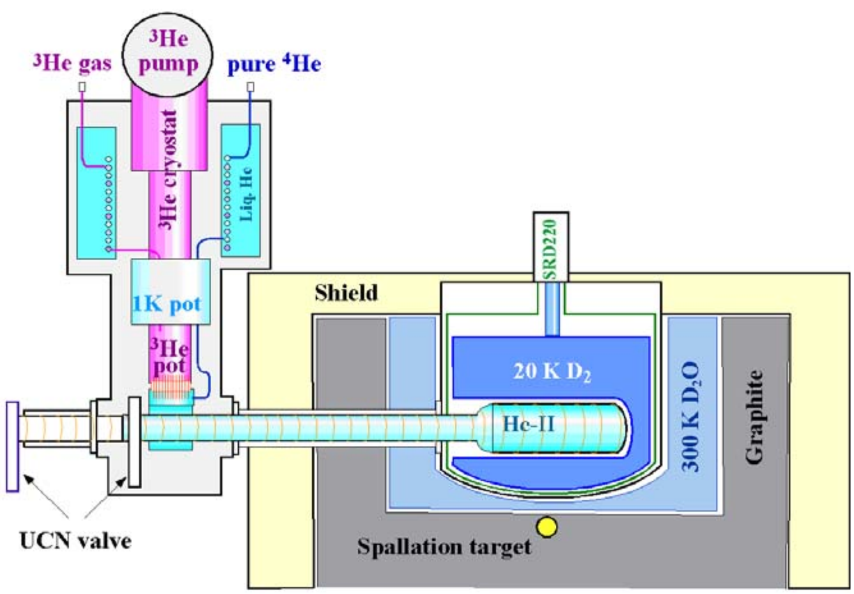
An Ultra-Cold Neutron Facility for TRIUMF

TRIUMF special 5-year plan EEC
26 March 2008

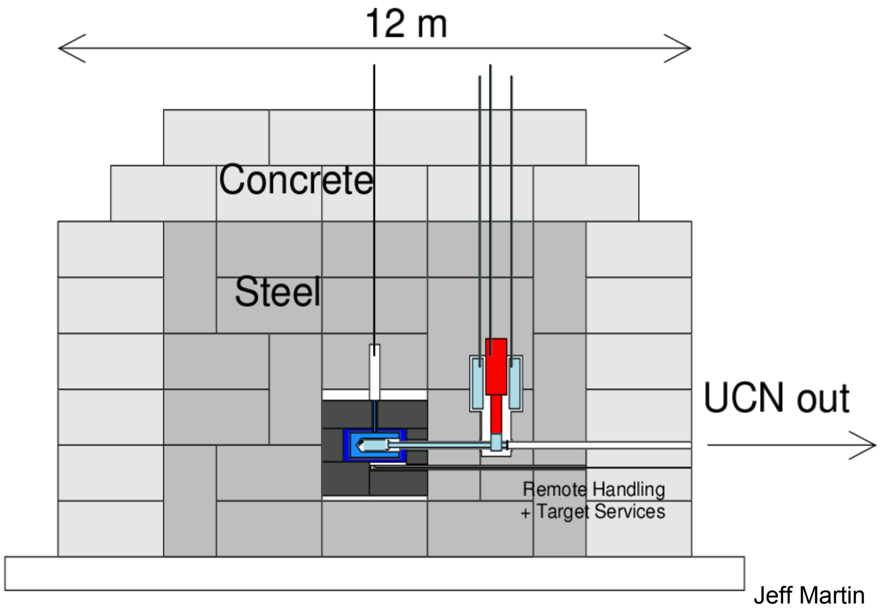
Des Ramsay

Schematic of Superfluid He UCN Source



Yasuhiro Masuda

How much room does it need?

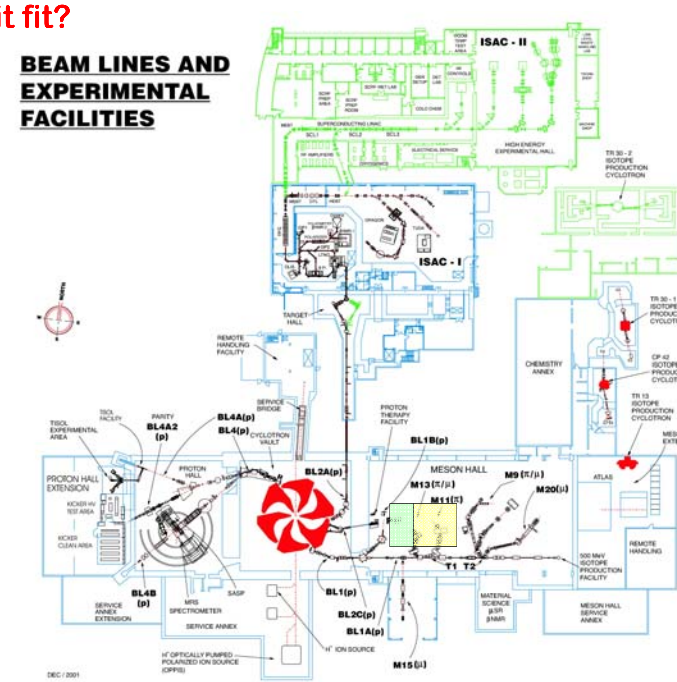


Jeff Martin

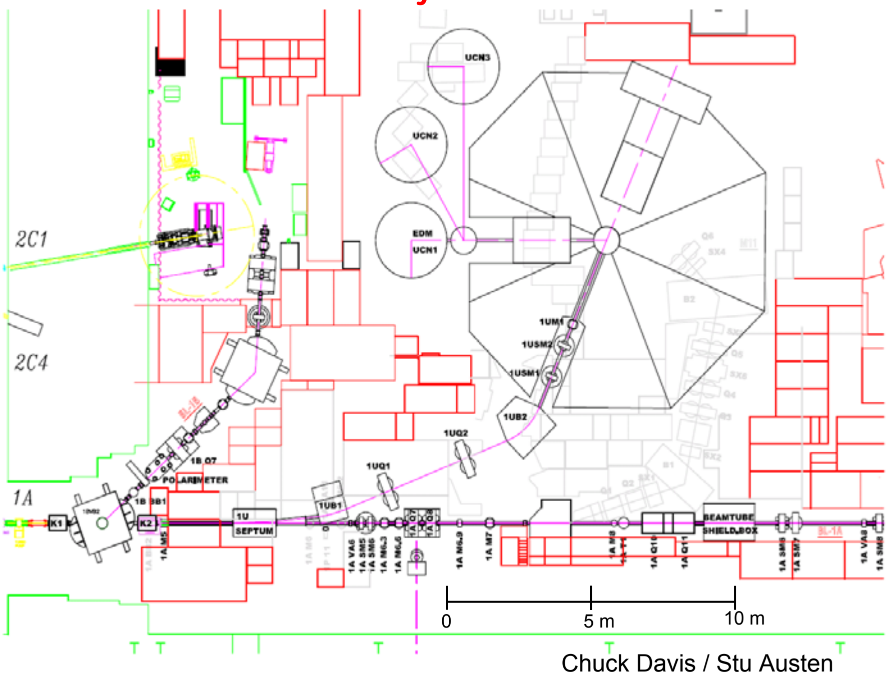
Where would it fit?

source

experiments



UCN Facility in Meson Hall

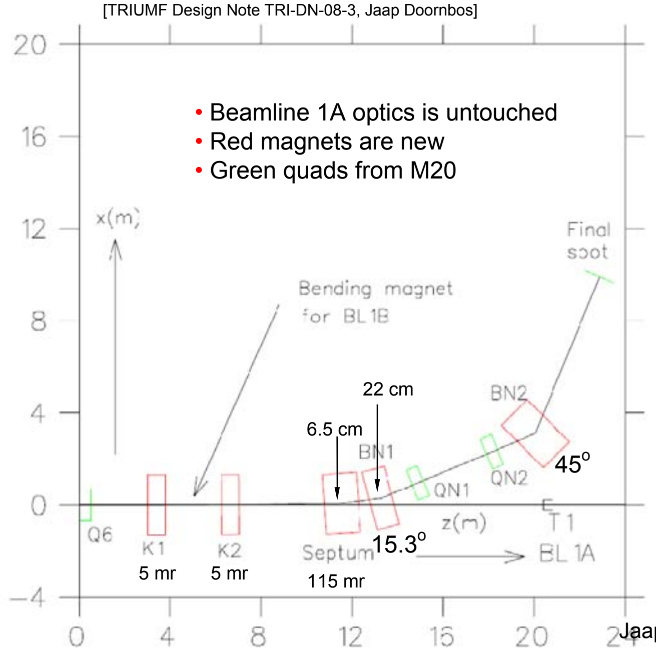


Chuck Davis / Stu Austen

Proposed Proton Beamline to UCN Source

[TRIUMF Design Note TRI-DN-08-3, Jaap Doornbos]

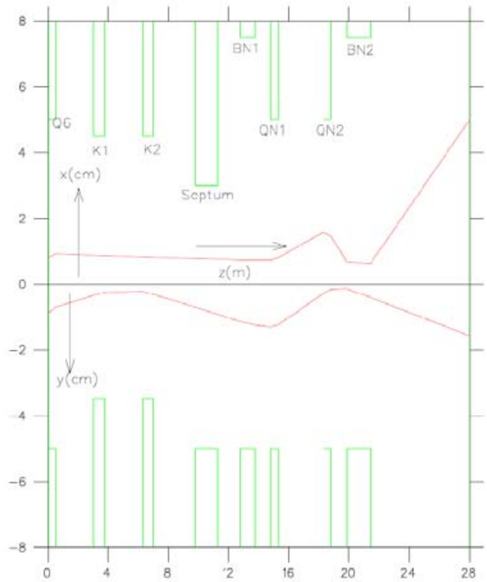
- Beamline 1A optics is untouched
- Red magnets are new
- Green quads from M20



Jaap Doornbos

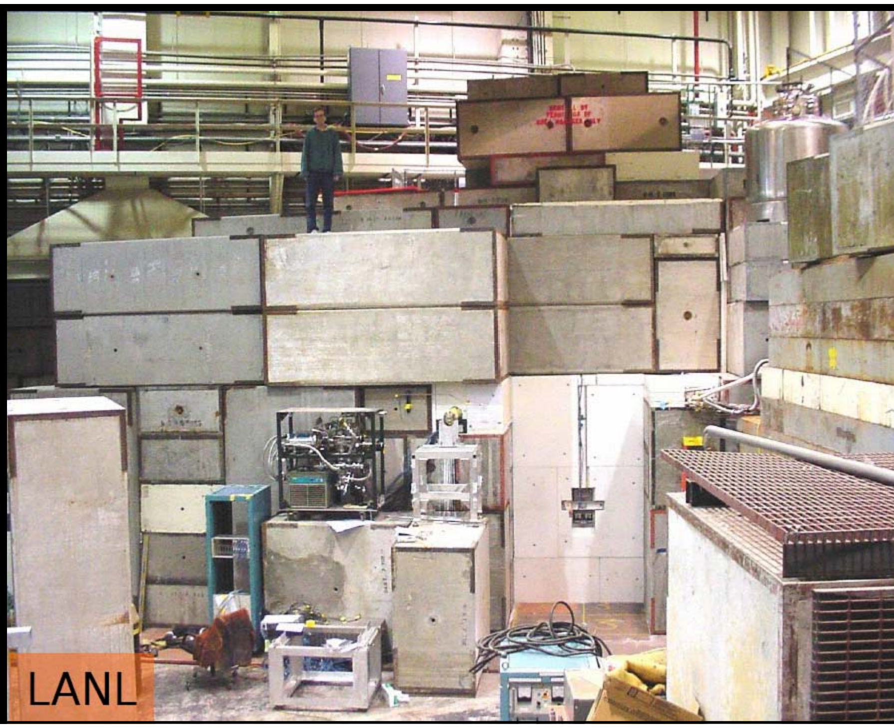
Beam Envelopes for the Proposed Proton Beam

[Jaap Doornbos Design Note – 25 Jan 2008]

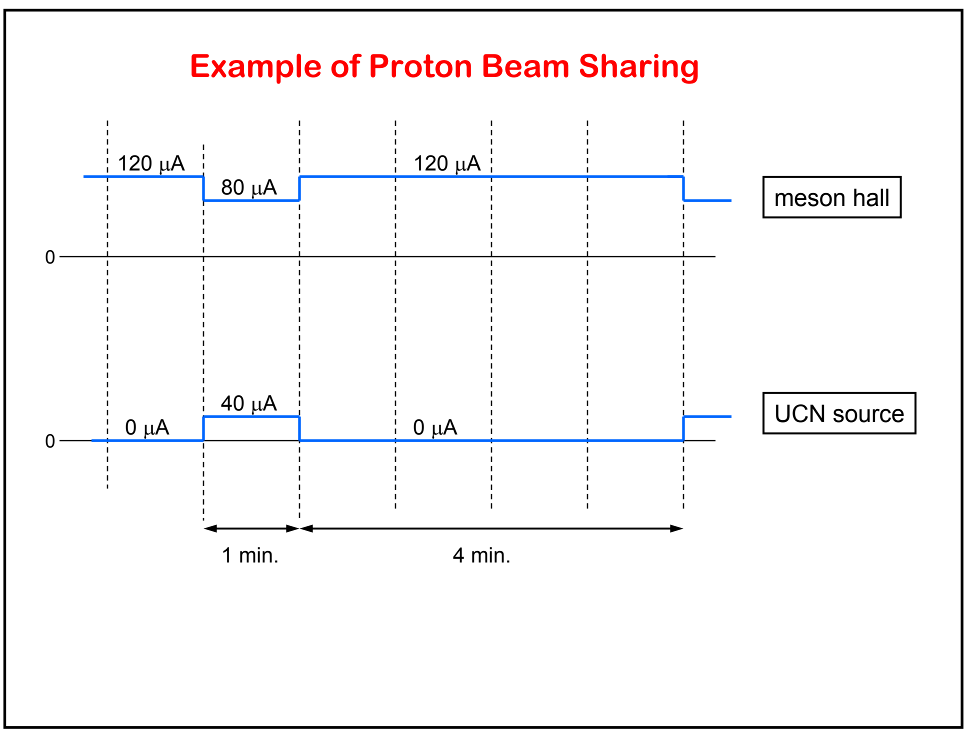


final (full size)
beam spot:
10 cm hor.
3 cm vert.

Jaap Doornbos



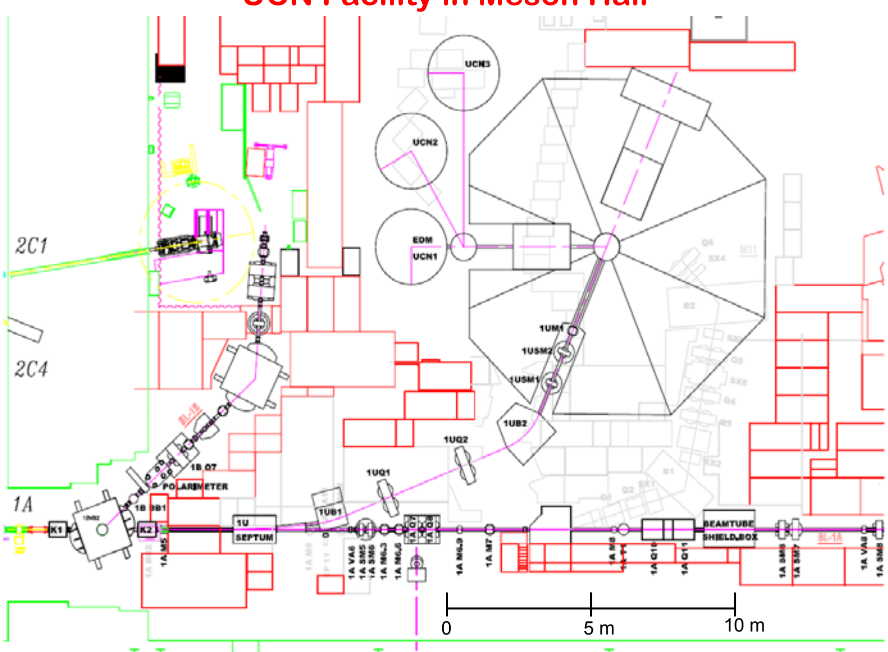

UCNA Los Alamos


Example of Proton Beam Sharing
120 μA
80 μA
120 μA
meson hall
0
40 μA
0 μA
0 μA
UCN source
0
1 min.
4 min.

Constraints on beam sharing schemes

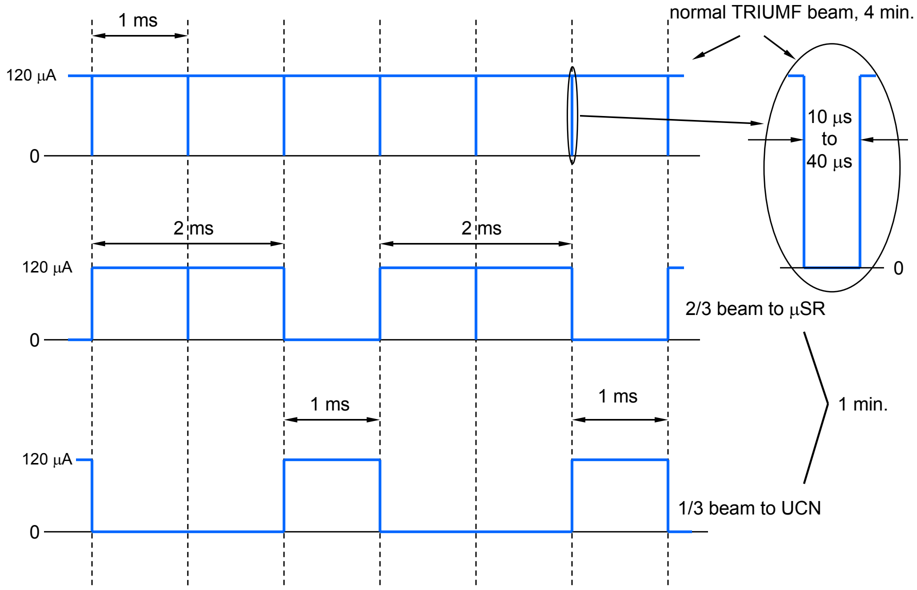
- The cyclotron beam can't be interrupted for more than ~1ms (ISAC target)
- The instantaneous meson hall beam should be stable.

UCN Facility in Meson Hall



Chuck Davis / Stu Austen

Proposed time division of beam



Features of the Proposed Beam Sharing Scheme

- The beam tune of beamline 1A is untouched.
- The instantaneous beam current does not change.
- A gate could be delivered to experimenters during beam-blanking.
- Downstream users only loose ~7% of their averaged beam.

Requirements for the Kicker Magnets

- Two magnets, each 24 mT x 0.75 m, 5 mr deflection.
- Would need about 1000 A, at least 1 ms flat-top
- Current rise and fall times (~5 μs).
- Low inductance (~2 μH ; power cables would have to be short)
- Mike Barnes suggests a power supply with several high power semiconductors (IGBTs), capacitor charging power supplies and capacitor banks.
- Power supply is biggest task. Must deliver the fast rise and fall times as well as at flat-top with low (<5%, 1% preferred) ripple and rapid cycle time.
- We definitely need some serious engineering on the kickers. Eventually we would need to test a prototype.

How much will all this cost?

Magnet Requirements

Magnet	Bend	Source	Power supply
K1 †	5 mr	new	new
K2 †	5 mr	new	new
1U septum	115 mr	new	new
1UB1	15 deg	new	M11
1UQ1	focus	M20	M11
1UQ2	focus	M20	M11
1UB2	45 deg	new	1B

- Need 5 new magnets and 3 new power supplies.

† ▪ The kickers, K1 and K2 will require engineering and prototyping.

Estimating Magnet Costs

Some examples of magnets:
S-bend dipole at ISAC – 5 cm gap, 1.35 Tesla x 0.91 m = 1.23 T.m $48 k
2AB1/2 Dipole, 1997 – 10 cm gap, 1.43 Tesla x 1.23 m = 1.77 T.m $119 k

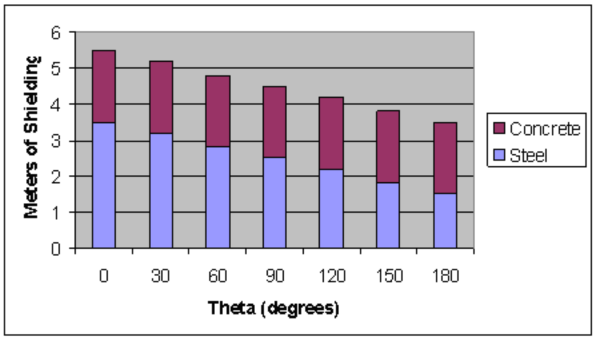
We want:
BN1 – 10 cm gap, 0.973 T x 1.0 m = 0.973 T.m
BN2 – 10 cm gap, 1.785 T x 1.6 m = 2.86 T.m
should allow ~$100 k each.

The septum could be expensive. The one downstream of T1 was almost $700k because it is very rad-hard.

The kickers are only 0.024 T x 0.75 m, but are fast and have fast power supplies of special design.

Ewart suggests that, including the power supplies we have to buy, that we allow an average of $250k for each of the 5 magnets.

Shielding Requirements



- calculations by Anne Trudel, assuming 40 μA, 500 MeV protons stopping in tungsten target
- assumes 0.5 m empty space around target (no moderator)
- figure shows shielding needed to reduce dose to 3 μSv/hr outside shielding
- integrating shielding gives 125 m^3 steel and 375 m^3 concrete not allowing for practicalities of stacking the blocks.

Estimating Shielding Costs

TRIUMF Shielding Cost Experience, TRI-DN-89-K26:
removable concrete: \$800/m^3
steel plate block (M20): \$11,900/m^3
off-grade steel ingots (M20): \$8000/m^3
In 2008 dollars, let's allow \$1200/m^3 for concrete and \$12000/m^3 for steel

In 1997,TRIUMF got 125 m^3 of re-cycled slightly radioactive steel for \$10k (\$80/m^3). Dominated by shipping costs. Say \$300/ m^3 in 2008.

For shielding volume add 20% to Anne's integrated volumes, giving 150 m^3 steel, and 450 m^3 concrete.

Summary of Major Costs

Item	Unit Cost	Total
UCN source apparatus		$2.4 M
5 magnets	$250 k	$1.25 M
Installation	$250 k per magnet	$1.25 M
Moderator		$1 M - $3 M
150 m^3 steel	$300/$m^3$ - $12000/$m^3$	$45 k - $1.8 M
450 m^3 removable concrete	$1200/$m^3$	$540 k
Total		$6.5 M - $10.2 M

Other Costs
(*may* be covered by $1.25M "installation")

- Stands, vacuum boxes, pipes, bellows, monitors, safety equipment,…
- Spallation target cooling loop
- Room temperature heavy water system.
- Liquid helium supply system (new central helium liquefier separate budget)
- Remote handling equipment

TRIUMF infrastructure support

- engineering and prototyping of fast kicker -- Mike Barnes estimates engineer, designer and technician on 50% for 2 years (3 FTE-year).
- detailed cost estimates for the project – 1 FTE-year
- project engineer and project manager.
- engineering, design, and technical support for actual installation

Recap

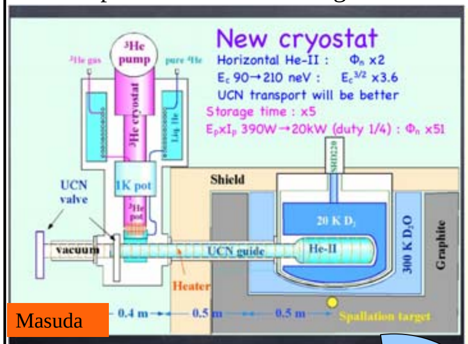
- It is feasible to build an Ultra Cold Neutron Source at TRIUMF
- Development of the heart of the source can proceed initially in Japan
- The source would need a 40 μA proton beam which can be split off from the existing meson hall beam using kickers
- Detailed costing, and engineering of details should begin as soon as possible at TRIUMF

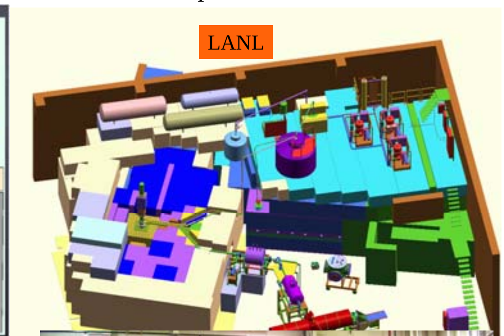
Summary

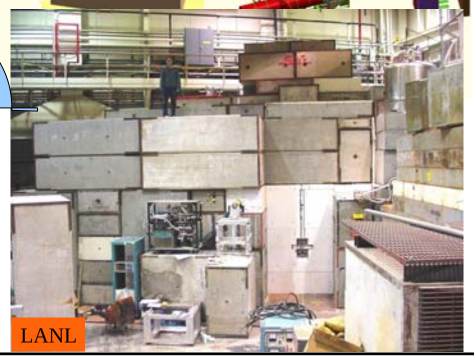
- This is a good project
- TRIUMF can do it

END

Conceptual to technical design for the UCN source and experiment







Other Issues:

- radiation, remote handling
- cryogenics
- neutronics
- division of labor
  - Masuda, Golub very interested in cryogenics and neutronics
  - Acsion (private company in Pinawa, MB) interested in neutronics (MCNP)
  - need TRIUMF support to bring to fruition

meson hall remote handling

transfer flask

hot cell entrance

hot cell window

Cost and Schedule

UCN-A Construction (Capital Equipment) Costs:

$454K DOE
- $308K for the source and $146K for the experiment

$640K NSF
- SCS and AFP/polarizer magnets

$4.1M from collaborating institutions

We are not requesting any additional construction funds from either the NSF or the DOE for the current UCN-A measurement.

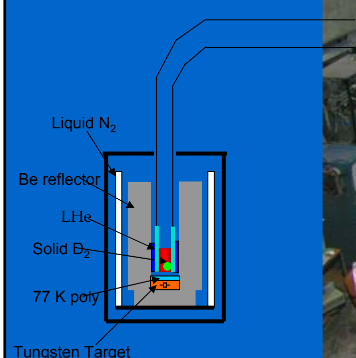
Rescoping the capabilities of the source and integrating with LANSCE's resource scheduling produced delays, however, it also produced cost savings of 50,000$/mo in operations

A.R.Young

LANSCE Area B

Experiment commissioning Underway
Initial goal is 0.2% measurement of A-correlation

UCNA



Interior dimensions: 23.8×28.9 m^2

7.2 m NS between N wall and dump

RF gallery 8×8 m^2

Cryogenic: 4×6 m^2

Main linac

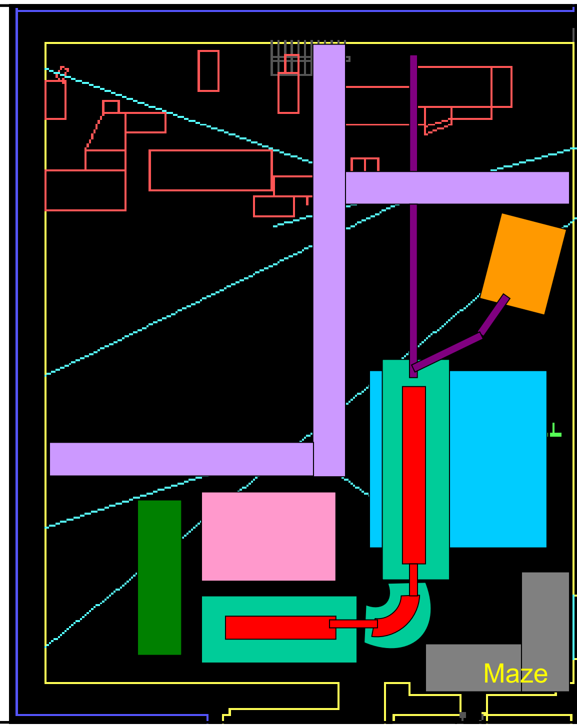
injector linac

50 kw dump: 4×3 m^2

Equipment racks & PS: 4×2 m^2

Total footprint approx ?

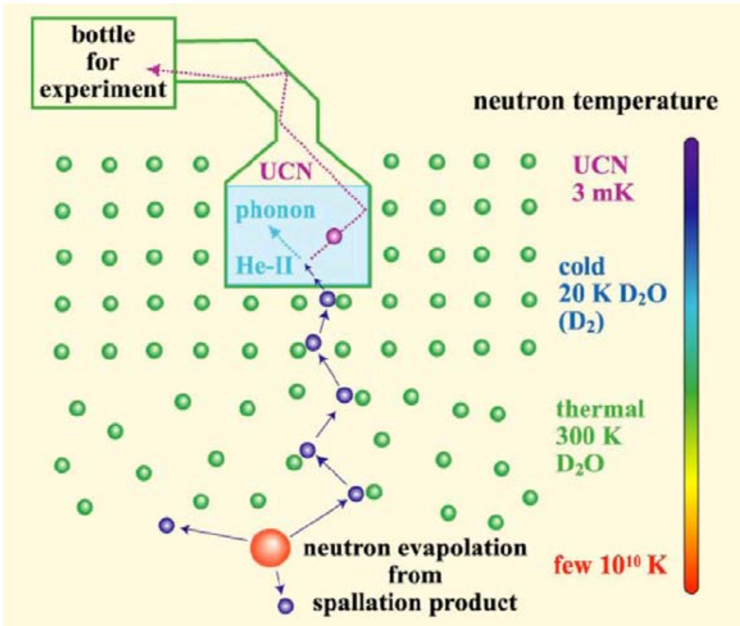
This includes shielding of 1.5 m concrete



Details of the Beamline Elements

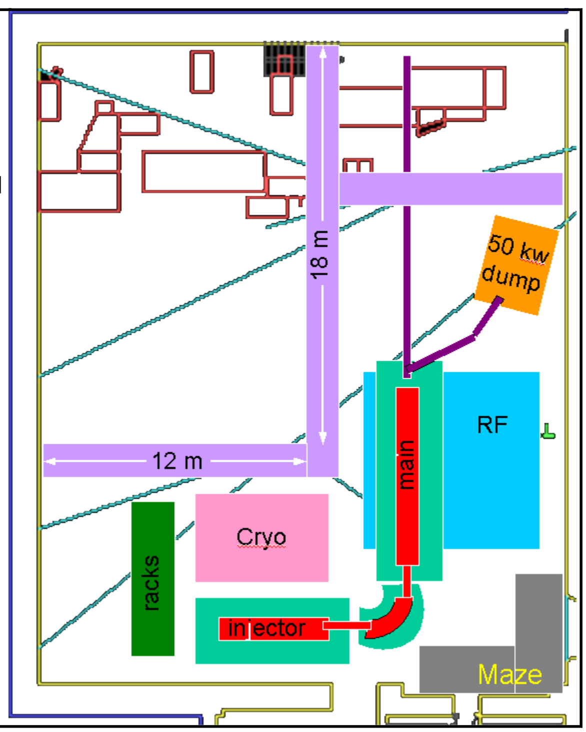
[Jaap Doornbos Design Note – 25 Jan 2008]

Element	Length (m)	Field (kG)	radius (cm)	angle
BL1A Q6	0.5238	1.98	5.156	
drift	2.50			
kicker K1	0.75	0.24		5 mr
drift	2.50			
kicker K2	0.75	0.24		5 mr
drift	2.75			
septum	1.50	2.79		115 mr
drift	1.50			
bend BN1	1.00	9.73		15.34 deg
drift	1.00			
quad QN1	0.5238	3.00	5.156	
drift	3.00			
quad QN2	0.5238	3.00	5.156	
drift	1.00			
bend BN2	1.60	17.85		45.0 deg
drift	6.00			

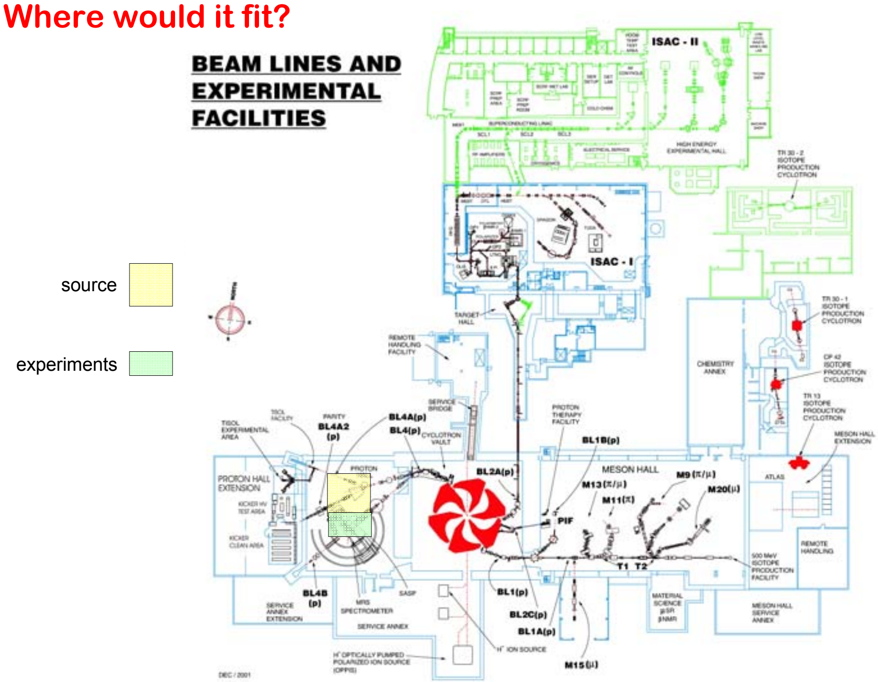


Proton Hall

- Shane Koscielniak tried to fit e-linac and UCN in Proton Hall
- Space is tight, probably too tight
- Sharing beam with ISAC is difficult technically.



Where would it fit?



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