



Aureus
Pergamum
19-18 BC
35724/3 – 7.58 g

XRF analysis of Augustan coins

Astrik Gorghinian *, Adolfo Esposito*, Marco Ferretti**, Fiorenzo Catalli***

Channeling 2012, Alghero
23-28 september 2012

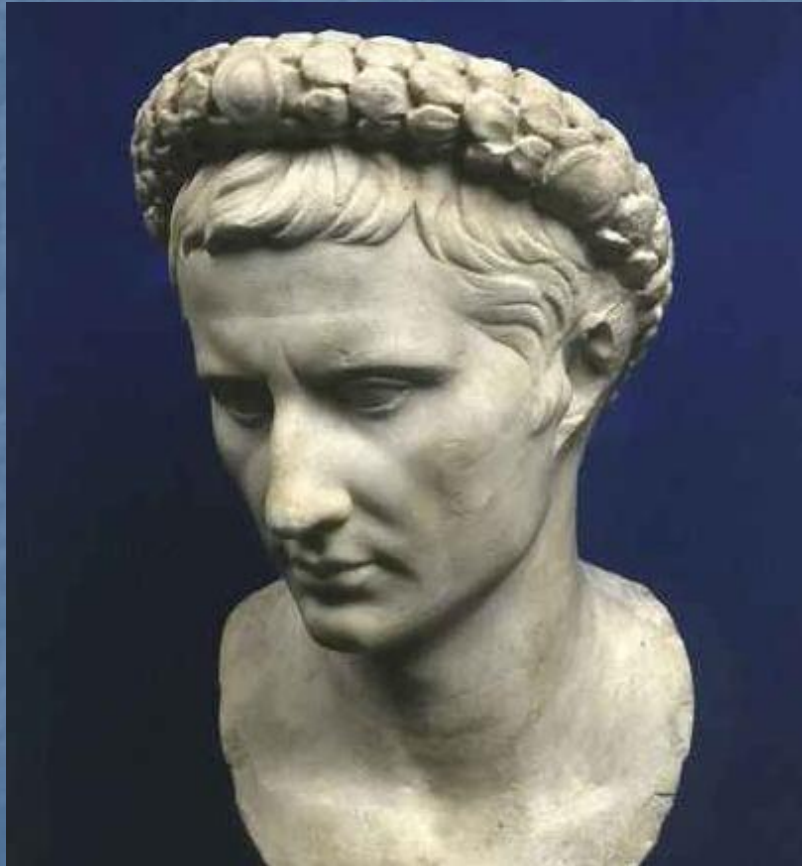


*Istituto Nazionale Fisica Nucleare
Laboratori Nazionali di Frascati

** Consiglio Nazionale delle Ricerche
Istituto per le Tecnologie Applicate ai Beni Culturali

AUGUSTUS

Caius Octavius Thurinus



First Roman Emperor
27 BC – 14 AD

Monetary Reform 23-20 BC
(Weights, changes, composition)

The collection

477 coins dated between 36 BC & 12 AD

➤ Provenance

Archaeological Museum of Florence

(Grand Ducal coin cabinet)

➤ Former owner

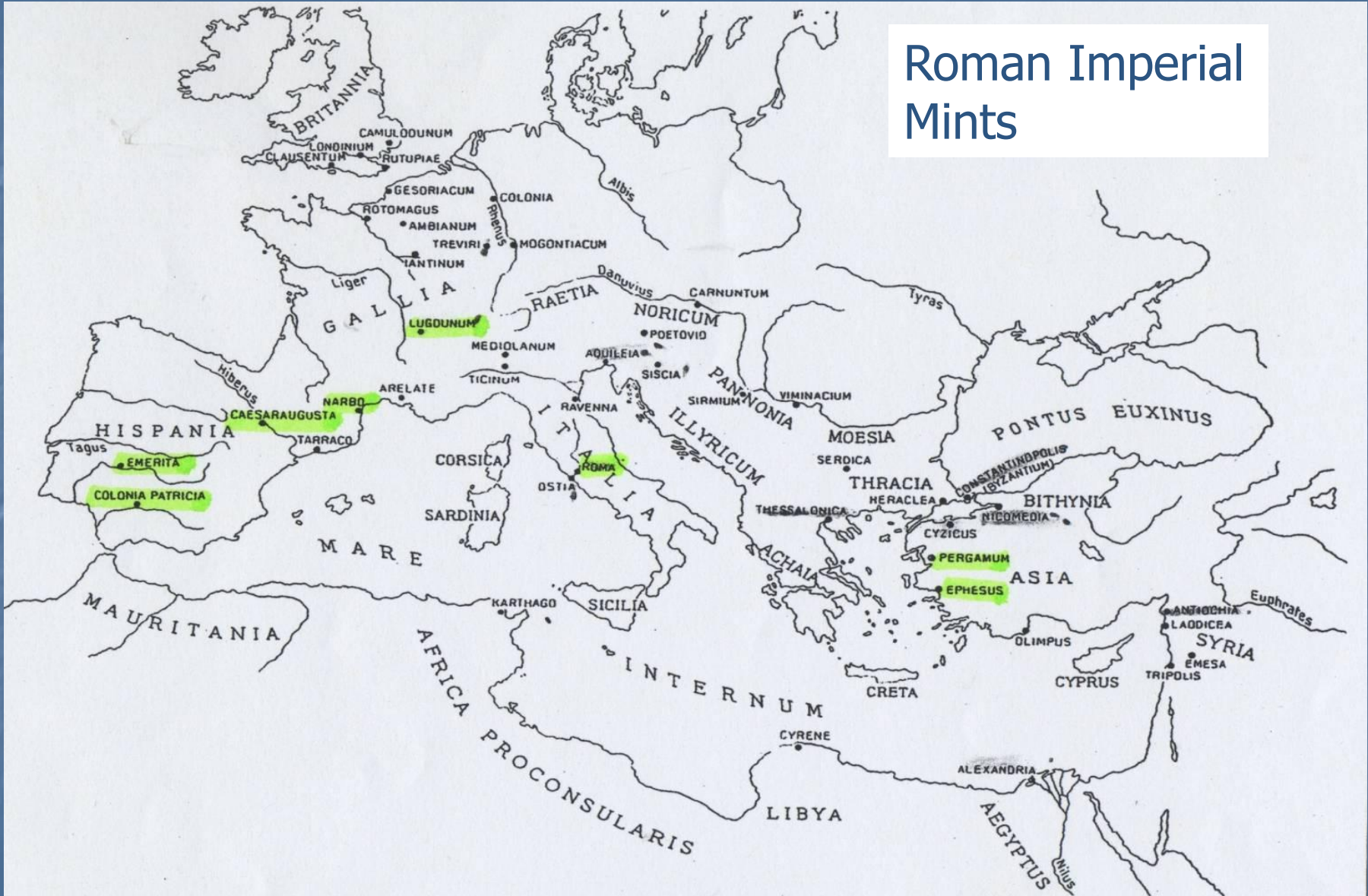
Medici and Este families

eagle mark in Ag
from Este collection



Aureus
Lugdunum
2 BC – 4 AD
35724/7 – 7.88 g

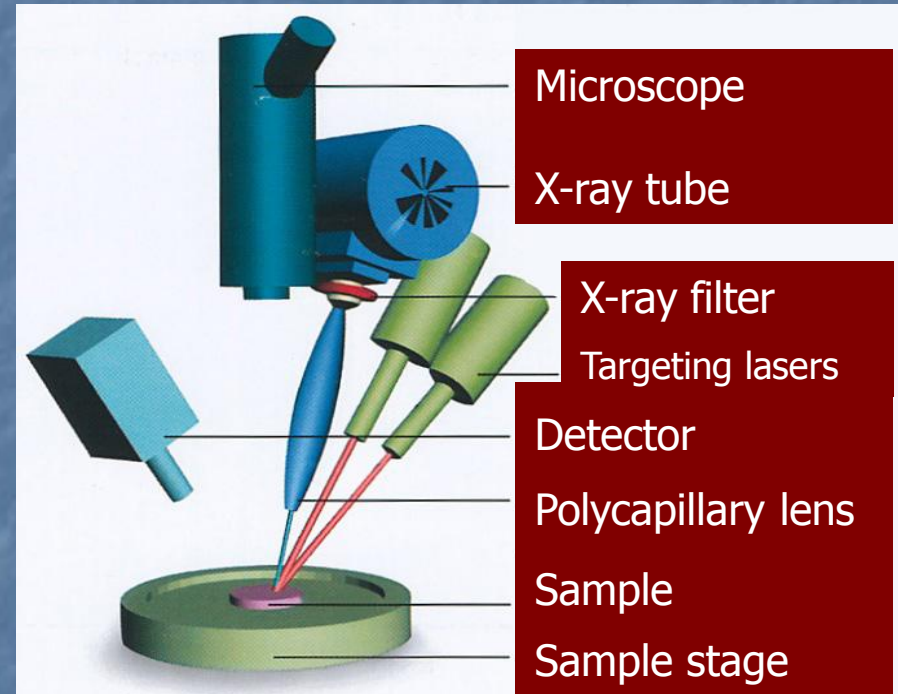
Roman Imperial Mints



XRF spectrometer



Unisantis XMF 104



Measurement Geometry

XRF features

ELEMENTAL COMPOSITION

SURFACE ANALYSIS (layer depth 10 to 50 μm)

QUANTITATIVE (if surface significant of bulk)

NON DESTRUCTIVE

RAPID

Elemental composition allows to
group objects / evaluate compositional differences / test
authenticity

Experimental set up

| | |
|------------------------|---|
| X-ray Tube Anode Mo | HV = 50 kV |
| | I = 100 μ A |
| | t = 200 s |
| Optics | Kumakhov lens $\phi = 50 \mu\text{m}$ |
| Detector | Si-PIN Shaping time 20 μs Area = 7 mm^2 |
| Detection limits | <u>Au matrix</u> : Ag 0.03%, Cu 1% |
| | <u>Ag matrix</u> : Cu, Zn, As 0.03%; Au, Pb, Bi 0.01% |
| | <u>Cu matrix</u> : Fe 0.006%; Ni 0.03%; Ag, Sn, Sb 0.2%; Pb 0.08% |

Au, Ag: General Results

Au

Aurei (46)

Gold Quinarii (4)

Au \approx 100% for 46 coins

Ag (15-19%) & Cu (4-6%)
for 4 coins

3 of them are suspect fakes

Ag

Ag > 92% for 150 denarii

Ag < 92% for 5 denarii

silver plated 10 coins

Cu \approx 98.5 % 1 coin **fake**

Minor elements distinguish
mints

Quinarii and Denarii from
Brundisium are different

Cu (AES): General Results

Cu-Zn (Aurichalcum-brass)

Zn < 19.2%

Sn and Pb correlated < 1%

Sestertii (30)

3 possible **fakes**

Dupondii (25)

Cu > 96% for 5 coins

Sn & Pb content > 1%

for 2 coins

Cu

Asses (152)

91% < Cu < 98%

Sn or Pb, Sn & Pb contents
> 1% for 7 coins

Trace elements distinguish
date of issue

Semisses (8): Cu-Zn alloy!!

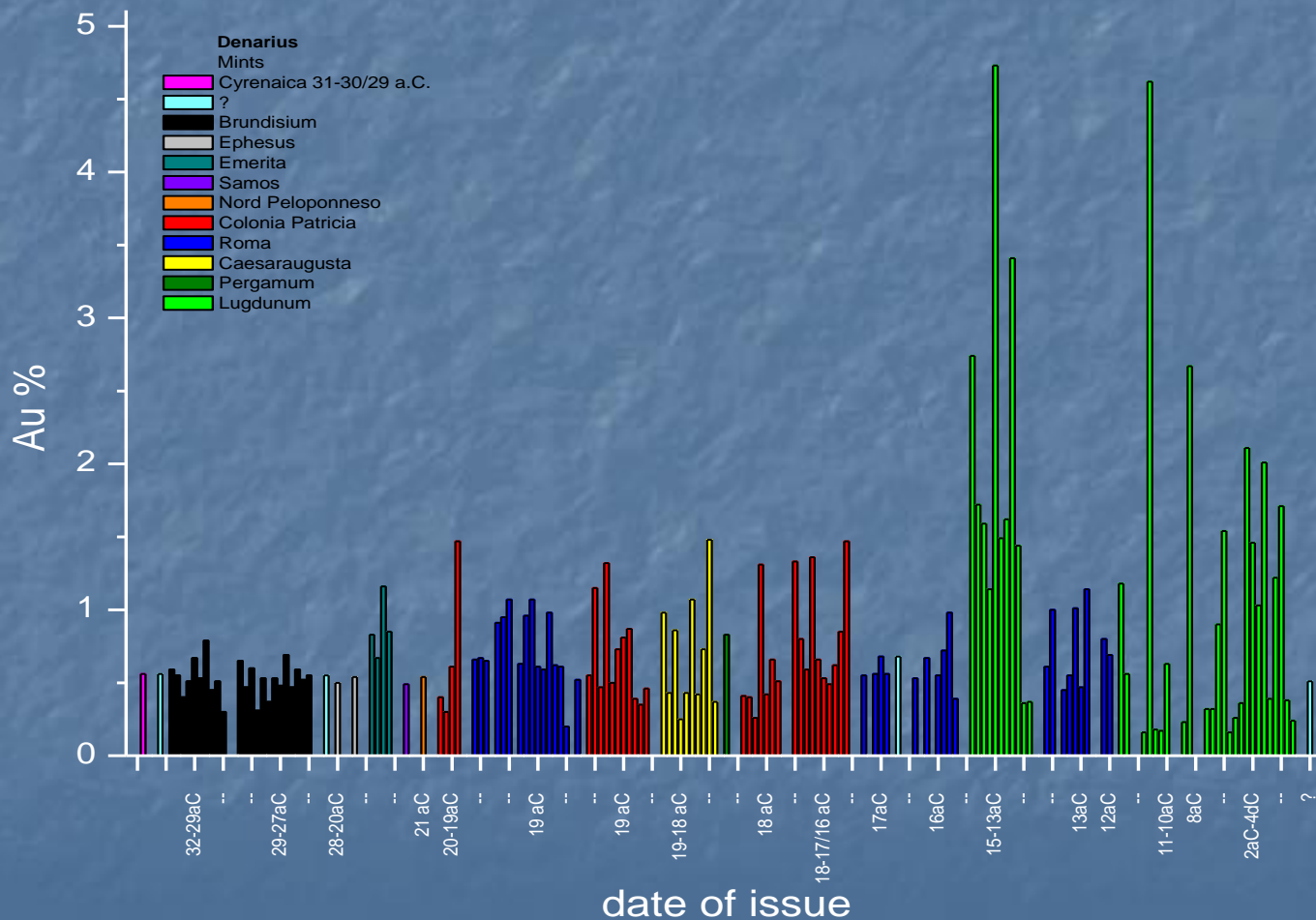
Quadrantes (32)

Cu \approx 98%



Denarius
Brundisium/Roma
29-27 BC
 35724/167 – 3.67 g

Denarii: Au content



Lugdunum
High Au

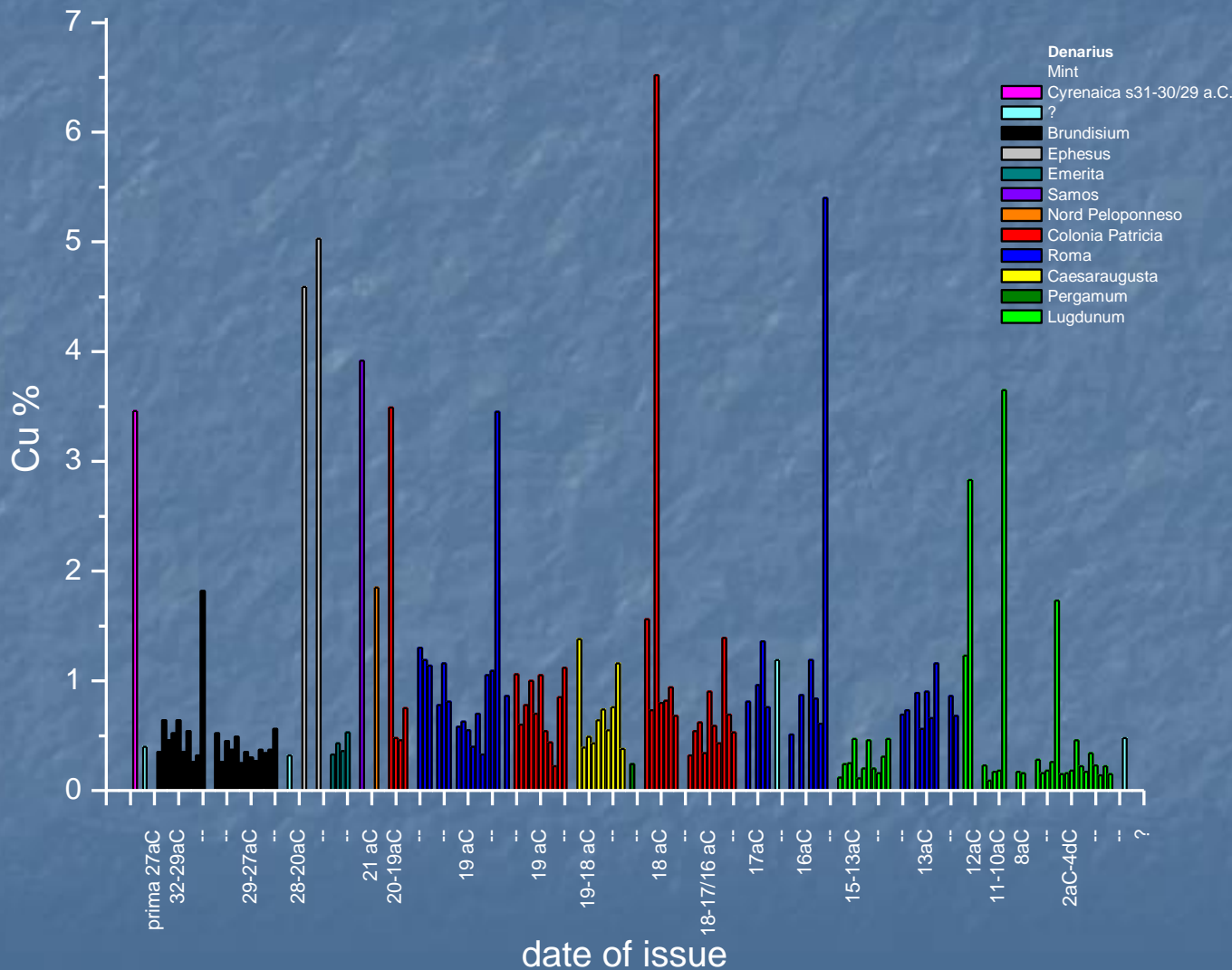
Rome/Spain
Medium Au

Brundisium
Low Au



Denarius
Brundisium/Roma
29-27 BC
 35724/167 – 3.67 g

Denarii: Cu content



Lugdunum
 Very low
 Cu

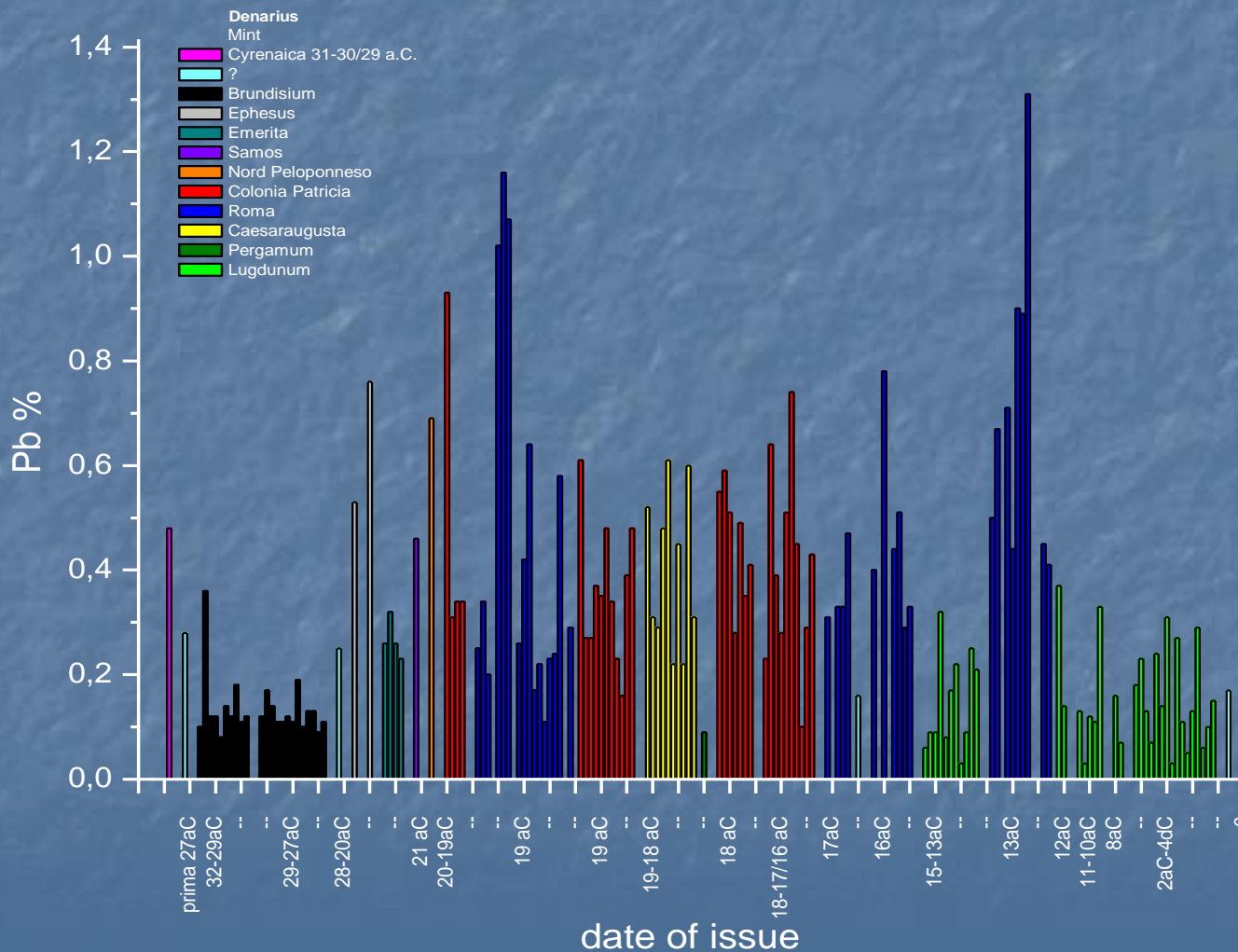
Rome/Spain
 Medium
 Cu

Brundisium
 Low Cu



Denarius
Brundisium/Roma
29-27 BC
 35724/167 – 3.67 g

Denarii: Pb content



Lugdunum
Low Pb

Rome/Spain
High Pb

Brundisium
Very low
Pb



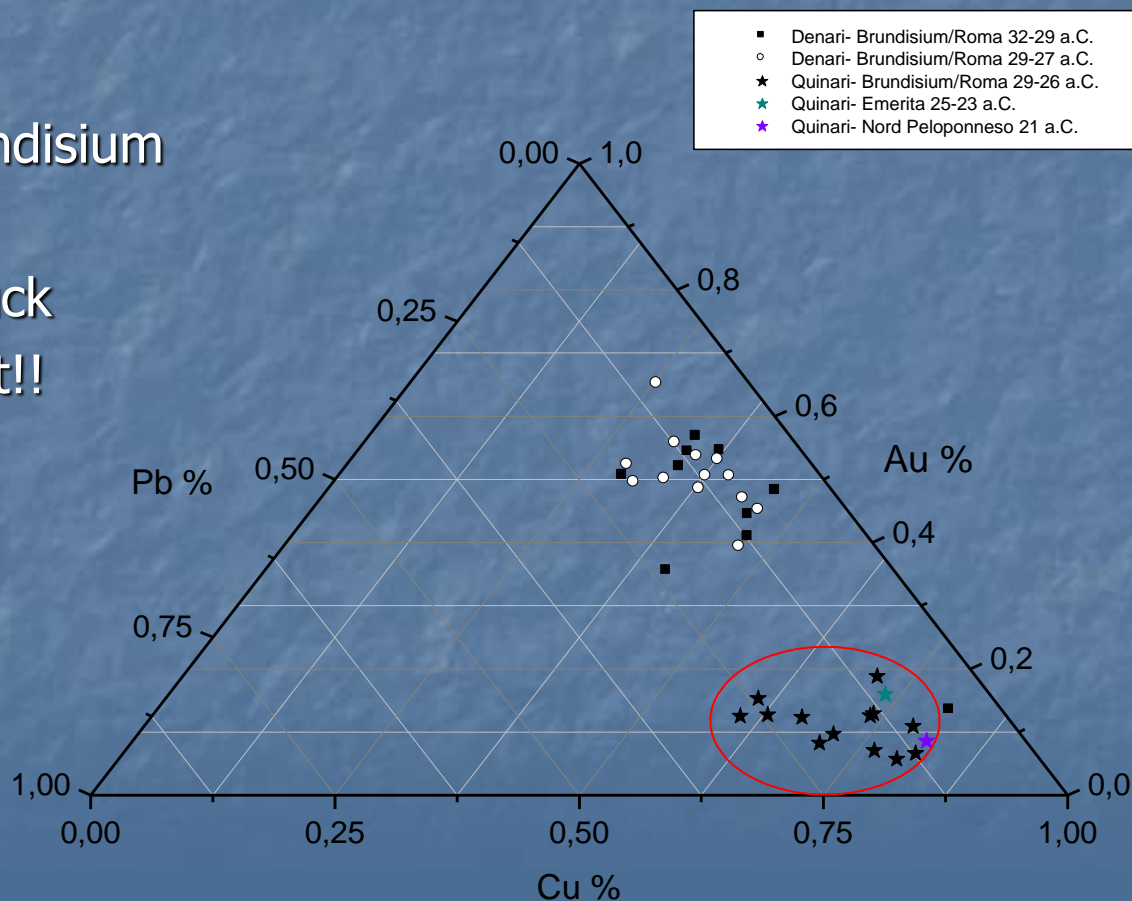
Quinarii

Quinarius = 1/2 denarius
Brundisium/Roma
29-26 BC
35724/207, 1.55 g

quinarii struck in Brundisium

Are different

from denarii struck
in the same mint!!



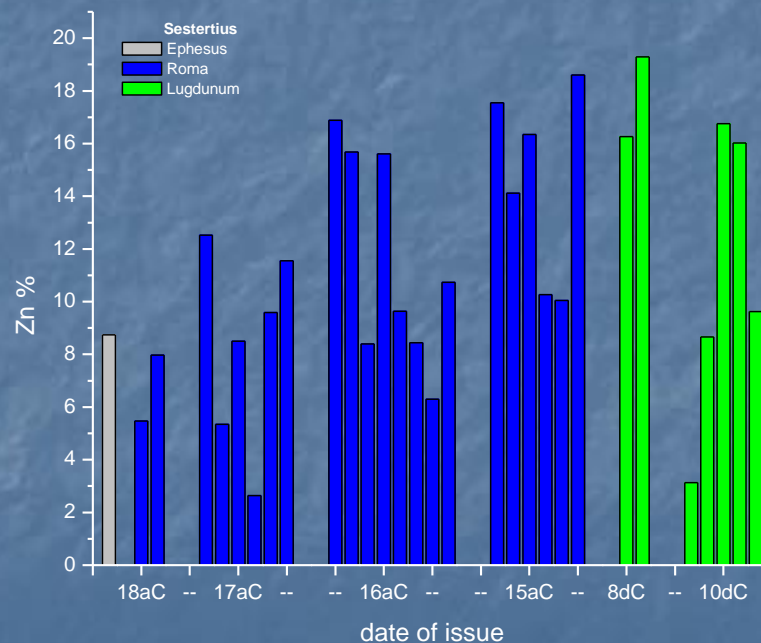
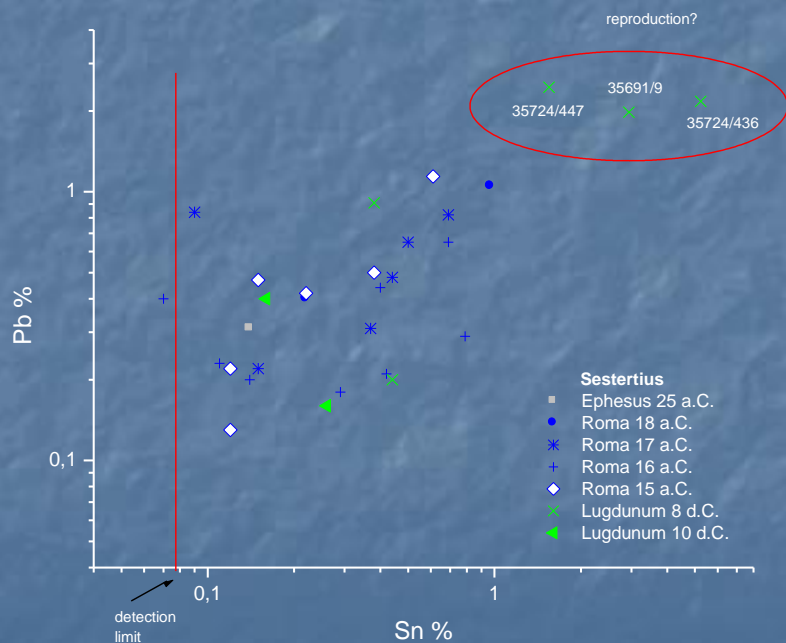
XRF analyses of Augustan coins



Sestertius
Rome, C. Asinius Gallus
16 BC
 35724/235 – 25.80 g

Sestertii

- $2.6\% < \text{Zn} < 19.2\%$ - Zn distribution increases by time – Sn and Pb correlated



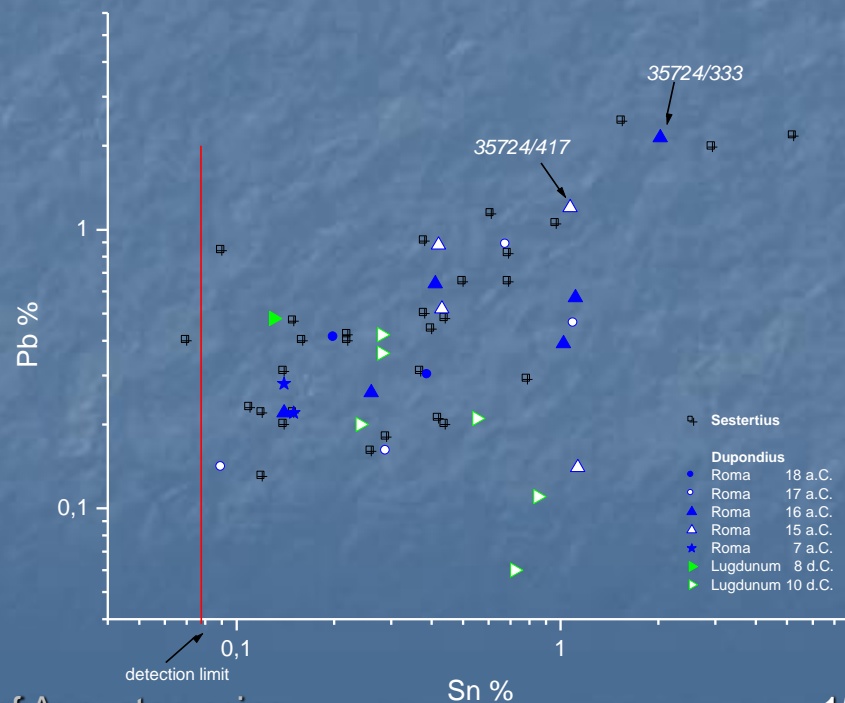


Dupondii

Dupondius = 1/2 Sestertius
Lugdunum
10 AD
 35724/256 – 10.70 g

5 coins (over 25) are made of $\text{Cu} > 96\%$
 2 coins have Sn and Pb content $> 1\%$

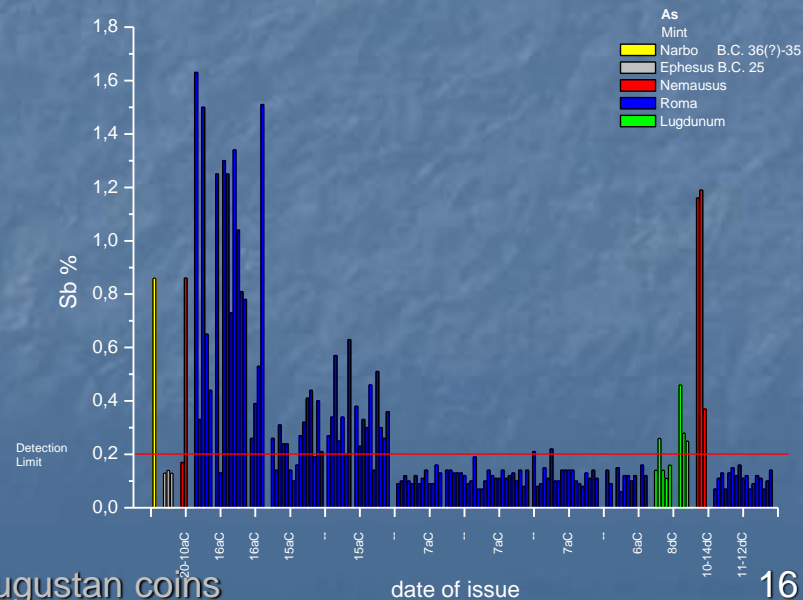
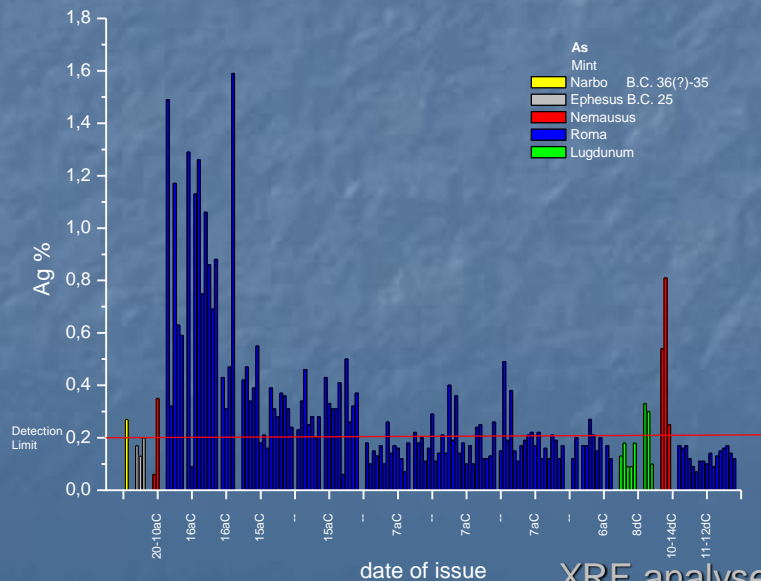
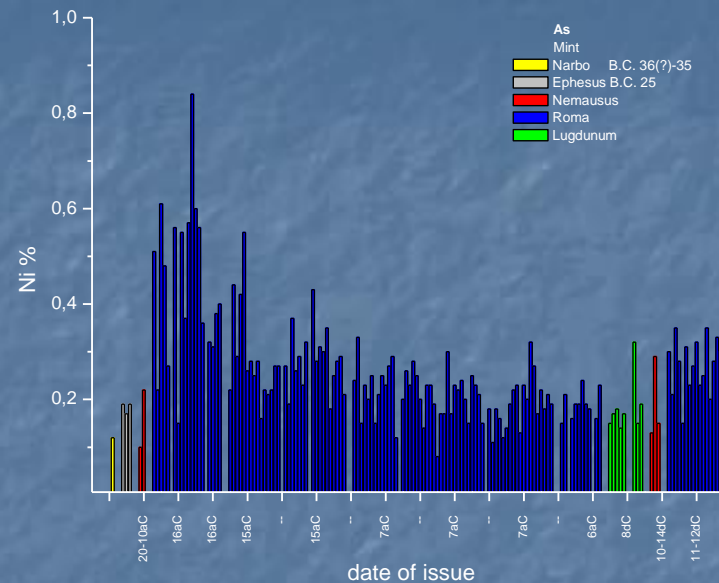
one of these (35724/333)
 has Sn and Pb contents
 near to the fake sestertii



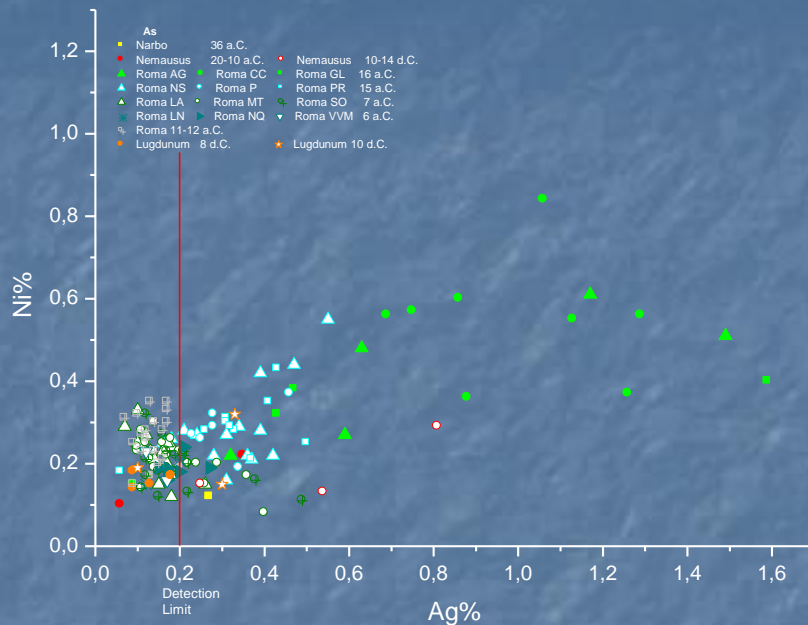


As
Rome, C. Cassius
Celer
16 BC
 35724/335 – 10.28g

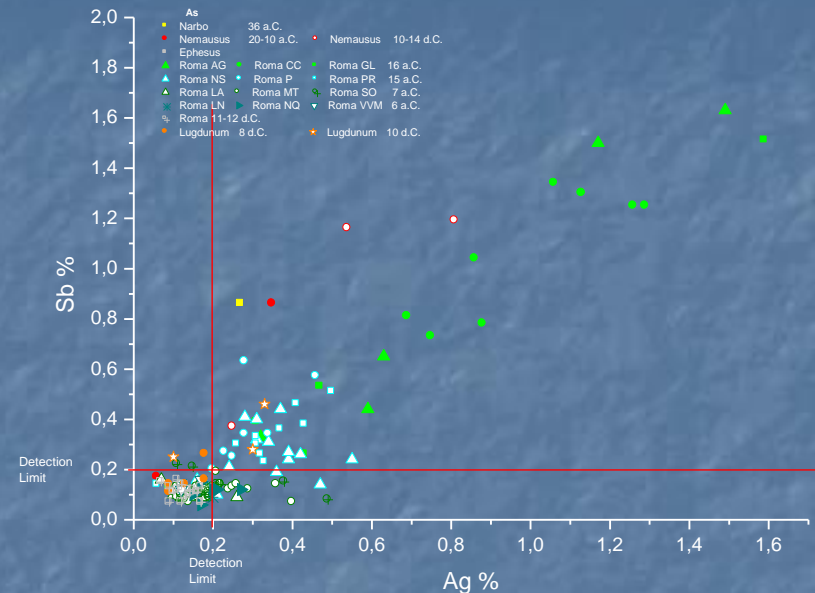
Ni, Ag, Sb are more abundant in
 7 BC production



XRF analyses of Augustan coins



Ag - Ni are slightly correlated



Ag - Sb are correlated

From Pb isotopes analysis
Copper supply:
mainly Sardinia and South Spain
occasionally Tuscany

S. Klein Y. Lahaye G.P. Brey,
The early roman imperial AES coniage II: tracing the copper sources by analysis of lead and copper isotopes-copper coins of Augustus and Tiberius, *Archeometry* **46**, 3 (2004) 469-480

Semisses



Semis = 1/2 as
Lugdunum
8 AD
35702/23 - 4.66g

Little statistics (8 coins)

Semisses are made of Cu-Zn alloy, similar to sestertii and dupondii (not pure Cu as request)

The only semis by Philippi is completely different from all the aes coins (Zn 0.3%, Sn 7.5%, Pb 3.4% : it's a bronze)



Quadrans= 1/4 as
Roma, Lamia Silius Annius
9 BC
35724/366, 3.03 g

Quadrantes

Quadrantes are mainly composed by $\text{Cu} \approx 98\%$
($\text{Sn} < \text{detection limit}$, Ag and Sb are around the
detection limit, $\text{Pb} < 0.6\%$)

$14\% < \text{Zn} < 18\%$ for 3 coins minted at
Lugdunum (one suspected **fake**)

Note: except 2 coins from Lugdunum
all the analyzed qadrantes are minted
after 9 BC



Quadrans
Lugdunum
10 AD
35724/446, 3.04 g

Modern reproduction

AES (base metal) Comparison

Sestertii/Dupondii

Pb & Sn: present

Sb: absent

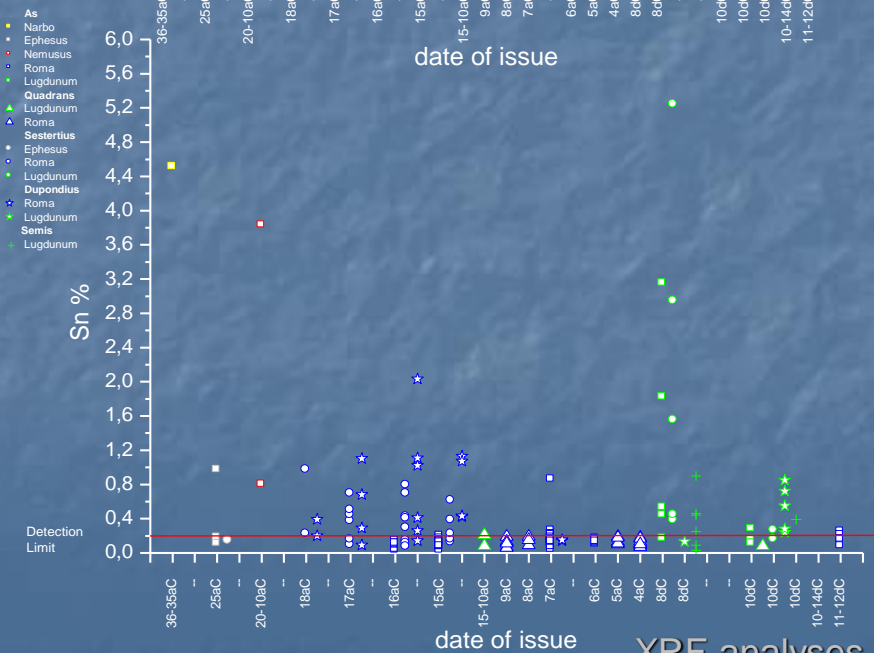
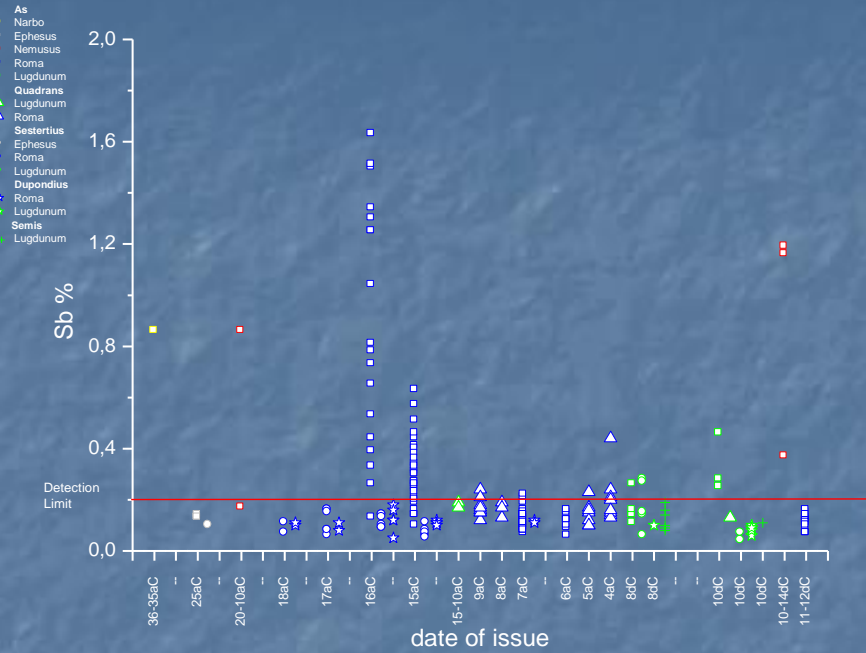
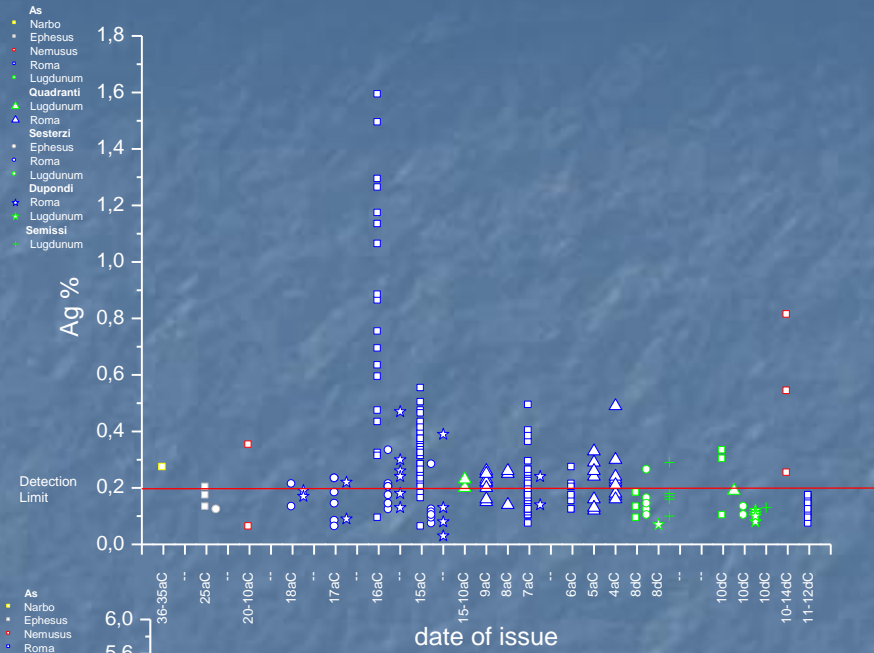
Ag: present in dupondii,
absent in sestertii

Asses/Quadrantes

Pb & Sn: almost absent

Sb: present (asses 16-15
BC, some quadrantes)

Ag: present (<asses 16-
15 BC, quadrantes 4-5
BC)



Conclusion:
 Cu coins contain Sb
 Cu-Zn coins contain Sn & Pb



Thanks for your Attention

Augustus, Pontifex Maximus
After B.C. 12

Museo Nazionale Romano
Palazzo Massimo
Rome

© - Tutti i diritti riservati

Mint provenance

Aurei (50) - Lugdunum 50%, Colonia Patricia 17%, Brundisium, 13%, Rome 7%, other 13%

Denarii (166) – Rome 24%, Lugdunum 23%, Colonia Patricia 20%, Brundisium 15%, other 18%;

Quinari (16) – Brundisium 88%

Sextertii (30) – Rome 77%, Lugdunum 23%, other 3%

Dupondii (25) – Rome 72%, Lugdunum 28%

Semisses (8) - Lugdunum 7 coins, Philippi 1 coin

Asses (152) – Rome 88.7%, Lugdunum 5.3%, other 6%

Quadrantes (32) – Rome 91%, Lugdunum 9%

The Augustan Reform

B.C. 23 – B.C. 20

| | aur | quin Au | denar | quin Ag | sester | dupon | as | sem | quad |
|------------|--------|------------|-------|------------|--------|---------|---------|--------|--------|
| aureus | 7,79 g | 2 | 25 | 50 | 100 | 200 | 400 | 800 | 1600 |
| quinarius | | 3,89g | 12,5 | 25 | 50 | 100 | 200 | 400 | 800 |
| denarius | | | 3,89g | 2 | 4 | 8 | 16 | 32 | 64 |
| quinarius | | | | 1,94 g | 2 | 4 | 8 | 16 | 32 |
| sestertius | | | | | 27,28g | 2 | 4 | 8 | 16 |
| dupondius | | | | | | 13,64 g | 2 | 4 | 8 |
| as | | | | | | | 10,91 g | 2 | 4 |
| semis | | | | | | | | 5,20 g | 2 |
| quadrans | | | | | | | | | 1,70 g |