

Introduction to GLOBES

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Outlines

- 1 Purpose of GLoBES
- 2 Downloading & Installing GLoBES
- 3 Features of GLoBES
- 4 Experiments using GLoBES
- 5 Basic Structure of GLoBES
- 6 Experiment Description in AEDL
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Purpose of GLoBES

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 - cd to GLoBES folder
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`make`
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 - unpack GLoBES file and change into the directory created by this
 - `./configure --disable-rpath --enable-no-binary=yes`
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- Arbitrary matter density profile & uncertainties

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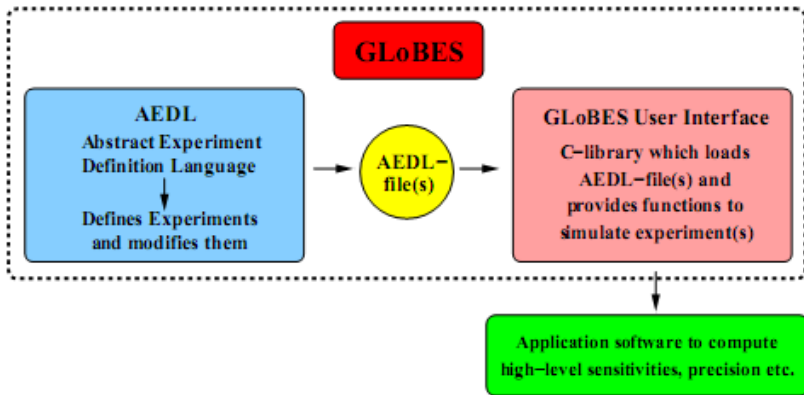
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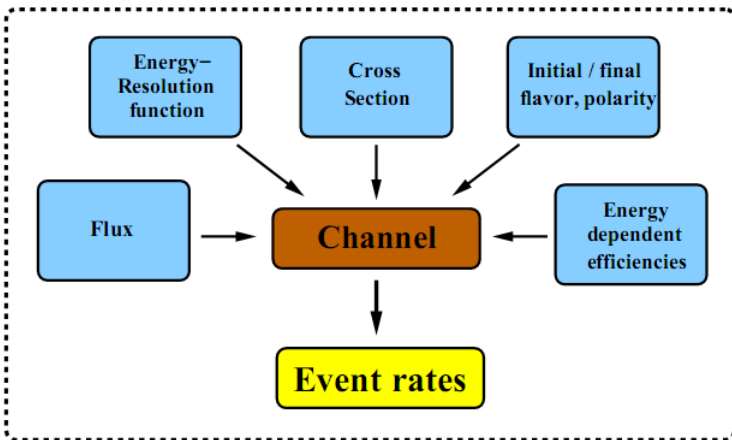
Basic Structure of GLOBES



- Figure taken from GLOBES manual 3.0.8

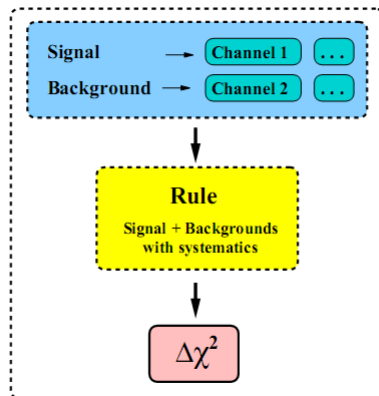
Experiment Description in AEDL

- The experiment is described within one file: Name.glb



Concept of a "channel"

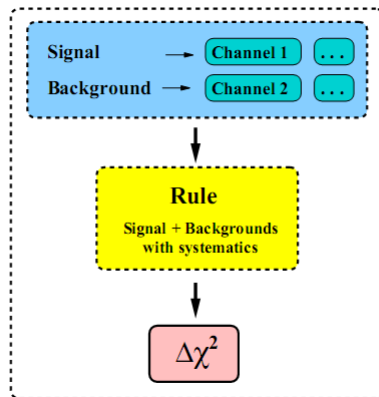
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Concept of a "rule"

- The experiment can contain any arbitrary number of rules
- GLOBES can handle any number of experiments

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Experiment Description in AEDL

- Flux can be loaded from external file:

```
/* ##### Beam flux ##### */  
  
nuflux(#JHFplus)<  
  @flux_file="JHFplus.dat"  
  @time = 2 /* years */  
  @power = 0.77 /* MW (proton intensity) */  
  @norm = 6.93185  
>
```

Taken from T2K-tutorial.glb

Experiment Description in AEDL

- Cross section can also be loaded from external file:

```
/* ##### Cross sections ##### */  
  
cross(#CC)<  
    @cross_file = "XCC.dat"    /* Charged current */  
>  
  
cross(#NC)<  
    @cross_file = "XNC.dat"    /* Neutral current */  
>  
  
cross(#QE)<  
    @cross_file = "XQE.dat"    /* Quasi-elastic */  
>
```

Taken from T2K-tutorial.glb

Experiment Description in AEDL

- Basic characteristics of Experiment

```
/* ##### Detector settings ##### */  
  
$target_mass = 22.5 /* kt (fiducial mass)*/  
  
/* ##### Number of energy bins in the simulation ##### */  
  
$sampling_points = 20  
  
/* ##### Number of bins in the analysis, and analysis energy  
window ##### */  
  
$bins = 1  
$emin = 0.4 /* GeV */  
$emax = 1.2 /* GeV */  
  
/* ##### Baseline setting ##### */  
  
$profiletype = 1 /* 1 = constant Earth matter  
density */  
$baseline = 295.0 /* km */  
  
/* ##### Technical information ##### */  
  
$filter_state = 0  
$filter_value = 1000000
```

Taken from [T2K-tutorial.glb](https://github.com/nuclab/T2K-tutorial/blob/master/globes/globes.aedl)

Experiment Description in AEDL

- Description of energy resolution

```
/* ##### Energy resolution ##### */
energy(#ERES)<      /* Energy resolution function is Gaussian, with
    @type = 1      /* sigma = sigma_e[0] * E + sigma_e[1] *
sqrt(e) + sigma_e[3] */
    @sigma_e = {0.0,0.0,0.085}
>
```

```
energy(#manual_smearing_matrix)<
@energy =
{0,2,0.863,0.182,0.00267}:
{0,3,0.151,0.697,0.151,0.00101}:
...
{16,19,0.00936,0.278,0.483,0.136};
>
```

Manual energy smearing:

energy smearing matrix M_{ij}

- number of rows: \$bins
- number of columns: \$sampling_points

Taken from T2K-tutorial.glb and R. Mark's slide

Experiment Description in AEDL

- Defining the channels:

```

/* ##### Channel definitions ##### */

/* The format is
 *      @channel =          <Name>: CP sign : initial flavor :
final flavor: cross section : energy resolution funtion */

```

```

/* 0 */
channel(#nu_mu_disappearance_CC)<
    @channel =          #JHFplus:  +:    m:    m:    #CC:    #ERES
>

```

```

/* 1 */
channel(#NC_bckg)<
    @channel =          #JHFplus:  +:    NOSC_m:    NOSC_m:    #NC:
#ERES
>

```

Experiment Description in AEDL

- Defining the rules

```
rule(#NU_E_Appearance_CC)<
  @signal = 0.50498@#nu_e_appearance_CC
  @signalerror = 0.05 : 0.0001 /* follow hep-ph/0504026:
5 per cent norm errors for appearance */

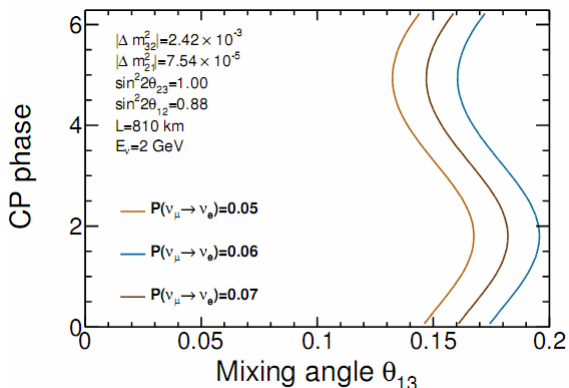
  @background = 0.00032671@#nu_mu_disappearance_CC :
0.0056373@#NC_bckg : 0.50498@#nu_e_beam : 0.50498@#nu_e_bar_beam
  @backgrounderror = 0.05 : 0.0001 /* do not use 0.05
for BG tilt here, since introduced twice uncorrelated then! */

  @sys_on_function = "chiTotalRatesTilt"
  @sys_off_function = "chiNoSysTotalRates"
>
```

Taken from T2K-tutorial.glb

Degenerate solution

- Degeneracy problem in $(\theta_{13}, \delta_{CP})$ measurement
- Equation $P_{\alpha\beta}(\bar{\theta}_{13}, \bar{\delta}) = P_{\alpha\beta}(\theta_{13}, \delta)$ has continuous number of solutions: **Equiprobability curves of $P(\nu_{\mu} \rightarrow \nu_e)$**



Taken from Cao Son's dissertation

Degenerate solution

- Introducing $P(\bar{\nu}_\mu \rightarrow \bar{\nu}_e)$ or using independent experiments (different L/E) can not completely solve the problem

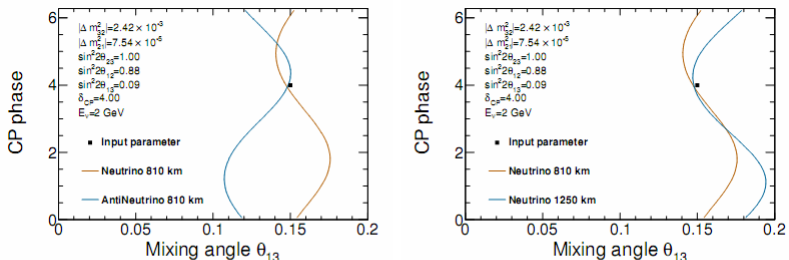


Figure A.2: Intrinsic clone due when introducing additional measurements with either $\bar{\nu}_\mu \rightarrow \bar{\nu}_e$ appearance (left) or different baseline (right).

Taken from Son Cao's dissertation

Degenerate solution

- Other sources of "clone solution"

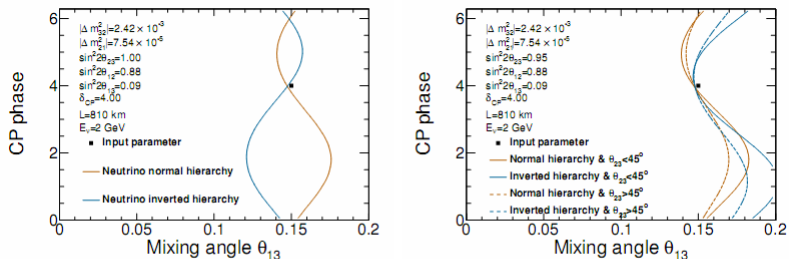


Figure A.3: Degeneracy of mass hierarchy (left) and θ_{23} -octant (right) in $\bar{\nu}_\mu \rightarrow \bar{\nu}_e$ appearance channel.

Taken from Cao Son's dissertation

Degenerate solution

- Solution: Eightfold degeneracy [S. Rigolin]

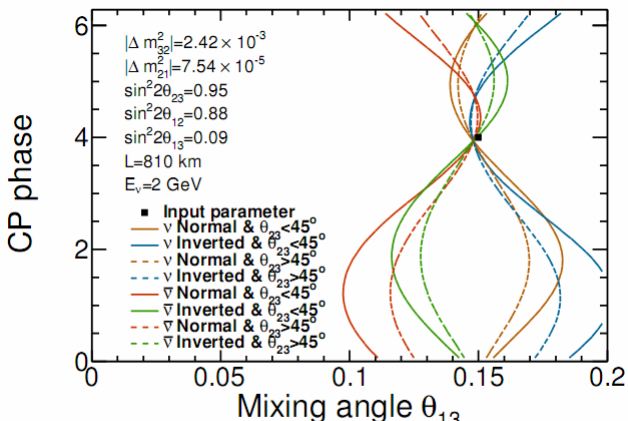


Figure A.4: Eightfold degeneracy in $\bar{\nu}_\mu \rightarrow \bar{\nu}_e$ appearance channel.

Taken from Cao Son's dissertation