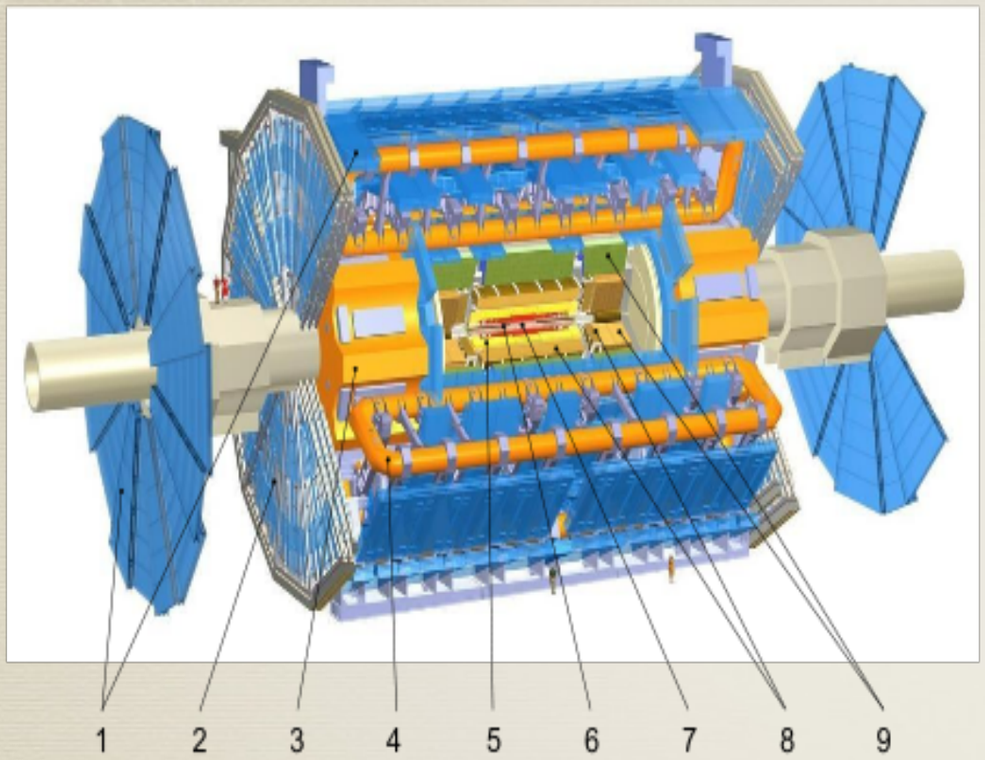
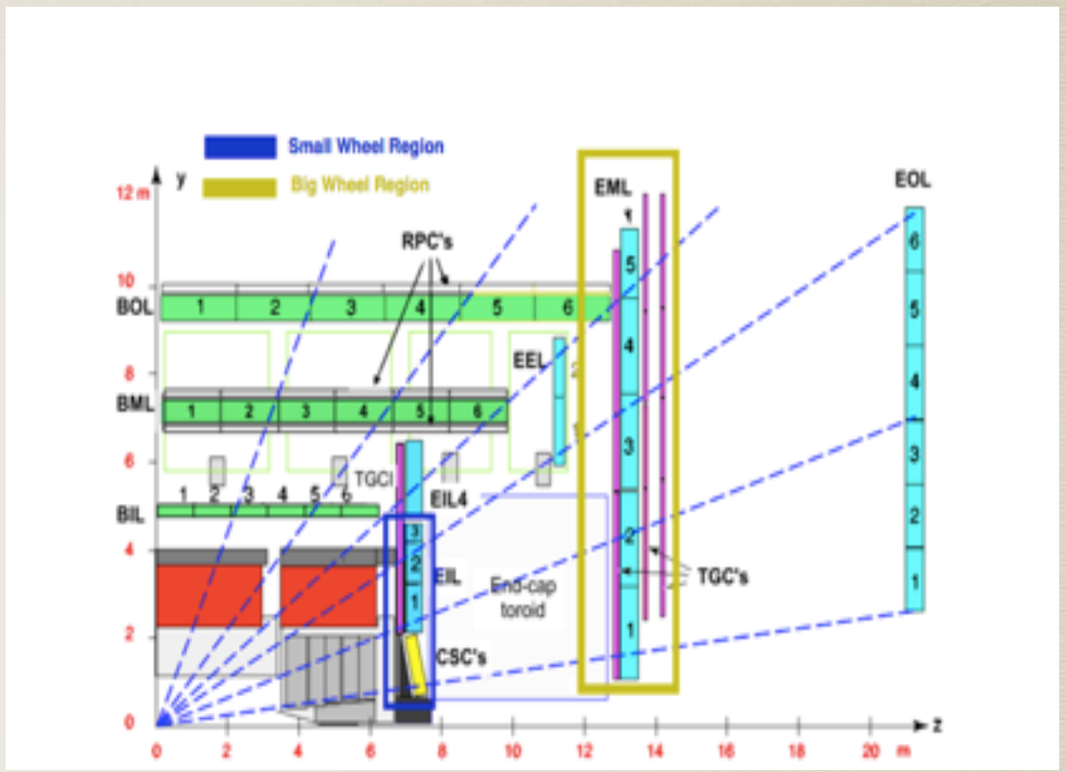
ATLAS NSW Upgrade and sTGC at Shandong University

都艳艳　　祝成光

山东大学

端盖muon谱仪

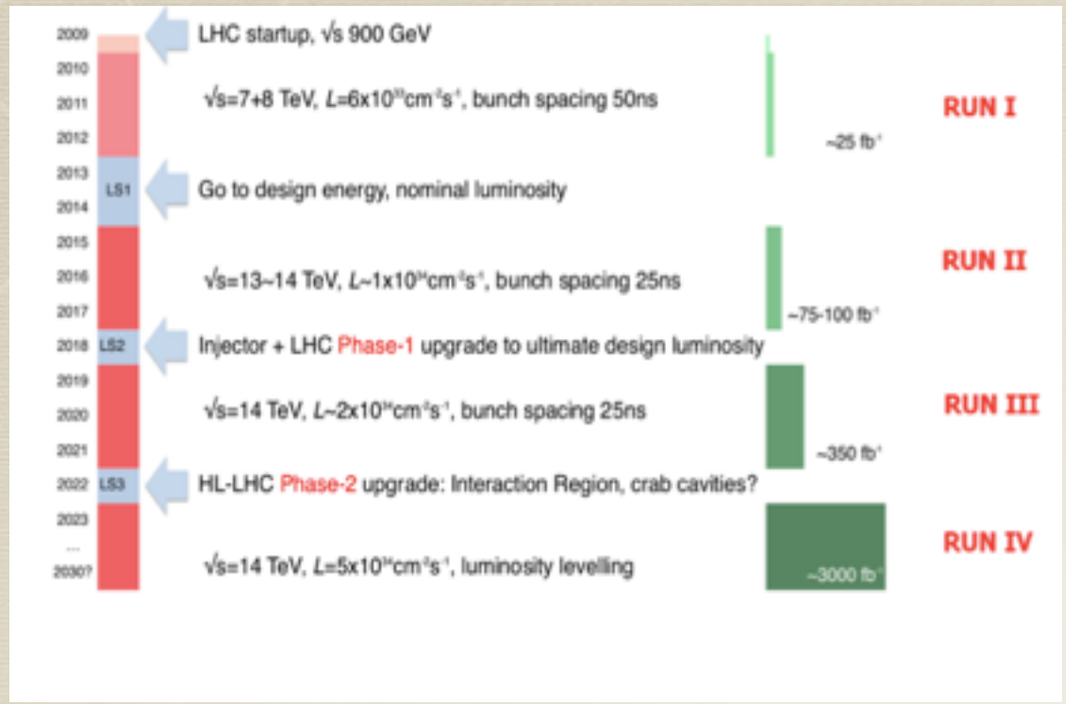


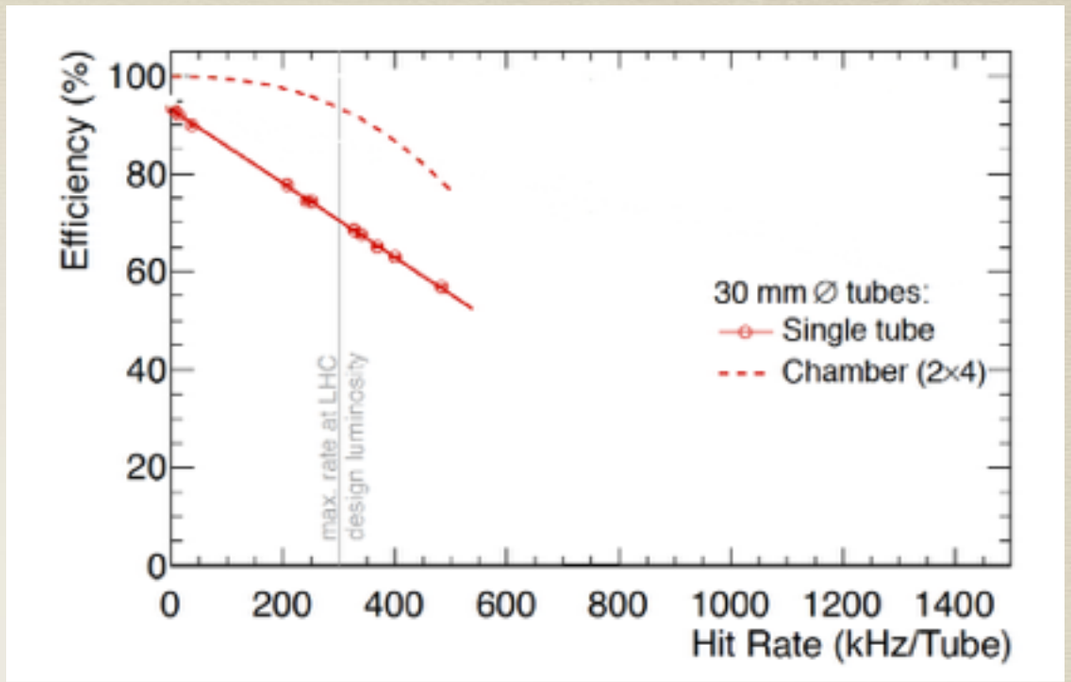


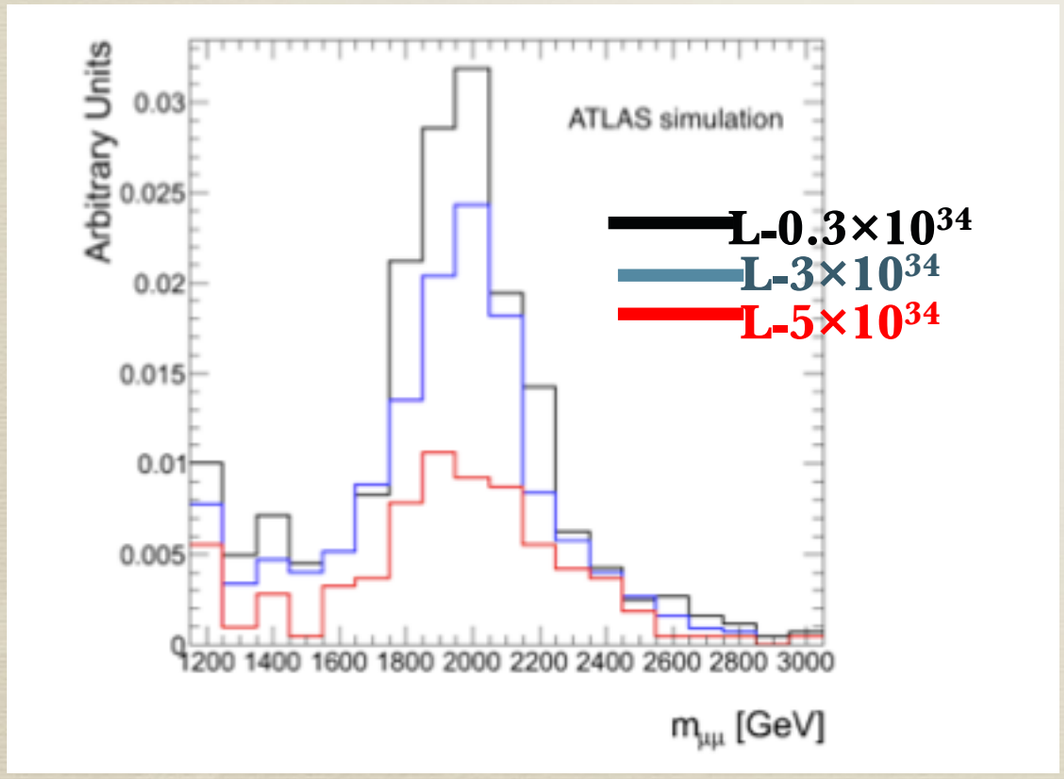
Muon端盖探测器的作用

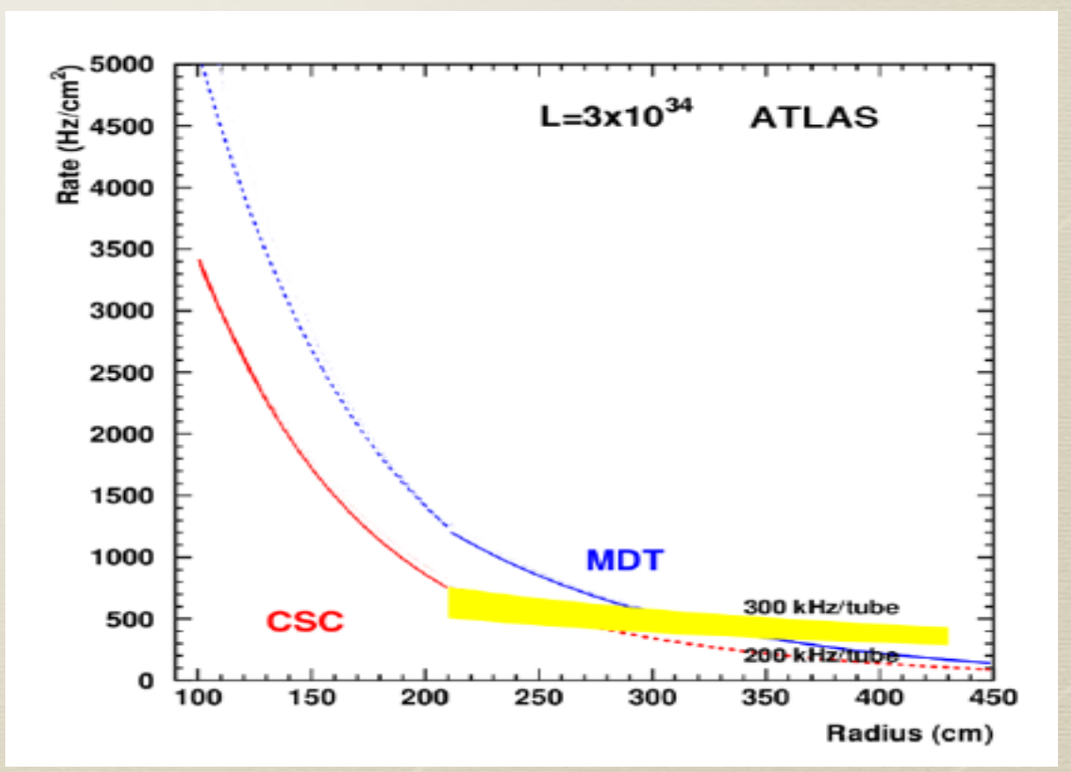
在线muon事例触发（TGC探测器）

离线muon的ID和动量测量（CSC和MDT探测器）


2009
2010
2011
2012
2013
LS1
2014
2015
2016
2017
2018
LS2
2019
2020
2021
2022
LS3
2023
...
2030?
LHC startup, √s 900 GeV
√s=7+8 TeV, L=6x10³³cm⁻²s⁻¹, bunch spacing 50ns
~25 fb⁻¹
RUN I
Go to design energy, nominal luminosity
√s=13~14 TeV, L~1x10³⁴cm⁻²s⁻¹, bunch spacing 25ns
~75-100 fb⁻¹
RUN II
Injector + LHC Phase-1 upgrade to ultimate design luminosity
√s=14 TeV, L~2x10³⁴cm⁻²s⁻¹, bunch spacing 25ns
~350 fb⁻¹
RUN III
HL-LHC Phase-2 upgrade: Interaction Region, crab cavities?
√s=14 TeV, L=5x10³⁴cm⁻²s⁻¹, luminosity levelling
~3000 fb⁻¹
RUN IV

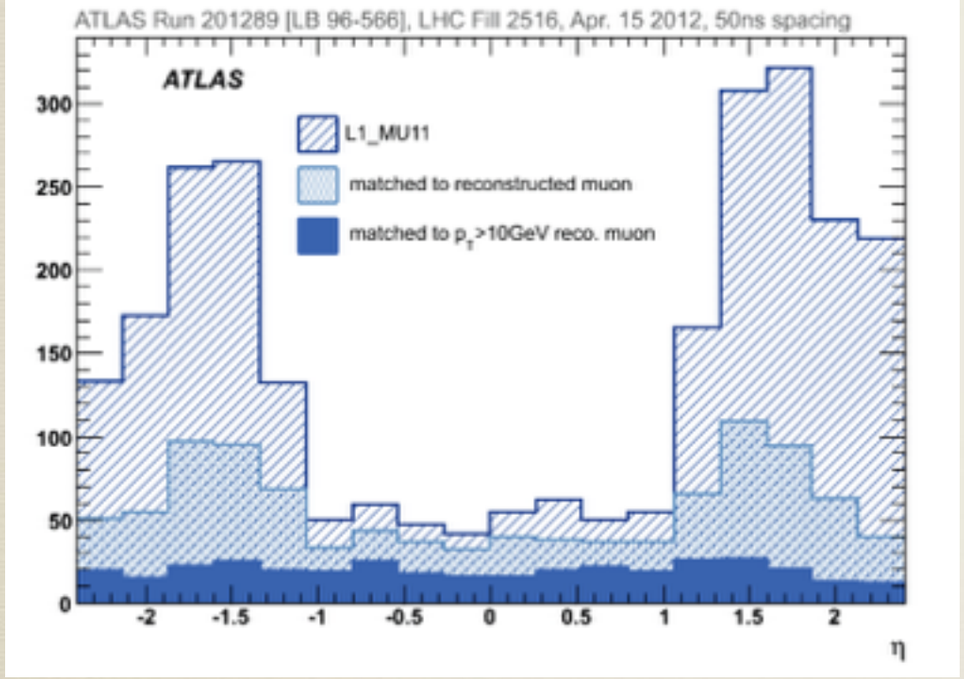

Efficiency (%)
100
80
60
40
20
0
0
200
400
600
800
1000
1200
1400
Hit Rate (kHz/Tube)
max. rate at LHC
design luminosity
30 mm ∅ tubes:
Single tube
Chamber (2×4)

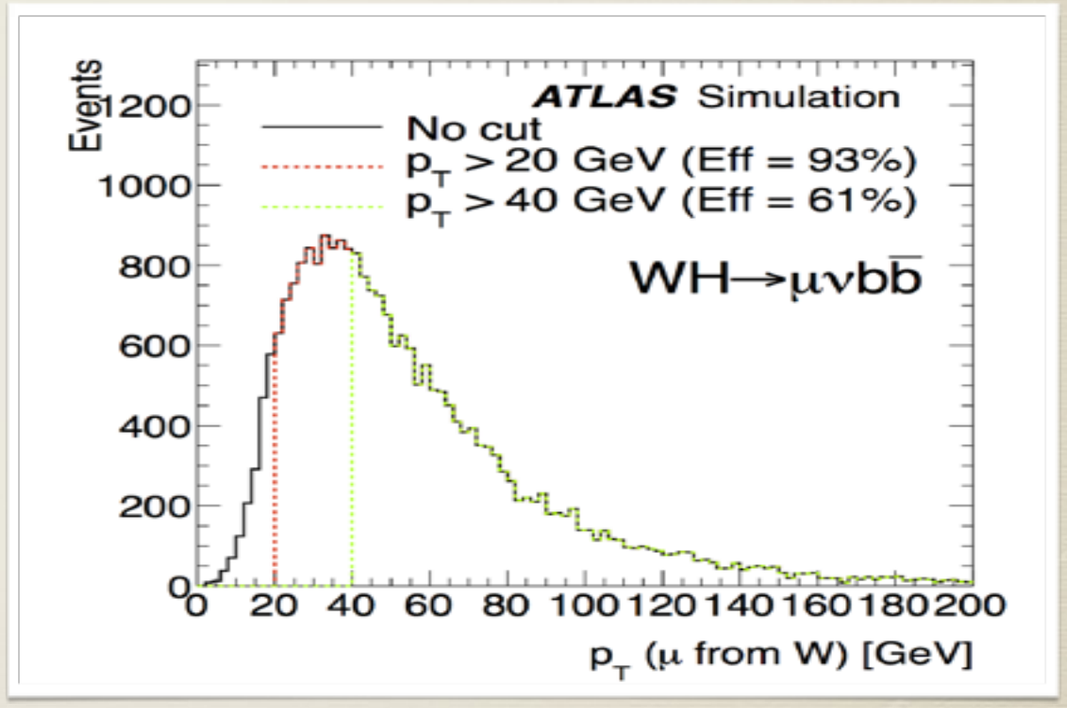

Arbitrary Units
0.03
0.025
0.02
0.015
0.01
0.005
0
ATLAS simulation
L-0.3×10³⁴
L-3×10³⁴
L-5×10³⁴
1200 1400 1600 1800 2000 2200 2400 2600 2800 3000
m_μμ [GeV]


Rate (Hz/cm²)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
L=3x10³⁴
ATLAS
MDT
CSC
300 kHz/tube
200 kHz/tube
100
150
200
250
300
350
400
450
Radius (cm)

L1MU threshold (GeV)	Level-1 rate (kHz)
$p_T > 20$	60 ± 11
$p_T > 40$	29 ± 5
$p_T > 20$ barrel only	7 ± 1
$p_T > 20$ with NSW	22 ± 3
$p_T > 20$ with NSW and EIL4	17 ± 2

L1MU threshold (GeV)	$H \to b\bar{b}$ (%)	$H \to W^+W^-$ (%)
$p_T > 20$	93	94
$p_T > 40$	61	75
$p_T > 20$ barrel only	43	72
$p_T > 20$ with NSW	90	92





DAQ带宽对L1 trigger的频率限制100kHz，对单muon的限制是20kHz

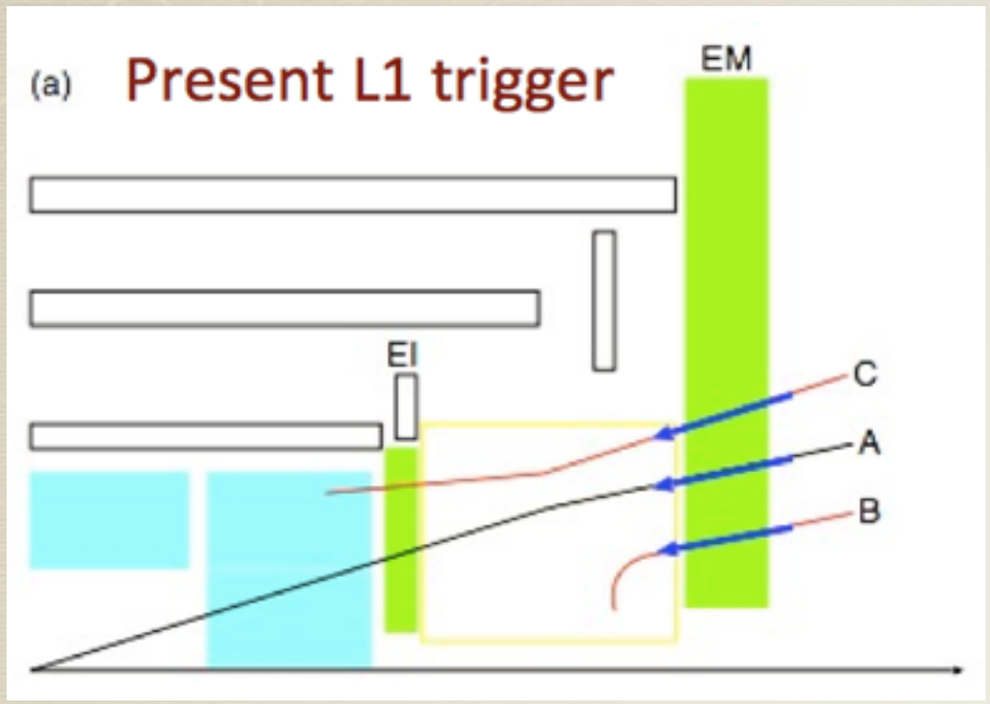
ATLAS Upgrade 的物理需求

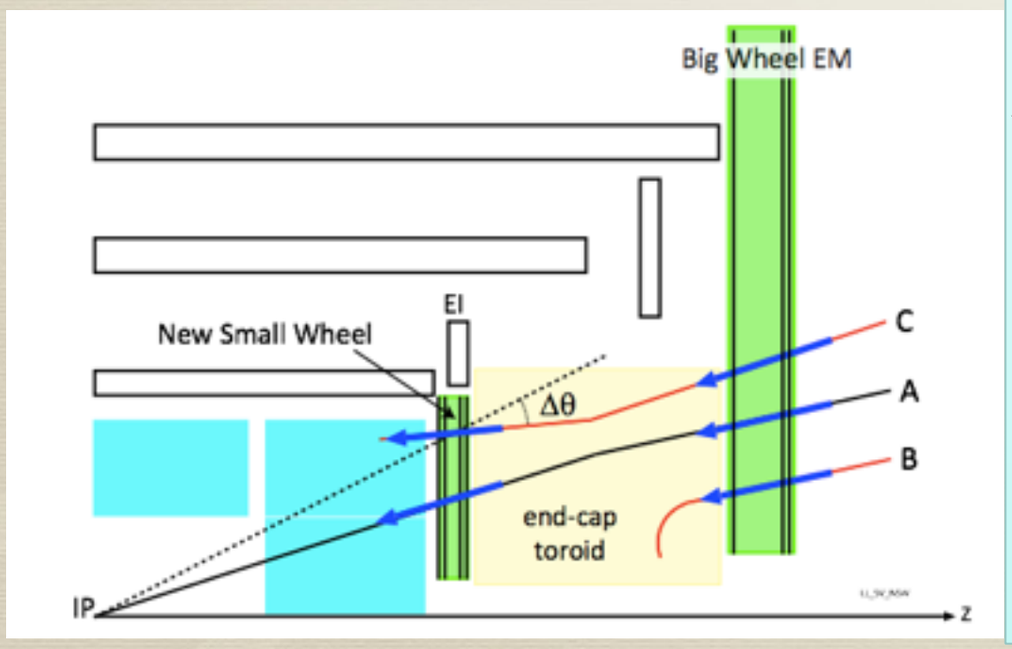
* 降低误触发率：Forward Muon trigger 的绝大部分都是fake trigger（仅仅是提高阈值来降低trigger rate，会产生严重的物理上的有用事例损失）

* 在强辐射环境下维持muon的动量分辨率：分辨率主要由muon 探测 器的位置精度决定

* 提高内层muon segments重建效率，从而提高track 重建效率

降低误触发





NSW会给forward　muons帮助提高触发准确度

（C）NSW能够帮助确认track是否来自对撞点

（B）通过NSW中高质量的segment可以重建出精确的track排除不是来自对撞中心的muon track

ATLAS Upgrade的设计需求

Track的精度和已经存在的径迹探测器（中层和外层 MDT）相匹配

能够纳入end- cap区域 的准直系统

提供高精度的track重建能力，协助原触发系统降低fake trigger

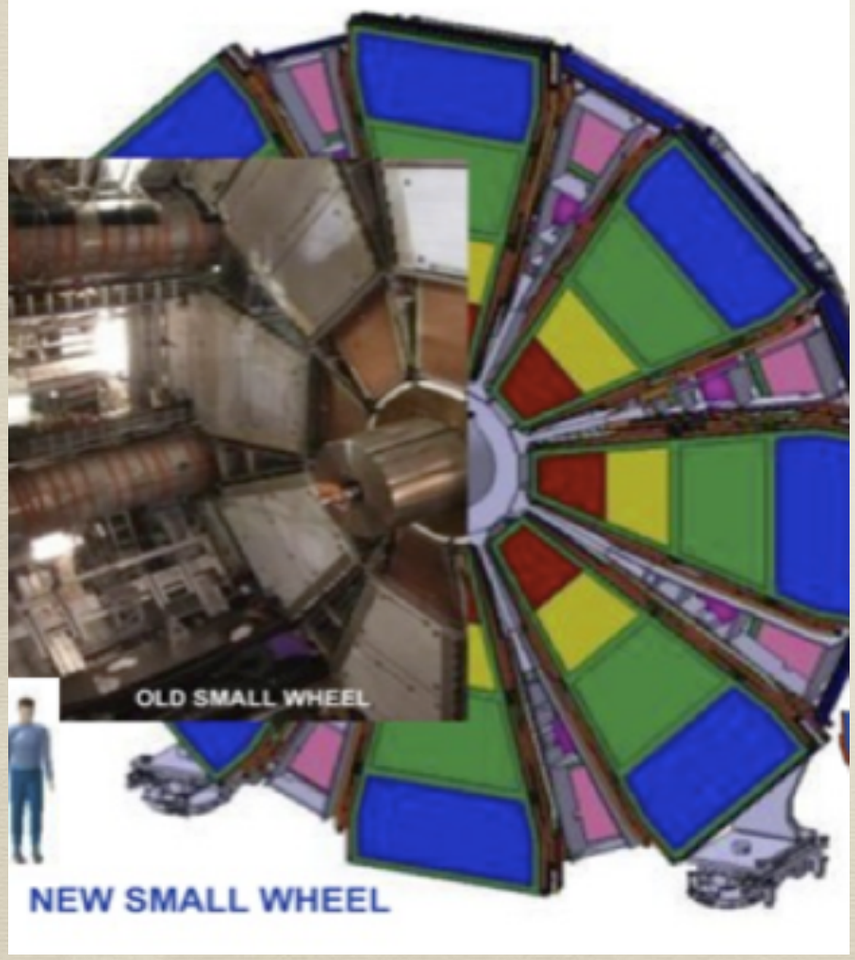
redundancy of tracking and trigger

ATLAS NSW Layout

NSW将会用两种探测器满足以上需求：

（1）sTGC（Small strip Thin Gap Chamber）：主要的触发，响应快，位置精度~60micro， >15kHz

（2）MM（Micromegas）：做主要的precision tracker， 位置精度~30micro , >15kHz

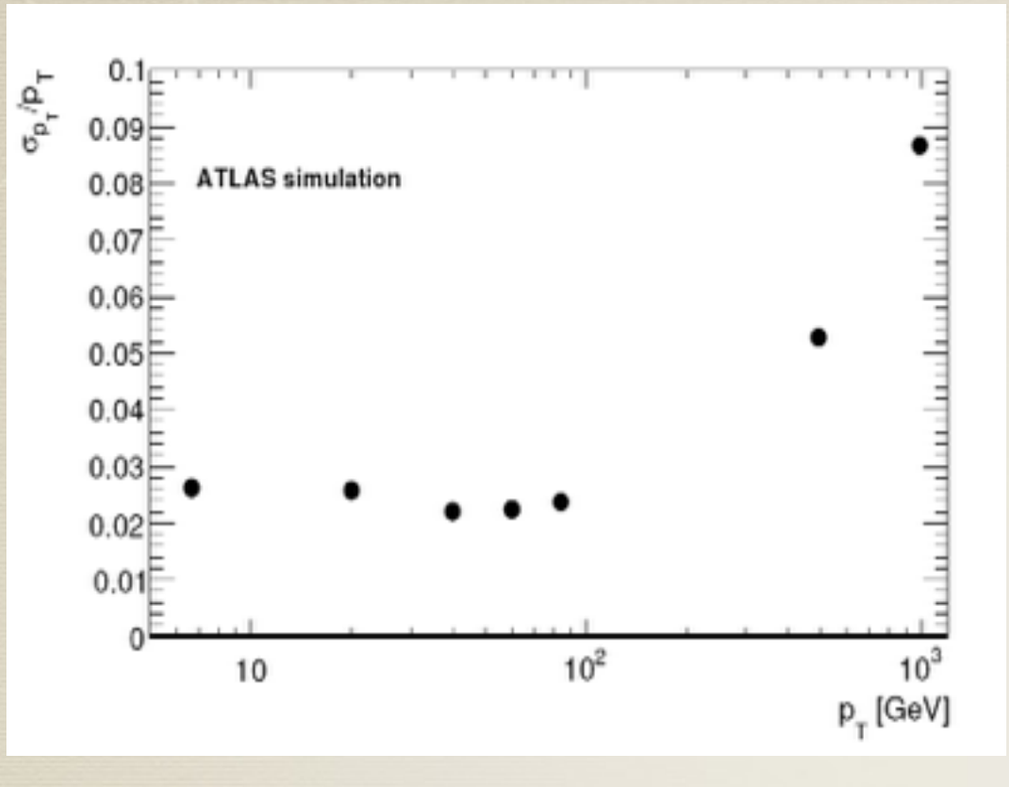


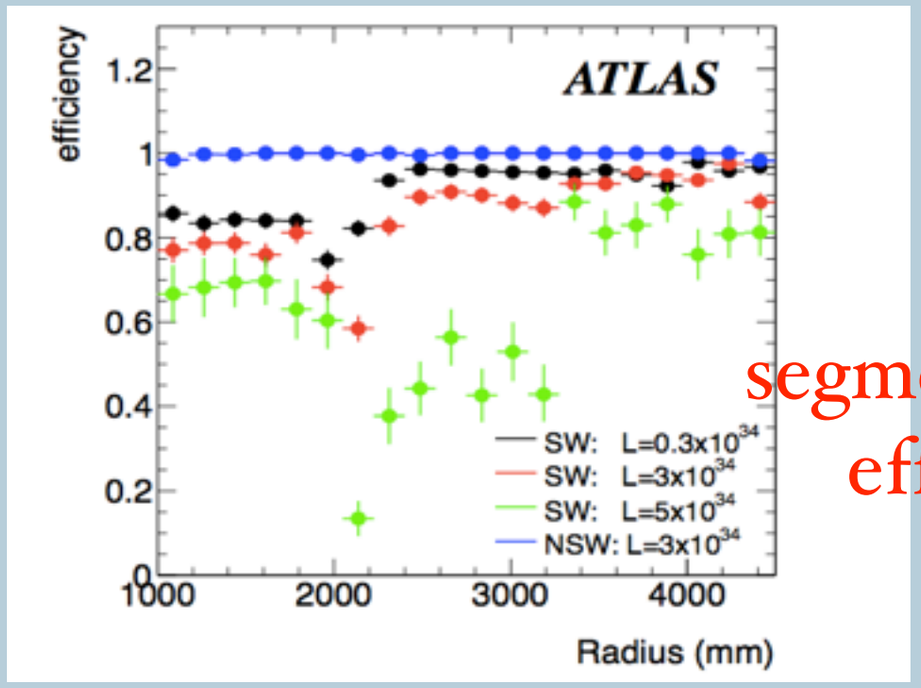
sTGC-4 MM-4 MM-4 sTGC-4

NSW有16个sectors，8个大的，8个小的

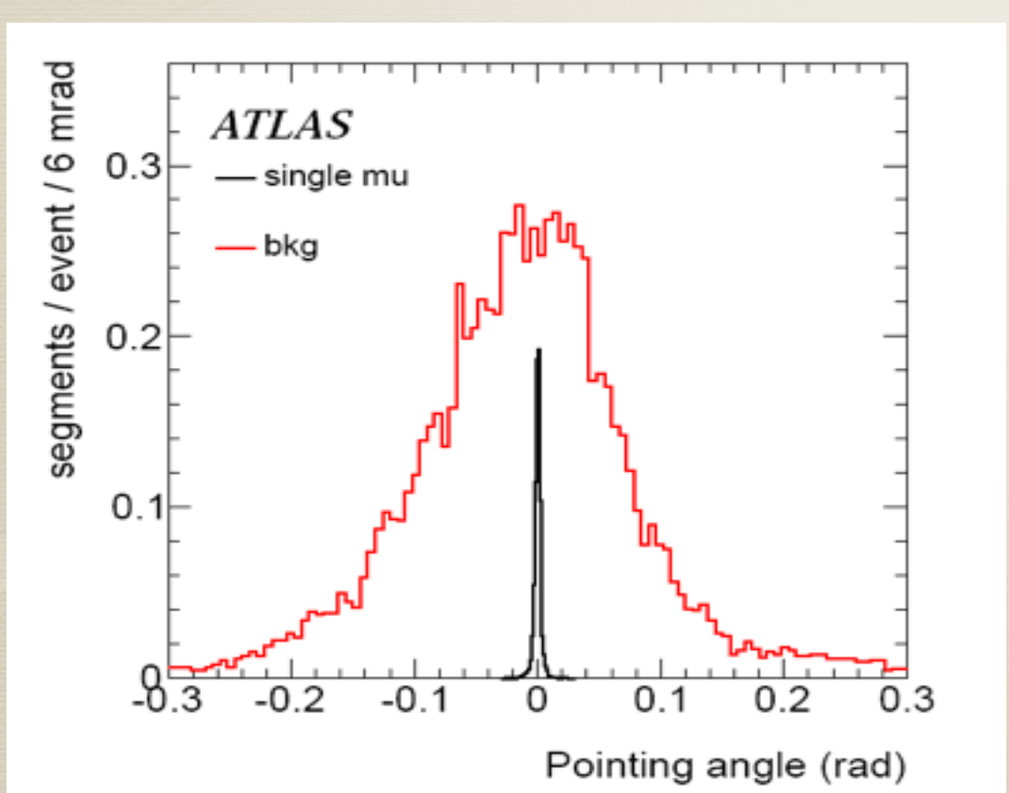
每个sector，有8层探测层，分为两组

New Small Wheel Performance

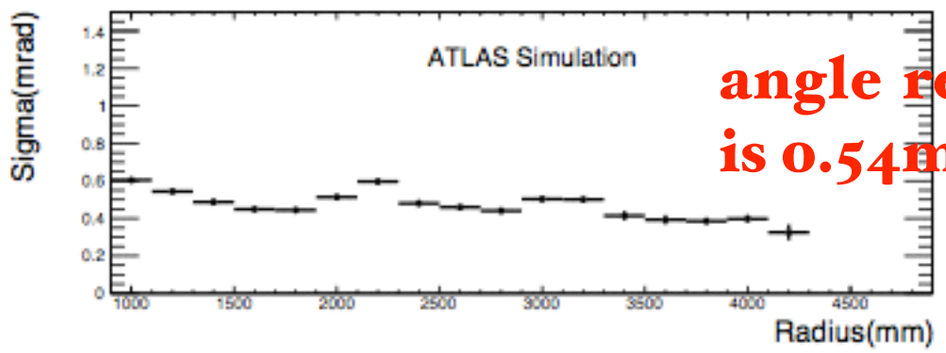




segments found efficiency

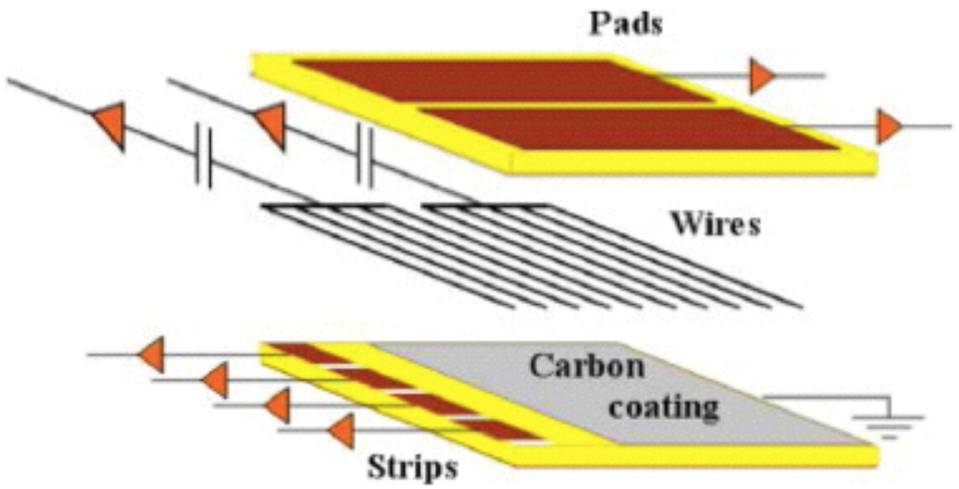


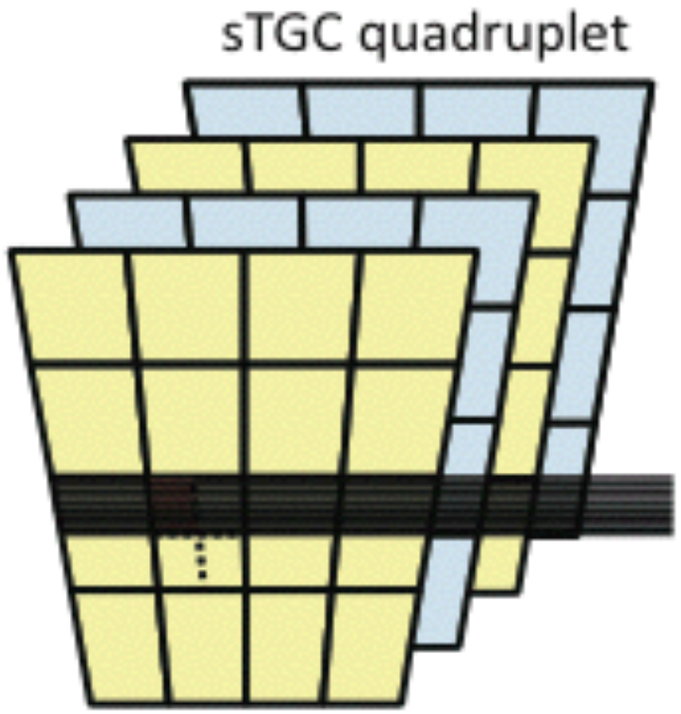
The angular resolution of the sTGC segment at difference radius



angle resolution is 0.54mrad

sTGC探测器性能及测试结果



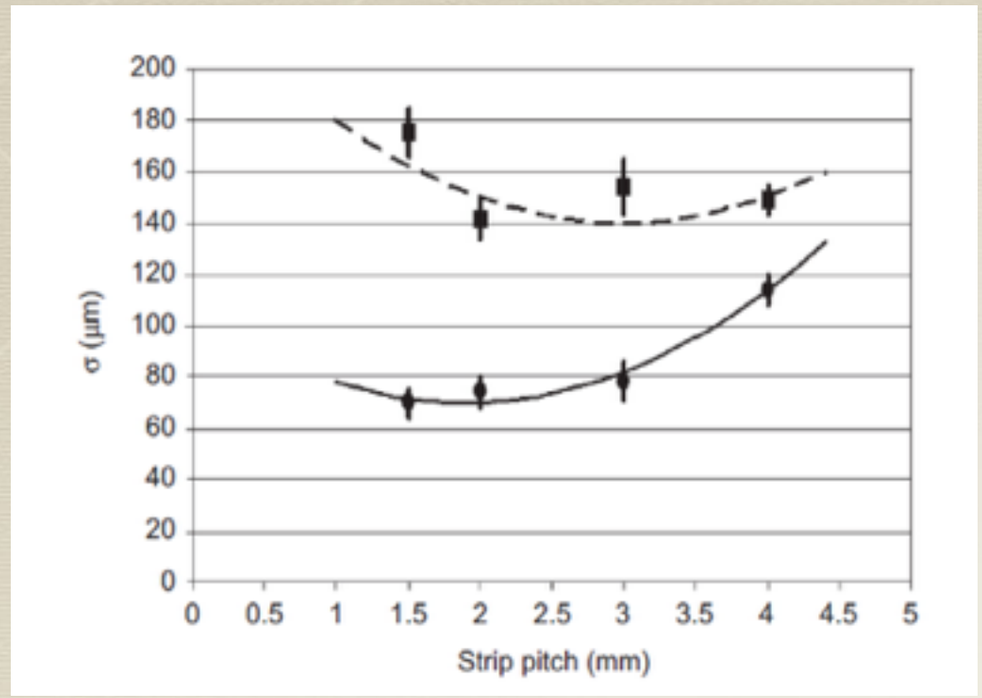


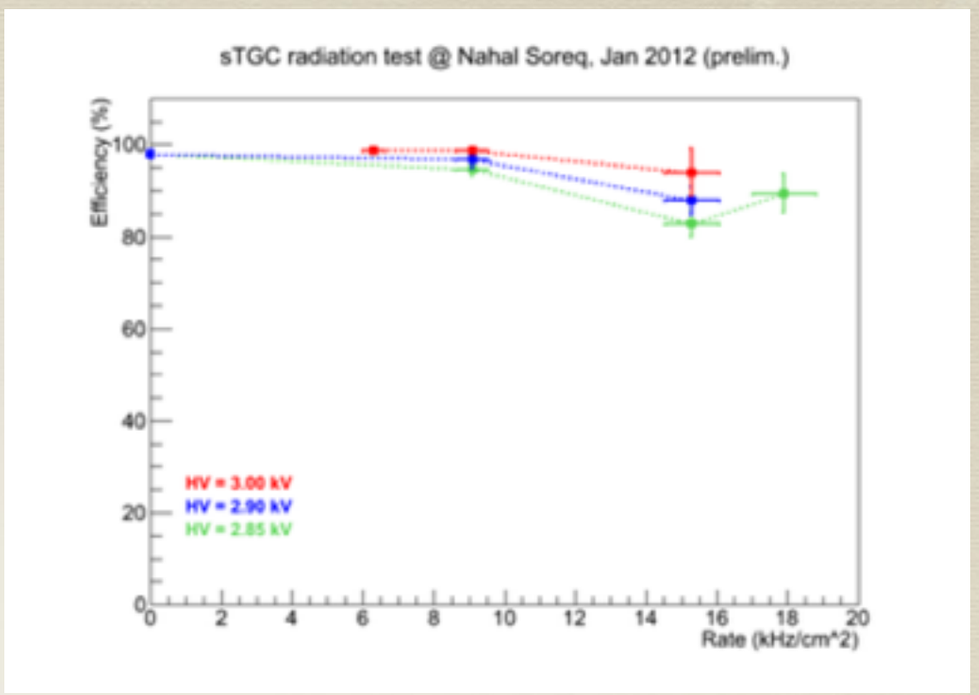
基于现在的ATLAS TGC的技术

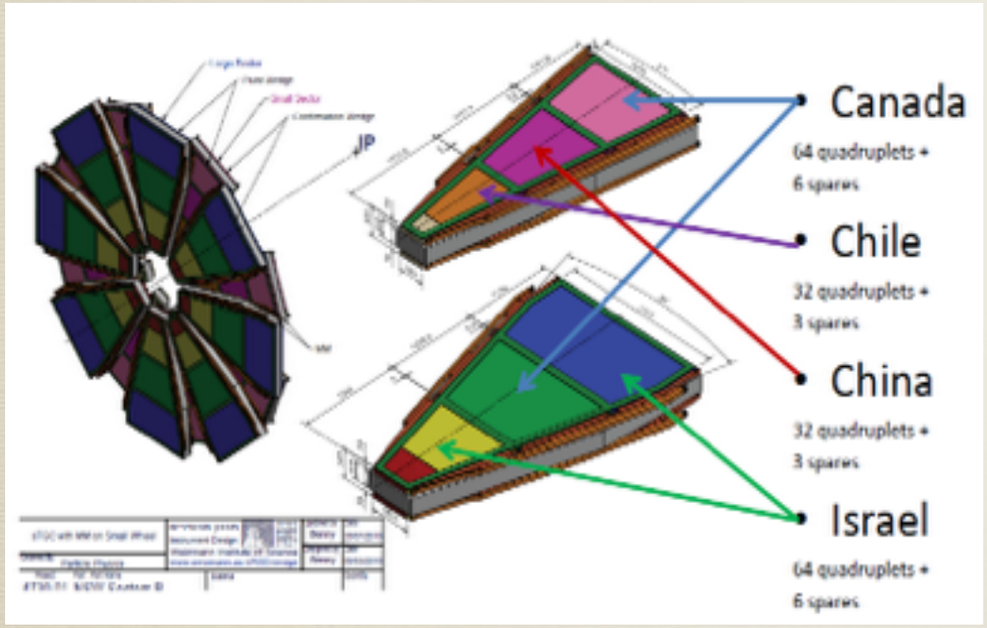
（1）strip pitch为3.2mm，比TGC小，运用电荷重心法可以得到更精确的坐标

（2）低阻抗的cathode可以很好的适应high rate

（3）pads读出，作为在线trigger tower，减少读出信号道数量



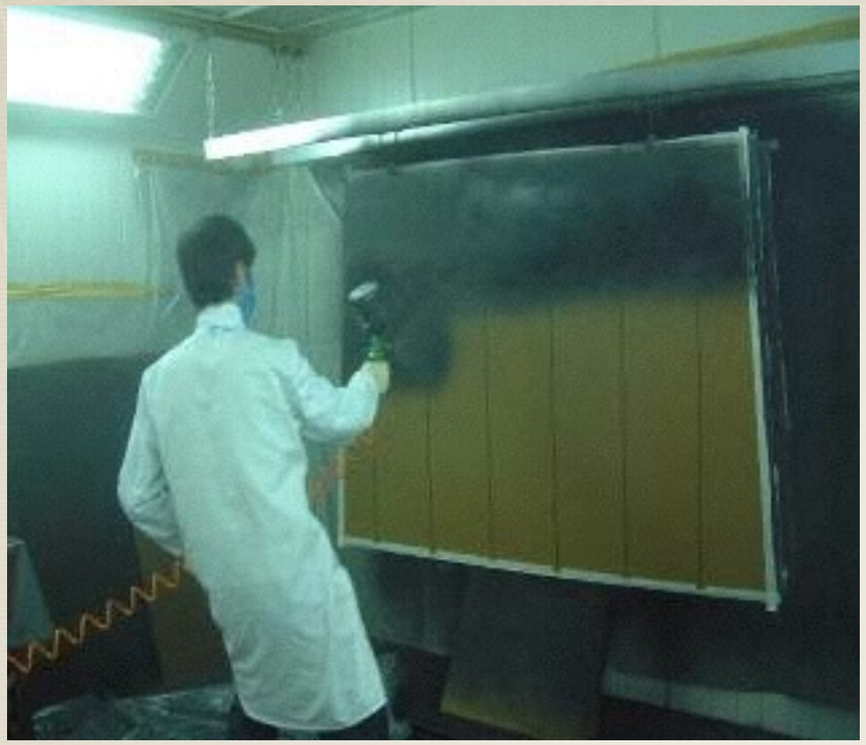


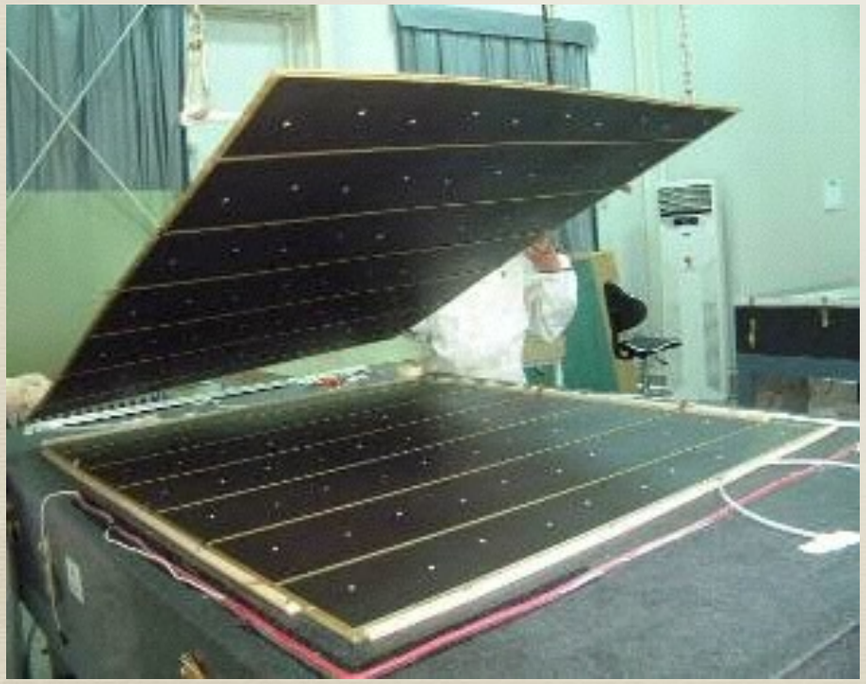


每个单独的探测层的位置分辨率为70-100um（直接数字读出，信号的length正比与过阈时间，因此具有非常快的相应能力）

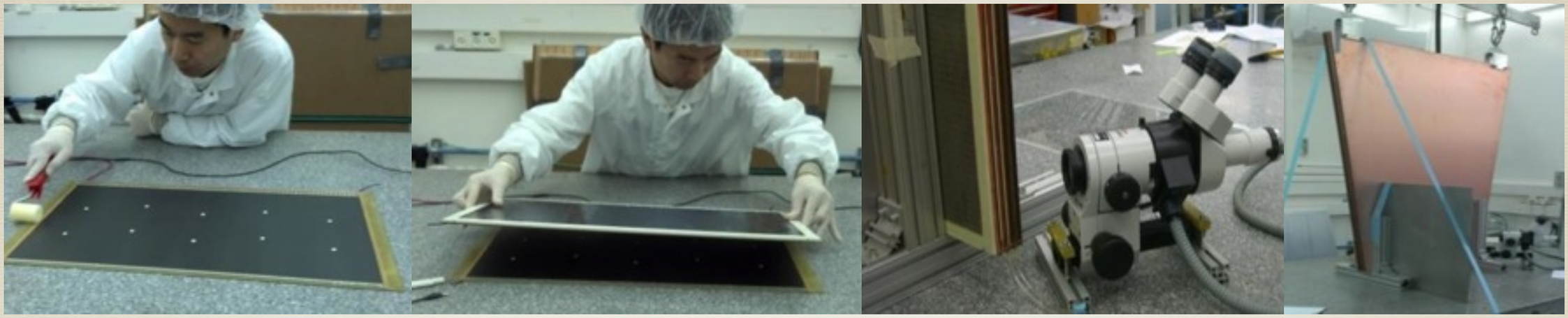
每层探测器平板的位置分辨60-70um（垂直入射，电荷测量方法）大角度入射每层分辨率会降低到150um, strip pitch 相对精度20微米

Thin gap chamber in Shandong Univ.



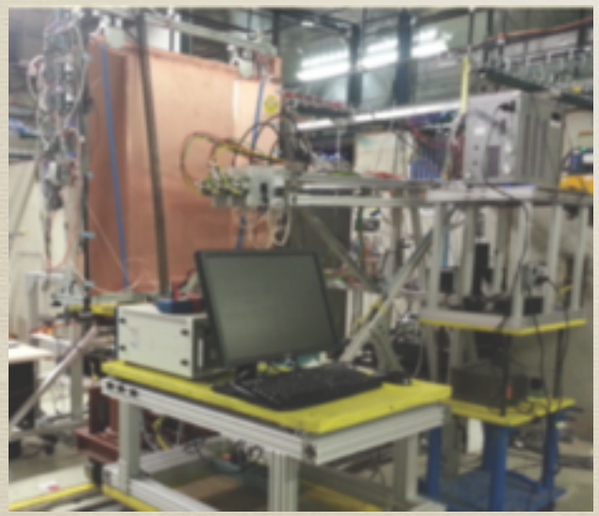


Full size sTGC prototype construction



Beam test of the prototype

Development of DAQ of the sTGC cosmic testing system, for construction sites.



Detector testing system— CoRaRS

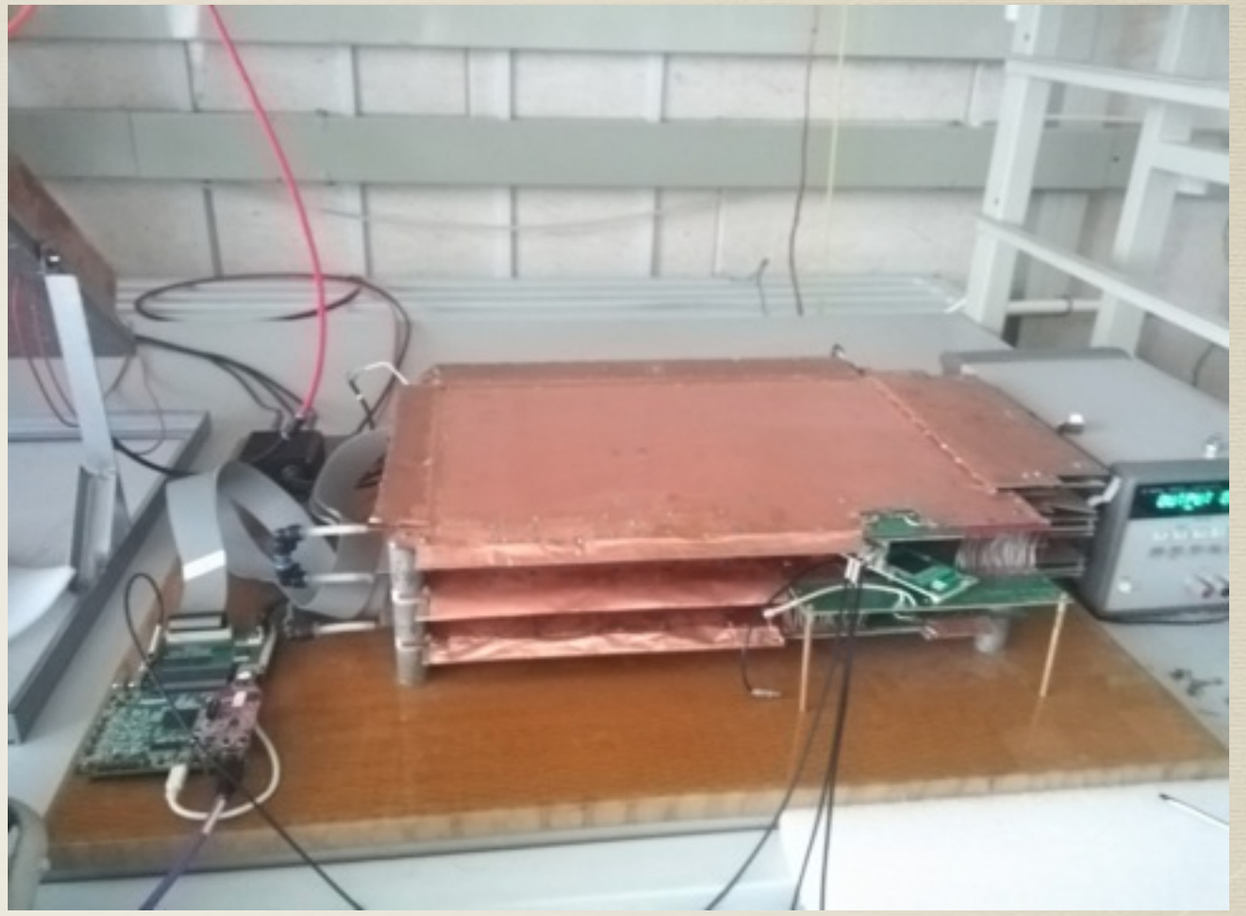
sTGC测试方法

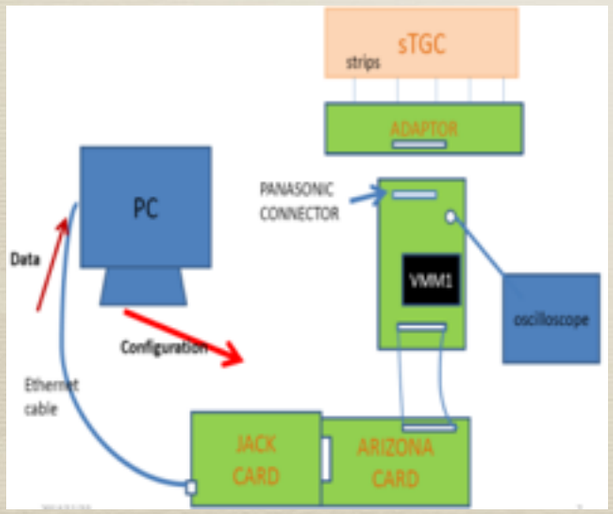
NSW 将会特征化为2.5M读出电子学

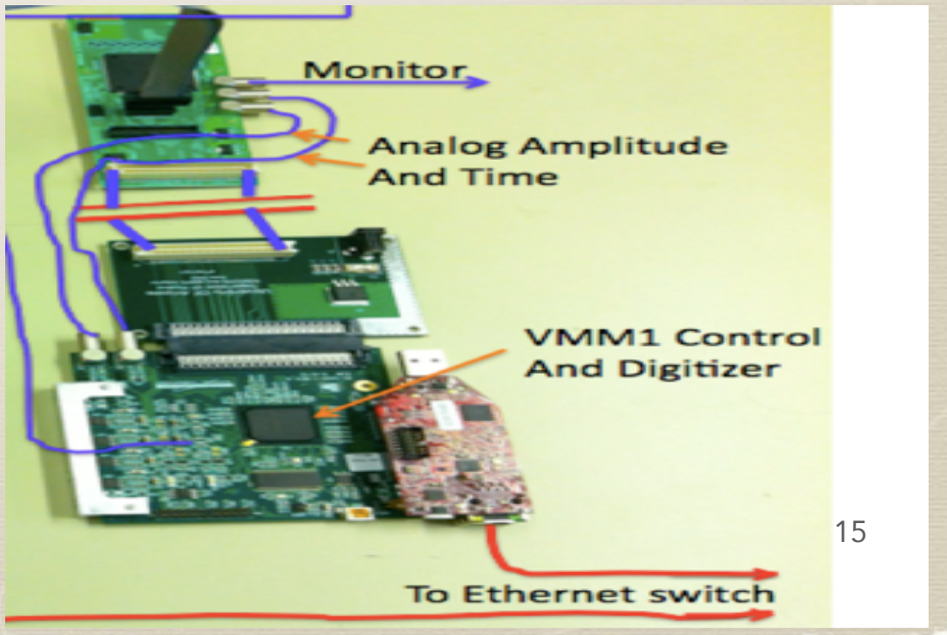
新发展的VMM芯片有64道，极大的降低了电子学的数量

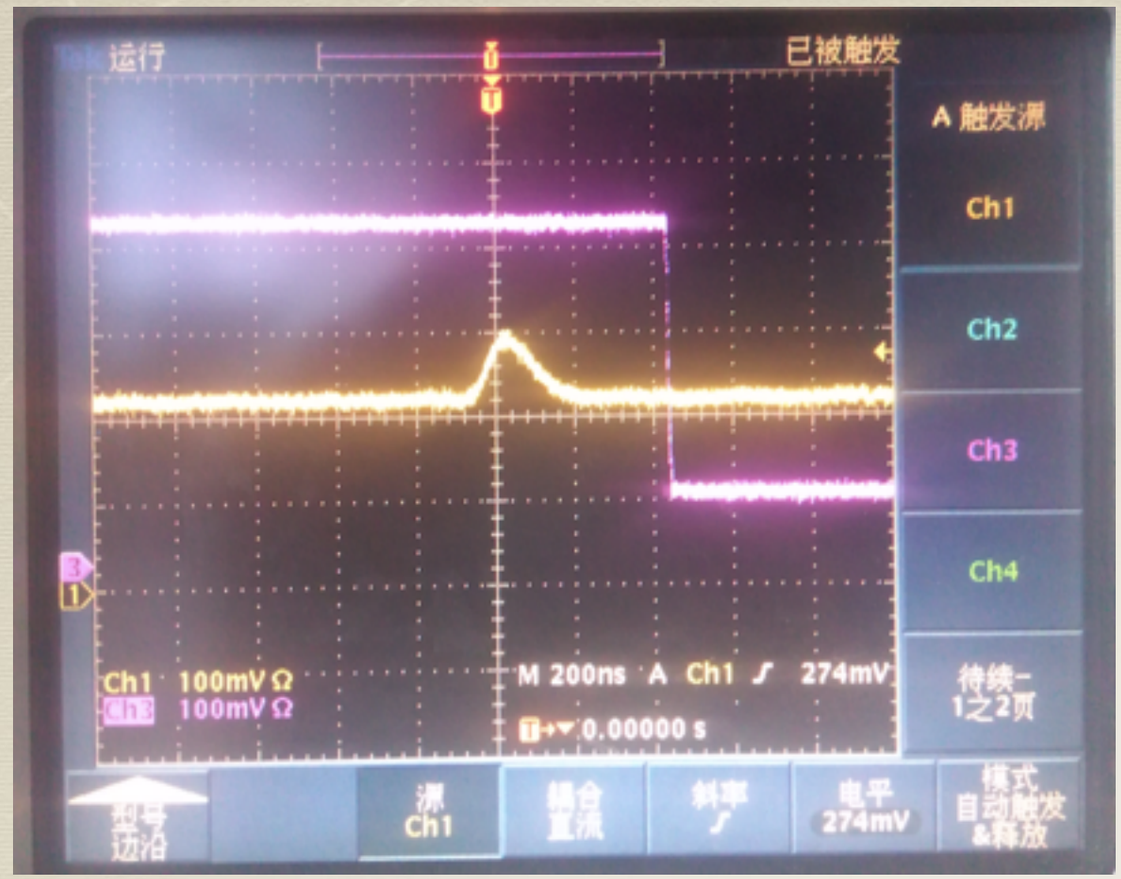
可调节的增益

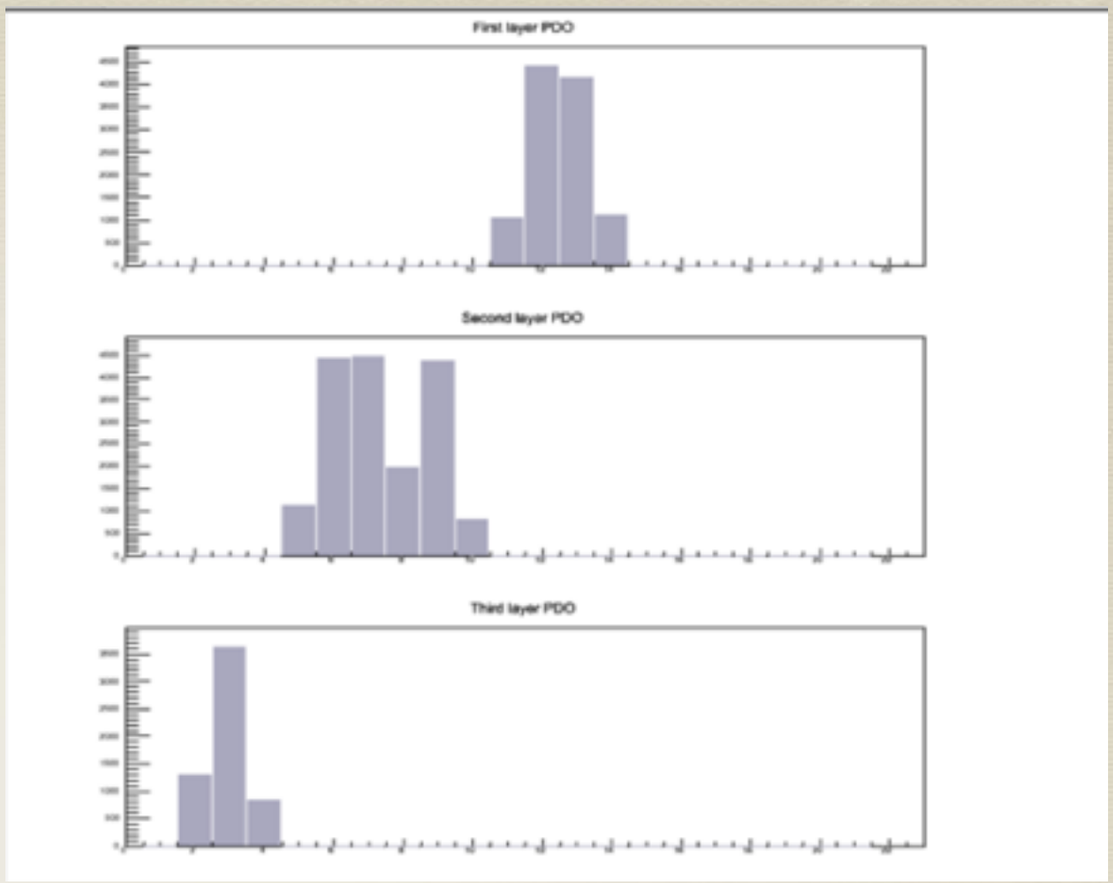
具有测量脉冲

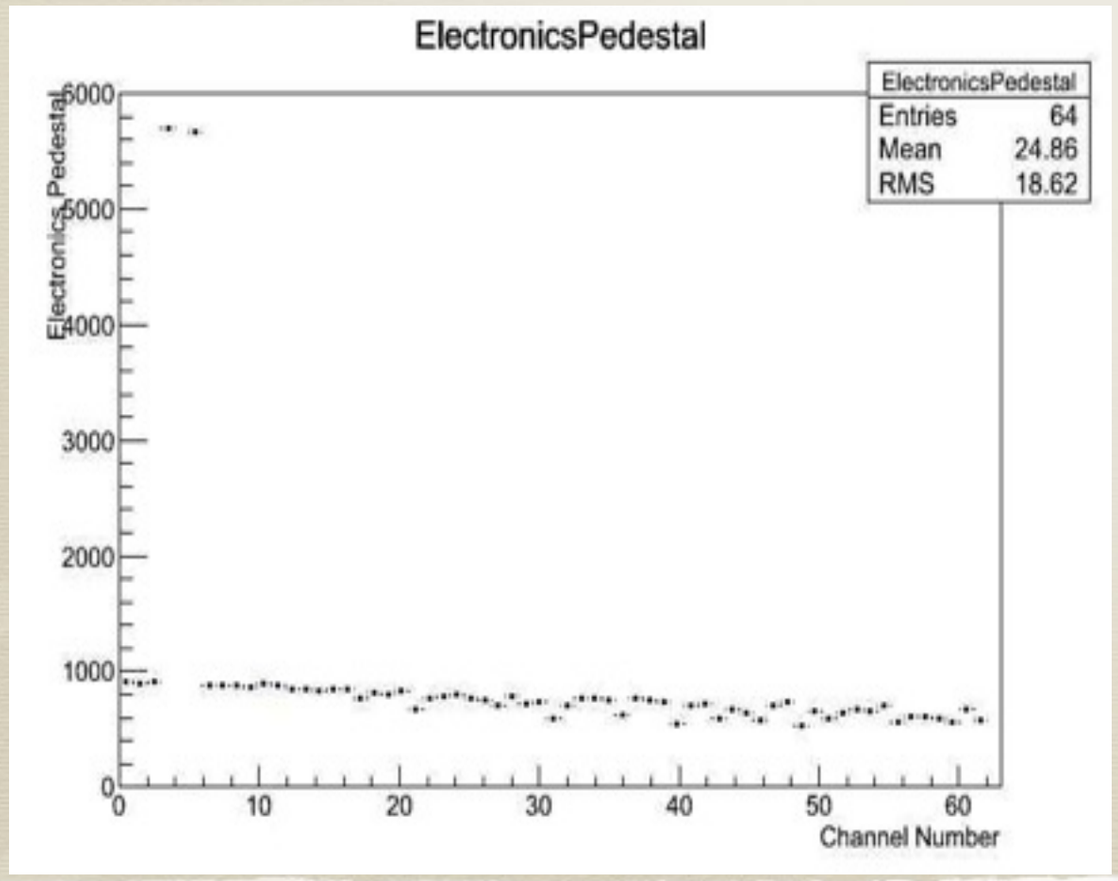







运行
已被触发
A 触发源
Ch1
Ch2
Ch3
Ch4
待续-
1之2页
Ch1 100mV Ω
Ch3 100mV Ω
M 200ns A Ch1 ∫ 274mV
0.00000 s
边沿
源
Ch1
耦合
直流
斜率
∫
电平
274mV
模式
自动触发
&释放


First layer PDO
Second layer PDO
Third layer PDO


ElectronicsPedestal
ElectronicsPedestal
Entries 64
Mean 24.86
RMS 18.62
Electronics Pedestal
6000
5000
4000
3000
2000
1000
0
0
10
20
30
40
50
60
Channel Number

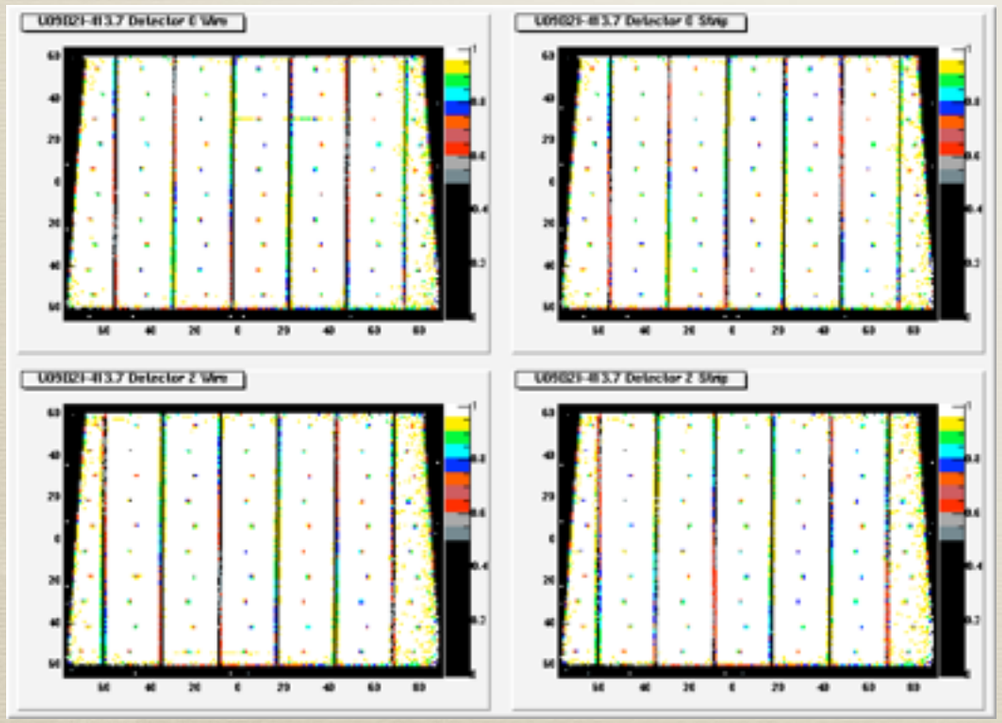
sTGC at Shandong University　读出系统

测试系统和数据分析会给出sTGC探测器：

（1）每一层分辨率分布图

（2）效率分布图

（3）不同探测器的旋转和相对位移



总结

ATLAS 在发现higgs后通过提高亮度来提高统计量，以便精确测量higgs的性质 以及寻找新物理

由于亮度的增加，事例率的大幅度提高，Small Wheel区域如果想要维持现在的精度必须要对触发系统和track重建系统进行升级

已经完成Small Wheel的升级预研，结果表明新的设计能够达到预期目标

山东大学承担了New Small Wheel 地区sTGC探测器的建造，正在按计划进行中