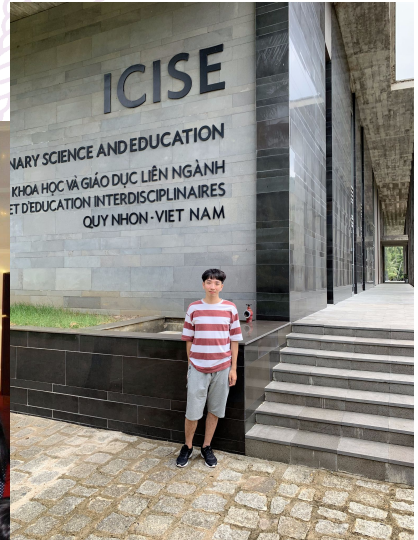
The Job Interview

Po-Jen Cheng
National Tsing Hua University
2021/07/16
TSMC RDPC Interview

Contents

Introduction - About Me

- Interest in science and mathematics
- Wanna to know the secret of the world
- Personality:To brave challenges, without being afraid of failure.



Introduction - Education and Experience

- National Tsing Hua University(NTHU) Sep. 2018 - Oct. 2020
  - M.Sc. in Physics Department
  - Advisor : Kingman Cheung (NTHU), Shih-Chieh Hsu (University of Washington)

- National Chung Cheng University(CCU) Sep. 2014 - Jun. 2018
  - B.Sc. in Physics Department
  - TA for general physics, general physics experiment, applied mathematics

- [Epe-ml] EPE meeting [link]
  - University of Washinton ML meeting
  - Host:Shih-Chieh Hsu (University of Washington)

Skill and Knowlege

Computer Science

•PROGRAMMING LANGUAGE : PYTHON, C/C++, JAVA, MATLAB, LABVIEW

Data Science

•MACHINE LEARNING : LINEAR REGRESSION, K-NN, DECISION TREE, DNN, CNN, GNN, DYNAMICS GRAPH NN[link], TRANSFORMER[link]

•DEEP LEARNING FRAMEWORK : TENSORFLOW2

•OS : LINUX

Physics

•BASIC : ELECTROMAGNETISM, QUANTUM MECHANICS, THEORETICAL MECHANICS

•SEMICONDUCTOR RELATED : ELECTRON DYNAMICS, SOLID PHYSICS, STATISTICS MECHANICS

•OPTICS RELATED : OPTICS, FOURIER OPTICS

•HIGH ENERGY PHYSICS RELATED : PARTICLE PHYSICS, COLLIDER PHYSICS, FIELD THEORY, GROUP THEORY, QUANTUM CHROMODYNAMICS

SWOT

Strengh

1.Understand the physics behind semiconductors.
2.Familiar with coding.
3.Good at finding some observables with simulation.
4.Can build up and optimize the ML models.

Weekness

1.Like to challenge difficult things.
2.Don't know how to wrap up myself.

Opportunity (AI)

1.Combine AI and experiments.

Threat (AI)

1.Would not fimiliar with process.

SWOT

Strengh

1.Understand the physics behind semiconductors.
2.Familiar with coding.
3.Good at finding some observables with simulation.
4.Can build up and optimize the ML models.

Weekness

1.Like to challenge difficult things.
2.Don't know how to wrap up myself.

Opportunity (M)

1. Can learn more about application of chips.

Threat (M)

1.

SWOT

Strengh

1.Understand the physics behind semiconductors.
2.Familiar with coding.
3.Good at finding some observables with simulation.
4.Can build up and optimize the ML models.

Weekness

1.Like to challenge difficult things.
2.Don't know how to wrap up myself.

Opportunity (RDPC)

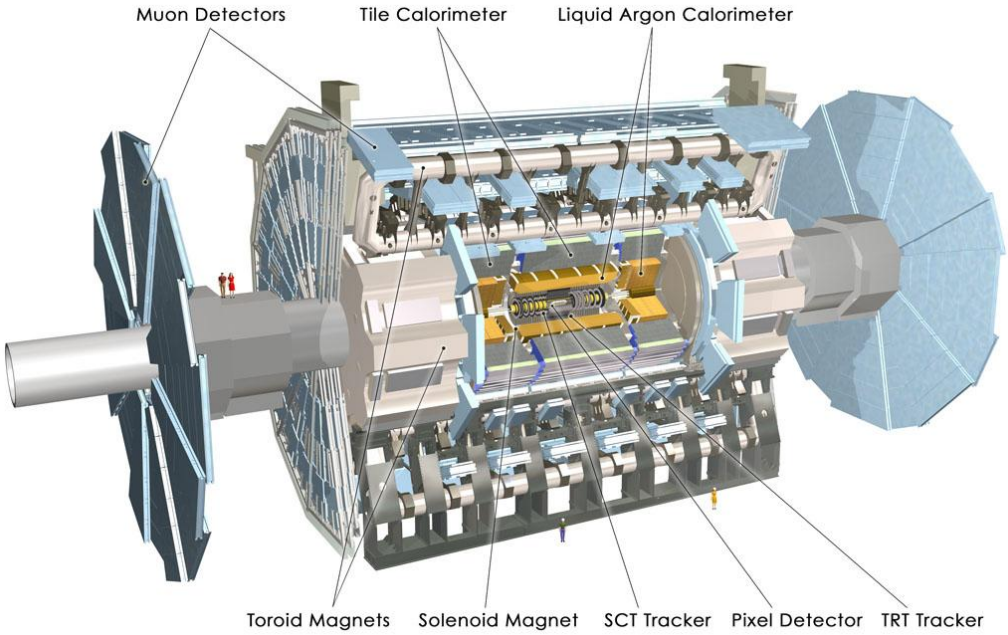
1.New process need basic science to solve problems.
2.TSMC has better technology in 5nm, 3nm than anyothers.

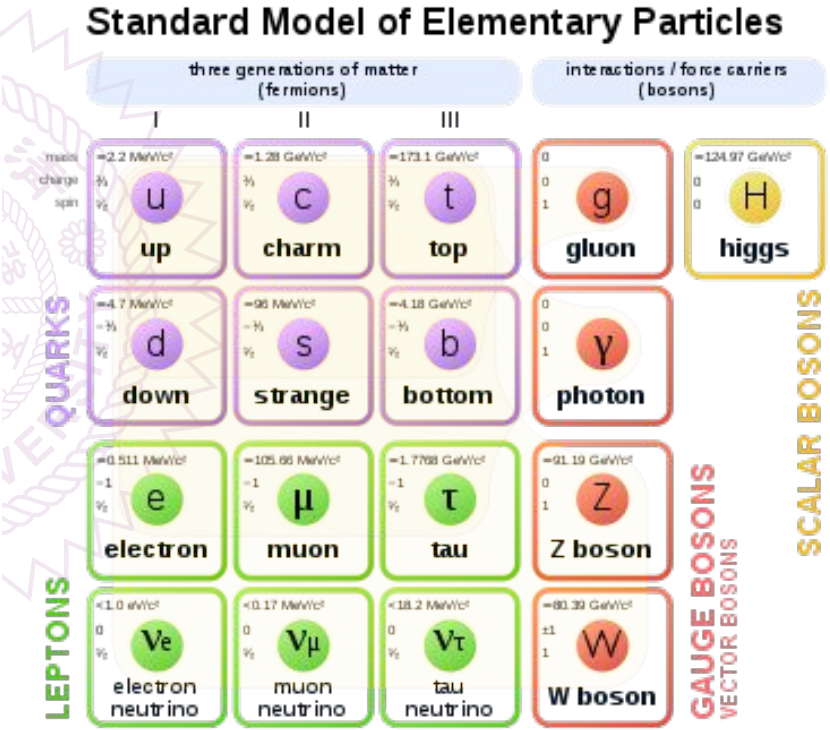
Threat (RDPC)

1.Do not have flexibility.

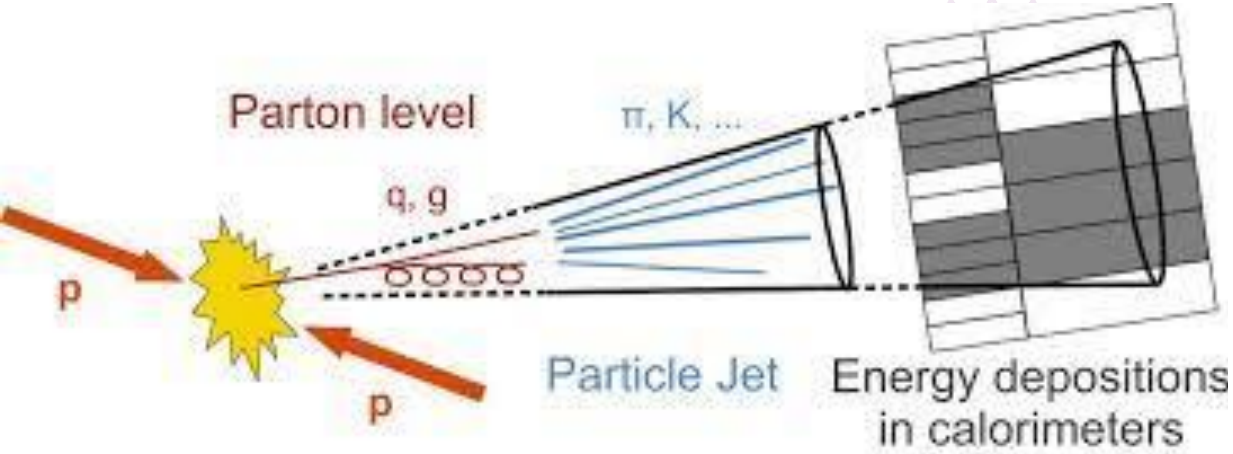
Writting and Award - Thesis

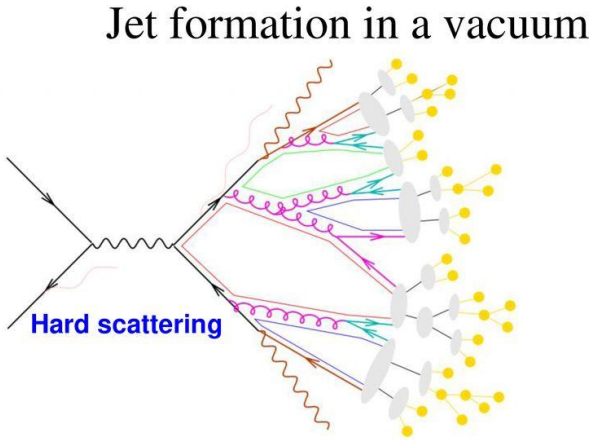
[Classification of Semi-visible Jets with Machine Learning]





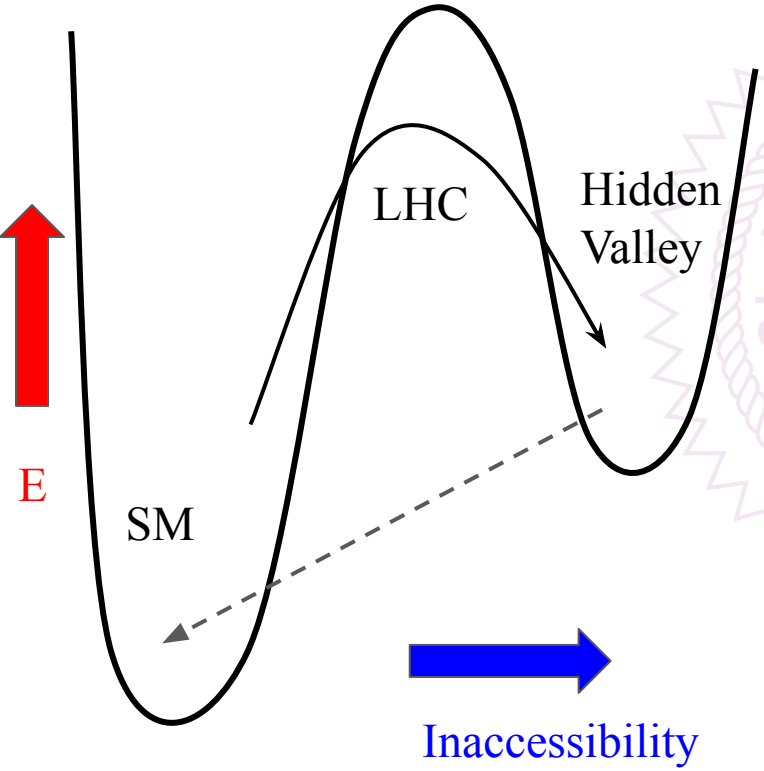
Writting and Award - Thesis



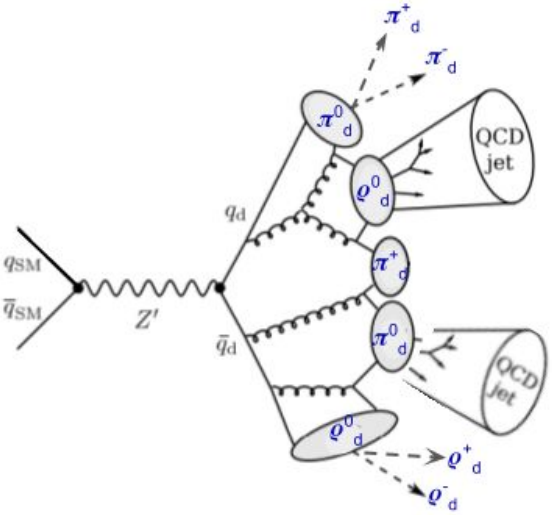


	Particle	Anti-particle	Z,W	Gluon	Photon
Incoming	→	←	Z, W	g	γ
Outgoing	←	→			

Writting and Award - Thesis

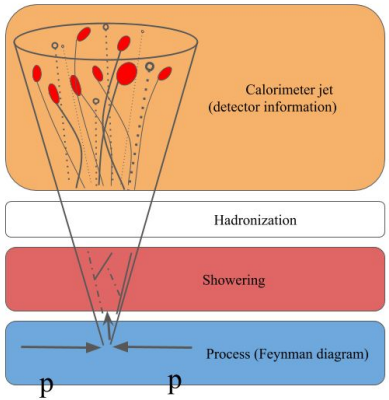


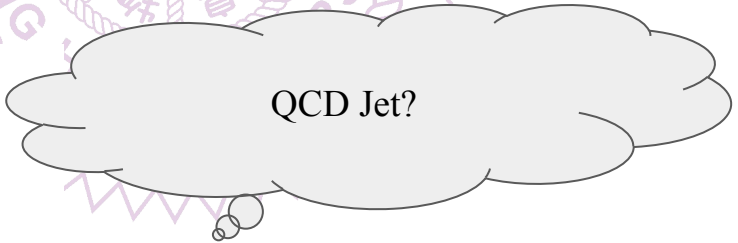
- Dark sector is a collection of some quantum fields we have not found yet.
- In our study, we use MadGraph and import the s-channel Dark Matter model. [Collision]



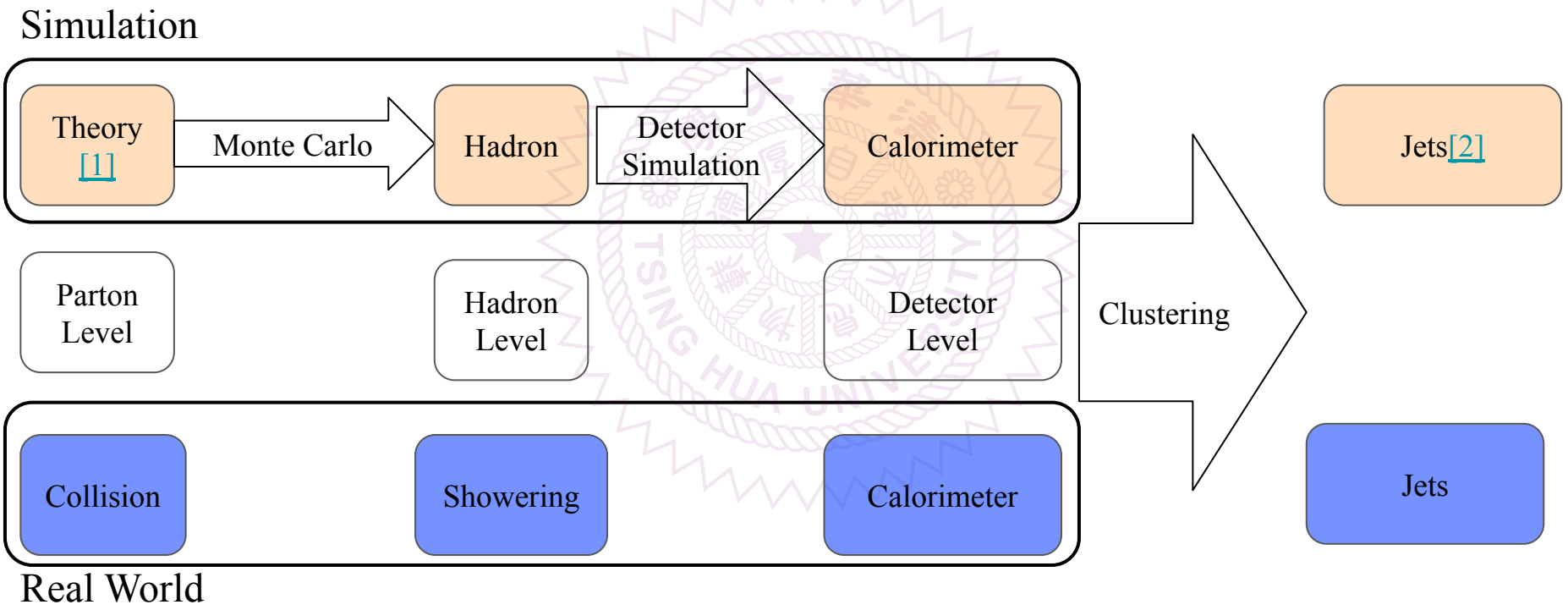
Writting and Award - Thesis

- Using ML to classify signal and background.
- Compare the performance of ML with the performance of physical observables.

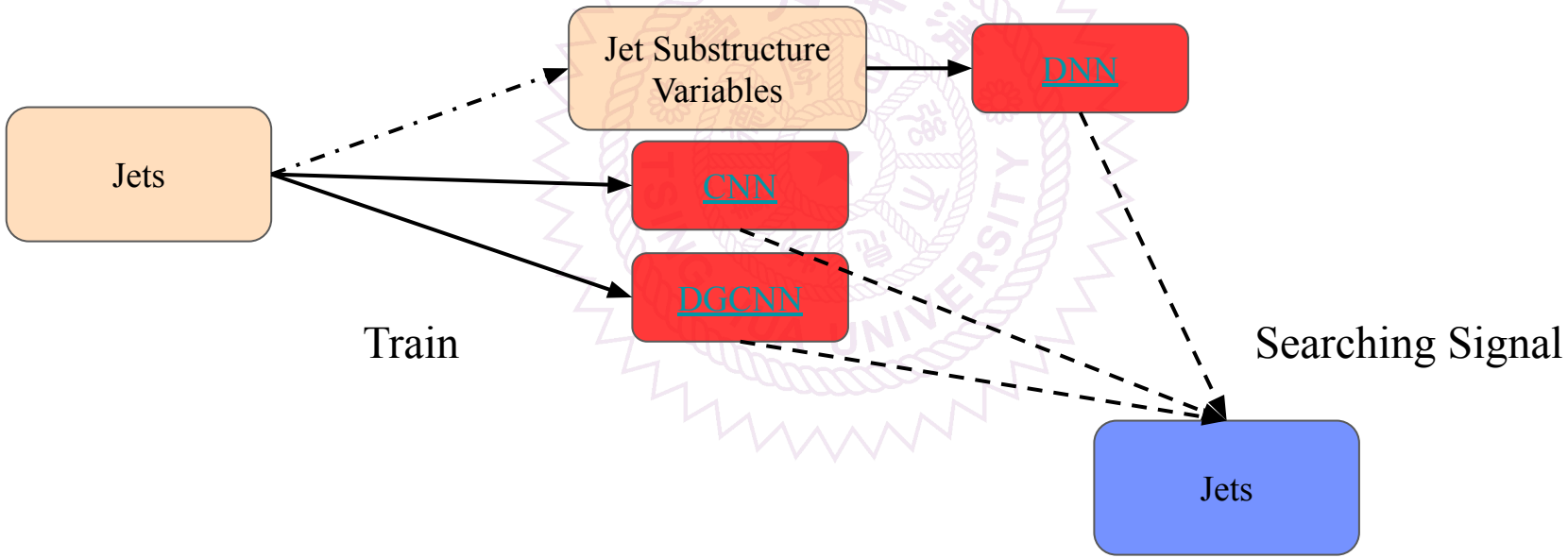




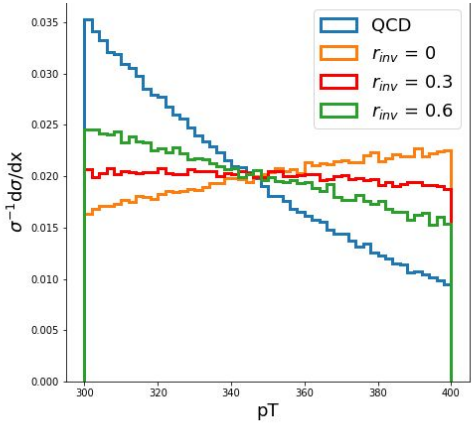
Writting and Award - Thesis

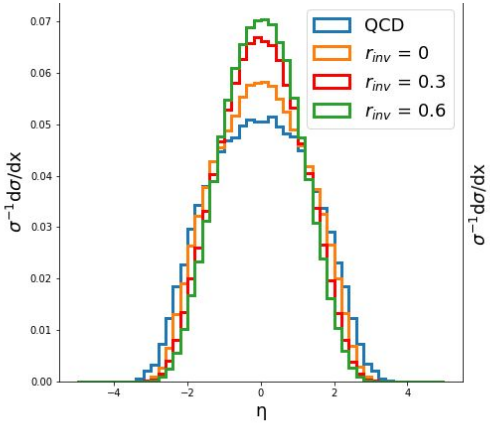


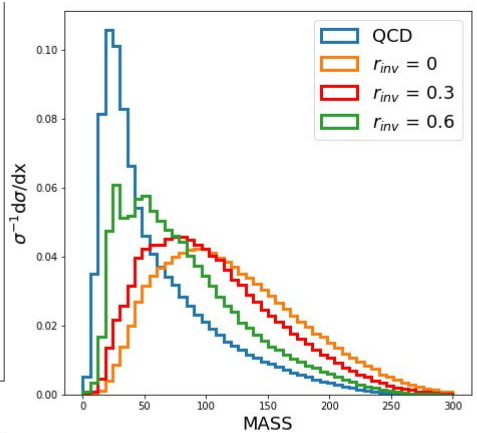
Writting and Award - Thesis

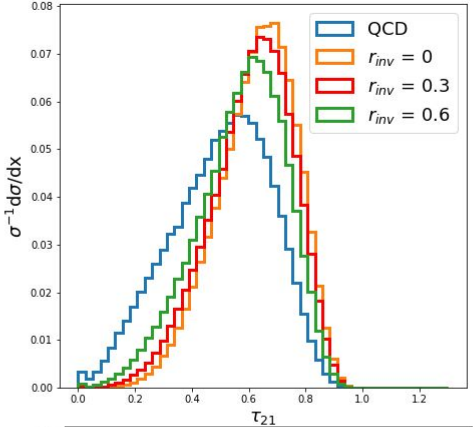


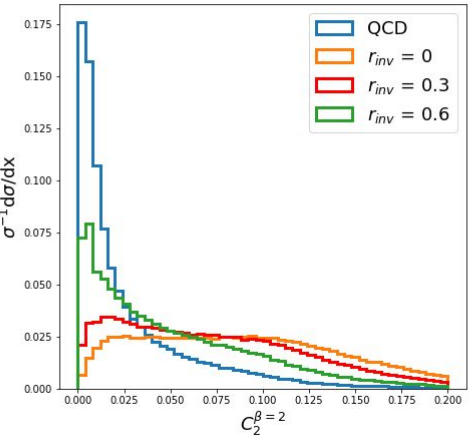
Writting and Award - Thesis

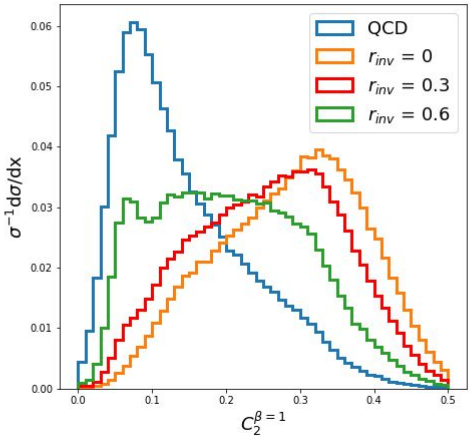


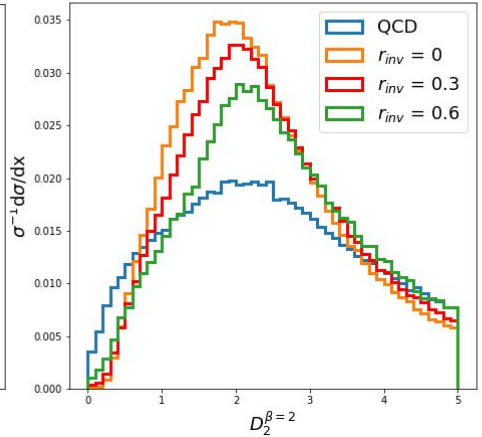


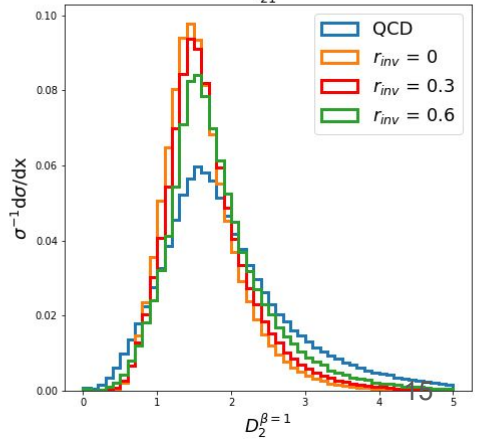






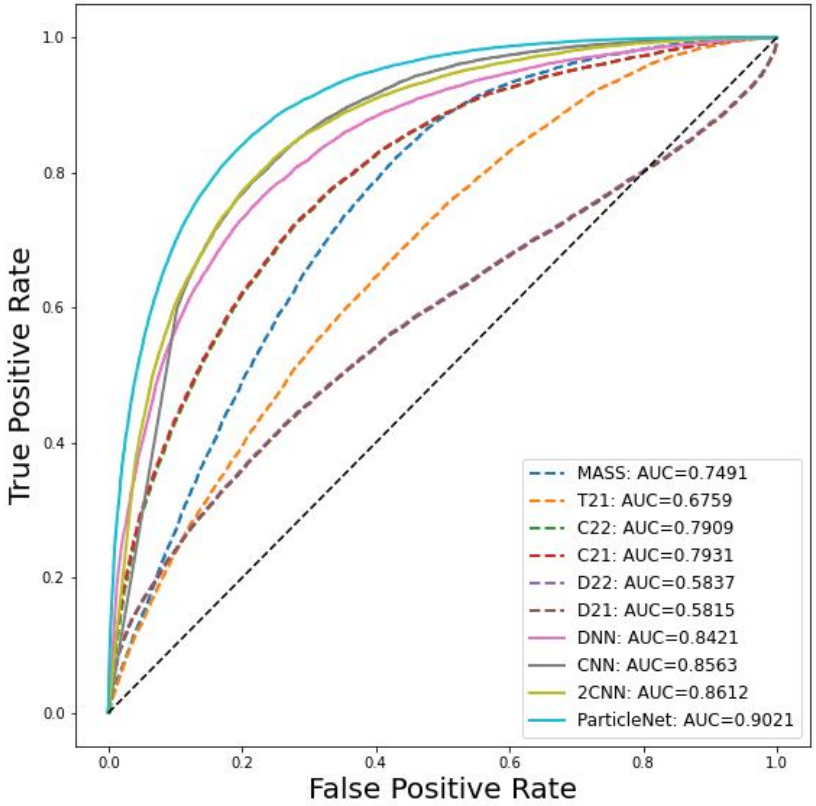




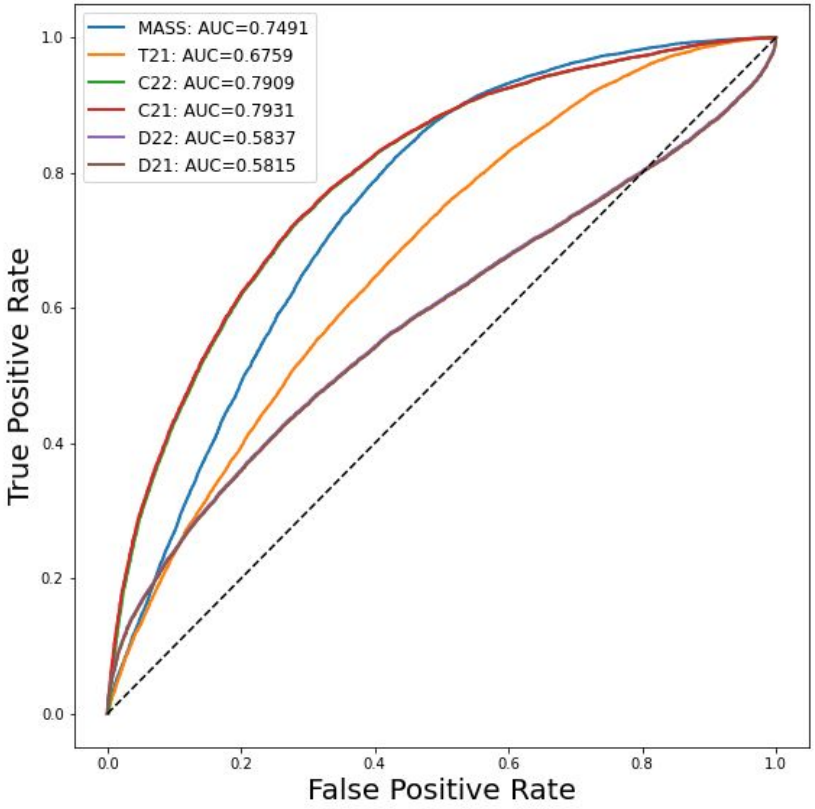


Writting and Award - Thesis

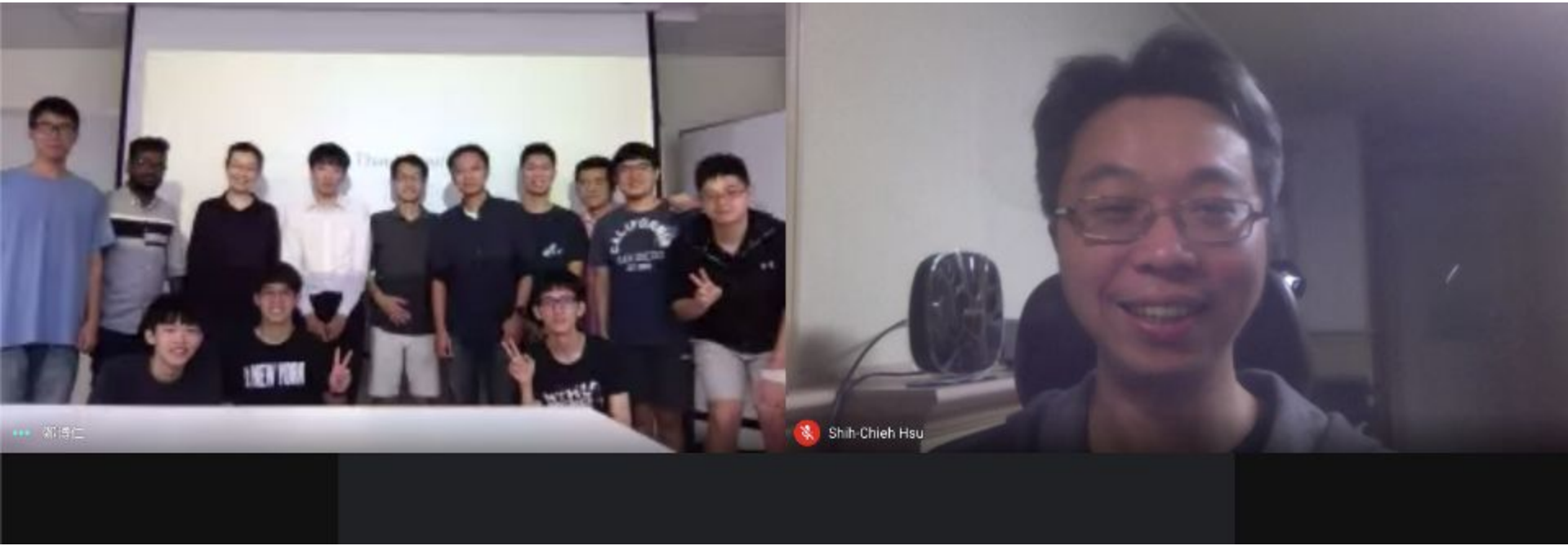
ROC curve of high-level features + ML models



ROC curve of high-level features



Writting and Award - Thesis



Writting and Award - Poster

Use Graph Theory method to Classify Gluon jets and Quark jets

POSTER, THE PHYSICAL SOCIETY OF TAIWAN, PARTICLES, AND FIELD
HONOURABLE MENTION

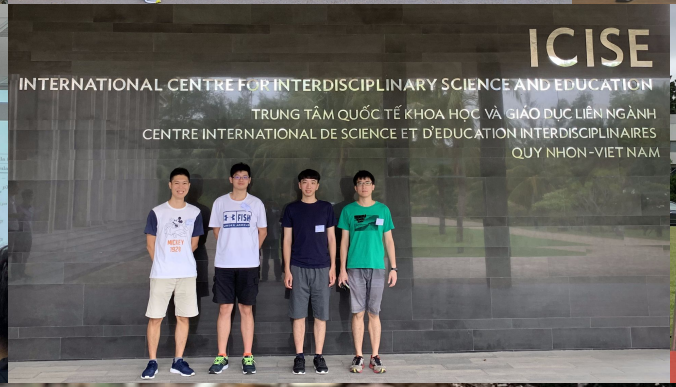
Description :

•Define the types of graphs that have different topologies.

•Improving the jet algorithm and adding the condition to define edges.

•Our method improves the classification 3% AUC of the ROC curve, comparing with pure DNN.

Life Sharing




Thank you for listening!

Feed Back

1. 2.薪水、1.產業發展、4.有趣工作內容、3.成就感
2. ~10hr/mon
3. 60~70%
4. 跟俊吉吉聊聊離職原因*
5. 加班費依法
6. 會盡量幫助新人
7. (一)、(二) 回復陳副理
8. 工作壓力大 ()
9. 假期要事先告知(2month)
10. 升等(3-4年)、人才難找

Backup

Dry Etching - Abstract[DE1]

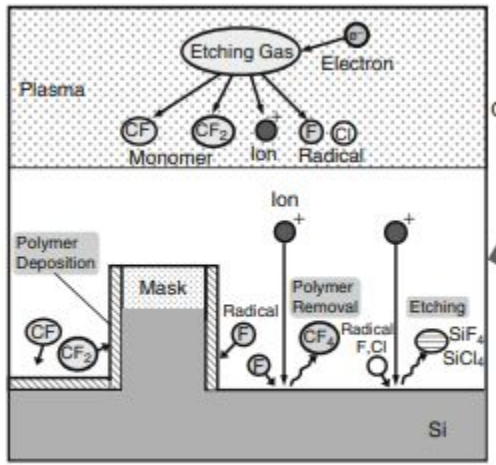
- 蝕刻製程目的是移除晶圓表面的特定區域, 以沉積其它材料
- 「乾式」(電漿) 蝕刻是用於電路清晰度步驟
- 乾式蝕刻是激發氣體(如氟或氯) 產生電漿(自由基、Ion...)來進行對薄膜之蝕刻

Dry Etching - Device[DE2],[DE3]

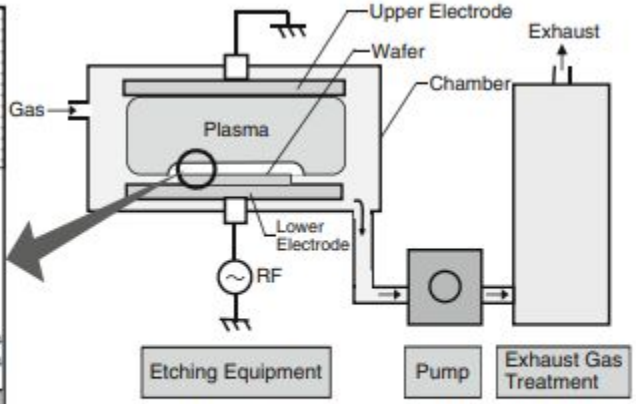
- 用電極激發Etching Gas
- 配合之前沉澱的Mask 做多晶矽蝕刻(或硬罩清除)
- 由Ion 轟炸要蝕刻的地方然後再由自由基帶走
- 由真空幫浦抽走廢氣
- 主要反應:

$$Si + 4Cl \rightarrow SiCl4$$

$$SiO_2 + 4F \rightarrow SiF4 + O_2$$



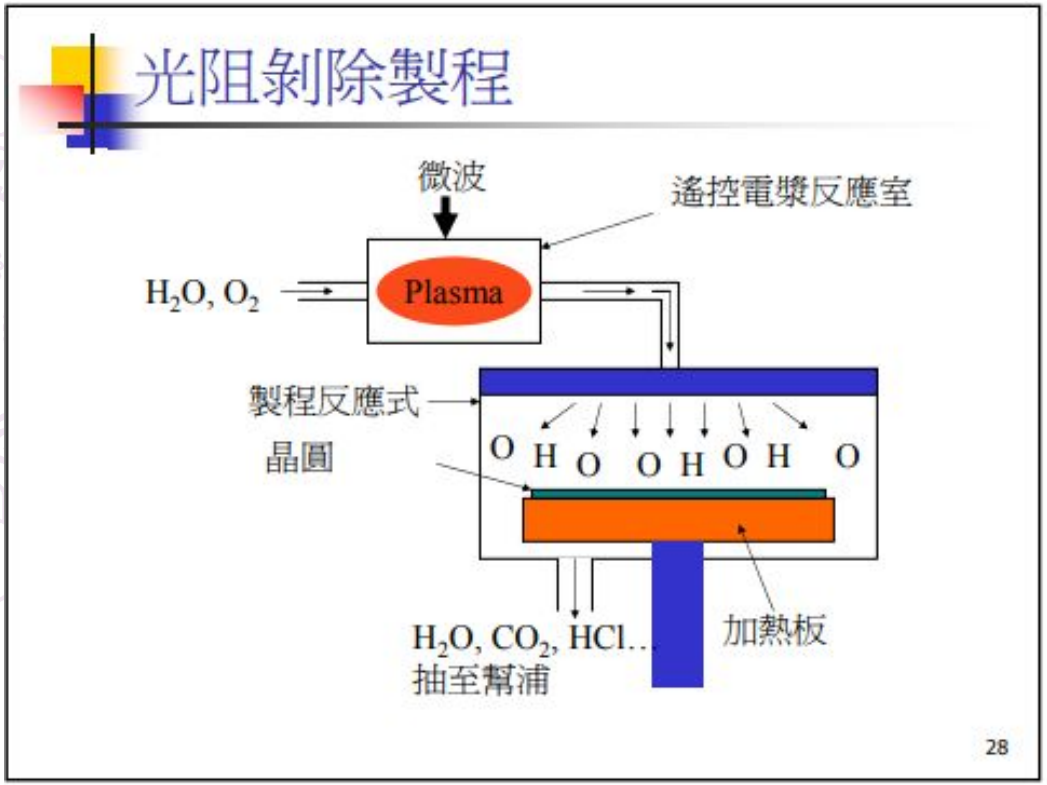
Reaction in Dry Etching



Dry Etching System

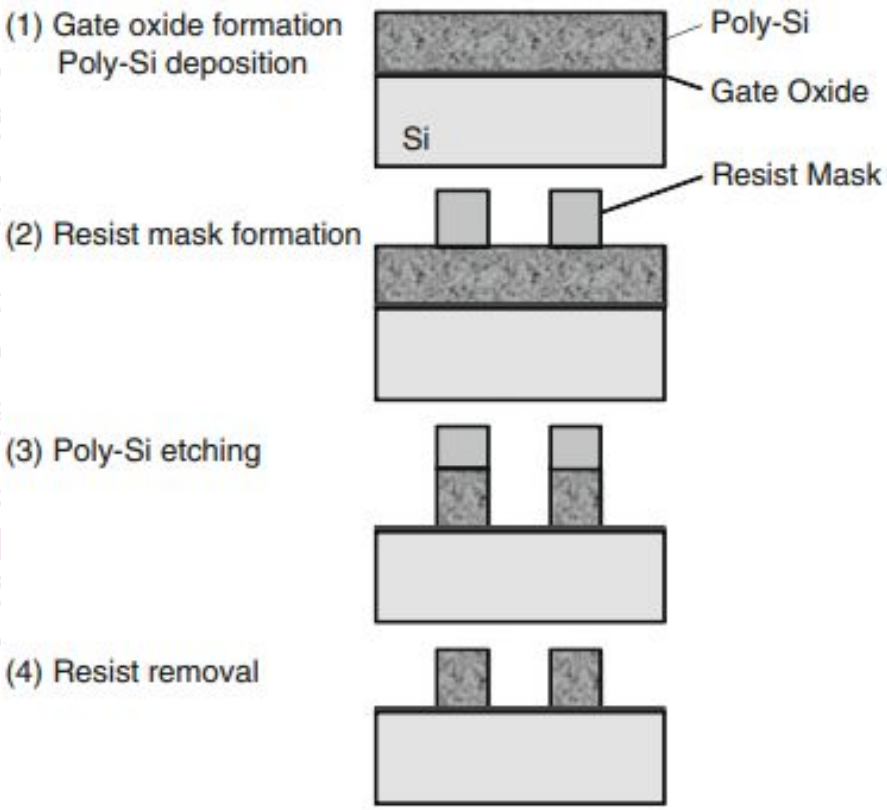
Dry Etching - Device[DE2],[DE3]

- 用微波激發水氣或氧氣
- 清除殘留的光阻



Dry Etching - Flow

- 微影部門(或薄膜)會把帶有特定圖案光阻劑/硬罩的wafer送來
- 實施多晶矽蝕刻
- 清除光阻/硬罩



Reference

- [DE1] APPLIED MATERIALS
- [DE2] Dry Etching Technology for Semiconductors [K. Nojiri, Published 2014, Materials Science]
- [DE3] Introduce to Semiconductor proecess
- [DE4] 電漿基礎原理
- [DE5] Highly selective Si3N4/SiO2 etching using an NF3/N2/O2/H2 remote plasma. II. Surface reaction mechanism [Ji-Eun Jung1,a), Yuri Barsukov1,a), Vladimir Volynets1,a), Gonjun Kim1,a), Sang Ki Nam1,a), Kyuhee Han1,a), Shuo Huang2,b), and Mark J. Kushner2,c)]

Dry Etching

Etched Layers

蝕刻名稱	硬式遮蔽層	接觸窗	金屬層接觸窗孔	連接墊片
材料	Si_3N_4 or SiO_2	PSG or BPSG	USG or FSG	Nitride and oxide
蝕刻劑	CF_4, CHF_3, …	CF_4, CHF_3, …	CF_4, CHF_3, …	CF_4, CHF_3, …
底層	Si, Cu, Au,	多晶矽或金屬矽化物	金屬	金屬
終點偵測	CN, N or O	P, O, and F	O, Al and F	O, Al and F

Dry Etching

-

Dry Etching

-

Contents

Thesis Content

Classification of Semi-visible Jets with Machine Learning

MASTER THESIS

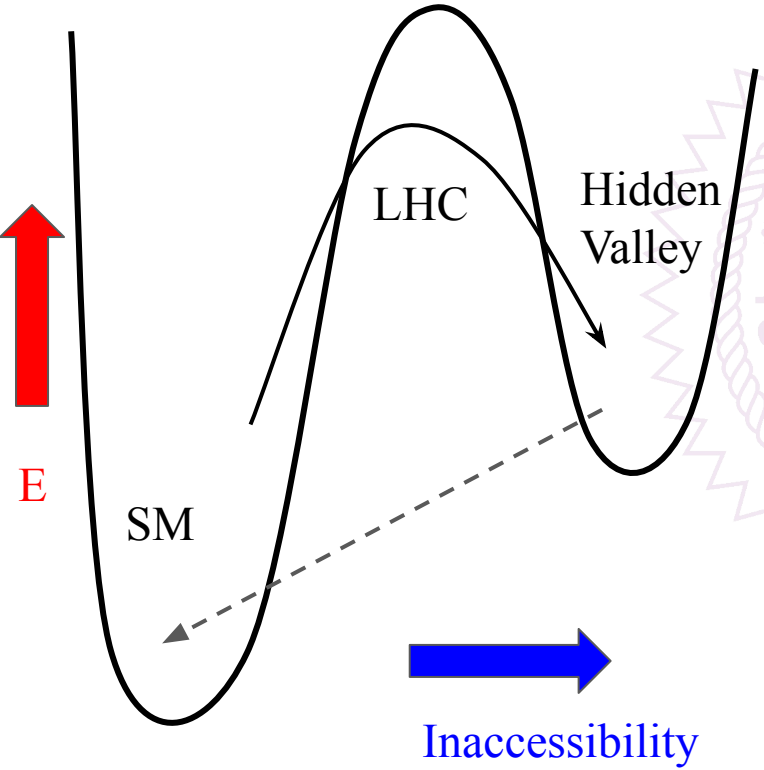
Description :

•Using machine learning eliminates the gap between theory and experiment.

•Dark matter can not be ”seen” in the Collider, our theory claim that visible particles come behind.

•We use theory to simulate data, and use jet constituents to train CNN, and Dynamics Graph NN.

Dark Sector (Hidden Sector)

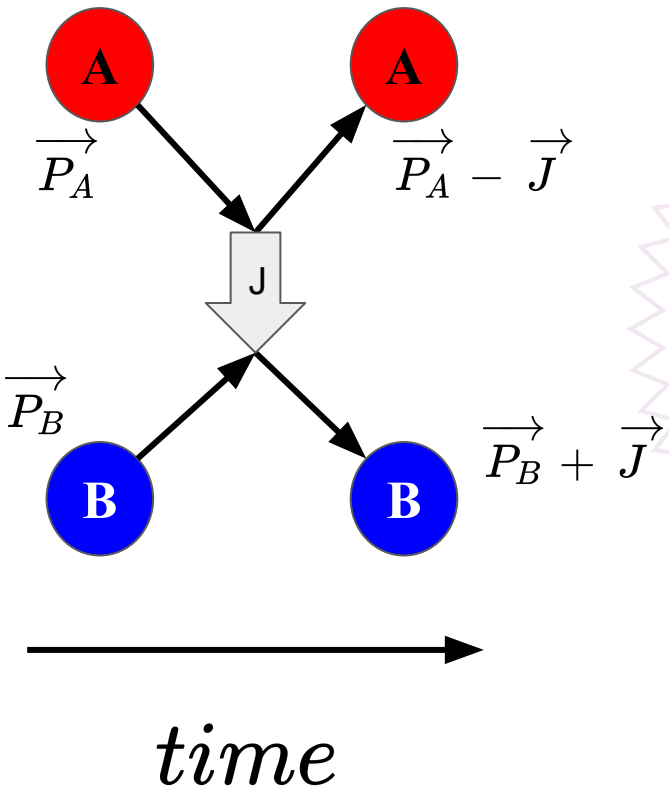


- Dark sector is a collection of some quantum fields we have not found yet.
- In our study, we use MadGraph and import the s-channel Dark Matter model [3].
- The Lagrange contains following form.

$$\mathcal{L}_{\text{dark}} \supset -\frac{1}{2}\text{tr}\, G^{d}_{\mu\nu} G^{d\mu\nu} - \overline{\chi}_a \left(i\not{D} - M_{d,a}\right) \chi_a$$

Where the fermionic states $\chi_a = \chi_1,\ \chi_2$, the dark gluon field strength $G^{\text{d}}_{\nu\mu}$ and the dark quark mass $M_{d,a}$;we assume all the dark quark mass $M_d = 10$ GeV.

Elastic Collision in Classic Physics



In classic collision we assume object exchange momentum "immediately". However it is not allow in Special Relativity, so we need some imediator to illustrate interaction.

We can design some mathematical tools to easily describe elastic collision, and our tools need to have:

1. Momentum conservation
2. Energy conservation
3. Easily get invariant mass

Our tool is(c=1) :

$$\overrightarrow{P} = \begin{pmatrix} E \\ ip_x \\ ip_y \\ ip_z \end{pmatrix} \text{ or } \begin{pmatrix} E \\ i\overrightarrow{p} \end{pmatrix}$$

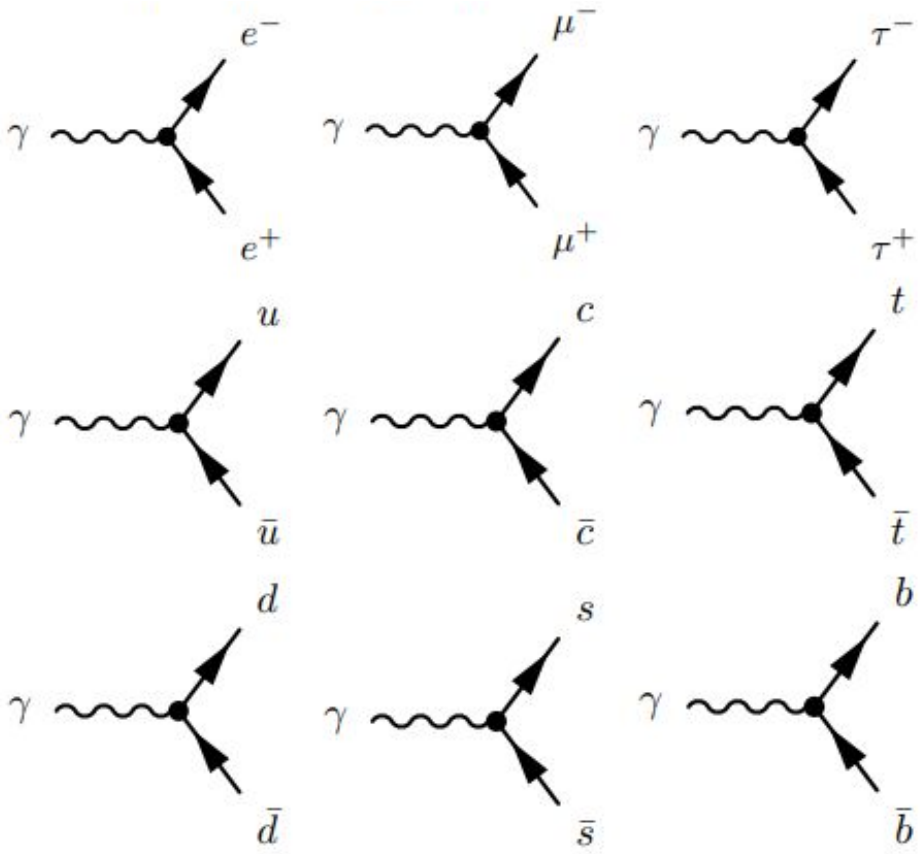
$$\overrightarrow{P_1} + \overrightarrow{P_2} = \begin{pmatrix} E_1 + E_2 \\ i\left(\overrightarrow{p_1} + \overrightarrow{p_2}\right) \end{pmatrix}$$

$$\overrightarrow{P_1} \cdot \overrightarrow{P_2} = \begin{pmatrix} E_1 E_2 \\ -\overrightarrow{p_1} \cdot \overrightarrow{p_2} \end{pmatrix}$$

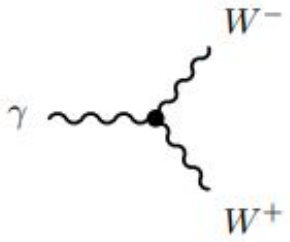
Feynman diagram

	Particle	Anti-particle	Z,W	Gluon	Photon
Incoming					
Outgoing			Z, W	g	γ

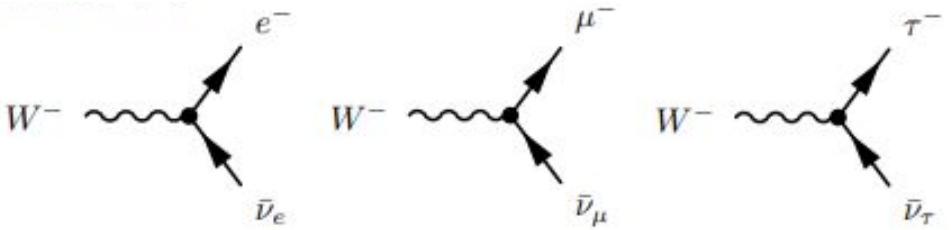
Allowed Vertices (EM) [3]

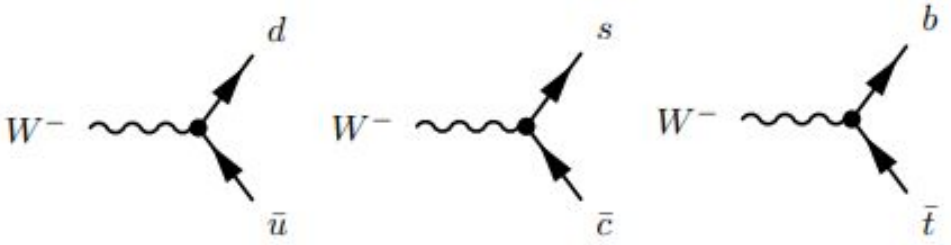


Triple Gauge Vertex

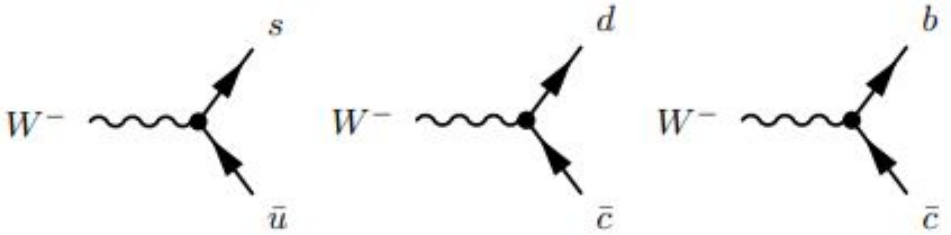


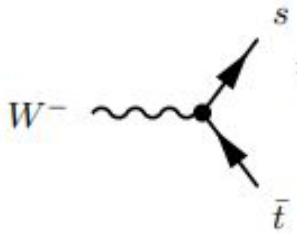
Allowed Vertices (Weak)





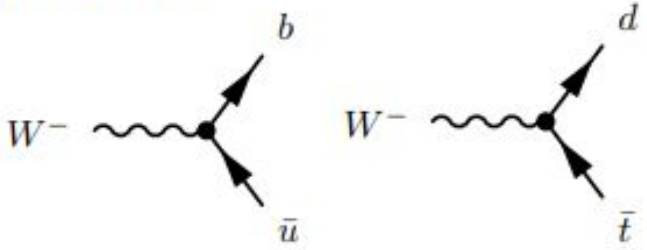
⇒ Same family quarks are **Cabibbo favoured**





⇒ Cross one family **Cabibbo suppressed**

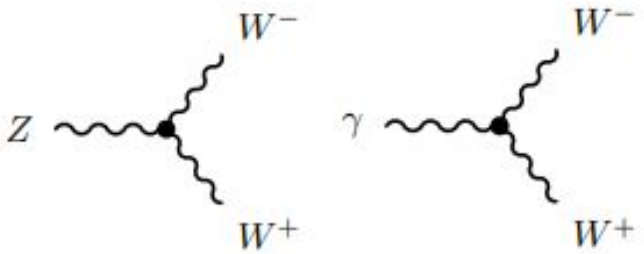
Allowed Vertices (Weak)

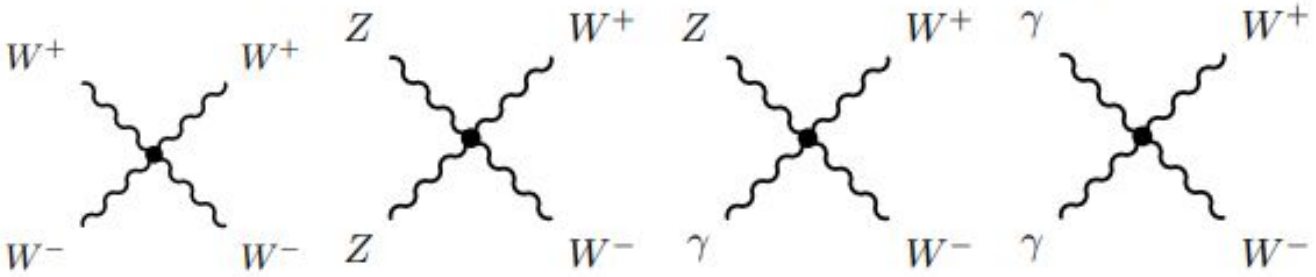


⇒ Cross two families

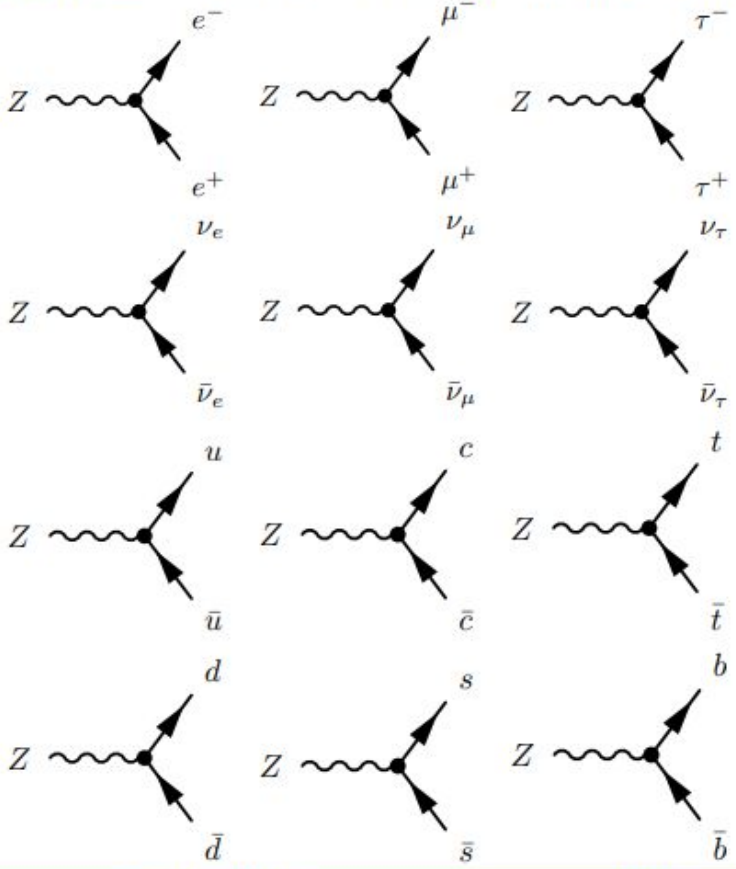
Doubly Cabibbo suppressed

Also, Triple/Four Gauge Vertex

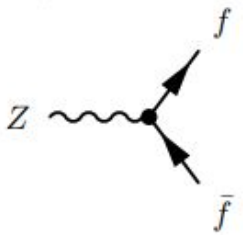




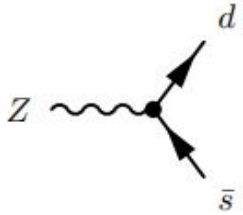
Allowed Vertices (Weak)



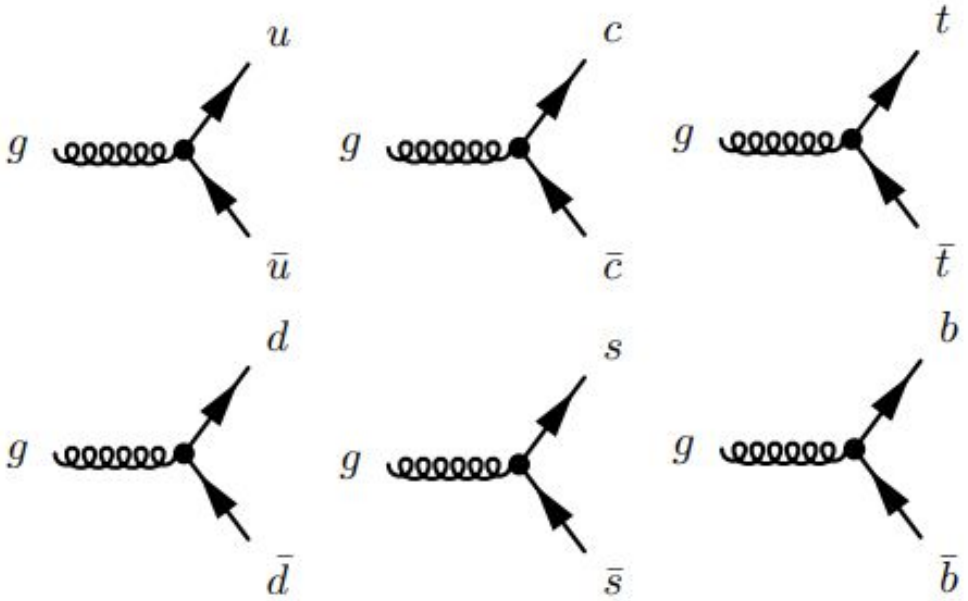
i.e.



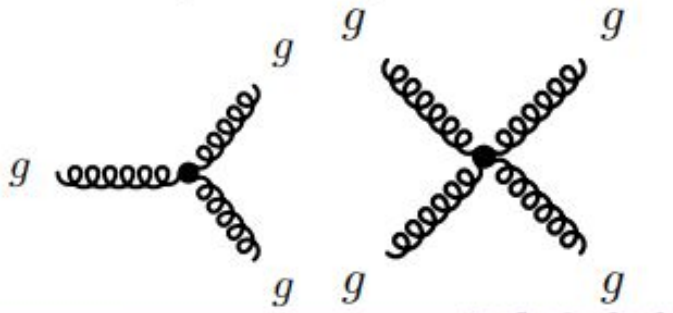
Not Allowed:
Flavour Changing
Neutral Currents (FCNC)



Allowed Vertices (Strong)



Also, Triple Gauge Vertex



Dark Sector - s-channel

- We use Pythia8 Hidden Valley (HV) process to do the dark shower
- The dark QCD is in a $SU(2)_d$ gauge group [3]

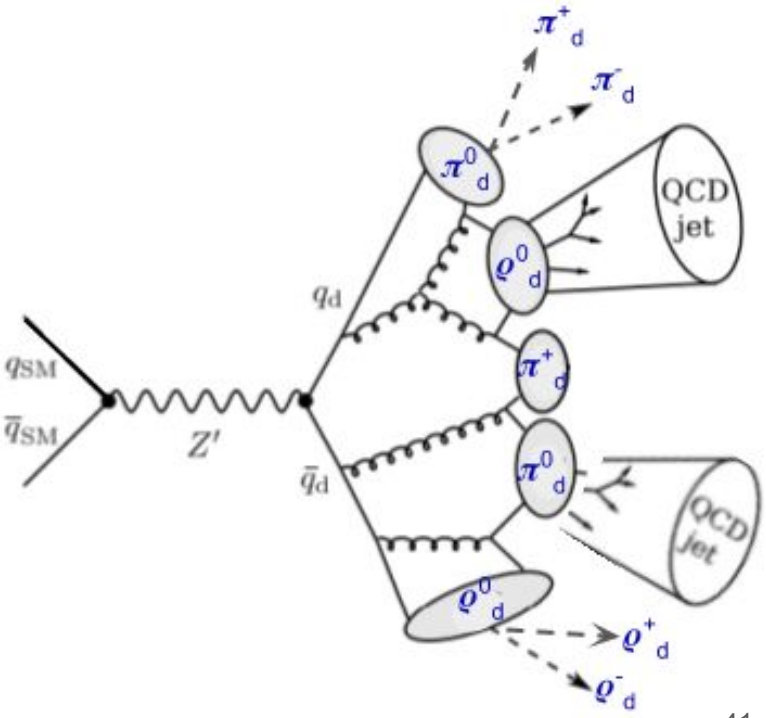
- The s-channel considers the process

$$q\ \bar{q} \to Z' \to \chi_a\ \bar{\chi}_a\ \ (q_d \equiv \chi_a)$$

- The Lagrange contains following term

$$\mathcal{L}_{s\text{-channel}} \supset -Z'_\mu \sum_{i,a} \left(g_q\, \bar{q}_i \gamma^\mu q_i + g_\chi\, \bar{\chi}_a \gamma^\mu \chi_a \right)$$

- The mass of Z' ~ TeV



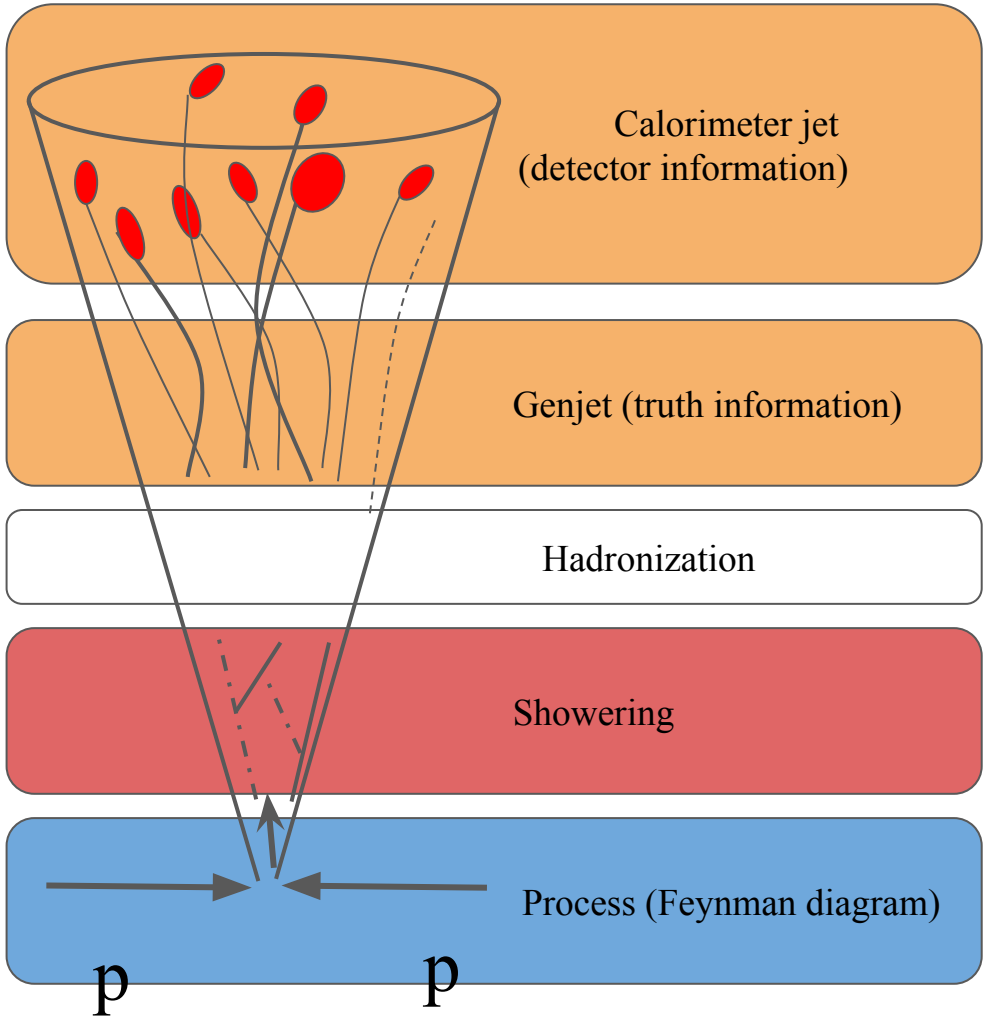
What is jet?
Why we need the jet?

Jet is the proxy of parton or other particles.

We can not see these particles in detector directly. If we want to study parton or other particles, we need to use it.

How to find it?

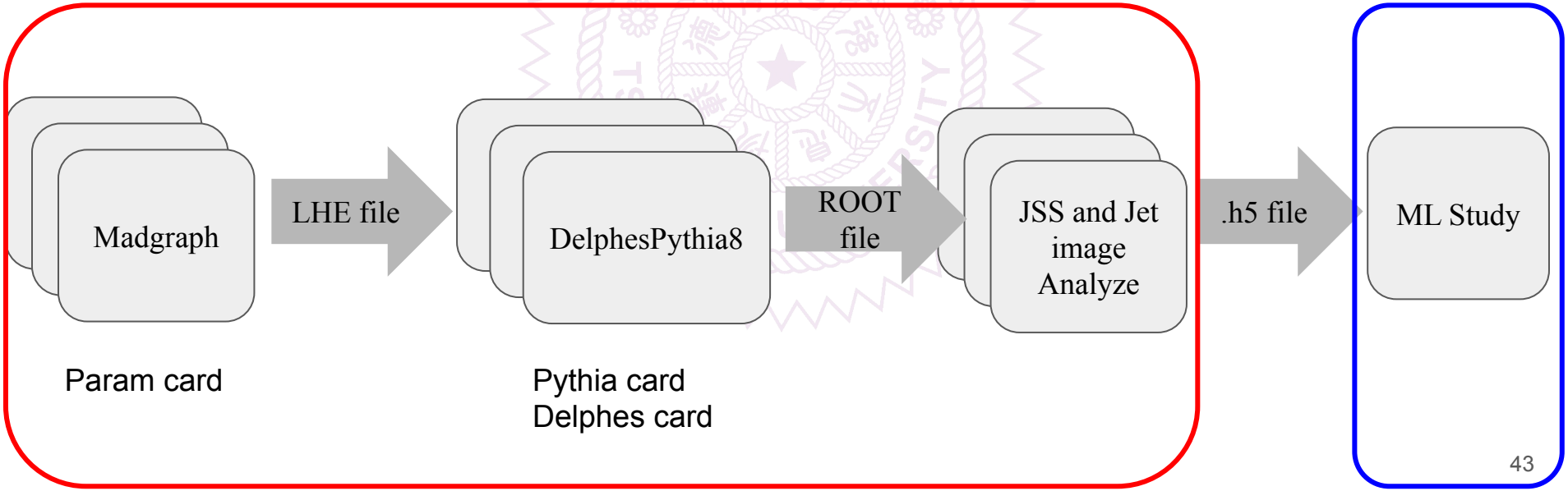
Jet is constructed by a collimated bunch of hadrons flying roughly in the same direction. There is a way that we can use jet algorithm to reconstruct the jet in calorimeter.



Event Production[code]

Jupyter notebook [code]

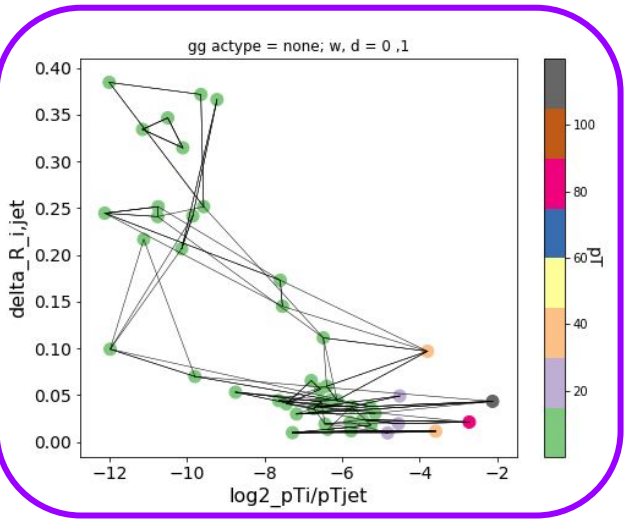
Notebook [code]



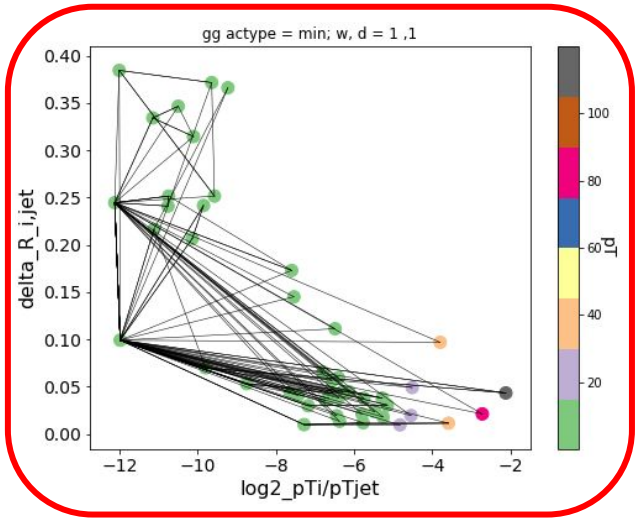
Sequential Algorithm (IRC-Safety)

pT

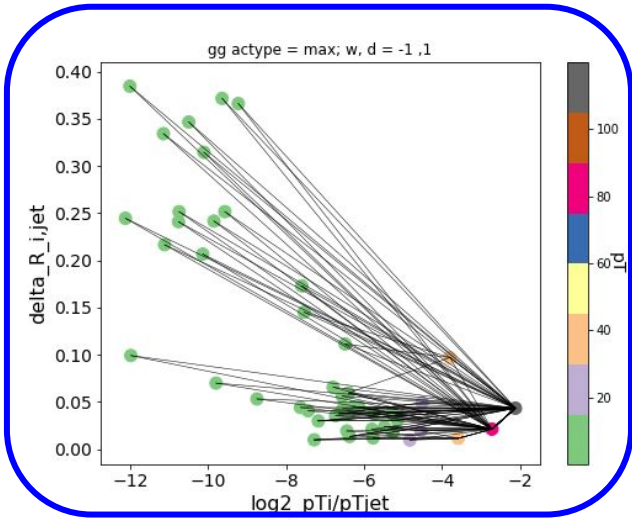
We connect each two particles wich has $min(d_{ij})$ in the jet



Cambridge



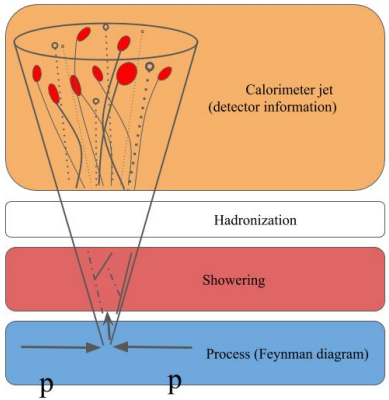
kT



anti-kT

Motivation

- Some models (beyond the Standard Model) claim that dark matters are composite particles which could be composed of dark quarks [2]
- Semi-visible jets (SVJ) are phenomena predicted by the models, and they could be searched in the LHC.
- SVJ may be lurking within hadronic jets
- Machine Learning is powerful in classification, so we apply it on our task



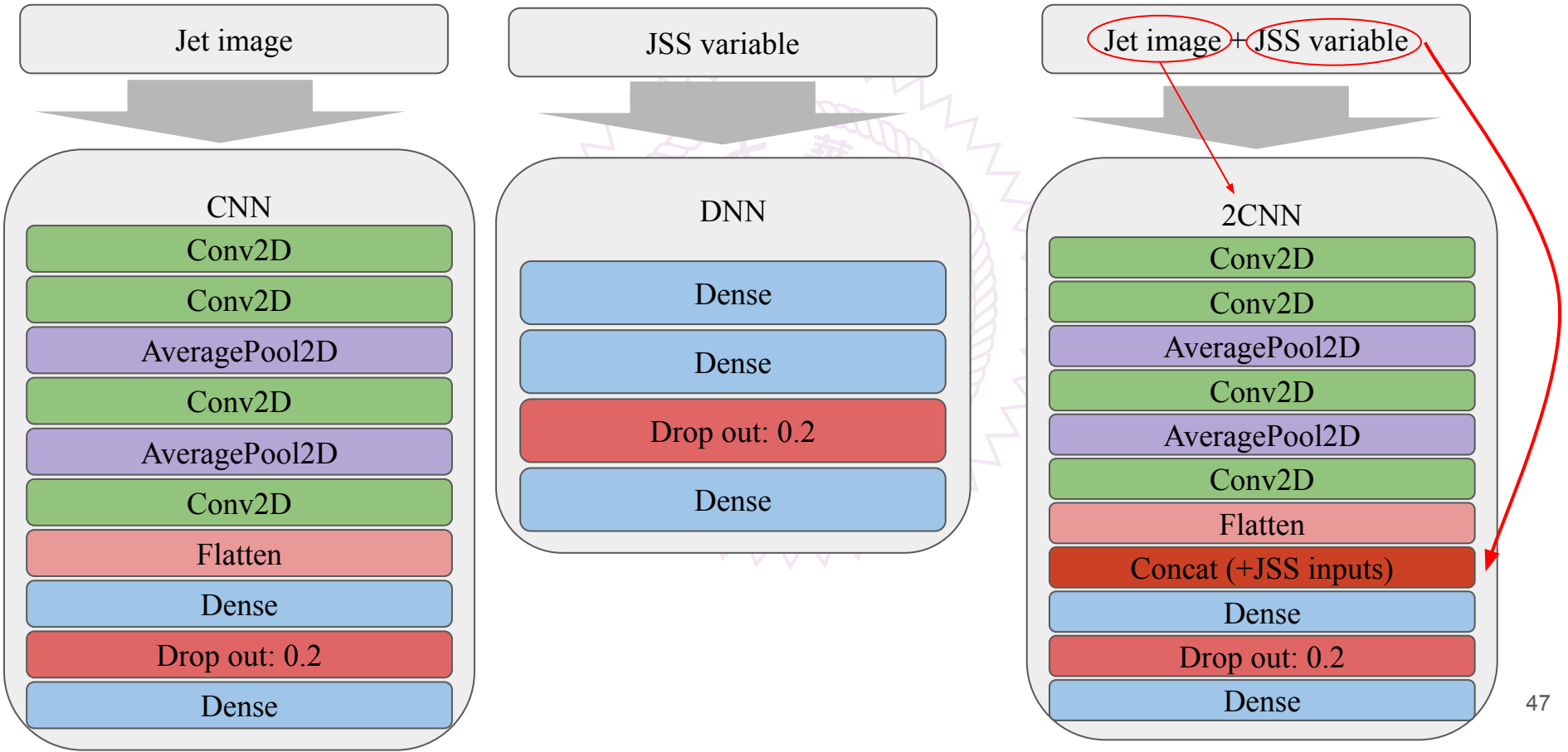
JSS study - Algorithm explanation

- The variables C and D are energy correlation functions[4]
- τ_{21} is N-subjettiness [5]

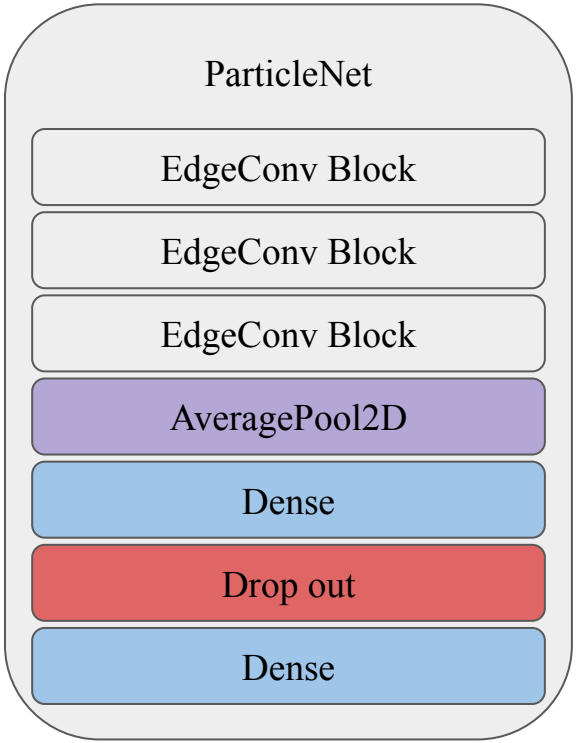
All of them are calculated by jet's constituents.

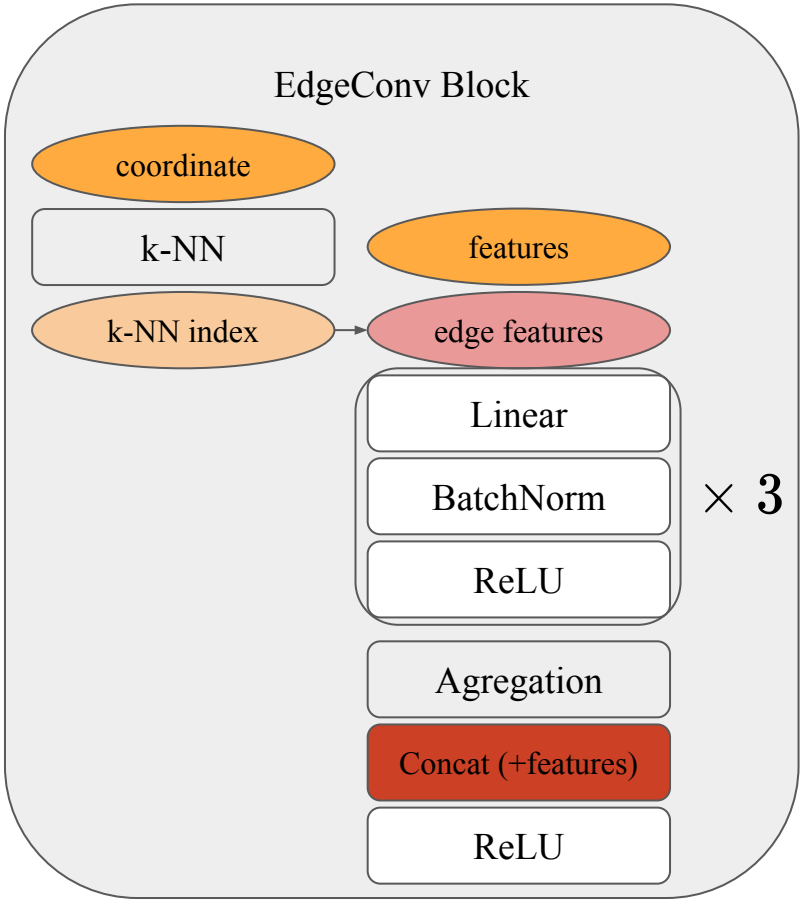
Formula for JSS	
Variable	Formula
Mass	$\sqrt{E^2 - \lvert\vec{p}\rvert^2}$
EE2	$\sum_{i<j\in jet} pT_i pT_j R_{ij}^{\beta}$
EE3	$\sum_{i<j<k\in jet} pT_i pT_j pT_k (R_{ij}R_{jk}R_{ik})^{\beta}$
$D_2^{\beta=1}$	$\frac{EE3}{EE2^3}$
$D_2^{\beta=2}$	$\frac{EE3^2}{(EE2^2)^3}$
$C_2^{\beta=1}$	$\frac{EE3}{EE2^2}$
$C_2^{\beta=2}$	$\frac{EE3^2}{(EE2^2)^2}$
τ_n	$\frac{1}{pT_{jet}R}\sum_{i\in jet} pT_i min(R_{ia_1}R_{ia_2}...R_{ia_n})$
τ_{21}	τ_2/τ_1

Model architecture - DNN, CNN and 2CNN [code]



Model Architecture - ParticleNet





Model compile

Model: "CNN"

Layer (type)	Output Shape	Param #
input_12 (InputLayer)	[(None, 64, 64)]	0
tf_op_layer_ExpandDims_10 (T	[(None, 64, 64, 1)]	0
conv2d_44 (Conv2D)	(None, 64, 64, 32)	64
conv2d_45 (Conv2D)	(None, 61, 61, 64)	32832
average_pooling2d_32 (Averag	(None, 15, 15, 64)	0
conv2d_46 (Conv2D)	(None, 12, 12, 128)	131200
average_pooling2d_33 (Averag	(None, 3, 3, 128)	0
conv2d_47 (Conv2D)	(None, 1, 1, 256)	295168
flatten_4 (Flatten)	(None, 256)	0
dense_9 (Dense)	(None, 128)	32896
dropout_4 (Dropout)	(None, 128)	0
dense_10 (Dense)	(None, 2)	258

Total params: 492,418
Trainable params: 492,418
Non-trainable params: 0

Model: "DNN"

Layer (type)	Output Shape	Param #
input_8 (InputLayer)	[(None, 6)]	0
dense_22 (Dense)	(None, 6)	42
dense_23 (Dense)	(None, 256)	1792
dropout_6 (Dropout)	(None, 256)	0
dense_24 (Dense)	(None, 2)	514

Total params: 2,348
Trainable params: 2,348
Non-trainable params: 0

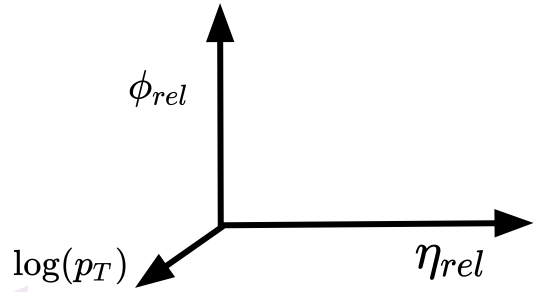
Model: "2CNN"

Layer (type)	Output Shape	Param #	Connected to
input_7 (InputLayer)	[(None, 64, 64)]	0	
tf_op_layer_ExpandDims_6 (Tenso	[(None, 64, 64, 1)]	0	input_7[0][0]
conv2d_12 (Conv2D)	(None, 64, 64, 32)	64	tf_op_layer_ExpandDims_6[0][0]
conv2d_13 (Conv2D)	(None, 61, 61, 64)	32832	conv2d_12[0][0]
average_pooling2d_6 (AveragePoo	(None, 15, 15, 64)	0	conv2d_13[0][0]
conv2d_14 (Conv2D)	(None, 12, 12, 128)	131200	average_pooling2d_6[0][0]
average_pooling2d_7 (AveragePoo	(None, 3, 3, 128)	0	conv2d_14[0][0]
conv2d_15 (Conv2D)	(None, 1, 1, 256)	295168	average_pooling2d_7[0][0]
flatten_4 (Flatten)	(None, 256)	0	conv2d_15[0][0]
input_8 (InputLayer)	[(None, 6)]	0	
tf_op_layer_concat_2 (TensorFlo	[(None, 262)]	0	flatten_4[0][0] input_8[0][0]
dense_2 (Dense)	(None, 128)	33664	tf_op_layer_concat_2[0][0]
dropout_1 (Dropout)	(None, 128)	0	dense_2[0][0]
dense_3 (Dense)	(None, 2)	258	dropout_1[0][0]

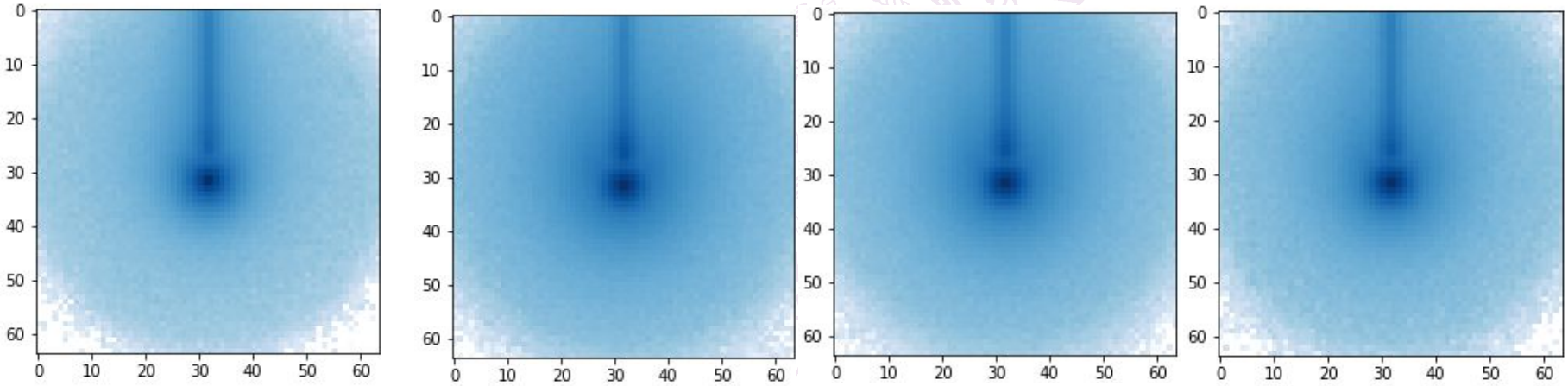
Total params: 493,186
Trainable params: 493,186
Non-trainable params: 0

Jet image study - Jet image Plot

The jet images are almost the same.



QCD r_{inv} =0 r_{inv} =0.3 r_{inv} =0.6

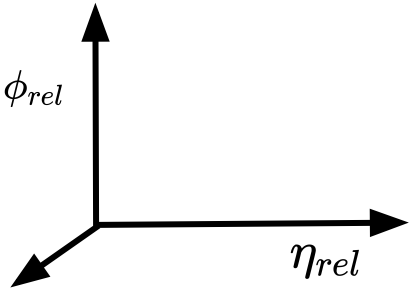


64x64

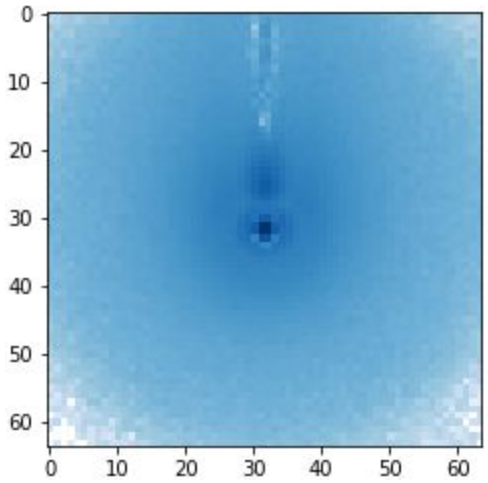
Jet image study - Discrepacy Plot

We look into the discrepancy between the SVJ image and QCD jet image using the formula

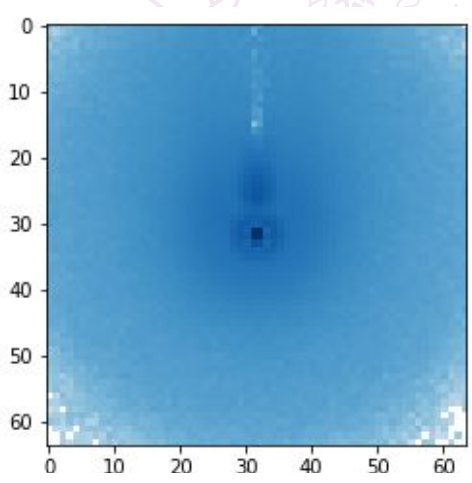
$$\log\left(\frac{\left|\frac{r_{\text{inv}}}{\text{len}(r_{\text{inv}})}-\frac{QCD}{\text{len}(QCD)}\right|}{\sum(QCD)}\right)$$



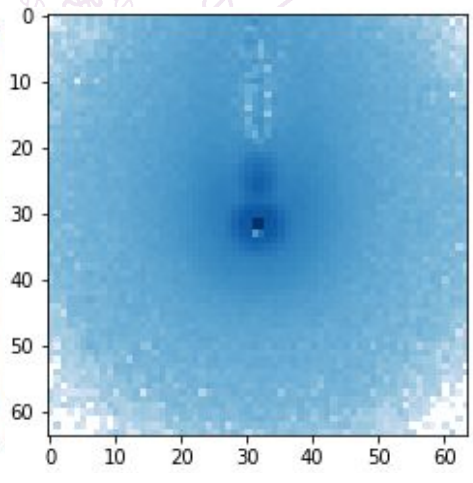
r_{inv} =0



r_{inv} =0.3



r_{inv} =0.6



Contents

- Motivation
- Dark Sector
  - s-channel
  - Semi-Visible Jets
- Event Production
  - SVJ
  - QCDJ
- JSS and Jet image
  - Algorithm explanation
  - Plot
- Model Architecture
  - DNN, CNN and 2CNN
  - ParticleNet
- Result
  - ROC explanation
  - ROC curve
- Conclusion and Outlook

Question

1. The Developmental
2. The Working Hours
3. The Work Content
4. The Pay

Contents

Q1: 商業模式eg 怎麼賣東西

Q2:跨部門合作

Q3:哪幾個月比較忙

Q4:轉研發到fab上面