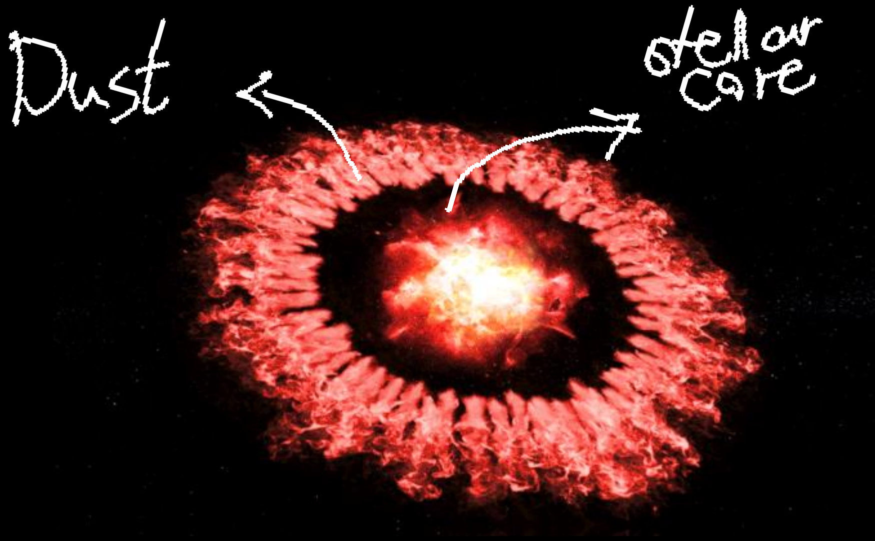
Supernova dust detection with neural networks

Zoe Ansari

Applied Machine Learning Course - NBI

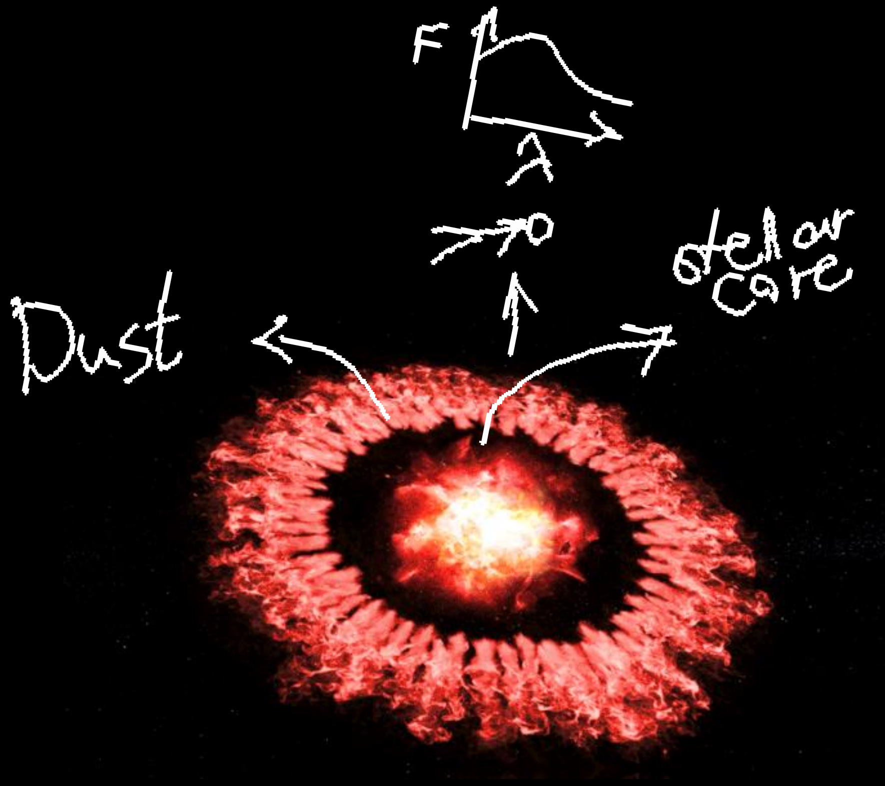
- Brief introduction on astrophysical aspects of the project
- Why dust?
- Data simulation
- Extracting desired features
- Try and tests on NN Model

Supernova

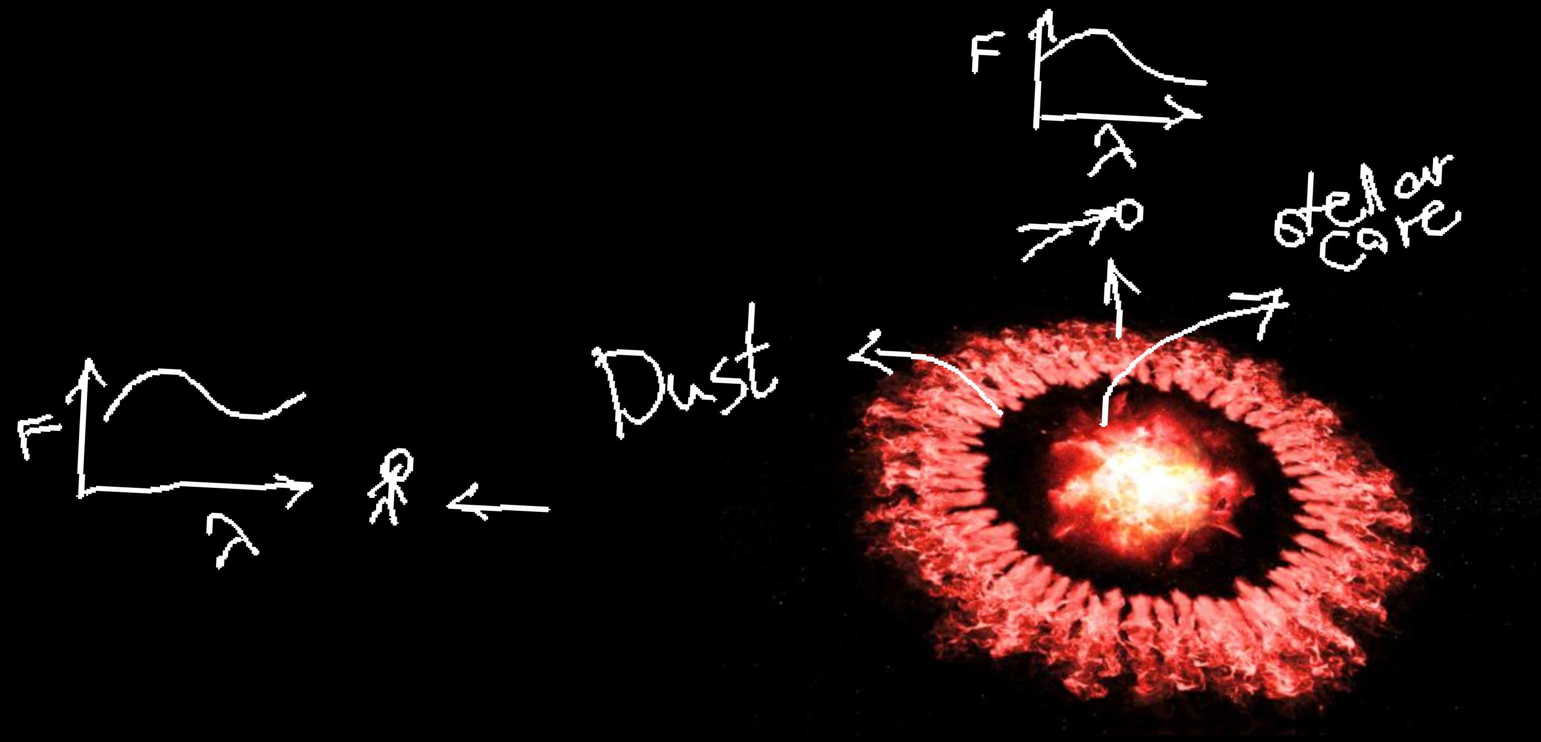


https://www.space.com/supernova-1987a-cosmic-dust-wake.html

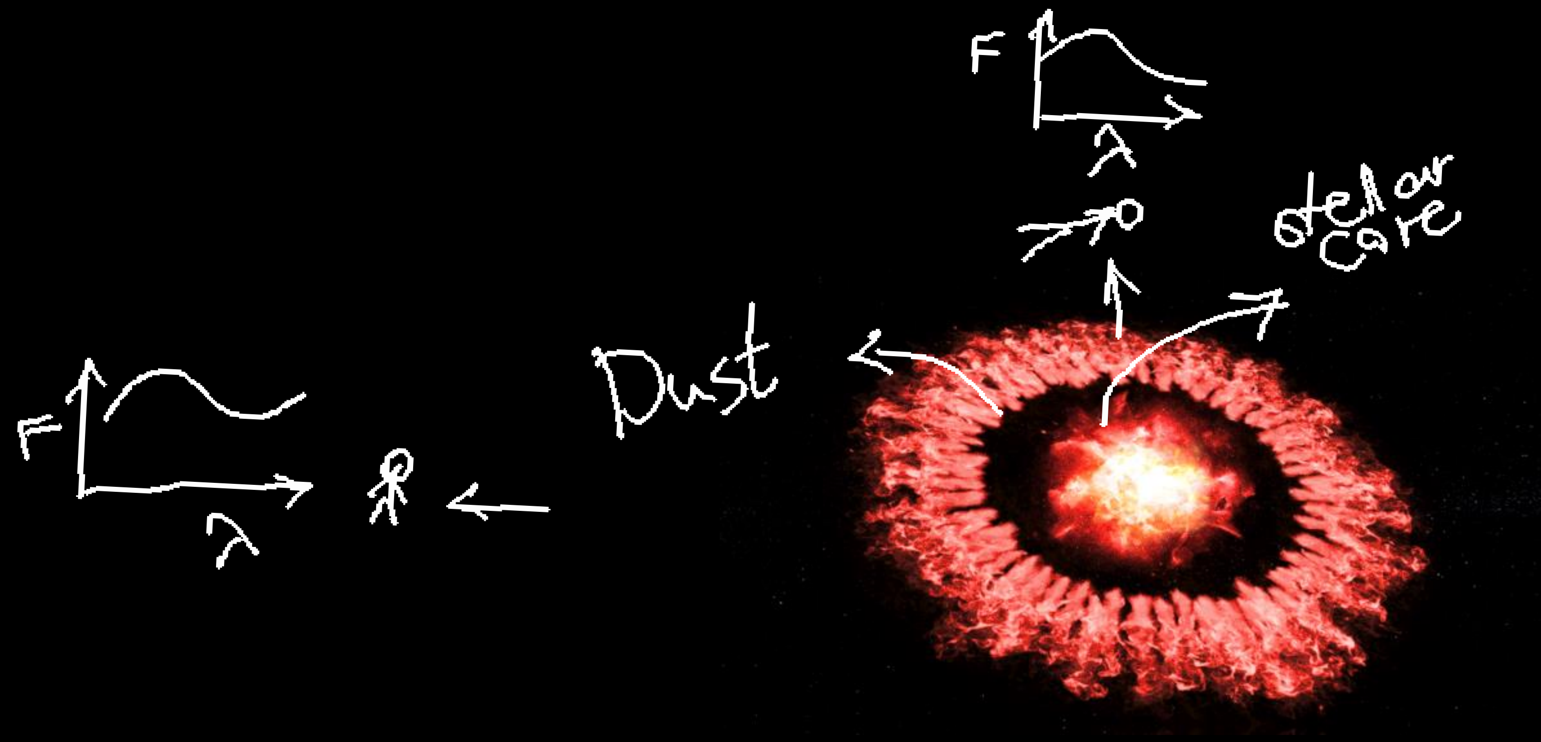
Supernova



Why Dust?



So long, and thanks for all the black bodies Planck



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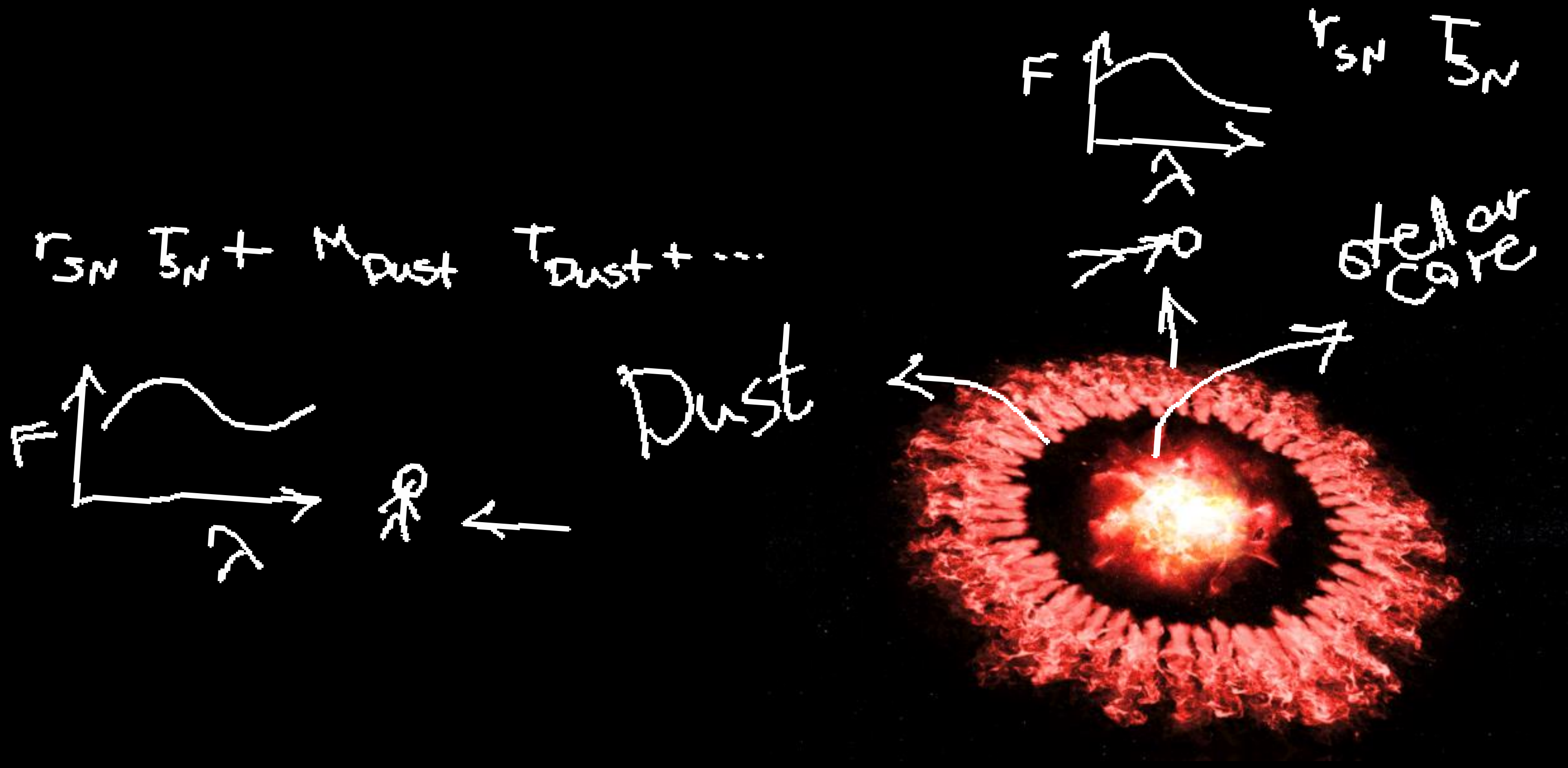

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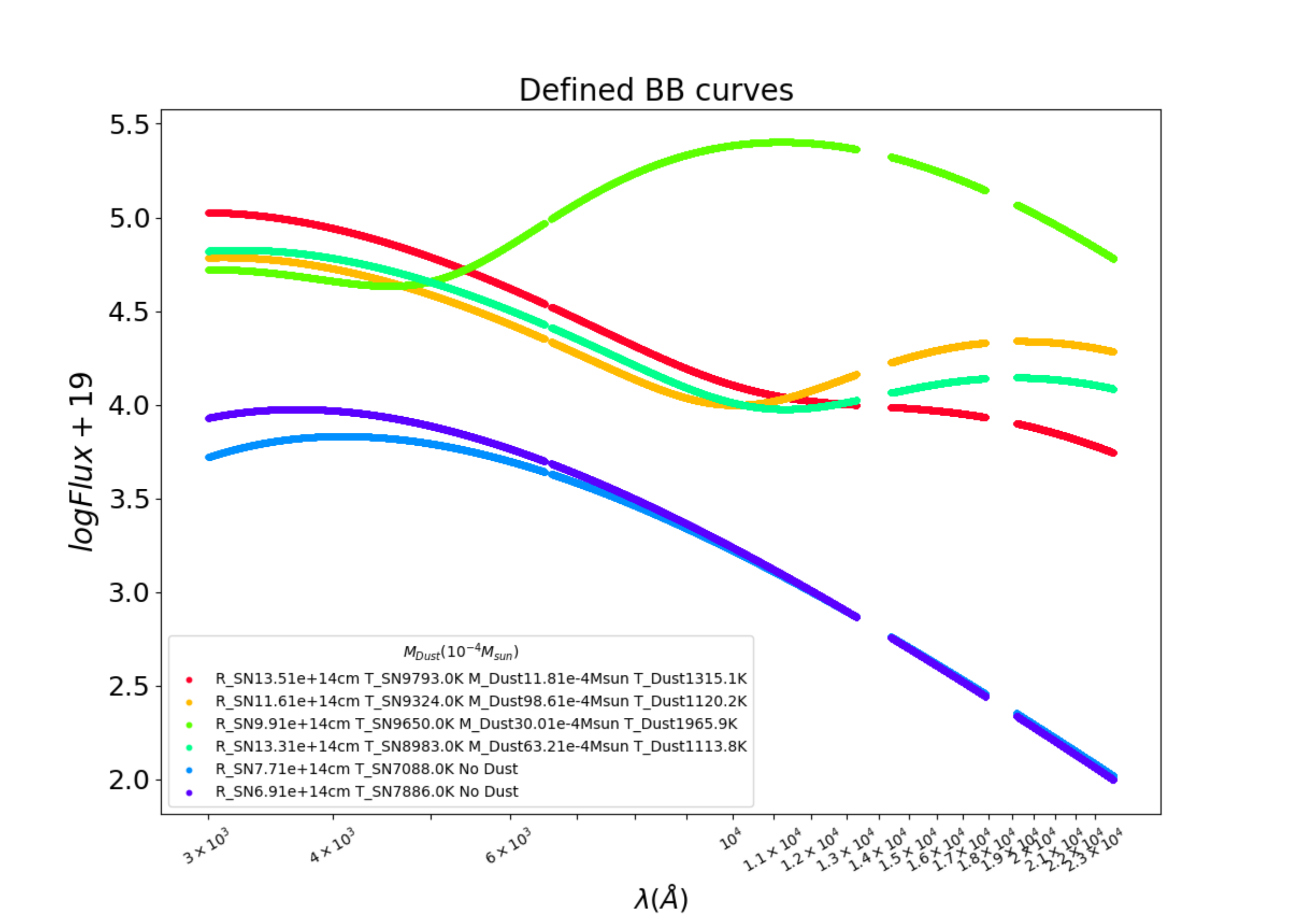
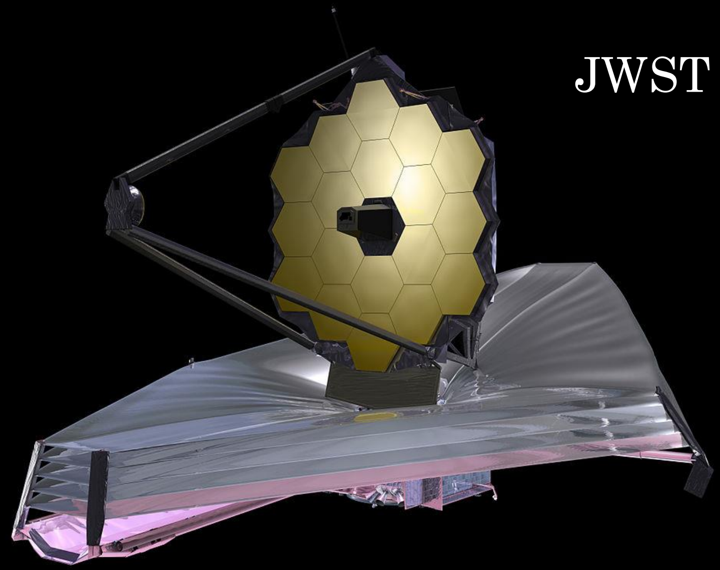
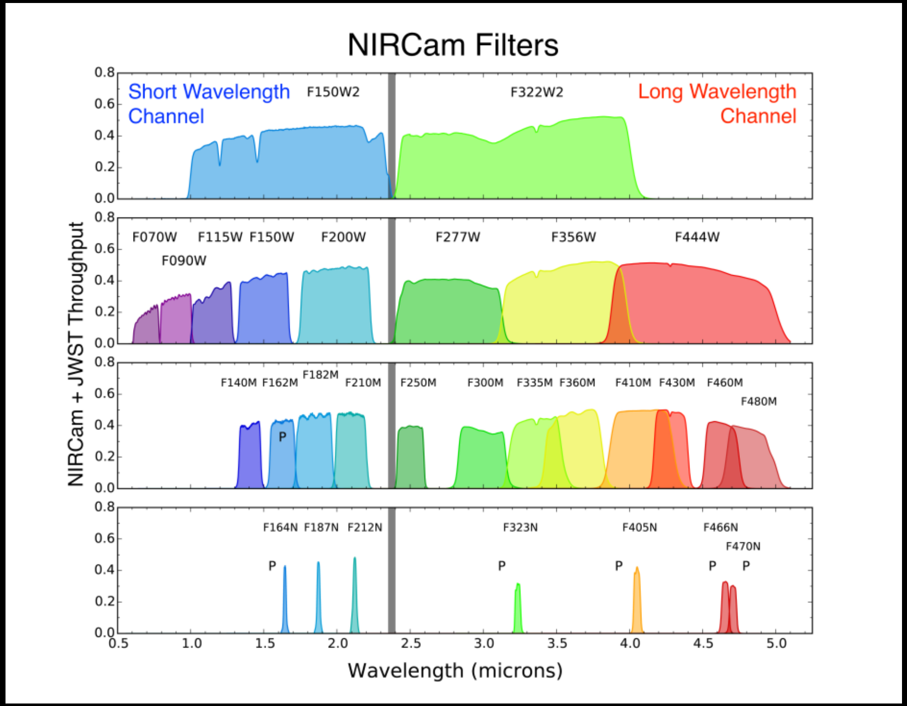


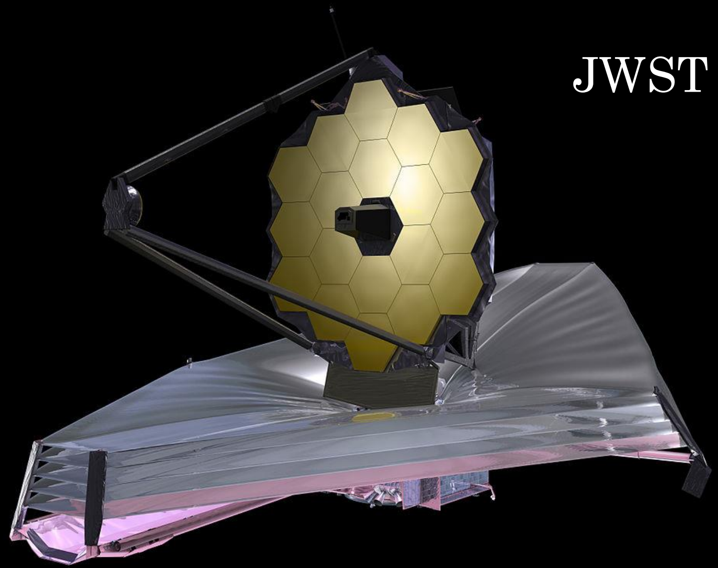
Photometric bands & the order of flux



JWST

Photometric bands & the order of flux

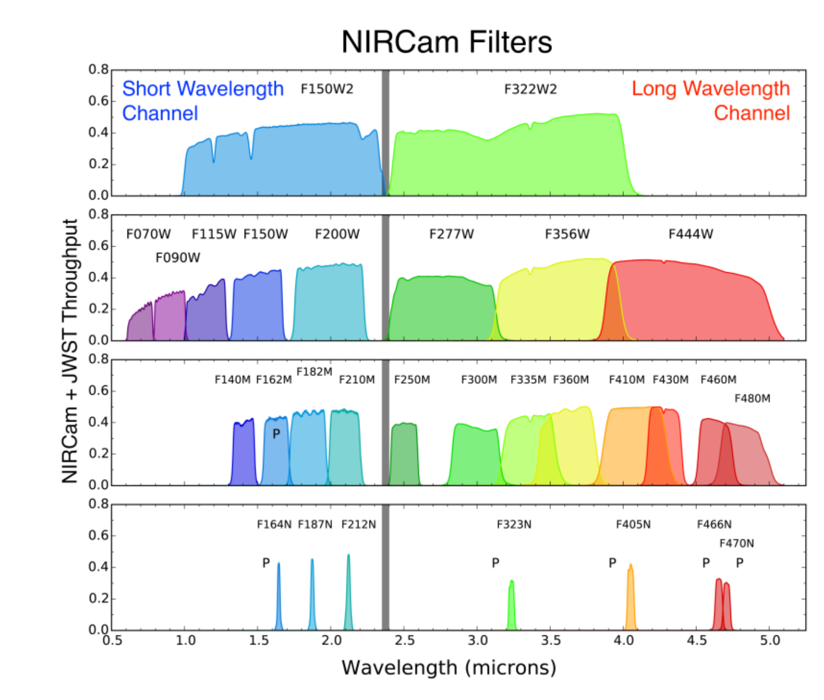


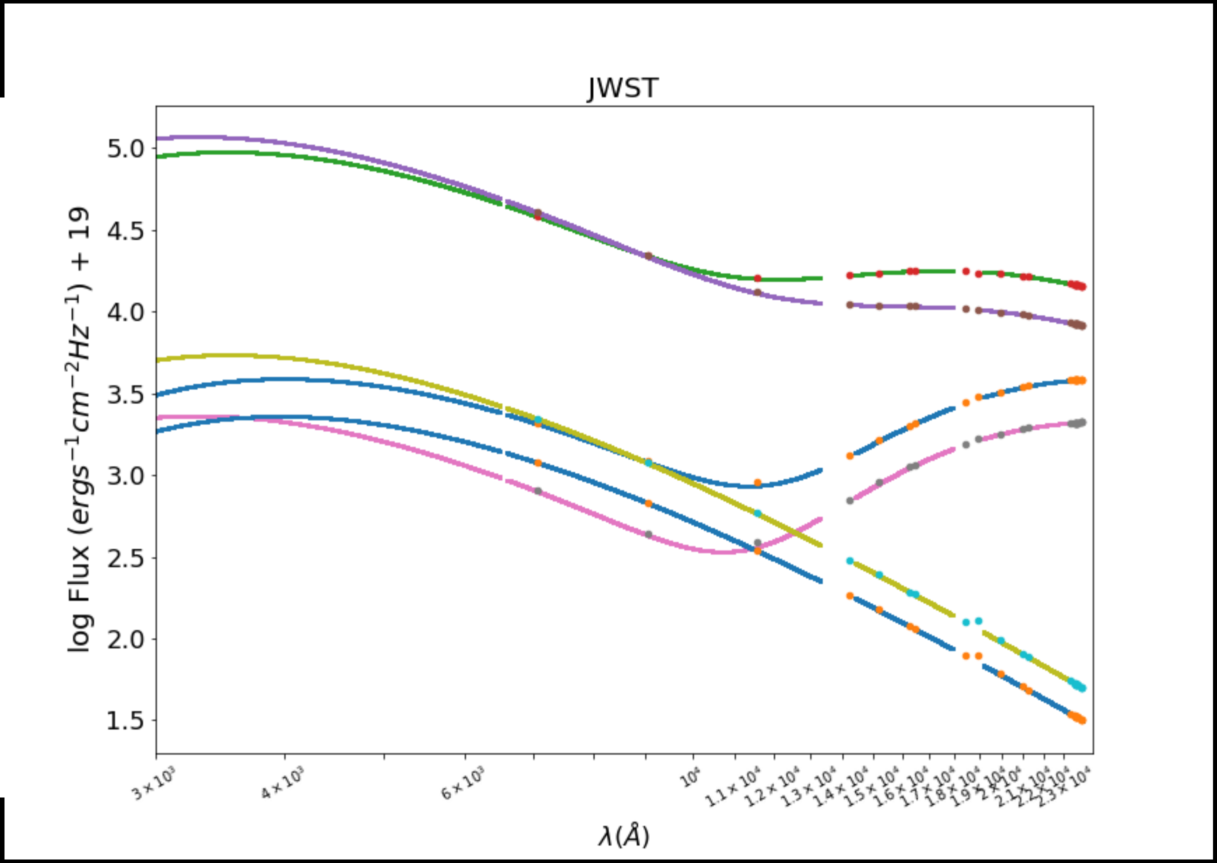


JWST

https://jwst-docs.stsci.edu/near-infrared-camera/nircam-instrumentation/nircam-filters

Photometric bands & the order of flux





https://jwst-docs.stsci.edu/near-infrared-camera/nircam-instrumentation/nircam-filters

Neural network begins

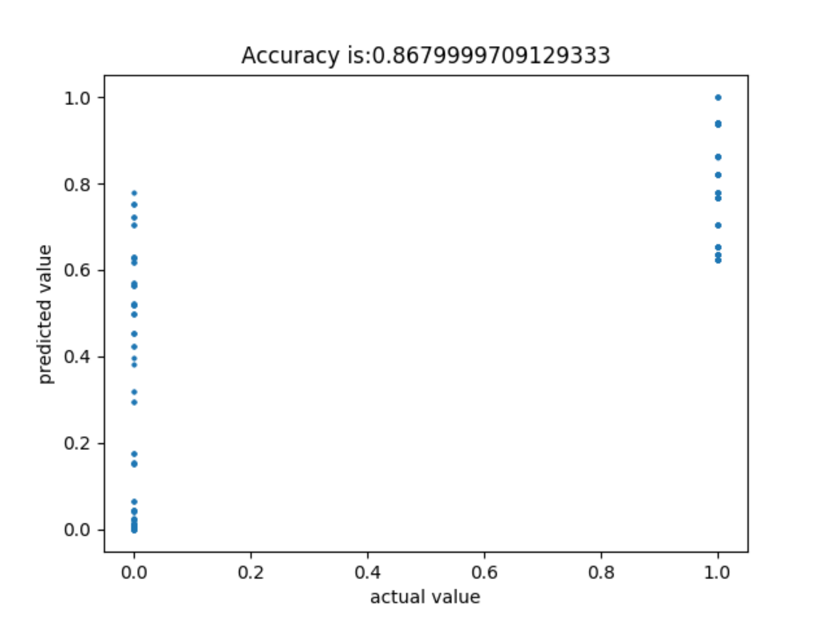
- Classification: identifying the existence of dust

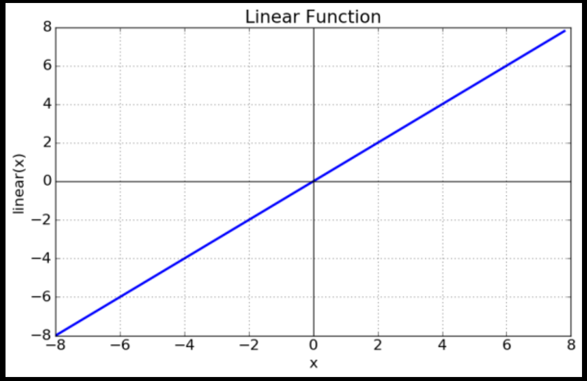
- Regression: estimating the amount of dust

- Classification: identifying the existence of dust

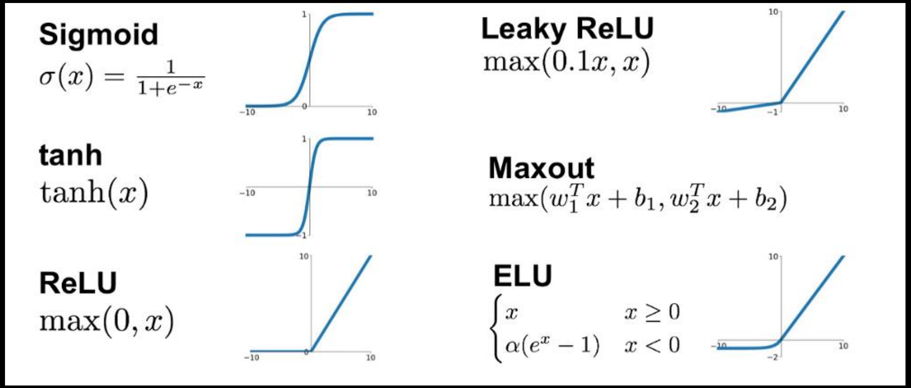
```
model.add(Conv1D(64, 1,input_shape=X_train.shape[1:]))
model.add(keras.layers.LeakyReLU(alpha=0.05))
model.add(Conv1D(filters=16, kernel_size=4))
model.add(keras.layers.LeakyReLU(alpha=0.05))
model.add(Conv1D(filters=32, kernel_size=1))#, activation='relu'))
model.add(keras.layers.LeakyReLU(alpha=0.05))
model.add(Dropout(rate=0.25))
model.add(Conv1D(filters=64, kernel_size=1))#, activation='relu'))
model.add(keras.layers.LeakyReLU(alpha=0.05))
model.add(Conv1D(filters=64, kernel_size=1))
model.add(keras.layers.LeakyReLU(alpha=0.05))
model.add(Dropout(rate=0.25))
model.add(Flatten())

model.add(Dense(1, activation='sigmoid'))
```



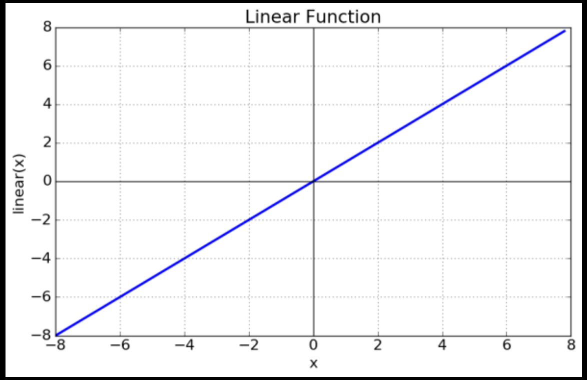


With the ame arch + last layer "linear"

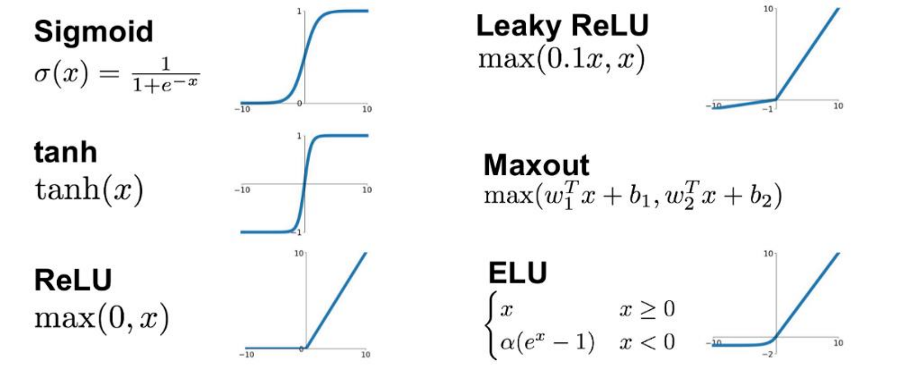

Sigmoid
$\sigma(x) = \frac{1}{1+e^{-x}}$
tanh
$\tanh(x)$
ReLU
$\max(0, x)$
Leaky ReLU
$\max(0.1x, x)$
Maxout
$\max(w_1^T x + b_1, w_2^T x + b_2)$
ELU
$\begin{cases} x & x \geq 0 \\ \alpha(e^x - 1) & x < 0 \end{cases}$

- Regression: estimating the amount of dust

https://mc.ai/complete-guide-of-activation-functions/



With the ame arch + last layer "linear"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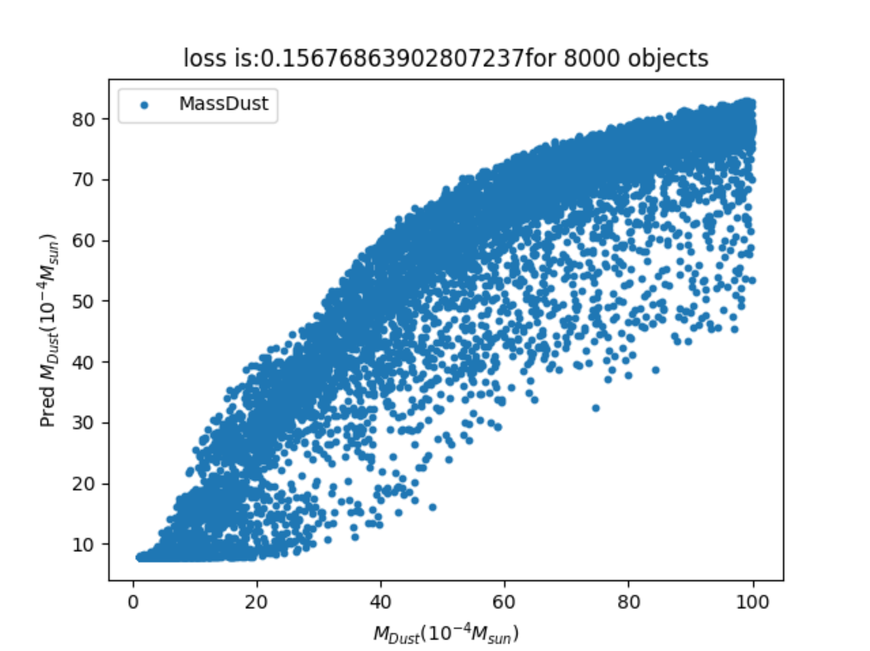
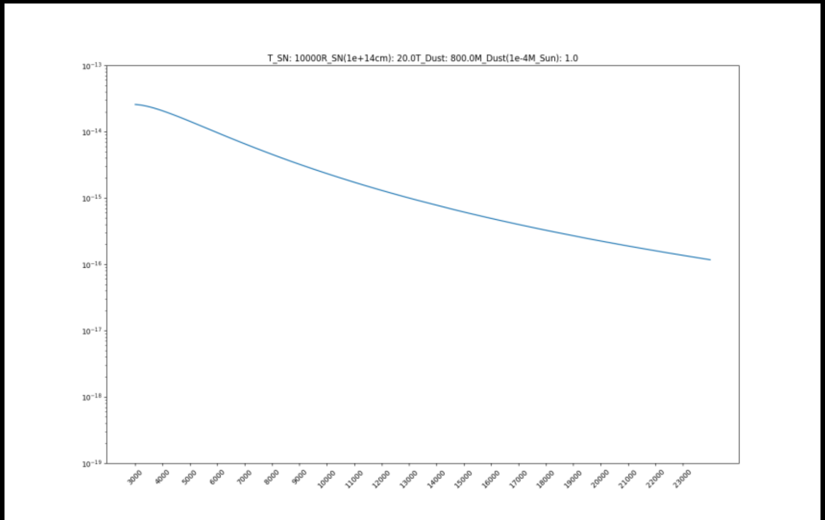
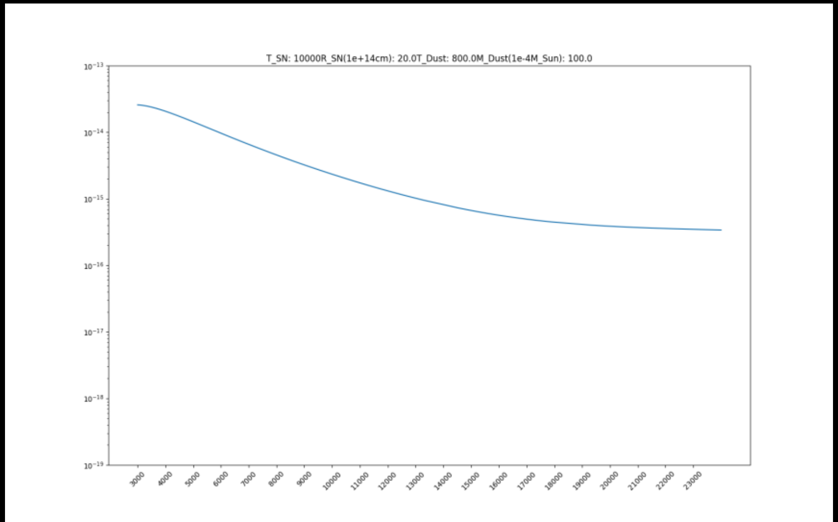
- Regression: estimating the amount of dust







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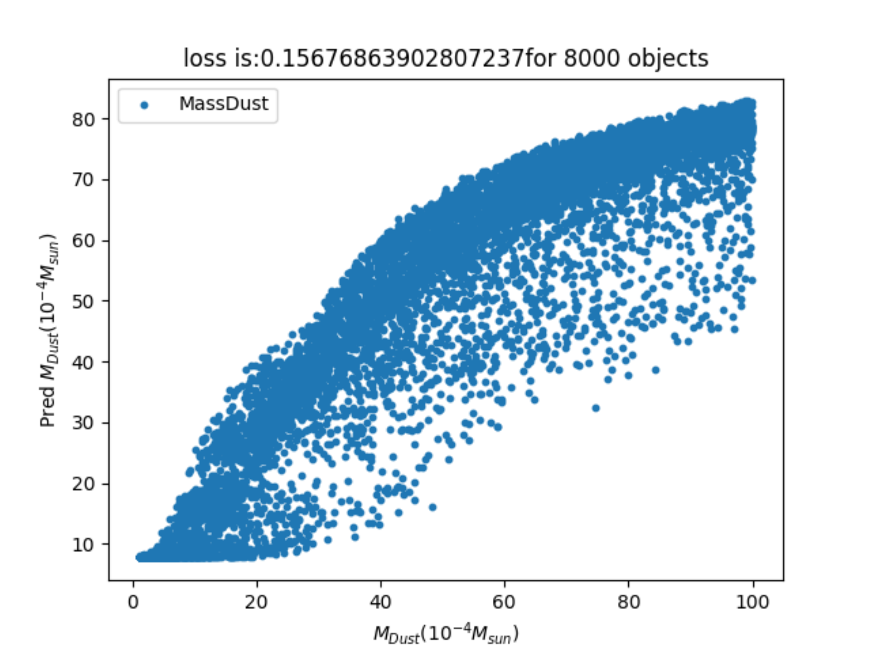

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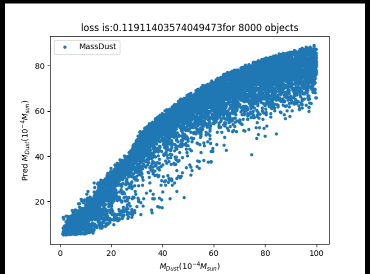
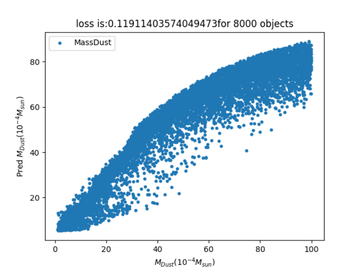


$$MSE = \frac{\sum_{i=1}^{n} (y_i - y_i^p)^2}{n}$$

$$MAE = \frac{\sum_{i=1}^{n} |y_i - y_i^p|}{n}$$

- Regression: estimating the amount of dust



https://heartbeat.fritz.ai/5-regression-loss-functions-all-machine-learners-should-know-4fb140e9d4b0

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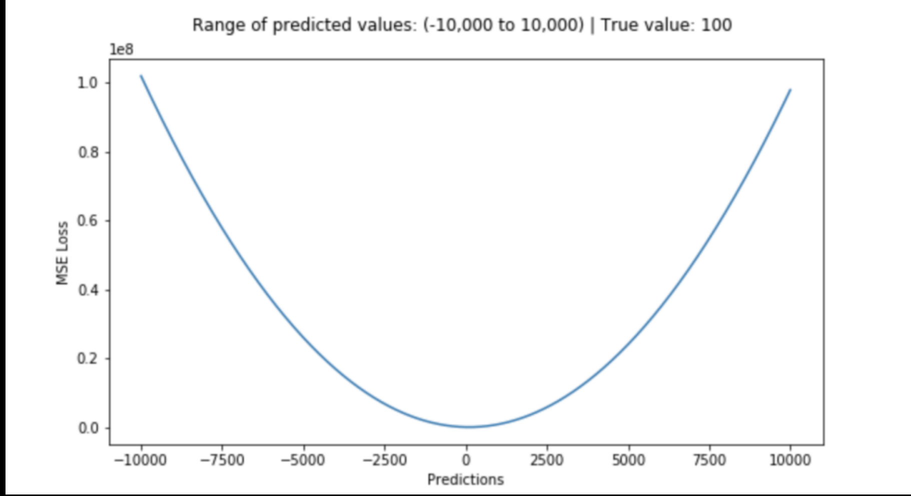
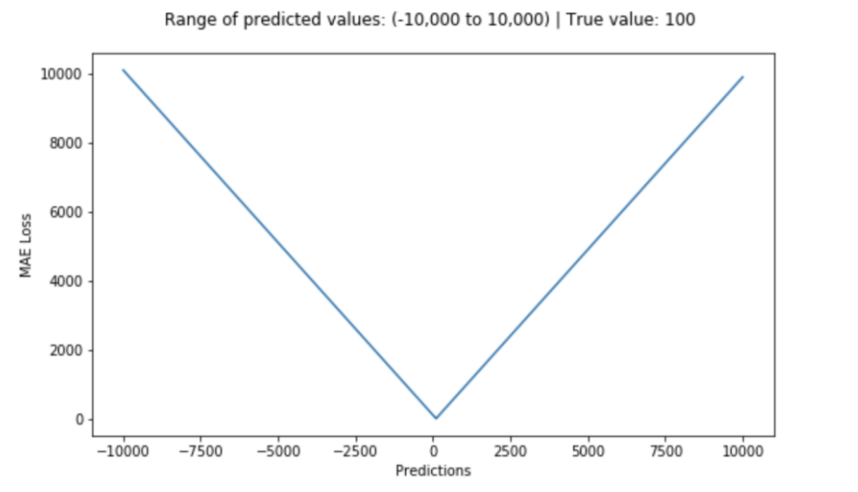

Range of predicted values: (-10,000 to 10,000) | True value: 100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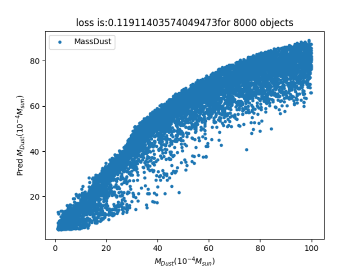
- Regression: estimating the amount of dust


loss is:0.11911403574049473for 8000 objects

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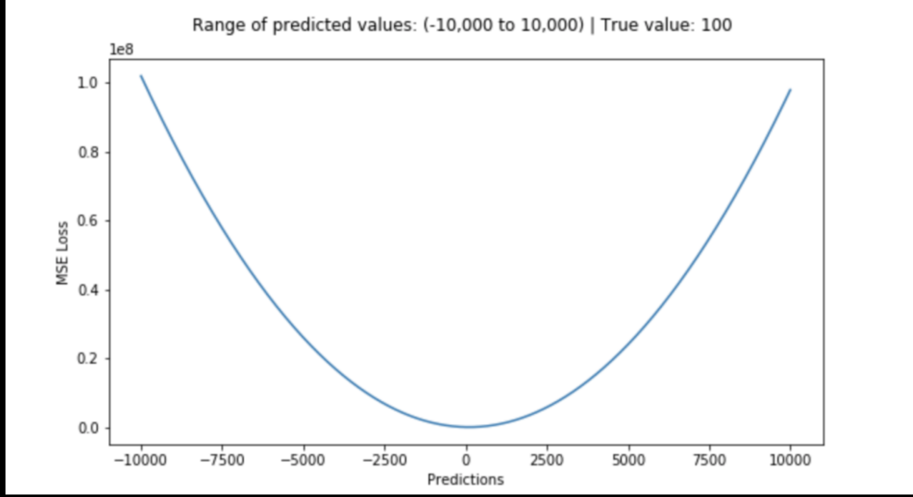
$$MSE = \frac{\sum_{i=1}^{n} (y_i - y_i^p)^2}{n}$$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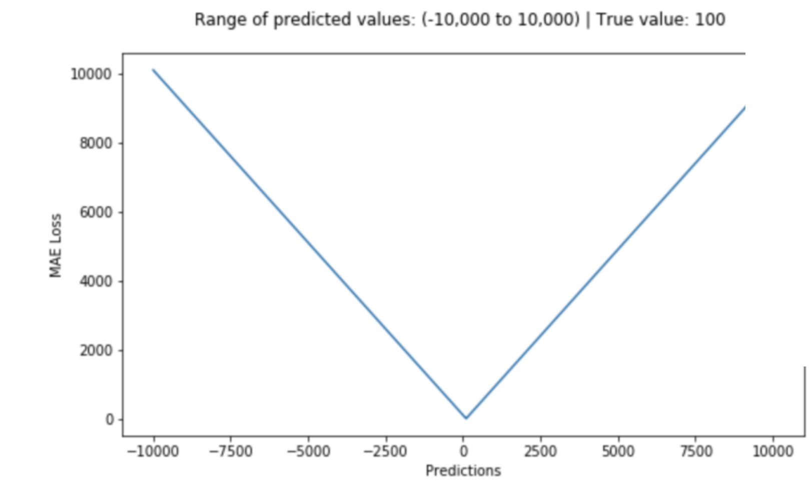
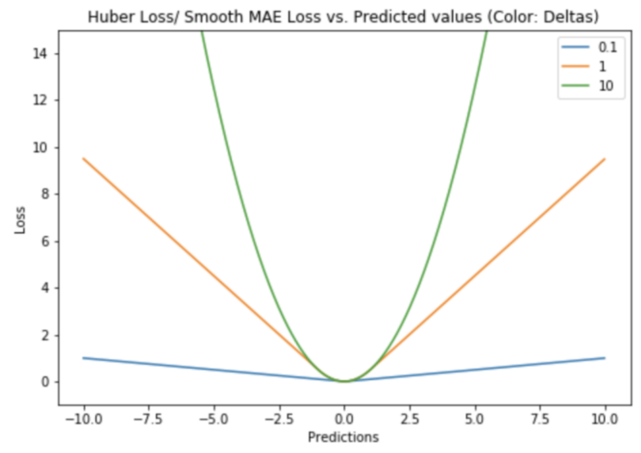
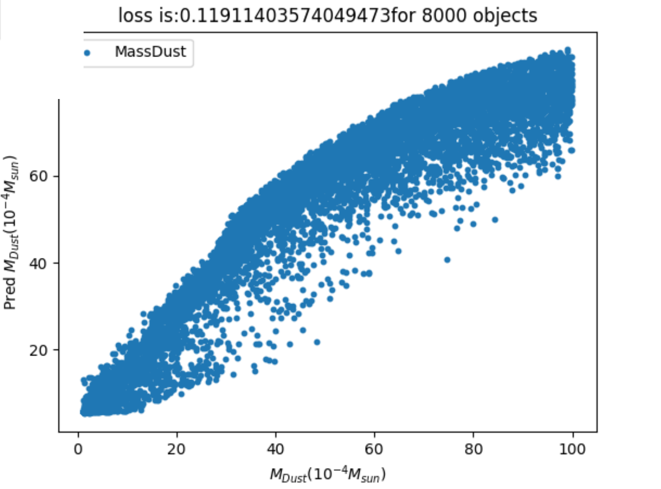

Range of predicted values: (-10,000 to 10,000) | True value: 100

$$L_\delta(y, f(x)) = \begin{cases} \frac{1}{2}(y - f(x))^2 & \text{for} |y - f(x)| \le \delta, \\ \delta\, |y - f(x)| - \frac{1}{2}\delta^2 & \text{otherwise.} \end{cases}$$


Huber Loss/ Smooth MAE Loss vs. Predicted values (Color: Deltas)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- Regression: estimating the amount of dust

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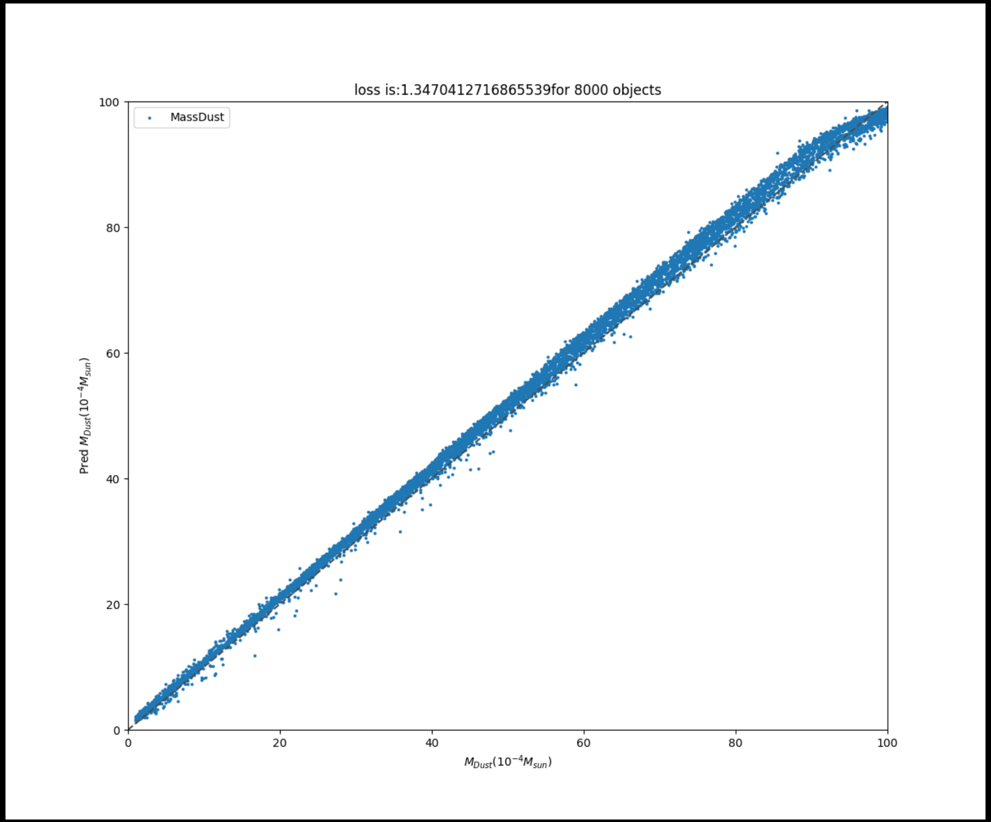
Huber for 3000 epochs

+drop the dropouts

+Used PReLU instead of ReLUs

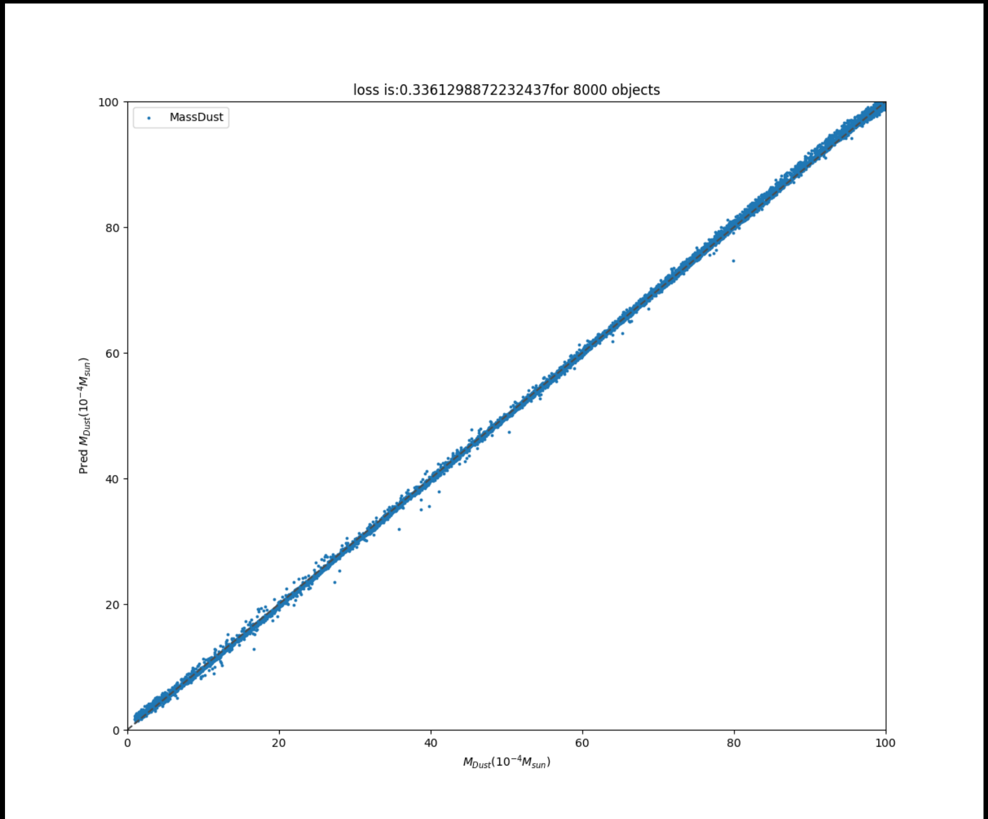


- Regression: estimating the amount of dust

Huber for **5000** epochs

+drop the dropouts

+Used PReLU instead of ReLUs



- Regression: estimating the amount of dust