Contents

Basic Information

Recent Updates:

v313: Found a bug in channel: ω -> $\pi^+\pi^-\pi^0$. Reconstructed ω mass is about 0.4% too high. While debugging, resolved an unrelated error. Marked ω -> $\pi^+\pi^-\pi^0$ as UNSTABLE in this document.

v311: (UNSTABLE) Added channel: ω -> $\pi^+\pi^-\pi^0$ with code (223211111).

v309: Added channels: ρ^0 -> e^+e^- and ρ^0 -> $\mu^+\mu^-$ with codes(113011) and (113013) respectively.

v308: Added an option to display a header in the output file. This header will show input parameters in a similar format to eSTARlight. Option is controlled by input parameter "OUTPUT_HEADER", see below.

v307: Fixed 4-prong mass spectrum, properly converting dsigma/ds to dsigma/dW. The net effect is to scale the mass spectrum by 1/M_{4\pi}, reducing the number of high-mass states.

v306: Updated gammavm.cpp, to properly output 4 pions with net charge 0. Also changed default Wmax for 4-prong final state to be the larger of the kinematic limit or 10 GeV; previously, it was unduly large for the LHC.

v305: Changed coefficient in calculation of pt2 in gammavm.cpp from 8 to 32. This changes the maximum p_T for vector mesons for calculations without interference from about 250 MeV/c to about 1 Gev/c. In the long run, we could rename INT_PT_MAX and make it required parameter with or without interference. This could make the running a bit more efficient.

v304: Fixed a bug in gammaaluminosity.cpp lines 404, where photonDensity was called with its arguments reversed. This bug affected the p_T spectrum when interference is turned on.

v299: Added hard-coded Woods-Saxon radii, thickness and density for ^{96}Ru and ^{96}Zr, for the RHIC isobar run. Data is from arXiv:1607.04697

v297: Changed normalized for Woods-Saxon density for non-predefined (i. e. not gold, lead, xenon or copper or nuclei with Z<7) so that the density is properly normalized \int d^3r rho(r) = A. The normalization was previously done for a hard-sphere nucleus, so this over-estimated the cross-sections by 5-10%.

v295: Added hard-coded values for xenon-129 to match the recent LHC run. Radius=5.36 fm, density=0.18406

v293: Introduced shared random number generator which can be externally passed by the user. All particle constants (masses, widths, branching ratios, and spins) can now also be set by the user, but should be changed from the default values with care.

v290: Added an new BREAKUP_MODE option to generate two-photon events in peripheral collisions. BREAKUP_MODE=8 sets a fixed impact parameter range, regardless of the presence of nuclear breakup; it is intended to study two-photon production in peripheral collisions. It requires two additional otherwise optional input lines, BMIN and BMAX, to set the impact parameter range. It does not (yet?) work for photonuclear interactions.

278: Added two new optional parameters:

IMPULSE_VM Normally 0, but can be set to 1 to perform an impulse approximation calculation (i.e. ignoring nuclear effects)

QUANTUM_GLAUBER. When set to 1, performs a quantum Glauber calculation, rather than a classical one. This leads to greatly increased rho and omega cross-sections for heavy nuclei, little effect for heavier mesons.

Also added a final state, 4432212, for J/psi -> pbar p

v276: Added two new optional parameters (BSLOPE DEFINITION and BSLOPE_VALUE) for the p_T spectrum ('bslope') for proton targets or incoherent production on nuclei

v275: Added $\gamma\gamma$ to axion channel as two-photon channel 88, per S. Knapen et al., arXiv:1607.07083 v273: "Baseline" version, described in arXiv:1607.03838)

Overview:

The STARlight Monte Carlo models 2-photon and photon-Pomeron interactions in ultra-peripheral heavy ion collisions. The physics approach for the photon-Pomeron interactions is described in Klein and Nystrand, Phys. Rev. C60, 014903 (1999), with the p_t spectrum (including vector meson interference) discussed in Phys. Rev. Lett. 84, 2330 (2000). The 2-photon interactions are described in Baltz, Gorbunov, Klein, Nystrand, Phys.Rev. C80 044902 (2009).

STARlight has several input files, all of which are expected to be in the same directory as the starlight code. User-specified input parameters are read from a file named "slight.in"; these parameters are described below in Input.

The simulated events are written to an ASCII file named "slight.out", which is described below in Output.

Installation:

To install & run STARlight in a *nix based environment, follow these steps(README):

Download the starlight package from 'Downloads' on the left sidebar of the homepage. The version in the example might be outdated.

```
-wget 'https://starlight.hepforge.org/downloads?f=starlight_r300.tar'
-mv 'downloads?f=starlight_r300.tar' starlight_r300.tar
-tar xvf starlight_r300.tar
```

Alternatively, one may obtain the latest version via svn.
HEPforge uses phabricator and no longer allows for anonymous checkouts of the repository. (Please read https://www.hepforge.org/guide.pdf .)

To obtain an account, register here: https://www.hepforge.org/register

Once you are registered, login:
https://phab.hepforge.org/auth/start/?next=%2F

Set up a version control settings (VCS) password under your account's Settings->AUTHENTICATION->VCS password . The VCS password is needed to checkout the code.

(For remote users) To identify yourself, upload a SSH public key under account's Settings->AUTHENTICATION->SSH Public Keys with the button SSH Key Actions->Upload Public Key. This key will provide your identity when checking out the code as VCS. If you do not have a public ssh key to upload, you may generate a pair on the same SSH Public Keys page with the button SSH Key Actions-> Generate Keypair.

With the private ssh key loaded on your machine (and public on their machine), use svn to checkout the trunk/:

```
-svn co svn+ssh://vcs@phab.hepforge.org/source/starlightsvn/trunk
```

Change to the installation directory of your choice

```
-mkdir /home/my/installation/dir
-cd /home/my/installation/dir
```

Setup the compilation with cmake

```
-cmake /path/to/trunk
```

Compile with (g)make

```
-gmake
```

Setup the input file, slight.in, for your simluation needs

```
-cp /path/to/trunk/config/slight.in .
-vim slight.in
```

Run

```
-./starlight >& output.txt&
```

For more information and special scenarios, such as running with PYTHIA or DPMJET, consult the README files located in trunk/

If you would like to browse the code, please visit:
https://phab.hepforge.org/source/starlightsvn/

------Before HEPForge updated their repository management system----

To obtain the latest version:

-svn co http://starlight.hepforge.org/svn/trunk

Alternatively:
-Visit https://starlight.hepforge.org/trac/browser
-Download the trunk [click on the download symbol in the Size column]
-Unpackage the zip file. The trunk/ represents <PathToSource>

To build Starlight:

- First create your build directory <BUILDDIR> (e.g. mkdir bin)
- $ cd <BUILDDIR>
- $ cmake <PathToSource>
- $ make

This creates an executable file, starlight, in the build directory.

To clean the build:

- $ make clean

To run starlight, a configuration file, slight.in, is needed. Examples of slight.in may be found in the config/ directory.

To run:

```
$ ./starlight
```

Enabling Pythia:

To simulate the η, η', and η_c channels, you need Pythia v8.2 or higher to handle their decays. To enable Pythia support you need to run cmake with the option -DENABLE_PYTHIA=ON and have $PYTHIADIR pointing to the top directory of Pythia8. [Note: when building Pythia, be sure to enable shared libraries(.so). ./configure --enable-shared before compiling Pythia.]

```
$ setenv PYTHIADIR /my/local/pythia8

$ cmake <PathToSource> -DENABLE_PYTHIA=ON
```

Note: v8.2+ is necessary since the Pythia directory structure changed[trunk/cmake_modules/FindPythia8.cmake depends on the structure layout], liblhapdfdummy was removed, and Standalone:allowResDec was removed.

To enable DPMJET, please see the passage on DPMJET

Input:

The input parameters are listed below with typical values for LHC Pb-Pb running given in parentheses. Optional parameters are denoted with *.

baseFileName	# The name of the output files. STARlight will copy the input slight.in to baseFileName.in, and produce output files baseFileName.txt and baseFileName.out. (slight)
BEAM_1_Z = 82	# Charge of beam one projectile. (82)
BEAM_1_A = 208	# Atomic number of beam one projectile. (208)
BEAM_2_Z = 82	# Charge of beam two projectile. (82)
BEAM_2_A = 208	# Atomic number of beam two projectile. (208)
BEAM_1_GAMMA = 1470	# Lorentz boost for beam one projectile(pz>0). (1470)
BEAM_2_GAMMA = 1470.0	# Lorentz boost for beam two projectile(pz<0). (1470)
W_MAX = 12.0	# Maximum value for the gamma-gamma center of mass energy, $W = 4E_1E_2$, in GeV. Setting W_MAX = -1 tells STARlight to use the default value specified in inputParameters.cpp (recommended for single meson production). For single mesons, the default W_MAX is the particle mass plus five times the width. For lepton pairs, the default W_MAX is given by $2\hbar c\gamma 1\gamma 2R1R2$. These are defined in src/inputParameters.cpp (-1)
W_MIN = -1	#Min value of w. Minimum value for the gamma-gamma center of mass energy, $W = 4E_1E_2$, in GeV. Setting W_MIN = -1 tells STARlight to use the default value specified in inputParameters.cpp (recommended for single meson production). The default W_MIN is the larger of the kinematic limit (*e.g.* $2m_\pi$ for ρ decays) or the particle mass minus five times the width. (-1)
W_N_BINS = 40	#Bins w maximum and minimum values for w (the gamma-gamma center of mass energy, $w = 4E_1E_2$), and the number of w bins in the lookup tables (40)
RAP_MAX = 8.	# Maximum rapidity of produced particle. (8)
RAP_N_BINS = 80	# Number of rapidity bins used in the cross section calculation (80)
CUT_PT* = 0	# Specifies whether the user chooses to place restrictions on the transverse momentum of the decay products. 0= no, 1 = yes. (0)
PT_MIN* = 1.0	# If a transverse momentum cut is applied, this specifies the minimum value produced, in GeV/c. (1.0)

PT_MAX* = 3.0	# If a transverse momentum cut is applied, this specifies the maximum value produced, in GeV/c. (3.0)
CUT_ETA* = 0	# Specifies whether the user chooses to place restrictions on the pseudorapidity of the decay products. 0= no, 1 = yes. (0)
ETA_MIN* = -10	# If a pseudorapidity cut is applied, this specifies the minimum value produced. (-10)
ETA_MAX* = 10	# If a pseudorapidity cut is applied, this specifies the maximum value produced. (10)
PROD_MODE = 2	#**PROD_MODE=1:** Two-photon interaction. **PROD_MODE=2:** Coherent photonuclear vector meson production assuming narrow resonances. This option should also be used for exclusive vector meson production in pp collision. In pA or pp collisions, this option means that the proton emits the photon and that the gamma-A interaction is coherent. **PROD_MODE=3:** Coherent photonuclear vector meson production assuming wide resonances. This option should in be used for exclusive ρ^0 production. **PROD_MODE=4:** Incoherent photonuclear vector meson production. In pA collisions, this option means that the nucleus emits the photon. Do not use for pp. **PROD_MODE=5:** Photonuclear one photon exchange uses DPMJET single. **PROD_MODE=6:** Photonuclear two photon exchange (both nuclei excited) uses DPMJET double. **PROD_MODE=7:** Photonuclearsinglepa uses DPMJET Single, proton mode. **PROD_MODE=8:** [not supported/verified] Photonuclear singlepapy uses Pythia 6
N_EVENTS = 10	#Number of events produced (1000)
PROD_PID = 443013	# For PROD_MODE 1 through 4, this selects the channel to be produced, in PDG notation. Currently supported options are list below. (443013)
RND_SEED = 34533	# Seed for random number generator. (34533)

BREAKUP_MODE = 5	# Specifies the way nuclear break-up is handled. This option only works for lead or gold. It has no meaning in proton-proton or proton-nucleus collisions
	1 = hard sphere nuclei (no hadronic break-up if impact parameter is greater than the sum of nuclear radii, no restriction on Coulomb break-up).
	2 = requires Coulomb break-up of both nuclei, with no restriction on the number of neutrons emitted by either nucleus (XnXn).
	3 = requires Coulomb break-up of both nuclei, but requires that a single neutron is emitted from each nucleus (1n1n).

4 = requires Coulomb break-up of neither nucleus. (0n0n)
5 = requires that there be no hadronic break up, no restriction on Coulomb break-up (This is similar to option 1, but with the actual hadronic interaction probability).
6 = requires Coulomb break up of one or both nuclei, with no restriction on the number of neutrons emitted (XnXn + 0nXn + Xn0n).
7 = requires Coulomb break up of only one nucleus, with no restriction on the number of neutrons emitted (0nXn+ Xn0n).
8 = selectable input parameter range (i.e. for peripheral collisions, not UPCs) regardless of nuclear breakup. Fixed input range between BMAX and BMIN (set by two otherwise optional cards, below)

INTERFERENCE = 0 — # Specifies whether interference based on the ambiguity of which nucleus emits the photon is included. The effect of this interference is only visible at very small transverse momentum. 0 = interference off, 1 = interference on. (0)

IF_STRENGTH = 1. — # If interference is turned on, specifies the percentage of interference. The range is -1.0 – 1.0.; 1 is the standard value for ion-ion collisions, while -1.0 is expected for proton-antiproton collisions. (1)

INT_PT_MAX = 0.24 — # Used only when the interference option above is turned on. This specifies the maximum transverse momentum considered, in GeV/c. (0.24)

INT_PT_N_BINS = 120 — # Used only when the interference option above is turned on. This specifies the number of bins in transverse momentum to use. (120)

INT_PT_WIDTH = 0 — #Used only when the interference option above is turned on. This specifies the width of bins in transverse momentum to use. (0)

XSEC_METHOD* = 0 — #Determines which method is used to calculate the cross-section for γγ cross-sections. XSEC_METHOD=0 is faster, but works only for symmetric collisions (*i.e.* with identical nuclei). XSEC_METHOD=1 always works, but is slower. (0)

BSLOPE_DEFINITION*=0 — Used for proton and nucleon (i. e. incoherent nuclear) collisions to set the t-spectrum, dN/dt=exp(-bt). When BSLOPE_DEFINITION=1, then the slope is determined by BSLOPE_VALUE (below). When BSLOPE_DEFINITION=2, the slope is calculated as a function of γp center of mass energy per the H1 analysis, Eur. Phys. J. C46, 585 (2006):
$b=4.63/\mathrm{GeV}^2 + 4\alpha \ln(W_{\gamma p}/90\ \mathrm{GeV})$
The default value, BSLOPE_DEFINITION=0 has no effect.
Note that this affects the t-slope only; it does not affect the total cross-section

BSLOPE_VALUE*	WHEN BSLOPE_DEFINITION=1, this determines the exponential slope for dN/dt=exp(-BSLOPE_VALUE*t)
SELECT_IMPULSE_VM	When set =1, performs an impulse approximation calculation (this ignores most nuclear physics, including shadowing). Default=0; no change
QUANTUM_GLAUBER	When set =1, perform a quantum Glauber calculation, rather than classical, which is the default (or when set =0)
BMIN	Needed for Breakup_mode=8. Sets the minimum impact parameter
BMAX	Needed for Breakup mode=8. Sets sthe maximum impact parameter.
OUTPUT_HEADER	Adds a header to the output file. This header will contain various input parameters. (1 for header, 0 for no header, default is no header)

The physics constants used by STARlight can be set with the following parameters:

deuteronSlopePar	deuteron slope parameter (effective temperature) [(GeV/c)^-2]
protonMass	mass of the proton [GeV/c^2]
pionChargedMass	mass of the pi^+/- [GeV/c^2]
pionNeutralMass	mass of the pi^0 [GeV/c^2]
kaonChargedMass	mass of the K^+/- [GeV/c^2]
mel	mass of the e^+/- [GeV/c^2]
muonMass	mass of the mu^+/- [GeV/c^2]
tauMass	mass of the tau^+/- [GeV/c^2]
f0Mass	mass of the f_0(980) [GeV/c^2]
f0Width	width of the f_0(980) [GeV/c^2]
f0BrPiPi	branching ratio f_0(980) -> pi^+ pi^- and pi^0 pi^0
etaMass	mass of the eta [GeV/c^2]
etaWidth	width of the eta [GeV/c^2]
etaPrimeMass	mass of the eta' [GeV/c^2]
etaPrimeWidth	width of the eta' [GeV/c^2]
etaCMass	mass of the eta_c [GeV/c^2]
etaCWidth	width of the eta_c [GeV/c^2]
f2Mass	mass of the f_2(1270) [GeV/c^2]
f2Width	width of the f_2(1270) [GeV/c^2]
f2BrPiPi	[GeV/c] f_2(1270) -> pi^+ pi^-
a2Mass	mass of the a_2(1320) [GeV/c^2]
a2Width	width of the a_2(1320) [GeV/c^2]
f2PrimeMass	mass of the f'_2(1525) [GeV/c^2]
f2PrimeWidth	width of the f'_2(1525) [GeV/c^2]
f2PrimeBrKK	branching ratio f'_2(1525) -> K^+ K^- and K^0 K^0bar
zoverz03Mass	mass of four-quark resonance (rho^0 pair production) [GeV/c^2]
f0PartialggWidth	partial width f_0(980) -> g g [GeV/c^2]
etaPartialggWidth	partial width eta -> g g [GeV/c^2]
etaPrimePartialggWidth	partial width eta' -> g g [GeV/c^2]
etaCPartialggWidth	partial width eta_c -> g g [GeV/c^2]

```
f2PartialggWidth       partial width f_2(1270) -> g g [GeV/c^2]
a2PartialggWidth       partial width a_2(1320) -> g g [GeV/c^2]
f2PrimePartialggWidth  partial width f'_2(1525) -> g g [GeV/c^2]
zoverz03PartialggWidth partial width four-quark resonance -> g g (rho^0
                       pair production) [GeV/c^2]
f0Spin                 spin of the f_0(980)
etaSpin                spin of the eta
etaPrimeSpin           spin of the eta'
etaCSpin               spin of the eta_c
f2Spin                 spin of the f_2(1270)
a2Spin                 spin of the a_2(1320)
f2PrimeSpin            spin of the f'_2(1525)
zoverz03Spin           spin of the four-quark resonance -> g g (rho^0
                       pair production)
axionSpin              spin of the axion
rho0Mass               mass of the rho^0 [GeV/c^2]
rho0Width              width of the rho^0 [GeV/c^2]
rho0BrPiPi             branching ratio rho^0 -> pi^+ pi^-
rho0PrimeMass          mass of the rho'^0 (4 pi^+/- final state)
                       [GeV/c^2]
rho0PrimeWidth         width of the rho'^0 (4 pi^+/- final state)
                       [GeV/c^2]
rho0PrimeBrPiPi        branching ratio rho'^0 -> pi^+ pi^-
OmegaMass              mass of the omega [GeV/c^2]
OmegaWidth             width of the omega [GeV/c^2]
OmegaBrPiPi            branching ratio omega -> pi^+ pi^-
PhiMass                mass of the phi [GeV/c^2]
PhiWidth               width of the phi [GeV/c^2]
PhiBrKK                branching ratio phi -> K^+ K^-
JpsiMass               mass of the J/psi [GeV/c^2]
JpsiWidth              width of the J/psi [GeV/c^2]
JpsiBree               branching ratio J/psi -> e^+ e^-
JpsiBrmumu             branching ratio J/psi -> mu^+ mu^-
JpsiBrppbar            branching ratio J/psi -> p pbar
Psi2SMass              mass of the psi(2S) [GeV/c^2]
Psi2SWidth             width of the psi(2S) [GeV/c^2]
Psi2SBree              branching ratio psi(2S) -> e^+ e^-
Psi2SBrmumu            branching ratio psi(2S) -> mu^+ mu^-
Upsilon1SMass          mass of the Upsilon(1S) [GeV/c^2]
Upsilon1SWidth         width of the Upsilon(1S) [GeV/c^2]
Upsilon1SBree          branching ratio Upsilon(1S) -> e^+ e^-
Upsilon1SBrmumu        branching ratio Upsilon(1S) -> mu^+ mu^-
Upsilon2SMass          mass of the Upsilon(2S) [GeV/c^2]
Upsilon2SWidth         width of the Upsilon(2S) [GeV/c^2]
Upsilon2SBree          branching ratio Upsilon(2S) -> e^+ e^-
Upsilon2SBrmumu        branching ratio Upsilon(2S) -> mu^+ mu^-
Upsilon3SMass          mass of the Upsilon(3S) [GeV/c^2]
Upsilon3SWidth         width of the Upsilon(3S) [GeV/c^2]
Upsilon3SBree          branching ratio Upsilon(3S) -> e^+ e^-
Upsilon3SBrmumu        branching ratio Upsilon(3S) -> mu^+ mu^-
```

The following parameters are used only when interfacing with the PYTHIA and/or DPMJET interfaces:

```
MIN_GAMMA_ENERGY = 6   #Allows the user to set the minimum photon energy
                       (in GeV) in the rest frame of the target nucleus.
                       The default is 6.0 GeV and it should never be set
                       below this value since DPMJET was not designed to
                       handle low energy interactions.
MAX_GAMMA_ENERGY  = 600000
                       #Allows the user to set the maximum photon energy
                       (in GeV) in the rest frame of the target nucleus.
                       The default is 60000.0 GeV.
PYTHIA_PARAMS = “”     #Used to supply input parameters to the PYTHIA
                       interface.  This takes a string to pass on semi-
                       colon separated parameters to PYTHIA 6.  eg:
                       "mstj(1)=0;paru(13)=0.1"  (the default is a blank
                       string " ")
PYTHIA_FULL_EVENT_RECORD = 1
                       #Determines whether the full event record from
                       PYTHIA is written to slight.out.  true = yes,
                       false = no (false).  The additional information
                       added is as follows: daughter production vertex (x
                       [mm], y [mm], z [mm], t [mm/c]), mother1, mother2,
                       daughter1, daughter2, PYTHIA particle status code.
                       PYTHA 8 Particle Properties page describes in more
                       detail the properties of mother, daughter, and
                       status code designations.
```

Channels of Interest:

2-Photon Channels
Currently supported 2-photon (prod. mode = 1) channel options:

jetset id	particle
221	eta
331	eta-prime
441	eta-c
9010221	f0(975)
225	f2(1270)
115	a2(1320)
335	f2(1525)
33	rho0 pair
11	e+/e- pair
13	mu+/mu- pair
15	tau+/tau- pair
88	axion-like particle (ALP)

Process 88 refers to the single production of a hypothetical axion-like particle (ALP), which decays to a pair of photons. The ALP mass has to be specified by the user through the parameter AXION_MASS. The narrow width approximation is assumed here, with a fixed axion decay constant of \Lambda=1 TeV. (See equation (1) of arXiv:1607.06083 for the appropriate conventions.) The cross section can be then rescaled to arbitrary \Lambda, as long as the narrow width approximation remains valid.

Pomeron-Photon Channels

```
Currently supported vector meson (prod. mode = 2/3/4) options:
      jetset id       particle
   ---------------------------------
      113         rho0
      113011      rho0 --> e+e-
      113013      rho0 --> mu+mu-
      223         omega
      223211111   omega --> pi+pi-pi0 (UNSTABLE)
      333         phi
      443011      J/psi --> e+e-
      443013      J/Psi --> mu+mu-
      4432212    J/psi --> proton antiproton
      444011      Psi(2S) --> e+e-
      444013      Psi(2S) --> mu+mu-
      553011      Upsilon(1S) --> e+e-
      553013      Upsilon(1S) --> mu+mu-
      554011      Upsilon(2S) --> e+e-
      554013      Upsilon(2S) --> mu+mu-
      555011      Upsilon(3S) --> e+e-
      555013      Upsilon(3S) --> mu+mu-
      913         rho0 + direct pi+pi- (with interference). The direct
                  pi+pi- fraction is from the ZEUS results, EPJ C2 p247
                  (1998)
      999         four-prong final states (rho'-like to pi+pi-pi+pi-)
```

DPMJET:

Simulation of photonuclear interactions with STARlight is possible through an interface with DPMJet. These interfaces can be enabled through options passed to cmake during the configuration process. [Depreciated: Using Pythia 6 as a substitute for DPMJet]

The gfortran compiler is required to use the photonuclear interfaces.

=============== 1. Photonuclear interactions with DPMJet ===============

------- 1.1. Obtaining and installing DPMJet -------

The DPMJet package can be obtained by contacting the authors as explained here: http://sroesler.web.cern.ch/sroesler/dpmjet3.html

Once you have the code proceed with these steps:

Change the line containing the OPT variable in the DPMJet Makefile:

```
OPT = -c -C -std=legacy -O  -O3 -g -fexpensive-optimizations
-funroll-loops -fno-automatic -fbounds-check -v -fPIC
```

------------- 64-bit -------------

Make sure that all -m32 options are removed from the Makefile.

Unfortunately, the DPMJet package depends on a floating point exception trap implementation, and only a 32-bit version of that is included in the package, which needs to be replaced. An example implementation can be found here:
http://www.arsc.edu/arsc/support/news/hpcnews/hpcnews376/

Under "Fortran Floating Point Traps for Linux" there is a code example. A file based on this, fpe.c, can be found in the external/ directory in STARlight. Move that to your DPMJet directory to replace the original file and run:

```
$ gcc -o fpe.o fpe.c
```

Note: if the above command returns the following error:
/usr/lib/../lib64/crt1.o: In function `_start':
(.text+0x20): undefined reference to `main'

/tmp/ccs2CQsd.o: In function `enable_exceptions_':
fpe.c:(.text+0xe): undefined reference to `feenableexcept'
collect2: error: ld returned 1 exit status
Try: gcc fpe.c -Wall -g -c
feenableexcept is a gcc extension and gcc may need all of the headers present.

------------- End 64-bit -------------

Then in the DPMJet directory run:

```
$ make
```

Note: When compiling at RCAS(BNL), needed to change g77 → gfortran, needed to install fluka and setenv FLUPRO /path/to/fluka, and modify phojet before compiling. The changes for phojet is at line 29875, from:

```
PRINT LO,'PHO_DIFSLP:ERROR: this option is not installed !'
```

to:

```
  WRITE(LO,'(/1X,A,I2)')
 & 'PHO_DIFSLP:ERROR: this option is not installed
 & !',ISWMDL(13)
```

------------ 1.2. Compiling Starlight with DPMJet interface ------------

To enable the compilation of the DPMJet interface please follow these steps:

CMake uses an environment variable $DPMJETDIR to locate the DPMJet object files, so define it.

```
$ export DPMJETDIR=<path to dpmjet>
```

Then create a build directory for STARlight

```
$ mkdir <build-dir>
```

and change into it

```
$ cd <build-dir>
```

Run CMake with the option to enable DPMJet

```
$ cmake <path-to-starlight-source> -DENABLE_DPMJET=ON
```

Then build it

```
$ make
```

Note: When compiling at RCAS(BNL), needed to add the gfortran library to the CMakeLists.txt and left it there.

----------- 1.3. Running Starlight with DPMJet interface -----------

To run Starlight with the DPMJet interface a couple of files are needed in the directory where you want to run Starlight.

The files needed are:

slight.in (Starlight config file. An example suitable for DPMJet can be found in config/slight.in.dpmjet)
my.input (DPMJet config file. An example can be found in config/my.input)
dpmjet.dat (Can be found in the DPMJet source directory)

In the slight.in file the relevant production modes (PROD_MODE) for DPMJET is:

5: A+A single excitation
6: A+A double excitation
7: p+A single excitation

In addition the minimum and maximum gamma energies must be set. These must be within the interval set in the my.input file.

To run:

```
$ ./starlight < my.input
```

[DPMJET reads from direct input/interactive]

Output

STARlight outputs an ASCII file named slight.out.

If OUTPUT_HEADER = 1 (set in input file), then there will be a header at the beginning of the output file followed by a list of events. If OUTPUT_HEADER = 0, or if OUTPUT_HEADER is not set, then there will be no header in the output file and the file will start with the list of events.

If there is a header, it will be three lines, with the following format:

CONFIG_OPT: prod_mod particle_id nevents q_glauber impulse seed

where prod_mod indicates if a wide or narrow resonance has been used, particle_id specifies the vector meson species (and decay channel) being produced, nevents indicates the total number of events in the simulation, q_glauber indicates if a quantum (=1) or classical (=0) Glauber has been selected, impulse indicates if the nuclear effects are being modelled (=0) or a simple impulse approx. is employed, and finally seed records the random number seed used when initializing the Monte Carlo. The config opt line is followed by two lines with brief descriptions of beams in the collision, with the format:

BEAM_1(2): beam1(2)Z beam1(2)A beam1(2)LorentzGamma

where beam1(2)Z is the is the charge of the particles in beam 1(2), beam1(2)A indicates the atomic number of beam 1(2) and beam1(2)LorentzGamma is the Lorentz gamma factor associated to beam 1(2)

For each event, a summary line is printed, with the format

EVENT: n ntracks nvertices ,

where n is the event number (starting with 1), ntracks is the number of tracks in the event, and nvertices is the number of vertices in the event (STARlight does not currently produce events with more than one vertex).

EVENT line is followed by a description of the vertex, with the format

VERTEX: x y z t nv nproc nparent ndaughters ,

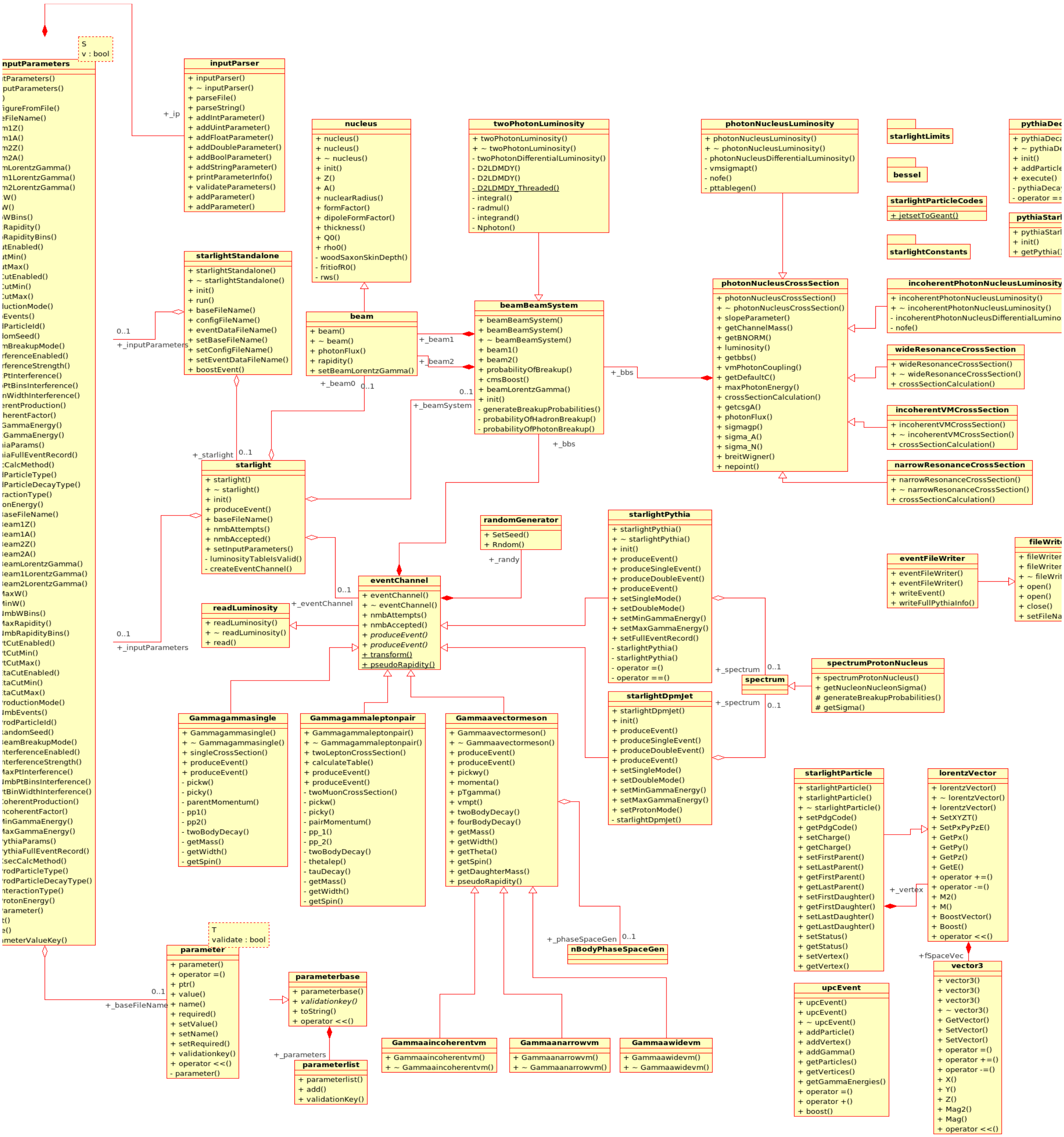
where x, y, z and t are the 4-vector components of the vertex location, nv is the vertex number, nproc is a number intended to represent physical process (always set to 0), nparent is the track number of parent track (0 for primary vertex) and ndaughters is the number of daughter tracks from this vertex.

This is followed by a series of lines describing each of the daughter tracks emanating from this vertex. Each track line has the format

TRACK: GPID px py py nev ntr stopv PDGPID ,

where GPID is the Geant particle id code, px, py and pz are the three vector components of the track's momentum, nev is the event number, ntr is the number of this track within the vertex (starting with 0), stopv is the vertex number where track ends (0 if track does not terminate within the event), and PDGPID is the Monte Carlo particle ID code endorsed by the Particle Data Group.

Class Diagram



File Descriptions

Readme.pdf

[This file.] provides information on the installation, operation, and construction of STARlight.

CMakeLists.txt

controls STARlight compilation. For details, please see above in Installation. This is the default/supported compilation method.

Makefile

A sample Makefile for compilation on *nix systems. This file is not actively supported. Please use CMake.

starlightconfig.h.in

passes on some compiler settings; such as enabling the Pythia/DPMJet sections within the source code.

starlightDoxyfile.conf

Doxygen configuration file.

CMake Modules:

FindPythia8.cmake

used by CMake to find the Pythia 8 files needed to compile STARlight with Pythia 8 dependent options enabled. It searches for: Pythia.h, Index.xml, libpythia8

FindPythia6.cmake

used by CMake to find the Pythia 6 files needed to compile STARlight with Pythia 6 dependent options enabled. It searches for: libPythia6. *Pythia 6 functionality has been deprecated.*

FindDPMJet.cmake

used by CMake to find the DPMJET files needed to compile STARlight with DPMJET dependent options enabled. It searches for: dpmjet3.0-5.o, pythia6115dpm3v1.o, and phojet1.12-35c4.o

FindROOT.cmake

used by CMake to find the ROOT files needed to compile STARlight with ROOT dependent options enabled. It searches for: root-config. root-config is then used to set the rest of the paths/options needed to enable ROOT within STARlight.

CommonMacros.cmake

A collection of useful cmake macos.

FindLHAPDF.cmake

used by CMake to find the LHAPDF dependent options enabled. This was necessary for older versions of Pythia8, but this is no longer the case. However, this file is being kept in the distribution for users that would like to re-enable it. It searches for: Pythia.h and liblhapdfdummy

Config files:

my.input

A sample DPMJET configuration file.

slight.in

A sample STARlight input file, to select the desired final state and associated options. The section Input has more information.

slight.in.dpmjet

A sample slight.in file to use the DPMJET options (eg: PROD_MODE = 5, 6, 7, and MIN_GAMMA_ENERGY, and MAX_GAMMA_ENERGY.).

slight.in.ee_rhic

A sample slight.in file for e+e- production by Au-Au at top RHIC energies

slight.in.jpsi_lhc

A sample slight.in file for J/ψ production by Pb-Pb at the LHC.

slight.in.pPb_lhc

A sample slight.in file for J/ψ production by p-Pb at the LHC.

slight.in.rho_rhic

A sample slight.in file for ρ production by Au-Au at top RHIC energies.

dpmjet:

dpmjetint.f

This is a DPMJET library, used in the CMakeLists.txt file to link when enabling DPMJET.

external:

fpe.c

corrects for the floating point trap differences between 32 and 64-bit. The DPMJET section has more information.

pythia6:

pythiainterface.h

interfaces Pythia6 with STARlight. *Pythia 6 functionality has been deprecated.*

utils:

Ana.C

This macro runs Analyze.cxx, which takes as input an ASCII STARlight output file, slight.out, and creates a standard set of histograms, which are stored in histograms.root

Analyze.cxx

This macro reads in a starlight output file and creates histograms of the p_T and rapidity of the daughters, as well as the p_T, rapidity and mass of the parent. It assumes there are only 2 daughter tracks that are electrons, muons, or pions. The histograms for the daughter particles are called fPt2, fPt2, fRap1, and fRap2. Parent histograms are created for each possible daughter species (e.g., parent p_T histograms are created with the names fPtEl, fPtMu, and fPtPi), but only the ones corresponding to the actual daughter particle are filled. The histograms are saved in a file called histograms.root.

To use this Analyze.cxx, modify the file Ana.C to call your input file (as downloaded, it calls slight.out) and the number of events you wish to process (as downloaded, it processes 20 events). Then open root and type ".x Ana.C" .

Analyze.h

The header file for Analyze.cxx and Ana.C.

AnalyzeTree.cxx

This macro reads the starlight.root file produced by ConvertStarlightAsciiToTree.C, which contains TLorentzVectors for the parents and a TClonesArray of TLorentzVectors for the daughters. It creates histograms of the p_T and rapidity of the daughters, as well as the p_T, rapidity and mass of the parent. While the parents may have been created as the vector sum of any number of daughter particles, this macro currently produces histograms for only the first two daughter particles. The daughter histograms are called D1Pt, D2Pt, D1Rapidity, and D1Rapidity. Parent histograms are named ParentPt, ParentRapidity, and ParentMass. The histograms are stored in starlight_histos.root.

To use Analyzetree.cxx, first run ConvertStarlightAsciiToTree.C to produce the starlight.root file. If needed, modify the file AnalyzeTree.h to call your input file (as downloaded, it calls starlight.root). Then open root and type .x AnaTree.C .

AnalyzeTree.h

The header file for AnalyzeTree.cxx.

AnaTree.C

compiles and runs AnalyzeTree.cxx, which takes as input the starlight.root file produced by ConvertStarlightAsciiToTree.cxx output histograms are stored in starlight_histos.root

ConvertStarlightAsciiToTree.C

reads a starlight output file (default name slight.out) and creates a root file with TLorentzVectors for the parent and a TClonesArray of TLorentzVectors for the daughter particles. The output is stored in a root file (default name starlight.root) with one branch labeled "parent" and the other labeled "daughters". Any number of daughter tracks can be accommodated. Daughter species currently accommodated are: electrons, muons, charged or neutral pions, charged or neutral kaons, and protons.

To use AnaTree.C, open root and then type .x ConvertStarlightAsciiToTree.C("inputfilename", "outputfilename") The root file produced can be examined in a root TBrowser.

A macro to read this root file and make some standard plots is also provided. This macro is called AnalyzeTree.cxx; it can be compiled and run with the AnaTree.C macro by opening root and typing .x AnaTree.C()

Source Files:

beam.cpp

generates the beam class, which inherits from the nucleus class (cf. nucleus.cpp). The object represents an accelerated nucleus, or a beam.

Functions:

beam::beam
beam::~beam
beam::photonFlux *// calculates the "photon density" given the impact parameter and energy.*

beambeamsystem.cpp

represents the colliding system of interest.

Functions:

beamBeamSystem::beamBeamSystem
beamBeamSystem::~beamBeamSystem
beamBeamSystem::probabilityOfBreakup
beamBeamSystem::generateBreakupProbabilities
beamBeamSystem::probabilityOfHadronBreakup
beamBeamSystem::probabilityOfPhotonBreakup

bessel.cpp

calculate modified Bessel functions of the first and second kind.

Functions:

bessel::besI0
bessel::dbesk0
bessel::dbesk1
bessel::besI1

eventchannel.cpp

inherits from readLuminosity. It is a base for class for functions to produce events that is overloaded by other classes (Gammagammaleptonpair, Gammagammasingle, Gammaavectormeson, starlightDpmJet, and starlightPythia).

Functions:

```
eventChannel::eventChannel
eventChannel::~eventChannel
eventChannel::transform  // Lorentz Tranforms the frame
eventChannel::pseudoRapidity // calculates the
      pseudorapidity with the input from px, py, and pz
```

eventfilewriter.cpp

writes event information in the output file.

Functions:

```
eventFileWriter::eventFileWriter
eventFileWriter::~eventFileWriter
eventFileWriter::writeEvent
```

filewriter.cpp

The base class for eventFileWriter, which is writes event information in the output file.

Functions:

```
fileWriter::fileWriter()
fileWriter::~fileWriter()
fileWriter::open
fileWriter::open(filename)
fileWriter::close
```

gammaaluminosity.cpp

contains the photonNucleusLuminosity class, which inherits from photonNucleusCrossSection. It calculates the differential cross-section for gamma-A interactions.

Functions:

```
photonNucleusLuminosity::photonNucleusLuminosity
photonNucleusLuminosity::~photonNucleusLuminosity
photonNucleusLuminosity::photonNucleusDifferentialLuminosi
ty  //Calculates and outputs the differential luminosity
photonNucleusLuminosity::pttablegen  //  Calculates the pt
spectra for VM production with interference per S. Klein
and J. Nystrand, Phys. Rev Lett. 84, 2330 (2000).
photonNucleusLuminosity::vmsigmapt //calculates th effect
of the nuclear form factor on the pt spectrum, for use in
interference calculations. It calculates the cross section
suppression SIGMAPT(PT) as a function of pt. The input pt
values come from pttable.inc
photonNucleusLuminosity::nofe  //calculates the 'photon
density'd^2N_gamma/db^2
```

gammaavm.cpp

is responsible for classes Gammaavectormesion, Gammaanarrowvm, and Gammaawidevm. Both Gammaanarrowvm and Gammaawidevm inherit from Gammaavectormeson, which inherits from eventChannel. The classes are responsible for generating and decaying the vector mesons produced by photon-nucleus interactions.

Functions:

Gammaavectormeson::Gammaavectormeson
Gammaavectormeson::~Gammaavectormeson
Gammaavectormeson::pickwy //responsible for selecting the events center of mass energy and rapidity
Gammaavectormeson::twoBodyDecay // This routine decays a particle into two particles of mass mdec, taking spin into account
Gammaavectormeson::fourBodyDecay // decays a particle into four particles with isotropic angular distribution
Gammaavectormeson::getDaughterMass //returns the daughter particles mass, & the final particles id...
Gammaavectormeson::getTheta //This depends on the decay angular distribution
Gammaavectormeson::getWidth
Gammaavectormeson::getMass
Gammaavectormeson::getSpin //it's a VM, returns 1
Gammaavectormeson::momenta // calculates momentum and energy of vector meson given W and Y, without interference.
Gammaavectormeson::pTgamma //finds the photon pT
Gammaavectormeson::vmpt // calculates momentum and energy of a vector meson given W and Y, including interference. It gets the pt distribution from a lookup table.
produceEvent
pseudorapidity
Gammaanarrowvm::Gammaanarrowvm
Gammaanarrowvm::~Gammaanarrowvm
Gammaanarrowvm::gammaaincoherentvm
Gammaawidevm::Gammaawidevm
Gammaawidevm::~Gammaawidevm

gammagammaleptonpair.cpp

inherits from eventChannel. It calculates the lepton pair's cross-section and generates and decayes the lepton pairs.

Functions:

Gammagammaleptonpair::Gammagammaleptonpair
Gammagammaleptonpair::~Gammagammaleptonpair
Gammagammaleptonpair::twoLeptonCrossSection // calculates section for 2-particle decay, per, see STAR Note 243, Eq. 9. It calculates the 2-lepton differential cross section
Gammagammaleptonpair::twoMuonCrossSection // gives the two muon cross section as a function of Y&W, per G.Soff et. al Nuclear Equation of State, part B, 579
Gammagammaleptonpair::pickw // Picks a w for the 2- photon calculation.
Gammagammaleptonpair::picky // Picks a y given a W
Gammagammaleptonpair::pairMomentum // calculates px,py,pz,and E given w and y
Gammagammaleptonpair::pp_1 // For beam 1, returns a random momentum drawn from from pp_1(E) distribution
Gammagammaleptonpair::pp_2 // For beam 2, returns a random momentum drawn from from pp_2(E) distribution
Gammagammaleptonpair::twoBodyDecay //decays a particle into two particles of mass mdec, taking spin into account

Gammagammaleptonpair::thetalep // calculates the cross-section as a function of angle for a given W and Y, for the production of two muons or taus, per Brodsky et al. PRD 1971, 1532 equation 5.7
Gammagammaleptonpair::produceEvent //returns the vector with the decay particles inside
Gammagammaleptonpair::calculateTable //calculates the tables that are used elsewhere in the Monte Carlo the tau decay follows V-A theory, 1 - 1/3 cos(theta)the energy of each of the two leptons in tau decay is calculated using formula 10.35 in "Introduction to elementary particles by D. Griffiths," which assumes that the mass of the electron is 0. The maximum electron energy in in such a system is 0.5 * mass of the tau
Gammagammaleptonpair::tauDecay // assumes that the tauons decay to electrons and calculates the directons of the decays
Gammagammaleptonpair::getMass
Gammagammaleptonpair::getWidth
Gammagammaleptonpair::getSpin

gammagammasingle.cpp

inherits from eventChannel. It calculates the cross-section for single mesons and generates and decays the single mesons from gamma-gamma interactions. It also generates single mesons which are then decayed by Pythia 8.

Functions:

Gammagammasingle::Gammagammasingle
Gammagammasingle::~Gammagammasingle
Gammagammasingle::singleCrossSection // calculates the cross-section in the narrow-width approximation, per STAR Note 243, Eq. 8
Gammagammasingle::pickw // picks a w for the 2-photon calculation.
Gammagammasingle::picky
Gammagammasingle::parentMomentum // calculates px,py,pz,and E given w and y
Gammagammasingle::pp_1 // For beam 1, returns a random momentum drawn from from pp(E) distribution
Gammagammasingle::pp_2 // For beam 2, returns a random momentum drawn from from pp(E) distribution
Gammagammasingle::twoBodyDecay //decays a particle into two particles of mass mdec, taking spin into account
Gammagammasingle::produceEvent
Gammagammasingle::getMass
Gammagammasingle::getSpin

incoherentPhotonNucleusLuminosity.cpp

is responsible for the incoherentPhotonNucleusLuminosity class and inherits from photonNucleusCrossSection. It houses the differential luminosity calculation for incoherent gamma-A interactions.

Functions:

incoherentPhotonNucleusLuminosity::incoherentPhotonNucleusLuminosity

incoherentPhotonNucleusLuminosity::~incoherentPhotonNucleusLuminosity
incoherentPhotonNucleusLuminosity::incoherentPhotonNucleusDifferentialLuminosity
incoherentPhotonNucleusLuminosity::nofe //Function for the calculation of the "photon density".

incoherentVMCrossSection.cpp
inherits from photonNucleusCrossSection. It calculates the cross-section for incoherent photon-nucleus interactions.
Functions:
incoherentVMCrossSection::incoherentVMCrossSection
incoherentVMCrossSection::~incoherentVMCrossSection
incoherentVMCrossSection::crossSectionCalculation // calculates the vector meson cross section assuming a narrow resonance. For reference, see STAR Note 386.

inputParameters.cpp
sets and stores STARlight's input parameters.
Functions:
inputParameters::inputParameters
inputParameters::~inputParameters
inputParameters::init
inputParameters::configureFromFile
inputParameters::print
inputParameters::write
inputParameters::parameterValueKey

inputParser.cpp
parses the input files and stores the information in the inputParameters.
Functions:
inputParser::inputParser()
inputParser::~inputParser()
inputParser::parseFile
inputParser::parseString
inputParser::addIntParameter
inputParser::addUintParameter
inputParser::addFloatParameter
inputParser::addDoubleParameter
inputParser::addBoolParameter
inputParser::addStringParameter
inputParser::printParameterInfo
inputParser::validateParameters

lorentzvector.cpp
holds Lorentz 4-vectors.
Functions:
lorentzVector::lorentzVector
lorentzVector::~lorentzVector
SetXYZT

main.cpp
the "main" file/function—where the program starts.

narrowResonanceCrossSection.cpp

inherits from photonNucleusCrossSection. It calculates the cross-section for narrow resonance vector mesons.

Functions:

narrowResonanceCrossSection::narrowResonanceCrossSection
narrowResonanceCrossSection::~narrowResonanceCrossSection
narrowResonanceCrossSection::crossSectionCalculation // calculates the vector meson cross section assuming a narrow resonance, per STAR Note 386.

nBodyPhaseSpaceGen.cpp

is responsible for the kinematics used in the four-prong decays.

Functions:

nBodyPhaseSpaceGen::nBodyPhaseSpaceGen
nBodyPhaseSpaceGen::~nBodyPhaseSpaceGen
nBodyPhaseSpaceGen::setDecay // sets decay constants and prepares internal variables
nBodyPhaseSpaceGen::generateDecay// generates event with certain n-body mass and momentum and returns event weight general purpose function
nBodyPhaseSpaceGen::generateDecayAccepted// generates full event with certain n-body mass and momentum only, when event is accepted (return value = true) this function is more efficient, if only weighted evens are needed
nBodyPhaseSpaceGen::pickMasses// randomly choses the (n - 2) effective masses of the respective (i + 1)-body systems
nBodyPhaseSpaceGen::calcWeight// computes event weight (= integrand value) and breakup momenta uses vector of intermediate two-body masses prepared by pickMasses()
nBodyPhaseSpaceGen::calcEventKinematics// calculates complete event from the effective masses of the (i + 1)-body systems, the Lorentz vector of the decaying system, and the decay angles uses the break-up momenta calculated by calcWeight()
nBodyPhaseSpaceGen::estimateMaxWeight// calculates maximum weight for given n-body mass
nBodyPhaseSpaceGen::print

nucleus.cpp

defines the basis properties of a nucleus such as radius, form factor, and thickness.

Functions:

nucleus::nucleus
nucleus::~nucleus
nucleus::init
nucleus::nuclearRadius
nucleus::formFactor
nucleus::dipoleFormFactor
nucleus::thickness// calculates the nuclear thickness function per Eq. 4 in Klein and Nystrand, PRC 60

photonNucleusCrossSection.cpp

calculates the cross-section for coherent photon-Nucleus interactions.

Functions:

photonNucleusCrossSection::photonNucleusCrossSection

photonNucleusCrossSection::~photonNucleusCrossSection
photonNucleusCrossSection::getcsgA // returns the cross-section for photon-nucleus interaction producing vector mesons
photonNucleusCrossSection::photonFlux // gives the photon flux as a function of energy Egamma for arbitrary nuclei and gamma. The first time it is called, it calculates a lookup table which is used on subsequent calls. It returns dN_gamma/dE (dimensions 1/E), not dI/dE energies are in GeV, in the lab frame
photonNucleusCrossSection::nepoint// gives the spectrum of virtual photons, dn/dEgamma, for a point charge q=Ze sweeping past the origin with velocity gamma, integrated over impact parameter from bmin to infinity, per Eq. 15.54 of Jacksons Classical Electrodynamics
photonNucleusCrossSection::sigmagp// gives the gamma-proton --> VectorMeson cross section. Wgp is the gamma-proton CM energy. Unit for cross section: fm**2
photonNucleusCrossSection::sigma_A// Nuclear Cross Section sig_N,sigma_A in (fm**2)
photonNucleusCrossSection::sigma_N// Nucleon Cross Section in (fm**2)
photonNucleusCrossSection::breitWigner// uses simple fixed-width s-wave Breit-Wigner without coherent backgorund for rho' (PDG '08 eq. 38.56)

pythiadecayer.cpp

links Pythia 8 and STARlight, and initalizes Pythia 8.

Functions:

pythiaDecayer::pythiaDecayer
pythiaDecayer::~pythiaDecayer
pythiaDecayer::init
pythiaDecayer::addParticle
pythiaDecayer::execute

randomgenerator.cpp

STARlight's random number generator, using the same algorithm as ROOTs TRANDOM3 class. It is based on M. Matsumoto and T. Nishimura, Mersenne Twistor: A 623-dimensionally equidistributed uniform pseudorandom number generator. For more information see http://www.math.keio.ac.jp/~matumoto/emt.html

Functions:

randomGenerator::SetSeed
randomGenerator::Rndom

readinluminosity.cpp

reads in the luminosity tables from slight.txt, which is generated in the early stages of the program.

Functions:

readLuminosity::readLuminosity
readLuminosity::~readLuminosity
readLuminosity::read

spectrum.cpp

sets up functions needed to make cross-section calculations for general photonuclear interactions modeled with DPMJET.

Functions:

spectrum::spectrum
spectrum::generateKsingle
spectrum::generateKdouble
spectrum::drawKsingle
spectrum::drawKdouble
spectrum::generateBreakupProbabilities
spectrum::getFnSingle
spectrum::getFnDouble
spectrum::getTransformedNofe

sprectrumprotonnucleus.cpp

sets up functions needed to make cross-section calculations for general photonuclear interactions modeled with DPMJET.

Functions:

spectrumProtonNucleus::spectrumProtonNucleus
spectrumProtonNucleus::generateBreakupProbabilities
spectrumProtonNucleus::getSigma

starlight.cpp

initializes and then produces and decays events.

Functions:

starlight::starlight
starlight::~starlight
starlight::init
starlight::produceEvent
starlight::luminosityTableIsValid
starlight::createEventChannel

starlightdpmjet.cpp

hosts the class starlightDpmJet which inherits from the eventChannel class. It includes methods to generate diffractive events with DPMJET.

Functions:

starlightDpmJet::starlightDpmJet
starlightDpmJet::init
starlightDpmJet::produceEvent
starlightDpmJet::produceSingleEvent
starlightDpmJet::produceDoubleEvent

starlightparticle.cpp

is a container to store particle information.

Functions:

starlightParticle::starlightParticle
starlightParticle::~starlightParticle

starlightparticlecodes.cpp

converts jetset particle numbers to the corresponding GEANT code.

Functions:

starlightParticleCodes::jetsetToGeant

starlightpythia.cpp

inherits from the eventChannel class. It includes methods to calculate diffractive events with Pythia6. *Pythia 6 functionality has been deprecated.*

Functions:

```
starlightPythia::starlightPythia
starlightPythia::~starlightPythia
starlightPythia::init
starlightPythia::produceEvent
```

starlightStandalone.cpp

is used by Main.cpp and in turn calls methods from the starlight class.

Functions:

```
starlightStandalone::starlightStandalone
starlightStandalone::~starlightStandalone
starlightStandalone::init
starlightStandalone::run
starlightStandalone::boostEvent
```

twophotonluminosity.cpp

inherits from beamBeamSystem, and is responsible for calculating the two photon luminosity table based on W and Y.

Functions:

```
twoPhotonLuminosity::twoPhotonLuminosity
twoPhotonLuminosity::~twoPhotonLuminosity
twoPhotonDifferentialLuminosity
twoPhotonLuminosity::D2LDMDY
twoPhotonLuminosity::D2LDMDY_Threaded
twoPhotonLuminosity::integral
twoPhotonLuminosity::radmul
twoPhotonLuminosity::integrand
twoPhotonLuminosity::Nphoton
```

upcevent.cpp

stores the final event information.

Functions:

```
upcEvent::upcEvent
upcEvent::operator=
upcEvent::operator+
upcEvent::boost
```

vector3.cpp

is a container for 3D-vectors.

Functions:

```
vector3::vector3
vector3::~vector3
vector3::SetVector
```

wideResonanceCrossSection.cpp

inherits from photnNucleusCrossSection. It is responsible for calculating the cross-section of vector mesons with a wide resonance (eg. Rho).

Functions:

```
wideResonanceCrossSection::wideResonanceCrossSection
wideResonanceCrossSection::~wideResonanceCrossSection
```

wideResonanceCrossSection::crossSectionCalculation // calculates the cross-section assuming a wide(Breit-Wigner) resonance.

Include Files:

beam.h //This class includes a single beam of nucleons

Included in files

beambeamsystem.h
twophotonluminosity.h
beam.cpp
gammaaluminosity.cpp
incoherentPhotonNucleusLuminosity.cpp
spectrumprotonnucleus.cpp
twophotonluminosity.cpp

Functions

beam
~beam
rapidity
photonFlux
setBeamLorentzGamma

beambeamsystem.h //This class covers a coliding beam system

Included in files

eventchannel.h
gammaaluminosity.h
gammaavm.h
gammagammasingle.h
incoherentPhotonNucleusLuminosity.h
photonNucleusCrossSection.h
starlightpythia.h
twophotonluminosity.h
beambeamsystem.cpp
gammaaluminosity.cpp
incoherentPhotonNucleusLuminosity.cpp
spectrum.cpp
spectrumprotonnucleus.cpp
twophotonluminosity.cpp

Functions

beamBeamSystem
~beamBeamSystem
cmsBoost
beamLorentzGamma
beam1
beam2
probabilityOfBreakup
init
generateBreakupProbabilities
probabilityOfHadronBreakup
probabilityOfPhotonBreakup

bessel.h

Included in files

beam.cpp
beambeamsystem.cpp

bessel.cpp
gammaaluminosity.cpp
incoherentPhotonNucleusLuminosity.cpp
photonNucleusCrossSection.cpp
twophotonluminosity.cpp

Functions

besI0
dbesk0
dbesk1
besI1

eventchannel.h

Included in files

gammaavm.h
gammagammaleptonpair.h
gammagammasingle.h
starlight.h
starlightdpmjet.h
starlightpythia.h
eventchannel.cpp
starlight.cpp

Functions

eventChannel
~eventChannel
nmbAttempts ///< returns number of attempted events
nmbAccepted ///< returns number of accepted events
produceEvent
transform ///< Lorentz-transforms given 4-vector
pseudoRapidity ///< calculates pseudorapidity for given 3-momentum

eventfilewriter.h

Included in files

eventfilewriter.cpp
main.cpp
starlight.cpp
starlightStandalone.cpp

Functions

eventFileWriter
writeEvent /** Write an UPC event to file */
writeFullPythiaInfo /** Set if we want to write full pythia information */

filewriter.h

Included in files

eventfilewriter.h
eventfilewriter.cpp
filewriter.cpp
main.cpp
starlight.cpp
starlightStandalone.cpp

Functions

fileWriter
~fileWriter
open //opens the file
setFileName//set the filename we're writing to

gammaaluminosity.h

Included in files

gammaaluminosity.cpp
starlight.cpp

Functions

photonNucleusLuminosity
~photonNucleusLuminosity
photonNucleusDifferentialLuminosity
vmsigmapt
nofe
pttablegen

gammaavm.h

Included in files

gammaavm.cpp
starlight.cpp

Functions

Gammaavectormeson
~Gammaavectormeson
produceEvent
pickwy
momenta
pTgamma
vmpt
twoBodyDecay
fourBodyDecay
getMass
getWidth
getTheta
getSpin
getDaughterMass
pseudoRapidity
Gammaanarrowvm
~Gammaanarrowvm
Gammaawidevm
~Gammaawidevm
Gammaaincoherentvm
~Gammaaincoherentvm

gammagammaleptonpair.h

Included in files

gammagammaleptonpair.cpp
starlight.cpp

Functions

Gammagammaleptonpair
~Gammagammaleptonpair
twoLeptonCrossSection
calculateTable
produceEvent
twoMuonCrossSection
pickw
picky
pairMomentum
pp_1
pp_2

twoBodyDecay
thetalep
tauDecay
getMass
getWidth
getSpin

gammagammasingle.h

Included in files

gammagammasingle.cpp
starlight.cpp

Functions

Gammagammasingle
~Gammagammasingle
singleCrossSection
produceEvent
pickw
picky
parentMomentum
pp
twoBodyDecay
thephi
getMass
getWidth
getSpin

incoherentPhotonNucleusLuminosity.h

Included in files

incoherentPhotonNucleusLuminosity.cpp
starlight.cpp

Functions

incoherentPhotonNucleusLuminosity
~incoherentPhotonNucleusLuminosity
incoherentPhotonNucleusDifferentialLuminosity
nofe

incoherentVMCrossSection.h

Included in files

gammaavm.cpp
incoherentVMCrossSection.cpp

Functions

incoherentVMCrossSection
~incoherentVMCrossSection
crossSectionCalculation

inputParameters.h

Included in files

beam.h
gammaaluminosity.h
incoherentPhotonNucleusLuminosity.h
readinluminosity.h
starlightpythia.h
beam.cpp
beambeamsystem.cpp
gammaaluminosity.cpp
incoherentPhotonNucleusLuminosity.cpp

inputParameters.cpp
nucleus.cpp
readinluminosity.cpp
starlight.cpp
starlightStandalone.cpp
twophotonluminosity.cpp

Functions

parameterlist
add
validationKey
parameterbase
toString
operator<<
parameter
operator=
ptr
value
name
required
setValue
setName
setRequired
inputParameters
~inputParameters
init
configureFromFile
baseFileName
beam1Z
beam1A
beam2Z
beam2A
beamLorentzGamma
beam1LorentzGamma
beam2LorentzGamma
maxW
minW
nmbWBins
maxRapidity
nmbRapidityBins
ptCutEnabled
ptCutMin
ptCutMax
etaCutEnabled
etaCutMin
etaCutMax
productionMode
nmbEvents
prodParticleId
randomSeed
beamBreakupMode
interferenceEnabled
interferenceStrength
maxPtInterference
nmbPtBinsInterference
ptBinWidthInterference
coherentProduction
incoherentFactor

minGammaEnergy
maxGammaEnergy
pythiaParams
pythiaFullEventRecord
xsecCalcMethod
prodParticleType
prodParticleDecayType
interactionType
protonEnergy
setBaseFileName
setBeam1Z
setBeam1A
setBeam2Z
setBeam2A
setBeamLorentzGamma
setBeam1LorentzGamma
setBeam2LorentzGamma
setMaxW
setMinW
setNmbWBins
setMaxRapidity
setNmbRapidityBins
setPtCutEnabled
setPtCutMin
setPtCutMax
setEtaCutEnabled
setEtaCutMin
setEtaCutMax
setProductionMode
setNmbEvents
setProdParticleId
setRandomSeed
setBeamBreakupMode
setInterferenceEnabled
setInterferenceStrength
setMaxPtInterference
setNmbPtBinsInterference
setPtBinWidthInterference
setCoherentProduction
setIncoherentFactor
setMinGammaEnergy
setMaxGammaEnergy
setPythiaParams
setPythiaFullEventRecord
setXsecCalcMethod
setProdParticleType
setProdParticleDecayType
setInteractionType
setProtonEnergy
setParameter
print
write
parameterValueKey
instance

inputParser.h

Included in files

inputParameters.h
inputParameters.cpp
inputParser.cpp

Functions

inputParser
inputParser
parseFile/** Parse a file */
parseString
addIntParameter
addUintParameter
addFloatParameter
addDoubleParameter
addBoolParameter
addStringParameter
printParameterInfo
validateParameters
_parameter
operator==
operator<
printParameterInfo
addParameter

lorentzvector.h

Included in files

nBodyPhaseSpaceGen.h
starlightparticle.h
lorentzvector.cpp

Functions

lorentzVector
~lorentzVector
SetXYZT
SetPxPyPzE
GetPx
GetPy
GetPz
GetE
operator +=
operator -=
M2
M
BoostVector
Boost
operator <<

narrowResonanceCrossSection.h

Included in files

narrowResonanceCrossSection.cpp
gammaavm.cpp

Functions

narrowResonanceCrossSection
~narrowResonanceCrossSection
crossSectionCalculation

nBodyPhaseSpaceGen.h

Included in files

gammaavm.h

[nBodyPhaseSpaceGen.cpp]

Functions

Factorial
breakupMomentum
nBodyPhaseSpaceGen
~nBodyPhaseSpaceGen
setDecay
random
generateDecay
generateDecayAccepted
setMaxWeight
maxWeight
normalization
eventWeight
maxWeightObserved
resetMaxWeightObserved
estimateMaxWeight
eventAccepted
daughter
daughters
nmbOfDaughters
daughterMass
intermediateMass
breakupMom
cosTheta
phi
print
operator <<
pickMasses
calcWeight
pickAngles
calcEventKinematics
eventAccepted

nucleus.h

Included in files

[beam.h]
[beambeamsystem.h]
[twophotonluminosity.h]
[gammaaluminosity.h]
[incoherentPhotonNucleusLuminosity.cpp]
[nucleus.cpp]
[spectrumprotonnucleus.cpp]
[starlightdpmjet.cpp]
[starlightpythia.cpp]
[twophotonluminosity.cpp]

Functions

nucleus
~nucleus
init
Z
A
nuclearRadius
formFactor
dipoleFormFactor
thickness

Q0
rho0
woodSaxonSkinDepth
fritiofR0
rws

photonNucleusCrossSection.h

Included in files

gammaaluminosity.h
incoherentPhotonNucleusLuminosity.h
incoherentVMCrossSection.h
narrowResonanceCrossSection.h
wideResonanceCrossSection.h
gammaavm.cpp
photonNucleusCrossSection.cpp

Functions

photonNucleusCrossSection
~photonNucleusCrossSection
slopeParameter///< returns slope of t-distribution [(GeV/c)^{-2}]
getChannelMass ///< returns mass of the produced system [GeV/c^2]
getBNORM
luminosity//< returns luminosity [10^{26} cm^{-2} sec^{-1}]
getbbs///< returns beamBeamSystem
vmPhotonCoupling ///< vectormeson-photon coupling constant f_v / 4 pi (cf. Eq. 10 in KN PRC 60 (1999) 014903)
getDefaultC
maxPhotonEnergy///< returns max photon energy in lab frame [GeV] (for vectormesons only)
crossSectionCalculation
getcsgA
photonFlux
sigmagp
sigma_A
sigma_N
breitWigner
nepoint

pythiadecayer.h

Included in files

gammagammasingle.h
pythiadecayer.cpp

Functions

pythiaDecayer
~pythiaDecayer
init// Initialize
addParticle// Add particle to current event
execute// Execute event and return starlight type event
pythiaDecayer
operator==

PythiaStarlight.h

Included in files

starlight.cpp

Functions

pythiaStarlight
init
getPythia

randomgenerator.h

Included in files

eventchannel.h
gammaavm.h
gammagammasingle.h
nBodyPhaseSpaceGen.h
inputParameters.cpp
randomgenerator.cpp
spectrum.cpp

Functions

SetSeed
Rndom
randomGenerator
instance

readinluminosity.h

Included in files

eventchannel.h
gammaavm.h
gammagammaleptonpair.h
gammagammasingle.h
readinluminosity.cpp

Functions

readLuminosity
~readLuminosity
read

reportingUtils.h

Included in files

inputParser.h
nBodyPhaseSpaceGen.h
beam.cpp
beambeamsystem.cpp
inputParameters.cpp
main.cpp
nucleus.cpp
photonNucleusCrossSection.cpp
pythiadecayer.cpp
starlight.cpp
starlightStandalone.cpp

Functions

getClassMethod__
printErr
printWarn
printInfo
svnVersion
printSvnVersion
compileDir
printCompilerInfo

operator <<
progressIndicator
trueFalse
yesNo
onOff
enDisabled

spectrum.h

Included in files

spectrumprotonnucleus.h
starlightdpmjet.h
spectrum.cpp
starlightdpmjet.cpp

Functions

spectrum // Spectrum must be constructed with beam-beam system, default constructor disallowed
generateKsingle // Generate a table of photon energy probabilities. Use NK+1 logarithmic steps between Et_min and Eg_max
generateKdouble // Generate a 2-D table of photon energy probabilities. Use NK+1 x NK+1 logarithmic steps between Et_min and Eg_max
drawKsingle // Get the energy of a single gamma @return energy of the gamma
drawKdouble // Get the energy of a single gamma @param egamma1 variable passed by reference to get the energy of the frst gamma @param egamma2 variable passed by reference to get the energy of the second gamma @return energy of the gamma
setBeamBeamSystem // Set the beam beam system
setMinGammaEnergy //Set the minimum gamma energy
setMaxGammaEnergy / Set the maximum gamma energy
setBmin //Set minimum impact parameter
setBMax //Set maximum impact parameter
generateBreakupProbabilities //Generate the hadron breakup probability table
getSigma ---1.05?
getTransformedNofe
getFnSingle
getFnDouble

sprectrumprotonnucleus.h

Included in files

spectrumprotonnucleus.cpp
starlightdpmjet.cpp
starlightpythia.cpp

Functions

spectrumProtonNucleus
getNucleonNucleonSigma --- 7.35?
generateBreakupProbabilities
getSigma

starlight.h

Included in files

main.cpp
starlight.cpp

starlightStandalone.cpp

Functions

starlight
~starlight
init
produceEvent
configFileName
nmbAttempts
nmbAccepted
luminosityTableIsValid
createEventChannel

starlightconstants.h

Included in files

eventchannel.h
gammaavm.h
gammagammasingle.h
gammagammaleptonpair.h
inputParameters.h
nBodyPhaseSpaceGen.h
photonNucleusCrossSection.h
upcevent.h
beam.cpp
beambeamsystem.cpp
gammaaluminosity.cpp
gammagammaleptonpair.cpp
gammagammasingle.cpp
incoherentPhotonNucleusLuminosity.cpp
incoherentVMCrossSection.cpp
inputParameters.cpp
narrowResonanceCrossSection.cpp
nucleus.cpp
photonNucleusCrossSection.cpp
readinluminosity.cpp
twophotonluminosity.cpp
wideResonanceCrossSection.cpp

Functions

N/A

starlightdpmjet.h

Included in files

starlight.cpp
starlightdpmjet.cpp

Functions

starlightDpmJet
init
produceEvent
produceSingleEvent
produceDoubleEvent
setSingleMode
setDoubleMode
setMinGammaEnergy
setMaxGammaEnergy
setProtonMode

starlightlimits.h

Included in files
gammagammaleptonpair.h
readinluminosity.h
twophotonluminosity.h
Functions
N/A

starlightparticle.h
Included in files
pyhthiadecayer.h
upcevent.h
starlightparticle.cpp
Functions
starlightParticle
~starlightParticle
setPdgCode
getPdgCode
setCharge
getCharge
setFirstParent
getFirstParent
setLastParent
getLastParent
setFirstDaughter
getFirstDaughter
setLastDaughter
getLastDaughter
getStatus
setStatus
setVertex
getVertex

starlightparticlecodes.h
Included in files
eventfilewriter.cpp
starlightparticlescodes.cpp
Functions
jetsetToGeant//Converts a jetset code into a GEANT codes

starlightpythia.h
Included in files
starlight.cpp
starlightpythia.cpp
Functions
starlightPythia
~starlightPythia
init
produceSingleEvent
produceDoubleEvent
produceEvent
setSingleMode
setDoubleMode
setMinGammaEnergy
setMaxGammaEnergy
setFullEventRecord

starlightStandalone.h

Included in files

[main.cpp]
[starlightStandalone.cpp]

Functions

starlightStandalone
~starlightStandalone
init
run
configFileName
eventDataFileName
setConfigFileName
setEventDataFileName
boostEvent

twophotonluminosity.h

Included in files

[starlight.cpp]
[twophotonluminosity.cpp]

Functions

twoPhotonLuminosity
~twoPhotonLuminosity
twoPhotonDifferentialLuminosity
D2LDMDY
D2LDMDY_Threaded
integral
radmul
integrand
Nphoton

upcevent.h

Included in files

[eventchannel.h]
[filewriter.h]
[gammaavm.h]
[pythiadecayer.h]
[starlight.h]
[starlightpythia.h]
[starlight.cpp]
[upcevent.cpp]

Functions

upcEvent
~upcEvent
addParticle
addVertex
addGamma
getParticles
getVertices
getGammaEnergies
operator=
operator+
boost

vector3.h

Included in files

lorentzvector.h
vector3.cpp

Functions

vector3
~vector3
GetVector
SetVector
operator +=
operator =
operator -=
X
Y
Z
Mag2
Mag
operator <<

wideResonanceCrossSection.h

Included in files

gammaavm.cpp
wideResonanceCrossSection.cpp

Functions

wideResonanceCrossSection
~wideResonanceCrossSection
crossSectionCalculation