

IN2P3 in DRD Calo

Roman Pöschl

Co-Coordinator Transition to DRD Calo

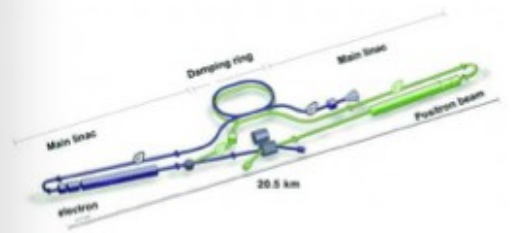
French PI of input-proposals to DRD Calo:

Vincent Boudry, Imad Laktineh, Patrick Robbe, Giulia Hull, Nicolas Morange, Christophe de la Taille, Christian Morel, Suzanne Gascon-Shotkin

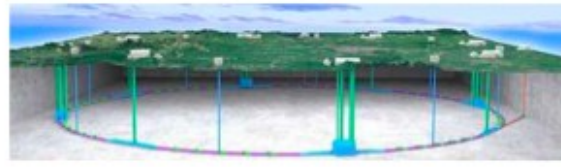
**The following slides contain confidential and
partially incomplete information
Please do not disseminate**

**Most of the information has been taken from the input-proposals
and the first round of digestion since April 1st 2023
Some changes w.r.t. input-proposals (update of IN2P3 participants)
during preparation of these slides**

ILC



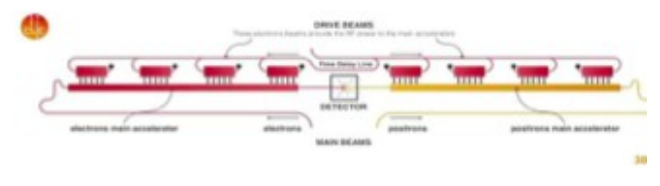
CEPC



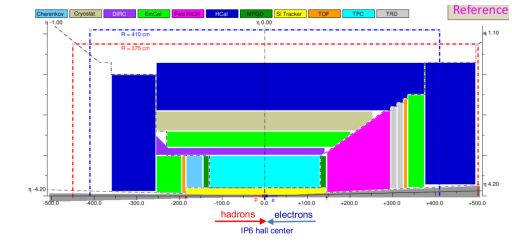
FCC-ee



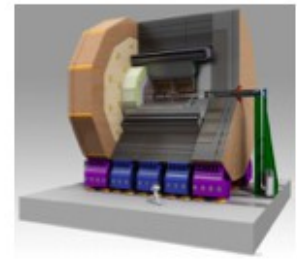
CLIC



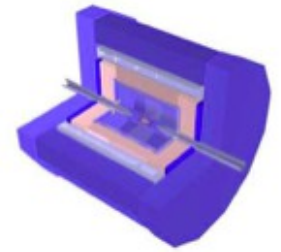
EIC



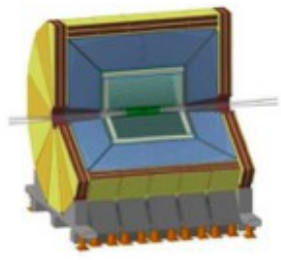
ILD



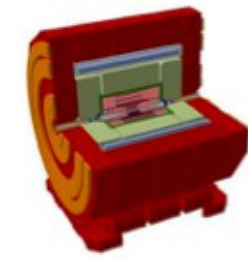
CEPC Baseline



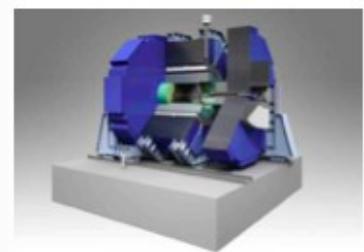
IDEA



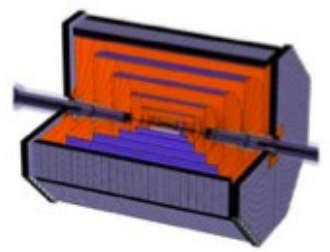
CLICdp



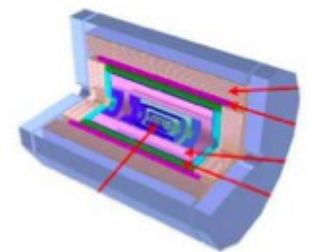
SiD



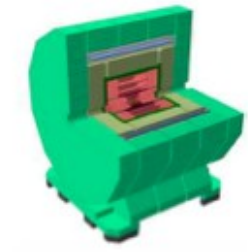
FST



CEPC 4th concept



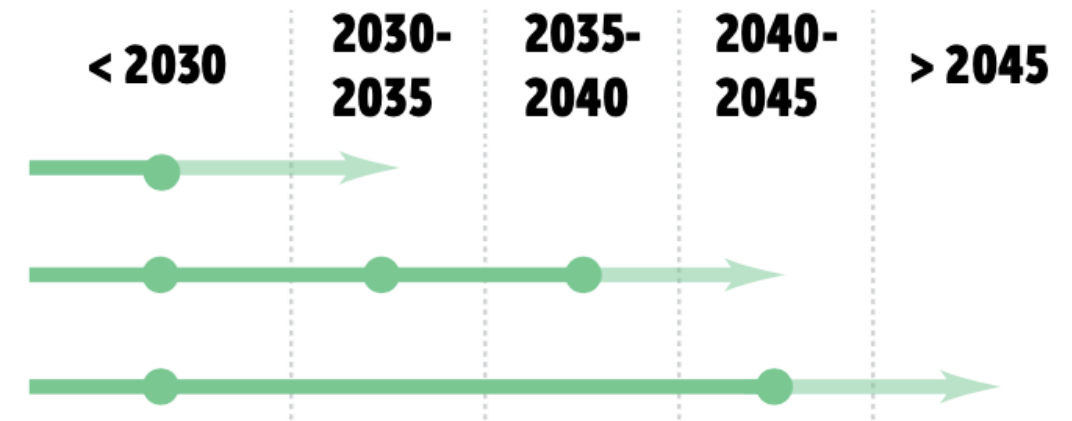
CLD



slide stolen from B. Dudar

Calorimetry

- DRDT 6.1** Develop radiation-hard calorimeters with enhanced electromagnetic energy and timing resolution
- DRDT 6.2** Develop high-granular calorimeters with multi-dimensional readout for optimised use of particle flow methods
- DRDT 6.3** Develop calorimeters for extreme radiation, rate and pile-up environments



The Proposal Team

Track 1: Sandwich calorimeters with fully embedded Electronics – Main and forward calorimeters

Track conveners:

Adrian Irlles (IFIC), Frank Simon (KIT), Jim Brau (U. of Oregon), Wataru Ootani (U. of Tokyo)

Track 2: Liquified Noble Gas Calorimeters

Track Conveners:

Martin Aleksa (CERN), Nicolas Morange (IJCLab), Marc-André Pleier (BNL)

Track 3: Optical calorimeters: Scintillating based sampling and homogenous calorimeters

Track Conveners:

Etiennette Auffray (CERN), Gabriella Gaudio (INFN-Pavia), Macro Lucchini (U. and INFN Milano-Bicocca), Philipp Roloff (CERN), Sarah Eno (U. of Maryland), Hwidong Yoo (Yonsei Univ.)

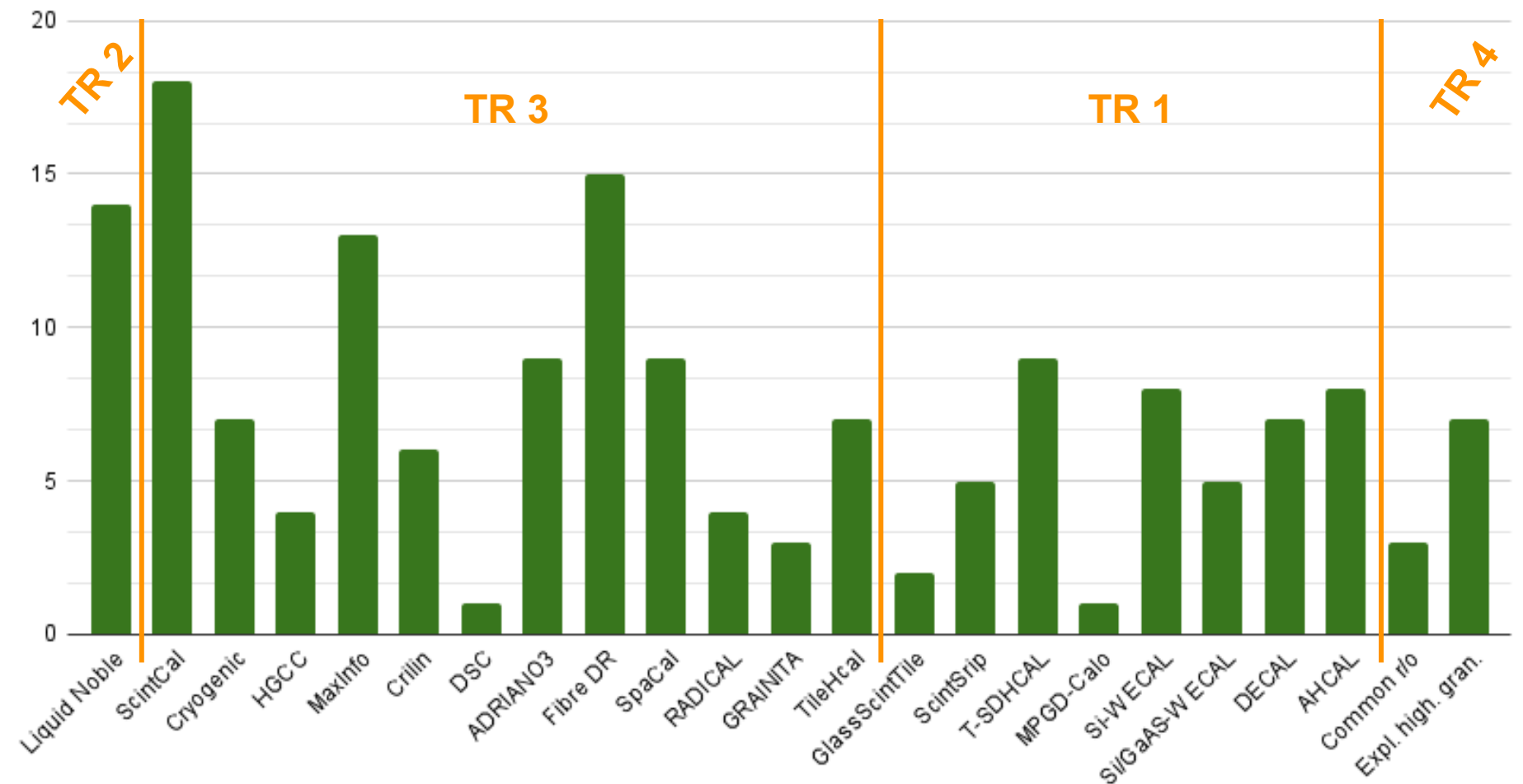
Track 4: Transversal Activities

Christophe de La Taille (Lab. Omega)

Input proposals

23 comprising 110 institutes/labs received

Institutes Per Proposal



For further details of input-proposals and formation of DRD Calo see:

<https://indico.cern.ch/event/1246381/>

DRD Calo@IN2P3 – June 2023

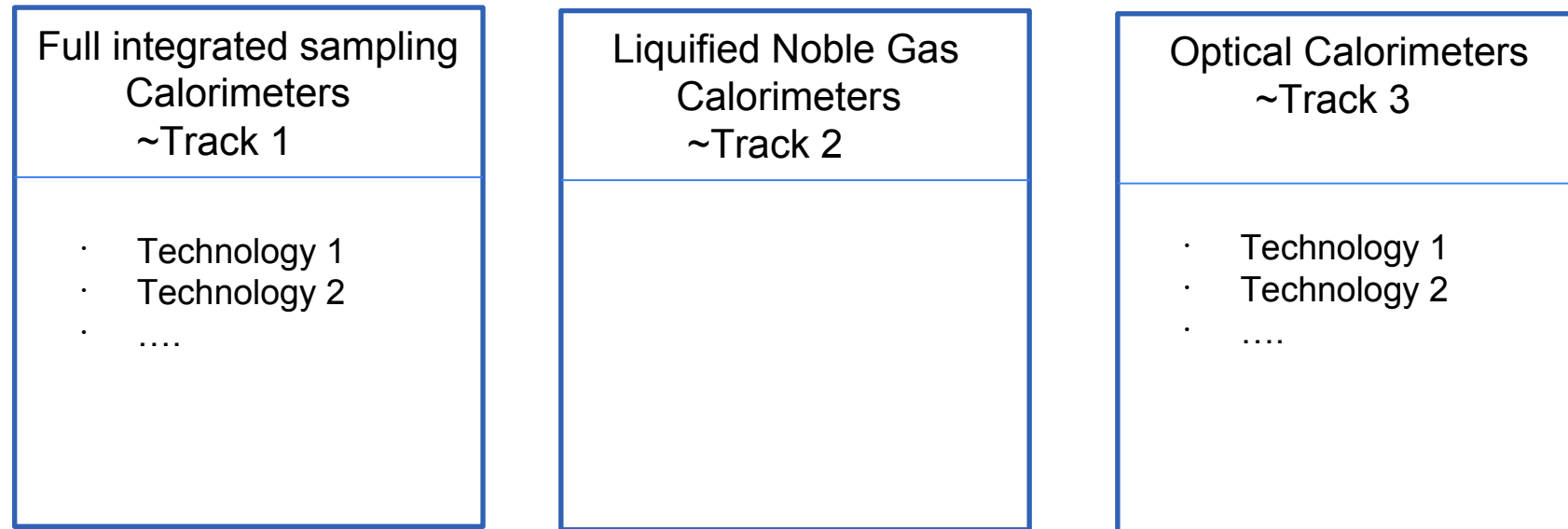
G. Gaudio

2nd Calorimeter Community Meeting

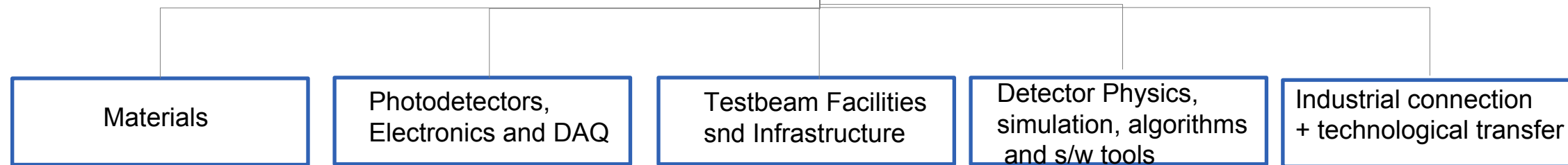
Management: Gouvernmental and executive bodies including Speakers Bureau (📄📄👤 Dissemination)

Work Areas: Will deliver monitorable results and enable R&D with shared interest

- Technologies will emerge from input-proposals
- Maybe after some minor regrouping



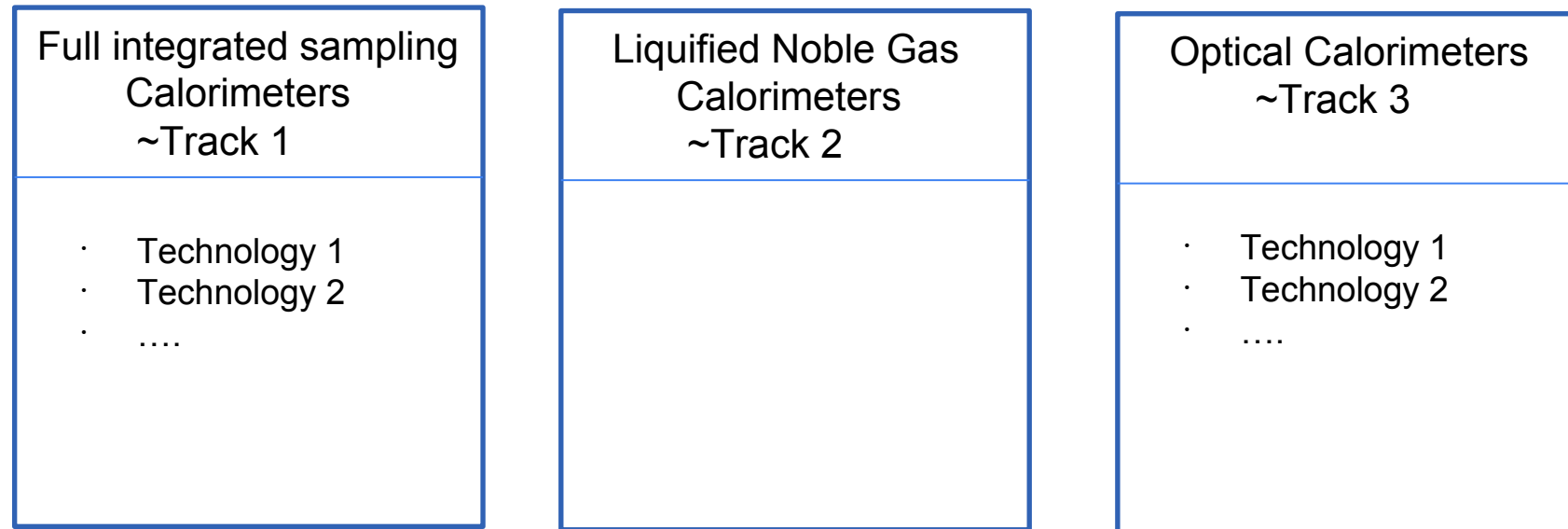
Transversal Activitites (common collaboration interests):



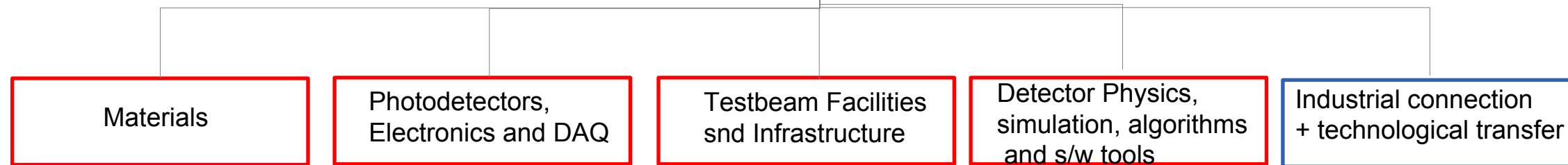
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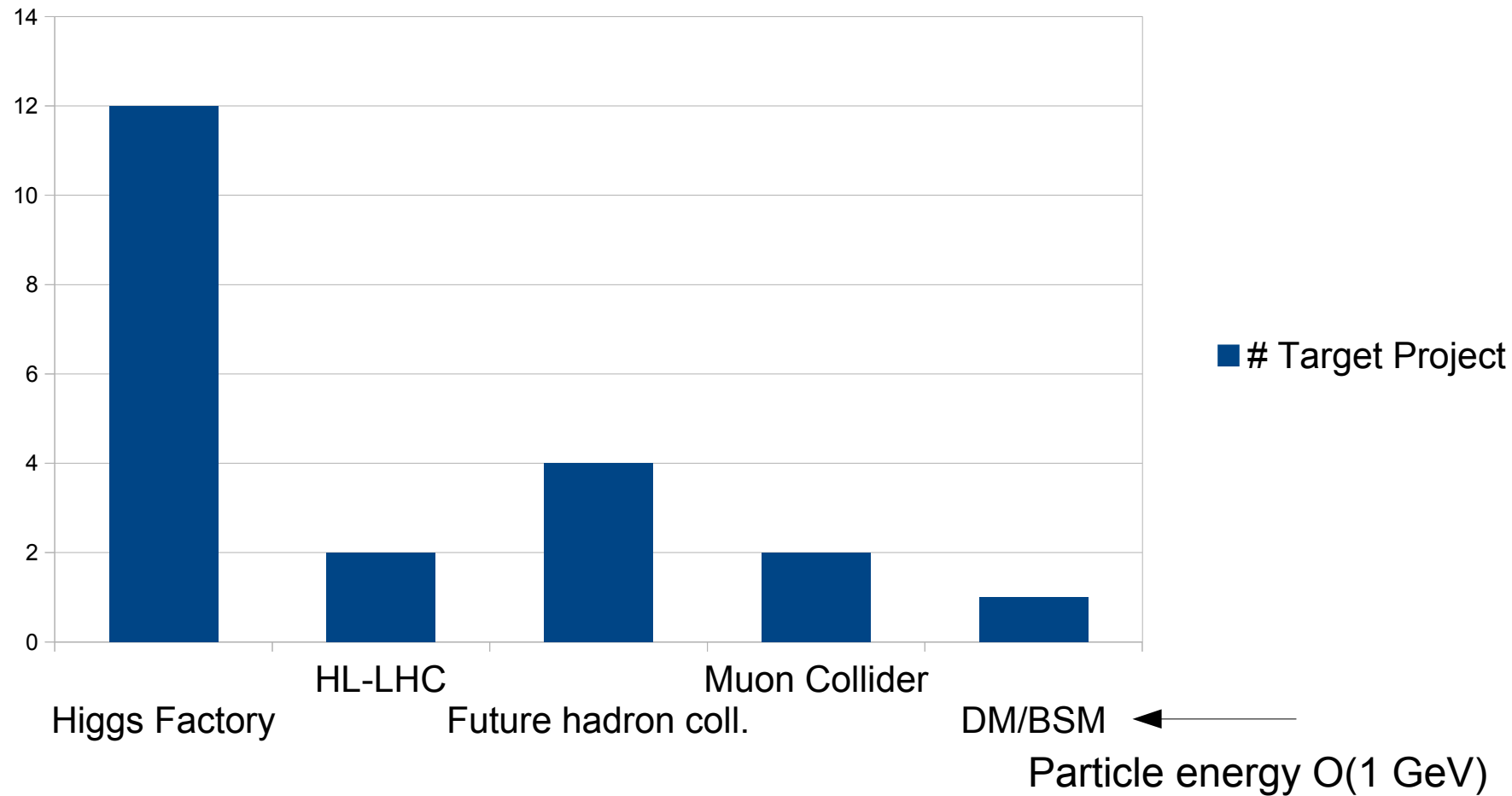
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Transversal Activities (common collaboration interests):

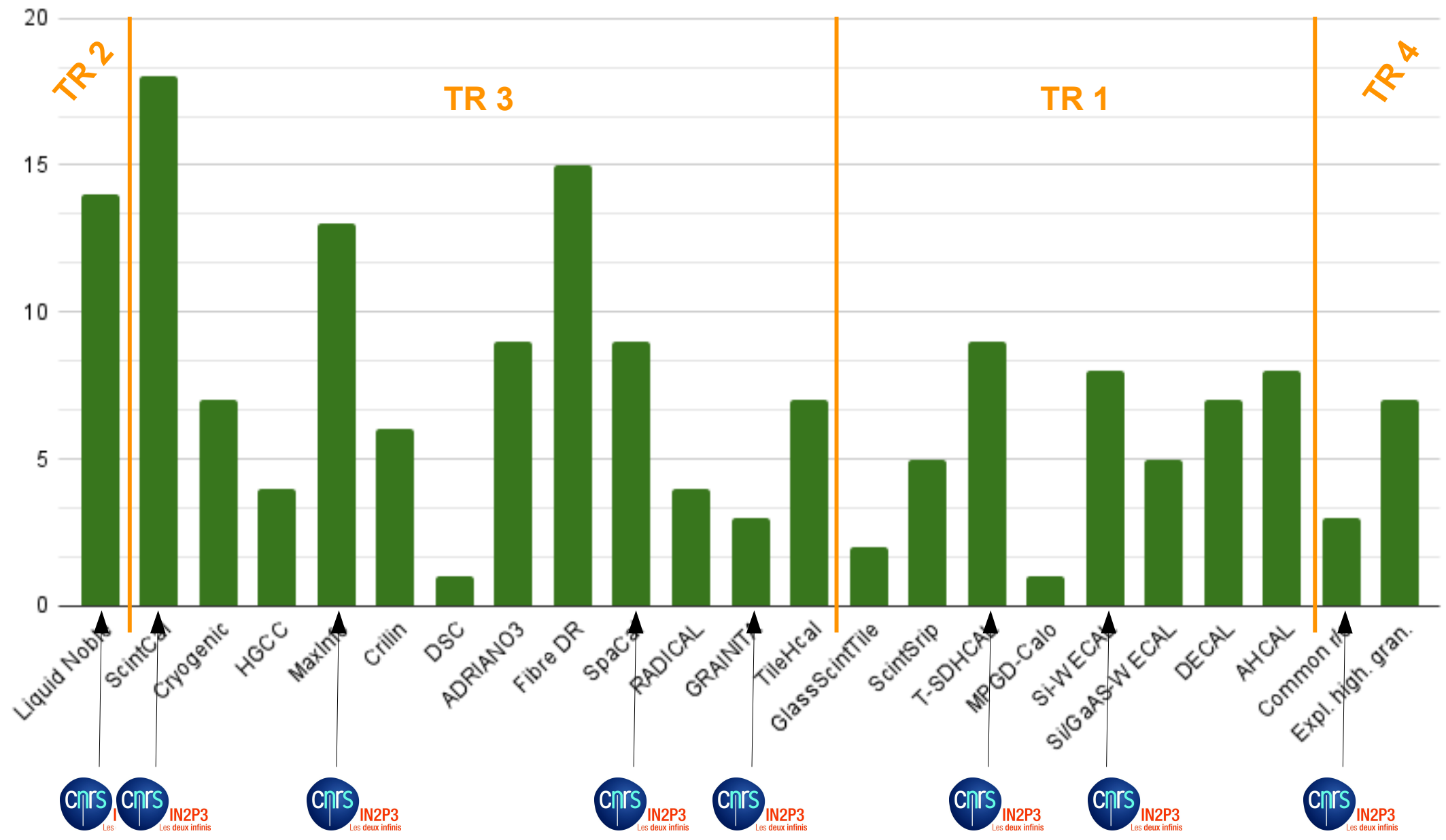


- Transversal Activities are vital for the success of the collaboration
- Transversal Activities will also ensure relations with other DRD

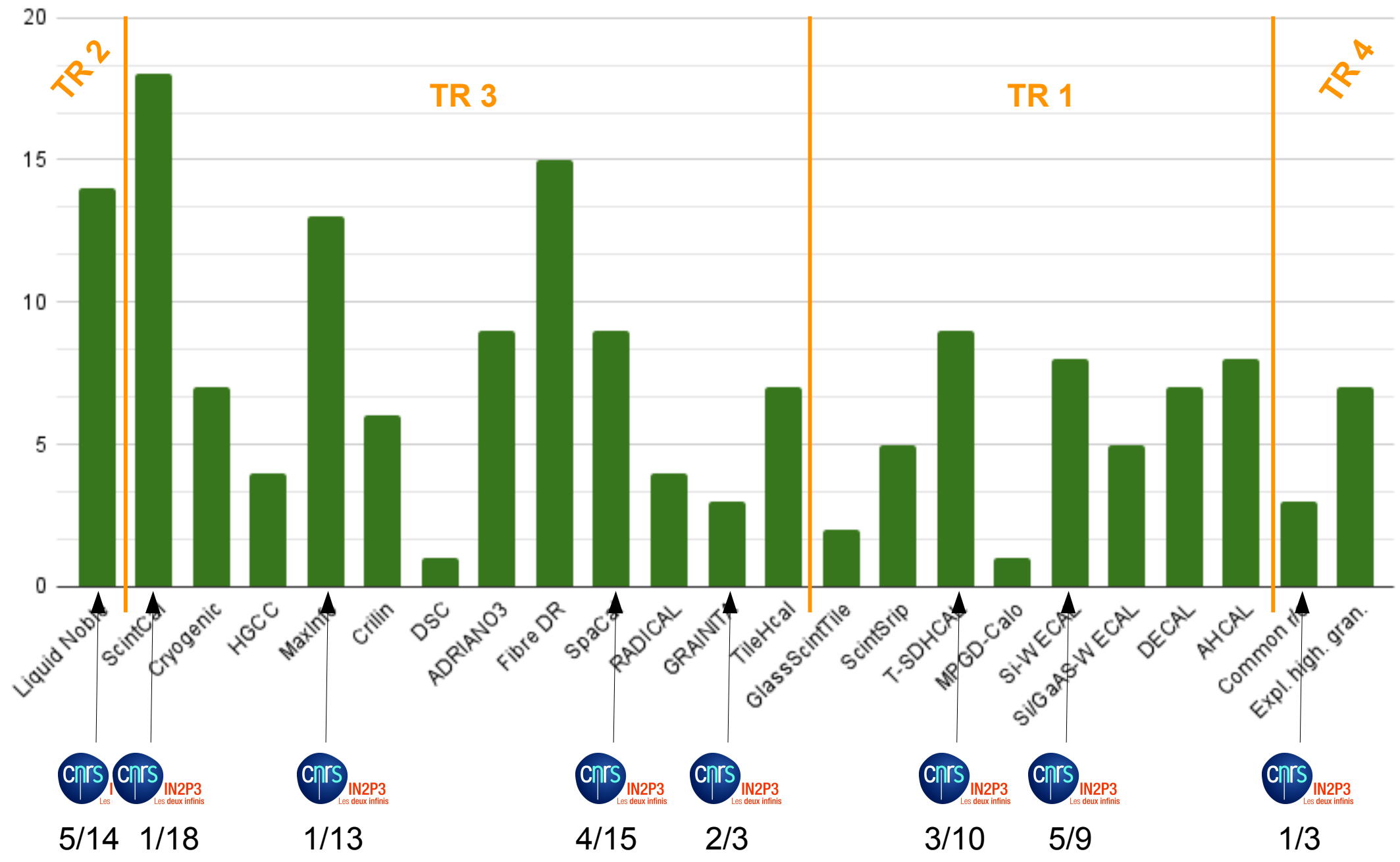


- Higgs factories dominate
 - HF includes heavy flavor that target superb elm. energy resolutions
- (Already now) orientation towards future hadron collider and muon collider

Institutes Per Proposal



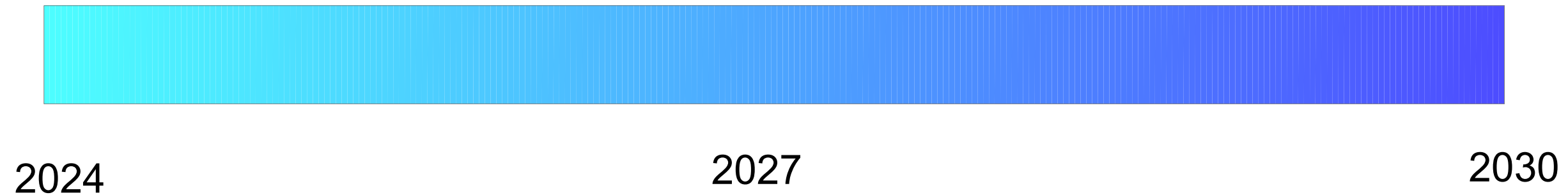
Institutes Per Proposal



IN2P3 labs/
Total labs

- **Liquid Noble: IJCLab, APC, CPPM, LPNHE, OMEGA**
 - Partners: CERN, D: TU Dresden, CZ: CU, SLK: U Kosice, US: BNL, Columbia, Stony Brook, Texas Austin, U Arizona; Targets: Higgs Factory, Future Hadron Collider
- **ScintCal: CPPM**
 - Partners: CERN, CZ: FZU, D: FH Aachen, Giessen U, US: U. Maryland, Notre Dame, ORNL, U Iowa, U Virginia, CALTECH, FNAL, F: CEA-Irfu, ILM UA: NAS, I: UNIVPM, INFN/Uni MIB, EST: IPUT; Target: Higgs Factory
- **MaxInfo: I2PI**
 - Partners: CERN, US: U. Maryland, U Michigan, Purdue, MIT, TTU, U Virginia, ANL CALTECH, FNAL, F: CEA-Irfu, ILM UA: NAS, I: INFN NA, INFN/Uni MIB; Target: Higgs Factory
Remark: Strong overlap with ScintCal project
- **SpaCal: IJCLab, LPC CF, LPC Caen, I2PI**
 - Partners: CERN, CZ: FZU, I: INFN/Uni MIB, ES: UB, IFIC; Target: HL-LHC after LS4 (LHCb)
- **GRAINITA: IJCLab, LPC CF**
 - Partners: UA: ISMA; Target: FCCee/CEPC Heavy Flavour
- **T-SDHCAL: I2PI, OMEGA, LPC CF**
 - Partners: CN: SJTU, ES: CIEMAT, UCO, SK: YCC, GWNU, B: VUB, TU: Tunis U; Target: Higgs Factory
- **SiW ECAL: IJCLab, LLR, LPNHE, OMEGA, DMLAB (IRL F-D, with German scintillator HCAL)**
 - Partners: CERN, JP: Kysuhu U, KEK, ES: IFIC; Target: Higgs Factory

Though OMEGA is part of the projects, OMEGA is also expected to take a coordinating role in the development and production of readout ASICs for future prototypes. Similar observation holds for IJCLab (SpaCal)

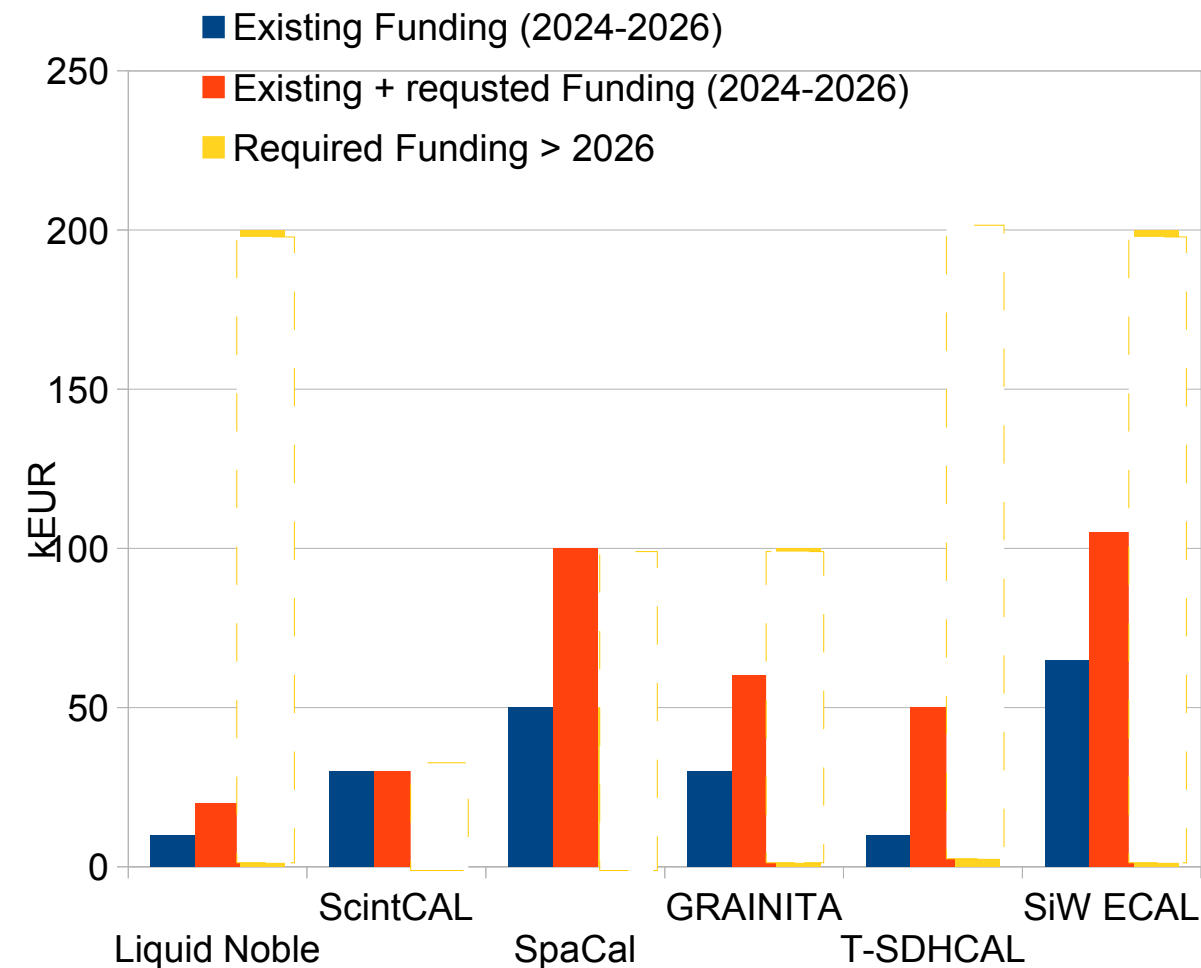
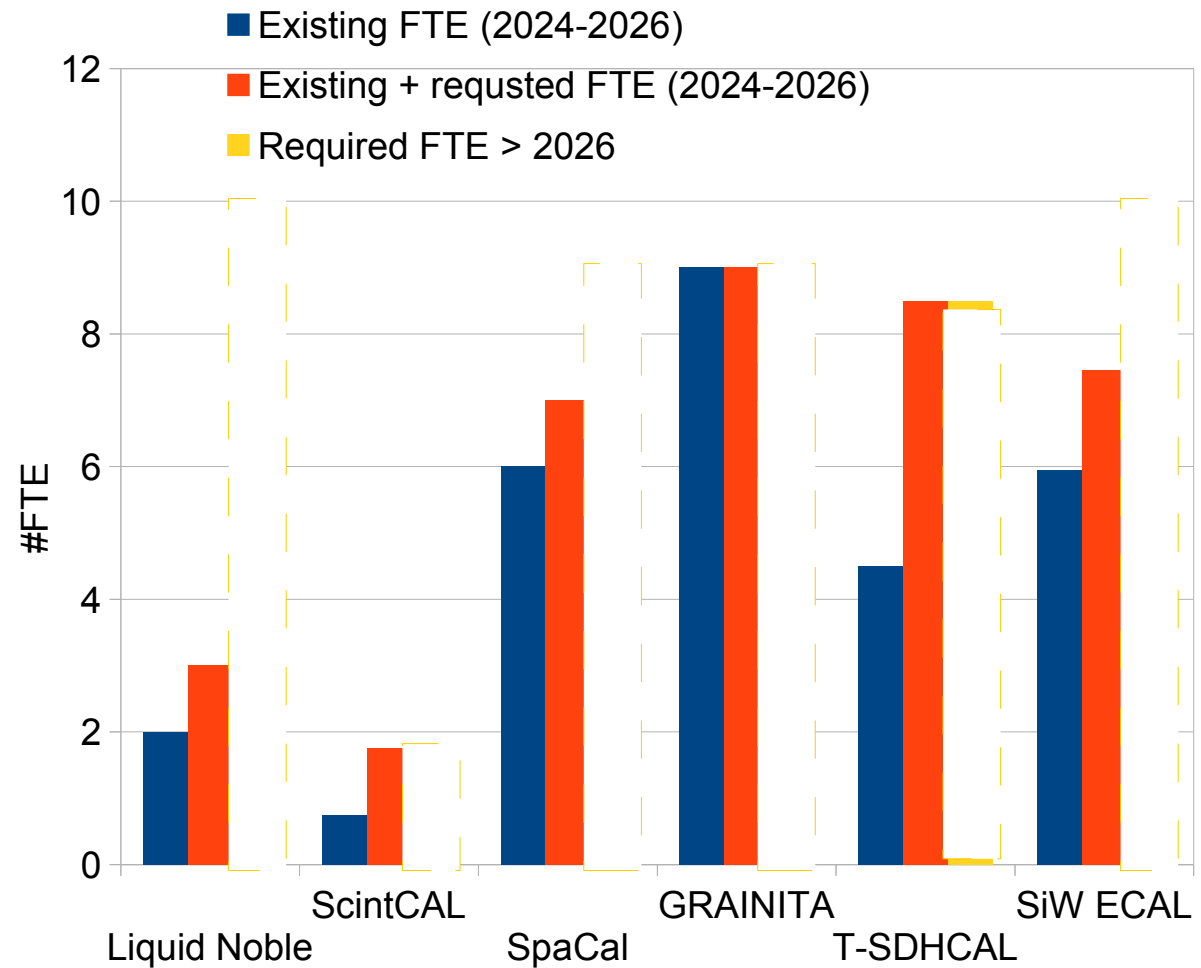


- **Input-proposals reveal little (extra) need at the beginning (2024-2026)**
 - Start with prototypes that are either existing or currently under construction
 - (Mainly) benefitting from existing funding at national level of international level (AIDAInnova and EUROLABS)
 - Specification studies, concept proof – Would require fresh funding

- **Relatively high density of beam tests with new (large scale) prototypes after 2026**
 - Four large scale prototypes activities with major IN2P3 participation
 - Granular SiW ECAL, T-SDHCAL, Liquid Noble, SpaCal
 - GRAINITA might get on the rise
 - Large prototypes will cost around 1 MEUR – IN2P3 share?

- **Execution of program requires availability and support of beam test facilities**
 - See also backup

Assume contribution by IN2P3 roughly given by (IN2P3 labs/Total labs) (see above)



Comments:

- FTE is sum of Researchers including postdocs, IT and PhD-Students
- Tried to account for existing hardware (e.g. 1KEUR/Si Sensor, 10EUR/ASIC)
- Numbers > 2026 speculation by R.P. - Just to indicate that significant funding increase will be needed or that activity will continue at a given level
- This funding should be subject to dedicated later reviews

Name	Track	Active media	readout
LAr	2	LAr	cold/warm elx"HGCR/CALICElike ASICs"
ScintCal	3	several	SiPM
Cryogenic DBD	3	several	TES/KID/NTL
HGCC	3	Crystal	SiPM
MaxInfo	3	Crystals	SiPM
CriLin	3	PbF2	UV-SiPM
DSC	3	PBBGlass+PbW04	SiPM
ADRIANO3	3	Heavy Glass, Plastic Scint, RPC	SiPM
FiberDR	3	Scint+Cher Fibres	PMT/SiPM,timing via CAENFERS, AARDVARC-v3,DRS
SpaCal	3	scint fibres	PMT/SiPMSPIDER ASIC for timing
Radical	3	Lyso:CE, WLS	SiPM
Grainita	3	BGO, ZnWO4	SiPM
TileHCal	3	organic scnt. tiles	SiPM
GlassScintTile	1	SciGlass	SiPM
Scint-Strip	1	Scint.Strips	SiPM
T-SDHCAL	1	GRPC	pad boards
MPGD-Calo	1	muRWELL,MMegas	pad boards(FATIC ASIC/MOSAIC)
Si-W ECAL	1	Silicon sensors	direct withdedicated ASICS (SKIROCN)
Si/GaAS-W ECAL	1	Silicon/GaAS	direct withdedicated ASICS (FLAME, FLAXE)
DECAL	1	CMOS/MAPS	Sensor=ASIC
AHCAL	1	Scint. Tiles	SiPM
MODE	4	-	-
Common RO ASIC	4	-	common R/O ASIC Si/SiPM/Lar

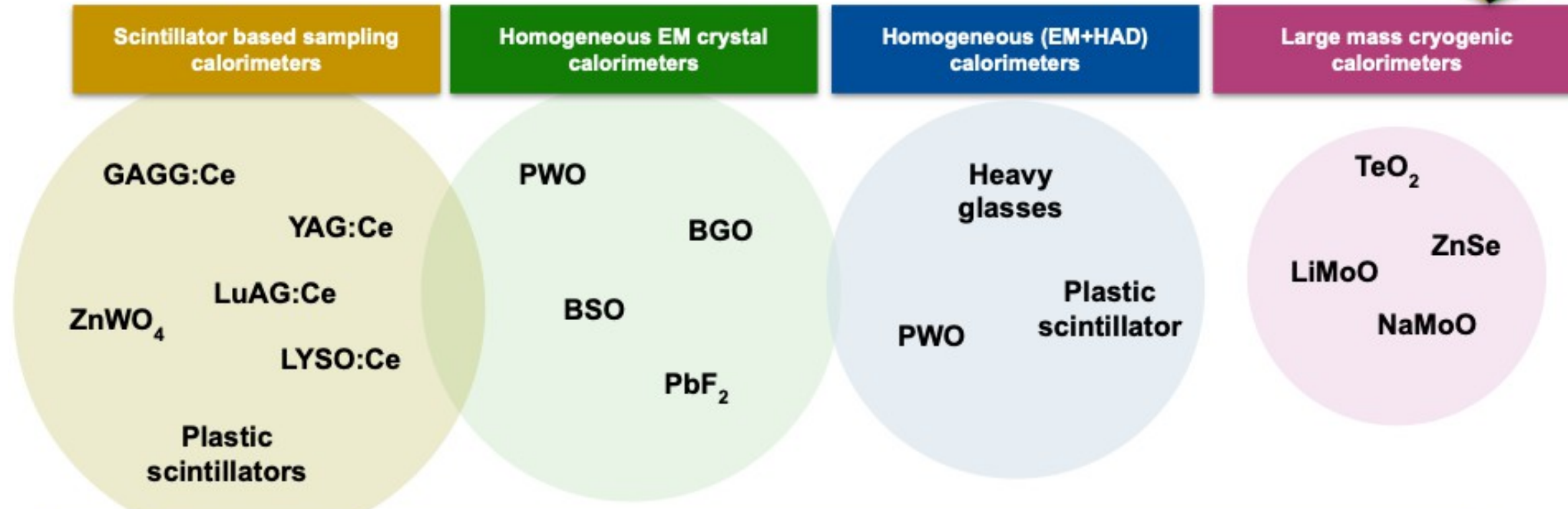
Trends:

- **On-detector embedded elx.**
 - Challenges: #channels, Low power digital noise, data reduction
- **Off-detector electronics:**
 - Fibre/crystal readout
 - Challenges:
 - Low power, data reduction
- **Digital calorimetry:**
 - Challenges:
 - (extreme) #channels, low power, data reduction

Different calorimeter types but similar challenges

- The main goal will be to avoid parallel developments
 - Take CALICE as example
- ASICs needed for prototypes > 2025/26 should be produced in a common MPW run that serve many projects within DRD Calo
 - ASICs for prototype that should take data in ~2027 have to be available latest around one year earlier
- => Common ASICs production will be one overarching goal of the DRD Calo
- Pricetag for MPW not clear but count 300 - 700 kEUR depending on technology to serve all DRD Calo
 - Evoke possibility to hook onto production for other large projects (EiC?)
 - Agree on sharing among DRD Calo institutes and maybe with MPW runs in other DRD
- Requires close communication with DRD 3 and DRD 7

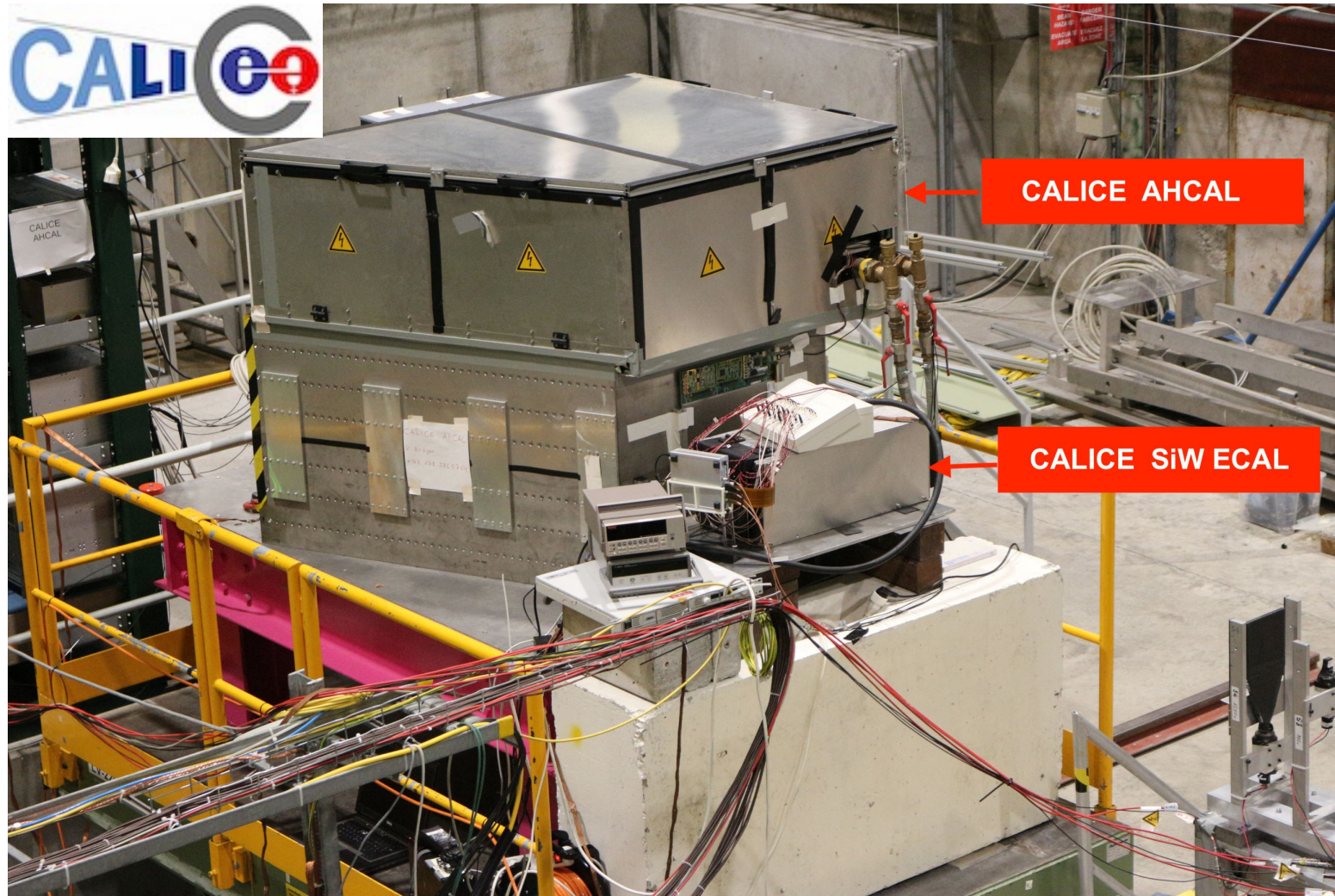
Which active light emitters?



LuAG:Ce, LYSO:Ce, GAGG:Ce, BGSO, BGO, BSO, PWO, BaF₂:Y, heavy glasses, plastic scintillators

Optimization and customization of active materials, light collection and readout is **common to all proposals** 5

- R&D will have to break down the plethora of materials to few on which the R&D will focus on
- Definition of criteria needed!



Common setup at CERN June 2022

- Calorimeters are typically large objects
 - A beam test is similar to a small experiment
- Difficult for facility managers to schedule calorimeter beam tests
 - No concurring running with other devices possible
- Takes lots of expertise to carry out a successful beam test campaign
 - Implies use of infrastructure
- A dedicated beam line maybe with dedicated slots during a year may help curing these issues
 - Would need sustained expertise on the beamline

- **Photodetectors**
 - Many optical systems need in particular novel SiPM --> Overlap with DRD 4
- **Unified backend/data acquisition systems**
 - Common ASICs should yield common backends
 - EUDAQ as backbone
- **Data analysis**
 - Calorimeter data have a high scientific value beyond the actual hardware tests
 - GEANT4 comparison including the inclusion into the geant4-val suite
 - Playground for algorithms (there was a dedicated input proposal on that)
 - The full exploitation of data requires the development of data models and the availability of CPU and storage resources
- **Human and financial resources are needed to ensure the service tasks**
 - IN2P3 should participate to these service tasks
 - => Add 10-15% of HR and financial resources for service tasks
 - Service tasks should be covered from Day 1 on (i.e. 1/1/2024)

Backup

• Key technologies and requirements are identified in ECFA Roadmap

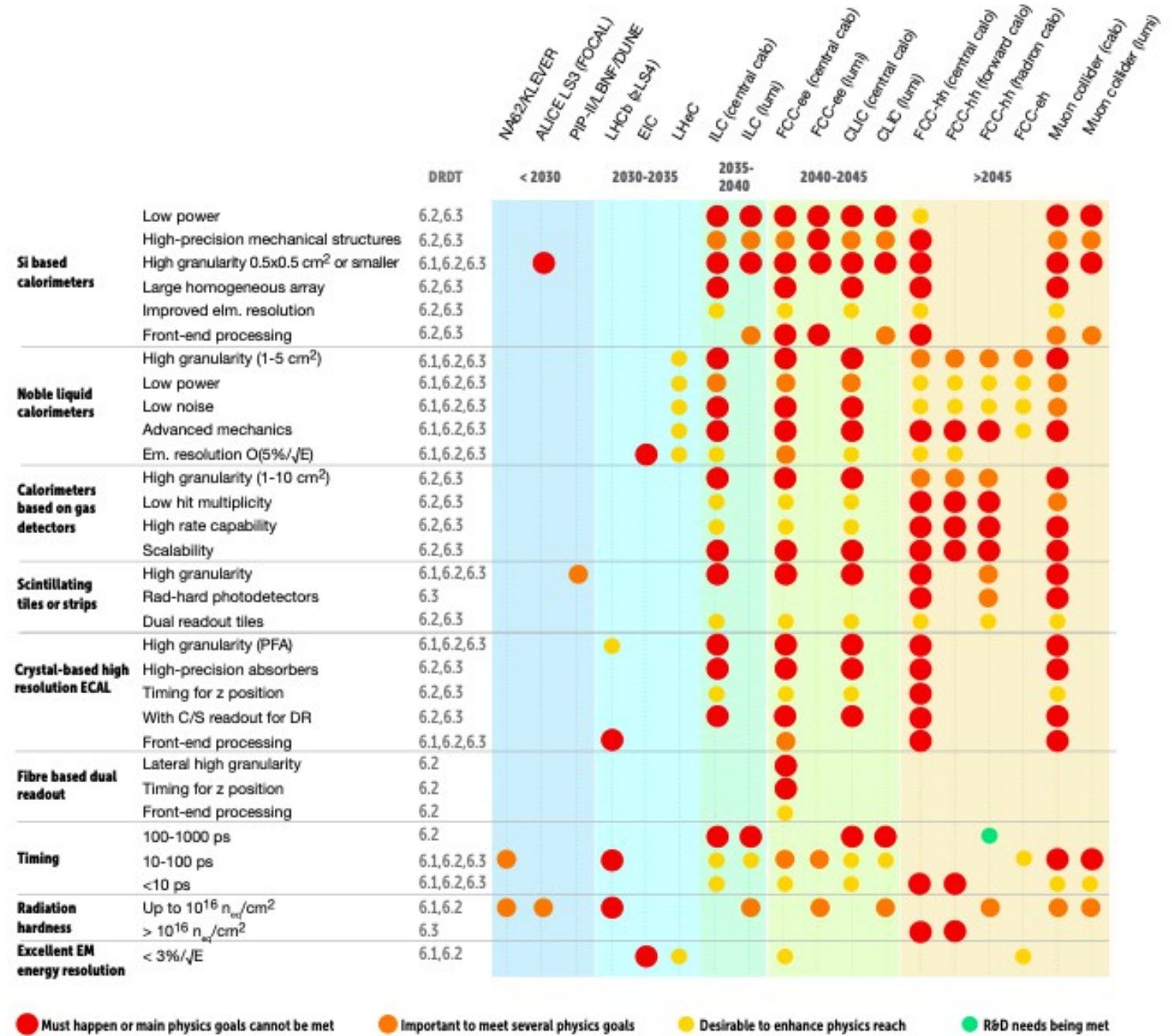
- Si based Calorimeters
- Noble Liquid Calorimeters
- Calorimeters based on gas detectors
- Scintillating tiles and strips
- Crystal based high-resolution Ecals
- Fibre based dual readout

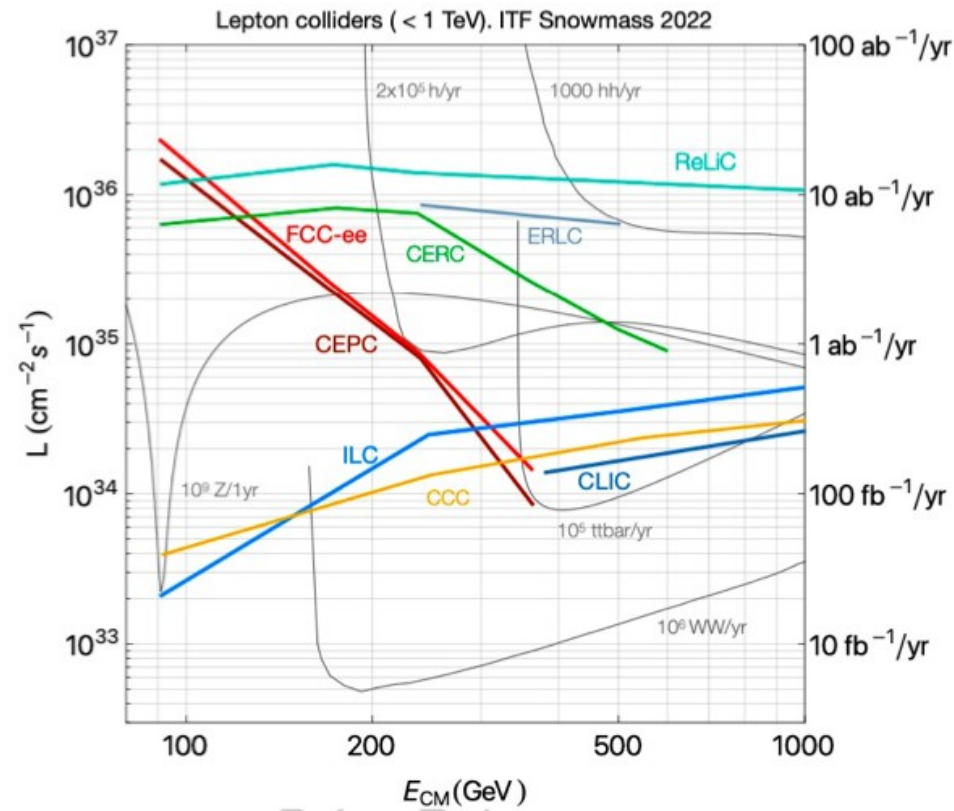
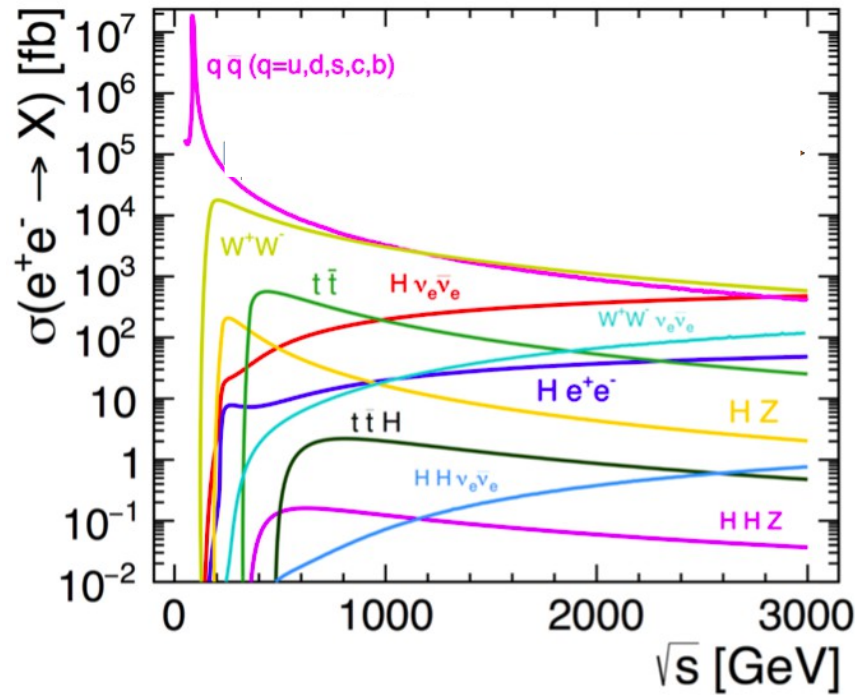
• R&D should in particular enable

- Precision timing
- Radiation hardness

• R&D Tasks are grouped into

- Must happen
- Important
- Desirable
- Already met



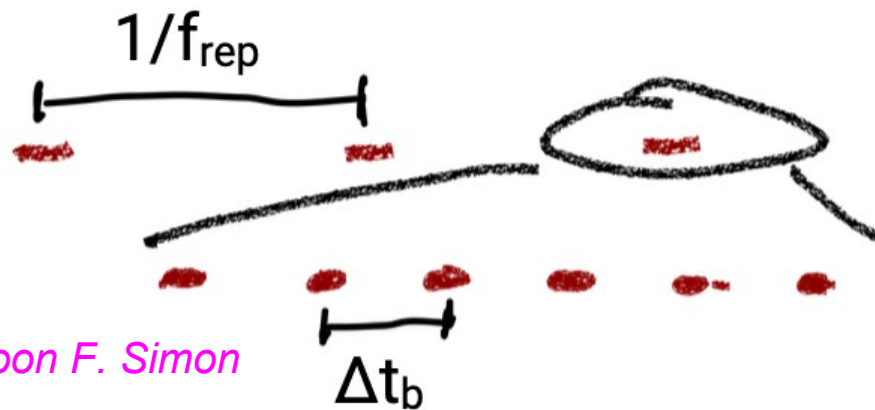


High energy e+e- colliders:

- Physics rate is governed by strong variation of cross section and instantaneous luminosity
- Ranges from 100 kHz at Z-Pole (FCC-ee) to few Hz above Z-Pole
- (Extreme) rates at pole may require other solutions than rates above pole

- Event and data rates have to be looked at differentially
 - In terms of running scenarios and differential cross sections
 - Optimisation is more challenging for collider with strongly varying event rates
 - Z-pole running must not compromise precision Higgs physics

- Linear Colliders operate in bunch trains

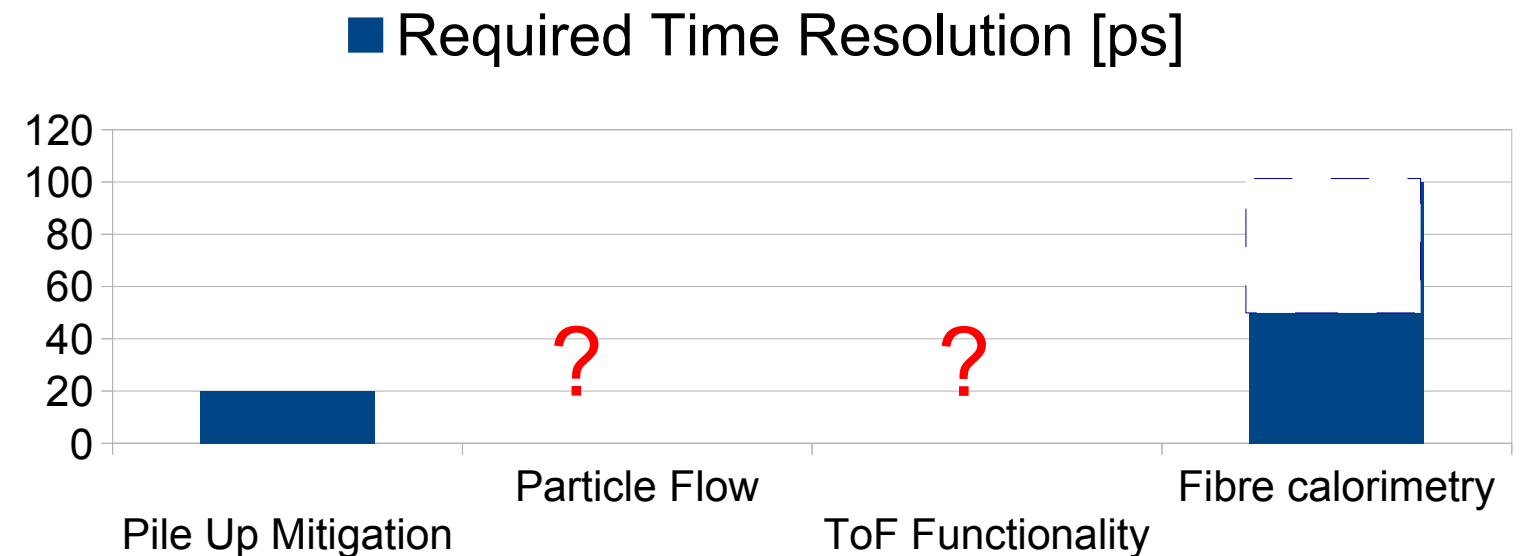


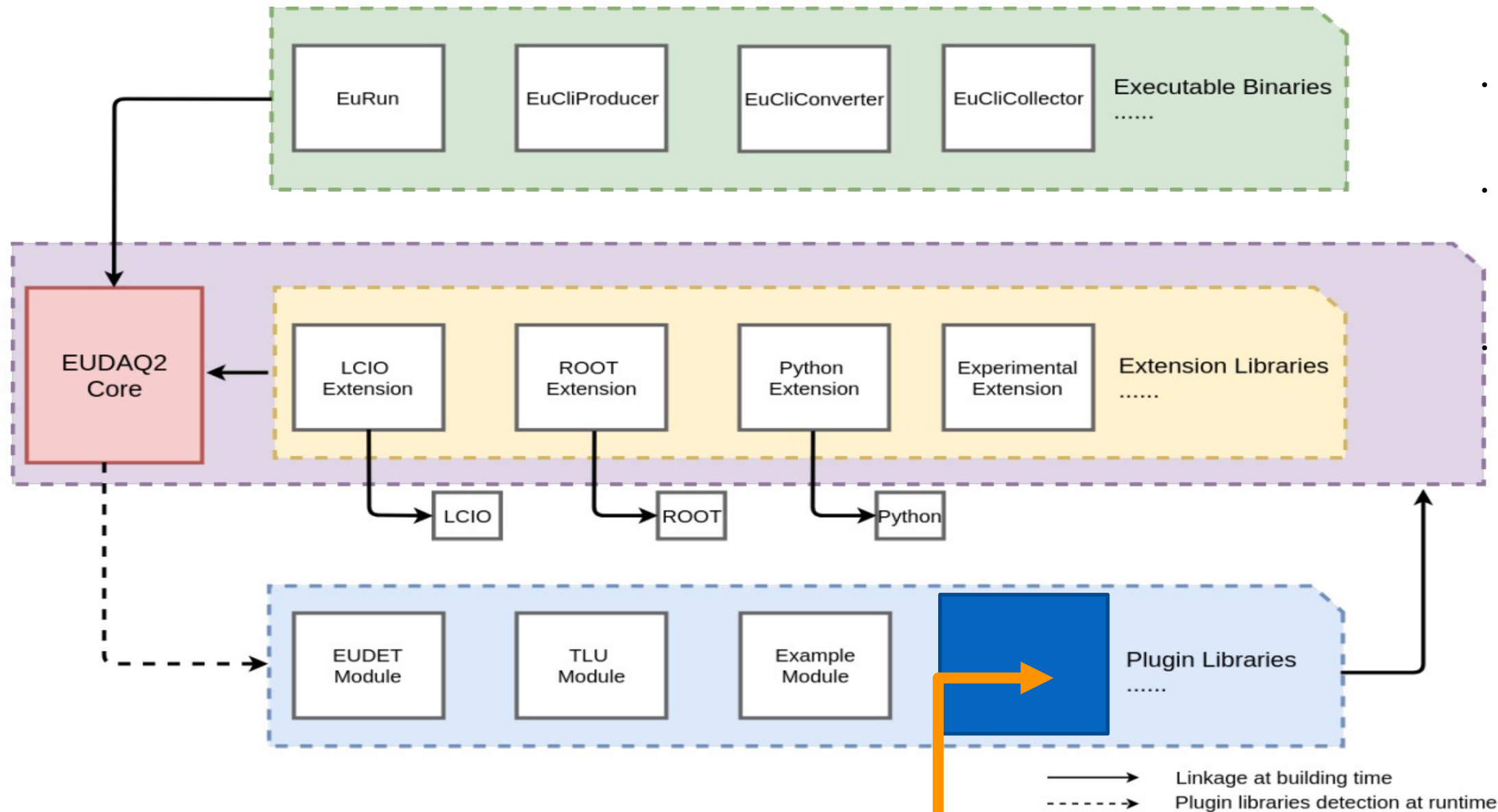
CLIC: $\Delta t_b \sim 0.5\text{ns}$, $f_{\text{rep}} = 50\text{Hz}$

ILC: $\Delta t_b \sim 550\text{ns}$, $f_{\text{rep}} = 5\text{ Hz}$ (base line)

- Power Pulsing reduces dramatically the power consumption of detectors
 - e.g. ILD SiECAL: Total average power consumption 20 kW for a calorimeter system with 10^8 cells
- Power Pulsing has considerable consequences for detector design
 - Little to no active cooling
 - => Supports compact and hermetic detector design
- **Upshot: Pulsed detectors face other R&D challenges than those that will be operated in “continuous” mode**
 - R&D Goal: Avoid/minimise active cooling also in continuous mode
 - Challenge differs depending on where the electronics will actually be located

- Timing is a wide field
- A look to 2030 make resolutions between 20ps and 100ps at system level realistic assumptions
- At which level: 1 MIP or Multi-MIP?
- For which purpose ?
 - Mitigation of pile-up (basically all high rate experiments)
 - Support of PFA – uncharted territory
 - Calorimeters with ToF functionality in first layers?
 - Might be needed if no other PiD detectors are available (rate, technology or space requirements)
 - In this case 20ps (at MIP level) would be maybe not enough
 - Longitudinally unsegmented fibre calorimeters
- A topic on which calorimetry has to make up it's mind
 - Remember also that time resolution comes at a price -> High(er) power consumption and (maybe) higher noise levels





- Implementation of custom producers is rather simple
- easier integration with other eudaq producers (TLU, Telescopes)
- Already a long list of custom producers integrated:
 - CALICE SiWECAL,
 - CALICE AHCAL,
 - CALICE SiWECAL + AHCAL,
 - CMS HGCALE silicon prototype + CALICE AHCAL, ...

PUT your calorimeter library here!

From experiments to geant-val, a winding road

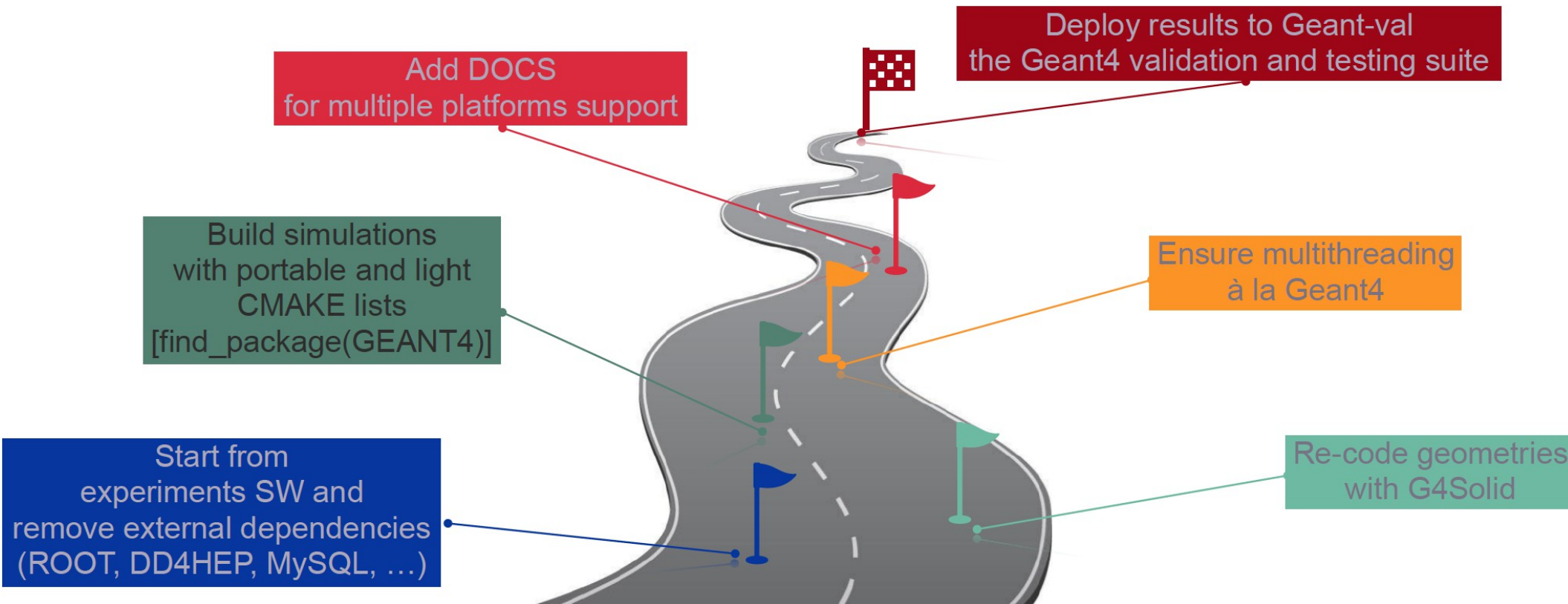


geant-val.cern.ch

Geant-val is the Geant4 validation and testing suite.

For the Community, it allows to deploy results on a common data-base and fetch the information via a web-interface.

For the developers, it allows to Create multiple jobs over beam energies, particle types, physics lists



Better to involve G4 collaboration at the beginning of the testbeam. G4 collaboration available to help with the geant4-val inclusion

Tommaso Dorigo and MODE Collaboration

Machine Learning approach is gaining more and more importance in HEP and in calorimetry in particular highly complex data with large number of detailed information
Simulation provides tagged data for supervised learning
Tracking, clustering, particle ID ...

Use training data with known labels
(often from Monte Carlo simulation)

