Milestone 1: An integrated prototype package of dynamic digital research products, the science data platform, and the Compute4PUNCH compute and storage resources (Storage4PUNCH) coupled with single sign on (AAI).

- **Dynamic digital research products** (DRPs) – the basis of reproducible data analysis and simulation, and of easily interfaceable workflows combining PUNCH (and other) data.
    - By 31.12.2022 Prototype implementation of DRPs, including a selected set of data and services
- **PUNCH science data platform** – the biotope for FAIR and open data / DRP lifecycles, providing access via portal and AAI.
    - By 31.12.2023: Prototype implementation of a platform with selected set of data, services, and workflows, based on one common AAI (see next point)
    - By 31.12.2023: One common AAI for the PUNCH communities and beyond – a convenient single-sign on method for secure data and service access.
- **Compute4PUNCH & Storage4PUNCH** – standards and prototypes for federating computing and storage infrastructures of the PUNCH4NFDI communities and beyond including advanced workflows for intelligent compute and data handling.
    - By 30.09.2022: Compute4PUNCH: prototype of a federated computing infrastructure
    - By 31.12.2022: Storage4PUNCH: prototype of a federated storage infrastructure
    - By 30.06.2023: standards for federating computing and storage infrastructures regarding protocols and specification of interfaces for the integration.

Benefit: This package of combined deliverables will allow to access open data and other open research products from a selected range of sources across PUNCH4NFDI and beyond using advanced workflows on federated compute and storage infrastructures. It will also enable creation and re-use of dynamic research products including analysis and simulation workflows based on a selected range of tools and required software environments. The milestone will enable the collaboration within and among research groups on the development of analysis workflows, and the combination of research products within the supported range of formats and tools.

Milestone 2: Data irreversibility solutions – a new kind of science in the age of too-large-to-be-stored data streams

- **Concepts and test environment for identifying highly complex (multi-parametric) signals in huge data** streams in order to provide irreversible data compression in real time and dynamic archiving capabilities**.**
    - By 30.06.2023: Details of the concepts for dynamic archives and time-critical metadata are worked out. These include the specification of the concept of dynamic archives and corresponding workflows linking to information present in traditional archives in view of time-critical metadata, dynamic filters and scalability of these workflows.
    - By 30.06.2024: A test system for identifying highly complex (multi-parametric) signals in huge data streams is set up in order to demonstrate irreversible data compression in real-time and dynamic archiving capabilities.

Benefit: Irreversible data reduction and compression based on real-time decisions as a prerequisite for future discovery science in the PUNCH fields and beyond. Consequently, dynamic archives and the identification of complex signals in increasingly large data streams – which will occur in more and more branches of science – are mandatory for gaining new scientific insights from the upcoming experiments and facilities already in near and mid-term future as e.g. HL-LHC, FAIR, CTA and SKA.

Milestone 3: The PUNCH market place including notice board and communication tools as a place for efficient exchange of data management solutions, methods, services, standards, tools, protocols, and software is an offer to the NFDI as part of a federated system of discipline-specific market places

- **Setup of PUNCH market place.**
    - By 31.12.2023: Set-up of PUNCH market place with basic notice board and communication tools

Benefit:
An essential element for the success of the entire NFDI is the exploitation of synergies and services across different communities. The marketplace will be a point of contact and general exchange within and beyond the PUNCH4NFDI community; it will facilitate the exploitation of synergies between PUNCH4NFDI and its partners and the joint use of services, as for example research products and workflows via the science data platform of milestone 1. This allows for an entirely new range of science to be exploited.

Milestone 4: Rolling out the PUNCH4NFDI outreach and education programme

- **Development of standardised university curricula**
    - o BY 30.09.2022: Set-up of standardised university curricula together with other physics-related NFDI consortia and the DPG, including teaching material and example implementations.
- **PUNCH4NFDI Young Academy –** for educating early-career researchers
    - o By 30.09.2024: Set-up and first evaluation of an event and course programme in PUNCH data management
- **Test of pedagogical approaches** – promote data science to children, including the setup of pilot extracurricular activities in schools and changes to school curricula.
    - o By 30.09.2024: Collecting first experience
    - o By 30.09.2026: Setup and testing of new extracurricular activities, e.g. Masterclasses beyond particle physics topics.
- **Development of research applications for citizen science projects**
    - o By 30.09.2024: mapping out first projects, installing and evaluating them.
- **WOMEN4PUNCH** – increasing the fraction of female researchers in PUNCH4NFDI positions.
    - o By 30.09.2024: Increase the fraction of female scientists in TA and WP lead positions
    - o By 30.09.2024: increase the fraction of active scientific participation of female scientists in PUNCH4NFDI TAs and WPs
    - o By 30.09.2024: increase the number of young female scientists in PUNCH sciences via girl's days, internships, ...

Benefit: It is mandatory to share the PUNCH expertise with the wider science community. Success in achieving training and outreach activities can be judged by studying the numbers of interested participants in events related to PUNCH4NFDI topics, in relevant master classes, in citizen science projects, and in training events. On the longer run, success would manifest in increased numbers of students in data-relevant subjects, scientists with data science backgrounds in leading positions, or bachelor / master / Ph.D. thesis with a focus on PUNCH4NFDI topics.