Implementation of the Belle Model for $D^0 \to K^0_S\pi^+\pi^-$ and $\bar{D}^0 \to K^0_S\pi^+\pi^-$ decay in ampGen

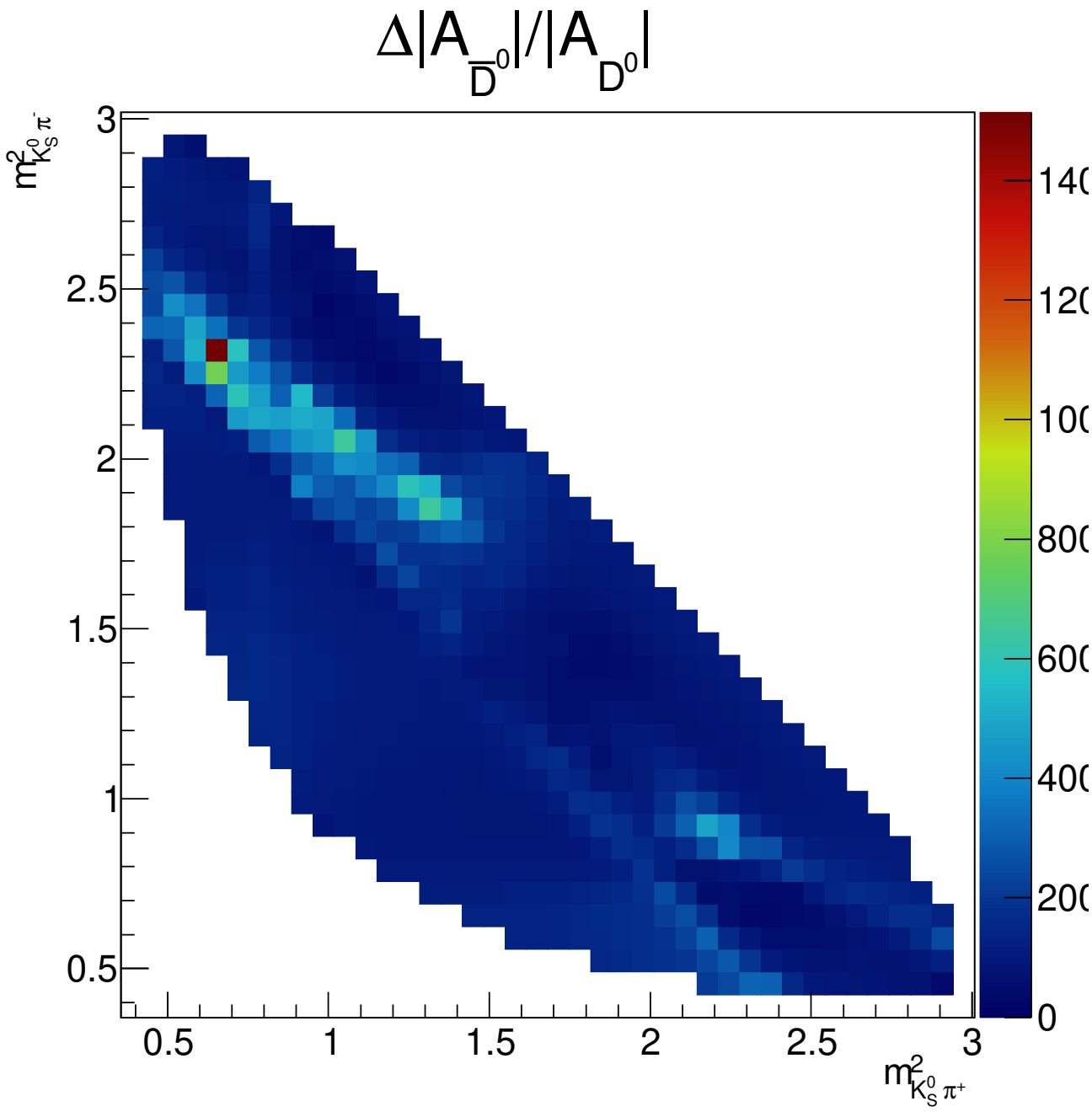
Jake Lane

July 5, 2019

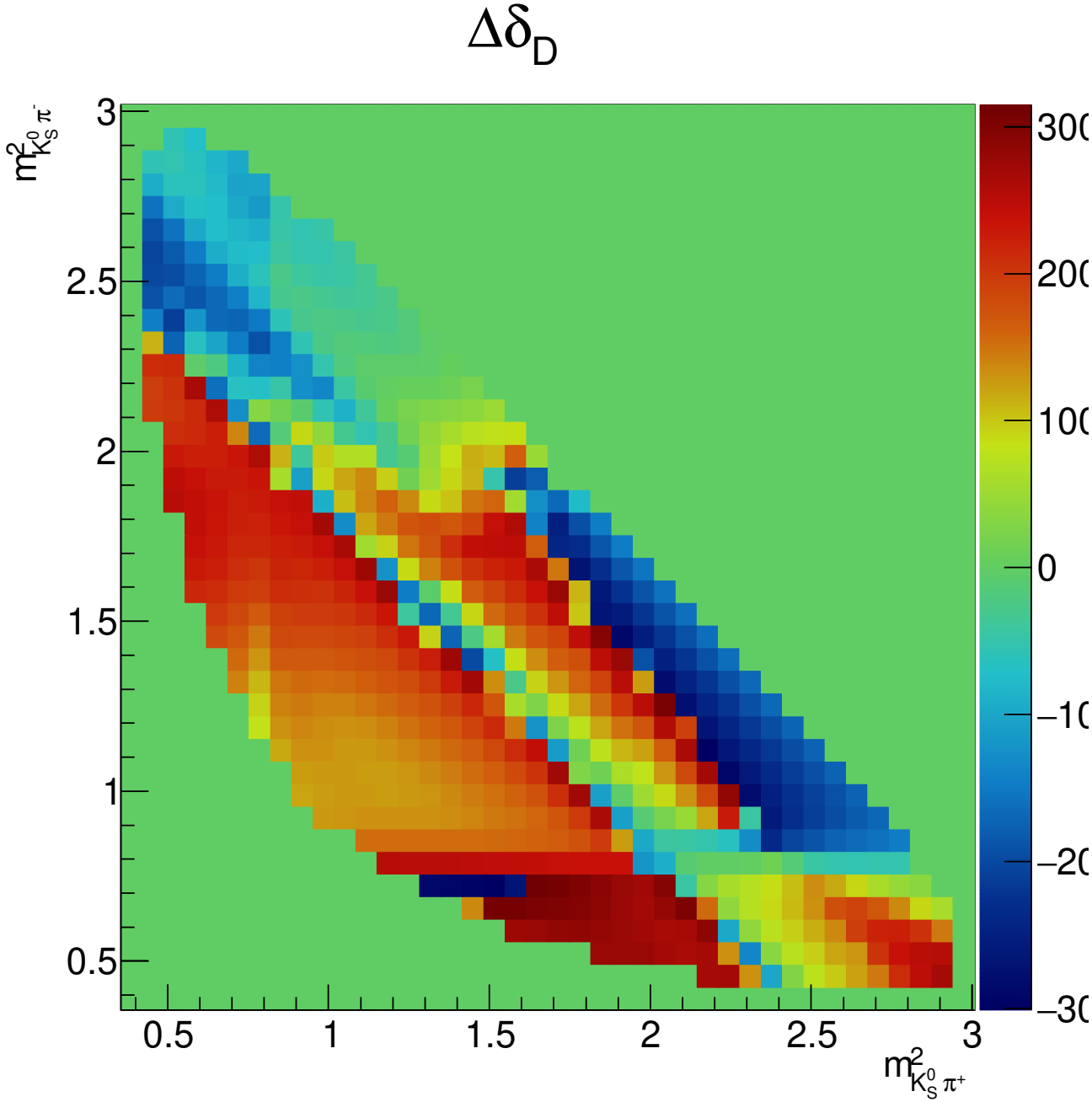
Belle in Cartesian

```
CouplingConstant::Coordinates  cartesian
Import $AMPGENROOT/options/kMatrix.opt
Particle::DefaultModifier BL
Particle::SpinFormalism   Canonical

D0{K(0)*(1430)+[GLASS]{K0S0,pi+},pi-}              0     0.0095653   0.000827718 0     0.00601207  0.00084
D0{K(0)*(1430)bar-[GLASS]{K0S0,pi-},pi+}           0     0.0255993   0.00122597  0     -0.194327   0.00105
D0{K(2)*(1430)+{K0S0,pi+},pi-}               0     0.0133101   0.00135651  0     0.0170886   0.00123279
D0{K(2)*(1430)bar-{K0S0,pi-},pi+}              0     -0.107163   0.00146194  0     0.104979    0.00164431
D0{K*(1410)+{K0S0,pi+},pi-}                0     0.00296544  0.00225542  0     0.014186    0.00247679
D0{K*(1410)bar-{K0S0,pi-},pi+}               0     -0.0339155  0.00309512  0     0.0613357   0.0037167
D0{K*(1680)bar-{K0S0,pi-},pi+}               0     -0.0535469  0.00651378  0     0.0272353   0.0073212
D0{K*(892)+{K0S0,pi+},pi-}                 0     0.126313    0.00245399  0     -0.140858   0.00235595
D0{K*(892)bar-{K0S0,pi-},pi+}                0     -1.37962    0.00769138  0     1.49371   0.00800201
D0{K0S0,PiPi00}                    2     1     0     2     0     0
D0{K0S0,f(2)(1270)0{pi+,pi-}}                0     -0.125526   0.00221442  0     0.0943573   0.00286431
D0{K0S0,omega(782)0{pi+,pi-}}                0     -0.0640864  0.00196373  0     0.12832   0.00170606
D0{K0S0,rho(1450)0{pi+,pi-}}               0     0.160532    0.00460311  0     0.0886014   0.00646564
D0{K0S0,rho(770)0{pi+,pi-}}                2     1     0     2     0     0


Dbar0{K(0)*(1430)bar-[GLASS]{K0S0,pi-},pi+}              0     0.0095653   0.000827718 0     0.00601207  0
Dbar0{K(0)*(1430)+[GLASS]{K0S0,pi+},pi-}           0     0.0255993   0.00122597  0     -0.194327   0.00105
Dbar0{K(2)*(1430)bar-{K0S0,pi-},pi+}               0     0.0133101   0.00135651  0     0.0170886   0.00123
Dbar0{K(2)*(1430)+{K0S0,pi+},pi-}              0     -0.107163   0.00146194  0     0.104979    0.00164431
Dbar0{K*(1410)bar-{K0S0,pi-},pi+}              0     0.00296544  0.00225542  0     0.014186    0.00247679
Dbar0{K*(1410)+{K0S0,pi+},pi-}               0     -0.0339155  0.00309512  0     0.0613357   0.0037167
Dbar0{K*(1680)+{K0S0,pi+},pi-}               0     -0.0535469  0.00651378  0     0.0272353   0.0073212
Dbar0{K*(892)bar-{K0S0,pi-},pi+}               0     0.126313    0.00245399  0     -0.140858   0.00235595
Dbar0{K*(892)+{K0S0,pi+},pi-}                0     -1.37962    0.00769138  0     1.49371   0.00800201
Dbar0{K0S0,PiPi00}                   2     1     0     2     0     0
Dbar0{K0S0,f(2)(1270)0{pi+,pi-}}               0     -0.125526   0.00221442  0     0.0943573   0.00286431
Dbar0{K0S0,omega(782)0{pi+,pi-}}               0     -0.0640864  0.00196373  0     0.12832   0.00170606
Dbar0{K0S0,rho(1450)0{pi+,pi-}}              0     0.160532    0.00460311  0     0.0886014   0.00646564
Dbar0{K0S0,rho(770)0{pi+,pi-}}               2     1     0     2     0     0
```

Belle in Cartesian



Belle in Cartesian



Belle in Cartesian

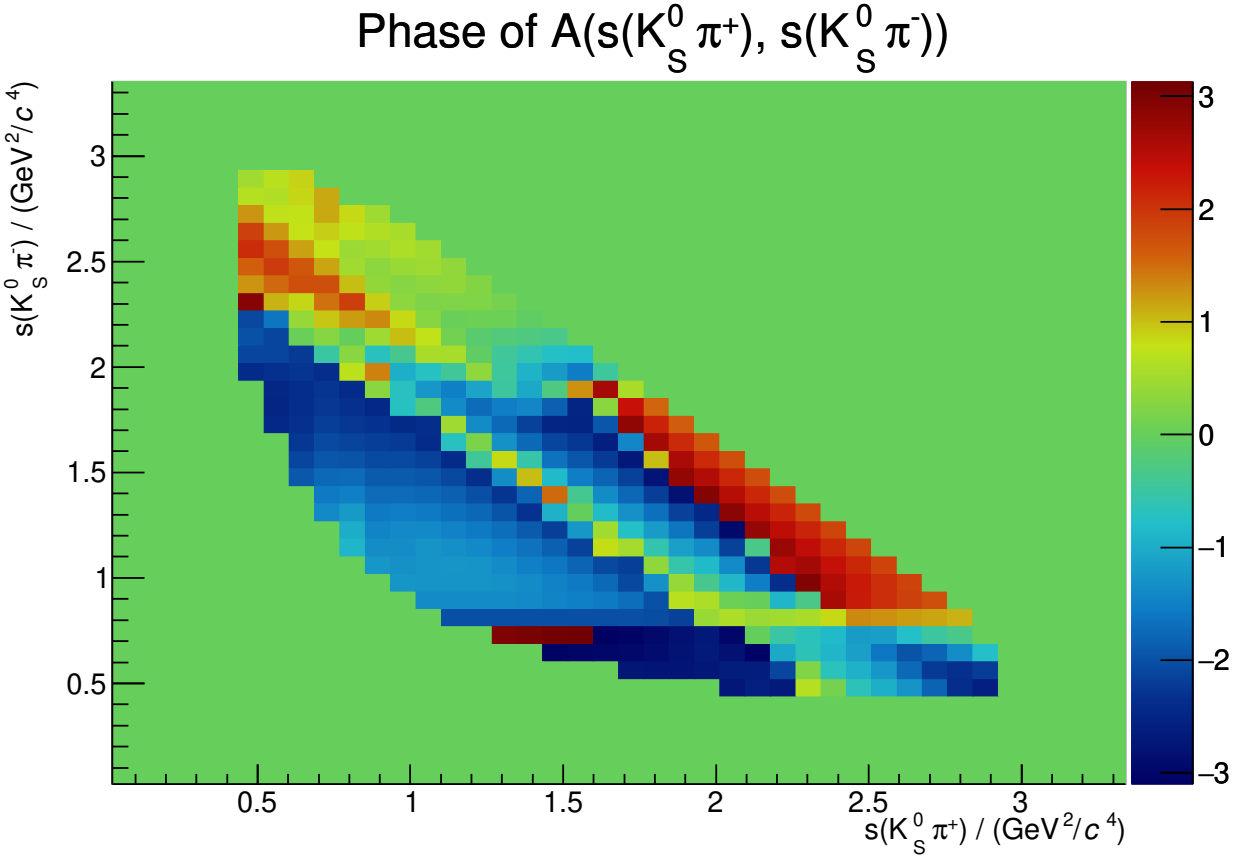


Figure: Argument for Belle in Cartesian

Belle in Cartesian

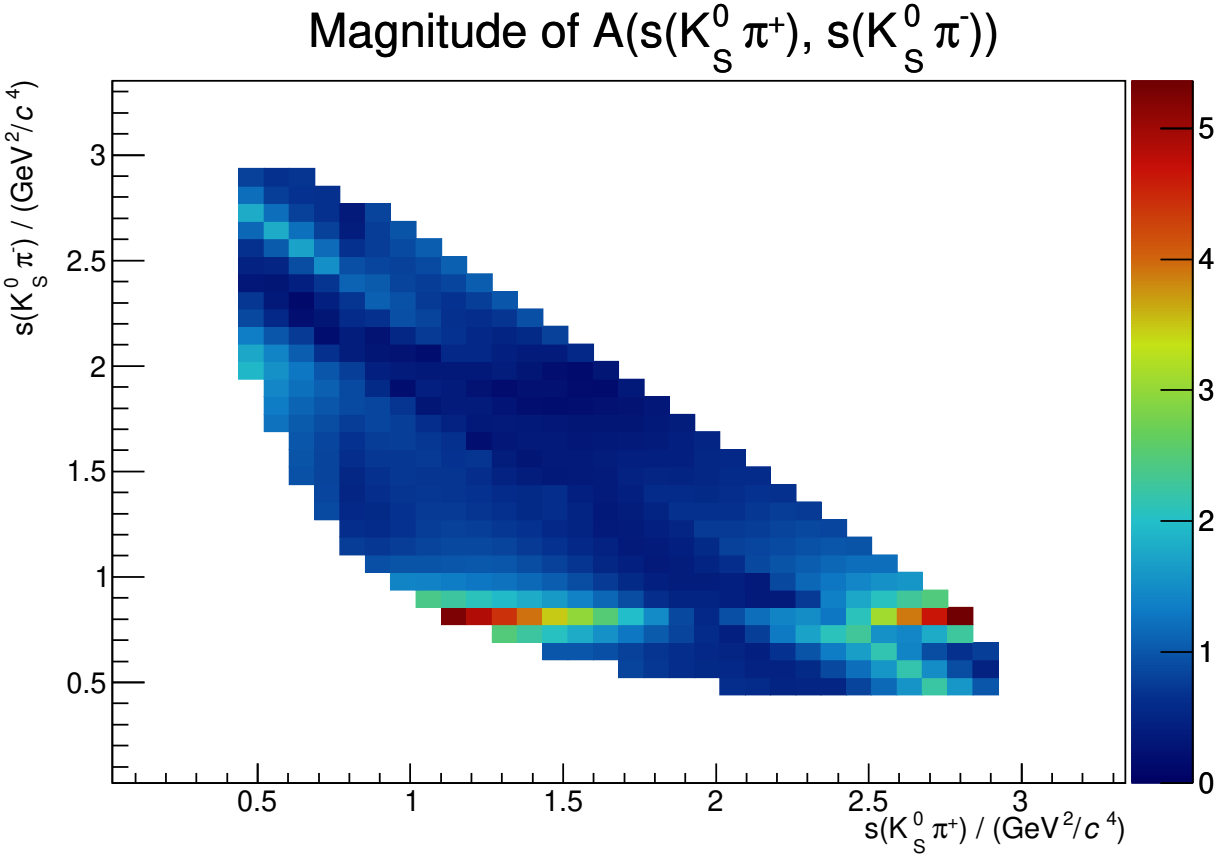


Figure: Magnitude for Belle in Cartesian

Belle in Cartesian

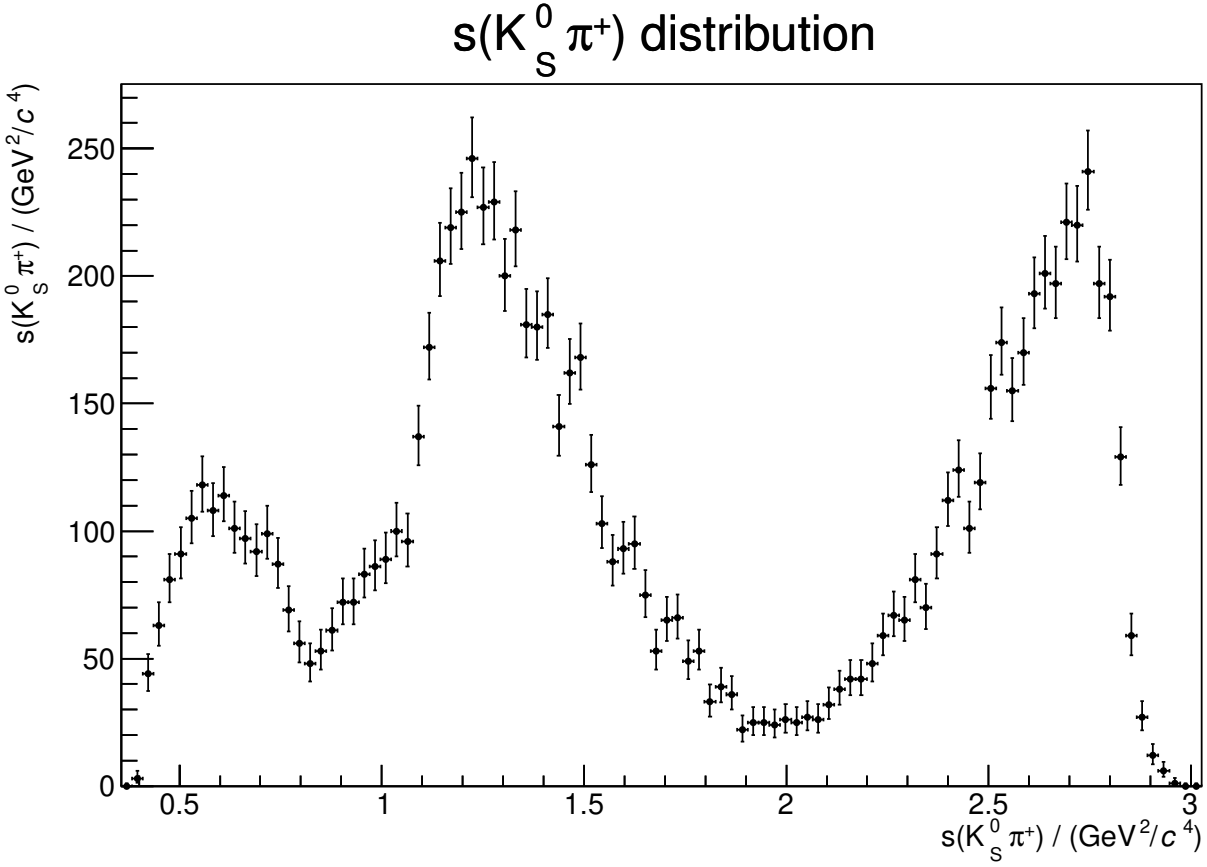


Figure: m_+^2 for Belle in Cartesian

Belle in Cartesian

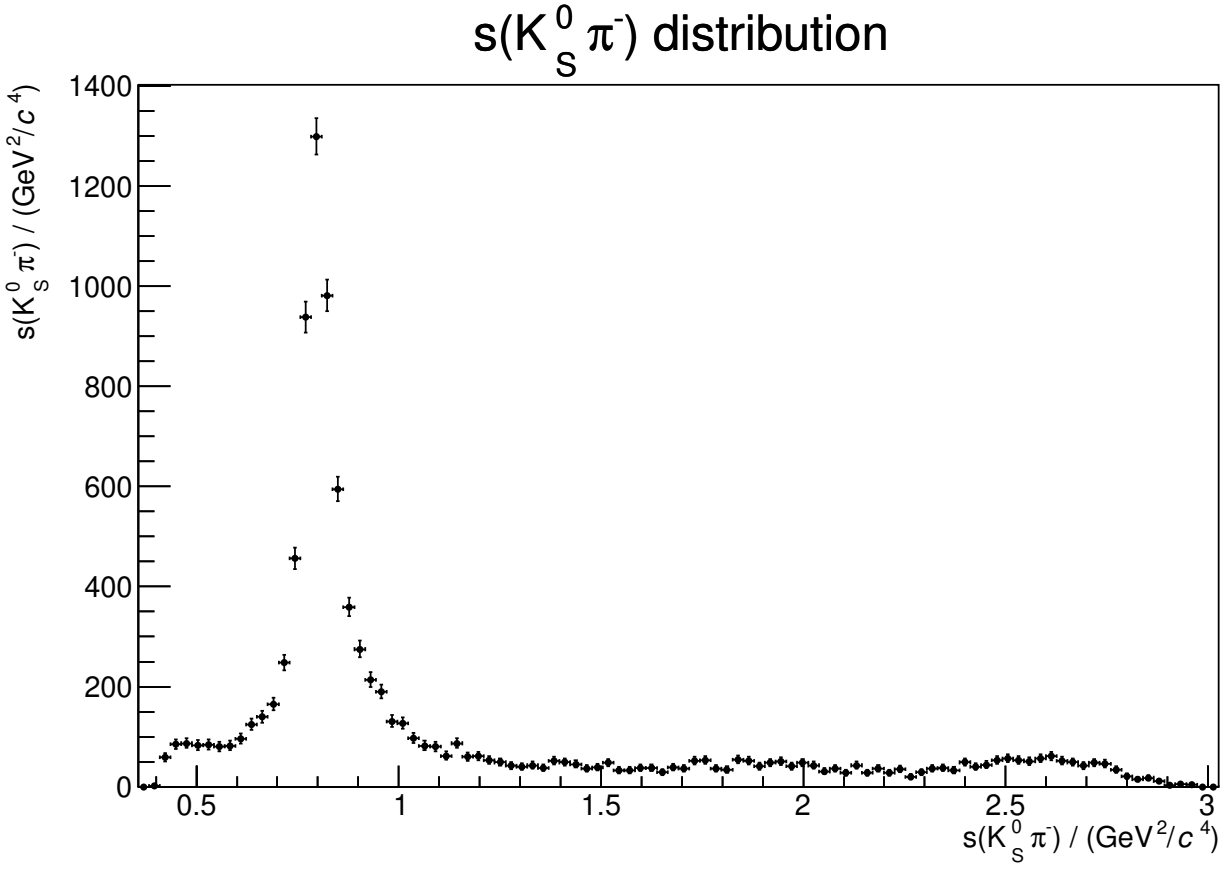


Figure: $m^2\_$ for Belle in Cartesian

Belle in Cartesian

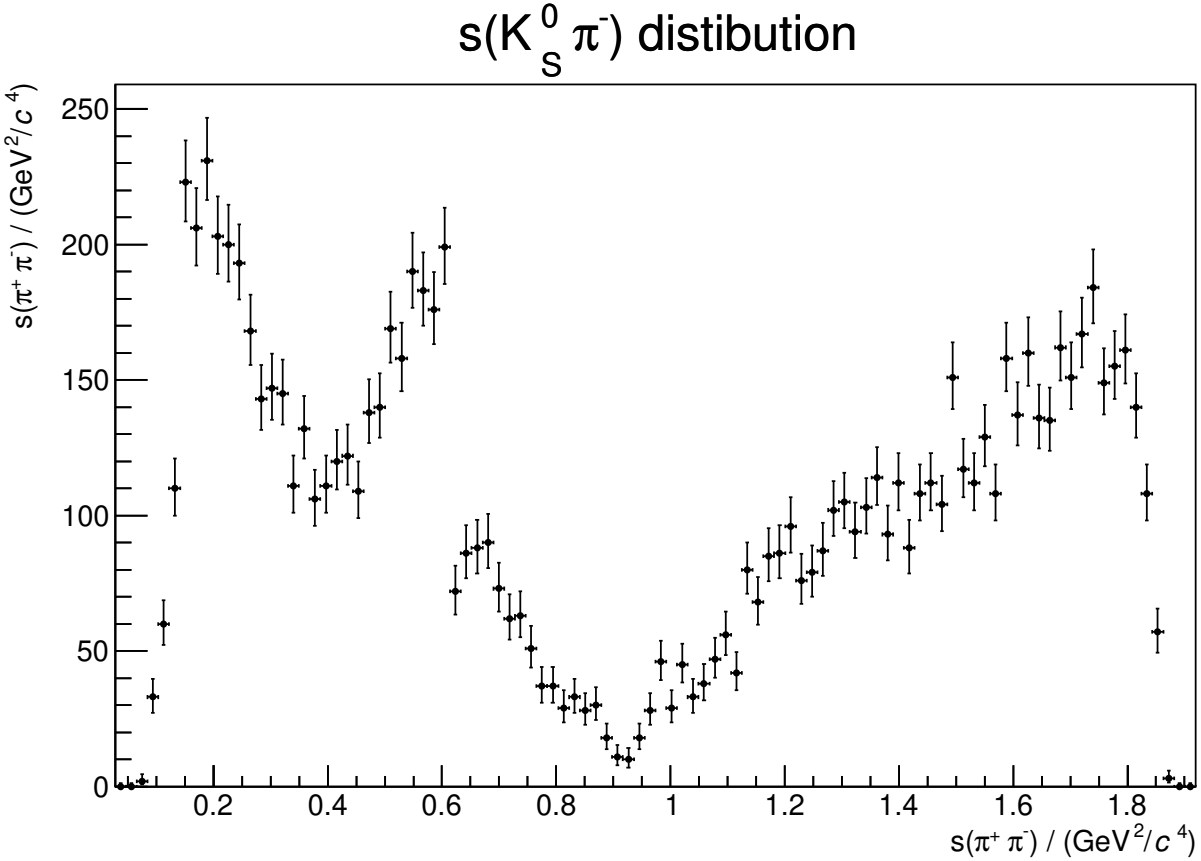


Figure: $m_0^2$for Belle in Cartesian

Belle in Cartesian

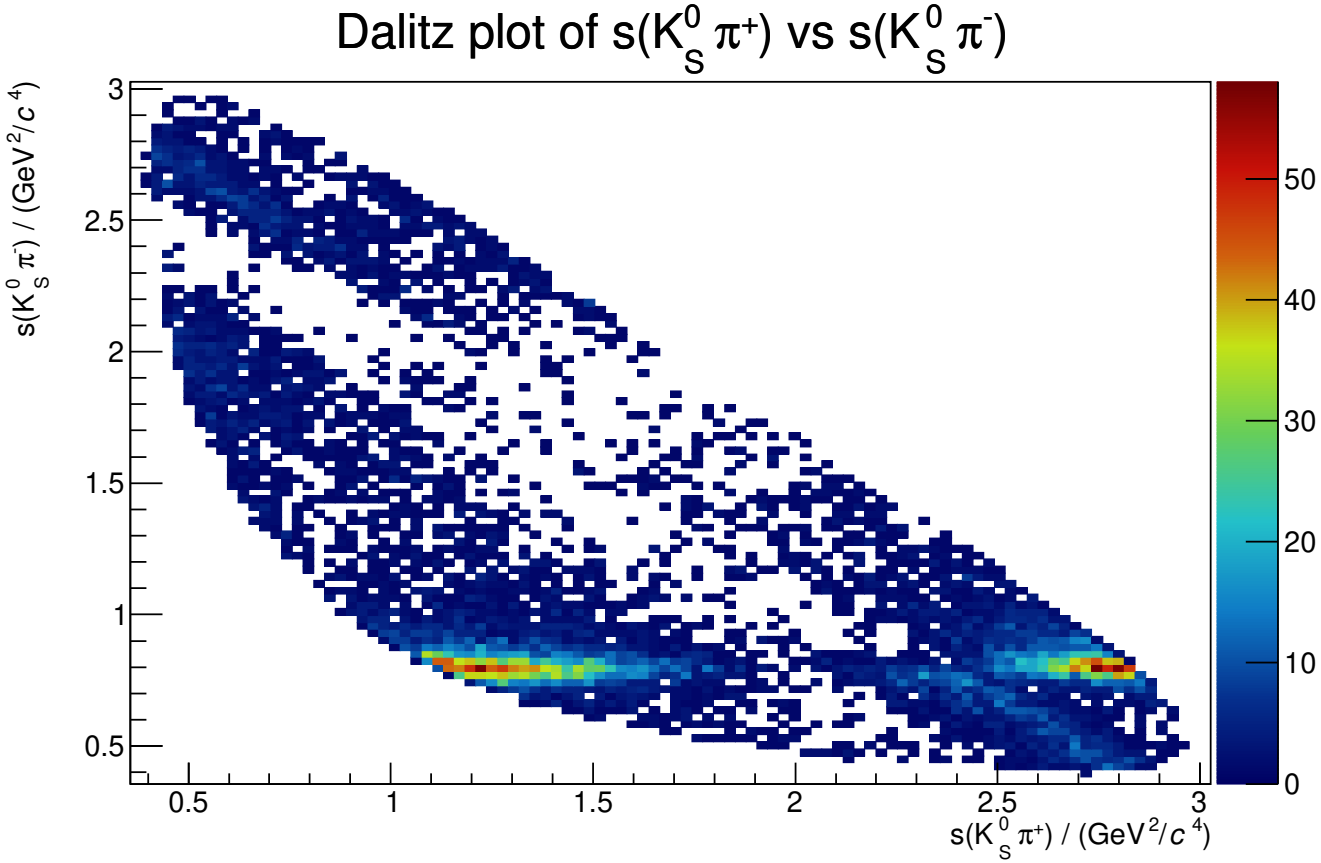


Figure: m^2_+ vs m^2_- for Belle in Cartesian

Belle in Cartesian

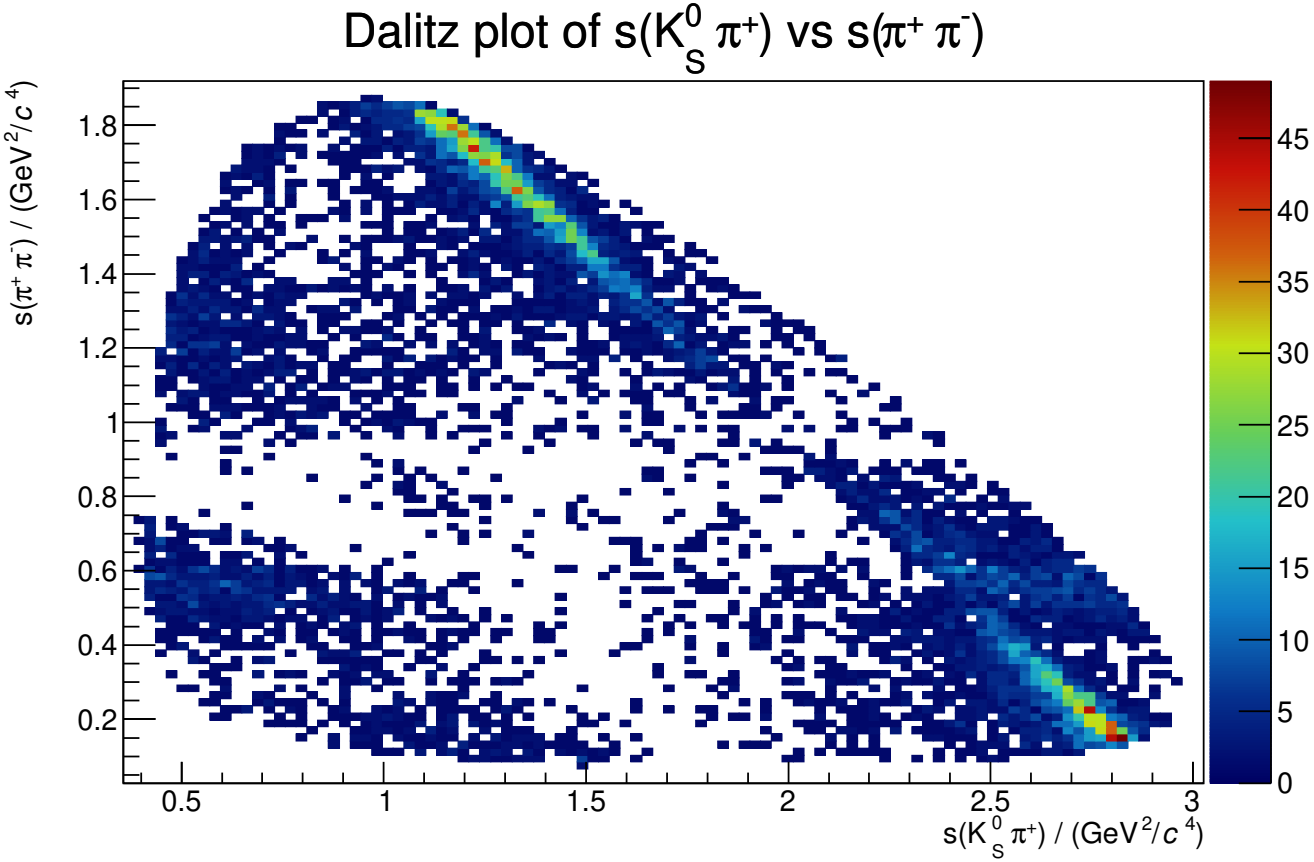


Figure: m_+^2 vs m_0^2 for Belle in Cartesian

Belle in Cartesian

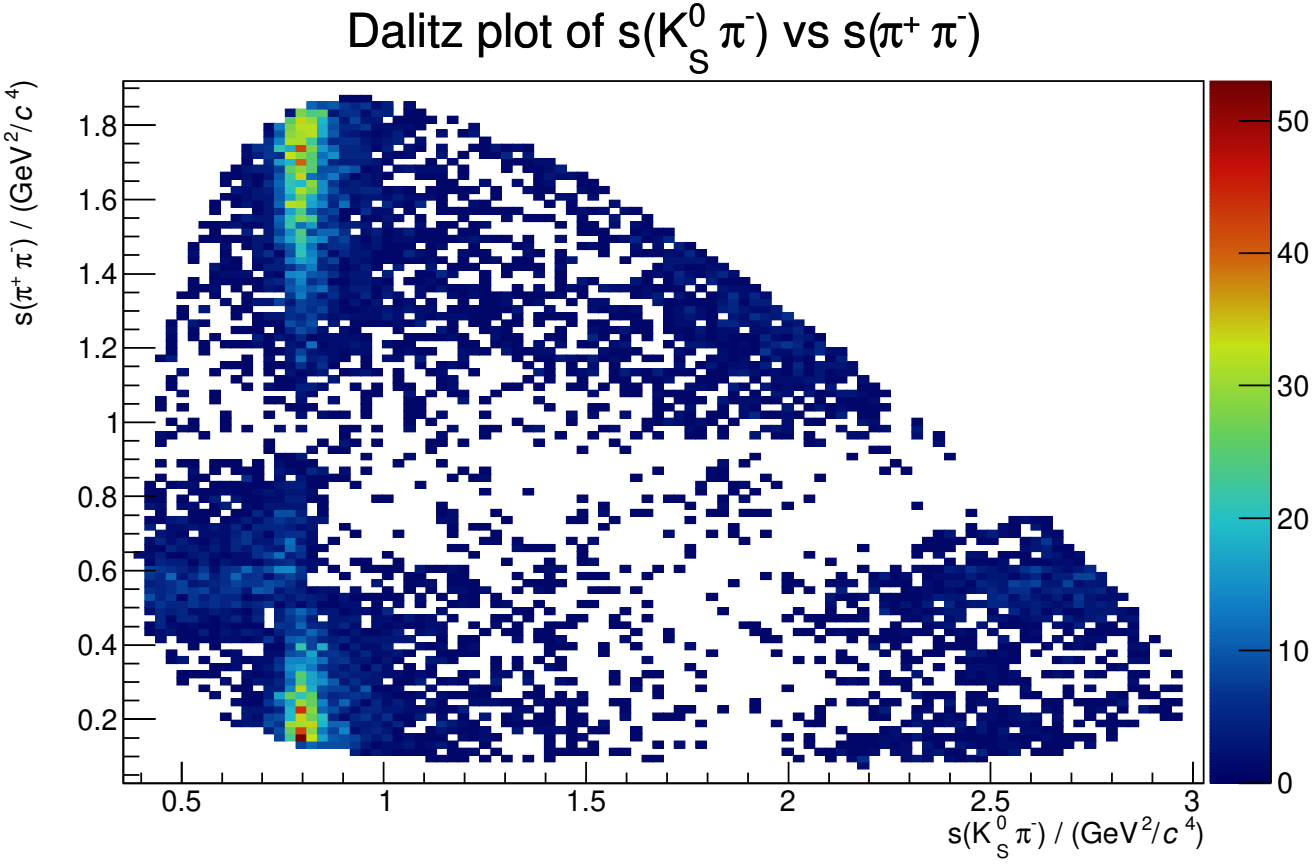


Figure: m_+^2 vs m_0^2 for Belle in Cartesian

Belle in Cartesian

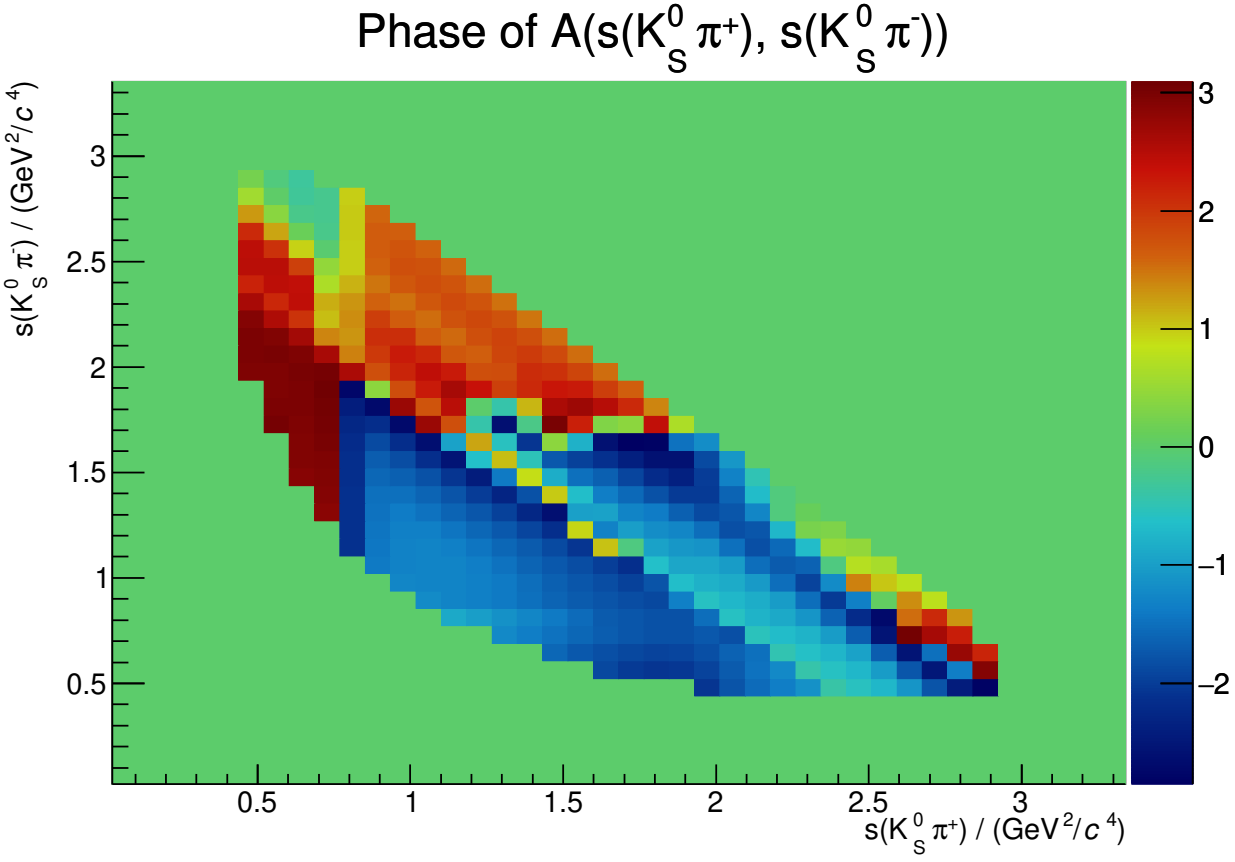


Figure: Argument for Belle in Cartesian

Belle in Cartesian

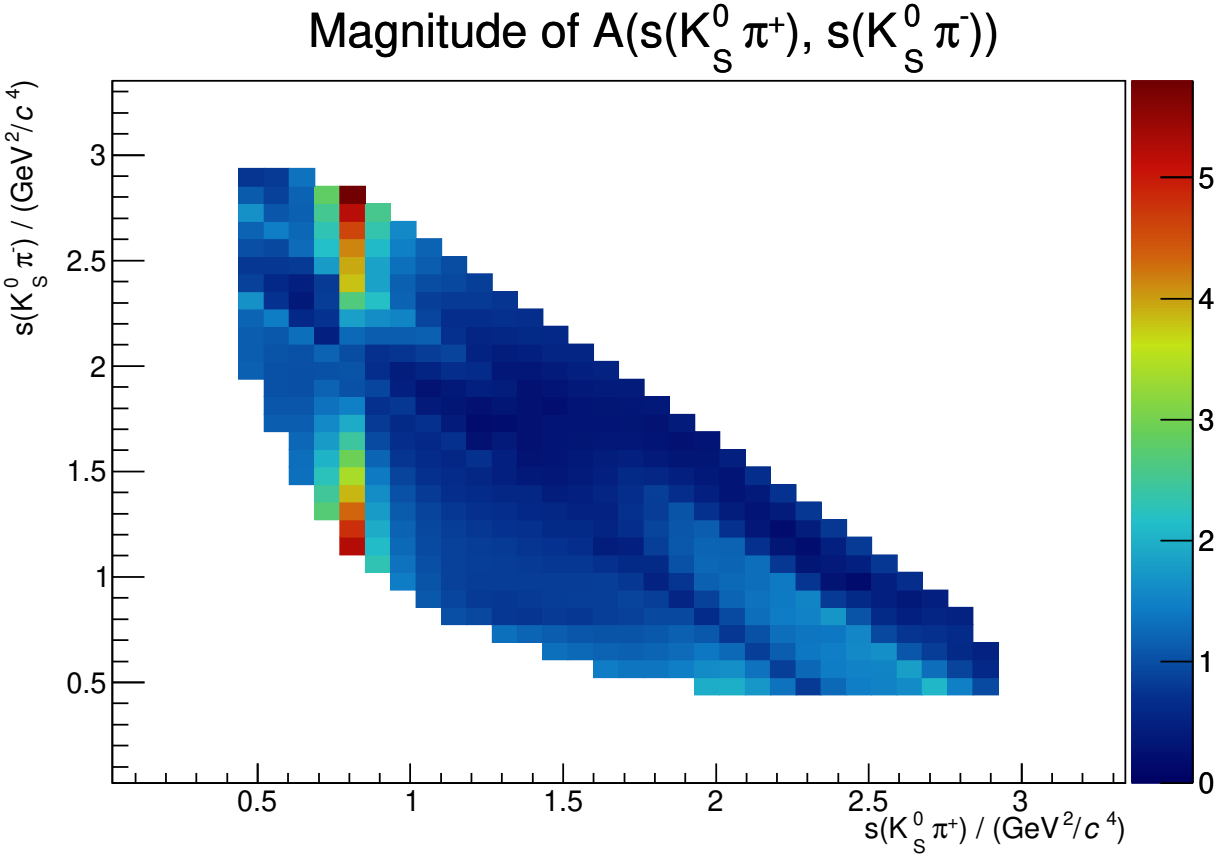


Figure: Magnitude for Belle in Cartesian

Belle in Cartesian

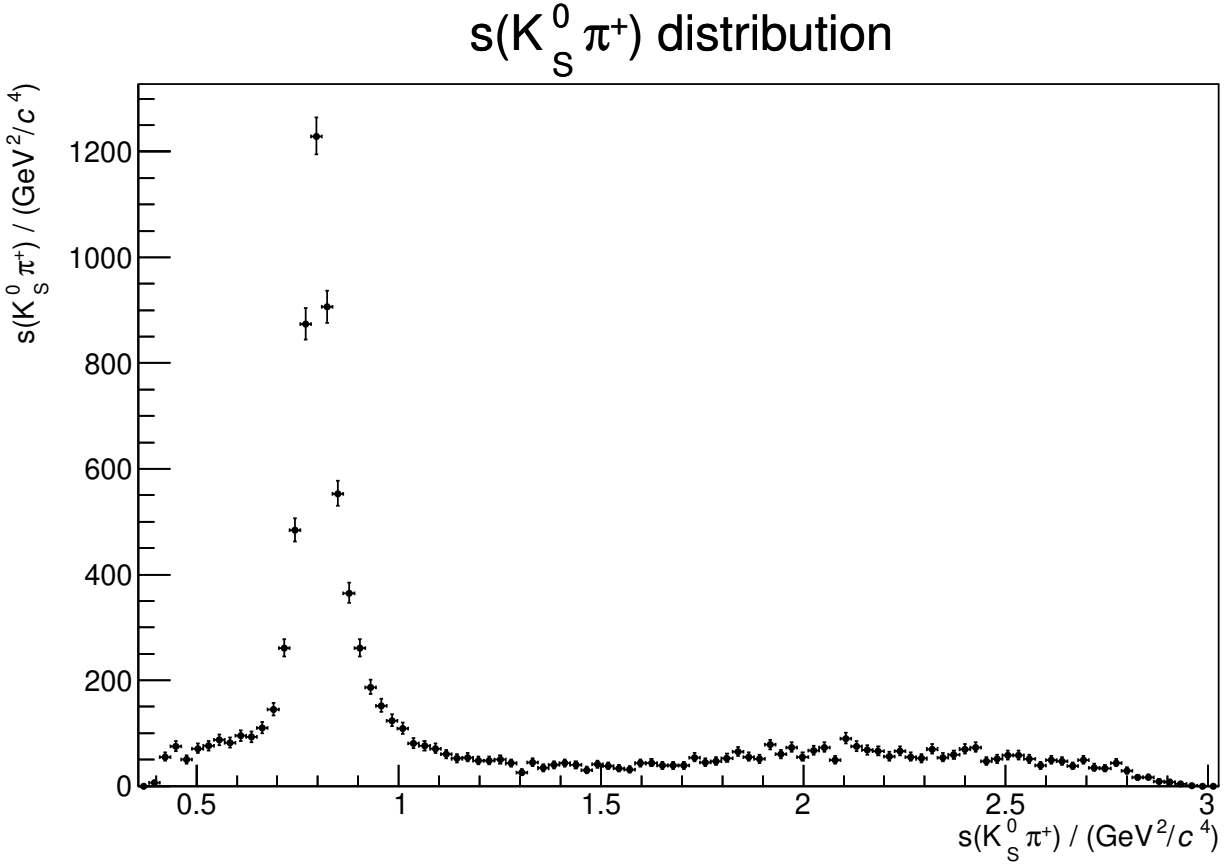


Figure: m_+^2 for Belle in Cartesian

Belle in Cartesian

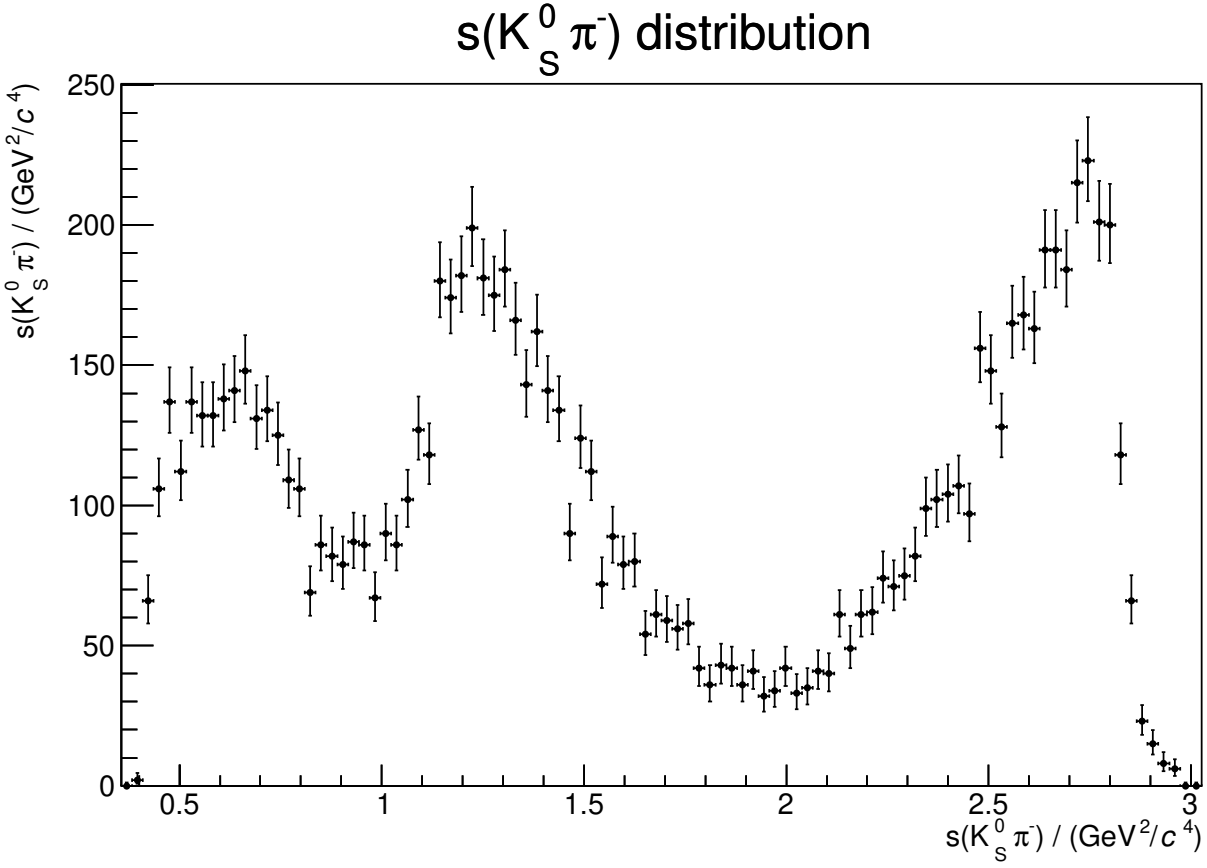


Figure: $m^2\_$ for Belle in Cartesian

Belle in Cartesian

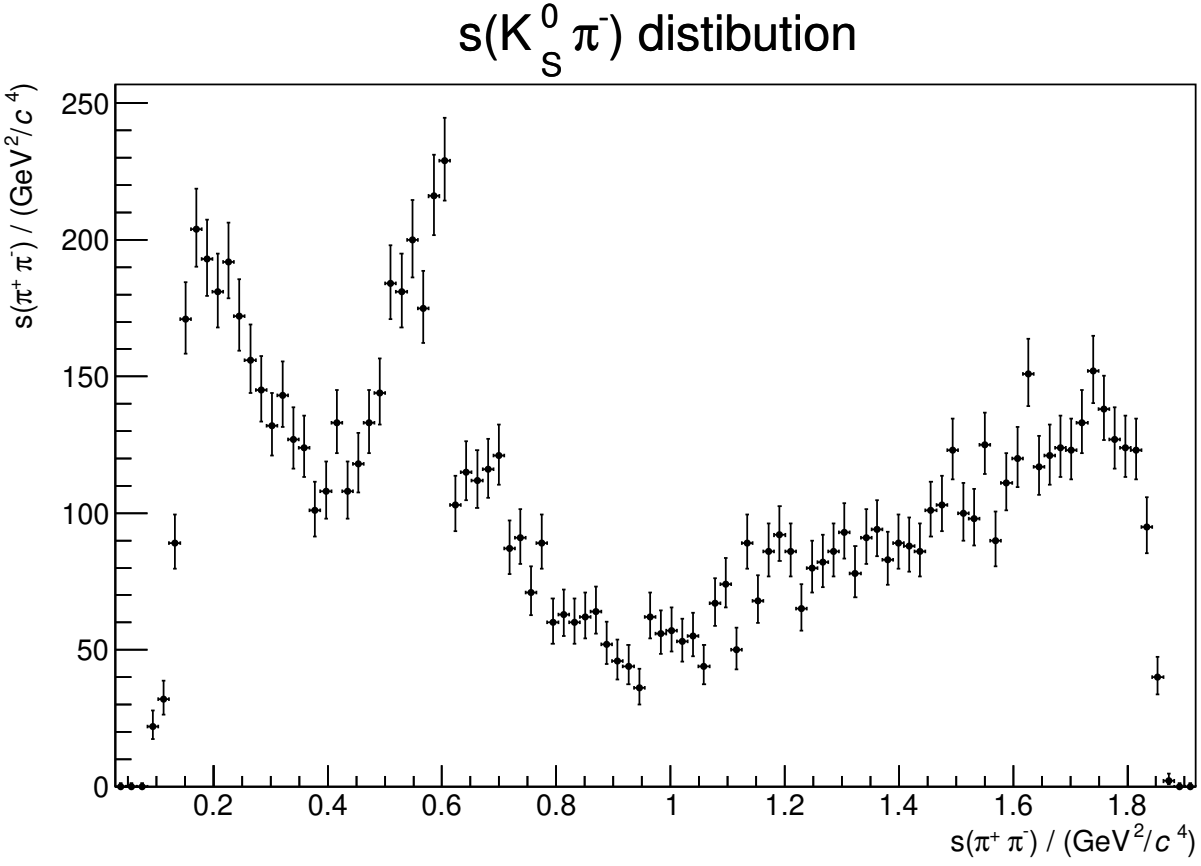


Figure: $m_0^2$for Belle in Cartesian

Belle in Cartesian

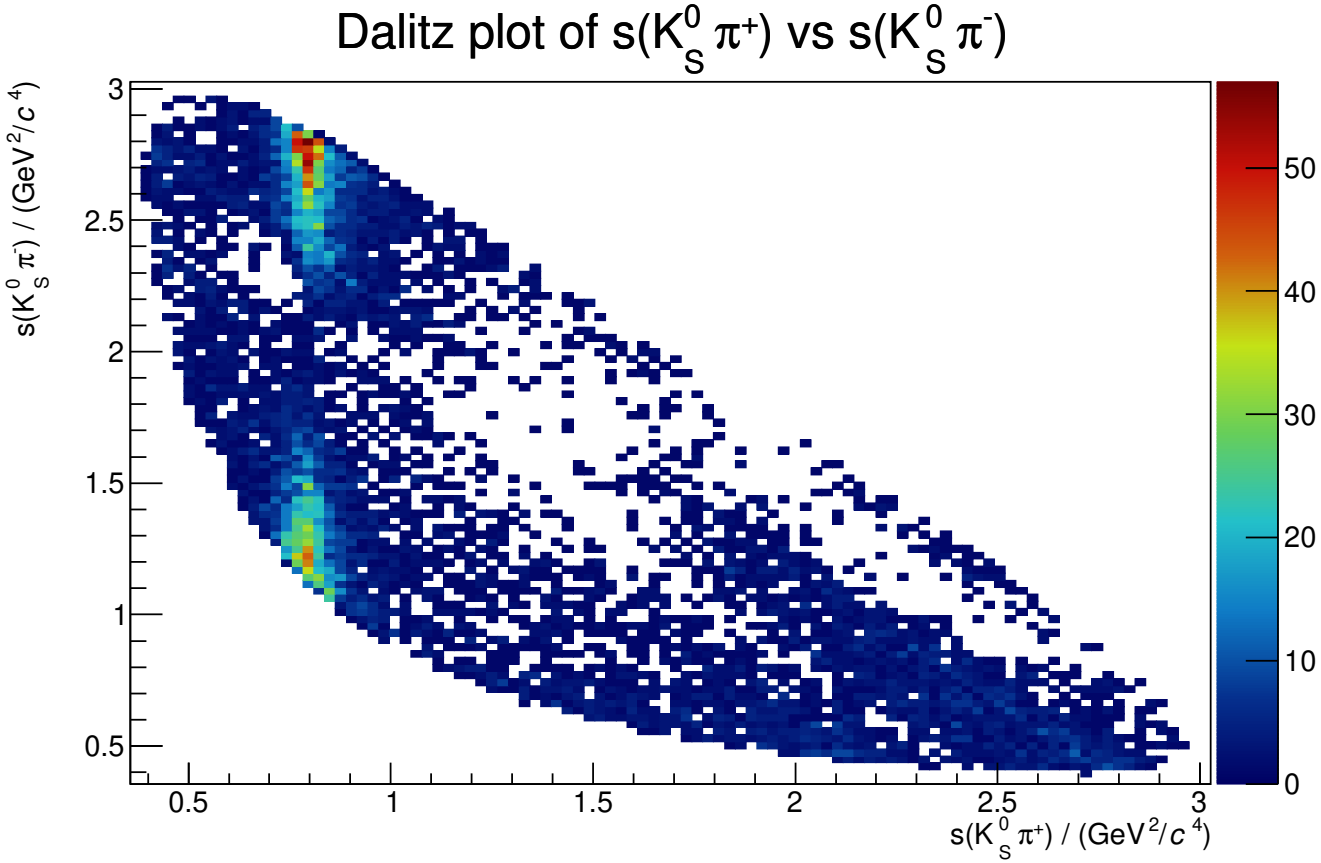


Figure: m_+^2 vs m_-^2 for Belle in Cartesian

Belle in Cartesian

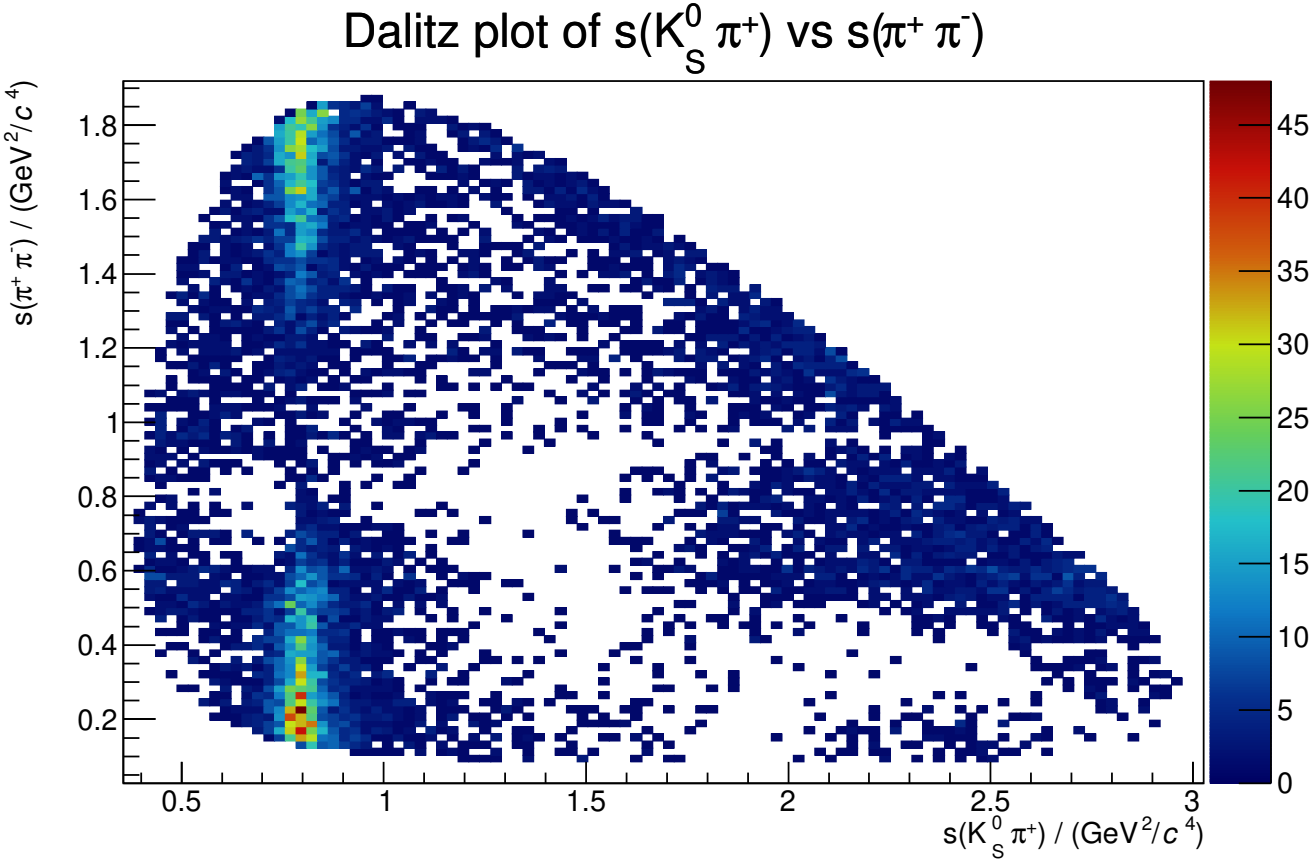


Figure: m_+^2 vs m_0^2 for Belle in Cartesian

Belle in Cartesian

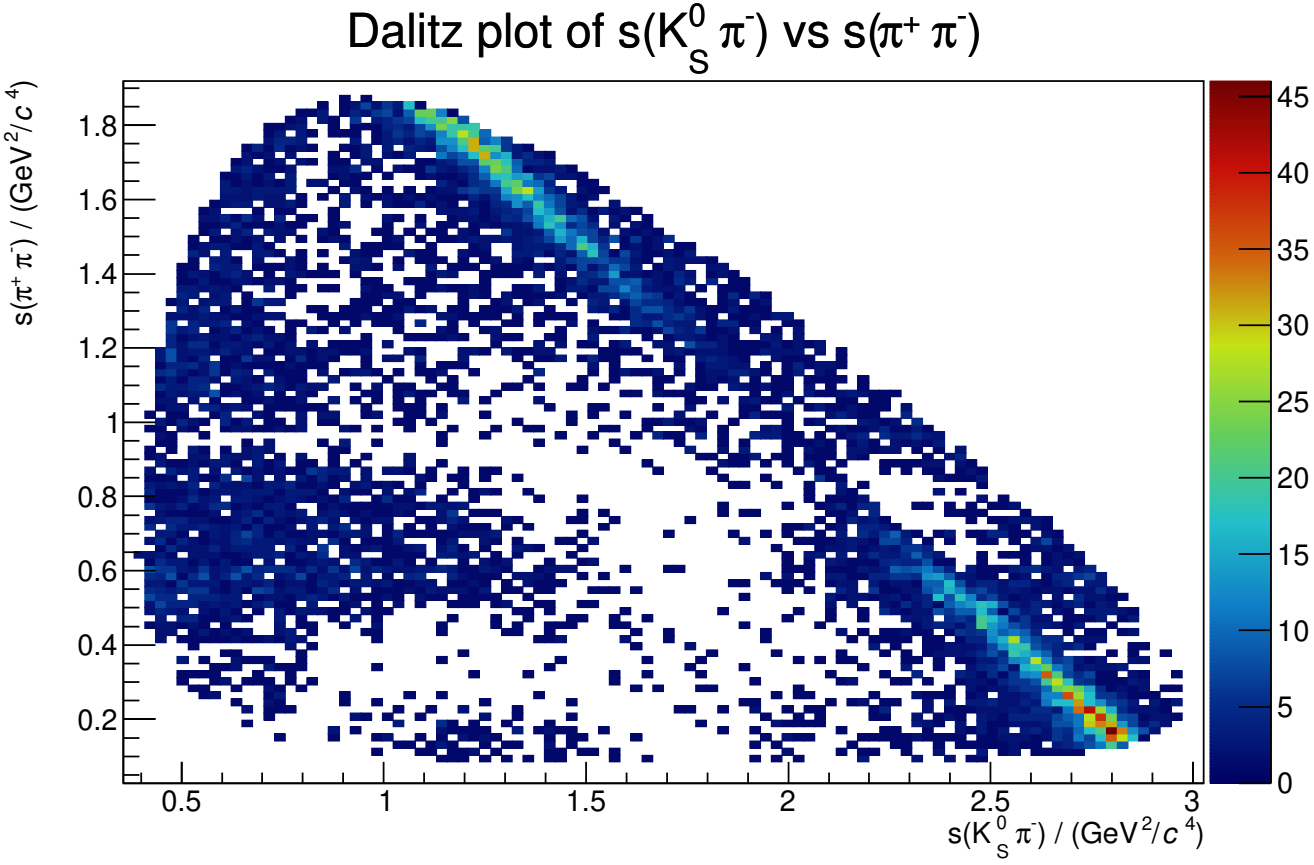
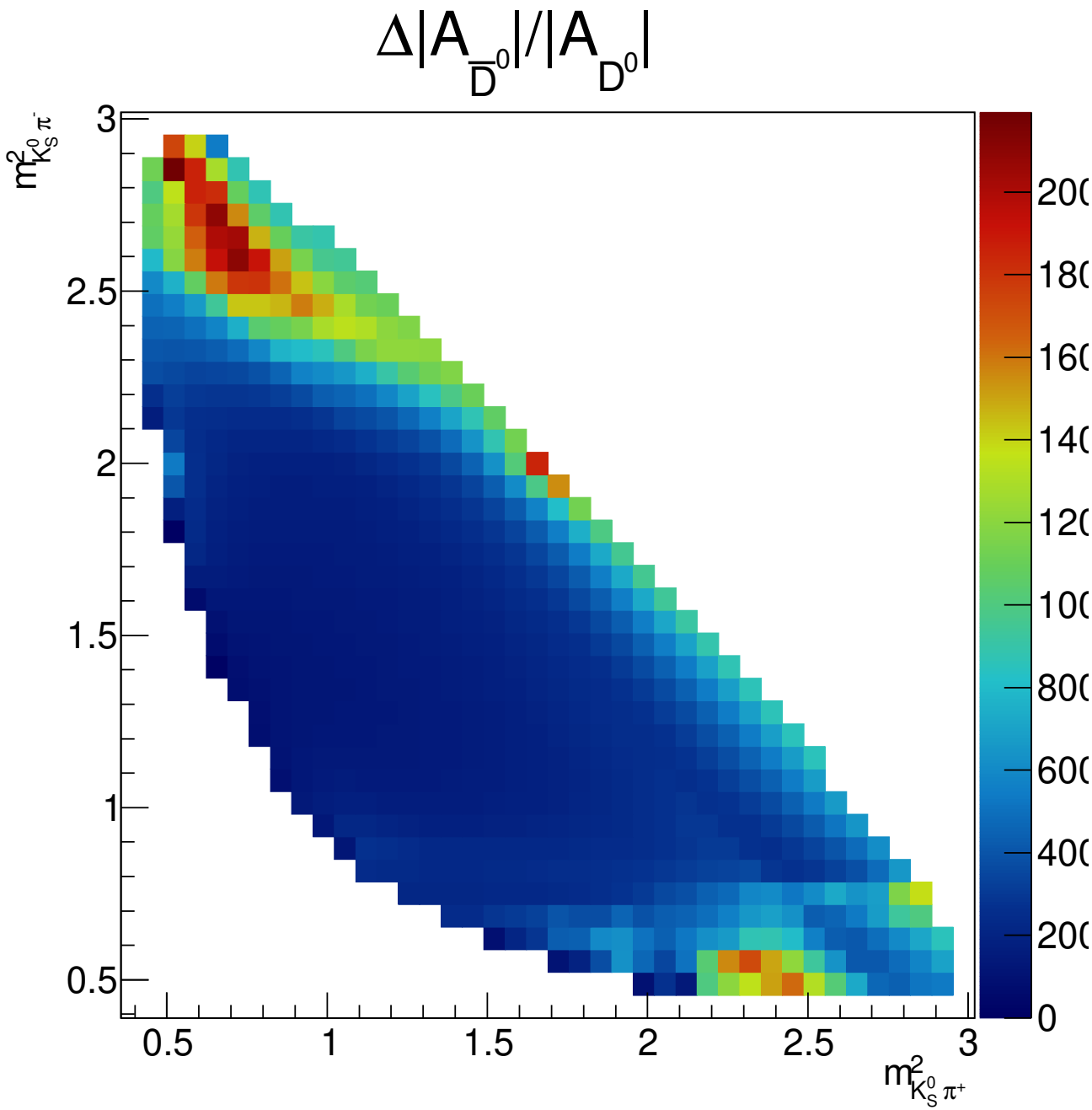


Figure: m_+^2 vs m_0^2 for Belle in Cartesian

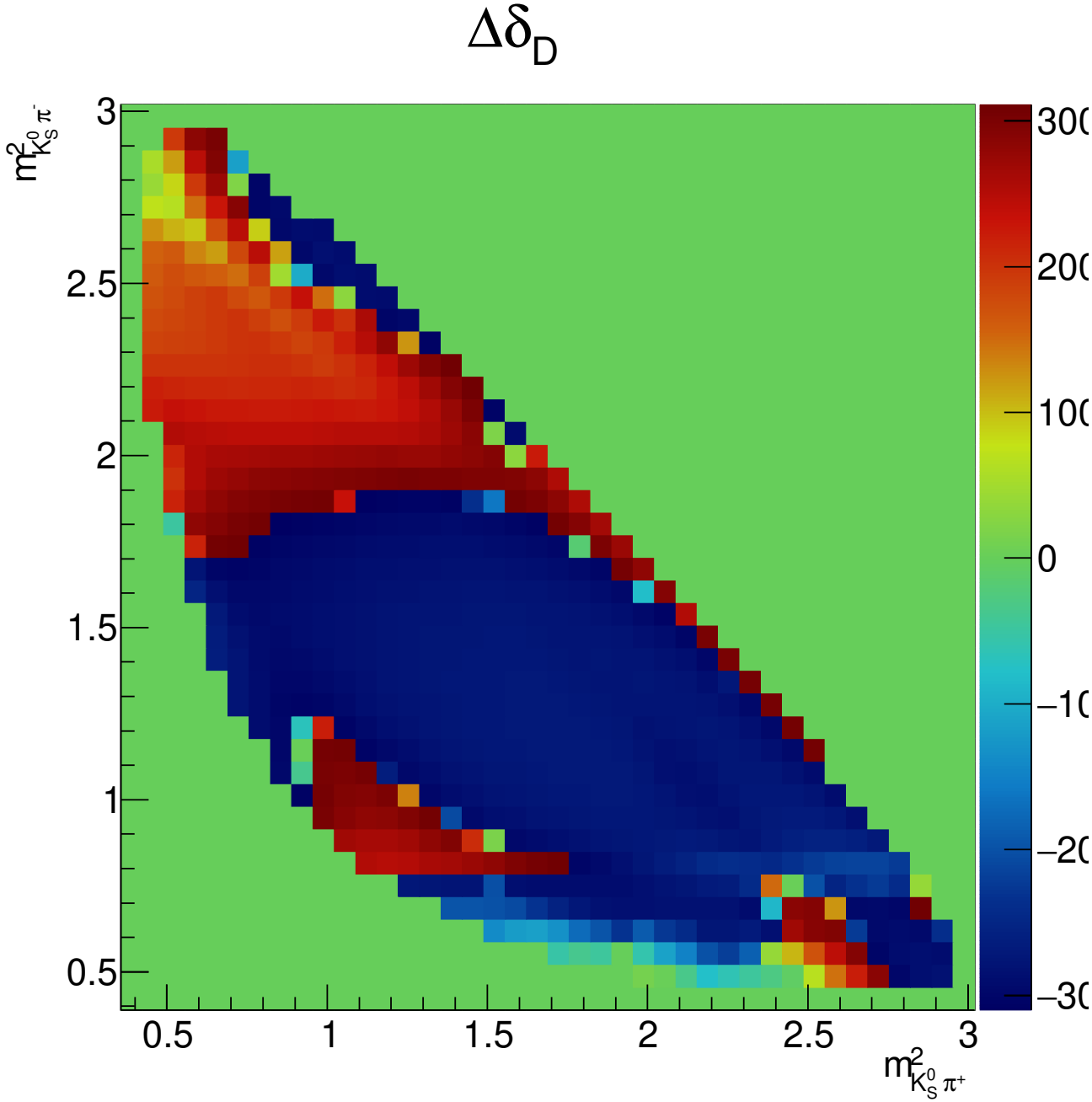
Belle in Polar

```
#Belle Model from https://arxiv.org/pdf/1804.06153v1.pdf

#EventType D0 K0S0 pi+ pi-
CouplingConstant::Coordinates  polar
CouplingConstant::AngularUnits deg
Import "$AMPGEN"/kspipi/kMatrix.opt
Particle::DefaultModifier BL
Particle::SpinFormalism   Canonical

D0{K*(892)bar-{K0S0,pi-},pi+}   0   1.72   0.006   0   136.8   0.2
D0{K(0)*(1430)bar-[GLASS]{K0S0,pi-},pi+}   0   2.36   0.06   0   99.4   1.7
D0{K(2)*(1430)bar-{K0S0,pi-},pi+}   0   1.27   0.02   0   -44.1   0.8
D0{K*(1410)bar-{K0S0,pi-},pi+}   0   0.29   0.03   0   99.4   5.5
D0{K*(1680)bar-{K0S0,pi-},pi+}   0   3.31   0.2   0   -118.2   3.1
D0{K*(892)+{K0S0,pi+},pi-}   0   0.0164   0.003   0   -42.2   0.9
D0{K*(1410)+{K0S0,pi+},pi-}   0   0.21   0.02   0   150.2   5.3
D0{K(0)*(1430)+[GLASS]{K0S0,pi+},pi-}   0   0.11   0.01   0   162.3   6.6
D0{K(2)*(1430)+{K0S0,pi+},pi-}   0   0.1   0.01   0   -89.6   7.6
D0{K0S0,rho(770)0{pi+,pi-}}   2   1   0   2   0   0
D0{K0S0,omega(782)0{pi+,pi-}}   0   0.0388   0.0005   0   120.7   0.7
D0{K0S0,f(2)(1270)0{pi+,pi-}}   0   1.43   0.03   0   -36.3   1.1
D0{K0S0,rho(1450)0{pi+,pi-}}   0   2.85   0.1   0   102.1   1.9
D0{K0S0,PiPi00}   0  0.1   0   0   0   0
Dbar0{K*(892)+{K0S0,pi+},pi-}   0   1.72   0.006   0   136.8   0.2
Dbar0{K(0)*(1430)+[GLASS]{K0S0,pi+},pi-}   0   2.36   0.06   0   99.4   1.7
Dbar0{K(2)*(1430)+{K0S0,pi+},pi-}   0   1.27   0.02   0   -44.1   0.8
Dbar0{K*(1410)+{K0S0,pi+},pi-}   0   0.29   0.03   0   99.4   5.5
Dbar0{K*(1680)+{K0S0,pi+},pi-}   0   3.31   0.2   0   -118.2   3.1
Dbar0{K*(892)bar-{K0S0,pi-},pi+}   0   0.164   0.003   0   -42.2   0.9
Dbar0{K*(1410)bar-{K0S0,pi-},pi+}   0   0.21   0.02   0   150.2   5.3
Dbar0{K(0)*(1430)bar-[GLASS]{K0S0,pi-},pi+}   0   0.11   0.01   0   162.3   6.6
Dbar0{K(2)*(1430)bar-{K0S0,pi-},pi+}   0   0.1   0.01   0   -89.6   7.6
Dbar0{K0S0,rho(770)0{pi+,pi-}}   2   1   0   2   0   0
Dbar0{K0S0,omega(782)0{pi+,pi-}}   0   0.0388   0.0005   0   120.7   0.7
Dbar0{K0S0,f(2)(1270)0{pi+,pi-}}   0   1.43   0.03   0   -36.3   1.1
```

Belle in Polar



Belle in Polar



Belle in Polar

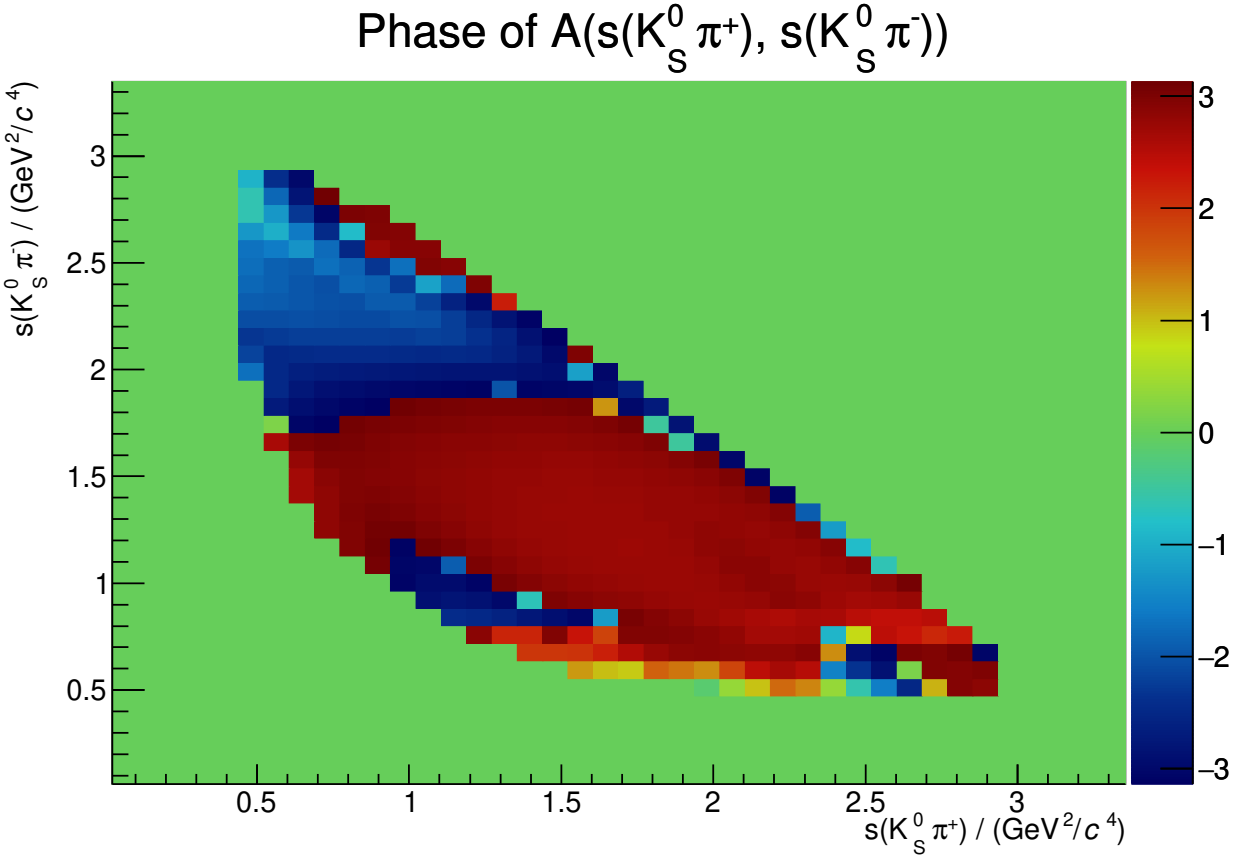


Figure: Argument for Belle in Polar

Belle in Polar

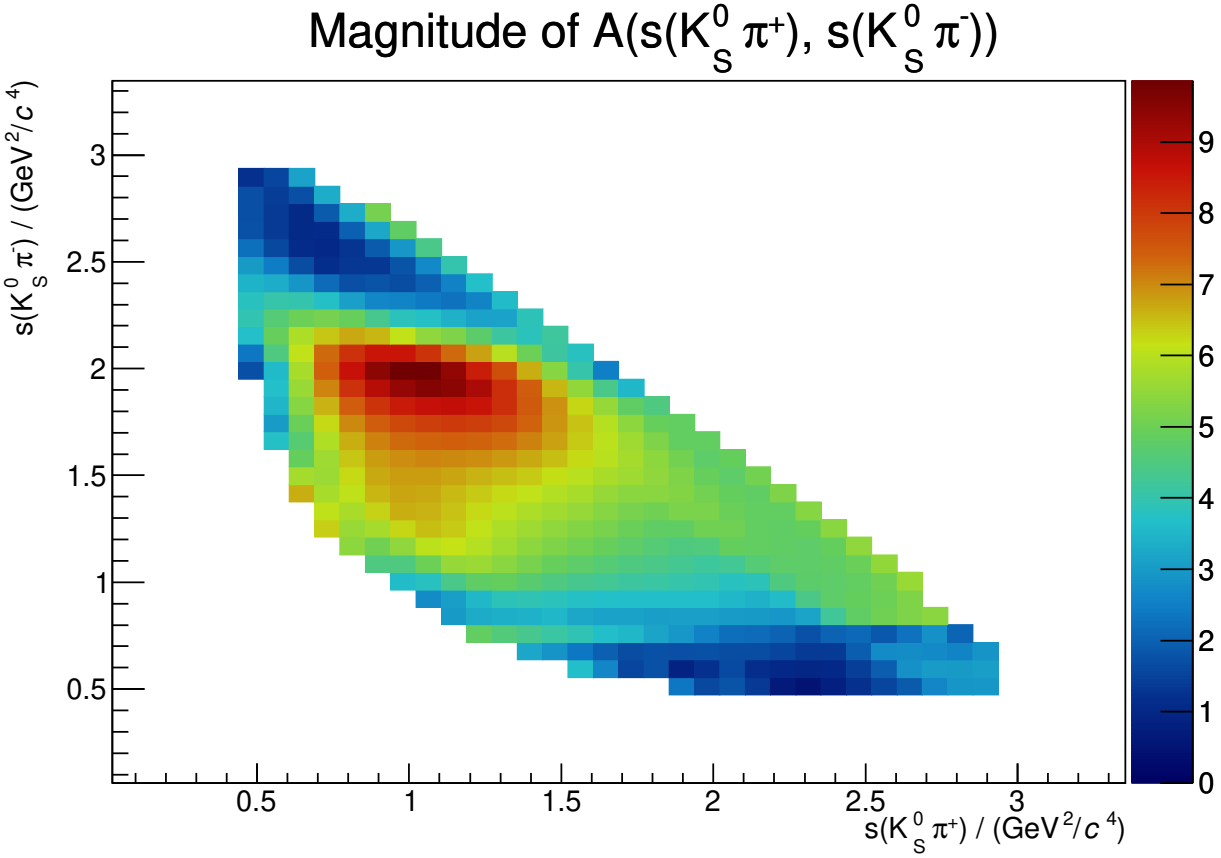


Figure: Magnitude for Belle in Polar

Belle in Polar

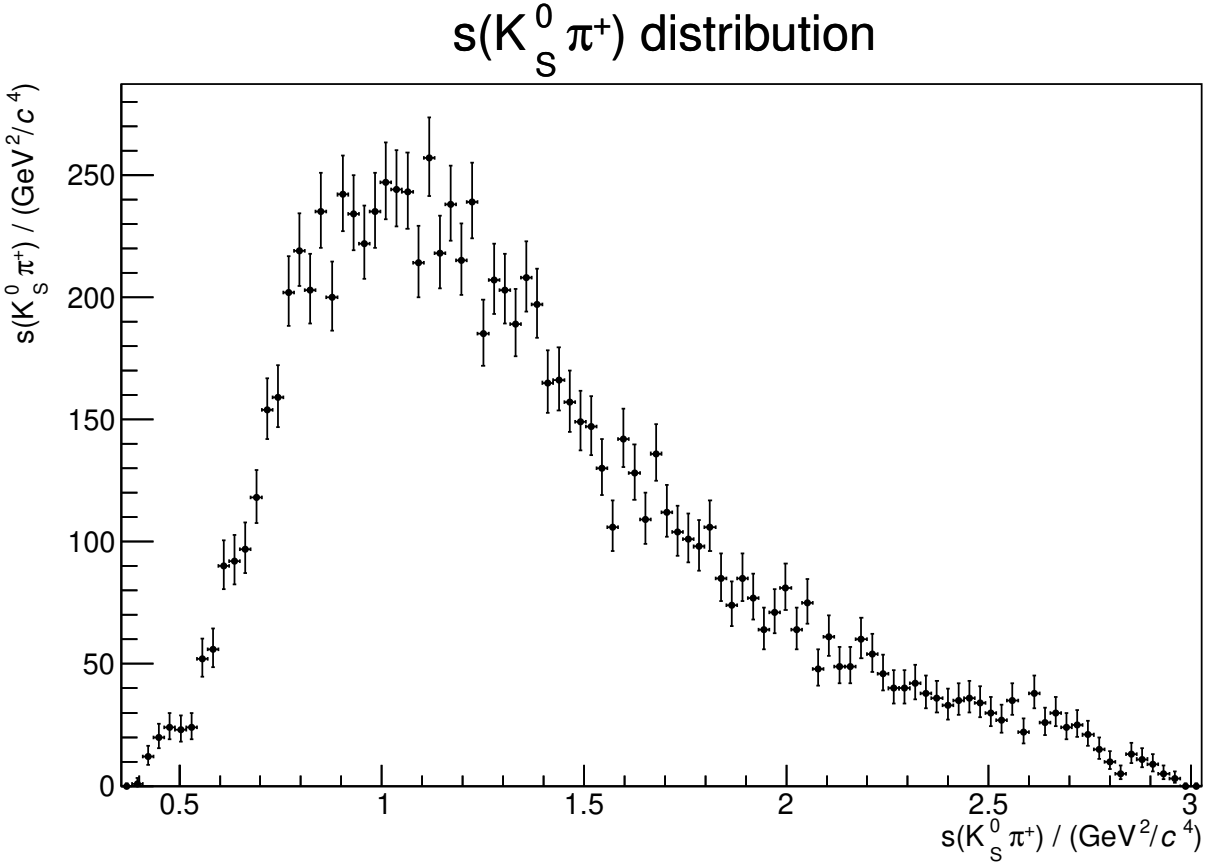


Figure: m^2_+ for Belle in Polar

Belle in Polar

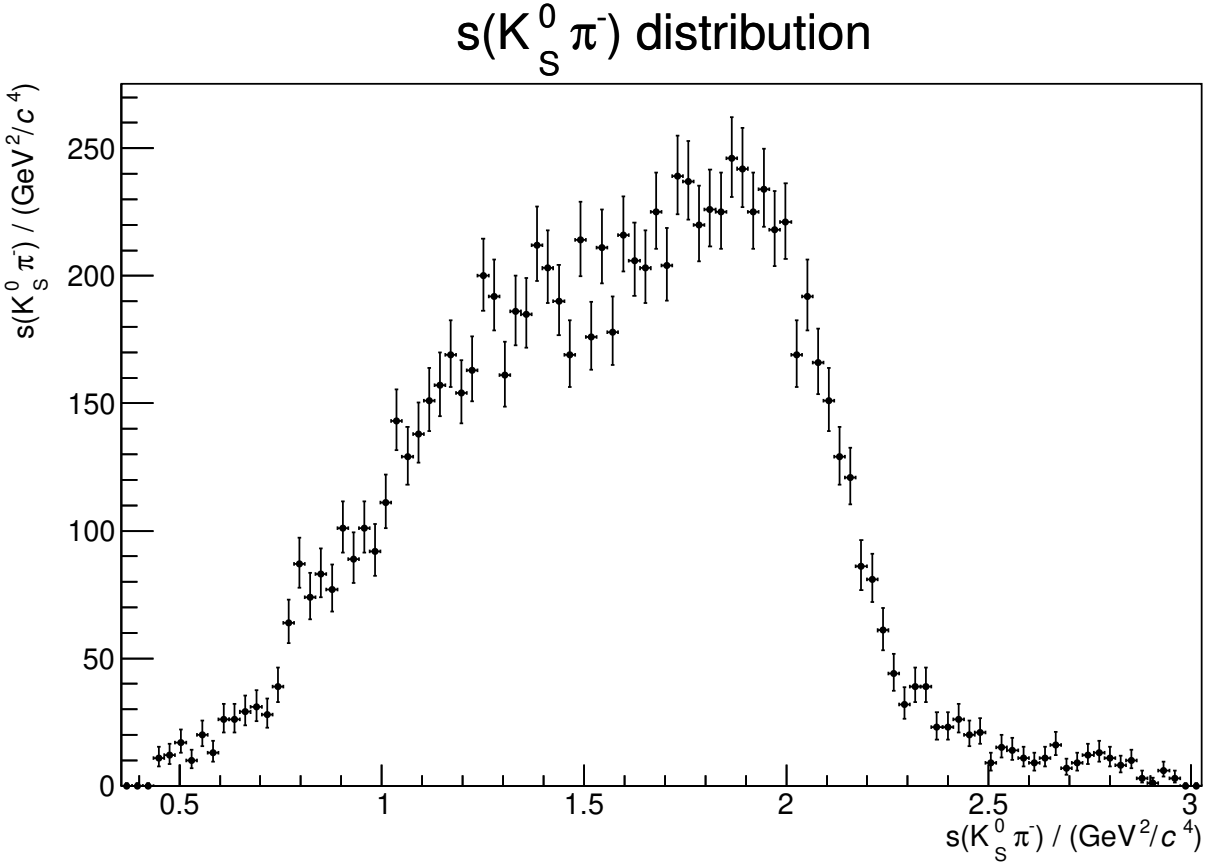


Figure: $m^2\_$ for Belle in Polar

Belle in Polar

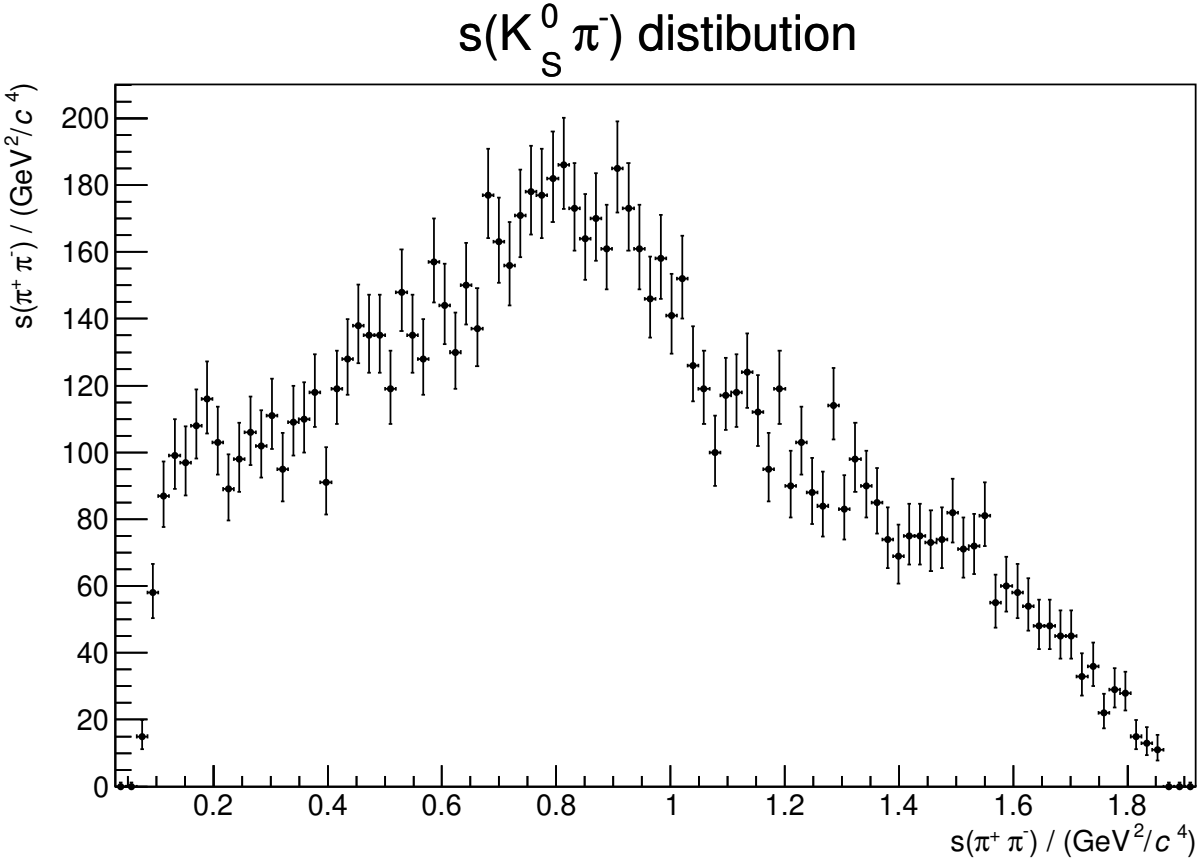


Figure: $m_0^2$for Belle in Polar

Belle in Polar

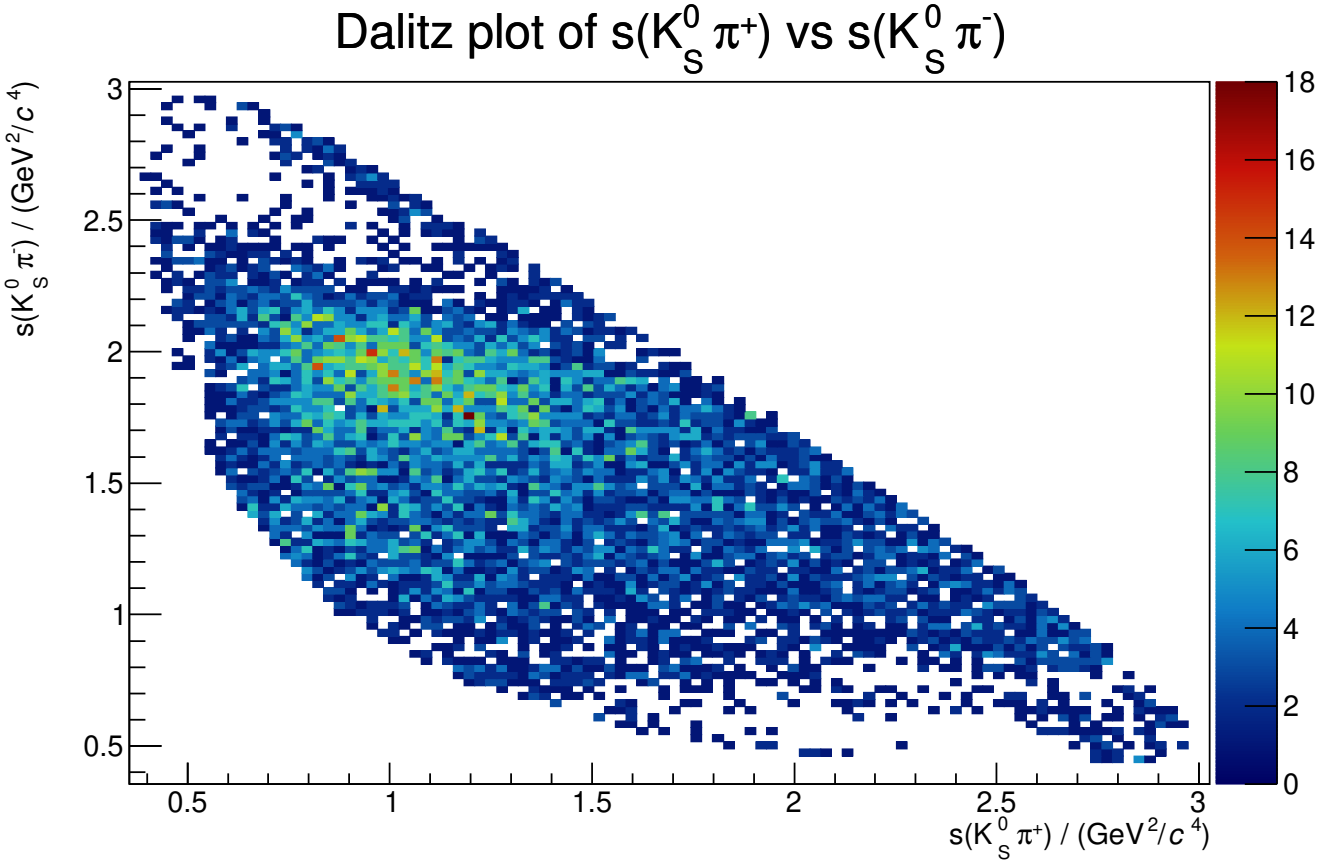


Figure: m^2_+ vs m^2_- for Belle in Polar

Belle in Polar

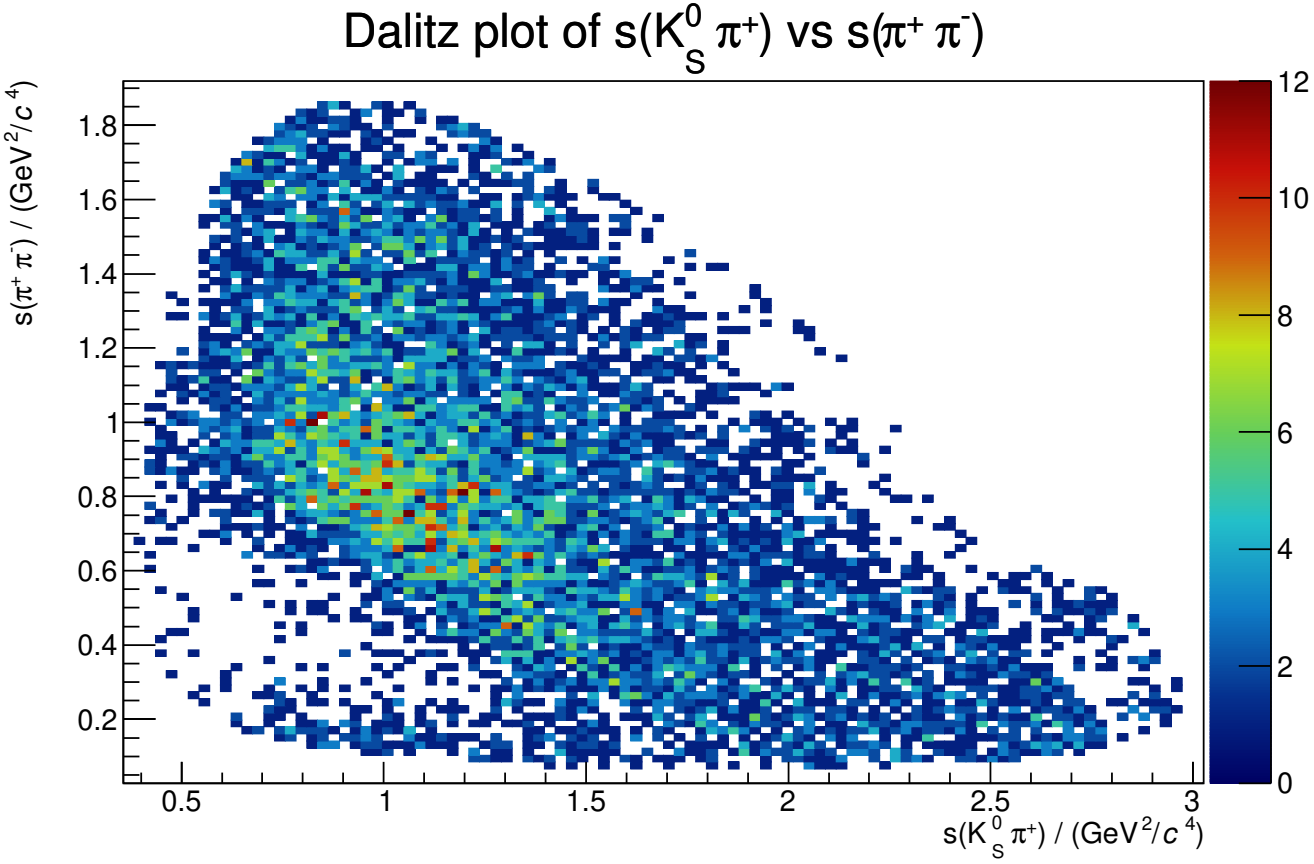


Figure: m_+^2 vs m_0^2 for Belle in Polar

Belle in Polar

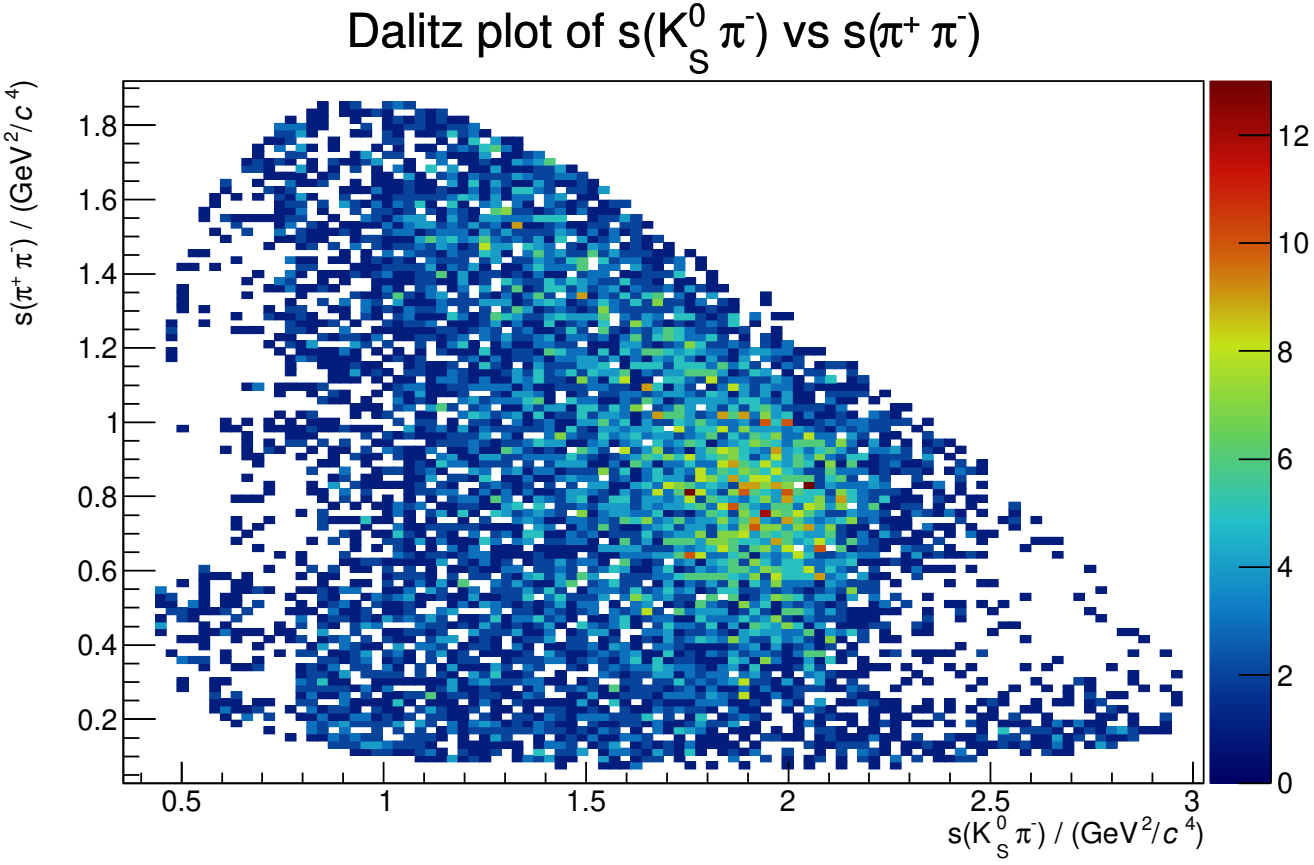


Figure: m_+^2 vs m_0^2 for Belle in Polar

Belle in Polar

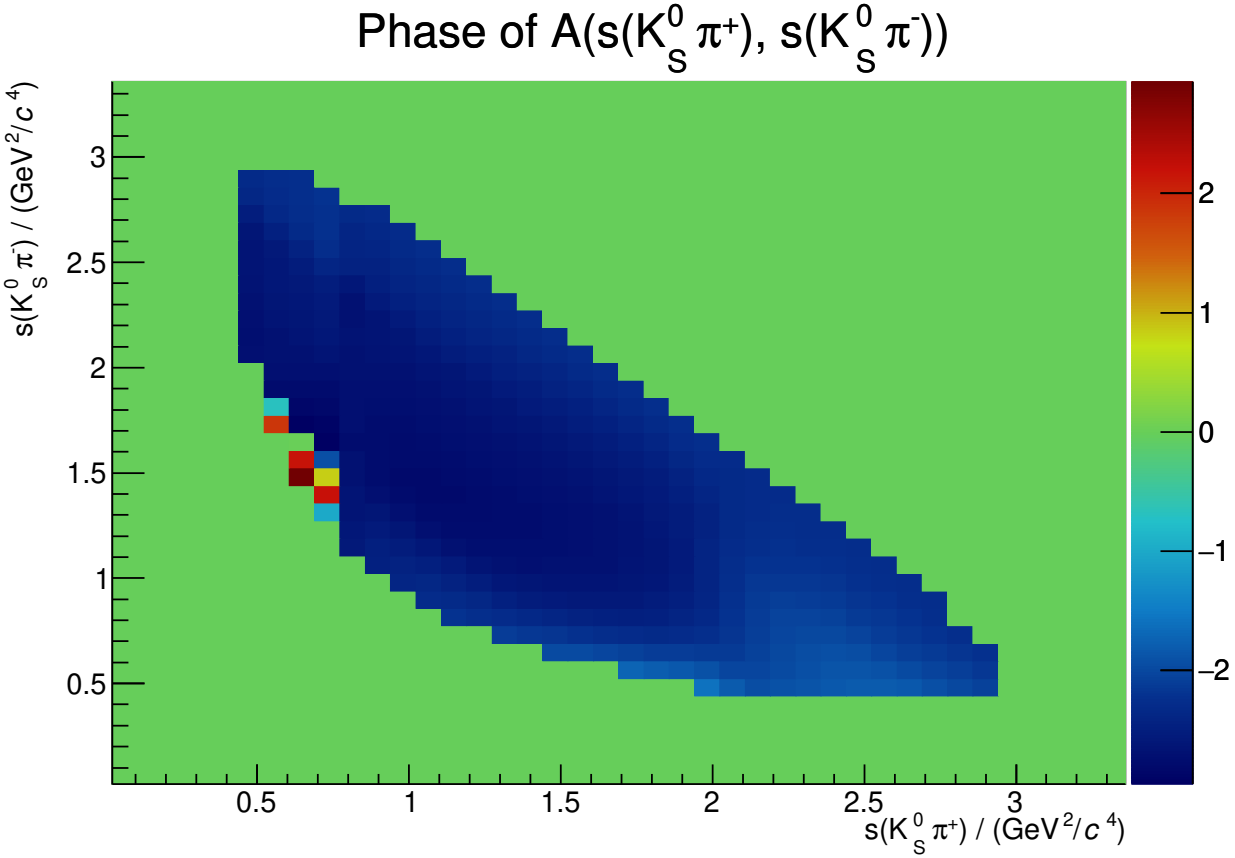


Figure: Argument for Belle in Polar

Belle in Polar

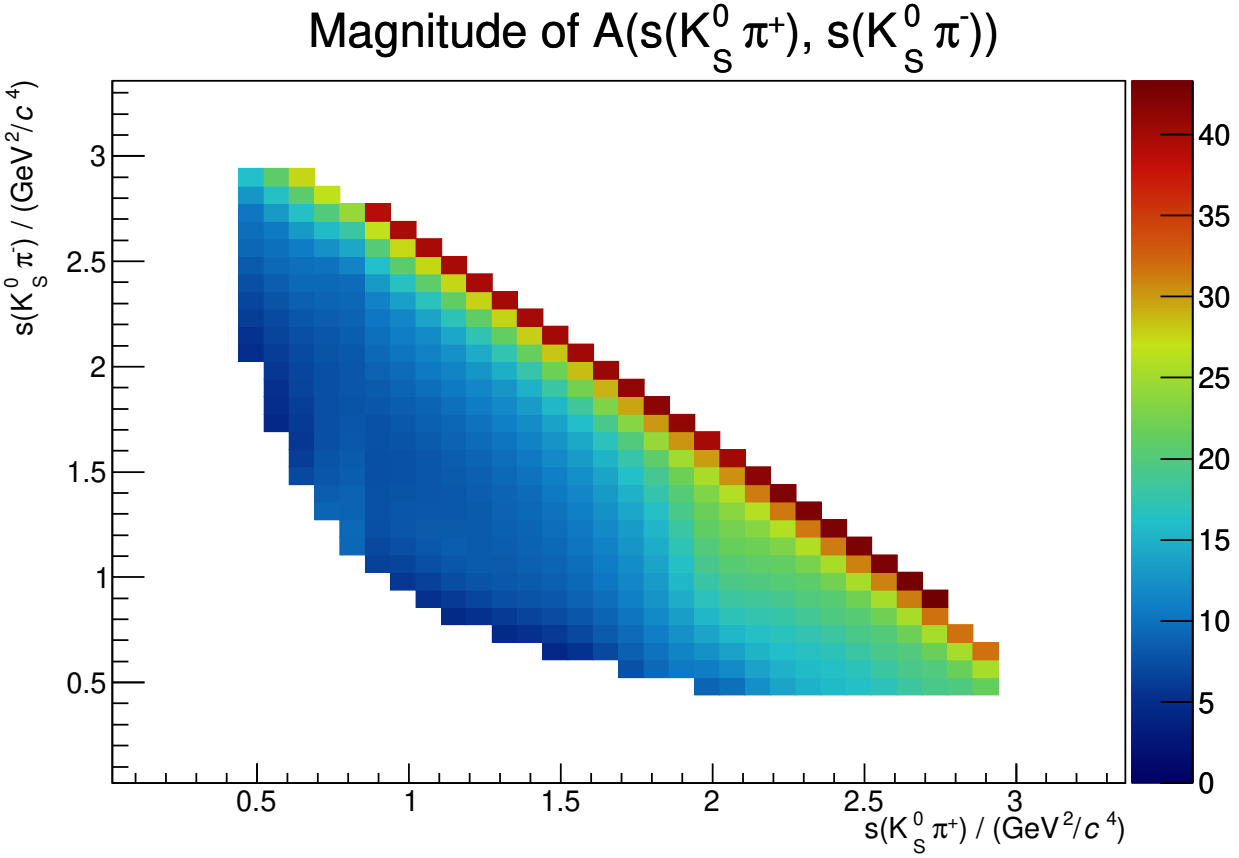


Figure: Magnitude for Belle in Polar

Belle in Polar

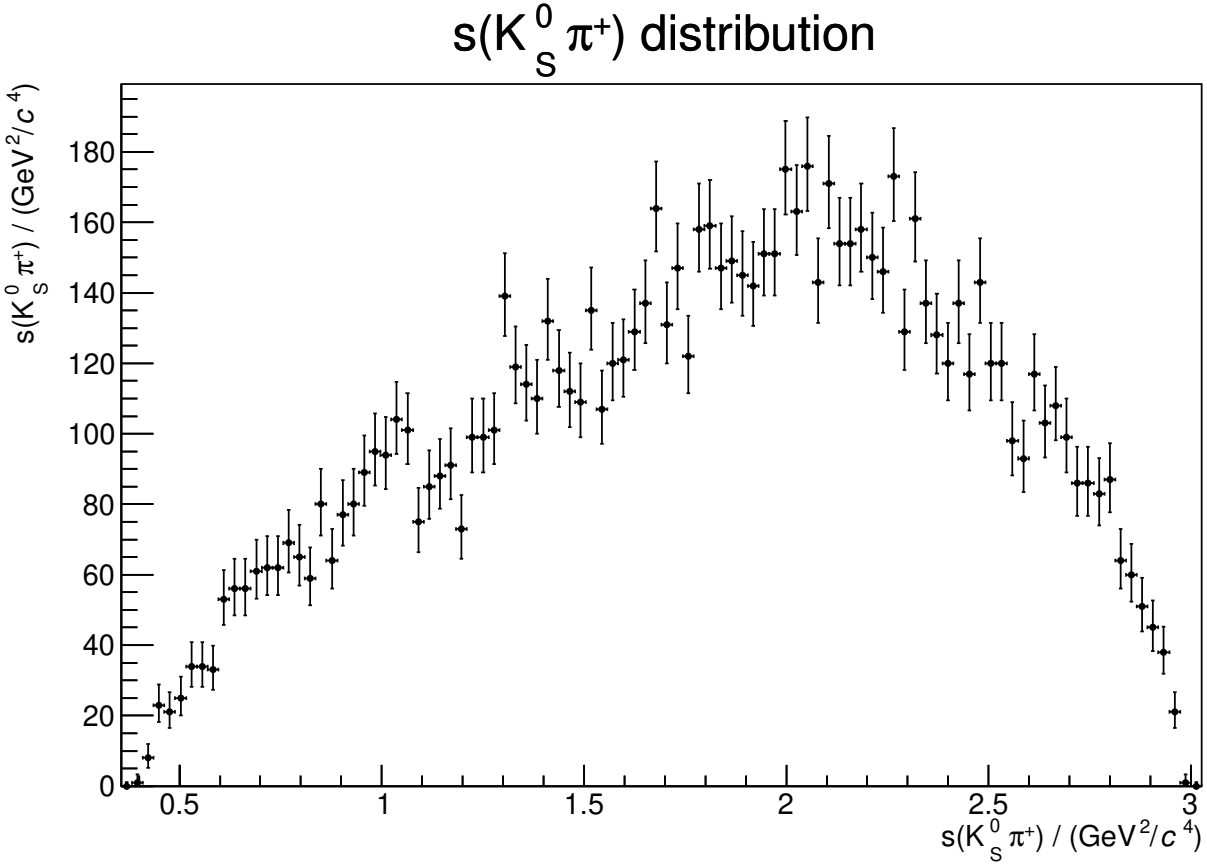


Figure: m_+^2 for Belle in Polar

Belle in Polar

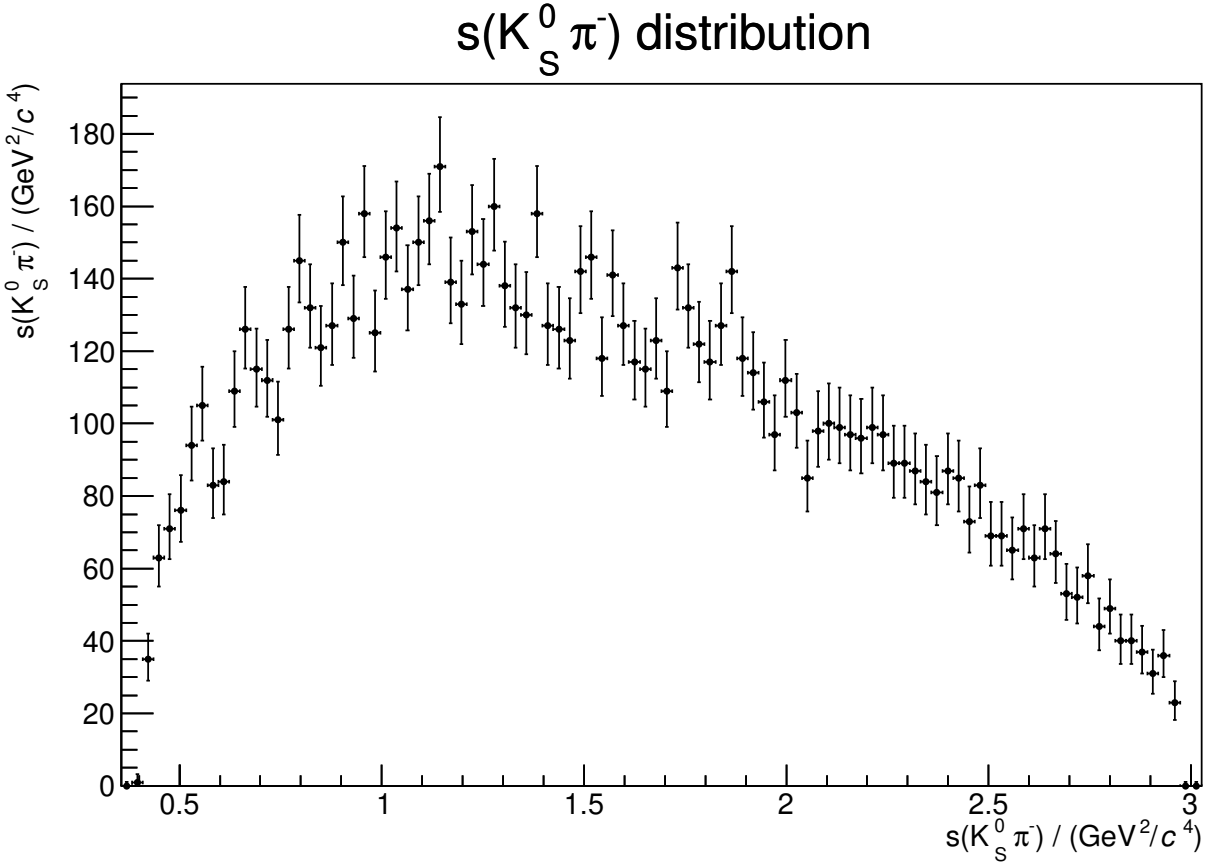


Figure: $m^2\_$ for Belle in Polar

Belle in Polar

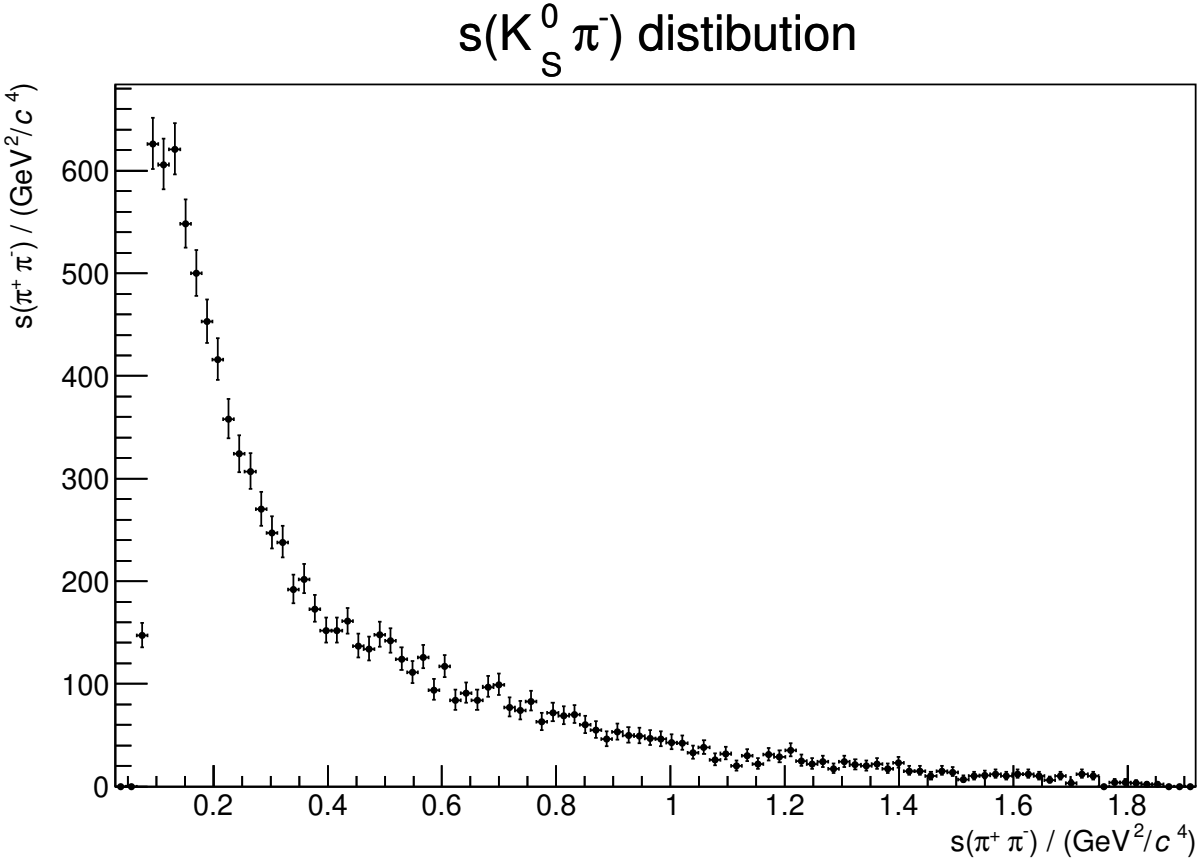


Figure: $m_0^2$for Belle in Polar

Belle in Polar

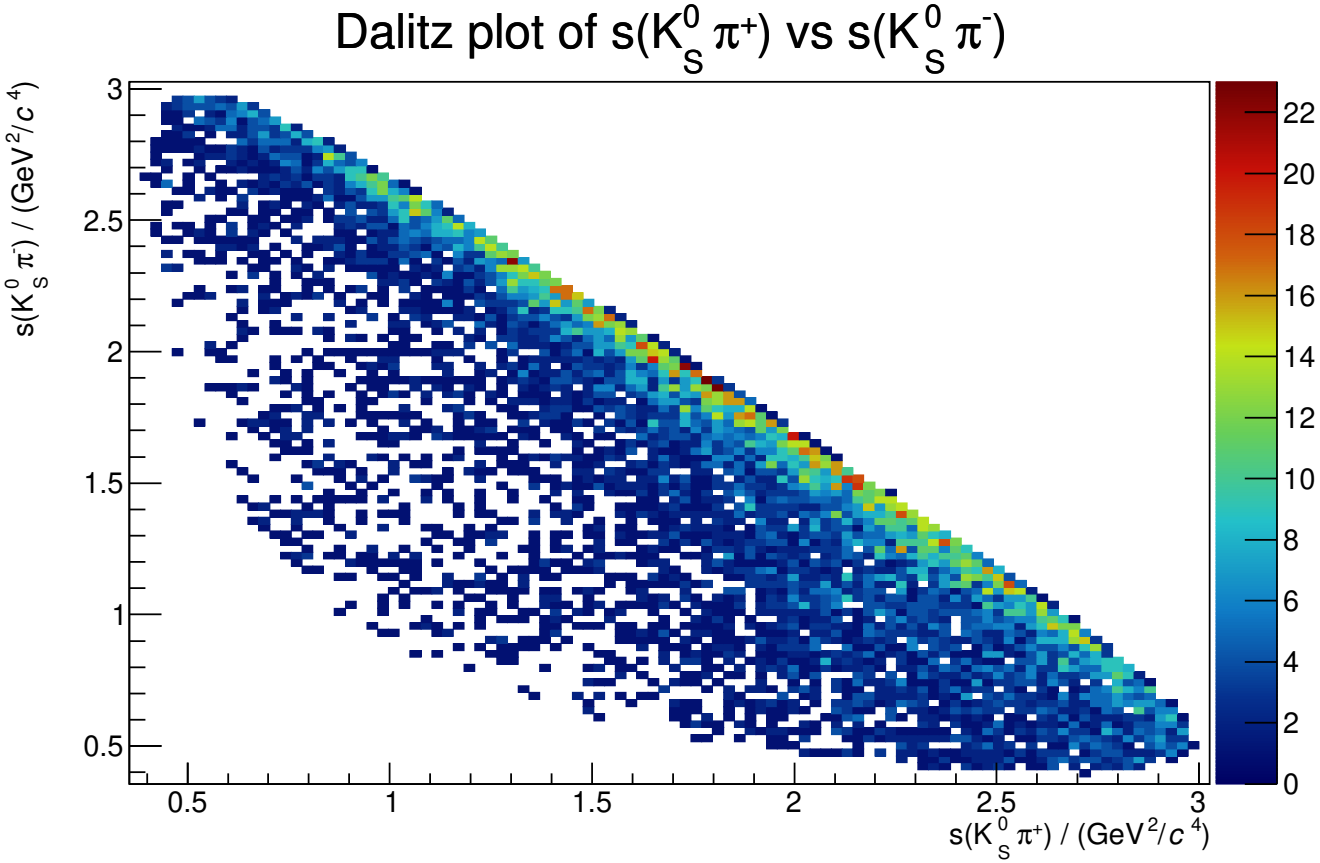


Figure: m^2_+ vs m^2_- for Belle in Polar

Belle in Polar

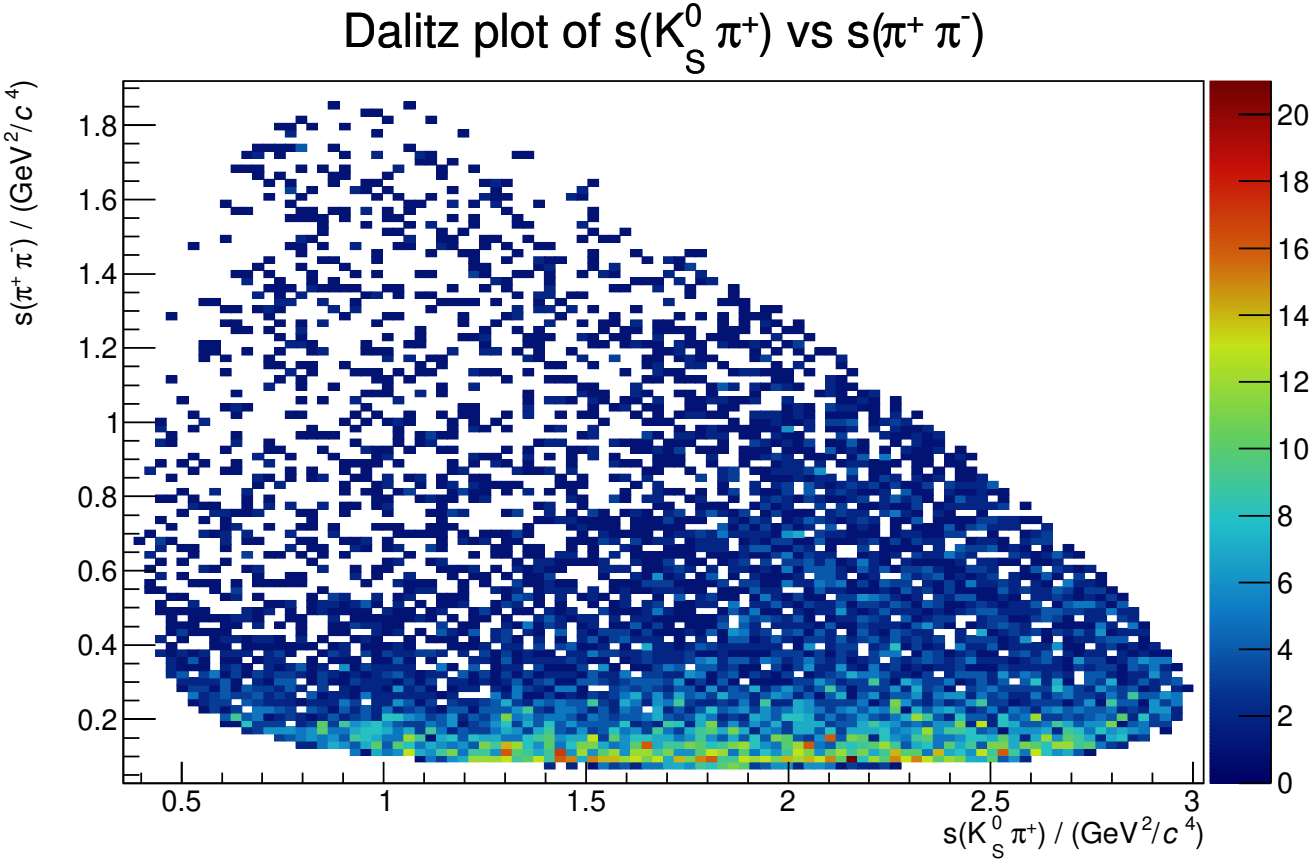


Figure: m_+^2 vs m_0^2 for Belle in Polar

Belle in Polar

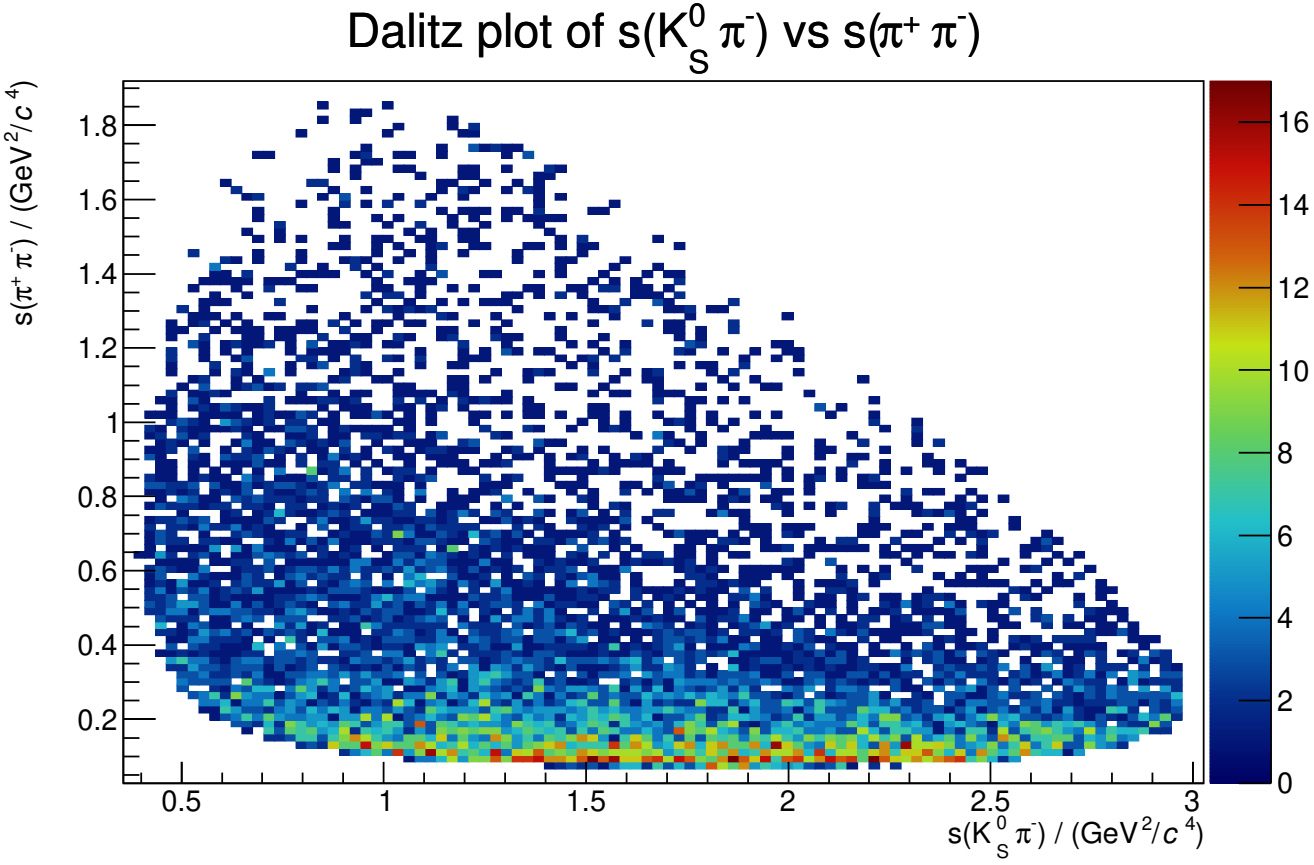
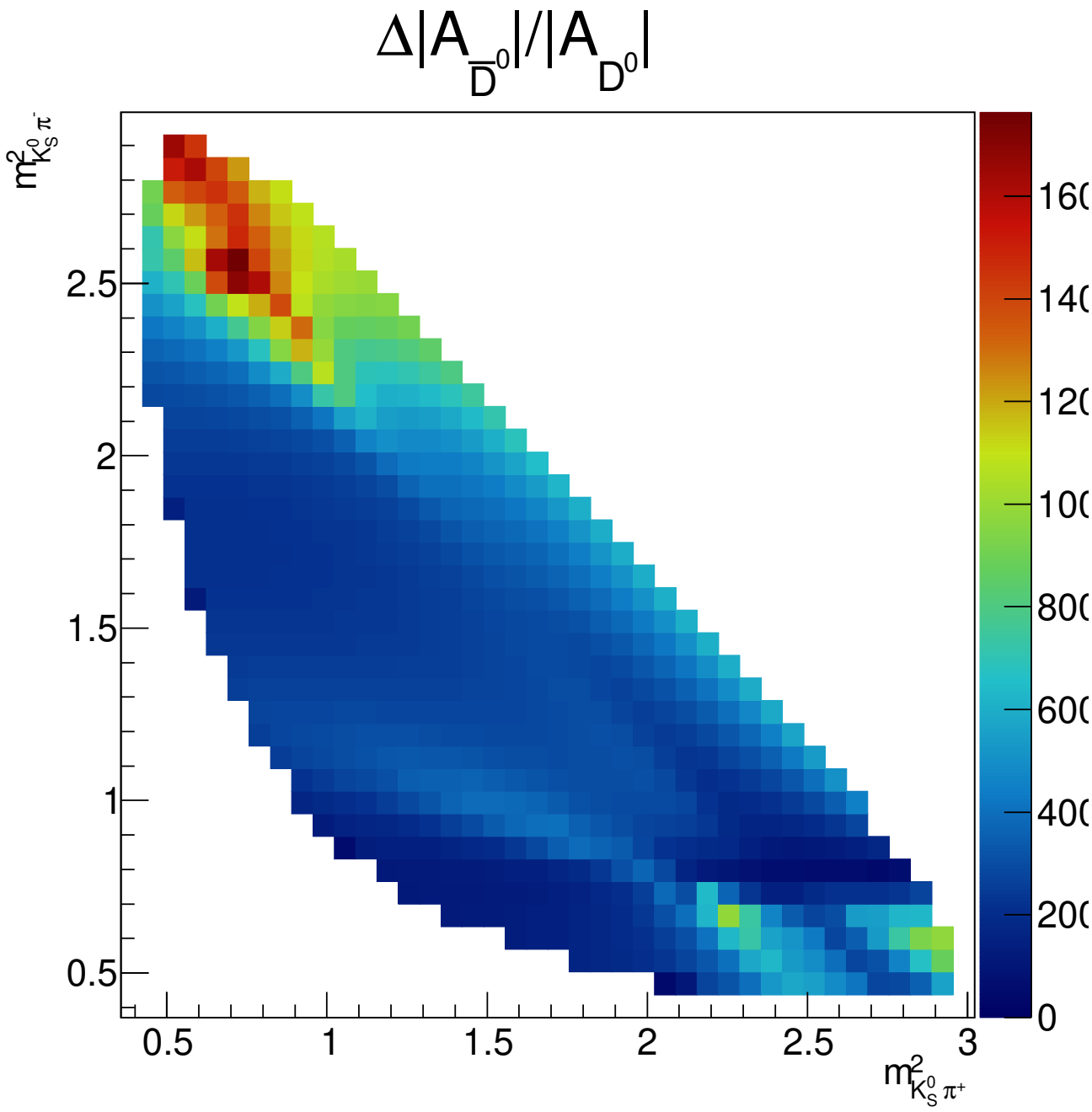


Figure: m_+^2 vs m_0^2 for Belle in Polar

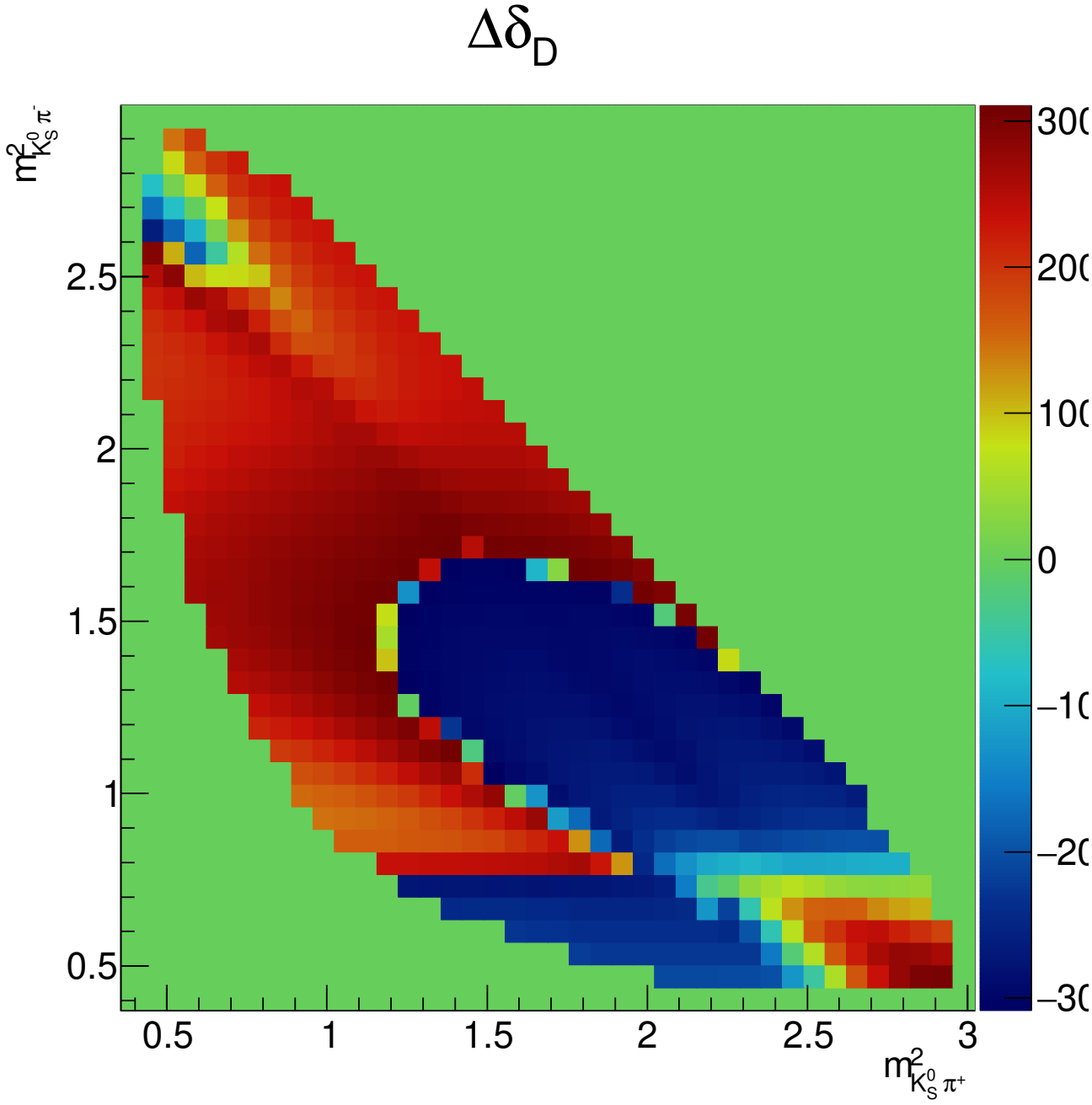
Belle in Polar times Fit Fractions

```
#EventType D0 K0S0 pi+ pi-
CouplingConstant::Coordinates  polar
CouplingConstant::AngularUnits deg
Import "$AMPGEN"/kspipi/kMatrix.opt
Particle::DefaultModifier BL
Particle::SpinFormalism   Canonical



D0{K*(892)bar-{K0S0,pi-},pi+}   0   1.03028   0.00359   0   136.8   0.2
D0{K(0)*(1430)bar-[GLASS]{K0S0,pi-},pi+}   0   0.16520   0.00420   0   99.4   1.7
D0{K(2)*(1430)bar-{K0S0,pi-},pi+}   0   0.01651   0.00026   0   -44.1   0.8
D0{K*(1410)bar-{K0S0,pi-},pi+}   0   0.00029   0.00003   0   99.4   5.5
D0{K*(1680)bar-{K0S0,pi-},pi+}   0   0.01655   0.00100   0   -118.2   3.1
D0{K*(892)+{K0S0,pi+},pi-}   0   0.00098   0.00002   0   -42.2   0.9
D0{K*(1410)+{K0S0,pi+},pi-}   0   0.00021   0.00002   0   150.2   5.3
D0{K(0)*(1430)+[GLASS]{K0S0,pi+},pi-}   0   0.00011   0.00001   0   162.3   6.6
D0{K(2)*(1430)+{K0S0,pi+},pi-}   0   0.00010   0.00001   0   -89.6   7.6
D0{K0S0,rho(770)0{pi+,pi-}}   0   0.20400   0.00000   2   0   0
D0{K0S0,omega(782)0{pi+,pi-}}   0   0.00019   0.00000   0   120.7   0.7
D0{K0S0,f(2)(1270)0{pi+,pi-}}   0   0.01144   0.00024   0   -36.3   1.1
D0{K0S0,rho(1450)0{pi+,pi-}}   0   0.01710   0.00060   0   102.1   1.9
D0{K0S0,PiPi00}   0   0.010000   0.00000   0   0   0
PiPi00[kMatrix.pole.0]{pi+,pi-}   0   8.5   0.5   0   68.5   3.4
PiPi00[kMatrix.pole.1]{pi+,pi-}   0   12.2   0.3   0   24   1.4
PiPi00[kMatrix.pole.2]{pi+,pi-}   0   29.2   1.6   0   -0.1   2.5
PiPi00[kMatrix.pole.3]{pi+,pi-}   0   10.8   0.5   0   -51.9   2.4
PiPi00[kMatrix.prod.0]{pi+,pi-}   0   8   0.4   0   -126   2.5
PiPi00[kMatrix.prod.1]{pi+,pi-}   0   26.3   1.6   0   -152.3   3
PiPi00[kMatrix.prod.2]{pi+,pi-}   0   33   1.8   0   -93.2   3.1
PiPi00[kMatrix.prod.3]{pi+,pi-}   0   26.2   1.3   0   -121.4   2.7
PiPi00_s0_prod   0   -0.07   0   0
K(0)*(1430)bar-_mass   0   1.441   0.002   0.002
K(0)*(1430)bar-_width   0   0.193   0.004   0.004
K(0)*(1430)+::GLASS::F   0   0.96   0.07   0.07
```

Belle in Polar times Fit Fractions



Belle in Polar times Fit Fractions



Belle in Polar times Fit Fractions

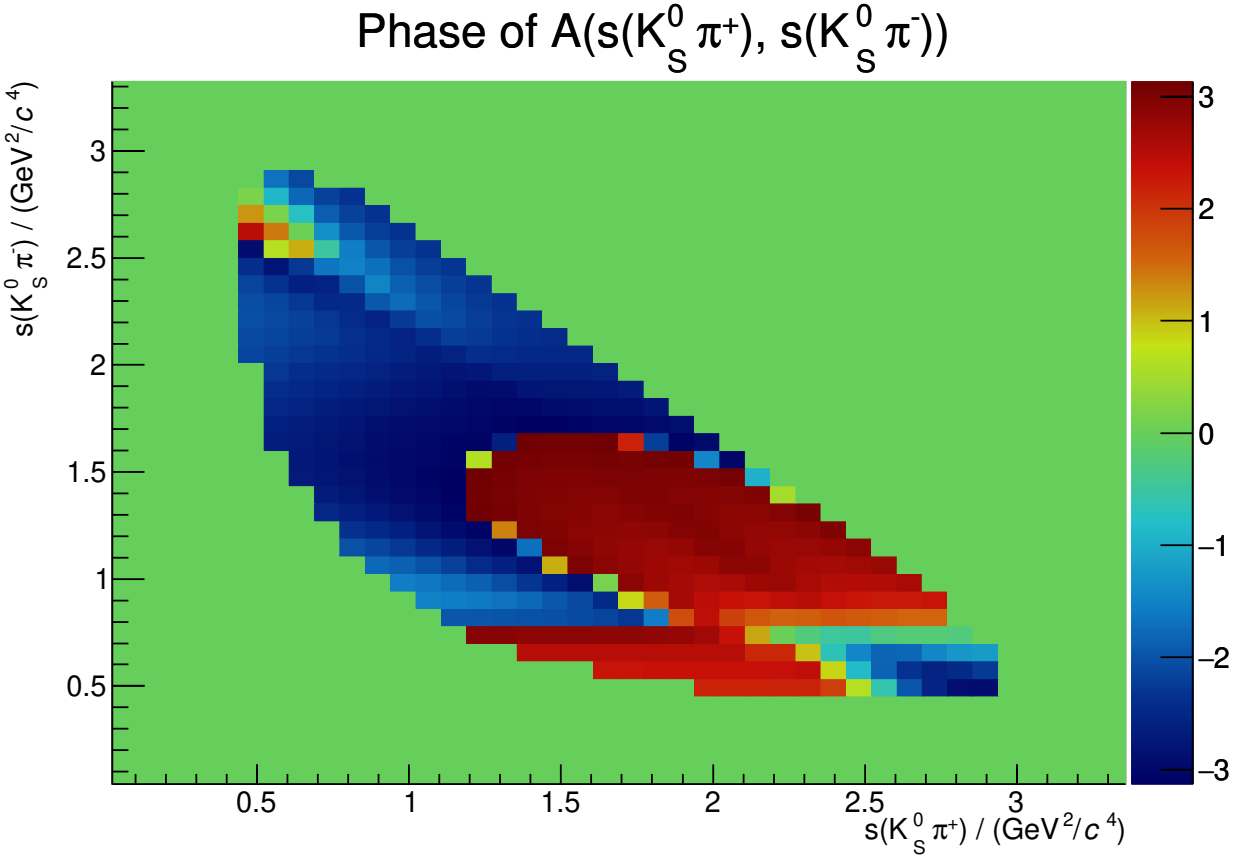


Figure: Argument for Belle in Polar times Fit Fractions

Belle in Polar times Fit Fractions

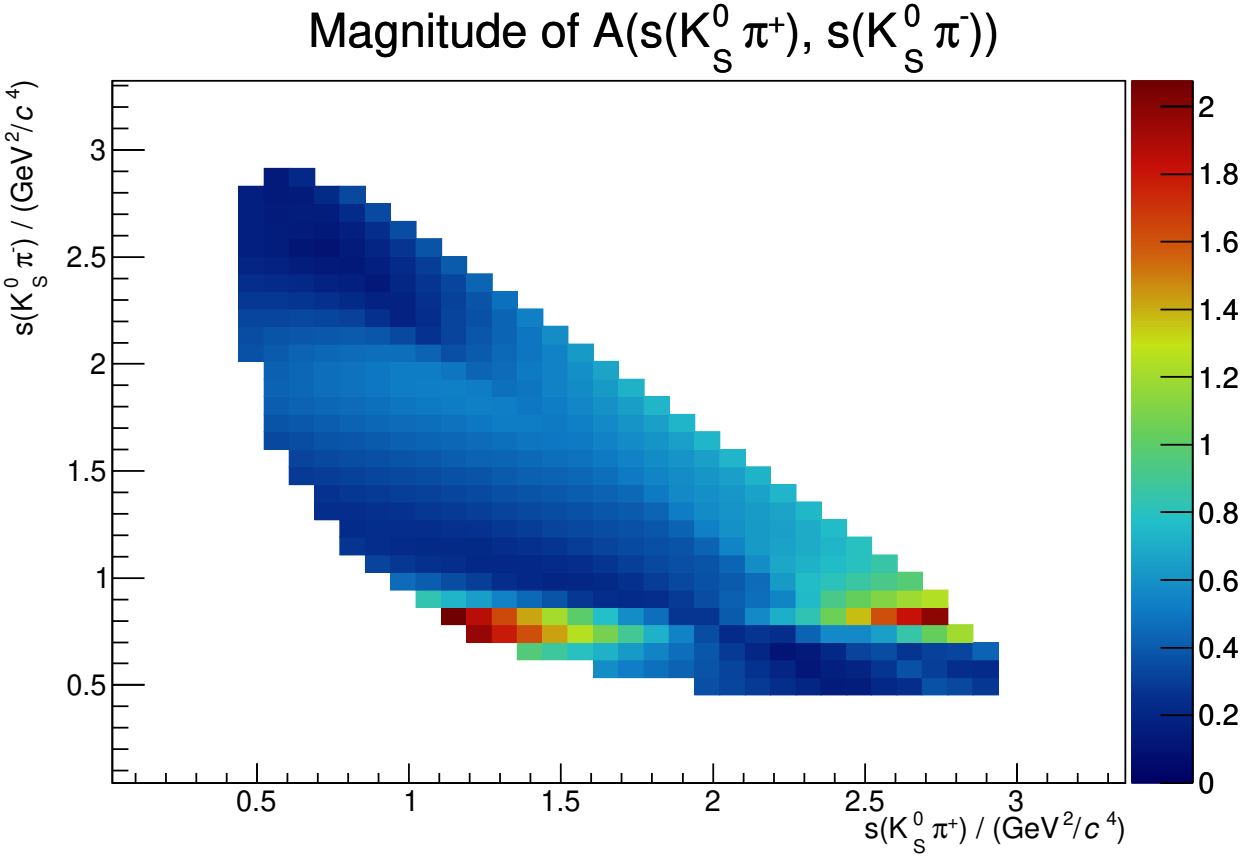


Figure: Magnitude for Belle in Polar times Fit Fractions

Belle in Polar times Fit Fractions

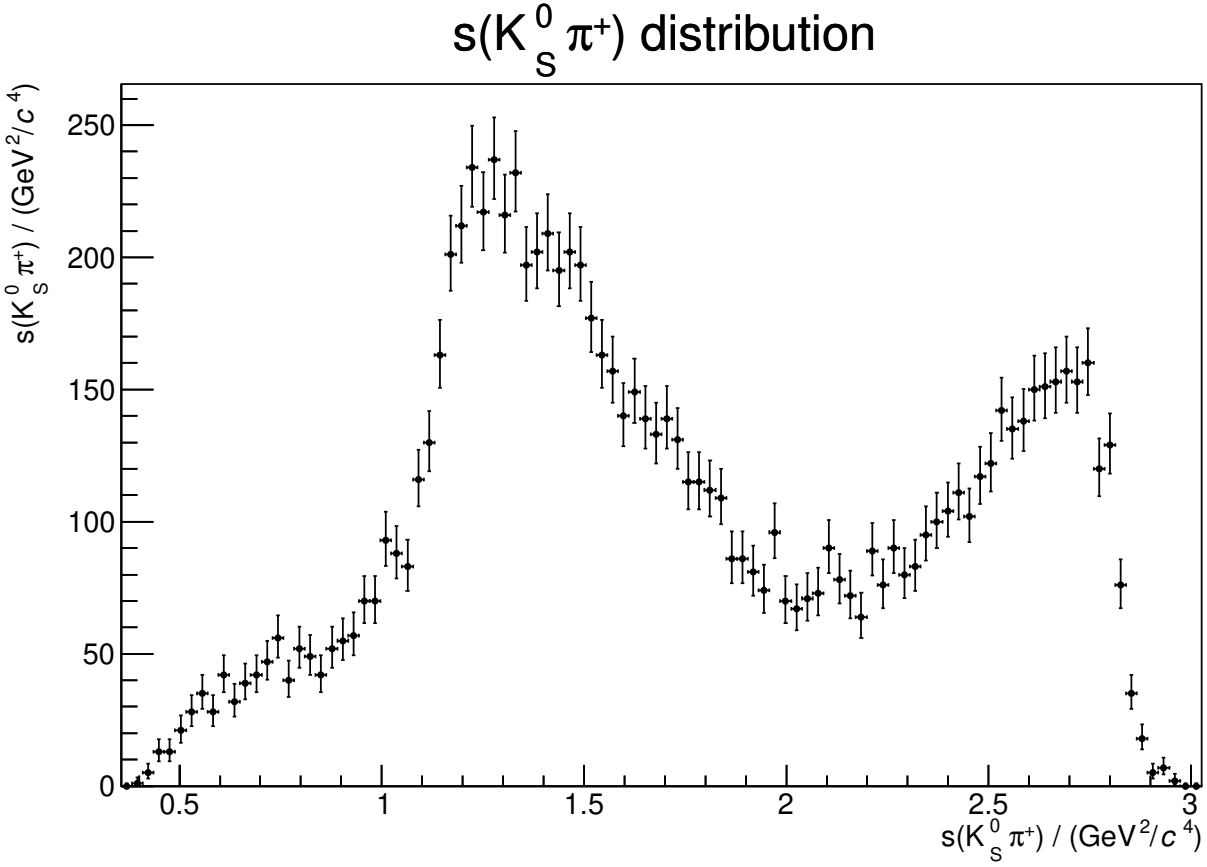


Figure: m^2_+ for Belle in Polar times Fit Fractions

Belle in Polar times Fit Fractions

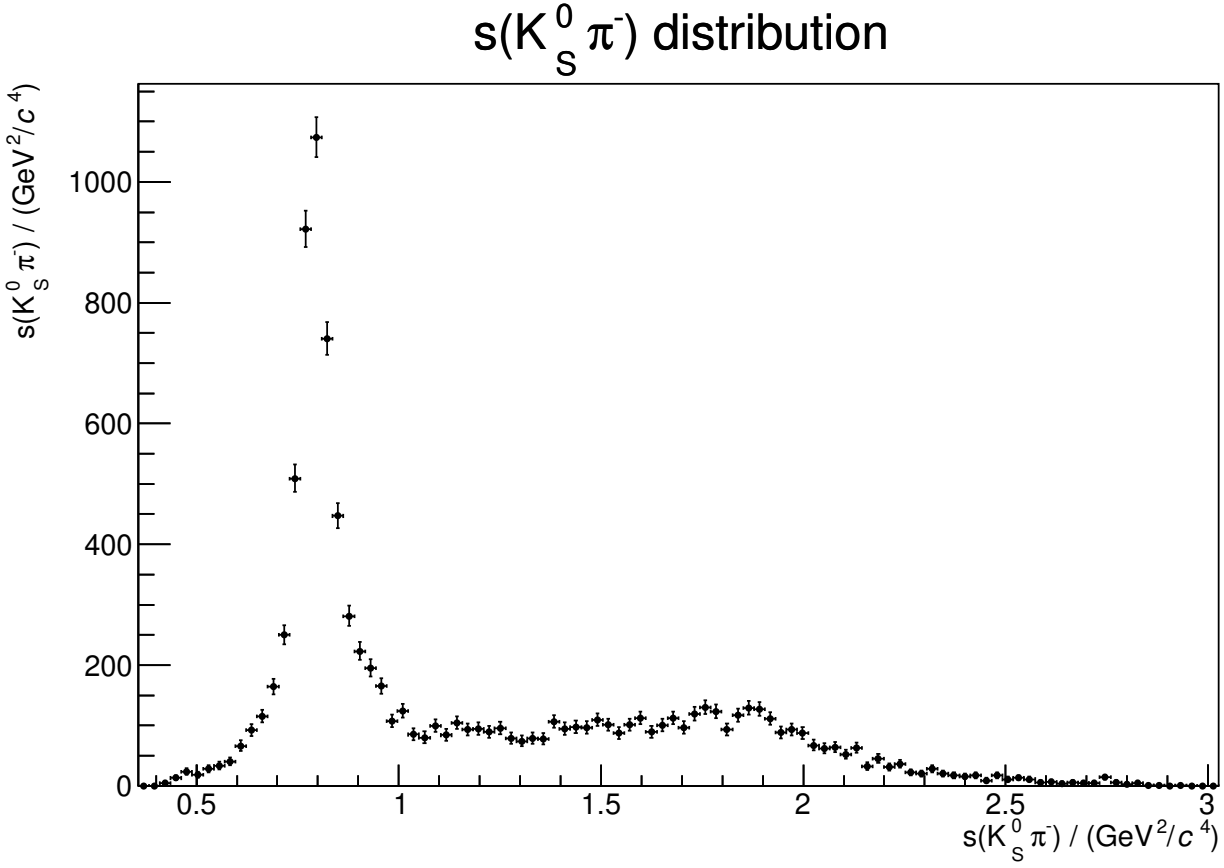


Figure: $m^2\_$ for Belle in Polar times Fit Fractions

Belle in Polar times Fit Fractions

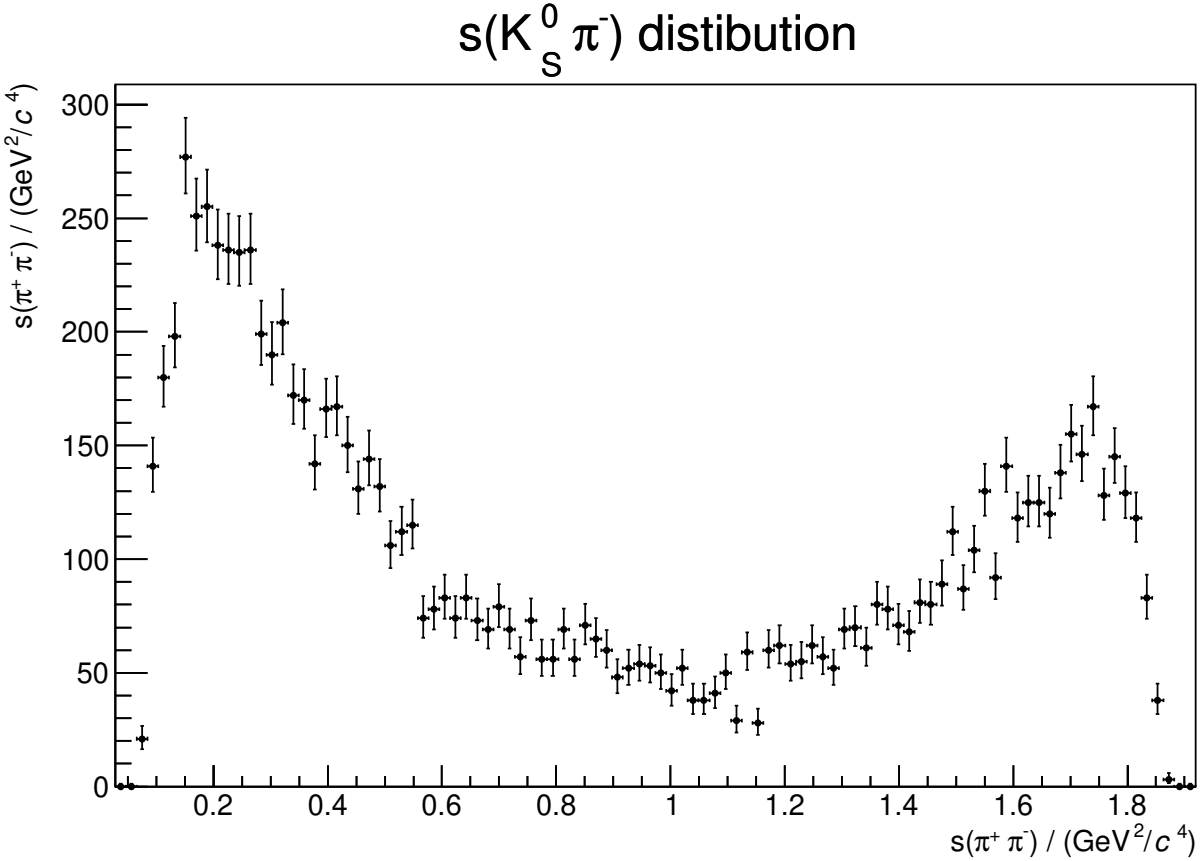


Figure: $m_0^2$for Belle in Polar times Fit Fractions

Belle in Polar times Fit Fractions

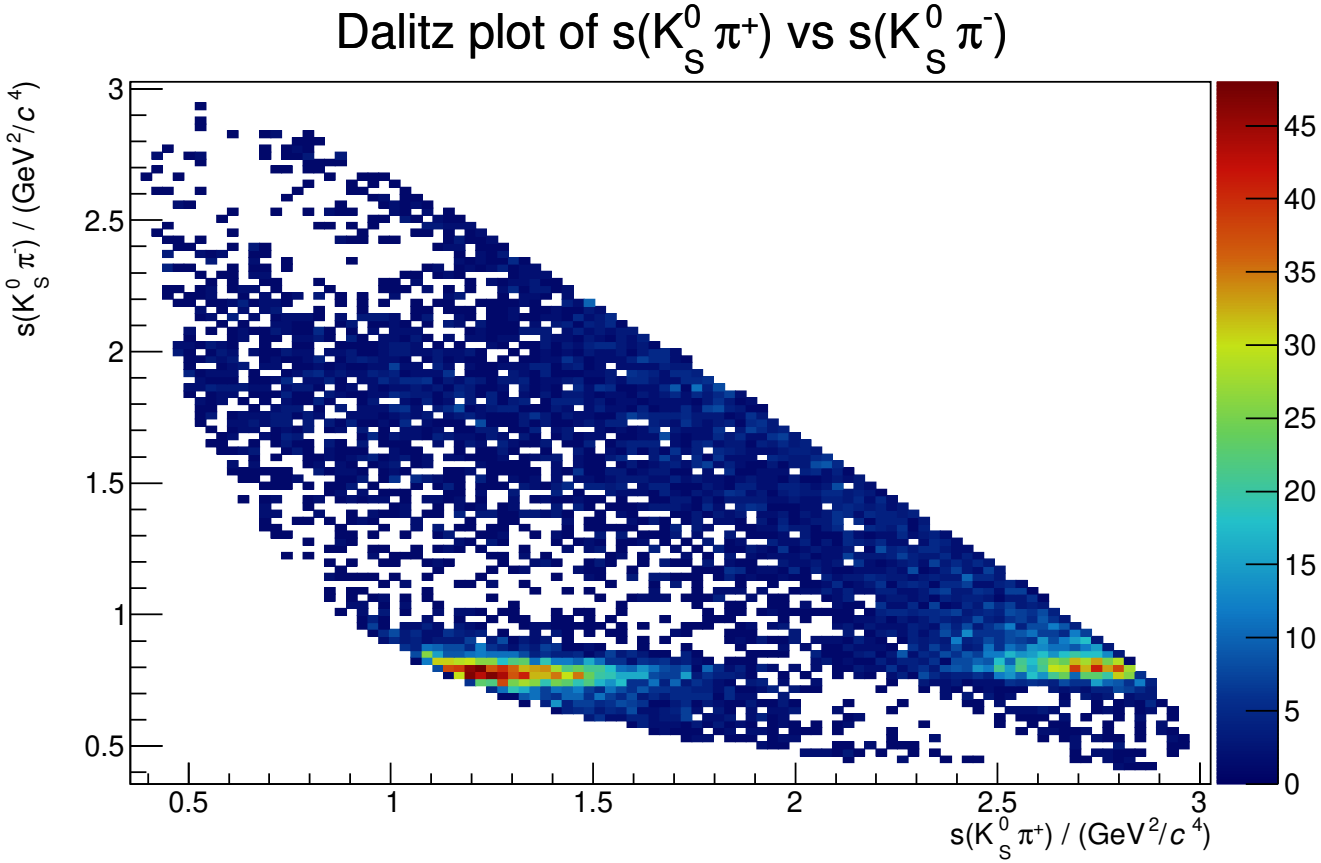


Figure: m^2_+ vs m^2_- for Belle in Polar times Fit Fractions

Belle in Polar times Fit Fractions

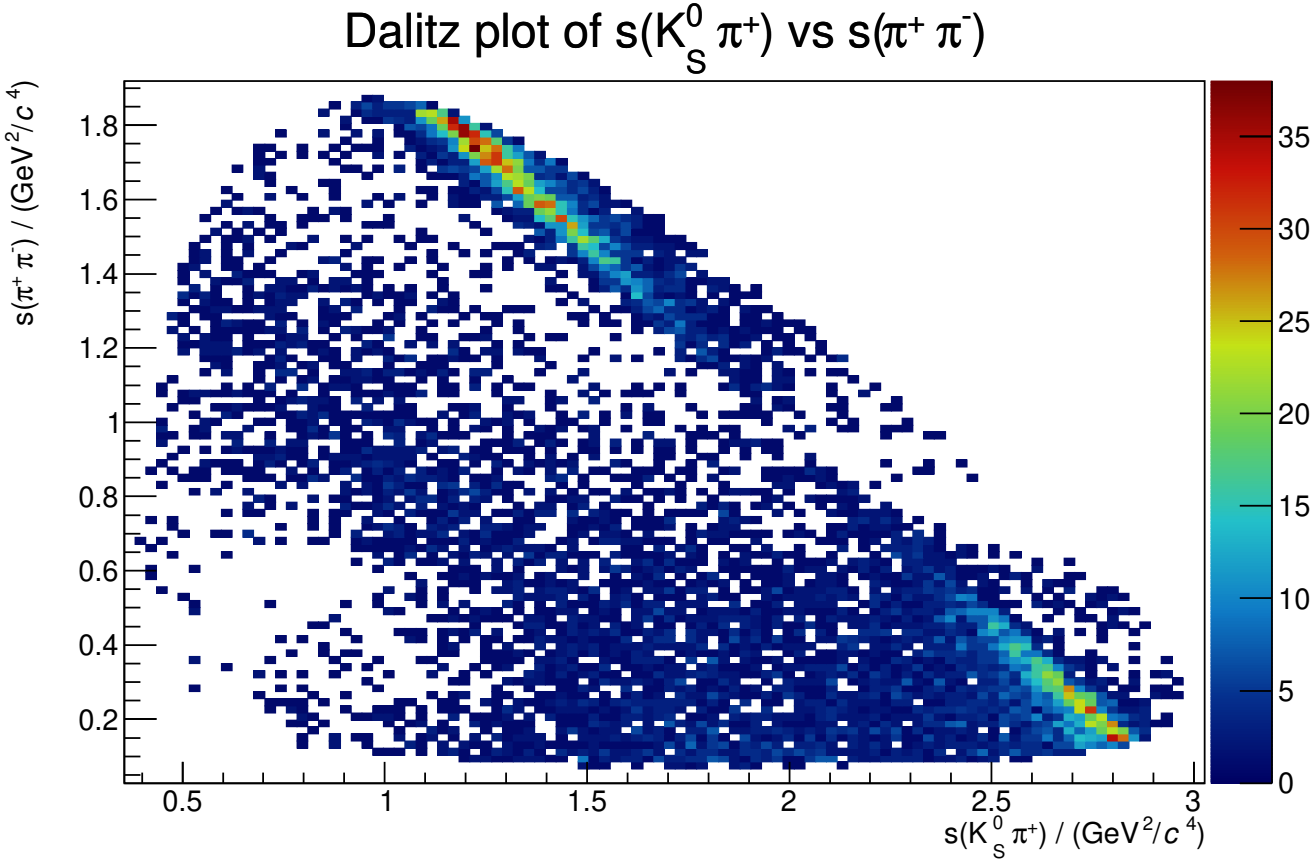


Figure: m_+^2 vs m_0^2 for Belle in Polar times Fit Fractions

Belle in Polar times Fit Fractions

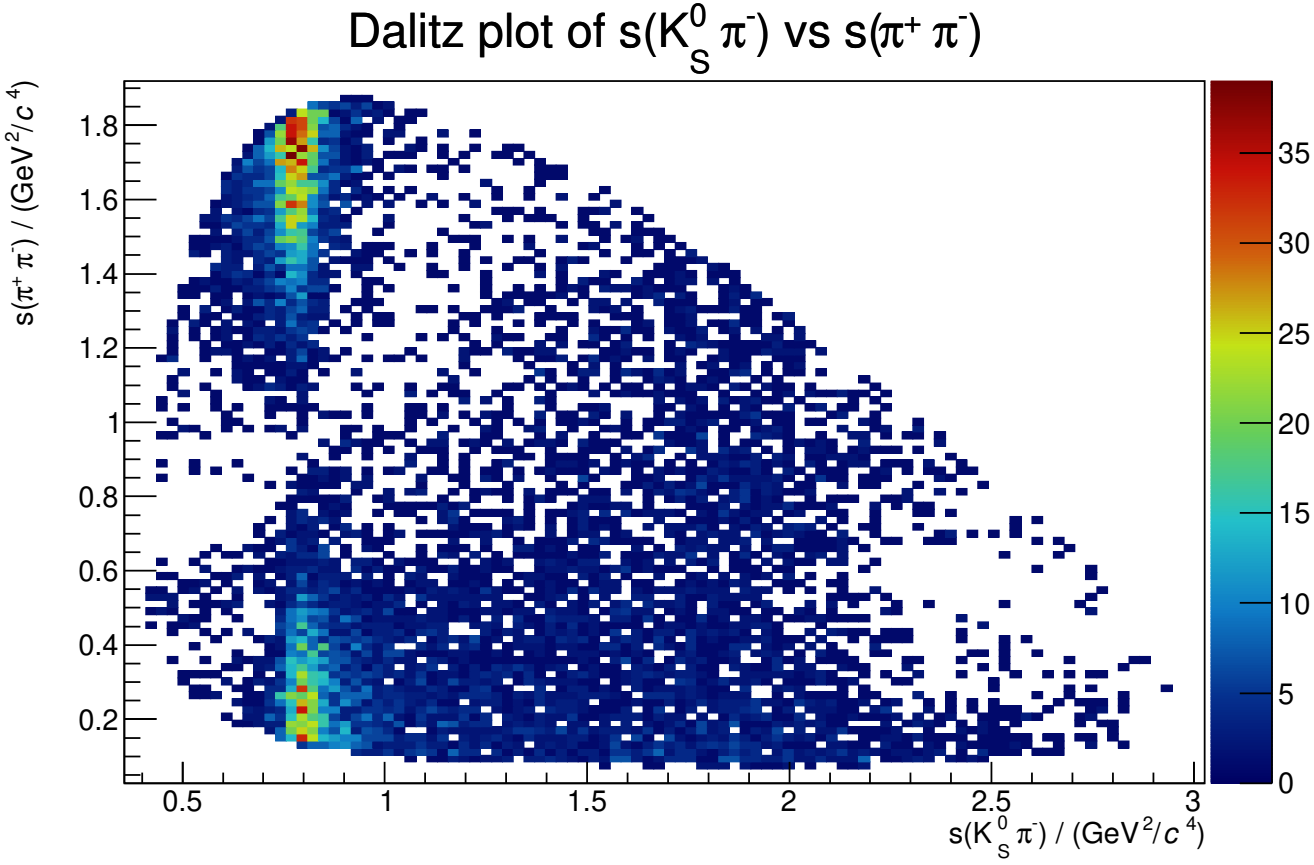


Figure: m_+^2 vs m_0^2 for Belle in Polar times Fit Fractions

Belle in Polar times Fit Fractions

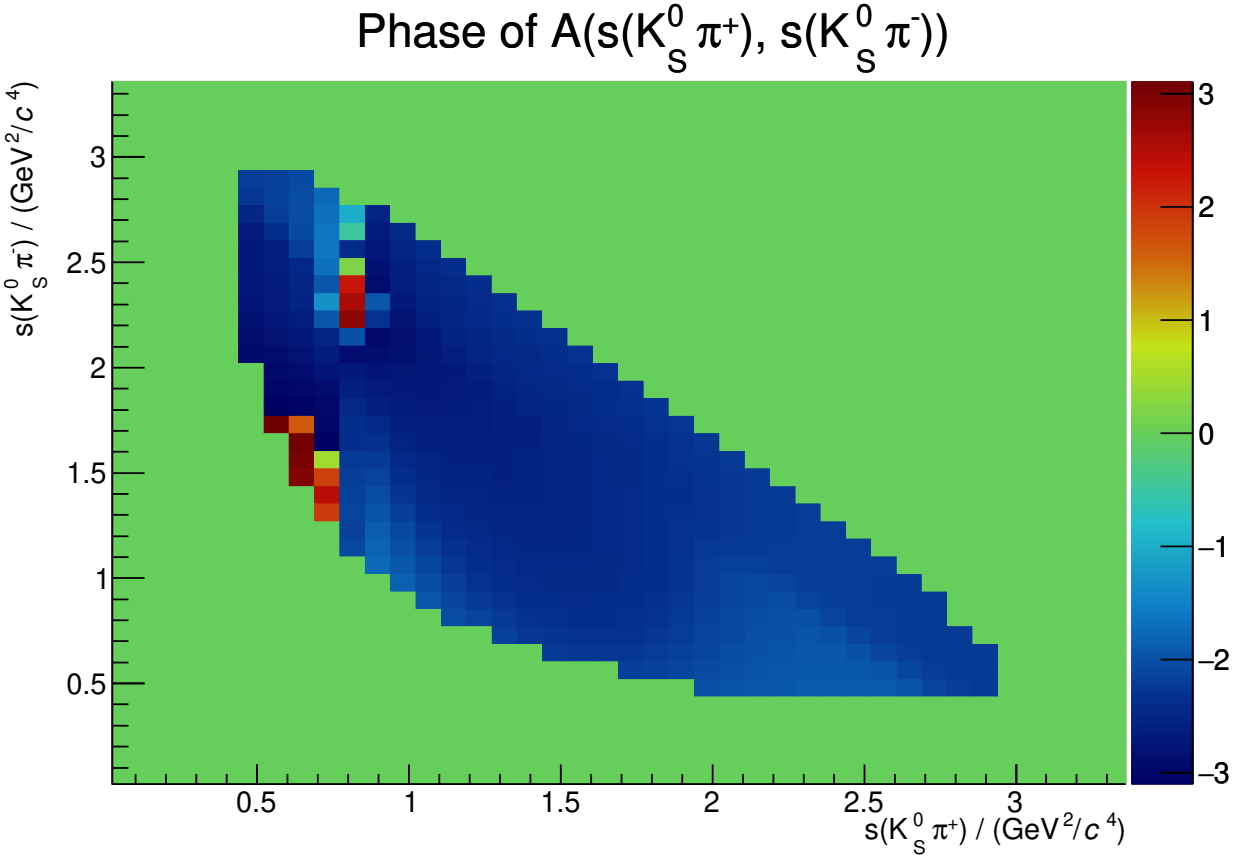


Figure: Argument for Belle in Polar times Fit Fractions

Belle in Polar times Fit Fractions

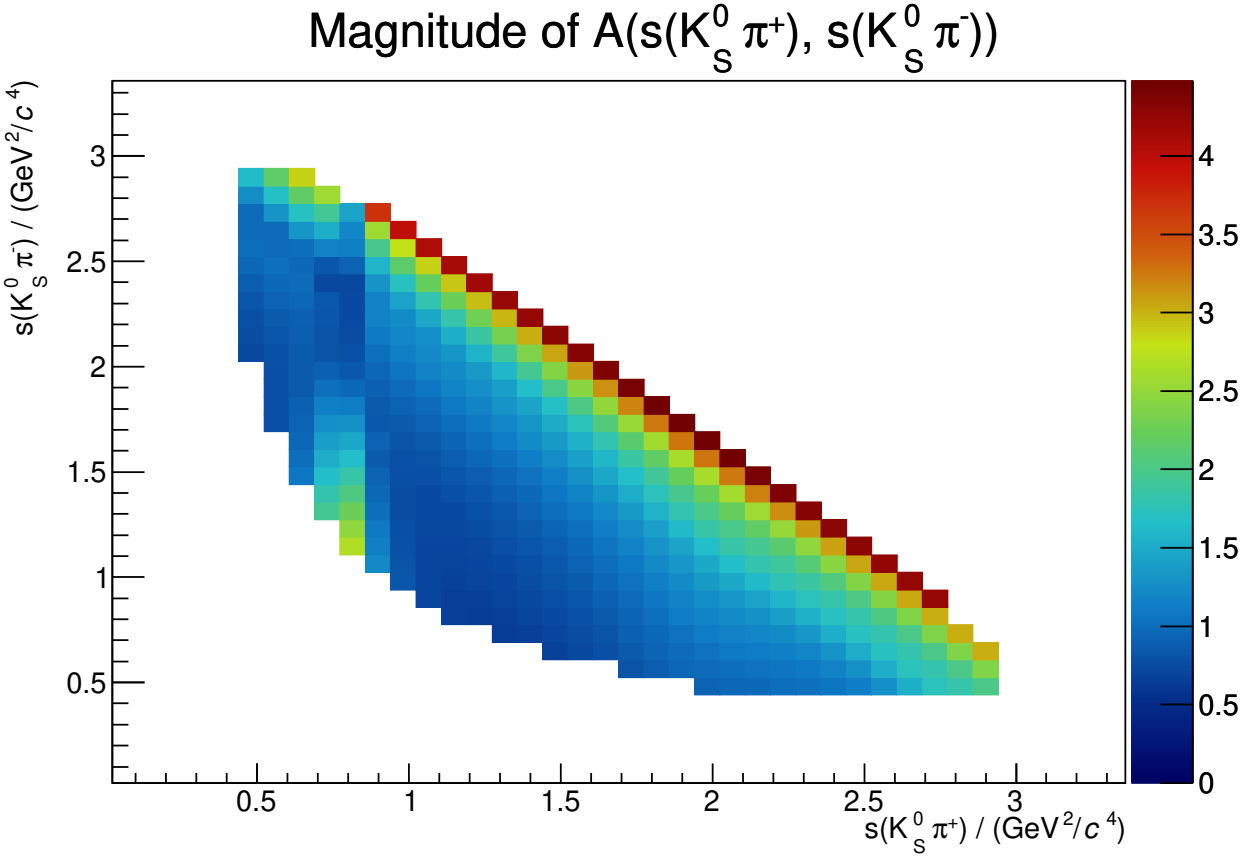


Figure: Magnitude for Belle in Polar times Fit Fractions

Belle in Polar times Fit Fractions

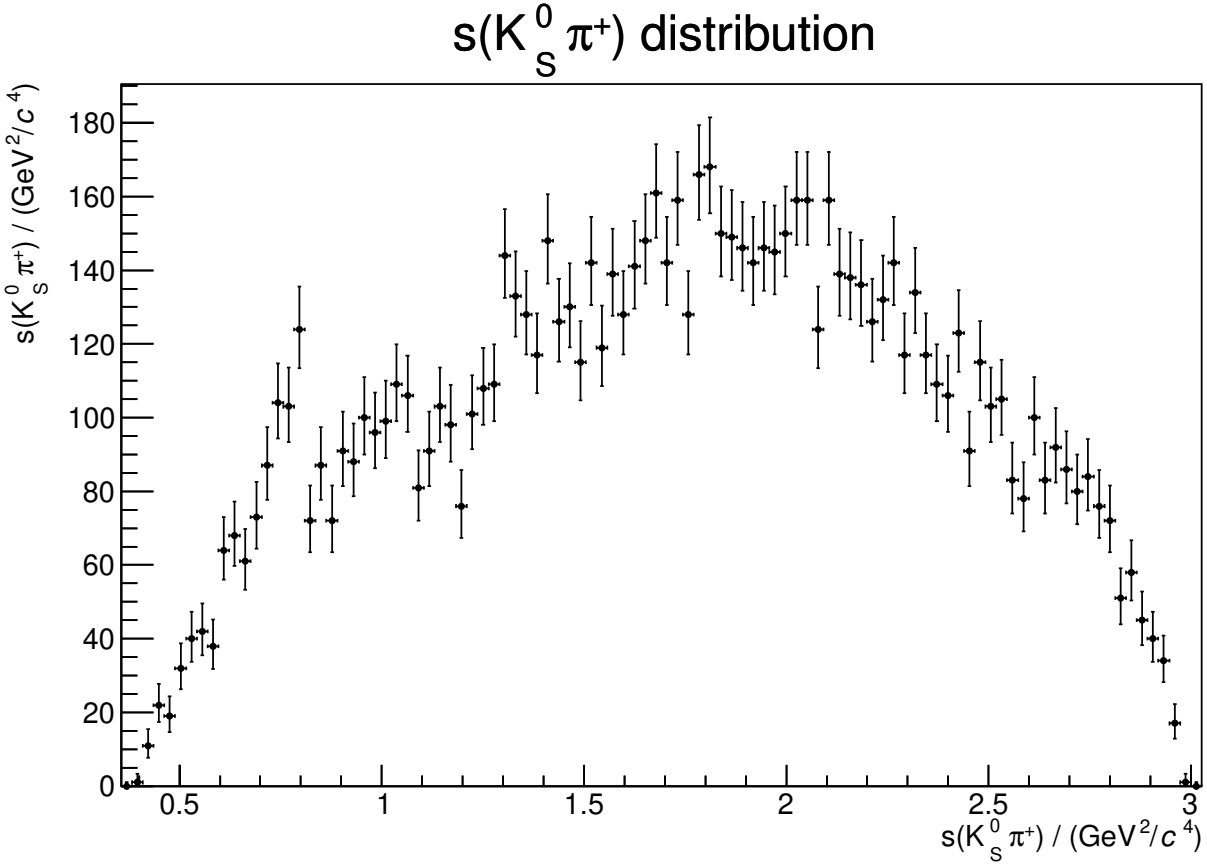


Figure: m_+^2 for Belle in Polar times Fit Fractions

Belle in Polar times Fit Fractions

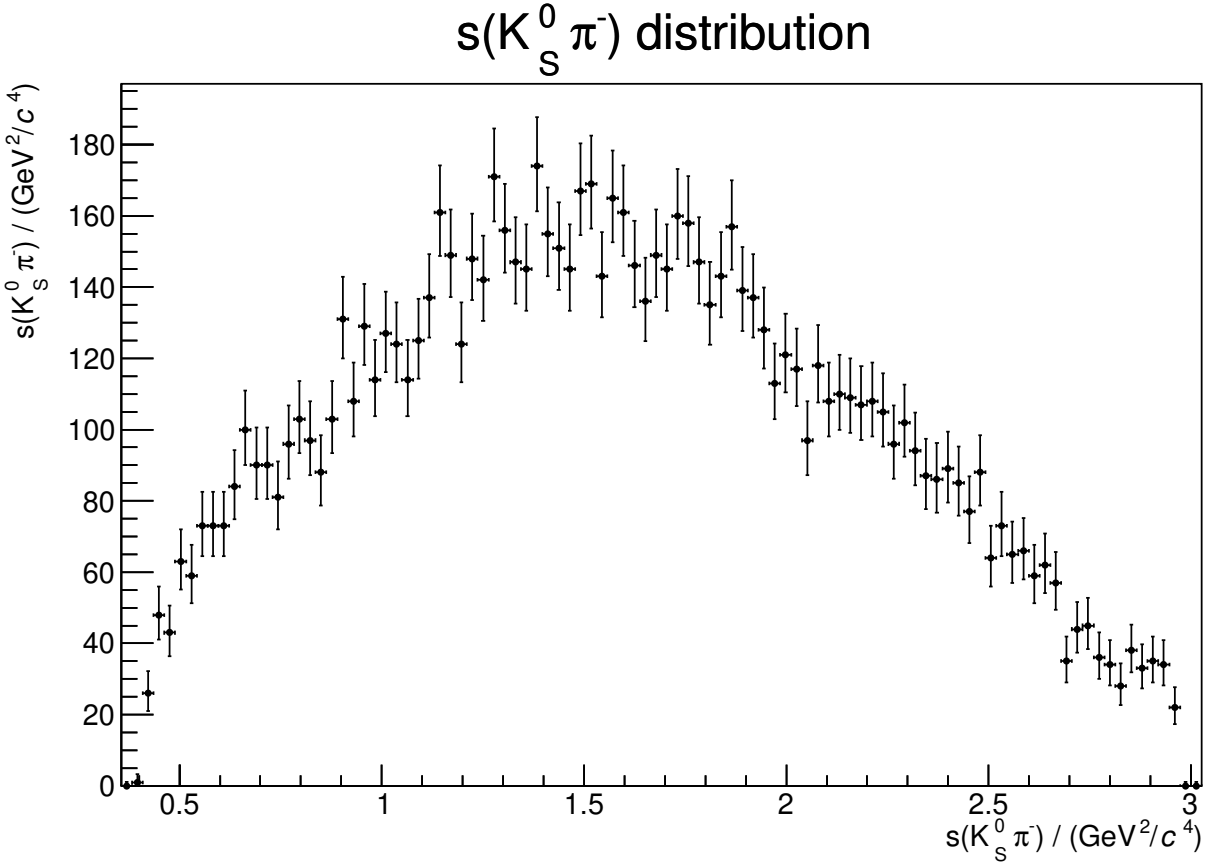


Figure: $m^2\_$ for Belle in Polar times Fit Fractions

Belle in Polar times Fit Fractions

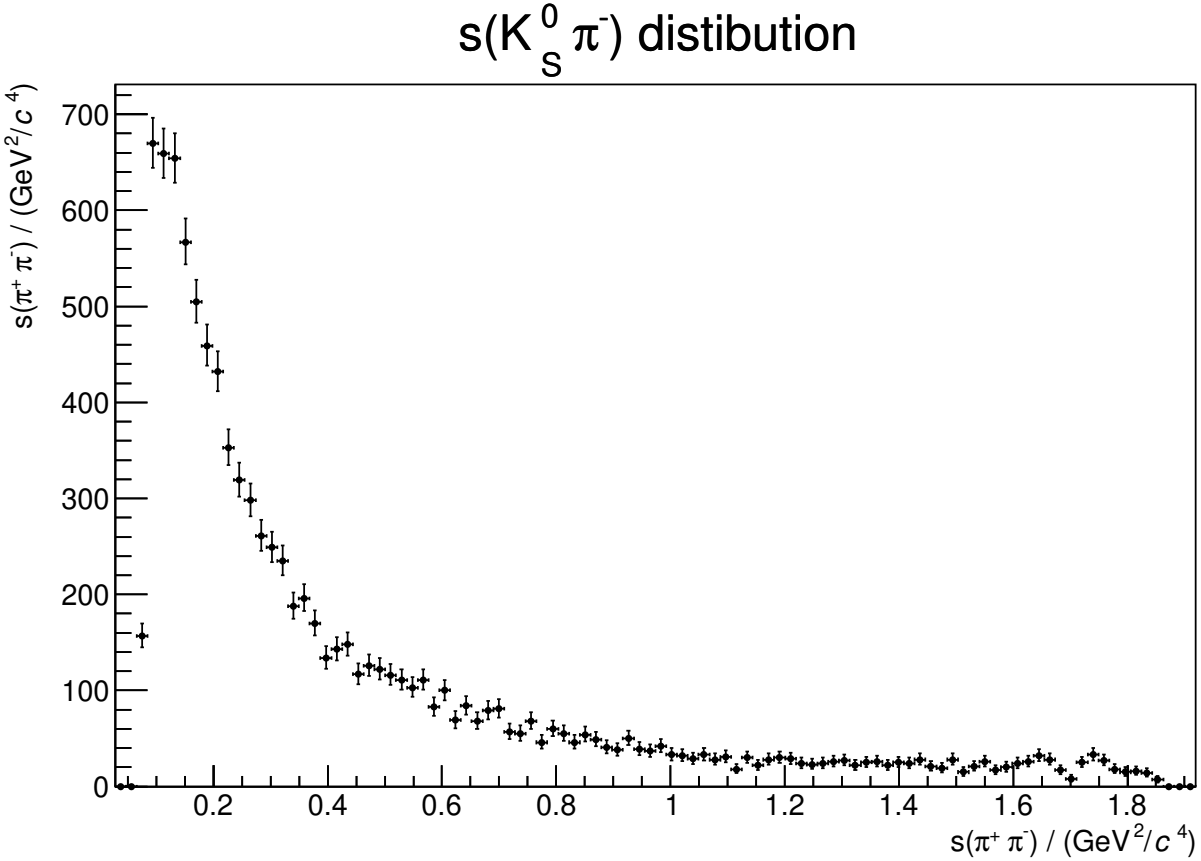


Figure: $m_0^2$for Belle in Polar times Fit Fractions

Belle in Polar times Fit Fractions

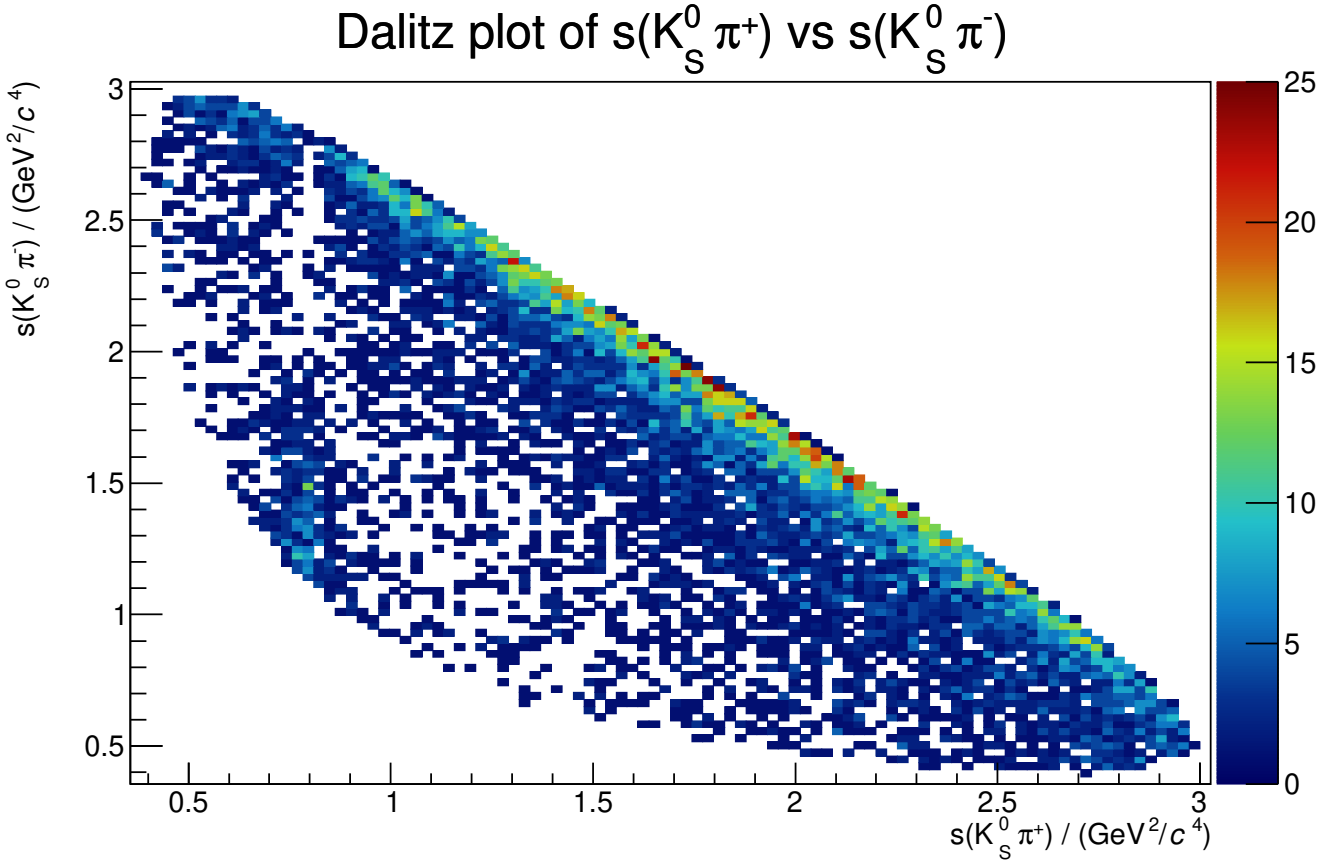


Figure: m^2_+ vs m^2_- for Belle in Polar times Fit Fractions

Belle in Polar times Fit Fractions

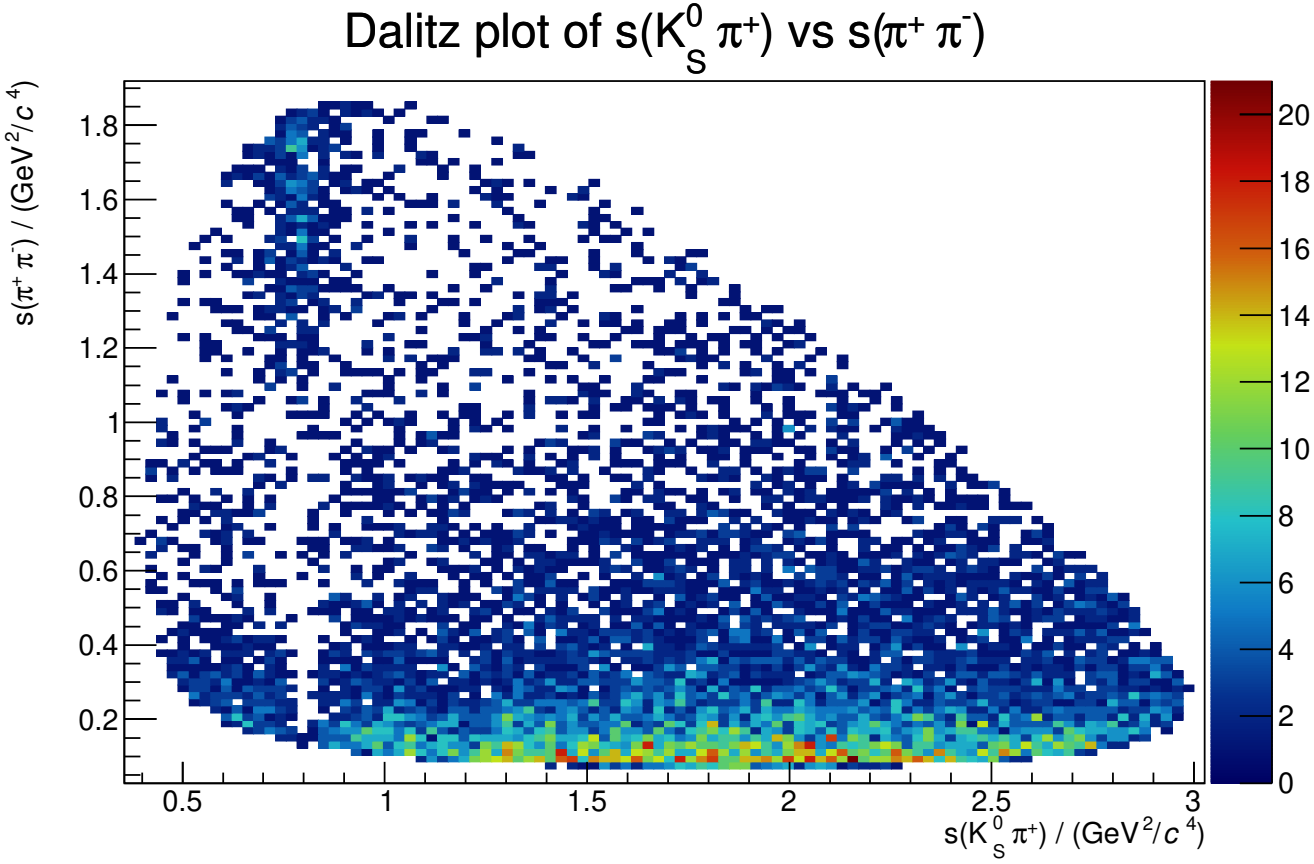


Figure: m_+^2 vs m_0^2 for Belle in Polar times Fit Fractions

Belle in Polar times Fit Fractions

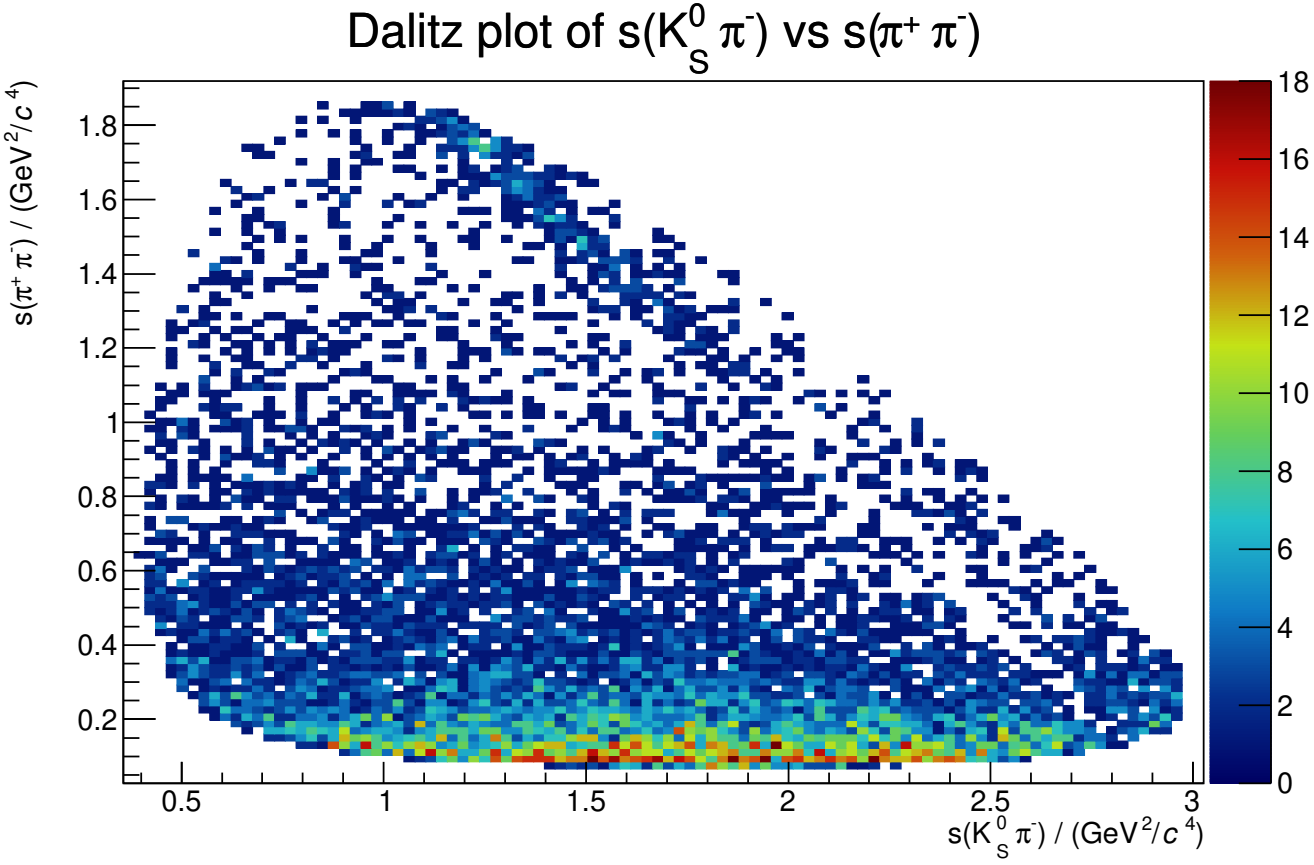


Figure: m_+^2 vs m_0^2 for Belle in Polar times Fit Fractions

To Do

- Cartesian times Fit Fraction
- Convert any model (Belle, BaBar) to Re,Im (use excel?)
- Fitting is also done in Re-Im, it might be an ampGen error?