資電所 碩 1
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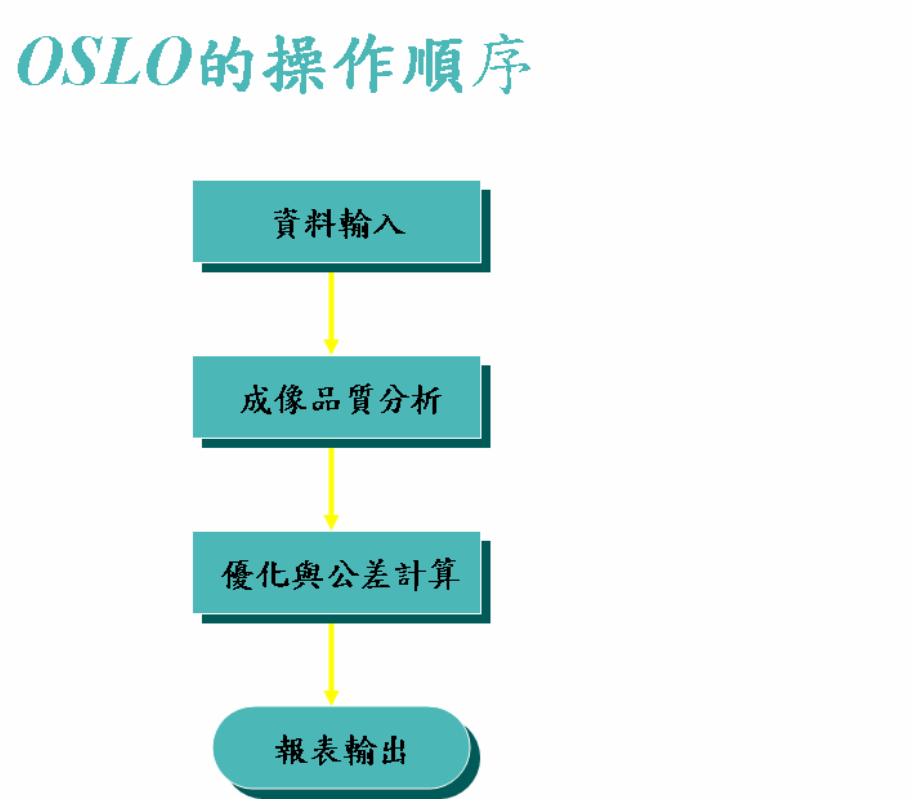
學生：柯榮傑
指導老師：賴雲龍 教授

期末作業

題目：請設計一個(3 片及 4 片構成)滿足下列條件的 A4-300dpi scanner 用鏡頭。

- ✧ 物像距爲 320mm　　物寬 216mm　　像寬 26.726mm
- ✧ F NO=7±3%　　Distortion ≦ 0.2%　　Vignetting 不容許
- ✧ 波長權重 540nm(主波長) : 440 : 620 = 1 : 1 : 1
- ✧ MTF 大於表列值

Frequency (lp/mm)	24	48
所有的 field	0.7	0.5



1. 設計步驟：了解整體結構圖

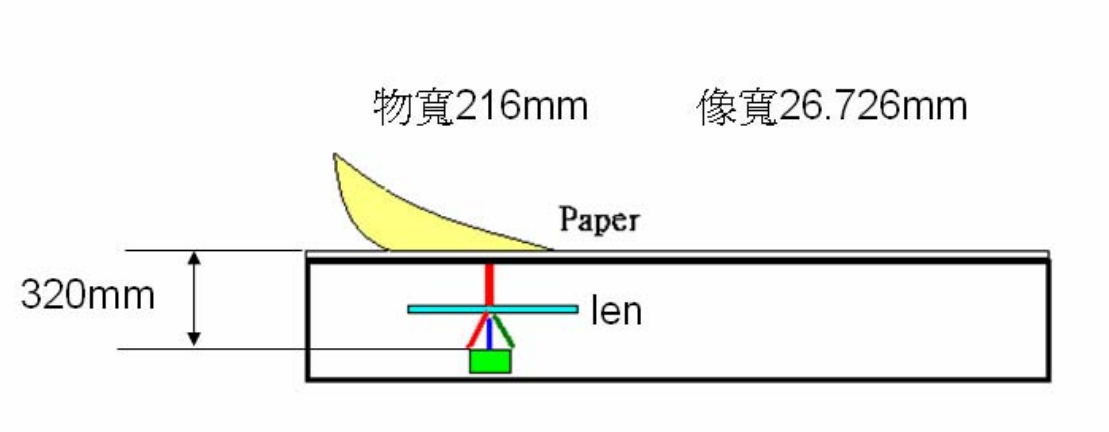


圖 1. 掃瞄機結構圖

2. 計算焦距

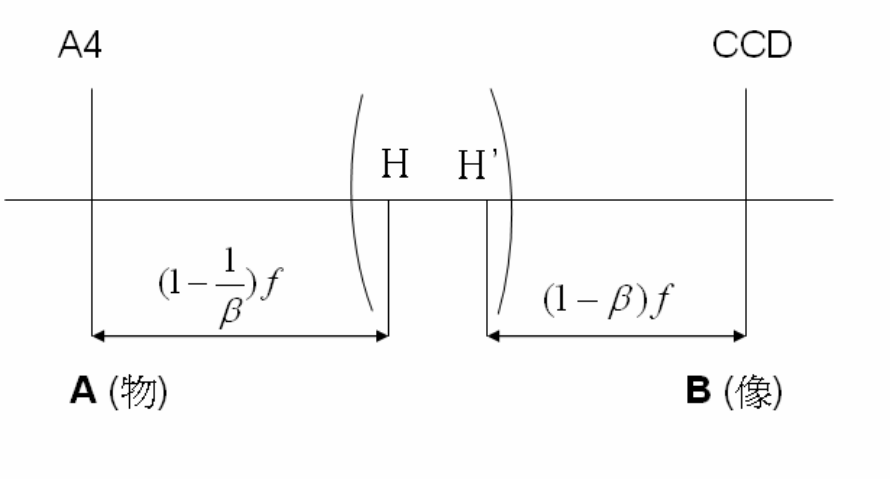


圖 2

有限距離時的物像距圖 2 中物像距 $\overline{AB}$

$$\overline{AB} = (2-\frac{1}{\beta}-\beta)f + \overline{HH'} \qquad (1)$$

$\overline{HH'}=0$ 帶入(1)

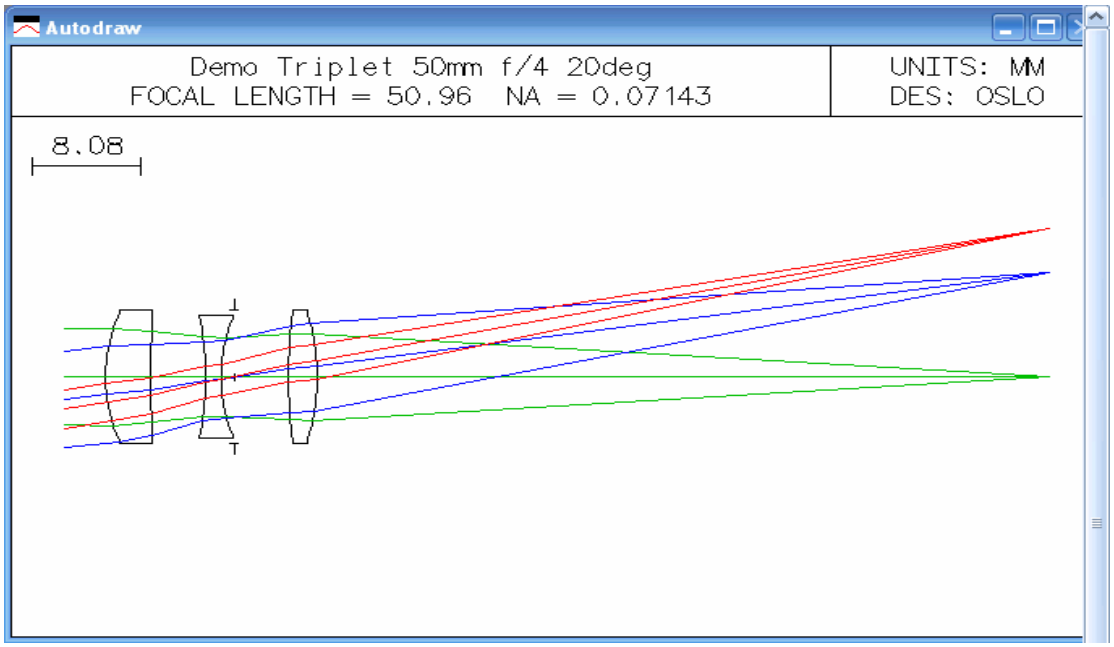
$$f = \frac{\overline{AB}}{(2-\frac{1}{\beta}-\beta)} \qquad (2)$$

註：$\beta = -\dfrac{\text{像寬}}{\text{物寬}}$

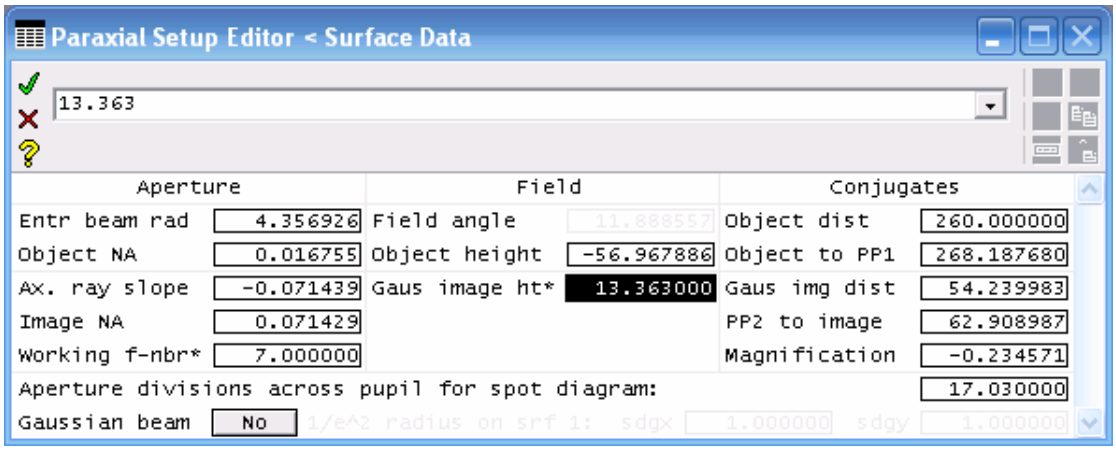
在 EXCEL 中寫入計算公式(2)計算出工作焦距(f)

物像距=	320	mm
物寬=	216	mm
像寬=	26.726	mm
β=	-0.12373	
f=	50.3256	

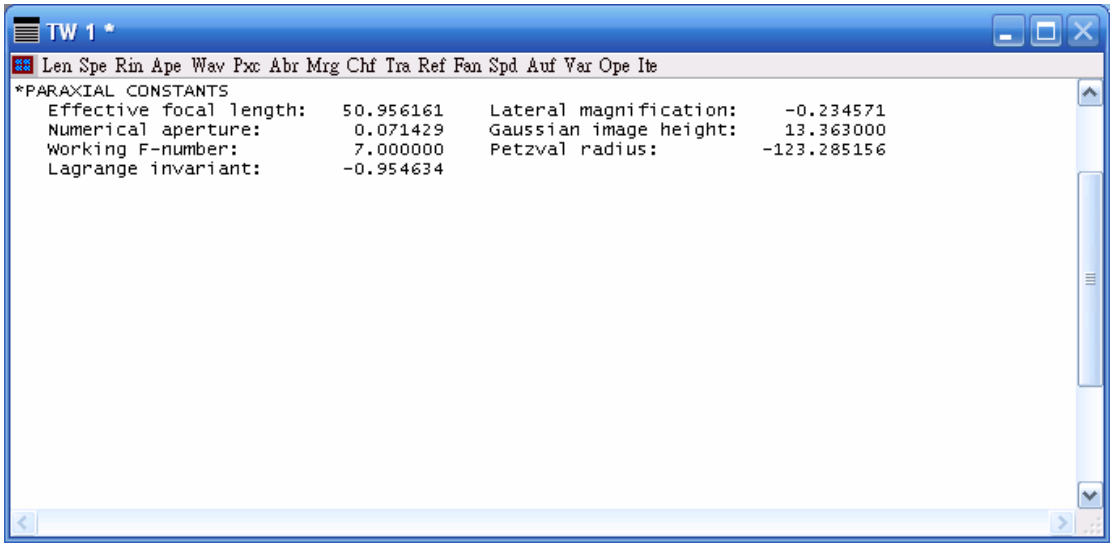
3. 首先在 OSLO 中找尋三片式鏡片範例來修改



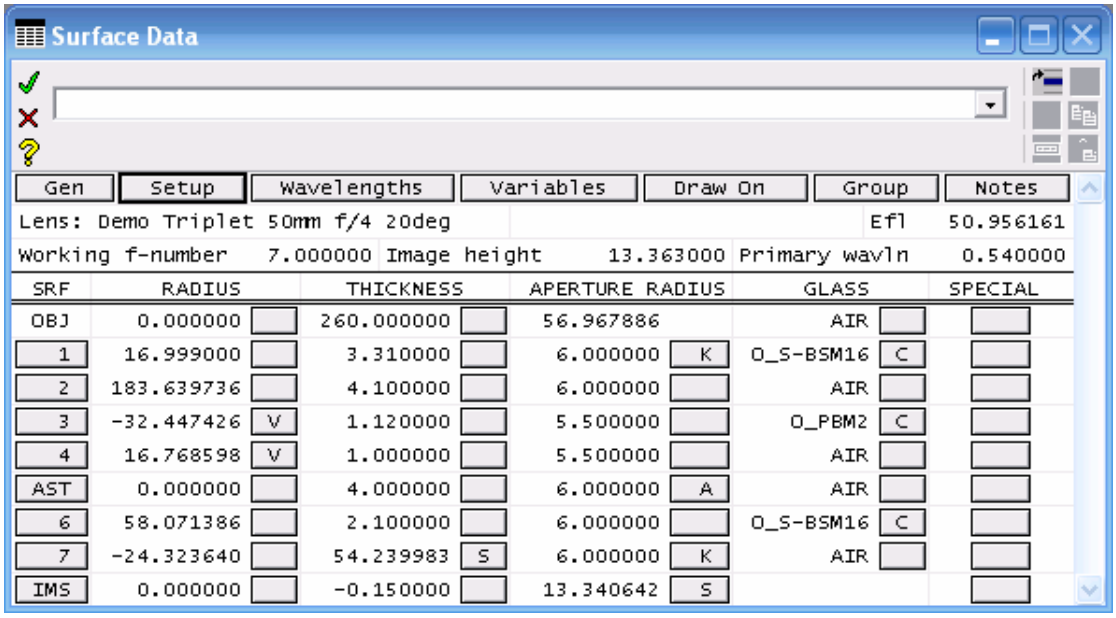
在 step 中輸入 F NO=7、Gaus image ht=26.726(像高/2：因為 OSLO 中的系統設計為一半；老師上課講解得知)



進行優化 f 須要維持 50；gaussian image height 須要維持 13.363

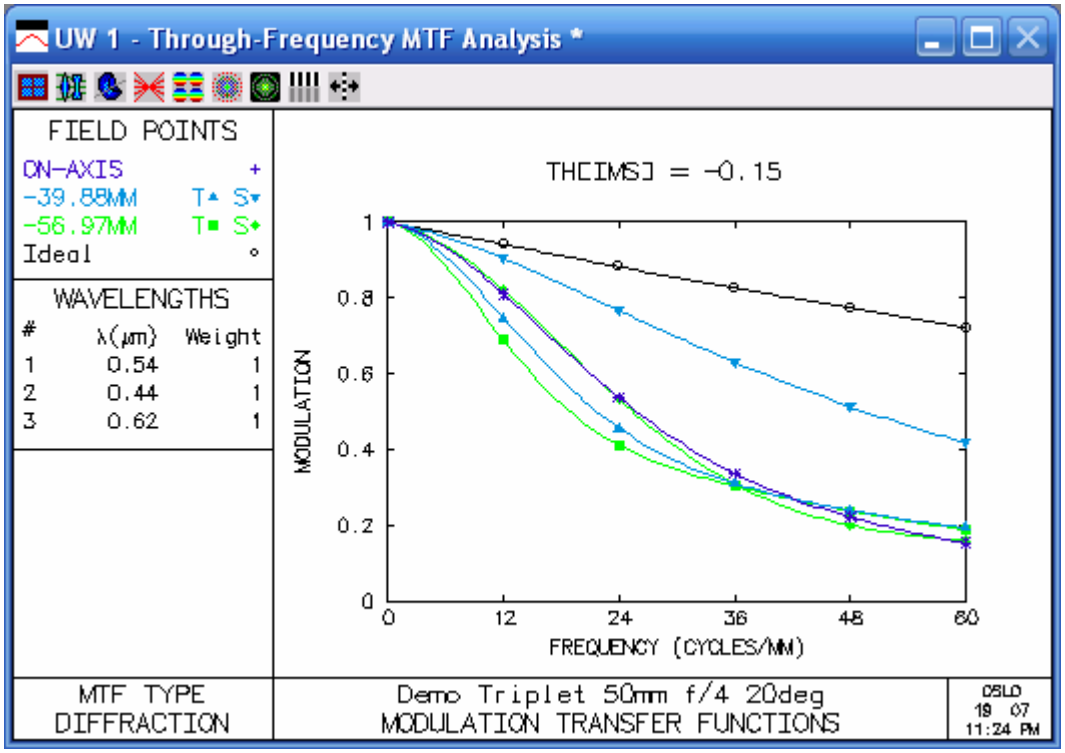


優化後修改鏡片 Surface Data 為下圖，且 THICKNESS 不能超過 320mm

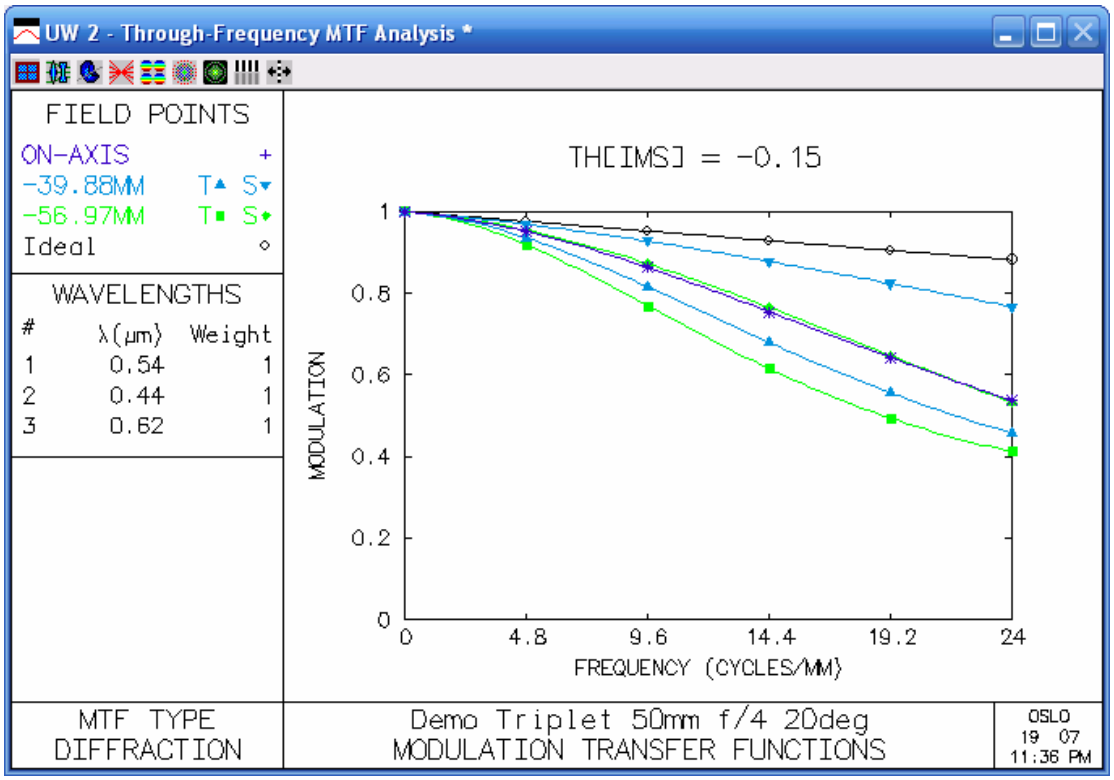


SRF	RADIUS		THICKNESS		APERTURE RADIUS		GLASS		SPECIAL
OBJ	0.000000		260.000000		56.967886		AIR		
1	16.999000		3.310000		6.000000	K	O_S-BSM16	C	
2	183.639736		4.100000		6.000000		AIR		
3	-32.447426	V	1.120000		5.500000		O_PBM2	C	
4	16.768598	V	1.000000		5.500000		AIR		
AST	0.000000		4.000000		6.000000	A	AIR		
6	58.071386		2.100000		6.000000		O_S-BSM16	C	
7	-24.323640		54.239983	S	6.000000	K	AIR		
IMS	0.000000		-0.150000		13.340642	S			

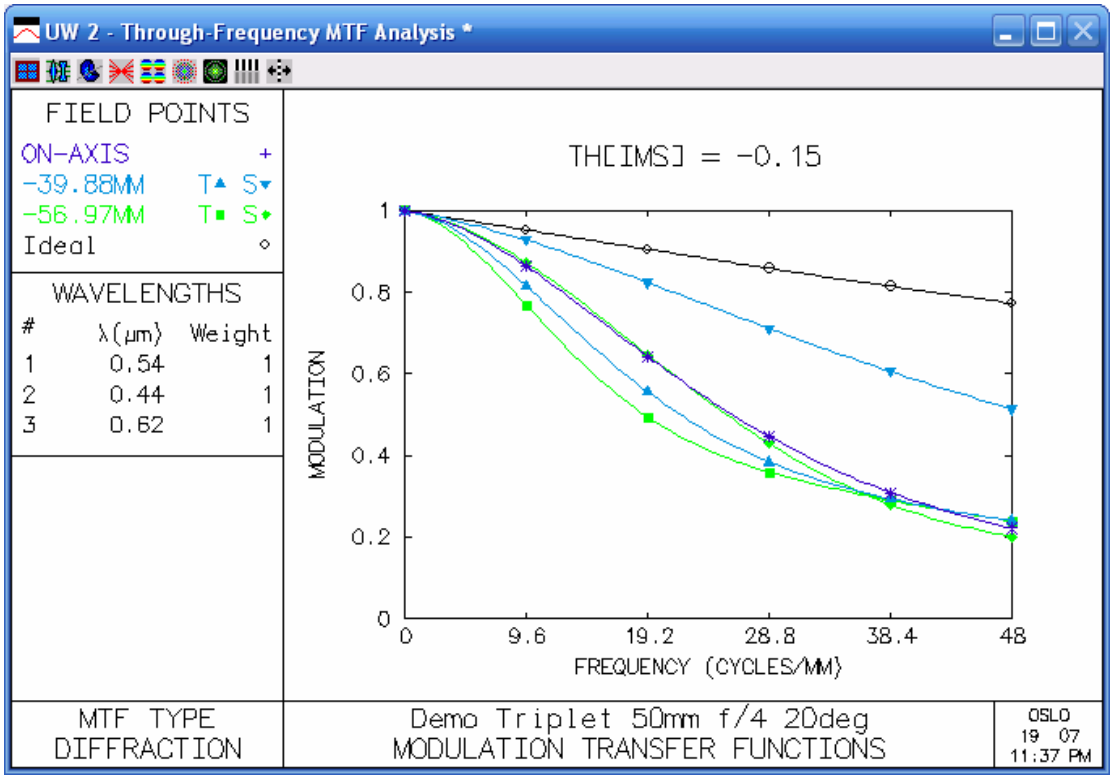
調節轉換函數（ Modulation Transfer Function **Max 60 lp/mm**）



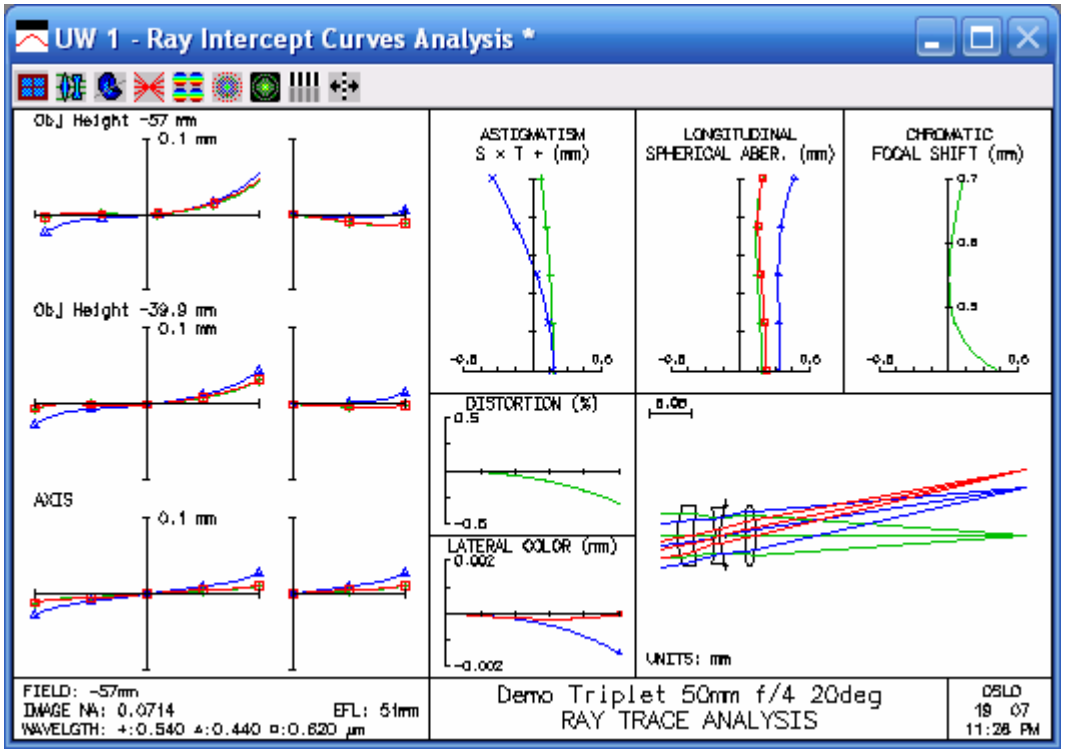
調節轉換函數（ Modulation Transfer Function **Max 24 lp/mm**）



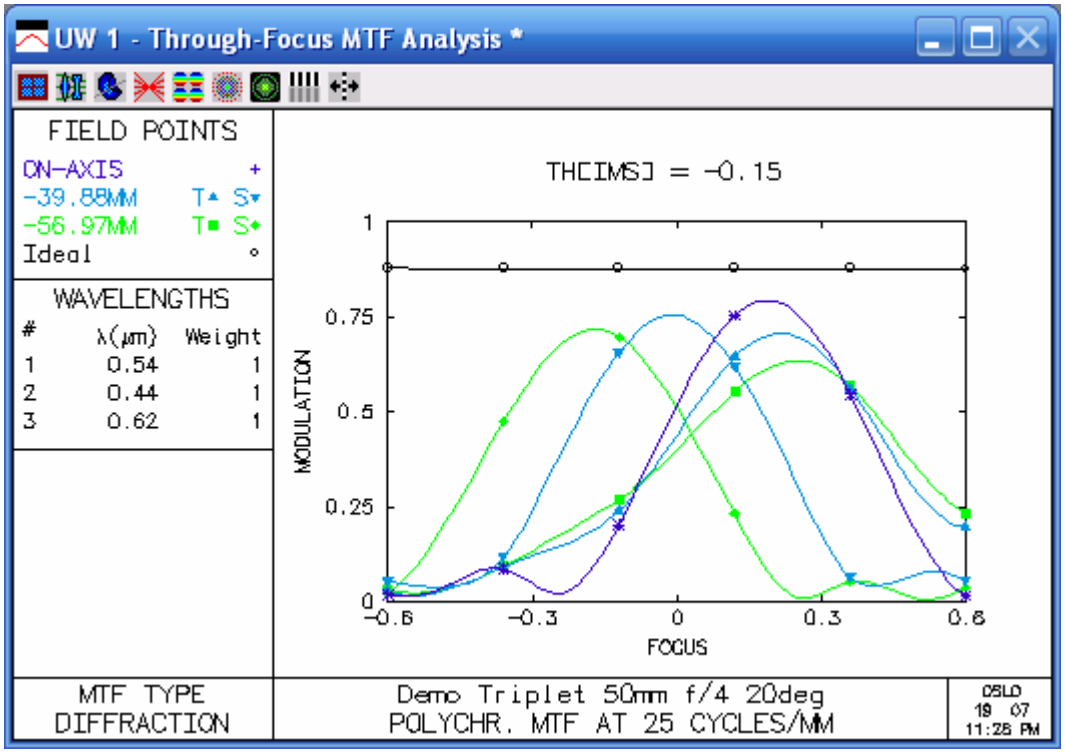
調節轉換函數（ Modulation Transfer Function **Max 48 lp/mm**）



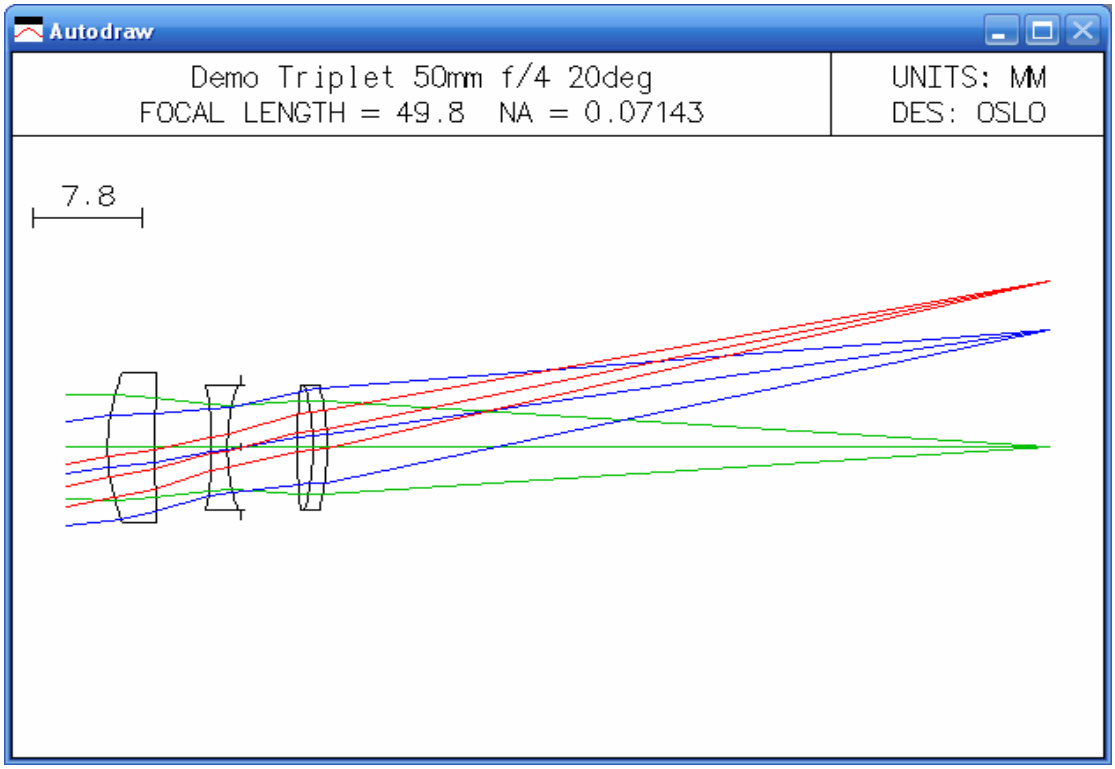
光線分析（ Ray Analysis ）



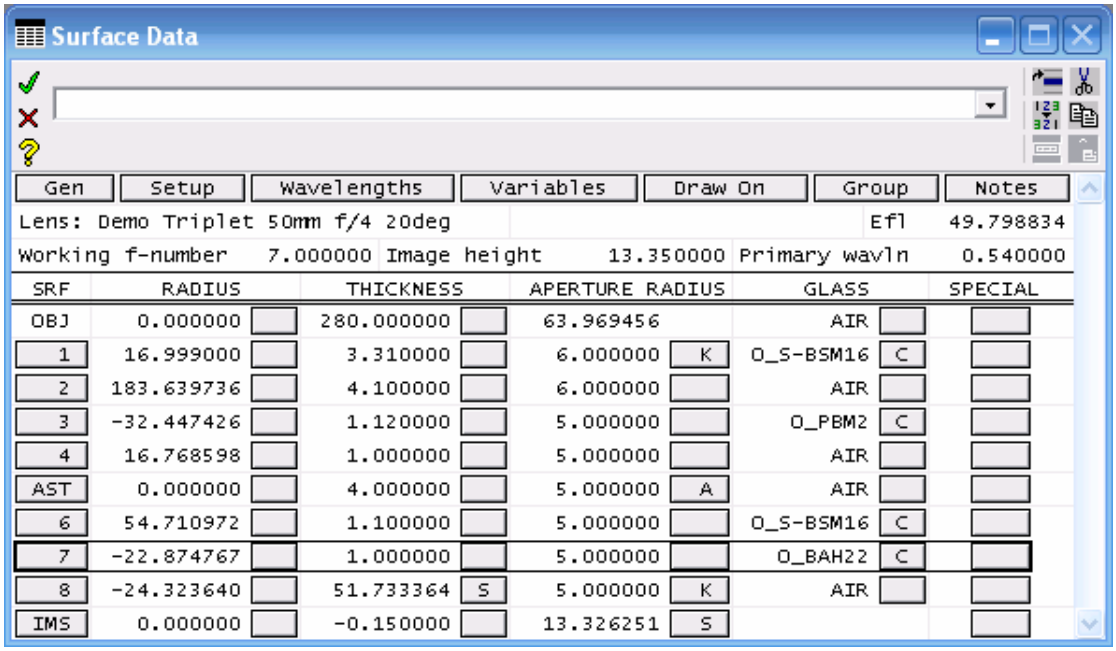
離焦MTF（ Through-Focus MTF ）



4. 將三片式鏡片修改成四片式鏡片



先將三片式鏡片中前兩片鏡片厚度設為 0，將第三片鏡片焦距求出，將一片改為兩片由 Harting table 找出。



Surface Data

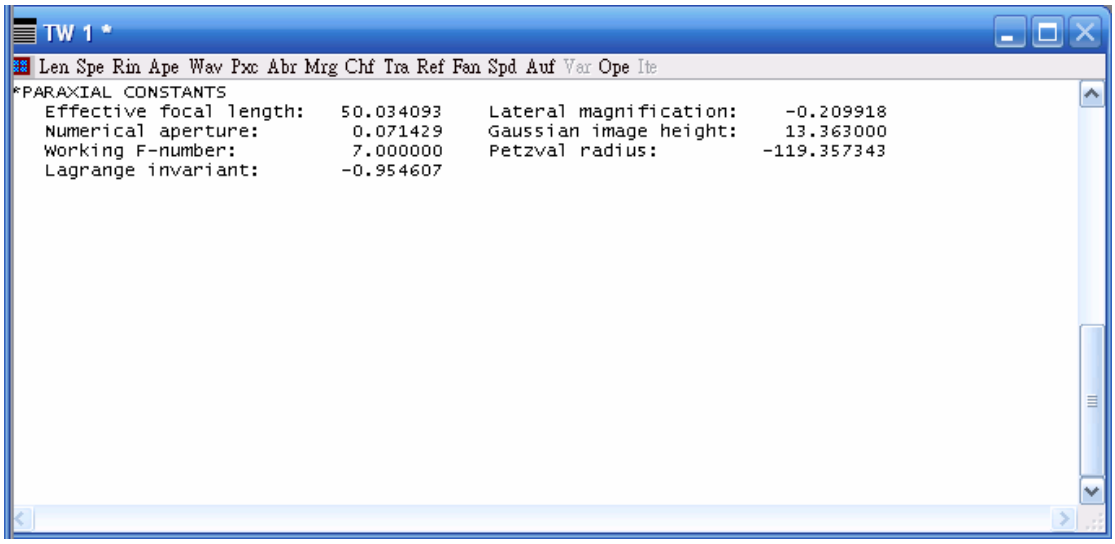
Gen | Setup | Wavelengths | Variables | Draw On | Group | Notes

Lens: Demo Triplet 50mm f/4 20deg Efl 49.798834

Working f-number 7.000000 Image height 13.350000 Primary wavln 0.540000

SRF	RADIUS		THICKNESS		APERTURE RADIUS		GLASS		SPECIAL
OBJ	0.000000		280.000000		63.969456		AIR		
1	16.999000		3.310000		6.000000	K	O_S-BSM16	C	
2	183.639736		4.100000		6.000000		AIR		
3	-32.447426		1.120000		5.000000		O_PBM2	C	
4	16.768598		1.000000		5.000000		AIR		
AST	0.000000		4.000000		5.000000	A	AIR		
6	54.710972		1.100000		5.000000		O_S-BSM16	C	
7	-22.874767		1.000000		5.000000		O_BAH22	C	
8	-24.323640		51.733364	S	5.000000	K	AIR		
IMS	0.000000		-0.150000		13.326251	S			

進行優化 f 須要維持 50；gaussian image height 須要維持 13.363



TW 1 *

Len Spe Rin Ape Wav Pxc Abr Mrg Chf Tra Ref Fan Spd Auf Var Ope Ite

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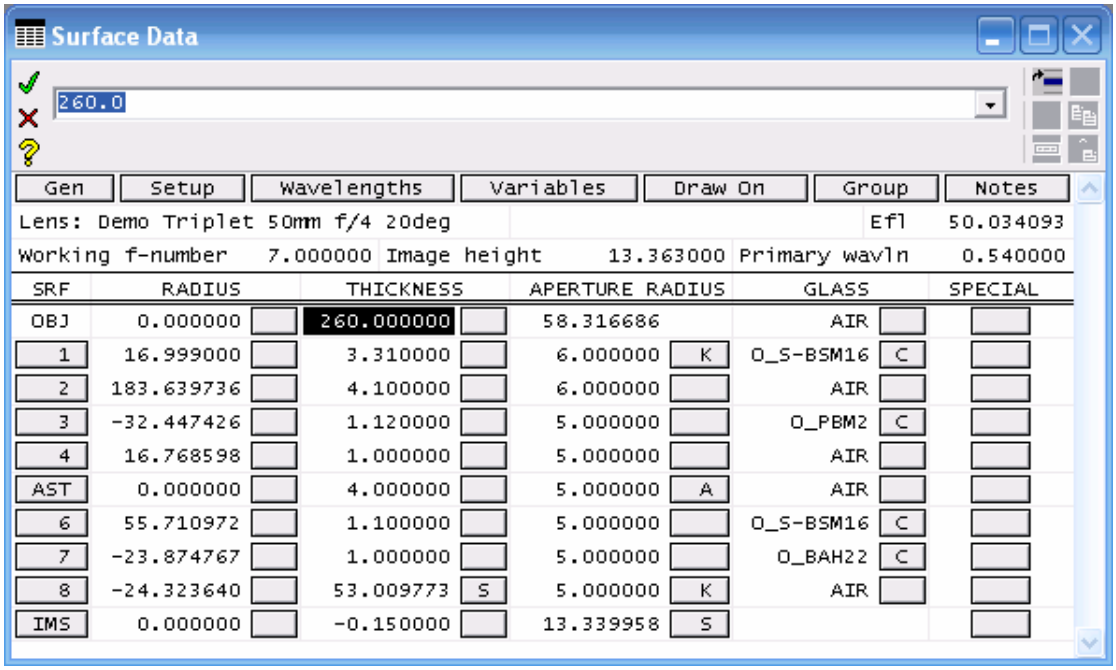
*PARAXIAL CONSTANTS
   Effective focal length:    50.034093    Lateral magnification:     -0.209918
   Numerical aperture:         0.071429    Gaussian image height:     13.363000
   Working F-number:           7.000000    Petzval radius:          -119.357343
   Lagrange invariant:        -0.954607
```

優化後修改鏡片 Surface Data 為下圖，且 THICKNESS 不能超過 320mm



Surface Data

260.0

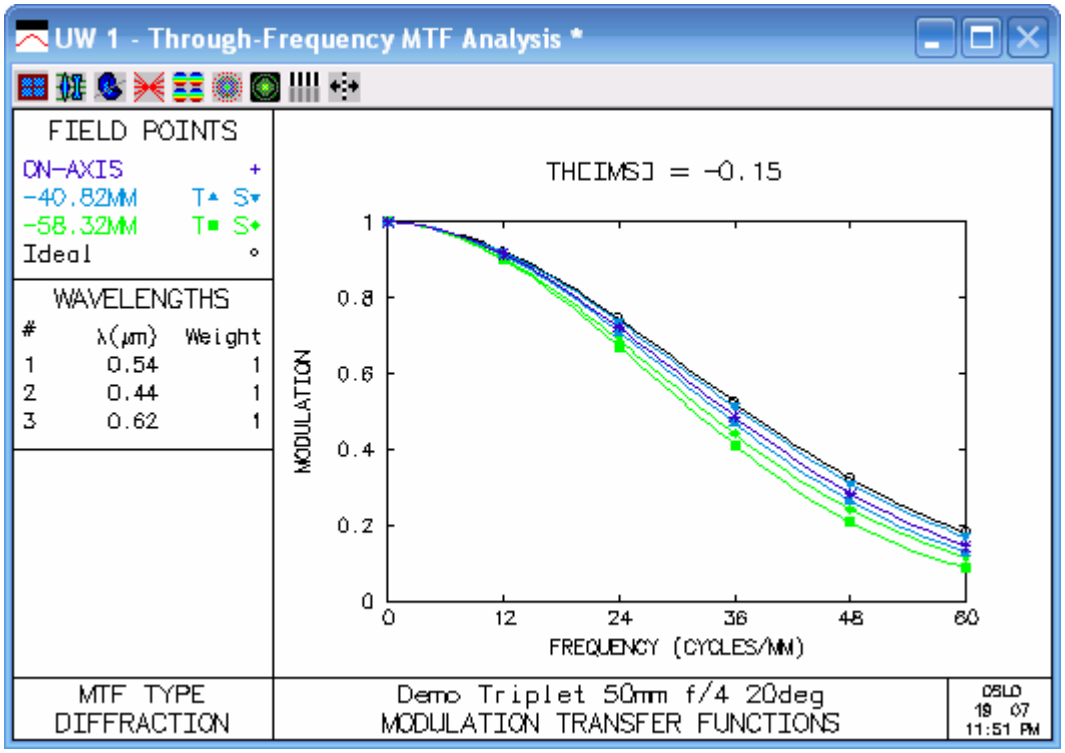
Gen | Setup | Wavelengths | Variables | Draw On | Group | Notes

Lens: Demo Triplet 50mm f/4 20deg Efl 50.034093

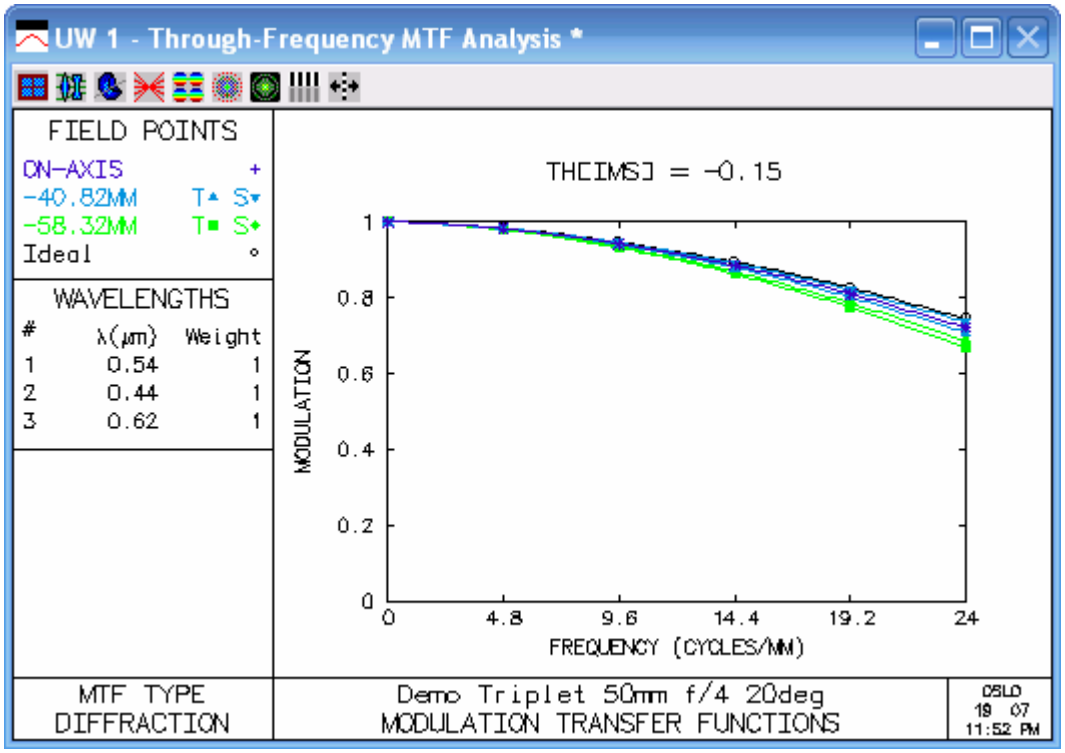
Working f-number 7.000000 Image height 13.363000 Primary wavln 0.540000

SRF	RADIUS		THICKNESS		APERTURE RADIUS		GLASS		SPECIAL
OBJ	0.000000		260.000000		58.316686		AIR		
1	16.999000		3.310000		6.000000	K	O_S-BSM16	C	
2	183.639736		4.100000		6.000000		AIR		
3	-32.447426		1.120000		5.000000		O_PBM2	C	
4	16.768598		1.000000		5.000000		AIR		
AST	0.000000		4.000000		5.000000	A	AIR		
6	55.710972		1.100000		5.000000		O_S-BSM16	C	
7	-23.874767		1.000000		5.000000		O_BAH22	C	
8	-24.323640		53.009773	S	5.000000	K	AIR		
IMS	0.000000		-0.150000		13.339958	S			

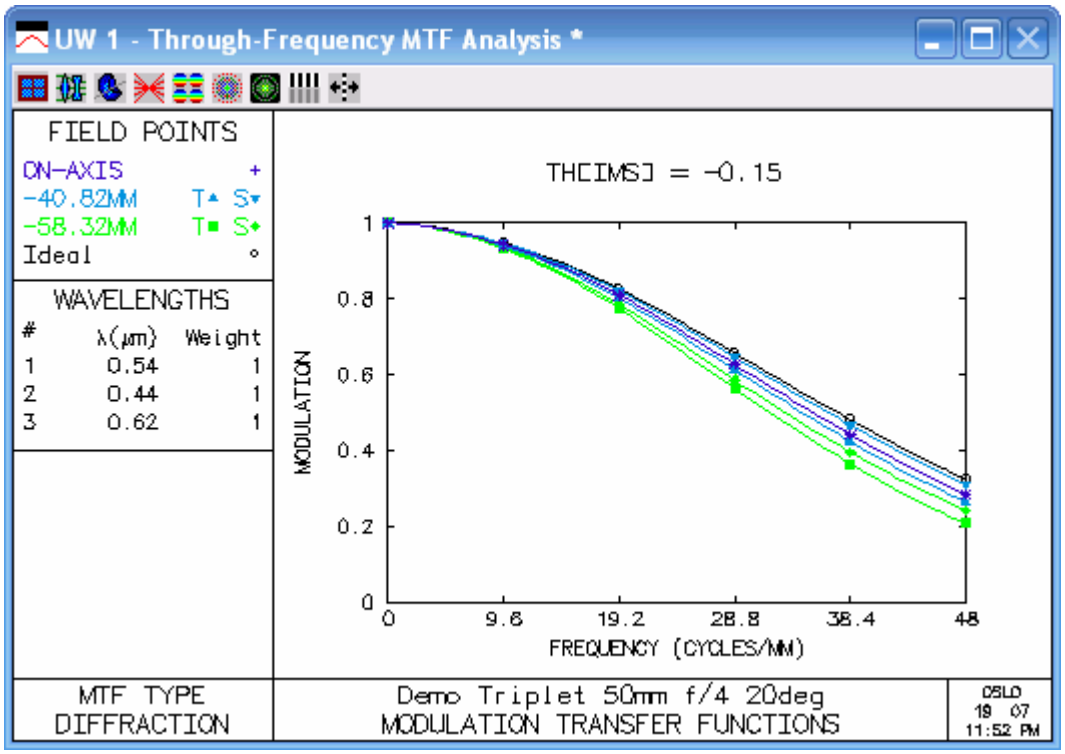
調節轉換函數（ Modulation Transfer Function **Max 60 lp/mm**）



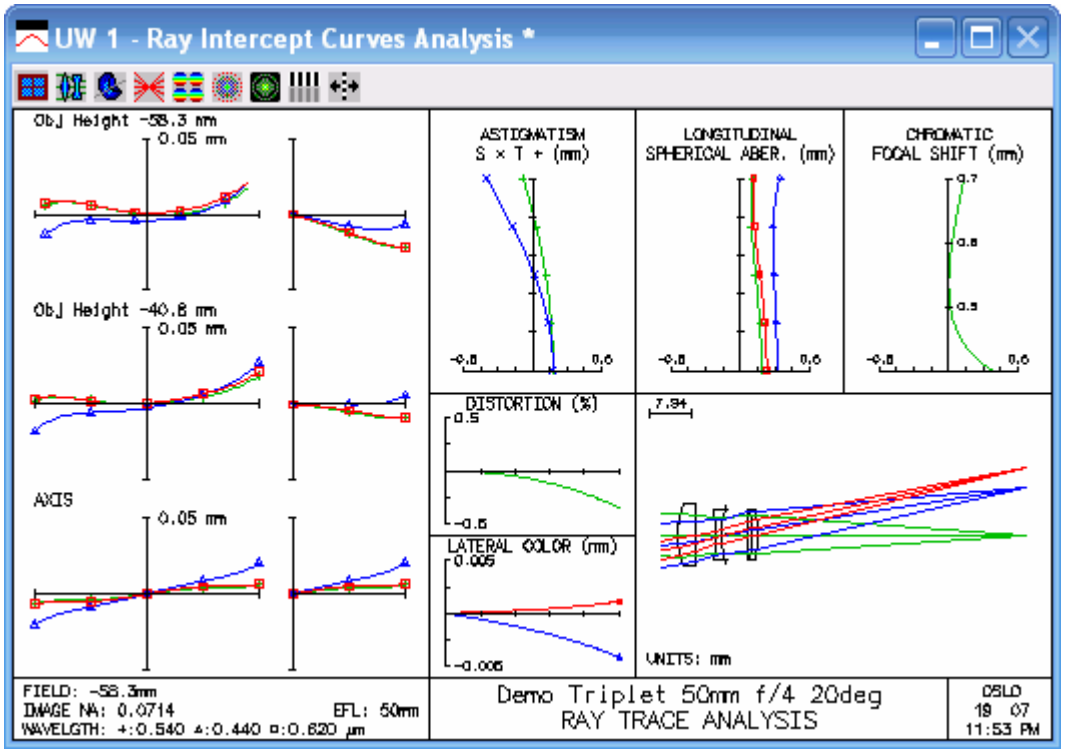
調節轉換函數（ Modulation Transfer Function **Max 24 lp/mm**）



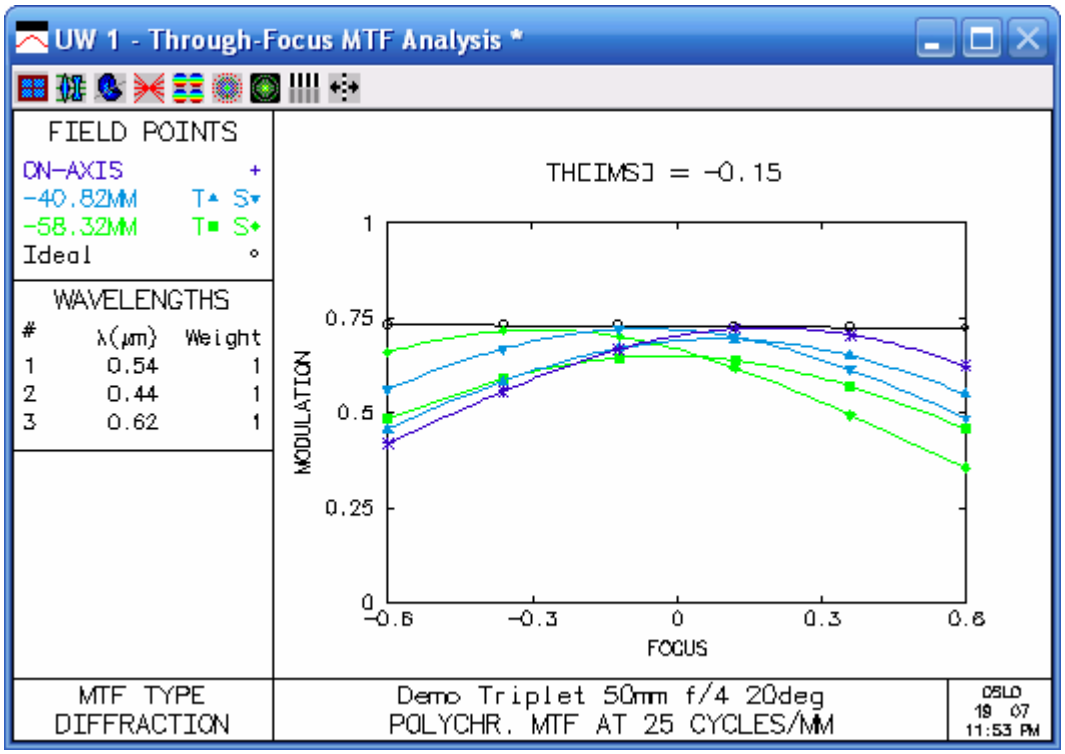
調節轉換函數（ Modulation Transfer Function **Max 48 lp/mm**）



光線分析（ Ray Analysis ）



離焦MTF（ Through-Focus MTF ）



5.比較三片式鏡片與四片式鏡片之差異：

將三片式鏡片改為四片式鏡片時，變更五至六種不同材料並進行優化，最後材料選用 Ohara 的 O_BAH22 是試了許多材料為目前最佳組合，變更後只優化雙膠合鏡之鏡片半徑及厚度，並觀察三片式鏡片改變為四片式鏡片之差異，由 MTF 比較在 Max 24、48 lp/mm，可知四片式較三片式鏡片 MTF 高。光線分析(Ray Analysis)四片式也比三片式鏡片好一些。

6.結論：

感謝老師的執導，在這學期讓我了解有限物距 LEN 的設計與許多需要注意與考慮的問題；比如：上學期課程像高、物高與物像距的計算焦距能在 OSLO 中模擬實現理論與實際的驗證。也在此感謝老師在一年來的指導，讓我懂得如何設計鏡片及分辨照機的好壞，在光電理論基礎上的常識與知識也皆有所增進及了解。