



DOCUMENT

EChO baseline telescope for Phase 0

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Typo correction	12/09/2012		Table 4
Figure 1	12/09/2012		Labels in figure 1



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1 INTRODUCTION

This document contains the description of the baseline telescope for the Phase 0 of EChO. This design is subject to changes which might be necessary in order to optimise the performance, adequate the optics to a particular implementation on the space craft, correct any possible vignetting, etc.. The data is given with the format described in AD 1, where the coordinate frames for the optic is also described. The appendix contains Code V sequence file and listing.

AD 1. Format for the prescription of the optics of EChO. SRE-F/2012.026. Iss. 1. Rev. 1.

2 OPTICS DESCRIPTION

The system is a three mirror Korsch telescope. A scaled drawing in two dimensions is included in Figure 1. An ideal focussing lens is included in the system to allow showing image quality in terms of spot diagrams in subsequent sections. Figure 2 is a 3-d view from the back of the primary mirror. The beam in blue in this figure corresponds to the light reflected by the pick-up mirror. This beam is displaced laterally from the vertical axis of symmetry of the telescope, as can be seen in the picture.

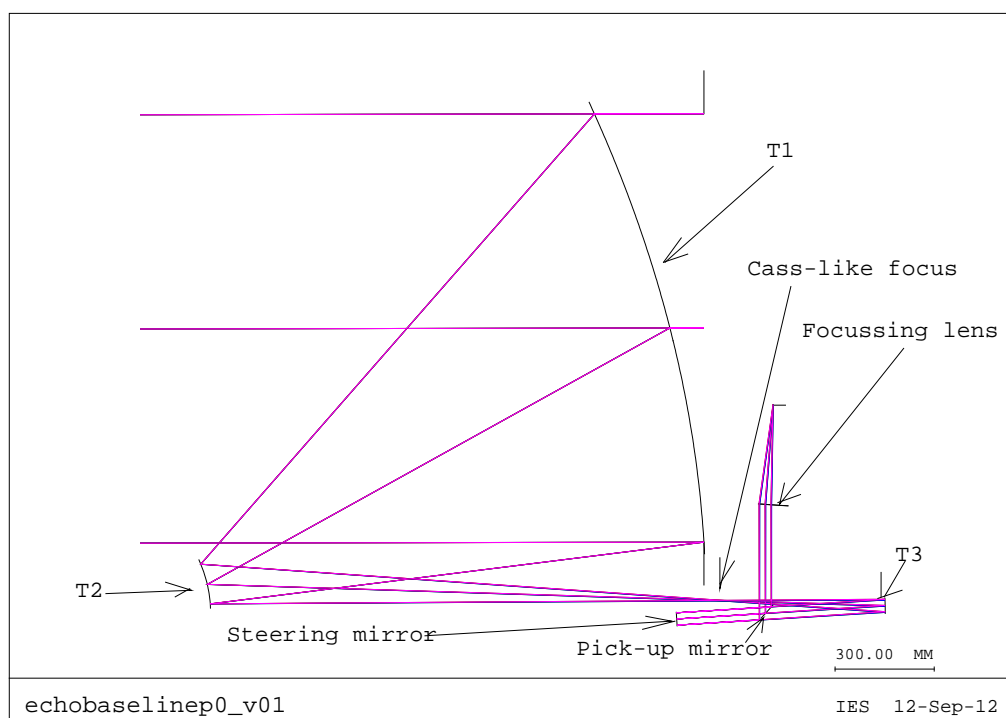


Figure 1. Scaled drawing of the baseline telescope for the Phase 0 study of EChO. An ideal focussing lens is included in the system to allow showing image quality in terms of spot diagrams in subsequent sections.

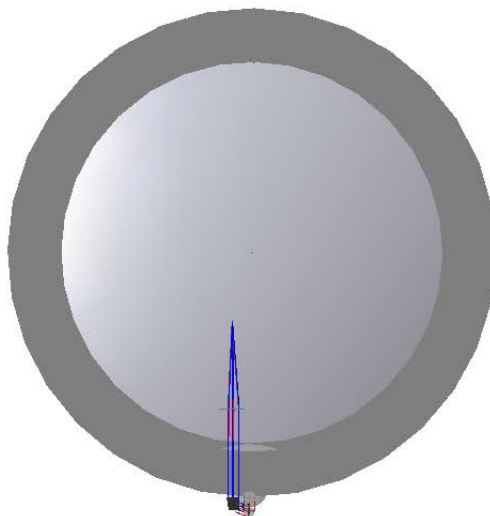


Figure 2. View of the baseline telescope for the Phase 0 study of EChO in three dimensions. The point of view is from the back of the primary towards the field of view of the telescope. The beam in blue corresponds to the light reflected by the pick-up mirror. This beam is displaced laterally from the vertical axis of symmetry of the telescope, as can be seen in the picture.

2.1 Optical components

The optical components of the telescope are described in Table 1.

Label	SURF No.(*)	Type	Radius of curvature (mm)	Conic constant	Clear aperture radius (mm)	Aperture decenters (mm)	Remarks
Stop	STO	Aperture stop	NA	NA	643.25	0.0000	
T1	3	Concave mirror	3296.3567	-1	670.0	849.6 (y axis)	
T2	4	Convex mirror	327.6878	-1.46768	70.0	80.8 (y axis)	
"Cass-like focus"	5	Dummy at intermediate focus	NA	NA	NA	NA	
T3	6	Concave mirror	981.3780	-1.00618	21.5	15.4 (y-axis)	
"Exit pupil"	7	Dummy at exit pupil	NA	NA	18.5	-24.37	
"SM tilt"	8	Dummy for steering mirror tilt	NA	NA	NA	NA	
"Steering mirror"	9	Flat mirror	NA	NA	19.0	-24.37	
"Pick up"	10	Flat mirror	NA	NA	19.5 (x axis)	-25.73	Rectangular

mirror"					27.7 (y axis)		aperture
"FL tilt"	11	Dummy for tilt of focussing lens	NA	NA	NA	NA	
"Focussing Lens"	12	Perfect lens	300 mm focal length	NA	NA	NA	
Image	IMG	Image surface	NA	NA	NA	NA	

Table 1. Description of optical components.

2.2 Location and orientation of optical surfaces

Table 2 contains the location of the optical components in global coordinates. The global coordinates system is at the entrance pupil as described in AD 1.

Label	SURF No. (*)	XSC	YSC	ZSC	LSC	MSC	NSC
Stop	STO	0.00000	0.00000	0.00000	0.000000	0.000000	1.000000
T1	3	0.00000	-849.90000	6.70000	0.000000	0.000000	1.000000
T2	4	0.00000	-849.90000	-1493.30000	0.000000	0.000000	1.000000
"Cass-like focus"	5	0.00000	-849.90000	54.81243	0.000000	0.000000	1.000000
T3	6	0.00000	-849.90000	548.67329	0.000000	0.000000	1.000000
"Exit pupil"	7	0.00000	-849.90000	-83.70061	0.000000	0.000000	1.000000
"SM tilt"	8	0.00000	-849.90000	-83.70061	0.000000	0.062660	0.998035
"Steering mirror"	9	0.00000	-849.90000	-83.70061	-0.095846	0.062371	0.993440
"Pick up mirror"	10	-57.24270	-831.44741	210.20886	-0.130627	-0.685383	0.716371
"FL tilt"	11	-60.82952	-531.46905	209.86416	0.023865	-0.997891	-0.060366
"Focussing Lens"	12	-60.82952	-531.46905	209.86416	0.023865	-0.997891	-0.060366
Image	IMG	-67.98906	-232.10176	227.97410	0.011984	-0.999928	0.001004

Table 2. Surface coordinates in global coordinate system. (*) Surface reference number corresponds to Code V listing. LSC, MSC and NSC express local Z axis in direction cosines.

2.3 System configuration

The main parameter of the telescope are as follows:

- Off axis Korsch
- Entrance pupil diameter 1286.5 mm
- Exit pupil diameter 36.5915 mm
- Effective focal length (for a 300mm focal length focusing lens) 10568.3055 mm



The field of view is described by the 5 field objects of Table 3.

Field no.	x-angle in object space (degrees)	y-angle in object space (degrees)
1	0	0.1028
2	0.0028	0.1
3	-0.0028	0.1
4	0.0028	0.1056
5	-0.0028	0.1056

Table 3. Field of view of the telescope described by four objects on the corners and the central object in the field.

3 OPTICS PERFORMANCE

3.1 Ray trace

The ray tracing of the principal ray for the object in the centre of the field of view yields the coordinates of Table 4 for a wavelength of 800 nm. Note that local surface coordinates are used in this table.

Surface label	No. (*)	X	Y	Z	L	M	N
Stop	STO	0.00000	0.00000	0.00000	0.00000	0.00179	1.00000
T1	3	0.00000	849.71553	-109.51734	0.00000	-0.48185	-0.87625
T2	4	0.00000	79.77906	-9.64514	0.00000	-0.03138	0.99951
"Cass-like focus"	5	0.00000	30.86905	0.00000	0.00000	-0.03138	0.99951
T3	6	0.00000	15.36673	-0.12031	0.00000	-0.06266	-0.99803
"Exit pupil"	7	0.00000	-24.32852	0.00000	0.00000	-0.06266	-0.99803
"SM tilt"	8	0.00000	-24.28071	0.00000	0.00000	0.00000	-1.00000
"Steering mirror"	9	0.00000	-24.28071	0.00000	-0.09585	0.00000	0.99540
"Pick up mirror"	10	0.00000	-35.46747	0.00000	0.00000	0.72892	-0.68460
"FL tilt"	11	0.00000	-24.32882	0.00000	0.00000	-0.06266	-0.99803
"Focussing Lens"	12	0.00000	-24.32882	0.00000	0.00000	0.01796	-0.99984
Image surface	IMG	0.00000	-18.89329	0.00000	0.00000	0.08043	-0.99676

Table 4. Coordinates of the principal ray for the object in the centre of the field of view given in local surface coordinates. (*) Surface reference number corresponds to Code V listing.



3.2 Spot diagrams

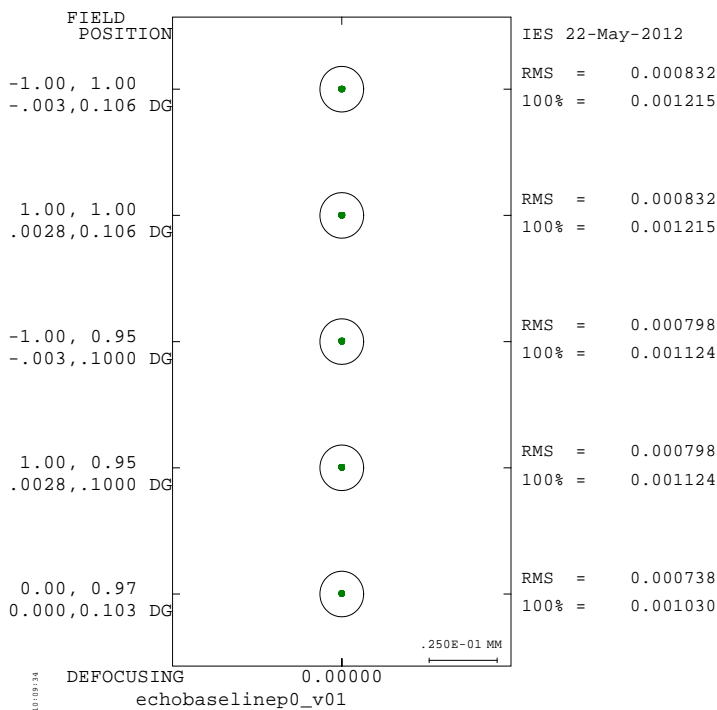


Figure 3. Spot diagrams at 800nm for 5 field objects: centre and corners of the field of view.



4 APPENDIX

Code V sequence file:

```

RDM;LEN          "VERSION: 10.4 SR1          LENS VERSION: 80          Creation Date: 12-
Sep-2012"
TITLE 'echobaselinep0_v01'
EPD   1286.5
DIM   M
WL    800.0
REF   1
WTW   1
INI   'IES'
XAN   0.0 0.0028 -0.0028 0.0028 -0.0028
YAN   0.1028 0.1 0.1 0.1056 0.1056
WTF   1.0 1.0 1.0 1.0 1.0 1.0 1.0
VUX   0.0 0.0 0.0 0.0 0.0 0.0 0.0
VLX   0.0 0.0 0.0 0.0 0.0 0.0 0.0
VUY   0.0 0.0 0.0 0.0 0.0 0.0 0.0
VLY   0.0 0.0 0.0 0.0 0.0 0.0 0.0
SO    0.0 0.9e17
S     0.0 1500.0
slb 'Drawing dummy'
S     0.0 6.7
      STO
      SLB "Stop"
S     -3296.356743705002 -1500.0 REFL
      SLB "T1"
      CON
      K    -1.0
      XDE 0.0; YDE -849.9; ZDE 0.0
      CIR 670.0
      ADY 849.6
S     -327.6878377803179 1548.112431 REFL
      SLB "T2"
      CON
      K    -1.467681098251933
      CIR 70.0
      ADY 80.8
S     0.0 493.860857
      SLB "Cass-like focus"
S     -981.3779787349129 -632.3739000000001 REFL
      SLB "T3"
      CON
      K    -1.006180294874332
      CIR 21.5
      ADY 15.4
S     0.0 0.0
      SLB "Exit pupil"
      CIR 18.5
      ADY -24.37
S     0.0 0.0
      SLB "SM tilt"
      XDE 0.0; YDE 0.0; ZDE 0.0
      ADE 3.5925; BDE 0.0; CDE 0.0

```



```

S      0.0 300.0 REFL
SLB "Steering mirror"
BEN
XDE 0.0; YDE 0.0; ZDE 0.0
ADE 0.0; BDE 5.5; CDE 0.0
CIR 19.0
ADY -24.37
S      0.0 -300.0 REFL
SLB "Pick up mirror"
BEN
XDE 0.0; YDE 0.0; ZDE 0.0
ADE -46.79625; BDE 0.0; CDE 0.0
REX 19.5; REY 27.7
ADY -25.73205
S      0.0 0.0
SLB "FL tilt"
XDE 0.0; YDE 0.0; ZDE 0.0
ADE -3.5925; BDE 0.0; CDE 0.0
S      0.0 0.0
SLB "Focussing Lens"
MOD
MFL -300.0
S      0.0 0.0
S      0.0 -300.0
SI     0.0 0.0
DAR
XDE 0.0; YDE 0.0; ZDE 0.0
ADE 3.584036895470629; BDE 0.0; CDE 0.0
GO

```

Code V listing

```

CODE V> lis
echobaselinep0_v01
      RDY      THI  RMD   GLA      CCY  THC  GLC
OBJ:  INFINITY  INFINITY
1:    INFINITY  1500.000000      100  100
SLB: "Drawing dummy"
STO:  INFINITY   6.700000      100  100
SLB: "Stop"
3:   -3296.35674 -1500.000000 REFL      100  100
SLB: "T1"
CON:
K : -1.000000 KC : 100
XDE: 0.000000 YDE: -849.900000 ZDE: 0.000000
XDC: 100 YDC: 100 ZDC: 100
ADE: 0.000000 BDE: 0.000000 CDE: 0.000000
ADC: 100 BDC: 100 CDC: 100

4:   -327.68784 1548.112431 REFL      100  100
SLB: "T2"
CON:
K : -1.467681 KC : 100

```



5: INFINITY 493.860857 100 100
 SLB: "Cass-like focus"

6: -981.37798 -632.373900 REFL 100 100
 SLB: "T3"
 CON:
 K : -1.006180 KC: 100

7: INFINITY 0.000000 100 100
 SLB: "Exit pupil"

8: INFINITY 0.000000 100 100
 SLB: "SM tilt"
 XDE: 0.000000 YDE: 0.000000 ZDE: 0.000000
 XDC: 100 YDC: 100 ZDC: 100
 ADE: 3.592500 BDE: 0.000000 CDE: 0.000000
 ADC: 100 BDC: 100 CDC: 100

9: INFINITY 300.000000 REFL 100 100
 SLB: "Steering mirror"
 XDE: 0.000000 YDE: 0.000000 ZDE: 0.000000 BEN
 XDC: 100 YDC: 100 ZDC: 100
 ADE: 0.000000 BDE: 5.500000 CDE: 0.000000
 ADC: 100 BDC: 100 CDC: 100

10: INFINITY -300.000000 REFL 100 100
 SLB: "Pick up mirror"
 XDE: 0.000000 YDE: 0.000000 ZDE: 0.000000 BEN
 XDC: 100 YDC: 100 ZDC: 100
 ADE: -46.796250 BDE: 0.000000 CDE: 0.000000
 ADC: 100 BDC: 100 CDC: 100

11: INFINITY 0.000000 100 100
 SLB: "FL tilt"
 XDE: 0.000000 YDE: 0.000000 ZDE: 0.000000
 XDC: 100 YDC: 100 ZDC: 100
 ADE: -3.592500 BDE: 0.000000 CDE: 0.000000
 ADC: 100 BDC: 100 CDC: 100

12: INFINITY 0.000000 100 100
 SLB: "Focussing Lens"
 MOD:
 MFL: -300.000000 MRD: 1.00E-10
 FLC: 100 RDC: 100
 MFF: 300.000000 MBF: -300.000000 MEN: 0.000000
 FFC: 100 BFC: 100 EPC: 100
 MED: 1.000000 MFD: 0.000000
 EDC: 100 FDC: 100

13: INFINITY 0.000000 100 100

14: INFINITY -300.000000 100 100
 > IMG: INFINITY 0.000000 100 100
 XDE: 0.000000 YDE: 0.000000 ZDE: 0.000000 DAR
 XDC: 100 YDC: 100 ZDC: 100
 ADE: 3.584037 BDE: 0.000000 CDE: 0.000000



ADC: 100 BDC: 100 CDC: 100

SPECIFICATION DATA

EPD	1286.50000				
DIM	MM				
WL	800.00				
REF	1				
WTW	1				
INI	IES				
XAN	0.00000	0.00280	-0.00280	0.00280	-0.00280
YAN	0.10280	0.10000	0.10000	0.10560	0.10560
WTF	1.00000	1.00000	1.00000	1.00000	1.00000
VUX	0.00000	0.00000	0.00000	0.00000	0.00000
VLX	0.00000	0.00000	0.00000	0.00000	0.00000
VUY	0.00000	0.00000	0.00000	0.00000	0.00000
VLY	0.00000	0.00000	0.00000	0.00000	0.00000
POL	N				

APERTURE DATA/EDGE DEFINITIONS

CA	
CIR S3	670.000000
ADY S3	849.600000
CIR S4	70.000000
ADY S4	80.800000
CIR S6	21.500000
ADY S6	15.400000
CIR S7	18.500000
ADY S7	-24.370000
CIR S9	19.000000
ADY S9	-24.370000
REX S10	19.500000
REY S10	27.700000
ADY S10	-25.732050

No refractive materials defined in system

No solves defined in system

No pickups defined in system

This is a non-symmetric system. If elements with power are decentered or tilted, the first order properties are probably inadequate in describing the system characteristics.

INFINITE CONJUGATES

EFL	10568.3055
BFL	-299.4355
FFL	0.3731E+06
FNO	-8.2148
IMG DIS	-300.0000
OAL	1416.2994
PARAXIAL IMAGE	
HT	19.4781



ANG 0.1056
ENTRANCE PUPIL
DIA 1286.5000
THI 1500.0000
EXIT PUPIL
DIA 36.5915
THI -600.0263 CODE V> out t