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

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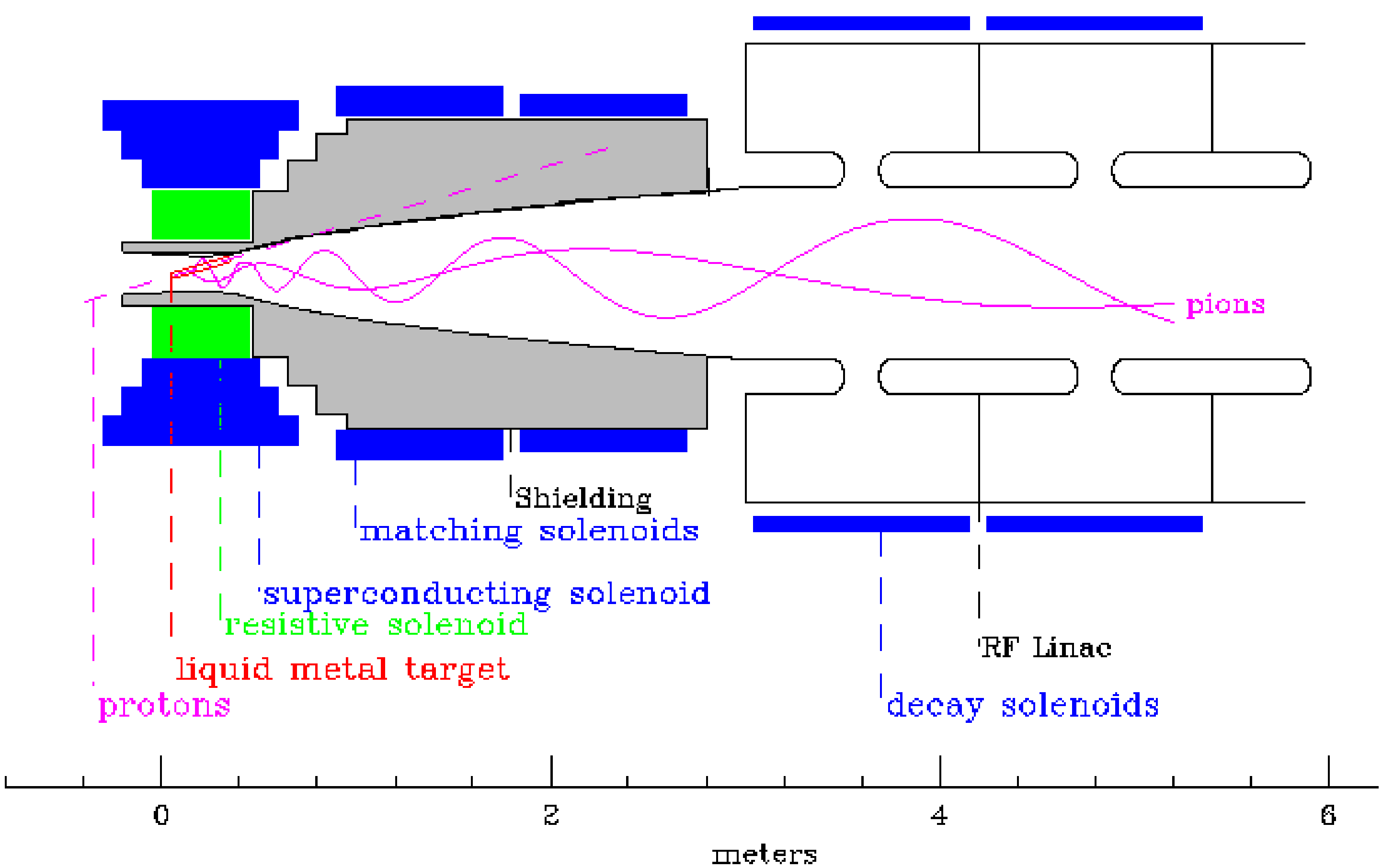
http://puhep1.princeton.edu/mumu/target/

Targetry Challenges

To achieve useful physics luminosity, a muon collider must produce a few $\times 10^{14}$ μ/sec.

- $> 10^{15}$ proton/sec onto a high-Z target.
- Capture pions of $P_\perp \lesssim 200$ MeV/c in a 20-T solenoid magnet.
- Transfer the pions into a 1.25-T-solenoid decay channel.
- Compress π/μ bunch energy with rf cavities and deliver to muon cooling channel.



Targetry Challenges, Cont'd

- Proton beam power $\approx$ 4 MW; 400 kW deposited in target.
- To minimize pion absorption, cannot cool target by thermal bath.
- Radiative cooling is inadequate.
- $\Rightarrow$ Move target material away from beam and cool remotely.
- Even so, target must survive radiation damage (10-100 dpa/year), and the thermal shock of 30 kJ/pulse ($\approx$ 30 J/gm) at 15 Hz.

A moving solid target is awkward (backup solution).

Pipes with liquid metal (as in future neutron spallation sources) won't survive the pressure wave of thermal shock.

A **free liquid metal jet** is presently the preferred option.

Will it work? Need a **Targetry R&D Program**.

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A Proposal to the BNL AGS Division

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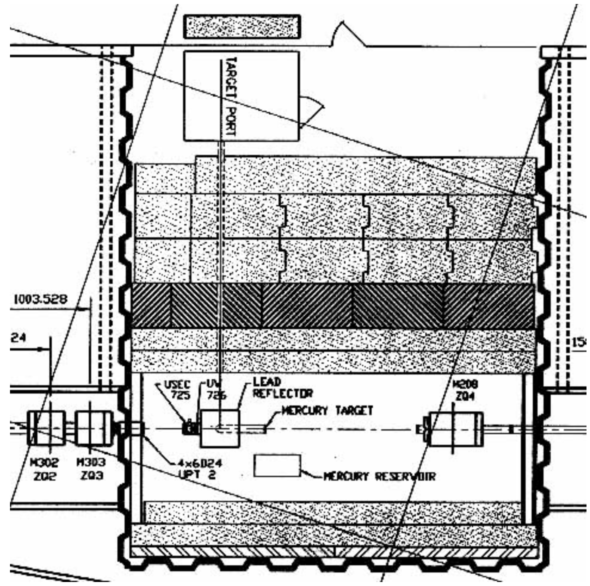
Studies to be performed in the BNL AGS F.E.B. U-line, and at the National High Magnetic Field Laboratory (Florida).



Critical Targetry Issues

- What is the effect of the pressure wave induced in the target by the proton pulse?

  If the liquid target is dispersed by the beam, do the droplets damage the containment vessel?

- What is the effect of the magnetic field of the capture solenoid on the motion of the liquid-jet target?

  Is the jet badly distorted by Lorentz forces on the eddy currents induced as the jet enters the field?

  Does the magnetic field damp the effects of the beam-induced pressure wave?

- Can the first rf cavity of the phase-rotation channel operate viably in close proximity to the target?

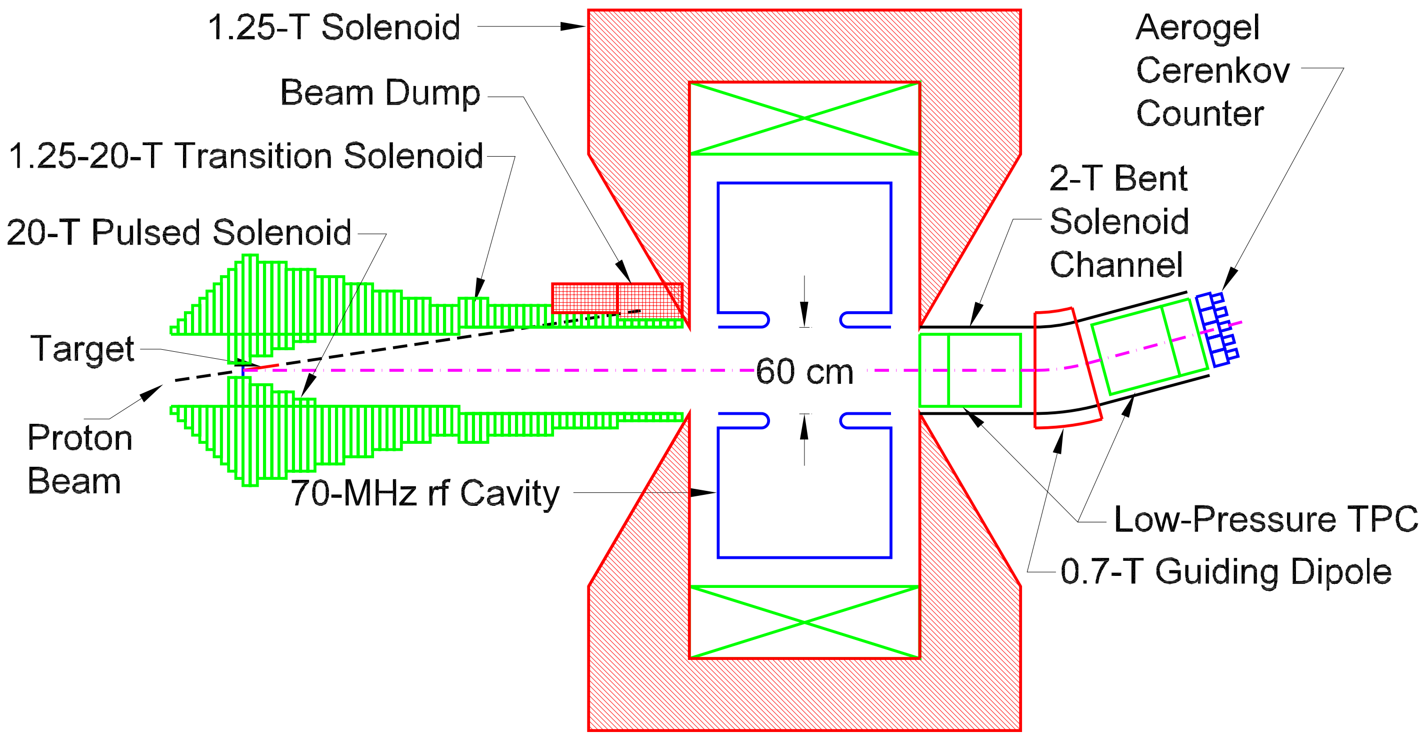
- What is the yield of low-energy pions from 16-24-GeV protons incident on the target of the muon-collider source?

- Can numerical simulations be developed that permit reliable extrapolation of the empirical answers we obtain?

The 8 Steps in the R&D Program

1. Initial studies of liquid (and solid) target materials with a proton beam at the AGS.
2. Studies of a liquid-metal jet entering a 20-T magnet at the National High Magnetic Field Laboratory.
3. Studies of a full-scale liquid-metal jet in a beam of 10^{14} protons per pulse, but without magnetic field.
4. Studies of a liquid-metal jet + proton beam + 20-T pulsed solenoid magnet.
5. Studies of a 70-MHz rf cavity downstream of target in proton beam, but without a magnet around the cavity.
6. Continuation of topic 5 with the addition of a 1.25-T, 1.25-m-radius solenoid surrounding the rf cavity.
7. Characterization of the pion yield downstream of the target + rf cavity.
8. Simulation of the performance of liquid-metal targets. Validation of the simulation by exploding-wire studies.

Overall Configuration of the Experiment



What Next?...

Heavier, higher-Z liquid metals: mercury, lead/bismuth...

Systems issues for long life, high rep. rate.

Hybrid DC 20-T magnet: superconducting outer, resistive inner.

Superconducting magnets around rf cavities.

Developing a CERN Connection

Experimental Physics:

Alain Blondel, John Ellis, Andre Rubbia: The physics case for a muon collider.

Accelerator Physics:

Bruno Autin: Low-energy muon beams/storage rings.

Colin Johnson: High-power targets, liquid jet.

Helge Ravn, Jacque Lettry: Liquid targets, nuclear engineering.

Werner Pirkl: Low-frequency rf.

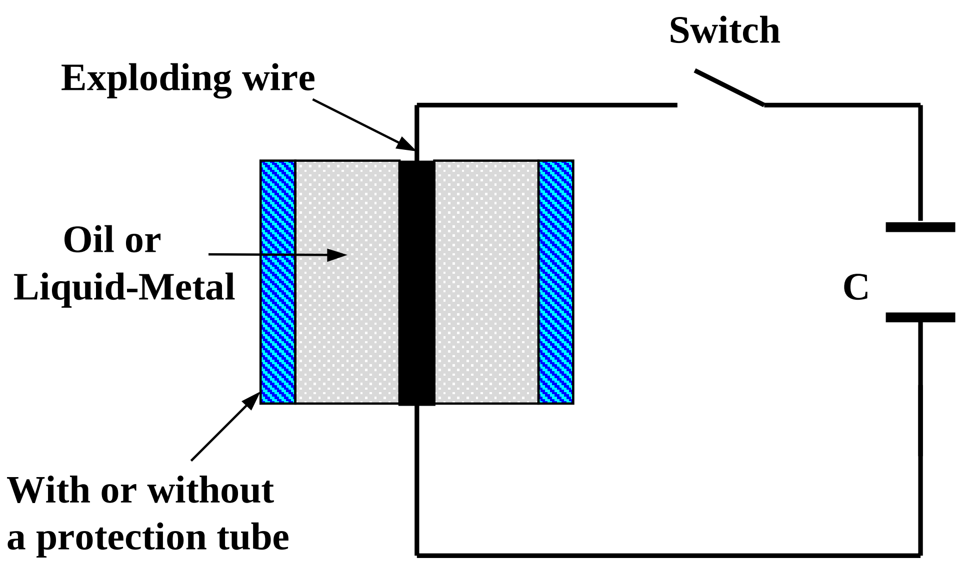
Possible scenario:

Submit proposal to ISOLDE for targetry studies at ≈ 1 GeV;

Emphasize nuclear physics of hadronic cascades in heavy-metal targets.

Exploding Wire Studies

Validate hydrodynamic simulations with data from exploding wire studies.



Possible collaboration with TRINITI Lab (Troitsk, Russia; contactperson V. Belan)

An exploding mercury jet studied by Rose *et al.*: