IN2P3 in DRD Calo

Roman Pöschl
Co-Coordinator Transition to DRD Calo

French PI of input-proposals to DRD Calo:

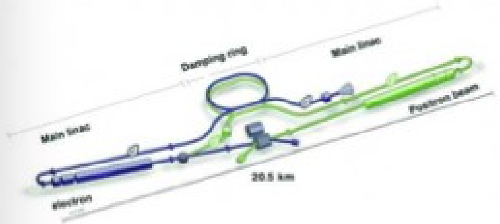
Vincent Boudry, Imad Laktineh, Patrick Robbe, Giulia Hull, Nicolas Morange, Christophe de la Taille, Christian Morel, Suzanne Gascon-Shotkin

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

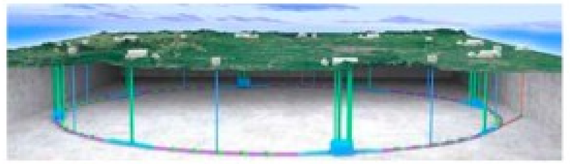
Most of the information has been taken from the input-proposals and the first round of digestion since April 1st 2023
Some changes w.r.t. input-proposals (update of IN2P3 participants) during preparation of these slides

Detector systems – Target projects

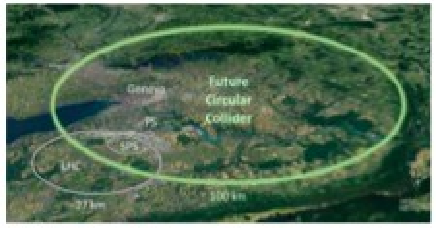
ILC



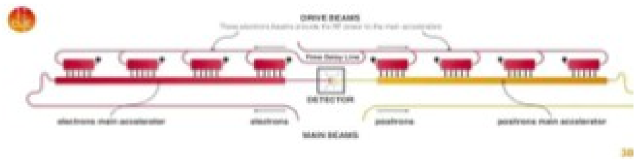
CEPC



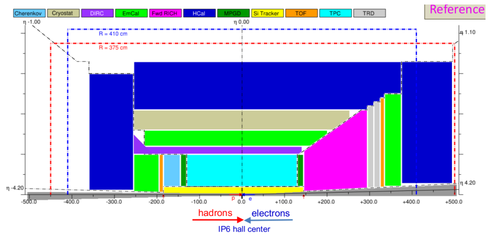
FCC-ee



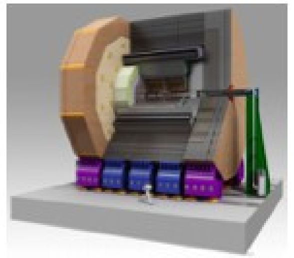
CLIC



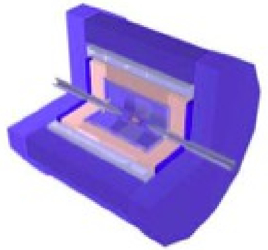
EIC



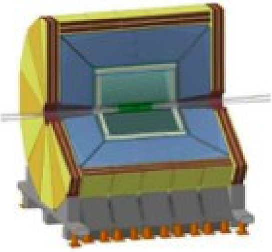
ILD



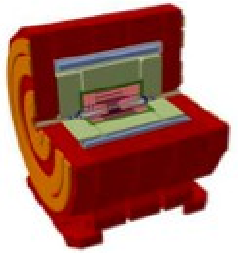
CEPC Baseline



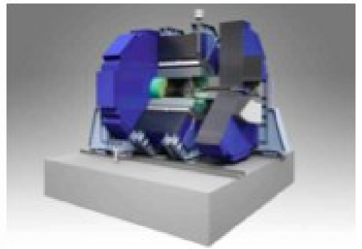
IDEA



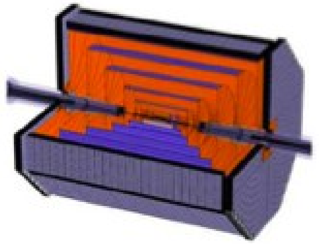
CLICdp



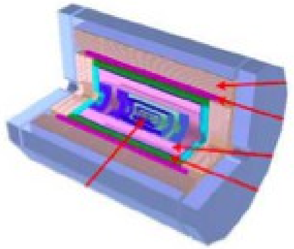
SiD



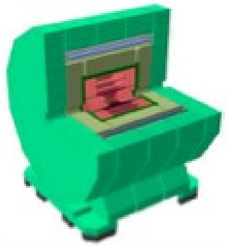
FST



CEPC 4th concept



CLD



slide stolen from B. Dudar

ECFA

Calorimetry – Research themes

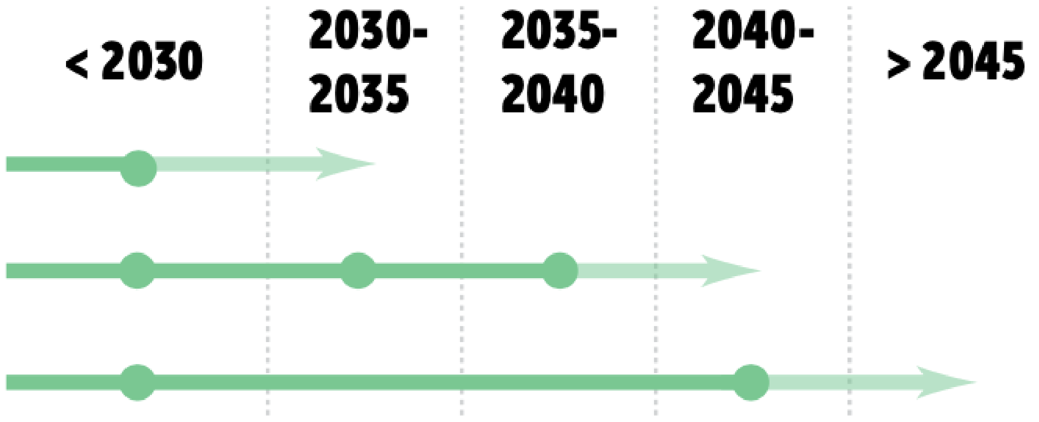
European Strategy Update

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



DRD Calo – From input proposals to working structure

The Proposal Team

Track 1: Sandwich calorimeters with fully embedded Electronics – Main and forward calorimeters
Track conveners:
Adrian Irles (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)

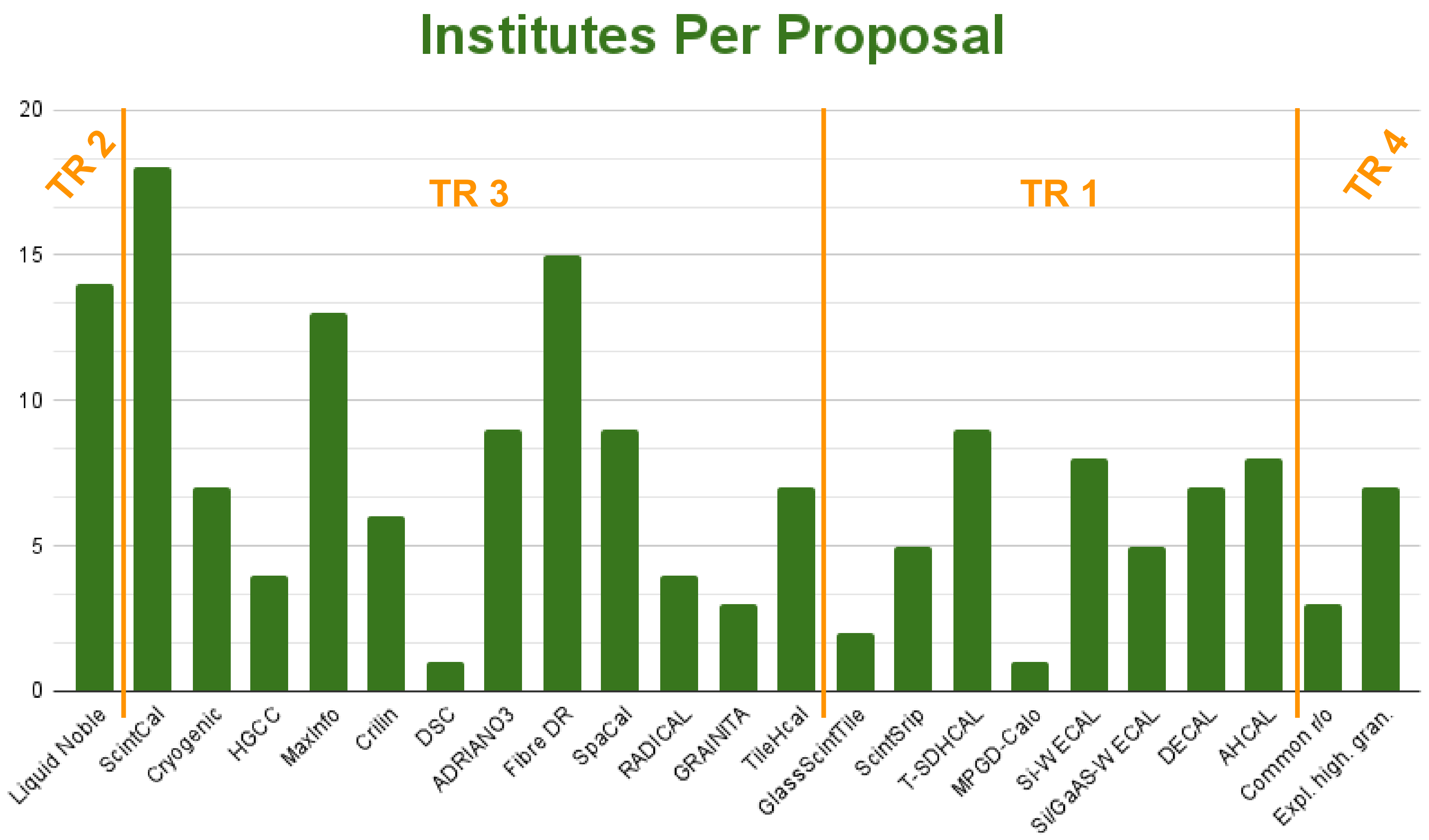
Track 3: Optical calorimeters: Scintillating based sampling and homogenous calorimeters
Track Conveners:
Etiennette Auffray (CERN), **Gabriella Gaudio** (INFN-Pavia), **Macro Lucchini** (U. and INFN Milano-Bicocca), **Philipp Roloff** (CERN), **Sarah Eno** (U. of Maryland), **Hwidong Yoo** (Yonsei Univ.)

Track 4: Transversal Activities
Christophe de La Taille (Lab. Omega)

G. Gaudio
2nd Calorimeter Community Meeting

Input proposals

23 comprising 110 institutes/labs received



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

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

DRD Calo – Basic structure

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

Full integrated sampling Calorimeters ~Track 1
- Technology 1
- Technology 2
- ….

Liquified Noble Gas Calorimeters ~Track 2

Optical Calorimeters ~Track 3
- Technology 1
- Technology 2
- ….

Transversal Activitites (common collaboration interests):

- Materials
- Photodetectors, Electronics and DAQ
- Testbeam Facilities snd Infrastructure
- Detector Physics, simulation, algorithms and s/w tools
- Industrial connection + technological transfer

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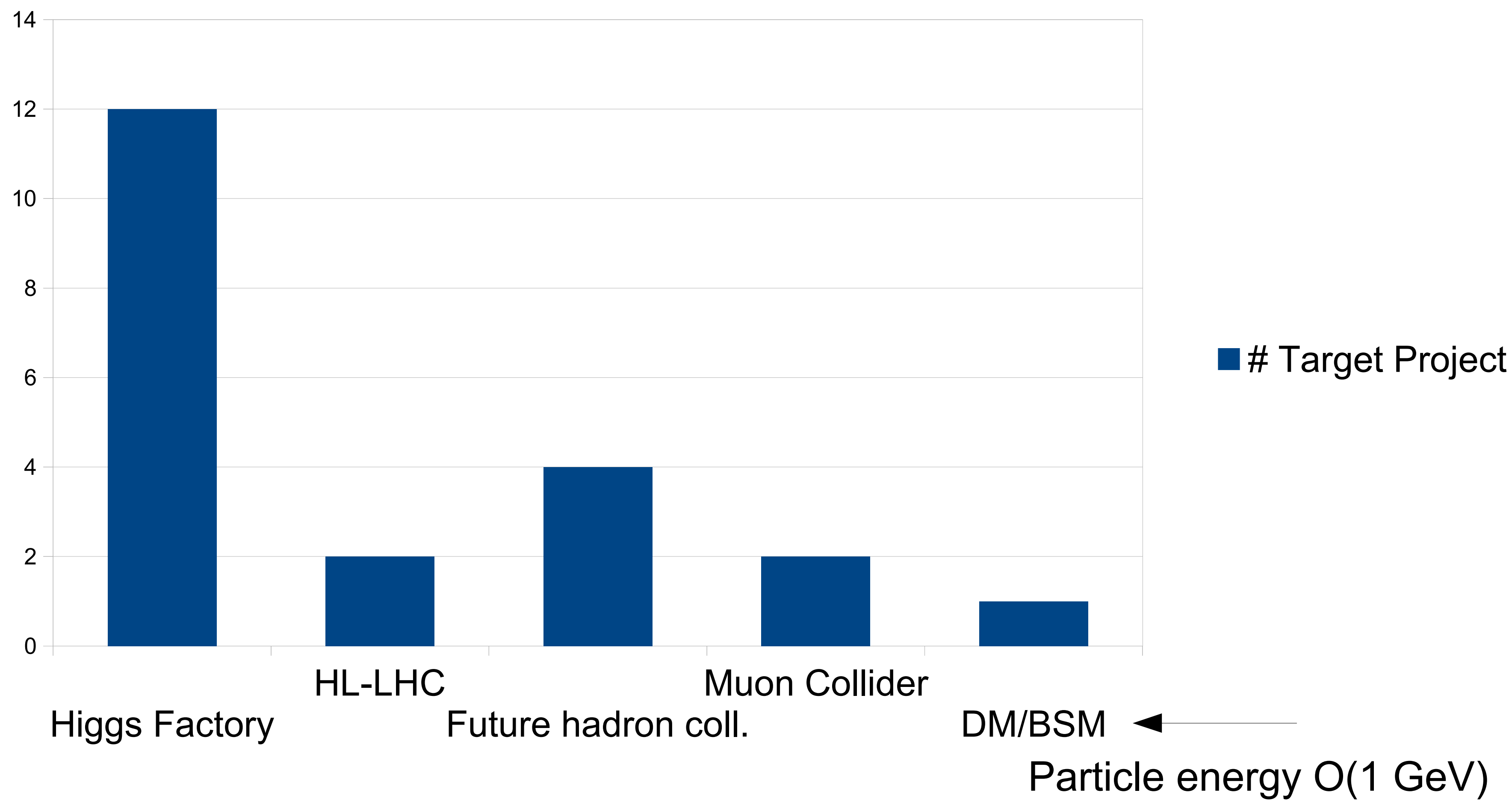
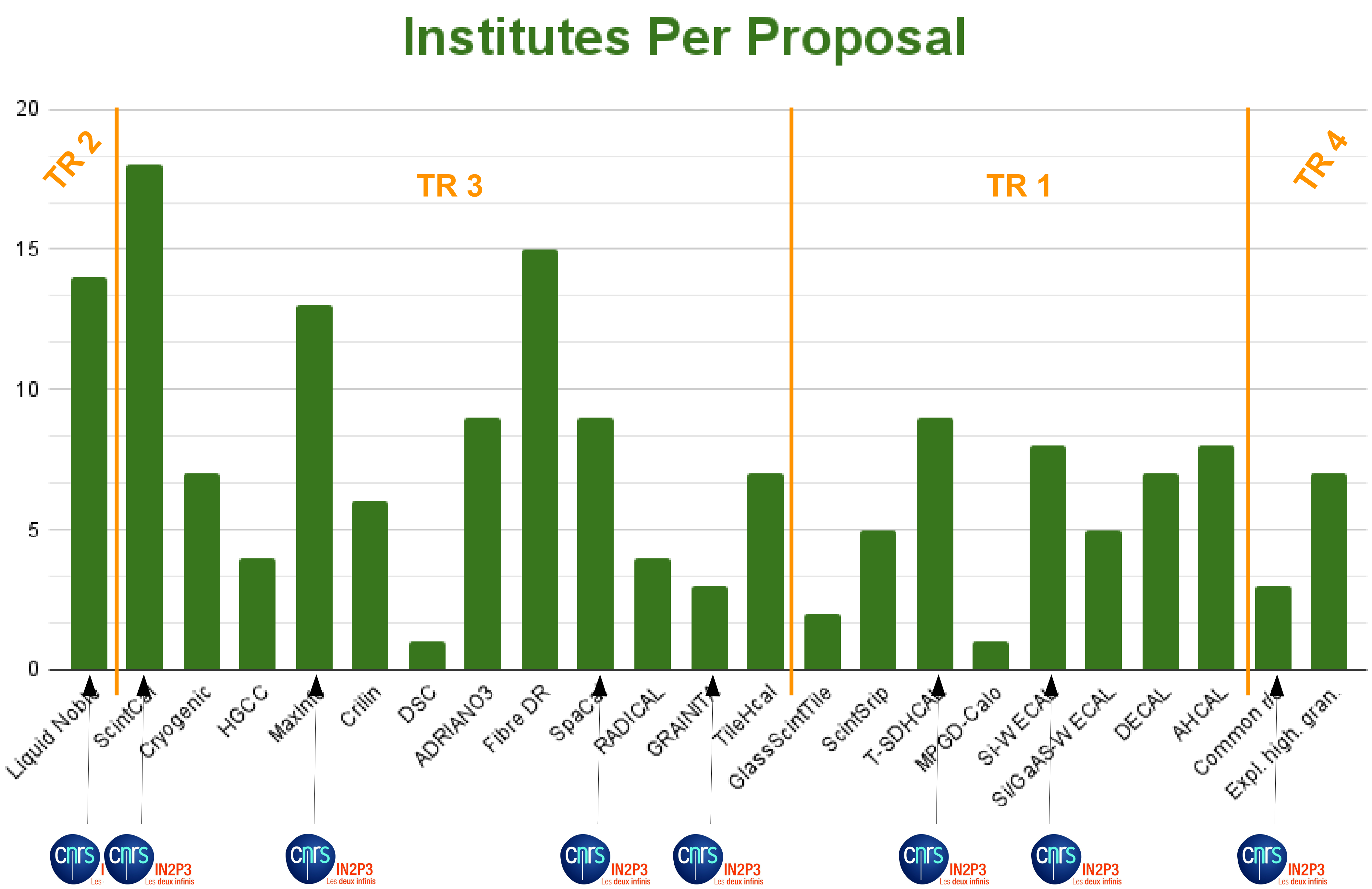
- Transversal Activities are vital for the success of the collaboration
- Transversal Activities will also ensure relations with other DRD

DRD Calo - Input proposals and target projects



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

DRD Calo – Interest expressed by in2p3 instiutes



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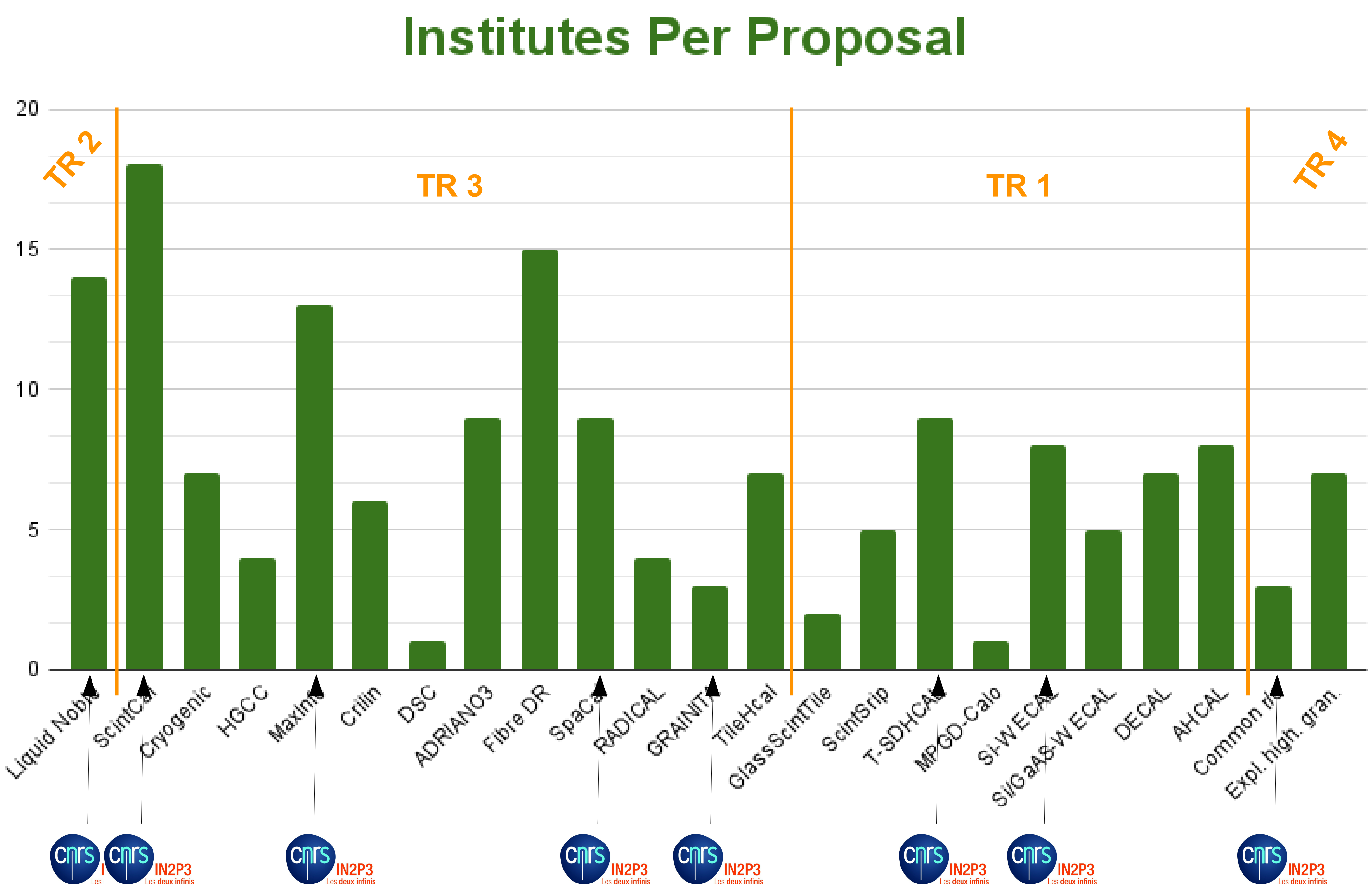


IN2P3 labs/ Total labs: 5/14, 1/18, 1/13, 4/15, 2/3, 3/10, 5/9, 1/3

ECFA

DRD Calo – Which IN2P3 institute where?

European Strategy Update

- 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: Kyushu 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)

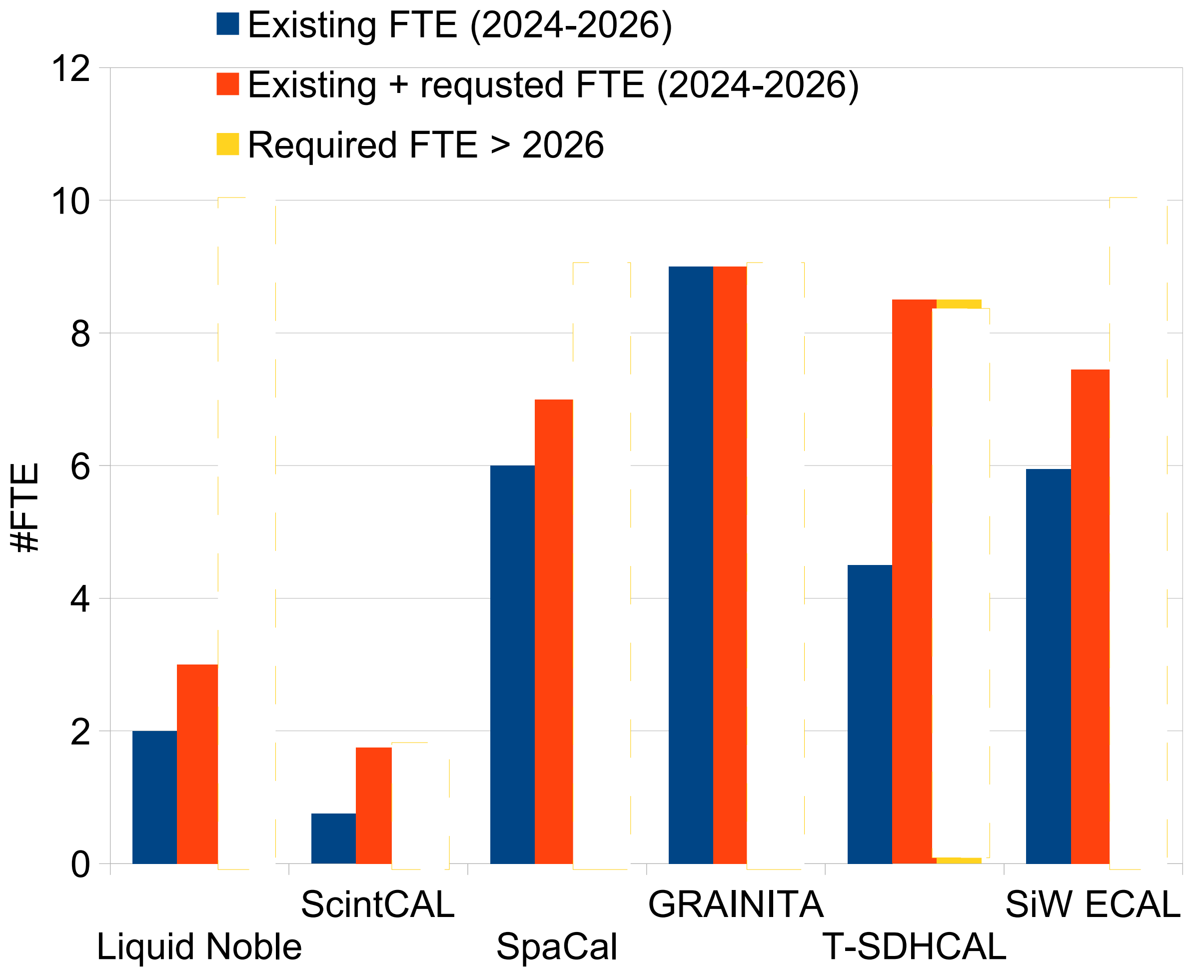
IN2P3 Activities – Rough View

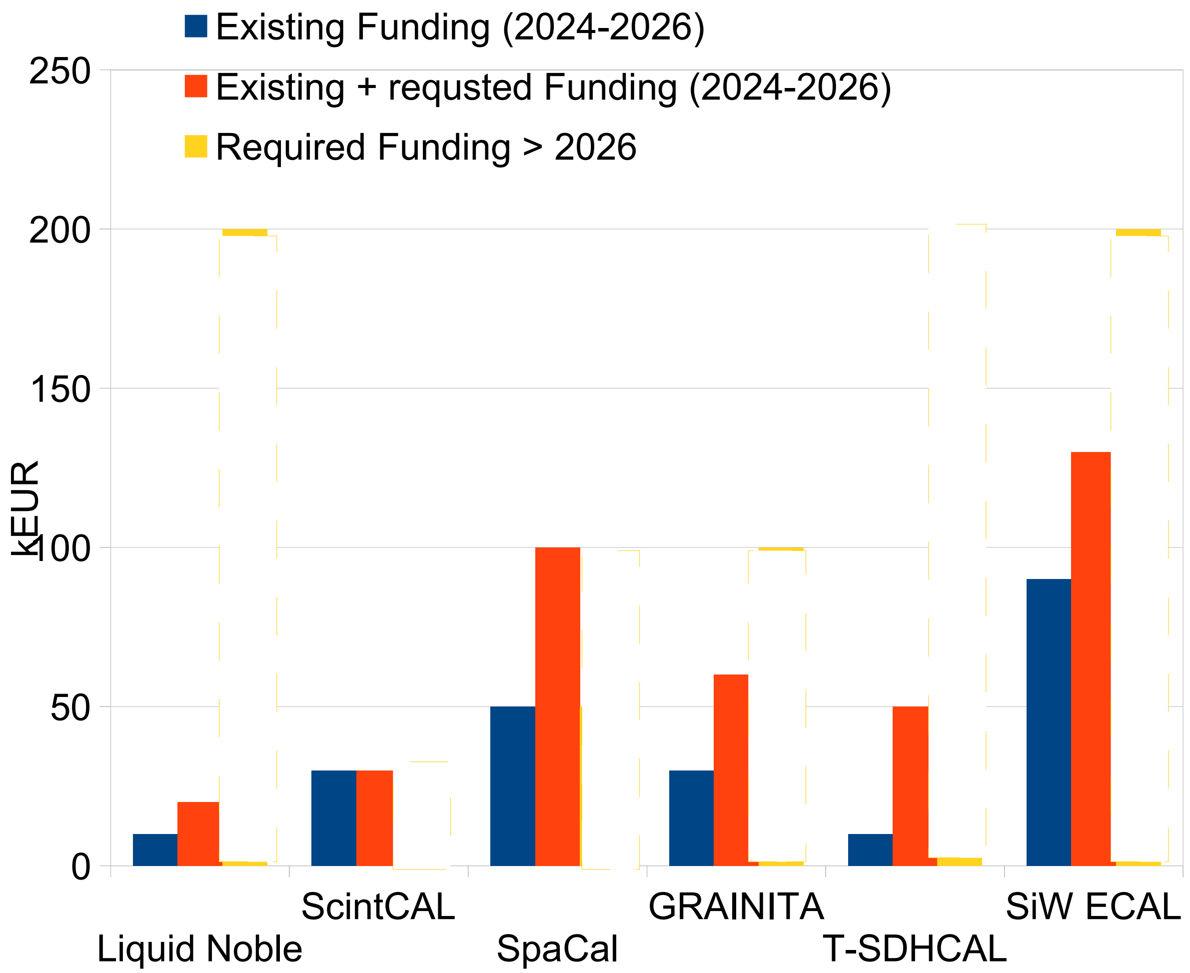
2024 2027 2030

- 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

IN2P3 Activities – Outlook on Resources

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

ECFA

DRD Calo - The “readout landscape”

European Strategy Update

Name	Track	Active media	readout
LAr	2	LAr	cold/warm elx"HGCROC/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

Common ASICs development within DRD Calo

- 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

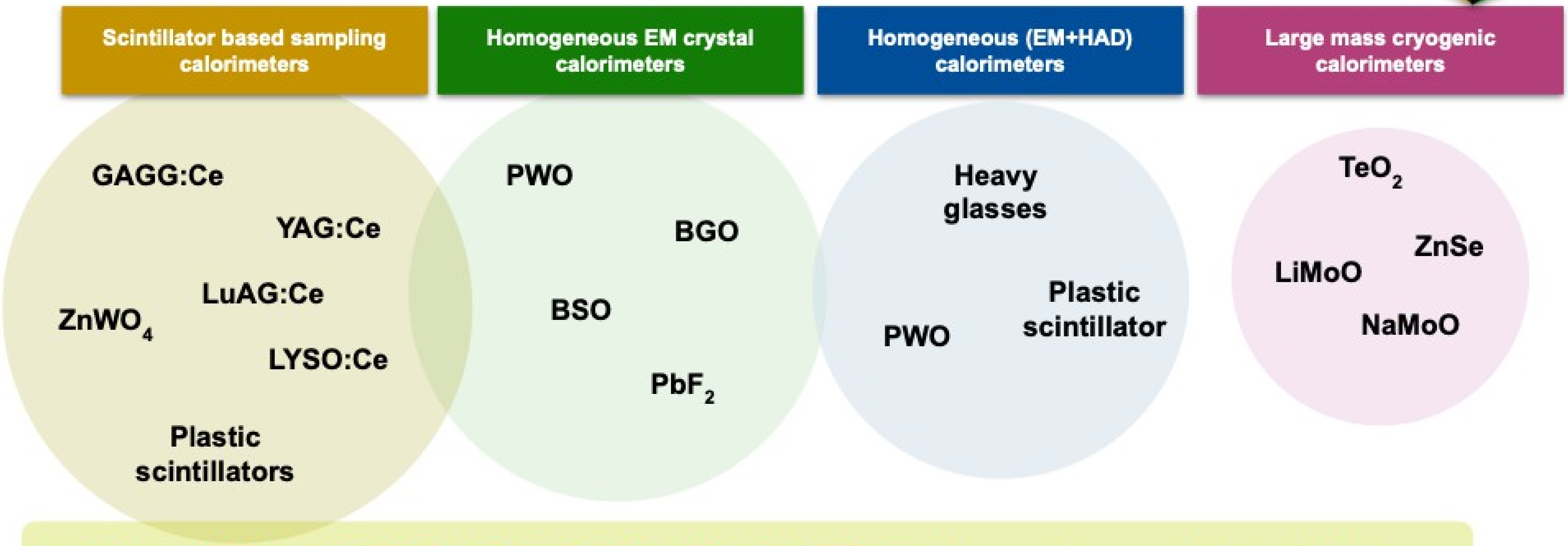
- Pricetag for MPW not clear but count 300 - 700 kEUR depending on technology to serve all DRD Calo
  - Evoke possibility to hook onto production for other large projects (EiC?)
  - Agree on sharing among DRD Calo institutes and maybe with MPW runs in other DRD

- Requires close communication with DRD 3 and DRD 7

Materials for optical calorimeters

P. Roloff, M. Lucchini
2nd Calo Community Meeting

Which active light emitters?

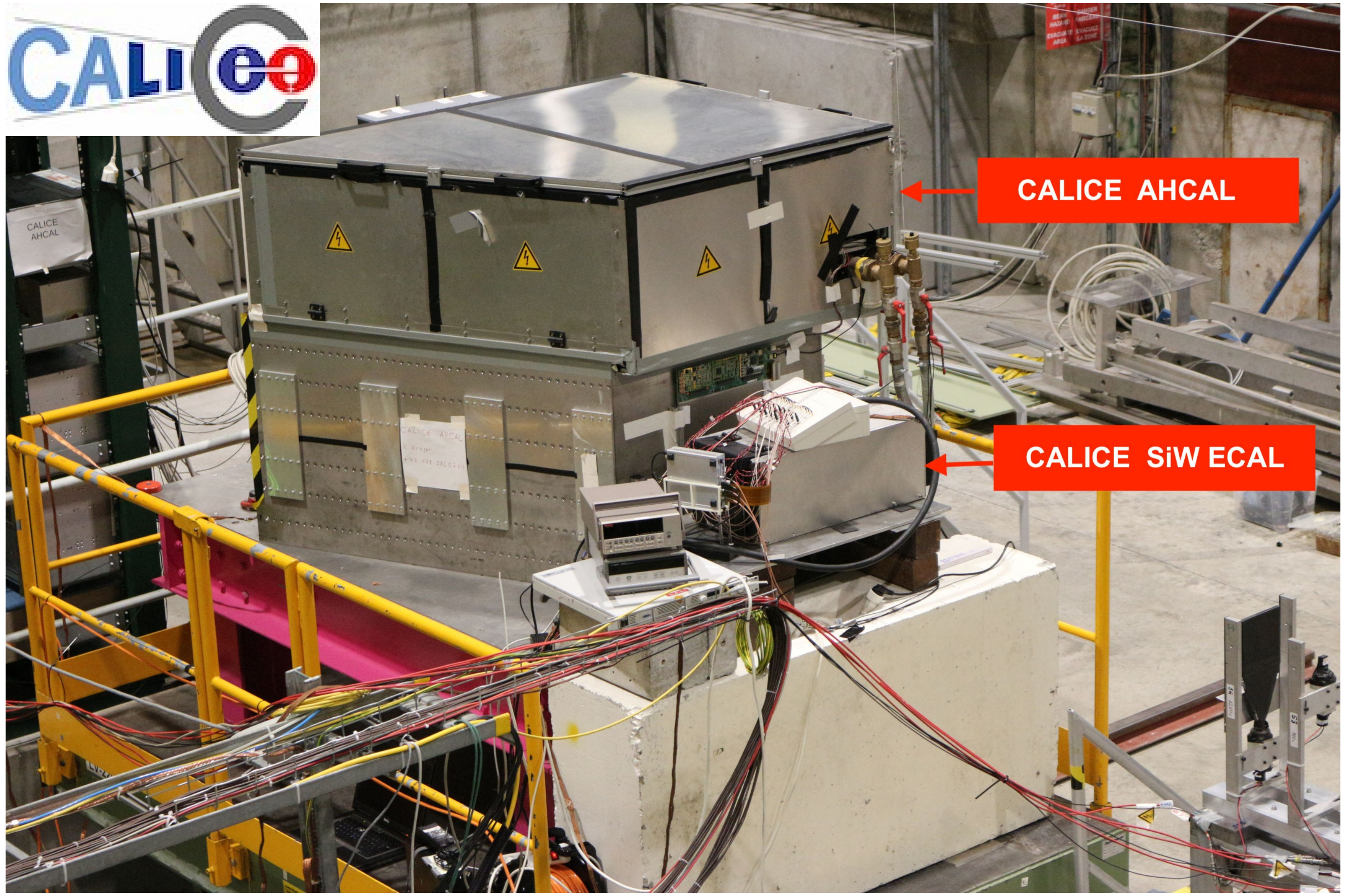


LuAG:Ce, LYSO:Ce, GAGG:Ce, BGSO, BGO, BSO, PWO, BaF_2:Y, heavy glasses, plastic scintillators

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!

Dedicated Calorimeter Beamline?



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

Further transversal activities and resources

- 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)

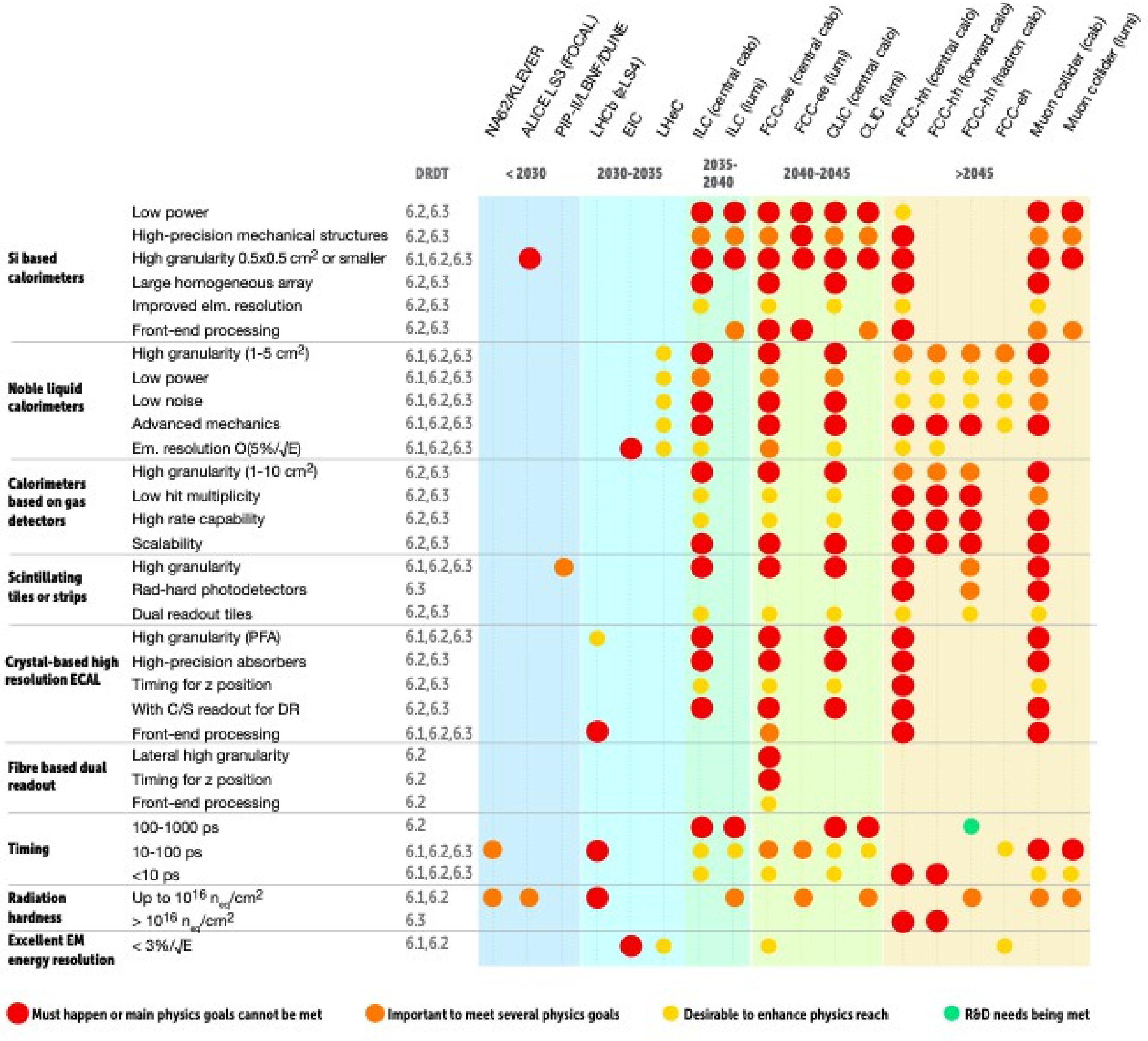
Proposal Cryogenic Calo for Double Beta Decay

- Proposal for Double Beta Decay with IN2P3 Participation
  - Submitted to DRD Calo but might be better hosted elsewhere
  - In contact with DRD 5 conveners (Meeting on Friday 16/6/23)
  - Partners:
    - IN2P3: IJCLAB (Pole APC)
    - Others: U Milano-Boccia/INFN Milano, La Sapienzia Rome/INFN Rome, INFN Gran Sasso, INFN LNL, CEA-Irfu

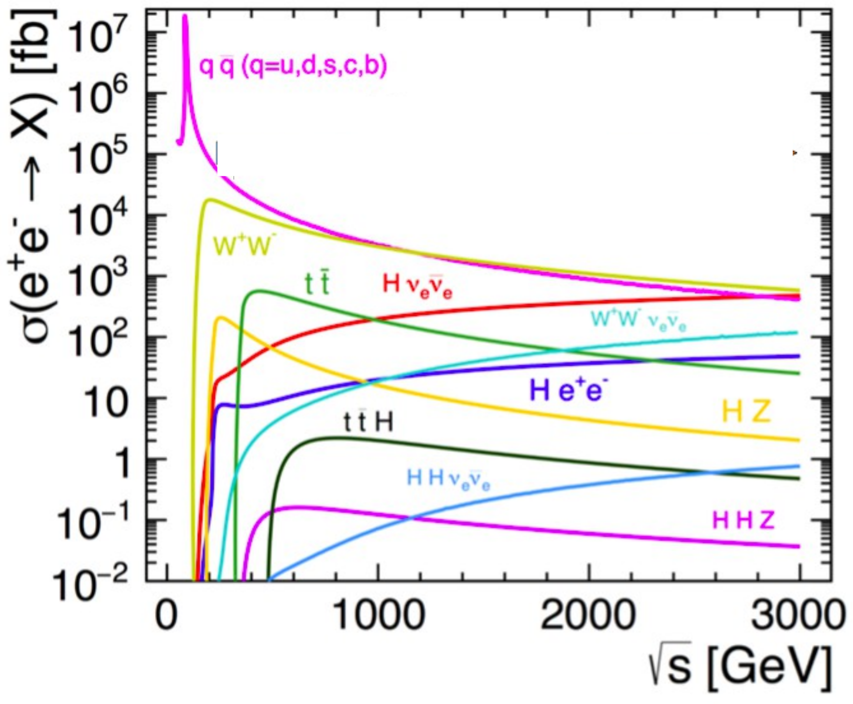
Backup

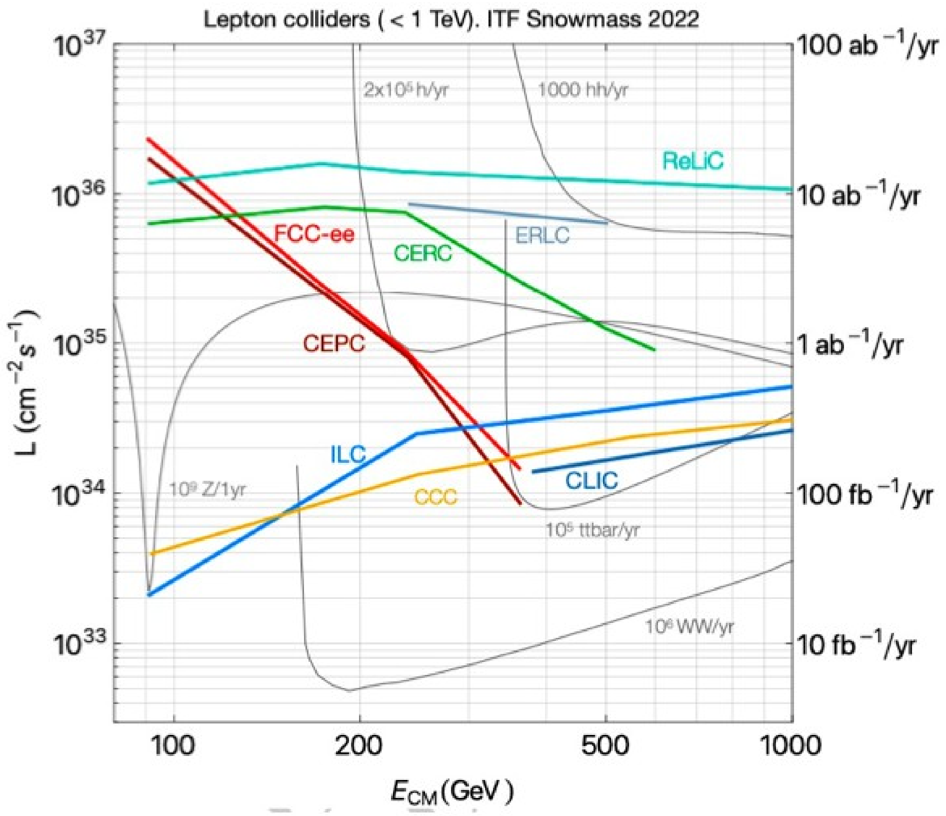
Calorimetry- Identified Key Technologies and R&D Tasks

- 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



Future direction of R&D - Impact of event rates





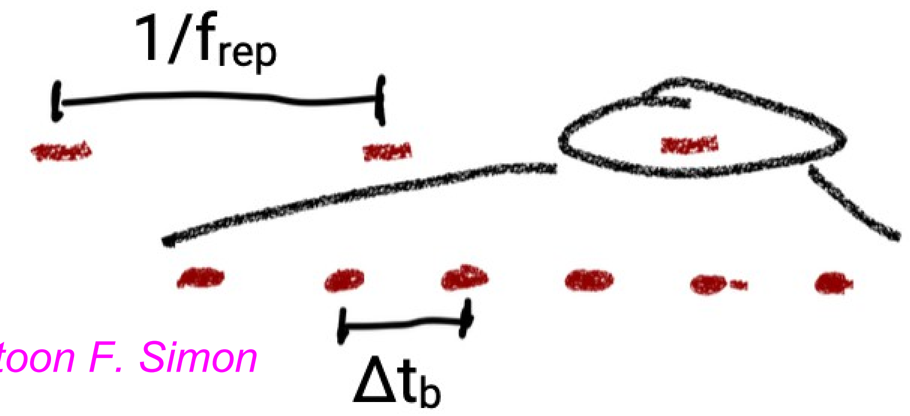
High energy e+e- colliders:

- 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 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

Operation mode- pulsed or continous

- Linear Colliders operate in bunch trains



Cartoon F. Simon

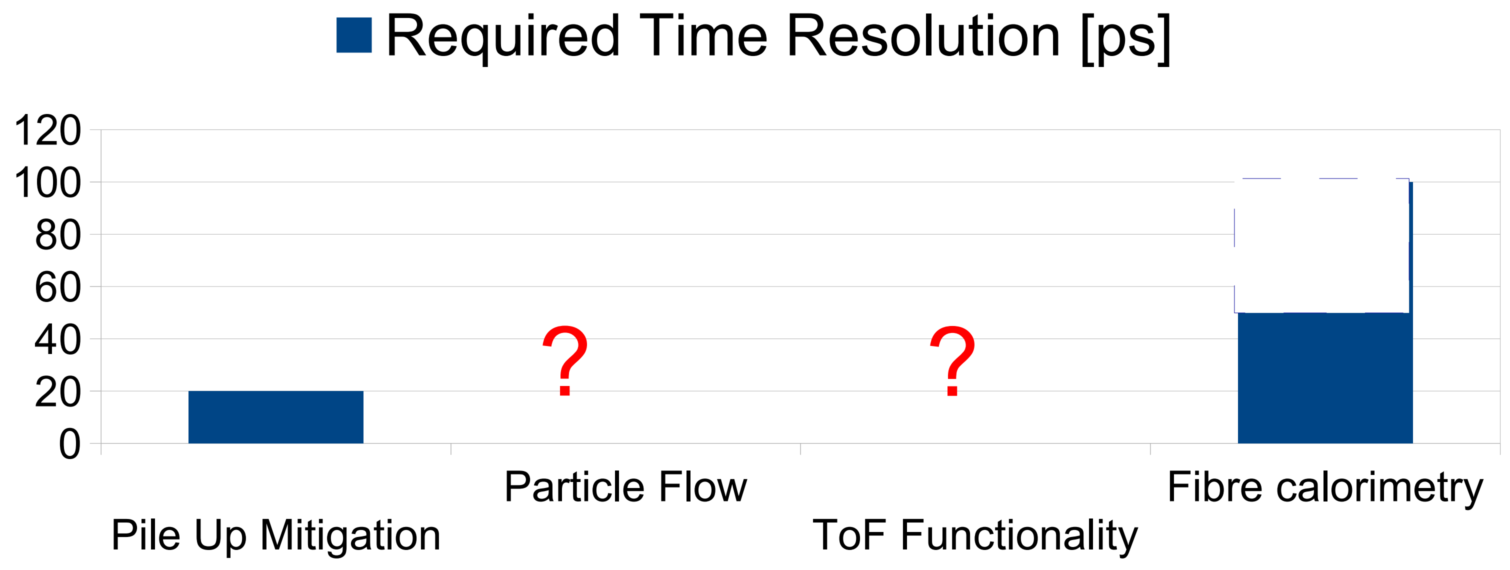
CLIC: Δt_b ~ 0.5ns, frep = 50Hz
ILC: Δt_b ~550ns, frep = 5 Hz (base line)

- 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

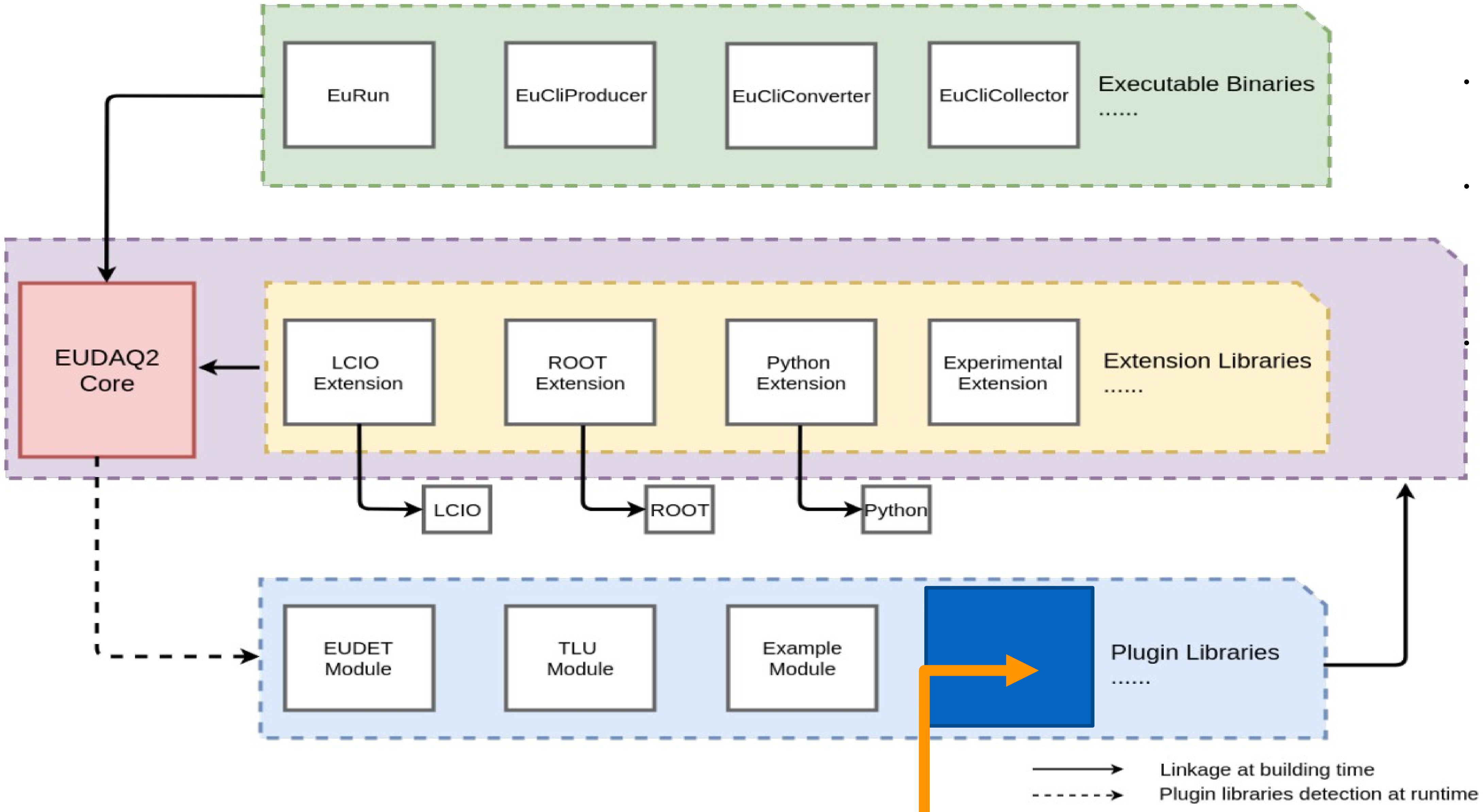
Timing ?

- 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 – unchartered 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

EUDAQ Data Acquisition Systems

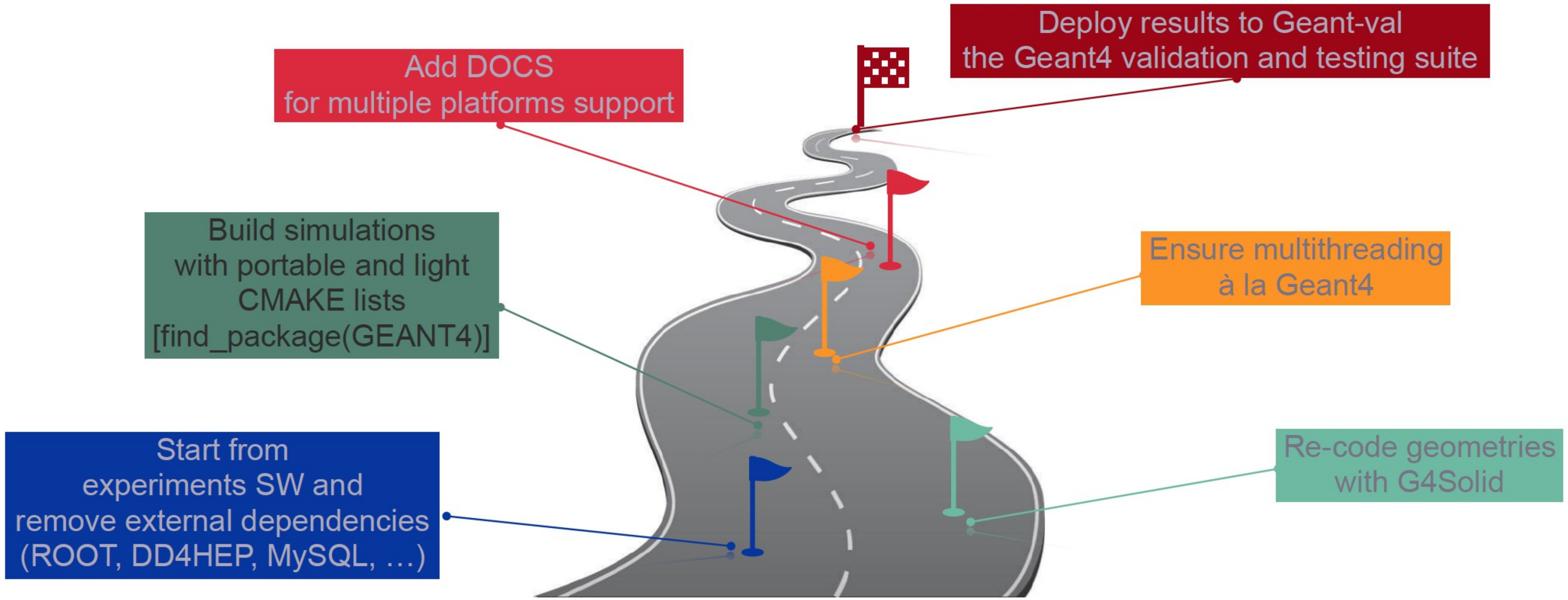


PUT your calorimeter library here!

- 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 HGCAL silicon prototype + CALICE AHCAL, ...

... and once the data are recorded

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

Complex Calorimeters – A playground for modern algorithms

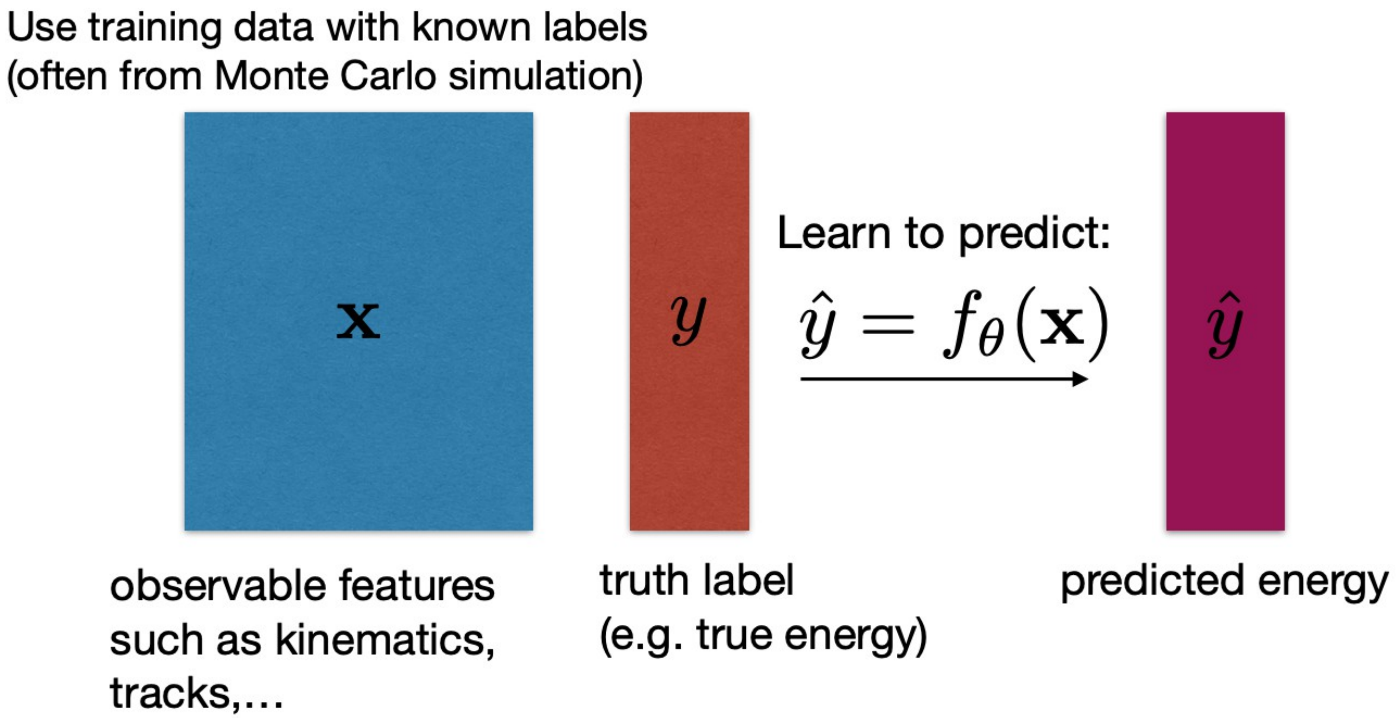
Tommaso Dorigo and MODE Collaboration

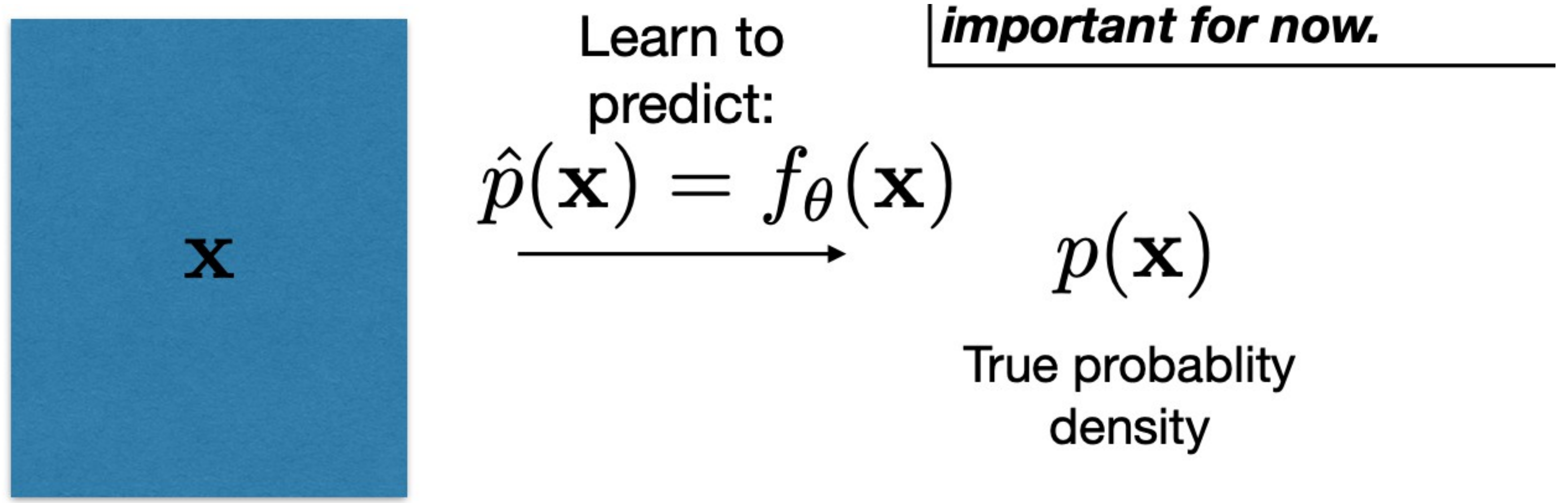
Machine Learning approach is gaining more and more importance in HEP and in calorimetry in particular

highly complex data with large number of detailed information

Simulation provides tagged data for supervised learning

Tracking, clustering, particle ID ...





ECFA

CERN Schedule according to recent MTP

European Strategy Update