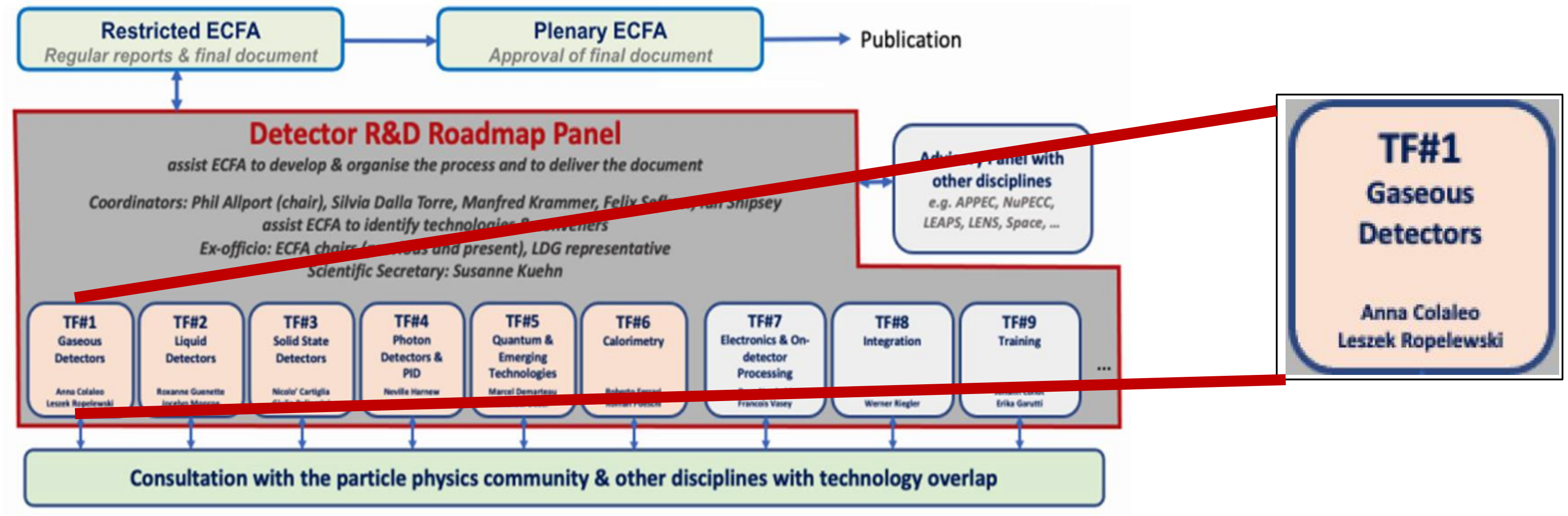
The ECFA Detector R&D Roadmap and implementation: Gaseous detectors

Anna Colaleo (University and INFN Bari), Leszek Ropelewski (CERN)

DRD1 Community meeting 1-3 March 2023

THE 2021 ECFA DETECTOR RESEARCH AND DEVELOPMENT ROADMAP

Detector Roadmap TF1 organization



TF1 Gaseous Detectors team

Conveners: Anna Colaleo (University and INFN Bari) , Leszek Ropelewski (CERN)

Experts: Klaus Dehmelt (SUNY), Barbara Liberti (INFN - Tor Vergata), Maxim Titov (CEA Paris-Saclay), Joao Veloso (University of Aveiro)

Link to the coordination team : Silvia Dalla Torre (INFN Trieste)

Process and Timeline

Expert & Community Consultation

Feb 2021
Collection of requirements of future facilities & projects

Feb/March 2021
Questionnaires of Task Forces to national contacts*

Task Forces liaise with experts in
- ECFA countries
- adjacent disciplines
- industry

March-May 2021
Open Symposia **

Organisation for Consultation of Relevant Communities

Input from future facilities

Session I (in general collider oriented), afternoon 19 February 2021: Input Session I
•Talk I: HL-LHC (incl. flavour physics)
•Talk II: strong interactions at future colliders
•Talk III: strong interactions at future fixed target facilities
•Talk IV: future linear high energy e+e- machines
•Talk V: future circular high energy e+e- machines
•Talk VI: FCC-hh
•Talk VII: muon collider
Session II (in general non-collider oriented) afternoon 22 February 2021: Input Session II
•Talk I : neutrino short and long baseline
•Talk II: astro-particle neutrinos
•Talk III: DM-like facilities
•Talk IV: decay facilities
•Talk V: low energy facilities

The full list of future facilities can be found in the Roadmap Mandate document.

Process and Timeline

Expert & Community Consultation

Feb 2021
Collection of requirements of future facilities & projects

Feb/March 2021
Questionnaires of Task Forces to national contacts*

Task Forces liaise with experts in
- ECFA countries
- adjacent disciplines
- industry

March-May 2021
Open Symposia **

Organisation for Consultation of Relevant Communities

TF1 Symposium

Technologies: overview, limitations and perspectives.

- MPGD: GEM, Micromegas, THGEM, uRWELL, and other ongoing developments
- RPC, MRPC, and other ongoing developments,
- Drift chambers, straw tubes, TGC, CSC, and other wire chambers
- PID: TPC, TRD, RICH and other large area detectors

Future applications.

- Tracking and muon detection at future colliders
- TPCs at future lepton and lepton-hadron colliders (TPCs, drift chambers, large volume gaseous detectors)
- Nuclear physics applications (tracking, extremely low mass detectors, photon detection, TRD, neutron detection)
- Recoils imaging for DM, neutrino, and BSM physics applications (TPCs variations, optical readout)
- Calorimetry (RPC, MPGD) at future colliders

Challenges and new developments.

- Detector stability (ageing, discharge issues) and rate capability: resistive electrodes
- Novel readout electrodes, optical readout, hybrids with ASICS
- Precise timing detectors
- IBF, photocathode stability and alternatives (including solid converters and nanotech)
- Precision manufacturing techniques (electrical.mechanical properties), additive manufacturing and new materials (low mass, radio-purity)
- Eco gas mixtures and mitigations procedures for GHG gas (recirculation, recuperation etc.)

Applications beyond fundamental research.

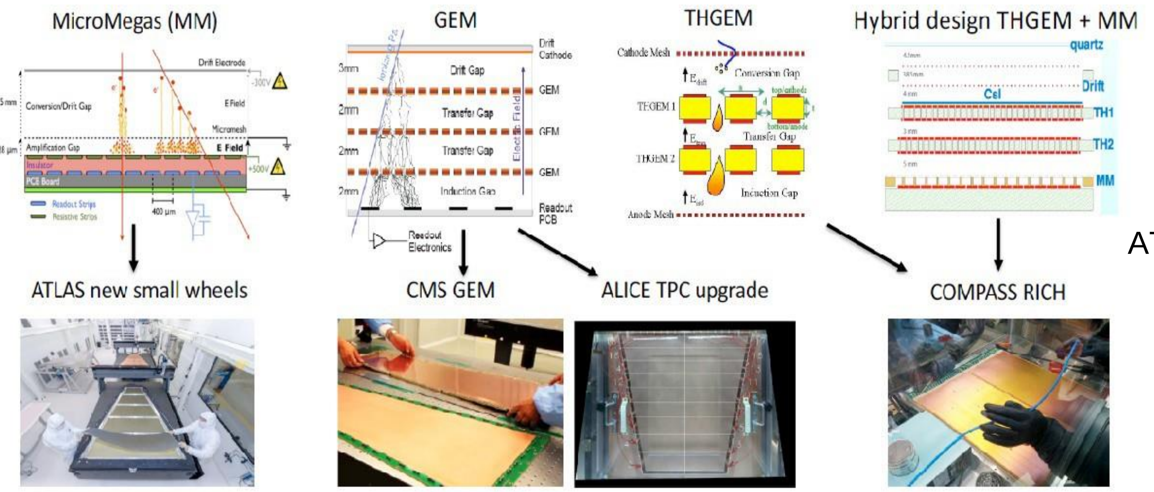
Development tools and R&D environment.

- Electronics (front-end and DAQ) for gaseous detectors R&D
- Software tools for detector physics simulations
- Infrastructures – development, testing and production facilities
- Relations with industry
- Networking – collaborations, technology dissemination and training

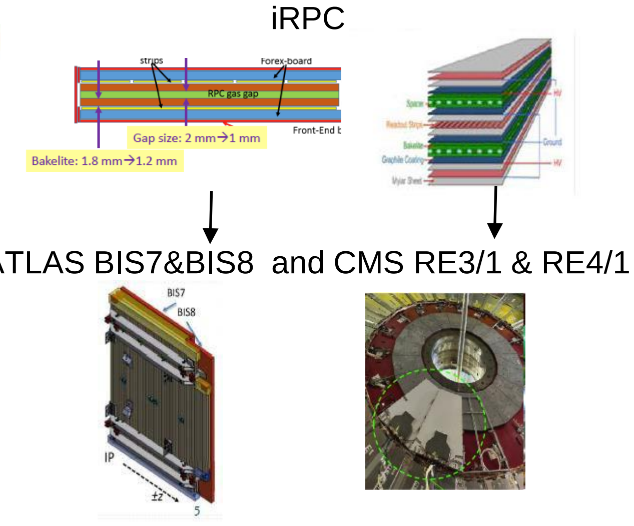
https://indico.cern.ch/event/999799/

The wide family of gaseous detectors

- **Upgrades at the LHC** for tracking, muon spectroscopy and triggering have **taken advantage of the renaissance in gaseous detectors** (*ex.* MPGDs, RPC.)
- **New generation of TPCs use MPGD-based readout**: e.g. ALICE Upgrade, T2K, ILC CepC

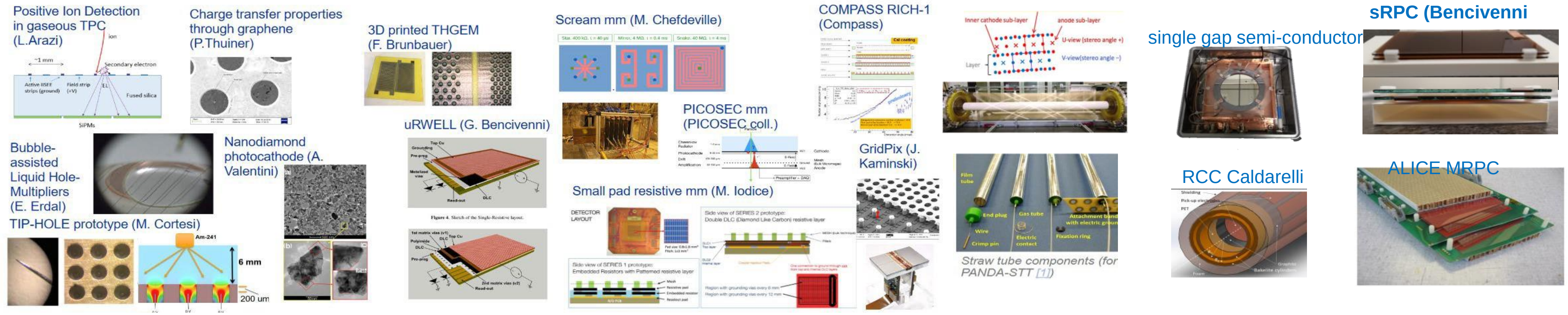


,



- **Gaseous detectors offer very competitive timing** through e.g.
  - **Multi-gap Resistive Plate Chambers** (down to 60 ps time resolution) (Alice TOF)
  - An enabling emerging R&D: **Micromegas with timing** (PICOSEC concept)

New Technologies, new architectures and hybridization of technologies



The wide family of gaseous detectors

Summary of R&D Challenges for the different applications

Figure 1.8:

Muon System	Inner and Central tracking	Calorimetry	Photon detection	TOF	Rare decays
● Radiation hardness and stability of large area up to integrated charges of hundreds of C/cm2: - aging issues and discharges; ● Operation in a stable and efficient manner with incident particle flows up to ~10 MHz/cm2: - miniaturization of readout elements needed to keep occupancy low; ● Manufacturing, on an industrial scale, large detectors at low cost, by means of a process of technological transfer to the industry and identifies processes transferable to industries ● Identification of eco-friendly gas mixture and mitigation of the issue related to the operation with high WGP gas mixture: - gas tightness;gas recuperation system;accessibility for repairing. ● Study of resistive materials (RPC and MPGD): - higher gain in a single multiplication layer, with a remarkable advantage for assembly, mass production and cost. - new material and production techniques for resistive layers for increasing the rate capability ● Thinner layers and mechanical precision over large area	**Drift chambers** ● High rate, unique volume, high granularity, low mass ● Hydrocarbon-free mixture for long-term and high-rate operation ● Prove the cluster counting principle with the related electronics ● Mechanics: new wiring procedure, new wire materials ● Integration: accessibility for repairing. **TPC** ● R&D on detector sensors to suppress the IBF ratio ● Optimize IBF together with energy resolution ● Gain optimization: IBF, discharge stability ● Uniformity of the response of the sensors ● Gas mixture: stability, drift velocity, ion mobility, aging ● Influence of Magnetic field on IBF) ● High spatial resolution ● Very low material budget (few %) ● Mechanics: thickness minimization but robust for precise electrical properties for stable drift velocity. ● Integration: cooling of electronics. **Straw chambers** ● Ultra-long and thin film tubes; ● “Smart“ designs: self-stabilized straw module, compensating relaxation; ● Small diameter for faster timing, less occupancy, high rate capability; ● Reduced drift time, hit leading times and trailing time resolutions, with dedicated R&D on the electronics; ● PID by dE/dx with “standard“ time readout and time-over-threshold; ● 4D-measurement: 3D-space and (offline) track time; ● Over-pressurized tubes in vacuum: control the leakage rate to maintain the shape.	● Uniformity of the response of the large area and dynamic energy range; ● Optimization of weights for different thresholds in digital calorimeters ● Rate capability in detectors based on resistive materials: resistivity uniformity, discharge issue at high rate and in large area detector; ● R&D on sub-ns in active elements: resolution stables over wide range of fluxes; ● Gas homogeneity and stable over time. ● Eco-friendly gas mixture for RPC; ● Stability of the gas gain: fast monitoring of gas mixture and environmental conditions; ● Mechanics: - large area needed to avoid dead zone: limitation on size and planarity of PCB is an issue. - multi-gap with ultra-thin modules: very thin layer of glass and HPL electrodes, gas gap thickness uniformity few micron	● Preserve the photocathode efficiency by IBF and more robust photoconverters; ● Gas radiator: alternative to CF4 ● Gas tightness ● Very low noise when coupling large capacitance; ● Large dynamic range of the FEE; ● Separate the TR radiation and the ionization process ● InTDD use of cluster counting technique and improve it by means of a Ingrid.	● Uniform rate capability and time resolution over large detector area; ● New material for high rate (low resistivity, radiation hardness); - uniform gas distribution; - thinner structures: mechanical stability and uniformity; ● Eco-gas mixture; ● Electronics: Low noise, fast rise time, sensitive to small charge; ● Possibly optical readout; ● Precise clock distribution and synchronization over large area.	● Radio-purity of the materials ● Low background ● High granularity ● For large volume detectors: transparency over large distance ● Pressure stability and control ● Electronics with large dynamic range and flexible configuration. ● Self-trigger capability ● Low noise electronics ● Fast electronics ● Optical readout

Report and timeline

- Timescale of projects as approved by European Lab Director Group (LDG)

The Roadmap has identified

- Set of detector R&D areas which are required if the physics programmes of experiments at these facilities are not to be compromised.

  Guiding principle: Project realisation must not be delayed by detectors R&D

- Detector R&D Themes (DRDT) for each of the taskforce topics

- General Strategic Recommendations (GSR)

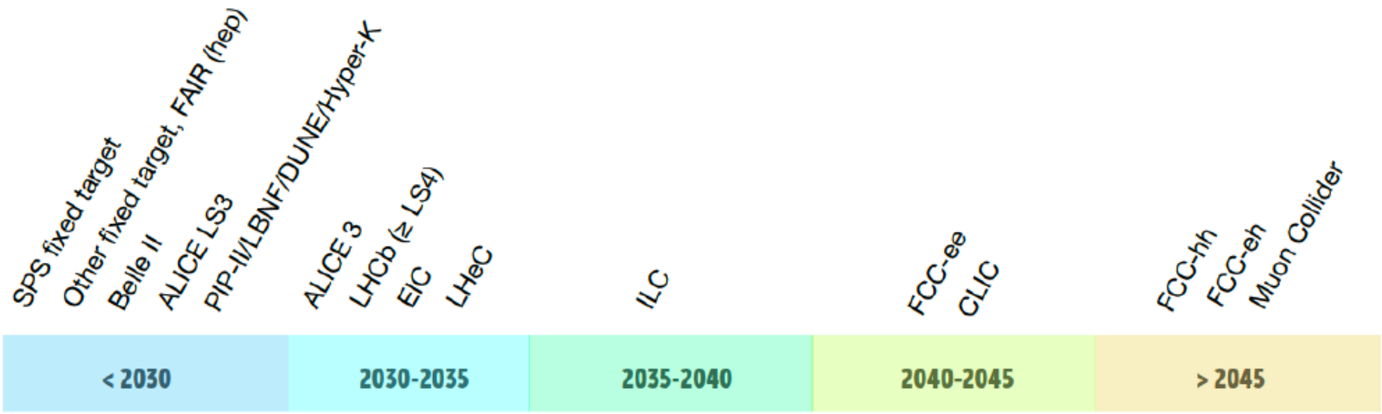


Figure 3: Large Accelerator Based Facility/Experiment Earliest Feasible Start Dates.

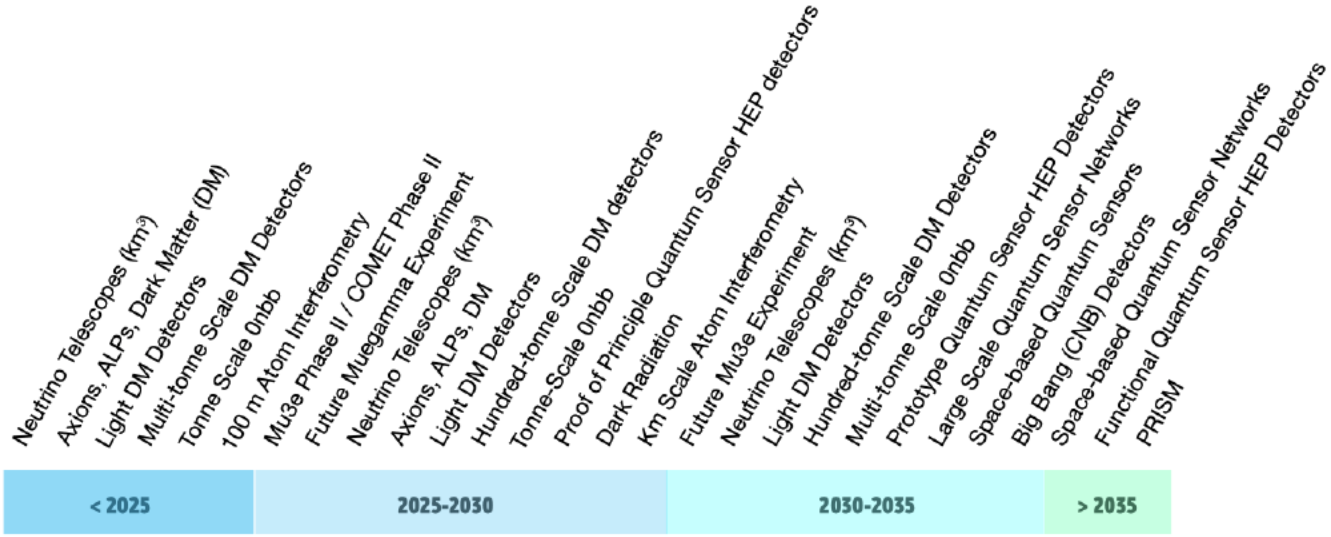


Figure 4: (Representative) Smaller Accelerator and Non-Accelerator Based Experiments Start Dates (*not intended to be at all an exhaustive list*).

DRD1 Themes and timeline

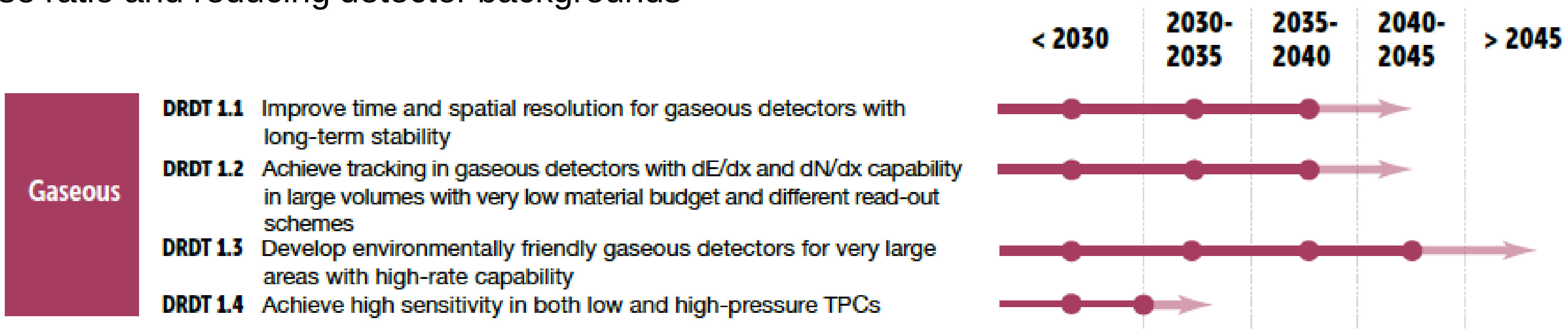
Major detector R&D themes (DRDTs) where longer-term research must be carried out, in most cases directed towards experiments at large future facilities with intermediate experiments in time as important “stepping stones”.

DRDT 1.1 - Improve time and spatial resolution for gaseous detectors with long-term stability
Future experiments require large areas to be instrumented with unprecedented timing capabilities both for time of fight particle identification and to aid track association to the correct event. Their physics programmes demand an improved momentum resolution and performance needs to be maintained over decades with minimal intervention.

DRDT 1.2 - Achieve tracking in gaseous detectors with dE/dx and dN/dx capability in large volumes with very low material Different readout methodologies are required for large volume tracking detectors including micro-pattern gas detector systems, optical readout and direct interfacing to ASICs. Low multiple scattering is essential as is enhanced particle identification through accurate determination of ionisation (either deposited energy or number of clusters) per unit length.

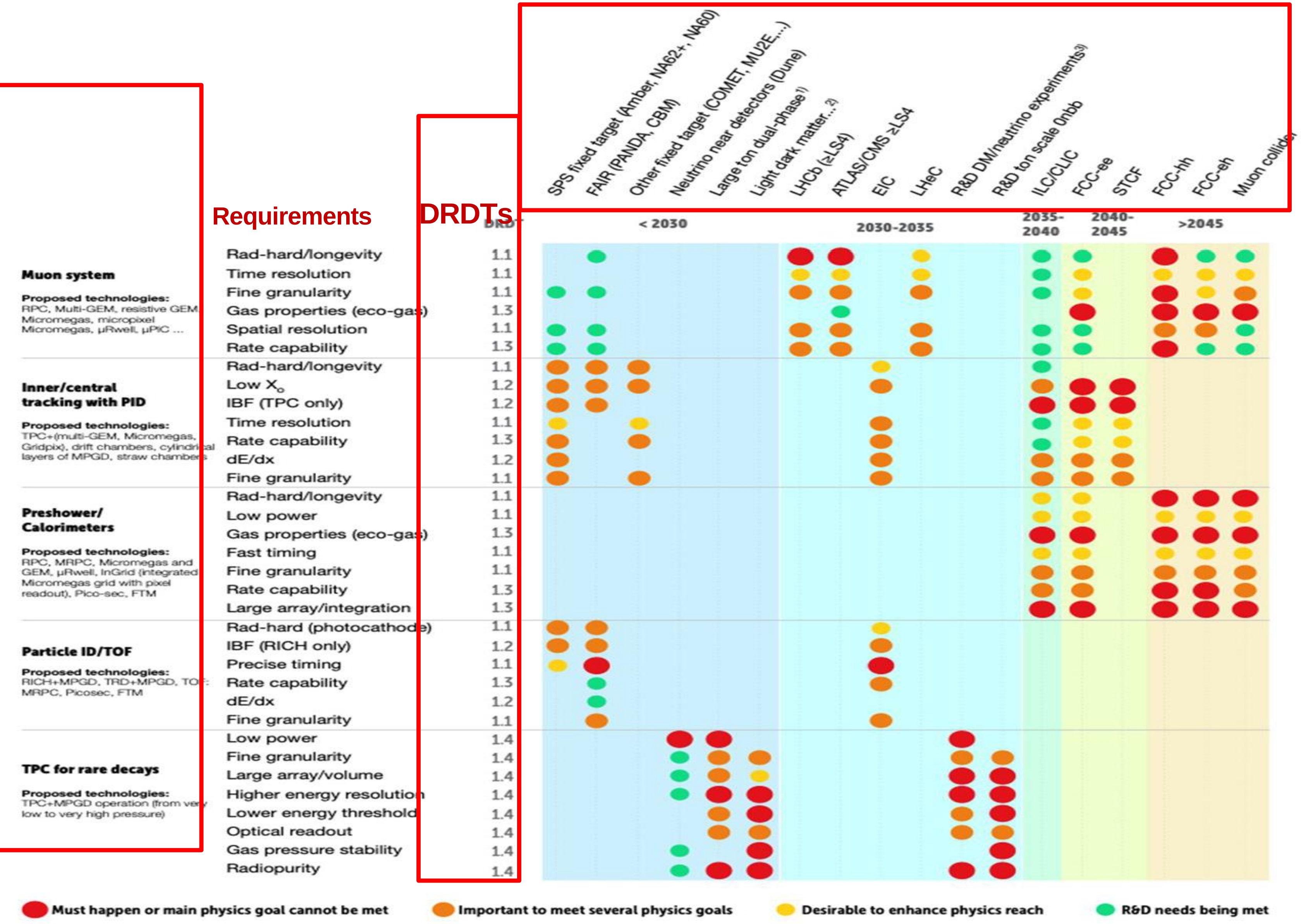
DRDT 1.3 - Develop environmentally friendly gaseous detectors for very large areas with high-rate capability
The largest area detector systems in an experiment are typically gaseous detectors, often as part of an outer muon spectrometer. Ease of maintenance, stable operation and, for some applications, the ability to cope with very large fluxes of charged particles are required. Key to future applications is the development of more ecologically friendly gas mixtures for gaseous detectors and mitigation procedures for use of greenhouse gases when this is unavoidable.

DRTD1.4: Achieve high sensitivity in both low and high-pressure TPCs
Large volume gaseous detectors provide a key technology for high efficiency searches for rare events with differing readout for optimizing the signal-to-noise ratio and reducing detector backgrounds



- The faded region acknowledges the typical time needed between the completion of the R&D phase and the readiness of an experiment at a given facility.

Gaseous detectors R&Ds timeline



1) Large ton dual-phase (PandaX-4T, LZ, DarkSide -20k, Argo 200k, ARIADNE ...)
2) Light dark matter, solar axion, 0nbb, rare nuclei&ions and astroparticle reactions, Ba tagging)
3) R&D for 100-ton scale dual-phase DM/neutrino experiments

It illustrate the way requirements could evolve over time to help define the planning for the corresponding detector R&D to ensure the main physics goals of the updated strategy for particle physics do not risk being compromised by detector readiness

Note the dots relate to the importance to the listed facilities of the R&D activity not the intensity of effort needed to meet these requirements

- Must happen or main physics goals cannot be met
- Important to meet several physics goals
- Desirable to enhance physics reach
- R&D needs being met

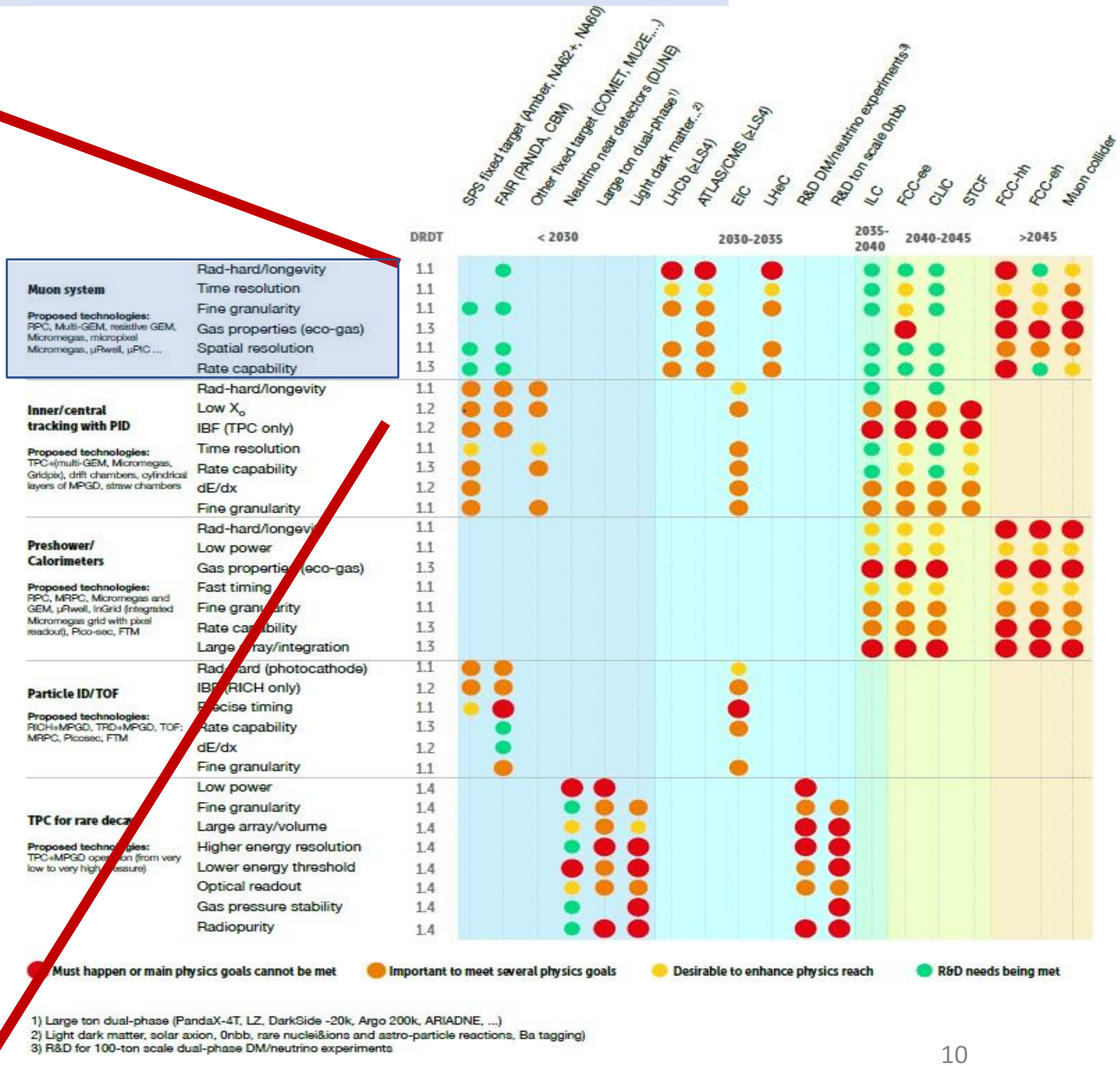
Muon System

Main drivers from facilities:

Muon systems:

- radiation hardness, longevity and stability
  - O(100 C/cm^2)
  - relevance of discharge studies
- large area (low cost),
- time resolution (< 1 ns)
  - mitigate uncorrelated background and pile-up
- fine granularity
  - Pile-up and space resolution
  - space resolution ➔momentum resolution
- rate capability
  - O (10MHz/ cm^2)
  - Resistive materials

- **FACILITIES:** HL-LHC, EW-Higgs-Top facilities, Mu-collider, hadron physics (EIC and fix target), FCC-hh
- **TECHNOLOGIES:** MPGDs and new (M)RPC



Inner/central tracking

Main drivers from facilities:

Inner/central tracking with PID capabilities:

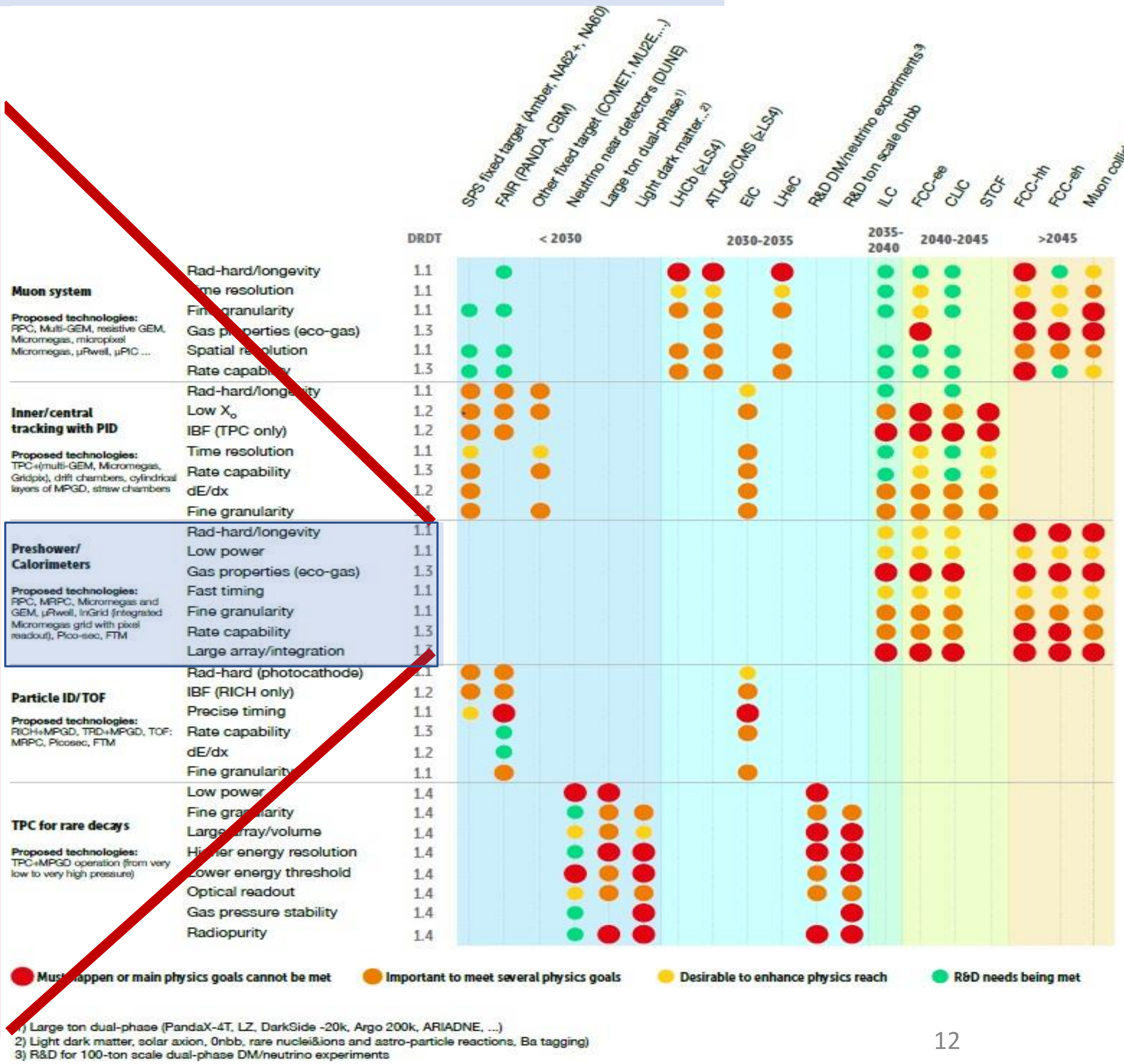
- radiation hardness, longevity and stability
- Low X_0
  - New materials as carbon monofilament
- Low IBF (TPC only)
- Time resolution
- dE/dx and Cluster counting:
  - *Grid-Pix, electronics*
- fine granularity
- rate capability

- **FACILITIES:** SCTF, CepC and FCC-ee, hadron physics, rare decays and rare events at accelerators, ν-physics
- **TECHNOLOGIES:** TPC, large volume drift chambers, straw tubes, set of co-axial cylindrical MPGDs

Calorimeter

- **Main drivers from facilities:**

- **Pre-shower and calorimetry:**
- CONTEXT: particle flow (PF) concept
- DHCAL/SDHCAL approaches
- radiation hardness, longevity and stability
  - Gas property (eco-gasses)
- Low power
- Fast timing, goal: 5D calorimeters (time development along the shower) ➔ *electronics*
- fine granularity
- rate capability
- Integration aspects:
  - Thin layers with integrated services
  - Large arrays: 10-100M ch.s, 10 k m^2 sensor surface
- **FACILITIES:** colliders: ILC, CLIC, STCF, FCCee, mu, e-h, FCC-hh
- **TECHNOLOGIES:** MPGDs (PicoSec, FTM), RPCs



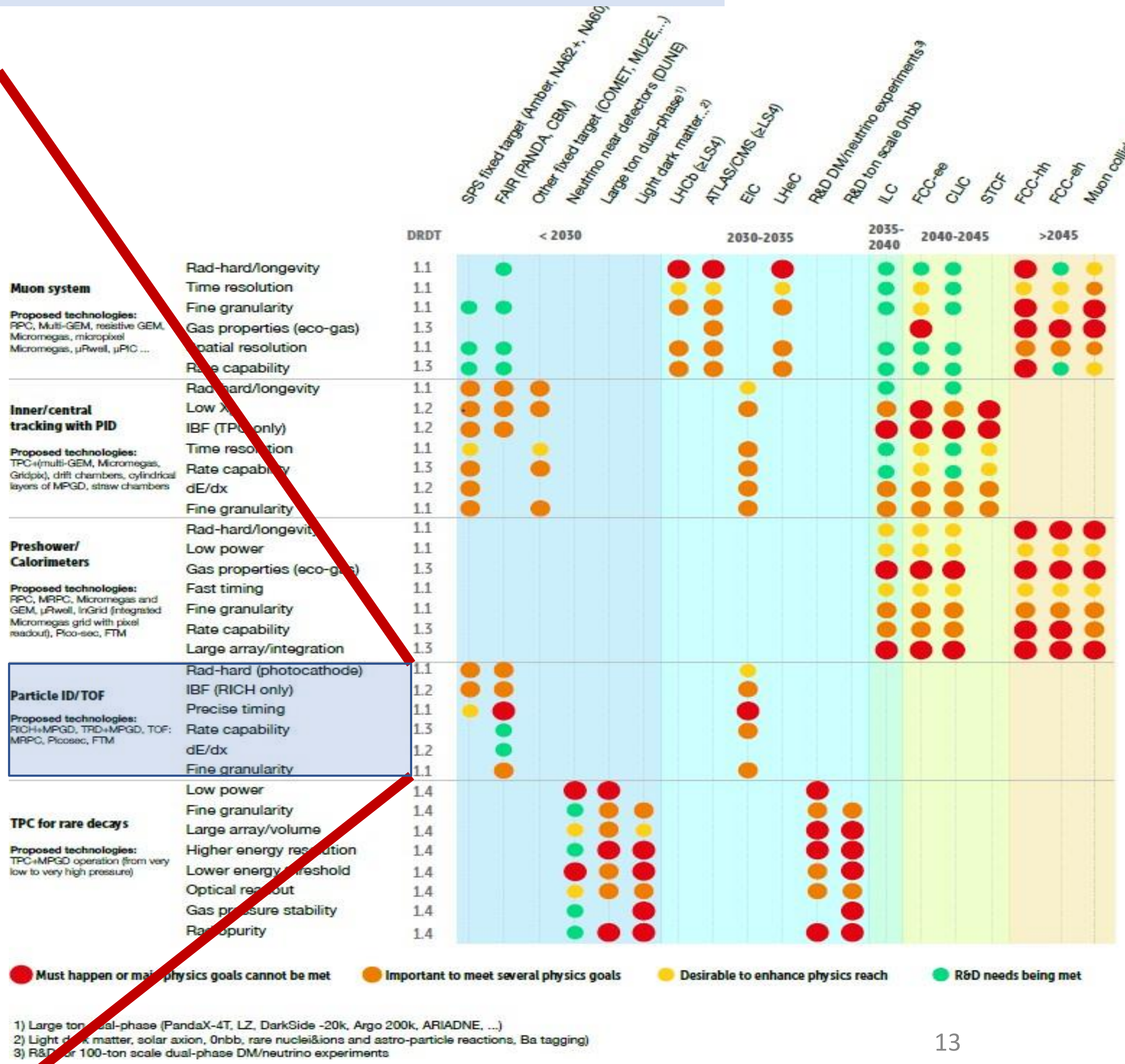
ParticleID/Time of Flight

Main drivers from facilities:

ToF:
- precise timing, goal: ~ 20 ps
- rate capability: 100 kHz/cm^2
  - Low resistivity glass for MRPCs
- Optical R-O approaches
- **FACILITIES:** h physics
- **TECHNOLOGIES:** MRPCs, MPGDs (PicoSec, FTM)

Gaseous sensors for RICHes:
- Photocathode radiation hardness
  - Low IBF rates
  - New photoconverters: nano-diamond powder
- Fine granularity
- **FACILITIES:** h and flavour physics
- **TECHNOLOGIES:** MPGDs

dE/dx and TRDs
- The frontier is cluster counting



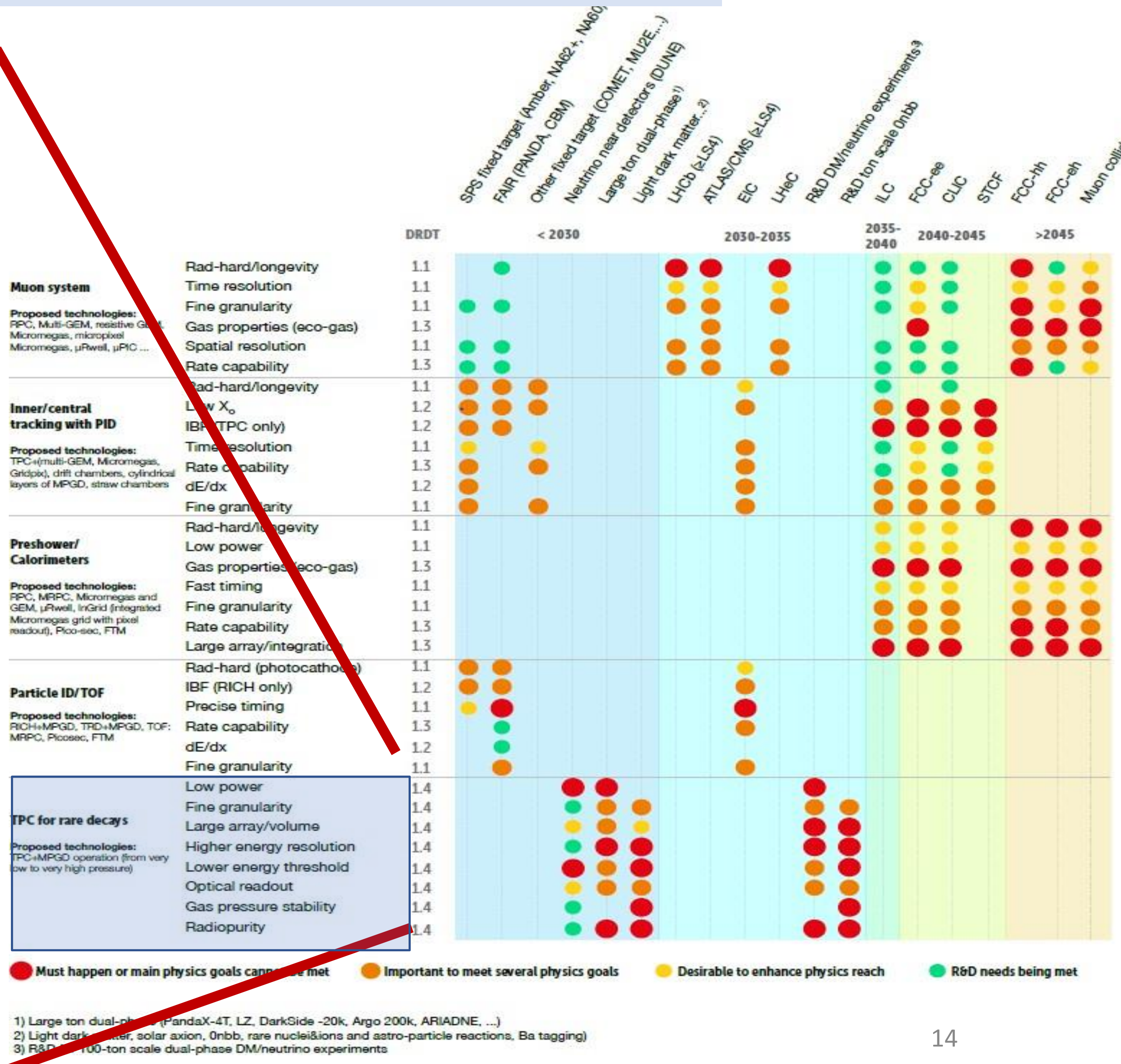
TPC for rare events search

Main drivers from facilities:

TPC for rare decays

- CONCEPT:
  - The TPC gas is the target material
    - Purified gas
    - Pressure 1-10 bar → *pressure control*
  - Detection of both ionization and scintillation in noble gasses
    - Purified gasses and radiopurity
    - Scintillation; CF_4 (gas tightness, recuperation)
- High space resolution
- Large arrays and large volumes
- High energy resolution, low energy threshold *(dynamic range→ electronics)*

- **FACILITIES:** WIMPS, Solar Axion, v-exp.s:
- **TECHNOLOGIES:** high-pressure TPC with MPGD sensors (also optical read-out)



General Strategic recommendations

In addition to the Detector R&D Themes described above and discussed in each chapter the following General Strategic Recommendations are made under the following headings.

GSR 1 - Supporting R&D facilities

See description in backup slides

GSR 2 - Engineering support for detector R&D

GSR 3 - Specific software for instrumentation

GSR 4 - International coordination and organisation of R&D activities

GSR 5 - Distributed R&D activities with centralised facilities

GSR 6 - Establish long-term strategic funding programmes

GSR 7 - Blue-sky R&D

GSR 8 - Attract, nurture, recognise and sustain the careers of R&D experts

GSR 9 - Industrial partnerships

GSR 10 - Open Science

General Strategic recommendations

In addition to the Detector R&D Themes described above and discussed in each chapter the following General Strategic Recommendations are made under the following headings.

See description in backup slides

GSR 1 - Supporting R&D facilities

GSR 2 - Engineering support for detector R&D

GSR 3 - Specific software for instrumentation

GSR 4 - International coordination and organisation of R&D activities

GSR 5 - Distributed R&D activities with centralised facilities

GSR 6 - Establish long-term strategic funding programmes

GSR 7 - Blue-sky R&D

GSR 8 - Attract, nurture, recognise and sustain the careers of R&D experts

GSR 9 - Industrial partnerships

GSR 10 - Open Science

Implementation started through the setting up of DRD collaboration

“Implementation roadmap”

Proposed implementation plan

K. Jackobs

- It is proposed to organise long-term R&D efforts into **newly established Detector R&D (DRD) Collaborations**

  Detector technology areas: larger DRD collaborations should be considered
  (one for each of the six areas and an additional similar structure for some of the transversal topics)

- **DRD Collaborations should be anchored at CERN** → CERN recognition, DRD label
  Open to world-wide participation! (following model of CERN experiments)

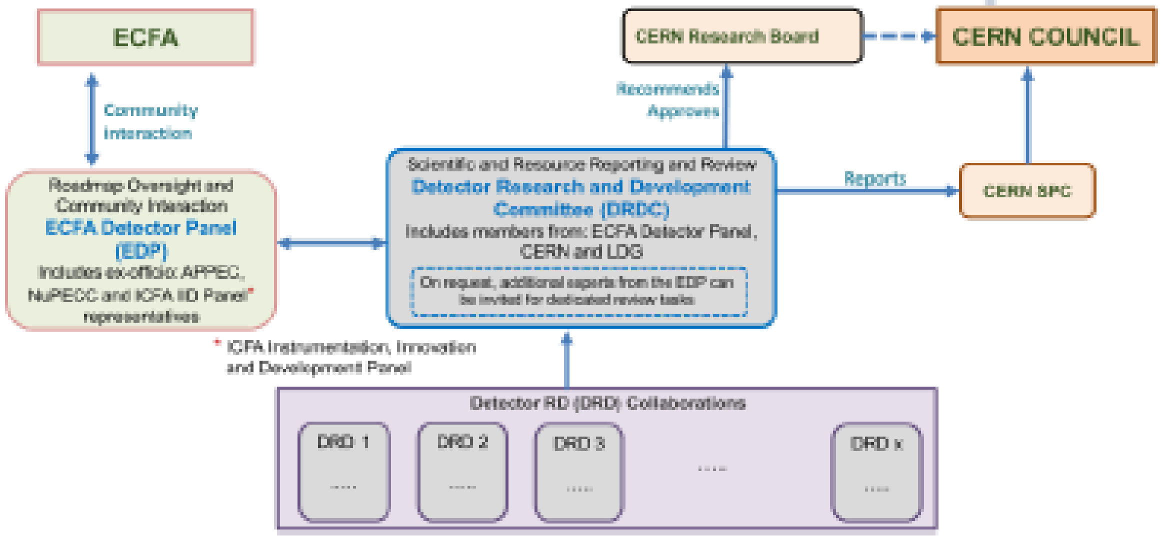
- **Taking full account of existing, well-managed and successful ongoing R&D collaborations and other existing activities**
  (RD50, RD51, …, CERN EP R&D programme, EU-funded initiatives, collaborations exploring particular technology areas for future colliders)

- The **formation of new DRD collaborations** should adopt a **community-driven approach**
  Supported by existing ECFA Detector R&D Roadmap Task Forces, with involvement of managements of existing R&D collaborations

- Aim for proposals in July 2023; New structure in place in January 2024;
  Ramp-up of resources during 2024/25, reaching a steady state in 2026
  For more details: see talk by Phil Allport at plenary ECFA in November 2022: https://indico.cern.ch/event/1212248/

Review and Approval Process

K. Jackobs



1. Scientific and Resource Reporting and Review by a Detector Research and Development Committee (DRDC)

   Assisted by the ECFA Detector Panel (EDP): the scope, R&D goals, and milestones should be vetted against the vision encapsulated in the Roadmap

2. Funding Agency involvement via a dedicated Resources Review Board (~once every two years)

3. Yearly follow-up by DRDC → report to SPC → Council

- As projects develop, **some aspects should be expected to transition into approved experiment-specific R&D** (outside the DRD programme)

- In addition, as stated in the General recommendations (GSR7) funding possibilities for **“Blue-sky” R&D** should be foreseen

ECFA Detector Panel (EDP):

K. Jackobs

The ECFA Detector Panel (EDP) is a subcommittee of ECFA, hosted at DESY
So far: a committee to review detector development efforts for future projects

http://cds.cern.ch/record/2211641/files

Mandate:

- Direct input on DRD proposals, through the appointment of members to the DRDC;
- Assists, particularly via topic-specific expert members, in the conduct of annual DRDC reviews;
- Monitors the overall implementation of the ECFA detector roadmap follows up targets and achievements in the light of evolving specifications from experiment concept groups, as well as proto-collaborations for future facilities
- Helps plan for future updates to the Detector R&D Roadmap.

Composition:

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)
PID & Photon Detectors:	Roger Forty (CERN)
Quantum and em Tech.	
Calorimetry:	Laurent Serin (IJCLab)
Electronics:	Valerio Re (Bergamo)
Ex Officio:	Karl Jakobs (ECFA Chair)
	Ian Shipsey (ICFA Detector Panel)

Implementation timeline

The timescales set by the necessity to prioritise HL-LHC deliverables, to take account of existing CERN RD collaborations RD50 (silicon), RD51 (gas detector) expire Dec 2023, and to allow a timely completion or transfer of existing funded R&D into this new framework.

Major Steps:

- Q4 2022; Through the ECFA roadmap, task **forces identify key players and stakeholders** from the wider international community who are interested in pursuing the DRDT topics identified in the ECFA roadmap. Where current relevant detector R&D collaborations exist, their managements need to be fully involved from the beginning of this process.
- **community input** (via existing R&D bodies where possible) by **Q1 2023**
- In parallel, **DRDC** mandate and membership defined
- **Written proposals**, based on ECFA Detector Roadmap and community interests, by **mid 2023**
  - including light-weight organisational structures and resource-loaded work plan for R&D programme start in 2024 and ramp up to a steady state in 2026 => guidance from EDP received.
- **Review** (by DRDC, assisted by EDP) in **fall 23,** approval by **end 2023**
- **New structures operational and new R&D programmes underway from beginning 2024.**
- **Through 2024,** collection **of MoU signatures** will need to take place, with defined contribution areas per institute.
- **Ramp up of new strategic funding and R&D activities 2024-2026**

Towards a DRD1 Collaboration

- Following the prescription of the ECFA panel, DRD1 formation promoted by the ECFA TF1,

  - taking advantage of existing RD51 experience and existing organization (CERN EPR&D, AIDAinnova):

- Major effort to reach out other communities, identify the stake holders, experts:

  - through the organizer committee of major detector workshop/conferences (RD51, RPC, TPC)

  - through TF1 Members (experts) and speakers of the TF1 symposium.

The following team has been put in place

- **ECFA TF1** Conveners: Anna Colaleo (Univ. and INFN-Bari), Leszek Ropelewski (CERN);

- Other TF1 Members: Klaus Dehmelt (Stony Brook Univ.-SUNY) , João Veloso (Univ. of Aveiro)
- **ECFA Coordinators Group Member:** Silvia Dalla Torre (INFN - Trieste)
- **MPGDs**: Eraldo Oliveri (CERN), Fulvio Tessarotto (INFN-Trieste), Maxim Titov (CEA Paris-Saclay)
- **RPCs**: Ingo Deppner (Univ. Heidelberg), Giuseppe Iaselli (Politecnico & INFN-Ba), Barbara Liberti (INFN –RM 2)
- **TPCs:** Esther Ferrer Ribas (IRFU/CEA), Jochen Kaminski (University of Bonn)
- **Large volume detectors:** Marco Panareo (Univ. and INFN-Lecce), Francesco Renga (INFN-Roma I)
- **Straw tubes, TGC, CSC, drift chambers, and other wire detectors:** Peter Wintz (IKP, FZ Jülich)
- **Infrastructure, R&D programs** (CERN EPR&D, AIDAinnova): Roberto Guida (CERN), Beatrice Mandelli (CERN)
- **Administrative support:** Hans Taureg (University of Bonn), Florian Brunbauer (CERN)

DRD1 implementation

The new Detector R&D (DRD) Collaborations (CERN/SPC/1190) are intended to be the main vehicles for driving strategic R&D targeting the priority programmes outlined in the updated European Strategy for Particle Physics.

The DRD1 proposals should establish a programme and a collaborative framework (organisation) to achieve the ECFA roadmap TF1 Detector R&D Themes (DRDTs)

The collaborative structure of DRD1 would allow:

- to access, being anchored at CERN, the facilities for detector evaluation (such as test beams and irradiation source), and the infrastructures facilitating detector developments (such as workshops and laboratories).

- facilitating joined efforts along common goals defined by the ECFA roadmap document

- the development of common tools (detector physics simulation software, electronics)

- to help in the education and training, for cross-fertilization among different particle physics (and neighboring discipline) detector development programs.

- to promote the visibility and prospects of young researchers in detector technologies.

Towards a DRD1 Structure: WGs and conveners

Keep RD51 structure in WGs including alignment with the scientific program of the ECFA roadmap, looking more generally to future facilities challenges and specifically to the Detector RD Themes (DRDT), but also to the GSRs

WG1: Technologies (**P.Colas**, F. Resnati, P. Wintz, I. Deppner, M. Tytgat, L. Moleri)

Includes experimental detector physics aspects

- MPGDs
- RPCs, MRPCs
- Large Volume Detectors (drift chambers, TPCs)
- Straw tubes, TGC, CSC, drift chambers, and other wire detectors
- New amplifying structures

WG2: Applications (F. Garcia, **P. Gasik**, F. Grancagnolo, D. Gonzalez Diaz, G. Aielli, G. Pugliese; A. Colaleo, M. Titov for the ECFA part)

Full alignment with the ECFA detector R&D roadmap Themes

- Muon systems
- Inner and central tracking with particle identification capability
- Calorimetry
- Photon detection
- Time of Flight systems
- TPCs for rare event searches
- Precision experiments
- Straw chambers in vacuum
- Fundamental research applications beyond HEP
- Medical and industrial applications

WG3: Gas and material studies (**B. Mandelli**, G. Morello, F. Renga, K. Dehmelt, S. Roth,D, Piccolo, A. Pastore, B. A. Gonzalez)

- Eco-gases searches
- Light emission in gases
- Ageing
- Radiation hardness
- Light (low material budget) materials
- Resistive electrodes
- Precise mechanics
- Photocathodes (novel, ageing, protection)
- New types of wires (coated carbon monofilaments)
- Solid converters
- Novel materials (nanomaterials)

WG4: Detector physics, simulations, and software tools (M.Abbrescia, M. Borysova, P. Fonte, O. Sahin, **P. Verwilligen**, R. Veenhof,)

- Detector Physics (modeling and simulations)
- Detector Performance Studies (modeling and simulations)
- Software development and maintenance
- Gas Properties Databases (e.g. cross-sections) - Use and/or Maintenance; Detector design

Towards a DRD1 Structure: WGs and conveners

Keep RD51 structure in WGs including alignment with the scientific program of the ECFA roadmap, looking more generally to future facilities challenges and specifically to the Detector RD Themes (DRDT), but also to the GSRs

WG5: Electronics for gaseous detectors (H. Muller, **J. Kaminski,** M. Gouzevitch, R. Cardarelli)

- Analog/Digital Electronics
- Discrete Readout Front End Electronics and ASICs
- Charge/Photon readout
- FE input protection & spark quenching
- Waveforms and Digitizer; Signal Processing
- Cluster Counting
- Specific needs: Timing, High rate, Low noise, Wide Dynamic Range,…)
- Grounding and Shielding; Calibration
- SoC based sensor readout
- General purpose DAQ, FPGA based readout/trigger and Trigger-less systems
- HV Systems and HV distribution schemes
- LV Powering, Cooling
- Laboratory instrumentation (High resolution floating ammeters, Monitoring and control systems)

WG8:Training and dissemination (**F. Brunbauer**, M. Iodice, E. Baracchini, B. Liberti, A. Paoloni)

- Schools and trainings
- Topical workshops
- Knowledge transfer
- (Young) Researcher Career
- Strategies to recognize and sustain the careers of R&D experts

WG6: Detector production (R. De Oliveira, **F. Jeanneau,** A. Delbart, G. Iaselli, I. Laktineh, G. Charles)

- CERN EP-DT Micro Pattern Technology (MPT) Workshop
- Saclay MPGD workshop
- RPC/MRPC workshop
- Wire chambers workshop
- Novel detector production methods
- CERN EP Thin Film & Glass service (photocathodes, coatings, ceramic)
- Technology and knowledge transfer (to industry and within the collaboration)
- Relationship with Industry

WG7: Common test facilities (**Y. Tsipolitis**, E. Oliveri, R. Guida, G. Iaselli, A. Ferretti)

Includes development of common detector characterization standards:

- General purpose detector development labs
- Ageing Study Facility
- Gas studies facility
- Irradiation facility
- Test beam facility
- Chemistry and material laboratory
- Clean Room
- Instrumentation for common detector characterization (e.g. gas, DAQ, HV systems)

Towards a DRD1 Structure and proposal

Strong link with ECFA roadmap selected DRDTs.

Inputs for proposal document (see EDP guidance):

→ The DRD proposal should establish a programme and a collaborative framework (organisation) to achieve the ECFA roadmap DRDTs

→ Define performance parameters targeted by the deliverables in association with the applications at the future strategic programmes considered in the updated European Strategy for Particle physics and listed in the Roadmap document.

→ For each DRDT and the associated technologies to be studied, key R&D deliverables during the coming three years, indicative deliverables planned for the following three years and longer-term ambitions should be identified

→ The key R&D deliverables should be identified within each corresponding technology area and the associated resources in each technology area estimated. → WG2 and synergy with other WG.

WG2: Applications

Full alignment with the ECFA detector R&D roadmap

- Muon systems
- Inner and central tracking with particle identification capability
- Calorimetry
- Photon detection
- Time of Flight systems
- TPCs for rare event searches
- Precision experiments
- Straw chambers in vacuum
- Fundamental research applications beyond HEP
- Medical and industrial applications

Towards a DRD1 Structure and proposal

Strong link with General Strategic Recommendation (GSR) reported in the Roadmap document

GSR 1 - Supporting R&D facilities

…the structures to provide **Europe-wide coordinated infrastructure in the areas of: test beams, large scale generic prototyping and irradiation be consolidated and enhanced to meet the needs of next generation experiments** with adequate centralised investment to avoid less cost-effective, more widely distributed, solutions, and to maintain a network structure for existing distributed facilities, e.g. for irradiation

WG7: Common test facilities

Incudes development of common detector characterization standards

- General purpose detector development labs
- Ageing Study Facility
- Gas studies facility
- Irradiation facility
- Test beam facility
- Chemistry and material laboratory
- Clean Room
- Instrumentation for common detector characterization (e.g. gas, DAQ, HV systems)

Towards a DRD1 Structure and proposal

Strong link with General Strategic Recommendation (GSR) reported in the Roadmap document

GSR 2 - Engineering support for detector R&D

…the R&D should be supported with **adequate mechanical and electronics engineering resources**, to bring in expertise in state-of-the-art microelectronics as well as advanced materials and manufacturing techniques, to tackle generic integration challenges, and to maintain scalability of production and quality control from the earliest stages.

WG3: Gas and material studies

- Eco-gases searches
- Light emission in gases
- Ageing
- Radiation hardness
- Light (low material budget) materials
- Resistive electrodes
- Precise mechanics
- Photocathodes (novel, ageing, protection)
- New types of wires (coated carbon monofilaments)
- Solid converters
- Novel materials (nanomaterials)

WG5: Electronics for gaseous detectors

- Analog/Digital Electronics
- Discrete Readout Front End Electronics and ASICs
- Charge/Photon readout
- FE input protection & spark quenching
- Waveforms and Digitizer; Signal Processing
- Cluster Counting
- Specific needs: Timing, High rate, Low noise, Wide Dynamic Range,…)
- Grounding and Shielding; Calibration
- SoC based sensor readout
- General purpose DAQ, FPGA based readout/trigger and Trigger-less systems
- HV Systems and HV distribution schemes
- LV Powering, Cooling
- Laboratory instrumentation (High resolution floating ammeters, Monitoring and control systems)

Towards a DRD1 Structure and proposal

Strong link with General Strategic Recommendation (GSR) reported in the Roadmap document

GSR 3 - Specific software for instrumentation

…**state-of-the-art R&D-specific software packages must be maintained and continuously updated**. The expert development of these packages - for core software frameworks, but also for commonly used simulation and reconstruction tools - should continue to be highly recognised and valued and the community effort to support these needs to be organised at a European level.

WG4: Detector physics, simulations, and software tools

- Detector Physics (modeling and simulations)
- Detector Performance Studies (modeling and simulations)
- Software development and maintenance
- Gas Properties Databases (e.g. cross-sections) - Use and/or Maintenance; Detector design

Towards a DRD1 Structure and proposal

Strong link with General Strategic Recommendation (GSR) reported in the Roadmap document

GSR 8 - Attract, nurture, recognise and sustain the careers of R&D experts

..continues the study of **recognition with a view to consolidate the route to an adequate number of positions with a sustained career in instrumentation R&D** to realise the strategic aspirations expressed in the EPPSU….

Consideration needs to be given to creating sufficiently attractive remuneration packages to retain those with key skills which typically command much higher salaries outside academic research.

Medical and industrial applications

WG8:Training and dissemination

- Schools and trainings
- Topical workshops
- Knowledge transfer
- (Young) Researcher Career
- Strategies to recognize and sustain the careers of R&D experts

Towards a DRD1 Structure and proposal

Strong link with General Strategic Recommendation (GSR) reported in the Roadmap document

GSR 9 - Industrial partnerships

…to **identify promising areas for close collaboration between academic and industrial partners**, to create international frameworks for exchange on academic and industrial trends, drivers and needs, and to establish strategic and resources-loaded cooperation schemes on a European scale to intensify the collaboration with industry, in particular for developments in solid state sensors and micro-electronics

WG6: Detector production

- CERN EP-DT Micro Pattern Technology (MPT) Workshop
- Saclay MPGD workshop
- RPC/MRPC workshop
- Wire chambers workshop
- Novel detector production methods
- CERN EP Thin Film & Glass service (photocathodes, coatings, ceramic)
- Technology and knowledge transfer (to industry and within the collaboration)
- Relationship with Industry

DRD1 implementation timeline

- **From January 2023**: Through the team members, collect the contact person(s) for each institution interested to join the collaboration, set up a proposal-writing group with goal to prepare DRD1 proposal
- **23 January :** Survey sent to contact persons identified by the team to get a first feedback from the community.
- **1-3 March** Community workshop at CERN
  - ➢ *Review of inputs received from the community until 15 February*
  - ➢ *Begin preparing a short proposal outlining the path to fulfilling and developing the technological goals outlined in the ECFA R&D roadmap for the gaseous detector.*
    - *presentation of the bullet skeleton during Friday's session (discussion and collection of the feedback)*
- **By Easter**: 3-4 pages draft chapter ready for community consultation
- **1st of May:** the end of the Survey and end of community consultation
- **May-Middle June**: Proposal Team works on proposal document within working groups
- **Middle June**: Community (Collaboration)-wide discussions / workshop for finalizing the proposal

DRD1 implementation timeline

- **In parallel** interaction with Agencies needed in parallel to proposal preparation for the MoU preparation

  - institute contact person should get in touch with their RECFA delegates, contact person and FA (list in the backup slides)

In each country / laboratory the DRD proposal process has to be discussed with the respective funding agencies;

- In Europe, **RECFA delegates** and **ECFA Roadmap National Contacts for Detectors** should help to launch this process and to set up the right structures
  (most likely, it will be different from country to country)

Dedicated discussion session on “Collaboration issues” on Thrusday at 15:00

DRD1 Community meeting 1-3 March

Wednesday/Thursday, March 1 -2:

- ✓ General Introduction - ECFA roadmap & roadmap implementation
- ✓ General survey outcome

- ✓ **WG1-WG8 (1 hour per session):**
  - WG1 Technologies
  - WG2 Applications
  - WG3 Gas and Material Studies
  - WG4 Detector Physics, Simulations, and Software Tools
  - WG5 Electronics for Gas Detectors
  - WG6 Detector Production
  - WG7 Common Test Facilities
  - WG8 Training and Dissemination

- ✓ **Collaboration issues:**
  - MoU and Common Fund(s)
  - Common Projects
  - Work Packages
  - Structure of the DRD1 Collaboration

Charge to the WG Conveners:

1. Introduction to the topics covered by the WG (listed in the Skeleton bullets).
2. Analysis and summary of the Survey.
3. Essential aspects from the Survey with relevance/impact in the context of the collaboration (topics, facilities, ideas).
4. Existing assets that can support the collaboration.
5. Existing or potential assets that the collaboration can support.
6. Synergies and common aspects between technologies.
7. For WG2 (applications), overlap with the ECFA roadmap document.

Friday, March 3:

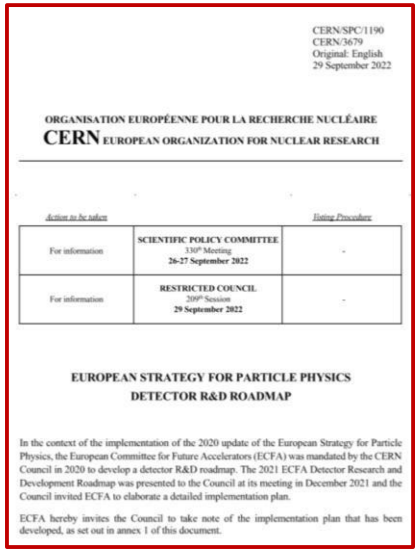
- ✓ Wrap-up (Open and Closed) Discussions
- ✓ Proposal drafting (Skeleton with bullets)
- ✓ Identification of an editorial team for the
- ✓ proposal writing

BACKUP SLIDES

Roadmap Implementation
Brief History

Phil Allport :111th Plenary ECFA

- **CERN Council charged ECFA with developing an implementation plan for the Detector R&D Roadmap recommendations.**
- **Initial proposals, worked out by the Roadmap Coordination Group, were presented and discussed in the Rome RECFA meeting in March 2022, followed by extensive discussions with Funding Agencies and further refinement of the proposals.**
- **The proposed Detector and Accelerator implementation plans were presented to all Funding Agencies at the April 2022 Plenary RRB https://indico.cern.ch/event/1133070/timetable/ by ECFA and LDG Chairs (Karl Jakobs and Dave Newbold).**
  - **Given the diverse funding and costing models for different Funding Agencies it was decided to utilise the existing understood framework for funding long-term investments in particle physics experiments at CERN as the basis for supporting Detector R&D (DRD) collaborations to deliver the multi-decadal Strategic R&D programmes to meet requirements identified by the DRDTs in the Roadmap documents.**
  - **The clear need for "strategic" R&D was emphasised as separate from, but additional to, that for "blue-sky" and "experiment-specific" activities (*see also back-up*).**
- **Slightly updated implementation proposals were then presented during June 2022 Council Week and at Plenary ECFA on 22nd July 2022.**
- **Further refinements of the implementation plan for the Detector R&D Roadmap were discussed over the summer with the Roadmap Panel, CERN management plus RD50, RD51 and CALICE representation.**
- **These led to the September 2022 SPC and Council approved implementation plan: CERN/SPC/1190.**



CERN/SPC/1190
CERN/3679
Original: English
29 September 2022

ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Action to be taken		*Voting Procedure*
For information	**SCIENTIFIC POLICY COMMITTEE** 330th Meeting **26-27 September 2022**	-
For information	**RESTRICTED COUNCIL** 209th Session **29 September 2022**	-

EUROPEAN STRATEGY FOR PARTICLE PHYSICS
DETECTOR R&D ROADMAP

In the context of the implementation of the 2020 update of the European Strategy for Particle Physics, the European Committee for Future Accelerators (ECFA) was mandated by the CERN Council in 2020 to develop a detector R&D roadmap. The 2021 ECFA Detector Research and Development Roadmap was presented to the Council at its meeting in December 2021 and the Council invited ECFA to elaborate a detailed implementation plan.

ECFA hereby invites the Council to take note of the implementation plan that has been developed, as set out in annex 1 of this document.

*community feedback via RECFA delegates and National Contacts

Restricted ECFA

Institutes have to get in touch with the RECFA

Restricted ECFA Composition

https://ecfa.web.cern.ch/restricted-ecfa

Chair	Prof. Dr Karl Jakobs	Appointed Jan. 2021
Secretary	Prof. Patricia Conde Muino	Appointed July 2021

Members		
Austria	Dr Manfred Jeitler	Appointed Jan. 2018
Belgium	Prof. Nick van Remortel	Appointed July 2018
Bulgaria	Prof. Plamen Iaydjiev	Appointed Jan. 2016
Croatia	Prof. Mirko Planinic	Appointed July 2020
Cyprus	Prof. Panos Razis	Appointed Oct. 2017
Czech Republic	Dr Marek Tasevsky	Appointed Jan. 2019
Denmark	Prof. Mogens Dam	Appointed Jan. 2018
Finland	Dr Kati Lassila-Perini	Appointed Jan. 2018
France	Dr Jean-Claude Brient	Appointed Jan. 2020
Germany	Prof. Heiko Lacker	Appointed July 2021
Greece	Prof. Paris Sphicas	Appointed July 2018
Hungary	Dr Ferenc Siklér	Appointed Jan. 2021
Italy	Prof. Chiara Meroni	Appointed July 2020
Israel	Prof. Eilam Gross	Appointed Jan. 2018
Netherlands	Prof. Stan Bentvelsen	Appointed Jan. 2015
Norway	Prof. Alexander Read	Appointed Jan. 2018
Poland	Prof. Justyna Łagoda	Appointed Jan. 2021
Portugal	Prof. Patricia Condes Muino	Appointed July 2020
Romania	Dr Alexandru-Mario Bragadireanu	Appointed Jan. 2019
Serbia	Prof. Peter Adžic	Appointed July 2012
Slovakia	Dr Pavol Stríženec	Appointed May 2016
Slovenia	Prof. Marko Mikuž	Appointed July 2018
Spain	Prof. Celso Martinez	Appointed Jan. 2021
Sweden	Prof. David Milstead	Appointed Jan. 2018
Switzerland	Dr Mike Seidel	Appointed Jan. 2019
Turkey	Prof. Mehmet Zeyrek	Appointed July 2018
United-Kingdom	Prof. Max Klein	Appointed Jan. 2021
Ukraine	Prof. Mykola Shul'ga	Appointed July 2018
CERN	Dr Roger Forty	Appointed Sept. 2015
Ex-Officio Members		
CERN	Dr Fabiola Gianotti Prof. Joachim Mnich	Appointed Jan. 2016 Appointed Jan. 2021
LDG	Prof. Dave Newbold	Appointed Jan. 2021
Observers		
EPS-HEPP Board Chair	Prof. Thomas Gehrmann	Appointed Sept. 2019
ApPEC Chair	Dr Andreas Haungs	Appointed Jan. 2021
NuPECC Chair	Prof. Marek Lewitowicz	Appointed March 2018
Russian Federation	Prof. Victor Matveev	Appointed Jan. 2007
Early Career Researchers (ECR)	Lydia Brenner	Appointed Feb. 2021

*community feedback via RECFA delegates and National Contac

National contacts – CERN Members States through ECFA

Not all countries have a national contact at this stage, i.e. table might be updated while we move forward

If TF convenors seek specific input from the CERN member state countries, these colleagues can be contacted with specific questions and they will organise such as to provide you with an inclusive answer from their country.

Country	Name	Function	email
Austria	Manfred Jeitler	RECFA member	Manfred.Jeitler@cern.ch
Belgium			
Bulgaria	Venelin Koshuharov	Sofia University "St. Kl. Ohridski"	Venelin.Kozhuharov@cern.ch
Croatia	Tome Anticic	Rudjer Boskovic Institute	anticic@irb.hr
Cyprus	Panos Razis		razis@ucy.ac.cy
Czech Republic	Tomáš Davídek		davidek@ipnp.mff.cuni.cz
Denmark			
Finland			
France	Didier Contardo	CEA/CNRS contact for France	contardo@cern.ch
Germany			
Greece	Dimitris Loukas	Institute of Nuclear Physics, Demokritos	loukas@inp.demokritos.gr
Hungary	Dezso Varga	Wigner RCP	varga.dezso@wigner.hu
Italy	Nadia Pastrone		nadia.pastrone@cern.ch
Israel	Erez Etzion	Tel Aviv University, head of School of Physics and Astronomy	ereze@tauex.tau.ac.il
Netherlands	Niels van Bakel	head of the R&D group at Nikhef	nielsvb@nikhef.nl
Norway	Gerald Eigen		Gerald.Eigen@ift.uib.no
Poland	Marek Idzik	University of Science and Technology AGH	idzik@ftj.agh.edu.pl
Portugal	Paulo Fonte	Polytechnic Institute of Coimbra	fonte@coimbra.lip.pt
Romania	Mihai Petrovici	Senior Researcher in IFIN-HH, Head of Hadronic Physics Department	mpetro@nipne.ro
Serbia	Lidija Zivkovic		Lidija.Zivkovic@cern.ch
Slovakia			
Slovenia	Gregor Kramberger		gregor.kramberger@ijs.si
Spain	Mary-Cruz Fouz	CIEMAT	mcruz.fouz@ciemat.es
Sweden	Christian Ohm		christian.ohm@cern.ch
Swtizerland	Ben Kilminster	Zurich University	ben.kilminster@physik.uzh.ch
Turkey	Kerem Cankocak	İstanbul Technical University	kerem.cankocak@cern.ch
United-Kingdom	Iacopo Vivarelli		I.Vivarelli@sussex.ac.uk
Ukraine			
CERN	Christian Joram		Christian.Joram@cern.ch

Detector R&D Roadmap: General Strategic Recommendations

GSR 1 - Supporting R&D facilities

It is recommended that the structures to provide **Europe-wide coordinated infrastructure in the areas of: test beams, large scale generic prototyping and irradiation be consolidated and enhanced to meet the needs of next generation experiments** with adequate centralised investment to avoid less cost-effective, more widely distributed, solutions, and to maintain a network structure for existing distributed facilities, e.g. for irradiation

GSR 2 - Engineering support for detector R&D

In response to ever more integrated detector concepts, requiring holistic design approaches and large component counts, the R&D should be supported with **adequate mechanical and electronics engineering resources**, to bring in expertise in state-of-the-art microelectronics as well as advanced materials and manufacturing techniques, to tackle generic integration challenges, and to maintain scalability of production and quality control from the earliest stages.

GSR 3 - Specific software for instrumentation

Across DRDTs and through adequate capital investments, the availability to the community of **state-of-the-art R&D-specific software packages must be maintained and continuously updated**. The expert development of these packages - for core software frameworks, but also for commonly used simulation and reconstruction tools - should continue to be highly recognised and valued and the community effort to support these needs to be organised at a European level.

GSR 4 - International coordination and organisation of R&D activities

With a view to creating a vibrant ecosystem for R&D, connecting and involving all partners, there is a **need to refresh the CERN RD programme structure and encourage new programmes for next generation detectors**, where CERN and the other national laboratories can assist as major catalysers for these. It is also recommended to revisit and streamline the process of creating and reviewing these programmes, with an extended framework to help share the associated load and increase involvement, while enhancing the visibility of the detector R&D community and easing communication with neighbouring disciplines, for example in cooperation with the ICFA Instrumentation Panel.

Detector R&D Roadmap: General Strategic Recommendations

GSR 5 - Distributed R&D activities with centralised facilities

Establish in the relevant R&D areas a distributed yet connected and supportive tier-ed system for R&D efforts across Europe. Keeping in mind the growing complexity, the specialisation required, the learning curve and the increased cost, consider more focused investment for those themes where leverage can be reached through centralisation at large institutions, while addressing the challenge that distributed resources remain accessible to researchers across Europe and through them also be available to help provide enhanced training opportunities.

GSR 6 - Establish long-term strategic funding programmes

Establish, additional to short-term funding programmes for the early proof of principle phase of R&D, also **long-term strategic funding programmes to sustain both research and development of the multi-decade DRDTs** in order for the technology to mature and to be able to deliver the experimental requirements. Beyond capital investments of single funding agencies, international collaboration and support at the EU level should be established. In general, the cost for R&D has increased, which further strengthens the vital need to make concerted investments.

GSR 7 – "Blue-sky" R&D

It is essential that **adequate resources be provided to support more speculative R&D** which can be riskier in terms of immediate benefits but can bring significant and potentially transformational returns if successful both to particle physics: unlocking new physics may only be possible by unlocking novel technologies in instrumentation, and to society. Innovative instrumentation research is one of the defining characteristics of the field of particle physics. "Blue-sky" developments in particle physics have often been of broader application and had immense societal benefit. Examples include: the development of the World Wide Web, Magnetic Resonance Imaging, Positron Emission Tomography and X-ray imaging for photon science.

Detector R&D Roadmap: General Strategic Recommendations

GSR 8 - Attract, nurture, recognise and sustain the careers of R&D experts

Innovation in instrumentation is essential to make progress in particle physics, and R&D experts are essential for innovation. It is recommended that ECFA, with the involvement and support of its Detector R&D Panel, continues the study of **recognition with a view to consolidate the route to an adequate number of positions with a sustained career in instrumentation R&D** to realise the strategic aspirations expressed in the EPPSU. It is suggested that ECFA should explore mechanisms to develop concrete proposals in this area and to find mechanisms to follow up on these in terms of their implementation. Consideration needs to be given to creating sufficiently attractive remuneration packages to retain those with key skills which typically command much higher salaries outside academic research. It should be emphasised that, in parallel, society benefits from the training particle physics provides because the knowledge and skills acquired are in high demand by industries in high-technology economies.

GSR 9 - Industrial partnerships

It is recommended to **identify promising areas for close collaboration between academic and industrial partners**, to create international frameworks for exchange on academic and industrial trends, drivers and needs, and to establish strategic and resources-loaded cooperation schemes on a European scale to intensify the collaboration with industry, in particular for developments in solid state sensors and micro-electronics.

GSR 10 – Open Science

It is recommended that the concept of **Open Science be explicitly supported in the context of instrumentation**, taking account of the constraints of commercial confidentiality where these apply due to partnerships with industry. Specifically, for publicly-funded research the default, wherever possible, should be open access publication of results and it is proposed that the Sponsoring Consortium for Open Access Publishing in Particle Physics ($SCOAP^3$) should explore ensuring similar access is available to instrumentation journals (including for conference proceedings) as to other particle physics publications.