SPS Beam Dump Facility

B. Goddard (CERN) on behalf of BDF Accelerator Subgroup:

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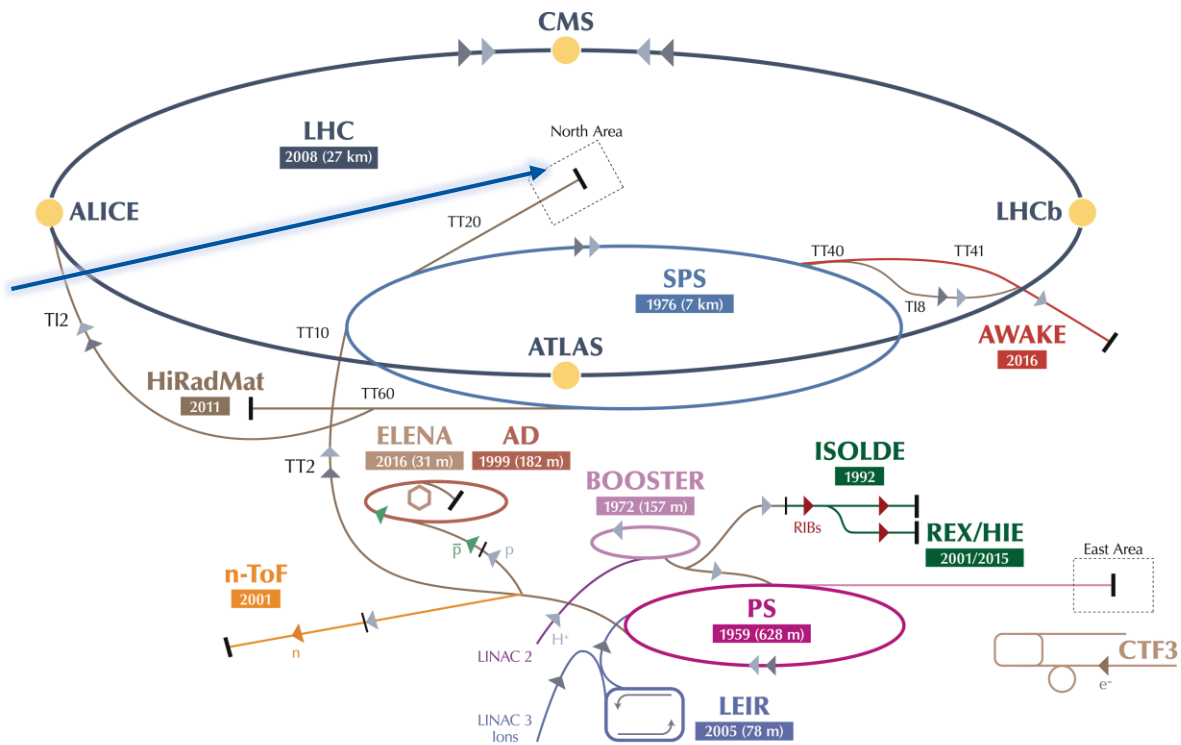
BDF subgroup study scope

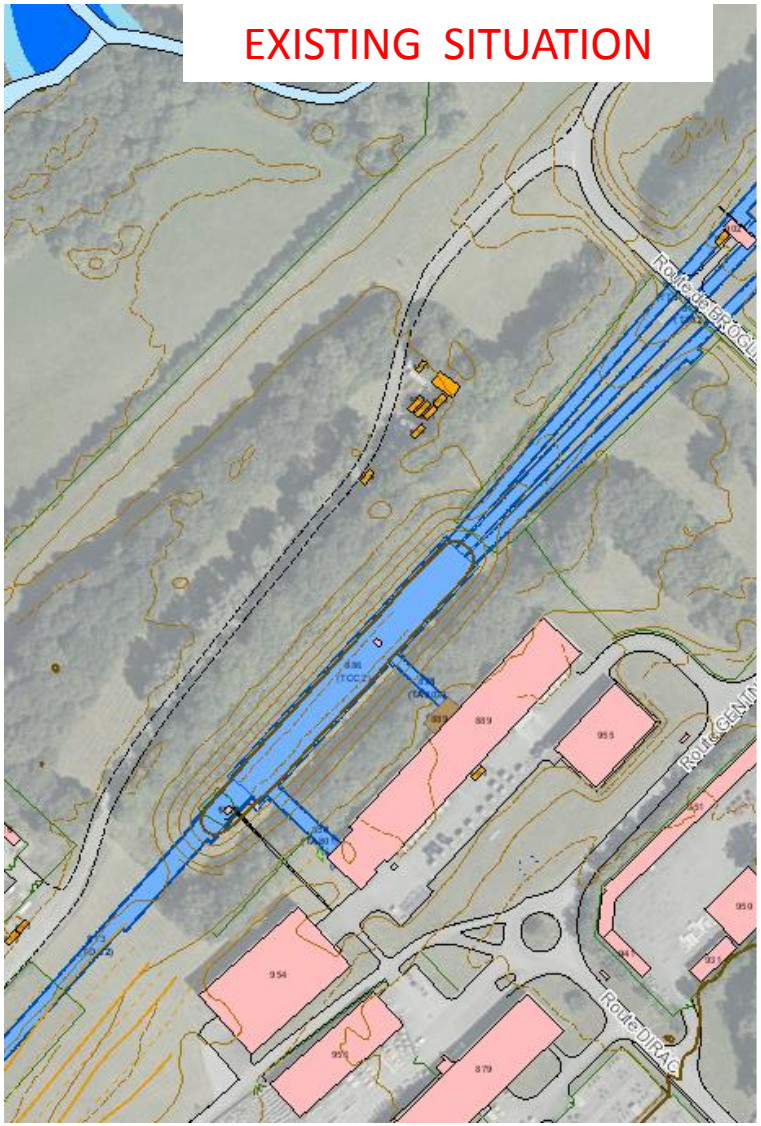
- "Complete the technical feasibility studies of a Bump Dump Facility as input to the SHiP **comprehensive** design study (CDS)"
- Aiming to deliver a preliminary Comprehensive Design Report of a general purpose fixed target facility for high intensity beam dump experiments in SPS complex

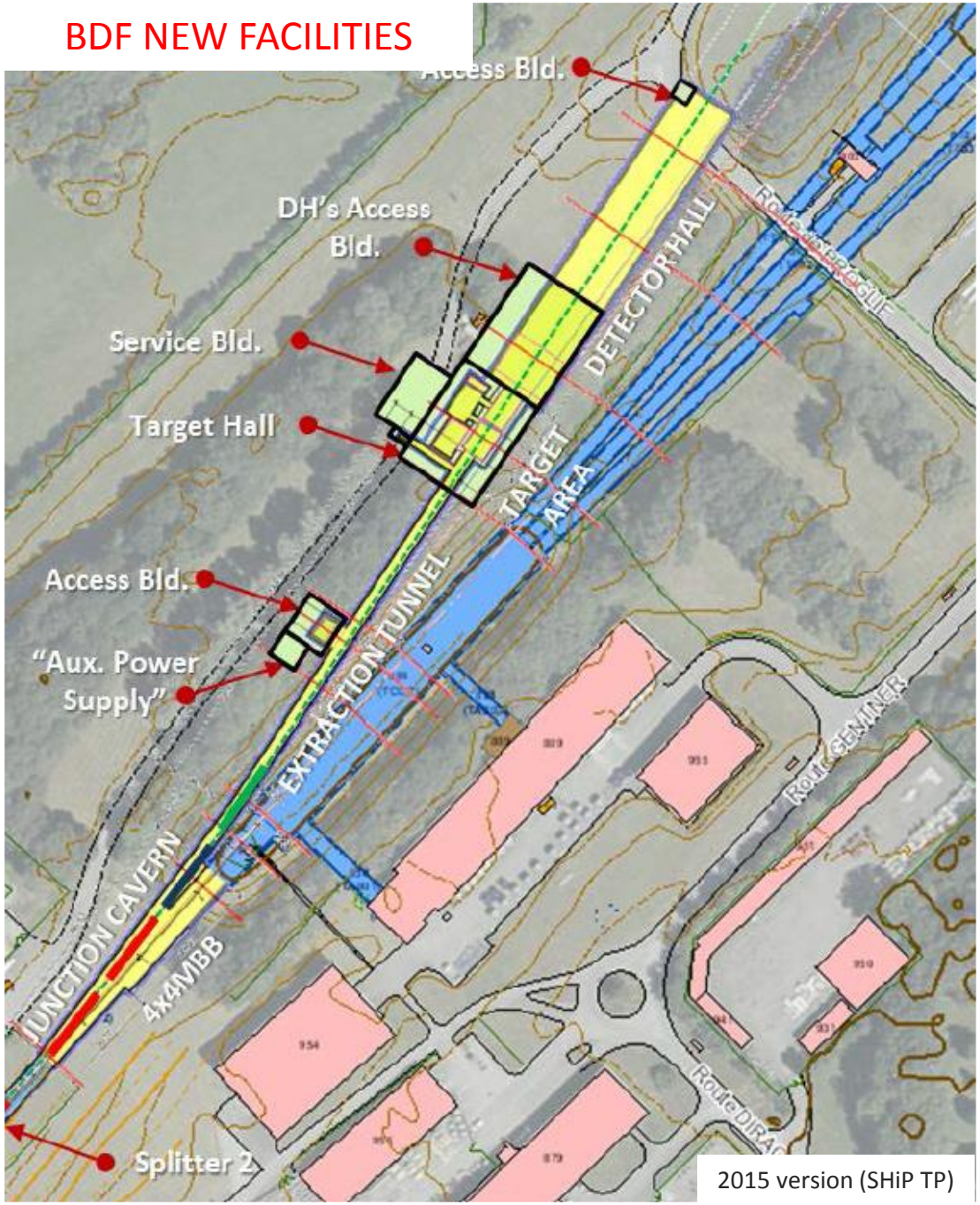
Proposed NA siting of SPS BDF



BDF NEW FACILITIES

EXISTING SITUATION





2015 version (SHiP TP)

Main challenges for BDF

- Beam loss at extraction from SPS
- Beam sharing with existing North Area targets
  - Needs development of new switch/splitter magnet
- Integration of new beamline and switch
- Target design for longevity and reliability
- Target complex design for handling and maintainability
- High cumulated radiation doses
  - Injectors, injection, extraction, target, etc…
- Radiation damage on materials
  - Extraction septa, target and target station
- Personnel and environmental protection
  - Close distance to the CERN site boundary
  - Detailed environmental study needed

BDF subgroup study organisation

- Presently 4 main work packages with associated WGs
  - Target and target complex (M.Calviani)
    - BDF target & target complex WG
  - Extraction and beam transfer (B.Goddard)
    - SPS Losses and Activation WG (SLAWG)
    - SPS Crystal-Assisted Slow Extraction WG (SPS-CASE WG)
    - TT20 for BDF WG: splitters and TL design
  - Radiation protection (H. Vincke)
  - Safety engineering (F.B. Pedrosa)
  - Incoming: Integration and infrastructure, civil engineering

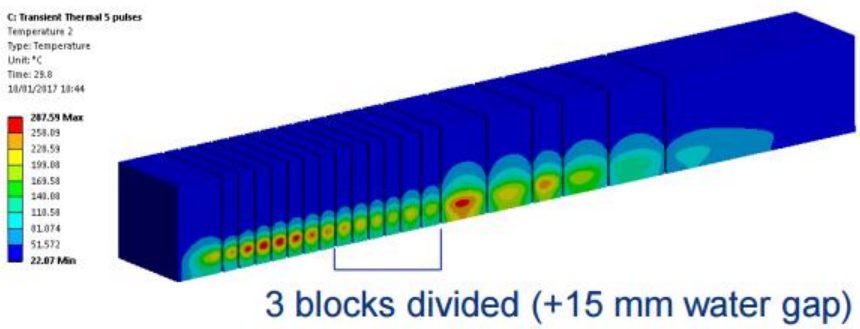
Deliverables

- D1: Beam requirements specification
  - Identify and document potential experiments and relevant beam parameters
    - Requested PoT (total and annual)
    - SPS beam intensity per cycle
    - Extracted cycles per year
    - Extraction type
    - Spill length
    - Spill harmonic content
    - Beam pointing stability on target
    - Beam emittance
    - Beam momentum characteristics
    - Beam characterisation requirements

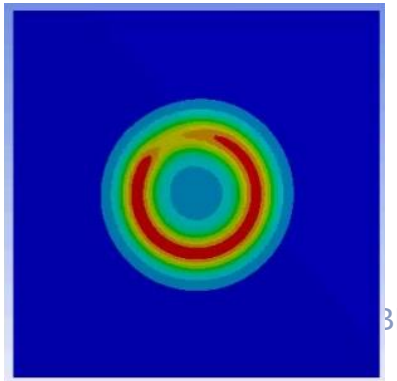
Deliverables

- D2: Key engineering subsystems (substantial!)
  - Document preliminary designs and feasibility evaluation (including performance limits) for key facility subsystems
    - Target
    - Target subsystems (He vessel, beam-target window, shielding cooling, magnetised hadron stop)
    - Target and shielding handling
    - Slow extraction loss mitigation
    - Dilution system
    - New section of transfer line (including new switch/splitter magnets)
  - Main cost and schedule drivers

Target design studies



Dilution sweep studies

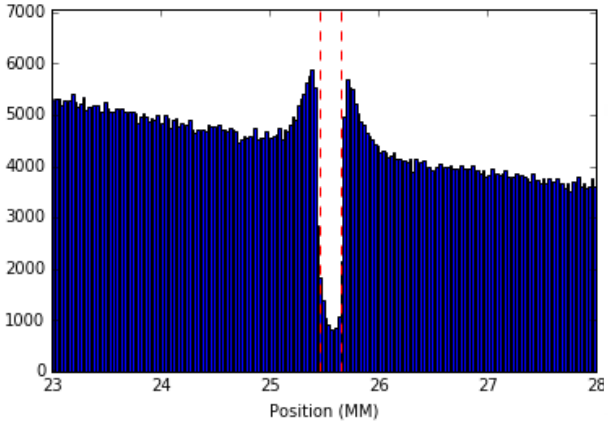


Existing splitter

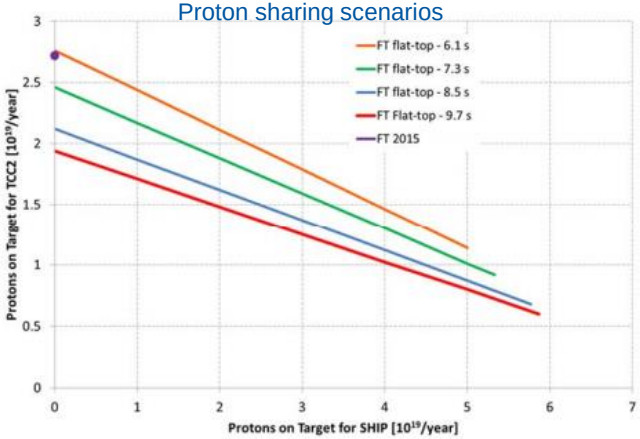
Deliverables

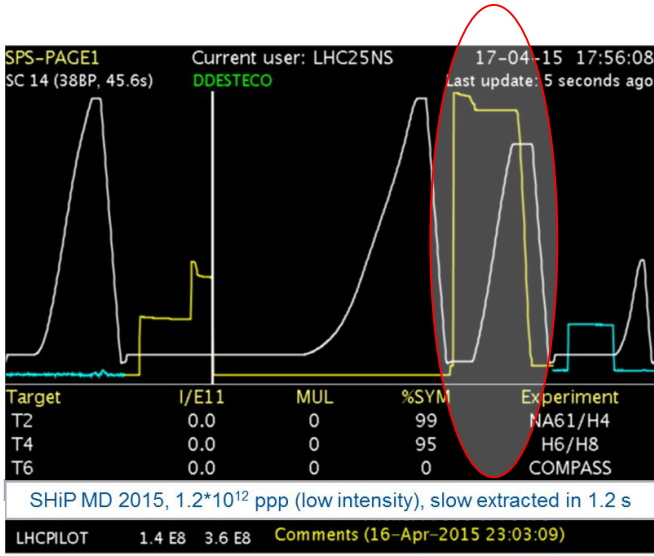
- D3: Evaluation of SPS performance reach per requested beam type
  - Identify and document limiting factors to evaluate overall reach
    - Beam losses at SPS extraction
    - Spill harmonic content
    - Radiation protection
    - Target
  - Summarise PoT per beam type, including impact on existing NA beamlines

Density at ZS entrance with 3 mm W/Re diffuser



Proton sharing scenarios

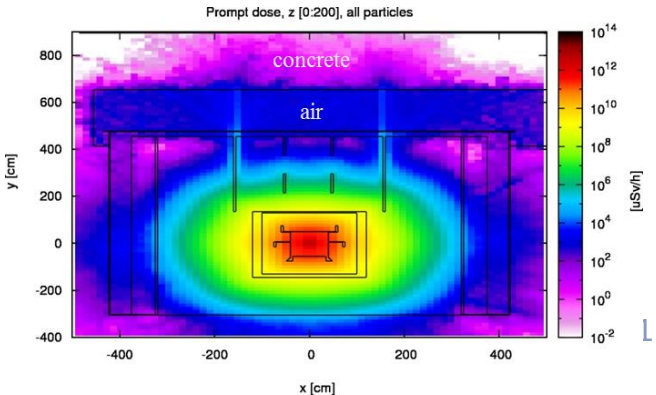




SHiP MD 2015, $1.2*10^{12}$ ppp (low intensity), slow extracted in 1.2 s

Deliverables

- D4: Safety impact studies
  - Safety impacts to the existing installations
    - On the different implemented mitigation measures
    - Possible improvements
  - Provide Safety risk assessments as input to design
  - Radiation protection assessments and optimization for target, junction cavern, extraction and transfer tunnels.
  - Environmental impact studies
    - Conventional aspects
    - Radiation protection

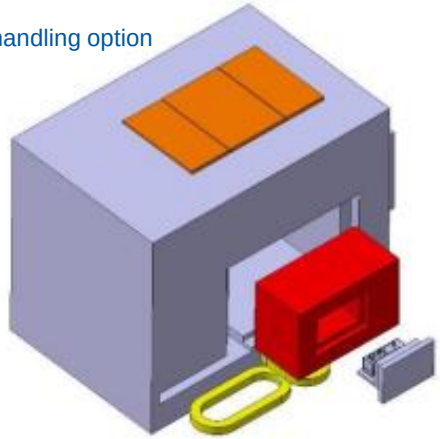


Strongly coupled to D2 (subsystems) and D5 (integration and infrastructure)

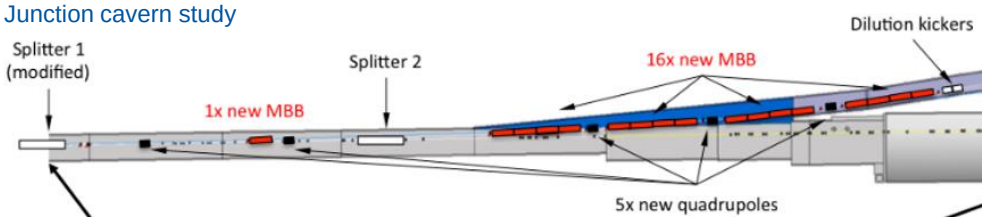
Deliverables

- D5: Preliminary integration and infrastructure study
  - Document preliminary integration and infrastructure aspects
    - Target complex
    - New section of transfer line
    - Junction cavern
    - Experimental area
    - Service requirements, including dimensioning of main systems
    - Conceptual routing of services
    - Access requirements
  - Main cost and schedule drivers

Target handling option



Junction cavern study



Strongly coupled to D2 (subsystems)

Deliverables

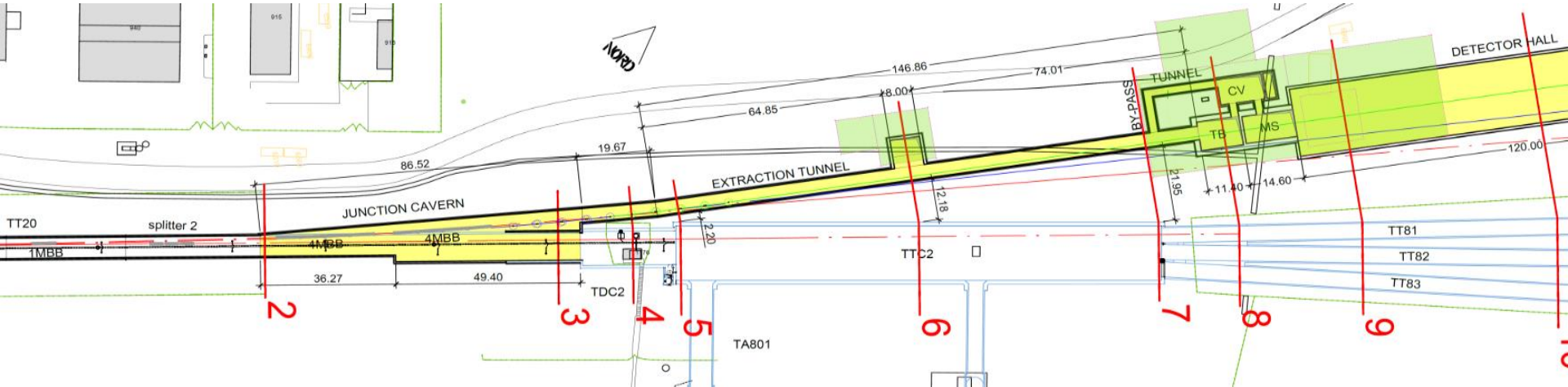
- D6: Facility connection planning
  - Analyse and document planning of connection to TT20, potentially impacting NA operation
    - Accelerator and services removal
    - Junction cavern civil engineering
    - Services installation
    - Accelerator installation
    - Commissioning
    - Overall

Deliverables

- D7: Preliminary project safety folder
  - Analyse and document aspects needed for descriptive and demonstrative part of Safety File for this Study Phase
    - Facility description from Safety point of view;
    - Preliminary list of hazards and risks;
    - Identification of Safety requirements that shall be considered at study phase;
    - Definition of Safety organisation within project
  - Study with different teams involved the feasibility of possible mitigation measures
  - Clear identification of major Safety risks for Organization

Deliverables

- D8: Preliminary Civil Engineering design
  - Preliminary design of new CE infrastructures, with 3D models, cross sections and plans
    - Junction to TT20
    - New transfer line
    - Target complex
    - Muon shielding infrastructure
    - Experimental area
  - Main cost and schedule drivers



Deliverables

- D9: Implementation analysis
  - Analysis and documentation of preliminary project-level aspects
    - Overall works and operational milestones fitted in CERN master schedule
    - Outline planning for main subsystems
    - Cost estimates
    - Resource estimates

Deliverables

- D10: Design Reports
  - Provide Comprehensive Design Report documents and related publications for BDF
  - Provide Comprehensive Design Report input for SHiP

Study status: key R&D activities

1. Target & Target complex: in progress
   - Pursue design of production target towards a robust and reliable configuration & radiation damage
   - Development of gas- and water-cooled target options
   - Helium vessel purification system
   - Design of a fully remote handling system for target area
2. Extraction and beam transfer: in progress
   - SPS extraction losses and activation minimization
   - TT20 & new beamline optics, powering, interlocking & instruments
   - Development of laminated splitter and dilution magnets
   - 1 s slow extraction spill quality
   - Deployment of BDF-like cycle

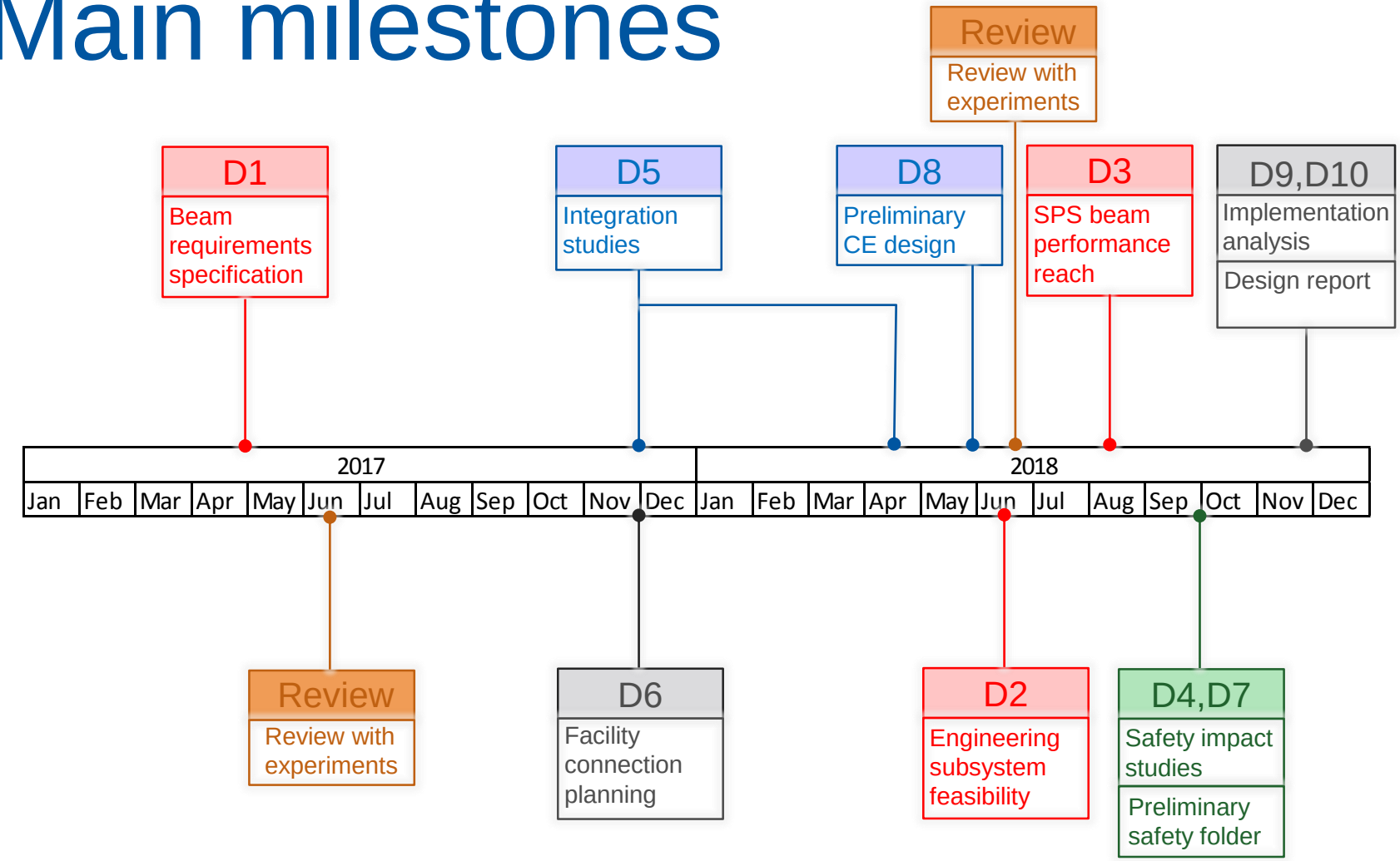
Study status: organisational

- BDF subgroup in place, meetings started
- Sub-sub WGs in place (and working) for Target and Beam Transfer
- Resources already allocated or being set up:
  - Fellow recruited in EN/STI and working on **target** design
  - Fellow recruited in TE/MSC and working on **splitter magnet** design
  - Fellow recruited in HSE and working on **conventional safety** aspects
  - 2 Fellows recruited in EN/MME and EN/CV and starting in March for **target and associated complex**
  - Fellow recruited in HSE for **RP aspects** starting March 2017
  - Fellow requested in TE/ABT for **extraction + beamline** for 05/17 AFC
  - Fellow requested in EN/ACE for 05/17 AFC for **integration**
  - Fellow requested in SMB/SE for 2018/19 for **civil engineering**

Recent technical highlights and progress

- Progress with target design (modified longitudinal segmentation)
- Two options for target remote handling identified and being compared
- Simulated single turn dilution sweep with 1 s spill: should be acceptable for target
- Adopted double coil system for hadron absorber magnetization
- Simulated concepts for passive / active crystal diluters give a factor 2 / 4 extraction loss reduction
- Demonstrated 270 GeV proton slow extraction into TT20 in 2016 using crystal channelling in SPS

Main milestones



Summary and next steps

- Roadmap to preliminary Comprehensive Design of a general purpose SPS Beam Dump Facility outlined
- Study teams (BDF subgroup, subsub groups) set up and active
- Results continue to come
- Need to demonstrate that the facility can be built with requested performances: key R&D identified
- Urgent to finalise beam parameters specification
- Need to start already on framework of CDR

CERN

Main milestones

- D1: Q2 2017: Beam requirements specification
- D5: Q4 2017: Conceptual integration study for CE baseline
  Q2 2018: Preliminary integration study
- D6: Q4 2017: Facility connection planning
- D8: Q2 2018: Preliminary Civil Engineering design
- D2: Q2 2018: Key engineering subsystem feasibility evaluations
- D3: Q3 2018: Evaluation of SPS performance reach per requested beam type
- D4: Q3 2018: Safety impact studies
- D7: Q3 2018: Preliminary project safety folder
- D9: Q4 2018: Implementation analysis
- D10: Q4 2018: Comprehensive Design Report