JÜLICH
FORSCHUNGSZENTRUM

A Simple Generator for $\bar{p}$A Collisions

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Antiproton-Nucleus Physics for „Day-1“

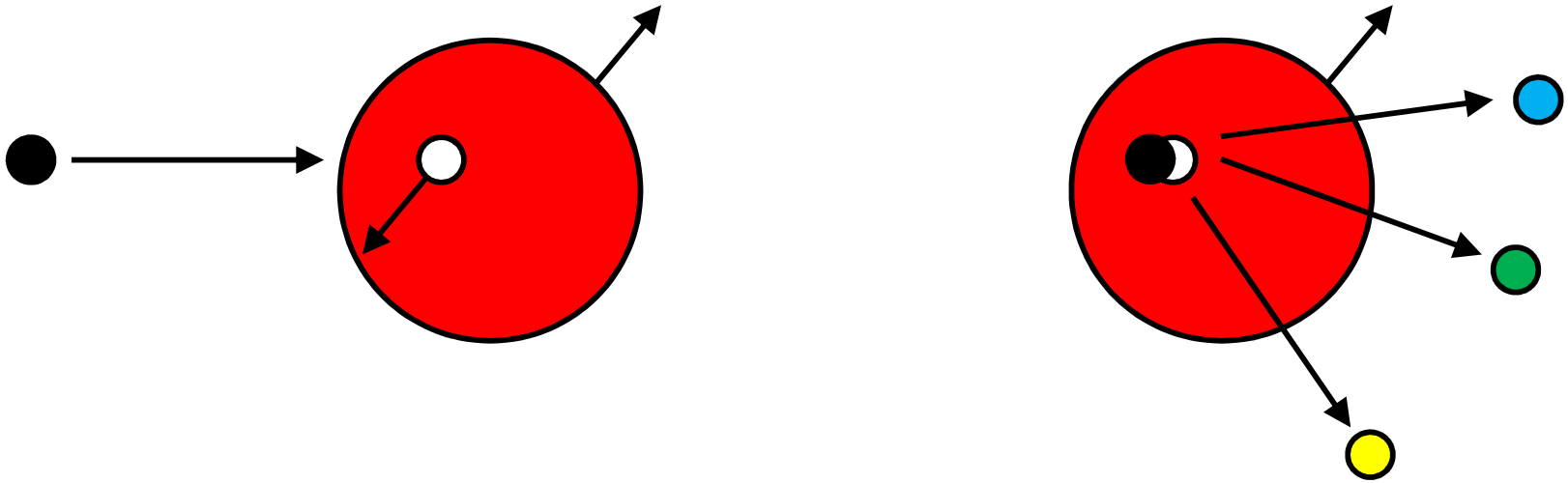
- Nuclear potential of $\overline{\Lambda}$
  - Mean p_T in correlated $\Lambda\overline{\Lambda}$ pairs
  - Missing mass in of forward Λ
- Color Transparency
- Short Range Correlations
- $\Delta\Delta$ component in the deuteron (and in nuclei)
- Additional ideas (?)

Existing Event Generators for $\bar{p}$A

- URQMD
  - background generator
  - little flexibility, no access to source code(?)
  - I‘ve never used it
- GiBUU
  - use for both background and signal
  - flexibility, many options, access to source code, very complex
  - I‘ve used it for $\bar{p}\,^{40}\mathrm{Ca} \rightarrow J/\psi\, X \rightarrow e^+e^-X, \mu^+\mu^-X$
- FTF
  - both for $\bar{p}p$ and $\bar{p}A$, emphasis on background
  - some flexibility
  - I‘ve used it for $\bar{p}d$ only

Need Simple Signal Generator in $\bar{p}$A

- Idea: implement $\bar{p}A$ collisions in EvtGen
- Physics model:
  quasi-free $\bar{p}N$ reactions with (A-1) spectator nucleus on nuclear proton or neutron with internal momentum



Decay File for EvtGen

pbarNe20_pbarpX.dec :

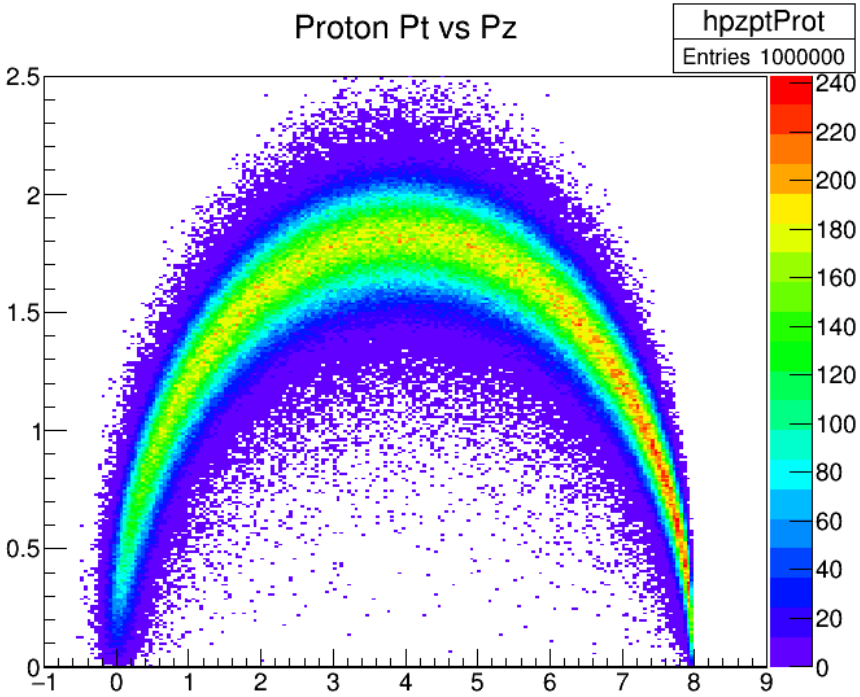
```
noPhotos
#
Decay pbarASystem
  1.0    A-1System  pbarpSystem          NucleusSpectator 20.0 1.0 1.88;
Enddecay
#
Decay pbarpSystem
  1.0    p+ anti-p-                 PHSP;
Enddecay
#
End
```

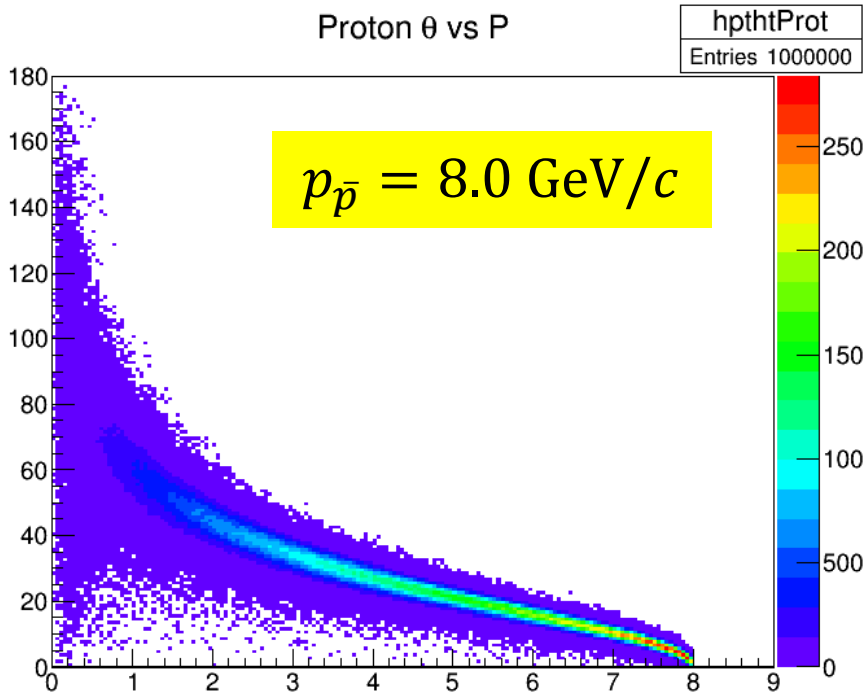
decay model

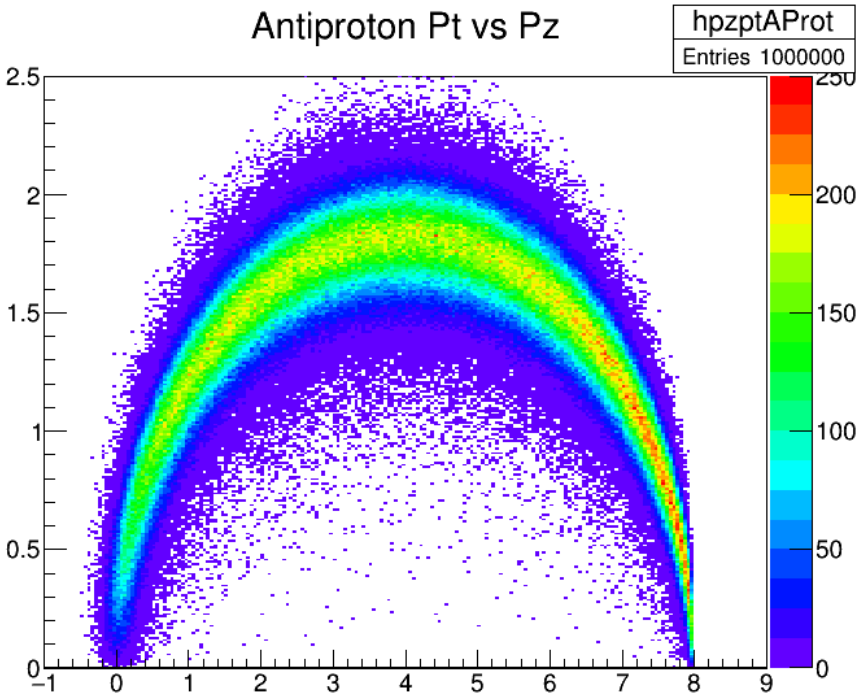
parameters

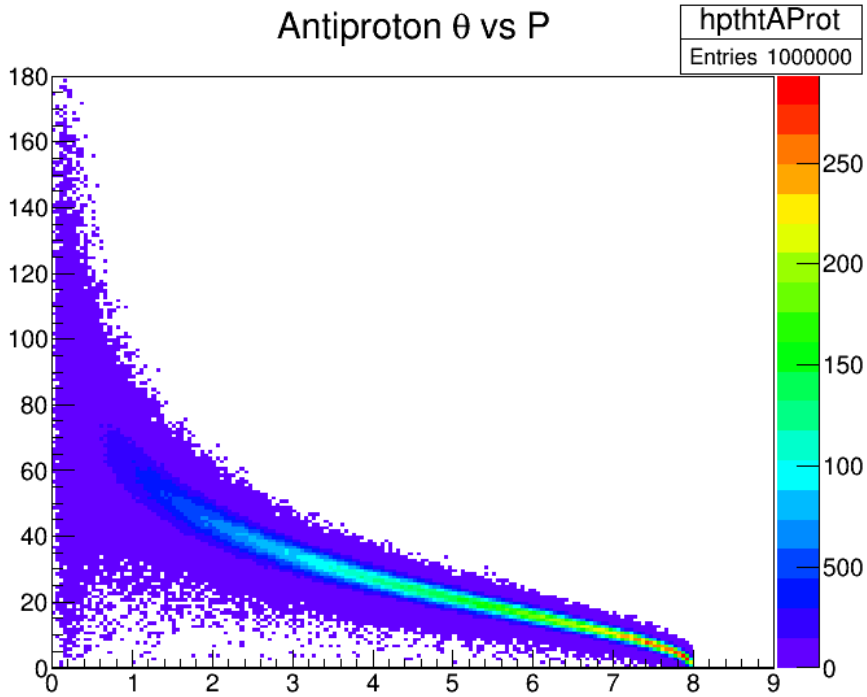
Decay Model

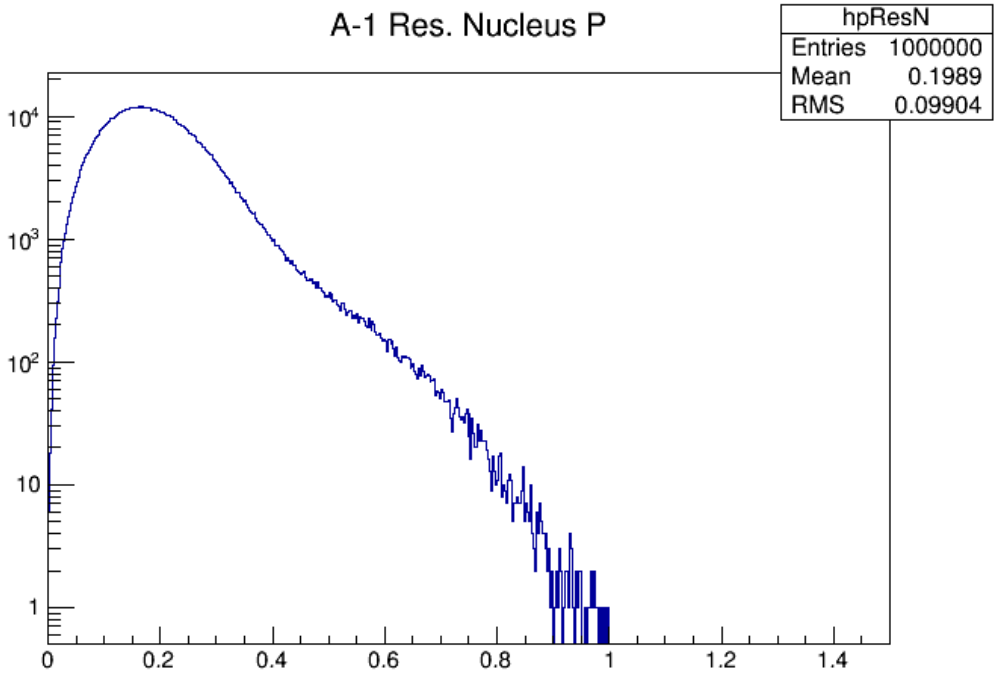
- momentum distribution: $\frac{dn}{d^3p}(p) \propto a_1 \exp\left[-\frac{p^2}{2{\sigma_1}^2}\right] + a_2 \exp\left[-\frac{p^2}{2{\sigma_2}^2}\right]$;
  $W(p) \propto p^2 \frac{dn}{d^3p}(p)$, $\sigma_1 = 115\,\mathrm{MeV}/c$, $\sigma_2 = 220\,\mathrm{MeV}/c$, $\frac{a_2}{a_1} = 0.0146$
- select absolute momentum of A-1 spectator
- select isotropic $\cos\theta, \varphi$
- calculate p4 of target nucleon: $\vec{p}_N = -\vec{p}_{A-1}$, $E_N = M_A - E_{A-1}$
- calculate p4 of $\bar{p}N$ system and boost to initial $\bar{p}A$ system
- then $\bar{p}N$ system decays as specified in decay file

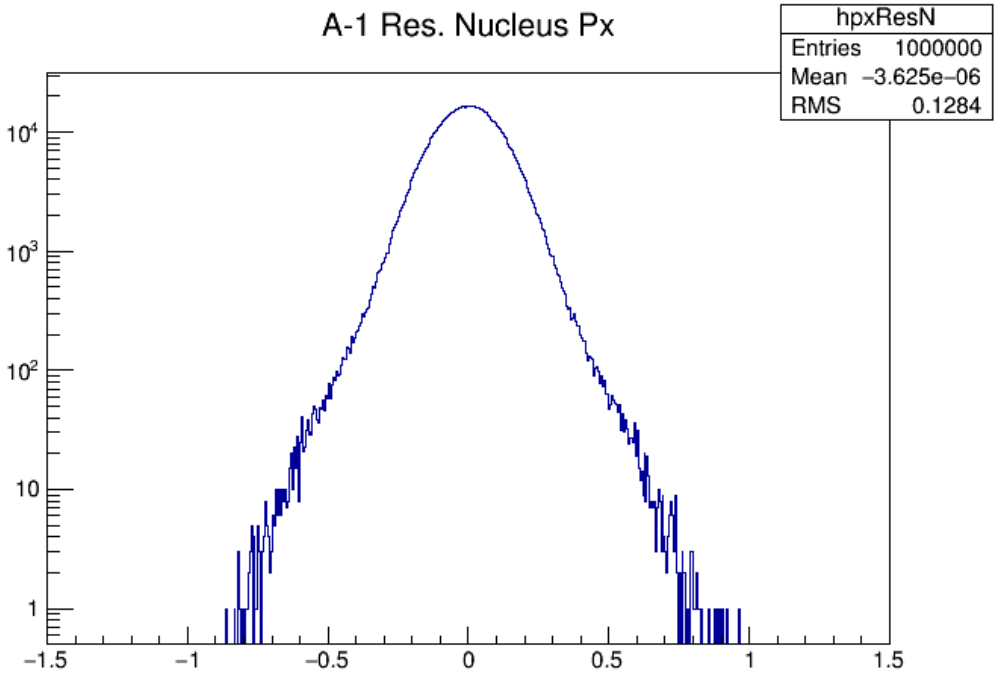

Proton Pt vs Pz
hpzptProt
Entries 1000000

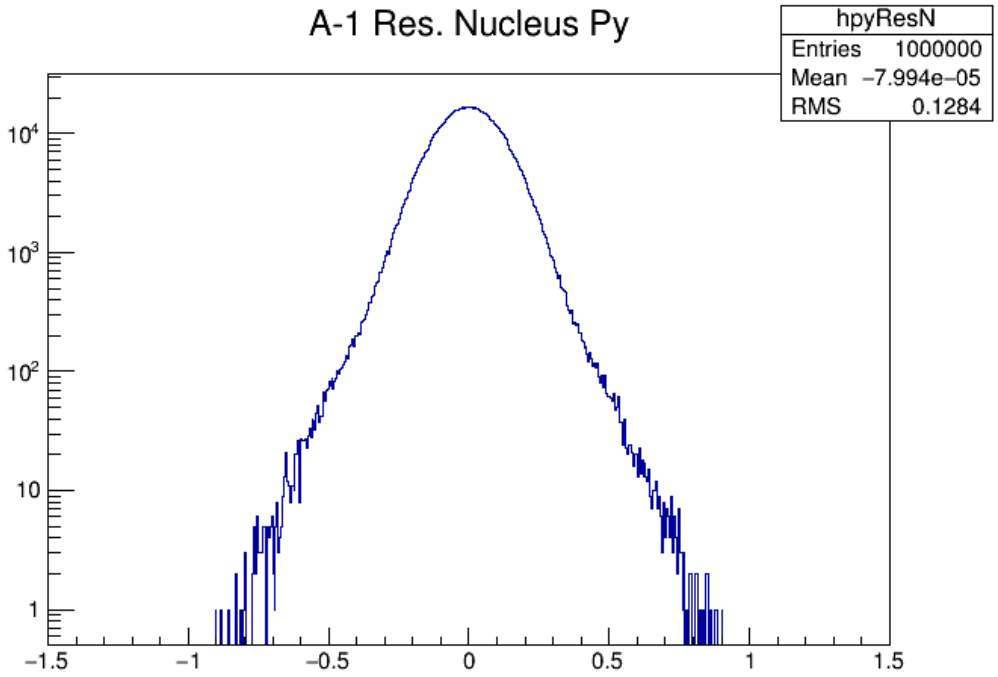

Proton θ vs P
hpthtProt
Entries 1000000
$p_{\bar{p}} = 8.0\ \mathrm{GeV}/c$

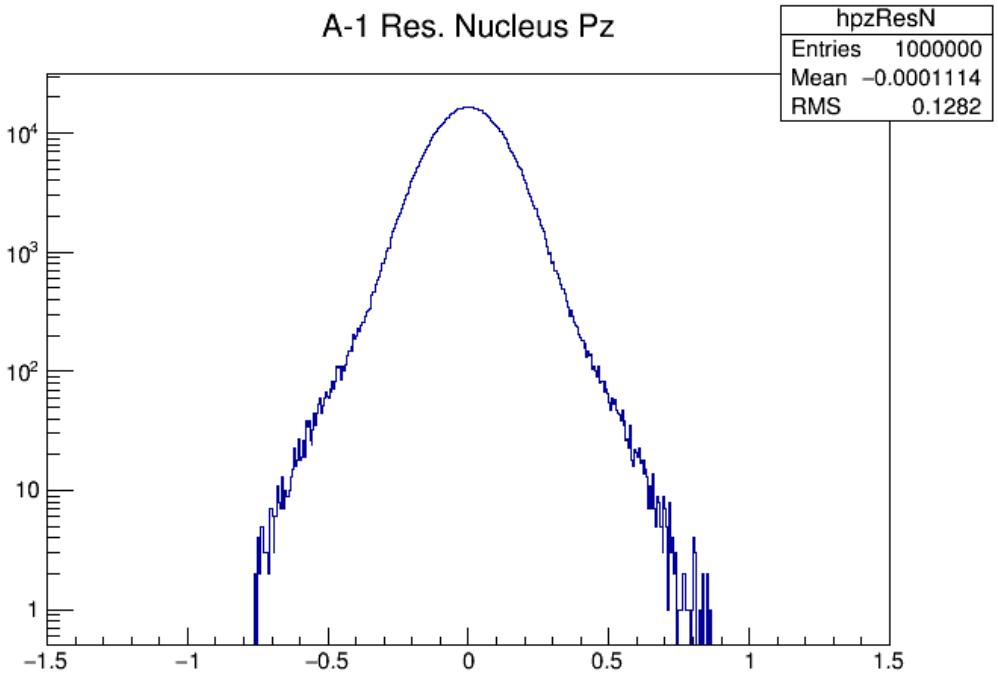

Antiproton Pt vs Pz
hpzptAProt
Entries 1000000

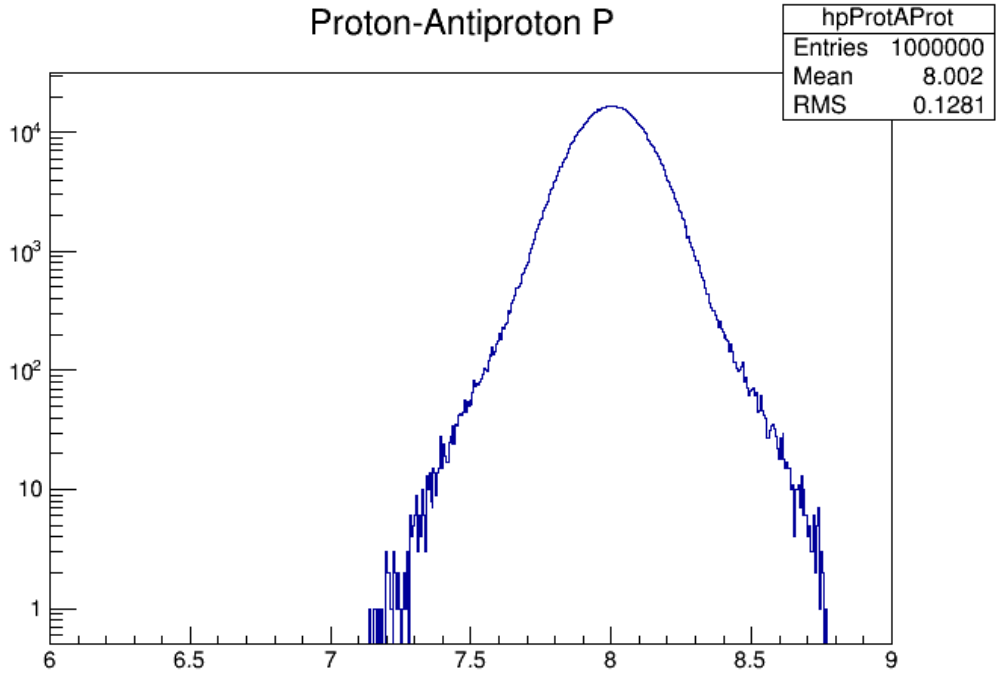

Antiproton θ vs P
hpthtAProt
Entries 1000000

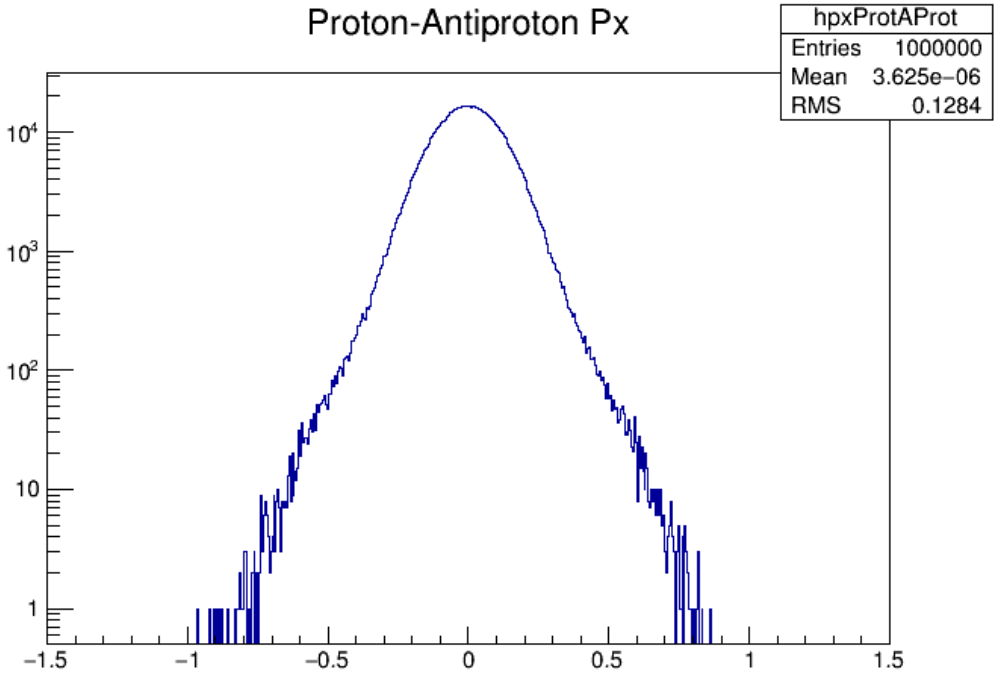

A-1 Res. Nucleus P
hpResN
Entries 1000000
Mean 0.1989
RMS 0.09904

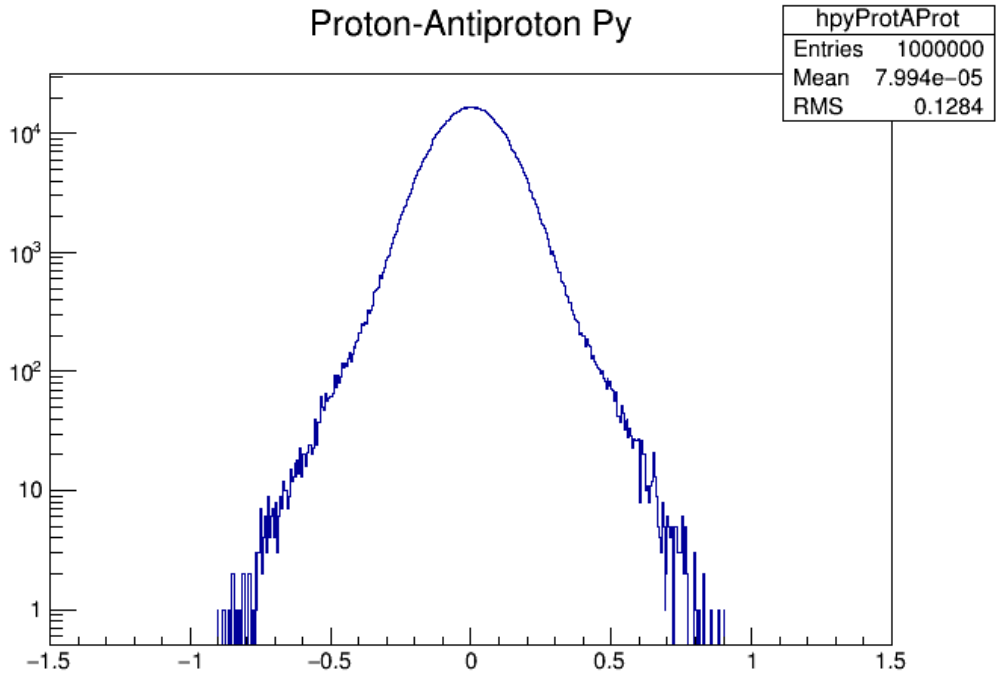

A-1 Res. Nucleus Px
hpxResN
Entries 1000000
Mean −3.625e−06
RMS 0.1284

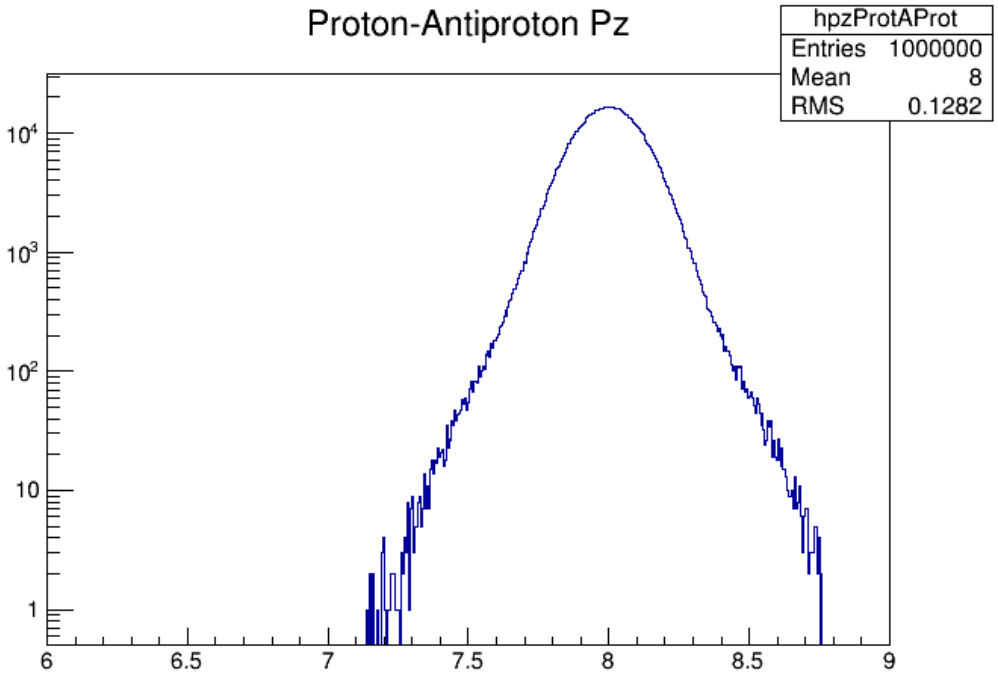

A-1 Res. Nucleus Py
hpyResN
Entries 1000000
Mean −7.994e−05
RMS 0.1284

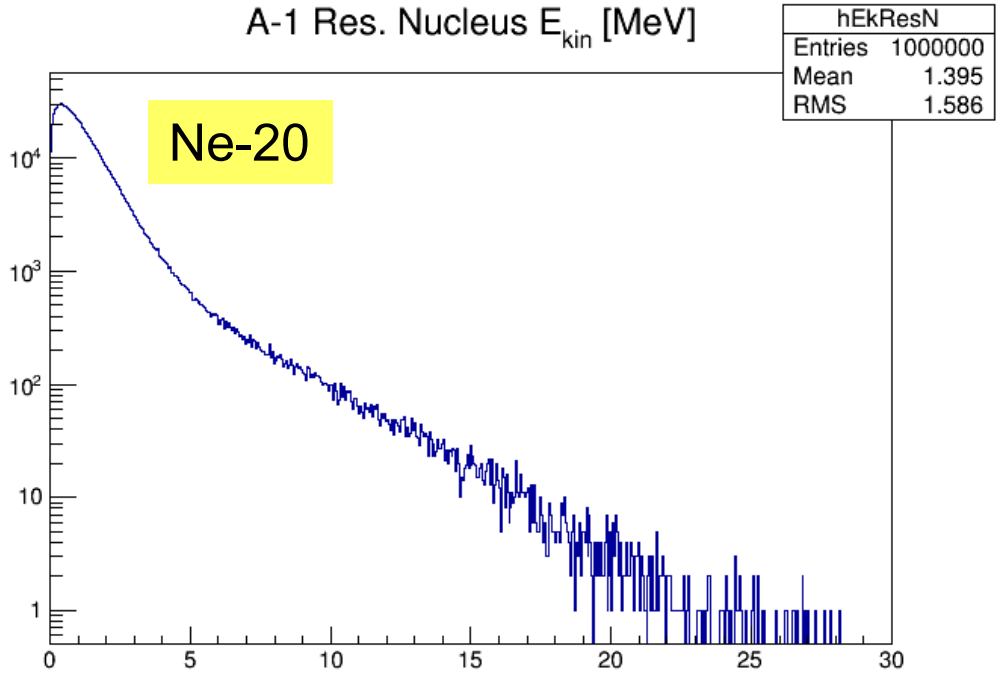

A-1 Res. Nucleus Pz
hpzResN
Entries 1000000
Mean −0.0001114
RMS 0.1282

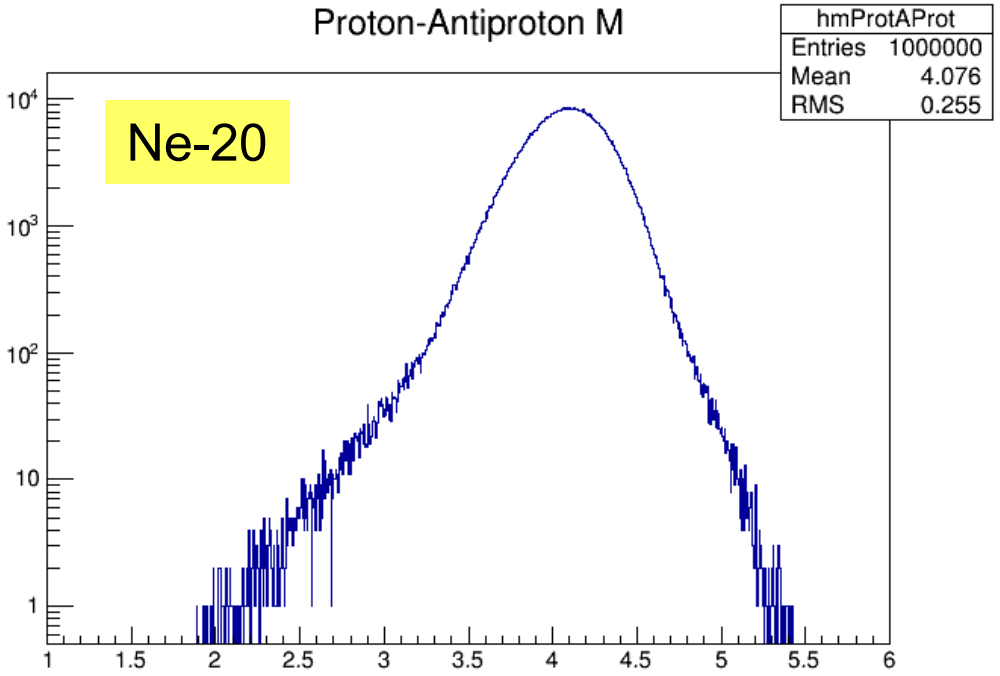

Proton-Antiproton P
hpProtAProt
Entries 1000000
Mean 8.002
RMS 0.1281
10^4
10^3
10^2
10
1
6
6.5
7
7.5
8
8.5
9

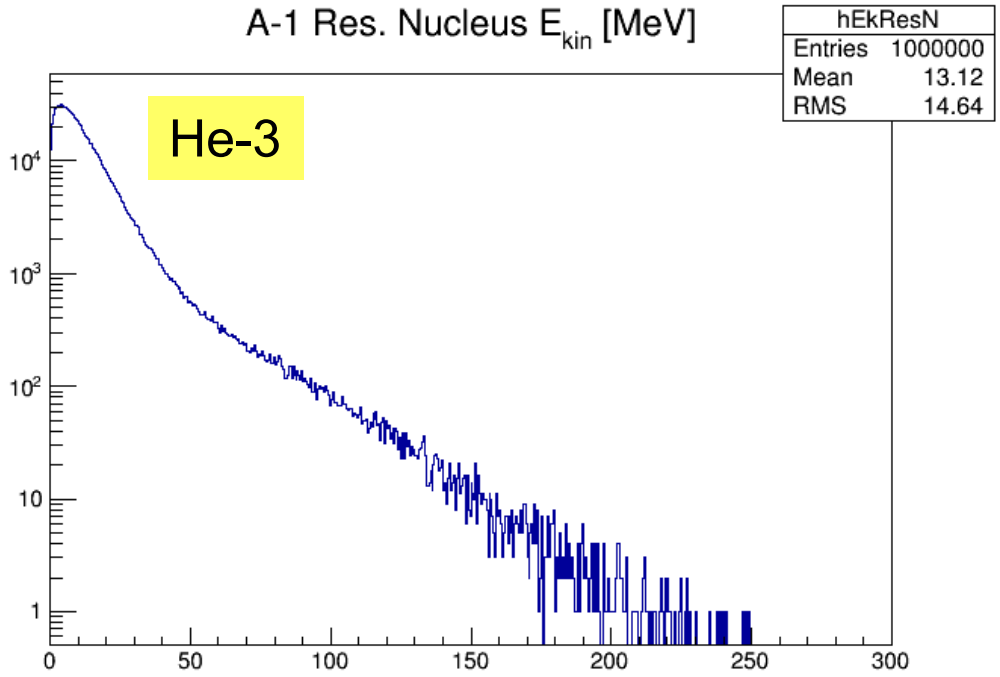

Proton-Antiproton Px
hpxProtAProt
Entries 1000000
Mean 3.625e−06
RMS 0.1284
10^4
10^3
10^2
10
1
−1.5
−1
−0.5
0
0.5
1
1.5

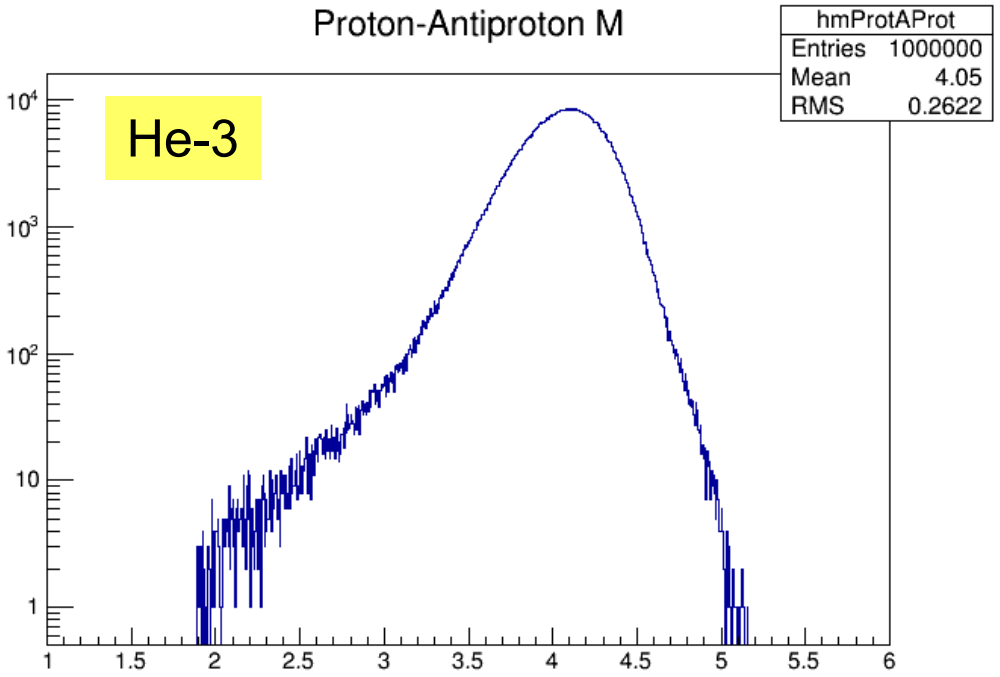

Proton-Antiproton Py
hpyProtAProt
Entries 1000000
Mean 7.994e−05
RMS 0.1284
10^4
10^3
10^2
10
1
−1.5
−1
−0.5
0
0.5
1
1.5


Proton-Antiproton Pz
hpzProtAProt
Entries 1000000
Mean 8
RMS 0.1282
10^4
10^3
10^2
10
1
6
6.5
7
7.5
8
8.5
9


A-1 Res. Nucleus E_{kin} [MeV]
hEkResN
Entries 1000000
Mean 1.395
RMS 1.586
Ne-20

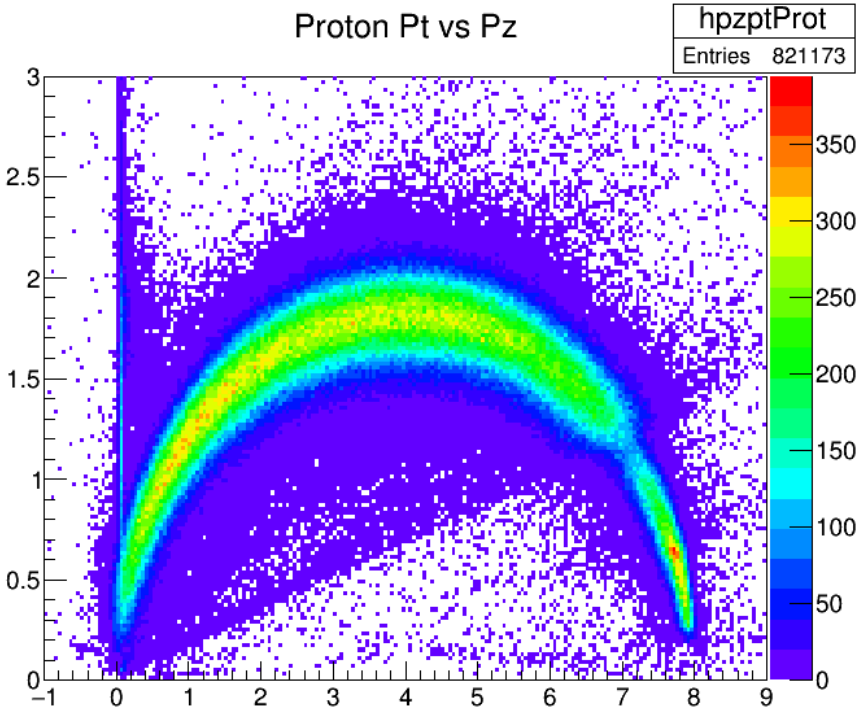

Proton-Antiproton M
hmProtAProt
Entries 1000000
Mean 4.076
RMS 0.255
Ne-20

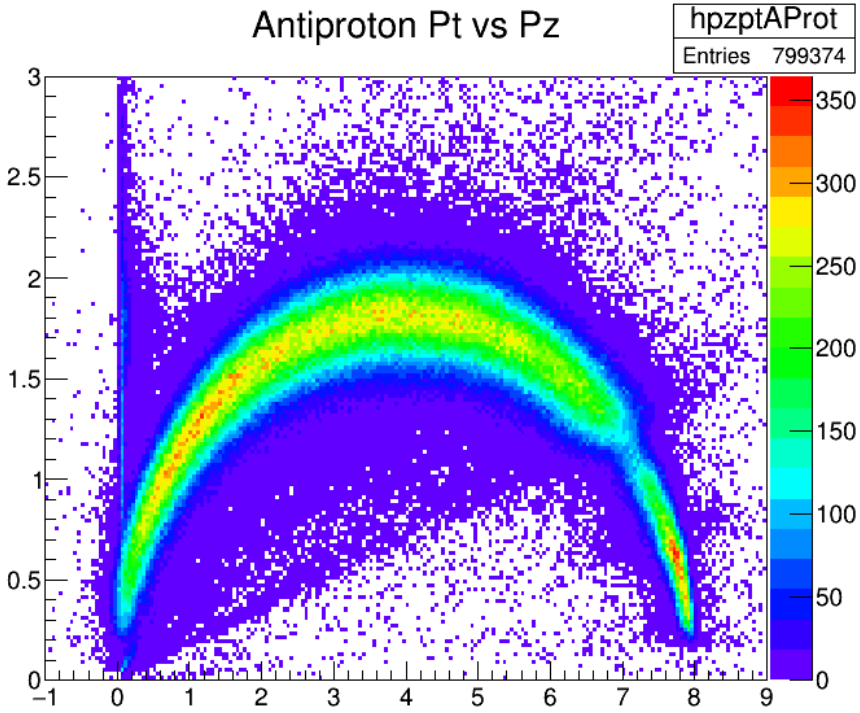

A-1 Res. Nucleus E_{kin} [MeV]
hEkResN
Entries 1000000
Mean 13.12
RMS 14.64
He-3

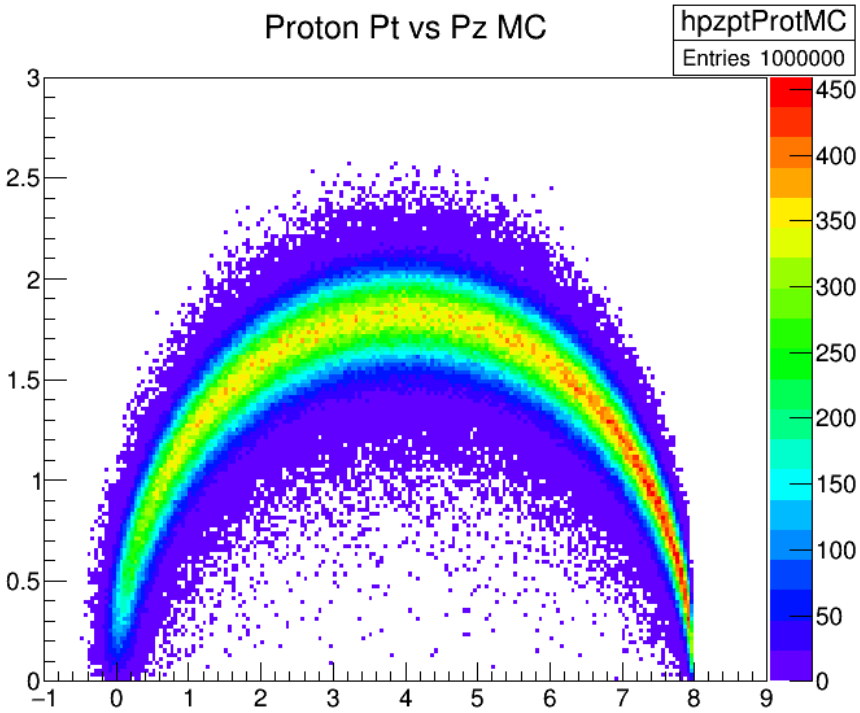

Proton-Antiproton M
hmProtAProt
Entries 1000000
Mean 4.05
RMS 0.2622
He-3

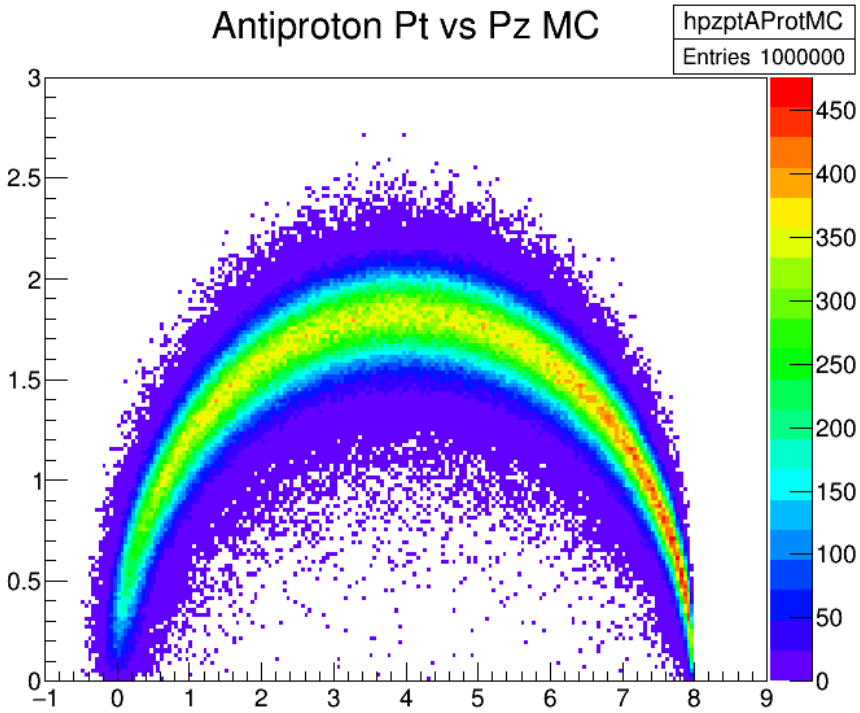
PandaRoot Simulation & Analysis

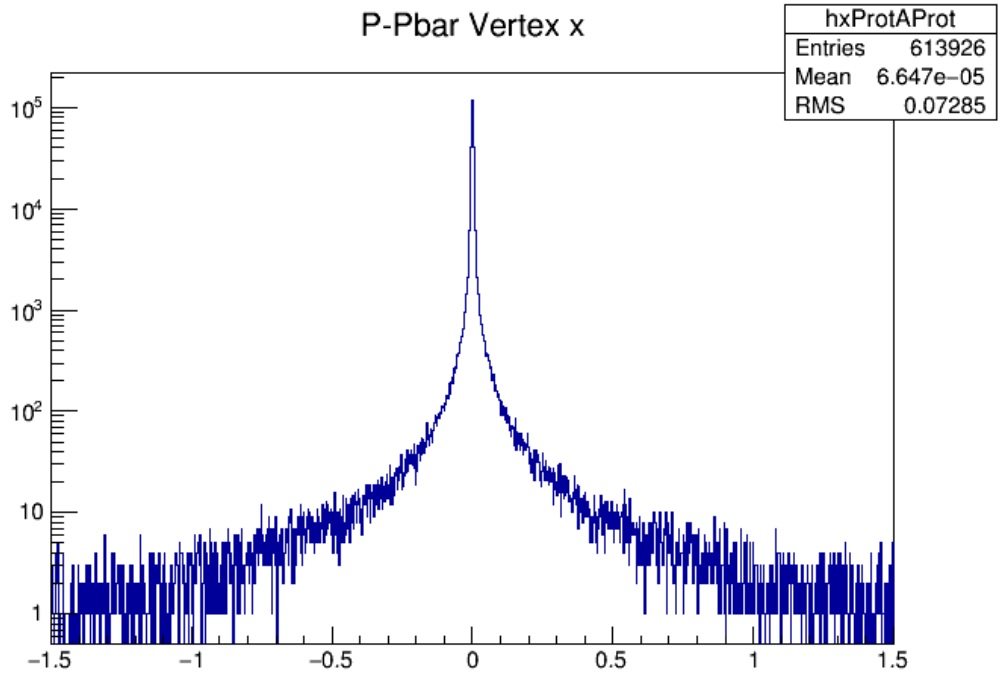
- trunk versions 29122, 29475
- p = 8.0 GeV/c
- target: ^{20}Ne (A = 20)
- final state: $\bar{p}\,p\,(A-1)$; in addition: $\bar{p}\,p\,\pi^0\,(A-1)$
- 1 M events / 0.4 M events
- MC truth match
- ideal PID

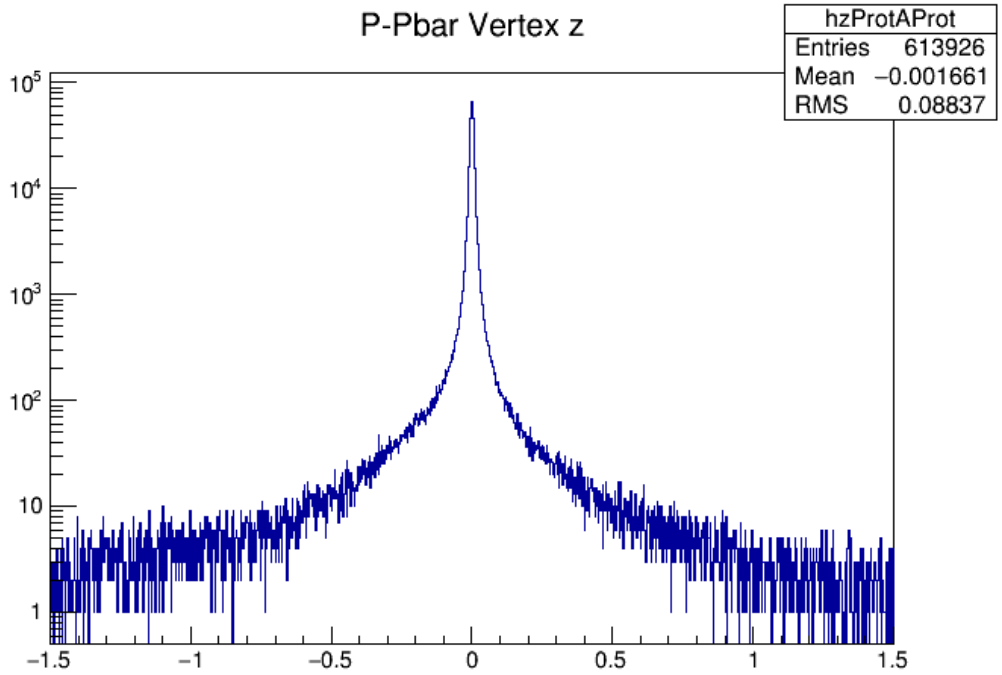

Proton Pt vs Pz
hpzptProt
Entries 821173

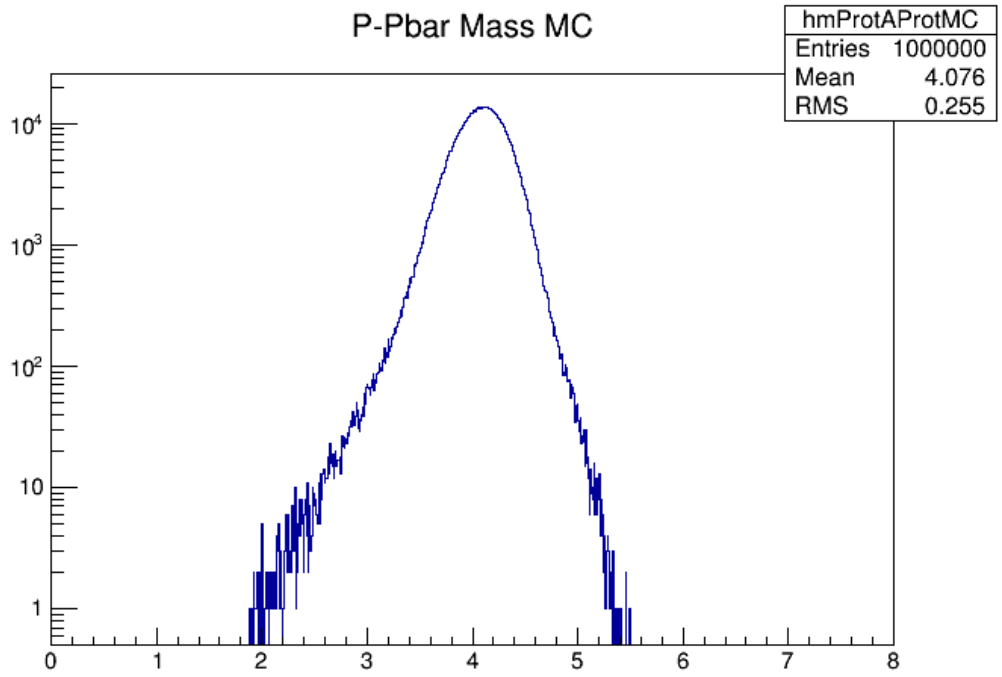

Antiproton Pt vs Pz
hpzptAProt
Entries 799374

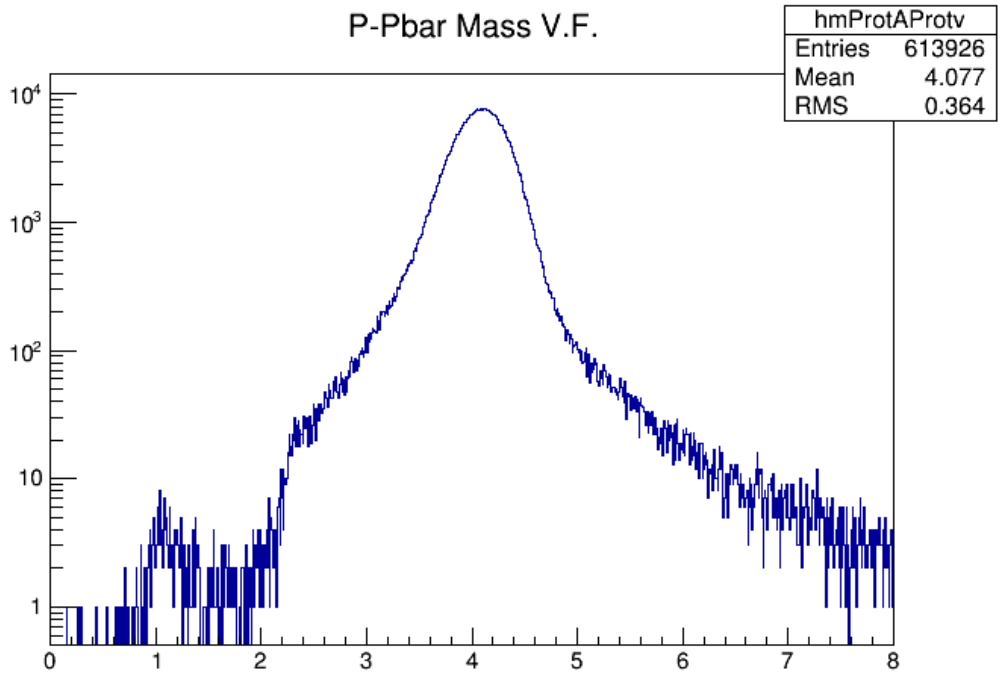

Proton Pt vs Pz MC
hpzptProtMC
Entries 1000000


Antiproton Pt vs Pz MC
hpzptAProtMC
Entries 1000000


P-Pbar Vertex x
hxProtAProt
Entries 613926
Mean 6.647e−05
RMS 0.07285


P-Pbar Vertex z
hzProtAProt
Entries 613926
Mean −0.001661
RMS 0.08837


P-Pbar Mass MC
hmProtAProtMC
Entries 1000000
Mean 4.076
RMS 0.255


P-Pbar Mass V.F.
hmProtAProtv
Entries 613926
Mean 4.077
RMS 0.364

Status

- Tested with simpleEvtGen for various nuclei: ^{3}He, ^{20}Ne, ^{40}Ca, ^{208}Pb, ^{238}U
- Full simulation & analysis: 1 M events $\bar{p}A \rightarrow \bar{p}p(A-1)$
- Full simulation & analysis: 0.4 M events $\bar{p}A \rightarrow \bar{p}p\pi^{0}(A-1)$
- Relevant files uploaded to the repository
- Should work from present trunk – Try it !