NN reconstruction development and performance

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$t\bar{t}$ reconstruction meeting

Jonas' NN

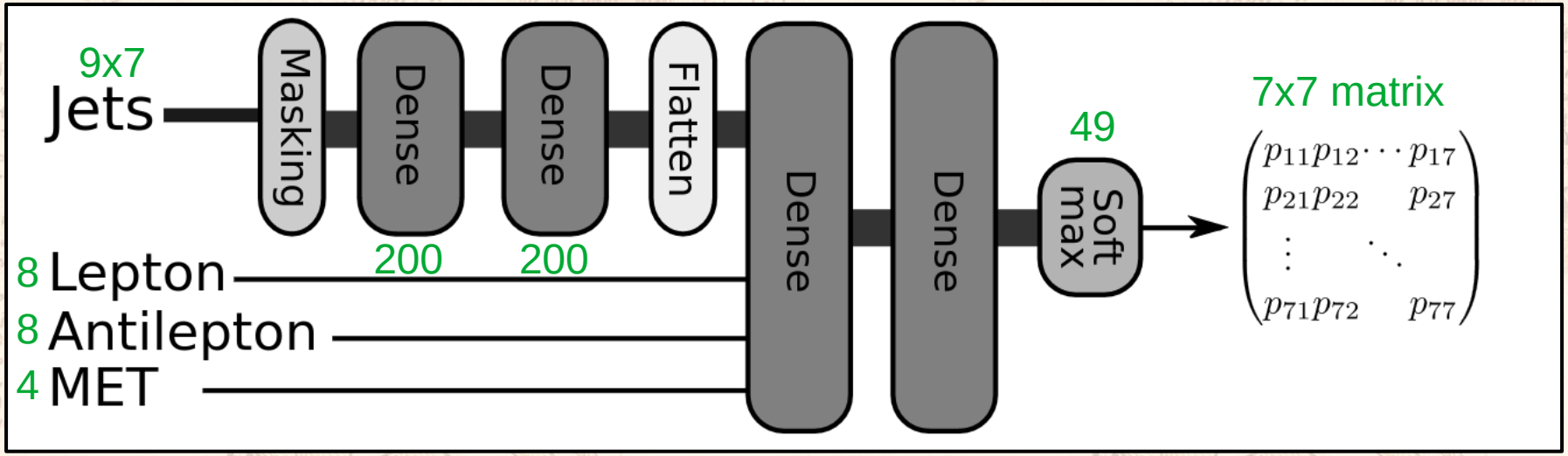
- Feed-forward NN developed by Jonas as alternative to Sonnenschein
- Gitlab repo for training (on pepper outputs): https://github.com/jrueb/reconn/tree/master
- Implementation in pepper: https://gitlab.cern.ch/jrubenac/pepper/-/blob/HIG-22-013/pepper/kinreco_ttbarnn.py?ref_type=heads
- Note: all truth level results are with last copy bottoms- not best choice, see Tim's talk

Jonas' NN Model

Neural Nework for bottom jet tagging

- Input:
  - 7 jets 4-momenta + DeepJet b tag
  - All 4-momenta are given in xyzE and $p_T\varphi\eta m$ coordinates
- Output:
  - A 7x7 matrix. Each entry O_{ij} is interpreted as the probability that the ij jets come from by bb-bar quarks

Number of neurons in green

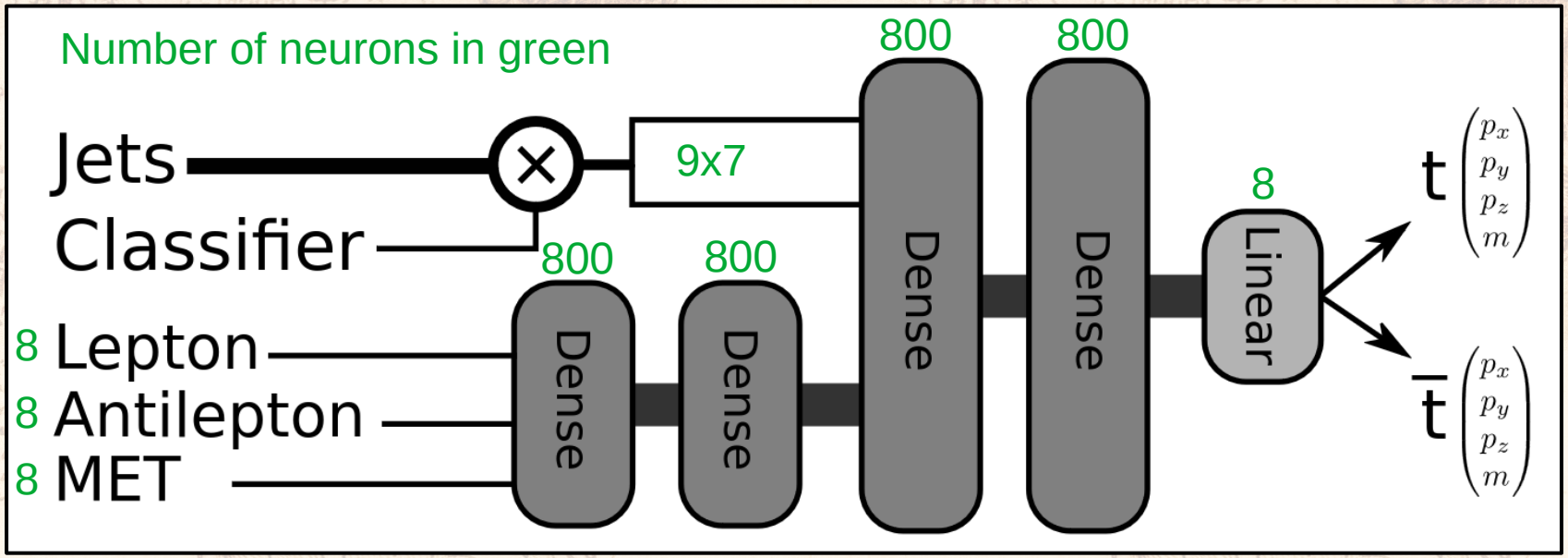


Dropout probability for each layer is 0.25

Jonas' NN Model

Neural Nework for top quarks 4-momenta reconstruction

- Input:
  - 7 jets 4-momenta + DeepJet b tag
  - All 4-momenta are given in xyzE and $p_T\varphi\eta m$ coordinates
- Output:
  - Reconstructed ttbar 4-momenta in xyzm coordinates



Dropout probability for each layer is 0.25

Metrics

Useful Definitions

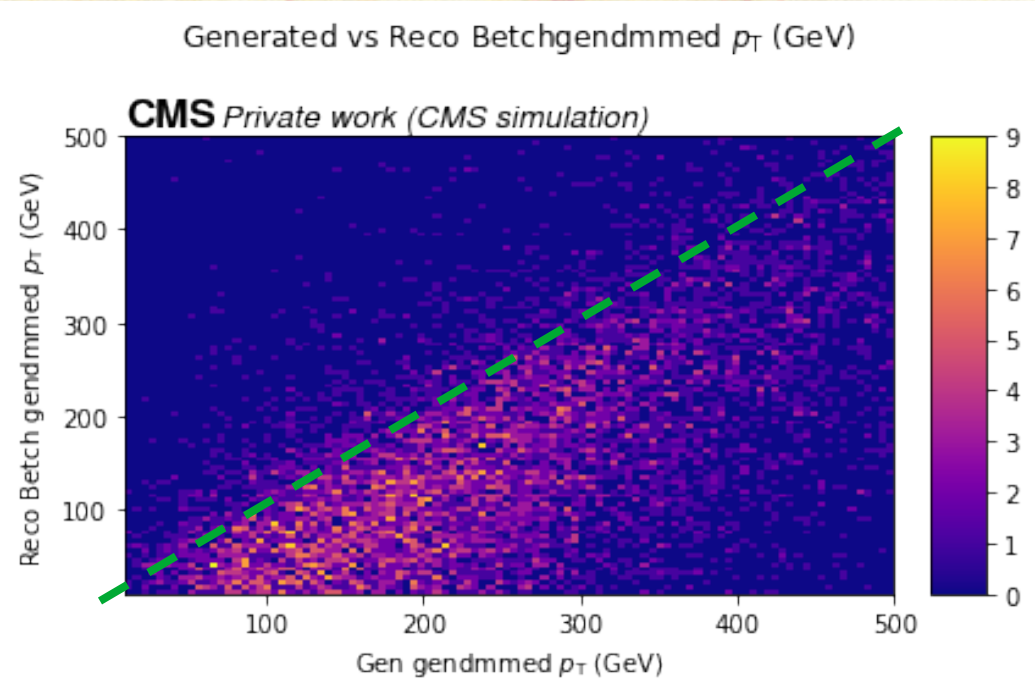
f (x) is the **prediction**, **t** represents the **true value**

$$Bias = \frac{1}{N}\sum_{i=1}^{N}\left(f(x_i) - t_i\right)$$

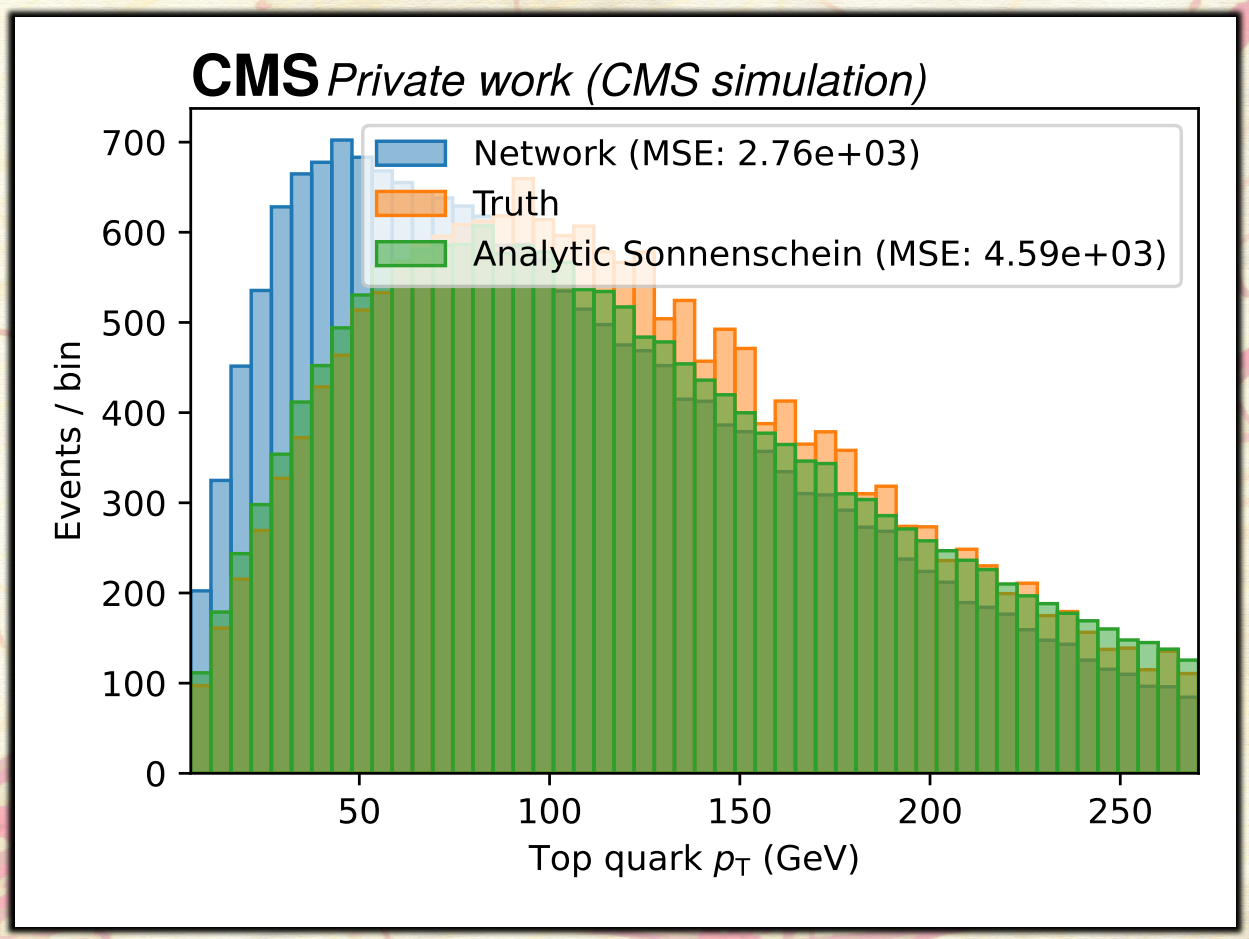
$$std\ dev = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(f(x_i) - t_i\right)^2 - (bias)^2}$$

$$Relative\ Bias = \frac{1}{N}\sum_{i=1}^{N}\left(\frac{f(x_i) - t_i}{t_i}\right)$$

$$Resolution = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(\frac{f(x_i) - t_i}{t_i}\right)^2 - (relative\ bias)^2}$$



Results with SM training



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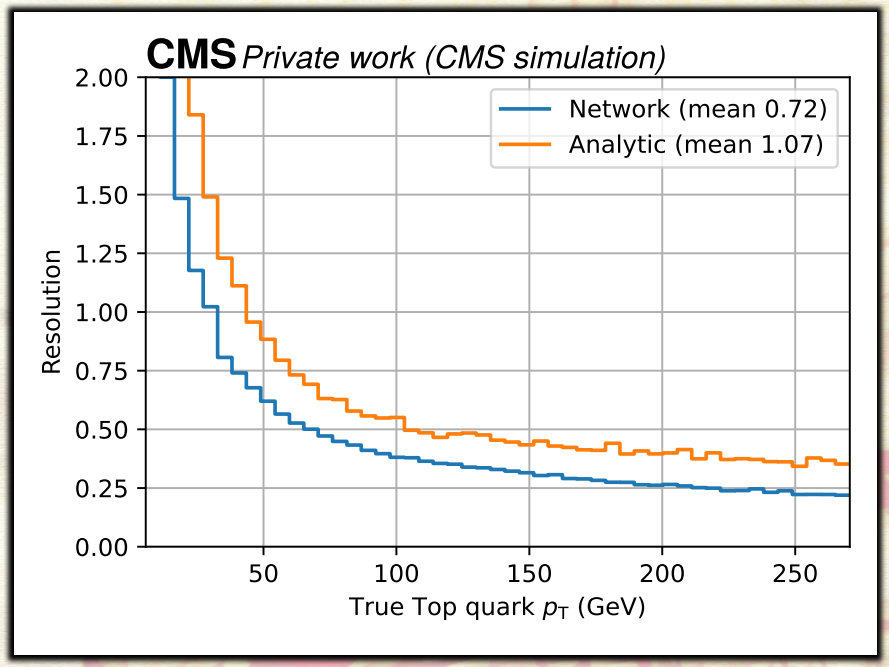
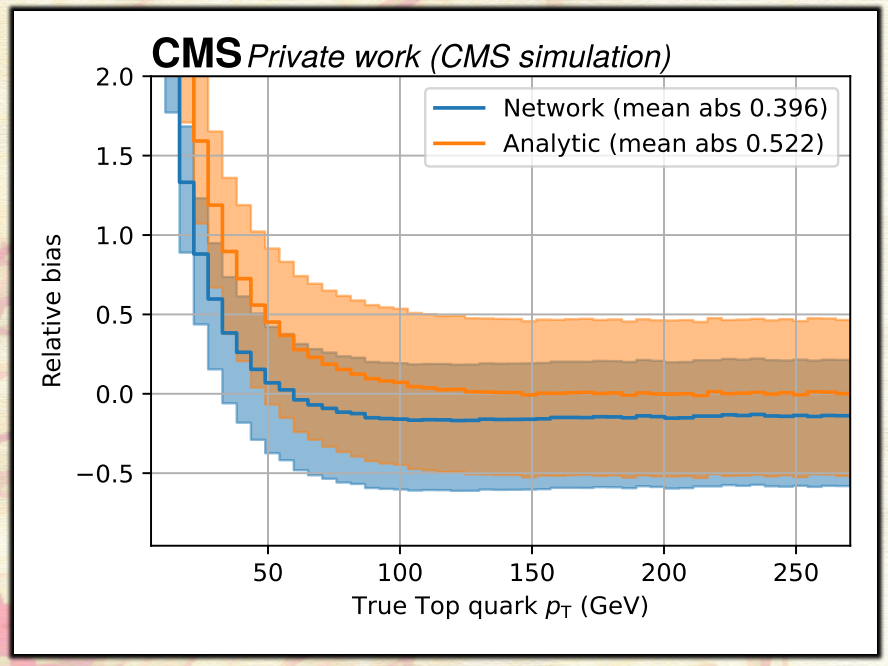


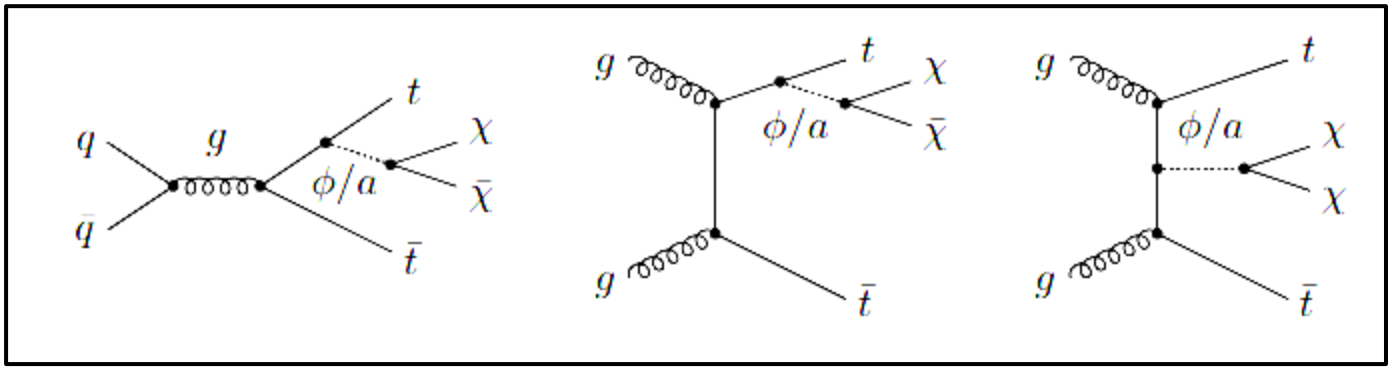


Emanuele's DM studies

- tt+DM is particularly interesting as an extension as DM adds third source of MET
- Problem is under-constrained
- However some variables can discriminate, e.g.:

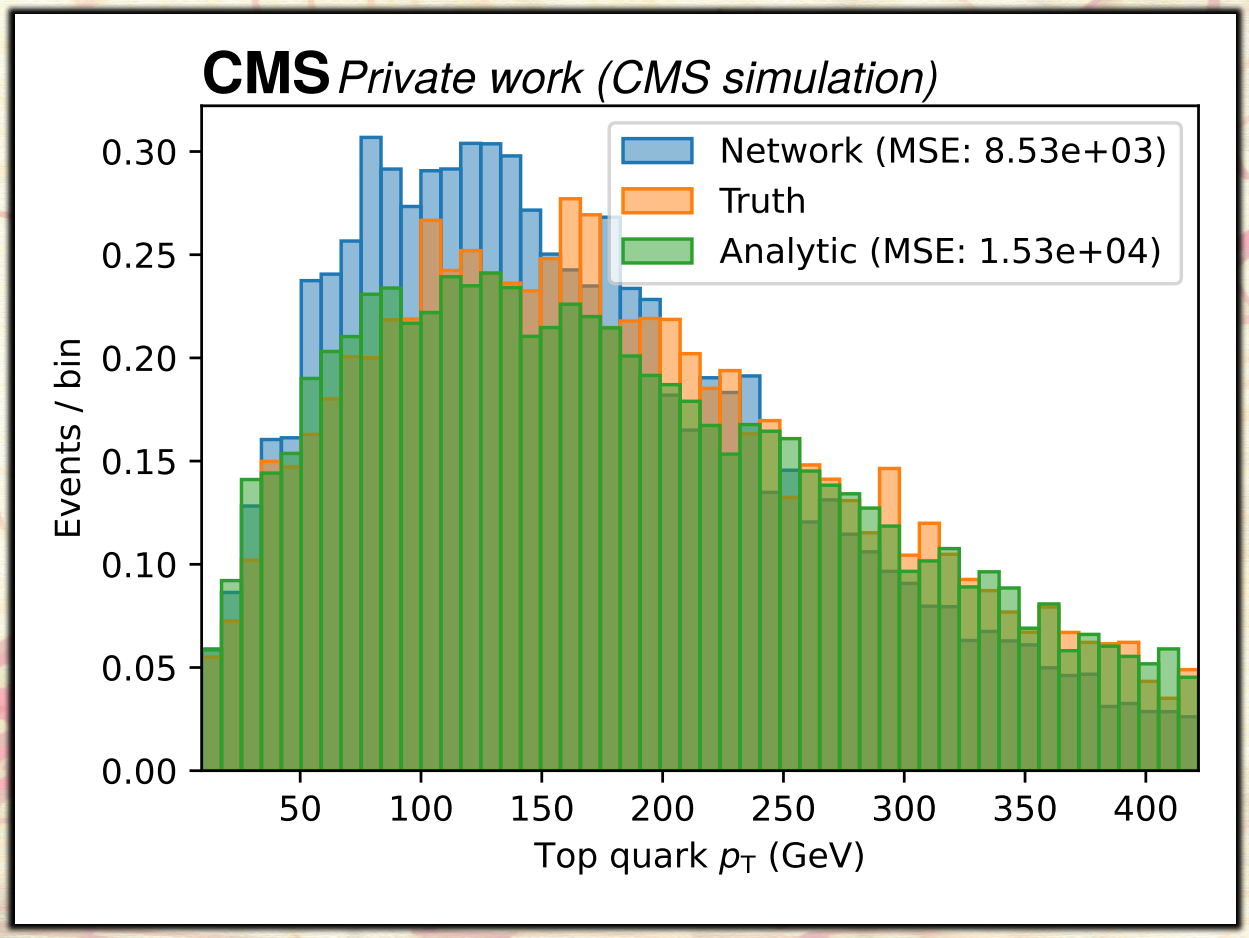
$$M_{T2}^{ll} = \min_{p_\nu + p_{\bar{\nu}} = p_T^{miss}} \left[\max\left(m_T(p_{l^+}, p_\nu), m_T(p_{l^-}, p_{\bar{\nu}}) \right) \right]$$

- A good NN should be able to do equally well



Results with DM training

Mediator mass 50 GeV: t quark p_T



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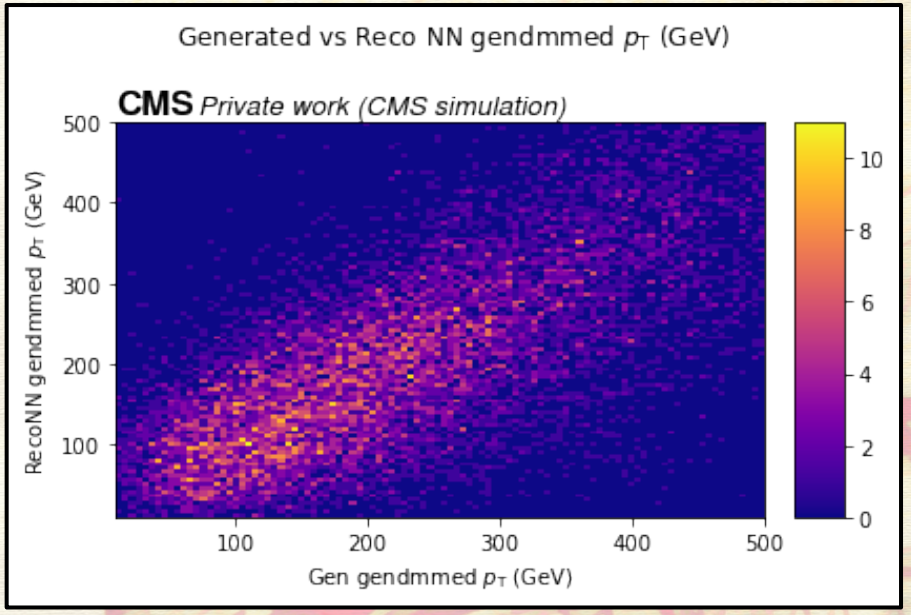
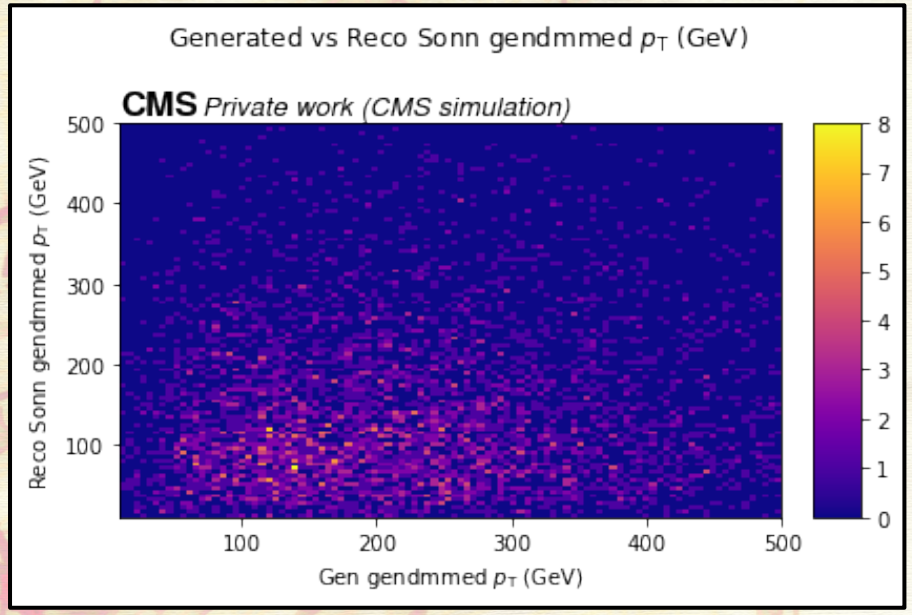
Mediator mass 500 GeV: DM p_T





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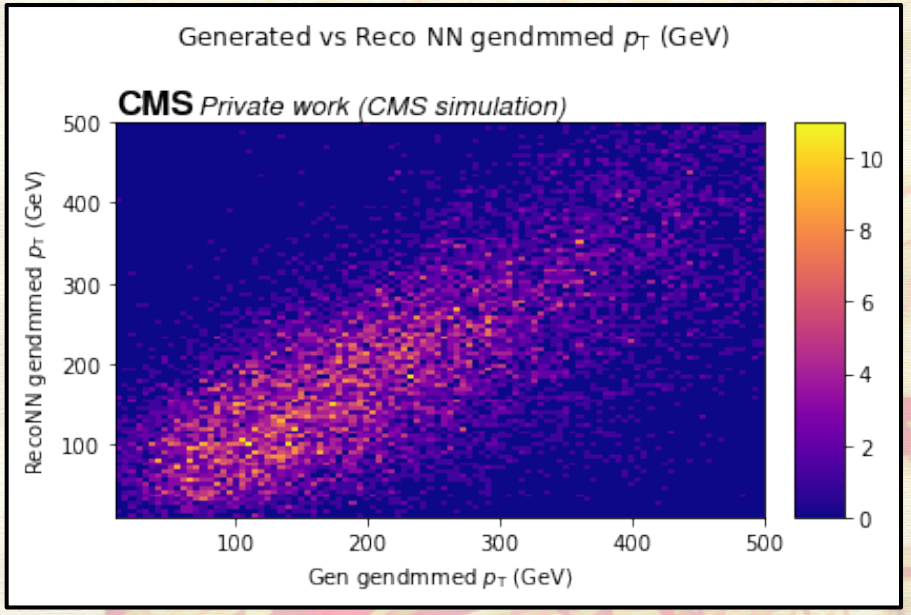

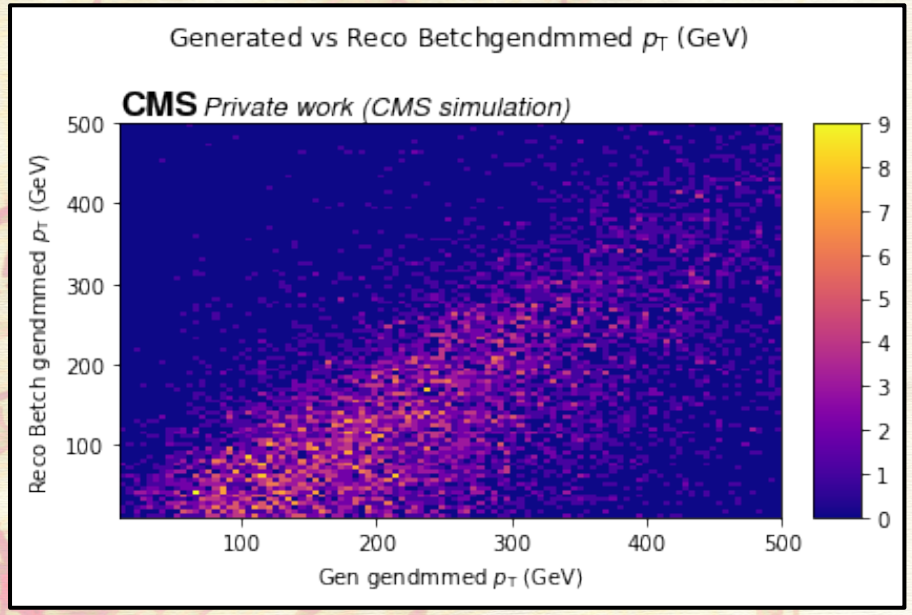

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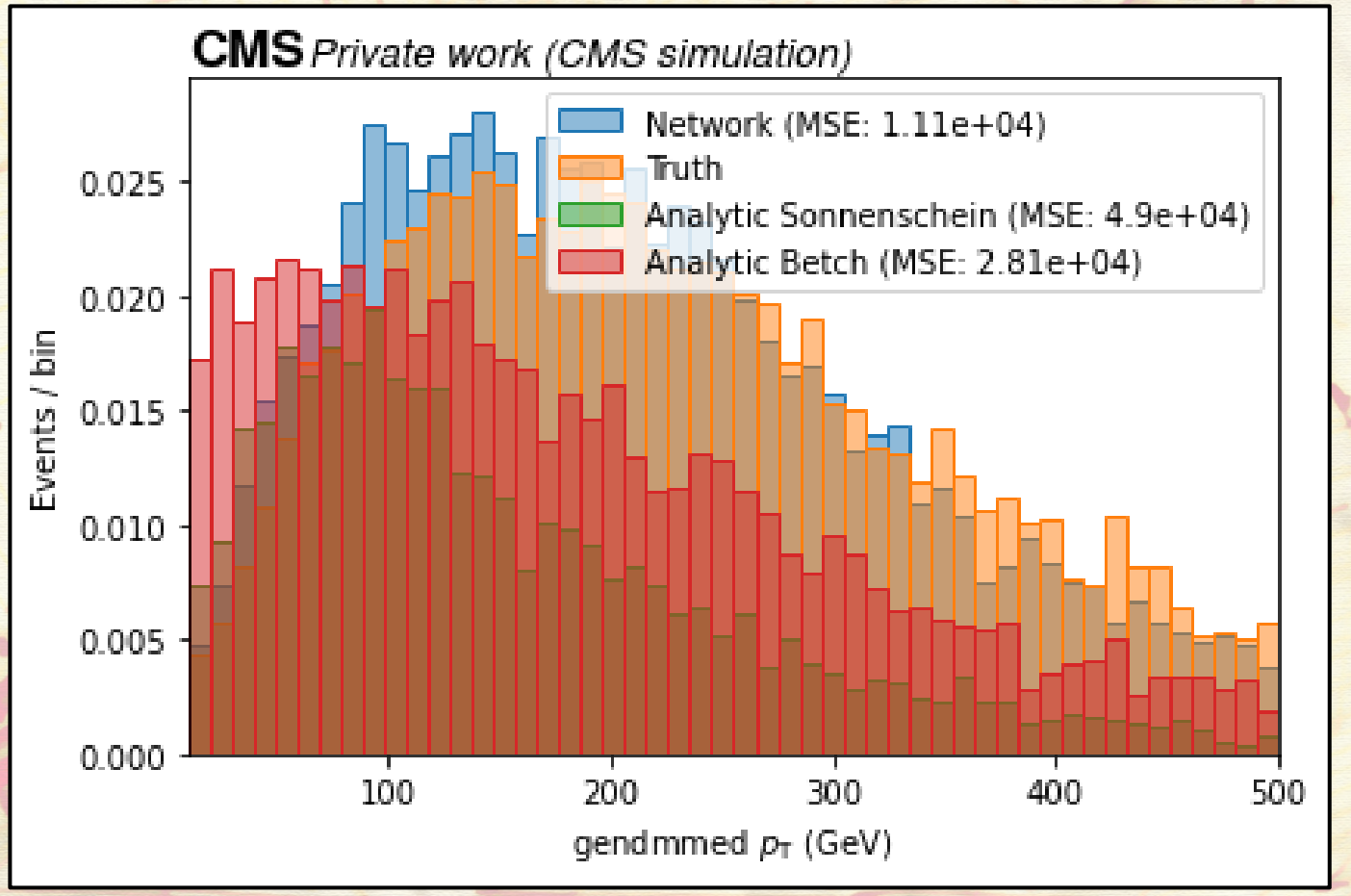

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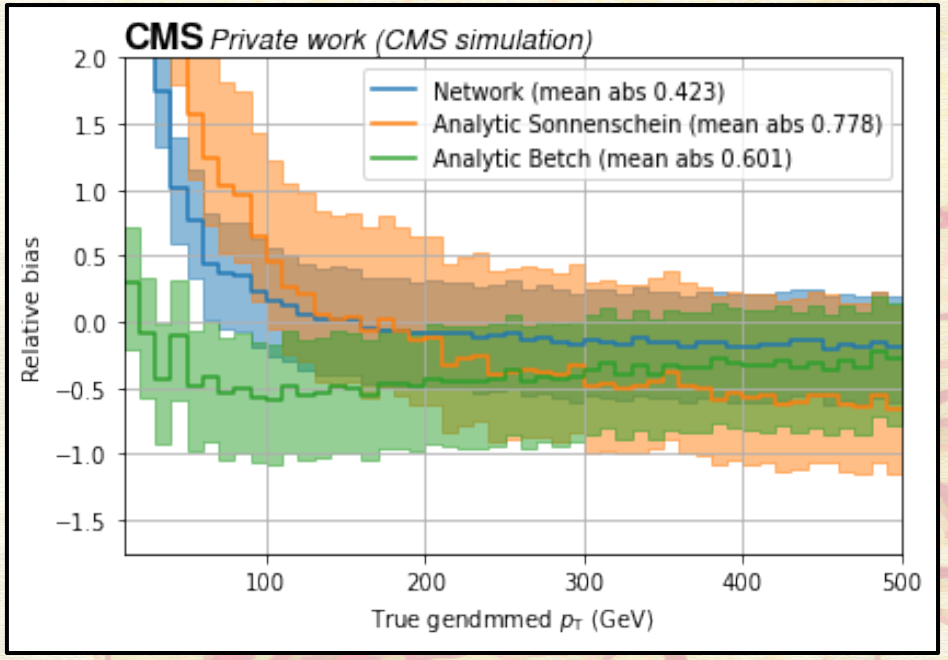
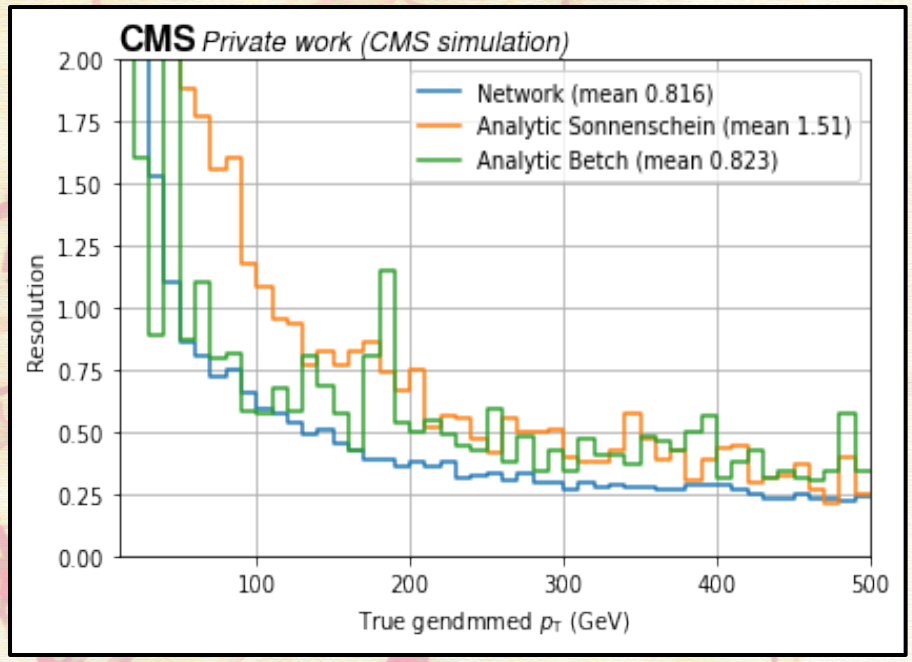
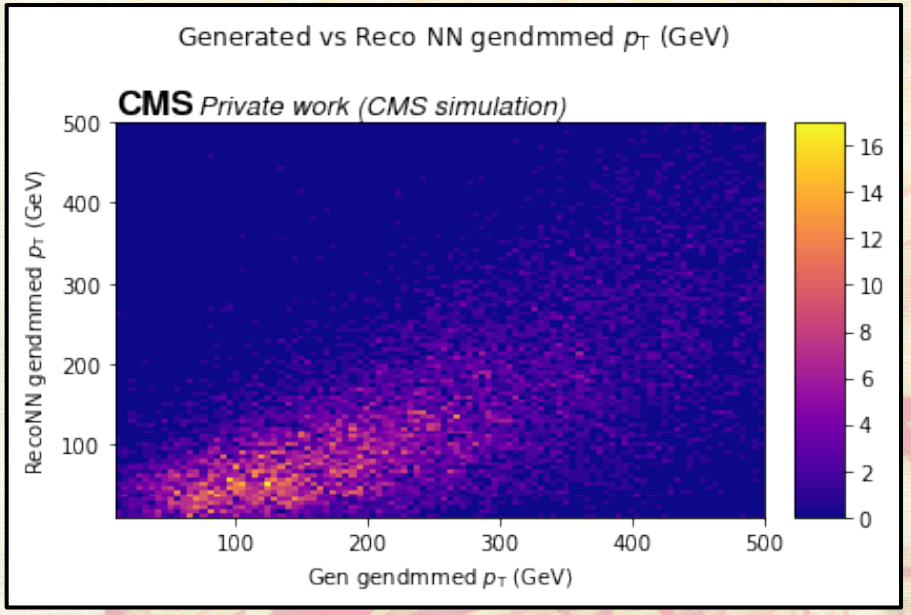


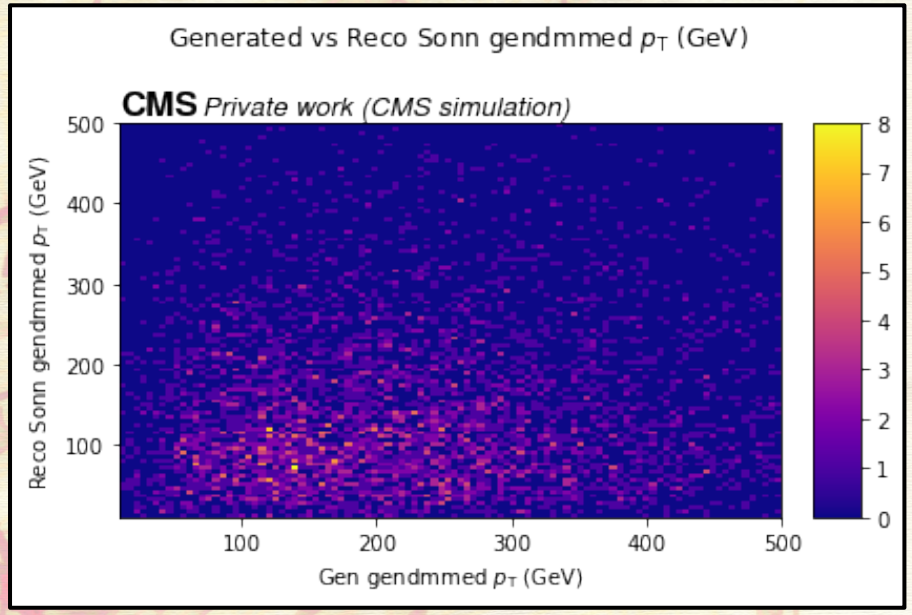


Results with DM training

Mediator mass training 50 GeV, valid 500 GeV:

DM p_T





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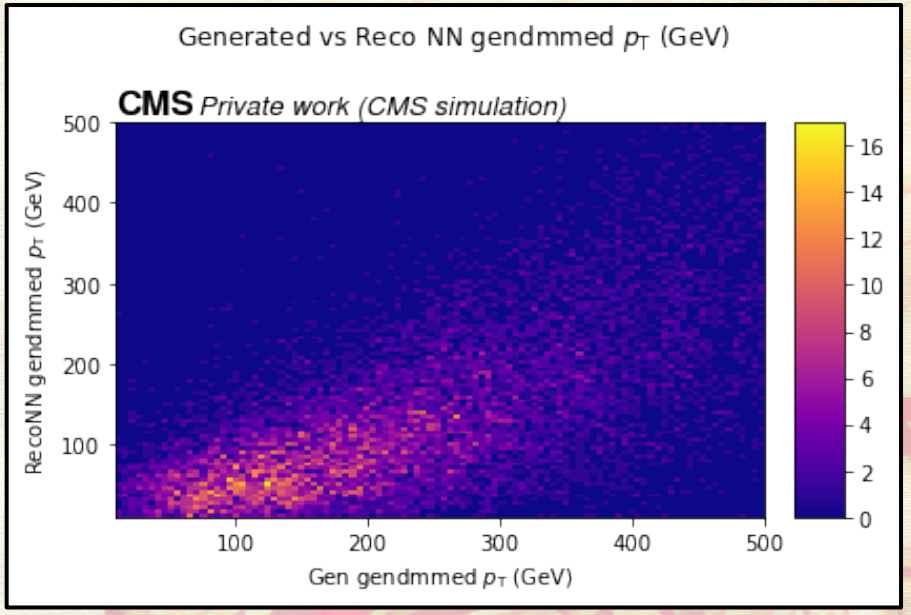

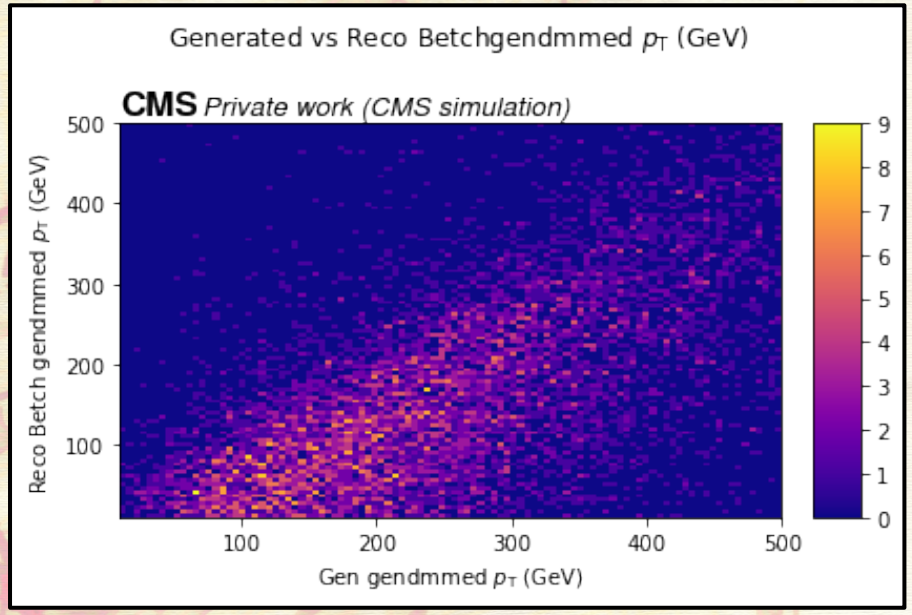

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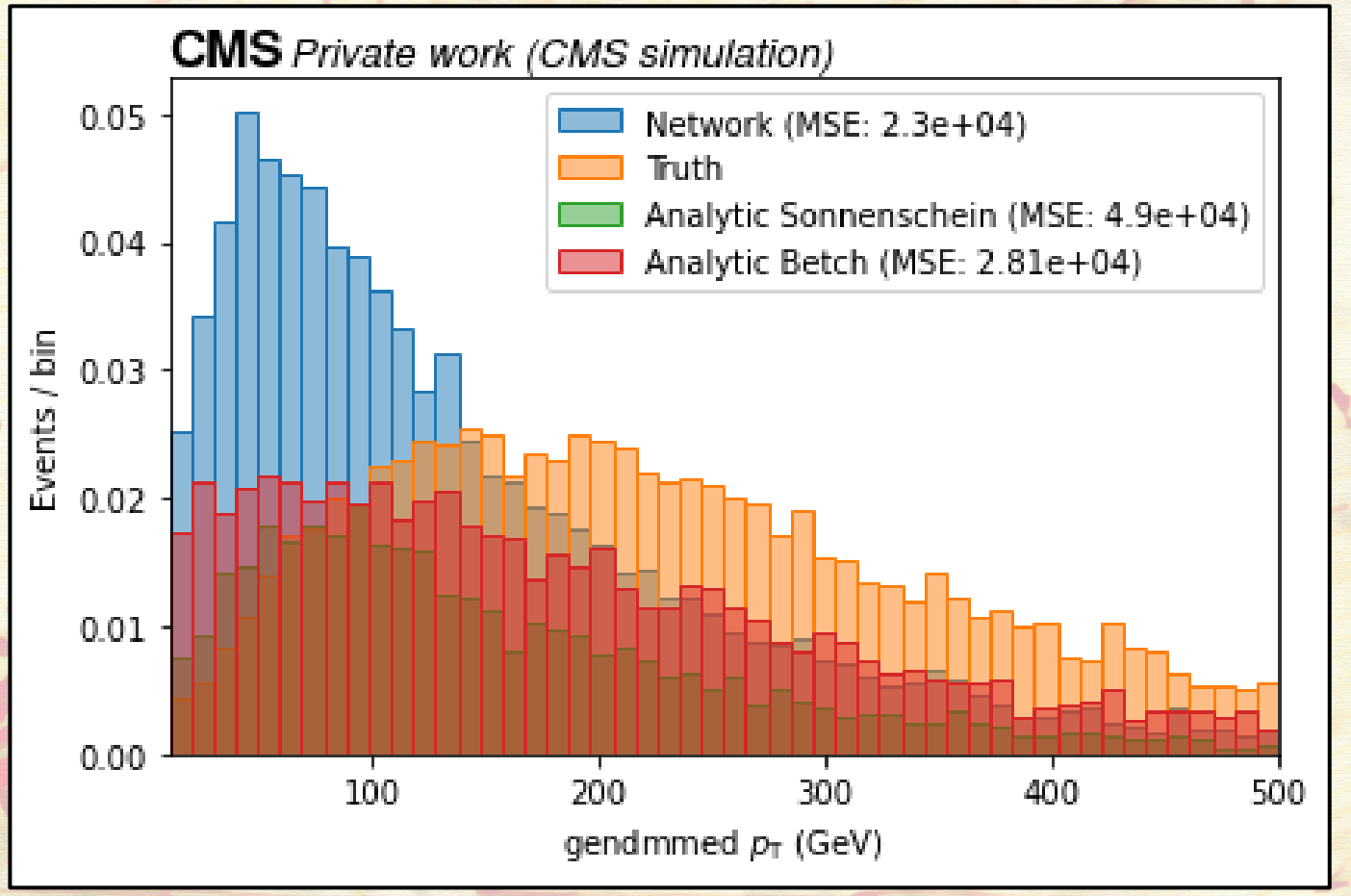

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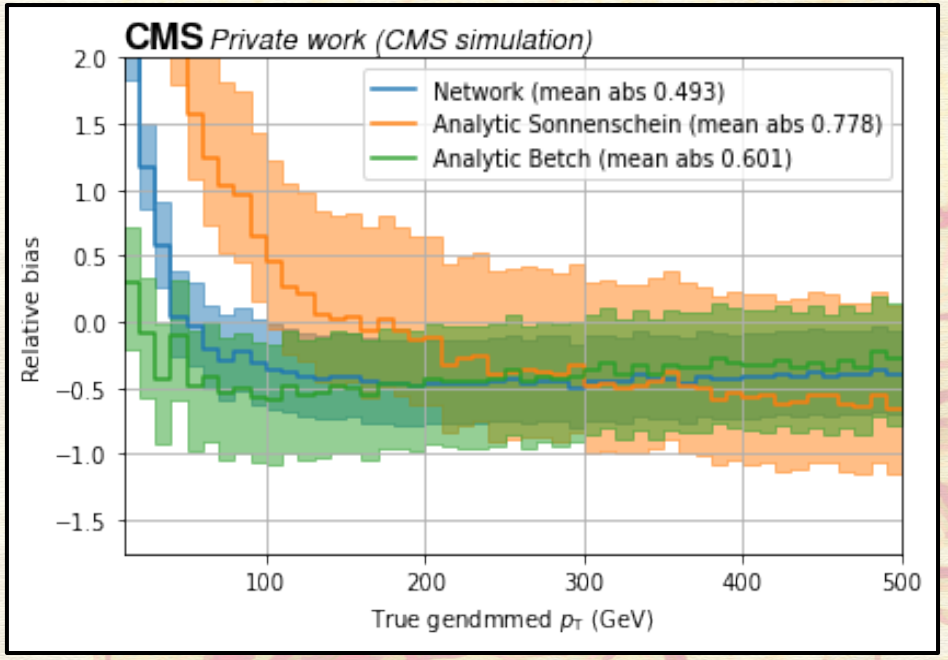
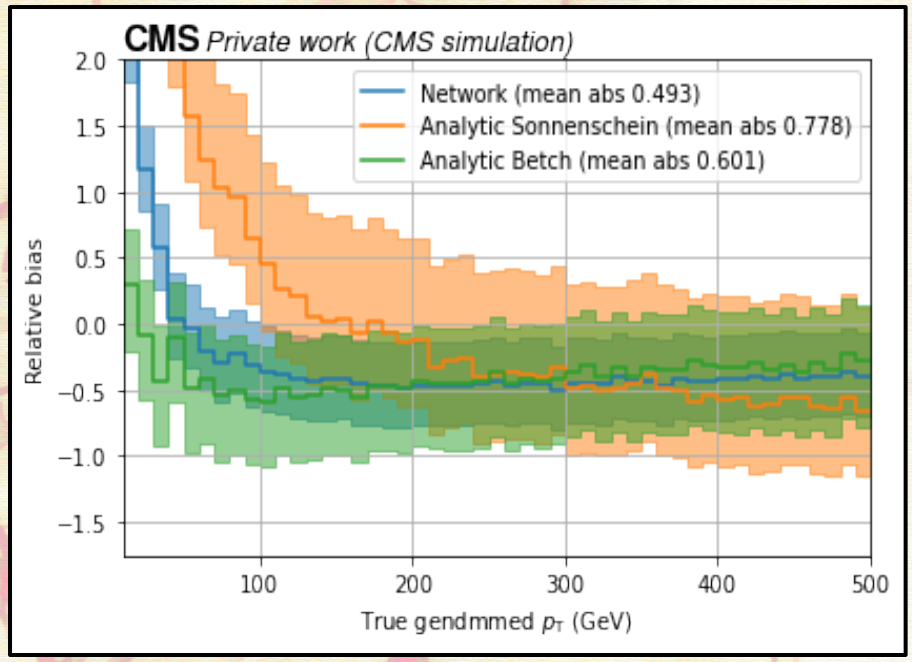




Conclusions

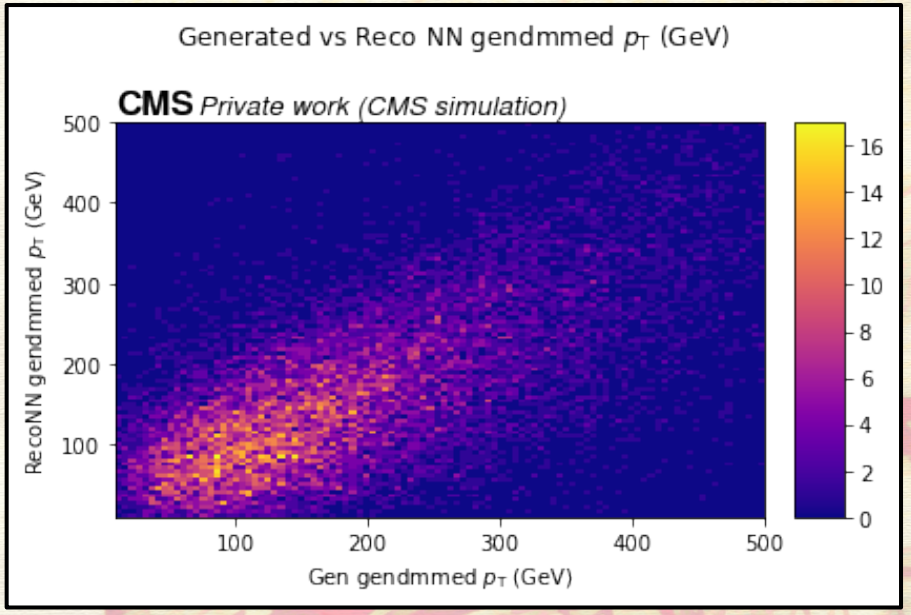
- Jonas' NN is available, and easy to interface to pepper
- Offers improved resolution, at the cost of higher bias and model dependency
- Two part NN: b-jet assignment and actual reco
  - Would be good to test improvement from Sonnenschein with b-jet assignment NN
- tt+DM is interesting extension case to test model independence

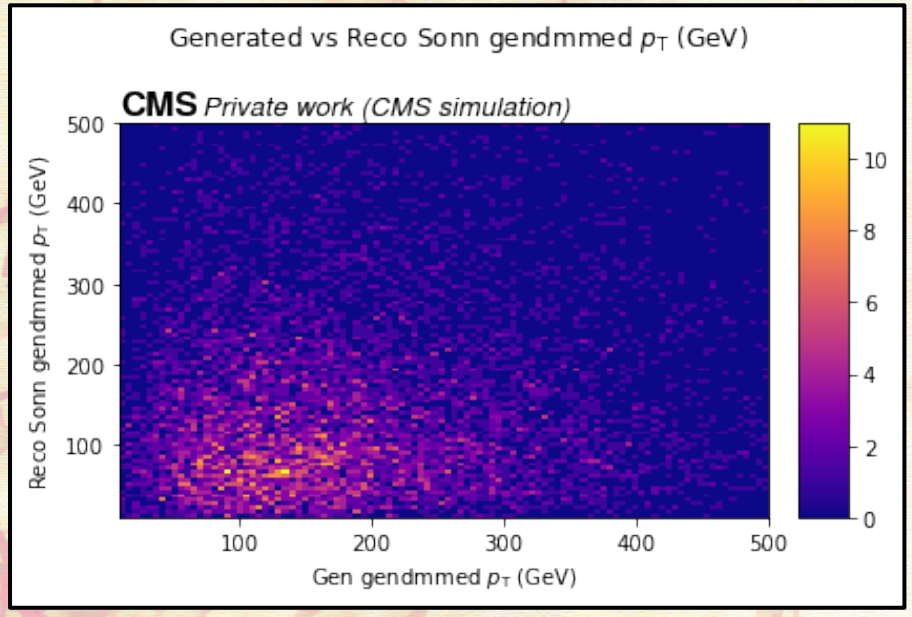
Thanks for your attention

First presentation: 07.08.24
Emanuele Coradin

Results with DM training

Mediator mass 250 GeV: DM p_T





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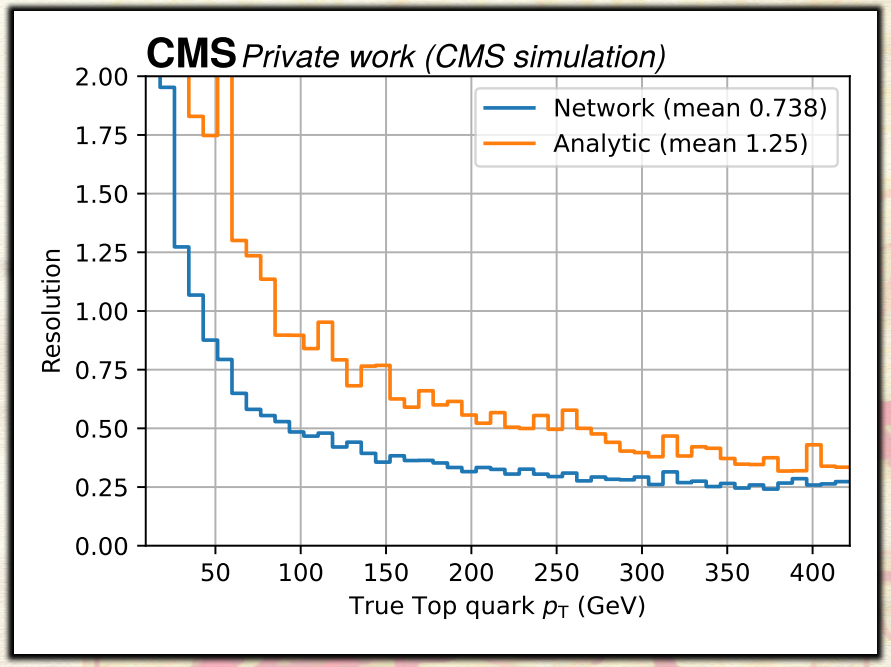

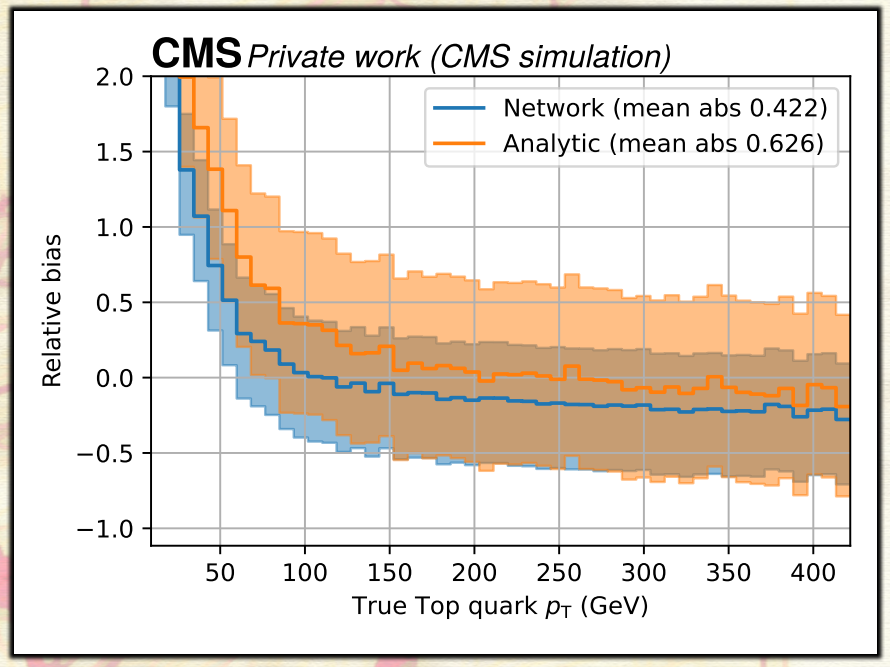

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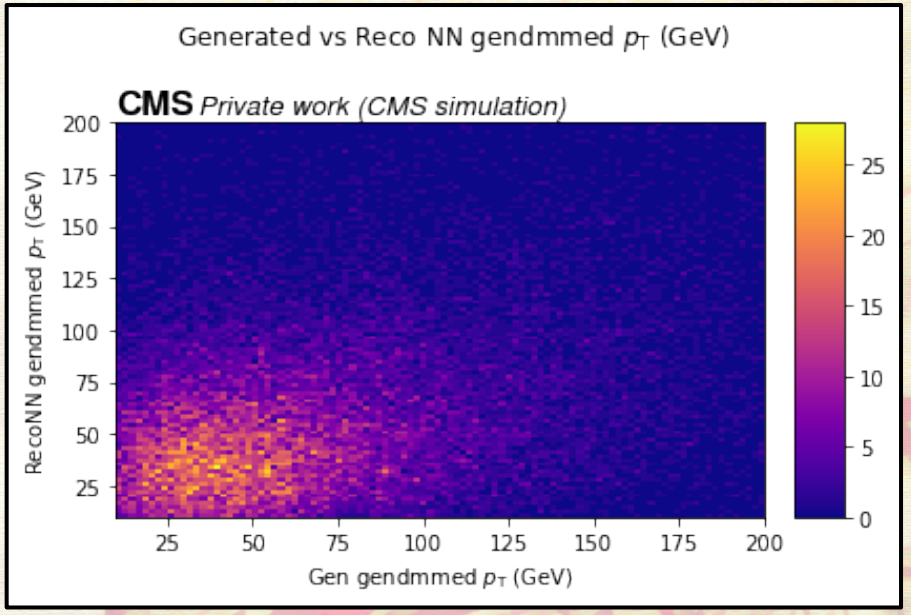
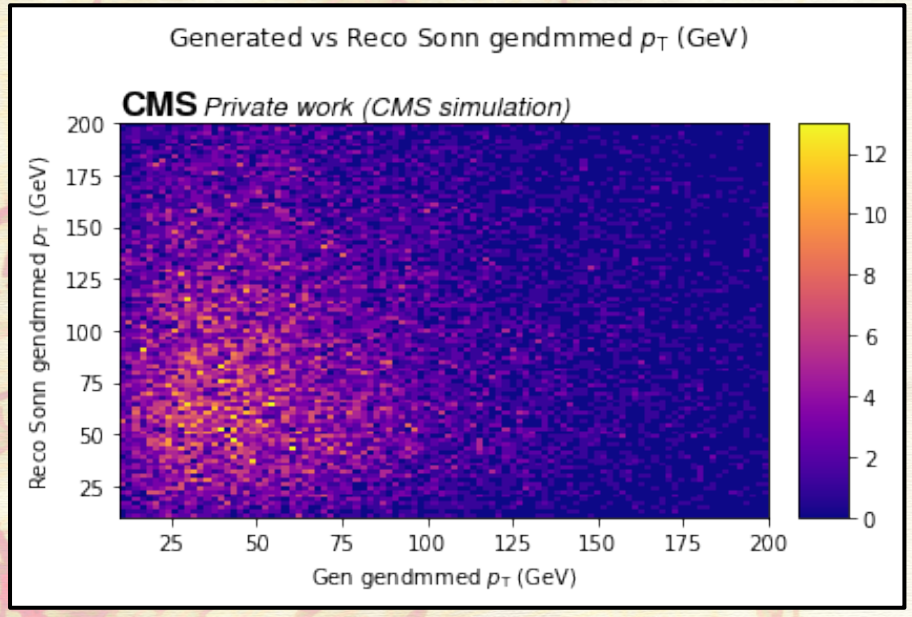
Mediator mass 50 GeV: DM p_T





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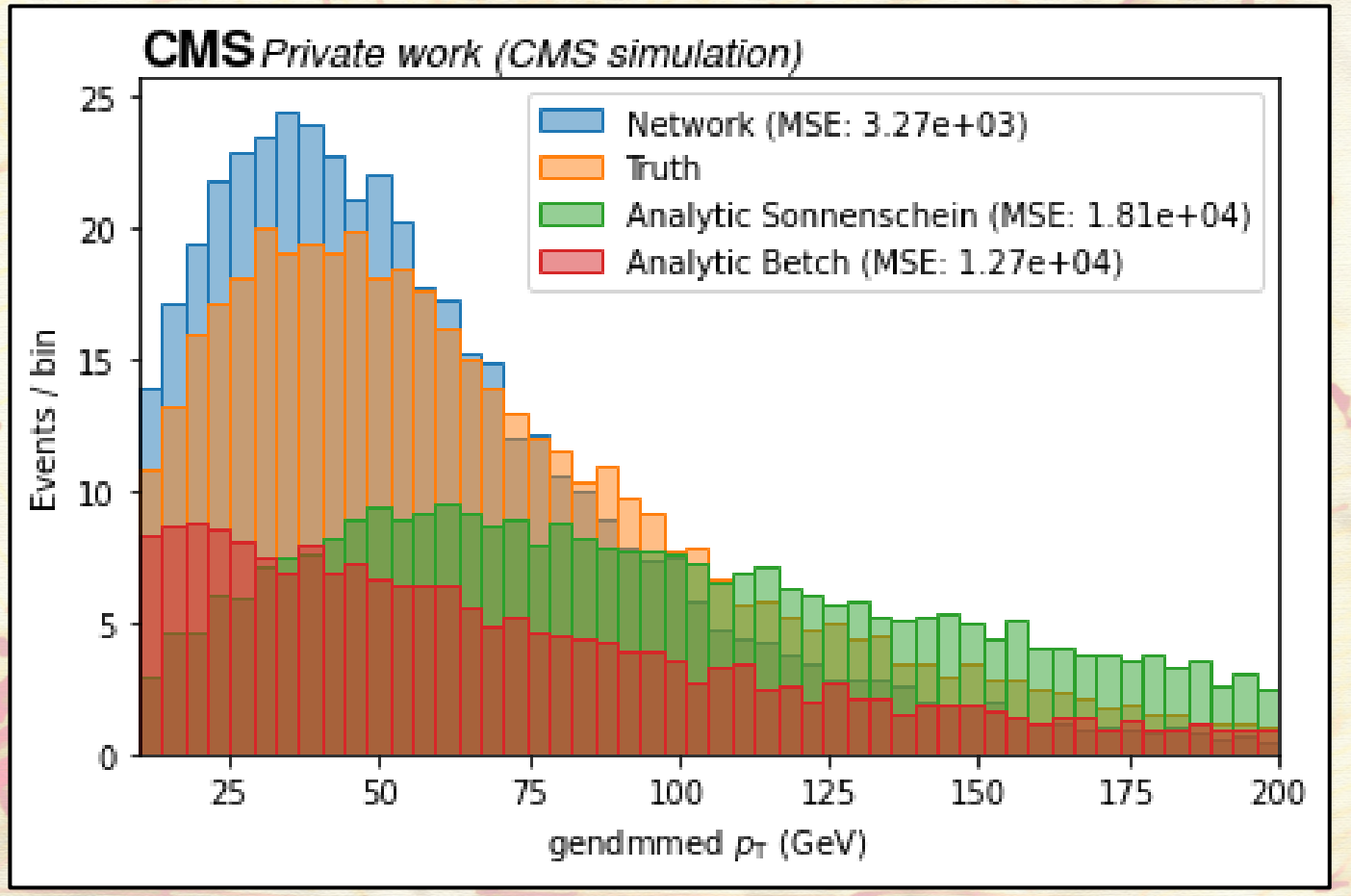

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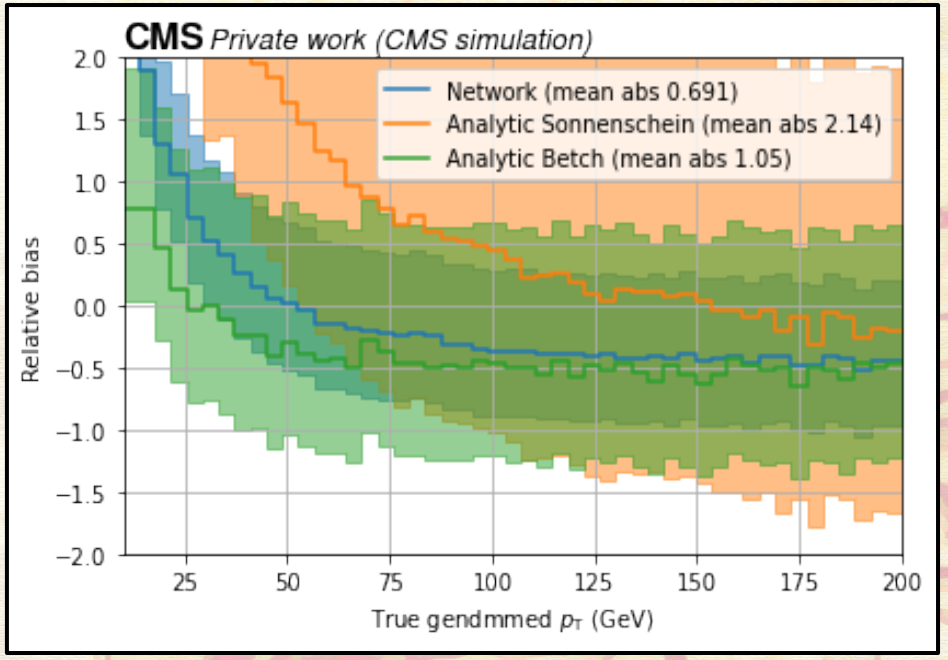

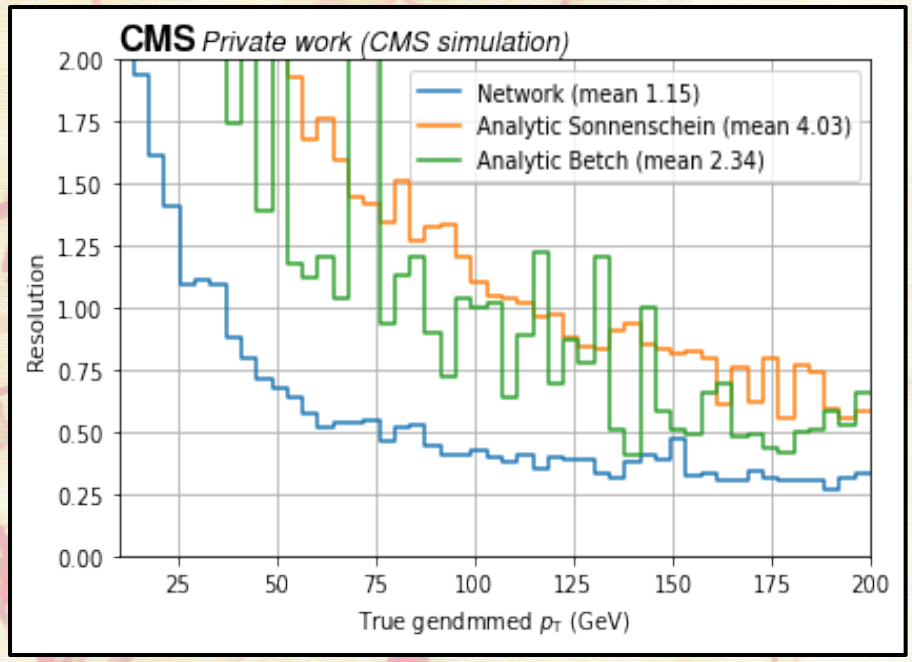

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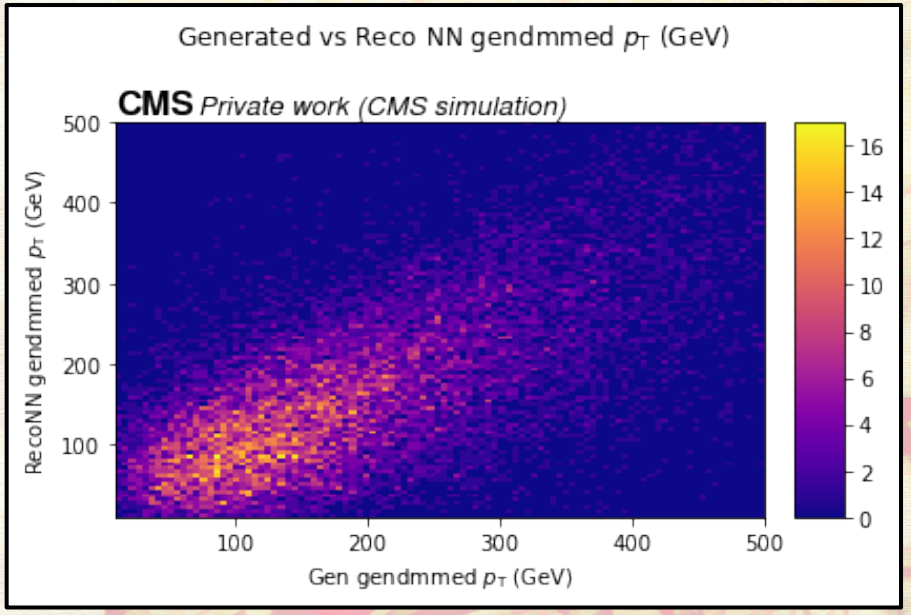

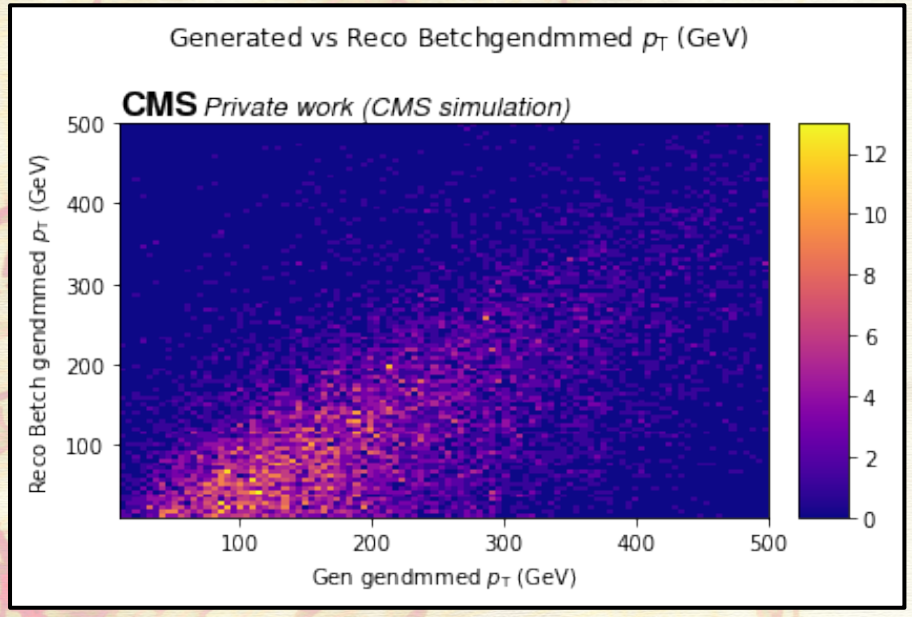

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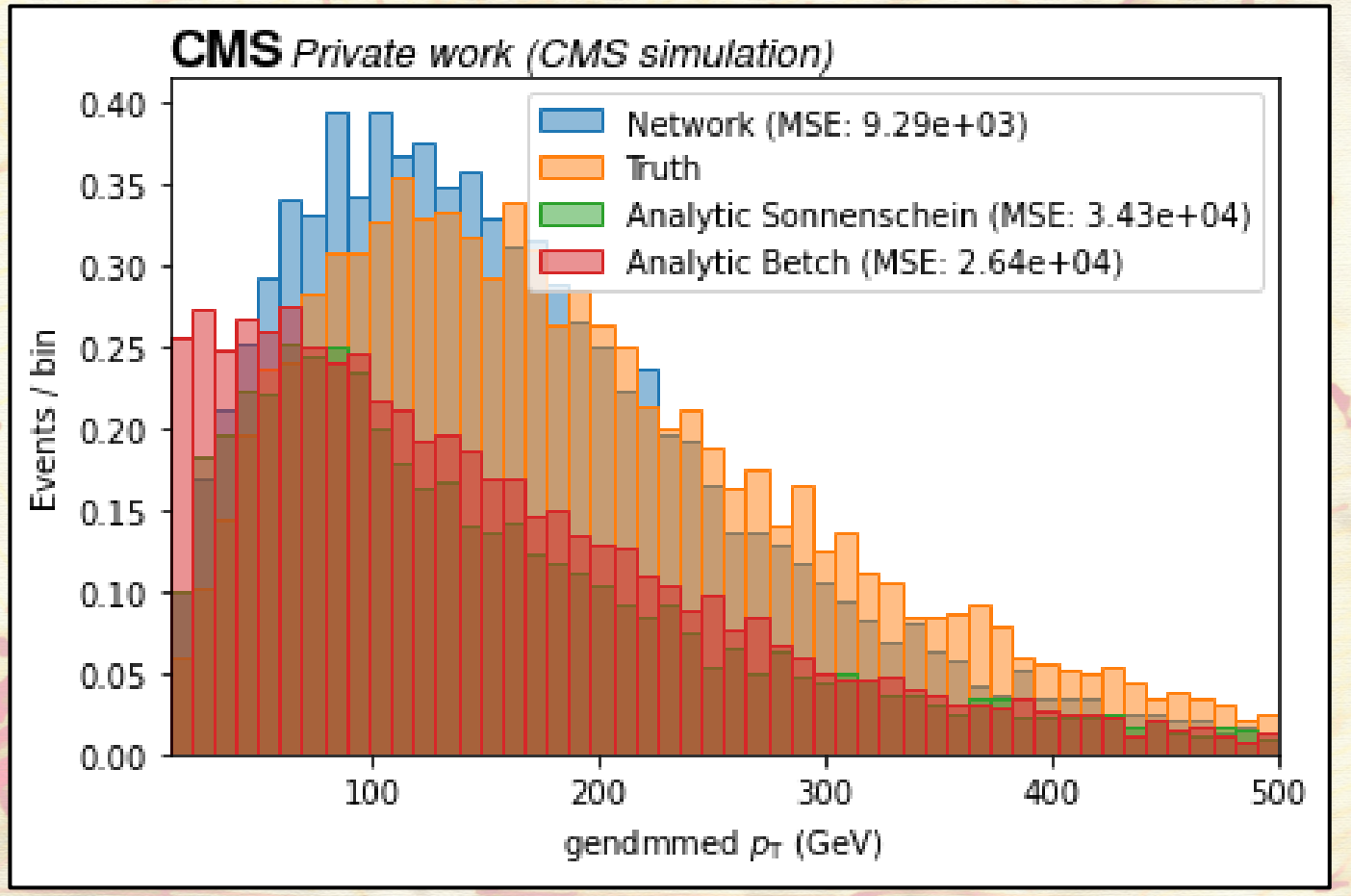

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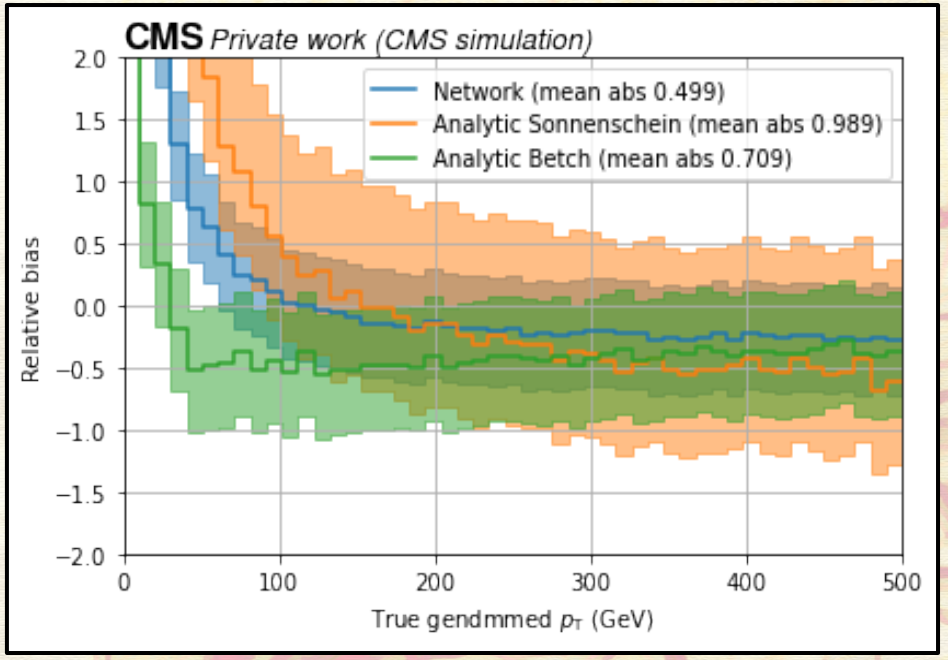

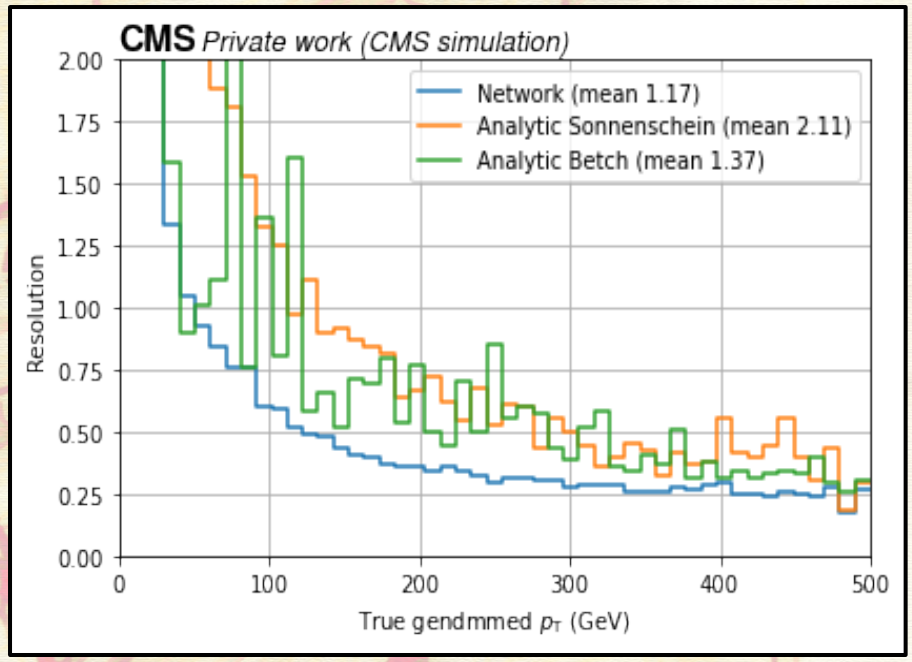

Results with DM training

Mediator mass training 50 GeV, valid SM, 500 GeV: DM p_T