Exploring Experimental Machine Learning in Film Restoration

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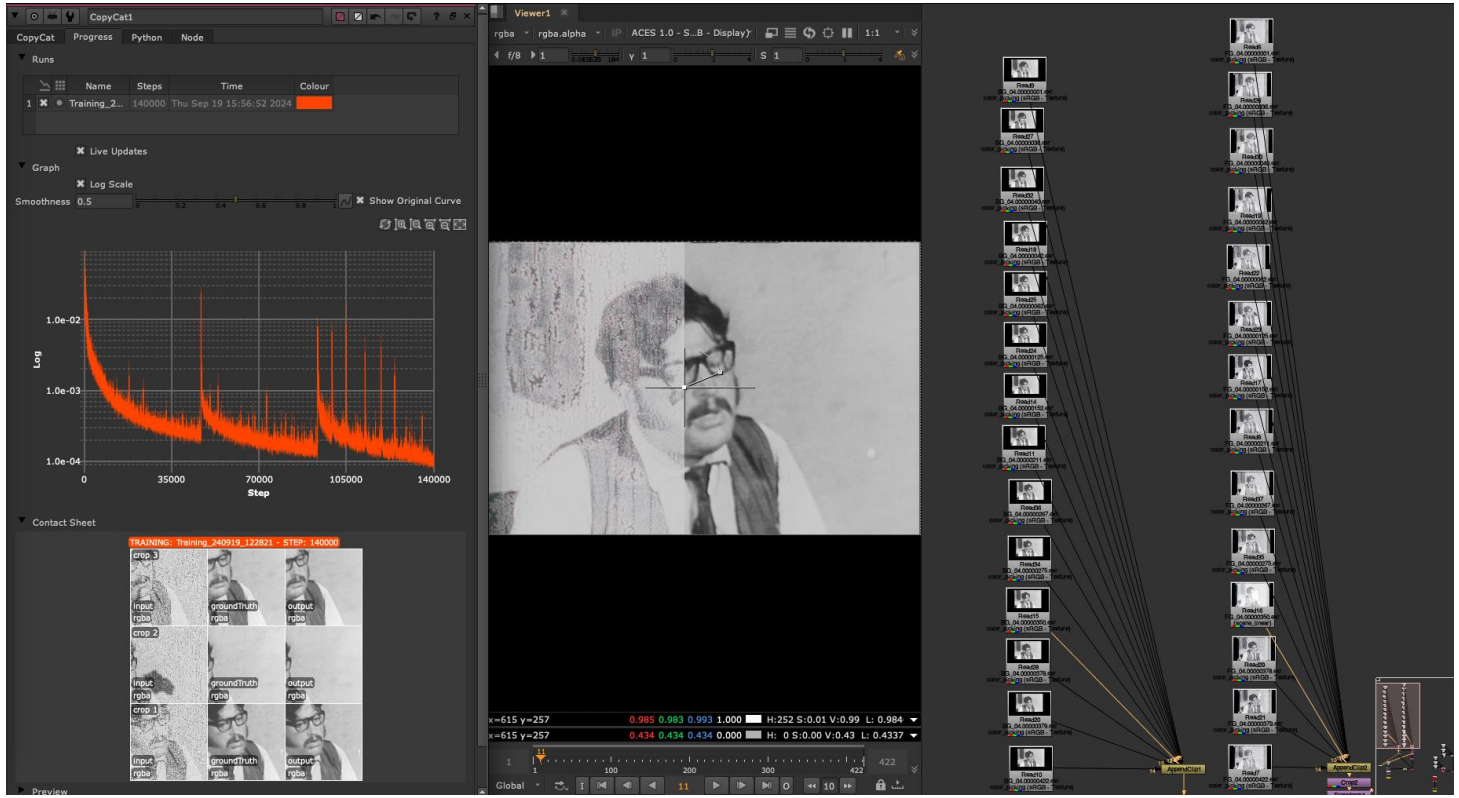
Presentation Overview

- What is machine learning and why create our own models?
- Color Recovery
- Spatial Recovery
- Gauge and Generation Matching
- Video/Analog Reference Recovery

What's Machine Learning?

- Machine Learning (ML) is a branch of Artificial Intelligence (AI) that involves the development of algorithms and models that can learn patterns from data, identify relationships, and make predictions based on that learning.



Why create our own models?

Examples: Runway, Firefly, Midjourney.

Trained on massive datasets for creating new content.

Not designed for specific film restoration challenges.

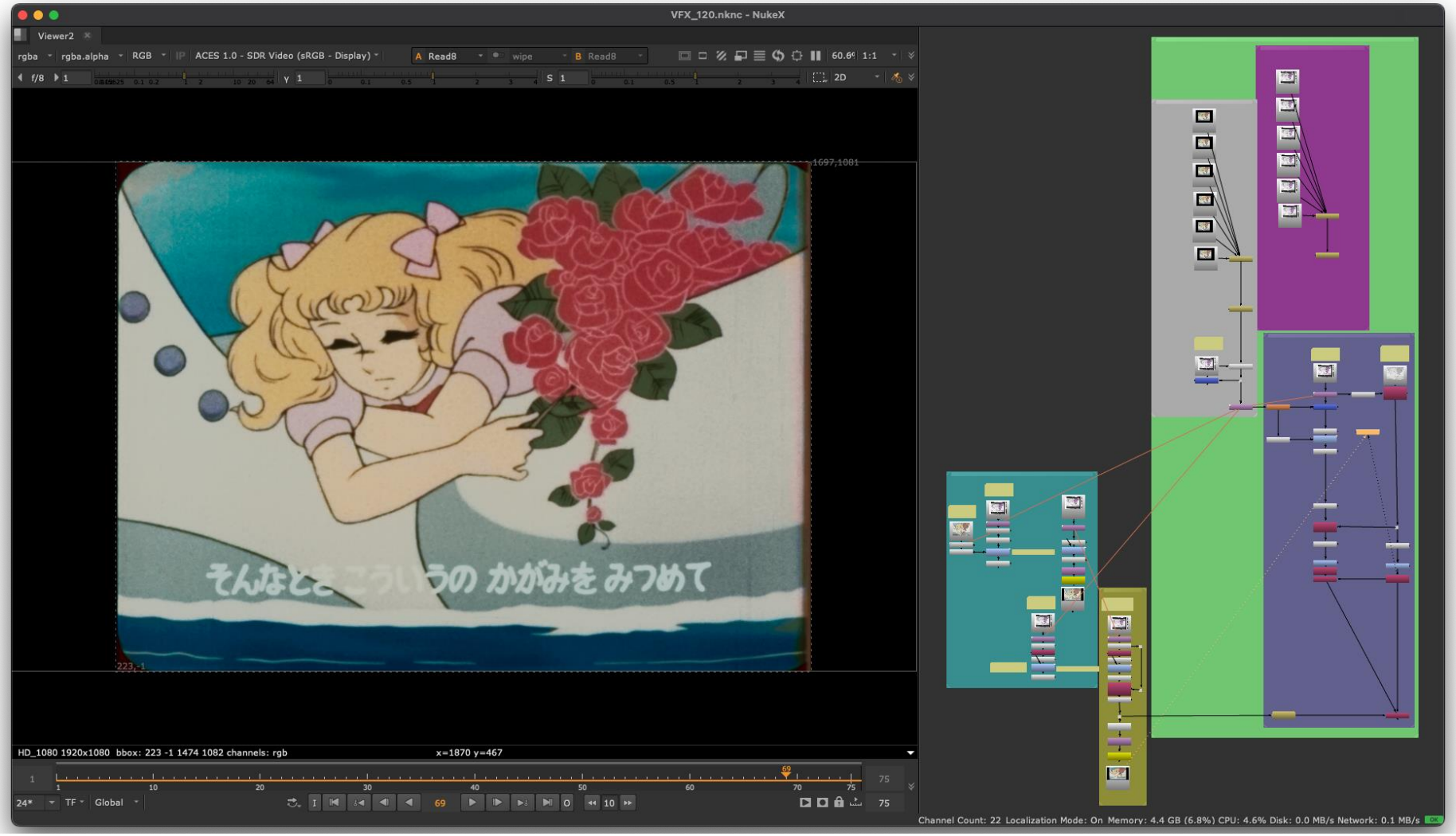
General models risk homogenizing unique film qualities.

Copyrighted training data raises legal concerns.

Advocate for smaller, focused models, running locally for specific issues.

Color Recovery with a reference

- Addresses dye fading and color degradation in chromogenic films (Eastman Color, Fuji Color, Agfa Color).
- Uses a color reference (e.g., DVD or telecine) to extract intact color info, even if resolution or compression issues exist.
- Trains a small ML model with *n* frames, adapted to footage complexity, to replicate color across shots, scenes, or reels.



Candy Candy Demo

16MM SOURCE

PAL DVD

ML RESULT

TRAINING STEPS

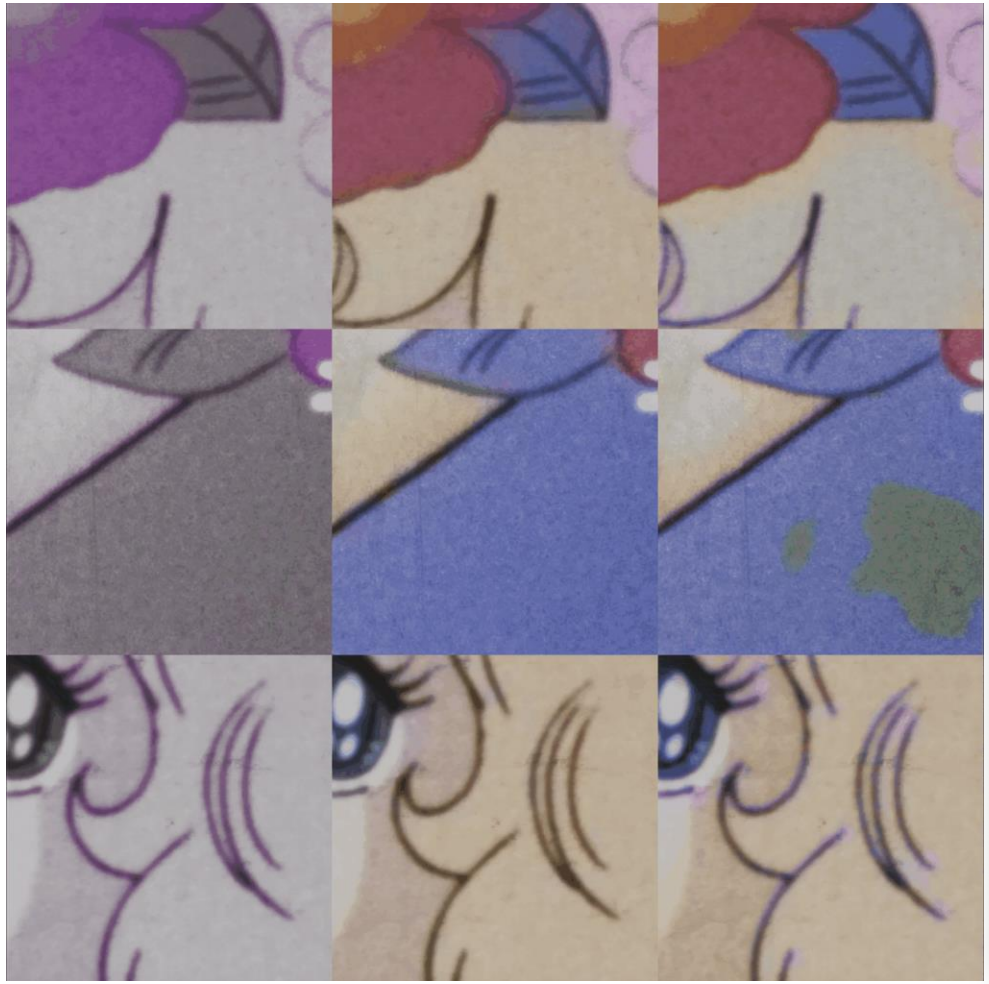
STEP 1

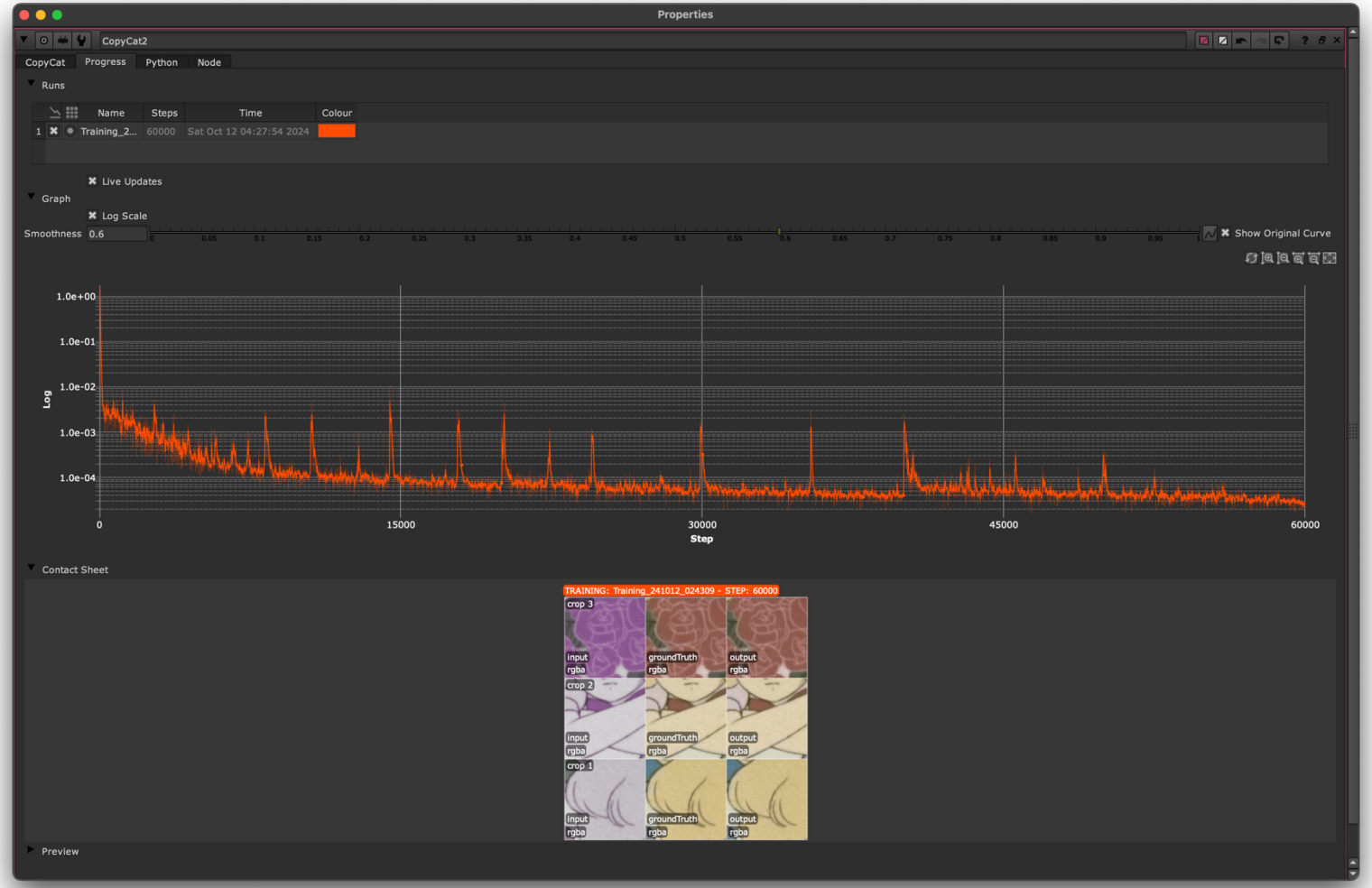
STEP 1000

STEP 30000

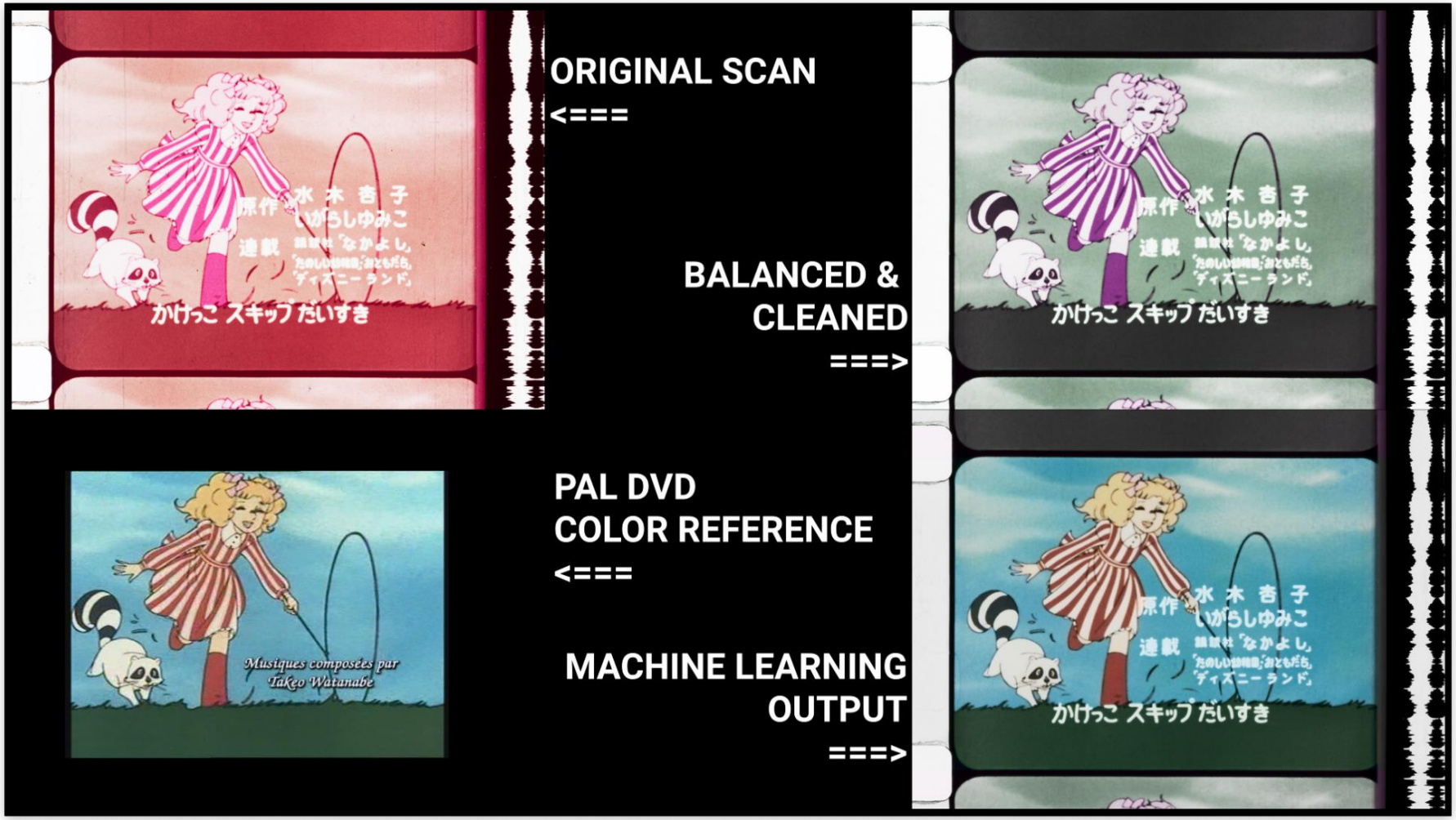
STEP 60000

Training Breakdown





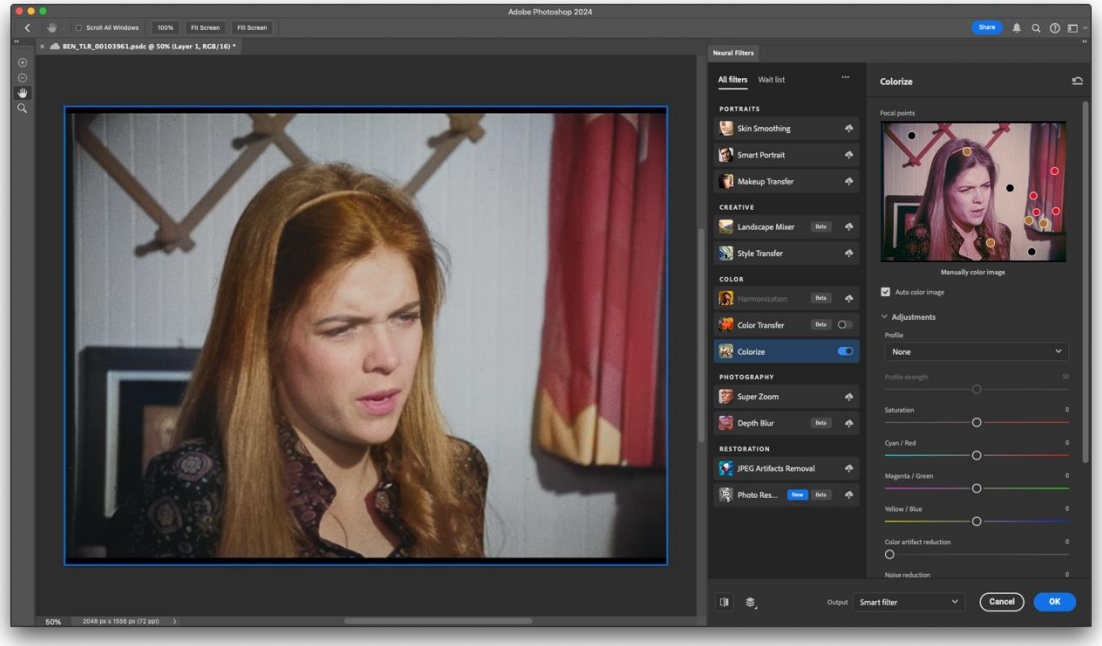
Machine Learning Steps

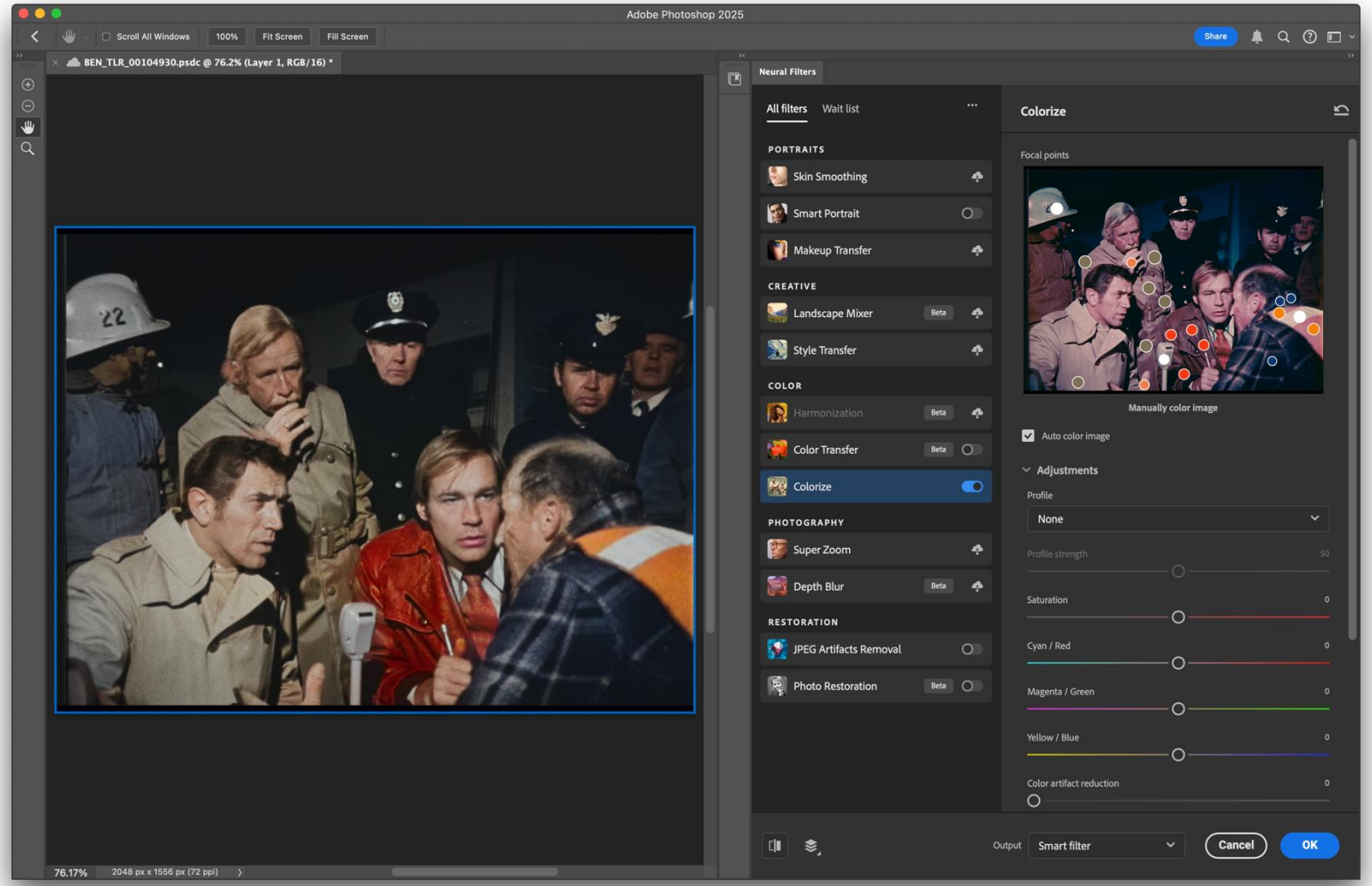


Candy Candy Comparison

Color Recovery without a reference

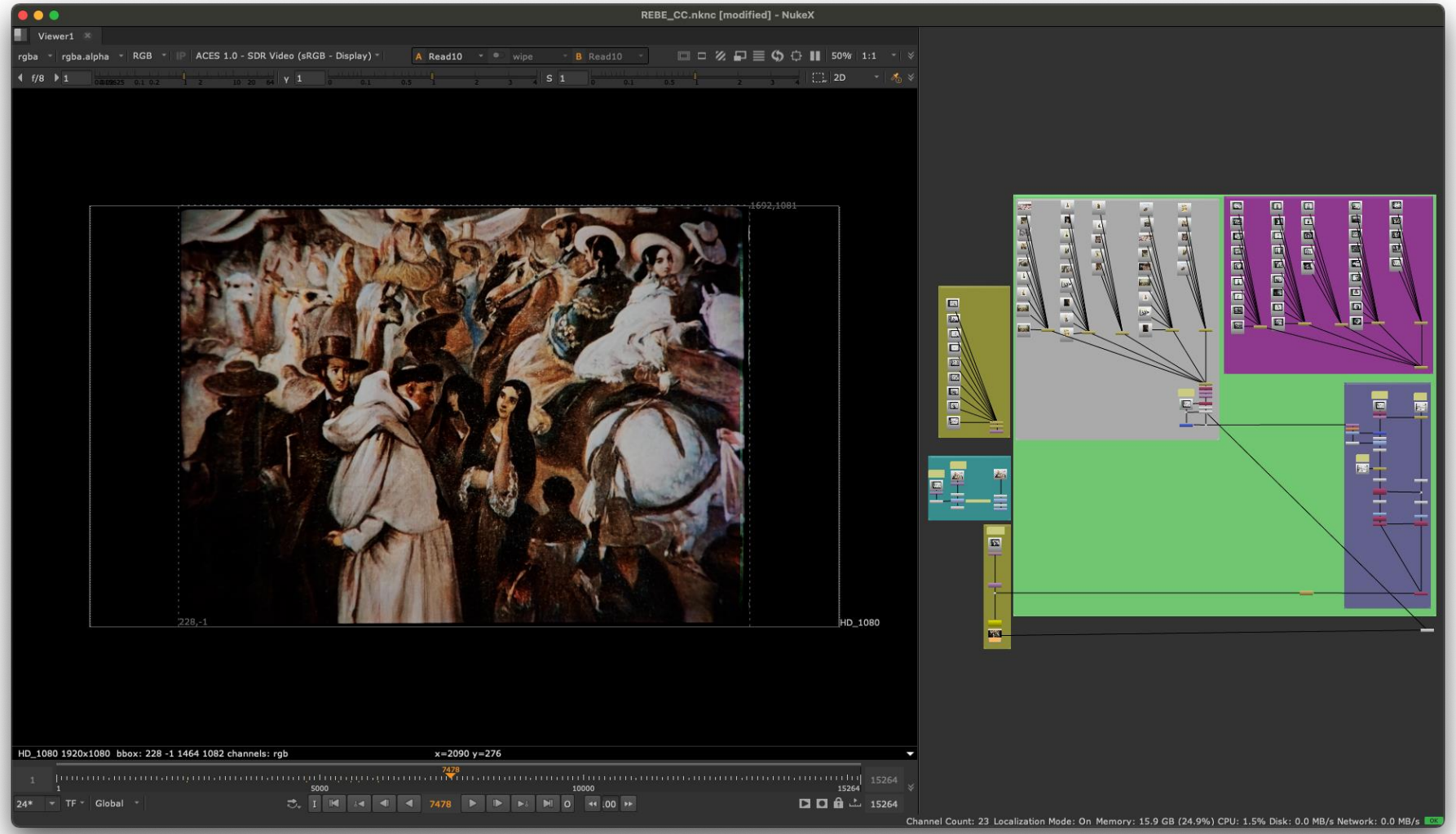
- When no reference exists (e.g., last copy of a magenta-faded film), two approaches are possible:
  - Use similar images (e.g., paintings, photos, or other parts of the same or a similar film) to colors through full-color data training.
  - Paint keyframes in Photoshop using data (photos, frames, etc.) as color references.




Adobe Photoshop 2025
Scroll All Windows
100%
Fit Screen
Fill Screen
Share
BEN_TLR_00104930.psdc @ 76.2% (Layer 1, RGB/16) *
Neural Filters
All filters
Wait list
PORTRAITS
Skin Smoothing
Smart Portrait
Makeup Transfer
CREATIVE
Landscape Mixer
Beta
Style Transfer
COLOR
Harmonization
Beta
Color Transfer
Beta
Colorize
PHOTOGRAPHY
Super Zoom
Depth Blur
Beta
RESTORATION
JPEG Artifacts Removal
Photo Restoration
Beta
Colorize
Focal points
Manually color image
Auto color image
Adjustments
Profile
None
Profile strength
50
Saturation
0
Cyan / Red
0
Magenta / Green
0
Yellow / Blue
0
Color artifact reduction
0
Output
Smart filter
Cancel
OK
76.17%
2048 px x 1556 px (72 ppi)

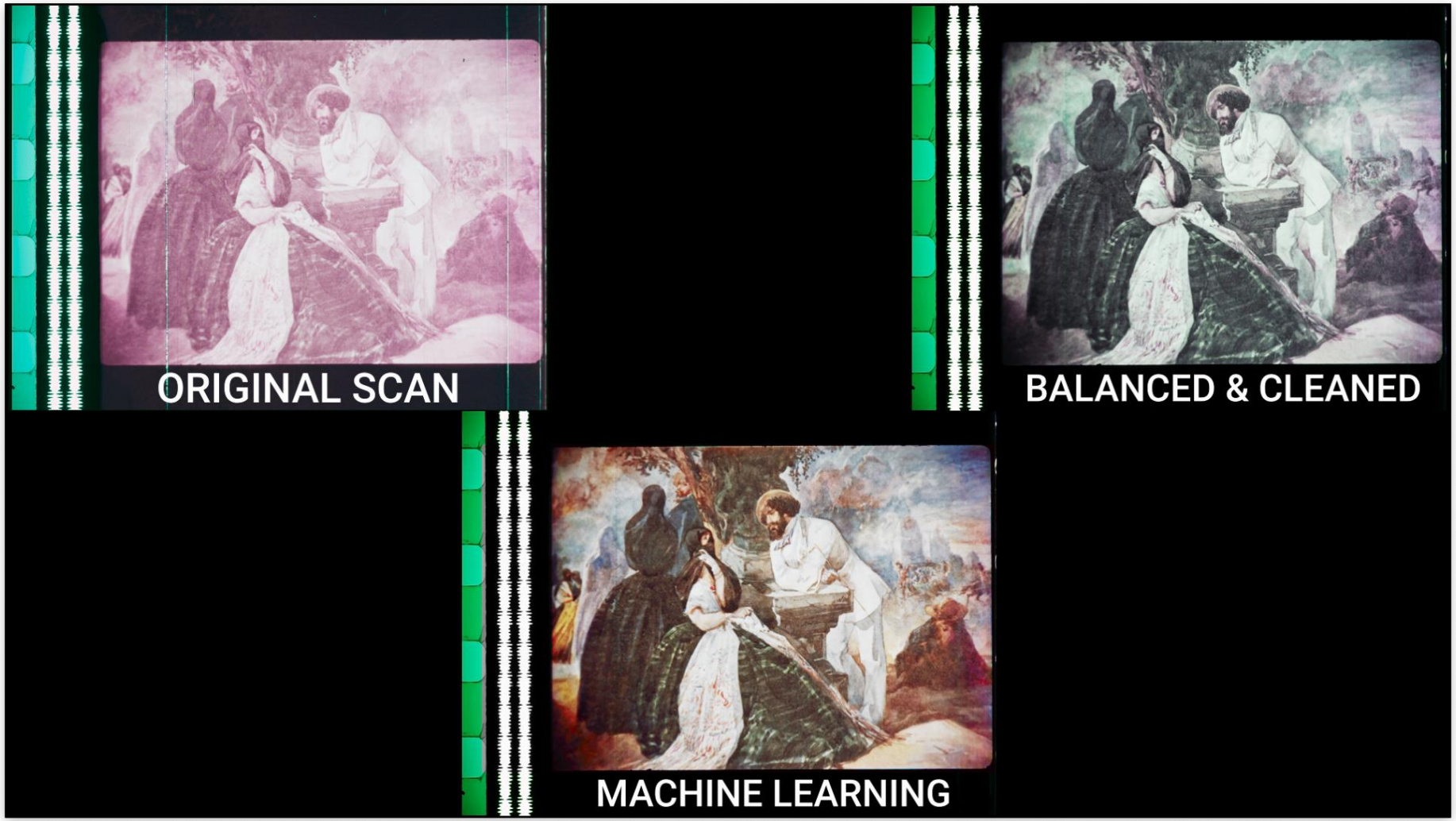
Ben Demo

Ben Comparison



Rebelion de Tapadas Demo

Artworks Demo



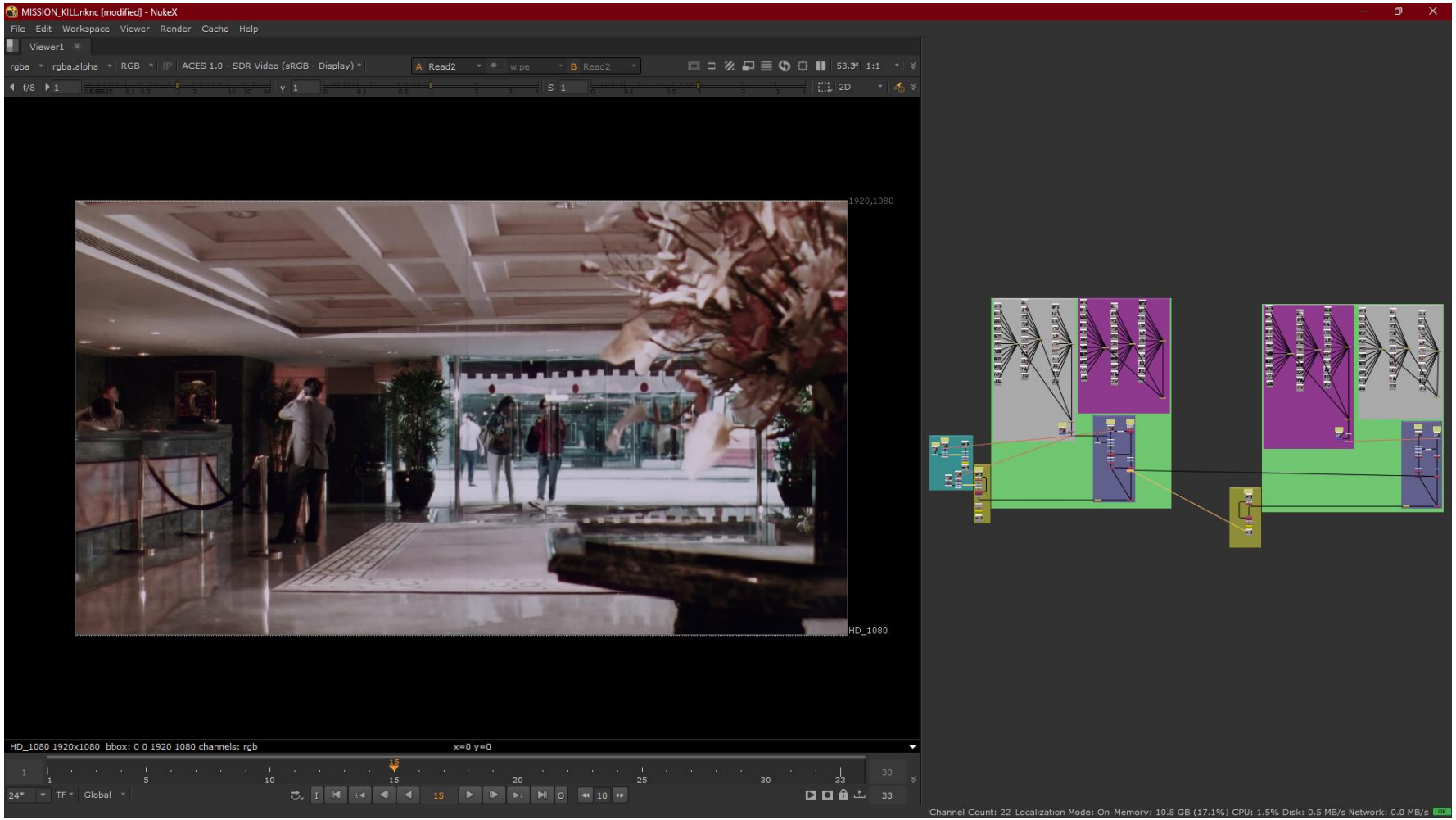
Rebelion de Tapadas Comparison

Spatial Recovery with a reference

- Aims to restore the film's lost spatial details caused by damage or generation loss
- Utilizes a secondary reference (telecine, different print, or alternate copy) to build a machine learning model that recovers the film's original spatial features
- **Key Techniques**:
  - Gauge Matching
  - Generation Matching
  - Video/Analog Reference Recovery

Gauge and Generation Matching

- Training a model with overlapping data from different gauges or generations helps the model learn and adapt to variations
- Aligning film quality to the best available source enhances visual consistency
- Improved matching of visual characteristics ensures a cohesive appearance across different source materials



Mission Kill Demo

16MM POSITIVE

35MM INTERNEGATIVE

ML RESULT

TRAINING STEPS

STEP 1

STEP 10000

STEP 150000

STEP 300000

Training Breakdown

A
!!
16MM POSITIVE PRINT

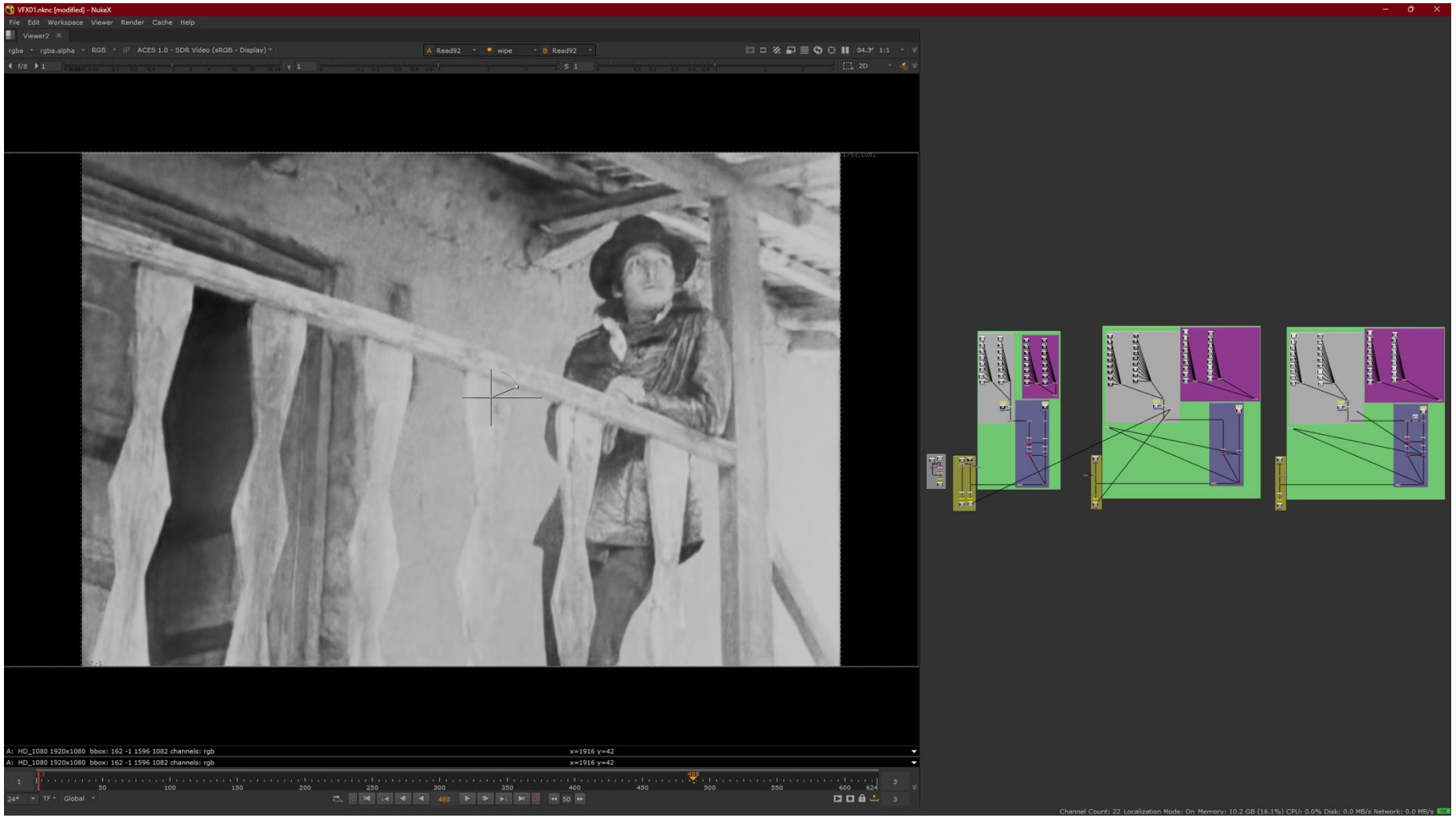
A
!!
35MM INTERNEGATIVE

<--
MACHINE LEARNING
RESULT

Mission Kill Comparison

Video/Analog Reference Recovery

- Recovery is possible using a digital or analog video source, such as a telecine.
- The process requires multiple steps to restore the full frame of the film.
- The first model trains on the least damaged parts of the film to capture uncontaminated spatial features.
- Results from this model inform a second model for full frame recovery.
- Direct recovery from the telecine is not feasible due to cropping and limited spatial information.



Tinterillo Demo

16MM SOURCE

+

TELECINE

=

ML RESULT

TELECINE SOURCE

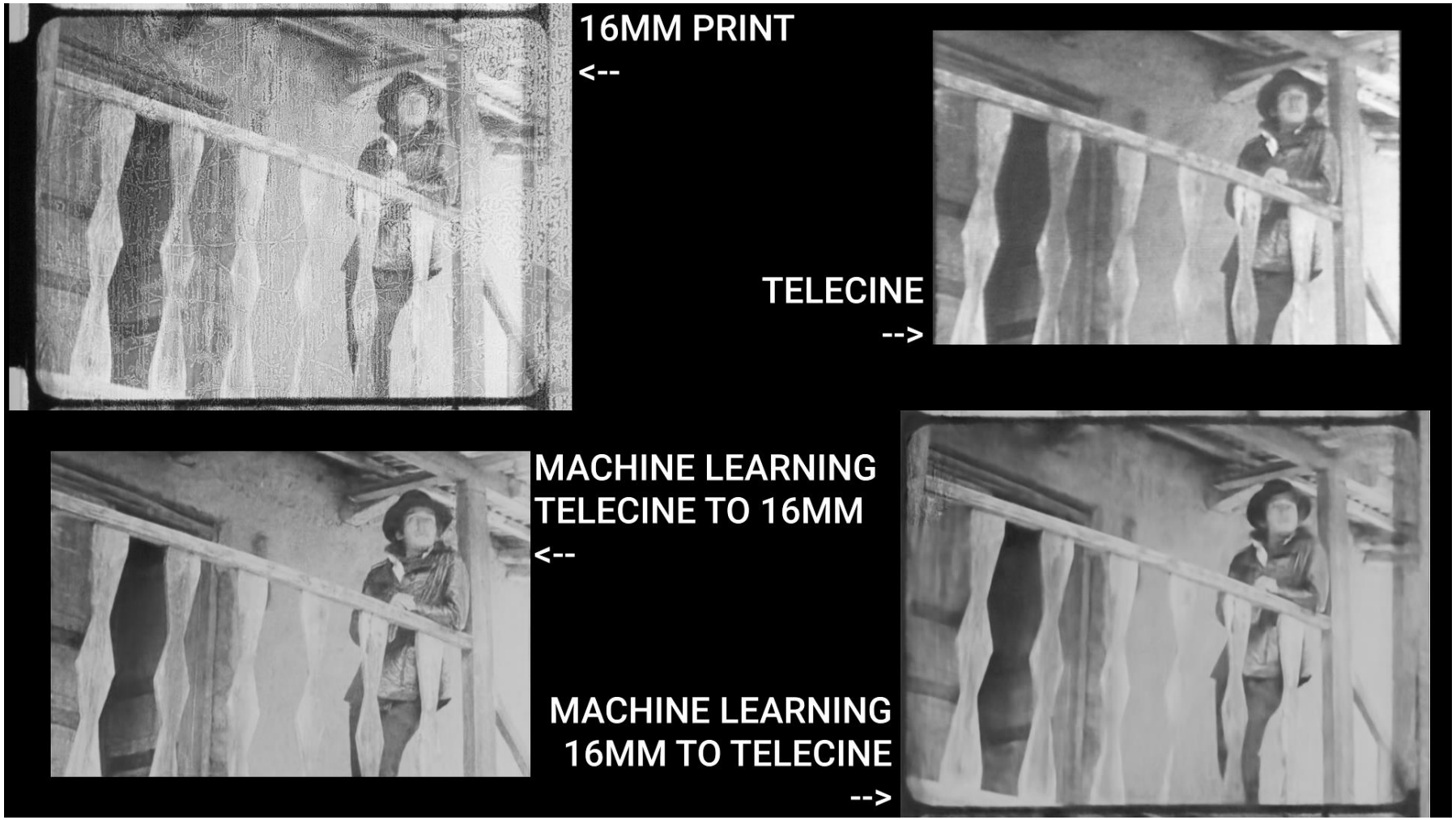
+

16MM

=

ML RESULT

Training Breakdown



Tinterillo Comparison

Thank you!

- **And you can do many more things:**
  - Print alignment recovery
  - Grain reconstruction
  - Damage detection
  - Dynamic Range Recovery
- **Support specific models running locally, trained with ethically sourced datasets.**