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Extreme
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A GNSS measurement for High School Students of EEE Project

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EEE Meetings for Students

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EEE Run Coordination Meeting open to schools

Wednesday 5 Jun 2019, 14:30 → 16:05 Europe/Rome

14:30	→ 14:35	**Introduzione** **Speaker**: Silvia Pisano (Centro Fermi)	5m
14:35	→ 14:45	**Chiusura Run-5** **Speaker**: Marcello Abbrescia (Università di Bari)	10m
14:45	→ 14:55	**Analisi dell'Asimmetria e della Curtosi degli istogrammi relativi alla velocità dei muoni** **Speaker**: Liceo Scientifico "Cavour" - Roma	10m
14:55	→ 15:05	**Cosmic Box measurements** **Speaker**: Liceo Scientifico "G. Galilei" - Lanciano	10m
15:05	→ 15:15	**Costruzione delle camere del rilevatore dei raggi cosmici al CERN** **Speaker**: Liceo Scientifico "A. Volta" - Reggio Calabria	10m
15:15	→ 15:25	**Stima della durata del freon tramite equazioni di stato dei gas** **Speaker**: Liceo Scientifico B. Touschek - Grottaferrata	10m
15:25	→ 15:35	**Misura automatica di tensione e corrente delle camere** **Speaker**: IIS Nobili - Reggio Emilia	10m
15:35	→ 15:40	**Oggi spiego io! - Dialogo sopra i minimi sistemi del mondo** **Speaker**: Liceo Moretti (sede associata IIS C. Beretta) - Gardone Val Trompia	5m

- Coordination Meetings
- Students report about their activity on EEE
- Status and Maintenance of the Telescopes, Data Analysis, Questions and Discussions
- General Lessons from EEE researchers
- Hardware, Software, Organization of events

- Conferences of EEE project
- Students describe their activities
- General Lessons and Masterclasses
- Students in groups perform measurements and data analysis and report about their work
- Prizegiving for best contributions and analysis

10° Conference of CF Projects
Turin, March 6-8, 2019

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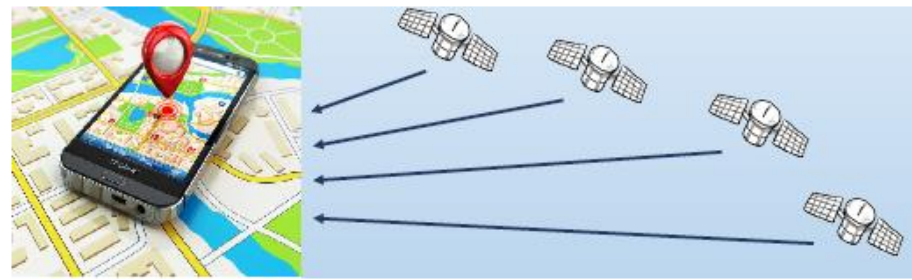
In collaboration with Dr. M. Sellone and Dr. G.Cerretto

Istituto **N**azionale di **R**icerca **M**etrologica

Global Navigation Satellite System

Simulation of GNSS functioning by measuring the range between local representative receiver and satellites

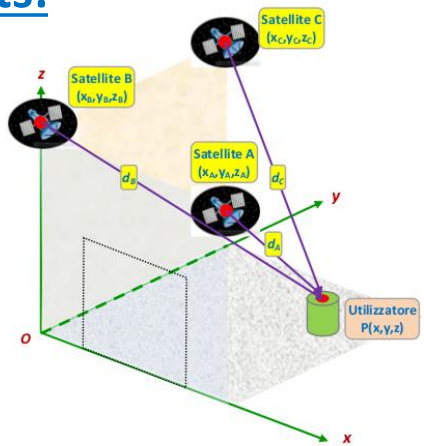
How a GNSS works



- 4 satellites in view
- Solve 4 non linear equations to get position and time
- Distance measurements
  - through the time of flight of a signal sent by a transmitter on the satellite
    - Δt between clock on satellite and on receiver

Exercise for students:

- Put 3 simulated satellites on a cartesian reference
  - Simple positions: on the intersections between walls
- Use a laser distance meter to measure their positions
  - $(x_A, y_A, z_A),(x_B, y_B, z_B),(x_C, y_C, z_C)$
- Measure your distances from the 3 satellites
  - d_A, d_B, d_C



The laser distance meter uses the time of flight of a laser to compute distances

→Then the signal is transmitted and received by the same instrument

→As the receiver and the satellite clocks are sinchronized → Only 3 range measurements required

- Compute your position by inverting the equations of distances
- Check the results with an "actual measurement" → rule, laser meter, etc.

$$R_A = \sqrt{(x - x_A)^2 + (y - y_A)^2 + (z - z_A)^2}$$
$$R_B = \sqrt{(x - x_B)^2 + (y - y_B)^2 + (z - z_B)^2}$$
$$R_C = \sqrt{(x - x_C)^2 + (y - y_C)^2 + (z - z_C)^2}$$

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Example of Results

- Python Code developed by Dr. V.Pettiti (INRIM)
  - 2 points → P1 and P2

		A	B	C	D	E	F	G	H	I	J	K	L
	1	Distanze misurate			Posizione stimata			Posizione misurata			Scostamento		
	2	d_A	d_B	d_C	x	y	z	x	y	z	Δx	Δy	Δz
	3	[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]
	4												
P_1	5	5.54	4.29	4.37	1.46	2.50	0.38	1.45	2.51	0.45	-0.01	0.01	0.07
	6												
	7	4.12	4.72	5.55	3.13	1.74	0.48	3.18	1.78	0.45	0.05	0.04	-0.03
	8	4.13	4.78	5.56	3.18	1.79	0.46	3.18	1.78	0.45	0.00	-0.01	-0.01
P_2	9	4.12	4.75	5.54	3.16	1.78	0.48	3.18	1.78	0.45	0.02	0.00	-0.03
	10	4.13	4.74	5.55	3.15	1.76	0.47	3.18	1.78	0.45	0.04	0.02	-0.02
	11	4.13	4.75	5.55	3.15	1.77	0.47	3.18	1.78	0.45	0.03	0.01	-0.02

```
*************************************
Distanza dal salellite A [m]: 5.54
Distanza dal salellite B [m]: 4.29
Distanza dal salellite C [m]: 4.37

Numero di iterazioni:  5

    x [m]:  1.46
    y [m]:  2.50
    z [m]:  0.38
>>>
```

Dati forniti da tastiera

Stime fornite dal programma

- Compare
  - Estimated Coordinates (given by the code)
  - Measured Coordinates (obtained by an instrument)

- Max observed deviation → 5 cm
  - Uncertainties of the same order of magnitude in satellite positions
  - Not complete orthogonality of the walls

A good method for didactic experiment!

Useful links

- **General lessons:**
  - https://agenda.centrofermi.it/event/120/contributions/1041/
  - https://agenda.centrofermi.it/event/120/contributions/1042/
- **Python code:**
- *****If you plan to use code, please cite author: "Valerio Pettiti (INRIM)""******
  - https://indico.cern.ch/event/855335/contributions/3627925/attachments/1953452/3244196/Simula_GPS_Pettiti_EEE.py