The Fermi Lab

Norbert Holtkamp

Target Meeting @ Fermi Lab, Dec. 2nd, 1999

- Program
- Introduction
- Muon Collider
- Neutrino Sources
- Parameters
- Neutrino Source Study @ Fermi Lab
- Summary

The Program

Speaker	Time	Subject
Norbert Holtkamp	9:00-9:30	Parameters and Introduction to the Fermi lab Feasibility Study
Nikolai Mokhov	9:30-10:00	Target Calculations and Radiation levels.
coffee break	10:00-10:15	
ORNL	10:15-11:00	Target Station layout and specifics for the Neutrino Source Target
John Miller (or repl.)	11:00-11:30	SC / NC magnets in the target station. Magnetic field requirement.
General Discussion	11:30-12:15	
Sam Childress	1:30-2:15	NuMI Target and experience + extrapolation to Neutrino Source
Sam Childress+ all	2:15-2:45	Cooling for the Target (Radiation Cooling or not)
Tom Kobilarcik	2:45-3:30	Proton Beam Optics in +out
Directors Coffee	3:30-4:00	
John Miller, Al Zeller, Nicolai Mokhov	4:00-4:30	Radiation Damage and Handling
Everybody	4:30-5:30	To Do List. Who does what. Schedule. Information Exchange. Who needs what from whom....
Everybody	6:30-.....	Dinner (self pay)

Friday morning is available in case we doen't make it. !!!!!

The Goal of the meeting

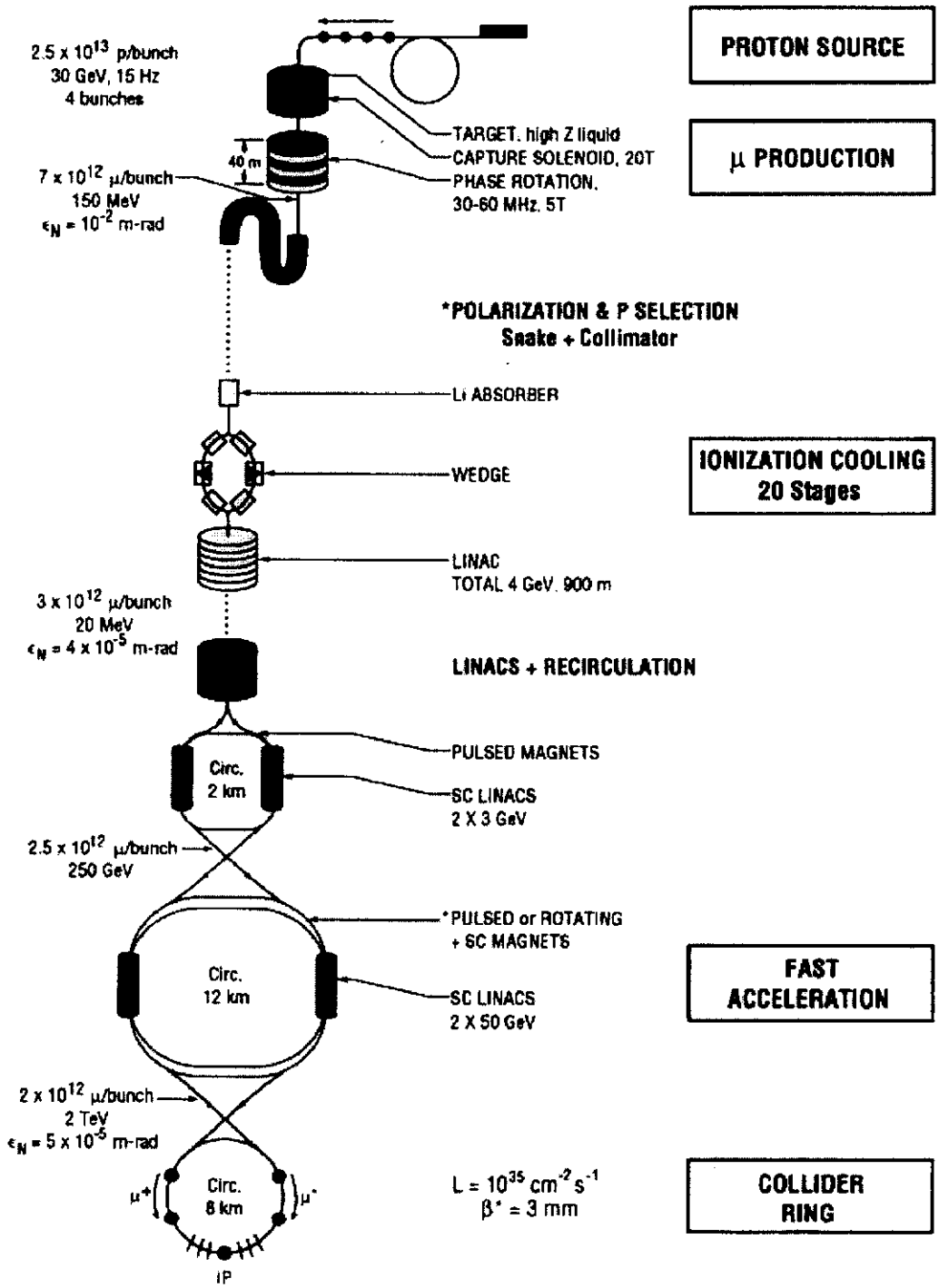
- The goal of the meeting is to establish the present understanding of a possible target station for a Neutrino source. The basis for the Target station should be a solid target with a primary proton beam power of 1.0-1.5 MW. The preferred target material is carbon, but this should be discussed again

- The target station layout should allow the ultimate beam power being discussed in the present layout (see Muon Collider report) which is four Megawatt. The infrastructure, shielding etc should be designed for this beam power on target as well.

- A further goal is to bring the required people together at least once before we go into the final phase of designing. This means people designing the collection magnet, the target itself, the optics for the incoming and outgoing proton beam and the experts in different fields therein.

- I believe, that we have a good chance of finishing the meeting Thursday, if not Friday morning is still available.

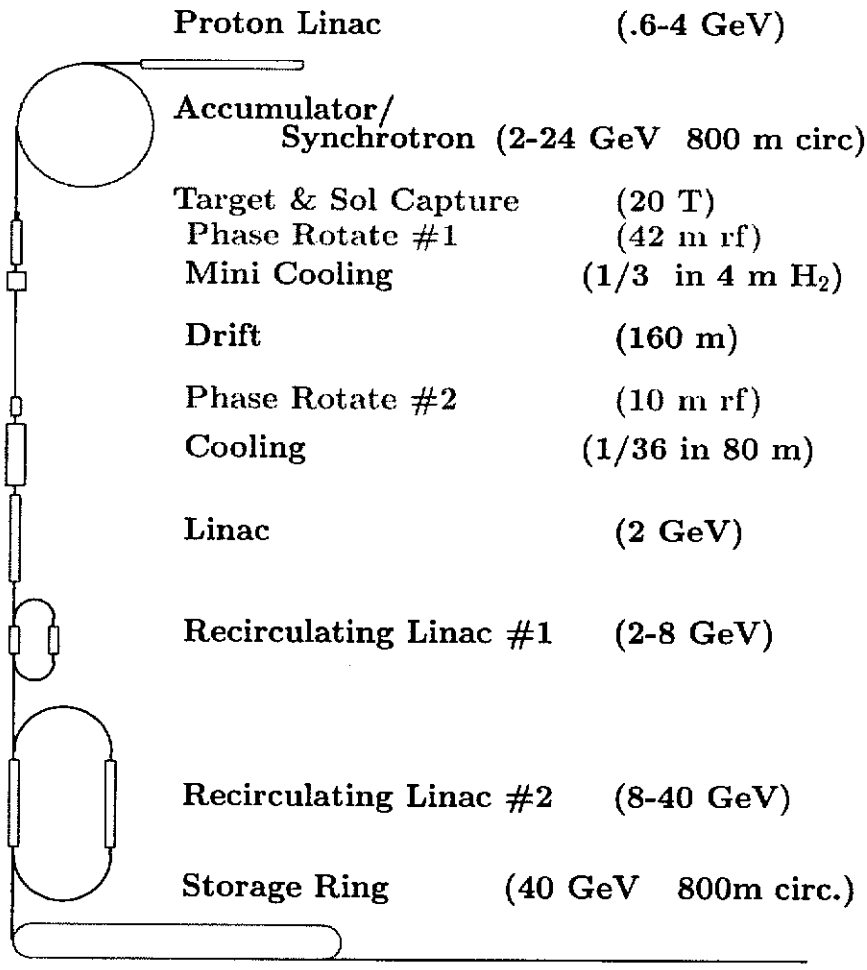
The Artists View of a Muon Collider



Web: **FNAL: http://www.fnal.gov/projects/muon_collider**
BNL : http://www.cap.bnl.gov/mucollider

Neutrino Source Study @ FERMI

- Application of a "Generic Neutrino Source" to specific site
- Base the study on specific set of Parameters
- 6 month period of time to define the R&D program and develop a layout to investigate the scope of such a complex



Generic Layout

⬇

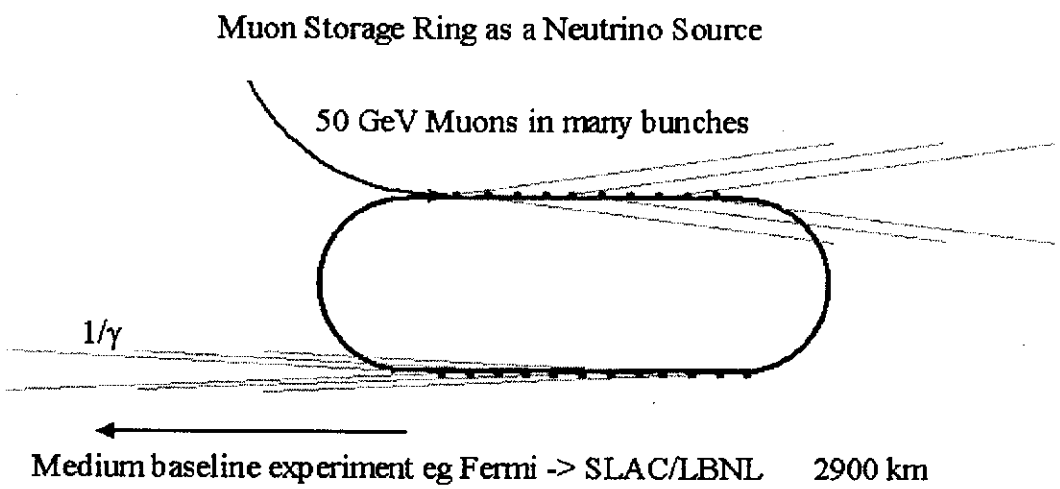
collaboration paper

"deviate wherever necessary or useful"

Physics Study in parallel
H. Schellmann / S. Geer

The Neutrino Source

- First experiment based on an intense muon source
  - small emittance not necessary because divergence is dominated by decay kinematics
  - recognized by S. Geer



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 $c*\gamma*\tau$	m	$3x10^5$

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

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
  - 10 protons for 1 μ into the storage ring
  - how long is the year: $2x10^7$ sec (versus $1x10^7$)
    - $2x10^{13}$ proton on target per pulse @ 16 GeV and 15 Hz
    - $2x10^{12}$ μ per pulse to be accelerated and injected into the ring
    - longer bunch in the proton driver and on target (1 nsec → 3)
    - ring tilt angle is 13deg (22 %) instead of 35 deg (57 %)
    - maximizing the straight section with respect to circumference

R & D Issues for the Proton Driver Design Study

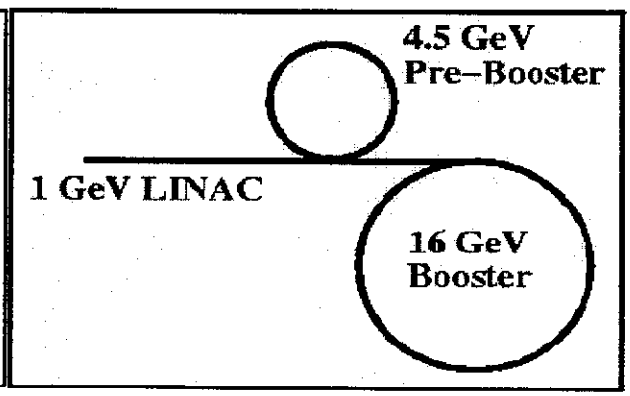
- The Proton driver study
  - –discusses optimum design for anything between 3 - 16 GeV
  - –probably around 8 GeV is maximum for Pion production
  - –so far locked into 16 GeV design

- R & D groups:
  - **–RF, beam loading, feedback**
  - **–Collective effects**
  - **–Magnet, power supplies, vacuum**
  - **–Lattice**
  - **–H^- source and linac / linac upgrade**
  - **–Collaboration with Kek/Japan**

Upgrade 400 MeV Linac –> 1 GeV

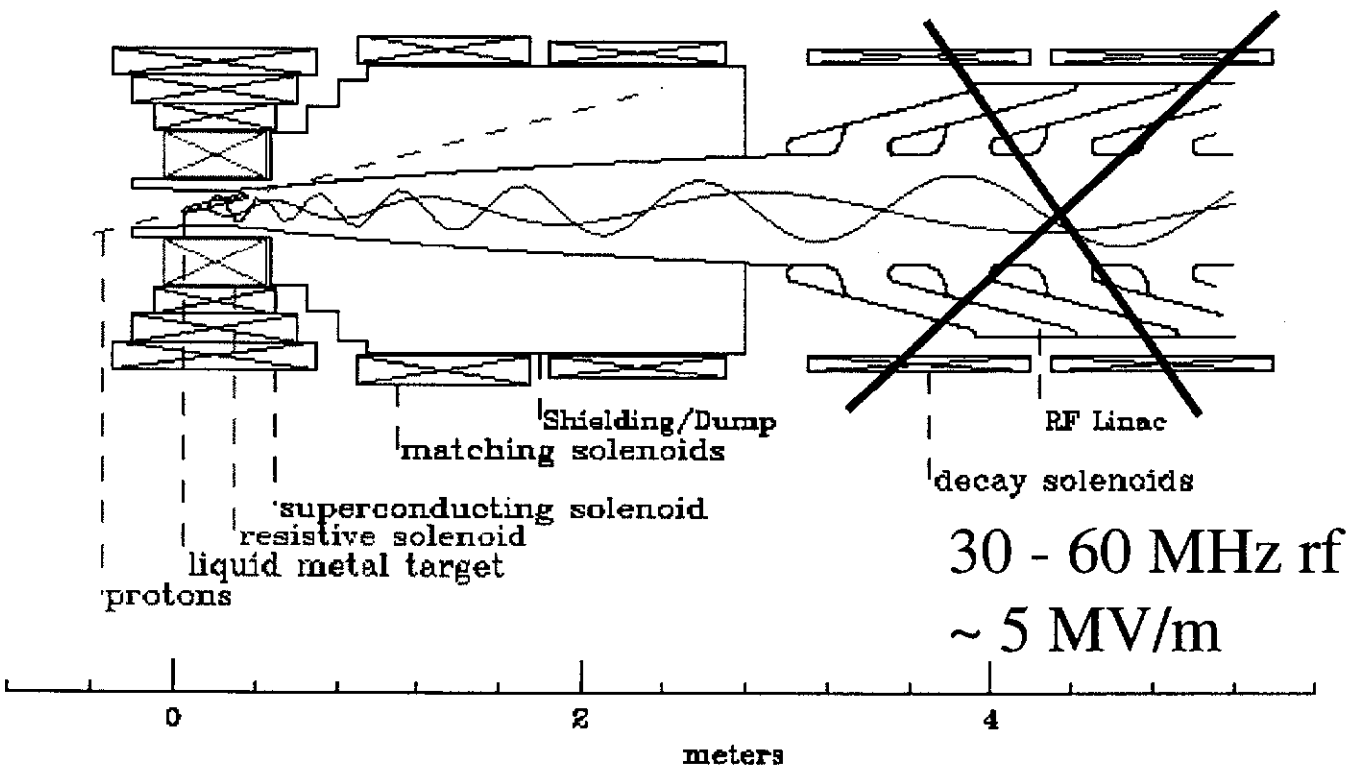
Upgrade 8 GeV Booster –> 16 GeV

Add a 4.5 GeV (3 GeV ?) Pre–Booster (facilitates short bunches).



What changes compared to MC

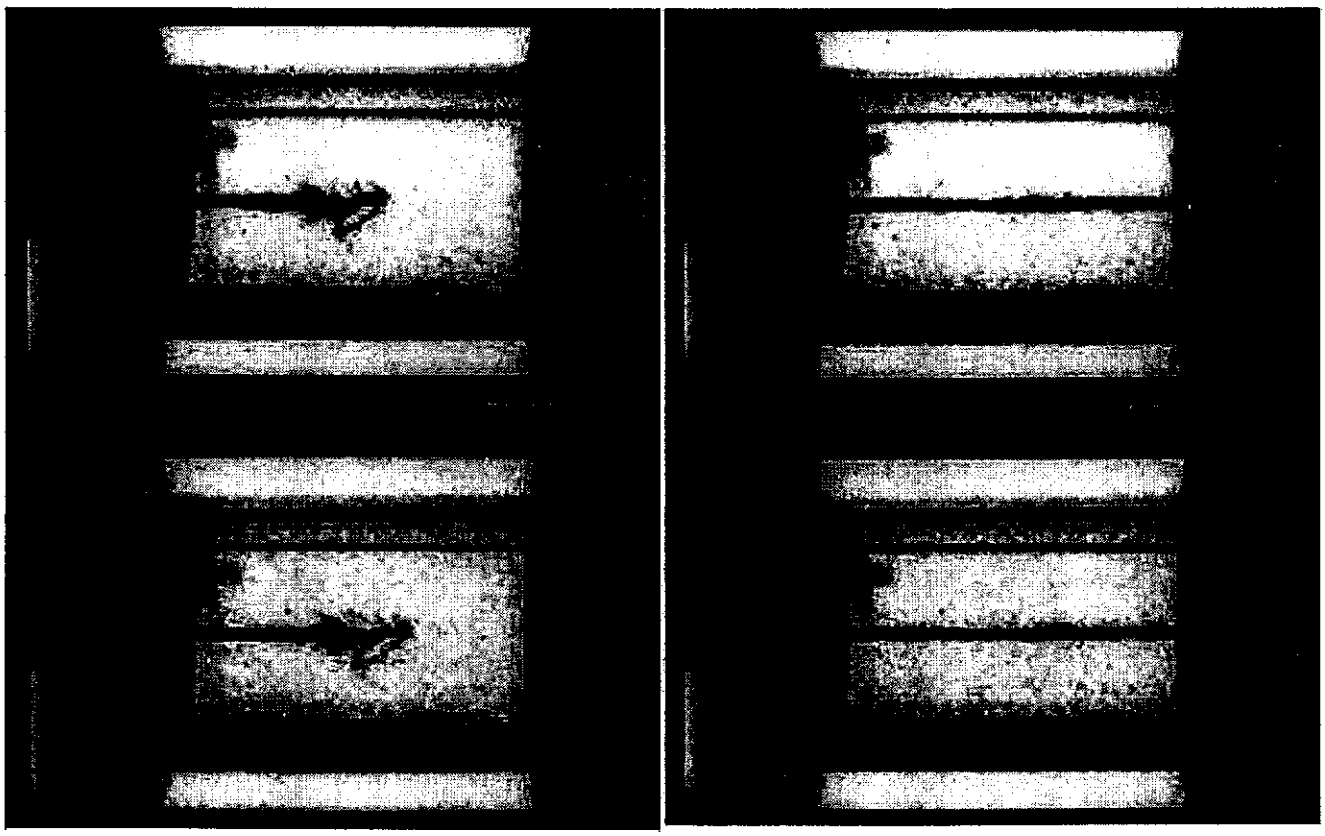
- The Proton driver
  - one bunch (if induction linac
  - longer bunch (-> no polarization)
- The target
  - could be: P_{target} is still of the order of 1, solid graphite)



- 16 GeV protons at 2.5×10^{13}
- 1 bunches per pulse on target
- solid graphite type target (NuMI)
- 0.6 π+ per proton
- $p_z \sim p_t$ 200 MeV/c with $\sigma_E \sim 100$ %

Targets

- New developments
  - liquid jets
  - powder
  - pellets



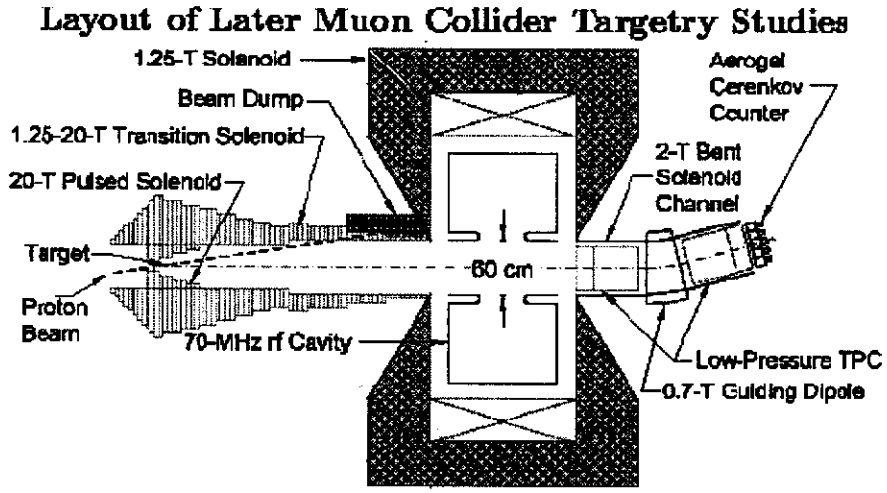
High-speed photographs of mercury jet target for CERN-PS-AA (laboratory tests)

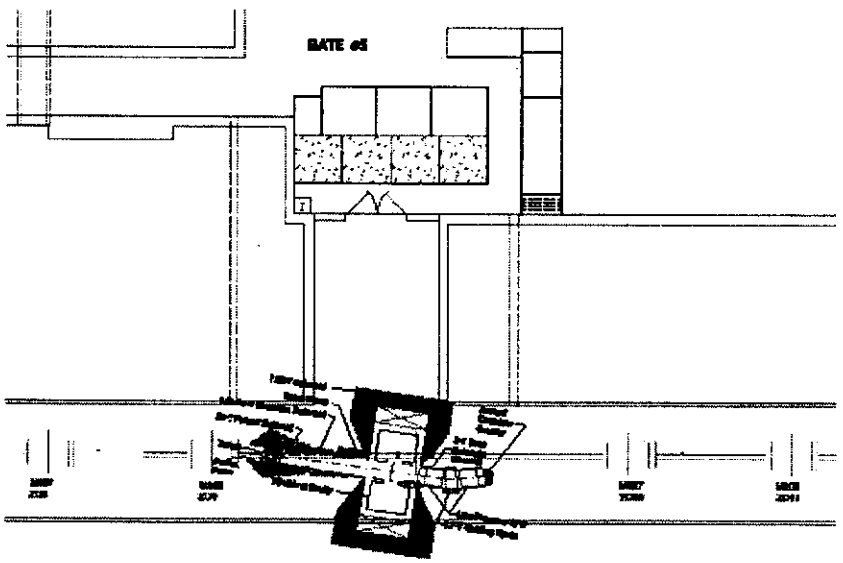
4,000 frames per second, Jet speed: 20 ms-1, diameter: 3 mm, Reynold's Number:>100,000

A. Poncet

Target Experiment

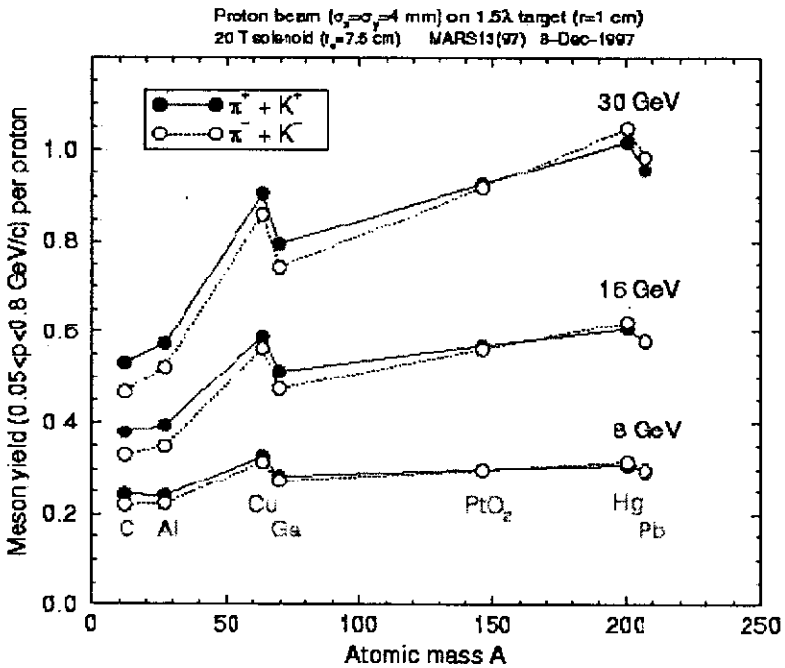
- The experiment in Brookhaven
  - AGS: 10^{14} protons in one bunch
    - study shock
    - build low Frequ. RF system in irradiated area





Why Change the Material?

- The pion production



- Low energy proton beams favor lower Z targets.
- For a Neutrino Source, the gain is proportional to the number of muons produced.
- For a Muon Collider, the gain is proportional to the number of muons squared

- The power deposition

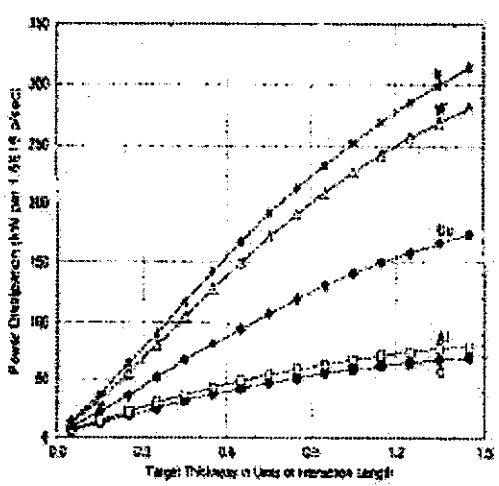
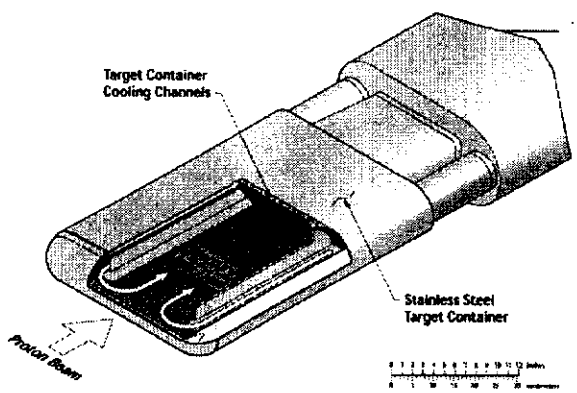


Figure 4.12: Average power dissipation in different 1 cm radius targets due to 8 GeV incident beam of 8×10^{13} protons at 30 Hz. Beam rms spot size $\sigma_x = \sigma_y = 4$ mm.

- Factor of ~ 5 less power stays in the target for the same primary beam power
- Still a factor of 3 or so less for the same yield (but higher beam power).

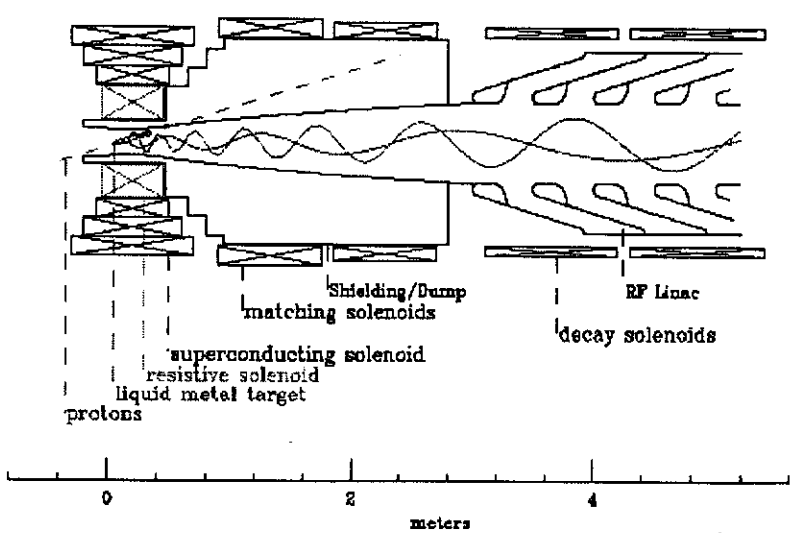
A Target for the Neutrino Factory

- Comparable Targets
  - RAL: Spallation neutron sources
  - CERN/ FNAL: p-Bar production
  - new developments for Muon sources
  - NSNS Oak Ridge



•Numi Target

•Target Experiment



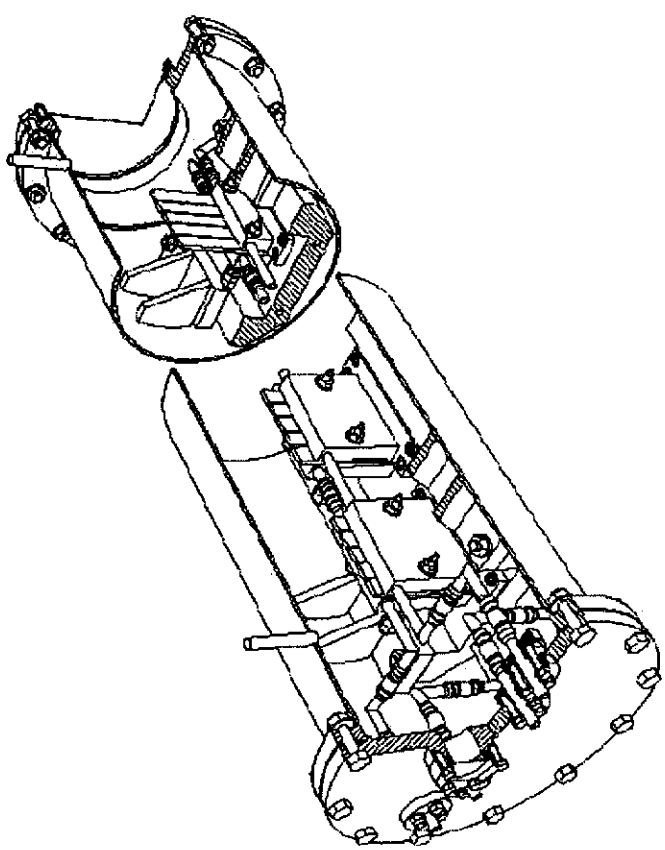


Figure 1.16: Perspective view of the target design.

The Neutrino Source

- Approach:
  - go more conventional where ever possible
    - target (solid), longer bunch in proton driver, remove (~30MHz) rf -> use induction linac,
    - get outside expertise where necessary and/or useful (target, acceleration, induction linacs, sc solenoids)

      - Oak Ridge, FHML, Argonne, Brookhaven ⇒ the target
      - Jefferson Lab / Cornell ⇒ sc rf and re-circulating linacs
      - LBNL , DUBNA ⇒ induction linacs (talk tomorrow)
      - IHEP Protvino ⇒ sc solenoid channels

    - general engineering (large scale rf systems, sc magnets, sc solenoid channels, ps, vacuum, beam lines, tunnel, water) → come out of BD / TD (whatever division I can get)

    - specific design and engineering (cooling channel, target collection, beam manipulation, beam tracking and simulation) → Muon Collider group

Goal & Schedule

- 6 Month study: → "10 pages of paper per subsystem+ 1 schedule + 1 cost"
  - Internal Review Mid January to align the different contributions
  - Documents in by mid February
  - Report out by March 1st
- Get the collaboration involved as much as possible to profit from the work going on
  - induction linac
  - cooling channel design and performance
  - acceleration: (→ largest cost driver)
    - Jefferson Lab ⇔ Cornell ⇔ Fermilab
  - Target study
    - the target and the target station
    - the magnets in the target area

Timelines

- Accelerator Physics Design
  - has started for most of the components
  - Preliminary designs ready by Mid December
  - specifications written up for all subsystems
- Engineering designs
  - have started for ~ 40 % of the subsystems
  - should fully start over the period from now to mid December (learning curve)
  - ready by mid - end January
- Pre Review (internal) within this group end of January
- 10 pages written by mid February
- report out by March 1st.

How to get more information and where post information ?

- Why: The is part of a collaboration effort…
  - sensitive issue
  - nothing we have to or should hide
  - open for criticism

- Web Page:
  - "http://www.fnal.gov/projects/muon_collider/nu-factory/nu-factory.html"
  - web master: T. Jurgens (tjurgens@fnal.gov) or me

- What kind of information:
  - Spec document:"Subsystem Specifications (Postscript)"
  - drawings, pictures, sketches, specs, tables, everything you can think of. If it is not ready, call it preliminary.