Step 1: get an overview of elements and their distribution in the whole head.

1. Experimental set-up:

2. Why? To get an overview of elements in the whole head and possible correlations between elements (hint for pigments).

3. How: 38.5 keV? Sufficient to get main elements possibly found, include Sb (Kα 26 keV) and Ba (Kα 32 keV).

4. How: 0.5x0.5 mm²? Compromise to get enough signal (SN ratio) in a feasible time: 256 pixels = 2 days.

5. Raster-scanning with pencil-beam 0.5x0.5 mm²

   FOV (field of view): 17.5 x 17.5 cm²

   Exposures: 38.5 keV
Step 2: Pose information about Antimony structural environment to determine pigment.

2. Why? To get information about Sb structural environment and pin some leads on potential pigments containing Sb (Reference Sb-pigments used for fingerprint).


X-ray beams // to particles to increase depth penetration and reach layer of the head. Fluorescence mode also for reference to avoid phos with self-absorb.
Step 3: Confirm identification of the pigments, yet their distribution and check they belong to the head and not in upper painting

2. Why? Confirm pigment and their location within the head and not in upper painting

3. How? - Small beam size to target single grains
- Low energy to better identify pigments (L-edge more distinct than K-edge)
- X-ray in beam bent to increase surface analysis
Step 4: Confirm representativity of the pigments found and stylistic aspects by analysis of other head paintings by Van Gogh (same period)

1. Experimental set-up

2. Why? To confirm that the pigments detected were also found in other paintings of the same period (representativity)

3. How? Several punctual spots, large enough to get good average overview. Non-invasive reported as it is just “a check”.

Point measurement with portable µXRF
punctual, non-invasive,
φ 1cm
Results - Analytical pathway

1. **muXRF mapping painting**
   - pigments of surface painting
     - chrome green, schweinfurt green, umber, white, barium sulfate
   - image shows correlation Hg, Sb, Zn in the head beneath
   - vermilion (HgS) lips and cheeks
   - zinc white in landscape + nose, ear, collar

   Could be Naples Yellow Pb₂Sb₂O₇
   (frequently used by Van Gogh)
   but also other (valentinite)

   Issue: no clear correlation between Pb lead & Sb K-shell emission

2. **muXANES painting**
   - Valentinite excluded
     - (Sb₂O₃)
   - spectra similar to Naples Yellow
     - same co-ordinated state (Sb⁵⁺)
   - Issue: does it come really from head?
     - only Naples Yellow?

3. **microsample**
   - muXRF + muXANES
   - Pb & Sb correlated
   - and with lower layer
   - to in agreement with Naples Yellow
   - but also Pb found without Sb
   - to "nase" presence of lead white

4. **XRF other Van Gogh paintings**
   - same elemental composition + other
   - Reconstruction of head color possible = Gunmetal?