
HiDRA2 – Pavia

Activities – WP1

WP1 Activity: Choice of baseline options for scintillating and Čerenkov fibres, choice of baseline options for absorber material and layout, choice of PMTs for external ring readout. Definition of construction procedure, including the coupling of fibres to light sensors. Construction of prototypes and modules for the full-containment calorimeter.

WP1 Description of Work and Role

- T1.1. Identification of candidates for Čerenkov and scintillating fibres [M1-12][MI,PI,PV]
- T1.2. Absorber material choice [M1-12][PI,PV]
- T1.3. PMT choice and layout optimisation [M1-12][PI]
- T1.4. Definition of Quality Control (QC) procedure and criteria for Čerenkov and scintillating fibres [M1-12][MI,PI,PV]
- T1.5. Definition of QC procedure and criteria for PMTs [M1-12][PI]
- T1.6. Dimensions and construction method of the building elements [M7-18][MI,PI,PV]
- T1.7. Dimensions and assembly procedure of single towers with a self-supporting structure [M13-18][PI,PV]
- T1.8. Definition of QC procedure and criteria for single towers [M13-18][MI,PI,PV]
- T1.9. PMT procurement and qualification [M13-18][PI]
- T1.10. Construction of full-containment prototype and the dSiPM module [M19-30][PI,PV]
- T1.11. Engineering design of projective towers [M19-36][PI]

Milestones & Deliverables – WP1

WP1 Milestones

- M1.1. Identification of baseline options: absorber, fibres and PMTs [M12]
- M1.2. Start of module construction [M19]
- M1.3. End of module construction and sensor integration [M30]

WP1 Deliverables

- D1.1. Full characterisation of chosen baseline options [M12]
- D1.2. Single tower of final dimensions built with the selected absorber and fibers and with the final procedure [M20]
- D1.3. Final prototype built and integrated with readout sensors [M30]

Activities – WP4

WP4 Activity: Evaluation of the performance of the proposed calorimeter both through comparison of detailed detector simulations with the data from the test beam modules and with the reconstruction of fully simulated events from an e^+e^- collider. Validation of GEANT4 nuclear interaction models. Development of ML algorithms for the identification of hadronic τ decays.

WP4 Description of Work and Role

T4.1. Development of a GEANT4 simulation of the modules with testbeam geometry

[M1-12][PV]

T4.2. Development of a detailed simulation for light propagation, SiPM response and related

electronics chain [M1-12][MI]

T4.3. Development of a GEANT4 simulation of a 4π geometry solution [M1-12][PV]

T4.4. Comparison of the simulation with test beam data and validation of the GEANT4 hadronic model [M13-36][BO, MI, PI, PV, RM1]

Activities – WP4

- T4.5. Development of a calibration strategy for single particles and jets, both analytical and based on ML algorithms [M13-18][PV]
- T4.6. Assessment of the energy resolution for single particles and jets [M19-24][PV]
- T4.7. Identification of single particles, both isolated and within jets [M25-36][MI,PV]
- T4.8. Identification and reconstruction of heavy-boson decays in 2-photon, 2-tau, 2-, 4-, 6-jet final states [M25-36][PV]
- T4.9. Development of a baseline DNN architecture based on Convolutional models [M1-12][RM1]
- T4.10. Development of novel DNNs based on Graph NNs optimised for a realistic detector simulation [M13-21][RM1]
- T4.11. Evolution of the Graph NNs with Bayesian structure in order to provide probabilistic assessment of the model predictions and implementation of the ability to identify single particle (photons, muons, electrons, charged pions) inside each cluster [M22-30][RM1]
- T4.12. Study of an optimised design of the DNN model developed for real-time applications (trigger, feature extractions) [M31-36][RM1]
- T4.13. Test beam data taking and analysis [M31-36][BO,MI,PI,PV,RM1]

Milestones & Deliverables – WP4

WP4 Milestones

- M4.1. Full simulation running and validated for both the TB prototype and a 4π detector [M12]
- M4.2. Assessment of the performance for jets and single particles [M24]
- M4.3. Baseline trained and optimised CNN model ready [M12]
- M4.4. Novel GNN demonstrator deployed [M21]

WP4 Deliverables

- D4.1. Full simulation completed for both the TB prototype and a 4π detector [M12]
- D4.2. Validation of GEANT4 hadronic model [M36]
- D4.3. Performance assessment with TB data [M36]
- D4.4. Physics performance assessment on benchmark physics processes completed [M36]
- D4.5. Baseline performance obtained with the best CNN model documented [M12]
- D4.6. Final performance assessment (physics and wrt design readout strategy) for the selected DNN model and its deployment for general use [M24]

Anagrafica HiDRa Pavia

| Researcher | RU | FTE | Contribution to Work Packages (months) | | | |
|----------------------------|----|------|--|------|-----|-----|
| | | | WP1 | WP2 | WP3 | WP4 |
| G. Gaudio | PV | 0,20 | 4 | | | 2,6 |
| J. Agarwala | PV | 0,30 | 5 | | | 4,9 |
| R. Ferrari | PV | 0,50 | 6,5 | | 5 | 5 |
| A. Negri | PV | 0,10 | | | | 3,3 |
| G. Polesello | PV | 0,20 | | | | 6,6 |
| S. Sottocornola | PV | 0,20 | 2 | | | 4,6 |
| L. Ratti | PV | 0,3 | | 8,9 | 1 | |
| C. Vacchi | PV | 0,5 | | 14,5 | 2 | |
| G. Torilla | PV | 1 | | 28 | 5 | |
| AdR (50% on project funds) | PV | 0,67 | 16 | | | 6 |

| Percentuali DR 2022 | | | | |
|---------------------|--------|------------|-------|--------------------------------|
| | RD_FCC | AidaInnova | Hidra | Tot Available (-ATLAS -Others) |
| Agarwala Jinky | 30 | | 30 | 30 |
| Ferrari Roberto | 20 | 10 | 50 | 30 |
| Gaudio Gabriella | 20 | 10 | 20 | 30 |
| Andrea Negri | 10 | | 10 | 10 |
| Polesello Giacomo | 20 | 10 | 20 | 30 |
| Sottocornola Simone | 20 | | 20 | 20 |
| Claudio Scagliotti | | 10 | | |
| Ratti Lodovico | | | 30 | |
| Vacchi Carla | | | 50 | |
| Torilla Gianmarco | | | 100 | |
| SUM | 1.2 | 0.4 | 3.3 | |

Assegnazioni Hidra Pavia 2022

| Capitolo | Riunione | Note Alla Richiesta | Rich. | Rich. SJ | Assegn. | Assegn. SJ | Assegn. Dot. | Commento Alla Assegnazione |
|-----------|------------------------|--|-------------|------------|-------------|-------------|--------------|--|
| MISS | Assegnazioni | meeting, conferenze | 3.0 | 0.0 | 0.0 | | | |
| | Assegnazioni | Project coordination | 2.0 | 0.0 | 0.0 | | | |
| | Totale MISS | | 5.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| CON | Assegnazioni | Mechanics: calorimeter QAQC | 2.0 | 0.0 | 1.0 | | | |
| | Assegnazioni | Capillary tubes | 15.0 | 0.0 | 0.0 | 10.0 | | Subjudice alla presentazione delle offerte |
| | Assegnazioni | Glue | 1.0 | 0.0 | 1.0 | | | |
| | Totale CON | | 18.0 | 0.0 | 2.0 | 10.0 | 0.0 | |
| INV | Assegnazioni | Mechanics: assembly system | 1.0 | 0.0 | 1.0 | | | |
| | Totale INV | | 1.0 | 0.0 | 1.0 | 0.0 | 0.0 | |
| SPSERVIZI | Assegnazioni | Assegno di ricerca | 31.0 | 0.0 | 31.0 | | | |
| | Febbraio | Restituzione alla CSN5 dei fondi dell'AdR senior 2022, rimandato al prossimo anno. | -31.0 | 0.0 | 0.0 | | | |
| | Totale SPSEVIZI | | 0.0 | 0.0 | 31.0 | 0.0 | 0.0 | |
| PV | | | 24.0 | 0.0 | 34.0 | 10.0 | 0.0 | |

| | | | | | | |
|----|-----|------------------------|--------------------|-------------|-----------|-------------|
| PV | 1 | glue | 1 | 2 | 2 | cons |
| | 1 | capillary | 15 | 70 | 35.4 | cons |
| | 1 | Mech: calorimeter box | | | 2 | cons |
| | 1 | Mech: patch pannel | | | 4.2 | cons |
| | 1 | Mech: assembly system | 1 | 4 | | inv |
| | 1 | Mech: calorimeter QAQC | 2 | | | cons |
| | 1,4 | Human resources (AdR) | 7.5 | 16 | 7.5 | AdR |
| | 1,4 | meetings, conference | 3 | 3 | 3.9 | travel |
| | 1,4 | test beam | | | 6.6 | travel |
| | all | Project Coordination | 2 | 2 | 2 | travel |
| | | | Total Pavia | 31.5 | 97 | 63.6 |

HiDRa money request
per year
2022-2023-2024

Fondi DR Pavia 2022

| Fondi | Capitolo | assegnazione | Importo | commento |
|------------|----------------|-------------------------|---------|--------------------------|
| RD_FCC | Missioni | metabolismo | 1.5 | |
| RD_FCC | Missioni | TB | 4 | SJ al TB |
| HiDRa2 | Consumo | Meccanica:QAQC | 1 | |
| HiDRa2 | Consumo | Meccanica:Capillari | 10 | SJ presentazione offerte |
| HiDRa2 | Consumo | Meccanica: colla | 1 | |
| DOT1 | Consumo | avanzo 2021 | 14 | |
| HiDRa2 | Inventariabile | Meccanica; assemblaggio | 1 | |
| AidaInnova | Altri Servizi | Assegni | 40 | |

Da Rendicontare per AIDAInnova

- 40 mesi uomo
- 10 K€ in missioni
- 10 k€ in equipment and consumable

Richiesta Assegno Pavia

Assegno di 1 anno rinnovabile (1° annualità AIDAInnova, rinnovabile fondi Sezione Pavia)

Inizio previsto: Luglio 2022

Nell'ambito di questo programma di ricerca sarà necessario seguire diversi aspetti come

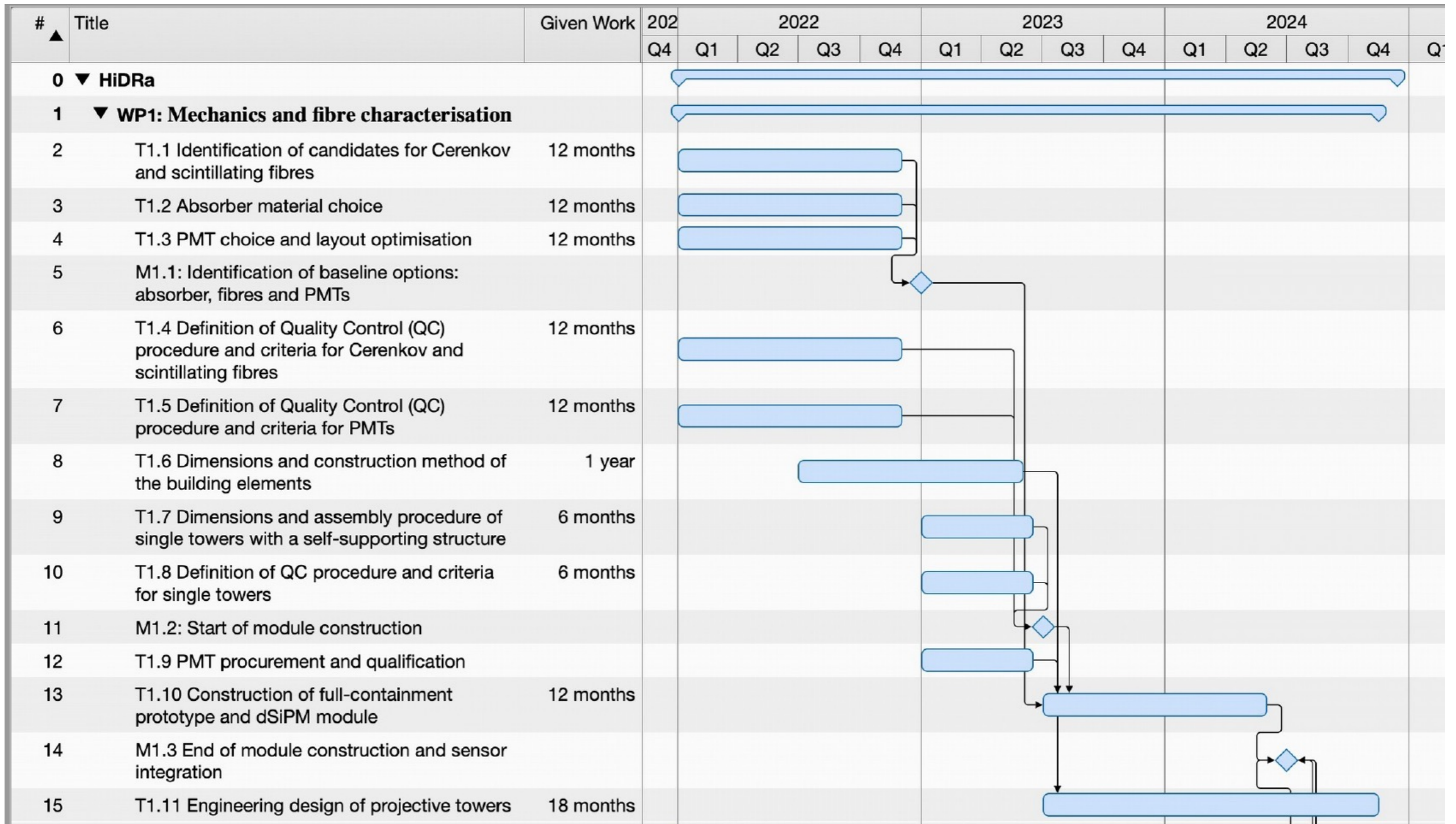
- La costruzione e la qualifica del prototipo costruito.
- Lo sviluppo di tool sia hardware che software per l'automatizzazione della procedura di costruzione e il controllo qualità (QAQC).
- La simulazione del prototipo con GEANT4 e l'analisi dei dati, in particolare per il confronto dati-simulazione.
- L'analisi dei dati acquisiti durante testbeam.

WP1 programma di lavoro

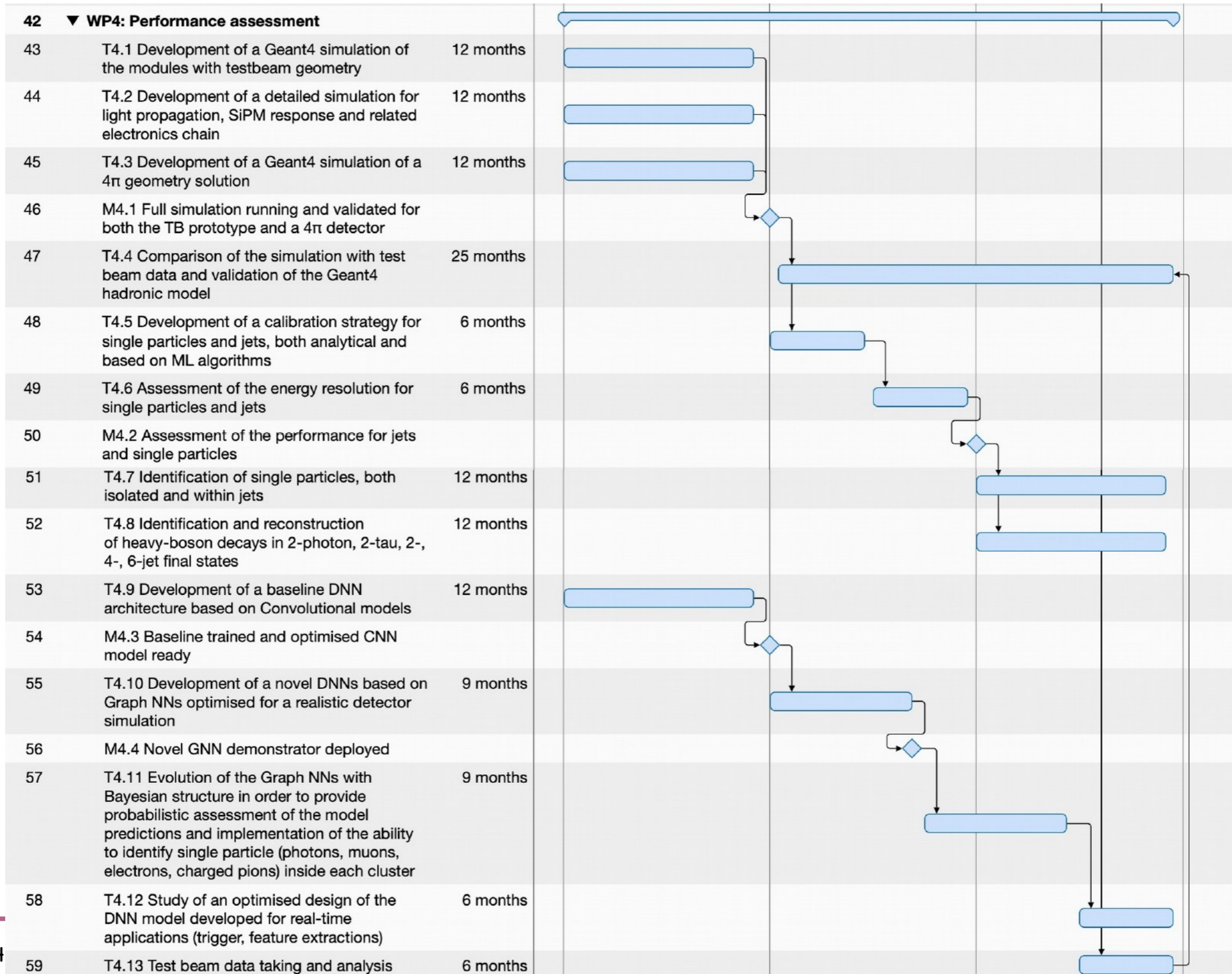
- sviluppo sistema di costruzione
- test di integrazione con SiPM board e elettronica
- sviluppo sistema QAQC
- costruzione di 2 minimoduli
 - 1200 capillari, $l = 2.5 \text{ m} \Rightarrow 3000 \text{ m}$
 - 1.85 CHF/m
 - 5500 CHF \Rightarrow 5250 € + IVA + importazione \Rightarrow 6800 € + Importazione

additional material

Gantt chart - WP1



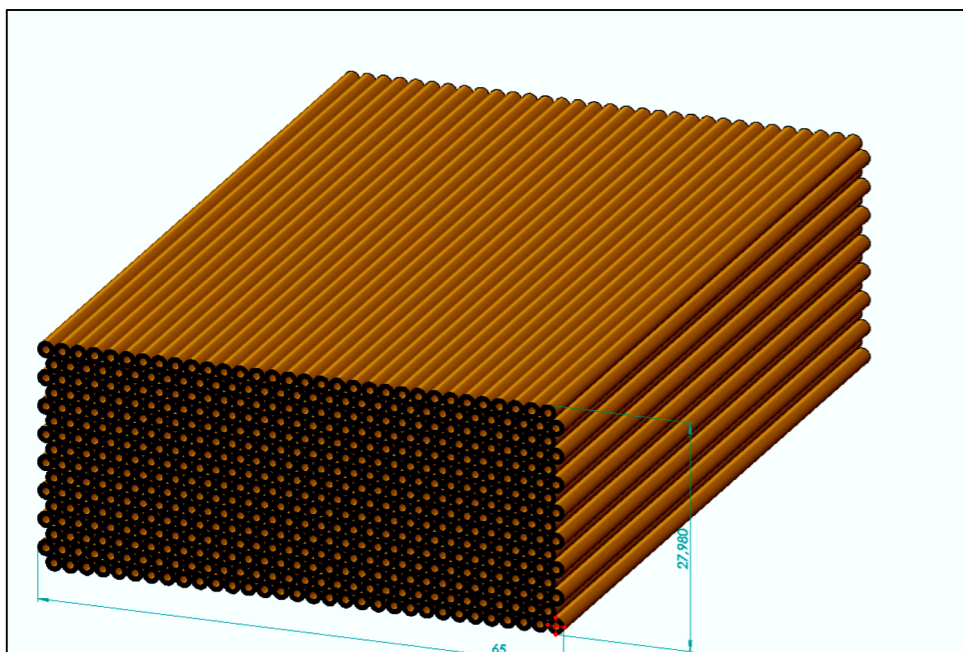
Gantt Chart WP4



Assegnazioni RD_FCC Pavia 2022

| Sigla Loc. | Capitolo | Riunione | Note Alla Richiesta | Rich. | Rich. SJ | Assegn. | Assegn. SJ | Assegn. Dot. | Commento Alla Assegnazione |
|------------|----------------------|--------------------|--|-------------|-------------|-------------|------------|--------------|----------------------------|
| PV DTZ | MISS | Assegnazioni | Test beam per nuovi moduli costruiti nel 2021 | 5.0 | 0.0 | 0.0 | 4.0 | | SJ ad effettuazione TB |
| | | Assegnazioni | Metabolismo | 1.5 | 0.0 | 1.5 | | | OK da formule |
| | | Totale MISS | | 6.5 | 0.0 | 1.5 | 4.0 | 0.0 | |
| | CON | Assegnazioni | SINERGIA con AIDAInnova: Tubi capillari. Anticipabile 2021 | 0.0 | 10.0 | 0.0 | | | |
| | | Assegnazioni | Colla per assemblaggio modulo (SJ alla non approvazione della call Hidra2) | 0.0 | 0.5 | 0.0 | | | |
| | | Assegnazioni | Meccanica per il quality control dei moduli (SJ alla non approvazione della call Hidra2) | 0.0 | 5.0 | 0.0 | | | |
| | Totale CON | | 0.0 | 15.5 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | INV | Assegnazioni | Upgrade del sistema di acquisizione per il test-beam | 10.0 | 0.0 | 0.0 | | | |
| | | Totale INV | | 10.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Totale PV DTZ | | | | 16.5 | 15.5 | 1.5 | 4.0 | 0.0 |

HiDRa detector design



1 Mini-Module (MM):

32 × 16 channels (512 ch)

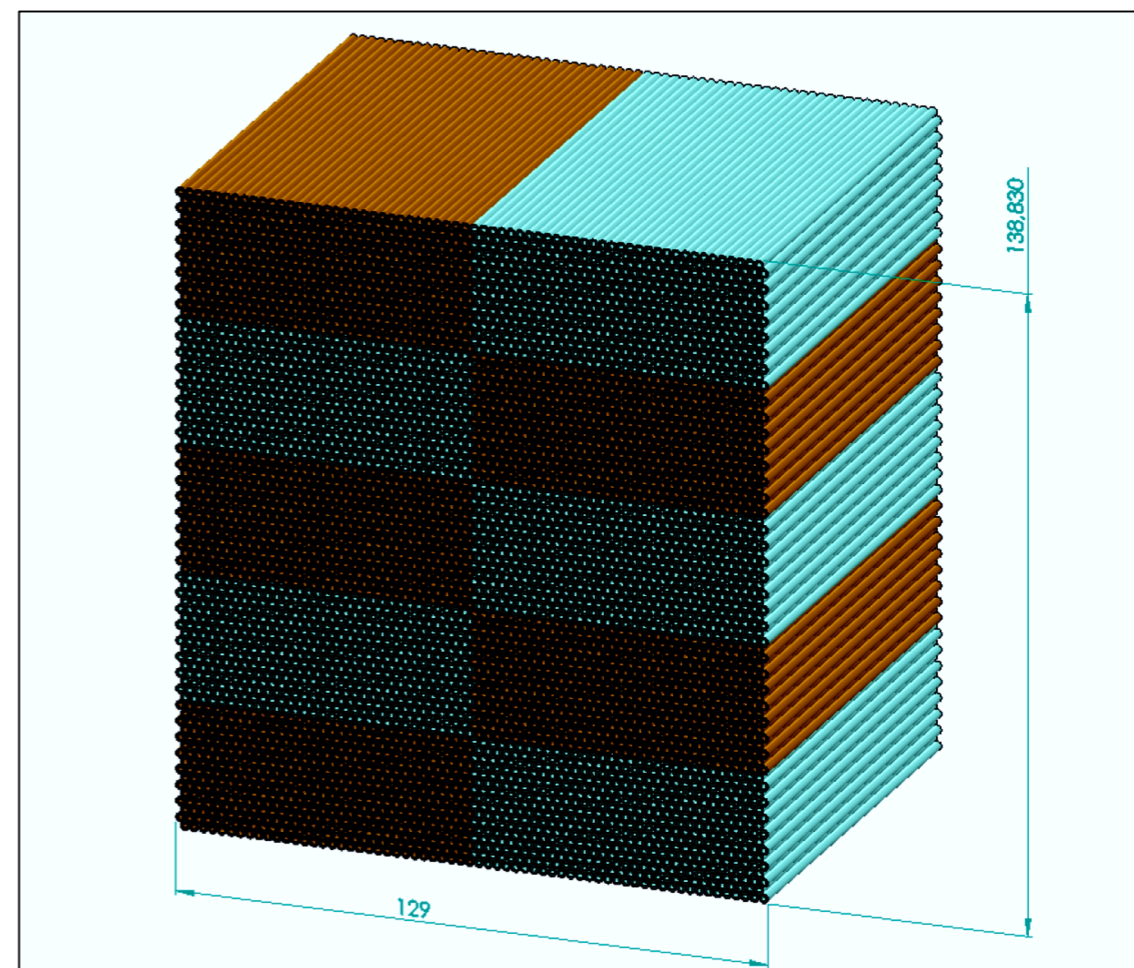
→ 256 S + 256 Č fibres

1 Module:

2 × 5 MMs

→ 10 FEE boards
(8-channel grouping)

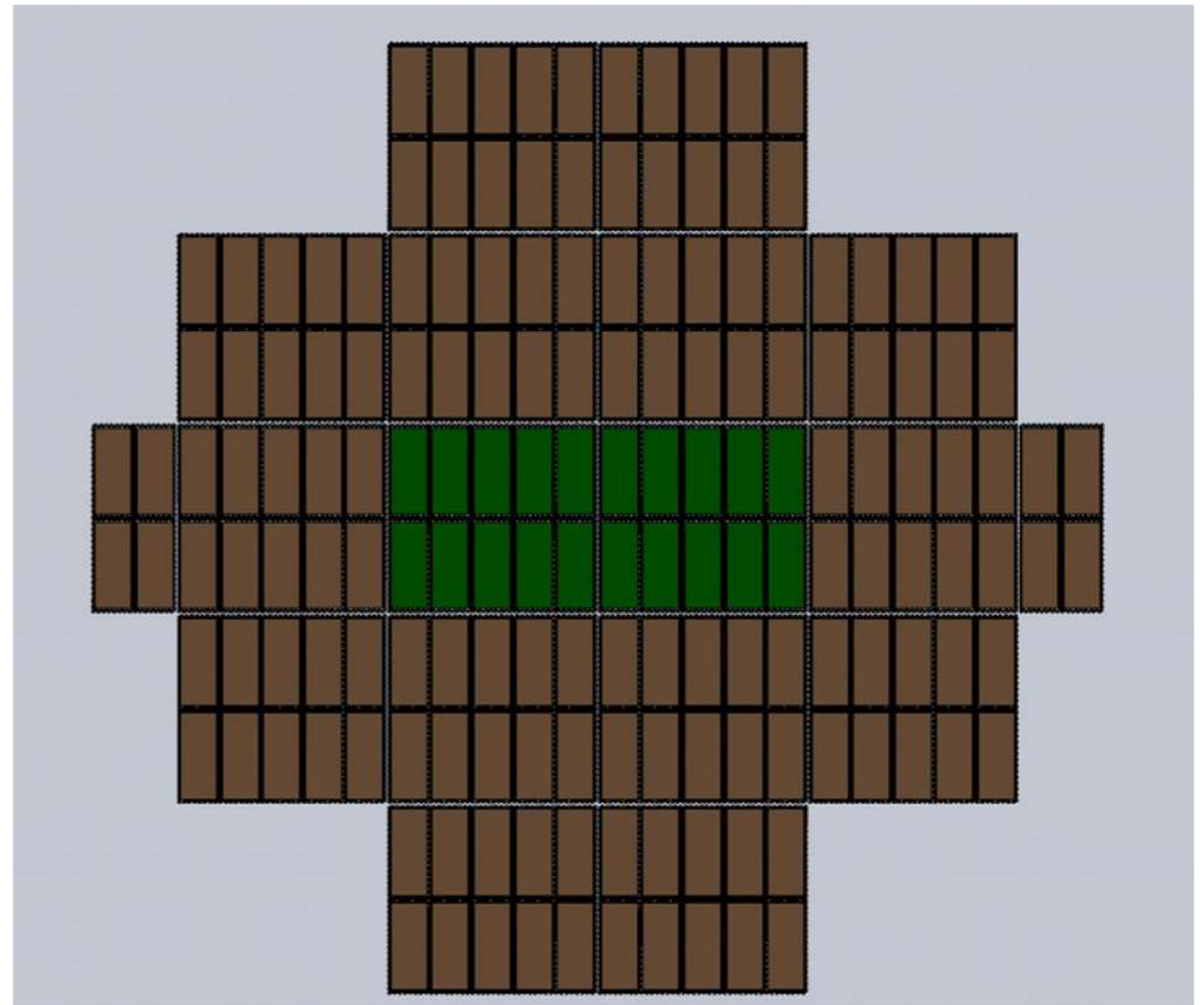
~ 13 × 13 × 200 cm³



Main deliverables

~16 modules:

- 2 central ones with SiPMs
 - ~ 10 k SiPMs
 - ~ 20 FEE boards
- all others with PMTs
 - ~ 150 PMTs



d-SiPMs: small 64-channel demonstrator
~ 1 × 1 × 100 cm³

Funding requests

Total request: 985.5 k€ (dominated by M&S)

| | | BO | CT | MI | PV | PI | RM1 | TIFPA | Total |
|-------------|---------|-------|------|-------|-------|-------|------|-------|-------|
| 2022 | M&S | 35 | 10 | 88.3 | 19 | 45 | | 38 | 235.3 |
| | PostDoc | 12.5 | | | 7.5 | | 12.5 | | 32.5 |
| | Travel | 1 | 0.9 | 1 | 5 | 0.8 | 0.3 | 1.2 | 10.2 |
| 2023 | M&S | 40 | | 73 | 76 | 152 | | 28 | 369 |
| | PostDoc | 12.5 | 12.5 | 19 | 16 | 12.5 | 12.5 | | 85 |
| | Travel | 1.4 | 0.9 | 1 | 5 | 0.8 | 0.3 | 1.2 | 10.6 |
| 2024 | M&S | 35 | | 4 | 43.6 | 93.6 | | | 176.2 |
| | PostDoc | | | 19 | 7.5 | 12.5 | | | 39 |
| | Travel | 4.1 | 1.7 | 3 | 12.5 | 2.4 | 0.4 | 3.6 | 27.7 |
| Total | M&S | 110 | 10 | 165.3 | 138.6 | 290.6 | 0 | 66 | 780.5 |
| | PostDoc | 25 | 12.5 | 38 | 31 | 25 | 25 | 0 | 156.5 |
| | Travel | 6.5 | 3.5 | 5 | 22.5 | 4 | 1 | 6 | 48.5 |
| Grand total | | 141.5 | 26 | 208.3 | 192.1 | 319.6 | 26 | 72 | 985.5 |

Funding request WP1

| | | | | | | |
|----|-----|--------------------------------------|---------------------|--------------|--------------|--------------|
| MI | 2 | D-SiPM: Design | 40 | | | cons |
| | 2 | D-SiPM: Test | | 20 | | cons |
| | 2 | A-SiPM: Procurement | 30.3 | 45 | | cons |
| | 2 | SiPM: Test station | 10 | | | inv |
| | 3 | Adapter boards, grouping and cabling | 8 | 8 | 4 | cons |
| | 2,3 | Human resources (AdR) | | 19 | 19 | AdR |
| | 2,3 | meetings, conference | 1 | 1 | 1 | travel |
| | 2,3 | test beam | | | 2 | travel |
| | | | Total Milano | 89.3 | 93 | 26 |
| PV | 1 | glue | 1 | 2 | 2 | cons |
| | 1 | capillary | 15 | 70 | 35.4 | cons |
| | 1 | Mech: calorimeter box | | | 2 | cons |
| | 1 | Mech: patch pannel | | | 4.2 | cons |
| | 1 | Mech: assembly system | 1 | 4 | | inv |
| | 1 | Mech: calorimeter QAQC | 2 | | | cons |
| | 1,4 | Human resources (AdR) | 7.5 | 16 | 7.5 | AdR |
| | 1,4 | meetings, conference | 3 | 3 | 3.9 | travel |
| | 1,4 | test beam | | | 6.6 | travel |
| | all | Project Coordination | 2 | 2 | 2 | travel |
| | | Total Pavia | 31.5 | 97 | 63.6 | 192.1 |
| PI | 1 | PMT | 10 | 32 | 30 | inv |
| | 1 | fibres | 30 | 120 | 63.6 | cons |
| | 1 | Mech: fibres qaqc | 5 | | | inv |
| | 1 | Human resources (AdR) | | 12.5 | 12.5 | |
| | 1 | meetings, conference | 0.8 | 0.8 | 0.8 | |
| | 1 | test beam | | | 1.6 | |
| | | Total Pisa | 45.8 | 165.3 | 108.5 | 319.6 |