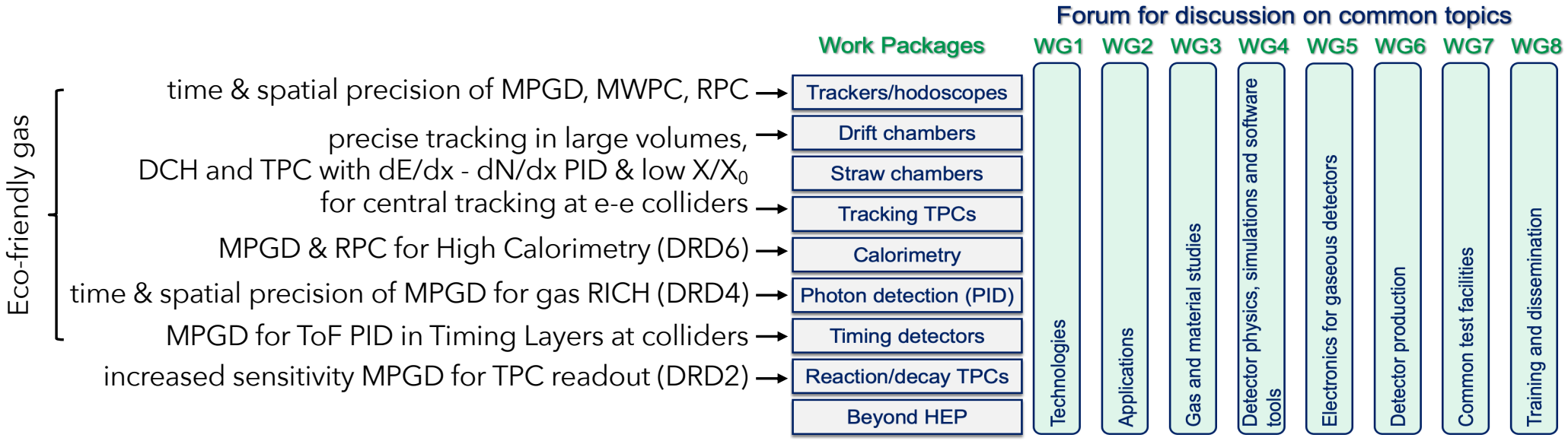
- management bodies
- Work Packages – contain "deliverables"
- Working Groups - transverse activity forums

** can include non recurrent funding from national grants or international programs (ex. EU AIDAinnova…)*

*** common fund can cover cost of running* collaboration, common infrastructures and projects, dissemination…

DRD1 "Gaseous Detectors" program highlights

165 institutes in 34 countries



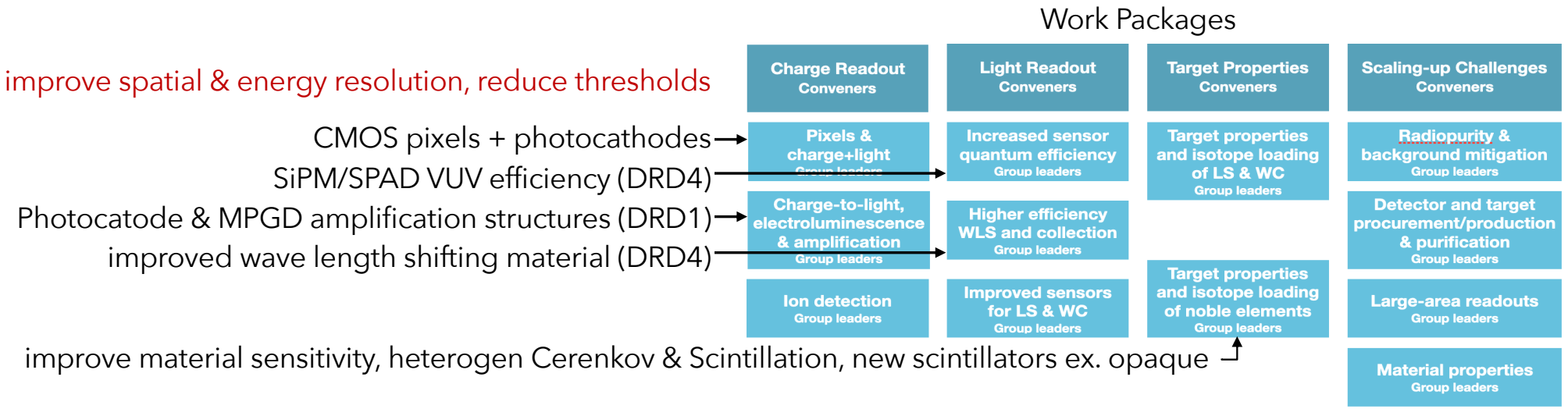
Broad brush "deliverable" program, 1st phase (≃ 3-4 years)

- review of SoA - small size demonstration of new sensing structures
- prepare new readout components
- produce, evaluate larger scale full prototypes

DRD2 "Liquid Detectors" program highlights

Water Cerenkov, Noble Liquids, Liquid Scintillators for DM, Neutrino, 0νββ, rare decays

78 institutes in 15 countries



Broad brush "deliverable" program, 1st phase (≃ 3-4 years)

provide technical solutions for first round of detector scaling

** further resource https://indico.cern.ch/event/1367848/timetable/#20240205*

DRD3 "Solid State Detectors" program highlights

143 institutes in 30 countries

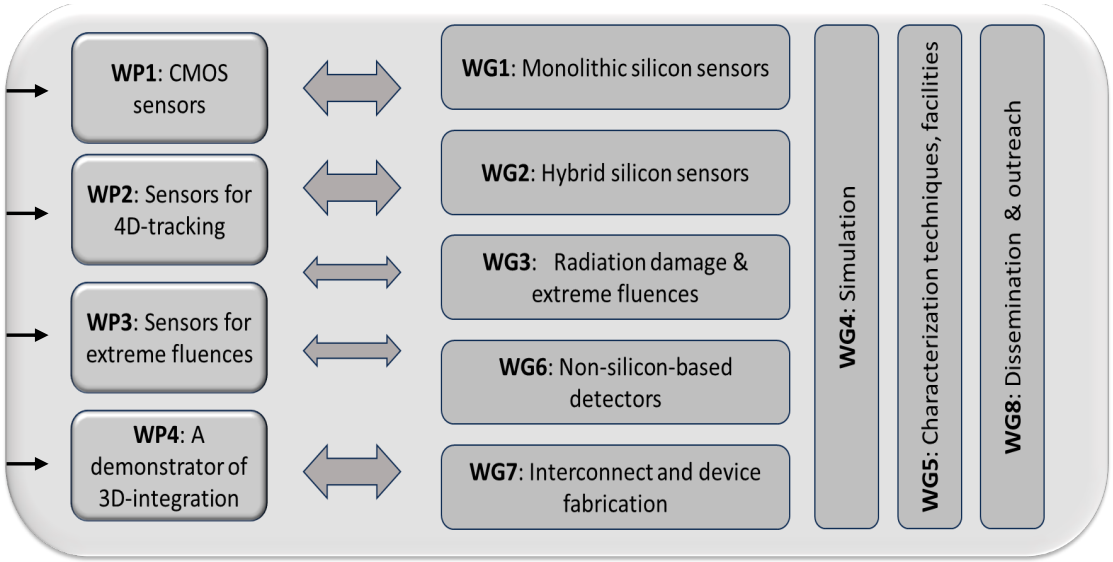
collapse propert ies

granularity in large size sensors at low power
few different processes
extend from VD to CT/Calo., implement σ_t

time & spatial resolution for ToF layers/ 4D tracking
LGAD and 3D hybrid sensors

increase radiation tol., Silicon and WBG materials
longer-term projects

3D integration of electronics



Broad brush program 1st phase (≃ 3-4 years)

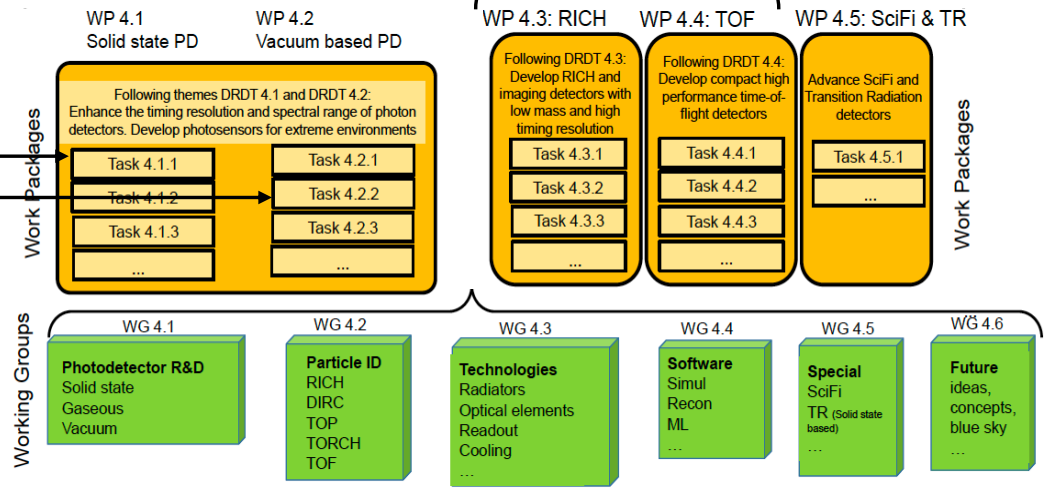
- evaluate foundry process phase space of parameters & performance
  - so far ≠ process privileged for ≠ applications in VD, CT, HGC, TL
  - targeting earlier projects - ITS3, EPIC, ALICE-3, LHCb-II, Belle-3, CMS/ATLAS LS4
- select process(es) for specific performance/application in 2nd phase
- prepare for 3D interconnection demonstrators in 2nd phase (w/ DRD7)

DRD4 "Photon and PID" program highlights

76 institutes in 18 countries

improve resolution and timing in RICH with new radiator materials, link to DRD1 for eco-friendly gas
new hetrogenous and light concepts for large momentum range
improve time resolution in ToF layers, link to DRD6 for scintillating materials

improve timing resolution, spectral range, and rad. tol.
of Photo-Detectors: solid state SiPM/SPADs
vacuum based MCP-PMT
link to DRD2 and DRD6 with focus on single/low
photon number (gaseous PD are in DRD1)



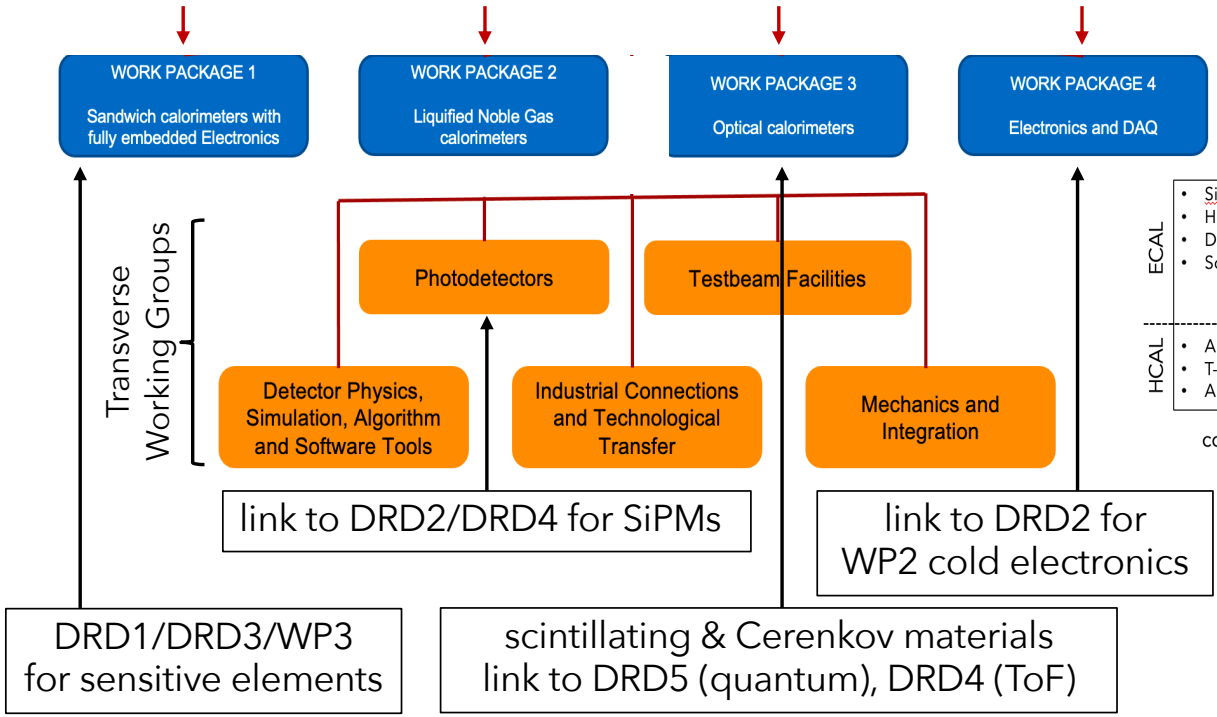
Broad brush program, 1st phase (≃ 3-4 years)

- PD: evaluation of SoA materials & designs, demonstrators new generation, including SPTR
- RICH: evaluation of SoA radiators and refractive index monitoring, new concept demonstrators
- ToF: mm^2 segmented SiPM arrays

DRD6 "Calorimetry" program highlights

131 institutes in 28 countries

Work Packages: 3 main classes of calorimeters + electronics



15 projects of configuration options and sensing technologies

ECAL

- SiW-ECAL
- Highly Compact calo
- DECAL digital w/ MCMOS pixels
- Sc-ECAL scintillating plastic strips

- LNG LAr/LKr in W/Pb
  - multi-layer PCBs
  - cold electronics
  - Dual Readout ?
  - light cryostat

- MAXiCC homog. ⊥ crystal w/ DR
- HGCCAL homog. // crystal bars
- Crilin quasi-homog. crystal
  - depth segmentation w/ SiPM readout
- GRAiNITA crystal grains in liquid + WLS
  - depth and DR w/ pulse shape digitizer

HCAL

- AHCAL(organic) - ScintGlassHCAL
- T-SDHCAL (RPC) - MPGD-HCAL
- ADRIANO3 DR (RPC/Scint/Glass)

- DRCAL scint./cerenkov fibers
  - single fibres for DR and w/ pulse shape digitizer, also for shower depth
  - absorber production and integration
- ScintCAL quasi-homog.
- TileHCal scint. tiles

common uniformity, hermeticity, mechanical precision

Broad brush program 1st phase (≃ 3-4 years)

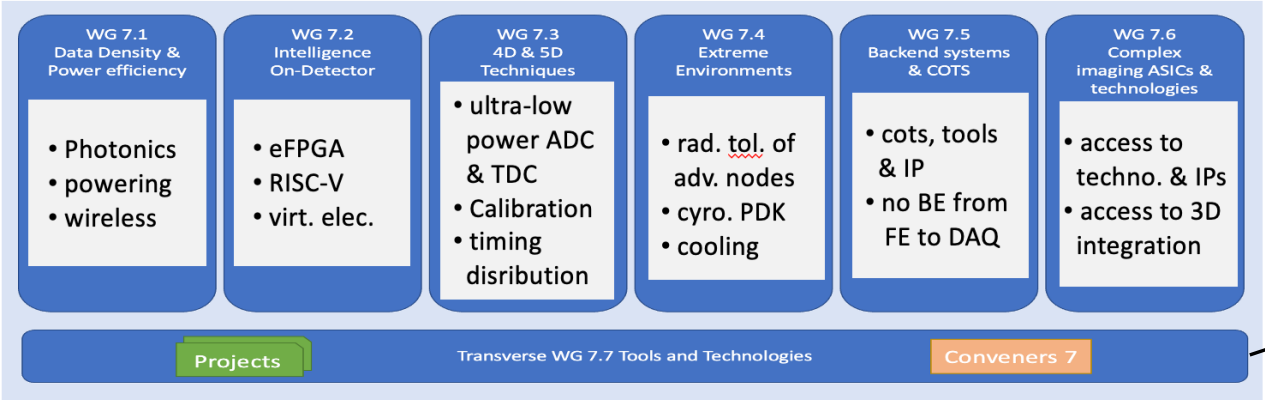
- performance demonstrators w/ SoA sensing and readout electronics
- prepare for "shower-scale" prototypes w/ new sensing elements (other DRDs) & new readout electronics

DRD7 "electronics and on-detector processing" program highlights

68 institutes in 19 countries

Work Packages - new generation of components

enabling 5D at high channel density & rates, w/ low power dissipation



Transverse Working Group

- disseminate common/standard practice in the community
- provide technology access & tools
- advise DRDs on their electronics projects

propose regional "hub" organization

Broad brush program, 1st phase (≃ 3-4 years)

- target relatively low TRL technologies (for HEP), prepare components, IP blocks in 16 projects
- prepare use of new technologies by other DRDs in 2nd phase
- watch technology (commercial) trends

DRD8 Mechanics & Cooling of future Vertex and Tracking systems

LoI submitted to DRDC in March 2023, proposal aims end-2024

22 institutes expressed interest so far (some outside DRD3)

Proposed Work Packages

- Global/System Design and Integration
  - structures, services, environmental aspects, MDI, sclability, robotics
- Low Mass Mechanics and thermal management
  - materials, advanced manufacturing techniques, embedded cooling
- Detector Cooling
  - evaporative and liquid, gas, connexions and instrumentation
- Design and Qualification Tools
  - open-source software, ML assisted topology optimization, virtual reality, methods for complex 3D integration, connection of CAD tools to Geant

light and compact systems, high mechanical precision, uniformity, hermeticity, stability

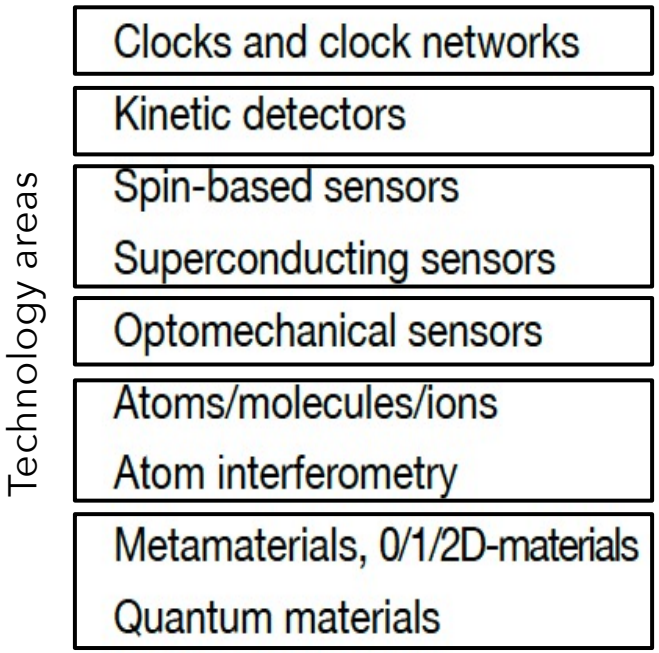
key to measurement precision and to systematic errors

program of deliverables can extend to calorimetry aspects…

** contacts Andreas Mussgiller, Burckard Schmidt*

DRD5 "Quantum Sensors" program highlights

high sensitivity sensors, nano/meta/heterogenous materials
so far applications in EDM, DM, neutrino, 0$\nu\beta\beta$ searches, fundamental forces
96 institutes in 23 countries*, considering platform/hub organization



Work Packages (defined considering and HEP collaborative model)

- atomic, nuclear & molecular systems in traps & beams
- quantum materials
- cryogenic materials, device and systems
- scaled-up quantum
- quantum techniques for sensing
- networking, training, shared expertise and infrastructure

low TRL for collider applications at this stage
some potential identified, particularly for quantum materials
possible synergies for common projects with other DRDs
(to enter their strategic program when TRL ≃ 3)

** ≃ 1/3 HEP + 1/3 outside HEP +1/3 dual*

Outlook

- DRD collaborations are becoming active
  - new institutes can join through established Collaboration Boards
  - organization of common work within DRDs is taking shape
  - resource needs and funding will clarify with preparation of MoU
    - ➢ in this process interfaces to national or EU programs are considered (ex. CPAD, AIDAInnova)
- Timelines across DRDs and their matching to strategic project
  - are monitored through EDP Managers Forum
  - ➢ ESPP updated is an opportunity to assess the situation and prepare next steps
- DRDs are looking forward to LDG Working Group inputs on GSR5 of ECFA Detector Roadmap
  - GSR5 - distributed R&D activities with centralised facilities

DRD resources and contact information: T. Bergauer, DRDC [open session](), June 3 - 2024

ÖAW AUSTRIAN ACADEMY OF SCIENCES

HEPHY INSTITUTE OF HIGH ENERGY PHYSICS

Resources

- Proposals of approved collaborations in [CERN CDS]()
- Collaboration Webpages:
  - https://drd1.web.cern.ch
  - https://drd3.web.cern.ch
  - https://drd4.web.cern.ch
  - Remaining to follow…
- Indico: Category "Experiments / R&D
  https://indico.cern.ch/category/6805/
  - Almost every collaboration had one or several collaboration meetings already
  - Week 17-21 June: DRD1,3 & 4
- Many Mailinglists:
  - Check [CERN Egroups]() and search for "drd"

DRD1 Development of Gaseous Detectors	93 events
DRD2 Liquid Detectors	1 event
DRD3 Solid State Detectors	23 events
DRD4 Photon Detectors and Particle ID	26 events
DRD5 Quantum and Emerging Technologies	empty
DRD6 Calorimetry	14 events
DRD7 Electronic Systems	18 events
DRD National Coordination	8 events