Strategy and organization for Comprehensive Design phase C(T)DR?

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2015 “MTP storm”

Pheeww… ?!

“It will not be all plain sailing”
>700 pages high quality documents by SHiP theorists, experimentalists, and CERN accelerator, engineering, and safety departments

- >1000 theory references!
- + documents with answers to SPSC questions

TP was aimed at demonstrating physics case, feasibility, performance, and motivation at CERN but it left many open ends (on purpose)

- Alternative experimental configuration
- Detector technologies
- Decay modes
- Etc

Next documents should have at least same quality and go well beyond TP!

Have to follow closely experimental and theoretical physics scene over the next 3 (10) years

- We have a very good theory support!!
New * FACE * of SHiP

For scale:
New phase of SHiP (already started and counting!)

- Comprehensive Design Report(s?) = “Tentative Design Report”…TDR for short…
  - Updated design elaborated with mechanics, electronics, and infrastructure
  - Safety aspects
  - Updated performance
  - Manufacturing
  - Updated cost and planning

- “Requirements” for this phase
  - Project organization with contact lists
  - Safety organization and preparation of Safety Document structure for Safety File
  - Documentation structure - EDMS
  - MoU exercise – draw up work packages with description and tasks, and resources

<table>
<thead>
<tr>
<th>Milestones</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimizations, simulation studies, small scale</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>prototyping</td>
<td>Q1 Q2 Q3</td>
<td>Q4 Q1 Q2</td>
<td>Q3 Q4 Q1</td>
</tr>
<tr>
<td>Design and prototyping</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Testing and updated performance and cost</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engineering Design Reviews</td>
<td></td>
<td></td>
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<td>Write-up</td>
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- Update sub-system milestones
Planning very well aligned with
- Update of European strategy 2018/2019
- Accelerator schedule (to be followed closely)
- Production Readiness Reviews (PRR) end 2019
- Construction / production 2021 –
- Data taking 2026 (start of LHC Run 4)
- Comprehensive Design Study 2016 – 2018

Time line for the CDR phase is critical
New phase of SHiP

General remarks

• SHiP success relies on full control of background and model independence
  ➔ Robust muon shield and detector within uncertainties and redundancy
  ➔ Best possible tracking and PID

• Proton-target simulation tuning
  ➔ Accurate particle flux and spectra both signal and background

• Explore novel and innovative options but stay within realistic envelope
  ➔ Three years is not a lot of time
  ➔ We are a zero background but also zero euro experiment (“broke but happy!”)…

• Large potentials for cost optimizations (see list below)

• Synergy in the use of plastic scintillators (MUON, STD, UVT, SBT,…)

• Increasing use of plastic scintillator will require safety derogation
  • What about neutron/photon exposure?

• We need a very large engineering effort
  ➔ Attract engineers rapidly, incl. students, set priorities and follow logical path

• Timelines and resources are still missing for several detectors

增加的灵敏度与TP关系

1. Cascade processes (signal and background)
2. Acceptance (distance and decay volume geometry)
3. Protons on target (spill intensity, sharing with other users, running time)
Global experiment optimization:

- Decay volume and muon shield are the central items
- Dimension of spectrometer+PID detector remains
- Engineering studies of alternative options should go in parallel
- Requirements for background taggers dictated
  - partially by experimental configuration
  - and partially by performance of spectrometer and PID

Notes on related questions and plans on following slides
**Question of intensity**

- Current baseline: $4 \times 10^{13}$ protons/7.2s and NA FT+LHC+MD = $4 \times 10^{19}$ p/year
  - NA FT proton consumption as now (no upgrades or other new projects)
  - Proton sharing to be discussed in Fixed Target Strategy group

- Running time 5 years translates to 10 years design criteria or more

- Increase intensity/spill?
  - Many slow-extraction studies planned in 2016
  - Operational follow-up to ensure ZS activation is monitored
  - Crystal assisted extraction to redirect losses being studied
  - News in June SHiP collaboration meeting

- Fast extraction = 23 μs, or $1/5 \times 5 \times 23$ μs?
  - Gives potential access to the famous $7 \times 10^{13}$ p/spill .....
  - Still limitation of 39 MW and 6 seconds for injection/acceleration
  - Dramatic reconsideration of situation for the whole experiment....

What’s the problem, Marco? 😊
Target
- Very clear milestones, engineering help very welcome!
- Collaboration on testing target material (PSI, UK, BNL…)?

Magnetization of hadron stopper
- Looks very realistic downstream of the water cooled proximity shielding
- Toroidal magnet already investigated for neutrino beam (D. Tommassini)
  ➞ Engineering needed!

Muon shield
- A lot of progress on new muon shield, but currently only 2D
- Super-conducting option
  - Knowledge about return fields? Learn from LHC loss simulations?
  - It’s BIG, cost?
- Dangerous to tailor this object literally to simulation?
  ➞ Uncertainties in real-life spectra and field could lead to unexpected effects
- Engineering study for warm magnets inspired a lot of confidence
  ➞ But sure, conical shape of decay volume, yes!
  ➞ Further benefit of magnetized hadron stopper to be studied
Decay volume

- Current vessel non-optimized (shape and vacuum) and very little is known about real cost
  - Recent results show that the stainless steel vessel wall thickness needs to be substantially increased in order to cope with the dynamic stability requirements
- Even if a pressure of 1/100 – 1/10 bar is Ok, vessel looks the same due to mechanical requirement and concrete walls become rather hefty as well
  - Concrete vessel would still be significantly cheaper
  - Clearly conical/trapezoidal shape is the way to go
- Engineering study is needed
  - Requires envelope to be know for decay vessel
  - Also expected background flux should be understood before making another iteration on the design
- Helium balloon looks very attractive, purification system should be straight-forward
  - A lot of new investigations follow
    - Shaping, proper mechanical structure, flanges, detector interfaces engineering
    - Effects of multiple scattering
- And what if
  - We can go to higher beam intensity?
  - Neutrino background is higher than expected?
- Other: Requirements for/on a an upstream V⁰ decay region?
  - How efficient are upstream neutrino detector/UVT?
  - Upstream Straw Veto Tagger? No need in helium option
Spectrometer Straw Tracker
- Tracking on track!
- Sagging effects and compensation in vacuum (on the way) and in helium (to be studied)
- Optimization of geometry on the way, including test of larger diameter straws
- Effect on tracking with degraded resolution in helium to be studied
  - High priority?
  - Alternative tracking technology in helium to be looked at?

ECAL
- Current ECAL based on Shaslik
  - Large number of modules/channel: Big price tag
- Detection of neutrals calls for directionality $\sigma \sim \text{mrads}$ with different technology
- Need information about longitudinal and transverse shape of showers
  - Calorimeter with longitudinal sampling and time projection transversally a la DELPHI HPC?
  - Preshower with mm resolution / combined with timing detector in combination with current ECAL?
  - ?
  - New ideas and manpower!
  - Urgent
- Requirement on PID in higher pressure/helium environment?
- Choice of PMT and requirement on PMT shield to be understood
HCAL
- Current HCAL based on Shashlik
- HCAL is a very good pion filter ➔ Low muon mis-id…
  ….but on the other hand MUON is blind to p<3 GeV
- Optimal HCAL/MUON configuration?
  • Replace HCAL with muon absorber or “build in” HCAL in muon absorber, or..?

- Alternative technology, tile HCAL a la LHCb, or?

MUON
- >99% muon efficiency for < 10^{-3} pion mis-identification with muon only, >3 GeV
  • HCAL contributes up to 10 GeV
  • Optimal configuration of HCAL + MUON?
  • Integrating HCAL as muon filter could lead to important cost saving
    ➔ To be investigated with existing manpower

- Very good time resolution contribution to rejection of combinatorial backgrounds
- Investigate doping of plastic scintillator for better light yield?
- Very clear timeline and resource needs

- Iron from Opera?
Notes system by system 5

- **Spectrometer Timing Detector**
  - Two alternative technologies for STD: SciBar+PMT/SIPM and MRPC
  - Very nice progress on SciBar prototype, time resolution on 3m bar to be demonstrated
  - Encourage collaboration on SAMPIC chip
  - Requirements to be refined

- **Upstream Veto Detector**
  - Configuration and requirements/benefits of UVT not clear at this stage
  - Pending re-optimization of muon shield and tau neutrino detector
  - How much can be achieved by detectors in tau neutrino muon spectrometer in new configuration

- **Surrounding Background Tagger**
  - Currently based on LiSci + WOM integrated into vessel as double wall
    - Clearly expensive housing, purification system?
  - Investigate optimal option for concrete vessel and for helium balloon
    - Concrete vessel: Integrated in concrete?
    - Helium balloon: Plastic scintillator (LiSci) held by light weight structure surrounding
  - Optimal thickness to be understood for both LiSci and plastic scintillator
    - Granularity/efficiency
    - Directionality?
    - LiSci sensitivity to $K_L \rightarrow \pi\pi\pi^0 (\rightarrow \gamma\gamma)$
  - Requirements driven by global optimization!
Tau neutrino detector

- Tau neutrino detector will see an important reshaping, length 10m?
- Emulsion and muon flux under control in current configuration
  ➔ To be re-verified after global re-optimization
- A lot of test beam activity for studying ECC+CES+TT
- Emulsion Shifter…. for time measurement…?
- Three options for target tracker: GEM/µRWELL, SciFi, MircoMegas
  - Study of slope measurement, space resolution vs B field and incident angle in GEM/µRWELL and MicroMega
  - Matching between emulsion-TT
  - Best test with SciFi in 2017
- OPERA RPC may be used or not?
  ➔ Otherwise redesign RPC modules
Uncovered areas!

What about trying to profit from the field of the muon shield wings?! (Oliver Lantwin)
TDAQ
- Specification of data protocol and readout protocol in 2016 will allow a common approach to FE
- Support for readout systems for test beam activities 2017, use of CheapDAQ demonstrator?
- TDAQ project should become Online project for CDR to include control system, readout control, DAQ, online processing software, computing infrastructure
  - Collect detector infrastructure requirements for controls

Computing
- Can only move forward with increasingly accurate response of the detectors implemented in simulation
  … and tools for providing reconstruction of track information, energy, PID, (combined) tagger information,…
- Generators are needed for all physics signals but HNLs
- Update of cavern shape needed, but assume it is still to be optimized
Beam line:

- Extraction beam loss reduction and mitigation
- Design study for laminated splitter magnet
- Expected 1s slow extracted spill quality
- New optics and powering of TT20
- Interlocking of key systems
- Dilution sweep system for the target
- New beamline from splitter to target
- New and upgraded beam instrumentation

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

⇒ PhD students very welcome!
⇒ CERN Fellows will be hired – let’s identify them!
“Subsystem interest” ➔ Sub-project responsibility ➔ MoU

<table>
<thead>
<tr>
<th>Component</th>
<th>Institutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beamline and target</td>
<td>CERN</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>CERN</td>
</tr>
<tr>
<td>Muon shield</td>
<td>RAL, Imperial College, Warwick, Bristol</td>
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<tr>
<td>HS vacuum vessel</td>
<td>NRC KI, NIKIET</td>
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<td>HS spectrometer magnet</td>
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<tr>
<td>Straw tracker</td>
<td></td>
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<tr>
<td>ECAL</td>
<td></td>
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<tr>
<td>HCAL</td>
<td></td>
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<tr>
<td>Muon</td>
<td></td>
</tr>
<tr>
<td>Surrounding background tagger</td>
<td></td>
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<td>Timing detector and upstream veto</td>
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<td>$\nu_{\tau}$ emulsion target,</td>
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<td>$\nu_{\tau}$ target tracker</td>
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<td>$\nu_{\tau}$ target magnet</td>
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<td>$\nu_{\tau}$ muon spectrometer magnet</td>
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<td>$\nu_{\tau}$ tracking system (RPC)</td>
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<td>$\nu_{\tau}$ tracking system (drift tubes)</td>
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<tr>
<td>Online computing</td>
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<tr>
<td>Offline computing</td>
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<td>MC simulation</td>
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- Need to define a project structure with project leaders and contact persons
  - Project description and intention as part of MoU
2016 Test beams

- Granted 7 weeks following our request to SPSC
  - SST, UVT/STD (SciBar/MRPC), ECAL, HCAL, SBT, MUON, ECC/CES/T T, µRPC?
    - Several uncertainties due to funding
      - Regrouping of test beam activities to ensure use of beam time
    - SHiP not highest priority → not ideal scheduling with too early period and too tight
      - Re-negotiating:

> + Parasitic area for SST behind H2 throughout the whole year (space for small prototype of other detector)
> + Test beam for CES/TT at SPS H4 together with RD51 collaboration with Goliath magnet.

> Tight schedule between SPS H2 (SST+ ECAL) and PS T9 (HCAL) to migrate readout and tracking chamber equipment

> Submit your safety form (ISIEC) at least 2 weeks before allocated beam time
Work space at CERN

- **Office space:** To be discussed with CERN management
- **Lab space:** Collect info about existing lab space “owned” by users within collaboration
- **Storage space:** First use case coming up with Opera equipment from Gran Sasso
- **Test beam area:** Difficult to imagine permanent test beam at this point

We have a SHiP repository in the CERN Document Server

- It has taken a very long time to have this setup according to our needs…
- Four categories of documents in use
  - **CERN-SHiP-NOTE-YYYY-##:** Public notes, convener is responsible for contents check and submission
  - **CERN-SHiP-INT-YYYY-##:** Internal notes, convener is responsible for contents check and submission
  - **CERN-SHiP-PROC-YYYY-##:** Conference proceedings, convener/Walter responsible for contents check
  - **CERN-SHiP-SLIDE-YYYY-##:** Conference and seminar slides, convener/Walter is responsible for contents check
  - **CERN-SHiP-DRAFT-YYYY-##:** Papers for publishing under internal review, no procedure yet
  - **CERN-SHiP-PAPER-YYYY-##:** Submitted papers, no procedure yet

- CDS link and Latex and Word templates are available on SHiP Website

- **Encourage use of CDS to document studies and works!**
- **Give talks at conferences and document them! Submit abstracts in contact with Walter!**

Secretarial status…help…

- We are getting very valuable best effort help from LHCb and EP-DI secretaries. Thanks!!
  - Nathalie Grub, Carnita Hervet, Cindy Denis, Patricia Mage-Granados
- To be discussed with CERN management
Conclusions

- We are lifting anchor for the next leg, and it’s a lot longer journey
  - But we have only three years!

- We need more crew and more food
  - Especially engineers!

- We need master students and PhD students,
  .... but also supervision!

- CDR ~ TDR level

- Design Reviews in the middle of 2018

- Goals of June Collaboration Meeting

- Future: extend collaboration meeting by 0.5 – 1 day?