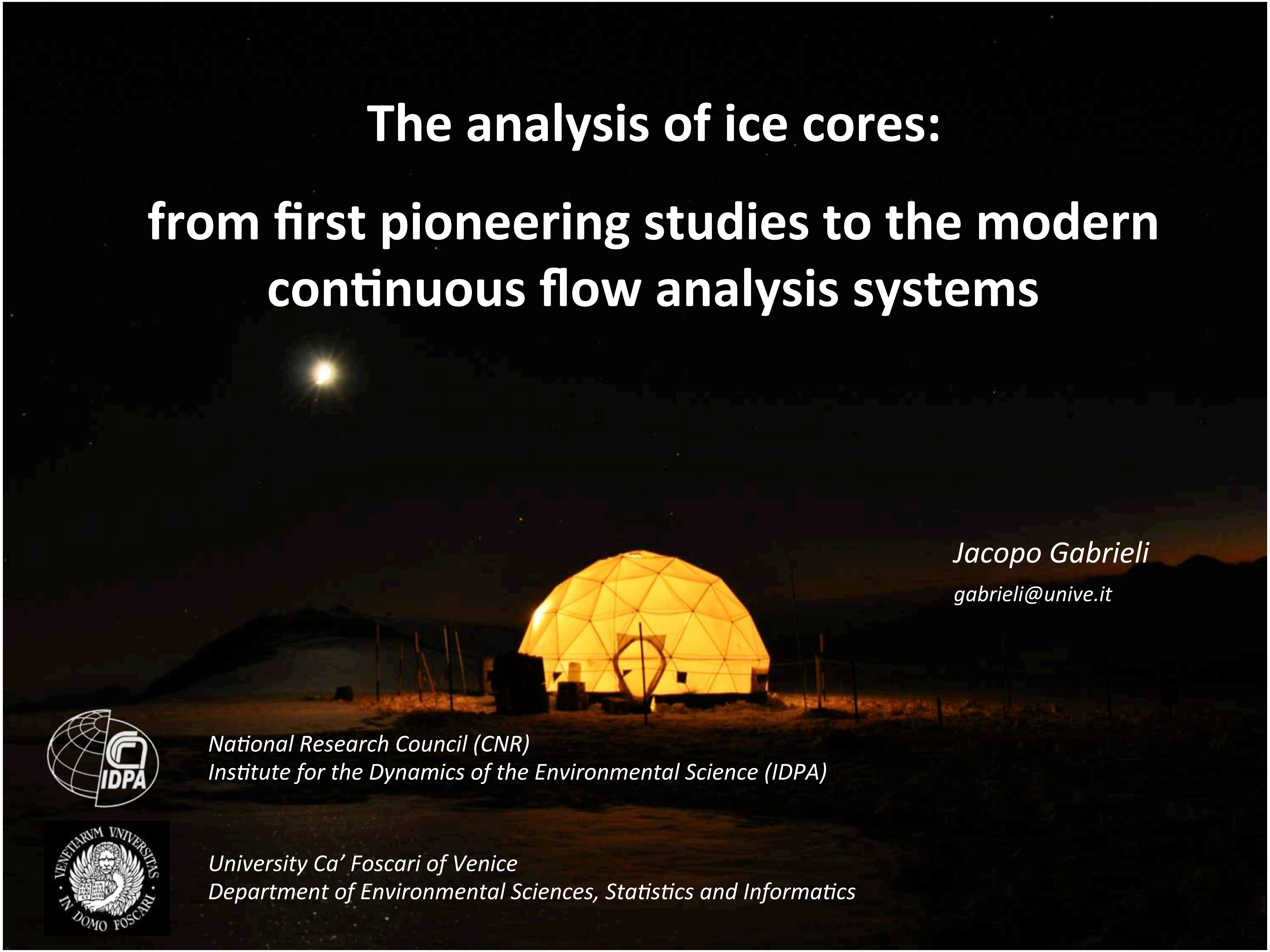


The analysis of ice cores:

from first pioneering studies to the modern continuous flow analysis systems

Jacopo Gabrieli

gabrieli@unive.it

National Research Council (CNR)
Institute for the Dynamics of the Environmental Science (IDPA)

University Ca' Foscari of Venice
Department of Environmental Sciences, Statistics and Informatics

news feature

Frozen time

Researchers have pulled the oldest-yet core of ice from the Antarctic — giving us a 740,000-year record of the planet's climate. Gabrielle Walker braves the cold to find out how they did it, and what they hope to learn.

Cold comfort

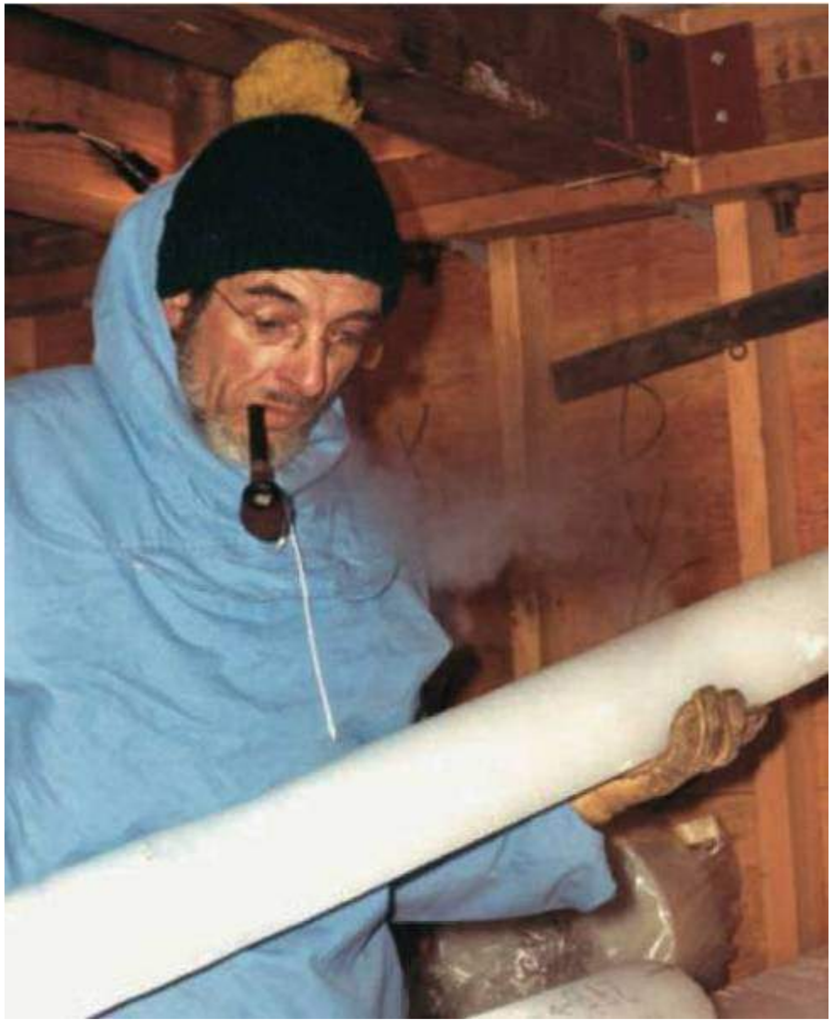
Ice… not only frozen water

1. Major ions (Ca^{2+}, K^+, NO_3^-, NH_4^+, SO_4^{2-}, Cl^-, …)
2. Stable O and H isotopes
3. Trace elements
   - Geochemical tracers (REEs, Pb, Sr isotopes)
   - Anthropogenic (Pb, Cd, Cr, U, As, PGEs, …)
   - Cosmogenic (^{10}Be, ^{36}Cl)
   - Radioactive tracers (^{137}Cs, ^{3}H, Pu, …)
4. Dust particles
5. Organic compounds
   - Combustion markers (OC, PAHs levoglucosan, …)
   - Industrial (PCBs, PBDEs, PCDEs, PFCs, …)
   - Agriculture (pesticides, HCB, …)
6. Dissolved greenhouse gasses (CO_2, CH_4, …)
7. …

Low concentrations

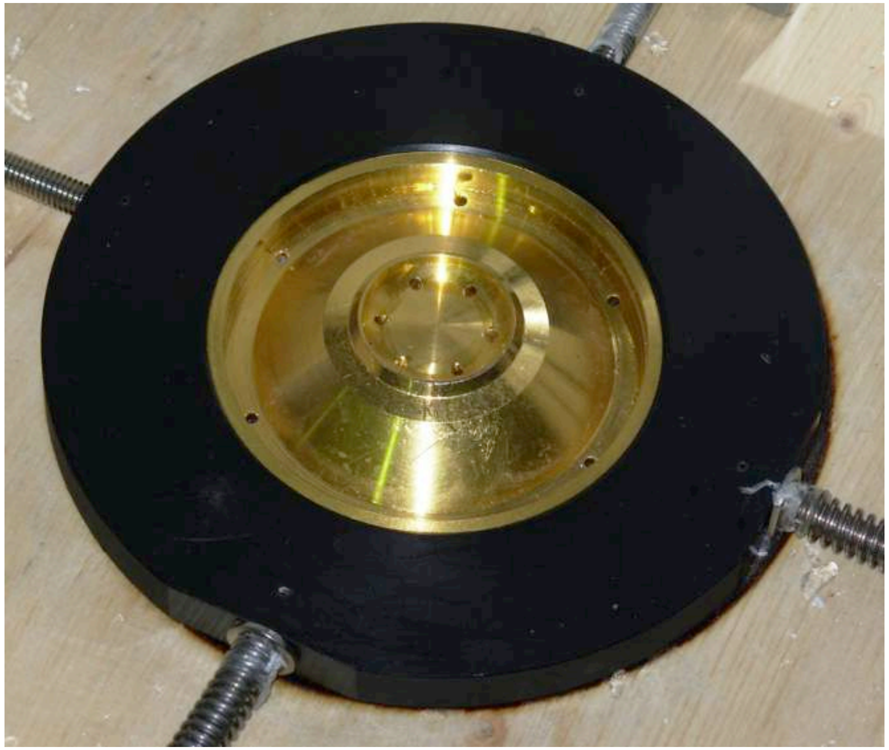
1.0 ng/kg (ppt) = 1 / 1,000,000,000,000 = 10^{-12}

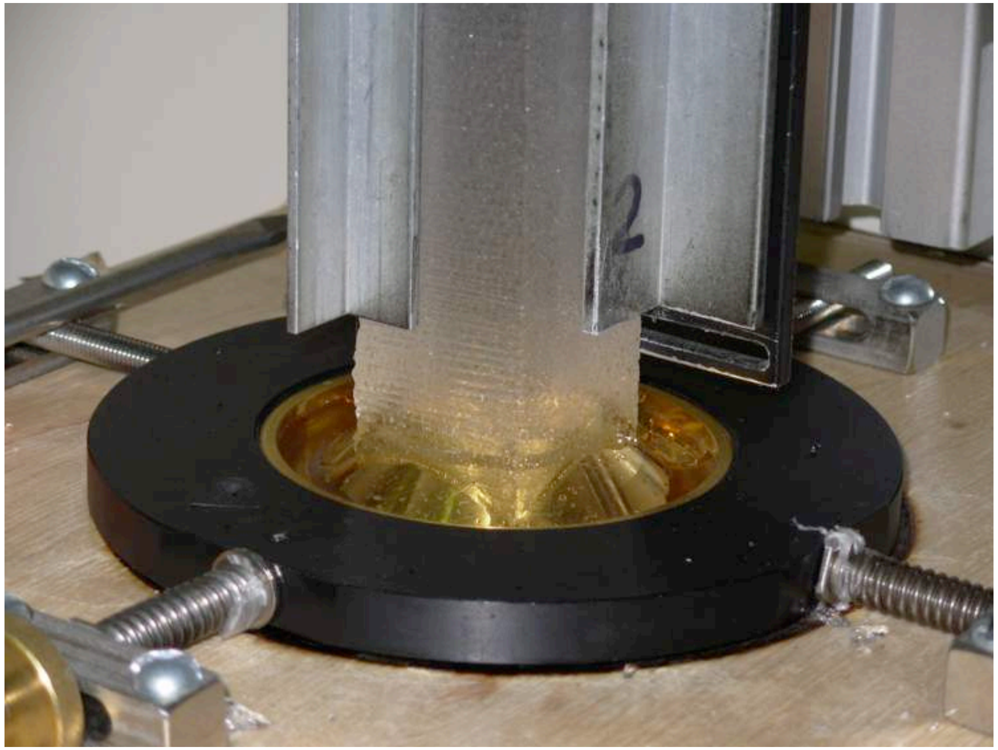
External contamination



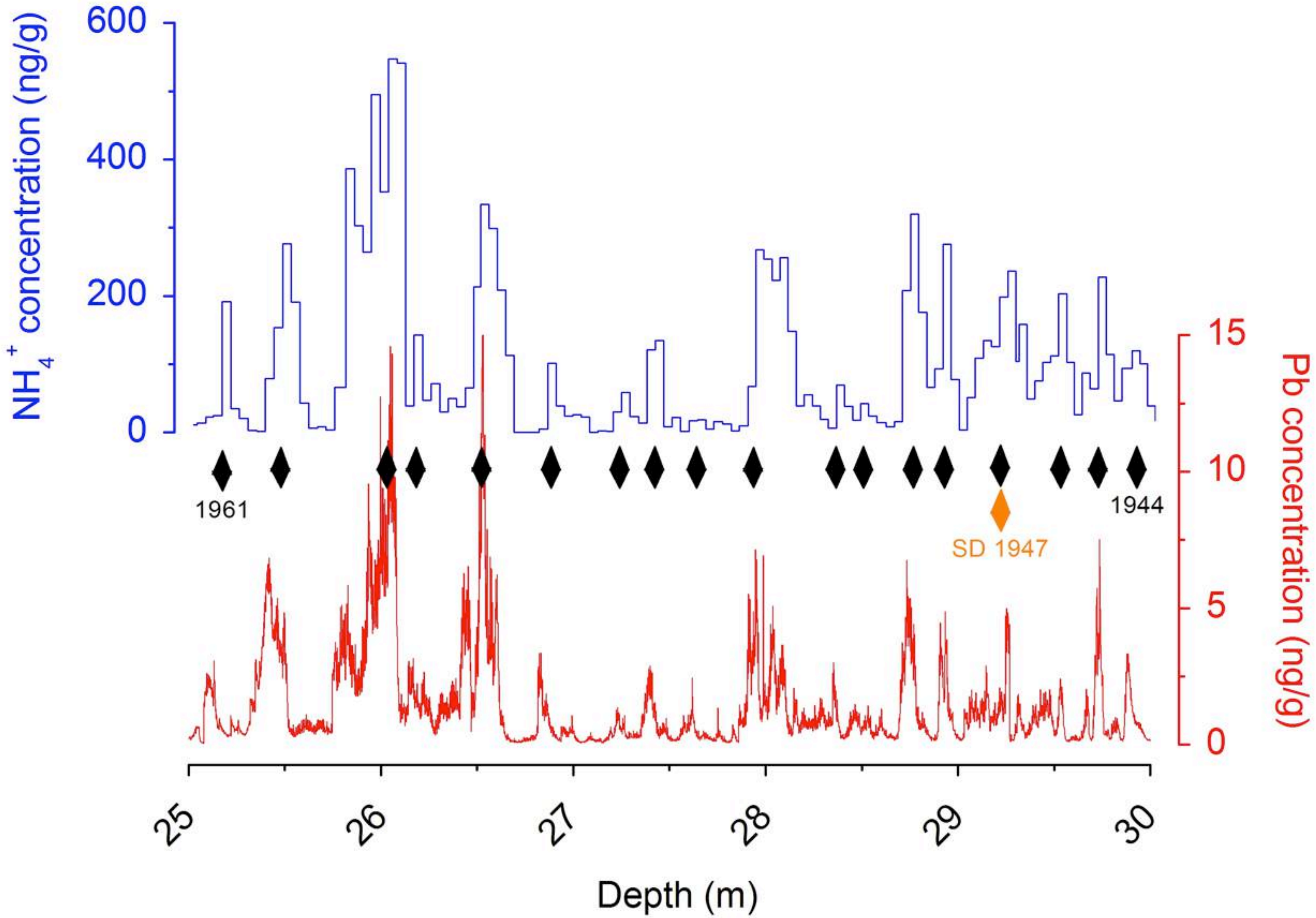
External contamination

From chisseling to continous melting systems

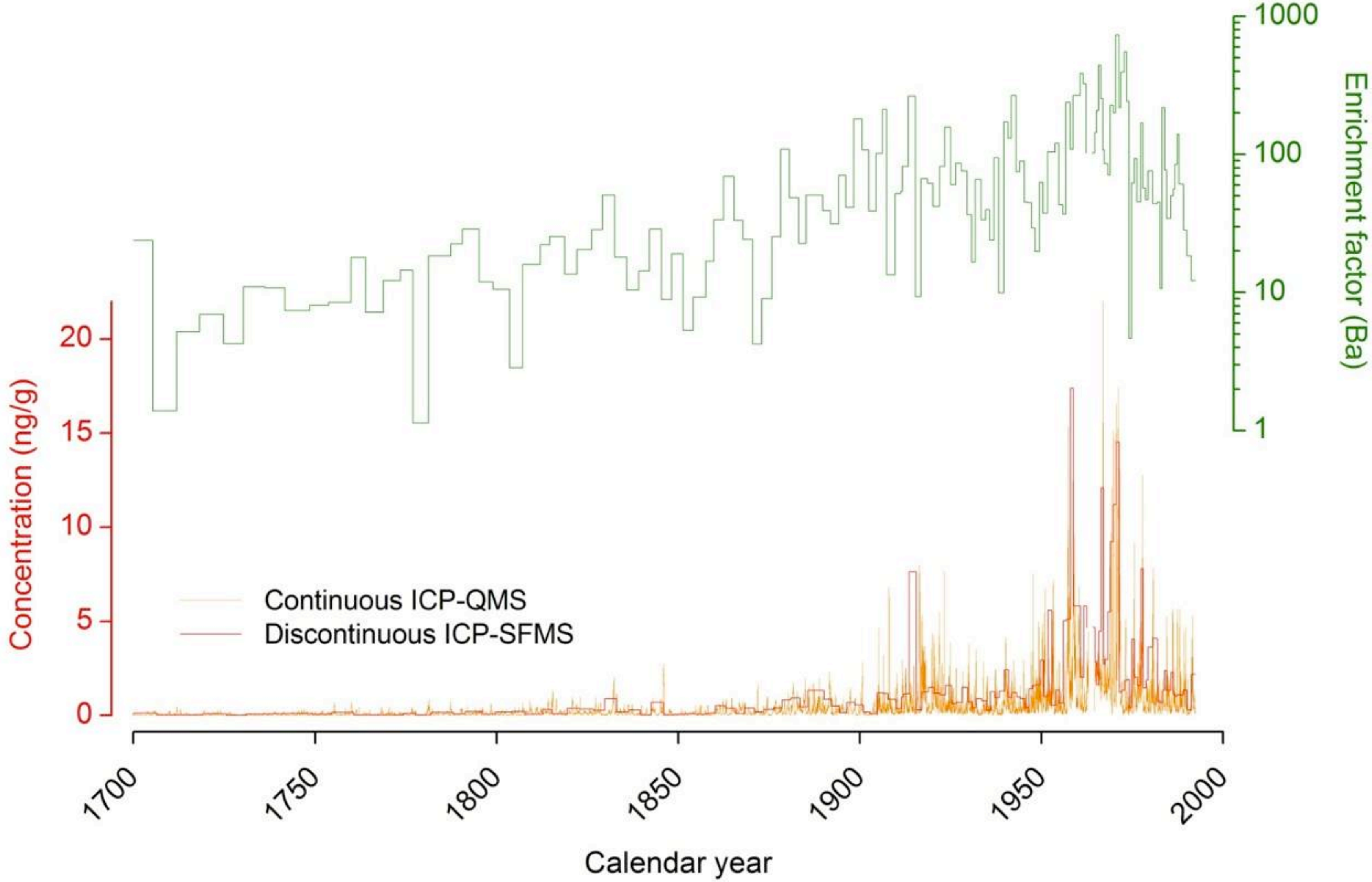


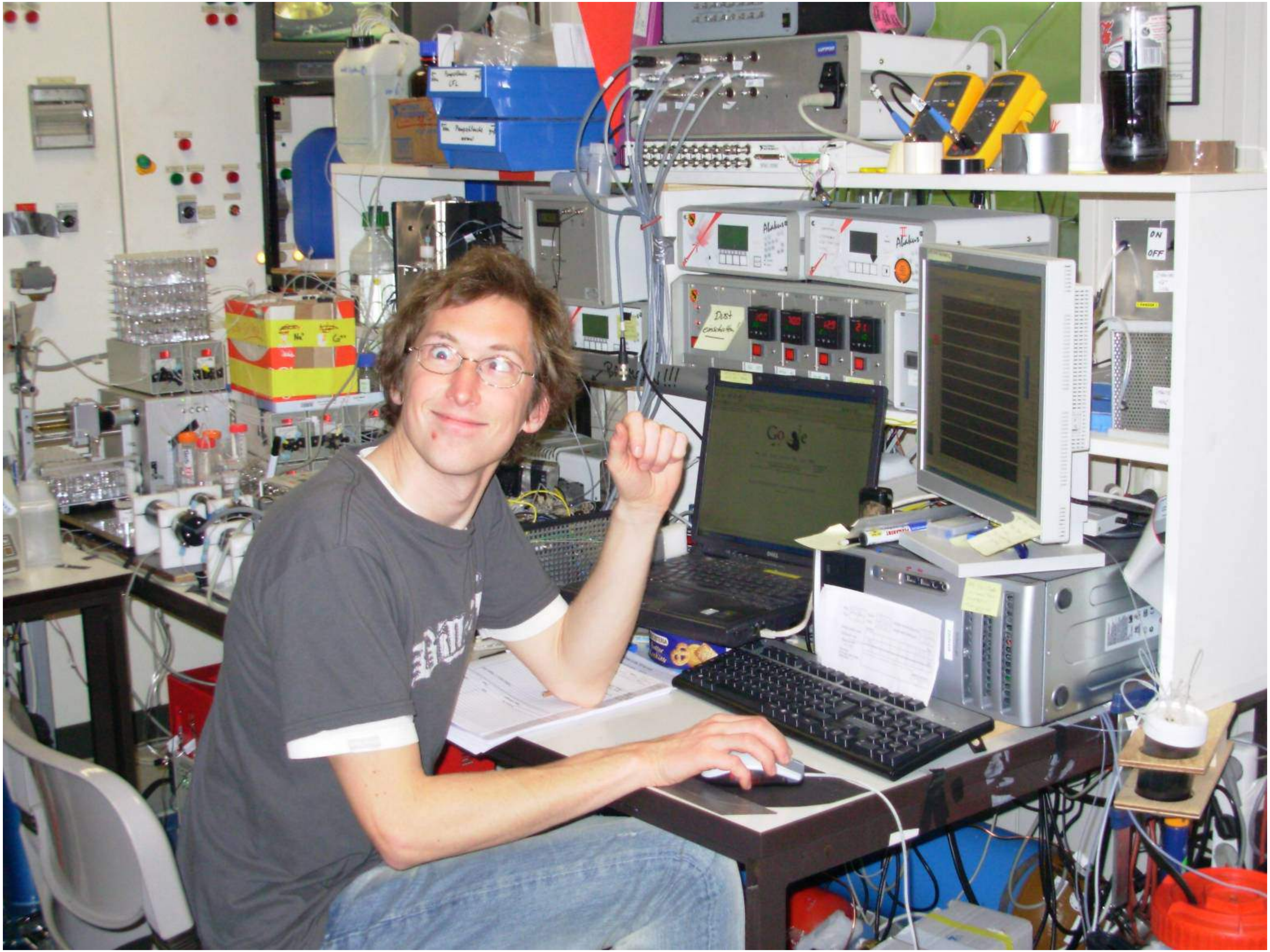


Colle Gnifetti – seasonal signals

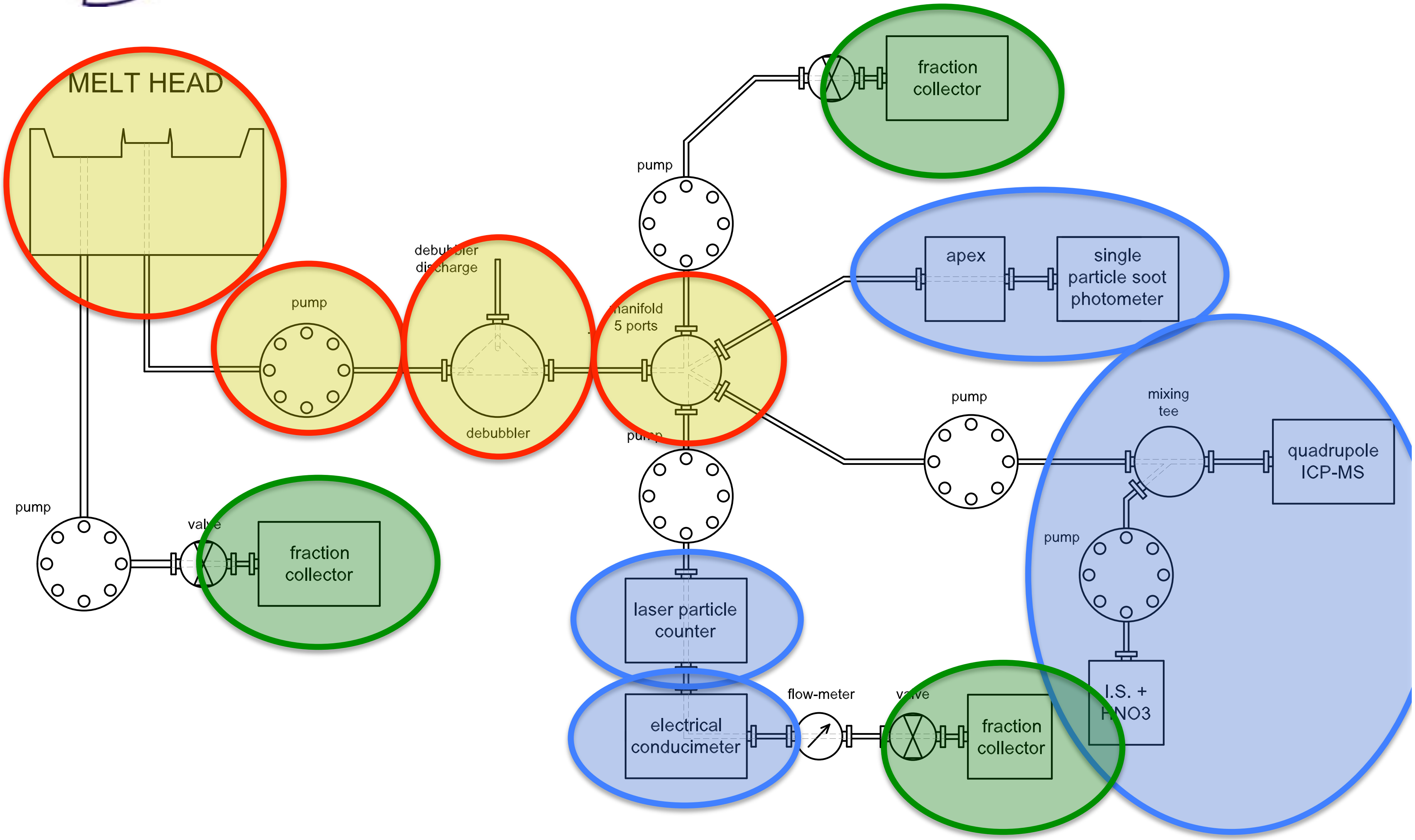


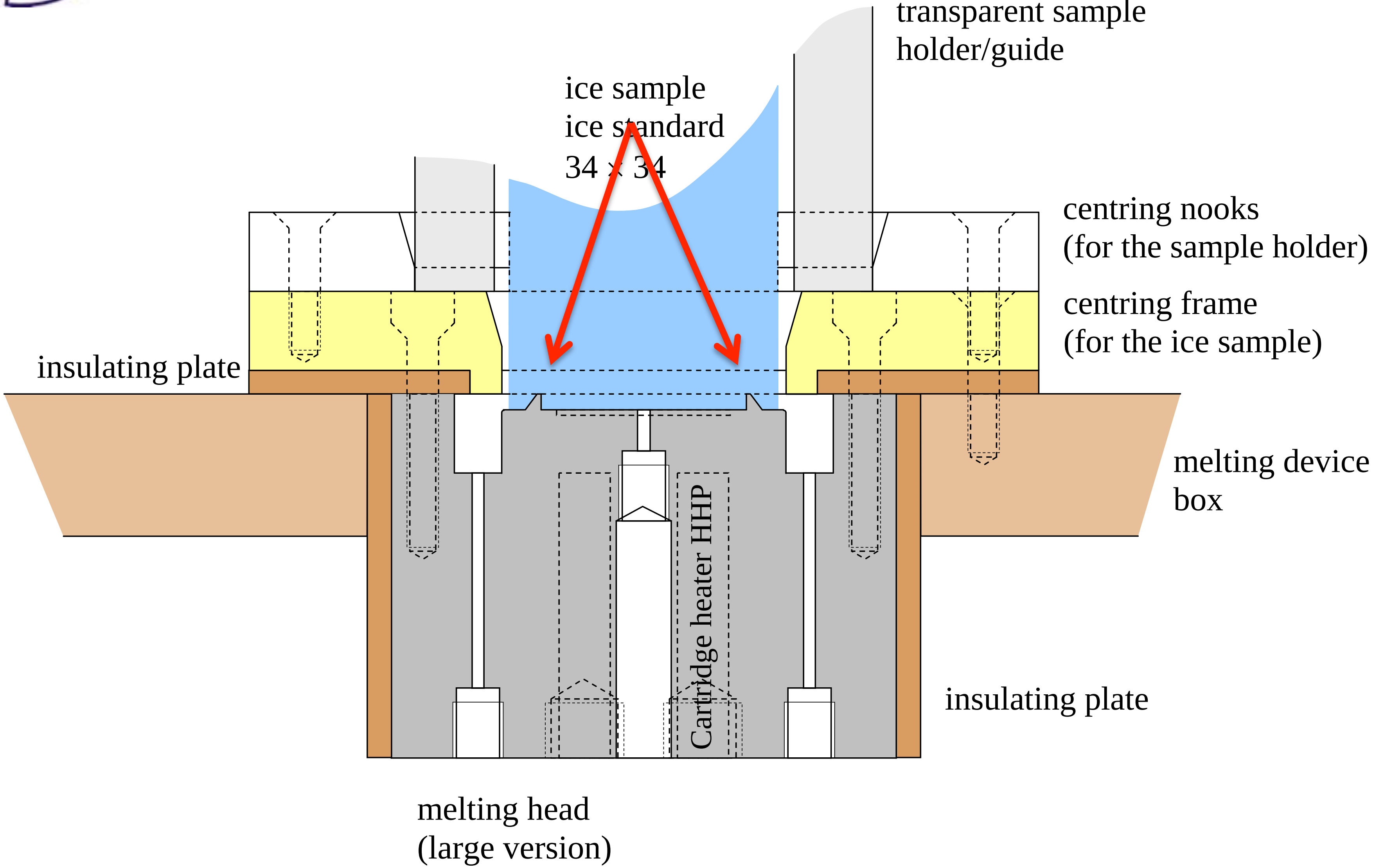
Colle Gnifetti – Pb deposition over the last 300 yrs



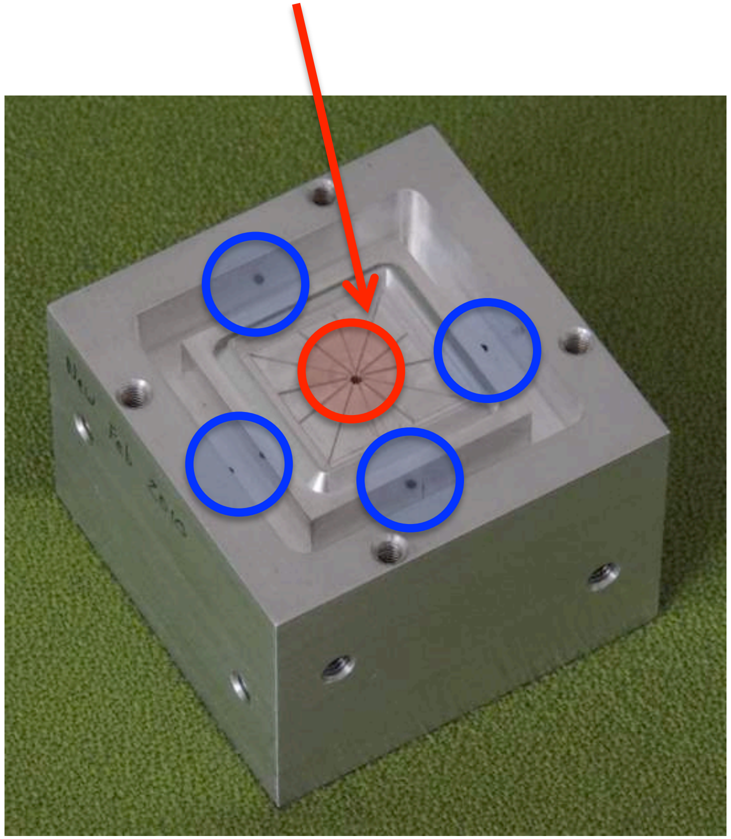

ON
OFF
Dust einschalten

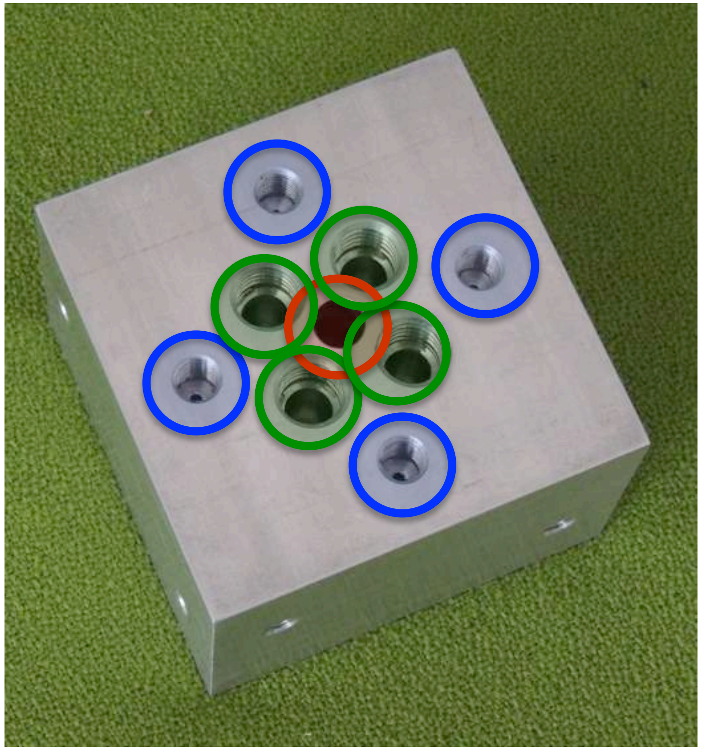
The new “venetian” melting system




transparent sample
holder/guide
ice sample
ice standard
34 x 34
centring nooks
(for the sample holder)
centring frame
(for the ice sample)
insulating plate
melting device
box
Cartridge heater HHP
insulating plate
melting head
(large version)

Melting head geometry



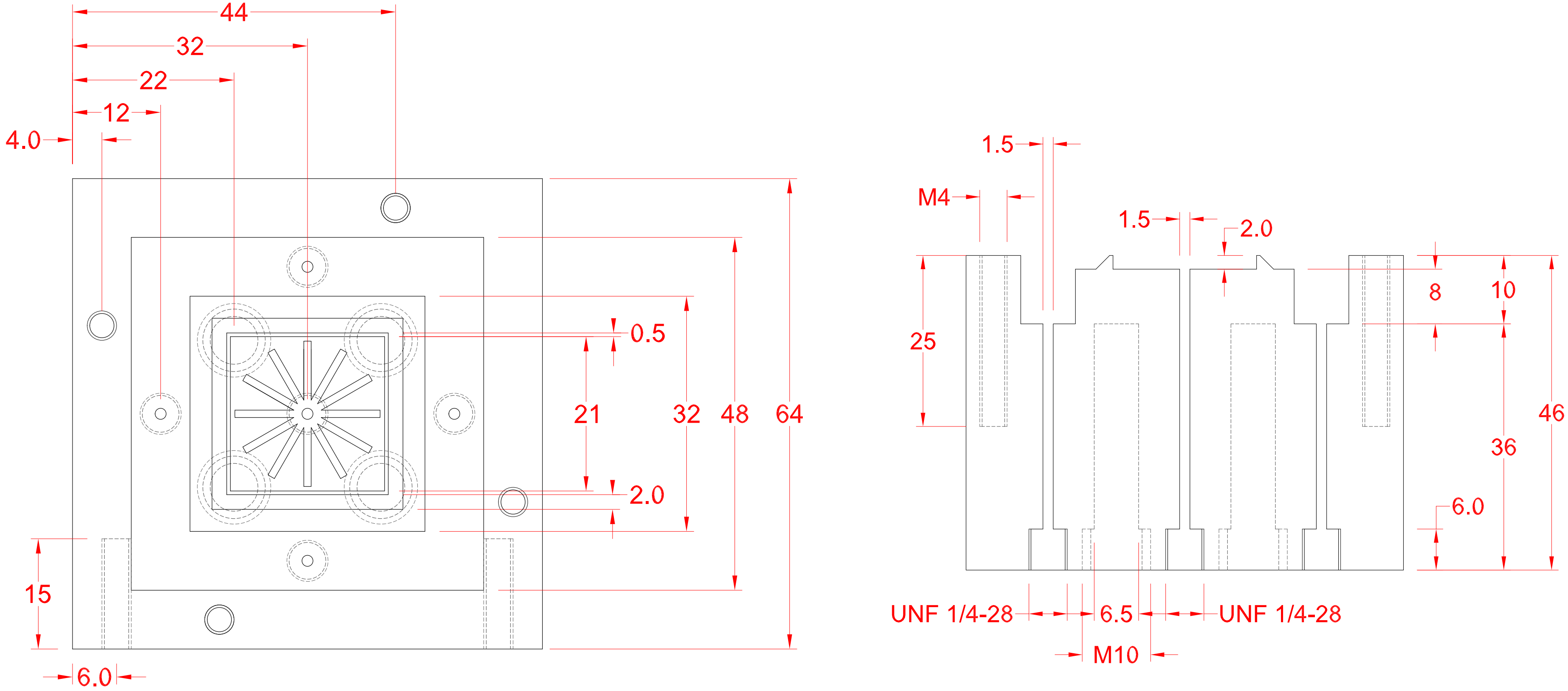


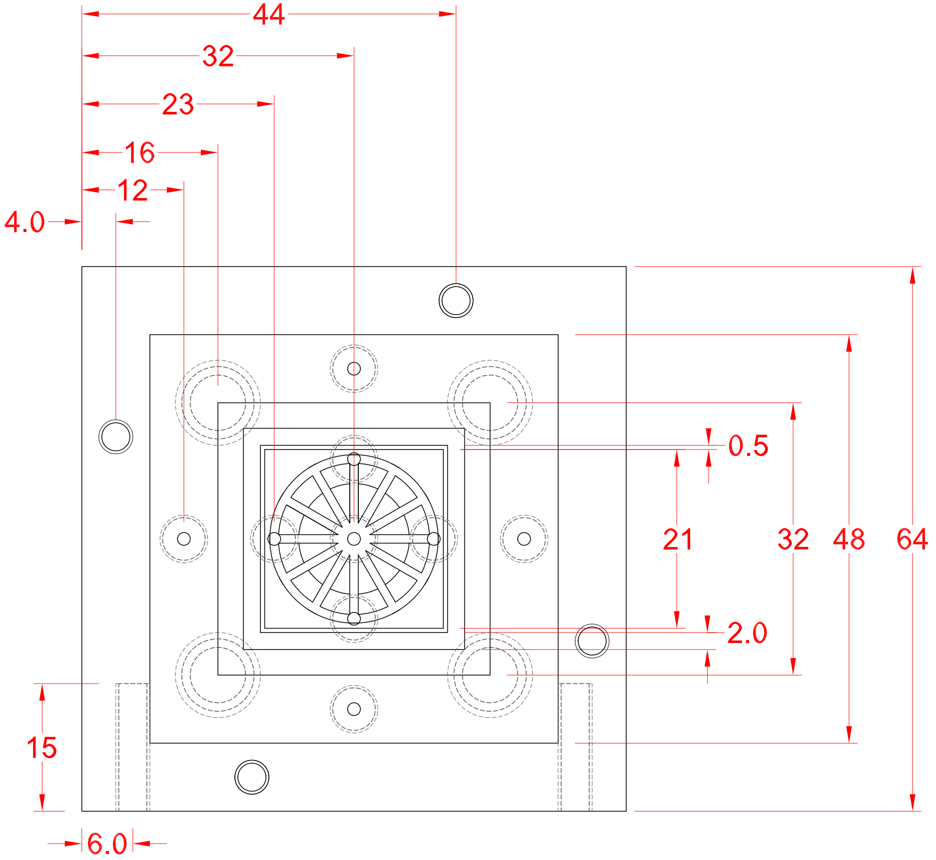
The melt head: which metal?

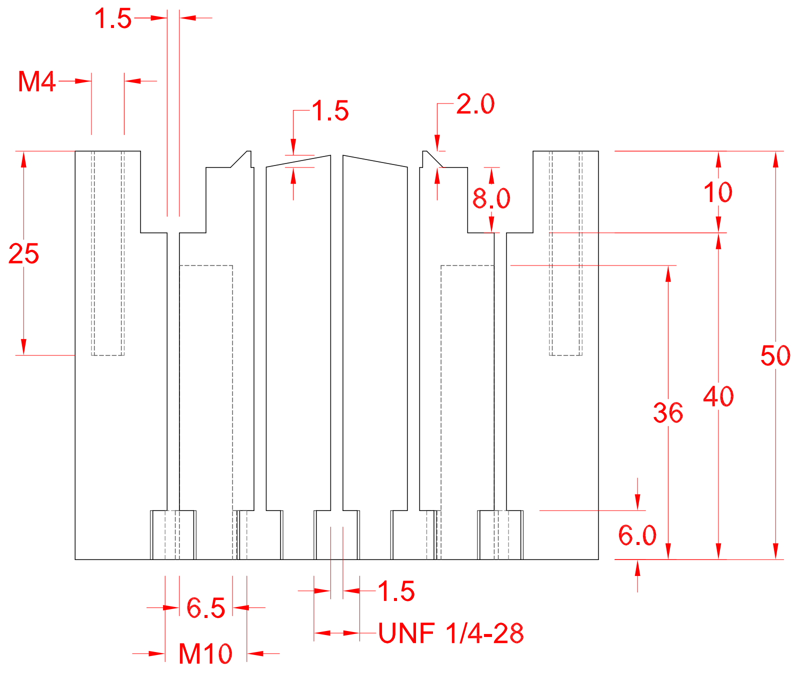
Metal	Thermal Cond. (W/mK)	Machinability	Chemical stability	Price
Cu	390	😉	🙁	€€ (*)
Al	237	🙂	🙂	€ (*)
Ni	91	😢	😉	€€€
Stainless-steel	16 - 52	🙁	🙂	€€
Ti	22	🙁	🙂	€€€

(*) Cu and Al meltheads require electrolytic deposition and anodizing, respectively

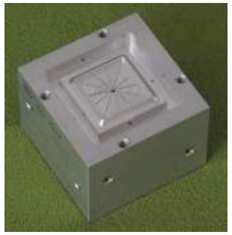
Melting head geometry

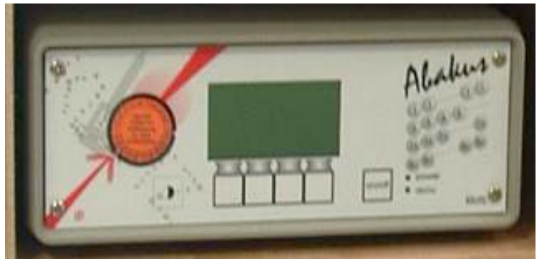



44
32
23
16
12
4.0
0.5
21
32
48
64
2.0
15
6.0

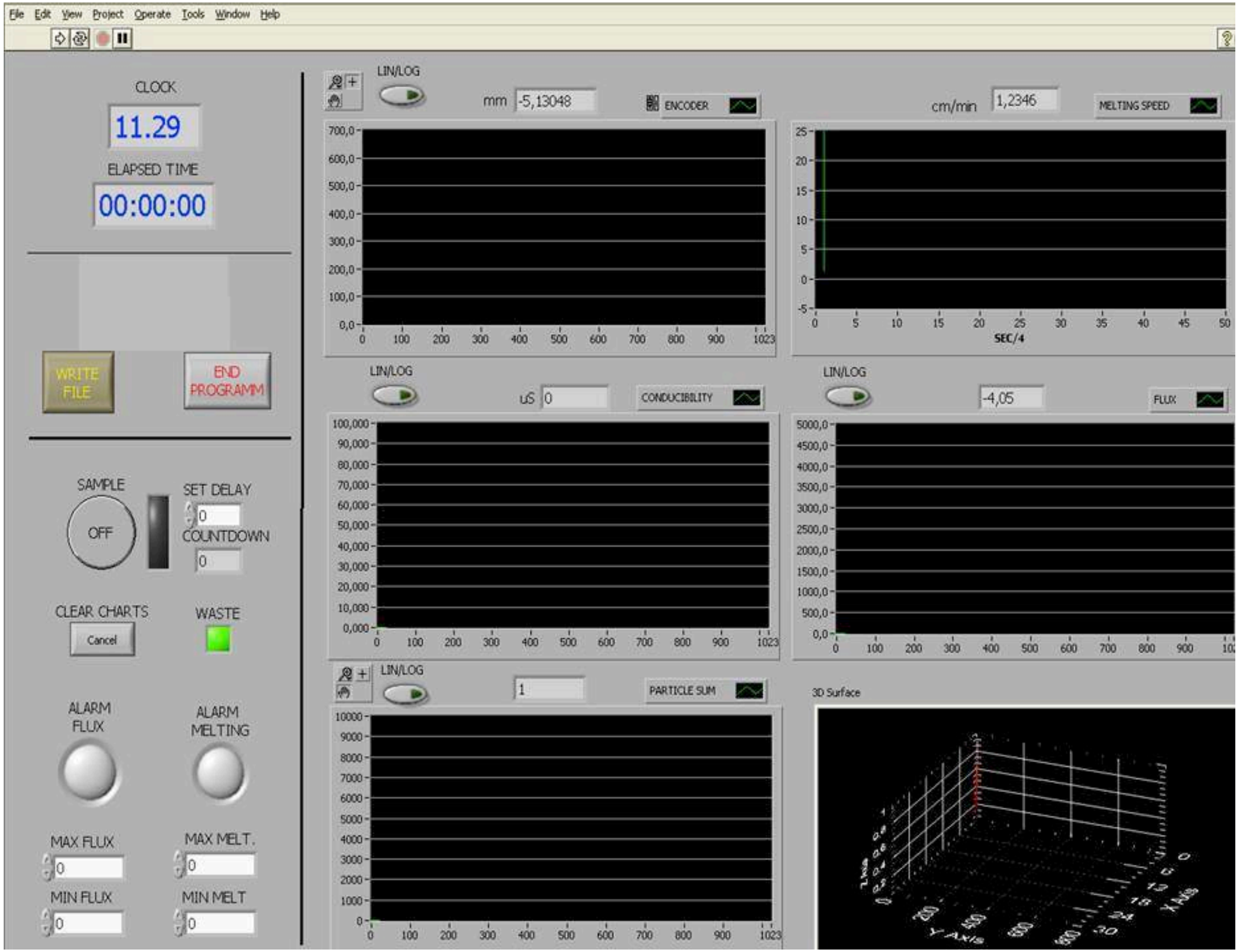

1.5
M4
1.5
2.0
25
8.0
10
50
36
40
6.0
6.5
M10
1.5
UNF 1/4-28

Continuous flow analysis





NI acquisition software



- Melting head temperature 25°C
- Melting rate 3.2 ± 0.16 cm/min (n=27)

CONTINUOUS MEASUREMENTS

- Electrical Conductibility
- Dust (ABAKUS, 32 channels)
- Up to 28 trace elements (Agilent ICP-QMS)
- Black carbon by SP2

ANCILLARY PARAMETERS

- Melting rate (drawwire sensor)
- Flux (Abakus-Conductibility channel)

Instrumental resolution 0.8 ÷ 1.1 mm (theorical…)
Final CFA resolution ~ 5 ÷ 8 mm

DISCRETE SAMPLING

- Two flows from inner channel
- 1°flow (dedicate tube), flux = 5.26 mL/min
- 2° flow (abakus-conductibility), flux = 2.84 mL/min
- External layer, flux > 9.6 mL/min

Heavy metals, REE, …	volume	2.5 ÷ 4.0 mL	5 cm
Major ions	volume	~ 5 mL (1.0 mL ?)	5 cm
Levoglucosan	volume	< 1.0 mL	30 cm
Stable isotopes	volume	~ 2 mL	3÷5 cm
Dust	volume	~ 10 mL	8÷10 cm
Pollen	volume	~ 25 ÷ 50 mL	15÷20 cm


Once upon a time…
…the Ortles drilling

Vedretta Alta

Surface (2006): 105 ha
Maximum elevation: 3905 m
Minimum elevation: 3018 m
Average elevation: 3535 m
Exposure: NW
Average slope: 29°

Climatology

Precipitation (valley floor, 1900 m): **750 mm y^{-1}**
Annual air temperature (3850 m): **-9°C**

IDPA

The Ortles work group

THE OHIO STATE UNIVERSITY

BYRD POLAR RESEARCH CENTER
THE OHIO STATE UNIVERSITY

IDPA

universität innsbruck

PARCO NAZIONALE DELLO STELVIO
NATIONAL PARK STILFSER JOCH

VENETIARUM UNIVERSITAS IN DOMO FOSCARI

ALMA TICINENSIS UNIVERSITAS

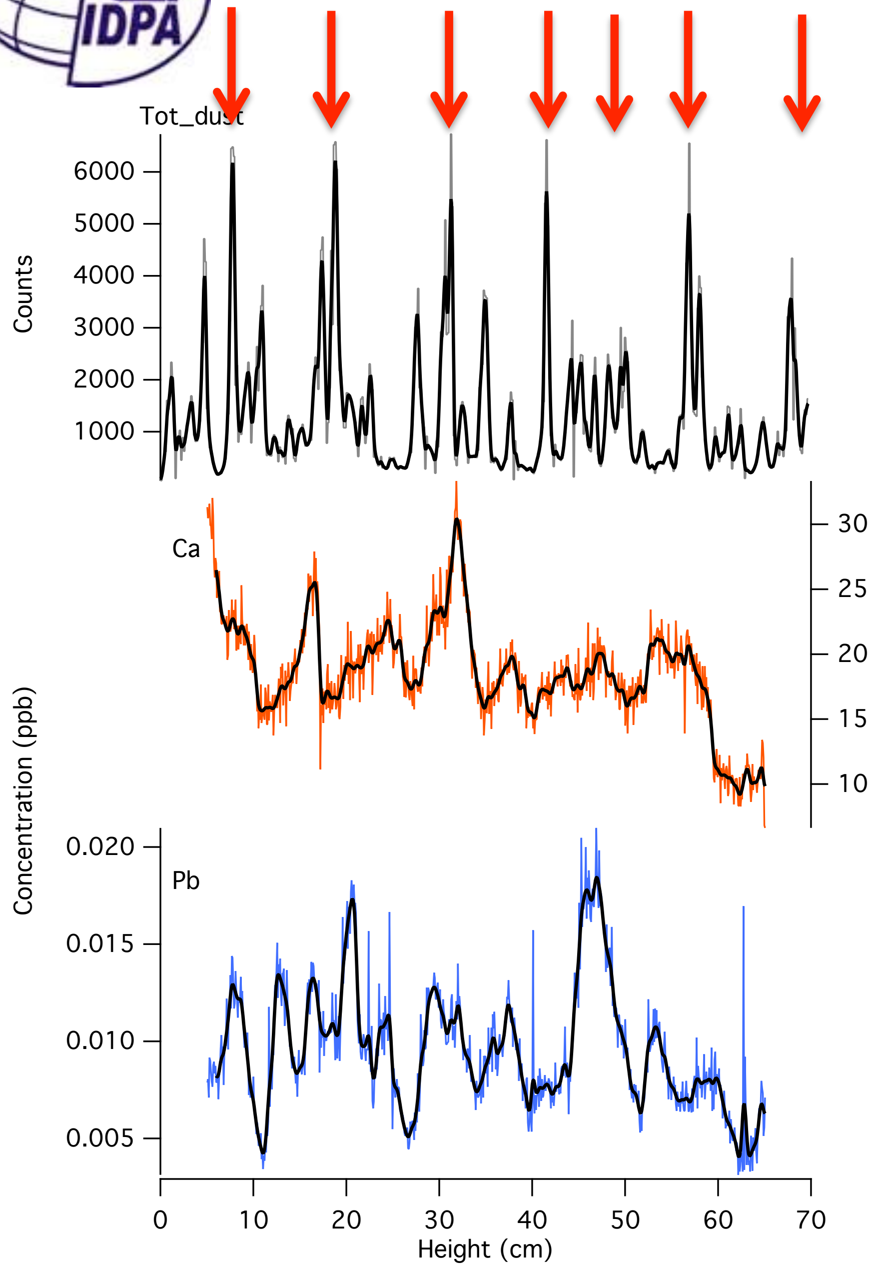
UNIVERSITAS STUDII PADUANI MCCXXII

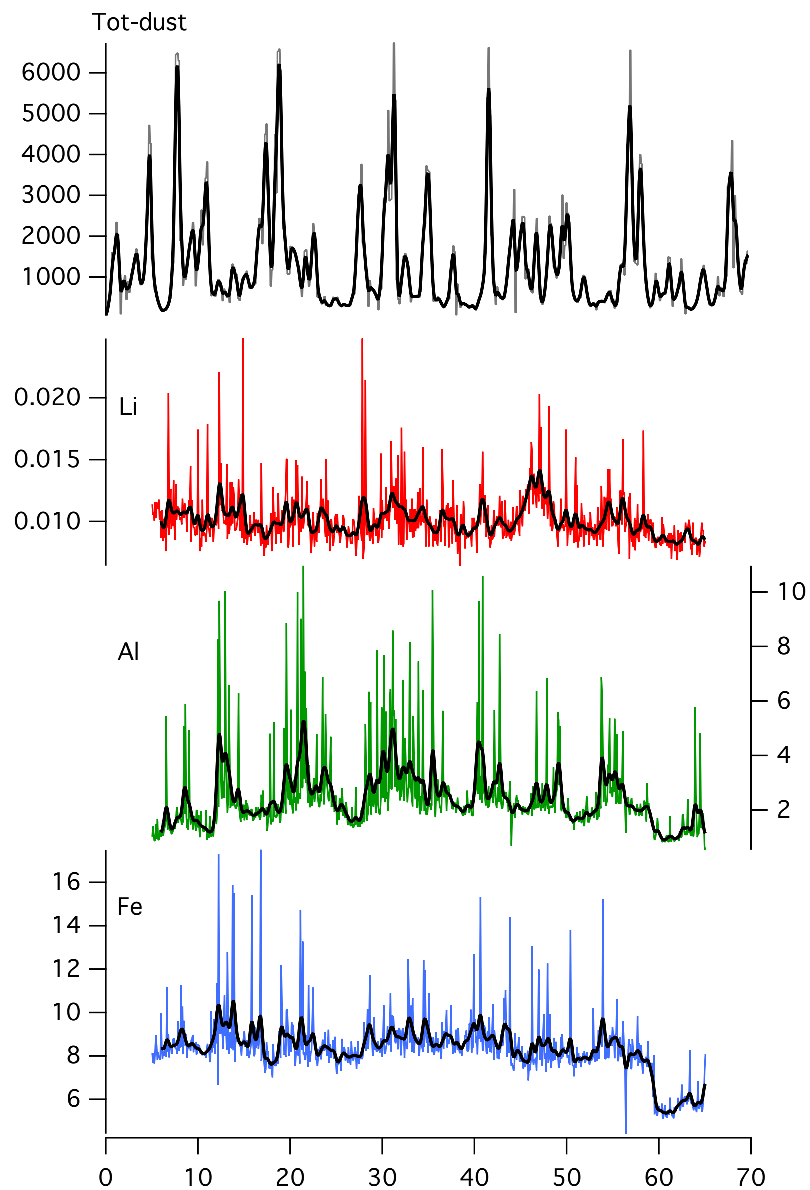
UNIVERSITÄT BERN

EURAC research


Some preliminary results…

First test– Ortles core #1, bag 85 (64.2 – 64.9 m)





Future perspective

- Fixing a few bugs identified from preliminary tests
- SP2 connection and testing
- Analysis of Ortles core #1 (106 bags, 75.1m)
- Replicate of a few Ortles bags for reproducibility tests
- Data processing and management

- Installation of a second CFA system at Ohio State Univ.
- Intercomparison tests between CNR, LGGE, OSU

Thanks for your attention !

Jacopo Gabrieli

gabrieli@unive.it

National Research Council (CNR)
Institute for the Dynamics of the Environmental Science (IDPA)

University Ca' Foscari of Venice
Department of Environmental Sciences, Statistics and Informatics