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Closeout Report

DOE Science & Technology Review of Fermilab

July 14, 2010

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Energy Frontier Physics

FINDINGS

- Best year ever for Tevatron

  Delivered 2.1 fb^{-1} so far in FY10, surpassing DOE high-level goal

- Physics output continues to be strong

	CDF	D0
Abstracts for ICHEP 2010	75	77
Journal submissions in 201016	15	
PhD theses since 2009	41	49

- Standard Model Higgs search updated Nov 2009

  Exclusion region is now 163-166 GeV

- Data up to March 2010 analyzed for ICHEP 2010
  - (about 6 fb^{-1} out of the recorded 7 fb^{-1})

Energy Frontier Physics

COMMENTS

- Tevatron results are of highest quality and continue to be of the greatest importance at the energy frontier
- Many signs of a robust physics program:
  - top: e.g., CPT conservation test from top anti-top mass difference
  - b physics: e.g., search for new CP effects from like-sign dimuon asymmetry
  - Higgs and Beyond Standard Model: new channels and new sophisticated analysis techniques are still being added
- Higgs searches are now sensitive enough to be interesting (expected 95% exclusion limits able to probe below Standard Model prediction)

Energy Frontier Physics

COMMENTS

- No indication was given for detector degradation, we assume there is no effect on the physics output on the FY11 time scale.
- There could be a computing resource bump needed in FY11 in order to quickly reprocess data for both CDF and D0 to get best tracking and b-tagging performance in the final data set.
- Collaboration staffing projections appear to be adequate to analyze data collected through FY11. However, reduced guest/visitor budgets in FY11 and beyond could jeopardize physics output. Seems to affect D0 more than CDF.
- Proposal to add three years of Tevatron running (FY12-14) was mentioned as being considered but no specific physics motivation was presented beyond “increase chance of Higgs discovery.” A specific and quantitative physics goal in relation to LHC performance, as well as the impact on the post-Tevatron future of Fermilab, must be included in such a decision.

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Energy Frontier Physics

RECOMMENDATIONS

- None

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Intensity Frontier Physics

- Findings
  - NuMI is producing high intensity and high quality beams. The beam has been reliable and stable. The accelerator division should be commended.
- Comments
  - When the lab is presenting the global neutrino strategy of its current and future plans it would be helpful to explicitly show its context to the rest of the world program including timescales.
- Recommendations
  - None

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Intensity Frontier - MINOS

- Findings
  - With its latest analysis MINOS has set limits on theta_13 near or below the Chooz bound. This is an result is especially impressive for a detector not optimized for this kind of measurement.
  - They have now done the first anti-neutrino long-baseline run.
  - They see an allowed regions in anti-neutrino that is inconsistent at the 5% level with their neutrino running.
- Comments
  - We think further running in anti-neutrinos is important.
  - We agree with the PAC that giving MINOS 90% of its requested anti-neutrino running such that they "share the pain" with Minerva's request is reasonable.
  - With approximately double the anti-neutrino statistics, it would be interesting to estimate the expected sensitivity for measuring a neutrino vs. anti-neutrino differences. This may be an important number to understand for future planning.
- Recommendations
  - None

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Intensity Frontier -SciBooNE

- Findings
  - SciBooNE is an impressive small experiment that was quickly built and operated (June 2007-Aug 2008)
  - They already have published three results in Phys Rev.
- Comments
  - We are particularly interested in seeing the joint SciBooNE–MiniBooNE analysis on neutrino disappearance.
  - Can SciBooNE say anything about the predicted antineutrino flux at MiniBooNE?
- Recommendations
  - None

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Intensity Frontier - MiniBooNE

- Findings
  - The latest MiniBooNE results present a confusing situation:
    - Neutrinos: excess at low energy , no oscillation signal.
    - Anti Neutrinos: No excess at low energy, but is now consistent with LSND.
  - MiniBooNE is making a large impact in the field of cross-section measurements. They have 5 publications already and more nearing publication. They are utilizing the detector after it was understood with the oscillation analysis to do a set of measurements which help everyone in the field.
- Comments
  - To the extent that is possible, it is important that the anti-neutrino oscillation situation is resolved so as not to have several years of uncertainty in the field.
  - The PAC's findings that the MiniBooNE letter of intent be should be revisited to determine the feasibility and/or desirability of moving the detector to a different baseline appears to be well founded.
- Recommendations
  - None

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Intensity Frontier - MINERvA

- Findings
  - Minerva completed construction and started data taking in March.
  - The project was on time and under budget.
  - It has already taken nearly $1x10^{20}$ POT in both neutrino and anti-neutrino modes.
  - The recently ran a test beam to calibrate the hadronic and tracker response of their detector.
- Comments
  - Minerva will measure cross-sections important for the future world-wide neutrino program.
- Recommendations
  - None

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Detector Operations

FINDINGS

- Collider experiments are operating smoothly and efficiently (91% and 83% data taking efficiencies for D0 and CDF respectively). The experiments are on track to record around 10 fb-1 of data by the end of FY11.
- Offline processing is keeping pace with data taking. Computing is currently keeping pace with the demands of MC production and analysis .
- The operation and computing manpower is around 80 FTE's per experiment. This is considerably reduced compared to the past--but without adverse effects thanks to streamlining of the tasks.

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Detector Operations

FINDINGS

- The scheduled shutdowns and infrequent detector accesses have been minimized but the detectors are still kept in good data taking condition. Careful plans for the work for the summer shutdown exist, and no large detector problems due to aging, or otherwise, are expected in the running to the end of 2011.
- Both collider experiments have began detailed planning of detector decommissioning.
- D0 collaboration estimates a period of 7 years for decommissioning at an estimated cost 49.3M$. CDF plans 3 years at a cost of 26.2M$. Both estimates have 100% contingency included.

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Detector Operations

COMMENTS

- Both collider experiments have achieved impressive data taking performance while reducing manpower needs.
- Both experiments have successfully utilized Grid resources for their computing.
- The computing budgets are half of the experimenter's requests in FY2011. This will delay the planned reprocessing of CDF data. It is not clear what furhter effect this will have on the physics output of the collaborations. The FY12 computing budget is anticipated to be even lower than in FY11.
- DOE and Fermilab support of visitors and guest scientists for operation and computing are an important part of the success so far.

Detector Operations

COMMENTS

- The decommissioning plans of both collaborations are still relatively roughly sketched out. In particular,
  - D0 planning still has large uncertainties in the cost and planning of the Uranium disposal.
  - CDF has not yet made plans taking into account the IARC construction which incorporates the CDF building.

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Detector Operations

RECOMMENDATIONS

- For the next S&T review CDF and D0 should develop detailed decommissioning plans that can be reviewed.
- At the next S&T review present a plan, developed in coordination with the collaborations, to exploit the full physics potential of the final Tevatron data set with adequate resources (e.g. computing and visitor support) and in a timely manner.

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Accelerator Operations

FINDINGS

- Overall accelerator uptime in FY2010 was very good for collider operations (89.6%) and fixed target operations (>90%). This exceeded the DOE availability performance measure of 80%.
- 2.1 fb^{-1} of integrated luminosity was delivered to D0 and to CDF in FY 2010 to date. This exceeds the FY2010 performance measure of 1.9 fb^{-1}. This also exceeded the 1.9 fb^{-1} delivered in FY09. The total from Run II is now 9 fb^{-1}.
- The FY2011 performance measure is 2.0 fb^{-1} for 46 weeks of physics operations and 5 weeks of accelerator studies.
- The integrated luminosity rate has now peaked at 52 pb^{-1} per week.
- Tevatron delivered an average of 123 hours at store (luminosity for experiments) per week, 73% of calendar time.

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Accelerator Operations

FINDINGS

- The Tevatron collider operation is expected to end in FY2011.
- 1.3E20 protons for MiniBooNE, 1.0E20 protons for MINERνA, 3.0E20 for MINOS/NUMI were delivered to date in FY2010. The FY2010 fixed target performance measure is 2.2E20. The FY2011 performance measure is 2.7E20 for 50 weeks operations. The FY2012 performance measure is 1.4E20 for 22 weeks operations.
- Proton delivery is limited mostly by Booster throughput (beam loss <525W) which is operating at this limit. A second limit is MI activation at 1 Watt/meter and 1 KWatt of proton beam power.

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Accelerator Operations

FINDINGS

- The maintenance periods, 12 weeks in FY2009 and 4 weeks in FY2010, were directed to critical needs.
- The Proton Source Task Force has been formed to determine vulnerabilities of each major accelerator subsystem. MicroBooNE and NOνA proton economics drives the plan. An implementation plan and cost estimate is expected by the end of FY2010.
- For the NuMI beamline, there is a short-fall in the total number of protons on target required to satisfy the requested additional 2.5E20 for MINOS antineutrino running and the requested 4.9E20 for MINERνA neutrino running before the NOνA shutdown in March 2012.

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Accelerator Operations

FINDINGS

- The current plan is to keep the Tevatron cold at 80K after Run 2, with the central nitrogen refrigerator off at an ~ $4M / year cryo operating cost. Additional costs were not identified. After the two year hiatus, a decision is planned to be made as to how to proceed.
- The estimate for dismantling the Tevatron and removing the infrastructure from the tunnel and moving the equipment to the surface for storage or shipment is $10M.

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Accelerator Operations

COMMENTS

- The FY2010 accelerator operations performance was excellent and a tribute to the accelerator teams professional work and dedication.
- Luminosity performance has peaked and the emphasis is to provide steady high performance operations until the closure of the Tevatron in FY2011.
- Performance metrics for luminosity were presented. It would be beneficial to develop a set of metrics for each end station that take into account integrated protons as well as facility up time.
- The projection for Tevatron integrated luminosity of 9 fb^{-1} thru FY2010 has been exceeded and the 11–12/fb^{-1} projection thru FY2011 appears reasonable and can be expected to be met.

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Accelerator Operations

COMMENTS

- The FY2010 system failures are indicative of the need to address the long term fixed target needs. Booster system upgrades must be addressed to satisfy the NOνA experiment that requires 9 Hz, 1.4E17/hour capability.
- The problem of ageing machine components for future fixed target operations must be aggressively addressed. An upgrade plan is under preparation. The one-year FY2012 shutdown is an ideal time to implement many of the corrective actions, but the time to plan, implement and stage the modifications, approximately one year from now, is minimal.

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Accelerator Operations

COMMENTS

- The replacement of the Cockcroft Walton pre-injector with an RFQ linac is long overdue. The Linac RF system and electronics require attention. The source for 7835 amplifier tubes is a continuing problem that needs to be addressed by Fermilab, BNL and LANL.
- We agree with the 2010 PAC recommendation that “sharing the short-fall of POT such that MINOS receives ~90% of the total requested protons for antineutrino running and MINERνA receives ~90% of the total requested protons for neutrino running - assuming the current operation capabilities of the NuMI beamline.” We however urge the Accelerator Division to continue to pursue a technical solution.

Accelerator Operations

COMMENTS

- Accelerator physicists to support new projects are expected to come from the reduction of Tevatron operations support. 70 persons are presently assigned to Tevatron operations. This has to be planned carefully so as to avoid a significant fixed target operations performance impact beyond FY2011, as well as during the final year of Tevatron operations.
- Various people/projects have placed requests to scavenge Tevatron infrastructure items. This includes NOνA, Project X, New Muon Lab (NML), Magnet Test Facility (MTF), Mu2e. The types of equipment requested are RF, BPM electronics and cryogenics compressors. The disposition of this equipment must be closely controlled and monitored

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Accelerator Operations

COMMENTS

- Fermilab management has not expressed a firm position on whether to extend collider operations beyond FY2011, but neither have they stated a position to decommission the Tevatron.

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Accelerator Operations

RECOMMENDATIONS

1. Provide by December 2010 a technical, cost, schedule and funding plan to HEP for the improvements to the proton source needed for the intensity frontier program.
2. Provide at the next S&T review the accelerator operations plan for the period beyond FY2011.

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Future Detectors - MicroBooNE

- Findings
  - In the last review a request was made for a LAR integrated plan with clear milestones. The lab has successfully completed that task.
  - MicroBooNE is the next step on the R&D development path and is a .1 kton detector.
  - Eventually they would like to use the results of MicroBooNE to build a ~20kton detector.
  - MicroBooNE achieved CD1 in July and is working towards a CD2 review in 2011.
- Comments
  - The work on MicroBooNE is acting as an anchor to many of the pieces of the integrated plan including testing of purity, evacuation, cold electronics etc.

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Future Detectors - MicroBooNE

- MicroBooNE is an important test-bed for LBNE. Argoneut, MicroBooNE and the LBNE LAr collaborators are working together on a common software and reconstruction framework.
- In view of the new MiniBooNE anti-neutrino results, MicroBooNE's physics goal to explore the low energy electron and now the LSND anti-electron excess is very important.
- Based on the integrated plan it is not clear why the consequences (not the likelihood) of the risk that there was no intermediate scale detector on the path to the LBNE detector was so low.
- It looks like there is a lot of work progressing on the argoSoft framework. Presenting some interim results comparing Argoneut data and MC even before full physics analysis can be undertaken may be useful to characterize some numbers needed for the LBNE technology decisions.

- Recommendations
  - None

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Future Detectors - NOvA

- Findings
  - Over 100kton of rock have been removed at the Ash River site, along with the construction of the service building and and some of the concrete walls.
  - There was some over-excavation near rim. There is a contractor claim pending related to this work.
  - Estimated costs at CD2 was 47M$ + 10M$ contingency for the building.
  - Currently costs are 16M$ + 16.5M$ left to go with a 5M$ contractor claim.
  - Cracks have been found in approximately 15% of the injection molded manifolds in the near detector prototype.

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Future Detectors - NOvA

- Comments
  - Nova project management is on top of all details and has a good handle on the contingency. It is a clearly a well run project.
  - They are adequately addressing issues they found in their first proto-type (cracking of manifolds).
  - Their contingency plan allows for the building of a new prototype if it is found necessary.
  - The use of available contingency to increase the sensitivity of the experiment would be very welcome provided it does not risk CD4.
  - Although the Nova program has the unique possibility to address the mass hierarchy until the 2020s, their ability to compete in the timely search for theta_13 would be further compromised if delayed.
- Recommendations
  - None

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Future Detectors – Mu2e

- Findings
  - CD0 is established.
  - Mu2e is making good progress on understanding how to make the solenoids and how to get the beam to the experiment.
- Comments
  - We are uncertain about competition for world leadership (for example COMET) . Is the time scale and reach of mu2e competitive?
  - Extinction for protons on target is 10-3 in the debuncher. This implies a needed extinction of 10-6 in the proton transport. We weren't shown evidence that there is a design to achieve this goal.
  - We weren't shown that there was a clear path to a down select for the tracking technology.

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Future Detectors – Mu2e

- The balance between FNAL engineering and contractor engineering for the design and construction of the solenoids must be carefully considered.
- Progress has been made since last year on the growing of the collaboration, but further effort is required.

- Recommendations:
  - None

Future Detectors - LBNE

- Findings
  - LBNE aims to measure sin^2(2theta_13) to a precision of <<0.01, to determine the mass hierarchy, and to search for CP violation in the neutrino sector. Also the massive underground detectors will undertake a broad physics program including the search for proton decay.
  - LBNE achieved CD0 in January of 2010
  - The collaboration is working towards CD1 and the writing of a CDR. The CD1 review is expected at the end of 2010.
  - The collaboration now includes 59 institutions.
  - FNAL has overall responsibility for the project and is working collaboratively with the project management teams and BNL and LANL.

Future Detectors - LBNE

- The FNAL beamline design work includes shielding and tritium calculations. The requirements for the conventional facilities have been defined.

- Comments
  - The LBNE collaboration has been effectively organized by FNAL project team.
  - The FNAL conventional facilities design for LBNE is well advanced.
  - The LBNE plan of down selecting the detector technology between water Cherenkov and LAr detectors has been carefully defined including input on the physics reach, the risk, and the costs. This decision should be made as soon possible after sufficient input has been provided.
- Recommendations
  - None

Accelerator R&D

FINDINGS

- Fermilab has now established itself as a major player in SRF accelerator technology
- The SRF activities have been integrated into a coherent program with clear deliverables
- The HINS project has been redefined and realigned with Project X
- A plan for Project X was presented. The preferred plan (IC2) is now a 3 GeV CW linac at 325, 650, and 1300 MHz, followed by a 8 GeV 1.3 GHz pulsed linac (preferred option that retains synergy with ILC) or possibly an RCS
- The low beta cryomodules have a large quantity of cavity and magnetic components in close proximity in a single cryomodule. The tight packing comes from the high phase advance due to the high cavity gradients.

Accelerator R&D

FINDINGS

- A plan to develop the front-end chopper for Project X in the former HINS test stand was presented
- A worldwide collaboration (supported by MOUs) has been put in place
- Project X assumed timeline:
  - CD0 early CY2011
  - Start construction 2015
  - Operation 2020
- SRF infrastructure at FNAL received $53M in ARRA funding, with $32M of the funds committed. The funds have been used to significantly expand the SRF infrastructure and its use has contributed to the global SRF database
- An upgrade plan for protons in the near term was presented. An upper limit of $70M was estimated to complete the plan

Accelerator R&D

COMMENTS

- The Project X machine design is sufficiently well developed for the pre-CD0 stage.
- The physics program for Project X is not well defined at this time. The scientific community should be engaged in defining the potential program.
- The beam requirements derived from the experimental program will influence the accelerator design. The proposal for Project X is suffering from the lack of a clearly defined experimental program.
- Project X accelerator design and optimization could benefit from involvement and vetting by the wider SRF community

Accelerator R&D

COMMENTS

- The 25 ms pulse length may present new challenges (dynamic Lorentz detuning and HOM control and extraction)
- The infrastructure built up from the ARRA funds is well thought out and the technical groups should be commended for efficient spending of the allotted funds.
- The Project X baseline includes a 1.3GHz beta=1 cavity from 2-3GeV. This should be optimized independently of the ILC program. 650MHz beta=0.95 may be a competitive alternative.
- The injection of the H- beam into the recycler with solid or gas stripper is a complicated technical problem and needs more attention.

Accelerator R&D

COMMENTS

- The operating temperature of the cw linac should be carefully chosen especially considering the costs of the cryogenic system.
- The Project X baseline includes a 1.3GHz beta=1 cavity from 2-3GeV. This should be optimized independently of the ILC program. 650MHz beta=0.95 may be a competitive alternative.
- The injection of the H- beam into the recycler with solid or gas stripper is a complicated technical problem and needs more attention. The 3GeV separation
- The operating temperature of the cw linac should be carefully chosen especially considering the costs of the cryogenic system.

Accelerator R&D

COMMENTS

- The intensity limit in the booster is related to the beam loss. Plans to upgrade the booster from 6 Hz to 9 Hz operation to raise proton delivery for NOVA are being discussed. Implementation is planned for the 2012 shutdown. The upgrade plans need sharper definition in order to meet the suggested schedule.
- The SRF infrastructure represents an excellent training ground for young researchers. A cooperative educational program in Accelerator Technology would be advantageous as the lab moves forward with the new accelerator initiatives.

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Strategic Planning

Findings

- The strategic plan for Fermilab is based on the concept of the triple frontiers: energy, intensity and cosmic.

Energy Frontier

- The baseline plan is operating the Tevatron for one more year.
- The machine and detectors are working extremely well
- LHC physics timeline has shifted about two years.
- The focus will then shift to LHC, with Fermilab acting as the host lab for US CMS while participating in the LHC accelerator upgrades.
- There has been a proposal presented to the PAC to run the Tevatron for three additional years; they have requested additional information from lab.
- The Directorate's position on this was not presented;

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Strategic Planning

- Fermilab has shifted from a focused ILC effort, with Fermilab being the lead laboratory for the Americas, to a broader SRF / Project X focus, that still positions Fermilab with respect to the ILC.
- Fermilab is participating in R&D for muon collider, as a future option for a next generation lepton collider.
- Fermilab has established a MAP Collaboration to develop an

Strategic Planning

Intensity Frontier Findings

- Based on continued running of MINOS thru FY11, Minerva has started operations, mini-Boone is shutting down before the end of the Tevatron run to permit the starting of installation of micro-Boone, and NOvA is in construction and in 2013 will start operations.
- The centerpiece of the future program at the intensity frontier is Project X, around which all of the future programs at Fermilab revolve.
- The lab has switched its primary plan from using an 8 GeV pulsed Linac (ICD-1) to using a 3 GeV CW Linac (ICD-2).

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Strategic Planning

- While ICD-1 met the needs of the neutrino beam for long baseline oscillation experiments, it was not a good match to other future activities.
- ICD-2 using a three-way RF splitter can support three concurrent areas with a 3 GeV 3 MW beam.
- With the addition of a 3-8 GeV booster, it can supply concurrently:
  - 3 GeV 2,870 kW beam
  - 8 GeV 200 kW beam
  - 120 GeV 2,200 kW beam

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Strategic Planning

COMMENTS

- The overall plan is missing detailed down-select decisions and timelines for these decisions.
- The layout of Project X has made a great deal of progress over the last few years, but the detailed final configuration is still needed (e.g. RCS or Linac).
- The overall scope of the vision is ambitious and will over-tax the staff in their ability to build and exploit everything that was presented.
- Once the overall plan is complete, the OHAP (Organization and Human Asset Plan) should be continued, analyzing differences between the resources available and the needs.
- The focus this year was on the scientists; this needs to be expanded to focus on the engineering effort required as Project X heads into the CD process.

Strategic Planning

COMMENTS

- The near term physics Strategic Plan focuses on the intensity frontier; 7+ major experiments are competing for resources.
- The proposal to run the Tevatron for three additional years would have a major impact on this program, which was not presented in any detail.
- It is important to understand the evolution of the physics reach of NOvA and the other Fermilab Neutrino experiments vs. the competition over time,.
- If the laboratory decides to request an extension to the Tevatron operation, it needs to do a comprehensive analysis of impacts including a long range staffing plan. If physics programs are delayed, their relevance on the global context should be discussed.

Strategic Planning

RECOMMENDATIONS

- None