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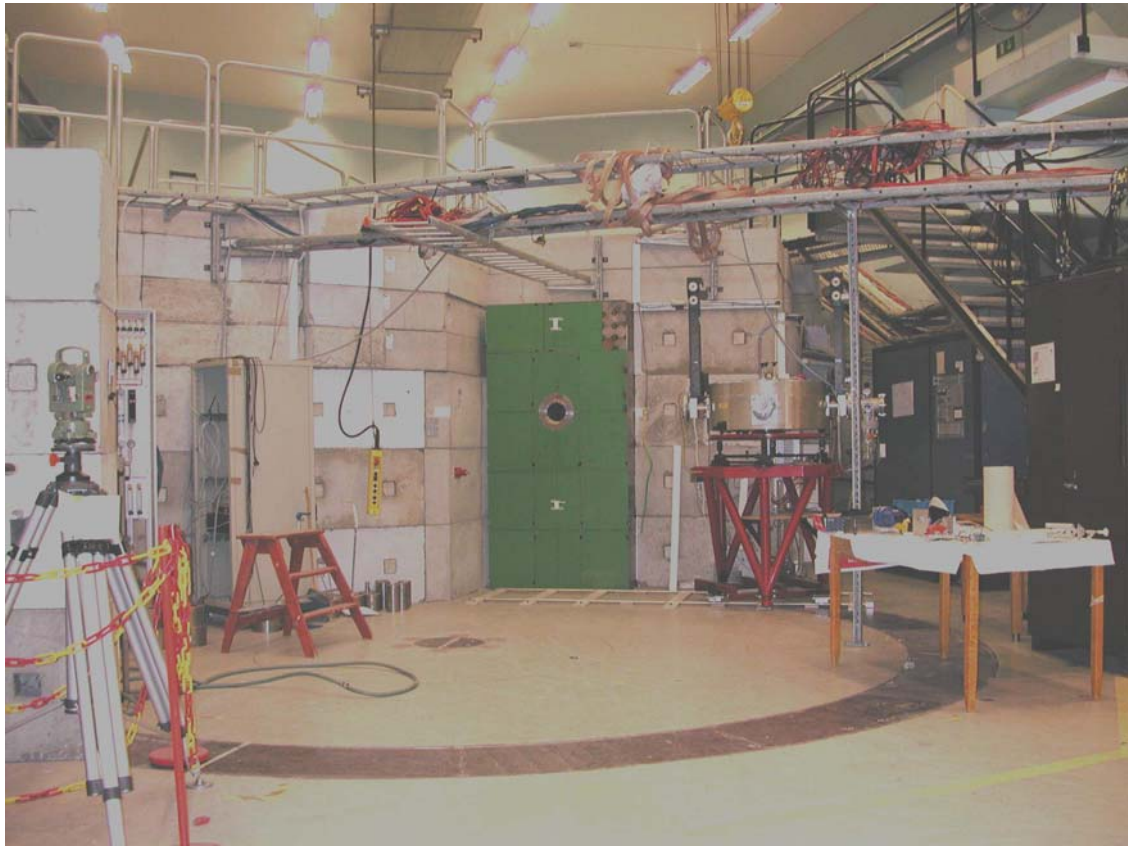
High Energy Neutron and Proton Irradiation Facilities at TSL



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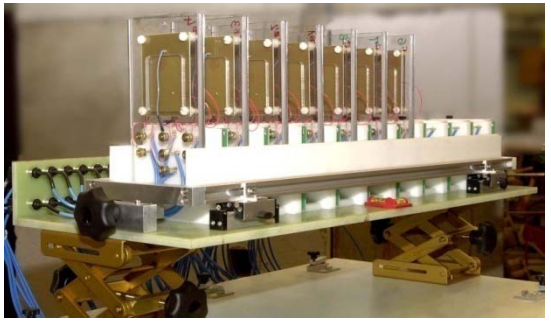
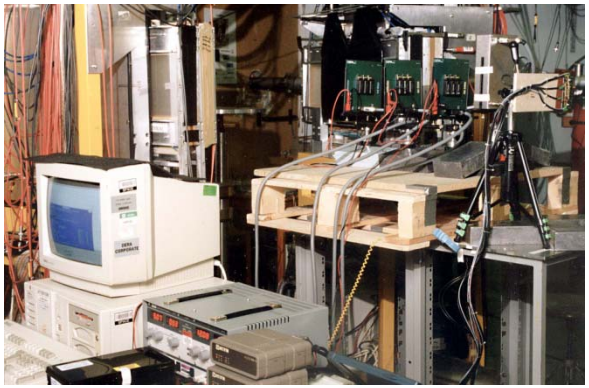
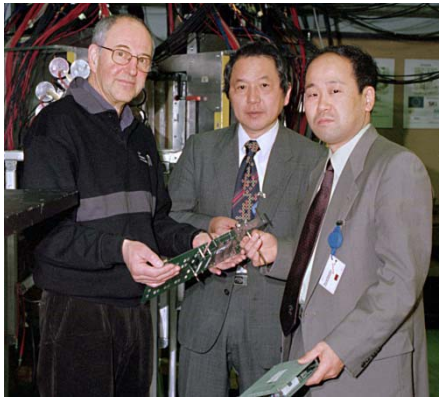
Contents

Facility	Status
Broad-beam proton irradiation	Steady operation
Quasi-monoenergetic neutrons	Steady operation, recently upgraded
White neutron beam (“ANITA”)	Recently installed and characterized







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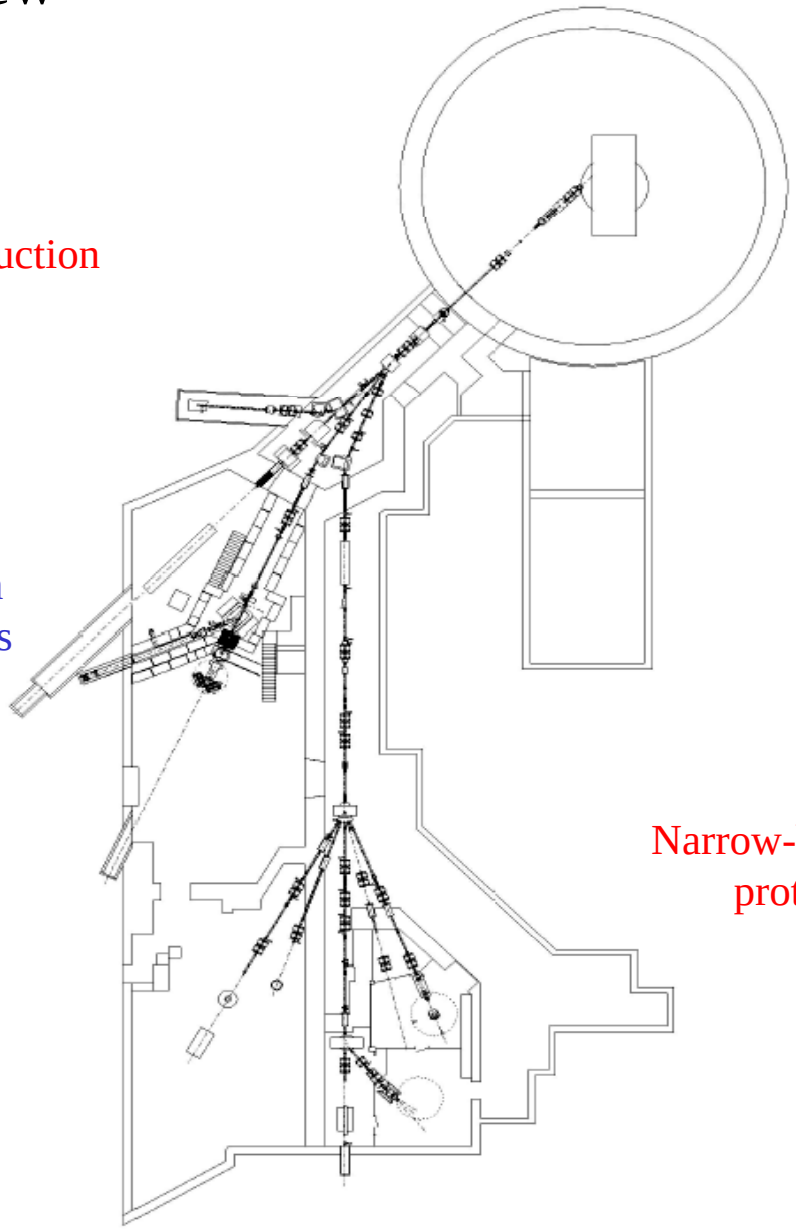
TSL overview



The Gustaf Werner cyclotron

Radionuclide production facility

Proton and neutron irradiation facilities

Narrow-beam and broad-beam proton treatment facilities

Heavy-ion beam irradiation facility

Light-ion beam irradiation facility

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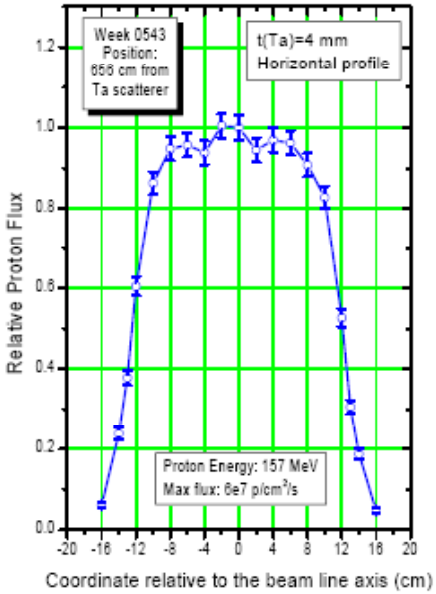
Broad proton beam facility

- Tantalum scatterer
- Collimation
- Protons in air
- E_p = 20 – 175 MeV
- 7 – 20 cm diameter beam
- Inhomogeneity not more than 10%
- Flux: 10^2 … 10^{10} protons/cm^2 (dep on E_p)



Nominal proton energy (MeV)	Maximum current of the unscattered proton beam (nA)	Distance from the scattering foil to the irradiation position (cm)	Beam diameter (cm)*	Maximum proton flux ($cm^{-2}s^{-1}$)
25	400	200	7.6	1.1E10
50	200	200	7.6	5.5E9
100	100	200	7.6	4.1E9
180	50	200	7.6	1.4E9
180	50	656	20	6E7

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Monoenergetic neutron beam

- Neutron production: ^{7}Li(p,n) , enriched to 99.99%, 1-24 mm thick
- Peak neutron energy: 11-174 MeV
- Characterized neutron fields: 11*, 22, 47, 94, 143, 174* MeV
- Peak neutron flux: $1 \cdot 10^{4}$ - $5 \cdot 10^{5}$ neutron/(cm^{2}/s)
- Area available for users at the beam line: 15 m long, 3 m wide
- Flexible size and shape of the neutron beam spot:
  - Size: 0-30 cm diameter close to target (~3 m from Li),
    Up to 1 m diameter at larger distances from the target
  - Shape: circular, square, any other shape upon request
- Beam spot uniformity: 0.5%
- No concern about residual radioactivity
- User's control of the neutron flux:
  - Flux decrease up to a factor 1000
  - User can turn the beam on/off any time

* Data under processing

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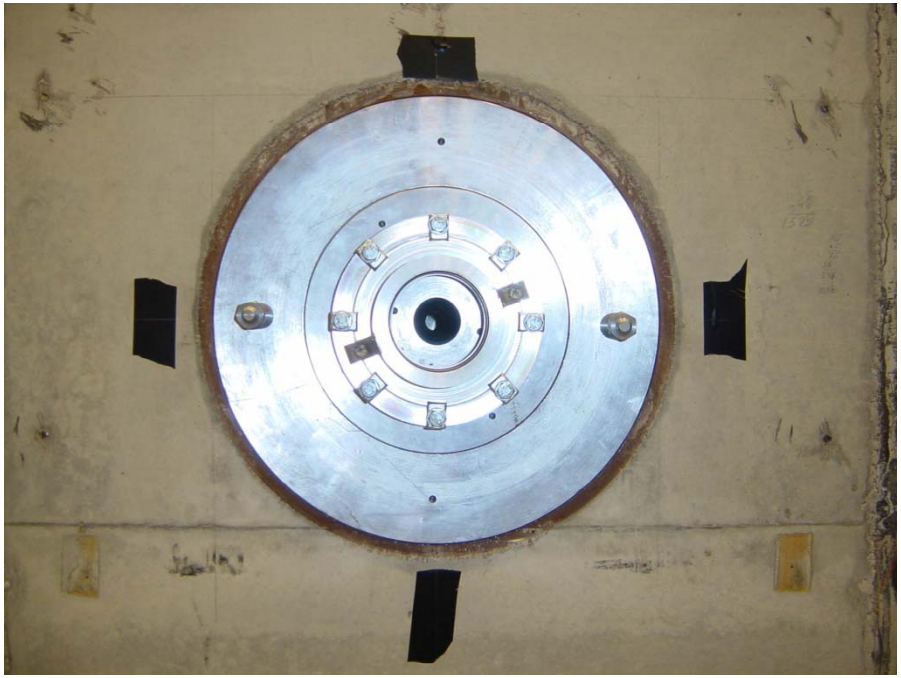
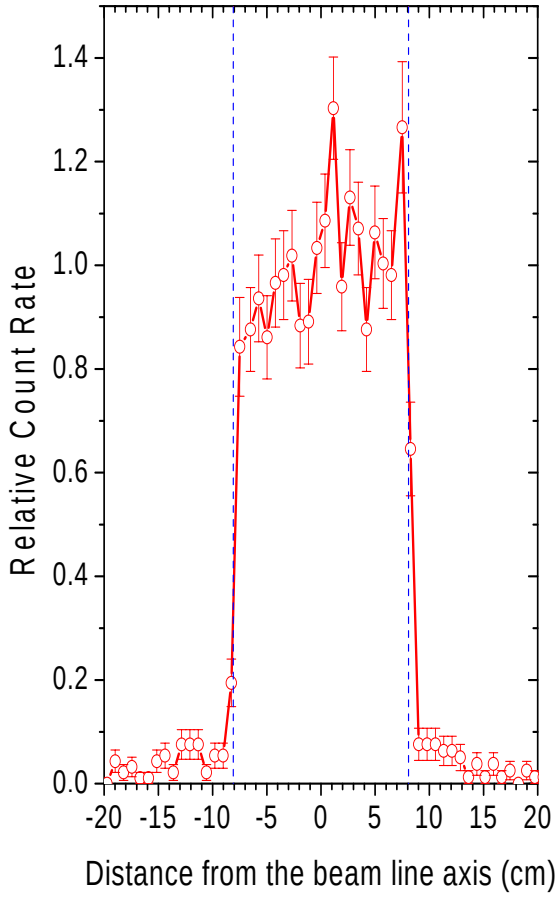
Neutron beam collimation

Collimation in air
Quick manual change
Any shape possible



Horizontal beam profile
Dashed lines:
expected boundaries



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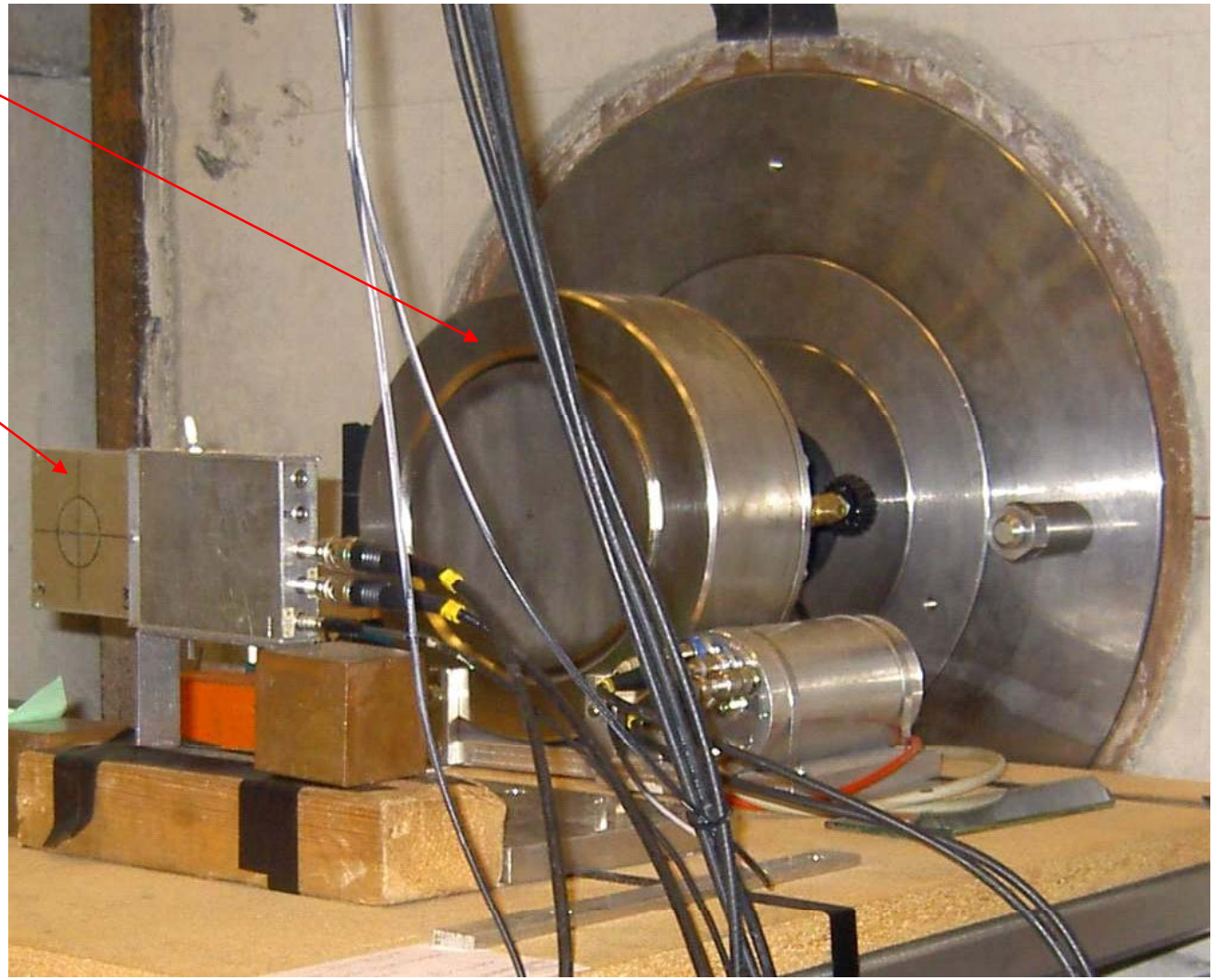
Neutron monitors

(1) Ionization chamber

(2) Thin-film breakdown counter

(3) Proton beam current

Monitors (1) and (2) are based on the fission of ^{238}U.



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Neutron spectrum characterization

Protons from H(n,p), MEDLEY setup

Peak neutron energy (MeV)	Neutron spectrum status
11	Preliminary/ unpublished
22, 47, 95, 143	Published
174	Measured, to be processed

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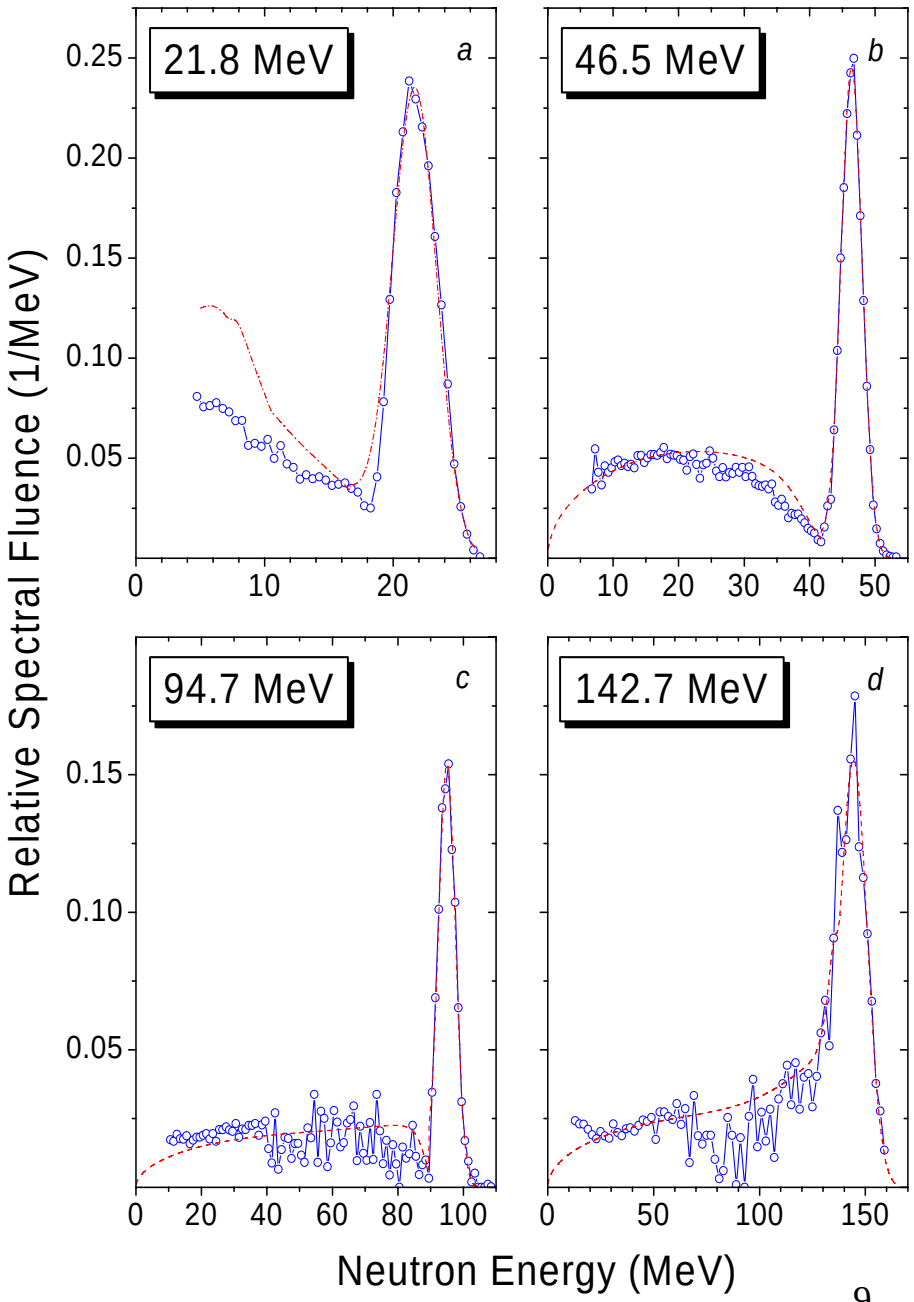
Neutron facility spectra

Neutron spectra at 0º
Experimental data:
Blue symbols
Model calculations:
Dashed red lines



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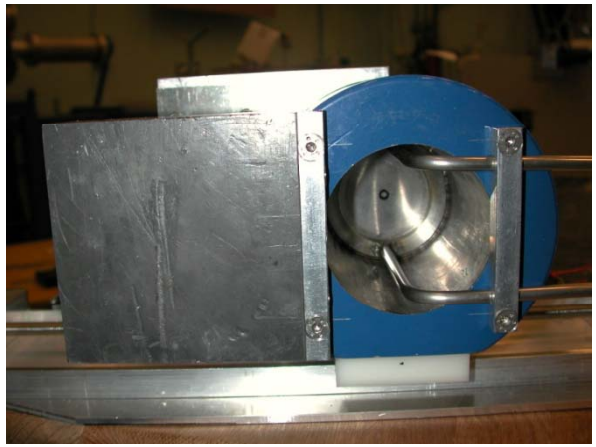
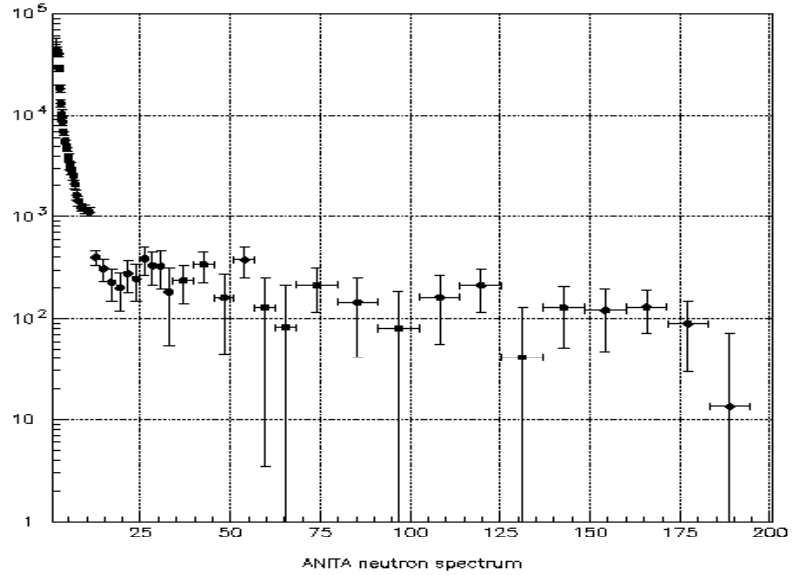
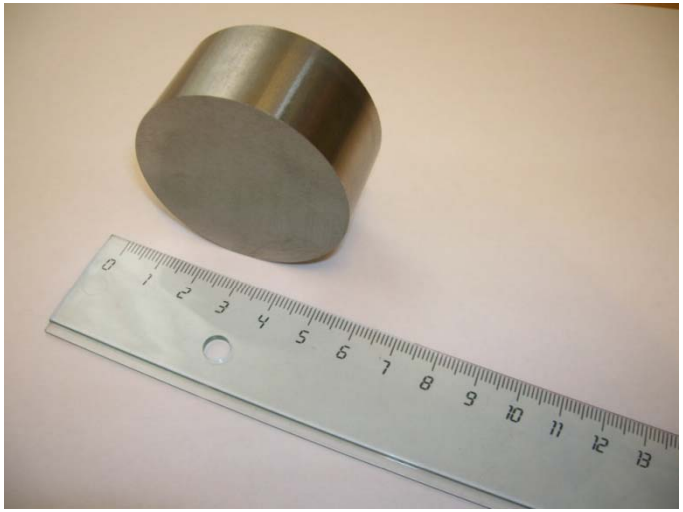
White neutron beam

ANITA (**A**tmospheric-like **N**eutrons from th**I**ck **Ta**rget)
180 MeV proton beam on a full-stop tungsten target







- First run: 2007
- Conclusion: **IT WORKS**

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White beam status

- Neutron flux: ~10^6 cm^{-2} s^{-1} *
- Gamma-ray dose rate:
  - With beam on: ≤60 mSv/h*
  - With beam off: ≤10 μSv/h**
- Preliminary results are available for the ANITA neutron spectrum measured with Medley.

* At collimator exit, proton current 200 nA, for neutrons above 10 MeV.

** Production target in parking position.

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White beam usefulness

- The neutron flux is suitable for SER testing.
- Controllable variation of the flux according to user's needs is quick & easy. The available range of variation covers any thinkable needs.
- The size of the neutron beam spot can be chosen by the user (anything from 1 cm up to 2 m) and can be quickly adjusted.
- The gamma dose rate in-beam is relatively low and not expected to pose problems for SER-testing.
- The testing area is spacy and suitable for bulky objects.
- The residual radioactivity of DUTs is expected to be well below allowed limits for handling and transportation.
- The testing area is available shortly after the irradiation. The ambient dose rates are below allowed limits for personnel.
- TSL/ANITA is a potential European alternative to LANSCE.
- Users from CERN are most welcome!

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Beam Time Schedule – Autumn 2007

Fall2007_070817.xls

See "Autumn 2007" for notation

July	Aug	Sep	Oct	Nov	Dec	
1	1	1	w40 FM		1	
w27	2	2	1 [1e]	1 FA196 3" (D)	2	
2	3	w36 FM	2 PT (daytime)	2	w49 FM	
3	4	3 [4e+1n]	3 BA42 1 (A)	3 All Saints Day	3 [?]	
4	5	4 PT (daytime)	4	4	4 PT (daytime)	
5	w32 ECR	5 FA161 4" (D)	5	w45 FM	5	
6	6 Start-up	6	6	5 [4e]	6	
7	7	7	7	6 PT (daytime)	7	
8	8	8	w41 ECR	7 ANITA 5" (D)	8	
w28	9	9	8 [4n]	8	9	
9	10 FA189 1 (K)	w37 FM	9 FA159 2 (I)	9	w50 FM	
10	11	10 [5e]	10 BA32+ 3 (C)	10	10 [2e]	
11	12	11 PT (daytime)	11 FA194 4 (K)	11	11 PT (daytime)	
12	w33 FM	12 FA172 5" (D)	12	w46 FM	12 FA135 3" (B/D)	
13	13 [-]	13	13	12 [?]	13	
14	14 PT (daytime)	14	14	13 PT (daytime)	14	
15	15	15	w42 FM	14 FA187 1" (B)	15	
w29	16	16	15 [4e]	15	16	
16	17	w38 FM	16 PT (daytime)	16	w51 FM	
17	18	17 [2n]	17 FA179 5" (D)	17	17 [?]	
18	19	18 PT (daytime)	18	18	18 PT (daytime)	
19	w34 FM	19 BA45 3 (N)	19	w47 CW	19	
20	20 [2n]	20	20	19 [4n]	20	
21	21 PT (daytime)	21	21	20 FA161 9 (D)	21	
22	22 BA45 3 (N)	22	w43 FM	21 FA187 2 (D)	22	
w30	23	23	22 [4e]	22	23	
23	24	w39 FM	23 PT (daytime)	23	w52	
24	25	24 [2e]	24 FA179 5" (D)	24	24 Christmas Eve	
25	26	25 PT (daytime)	25	25	25 Christmas Day	
26	w35 CW	26 FA135 3" (B/D)	26	w48 FM	26 holiday	
27	27 [4n]	27	27	26 [3e]	27	
28	28 FA161 9 (D)	28	28	27 PT (daytime)	28	
29	29	29	w44 FM	28 FA161 4" (D)	29	
w31	30	30	29 [4e]	29	30	
30	31		30 PT (daytime)	30	w1	
31			31 FA179 5" (D)		31 New Years Eve	
FA161 Dezbay	FA159 Spohr	PT BA49 Blomquist		Proton Therapy (C	2007-08-17	
FA172 Sauvedra	FA189 Malyshev	BA45 Ahmetjic		bio-med exp (C,A)	v.4	
FA135 Soelkner	FA194 Malyshev			material exp (I,K)	n"=beam share shifts	
FA154 Prokofiev	FA187 Palfalvi	BA42 Lundgren		Blue Hall irrad (D,I	[#e]=evenings	
FA179 Pomp	FA196 Watanabe	BA32+ Sauerlow		extended service	[#n]=nights	

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Beam Time Schedule – 1st half of 2008

Spring2008_071022.xls

Jan	Feb	March	April	May	June	
w01		1			1	
1 New Year's Day	1	2		1 Ascension	w23 ECR	
2 Service	2	w10 FM	1 PT (daytime)	2 holiday	2 [3n]	
3	3	3 [4n]	2 FA186 5" (D)	3	3 FA159 3 (I)	
4	w06 FM	4 PT (daytime)	3	4	4 BA52+ 3 (C)	
5	4 []	5 FA135 5" (B/D)	4	w19 FM	5	
6	5 PT (daytime)	6	5	5 []	6 SE national day	
w02	6	7	6	6 PT (daytime)	7	
7 Service	7	8	w15 FM	7	8	
8	8	9	7 []	8	w24 FM	
9	9	w11 FM	8 PT (daytime)	9	9 []	
10	10	10 [4n]	9	10 Whitsun Eve	10 PT (daytime)	
11	w07 FM	11 PT (daytime)	10	11 Whit Sunday	11	
12	11 [2n]	12 FA172 5" (D)	11	w20 FM	12	
13	12 PT (daytime)	13	12	12 [4n]	13	
w03 FM	13 FA161 3" (D)	14	13	13 PT (daytime)	14	
14 [2n]	14	15	w16 FM	14 FA135 5" (B/D)	15	
15 PT (daytime)	15	16	14 [2n]	15	w25 FM	
16 BA58 3 (N)	16	w12 ECR	15 PT (daytime)	16	16 [2n]	
17	17	17 [3n]	16 BA58 3 (N)	17	17 PT (daytime)	
18	w08 CW	18 FA194 3 (K)	17	18	18 FA161 3" (D)	
19	18 [5n]	21 BA52+ 3 (C)	18	w21 FM	19	
20	19 FA161 9 (D)	20	19	19 []	20 Midsummer Eve	
w04 FM	20 FA198 3 (B)	21 Long Friday	20	20 PT (daytime)	21 Midsummer Day	
21 []	21	22 Easter Eve	w17 FM	21	22	
22 PT (daytime)	22	23	21 []	22	w26 CW	
23	23	w13 FM	22 PT (daytime)	23	23 [4n]	
24	24	24 Easter Monday	23	24	24 FA161 9 (D)	
25	w09 FM	25 []	24	25	25	
26	25 []	26 PT (daytime)	25	w22 FM	26	
27	26 PT (daytime)	27	26	26 []	27	
w05 FM	27	28	27	27 PT (daytime)	28	
28 []	28	29	w18	28	29	
29 PT (daytime)	29	30	28 Service	29	w27	
30		w14 FM	29	30	30 Service	
31		31 [4n]	30 Iast of April	31		
FA135 Soelkner	FA159 Spohr	PT BA49 Blomquist		Proton Therapy (G	2007-10-22	
FA161 Dethey	FA194 Malyshev	BA58 Trmeus		bio/med exp (C,A)	v.2	
FA172 Romain				material exp (I,K)	#"=beam share shifts	
FA186 Ryzhov				Blue Hall irrad (D,I	[#e]=evenings	
FA198 Hands		BA52+ Stenerlow		extended service	[#n]=nights	

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Pricing, scheduling, contact

- 400 Euro/hour* are charged for:
  - User's time
  - Trimming time up to 4 hours/energy/particle type
- 20% discount for irradiation campaigns of 1 week or longer
- No minimum irradiation time
- No cost for set-up time at the irradiation area and at the counting rooms

Information on TSL, including beam-time request: www.tsl.uu.se
Laboratory director: Curt.Ekstrom@tsl.uu.se
Coordinator of irradiation facilities: Alexander.Prokofiev@tsl.uu.se
Scientific programs: Jan.Blomgren@tsl.uu.se

Request	**Scheduling**
January 15	April-June
April 15	August-October
July 15	November-December
October 15	January-March

* Valid until 2007-12-31