JCC

TRB Meeting 18 March 1997
Baffle Shedding Investigations

- Agenda
  - ›› Investigation of glass shedding
    - – Temperature cycle stimulation
    - – Repair investigations
  - ››Oxidized shiny steel (backup) development
  - ››Projected performance
  - ›› Status as of today
  - ››Present schedule assessment

Particle Shedding from Baffles

Location	Type	Glaze T_1+T_2 .001 in		Time days	Size μm	Number	LIGO Rate count/hr
		Cone	Teeth				
#18 (MIT shake)	Serrated	18	31	3	> 100	500	160
#19 (MIT shake)	Serrated	14	17	2	> 100	18	9
CIT mockup #1	Serrated	17	27	16	> 100	360	22
WA BT #1	Serrated			21	> 500	500	70
WA BT #2	Serrated			21	> 500	60	9
WA BT #3	Serrated			16	> 500	40	7
WA BT #4	Serrated			16	> 500	20	4
WA BT #5	Non-serrated			20	> 500	2-5	.2-.6
CIT mockup #2	Non-serrated	4-8		4	> 100	21	5
						Maximum allowable:	1

LIGO-G970012-00-P

Thermal Cycling of Baffles

›› Used NTS facilities in Saugus, CA

››Ran 2 tests, 12 cycles/test, 2 hr/cycle @ {-30C - +50C} -- planning one more when additional baffles are available

››Investigated only effect of exposed serrations (taped all hinges; planned to need to clean all hinges)

››Investigated shedding from side of cone facing near mirror (0.5X scaling to full baffle)

››Established baseline comparison between ambient environment (CIT) and cycling environment: tested one baffle for 5 days in mock-up and 1 day in NTS

- Used ratio of amounts of material shed to scale cycling environment

››Established background levels at NTS (needs improvement)

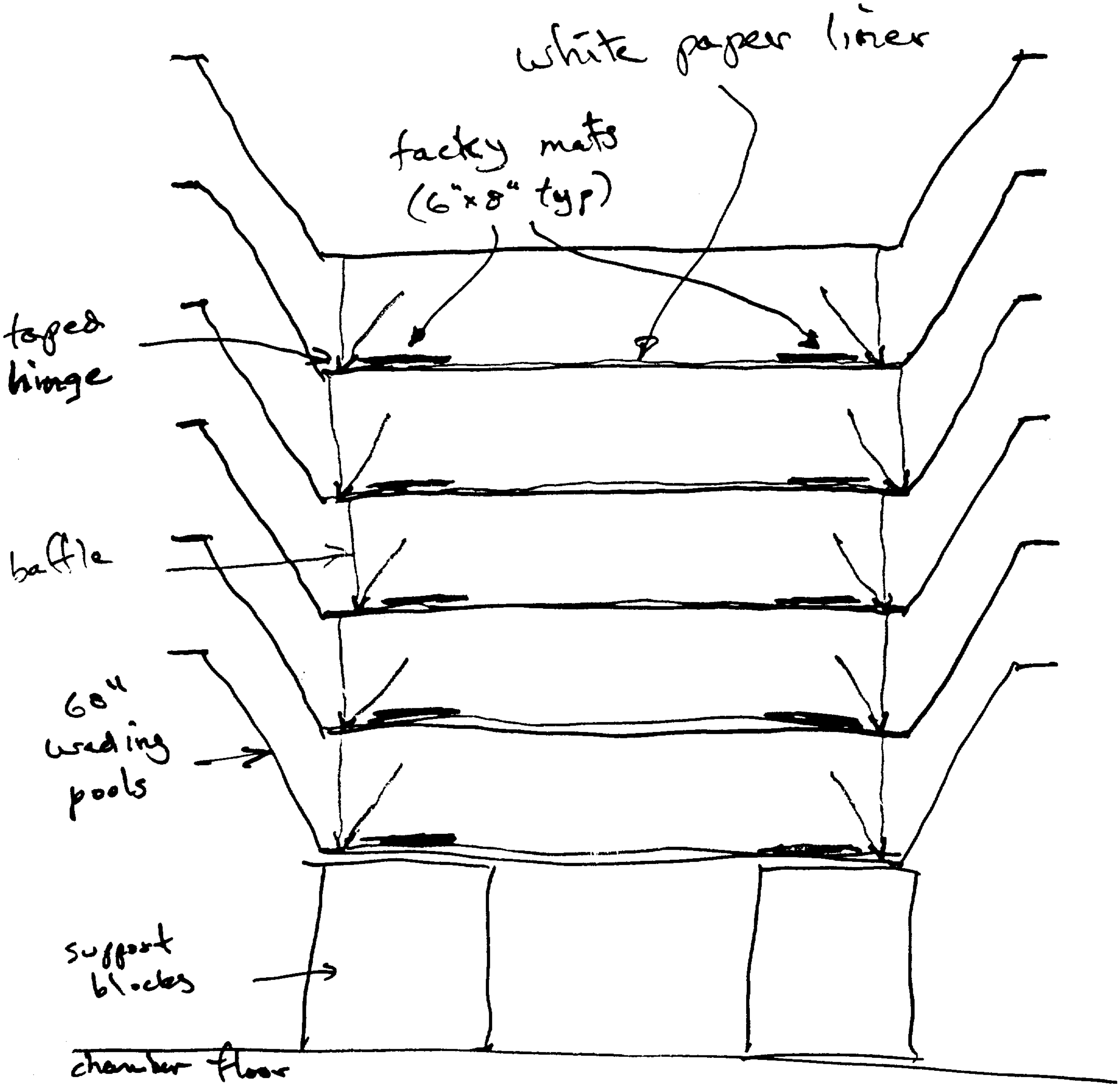
››Tested:

- 2 ea. serrated baffles - bad shedders
- 2 ea. nonserrated baffles - first look
- 4 ea. newly made thin-glaze baffles (.002" - .004" thickness)
  - **2 ea. with hinge uncoated;**
  - **2 ea. with hinge taped over** — Test 1

- 2 ea. O_2 flame-treated baffles (dubious test) — Test 2
- 5 ea. nonserrated baffles (obtain better statistics)
- repeated a test of worst serrated baffle to see effect of repeated thermal cycling (24 vs. 12 cycles)

››Setup: see sketch

NTS Test setup -
Section view



NTS Testing Results

- Cycling discriminates between heavily and weakly shedding baffles
- Repeated cycling reduces shedding (~~1~~ 3 examples)
- NONE of the baffles tested passed originally agreed upon limits

  >>The smaller the scale one inspects on, the more particles that are found - used OTF microscope to scan 0.2 cm^2 patch where nothing was seen @ 2x magnification - detected particles smaller than 5 microns - particle count continues to grow at smaller scales.

- NONE of baffles presently in BT are judged acceptable - they should be removed
- Thin glazed baffles perform much better - comparable to type NS
- Background test gave positive results

  >>energetic shedding by nearby baffles (?)

  >>control baffle itself shed (?) -- 100% surface cover w/ tacky mat

  >>if we are going to pursue glazed baffles further, need to improve setup.

Parallel Investigations - Fixes and Rework Considered & Explored

- Centerless grinding to thin coating

  ›› Met with Intercity Centerless Grinding - specializes in tubular (to 4") steel and glass materials

  ›› Our geometry (cone) and nature of material (sheet metal) make too expensive to pursue

  - Need to invent a machine/jig
  - Need high precision grinding (i.e., remove a few .001" of material from both sides) of a deformed conical sheet.

- HF acid etch to thin coating

  ›› Sibley approached 7 different users of HF to etch/clean parts - aerospace & glass industries

  ›› 0/7 responses of interest:

  - Not economically interesting
  - Environmental impact -- permit requirements

- O_2 (bushy) flame treatment

  ›› Working with Glass Instruments, Inc in Pasadena

  ›› Treated 2 baffles -- poor quality/wrong side

  ›› Still, showed some promise

  ›› Awaiting for GII to fabricate jig and to properly treat 5 additional baffles (type S)

  ›› Bottleneck in schedule - cannot impart sense of urgency to proprietor ("intellectually interesting problem")

Parallel Investigations - Fixes and Rework Considered & Explored

- Grit blast to thin
  - ››mechanically rough on product
  - ››controls expensive
  - ››need to retreat surface with refiring to restore finish/anneal/fuse grit in steel
  - ››not pursued
- Recapture existing baffle inventory
  - ››Need to remove glaze by grit blasting
  - ››Standard method is too rough - product loss due to bending, deformation
  - ››Need to "precision" grit blast
  - ››Surface is very rough - backscatter worse than BT wall
  - ››Need to either polish (?) ... or ...
  - ››Re-coat -- with what ?
  - ››not pursued
- New baffles with thinner coating (?)
  - ››Process control/uniformity is difficult
  - ››Thinner coating baffles still shed

Projected Performance of Reworked Products

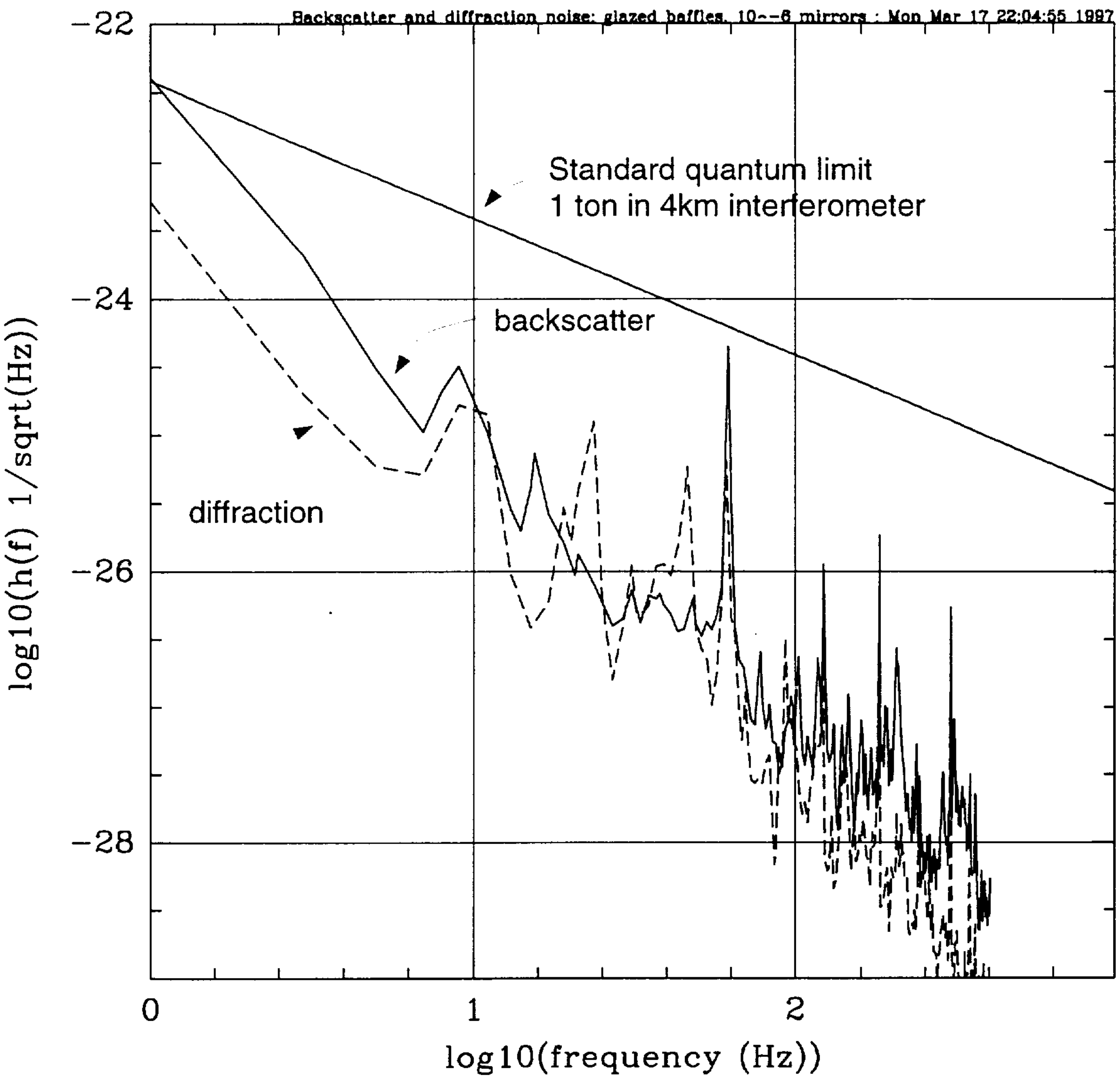
- R. Weiss took our shedding particle count data, normalized to account for NTS environment, and projected counts in LIGO BT per previous presentation at TRB of 16 January 1997
- Reanalysis of phase noise estimate for oxidized 304SS baffles
  - Used measured BRDF, reflectivity of baffle coupons
  - Used BT wall motion measured at Hanford
  - Used Pathfinder surface roughness data
    - GO optic - (best surface
    - still uncoated

Table 2: Environmental Chamber Measurements: temperature 44C to -16C

Description	exposure	glaze thickness 2*t	number of particles on paper	number of particles on mat	rate in LIGO beam
		mils			number/hr
#52 s	5 days	18(32)	800 *		160
#52 s	12 cycles	18(32)		202 *	160
#52 s	2nd 12 cycl	18(32)	362	32 *	25
#54 s	12 cycles	21(29)		150 *	118
#57 ns	12 cycles	17		53 *	42
#57 ns	2nd 12 cycl	17	205	42 *	33
#58 ns	12 cycles	10	42 *	70	3
#58 ns	2nd 12 cycl	10	29 *	15	2
#64 s	12 cycles	4 (4)	64 *	20	5
#73 s	12 cycles	?	80 *	15	6
#73 s	2nd 12 cycl	?	12 *	40	0.8 Bkgnd.
#65 s	12 cycles	6 (6)	118 *	17	8
#76 s	12 cycles	7 (7)	119 *	93	8
#75 ns	12 cycles	12	195 *	28	13
#61 ns	12 cycles	10	41 *	78	3
#82 ns	12 cycles	12	28 *	40	2
#83 s ox	12 cycles	19(25)	246 *	74	19
#69 s ox	12 cycles	20(28)	392 *	112	30

* indicates the basis for the extrapolation to LIGO rates
particle size is assumed larger than 100 microns
mat measurements are the average for two mats

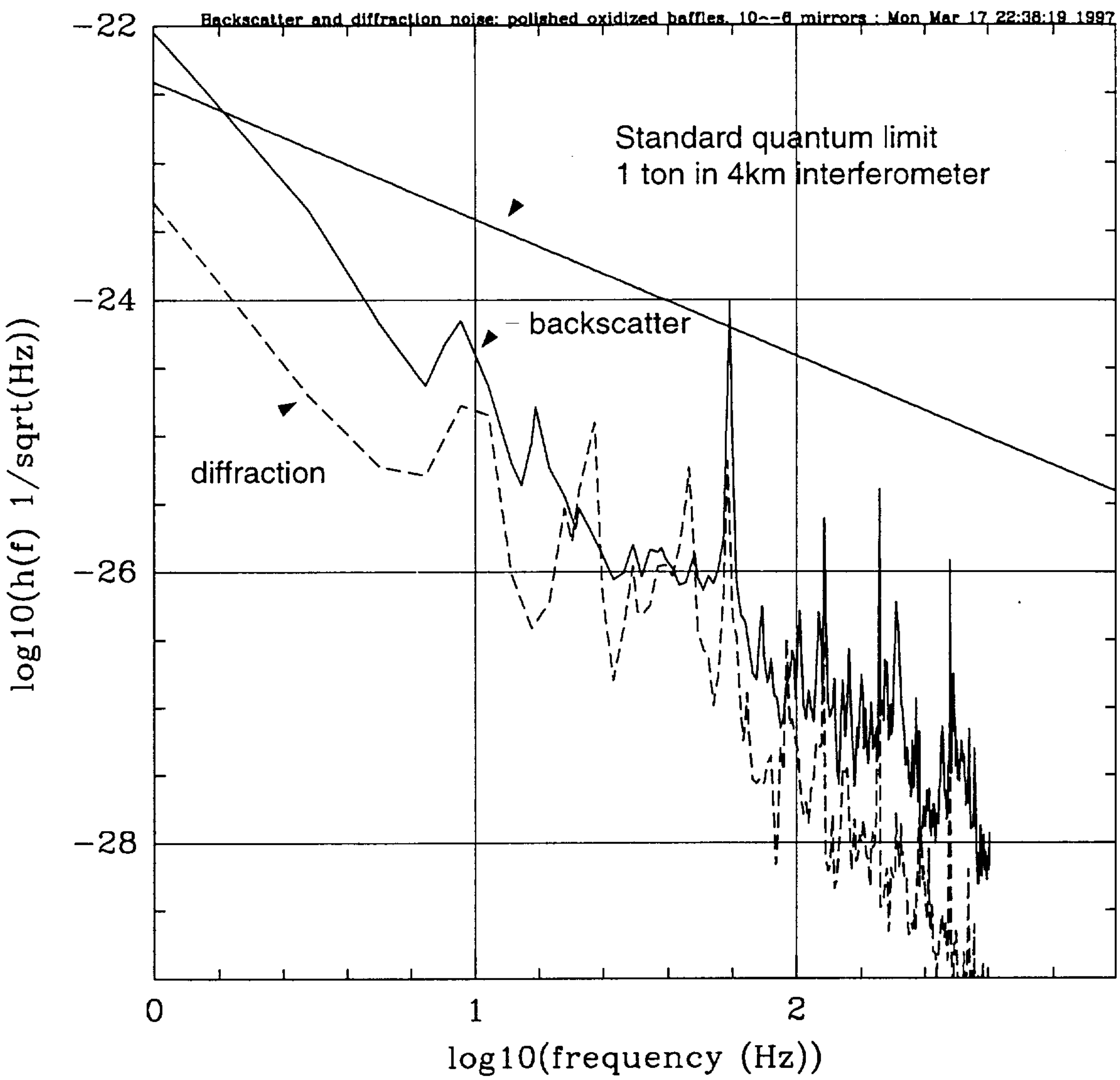
The extrapolation to LIGO rates is based on baffle #52 which was measured both in the environmental chamber and for 5 days at room temperature. The extrapolation is done the same way as in **Table 1** assuming a linear distribution.



Baffle backscatter BRDF = 1 x 10^{-3} sr^{-1} Glaze baffles

Mirror scattering $\text{BRDF} = \dfrac{1\times10^{-6}}{\theta^2}$ Initial mirrors

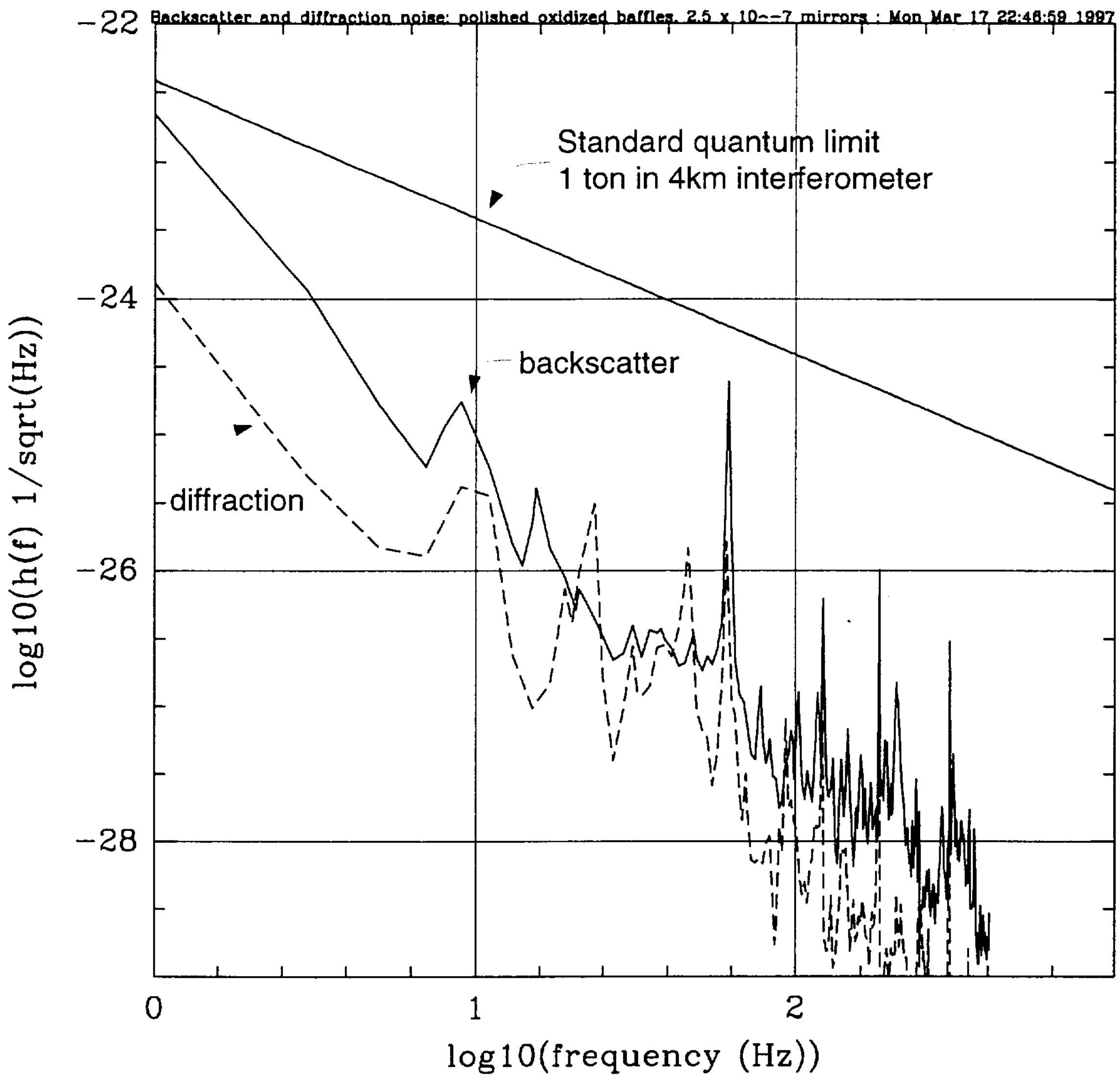
Longitudinal spectrum 1/30/97 used for backscatter modulation
Horizontal spectrum 1/30/97 used for diffraction modulation



Baffle backscatter BRDF = 4.8 x 10^{-3} sr^{-1} Polished oxidized baffles

Mirror scattering $\text{BRDF} = \frac{1\times10^{-6}}{\theta^2}$ Initial mirrors

Longitudinal spectrum 1/30/97 used for backscatter modulation
Horizontal spectrum 1/30/97 used for diffraction modulation



Baffle backscatter BRDF = 4.8 x 10^{-3} sr^{-1} Polished oxidized baffles

Mirror scattering $BRDF = \dfrac{2.5\times10^{-7}}{\theta^2}$ Super polished GO mirrors

Longitudinal spectrum 1/30/97 used for backscatter modulation
Horizontal spectrum 1/30/97 used for diffraction modulation

Alternative Materials Optical Performance

Material	Oxide	BRDF @1μm, 55° 1000•sr^{-1}	R	R^2•$BRDF_{wall}$ 1000•sr^{-1} $BRDF_{wall} = 60 \cdot 10^{-3}$ @ 20°	Sum 1000•sr^{-1}	Effect on Strain Sensitivity
Glass	–	1-3	< .13	< 1	1-3	1
#2B	none	1-3	.5-.55	15-18	16-21	3
#2B	450°C, 4hr	1-4	.4-.45	10-12	11-16	2.5
#2B	450°C, 8hr	4	.35-.45	7-12	11-16	2.5
#2B	450°C, 40hr	13	.22-.4	3-10	16-23	3
Grit-blasted SS	glass firing process	60	diffuse	–	60	6
BT wall mat'l		30	diffuse	–	30	4
• Current BA material	850°C, 10 min.	4	0.1	< 1	4	1.4

Status of Backup Oxidized 304SS (shiny) Baffles

- Jan - Mar

  >>Procured BA 304SS material for 50 baffles

  >>Unexpected delays in reproducing oxidation recipe derived by Weiss in 1995

  - Original recipe: 8 hr @ 450C
  - Determined a need to fire *second* time for 2 passes in WCP tunnel oven @ 850C
  - Baffles delivered by Capitol Ind. from bake (Wash. Metallurgical) were too dirty to use without another cleaning.
  - H_2 outgassing measured to be at instrument noise floor (LIGO/VTF)

  >>"Ruined" first 20 baffles - cleaned using WCP (NaOH + grime) dip

  >>Finally obtained 27 baffles with visual/optically acceptable appearance

  >>Dual steam cleaning in WA

  >>These had high Auger C peaks - 1/2 as dirty as BT w/ oil

  >>Decided in the end to install:

  - Few baffles
  - Wanted data point on installation difficulties
  - The treatment @ 850C after a 450C/8hr bake made us comfortable that any C on material IS NOT HC --> elemental C on steel surface

Status of Backup Oxidized 304SS (shiny) Baffles

- Jan - Mar (continued)
  - >>This proved to be a VERY EXPENSIVE sequence:
    - 2 steam cleanings in WA
    - 2 bakes (WA 450C/8Hr; CA 850C/10min)
    - 2 shipments (WA->CA->WA)
  - >>Procured enough 304SS BA material to make 1100 new baffles
    - cost of matl: $2/lb@20lb/baffles X 1000 baffles = $40k
    - matl hard to find -- "insurance"
- Today
  - >>Seeking to streamline process
    - Fab @ Capitol (Seattle)
    - Ship to local (southern Cal.) steam cleaner - get better turn-around on unforeseen developments
    - Bake once @ WCP
    - Ship to Hanford
  - >>Had 100 1" x 18" strips of new BA matl cut @ CES for tests
    - Immediate shipment of 3 to Weiss - Auger/small scale bake/ optical tests

      Raw matl is quite clean - after proper cleaning expect excellent cleanliness

      10 min bake @ 850C gives acceptable "blued" matl
    - Planning to fire 50 @ WCP this week to get statistics and for H_2 outgassing evaluation in LIGO VTF
    - Will have Capitol start immediately making 100 baffles (originally for X arm and 1st installment on Y arm)

Status of Backup Oxidized 304SS (shiny) Baffles

- Today (continued)
  - Last Friday tried to install 27 baffles on X arm
    - 16 hours of work resulted in only 7 being installed
    - Lessons learned

Field Experience in Installing Baffles Deeply into a Beam Tube Module

- Transportation Issues:

  ›› A wheeled cart is important: back & leg cramps experienced from walking stooped

  ›› The position of the baffle being carried by the cart dictates the amount that the baffle will have to be "wound up"; a baffle too tightly wound is difficult to unwind for installation and may cause damage to the stitch welds

  ›› The cart wheel size, wheel material, and travel speed need to be carefully selected to minimize jolts over expansion joints and to:

  - minimize contamination from wheel breakup and leaving abraded material
  - minimize the potential for bronze particle contamination found in expansion joint grooves (currently not understood; may be from the cart travel)

- Protective Clothing Issues:

  ›› Propelling the cart with feet leaves abraded contaminants from booties (or shoes, if booties are deleted); these should be checked for removal requirements

  ›› Care must be taken to prevent abraded clothing/bleeding due to cart falls

Field Experience in Installing Baffles Deeply into a Beam Tube Module

- Cleaning Issues:

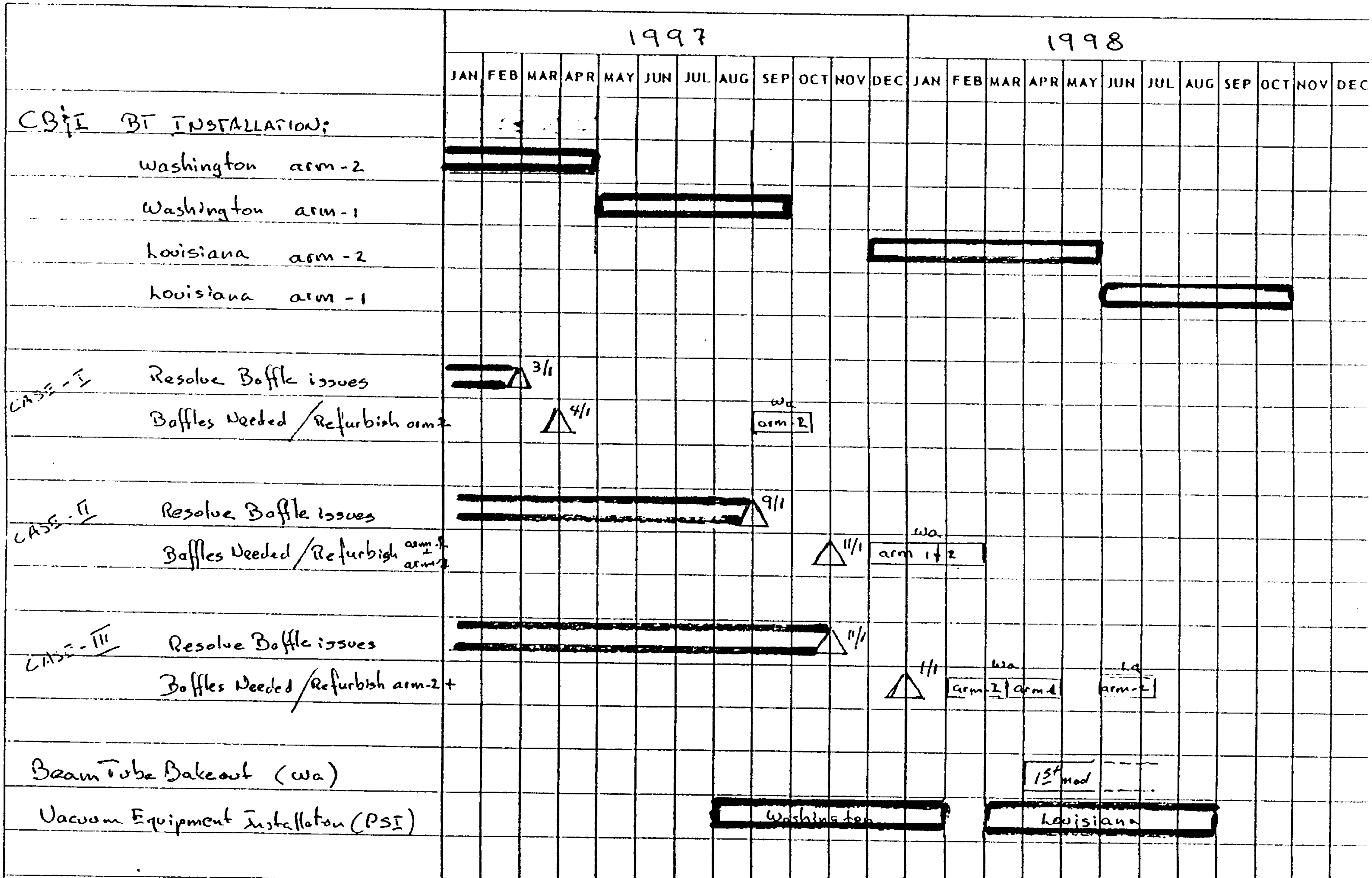
  ›› We may need to secure/develop a battery powered "DustBuster" (with a HEPA filter on its exhaust?) for final cleaning in the tube. Current plans to use a (water) wetted cloth for particle pickup do not fully address known problems:

  – abraded material may be too small to see and pickup

  – water is not appropriate for use nearer the ends of the modules, where BDF air will not have as much time to effect microdrying; alcohol may not be a good substitute, depending upon concentration vs. air flow volume

COST ESTIMATE

- AVERAGE COST OF PRESENT BAFFLES
  ~$100K/MODULE - $800K TOTAL
- ESTIMATED COST OF BAFFLE FIX (PER MOD)
  $12.5K (MIN) $100K (MAX)
- COST OF INSTALLING BAFFLES (CREW OF 4 FOR 6 WKS PLUS SOME EQUIPMENT
  $60K/MODULE
- CASE-I DELTA COST $920K - $220K
- CASE-II DELTA COST $1040K - $340K
- CASE-III DELTA COST $1160K - $460K



PREPARED BY: DATE:

APPROVED BY: DATE:

List of Exhibits

- Oxidized 304SS samples
  - coppertone strip (1" x 18"); 8 hours @ 450C
  - blued strip (1" x 6"); same as above plus 2X in WCP tunnel @ 850C (estimated time @ max. temp. 12 minutes)
  - tag # 60; WCP process only: NaOH dip + dip rinse, 2X @ 850C
  - blued plate (6" x 8") L1; home wash + 1X @ 850C, WCP
  - blued plate (6" x 8") l2; home wash + 3X @ 850C, WCP
  - bright strip (1" x 18") - raw material - latest batch
- Glass flake samples

#52	2/18/97	5 day baseline	Serrated, extreme shedder
	2/20/97	1^{st} temp cycle	
	2/25/97	2^{nd} temp cycle	
#54	2/20/97	1^{st} temp cycle	Serrated, nominal shedder
#58	2/20/97	1^{st} temp cycle	type NS, best example
	2/25/97	2^{nd} temp cycle	
#73	2/20/97	1^{st} temp cycle	Serrated, thin glaze
#69	2/25/97	2^{nd} temp cycle	O_2 rich flame treatment
#83	2/25/97	2^{nd} temp cycle	O_2 rich flame treatment