GLoBES

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What?

General Long Baseline Experiment Simulator

GLoBES is a software package designed for

- Simulation
- Analysis
- Comparison

of neutrino oscillation experiments

Who & Where?

It is developed and maintained by

- PH
- Joachim Kopp
- Manfred Lindner
- Walter Winter

URL – http://www.mpi-hd.mpg.de/lin/globes/
email – globes@mpi-hd.mpg.de

Design considerations

- GPL – open source

- C-library – very portable, easy to interface, numerically efficient

- Unix style separation of functionality – freedom to design analysis and to use any graphics tools

- Experiments are defined using AEDL – relatively complicated parser, transparent experiment definition

- Pull approach for systematics – flexible and intuitive

- Local minimization instead of grids – much faster

Reliability

- Re-use of code, the more a code has been used in real world applications the less likely are severe bugs.

- Extensive testing

- Good documentation

- Intuitive API with error checking

Reproducibility

The information given a publication or proposal is not sufficient to reproduce the sensitivity estimates.

- General data storage and exchange format for the inputs $\Leftrightarrow$ flexibility?

- All implicit assumptions and approximations have to be documented, that includes the actual algorithms $\Leftrightarrow$ accuracy of documentation?

- Version control and archiving

Flexibility

General data structures and a high level of abstraction allow to describe a widely different number of experiments and physics scenarios

- mark-up language for experiment description (AEDL)

- clear interface to physics module – user-defined physics easy to integrate

- fully general numerical routines – no *ad hoc* approximations

Flexibility quite often is difficult to reconcile with the other requirements.

Efficiency

The faster the code, the more thorough the analysis will be because more parameter studies can be performed

- physics parameters

- systematics parameters

- L-E

- . . .

Efficient code is the easier to write, the more specific the task is.

Documentation

Without good documentation, the best software is useless or will be after very short time (=memory decay constant of typical physicist). This is a general problem with legacy code!

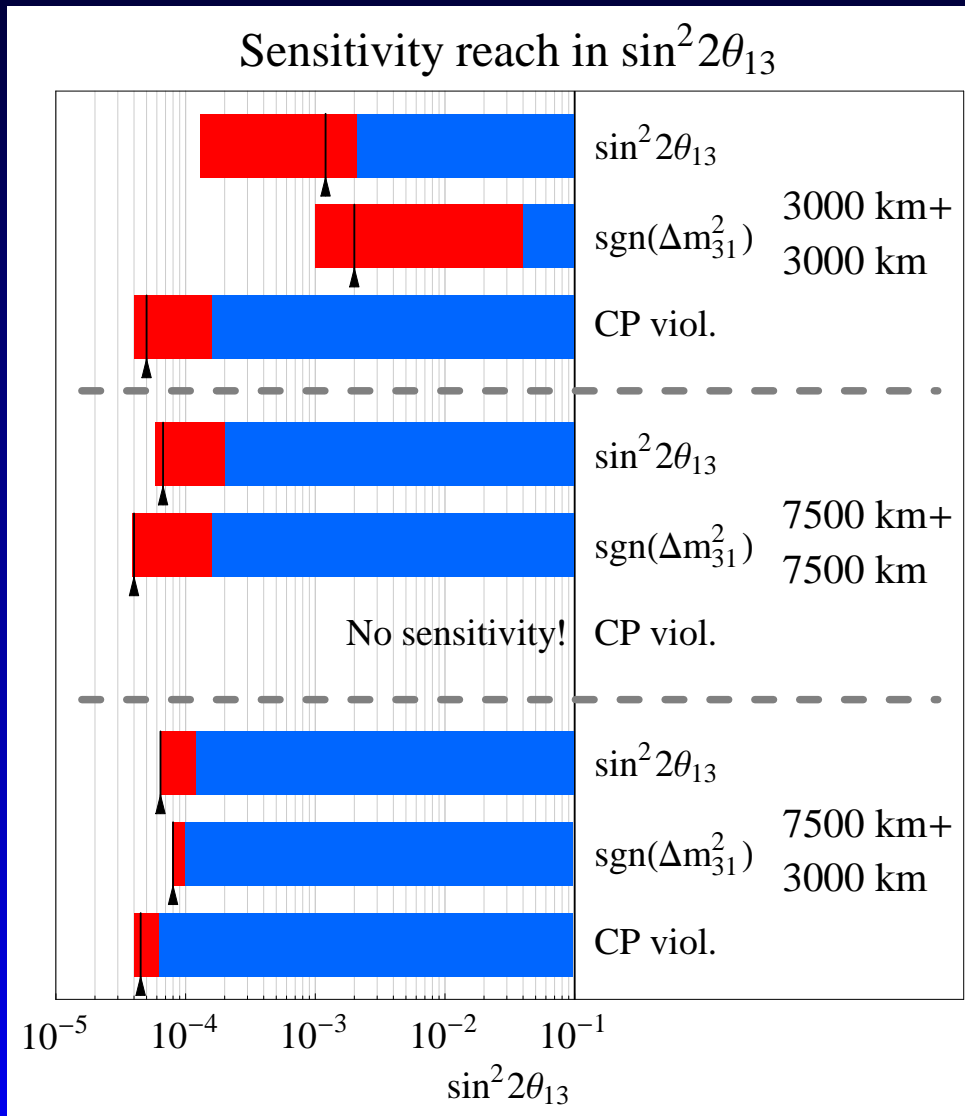A major effort is dedicated to implement
Document what you do – do what you document

GLoBES history

- development started 2004 – PH, M. Lindner, W. Winter

- major effort went into documentation

- first release August 2004 – version 2.0.0

- major bug fix release March 2005 version 2.0.11

- J. Kopp and M. Rolinec joined in July 2005

- January 2007 – version 3.0, addition of major features

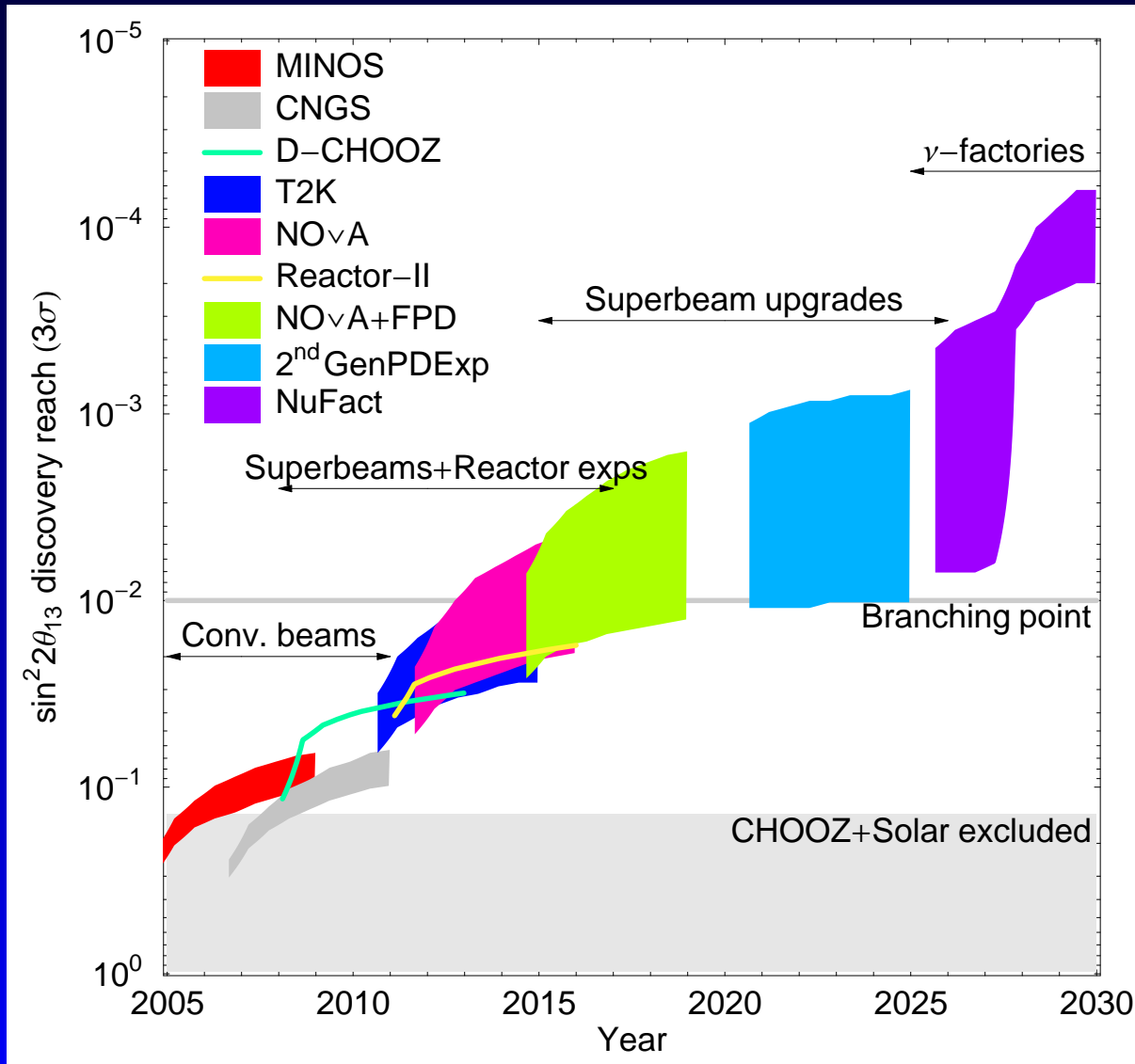- 93 publications citing the GLoBES papers, creating a total of 1514 citations
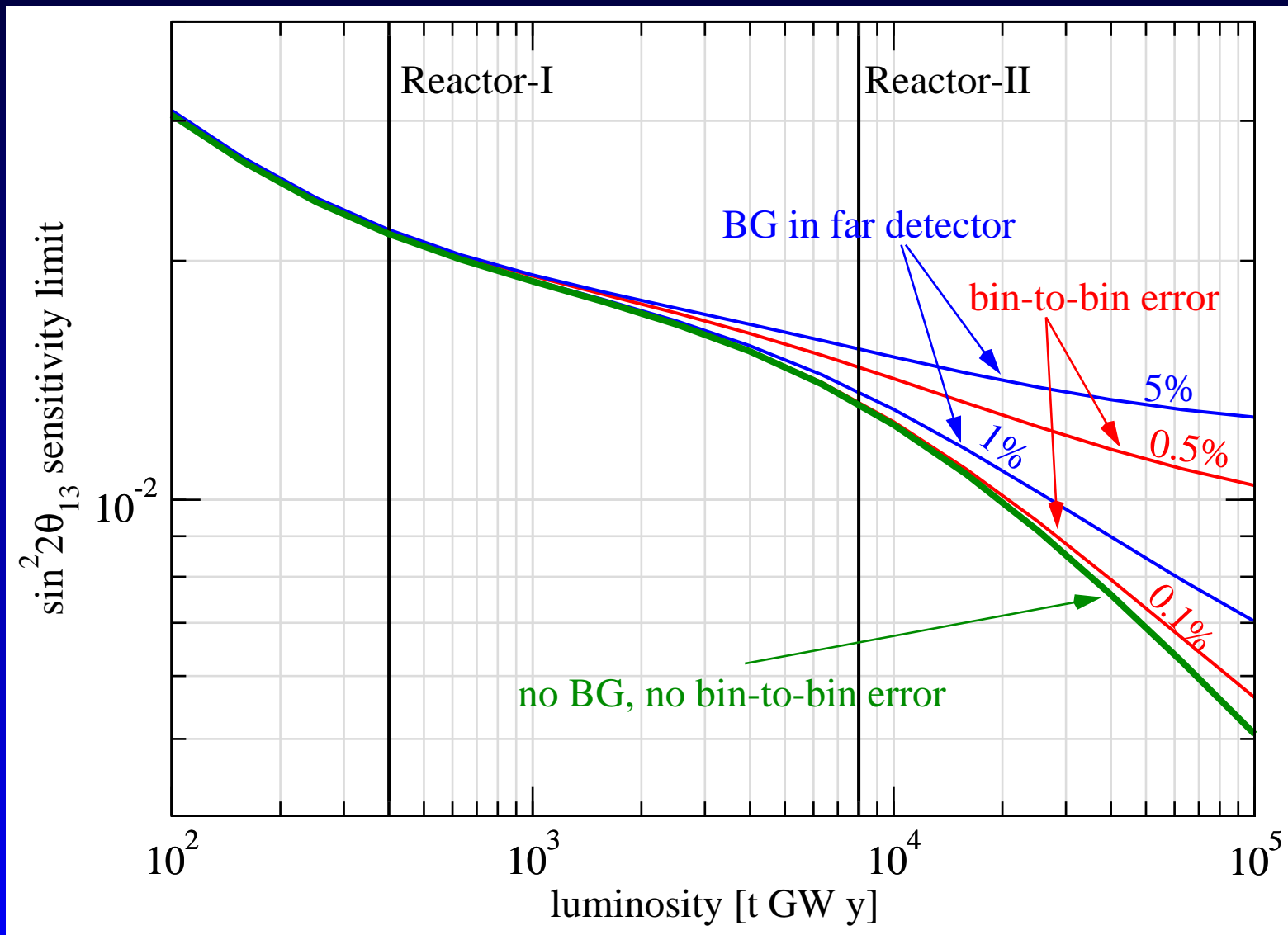
Milestones

APS study

Sensitivity reach in $\sin^2 2\theta_{13}$

$\sin^2 2\theta_{13}$	
$\mathrm{sgn}(\Delta m^2_{31})$	3000 km+ 3000 km
CP viol.	
$\sin^2 2\theta_{13}$	
$\mathrm{sgn}(\Delta m^2_{31})$	7500 km+ 7500 km
No sensitivity! CP viol.	
$\sin^2 2\theta_{13}$	
$\mathrm{sgn}(\Delta m^2_{31})$	7500 km+ 3000 km
CP viol.	

10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1}

$\sin^2 2\theta_{13}$

Milestones

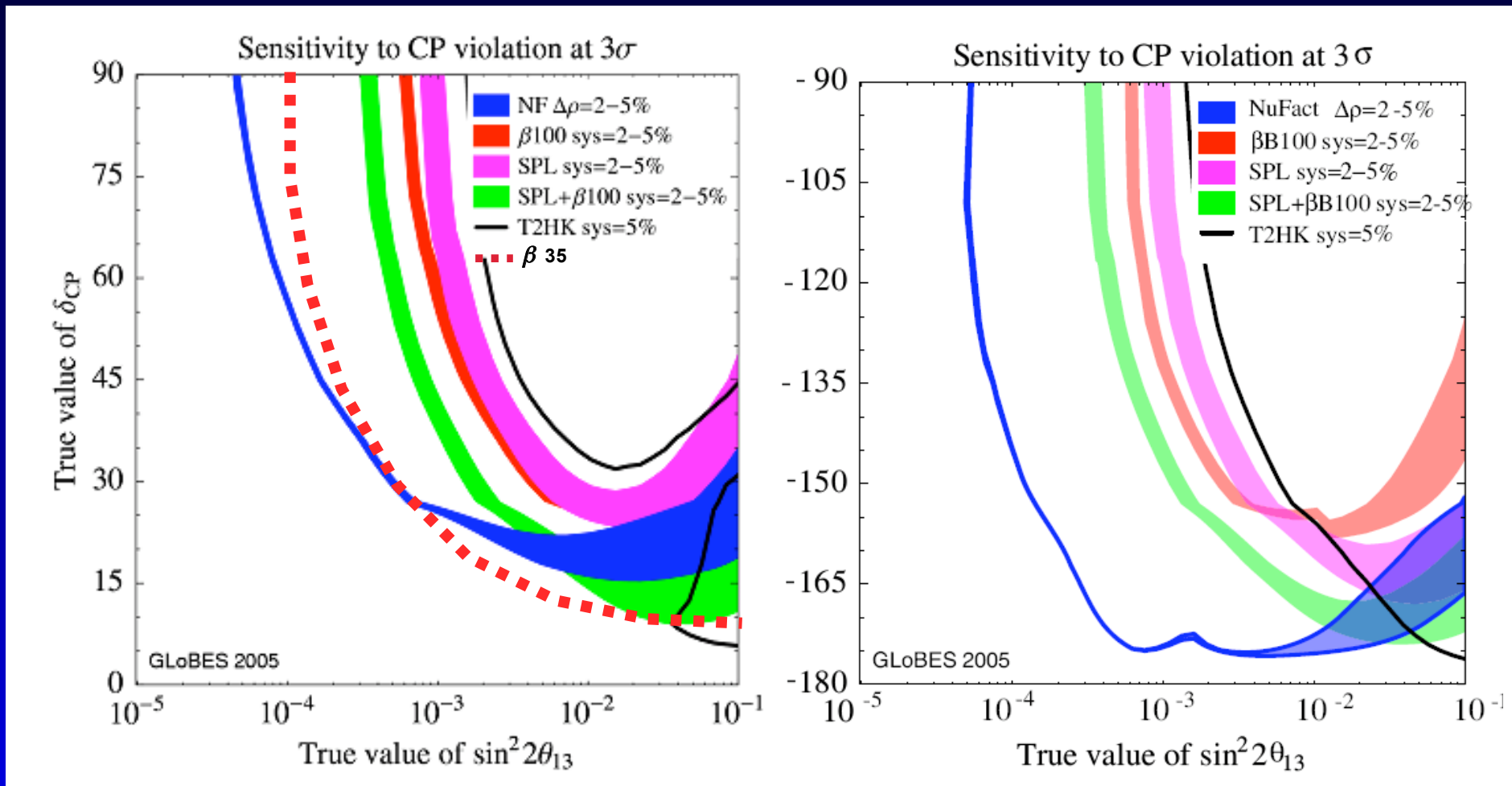## Fermilab's Proton driver report
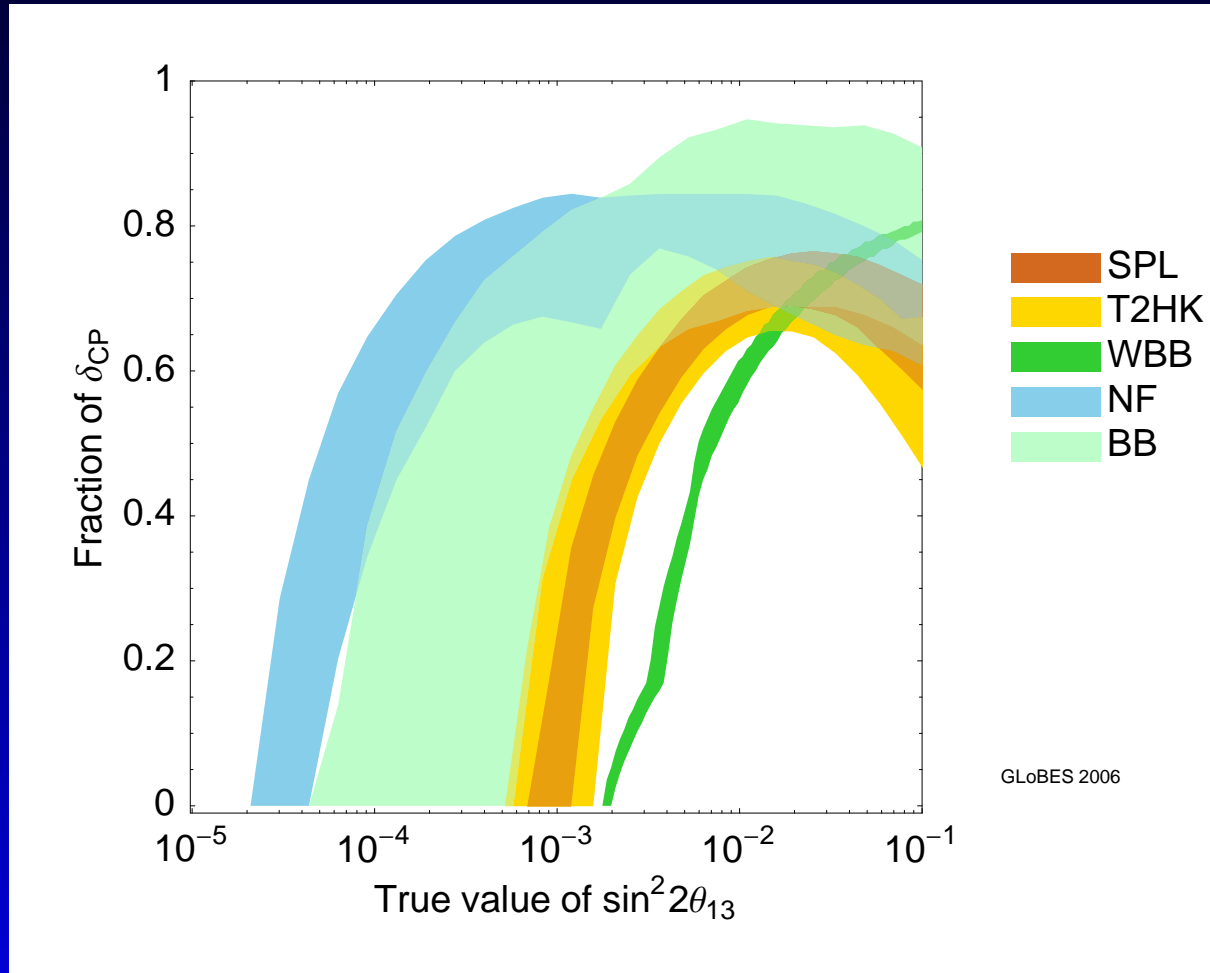
Milestones

White paper on reactor neutrinos

Milestones
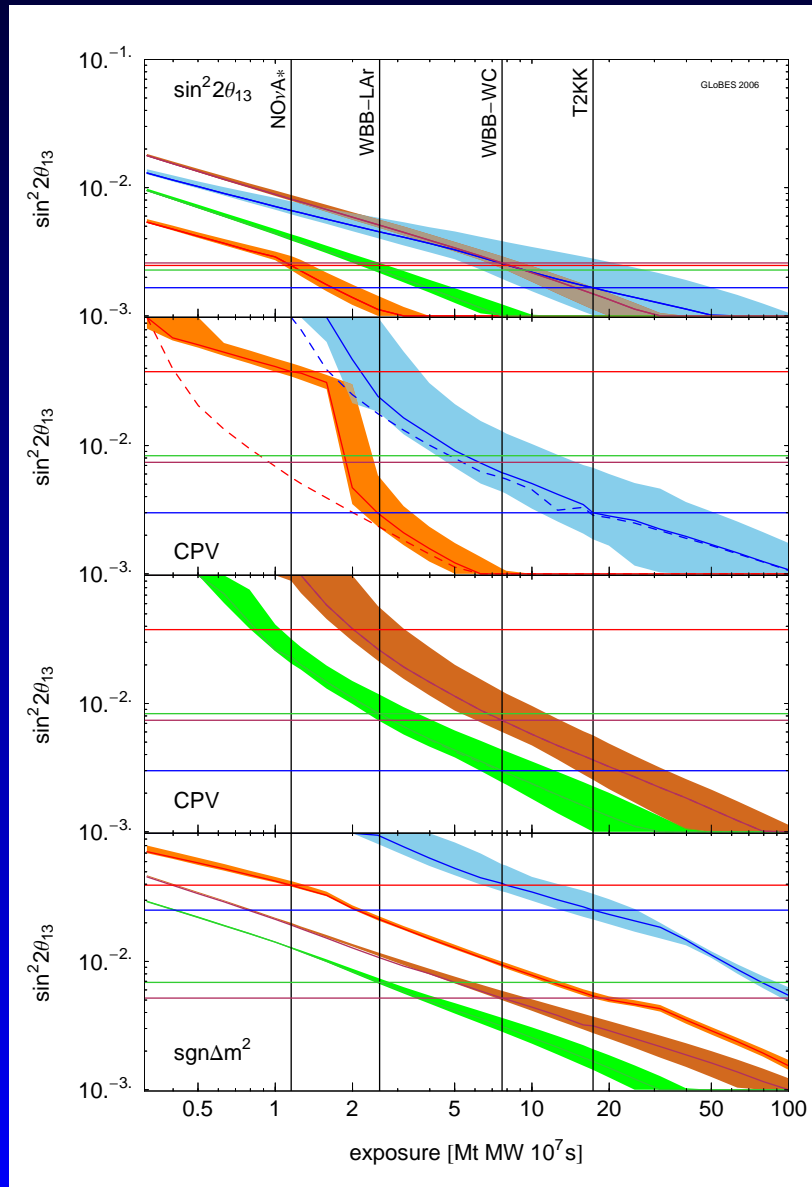
CERN strategy group

Milestones

ISS

Milestones

Joint BNL-FNAL study group

Features

- Accurate treatment of systematical errors
- Arbitrary matter profile & uncertainties
- Arbitrary energy resolution function
- Single and multiple experiment simulation
- Simple χ^2 calculation
- Inclusion of external input
- Projection of χ^2 (minimization)
- User-defined systematics, oscillation probability engine, priors
- Full support for lists in AEDL
- Interpolating functions in AEDL
- . . .

User-defined systematics

This feature allows to simulate two detector setups like Double Chooz.

- define χ^2-function
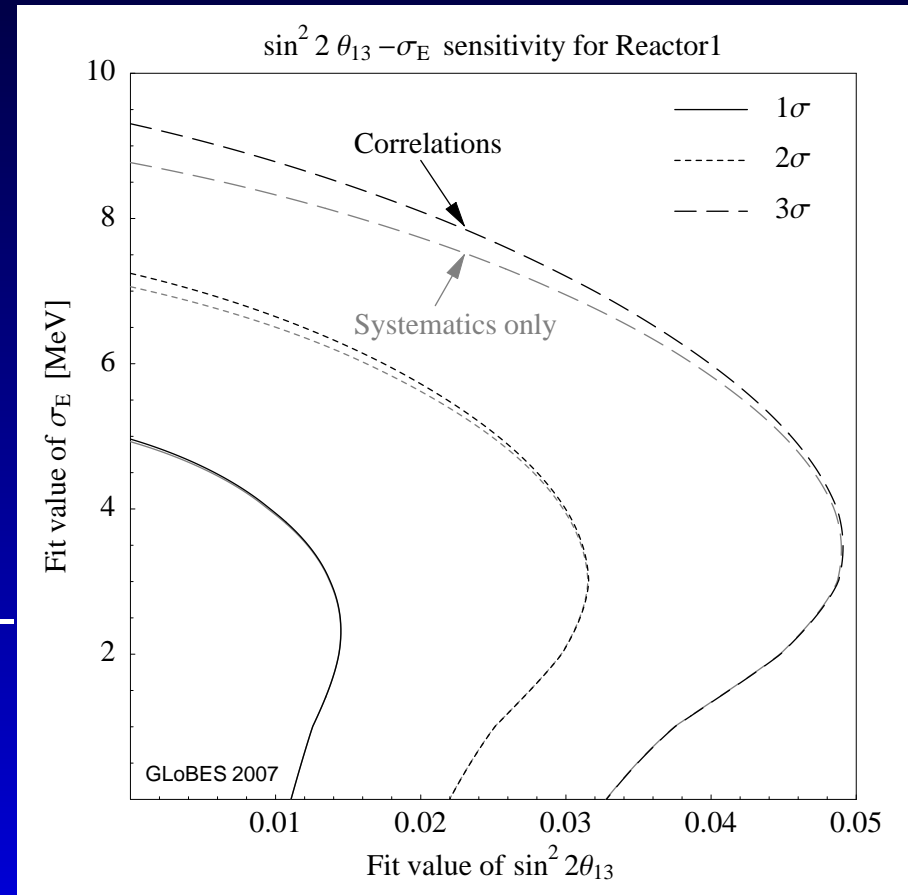- register it at run-time
- refer to it in AEDL by name
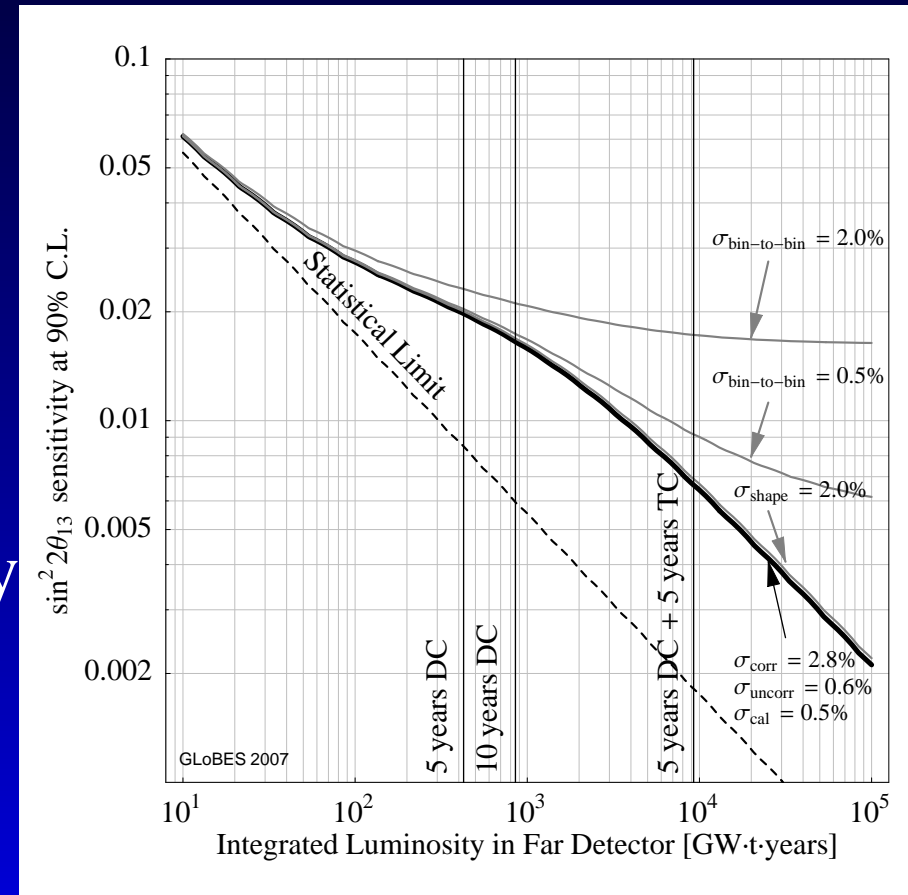
output of `example5`

User-defined oscillation engine

This feature allows to analyses non-standard physics
scenarios like decoherence

- define oscillation engine
- register it at run-time
- use the new parameters
- can also be used to im-
  prove speed

output of `example6`

Advanced AEDL

Interpolation allows easy, bin-independent definition of efficiencies, backgrounds etc.

```
/* ####### Energy dependent efficiencies ##### */

%posteffs={0.,1.,1.}

%energ={4.,20.,50.}

%bc=bincenter()

%inter=interpolation(%energ,%posteffs,1,%bc)
```

from `NFstandard.glb`

Additional: strict version control, `@norm` clarified

Summary

GLoBES

- is the only open source software of its kind
- has withstood the test of time (next month, 5 years!)
- is at the core of most strategy documents
- completely in C
- flexibility to deal with complex many detector setups and non-standard physics