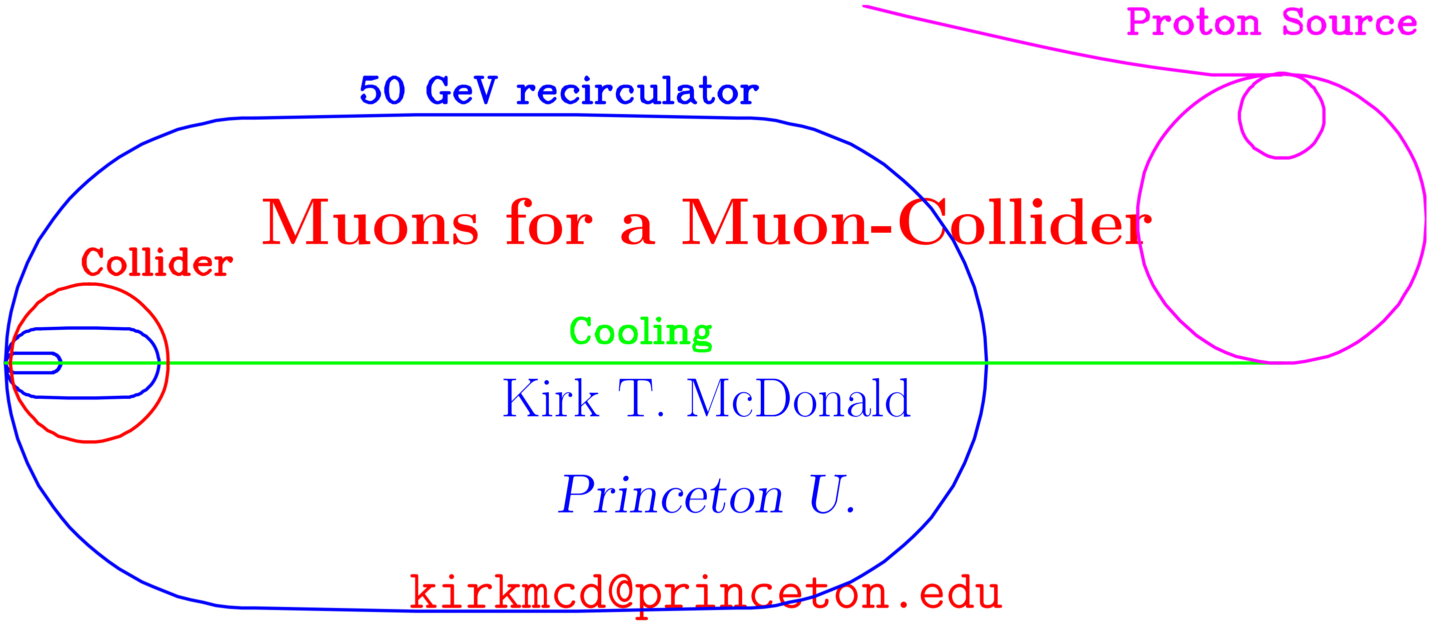

Muons for a Muon-Collider

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Muon Collider main page:

http://www.cap.bnl.gov/mumu/mu_home_page.html

Muon Collider R&D Status Report:

http://www.cap.bnl.gov/mumu/status_report.html

Muon Collider Targetry page:

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

AIP Conference Proceedings, Vols. 352, 372, 435 & 441

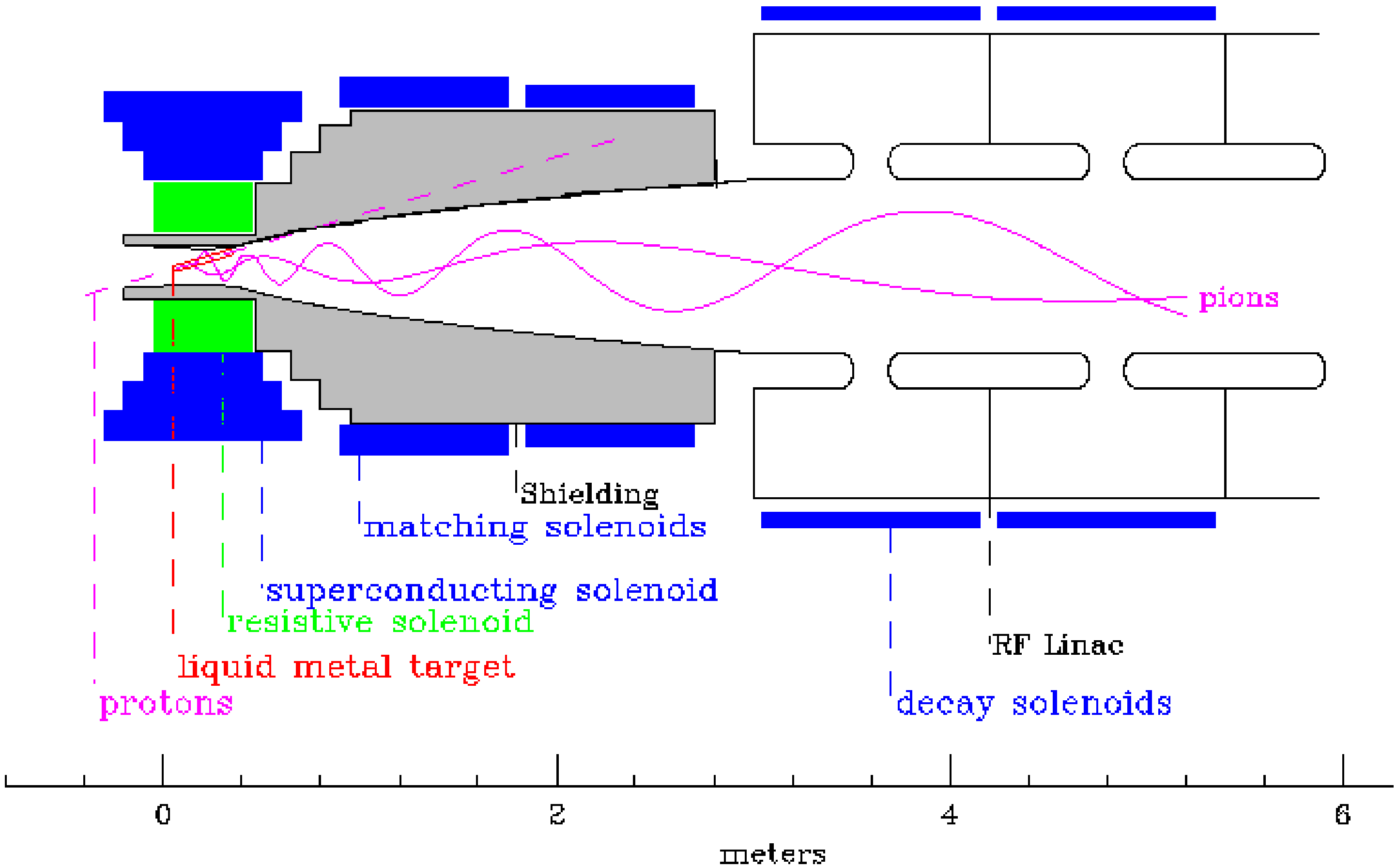
Muon Requirements

- 1.2×10^{14} $\mu^{\pm}$/s.
- 15 pulses/s.
- Invariant 6-D emittance of 2×10^{-10} $(\pi \mathrm{mm})^3$.
- Initial pulse length only 1-2 ns.

The Source

- The muons come from the decay of soft pions produced in p-nucleus collisions.
- Need at least 1.5×10^{15} p/s at 16-24 GeV
  $\Leftrightarrow$ 4 MW beam power.
- Initial muon emittance is about 10^6 larger than desired
  $\Rightarrow$ Need fast cooling.
- [Our muon beam is 10^6 times hotter than existing beams.]

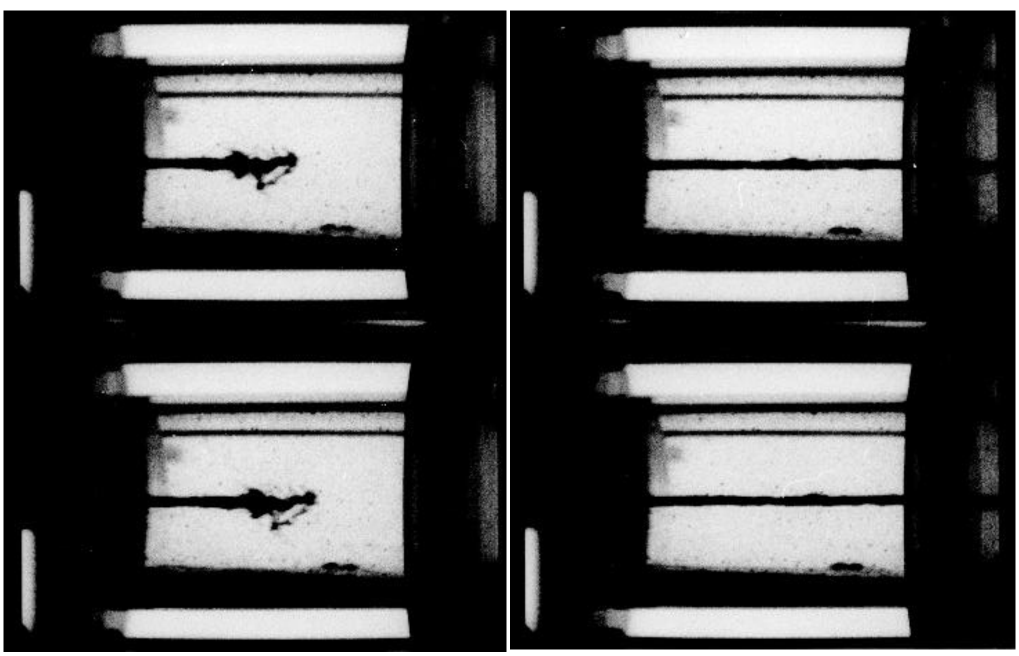
Overview of Targetry for a Muon Collider



- 1.2×10^{14} $\mu^{\pm}$/s via π-decay from a 4-MW proton beam.
- Liquid-metal jet target: Hg, (or Ga/Sn, Pb/Sn, ...).
- 20-T solenoid captures pions with $P_{\perp} < 220$ MeV/c.
- π-decay channel in 1.25-T field, with phase-rotation via rf (to compress energy of the muon bunch).

Targetry Issues

- Is a liquid jet target viable?
  - 1-ns beam pulse ⇒ shock heating of target.
  - Resulting pressure wave may disperse liquid (or crack solid).
  - Damage to target chamber walls?
  - Magnetic field will damp effects of pressure wave.
  - Eddy currents arise as metal jet enters the capture magnet.
  - Jet is retarded and distorted, possibly dispersed.
  - Hg jet studied at CERN, but not in beam or magnetic field:



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

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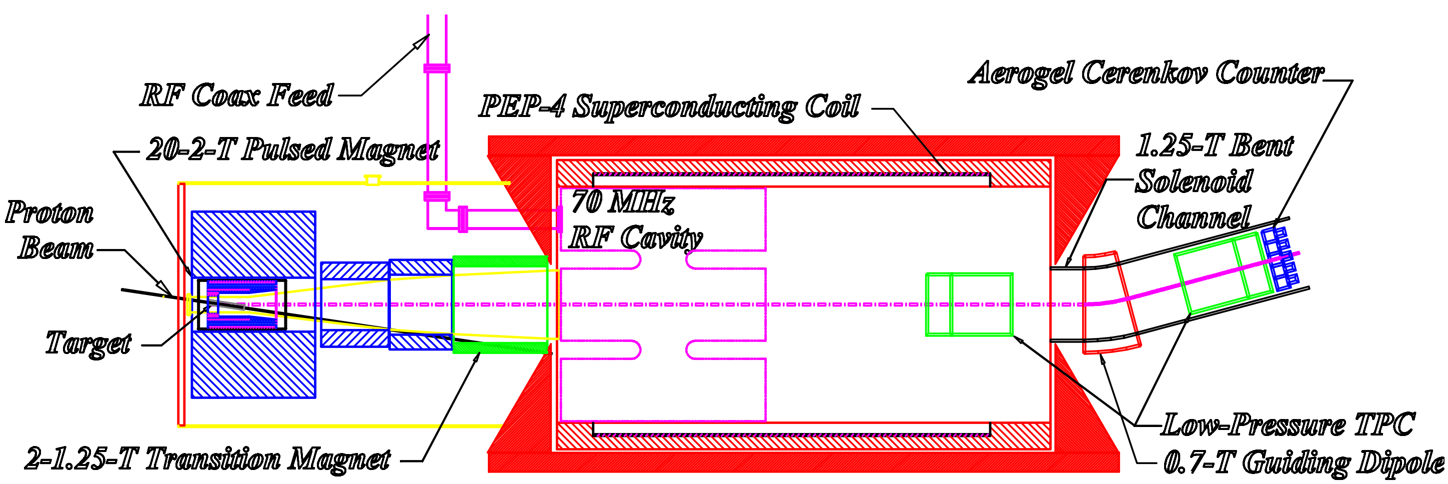
- Is the first rf cavity viable?
  - First cavity should be as close as possible to target to minimize longitudinal dispersion of the soft pions.
  - $\Rightarrow$ Must operate during pulse of $\approx 10^{14}$ pions.
  - Little known about particle-induced breakdown of rf cavities.
- Is the 20-T Solenoid viable?
  - Even with water-cooled tungsten inserts, this hybrid (copper/superconductor) magnet will experience a very high radiation dose.
  - LANL has experience with superconductng magnets in high radiation areas.
- Other Radiological Issues
  - A 4-MW beam leads to activiation issues characteristic of a small nuclear reactor.
  - Remote handling of activated liquid target material is under study at CERN ISOLDE, the ORNL NSNS, ...

R&D Goals of BNL P951

Long Term: Provide a facility to test key components of the front-end of a muon collider in realistic 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.



Not included in P951: studies of long-term radiological issues.

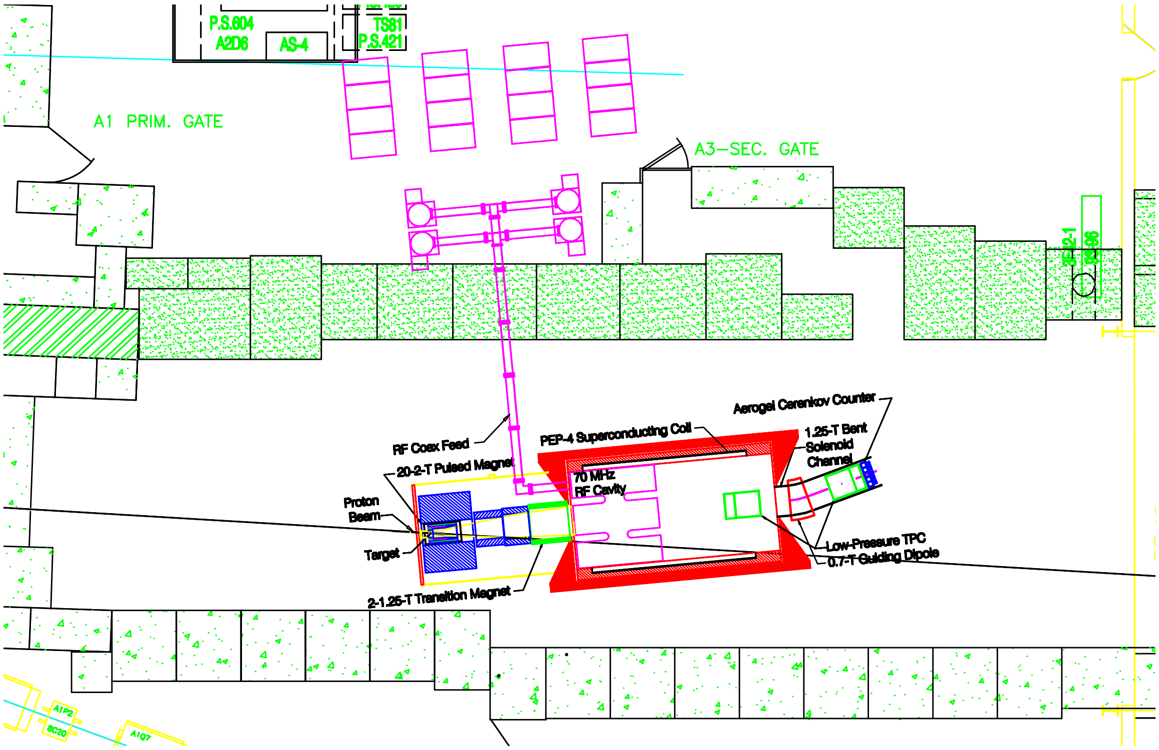
Why BNL?

The BNL AGS has proton beam parameters conditions closest to those desirable for a muon collider source.

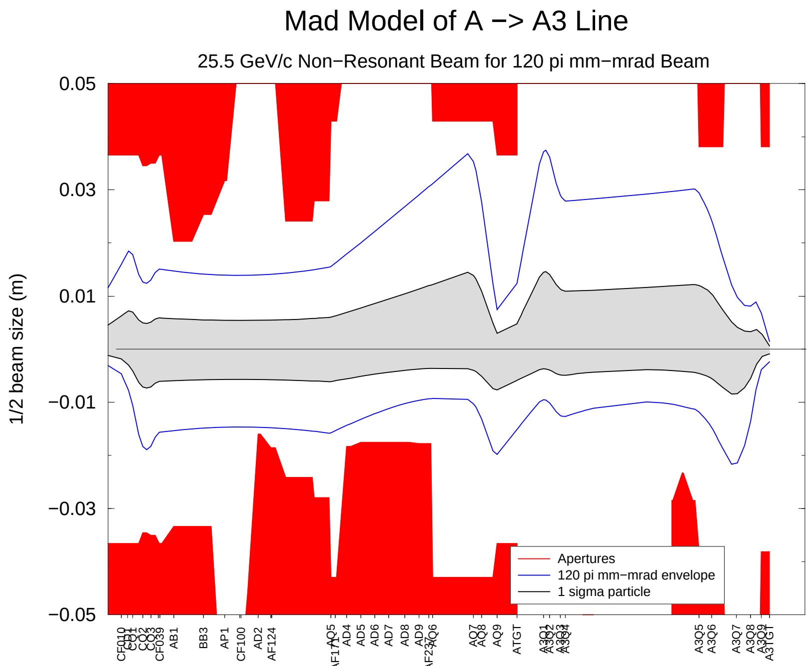
Parameter	Muon Collider	BNL AGS	FNAL Booster	CERN PS	LANSCE PSR
Proton Energy (GeV)	16-24	24	8.9	24	0.8
p/bunch	5×10^{13}	1.6×10^{13}	6×10^{10}	4×10^{12}	3×10^{13}
No. of bunches	2	6	84	8	1
p/cycle	1×10^{14}	1×10^{14}	5×10^{12}	3×10^{13}	3×10^{13}
Bunch spacing (ns)	≈ 1000	440	18.9	250	–
Bunch train 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.

Possible Site for P951: A3 Line in AGS Hall



- Must add quad triplet to bring a 100-mm-mrad, 24-GeV beam to a spot with $\sigma_r = 1$ mm? (Kevin Brown)



- Need beamline instrumentation upgrades: spot size, beam current, FEB radiation monitoring.
- Data taking via pulse-on-demand once every few minutes; but desire 1-Hz running for beam tuning.
- Shielding needed for 1-Hz running with 10^{14} ppp = 100 TP (Ripp Bowman, Ralf Prigl).
- Could run first tests parasitic to $g - 2$ in Mar/Apr 2000.
- Must begin work now (6/1/99) to use beam at that time!

AGS Operations Issues

- In FY00/01 HEP operation of AGS is for $g-2$ running, with fast extraction. P951 is very compatible with parasitic running in this condition.
- 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.
- P951 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, P951 would then bear the full incremental cost of proton beam running.

Schedule

- FY99:

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

- FY00:

  Initial tests in A3 line.

  (600 hours).

- 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).