Fermilab KA12 Summary and Future Plans

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DOE KA12 Review
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U.S. DEPARTMENT OF ENERGY

Fermilab

Current KA12 Program

- Scientific effort on detector R&D supported by KA12
  - Program strongly leverages core engineering and user facilities
  - Three branches of R&D strengthen and enhance each other
- Detector R&D program is ambitious with focus on truly transformational technologies
  - One area has already booked enormous success: Adoption of 3D MPW, initiated by Fermilab, by semi-conductor industry
- Effort enhanced through international collaboration
  - 14 European participants in 3D run, collaboration with industry
  - Use of software infrastructure developed at SLAC
  - LBL, Caltech, IHEP Beijing, SICCAS collaboration on development of materials for calorimetry
- Scientific leadership is recognized well beyond Fermilab and DOE KA12 program

Plan for Existing Effort

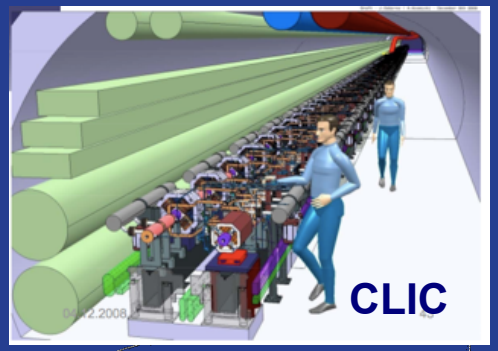
- Our FY10 KA12 budget is $756k
- Request to augment effort by 1 FTE

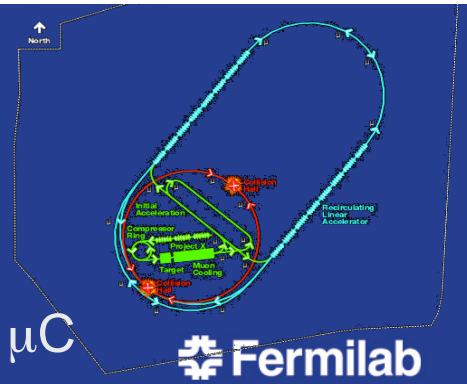
	FY2011	FY2012	FY2013
Total	**$1,000k**	**$1,027k**	**$1,050k**

- Unique opportunity to further develop truly transformational technologies initiated by KA12 support
  - Opportunities of the 3D silicon effort are immense
    - Explore other areas of applicability and areas of broad societal implications
  - SiPM and dual readout very promising
    - Strong synergies with 3D technology

Future Collider Projects

- The field is evaluating which facility to succeed the (s)LHC
- Three major projects are being discussed:
  - ILC: International Linear Collider
    - e^+e^- collider based on SRF technology
    - $\sqrt{s}$ = 500 GeV – 1 TeV
  - CLIC
    - e^+e^- collider based on warm X-band
    - $\sqrt{s}$ = 3 TeV
  - Muon Collider
    - $\sqrt{s}$ = 3 TeV





MAP Initiative

- A concerted national R&D program to address the technical challenges and feasibility issues for a future Neutrino Factory and multi-TeV Muon Collider was called for by DOE
- Muon Accelerator Proposal (MAP) submitted in March 2010

FERMILAB-TM-2459-APC

R&D PROPOSAL FOR THE NATIONAL MUON ACCELERATOR PROGRAM

Revision 5b; February 24, 2010

Abstract

This document contains a description of a multi-year national R&D program aimed at completing a Design Feasibility Study (DFS) for a Muon Collider and, with international participation, a Reference Design Report (RDR) for a muon-based Neutrino Factory. It also includes the supporting component development and experimental efforts that will inform the design studies and permit an initial down-selection of candidate technologies for the ionization cooling and acceleration systems. We intend to carry out this plan with participants from the host national laboratory (Fermilab), those from collaborating U.S. national laboratories (ANL, BNL, Jlab, LBNL, and SNAL), and those from a number of other U.S. laboratories, universities, and SBIR companies. The R&D program that we propose will provide the HEP community with detailed information on future facilities based on intense beams of muons—the Muon Collider and the Neutrino Factory. We believe that these facilities offer the promise of extraordinary physics capabilities. The Muon Collider presents a powerful option to explore the energy frontier and the Neutrino Factory gives the opportunity to perform the most sensitive neutrino oscillation experiments possible, while also opening expanded avenues for the study of new physics in the neutrino sector. The synergy between the two facilities presents the opportunity for an extremely broad physics program and a unique pathway in accelerator facilities. Our work will give clear

214 MAP participants from 14 institutions

Department of Energy
Office of Science
Washington, DC 20585

October 2, 2009

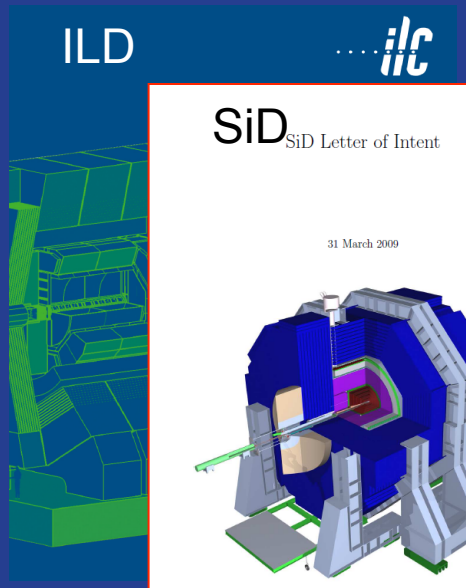
Dr. Pier Oddone
Fermi National Accelerator Laboratory
P.O. Box 500
Batavia, Illinois 60510

Dear Dr. Oddone:

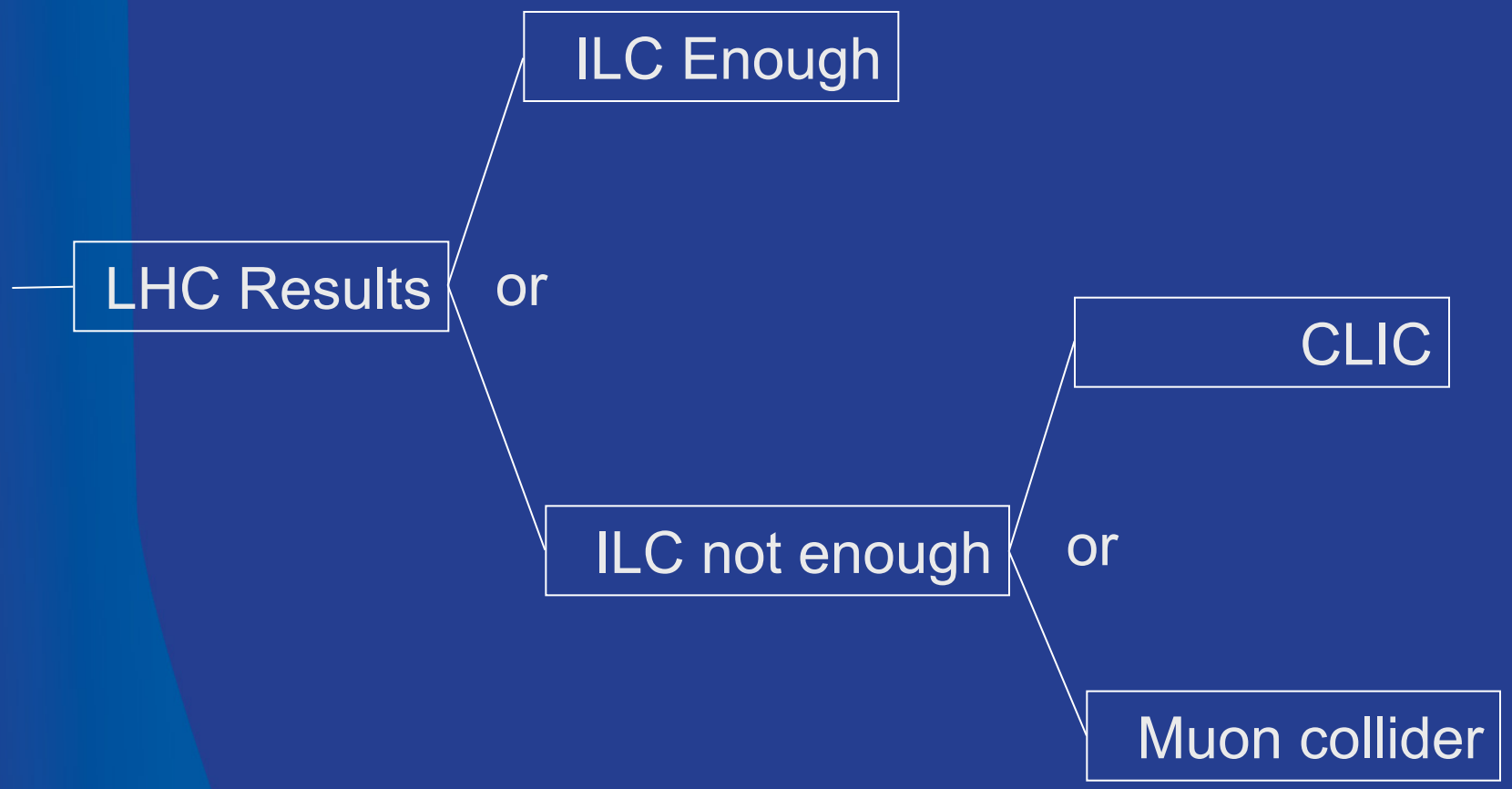
Our Office believes that it is timely to mount a concerted national R&D program that addresses the technical challenges and feasibility issues relevant to the capabilities needed for future Neutrino Factory and multi-TeV Muon Collider facilities. This is consistent with the guidance we obtained from the Accelerator Science Review in December, 2008 and with the envisioned overall national strategy as articulated in the P5 Report in 2008.

Timeline

- The ILC concept detectors submitted detailed LOIs in March 2009
- CLIC is preparing a 3-volume CDR by April 2011, to be followed by TDR in ~2016
- Validated ILC detectors preparing for a Detailed Baseline Design (DBD) in 2012
- MAP proposal (accelerator) ~6year long program
- No accompanying Physics and Detector effort and report for a Muon Collider



Options



- To ensure that the community has an option for a ~3 TeV lepton collider, an objective, quantitative comparison study needs to be carried out

Current Status

- Coordinated effort begun on physics, detector and background studies (see Mokhov's talk)
  - New studies show encouraging results
  - Kick-off workshop on Physics and Detectors held at Fermilab Nov. 10-12, 2009
    - organizers: Ken Peach(UK), Jacobo Konigsberg (Florida), Estia Eichten
    - (http://www.fnal.gov/directorate/Longrange/Steering_Public/workshop-muoncollider.html)
  - Rapid feedback between background and lattice
- Started biweekly meetings including SLAC, Fermilab, INFN and other interested parties
- Another workshop planned for the end of the year
- Aim is to create an active detector design and simulation group, but current resources are not adequate

Synergies

- The overall physics goals of a future lepton collider are very similar for ILC/CLIC/MC, though operational conditions vary substantially
  - Analysis techniques are essentially the same
  - Some detector technologies are shared
  - Software infrastructure could be common
- Need to develop an objective comparison of the options in terms of physics performance so that the relevant information is available to enable a well-informed choice for a future energy frontier lepton collider
- Within the US WWS there “are already small efforts in the direction of interaction between the linear collider physics and detector community, and those working on the muon collider detectors” (Jim Brau)

Muon Simulation Effort at Fermilab

- 2011
  - 1.0 FTE Optimization of nozzle and shielding at MDI
  - 1.0 FTE Development of fast Monte Carlo
  - 0.3 FTE Computing support
- 2012
  - 2.0 FTE Full integration of backgrounds in simulation
  - 2.0 FTE Development of physics analyses tools and benchmarking
  - 0.5 FTE Computing support
- 2013
  - 1.0 FTE Full integration of backgrounds in simulation
  - 4.0 FTE Development of physics analyses tools and benchmarking
  - 1.0 FTE Computing support

Proposed Muon Collider Activity

- Request for support at the level of 2.3 FTE in 2011, growing to 6 FTE in 2013, mainly for simulation studies

DOE Support			
	2011	2012	2013
Personnel Support from DOE:	Muon Collider	Muon Collider	Muon Collider
	FTE	FTE	FTE
Permanent PhD	2.00	4.00	5.00
Temporary PhD			
Graduate Students			
Engineer			
Computing Professional	0.30	0.50	1.00
Technician			
Administrative			
TOTAL	2.30	4.50	6.00
DOE/HEP Funding (per activity):			
SWF (in $, include overhead)	$625,000	$1,250,000	$1,715,000
M&S (in $, include overhead)	$70,000	$100,000	$130,000
Travel (in $, include overhead)	$15,000	$15,000	$15,000
TOTAL	**$710,000**	**$1,365,000**	**$1,860,000**

Deliverables

- The Fermilab Muon Collider specific contribution of the 5-lab program carried out in the framework of the ‘white paper’ would include:
  - Follow-up workshop late fall 2010
    - ILC and CLIC community included
  - Investment in the further development of fast Monte Carlos for lepton collider physics simulations
  - Feasibility study for a Muon Collider physics and detector program by the end of 2011
  - Development of conceptual detector designs by end 2013 for the Muon Collider
  - Conceptual design report late 2013, early 2014
  - Support for associated detector development

Lepton Collider Program

- Expertise available at Fermilab for the community to develop a unified lepton collider program:
  - Magnetic lattice and magnet design group for MuC resides at Fermilab
  - Beam background calculations and experts, reside at Fermilab
  - Geant4 beamline simulation group resides at Fermilab
    - Feeds in directly to org.lcsim simulations
  - HEP software expertise

- Moreover, current KA12 scientific efforts will leverage a unified lepton collider program

Overall Level of Effort Requested

	2010	2011	2012	2013
“Electron” FTE	2.6	3.35	3.35	3.35
“Electron” k$	$756	$1,000	$1,027	$1,050
“Muon” FTE		2.3	4.5	6.0
“Muon” k$		$710	$1,365	$1,860
Total FTE	2.6	5.65	7.85	9.35
Total (k$)	$756	$1,710	$2,392	$2,910

Unified Approach

- A coordinated Lepton Collider Program would
  - Develop the physics and detector program of lepton colliders
  - Coordinate the US efforts within the global physics and detector efforts
  - Define the physics case and the required detector and machine performance
  - Define required detector concepts (if they do not exist)
  - Determine whether existing detector concepts can be used
  - Compare the physics potential of all options on an equal footing
  - Make use of existing software frameworks to do the work, avoiding duplication
  - Define the R&D needs of the detector concepts
  - Guide and monitor the R&D
  - Define a program that can be executed within a certain budget

- A coordinated program of detector research is timely and appropriate. The 5 labs have proposed this to DOE (See D. MacFarlane's introduction)

Unified Approach

- A coordinated Lepton Collider Program would build on and fully leverage the impressive accomplishments and investments in ILC development

- It would provide the community with a mechanism to:
  - Continue to play a leadership role in the design of concept detectors at lepton colliders in general
  - Have directed investment in the development of new detector technologies
  - Enable an informed objective comparison of the various options in terms of physics performance

- Fermilab supports this unified approach and offers its expertise to develop a successful program