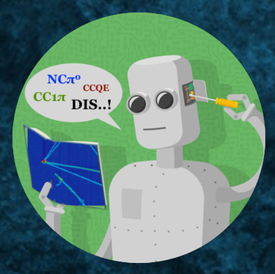
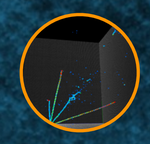
Collaborative Development of Deep Neural Networks for Particle Imaging Detectors



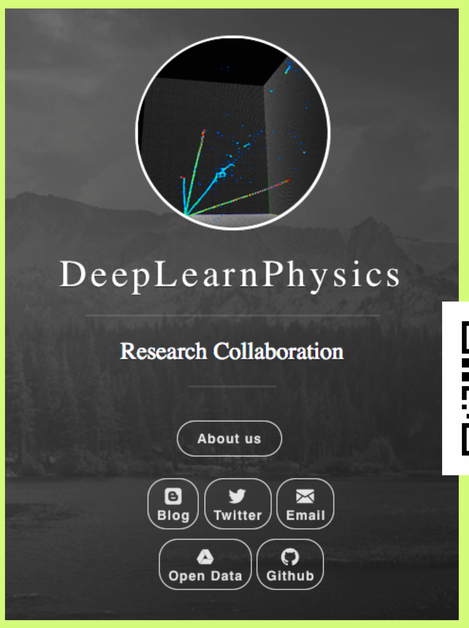


DeepLearnPhysics Collaboration

SLAC NATIONAL ACCELERATOR LABORATORY

DeepLearnPhysics

Collaboration: **Physicists from different groups** (theoretical/experimental) working together to develop **machine learning (ML)** applications and software tools. In particular computer-vision techniques for imaging detectors (time projection chambers, CCD, etc.)

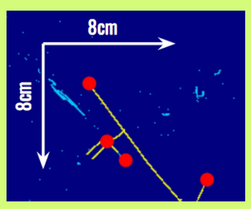


Collaborate beyond physics
Software Tools
Public data sharing
ML Algorithm R&D
Conference Workshop
Bi-weekly meetings

Poster# 288 @ wall 120

Applying Deep Neural Network Techniques for LArTPC Data Reconstruction

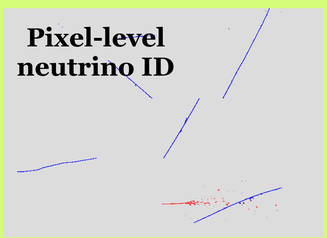
Using deep neural networks to identify particle types and neutrino interaction topology analysis.



Poster# 190 @ wall 93

Deep Learning in SBND

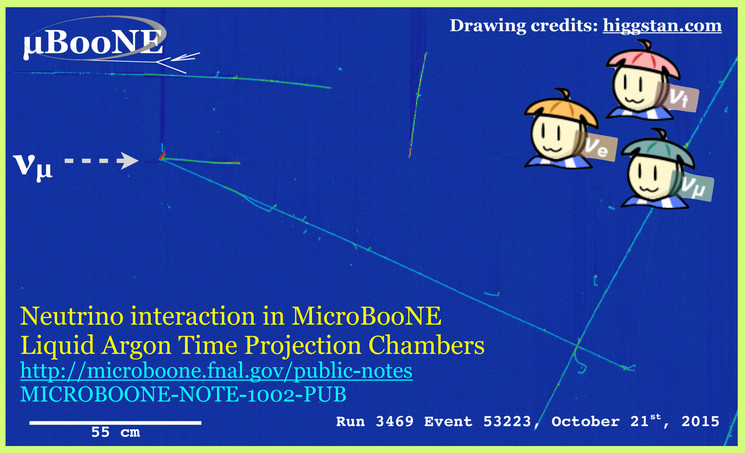
Using a deep neural network to tag background cosmogenic particles at the pixel level, the biggest background to analyses.

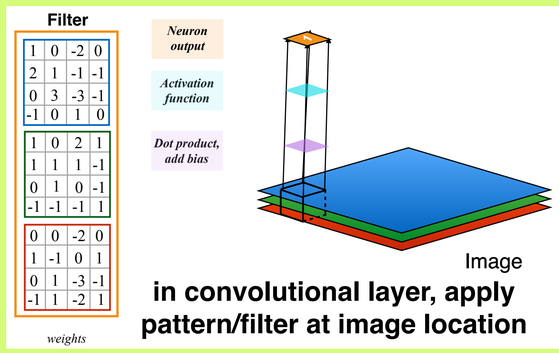


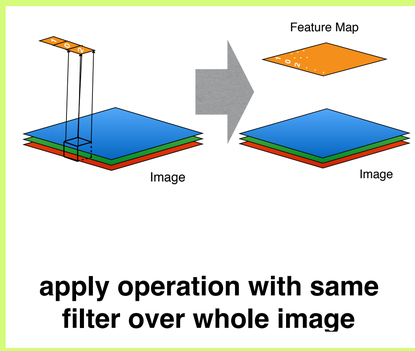
Convolutional Neural Networks (CNNs)

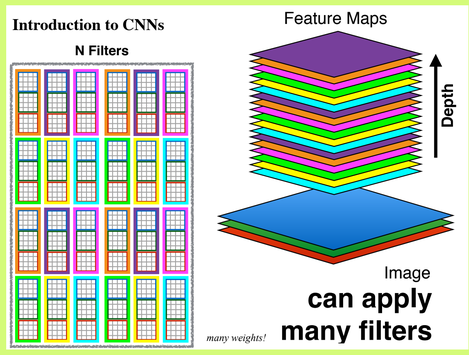
In traditional image analysis with neural networks, first find features (x) and then train to associate them with some output (y). Features examples: vertices, tracks,

CNNs made of successive ***convolutional layers*** that identify location of specific pattern. Network trained to output vector for certain image types by learning the convolutional layer patterns on its own

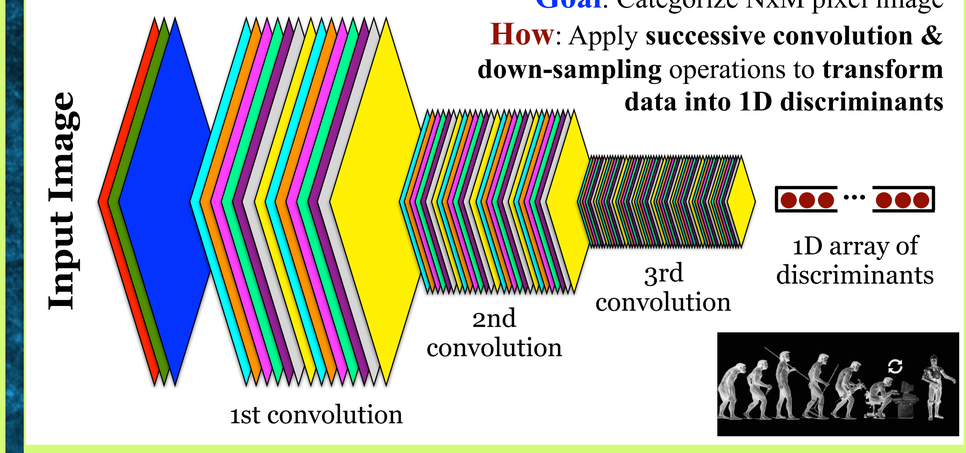




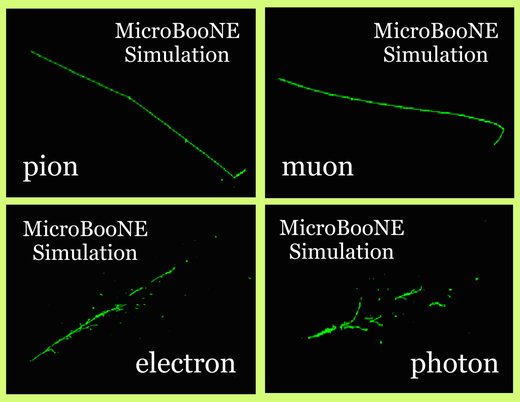




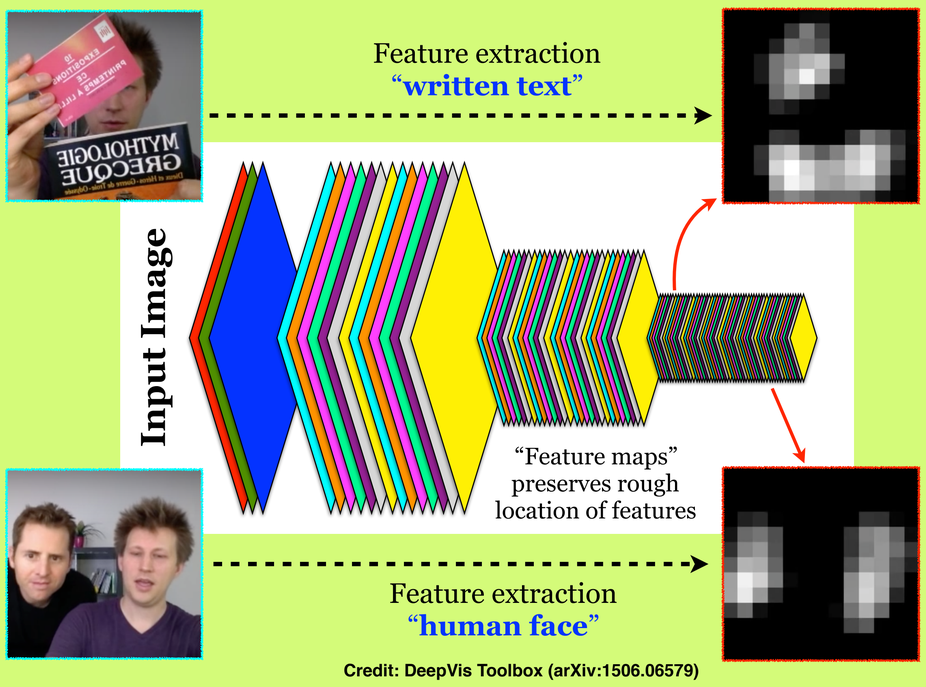
CNN for Image Classification



Example: Particle type identification in MicroBooNE LArTPC **(JINST P03011.12, 2017)**



Region-CNN (R-CNN) for Object/Feature Detection

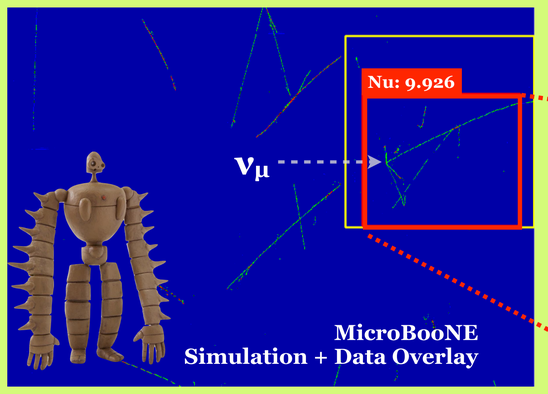


Use the output of deep layer to estimate the object location in the original image resolution.

Assumption: feature maps encode information to deduce higher precision.

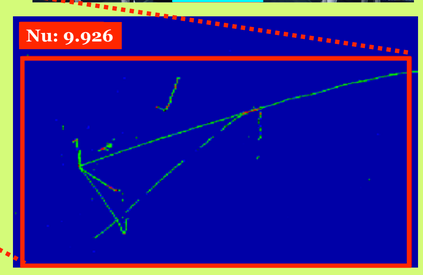
Runs faster than a traditional object detection algorithm by making a prediction from the reduced image resolution.

Multi-task Network: the whole image classification + local feature detection.



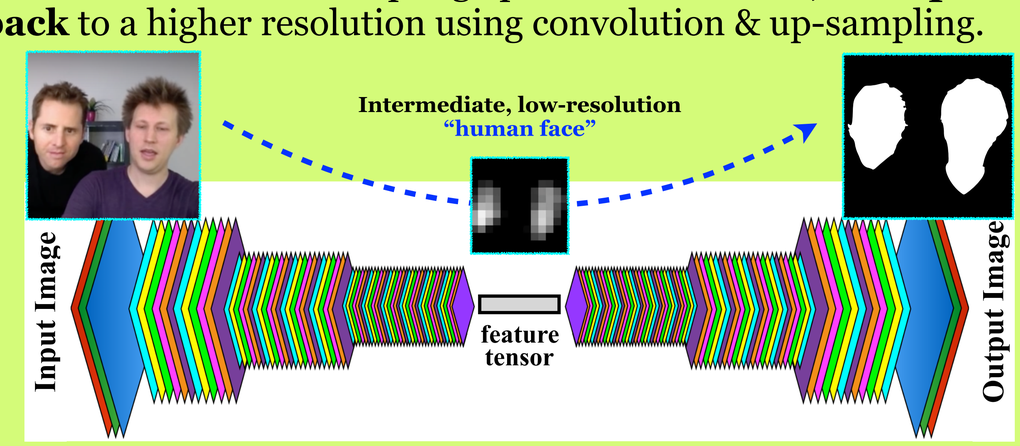
Faster R-CNN

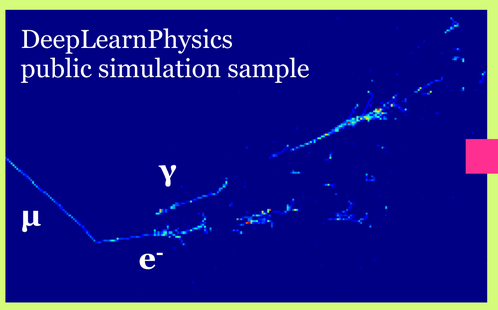
Trained to detect 23 objects in photographs **(arXiv:1506.01497)**, re-trained to detect neutrino interaction in MicroBooNE LArTPC **(JINST P03011.12, 2017)**.

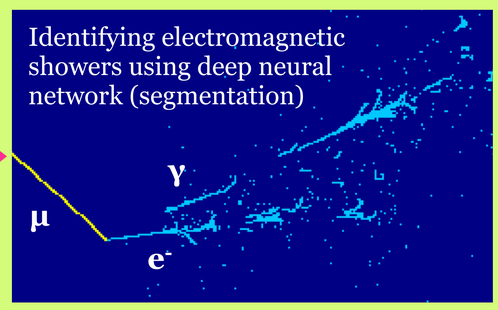


CNN for Pixel-Level Analysis (Segmentation)

Pixel Segmentation: Analyze features at the pixel-level.
How: **First, extract high-level features** by successive convolution & down-sampling operations. **Second, extrapolate back** to a higher resolution using convolution & up-sampling.





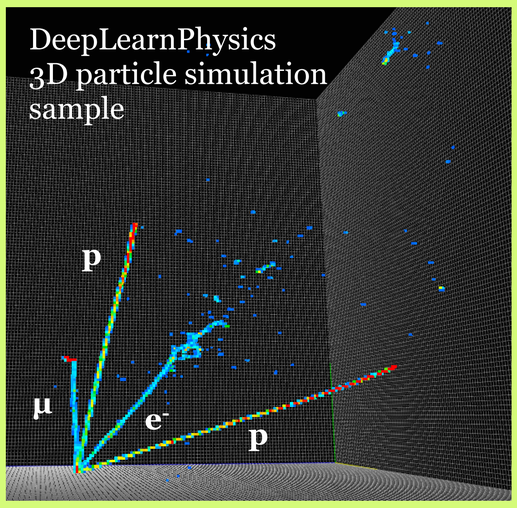


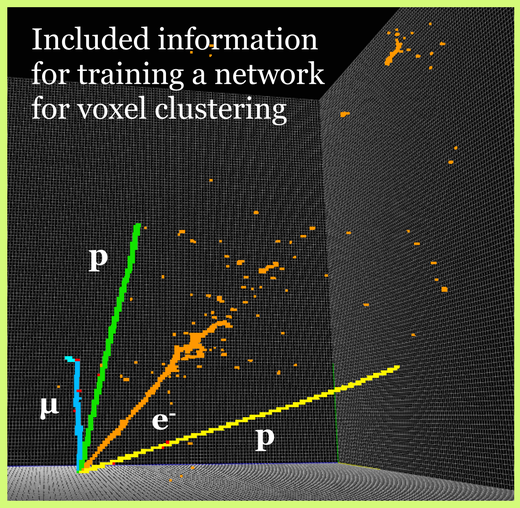
Getting Started: Software & Samples

Software: Many good open-source deep learning (DL) softwares developed in tech. industries. LArCV is a bridge between your experiment & those softwares.

LArCV: Our software provides event processing framework with file format & I/O, data structure designed for 2D/3D information, multi-threaded fast data-read for network training, and extensive Python APIs to interface DL softwares.

Open Data Sample: Data is the heart of modern machine learning. We provide open physics simulation samples for collaborative development work.





GitHub

Open Data