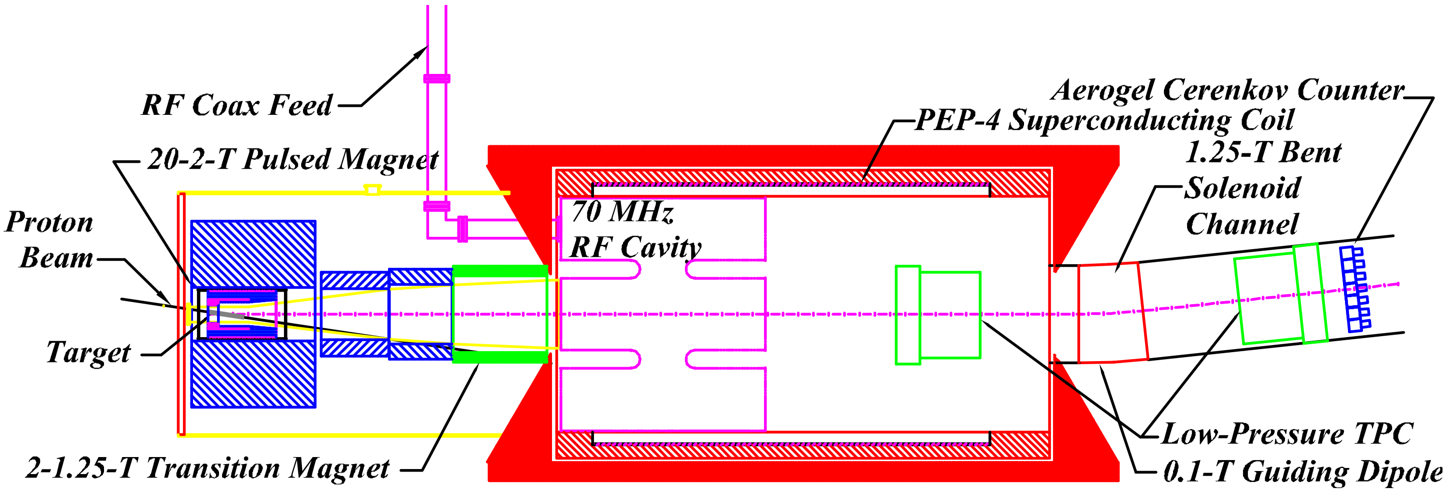

The R&D Program for Targetry and Capture at a Neutrino Factory/Muon-Collider Source

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Princeton U.

Neutrino Factory/Muon Collider Technical Board Meeting

December 6, 1999

Neutrino Factory/Muon Collider Targetry page:

http://puhep1.princeton.edu/mumu/target/

The Opportunity of a Neutrino Factory

- The next generation of neutrino experiments will firm up present indications of couplings of pairs of neutrinos – but will not explore simultaneous effects of 3 neutrinos.
- Many of the neutrino oscillation solutions permit complete study of the couplings between 3 (4?) neutrinos at a neutrino factory.
- But, $> 10^{21}$ ν's/year are needed for this!
- A neutrino factory is a path to a muon collider.

However, there are at present too many explanations of neutrino oscillation data to define an optimal parameter set for a neutrino factory: energy, distance to remote detectors....

It will take several years for the physics to be clarified enough to make a wise choice of parameters for an initial neutrino factory.

These facts afford both an opportunity and a need for an ambitious R&D program.

We Need a High Performance Source

- We need lots of protons: several megawatts.
- We need to maximize the yield of ν's, and hence μ's per proton.
- For advanced neutrino studies (ν_e in final state), and for a muon collider, we desire controlled muon polarization.
- High yield seems best accomplished in a solenoidal capture system with a dense target and little support structure.
- Solid targets extremely marginal in multimegawatt beams with 10^8 cycles/year.
- A "disposable" target is preferred; use once and throw away.
- $\Rightarrow$ Mercury jet target.
- Maximal capture + polarization control
  $\Rightarrow$ High-gradient, low-frequency rf close to target.

Two Classes of Issues

1. Viability of targetry and capture for a single pulse.
    - Effect of pressure wave induced in target by the proton pulse.
    - Interaction of a moving metal target with the solenoid field.
    - Operation of the first rf cavity in a magnetic field and in large particle flux.
2. Long-term viability of the system in a high radiation area.

   [Issues for solid target are of the second type.]

The most novel issues (1) are addressable in studies with low rep. rate but a large number of protons/pulse (BNL).

These issues would NOT be readily addressed at a 0.5-1 MW source for an entry-level neutrino factory, due to high radiation levels.

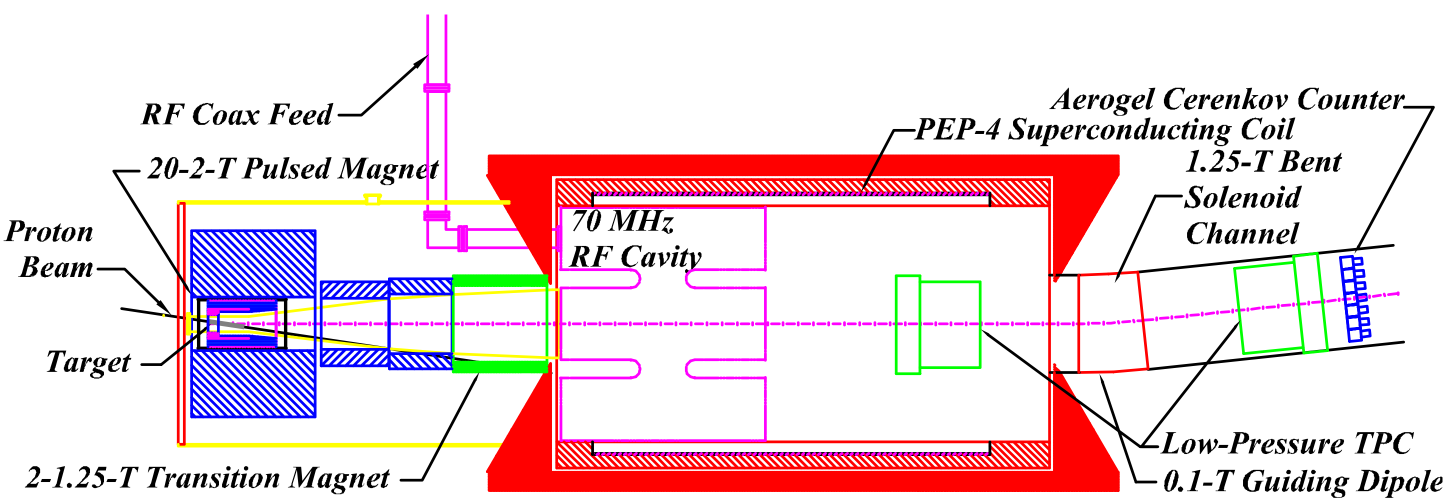
Long-term issues, including solid targets, are better studied in a high-rep.-rate, high-average-power beam (Los Alamos).

R&D Goals

Overall: Provide a facility to test key components of the front-end of a neutrino factory in realistic single-pulse beam conditions.

Near Term (1-2 years): Explore viability of a liquid metal jet target in intense, short proton pulses and (separately) in strong magnetic fields.
(Change target technology if encounter severe difficulties.)

Mid Term (3-4 years): Add 20-T magnet to AGS beam tests; Test 70-MHz rf cavity (+ 1.25-T magnet) downstream of target; Characterize pion yield.



An R&D Program for Targetry and Capture at a Muon Collider Source

A Proposal to the BNL AGS Division

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First discussed at Orcas Island, May, 1997.

Submitted Sept. 28, 1998.

Approved as BNL E951 Oct. 1, 1999.

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The 8 Steps in the R&D Program

1. Simple tests of liquid (Ga-Sn, Hg) and solid (Ni) targets with AGS Fast Extracted Beam (FEB).

2. Test of liquid jet entering a 20-T magnet (20-MW cw Bitter magnet at the National High Magnetic Field Laboratory).

3. Test of liquid jet with 10^{14} ppp via full turn FEB (without magnet).

4. Add 20-T pulsed magnet (4-MW peak) to liquid jet test with AGS FEB.

5. Add 70-MHz rf cavity downstream of target in FEB.

6. Surround rf cavity with 1.25-T magnet. At this step we have all essential features of the source.

7. Characterize pion yield from target + magnet system with slow extracted beam (SEB).

8. Ongoing simulation of the thermal hydraulics of the liquid-metal target system.

Schedule

- FY99:

  Prepare A3 area; begin work on liquid jets, extraction upgrade, magnet systems, and rf systems.

- FY00:

  Initial beam tests in A3 line. Liquid jet test at NHMFL.

  (300 hours of AGS beamtime).

- FY01:

  Complete extraction upgrade; test of liquid jet + beam.

  (600 hours).

- FY02:

  Complete magnet and rf systems; test with 2 ns beam.

  (600 hours).

- FY03:

  Complete pion detectors; test with low intensity SEB.

  (600 hours).

AGS Operations Issues

- In FY00/01, HEP operation of AGS is only for the $g - 2$ experiment, with fast extraction. E951 is very compatible with parasitic running in this condition, but must pay incremental costs of operating the A3 line: $\approx$ \$35k/week.
- After FY01, no DOE approved HEP operation of the AGS.
- The AGS2000 program proposes running slow extracted proton beam 30-35 weeks/yr, for 16-20 hours/day during RHIC operation.
- E951 requires fast extracted beam, so cannot parasite off the AGS2000 program; we must interleave running with AGS2000, but seek $\lesssim 6$ weeks/yr.
- If there is no other HEP operation of the AGS after FY01, E951 would then bear the full incremental cost of proton beam running; $\approx$ \$70k/week.

Budgets, I

Yearly Projections (made in 1998)

Category	FY99	FY00	FY01	FY02	FY03	Total
Base Program	$0.5M	$1.5M	$2M	$2M	$1M	$7M
AGS Operations		$0.2M	$0.2M	$0.4M	$0.4M	$1M
RF Power Source	$0.05M	$0.5M	$1M	$1M	$1M	$3.5M

FY99, Allocated

Task	ANL	BNL	LBL	Princeton	Industry	Total
Initial Target Studies		20		85		105
AGS Beamline Upgrades		100				100
Pulsed Solenoid Design		50				50
RF Systems		65	75		50	190
Simulation Studies	75			5		80
Total	75	285	75	90	50	**$525k**

Q1 + Q2 FY00, Allocated

Task	ANL	BNL	LBL	Princeton	Total
Initial Target Studies		50		35	85
AGS Beamline Upgrades		625			625
Magnet Systems		145		20	165
RF Systems		120	75		195
Simulation Studies	80				80
Engineer Salaries		160			160
Total	80	1100	75	55	**$1310k**

FY00 Request: Details

1. **Initial Target Studies $140k**
    - Remote postioner for target box (BNL) $50k
    - Target box, targets, cameras (Princeton) $50k
    - Mercury jet for NHMFL tests (Princeton) $40k
2. **AGS Beamline Upgrades $1400k**
    - Labor (11,000 hours, BNL) $1100k
    - Materials (BNL) $200k
    - Radiation Safety (BNL) $20k
    - 6-Bunch kicker design (BNL) $80k
3. **AGS Operations: 3 weeks, A3 + linac costs $200k**

4. **Magnet Systems** **$250k**

- 1/4 mech. engineer (Princeton) $40k
- 2/3 designer (BNL) $70k
- Shipment of PEP4-TPC magnet (BNL) $20k
- PEP4 magent refurbishing (BNL) $60k
- Design of 5 MW magnet power supply (BNL) $60k

5. **RF Systems** **$475k**

- Recommissioning of the 8973 power supplies (LBL) . $75k
- 1/2 RF engineer (BNL) $80k
- 1/2 Mech. engineer (BNL) $80k
- $2 \times 1/2$ Technician (BNL) $100k
- Shipping of rf gear from LBL to BNL $20k
- Materials (BNL) $100k
- Pirkl visits to BNL $20k

6. **Simulation Studies** **$235k**

- (ANL) $150k
- (ORNL) $75k
- (Princeton) $10k

7. **Engineer Salaries (BNL)** **$345k**

Budgets, II

Total FY00 Request

Task	ANL	BNL	LBL	ORNL	Princeton	Industry	Total
Initial Target Studies		50			60		110
AGS Beamline Upgrades		1400					1400
AGS Operations		200					200
Magnet Systems		210			40		250
RF Systems		400	75			500	975
Simulation Studies	150			75	10		235
Engineer Salaries		345					345
Total	150	2605	75	75	110	500	**$3515k**

Q3 + Q4 FY00 Request

Task	ANL	BNL	LBL	ORNL	Princeton	Industry	Total
Initial Target Studies					25		25
AGS Beamline Upgrades		775					775
AGS Operations		200					200
Magnet Systems		65			20		85
RF Systems		280				500	780
Simulation Studies	70			75	10		155
Engineer Salaries		185					185
Total	70	1505		75	55	500	**$2205k**

Budgets, III

Total FY00, Allocated

Task	ANL	BNL	LBL	ORNL	Princeton	Industry	Total
Initial Target Studies		50			50		100
AGS Beamline Upgrades		1400					1400
AGS Operations		0					0
Magnet Systems		70			40		110
RF Systems		100	75			0	175
Simulation Studies	80			0	10		90
Engineer Salaries		345					345
Carryover		−100					−100
Total	80	1865	75	0	100	0	**$2120k**

Q3 + Q4 FY00, Allocated

Task	ANL	BNL	LBL	ORNL	Princeton	Industry	Total
Initial Target Studies					15		15
AGS Beamline Upgrades		775					775
AGS Operations		0					0
Magnet Systems		−75			20		−55
RF Systems		−20	0				−20
Simulation Studies	0			0	10		10
Engineer Salaries		185					185
Carryover		−100					−100
Total	0	765	0	0	45	0	**$810k**