AGS Experiment E951

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

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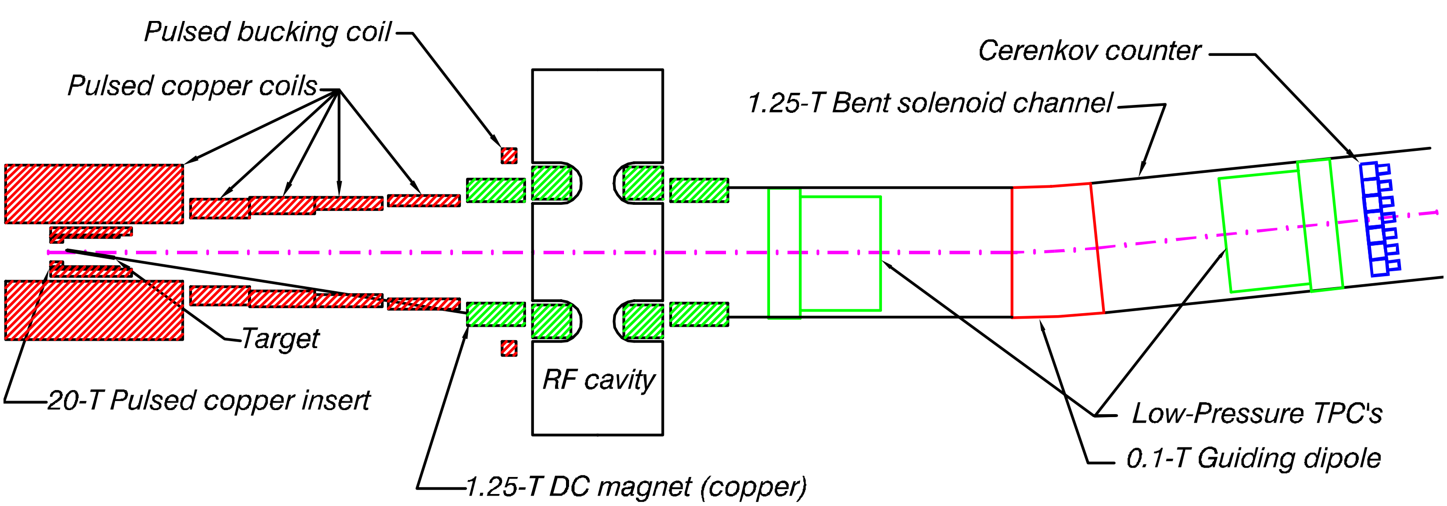
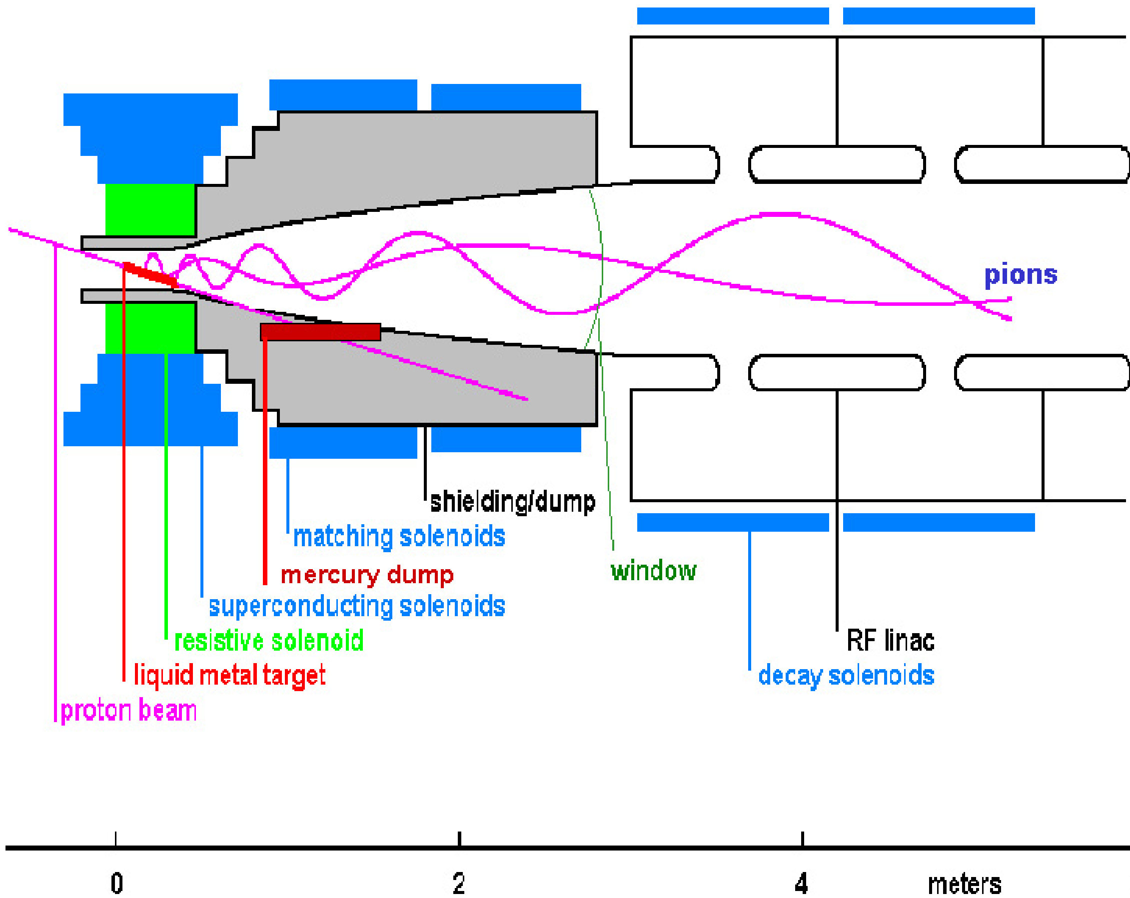


BNL DOE Annual Program Review, April 27, 2000

Requirements for Targetry and Capture at a Neutrino Factory/Muon Collider



- 1.2×10^{14} $\mu^{\pm}$/s via π-decay from a 4-MW proton beam.
- Proton pulse $\approx$ 1 ns rms.
- Mercury jet target.
- 20-T capture solenoid followed by a 1.25-T π-decay channel with phase-rotation via rf (to compress energy of the muon bunch).

Two Classes of Issues

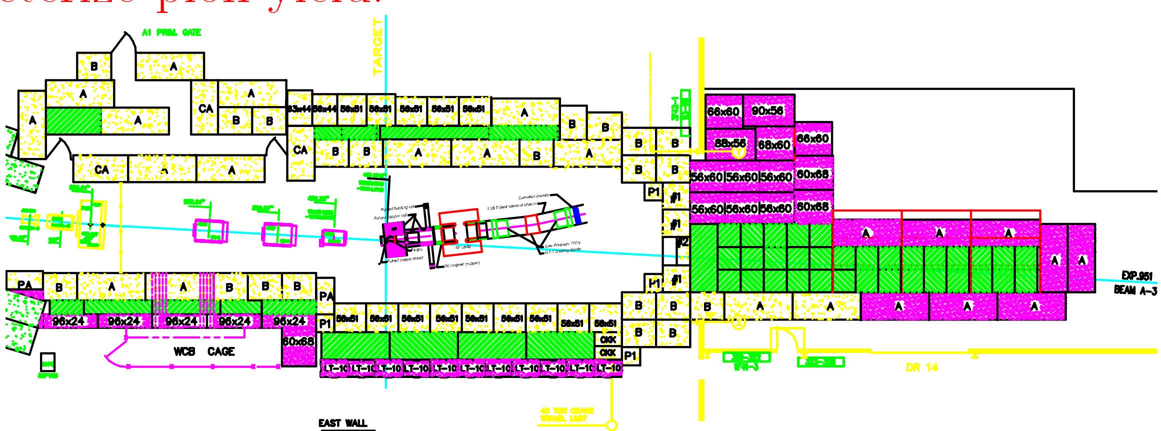
1. Viability of targetry and capture for a single pulse.
2. Long-term viability of the system in a high radiation area.

E951 Studies the Single Pulse Issues

Overall Goal: 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.

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



Why BNL?

The BNL AGS has proton beam parameters conditions closest to those desirable for a muon collider source, and essentially identical to those needed for a neutrino factory.

Parameter	Muon Collider	BNL AGS	FNAL Booster	CERN PS	LANSCE PSR
Proton Energy (GeV)	16-24	24	8	24	0.8
p/bunch	5×10^{13}	1.6×10^{13}	6×10^{10}	4×10^{12}	3×10^{13}
No. of bunches	2	6	84	8	1
p/cycle	1×10^{14}	1×10^{14}	5×10^{12}	3×10^{13}	3×10^{13}
Bunch spacing (ns)	≈ 1000	440	18.9	250	–
Bunch train length (μs)	≈ 1	2.2	1.6	2.0	0.25
RMS Bunch length (ns)	≈ 1	≈ 10	≈ 1	≈ 10	≈ 60

The advanced capability of the AGS is still very relevant to the national high energy physics program.

Reviews of E951

- Proposal P951 submitted to BNL AGS Division Sept. 1998.
- Presented to the AGS/RHIC PAC on May 25, 1999:

  "The PAC recognizes that future progress in elementary particle physics will require accelerators of higher energy than those currently operating or under construction.

  There are only a few possible paths to this higher energy. Of these, the muon collider offers interesting and promising features. However, it is clear that before a decision could be made to choose this option, substantial research and development must demonstrate that the muon collider approach is realistic.

  The AGS offers significant and unique capabilities as a test facility for the targeting and capture phase of the muon collider R&D. We were pleased to hear that members of the muon collider collaboration are pursuing these directions. We encourage the proponents of P951 and others to continue their work.

  Additional technical study is needed to determine what is required for the lab to make a significant contribution to the muon collider R&D program within the frame work of a national, possibly international, effort. Such a study should maintain a broad perspective and take technical, cost, schedule and safety issues into account."
- Presented to the BSA Science and Technology Steering Committee, June 4, 1999.
- Presented to the Muon Collider Technical Advisory Committee, July 22, 1999; approval recommended, Aug. 27, 1999.
- Approved as BNL E951 by Tom Kirk, Oct. 1, 1999.
- Approved by the Muon Collider Oversight Group, Oct. 19, 1999.

The 8 Steps in the R&D Program

1. Simple tests of liquid (Ga-Sn, Hg) and solid (C, Ni) targets with AGS Fast Extracted Beam (FEB)of 1.5×10^{13} $p$pp.
2. Test of liquid jet entering a 20-T, 20-MW, cw Bitter magnet at the National High Magnetic Field Laboratory).
3. Test of liquid jet and other targets with 10^{14} $p$pp via fast extraction of 6 AGS bunches.
4. Add 20-T pulsed magnet (5-MW peak) to target tests 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 systems.

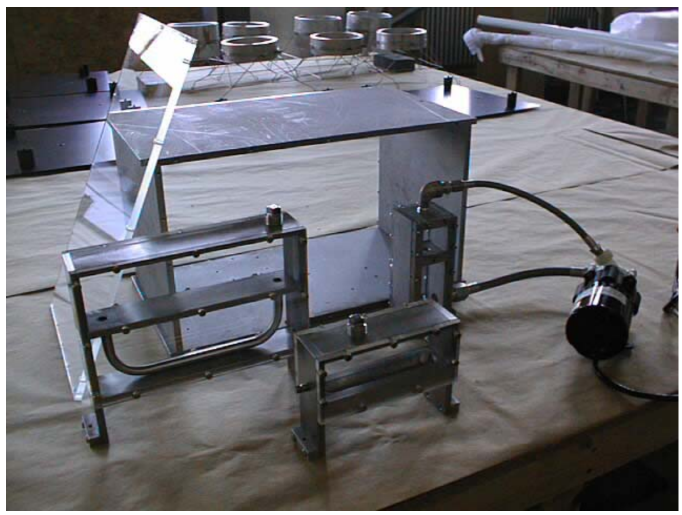
E951 Schedule

- FY99:
  Prepare A3 area at the AGS (Step 1);
  Begin work on liquid jets, magnet and rf systems (Steps 2, 4-6).
- FY00:
  Complete A3 line (Step 1);
  Continue work on jet, magnet and rf systems (Steps 2, 4-6);
  Begin work on AGS extraction upgrade (Step 3).
- FY01:
  First test of targets in A3 (Step 1);
  Liquid jet test in 20-T magnet at NHMFL (Step 2);
  Continue work on extraction, magnet, and rf systems (Steps 3-6).
- FY02:
  Complete extraction upgrade, magnet, and rf systems (Steps 3-6);
  Test targets with 10^{14} $p$pp (Step 3);
  Begin work on pion yield diagnostics (Step 7);
  Option to study mercury dump in vertically pitched beam (Step 3.5).
- FY03:
  Beams tests of target + 20-T pulsed magnet + rf cavity (Steps 4.6);
  Complete pion detectors; test yield with low intensity SEB (Step 7).

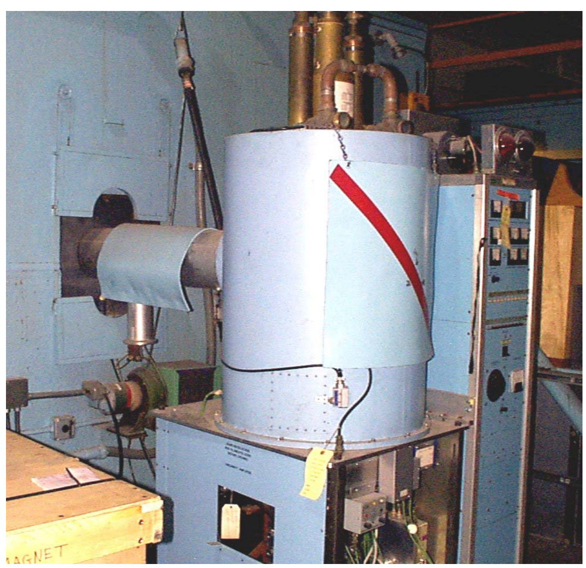
E951 Progress

Construction in the AGS A3 line:

Simple targets:
Pipe, trough, waterfall:

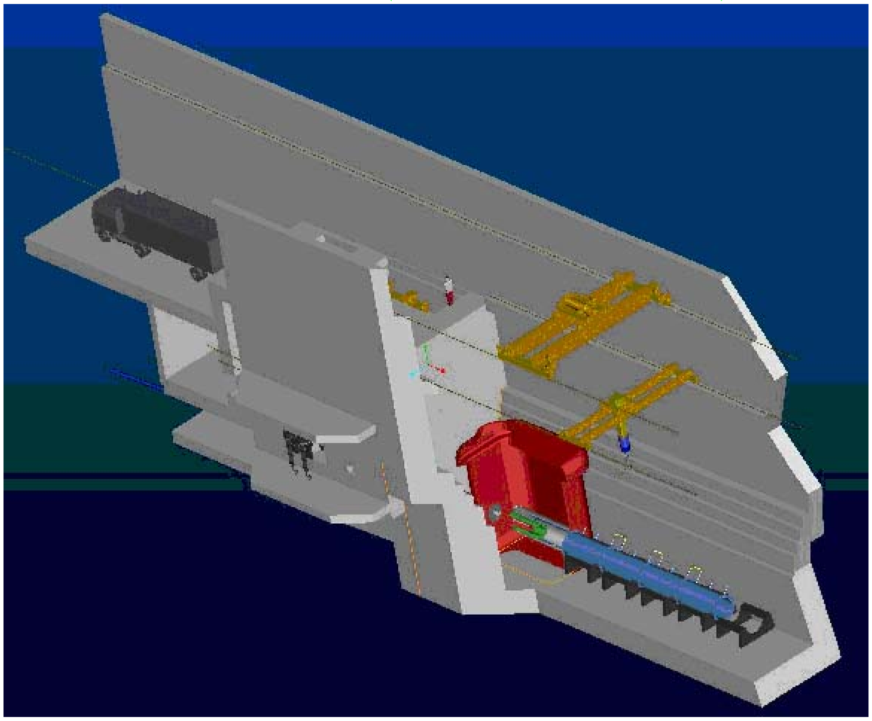


70 MHz rf power source at LBNL:



Extensions to Targetry R&D

- Target Station Infrastructure (P. Spampinato):



- Tests of solid targets at LANL (T. Gabriel).
- Radiation damage to target materials (A. Zeller).
- Measurement of neutron fluxes in A3 (H. Kirk).
- Calculation of radionucleide inventory (H. Ludewig).
- Magnetohydrodynamic simulation of mercury (R. Samulyak).