

# Satellite Laser Ranging Portable Calibration Standard Missions 1997-2002

Geophysical Research Abstracts, Vol. 5, 14013, 2003

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## **SATELLITE LASER RANGING PORTABLE CALIBRATION STANDARD MISSIONS 1997-2002**

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The recent requirement of the Satellite Laser Ranging SLR technique is to reach the accuracy of a millimeter. This requires keeping all the system biases on the sub millimeter level. The Portable Calibration Standard is a global reference for Satellite Laser Ranging systems biases identification and evaluation. It consists of the Pico Event Timer P-PET, meteorological station, epoch and frequency time base, set of reference retroreflectors and the control / data processing software package. The P-PET is compact, stable and easy to re-allocate within days. Its properties are appropriate for calibration standard purposes: the timing resolution is 1.2 psec, 2.5 psec per channel timing jitter, the temporal stability is less than 0.5 psec per hour and below 0.5 psec per Kelvin. The key feature of the timing system is its long term stability: no adjustments and settings are needed. Before we could start the global SLR network calibration, we had to succeed with the calibration missions at several SLR stations in Austria, Germany, Switzerland, United Kingdom, China and Chile. This enabled us to understand the feasibility of using the Pico Event Timer P-PET. Summarizing the results: the ranging precision to ground target is 1-3 millimeters, to satellites is 3-7 millimeters rms, the Calibration Standard demonstrated its capability to identify the SLR system range and time biases at the one-millimeter level. These results might serve as a background to the proposed 6th Framework programme EU EUROLAS CALNet.

K. Hamal et al, EGS-AGU-EUG Joint Assembly, Nice, April 2003

# Satellite laser ranging Portable Calibration Standard missions 1997-2002

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*presented at EGS-AGU-EUG Joint Assembly, Nice, April 2003*

<http://kfe.fjfi.cvut.cz/~blazej/en/res/pub/nice2003.pdf>

# GOALS

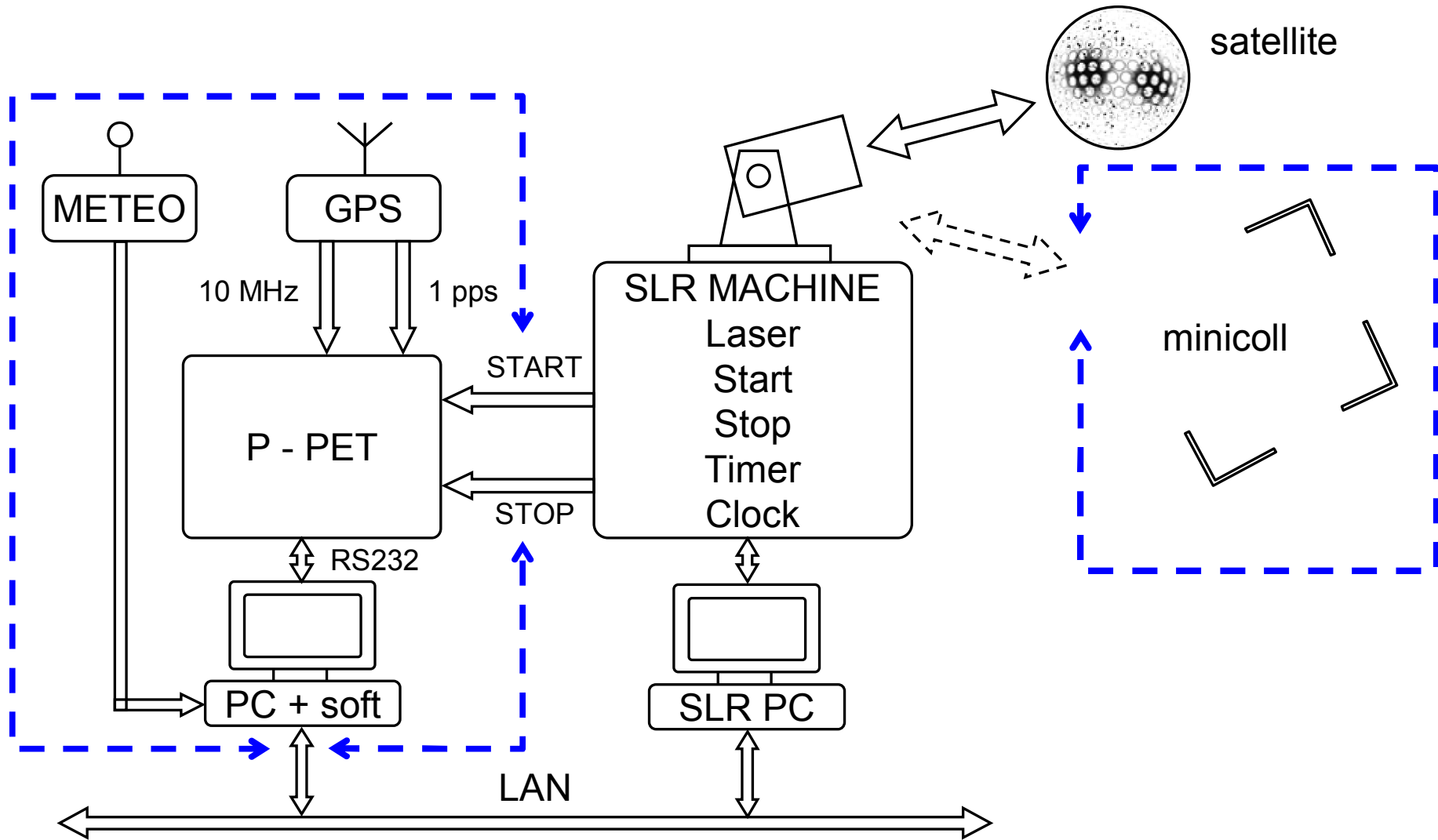
- Satellite Laser Ranging systems diagnostics
- Precision improvement:
  - detection
  - timing
- Bias sources identification:
  - epoch and time interval
  - data acquisition and processing
  - calibration and ground survey
  - operational procedures
  - radio frequency interference
  - other source(s)

# PHILOSOPHY

- high degree of **redundancy**
- based on top **quality and certified** hardware
- **independent** on SLR under test
- operated **in parallel to existing SLR**
- **easy to re-locate** (personal luggage)
- fast and easy to install and operate

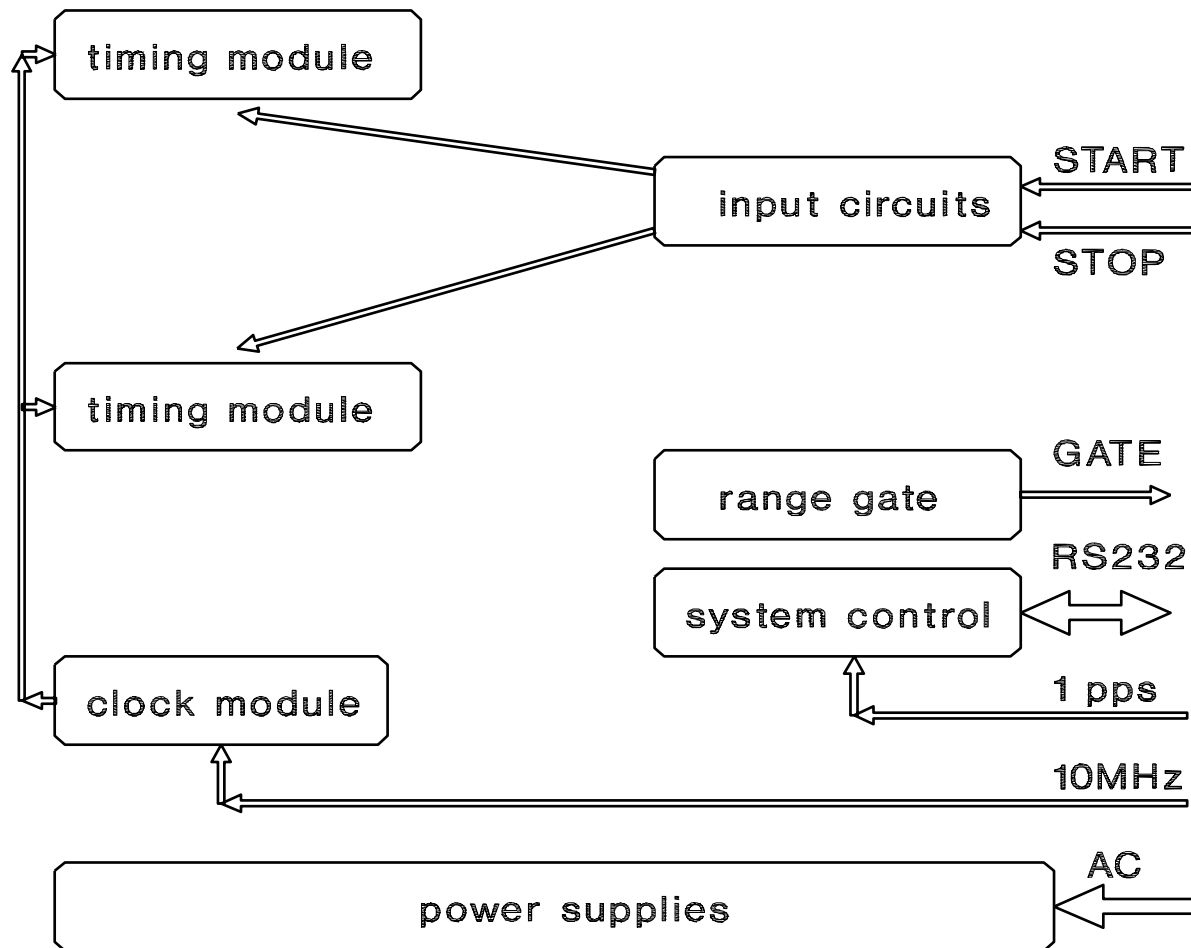
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# PORTABLE CALIBRATION STANDARD



# Satellite Laser Ranging Portable Calibration Standard Missions 1997-2002

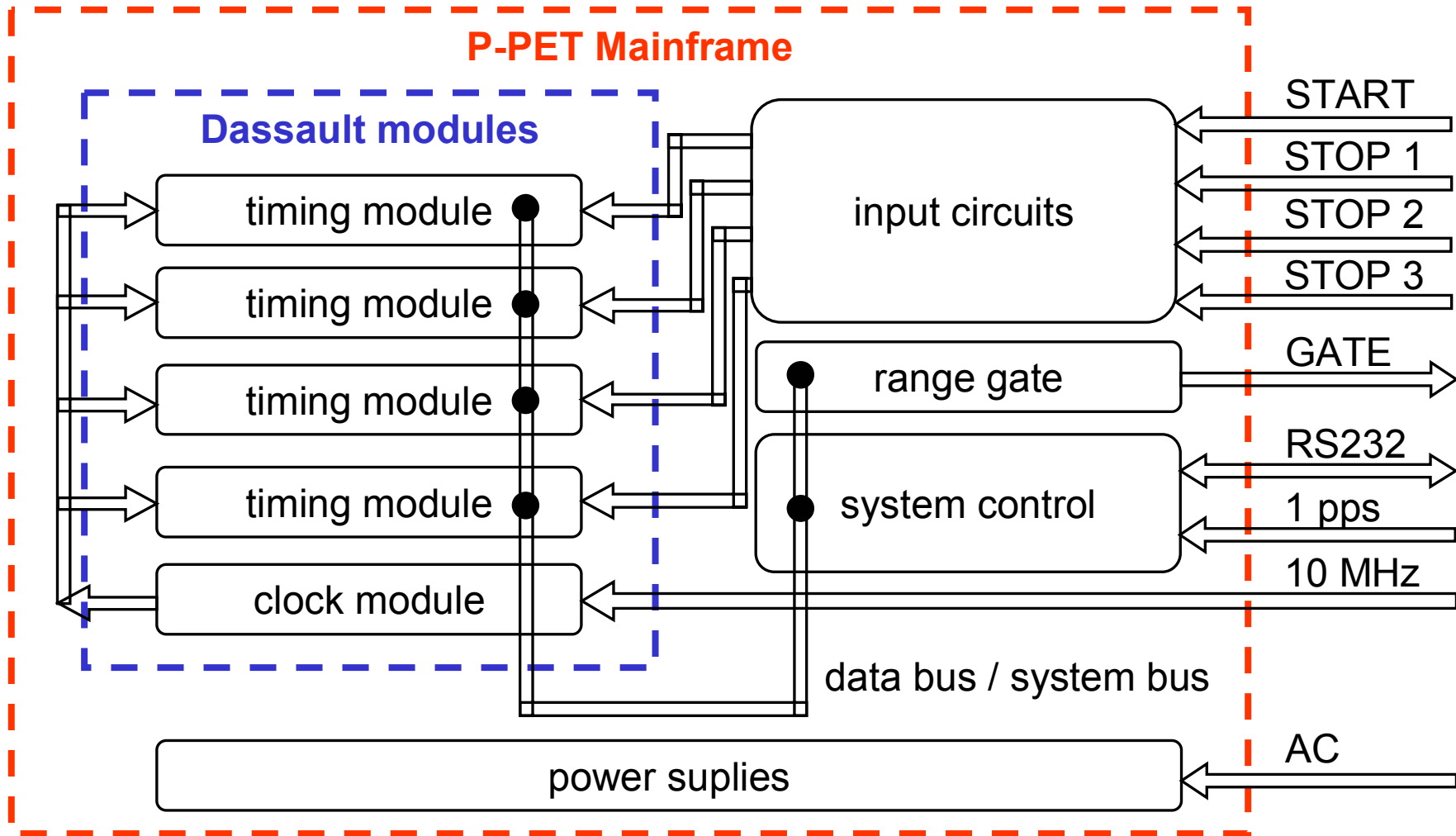
## Portable - Picosecond Event Timer P-PET BLOCK SCHEME



K.Hamal,I.Prochazka, EurOpto, London 1997

K. Hamal et al, EGS-AGU-EUG Joint Assembly, Nice, April 2003

# PORTABLE - PICO EVENT TIMER P-PET



orig: K. Hamal, I. Procházka, EurOpto, London, 1997  
K. Hamal et al, EGS-AGU-EUG Joint Assembly, Nice, April 2003

# P-PET PARAMETERS

## Upgrade Summary

London '97 => **Wash 2002**

• timing resolution	1.2 ps	
• timing jitter / channel	5 ps	<b>2.5 ps</b>
• non-linearity / channel	< 5 ps (spec)	<b>&lt; 2.5 ps (meas)</b>
• temperature drift	< 0.7 ps/K	<b>&lt; 0.53 ps/K</b>
• adjustment	NO	
• temporal stability	$\pm 1.0$ ps/hr	<b><math>\pm 0.45</math> ps/hr</b>
• max. repetition rate	30 Hz	<b>100 Hz, 2MHz sampl</b>
• No. of channels	2(4)	
• interface	RS232	
• mass transport	32 kg	



## PORTABLE CALIBRATION STANDARD MISSIONS

Prague	1997	development
Graz	97/98/99	high precision SLR, stability comparison to counter cluster
WLRS Wettzell	97/99	t/r biases, low jitter, stability
TIGO Wettzell	1998	TW, t/r biases, low jitter, stability
Zimmerwald	1998	TW, t/r biases, low jitter, stability
Herstmonceux	1998	counters linearity
Shanghai	2001	t/r biases, low jitter, survey, operation procedures HP5370B counter linearity
Potsdam	2001	low jitter, SR620 counters linearity
Prague	2002	P-PET upgrade

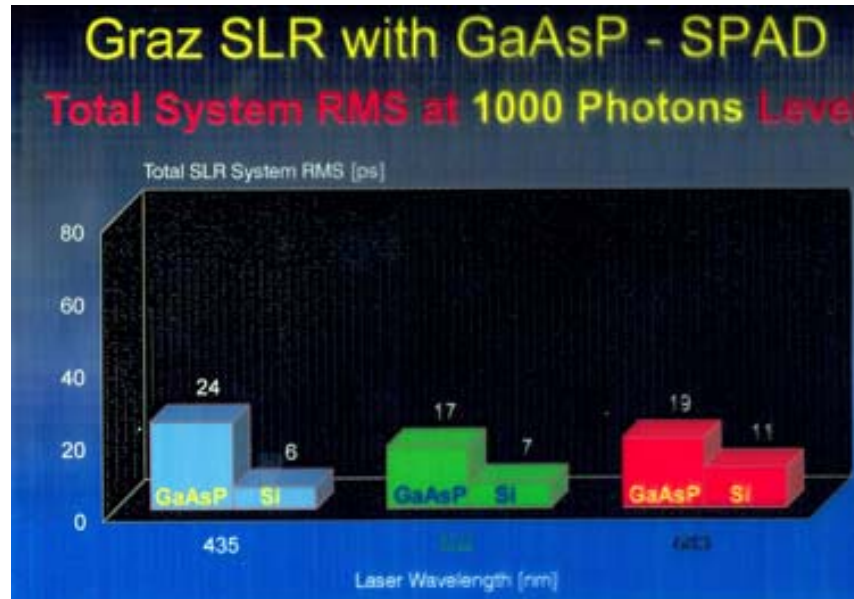
# Satellite Laser Ranging Portable Calibration Standard Missions 1997-2002

Portable Calibration Standard for SLR Capabilities

Pico Event Timer  
Portable Calibration Standard

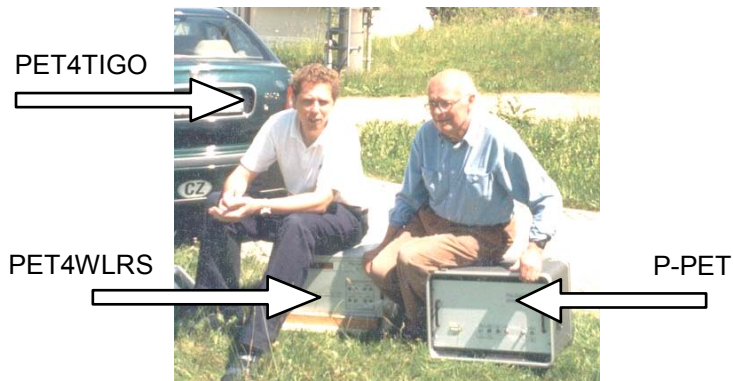


K. Hamal, I. Procházka, EurOpto, London 1997



SLR Portable Calibration Standard Mission Review

P-PET Mission, WLRs & TIGO, Wettzell 1998  
worldwide maximum P-PET density per m<sup>2</sup>



K. Hamal, I. Prochazka,  
Washington 2002

Satellite Laser Ranging Portable Calibration Standard Missions 1997-2002

TIGO installation, Concepcion, Chile, 2002

S.Riepfl et al, 13h WLR, Washington, Nov. 2002



K. Hamal et al, EGS-AGU-EUG Joint Assembly, Nice, April 2003

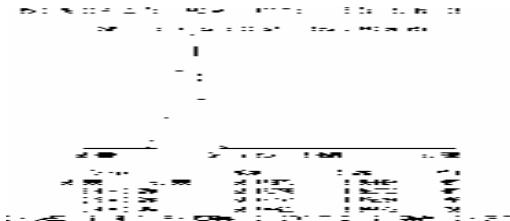
K. Hamal et al, EGS-AGU-EUG Joint Assembly, Nice, April 2003

# Satellite Laser Ranging Portable Calibration Standard Missions 1997-2002

SLR Portable Calibration Standard Mission Review  
 Zimmerwald, 24hour Mission, May 27- 28, 1998  
 Two wavelength ranging

Original station setup 150 psec

After system re-cabling and detectors tuning  
 SLR system 120 psec  
 P- PET timing 76 psec @ red  
 58 psec @ blue



K. Hamal, I. Prochazka, Washington 2002

SLR Portable Calibration Standard Mission Review  
 P-PET Mission, Shanghai, August 2001  
 Personal Luggage Transportation



Shanghai Observatory SLR



Lufthansa Check-in

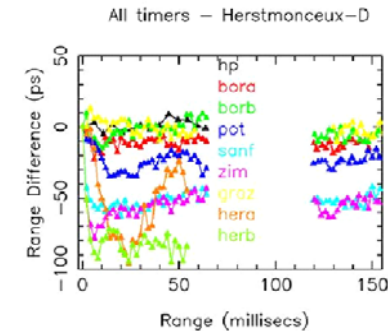
K. Hamal, I. Prochazka, Washington 2002

Satellite Laser Ranging Portable Calibration Standard Missions 1997-2002

## RANGING COUNTERS COMPARISON TO P-PET

P. Gibs, Herstmonceux, 2002

Shown here is a summary plot of all the devices.



K. Hamal et al, EGS-AGU-EUG Joint Assembly, Nice, April 2003

Satellite Laser Ranging Portable Calibration Standard Missions 1997-2002

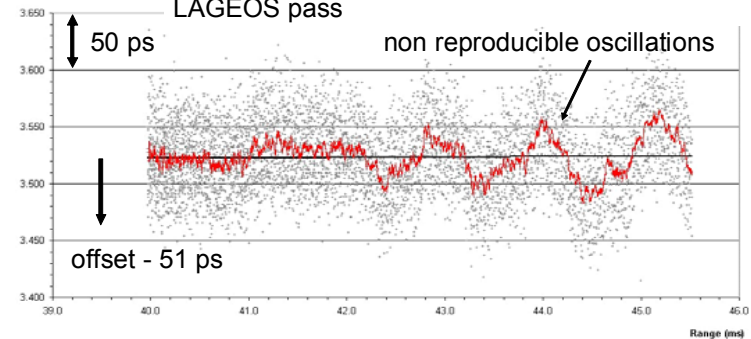
## SR620 / P-PET COUNTER LINEARITY

R. Neubert, L. Grunwald, Potsdam, September 2001

SR620 - P-PET (ms)

Counter s/n 1014 (in routine use)

LAGEOS pass



K. Hamal et al, EGS-AGU-EUG Joint Assembly, Nice, April 2003

K. Hamal et al, EGS-AGU-EUG Joint Assembly, Nice, April 2003

Satellite Laser Ranging Portable Calibration Standard Missions 1997-2002

# ILRS NETWORK TIME OF FLIGHT DEVICES

Van Husson, Loyal Stuart, 13th WLR, Washington, Nov. 2002

Manufacturer	Curent Model	Year	Approach	Resolution (ps)	Jitter (ps)	Linearity (ps)	Stability [ps/K]	Stability [ps/hour]	Max. repetition rate	Max. TOF (Secs)
SR	620	1988	Interval	4	22	50	5		100	1000
HP	5370B	1982	Interval	20	35	20			10	10
Latvian Univ.	A013a	2002	Interval	10	20	2		2	80	0.209
Ortec	TD811	<1980	Event	100			40			N.A.
PESO Cons.	PET4/TIGO	1999	Event	1.2	3.5	3	<0.3	<0.5	>100	N.A.
EOS	MRC5 V.4	1998	Event	2	10	1		1	1000	N.A.
HTSI	MLRO	1998	Event	0.5	<2			0.5	2000	N.A.

# SLR PRECISION DISCREPANCY

## Matera, Graz

Contributor	Precision
Ranging Machine (calibration)	1 mm
Atmosphere	
Satellite (sphere)	0 mm
	<hr/>
r.s.s.	1 mm
Measured SLR	2 - 3 mm
Not identified contributors	~ 2 mm

# RESULTS

## Calibration Ranging Biases

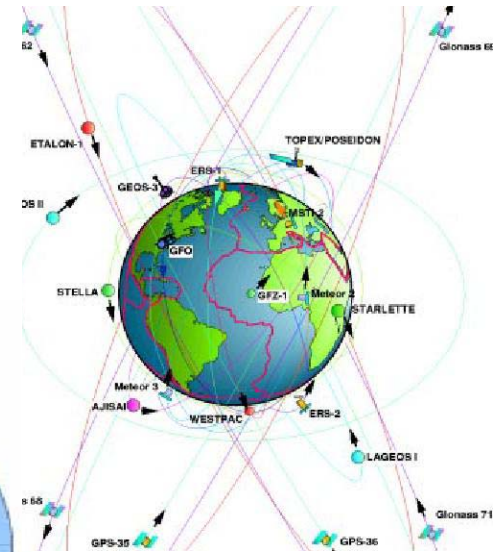
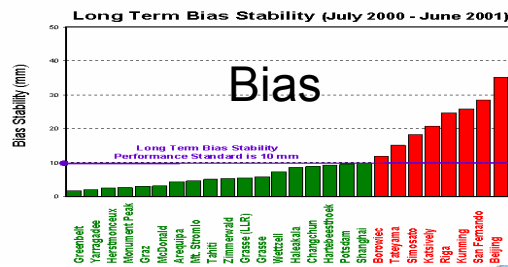
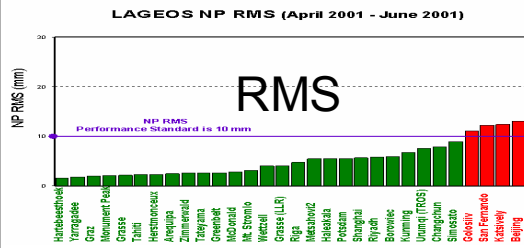
SLR site	range bias	time bias
CRL Tokyo, 1997	13 mm	400 nsec
Graz, 1997	< 1 mm	< 50 nsec
TIGO Wettzell, 1998	1 mm	< 50 nsec
Shanghai, 2001	< 3 mm	< 50 nsec

## CONCLUSION

- Portable Calibration Standard based on a Pico Event Timer is a powerful tool to identify error sources in the SLR “ranging machine”
- analysis                      precision  
   range bias  
   time bias
- the entire system is        compact,  
   easy to transport,  
   user friendly
- the calibration mission    one week time slot

# Satellite Laser Ranging Portable Calibration Standard Missions 1997-2002

## Toward Millimeter Accuracy



DATA USERS

K. Hamal et al, EGS-AGU-EUG Joint Assembly, Nice, April 2003



# Satellite Laser Ranging Portable Calibration Standard Missions 1997-2002

## EXPRESSION OF INTEREST

### Integrated Project

## European Laser Ranging Precise Calibration and Orbit Evaluation Network (EUROLAS CALNet)

Prepared by

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 Werner Gurtner, Astronomic Institute, University of Berne (AIUB), Switzerland  
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 Wolfgang Seemüller, Deutsches Geodätisches Forschungsinstitut (DGFI), Germany

This Expression of Interest was submitted in response to Call B01.FP6.2002

Annex 3

Update 2 May 2002

		EUROPEAN COMMISSION		EXPRESSING OF INTEREST TO IDENTIFY RESEARCH ACTIONS READY FOR SPECIFIC PROGRAMME TOPICS AS A BASIS FOR THE PREPARATION OF WORK PROGRAMMES FOR THE 6 <sup>th</sup> FRAMEWORK PROGRAMME FOR RESEARCH		Eol n°: _____	
ADMINISTRATIVE INFORMATION							
Name of organisation submitting the Eol		Bundesamt für Kartographie und Geodäsie					
Contact person details		Title (Dr, Prof, ...)		Dr.		Gender	
		Family Name		Schlüter		First Name	
Address		Bundesamt für Kartographie und Geodäsie Fundamentalstation Wettzell D-93444 Kötzing, Germany					
Telephone No.		+499941603107		Fax No.		+499941603222	
E-mail		schlueter@wettzell.itag.de					
Title of the expression of interest (up to 10 words)		European Laser Ranging Precise Calibration and Orbit Evaluation Network					
Acronym (up to 20 Characters)		EUROLAS CALNet					
This Eol refers to an Integrated Project		<input checked="" type="checkbox"/>		This Eol refers to a Network of Excellence		<input type="checkbox"/>	
Sub-Thematic Priority <sup>1</sup> most relevant to your topic		1.1.4.ii					
Other relevant Sub-Thematic Priorities <sup>2</sup>							
Abstract (max. 10 lines)		Satellite Laser Ranging (SLR) is a space geodetic technique, which provides a clear and unambiguous reference for the satellite orbit determination, altimeter calibration and the connection of satellite missions to the global reference frame. The goal of proposed EUROLAS CALNet is to improve the European SLR capability, to establish a state of the art calibration and orbit evaluation network for all future satellite missions (GALILEO, ENVISAT, GOCE) related to research in navigation and global change with underlying and vital need for a long-term consistent reference frame. By its nature, the SLR is based on a close collaboration of research institutions and on the strong relation to industry for the development of the required technology at highest level..					
I request that the information given in this form is not published <sup>3</sup>		YES <input type="checkbox"/>					
This form must be accompanied by the short document (maximum 5 pages) referred to in Section 3 of the Guide for Submitters.							

<sup>1</sup> Indicate only one sub-thematic priority number given in Annex 1, eg. 1.1.6.1.i or 1.1.1.ii.b or 2.3

<sup>2</sup> If appropriate, indicate one or more sub-thematic priority numbers given in Annex 1.

<sup>3</sup> Unless you tick the YES box the information included in the Annex 3 form will be published by the Commission Services. The 5 Pages Eol short document will not be published.