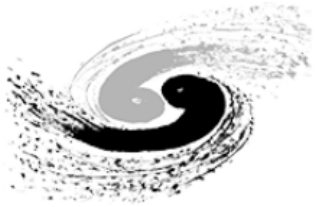

Institute of High Energy Physics
Chinese Academy of Sciences

ATLAS EXPERIMENT

科创报告

Jiarong Yuan

2023/7/27

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- Search for direct stau production
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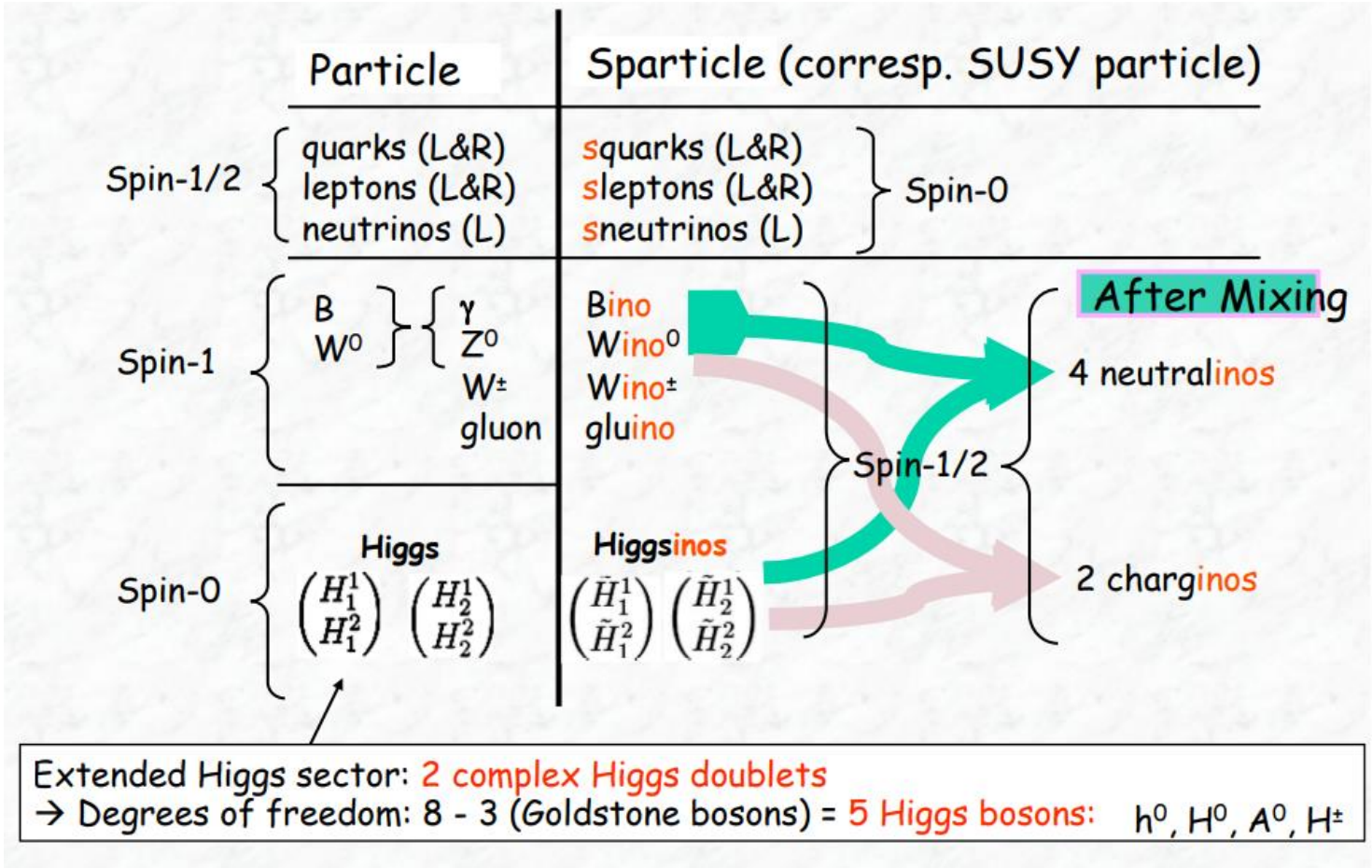
IHEP Single Sign On, 集群

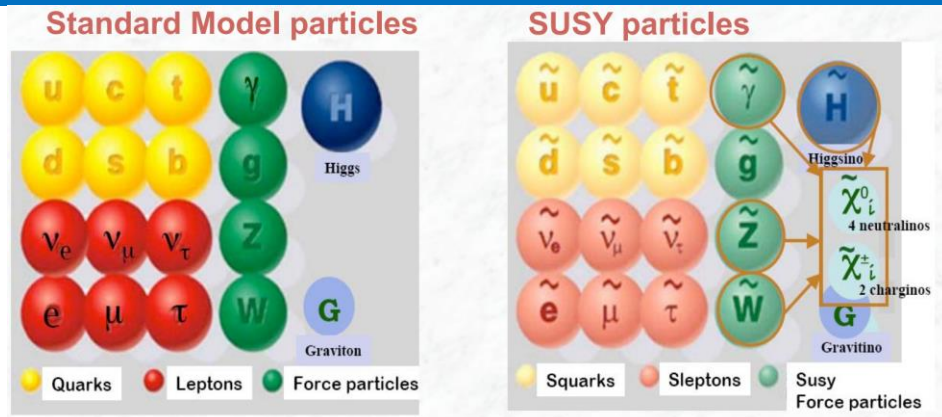
- IHEP Single Sign On
- https://login.ihep.ac.cn/login
- 教程
- http://afsapply.ihep.ac.cn/cchelp/zh/accounts/

SUSY

超对称假设了费米子与玻色子间存在着一种对称性,

$$Q|\text{Boson}\rangle = |\text{Fermion}\rangle, \qquad Q|\text{Fermion}\rangle = |\text{Boson}\rangle$$





- Physical neutralinos and charginos are mixtures of Wino, Bino, Higgsinos

- Charginos:

$$\begin{pmatrix} \chi_1^+ \\ \chi_2^+ \end{pmatrix} = \begin{pmatrix} M_2 & \sqrt{2} m_W \sin\beta \\ \sqrt{2} m_W \cos\beta & \mu \end{pmatrix} \begin{pmatrix} \tilde{W}^+ \\ \tilde{H}^+ \end{pmatrix}$$

- Neutralinos:

$$\begin{pmatrix} \chi_1^0 \\ \chi_2^0 \\ \chi_3^0 \\ \chi_4^0 \end{pmatrix} = \begin{pmatrix} M_1 & 0 & -m_Z c_\beta s_W & m_Z s_\beta s_W \\ 0 & M_2 & m_Z c_\beta c_W & -m_Z s_\beta c_W \\ -m_Z c_\beta s_W & m_Z c_\beta c_W & 0 & -\mu \\ m_Z s_\beta s_W & -m_Z s_\beta c_W & -\mu & 0 \end{pmatrix} \begin{pmatrix} \tilde{B} \\ \tilde{W}^3 \\ \tilde{H}_1^0 \\ \tilde{H}_2^0 \end{pmatrix}$$

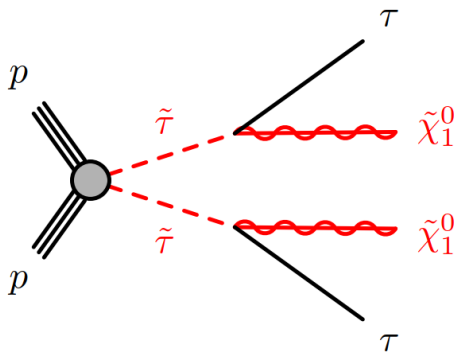
Mass eigenstates depend on:

M_1, M_2, tan β, μ SUSY masses and breaking parameters

m_Z, $\sin^2\theta_W$ EWSB (mixing: B^0,W^0 → Z, γ)

Search for direct stau production

- 分析信号：$\tau_{had}\tau_{had}$ channel

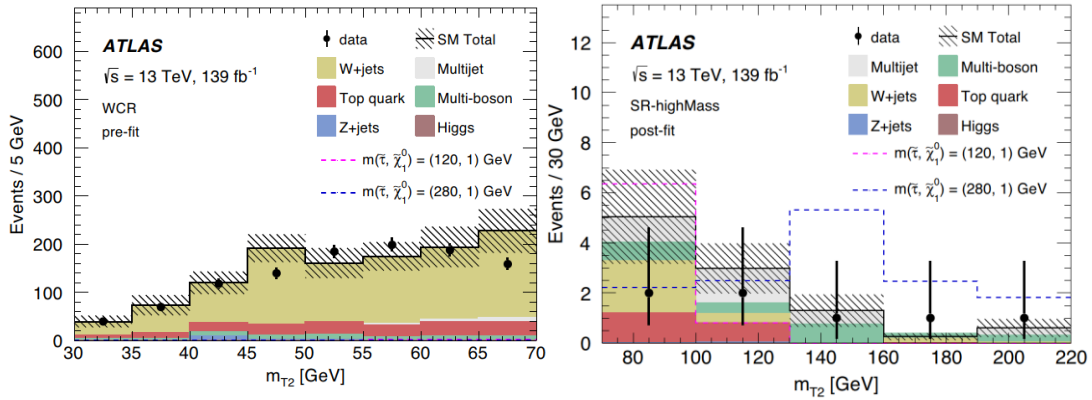


- **海量标准模型过程 v.s. 稀有的SUSY过程**
- 事例初选(preselection):
- 在寻找信号区的过程中，一般会根据信号本底特征首先使用**一些可以压制本底过程而对信号影响不大的筛选条件**进行事例初选。

Preselection of low $E_{\mathrm{T}}^{\mathrm{miss}}$ SR	Preselection of high $E_{\mathrm{T}}^{\mathrm{miss}}$ SR
== 2 medium taus (OS)	
light lepton veto and 3rd baseline tau veto	
b-jet veto	
Z/H-veto ($m(\tau_1, \tau_2) > 120$ GeV)	
asymmetric di-tau trigger	di-tau+E_T^{miss} trigger
$E_T^{miss} < 150$ GeV	$E_T^{miss} > 150$ GeV
τ p_{T} cut described in Table 5.3	

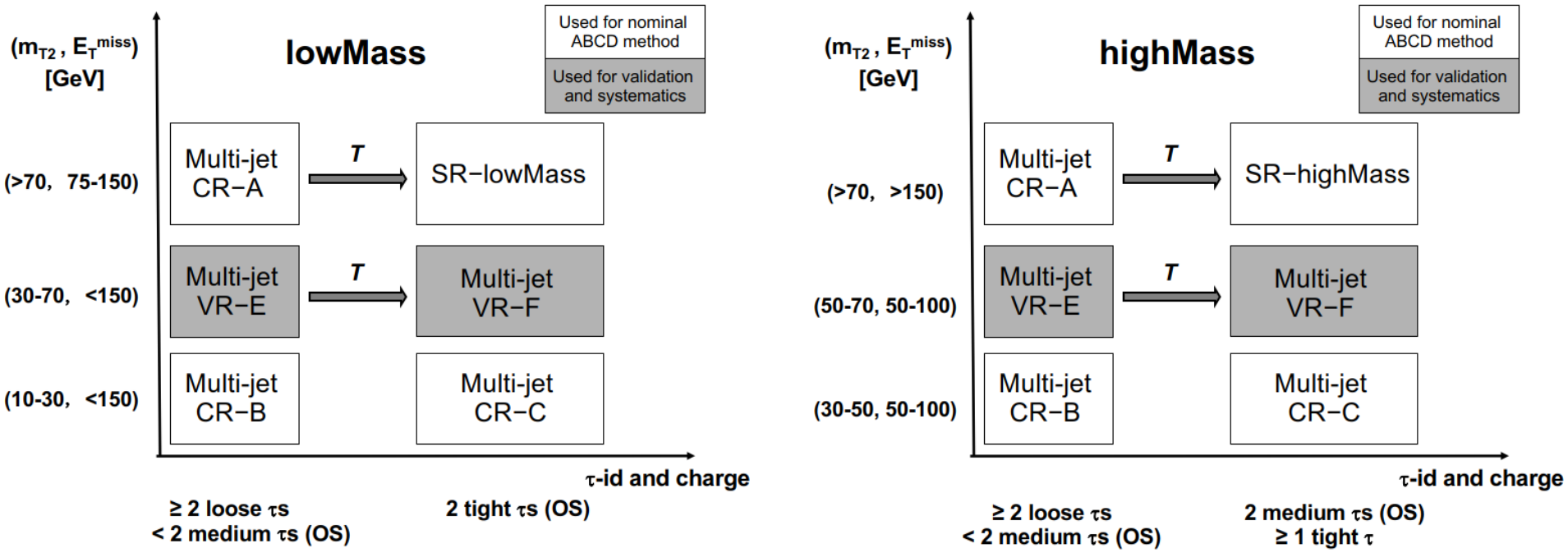
- 信号区(Signal Region)
- 为了**尽大可能的寻找到信号粒子**，需要定义出使信号样本显著性尽量大的区域并在此区域与真实的对撞数据进行假设检验，此区域被称为信号区。

SR-lowMass	SR-highMass
2 tight τ (OS)	2 medium τ (OS) , $\geq$ 1 tight τ
asymmetric di-τ trigger	di-τ+E_T^{miss} trigger
$75 < E_T^{miss} < 150$ GeV	$E_T^{miss} > 150$ GeV
τ p_{T} cut described in Section 5.3	
light lepton veto and 3rd medium τ veto	
b-jet veto	
Z/H veto ($m(\tau_1, \tau_2) > 120$ GeV)	
$\lvert\Delta\phi(\tau_1, \tau_2)\rvert > 0.8$	
$\Delta R(\tau_1, \tau_2) < 3.2$	
$m_{\mathrm{T2}} > 70$ GeV	



Search for direct stau production

- 本底估计：多喷注事例（两个喷注被误识别为τ）
- 如果某一物理量与某些物理量是相互独立的。那么该物理量在这些与其独立的物理量的不同选择条件下将服从相似的分布。由此原理，可以把这两个区间分为 4 部分，称为 A，B，C，D。
- 那么这四个区域的事例数 N_A，N_B，N_C，N_D就满足 $N_A/N_D = N_B/N_C$
- D: SR
- $N_D = N_A \times \frac{N_C}{N_B} = N_A \times T$



Tutorial

- ROOT: https://root.cern/
- Reference: https://root.cern.ch/doc/master/classTTree.html
- User-Guide: https://root.cern.ch/root/htmldoc/guides/users-guide/ROOTUsersGuide.html
- 数据里有什么：很多个事例，每个事例有很多个变量
- 我们现在要做什么：使用原有变量计算一些新的变量，做一下选择，画一些直方图。
- MiniAnalysis: https://gitlab.cern.ch/yuanj/MiniAnalysis/-/tree/master?ref_type=heads

- Tutorial: /publicfs/atlas/atlasnew/SUSY/users/yuanjiarong/DS_Tutorial

```
atlasui01:/publicfs/atlas/atlasnew/SUSY/users/yuanjiarong/DS_Tutorial 22:58:49
$ls
docs  draw  inputs  metadata  preSR  readme.md  reference  setup.sh  slim_cd
```

Tutorial made by Jiarong Yuan. July 26th 2023.

- setup.sh: just source it to set up environment.
- docs: papers about previous search for direct stau production
- inputs: links to ntuples. Very large. It is slow to run all of them for every time.
- metadata: produce metadata of samples. Results from it are well prepared.
- slim_cd: produce samples after some basic cuts.
  - You are suggested using these samples for studies in SR.
  - basic cuts: >= 2 medium tau, >= 1 tight tau, no light lepton, no b-jet, MET>40.
  - How to use:
    - Submit jobs: source run.sh
    - Produce merge scripts: python merge.py
    - Then, source all sh file created by the last step.
- preSR: check events with more cuts.
  - How to use: source run.sh
- draw: draw histograms.
  - How to use: root -b -q snewdraw.C

Some example plots

- Some plots using *slim_cd*
- *Signal: dashed lines. SM backgrounds: color block. Data: black dots.*
- *Upper pad: kinematic distributions. Lower pad: ratio between data and mc.*