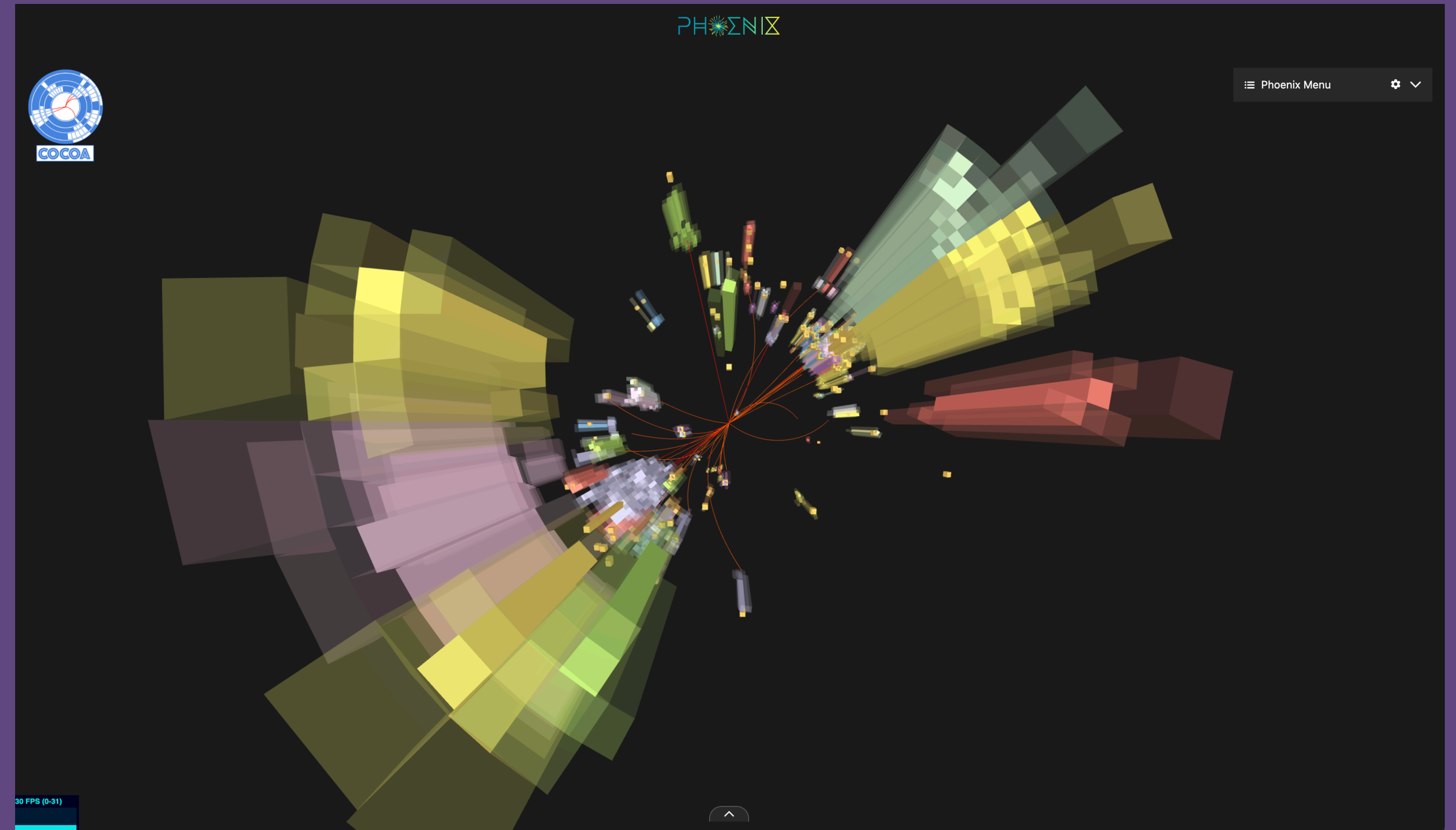


# De-noising Graph Super Resolution with Diffusion Models and transformers

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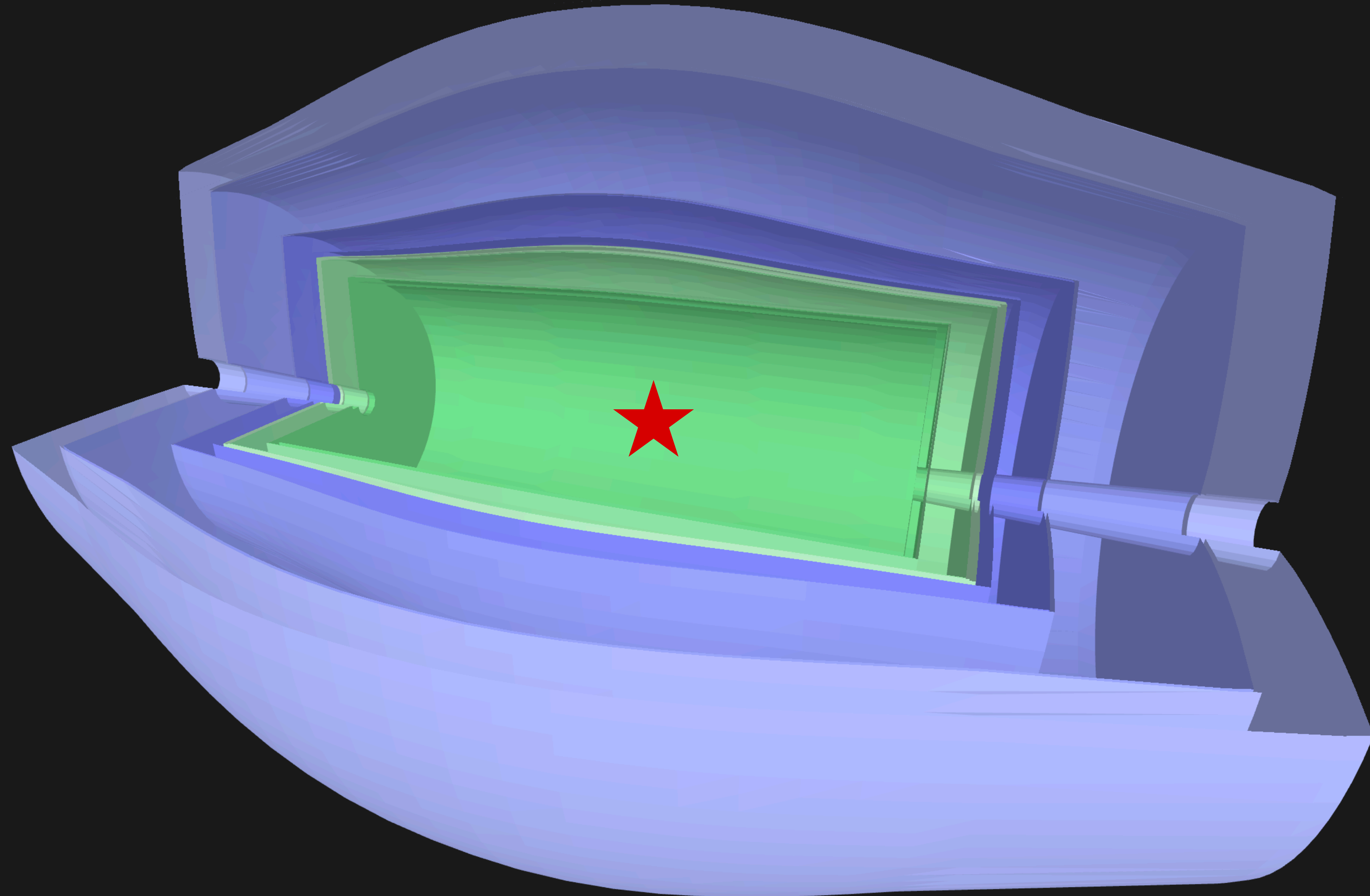


**ACAT 2024**  
12 March, 2024

# Super Resolution with Diffusion

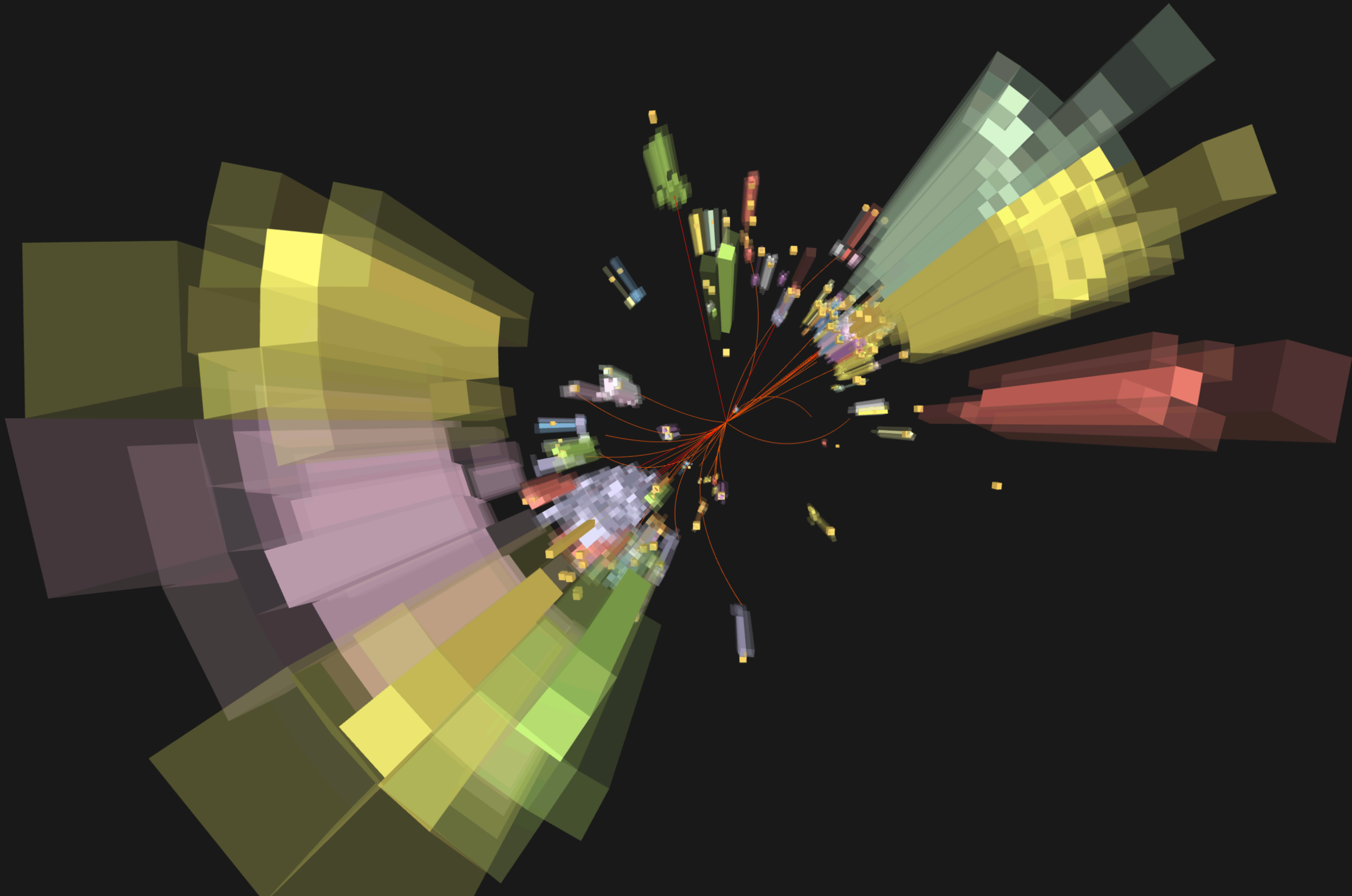
- ◆ Slightly less popular cousin of “text to image with Diffusion”
  - ➔ Quite popular in CV
  - ➔ Feels a bit under-utilized in Particle Physics



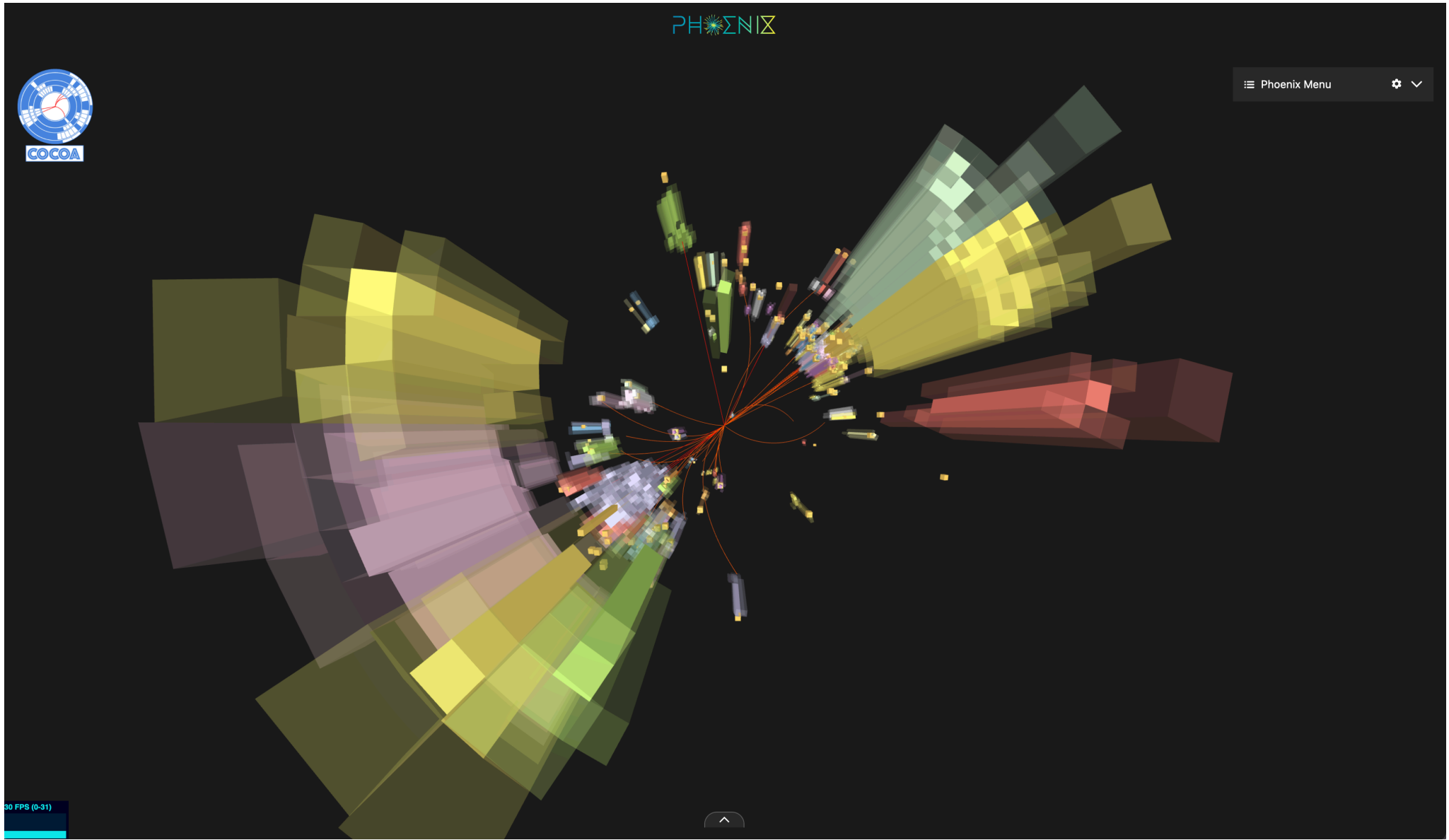






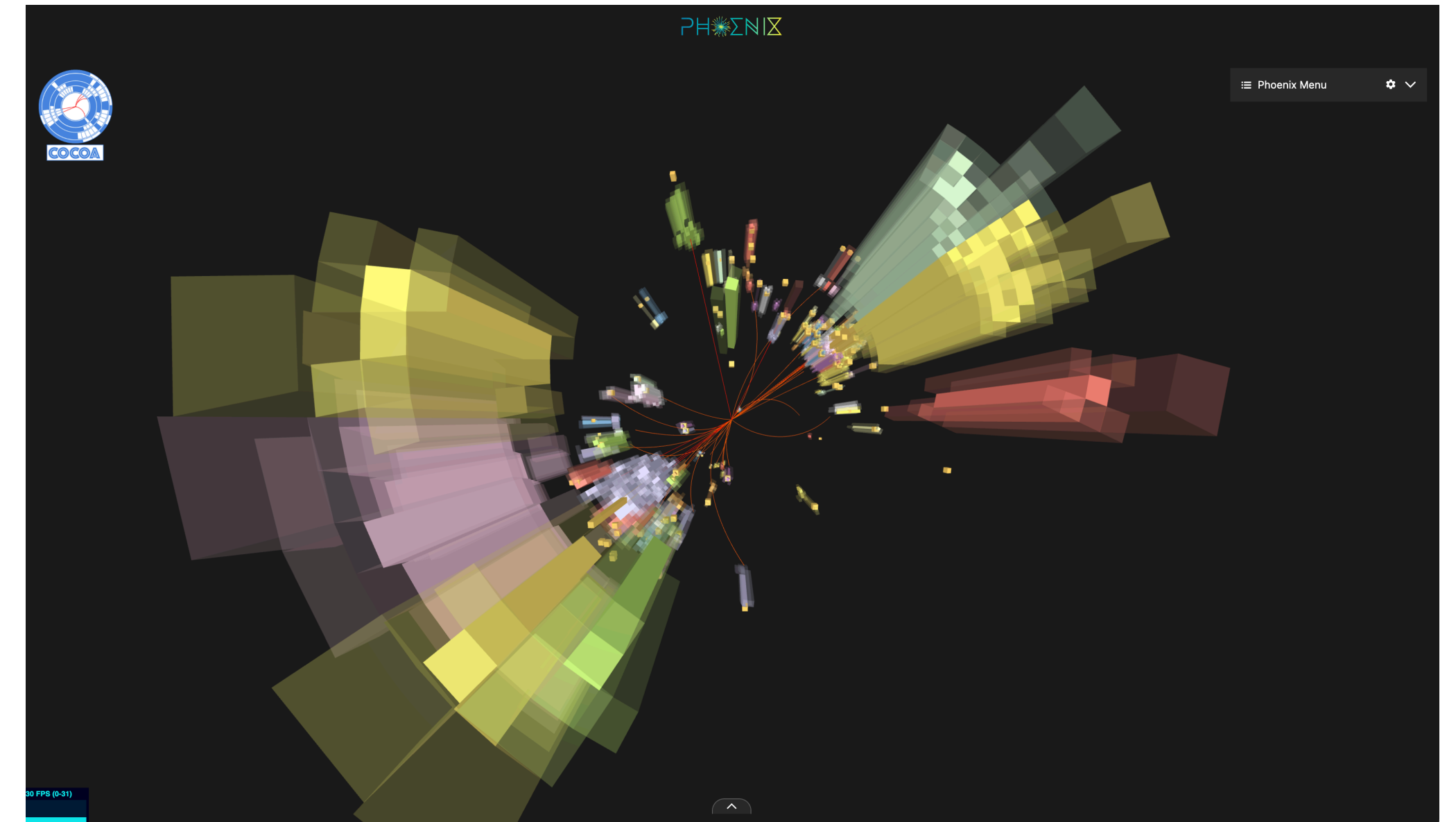


# Why Super Resolution in Particle Physics?



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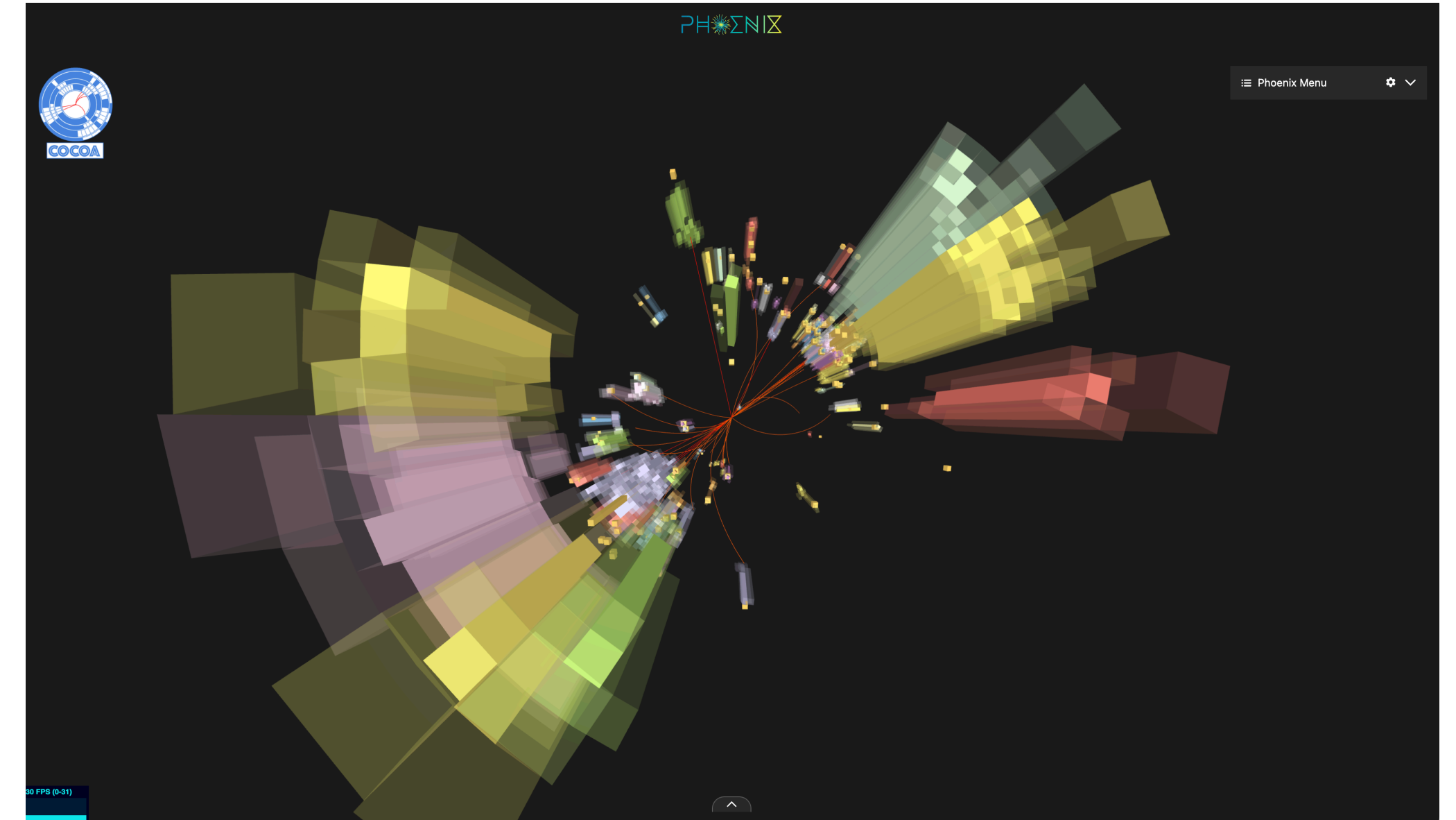
- ◆ Reconstruction quality depends on the detector granularity
  - ➔ More granular -> better reconstruction
  - ➔ Granularity puts a cap on theoretical reconstruction capability





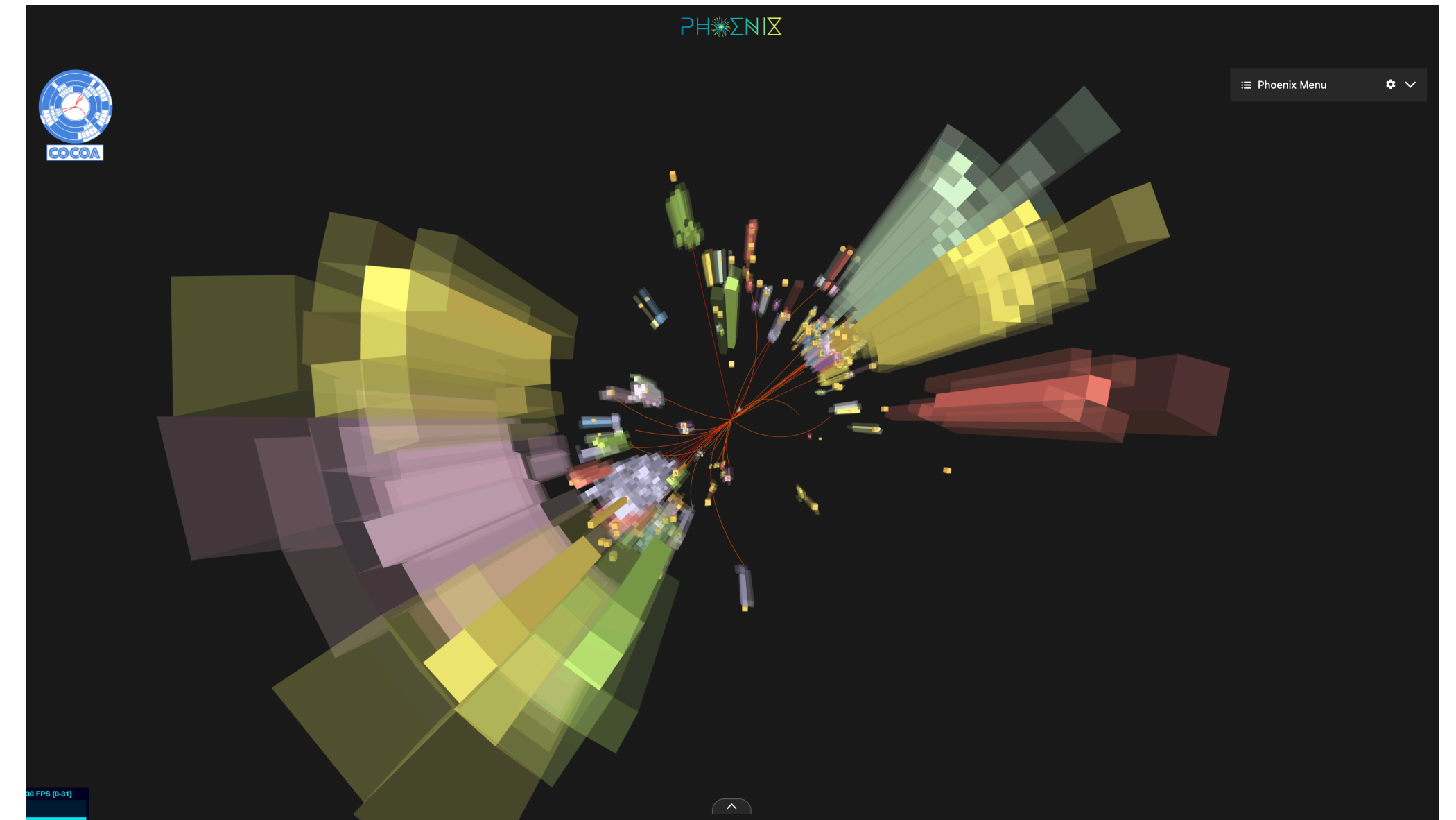
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- ◆ High granularity detectors (simulations) are very expensive!
  - ➔ Increasing resolution in post can be a solution!
- ◆ Graph super resolution is not a common problem in general
  - ➔ Graphs are very natural in Particle Physics
  - ➔ Hence Graph Super resolution

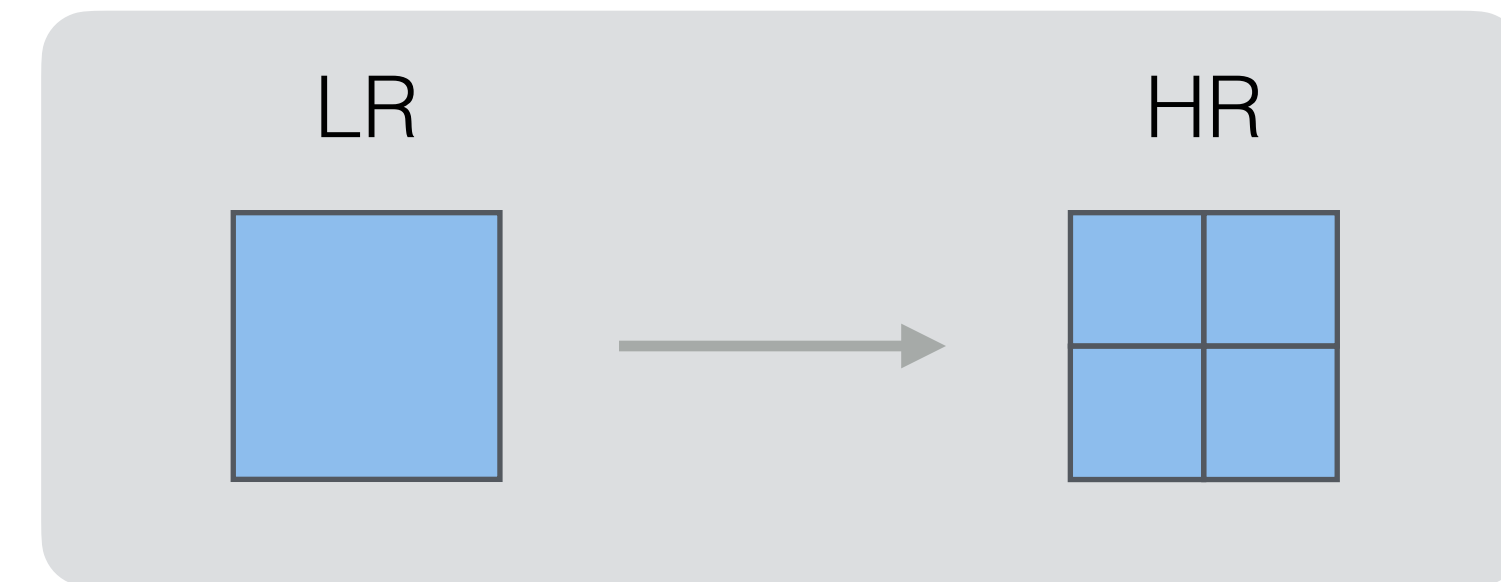


# The SetUp

- ◆ COCOA mod (<https://iopscience.iop.org/article/10.1088/2632-2153/acf186/pdf>)
- ◆ Shooting single electron as a starting point

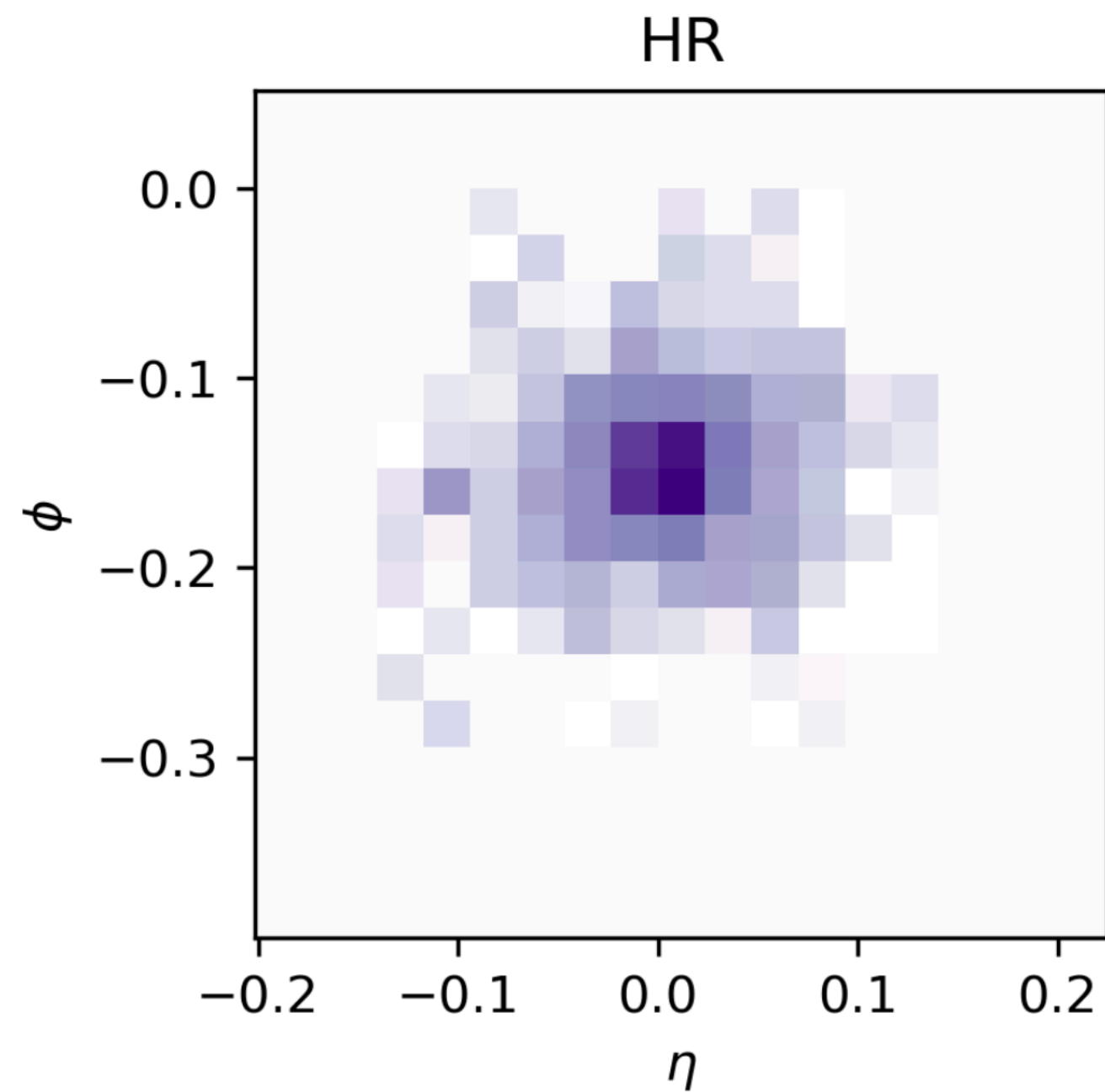
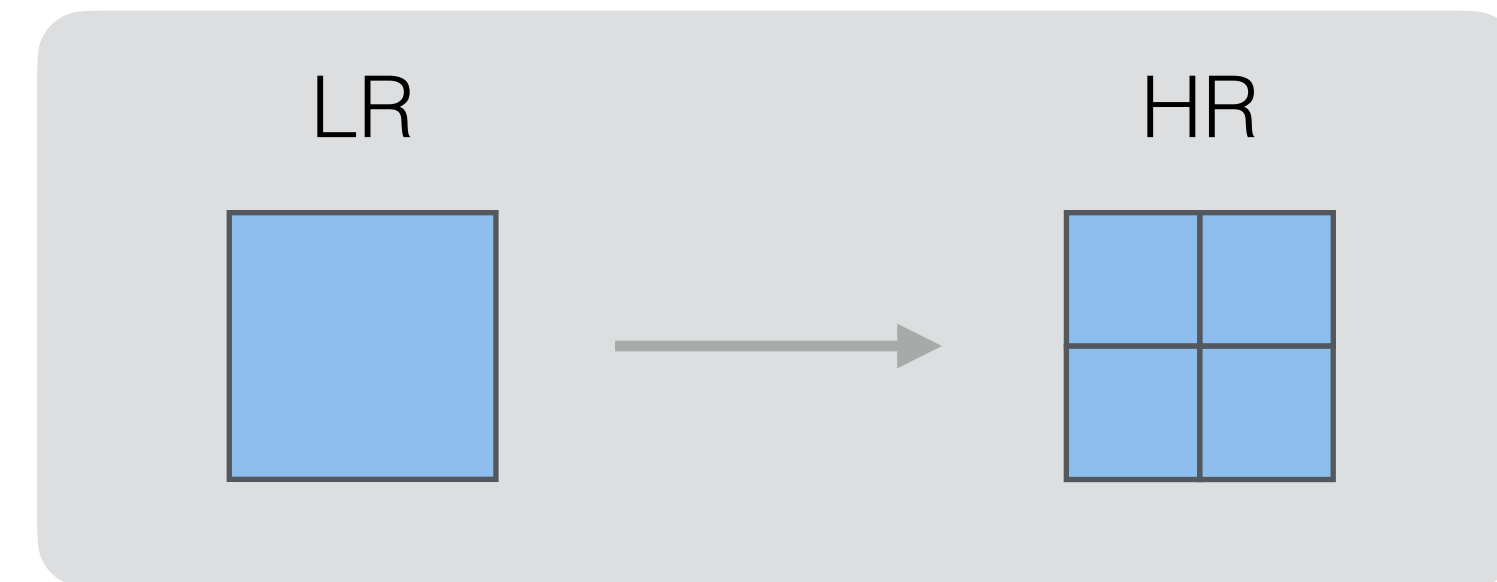
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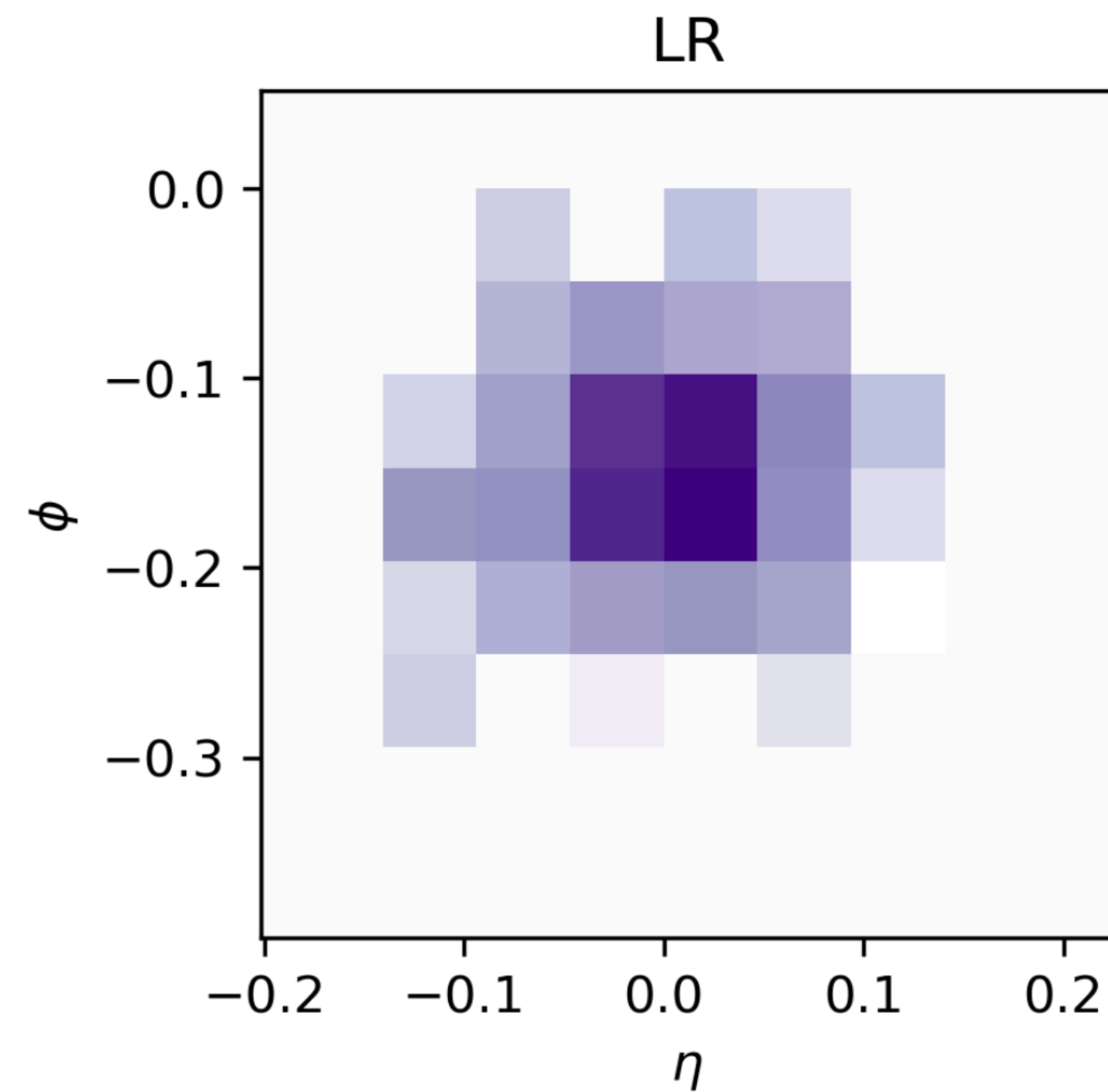
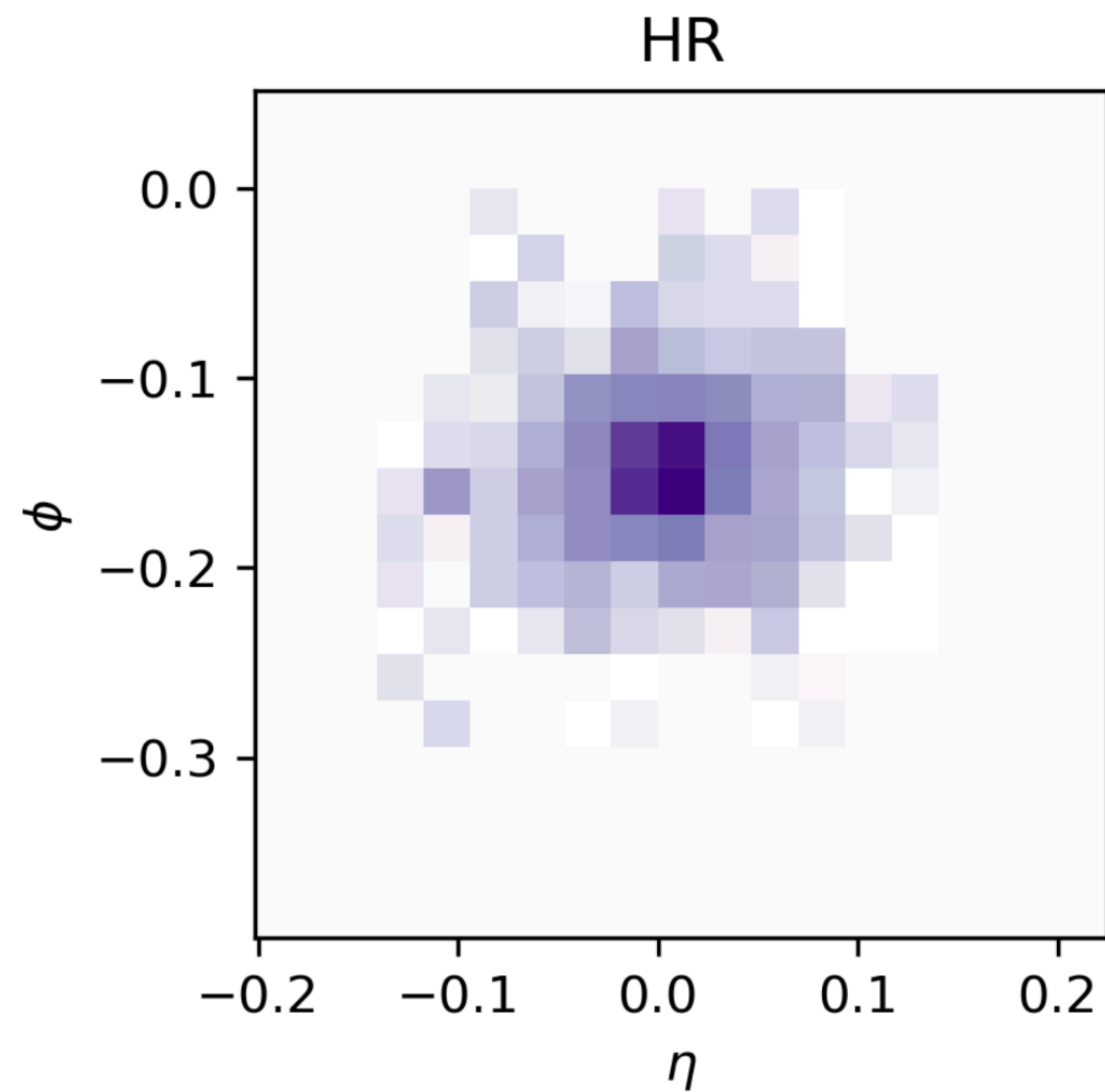
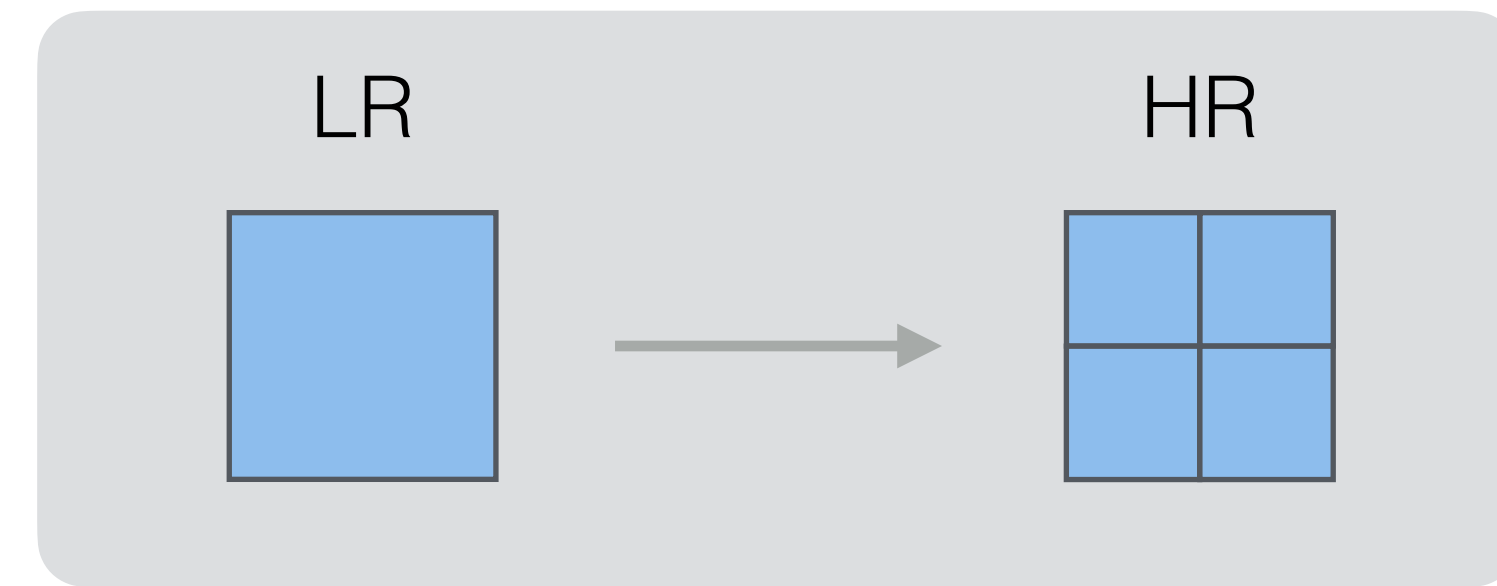
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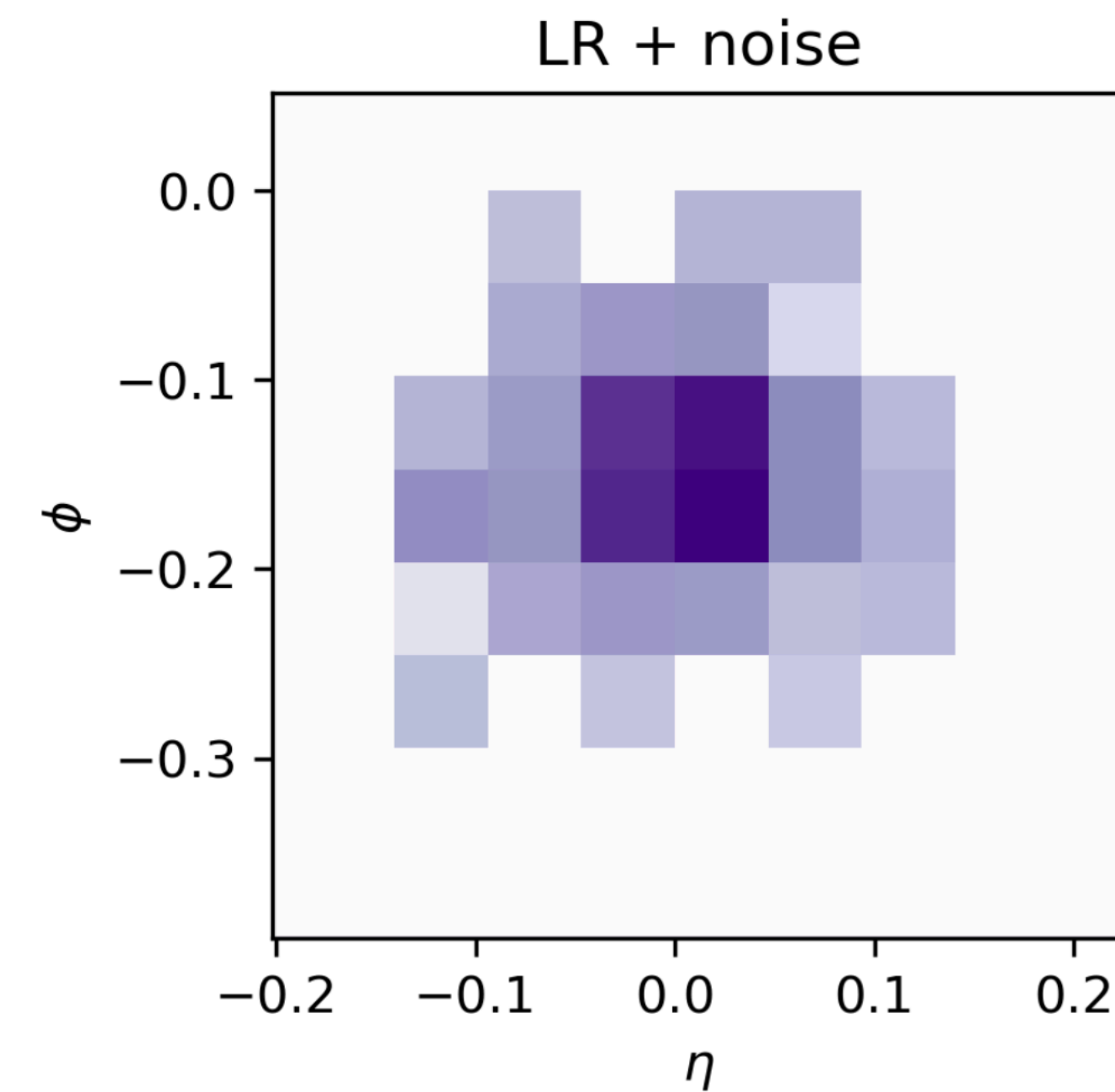
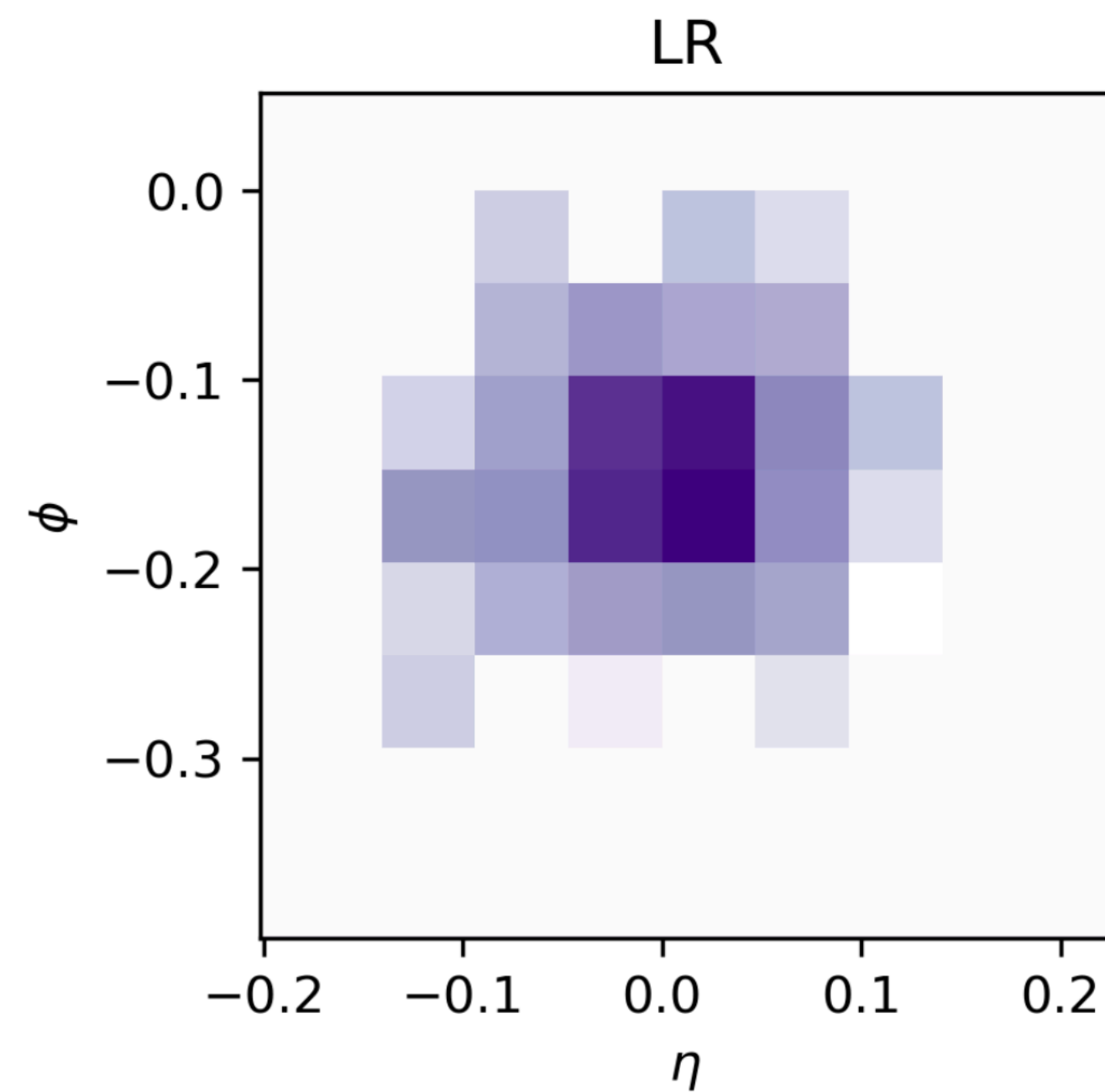
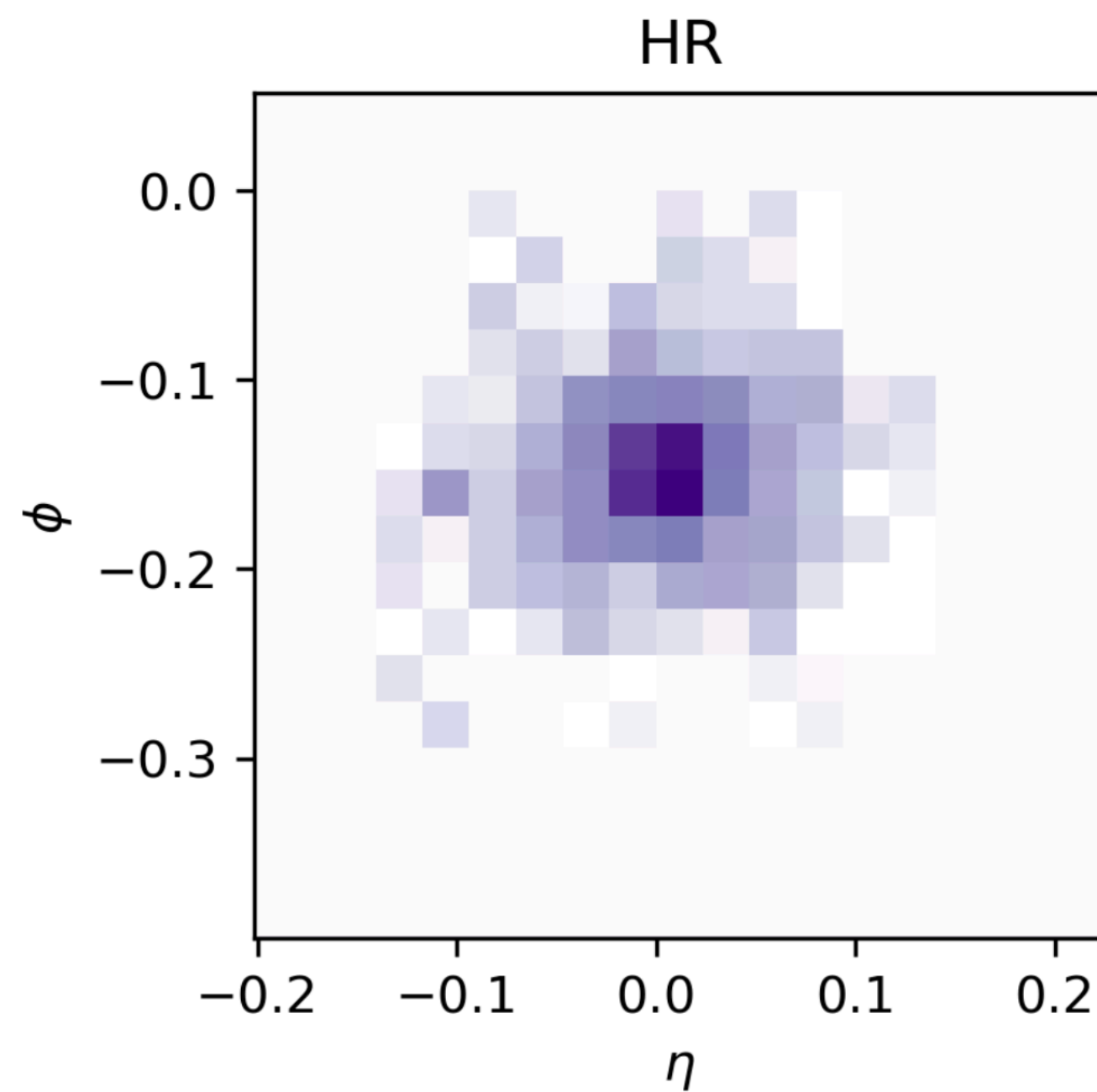
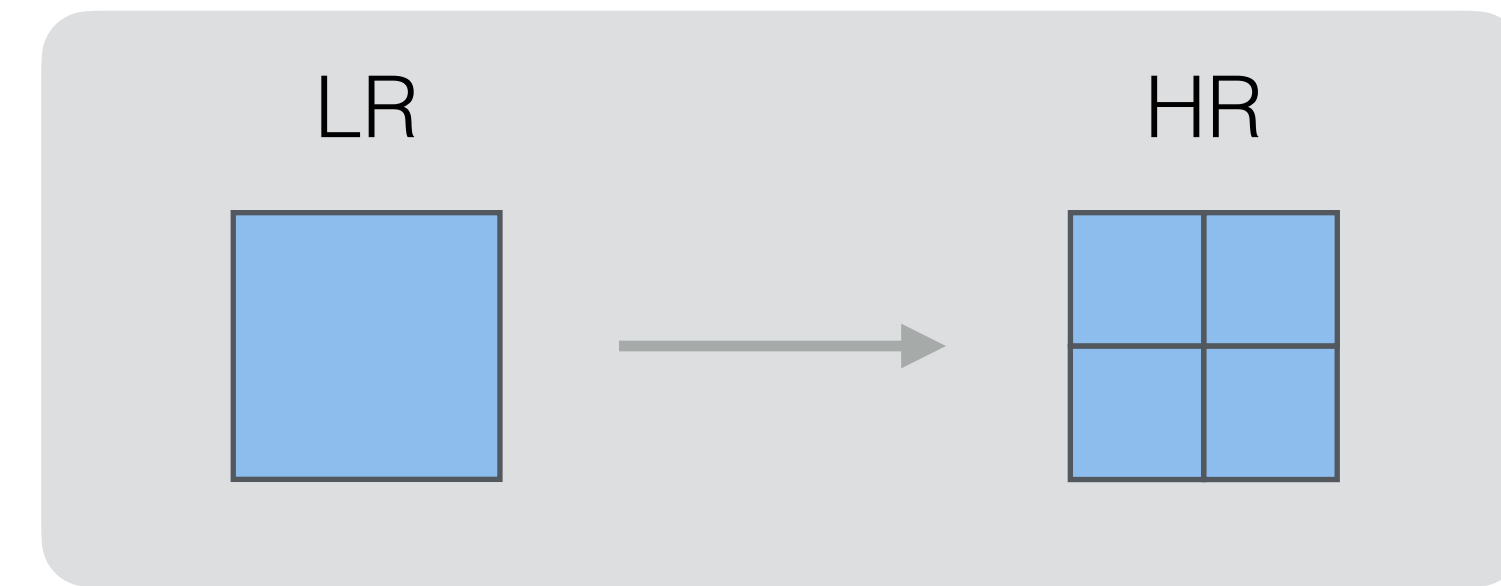
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# Diffusion set up

- ◆ Inspired by the SR3 paper

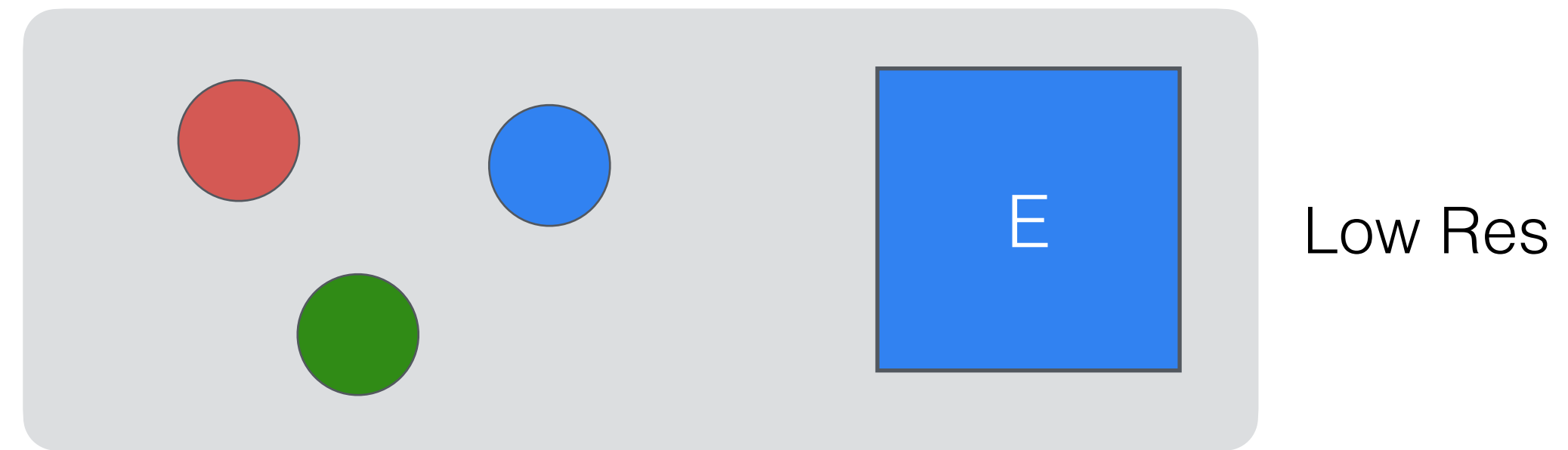
Image Super-Resolution via Iterative Refinement (<https://arxiv.org/pdf/2104.07636.pdf>)



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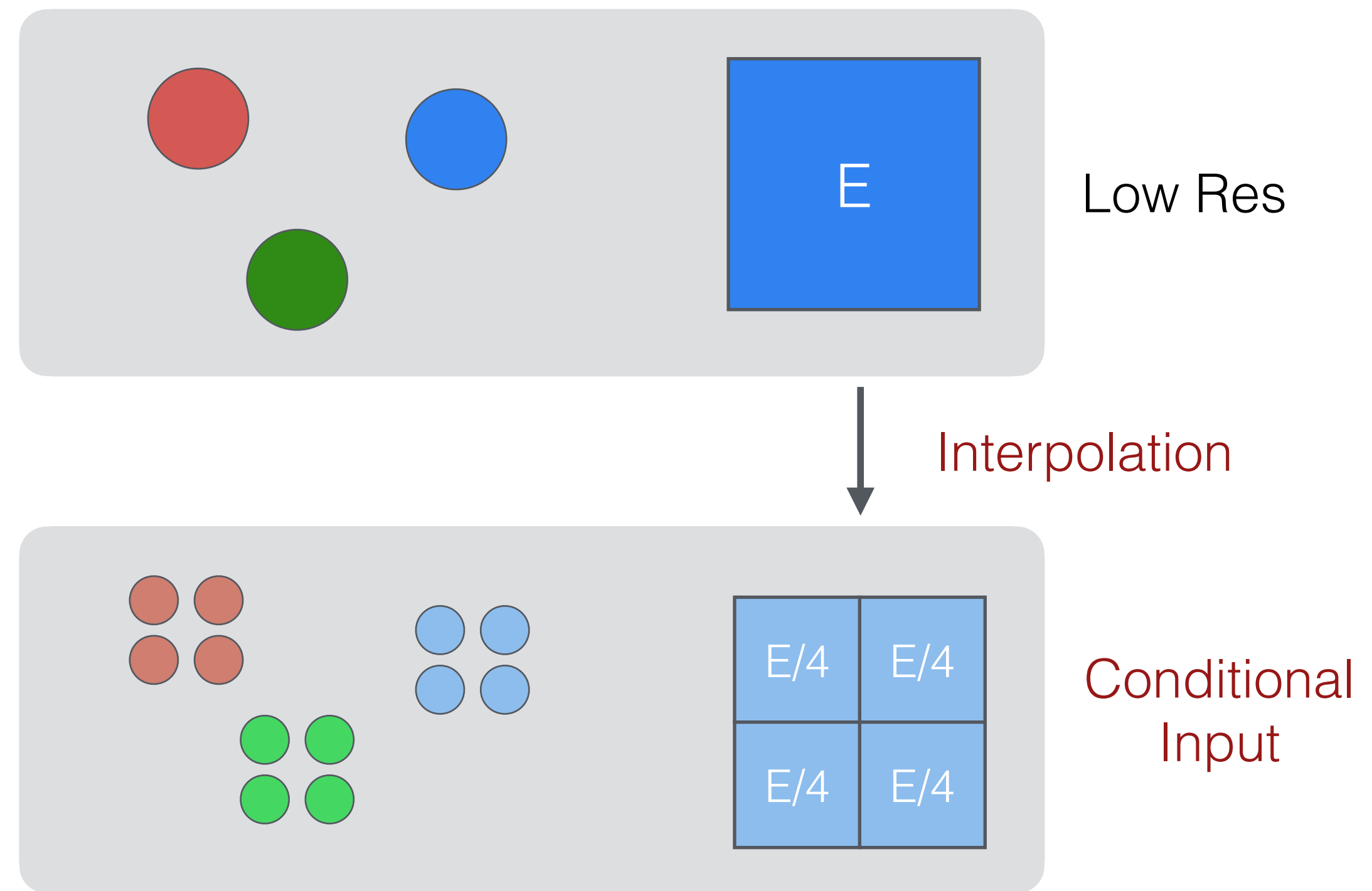
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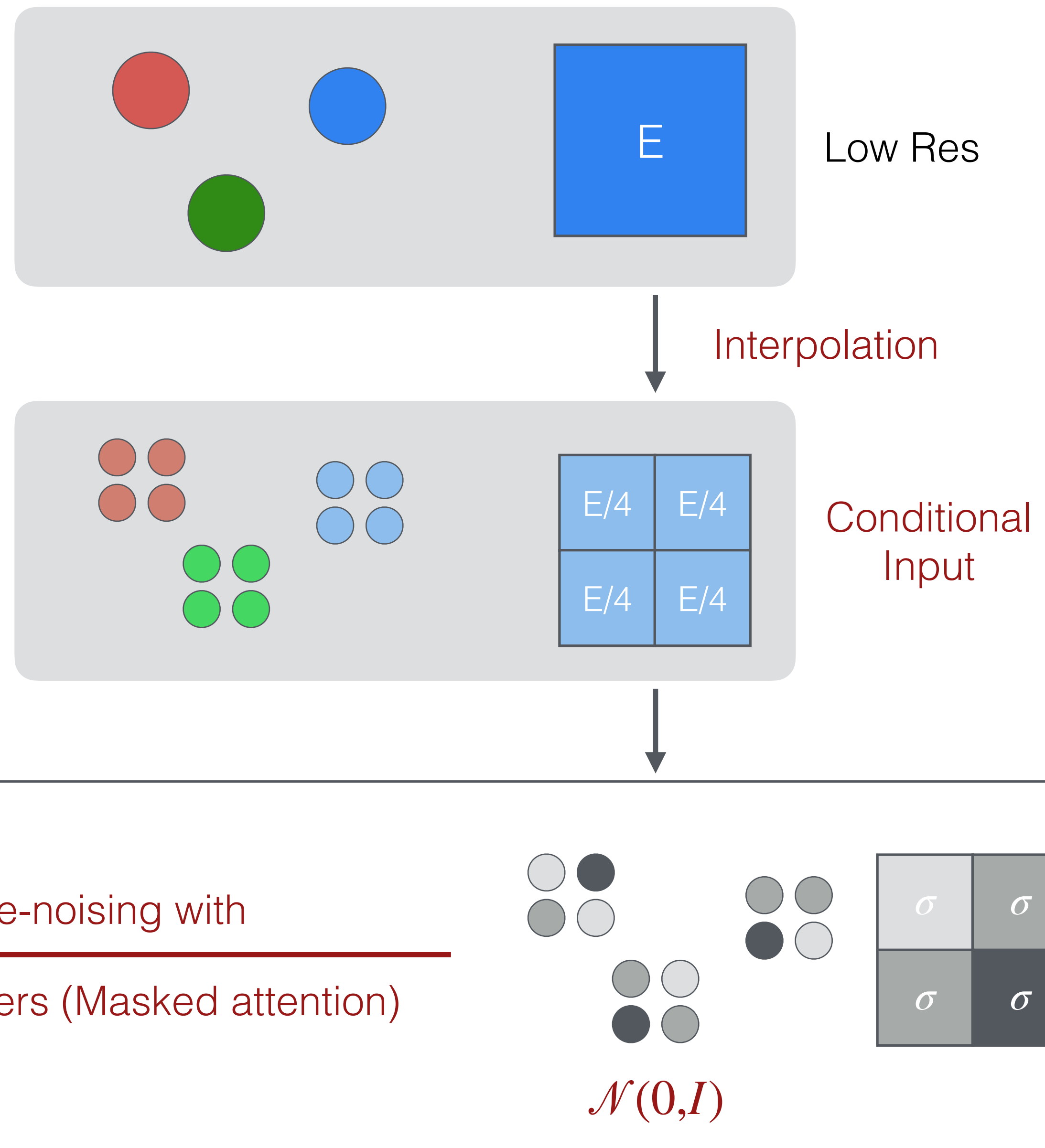
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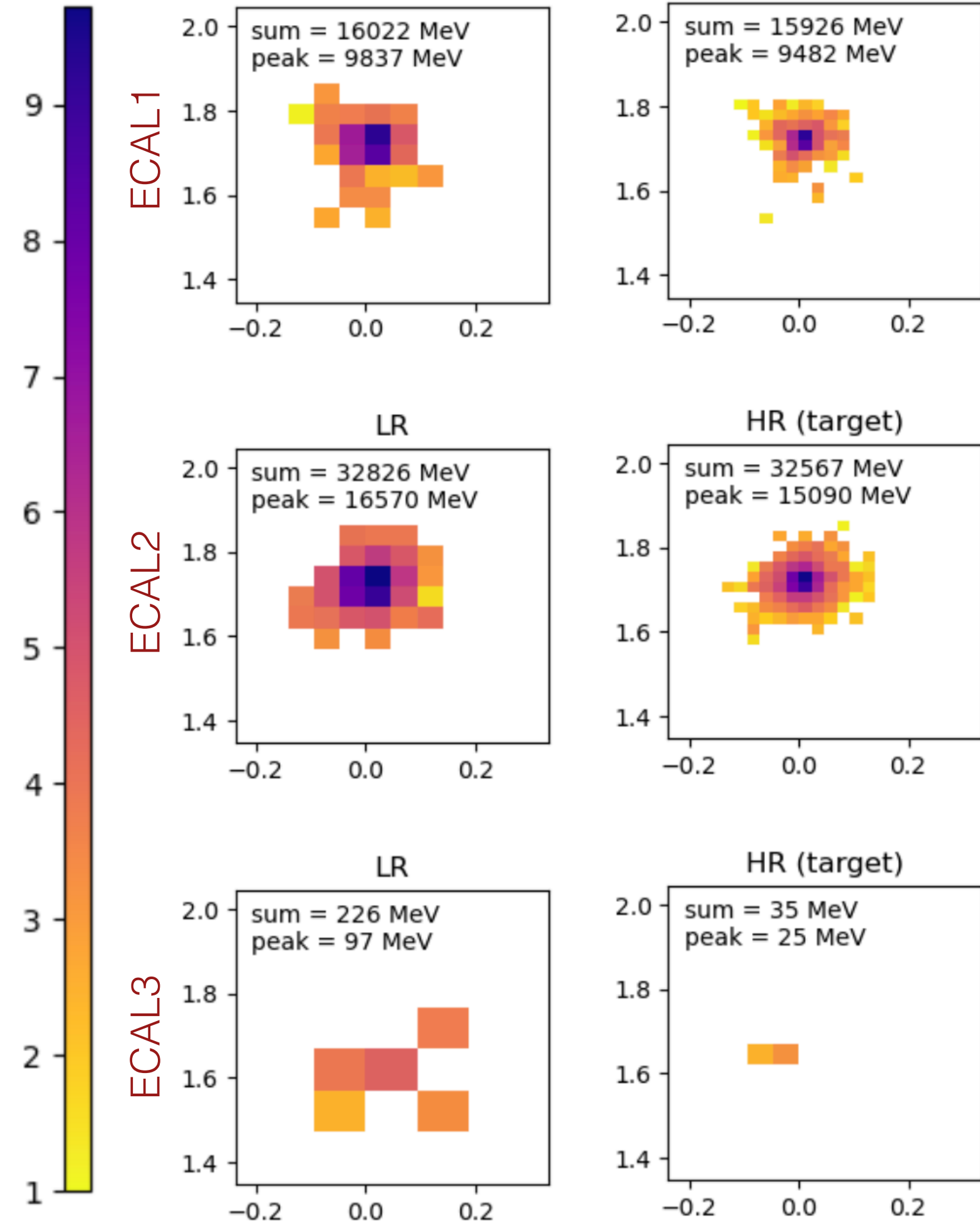
# Sneak peak into the results

LR

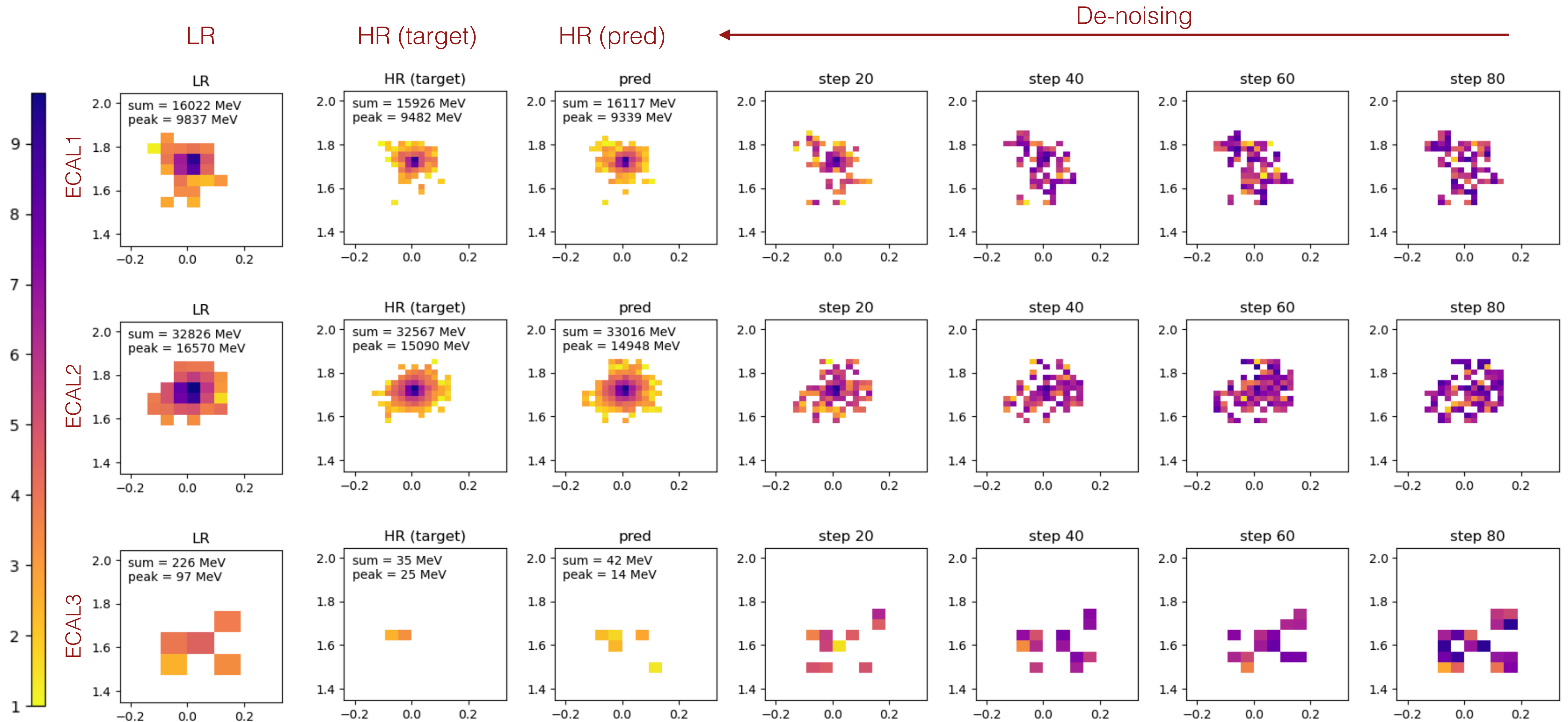
HR (target)

LR

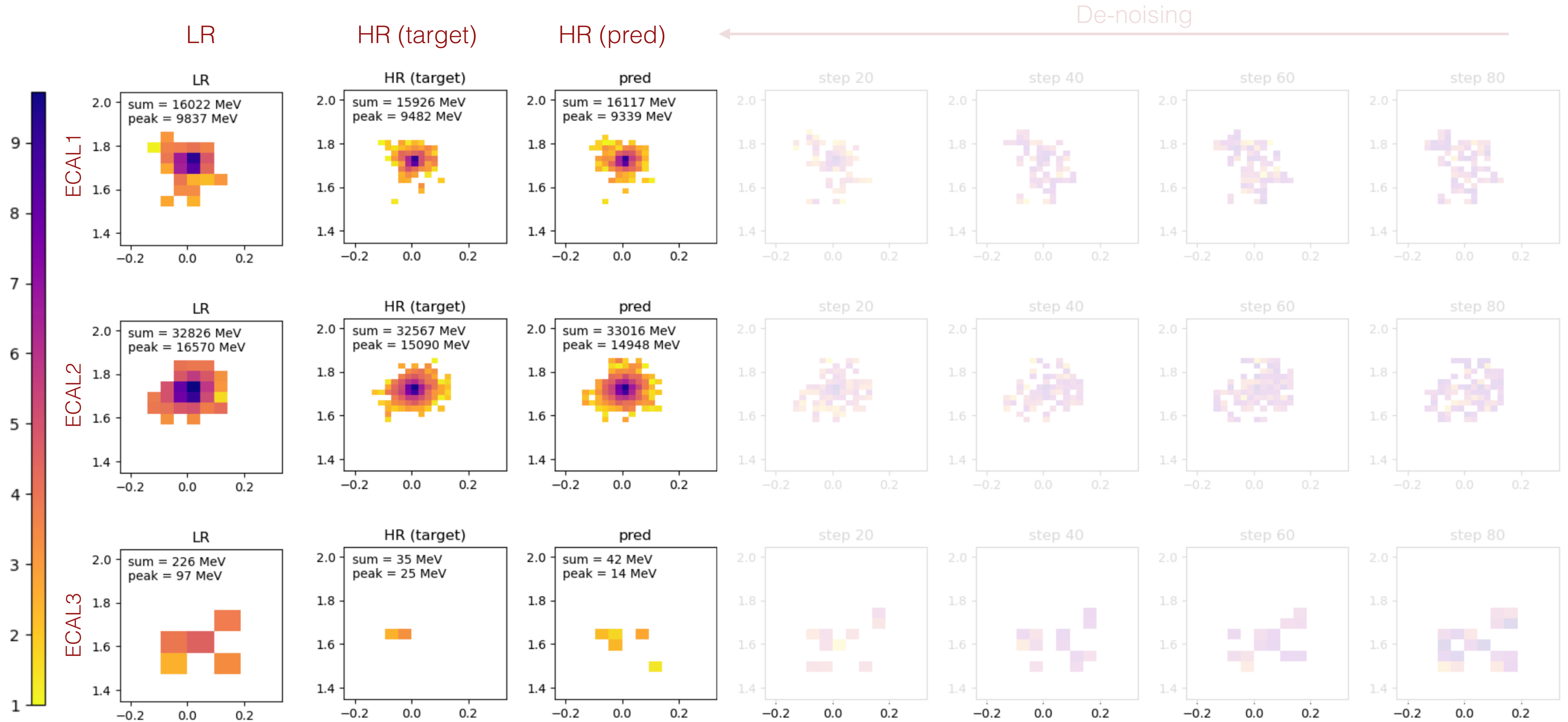
HR (target)



# Sneak peak into the results



# Sneak peak into the results



# De-noising

LR

HR (target)

HR (pred)

De-noising

LR

HR (target)

pred

step 20

step 40

step 60

step 80

LR

HR (target)

pred

step 20

step 40

step 60

step 80

LR

HR (target)

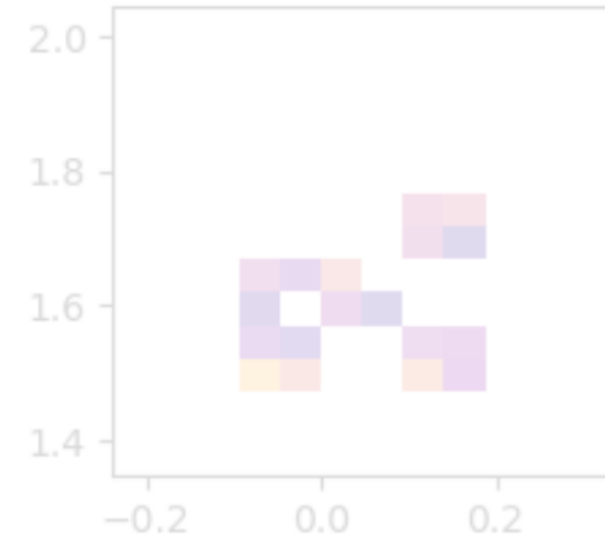
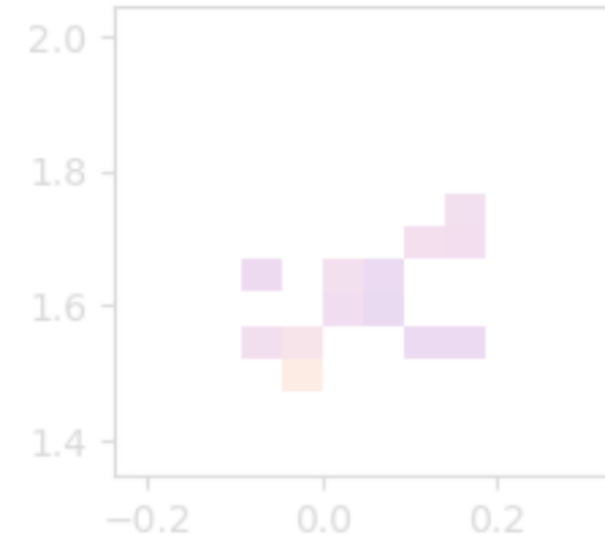
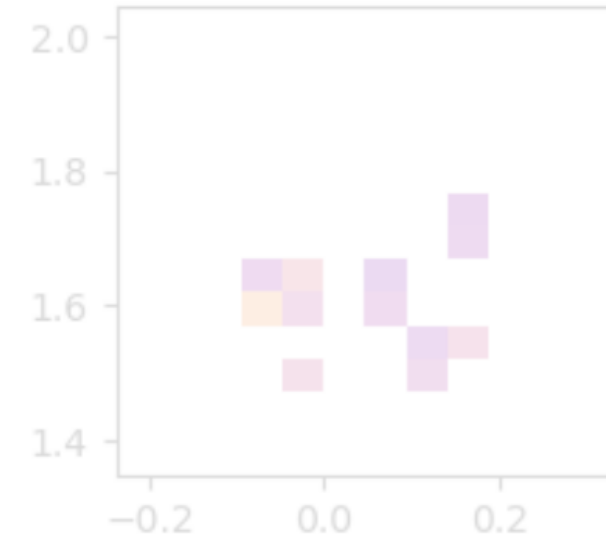
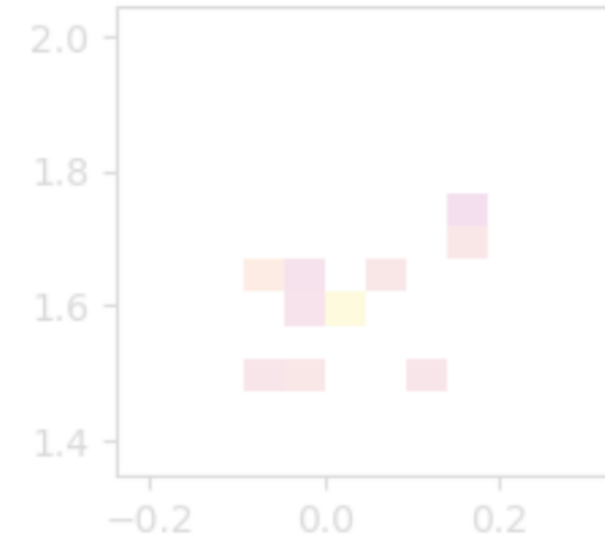
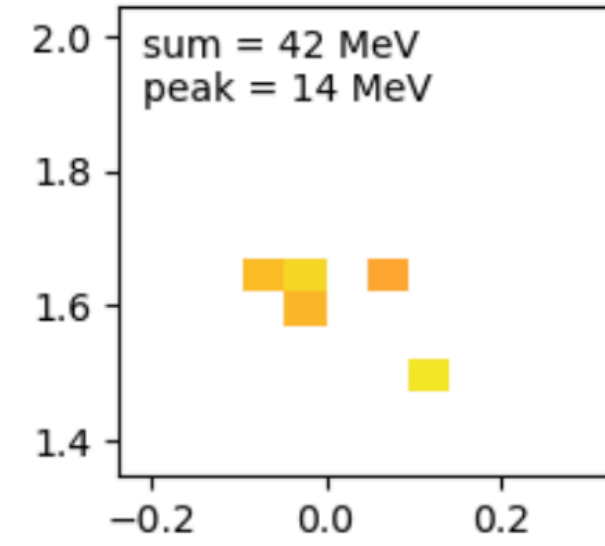
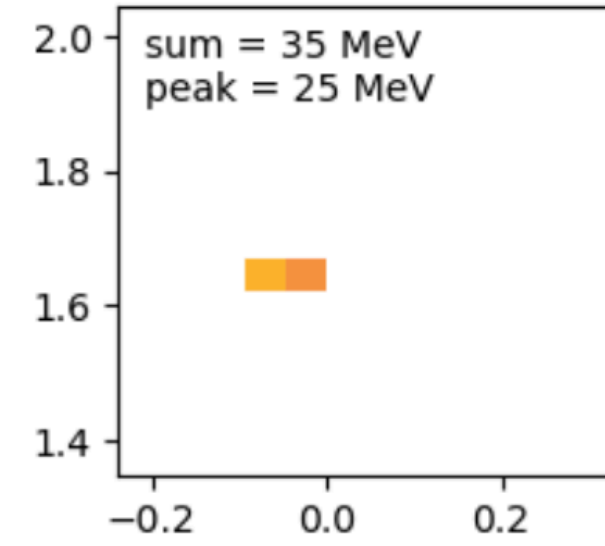
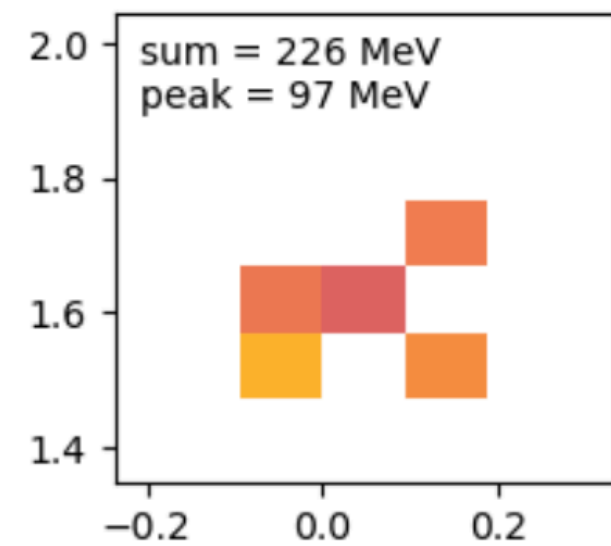
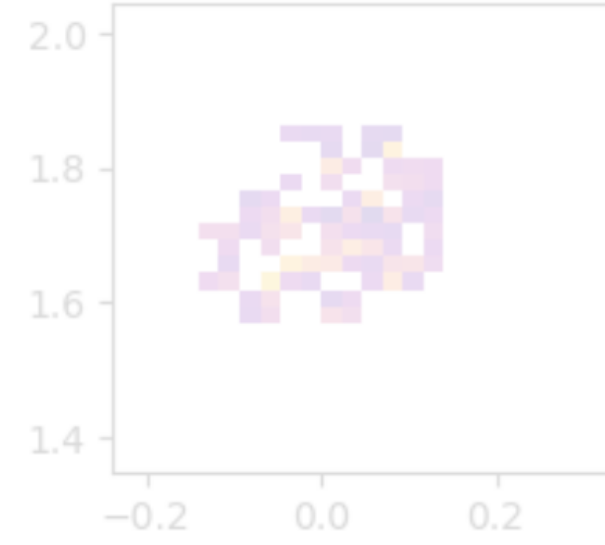
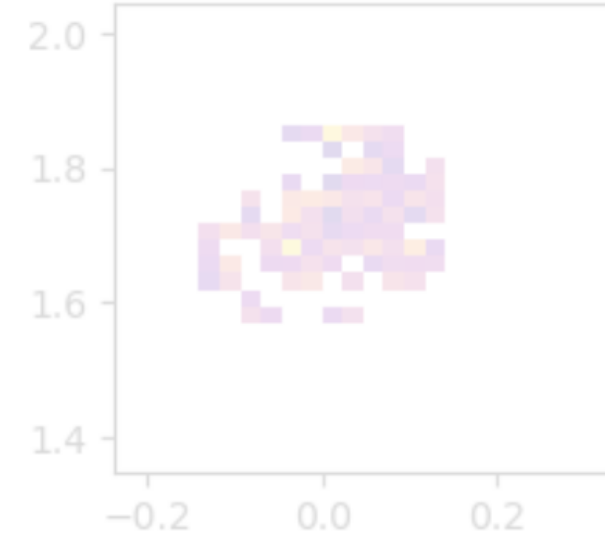
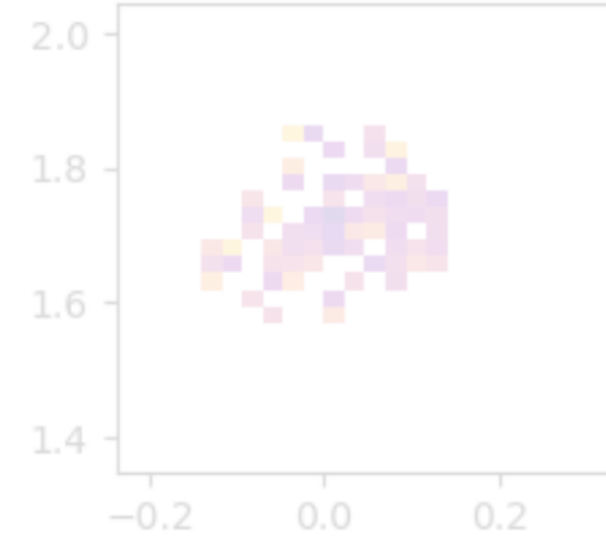
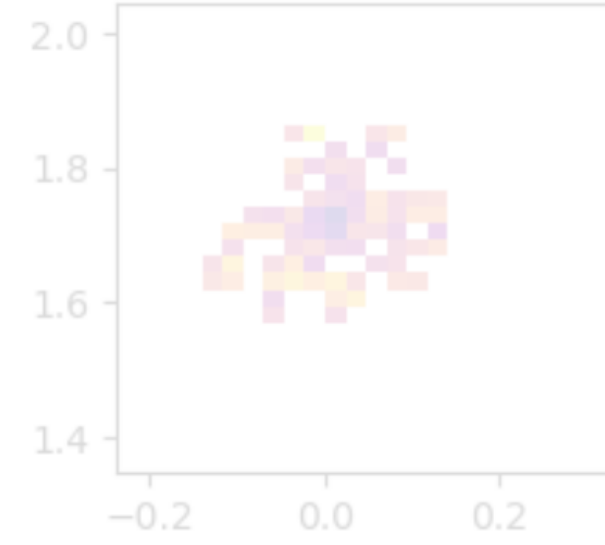
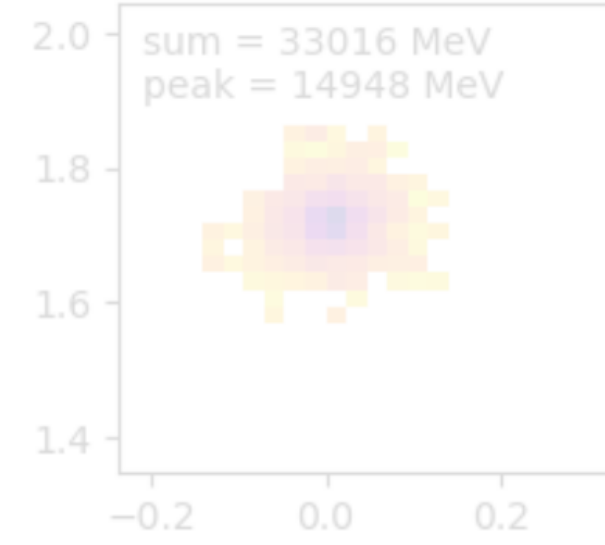
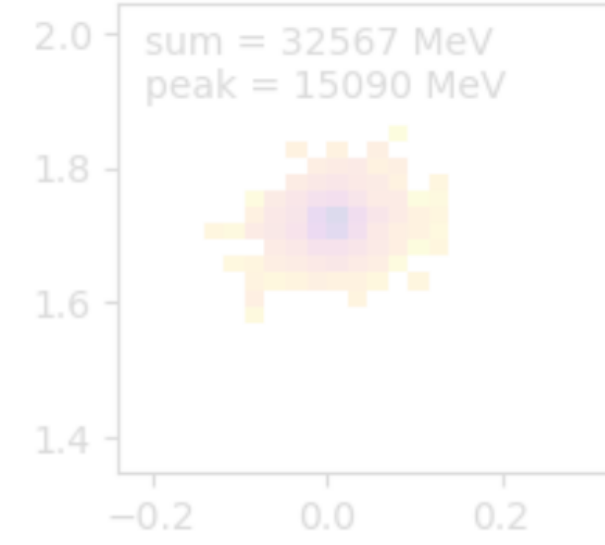
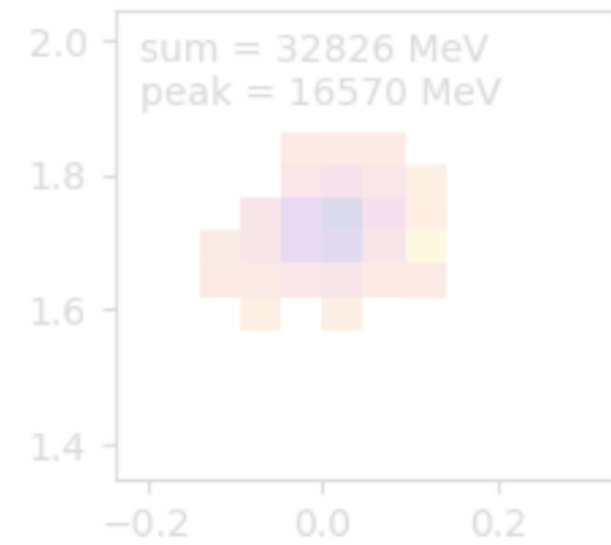
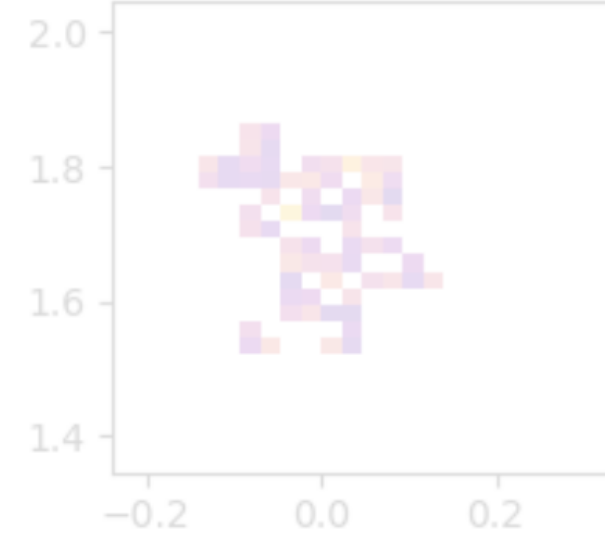
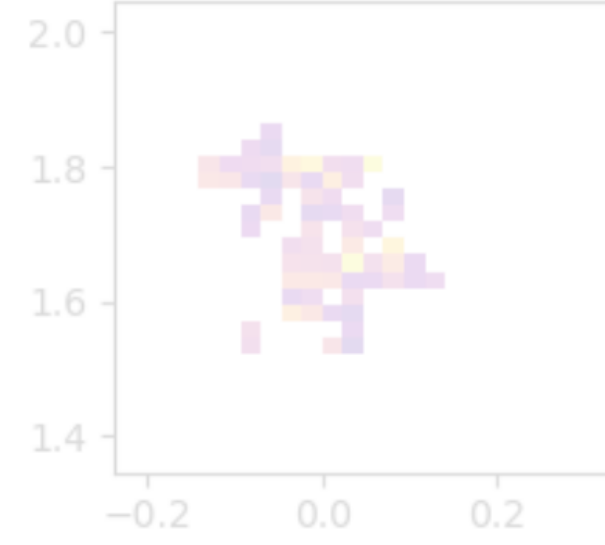
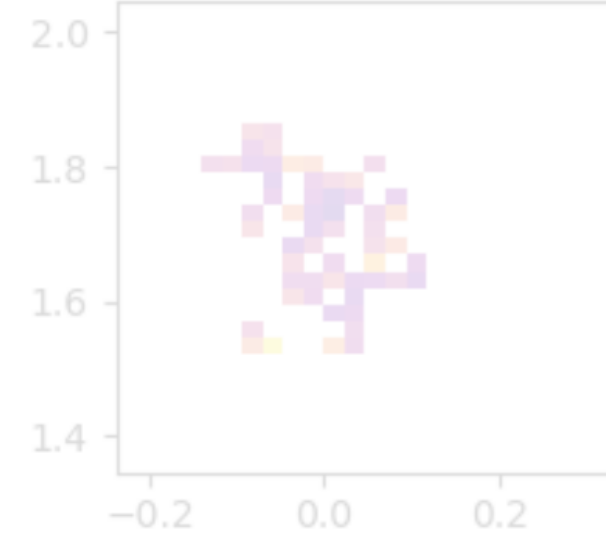
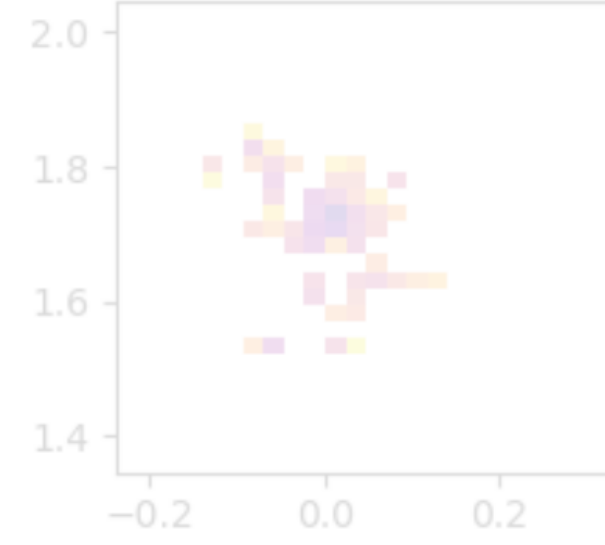
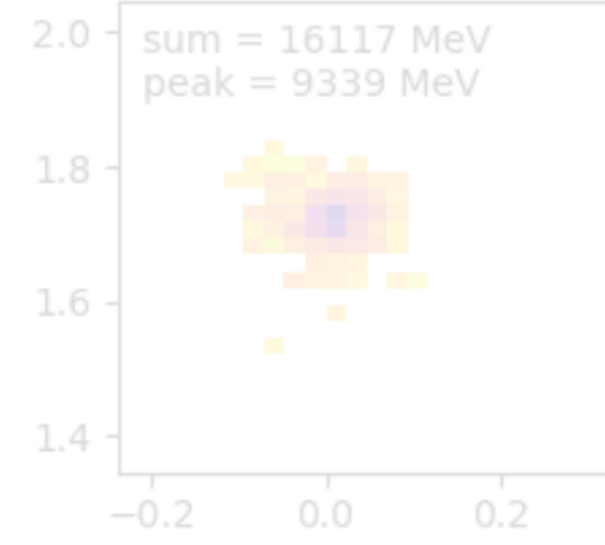
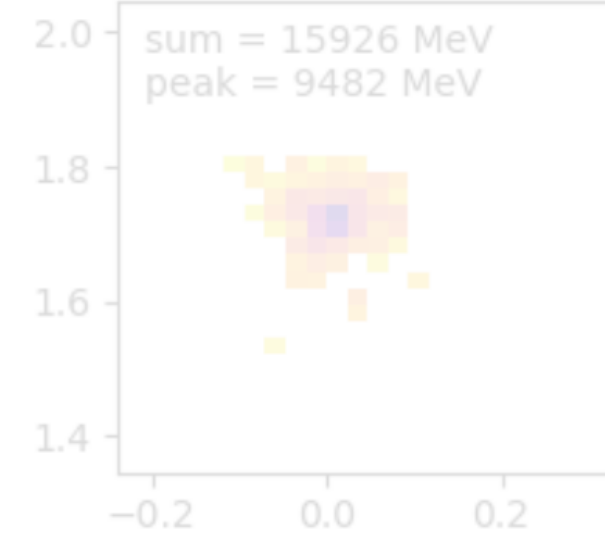
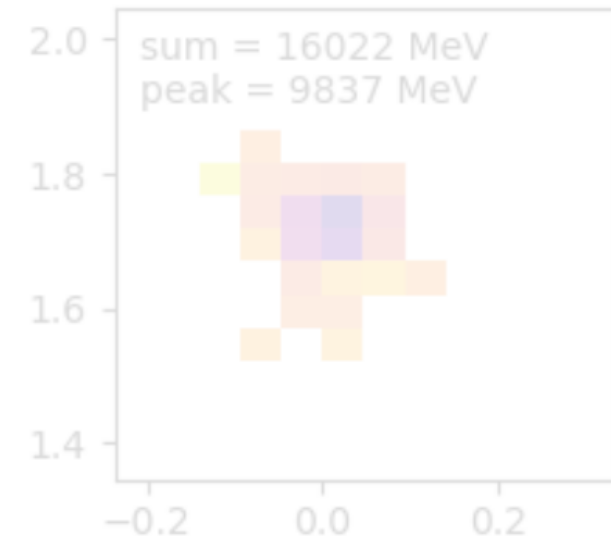
pred

step 20

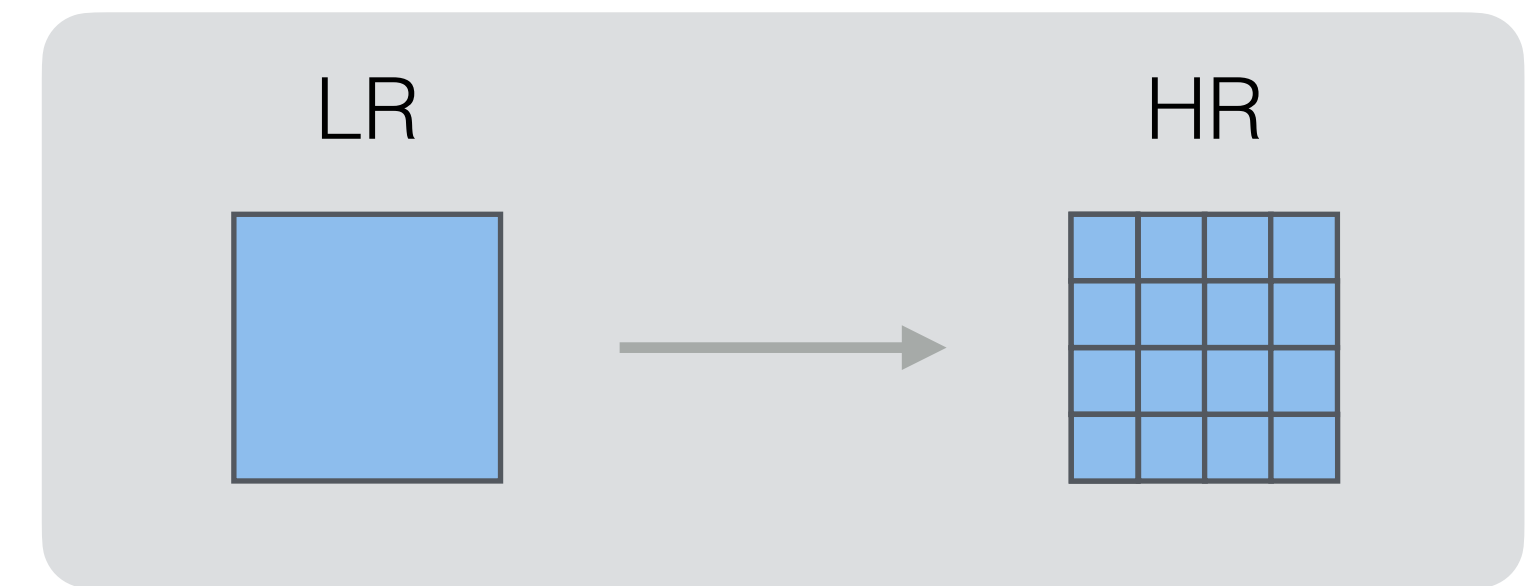
step 40

step 60

step 80



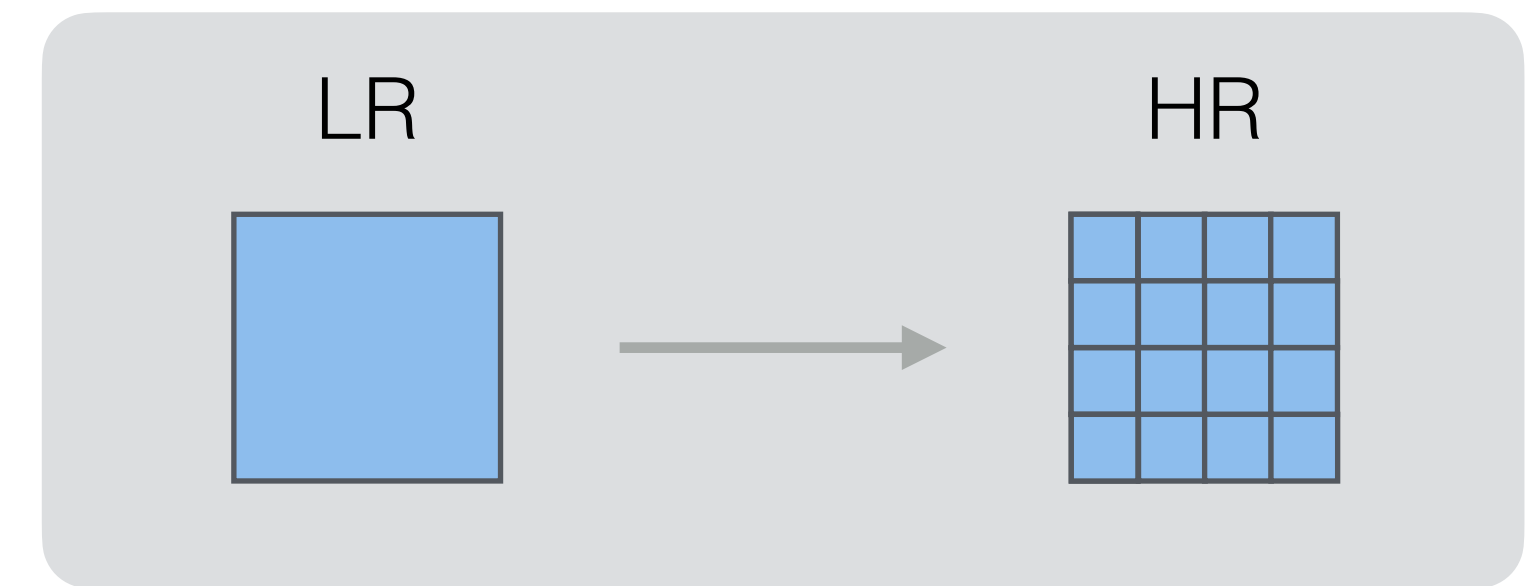
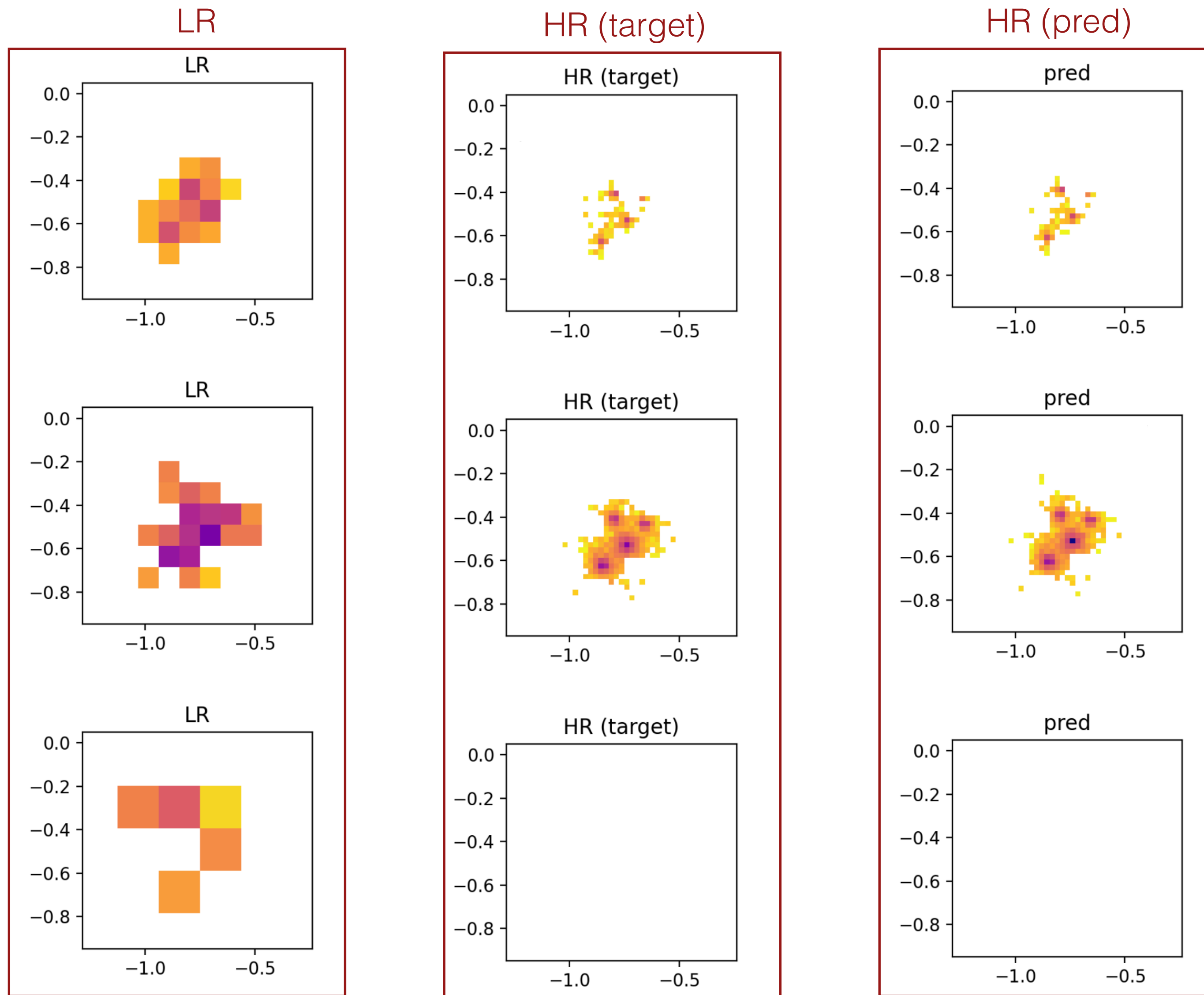
# A more Interesting case!



- Multiple particles
- 1-5 particles
- Electrons and photons



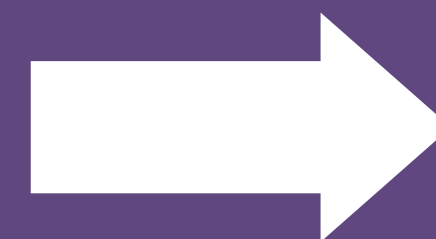
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*example for demonstration*

**Is it  
hallucination?**



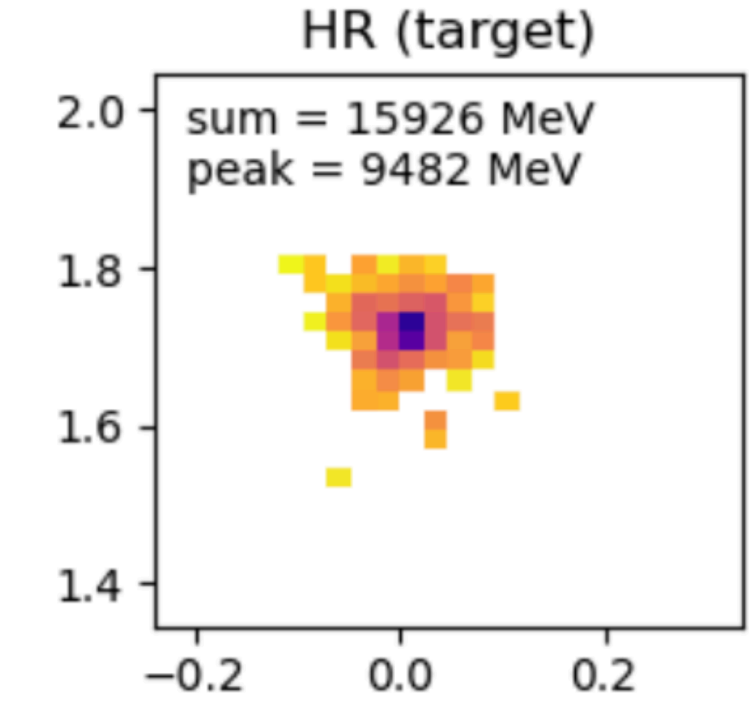
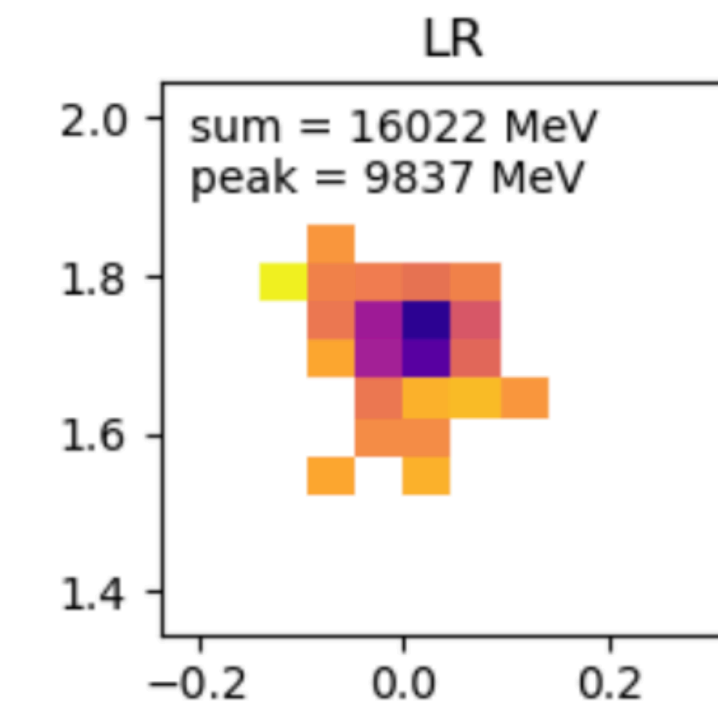
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*Creating information out of nowhere?*

# Where does the extra info come from?

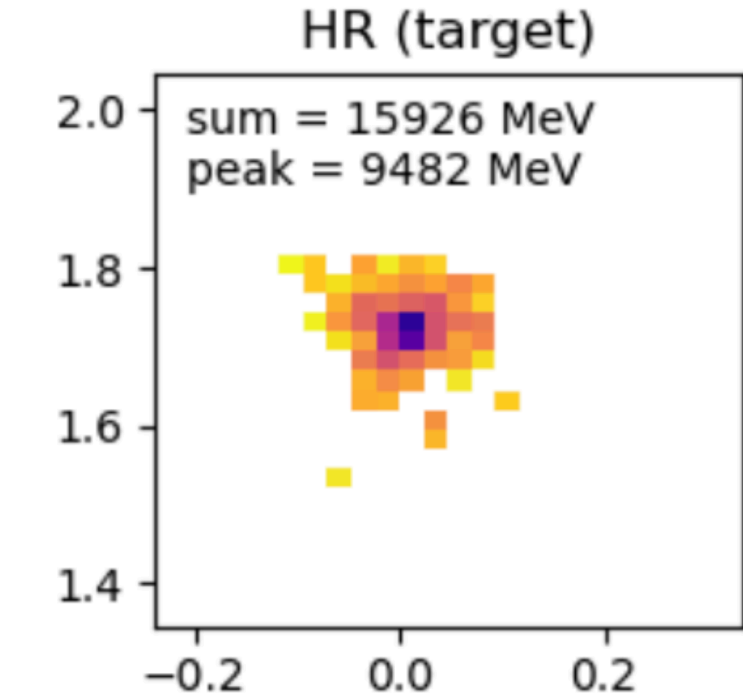
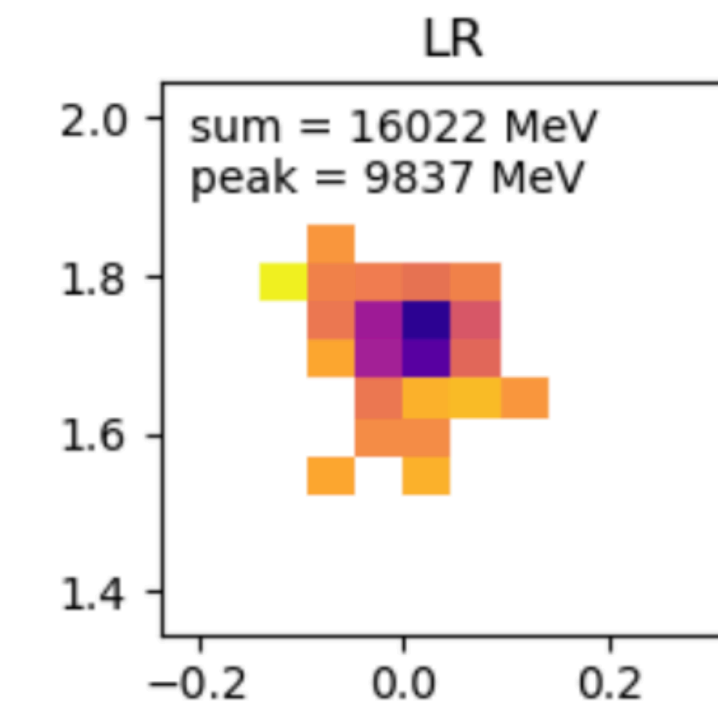
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- ◆ From training data!
  - ➔ Energy deposition, by let's say a photon, is not random
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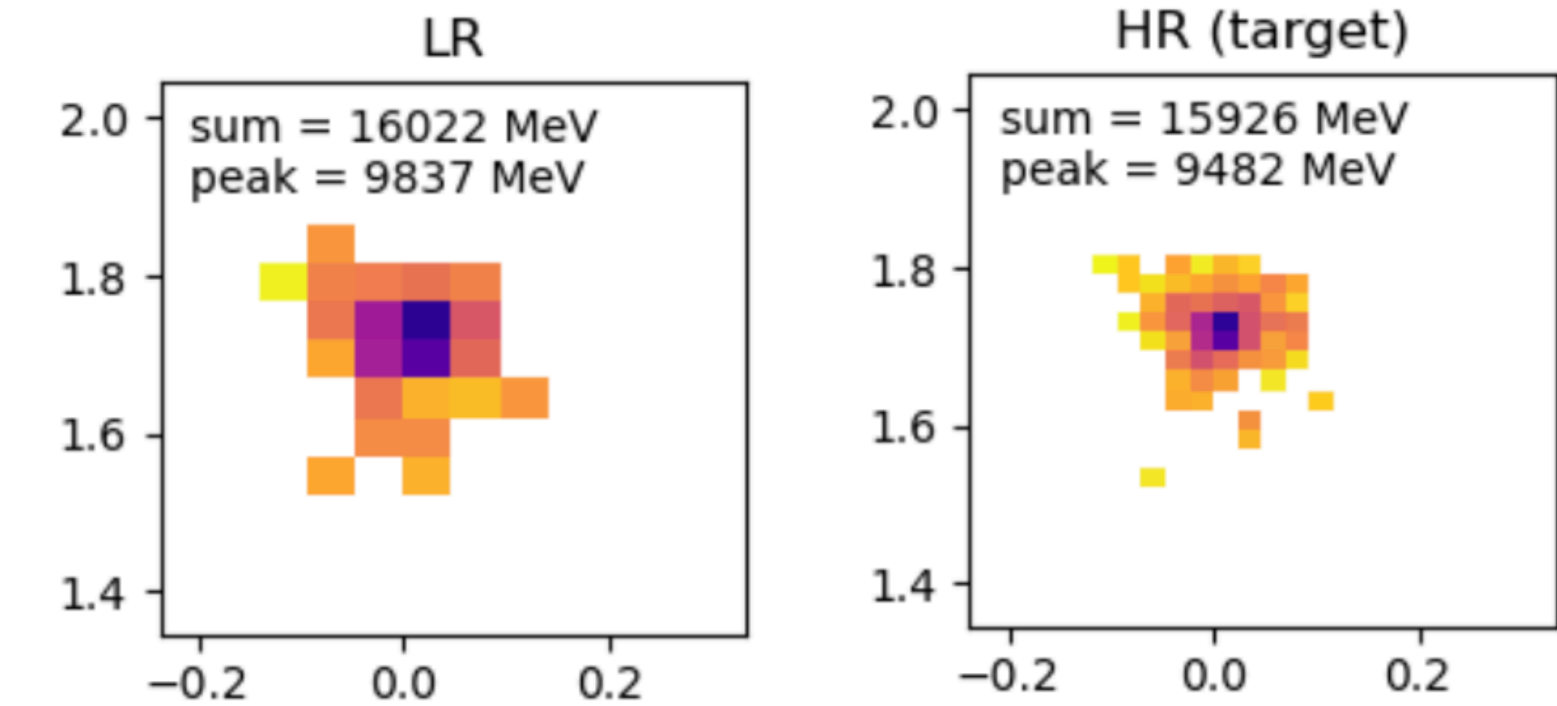
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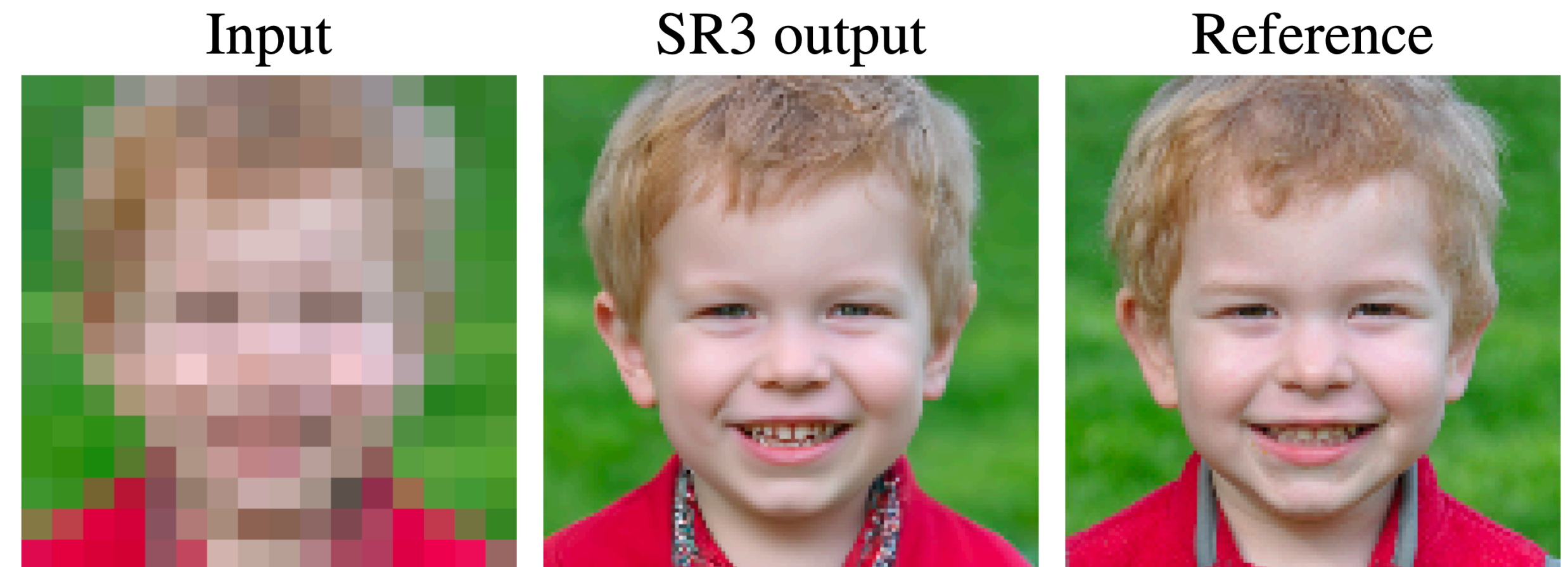


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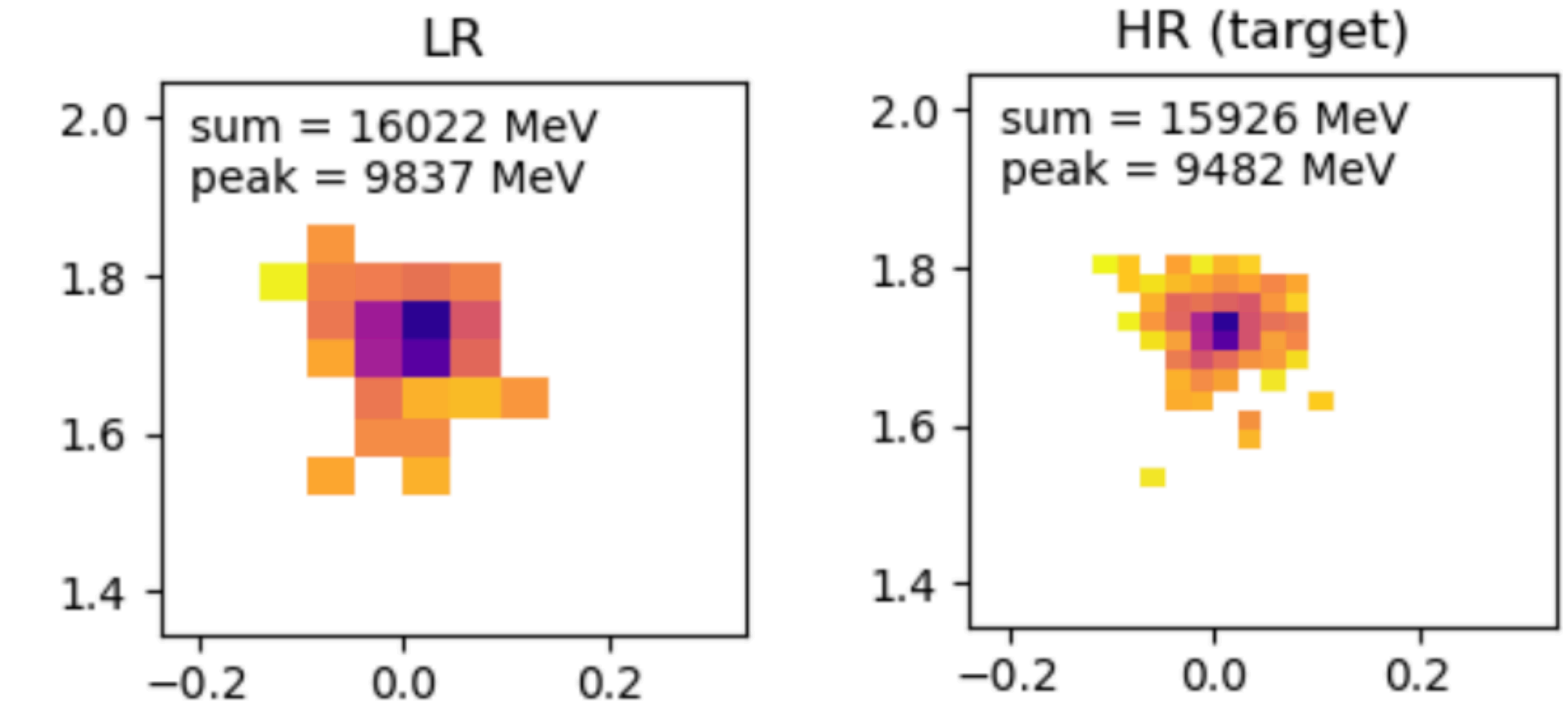


- ◆ HR output = **Educated estimation** of the model based on the **patterns learned from the training data**
  - ➔ Similar to how SR work in Computer vision



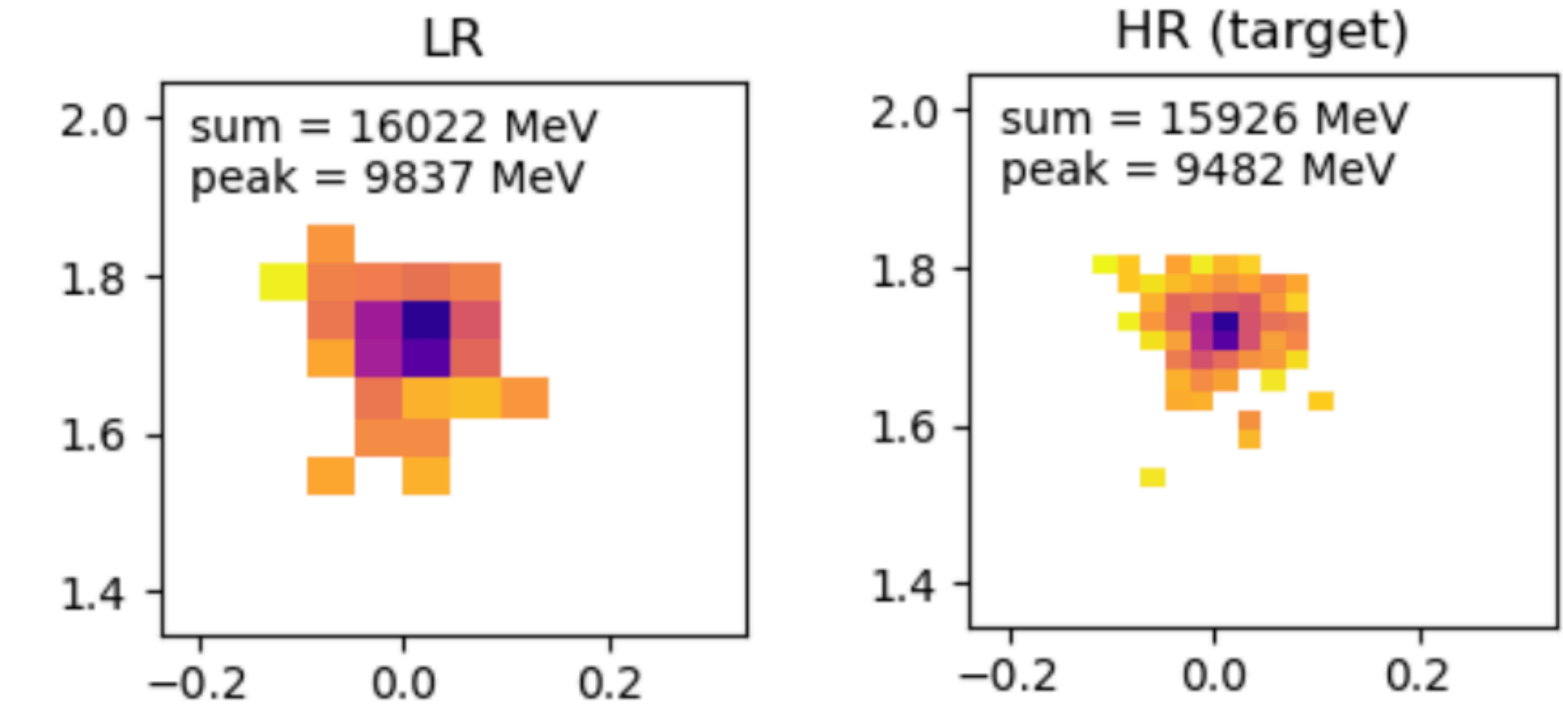
SR3: <https://arxiv.org/pdf/2104.07636.pdf>

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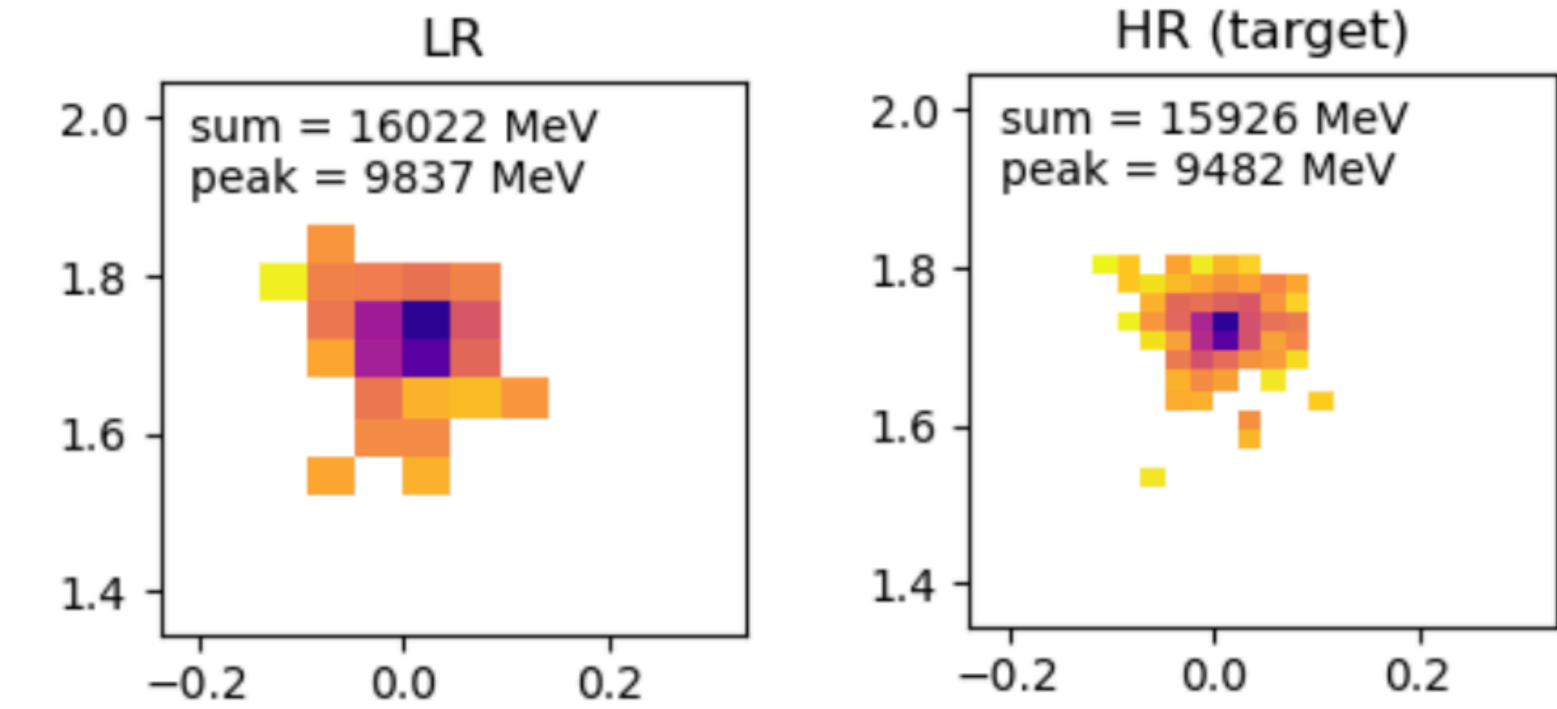
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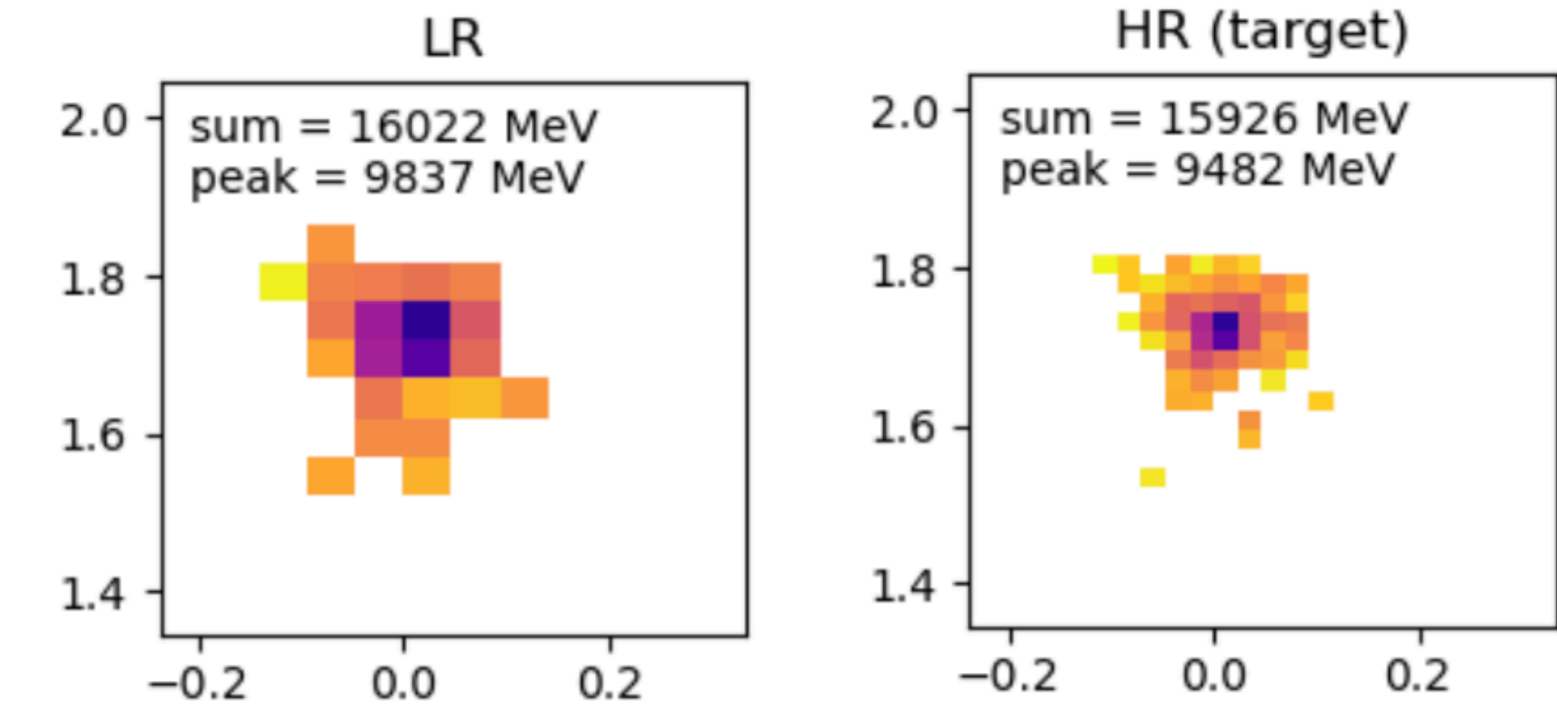
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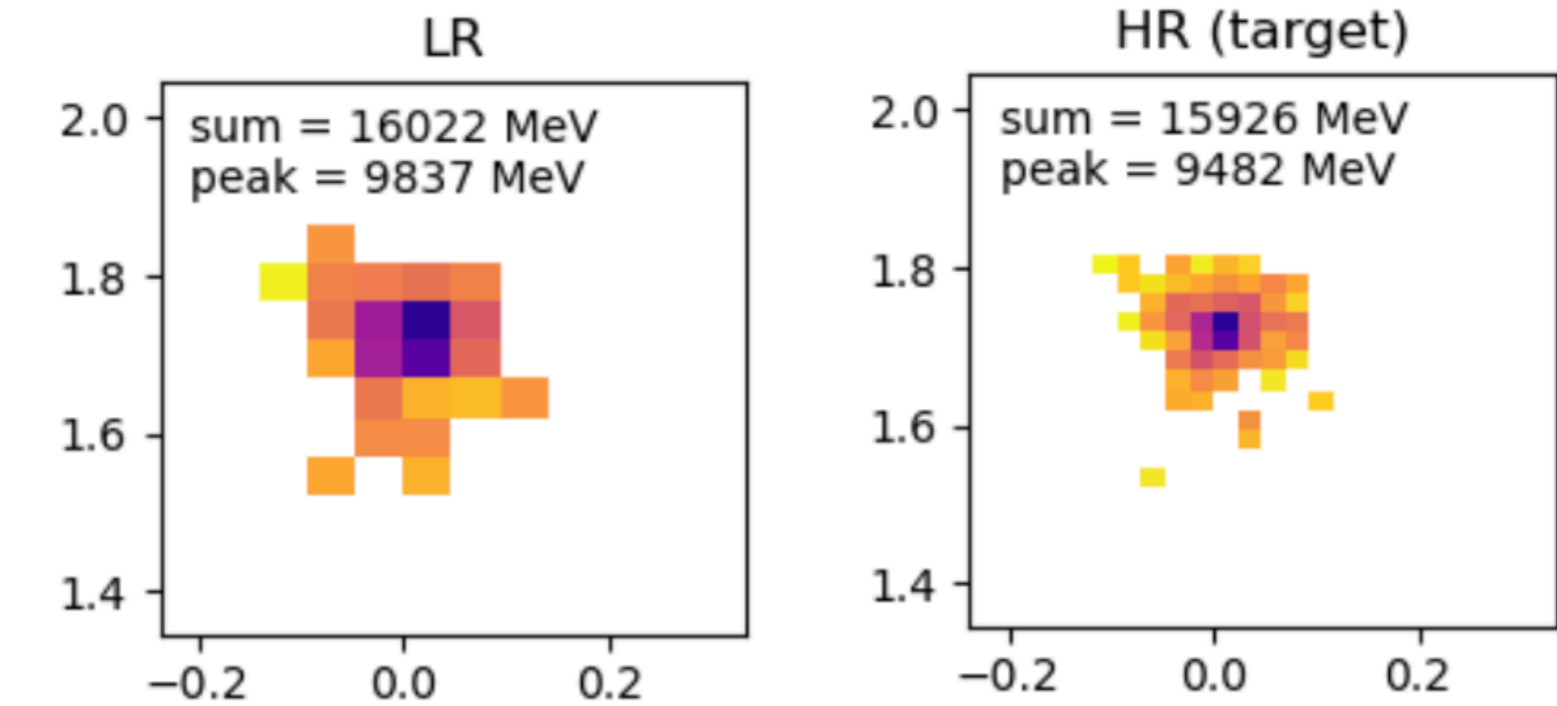
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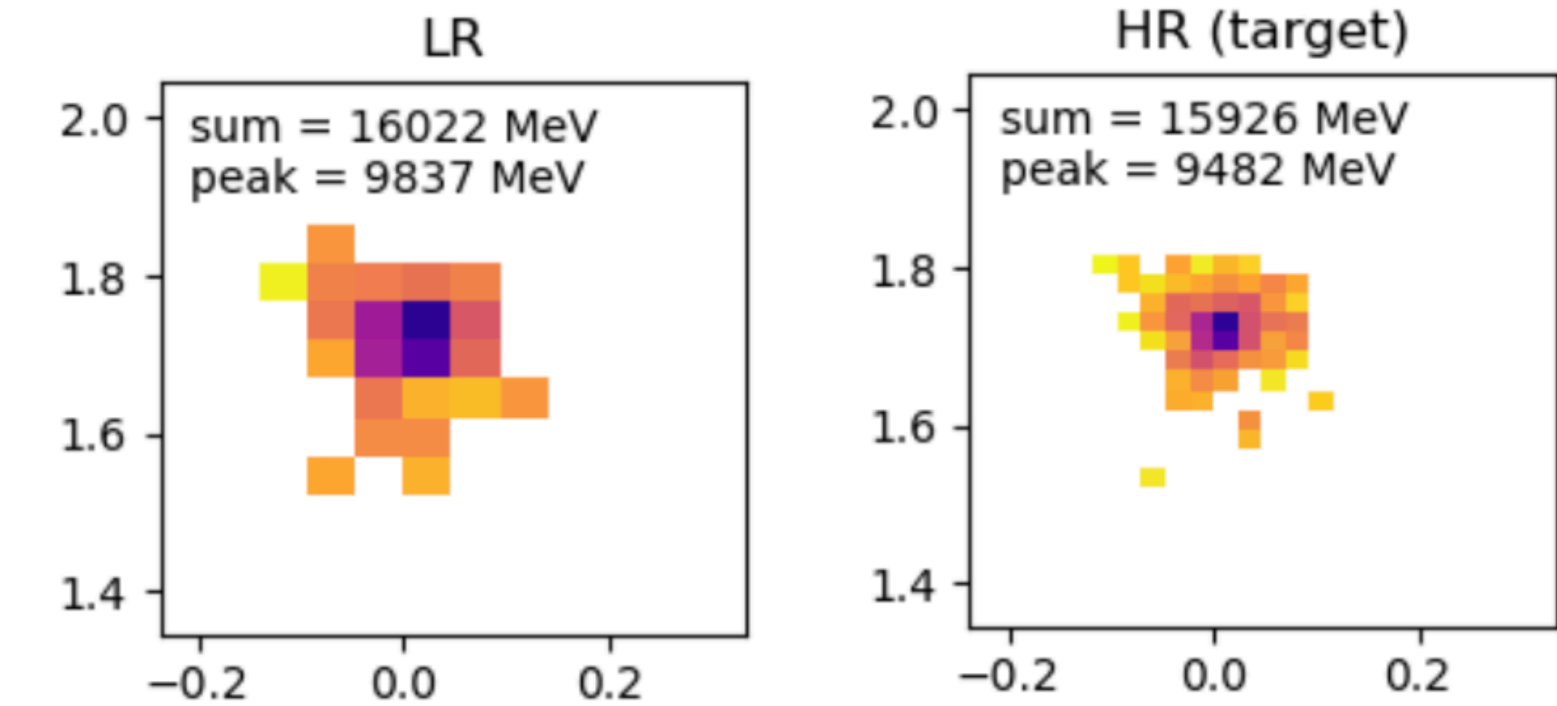
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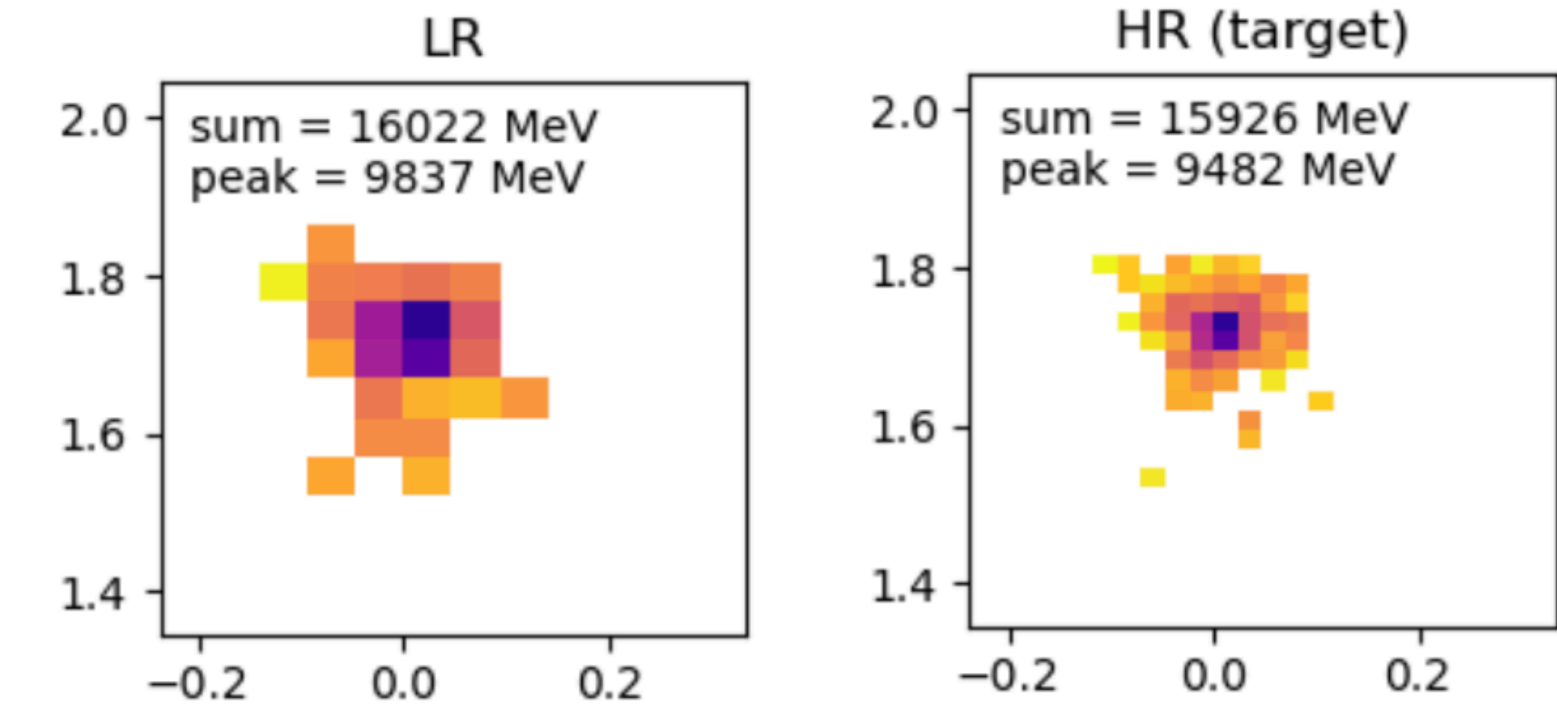
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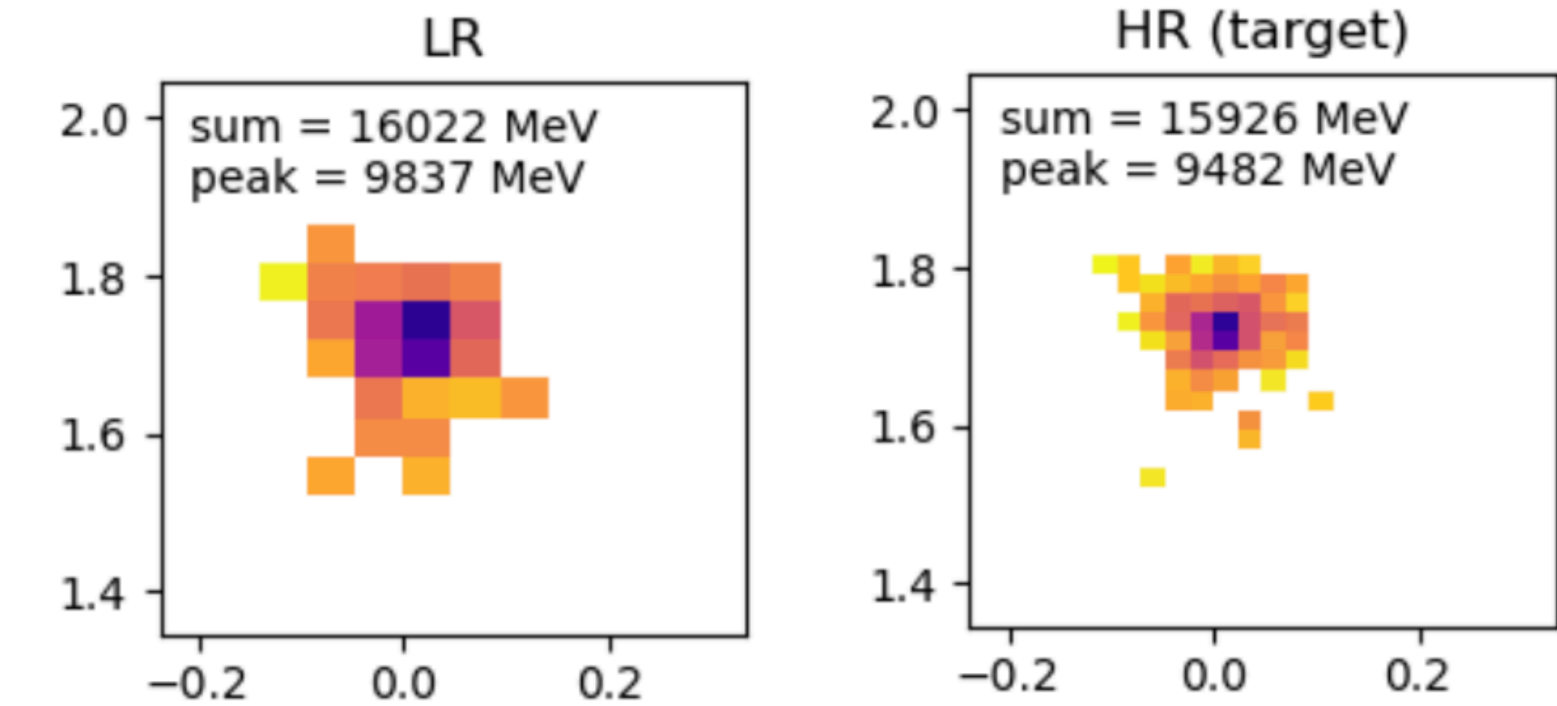
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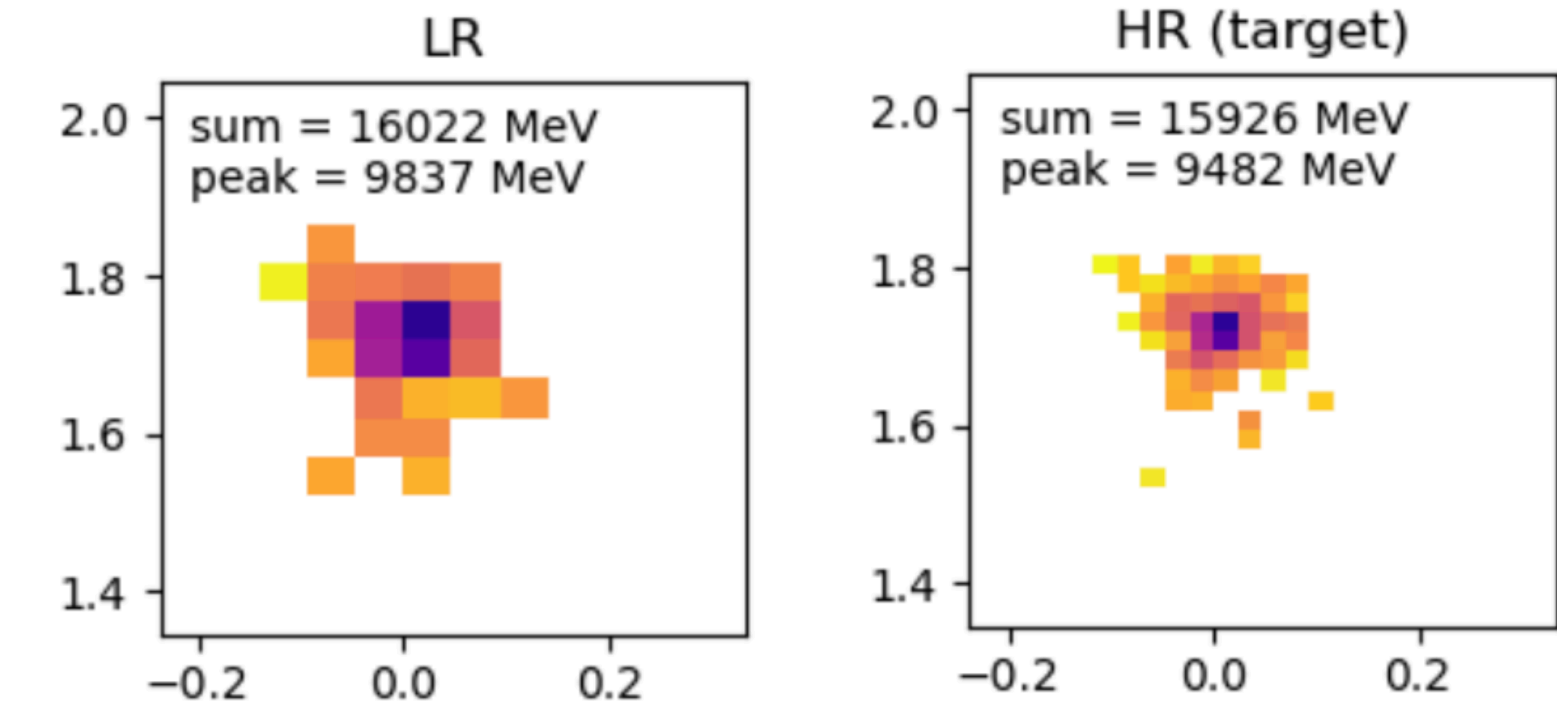
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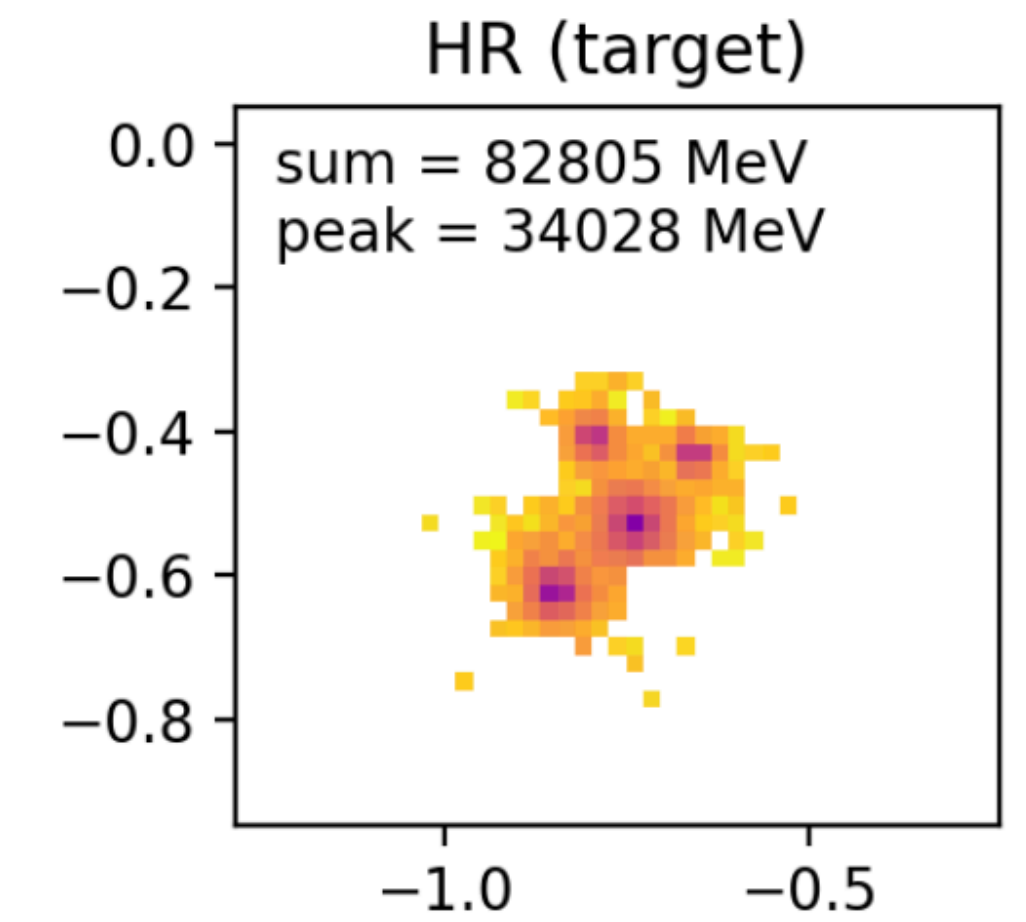
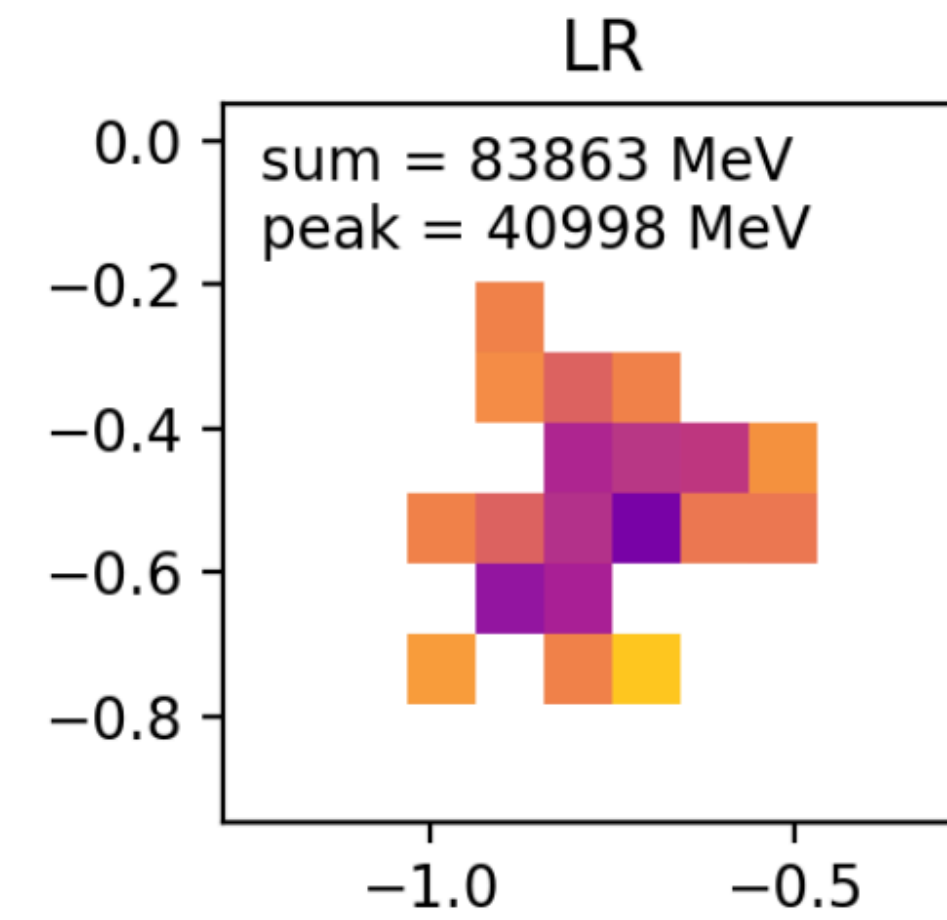


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- ◆ With actual data,
  - ➔ Not so easy. (How much we trust our simulations?)
  - ➔ **Calibration problem** (tricky, but I believe doable)



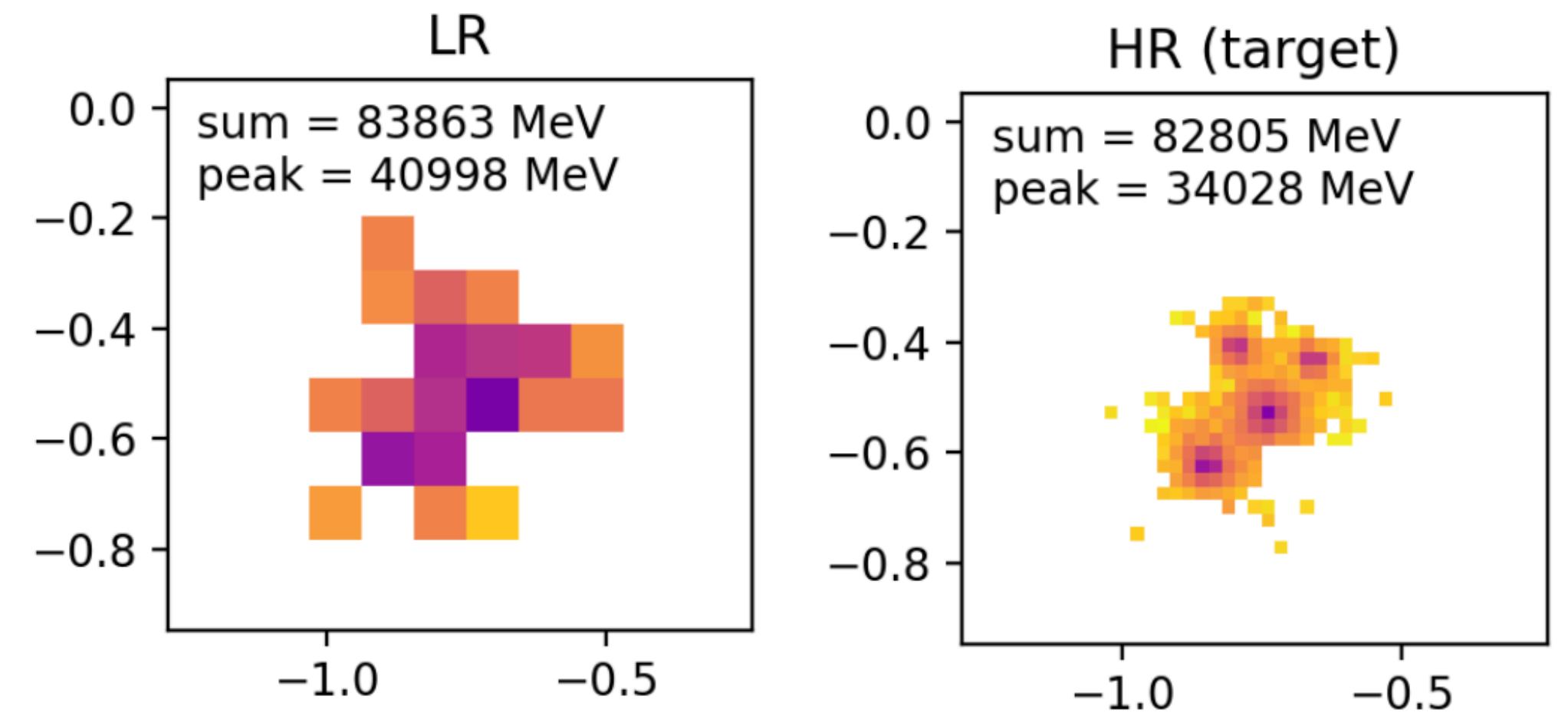
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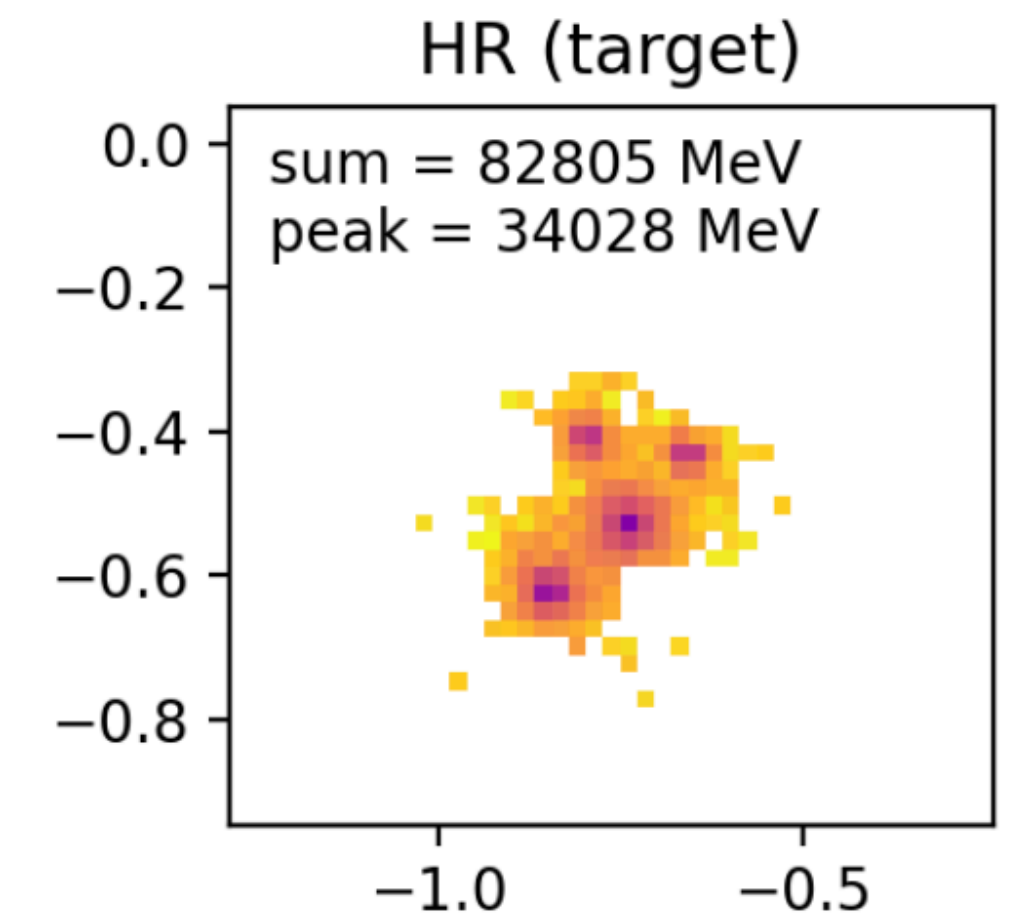
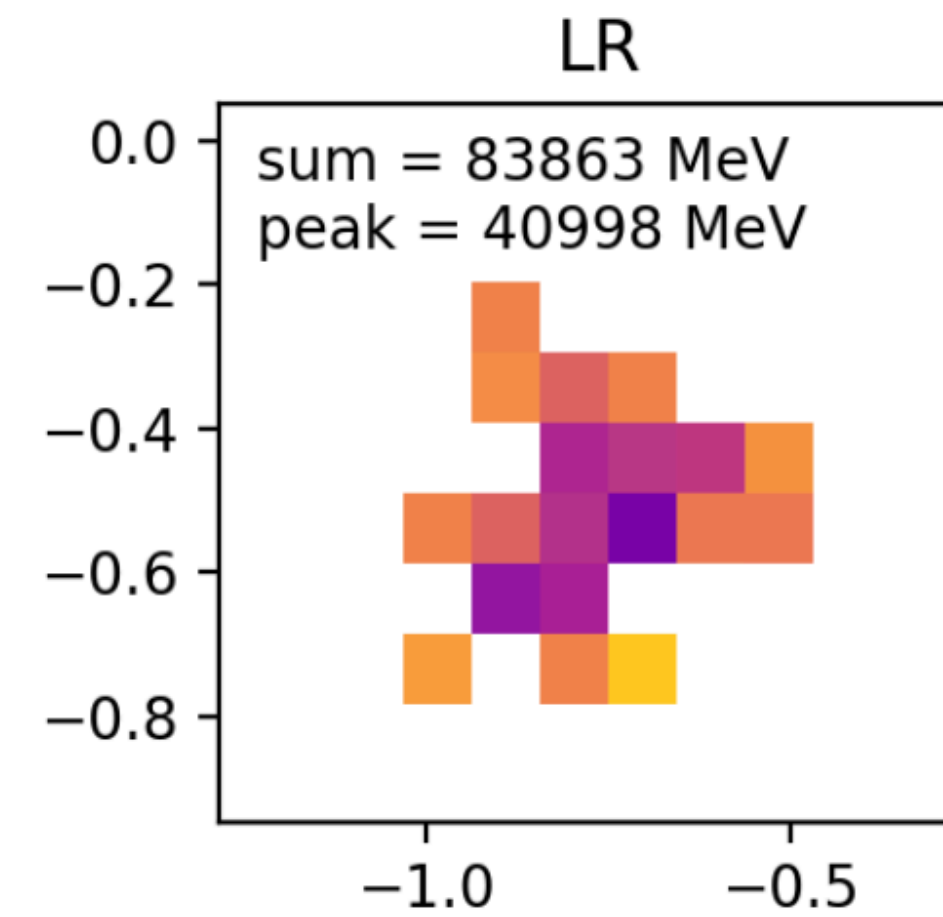
# But, most importantly,

- ◆ We shouldn't look at it in isolation



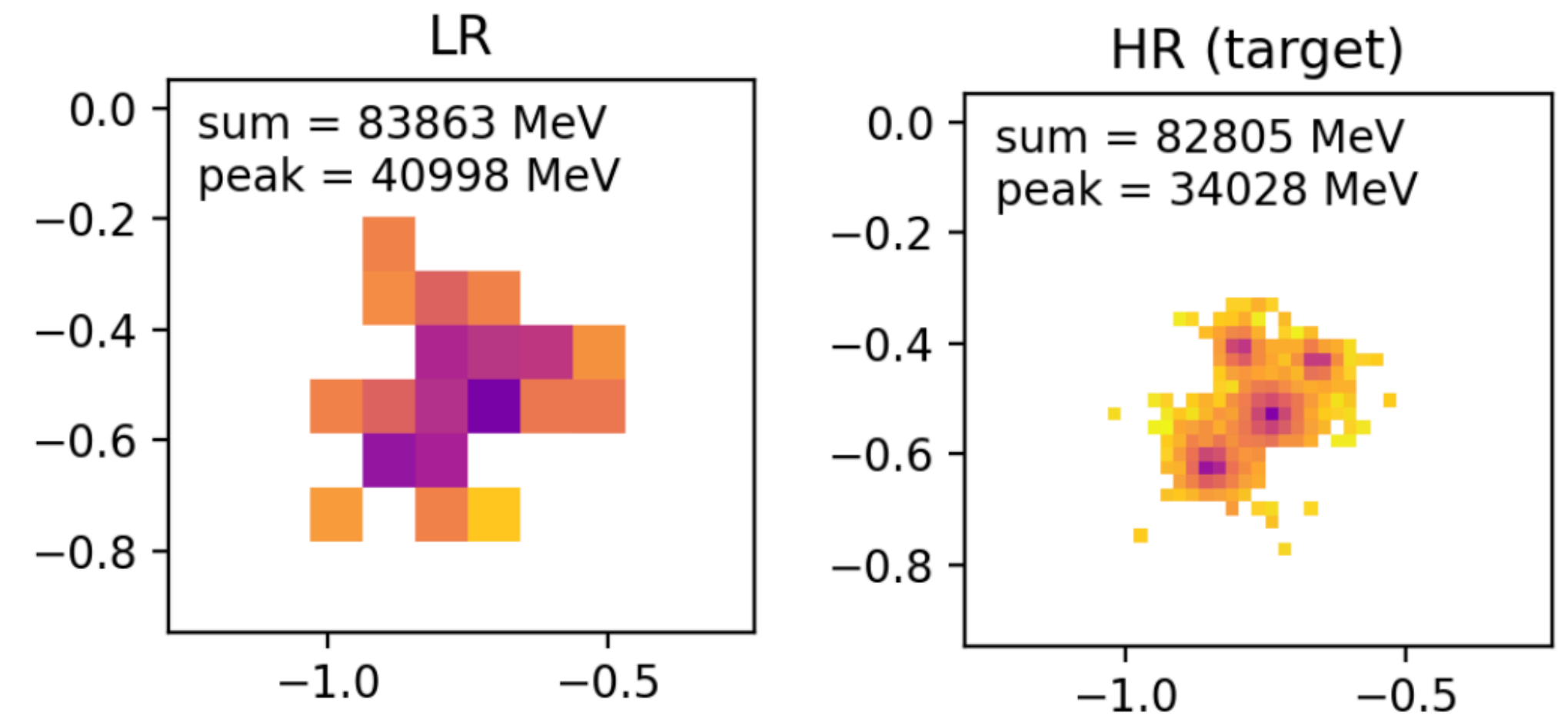
# But, most importantly,

- ◆ We shouldn't look at it in isolation
- ◆ Primary goal -
  - ➔ Assist downstream reconstruction task



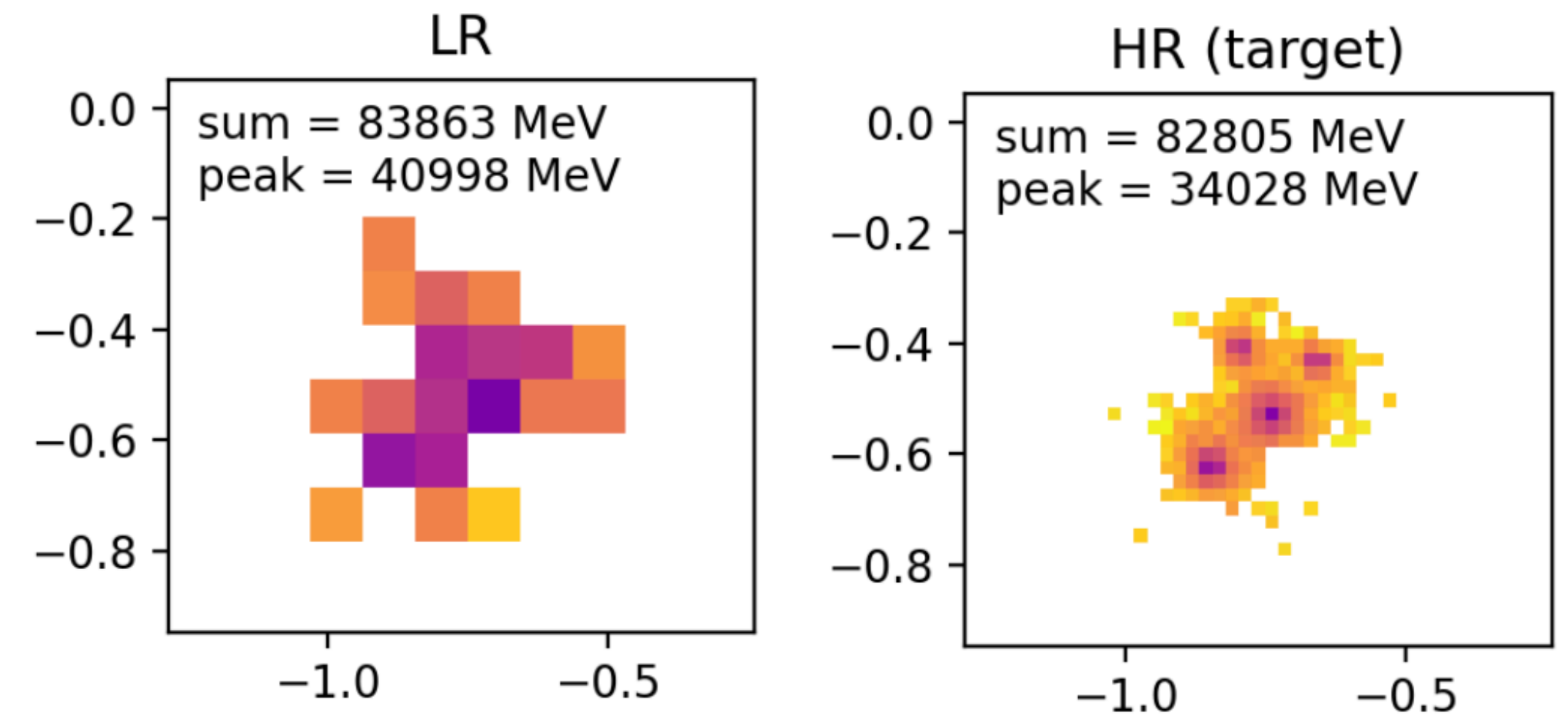
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- ➔ Multi-particle example demonstrates *cardinality*



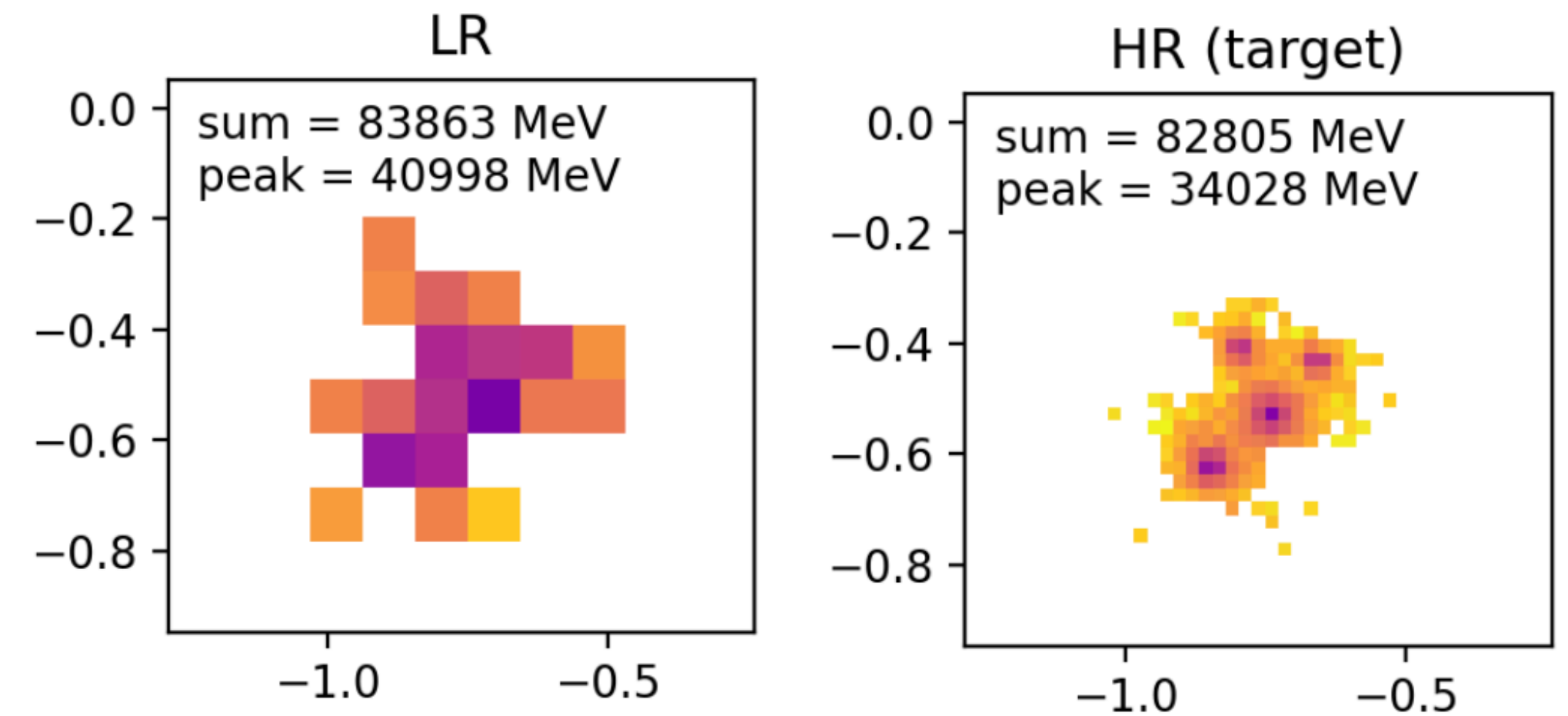
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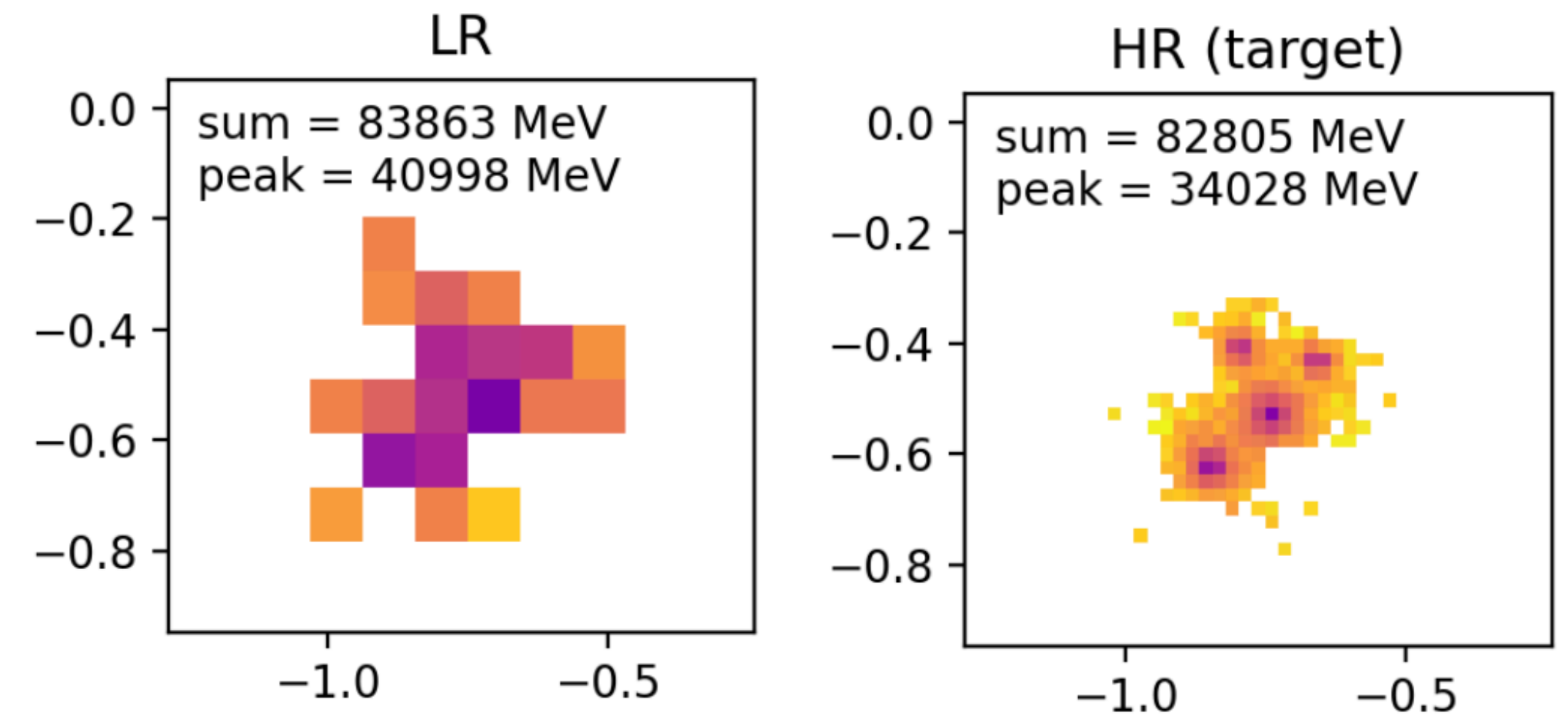
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*Thanks!*