DRD2 – Task 4.1 Radiopurity and background mitigation.

Paul Scovell – STFC

Roberto Santorelli – CIEMAT

10/Oct/2024

Detector R&D topics in the recent past (LHC main motivation)

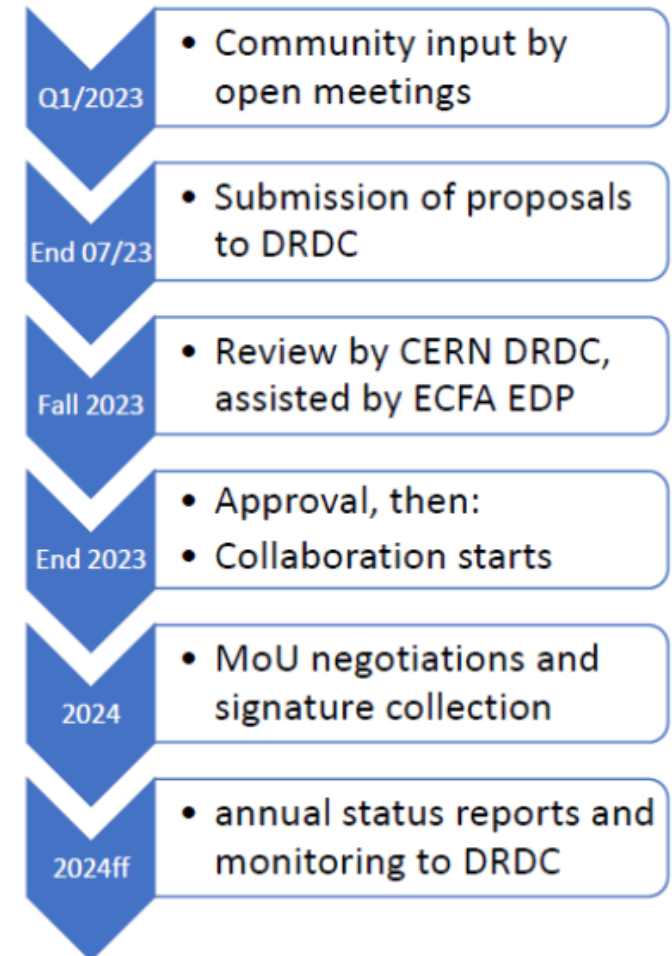|					
RD-1	SPACAL	Scintillating Fibre Calorimetry at the LHC	R&D	20-09-1990	Finished
RD-10	RADHARD	A St.to Improve the Radiat.Hardness of Gas.Detect.for Use at Very-H Luminosities	R&D	04-04-1991	Finished
RD-11	EAST	Embedded Architectures for Second-level Triggering in LHC Experiments (EAST)	R&D	04-04-1991	Finished
RD-12	TTC	Timing, Trigger and Control Systems for LHC Detectors	R&D	04-04-1991	Finished
RD-13	LHCTB	A Scalable Data Taking System at a Test Beam for.LHC	R&D	04-04-1991	Finished
RD-14	XENON	Noble Liquid (Xenon or Krypton) Totally Active Calorimetry	R&D	04-04-1991	Finished
RD-15	PPC	The Prism Plastic Calorimeter (PPC)	R&D	04-04-1991	Finished
RD-16	FERMI	A digital Front-End and Readout Microsystem for calorimetry at LHC	R&D	04-04-1991	Finished
RD-17	FAROS	Ultrafast Readout of Scintill.Fibres Us.Upgr.Position-Sensitive Photomultipliers	R&D	04-04-1991	Finished
RD-18	CRYSTAL CLEAR	R&D on scintillation materials for novel ionizing radiation detectors for High Energy Physics, medical imaging and industrial applications	R&D	04-04-1991	In-Progr
RD-19	PIXEL	Development of Hybrid and Monolithic Silicon Micropattern Detectors	R&D	27-06-1991	Finished
RD-2	SITP	Study of a Tracking/Preshower Detector for the LHC	R&D	20-09-1990	Finished
RD-20	SI TRACKER	Dev.of High Resolution Si Strip Detectors for Exp.at High Luminosity at the LHC	R&D	27-06-1991	Finished
RD-3	ACCORDION	Liquid Argon Calorimetry with LHC-Performance Specifications	R&D	20-09-1990	Finished
RD-4	DOPANTS	Study of Liquid Argon Dopants for LHC Hadron Calorimetry	R&D	20-09-1990	Finished
RD-5	LHC-MUONS	St.of Muon Triggers & Momentum Rec.in a Str.Magn.Field x a Muon Detector at LHC	R&D	07-02-1991	Finished
RD-6	TRD-TRACKER	Integr.High-Rate Transition Radiation Detector & Tracking Chamber for the LHC	R&D	07-02-1991	Finished
RD-7	FITRACK	Central Tracking Detector Based on Scintillating Fibres	R&D	07-02-1991	Finished
RD-8	GAASWORKS	Development of GaAs Detectors for Physics at the LHC	R&D	07-02-1991	Finished
RD-9	SOI	A Demonstrator Analog Signal Process.Circoit in a Radiation Hard SOI-CMOS Techn.	R&D	07-02-1991	Finished
RD21	COLLIDER-BEAUTY	R&D for Collider Beauty Physics at the LHC	R&D	28-11-1991	Finished
RD22		Test of Beam Extr.by Crystal Chann.at the SPS:First Step tow.a LHC Extr.Beam	R&D	28-11-1991	Finished
RD23	OPTOELECTRONICS	Optoelectronic Analogue Signal Transfer for LHC Detectors	R&D	06-02-1992	Finished
RD24	SCI	Application of the Scalable Coherent Interface to Data Acquisition at LHC	R&D	06-02-1992	Finished
RD25	LFC	Continuing Studies on Lead/Scintillating Fibres Calorimetry (LFC)	R&D	16-04-1992	Finished
RD26	CSIRICH	Development of a Large Area Advanced Fast RICH Detector for Particle Identification at the Large Hadron Collider Operated with Heavy Ions	R&D	16-04-1992	Finished

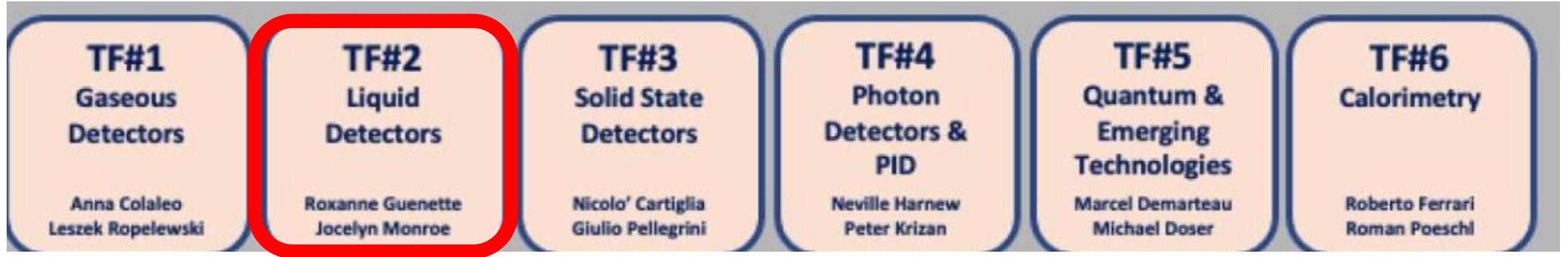|					
RD27		First-Level Trigger Systems for LHC Experiments	R&D	30-06-1992	Finished
RD28	GAS MICROSTRIPS	Dev.of Gas Micro-Strip Chambers for Radiation Det.& Tracking at High Rates	R&D	30-06-1992	Finished
RD29	DMILL	A Mixed Analog-Digital Radiation Hard Technology for High Energy Physics Electronics: DMILL (Durci Mixte sur Isolant Logico-Lineaire)	R&D	30-06-1992	Finished
RD30	OPTICAL TRIGGER	St.of Impact-Par.Opt.Discrim.to be used x Beauty Sch in Fixed-Tgt Mode at LHC	R&D	26-11-1992	Finished
RD31	NEBULAS	NEBULAS.br H-P.Data-Dr.Event-Build.Arch.bas.on Asynchr.Self-R.Pack-Switch.Netw.	R&D	26-11-1992	Finished
RD32	ALICE TPC	Dev.of a Time Projec.Chamber w.High Two Tr.Resol.Cap.x Exp.at Heavy Ion Collid.	R&D	26-11-1992	Finished
RD33	TGT	Study of a Novel Concept for a Liquid Argon Calorimeter The "Thin gap Turbine" (TGT)	R&D	11-02-1993	Finished
RD34	TILECAL	Constr.& Perf.of an Iron-Scintill.Hadron Calorim.w.Longitudinal Tile Configurat.	R&D	15-04-1993	Finished
RD35	SICAL	A Silicon Hadron Calorim. Module Op.in a Strong Magn.F.w.VLSI Readout for LHC	R&D	17-06-1993	Finished
RD36		Shashlik Calorimetry.br - A Combined Shashlik + Preshower Detector for LHC	R&D	25-11-1993	Finished
RD37		Very Forward Hadron Calorimetry at the LHC Using Parallel Plate Chambers	R&D	10-02-1994	Finished
RD38	CICERO	CICERO:Ctrl Inf.syst.Conc.b.on Enc.R-T.Obj.St.on Gen.Ctrl Syst.x Lge Sc.LHC Exp.	R&D	10-02-1994	Finished
RD39	SMSD	Cryogenic Tracking Detectors	R&D	10-02-1994	Finished
RD40	Q-CAL	Development of Quartz Fiber Calorimetry	R&D	21-04-1994	Finished
RD41	MOOSE	Object Oriented Approach to Software Development for LHC Experiments	R&D	16-06-1994	Finished
RD42		Development of Diamond Tracking Detectors for High Luminosity Experiments at the LHC	R&D	22-09-1994	In-Progress
RD43	BHCAL	Proposal for Research & Develop.of a Hadron Calorimeter for High Magnetic Fields	R&D	22-09-1994	Finished
RD44	GEANT4	GEANT 4: an Object-Oriented toolkit for simulation in HEP	R&D	24-11-1994	Finished
RD45		A Persistent Object Manager for HEP	R&D	09-02-1995	Finished
RD46		High Resolution Tracking Devices Based on Capillaries Filled with Liquid Scintillator	R&D	15-06-1995	Finished
RD47		High Energy Physics Processing using Commodity components (HEP PC)	R&D	08-02-1996	Finished
RD48	ROSE	Radiation Hardening of Silicon Detectors	R&D	13-06-1996	Finished
RD49	RADTOL	Studying Radiation Tolerant ICs for LHC	R&D	12-06-1997	Finished
RD50		Development of Radiation Hard Semiconductor Devices for Very High Luminosity Colliders	R&D	30-05-2002	In-Progress
RD51		Development of Micro-Pattern Gas Detectors Technologies	R&D	05-12-2008	In-Progress
RD52		Dual-Readout Calorimetry for High-Quality Energy Measurements	R&D	31-08-2011	Finished
RD53		Development of pixel readout integrated circuits for extreme rate and radiation	R&D	28-08-2013	In-Progress

The Detector R&D collaborations (DRDs)

- Focused R&D collaboration on Specific R&D

- Coordinate the development of advanced detector technologies

- To be operational in 2024

Approvaland Reviewing:DRDC Committee

- New committee at CERN on the same level as SPSC and LHCC:
  - Reviewed submitted DRD proposals
  - Monitoring the progress of each DRD collaboration by requesting
  - Annual status reports
- Assisted by ECFA detector Paned

Q1/2023	• Community input by open meetings
End 07/23	• Submission of proposals to DRDC
Fall 2023	• Review by CERN DRDC, assisted by ECFA EDP
End 2023	• Approval, then: • Collaboration starts
2024	• MoU negotiations and signature collection
2024ff	• annual status reports and monitoring to DRDC

Identification of the most pressing R&D priorities within each Task Force area.

TF#1
Gaseous
Detectors

Anna Colaleo
Leszek Ropelewski

TF#2
Liquid
Detectors

Roxanne Guenette
Jocelyn Monroe

TF#3
Solid State
Detectors

Nicolo' Cartiglia
Giulio Pellegrini

TF#4
Photon
Detectors &
PID

Neville Harnew
Peter Krizan

TF#5
Quantum &
Emerging
Technologies

Marcel Demarteau
Michael Doser

TF#6
Calorimetry

Roberto Ferrari
Roman Poeschl

TF#7
Electronics & On-
detector
Processing

Dave Newbold
Francois Vasey

TF#8
Integration

Frank Hartmann
Werner Riegler

TF#9
Training

Johann Collot
Erika Garutti

DRD2 proposal Dec23

DRD2: Liquid Detectors v5

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b: University of Oxford, United Kingdom

c: University of Texas Arlington, United States

d: Johannes Gutenberg-Universität Mainz, Germany

e: Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas, Spain

f: Università degli Studi di Napoli "Federico II" & INFN Sezione di Napoli, Italy

g: University of Edinburgh, United Kingdom

h: University of Alberta, Canada

i: TRIUMF, Canada

j: University of Liverpool, United Kingdom

k: Brookhaven National Laboratory, United States

l: Instituto de Física Corpuscular (IFIC), CSIC & Universitat de València, Spain

m: Astrocent, Nicolaus Copernicus Astronomical Center of the Polish Academy of Sciences, Poland

n: INFN Sezione di Cagliari, Italy

o: INFN Sezione di Milano, Italy

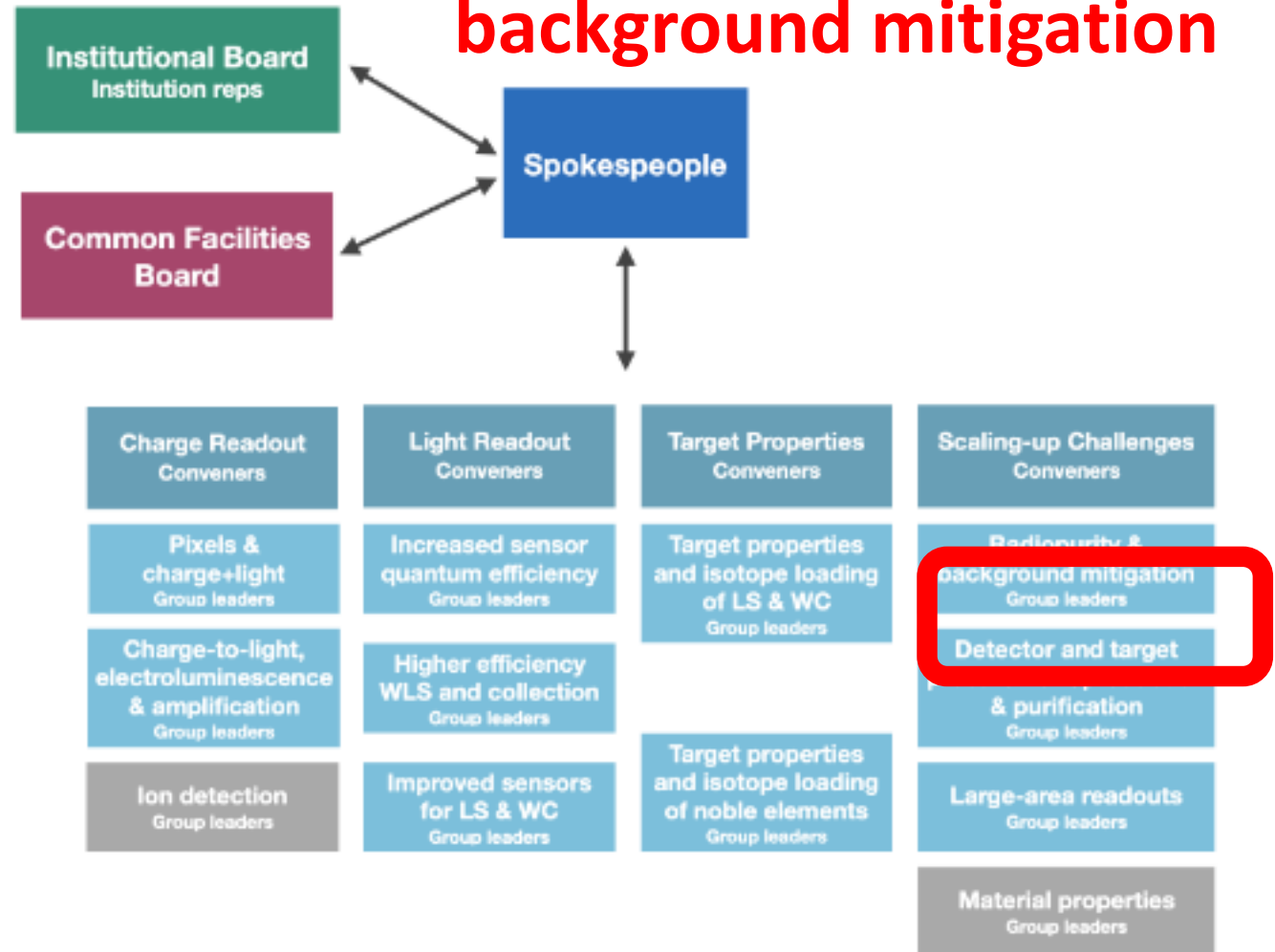p: APC, Université de Paris Cité, CNRS, Astroparticule et Cosmologie, France

q: King's College London, United Kingdom

6th December 2023

DRD2_Proposal-v5_6Dec2023

Task 4.1 Radiopurity and background mitigation

Task 4.1: *"Radiopurity and background mitigation. This addresses the need for development in new and more sensitive assay methods, new material selection and cleaning protocols, and development of radiopure materials."*

6

		Timeline of milestones and major deliverables			
Goals	Deliverables	Milestones 2024	Milestones 2025	Milestones 2026	Milestones 2027-2030
WP4: Scaling-up Challenges					
T4.1: Radiopurity and background mitigation					
T4.1.G1: Radioassay techniques at required sensitivity for next generation of rare-event search experiments	T4.1.G1.D1 Measurement demonstrating <5 µBq sensitivity for warm/cold Rn emanation (2026)	Design and material selection for warm/cold Rn emanation at <5 µBq sensitivity	Portable gas Rn monitor constructed and tested	Rn emanation warm/cold sensitivity demonstrated at <5 µBq;	Throughput scale up for all techniques; Characterisation of stock materals and barrier methods for next-generation experiments.
	T4.1.G1.D2 Measurements demonstrating <20 ppq U/Th sensitivity with ICP-MS and HPGe to <2 µBq/kg (2026)	ICP-MS sample preparation protocols for key materials at <20 ppq U/Th	HPGe detector built and characterised	Demonstration rapid pre-screening using laser ablation ICP-MS to 10 ppt U/Th.	Throughput scale up for all techniques; Characterisation of stock materials and barrier methods for next-generation experiments.
T4.1.G2: Mitigation through material selection/treatment and clean manufacture	T4.1.G2.D1 Technical report on surface treatments and clean protocols to achieve few ng/cm² surface cleanliness levels (2026)	Evaluation of barrier materials and methods (electroplating, conventional)	Demonstration of dust removal using atmospheric plasma surface treatment	Protocols for dust removal surface treatments (chemical/electrochemical) demonstrated (few ng/cm²); Barrier surface treatment of large scale detector components operational.	Demonstration of dust removal using vacuum plasma surface treatment
	T4.1.G2.D2 Prototype assay techniques to characterise few ng/cm² and 100 µBq/m² contamination levels (2026)	Demonstration of ML-enabled optical and flurescence surface dust contamination to few ng/cm²	Design and material selection for surface alpha-screening system (with industrial partners) with 100 µBq/m² sensitivity	Facility for tests of surface contamination of large electrodes O(m²); Barrier surface treatment of large scale detector components operational; Surface alpha-screening system operational with 100 µBq/m² sensitivity	Demonstration of dust removal using vacuum plasma surface treatment
T4.1.G3: Development of novel materials for background suppression	T4.1.G3.D1 Report on performance and production at scale of novel veto materials (2026)	Development of low-background polymerization processes for passive shields and light guides; Design optimisation for Gd-PMMA system (maximum Gd-fraction, veto thickness)	Scale-up passive shield production; Materials screening/selection for high-radiopurity Gd-PMMA active shielding	Gd-PMMA scale-up via industrial transfer	
	T4.1.G3.D2 Prototype of Rn removal system based on microporous adsorbents (2026)	Synthesis of new microporous adsorbents for Rn capture in gas phase (Ar, Xe, N2)	New generation of microporous radon adsorbents characterised in Ar, Xe gas a function of T, P.	Design and construct Rn removal system based on microporous adsorbents	
T4.1.G4: Tools for the evaluation of backgrounds	T4.1.G4.D1 Public release of simulation and accounting tools (2026);	Implementation of generic highly shielded detector in GEANT4; Development of GPU-accelerated statistical inference tools; Improvement in accuracy of neutron yield calculations with uncertainties of 10% for most materials; Comparison between codes, models and datasets for cosmogenic and beam activation products; Development of material background accounting tool and data formats	Development of techniques for high-stats simulations of highly shielded detectors (event biasing, bootstrapping, GPU/TPU accelerated); Release updated neutron yield library (SOURCE4) and paper; Toolkit for accurate simulation of cosmogenic production and activation of detector components and target materials	Improved (α-n) production cross-section measurements for key materials (e.g., argon); Report on design studies optimising active veto strategies vs fiducial trade off for 0νBB, DM.	

Institute	PI	T4.1			
Deliverable		G1	G2	G3	G4
T4.1: Radiopurity and Background Mitigation					
Aix Marseille Univ, CNRS/IN2P3, CPPM	Busto	×	×		
CIEMAT	Cano/Santorelli				×
Complutense University of Madrid	Fraile				×
GSSI	Di Marco			×	
INFN Genova	Testera				×
INFN LNL	Azzolini		×		
Jagiellonian University	Zuzel	×			
JGU Mainz	Oberlack/Deisting		×		
King's College London	Dobson	×	×		×
LIP	Lindote				×
LLNL	Pereverzev			×	
Padova University/INFN	Brugnera			×	
Polytechnic University of Catalonia	Tarifeño				×
Roma Tre University/INFN	Salamanna			×	
STFC Boulby Underground Laboratory/BUGS	Scovell	×	×		
STFC RAL PPD	Van der Grinten	×			
University College London	Ghag/Saakyan/Waters	×			×
University of Edinburgh	Murphy	×	×		×
University of Sheffield	Kudryavtsev/Tovey	×	×		×
University of Zaragoza	Sarsa		×		

T4.2: Detector & target procurement/production & purification

Quick facts 1:

- CERN will not directly provide funds for this R&D

- Funding should be sought through national calls (either general or dedicated)

- It is expected that being part of a DRD will increase the chances of obtaining funding

- Additionally, DRDs are official CERN collaborations, allowing access to CERN's resources

What you are supposed to do:

- Prepare some basic information to include your R&D in the final proposal

  - PI name
  - Participating institutions
  - FTE (total for duration) (Physicists)
  - FTE (PhD students)
  - FTE (Eng+Tech)
  - Funding available (k€) (if any)
  - Start date of the proposed activity
  - End date of the proposed activity
  - Activity description (a few lines)

- Sign a "light" MoU with CERN