Plans and resources for TDR phase

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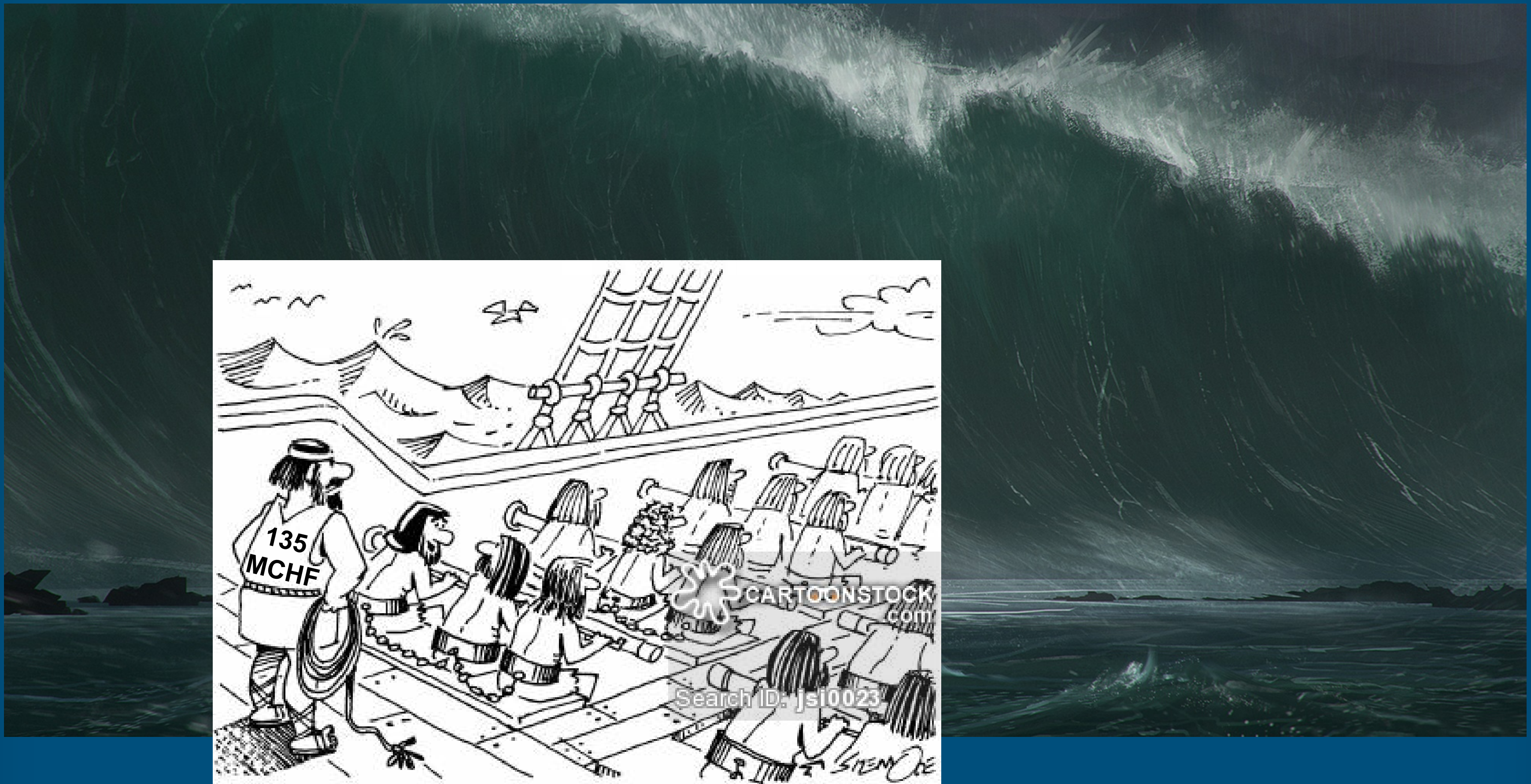
for SHiP and CERN Facility WG

“MTP storm”?

“Bow facing wave and row, row, row….”

“MTP storm”?

Bow facing wave and row, row, row….



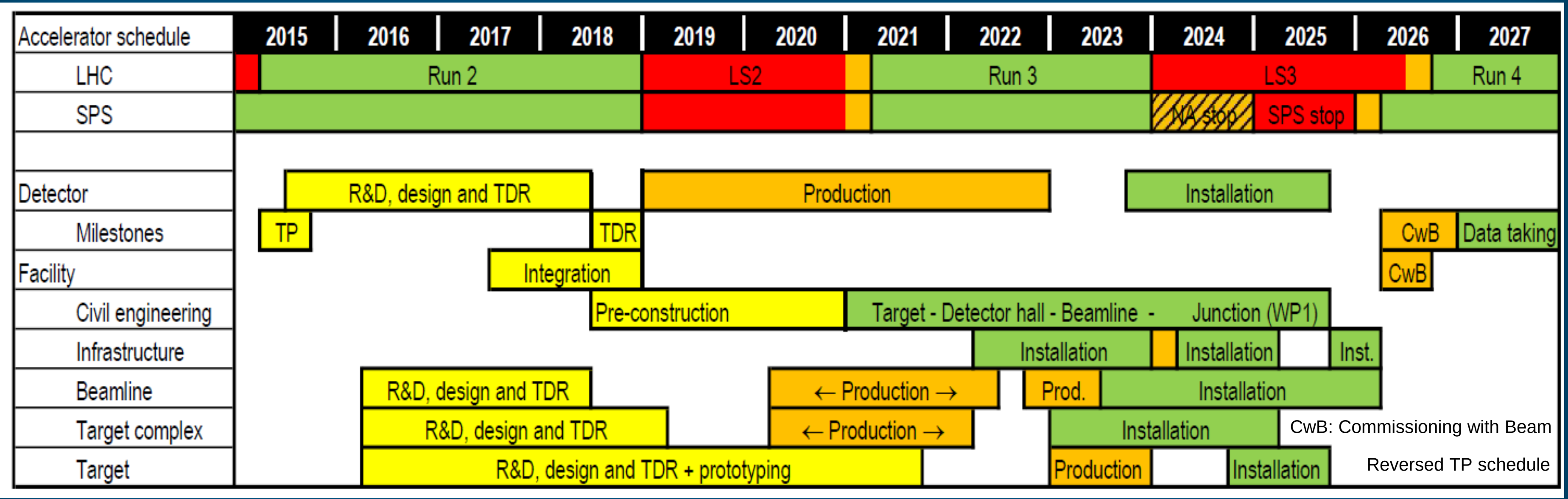
“I like to keep busy. It makes the day go faster.”

Preparation for next phase

- Drawing up the TDR phase
  - Definition of milestones and priorities, facility and detector
  - Project organization
  - Safety organization and preparation of Safety Document structure for Safety File
  - Documentation structure - EDMS
  - Resource profiles
  - MoU exercise – draw up work packages and tasks

Schedule with WP1 in LS3: baseline

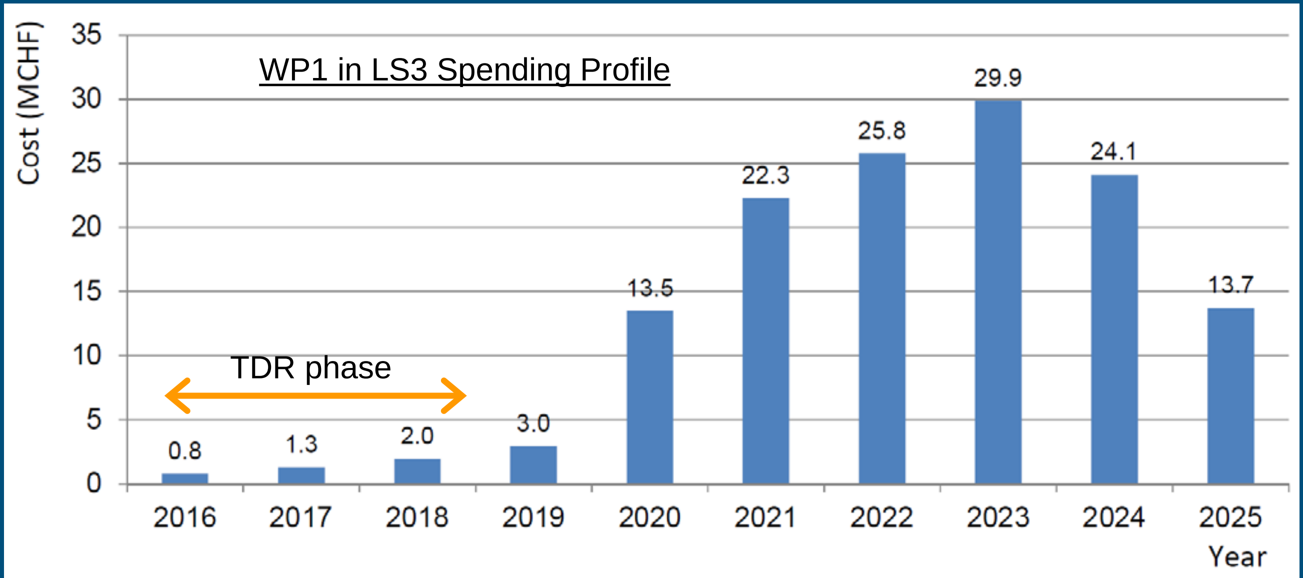
With updated accelerator schedule (Run 2 up to end 2018 and two years LS2)



- Allows decoupling TDR phase from construction and production phase
- Allows avoiding the peak activity of the HL-LHC underground civil engineering
- Start facility commissioning and data taking in 2026
  - Stop NA with LHC stop in 2024Q1 instead of 2025Q1 to have 2 years for WP1 civil engineering
  - Latest start of SHiP CE works (counting back for WP3 – WP4 – WP2): 2021Q1
  - Start of preconstruction studies (integration, EIA, permit, tendering): 2018Q3
  - Relaxed initial phase and overall schedule, detector installation in ready to use experimental hall 2024 – 2025
  - TDRs for 2018
    - Manpower allocation and limited resources in 2016 – 2018 for TDR as before

Schedule with WP1 in LS3: Cost profile

- Cost profile shifted by ~2 years and flatter (cost of facility remains unchanged)



Year	CE	CE engineer	Beamline	Target	Muon shield	"Services"	Cost/Year (MCHF)
2016	0	0	0.3	0.15	0	0.3	0.75
2017	0	0	0.6	0.4	0	0.3	1.3
2018	0	0.201	0.4	1.05	0	0.3	1.951
2019	0.25	0.804	0.3	1.3	0	0.3	2.954
2020	3	0.804	4.8	1.5	2.4	1	13.504
2021	7.5	0.804	6	1.5	4.5	2	22.304
2022	10	0.804	5	1.5	4.5	4	25.804
2023	13	0.804	3	8.1	0	5	29.904
2024	10	0.804	0.3	8	0	5	24.104
2025	7.8	0.804	0.3	0.5	0	4.3	13.704
Total (MCH	51.55	5.829	21	24	11.4	22.5	136.279

Facility: Resources in new schedule

- Resources required for the facility TDRs (2016 – 2018)
  - Extraction, beam line and splitter/switch: 1.3 MCHF + 3 FTEs
  - Target and target complex: 1.6 MCHF + 2.5 FTEs (was 8 FTEs)
  - Muon shield: 0.5 FTEs
  - Radiation protection: 0.4 MCHF + 1.5 FTEs
  - Safety engineering and environment: 0.5 MCHF + 1.5 FTEs
  - ➔ Total of 3.9 MCHF and 9 FTEs required between 2016 and end of 2018
  - ➔ Close contact with CERN experts for development of muon shield, vessel, experiment magnets on aspects of transport, in situ assembly, integration, and safety
- Milestones are clear
  - ➔ Many of the milestones related to the facility are of general interest beyond SHiP
  - ➔ External manpower welcome
- Integration (2018):
  - CV, EL, ABT, MEF, STI, RP, SEE, CE groups: 4 FTEs
  - CE: 0.2 MCHF + 1 FTE (associated with preconstruction phase)
- Preconstruction phase (2019 – 2020):
  - 2.5 MCHF + 4.5 FTEs of engineers + 3 FTEs of draughts men.

Facility TDR plan in preparation

Beam line:

FTE for TDR	2015 Q4	2016 Q1	2016 Q2	2016 Q3	2016 Q4	2017 Q1	2017 Q2	2017 Q3	2017 Q4	2018 Q1	2018 Q2	2018 Q3	2018 Q4
0.50 Extraction beam loss reduction and mitigation	SPS MD	Install Crystal			SPS MD			SPS MD			SPS MD	Report	
0.50 Design study for laminated splitter magnet		Market survey		Techncial specs		Design			Prototype		Complete tests	Report	
0.20 Expected 1 s slow extracted spill quality			Start PhD student		SPS MD			SPS MD			SPS MD	Report	
0.50 New optics and powering of TT20				Complete studies	Report								
0.20 Interlocking of key systems				Complete studies	Report								
0.40 Dilution sweep system for the target			Update specs				Magnet concept		Converter concept	Report			
0.50 New beamline from splitter to target				Update design			Update specs				Complete optics	Report	
0.20 New and upgraded beam instrumentation			Update specs				Techncial concepts	Report					

Target:

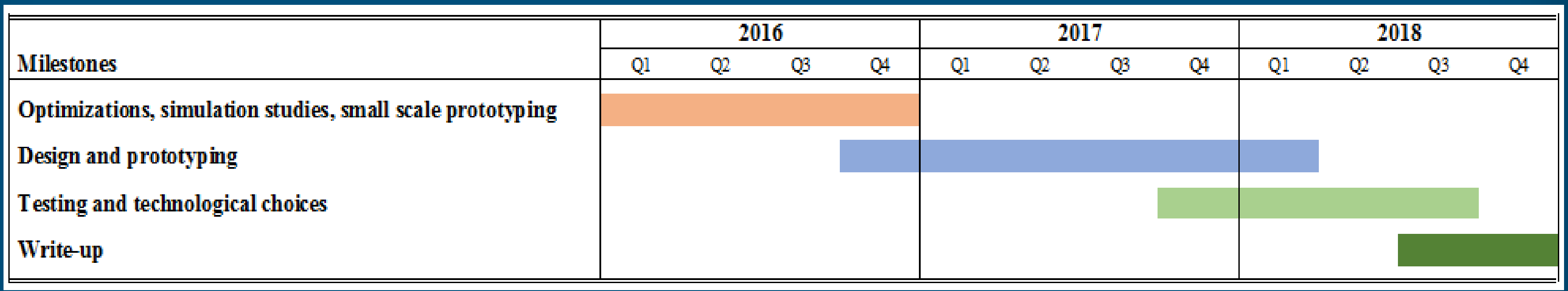
- Target design and simulation, He cooled solution
- Helium vessel and circulation
- Shielding blocks design and cooling system
- Target material studies and tests
- (Prototyping including irradiation and material tests is expected to take four years → later)

Radiation protection and safety:

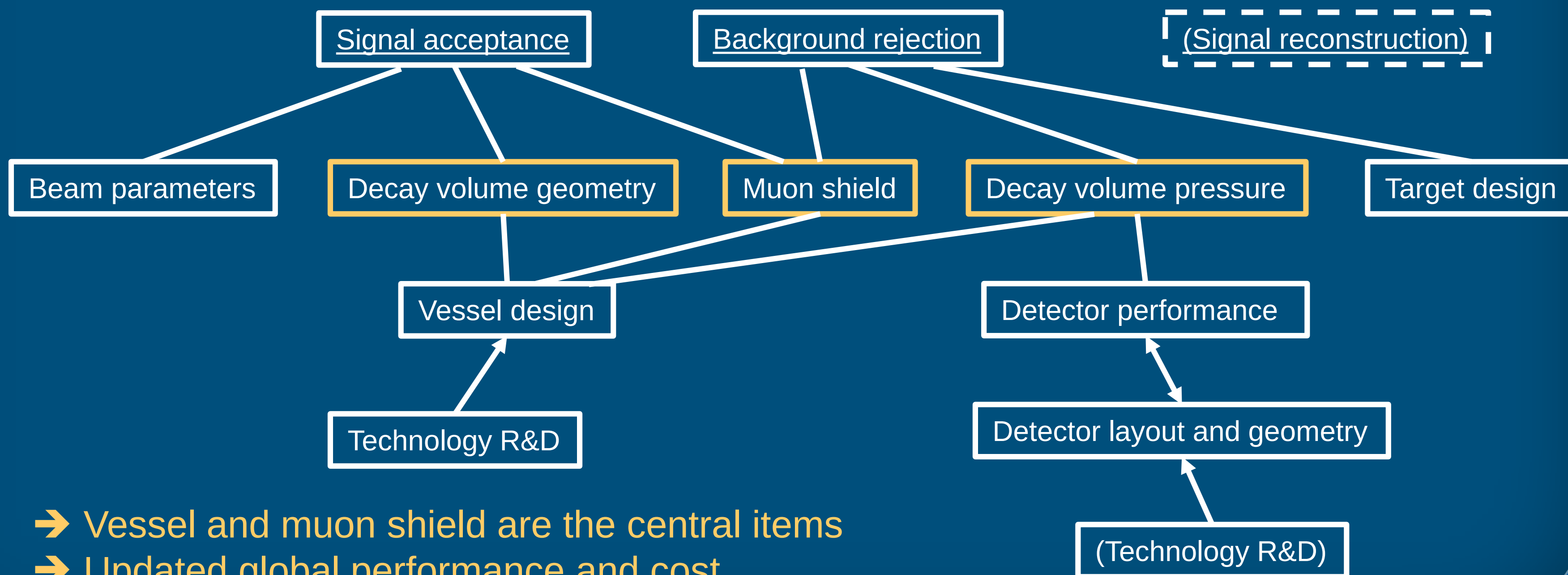
- All aspects related to the shielding, dose monitoring, and work procedures
- Demolition of TDC2 and in-situ recycling of radioactive material
- Mitigation and intervention techniques related to activation in SPS extraction region and splitter region
- Optimization of target shielding
- Verification of doses in experiment facility along with optimization of muon shield and area layout
- Supervision of safety aspects of experiment design

Experiment TDRs : Milestone priorities

- Two “types” of milestones:
  - Global experiment optimization : highest priority ➔ cost reductions
  - “Technological” : Delay in funding shifts these activities



Global experiment optimization:



➔ Vessel and muon shield are the central items

➔ Updated global performance and cost

Vacuum chambers...!

- NASA Plum Brook Station vacuum chamber
  - D:30m x H:37.2m = 22 600 m^3 (~10 x SHiP vessel….) ➔ *~ SHiP experiment hall!*
  - Aluminum wall 25/35mm (2000 tons)
  - Pressure < 2 x 10^{-9} bar…
  - 8h pumping at 500 000 l/s !...
  - Surrounding concrete structure provide resistance to atmospheric pressure
  - Leak-tight steel containment barrier embedded within concrete support ~25 mbar

Key milestones breakdown

- Key milestones to approach funding agencies for modest resources
  - Milestones prioritized and organized to limit resource request for 2016 without impacting progress

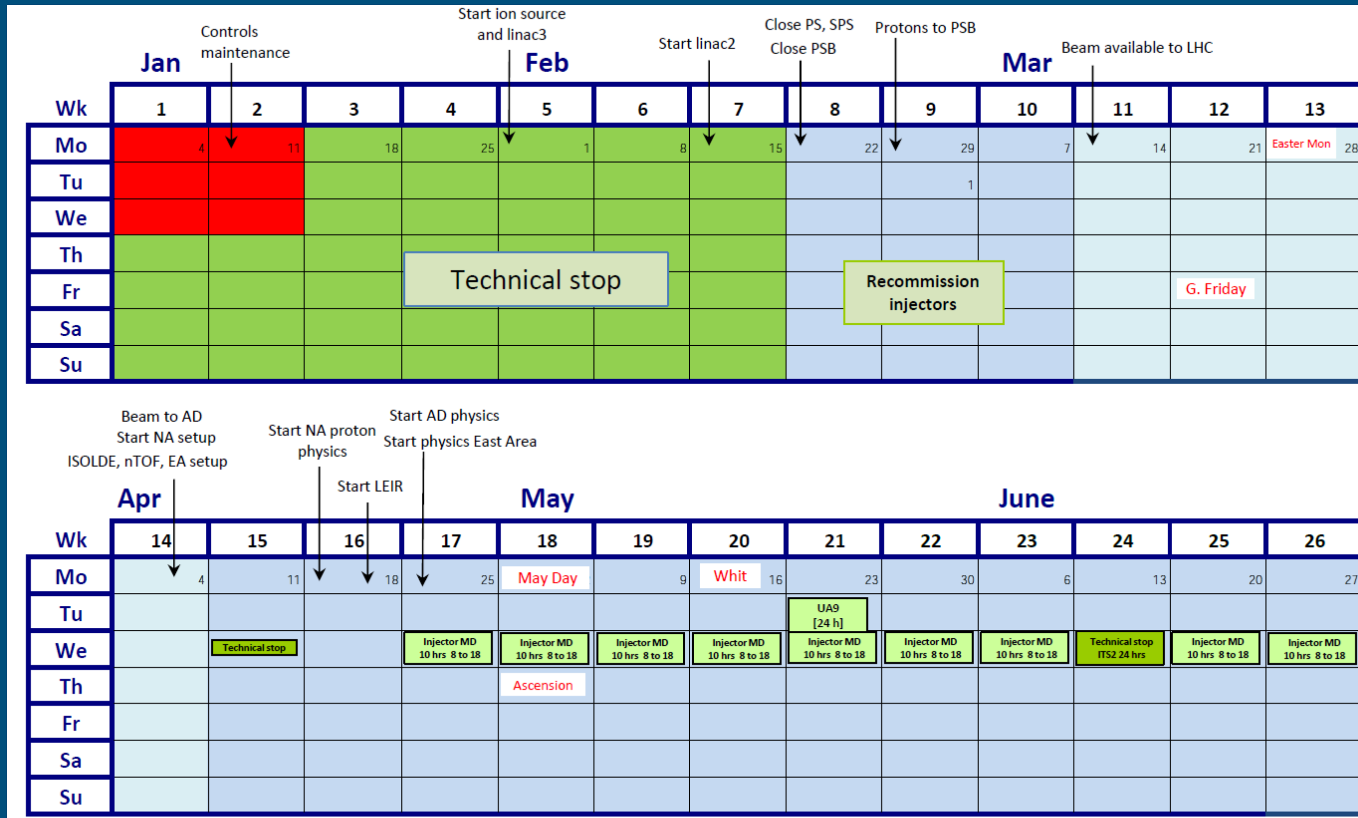
Key milestones	2016 Q1	2016 Q2	2016 Q3	2016 Q4	2017 Q1	2017 Q2	2017 Q3	2017 Q4	2018 Q1	2018 Q2	2018 Q3	2018 Q4
0 Active muon shield												
Optimization of the field map for background suppression						■						
Design of coil and yoke + optimization soft/GO steel, manufacturing method								■				
Prototype construction and test										■		
Study of (partially) superconducting option										■		
1 Neutrino Target												
Optimisation of brick structure to separate electron anti-neutrinos/neutrinos				■								
Optimization of ECC and CES mechanical assembly and target material							■					
Demonstrate charge and momentum measurement in CES								■				
2 Target Tracker (nTT)												
Demonstrate capability of connecting nTT and emulsion tracks at occupancy								■				
Choice of technology for final design: GEM vs SciFi vs Micromegas										■		
3 Muon Magnetic Spectrometer (nMMS)												
Test streamer mode operation for RPC at the design rates				■								
Test OPERA RPCs for their possible re-use				■								
4 Vacuum Vessel												
Study of the required vacuum pressure and optimal geometry					■							
Optimization of the entrance/exit window of the vacuum vessel							■					
Design study including integration of liquid scintillator cells, incl market survey									■			
Study of alternative vessel designs - concrete bunker									■			
Choice of vessel design											■	
5 Surround Background Tagger (SBT)												
Optimization of liquid scintillator cell dimensions and PMT locations						■						
Development of complete cell prototype with reflection paint and *N* flushing										■		
Prototype performance tests										■		
6 Upstream VETO Tagger (UVT)												
Performance tests of 4m scintillating bars					■							
Optimization of the layout and support to minimize passive material									■			
Prototype construction and test										■		
7 Straw VETO Tagger (SVT)												
Background study to determine applicability and background rejection								■				
Design study										■		

Key milestones per subsystem

		2016				2017				2018			
	Key milestones	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
8	**Spectrometer Straw Tracker (SST)**												
	Small-scale prototype construction and test				■								
	Demonstrate methods to control effect of straw sagging and alignment							■					
	Optimization of straw geometry, readout (1-, or 2-sided), overall geometry								■				
9	**Spectrometer magnet**												
	Definition of mechanical interface beteen HS magnet and vacuum vessel						■						
	Magnet design including mechanical analysis									■			
	Study of a superconducting alternative										■		
10	**Spectrometer Timing Detector (STD)**												
	Optimization of geometry, readout and mechanical support						■						
	Prototype construction and performance test								■				
	Choice of technology for final design: Scintillating bars vs MRPC										■		
	Demonstrate method of fine time alignment										■		
11	**Electromagnetic calorimeter (ECAL)**												
	Optimization of cell size and module structure				■								
	Demonstrate method of monitoring and calibration								■				
	Prototype construction and test									■			
12	**Hadronic calorimeter (HCAL)**												
	Optimization of cell size and module technology				■								
	Engineering prototype of HCAL								■				
	Development of monitoring system								■				
13	**Muon detector (MUON)**												
	Optimization of the general layout and dimensions of scintillating bars								■				
	Demonstrate the time resolution of 1ns									■			
	Full-size prototype construction and test										■		
14	**Online system**												
	Definition of the common readout protocol			■									
	TDAQ demonstrator performance evaluated							■					
	Readout control specification for the FE and the BE											■	

Beam time in test beams will be important in 2016, expected to continue in 2017 and 2018.

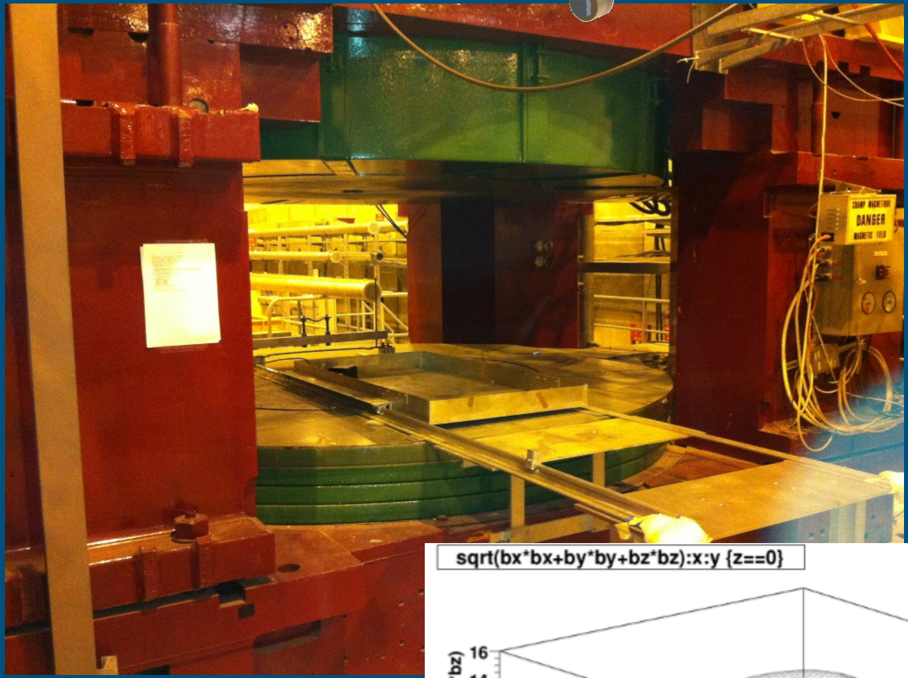
Test beams 2016

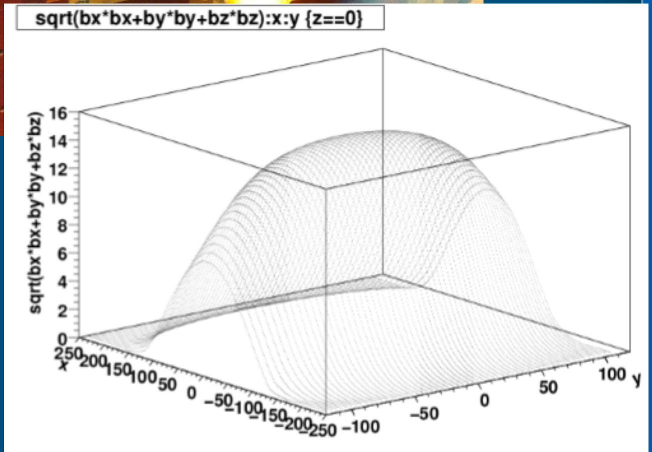


- Test beams in 2016
- NA and EA proton physics run from ~mid April to mid November
  - ➔ Use SPSC questions to motivate the requests
- Expertise, support and hardware needs from entire collaboration

Neutrino target magnet

- Existing magnet: Goliath
  - Power: ~2 MW
  - Maximum field: 1.4 T
  - Gap volume: ~5 m^3 (>50% field)
  - Availability uncertain





- R&D: Redesign in a slimmer version and lower power
  - Maximum total width: ~2.5 m
  - Aperture ~0.75 x 0.9 x 3 m^3 at 1 T (to be revised)
  - Estimated at 700 kCHF + 800 kCHF (power, cooling, interlocks)

SHiP: Table of interests

Component	Institutes
Beamline and target	CERN
Infrastructure	CERN
Muon shield	RAL, Imperial College, Warwick, Bristol
HS vacuum vessel	NRC KI, NIKIET
HS spectrometer magnet	
Straw tracker	CERN, JINR, MEPhI, PNPI
ECAL	ITEP, Orsay, IHEP, INFN-Bologna
HCAL	ITEP, IHEP, INFN-Bologna, Stockholm
Muon	INFN-Bologna, INFN-Cagliari, INFN-Lab. Naz. Frascati, INFN-Ferrara, INR RAS, MEPhi
Surrounding background tagger	Berlin, LPNHE, MEPhI
Timing detector and upstream veto	Zürich, Geneva, INFN-Cagliari, Orsay, LPNHE
ν_τ emulsion target,	INFN-Naples, INFN-Bari, INFN-Lab. Naz. Gran Sasso, Nagoya, Nihon, Aichi, Kobe, Gyeongsang, Moscow SU, Lebedev, Toho, Middle East Technical University, Ankara
ν_τ target tracker	NRC KI, INFN-Lab. Naz. Frascati
ν_τ target magnet	
ν_τ muon spectrometer magnet	INFN-Bari, INFN-Naples, INFN-Roma
ν_τ tracking system (RPC)	INFN-Bari, INFN-Lab. Naz. Gran Sasso, INFN-Naples, INFN-Roma
ν_τ tracking system (drift tubes)	Hamburg
Online computing	CERN, Niels Bohr, Uppsala, UCL, YSDA, LPHNE
Offline computing	CERN, YSDA
MC simulation	CERN, Sofia, INFN-Cagliari, INFN-Lab. Naz. Frascati, INFN-Napoli, Zürich, Geneva and EPFL Lausanne, Valparaiso, Berlin, PNPI, NRC KI, SINP MSU, MEPhI, Middle East Technical University, Ankara, Bristol, YSDA, Imperial College, Florida, Kyiv

- We need strong and very available engineering team(s) for decay volume and muon shield

(News: PS to SPS beam transfer)

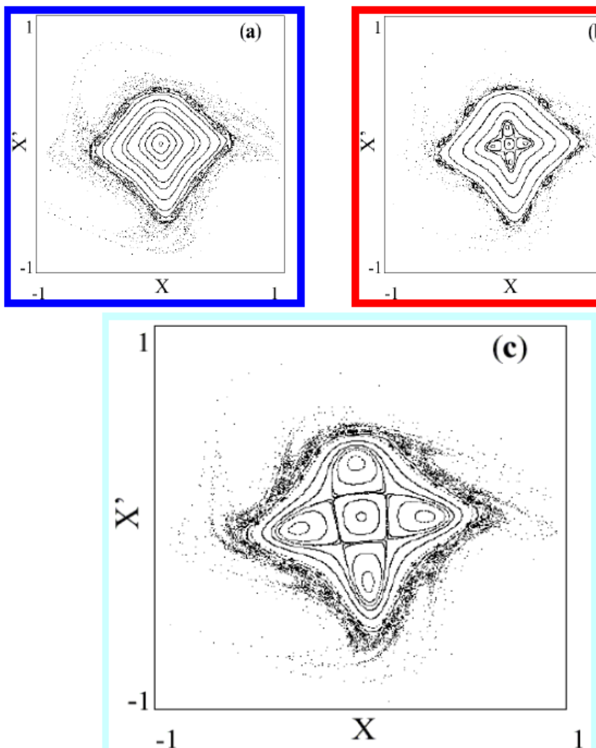
D. Manglunki:

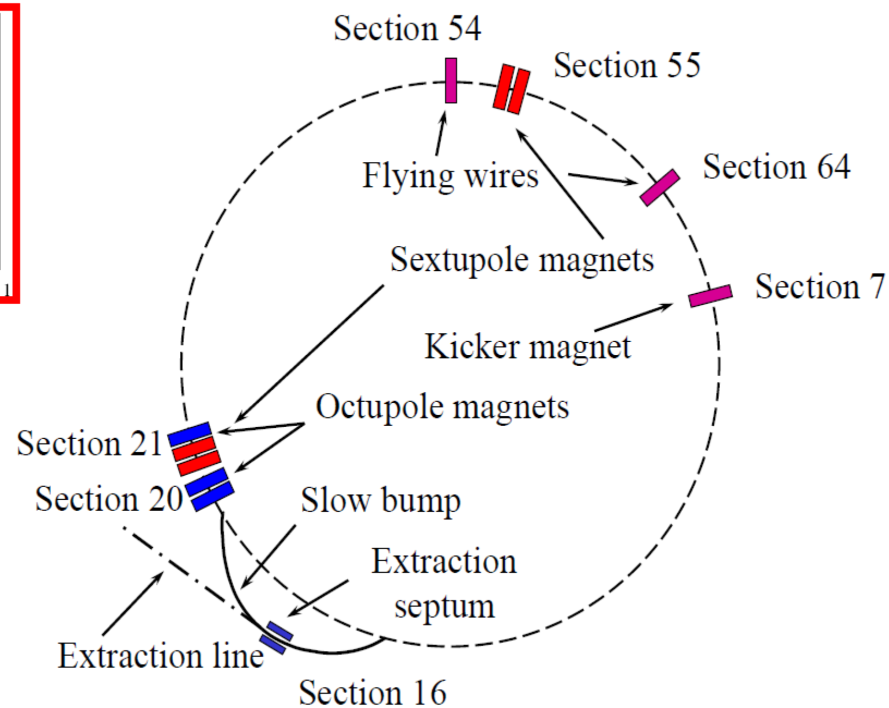
- Continuous Transfer
  - 10% to 15% of the beam sent to the SPS for fixed target is lost on SEH31. Taking into account the subsequent machine efficiencies (injection, capture, acceleration and slow extraction), it is a conservative estimation to state that for 1e20 protons on target, more than 2e19 14GeV/c protons are lost on SEH31!
  - SEH31 is one of the most irradiated locations of the PS
  - Changing cable or oil gives a collective dose of 1mSv

➔ Study and test novel technique based on Multi-Turn Extraction

Principle of the new MTE

- Use non linear fields to create stable islands in the horizontal phase space (“transverse splitting”)
- Use fast kicker to jump magnetic septum and extract the 5 beamlets





USERS'MEETING – September 17th, 2015   MTE vs CT - D.Manglunki   5

➔ Put in operation on 21/9/2015, workshop in two weeks