R/V EWING
leg EW9412 --"ACCRETE"

12 Sept. - 22 Sept. 1994
Prince Rupert B.C. - Prince Rupert

Cruise Report

John Diebold, Chief Scientist

Date: November 1, 1994

To:	Arko, Bob	L-DEO Data Center
	Chayes, D.	L-DEO Hydrosweep
	Hayes, D.	L-DEO Associate Director
	Mutter, J.	L-DEO Interim Director
	MARSCICO,	L-DEO Marine Department
	Stennett, J.	L-DEO Science Officer
	Francis, Bruce	L-DEO Science Officer
	Robinson, W.	L-DEO Data Reduction
	Science Officer	EWING Science Files
	Captain	EWING Captain Files
	Chief Engineer	EWING Engineer Files

RESEARCH CRUISE REPORT

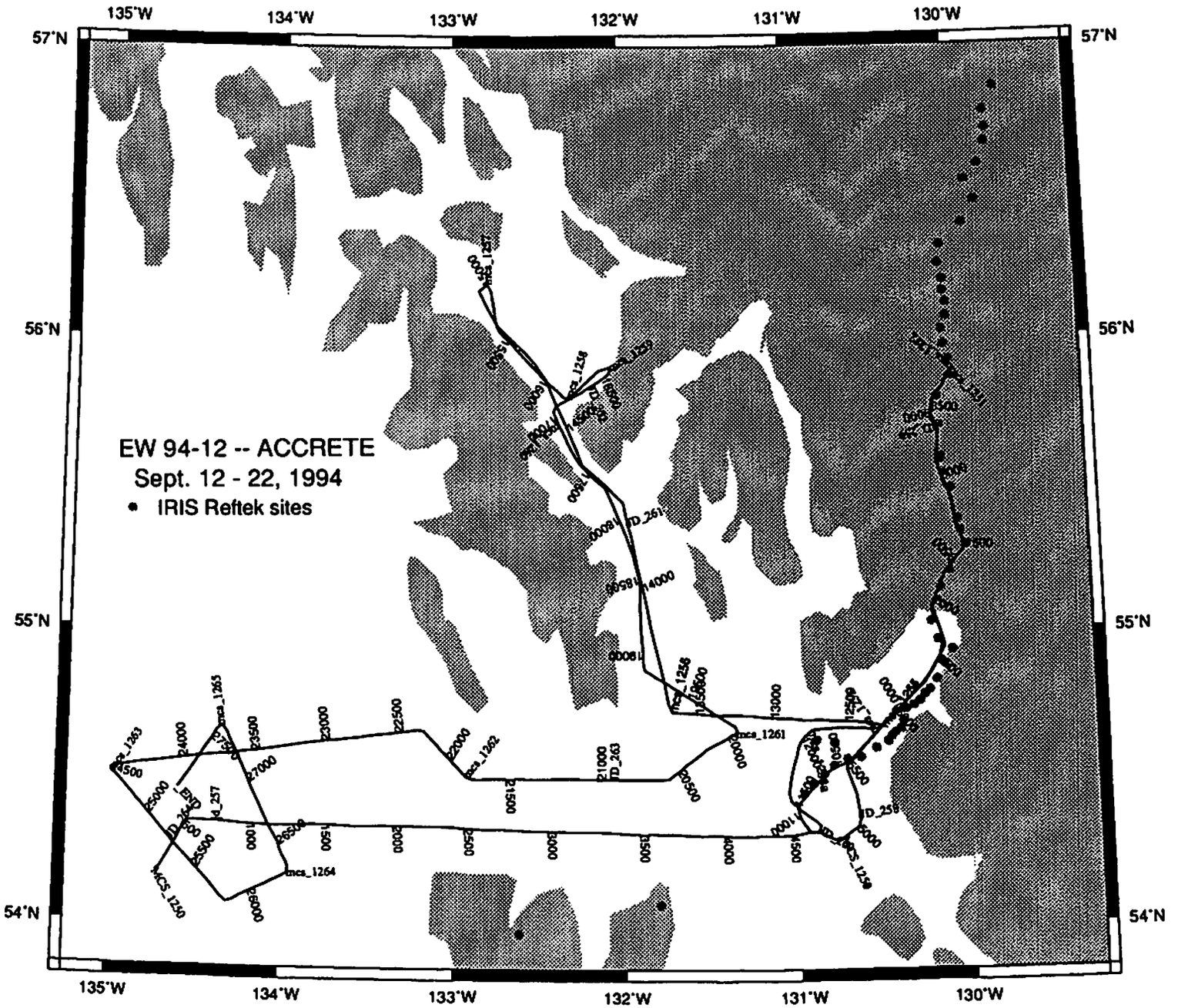
R/V MAURICE EWING, LEG 94-12

"ACCRETE"

P.I. Dr. Lincoln S. Hollister
Dates: 12 September - 22 September, 1994
Ports: Prince Rupert to Prince Rupert British Columbia

Michael Rawson
Marine Department

November 2, 1994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EW 94-12 -- ACCRETE
Sept. 12 - 22, 1994
IRIS Reftek sites

Abstract

EW9412 was the marine component of the "pilot" phase of ACCRETE, a highly integrated geophysical and geological study of continental accretion via processes of terrane docking. R/V*EWING*'s role in this survey was to acquire gravity, magnetic and bathymetric profiles in the area, but most importantly, to shoot and record Multichannel seismic [MCS] data, and to provide the acoustic seismic source for an array of some seventy portable seismometers installed on land. This work was done between 12 Sept. and 22 Sept., 1994; Julian days 255 - 265. The Canadian Coastguard base in Prince Rupert was used both as a center of operations and communication and as a berth for the ship at both ends of the project. Cooperation and service was freely and gladly given by Canadian Coastguard personnel, and this assistance was vital to the success of the work. The continuous and unstinting efforts of Master Ian Young and the *EWING*'s crew were a key element in the high level of success which was achieved during this expedition, during which *EWING* fired its 20 airgun source array nearly 28,000 times, recording 224-channel data over some 1700 km of MCS line.

Science Personnel

Lamont Technical staff comprised:

Joe Stennett	Science Officer
Chris Leidhold	Electronic Technician
William Robinson	Systems manager
John DiBernardo	Airgun Officer
Carlos Gutierrez	Air Gunner
Ropate Maiwiriwiri	Air Gunner
Octavio Phillips	Air Gunner

Cruise-specific Scientific staff:

John Diebold	Chief Scientist	Lamont/Columbia U.
Carmel Lowe	Senior scientist	Canadian Geol. Survey
Kristin Rohr	Senior scientist	Canadian Geol. Survey
Anne Trehu	Senior scientist	Oregon State U.
William Clement	Watchstander	U. Wyoming
Triparna Das	Watchstander	Princeton U.
Dierdre Farly	Watchstander	U. Idaho
Elizabeth Jackson	Watchstander	Lamont
George Gosnell	Fisheries Observer	Nisga'a Fisheries
George Gehrels	Geological Observer	U. Arizona
Sally Mizroch	Marine Mammals Observer	NMFS/NOAA

Each watchstander was assigned a once-per-day six-hour watch and paired with a senior scientist. This system seemed to work well, reducing fatigue and allowing free time for participation in ship's affairs and scenic observation.

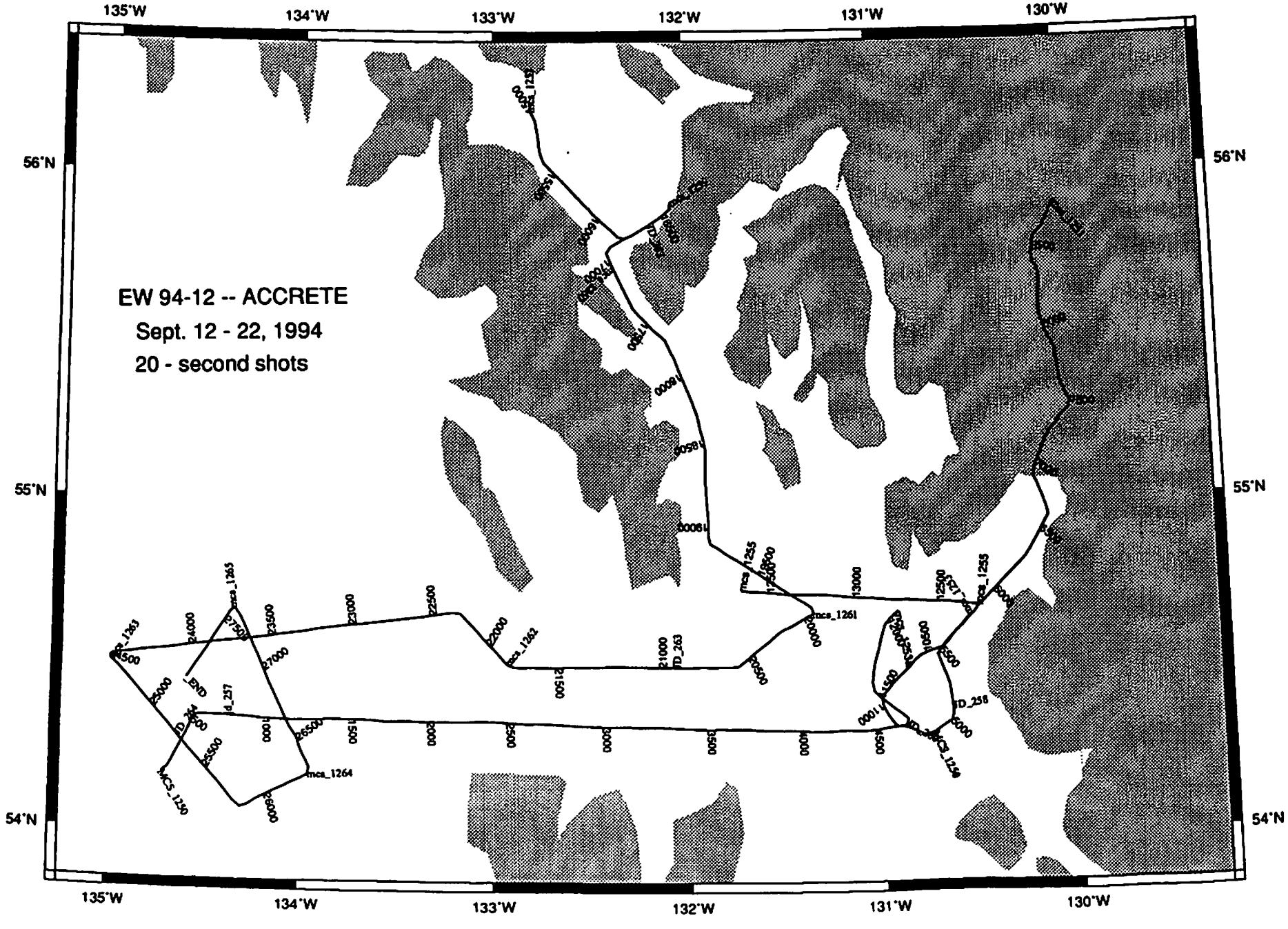
Cruise Plan

A generous 10 days of ship time had been allocated for the ACCRETE project. Although only three days would be required for the proposed lines up and down Portland Canal, extra time was set aside to allow for commercial fishing "openings" which occur at intervals between July and September. Since we were actually scheduled so late in the year, we experienced no conflict with fishing, and were able to use the entire 10 days for data acquisition. The other side of the coin was that winter weather patterns had started to set in, and we had high winds (20kt+) and wave action during much of the survey.

I decided to deploy the MCS gear in deep water west of the Queen Charlotte fault, since this was going to be a lengthy process, during which the streamer would be uncontrollable. Therefore the first line, L-DEO designation 1250, was a reflection line, shot at our standard 20-second rate (nominal shot spacing 50 meters.) Line 1251 was a reflection line into Portland Inlet and on up Portland Canal. The Southwestern end of this line was to have been shot through Hudson Bay Passage, but high winds forced us to defer this segment until later. An added complication was the necessity to take aboard two Canadian pilots near Triple Island, and to keep them aboard throughout the entire Portland Canal two-way trip.

At the head of Portland Canal, *EWING* made a quick U-turn, and line 1252, back down the canal was shot at a 59-second rate, providing long record times for the passive portable seismometers. Upon exiting Portland Inlet, we picked up the leg through Hudson Bay Passage as line 1253, shot at 20 seconds. We dropped the Pilots and turned back north. Circumnavigation of Dundas Island was completed as line 1254, shot at 59 seconds, from west to east, and tying into lines 1251 and 1252.

At the tie point, *EWING* U-turned again, and reflection line 1255 was shot along the north edge of the international border "A-B" line. Shifting back to 59 seconds and turning northward, line 1256 was shot up Clarence Strait to Zarembo Island. The purpose of this line was to provide a "fan shot" survey with rays transmitted through all of the structures west of the Portland Canal Reftek line. Reflection line 1257 was acquired in Clarence Strait between Zarembo Island and Ernest Sound. An enhancement to the fan shooting was made in the form of 59 second shots on line 1258, which proceeded a short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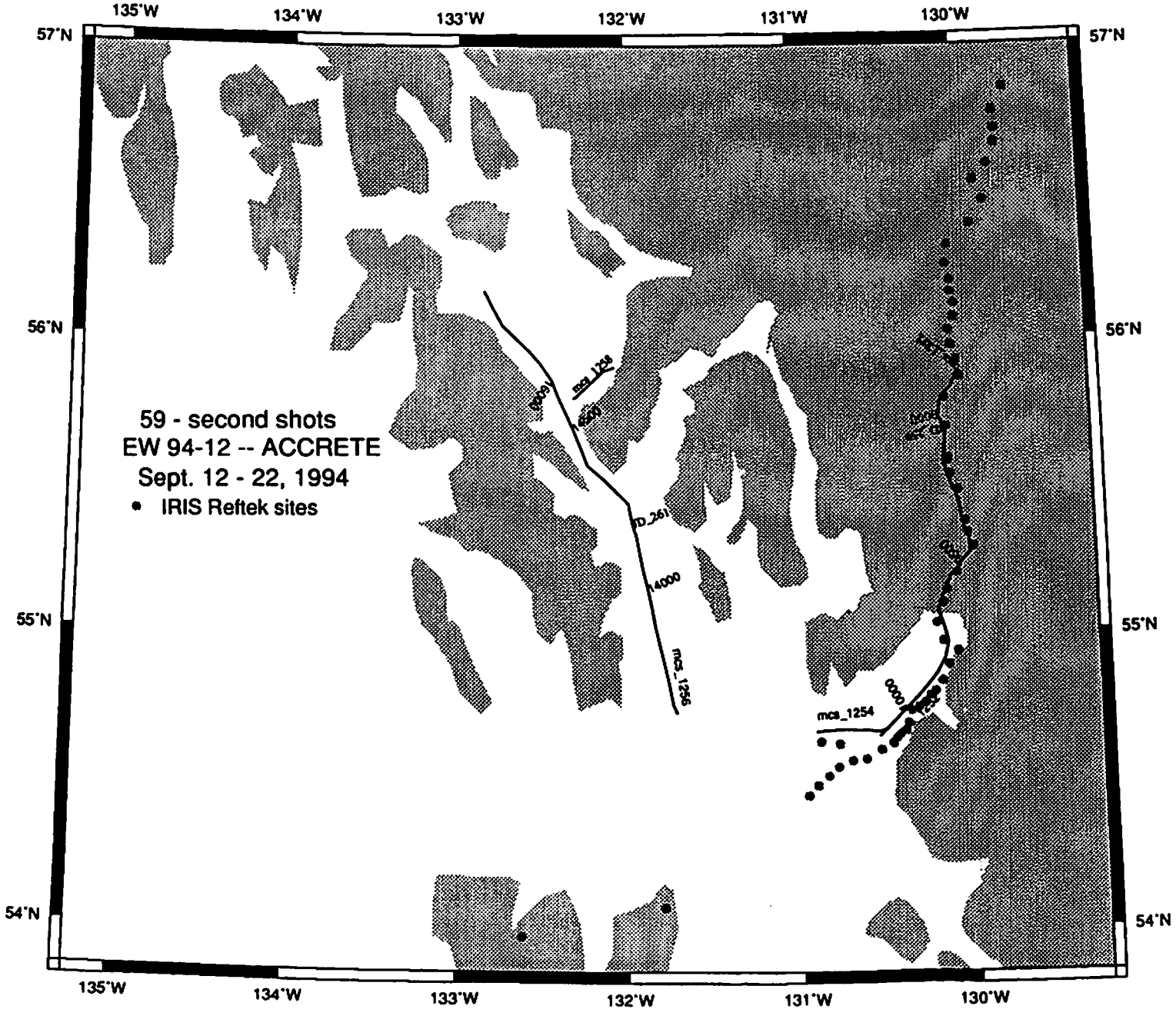
EW 94-12 -- ACCRETE
Sept. 12 - 22, 1994
20 - second shots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59 - second shots
EW 94-12 -- ACCRETE
Sept. 12 - 22, 1994
• IRIS Reftek sites
mcs_1256
mcs_1254

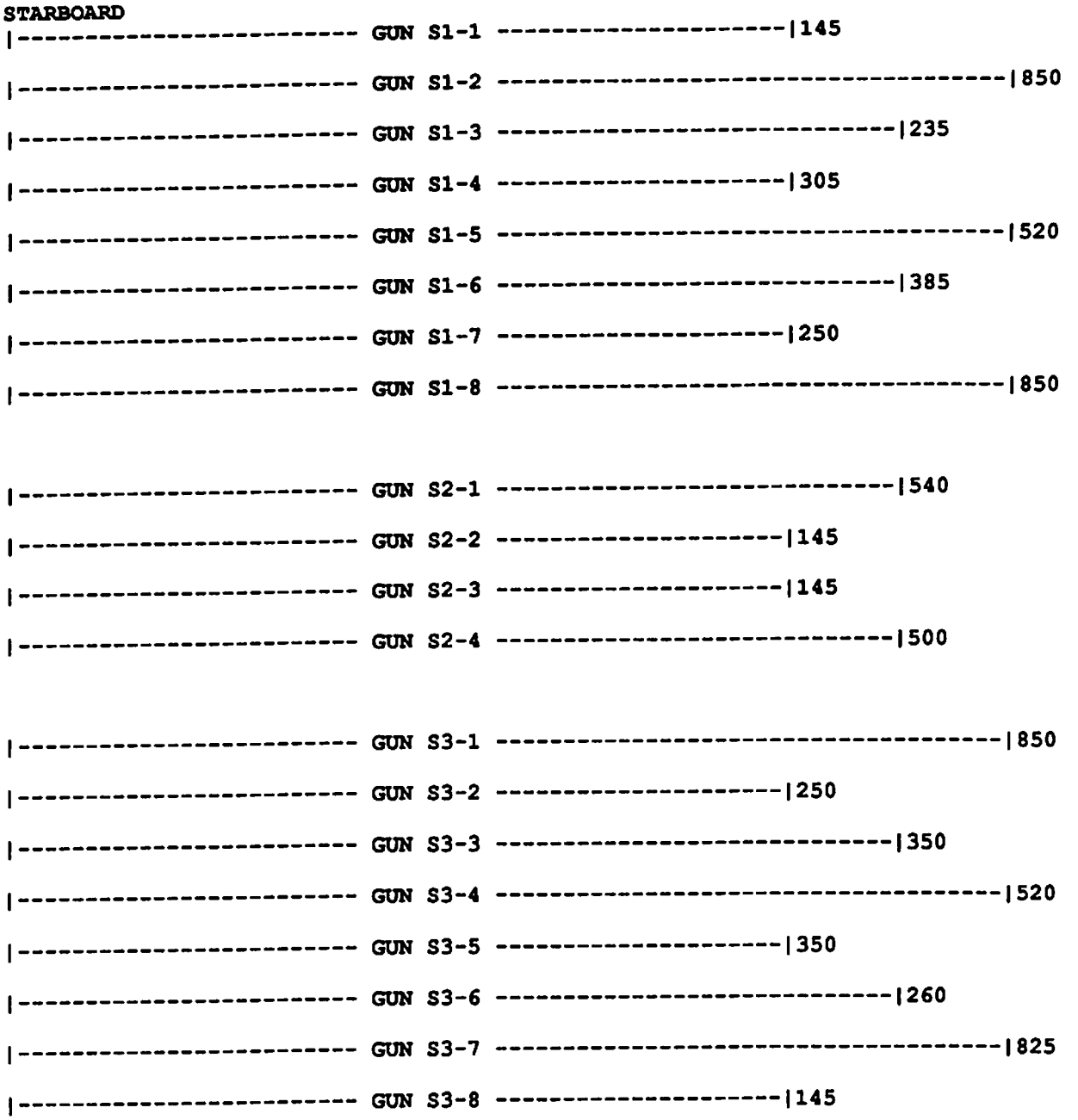
distance up Ernest Sound. Extremely strong winds had been encountered up to this point, and the line up Ernest Sound was prudently truncated. Turning back, we shot reflection lines 1259 and 1260, respectively, back down Ernest Sound and Clarence Strait.

A final set of reflection lines was shot; 1261 completing the northern transect of Dixon Entrance, and several more short lines tying the two east-west transects, and covering features of interest in the offshore transpressional zone, were acquired. In all, about 1700 km of MCS data were recorded, 1320 km during reflection lines, and the rest as lower fold data, intended primarily for Reftek refraction work.

MCS Parameters

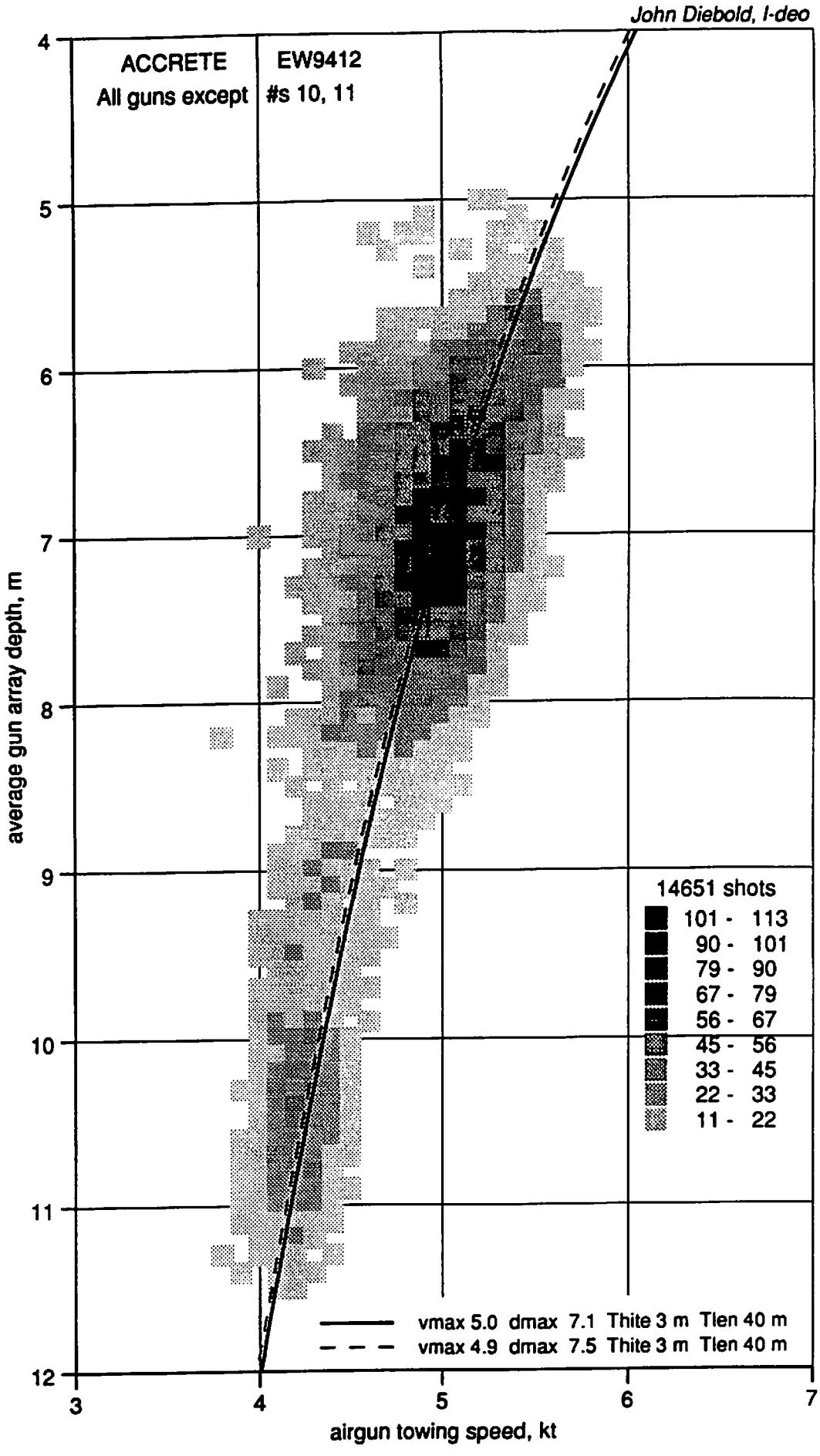
Two requirements constrained the way in which *EWING*'s MCS equipment was set up and used. First, the source array should provide maximum power and penetration. The "standard" 20 - airgun array, with total volume of 8400 cu. in. (138 l.) was used (Fig. 2). Several of the lines were shot twice; once at a 20-second repetition rate, for acquisition of common depth point [CDP] reflection data, and again at a 59-second rate, to provide clean refraction arrivals for the land - based seismometers. During these 59-second profiles, ship speed was reduced to 4.2 - 4.4 kt, so as to increase gun depths to 10 meters, and to enrich the low frequency content of the farfield signature. The second requirement was to keep the streamer under control and out of danger during our two-way passage of Portland Canal, where low temperature and salinity greatly reduce the hydrophone array's buoyancy. (The consequences of improperly adjusting for this condition were painfully brought home during *CONRAD*'s Hudson River profile in 1987.) This time, we removed all of the old-style external can sections from *EWING*'s Digicon streamer, retaining for use 2800 meters of the new "Canto" (pronounced "can two") streamer, with its internal digitizing and telemetry modules ("cans".) These streamer sections are larger in diameter than the older style sections, and can thus be ballasted for a wider range of conditions via addition of oil. We added 1/2 gallons of mineral oil to each of the 12.5 meter sections in the outboard 2500 meters of streamer, a lengthy (7 hour) process. At the same time, we increased the density of Syntron depth controllers ("birds") at the head and tail, making use of the birds which had previously been attached to the 1200 m of unused old-style streamer. The result was a streamer which was very "light" and difficult to control in the warm (ca. 14 ^{o} C.) saline waters outside Dixon entrance. Thanks to the increased bird density, however, we were able to achieve the desired 10 m. streamer depth, though the array tended to rise quickly during bad weather, with a head-on or following sea.

EW9412 - 20 gun towing configuration
With Digicon TAGS designations

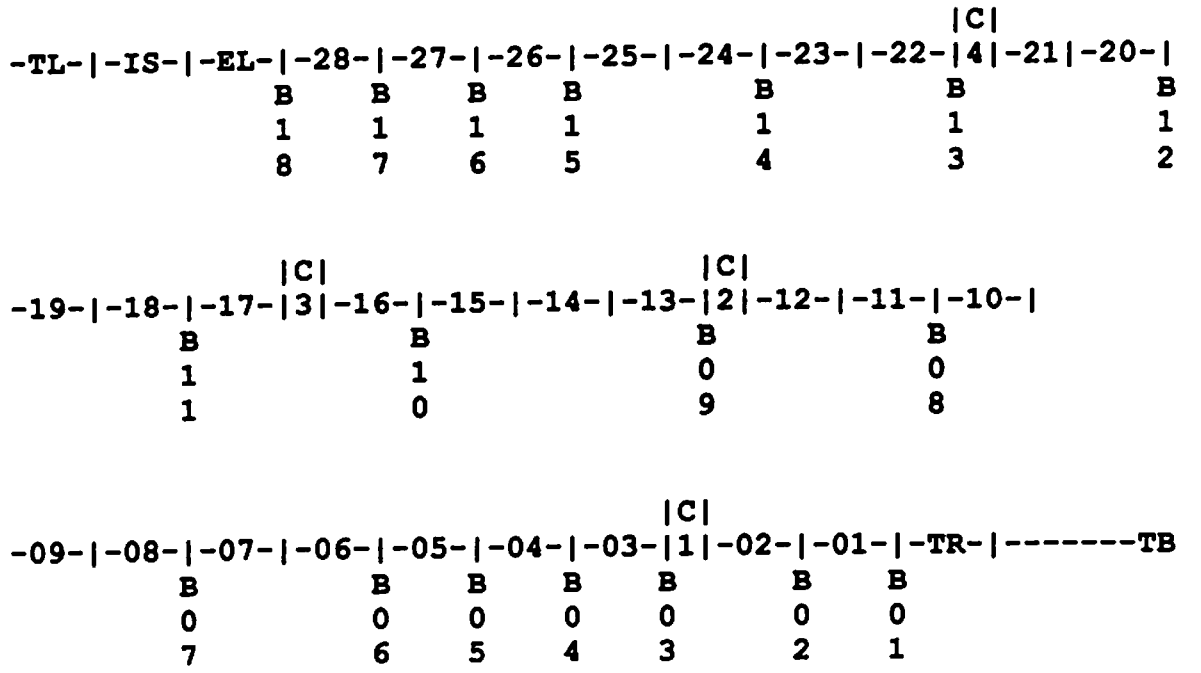


Guns 1-8 of String S1 are towed from the starboard boom
Guns 1-4 of String S2 are towed from the stern A-frame
Guns 1-8 of String S3 are towed from the port boom
The towing lines in S1 and S3 are separated by 5 ft.
Numbers to the right are gun volumes in cu. in.

Cruise Report Fig. 2


John Diebold, l-deo
ACCRETE
EW9412
All guns except
#s 10, 11
average gun array depth, m
airgun towing speed, kt
14651 shots
101 - 113
90 - 101
79 - 90
67 - 79
56 - 67
45 - 56
33 - 45
22 - 33
11 - 22
vmax 5.0 dmax 7.1 Thite 3 m Tlen 40 m
vmax 4.9 dmax 7.5 Thite 3 m Tlen 40 m

Streamer Configuration for EW9412
224-channels, 2.8-km active



|-TL-|----------100 m tow cable
|-IS-|----------100 m Isolator Section
|-EL-|----------100 m Elastic Section
|-TR-|----------100 m Tail Rope Section
|-xx-|----------100 m Active Section with Internal Electronics
|C|----------3 m Compass Section
B----------Depth Controller(Bird)

EW9412 Section and Compass Serial Numbers with Bird Locations.
September 15, 1994

Section	Compass	Corr.	Serial Number	Bird(at tail of section)
Tail Rope			None	
1			2046	1
2			2036	2
-	1	-0.1	8165	
3			2031	3
4			2035	4
5			2024	5
6			2048	6
7			2025	
8			2015	7
9			2043	
10			2003	
11			2033	8
12			2049	
-	2	0.9	8149	
13			2004	9
14			2039	
15			2026	
16			2009	10
-	3	-0.8	8045	
17			2001	
18			2019	11
19			2010	
20			2005	12
21			2044	
-	4	0.2	8152	
22			3038	13
23			2045	
24			2011	14
25			2030	
26			2016	15
27			2047	16
28			2037	17
Elastic			6001	18
Isolator			6000	

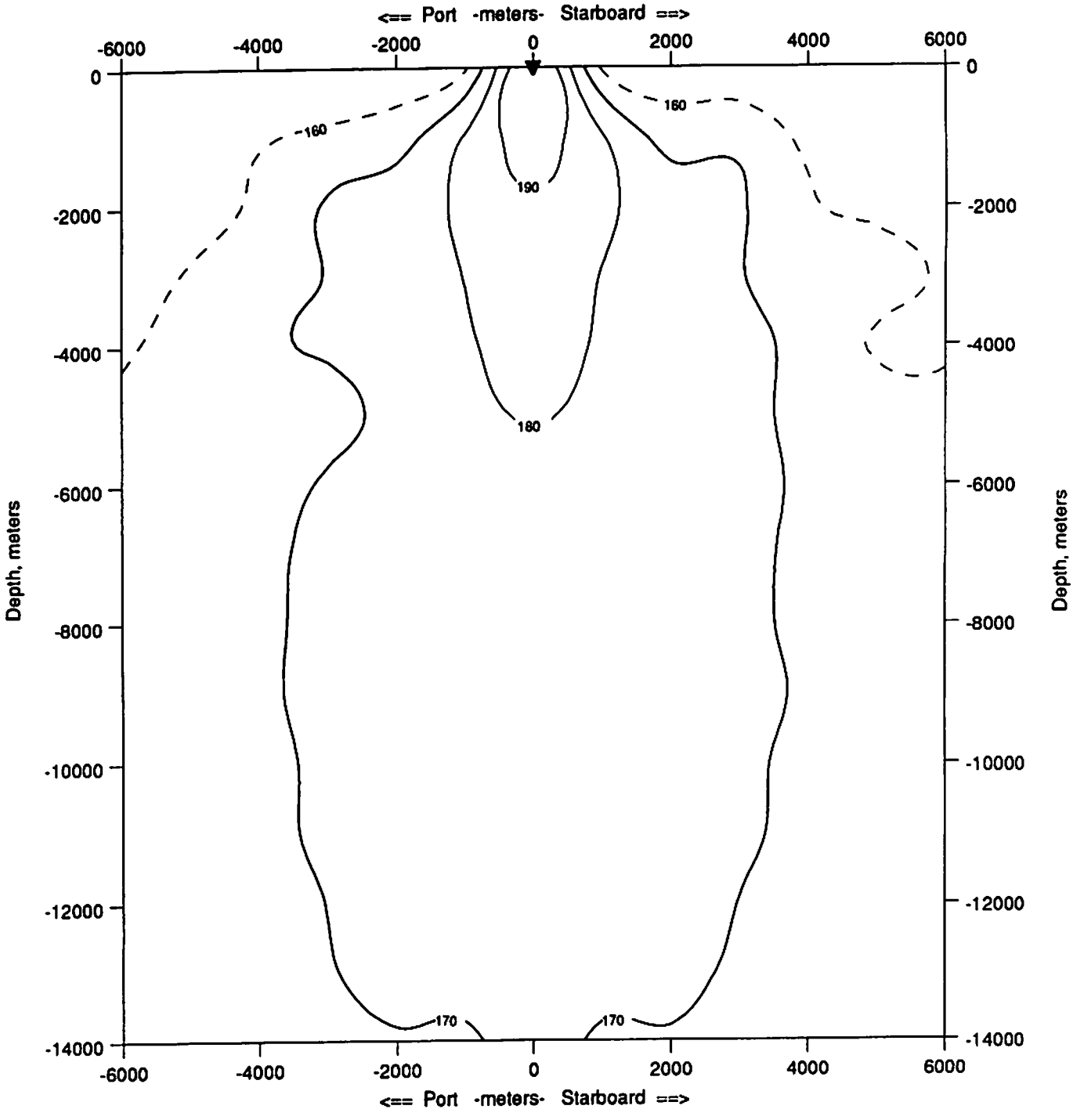
All Active Sections are Canto-type. There are 28 Active Sections and Five Passive, including an unused On-Board Digitizing Module(OBAD). Actually, 29 Active Sections were built, but section 29 is the elastic section.

All of the lines were shot "by time," rather than by distance. There were several reasons for this. Similarity of the source from shot to shot is best maintained with a regular shot time interval, whereas distance shooting inevitably results in some shots being fired with partial air pressure. Shooting by time allows the most efficient duty cycle when recording data, so that maximum possible record lengths are obtained. Finally, problems of obtaining accurate real-time navigation are bypassed. When the navigation is finalized, smoothed and integrated with the seismic data logs, CDP binning is a simple process, even in the presence of varying shot spacing. For all shots, a random time factor within the range -500 to +500 milliseconds was added, to eliminate the possibility of harmonic buildup of previous shot multiples. The 20 second shot data were recorded with 16.5 second trace lengths, the 59 second shots with 20 sec lengths. The number and active lengths of Canto sections is software selectable, and we elected to use the maximum possible number: 224 12.5 meter sections.

Marine Mammals

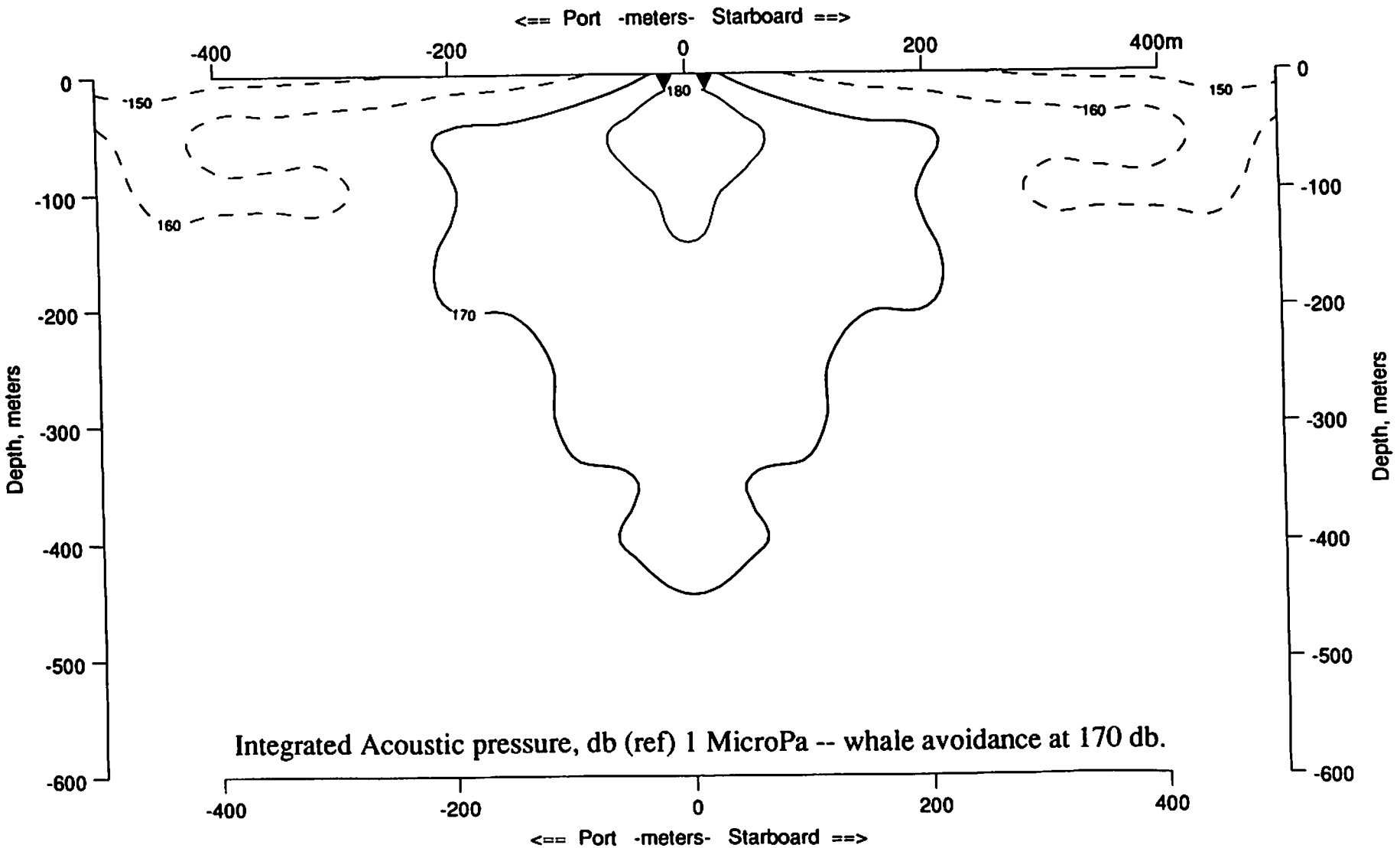
Dr. Sally Mizroch of the NMFS/NOAA National Marine Mammal Laboratory in Seattle joined the cruise to observe the effect of MCS activity upon marine mammals. Before acquisition began, we worked out procedures for reducing airgun output in case MCS acquisition appeared likely to interfere with feeding whales. Dr. Mizroch felt that reduction was preferable to abrupt cessation of shooting, since this would allow the whales to track our position better. We agreed that if the ship was approaching a group of feeding whales, eighteen of the airguns would be shut off, leaving only the two smallest, located at the lateral extremes of the array firing. In this way, the source level would be greatly reduced, but the whales would still be able to determine our spatial location and direction while we moved out of their feeding area. We developed a schedule for subsequently ramping up the array output, adding guns at the rate of one pair every two minutes. In all cases, we were to begin firing following this ramp pattern, so as to give acoustic warning to any nearby mammals. As it turned out, few whales were observed during the cruise, and we were never required to reduce the source array output.

EWING 9412 20 - airgun array directivity



Integrated acoustic pressure, db (ref 1 MicroPa)

EWING 9412 Minimum size 2 x 145 cu. in. airgun array directivity



Fish

Chief George Gosnel, of the Nisga'a tribal council and fisheries, participated in the expedition, to observe the effect of MCS activities on the fish, which are an important part of his tribe's diet and income. He also documented the cruise by recording four hours of videotape and interviews.

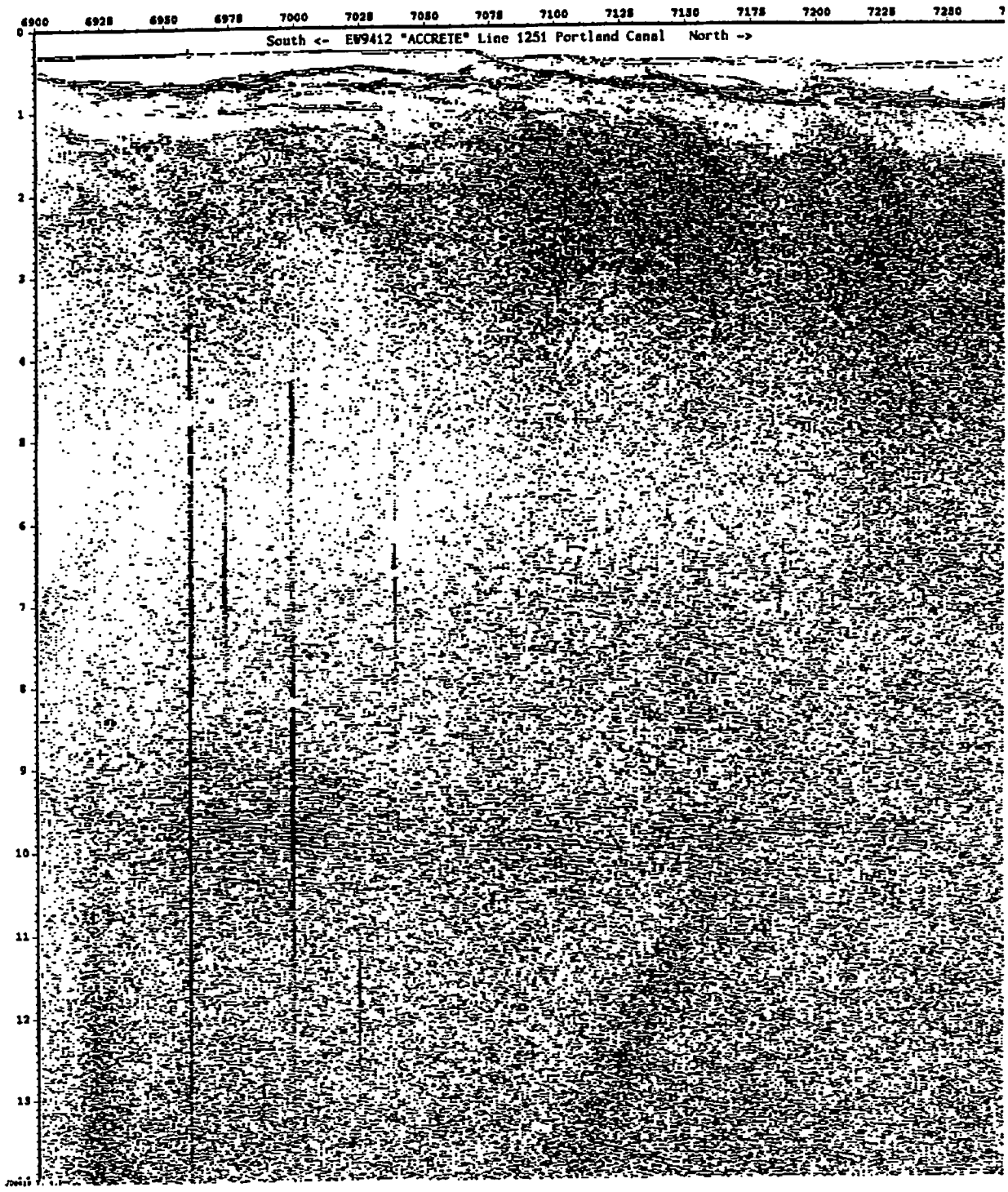
Data

The EWING's Digicon DMS-2000 seismic acquisition system performed well, overall. We suffered somewhat from the system's occasional rejection of tapes, a problem which has plagued us starting with the system's second outing, during EW9409. In almost every case, the problem was ended by using tapes from a different box, suggesting that subtle flaws, either from manufacture or vibration during storage, were infecting the media. I suspect also that the system's error handling is not as robust as it might be, since tapes from "bad" boxes have been used for other recording purposes without failure.

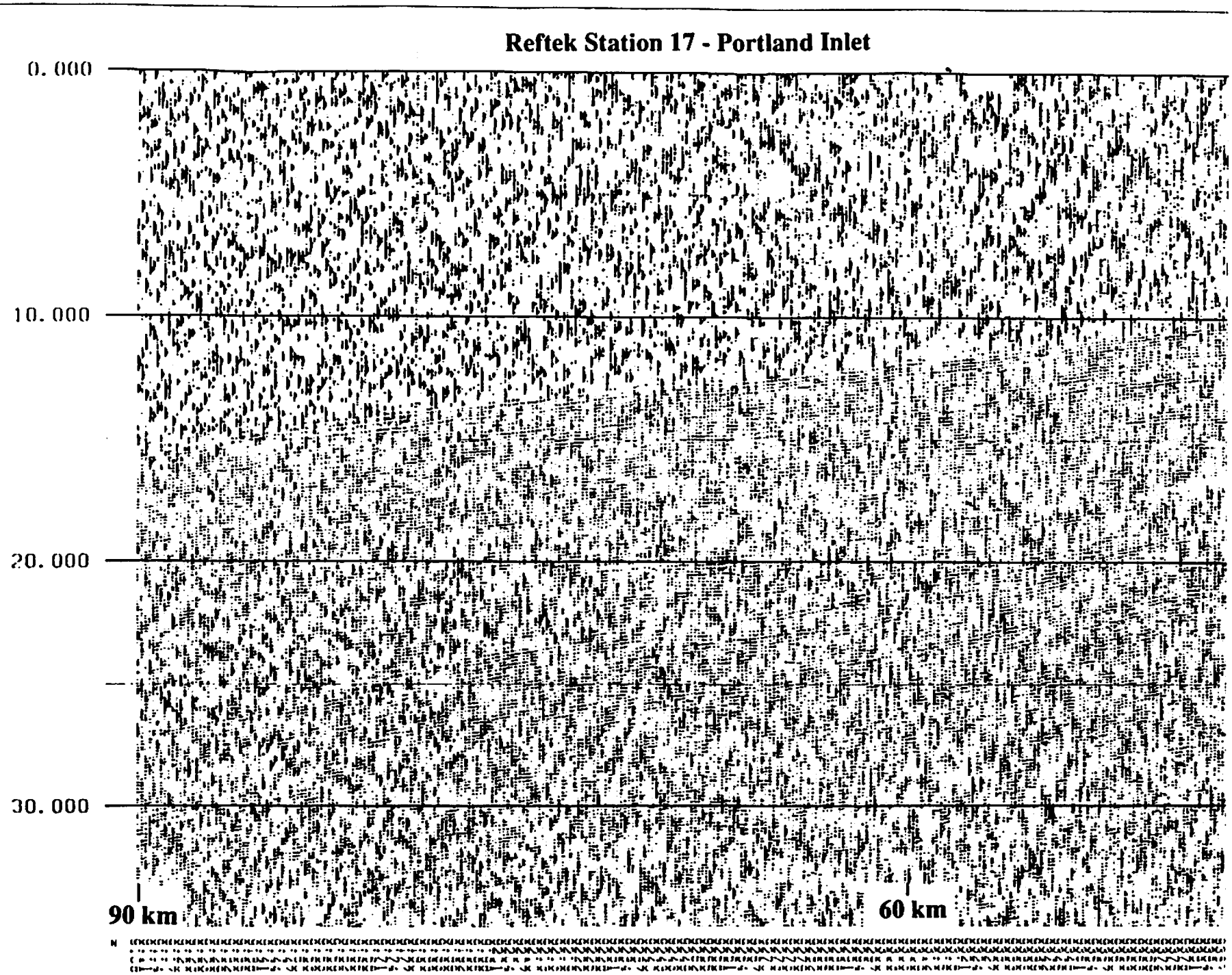
Shipboard brute stacks of the CDP data were made to determine whether the system had sufficient power to penetrate to Continental Moho depths, and to evaluate the effects of side echoes and reverberations, which had been predicted to cause problems in the Fjord-like environment of Portland Canal (Fig. 3.) It is clear that strong diffractions contaminate the data (these were ameliorated in the brute stacks by using a 25 meter bin size; effectively mixing traces), but for the most part, these arrivals show very low phase velocities, and frequency-wavenumber filtering of the shot gathers will almost certainly be very effective in removing them. The data in Fig. 3 were recorded as 20 second shots in Portland Inlet. The brute stack shows a thin (ca. 30 km) but typical continental crustal section, with transparent upper crust, layered reflectors in the lower crust, and reflection Moho dipping gently northward between 9 and 10 sec two-way time.

Many of the IRIS Reftek seismometers had been recovered by the time of EWING's return to Prince Rupert; data were being downloaded and with the arrival of our shot instant files, traces could be extracted. Figure 4 shows a small section of a common-receiver gather from Reftek 17, located on the South shore of Portland Inlet. Strong and coherent arrivals are plainly evident at the farthest offsets present in this particular partial gather.

<----------10 km ---------->



EW9412 Cruise Report Fig. 3



EW9412 Cruise Report Fig. 4

Conclusions

Thanks to the hard work of many participants, most importantly the lead principal investigator, Prof. Lincoln Hollister of Princeton University, the ACCRETE pilot study fulfilled its goals and, in fact, far outstripped them. *EWING*'s 20 airgun source array has served once again as a highly satisfactory seismic source for large offset work. Benefiting from past experience and from the increased capabilities of our current generation of MCS equipment, we have learned how to operate in inland waterways. We have shown that, at least in the case of Portland Canal, the effects of side echoes and reverberations can be overcome to provide deep crustal images with MCS reflection techniques.

Once again, I thank Master Ian Young, *EWING*'s crew, scientific staff, and all of the participating scientists and observers for their difficult but crucial roles in making EW9412 an enjoyable and successful expedition.

Cruise EW9412 "ACCRETE" -- Chief Scientist's log. All times local

12 Sept jd255
10:00 Left Prince Rupert
13:00 Science organizational, lab and geology meeting
15:20 F&B drill

13 Sept jd256
01:15 reached SOL started deploying streamer. 25 - 30 kt wind,rain squalls. Added ca. 4 gal. oil per section, except first five sections. had to estimate this, as gauge shorted out after 5 sections.
08:45 Finished streamer. Towing shallow, as expected. Sea surf temp 14+
09:00 Steaming upwind at 5 kt to get streamer down. wind 30-35kt.
09:30 Tail is down, turning into trough to get head down.
10:30 Begin to deploy guns.
11:30 Guns & maggie deployed, streamer won't build past can 7. TAGS hung.
12:20 Re-build system, start line 1250.

14 Sept jd257
03:30 Streamer is finally in good shape, up only at head. Sea surf temp down to 12.0.
05:15 Broke middle section - chamber clamp, #16.
10:00 Weather gets bad - up to 35 kt.
11:00 As a result, pilots won't come out from triple rocks to meet us.
12:00 Capt. elects not to go through Hudson Bay Passage; we will continue east after picking up pilots and go inland of Melville Island.

15 Sept jd258 +7
00:00 Portland Inlet. sea surf temp 10.7 deg. calm, recent glacial seds.
03:00 reel 197 every record a square tape 84 error, nearly every shot is incomplete. In US waters.
10:00 sea temp now 8 deg C. water very silty. Streamer in very good shape. Many floating snags. Overcast & Drizzle.
13:00 Approaching Stewart. Bird fin angles indicate streamer ~ neutrally buoyant. Ch. Sci. also.
13:35 Pull guns & hoses in preparation for sharp U-turn.
13:50 start Turn at Stewart.
14:00 Turn complete.
14:28 Begin shooting @ 59 sec rate 55 deg 50.9 min N.

16 Sept jd259 +7
04:00 Entering Portland Inlet. speed through water has been slow (4 - 4.2 kt) and gun depths consistent around 10 meters. Constant rain thru the night, but wind moderate. Water temp back up to 10.5, streamer OK.
10:30 When shift back to 20 sec shooting, Joe reboots CEO and it forgets current setup. Tapes read "Stanford," etc. Dates, times, sp, reel #'s OK
13:00 Shoot Hudson Bay passage, streamer at 7.5 meters. No apparent problems.
23:30 Reach tie point, U-turn back west.

17 Sept jd260 +7

12:00 In Clarence, ca. 2 hours ahead of "schedule" slowed ship down from 4.4

to 4.2kt to increase gun depth. weather calm, with overcast.

13:00 Radio with Smithson. Concerned about non-60sec shooting sched.

13:30 Fax from Smithson/Hollister -- re shot instants, Moho at Dundas.

16:00 Fax back with shot instant explanation, brute stack of Hudson Bay Pass.

18 Sept jd261 +7

00:00 Headed North in Clarence. ETA to turning point at Zarembo Island 06:00, ca. 4 hr ahead of "schedule." Traffic steady and fairly heavy all night.
11:30 Still blowing. Agreed to visit Ernest Sound anyway.
15:30 Truncate Ernest Sound, to allow larger turning radius. Weather ameliorating -- down to 15 kt.
20:00 Fine sunset.

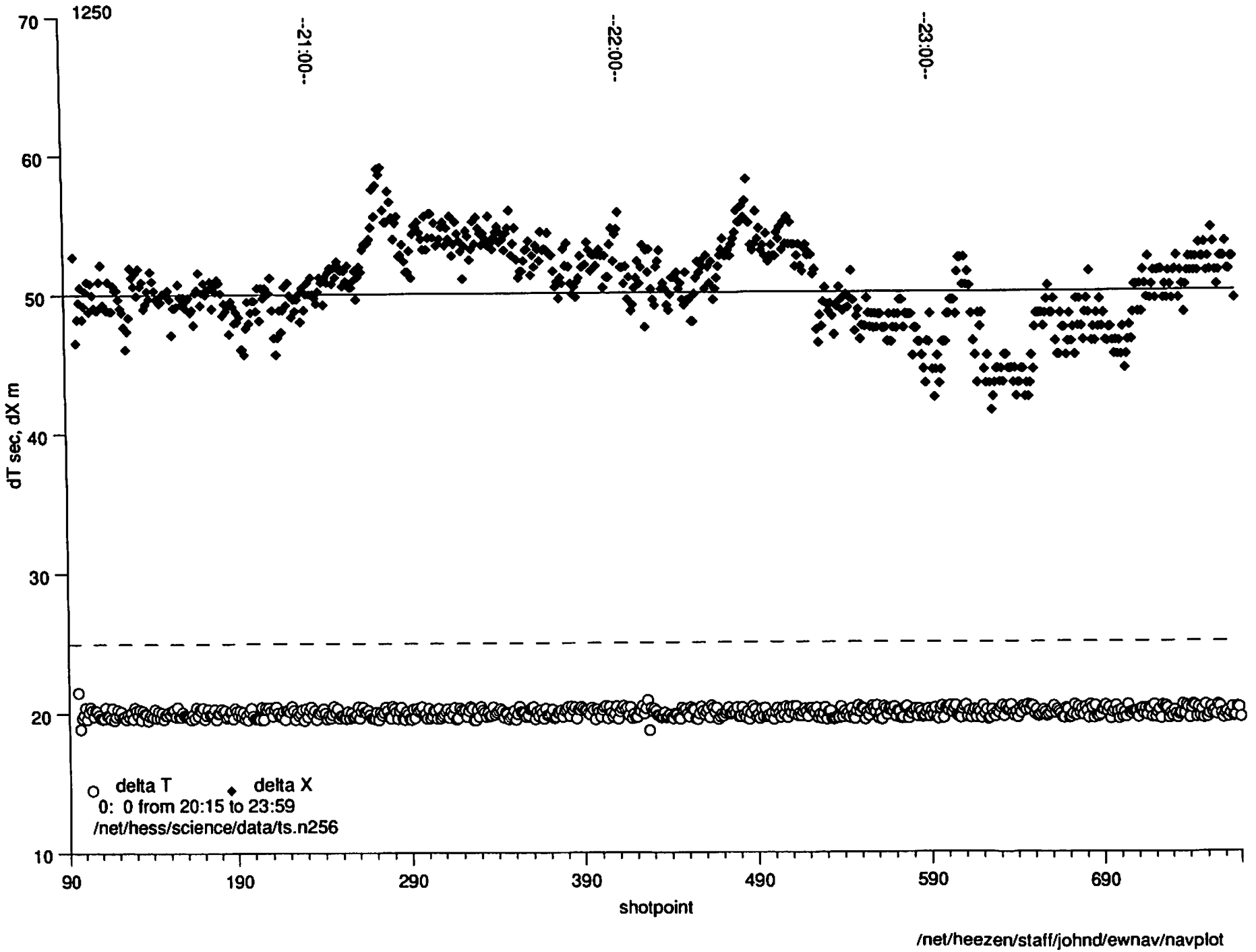
19 Sept jd262 +7
00:00 Full moon and relatively clear sky.
06:30 Many squaretape 84 errors. Changed box of tapes. errors went away.
07:00 Bright sunlight, very calm.
08:30 Enter low lying fog. sky above is blue. foghorn blasts.
18:00 Moving west, get out of fogbank. Communication with Linc via fax.

20 Sept jd263 +7
04:00 Many squaretape 84 errors -- changed box of tapes, no more errors. Streamer very noisy, though it appears to be towing OK and wind is mild.
14:00 Wind up to 14 kt. water temp up to 14 deg, streamer won't stay down after last turn. -- eventually came down at ca. 6 kt.

21 Sept jd264
02:00 Streamer OK, but wind is rising.
07:45 Streamer crashed, failed can 29 - stretch
07:55 Shut down shooting, begin recovery
18:00 Removed stretch section 29. Streamer now builds OK. Long time spent extracting oil. Need squeezer for Canto sections, which are accessible only from head end. Trouble with streamer winch brake -- bypassed accumulator. Canto sections and tailbuoy in. Break for dinner and run into lee of Graham Island.

22 Sept jd265
04:00 Take 1200 m of old style streamer, including 1 canto section, down from A deck and attach to streamer. Finish at 07:30. Four people. Streamer reel operating OK.
12:00 Tie up at Seal Cove Coastguard dock.
02:00 Lead high school geol. class tour.

John Diebold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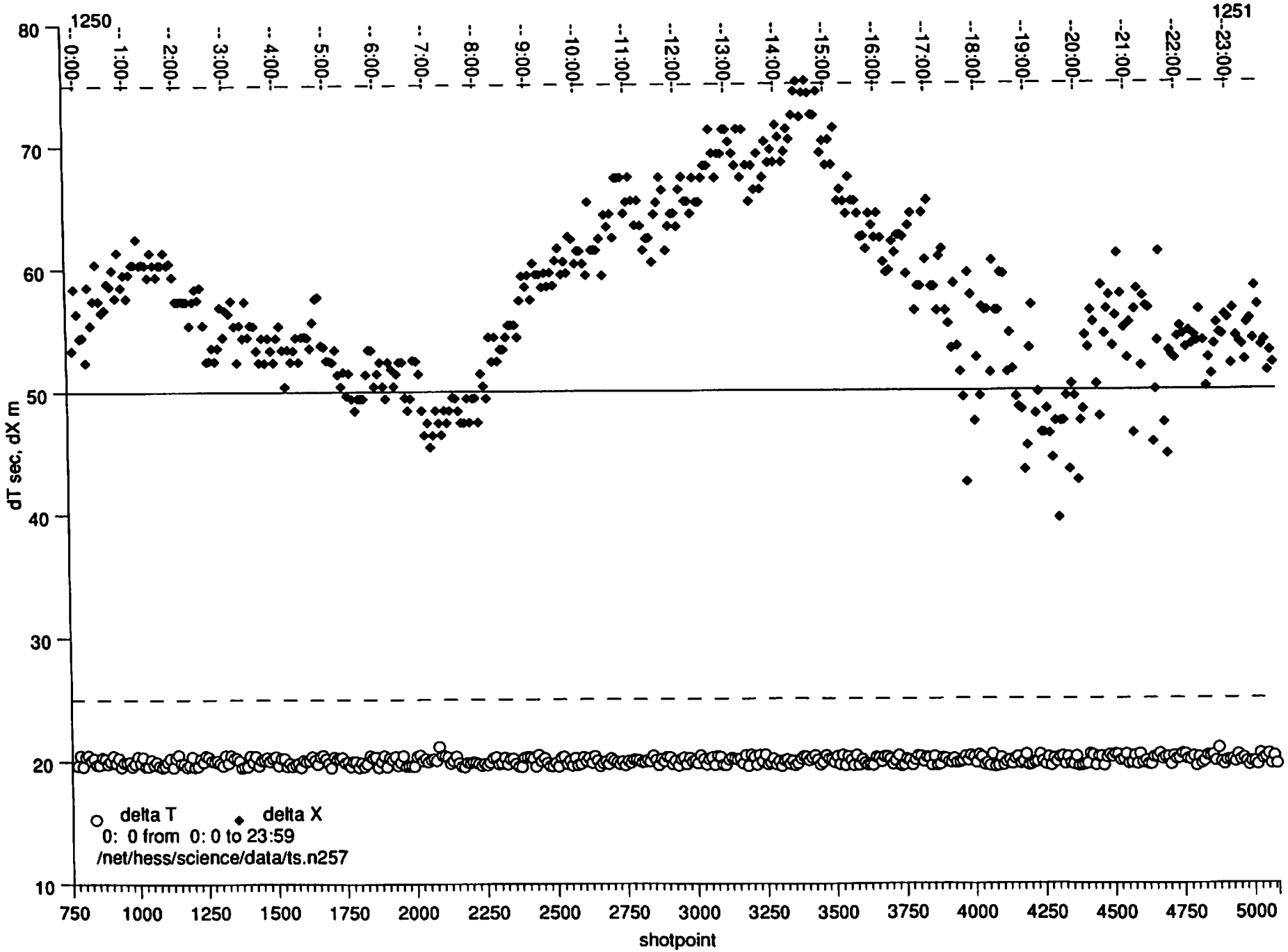

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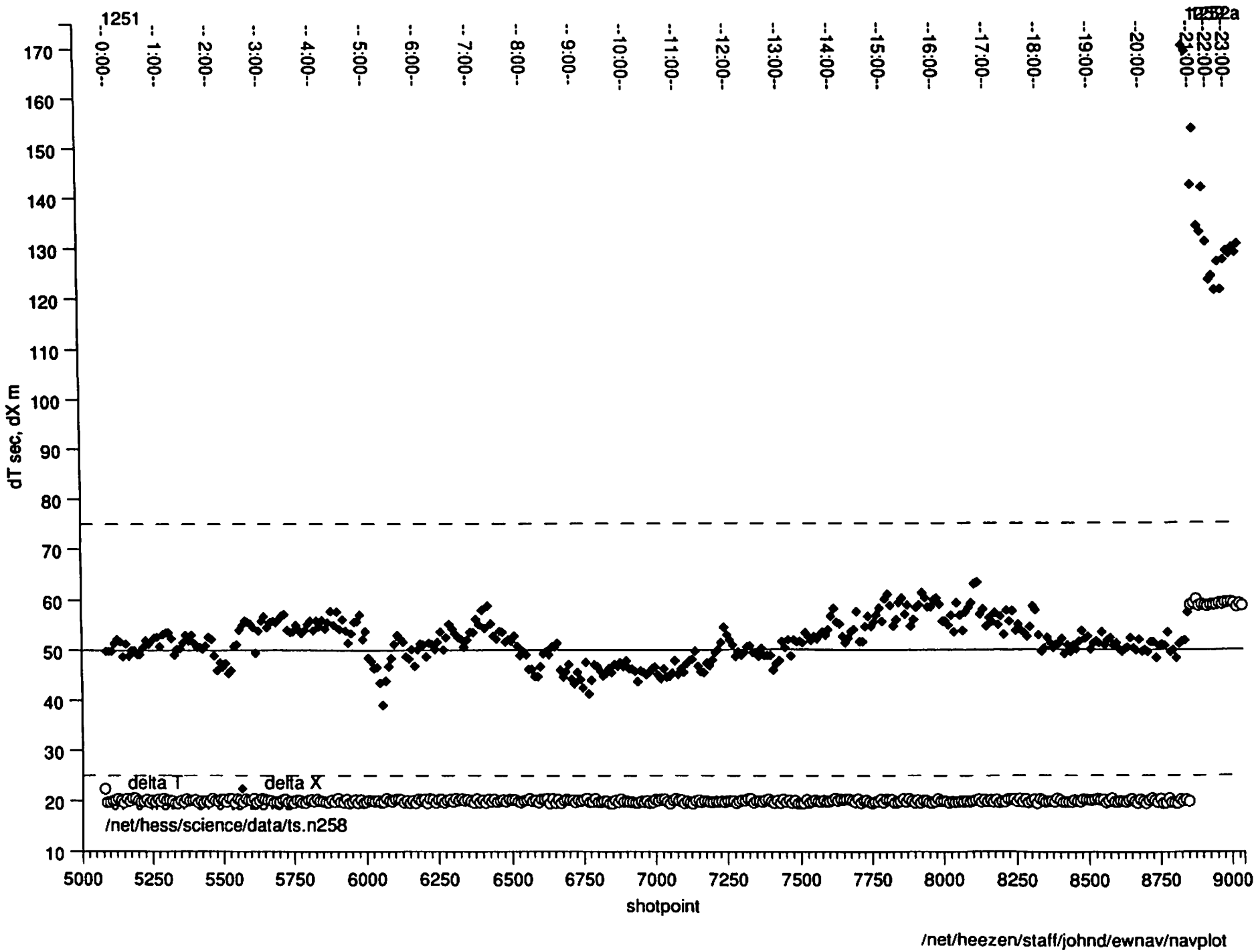
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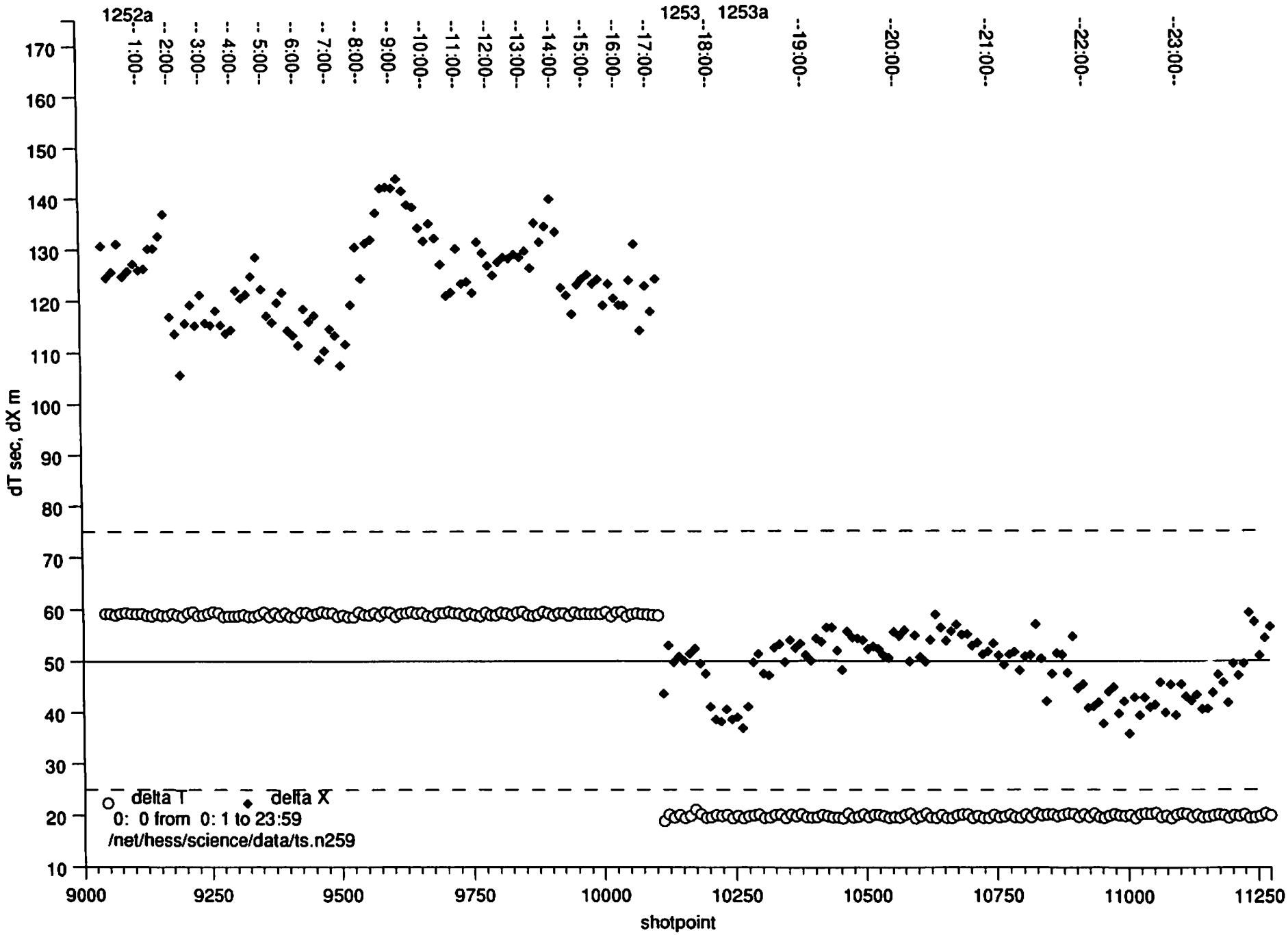
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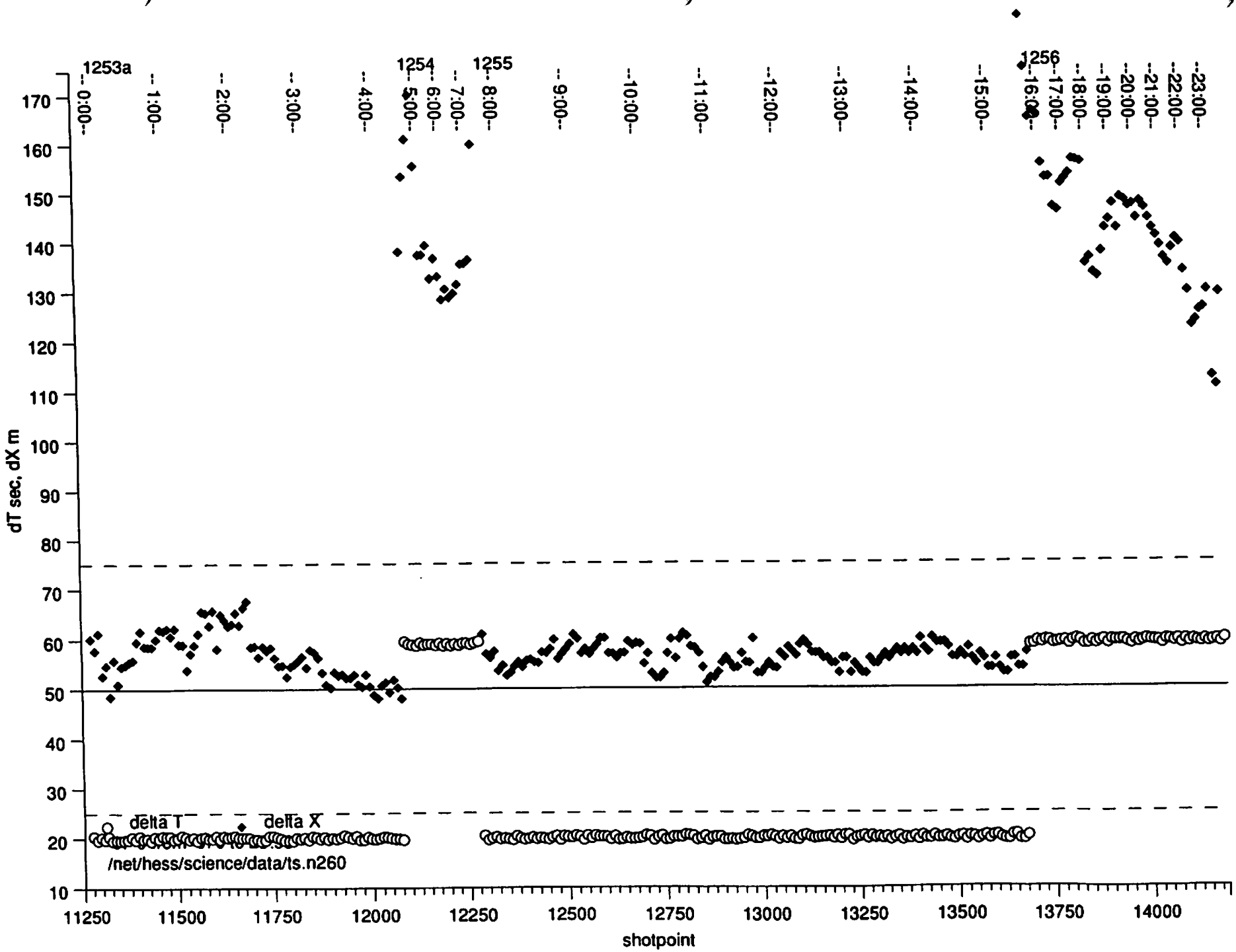
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dT sec, dX m
delta T
delta X
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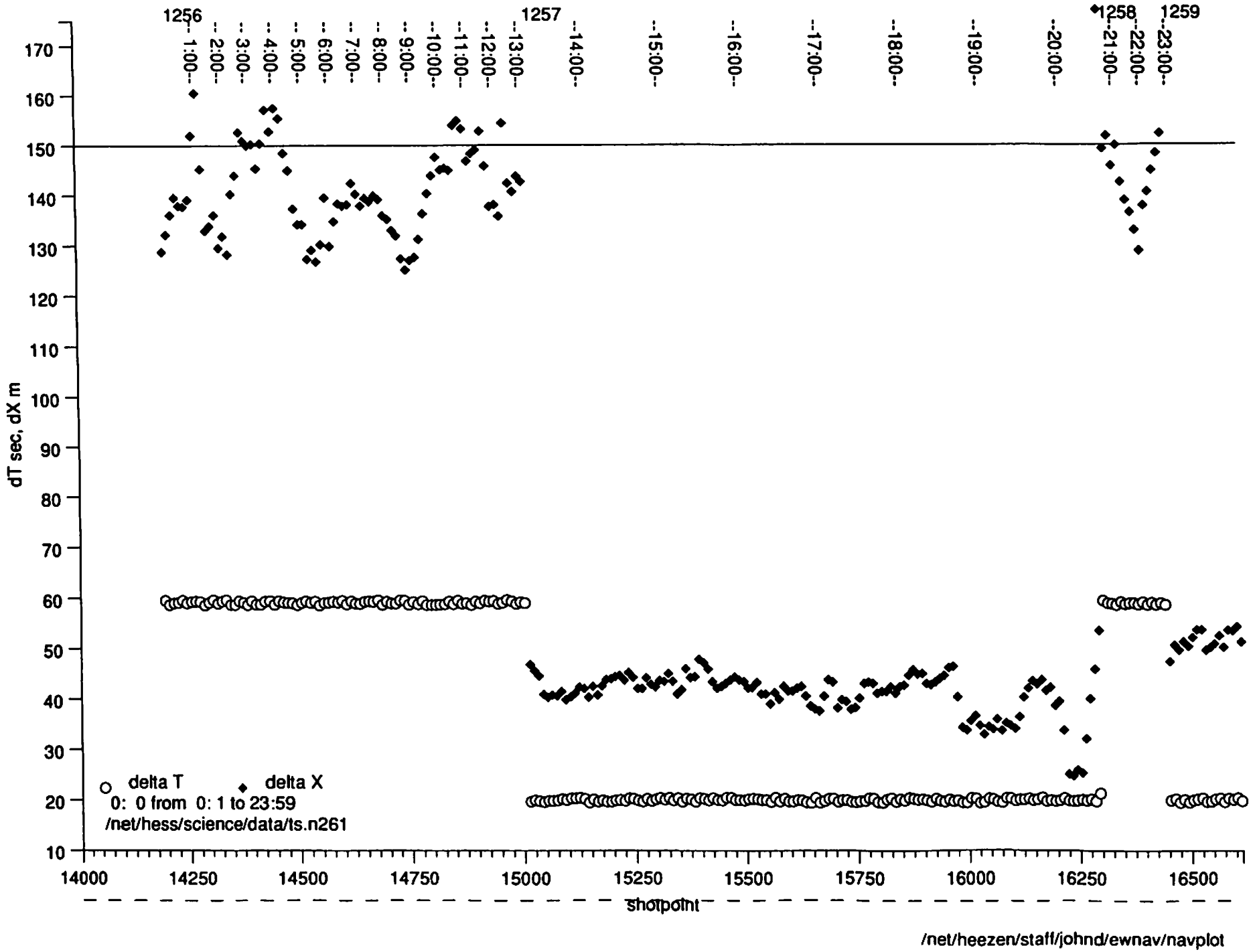
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dT sec, dX m
delta T
delta X
0: 0 from 0: 1 to 23:59
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shotpoint
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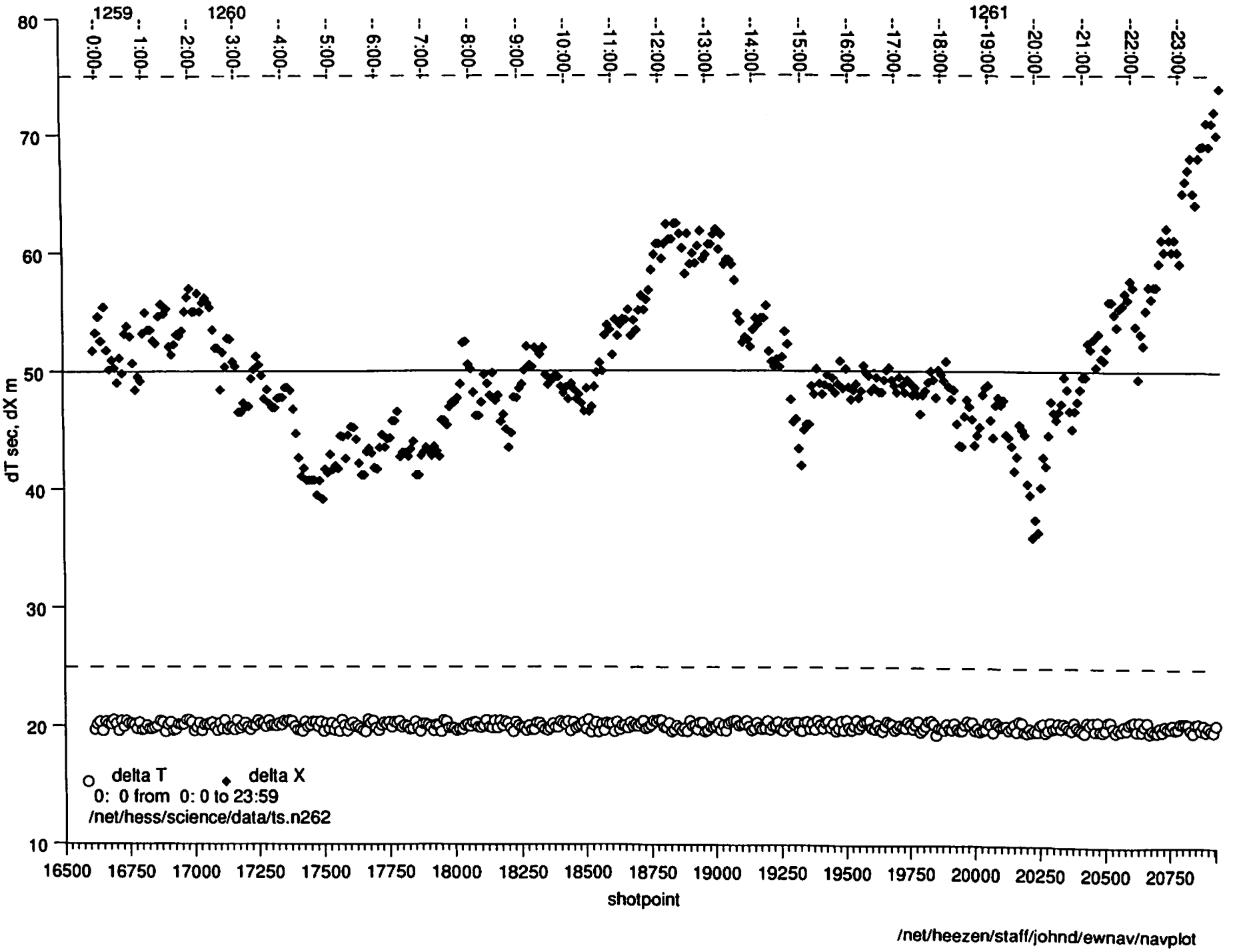
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70
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10
dT sec, dX m
delta T
delta X
0: 0 from 0: 0 to 23:59
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shotpoint
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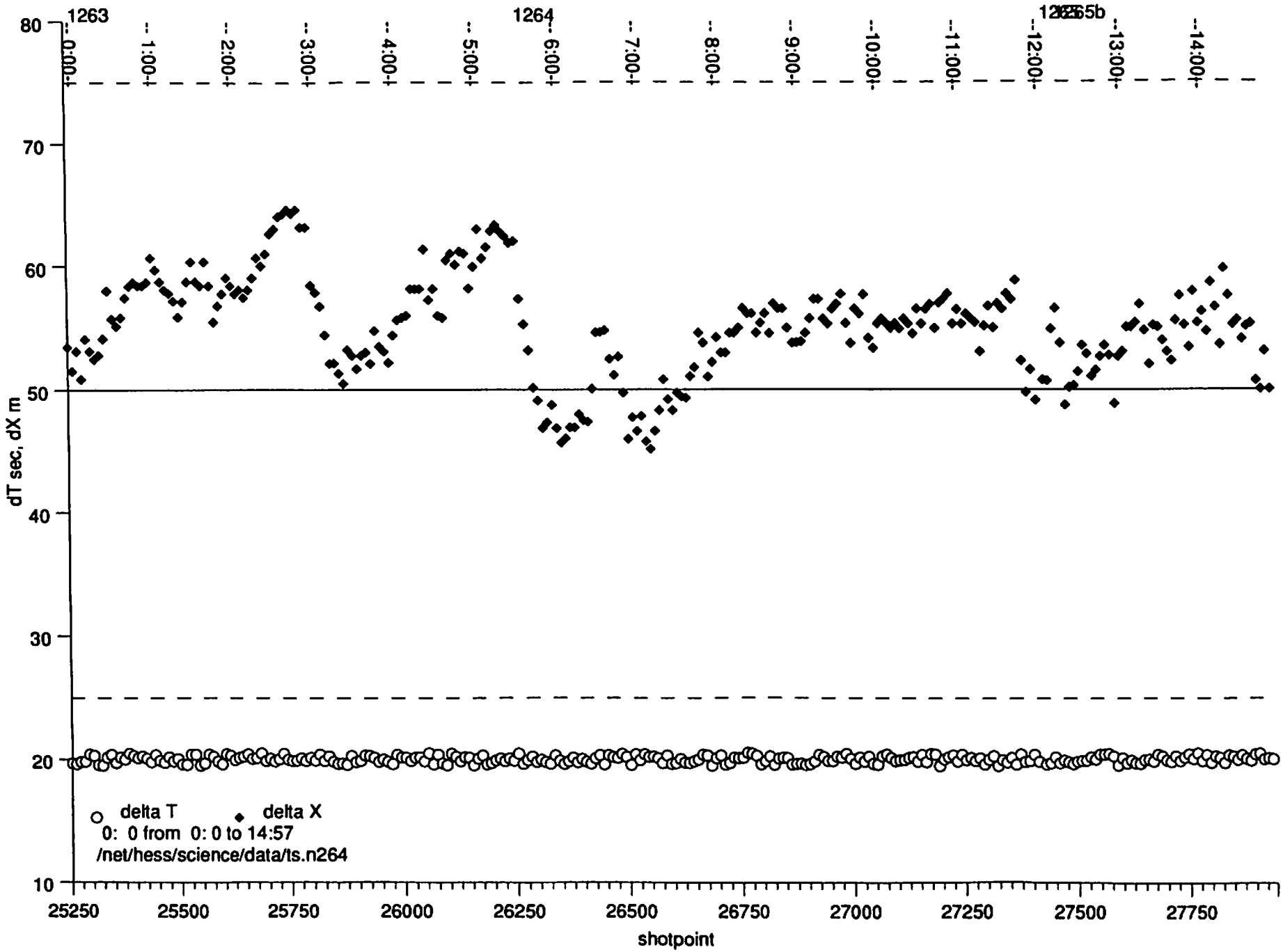
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1264
1265b
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50
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30
20
10
dT sec, dX m
delta T
delta X
0: 0 from 0: 0 to 14:57
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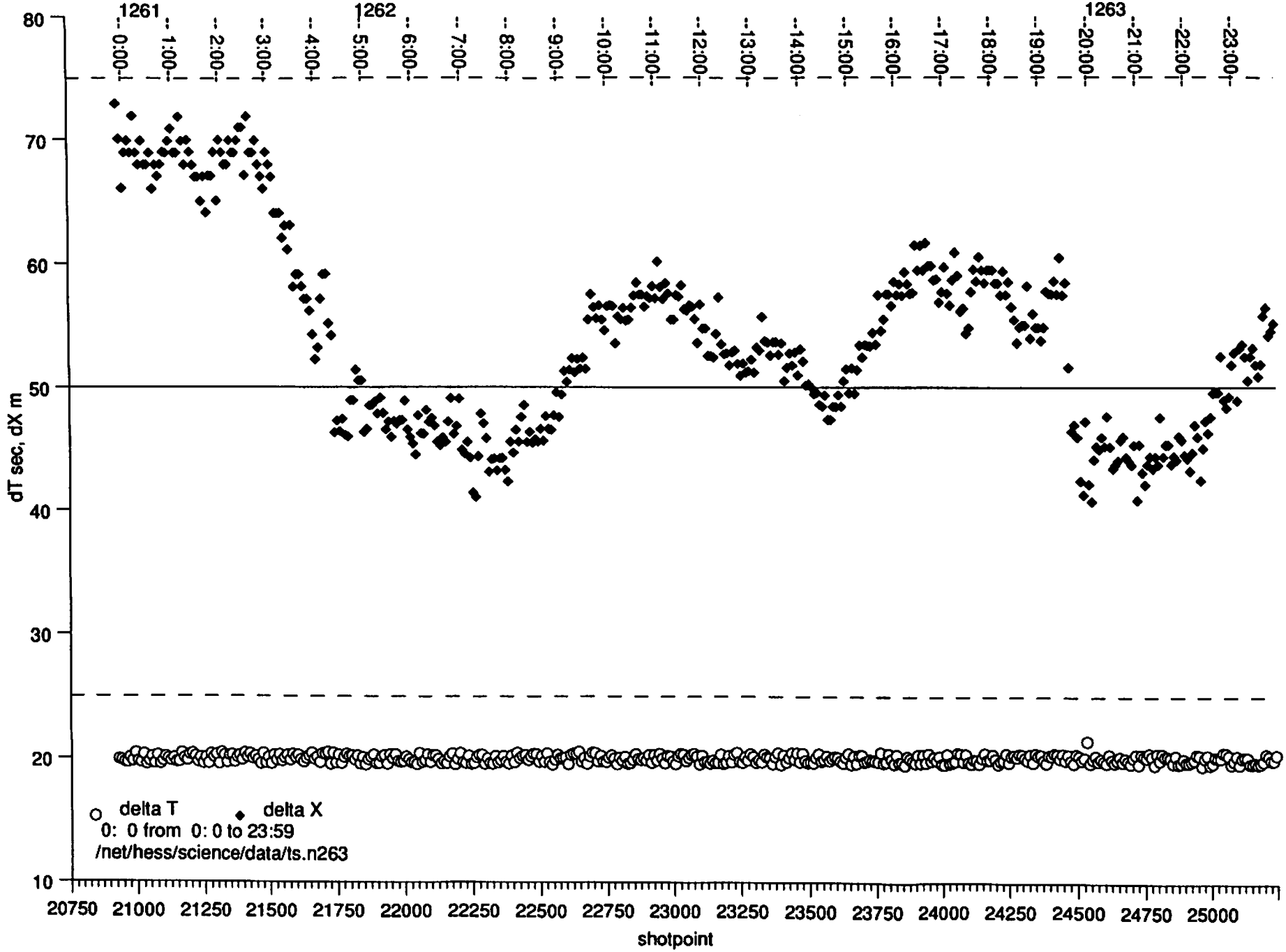

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