

RAGGI COSMICI PER L'ARCHEOLOGIA DEI PORTI DELL'ANTICA ROMA AD AQUILEIA E FIUMICINO (PORTUS)

Dipartimento di

Fisica



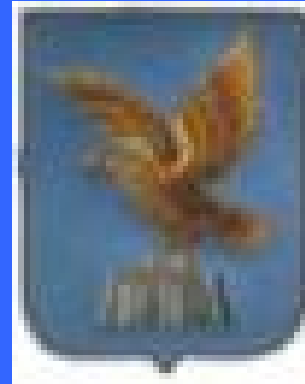
Universita' di TRIESTE

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**ISTITUTO NAZIONALE DI
OCEANOGRAFIA
E DI GEOFISICA SPERIMENTALE
DIPARTIMENTO DI GEOFISICA DELLA
LITOSFERA (GDL)
CARS GROUP (CARTOGRAPHY AND
REMOTE SENSING)
E-MAIL:FCOREN@OGS.TRIESTE.IT**



Legge regionale
n.3/1998, art.16.
Finanziamenti progetti
di ricerca e
divulgazione scientifica.
Anno 2002.



Helicopter Service and Remote Sensing
Amaro (Udine)

IL COSMO

Osservazione del cielo

→ Astronomia



Galassia simile alla Via Lattea

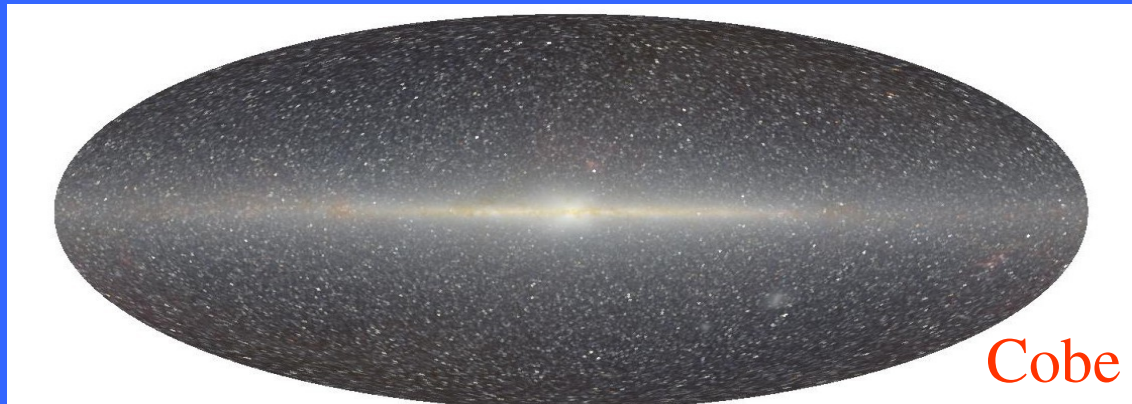


Galassia
Spirale
NGC 628

Il sole sarebbe
circa qui

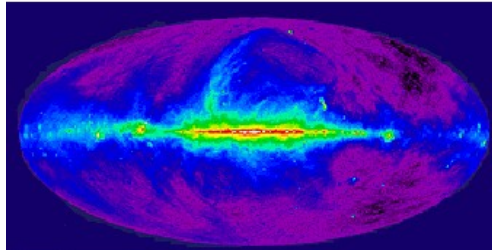
Gemini North

VIA LATTEA: La nostra Galassia (in coordinate galattiche)



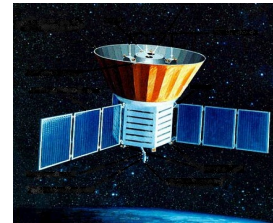
Fotoni a molte Lunghezze d'Onda

Radio



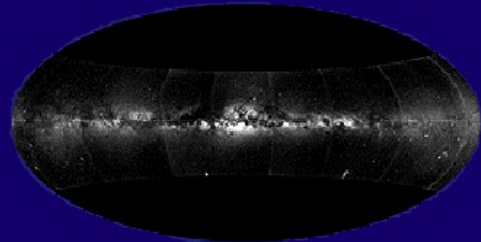
Radio télescope
de Bonn

Infrarosso



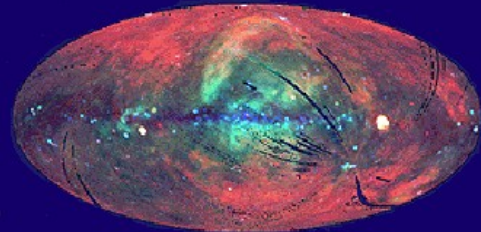
Satellite
COBE

Luce Visibile



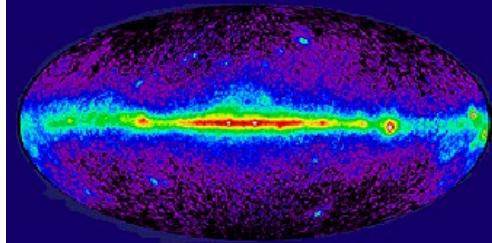
Télescope du
Mont Palomar

Raggi-X



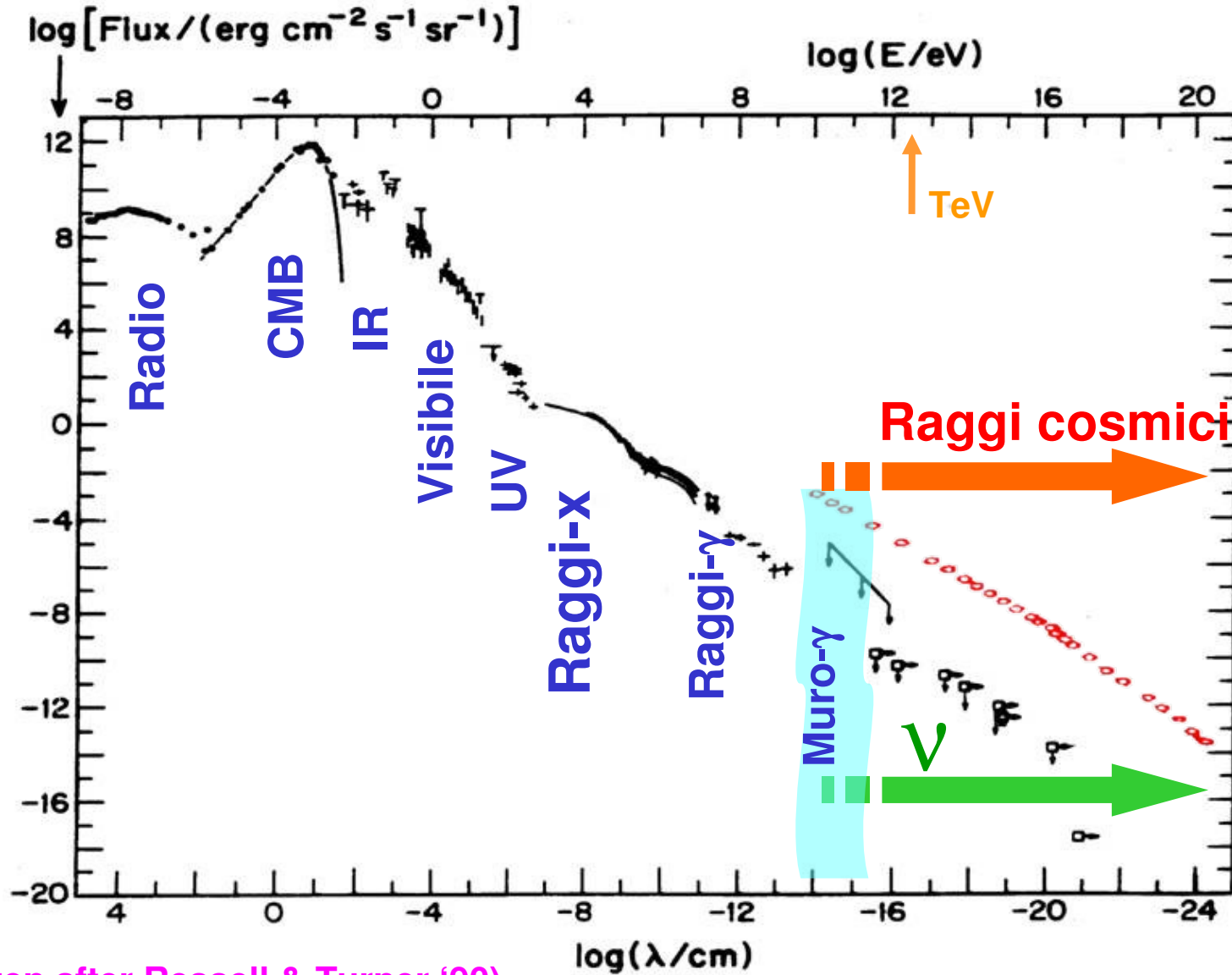
Satellite
INTEGRAL

Raggi Gamma



Satellite
CGRO

Radiazione Cosmica



(by Halzen after Ressell & Turner '90)

Raggi Cosmici (Composizione)

PRIMARI:

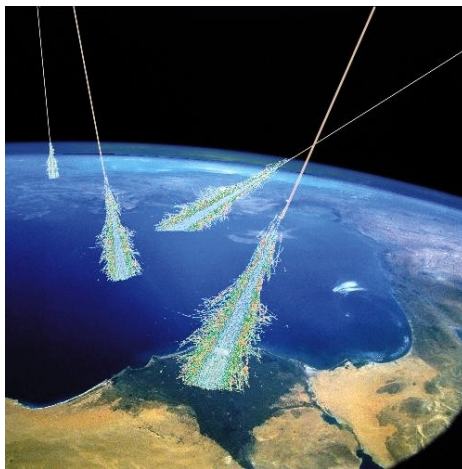
$p \sim 87 \%$, $\alpha \sim 10 \%$, $N \sim 1 \%$

$e \sim 2 \%$

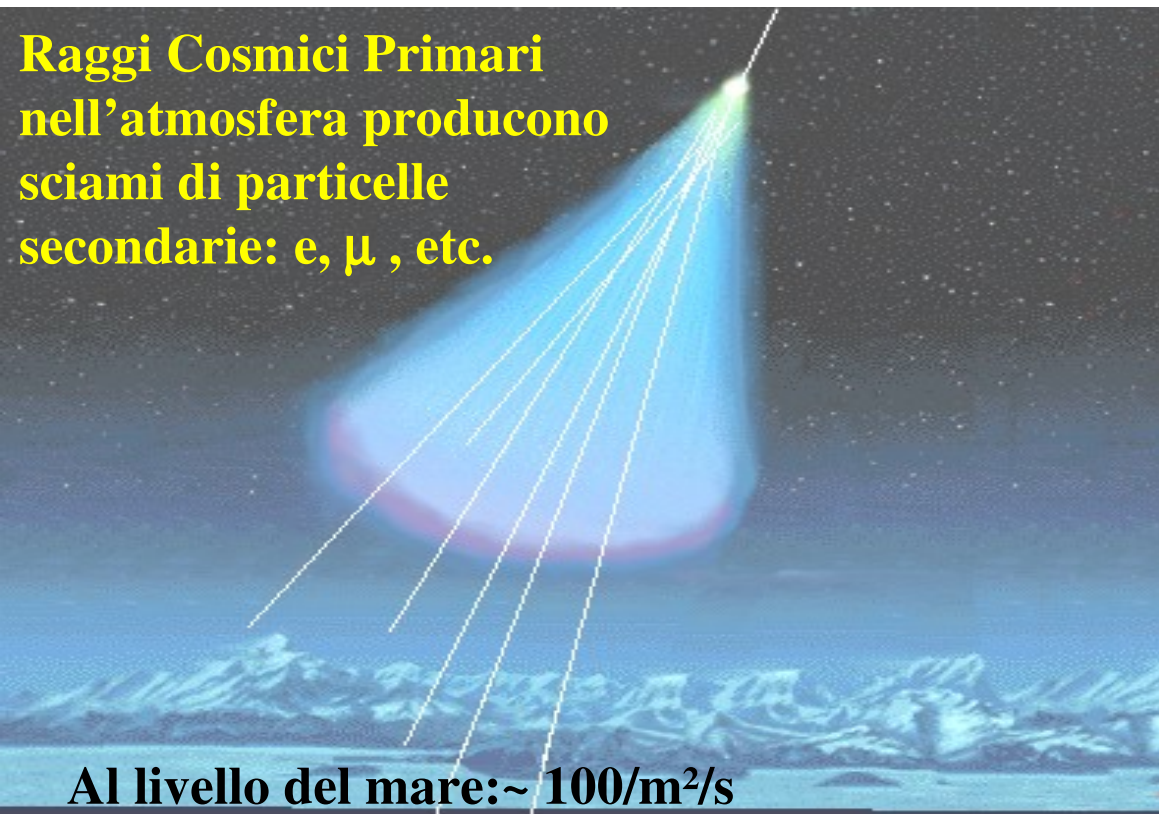
$\gamma \sim 0.1 \%$, $\nu \sim 0.1 \%$?

Alta

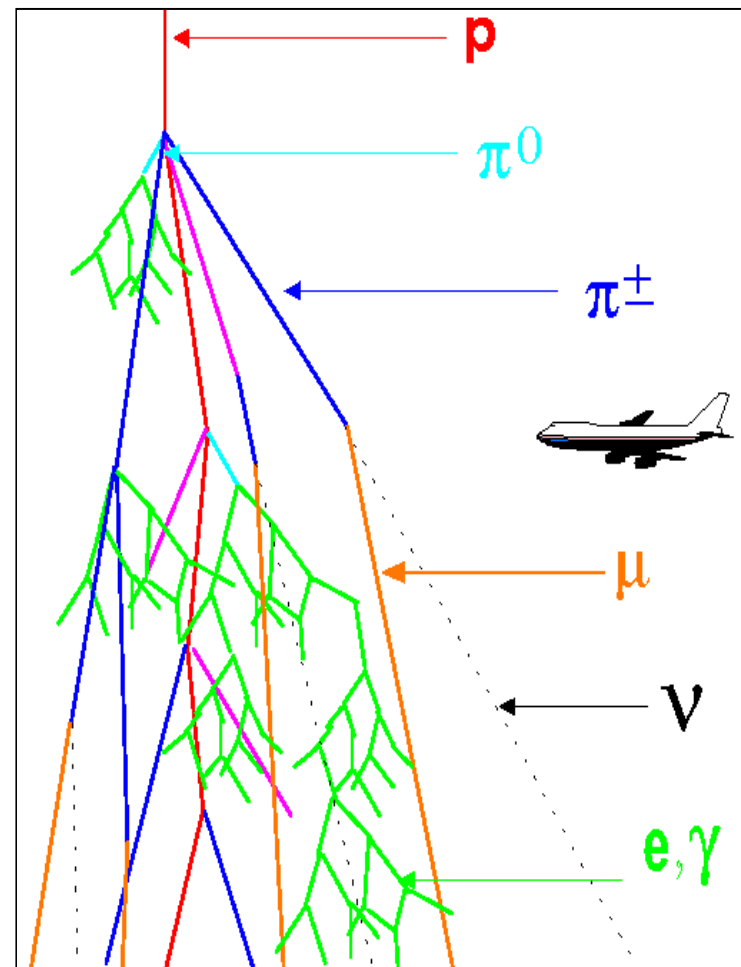
atmosfera: $\sim 1000/m^2/s$



Raggi Cosmici Primari
nell'atmosfera producono
sciame di particelle
secondarie: e, μ , etc.



Al livello del mare: $\sim 100/m^2/s$

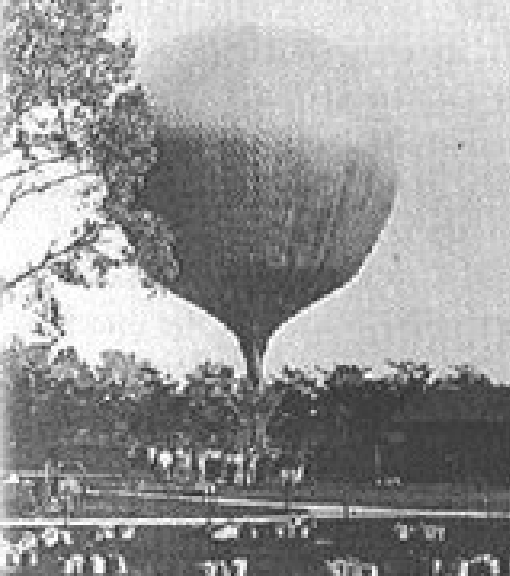


Secondari al livello del mare:

$\mu \sim 30 \%$

$p, n, \dots \sim 2 \%$

$\nu \sim 68 \%$



Colhoster 1914
@ 9km

Altitude
(km)

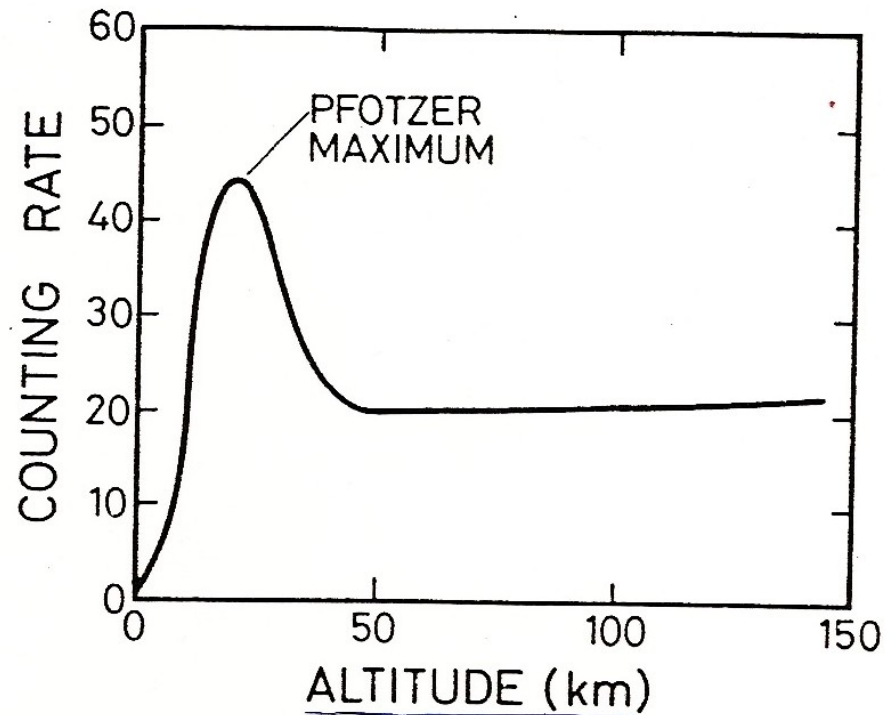
Difference between observed
ionisation and that at sea-level
(ions cm^{-3}) ξ^{-1}

1	-1.5
2	+1.2
3	+4.2
4	+8.8
5	+16.9
6	+28.7
7	+44.2
8	+61.3
9	+80.4

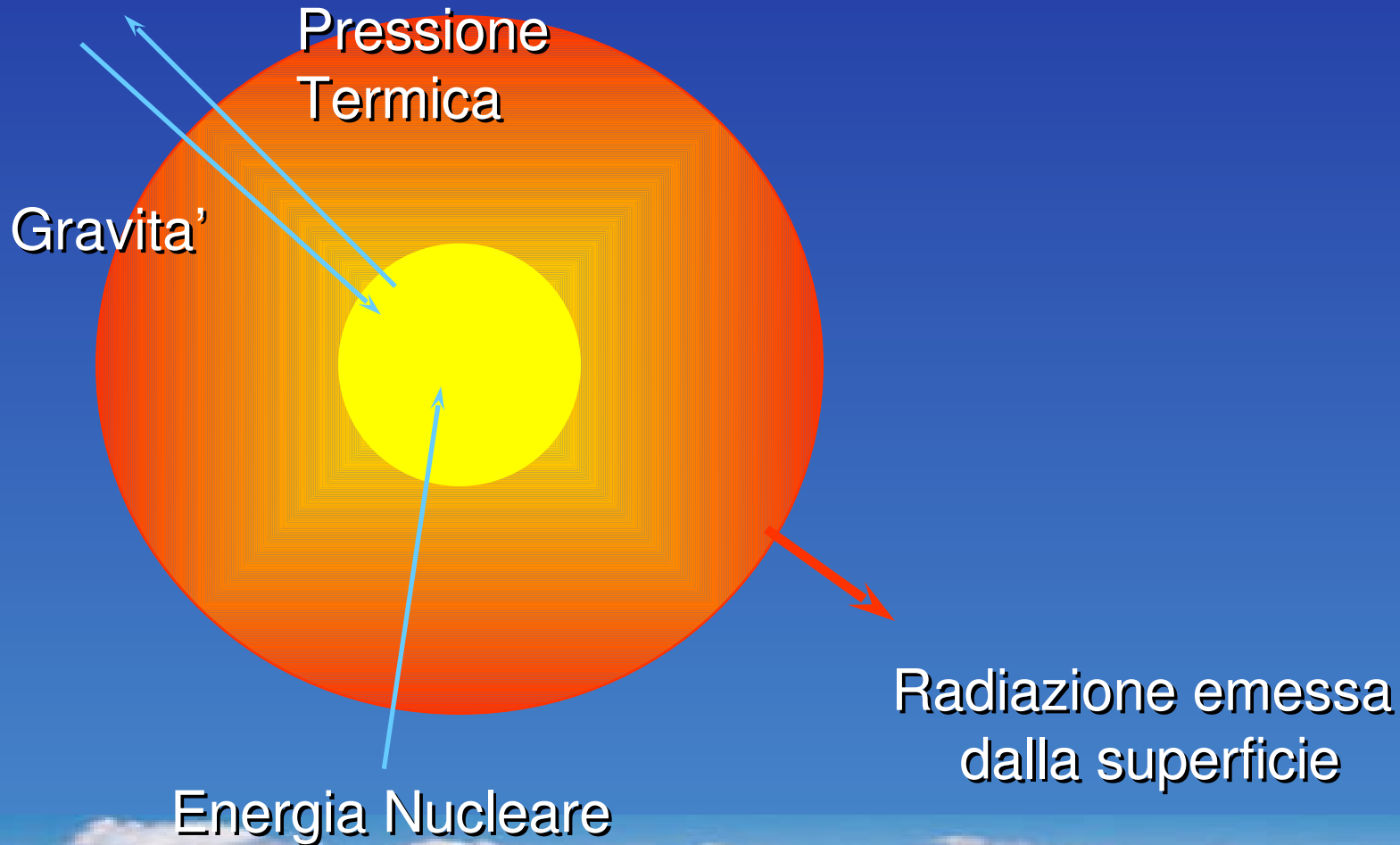
Ascese in Pallone:
Hess 1912 @ 5km



Millikan scettico circa I “ ... Raggi Cosmici?...”



Struttura Stellare





Nascita

**delle
stelle**

Evoluzione Stellare



Vita di una stella grande ($M > 1,4 M_{\odot}$)

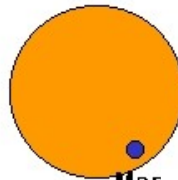
Forms in
Dust & Gas
Cloud



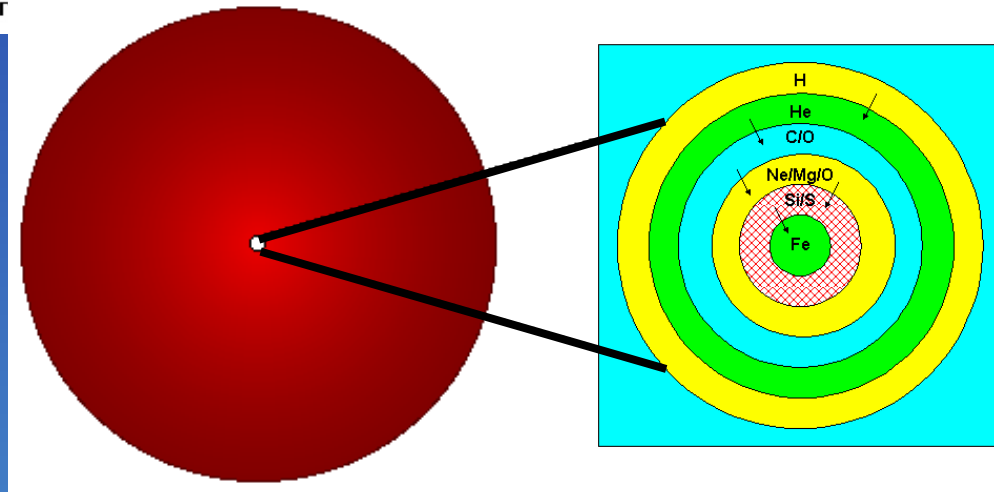
Burns Hydrogen
for 50 Million Years



Becomes Red
SuperGiant Star for
1 Million Years



Mar



Esplosione di Supernova (tipo II, Ib e Ic)



Supernova

Campo della
supernova SN1987A
Dopo del 23 Febbraio 1987

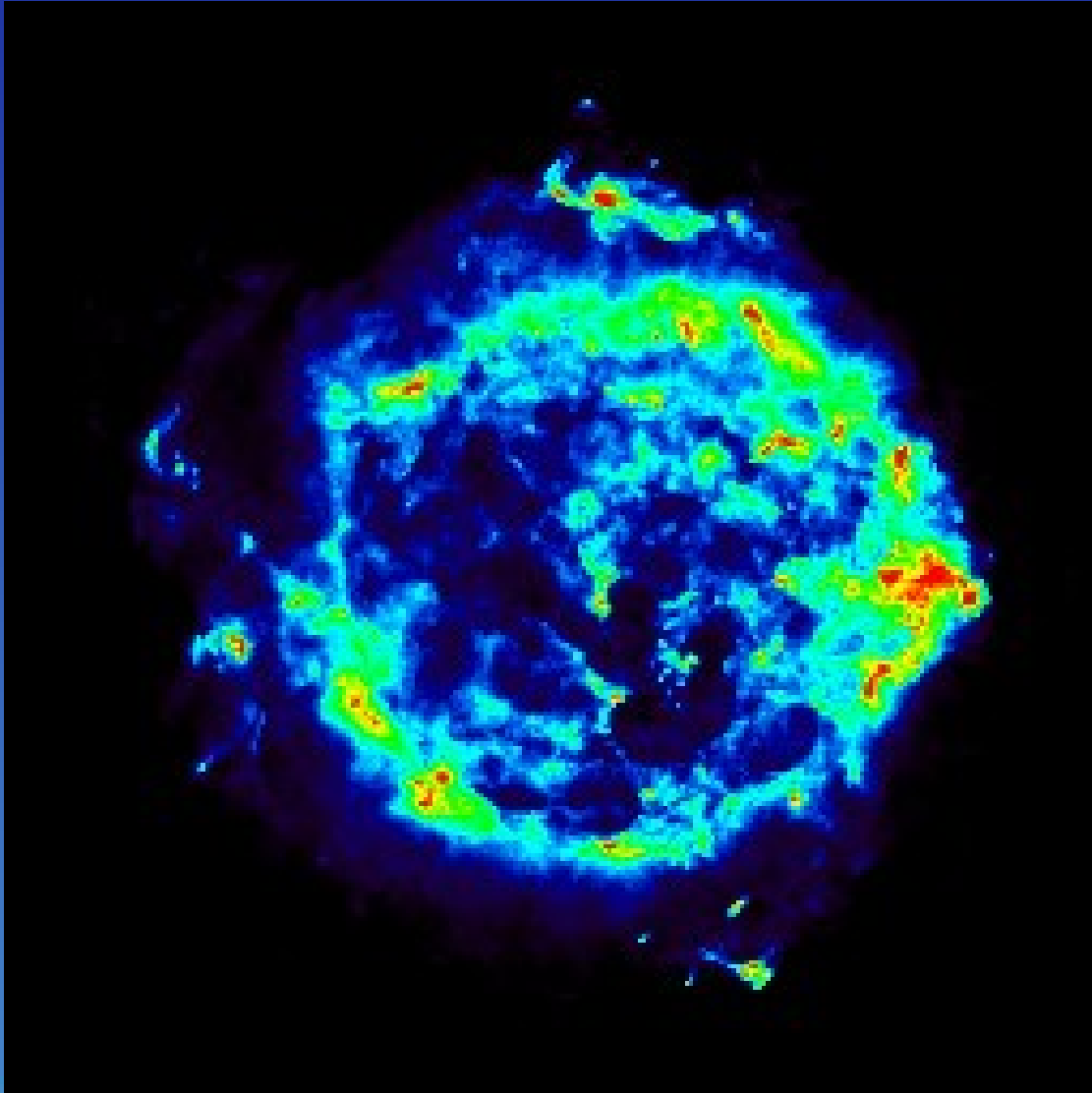
Grande Nube di Magellano



Anglo-Australian Telescope

Cassiopeia A

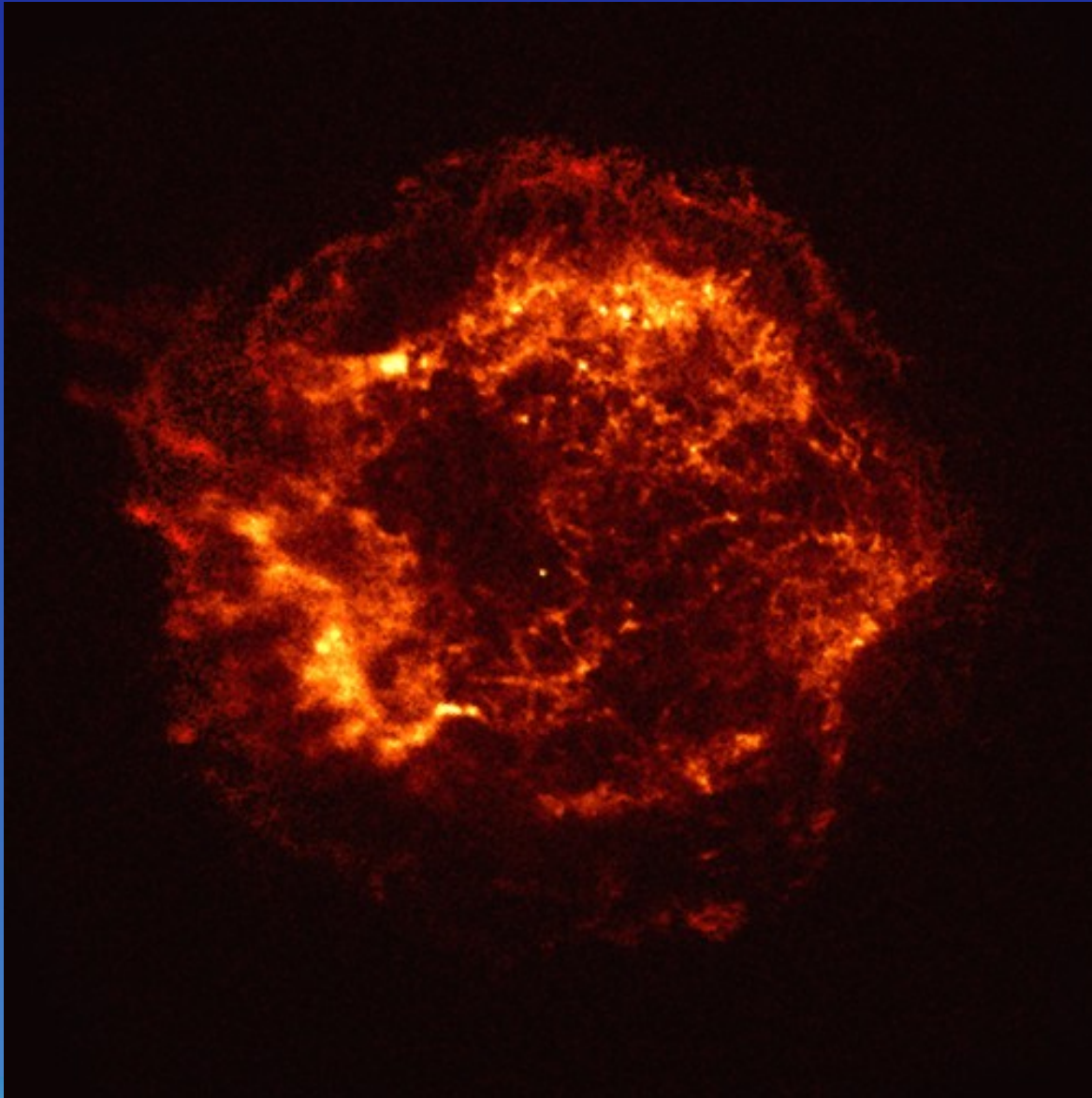
Supernova
esplosa circa
250 anni fa.
Immagine
Radio .



NRAO Very Large Array

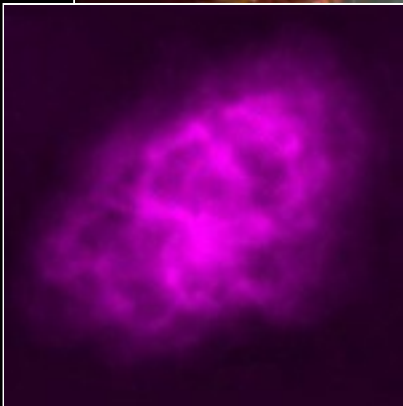
Cassiopeia A

Supernova
esplosa circa
250 anni fa.
Immagine
a Raggi-X

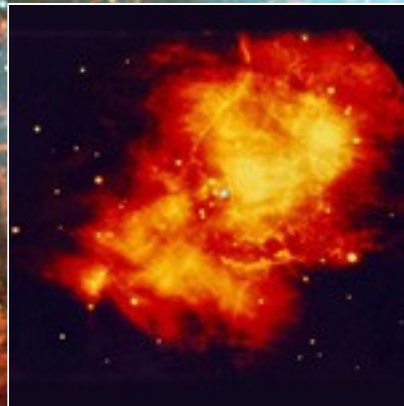


Chandra X-ray Observatory of NASA

La nebulosa del Granchio (Crab Nebula) Supernova osservata dalla Cina nel 1054



Radio



Infrarossi



Ottico

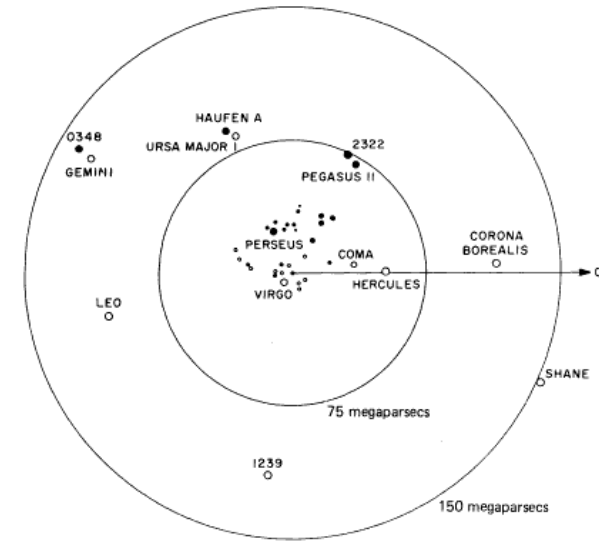


Raggi-X

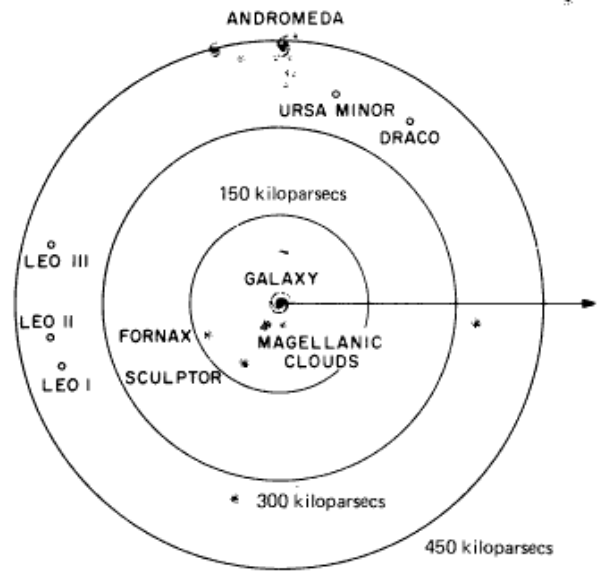
Scale Astronomiche

Gruppi di Galassie

Galassie

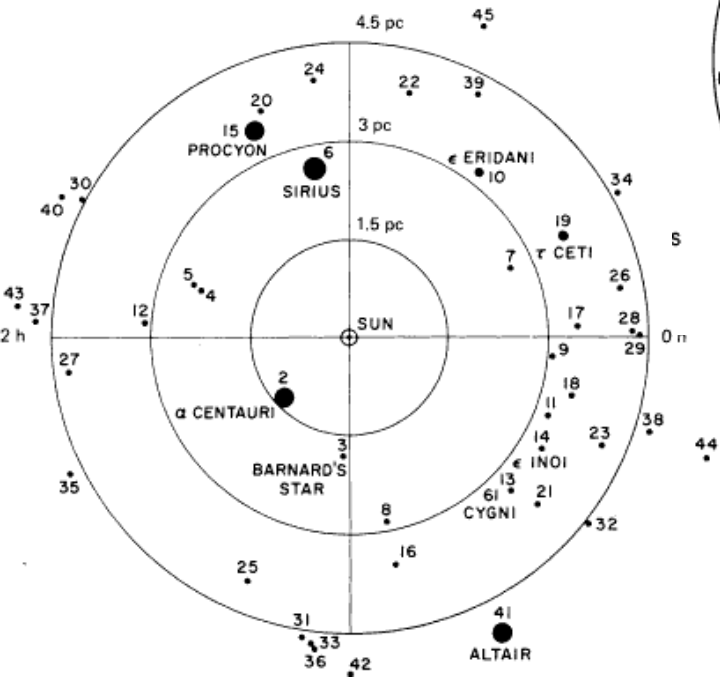


150 Mpc



450 kpc

Stelle



4.5 pc

1 pc (1 parsec) = 3 anni luce



Gruppi (Cluster) di galassie

circa 50 volte le dimensioni della Via Lattea.

Abell2218



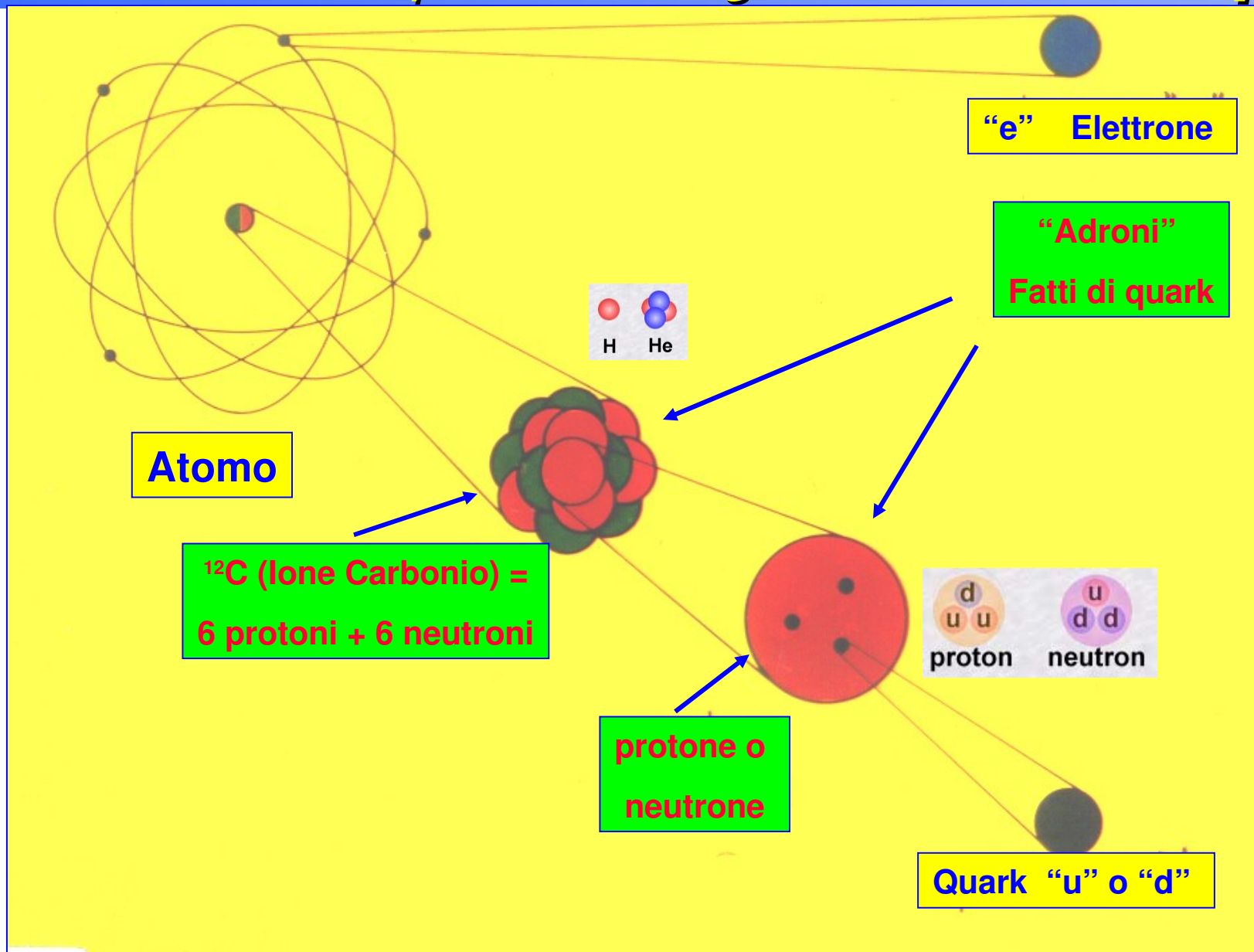
Archi

effetto di lente
gravitazionale su
immagine di galassie
piu' distanti.

HST



*Atomo → Nucleo → Nucleoni: protoni e neutroni,
ADRONI = Fatti di quark: con legame nucleare forte]*



Modello Standard:

FERMIONI

Leptoni e quark

Costituenti Della Materia

e BOSONI

Fotoni/W,Z, gluoni

Portatori di Forza:

Elettromagnetica/

Nucleare Debole,

Nucleare Forte

(G) Gravitazionale?

FERMIONS

matter constituents
spin = 1/2, 3/2, 5/2, ...

Leptons spin = 1/2		
Flavor	Mass GeV/c ²	Electric charge
ν_e electron neutrino	$<1 \times 10^{-8}$	0
e electron	0.000511	-1
ν_μ muon neutrino	<0.0002	0
μ muon	0.106	-1
ν_τ tau neutrino	<0.02	0
τ tau	1.7771	-1

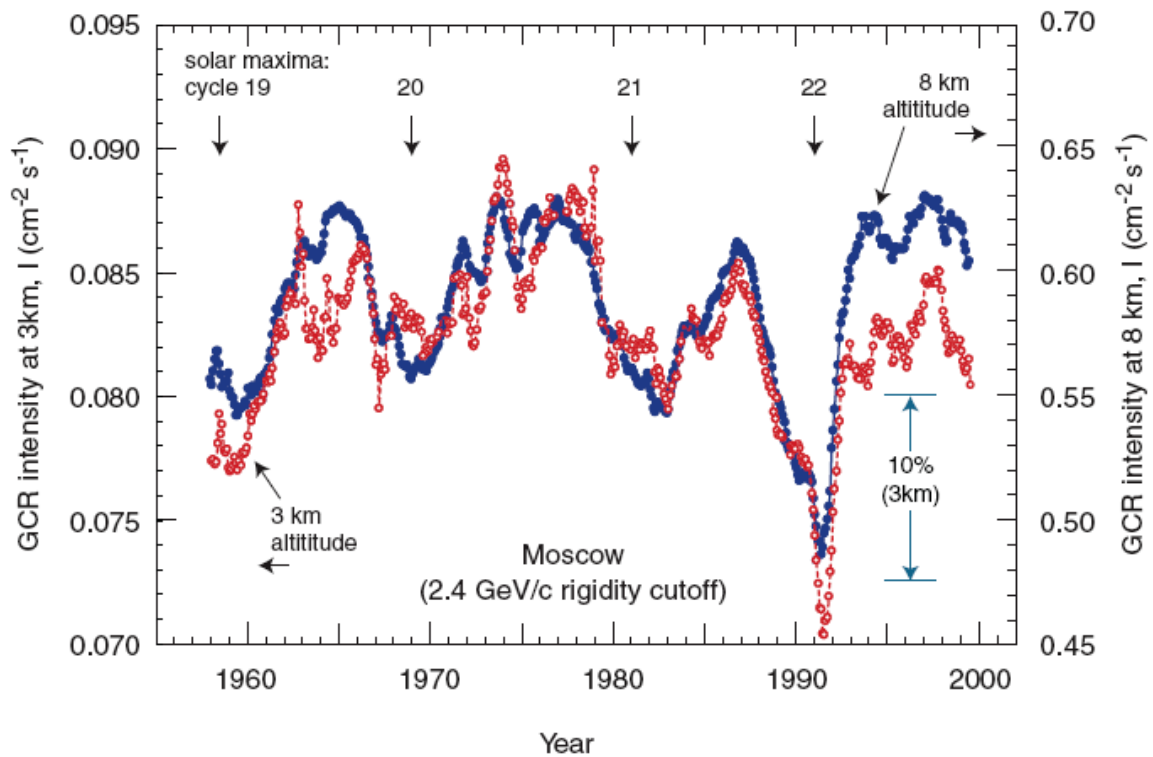
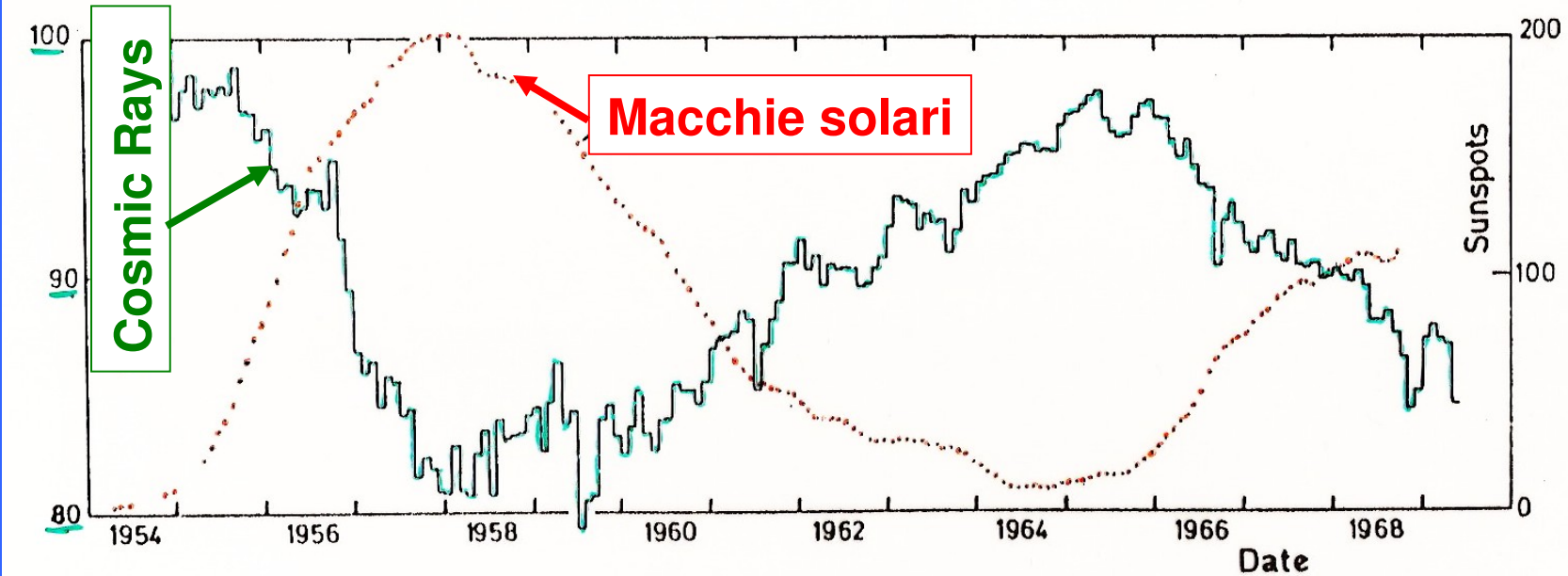
Quarks spin = 1/2		
Flavor	Approx. Mass GeV/c ²	Electric charge
u up	0.003	2/3
d down	0.006	-1/3
c charm	1.3	2/3
s strange	0.1	-1/3
t top	175	2/3
b bottom	4.3	-1/3

BOSONS

force carriers
spin = 0, 1, 2, ...

Unified Electroweak spin = 1		
Name	Mass GeV/c ²	Electric charge
γ photon	0	0
W^-	80.4	-1
W^+	80.4	+1
Z^0	91.187	0

Strong (color) spin = 1		
Name	Mass GeV/c ²	Electric charge
g gluon	0	0



Anticorrelazione con i Massimi del ciclo solare

Raggi cosmici galattici

Particelle energetiche

Neutral Particles

Vento solare

Mezzo interstellare locale

Sole

Atmosfera

Magnetosfera

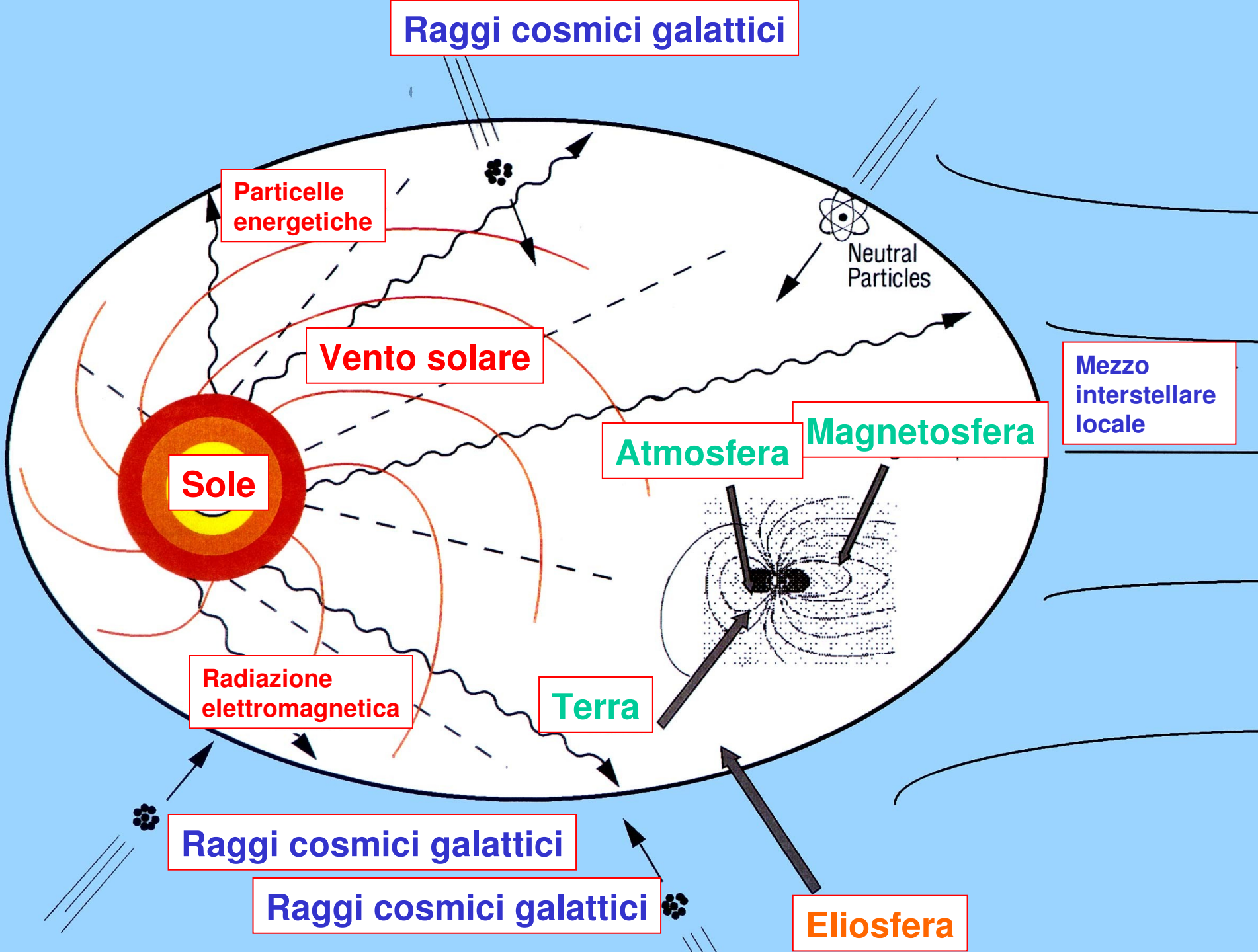
Radiazione elettromagnetica

Terra

Raggi cosmici galattici

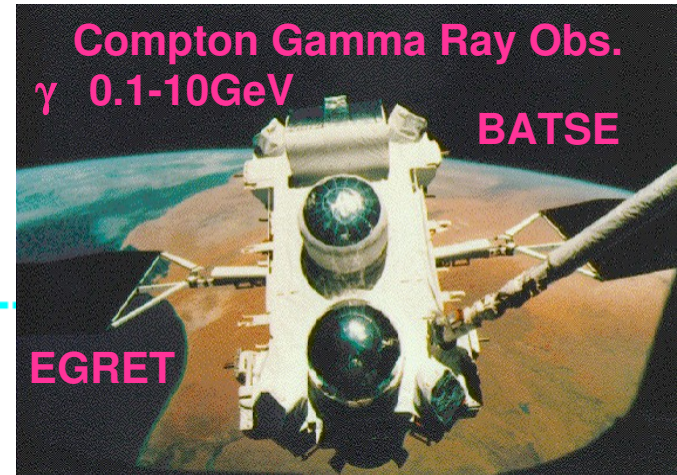
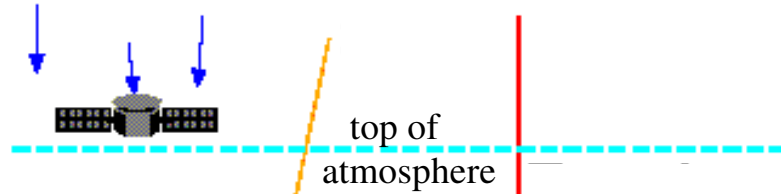
Raggi cosmici galattici

Eliosfera

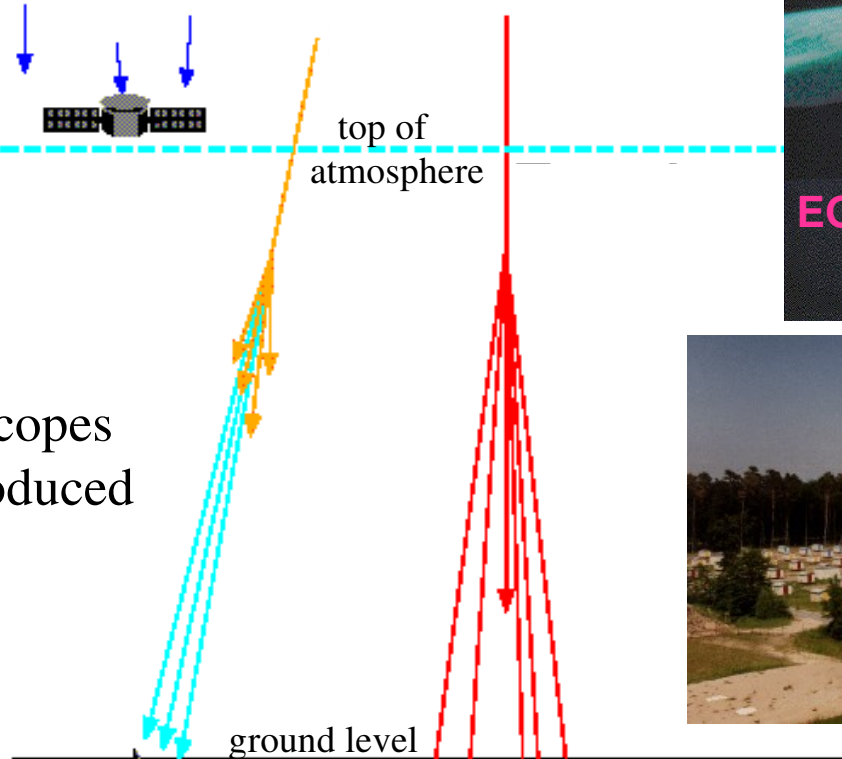


Rivelatori di raggi cosmici

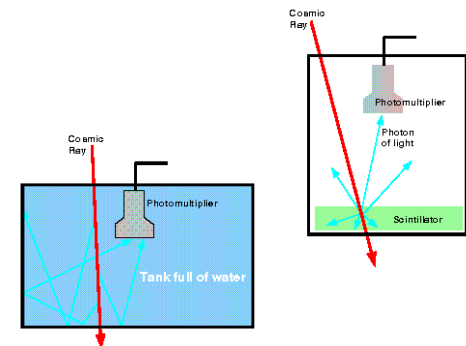
Satellites

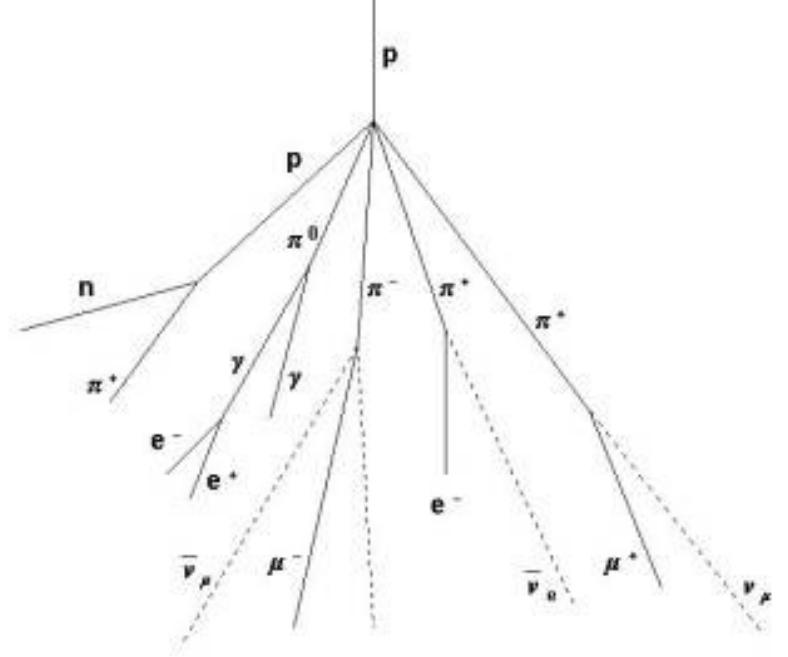
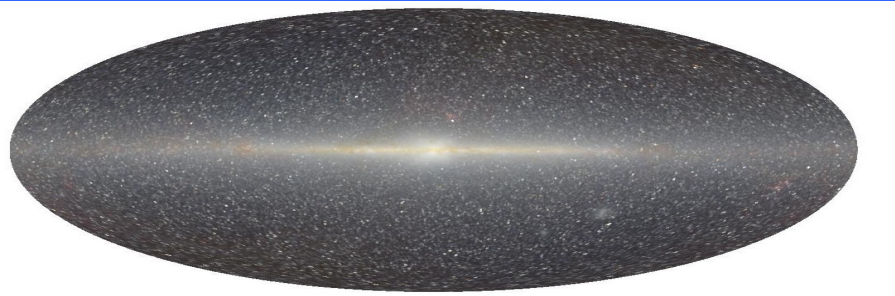


Ground based telescopes
looking at light produced
in atmosphere

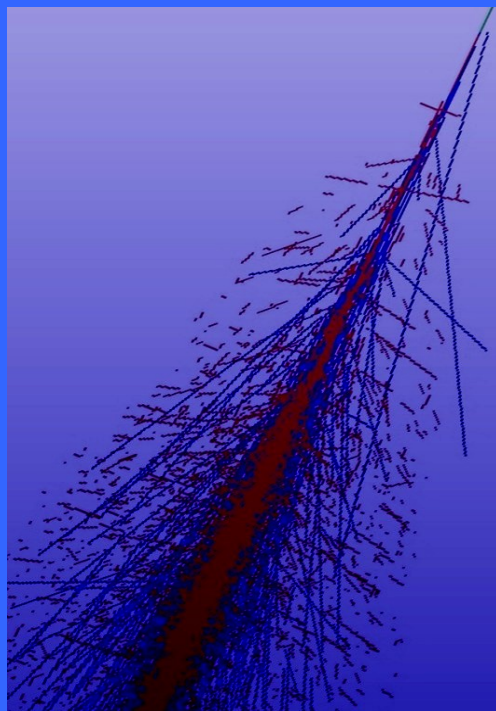


Arrays of particle detectors

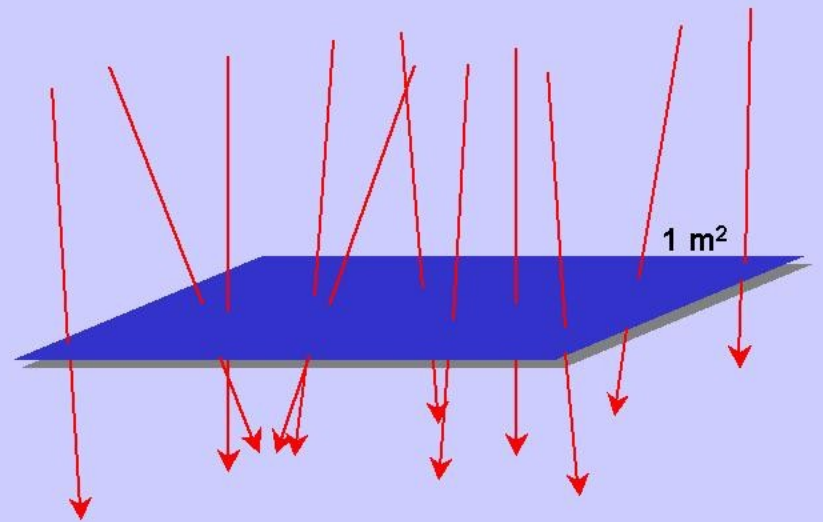




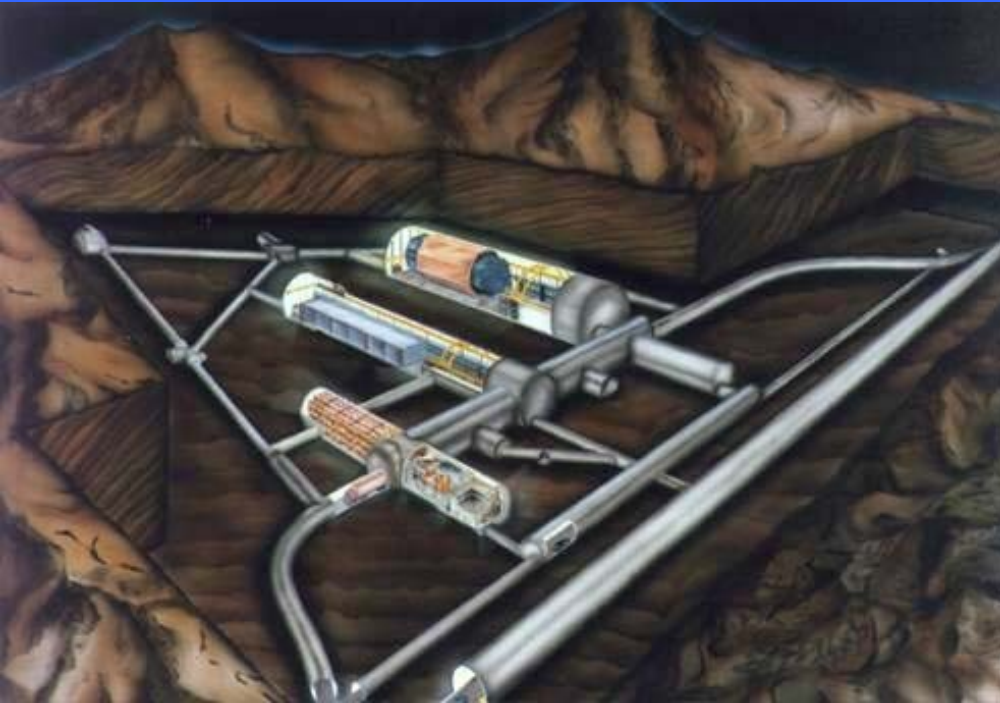
Raggi Cosmici



130 muoni al secondo



MACRO@ Gran Sasso (AQ) (1984-1999)



Grotta Gigante @Carso Triestino (1996)



Con :F. Coren, E. Caffau, S. Spagnul, G. Santin, M.Apollonio

Search for Hidden Chambers in the Pyramids

The structure of the Second Pyramid of Giza is determined by cosmic-ray absorption.

Luis W. Alvarez, Jared A. Anderson, F. El Bedwei, James Burkhard, Ahmed Fakhry, Adib Girgis, Amr Goneid, Fikhry Hassan, Dennis Iverson, Gerald Lynch, Zenab Miligy, Ali Hilmy Moussa, Mohammed-Sharkawi, Lauren Yazolino

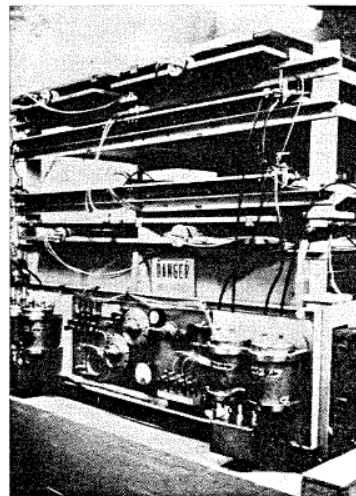
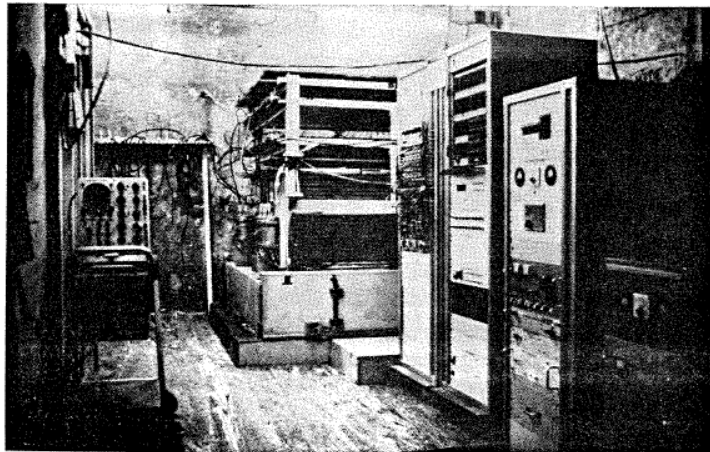
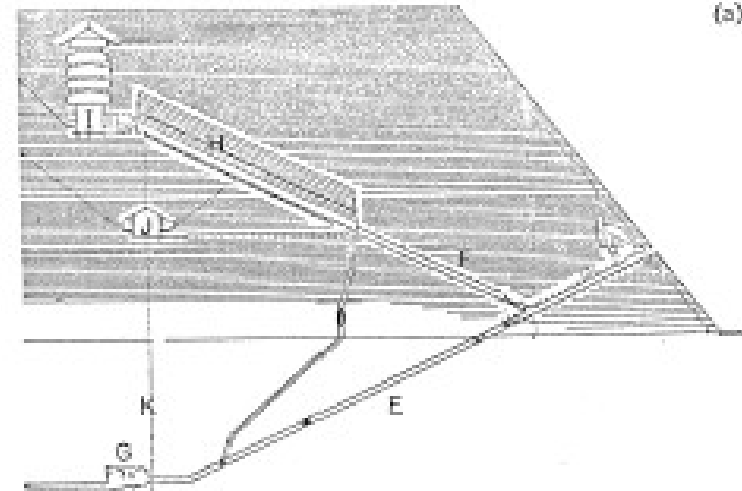


Fig. 6 (left). The equipment in place in the Belzoni Chamber under the pyramid. Fig. 7 (right). The detection apparatus containing the spark chambers.

Anni 1970
Luiz W. Alvarez
(Premio Nobel per la Fisica)

Risultati Piramide di Chefren (KHA-F-RA)

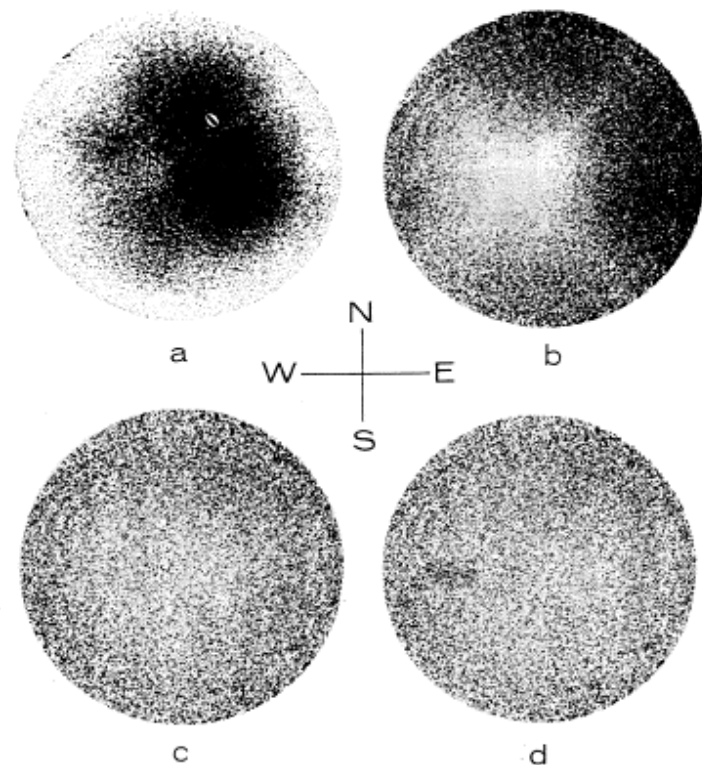
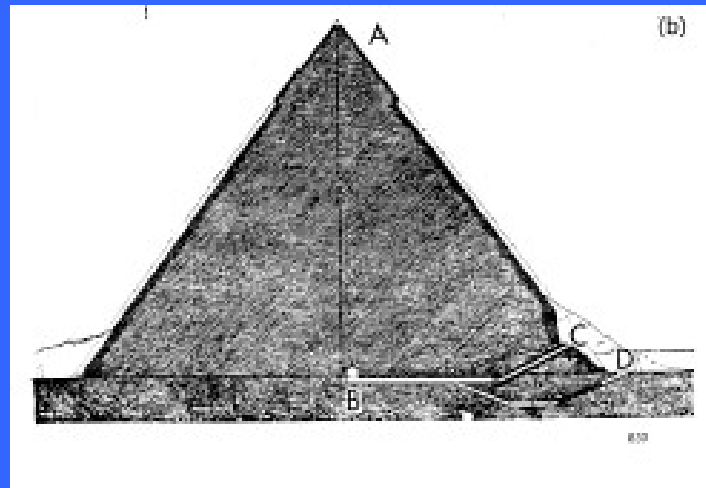


Fig. 13. Scatter plots showing the three stages in the combined analytic and visual analysis of the data and a plot with a simulated chamber. (a) Simulated "X-ray photograph" of uncorrected data. (b) Data corrected for the geometrical acceptance of the apparatus. (c) Data corrected for pyramid structure as well as geometrical acceptance. (d) Same as (c) but with simulated chamber, as in Fig. 12.

858

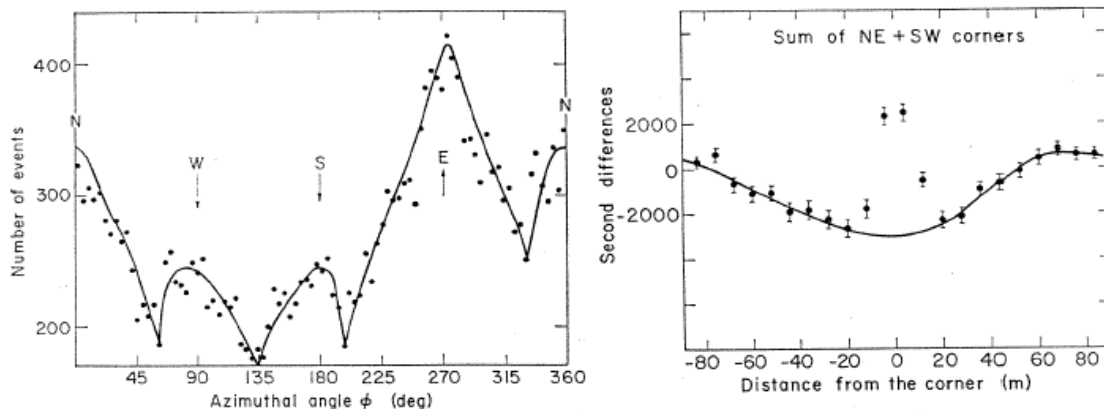
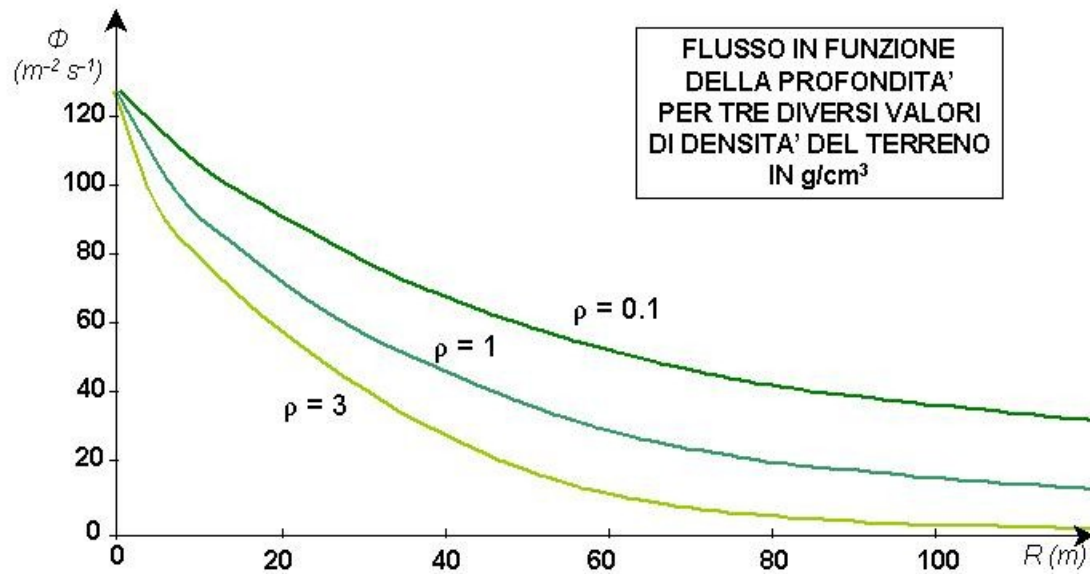
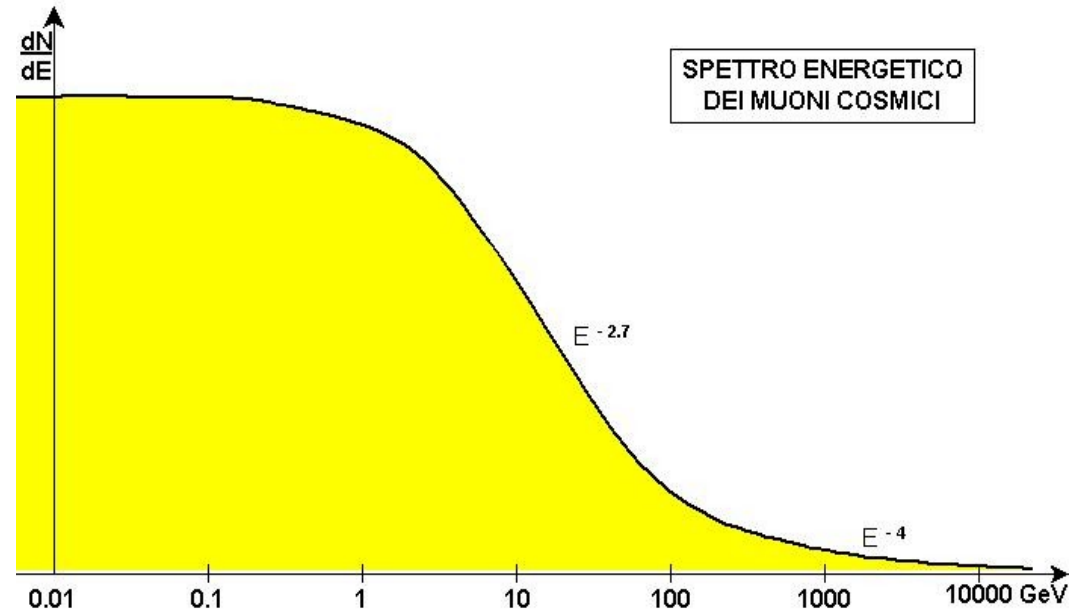
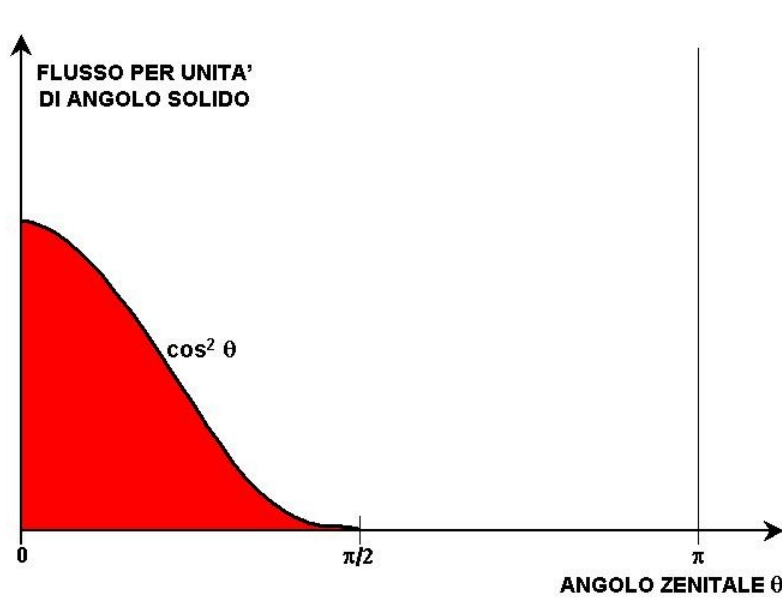


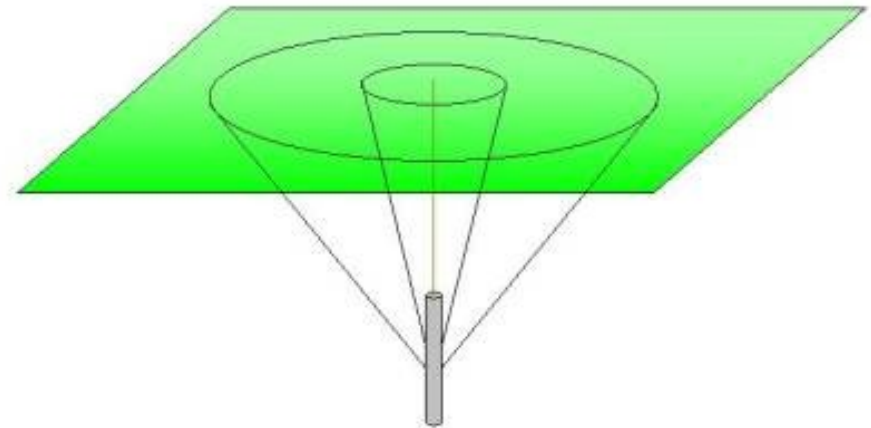
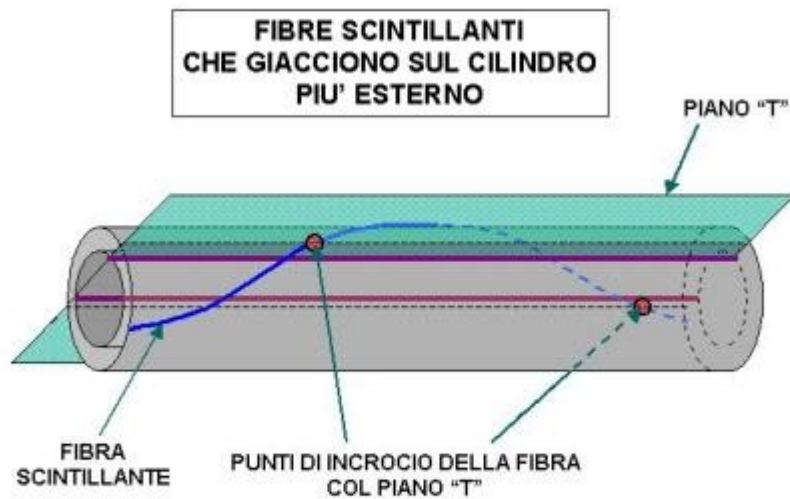
Fig. 3 (left). The initial measurement (with zenith angle of counts from 20 to 40 degrees) of the variation of cosmic-ray intensity with azimuthal angle, as observed from the Belzoni Chamber underneath the Second Pyramid of Chephren. Fig. 4 (right). Detection of the northeast and southwest corners of the pyramid obtained by plotting the second differences of the counting rate on the planes tangent to the corners as a function of distance from the corners.

Caratteristiche dei raggi cosmici

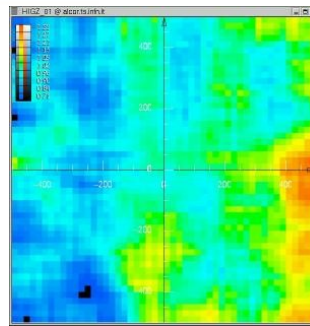
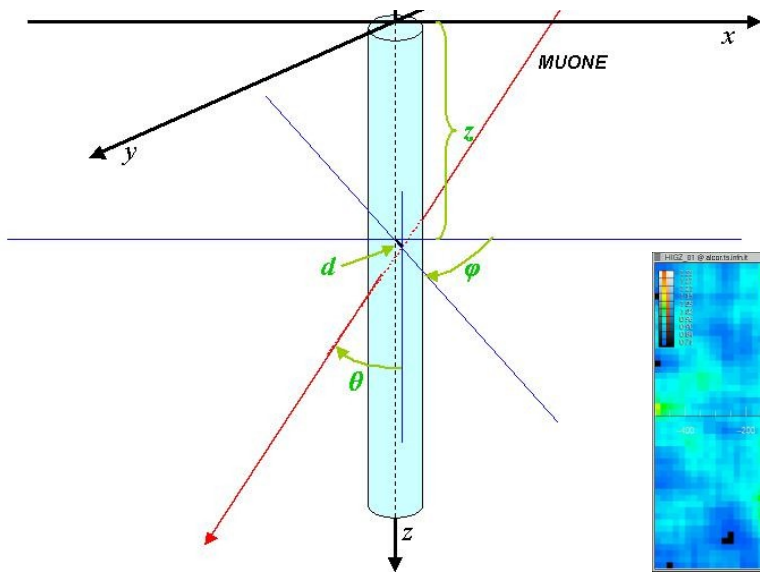


RADIOGRAFIA MUONICA DEL SOTTOSUOLO

MGR Muon Ground Radiography



IL RIVELATORE CILINDRICO
RIESCE AD ANALIZZARE IL TERRENO
COMPRESO TRA I DUE CONI DISEGNATI



M.Menichelli¹, S.Ansoldi², M.Bari³, M. Basset³, R.Battiston^{1,4}, S.Blasko¹,
F.Coren⁵, E.Fiori¹, G.Giannini^{2,3}, D.Iugovaz^{2,3}, A.Papi¹, S.Reia^{2,3}, G.Scian³.

¹INFN Sezione di Perugia,

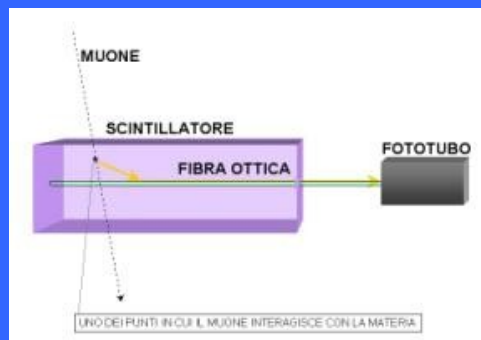
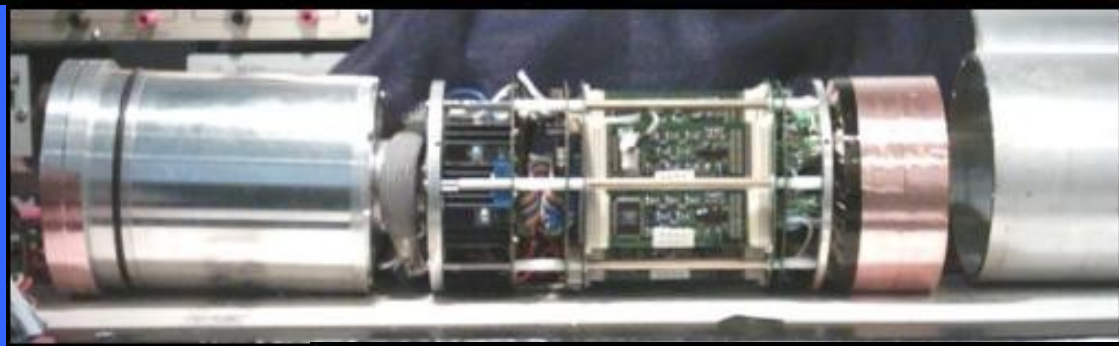
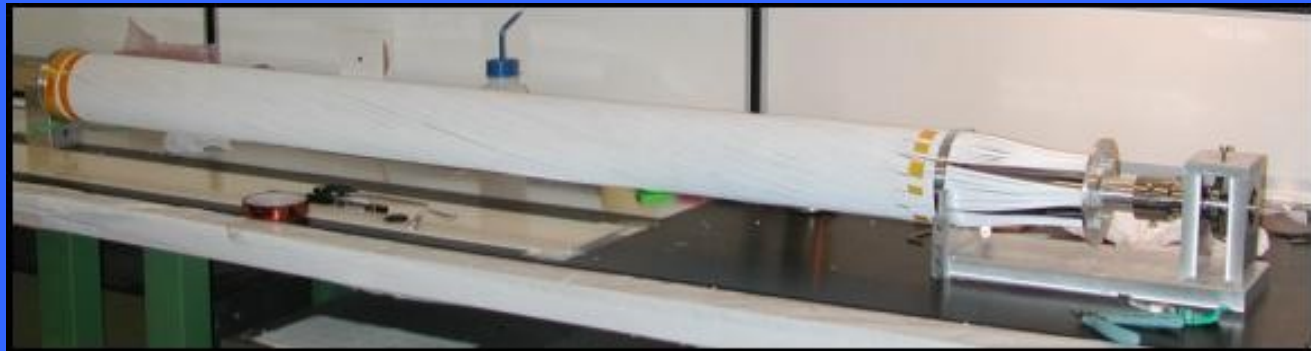
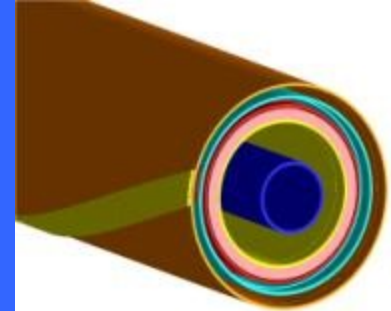
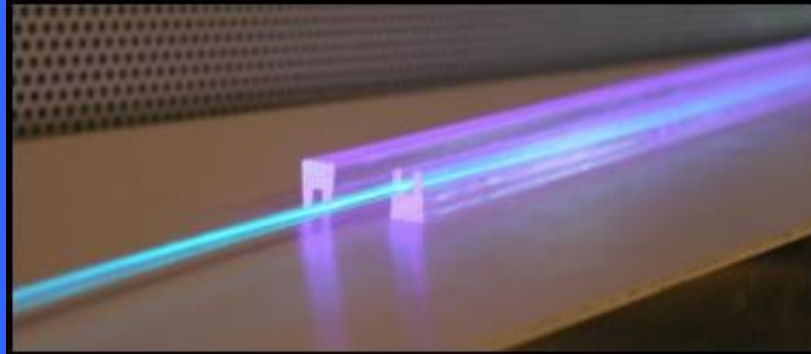
²Universita' degli Studi di Trieste,

³INFN Sezione di Trieste,

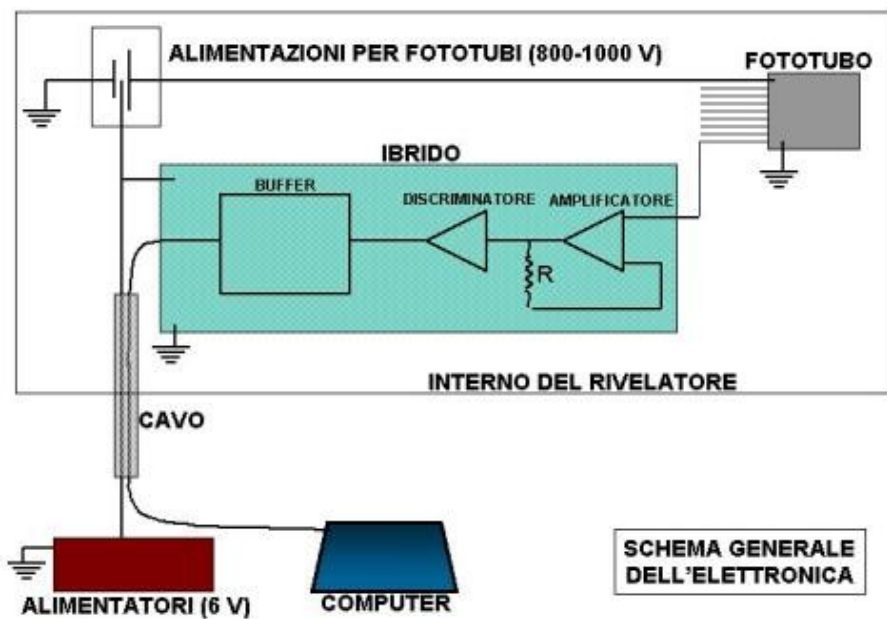
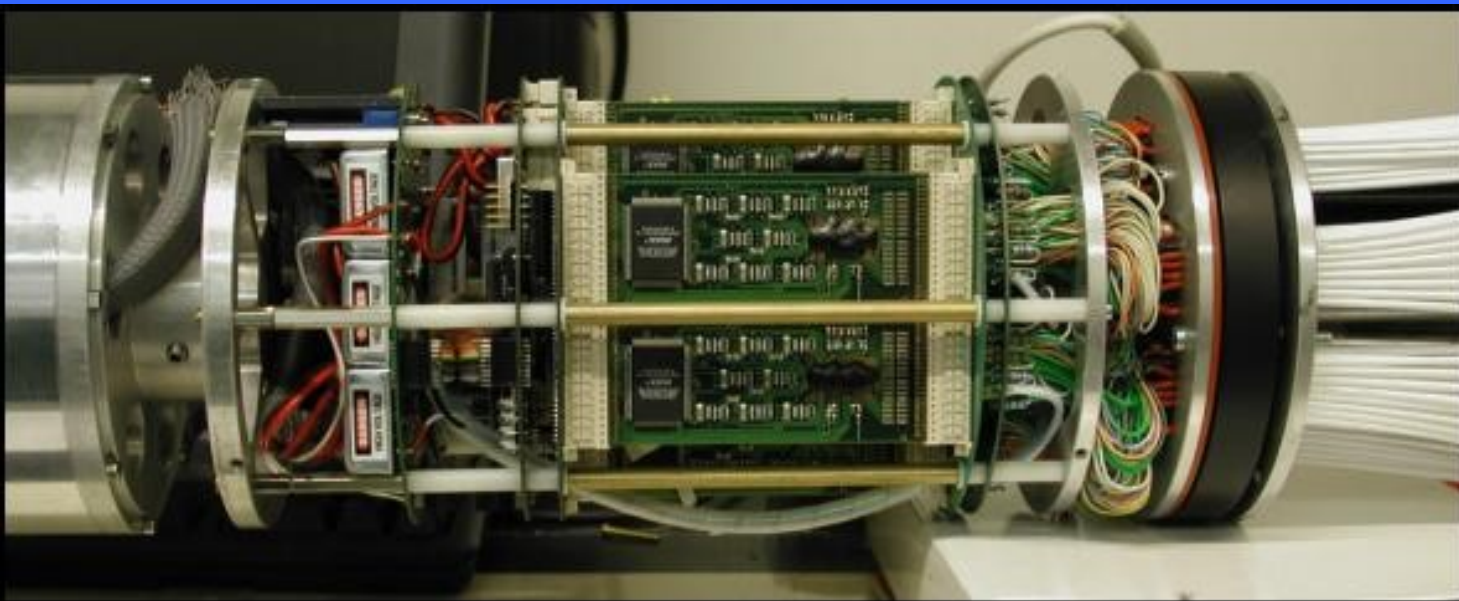
⁴Universita' degli Studi di Perugia,

⁵OGS Trieste.

Il rivelatore



L'elettronica



1997 "Archeologia senza scavo XLV settimana di studi Aquileiesi

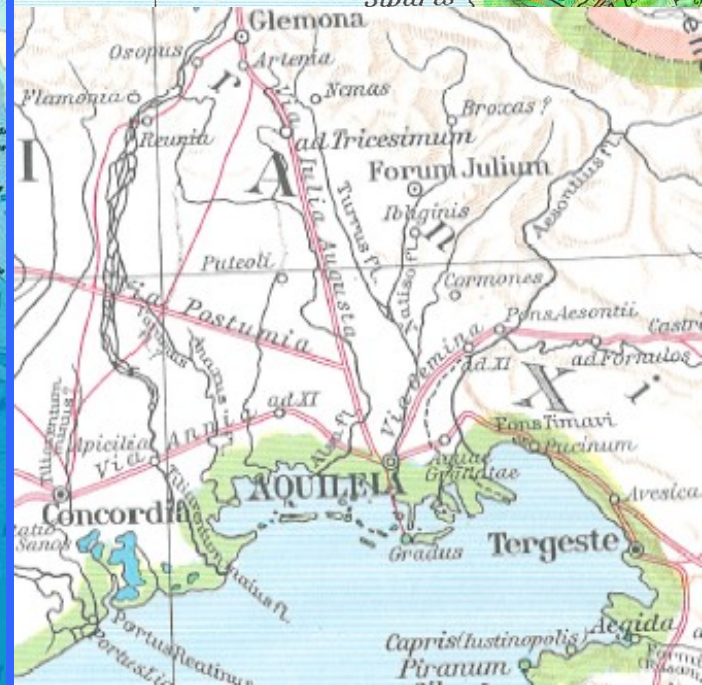
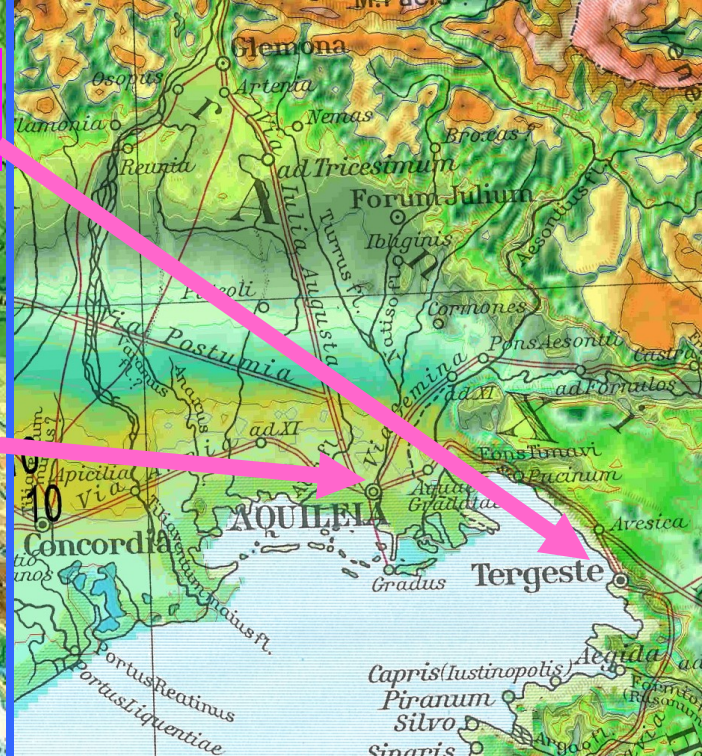


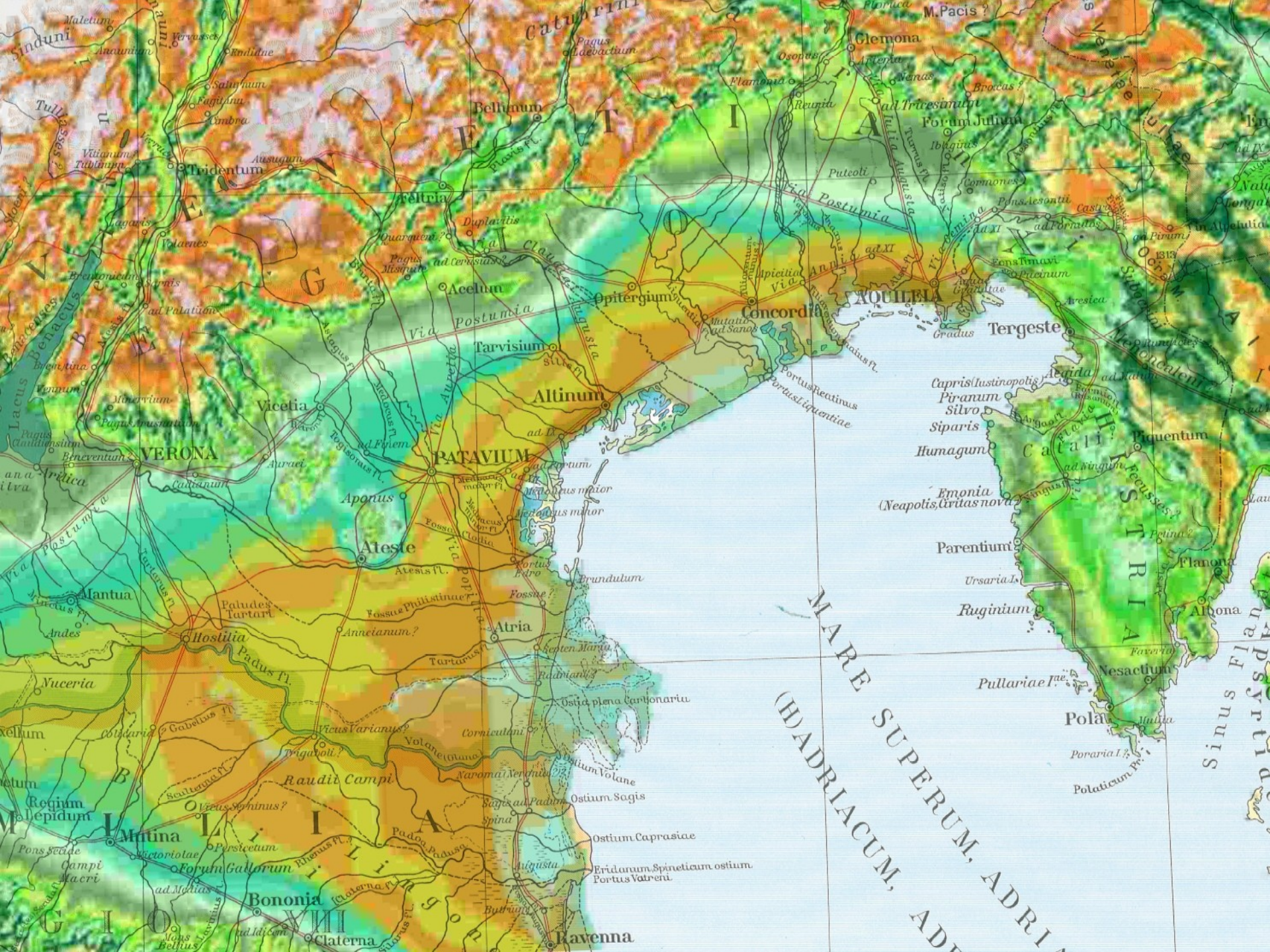


Trieste

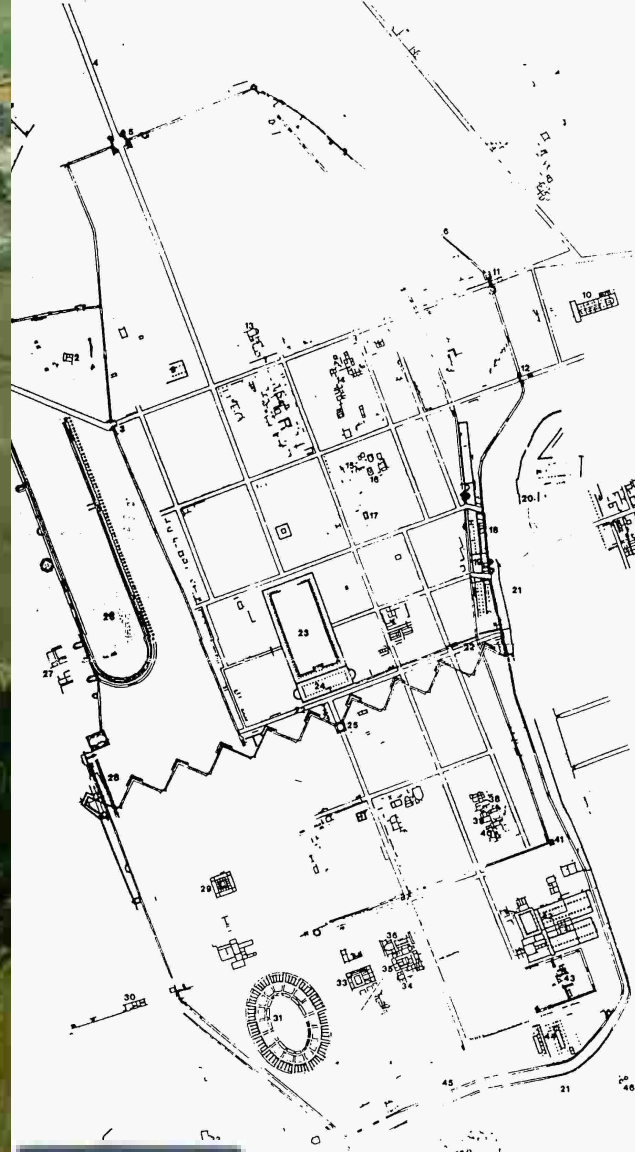
Aquileia

Roma

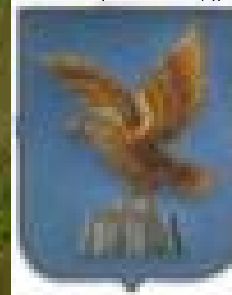




Aquileia



**APPLICAZIONE ALL'ARCHEOLOGICA DELLA
RADIOGRAFIA CON I RAGGI COSMICI**

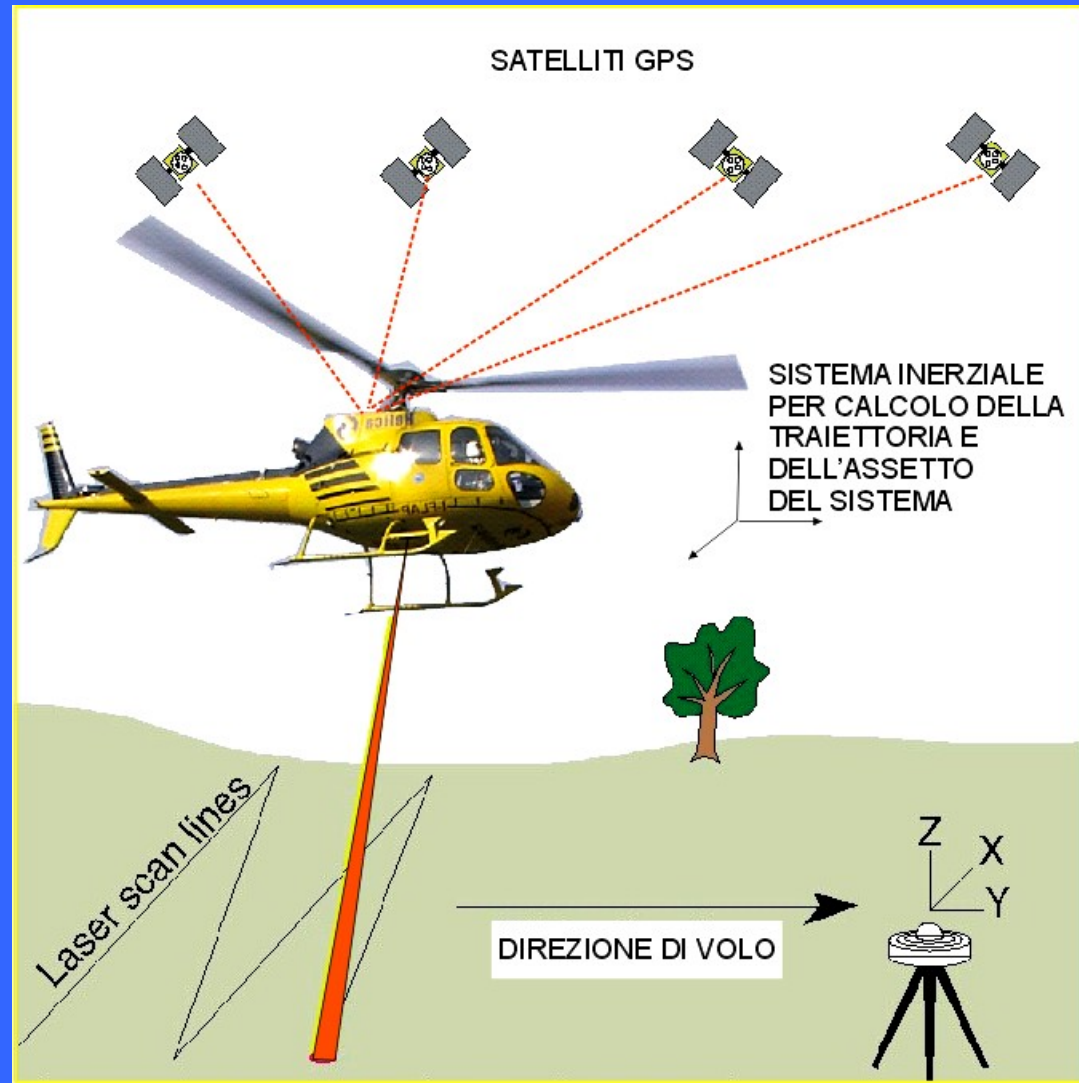


**Legge regionale
n.3/1998, art.16.
Finanziamenti progetti
di ricerca e
divulgazione scientifica.
Anno 2002.**

IL SISTEMA LASER A SCANSIONE

Il sistema laser a scansione è uno strumento che integra quattro unità principali:

- 1) Un laser ranger, il cui raggio viene fatto oscillare normalmente alla direzione di volo
- 2) Un sistema di posizionamento GPS
- 3) Una unità inerziale



- 4) Un computer di bordo per l'acquisizione dei dati

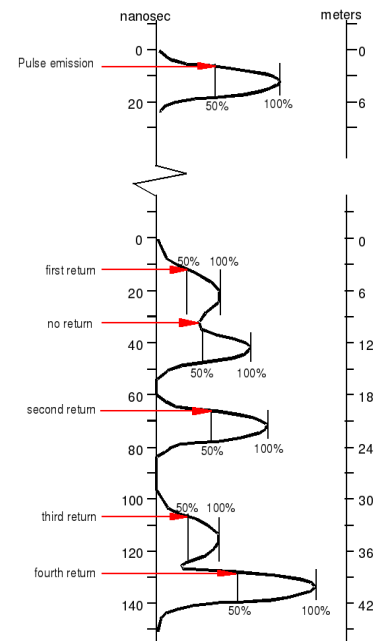
IL SISTEMA LASER A SCANSIONE

Il laser ha un apertura di 0.2 mrad (impronta al suolo di 0.2 m da 1000 m di distanza).

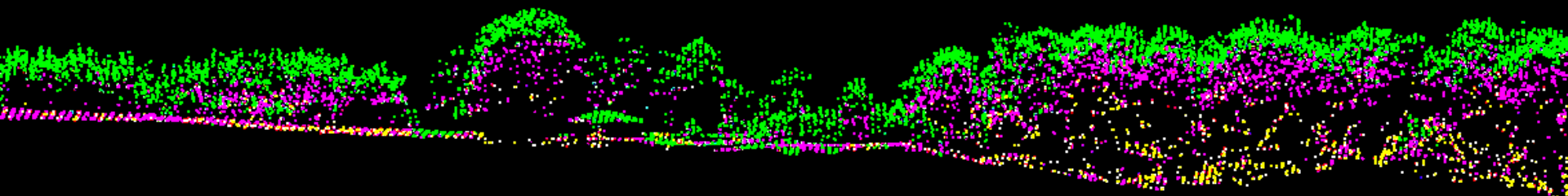
Il sistema registra sia la posizione che la radiometria del primo e dell'ultimo impulso inviato al suolo.

Questo permette di poter penetrare significativamente attraverso la copertura vegetale determinando:

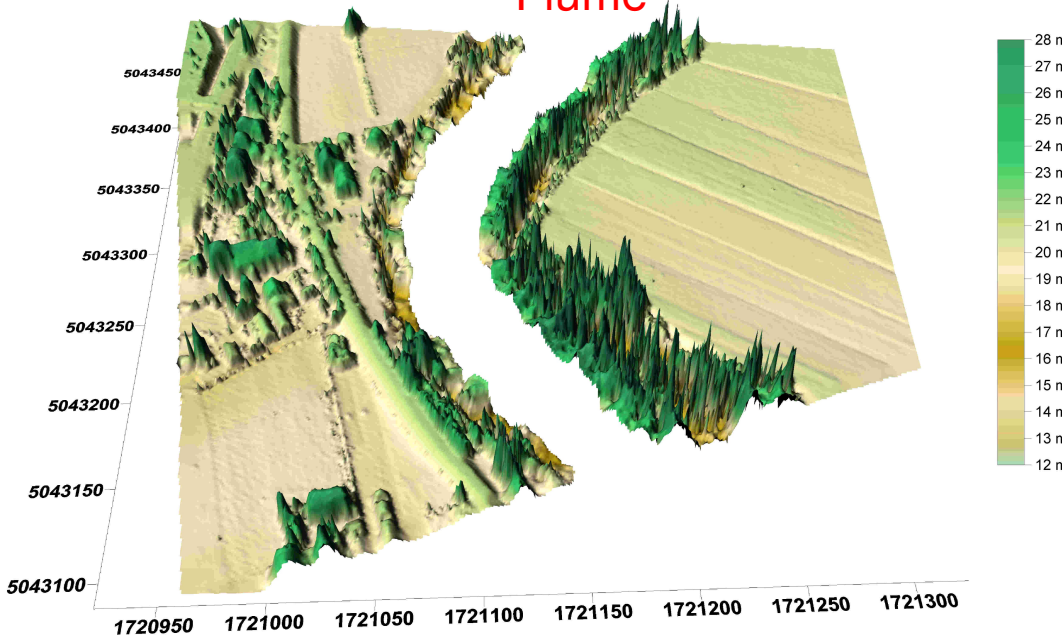
- L'elevazione della vegetazione
- La quota del terreno anche al di sotto della vegetazione.



“la sezione vegetale”



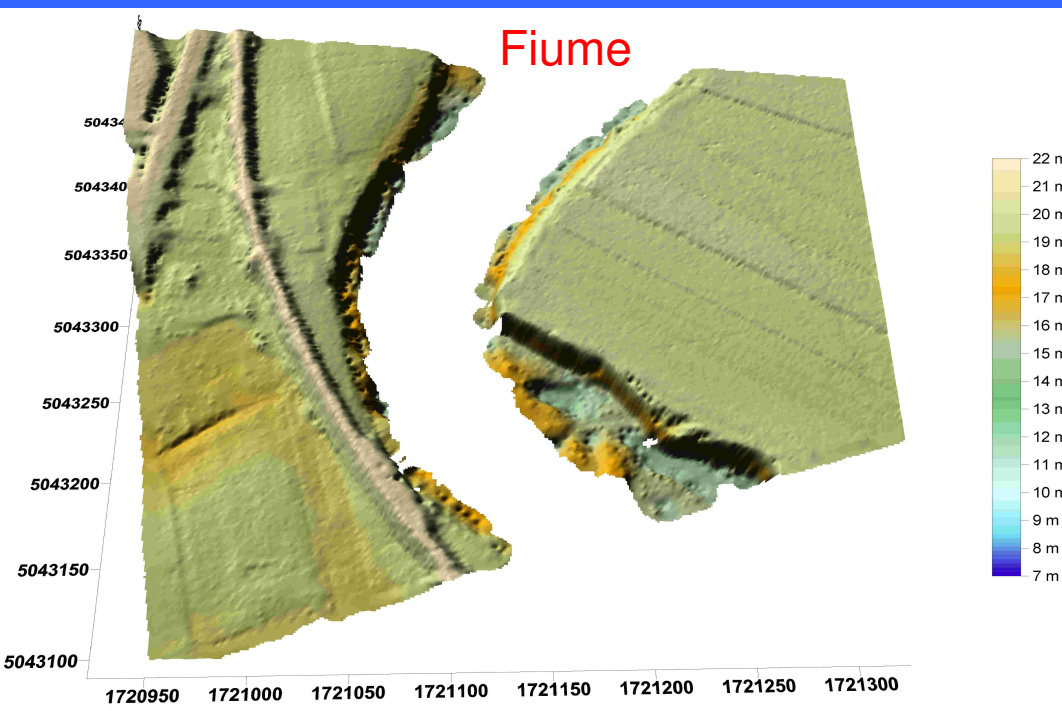
Fiume



MODELLO DEL TERRENO

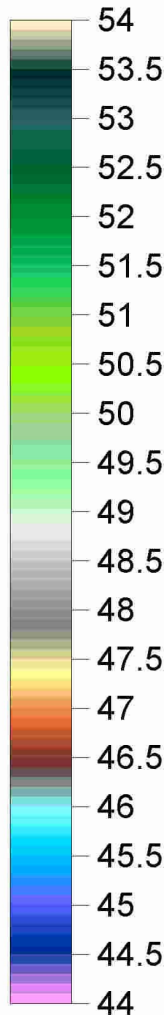
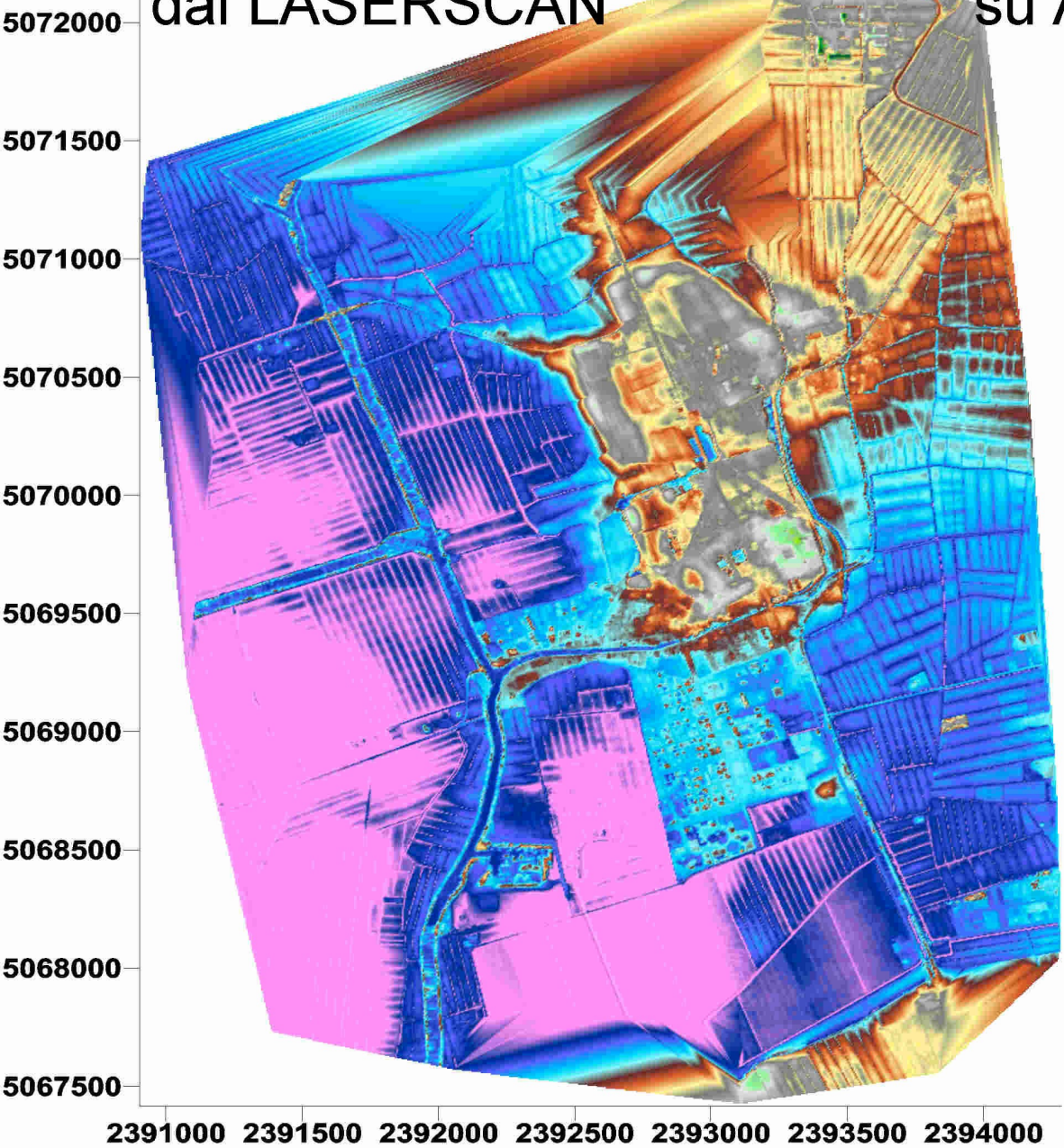
dal primo impulso

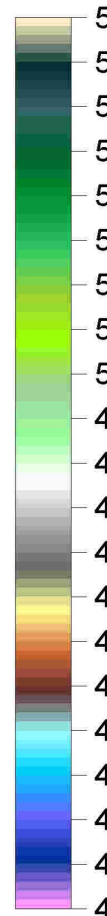
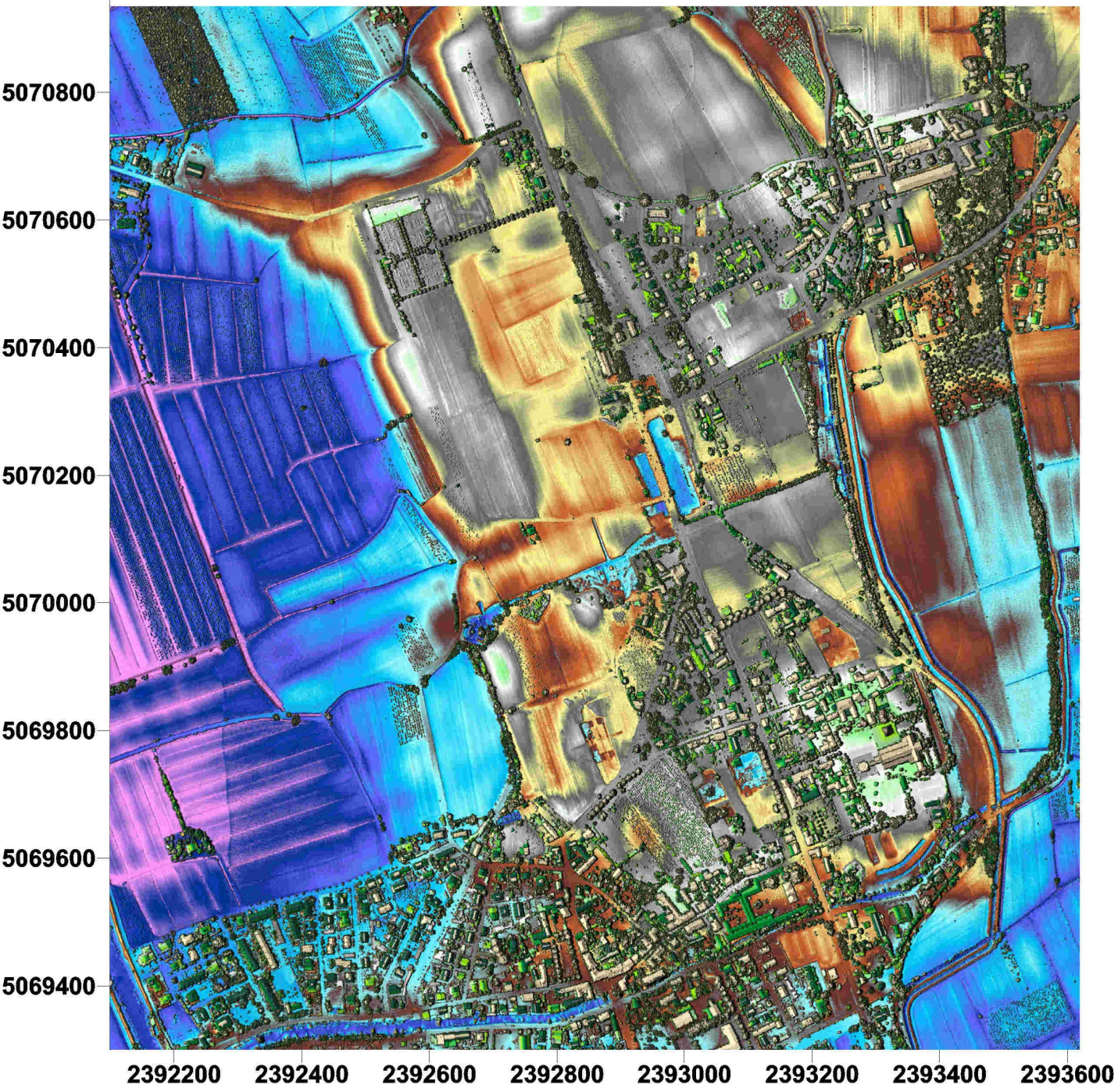
Fiume



dall'ultimo impulso

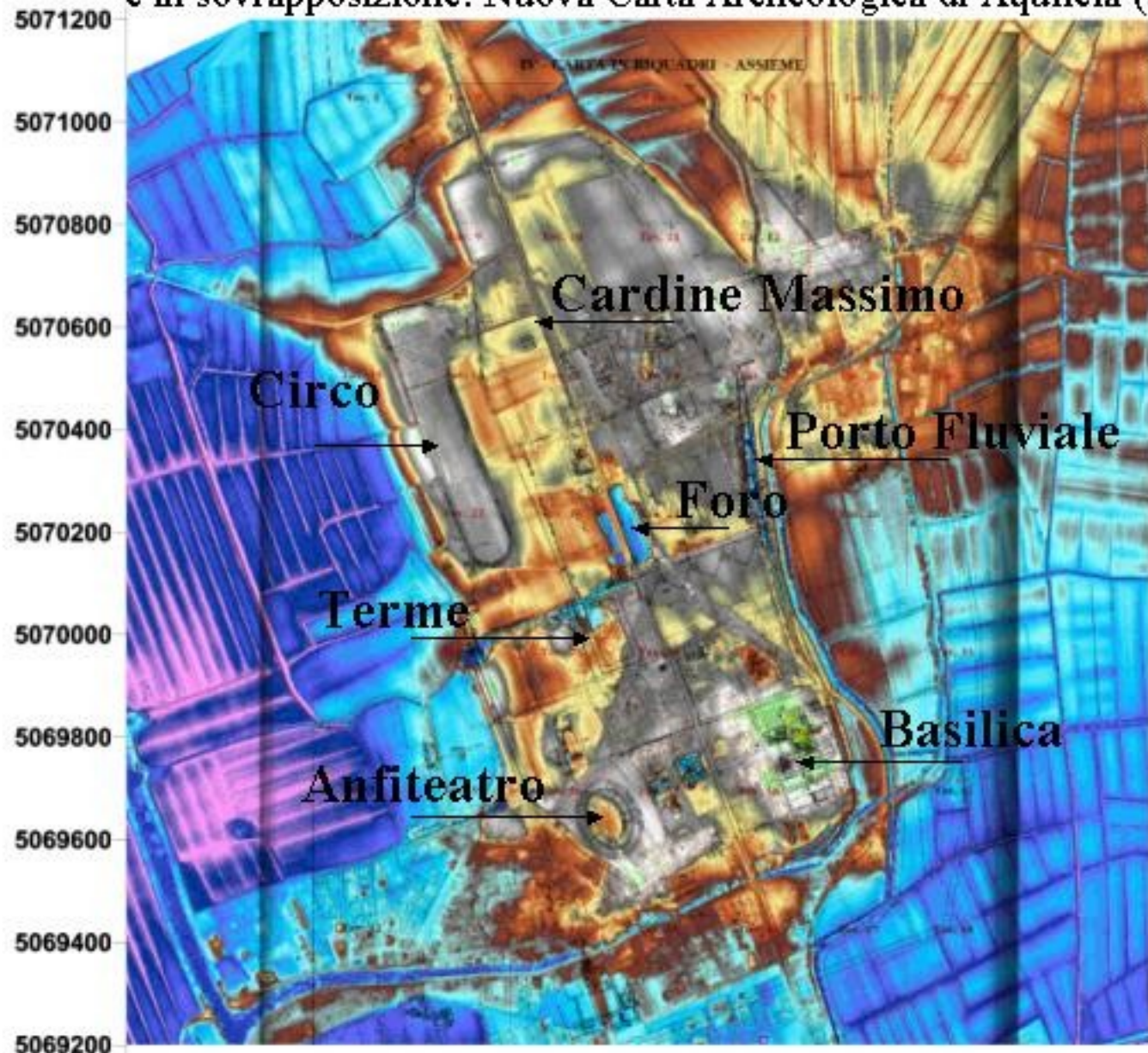
Immagine digitale che mostra tutta l'estensione coperta dal LASERSCAN su Aquileia e dintorni



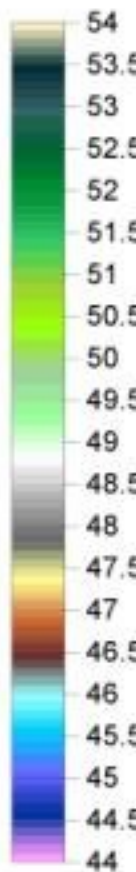


AQUILEIA TOPOGRAFIA LASERSCAN da Elicottero

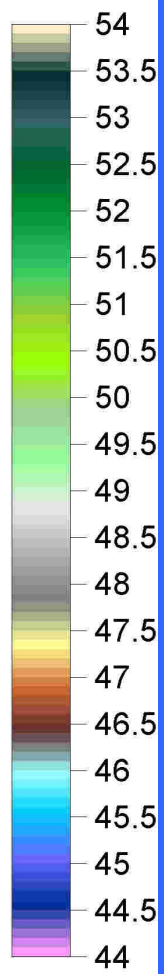
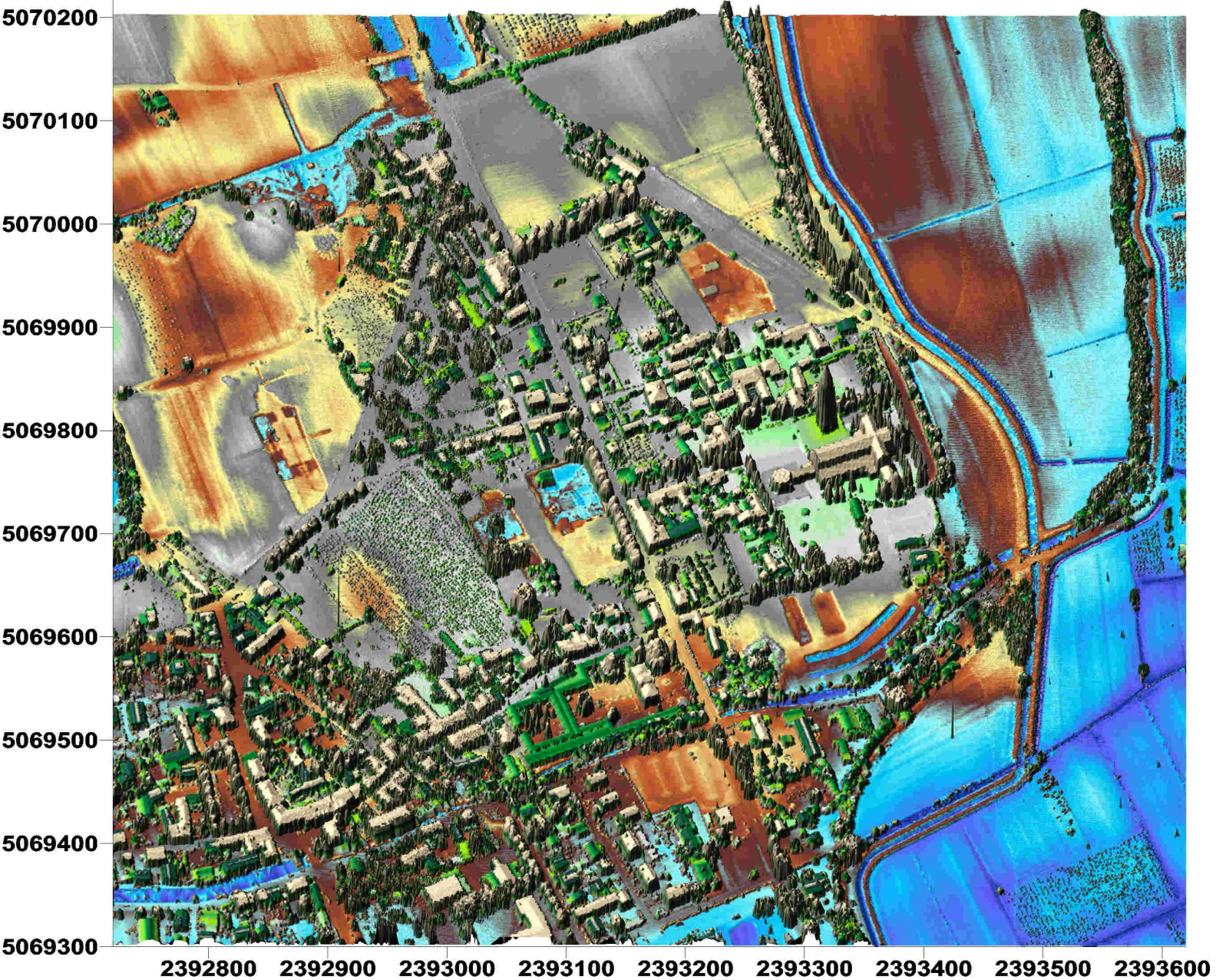
e in sovrapposizione: Nuova Carta Archeologica di Aquileia (aut.: Luisa Bertacchi)

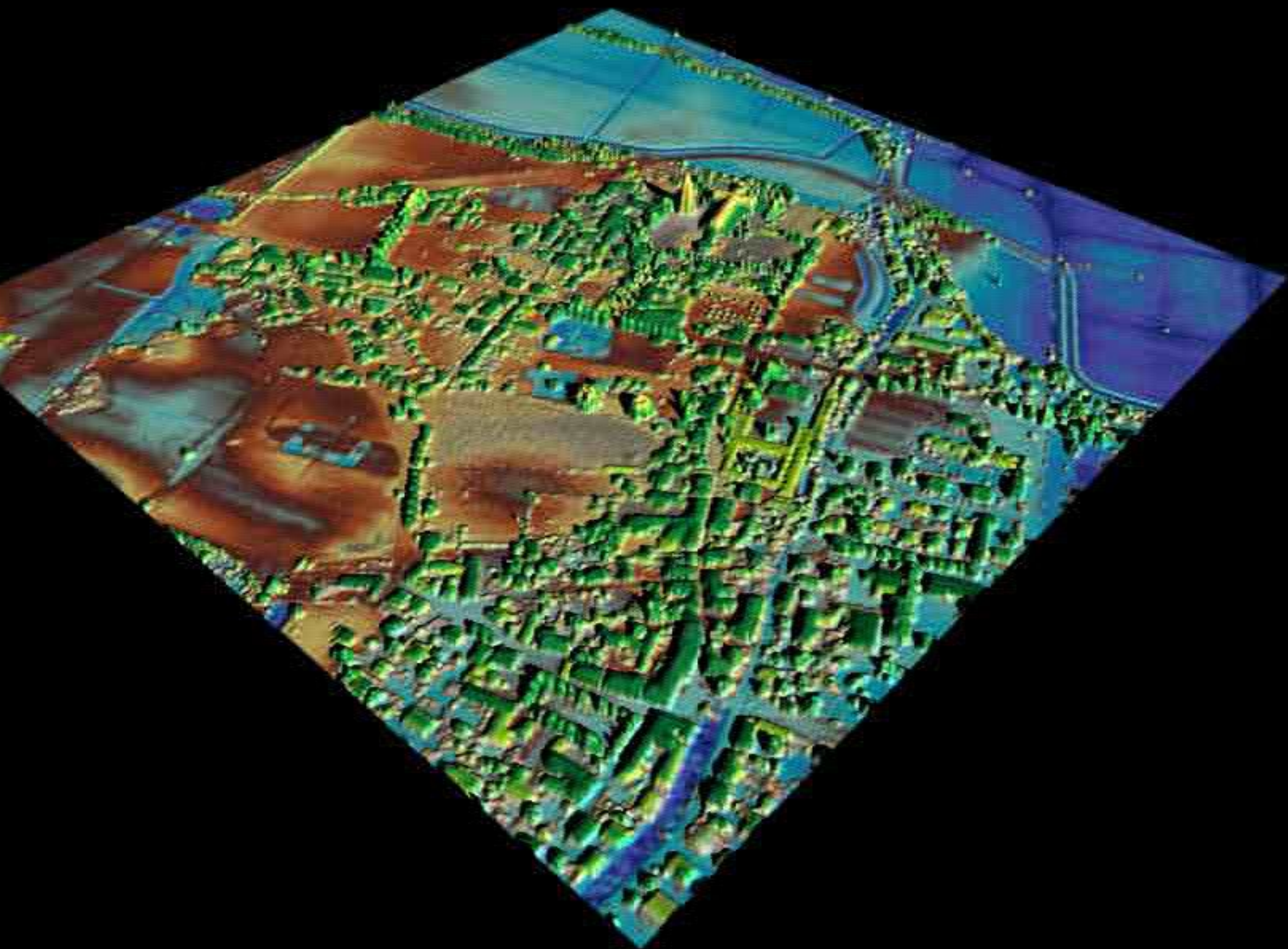


- + Regione Friuli Venezia Giulia
- + Dip. di Fisica Universita' Trieste
- + INFN-Trieste e Perugia /MGR
- + OGS
- + Helica



2392000 2392200 2392400 2392600 2392800 2393000 2393200 2393400 2393600 2393800 2394000

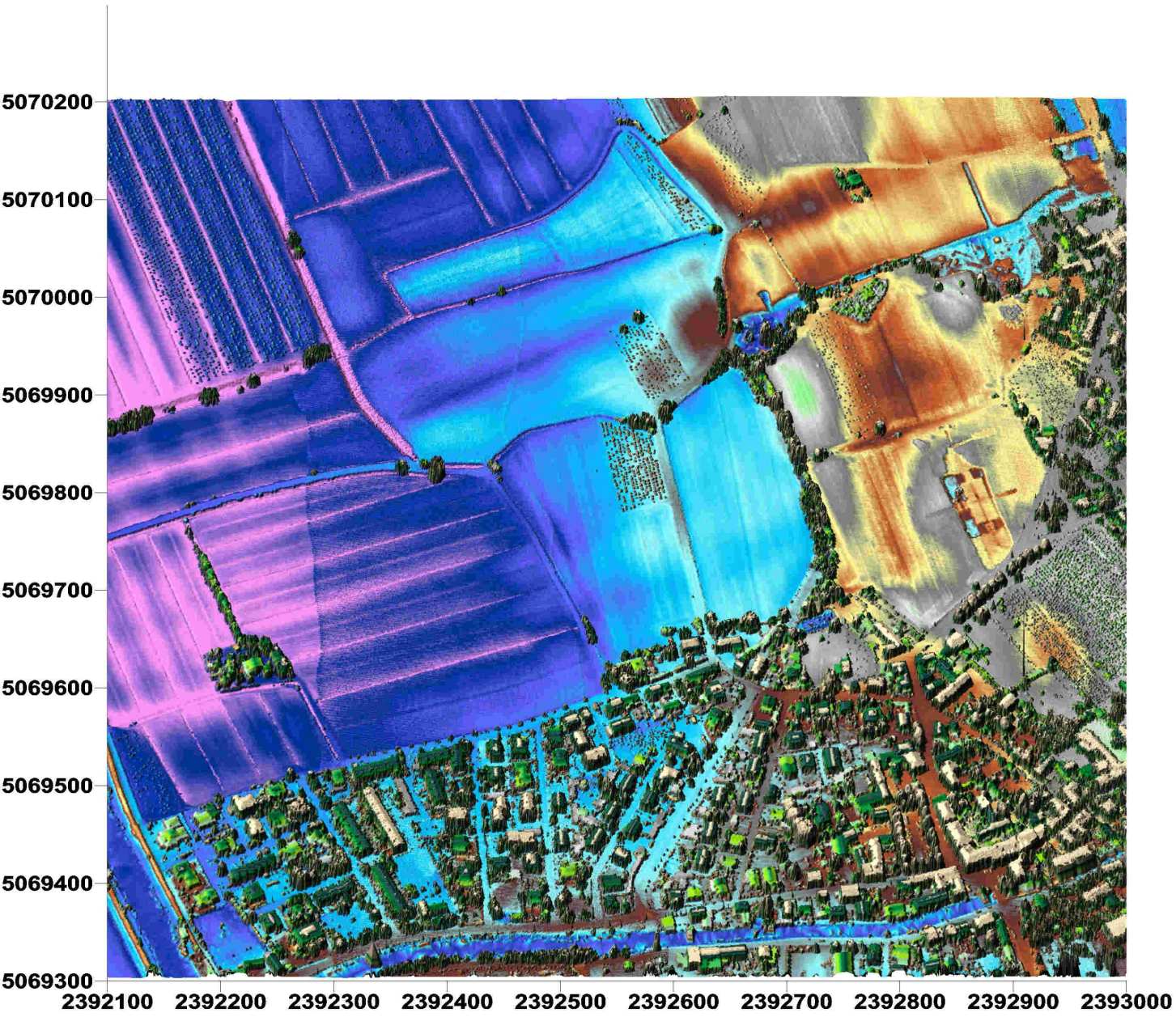








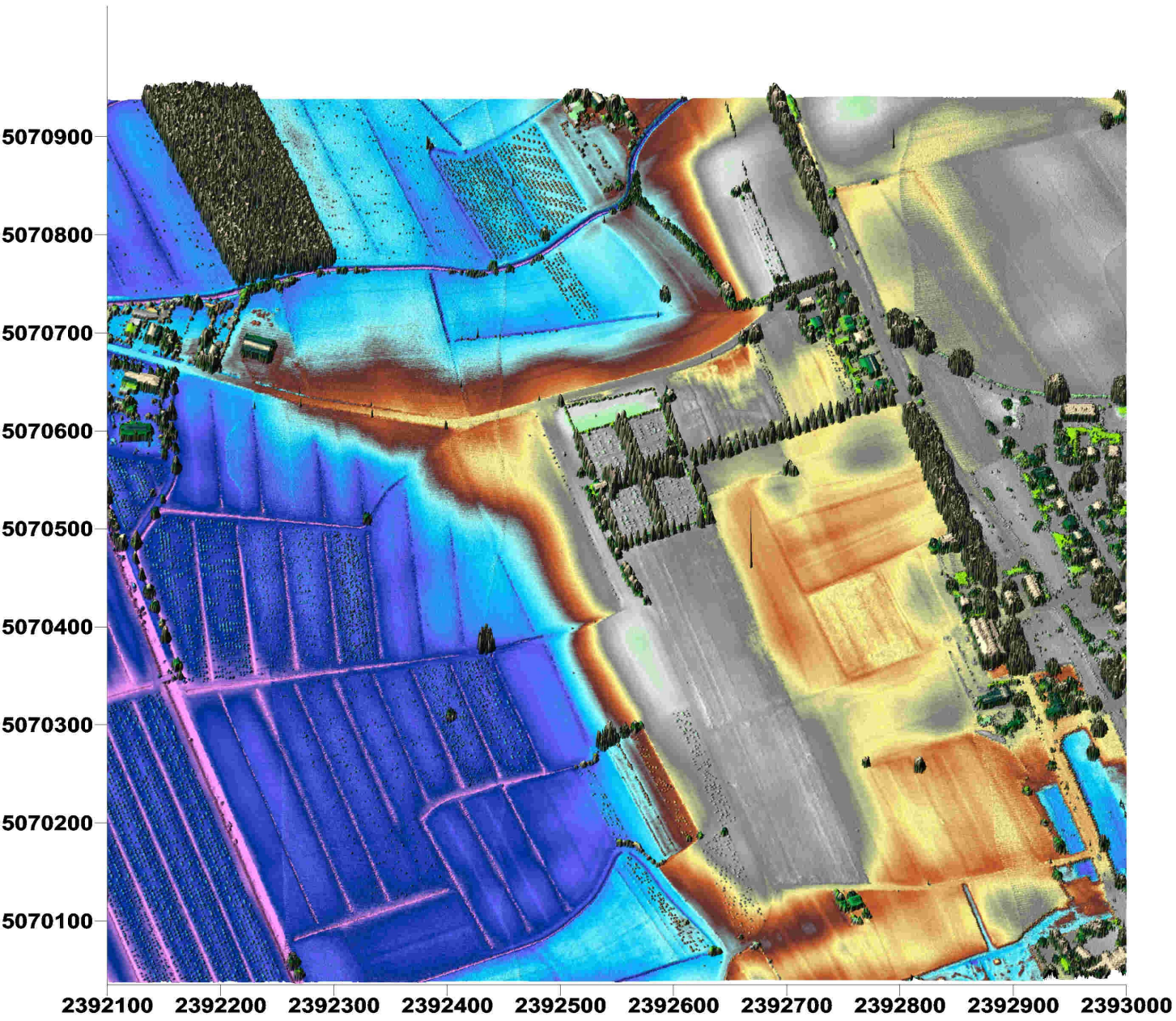
Anfiteatro



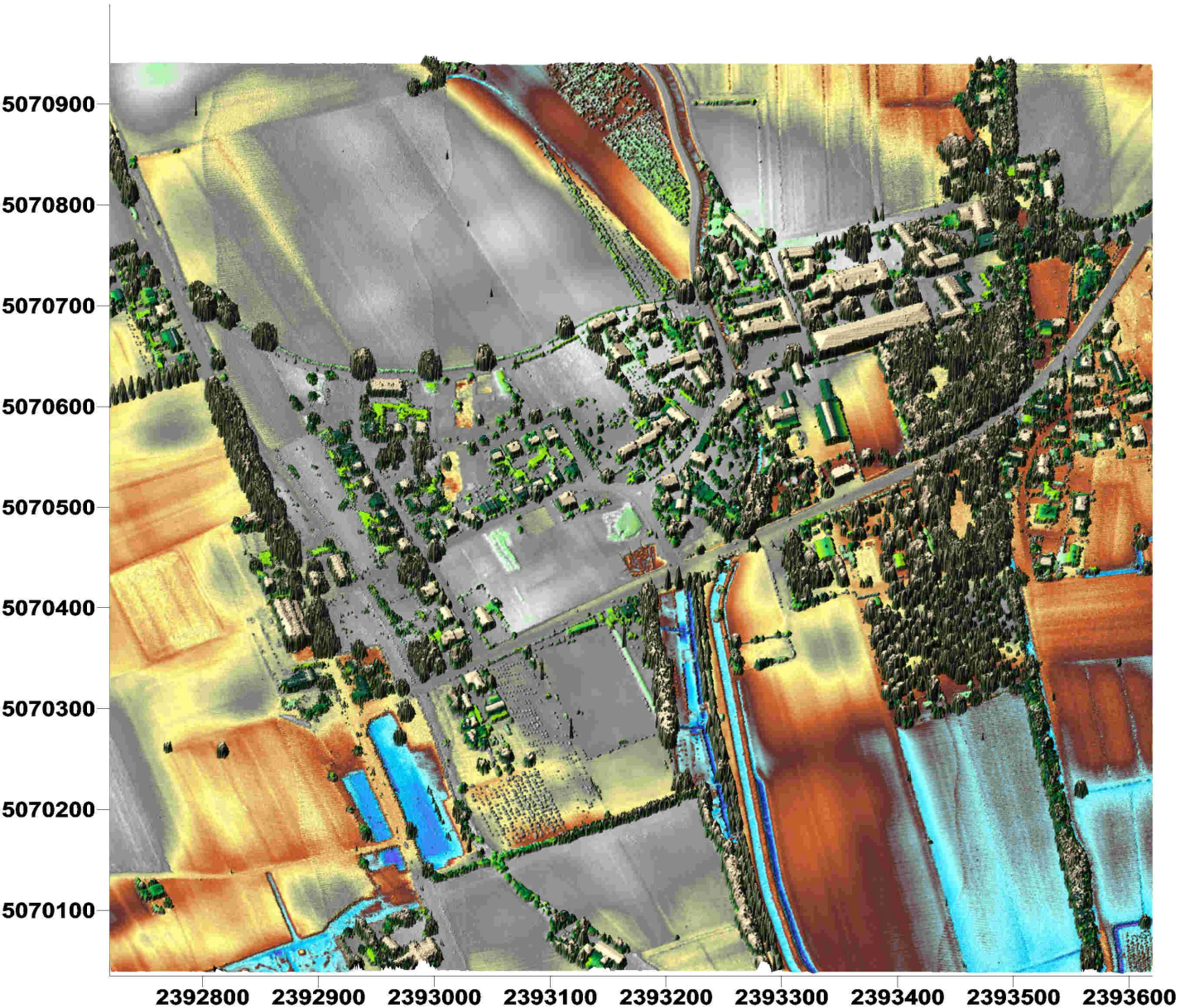
Vigna (ex Anfiteatro)



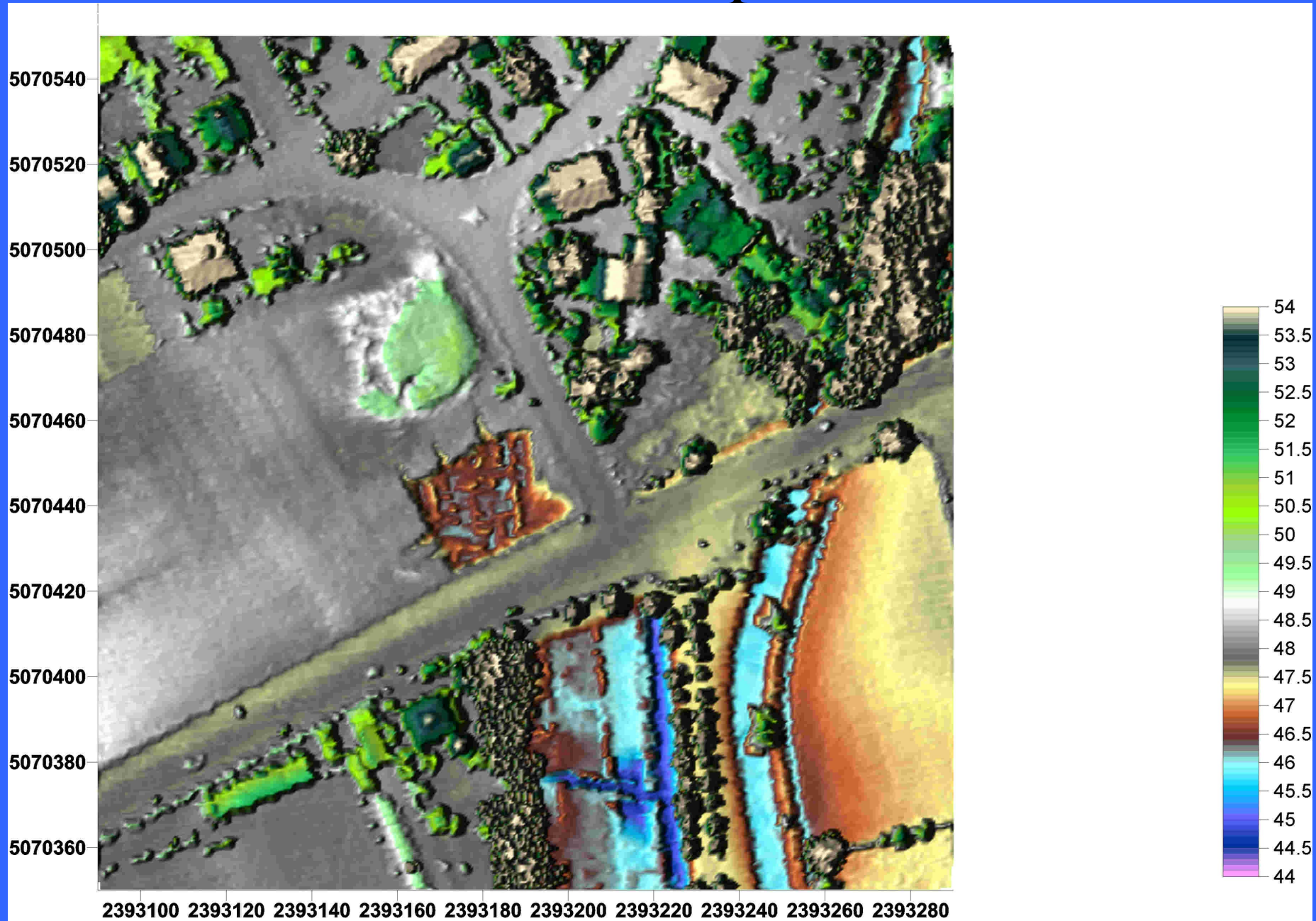
Circo

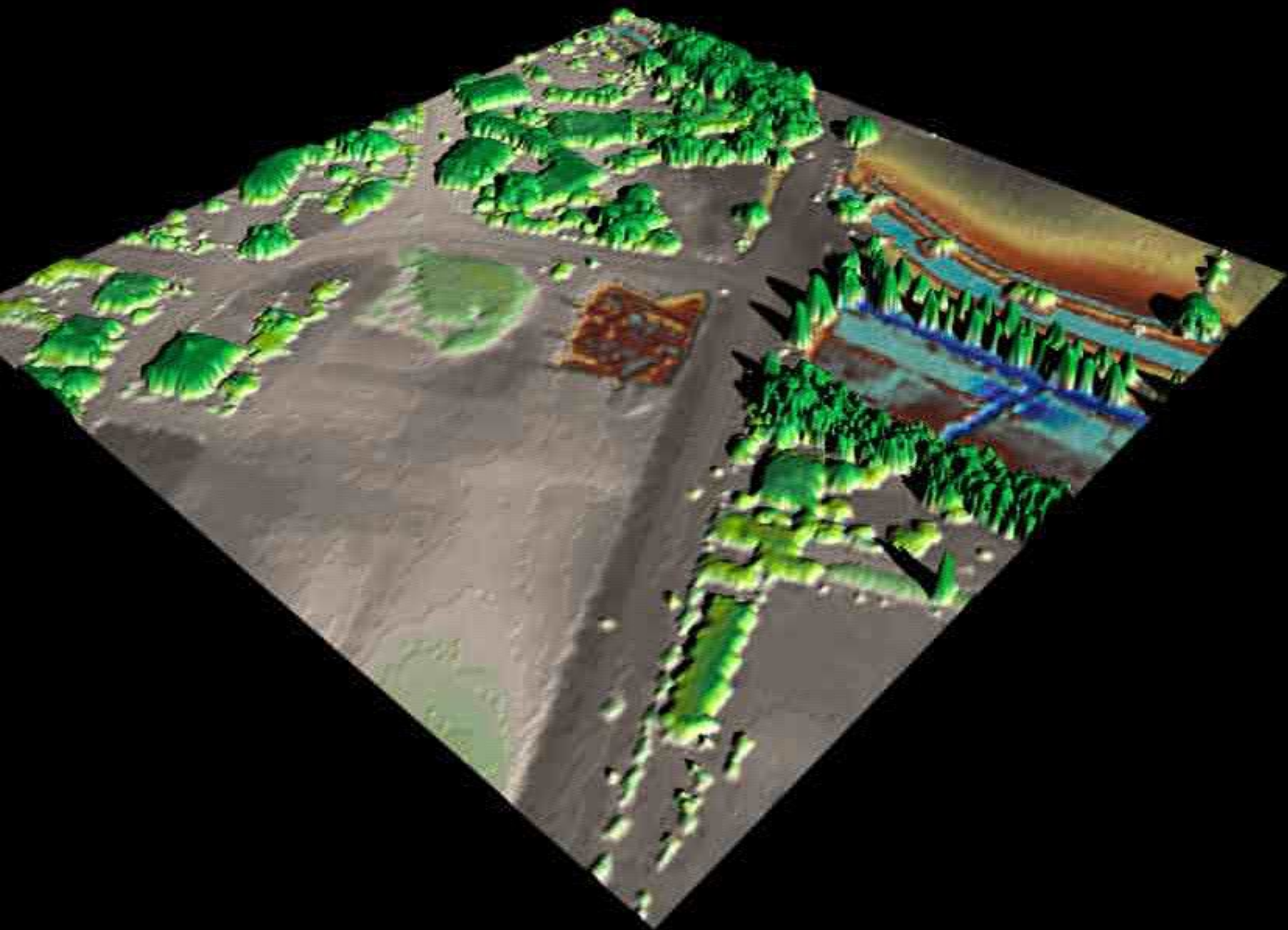


Sito MGR



Sito MGR amplificato





Aquileia Porto Romano.

Scavo Archeologico della Ecole Francaise de Rome



UNIVERSITA' DI TRIESTE
DIPARTIMENTO DI FISICA



Indagine eseguita nel mese di luglio 2003

Perf. e carotaggio



Carotaggio



UNIVERSITA DI TRIESTE
RADIOGRAFIA MUONICA
- AQUILEIA -
S.1
PROF. 0.00 - 5.00 m
03/07/03

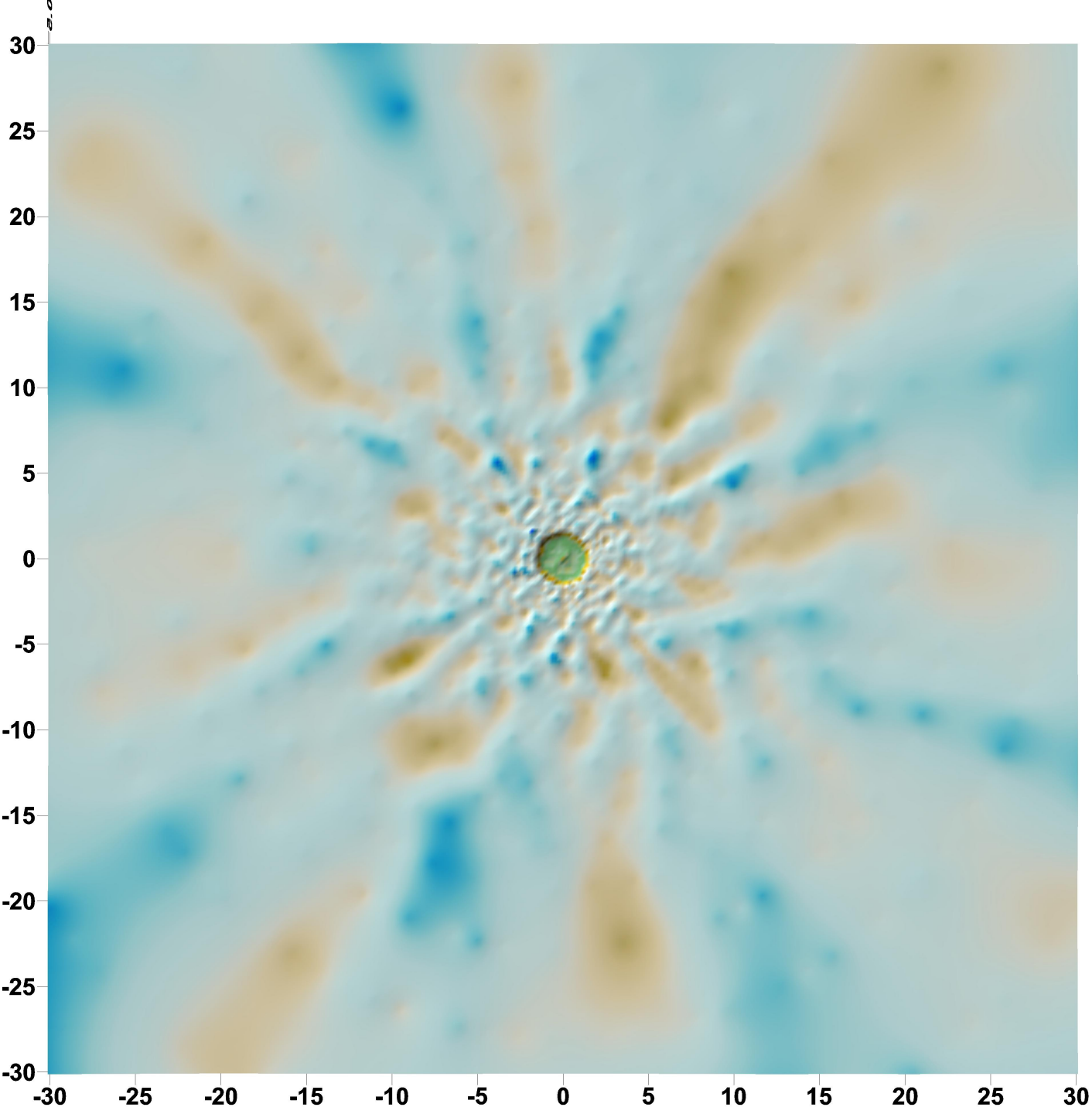


Dislocazione Apparato MGR 8/2003



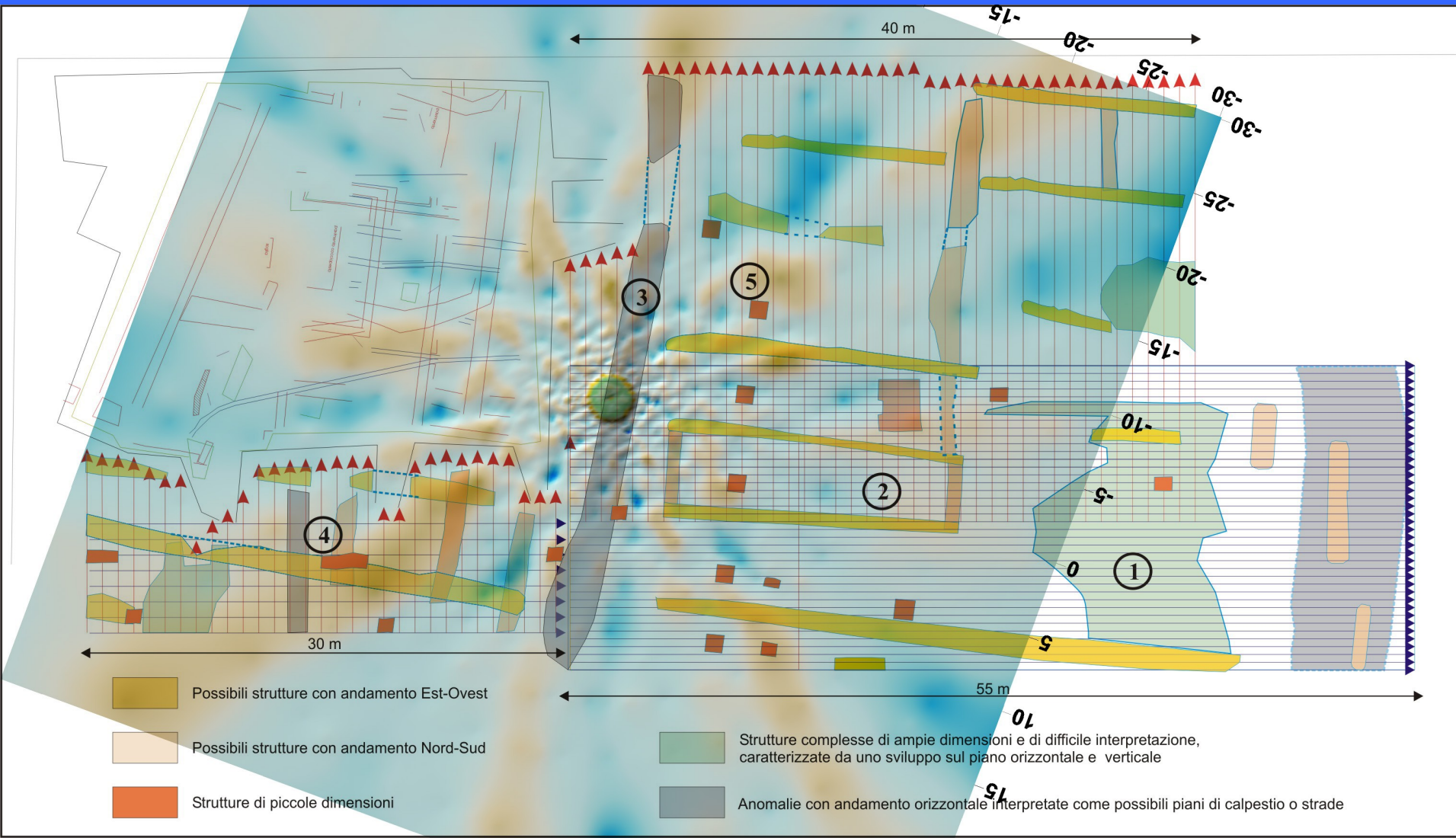


Foro per MGR



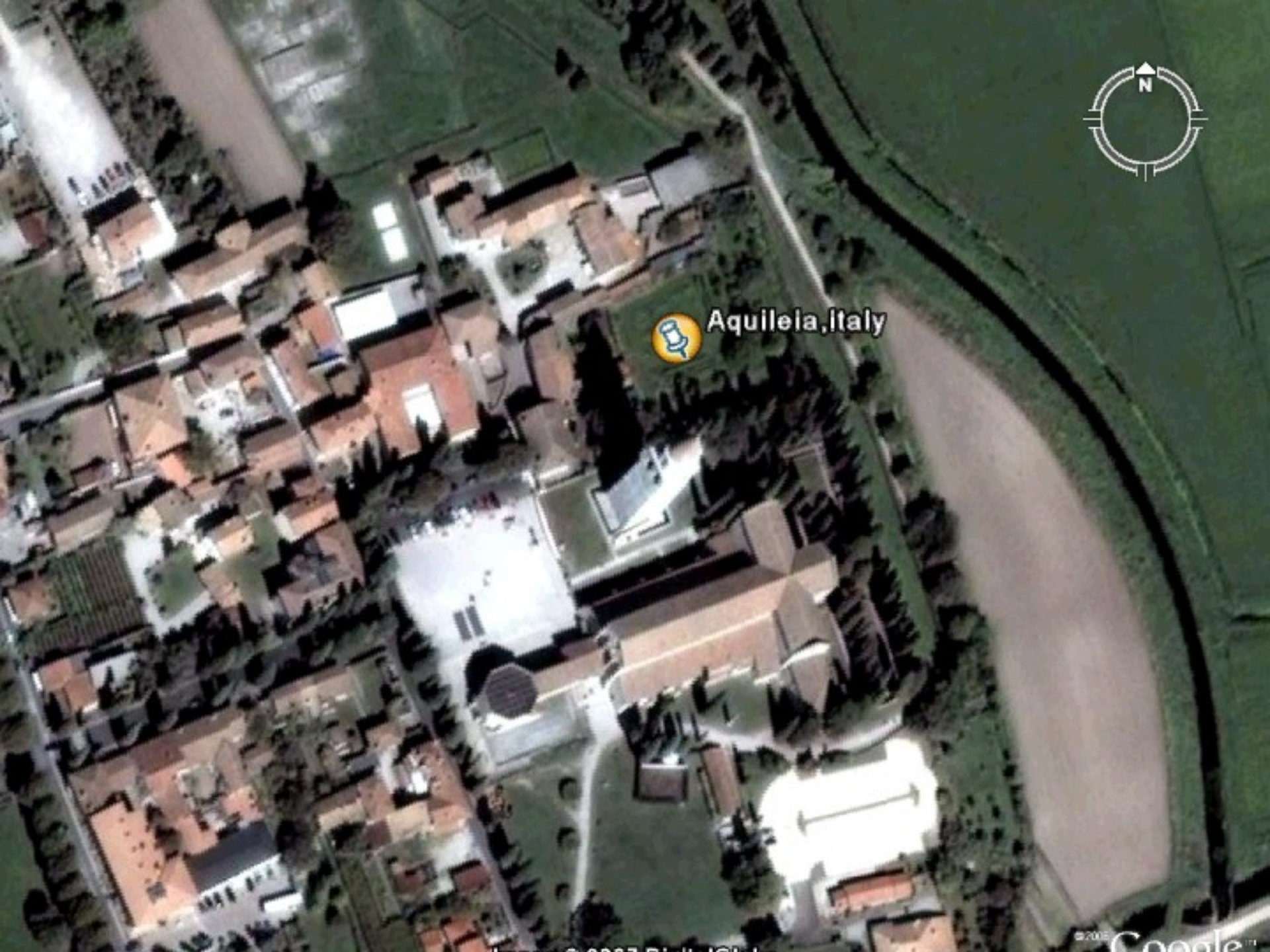
Alessandro Prizzon

Metodologie geofisiche integrate 3-D per indagini archeologiche e paleoambientali in aree costiere Tesi Dottorato di ricerca





Aquileia, Italy



Antico bacino esagonale



Fiumicino

Isola Sacra

Foce del fiume Tevere

Area scavi di Ostia Antica





Claudio Cesare

Da SVETONIO : LE VITE DEI DODICI CESARI

Traduzione di Paolo Del Rosso (frate dom. AD1544)

“Quanto al porto d’Ostia, tiro’ un’ala di muro dalla destra e uno dalla sinistra, ed allo entrare, dove il mare era ancora profondo, tiro’ un molo traverso. E per gittare i fondamenti piu’ gagliardi e stabili affondo’ nel detto luogo la nave, che aveva portato l’obelisco grande d’Egitto, ed accozzati insieme molti pilastri, vi edifico’ sopra una torre altissima, come quella Alessandrina, per tenervi il lume acceso la notte, accio’ che i naviganti conoscessero il cammino.”



I Porti di Claudio e Traiano

Moneta del I sec. D.C.



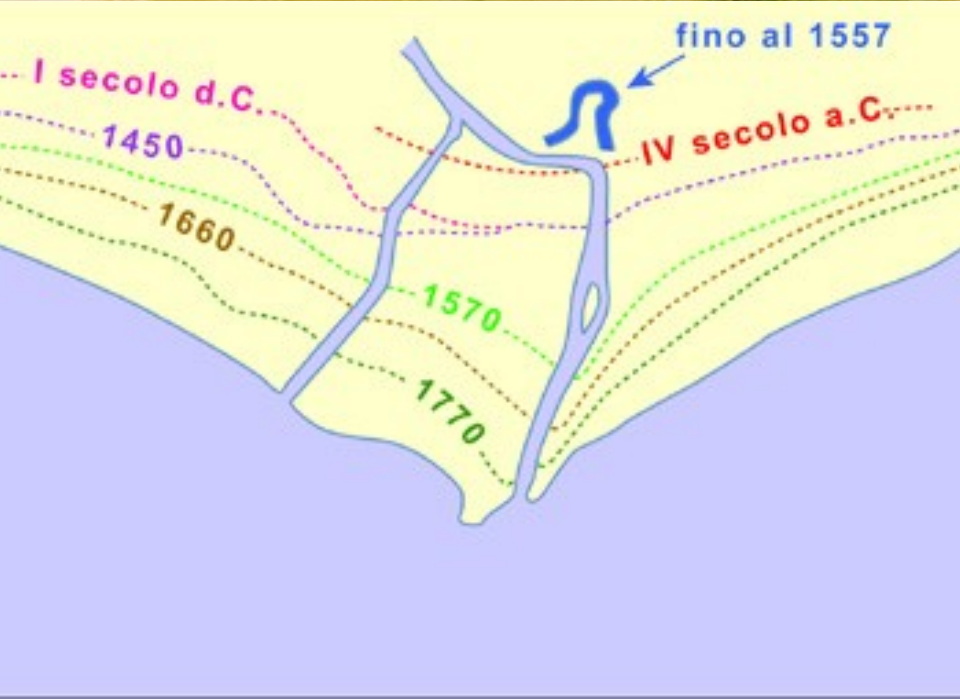
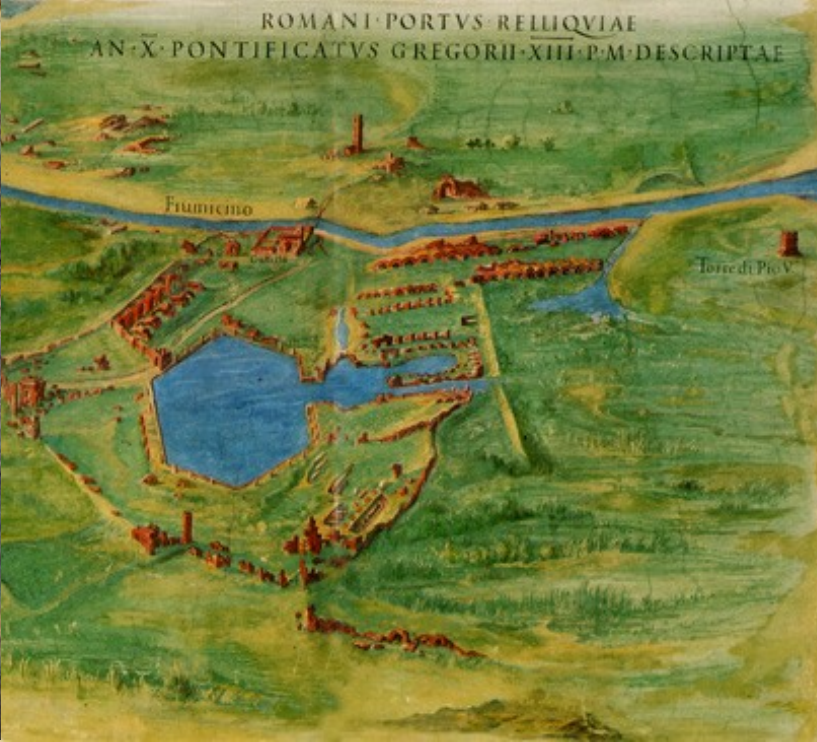
Ricostruzione del 1500



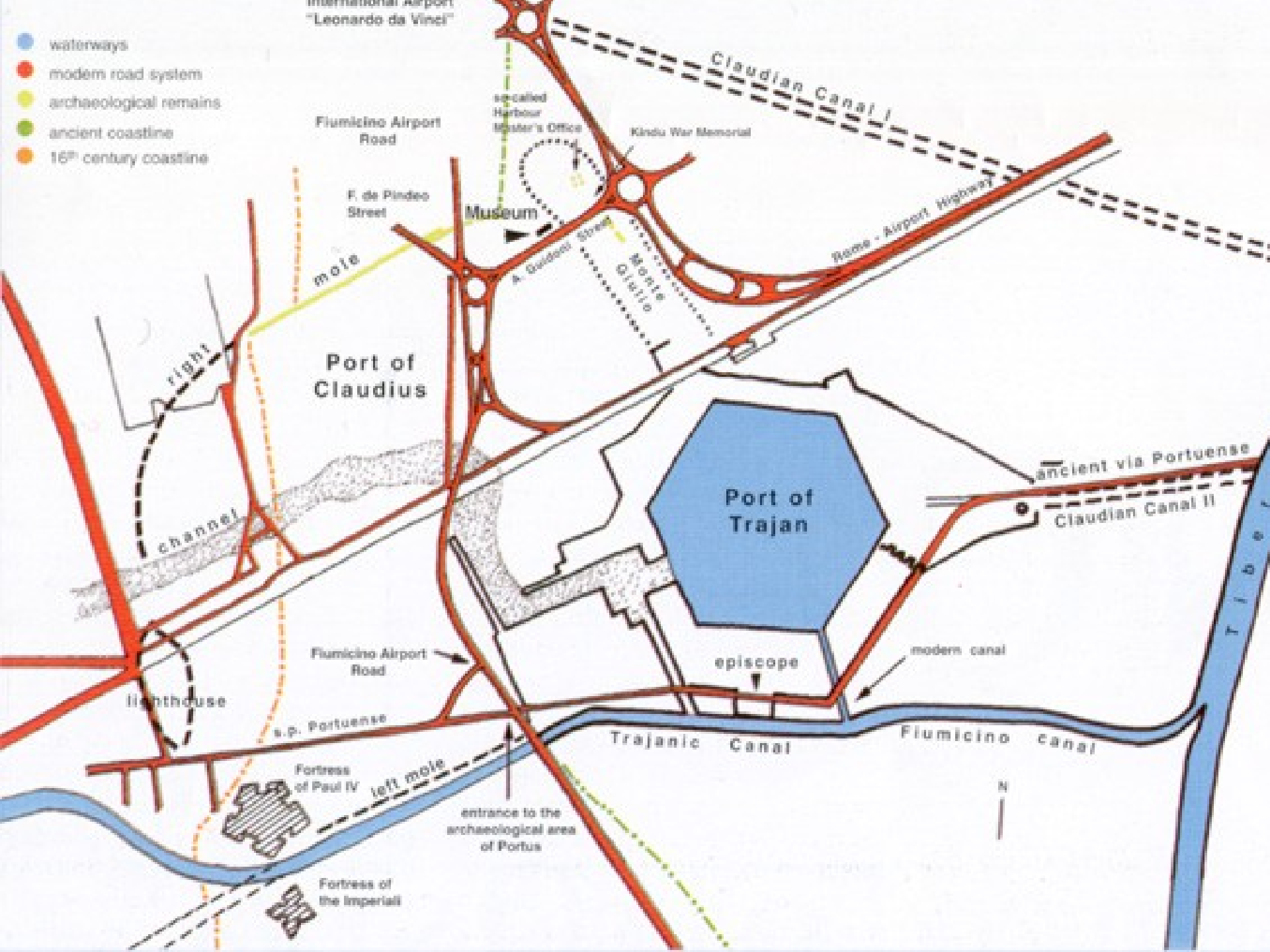
ROMANVS PORTVS A CLAVDIO IMP
CONSTRVCTVS



ROMANI PORTVS RELIQUIAE
AN X PONTIFICATVS GREGORII XIII P M DESCRIPTAE



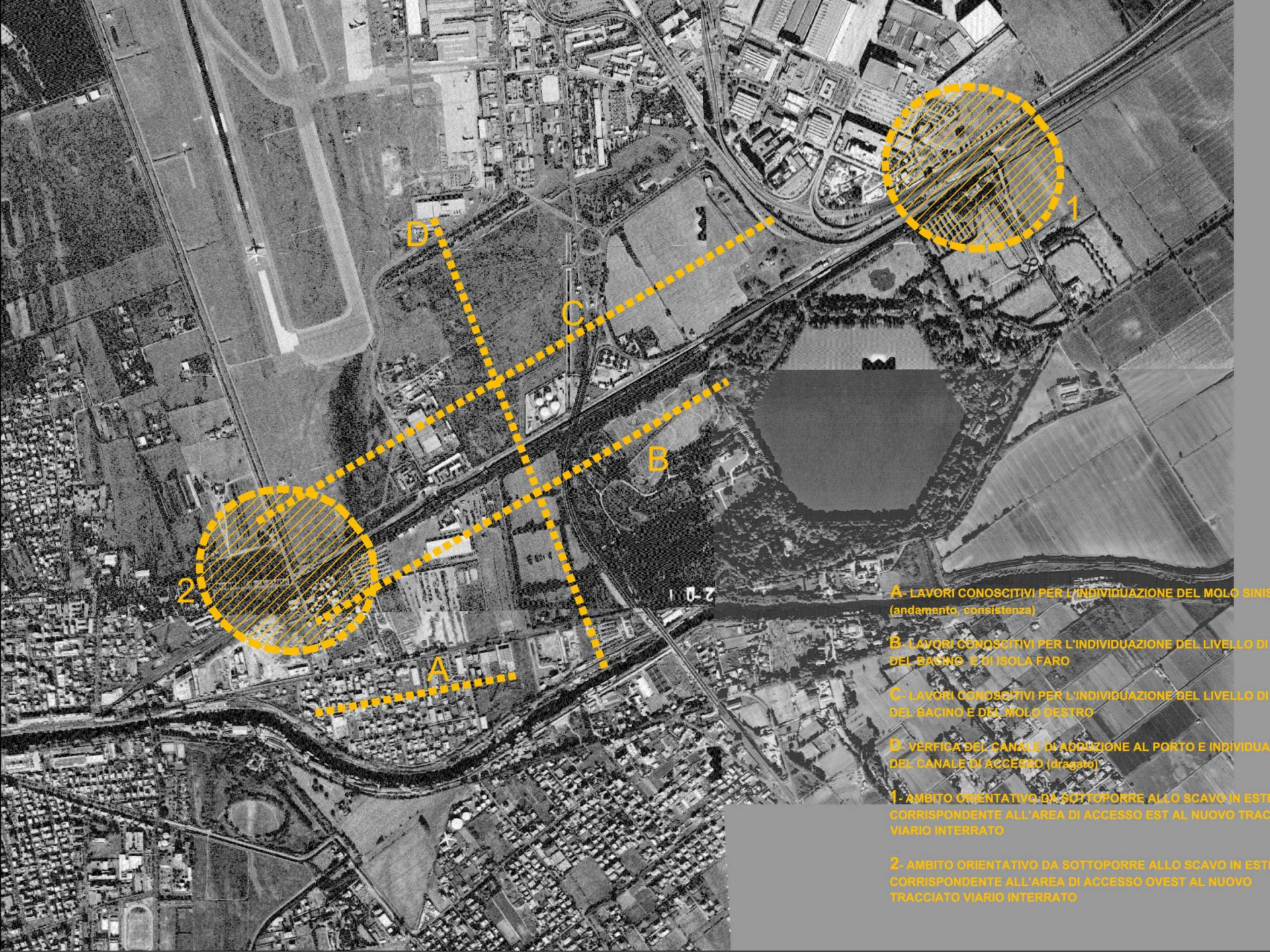
- waterways
- modern road system
- archaeological remains
- ancient coastline
- 16th century coastline



Oggi: il Lago di Traiano
(Esagonale: $L \sim 370\text{m}$, $S \sim 33$ ettari)







A - LAVORI CONOSCITIVI PER L'INDIVIDUAZIONE DEL MOLO SINISTRO
(andamento, consistenza)

B - LAVORI CONOSCITIVI PER L'INDIVIDUAZIONE DEL LIVELLO DI
DEL BACINO E DI ISOLA FARO

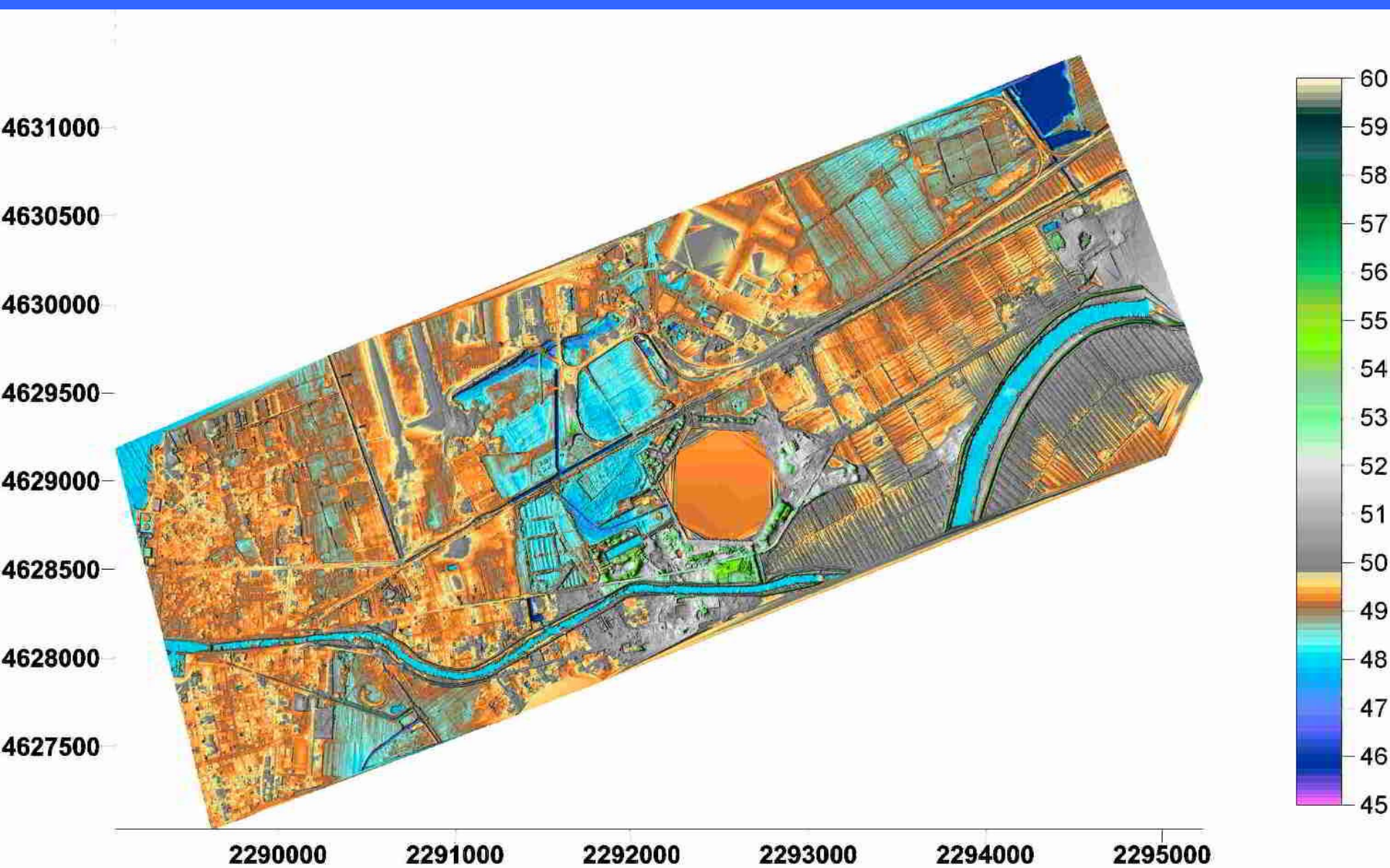
C - LAVORI CONOSCITIVI PER L'INDIVIDUAZIONE DEL LIVELLO DI
DEL BACINO E DEL MOLO DESTRO

D - VERIFICA DEL CANALE DI ADDUZIONE AL PORTO E INDIVIDUAZIONE
DEL CANALE DI ACCESSO (dragato)

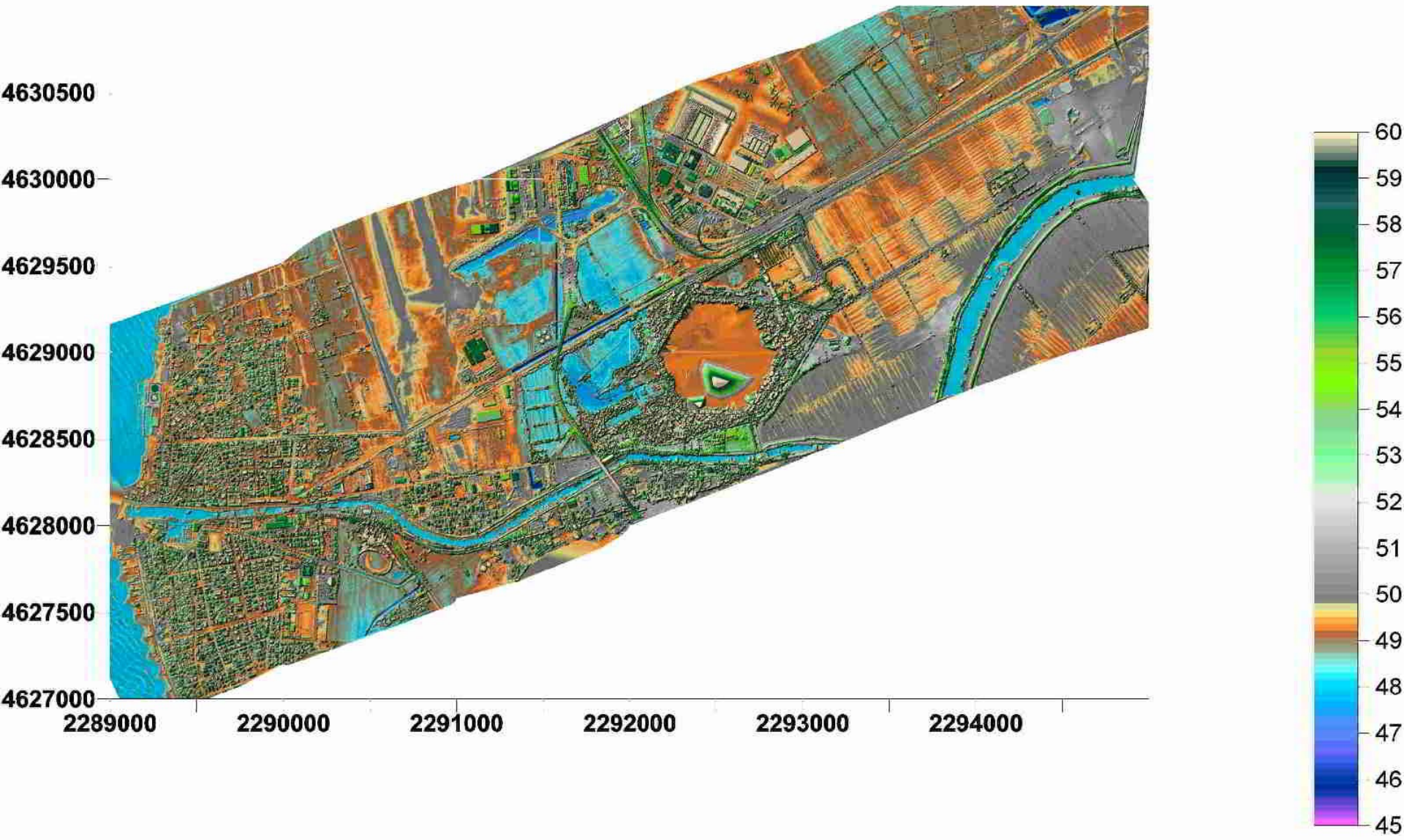
1 - AMBITO ORIENTATIVO DA SOTTOPORRE ALLO SCAVO IN ESTERNO
CORRISPONDENTE ALL'AREA DI ACCESSO EST AL NUOVO TRACCIATO
VIARIO INTERRATO

2 - AMBITO ORIENTATIVO DA SOTTOPORRE ALLO SCAVO IN ESTERNO
CORRISPONDENTE ALL'AREA DI ACCESSO OVEST AL NUOVO
TRACCIATO VIARIO INTERRATO

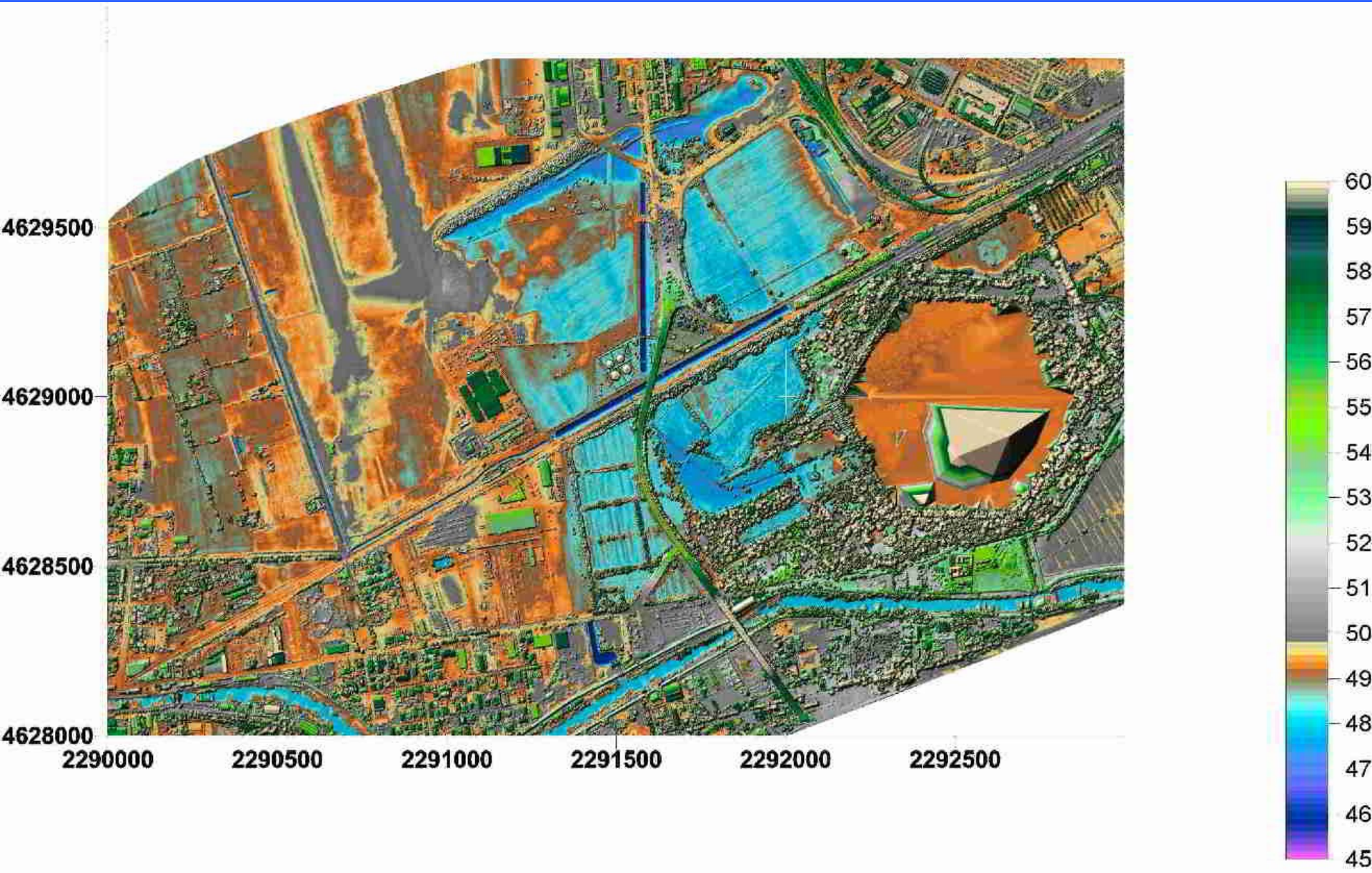
Laser Scan Fiumicino: Porti di Claudio e Traiano



Fiumicino (primo impulso)



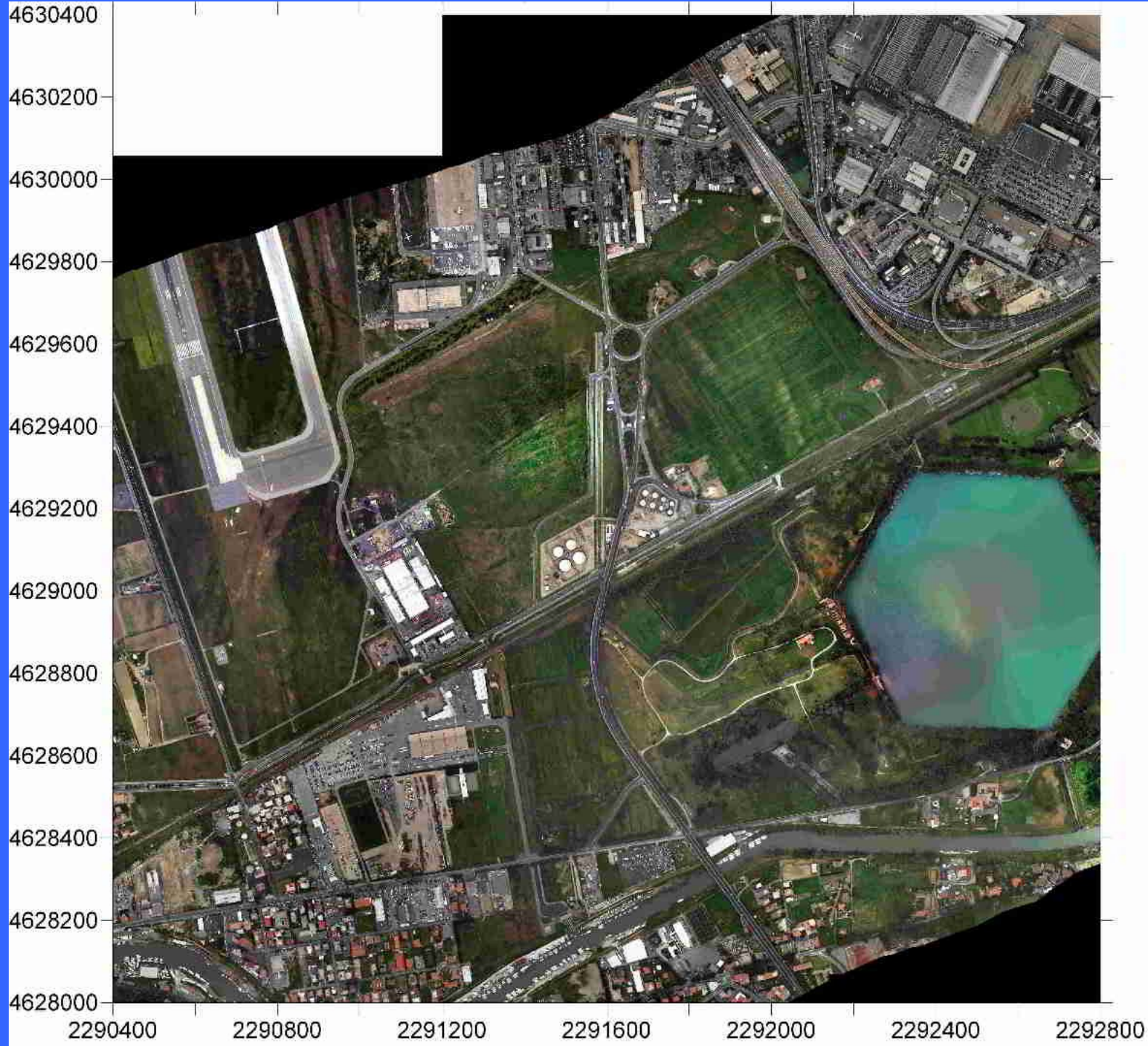
Zona Porti di Claudio e Traiano



Fiumicino Citta'



Ortofoto





Molo Nord del Porto di Claudio

Laser scan + Ortofoto Vista 20 gradi inclinazione da Est



Museo delle navi



4629950

4629900

4629850

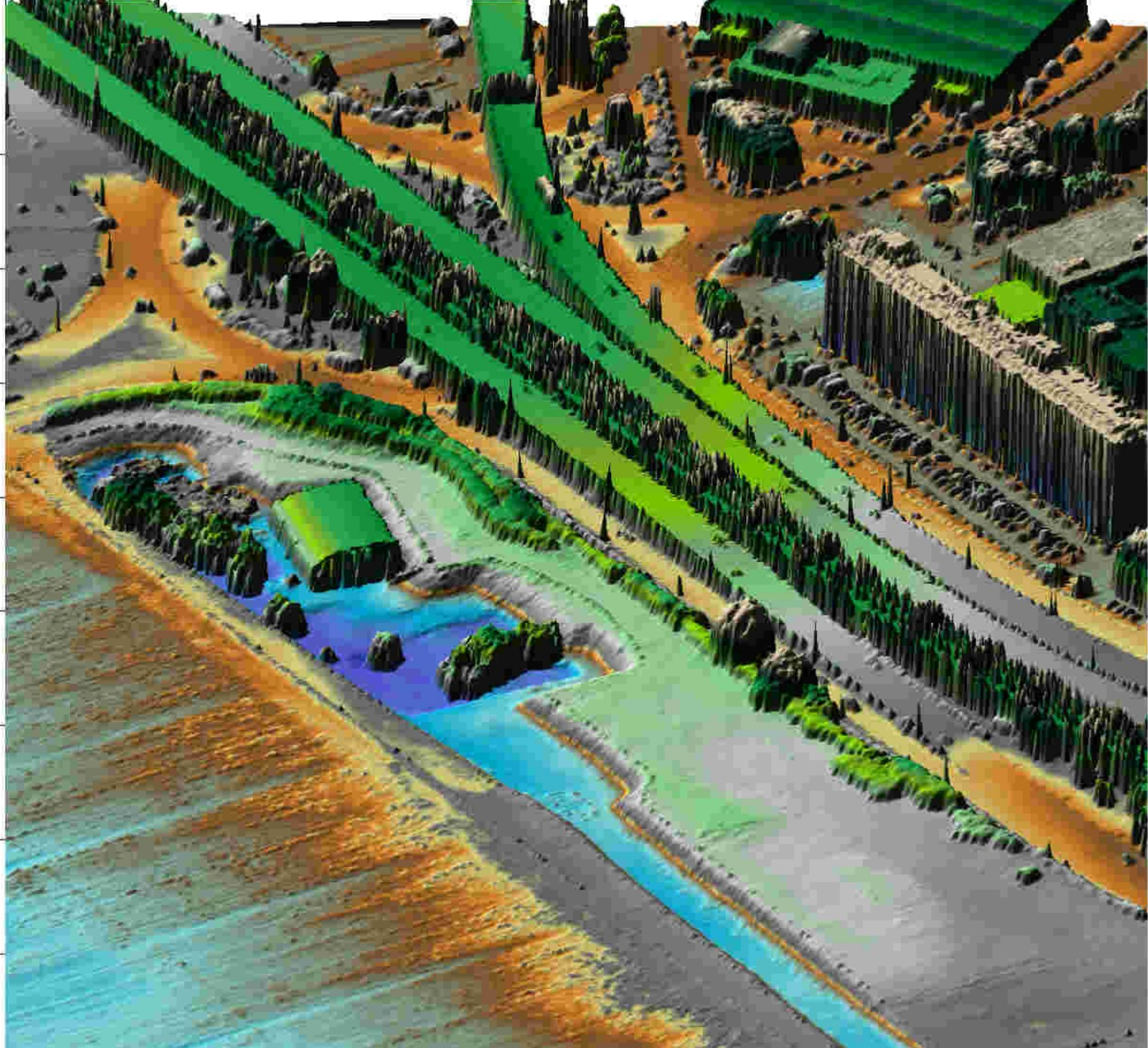
4629800

4629750

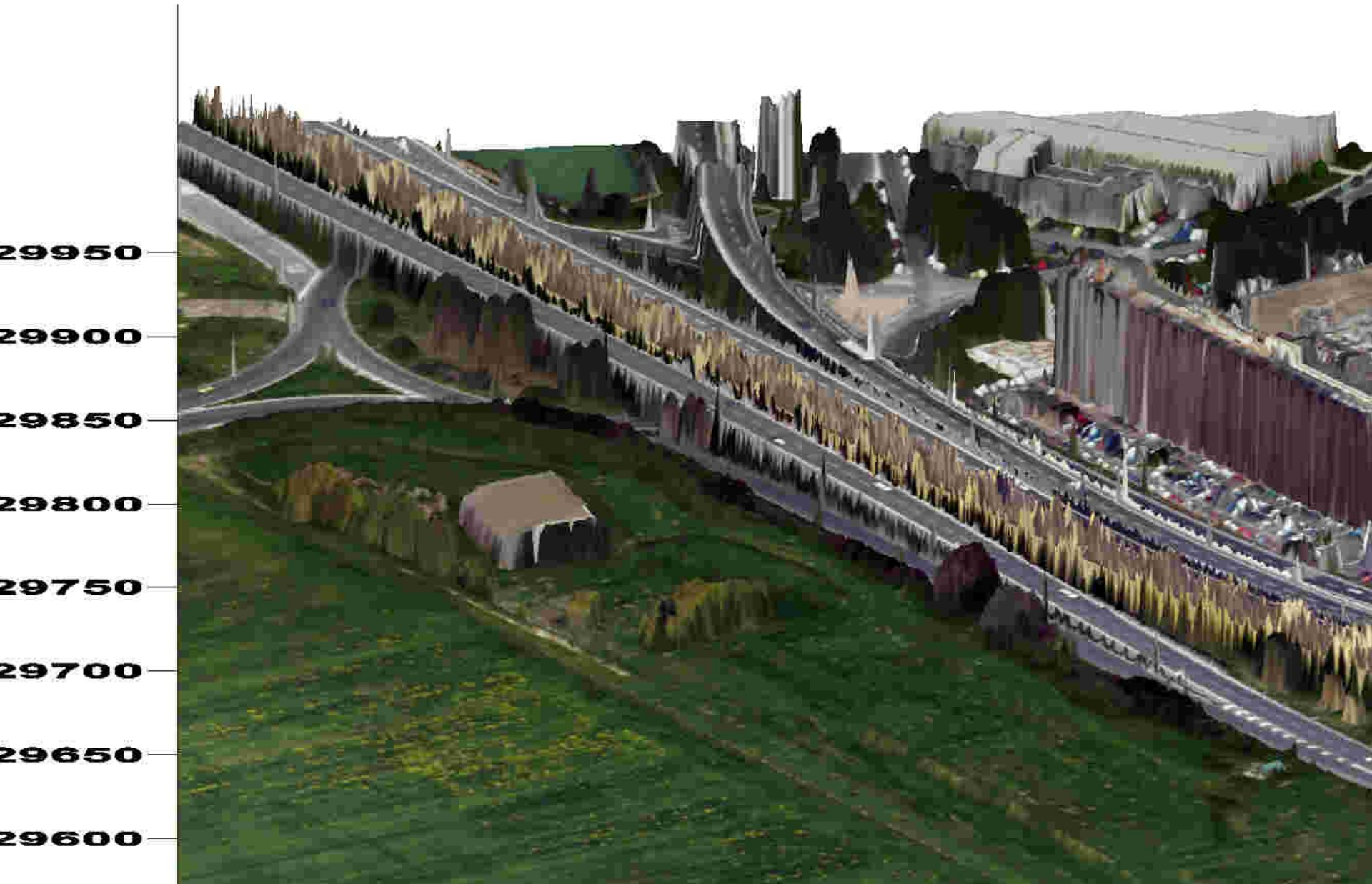
4629700

4629650

4629600



Laser+Orto Monte Giulio





AREA ARCHEOLOGICA DEL PORTO DI CLAUDIO E TRAIANO

Porto di Claudio

MONTE GIULIO TERME E CISTERNA

Indirizzo:

Via A. Guidoni, s.n.c.

C.8.2

Soprintendenza per i Beni
Archeologici di Ostia

Compilazione:
Ersilia D'Ambrosio

Data:
2004



Monte Giulio: la Cisterna



Monte Giulio: le Terme







Máx. 1 Mt

ELI

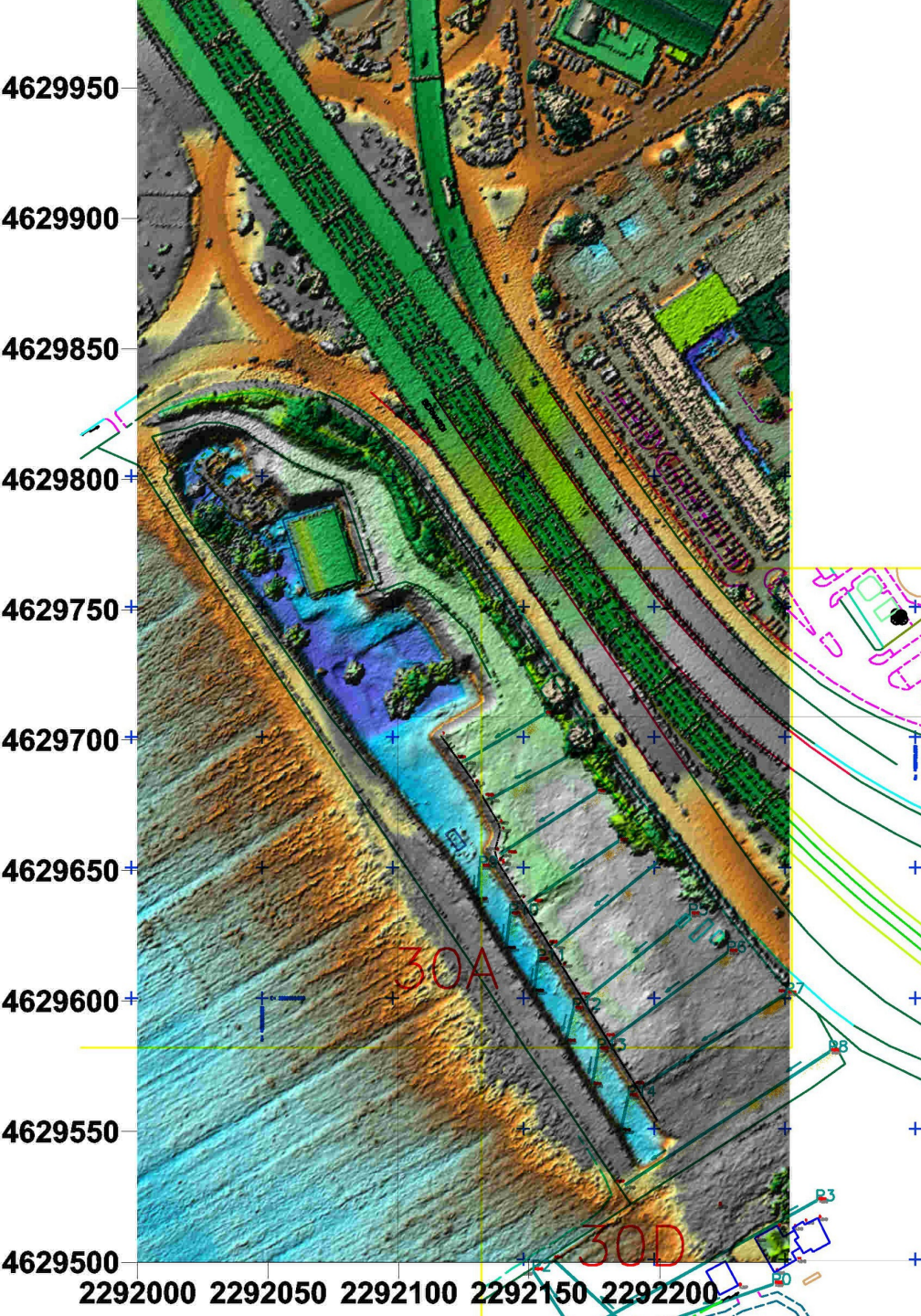
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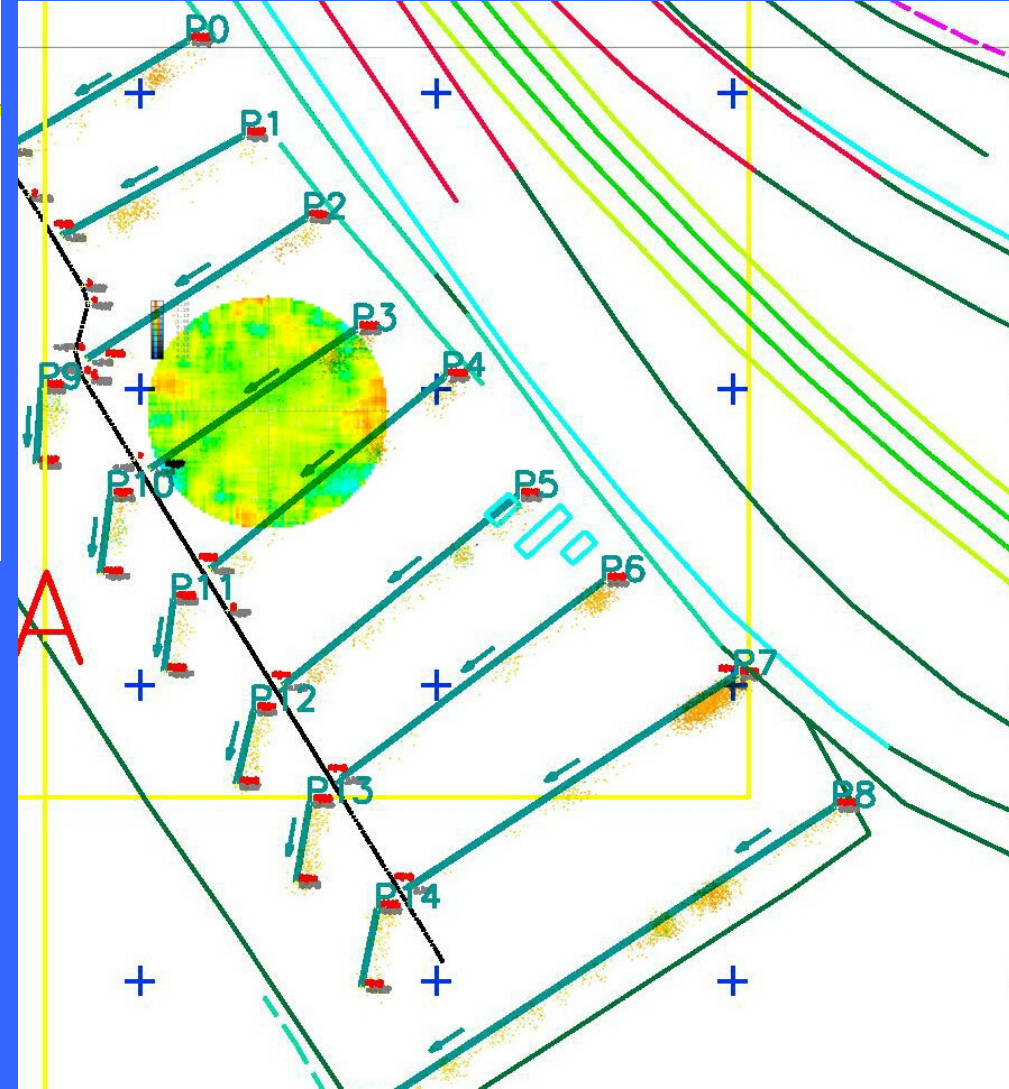
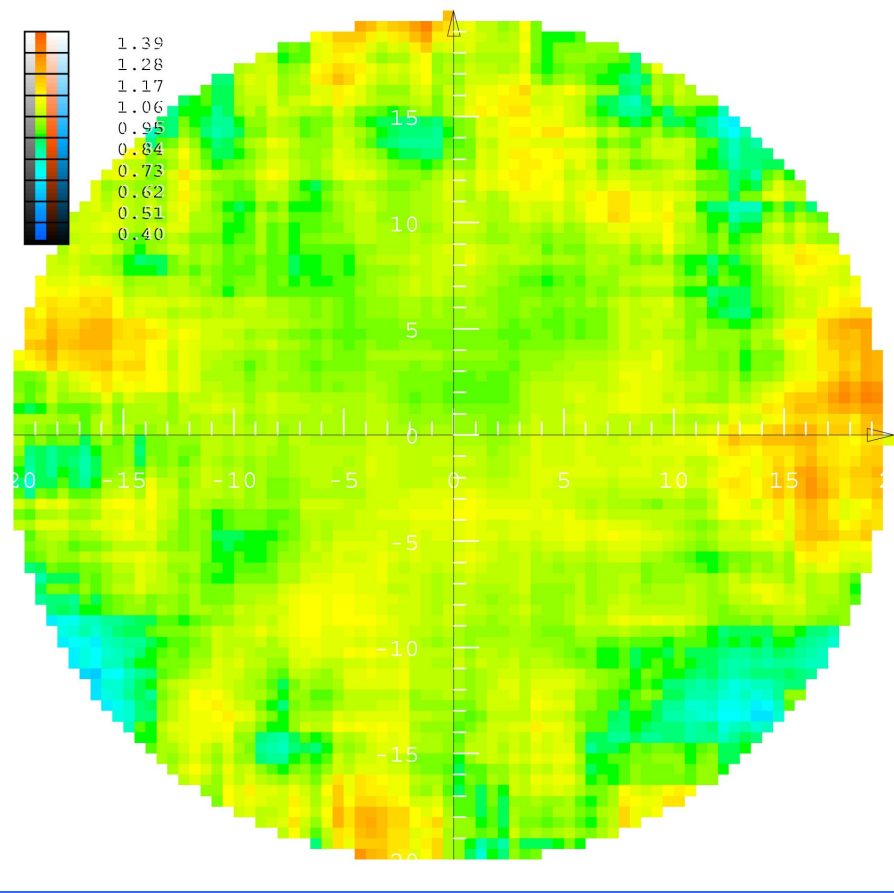




Monte Giulio

Sovrapposizioni LaserScan, GeoRadar e OrtoPhoto







Istituzioni e Ringraziamenti

- Dipartimento di Fisica dell' Università' di Trieste e
- Istituto Nazionale di Fisica Nucleare, INFN/Sezione di Trieste
- Dipartimento di Fisica dell' Università' di Perugia e
- Istituto Nazionale di Fisica Nucleare, INFN/Sezione di Perugia
- Exploration Geophysics Group, Università di Trieste
- Dipartimento di Scienze Geologiche, Ambientali e Marine
- Istituto Nazionale di Oceanografia e di Geofisica Sperimentale
- HELICA Remote Sensing
- GEXON *Geofisica avanzata per l'industria e l'ambiente*

- Regione Friuli Venezia Giulia/ Div. Ricerca
- ANAS Dir. Gen. Autostrade e Trafori
- Prov. OO.PP. Regione Lazio
- Soprintendenza BAAAAS Ostia
- Soprintendenza BAAAAS Friuli Venezia Giulia
- Dir. Musei Capitolini Roma

DOMANDA:

- I Raggi Cosmici raggiungono piu' facilmente la profondita' di un metro nella sabbia che nell'acqua del mare.

VERO?.....

FALSO?.....

(Sapresti anche spiegare perche'?)

- Nome:.....Cognome:.....
- Provenienza:.....