Superbeams

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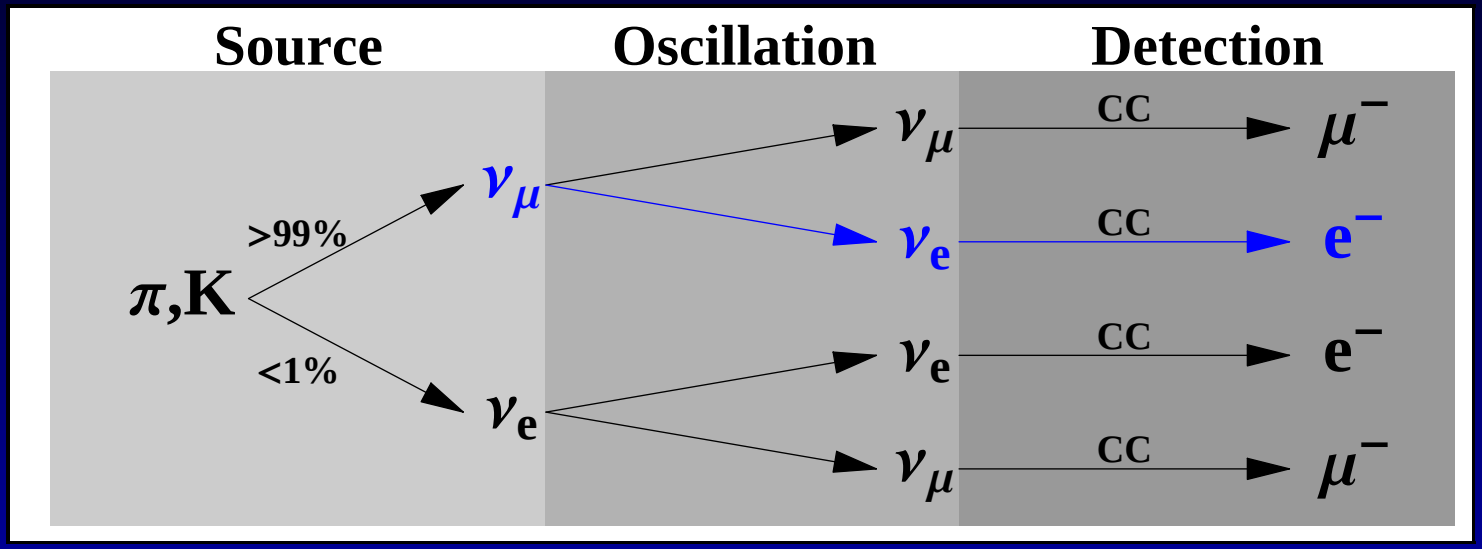
Outline

- Definition
- Setups
- Comparison
- Systematics
- Summary

Superbeams

Neutrino beam from π-decay



They are called 'super'

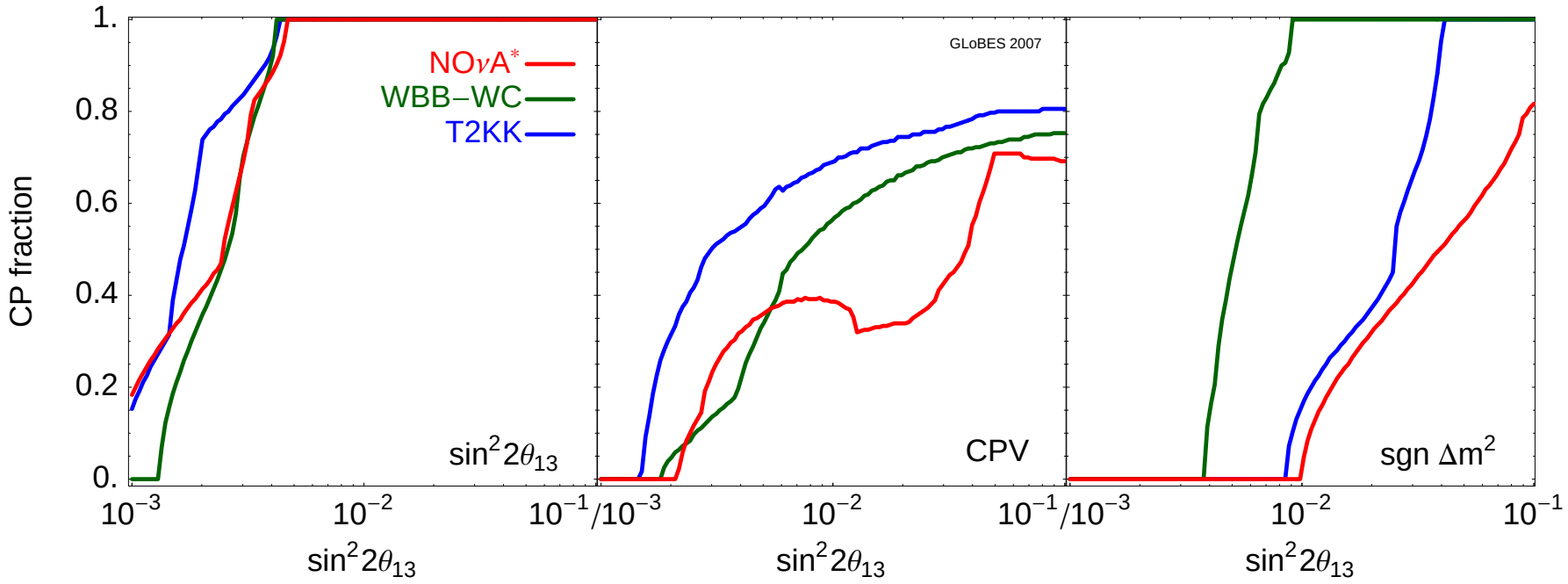
- beam power $\sim 1\,\mathrm{MW}$
- detectors mass $\sim 100\,\mathrm{kt}$
- running time of the experiment ~ 10 years
- price

Setups

- T2KK – beam from JAERI, $P = 4\,\mathrm{MW}$, two water Cherenkov detectors at $L = 295\,\mathrm{km}$ and $L = 1050\,\mathrm{km}$ with a fiducial mass of $270\,\mathrm{kt}$, off-axis
- WBB – beam from FNAL, $P = 1.1\,\mathrm{MW}$, one water Cherenkov detector at $L = 1300\,\mathrm{km}$ with a fiducial mass of $300\,\mathrm{kt}$, on-axis
- NOνA* – beam from FNAL, $P = 1.1\,\mathrm{MW}$, one liquid Argon TPC at $L = 810\,\mathrm{km}$ with a fiducial mass of $100\,\mathrm{kt}$, off-axis
- SPL - similar to T2HK in its physics reach, main difference beam energy and baseline.

Joint BNL-FNAL study group report reviews the US based options

Comparison



adapted from Barger, PH, Marfatia, Winter, Phys.Rev.D76:031301,2007.

- $\sin^2 2\theta_{13}$ performances are very similar
- T2KK clearly best for CPV
- WWB clearly best for mass hierarchy

Exposure

Everyone has different assumptions about

- seconds in a year
- number of years
- detector size
- beam power (or pot)

Therefore we introduce the concept of exposure

$$\text{detector mass [Mt]} \times \text{target power [MW]} \times \text{running time} \left[10^7 \text{ s}\right].$$

Exposure and systematics

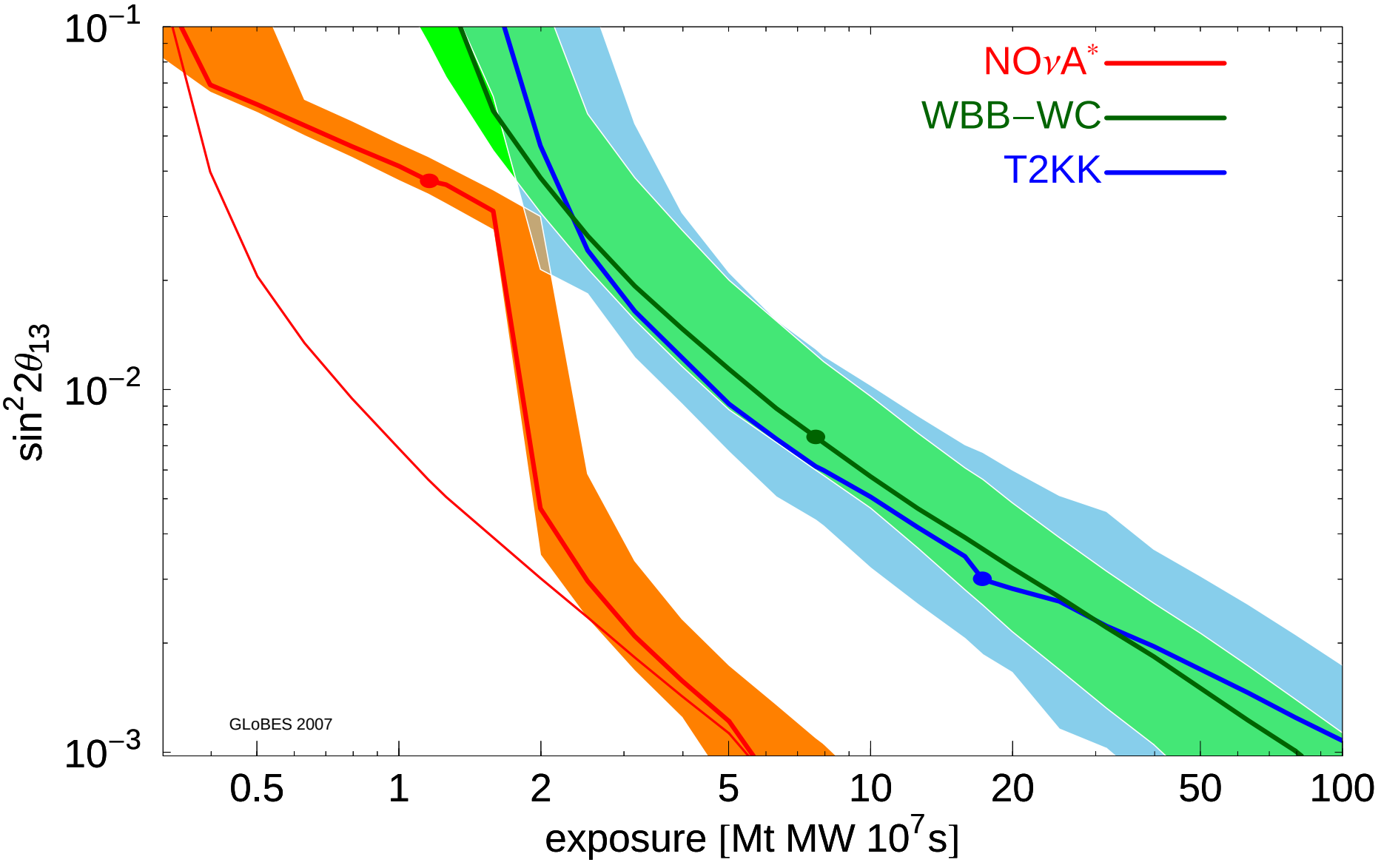
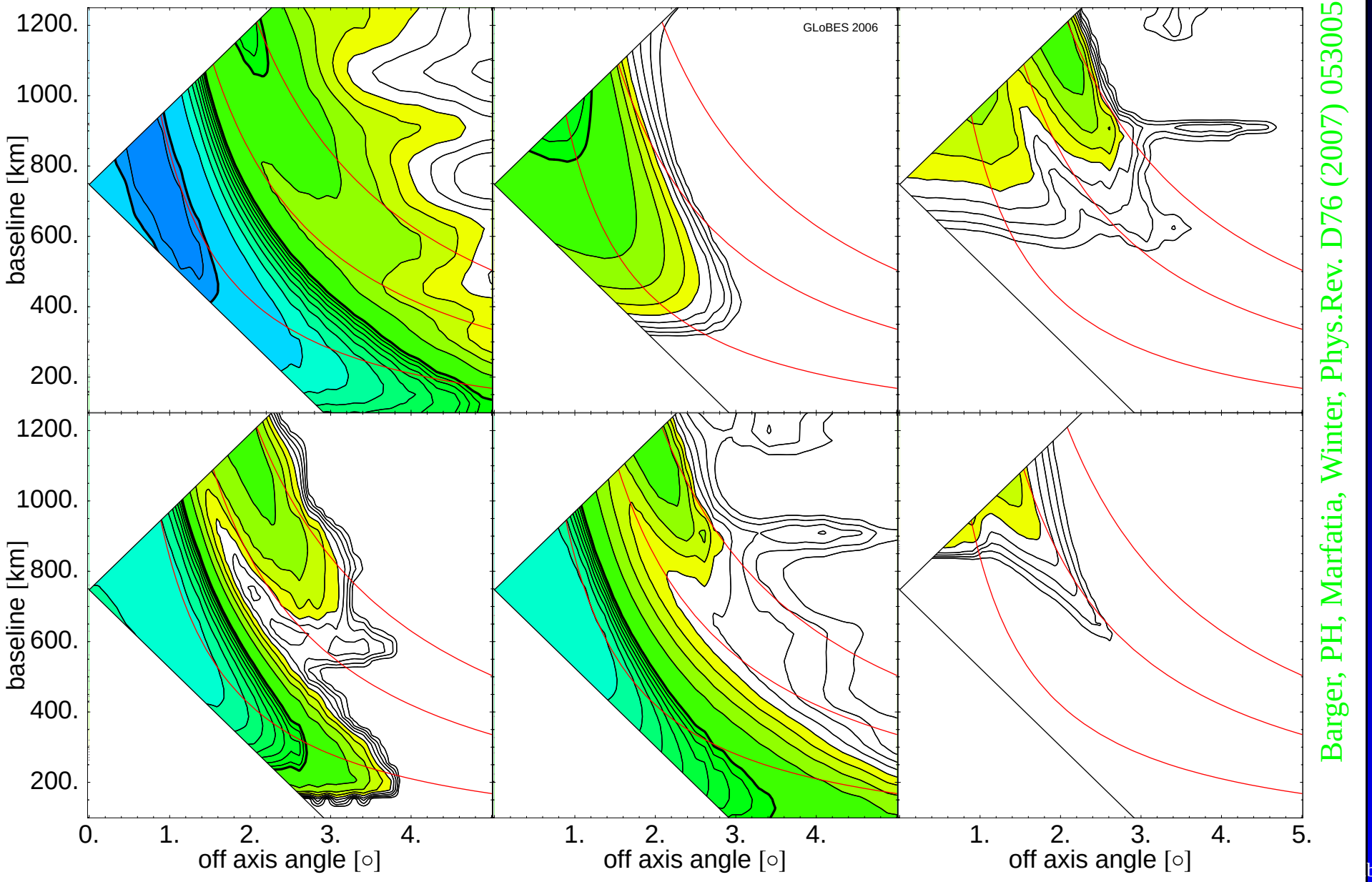
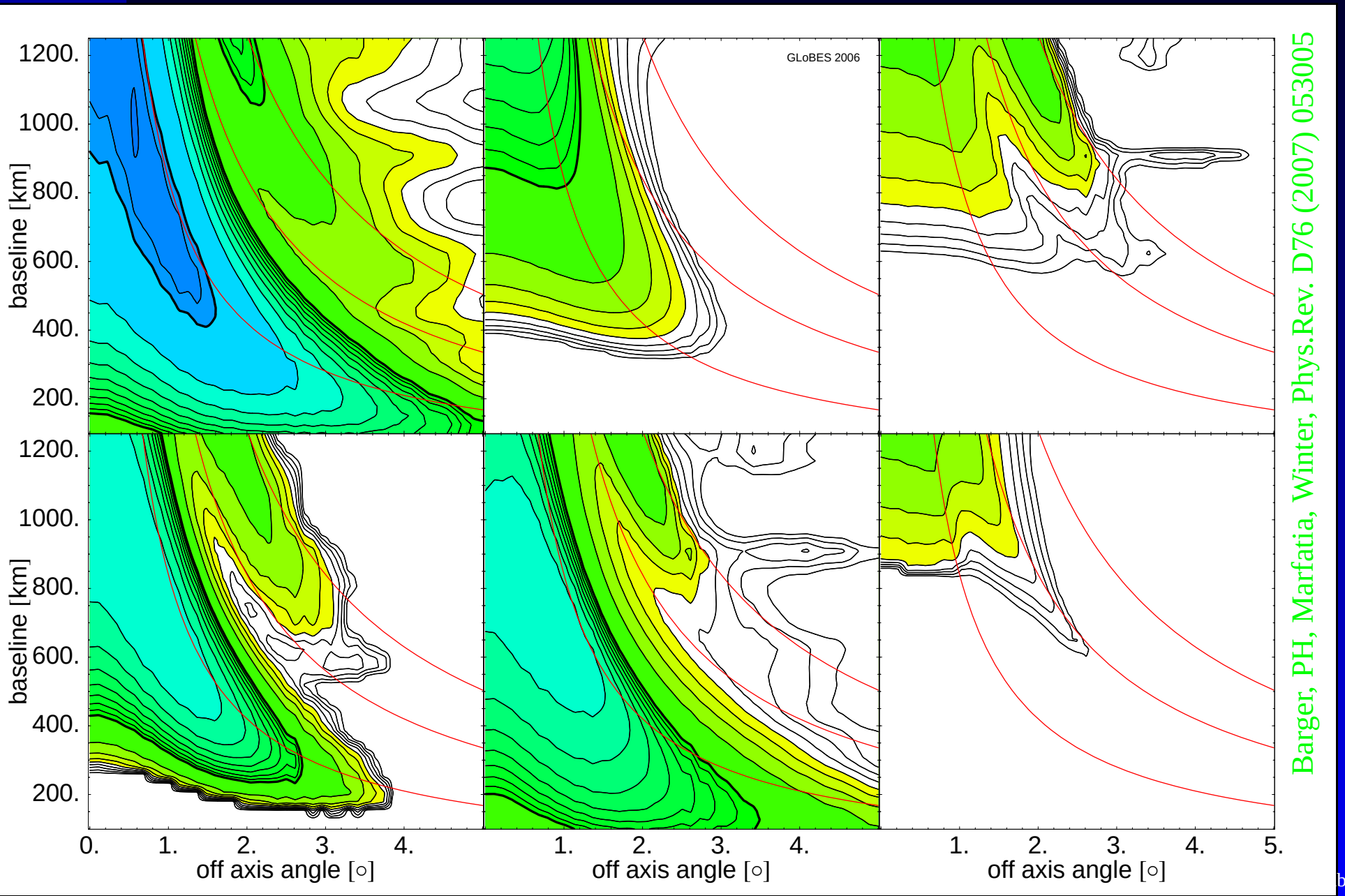


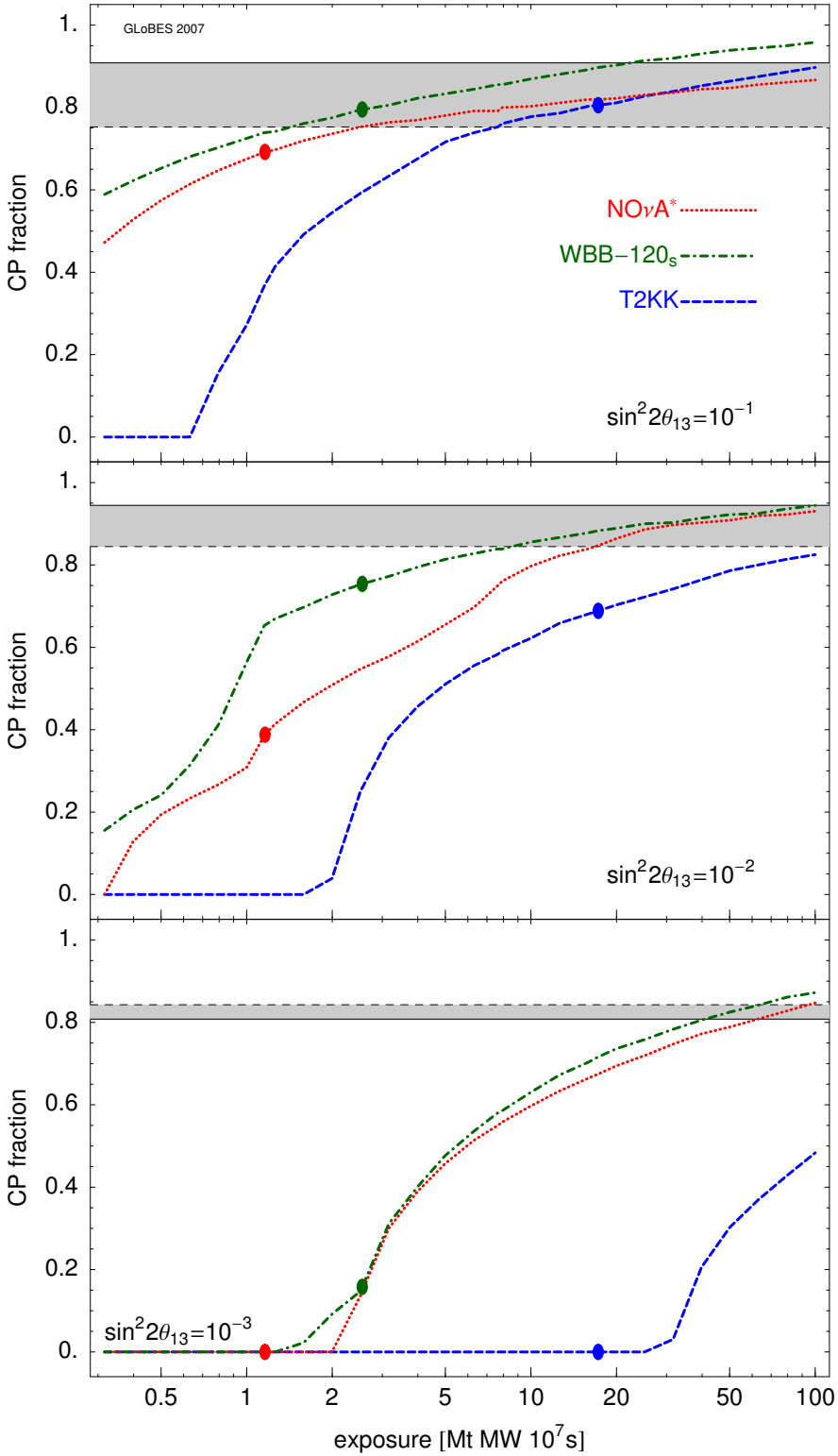
figure adapted from Barger, PH, Marfatia, Winter, Phys.Rev. D76 (2007) 053005

On vs off-axis



On vs off-axis





At large θ_{13} any of the three setups can have the same performance as a NuFact* or β-beam.

These large values would be certainly discovered by Double Chooz, Daya Bay, T2K and NOνA!

$\Rightarrow$ decision on next generation facility should wait at least for the first reactor data

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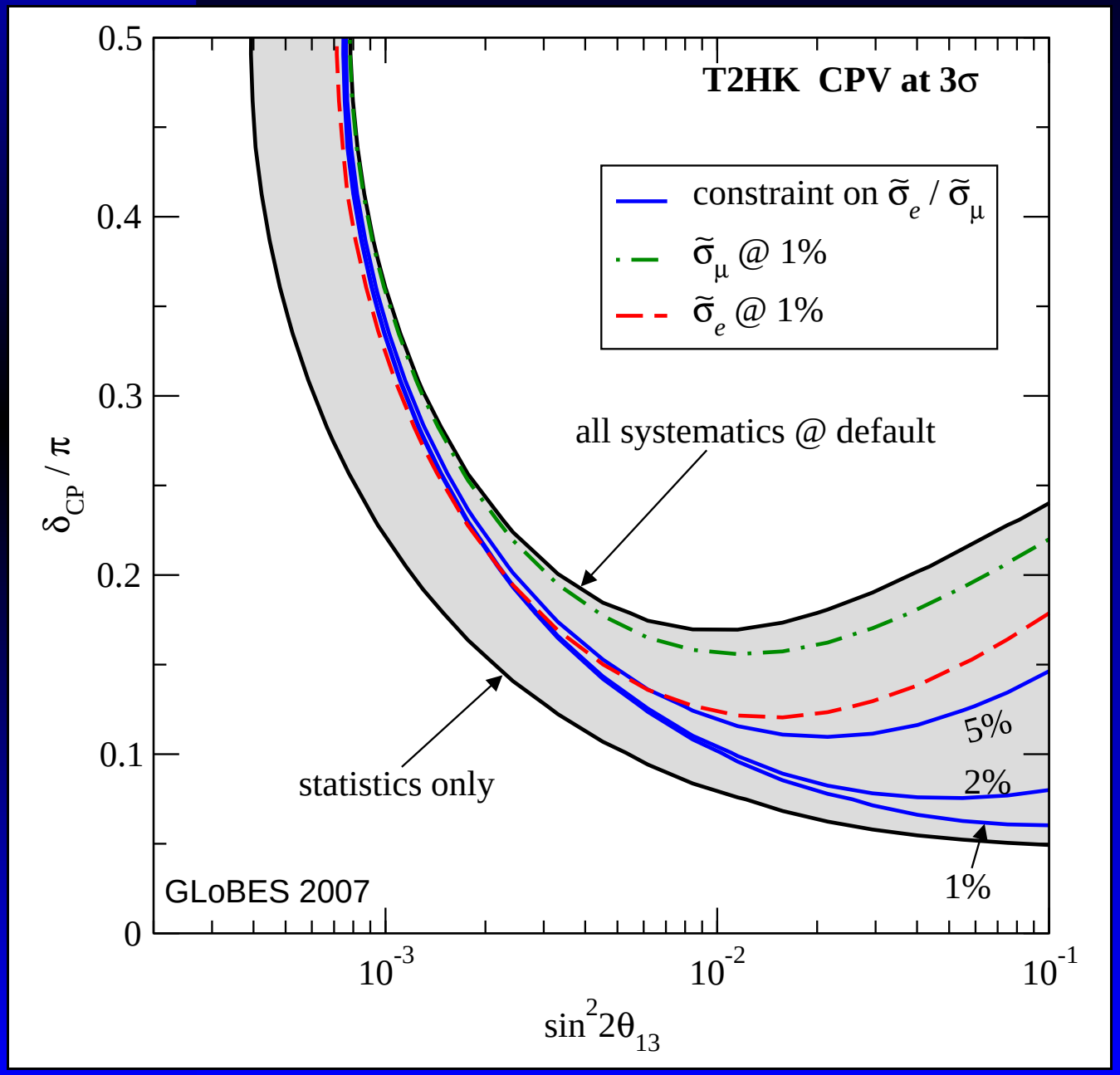
* pre-IDS NuFact, actual IDS 0.10 is worse

CP violation & systematics



Includes near detector!
$\tilde{\sigma}_\mu/\tilde{\sigma}_e$ is the by far most important parameter

Large θ_{13} is the most difficult region

P. Huber, M. Mezzetto, T. Schwetz, arXiv:0711.2950.

Summary

Superbeams

- Exposure is the key factor – money and physics
- Detector technology plays a big role
- cross section systematics crucial at large θ_{13}
- Off vs On-axis decision requires careful analysis
- Short distances ($< 500\,\mathrm{km}$) are disfavored
- Every strategy requires MW beams, 0.1 Mt detectors, 10 years of running

For large θ_{13} strong competition for NF.