

One Generator, Any Process

LLM-Conditioning for the LHC

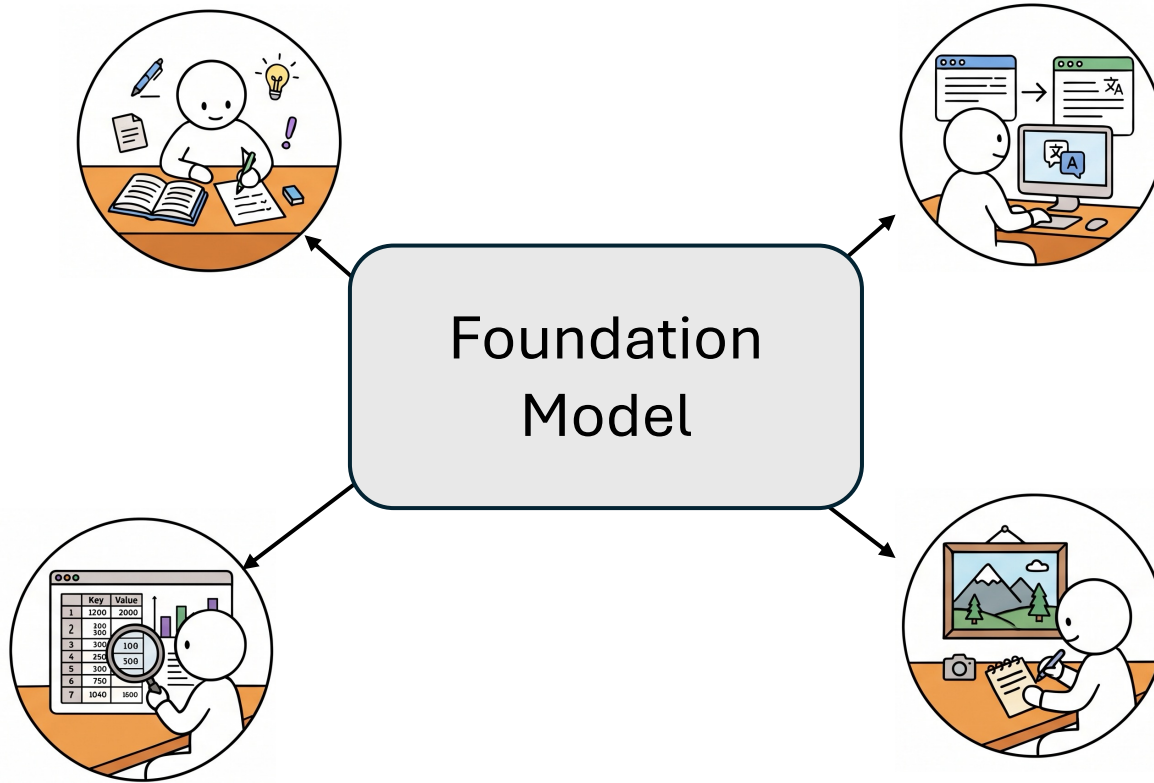
Thanush Sivagnanalingam

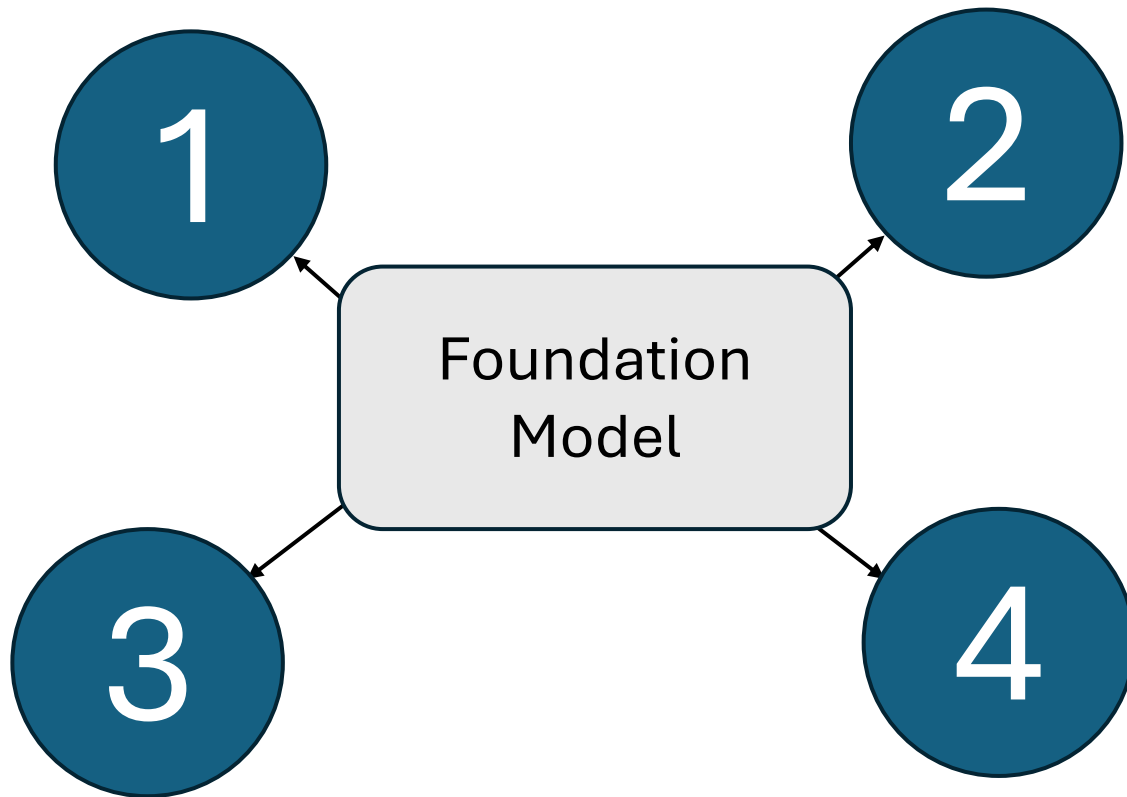
Based on: [arXiv:2606.23791](https://arxiv.org/abs/2606.23791)

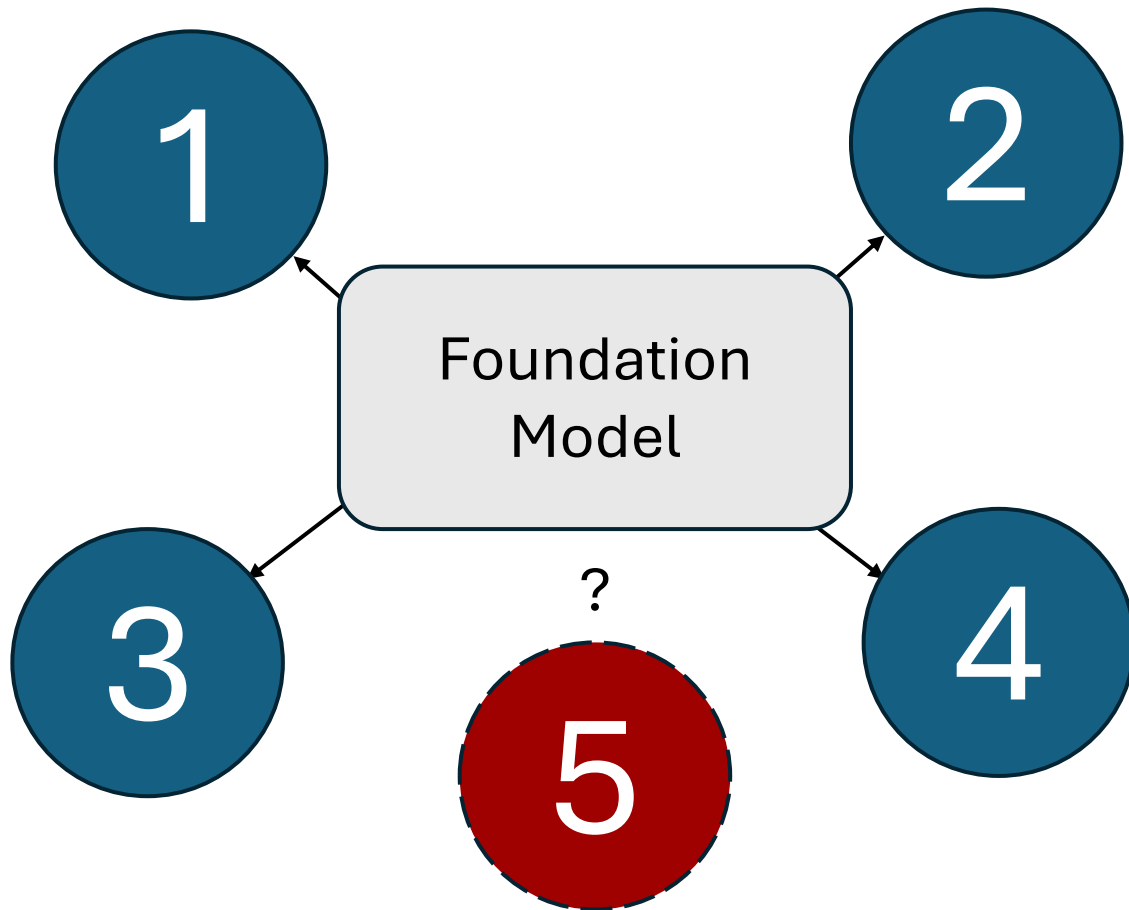
With H. Bahl, T. Plehn and D. Schiller

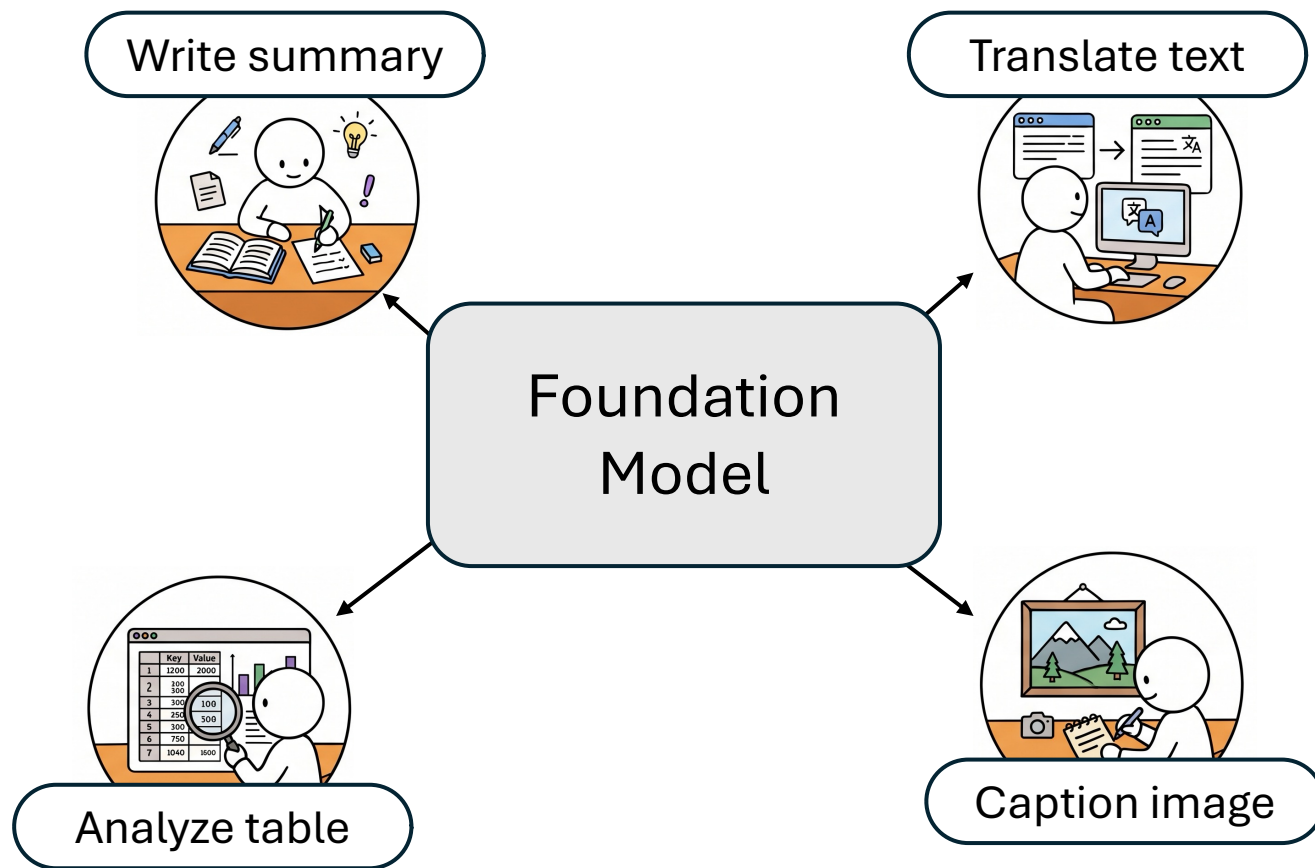
ML4Jets 18.08.2026

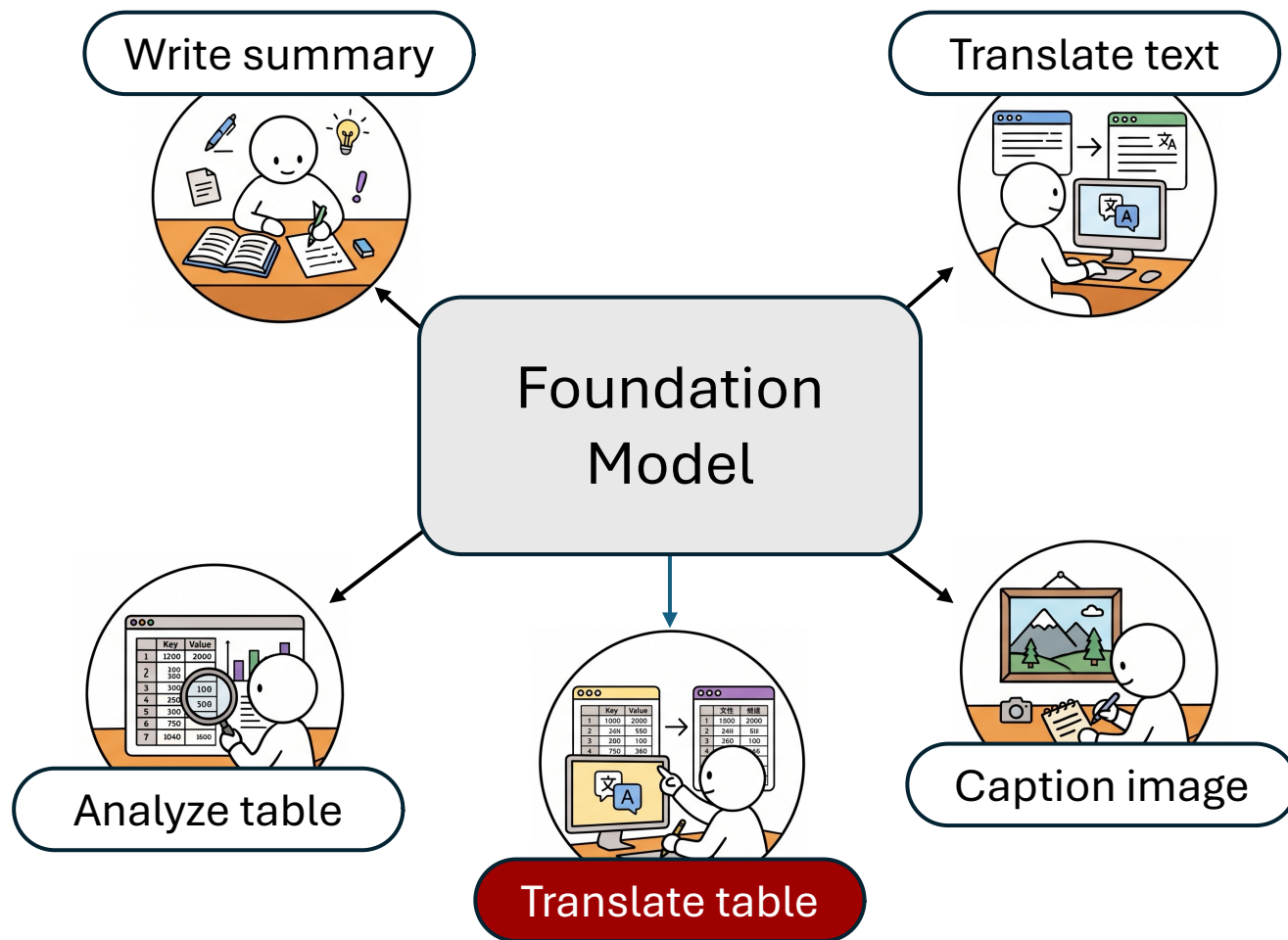


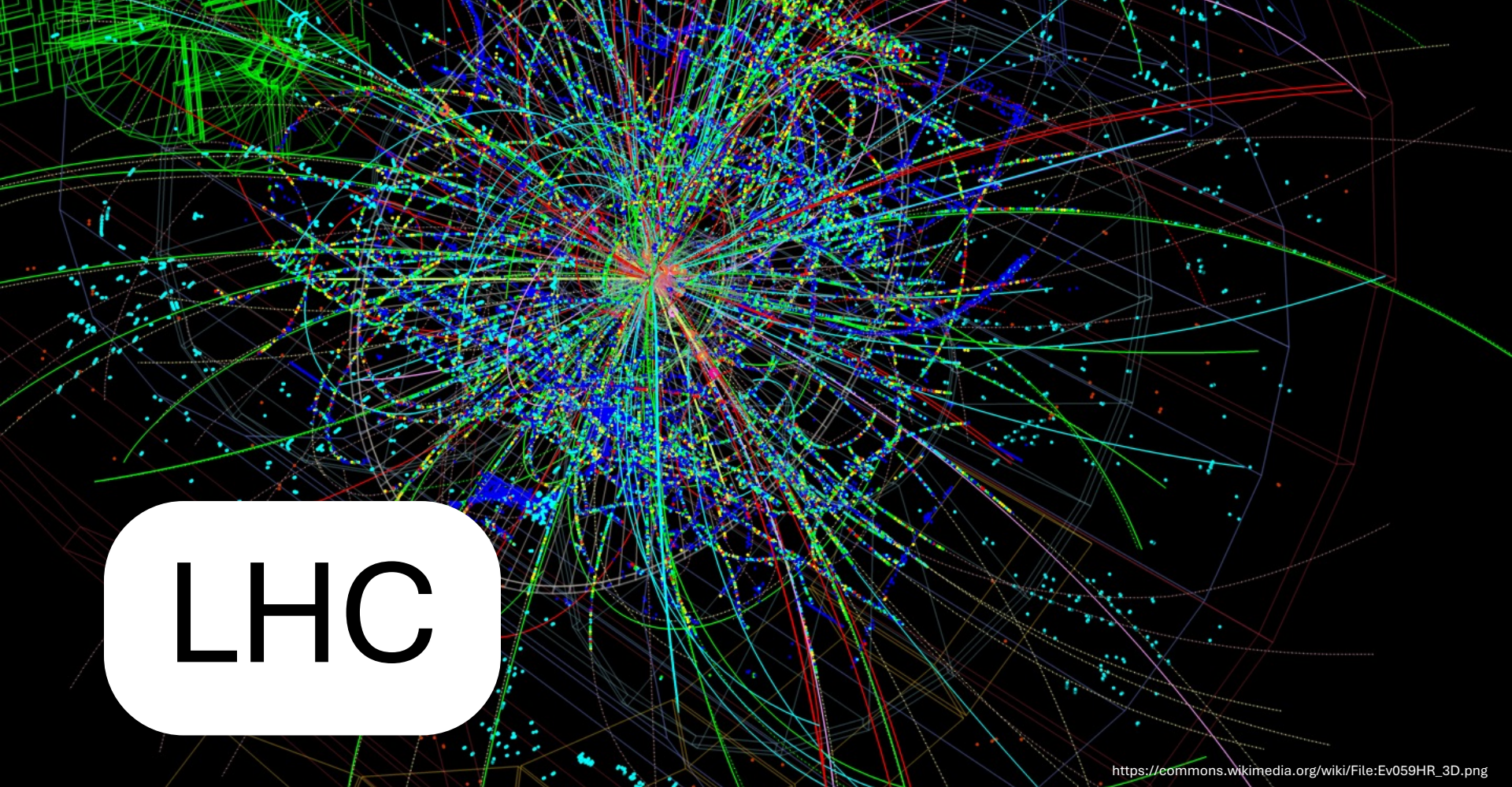




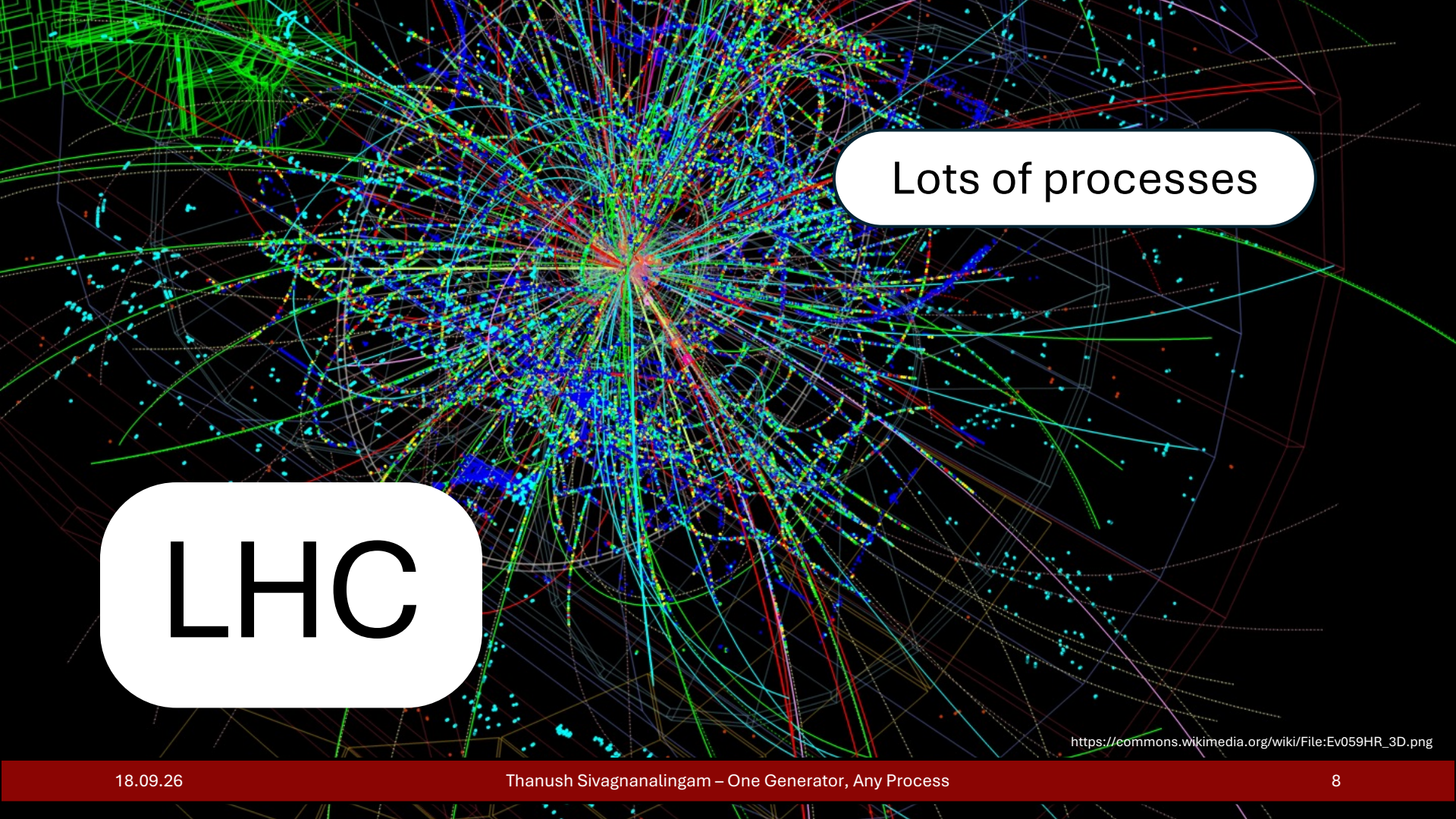








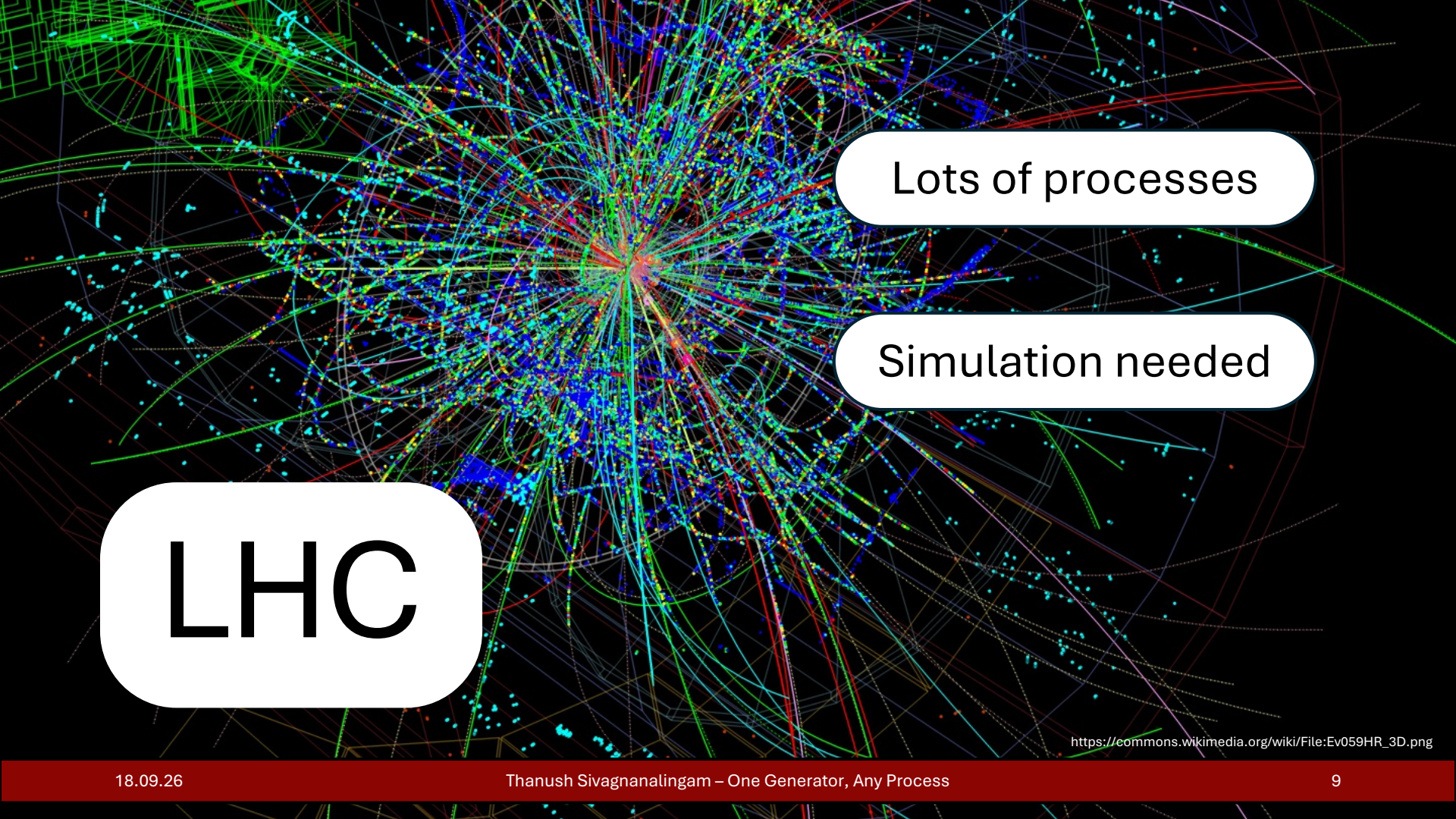
https://commons.wikimedia.org/wiki/File:Ev059HR_3D.png



Lots of processes

LHC

https://commons.wikimedia.org/wiki/File:Ev059HR_3D.png

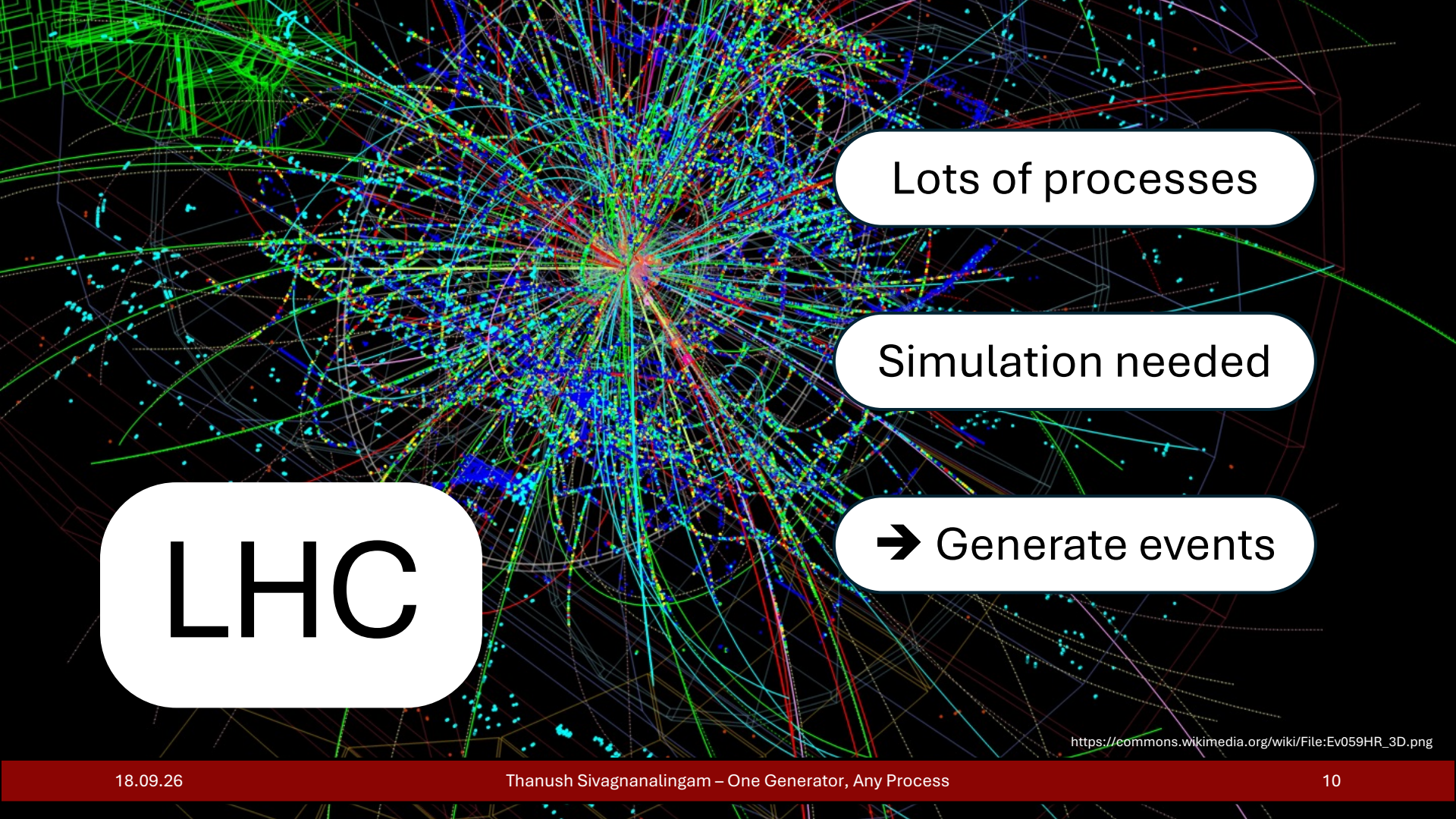


LHC

Lots of processes

Simulation needed

https://commons.wikimedia.org/wiki/File:Ev059HR_3D.png



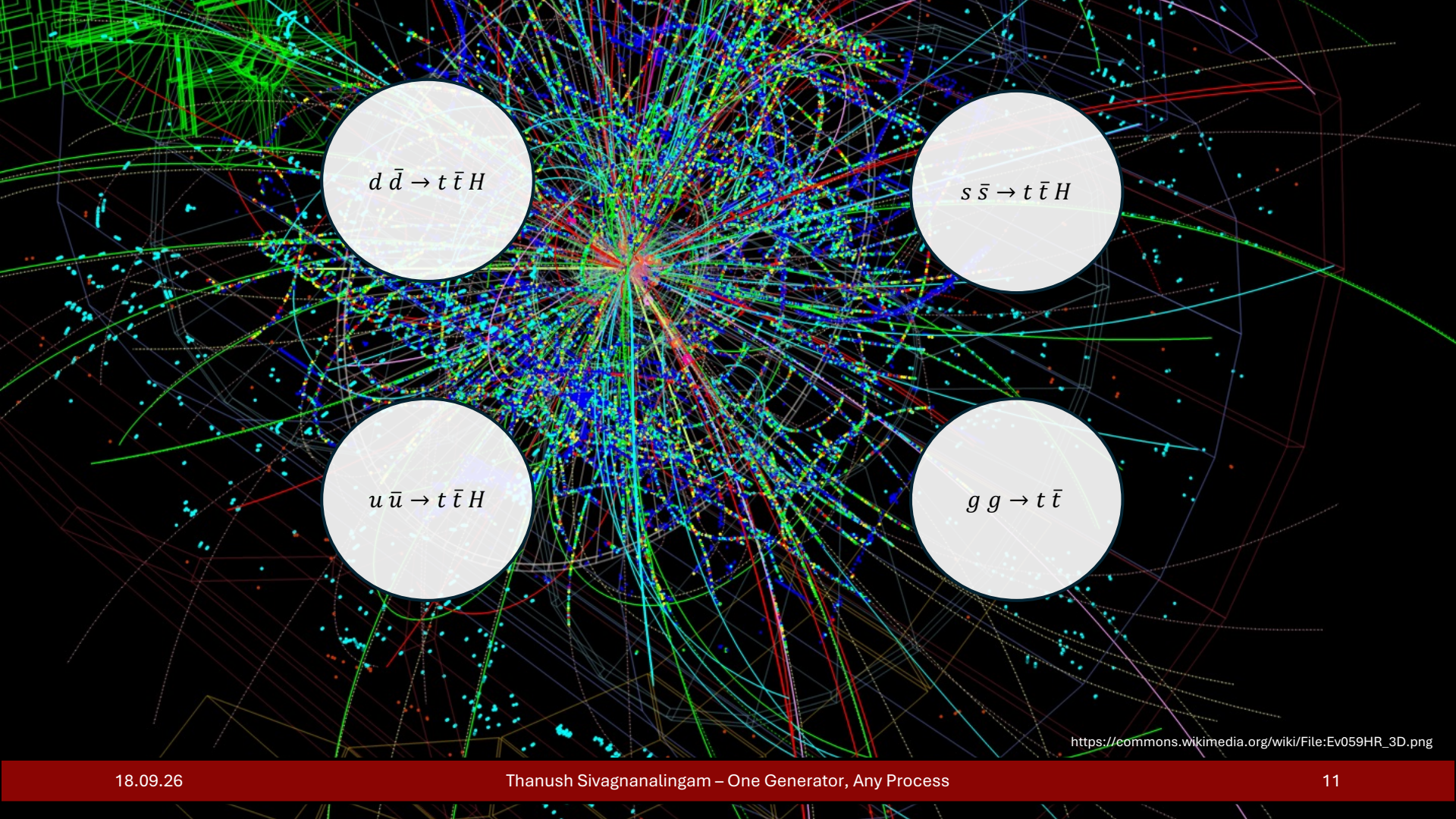
LHC

Lots of processes

Simulation needed

➔ Generate events

https://commons.wikimedia.org/wiki/File:Ev059HR_3D.png

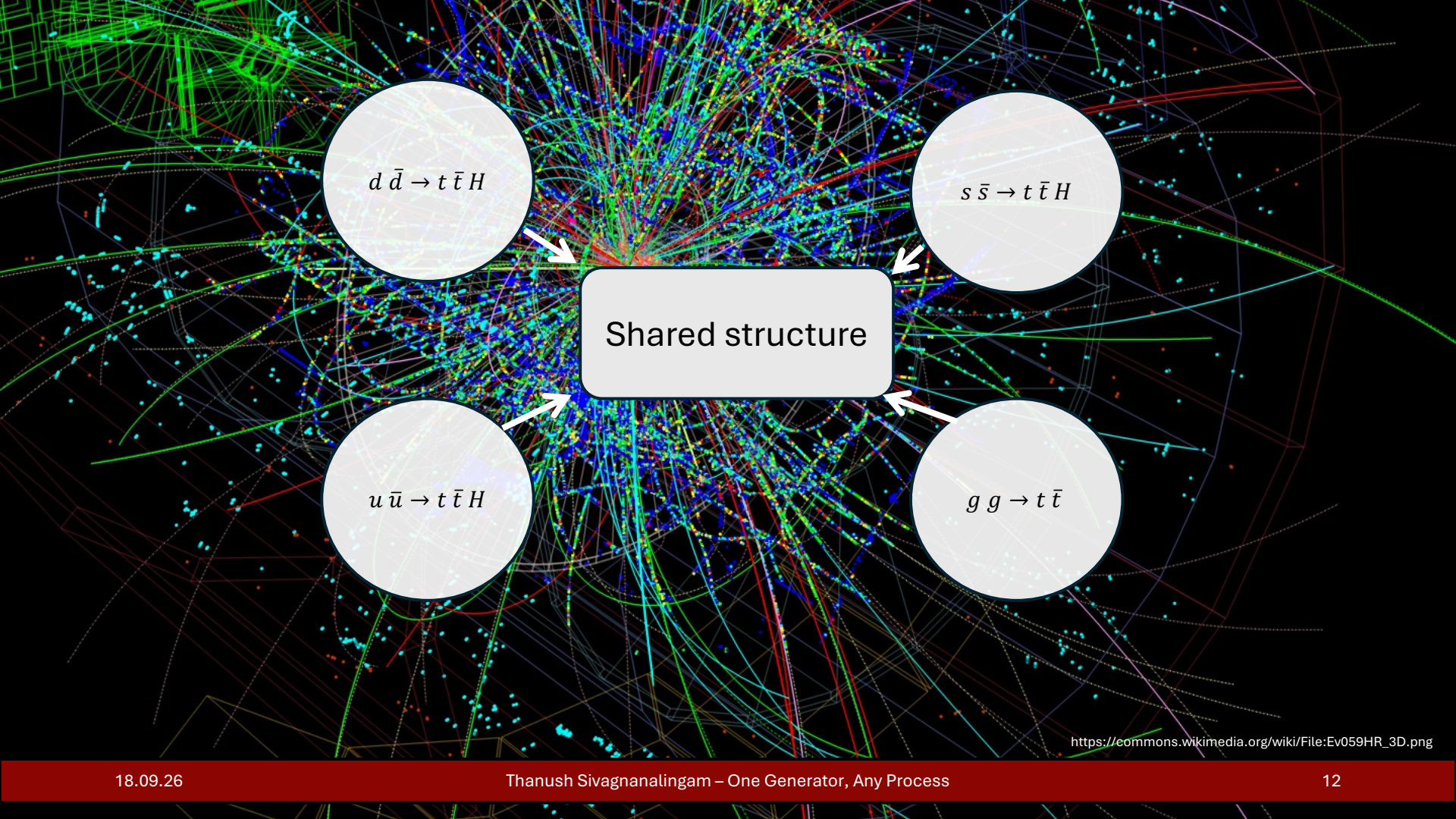

$$d \bar{d} \rightarrow t \bar{t} H$$

$$s \bar{s} \rightarrow t \bar{t} H$$

$$u \bar{u} \rightarrow t \bar{t} H$$

$$g g \rightarrow t \bar{t}$$

https://commons.wikimedia.org/wiki/File:Ev059HR_3D.png


$$d \bar{d} \rightarrow t \bar{t} H$$

$$s \bar{s} \rightarrow t \bar{t} H$$

Shared structure

$$u \bar{u} \rightarrow t \bar{t} H$$

$$g g \rightarrow t \bar{t}$$

https://commons.wikimedia.org/wiki/File:Ev059HR_3D.png

$d \bar{d} \rightarrow t \bar{t} H$

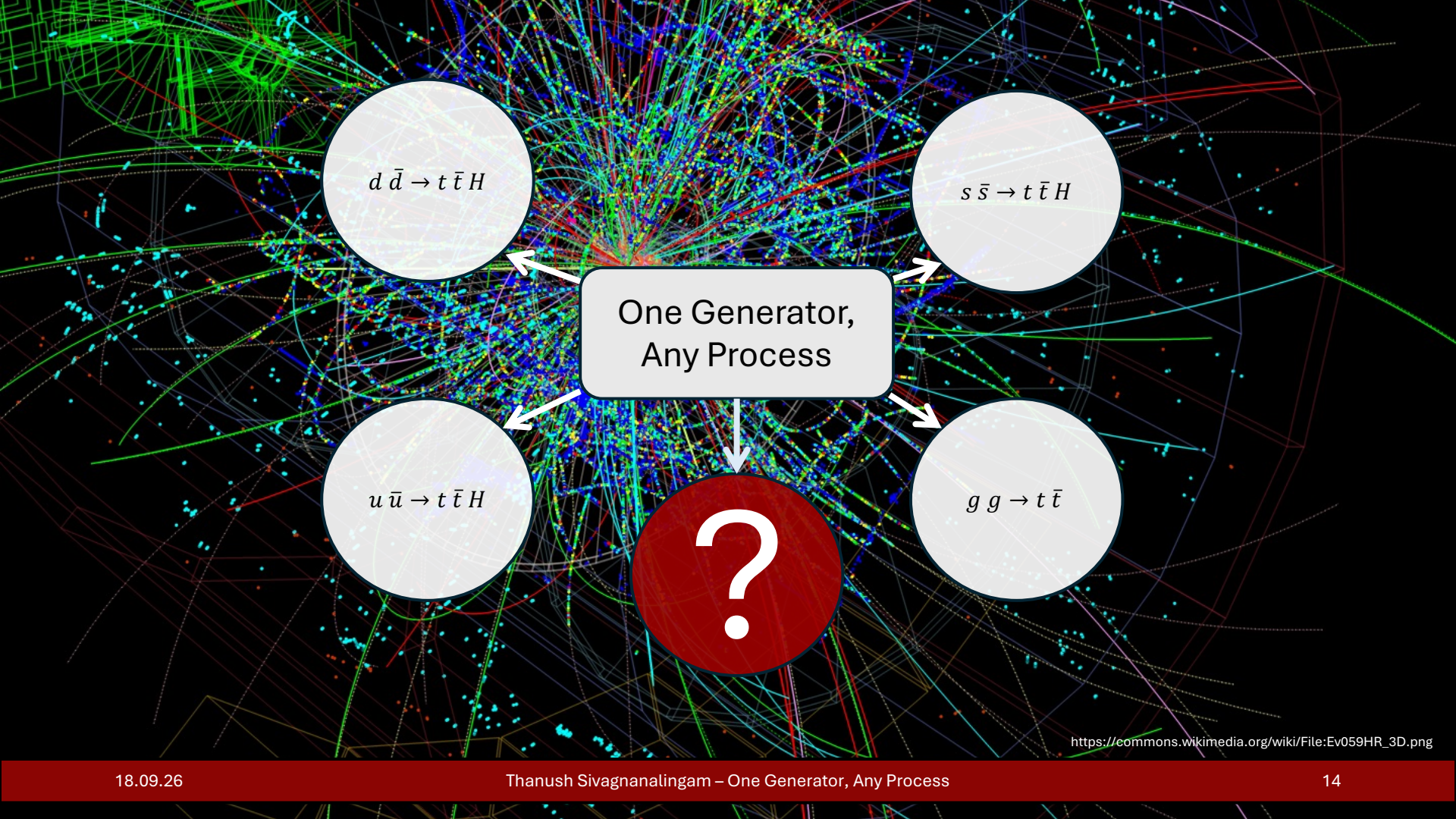
$s \bar{s} \rightarrow t \bar{t} H$

One Generator,
Any Process

$u \bar{u} \rightarrow t \bar{t} H$

$g g \rightarrow t \bar{t}$

https://commons.wikimedia.org/wiki/File:Ev059HR_3D.png



$d \bar{d} \rightarrow t \bar{t} H$

$s \bar{s} \rightarrow t \bar{t} H$

One Generator,
Any Process

$u \bar{u} \rightarrow t \bar{t} H$

$g g \rightarrow t \bar{t}$



https://commons.wikimedia.org/wiki/File:Ev059HR_3D.png

Process description

$$g g \rightarrow t \bar{t} H$$

Process description

One-Hot

$$\begin{pmatrix} 0 \\ \vdots \\ 0 \\ 1 \\ 0 \\ \vdots \\ 0 \end{pmatrix}$$

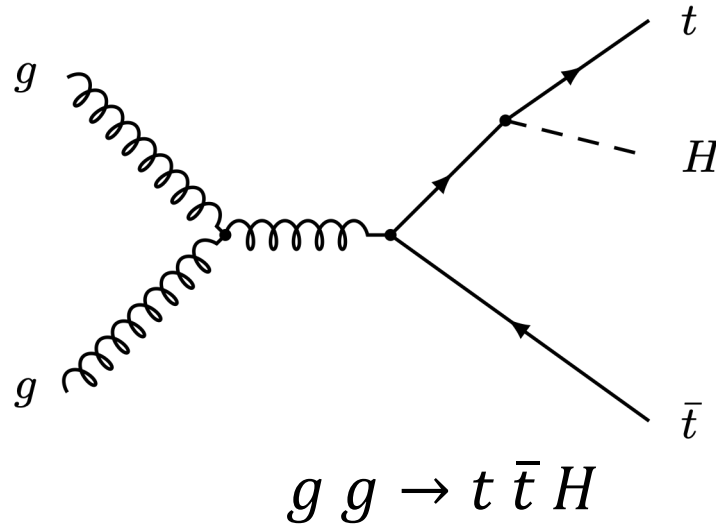
$$g g \rightarrow t \bar{t} H$$

Process description

One-Hot

$$\begin{pmatrix} 0 \\ \vdots \\ 0 \\ 1 \\ 0 \\ \vdots \\ 0 \end{pmatrix}$$

Image

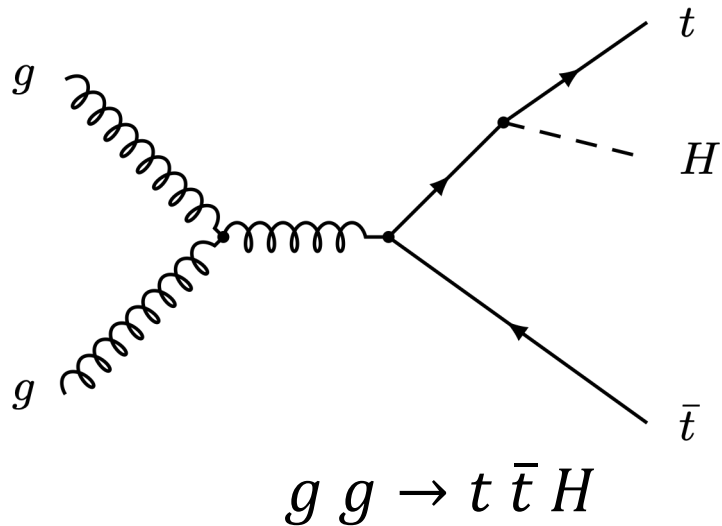


Process description

One-Hot

$$\begin{pmatrix} 0 \\ \vdots \\ 0 \\ 1 \\ 0 \\ \vdots \\ 0 \end{pmatrix}$$

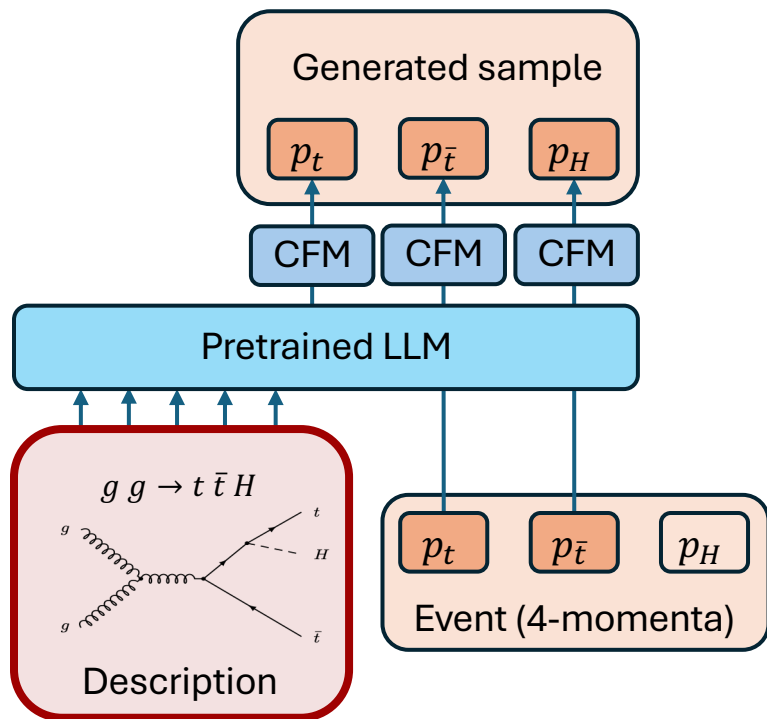
Image



Text

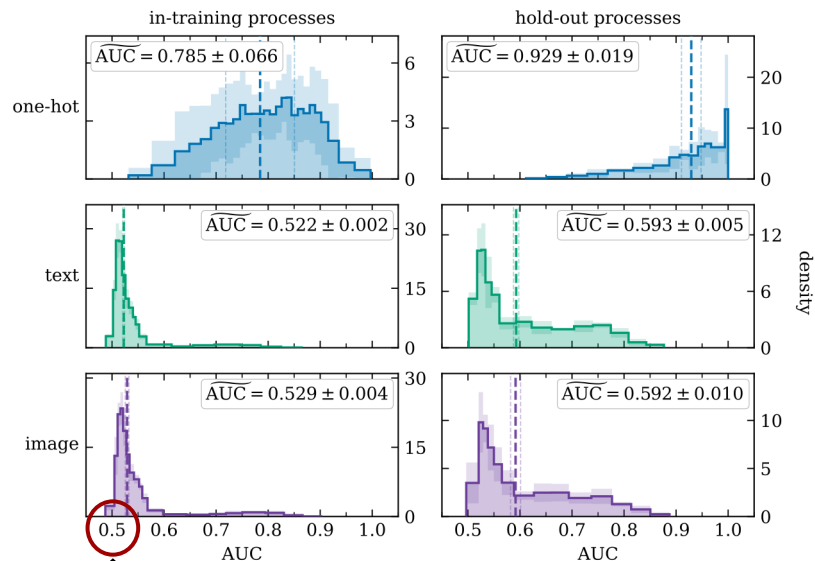
$$\begin{aligned} g(1) - g(2) - V0 \\ \sim g \sim t \sim (4) - \\ V2 \sim t \sim t(3) \\ -h(5) - V1 \end{aligned}$$

LLM Event Generation



- Pretrained 0.5B/2B LLMs
- Embed description & event
- Multimodal conditioning
- Autoregressive generation
- Evaluate samples by classifier

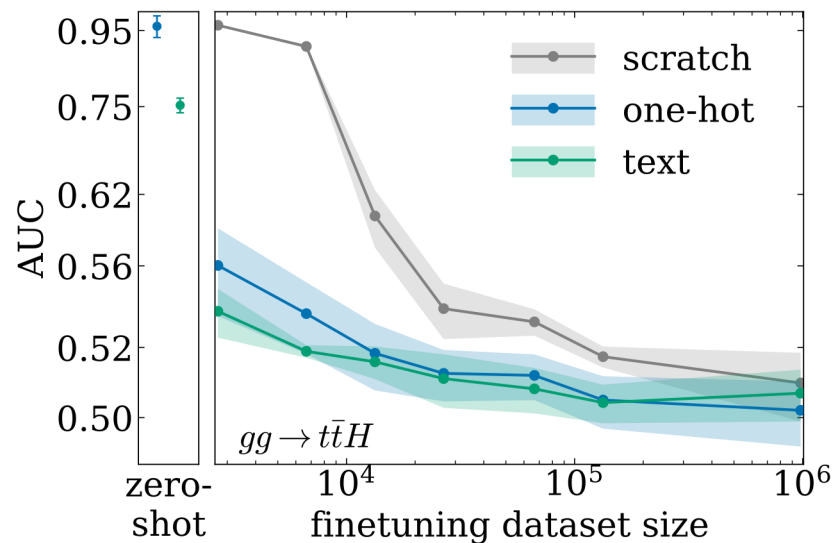
Processes – Zero-Shot!



indistinguishable

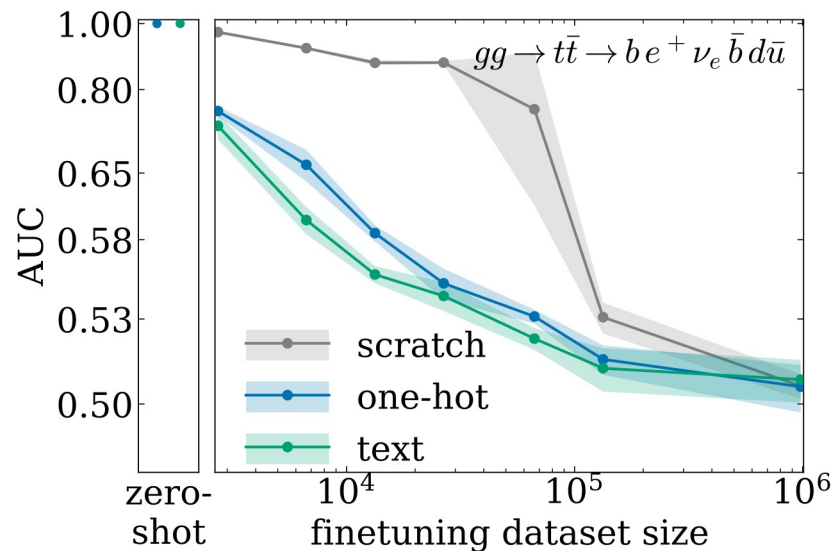
- 1352 in-training, 139 held out
- 2 or 3 final state particles
- AUC measures quality
- One-Hot embedding trained
- ➔ One-Hot worse on training
- ➔ Descriptions generalize

Processes – Finetuned!



- Hold-out: $g g \rightarrow t \bar{t} H$
- Scratch = No pretraining, only single process
- High efficiency in low data regime

Processes – More, finetuned!



- New process: 6 final states
- Zero-shot fails
- Pretraining still highly data efficient

What else?



- Representation is key!
- LLMs are great!
- Also in the paper:
 - Graph network alternative to LLM
 - Parameter Conditioning
 - Technical finesses

Let's chat!



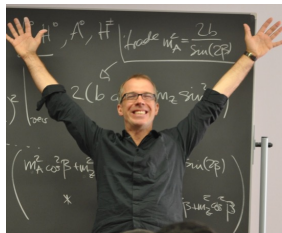
Thanush Sivagnanalingam
MSc Student



Daniel Schiller
PhD Student



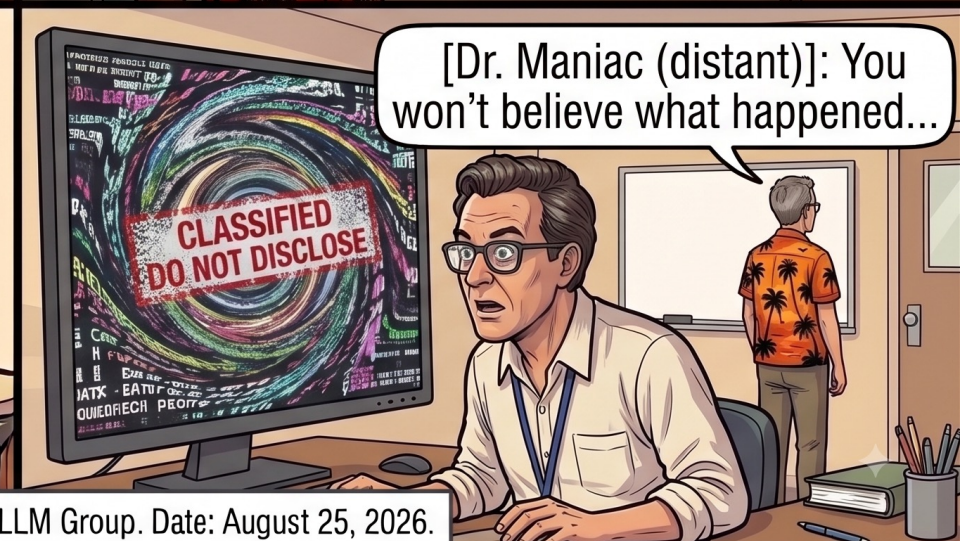
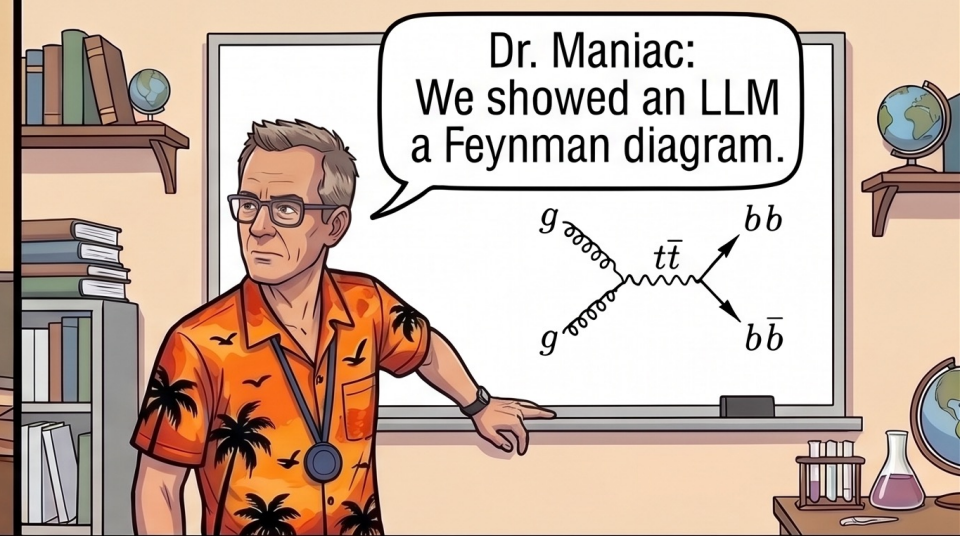
Henning Bahl
Post-Doc



Tilman Plehn
Micromanager

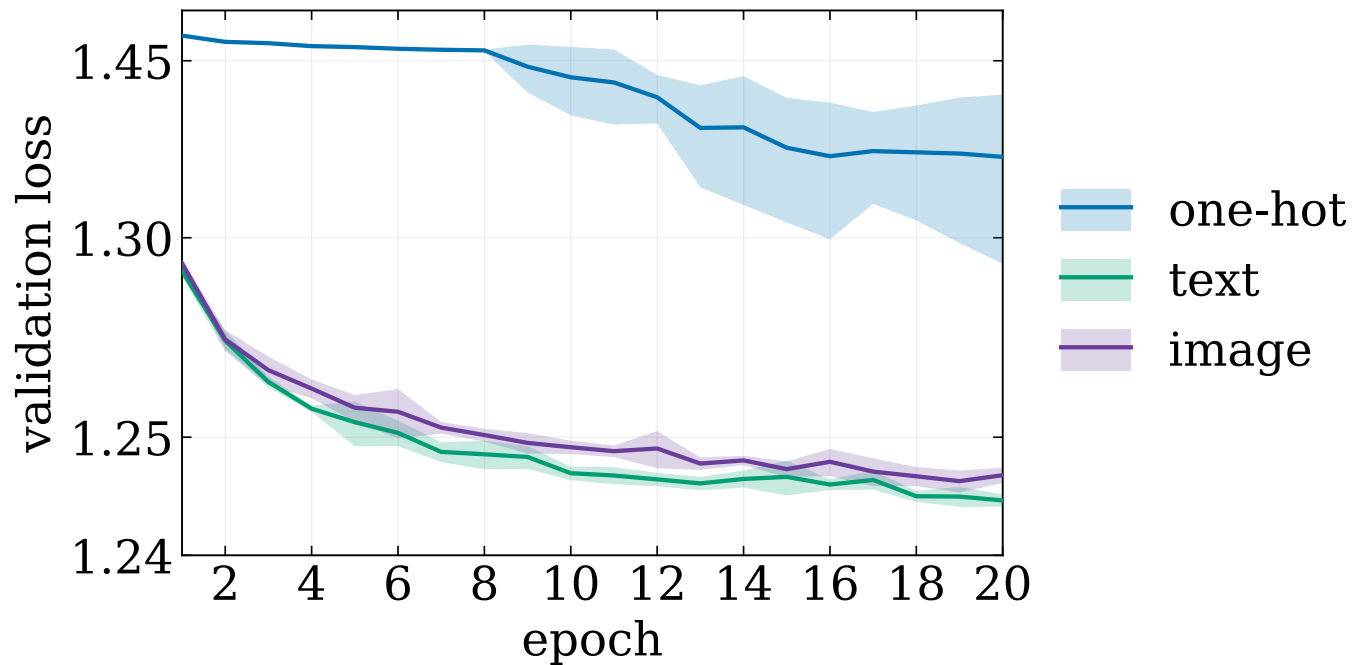


<https://arxiv.org/abs/2606.23791v2>

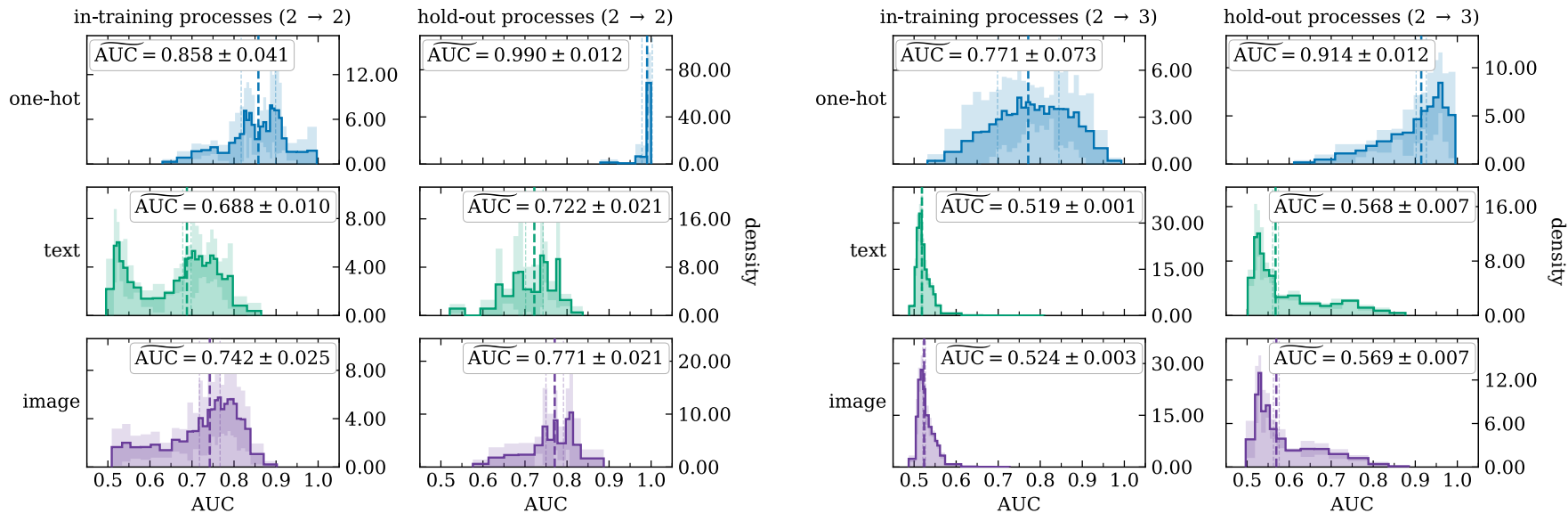


BACKUP

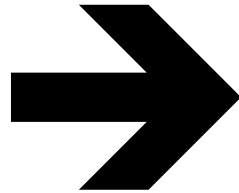
Processes – Trained faster!



Processes – Zero-Shot!



LOOKING FOR MORE BACKUP?



READ THE PAPER!



<https://arxiv.org/abs/2606.23791v2>