The AGATA Simulation code ASC

Session III

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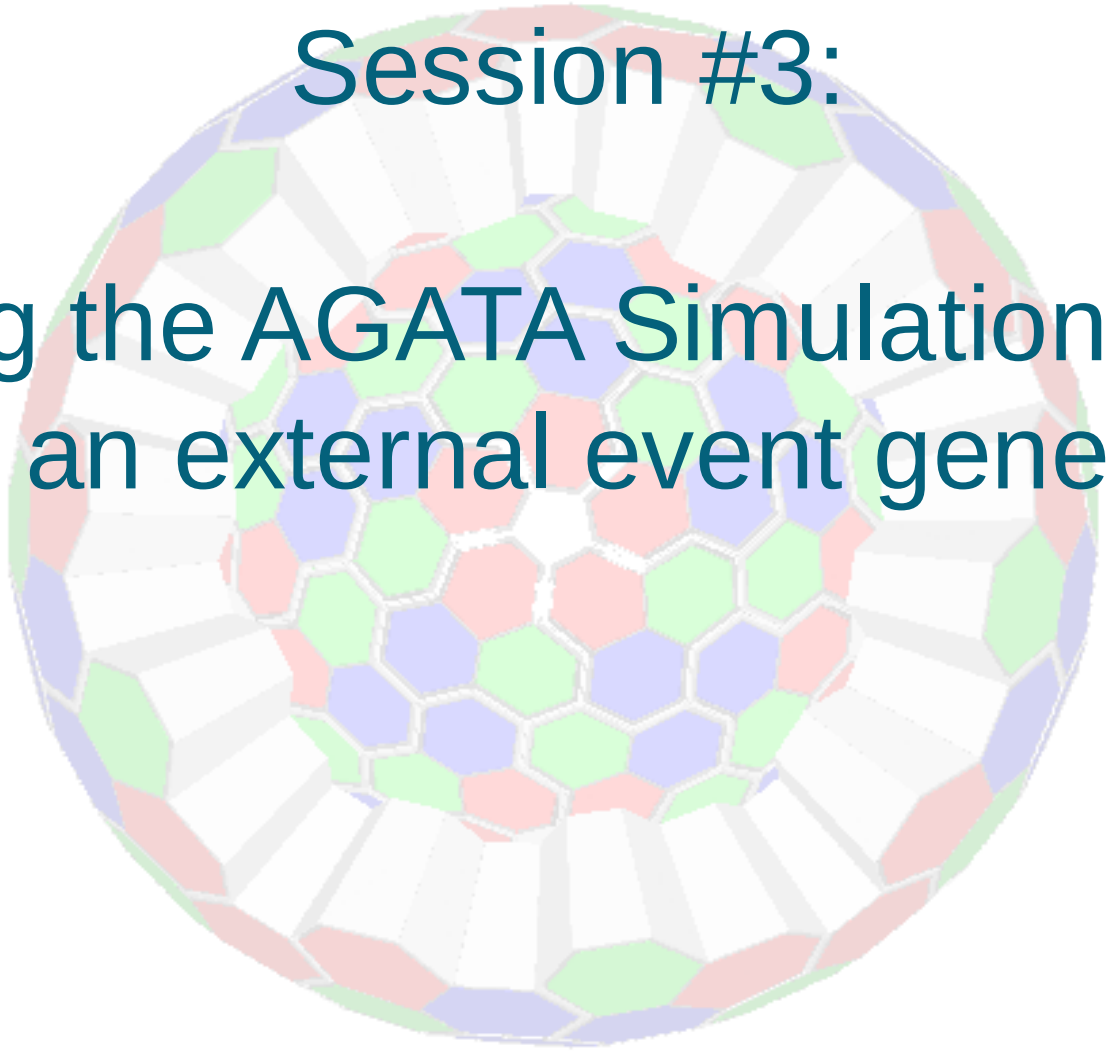
Session #3:

Using the AGATA Simulation code with an external event generator



Outline

- Session #3: External evt generators
  - Format needed for input event file
  - Example with EvtGen
- Tutorials

Using an external event generators

- AGATA code accepts ASCII file of events as input.
  - Some examples are in trunk/events/:
    - Events*XY* *(with X and Y the format level of emitter and emitted particle)*
- Running option is –Ext: ./build/Agata -Ext
- You can use/create your own event generator to produce this event file or you can use:
  - GammaWare (From .ags files)
  - ext_generators/
    - distributed with the AGATA code

Format of the event input file

Example: Events00 file in Agata/events/:

FORMAT 0 0	= Emitter info , Emitted info
#	(Level of detailed information: 0 to 4)
#	
REACTION 6 12 16 32 88.0	= Z_{beam}, A_{beam}, Z_{target}, A_{Target}, E_{beam}
#	(Default= 1, 1, 6, 12, 0)
#	
EMITTED 2 1 4	= N_{total}, $Type_{i=0}$, …, $Type_{i-N}$
#	
$	= Beginning of event
-101 12 26 44. 0. 0. 1. 0. 0. 0.	= Emitter: z, A, E, x_{Dir}, y_{Dir} ,z_{Dir}, x_S, y_S ,z_S
1 3000. 0. 1. 0. 0. 0. 0. 0. 0.	= 1st emitted: E, x_{Dir}, y_{Dir} ,z_{Dir}, x_S, y_S ,z_S, [t, P]
4 5000. 1. 0. 0. 0. 0. 0. 0.5 1	= 2nd emitted: E, x_{Dir}, y_{Dir} ,z_{Dir}, x_S, y_S ,z_S, [t, P]

Command:
$G4BIN/agata -Ext -n
Idle>/control/execute macros/geom180.mac
Idle>/Agata/generator/emitter/eventFile /Path/to/Eventfile/EventfileName

index	Type
1	gamma
2	neutron
3	proton
4	deuterium
5	Triton
6	3He
7	alpha
8	Generic ion
97	Electron
98	Positron
99	Geantino

The “ Format X Y “ line

X

Emitter line

EmitterType	Line
0	-101 zEmi aEmi eEmi Dx Dy Dz Sx Sy Sz
1	-101 zEmi aEmi eEmi Dx Dy Dz
2	-101 zEmi aEmi eEmi
3	-101 zEmi aEmi
4	-101
5	**-101 zEmi aEmi qEmi Dx Dy Dz Sx Sy Sz**

Y

Emitted line

EmittedType	Line
0	type Elab Dx Dy Dz Sx Sy Sz [t P]
1	type ECM D'x D'y D'z Sx Sy Sz [t P]
2	type Elab Dx Dy Dz [t P]
3	type ECM D'x D'y D'z [t P]
4	type ECM [t P]

Ex: events/Events00

To run the agata code:

> $G4WORKDIR/…/Agata -Ext
Idle>/Agata/file/enableLM
Idle>/control/execute macros/geom180-Demo.mac
Idle>/Agata/generator/emitter/eventFile events/Events00
Idle> /Agata/run/beamOn 3000

Then, run mgt or oft to read the output

Producing event input files with GammaWare

- Install GammaWare (with cmake)
- source Gw-env.csh (or Gw-env.sh)
- Download a .*ags* file from: https://radware.phy.ornl.gov/agsdir1.html

> cd PathTo/gammaware/demos/gem directory and run:

```
root –l
.L ToGeant.C
toGEANT1("PathTo/yourfile.ags", 1000, "YourOutputfile")
.q
```

> YourOutputfile.event (in ascii & ROOT) is created !

Producing event input files ext_generators/

- EvtGen/
  - Developed by M. Reese (TU Darmstadt) & myself
  - Gamma rays emitted by Recoil nucleus in Inverse Coulex, Knock-out and fusion evaporation
  - 2-body reactions (inelastic/transfer)
- MyMocadiEvtGene/
  - Developed by M. Taylor (York University) for LyccaSim (GEANT4)
  - Uses MOCADI Ascii output files as input to AGATA Simulation
  - Adapted to AGATA by myself
- DBEvtGene/
  - Developed by D. Bloor (York)
  - MOCADI+AGATA+LYCCA

Using ext_generators/evtGen

- The executable *Event_generator* generates an event output file with Format 0 0.
- To compile it, you'll need gsl (gnu scientific library) installed
  - Then run: make
- To run it:

  >./event_generator yourSetupFile outputFileName

- Several example of setup files are given for different reactions:
  - Example.setup (typical plunger setup)
  - exampleInelastic.Setup
  - exampleTransfer.Setup

Input file: example.setup (1/3)

NumberProjectiles: 21000
##
 # definition of a target layer:
##
 # Layer: A Z density(in g/cm^3) thickness(in um) relative_excitation_probability angular_straggling(in mrad/um) reaction_type
 # all length in micometers
 # A = Z = 1 and density = 0 means vacuum
 # available reaction types: ***C*** ***"inverse coulex"*** *(do nothing : ejectile flys with velocity of projectile)*
***k*** ***knock out*** *(or fragmentation) : Relative change of velocity (Borrel et al.)*
***f*** ***fusion evaporation****: ejectile flys with center of mass velocity*
***T*** ***Elastic/Inelastic scattering and n-transfer in inverse kinematics***
##
Layer: 197 79 19.3 208.0 90.0 0.0 ***C***
Layer: 1 1 0 500.0 0.0 0.0 ***C***
Layer: 197 79 19.3 208.0 90.0 0.0 ***C***

…

Input file example.setup (2/3)

```
....
##########################################
# characteristics of projectile and beam
##########################################
Ap:  85                 # projectile mass
Zp:  35                 # projectile charge number

E0: 201.7                       # initial projectile energy (in MeV/A)
deltaE: 0.005                   # variance of initial projectile energy (in MeV/A)

x0: 0.0                         # primary beam position and variance in x-direction (in um)
deltax: 25000
y0: 0.0                         # primary beam position and variance in y-direction (in um)
deltay: 17000

##########################################
# characteristics of ejectile
##########################################
Ae:  85                 # ejectile mass
Ze:  35                 # ejectile charge number
Bn:   8.0   # binding energy in MeV/u

decay_filename: example.decay
```

Input file example.setup (3/3)

```
....
##########################################
# if heavy ion spectrometer (Prisma) is used
##########################################
Prisma:          0        # set to 1 for emitter format 5
MeanZeq:         30       # effective charge state (could be Ze of lower valu
deltaZeq:        2        # variation
```

WORK IN PROGRESS:
To smear energy and direction of charged products in 2-body transfer reactions when ancillaries are not available in the code

```
##########################################
## AddRes is Optional( 0 is off 1 is on):
##
## AngRes:  FWHM in deg
## NrjRes: FWHM in keV
##########################################
AddRes: 0
AngRes: 0
NrjRes: 0
```

The γ decay file: example.decay

```
level: ground_state 0.0

level: excited_state2  373.8   6.71
        decay: ground_state 100 1

level: excited_state1 630   3.71
        decay: excited_state2 100 1

level: exciter 10000 0.1
        decay: excited_state2 100 1
```

← Energy limit, dummy

← Branching, id(dummy)

level: <state> <energy_level> <lifetime>
decay: <state destination> <branching> <dummy>

"ground_state", "excited_stateX "and "exciter" are token words

NOTE:
- *The energy must be in keV*
- *The state lifetime must be in ns*
- *The highest excited state is called "excited_state1"*

Output file from EvtGen:

FORMAT 0 0
REACTION 35 85 197 79 17144.5
EMITTED 1 2
$
-101 35 85 14781.7 0 0 1 0.334797 -0.149772 0.13051
1 346.708 0.824704 -0.258418 0.503074 0.334797 -0.149772 0.13051
1 364.115 0.904425 -0.345118 0.250815 0.334797 -0.149772 0.194586
$
-101 35 85 15992.8 0 0 1 2.23389 -0.0300013 0.0211288
1 446.355 -0.503235 0.340333 0.79431 2.23389 -0.0300013 0.0211288
1 450.624 -0.337965 -0.757537 0.558496 2.23389 -0.0300013 0.0352129
$
-101 35 85 16000.2 0 0 1 -1.67463 -1.4072 0.0299378
1 337.015 -0.862069 -0.195287 0.467653 -1.67463 -1.4072 0.0299378
1 454.966 0.544592 0.614913 0.570353 -1.67463 -1.4072 0.0361693
$

Input file: exampleInelastic.Setup (1/5)

```
NumberProjectiles: 10000
#
##########################################
# definition of a target layer:
##########################################
# Layer: A Z density(in g/cm^3)   thickness(in um)  relative_excitation_probability
angular_straggling(in mrad/um) reaction_type
# all length in micometers
# A = Z = 1 and density = 0 means vacuum
# available reaction types: C   inverse coulex  ( do nothing : ejectile flys with velocity of
projectile )
#                          k   knock out (or fragmentation) : Relative change of velocity
(Borrel et al.)
#                          f   fusion evaporation                    : ejectile flys with center of
mass velocity
#                          T   Elastic/Inelastic scattering and n-transfer in inverse kinematics
##########################################
Layer: 1 1  0.001      50.0         90.0  0.0  T
##########################################

...
```

Input file: exampleInelastic.Setup (2/5)

```
…

##############################################
# characteristics of projectile and beam
##############################################
Ap:  114              # projectile mass
Zp:   54              # projectile charge number
Xsp: -67.18                   # Mass excess [MeV]

E0: 50.                    # initial projectile energy (in MeV/A)
deltaE:  0.005             # variance of initial projectile energy (in MeV/A)

x0: 0.0               # primary beam position and variance in x-direction (in um)
deltax: 25000
y0: 0.0               # primary beam position and variance in y-direction (in um)
deltay: 17000
#

…
```

Input file: exampleInelastic.Setup (3/5)

```
…
##########################################
# characteristics of target nucleus
##########################################

Atg:        1                   # target ejectile mass
Ztg:        1                   # target z
Xstg:       7.289               # Mass excess [MeV]

##########################################
# characteristics of heavy ejectile
##########################################

Ae:  114            # ejectile mass
Ze:   54            # ejectile charge number
Bn:   8.0                   # binding energy in MeV/u
Xse:  -67.18                # Mass excess [MeV]
Ex:   12.888                # Excitation energy [MeV] populated after reaction
                            # (used for the kinematics)
#
…
```

exampleInelastic.Setup (4/5)

```
…
##################
# gamma decay file
decay_filename: 114Xe.decay
#

# Cross section file for transfer or elastic/Inelastic scattering (cross section vs thetaCM)
Xsec_filename: CrossSection/flat.txt
#Xsec_filename: CrossSection/sn132dp_gs_10AMeV.txt
#

##########################################################
# characteristics of light ejectile (for inelastic or transfer reaction)
##########################################################
Ale: 1                          # light ejectile mass
Zle: 1                          # light ejectile z
Xsle:       7.289               # Mass excess [MeV]
```

Input file exampleInelastic.setup (5/5)

```
….
##########################################
# if heavy ion spectrometer (Prisma) is used
##########################################
Prisma:          0        # set to 1 for emitter format 5
MeanZeq:         30       # effective charge state (could be Ze of lower valu
deltaZeq:        2        # variation
```

WORK IN PROGRESS:
To smear energy and direction of charged products in 2-body transfer reactions when ancillaries are not available in the code

```
##########################################
## AddRes is Optional( 0 is off 1 is on):
##
## AngRes:  FWHM in deg
## NrjRes: FWHM in keV
##########################################
AddRes: 0
AngRes: 0
NrjRes: 0
```

EvtGen - HowTo

1- Run the event generator:

>./event_generator exampleInelastic.setup output.dat

2- Run the AGATA code:

>./Agata –Ext

Idle>/Agata/file/enableLM

Idle>/control/execute macros/geom180-Demo.mac

Idle>/Agata/generator/emitter/eventFile /path/to/output.dat

Idle>/Agata/rrun/beamOn 10000

3- Run mgt or oft

EvtGen - HowTo

With oft, use the code in analysis/oft/**external**

OFTinput format:

1 3000 1	// number of events to be treated together; total number of events, number of simulation files
AgataSimulationFileName	// input AGATA Geant4 data file name
RootFile.root	// output Root file
RadwareFile.sec	// output Radware file
0.8 0.05 1	// sigma_theta, minprobtrack and clusterisation angle reduction factor
0 0 0	// flags off to treat single int. clusters; to include pair production; flag off for Ge sphere approximation
0.015 0 1 1	// energy threshold in MeV; flag to pack points in segment, flag to smear positions & energies, flag to pack points within 5 mm (this last flag is generally on)
0 0 0.0	// position of source (with respect to geometrical centre of AGATA)
0	// set to 1 to read v/c and direction of recoil for each event
	// set to 0 to read line below (fixed average v/c and direction)
0. 0. 0. 0.	// recoil velocity v/c, vx, vy, vz

End of presentation #3

Start of tutorial

Ex1: events/60CoEvents44

1. Have a look at the 60CoEvents file in the trunk/events

2. Run the agata code:

```
> ./build/Agata  -Ext
Idle> /Agata/file/enableLM
Idle> /control/execute  macros/geom180-Demo.mac
Idle> /Agata/generator/emitter/eventFile  events/60CoEvents44
Idle> /Agata/run/beamOn 3000
```

3. Then run mgt++ or oft (in analysis/oft/extern/) to read GammaEvent.0000 and produce the energy spectrum

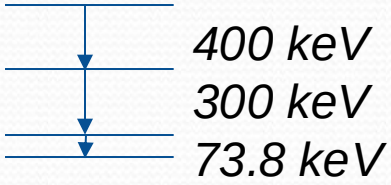
Ex2 (1/2):

Go ext_generators/EvtGen

Check example.setup:

- Excitation of ^{85}Br at 201.7 MeV/A passing through 2 layers of ^{197}Au separated by 500um.
- Set event number to 20000

Check example.decay:



Run:

> event_generator example.setup example.event

Check example.event is created

Ex2 (2/2):

Back in trunk/ directory, edit the macros:
macros_LNL/agata_batch_Ext.mac

Update the path to the input event file:
/Agata/generator/emitter/eventFile
../../../ext_generators/EvtGen/example.event

Run simulation for 20000 events
./build/Agata -Ext -b macros_LNL/agata_batch_Ext.mac

Run OFT in analysis/oft/extern/ after updating OFTinput file

Now try to change beam energy and thickness layers and repeat process

Ex3 : ^{88}Ru – rotational band

Go ext_generators/EvtGen

Check 88Ru.setup:

- Excitation of ^{88}Ru at 102 MeV/A passing a thin layer of ^{208}Pb.
- Set event number to 10^6

Check 88Ru.decay: gamma cascade

Run:

> event_generator 88Ru.setup 88Ru.event

Check 88Ru.event is created

Ex3 (2/2):

Back in trunk/ directory, edit the macros: macros_LNL/agata_batch_Ext.mac

Update the path to the input event file:
/Agata/generator/emitter/eventFile ../../../ext_generators/88Ru.event

Run simulation for 1e6 events
> ./build/Agata -Ext -b macros_LNL/agata_batch_Ext.mac

Run OFT in analysis/oft/extern/ after updating OFTinput file with:
v/c=0.0499
output file save as OFToutput88Ru.root

Check spectra in OFToutput88Ru.root

Applying gates:
> root –l AnalysOFTEvent4G_Ru88.C for g-g-g-g
> root –l AnalysOFTEvent2G_Ru88.C   for g-g

Ex4:

For an example of complex decay file: see 158Er.decay file.