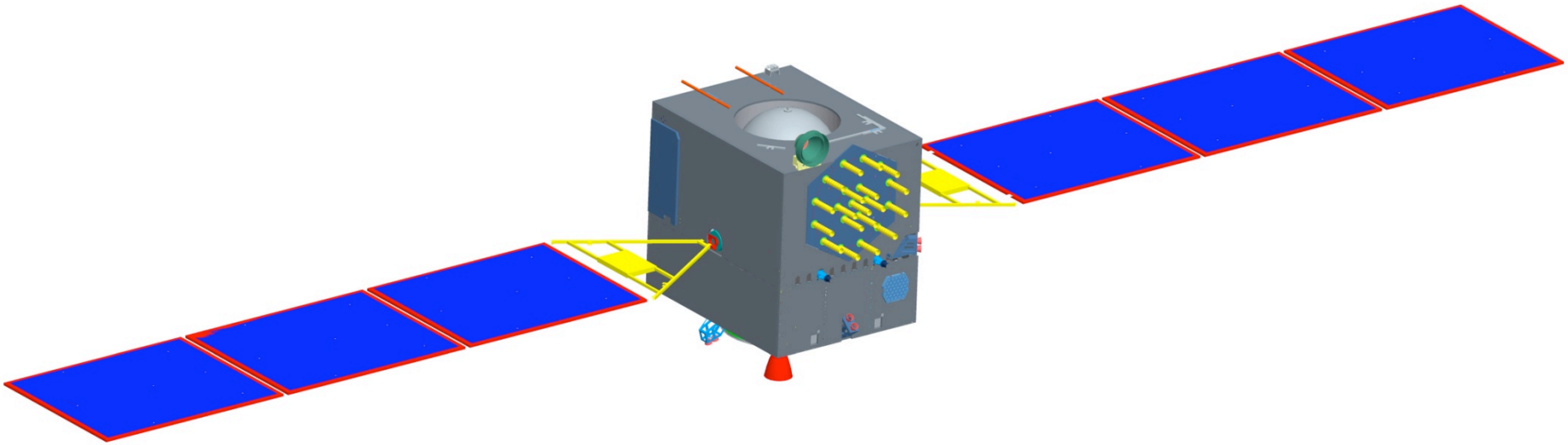
# Laser Retro-reflector Arrays on the Compass Satellites

Chen WanZhen, Yang FuMin,
Wang YuanMing, Li Pu

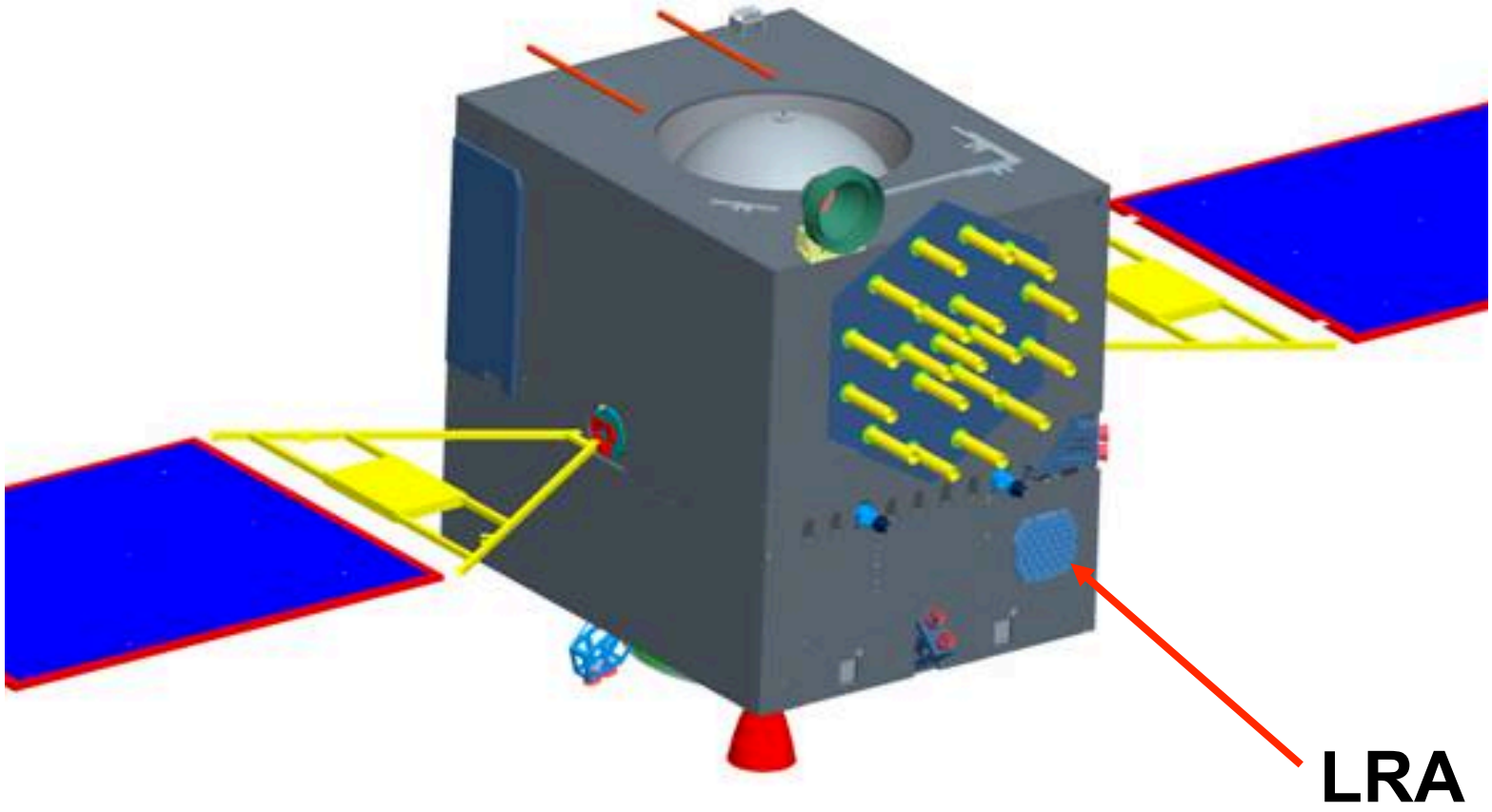
Shanghai Observatory, Chinese Academy of Sciences

Yangfm@shao.ac.cn

- “COMPASS” (or “BeiDou”) is the regional satellite navigation system in China, which will cover the most areas of the East Asia region, and expect to be operational by 2011.
- The Compass constellation will consist of 12 satellites all equipped with LRA:
  - ✓ GEO 5
  - ✓ IGSO 3
  - ✓ MEO 4



# Drawing of COMPASS-M1 Navigation Satellite




Location of the LRA on COMPASS-M1

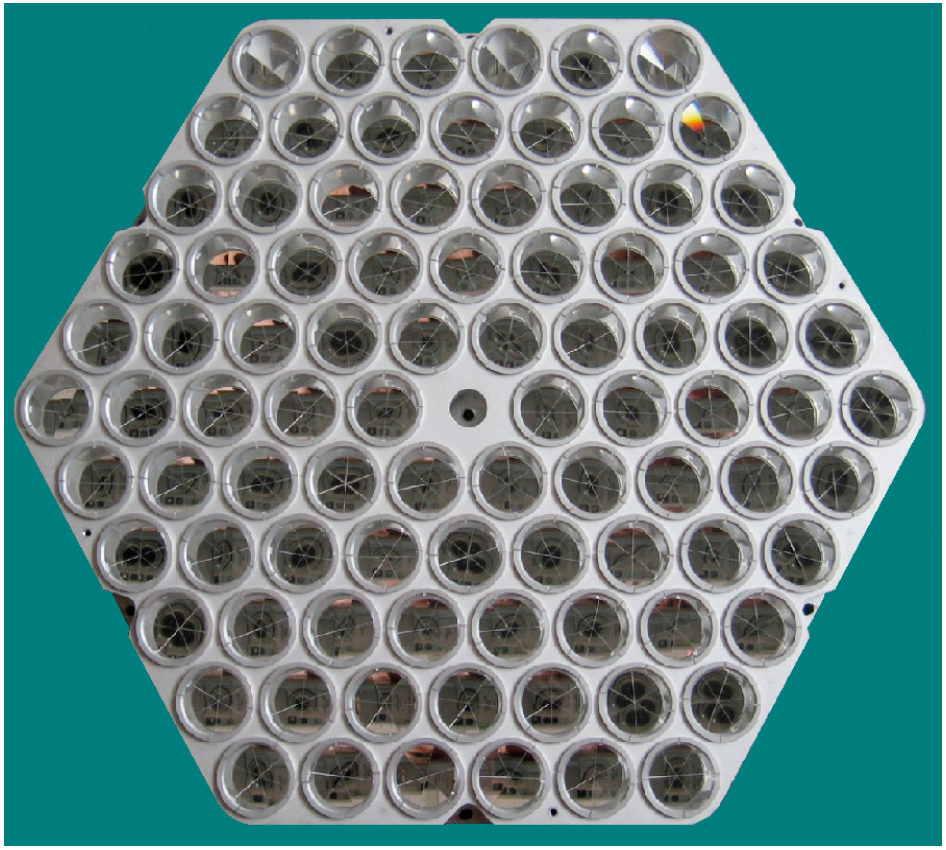
| | |
|---|---|
| Size | 31.6×28 cm |
| Diameter of corner cube | 33mm |
| Number | 42 |
| Reflective area | 360cm$^2$ |
| Material | fused silica |
| Weight | 2.45 kg |

The corner cubes are uncoated both front and back surfaces

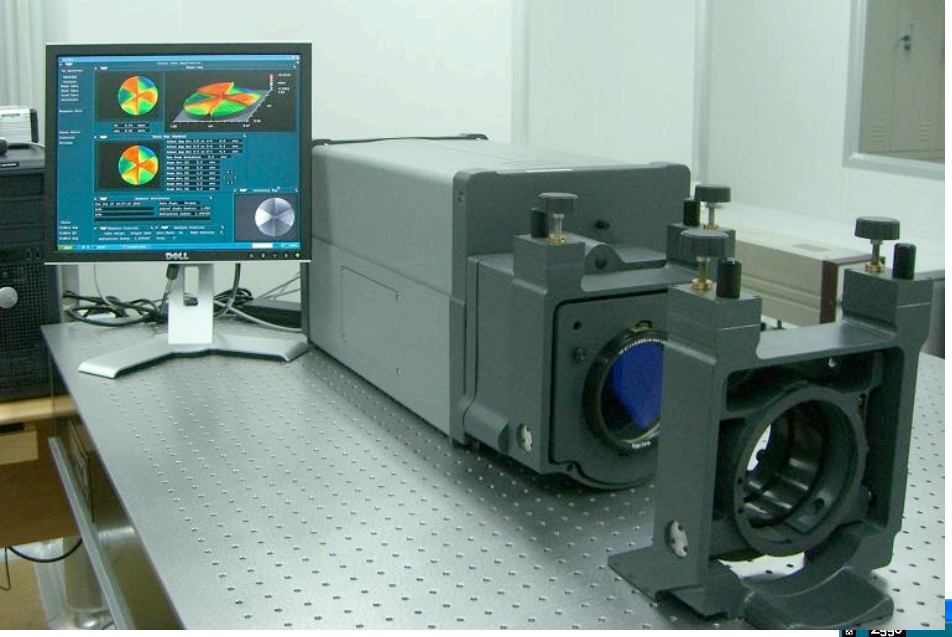
# The LRA on Compass-M1 (MEO)

| | |
|---|---|
| Size | 49×43cm |
| Diameter of corner cube | 33mm |
| Number | 90 |
| Reflective area | 770cm$^2$ |
| Material | Fused silica |
| Weight | 5.0 kg |

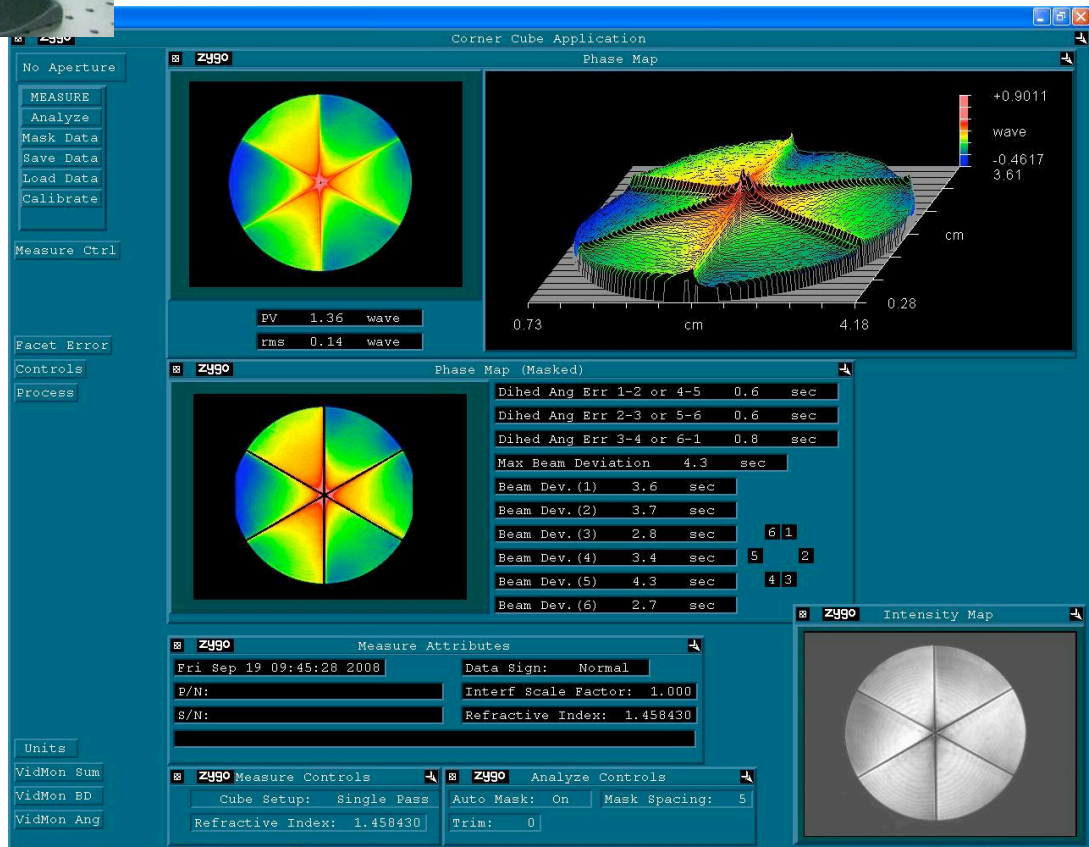
The corner cubes are uncoated both front and back surfaces



# The LRA on Compass GEO/IGSO



# Testing of LRA's optical performance with ZYGO interferometer



# Environment testing of LRA

# Cross section, range and signal for different satellites

## By David Arnold*

| Sat. | Cross section | Range (0 deg.) | Range** 4 | Signal strength | Range (45 deg.) | Range** 4 | Signal strength |
|---|---|---|---|---|---|---|---|
| Lageos | 15 | 5.8 | 1 | 1.000 | 6.8 | 1 | 1.000 |
| Etalon | 55 | 19.0 | 115 | .032 | 20.5 | 82 | .044 |
| GPS | 19 | 20.0 | 141 | .009 | 21.5 | 100 | .012 |
| GIOVE-A | 45 | 23.9 | 288 | .010 | 25.4 | 195 | .015 |
| Glonass | 80 | 19.0 | 115 | .046 | 20.5 | 82 | .065 |
| Compass | 80 | 21.0 | 189 | .028 | 23.0 | 131 | .041 |
| ETS-8 | 140 | 36.0 | 1484 | .0063 | 37.6 | 935 | .010 |

* Private communication

# Parameters of LRA on satellites*

| Satellite | Cube Number | Diameter (inch) | Coating | Dihedral Offset | Vendor |
|---|---|---|---|---|---|
| Lageos1 | 422 | 1.5 | uncoat | 1.25 | Perkin-Elmer |
| Lageos2 | 422 | 1.5 | uncoat | 1.25 | Zygo |
| Etalon | 2140 | 1.06 | coat | - | IPIE |
| GPS | 32 | 1.06 | coat | - | IPIE |
| GIOVE-A | 76 | 1.06 | coat | - | IPIE |
| Glonass | 132 | 1.06 | coat | - | IPIE |
| Compass | 42 | 1.3 | uncoat | 0.6 | SHAO |
| ETS-8 | 36 | 1.6 | uncoat | 0.5 | ITE |

* From David Arnold, private communication

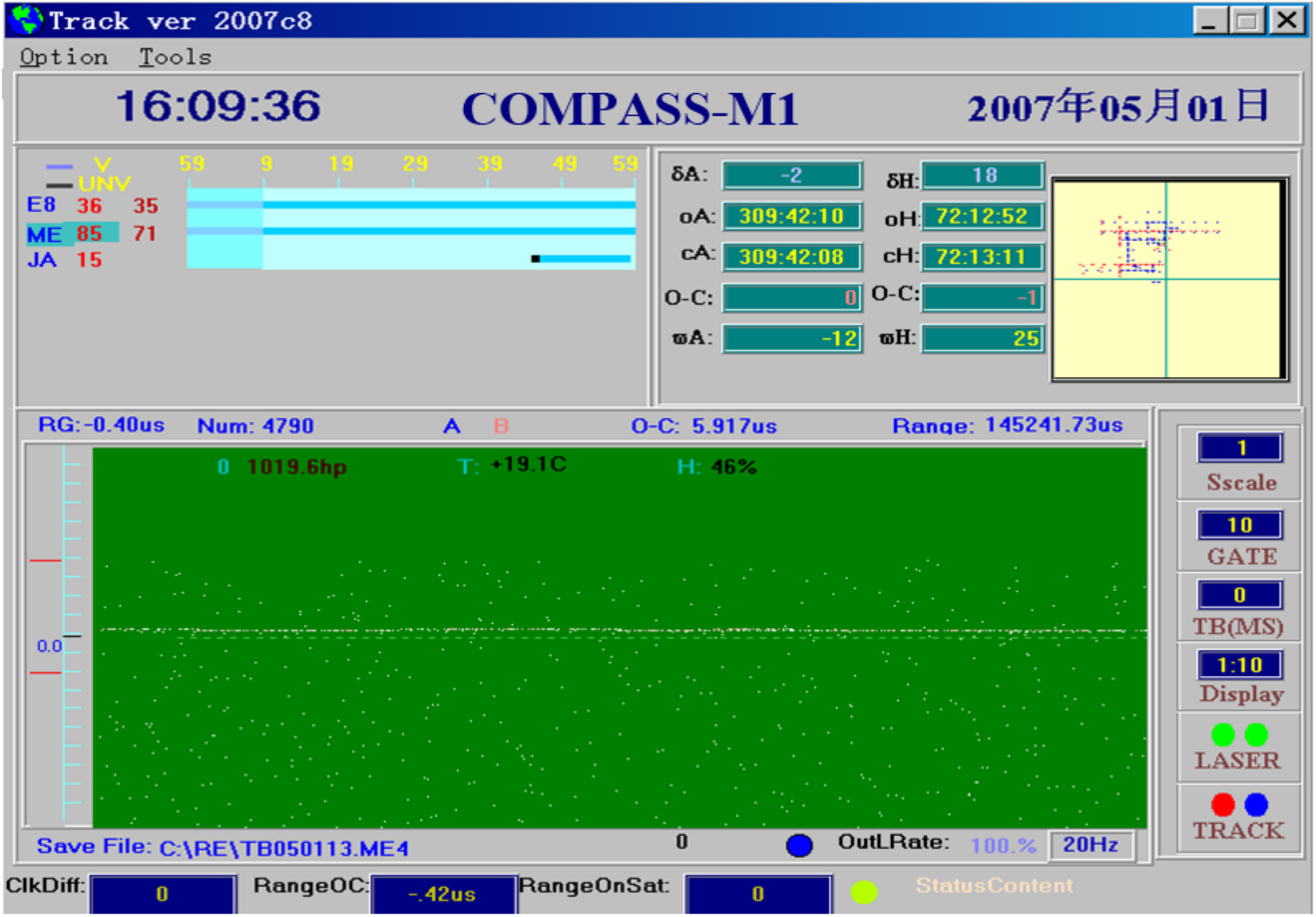
# Manufacturer of LRAs

- ITE ITE, Inc., Laurel, MD, USA
- ZYGO Zygo Corp., Middlefield, CT, USA
- IPIE Institute for Precision Instrument Engineering, Russia
- Perkin-Elmer Headquarters-- Waltham, MA, USA
- SHAO Shanghai Astronomical Observatory, China. The fused silica was made by the Shanghai LengGuang Co., China

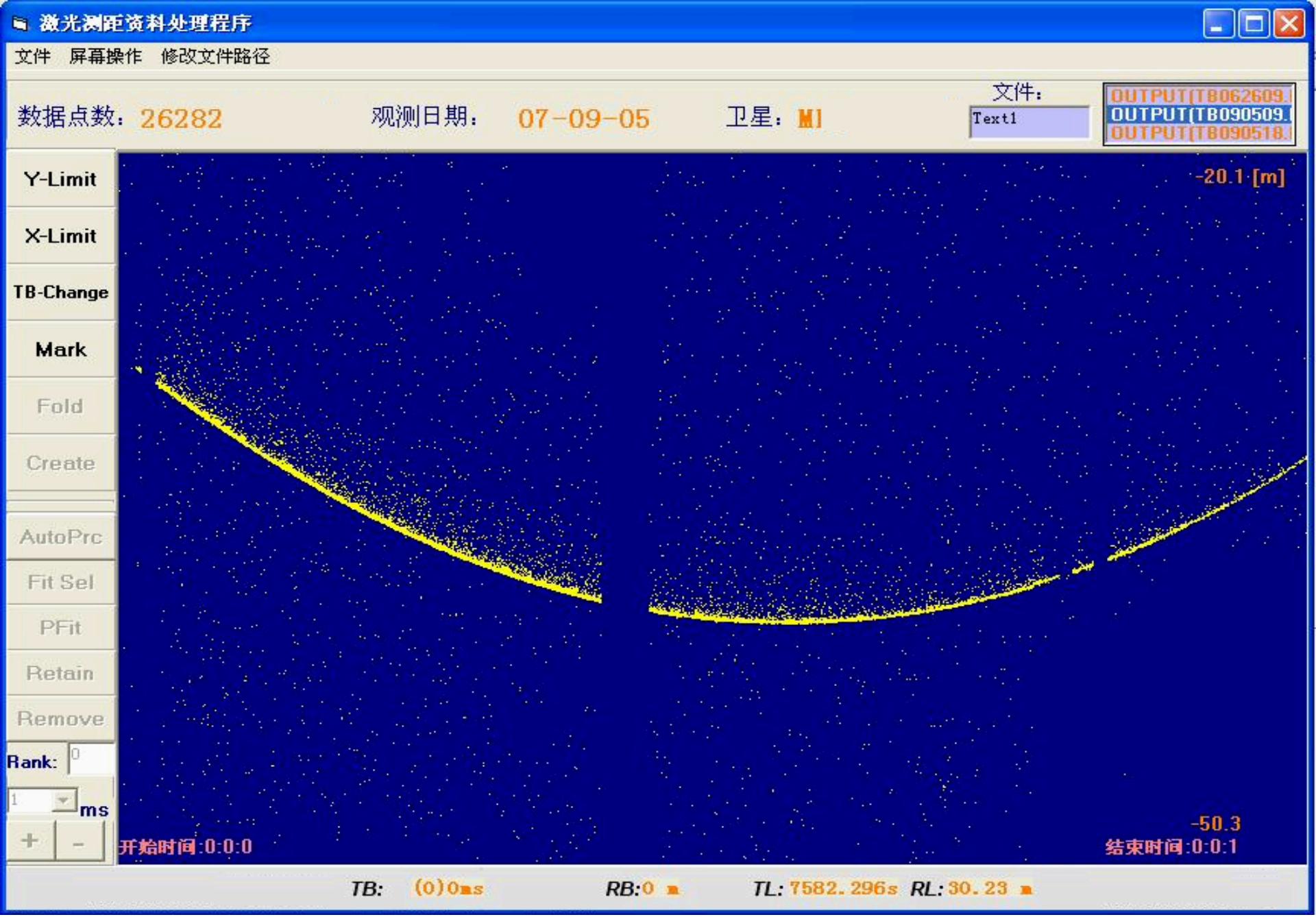
# New Laser and Transmitter for Compass-M1 ranging at Changchun

- The new laser was loaned from the NCRIEO in Beijing
  - Active-active mode locked Nd:YAG laser
  - 100-150mJ in 532nm, 250ps, 20Hz
  - 10ns firing jitter
- New Coude mirrors
- New 210mm diameter transmitting telescope

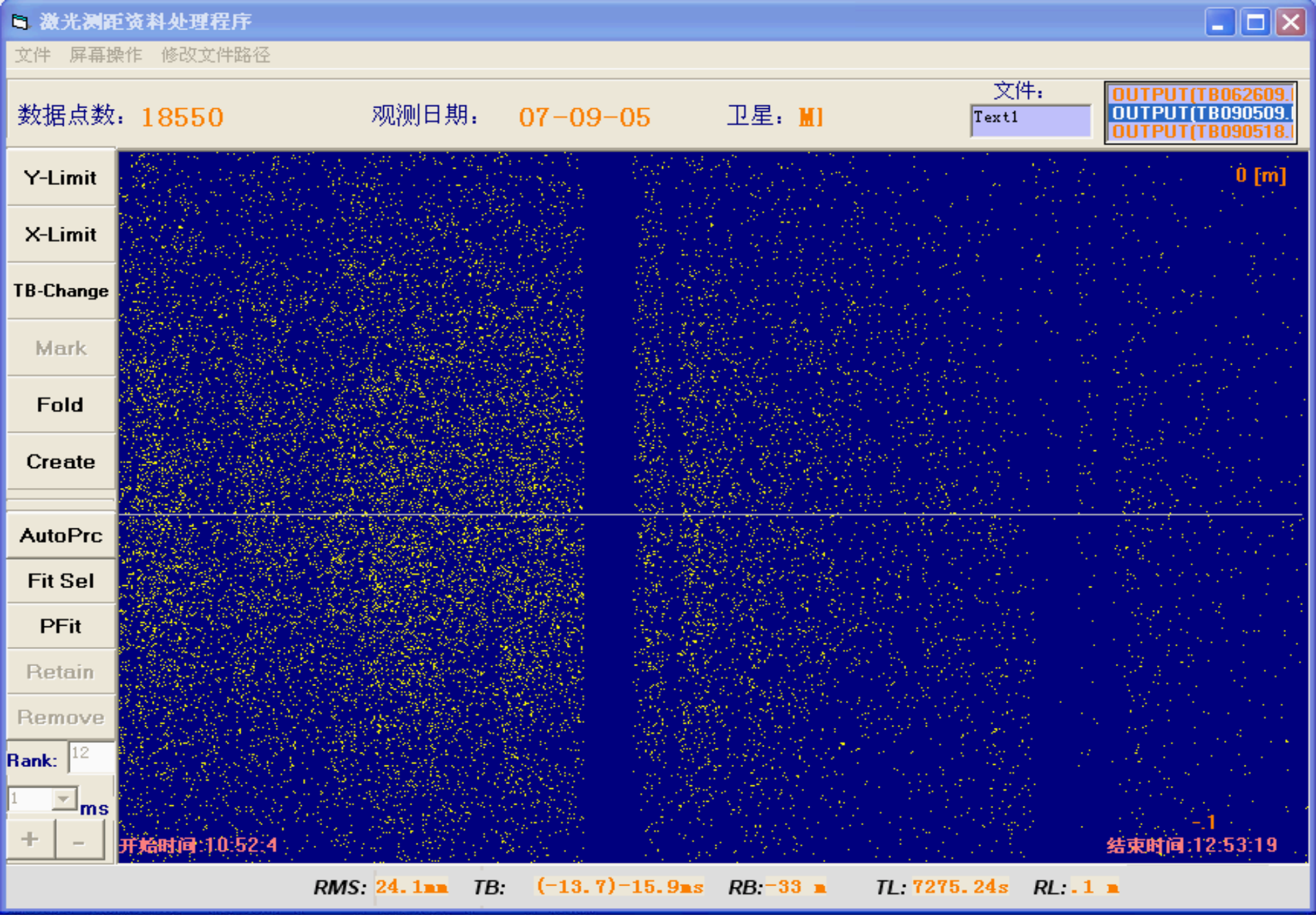
  10 aresec laser beam divergency




Real-time display for Compass-M1 tracking




# Range residuals of Compass-M1 on Sept. 5, 2007




# Range residuals after data fitting

# Conclusions

- The parameters of 12 sets of COMPASS LRA arrays are introduced in this paper
- The performance of the Compass M1 LRA is excellent. It is shown in the ranging experiment that the returned signal strength from the Compass-M1 LRA is much stronger than those from GPS-35/36 and GIOVE-A
- The uncoated corner cubes are fine for high orbit satellites

# Thank you

# Active-active mode-locked Nd:YAG laser

## 100-150mJ (532nm), 250ps,20Hz

# Changchun SLR Telescope


# Changchun SLR Control Room