Targetry Issues at a Muon Collider

[`http://www.hep.princeton.edu/~mcdonald/mumu`]

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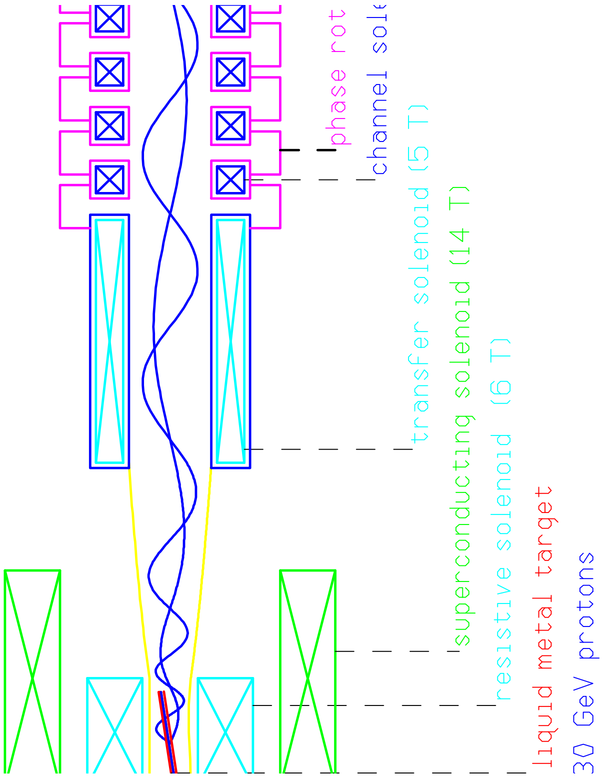
Overview of Targetry for a Muon Collider

- Get muons from pion decay: $\pi^{\pm} \rightarrow \mu^{\pm}\nu$.
- Pions from proton-nucleus interactions in a **target**.
- Goal: 1.2×10^{14} $\mu^{\pm}$/s.
- $\Rightarrow$ High-Z target,

  High-energy proton beam,

  High magnetic field around target to capture soft pions.
- $\mu/p = 0.08$ at 16 GeV $\Rightarrow 1.5 \times 10^{15}$ p/s.
- 15-Hz proton source.
- 4 MW power in p beam.
- Compare: 0.1 MW in 900-GeV extracted p beam at FNAL; 0.25 MW in 30-GeV extracted beam at BNL AGS.

Baseline Scenario



- Liquid metal target: Ga, Hg, or solder (Bi/In/Pb/Sn alloy)

- 20-T capture solenoid followed by 5-T phase-rotation channel.

- 20 T = 8-T, 8-MW water-cooled Cu magnet

  + 12-T superconducting magnet.

- Cost of 12-T magnet ≈ 0.8 M\$ $(B[\mathrm{T}]\ R[\mathrm{m}])^{1.32}(L[\mathrm{m}])^{0.66}$

  $\approx$ \$6M.

- Capture pions with $P_\perp < 220$ MeV$/c$.

- Adiabatic invariant: $\Phi = \pi r^2 B$ as B drops from 20 to 5 T.

- $r = P_\perp / eB$ = radius of helix.

- $\Rightarrow P_{\perp,f} = P_{\perp,i}\sqrt{B_f/B_i} = 0.5$ (and $P_{\parallel,f} > P_{\parallel,i}$).

- Tilt target by ≈ 0.1 rad to minimize absorption of spiralling pions (factor of 2 effect).

- Target should be short and narrow,
  $\Rightarrow$ high density; no cooling jacket.

- High power of beam would crack stationary target.

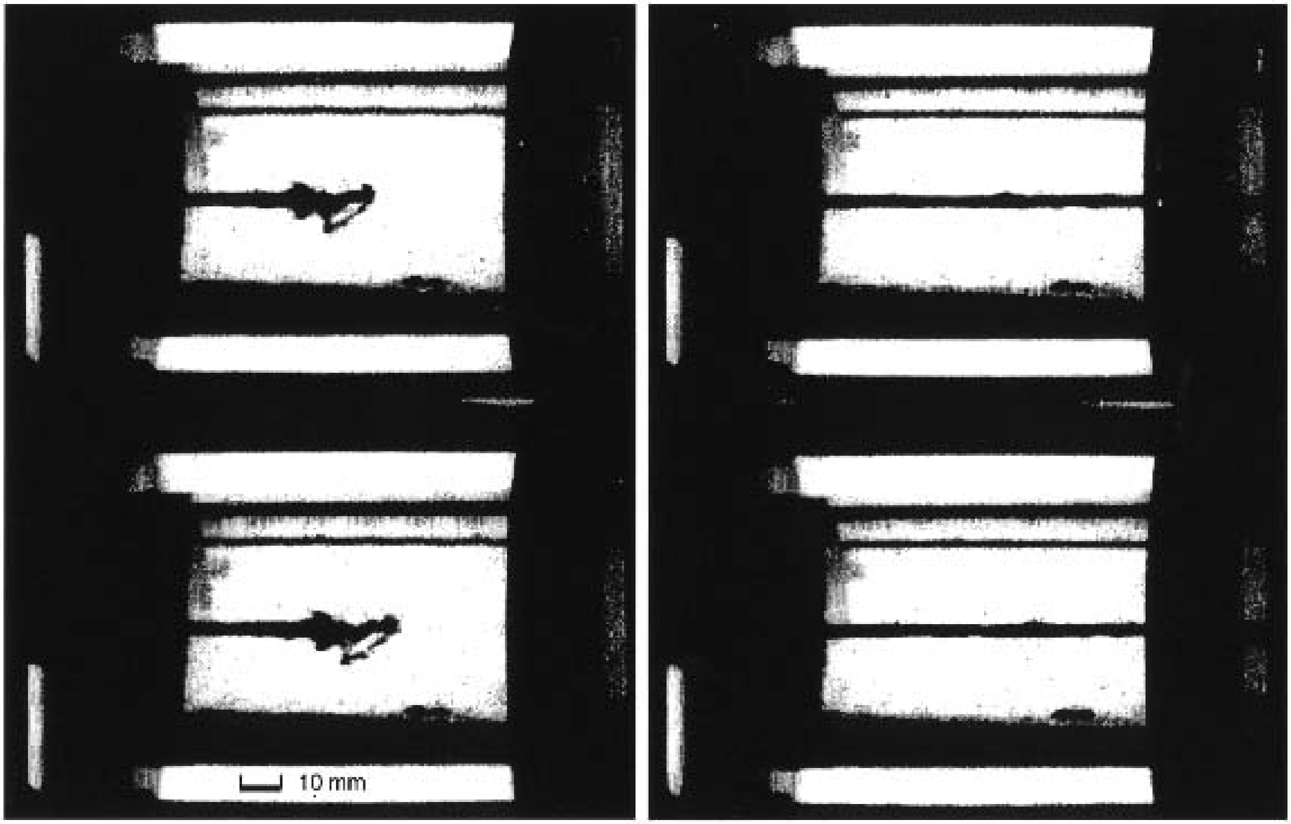
- $\Rightarrow$ **Pulsed heavy-metal liquid jet** as target.

Targetry Workshop, Princeton U., Feb. 28, 1998

- B. Palmer: Requirements for Targetry at a Muon Collider.
- C. Johnson: Experience with High Flux Targets.
- D. Smith: The Argonne Liquid Metal Program.
- J. Hastings: The AGS Spallation Target Experiment.
- B. Weggel: Motion of Conductors in Magnetic Fields.
- K. McDonald: Options for Liquid Jets.
- C. Lu: ANSYS Simulations of Eddy Current Effects.
- B. King: Slab Geometry (Bandsaw) Target.
- D. Summers: Target Materials.
- B. Weggel: High Field Magnets for the Primary Target Region.
- E. Prebys: The Princeton Superconducting Magnet.
- H. Kirk: Laser Compressed Targets.
- + J. Gallardo, Y. Torun and S. Vahsen.

Colin Johnson: The Voice of Experience

- See, Hyperfine Interactions **44**, 21 (1988).
- High-power pulsed beams crack solid targets.
- Try a mercury jet:



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