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

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*Princeton U.*

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*Targetry Meeting at Fermilab*

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

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

## A Proposal to the BNL AGS Division

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(Submitted Sept. 28, 1998)

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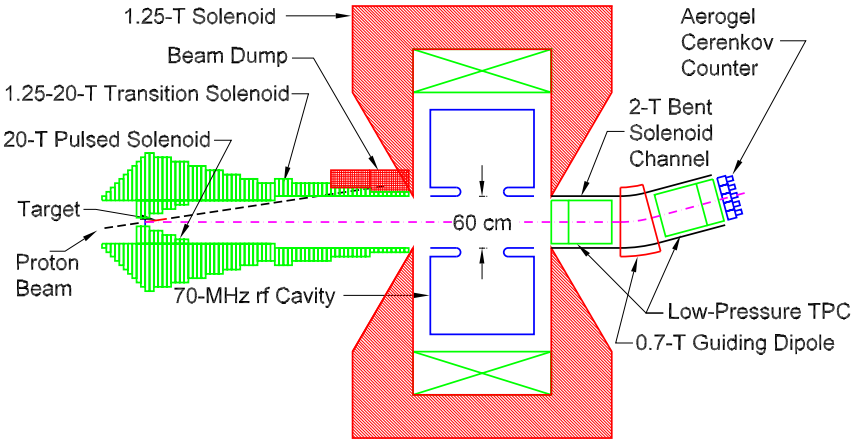
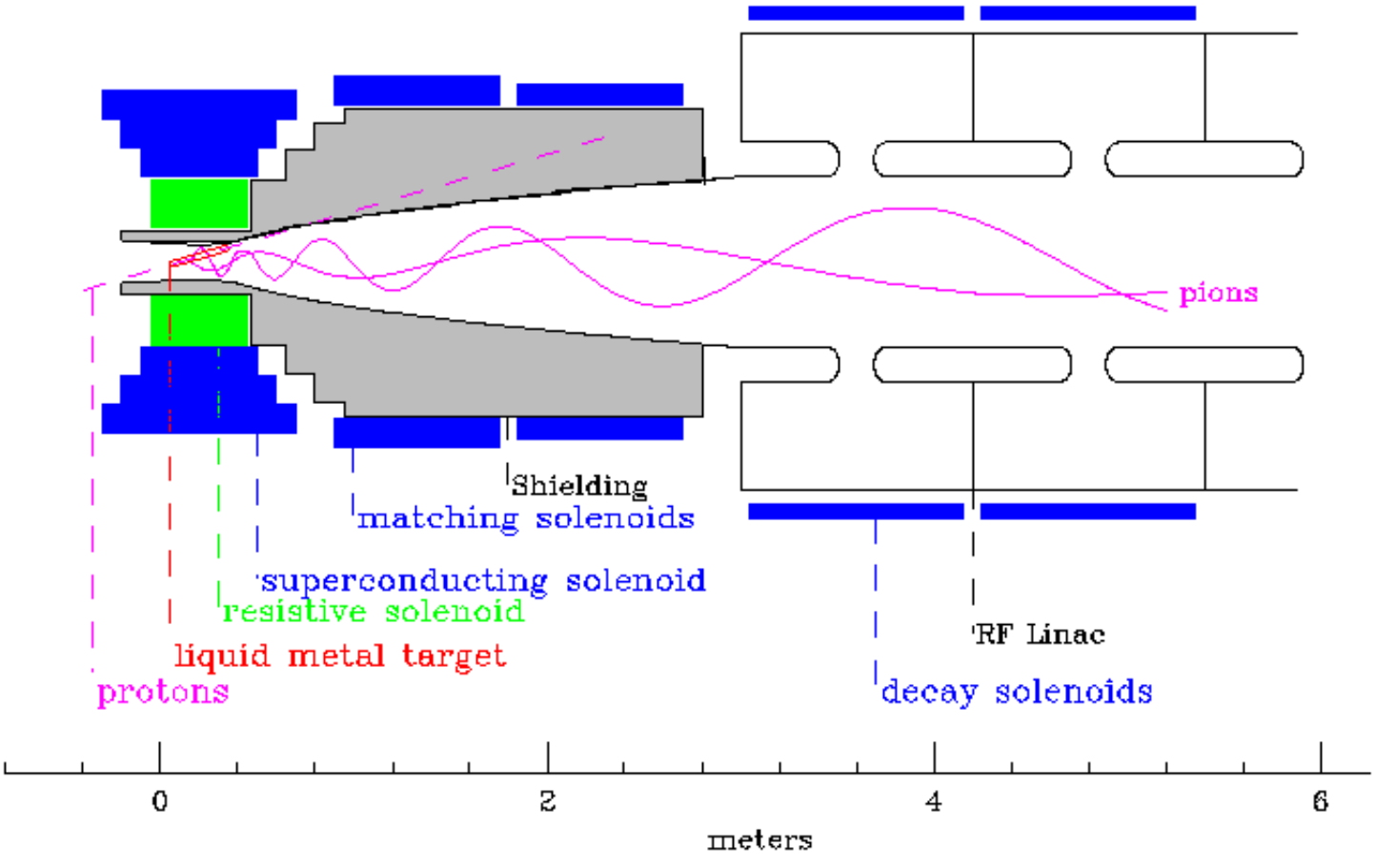

1.25-T Solenoid
Beam Dump
1.25-20-T Transition Solenoid
20-T Pulsed Solenoid
Target
Proton
Beam
70-MHz rf Cavity
60 cm
Aerogel
Cerenkov
Counter
2-T Bent
Solenoid
Channel
Low-Pressure TPC
0.7-T Guiding Dipole

# Targetry Challenges

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

- $> 10^{15}$ proton/sec onto a high-$Z$ target $\Leftrightarrow$ 4 MW beam power.
- 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 $\pi/\mu$ bunch energy with rf cavities and deliver to muon cooling channel.



Issues:

- 400 kW deposited in target.

  $\Rightarrow$ Move target material away from beam and cool remotely.

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

- First rf cavity should be $\approx 3$ m from target.

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

# ISOLDE Liquid Targets Damaged by Short Pulses

Cracks developed at braised joints and lead sprayed out.

# R&D Goals

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

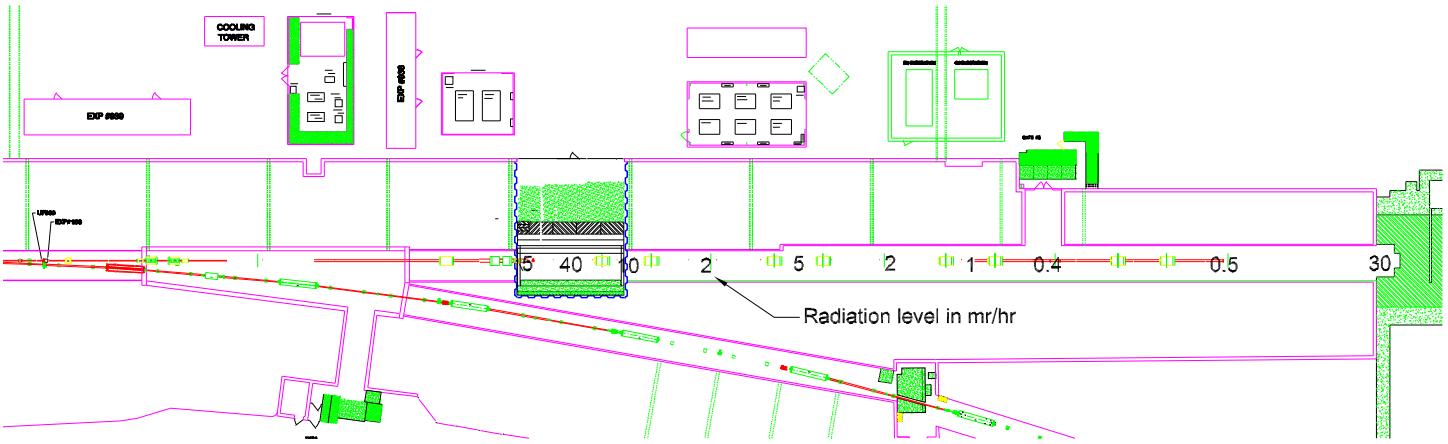
**Near Term** (1-2 years): Explore viability of a liquid metal jet target in intense, short proton pulses and (separately) in strong magnetic fields.
(Change target technology if encounter severe difficulties.)

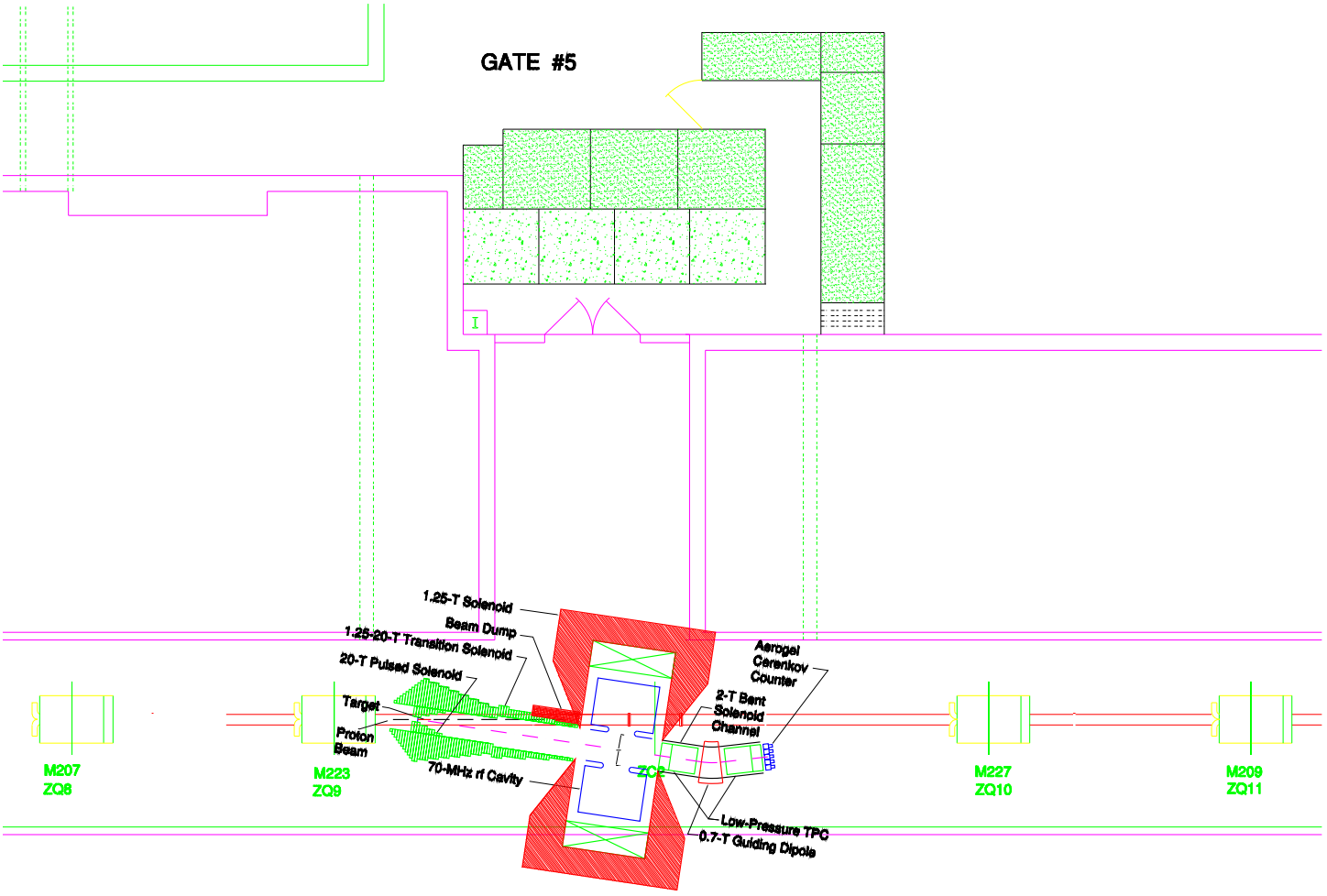
**Mid Term** (3-4 years): Add 20-T magnet to AGS beam tests; Test 70-MHz rf cavity (+ 1.25-T magnet) downstream of target; Characterize pion yield.

# The 8 Steps in the R&D Program

1. Simple tests of liquid (Ga-Sn) targets in the AGS FEB U-line.
2. Test of liquid jet entering a 20-T magnet (20-MW cw Bitter magnet at the National High Field Magnet Laboratory).
3. Test of liquid jet in the FEB U-line (without magnet).
4. Add 20-T pulsed magnet (4-MW peak) to the FEB U-line.
5. Add 70-MHz rf cavity downstream of target in FEB U-line.
6. Surround rf cavity with 1.25-T magnet.
7. Characterize pion yield from target + magnet system in FEB U-line.
8. Ongoing simulation of the thermal hydraulics of the liquid-metal target system.

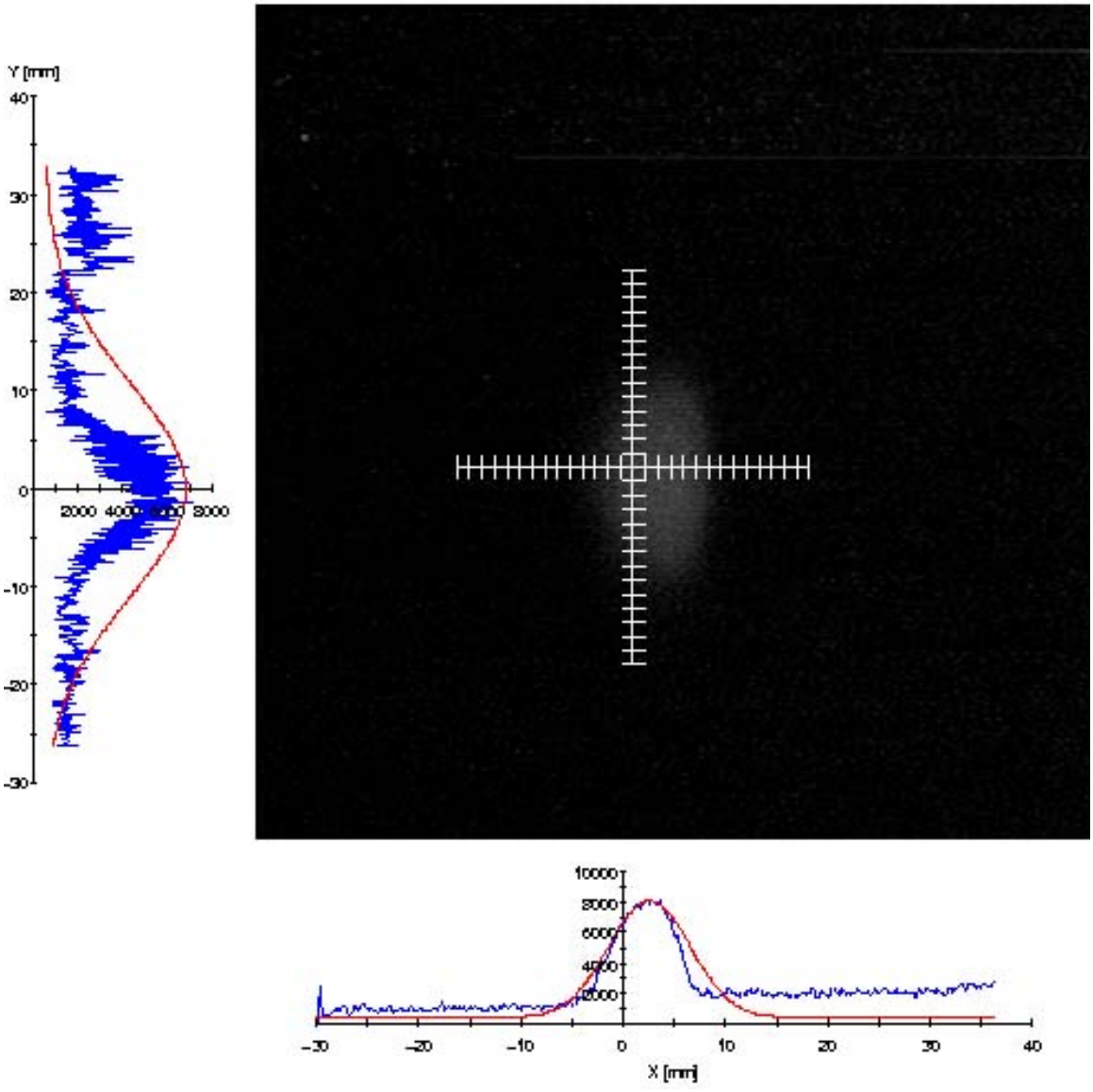
# Test Beam: AGS FEB U-Line



# Immediate Goal: Upgrade FEB U-Line for Smaller Spot Size and Greater Intensity

-- uf730 Wed Nov 18 06:42:53 1998 --
Framegrabber = seb-fg1
Signal Range = 0 157
Centroid = 7.07032 3.39971 mm
Center = 2.58813 -0.144885 mm
Sigma = 4.01048 10.8851 mm
!!Failed 2D Gauss Fit!!
Intensity = 1152191
Attenuation = 0%

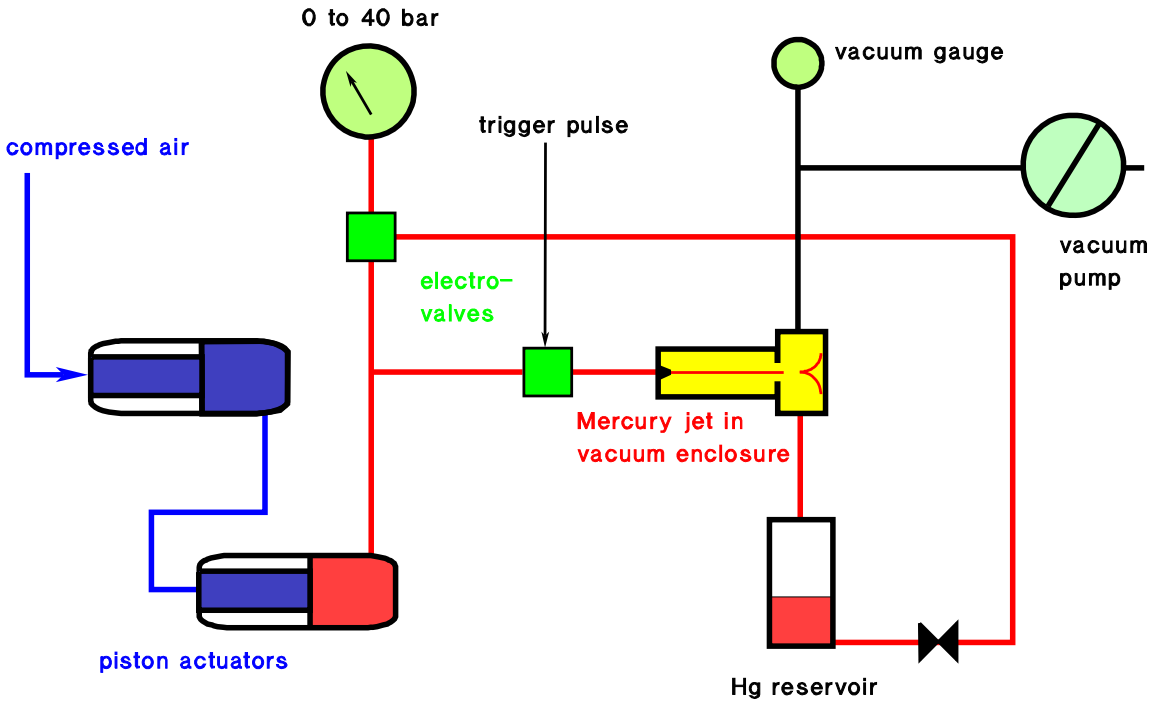


## Begin with Ga/Sn Liquid-Metal Alloy

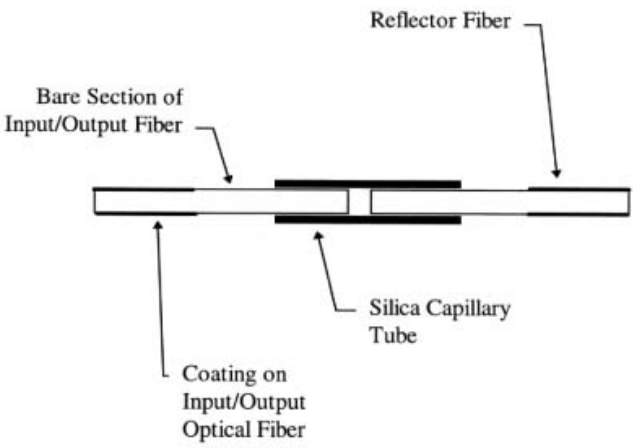
Eutectic Ga/Sn alloy melts at 20C. Density = 6 g/cm$^3$.

Easy to make and handle; very low viscosity.

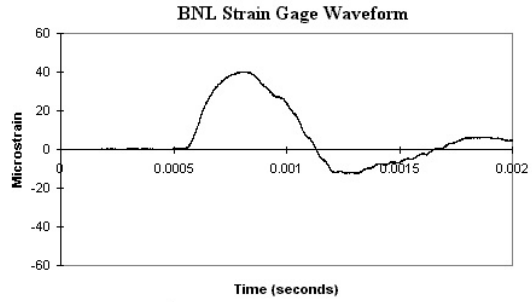
Build pulsed jet following design of C. Johnson:

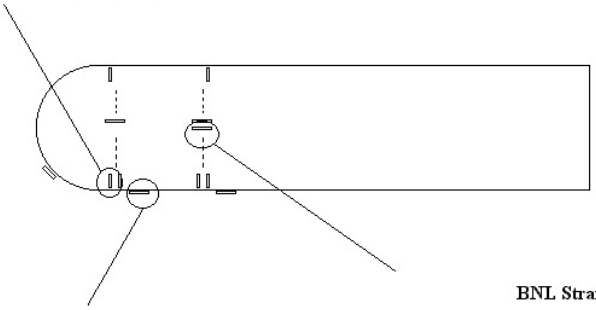


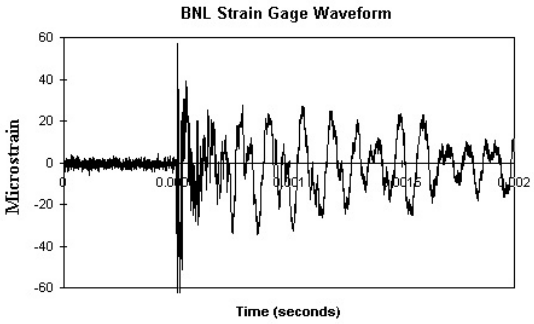
# Fiberoptic Strain Sensors

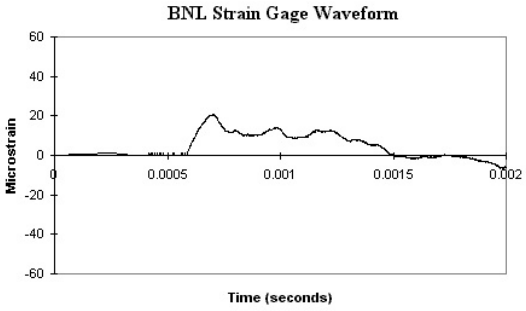






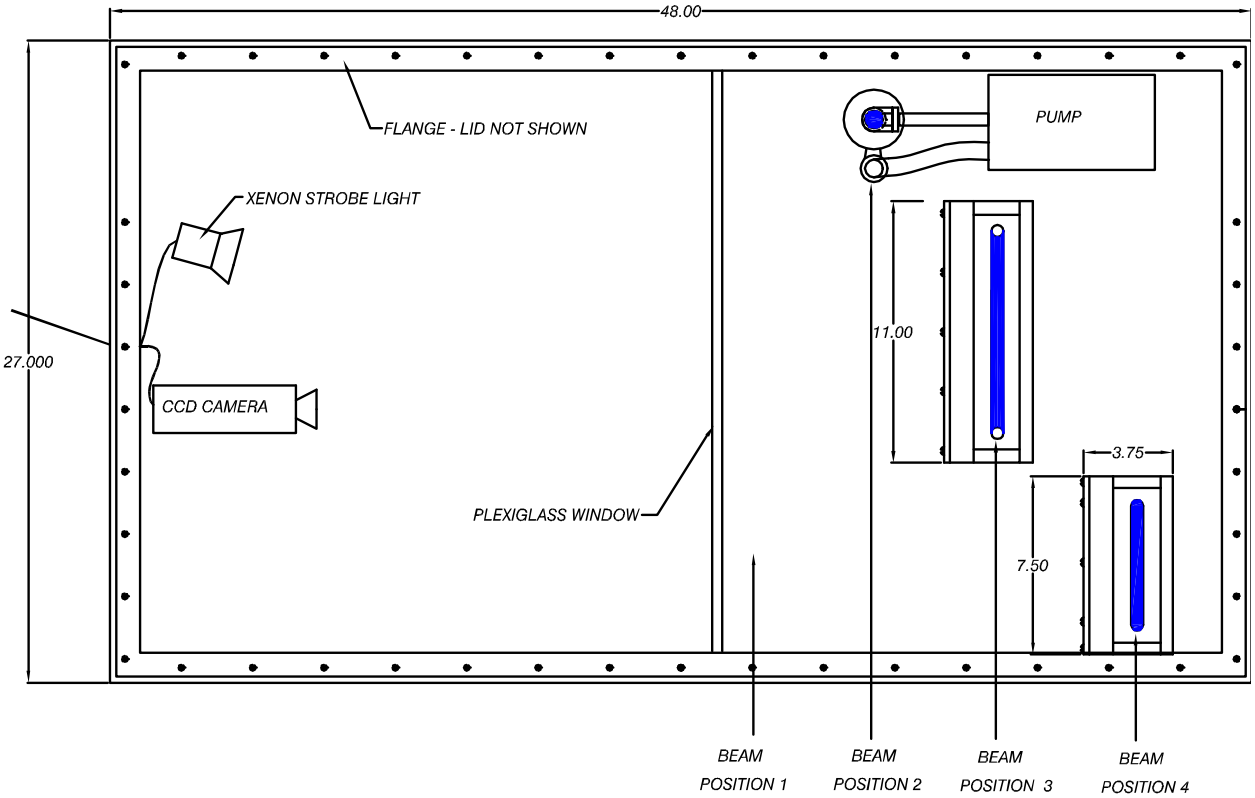





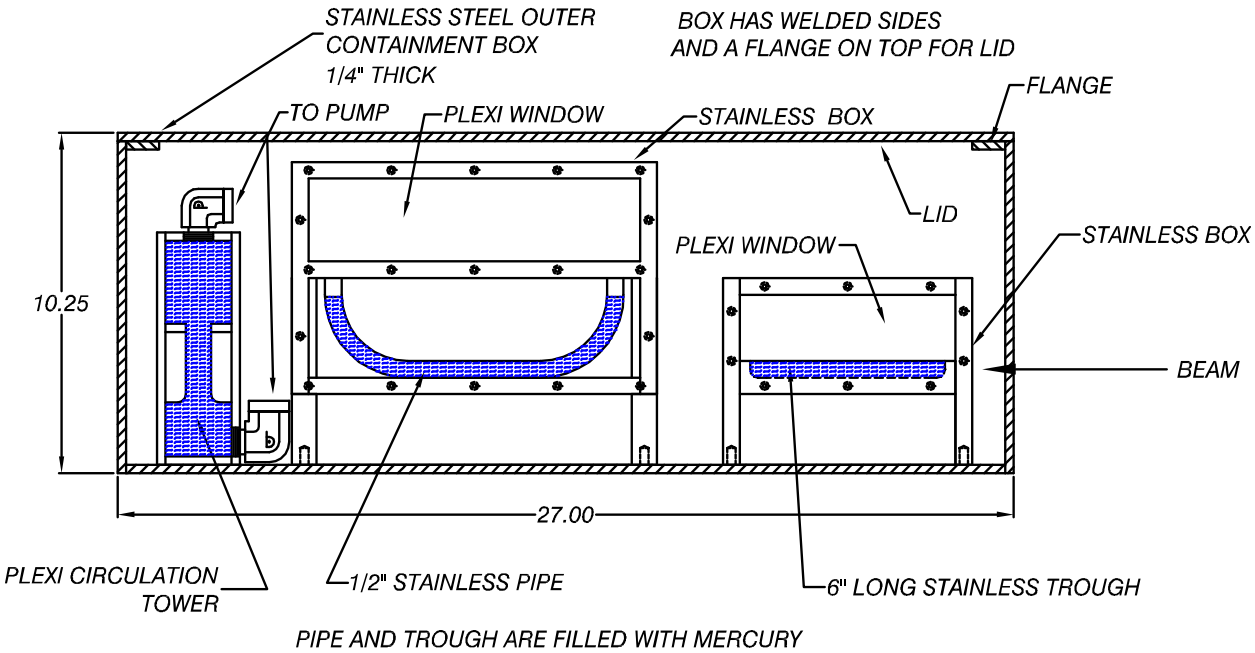



# First Test: Liquid Metal in a Trough, a Pipe and Free Flow

*TOP VIEW*




*CAMERA VIEW*




*PIPE AND TROUGH ARE FILLED WITH MERCURY*

# Institutional Involvement

| Topic | Institutions |
|---|---|
| 1. Initial Tests | BNL, CERN, ORNL, **Princeton** |
| 2. Liquid jet + 20-T magnet | BNL, **Princeton**, NHMFL |
| 3. Full-scale jet, $10^{14}$ $p$pp | ANL, **BNL**, CERN, Princeton |
| 4. Full-scale jet + pulsed 20-T magnet | ANL, **BNL**, CERN, Princeton |
| 5. RF cavity + short beam pulse | **BNL**, CERN, Fermilab, LBL, Princeton |
| 6. RF cavity + 1.25-T magnet | **BNL**, LBL, Princeton |
| 7. Pion-production measurement | **BNL**, Fermilab, LBL, Princeton |
| 8. Simulation + exploding wire tests | **ANL**, BNL, Fermilab, ORNL, Princeton |

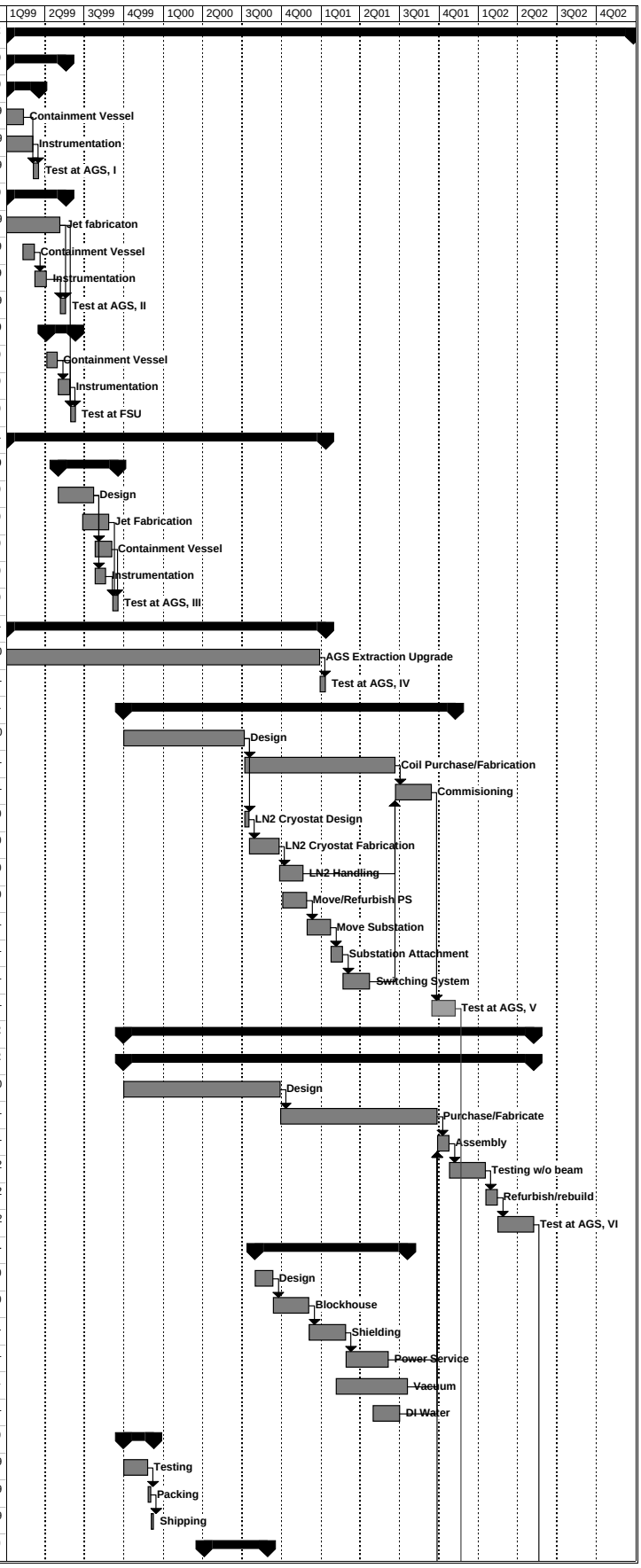
# Targetry R&D Budget

# FY 99

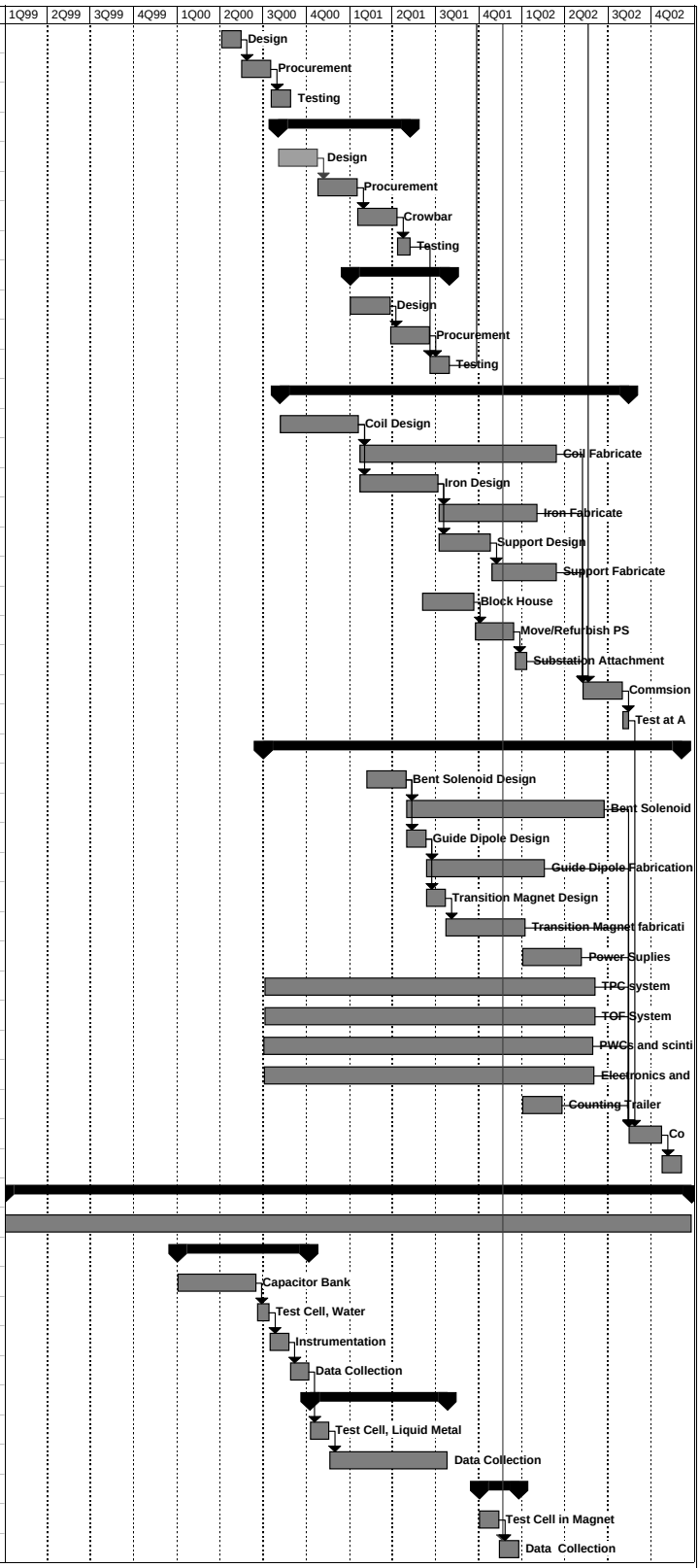
| Task | ANL | BNL | Princeton | Total |
|---|---|---|---|---|
| Initial Jet Studies | | 85 | 85 | 170 |
| AGS Beamline Upgrades | | 100 | | 100 |
| Pulsed Solenoid Design | | 50 | | 50 |
| RF Systems | | 100 | | 100 |
| Simulation Studies | 75 | | 5 | 80 |
| Total | 75 | 335 | 90 | **$500k** |

# Appendices:

| ID | Task Name | Duration | Cost | Start | Finish |
|---|---|---|---|---|---|
| 1 | **Targetry R&D** | **1040 days** | **$7,110,000** | **Fri 1/1/99** | **Thu 12/26/02** |
| 2 | **Liquid Metal I** | **100 days** | **$130,000** | **Fri 1/1/99** | **Thu 5/20/99** |
| 3 | **Initial Beam Test** | **55 days** | **$80,000** | **Fri 1/1/99** | **Thu 3/18/99** |
| 4 | Containment Vessel | 30 days | $30,000 | Fri 1/1/99 | Thu 2/11/99 |
| 5 | Instrumentation | 45 days | $40,000 | Fri 1/1/99 | Thu 3/4/99 |
| 6 | Test at AGS, I | 10 days | $10,000 | Fri 3/5/99 | Thu 3/18/99 |
| 7 | **3 mm Jet Test** | **100 days** | **$50,000** | **Fri 1/1/99** | **Thu 5/20/99** |
| 8 | Jet fabricaton | 90 days | $20,000 | Fri 1/1/99 | Thu 5/6/99 |
| 9 | Containment Vessel | 20 days | $10,000 | Tue 2/9/99 | Mon 3/8/99 |
| 10 | Instrumentation | 20 days | $10,000 | Tue 3/9/99 | Mon 4/5/99 |
| 11 | Test at AGS, II | 10 days | $10,000 | Fri 5/7/99 | Thu 5/20/99 |
| 12 | **Jet Test at FSU Magnet** | **50 days** | **$60,000** | **Mon 4/5/99** | **Fri 6/11/99** |
| 13 | Containment Vessel | 20 days | $20,000 | Mon 4/5/99 | Fri 4/30/99 |
| 14 | Instrumentation | 20 days | $20,000 | Mon 5/3/99 | Fri 5/28/99 |
| 15 | Test at FSU | 10 days | $20,000 | Mon 5/31/99 | Fri 6/11/99 |
| 16 | **2 cm Jet, 1e14 p's** | **530 days** | **$600,000** | **Fri 1/1/99** | **Thu 1/11/01** |
| 17 | **2 cm Jet** | **100 days** | **$90,000** | **Mon 5/3/99** | **Fri 9/17/99** |
| 18 | Design | 60 days | $20,000 | Mon 5/3/99 | Fri 7/23/99 |
| 19 | Jet Fabrication | 45 days | $20,000 | Mon 6/28/99 | Fri 8/27/99 |
| 20 | Containment Vessel | 30 days | $20,000 | Mon 7/26/99 | Fri 9/3/99 |
| 21 | Instrumentation | 20 days | $20,000 | Mon 7/26/99 | Fri 8/20/99 |
| 22 | Test at AGS, III | 10 days | $10,000 | Mon 9/6/99 | Fri 9/17/99 |
| 23 | **1e14 ppp** | **530 days** | **$510,000** | **Fri 1/1/99** | **Thu 1/11/01** |
| 24 | AGS Extraction Upgr | 520 days | $500,000 | Fri 1/1/99 | Thu 12/28/00 |
| 25 | Test at AGS, IV | 10 days | $10,000 | Fri 12/29/00 | Thu 1/11/01 |
| 26 | **Pulsed Solenoid** | **550 days** | **$1,020,000** | **Fri 10/1/99** | **Thu 11/8/01** |
| 27 | Design | 200 days | $100,000 | Fri 10/1/99 | Thu 7/6/00 |
| 28 | Coil Purchase/Fabrication | 250 days | $500,000 | Fri 7/7/00 | Thu 6/21/01 |
| 29 | Commisioning | 60 days | $100,000 | Fri 6/22/01 | Thu 9/13/01 |
| 30 | LN2 Cryostat Design | 7 days | $50,000 | Fri 7/7/00 | Mon 7/17/00 |
| 31 | LN2 Cryostat Fabrication | 50 days | $100,000 | Tue 7/18/00 | Mon 9/25/00 |
| 32 | LN2 Handling | 40 days | $20,000 | Tue 9/26/00 | Mon 11/20/00 |
| 33 | Move/Refurbish PS | 40 days | $40,000 | Wed 10/4/00 | Tue 11/28/00 |
| 34 | Move Substation | 40 days | $40,000 | Wed 11/29/00 | Tue 1/23/01 |
| 35 | Substation Attachment | 20 days | $20,000 | Wed 1/24/01 | Tue 2/20/01 |
| 36 | Switching System | 45 days | $30,000 | Wed 2/21/01 | Tue 4/24/01 |
| 37 | Test at AGS, V | 40 days | $20,000 | Fri 9/14/01 | Thu 11/8/01 |
| 38 | **RF Systems** | **680 days** | **$1,650,000** | **Fri 10/1/99** | **Thu 5/9/02** |
| 39 | **RF Cavity** | **680 days** | **$950,000** | **Fri 10/1/99** | **Thu 5/9/02** |
| 40 | Design | 260 days | $120,000 | Fri 10/1/99 | Thu 9/28/00 |
| 41 | Purchase/Fabricate | 260 days | $600,000 | Fri 9/29/00 | Thu 9/27/01 |
| 42 | Assembly | 20 days | $20,000 | Fri 9/28/01 | Thu 10/25/01 |
| 43 | Testing w/o beam | 60 days | $30,000 | Fri 10/26/01 | Thu 1/17/02 |
| 44 | Refurbish/rebuild | 20 days | $150,000 | Fri 1/18/02 | Thu 2/14/02 |
| 45 | Test at AGS, VI | 60 days | $30,000 | Fri 2/15/02 | Thu 5/9/02 |
| 46 | **Site Preparation** | **254 days** | **$300,000** | **Tue 8/1/00** | **Fri 7/20/01** |
| 47 | Design | 30 days | $30,000 | Tue 8/1/00 | Mon 9/11/00 |
| 48 | Blockhouse | 60 days | $150,000 | Tue 9/12/00 | Mon 12/4/00 |
| 49 | Shielding | 60 days | $30,000 | Tue 12/5/00 | Mon 2/26/01 |
| 50 | Power Service | 70 days | $20,000 | Wed 2/28/01 | Tue 6/5/01 |
| 51 | Vacuum | 120 days | $50,000 | Mon 2/5/01 | Fri 7/20/01 |
| 52 | DI Water | 45 days | $20,000 | Tue 5/1/01 | Mon 7/2/01 |
| 53 | **LBL Transfer** | **50 days** | **$50,000** | **Fri 10/1/99** | **Thu 12/9/99** |
| 54 | Testing | 40 days | $40,000 | Fri 10/1/99 | Thu 11/25/99 |
| 55 | Packing | 5 days | $5,000 | Fri 11/26/99 | Thu 12/2/99 |
| 56 | Shipping | 5 days | $5,000 | Fri 12/3/99 | Thu 12/9/99 |
| 57 | **Low Level RF** | **105 days** | **$40,000** | **Wed 4/5/00** | **Tue 8/29/00** |



| ID | Task Name | Duration | Cost | Start | Finish |
|---|---|---|---|---|---|
| 58 | Design | 30 days | $10,000 | Wed 4/5/00 | Tue 5/16/00 |
| 59 | Procurement | 45 days | $20,000 | Wed 5/17/00 | Tue 7/18/00 |
| 60 | Testing | 30 days | $10,000 | Wed 7/19/00 | Tue 8/29/00 |
| 61 | **Pulsing System** | **200 days** | **$110,000** | **Thu 8/3/00** | **Wed 5/9/01** |
| 62 | Design | 60 days | $30,000 | Thu 8/3/00 | Wed 10/25/00 |
| 63 | Procurement | 60 days | $30,000 | Thu 10/26/00 | Wed 1/17/01 |
| 64 | Crowbar | 60 days | $30,000 | Thu 1/18/01 | Wed 4/11/01 |
| 65 | Testing | 20 days | $20,000 | Thu 4/12/01 | Wed 5/9/01 |
| 66 | **Power Combiner** | **150 days** | **$200,000** | **Wed 1/3/01** | **Tue 7/31/01** |
| 67 | Design | 60 days | $80,000 | Wed 1/3/01 | Tue 3/27/01 |
| 68 | Procurement | 60 days | $100,000 | Wed 3/28/01 | Tue 6/19/01 |
| 69 | Testing | 30 days | $20,000 | Wed 6/20/01 | Tue 7/31/01 |
| 70 | **RF Solenoid** | **529 days** | **$1,110,000** | **Mon 8/7/00** | **Thu 8/15/02** |
| 71 | Coil Design | 120 days | $60,000 | Mon 8/7/00 | Fri 1/19/01 |
| 72 | Coil Fabricate | 300 days | $500,000 | Mon 1/22/01 | Fri 3/15/02 |
| 73 | Iron Design | 120 days | $60,000 | Mon 1/22/01 | Fri 7/6/01 |
| 74 | Iron Fabricate | 150 days | $200,000 | Mon 7/9/01 | Fri 2/1/02 |
| 75 | Support Design | 80 days | $40,000 | Mon 7/9/01 | Fri 10/26/01 |
| 76 | Support Fabricate | 100 days | $50,000 | Mon 10/29/01 | Fri 3/15/02 |
| 77 | Block House | 80 days | $20,000 | Mon 6/4/01 | Fri 9/21/01 |
| 78 | Move/Refurbish PS | 60 days | $30,000 | Mon 9/24/01 | Fri 12/14/01 |
| 79 | Substation Attachment | 20 days | $20,000 | Mon 12/17/01 | Fri 1/11/02 |
| 80 | Commsioning | 60 days | $120,000 | Fri 5/10/02 | Thu 8/1/02 |
| 81 | Test at AGS, VII | 10 days | $10,000 | Fri 8/2/02 | Thu 8/15/02 |
| 82 | **Capture Experiment** | **634 days** | **$1,770,000** | **Mon 7/3/00** | **Thu 12/5/02** |
| 83 | Bent Solenoid Design | 60 days | $30,000 | Tue 2/6/01 | Mon 4/30/01 |
| 84 | Bent Solenoid Fabrication | 300 days | $500,000 | Tue 5/1/01 | Mon 6/24/02 |
| 85 | Guide Dipole Design | 30 days | $20,000 | Tue 5/1/01 | Mon 6/11/01 |
| 86 | Guide Dipole Fabrication | 180 days | $150,000 | Tue 6/12/01 | Mon 2/18/02 |
| 87 | Transition Magnet Design | 30 days | $20,000 | Tue 6/12/01 | Mon 7/23/01 |
| 88 | Transition Magnet fabricat | 120 days | $100,000 | Tue 7/24/01 | Mon 1/7/02 |
| 89 | Power Suplies | 90 days | $100,000 | Wed 1/2/02 | Tue 5/7/02 |
| 90 | TPC system | 500 days | $240,000 | Wed 7/5/00 | Tue 6/4/02 |
| 91 | TOF System | 500 days | $120,000 | Wed 7/5/00 | Tue 6/4/02 |
| 92 | PWCs and scintillators | 500 days | $150,000 | Mon 7/3/00 | Fri 5/31/02 |
| 93 | Electronics and DAQData | 500 days | $200,000 | Tue 7/4/00 | Mon 6/3/02 |
| 94 | Counting Trailer | 60 days | $60,000 | Thu 1/3/02 | Wed 3/27/02 |
| 95 | Commisioning | 50 days | $50,000 | Fri 8/16/02 | Thu 10/24/02 |
| 96 | Test at AGS, VIII | 30 days | $30,000 | Fri 10/25/02 | Thu 12/5/02 |
| 97 | **Simulation & Validation** | **1040 days** | **$770,000** | **Fri 1/1/99** | **Thu 12/26/02** |
| 98 | Simulation | 1040 days | $600,000 | Fri 1/1/99 | Thu 12/26/02 |
| 99 | **Exploding Wire I** | **200 days** | **$110,000** | **Mon 1/3/00** | **Fri 10/6/00** |
| 100 | Capacitor Bank | 120 days | $60,000 | Mon 1/3/00 | Fri 6/16/00 |
| 101 | Test Cell, Water | 20 days | $10,000 | Mon 6/19/00 | Fri 7/14/00 |
| 102 | Instrumentation | 30 days | $30,000 | Mon 7/17/00 | Fri 8/25/00 |
| 103 | Data Collection | 30 days | $10,000 | Mon 8/28/00 | Fri 10/6/00 |
| 104 | **Exploding Wire II** | **210 days** | **$40,000** | **Mon 10/9/00** | **Fri 7/27/01** |
| 105 | Test Cell, Liquid Meta | 30 days | $10,000 | Mon 10/9/00 | Fri 11/17/00 |
| 106 | Data Collection | 180 days | $30,000 | Mon 11/20/00 | Fri 7/27/01 |
| 107 | **Exploding Wire III** | **60 days** | **$20,000** | **Wed 10/3/01** | **Tue 12/25/01** |
| 108 | Test Cell in Magnet | 30 days | $10,000 | Wed 10/3/01 | Tue 11/13/01 |
| 109 | Data Collection | 30 days | $10,000 | Wed 11/14/01 | Tue 12/25/01 |



| | 1999 | 2000 | 2001 | 2002 | Total |
|---|---|---|---|---|---|
| Targetry R&D | | | | | |
| Liquid Metal I | | | | | |
| Initial Beam Test | | | | | |
| Containment Vessel | $30,000 | | | | $30,000 |
| Instrumentation | $40,000 | | | | $40,000 |
| Test at AGS, I | $10,000 | | | | $10,000 |
| 3 mm Jet Test | | | | | |
| Jet fabricaton | $20,000 | | | | $20,000 |
| Containment Vessel | $10,000 | | | | $10,000 |
| Instrumentation | $10,000 | | | | $10,000 |
| Test at AGS, II | $10,000 | | | | $10,000 |
| Jet Test at FSU Magnet | | | | | |
| Containment Vessel | $20,000 | | | | $20,000 |
| Instrumentation | $20,000 | | | | $20,000 |
| Test at FSU | $20,000 | | | | $20,000 |
| 2 cm Jet, 1e14 p's | | | | | |
| 2 cm Jet | | | | | |
| Design | $20,000 | | | | $20,000 |
| Jet Fabrication | $20,000 | | | | $20,000 |
| Containment Vessel | $20,000 | | | | $20,000 |
| Instrumentation | $20,000 | | | | $20,000 |
| Test at AGS, III | $10,000 | | | | $10,000 |
| 1e14 ppp | | | | | |
| AGS Extraction Upgrade | $250,962 | $249,039 | | | $500,000 |
| Test at AGS, IV | | $1,000 | $9,000 | | $10,000 |
| Pulsed Solenoid | | | | | |
| Design | $33,000 | $67,000 | | | $100,000 |
| Coil Purchase/Fabrication | | $252,000 | $248,000 | | $500,000 |
| Commisioning | | | $100,000 | | $100,000 |
| LN2 Cryostat Design | | $50,000 | | | $50,000 |
| LN2 Cryostat Fabrication | | $100,000 | | | $100,000 |
| LN2 Handling | | $20,000 | | | $20,000 |
| Move/Refurbish PS | | $40,000 | | | $40,000 |
| Move Substation | | $23,000 | $17,000 | | $40,000 |
| Substation Attachment | | | $20,000 | | $20,000 |
| Switching System | | | $30,000 | | $30,000 |
| Test at AGS, V | | | $20,000 | | $20,000 |
| RF Systems | | | | | |
| RF Cavity | | | | | |
| Design | $30,462 | $89,539 | | | $120,000 |
| Purchase/Fabricate | | $152,308 | $447,692 | | $600,000 |
| Assembly | | | $20,000 | | $20,000 |
| Testing w/o beam | | | $23,500 | $6,500 | $30,000 |
| Refurbish/rebuild | | | | $150,000 | $150,000 |
| Test at AGS, VI | | | | $30,000 | $30,000 |
| Site Preparation | | | | | |
| Design | | $30,000 | | | $30,000 |
| Blockhouse | | $150,000 | | | $150,000 |
| Shielding | | $9,500 | $20,500 | | $30,000 |
| Power Service | | | $20,000 | | $20,000 |
| Vacuum | | | $50,000 | | $50,000 |
| DI Water | | | $20,000 | | $20,000 |
| LBL Transfer | | | | | |
| Testing | $40,000 | | | | $40,000 |
| Packing | $5,000 | | | | $5,000 |
| Shipping | $5,000 | | | | $5,000 |
| Low Level RF | | | | | |
| Design | | $10,000 | | | $10,000 |
| Procurement | | $20,000 | | | $20,000 |
| Testing | | $10,000 | | | $10,000 |
| Pulsing System | | | | | |
| Design | | $30,000 | | | $30,000 |
| Procurement | | $77,125 | ($47,125) | | $30,000 |
| Crowbar | | | $30,000 | | $30,000 |
| Testing | | | $20,000 | | $20,000 |
| Power Combiner | | | | | |
| Design | | | $80,000 | | $80,000 |
| Procurement | | | $100,000 | | $100,000 |
| Testing | | | $20,000 | | $20,000 |
| RF Solenoid | | | | | |
| Coil Design | | $52,500 | $7,500 | | $60,000 |
| Coil Fabricate | | | $410,000 | $90,000 | $500,000 |
| Iron Design | | | $60,000 | | $60,000 |
| Iron Fabricate | | | $168,000 | $32,000 | $200,000 |
| Support Design | | | $40,000 | | $40,000 |
| Support Fabricate | | | $23,000 | $27,000 | $50,000 |
| Block House | | | $20,000 | | $20,000 |
| Move/Refurbish PS | | | $30,000 | | $30,000 |
| Substation Attachment | | | $11,000 | $9,000 | $20,000 |
| Commsioning | | | | $120,000 | $120,000 |
| Test at AGS, VII | | | | $10,000 | $10,000 |
| Capture Experiment | | | | | |
| Bent Solenoid Design | | | $30,000 | | $30,000 |
| Bent Solenoid Fabrication | | | $291,667 | $208,333 | $500,000 |
| Guide Dipole Design | | | $20,000 | | $20,000 |
| Guide Dipole Fabrication | | | $120,833 | $29,167 | $150,000 |
| Transition Magnet Design | | | $20,000 | | $20,000 |
| Transition Magnet fabrication | | | $95,833 | $4,167 | $100,000 |
| Power Suplies | | | | $100,000 | $100,000 |
| TPC system | | $61,440 | $125,280 | $53,280 | $240,000 |
| TOF System | | $30,720 | $62,640 | $26,640 | $120,000 |
| PWCs and scintillators | | $39,000 | $78,300 | $32,700 | $150,000 |
| Electronics and DAQData acquisition | | $200,000 | | | $200,000 |
| Counting Trailer | | | | $60,000 | $60,000 |
| Commisioning | | | | $50,000 | $50,000 |
| Test at AGS, VIII | | | | $30,000 | $30,000 |
| Simulation & Validation | | | | | |
| Simulation | $150,577 | $150,000 | $150,577 | $148,846 | $600,000 |
| Exploding Wire I | | | | | |
| Capacitor Bank | | $60,000 | | | $60,000 |
| Test Cell, Water | | $10,000 | | | $10,000 |
| Instrumentation | | $30,000 | | | $30,000 |
| Data Collection | | $10,000 | | | $10,000 |
| Exploding Wire II | | | | | |
| Test Cell, Liquid Metal | | $10,000 | | | $10,000 |
| Data Collection | | $5,000 | $25,000 | | $30,000 |
| Exploding Wire III | | | | | |
| Test Cell in Magnet | | | $10,000 | | $10,000 |
| Data Collection | | | $10,000 | | $10,000 |
| Total | $795,000 | $2,039,170 | $3,058,198 | $1,217,633 | $7,110,000 |