In[1099]:=
```
Needs["ErrorBarPlots`"]
```

In[1100]:=
```
SetDirectory[NotebookDirectory[]]
```

Out[1100]= /Users/miham/Desktop/ISR/RadiusFit

Normalized to First two points

Data

In[1174]:=
```
M = 0.93827;
mup = 2.79;
ħc = 0.197327;
```

In[1177]:=
```
Tau[Q2_] := Q2/(4 M^2)
```

In[1178]:=
```
Eps[th_, Q2_] := (1 + 2 (1 + Tau[Q2]) Tan[th/2]^2)^-1
```

In[1179]:=
```
GD[x_, a_, n_] := 1/(1 + x/a)^2 * n
```

In[1180]:=
```
GM[Q2_, R_, n_, a_, b_] := n (1 - 1/(6 * ħc^2) R^2 Q2 + a/(120 * ħc^4) Q2^2 - b/(5040 * ħc^6) Q2^3)
```

In[1181]:=
```
data1 = Select[Map[{#[[1]], #[[2]], #[[3]]} &,
   Import["ISRFormFactor495MeV.dat"]], #[[1]] < 0.016 &]
```

Out[1181]=
```
{{0.0153986, 0.954274, 0.00248027},
 {0.0128783, 0.958762, 0.00166176}, {0.0110455, 0.967815, 0.00182807},
 {0.0095245, 0.965169, 0.00165552}, {0.00819877, 0.974091, 0.00239891},
 {0.00708697, 0.973257, 0.00201998}, {0.0061315, 0.975922, 0.00200291}}
```

In[1182]:=
```
data2 = Select[Map[{#[[1]], #[[2]], #[[3]]} &,
   Import["ISRFormFactor330MeV.dat"]], (#[[1]] < 0.0078) &]
```

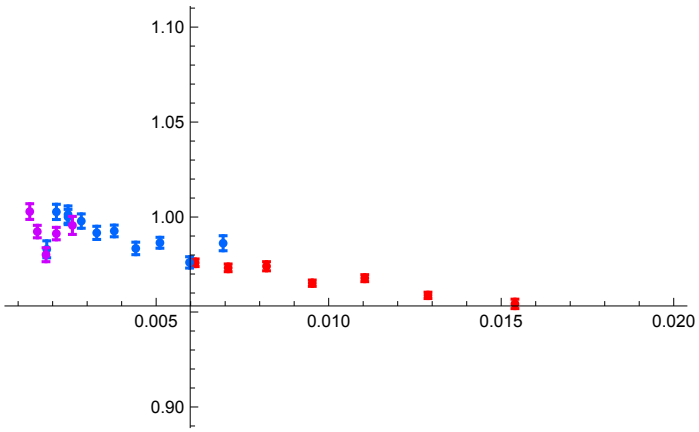
Out[1182]=
```
{{0.0069408, 0.986208, 0.00395242},
 {0.00596758, 0.976116, 0.00297658}, {0.00510955, 0.986458, 0.00286456},
 {0.00440878, 0.983472, 0.00328641}, {0.0037858, 0.992677, 0.00306621},
 {0.00327766, 0.991667, 0.00346276}, {0.00283015, 0.997873, 0.00377442},
 {0.00244682, 1.00003, 0.00401119}, {0.00244627, 1.00132, 0.00452273},
 {0.00210893, 1.00271, 0.00400617}, {0.00182937, 0.983021, 0.00445701}}
```

In[1183]:=
```
data3 = Select[Map[{#[[1]], #[[2]], #[[3]]} &,
   Import["ISRFormFactor195MeV.dat"]], (#[[1]] < 0.0027) &]
```

Out[1183]=
```
{{0.00257314, 0.995588, 0.00474331},
 {0.00210662, 0.991287, 0.00326861}, {0.00180739, 0.980164, 0.00367344},
 {0.001556, 0.992348, 0.00328127}, {0.00133657, 1.00288, 0.00412765}}
```

In[1184]:=
```
Show[ErrorListPlot[Map[{{#[[1]], #[[2]]}, ErrorBar[#[[3]]]} &, data1],
  PlotStyle → Hue[0]], ErrorListPlot[
  Map[{{#[[1]], #[[2]]}, ErrorBar[#[[3]]]} &, data2], PlotStyle → Hue[0.6]],
 ErrorListPlot[Map[{{#[[1]], #[[2]]}, ErrorBar[#[[3]]]} &, data3],
  PlotStyle → Hue[0.8]], PlotRange → {{0.001, 0.02}, {0.9, 1.1}}]
```

Out[1184]=



Join

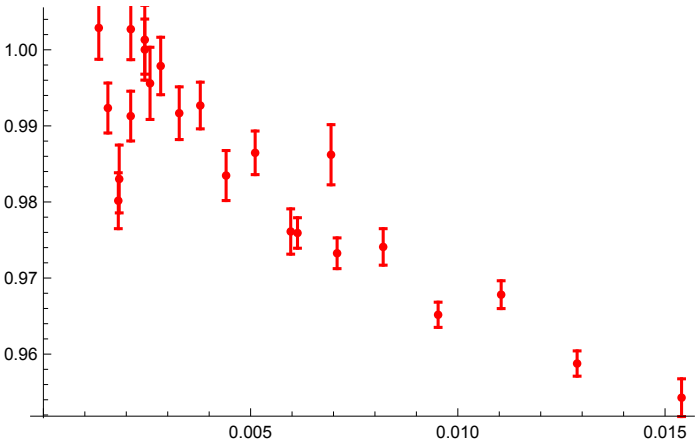
In[1185]:=
```
data = Join[data1, data2, data3];
```

In[1186]:=
```
Length[data]
```

Out[1186]= 23

In[1187]:=
```
s1 = Show[ErrorListPlot[
    Map[{{#[[1]], #[[2]]}, ErrorBar[#[[3]]]} &, data], PlotStyle → Hue[0]]]
```

Out[1187]=



Manual Fit with Chi2

In[1200]:=
```
Chi2b[R_, n1_, n2_, n3_, a_, b_, data1_, data2_, data3_] :=
 (1 / (Length[data1] + Length[data2] + Length[data3] - 2))
  (Sum[(GM[data1[[i, 1]], R, 1, a, b] - n1 * data1[[i, 2]])^2 / (n1^2 * data1[[i, 3]]^2),
    {i, 1, Length[data1]}] +
   Sum[(GM[data2[[i, 1]], R, 1, a, b] - n2 * data2[[i, 2]])^2 /
     (n2^2 * data2[[i, 3]]^2), {i, 1, Length[data2]}] +
   Sum[(GM[data3[[i, 1]], R, 1, a, b] - n3 * data3[[i, 2]])^2 / (n3^2 * data3[[i, 3]]^2),
    {i, 1, Length[data3]}])
```

In[1201]:=
```
min = FindMinimum[Chi2b[RR, nnn1, nnn2, nnn3, 2.59, 29.8, data1, data2, data3],
  {{RR, 0.88}, {nnn1, 1}, {nnn2, 1}, {nnn3, 1}}, AccuracyGoal → 6]
```

FindMinimum::lstol :
The line search decreased the step size to within the tolerance specified by AccuracyGoal and PrecisionGoal but was unable to find a sufficient decrease in the function. You may need more than MachinePrecision digits of working precision to meet these tolerances. >>

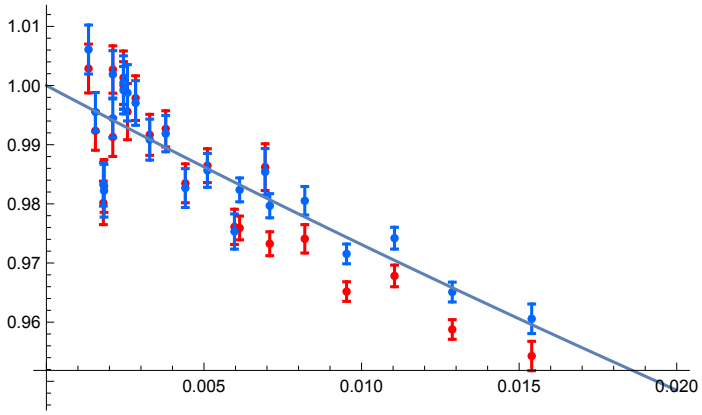
Out[1201]=
```
{2.7069, {RR → 0.811734, nnn1 → 1.0066, nnn2 → 0.999184, nnn3 → 1.0032}}
```

In[1198]:=
```
min[[2]]
```

Out[1198]=
```
{RR → 0.811734, nnn1 → 1.0066, nnn2 → 0.999184, nnn3 → 1.0032}
```

In[1199]:=
```
Show[s1, ErrorListPlot[
  Map[{{#[[1]], #[[2]] * nnn1 /. min[[2]]}, ErrorBar[#[[3]] * nnn1] /. min[[2]]} &,
   data1], PlotStyle → Hue[0.6]], ErrorListPlot[
  Map[{{#[[1]], #[[2]] * nnn2 /. min[[2]]}, ErrorBar[#[[3]] * nnn2] /. min[[2]]} &,
   data2], PlotStyle → Hue[0.6]] , ErrorListPlot[
  Map[{{#[[1]], #[[2]] * nnn3 /. min[[2]]}, ErrorBar[#[[3]] * nnn3] /. min[[2]]} &,
   data3], PlotStyle → Hue[0.6]],
 Plot[GM[x, RR, 1, 2.59, 29.8] /. min[[2]], {x, 0, 0.02}], PlotRange → All]
```

Out[1199]=



Form - Factor Errorband

In[1202]:=
```
FindMyUncertainty[a_, b_, data1_, data2_, data3_] := Module[{},
  Sata1 = Map[{#[[1]], RandomVariate[NormalDistribution[#[[2]], #[[3]]], 1][[1]],
      #[[3]]} &, data1];
  Sata2 = Map[{#[[1]], RandomVariate[NormalDistribution[#[[2]], #[[3]]], 1][[1]],
      #[[3]]} &, data2];
  Sata3 = Map[{#[[1]], RandomVariate[NormalDistribution[#[[2]], #[[3]]], 1][[1]],
      #[[3]]} &, data3];
  min = FindMinimum[Chi2b[RR, nnn1, nnn2, nnn3, a, b, Sata1, Sata2, Sata3],
    {RR, nnn1, nnn2, nnn3}, AccuracyGoal → 10];
  {min[[1]], RR, nnn1, nnn2, nnn3} /. min[[2]]
 ]
```

In[1206]:=
```
FindMyUncertainty[2.59, 29.8, data1, data2, data3]
```

Out[1206]=
```
{4.07194, 0.864463, 1.00262, 0.997617, 1.00127}
```

In[1204]:=
```
FindMyUncertainties[a_, b_, data1_, data2_, data3_, NN_] := Module[{},
  list = Table[FindMyUncertainty[2.59, 29.8, data1, data2, data3], {x, 1, NN}];
  rlist = Map[#[[2]] &, list];
  mr = Mean[rlist];
  sr = Sqrt[Variance[rlist]];
  n1list = Map[#[[3]] &, list];
  mn1 = Mean[n1list];
  sn1 = Sqrt[Variance[n1list]];
  n2list = Map[#[[4]] &, list];
  mn2 = Mean[n2list];
  sn2 = Sqrt[Variance[n2list]];
  n3list = Map[#[[5]] &, list];
  mn3 = Mean[n3list];
  sn3 = Sqrt[Variance[n3list]];
  {mr, sr, mn1, sn1, mn2, sn2, mn3, sn3}
 ]
```

In[1205]:=
```
res = FindMyUncertainties[2.59, 29.8, data1, data2, data3, 5000]
```

FindMinimum::lstol :
The line search decreased the step size to within the tolerance specified by AccuracyGoal and PrecisionGoal but was unable to find a sufficient decrease in the function. You may need more than MachinePrecision digits of working precision to meet these tolerances. ≫

FindMinimum::lstol :
The line search decreased the step size to within the tolerance specified by AccuracyGoal and PrecisionGoal but was unable to find a sufficient decrease in the function. You may need more than MachinePrecision digits of working precision to meet these tolerances. ≫

FindMinimum::lstol :
The line search decreased the step size to within the tolerance specified by AccuracyGoal and PrecisionGoal but was unable to find a sufficient decrease in the function. You may need more than MachinePrecision digits of working precision to meet these tolerances. ≫

General::stop : Further output of FindMinimum::lstol will be suppressed during this calculation. ≫

Out[1205]=
```
{0.81192, 0.0345931, 1.00652, 0.00257676,
 0.999169, 0.00144796, 1.00316, 0.00172539}
```

Systematic Uncertainty

495 MeV

In[1207]:=
```
PointSyst495MeVData = Import["ISRFFSystematicalErrorPoint495MeV.dat"]
PointSyst495 = Interpolation[Map[{#[[1]], #[[2]] / 100} &, PointSyst495MeVData]];
```

Out[1207]=
```
{{0.0153986, 0.403967, 0}, {0.0128783, 0.384207, 0},
 {0.0110455, 0.361889, 0}, {0.0095245, 0.344299, 0},
 {0.00819877, 0.338176, 0}, {0.00708697, 0.35687, 0}, {0.0061315, 0.35908, 0}}
```

In[1209]:=
```
PointSyst495[0.01]
```

Out[1209]=
```
0.00349017
```

In[1210]:=
```
Combined495MeV = Map[{#[[1]], #[[2]], #[[3]], PointSyst495[#[[1]]]} &, data1]
```

Out[1210]=
```
{{0.0153986, 0.954274, 0.00248027, 0.00403967},
 {0.0128783, 0.958762, 0.00166176, 0.00384207},
 {0.0110455, 0.967815, 0.00182807, 0.00361889},
 {0.0095245, 0.965169, 0.00165552, 0.00344299},
 {0.00819877, 0.974091, 0.00239891, 0.00338176},
 {0.00708697, 0.973257, 0.00201998, 0.0035687},
 {0.0061315, 0.975922, 0.00200291, 0.0035908}}
```

In[1211]:=
```
SlopeSyst495MeVData =
 Map[{#[[1]], #[[2]] / 100} &, Import["ISRFFSystematicalErrorSlope495MeV.dat"]]
SlopeSyst495 = Interpolation[Map[{#[[1]], #[[2]]} &, SlopeSyst495MeVData]];
```

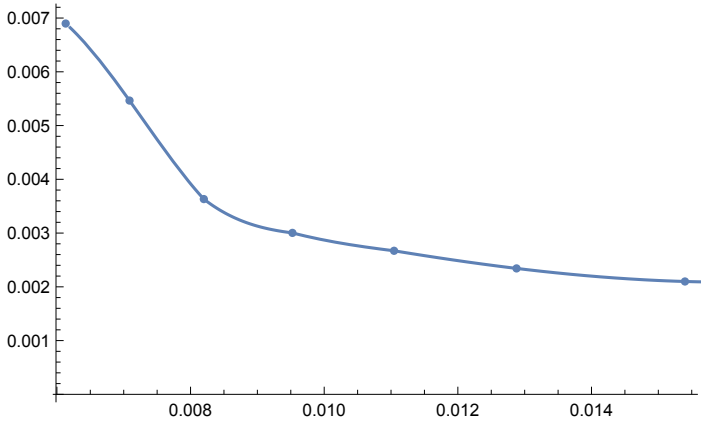
Out[1211]=
```
{{0.0153986, 0.0020994}, {0.0128783, 0.00234249},
 {0.0110455, 0.00267047}, {0.0095245, 0.00300334},
 {0.00819877, 0.00363237}, {0.00708697, 0.00546488}, {0.0061315, 0.0068979}}
```

In[1213]:=
```
SlopeSyst495[0.01]
```

Out[1213]=
```
0.00286954
```

In[1214]:=
```
Show[ListPlot[SlopeSyst495MeVData], Plot[SlopeSyst495[x], {x, 0.0062, 0.017}]]
```

Out[1214]=



In[1215]:=
```
RandomVariate[NormalDistribution[0, 1], 1][[1]]
```

Out[1215]=
```
-1.58639
```

330 MeV

In[1216]:=
```
PointSyst330MeVData = Import["ISRFFSystematicalErrorPoint330MeV.dat"]
PointSyst330 = Interpolation[Map[{#[[1]], #[[2]] / 100} &, PointSyst330MeVData]];
```

Out[1216]=
```
{{0.0069408, 0.463081, 0}, {0.00596758, 0.44474, 0},
 {0.00510955, 0.427791, 0}, {0.00440878, 0.439617, 0}, {0.0037858, 0.434908, 0},
 {0.00327766, 0.436471, 0}, {0.00283015, 0.449245, 0}, {0.00244682, 0.485443, 0},
 {0.00244627, 0.485439, 0}, {0.00210893, 0.548021, 0}, {0.00182937, 0.634935, 0}}
```

In[1218]:=
```
PointSyst330[0.005]
```

Out[1218]=
```
0.00429323
```

In[1219]:=
```
Combined330MeV = Map[{#[[1]], #[[2]], #[[3]], PointSyst330[#[[1]]]} &, data2]
```

Out[1219]=
```
{{0.0069408, 0.986208, 0.00395242, 0.00463081},
 {0.00596758, 0.976116, 0.00297658, 0.0044474},
 {0.00510955, 0.986458, 0.00286456, 0.00427791},
 {0.00440878, 0.983472, 0.00328641, 0.00439617},
 {0.0037858, 0.992677, 0.00306621, 0.00434908},
 {0.00327766, 0.991667, 0.00346276, 0.00436471},
 {0.00283015, 0.997873, 0.00377442, 0.00449245},
 {0.00244682, 1.00003, 0.00401119, 0.00485443},
 {0.00244627, 1.00132, 0.00452273, 0.00485439},
 {0.00210893, 1.00271, 0.00400617, 0.00548021},
 {0.00182937, 0.983021, 0.00445701, 0.00634935}}
```

In[1220]:=
```
SlopeSyst330MeVData =
 Map[{#[[1]], #[[2]] / 100} &, Import["ISRFFSystematicalErrorSlope330MeV.dat"]]
SlopeSyst330 = Interpolation[Map[{#[[1]], #[[2]]} &, SlopeSyst330MeVData]];
```

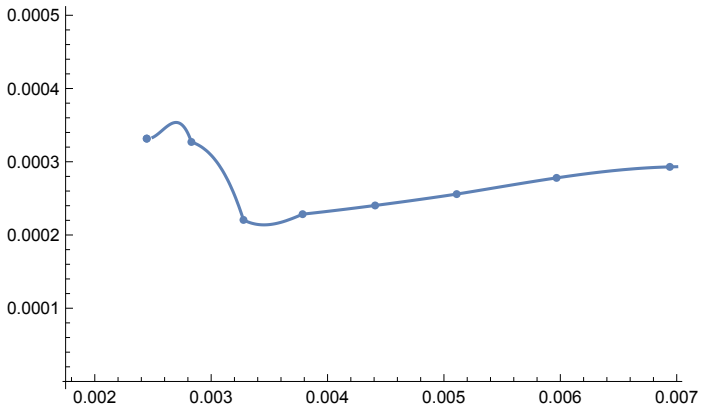
Out[1220]=
```
{{0.0069408, 0.000292997}, {0.00596758, 0.000277971},
 {0.00510955, 0.000255821}, {0.00440878, 0.00024032}, {0.0037858, 0.00022842},
 {0.00327766, 0.000220566}, {0.00283015, 0.000327011}, {0.00244682, 0.00033159},
 {0.00244627, 0.000331603}, {0.00210893, 0.000599604}, {0.00182937, 0.00109362}}
```

In[1222]:=
```
SlopeSyst330[0.005]
```

Out[1222]=
```
0.000253247
```

In[1223]:=
```
Show[ListPlot[SlopeSyst330MeVData], Plot[SlopeSyst330[x], {x, 0.0025, 0.007}]]
```

Out[1223]=



195 MeV

In[1224]:=
```
PointSyst195MeVData = Import["ISRFFSystematicalErrorPoint195MeV.dat"]
PointSyst195 = Interpolation[Map[{#[[1]], #[[2]] / 100} &, PointSyst195MeVData]];
```

Out[1224]=
```
{{0.00257314, 0.551932, 0}, {0.00210662, 0.553318, 0},
 {0.00180739, 0.56944, 0}, {0.001556, 0.633197, 0}, {0.00133657, 0.687167, 0}}
```

In[1226]:=
```
PointSyst195[0.002]
```

Out[1226]=
```
0.00554269
```

In[1227]:=
```
Combined195MeV = Map[{#[[1]], #[[2]], #[[3]], PointSyst195[#[[1]]]} &, data3]
```

Out[1227]=
```
{{0.00257314, 0.995588, 0.00474331, 0.00551932},
 {0.00210662, 0.991287, 0.00326861, 0.00553318},
 {0.00180739, 0.980164, 0.00367344, 0.0056944},
 {0.001556, 0.992348, 0.00328127, 0.00633197},
 {0.00133657, 1.00288, 0.00412765, 0.00687167}}
```

In[1228]:=
```
SlopeSyst195MeVData =
 Map[{#[[1]], #[[2]] / 100} &, Import["ISRFFSystematicalErrorSlope195MeV.dat"]]
SlopeSyst195 = Interpolation[Map[{#[[1]], #[[2]]} &, SlopeSyst195MeVData]];
```

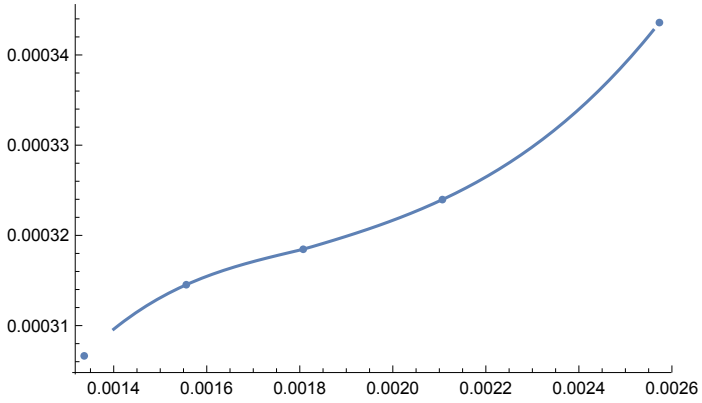
Out[1228]=
```
{{0.00257314, 0.00034359}, {0.00210662, 0.000323967},
 {0.00180739, 0.00031846}, {0.001556, 0.000314531}, {0.00133657, 0.000306643}}
```

In[1230]:=
```
SlopeSyst195[0.002]
```

Out[1230]=
```
0.000321669
```

In[1231]:=
```
Show[ListPlot[SlopeSyst195MeVData], Plot[SlopeSyst195[x], {x, 0.0014, 0.00256}]]
```

Out[1231]=



Analysis with Systematic Uncertainty

In[1232]:=
```
dataWithSys495MeV =
 Map[{#[[1]], #[[2]], Sqrt[#[[3]]^2 + #[[4]]^2]} &, Combined495MeV]
dataWithSys330MeV =
 Map[{#[[1]], #[[2]], Sqrt[#[[3]]^2 + #[[4]]^2]} &, Combined330MeV]
dataWithSys195MeV =
 Map[{#[[1]], #[[2]], Sqrt[#[[3]]^2 + #[[4]]^2]} &, Combined195MeV]
```

Out[1232]=
```
{{0.0153986, 0.954274, 0.00474032},
 {0.0128783, 0.958762, 0.00418604}, {0.0110455, 0.967815, 0.00405441},
 {0.0095245, 0.965169, 0.00382033}, {0.00819877, 0.974091, 0.00414621},
 {0.00708697, 0.973257, 0.00410072}, {0.0061315, 0.975922, 0.00411163}}
```

Out[1233]=
```
{{0.0069408, 0.986208, 0.00608819},
 {0.00596758, 0.976116, 0.00535158}, {0.00510955, 0.986458, 0.00514842},
 {0.00440878, 0.983472, 0.00548879}, {0.0037858, 0.992677, 0.00532129},
 {0.00327766, 0.991667, 0.00557148}, {0.00283015, 0.997873, 0.00586757},
 {0.00244682, 1.00003, 0.00629723}, {0.00244627, 1.00132, 0.00663477},
 {0.00210893, 1.00271, 0.00678838}, {0.00182937, 0.983021, 0.00775752}}
```

Out[1234]=
```
{{0.00257314, 0.995588, 0.00727749},
 {0.00210662, 0.991287, 0.0064265}, {0.00180739, 0.980164, 0.00677646},
 {0.001556, 0.992348, 0.00713166}, {0.00133657, 1.00288, 0.00801607}}
```

In[1235]:=
```
FindMyUncertaintySys[a_, b_, data495_, data330_, data195_,
  SlopeSyst495_, SlopeSyst330_, SlopeSyst195_] := Module[{},
  R495 = RandomVariate[NormalDistribution[0, 1], 1][[1]];
  CC495MeV = Map[
    {#[[1]], #[[2]], Sqrt[#[[3]]^2 + (R495 * SlopeSyst495[#[[1]]])^2]} &, data495];
  R330 = RandomVariate[NormalDistribution[0, 1], 1][[1]];
  CC330MeV = Map[
    {#[[1]], #[[2]], Sqrt[#[[3]]^2 + (R330 * SlopeSyst330[#[[1]]])^2]} &, data330];
  R195 = RandomVariate[NormalDistribution[0, 1], 1][[1]];
  CC195MeV = Map[
    {#[[1]], #[[2]], Sqrt[#[[3]]^2 + (R195 * SlopeSyst195[#[[1]]])^2]} &, data195];
  Sata495 = Map[{#[[1]], RandomVariate[NormalDistribution[#[[2]], #[[3]]], 1][[
       1]], #[[3]]} &, CC495MeV];
  Sata330 = Map[{#[[1]], RandomVariate[NormalDistribution[#[[2]], #[[3]]], 1][[
       1]], #[[3]]} &, CC330MeV];
  Sata195 = Map[{#[[1]], RandomVariate[NormalDistribution[#[[2]], #[[3]]], 1][[
       1]], #[[3]]} &, CC195MeV];
  min = FindMinimum[Chi2b[RR, nnn1, nnn2, nnn3, a, b, Sata495, Sata330, Sata495],
    {RR, nnn1, nnn2, nnn3}, AccuracyGoal → 10];
  {min[[1]], RR, nnn1, nnn2, nnn3} /. min[[2]]
 ]
```

In[1236]:=
```
FindMyUncertaintiesSys[a_, b_, data1_, data2_, data3_,
  SlopeSyst495_, SlopeSyst330_, SlopeSyst195_, NN_] := Module[{},
  list = Table[FindMyUncertainty[2.59, 29.8, data1, data2,
     data3, SlopeSyst495, SlopeSyst330, SlopeSyst195], {x, 1, NN}];
  rlist = Map[#[[2]] &, list];
  mr = Mean[rlist];
  sr = Sqrt[Variance[rlist]];
  n1list = Map[#[[3]] &, list];
  mn1 = Mean[n1list];
  sn1 = Sqrt[Variance[n1list]];
  n2list = Map[#[[4]] &, list];
  mn2 = Mean[n2list];
  sn2 = Sqrt[Variance[n2list]];
  n3list = Map[#[[5]] &, list];
  mn3 = Mean[n3list];
  sn3 = Sqrt[Variance[n3list]];
  {mr, sr, mn1, sn1, mn2, sn2, mn3, sn3}
 ]
```

In[1237]:=
```
res2 = FindMyUncertainties[2.59, 29.8,
  dataWithSys495MeV, dataWithSys330MeV, dataWithSys195MeV, 5000]
```

FindMinimum::lstol :
The line search decreased the step size to within the tolerance specified by AccuracyGoal and PrecisionGoal but was unable to find a sufficient decrease in the function. You may need more than MachinePrecision digits of working precision to meet these tolerances. >>

FindMinimum::lstol :
The line search decreased the step size to within the tolerance specified by AccuracyGoal and PrecisionGoal but was unable to find a sufficient decrease in the function. You may need more than MachinePrecision digits of working precision to meet these tolerances. >>

FindMinimum::lstol :
The line search decreased the step size to within the tolerance specified by AccuracyGoal and PrecisionGoal but was unable to find a sufficient decrease in the function. You may need more than MachinePrecision digits of working precision to meet these tolerances. >>

General::stop : Further output of FindMinimum::lstol will be suppressed during this calculation. >>

Out[1237]=
```
{0.818108, 0.0703558, 1.00573,
 0.00516213, 0.998479, 0.00264768, 1.0029, 0.00332497}
```

Manual Form - Factor Error band

In[1238]:=
```
FormFactor[Q2_, NN_, R_, dR_, a_, da_, b_, db_] := Module[{},
  rList = RandomVariate[NormalDistribution[R, dR], NN];
  aList = RandomVariate[NormalDistribution[a, da], NN];
  bList = RandomVariate[NormalDistribution[b, db], NN];
  fulllist = Table[{rList[[i]], aList[[i]], bList[[i]]}, {i, 1, NN}];
  FF = Map[GM[Q2, #[[1]], 1, #[[2]], #[[3]]] &, fulllist];
  mean = Mean[FF];
  sigma = Sqrt[Variance[FF]];
  {Q2, mean, sigma}
 ]
```

In[1239]:=

In[1240]:=
```
FormFactor[0.01, 100, res[[1]], res[[2]], 2.59, 0.194, 29.8, 14.71]
```

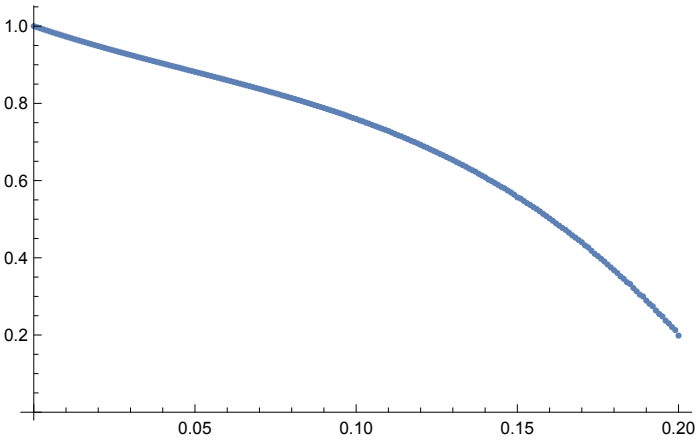
Out[1240]=
```
{0.01, 0.972467, 0.00259191}
```

In[1250]:=
```
FFTable = Table[FormFactor[Q2, 100 000, res[[1]],
    res[[2]], 2.59, 0.194, 29.8, 14.71], {Q2, 0.000, 0.2, 0.001}];
```

In[1242]:=

In[1251]:=
```
ListPlot[Map[{#[[1]], #[[2]]} &, FFTable]]
```

Out[1251]=



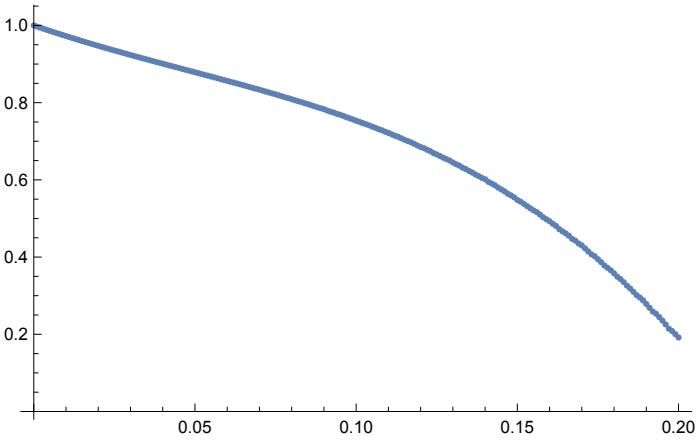
In[1252]:=
```
Export["ResultsISRStandAloneManualNew.dat", FFTable];
```

In[1245]:=

In[1253]:=
```
FFTable = Table[FormFactor[Q2, 100 000, res2[[1]],
    res2[[2]], 2.59, 0.194, 29.8, 14.71], {Q2, 0.000, 0.2, 0.001}];
```

In[1254]:=
```
ListPlot[Map[{#[[1]], #[[2]]} &, FFTable]]
```

Out[1254]=



In[1255]:=
```
Export["ResultsISRStandAloneManualNew2.dat", FFTable];
```

C.F. Normalized to First Two Points

Continuum Fraction

In[1256]:=
```
GCF[Q2_, n_, x_, a_, b_] := n / (1 + x Q2 / (1 + Q2 a / (1 + Q2 b / 1)))
```

In[1257]:=
```
zz = Simplify[D[GCF[Q2, 1, z, a, b], {Q2}]] /. {Q2 → 0}
```

Out[1257]=
$$-z$$

In[1258]:=
```
sol0 = Flatten[Solve[zz == -1/(6 * (0.1973)^2) R^2, z]]
```

Out[1258]=
$$\{z \to 4.28149\, R^2\}$$

In[1259]:=
```
xx = Simplify[D[GCF[Q2, 1, z, a, b], {Q2, 2}]] /. {Q2 → 0}
```

Out[1259]=
$$2\, z\, (a + z)$$

In[1260]:=
```
sol1 = Flatten[Solve[xx == aa/(120 * ħc^4), a]]
```

Out[1260]=
$$\left\{a \to \frac{0.5\, \left(5.49633\, aa - 2.\, z^2\right)}{z}\right\}$$

In[1261]:=
```
yy = Simplify[D[GCF[Q2, 1, z, a, b], {Q2, 3}]] /. {Q2 → 0}
```

Out[1261]=
$$-6\, z\, \left(a^2 + z^2 + a\, (b + 2\, z)\right)$$

In[1262]:=
```
sol2 = Flatten[Solve[yy == -bb/(5040 * ħc^6), b]]
```

Out[1262]=
$$\left\{b \to -\frac{1}{a\, z} 0.166667\, \left(-3.36086\, bb + 6.\, a^2\, z + 12.\, a\, z^2 + 6.\, z^3\right)\right\}$$

In[1263]:=
```
GCFF[Q2_, RR_, n_, aaa_, bbb_] :=
 GCF[Q2, n, z /. sol0, a /. sol1 /. sol0, b /. sol2 /. sol1 /. sol0] /.
  {aa → aaa, R → RR, bb → bbb}
```

In[1264]:=
```
Simplify[D[GCFF[Q2, R, 1, aa, bb], {Q2}] /. {Q2 → 0}]
```

Out[1264]=
$$0. - 4.28149\, R^2$$

In[1265]:=
```
Simplify[D[GCFF[Q2, R, 1, aa, bb], {Q2, 2}] /. {Q2 → 0}]
```

Out[1265]=
$$0. + 5.49633\, aa$$

In[1266]:=
```
Simplify[D[GCFF[Q2, R, 1, aa, bb], {Q2, 3}] /. {Q2 → 0}]
```

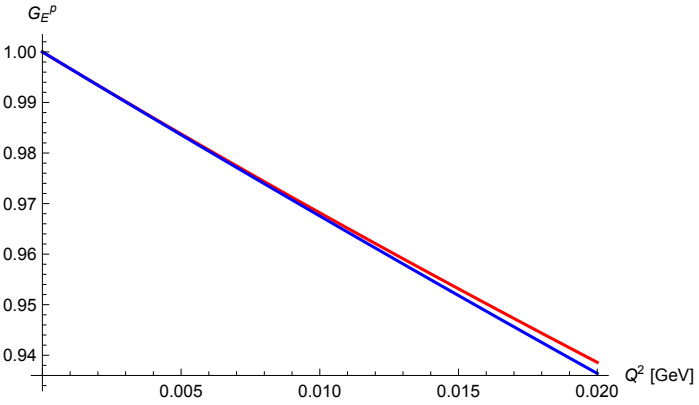
Out[1266]=
$$0. - 3.36086\, bb - \frac{1.77636 \times 10^{-15}\, aa^2}{R^2}$$

In[1267]:=
```
GCFF[0.05, 0.88, 1, 2.59, 29.8]
```

Out[1267]=
$$0.850144$$

In[1268]:=
```
Plot[{GM[x, 0.88, 1, 2.59, 29.8], GCFF[x, 0.88, 1, 2.59, 29.8]},
 {x, 0, 0.02}, PlotStyle → {Red, Blue}, AxesLabel → {"Q² [GeV]", "G_E^p"}]
```

Out[1268]=



Data

In[1269]:=
```
M = 0.93827;
mup = 2.79;
ħc = 0.197327;
```

In[1272]:=
$$\text{Tau}[Q2\_] := \frac{Q2}{4\,M^2}$$

In[1273]:=
$$\text{Eps}[th\_, Q2\_] := \left(1 + 2\,(1 + \text{Tau}[Q2])\,\text{Tan}\left[\frac{th}{2}\right]^2\right)^{-1}$$

In[1274]:=
```
data1 = Select[Map[{#[[1]], #[[2]], #[[3]]} &,
    Import["ISRFormFactor495MeV.dat"]], #[[1]] < 0.016 &]
```

Out[1274]=
```
{{0.0153986, 0.954274, 0.00248027},
 {0.0128783, 0.958762, 0.00166176}, {0.0110455, 0.967815, 0.00182807},
 {0.0095245, 0.965169, 0.00165552}, {0.00819877, 0.974091, 0.00239891},
 {0.00708697, 0.973257, 0.00201998}, {0.0061315, 0.975922, 0.00200291}}
```

In[1275]:=
```
data2 = Select[Map[{#[[1]], #[[2]], #[[3]]} &,
    Import["ISRFormFactor330MeV.dat"]], (#[[1]] < 0.0078) &]
```

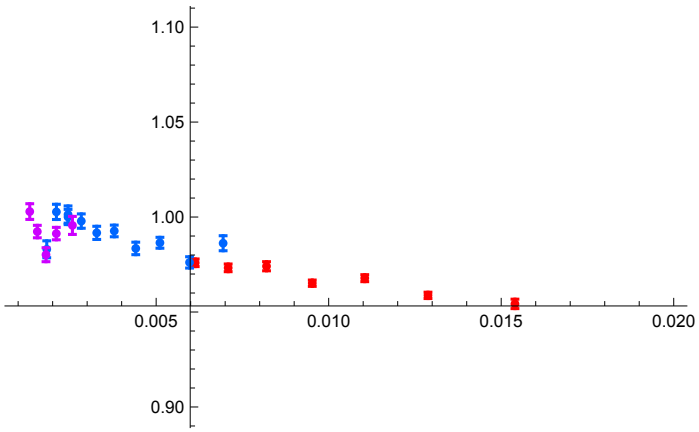
Out[1275]=
```
{{0.0069408, 0.986208, 0.00395242},
 {0.00596758, 0.976116, 0.00297658}, {0.00510955, 0.986458, 0.00286456},
 {0.00440878, 0.983472, 0.00328641}, {0.0037858, 0.992677, 0.00306621},
 {0.00327766, 0.991667, 0.00346276}, {0.00283015, 0.997873, 0.00377442},
 {0.00244682, 1.00003, 0.00401119}, {0.00244627, 1.00132, 0.00452273},
 {0.00210893, 1.00271, 0.00400617}, {0.00182937, 0.983021, 0.00445701}}
```

In[1276]:=
```
data3 = Select[Map[{#[[1]], #[[2]], #[[3]]} &,
    Import["ISRFormFactor195MeV.dat"]], (#[[1]] < 0.0027) &]
```

Out[1276]=
```
{{0.00257314, 0.995588, 0.00474331},
 {0.00210662, 0.991287, 0.00326861}, {0.00180739, 0.980164, 0.00367344},
 {0.001556, 0.992348, 0.00328127}, {0.00133657, 1.00288, 0.00412765}}
```

In[1277]:=
```
Show[ErrorListPlot[Map[{{#[[1]], #[[2]]}, ErrorBar[#[[3]]]} &, data1],
  PlotStyle → Hue[0]], ErrorListPlot[
  Map[{{#[[1]], #[[2]]}, ErrorBar[#[[3]]]} &, data2], PlotStyle → Hue[0.6]],
 ErrorListPlot[Map[{{#[[1]], #[[2]]}, ErrorBar[#[[3]]]} &, data3],
  PlotStyle → Hue[0.8]], PlotRange → {{0.001, 0.02}, {0.9, 1.1}}]
```

Out[1277]=



Join

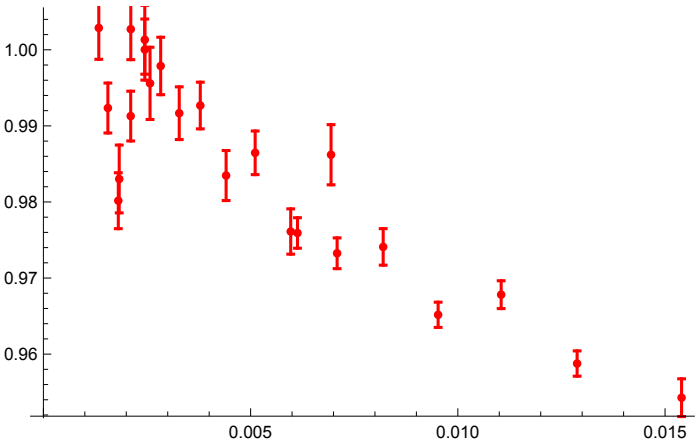
In[1278]:=
```
data = Join[data1, data2, data3];
```

In[1279]:=
```
Length[data]
```

Out[1279]= 23

In[1280]:=
```
s1 = Show[ErrorListPlot[
    Map[{{#[[1]], #[[2]]}, ErrorBar[#[[3]]]} &, data], PlotStyle → Hue[0]]]
```

Out[1280]=



Manual Fit with Chi2

In[1281]:=
```
Chi2b[R_, n1_, n2_, n3_, a_, b_, data1_, data2_, data3_] :=
 (1 / (Length[data1] + Length[data2] + Length[data3] - 2))
  (Sum[(GCFF[data1[[i, 1]], R, 1, a, b] - n1 * data1[[i, 2]])^2 /
      (n1^2 * data1[[i, 3]]^2), {i, 1, Length[data1]}] +
   Sum[(GCFF[data2[[i, 1]], R, 1, a, b] - n2 * data2[[i, 2]])^2 /
     (n2^2 * data2[[i, 3]]^2), {i, 1, Length[data2]}] +
   Sum[(GCFF[data3[[i, 1]], R, 1, a, b] - n3 * data3[[i, 2]])^2 /
     (n3^2 * data3[[i, 3]]^2), {i, 1, Length[data3]}])
```

In[1282]:=
```
min = FindMinimum[Chi2b[RR, nnn1, nnn2, nnn3, 2.59, 29.8, data1, data2, data3],
  {{RR, 0.88}, {nnn1, 1}, {nnn2, 1}, {nnn3, 1}}, AccuracyGoal → 6]
```

Out[1282]=
```
{2.72201, {RR → 0.79559, nnn1 → 1.00705, nnn2 → 0.999507, nnn3 → 1.00338}}
```

In[1283]:=
```
min[[2]]
```

Out[1283]=
```
{RR → 0.79559, nnn1 → 1.00705, nnn2 → 0.999507, nnn3 → 1.00338}
```

In[1284]:=
```
Show[s1, ErrorListPlot[
  Map[{{#[[1]], #[[2]] * nnn1 /. min[[2]]}, ErrorBar[#[[3]] * nnn1] /. min[[2]]} &,
   data1], PlotStyle → Hue[0.6]], ErrorListPlot[
  Map[{{#[[1]], #[[2]] * nnn2 /. min[[2]]}, ErrorBar[#[[3]] * nnn2] /. min[[2]]} &,
   data2], PlotStyle → Hue[0.6]] , ErrorListPlot[
  Map[{{#[[1]], #[[2]] * nnn3 /. min[[2]]}, ErrorBar[#[[3]] * nnn3] /. min[[2]]} &,
   data3], PlotStyle → Hue[0.6]],
 Plot[GM[x, RR, 1, 2.59, 29.8] /. min[[2]], {x, 0, 0.02}], PlotRange → All]
```

Out[1284]=