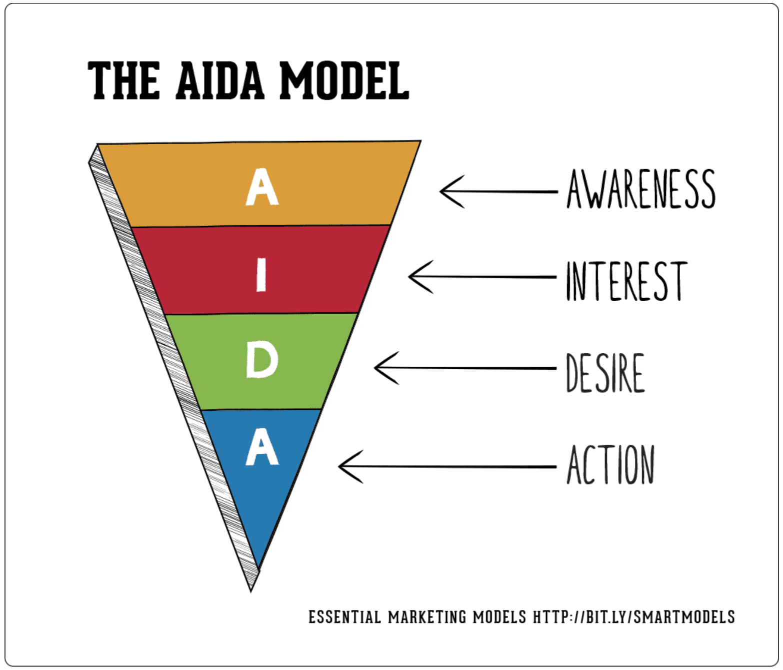


Pisa in AidaInnova

F.Bedeschi, F. Forti, F.Palla, T.Boccali

Slides introduttive di Nadia Pastrone

AIDAinnova @ INFN

Advancement and Innovation for Detectors at Accelerators

progetto sottomesso 14 Maggio 2020

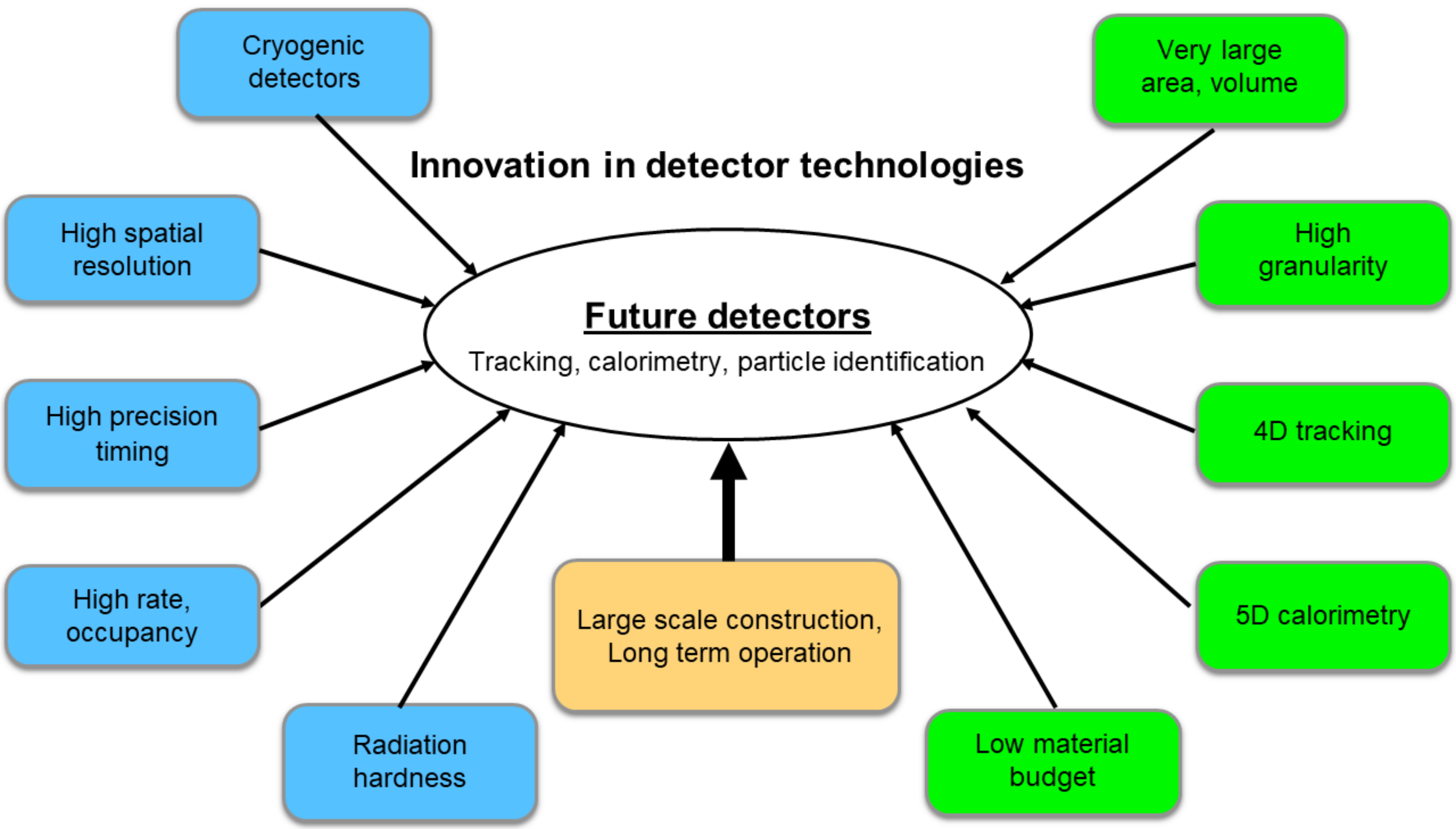
INFN Scientific Coordinator: ***Nadia Pastrone – INFN-TO***
INFN Financial Officer: ***Rosaria Porcu – INFN-TO***

12 giugno 2020

AIDAinnova consortium: obbiettivi

1. **To push detector technologies beyond the state-of-the art**, with a special emphasis to the needs of a **future Higgs factory**, and to offer well equipped infrastructures for testing detector systems to the European particle physics community;
2. To strengthen links between academic Institutes and European industry across the projects/experiments;
3. To contribute to maintaining the recognized worldwide leadership of particle physics in Europe;
4. To serve as the **European forum for the development of detectors and infrastructure for HEP**;
5. To support the co-development with Research Infrastructures and the European industry (especially SMEs) for large scale-scale production of detector instrumentation and for development of innovative products;
6. **To enhance the S&T training and job prospects for young European researchers**.

AIDA innova


Innovation in detector technologies
Future detectors
Tracking, calorimetry, particle identification
Cryogenic detectors
High spatial resolution
High precision timing
High rate, occupancy
Radiation hardness
Large scale construction, Long term operation
Low material budget
5D calorimetry
4D tracking
High granularity
Very large area, volume

Istituto Nazionale di Fisica Nucleare

CAEN S.p.A.
Eltos S.p.A.
Fondazione Bruno Kessler

ASSOCIATED PARTNERS:
ENEA
GLASStoPOWER (spinoff-UniMIB)

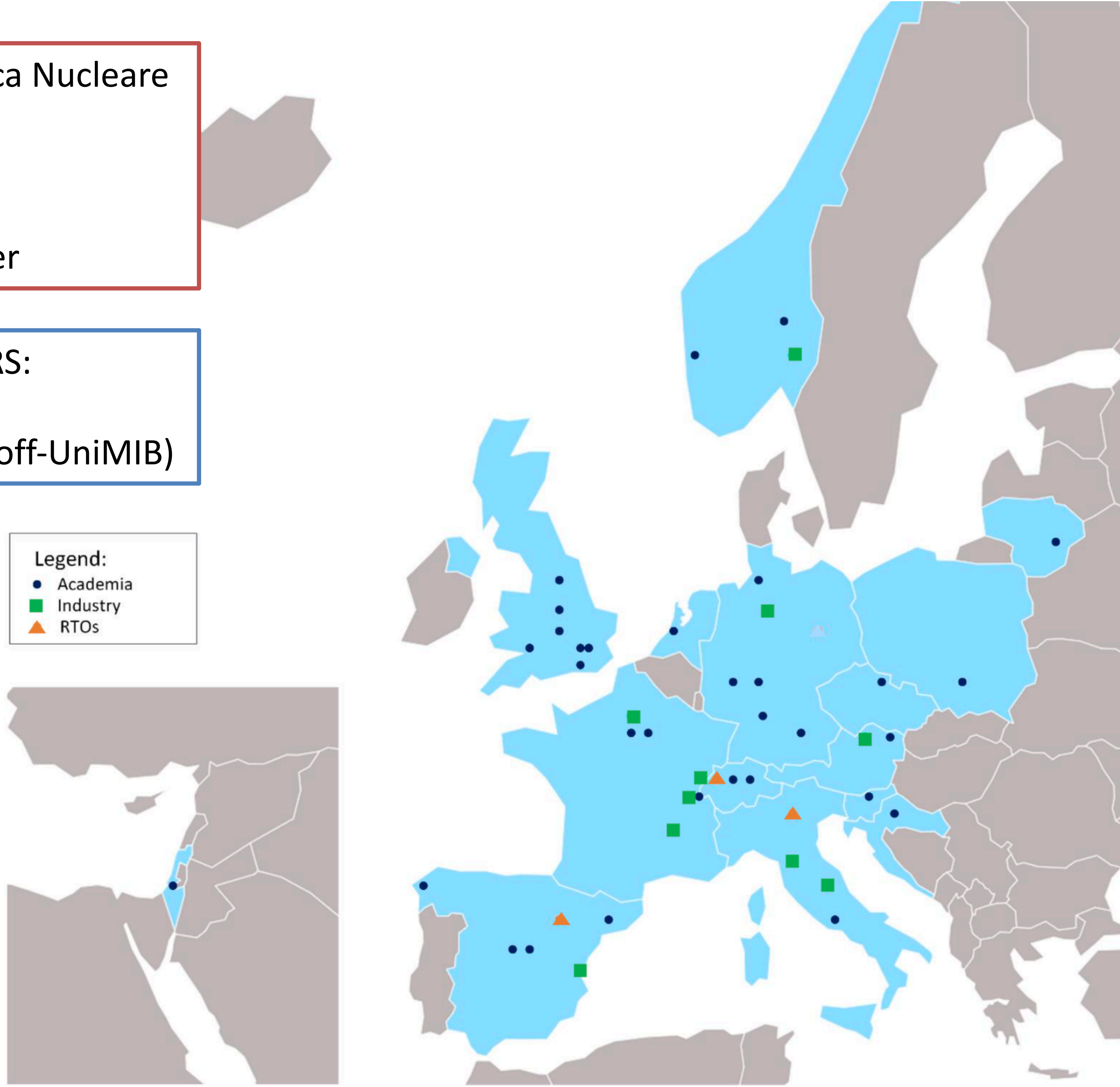


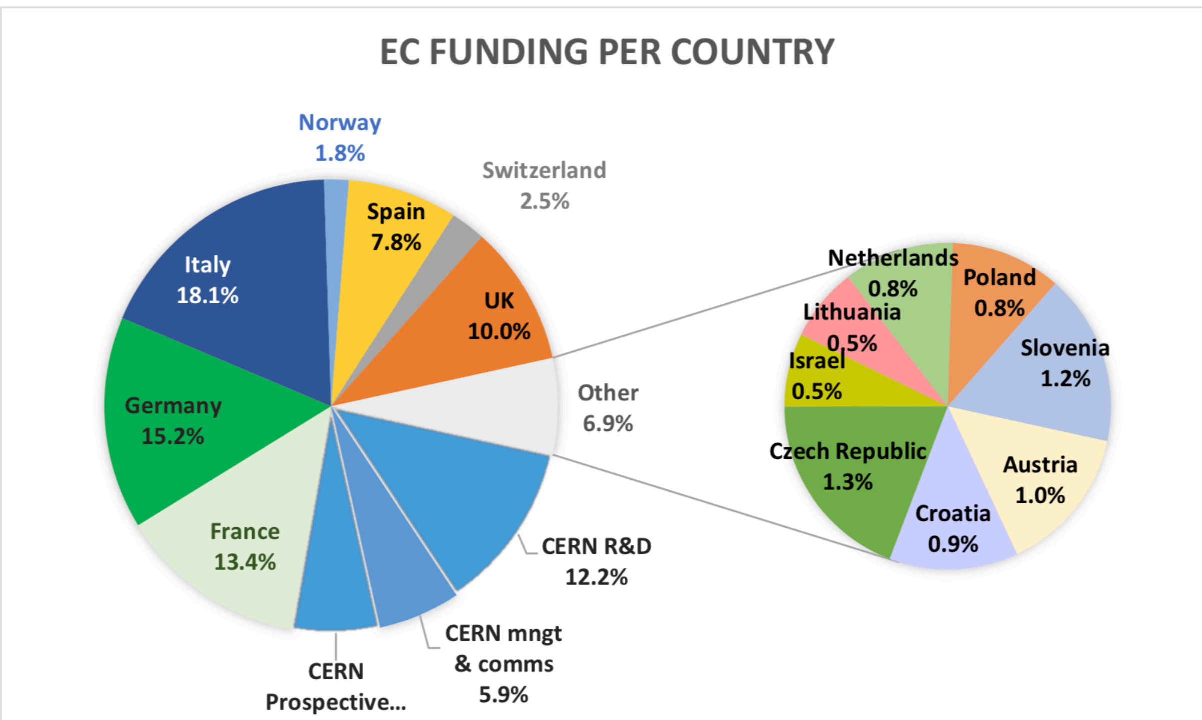
Figure 1: Map of beneficiaries and countries involved in AIDAinnova.

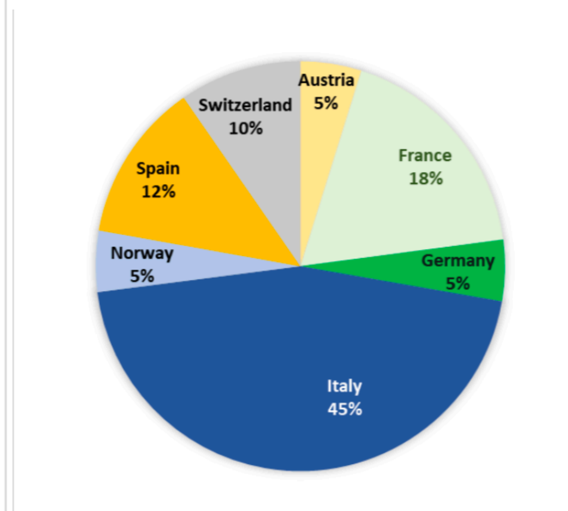
Management

- The members of the Project Management Team and the Steering Committee will be approved by the Governing Board
- Scientific Coordinator: Felix Sefkow (DESY) + two Deputy Coordinators
- The Consortium is composed of 38 beneficiaries from 19 European countries

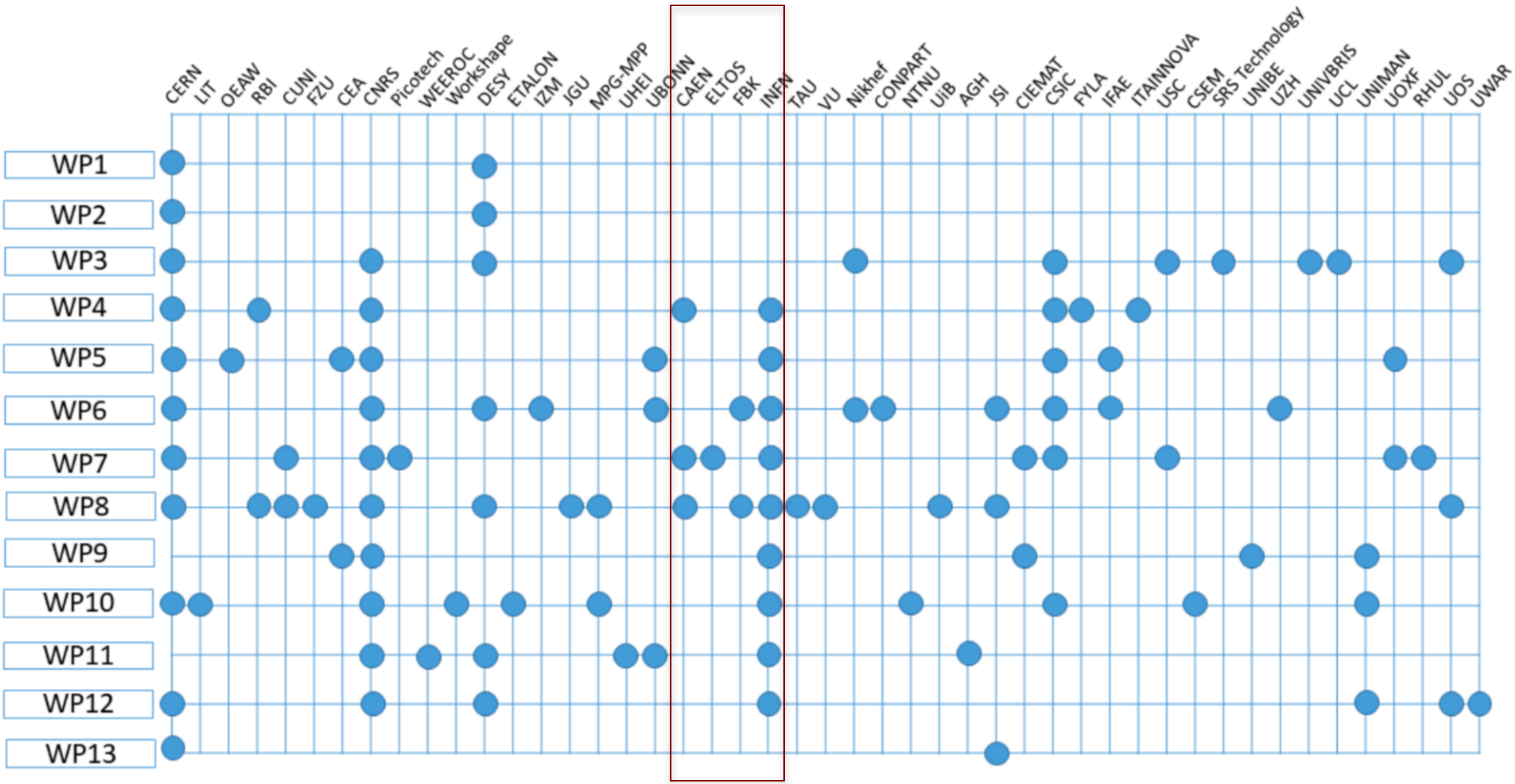
Budget

Beneficiary no.	Beneficiary	Person-months	Personnel costs	Travel	Equipment and consumables	Other direct costs	Sub-contracting	Material direct costs	Total direct costs	EC requested funding (including overheads)
1	CERN	465.5	3,834,850.00	102,600.0	178,250.0	749,000.0	0.0	1,029,850.00	4,864,700.00	2,590,625.00
19	CAEN	53.0	227,900.00	12,400.0	22,000.0	0.0	0.0	34,400.00	262,300.00	162,500.00
20	ELTOS	12.0	72,000.00	7,000.0	50,000.0	13,500.0	0.0	70,500.00	142,500.00	87,500.00
21	FBK	23.4	154,440.00	20,220.0	9,000.0	157,000.0	0.0	186,220.00	340,660.00	218,750.00
22	INFN	586.0	2,930,000.00	120,000.0	125,000.0	27,000.0	0.0	272,000.00	3,202,000.00	1,345,000.00

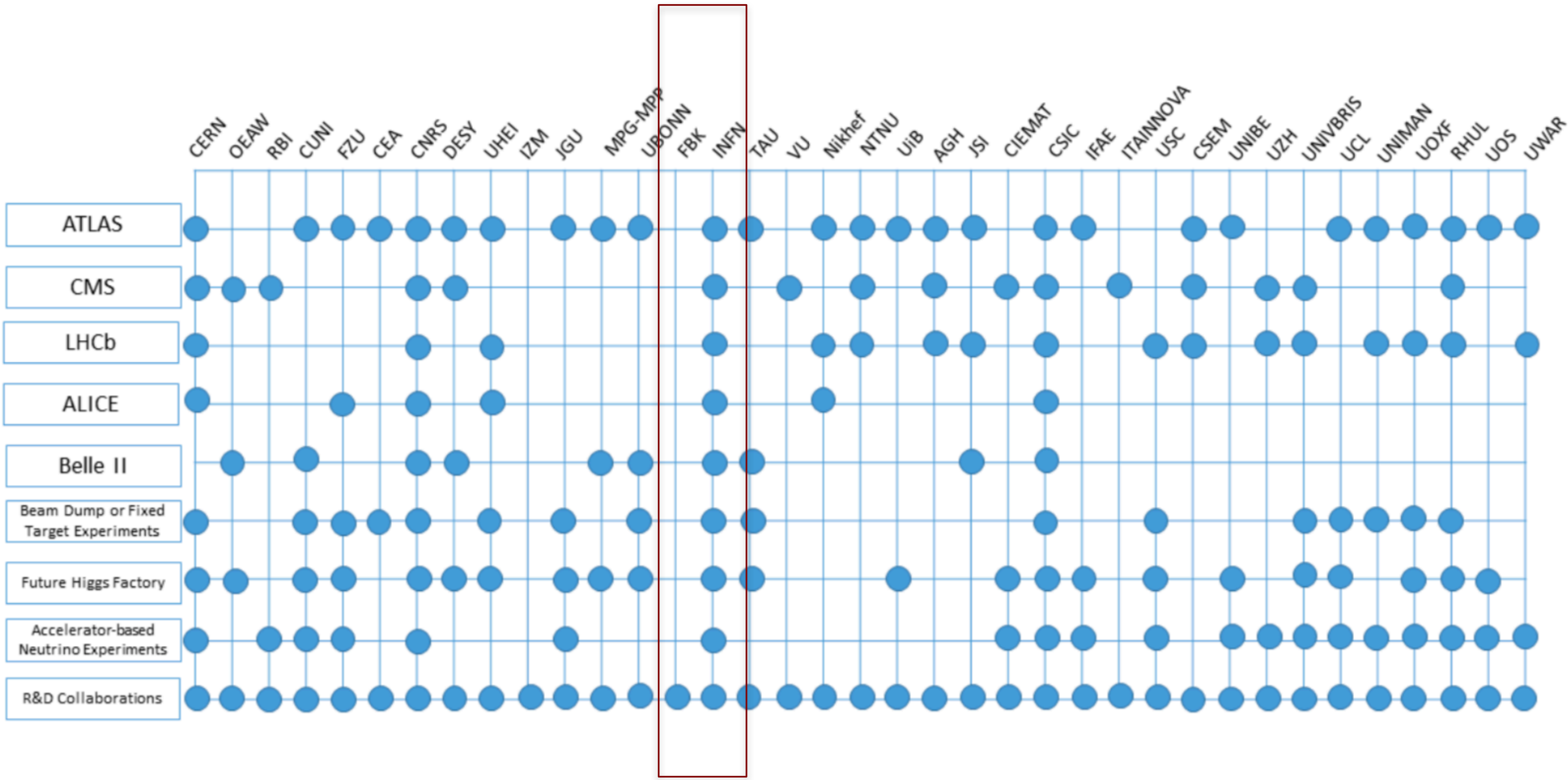




Italy


CERN
LIT
OEAW
RBI
CUNI
FZU
CEA
CNRS
Picotech
WEEROC
Workshape
DESY
ETALON
IZM
JGU
MPG-MPP
UHEI
UBONN
CAEN
ELTOS
FBK
INFN
TAU
VU
Nikhef
CONPART
NTNU
UiB
AGH
JSI
CIEMAT
CSIC
FYLA
IFAE
ITAINNOVA
USC
CSEM
SRS Technology
UNIBE
UZH
UNIVBRIS
UCL
UNIMAN
UOXF
RHUL
UOS
UWAR
WP1
WP2
WP3
WP4
WP5
WP6
WP7
WP8
WP9
WP10
WP11
WP12
WP13

Synergies


CERN
OEAW
RBI
CUNI
FZU
CEA
CNRS
DESY
UHEI
IZM
JGU
MPG-MPP
UBONN
FBK
INFN
TAU
VU
Nikhef
NTNU
UiB
AGH
JSI
CIEMAT
CSIC
IFAE
ITAINNOVA
USC
CSEM
UNIBE
UZH
UNIVBRIS
UCL
UNIMAN
UOXF
RHUL
UOS
UWAR
ATLAS
CMS
LHCb
ALICE
Belle II
Beam Dump or Fixed Target Experiments
Future Higgs Factory
Accelerator-based Neutrino Experiments
R&D Collaborations

Person-months

funded by the EC and provided in-kind by beneficiaries

lo.	Beneficiary	WP1		WP2		WP3		WP4		WP5		WP6		WP7	
		EC	in-kind	EC	in-kind	EC	in-kind	EC	in-kind	EC	in-kind	EC	in-kind	EC	in-kind
1	CERN	25.2	10.8	19.5	21.5	22.0	29.0	23.0	50.0	26.5	29.5	9.6	19.4	9.9	8.1
19	CAEN	-	-	-	-	-	-	11.0	9.0	-	-	-	-	11.0	10.0
20	ELTOS	-	-	-	-	-	-	-	-	-	-	-	-	11.0	1.0
21	FBK	-	-	-	-	-	-	-	-	-	-	17.0	0.0	-	-
22	INFN	-	-	-	-	-	-	5.0	12.0	19.5	39.5	24.0	53.0	62.0	119.0

lo.	Beneficiary	WP8		WP9		WP10		WP11		WP12		WP13		Total PM per Participant	
		EC	in-kind	EC	in-kind	EC	in-kind	EC	in-kind	EC	in-kind	EC	in-kind	EC	in-kind
1	CERN	13.7	23.3	-	-	9.2	36.8	-	-	26.4	50.1	0.0	2.0	**185.0**	**280.5**
19	CAEN	6.0	6.0	-	-	-	-	-	-	-	-	-	-	**28.0**	**25.0**
20	ELTOS	-	-	-	-	-	-	-	-	-	-	-	-	**11.0**	**1.0**
21	FBK	6.4	0.0	-	-	-	-	-	-	-	-	-	-	**23.4**	**0.0**
22	INFN	24.0	35.0	6.0	12.0	4.0	8.0	44.0	77.0	14.0	28.0	-	-	**202.5**	**383.5**

DOPO L'APPROVAZIONE DEL PROGETTO → per il 2021

- → Apertura della sigla in tutte le sezioni beneficiarie
- → Dichiarazioni percentuali da rendicontare su timesheet
- → Questa sigla dovra' essere considerata sinergica ai progetti coinvolti
- → Preparazione bandi per personale finanziato (co-finanziato) dal progetto

WP dove Pisa è coinvolta

- WP 5: Depleted Monolithic Active Pixel Sensors
- WP 8: Calorimeters and Particle Identification Detectors
- WP 10: Advanced Mechanics for Tracking and Vertex detectors
- WP 11: Microelectronics (28 nm)
- WP 12: Software for Future Detectors
- Tutte singergiche con attività in corso o in sviluppo
- I fondi verranno utilizzati quasi esclusivamente per co-finanziare personale (a parte in WP11)
- Ci aspettiamo un totale tra 2 e 4 annualità di assegni
- I dettagli dovranno essere definiti dopo l'approvazione del progetto (fine 2020)
- Nel caso più favorevole (4 annualità = 100k totali) dovremmo rendicontare circa 3.3 FTE di personale INFN su 4 anni.

WP 5: Depleted Monolithic Active Pixel Sensors

- Task 5.2. Development of high granularity DMAPS
- (CNRS-IPHC, CERN, INFN-PI, INFN-MI, INFN-PV, INFN-TO, UBONN, CNRS-CPPM, CSIC-IFIC, IFAE, UOXF)
- Ref. experiments: BelleII, ARCADIA, (FCCee, CEPC)
- INFN: Funding 100 kE (4 annualità assegni)
- INFN: Person months: 19.5 (39.5)
- Esperimenti a PI: Belle2 - Testing and system specs/integration per VTX upgrade
- Persone a PI: Forti, Bettarini, Rizzo, Casarosa, Bosi, Minuti, Massa, …
- Richieste assegni cofinanziati a Pisa: circa uno ma collaborazione con (TO) puo' diventare un altro assegno che lavora sia per To che per Pi.
- Interazione solo con CSN1 (Belle2) per 2021, poi nel 2022 potrebbe continuare con una progetto ARCADIA-like in CSN5.

WP 8: Calorimeters and Particle Identification Detectors

- Task 8.4. Calorimeters and Particle Identification Detectors
- (INFN-PV, INFN-MI, INFN-PI, INFN-BO, UOS, RBI, CAEN)
- Ref. Experiments: FCCee, CEPC
- Funding: 40 PV/ 30 CAEN/ 40 Sussex/ 20 RBI = 130 kE
- INFN Person months: 24 (35)
- Impegno a Pisa: Basti, Bedeschi, Cavasinni, Roda
- Al momento nessun assegno cofinanziato a Pisa, ma a a PV e MI

WP 10: Advanced Mechanics for Tracking and Vertex detectors

- Task 10.2. Engineering of optimised cooling substrates
- (CSIC-IFIC, CSIC-CNM, CERN, CSEM, INFN-PI, INFN-PG, LIT, MPG-MPP, WORKSHAPE)
- Sculpting in silicon: Integrated micro-channels in silicon sensors
- (CSIC-IFIC, CSIC-CNM, CERN, INFN-PI, INFN-PG, MPG-HLL)
- Funding: 25 PI/PG (si includono anche gli overheads)
- INFN: Person months: 4 (8)
- Impegno a Pisa: Bosi, Palla, Massa, Dell'Orso ...
- Richieste assegni cofinanziati: probabilmente due cofinanziamenti PI-PG
- Importante connessione con ingegneria per buoni candidati

WP 11: Microelectronics (28 nm)

- **Task 11.2. Exploratory study of advanced CMOS (28 nm)** (INFN-PV, AGH, CNRS-CPPM, UBONN)
- INFN: Person months: 44 (77) tolto PI per motivi non chiari.
- Fondi principalmente per sottomissioni
- Sinergie: PHOS4BRAIN in CSN5, Falaphel
- Persone: Palla, Saponara (ingegneria), G. Magazzu e Morsani sulla call per link veloci (+ Massa e Bosi per studi termici in overlap con WP10)
- nella CALL richiesti 2 junior + 1 Senior assegni per disegnatori chip a Pisa

WP 12: Software for Future Detectors

- Task 12.2. Turnkey Software
- (DESY, CERN, INFN-PI, INFN-PD, INFN-BA, INFN-BO)
- INFN Funding: 87,5 kE total
- INFN: Person months 14 (28)
- Impegno a Pisa: Boccali, Bagliesi
- Richiesti assegni cofinanziati: Uno forse a BA o PD

Tempi

- Si dovrebbe sapere se il progetto dovrebbe essere approvato in autunno
- Dopo l’approvazione ci sarà un aggiustamento delle percentuali 2021 per inserire nella nuova sigla: nessun impatto sui finanziamenti INFN già assegnati in quanto attività sinergiche.
- Inizio intorno a Febbraio-Marzo 2021
- Primi assegni a metà 2021

NB: il finanziamento di AIDAinnova è piccolo perché diffuso su tante istituzioni. Deve servire come volano per ottenere altri fondi

extras

INFN @ WP

WP		Industries	INFN
3	beam telescopes + DAQ @ CERN & DESY		
4	irradiation/EMC, characterization facilities	CAEN	***ENEA-FNG*** *irradiation*
5	Depleted Monolithic Active Pixel Sensors		PI, TO, MI, PV, CA
6	hybrid silicon pixel including timing (4D)	FBK	CA, GE, PG, TN,TO
7	new gas detector MPGD, RPC,TPC	CAEN ELTOS	BA, BO, LE, LNF, PV, RM3, TS
8	calorimeters and particle ID detectors	CAEN FBK	BO,LNF,NA,PD,PG,PV,TO ***Glass2Power***
9	cryogenic neutrino detectors: LAr TPC		MIB
10	advanced mechanics for ultra-light Sidetector		PI, PG
11	microlectronics: ASIC design		BA, BO, PV, TO
12	software/reco: Turnkey Software Stack		FE, PD, PI
13	prospective and technology-driven R&D		

INFN @ WP

WP			Indus	INFN
3	beam telescopes + timing			
4	irradiation/EMC,	capire meglio - irraggiamenti	CAEN	***ENEA-FNG*** ➔ ***RM1***
5	DAMPS	Belle2 ALICE Higgsfact/ATLAS		PI, TO, MI, PV, CA
6	hybrid silicon pixel (4D)	ATLAS – CMS – LHCb - Higgsfact – (Timespot)	FBK	CA, GE, PG, TN,TO
7	gas detector MPGD, RPC,TPC	ATLAS – CMS – LHCb – EIC – Higgsfact - neutrino	CAEN ELTOS	BA, BO, LE, LNF, PV, RM3, TS
8	calorimeters and particle ID	BELLE2 – KLEVER – Higgsfact – SHIP – LHCb – DUNE	CAEN FBK	BO,LNF,NA,PD,PG,PV,TO RM1MI PI ***Glass2Power***
9	cryogenic neutrino: LAr TPC	DUNE ➔ solo CSN2		MIB
10	advanced mechanics	ATLAS – CMS – BELLE2 – Higgsfact		PI, PG
11	microlectronics: ASIC design	all		BA, BO, PV, TO, MI, CA, FE, LNF
12	software/reco	all		FE, PD, PI, BA, RM3, BO,PV
13	technology-driven R&D	**Future to be discussed soon**		

Objectives
Task 4.1 Coordination and Communication *See introductory section on page 29.* **Task 4.2 Micro-beam upgrade at RBI accelerator facility** • Upgrade the RBI Accelerator Facility (RBI-AF) infrastructure for detector characterisation and radiation hardness studies at micron-scales, including the upgrade of the motorised precision device positioning, cooling and data acquisition systems **Task 4.3 Common tools for irradiation facilities quality control: data management, traceability, dosimetry and activation measurements** • Generalise the IRRAD facility Data Manager (IDM) system to include new facilities (e.g., CERN GIF++, ENEA-FNG) and improve the sharing of irradiation experiment results and operational data • Produce a common dosimetry calibration set for cross-comparison of irradiation facilities • Design and develop the prototype for an integrated system to manage induced activation (gamma spectrometry) and traceability data for irradiated objects **Task 4.4 Design & development of a new sensor characterisation system based on the TPA-TCT technique** • Complete the development from the proof-of-concept installation towards a customisable user friendly Two-Photon Absorption (TPA) Transient Current Technique (TCT) system with data acquisition and data analysis tools • Support the evaluation of newly developed sensors (Low-Gain Avalanche Detectors and depleted CMOS devices) developed in WP5 and WP6 • Offer support towards the implementation of similar systems in other European institutions **Task 4.5 Design & development of new electronics characterisation system for EMC control** • Design and develop an Electromagnetic Compatibility (EMC) test bench to measure the noise transfer function (TF) curves of physics detectors • Design and develop a portable test bench to perform in-situ EMC emission measurements of power supply unit in irradiation facilities

WP4

Objectives

Task 5.1 Coordination and Communication

See introductory section on page 29.

WP5

Task 5.2. Development of high granularity DMAPS

- Design of test structures and high granularity monolithic devices meeting different requirements, specifically high position resolution, low material thickness and power consumption, in particular targeting experiments at e^+e^- colliders such as Belle II and Higgs factories. Two versions are planned, the second after evaluation of the performance of the first one
- Fabrication of test structures and high granularity prototypes in multi-project wafer runs (MPW) runs.
- Development of a readout and test system for the devices
- Characterisation of the devices in the laboratory and in beam tests before and after irradiation to medium doses and fluences

Subtask Design

- Design of monolithic pixel sensors with high spatial granularity

Subtask Characterisation

- Tests and characterising measurements of high granularity monolithic pixel sensors

Task 5.3. Development of radiation hard DMAPS

- Design of test structures and radiation hard monolithic devices for applications in experiments with very high rate and high radiation levels, such as LHC Upgrades (e.g. for after long shut-down 4, LS4) or future hadron colliders
- Fabrication of test structures and a radiation hard prototype in a MPW run
- Development of a readout and test system for the devices
- Characterisation of the devices in the laboratory and in beam tests before and after irradiation to high fluence

Subtask Design

- Design of monolithic pixel sensors with high radiation tolerance

Subtask Characterisation

- Characterisation of monolithic pixel sensors with high radiation tolerance

Objectives

WP6

Task 6.1. Coordination and Communication

See introductory section on page 29.

Task 6.2. Simulation and processing of common 3D and LGAD sensor productions

- Optimisation of processes for 3D and LGAD sensors for timing applications
- Simulations of various designs for 3D and LGAD sensors to compare and optimise the layout in terms of timing performance
- Simulations of surface and bulk radiation damage for 4D (tracking+timing) detectors toward more radiation tolerant solutions
- Processing of two common 3D sensor productions and two common LGAD productions by FBK/CNM
- Design and implementation of simulation software which is applicable to a large range of technologies and includes models for the description of effects from sensor level to readout electronics in semiconductor detectors

Task 6.3. Validation of common 3D and LGAD sensor productions

- Characterisation of the 3D sensors in terms of timing, radiation hardness, efficiency and uniformity via measurements in the laboratory and beam tests
- Characterisation of small pitch LGAD and inverse LGAD sensors (iLGADs) from the common production in terms of timing and efficiency via measurements in the laboratory and beam tests
- Feedback to the foundries for further process optimisation of 3D and LGAD sensors

Task 6.4. Development of interconnection technologies for future pixel detectors

- Development of suitable Anisotropic Conductive Films (ACF) material and die-to-die bonding process flows for small pixel pitches
- Production and post-processing of dedicated planar sensor wafers for ACF trials
- Test of the performance of sensor modules interconnected with ACF
- Production and test of ultra-thin assemblies interconnected with a wafer to wafer bonding technology
- Post-processing of sensor prototypes developed in Task 6.3

WP7

Objectives

Task 7.1. Coordination and Communication

See introductory section on *page 29.*

Task 7.2. Multigap RPCs (MRPCs) for fast timing and Eco-friendly gas mixtures for RPCs

- Developing and testing material (thin plates of low resistivity glass)
- Construction, characterisation and test beam of small-size prototypes
- Construction of 1×1 m^2 prototypes with the new readout plane structure for a semi-digital hadron calorimeter (SDHCAL)
- Test beam study of the shower time development in an SDHCAL, equipped with the prototype detectors
- Identification and characterisation of new gas mixture candidates
- Validation of the gas mixtures after large integrated doses at GIF++

Task 7.3. Development of resistive electrodes for MPGDs and Industrial engineering of high-rate μ-RWELL detector

- Production of Diamond Like Carbon (DLC) with ion beam deposition and pulsed laser deposition
- Study of the resistance of graphene to polyimide etching liquids
- Characterisation of 10×10 cm^2 foils by DLC and graphene
- Industrial production of small-size prototypes and their characterisation
- Industrial production of large-size prototypes (~ 0.5 m^2) and their characterisation

Task 7.4. A 4-channel electronic board prototype for cluster counting and Hybrid readout for high pressure gas TPC for neutrino physics

- Design electronics and realise a 4-channel prototype for cluster counting in ultra-light drift chambers
- Identification and characterisation of adequate gasses
- Construction of a small-scale TPC prototype (~10 l) with a hybrid charge and optical readout

Task 7.5. Photon detectors for hadron particle identification at high momenta

- Development of MPGD single photon detectors for compact Ring Imaging Cherenkov detectors
- Comparison of measured prototype characteristics with Silicon Photomultipliers (SiPMs) and Large Area Picosecond Photodetectors (LAPPDs)

Objectives

WP8

Task 8.1. Coordination and Communication

See introductory section on page 29.

Task 8.2. Towards next generation highly granular calorimeters

- Development of a common electromagnetic and hadronic calorimeter data concentration interface for minimised space and power consumption
- Demonstrator with functional active detector elements and full read-out chain
- Development of a high granularity demonstrator for Liquid Noble gas calorimeters with innovative readout technologies

Task 8.3. Innovative calorimeters with optical readout

- Optimisation of crystal materials and processes for fast timing applications in radiation environments
- Industrialisation of the production process of fast and radiation-hard crystals
- Study of neutron detection with organic scintillators
- Develop scalable production procedures for large-scale highly granular scintillator calorimeters

Task 8.4. Innovative solid-state light sensors and highly-granular dual-readout fibre-sampling calorimetry

- Systematic study of neutron irradiated SiPMs at different temperatures
- Development of SiPMs with improved radiation resistance
- Definition of the specifications for an optimal ASIC and the readout for fibre-sampling dual-readout calorimeters
- Construction of several 10×10 cm^2, 2 m long, dual-readout matrices with SiPM sensors and readout electronics

Objectives
Task 10.1. Coordination and Communication
See introductory section on page 29.
Task 10.2. Engineering of optimised cooling substrates

WP10

- Develop the process of cooling channel integration in CMOS structures into scalable solutions
- Define the optimal geometrical features attainable for 3D printed ultra-thin cold plates in metal alloys and ceramic composites
- Implement the full integration of cooling features into ultra-light carbon composite structures

Task 10.3. Micro-connectivity

- Define advanced engineered solutions for the hydraulic interconnection of multiple micro-structured silicon cold plates

Task 10.4. Supercritical CO_2 as refrigerant

- Characterise Supercritical CO_2 (sCO_2) as a possible ultra-effective single-phase refrigerant for "warm" detector cooling
- Study the design of new supercritical heat exchangers for optimal energy recovery at higher temperatures in transcritical CO_2 cycles

Task 10.5. Characterisation of ultra-light structures

- Evaluate the feasibility of a new version of the existing Frequency Scanning Interferometry (FSI) instrumentation suited for use as an accurate survey of ultra-light and small detector structures
- Refine and standardize the methodology for vibration and distortion measurements in view of new and more precise specifications for future detectors

WP11

Objectives
Task 11.1. Coordination and Communication
See introductory section on page 29.
Task 11.2. Exploratory study of advanced CMOS (28 nm)
• Explore advanced 28 nm CMOS for future trackers • Qualify radiation tolerance • Design and test front-end prototype ASIC
Task 11.3. Networking and ASICs for other WPs (65/130 nm)
• Cold and timing ASICs in 65/130nm CMOS • MPGD readout ASICs • Silicon and SiPM readout ASICs for future colliders and timing applications

Objectives
Task 12.1. Coordination and Communication *See introductory section on page 29.* **Task 12.2. Turnkey Software** • Integrated Turnkey Software Stack, for physics and performance studies • Simplified data model toolkit for modern hardware platforms • Digitisation extensions for geometry toolkit • R&D study on frameworks to manage heterogeneous resources **Task 12.3. Simulation** • Fast simulation techniques integrated into Geant4 • Machine learning based calorimeter simulation toolkit for training and inference **Task 12.4. Track Reconstruction** • Develop complete track reconstruction chain with Acts composable algorithms • Implement a portable version of Acts algorithms, for heterogeneous computing • Machine learning reconstruction algorithm for MPGD detectors **Task 12.5. Particle Flow Reconstruction** • Advanced PFA algorithms for DUNE detectors using new readout technologies • PFA algorithm with particle ID for dual-readout calorimeters • Optimised APRIL PFA algorithm for hadronic jets

WP12

WP13

Objectives
Task 13.1. Coordination and Communication • Define and supervise the selection procedure for the generic R&D projects • Establish the connection to the Management and the communication with other WPs • Manage the administrative, financial and IPR aspects of the projects
Task 13.2. Follow-up and Evaluation • Monitor the progress of individual projects and ensure regular reports to the community • Evaluate the results and the effectiveness of the supporting measures