Muon Collaboration

LH2 ABSORBER R & D AT FERMILAB

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LH2 ABSORBER R & D MOTIVATION

→ Driving Issues

1. Minimize beam scattering

   * Largest possible L_R ⟹ choose LH2
   * Much work towards optimizing window thickness

2. Remove large dE/dx heat

   * Drives most of the absorber design
   * Operation in a confined and complex environment

3. Too complicated to simulate completely

⟹ must build prototypes and set up engineering runs.

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R & D PROGRAM

➡ Final cooling channel design components are not yet determined. Need to factorize major design concerns independent of the particular channel parameters

1. Windows

   * Develop a suitable window design and flange system to satisfy cooling channel requirements and mechanical stability
   * Precision dimensional measurement
   * Instrumented strain tests and FEA confirmation

2. Manifold

   * Internal configuration for LH2 flow
   * Non-cryo fluid flow tests
   * Temp, pressure and flow monitoring
   * Sufficient mechanical failsafes

3. Refrigeration

   * Heat exchange between LH2 and helium systems

LH2 ABSORBER DESIGN

- Different lattice designs require different absorber dimensions:

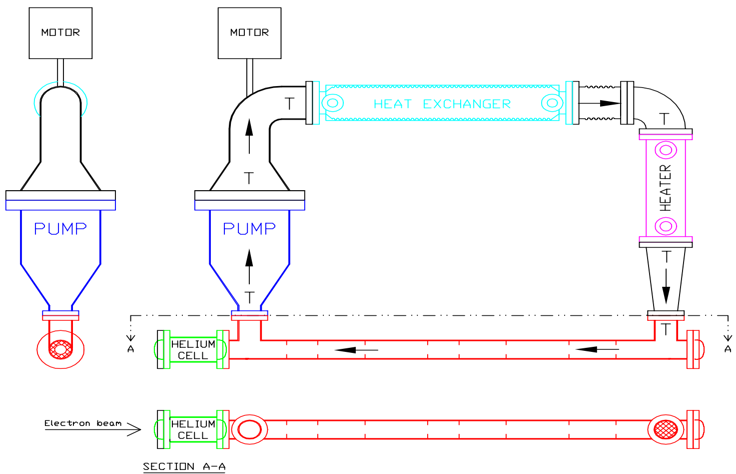
CONFIG/ PARAM	Single Flip	FOFO1	FOFO2	units
Length	30	12.6	13.2	cm
Radius	20	15	10	cm
Volume	38	9	4	liters

- Energy/second deposited for all absorber shapes and muon momenta is O(100) Watts:

Length	p_μ Mev/c	dE/dx Mev/(g/cm^2)	$\langle\Delta E\rangle$ Mev	$\langle P\rangle$ (4×10^{12} @15 Hz) Watts
30 cm	106	6.0	13	183
	211	4.2	5.6	128
	317	4.1	5.5	125
12.6 cm	106	6.0	3.4	77
	211	4.2	2.4	54
	317	4.1	2.3	53

TWO LH2 ABSORBER DESIGNS

➞ External heat exchange:

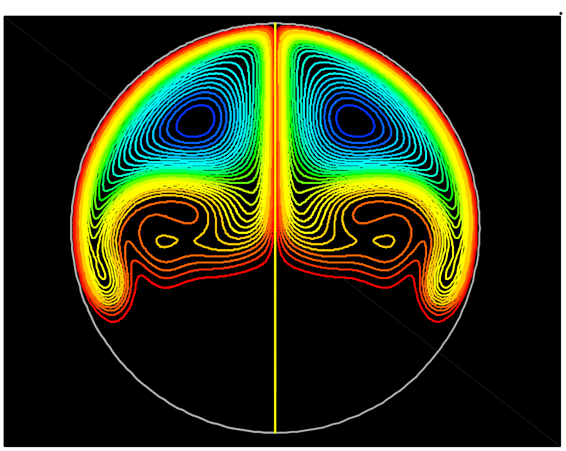


SLAC E158 ~500W

Small beam width
small scale turbulence

Establish transverse turbulence with fine mesh screens

➞ Internal heat exchange:



Output from 2-dimensional Computational Fluid Dynamics (CFD) calcs. illustrate the concept. (K. Cassel, IIT)

Streamlines indicate greatest flow near beam center.

BOTH DESIGNS NEED PROTOTYPING

Both need to handle ~ 6W/cm heat deposition.

Neither easily simulated – essentially 3D problem.

LH2 ABSORBER HEAT EXTRACTION

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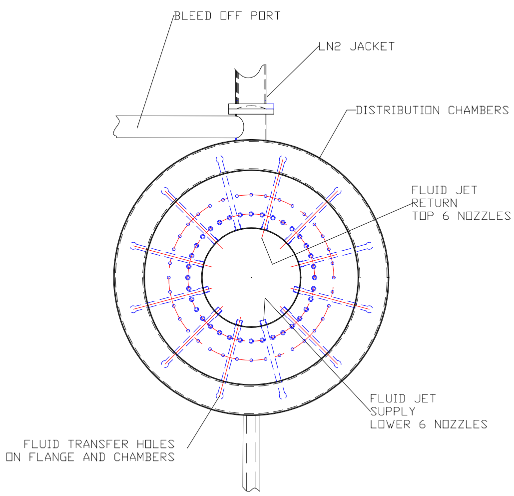
→ External heat exchange:



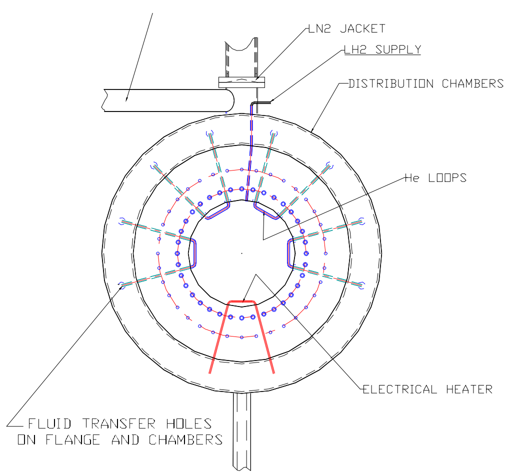
MUCOOL ~ 100W
(E. Black, IIT)

Large and variable beam width
large scale turbulence

Establish transverse turbulent
flow with nozzles

For ~ 6W/cm heat deposition,
need to cycle 0.05 volumes/sec
LH2 (e.g. 180W/30cm).

→ Internal heat exchange:



Convection cell is
driven by heater.

Heat exchange via helium
tubes near absorber wall.

Flow is intrinsically
transverse.

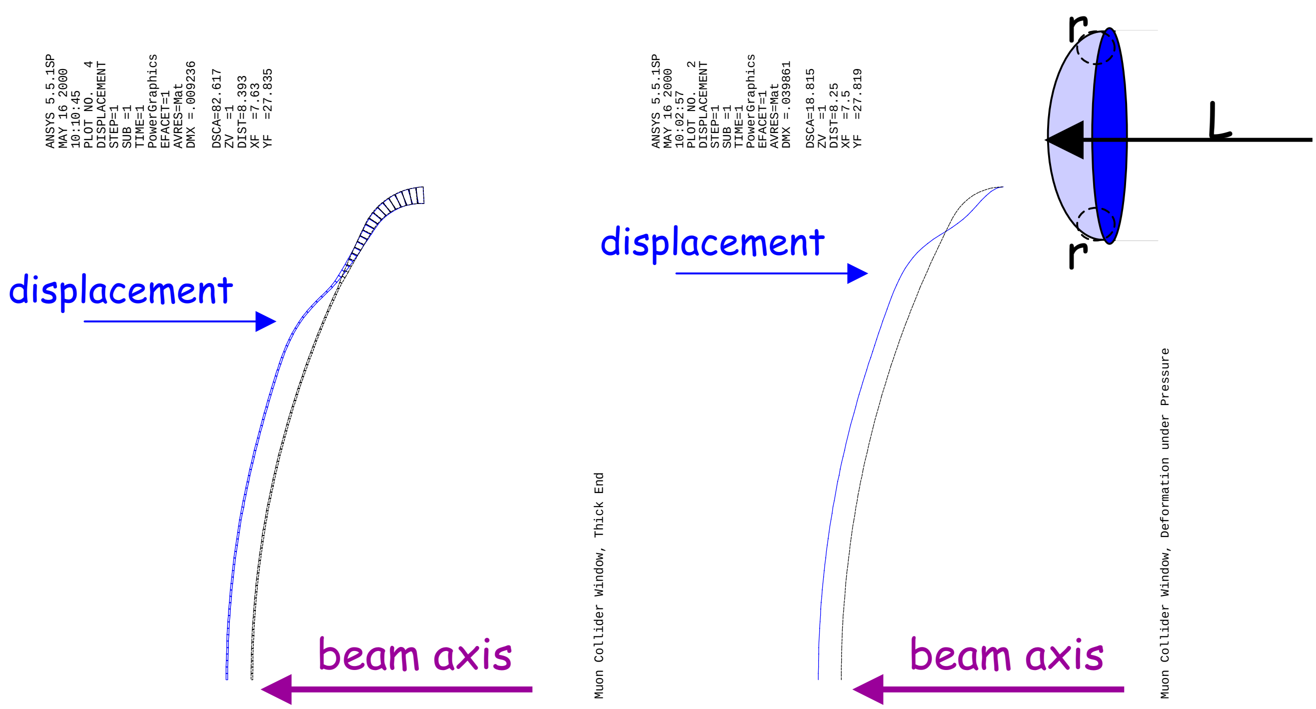
CHALLENGES:

- FORCED-FLOW: Nozzle design is complicated, hard to simulate.
- CONVECTION: Studies are encouraging, but there is a poorly known parameter: h_{LH2}, coefficient of convective heat transfer.

WINDOW DESIGN

➞ Increased thickness near window edges can further reduce the minimum window thickness near beam:

ANSYS Finite Element Analysis, Zhizing Tang, FNAL:

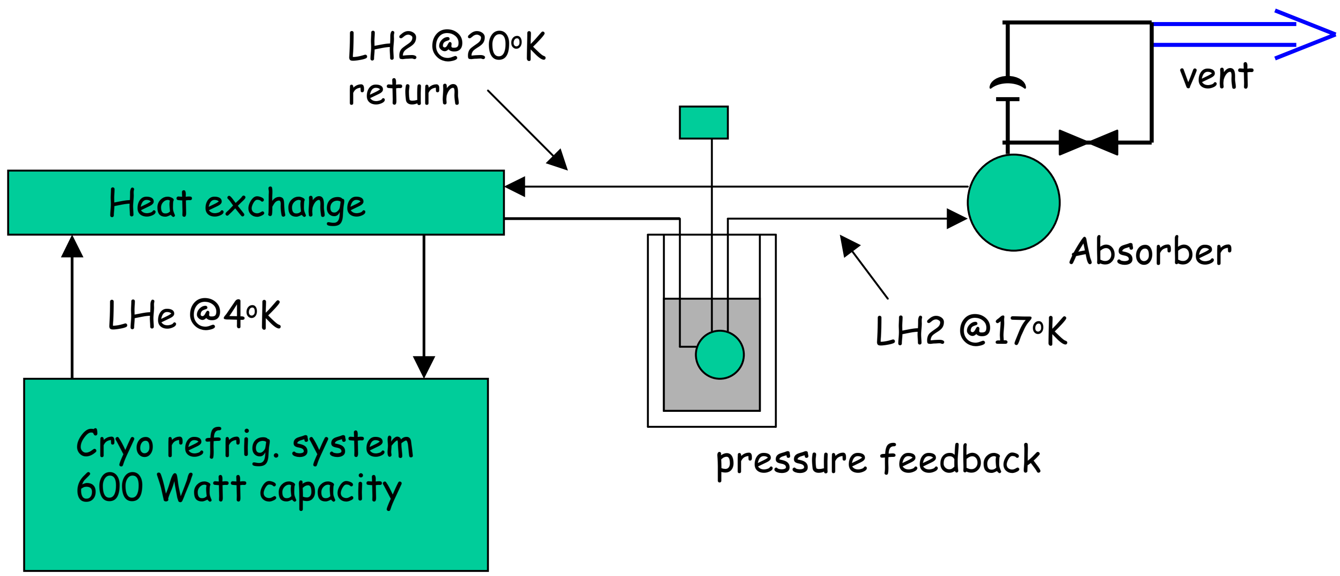


➞ Operational LH2 gas pressure

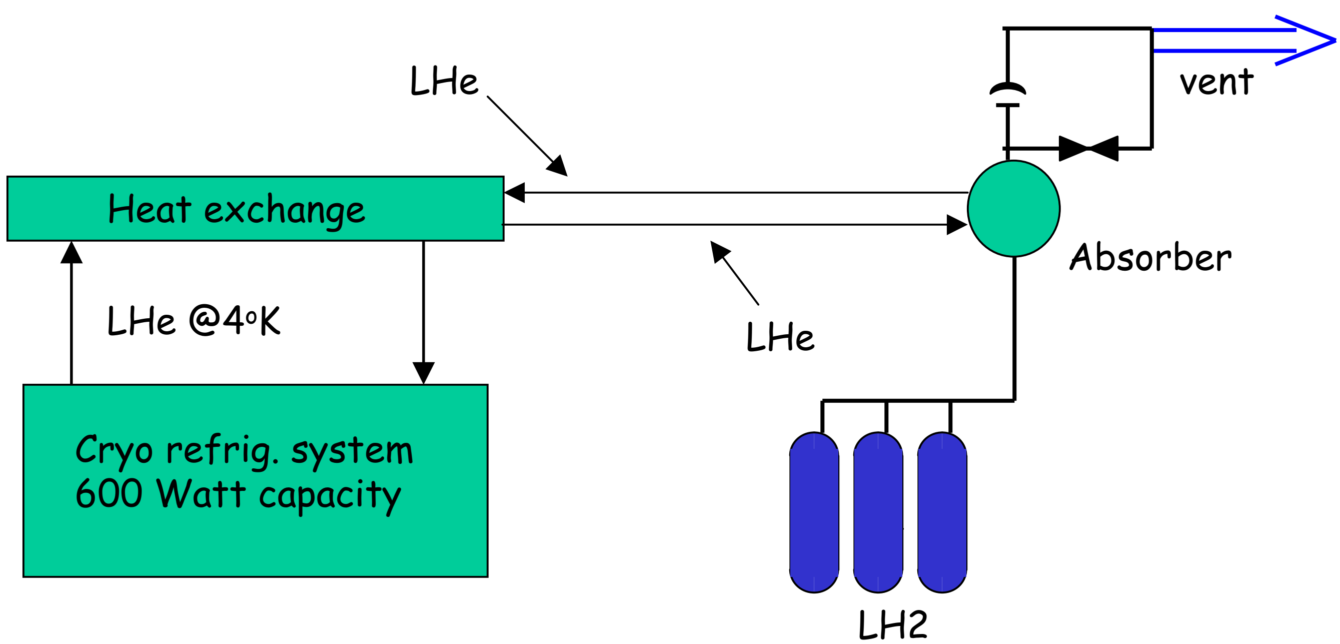
- Current FNAL recommendations ~ 2atm ; prevents line freezing and air flow (oxygen) into LH2 .
- Lower pressure (hence thinner windows) may be possible ⟹ R & D required.

REFRIGERATION SYSTEMS

➡ For forced-flow absorber:



➡ For convection absorber:



RECENT DEVELOPMENTS

→ Successful Window Fabrication

- Four modified torospherical window/flange units produced from U Miss
- Dimensional measurements proceeding
- Over-pressure test setup construction underway

→ Instrumentation

- U. Chicago (M. Oreglia) developing bolometric methods of luminosity measurements
- Plans to implement this in the absorber design as early as the overpressure tests

→ New research efforts on convection model

- KEK collaborators, Yoshi Kuno and Shigeruson Itomoro have design for full cryogenic test of convection concept
- Plans to integrate this into second cryogenic absorber test

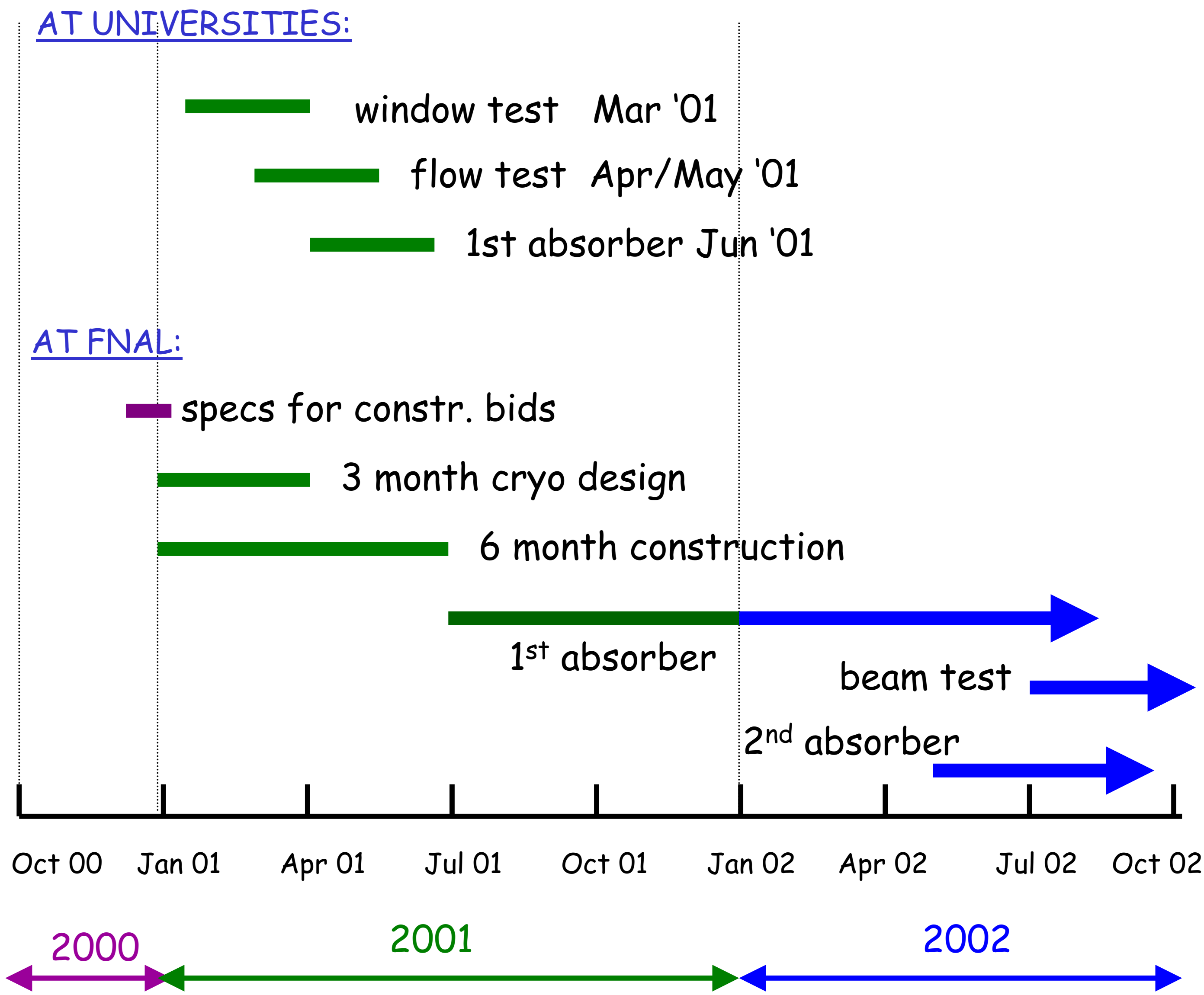
→ New test beam site off of the FNAL Linac

- Despite additional up-front costs, this combines assembly phase and test beam efforts.
- Boosts efforts to integrate instrumentation into
- Big step toward integration

LH2 PROJECT TIMELINES (NEW)

➡ R & D program:

1. Overpressure window test (FNAL requirement) (IIT/NIU/UMiss)
2. Fluid flow tests (IIT/NIU/FNAL)
3. Cryogenic LH2 absorber assembly, instrumentation and tests (IIT/NIU/UIUC/FNAL/KEK)



LH2 ABSORBER R & D AND THE PROPOSED TEST FACILITIES

➡ Current plan:

- Dedicated area for Mucool component testing
- Two phases of construction and use:
  1) LH2 construction and test (no beam)
  2) RF/Solenoid/LH2 high-powered tests (beam)

➡ Current goals (LH2):

- Build absorber prototypes and integrate into instrumented cryo systems
- Developing monitoring instrumentation
- Develop beam instrumentation: ?
  1) DE/dx …
  2) Anything compatible proton/muon (charged particles)

- Integration with other components

➡ Current goals - the rest:

- Solenoids (S.C.)
- RF
- Cooling Cell

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INSTRUMENTATION CHALLENGES

- Approaches - what this means for the LH2 absorber
  - Non – contact
    1) Heat detection
    2) Cerenkov/transition radiation/decay products
  - Non – contact/component-altering
    1) Scintillation
    2) Lasers/Schlieren techniques
  - Contact/component-altering
    1) VLPC's, pick-ups,
    2) Bolemetry/calorimetry
  - Beam altering
    1) Faraday cups
    2) Low/mass profile

- Engineering :
  - Realistic fit
    1) Physical space
    2) Radiation hardness
  - Component-altering
  - Read-out

WHAT CAN BE DONE WITH ~10^{13} H^-'s ?

- Possible next-year activities
  - dE/dx
    1) Luminosity
    2) Monitoring
    3) Lasers/Schlieren techniques - possible Convection absorber necessity NEED A WINDOW
  - Charge
    1) Scintillation
    2) Backgrounds
  - Component re-design
    1) VLPC's, pick-ups, feedthrough, attachment
    2) Bolemetry/calorimetry. Window design.
  - Direct/indirect beam measurements
    1) Any thing we can find out?
    2) Low/mass profile-type
- Reasons for going ahead with non-μ's :
  - We can start to weigh info desirability with doability
  - Read-out
  - Early component re-design and cooling cell alterations

SUMMARY

- Ambitious program, but critical to demonstrating the feasibility of building a cooling channel.

- Much engineering and study has already gone into the major design issues. Windows have materialized! Initial phases of the project are happening NOW.

- Illinois University Consortium (ICAR) has State of Illinois $$ to provide the scientific staff and additional equipment to carry out this project.

- The support of FNAL has always been key to move this project forward. In particular, was the issue of a dedicated AREA, and LINAC test beam facility is a major contribution. The collaborating universities will necessarily be working closely with FNAL experts to satisfy stringent safety requirements. We're finally forced to do something.