DRD1
Survey : Calorimetry and Other Applications beyond HEP

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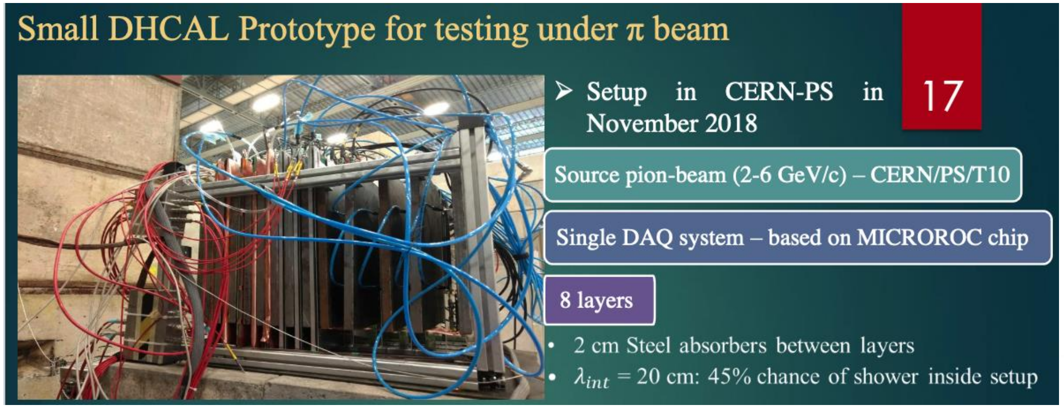
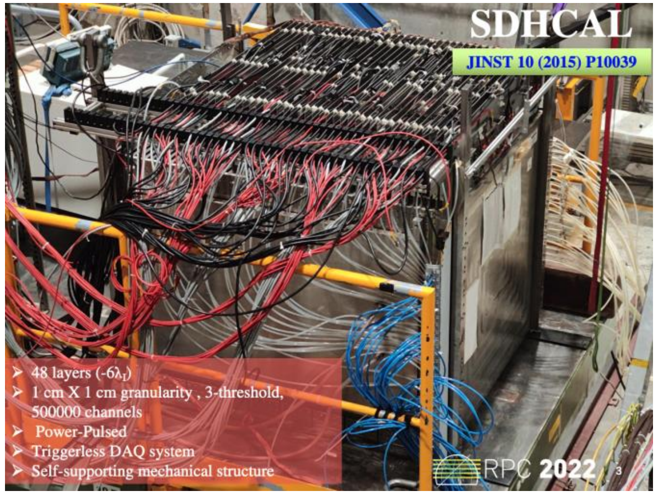
Calorimetry with Gas Detectors

- Hadronic calorimeters with alternating layers of absorbers and sampling elements, based on Gas Detectors, are considered for ILC, FCC-ee, EIC, FCC-hh and muon collider

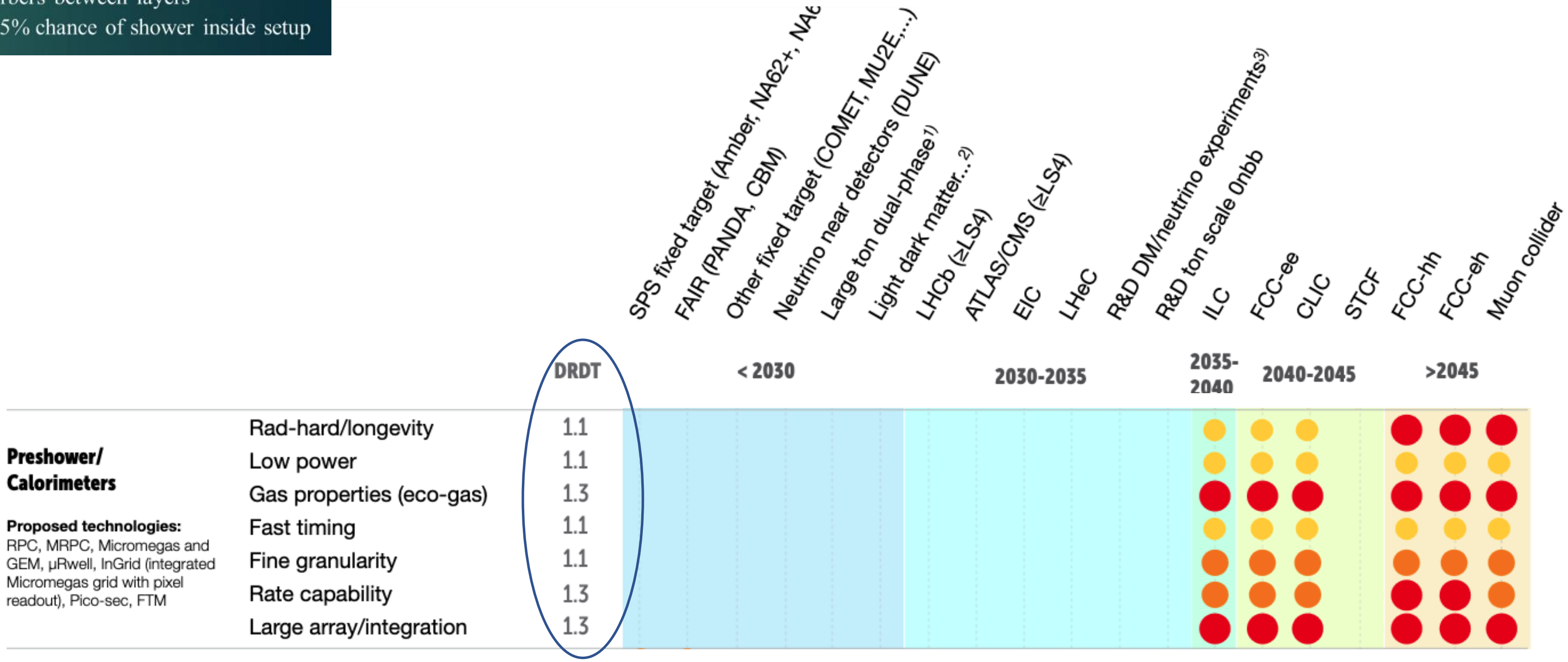


Resistive Plate WELL (RPWELL)

In digital or semi-digital approach



RPC



Calorimetry with GD: Technologies and main challenges from ECFA

Facility	Technologies	Challenges	Most challenging requirements at experiment
Higgs-EW-Top Factories (ee) (ILC/FCC-ee/CepC,/SCTF)	RPC, Micromegas and GEM, μ-RWELL, GridPix, PICOSEC, FTM	High granularity, excellent hit timing, large area detectors, stabiliy, uniform response, eco-gases	**(ILC)** Max. rate:1 kHz/cm² Granularity (~1 cm²) Radiation hardness: no Jet Energy resolution: 3-4 % Power-pulsing, self-triggering readout
Muon collider	RPC, Micromegas and GEM, μ-RWELL, GridPix, PICOSEC, FTM	High granularity, radiation hardness, excellent hit timing, stabiliy, uniform response, eco-gases	Granularity (~1cm²) Fat jet identification Time resolution= O(100ps) Energy resolution =(5%)/sqrt(E) for fat-jet High radiation hardness
Hadron physics (EIC)	RPC, Micromegas and GEM, μ-RWELL, GridPix, PICOSEC, FTM	High granularity, radiation hardness, excellent hit timing, stabiliy, uniform response, eco-gases	**(EIC option)** DHCAL

→ Require thin gas layers, which might affect signal amplification and timing resolution, and embedded electronics integrated in a very compact system.

Figure 1.4: Main drivers for Calorimeters at future facilities. The most stringent requirements for the future R&D activities are quoted in the last column.

Main challenges of the future R&D in the GD-based calorimetry:

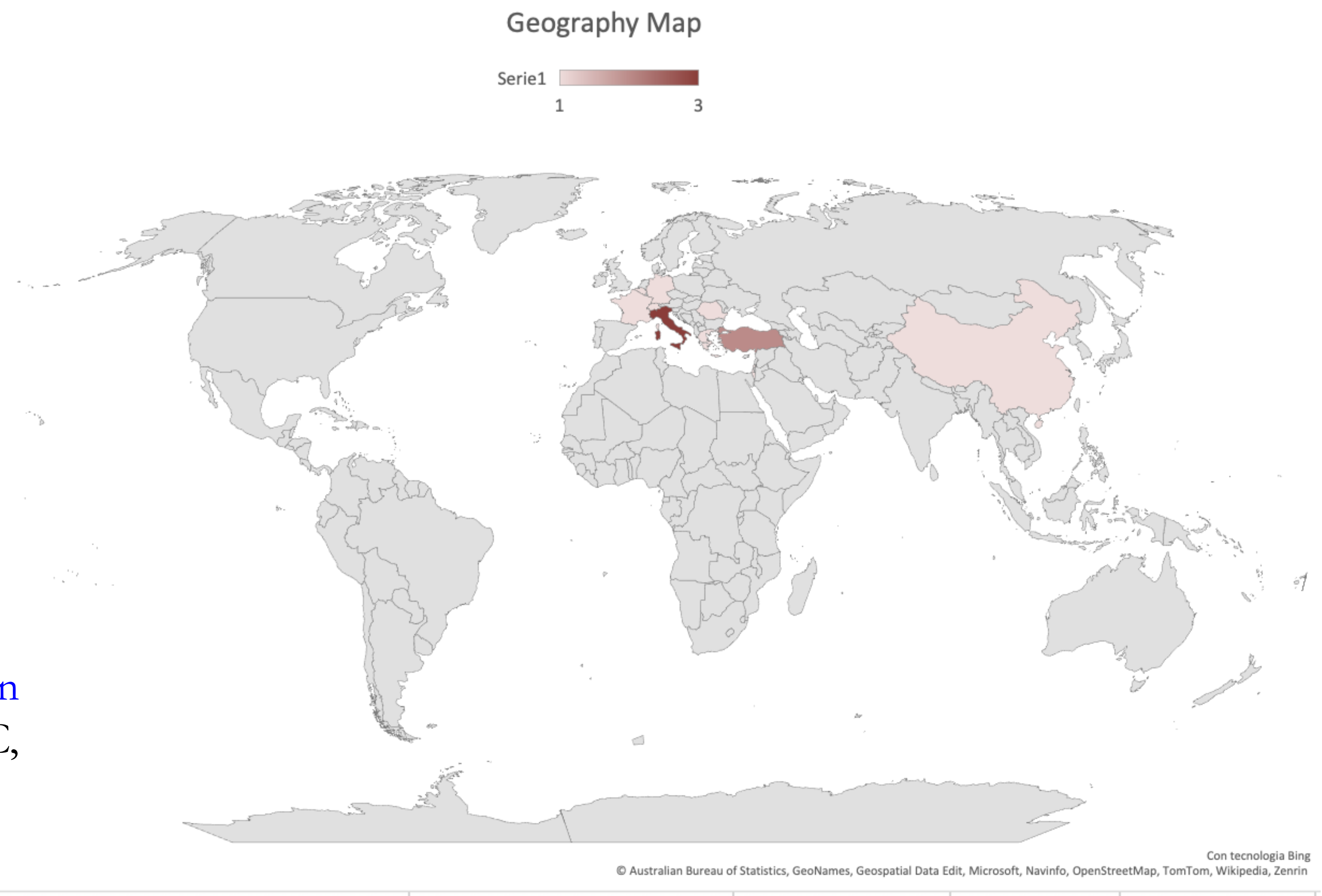
- ensure a uniform response over the large detector area (DRDT 1.1)

  Production of high planarity and large area of PCBs for MPGDs or of very thin High Pressure Laminate RPCs is a challenge (just an example)
- radiation hard gaseous detectors are needed in some cases
- operation with eco-friendly gas mixtures (DRDT 1.3)…

Survey: Calorimetry at Futures Facilities

- 13 out of 69 institutes expressed interest on Calorimetry application
- These institutes are mainly located in EU and China (1)

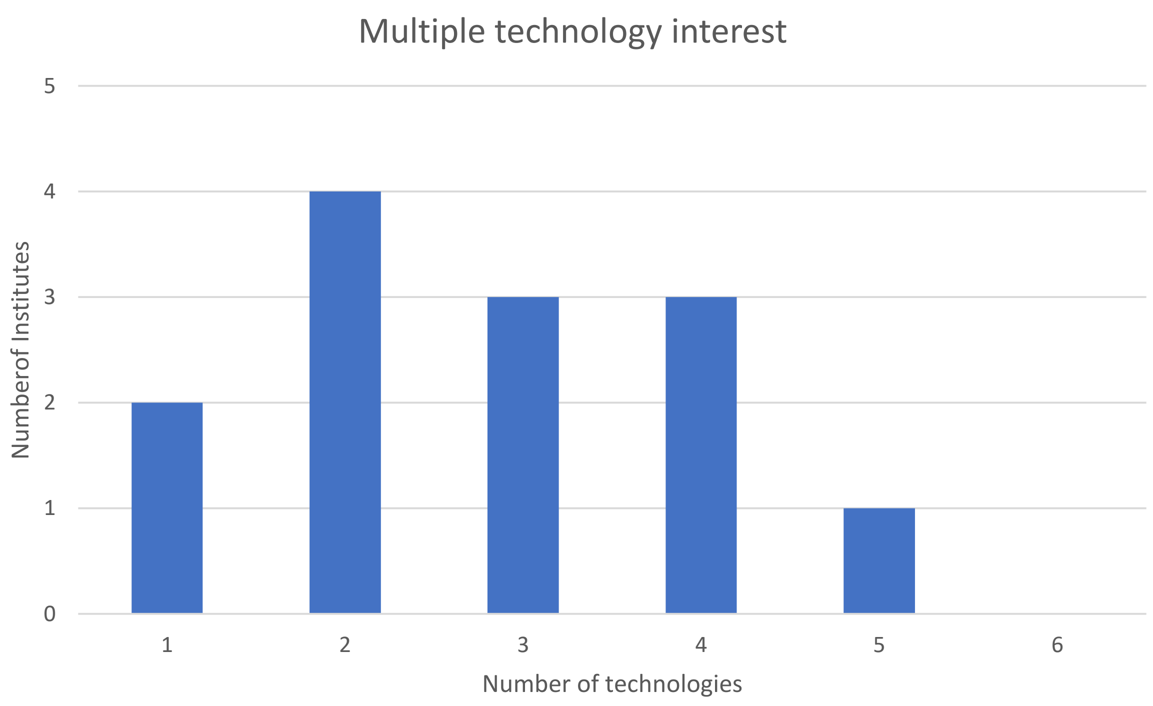
Belgium
China
France
Germany
Greece
Israel
Italy
Romania
SWITZERLAND
Turkey

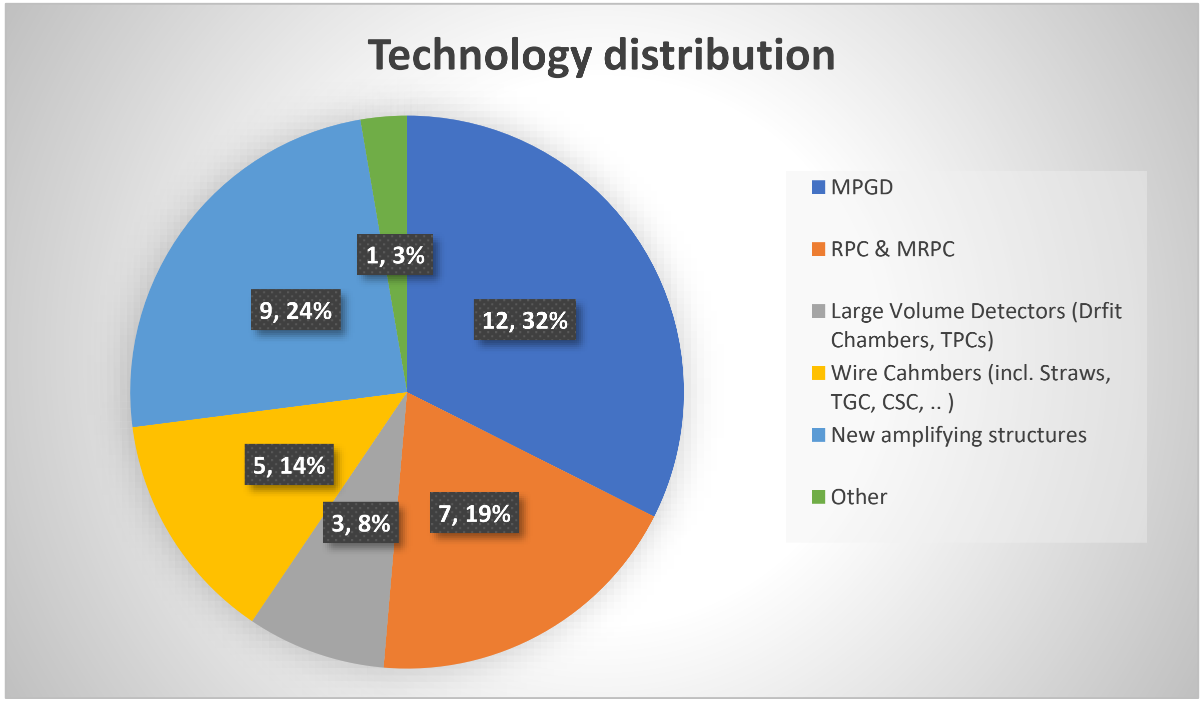


- Few institutes declared to be already active on R&D calorimetry with gas detectors (RPC, resistive Micromegas, mRWEEL,..)

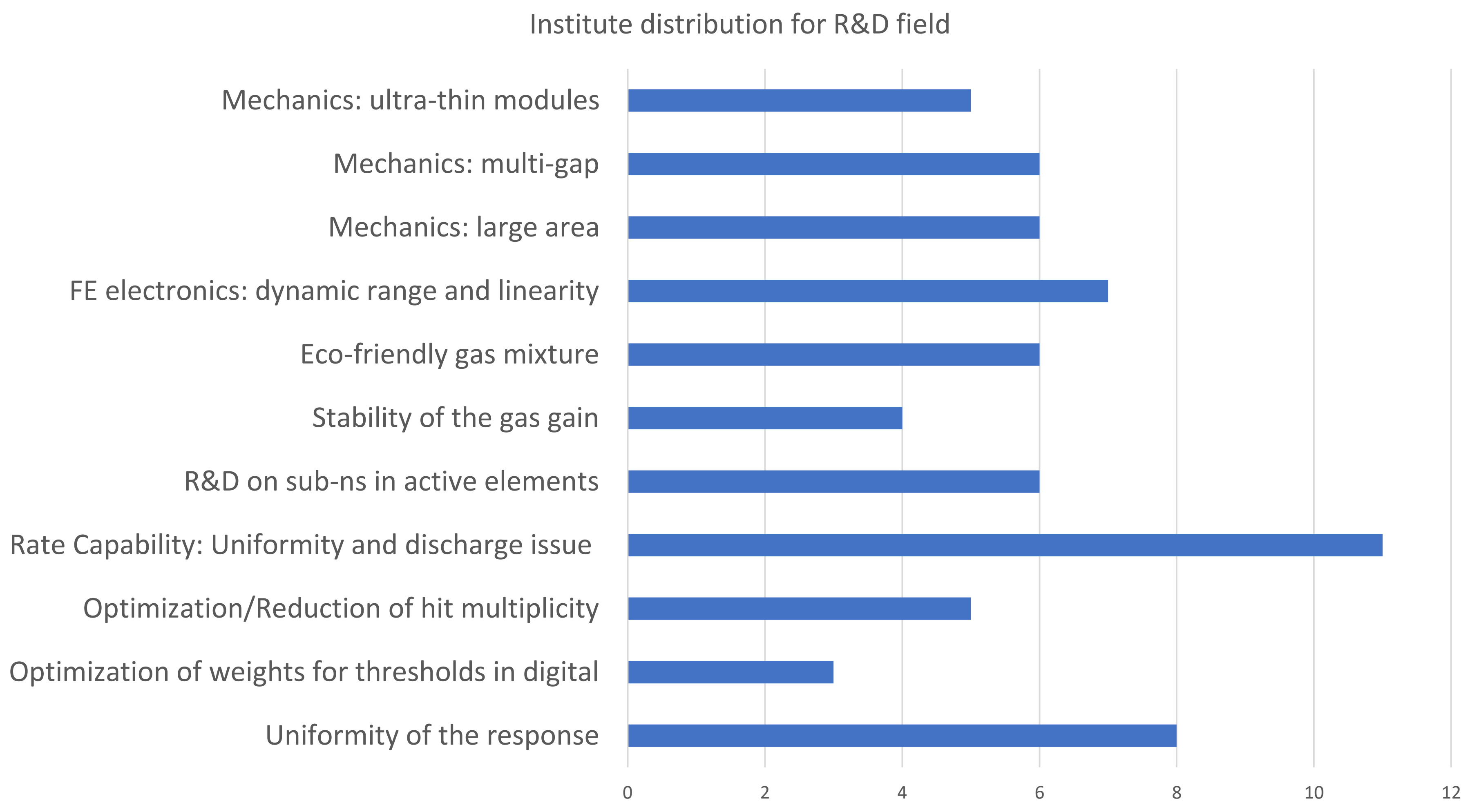
Survey: technology interest for Calorimetry applications

- All detector technologies are well represented
- Each institute is involved in more than one technology: typically MPGD plus one or two other technology





Number of institutes interested for each R&D



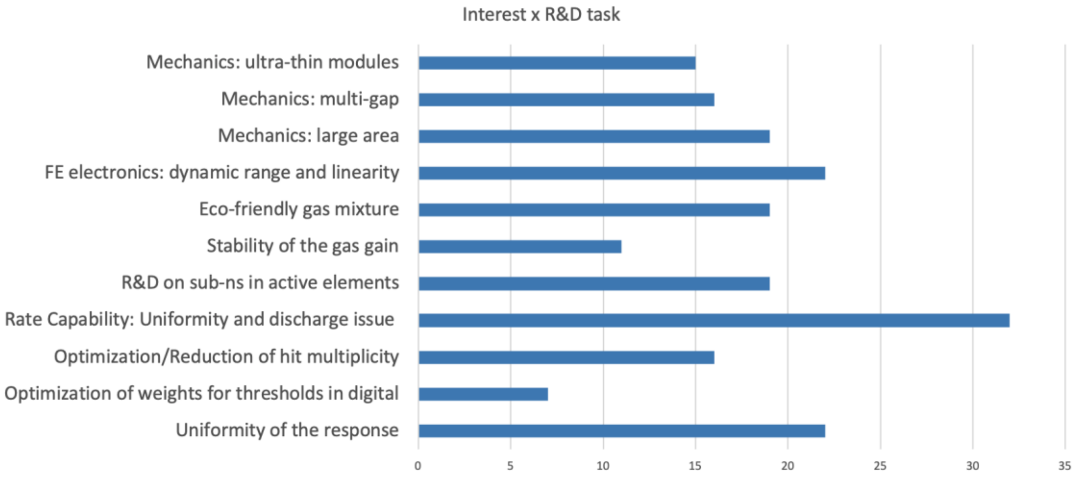
➢ Each R&D task is well covered by a good number of institutes (here there is no distinguish by the technologies used) →

Calorimetry
• 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 List of R&D in the SURVEY

Technologies vs. R&D

	Uniformity of the response	Optimization of weights for thresholds in digital	Optimization/Reduction of hit multiplicity	Rate Capability: Uniformity and discharge issue	R&D on sub-ns in active elements	Stability of the gas gain	Eco-friendly gas mixture	FE electronics: dynamic range and linearity	Mechanics: large area	Mechanics: multi-gap	Mechanics: ultra-thin modules
DRDT	1,1			1,3	1.1-1.3		1,3		1,1	1,1	1,1
TOTALS	8	3	5	11	6	4	6	7	6	6	5
MPGD	7	3	5	10	6	3	5	6	5	5	4
RPC and MRPC	5	2	3	6	4	2	6	5	5	4	4
Large Volume Detectors (Drfit Chambers, TPCs)	2	0	2	3	2	1	1	2	2	1	1
Wire Cahmbers (incl. Straws, TGC, CSC, ..)	2	0	2	4	3	2	3	3	2	2	2
New amplifying structures	6	2	4	9	4	3	4	6	5	4	4
number of declared tech. x R&D	16	5	12	23	15	8	15	16	14	12	11

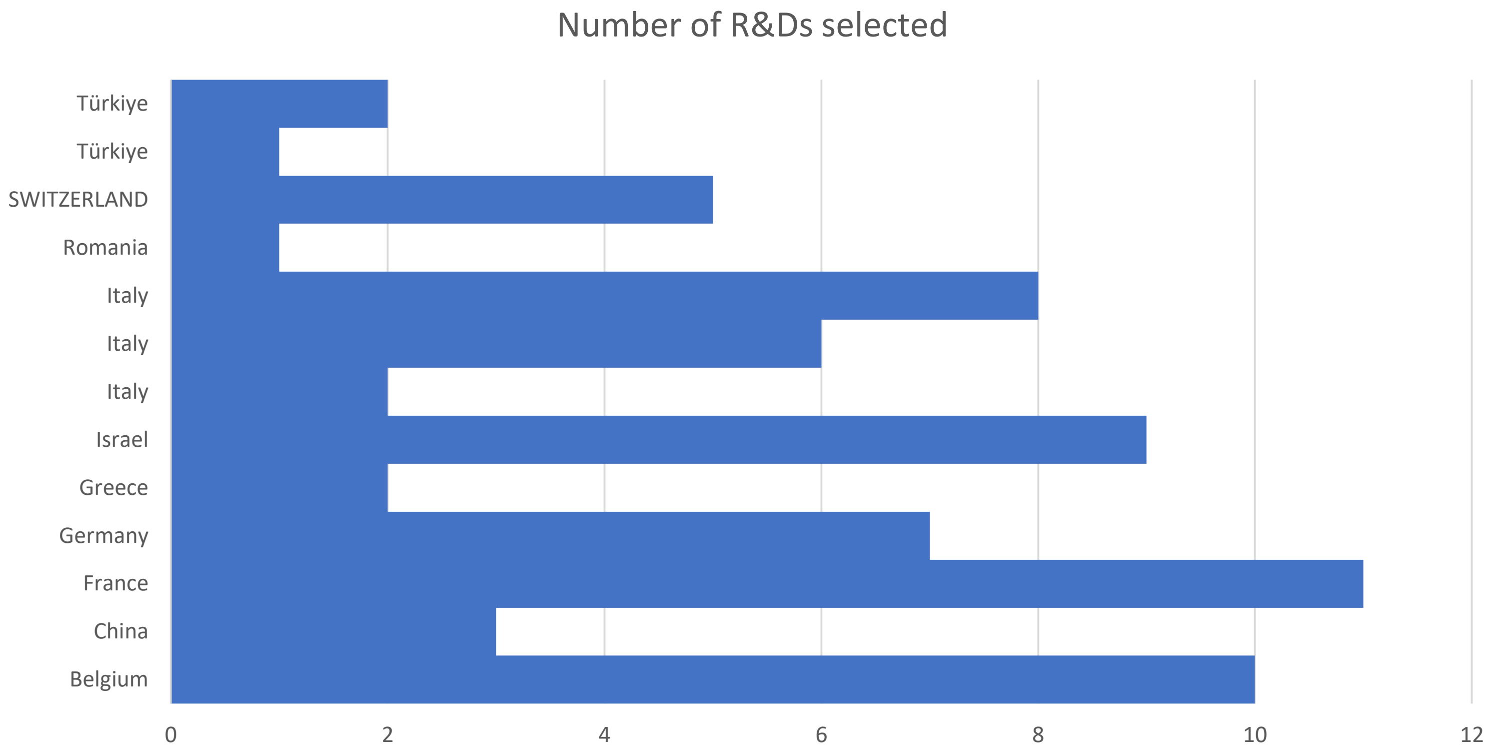
- For each R&D task, there are at least two or more technologies: synergies are possible cross institutes and cross technology



Calorimetry

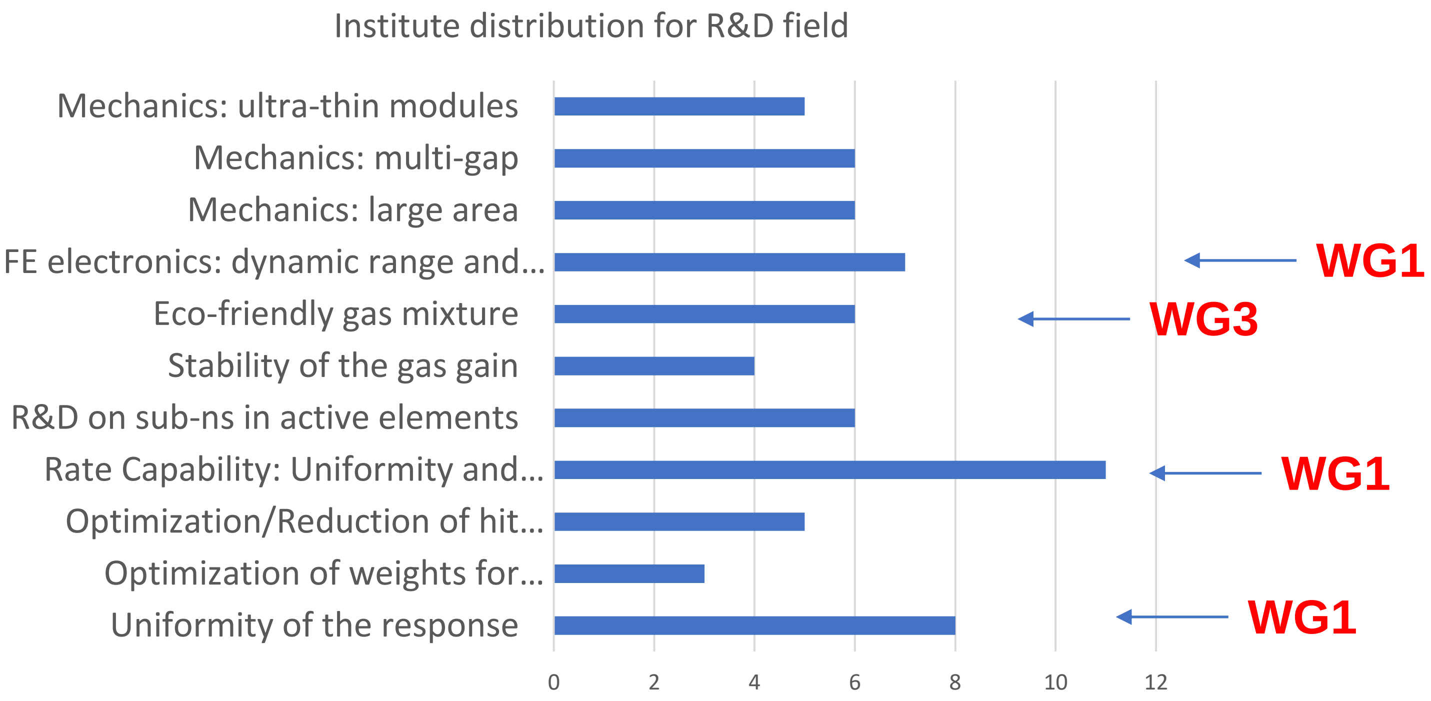
- Uniformity of the response of the large area and dynamic energy range
- Optimization of weights for different thresholds in digital calorimeters
- Rate capability in detectors based on resistive materials: resistivity uniformity, discharge issue at high rate and in large area detector
- R&D on sub-ns 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

Number of R&D task selected by each institute



- Some institutes are interested in most the R&Ds →These multiple R&Ds activities could facilitate synergies among the institutes
- Some institutes are interested on few specific R&Ds
- Institutes with already some experience on this field could share ideas/experience with institutes new on this field

And….Synergies with other WGs



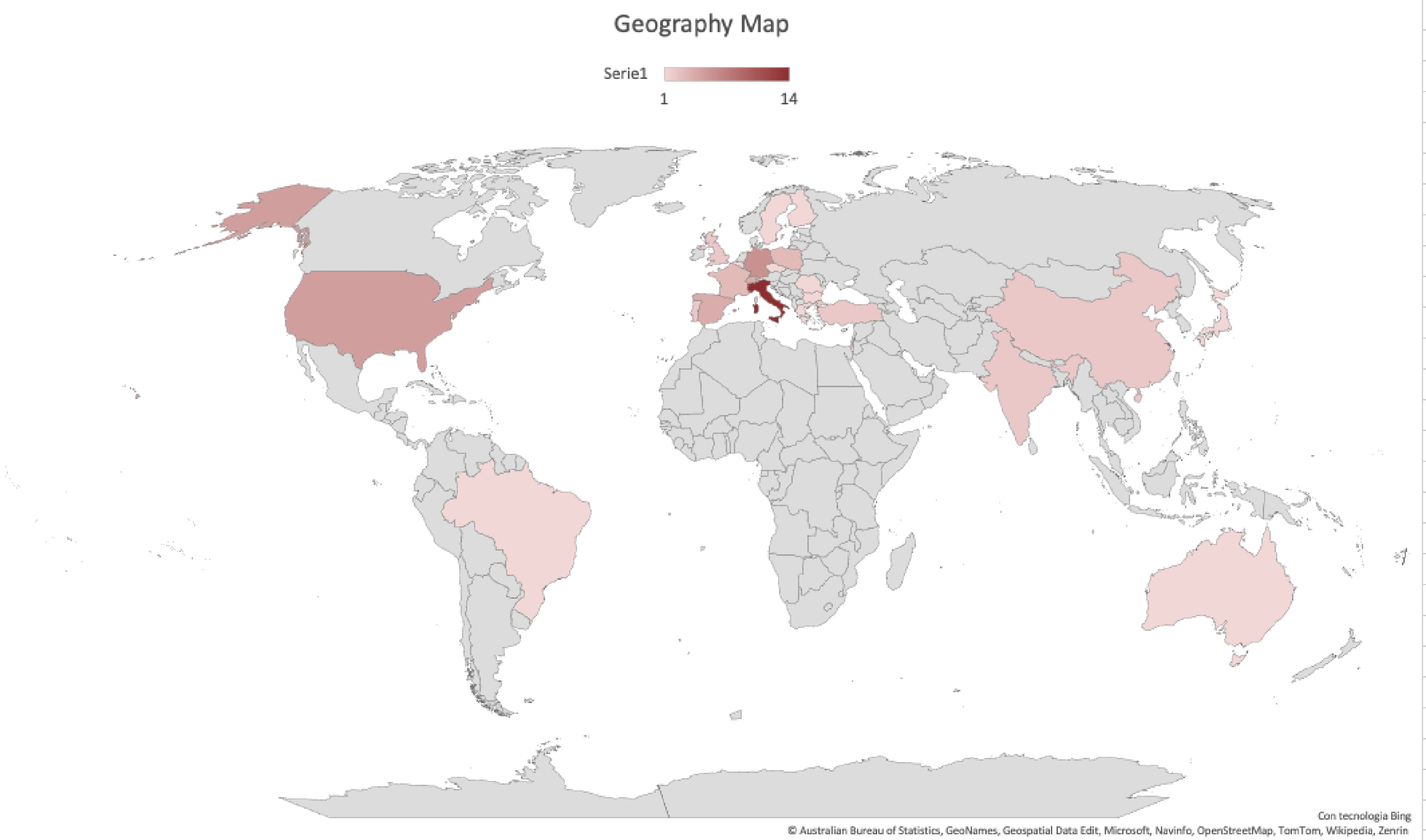
… And of course with DRD6

Fundamental Research and Applications beyond HEP…

Fundamental Research and Applications beyond HEP

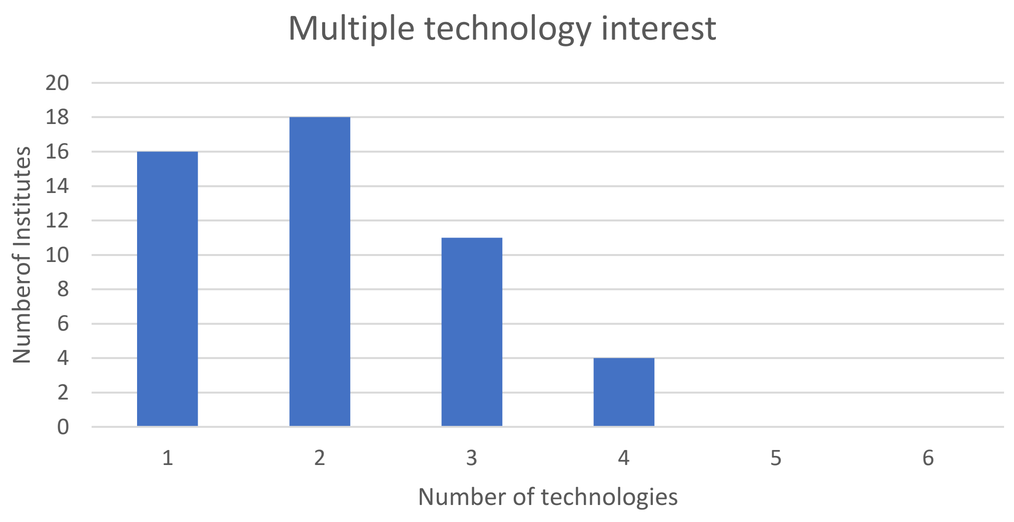
- 49 out of 69 institutes **(70%)** expressed interest FR and Applications beyond HEP
- Great interest, spread all over the world. Biggest cluster in Italy (14), Germany (6) and US (5)
- In most of the cases (but 4), the institutes are interest in applications beyond HEP plus other applications (Muon, etc)

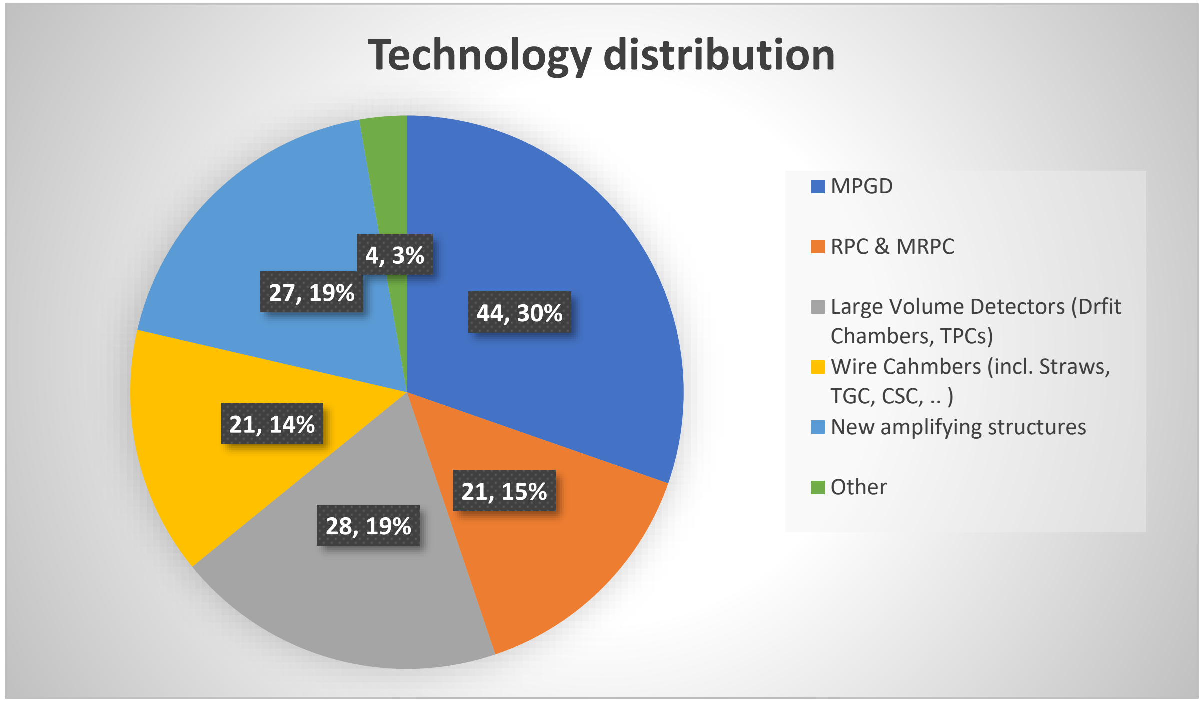
Australia
Belgium
Brazil
Bulgaria
China
Czech Republic
Finland
France
Germany
Greece
India
Israel
Italy
JAPAN
Poland
Portugal
Romania
Spain
Sweden
SWITZERLAND
Türkiye
UK
United States



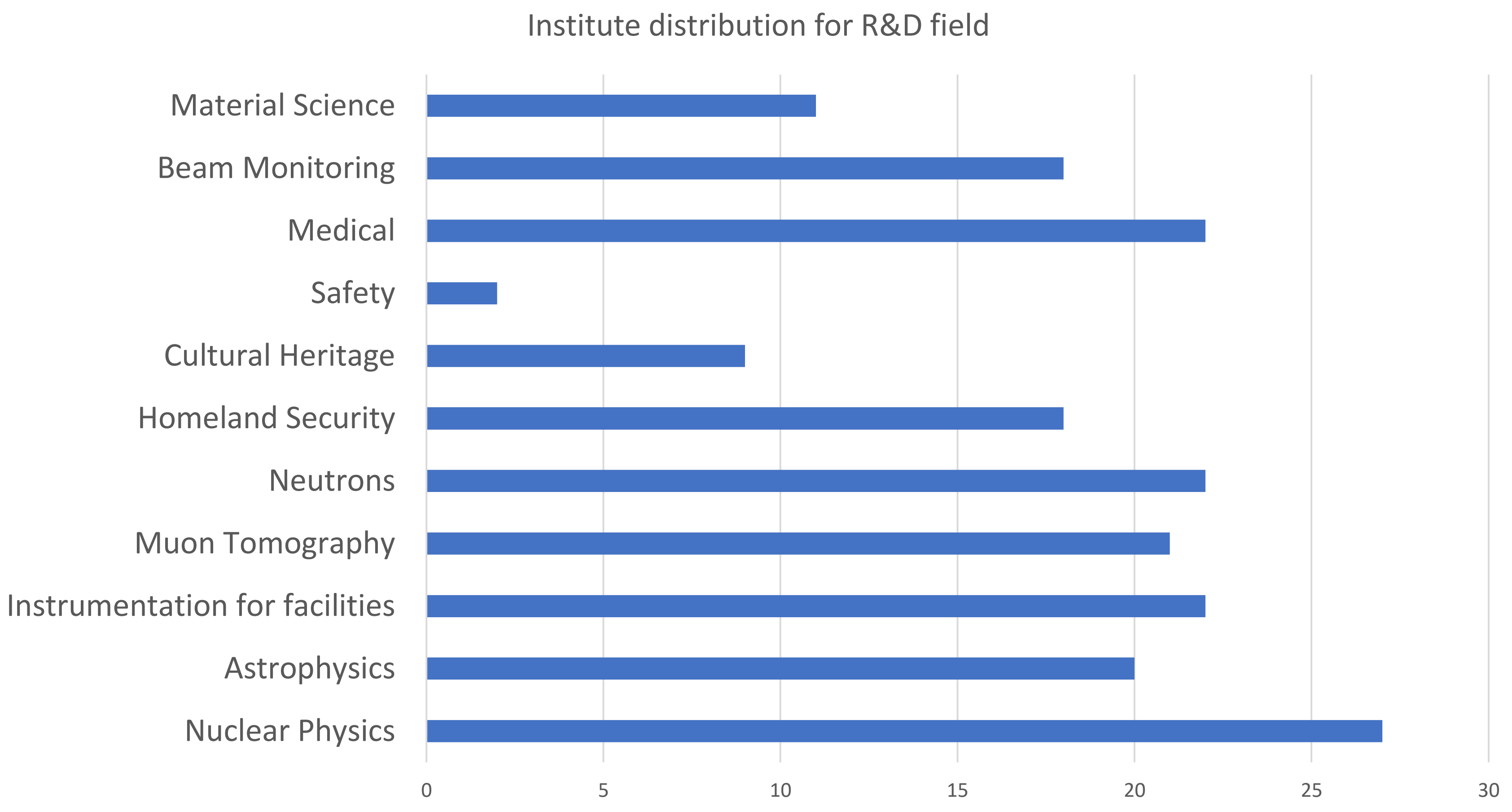
Survey: which technologies for FR and Other applications Beyond HEP

- All detector technologies are well represented. Wide interest for these ”other applications”
- Each institute is involved in more than one technology





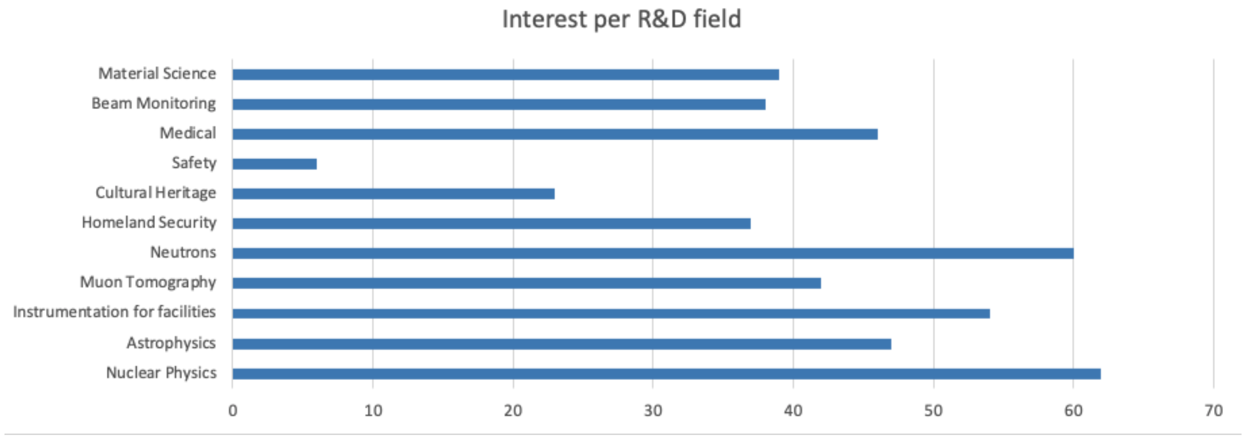
Fundamental Research and Applications beyond HEP



Technologies vs. R&D

	Nuclear Physics	Astrophysics	Instrumentation f	Muon Tomography	Neutrons	Homeland Security	Cultural Heritage	Safety	Medical	Beam Monitoring	Material Science
	1,1			1,3	1.1-1.3	1,3			1,1	1,1	1,1
TOTALS	27	20	22	21	22	18	9	2	22	18	11
MPGD	21	17	18	16	21	14	9	2	18	13	10
RPC & MRPC	11	8	8	11	7	9	5	1	10	7	6
Large Volume Detectors (Drfit Chambers, TPCs)	16	11	16	7	17	8	3	1	8	11	8
New amplifying structures	13	8	9	6	12	5	5	1	8	6	8
Others	1	3	3	2	3	1	1	1	2	1	7
	62	47	54	42	60	37	23	6	46	38	39

- For each R&D task, there are at least two or more technologies: synergies are possible cross institutes and cross technologies



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