Comparison of reactor experiments for θ_{13} measurement

Guillaume MENTION

Thierry LASSERRE

CEA Saclay

GLoBES Workshop
Heidelberg
January, the 26th 2007

Outline

The point on θ_{13}

Reactor neutrino experiment analysis method

Reactor experiment description

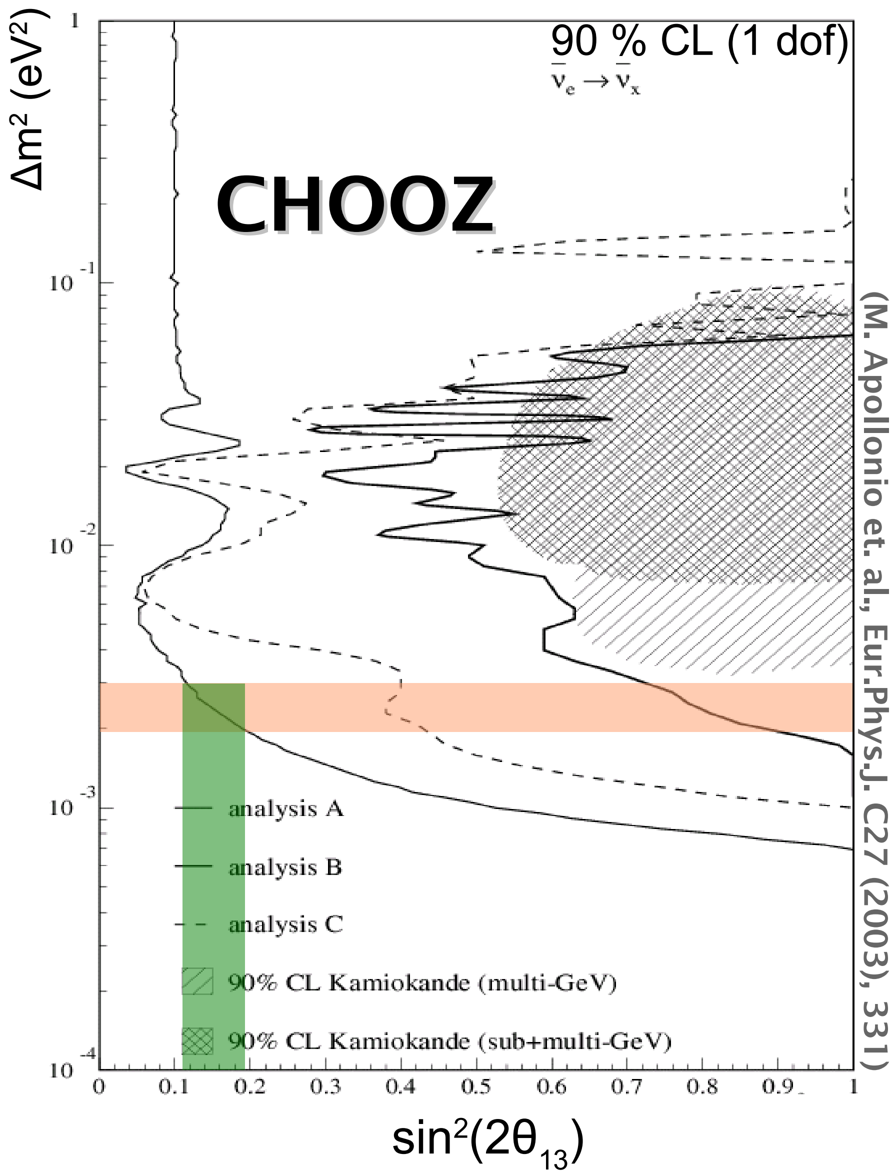
Reactor experiment comparison

Double Chooz *Daya Bay* *RENO*

Angra *KasKa*

Not included here

Last limits (90 % C.L.)

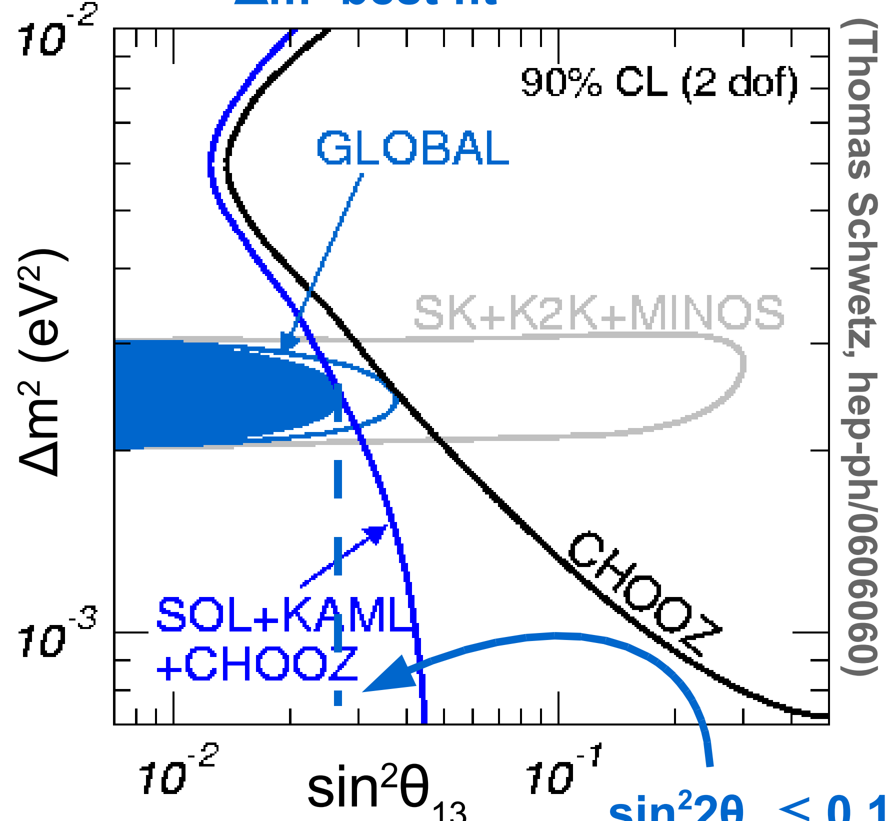


$\sin^2 2\theta_{13} \lesssim 0.12 - 0.20$

CHOOZ avec Δm^2 best fit

$\sin^2 2\theta_{13} \lesssim 0.14$

Global analyses
+ Δm^2 best fit

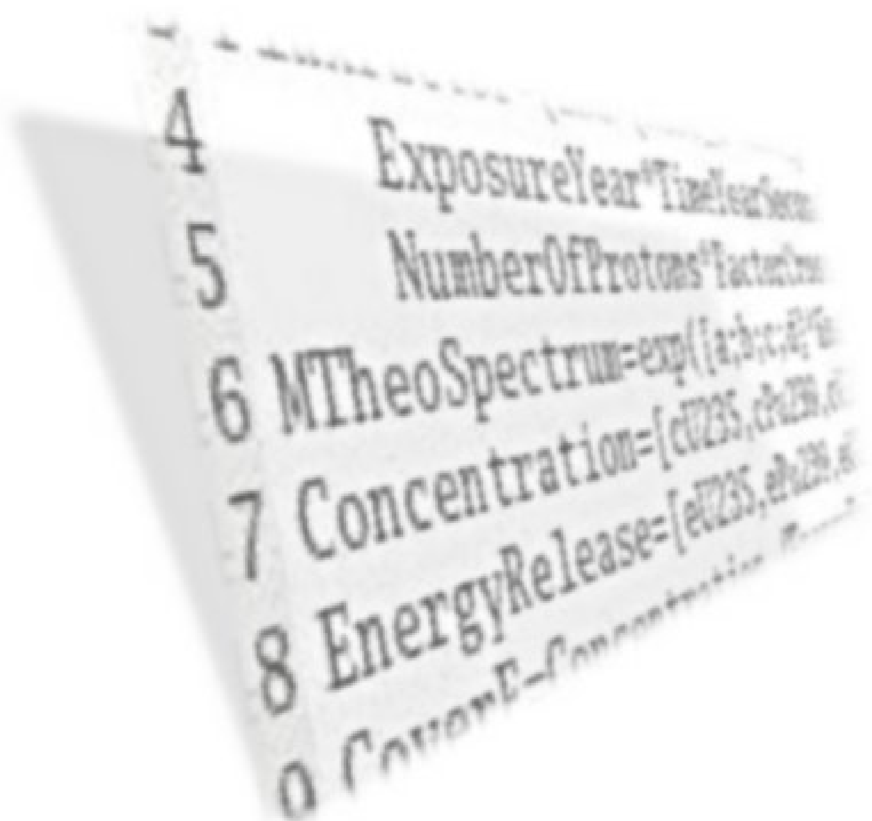


$\sin^2 2\theta_{13} \lesssim 0.11$

Experiments comparison code

Reactor experiments simulation code → based on Double Chooz extended one

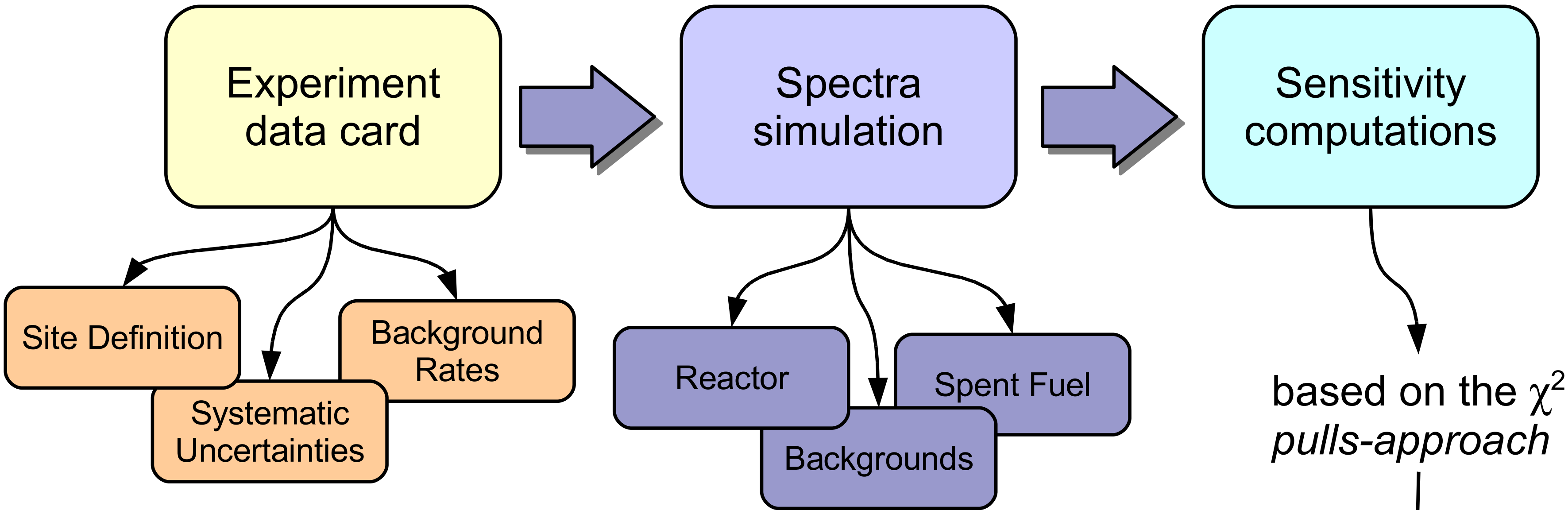
Pure Matlab™ code optimized for fast answers specific to reactor simulations



Take into account:

- Identification card of each experiment
- Installation scenarii
- Turn ON/OFF reactors/detectors
- Systematics
  - reactors
  - detectors
  - backgrounds
- backgrounds: accidentals & correlated (cosmogenics, and proton recoils)
- Detailed filling procedure

The method



Data-Theory

Systematic shifts

$$\chi^2 = \min_{\{\alpha_{i,k}^D\}} \sum_D \sum_{i=1}^{N_b} \left[\left(\Delta_i^D - \sum_{k=1}^{K} \alpha_{i,k}^D S_{i,k}^D \right)^2 + \sum_{k=1}^{K} c_{i,k}^D \left(\alpha_{i,k}^D \right)^2 \right]$$

$$\Delta_i^D = \frac{N_i^{D*} - N_i^D}{U_i^D}$$

Systematic weights

Set $\sin^2(2\theta_{13})^*$ to 0

Search for $\sin^2(2\theta_{13})$ such that $\Delta\chi^2 = 2.71$ (1 d.o.f., 90 % C.L.)

Sensitivity formula

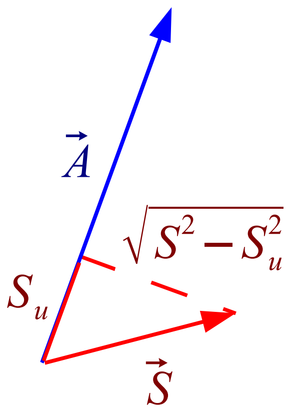
$$\chi^2 = \min_{\{\alpha_{i,k}^D\}} \sum_D \sum_{i=1}^{N_b} \left[\left(\Delta_i^D - \sum_{k=1}^{K} \alpha_{i,k}^D S_{i,k}^D \right)^2 + \sum_{k=1}^{K} c_{i,k}^D \left(\alpha_{i,k}^D \right)^2 \right]$$

Search for $\sin^2(2\theta_{13})$ such that $\Delta\chi^2 = 2.71$ (1 d.o.f., 90 % C.L.)

$$\Delta\chi_F^2 = \Delta\chi^2 - \sum_{D=N_1,N_2} \Delta\chi_D^2 - \Delta\chi_{pulls}^2$$

Writing the oscillation averaging per energy bin as: $D_i = \left\langle \sin^2\left(\frac{\Delta m^2 L}{E}\right)\right\rangle_{[E_i, E_{i+1}]}$

We define the oscillation over spectrum vector: $\vec{A} = \begin{pmatrix} \vdots \\ \frac{D_i N_i}{U_i} \\ \vdots \end{pmatrix}$ $\quad \vec{u} = \frac{\vec{A}}{A}$



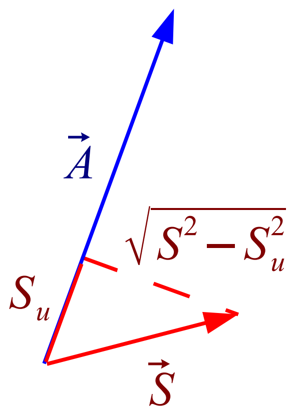
The systematic vector is defined as: $\vec{S} = \begin{pmatrix} \vdots \\ \sum_{k=1}^{K} \tilde{\alpha}_{i,k} S_{i,k} \\ \vdots \end{pmatrix}$

Then the sensitivity is $\sin^2(2\theta_{13}) \simeq \frac{S_u}{A} + \sqrt{\frac{\Delta\chi_F^2}{A^2} - \frac{S^2 - S_u^2}{A^2}}$ where $S_u = \vec{S}\cdot\vec{u}$

This approximation is valid as long as near detector stands close to the NPP cores.

Sensitivity formula

$$\sin^2(2\theta_{13}) \simeq \frac{S_u}{A} + \sqrt{\frac{\Delta\chi_F^2}{A^2} - \frac{S^2 - S_u^2}{A^2}}$$



The more S is colinear to A, the more the sensitivity degrades

which means

The more the systematics tend to mimick the oscillation signal the less sensitive is the experiment...

Systematics in the χ^2

Detector – Analysis cuts

Error type	k	$c^D_{i,k}$	$S^D_{i,k} \times U^D_i$	$\alpha^D_{i,k}$
Absolute normalization	1	$1/N_d N_b$	$\sigma_{abs} N_i^D$	α_{abs}
Relative normalization				
in D_1	2	$\delta_{D,D_1}/N_b$	$\sigma_{rel} N_i^{D_1}$	$\alpha_{rel}^{D_1}$
⋮	⋮	⋮	⋮	⋮
in D_{N_d}	$N_d + 1$	$\delta_{D,D_{N_d}}/N_b$	$\sigma_{rel} N_i^{D_{N_d}}$	$\alpha_{rel}^{D_{N_d}}$

$\sigma_{abs} = 2.0$ %

$\sigma_{rel} = 0.6$ % *Double Chooz conservative case*

$\sigma_{rel} = 0.38$ % *Daya Bay conservative but optimistic case*

+ { $\sigma_{scl} = 0.5$ %, $\sigma_{scl,rel} = 0.5$ % }

Systematics in the χ^2

Reactor

Error type	k	$c^D_{i,k}$	$S^D_{i,k} \times U^D_i$	$\alpha^D_{i,k}$
Absolute normalization	1	$1/N_d N_b$	$\sigma_{abs} N_i^D$	α_{abs}
Reactor spectrum shape				
in bin 1	$4N_d + N_p + 2$	$\delta_{i,1}/N_d$	$\sigma_{shp} N_1^D$	$\alpha_{shp,1}$
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
in bin N_b	$4N_d + N_p + N_b + 1$	$\delta_{i,N_b}/N_d$	$\sigma_{shp} N^D_{N_b}$	α_{shp,N_b}
Reactor composition				
from ^{235}U	$4N_d + N_p + N_b + N_r + 2$	$1/N_d N_b$	$\sigma_{^{235}U} N_i^{^{235}U,D}$	$\alpha_{cmp}^{^{235}U}$
from ^{239}Pu	$4N_d + N_p + N_b + N_r + 3$	$1/N_d N_b$	$\sigma_{^{239}Pu} N_i^{^{239}Pu,D}$	$\alpha_{cmp}^{^{239}Pu}$
from ^{238}U	$4N_d + N_p + N_b + N_r + 4$	$1/N_d N_b$	$\sigma_{^{238}U} N_i^{^{238}U,D}$	$\alpha_{cmp}^{^{238}U}$
from ^{241}Pu	$4N_d + N_p + N_b + N_r + 5$	$1/N_d N_b$	$\sigma_{^{241}Pu} N_i^{^{241}Pu,D}$	$\alpha_{cmp}^{^{241}Pu}$
Spent fuel pools				
from pool P_1	$4N_d + 2$	$1/N_d N_b$	$\sigma^D_{B_4} B^D_{4,i}$	$\alpha^{P_1}_{B_4}$
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
from pool P_{N_p}	$4N_d + N_p + 1$	$1/N_d N_b$	$\sigma^D_{B_4} B^D_{4,i}$	$\alpha^{P_{N_p}}_{B_4}$

Not included here

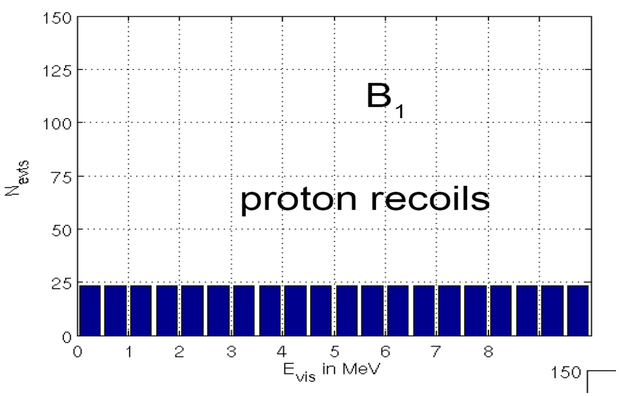
σ_{shp} = 2.0 % *conservative since uncorr. b2b but a bit higher over the whole spectrum*

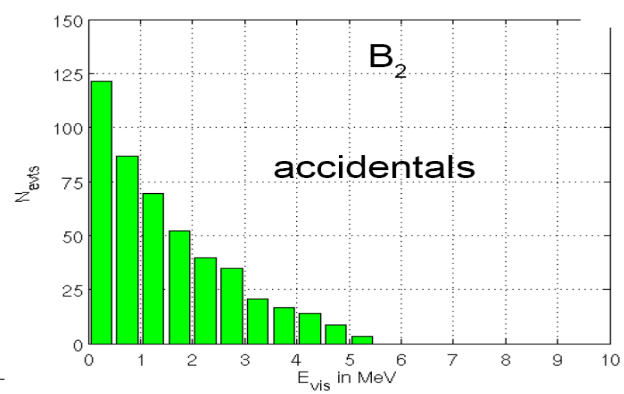
σ_{elt} = 5.0 % *rough estimate, first guess*

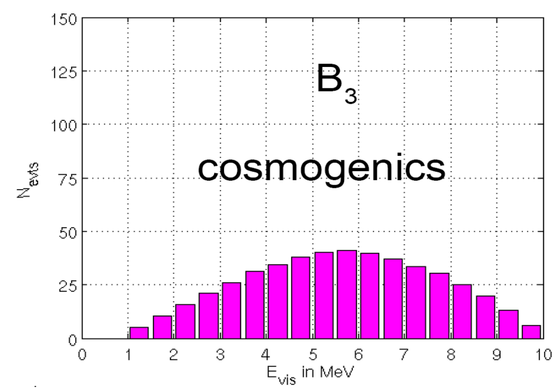
Systematics in the χ^2
Backgrounds

Error type	k	$c^D_{i,k}$	$S^D_{i,k} \times U^D_i$	$\alpha^D_{i,k}$
Backgrounds				
accidentals in D_1	$N_d + 2$	$\delta_{D,D_1}/N_b$	$\sigma^{D_1}_{B_1} B^{D_1}_{1,i}$	$\alpha^{D_1}_{B_1}$
⋮	⋮	⋮	⋮	⋮
accidentals in D_{N_d}	$2N_d + 1$	$\delta_{D,D_{N_d}}/N_b$	$\sigma^{D_{N_d}}_{B_1} B^{D_{N_d}}_{1,i}$	$\alpha^{D_{N_d}}_{B_1}$
cosmogenics in D_1	$2N_d + 2$	$\delta_{D,D_1}/N_b$	$\sigma^{D_1}_{B_2} B^{D_1}_{2,i}$	$\alpha^{D_1}_{B_2}$
⋮	⋮	⋮	⋮	⋮
cosmogenics in D_{N_d}	$3N_d + 1$	$\delta_{D,D_{N_d}}/N_b$	$\sigma^{D_{N_d}}_{B_1} B^{D_{N_d}}_{2,i}$	$\alpha^{D_{N_d}}_{B_2}$
proton recoils in D_1	$3N_d + 2$	$\delta_{D,D_1}/N_b$	$\sigma^{D_1}_{B_3} B^{D_1}_{3,i}$	$\alpha^{D_1}_{B_3}$
⋮	⋮	⋮	⋮	⋮
proton recoils in D_{N_d}	$4N_d + 1$	$\delta_{D,D_{N_d}}/N_b$	$\sigma^{D_{N_d}}_{B_3} B^{D_{N_d}}_{3,i}$	$\alpha^{D_{N_d}}_{B_3}$

Background rate systematics







Background shape systematics

$$U_i^D = \sqrt{N_i^D + \sum_{n=1}^{N_{bkg}} \sigma_{Bn}^2 \left(B_{n,i}^D\right)^2}$$

Depends on the overburden and the detector shieldings

Panel view of reactor experiments

site, power, distances, overburden, target masses

	Location	Power (in GW_{th})	Distances (in meters)	Overburden (in mwe)	Target mass (in tons)	Nb of events compared to DC
Double Chooz	France	8.5	280/1050	80/300	8.3	**1**
Daya Bay	China	11.6/17.4 (2010)	360/500/1750	260/910	2x20/2x20/4x20	**6**
RENO	Korea	16.4	150/1500	230/675	20	**2**

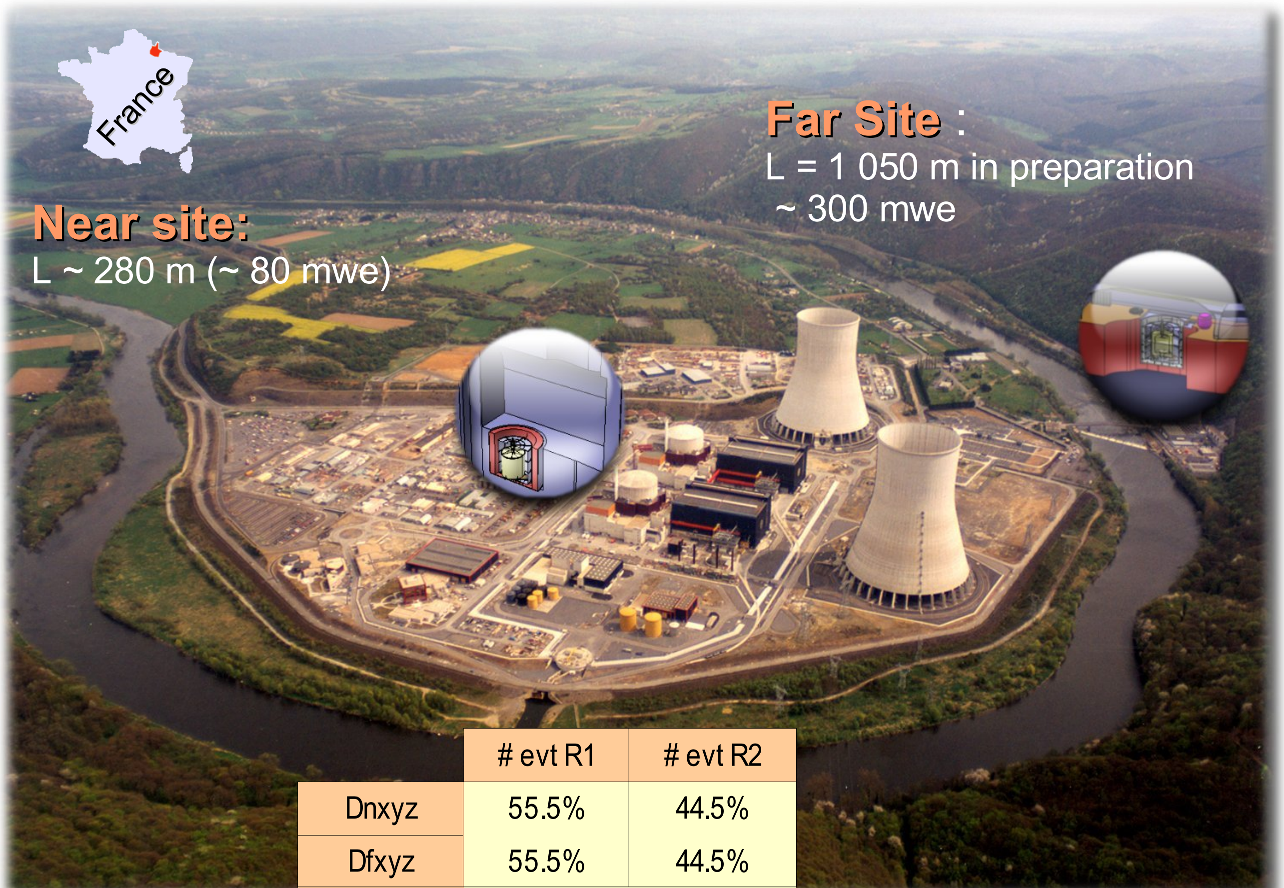
1st generation

- Double Chooz
- RENO, Phase I
- Daya Bay, Phase I?

2nd generation

- Daya Bay, Phase II
- *Angra, KasKa*

Double Chooz



	# evt R1	# evt R2
Dnxyz	55.5%	44.5%
Dfxyz	55.5%	44.5%

2 cores – 1 site – 8.5 GW_{th}

1 near position, 1 far

- target: 2 x 8.3 t

Civil engineering

- 1 near lab ~ Depth 40 m, Ø 6 m
- 1 available lab

Statistics (including ε)

- far: ~ 40 evts/day
- near: ~ 460 evts/day

Systematics

- reactor : ~ 0.2%
- detector : ~ 0.5%

Backgrounds

- σ_{b2b} at far site: ~ 1%
- σ_{b2b} at near site: ~ 0.5%

Planning

1. Far detector only
   - 2008-2009
   - Sensitivity (1.5 ans) ~ 0.06
2. Far + Near sites
   - available from 2010
   - Sensitivity (3 years) ~ 0.025

Daya Bay

Average F. R.	DB	LA1	LA2
Dn1xyz (DB)	83.1%	11.4%	5.5%
Dn2xyz (LA)	6.5%	50.6%	42.8%
Dfxyz (Mid)	22.5%	47.1%	30.4%
Dfxyz (Far)	24.9%	37.4%	37.7%

4 cores – 2 sites – 11.6 GW_{th}

⇨ 6 – 3 in 2011, with 17.4 GW_{th}

2 near positions, 1 mid, 1 far

- far: 4 modules of 20 t
- near: 2 modules of 20 t each

Civil Engineering

- ~ 3.4 km tunnels
- 4 laboratories to be build

Statistics (including ε)

- far: 70 evt/day/mod
- mid-site: 200 evts/day/mod
- near: 600 evts/day/mod

Mobile modules ⇨ swapping (Theo.)

Systematics

- reactors : ~ 0.1%
- detectors : ~ 0.38%

Backgrounds

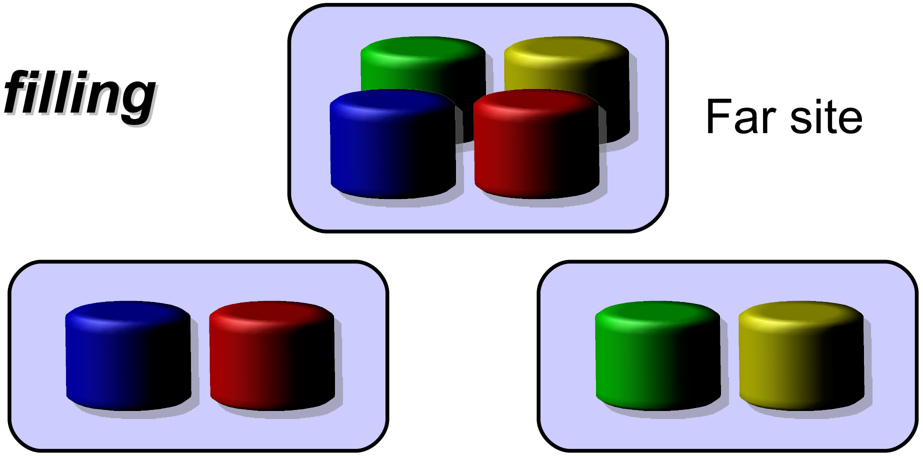
- B/S @ near sites: ~ 0.5%
- B/S @ far site: ~ 0.2%

Planning

1. Fast Measurement (Phase I)
   - DYB+Mid-site, 2008-2009
   - Sensitivity (1 year) ~ 0.035
2. Complete measurement
   - DYB+LA+Far, from 2010
   - Sensitivity (3 years) < 0.01

Daya Bay

Pair by pair filling



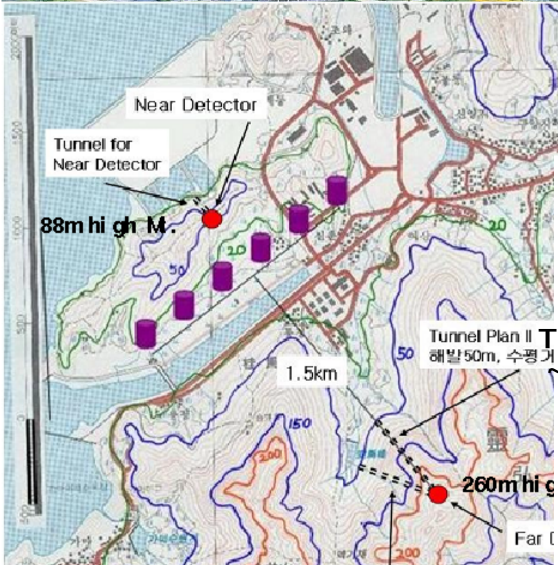
Error type	k	$\mathbf{c^D_{i,k}}$	$\mathbf{S^D_{i,k} \times U^D_i}$
Relative normalization			
inside batch 1	2	$(\delta_{D,D_1} - \delta_{D,D_5})/N_b$	$\sigma_{\text{fill}} N_i^D$
of batch 1	3	$(\delta_{D,D_1} + \delta_{D,D_5})/N_b$	$\sigma_{\text{p2p}} N_i^D$
inside batch 2	4	$(\delta_{D,D_2} - \delta_{D,D_6})/N_b$	$\sigma_{\text{fill}} N_i^D$
of batch 2	5	$(\delta_{D,D_2} + \delta_{D,D_6})/N_b$	$\sigma_{\text{p2p}} N_i^D$
inside batch 3	6	$(\delta_{D,D_3} - \delta_{D,D_7})/N_b$	$\sigma_{\text{fill}} N_i^D$
of batch 3	7	$(\delta_{D,D_3} + \delta_{D,D_7})/N_b$	$\sigma_{\text{p2p}} N_i^D$
inside batch 4	8	$(\delta_{D,D_4} - \delta_{D,D_8})/N_b$	$\sigma_{\text{fill}} N_i^D$
of batch 4	9	$(\delta_{D,D_4} + \delta_{D,D_8})/N_b$	$\sigma_{\text{p2p}} N_i^D$

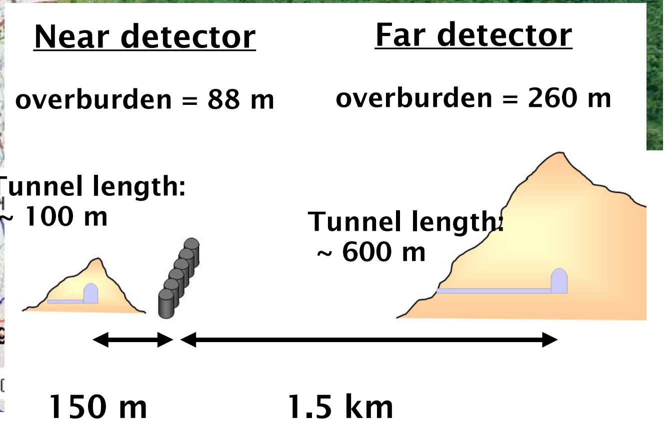
σ_{fill} = 0.3 % σ_{p2p} = 1.0 % **+** σ_{rel} = 0.25 %

RENO

In South Corea
Yongwang,

	R1	R2	R3	R4	R5	R6
Near	3%	8%	39%	39%	8%	3%
Far	15%	17%	18%	18%	17%	15%





6 cores – 1 site – 16.4 GW_{th}

1 near site, 1 far,

3 "*very near*" sites

- target: 2 x 20 t
- + target: 3 x ~ 200-300 kg

Civil Engineering

- ~ 700 m tunnels
- 2 laboratories to be build

Statistics (including ε)

- Far: ~ 70 evts/day
- Near: ~ 1,700 evts/day

Systematics

- total: ~ 1%

Overburden

- Far: ~ 700 mwe
- Near: ~ 240 mwe

Planning

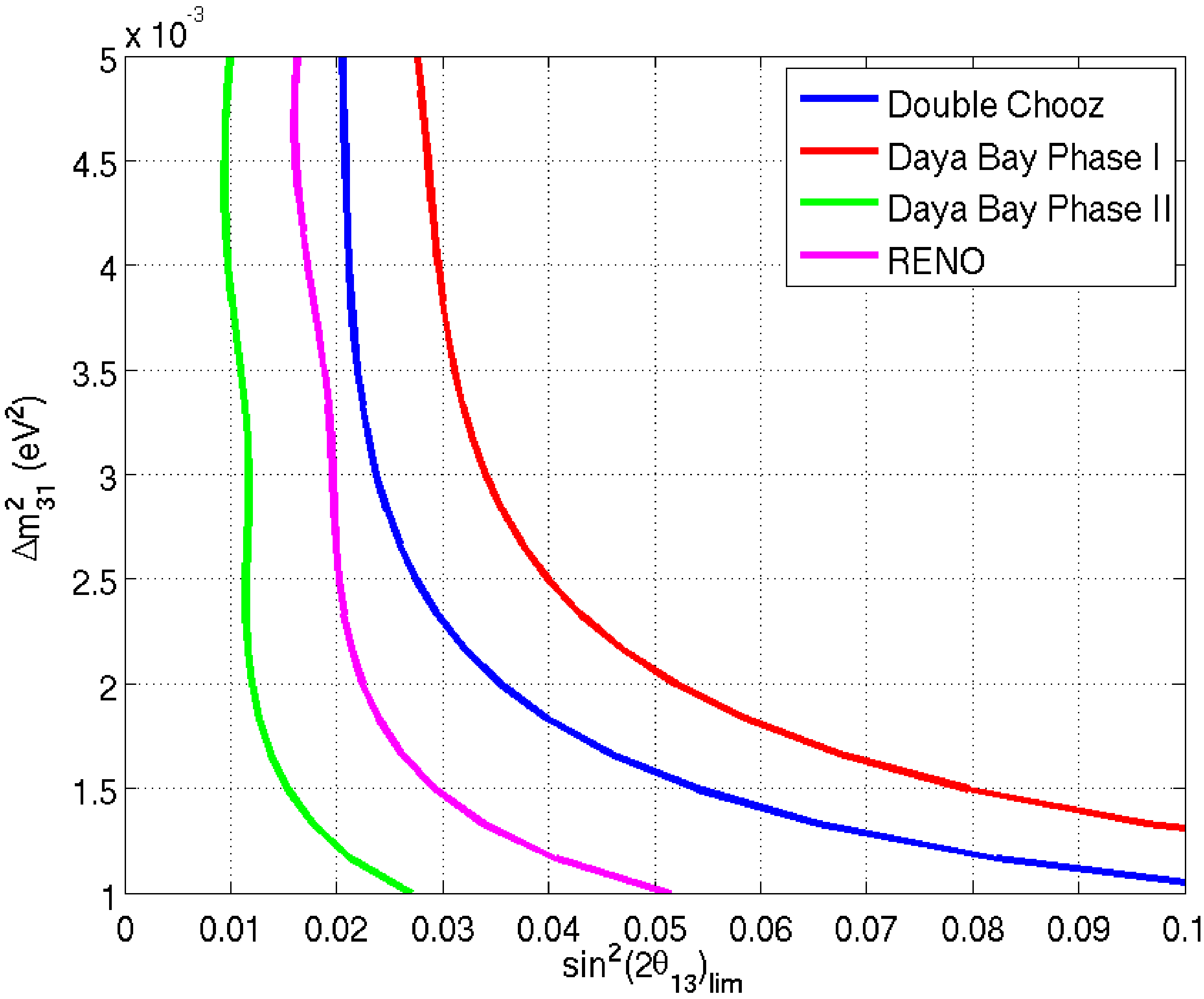
- Start construction on beginning of 2007...
- Sensitivity: ~ 0.02

Systematic business

CHOOZ – Double Chooz – Daya Bay

Error Source	Error Type	Error Description	CHOOZ	DC	DC	DB	DB (No R&D)	DB (Claim)
			Absolute	Absolute	Relative	Absolute	Relative	Relative
		Reactor						
		Production Cross Section	1.90%	1.90%		1.90%		0.13%
Reactor		Core Powers	0.70%	0.70%		0.70%		
		Energy per Fission	0.60%	0.60%		0.60%		
		Solid Angle/Bary. Displct.			0.20%		0.08%	0.08%
		Detector						
		Detection Cross Section	0.30%	0.10%		0.30%		
Detector	Free H in TG	Volume	0.30%	0.20%	0.20%	0.20%	0.20%	0.02%
		Fiducial Volume	0.20%	0.20%				
		Density		0.10%	0.01%		*0.01%*	*0.01%*
		H/C (Chemical Composition)	0.80%	0.80%	0.10%	0.20%	0.20%	0.10%
	Electronics	Dead Time	0.25%		0.00%			
Analysis		**Analysis**						
	Particle Id							
	Positron	Escape	0.10%					
		Capture	0.00%					
		Identification Cut	0.80%	0.10%	0.10%		0.20%	0.05%
	Neutron	Escape	1.00%				0.01%	0.01%
		Capture (% Gd)	0.85%	**0.30%**	**0.30%**		**0.01%**	**0.01%**
		Identification Cut	0.40%	0.10%	0.10%		0.10%	0.03%
	Anti-neutrino	Time Cut	0.40%	0.10%	0.10%		0.10%	0.03%
		Distance Cut	0.30%					
		Unicity (neutron multiplicity)	0.50%				0.05%	0.01%
		Efficiency uncert due to bkg						
Total			**2.90%**	**2.31%**	**0.46%**	**2.15%**	**0.39%**	**0.20%**

ALL experiments BL option



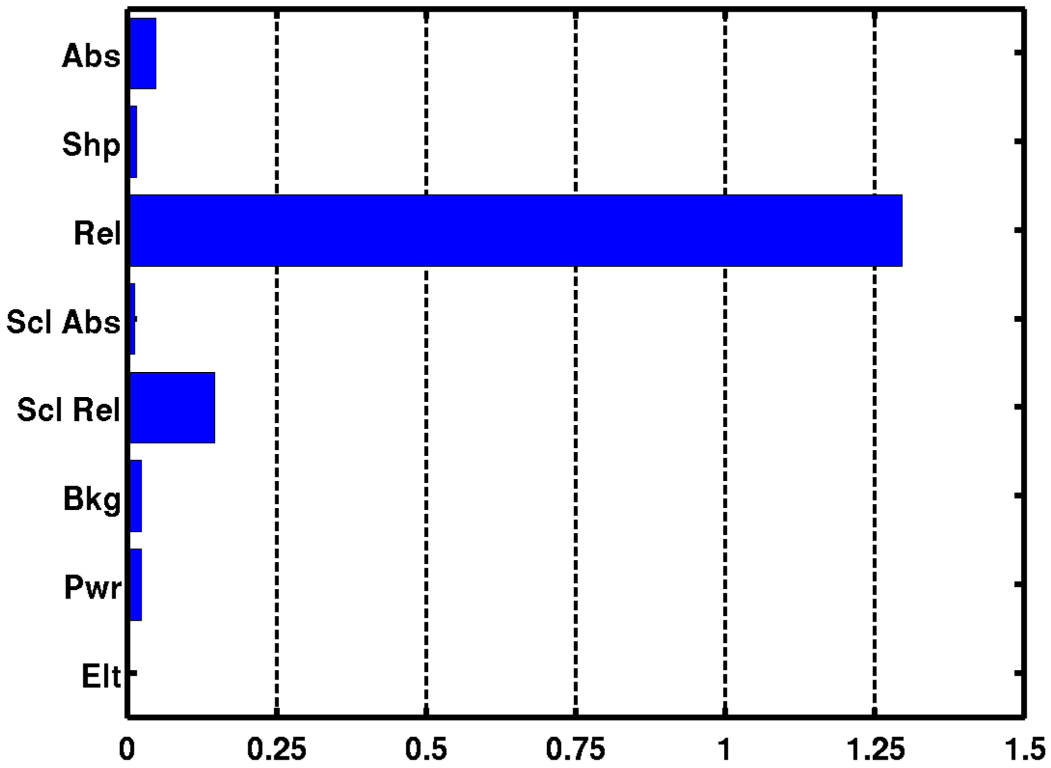
Exposure:

DC, DB II & RN: 3 years

DB I: 1 year

Double Chooz

Contribution of the pulls to the χ^2
for the determination of $\sin^2(2\theta_{13})_{lim}$ (@ 90 % C.L.)



$$\Delta\chi^2_{pulls} = \sum_{k=1}^{K} \sum_{D} \sum_{i=1}^{N_{bins}} c^D_{i,k} \left(\alpha^D_{i,k}\right)^2$$

The dominant contribution clearly comes from

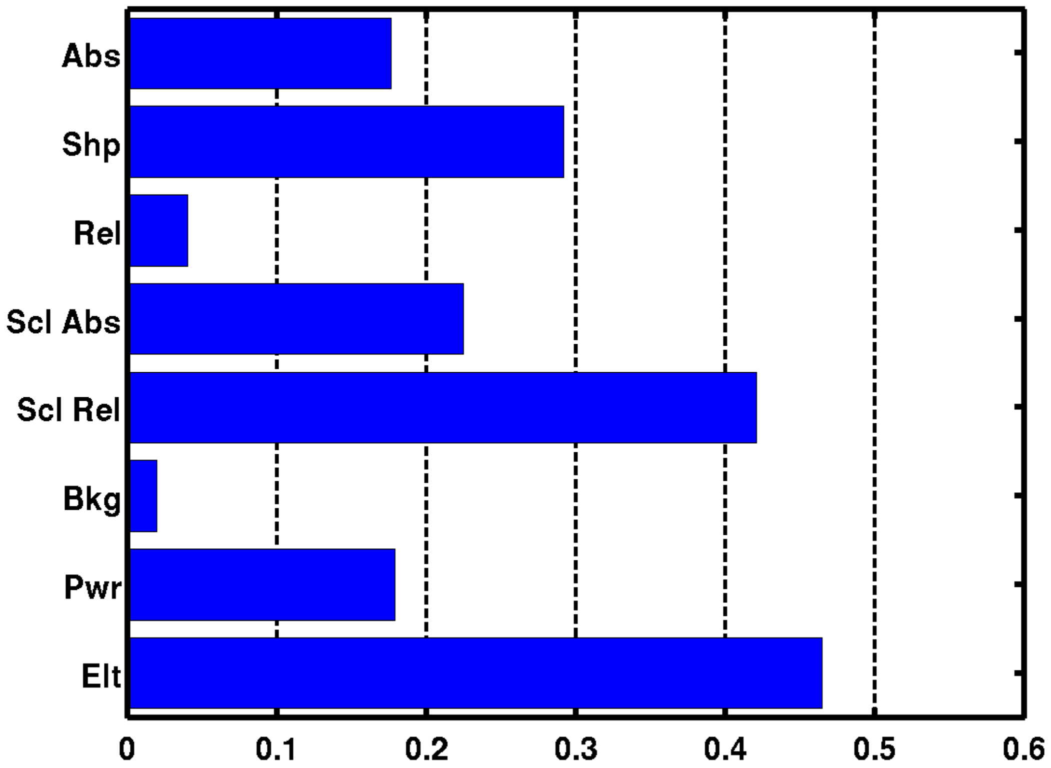
- σ_{rel} on relative normalization

some impact of

- σ_{scl} on relative energy scale

Daya Bay Mid

Contribution of the pulls to the χ^2



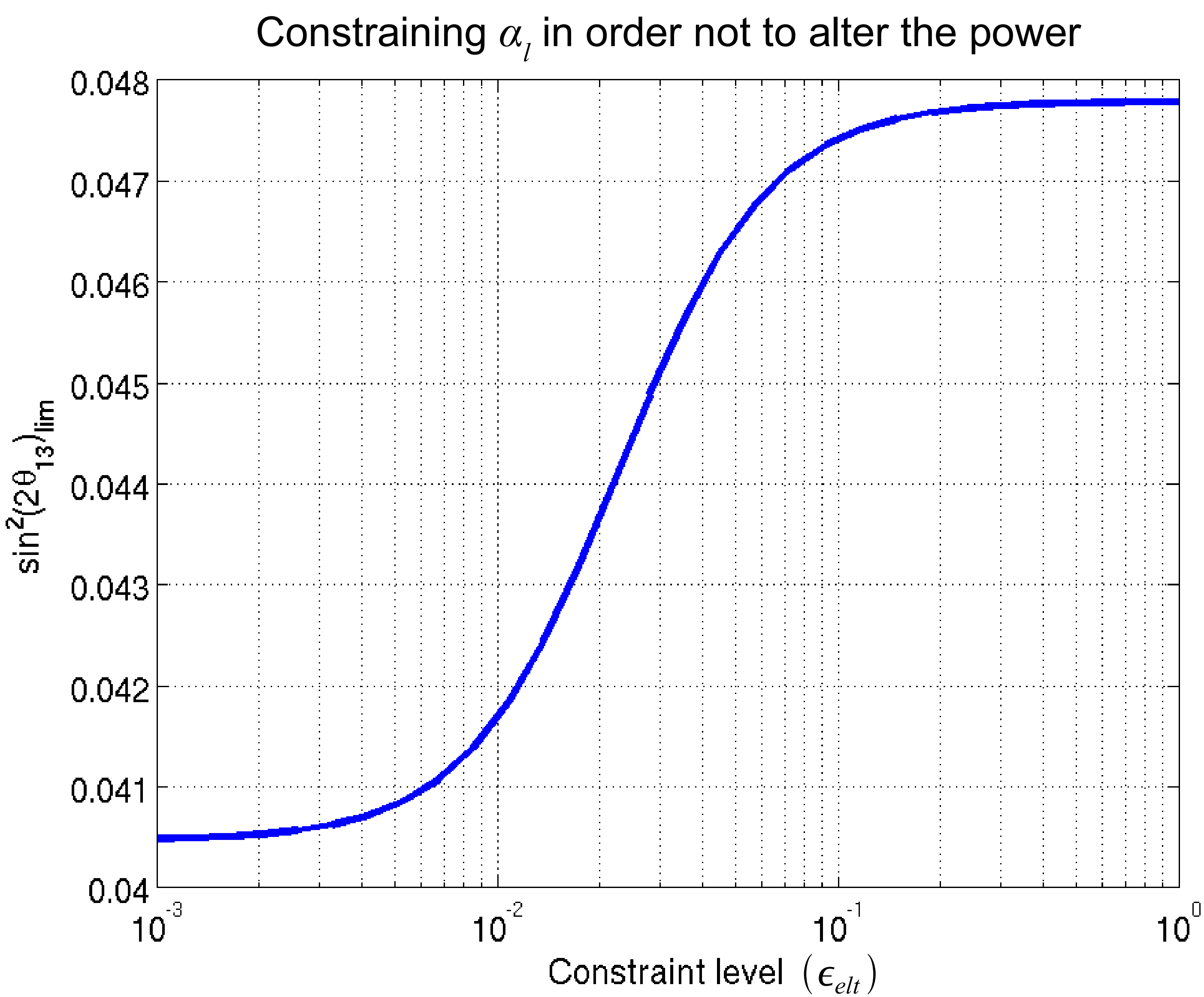
The dominant contributions come from

- σ_{elt} on NPP core fuel composition
- σ_{scl} on energy scale
- σ_{shp} on spectrum shape
- σ_{abs} on absolute normalization
- σ_{pwr} on NPP core power

Why such an impact of σ_{elt}?
Does it affect directly the power?

Average F. R.	DB	LA1
Dn1xyz (DB)	87.9%	12.1%
Dfxyz (Mid)	32.3%	67.7%

Daya Bay Mid



- First method:

Add a constraint-weight term to the χ^2

$$\left(\frac{\sum_{l=U5,\,P9,U8,\,P1} \alpha_l \, c_l}{\epsilon_{elt}} \right)^2$$

where c_l are fuel concentration coefficients for each core.

- Second method:

Force α_l coefficients to be in the kernel of c_l^*, *i.e.*

$$\sum_{l=U5\,,\,P9\,,U8\,,\,P1} \alpha_l c_l = 0$$

through parameter matrix redefinition

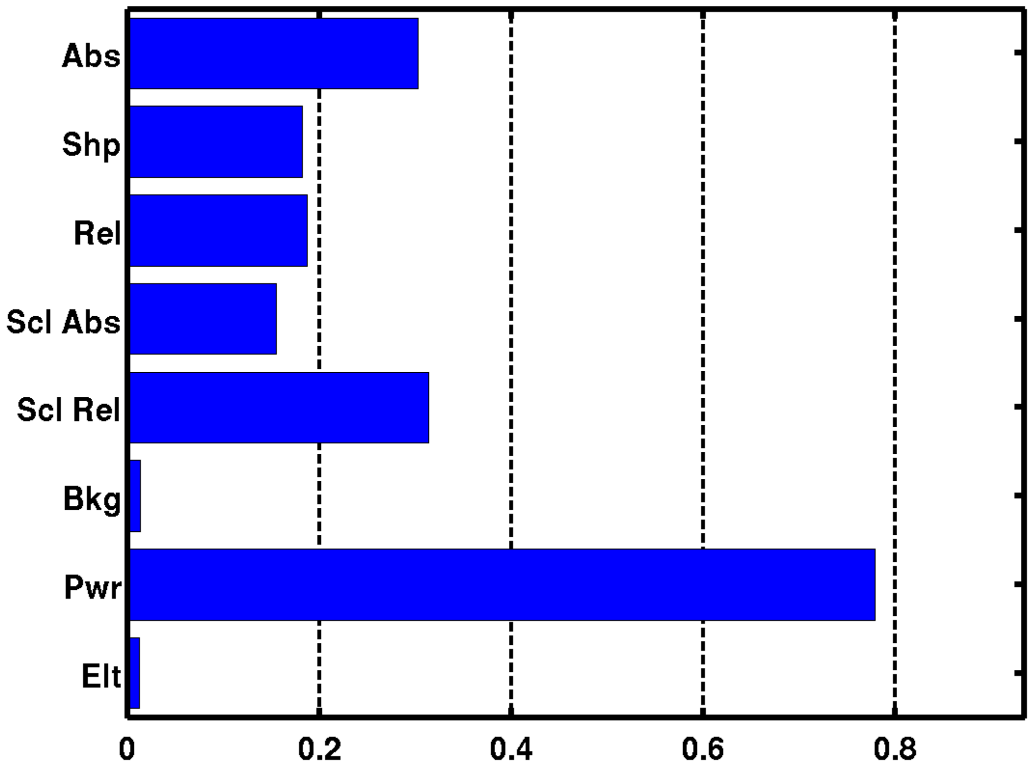
We may at the same time impose

$$\sum_{i=1}^{N_{bins}} \alpha_{shp,i} N_i = 0$$ *for shape coef.*

⇨ *almost no impact*

Daya Bay Mid

Contribution of the pulls to the χ^2



If we constrain mathematically α_l not to contribute to power uncertainties

The dominant contributions come from

- σ_{pwr} on power
- σ_{scl} on energy scale
- σ_{abs} on absolute normalization
- σ_{rel} on relative normalization
- σ_{shp} on shape

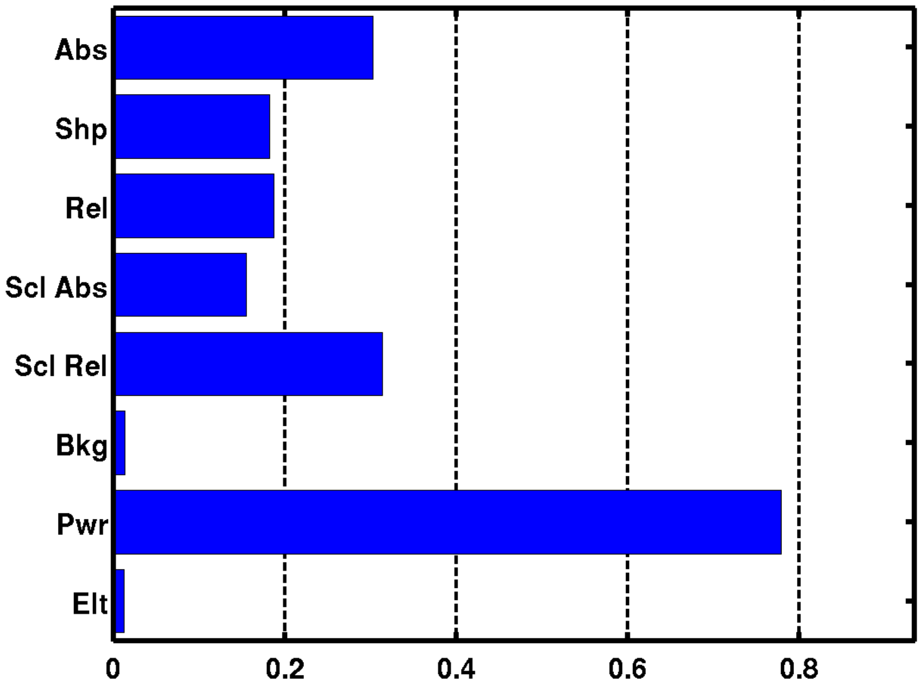
Average F. R.	DB	LA1
Dn1xyz (DB)	87.9%	12.1%
Dfxyz (Mid)	32.3%	67.7%

Daya Bay Mid

If Daya Bay Phase I starts after 2010-2011, when LA II cores will start

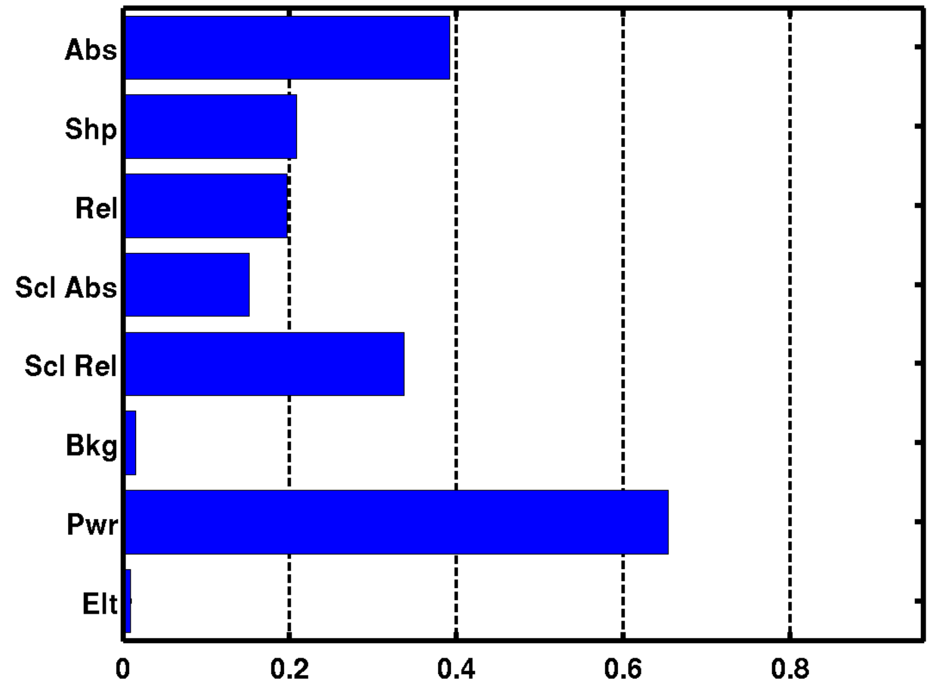
1 year of operation before 2011

Contribution of the pulls to the χ^2



1 year of operation after 2011

Contribution of the pulls to the χ^2

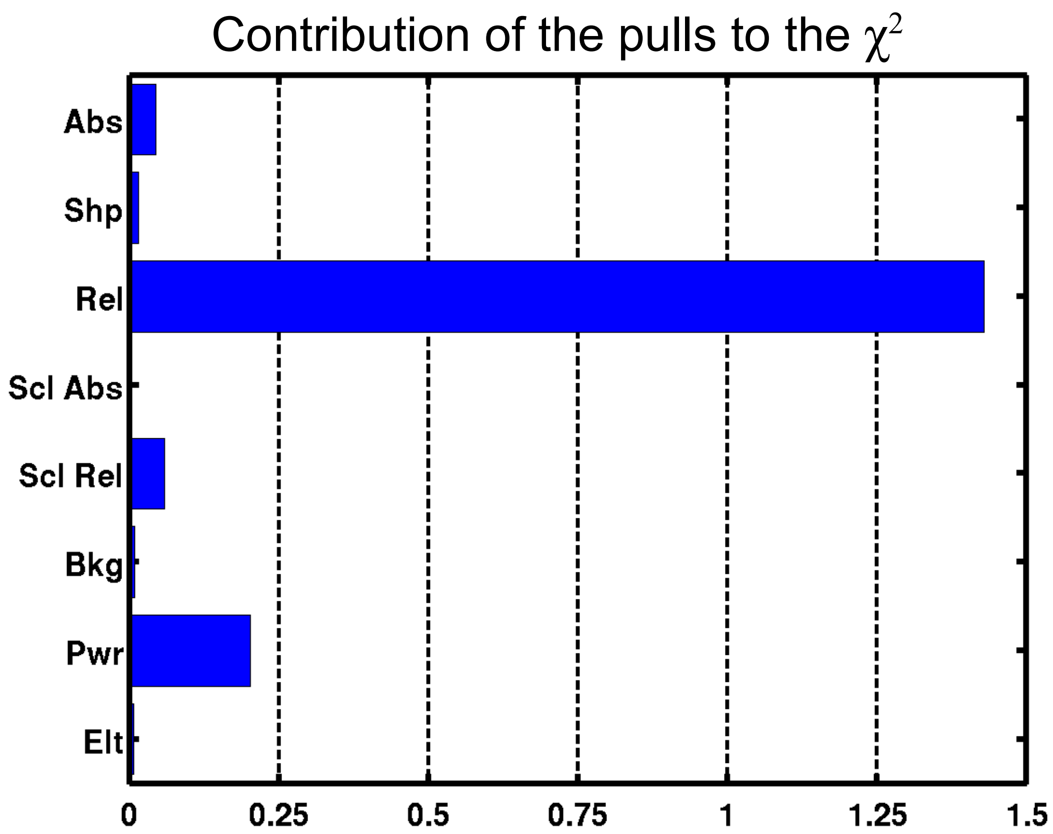


The scheme remains the same, just a bit less sensitive to σ_{pwr} on NPP core power, more sensitive to σ_{abs} on absolute normalization when LA II is ON

Average F. R.	DB	LA1
Dn1xyz (DB)	87.9%	12.1%
Dfxyz (Mid)	32.3%	67.7%

Average F. R.	DB	LA1	LA2
Dn1xyz (DB)	83.1%	11.4%	5.5%
Dfxyz (Mid)	22.5%	47.1%	30.4%

Daya Bay Full



The dominant contributions come from

- σ_{rel} on relative normalization

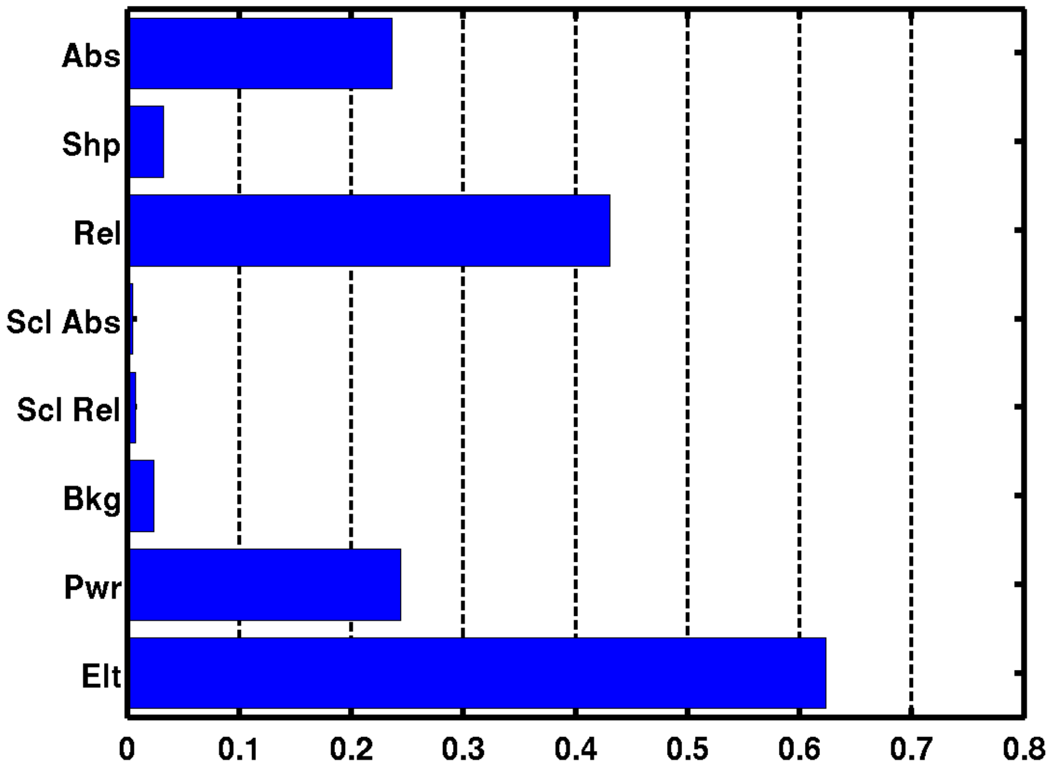
Also some impact from

- σ_{pwr} on NPP core power

Average F. R.	DB	LA1	LA2
Dn1xyz (DB)	83.1%	11.4%	5.5%
Dn2xyz (LA)	6.5%	50.6%	42.8%
Dfxyz (Far)	24.9%	37.4%	37.7%

RENO

Contribution of the pulls to the χ^2



The dominant contributions come from

- σ_{elt} on NPP core fuel composition
- σ_{rel} on relative normalization

Also some impact from

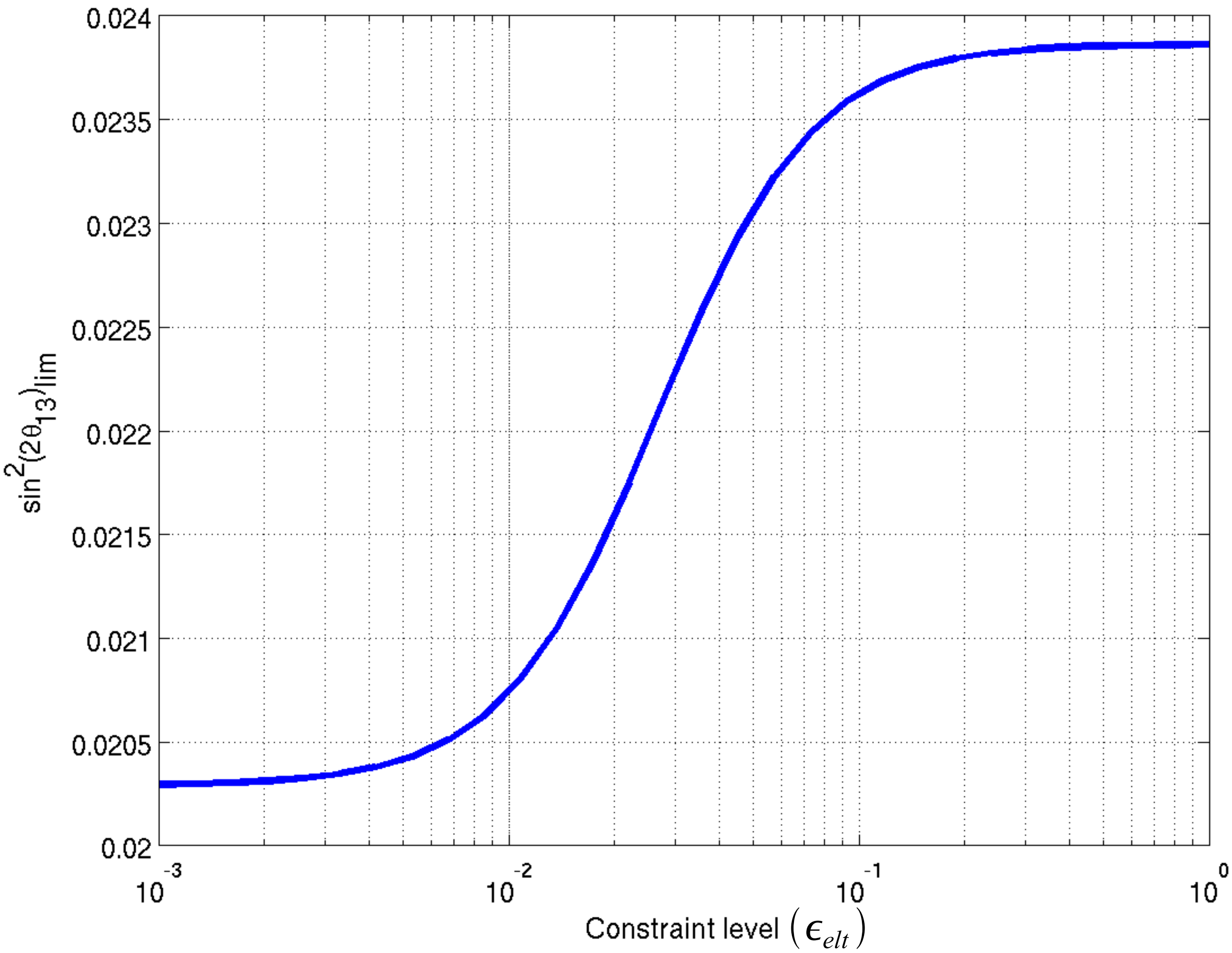
- σ_{abs} on absolute normalization
- σ_{pwr} on NPP core power

Same remark as for DB Mid

	R1	R2	R3	R4	R5	R6
Near	3%	8%	39%	39%	8%	3%
Far	15%	17%	18%	18%	17%	15%

RENO

Constraining α_l in order not to alter the power



- First method:

Add a constraint-weight term to the χ^2

$$\left(\frac{\sum_{l=U5,\,P9,U8,\,P1} \alpha_l c_l}{\epsilon_{elt}} \right)^2$$

where c_l are fuel concentration coefficients for each core.

- Second method:

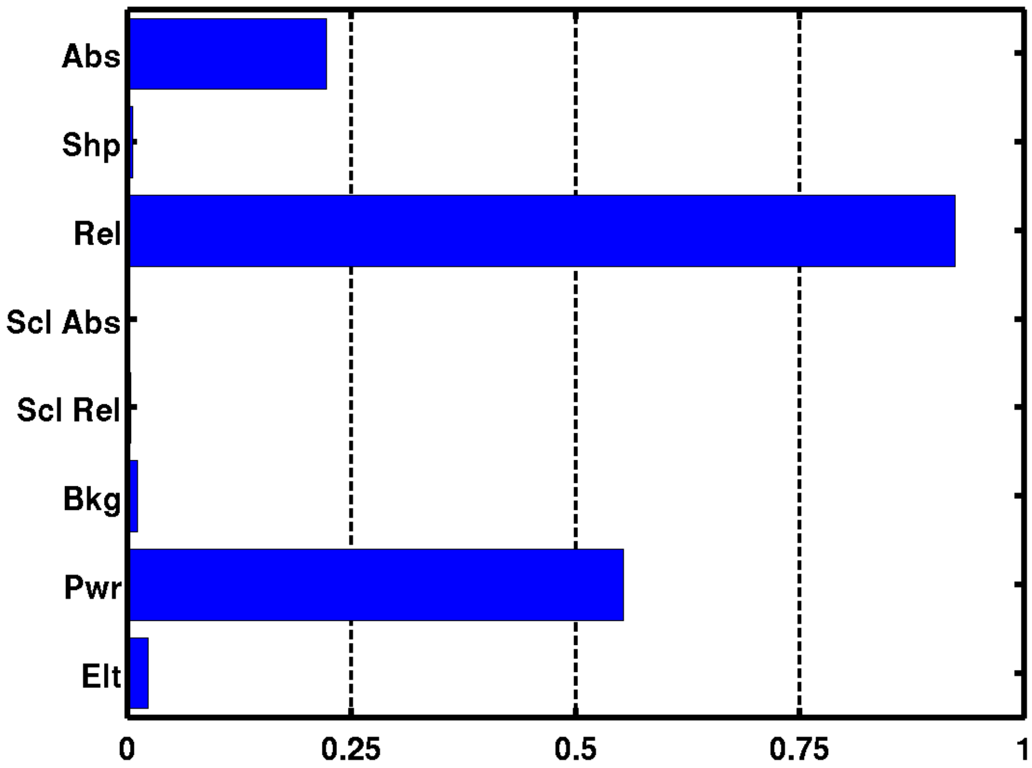
Force α_l coefficients to be in the kernel of c_l^*, *i.e.*

$$\sum_{l=U5,\,P9,\,U8,\,P1} \alpha_l c_l = 0$$

through parameter matrix redefinition

RENO

Contribution of the pulls to the χ^2



If we constrain mathematically α_l not to contribute to power uncertainties

The dominant contributions come from

- σ_{rel} on relative normalization
- σ_{pwr} on NPP core power

Also some impact from

- σ_{abs} on absolute normalization

	R1	R2	R3	R4	R5	R6
Near	3%	8%	39%	39%	8%	3%
Far	15%	17%	18%	18%	17%	15%

Summary

Double Chooz is mainly sensitive to

- σ_{rel}

The near det. plays its full role. The overall sensitivity depends clearly on this systematic

Daya Bay Phase I is sensitive to

- σ_{pwr}, σ_{elt}
- σ_{scl}
- σ_{abs}
- σ_{rel}
- σ_{shp}

In Daya Bay Phase I, the near dets. do not play their full role, and the overall sensitivity relies on absolute knowledges (σ_{pwr} and/or σ_{elt}, σ_{shp}, σ_{abs}).

Daya Bay Phase II is sensitive to

- σ_{rel}
- σ_{pwr}, σ_{elt}

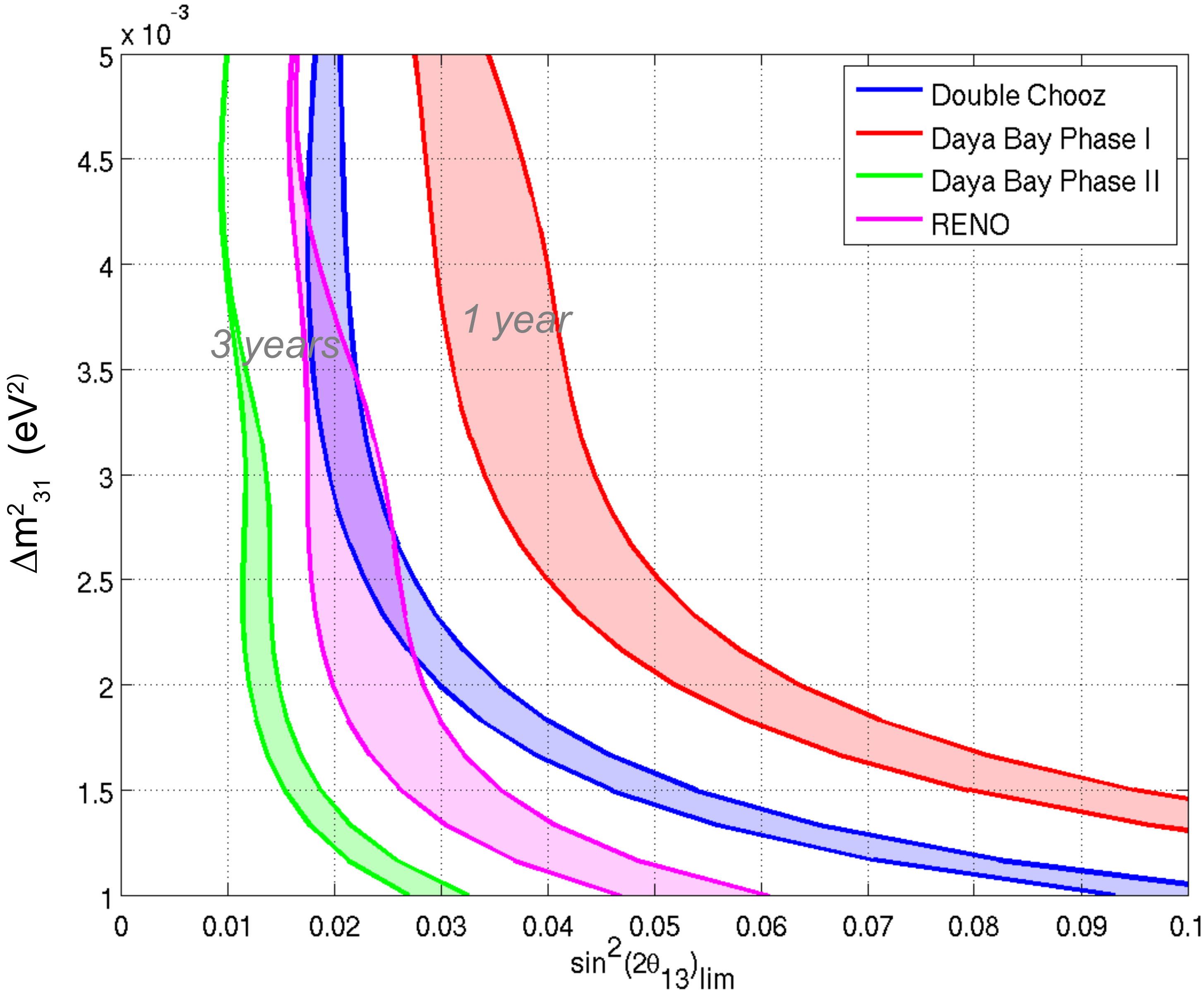
In Daya Bay Phase II, the near dets. play mostly their full role, except the site is so widespread, that there remains a sensitivity to the core power/composition uncetainties

RENO is sensitive to

- σ_{rel}
- σ_{pwr}, σ_{elt}
- σ_{abs}

In RENO, the single near det. can't see equivalently all the cores. Thus, it remains some sensitivity to the power uncertainties but also to the overall spectra normalization.

Playing on the systematic string



Best constraint

σ_{rel} = 0.38 %

$\varepsilon_{elt} = 10^{-4}$

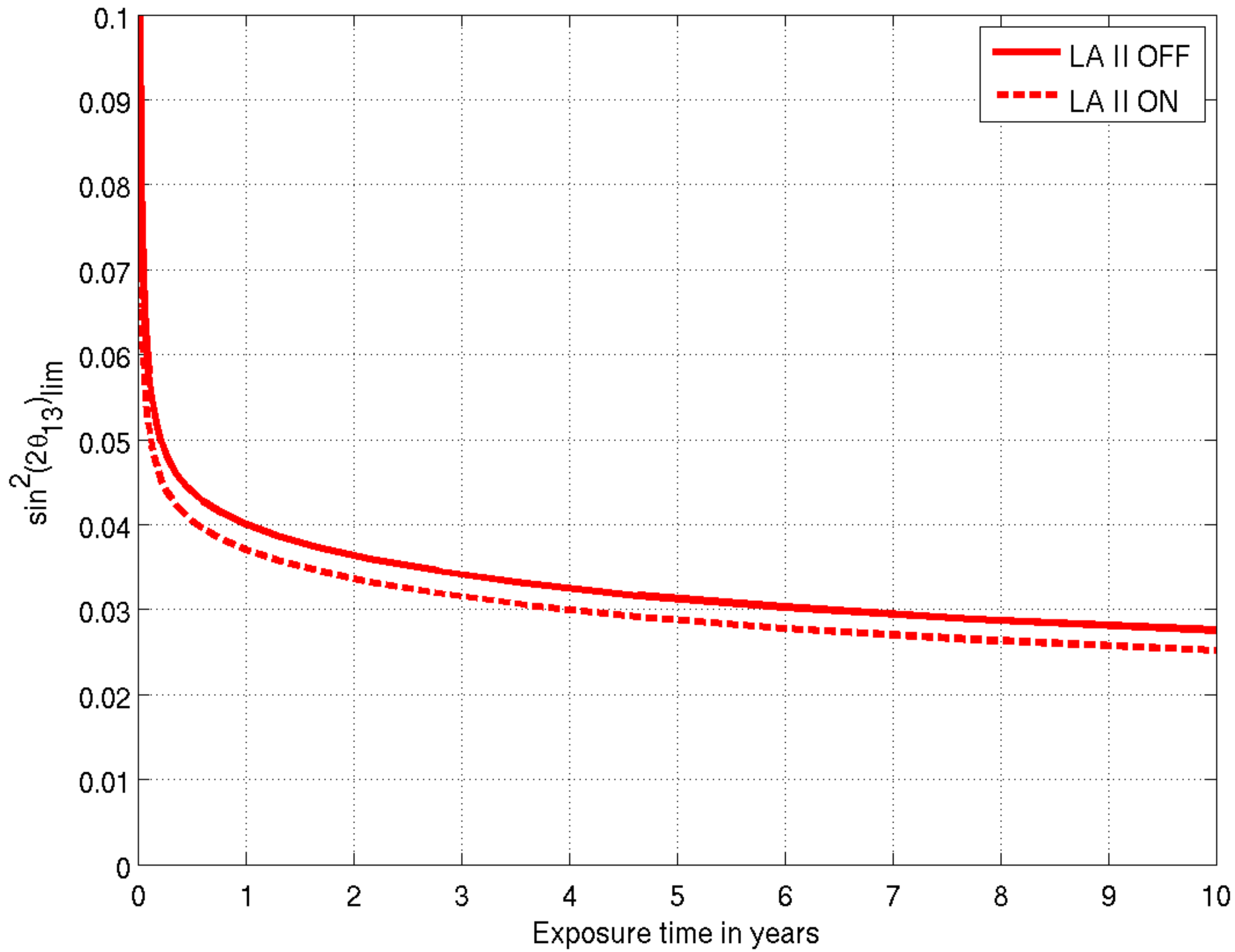
Worst constraint

σ_{rel} = 0.6 %

σ_{pwr} = 3.0 %

σ_{abs} = 3.0 %

Daya Bay Phase I over time



Even after 3 years of data taking with current proposal,

Daya Bay phase I won't go below

$\sin^2(2\theta_{13}) \simeq 0.03\text{-}0.035$

Global conclusion
(an article is in preparation)

- ➔ 3 first generation experiments: **Double Chooz**, **RENO**
  sensitivity ~ 0.02 to 0.03 (depending on sytematics, Δm^2 value, and backgrounds)
  and **Daya Bay Phase I** with sensitivity ~ 0.04 to 0.05 (1 year) ~ 0.03 to 0.035 (3 years)
- A second generation experiment: **Daya Bay** with forseen sensitivity ~ 0.01.
- ➔ To go below 0.01 with reactor experiments seems difficult.

Specific conclusion

First generation

- **Double Chooz**: ~ 0.02-0.03
  - Few reactors, good relative power. Overburden sufficient.
  - Detector locations => insensitive to fuel composition and power uncertainties of the cores;
    Full performence of the far detector position (for $\Delta m^2 > 2.5\ 10^{-3}\ eV^2$) for a 0.02-0.03 sensitivity.
  - To go below 0.01, one need to go farther...
- **RENO**: ~ 0.02-0.03
  - Good site: overburden/available power.
  - Core location = disfavorable.
  - Sensitive to fuel composition and power uncertainties of the cores (even with 3 small detectors of 200-300 kg).
  - => even with 2 x more events than DC, same field of sensitivity as DC.
- **Daya Bay Phase I (?)**: ~ 0.03-0.05 (1 to 3 years?)
  - Clearly suffers from the NPP cores spread.
  - Sensitive to a lot of systematics => sensitivity will rely on difficult analyses, estimations of all these systematics
  - 2 x 40 tons is already a large experiment...!

Specific conclusion

Second generation

- **Daya Bay**: ~ 0.01
  - Very good site for its overburden
  - The power appealing is a lure especially for Daya Bay Phase I: the 2 cores of Daya Bay alone (w/o LA I) gives a better sensitivity
  - It remains some impact of the uncertainty on the NPP core powers on the sensitivity