Conducting Pulsed Taget

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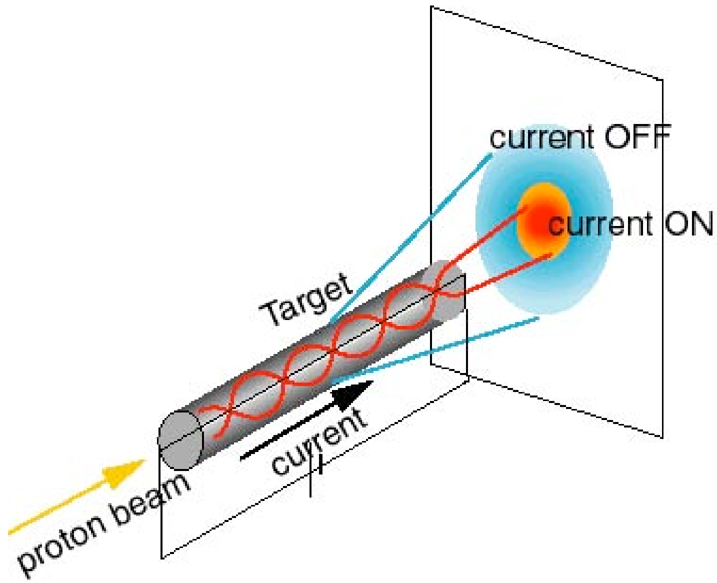
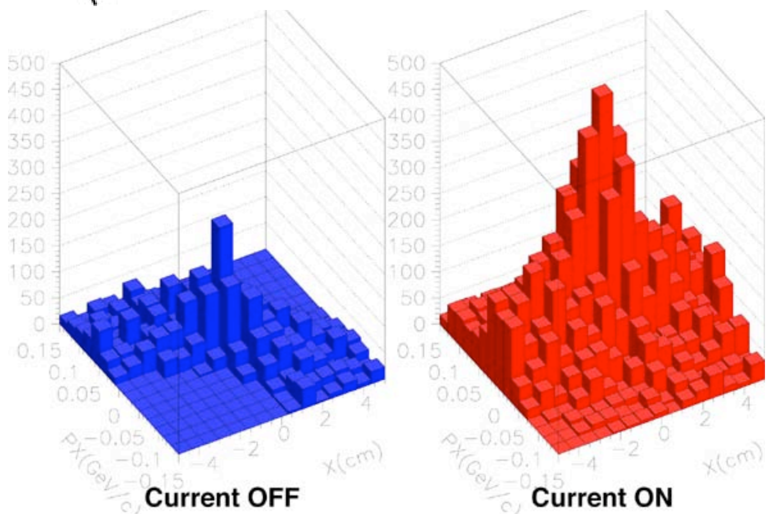
Outline

- Introduction
- Design Study
- Hardware
- Summary

Conducting Target

- Confine pions inside the target with troidal field
  - B. Autin, @Nufact01
- Advantage over Solenoid
  - Low emittance beam
  - Linear transport element
    - No SC solenoid channel
    - Cheaper!
  - Cooling condition better?



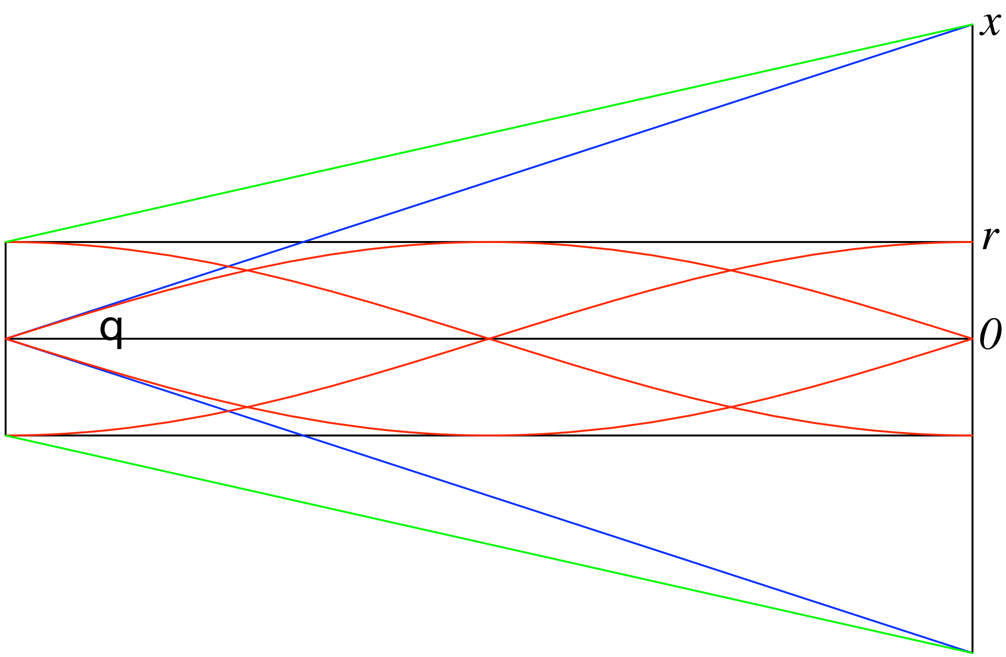


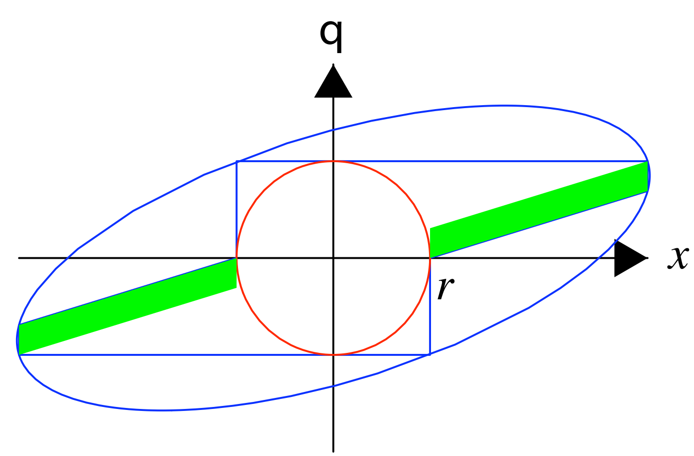
Priciple of CT

Real Space

Phase Space

Poincaré section





Comparison of target material

- Mercury is good candidate
  - Minimum Power
  - Easy to cooling
  - Higher pion yield
- Technical Issues
  - How to cut off electrical circuit?
  - Stress due to pinch effect
  - Container
    - Shockwave
    - Cavitation
    - Thicker wall can be used!
      - No reabsorption
  - Window

	Mercury	Beryllium	Lithium
Power [MW]	3.18	9.95	33.6
Temerature rise per pulse[K]	160	83	142
Field [T]	22.04	21.12	20.84
Intensity [MA]	2.49	2.49	2.49
Frequency [Hz]	50	50	50
Phase[π]	1.	3.	10.
Puls length [ms]	0.264	4.68	3.3
Targe length [m]	0.13	0.407	1.37
Targ radius [m]	0.0226	0.0236	0.024

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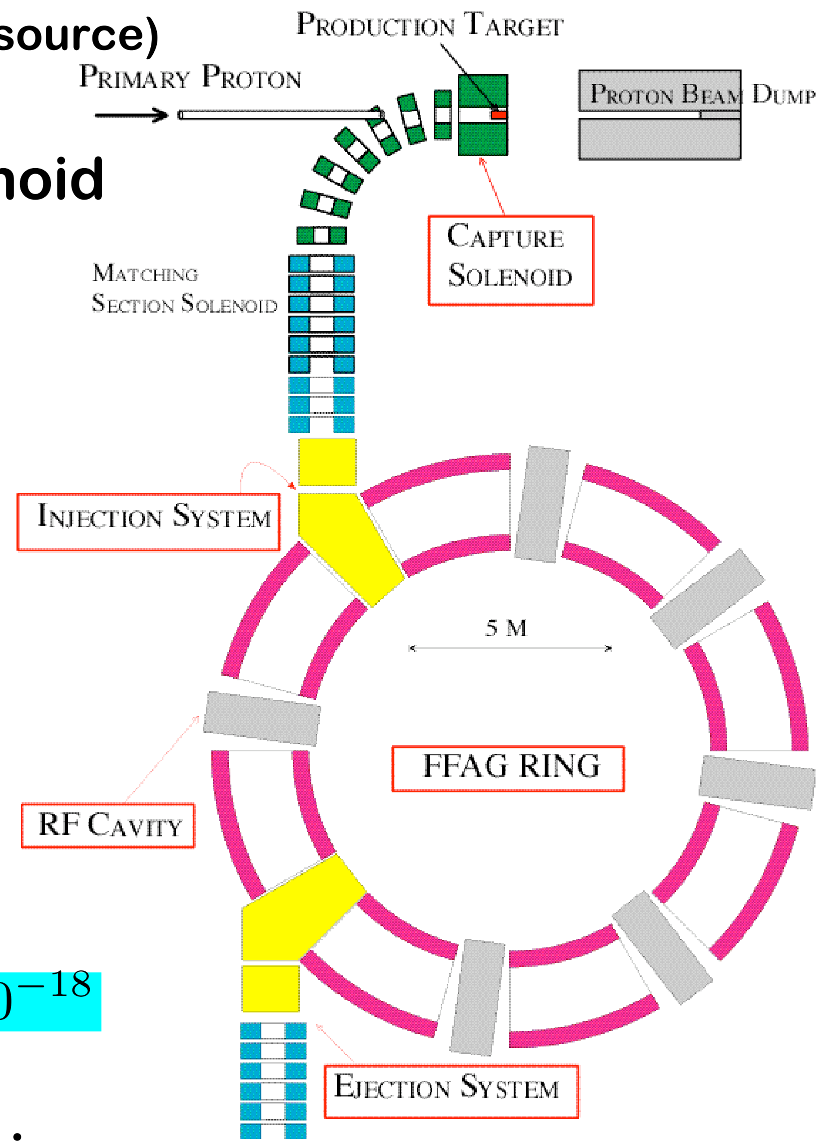
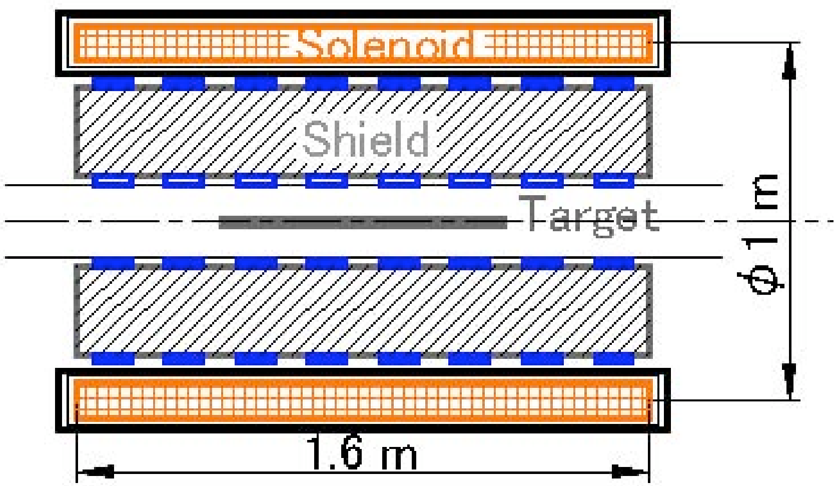
Design study

PRISM Project

- PRISM (=Phase Rotated Intense Slow Muon source)
  - High power Proton Driver
  - Pion capture with High Field Solenoid
  - Phase rotation
- Beam characteristic
  - Intense x 1000~10000
    - 20 MeV (68 MeV/c)
    - 10^{11}~10^{12} μ/s
  - Bright
    - dE/E ~ a few %
  - Pure
    - no pion contamination
- For muon experiment
  - m-e conversion $Br(\mu N \to eN) < 10^{-18}$
  - muon EDM $10^{-24} e \cdot cm$
  - application for material and life science



Baseline option

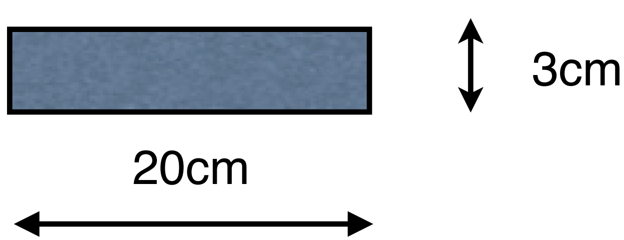


- Baseline option
  - B=6T
  - IR=450 cm, L=160 cm
  - Graphite Target L=2λ=80 cm
  - Shield thickness 25cm
- Still Necessary for R&D
  - Cooling ~500 W
  - Quench protection
  - Radiation safety
  - Thin Graphite target

CT for Alternative

- **Parameters**

Material	Mercury
R: Radius	1.5 cm
L: Lengh	20 cm
I: Peak Current	1 MA
B: Surface Field	13 T
G: Field gradient	870 T/m
f: Repetition rate	50 Hz

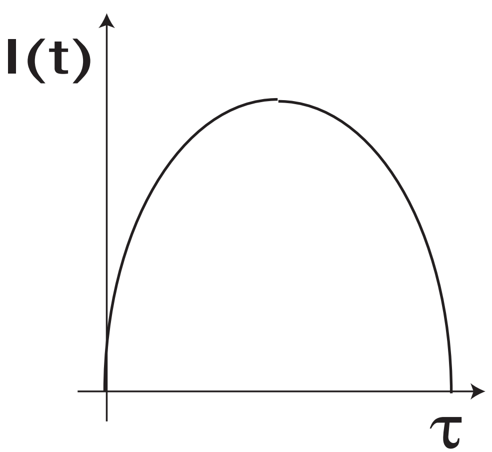


Pulsed current

- Skin depth for mercury

$$\delta = \sqrt{\frac{2\tau}{\pi\mu_0}\sigma} = \frac{R}{2} \qquad (\sigma : conductivity)$$

$$\tau = 0.112\ ms\ \ for\ \ \delta = 0.75\ cm$$



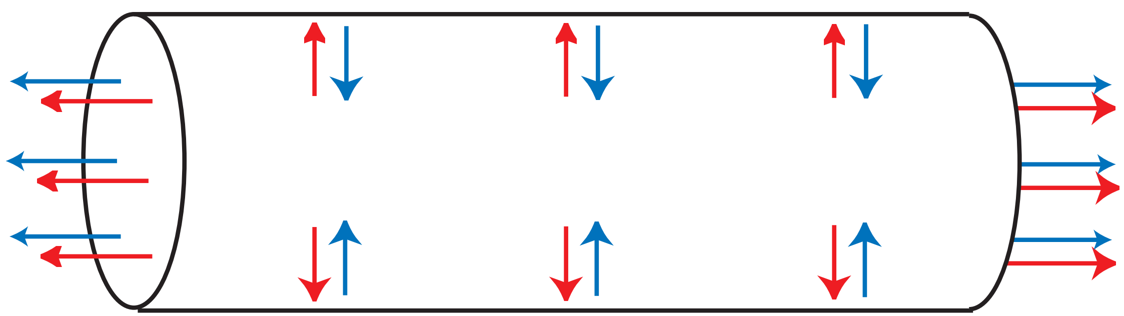
Pressure

- **Thermally induced**

$$\Delta Q = \frac{\mu_0}{16} I_0^2 \cdot l = 17kJ/pulse$$

$$\Delta T = \frac{\Delta Q}{c \cdot m} = 70K/pulse$$

$$P_{ti} = \frac{\alpha_v \cdot \Delta T}{\kappa} = 280MPa$$

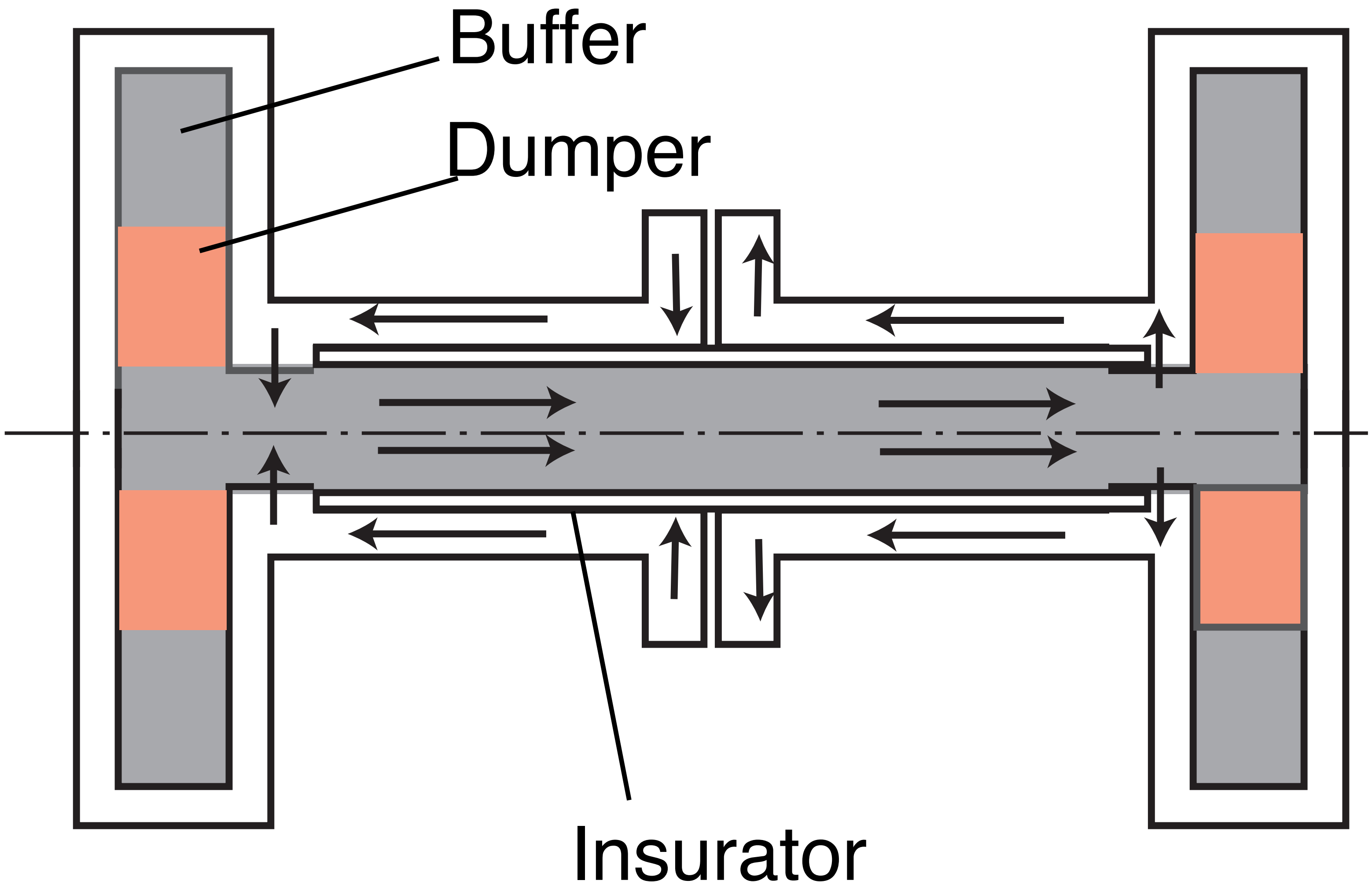


- **Pinch effect**

$$\hat{P}_{mag} = \frac{B_o^2}{\mu_0} = 120MPa$$

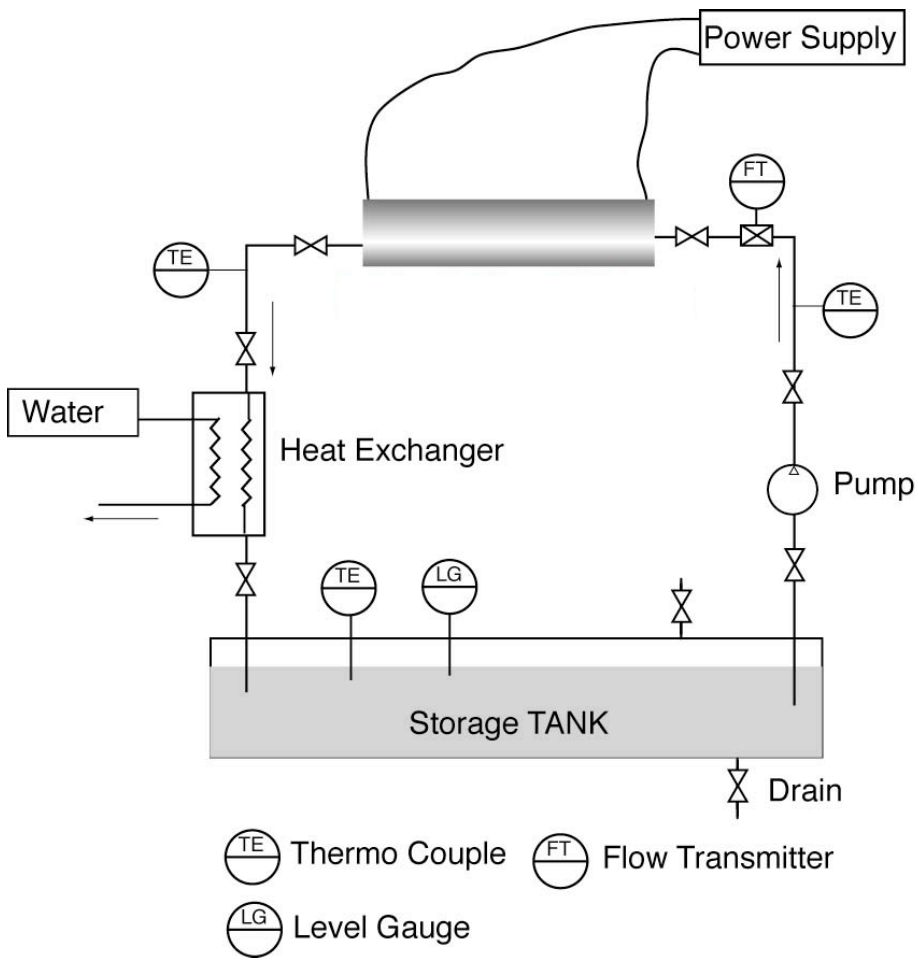
$$\hat{P}_{Z_{mag}} = \frac{\hat{P}_{mag}}{2}$$

Conceptual Design



Hardware

Setup for current test



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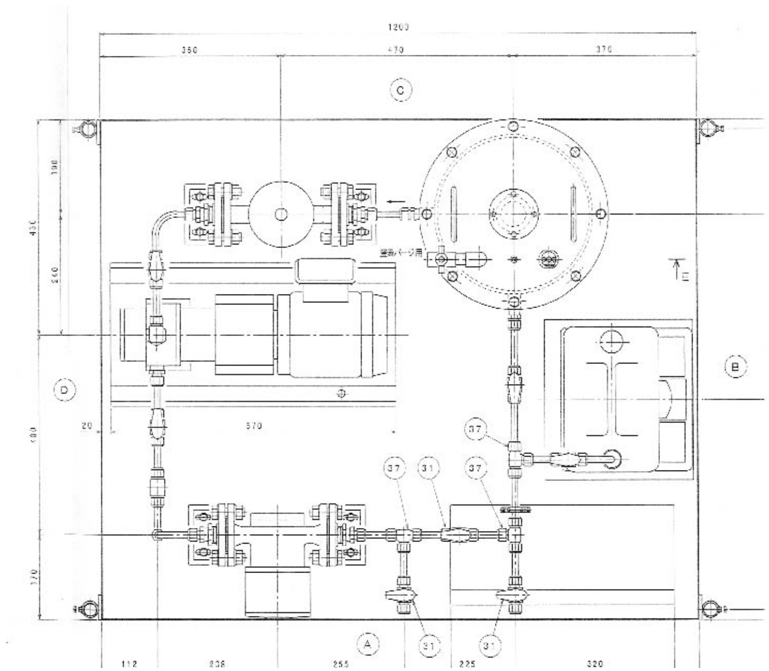
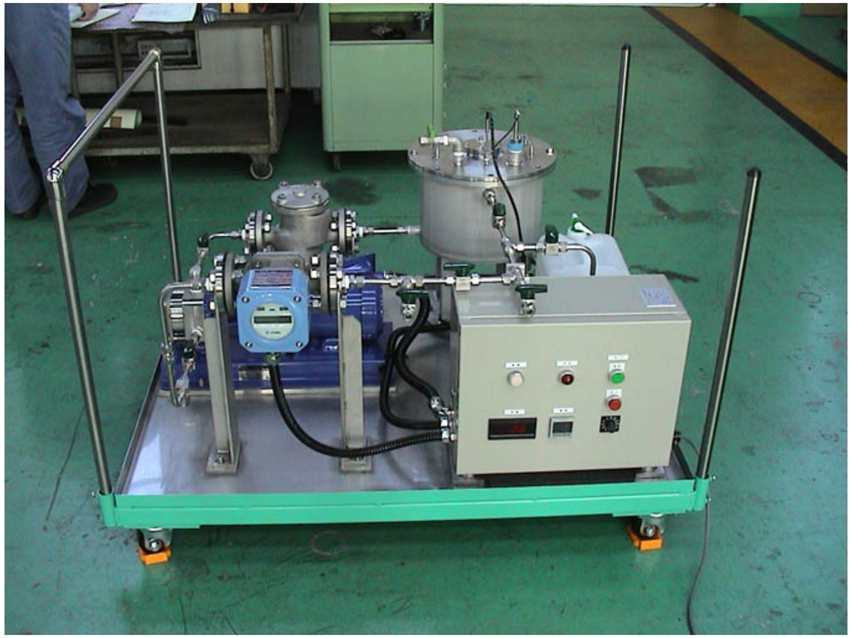
Mercury Test Loop

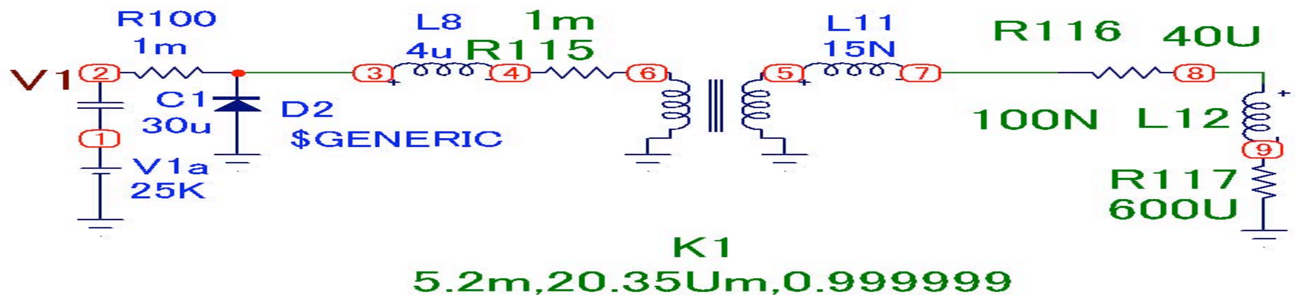
- Mercury 18 litter ~ 250 kg
- Study mercury flow

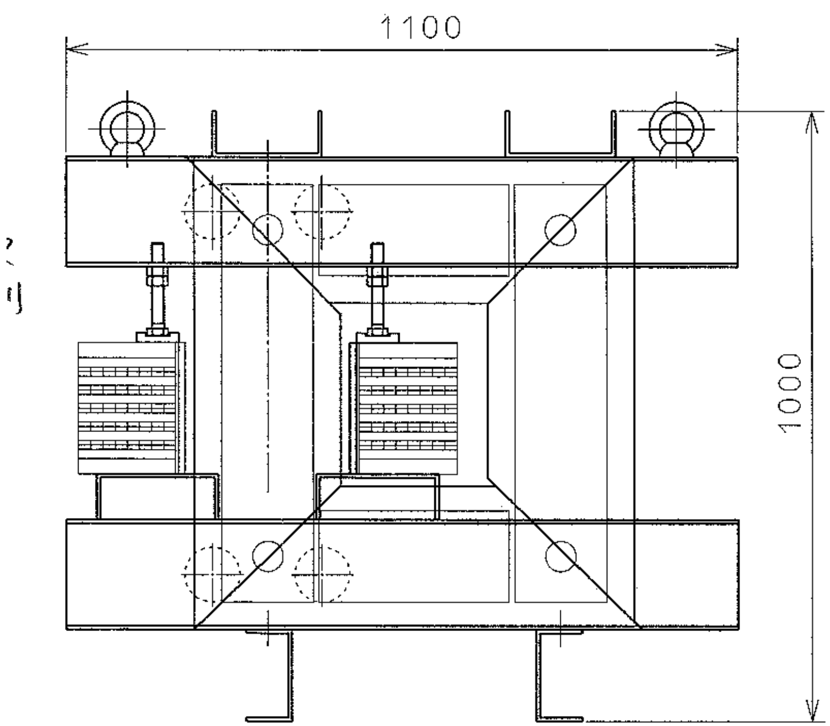


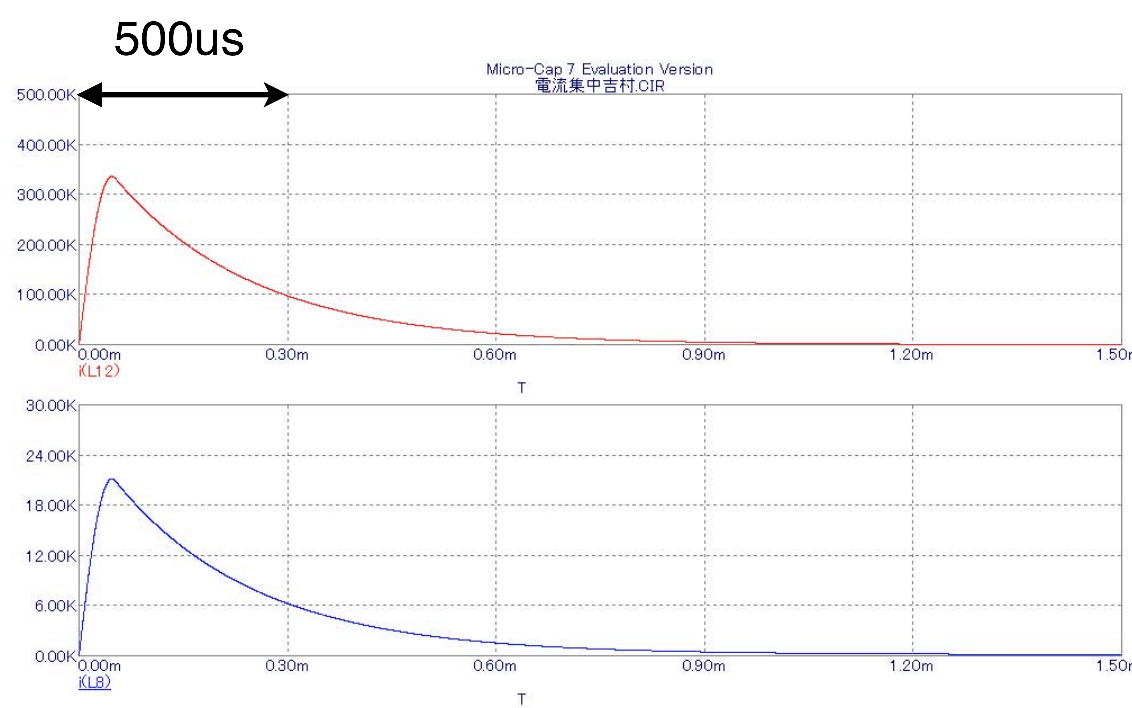


Pulse transformer

Peak Current	300KA
Inductance	0.1uH
Registance	0.58m
Risetime	50us







Summary

- Pused conducting target
  - Target for neutrino factory
  - Alternative solution of PRISM target
    - comparable yield with capture solenoid option
- Proof of Principle Test have been prepared.
  - Mercury loop
  - Pulse Transformer
  - Conducting Target