DRD5 aka RDq

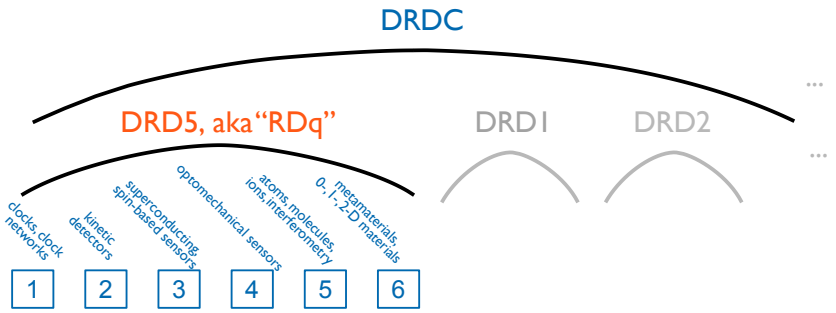
Michael Doser, Marcel Demarteau
April 3-6, 2023

Implementation Planning

RDq / DRD5

The mission of RDq is to:

i) Promote the development of advanced quantum sensing technologies;
ii) Investigate and adapt state-of-the-art developments in quantum technologies to particle physics;
iii) Establish the necessary frameworks and mechanisms to allow exploration of emerging technologies;
iv) Develop and provide advanced enabling capabilities and infrastructure.



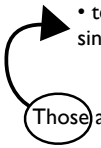
6 families identified in ECFA roadmap

the goals are *not* linked to CERN (nor accelerator-based particle physics) *specifically*

They cover the full range of particle physics, from ultra-light particles/ fields all the way up to particles produced at accelerators, including tests of fundamental symmetries.

The idea is to look at the required technologies to advance promising approaches, and to focus on those that are beyond the capabilities of groups working in isolation;

- not to merely monitor advances, but to actively drive them.
- some of the technologies being contemplated may drop out - in spite of their interest - since they do not require collaboration across groups and/or fields in order to be developed and pursued.
- technologies that do however require collaboration are at risk of not being developed, since they either require too many resources, or too much multi-disciplinary knowledge.



Those are the 'work packages' we'd be looking for and that would justify a global collaboration

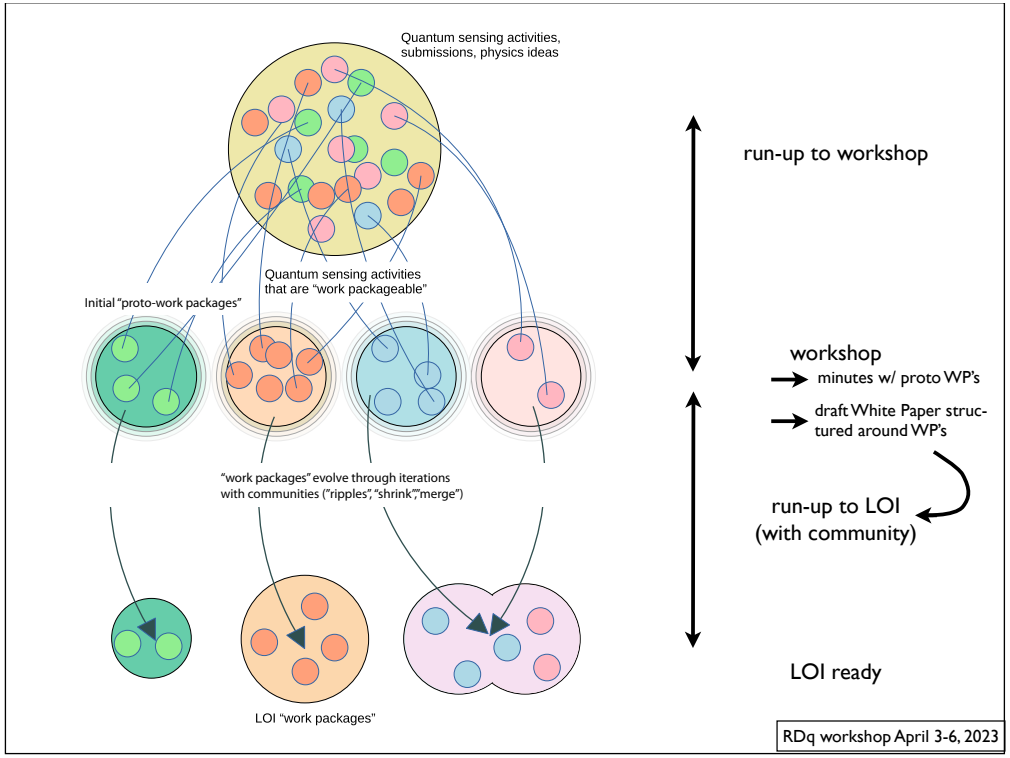
we need to follow a pre-defined process:

ECFA, CERN, funding agencies, evaluation boards (DRDC): they are geared to understand:

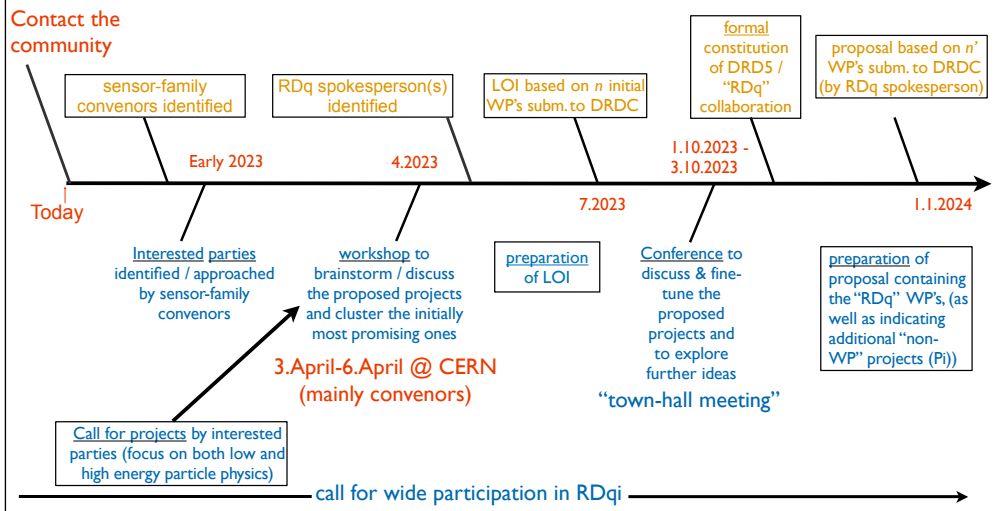
- collaborations
- proposals
- memoranda of understanding

If we can define particular 'work packages' that would justify a global collaboration,
then pursuing those is most straightforward if we:

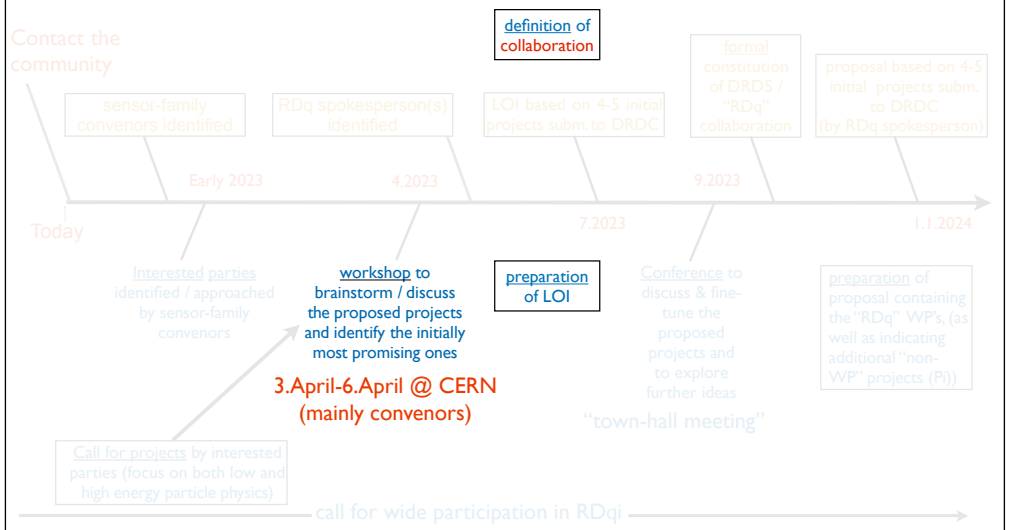
- form a collaboration,
- submit a proposal listing the work packages
- sign a memorandum of understanding


Quantum sensing activities,
submissions, physics ideas
Quantum sensing activities
that are "work packageable"
Initial "proto-work packages"
"work packages" evolve through iterations
with communities ("ripples", "shrink","merge")
LOI "work packages"
run-up to workshop
workshop
minutes w/ proto WP's
draft White Paper struc-
tured around WP's
run-up to LOI
(with community)
LOI ready
RDq workshop April 3-6, 2023

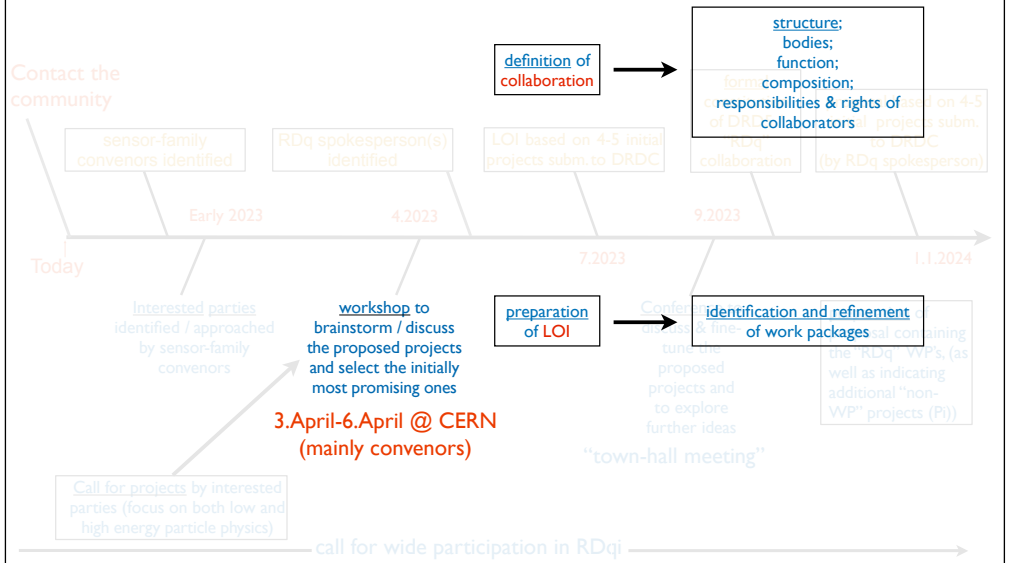
Rough Timeline



goal of this workshop



goal of this workshop



two main hoped-for expected outcomes of the workshop

• proto-work packages around which the work packages that will form the proposal for technical developments will cluster;

→ draft White Paper structured around WP's

• and draft structure of the collaboration that should be formed to carry out the work).

→ draft structure for LoI

next steps after that

After the workshop, we'll publicize these and - more importantly - open the door to all to provide their input, shape the process, etc.

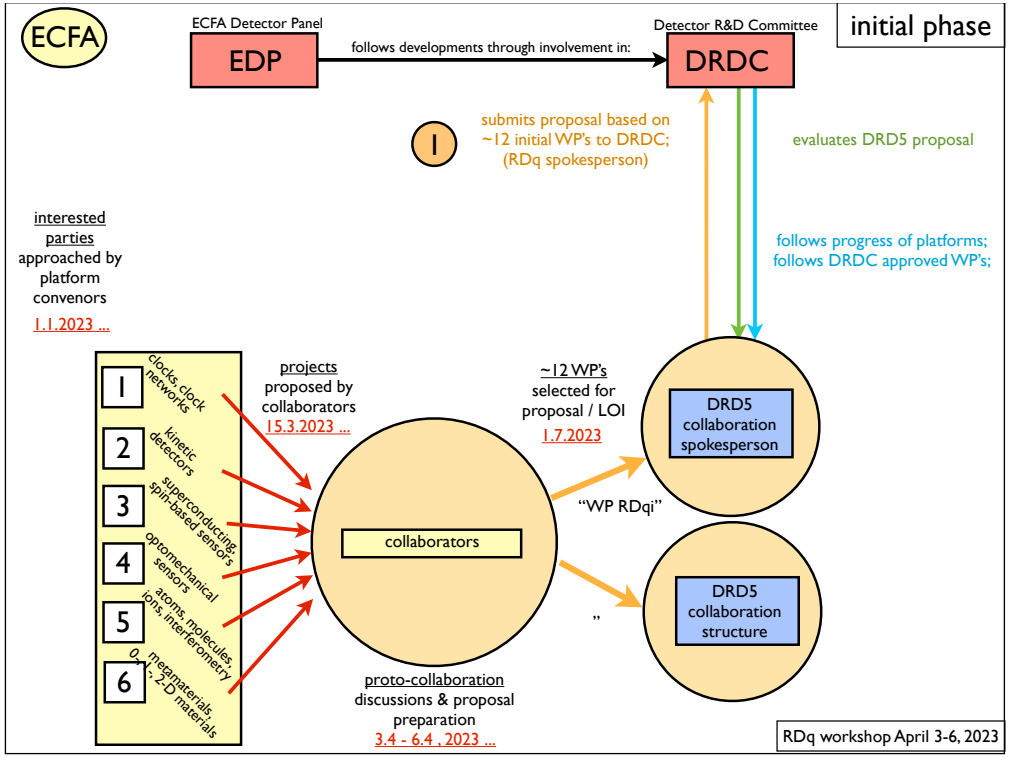
This sequence addresses the problem that kick-starting something like this in a full room is harder than taking it in two steps,

• a first one to provide some rough targets (which is what the output of this workshop should provide) - "crystallization centers"

• and then an open process with contributions from all

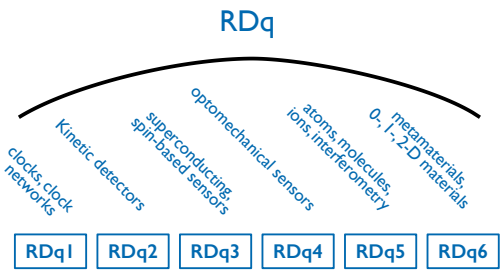
that will hopefully result in clarifying / detailing:

- WP's
- groups interested in participating
- cost of WP

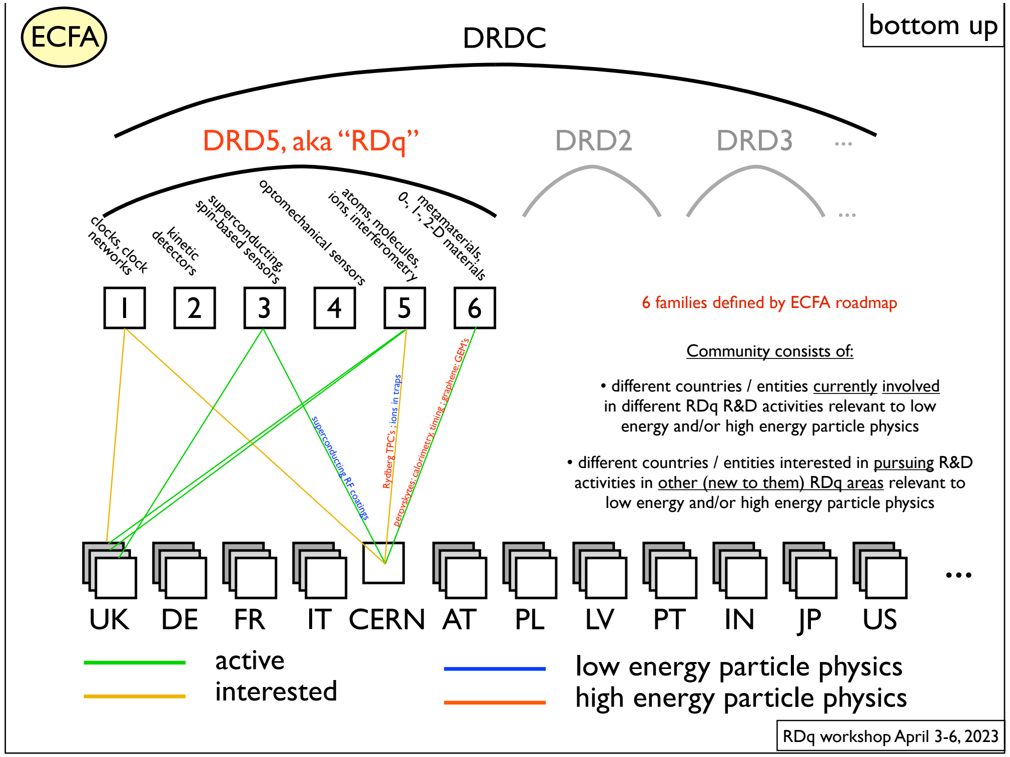

ECFA
ECFA Detector Panel
EDP
follows developments through involvement in:
Detector R&D Committee
DRDC
initial phase
1
submits proposal based on ~12 initial WP's to DRDC; (RDq spokesperson)
evaluates DRD5 proposal
follows progress of platforms; follows DRDC approved WP's;
interested parties approached by platform convenors
1.1.2023 ...
1 clocks, clock networks
2 kinetic detectors
3 superconducting, spin-based sensors
4 optomechanical sensors
5 atoms, molecules, ions, interferometry
6 0, metamaterials, 1-, 2-D materials
projects proposed by collaborators
15.3.2023 ...
collaborators
proto-collaboration discussions & proposal preparation
3.4 - 6.4 , 2023 ...
~12 WP's selected for proposal / LOI
1.7.2023
"WP RDqi"
"
DRD5 collaboration spokesperson
DRD5 collaboration structure
RDq workshop April 3-6, 2023

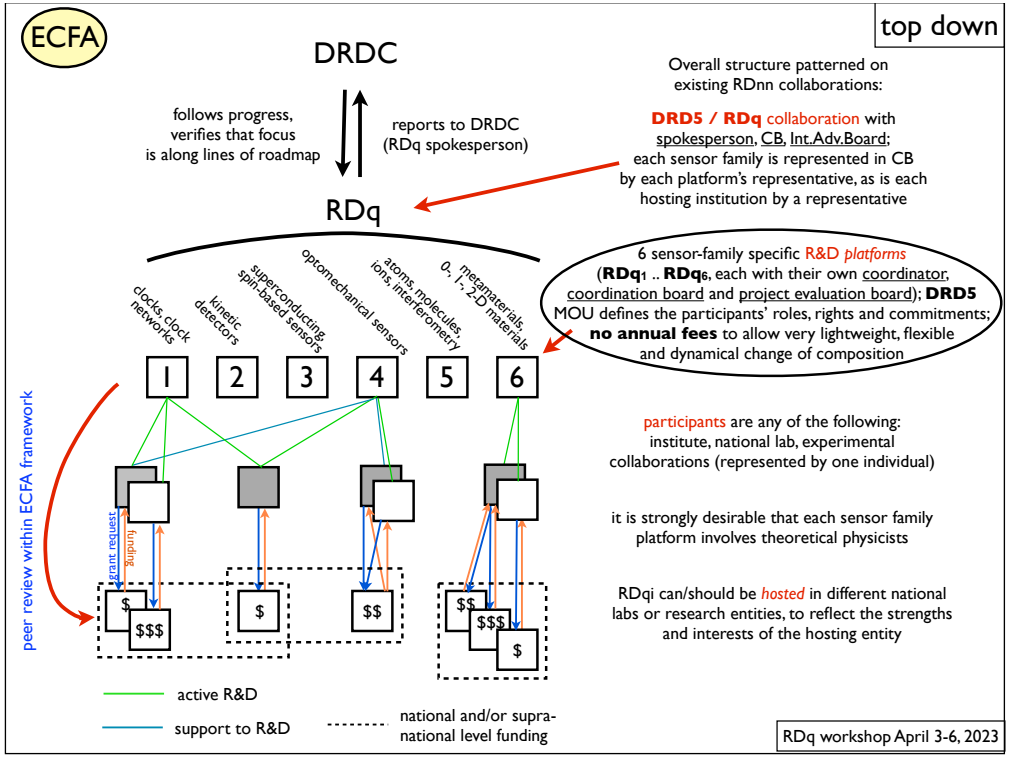
some words on the structure of this collaboration ...

RDq Collaboration and Platforms

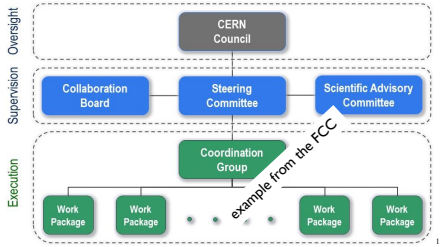


- RDq collaboration anchored at CERN with spokesperson, CB, Int. Adv. Board;
- RDq has 6 sensor-family specific R&D platforms (RDq1 .. RDq6) each with their own coordinator, coordination board and project evaluation board;
- RDqi can and should be hosted in different national labs or research institutions world-wide, to reflect the strengths and interests of the hosting entity
- Attempt to have theoretical physicists involved in each platform

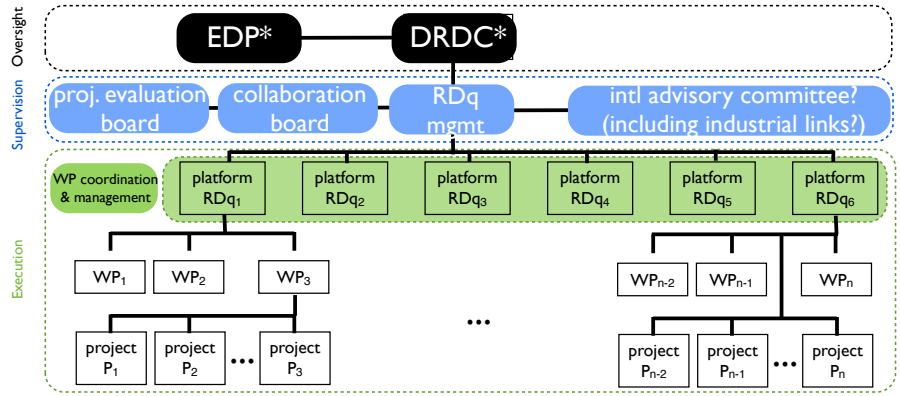

ECFA
DRDC
bottom up
DRD5, aka "RDq"
DRD2
DRD3
...
clocks, clock networks
kinetic detectors
superconducting, spin-based sensors
optomechanical sensors
atoms, molecules, ions, interferometry
metamaterials, 0-, 1-, 2-D materials
1
2
3
4
5
6
superconducting RF coatings
Rydberg TPC's ; ions in traps
perovskytes: calorimetry, timing ; graphene: GEM's
UK
DE
FR
IT
CERN
AT
PL
LV
PT
IN
JP
US
...
active
interested
low energy particle physics
high energy particle physics
6 families defined by ECFA roadmap
Community consists of:
• different countries / entities currently involved in different RDq R&D activities relevant to low energy and/or high energy particle physics
• different countries / entities interested in pursuing R&D activities in other (new to them) RDq areas relevant to low energy and/or high energy particle physics
RDq workshop April 3-6, 2023


ECFA
DRDC
top down
follows progress,
verifies that focus
is along lines of roadmap
reports to DRDC
(RDq spokesperson)
Overall structure patterned on
existing RDnn collaborations:
DRD5 / RDq collaboration with
spokesperson, CB, Int.Adv.Board;
each sensor family is represented in CB
by each platform's representative, as is each
hosting institution by a representative
RDq
clocks, clock networks
kinetic detectors
superconducting, spin-based sensors
optomechanical sensors
atoms, molecules, ions, interferometry
0-, 1-, 2-D materials, metamaterials
1
2
3
4
5
6
6 sensor-family specific R&D platforms
(RDq1 .. RDq6, each with their own coordinator,
coordination board and project evaluation board); DRD5
MOU defines the participants' roles, rights and commitments;
no annual fees to allow very lightweight, flexible
and dynamical change of composition
peer review within ECFA framework
grant request
output
$
$$
$$$
participants are any of the following:
institute, national lab, experimental
collaborations (represented by one individual)
it is strongly desirable that each sensor family
platform involves theoretical physicists
RDqi can/should be hosted in different national
labs or research entities, to reflect the strengths
and interests of the hosting entity
active R&D
support to R&D
national and/or supra-
national level funding
RDq workshop April 3-6, 2023

collaboration structure

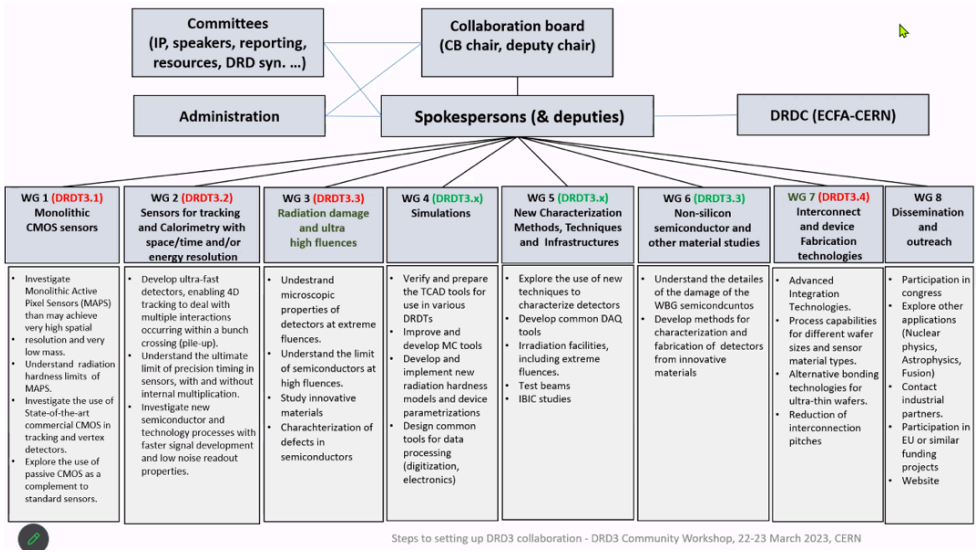


https://fcc.web.cern.ch/Documents/Organisation/FCC-1409051000-JGU_GovernanceStructure_V0200.pdf



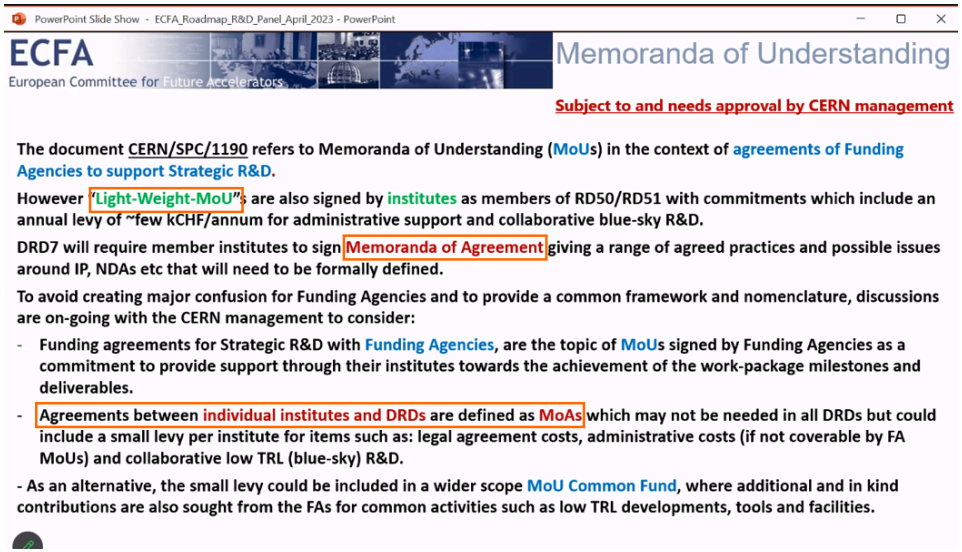
*EDP: ECFA Detector Panel *DRDC: Detector R&D Committee

example from DRD3



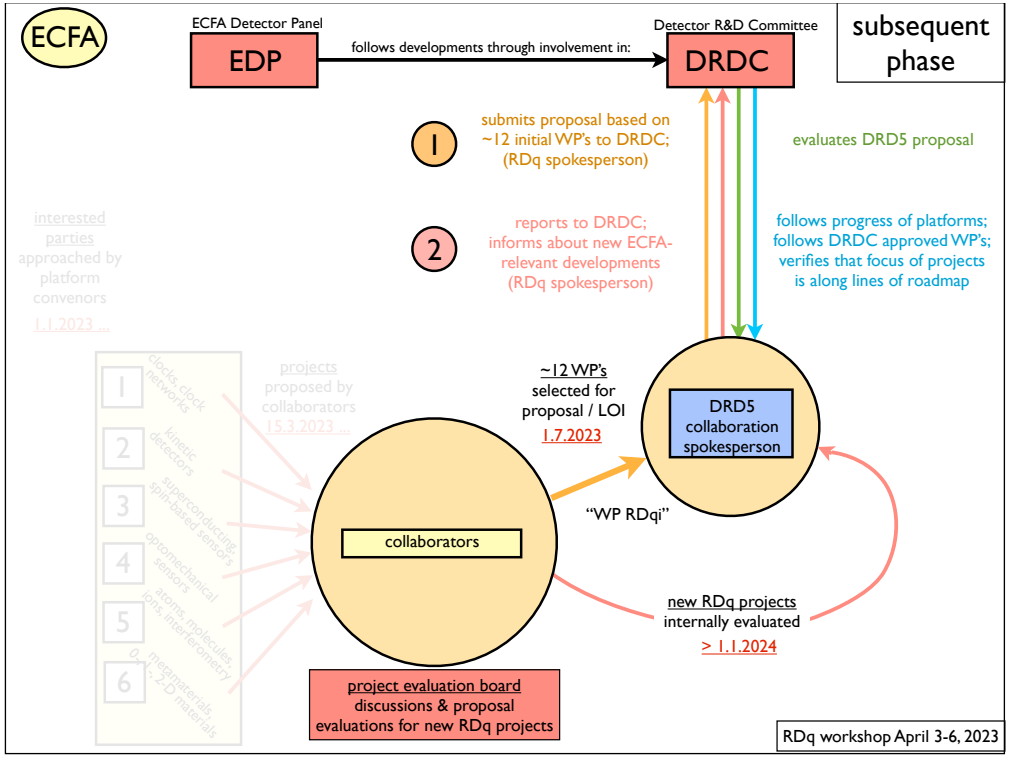
RDq workshop April 3-6, 2023

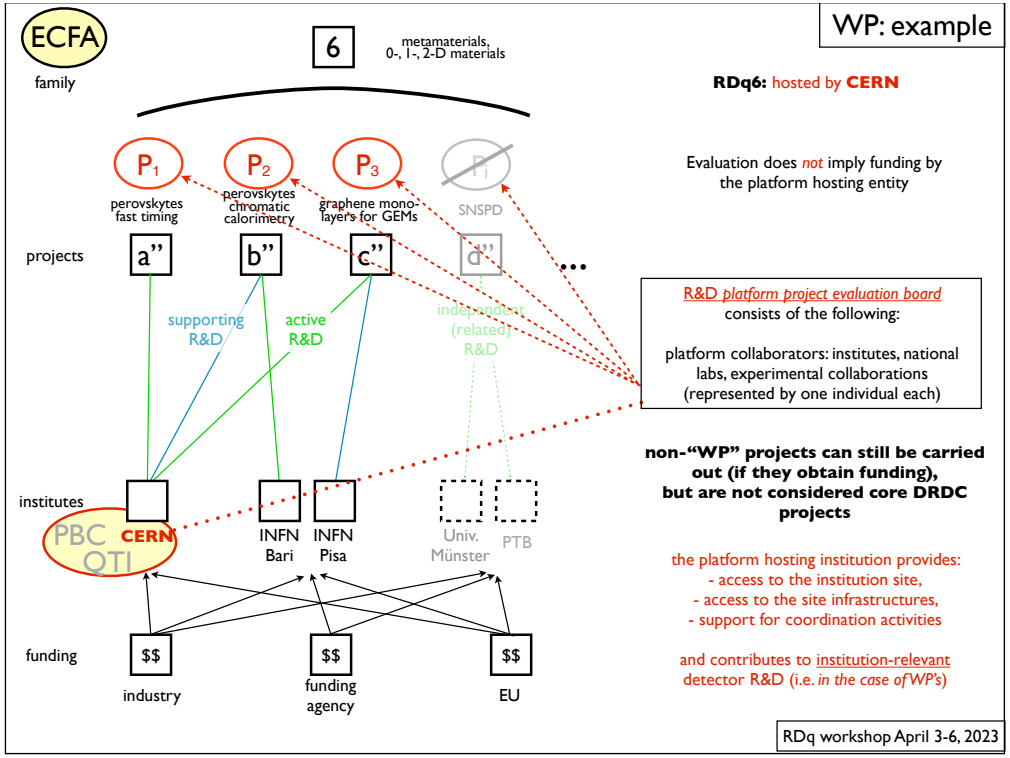
(from ECFA implementation meeting April 3, 2023)

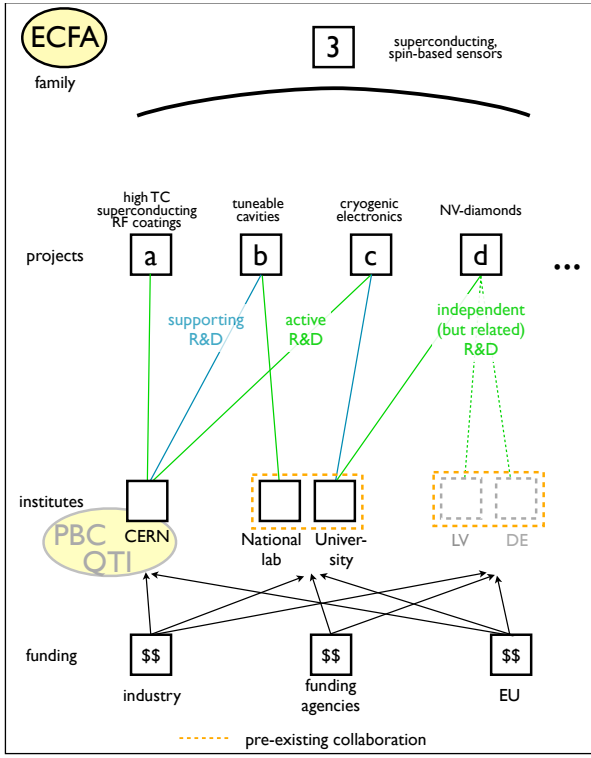


on-going discussion between ECFA - CERN - DRD's ...
("having annexes to MOU is reasonable";"bi-annual updates to add/remove work packages")

some words on (further?) functions of this collaboration ...


ECFA
ECFA Detector Panel
EDP
follows developments through involvement in:
Detector R&D Committee
DRDC
subsequent phase
1
submits proposal based on ~12 initial WP's to DRDC; (RDq spokesperson)
evaluates DRD5 proposal
2
reports to DRDC; informs about new ECFA-relevant developments (RDq spokesperson)
follows progress of platforms; follows DRDC approved WP's; verifies that focus of projects is along lines of roadmap
interested parties approached by platform convenors 1.1.2023 ...
projects proposed by collaborators 15.3.2023 ...
~12 WP's selected for proposal / LOI 1.7.2023
DRD5 collaboration spokesperson
"WP RDqi"
collaborators
new RDq projects internally evaluated > 1.1.2024
project evaluation board discussions & proposal evaluations for new RDq projects
RDq workshop April 3-6, 2023


WP: example
ECFA
family
6
metamaterials,
0-, 1-, 2-D materials
RDq6: hosted by CERN
P1
P2
P3
P4
perovskytes
fast timing
perovskytes
chromatic
calorimetry
graphene mono-
layers for GEMs
SNSPD
projects
a"
b"
c"
d"
...
supporting
R&D
active
R&D
independent
(related)
R&D
Evaluation does not imply funding by
the platform hosting entity
R&D platform project evaluation board
consists of the following:
platform collaborators: institutes, national
labs, experimental collaborations
(represented by one individual each)
non-"WP" projects can still be carried
out (if they obtain funding),
but are not considered core DRDC
projects
institutes
PBC
QTI
CERN
INFN
Bari
INFN
Pisa
Univ.
Münster
PTB
the platform hosting institution provides:
- access to the institution site,
- access to the site infrastructures,
- support for coordination activities
and contributes to institution-relevant
detector R&D (i.e. in the case of WP's)
funding
$$
industry
$$
funding
agency
$$
EU
RDq workshop April 3-6, 2023



RDqi:

evaluation

• dynamical overview of projects & involved groups; continuous updates of projects' status; dissemination and educational resource

• projects evaluated by family-level project evaluation board based on relevance to sensor family goals *as part of the ECFA roadmap*

possible evaluation criteria include:

• characteristics required for physics goal
• evaluation of impact on results
• staged functionality (e.g. detection, energy, directionality)

but also:

• redundancy of efforts • feasibility • potential
• complementary of approaches • overall cost

typical project time line:

• proof of principle
• basic functionality
• prototype
• functional module

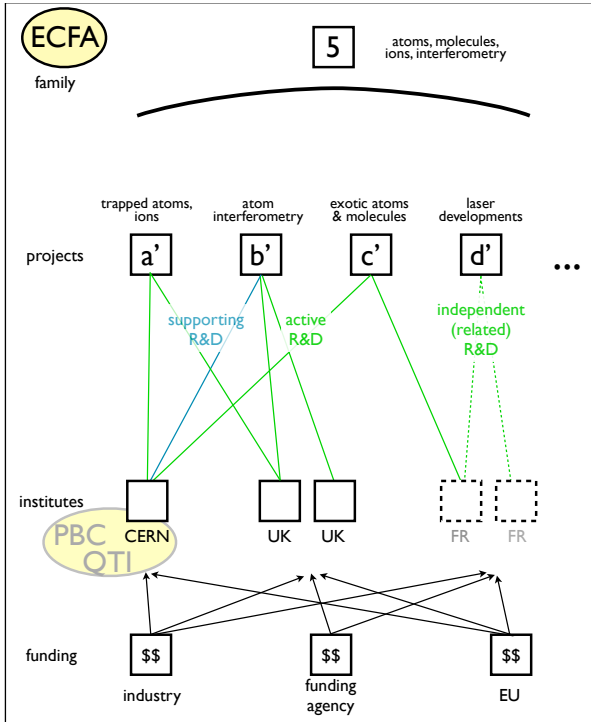
proposals and evaluations may encompass:

• multiple participant institutes / country
• multiple sub-projects / country
• varying levels of funding / project / institute

multiple sources of funding / project / institution

the outcome of the evaluation will help funding agencies judge corresponding individual grant requests and see them in a global context

priorities



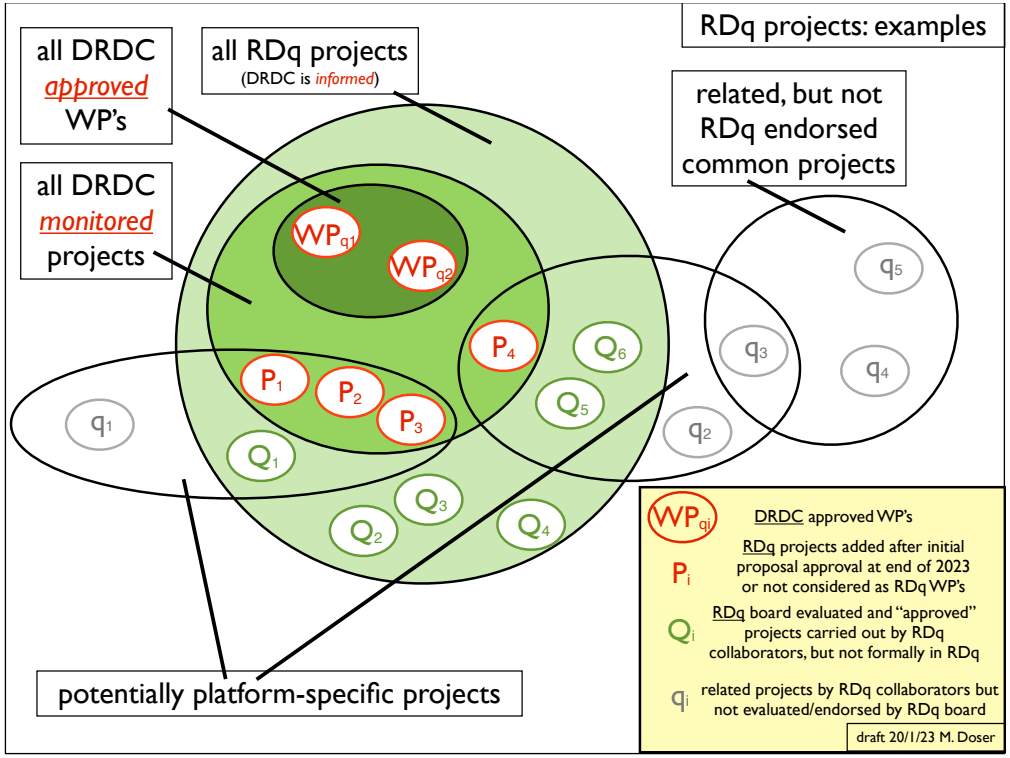
RDqi:

- priorities, focus, research directions for each sensor family to be defined within the platform coord. board (bottom up)

each family ensures balance between projects:
HEP / low energy particle physics / blue sky
40 / 40 / 20

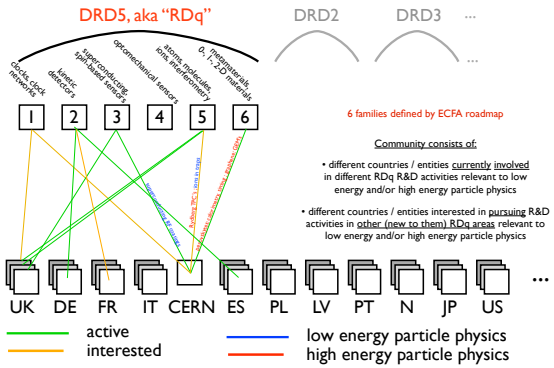
- projects must conform to the ECFA roadmap, and are monitored by the DRDC via the RDq collaboration's regular reviews (top down)
- work carried out at a hosting platform must in addition match the research priorities of that hosting institution

there is no overall funding envelope that would be agreed in advance for each family, since the geographical spread would require unwieldy negotiations; instead, each project (individual institute, consortia) is submitted and evaluated by the relevant funding agencies independently, the only oversight provided by RDqi being the consistency with the ECFA and 40/40/20 balancing goals


RDq projects: examples
all DRDC approved WP's
all RDq projects
(DRDC is informed)
related, but not RDq endorsed common projects
all DRDC monitored projects
WPq1
WPq2
P1
P2
P3
P4
Q1
Q2
Q3
Q4
Q5
Q6
q1
q2
q3
q4
q5
potentially platform-specific projects
WPqj
DRDC approved WP's
Pi
RDq projects added after initial proposal approval at end of 2023 or not considered as RDq WP's
Qi
RDq board evaluated and "approved" projects carried out by RDq collaborators, but not formally in RDq
qi
related projects by RDq collaborators but not evaluated/endorsed by RDq board
draft 20/1/23 M. Doser

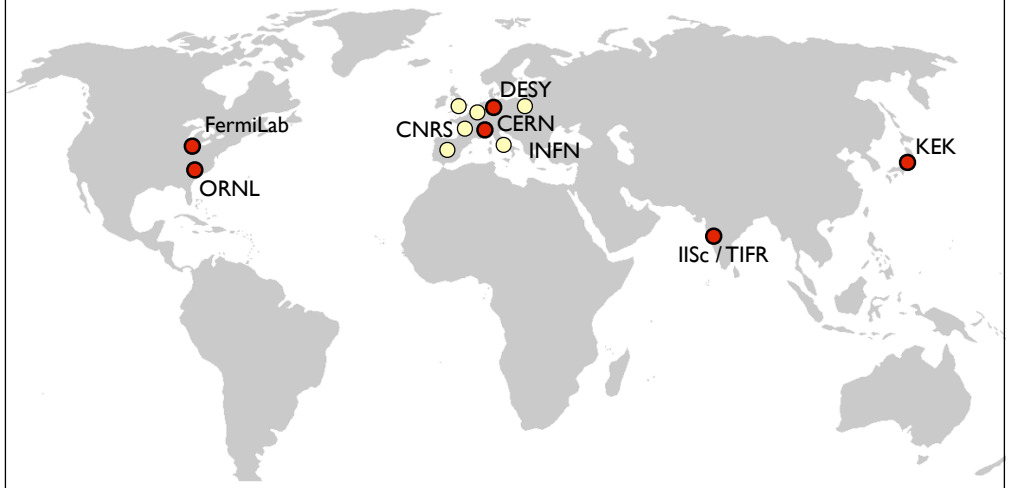
define structure of implementation of TF5:

- formal collaboration ("DRD5", a.k.a. "RDq")
- consists of 6 families of quantum technologies, each with many sub-activities and sub-collaborations



- spread load by hosting families in several platforms

possible platform hosting sites



- possible ECFA TF5 family platforms
- national Quantum initiatives (possibly particle physics-related)

background from ECFA roadmap / TF5 ...

ECFA: TF5

Anna Grassellino, Marcel Demarteau,
Michael Doser, Caterina Braggio,
Stafford Withington, Peter Graham,
John March-Russel, Andrew Geraci

“Recommendations”

- many fascinating opportunities in nascent fields
- encourage exploratory approaches
- adapt funding profiles to both exploratory as well as consolidation approaches:
  - exploratory: funding cycle of 3 years, lightweight grant application, “fail early / fail often / proof-of-principle” mindset
  - consolidation: funding cycle of 10 years, after initial proof of principle, proposal
- importance of interdisciplinarity
  - training not only of early stage researchers but also of established researchers
  - opportunistic (awareness of developments elsewhere - physics or industry)

Open symposium organized by TF5

Anna Grassellino, Marcel Demarteau, Michael Doser, Caterina Braggio, Stafford Withington, Peter Graham, John March-Russel, Andrew Geraci

ECFA Detector R&D Roadmap Symposium of Task Force 5 Quantum and Emerging Technologies

Symposium: April 12, 2021 https://indico.cern.ch/event/999818/

14 presentations

first block covering physics landscape

following blocks focusing on technologies

discussion of three important points

ECFA Detector R&D Roadmap Symposium of Task Force 5: Quantum and emerging technologies

Monday 12 Apr 2021, 09:00 → 18:30 Europe/Zurich

09:00 → 09:15 Introduction

09:15 → 11:00 science targets – Overview and Landscape

9:15 EDM searches & tests of fundamental symmetries Peter Fierlinger / TU Munich

9:45 Tests of QM [wavefunction collapse, size effects, temporal separation, decoherence]

10:15 Multimessenger detection [including atom interferometer or magnetometer networks] Giovanni Barontoni / Birmingham

10:45 Axion and other DM (as well as non-DM Ultra-light) particle searches Mina Arvanitaki / Perimeter Institute

11:15 → 11:30 Coffee break

11:30 → 12:30 Experimental methods and techniques - Overview and Landscape

11:30 Precision spectroscopy and clocks, networks of sensors and of entangled systems [optical atomic clocks] David Hume / NIST

12:00 Novel ionic, atomic and molecular systems [RaF, multiatomic molecules, exotic atoms] Marianna Safranova / U. Delaware

12:30 → 13:30 Lunch break

13:30 → 16:00 Experimental and technological challenges, New Developments

13:30 Superconducting platforms [detectors: TES, SNSPD, Haloscopes, including single photon detection]

14:00 High sensitivity superconducting cryogenic electronics, low noise amplifiers Stafford Withington / Cambridge

14:30 Broadband axion detection Kent Irwin / Stanford

15:00 Mechanical / optomechanical detectors Andrew Geraci / Northwestern

15:30 Spin-based techniques, NV-diamonds, Magnetometry Dima Budker / Mainz

16:00 → 16:15 Coffee break

16:15 → 18:30 Experimental and technological challenges, New Developments

16:15 Calorimetric techniques for neutrinos and axions potential speaker identified

16:35 Quantum techniques for scintillators potential speaker identified

16:55 Atom interferometry at large scales (ground based, space based) Jason Hogan / Stanford

17:25 → 18:15 Discussion session : discussion points
- Scaling up from table-top systems
- Networking – identifying commonalities with neighboring communities
- Applying quantum technologies to high energy detectors

18:15 → 18:30 Wrap-up

Quantum Technologies for High Energy Physics (QT4HEP) (Nov. 1-4, 2022)

https://indico.cern.ch/event/1190278/timetable/

	topics chosen to overlap with CERN focus and expertise
Applications of superconducting technologies to particle detection Caterina Braggio (Univ. Padova (IT))	DM searches via RF, superconducting electronics, coatings, cavities
Scaling up of atomic interferometers for the detection of dark matter Oliver Buchmuller (Imperial College (GB))	AION, MAGIS, ... DM searches via atom interferometers in vertical shaf
Applying traps and clocks to the search for new physics Piet Schmidt (Univ. Hannover / PTB (DE))	AD, ISOLDE: symmetry & BMS tests via precision spectroscopy
Applications of quantum devices to HEP detectors Ian Shipsey (University of Oxford (GB))	Quantum systems for HEP (novel or enhanced detectors)
Molecular systems for tests of fundamental physics Steven Hoekstra (Univ. Groeningen (NL))	AD, ISOLDE: symmetry & BMS tests via precision spectroscopy
Development of detectors for ultra-low energy neutrinos Gianluca Cavoto (Sapienza Universita e INFN, Roma I (IT))	neutrino physics at the low energy frontier (CNB)