



Surveying the GPS – VLBI eccentricity at Medicina: methodological aspects and practicalities

Vittuari L.¹, Sarti P.², Tomasi P.², Sillard P.^{3,4}, Negusini M.²

¹ DISTART Dept. (Geodesy and Topography) – Engineering Faculty – University of Bologna, Italy

² Istituto di Radioastronomia - CNR - c/o CGS-ASI Matera, Italy

³ Institut National de la Statistique et des Etudes Economiques – Paris, France

⁴ Institute Géographique National – France

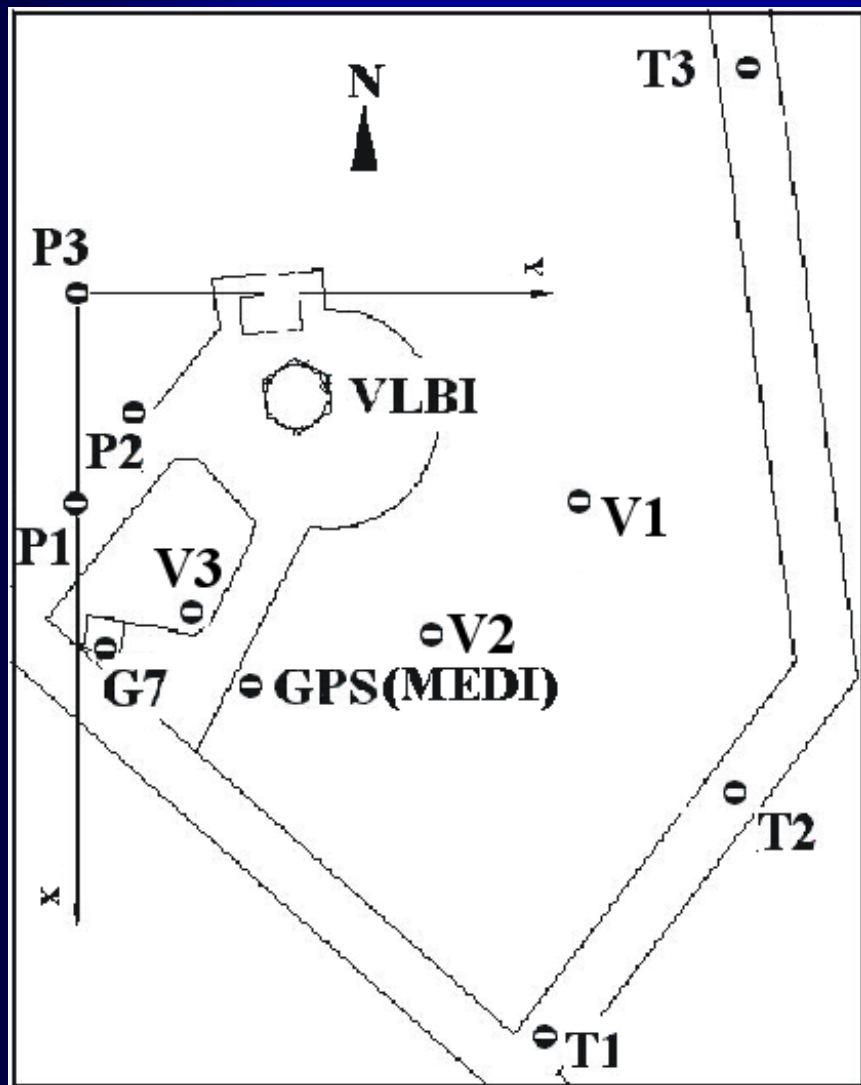


Goals

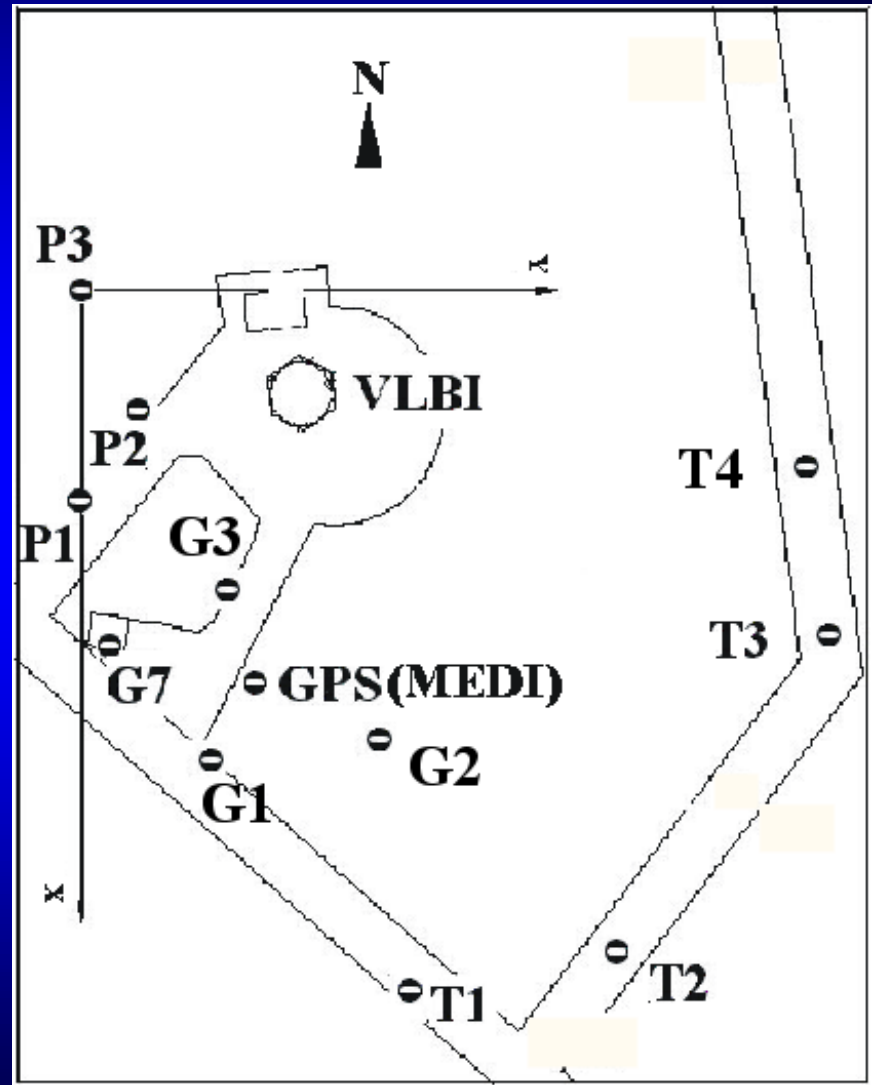
- Monitor the stability of ground control network
- Test a rigorous methodology for local ties based on terrestrial local survey
- Focus on VLBI reference point (geometrical and implicit definition)
- Full covariance matrix and SINEX production

SURVEYS

(2000)-2001-2002

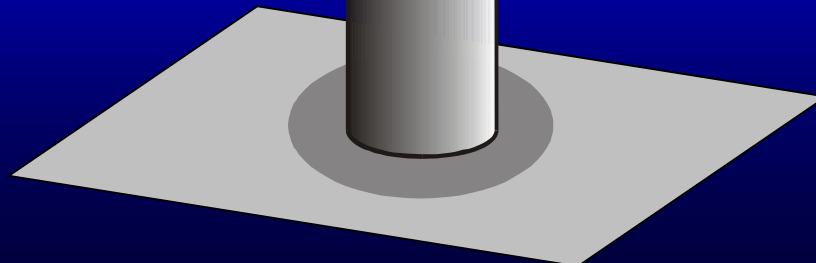
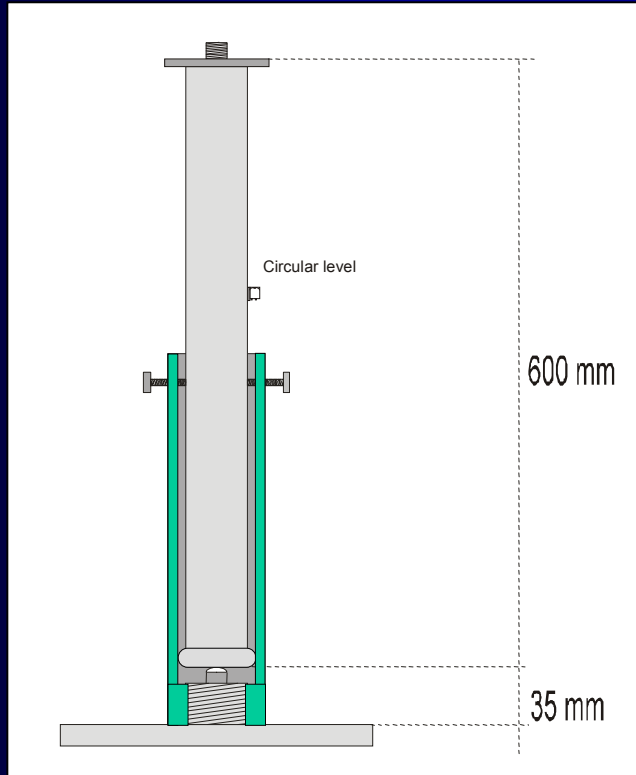


2003

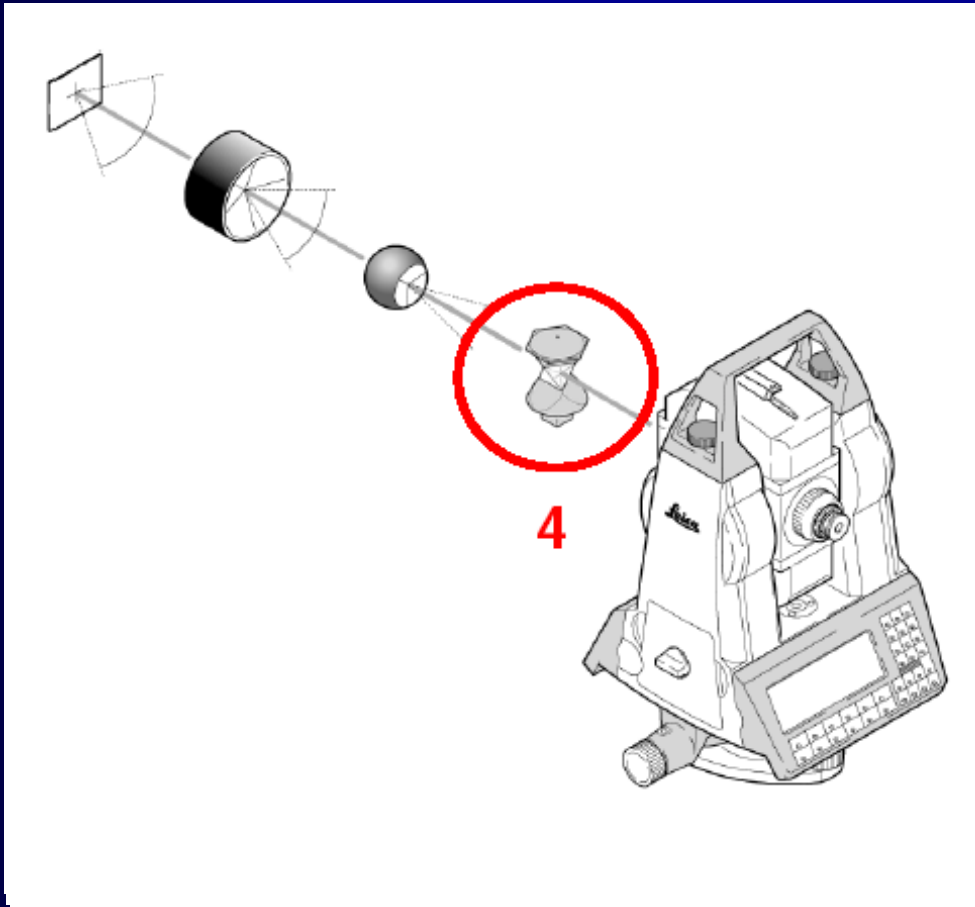


- Instrumentation:
 - TDA5005 (0.15 mgon; 1 mm + 2 ppm) with ATR
 - TCA2003 (0.15 mgon; 1 mm + 1 ppm) with ATR (survey 2000)
 - TC2003 (0.15 mgon; 1 mm + 1 ppm)
 - All provided by a biaxial compensator
- Surveying approach:
 - Three strata (position I-II) with distances and angles
- Set-up of all tribrachs: using biaxial compensator of total stations
- Equal height between tribrach-prisms centre and tribrach-total station reference point
- One three-dimensional benchmark was fixed as origin of elevations and instrumental heights were direct measured on auto-centring devices
- 10 retro-reflecting prisms were installed on the VLBI antenna, with prism constants equal to EDM internal calibration path (approximate zero constant)

Instrumental heights measurement



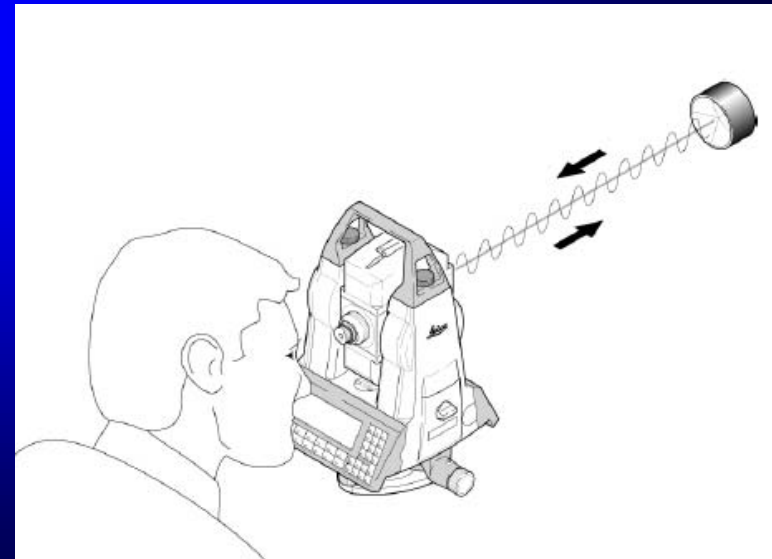
Reflector types for measurement of distances



360° prism reflector

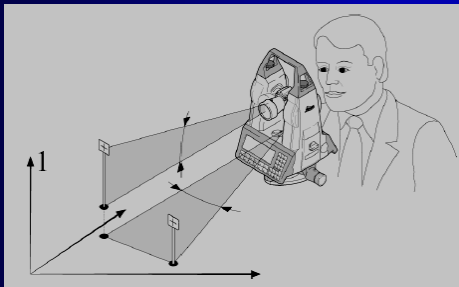
$$1\sigma_{\text{EDM}} = 2 \text{ mm}$$

($d < 120 \text{ m}$)

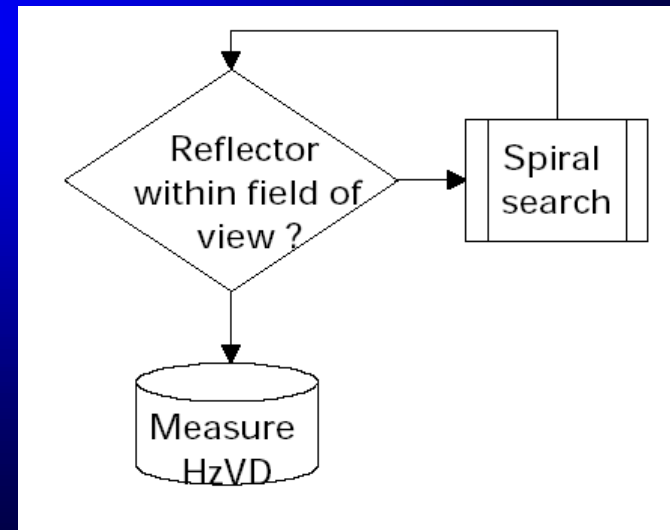
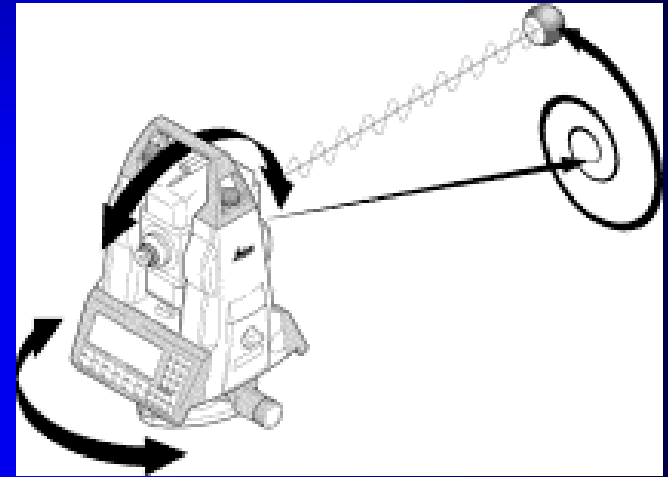


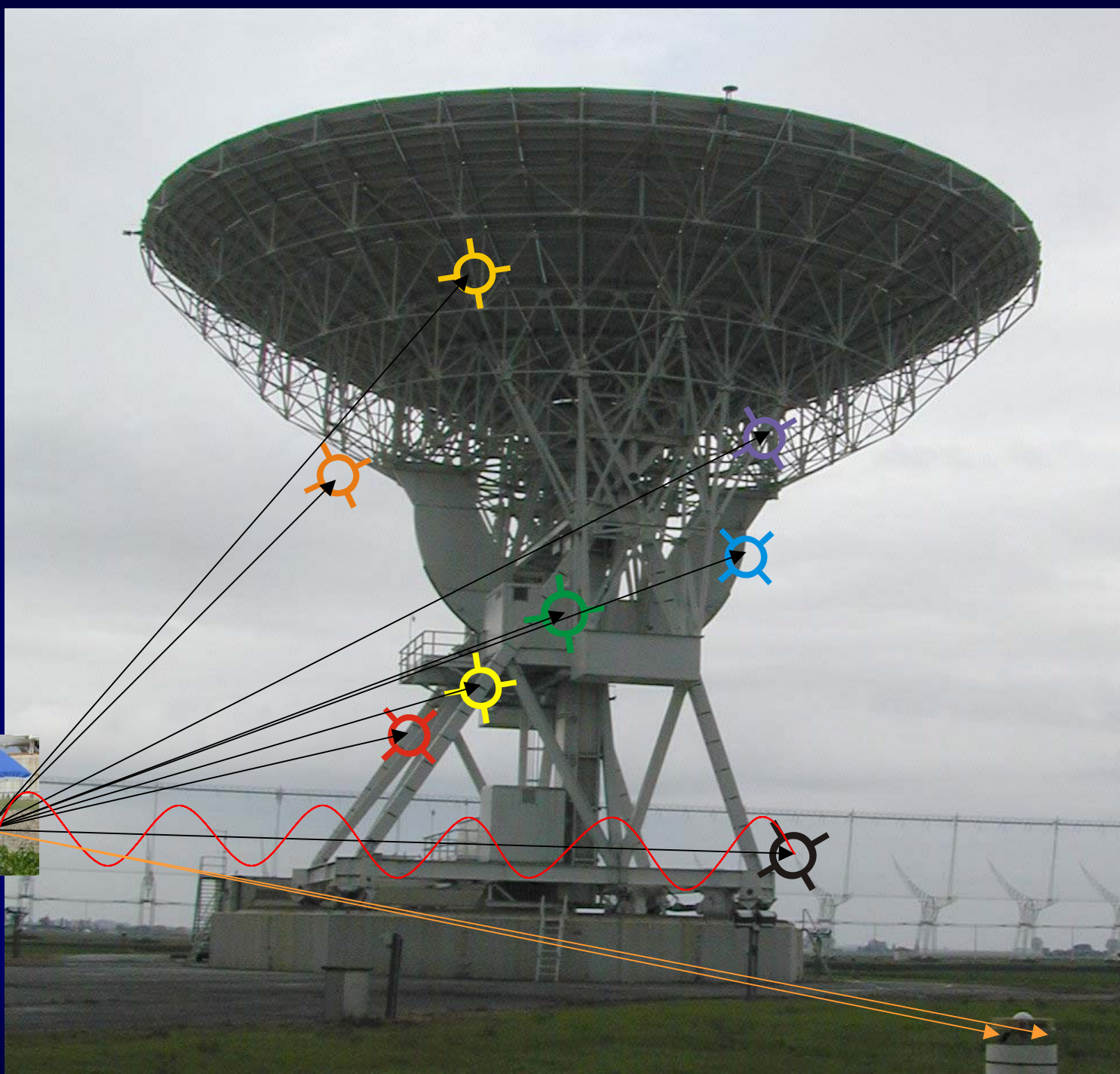
Targets for angular measurements

Manual target collimation



Aut. Target Recognition

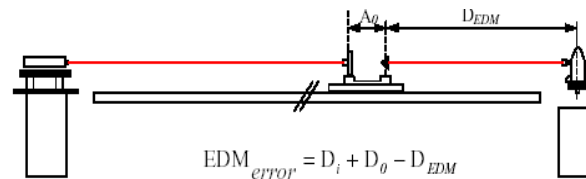




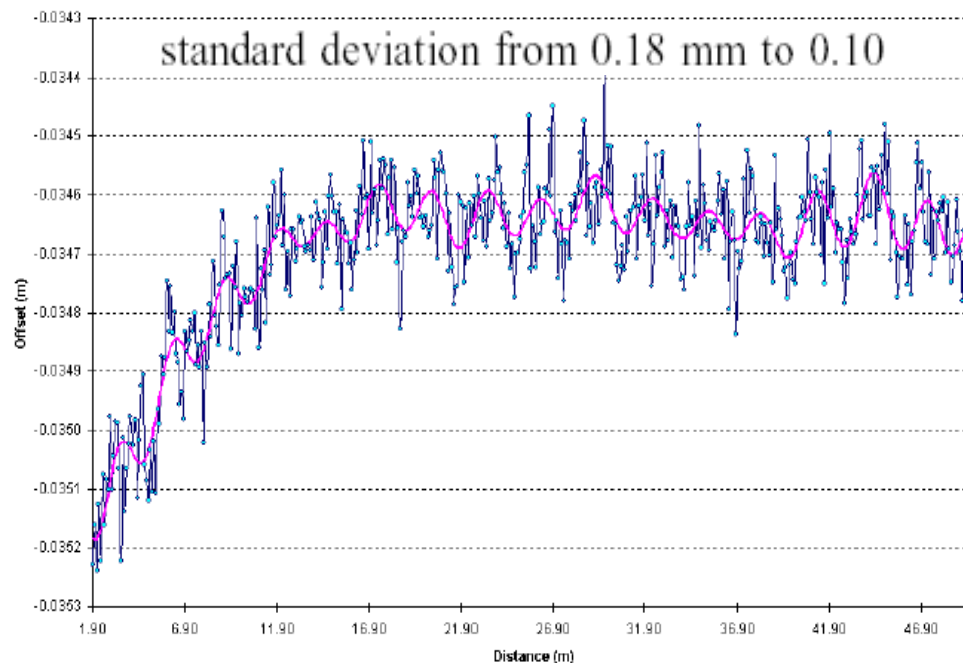
Angles and distances: reciprocal weights

D. Martin

The European Synchrotron Radiation Facility (ESRF)



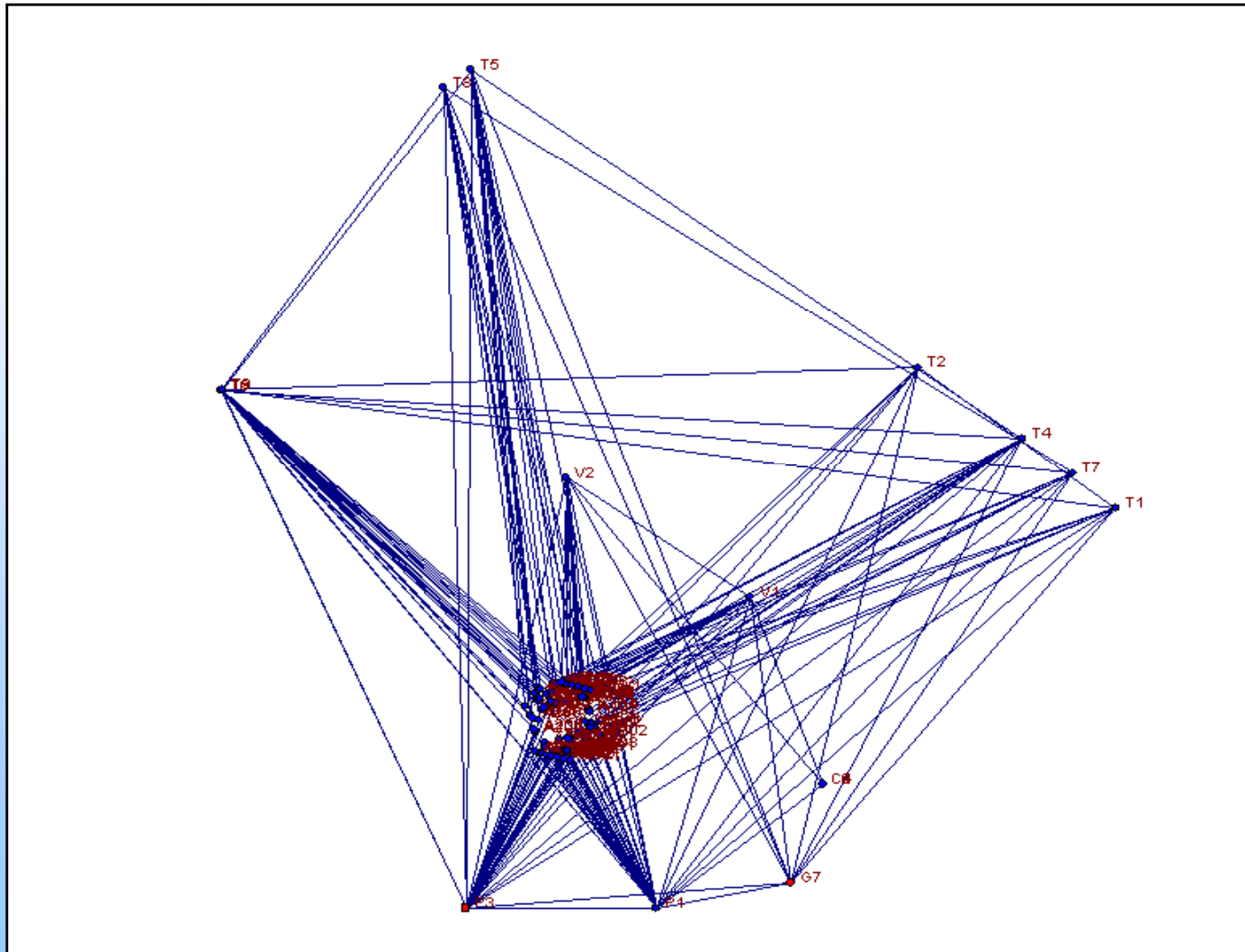
Calibration Results (Mean = -34.69 mm; Standard Deviation = 0.14 mm) and Best Model

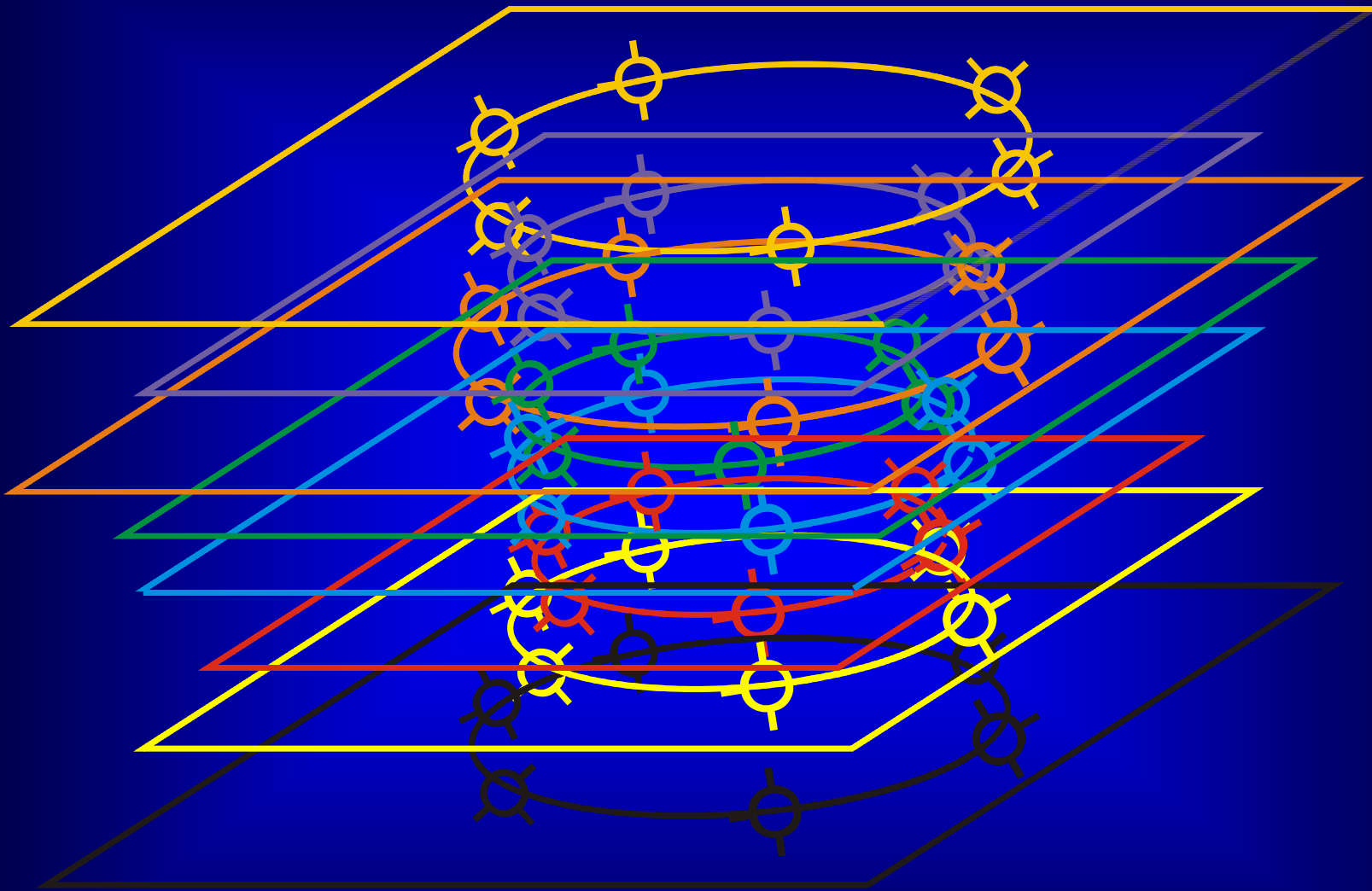


Classical network processing

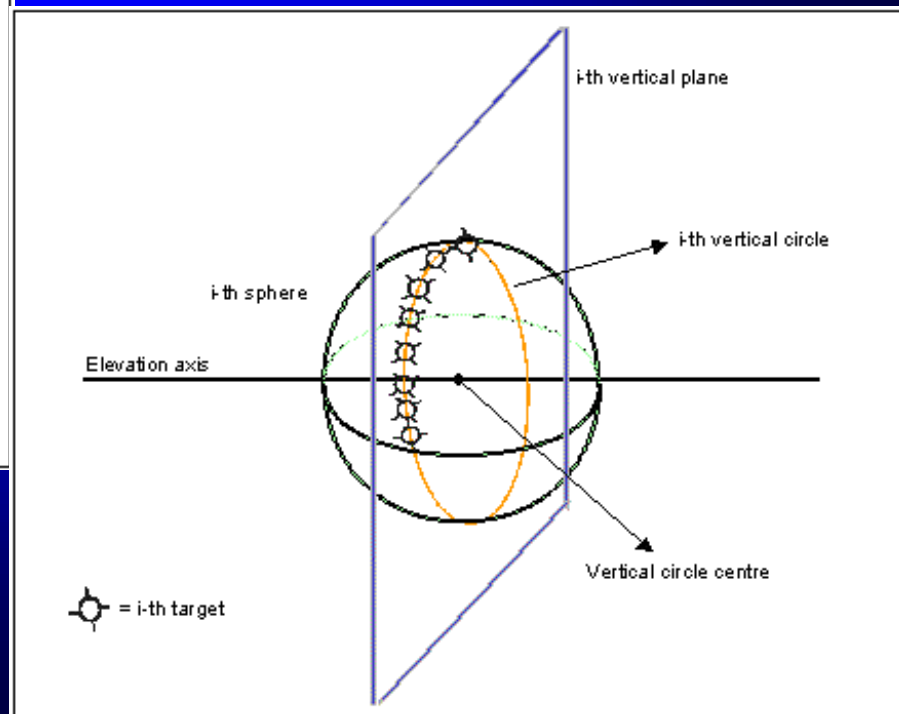
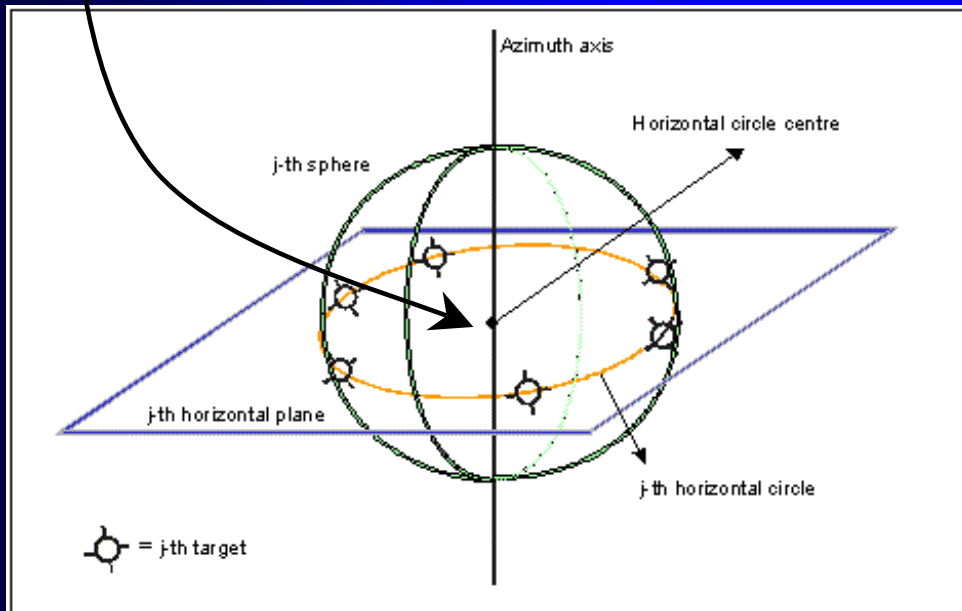
- Using STAR*NET (Starplus software Inc.) least square adjustment software
- Planimetric origin on pillar P3
- Height reference on 3D benchmark G7
- Fixed bearing from P3 to pillar P1

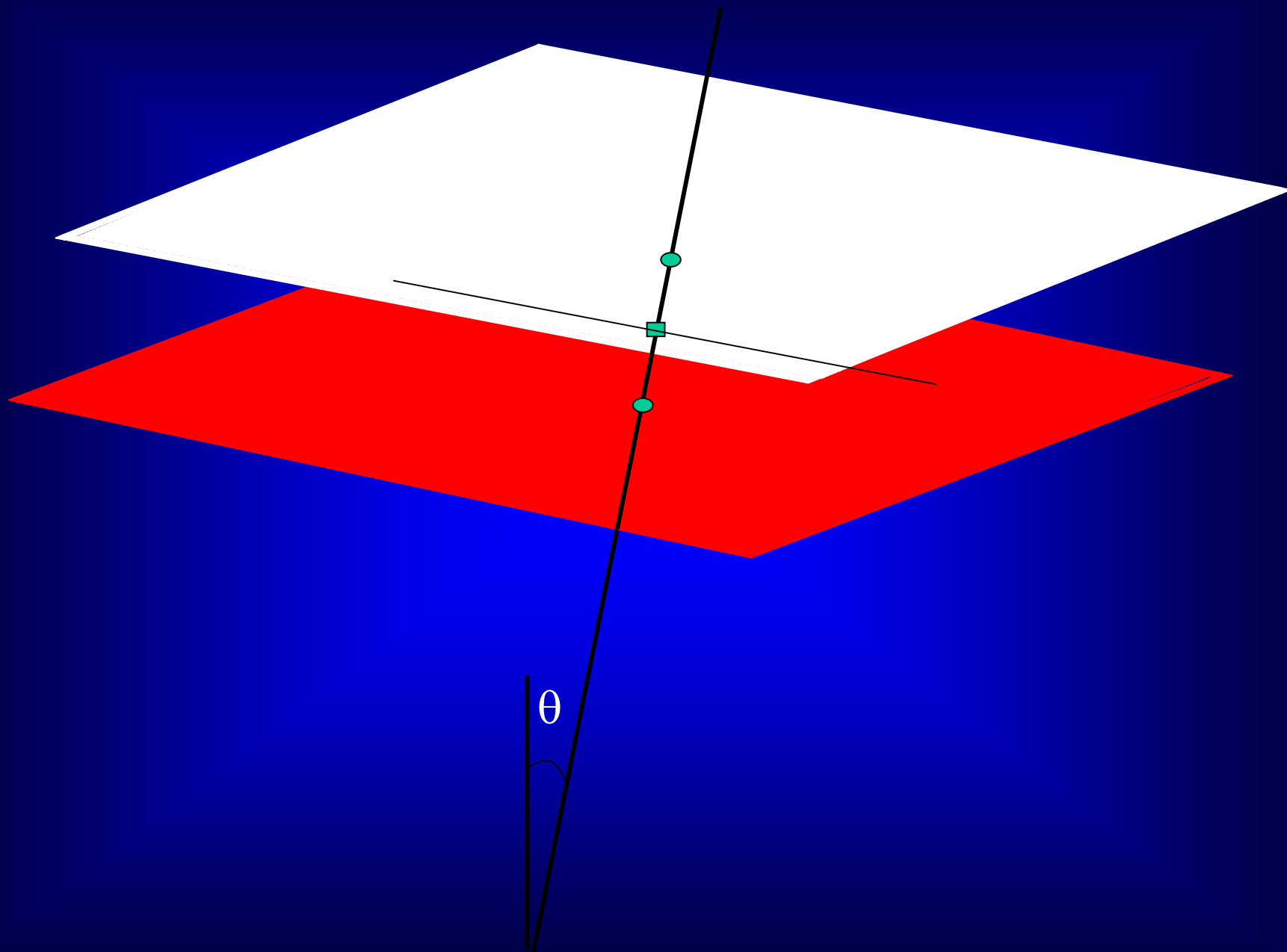
Total ground control network 2002

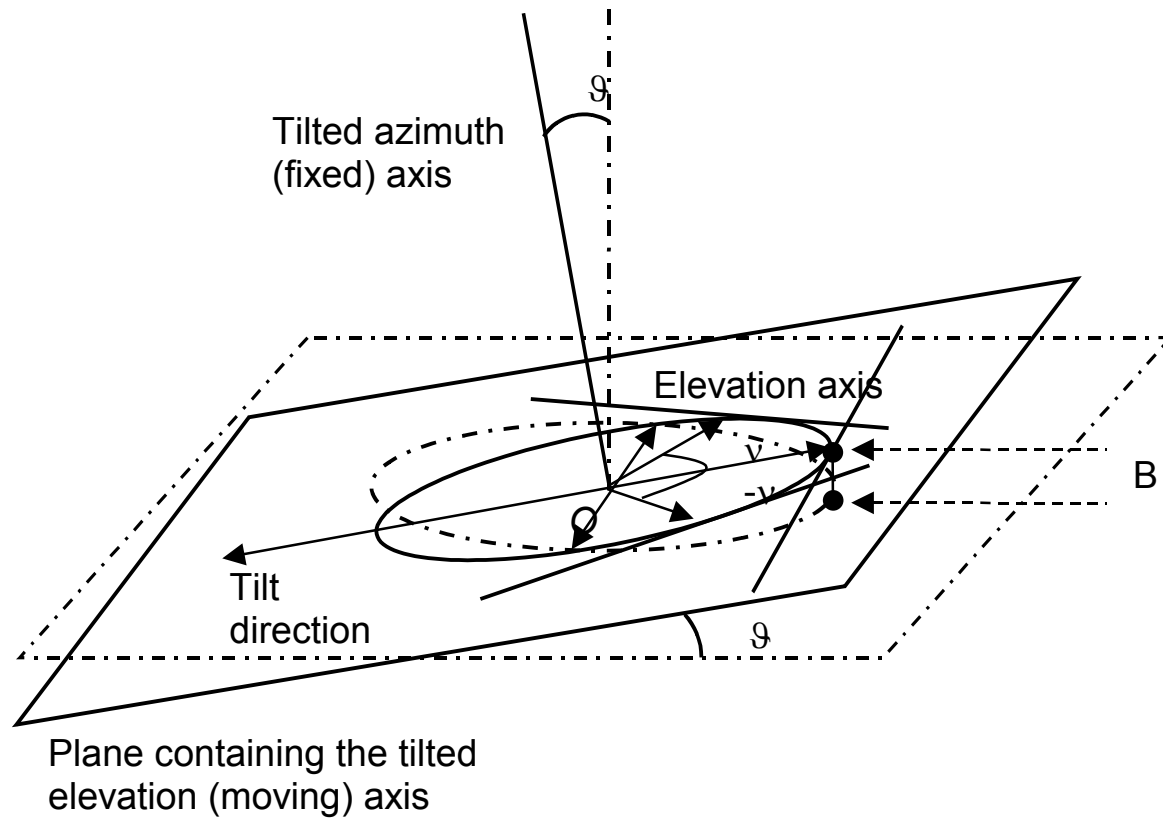




$$c^j : \begin{cases} P^j : a^j x_i^j + b^j y_i^j + c^j z_i^j + d^j = 0 \\ S^j : (x_i^j)^2 + (y_i^j)^2 + (z_i^j)^2 - 2 \cdot (\alpha^j x_i^j + \beta^j y_i^j + \gamma^j z_i^j) + o^j = 0 \end{cases}$$

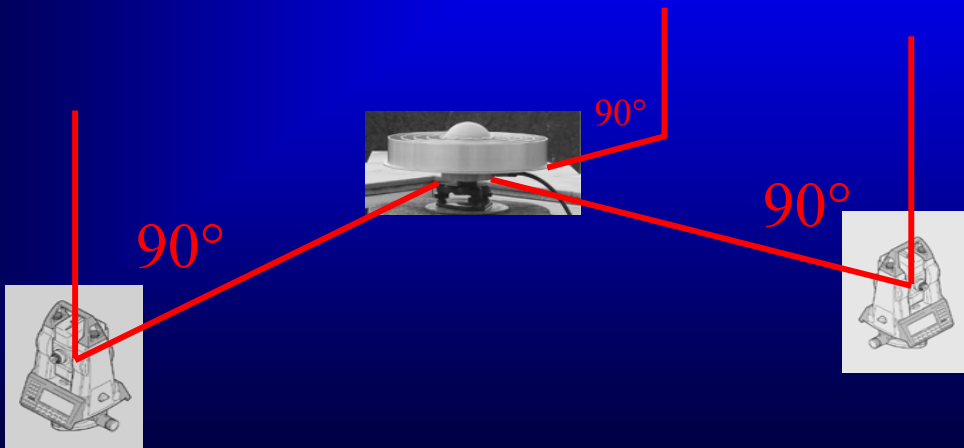
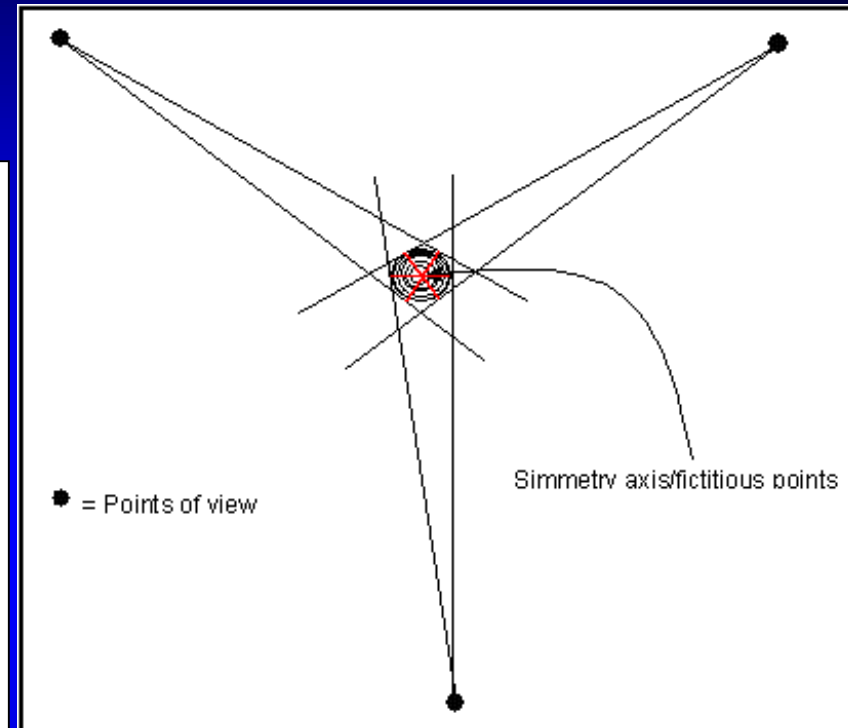
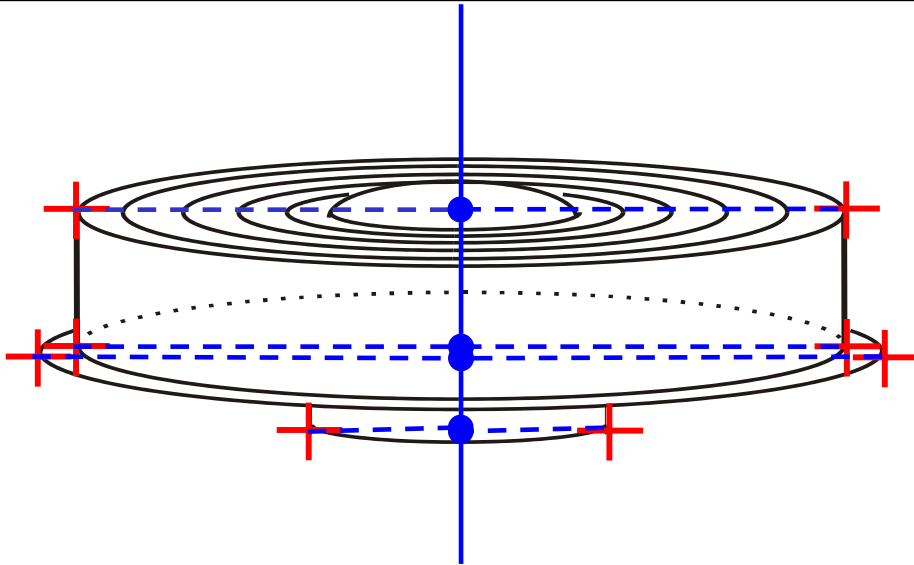






GPS antenna survey approach

Horizontal angles



Vertical angles

VLBI reference point estimated with terrestrial measurements

Survey Year	ITRF2000 (epoch 10/09/02)			Local frame		
	X	Y	Z	X	Y	Z
2000	-	-	-	21.581 ± 0.001	45.534 ± 0.001	17.699 ± 0.001
2001	4461369.876 ± 0.001	919596.931 ± 0.001	4449559.255 ± 0.001	21.5805 ± 0.0004	45.5356 ± 0.0003	17.6995 ± 0.0008
2002	4461369.8769 ± 0.0004	919596.9313 ± 0.0010	4449559.2532 ± 0.0010	21.5825 ± 0.0003	45.5360 ± 0.0002	17.7024 ± 0.0006

%=SNX 1.00

*-----

+FILE/COMMENT

* The DOMES are correct

* Variance factor equal to 1.00

-FILE/COMMENT

*-----

+SITE/ID

*CODE PT ___DOMES___ T ___STATION DESCRIPTION___ APPROX_LON_ APPROX_LAT_ _APP_H_

VLBR A 12711S001

GPSR A 12711M003

-SITE/ID

*-----

+SOLUTION/ESTIMATE

*INDEX	TYPE	CODE	PT	SOLN	_REF_EPOCH_	UNIT	S	ESTIMATED VALUE	_STD_DEV_
1	STAX	VLBR	A	1	0:000:00000	m	2	4.461369979510414E+06	3.53172E-004
2	STAY	VLBR	A	1	0:000:00000	m	2	9.195968254768435E+05	7.98877E-004
3	STAZ	VLBR	A	1	0:000:00000	m	2	4.449559199128945E+06	3.98169E-004
4	STAX	GPSR	A	1	0:000:00000	m	2	4.461400894389587E+06	1.21589E-003
5	STAY	GPSR	A	1	0:000:00000	m	2	9.195934232231564E+05	8.45007E-004
6	STAZ	GPSR	A	1	0:000:00000	m	2	4.449504682171055E+06	8.48266E-004

-SOLUTION/ESTIMATE

*-----

+SOLUTION/MATRIX_ESTIMATE L COVA

*PARA1	PARA2	PARA2+0	PARA2+1	PARA2+2
1	1	1.247302516102714E-07		
2	1	1.070616748207442E-08	6.382049648848917E-07	
3	1	-3.45893878519546E-08	1.286177721140089E-07	1.585386126962561E-07
4	1	1.450773449662466E-08	6.619023700247679E-08	8.041846065194363E-09
4	4	1.478387343400914E-06		
5	1	8.872940924000697E-09	2.818508001119155E-07	6.581914998486441E-08
5	4	3.293477064931050E-09	7.140361834719233E-07	
6	1	-3.79540049408266E-08	6.583918267119025E-08	3.962229159026654E-08
6	4	-4.50003259709083E-08	1.296042716134309E-09	7.195559638398684E-07

-SOLUTION/MATRIX_ESTIMATE L COVA

%ENDSNX

%=SNX 1.00

*-----

+FILE/COMMENT

* The DOMES are correct

* Variance factor equal to 1.00

-FILE/COMMENT

*-----

+SITE/ID

*CODE PT ___DOMES___ T ___STATION DESCRIPTION___ APPROX_LON_ APPROX_LAT_ _APP_H_

VLBR A 12711S001

GPSR A 12711M003

-SITE/ID

*-----

+SOLUTION/ESTIMATE

*INDEX	TYPE	CODE	PT	SOLN	_REF_EPOCH_	UNIT	S	_ESTIMATED VALUE_	_STD_DEV_
1	STAX	VLBR	A	1	0:000:00000	m	2	4.461369978747157E+06	2.67134E-004
2	STAY	VLBR	A	1	0:000:00000	m	2	9.195968255608416E+05	5.44588E-004
3	STAZ	VLBR	A	1	0:000:00000	m	2	4.449559200474912E+06	2.80537E-004
4	STAX	GPSR	A	1	0:000:00000	m	2	4.461400895152843E+06	6.81391E-004
5	STAY	GPSR	A	1	0:000:00000	m	2	9.195934231391583E+05	5.43265E-004
6	STAZ	GPSR	A	1	0:000:00000	m	2	4.449504680825088E+06	7.14008E-004

-SOLUTION/ESTIMATE

*-----

+SOLUTION/MATRIX_ESTIMATE L COVA

*PARA1	PARA2	_PARA2+0_	_PARA2+1_	_PARA2+2_
1	1	7.136055600058919E-08		
2	1	2.715051926328614E-09	2.965758690842930E-07	
3	1	-1.95794692585922E-08	6.082195561979286E-08	7.870072882320828E-08
4	1	1.258598565862185E-08	2.544143821923472E-09	-1.30651184228835E-08
4	4	4.642941241946729E-07		
5	1	3.092006786654302E-09	1.113665739364520E-07	2.422511344148857E-08
5	4	-5.22352882429244E-08	2.951370324747009E-07	
6	1	-1.50134215451420E-08	2.450421396973857E-08	2.347633522844270E-08
6	4	1.762122104338922E-07	-6.11625873270111E-08	5.098075311688250E-07

-SOLUTION/MATRIX_ESTIMATE L COVA

%ENDSNX

Conclusions

- Two high precision total stations are advisable: in order to reduce time of antenna inactivity, and to supply a calibration check of EDM on common distances
- In our survey scheme, distances between points have to be contained in 100-120 m in order to maintain accurate, angular collimation at prisms centre, and distance measurements.
- Constants of reflectors have to be evaluated before in laboratory, and high accuracy accessories are required
- Local survey has met high precision requirements
- Full covariance and SINEX were produced