La missione ESMO

European Student Moon Orbiter

e il Radiometro a Microonde MiWaRS

proposto dalle Università di

Roma "La Sapienza" e di L'Aquila

Piero Tognolatti, IØKPT

Facoltà di Ingegneria, Università di L'Aquila

- Che cosa è SSETI

- Descrizione della missione ESMO

- Il radiometro a microonde quale payload scientifico

- Un possibile contributo della comunità dei radioamatori

Che cosa è SSETI

The main objective of the Student Space Exploration and Technology Initiative is to create a network of students, educational institutions and organisations across Europe in order to design, construct and launch micro satellites and other spacecraft. This, by nature, distributed task can be handled by using available internet tools.

This objective is reached when a spacecraft is designed, built and launched by a significant number of European students in a highly distributed way. The completion of this project objective is independent of a mission success or failure.

The complexity of this task leads to a necessary kind of missions to reach the goal by the participating students and professors with the support of the European Space Agency and Arianespace.

Che cosa è SSETI

Objective

- to actively involve European students in real space missions
- to give students practical hands-on experience
- to enhance their motivation to work in the fields of space technology and science
- to ensure the availability of a suitable and talented workforce for the future

Participation

- Started in 2000 for European students
- Hands-on project on a real space mission
- Over 350students actively involved
- 28 universities in 15 European countries (+ Canada)

Projects

- SSETI Express: 62 Kg, launched 27 October 2005 into LEO(*)
- ESEO: 120 kg, planned for launch in 2008 into GTO
- ESMO: planned for launch 2011

(*) carrying an Amateur Radio Transponder

SSETI esa La Sapienza Università degli Studi di Roma IMT Ingegneria Marketing Tecnologia

La missione ESMO

In March 2006, the Education Department of the European Space Agency approved the European Student Moon Orbiter (ESMO) mission proposed by the Student Space Exploration & Technology Initiative (SSETI) association for a Phase A Feasibility Study. If found to be feasible, ESMO will be the third mission to be designed, built and operated by European students through the SSETI association, and would join many other contemporary missions to the Moon such as ESA's SMART-1, the Chinese Chang'e-1, the Indian Chandrayaan, JAXA's SELENE and Lunar-A, and NASA's Lunar Reconnaissance Orbiter.

Italy has taken part in the project with:

- Università di Roma "La Sapienza"
- Politecnico di Milano
- Università di Napoli "Federico II"
- Università di L'Aquila

La missione ESMO

ESA provides :

- AO, payload & subsystem selection, selection of student teams
- Full-time project, risk & system engineering management
- Quality/Product assurance support from ESA experts to ensure compliance with ECSS
- Organisation and sponsorship of regular student workshops
- Technical advice to student teams via controlled interaction with ESA experts
- Formal project reviews of documentation during all phases
- Support and facilities for AIV of student payload/subsystem at ESTEC
- The launch opportunity

SSETI Association provides:

- Agreements with universities on student team participation
- Infrastructure for use by project managers,
- public relations to promote SSETI and its projects

Student teams provide:

- System engineering/ Technical management functions, Payload experiments, Spacecraft subsystem hardware, Onboard software, Ground segment, Mission operation

SSETI esa La Sapienza Università degli Studi di Roma IMT Ingegneria Marketing Tecnologia

La missione ESMO

The **ESMO mission** objectives are summarised as follows:

- **Education**: prepare students for careers in future projects of the European space exploration and space science programmes by providing valuable hands-on experience on a relevant & demanding project
- **Outreach**: acquire images of the Moon and transmit them back to Earth for public relations and education outreach purposes
- **Science**: perform new scientific measurements relevant to lunar science & the future human exploration of the Moon, in complement with past, present and future lunar missions
- **Engineering**: provide flight demonstration of innovative space technologies developed under university research activities

La missione ESMO

The ESMO spacecraft would be launched in 2011 as an auxiliary payload into a highly elliptical, low inclination Geostationary Transfer Orbit (GTO) on the new Arianespace Support for Auxiliary Payloads (ASAP) by either Ariane 5 or Soyuz from Kourou.

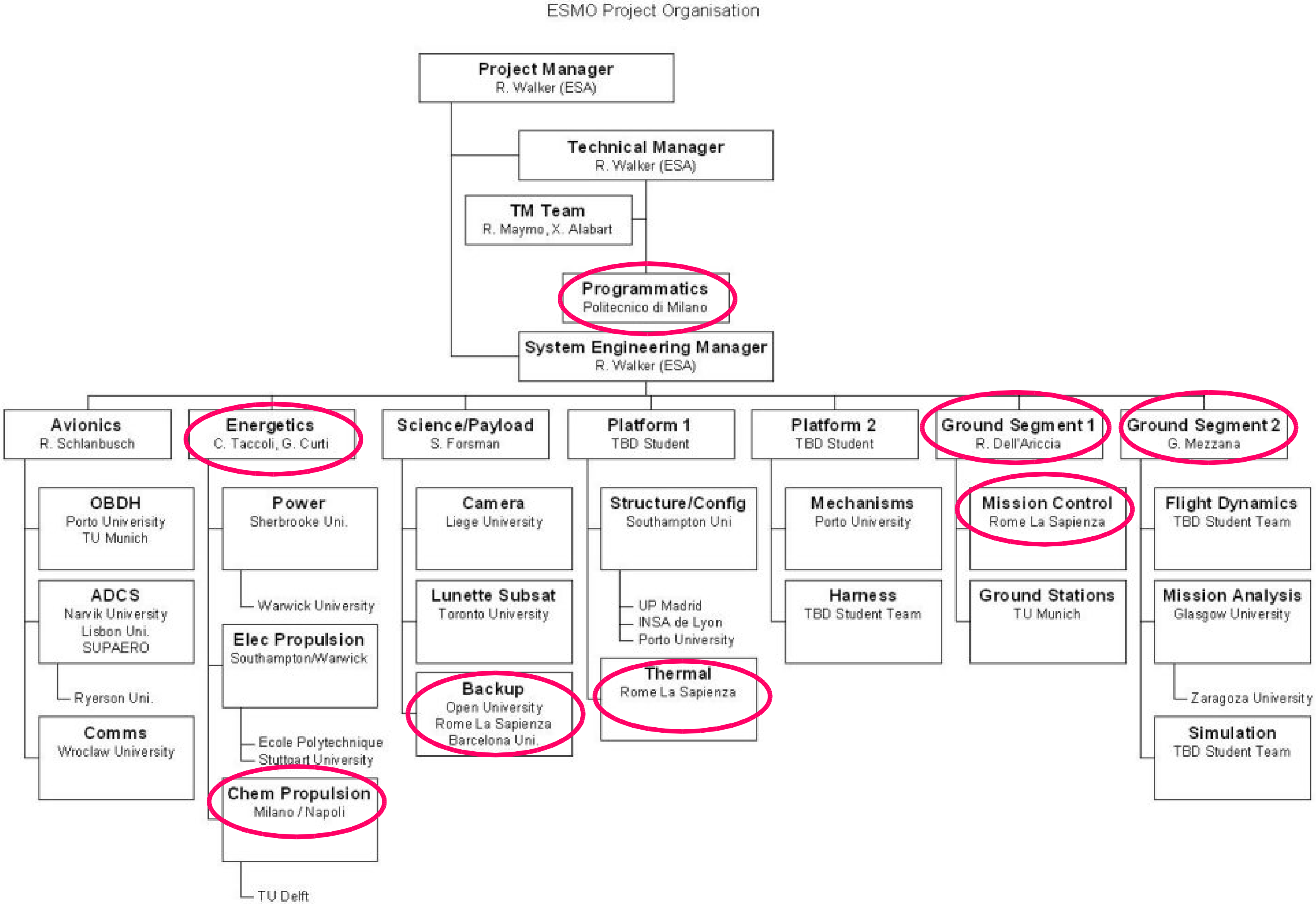
From GTO, the 200 kg spacecraft would use its on-board propulsion system for lunar transfer, lunar orbit insertion and orbit transfer to its final low altitude polar orbit around the Moon.

A 10 kg miniaturised suite of scientific instruments (also to be provided by student teams) would perform measurements during the lunar transfer and lunar orbit phases over the period of a few months, according to highly focussed science objectives. The core payload would be a high-resolution narrow angle CCD camera for optical imaging of lunar surface characteristics and a Cubesat subsatellite for precision gravity field mapping via accurate ranging of the subsatellite from the main spacecraft. Optional payload items being considered include a **Microwave Radiometer** and a LIDAR

Le missioni scientifiche sulla Luna

Le missioni più famose del passato

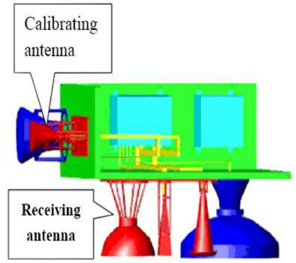
ESMO Project Organisation



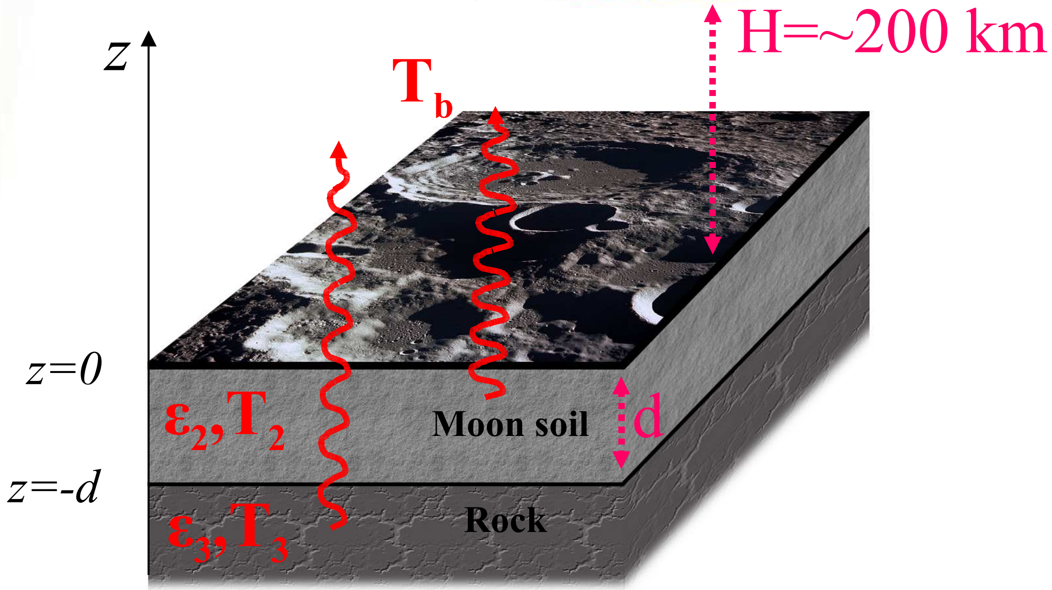
Obiettivi scientifici del radiometro a microonde

- Global mapping of the surface and sub-surface temperature.
- Global mapping of the lunar microwave emissivity.
- Estimate of the lunar soil thickness and properties.
- Estimate of the lunar sub-surface thermal conductivity.

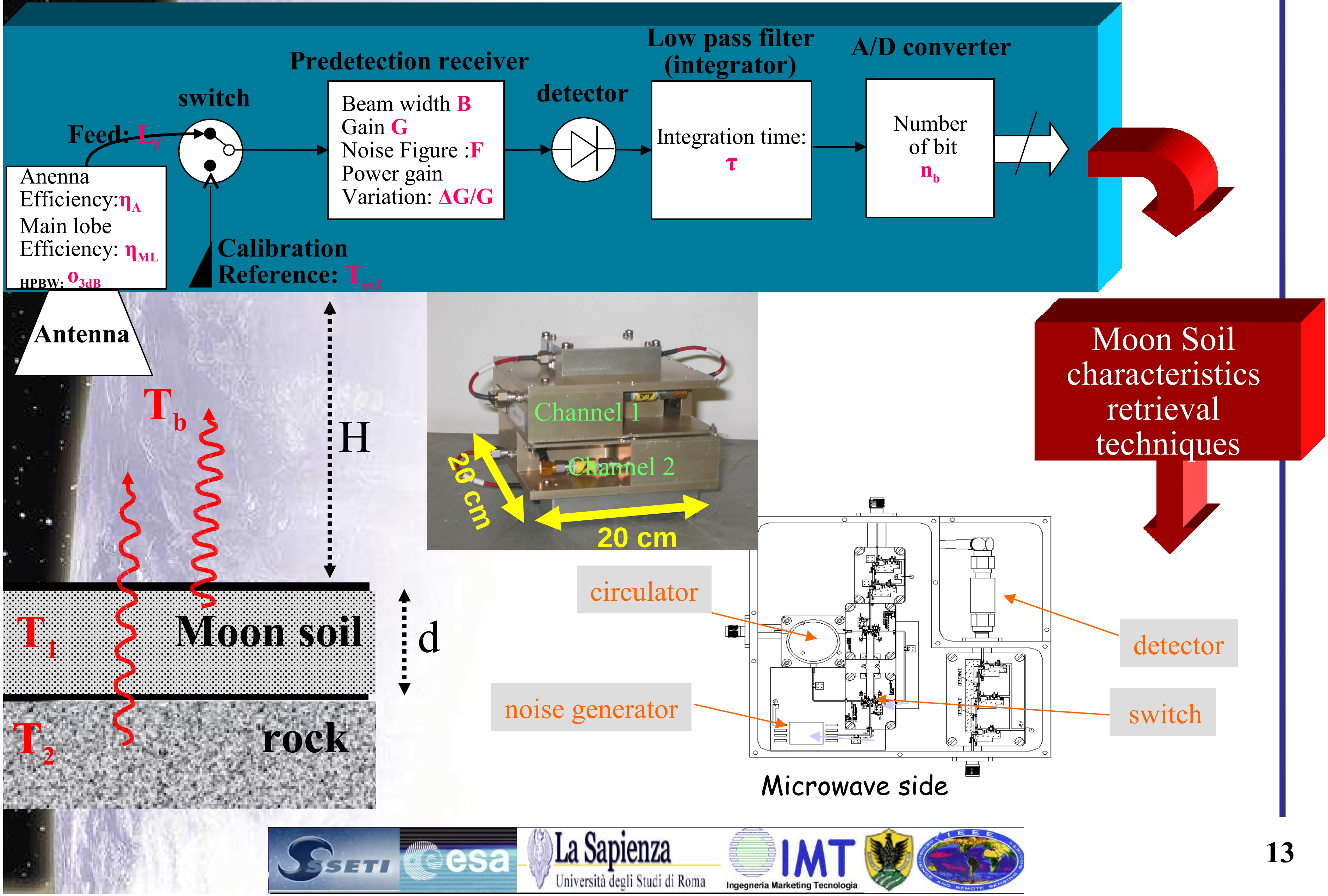
Proposed F=3 GHz & 10 GHz



Wu Ji (Earth Syst. Sci. Dec. 2004)



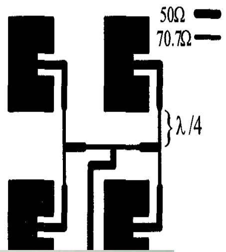
Radiometer payload

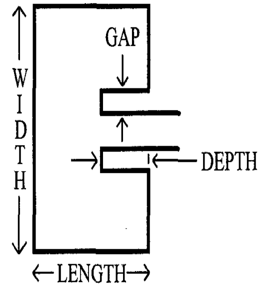


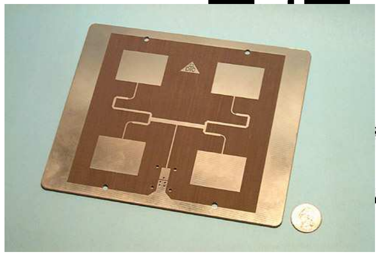
Possible antenna types for MiWaRS

Patch antenna

~23×15 cm







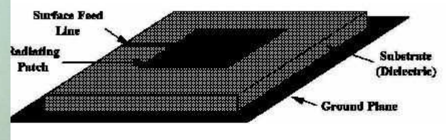
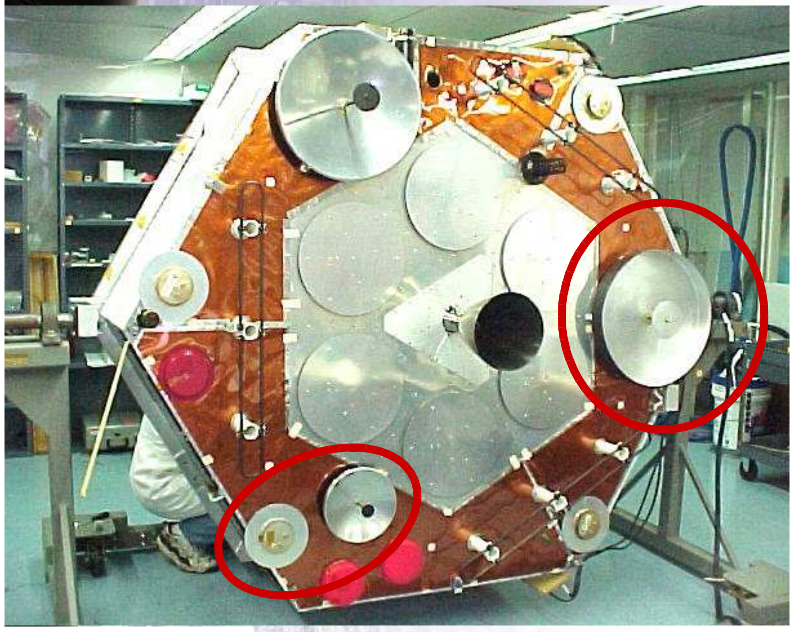
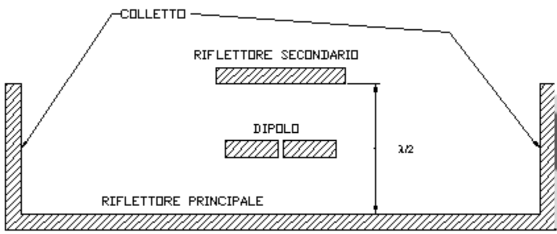


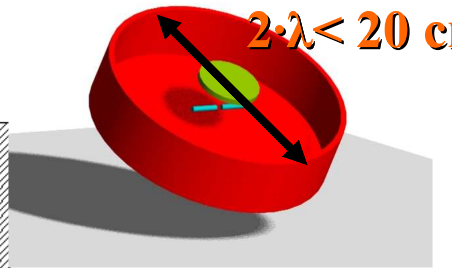
Figure 4. 'Classical' Rectangular Microstrip Patch Antenna[4]*.*

Short Backfire antenna (SBFA)



MSAT P3-D



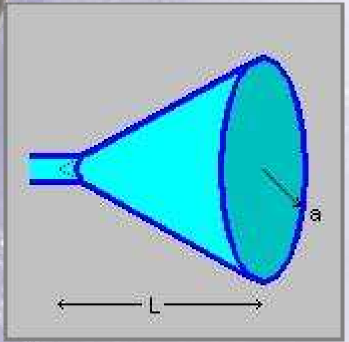


2·λ< 20 cm

SETI esa La Sapienza Università degli Studi di Roma IMT Ingegneria Marketing Tecnologia

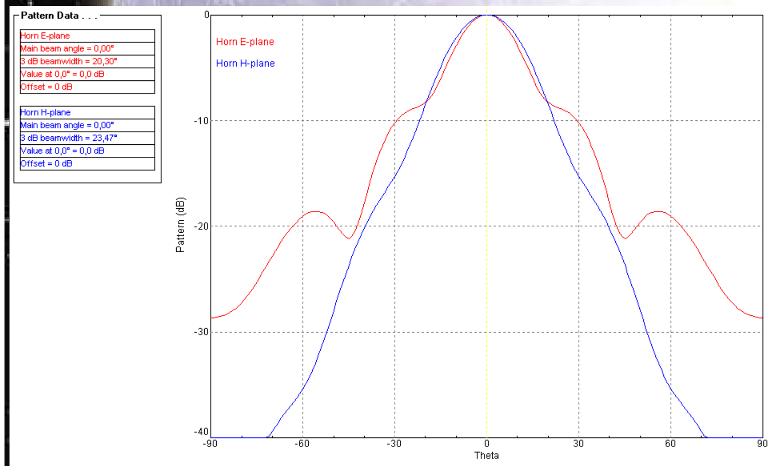
Antenna performances

Conical horn @ 10 GHz

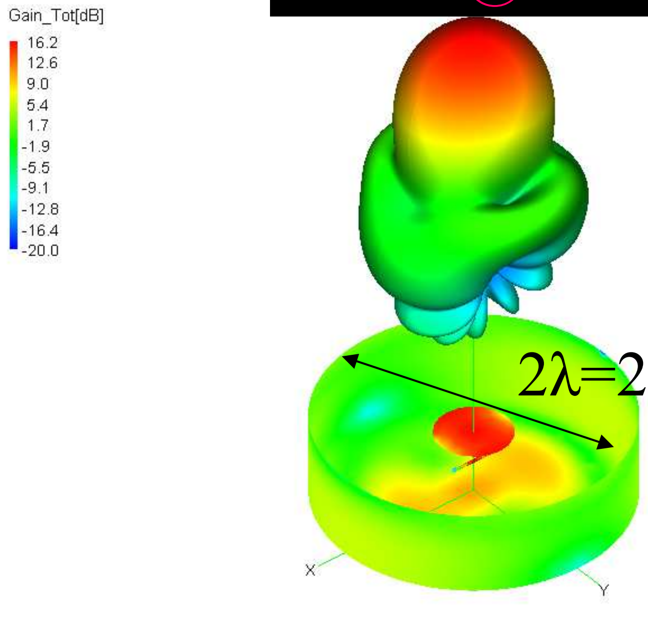


a=4.74 cm

L=10 cm

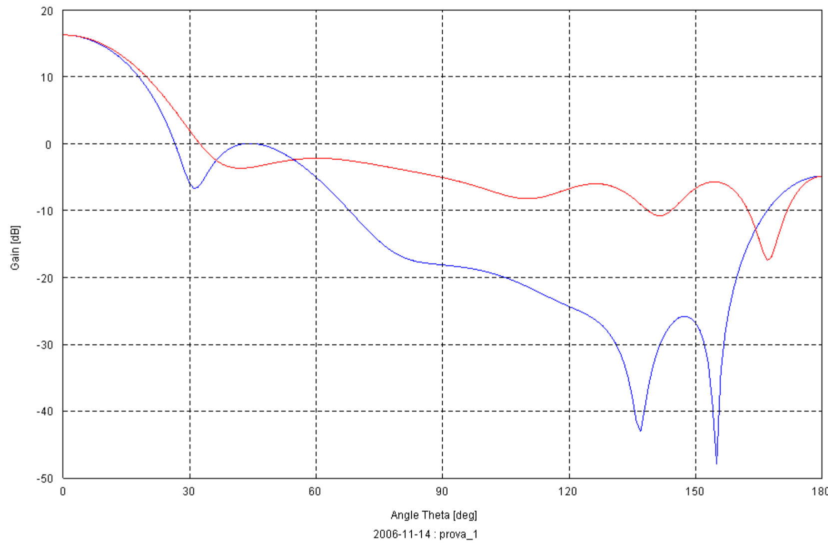


SBFA @ 3 GHz



2λ=20 cm

$\lambda/2$=5 cm

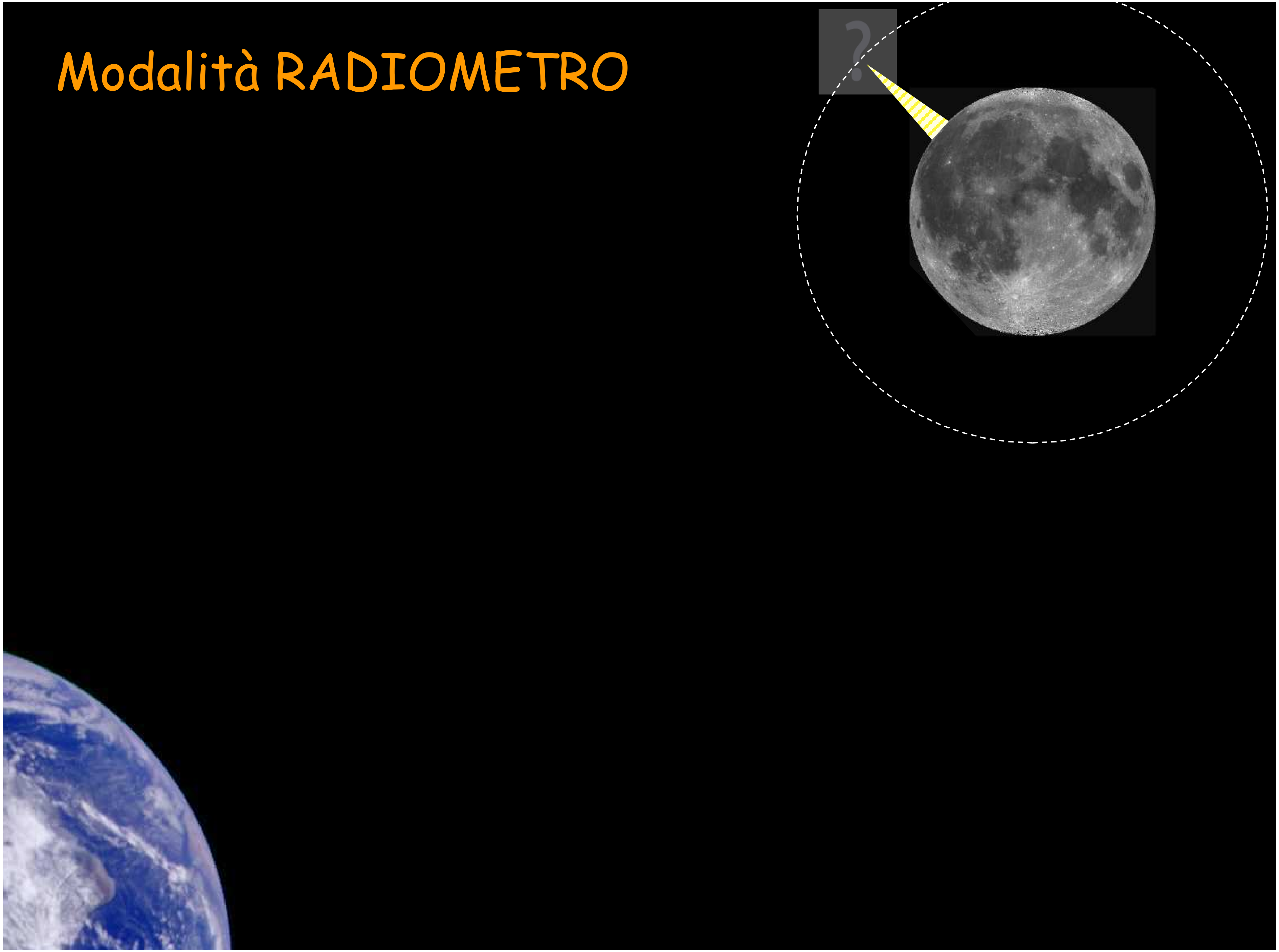


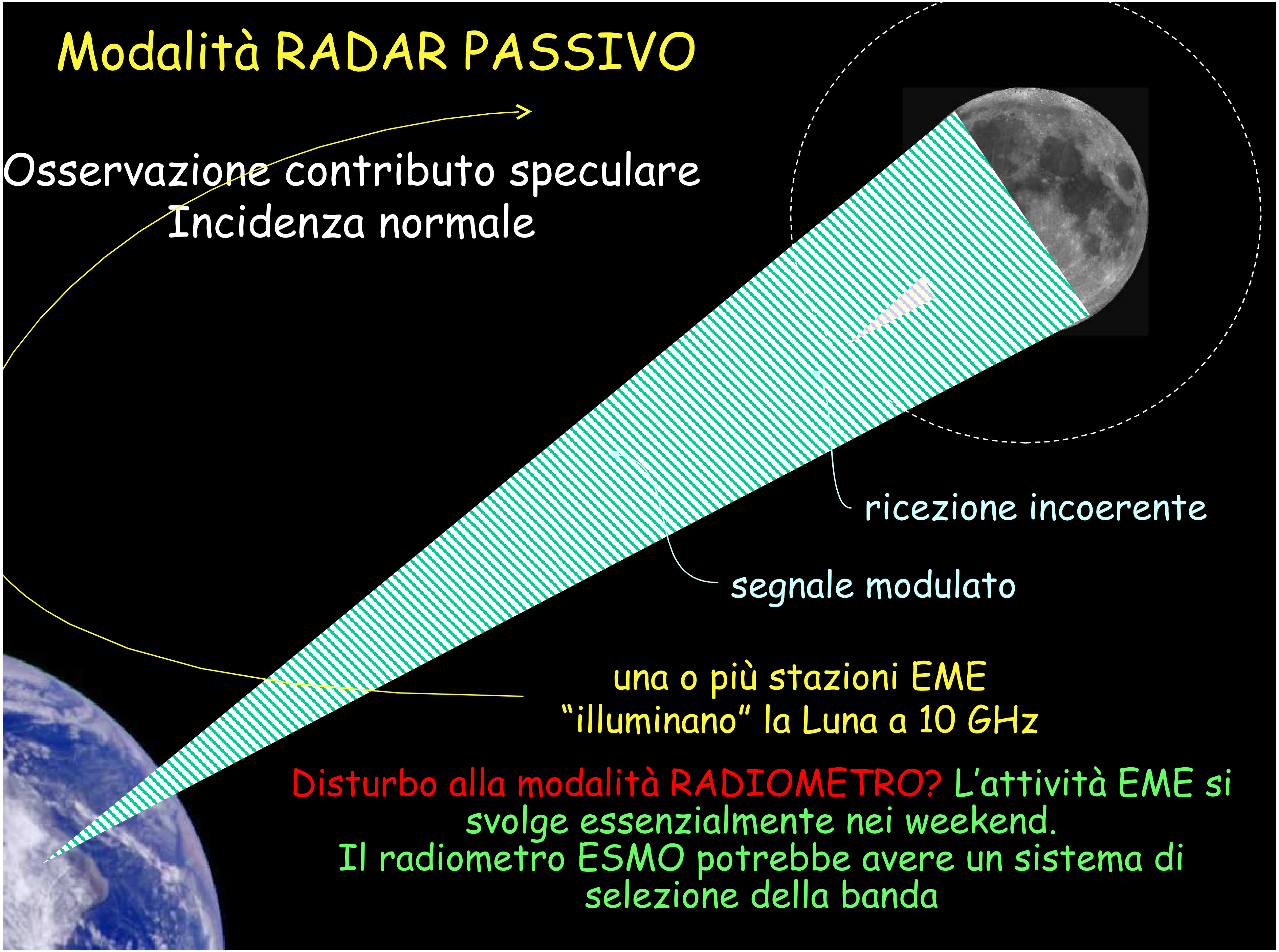
Un possibile contributo dei Radioamatori alla missione MiWaRS di ESMO:

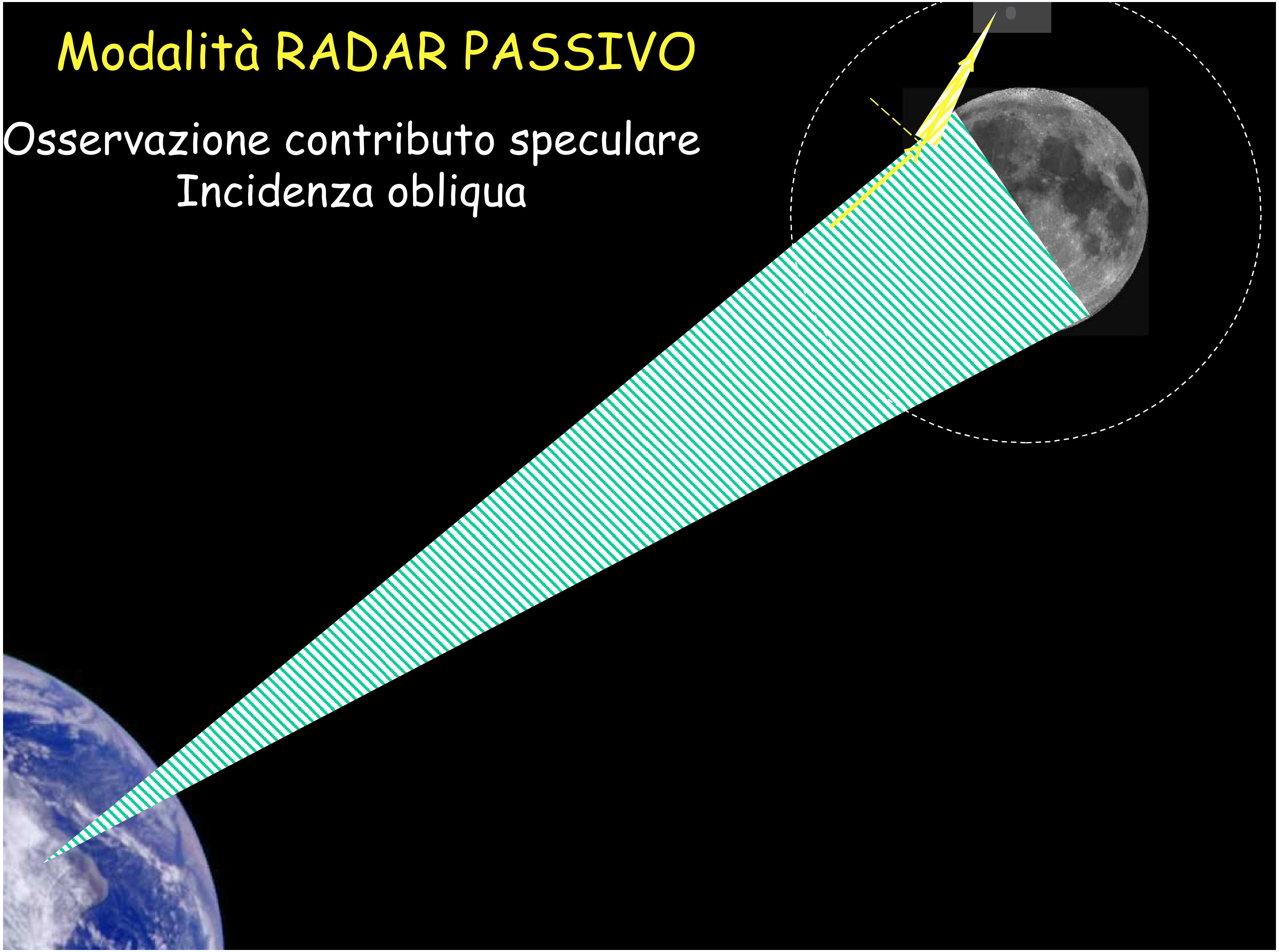
consentire al sensore di operare come RADAR PASSIVO

per ottenere mappe di riflettività bistatica e diffusività lunare

Modalità RADIOMETRO




Modalità RADAR PASSIVO
Osservazione contributo speculare
Incidenza normale
ricezione incoerente
segnale modulato
una o più stazioni EME
“illuminano” la Luna a 10 GHz
Disturbo alla modalità RADIOMETRO? L’attività EME si svolge essenzialmente nei weekend.
Il radiometro ESMO potrebbe avere un sistema di selezione della banda


Modalità RADAR PASSIVO
Osservazione contributo speculare
Incidenza obliqua

Power budget

Radiometro "total power" B=50 MHz (banda equivalente di rumore)

Tsys=Ta+Trec=300K+100K=400 K τ=1 s (tempo di integrazione)

Risoluzione radiometrica ΔT=0.06 K

Guadagno d'antenna 16 dBi

Modalità **RADIOMETRO** (assenza di illuminazione)
Il radiometro, opportunamente calibrato, misura una Ta=300K.
La potenza raccolta dal radiometro è KTsysB= -125.6 dBW

Modalità **RADAR PASSIVO** - contributo speculare (presenza di illuminazione)
In questo caso la potenza ricevuta è la somma di quella termica, prima calcolata, e di quella dovuta al segnale che illumina la Luna.

La potenza totale misurata è: KTsysB + ΔP dove ΔP =-142 dBW Ma ΔP rappresenta un incremento, letto sulla scala delle temperature misurate dal radiometro, che è pari a 9.16 K.

EIRP TX : 77 dBW (antenna 7 metri, TX 150 W, come da IQ4DF di Bagnara)

R= 370 000 km F=10 GHz

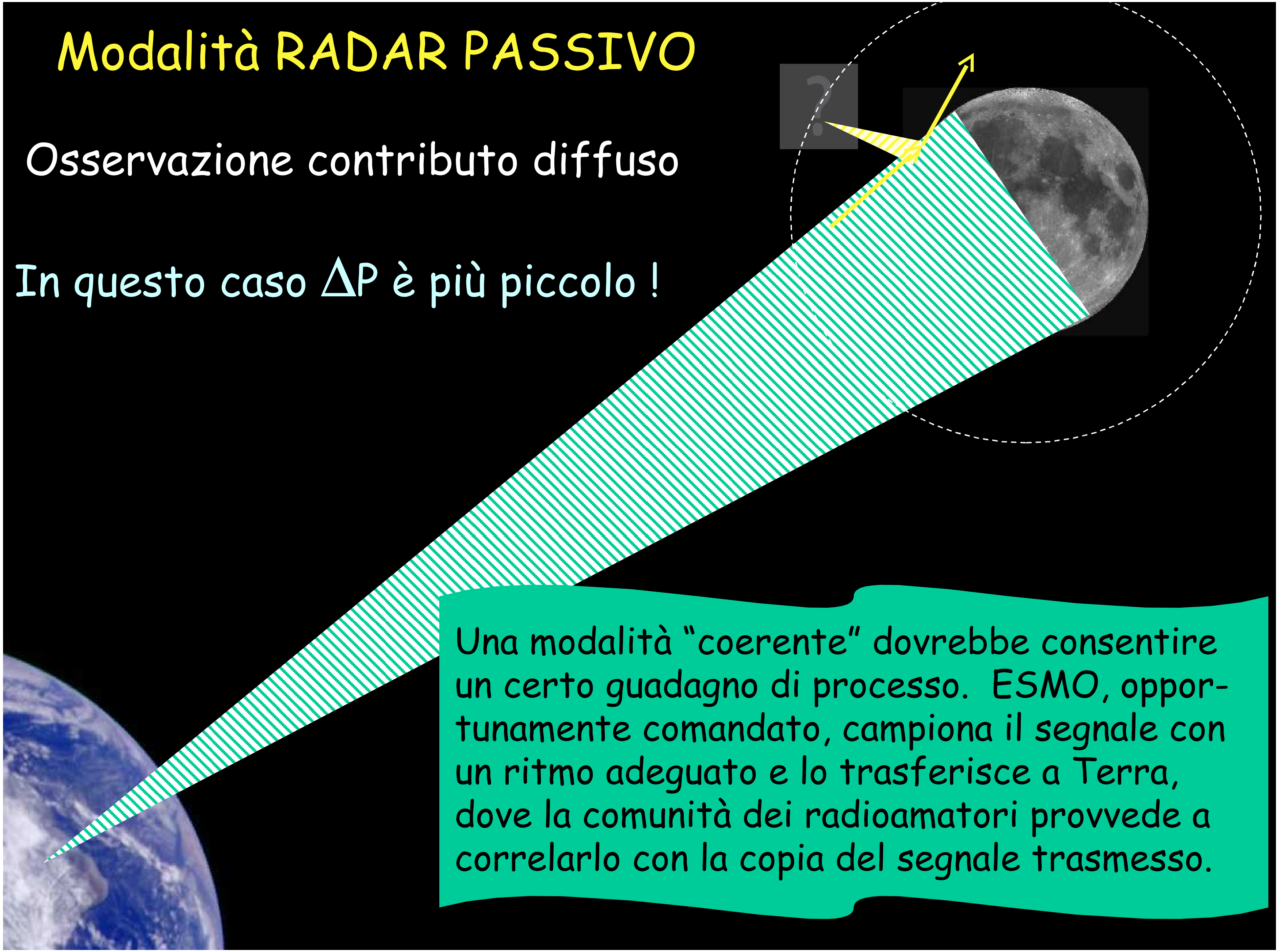
Luna supposta con riflettività -12 dB (valore di letteratura)

La stazione EME di Bagnara di Romagna

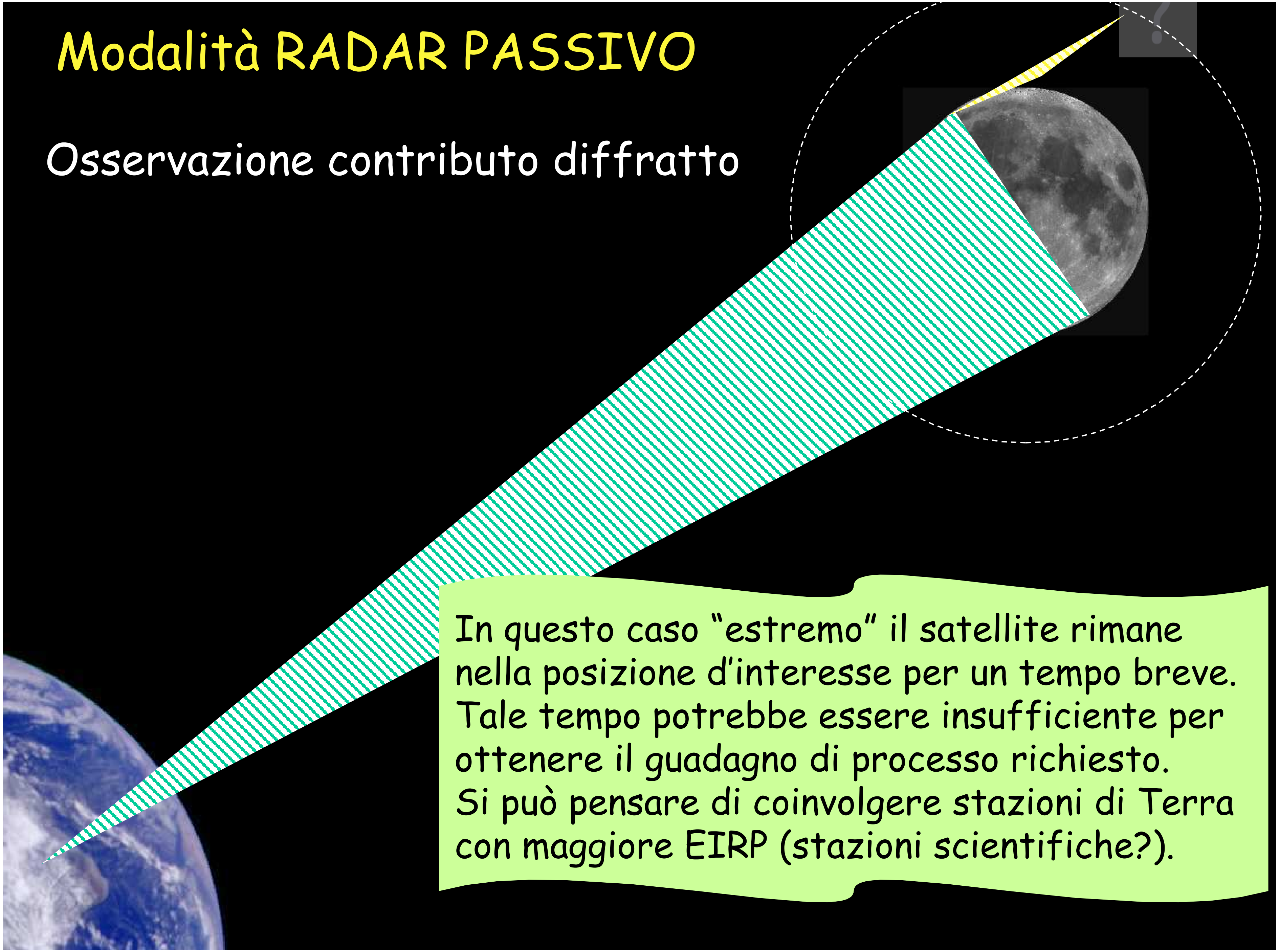
Modalità RADAR PASSIVO

Osservazione contributo diffuso

In questo caso ΔP è più piccolo !



Una modalità “coerente” dovrebbe consentire un certo guadagno di processo. ESMO, opportunamente comandato, campiona il segnale con un ritmo adeguato e lo trasferisce a Terra, dove la comunità dei radioamatori provvede a correlarlo con la copia del segnale trasmesso.


Modalità RADAR PASSIVO
Osservazione contributo diffratto
In questo caso "estremo" il satellite rimane nella posizione d'interesse per un tempo breve.
Tale tempo potrebbe essere insufficiente per ottenere il guadagno di processo richiesto.
Si può pensare di coinvolgere stazioni di Terra con maggiore EIRP (stazioni scientifiche?).

http://www.die.uniroma1.it/esmo-urm/