Science & Integration Meeting

Agenda

- Detector & R&D
  - ›› NPRO stabilization results — Mason/Savage
  - ›› Interferometer acquisition modeling results — Sievers
  - ›› FMI wavefront sensing results — Mavalvala/Sigg
  - ›› PNI status & plans — Fritschel
  - ›› 40m recycling status — Logan/Spero
  - ›› Core Optics Status: REO coating performance analysis — Jungwirth
  - → ›› FFT modeling (20 min) — Kells
  - ›› DAQ prototype plan for 40m — Bork/Barker

COC performance from FFT viewpoint

- Extensive FFT model runs since Spring '96

  ››Paragon parallel computer (Bochner, Phung);32 nodes;~40 times Sparc 20 speed.

  ››Over 8000 node hours, severl hundred runs (the bulk for consitancy, diagnostics so far).

  ››Full splitter algorithm: 2 sided; 45^o beams; thickness and distortions.

  ››Self consistant, bi-directional transmissive optics:

  $L_r , R_r = L_l , R_l$

- Current program and goals

  ››Support LIGO design and procurement specifics

  ››Make code usage and result data base more accessable

  ››Investigate properties of Recycling Cavity: degeneracy

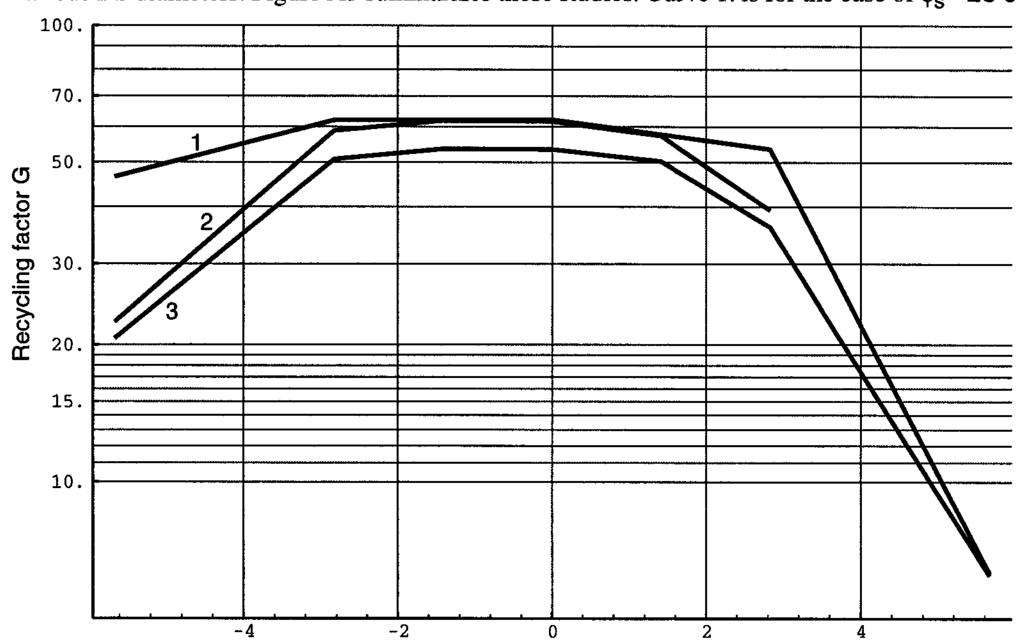
  ››

  ››

Confirmation of COC Sizes

››code results agree well with “gemetrical clipping”

- As a follow up to these geometrical studies of loss, FFT code modeling was performed to study the effect of beam splitter clipping for various BS diameters. Figure A3 summarizes those studies. Curve 1. is for the case of ϕ_S =28 cm, d_S= 5 cm, with



Calflat mirror surface maps and 50 ppm base loss per mirror surface. Curve 2 and 3 are for ϕ_S =25 cm, d_S= 4 cm. Curve 2 employs the same mirrors as Curve 1.

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Develop "Benchmark Run"

- Summary of state of COC knowledge: Spring '96:
  - ››polished surfaces only: 50 ppm "base loss"; λ/600 CalFlats
  - ››Updated to DSR, 10/96, 4000 m ifo

CORNING bulk tranmission maps

Property	*Requirement*
Recycling cavity optical length (physical length shorter due to substrate index)	9.38 m (4km) 11.67 m (2km)
Mode cleaner optical length	12.55 m (4km) 14.75 m (2km)
Schnupp optical length asymmetry (4 km)	$l_1 - l_2 = 31$ cm nominal; -1 to +50 cm range
GW readout modulation frequency (4 km)	24.0 MHz
GW readout modulation depth (4 km) at recycling cavity input	Γ=0.45 nominal; range TBD $0 < \Gamma < 1.0$

Property	*Requirement*	*Reference*
Optic Sizes	TM, RM: 25 cm dia., 10 cm thick	
	BS: 25 cm dia., 4 cm thick	
Coated surface	24 cm dia.	
Beam Sizes	ITM: 3.6343 cm w_0	
	ETM: 4.5655 w_0	
	BS: 3.6359 w_0	
	RM: 3.6377 w_0	

Property	*Requirement*	*Reference*
Radii of Curvature (tolerances to maintain strain sensitivity to 0.95 nominal)	ITM: 14571 m; $-0.07 < \Delta R_{ITM}/R_0 < 0.01$	
	ETM: 7400.0 m; $\Delta R/R_0$ of 0.03	
	BS: flat/flat, tolerance TBD	
	~~RM: 9998.33m; $0.01 < \Delta R_{RM}/R_0 < 0.05$~~	
Surface figure	equivalent to ' 1.5 × Calflat '	
Mirror transmissions	ITM: 0.030±0.00015	
	ETM: 10<T<20 ppm	
	BS: 0.50±0.01 TBD	
	RM: Overcoupled, 0.1 E field reflected	
AR Coatings:	ITM, RM: 600±300 ppm	
	BS, ETM: 200±100 ppm	
Mirror losses:	50 ppm scatter+absorption	
Substrate index	1.44963 (Heraeus)	
Substrate OPD for BS, ITM, RM	5×10^{-7} p-v, $\lambda = 632.8$ nm, cntr 150 mm 2.5×10^{-6} p-v, $\lambda = 632.8$ nm, cntr 225 mm	
Substrate absorption	<2 ppm/cm	
Substrate scatter	<5 ppm/cm	

FFT model computation result:

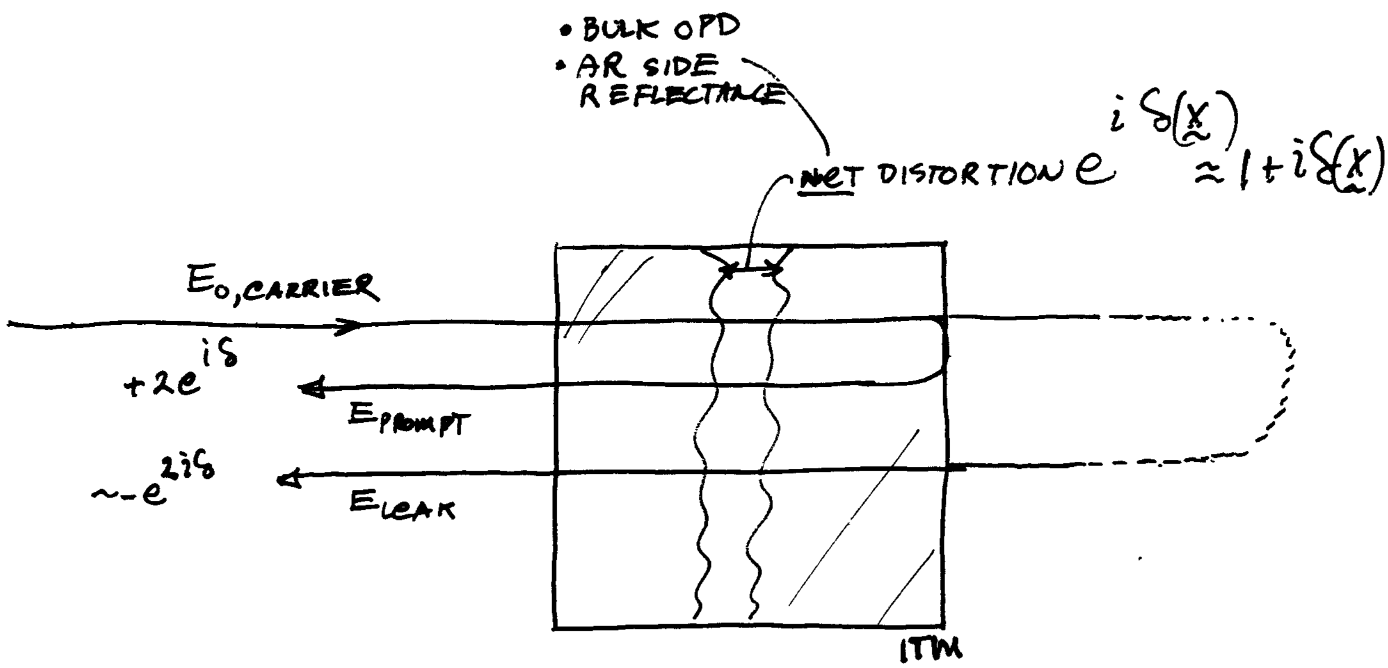
P_{arm}	$P_{DP,Cr}$	G_{00}	$L_{A,OPT}$	$P_{DP,SB}$	P_{RFL}	$h_{100\ Hz}$	R_{RM}
18250	.0794	51.1	15.1 cm	.499	.0541	$1.38\ 10^{-23}$	.97635

Tolerances

- Apodization of mirror map reflectivity (centered beams).
- Absolute and differential tolerances for mirror curvatures:
  - ››Criterion: worst combination of errors gives $\delta h/h_{100} < 5\%$
  - ››Summary: $-.07 < \Delta R/R_{ITM} < +.01$ $\quad -.01 < \Delta R/R_{RM} < +.05$ $\quad -.015 < \Delta R/R_{ETM} < +.015$

R.C. DISTORTION APPROXIMATION

- R.C. DISTORTIONS HARDLY EFFECT CARRIER
- THIN, SMALL PERTURBATION APPROX
- ~ OK FOR ITM BULK, r vs r_{AR} MAPS : BUT FOR B.S. ?



E_{PROMPT} : DOUBLE PASS

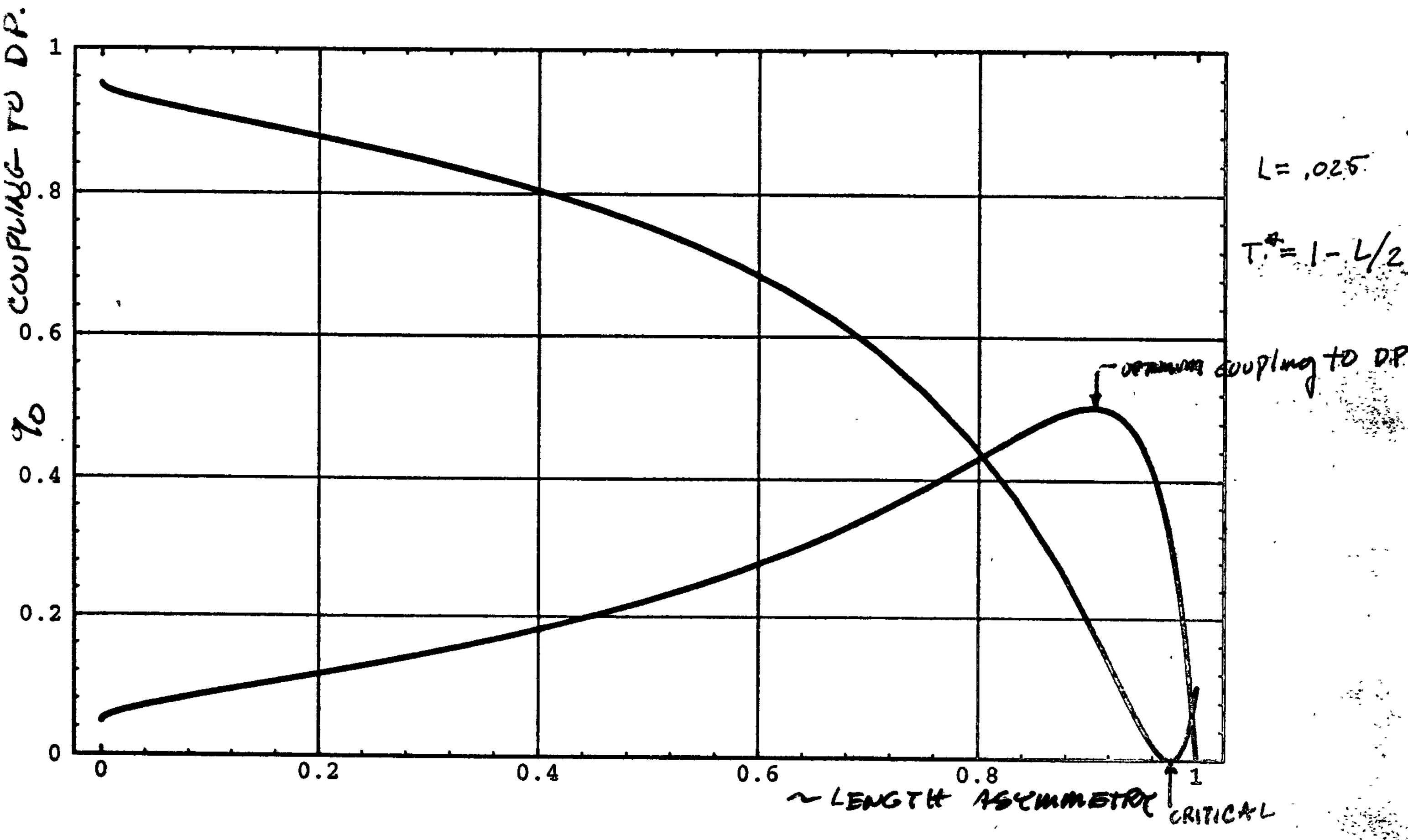
E_{LEAK} : (−) phase AND ~ 2x amplitude

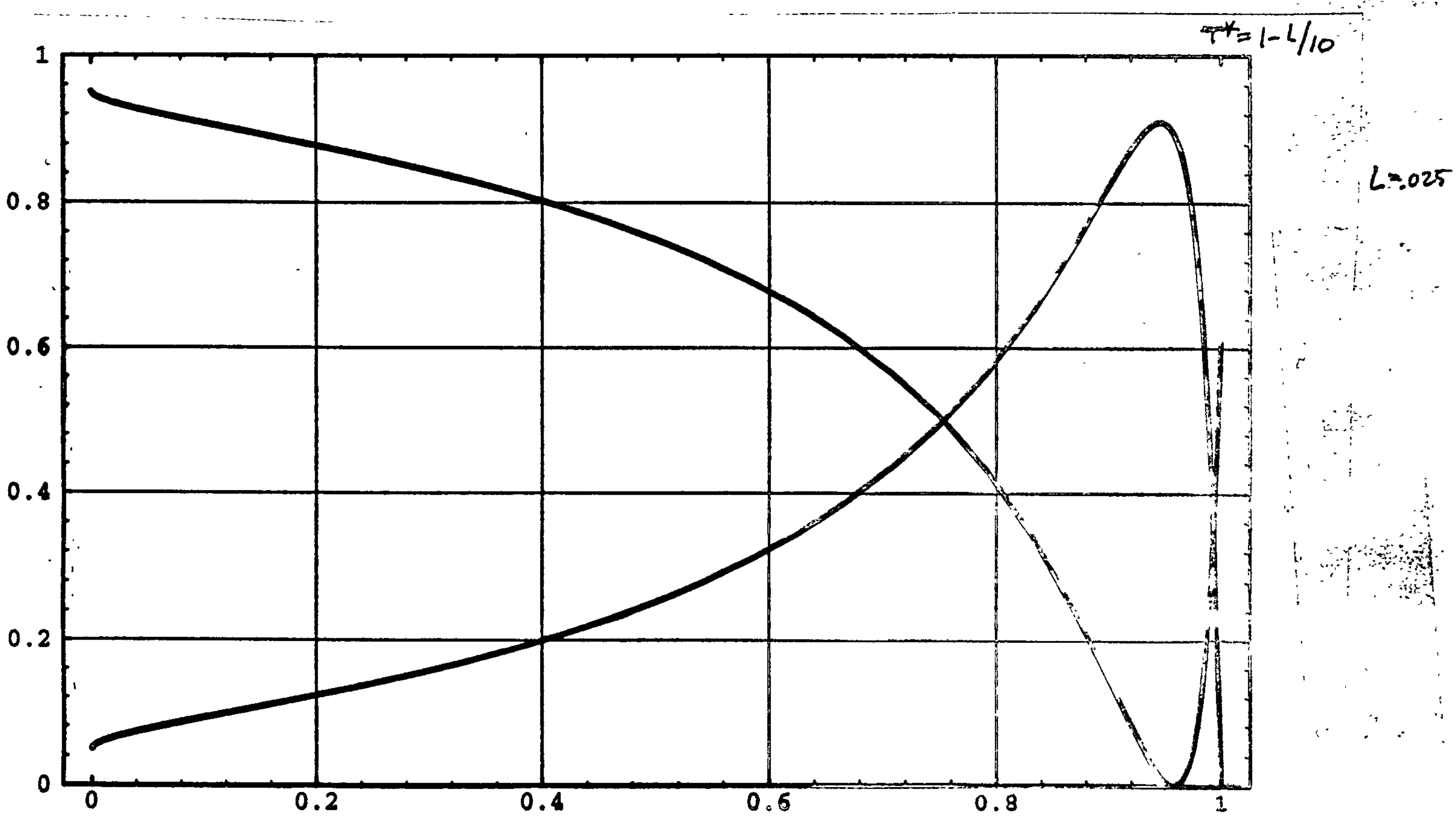
} → CANCEL

NOT SO FOR SB's

MODIFY NOTEBOOK → ~kells/OPTCAV/RCmod.ma

⇒ $r \neq T^*$ AND $T^* = 1 - \chi L$





Design Guidance Cases

- ››effect of coating uniformity: stack layering
- ››effect of thermal lens (ITM so far)

FFT model results normalized to one Watt input power

Feature	CARRIER			SIDE BANDS			h_{100Hz} x 10^{23}
	G	P_{RFL}	P_{DP}	Γ	P_{RFL}	P_A	
Benchmark	*51.1*	*.0098*	*.015*	*.46*	*.16*	*.79*	*1.38*
Splitter: .51 / .49	51.8	.0054	.02	.49	.20	.73	1.46
Arm Loss up 30 %	40.7	.0004	.012	.42	.16	.79	1.77
Arm Loss imbal of 60%	51.1	.0099	.015	.47	.16	.79	1.38
$\Delta T / T_{ITM} \sim 20\%$	50.7	.009	.016	.46	.16	.79	1.57
ITM Bulk Absorp. Thermal lens	50.8	.0093	.014	.54	.61	.37	1.69
coated (ITM)	55.0	-----	.014	.45	.18	.76	1.33
coated CalFlat (ITM)	49.8	-----	.024	.49	.23	.72	1.48
coated CalFlat (ITM) coated (ETM)	28.8	-----	.029	.51	.14	.82	1.91
coated CalFlat (Both)	27	-----	.032	.53	.131	.84	1.97