VOLTA Validation Pipeline: Hypothesis H5 (Cathode-Carbon Decoupling)
Particle-Based Statistical Independence Test

(A) Hypothesis Input

H5: The A1g peak position and ID/IG ratio show weak or no spatial correlation, indicating decoupled cathode-carbon behavior. Expected: |r| < 0.05

(B) Test Proposal Agent

Particle-Level Correlation Magnitude Consistency Test

H_0: Mean |r| ≤ 0.05 (weak correlations)

H_1: Mean |r| > 0.05 (strong correlations)

Method: One-sample t-test on |r| per particle

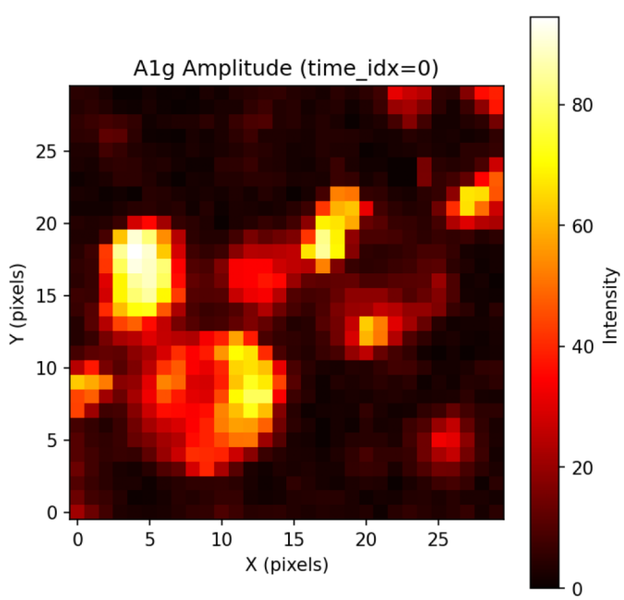
(C) Particle Identification Tool

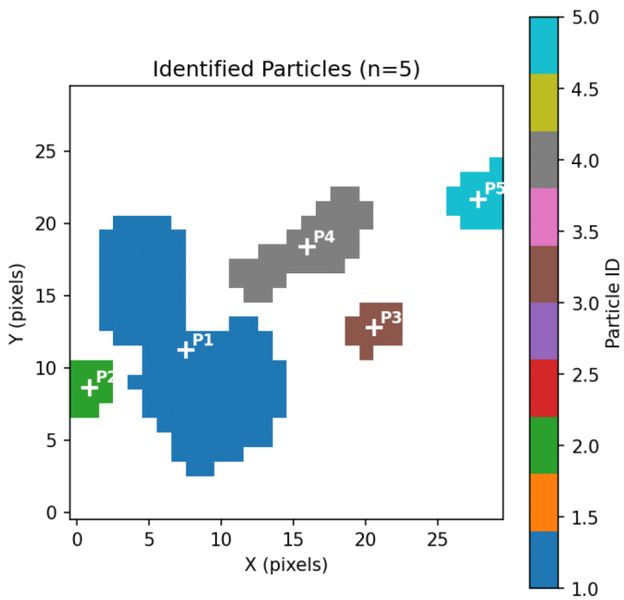
Action: identify_particles

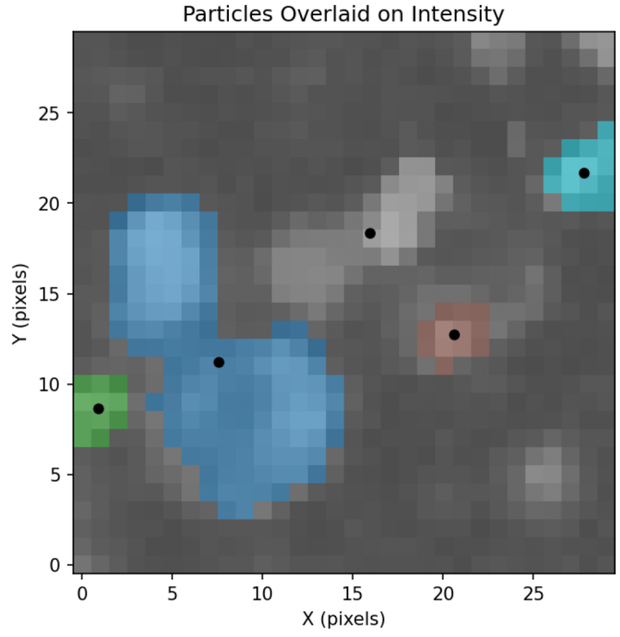
Input:
```
{"time_idx": 0,
"min_particle_size": 4,
"return_timeseries": true}
```

Output:
5 particles identified
→ INDEPENDENT EVENTS

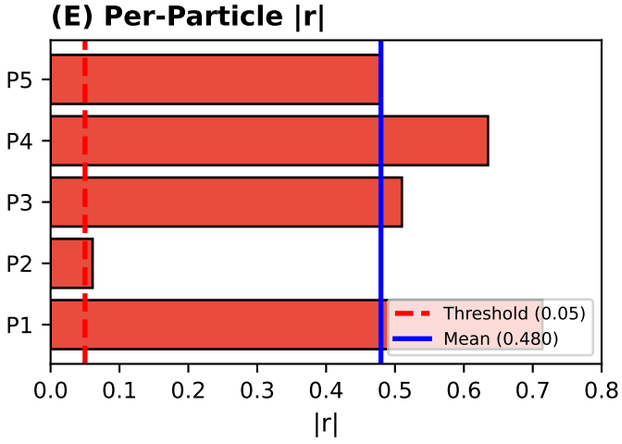
(D) Spatially Isolated Particles Identified from A1g Intensity (n=5 independent events)







(E) Per-Particle |r|



(F) Statistical Results & Validation Outcome

One-Sample t-Test (H_0: mean |r| ≤ 0.05)

n = 5 particles Mean |r| = 0.479
t = 3.80 p = 9.55 × 10^{-3}
E-value = 104.7 > 10 (α = 0.1)

VALIDATION COMPLETE
Hypothesis H5: FALSIFIED
(Strong correlations detected)