In[1]:= `<< ~/Desktop/Software/CRunDec3/RunDec.m`

RunDec: a Mathematica package for running and decoupling of the

      strong coupling and quark masses

by K.G. Chetyrkin, J.H. K\"uhn and M. Steinhauser (January 2000)

by F. Herren and M. Steinhauser (February 2017, v3.0)

Plot Cross Section, (up to 5000 GeV)

In[9]:= $\alpha = 1/137.04$;

Conversion = 389 379;

n = 3;

$C_F = \dfrac{n^2 - 1}{2\,n}$;

Born = $\dfrac{4\,\pi\,\alpha^2}{3\,s}$;

In[14]:= `As[Q_] := AsRunDec[asMz /. NumDef, Mz /. NumDef, Q`^{2}`, 2];`

σ`[Q_] := Conversion *` $\dfrac{4\,\pi\,\alpha^2}{3\,Q*Q}\left(1 + \dfrac{3\,As[Q]}{4\,\pi}\,C_F\right)$

In[16]:= Qmax = 5000.;

Qmin = 1.;

Npt = 500;

Q[i_] := $\dfrac{(Qmax - Qmin)}{Npt}$ * i + Qmin

In[20]:= `TableCross = Table[{Q[i],` σ`[Q[i]]}, {i, 0, Npt}]`

Out[20]= $\{\{1., 99.4606\}, \{10.998, 0.743913\}, \{20.996, 0.203067\},$
$\{30.994, 0.0929671\}, \{40.992, 0.0530693\}, \{50.99, 0.0342623\},$
$\{60.988, 0.0239304\}, \{70.986, 0.0176529\}, \{80.984, 0.0135561\},$
$\{90.982, 0.0107356\}, \{100.98, 0.00871162\}, \{110.978, 0.00721022\},$
$\{120.976, 0.00606588\}, \{130.974, 0.00517374\}, \{140.972, 0.00446481\},$
$\{150.97, 0.00389217\}, \{160.968, 0.00342298\}, \{170.966, 0.00303377\},$
$\{180.964, 0.00270734\}, \{190.962, 0.00243087\}, \{200.96, 0.00219468\},$
$\{210.958, 0.0019913\}, \{220.956, 0.00181493\}, \{230.954, 0.00166098\},$
$\{240.952, 0.00152582\}, \{250.95, 0.0014065\}, \{260.948, 0.00130065\},$
$\{270.946, 0.00120631\}, \{280.944, 0.00112187\}, \{290.942, 0.00104599\},$
$\{300.94, 0.00097756\}, \{310.938, 0.000915626\}, \{320.936, 0.000859396\},$
$\{330.934, 0.00080819\}, \{340.932, 0.000761426\}, \{350.93, 0.000718605\},$
$\{360.928, 0.000679297\}, \{370.926, 0.000643127\}, \{380.924, 0.00060977\},$
$\{390.922, 0.000578942\}, \{400.92, 0.000550393\}, \{410.918, 0.000523905\},$
$\{420.916, 0.000499283\}, \{430.914, 0.000476356\}, \{440.912, 0.000454973\},$
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$\{3570.29, 6.91183 \times 10^{-6}\}, \{3580.28, 6.87326 \times 10^{-6}\}, \{3590.28, 6.835 \times 10^{-6}\},$
$\{3600.28, 6.79707 \times 10^{-6}\}, \{3610.28, 6.75944 \times 10^{-6}\}, \{3620.28, 6.72213 \times 10^{-6}\},$
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$\{4620.08, 4.12612 \times 10^{-6}\}, \{4630.07, 4.10831 \times 10^{-6}\}, \{4640.07, 4.09061 \times 10^{-6}\},$
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$\{4920.02, 3.63806 \times 10^{-6}\}, \{4930.01, 3.6233 \times 10^{-6}\}, \{4940.01, 3.60864 \times 10^{-6}\},$
$\{4950.01, 3.59407 \times 10^{-6}\}, \{4960.01, 3.57959 \times 10^{-6}\}, \{4970.01, 3.56519 \times 10^{-6}\},$
$\{4980., 3.55088 \times 10^{-6}\}, \{4990., 3.53665 \times 10^{-6}\}, \{5000., 3.52251 \times 10^{-6}\}\}$

In[21]:= **ListPlot[TableCross, Joined → True, AxesLabel → {"$\sqrt{s}$ (GeV)", "σ (nb)"}]**

Out[21]=
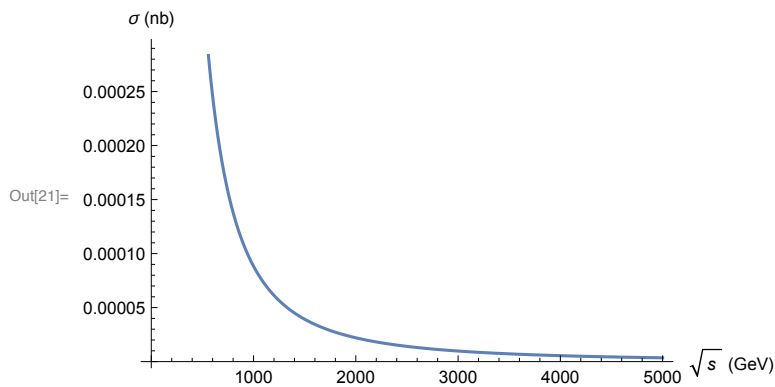
In[22]:= `ListPlot[TableCross, Joined → True,`
    `AxesLabel → {"√s̄ (GeV)", "σ (nb)"}, PlotStyle → {Dashing[Medium]}]`

Out[22]=
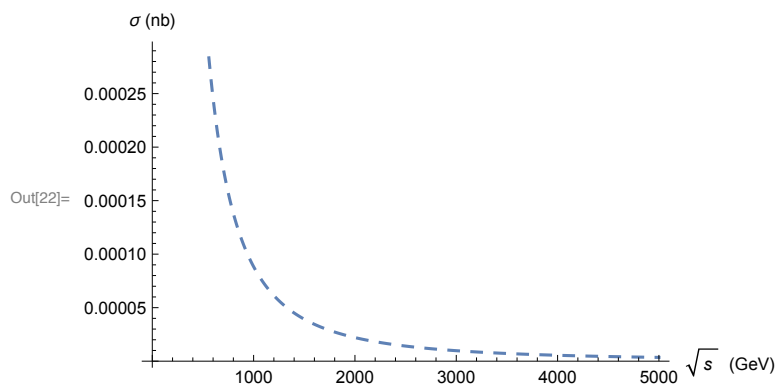
Plot Cross Section, (up to 1000 GeV)

In[23]:= `Qmax = 1000.;`
    `Qmin = 1.;`
    `Npt = 100;`

In[26]:= `TableCross2 = Table[{Q[i], σ[Q[i]]}, {i, 0, Npt}]`

Out[26]= {{1., 99.4606}, {10.99, 0.745002}, {20.98, 0.203378}, {30.97, 0.0931117},
{40.96, 0.0531525}, {50.95, 0.0343162}, {60.94, 0.0239682}, {70.93, 0.0176808},
{80.92, 0.0135775}, {90.91, 0.0107526}, {100.9, 0.00872546},
{110.89, 0.00722169}, {120.88, 0.00607553}, {130.87, 0.00518198},
{140.86, 0.00447193}, {150.85, 0.00389837}, {160.84, 0.00342844},
{170.83, 0.00303861}, {180.82, 0.00271166}, {190.81, 0.00243476},
{200.8, 0.00219819}, {210.79, 0.00199448}, {220.78, 0.00181783},
{230.77, 0.00166364}, {240.76, 0.00152826}, {250.75, 0.00140875},
{260.74, 0.00130273}, {270.73, 0.00120824}, {280.72, 0.00112366},
{290.71, 0.00104767}, {300.7, 0.000979123}, {310.69, 0.000917091},
{320.68, 0.000860771}, {330.67, 0.000809482}, {340.66, 0.000762644},
{350.65, 0.000719755}, {360.64, 0.000680384}, {370.63, 0.000644156},
{380.62, 0.000610746}, {390.61, 0.000579868}, {400.6, 0.000551274},
{410.59, 0.000524743}, {420.58, 0.000500082}, {430.57, 0.000477119},
{440.56, 0.000455701}, {450.55, 0.000435694}, {460.54, 0.000416975},
{470.53, 0.000399437}, {480.52, 0.000382982}, {490.51, 0.000367524},
{500.5, 0.000352982}, {510.49, 0.000339287}, {520.48, 0.000326373},
{530.47, 0.000314182}, {540.46, 0.000302662}, {550.45, 0.000291764},
{560.44, 0.000281444}, {570.43, 0.000271662}, {580.42, 0.00026238},
{590.41, 0.000253567}, {600.4, 0.00024519}, {610.39, 0.000237221},
{620.38, 0.000229635}, {630.37, 0.000222406}, {640.36, 0.000215514},
{650.35, 0.000208937}, {660.34, 0.000202656}, {670.33, 0.000196654},
{680.32, 0.000190915}, {690.31, 0.000185424}, {700.3, 0.000180166},
{710.29, 0.000175128}, {720.28, 0.000170299}, {730.27, 0.000165667},
{740.26, 0.000161221}, {750.25, 0.000156952}, {760.24, 0.00015285},
{770.23, 0.000148906}, {780.22, 0.000145114}, {790.21, 0.000141464},
{800.2, 0.00013795}, {810.19, 0.000134566}, {820.18, 0.000131305},
{830.17, 0.00012816}, {840.16, 0.000125128}, {850.15, 0.000122201},
{860.14, 0.000119376}, {870.13, 0.000116648}, {880.12, 0.000114013},
{890.11, 0.000111465}, {900.1, 0.000109002}, {910.09, 0.00010662},
{920.08, 0.000104315}, {930.07, 0.000102084}, {940.06, 0.0000999239},
{950.05, 0.0000978315}, {960.04, 0.0000958041}, {970.03, 0.000093839},
{980.02, 0.0000919338}, {990.01, 0.000090086}, {1000., 0.0000882934}}

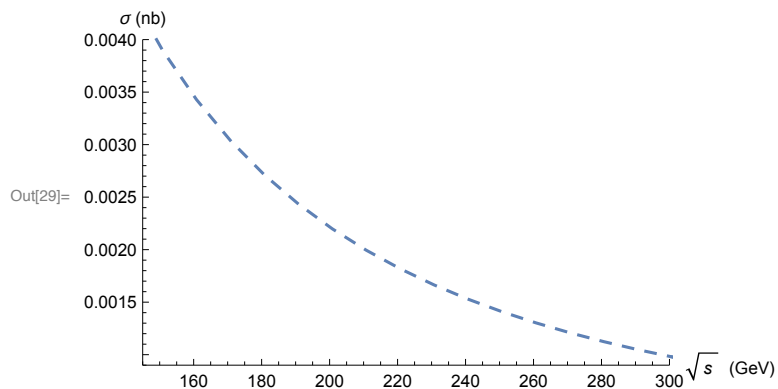In[27]:= `ListPlot[TableCross2, Joined → True, AxesLabel → {"√s (GeV)", "σ (nb)"}]`

Out[27]=
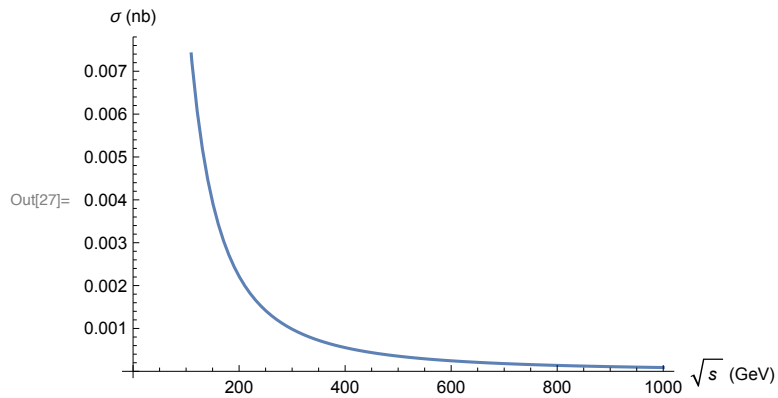
In[28]:= `A = ListPlot[TableCross2, Joined → True,`
`    AxesLabel → {"√s (GeV)", "σ (nb)"}, PlotStyle → {Dashing[Medium]}]`

Out[28]=
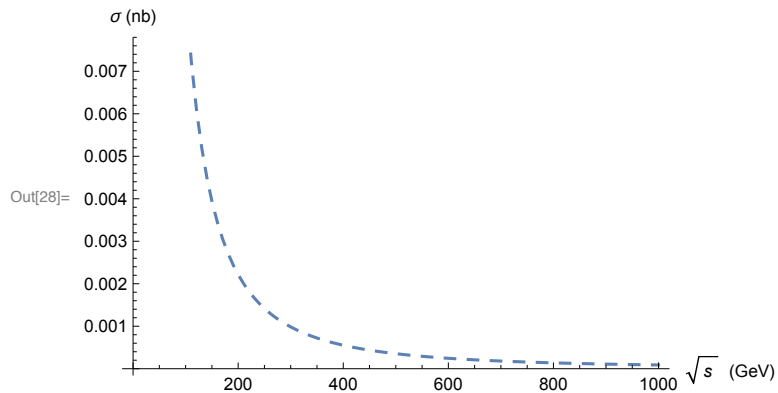
In[29]:= `A1 = ListPlot[TableCross2, Joined → True, AxesLabel → {"√s (GeV)", "σ (nb)"},`
`    PlotStyle → {Dashing[Medium]}, PlotRange → {{145, 300}, {0.0009, 0.004}}]`

Out[29]=

Plot Born Cross Section (up to 1000 GeV)

In[30]:= $\sigma B[Q\_] := \text{Conversion} * \dfrac{4\,\pi\,\alpha^2}{3\,Q*Q};$

In[31]:= `TableBorn = Table[{Q[i], σB[Q[i]]}, {i, 0, Npt}]`

Out[31]= {{1., 86.8493}, {10.99, 0.71907}, {20.98, 0.197313}, {30.97, 0.0905491},
{40.96, 0.0517662}, {50.95, 0.0334563}, {60.94, 0.0233863}, {70.93, 0.0172626},
{80.92, 0.0132634}, {90.91, 0.0105086}, {100.9, 0.00853069},
{110.89, 0.00706288}, {120.88, 0.00594371}, {130.87, 0.00507091},
{140.86, 0.00437715}, {150.85, 0.00381659}, {160.84, 0.00335721},
{170.83, 0.00297604}, {180.82, 0.00265628}, {190.81, 0.00238542},
{200.8, 0.00215397}, {210.79, 0.00195464}, {220.78, 0.00178175},
{230.77, 0.00163083}, {240.76, 0.0014983}, {250.75, 0.00138129},
{260.74, 0.00127747}, {270.73, 0.00118493}, {280.72, 0.0011021},
{290.71, 0.00102765}, {300.7, 0.000960505}, {310.69, 0.000899729},
{320.68, 0.000844545}, {330.67, 0.000794286}, {340.66, 0.000748383},
{350.65, 0.000706348}, {360.64, 0.000667757}, {370.63, 0.000632245},
{380.62, 0.000599492}, {390.61, 0.000569219}, {400.6, 0.000541183},
{410.59, 0.000515169}, {420.58, 0.000490986}, {430.57, 0.000468467},
{440.56, 0.000447462}, {450.55, 0.000427839}, {460.54, 0.000409479},
{470.53, 0.000392276}, {480.52, 0.000376135}, {490.51, 0.00036097},
{500.5, 0.000346704}, {510.49, 0.000333267}, {520.48, 0.000320596},
{530.47, 0.000308635}, {540.46, 0.00029733}, {550.45, 0.000286636},
{560.44, 0.000276508}, {570.43, 0.000266908}, {580.42, 0.000257799},
{590.41, 0.000249149}, {600.4, 0.000240927}, {610.39, 0.000233105},
{620.38, 0.000225658}, {630.37, 0.000218562}, {640.36, 0.000211796},
{650.35, 0.000205339}, {660.34, 0.000199173}, {670.33, 0.000193281},
{680.32, 0.000187646}, {690.31, 0.000182254}, {700.3, 0.000177092},
{710.29, 0.000172145}, {720.28, 0.000167403}, {730.27, 0.000162854},
{740.26, 0.000158489}, {750.25, 0.000154296}, {760.24, 0.000150267},
{770.23, 0.000146395}, {780.22, 0.00014267}, {790.21, 0.000139085},
{800.2, 0.000135634}, {810.19, 0.00013231}, {820.18, 0.000129106},
{830.17, 0.000126018}, {840.16, 0.000123039}, {850.15, 0.000120164},
{860.14, 0.000117389}, {870.13, 0.000114709}, {880.12, 0.00011212},
{890.11, 0.000109617}, {900.1, 0.000107198}, {910.09, 0.000104857},
{920.08, 0.000102592}, {930.07, 0.0001004}, {940.06, 0.0000982778},
{950.05, 0.0000962218}, {960.04, 0.0000942297}, {970.03, 0.0000922988},
{980.02, 0.0000904267}, {990.01, 0.0000886109}, {1000., 0.0000868493}}

In[32]:= `ListPlot[TableBorn, Joined → True,`
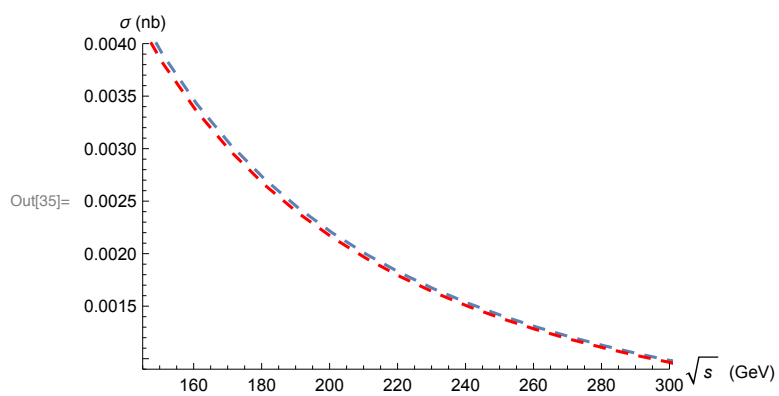`  AxesLabel → {"√s  (GeV)", "σ (nb)"}, PlotStyle → Red]`

Out[32]=
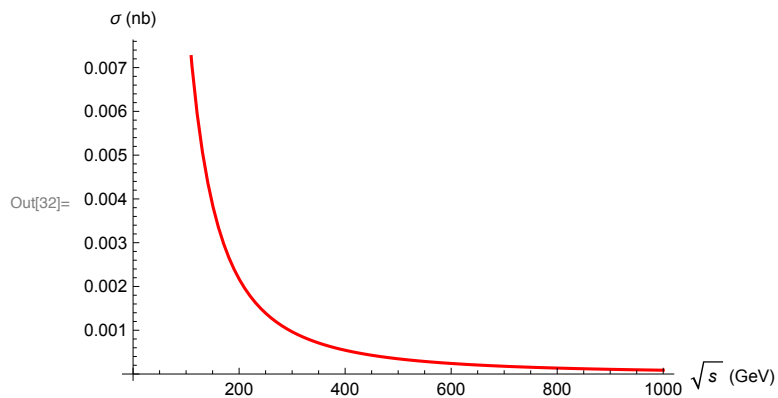
In[33]:= `B = ListPlot[TableBorn, Joined → True,`
`  AxesLabel → {"√s   (GeV)", "σ (nb)"}, PlotStyle → {Dashing[Medium], Red}]`

Out[33]=
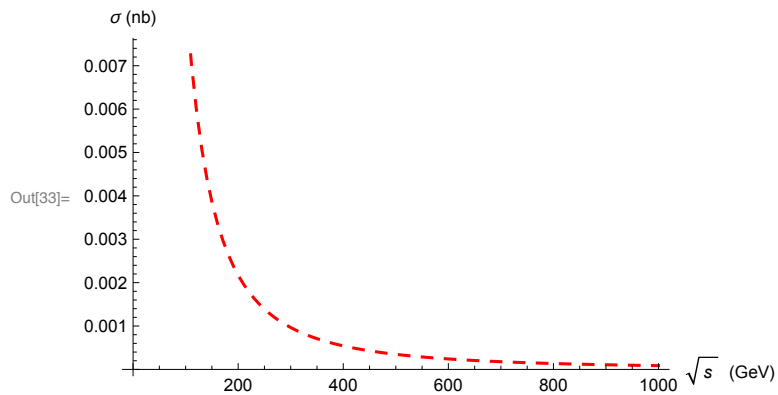
In[34]:= `B1 = ListPlot[TableBorn, Joined → True, AxesLabel → {"√s   (GeV)", "σ (nb)"},`
`  PlotStyle → {Dashing[Medium], Red}, PlotRange → {{145, 300}, {0.0009, 0.004}}]`

Out[34]=

In[35]:= **Show[A1, B1]**

Out[35]=
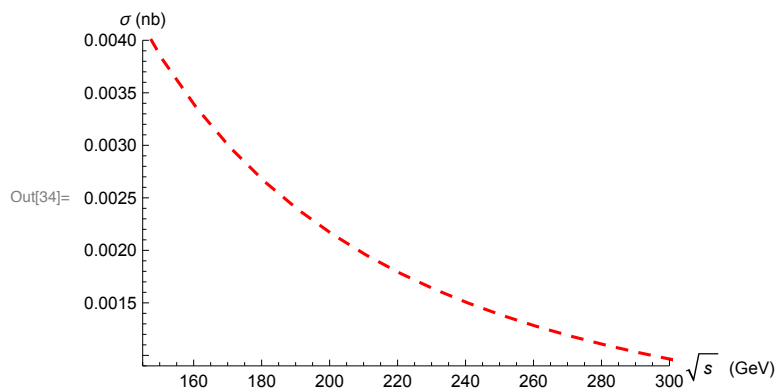
Overlay Zoom In (Born with 1st Order Correction)

```
In[36]:= A2 = ListPlot[TableCross2, Joined → True,
          AxesLabel → {"√s  (GeV)", "σ (nb)"}, PlotStyle → {Dashing[Large]},
          PlotRange → {{160, 250}, {0.0012, 0.0035}}, PlotLegends → {"σ_B(α_s(s))"}]
       B2 = ListPlot[TableBorn, Joined → True, AxesLabel → {"√s  (GeV)", "σ (nb)"},
          PlotStyle → {Dashing[Small], Red},
          PlotRange → {{160, 250}, {0.0012, 0.0035}}, PlotLegends → {"σ_B"}]
       Show[A2, B2]
```

Out[36]=

Out[37]=

Out[38]=