A Feasibility Study on a Neutrino Source Based on a Muon Storage Ring

Interim Study Meeting, Feb. 15th/16th '00

Norbert Holtkamp

- Introduction
- Charge
- Basic Parameters
- Site Specific ??
- The Report
- Cost
- Goal for the Meeting
- Timing
- Miscellaneous

The Program

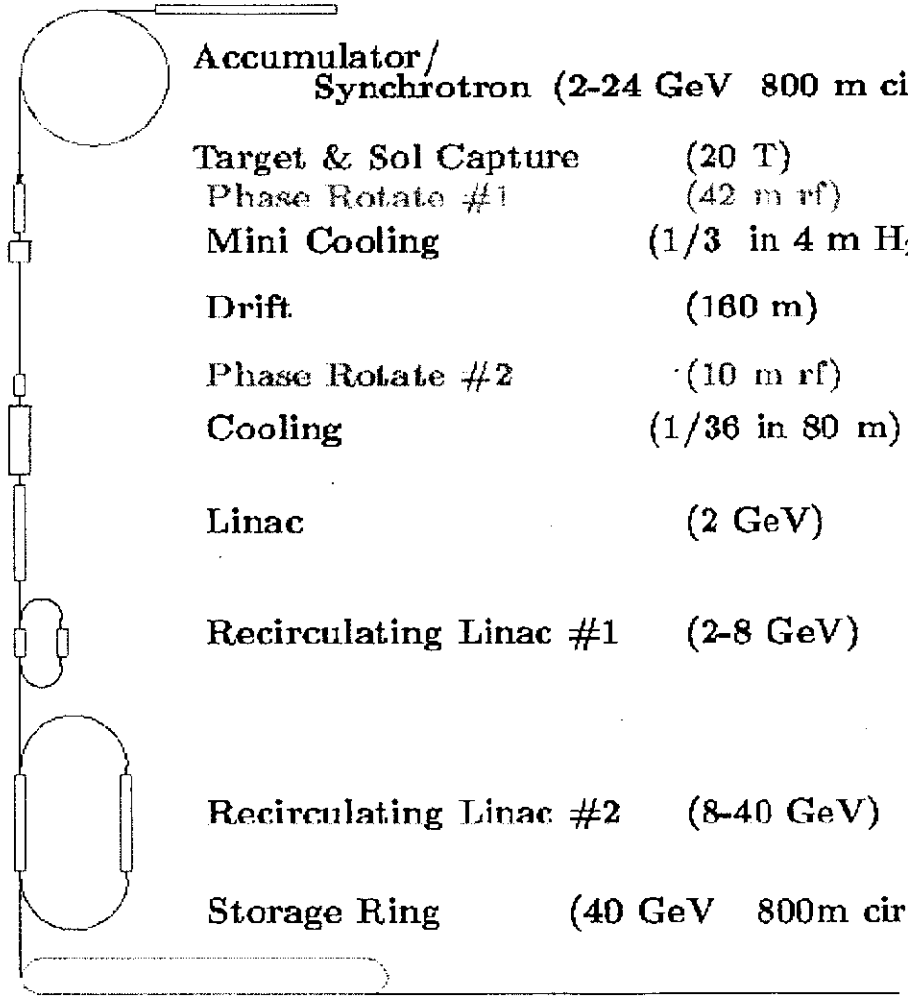
Time	Topic	Speaker	
08:30 AM	**Welcome**	A. Sessler	LBNL
08:40	**Introduction and Tasks**	N.Holtkamp	FNAL
09:00	**Physics Motivation and Boundary Conditions**	S. Geer / H.Schellman	FNAL
09:30	**coffee break**		
09:45	**Proton Driver**	W. Chou	FNAL
	Target		
10:30	Target Proposal	S. Childress	FNAL
10:45	Particle Production, Shelding, Capture	N. Mokhov	FNAL
11:05	Target Support	P. Spampinato	ORNL
11:25	Target Magnet and Taper	J. Miller	FHML
11:45	Target Development	K. McDonald	Princeton
12:00	**Discussion**		
12:30 PM	**Lunch**		
	Decay Channel, Phase Rotation & Induction Linac		
01:30	Concept + Mini Cooling Strategy	V. Balbekov	FNAL
02:00	Induction Linac Technology	S. Yu	LBNL
02:30	**Adiabatic Capture**	D. Neuffer	FNAL
	Cooling		
03:00	Integrated Front End Simulation	C. Kim	LBNL
03:40	**Coffee Break**		
04:00	Cooling cells + Refrigeration	D. Kaplan	IIT/FNAL
04:30	High power RF	J. Reid	FNAL
05:00	Magnets	S. Kozub	IHEP
05:30	Cavity Design	T. Juergens	FNAL
05:50	Discussion		
07:30	**Dinner**		
Wednesday	**Muon Acceleration**		Wed.
08:30	Introduction and Simulations		Jefferson Lab.
09:30	Cavities + RF Systems	J. Delayen	Jefferson Lab.
10:00	Low Frequency RF systems consideration	H. Padamsee	Cornell
10:30	**Coffee Break**	C. Johnstone	FNAL
10:45	Arc's Design and Bending Magnet Requ		
	Storage Ring		
11:05	General	D. Finley	FNAL
11:25	Lattice Layout, Injection, Production Straights	C. Johnstone	FNAL
11:55	Magnets for the Storage Ring	N. Andreev	FNAL
12:20	Beam Induced Energy Deposition	N. Mokhov	FNAL
12:40	**Discussion**		
01:00 PM	**Lunch**		
02:00	**Solenoid Channels**		IHEP
	(4 types of channels)		
02:20	**Power Supplies & Power Consumption**	D. Wolff	FNAL
02:40	**Cryo Systems**	M. McAshan	FNAL
	(without RLAs and sc linac)		
03:00	**Power/Cooling/Utilities**		FNAL
03:10	**Discussion**		
03:20	**Coffee Break**		
03:30	**ES&H**	D. Cossairt	FNAL
03:50	**FESS**	J. Sims/D. Finley	FNAL
04:20	**The R&D Program**	M. Zisman	LBNL
05:00	**Discussion**		

This Meeting

- The program:
  - Time very tight: David Finley and me will run the meeting and interrupt discussion if necessary
  - Alternative solutions: there will only be very limited discussion on deviations from our baseline scenario
- Copies from Transparencies:
  - please prepare transparencies for copying after your talk. Will be collected and given back to you.
  - Will try to get the copies on the web asap
  - will be on our major web page: http://www.fnal.gov/projects/muon_collider/nu-factory/
- 20 folders are being prepared for people to take, at least each institute should have one.
- Email service: 9th floor west, terminals
- The restaurant:
  - reservation for ~40 people tonight. Maps will be distributed.

Neutrino Source Study

- ICFA/ECFA workshop on Neutrino Factories Based on Muon Storage Rings, 5-9/7/99, Lyon (France). -> PJK
- Application of a "Generic Neutrino Source" to specific site



Generic Layout

↓

collaboration paper

"deviate wherever necessary or useful"

Physics Study in parallel
H. Schellmann / S. Geer

The Charge

- **A design concept for a muon storage ring and associated support facilities that could, with reasonable assurance, meet performance goals required to support a compelling neutrino based research program.**

- **2.Identification of the likely cost drivers within such a facility.**

- **3.Identification of an R&D program that would be required to address key areas of technological uncertainty and cost/performance optimization within this design, and that would, upon successful completion, allow one to move with confidence into the conceptual design stage of such a facility.**

- **4.Identification of any specific environmental, safety, and health issues that will require our attention.**

Choice has been made !

Parameters for the Neutrino Source		
- Energy of the ring	**GeV**	**50**
- Number of neutrinos / straight		**$2x10^{20}$/y**
- no polarization		
- capability to switch between μ^+ μ^-		
- FERMI to SLAC / LBNL		

- Basic Calculation
  - 1/3 of the muons decay in the straight section (38 %)
  - 10 protons for 1 μ into the storage ring (>10; >20-50)
  - $2x10^7$ sec
    - $2x10^{13}$ proton on target per pulse @ 16 GeV and 15 Hz
      - $3x10^{13}$ proton because of carbon target
    - $2x10^{12}$ μ per pulse to be accelerated and injected into the ring
      - cooling channel ???
    - longer bunch in the proton driver and on target (1 nsec → 3)
      - helps
    - ring tilt angle is 13deg (22 %) instead of 35 deg (57 %)
      - ring with these params: not a cost driver at all

The Neutrino Source

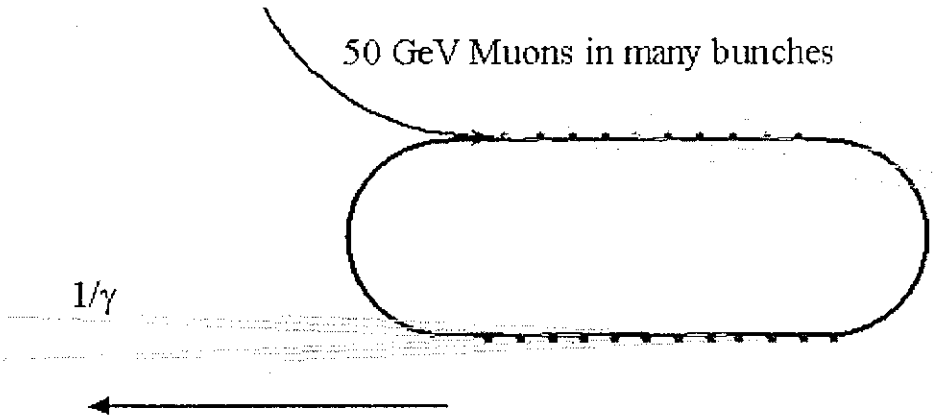
- Approach:
  - **go more conventional where ever possible**
  - Oak Ridge, NHMFL, Brookhaven ⇒ the target
    - solid target
  - Jefferson Lab / Cornell ⇒ sc rf and re-circulating linacs
    - probably the cost driver
  - LBNL , DUBNA ⇒ induction linacs
    - goes much better than expected but not cheap
  - IHEP Protvino ⇒ sc solenoid channels
    - convenient, + cross checked with NHMFL, LBNL, FERMI
  - specific design and engineering (cooling channel, target collection, beam manipulation, beam tracking and simulation) → Muon Collider group (~12 people @FNAL) + the collaboration
    - (thanks to Andy and Mike for the enormous support they organized)
  - general engineering (large scale rf systems, sc magnets, sc solenoid channels, ps, vacuum, beam lines, tunnel, water) (20 FTE for 6 month)

The Neutrino Source

based on stripped PJK scenario

- First experiment based on an intense muon source -> does it have to be 50 GeV ??
  - 10 GeV and 50 kT or more magnetized water detector: Goal: Balance detector cost with Accelerator: E*kT*I=const.
  - Start with $2x10^{19}$/year (Sessler, Geer) and still good physics ?

Muon Storage Ring as a Neutrino Source



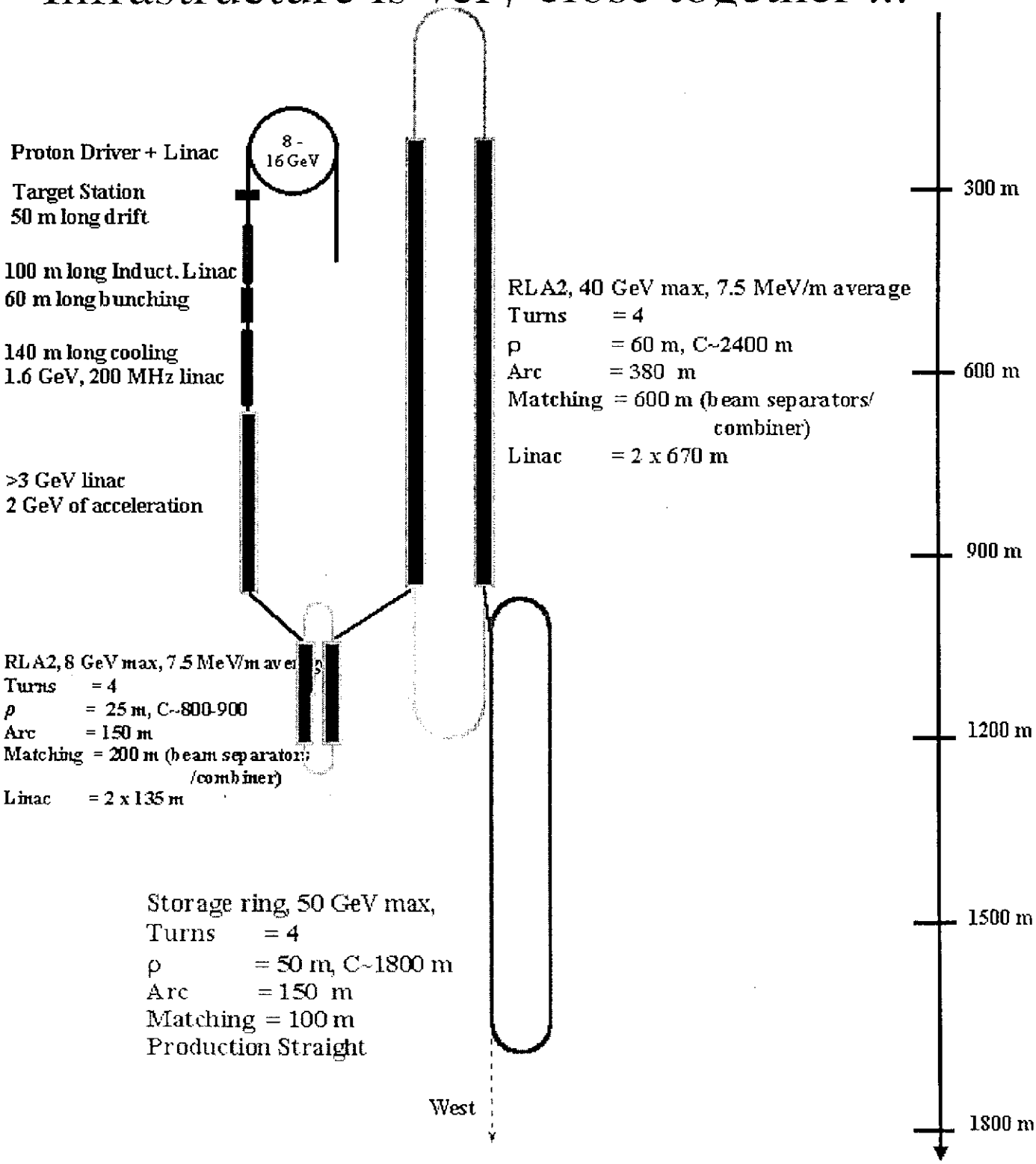
Medium baseline experiment eg Fermi -> SLAC/LBNL 2900 km

Parameters for the Muon Storage Ring		
Energy	GeV	50
decay ratio	%	>40
inv. Emittance	m*rad	**0.0032**
β in straight	m	160
N_μ/pulse	10^{12}	6
typical decay angle of μ = 1/γ	mrad	2.0
Beam angle ($\sqrt{\varepsilon}/\beta_o$) = ($\sqrt{\varepsilon}\,\gamma$)	mrad	0.2
Lifetime c*γ*τ	m	$3x10^5$

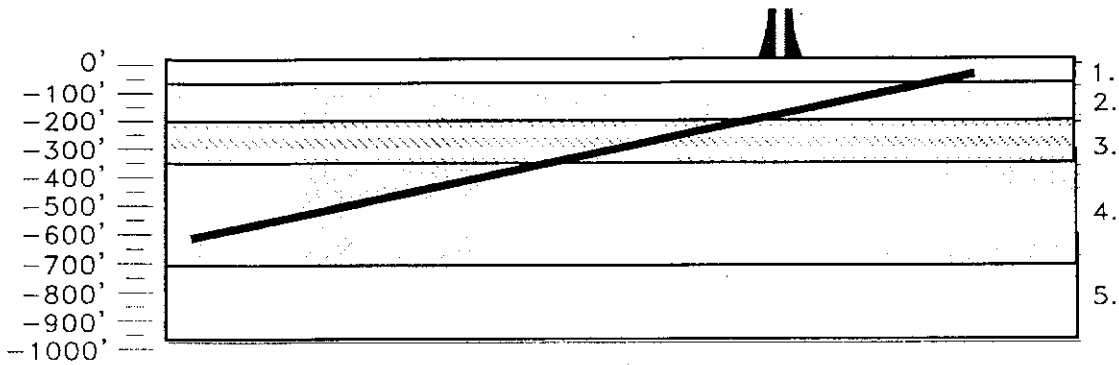
$\gamma = (1-\alpha^2)/\beta$

Footprint for a 50 GeV Neutrino Source

- Infrastructure is very close together ...



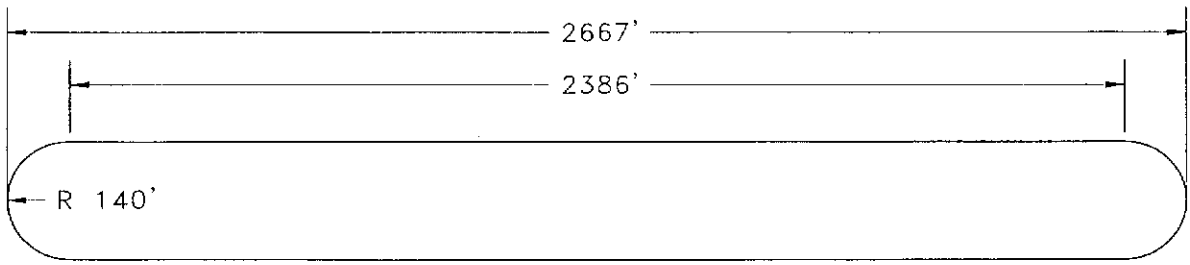
What is Site Specific ?



GEOLOGY DETAIL

1"=100'-0"

1. GLACIAL TILL – AQUIFER
2. SILURIAN GROUP – AQUIFER (PRIMARILY DOLOMITE)
3. MAQUOKETA GROUP – AQUIFER (PRIMARILY SHALE)
4. GALENA / PLATTEVILLE GROUP – AQUATARD (PRIMARILY DOLOMITE)
5. ANCEL GROUP – AQUIFER (PRIMARILY SANDSTONE)



CE 2.1 LATTICE PLAN

N.T.S.

ORIENTATION:

NAME	AZIMUTH (DEG-MIN-SEC)	VERT. ANGLE (DEG-MIN-SEC)
PALO ALTO CA.	271-20'-42.27"	-13-09'-26.99"

MuSR

CTE 15-OCT-99

The Report

Fermilab March 2000

A Feasibility Study of a Neutrino Source based on a Muon Storage Ring

edited by:

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The Report

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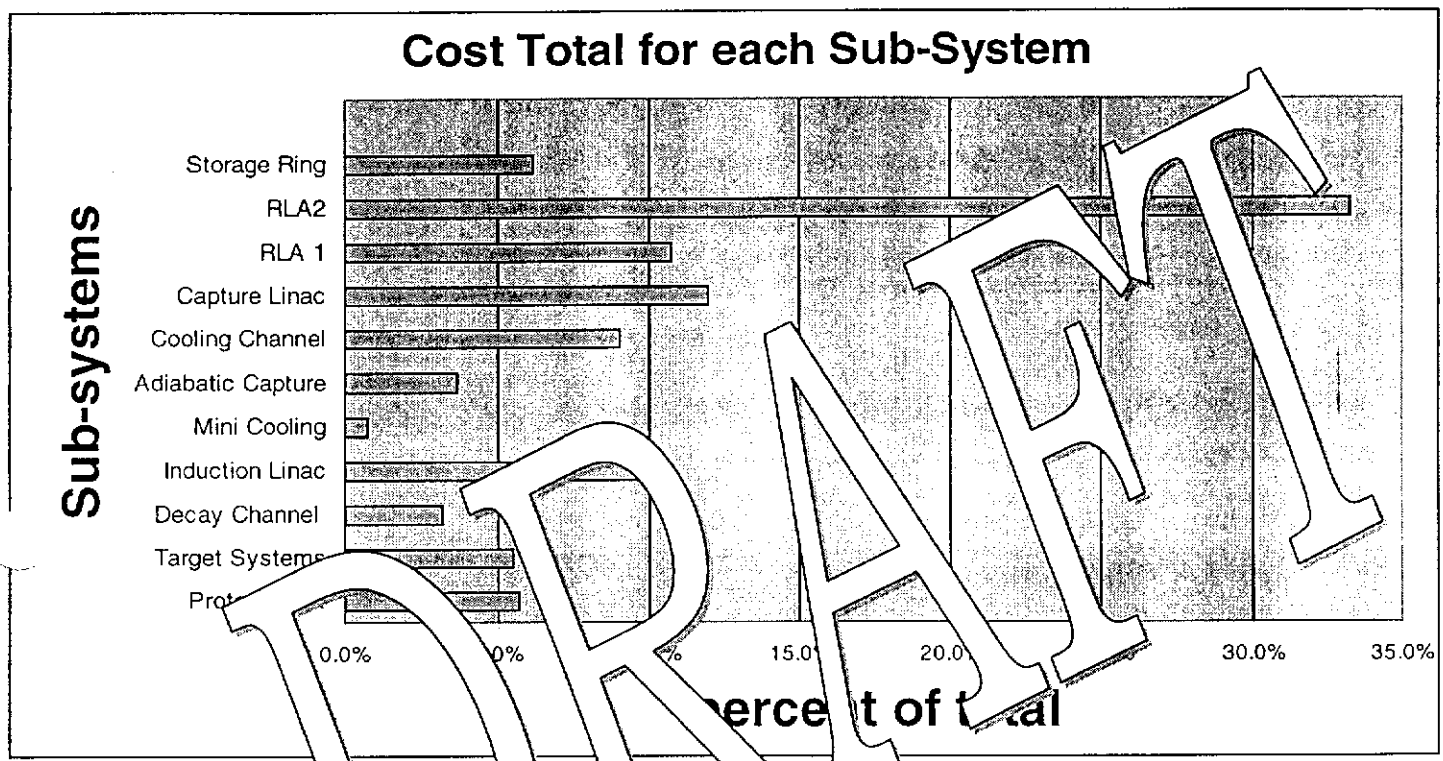
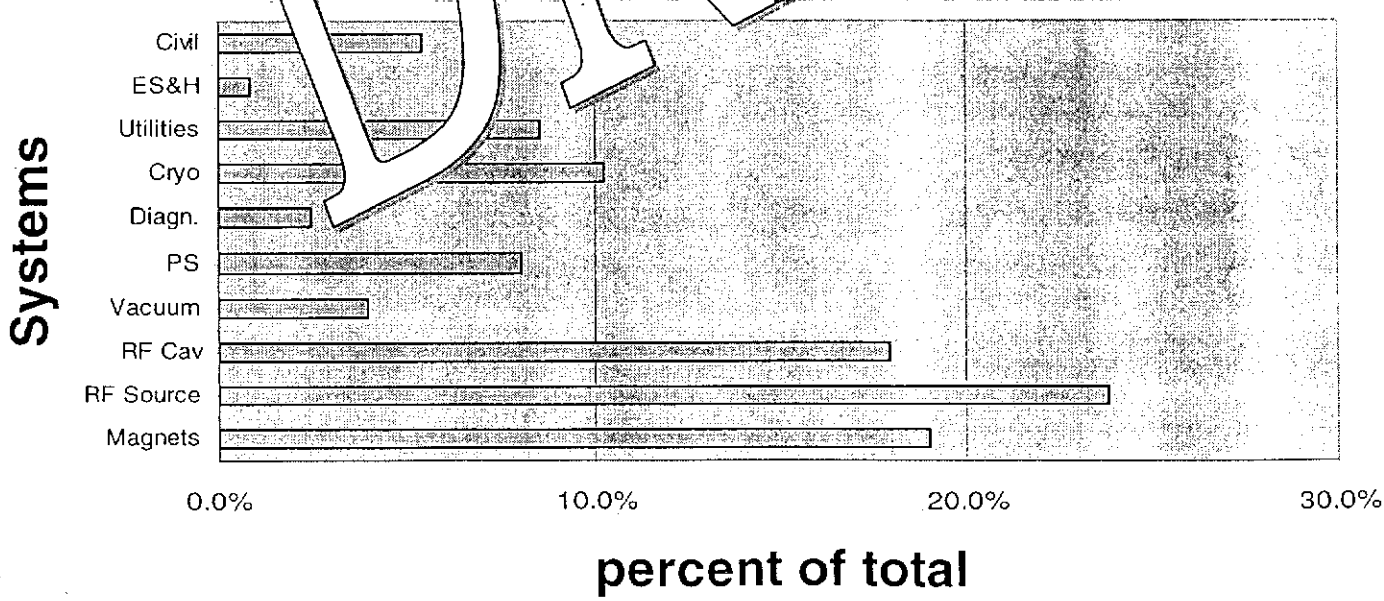
1: Members of the Neutrino Factory and Muon Collider Collaboration
2: Participants in this specific study

Cost

- Hot Topic: Proposal for Presentation.





Goals

- The overall goal for the meeting is to present the status of the work,
- It is mainly to prepare the report and make it smooth to read but still clear in what we accomplished and what we think.

- Goal 1) Presentation for each subsystem. What are the assumptions, what are the accomplishments and where are the issues and what are they. This will lead to the famous "10 pages per subsystem".

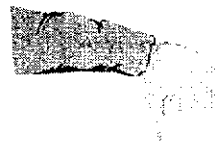
- Goal 2) Cost drivers. That means estimating cost and finding out what are the most expensive pieces. I would like to ask everybody to talk about cost in a responsible and careful manner at this point in time. We will not talk about the specific cost for each subsystem in this meeting but it is useful to understand for everybody what drives cost. For the people preparing cost number:
  - without contingency
  - without escalation
  - with error bar if possible

- Goal 3) R&D on a route to a Neutrino Source. This will lead to the famous "1 page for R&D".

Schedule

- 6 Month study: → "10 pages of paper per subsystem+ 1 schedule + 1 cost"
  - Started on Sept. 1st.
  - Internal Review Feb. 15th and 16th for the Accelerator part, Feb. 17th and 18th for Geer/Shellman to align the different contributions
  - Documents in by March 15th
  - Report out by March 30th (6 month ???)
- The Cost Page:
  - Propriety information which people can get from the 2nd Floor at Fermi -> Steve Holmes etc.
  - Document will include cost scaling for lower energy facility (20 GeV) and lower intensity ($2x10^{19}$) /year
- The R&D page
  - Mike Zisman volunteered to write this matching the R&D program proposed by the collaboration

Questions

- What comes after the study ?
  - Review the results
  - Is the physics compelling enough 
  - **Does the lab want to do this ?** 
  - Are we in a position to go into a Hardware R&D program for a Neutrino Factory?
  - What are the required resources to have a ZDR 5 years from now?