首届LHAASO合作组会议

LHAASO10PeV-100PeV宇宙线能谱测量

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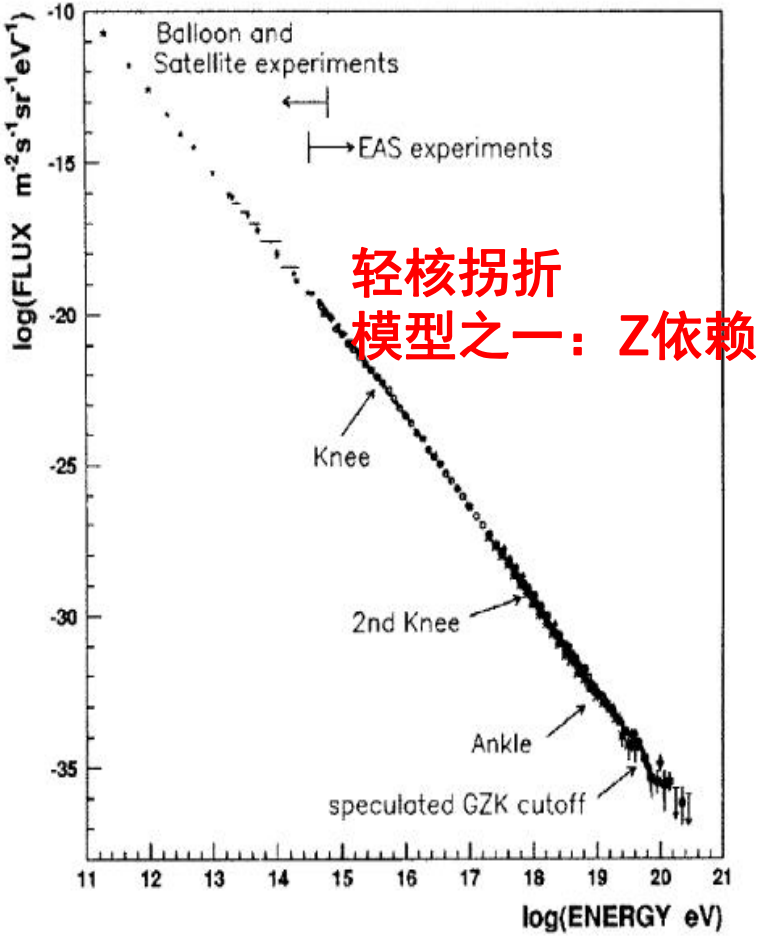
高能所 2016.8.15-18

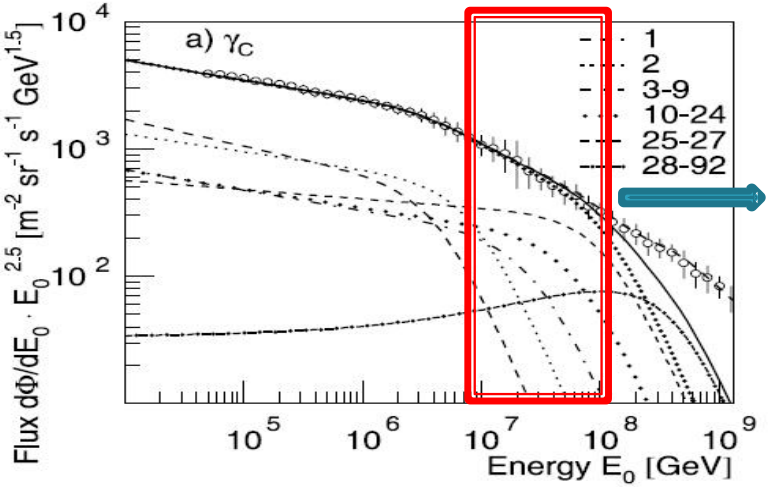
主要内容

- 10PeV-100PeV宇宙线能谱测量的意义
- LHAASO的多参数测量
- LHAASO-WFCTA，LHAASO-KM2A探测器及模拟简介
- 宇宙线几何重建
- 宇宙线成分的多参数鉴别
- 宇宙线能量重建
- LHAASO对宇宙线能谱的测量能力
- 总结和[illegible]

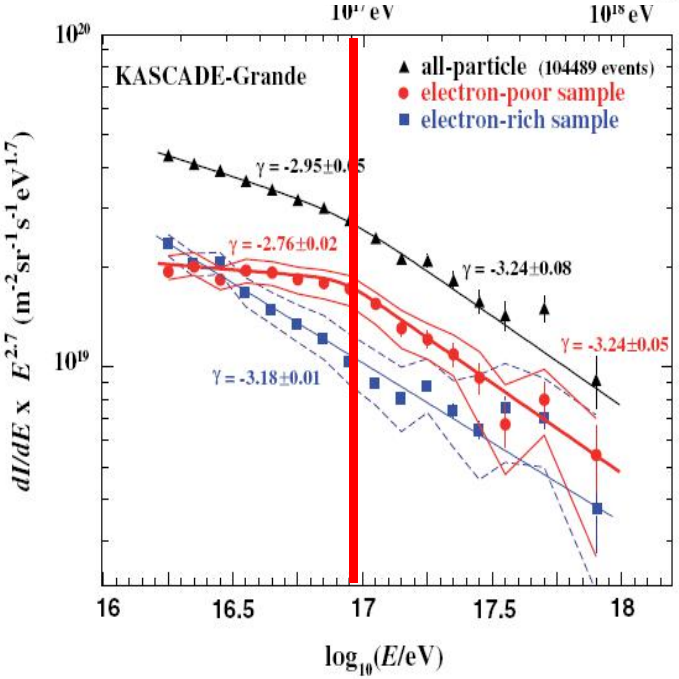
10-100PeV宇宙线能谱的测量意义



轻核拐折
模型之一：Z依赖



重核拐折
重核膝



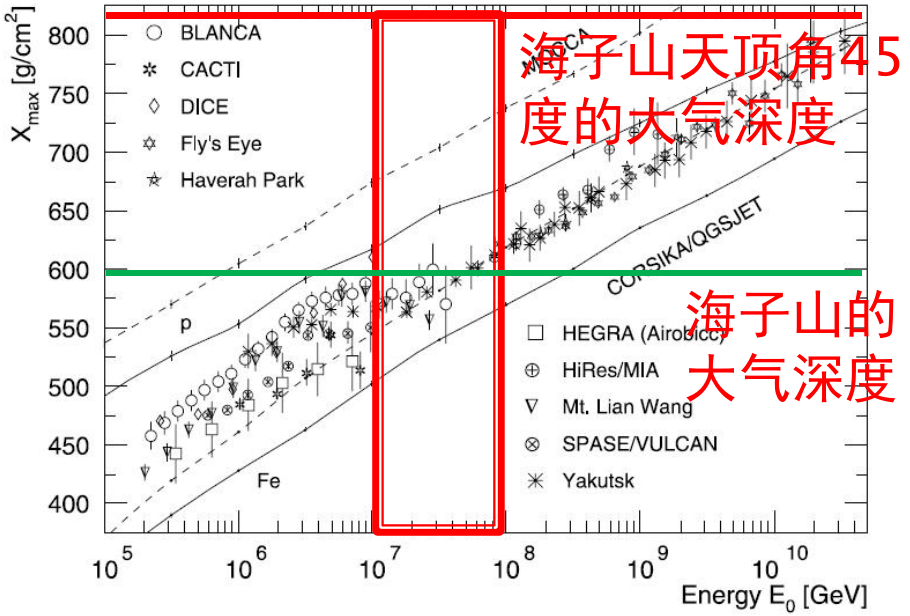
KASCADE-Grande

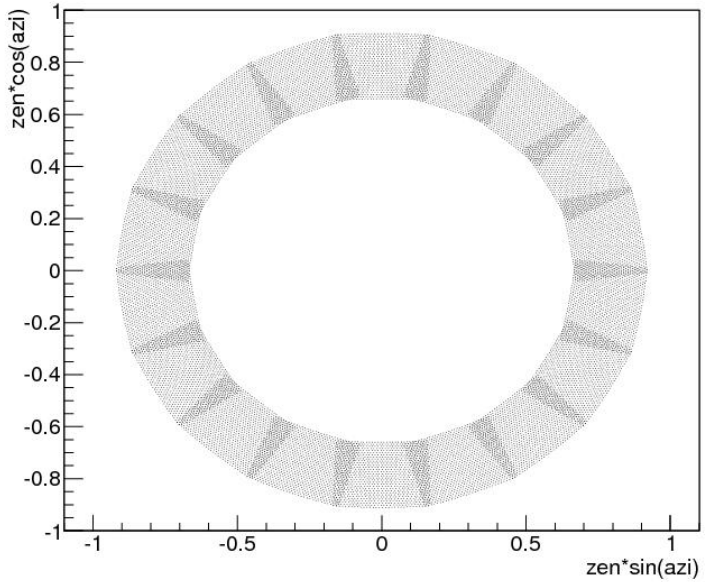
80PeV，
-2.76 ~~ -3.24


Water Cherenkov detector Array (WCDA) 78,000m²
Wide Field Water Cherenkov telescope Array (WFCTA) 18 Telescopes
能量测量，Hillas参数
几何重建，Muon信息
1KM² Array (KM2A)
5195 scintillator detectors every 15 m
1171 muon detectors every 30m

LHAASO-WFCTA简介及布局

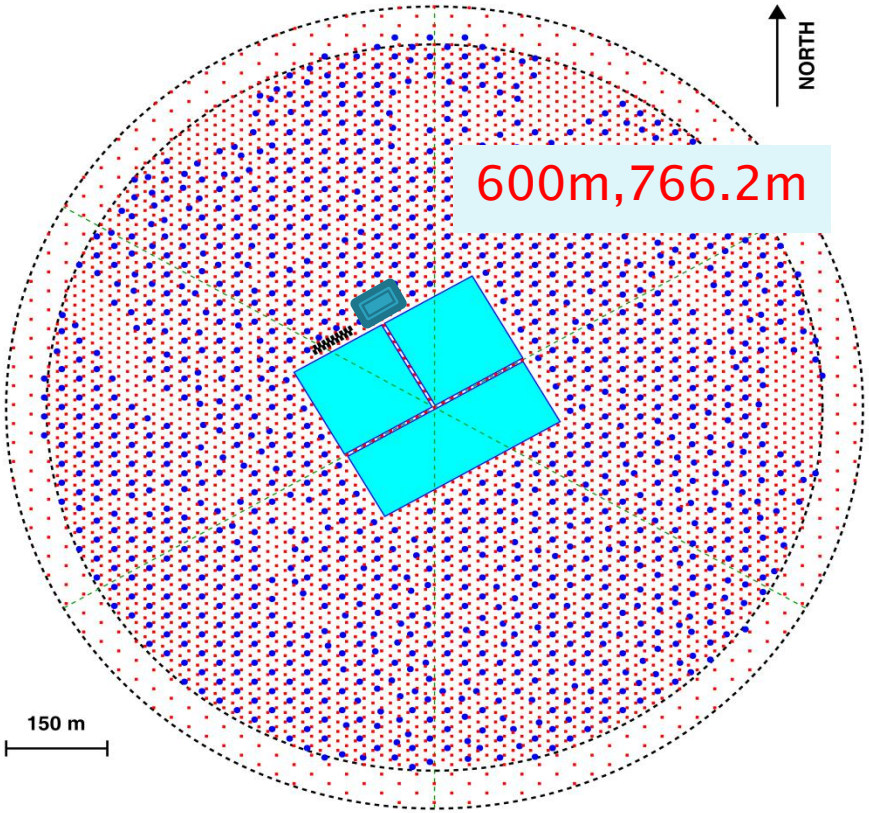
- 反射镜
  - 25面球面镜拼接而成
  - 边长：300mm
  - 曲率半径：5800mm
- PMT阵列
  - 32 x 32 PMTs/SiPM
  - PMT直径: 26.9mm
  - 光阴极距离反射镜中心的距离: 2870mm
- 可移动性设计：
  - 根据不同的观测阶段进行不同的排布
- 望远镜主轴指向：
  -
  - 方位[redacted]20度间隔

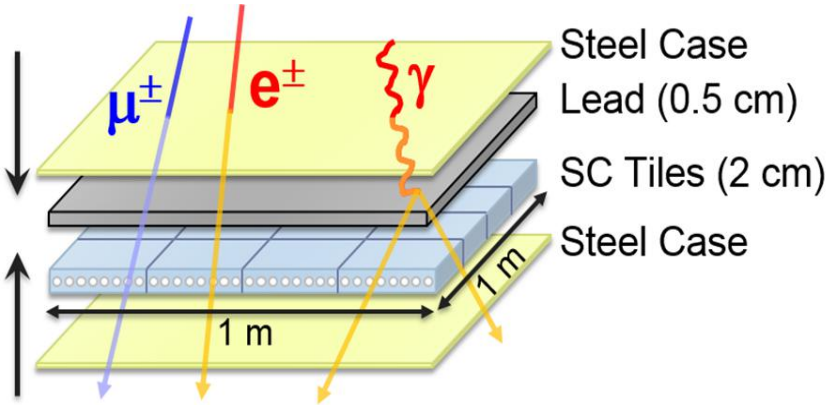


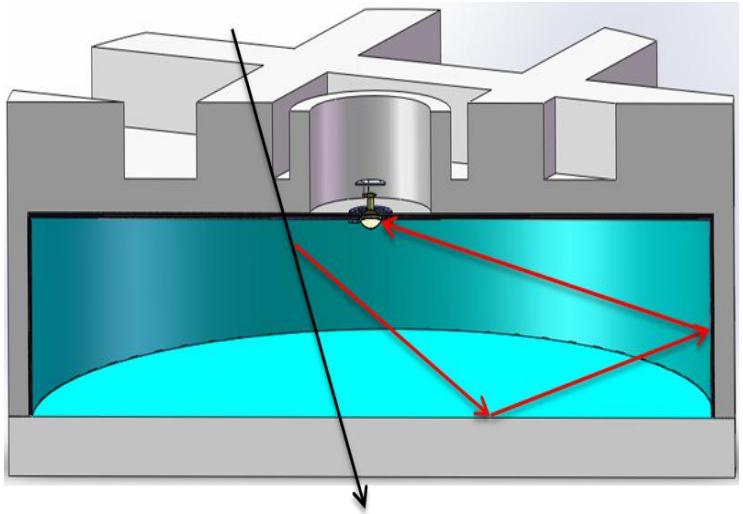


KM2A探测器简介

- 电磁探测器(ED)
  - 有效面积: 1m²
  - 间距 :15m
  - 探测器数目: 5195
  - 动态范围: 1~10,000 particles
- Muon Detector (MD)
  - 有效面积: 36m²
  - 间距:30m
  - 探测器数目:1171
  - 动态范围: 1~10000 particles







WFCTA、KM2A探测器模拟数据样本介绍

- CORSIKA V74005，修改版，输出波长

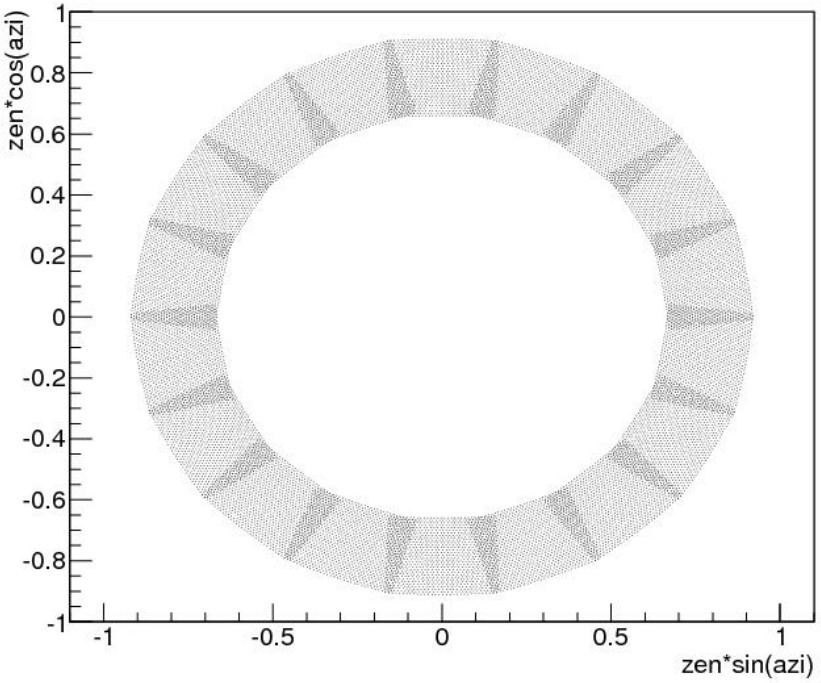
- 能量：10PeV~100PeV
- 成分：质子，氦核，CNO，铁核
- 相互作用模型：QGSJETII04+FLUKA

- 角度范围：
  - 天顶角：35度-55度
  - 方位角：0度-360度
- 投点范围（xy）：-400m至400m

- 统计量：每种成分5000个事例
  - 重复使用：20次
  - 相当于100000个事例

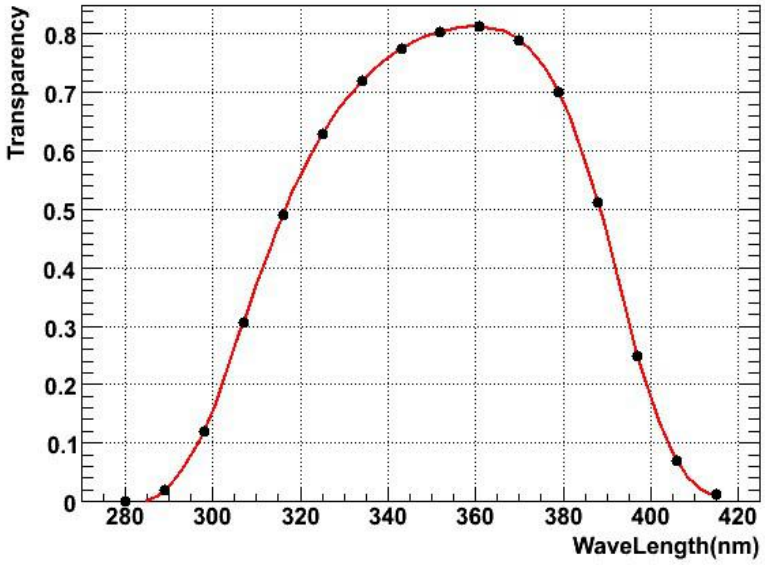
WFCTA望远镜模拟

- 望远镜台数：18台
  - 位置：0，0
  - 指向：
    - 天顶角45，方位角iTel*20（itel=0,
- 在镜筒入口处设置滤光片：
  - 减少饱和



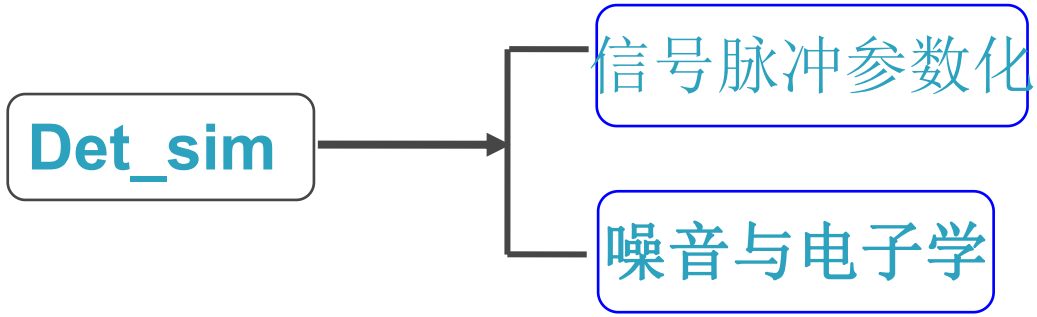
1：光子进入望远镜后的光子追踪

2：光子进入焦平面后夜空背景的模拟、PMT及电子学的响应

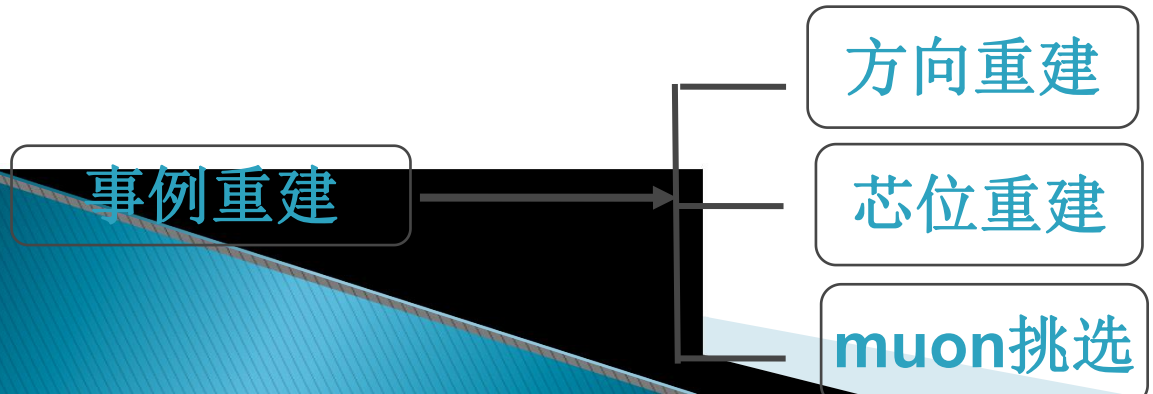


KM2A快速模拟

记录下 探测器接收到的粒子数 并输出粒子数



将探测器接收到的粒子数转换为光电子数 并输出光电子数

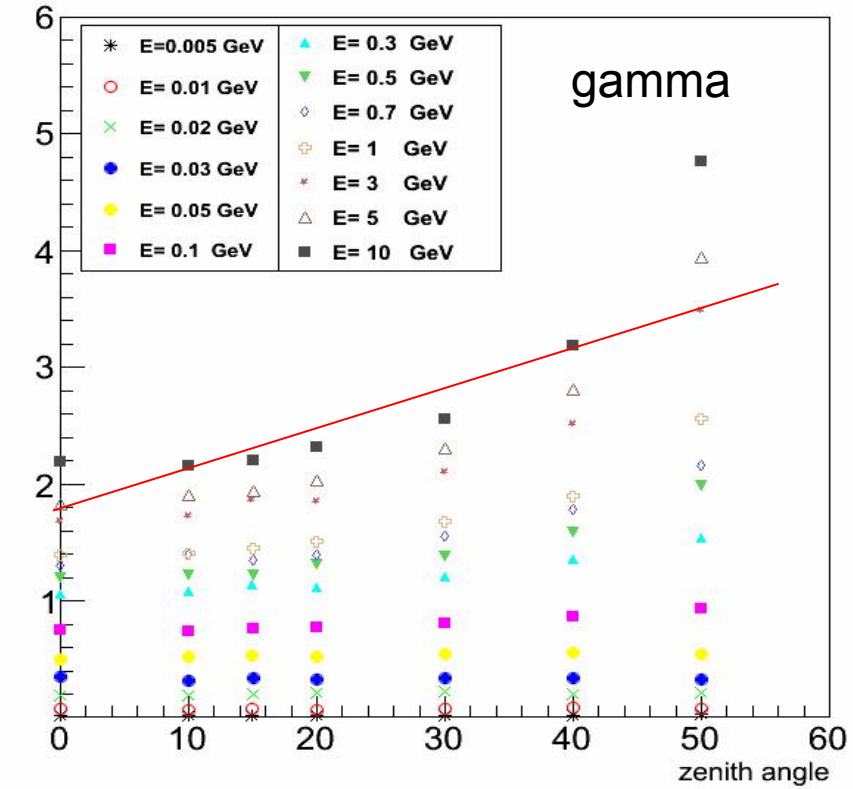


对事例进行重建 输出重建信息

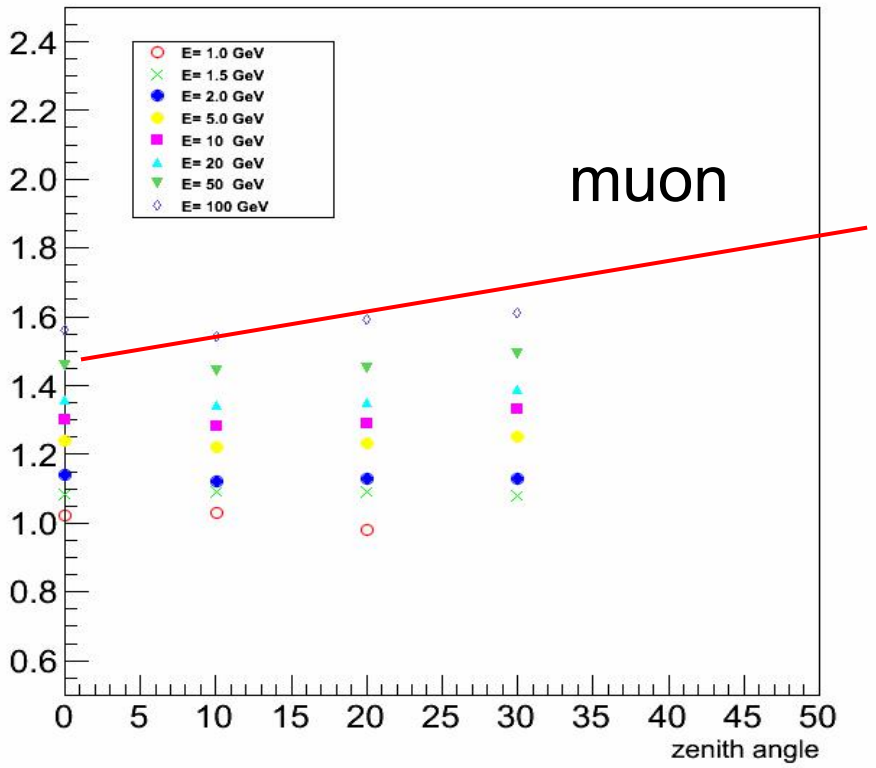
参数化

(1). ED:　0.5cm铅板　　(2). MD：2.5m 土层

粒子穿过铅板后的电子数目

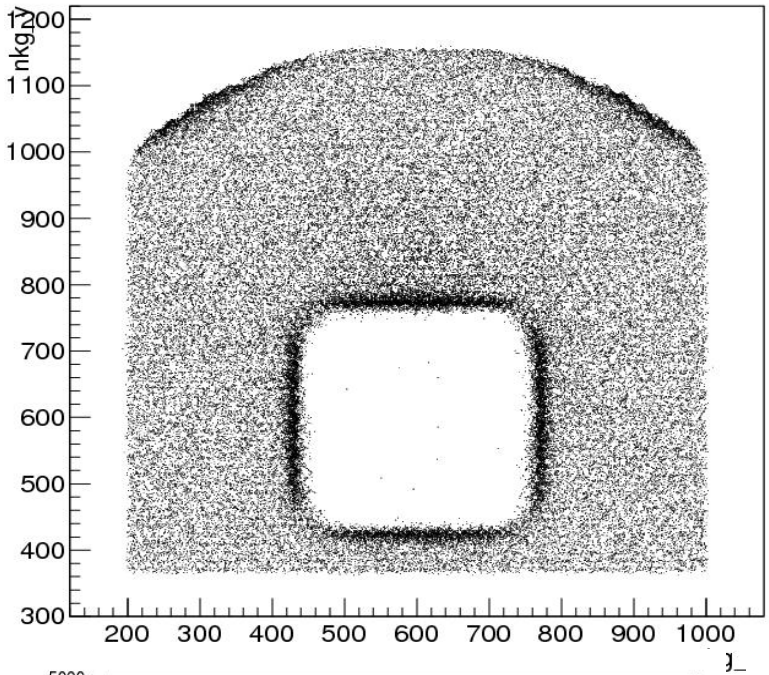


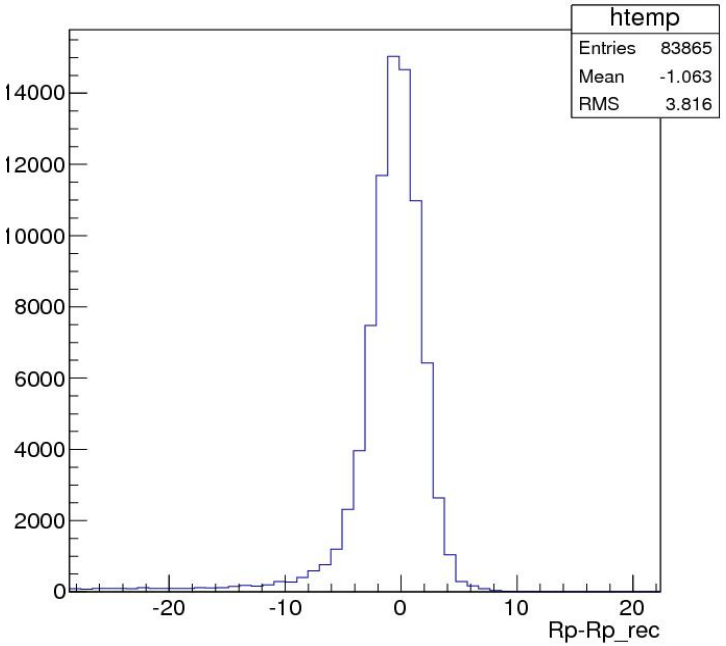
muon数

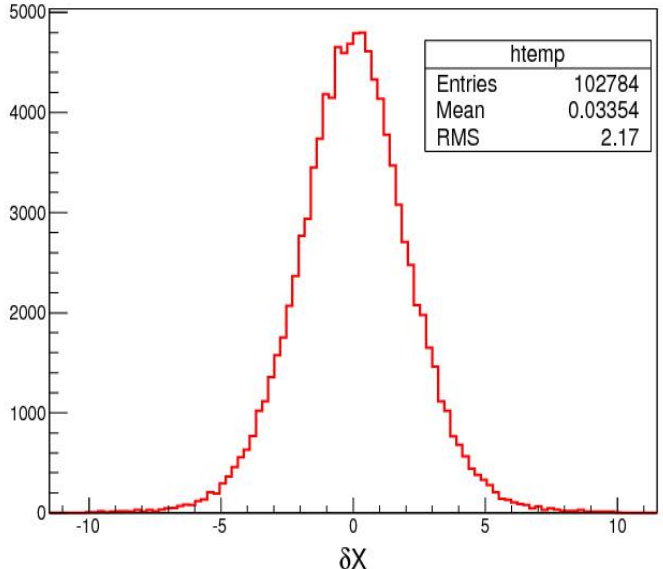


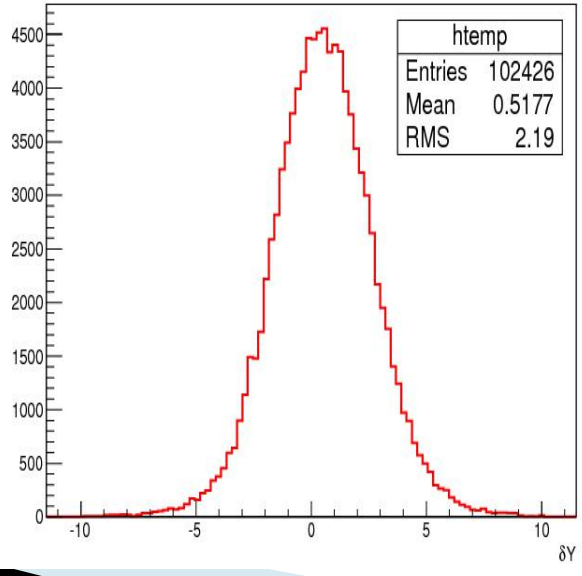
入射角线性延伸至55度

KM2A的宇宙线几何重建





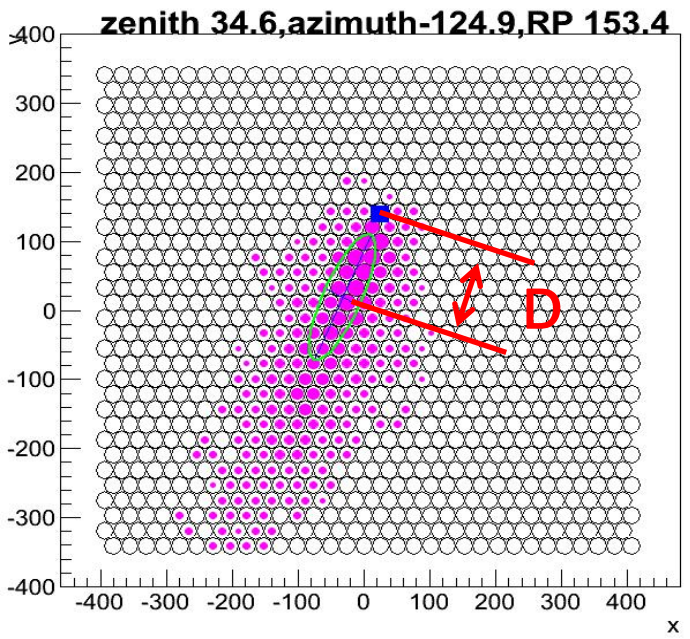




选择距离阵列中心R
180m<R<500m
的事例

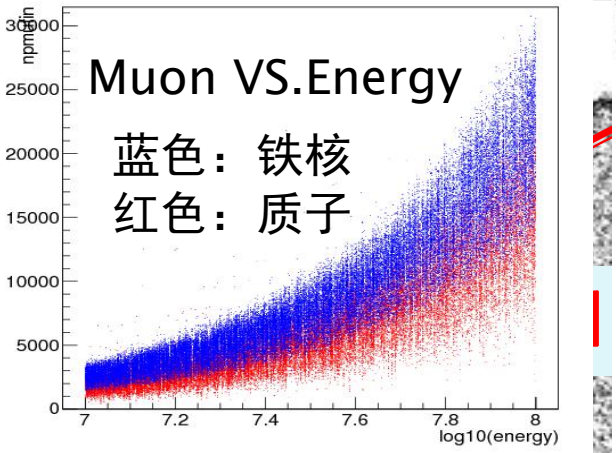
Rp分辨率：3.8m

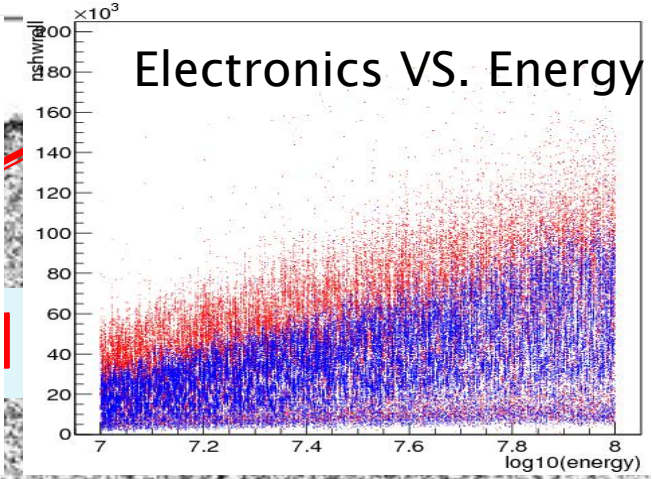
多参数鉴别宇宙线成分

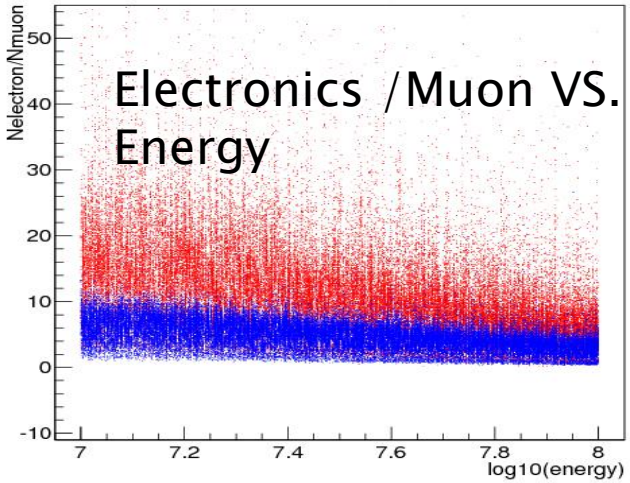


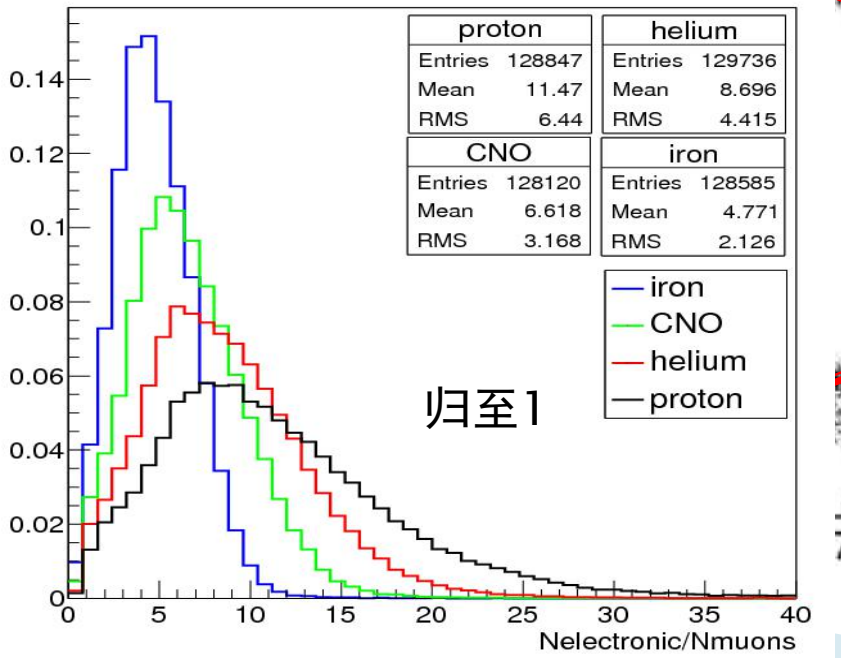
- **难点：**
  - 原初信息丢失，无法直接探测
  - 受能量重建，和相互作用模型的影响
- **解决办法：**
  - 多参数分析
    - KM2A：
      - Muon数，电磁粒子数目
    - WFCTA，契伦科夫成像
      - 像的质心到簇射方向的距离与Xmax相关，
      - 但依赖于望远镜到簇射轴的距离（RP）

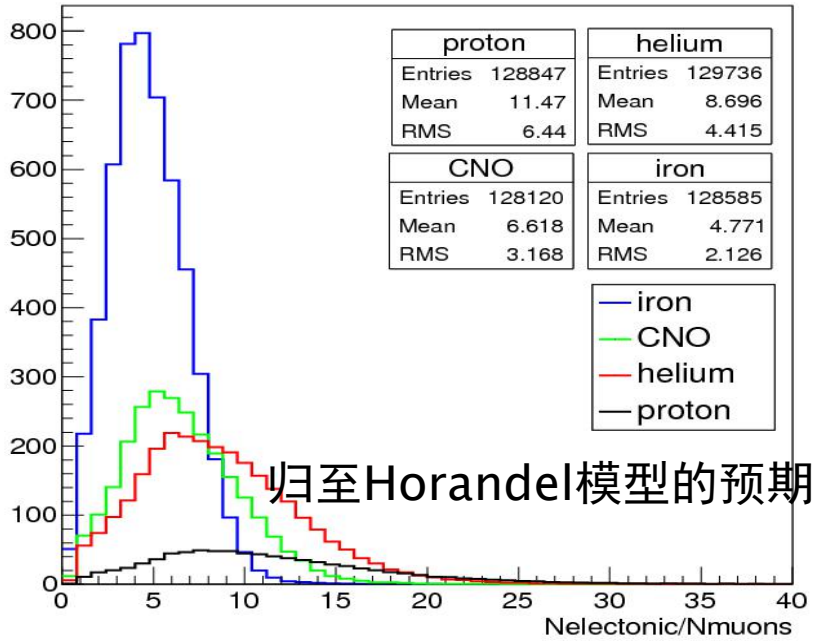
Muon数目，电磁粒子的数目



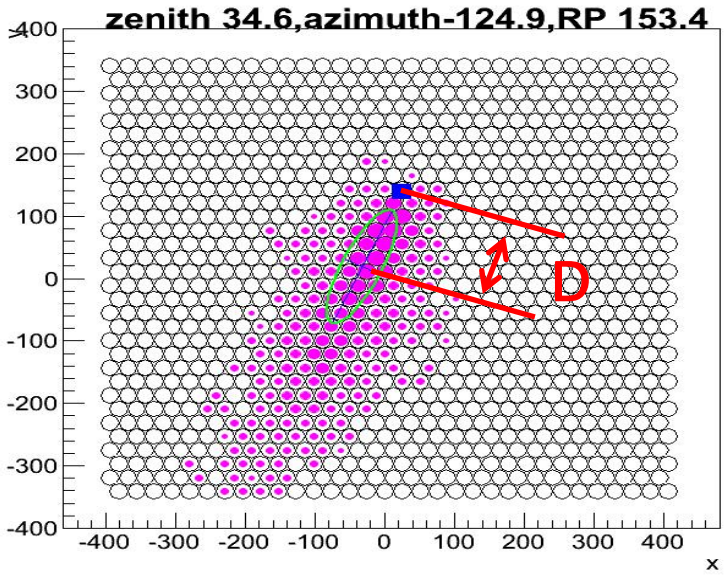


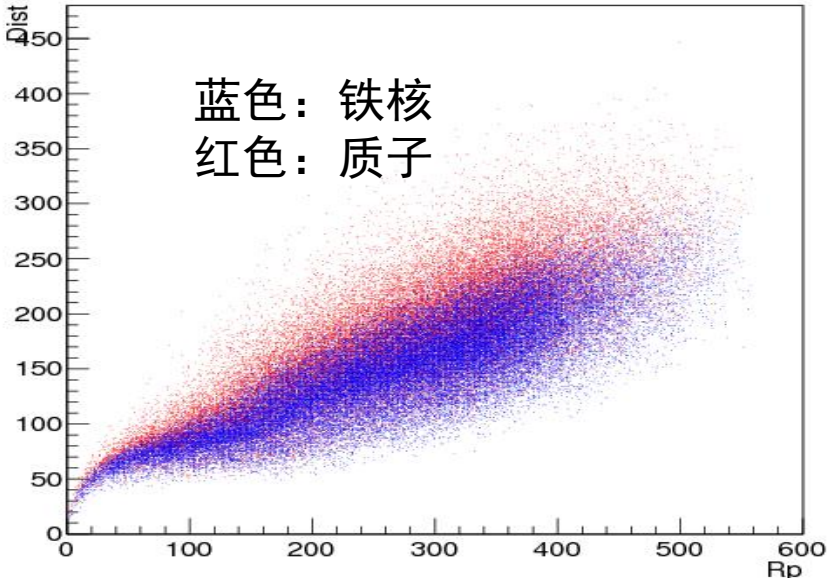


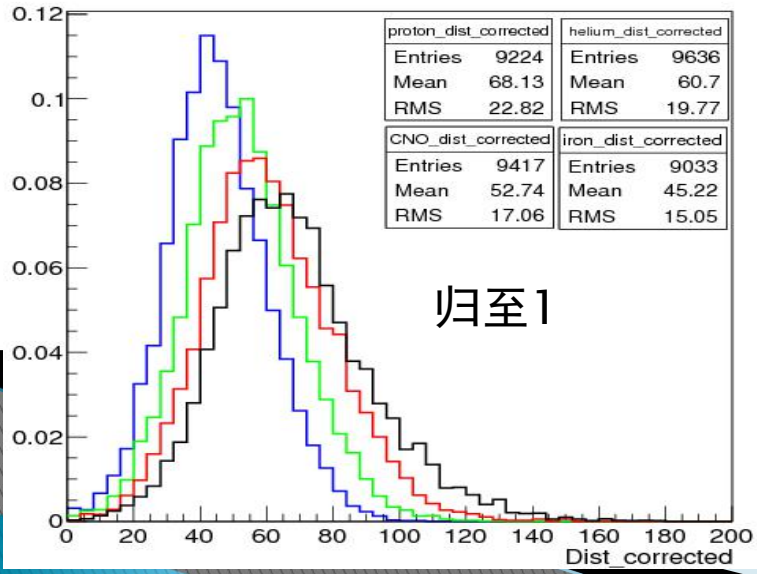


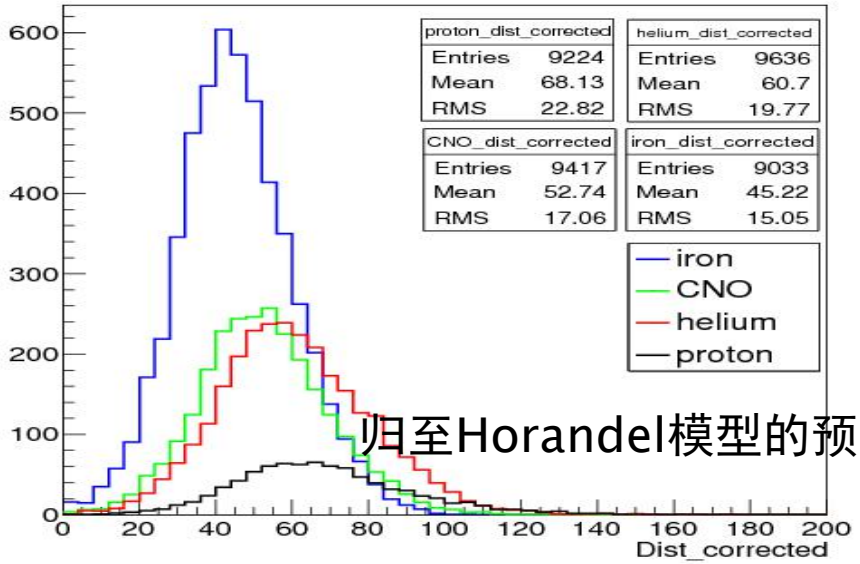


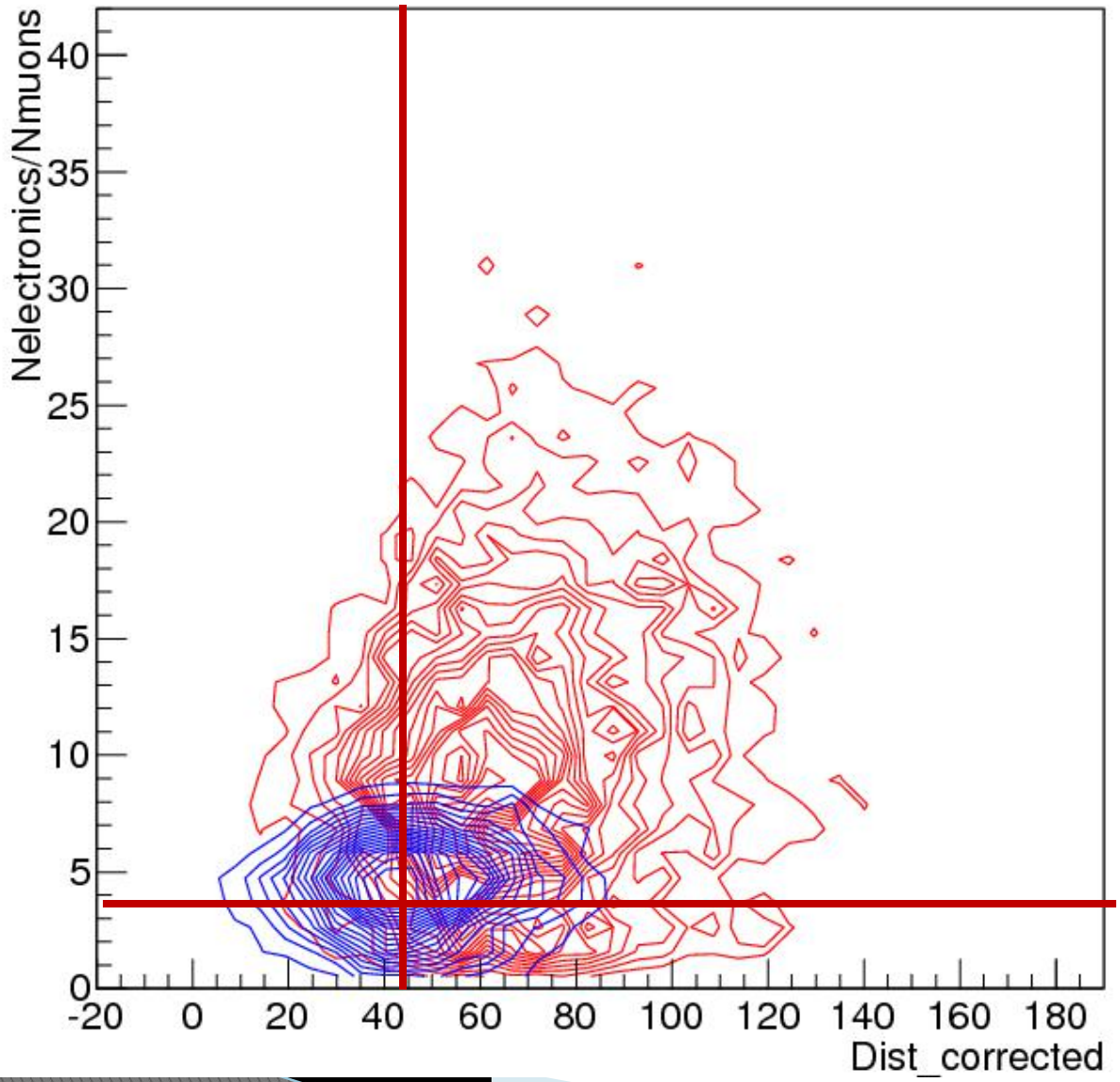
像的质心到簇射方向的距离







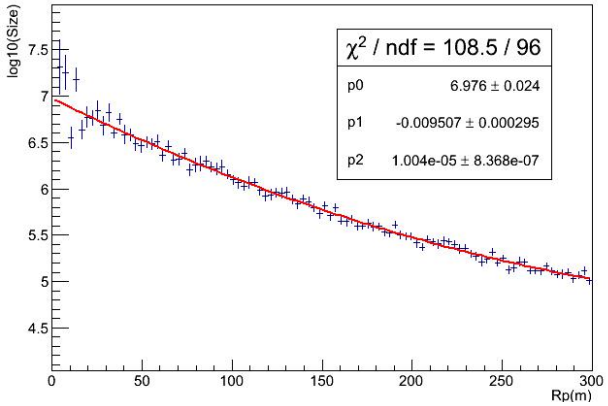


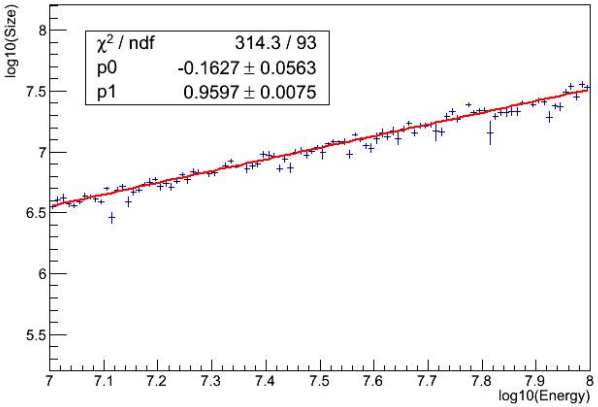

Nelectronics/Nmuons
40
35
30
25
20
15
10
5
0
-20
0
20
40
60
80
100
120
140
160
180
Dist_corrected

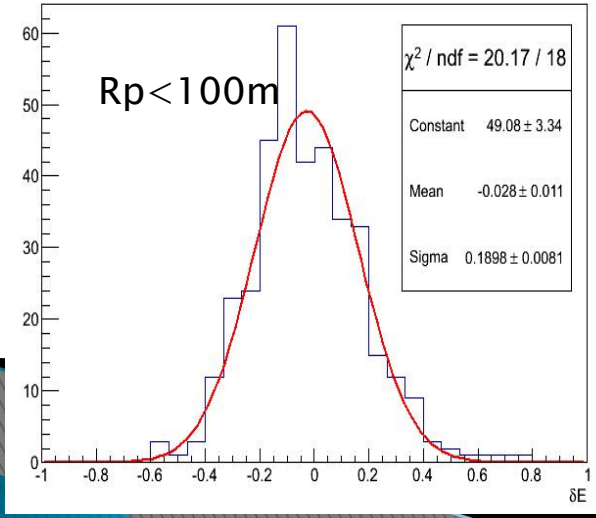
对铁核的污染率为32%

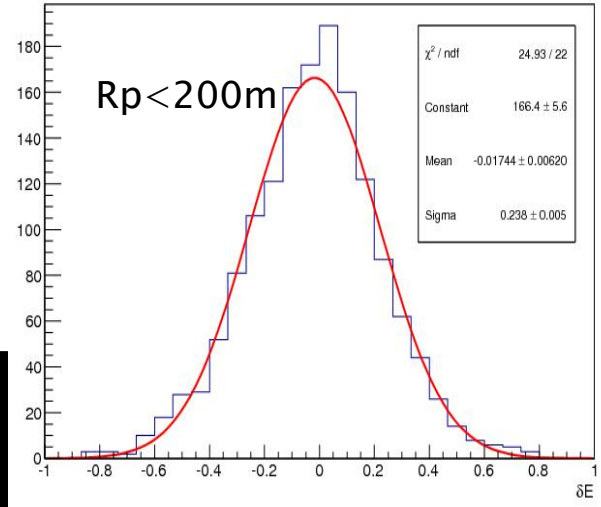
能量重建

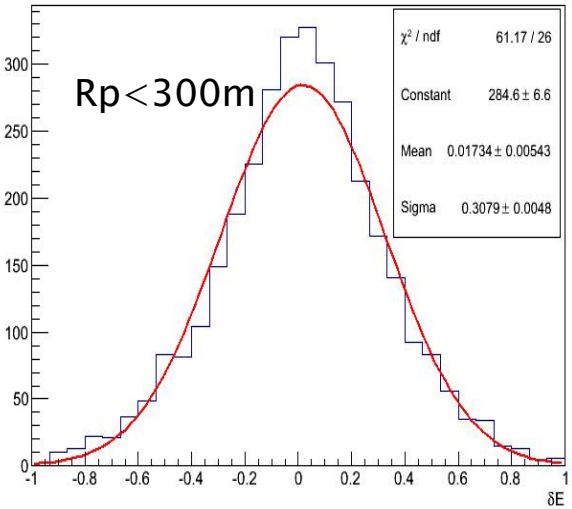
- 望远镜记录到的光电子数（Size）与能量相关，但是依赖于Rp。
- 能量分辨率:
  - <20% (Rp<100m)
  - <25%(Rp<200m)
  - ~30%(Rp<300m)



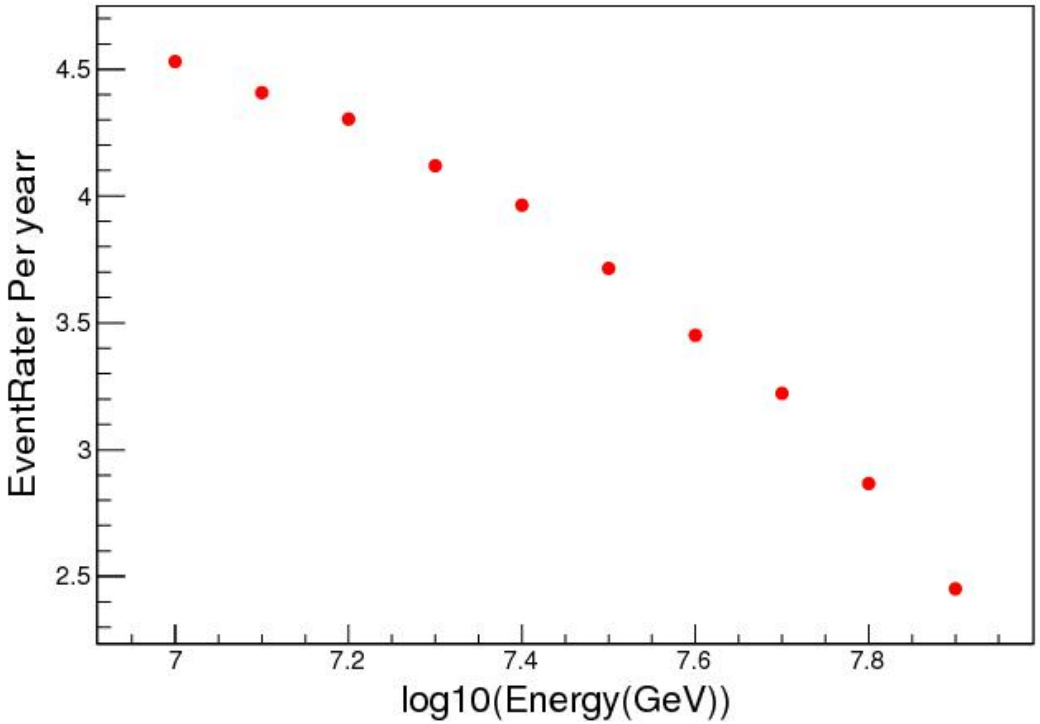








年事例数



- 18台望远镜
- 15%有效工作时间
- 50m<Rp<300m

100Events @100PeV

总结和计划

- 通过KM2A和WFCTA之间的联合观测：
  - 成分鉴别能力：对铁核的污染率为32%
  - 能量重建精度：25%
  - 有效观测事例数：100Events@100PeV
- 加入MgAlSi的模拟
- 不同相互作用模型所引起的系统误差