Feasibility Study III

~~U.S.~~ My Perspective

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Outline

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Introduction

- Possibility of doing "world" Neutrino Factory Feasibility Study is under discussion
  - this is an increase in scope compared with previous Studies
    - and requires a corresponding increase in planning
- U.S. MC has been involved in both of the earlier Studies
  - we have some experience in organizing such an endeavor
- Comments here are my own personal views and do not purport to represent the "official" position of the MC, much less the U.S.
- I doubt I'll tell you anything you haven't already figured out

Previous Studies

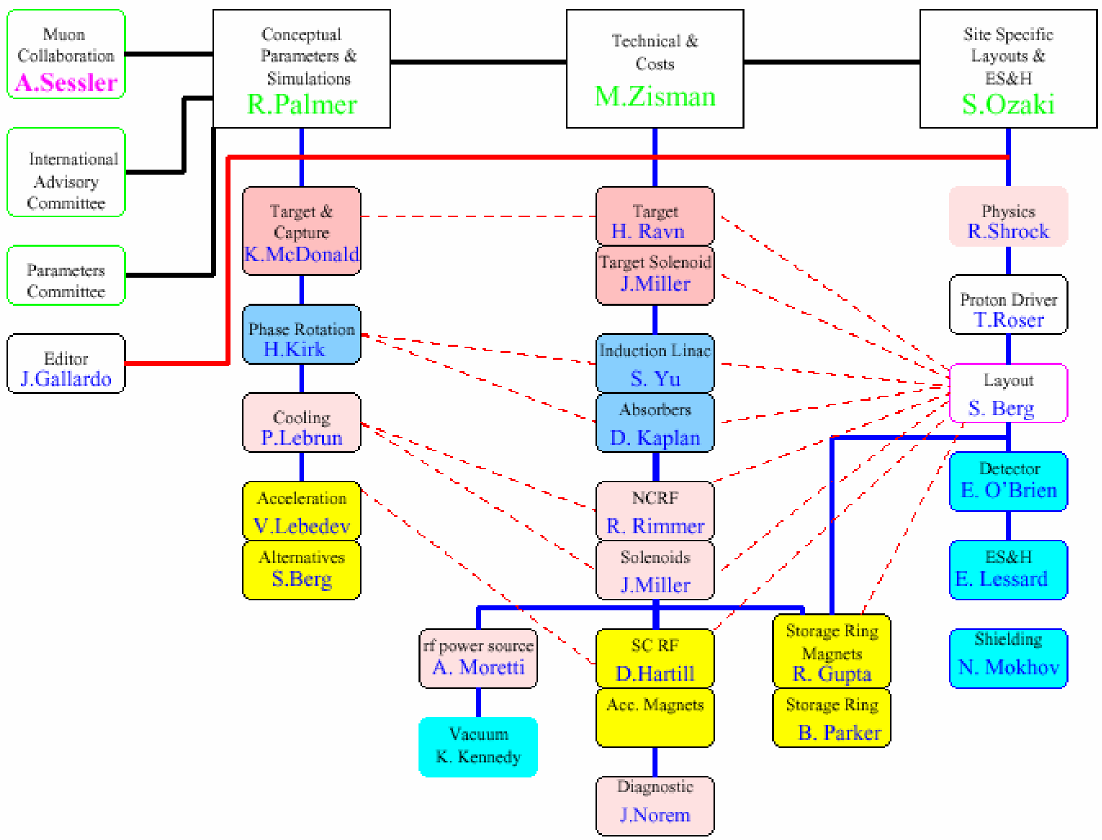
- Study I instigated by the Fermilab Director
  - MC was invited to participate
  - basic organization and decision-making done by Fermilab editors (Holtkamp and Finley)
  - MC had "input" into planning process but no formal responsibility
- Basic desire was to focus on feasibility
  - this was the first attempt to specify a Neutrino Factory from end to end
  - approach: base design on (reasonably) well-understood technologies
  - cost estimate for the facility was a deliverable
    - but no attempt made to optimize either costs or overall performance
- Proper approach at that time, as feasibility itself was most in doubt

Previous Studies

- Led to predictable result: feasibility established, performance poor, and costs relatively high
- Examples of design choices
  - use carbon target modeled after NUMI design
  - use induction linac for phase rotation
  - use 50 GeV final beam energy
- Site-specific proton driver (8 GeV) and detector location
  - baseline of 3000 km corresponded to SLAC as detector venue
  - conventional facility costs were based on Fermilab geology
- In large measure results are generic and not dominated by site-specific parameters

Previous Studies

- Study II was done from the outset as collaboration between MC and BNL as sponsoring laboratory
  - co-led by S. Ozaki (BNL), R. Palmer (BNL-MC), M. Zisman (MC)



Previous Studies

- Relationship worked smoothly
  - Ozaki handled site-specific aspects
  - Palmer handled simulations and design concept
  - I handled technical implementation and costing
- Joint management sent clear message that MC was an equal partner in the process
  - BNL leaders were able to draw in resources from the lab that were invaluable in carrying out the study
    - especially in areas of conventional construction and cost estimating

Previous Studies

- Goal: maintain convincing feasibility but improve performance substantially
  - minimizing costs was again given lower priority
- Examples of design choices
  - use Hg jet target to improve muon yield
  - use multiple induction linacs for "non-distorting" phase rotation
  - use 20 GeV final beam energy
- Site-specific proton driver (AGS, 24 GeV) and detector location
  - baseline of 3000 km corresponded to WIPP as detector venue
  - conventional facility costs were based on BNL geology
    - in particular, requirement to avoid penetrating water table meant we had to build a hill to house the storage ring

Previous Studies

- Results:
  - performance 6x that of Study I
    - 1.2×10^{20} vs. 2×10^{19} ν_e per year (10^7 s) per MW
  - cost about 75% of Study I
    - but this was mainly due to using 20 GeV rather than 50 GeV, saving one RLA
  - performance scalable with proton power, as jet target does not limit this parameter
    - should be able to operate at 4 MW

Previous Studies

- Lessons learned from the two Studies
  - necessary to optimize the "front end" (decay, bunching, phase rotation, cooling) as one system to get high performance
  - necessary to simulate entire concept before starting detailed engineering (self-consistent solution)
    - otherwise engineers chase a "moving target"
      - or cost something whose parameters are incompatible with what is ultimately specified by simulations
  - also necessary to interact with engineers during initial simulation studies to ensure that specified parameters are achievable

    ⇒ it is necessary to work as partners with the key engineers to converge to a good design
  - facility as conceived is costly, $\mathcal{O}$($2B)
  - increasing proton driver is a cost-effective way to get higher performance

Goals for Study III

- As noted, we have already covered those portions of design space representing
  - low performance, high cost
  - high performance, high cost
- What's left?
  - high performance, optimized cost
    - note that I resisted the temptation to say "low" cost

Goals for Study III

- Based on previous work, we in MC have some ideas where to begin
  - replace induction linacs with Neuffer RF bunching and phase rotation scheme
  - replace RLA with some form of FFAG ring or possibly very fast cycling synchrotron
  - look for cost optimum between amount of cooling and acceleration system/storage ring acceptance
  - examine possibility of using cooling ring for 6D cooling
    - this would have a considerable impact on the downstream implementation
      - bunch length cannot be arbitrarily long when using a cooling ring
    - it's time to try this in earnest
- It is recognized that others will have equally strong ideas how to proceed

Resources and Organization

- Having resources for a serious feasibility study requires the backing of a laboratory
  - none of the world's Neutrino Factory R&D groups has the financial or engineering resources by itself
    - even in combination, their engineering resources are insufficient
- Given their interest in MICE, RAL is natural site to host such a study
  - this means that the site-specific aspects of a study reflect RAL conditions
- Resultant study will represent a much better product if all of the world's Neutrino Factory R&D groups collaborate on it
  - this implies agreeing on the goals of the study and also agreeing on a single, optimized, scenario to examine
    - it's poor strategy to consider alternative implementations in the study, as it gives the impression we cannot decide
  - this will be a difficult hurdle to clear

Resources and Organization

- Lab's upper management must support the Study
  - key resources always over-committed
  - management approval needed to make them available
- In both our studies, request came directly from Lab Director
- Engineering resources will be needed for designing and costing
  - conventional facilities
  - power supplies
  - vacuum
  - magnets
  - RF (especially power)
  - vacuum
  - safety

Resources and Organization

- Some effort on the detector is desirable
  - identifying a viable remote site goes far in making the host lab look like a realistic candidate to host a future facility
- Proper cost optimization of a Neutrino Factory must include both the accelerator and detector
- Scale of effort: ≈20–30 person-years for a Study lasting one year
- For a world Study, leadership activities must be shared among participating groups
  - if all leadership roles taken by host lab, it will not be perceived as a shared activity
  - if none are taken by host lab, the study will likely fail
- Decision-making must likewise be shared, as in any collaboration
- We designated editors to guide major technical areas and write them up for the report, along with an overall editor
  - met in person several times and also via video conference

Summary

- Successful Study will involve effective collaboration among parties with different interests
- Upper management at host lab must support the effort, and recognize the benefits of collaboration
- One of the first issues to resolve is defining (generally site-specific) proton driver parameters
- Then define remaining "ingredients" of chosen design
- Carry out end-to-end simulations early, interacting with key engineers at this stage
- Don't turn engineers loose on design until parameters well defined
- Exercise discipline in changing designs ("better is the enemy of good")
- In addition to the Study report, publishing a summary paper in a journal (e.g., PRST-AB or NIM) is highly desirable
- Doing this Study well will improve the odds of someday having a Neutrino Factory...and that's what we all want!