Multinational Collaboration

- **France**
  - Detector Mechanics
  - Digitization/DAQ
  - Near and Far Laboratory Infrastructure
  - Technical Coordination and detector integration

- **Germany**
  - Scintillators
  - Purification and fluid handling systems
  - Inner muon veto
  - Level 1 trigger System

- **England**
  - PMT Concentrators
  - Laser Calibration

- **Italy**
  - Scintillator development at INFN-LNGS with Russians

- **Spain**
  - Inner detector Photo detection and mechanics

- **Russia**
  - Simulation and Calibration
  - Scintillator Development

- **USA**
  - Inner PMTs
  - Front End Electronics
  - Calibration system
  - Slow control system
  - Outer Muon Veto system

119 Authors from 26 Institutions on the Proposal
hep-ex/0606025

15 June 2006
D. Reyna (ANL)
The Site
The Detector

**TARGET:** (th = 2.3 m)
- Acrylic vessel (th = 8 mm)
- 10.3 m³ LS doped with 0.1% Gd

**GAMMA CATCHER:** (th. = 0.55 m)
- Acrylic vessel (th = 12 mm)
- 22.6 m³ LS (identical to target)

**Buffer:** (th. = 1.05 m)
- Stainless steel vessel (th = 3 mm)
- 114.2 m³ mineral oil
- ~534 PMTs (8 inches)

**Inner VETO:** (t = 0.5 m)
- Steel vessel (th = 10 mm)
- ~80 m³ LS
- ~70 PMTs

**SHIELDING (th. = 170 mm)**
- Steel

**OTHER SYSTEMS**
- Outer Muon Veto System
- Calibration Systems
- Glove Boxes

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Scintillator

- One of the main limiting factors in CHOOZ and Palo Verde
- 4 year development of new Gd doped scintillator compounds at Heidelberg and LNGS
  - 2 viable options have been developed and each has been demonstrated to be stable for more than 400 days
- Best choice is now in transition to industrial production
  - Confidentiality agreement
  - First sublimation tests on 50 g scale finished
  - Sublimation of about 400 g finished last week
    - MPIK synthesis to produce ~80 liters of scintillator
  - Industrial Production of 700 g (synthesis + sublimation) started (will produce 150 liters of scintillator)
  - For Double Chooz a total of 100 kg (2 detectors) needed
- Heidelberg is constructing a building for storage and purification of all scintillators for both detectors
- Second choice scintillator was tested in 1/5 scale prototype
Technical Validation with 1/5 scale prototype

- **Technical Goals**
  - Validate design of acrylic vessels
  - Validate mechanical solutions
  - Validate detector integration
  - Final check of material compatibility
  - Define control procedures for acrylis
  - Define interfaces for liquid handling
  - Prepare filling procedure

- **Additional Benefits**
  - Test run for the assembly in the real detector
  - Finalize the definition of interfaces
  - Finalize the assignment of responsibilities
A Learning Experience

- Some technical solutions for the acrylic mechanics need revisions
- Tightness of the filling system is not trivial
- Interfaces are difficult

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Testing and Prototypes

- PMT Uniformity
- HV Splitter
- Outer Veto
- De-Magnetization
- Mass Measurement
- Front End Electronics
- PMT Mounts

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Engineering Work

Acrylic Stress Analysis

Shielding Steel

Laboratory Layout

PMT Concentrators
Installation Procedures
## Detailed Schedule for Far Detector Assembly

<table>
<thead>
<tr>
<th>N°</th>
<th>Responsible</th>
<th>Ext</th>
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<th>2006</th>
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<td>25/07/08</td>
</tr>
</tbody>
</table>

15 June 2006 D. Reyna (ANL)
Detector Integration

Starting date: 11/2006 (2 months)

- sub contractor on site
- Painting of inner surface
- APC studies
- Veto vessel
- White painted
- Side shielding
- E.M. shield?
Detector Integration

Starting date: 03/2007
(2 months)

Buffer vessel realize with 3 welded rings

(Cylinder transport in 6 half rings)
Welding of 2 half cylinders.

Rebuilding of piece of cylinders in the pit

sub contractor on site
Detector Integration

Starting date: 04/2007 (2 months)

Mounting of 534 buffer PMTs (vessel and lid)

Cleaning after mounting?

Acrylics feet mounting

Free area for preparation

Length of cables = 35 meters
Detector Integration

Rotation of the gamma catcher into the detector
Detector Integration

Insertion by translation of the target vessel into the gamma catcher
Starting date: 08/2007

Detector Integration

Tank for mass measurement of target liquid

- Closing of buffer vessel
- Closing of the veto vessel
- Filling up of the different vessels

How long?
Detector Integration

Integration of OUTER VETO

Glove box for calibration
• FAR site
  – Received authorization to use the building near the neutrino lab to house liquid tanks
  – Activity started last week in the lab to dismantle the old tank and update infrastructure
  – Could start building a new detector in Summer 2007

• NEAR site
  – EDF provided first civil engineering study in January. Overburden = 90m.w.e.
  – Further development of design by the fall → have a precise cost (±20%) to gather funding from local authorities
  – Final designs to be completed in 2007
  – Lab ready in 3 years: 2009
## Systematic Errors

<table>
<thead>
<tr>
<th></th>
<th>Chooz</th>
<th>Double Chooz</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reactor-induced</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \nu ) flux and ( \sigma )</td>
<td>1.9 %</td>
<td>&lt;0.1 %</td>
</tr>
<tr>
<td>Reactor power</td>
<td>0.7 %</td>
<td>&lt;0.1 %</td>
</tr>
<tr>
<td>Energy per fission</td>
<td>0.6 %</td>
<td>&lt;0.1 %</td>
</tr>
<tr>
<td><strong>Detector-induced</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solid angle</td>
<td>0.3 %</td>
<td>&lt;0.1 %</td>
</tr>
<tr>
<td>Volume</td>
<td>0.3 %</td>
<td>0.2 %</td>
</tr>
<tr>
<td>Density</td>
<td>0.3 %</td>
<td>&lt;0.1 %</td>
</tr>
<tr>
<td>H/C ratio &amp; Gd concentration</td>
<td>1.2 %</td>
<td>&lt;0.1 %</td>
</tr>
<tr>
<td>Spatial effects</td>
<td>1.0 %</td>
<td>&lt;0.1 %</td>
</tr>
<tr>
<td>Live time</td>
<td>few %</td>
<td>0.25 %</td>
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<tr>
<td><strong>Analysis</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>From 7 to 3 cuts</td>
<td>1.5 %</td>
<td>0.2 - 0.3 %</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>2.7 %</td>
<td>&lt; 0.6 %</td>
</tr>
</tbody>
</table>

- Two "identical" detectors, Low bkg
- Distance measured @ 10 cm + monitor core barycenter
- Same weight sensor for both det.
- Accurate T control (near/far)
- Same scintillator batch + Stability
- "identical" Target geometry & LS
- Measured with several methods

15 June 2006

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Studies of Systematic Effects

Systematic Pulls on $\chi^2$ Analysis
Study of Near Detector

Analysis Includes Location of Spent Fuel Storage (~0.5% of signal)

Far location is optimal for $\Delta m^2 > 2.5 \times 10^{-3}$ eV$^2$
### Background Summary

<table>
<thead>
<tr>
<th>Detector</th>
<th>Site</th>
<th>Accidental Materials</th>
<th>PMTs</th>
<th>Correlated Fast n</th>
<th>μ-Capture</th>
<th>(^9\text{Li})</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHOOZ</td>
<td></td>
<td>Rate ((d^{-1}))</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>0.6 ± 0.4</td>
</tr>
<tr>
<td>(24 (\nu/d))</td>
<td></td>
<td>Rate ((d^{-1}))</td>
<td>0.42 ± 0.05</td>
<td>1.01 ± 0.04\textit{(stat)} ± 0.1\textit{(sys)}</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Far bkg/(\nu)</td>
<td>1.6%</td>
<td></td>
<td>0.2%</td>
<td>0.4%</td>
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<td></td>
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<td>Systematics</td>
<td>0.2%</td>
<td></td>
<td>0.2%</td>
<td></td>
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<tr>
<td>Double Chooz</td>
<td></td>
<td>Rate ((d^{-1}))</td>
<td>1 ± 0.1</td>
<td>1 ± 0.1</td>
<td>0.15 ± 0.15</td>
<td>0.06 ± 0.03</td>
</tr>
<tr>
<td>(69 (\nu/d))</td>
<td></td>
<td>Far bkg/(\nu)</td>
<td>1.4%</td>
<td>1.4%</td>
<td>0.2%</td>
<td>0.1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Systematics</td>
<td>0.2%</td>
<td>0.2%</td>
<td>0.2%</td>
<td>0.05%</td>
</tr>
<tr>
<td>Double Chooz</td>
<td></td>
<td>Rate ((d^{-1}))</td>
<td>7.2 ± 1.0</td>
<td>7.2 ± 1.0</td>
<td>1.4 ± 1.4</td>
<td>0.42 ± 0.2</td>
</tr>
<tr>
<td>(990 (\nu/d))</td>
<td></td>
<td>Near bkg/(\nu)</td>
<td>0.7%</td>
<td>0.7%</td>
<td>0.14%</td>
<td>0.04%</td>
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<td></td>
<td>Systematics</td>
<td>0.1%</td>
<td>0.1%</td>
<td>0.2%</td>
<td>0.02%</td>
</tr>
</tbody>
</table>

![Fast neutron](image1)

![\(^9\text{Li}\)](image2)

![Accidentals](image3)
Possible Measurement

- **Systematic Errors**
  - $\sigma_{\text{abs}} = 2.0\%$
  - $\sigma_{\text{rel}} = 0.6\%$
  - $\sigma_{\text{scale}} = 0.5\%$
  - $\sigma_{\text{shape}} = 2.0\%$

- **Energy Resolution**
  - $\sigma_E = 7\%$

- **1% uncorrelated bin-to-bin background subtraction error**

- **Oscillation Parameters**
  - $\Delta m^2_{31} = 2.5 \times 10^{-3} \text{ eV}^2$
  - $\sin^2(2\theta_{13}) = 0.08$

![Double Chooz](image)
Funding

- **France**
  - Scientific approval by both DSM-DAPNIA and CNRS-IN2P3 since March 2004
  - Recently reviewed and approved for funding starting in 2006
- **Germany**
  - Currently funded through the Max Planck society with major increase in 2006
  - Universities groups are in the final approval process at the Deutsche Forschungsgemeinschaft (DFG)
- **United States**
  - Recommended by NuSAG and HEPAP
  - DOE-HEP has taken no action on the construction proposal (submitted in Oct. 2004) but has rejected a separate R&D request for 2006
  - Funding from NSF is being investigated
- **Russia**
  - Participation funded through Russian Foundation of Basic Research
- **Spain**
  - Just completed review.
  - Funding approval is expected in 1-2 weeks.
- **England**
  - Already funded for developmental work

**French Press Release (this week):**

*Double previous contribution to avoid delay*
Expected Milestones

Limit @ 90% C.L. for $\sin^2(2\theta)=0$

$\Delta m^2_{atm} = 2.5 \times 10^{-3} \text{ eV}^2$ (with 20% uncertainty)

- **2007**: assembly of far detector on site
- **2008**: data taking with far detector
  - Start of Near lab building
- **2009**: assembly of near detector
- **2010**: data taking with 2 detectors
Final Comments

- Double Chooz is ready to begin construction
  - Funding has been established
    - covering the shortfalls of the US-DOE
  - Expect to begin data in 2008
    - Should confirm previous limit within 6 months
- Double Chooz is also participating in an international effort on Nuclear Non-Proliferation
  - See also talk by M. Cribier
- More details in Poster Session V
  - Abs. 51: Physics Potential
  - Abs. 58: Scintillator Development
  - Abs. 63: Simulation Strategy
  - Abs. 64: Non-Proliferation Studies