SNS Document No. 110000000-PN0002-R00

Date: **August 20th, 2003**

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SNS FE-DTL1-Dplate Fault Study Plan

This document details the fault study plan for FE-DTL1-Dplate during the commissioning phase planned for August-October 2003. The studies are limited to unchopped beam.
The layout of the facility is given in section 1. The outline of the fault study plan is laid out in section 2, including the goals and a general method for achieving them. Section 3 is a more detailed plan, each subsection viewed as a plan for each fault outlined in section 2.

1 Layout

Figure 1 shows the top view layout of the FE-DTL1-Dplate beam line, including part of the enclosure for DTL1-Dplate along with the labyrinth leading from it to the Front End (FE) control room and the cable and waveguide penetrations leading to outside the enclosure. Figure 2 shows the entire enclosure for DTL1-Dplate-DTL3.
The FE-DTL1-Dplate area may be divided into three zones: Zone 1 covers the FE control room and the FE portion of the beam line (i.e. Ion source, LEBT, RFQ and MEBT). Zone 2 covers the DTL1-Dplate-DTL3 enclosure, including the labyrinth to it from the FE control room. Zone 3 is the linac tunnel downstream of the DTL1-Dplate-DTL3 enclosure (see figures 1 and 2).

2 Fault Study Plan

2.1 Goals

The fault study goals are:

(a) Establish routine dose rates outside shielding

(b) Measure the dose at various points outside the DTL1 enclosure area while controlled faults are occurring, in order to determine the optimal location of interlocked area radiation monitors (Chipmunks), the attenuation achieved by radiation shielding and the labyrinth, and the maximum fault dose rates at all penetrations

(c) Estimate the quality factor of neutrons to be used to set the Chipmunks.

2.2 Method

(a) Routine dose rates:

1. For an initial nominal beam going into the MEBT beam stop, record all chipmunk readings and check dose rates near this beam stop.
2. Accelerate the beam under 1. up to 7.5 MeV and transport it into the D-plate beam stop, record all chipmunk readings and check doses in the locations i.-vi. as marked below and check dose rates near this beam stop with remote readout.

i. near entrance to labyrinth from FE control room
ii. outside the north side of labyrinth
iii. downstream the DTL1-Dplate-DTL3 enclosure in tunnel near fence
iv. near DTL1 upstream gate valve
v. near all penetrations
vi. in the mezzanine area above DTL1

Note that for later studies (e.g. at different repetition rates and pulse lengths), dose rate estimates may be obtained by scaling these measurements.

(b) Create the 4 faults listed below and check doses in corresponding locations:

1. Beam of 2.5 MeV on SST304 ring downstream of DTL1 upstream gate valve and first drift tube(s) of DTL1 by switching off MEBT quad#13. Survey near this quad and the upstream DTL1 gate valve and record all chipmunk readings.

2. Beam of 2.5 MeV on the last drift tube(s) of DTL1 by switching off the RF of DTL tank 1. Survey at locations as listed under 2.2 (a) and record all chipmunk readings. Survey near the end of the DTL1 tank and the DTL1 downstream gate valve using remote read-out.

3. Dplate emittance slit positioned into a beam of 7.5 MeV. Survey at locations as listed under 2.2 (a) and record all chipmunk readings. Survey near the Dplate emittance slit using remote read-out.

4. Dplate view screen positioned into a beam of 7.5 MeV. Survey at locations as listed under 2.2 (a) and record all chipmunk readings. Survey near the Dplate view screen using remote read-out.

(c) Each of the above radiation measurements will be carried out by the RCT using a calibrated Health Physics Instruments Model 1030. Calibration will be confirmed by ORNL's calibration facility (RICL). In live-time mode, the most sensitive scale is 10 mrad/h (same as 10 mrem/h for photons). The integrate mode has a more sensitive scale (the literature says 0.01 mrad). The fact that it reads in absorbed dose (rads) instead of mrem shows that no quality factor is assumed. We will check our standard ORNL instruments (Remball with integrating electronics for neutrons, ion chamber for photons) against this instrument to determine/confirm that they work suitably in our length pulsed fields. In addition, a REM500 neutron spectrometer will be used to directly measure quality factors where the neutron flux is adequate to allow a measurement. A Chipmunk and a commercial version of the Chipmunk radiation monitor are also available to compare to the Model 1030 and to the sum of the measurements from an ion chamber and Remball.

2.3 Chipmunks Locations

A total of five chipmunks are currently positioned in the following locations (see figure 3):

- Between Ion Source and FE control room (#100).
- Just north of the MEBT (#101).
- South of the DTL1 shield wall (#102).
- Just east of the downstream PPS gate (#103).
- Up in the mezzanine above the DTL1-Dplate enclosure (#105).

3 Fault Studies Step-By-Step

In this section the different fault studies are detailed one by one. The expected dose rates, in mrem/hour, at various key locations are listed for each fault mode. All fault studies will be conducted under MPS protection. No RF power should be present in DTL3. Fault studies other than those found in this chapter (e.g. with MEBT steerers, which according to simulations cause beam loss of less than 4% in the DTL1-Dplate-DTL3 enclosure) will be prompted if needed, as set out in SNS-OPM 2.H-16 (Fault Study Procedure for Primary and Secondary Beam Areas).
The risk of damage to the DTL1 upstream and downstream stainless steel gate valves for a 20 mA, 1Hz beam (be it 2.5 MeV or 7.5 MeV; compare with the initial beam conditions under (a) and (b) below) starts to occur for pulse lengths of about 10 to 20 microsec (compare with results reported for copper in SNS-Note-AP-111). Therefore no fault studies will be made with these gate valves.

(a) Routine dose rates:

1. For an initial nominal beam (2.5 MeV, 20 mA, 40 microsec, 2 Hz) going into the MEBT beam stop, record all chipmunk readings and check dose rates near this beam stop.

   Expected dose rate estimates (mrem/hour):

Location	neutron	gamma
30 cm from beam stop	0.27	0.005
100 cm from beam stop	0.024	<0.001

2. Accelerate the beam under **3** (a) 1. up to 7.5 MeV and transport it into the D-plate beam stop, record all chipmunk readings and check dose rates in the locations i.-vi. as marked under 2.2 (a). This measurement should be repeated at the end of the DTL1 commissioning at maximum allowed beam power as defined by the beam commissioning plan. Measure near beam stop using remote readout. Locations L1 through L4 are shown in figure 1.

   Expected dose rate estimates (mrem/hour):

Location (inside enclosure)	Neutron	gamma
North of beam stop, against poly	1.5	100.
South of beam stop, against poly	2.6	20.
Above beam stop, on top of poly	1.1	100.
L1	0.25	2.2
L2	0.034	0.12
L3	0.013	0.03
L4	0.001	0.004

Expected dose rate estimates (mrem/hour):

Location (outside enclosure)	neutron	gamma
i.	1.E-5	1.E-6
ii.	2.E-4	0.03
iii.	1.E-5	5.E-5
iv.	0.1	0.05
v.	<0.1	<0.5
vi.	0.001	0.01

(b) After reducing the beam power of the beam under 2.2 (a) by **reducing the repetition rate to 1 Hz,** perform the following fault studies:

1. Beam of 2.5 MeV on SST304 ring downstream of DTL1 upstream gate valve and first drift tube(s) of DTL1 by switching off MEBT quad#13. **Reduce the pulse length to 8 microsec.** Survey near this quad and the upstream DTL1 gate valve and record all chipmunk readings.

Expected beam loss estimates: 20% on SST304 ring, 40% on first 2 drift tubes, 25% near first BPM behind DTL1, 15 % on Dplate beam stop.

Expected dose rate estimates (mrem/hour):

Location	neutron	gamma
30 cm from gate valve	0.26	0.08
100 cm from gate valve	0.03	0.01

2. Beam of 2.5 MeV on the last drift tube(s) of DTL1 by switching off the RF of DTL tank 1. **Set the pulse length to 20 microsec.** Survey at locations as listed under 2.2 (a) and record all chipmunk readings. Survey near the downstream end of the DTL1 tank and the DTL1 downstream gate valve using remote read-out.

Expected beam loss estimates: 65% on last 8 drift tubes, 30% near first BPM behind DTL1, 5 % on Dplate beam stop

Expected dose rate estimates (mrem/hour):

Location	neutron	gamma
30 cm from BPM	0.38	0.34
100 cm from BPM	0.03	0.03

No measurable dose rates expected outside the DTL-Dplate enclosure.

3. Dplate emittance slit positioned into a beam of 7.5 MeV. **Set the pulse length to 50 microsec.** Survey at locations as listed under 2.2 (a) and record all chipmunk readings. Survey near the Dplate emittance slit using remote read-out.

Expected beam loss estimates: 100% on Dplate emittance slit

Expected dose rate estimates (mrem/hour):

Location	neutron	gamma
30 cm from slit	40.9	577.
100 cm from slit	3.7	51.9

No measurable dose rates expected outside the DTL-Dplate enclosure.

4. Dplate view screen positioned into a beam of 7.5 MeV. **Reduce the pulse length to 6 microsec.** Survey at locations as listed under 2.2 (a) and record all chipmunk readings. Survey near the Dplate view screen using remote read-out.

Expected beam loss estimates: 100% on Dplate view screen

Expected dose rate estimates (mrem/hour):

Location	neutron	gamma
30 cm from screen	31.1	7.2
100 cm from screen	2.8	0.7

No measurable dose rates expected outside the DTL-Dplate enclosure.

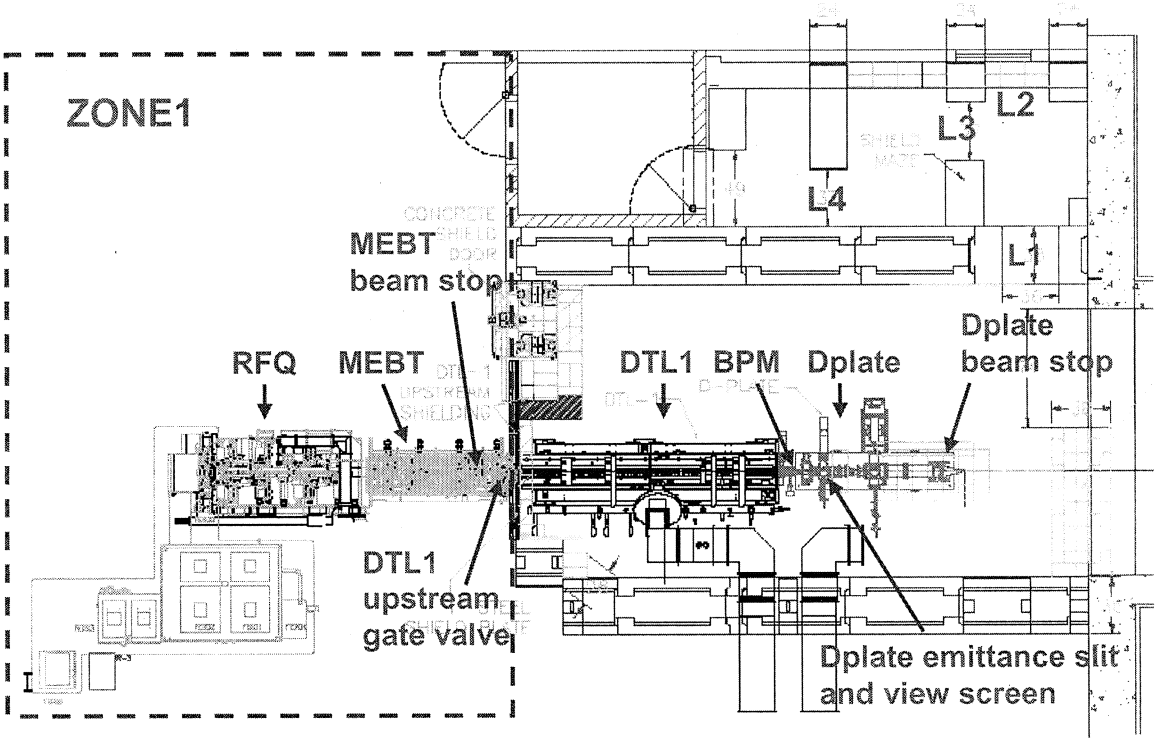

Figure 1 Layout of the FE-DTL1-Dplate beam line. L1, L2, L3 and L4 are locations for measurements in the labyrinth.

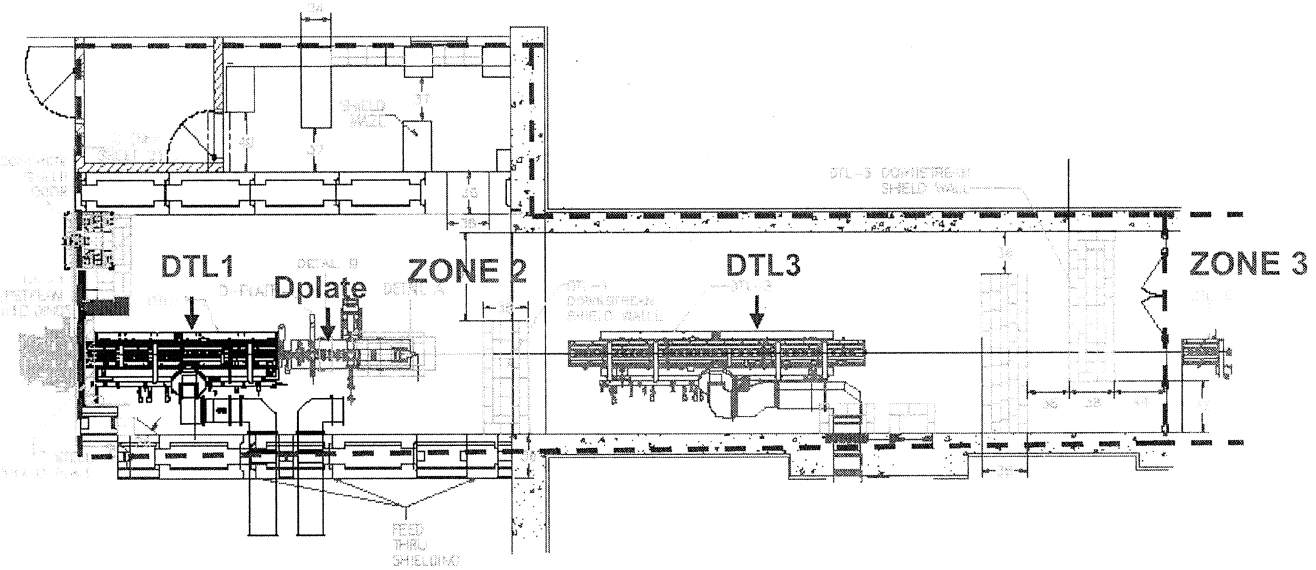

Figure 2 Layout of the enclosure containing the DTL1-Dplate beam line and DTL3

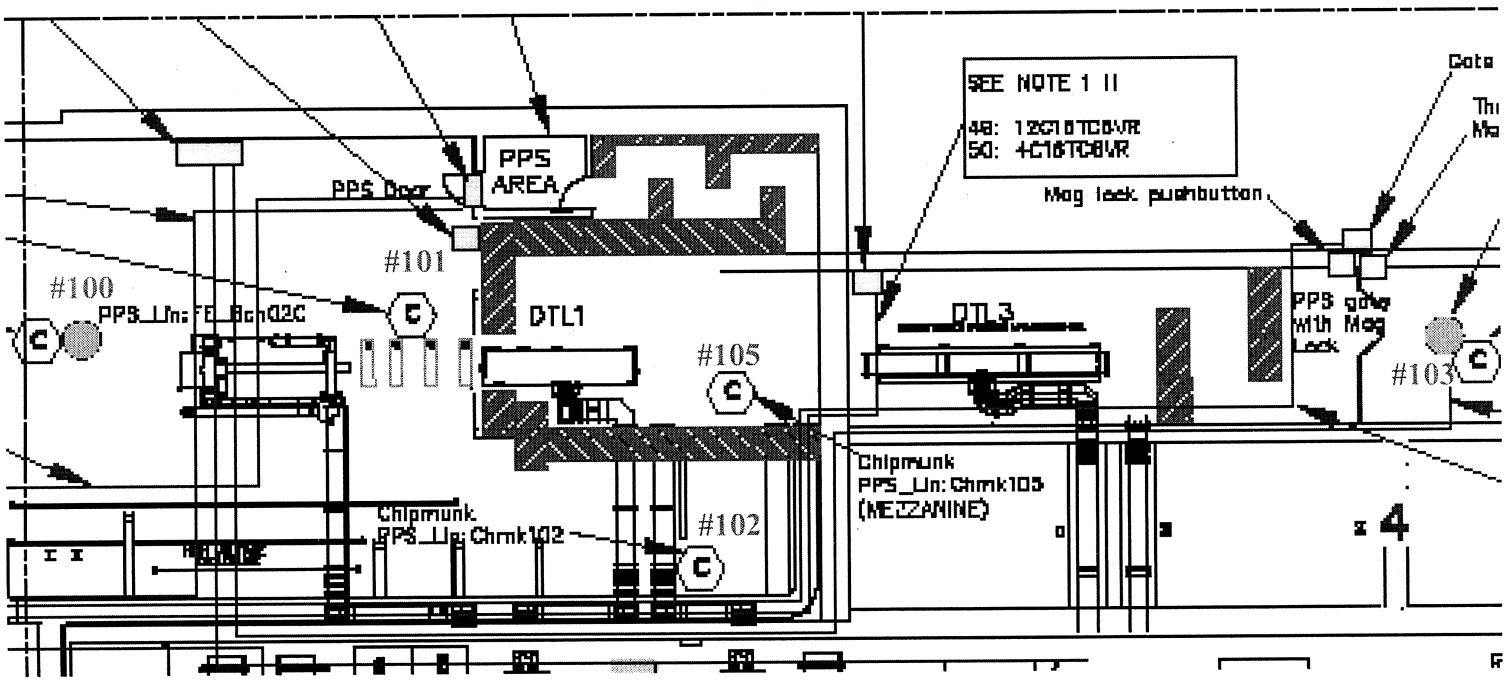

Figure 3 Personnel Protection System (PPS) layout of the FE-DTL1-Dplate beam line; Chipmunks are marked as Ⓒ. Refer to drawing 109090101-R8C-8100-A082 Rev1 for details.