考核报告

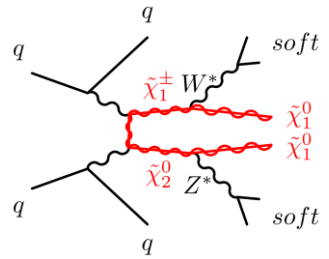
报告人: 翟明杰

导师：Joao Guimaraes da Costa, 徐达

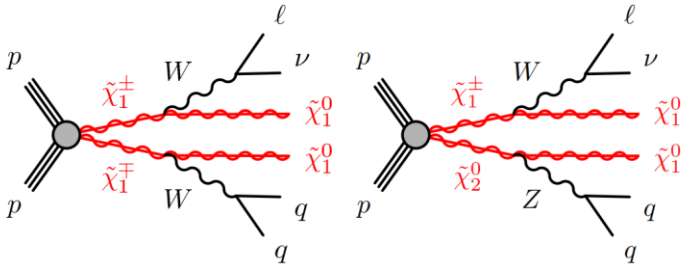
报告日期：2023.04.23

研究工作（2023.01 – 2023.04）

1. ATLAS实验超对称（SUSY）寻找
   1. 通过Compressed末态寻找gaugino

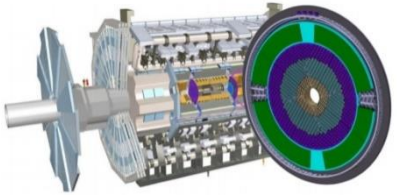


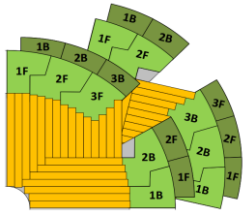
   2. 通过单轻子末态寻找gaugino



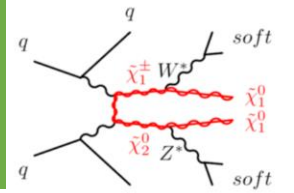
   3. 担任ATLAS SUSY HEPData coordinator

2. ATLAS实验高颗粒度时间探测器（HGTD）项目
   1. 研究周边电子学(PEB) BPOL12V的效率、输出纹波等性能。
   2. 研究PEB 区域的辐照通量和磁场环境。



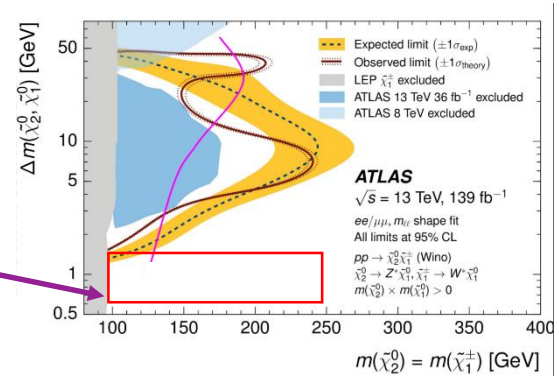


研究工作1-1: ATLAS SUSY Compressed分析



该分析主要研究质量压缩的SUSY空间；是寻找Higgsino粒子最适合的研究和热门课题。

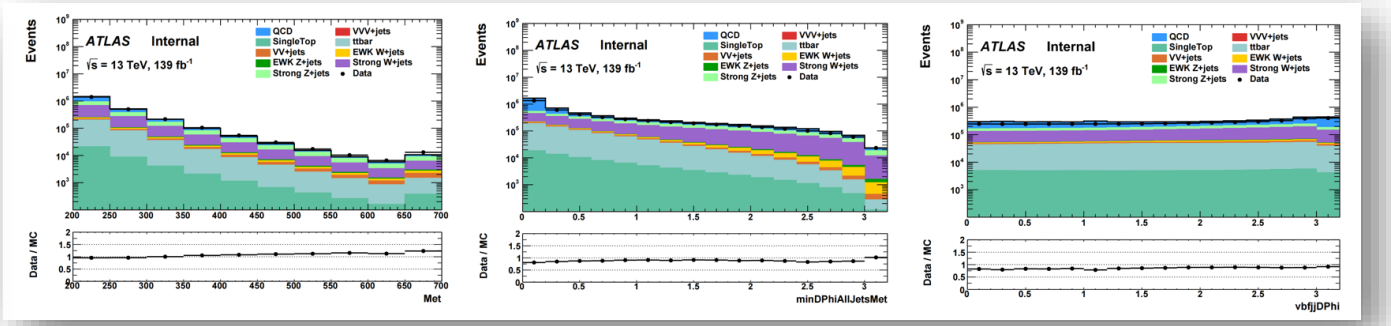
- 研究目标：通过新“矢量玻色子融合VBF进程”进一步拓展deltaM<1GeV空间。
  - 质量压缩空间的末态粒子动量很低->难以重建
  - 标记两个VBF jets->触发事例
  - 末态：2 VBF jets + MET（0 轻子）
- 该分析已于2021.06.11完成ATLAS的Partial Analysis Review；计划于明年发表。
- 本人目前担任该分析**主要分析人员。**
- **主要工作1：负责最终版Nominal Ntuple和Full syst Ntuple 的产生。包括分析框架的更新和测试，样本的运行，以及Ntuple的检验工作。**



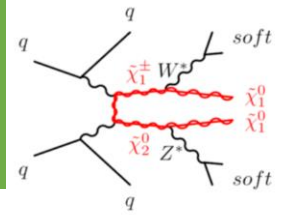
Ntuple的更新

- Main Changes from previous production:
  - Full set of Experimental systematics
  - Remove variables we're not using (e.g different lepton working points, vectors holding pt of all jets etc.)
  - For full syst tree, only keep events in SR/CR/VR.
  - Add EWK correction weight branch for W/Z + jets.

Ntuple的检验



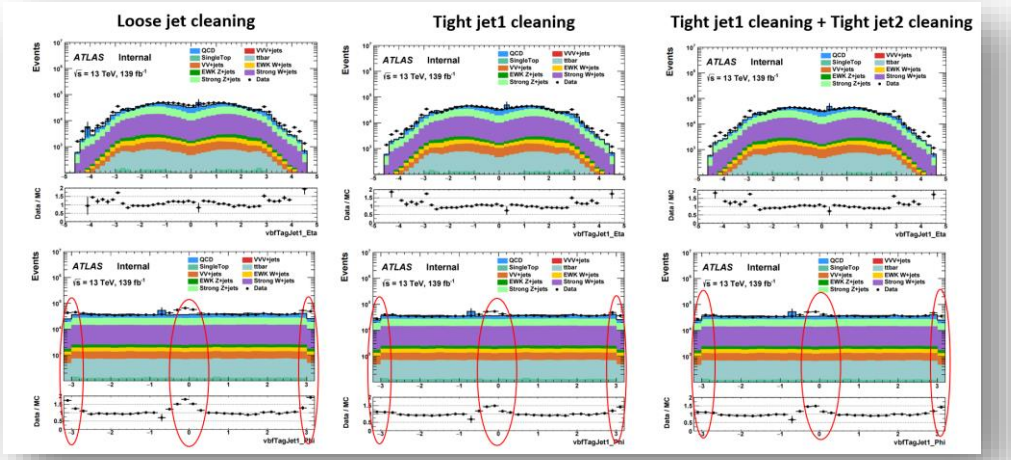
研究工作1-1: ATLAS SUSY Compressed分析

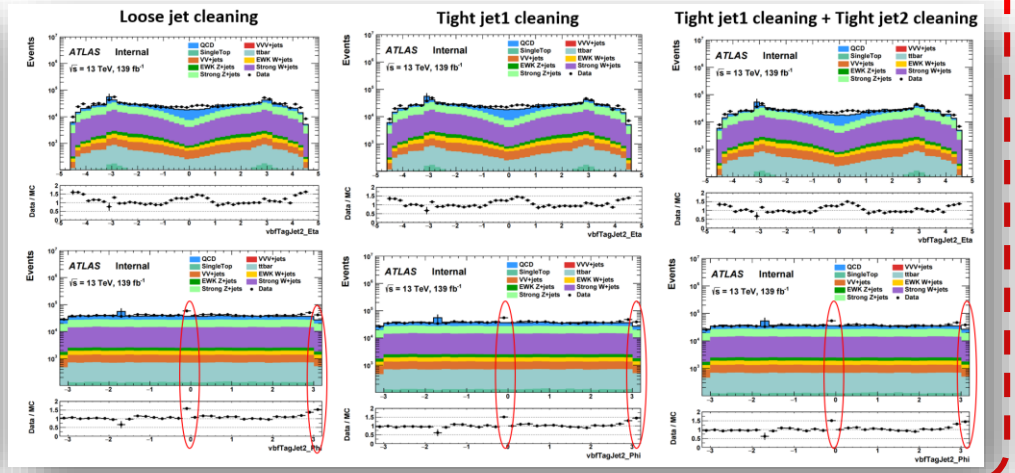


➢ **主要工作2：研究tightjetcleaning和badtilejetveto对data/MC的影响。**

Tightjetcleaning

- ✓ *通过tightjet cleaning，可以去除beam-induced 的本底。*
- ✓ *对jet1进行cleaning可以有效改善data/MC的符合程度，进一步对jet2进行cleaning,对data/MC的改善不明显。*



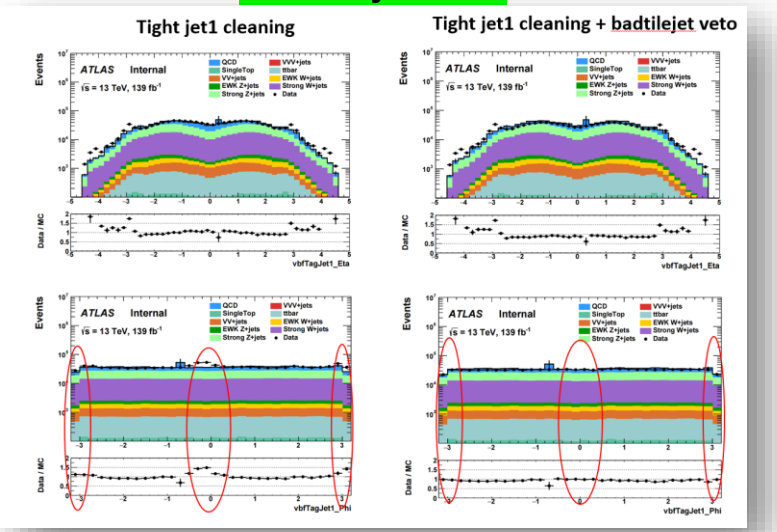


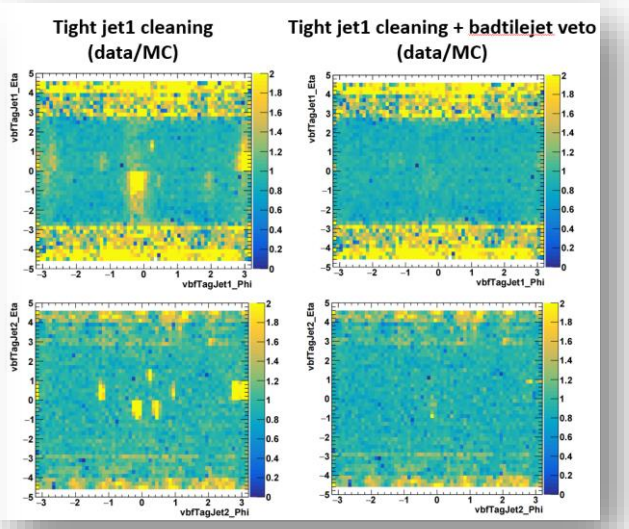
Badtilejetveto

- ✓ *在探测器运行的过程中，某些runnumber里面存在一些坏的module，对jet的测量不准确。*
- ✓ *在分析中，需要把这部分事例去除掉，进一步改善data/MC的符合程度。*

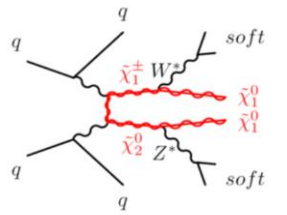
Year	RunNumber	Module name	η region	ϕ region
2015	266904–284484	LBA10	$0. < \eta < 0.9$	$0.8 < \phi < 1.0$
		EBC21	$-1.6 < \eta < -0.9$	$1.9 < \phi < 2.1$
2016	302053–311481	LBA52	$0. < \eta < 0.9$	$-1.33 < \phi < -1.13$
	306988–311481	LBC5	$-0.9 < \eta < 0.$	$0.34 < \phi < 0.54$
2017	325713–340453	LBC63	$-0.9 < \eta < 0.$	$-0.25 < \phi < -0.05$
		EBA3	$0.8 < \eta < 1.7$	$0.14 < \phi < 0.34$
2018	350310–352514	LBA29, 30	$0. < \eta < 0.9$	$2.7 < \phi < -3.0$
	355261–364292	LBA32	$0. < \eta < 0.9$	$\|\phi\| > 3.0$

Table 10: Location of dead tile modules over the Run2 (from Table 5 in page 120 of Ref [97]). Modules that are partially dead or are accounted by the simulation/reconstruction are not listed.

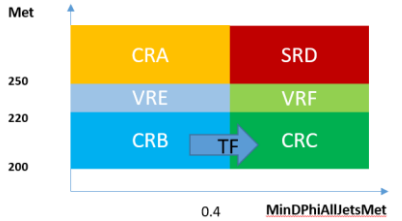




研究工作1-1: ATLAS SUSY Compressed分析

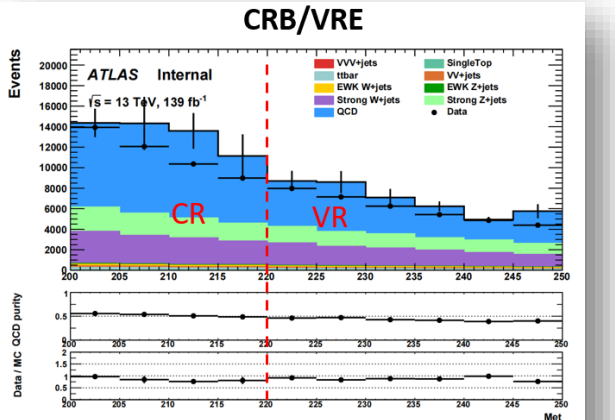


- 主要工作3：使用data driven的方法，估计QCD本底。
  - 之前的QCD本底估计是基于jet_pt 和 minDPhiAllJetMet进行的，CR/VR里面的纯度较低。
  - 更新：产生了low-Met的样本，并进一步改善了QCD的本底估计。

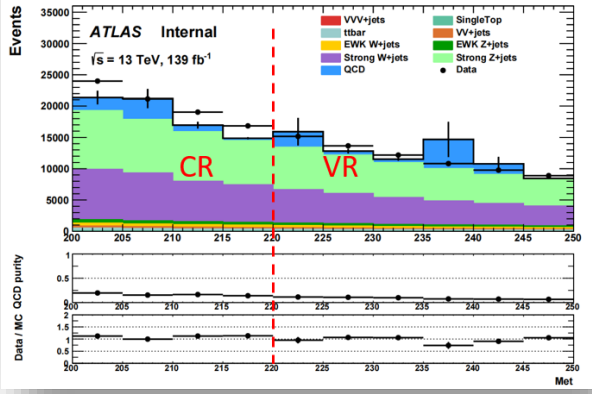


CR/VR

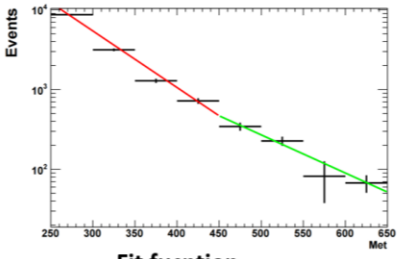
CRB/VRE

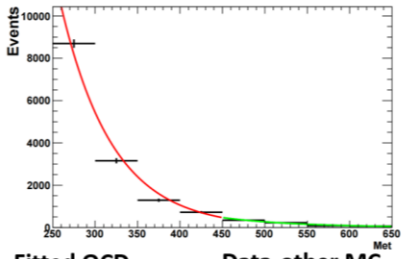


CRC/VRF



CRA的QCD拟合





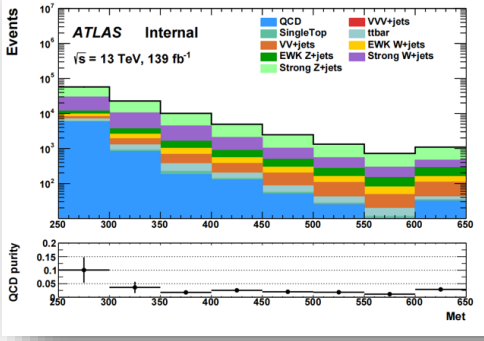
$QCD = 1067723 \times e^{-0.0163 \times Met}$ (250 < Met < 450)

$QCD = 66775 \times e^{-0.0110 \times Met}$ (Met > 450)

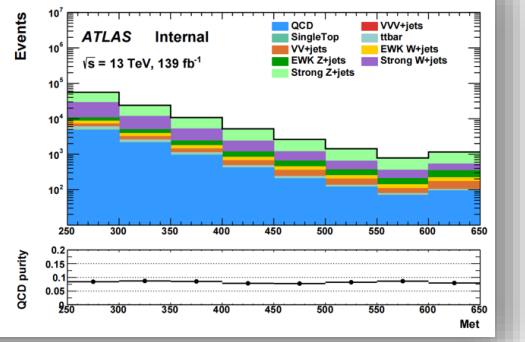
bin1=8405	bin 1	= 8695 $\pm$ 198.5
bin2=3715	bin 2	= 3156 $\pm$ 124.8
bin3=1642	bin 3	= 1291 $\pm$ 80.29
bin4=725.8	bin 4	= 721.6 $\pm$ 58.73
bin5=360.9	bin 5	= 344.9 $\pm$ 40.2
bin6=208.1	bin 6	= 227.1 $\pm$ 30.03
bin7=119.9	bin 7	= 81.96 $\pm$ 44.2
bin8=69.14	bin 8	= 67.59 $\pm$ 16.72

SR的QCD估计

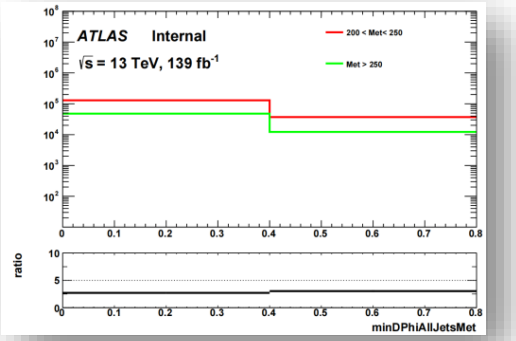
QCD MC



Estimated QCD

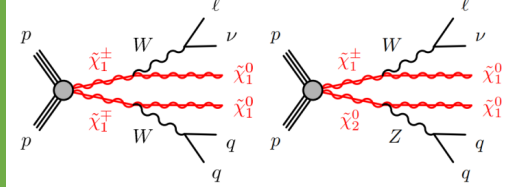


变量相关性



- ✓ *第1步：基于SR，设计CR+VR。*
- ✓ *第2步：在CRB, CRC计算出TF。*
- ✓ *第3步：通过VRE里面的data-other MC，估计VRF里面的QCD。结果发现，**VRF里面data/MC有所提升。***
- ✓ *第4步：对CRA里面的 data-other MC 进行拟合，得出每个bin QCD的估计值。*
- ✓ *第5步：使用$QCD_{SR} = QCD_{CRA} * TF$, $QCD_{VRF} = QCD_{VRE} * TF$, 估计SR每个bin的QCD。*

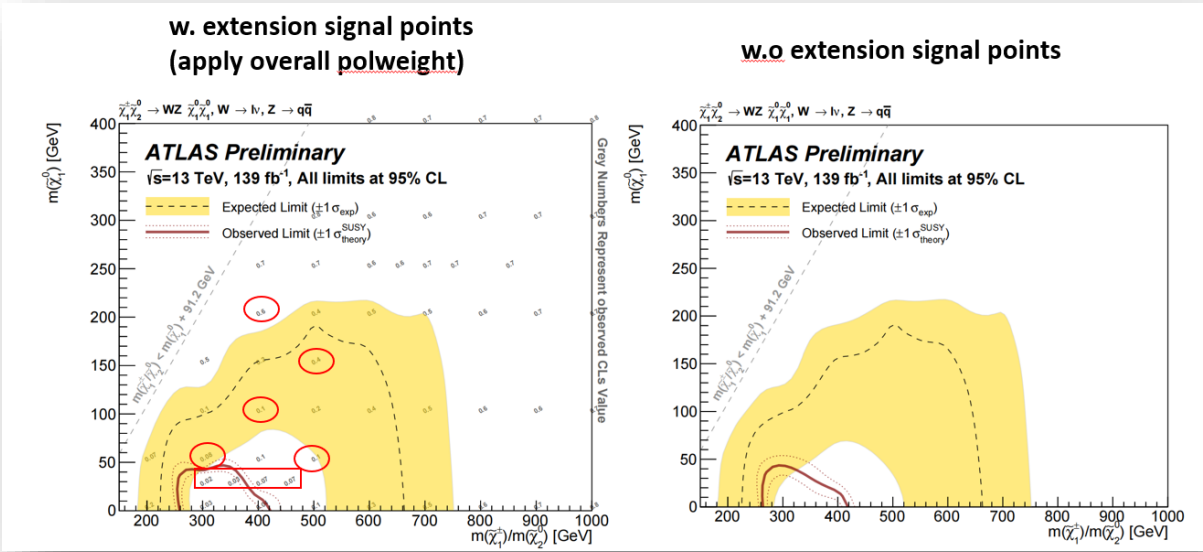
研究方向1-2: ATLAS SUSY 单轻子分析



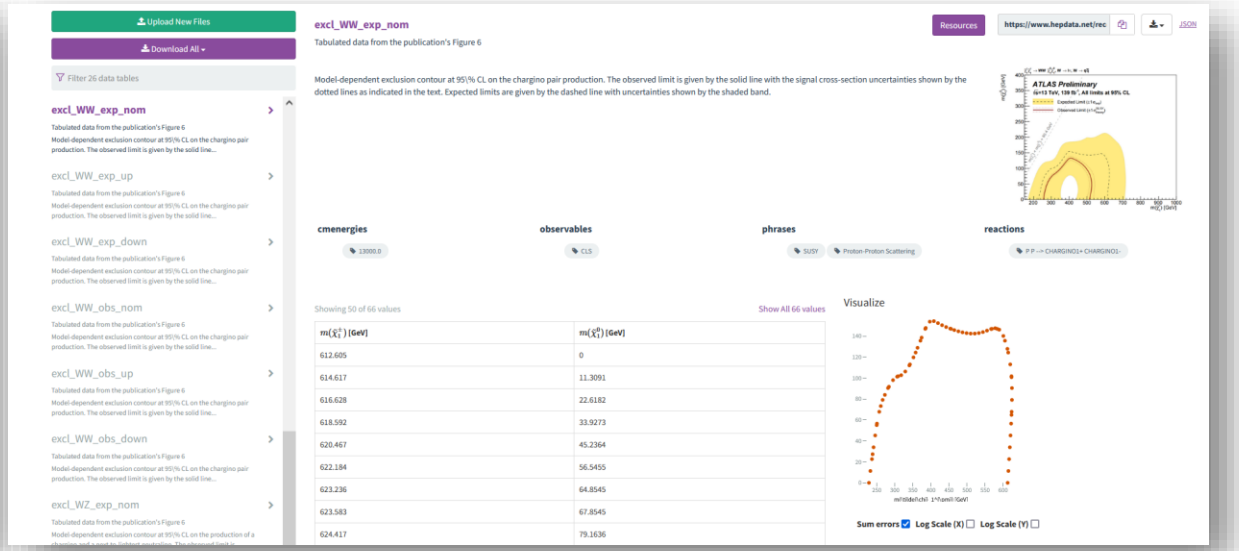
该分析首次研究1L末态的gaugino—>WW/WZ信号。

- 电弱相互作用的gaugino 通过 WW/WZ的衰变：
  - 该分析产生截面小/信号与SM本底类似->challenge->首次使用boost tagging技术
  - 末态： 1 lepton + 2-3 jets + MET
- 该分析通过了最终的ATLAS审核，于2022年9月发表公开的ATLAS CONF Note，预计今年发表一篇期刊文章。作为分析**最主力分析人员**，本人代表分析组进行SUSY物理大组审核报告和ATLAS合作组审核报告。
- **主要工作1：负责产生C1N2->WZ过程拓展信号点的样本，并使用HistFitter进行拟合，得到更精确的排除域。**
- **主要工作2：负责准备C1C1->WW/C1N2->WZ分析的Hepdata。**

信号点拓展



Hepdata准备工作

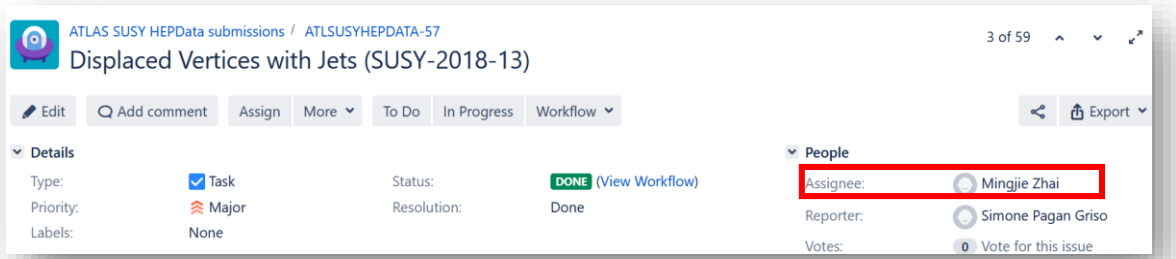


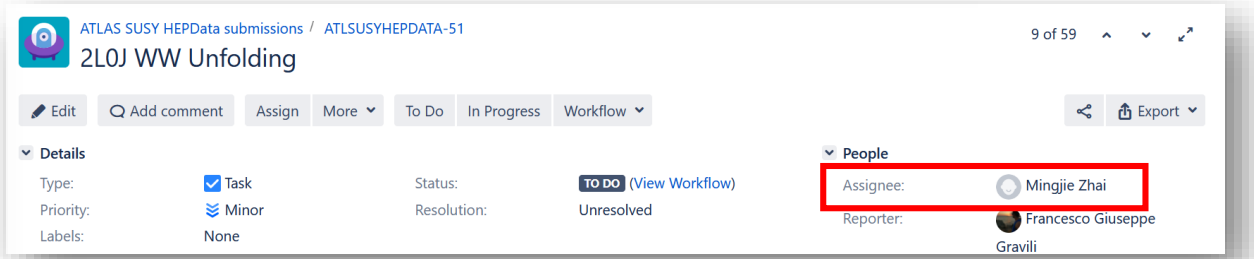
研究方向1-3: ATLAS SUSY HEPData负责人

HEPData
Repository for publication-related High-Energy Physics data

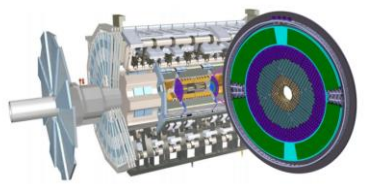
- HEPData (High Energy Physics Data Repository) 高能物理数据平台： https://www.hepdata.net/
  - 收集粒子物理实验发表的分析数据，将图表等结果转化为更精确的数字信息。
  - 提供理论家所需的各类分析细节（信号产生，粒子重建，误差，acc & eff）
- 本人自2022年7月1日开始**担任ATLAS实验SUSY大组的HEPData负责人**。
  - 组织管理各分析组的HEPData数据搜集转化等工作，并负责最终的审核。
  - 该季度(2022.09 – 2022.12)，**本人负责组织了2个分析的HEPData提交工作，并进行最终的审核**。

Francesco Giuseppe Gravili (francesco.giuseppe.gravili@cern.ch) and Mingjie Zhai (mingjie.zhai@cern.ch) are the HEPData coordinators for ATLAS SUSY. Any questions and issues concerning the preparation and upload of material should first be addressed to them.





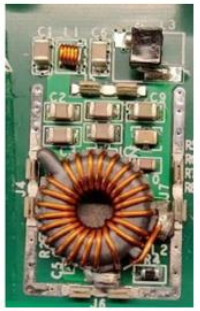
研究方向2-1: PEB BPOL12V的性能研究



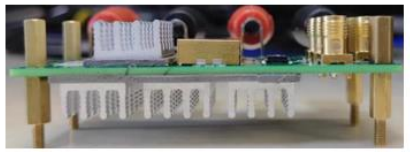
- BPOL12V可以把12V的电压转化成1.2V或2.5V的电压，进而给module和PEB的其他部件供电。
- **主要工作1：研究比较了在不同温度下不同BPOL12V的效率、输出纹波、纹波抑制能力、和上升/下降沿等性能。**

B42 vs B51

- **使用了不同的电感，根据电感对其他元件采用了不同的布局。**

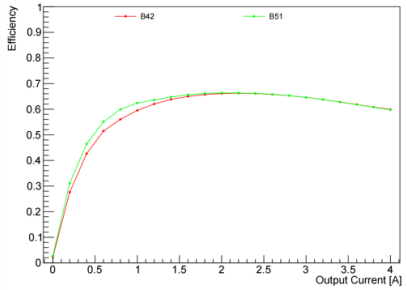


- **B51增加了散热装置。**

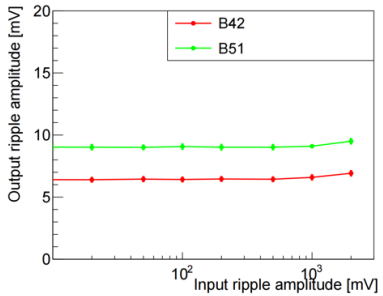


BPOL性能研究(T=-30C，Vin=11V)

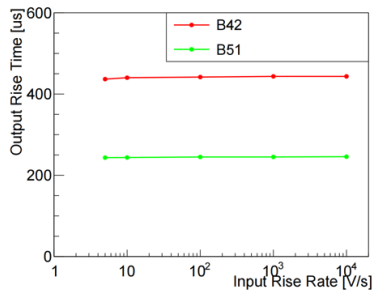
效率



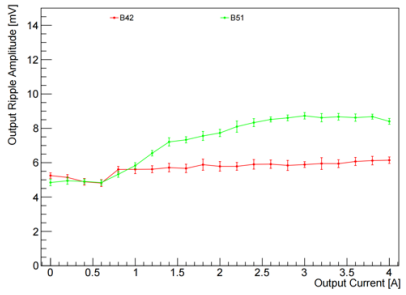
纹波抑制 (输入纹波50HZ)



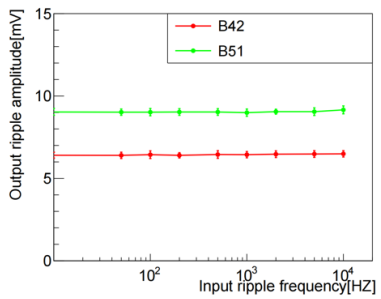
上升沿



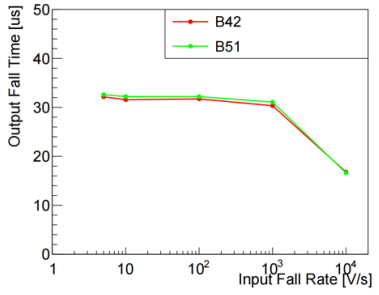
输出纹波



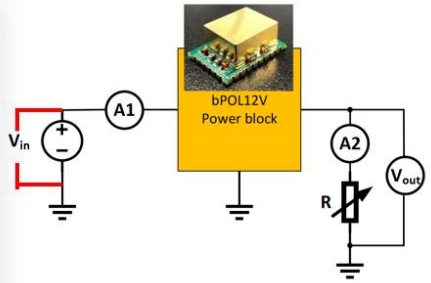
纹波抑制 (输入纹波20mV)

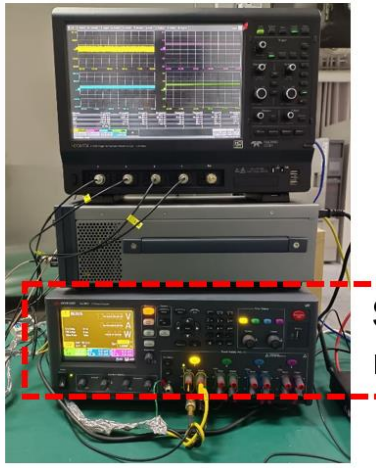


下降沿



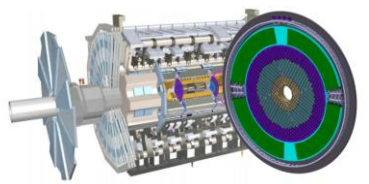
实验装置





- ✓ *B51比B42的效率更高，但纹波更大。*
- ✓ *50HZ/20mV的输入纹波，对输出纹波影响不大。*
- ✓ *输入电压取不同的上升/下降速率，输出电压的上升/下降速度都很快。*

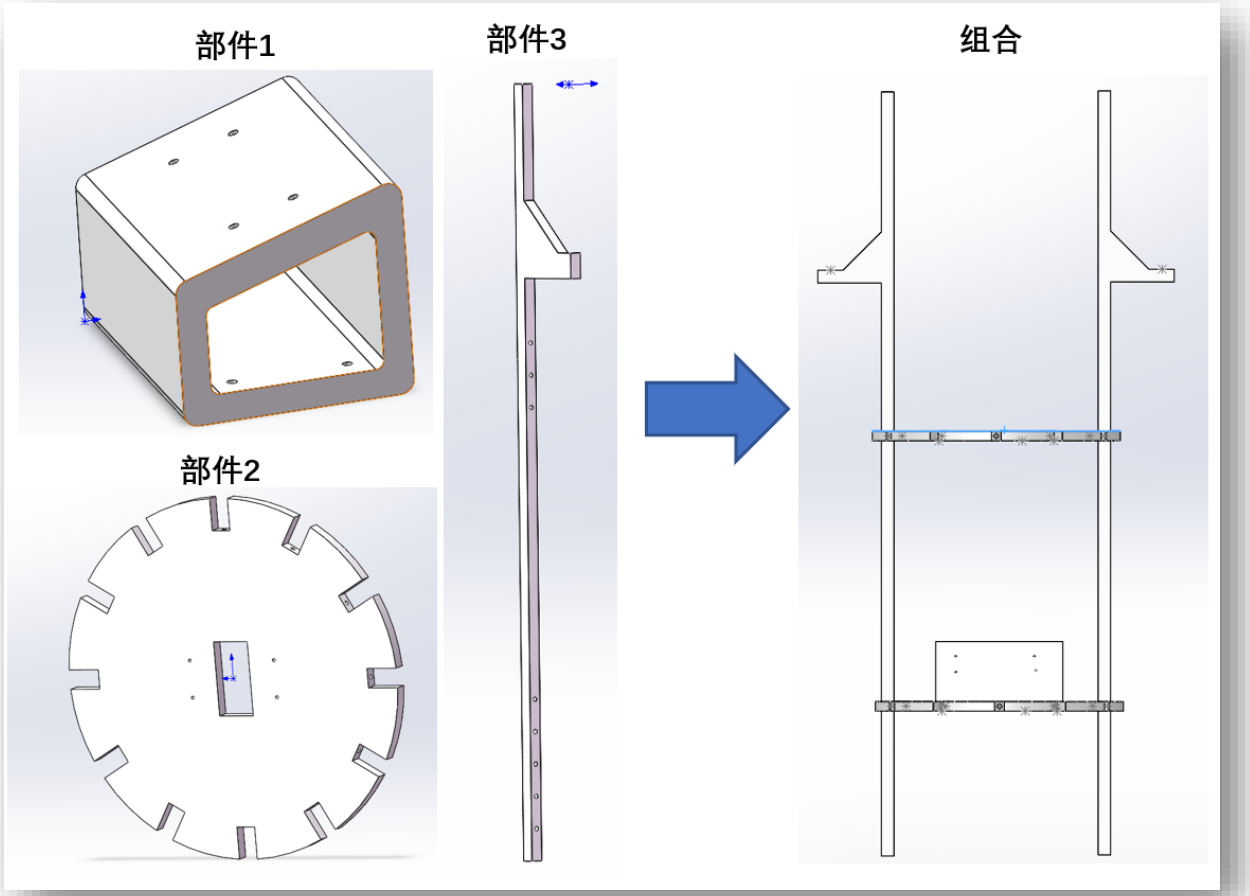
研究方向2-1: PEB BPOL12V的性能研究



- 主要工作2：负责首次BPOL12V在磁场下性能研究的整体实验设计，包括实验计划的制定，实验装置的设计及生产。计划5月负责BPOL12V在磁场下的性能研究工作。

磁场桶

实验装置

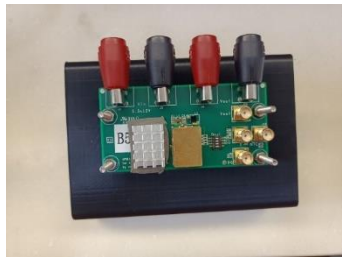


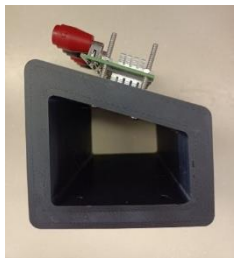
测试计划

First, we will test BPOL12V efficiency and ripple based on the magnetic field at PEB position. Later, we can extend our test.

- Magnitude: 0.38T, 0.41T, 0.44T, 0.5T
- Angle between BPOL and fields: 18°, 23°, 28°, 33°,38°, 142°, 147°, 152°, 157°,162°.

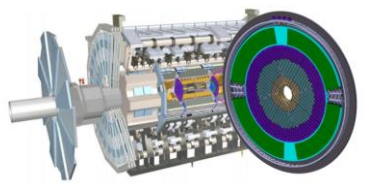
- ✓ *计划基于PEB磁场环境研究的结果，测试不同大小、方向下PEB的性能。*
- ✓ *磁场桶可以产生0-4T 可调节的磁场，桶中部磁场均匀，方向竖直向上。*
- ✓ *设计实验装置（3个部件），将BPOL12V固定在磁场桶中部，并调节BPOL12V和磁场的角度。*
- ✓ *目前，部件1已经通过所里的3D打印完成。*





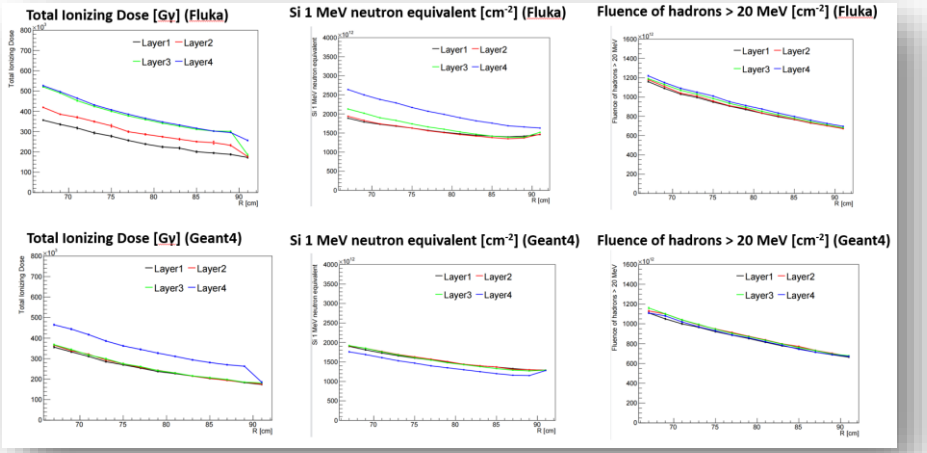
- ✓ *部件2计划送到企业进行3D打印，部件3计划用木材加工获得。*

研究方向2-2: PEB辐照通量和磁场环境



- 主要工作1: 研究了HGTD PEB区域的辐照通量(包括Genta4 和FLUKA的模拟结果)
- 主要工作2: 研究了HGTD PEB区域的磁场环境(基于ATLAS组的模拟结果)

辐照通量



Total Ionizing Dose [Gy]

	Requirement (ave of genta and fluka)	Requirement (Max of genta and fluka)	Test results
BOPL	4.09×10^5	4.32×10^5	$> 10^6$
IPGBT	4.96×10^5	5.27×10^5	$> 2 \times 10^6$
vrtx	3.30×10^5	3.48×10^5	To be checked with fiber
MUX	4.71×10^5	4.97×10^5	----------

Si 1 MeV neutron equivalent [cm⁻²]

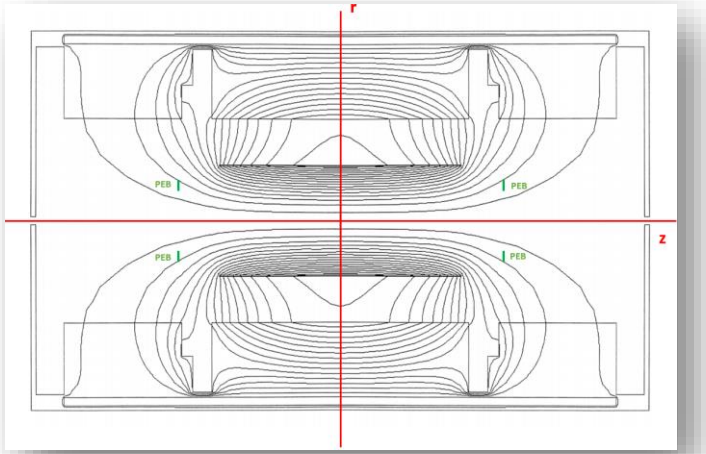
	Requirement (ave of genta and fluka)	Requirement (Max of genta and fluka)	Test results
BOPL	2.03×10^{15}	2.29×10^{15}	$> 7 \times 10^{15}$
IPGBT	2.28×10^{15}	2.64×10^{15}	----------
vrtx	1.67×10^{15}	1.90×10^{15}	To be checked with fiber
MUX	2.18×10^{15}	2.50×10^{15}	$> 2.09 \times 10^{15}$

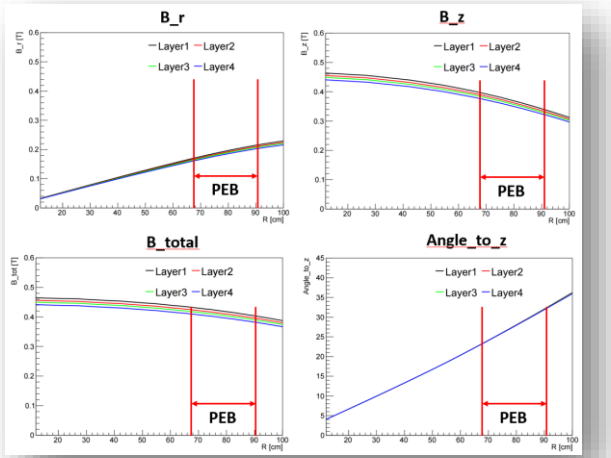
Fluence of hadrons > 20 MeV [cm⁻²]

	Requirement (ave of genta and fluka)	Requirement (Max of genta and fluka)	Test results
BOPL	1.02×10^{15}	1.05×10^{15}	----------
IPGBT	1.19×10^{15}	1.22×10^{15}	----------
vrtx	0.86×10^{15}	0.88×10^{15}	----------
MUX	1.12×10^{15}	1.15×10^{15}	----------

- ✓ *第1步：基于Fluka和Genta4的模拟结果，考虑安全因子后，给出辐照耐受能力的要求。*
- ✓ *第2步：基于PEB各部件的具体位置，给出各部件的辐照耐受能力的要求。*
- ✓ *第3步：与已有的实验结果进行对比，判断各部件是否符合要求。并为后续辐照测试实验提供依据。*

磁场环境





	Value
B_r	0.161 - 0.215 T
B_z	0.323 - 0.398 T
B_tot	0.382 - 0.433 T
Angle to z	23.1 – 32.3°

研究PEB区域磁场的大小和方向，可以为下一步PEB在磁场中的性能测试提供指导。

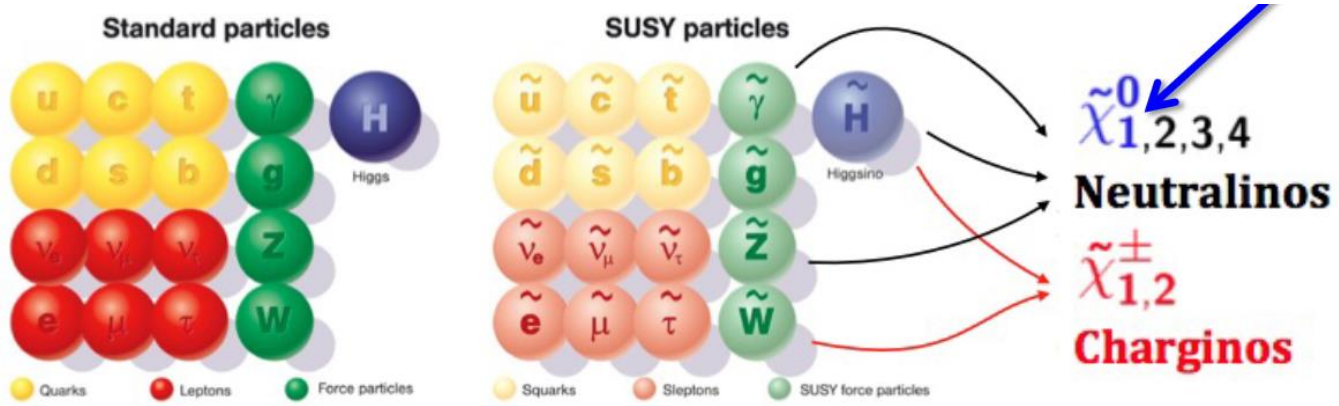
总结与展望

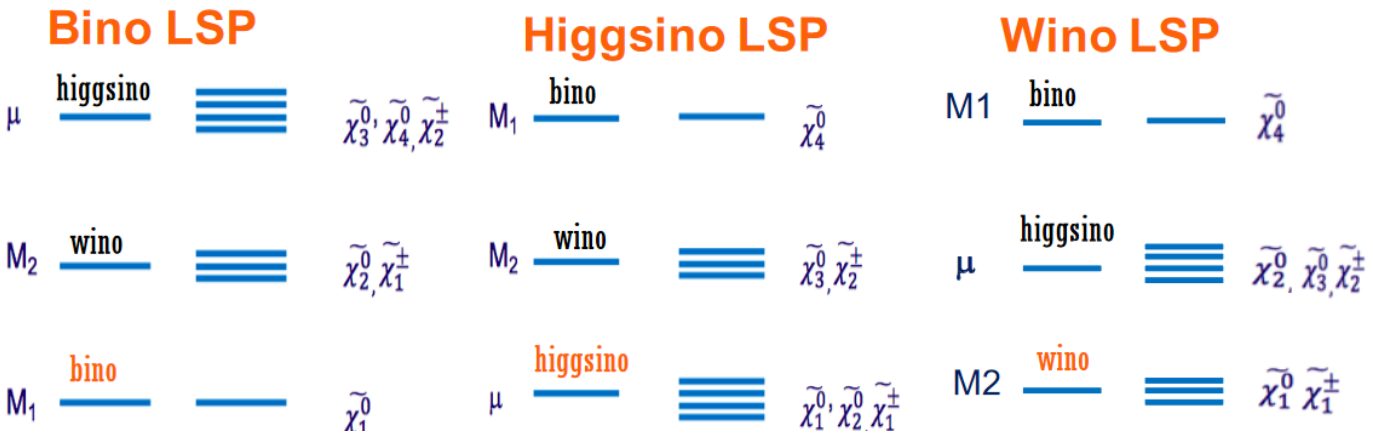
- 超对称物理探寻：
  - 担任**SUSY 单轻子分析的最主力分析人员**和**SUSY compressed分析的主力分析人员**。数次在这两个分析的组会作报告。目前，SUSY单轻子分析**已发表一篇CONF Note**。
  - 另外，本人还担任了**ATLAS SUSY hepdata的负责人**，该季度负责审核**2**个分析的hepdata。
  - 下一步：推动以上两分析，单轻子分析预计今年发表一篇期刊文章。Compressed分析预计明年发表一篇文章。
- HGTD 研究：
  - 研究了PEB辐照通量和磁场环境。研究成果多次在ATLAS HGTD PEB小组会上进行汇报，并且在**ATLAS HGTD Week (link)**汇报成果1次。

  - 正在对BPOL12V在低温下的性能进行研究，并准备BPOL12V在磁场下的性能研究。
  - 下一步：继续负责BPOL12V在低温和磁场下的性能研究，计划今年基于此发表一篇文章。

Backup

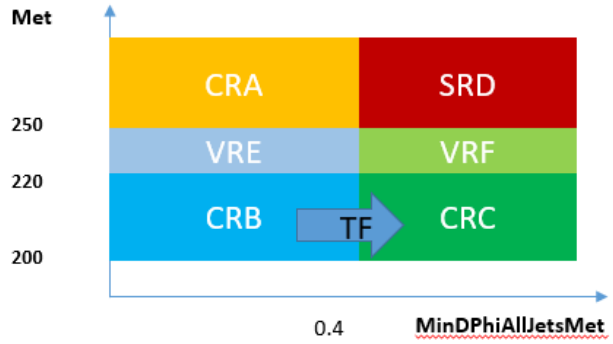
超对称简介

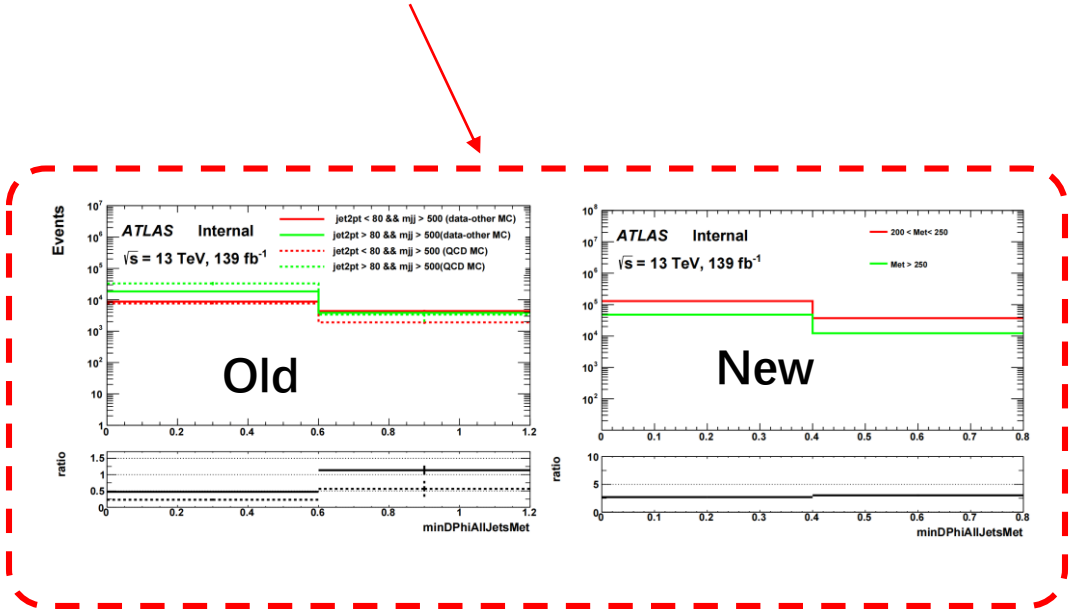

Standard particles
Higgs
Quarks
Leptons
Force particles
SUSY particles
Higgsino
Squarks
Sleptons
SUSY force particles
Neutralinos
Charginos


Bino LSP
Higgsino LSP
Wino LSP
μ
higgsino
M2
wino
M1
bino
M1
bino
M2
wino
μ
higgsino
M1
bino
μ
higgsino
M2
wino

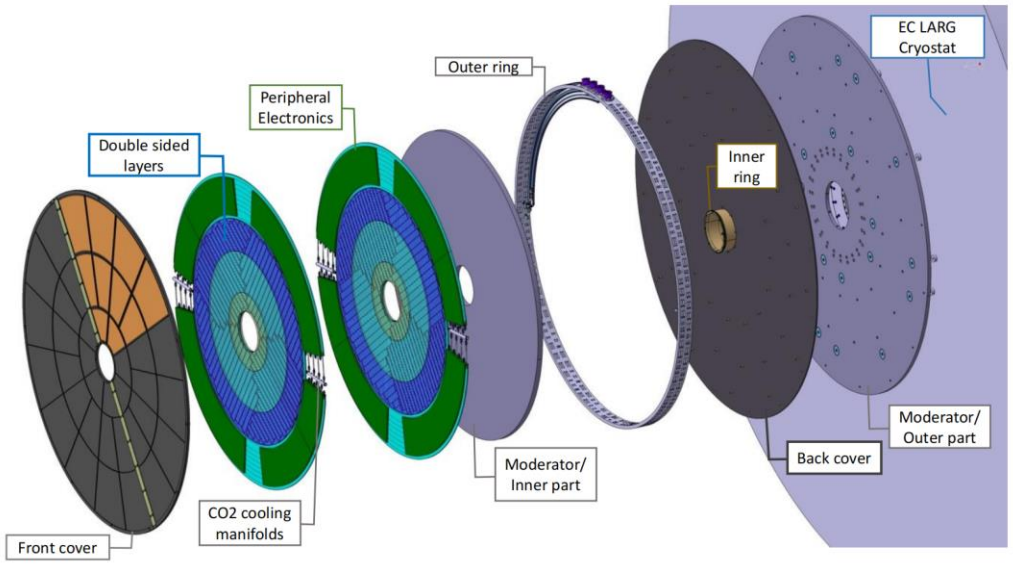
QCD estimation

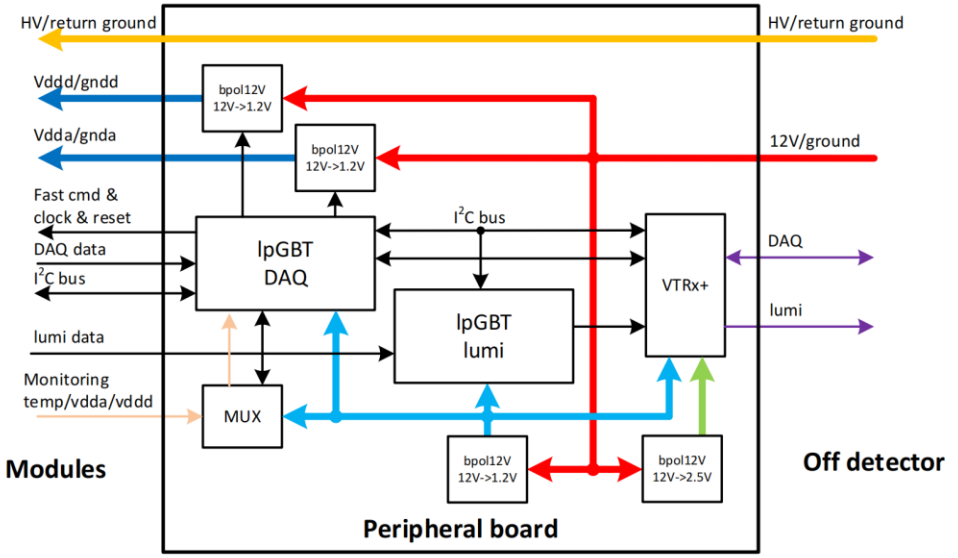
- Low-met ntuples (met < 200) production and validation.
- QCD estimation for CC SR:
  - Data/MC in VRF becomes better if using estimated QCD.
  - Correlation between Met and minDPhiAllJetMet is much smaller than jet_pt and minDPhiAllJetMet.
  - QCD purity for CR and VRs are also improved.
    - Old results: 13% - 32% for CRs and 6% - 14% for VRs.
    - New results: 16% - 53% for CRs and 11% - 17% for VRs
  - Stat for estimated QCD becomes much smaller.
    - Old results: 18% - 22% for overall VRF and SR.
    - New results: 3% - 4% for overall VRF and SR
  - QCD estimation in each bin are also given.

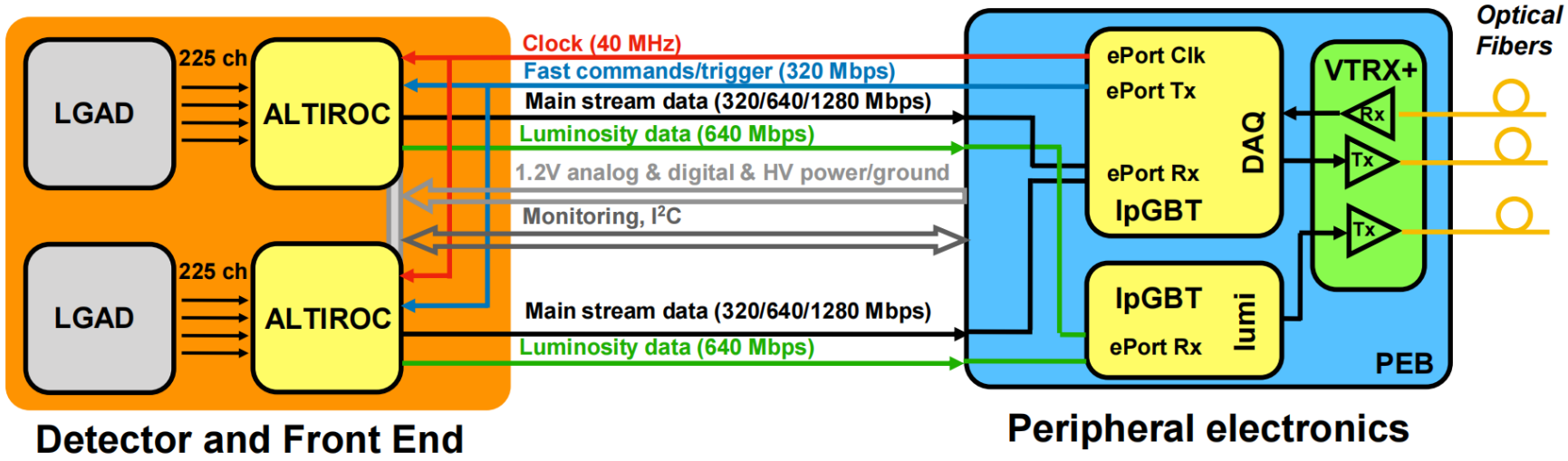




PEB结构


EC LARG Cryostat
Outer ring
Peripheral Electronics
Double sided layers
Inner ring
Moderator/ Outer part
Back cover
Moderator/ Inner part
CO2 cooling manifolds
Front cover


HV/return ground
HV/return ground
Vddd/gndd
bpol12V 12V->1.2V
Vdda/gnda
bpol12V 12V->1.2V
12V/ground
Fast cmd & clock & reset
DAQ data
I²C bus
lpGBT DAQ
I²C bus
VTRx+
DAQ
lumi
lumi data
lpGBT lumi
Monitoring temp/vdda/vddd
MUX
bpol12V 12V->1.2V
bpol12V 12V->2.5V
Modules
Off detector
Peripheral board


LGAD
225 ch
ALTIROC
LGAD
225 ch
ALTIROC
Clock (40 MHz)
Fast commands/trigger (320 Mbps)
Main stream data (320/640/1280 Mbps)
Luminosity data (640 Mbps)
1.2V analog & digital & HV power/ground
Monitoring, I²C
Main stream data (320/640/1280 Mbps)
Luminosity data (640 Mbps)
ePort Clk
ePort Tx
ePort Rx
lpGBT
DAQ
lpGBT
ePort Rx
lumi
VTRX+
Rx
Tx
Tx
Optical Fibers
PEB
Detector and Front End
Peripheral electronics