Status of Double Chooz

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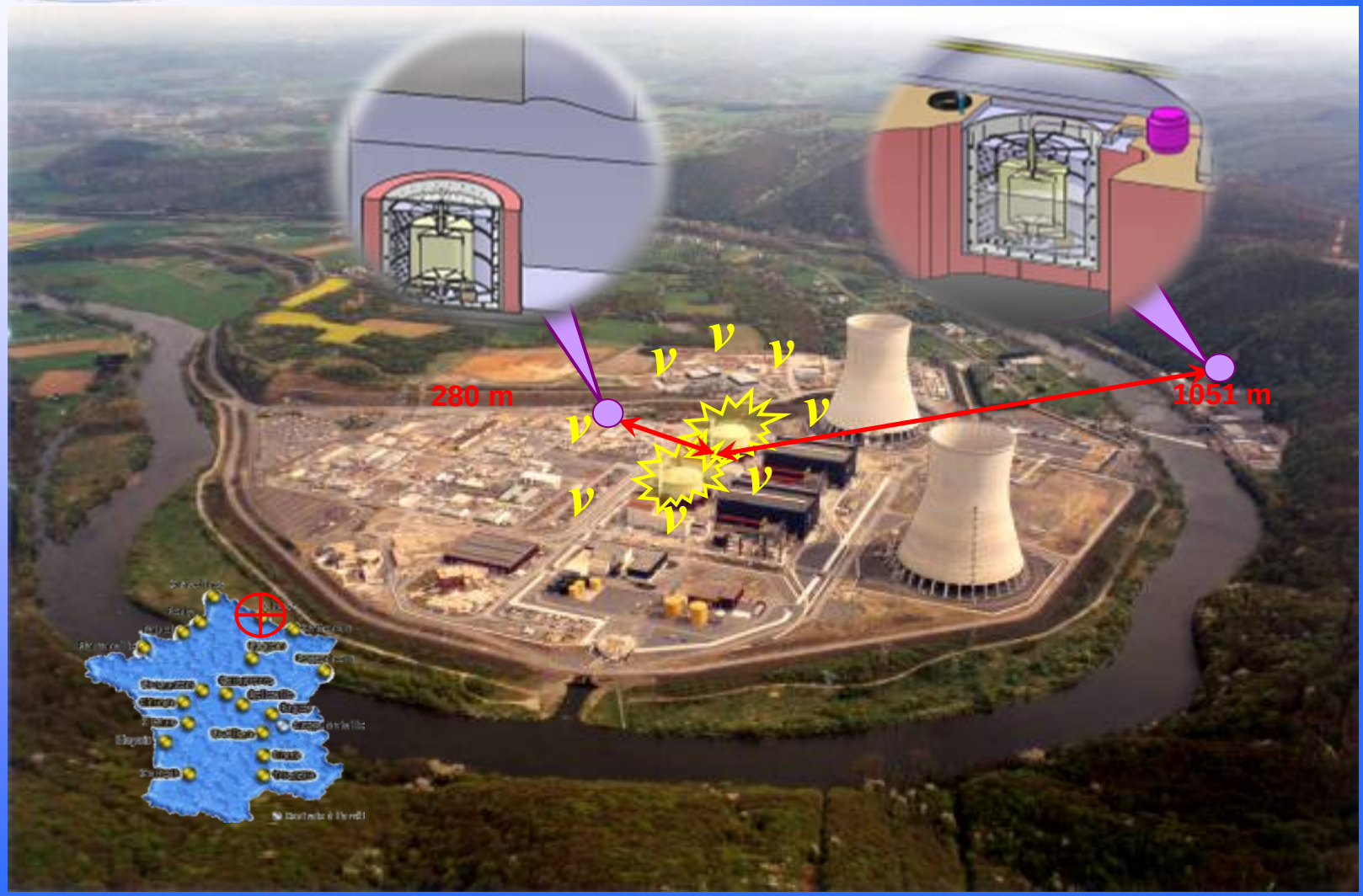
Multinational Collaboration

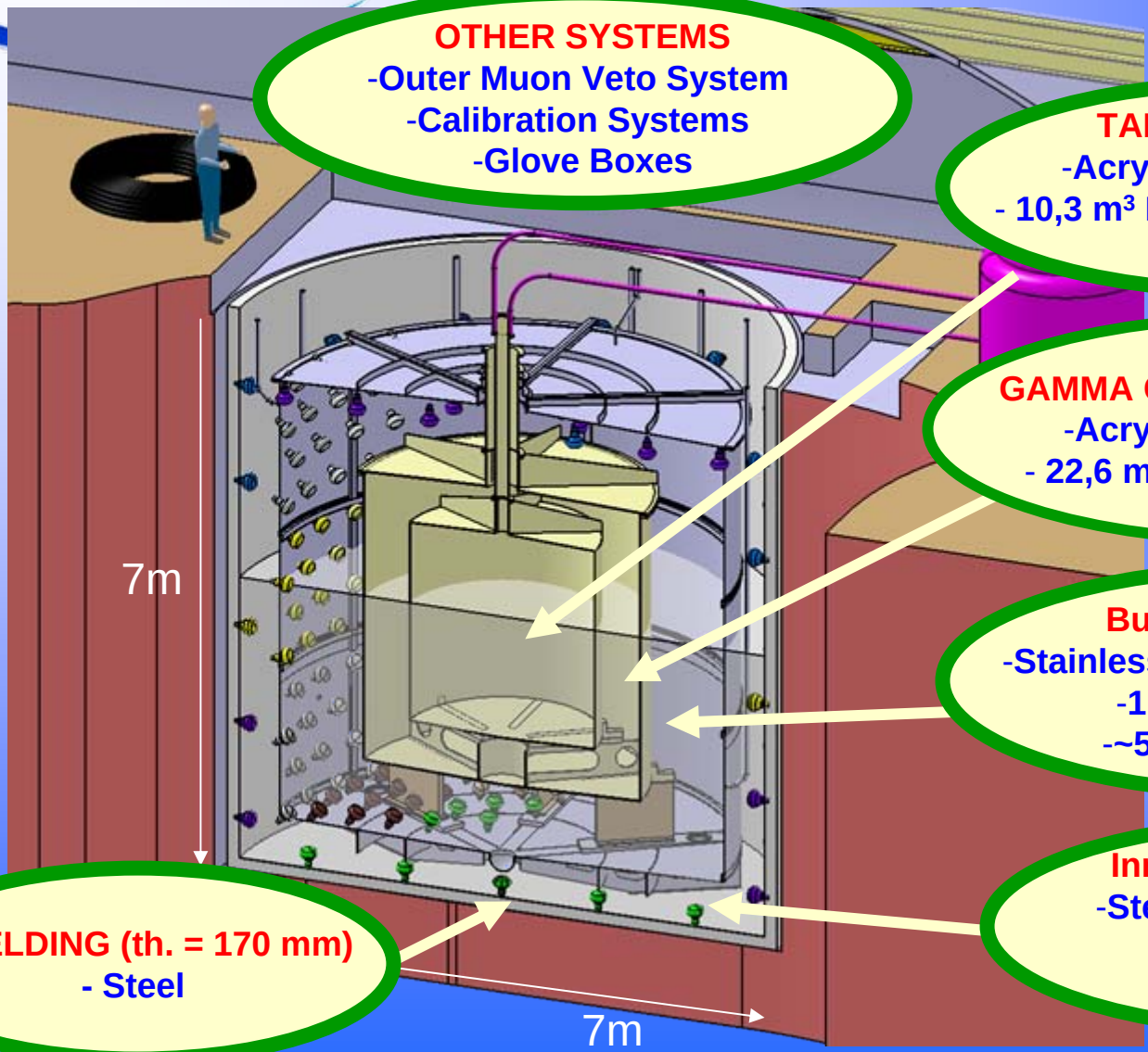
- France
  - Detector Mechanics
  - Digitization/DAQ
  - Near and Far Laboratory Infrastructure
  - Technical Coordination and detector integration
- Germany
  - Scintillators
  - Purification and fluid handling systems
  - Inner muon veto
  - Level 1 trigger System
- England
  - PMT Concentrators
  - 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

The Site



The Detector



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

TARGET : (th=2,3m)
-Acrylic vessel (th=8mm)
- 10,3 m^3 LS doped with 0,1% Gd

GAMMA CATCHER : (th. = 0,55m)
-Acrylic vessel (th= 12mm)
- 22,6 m^3 LS (identical to target)

Buffer : (th. = 1,05m)
-Stainless steel vessel (th = 3 mm)
-114,2 m^3 mineral oil
-~534 PMTs (8 inches)

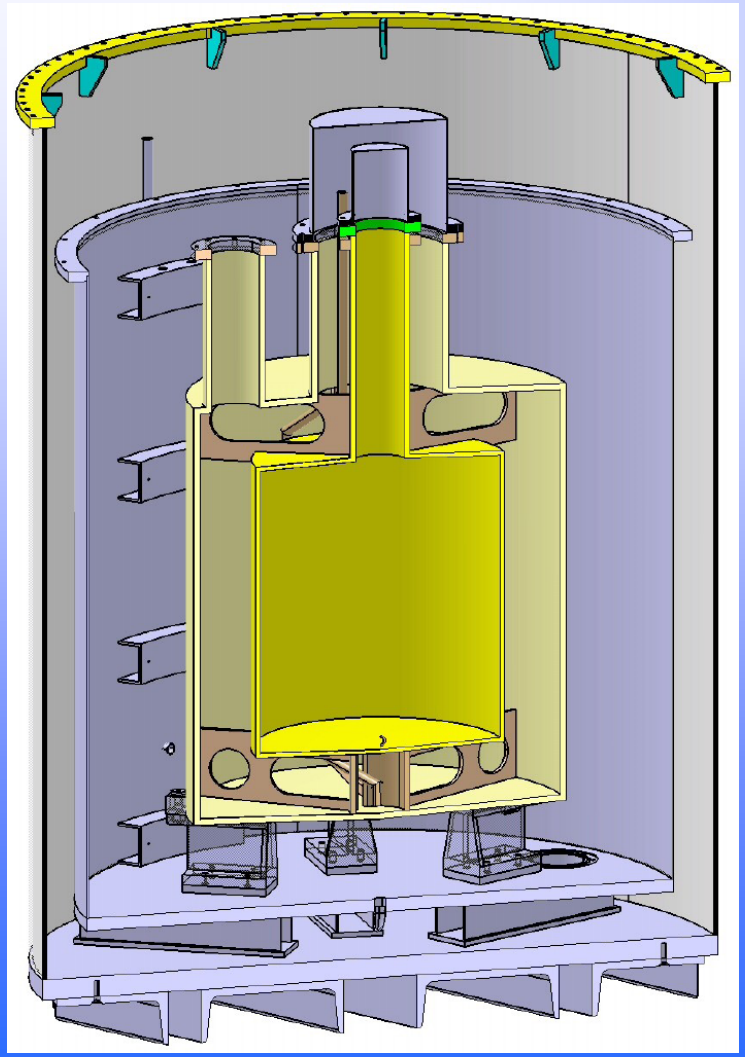
Inner VETO: (t = 0,5 m)
-Steel vessel th = 10 mm)
-~80 m^3 LS
-~70 PMTs

SHIELDING (th. = 170 mm)
- Steel

Scintillator

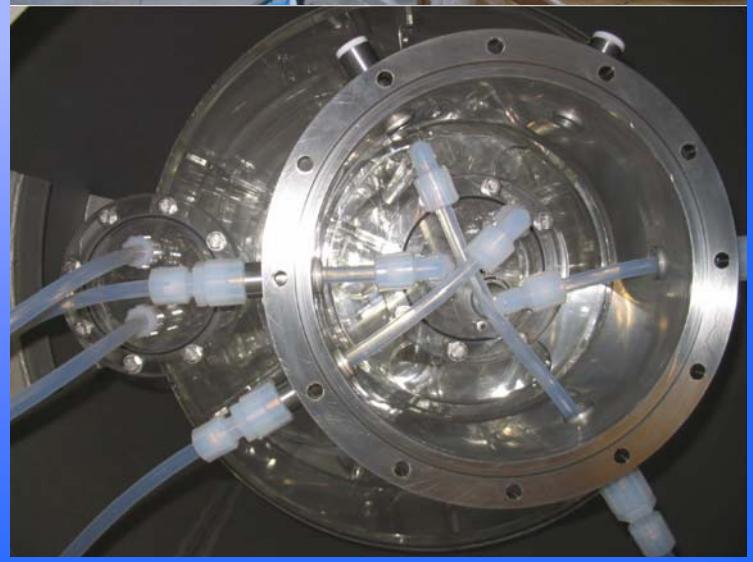
- One of the main limiting factors in CHOOZ and Palo Verde
- 4 year development of new Gd doped scintillator compounds at Heidelberg and LNGS
  - 2 viable options have been developed and each has been demonstrated to be stable for more than 400 days
- Best choice is now in transition to industrial production
  - 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 acrylics
  - 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

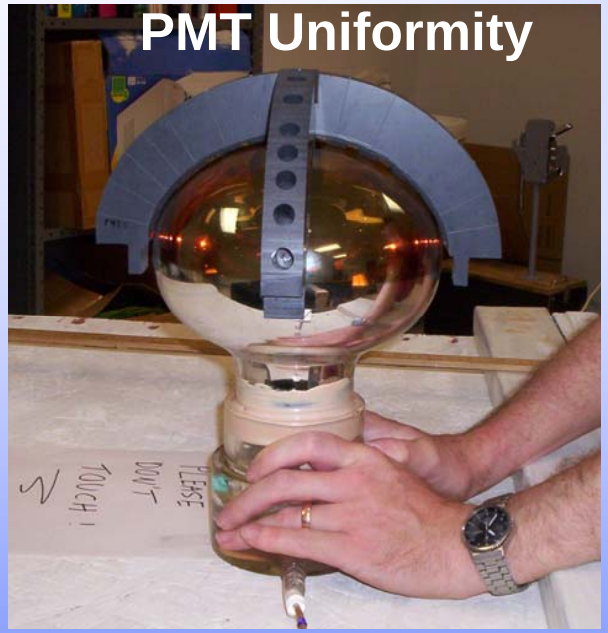
A Learning Experience



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

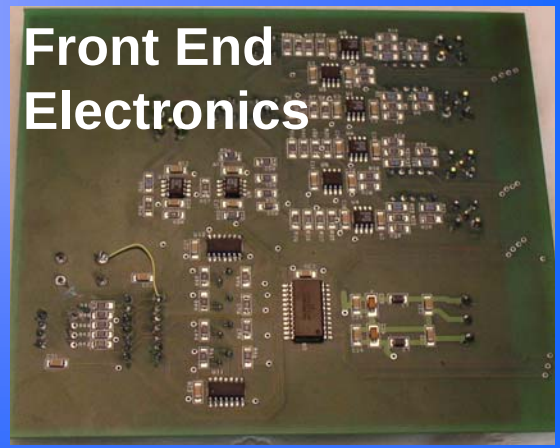
Testing and Prototypes

PMT Uniformity



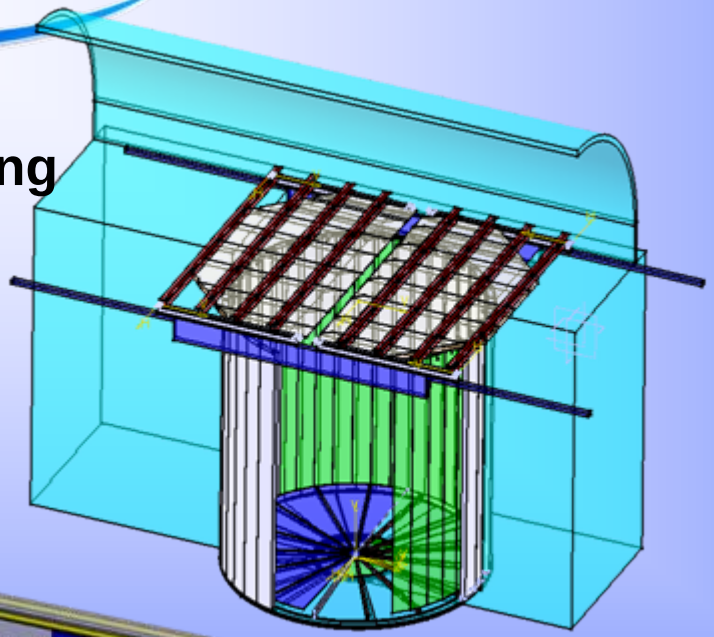
De-Magnetization

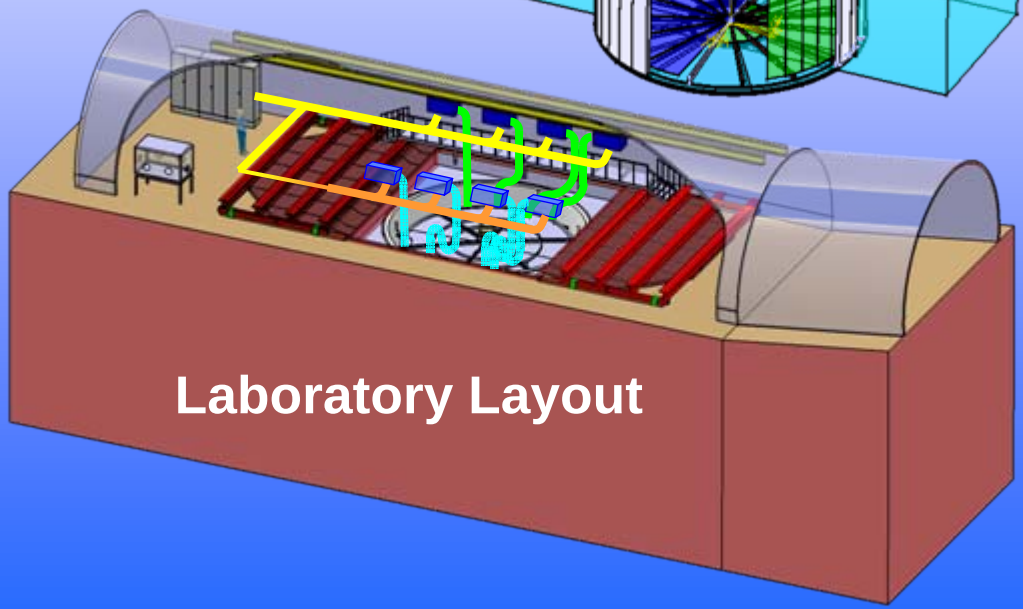
Mass Measurement



Engineering Work

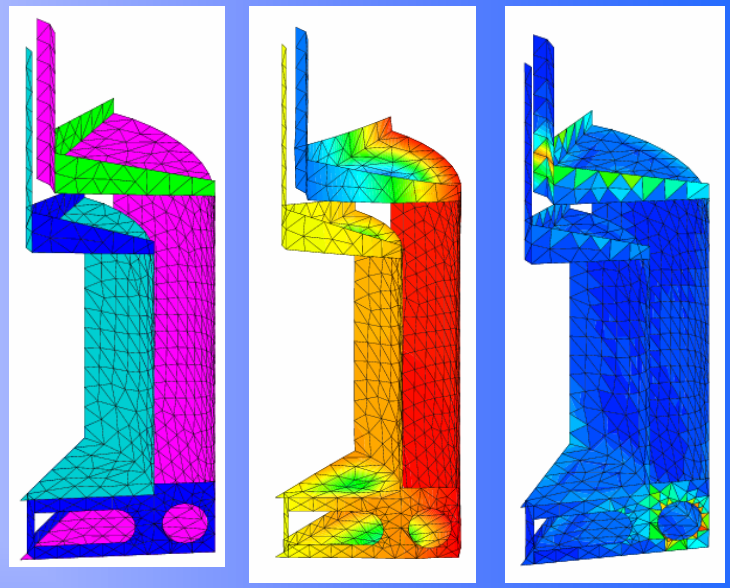
Shielding Steel



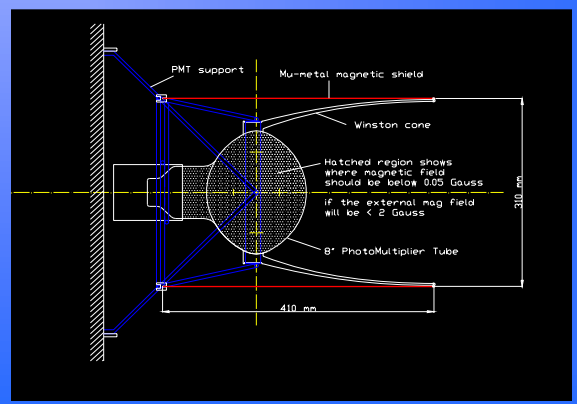


Laboratory Layout

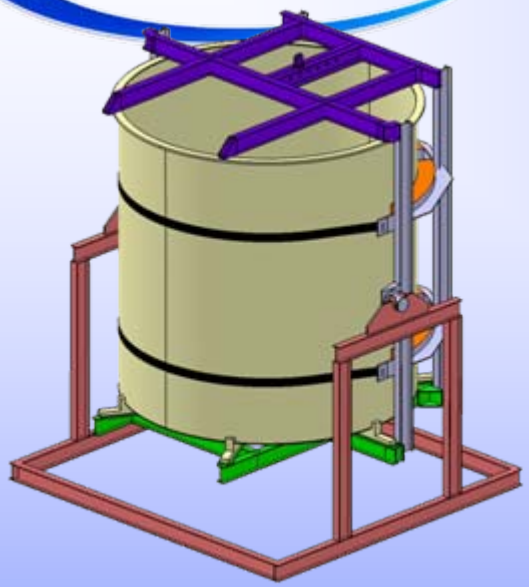
Acrylic Stress Analysis

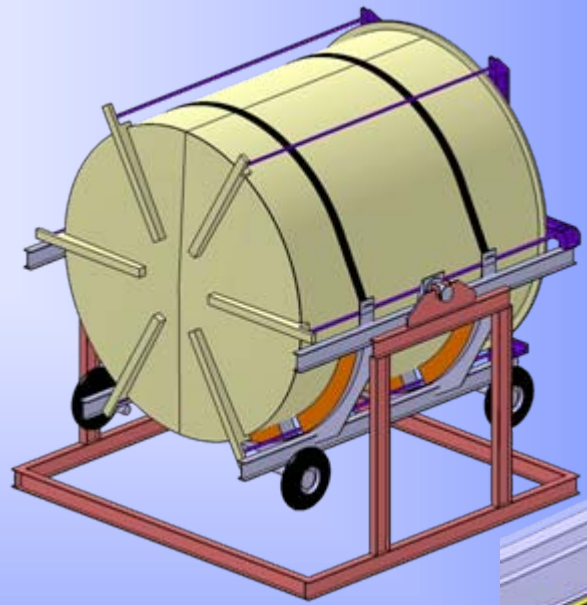


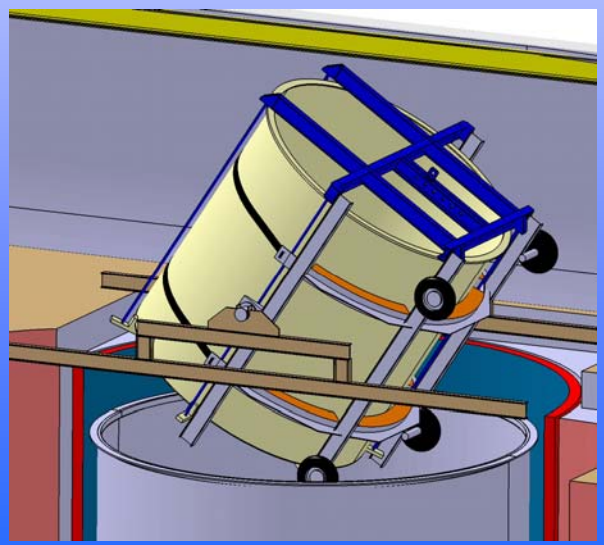
PMT Concentrators

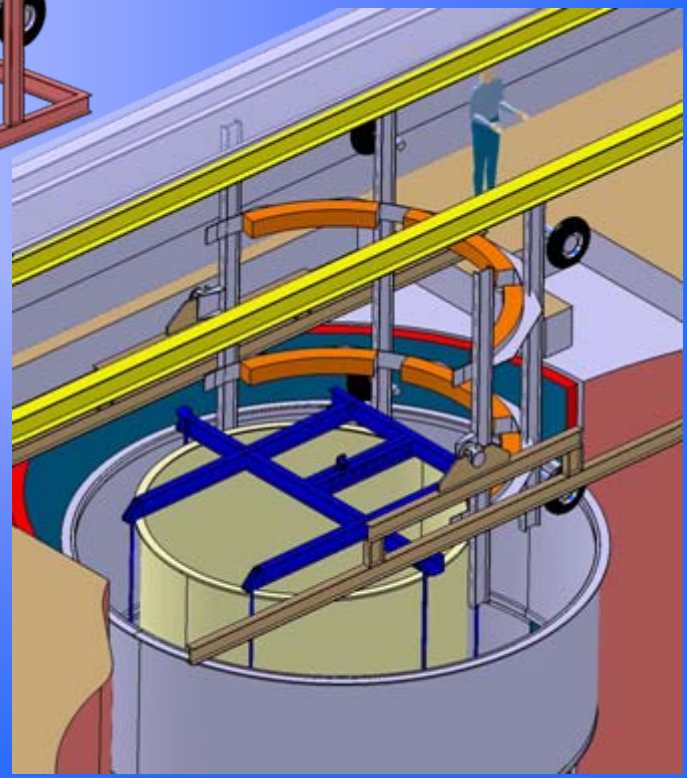


Installation Procedures



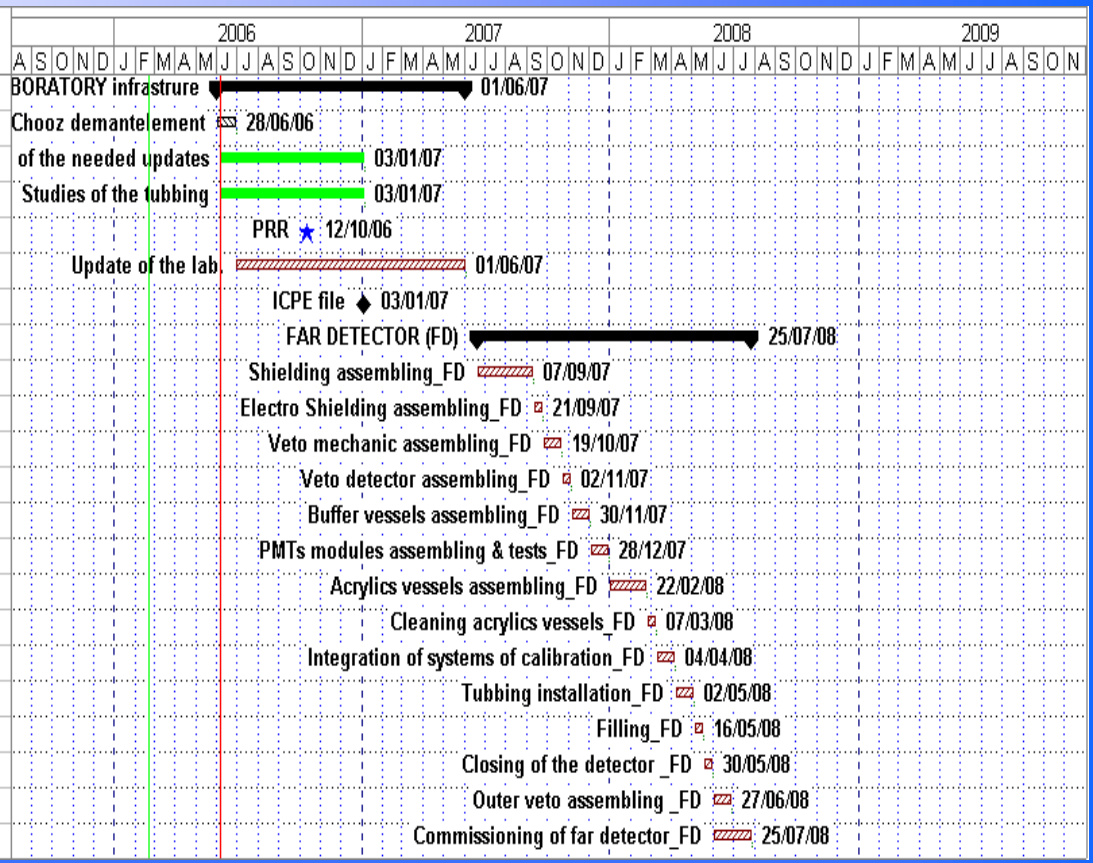






Detailed Schedule for Far Detector Assembly

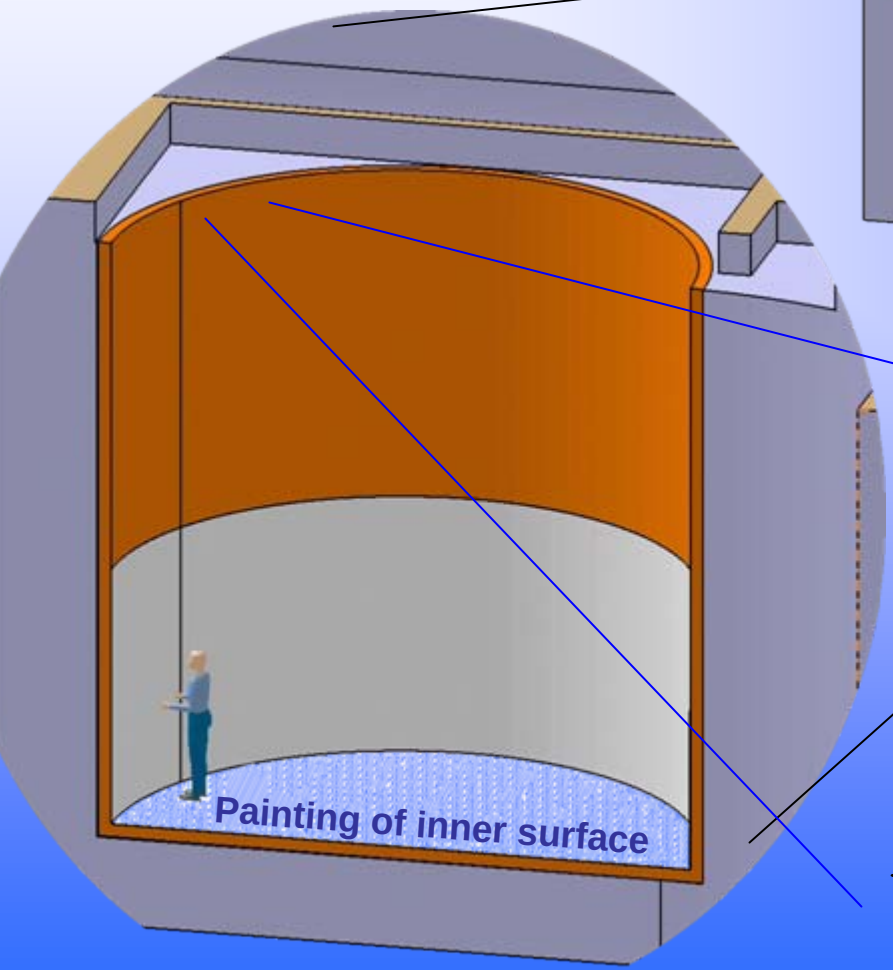
N°	Responsible	Ext.	Task
12			**FAR LABORATORY infrastrure**
13	APC		Chooz demantelement
14	CEA / APC		Studies of the needed updates
15	HEID./MUNICH		Studies of the tubbing
16			**PRR**
18	CEA / APC		Update of the lab.
19	CEA / APC		ICPE file
20			**FAR DETECTOR (FD)**
21	APC	X	Shielding assembling_FD
22	APC		Electro Shielding assembling_FD
23	APC	X	Veto mechanic assembling_FD
24	TUBINGEN		Veto detector assembling_FD
25	CEA	X	Buffer vessels assembling_FD
26	USA		PMTs modules assembling & tests_FD
27	CEA		Acrylics vessels assembling_FD
28	CEA		Cleaning acrylics vessels_FD
29	CEA		Integration of systems of calibration_FD
30	HEID./MUNICH		Tubbing installation_FD
31	HEID./MUNICH		Filling_FD
32	APC		Closing of the detector _FD
33			Outer veto assembling _FD
34			Commissioning of far detector_FD

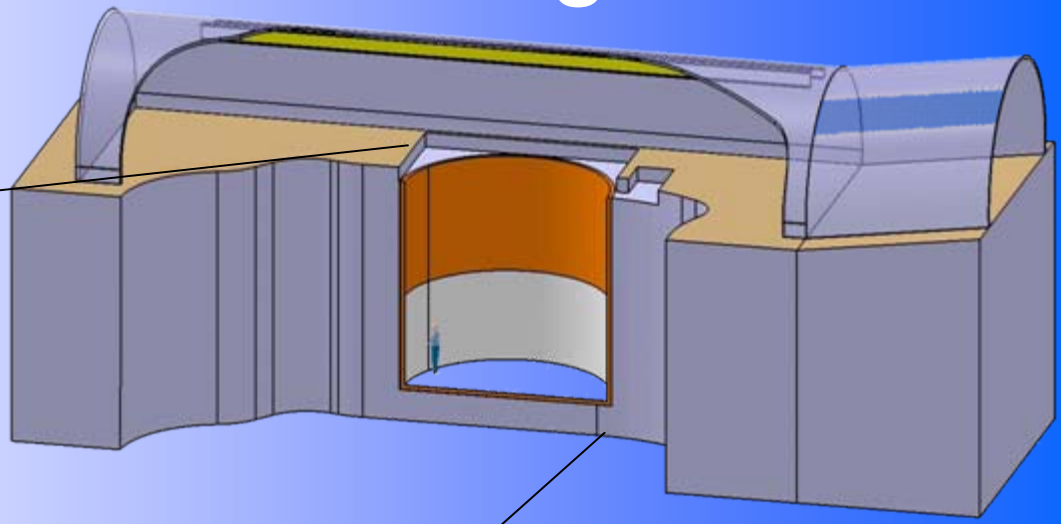


Detector Integration

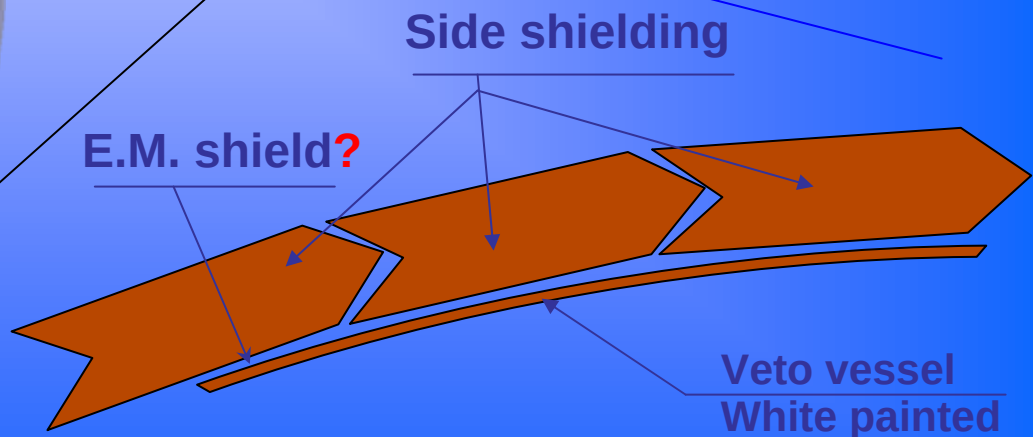
Starting date: 11/2006
(2 months)

sub contractor on site





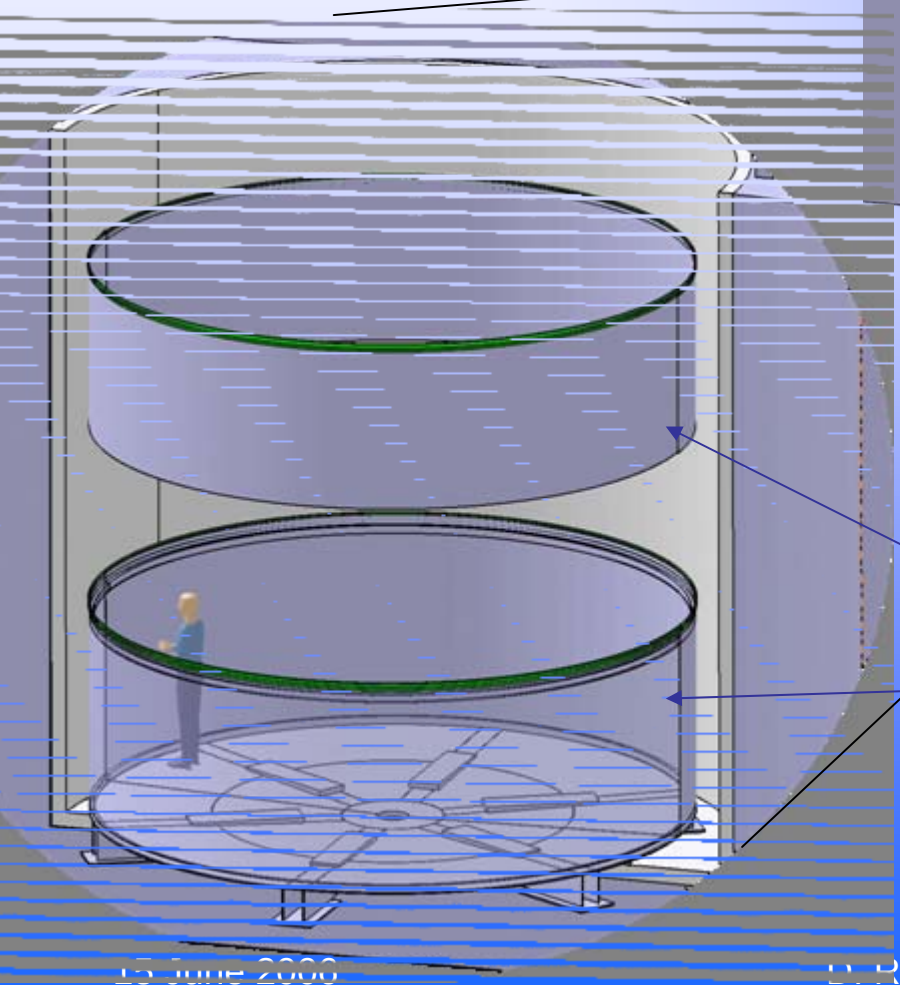
APC studies

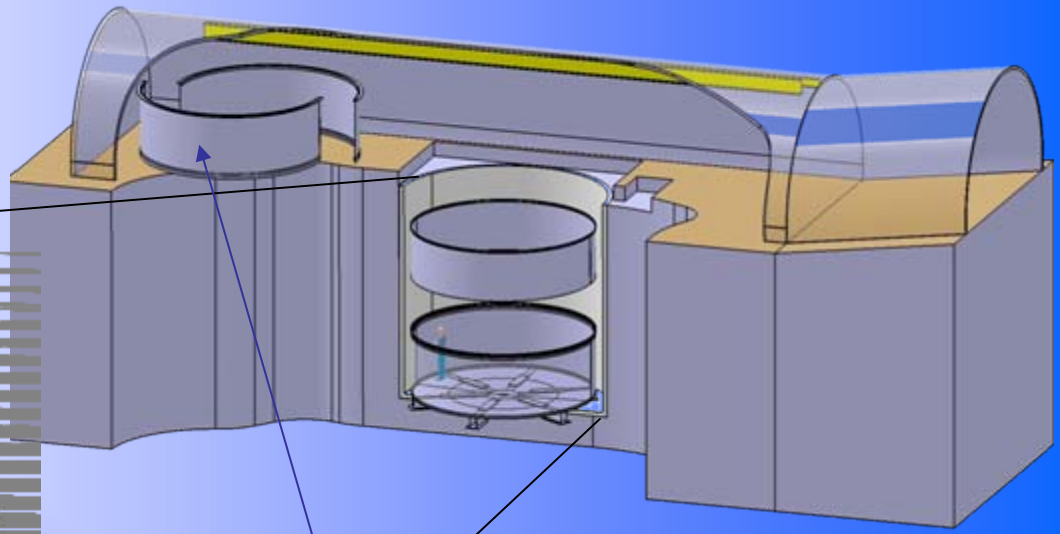


Detector Integration

Starting date: 03/2007
(2 months)

sub contractor on site





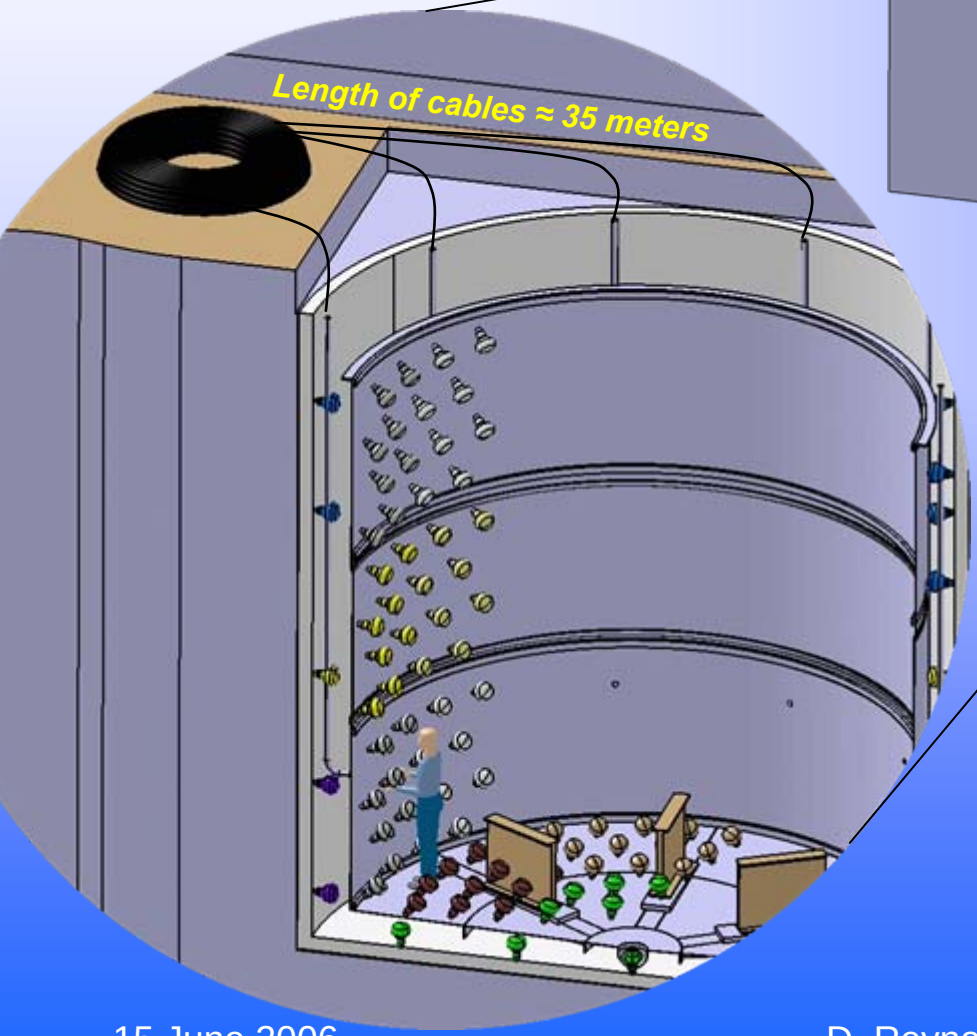
(Cylinder transport in 6 half rings)
Welding of 2 half cylinders.

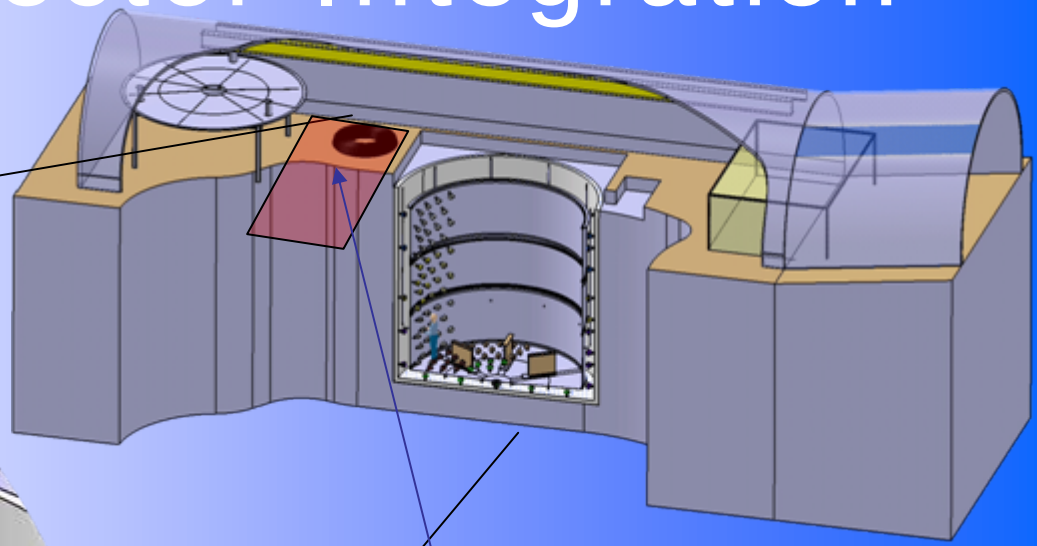
Rebuilding of piece of cylinders in the pit

Buffer vessel realize with 3 welded rings

Detector Integration

Starting date: 04/2007
(2 months)



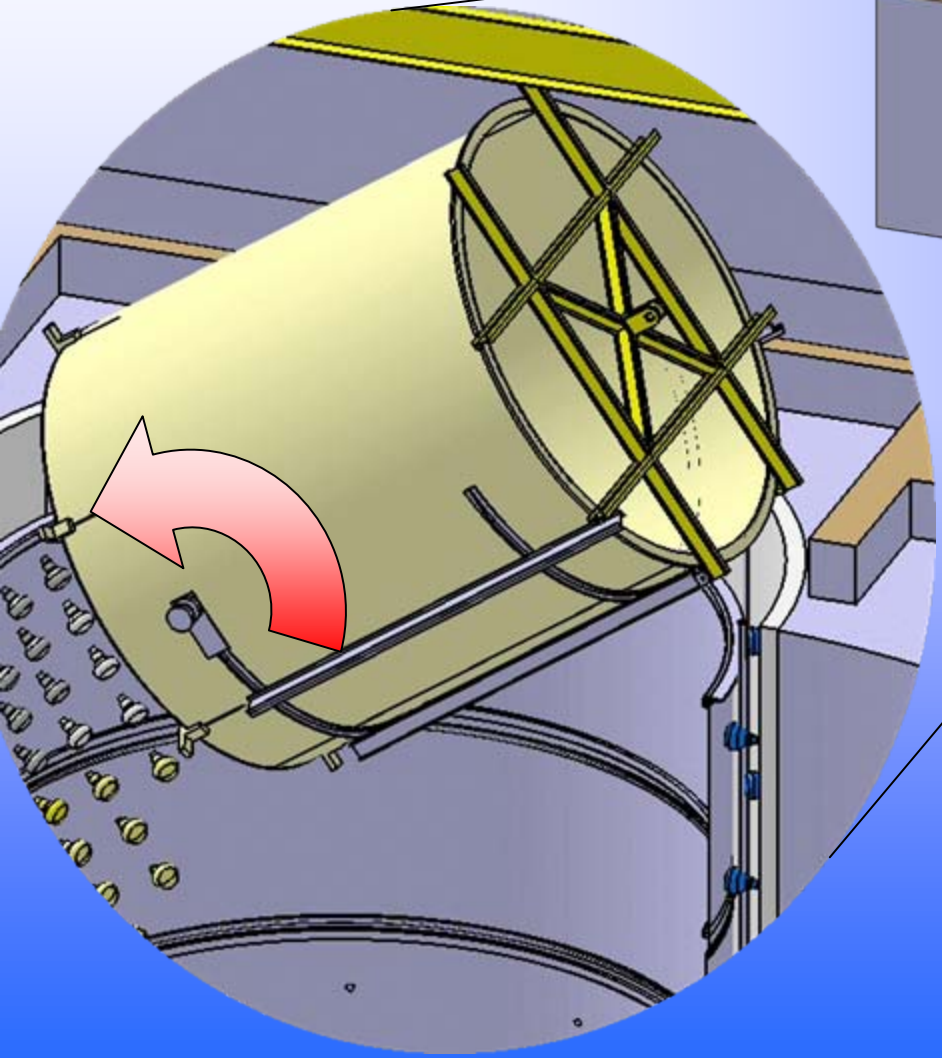


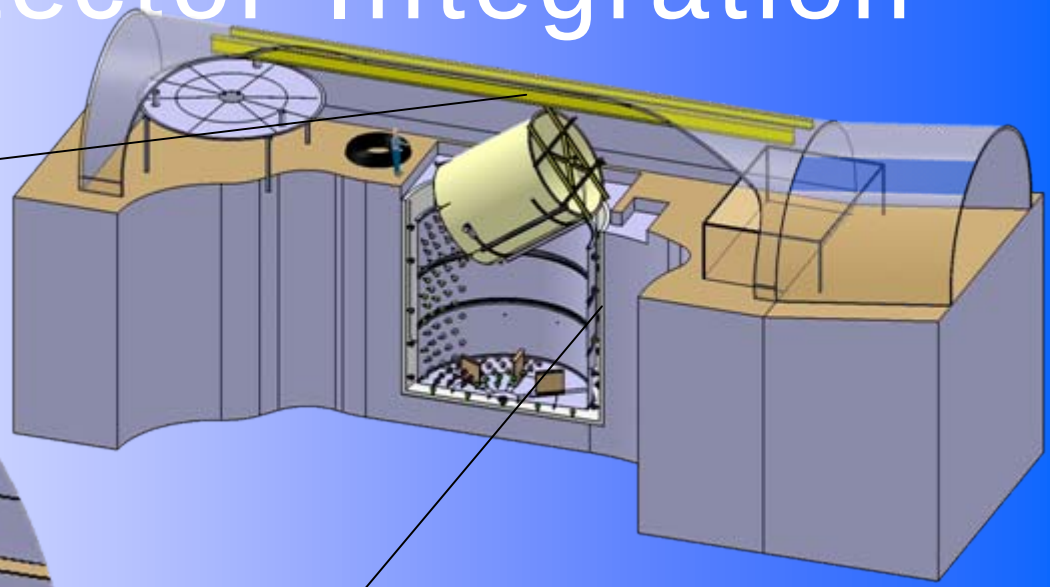
Free area for preparation

Mounting of 534 buffer PMTs (vessel and lid)
Cleaning after mounting?

Acrylics feet mounting

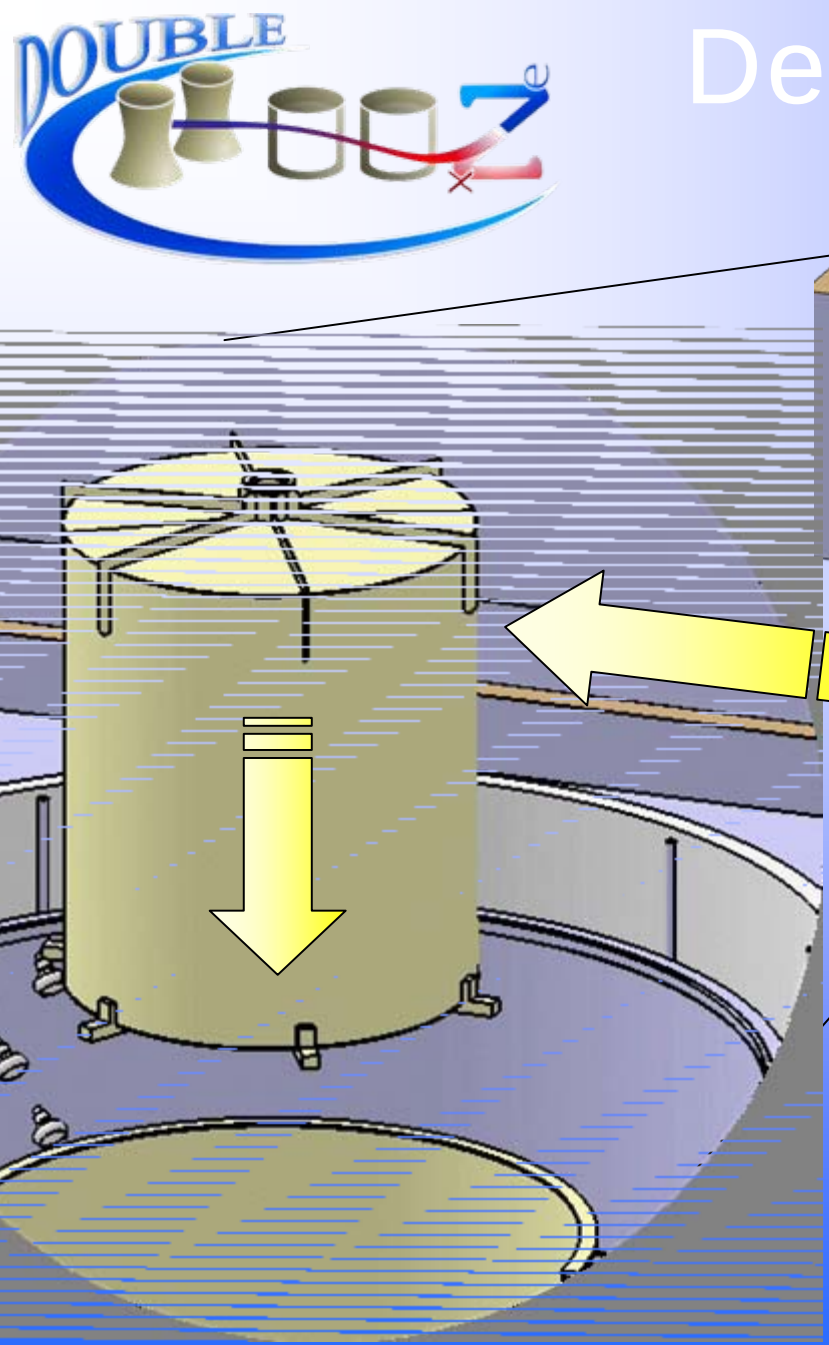
Detector Integration

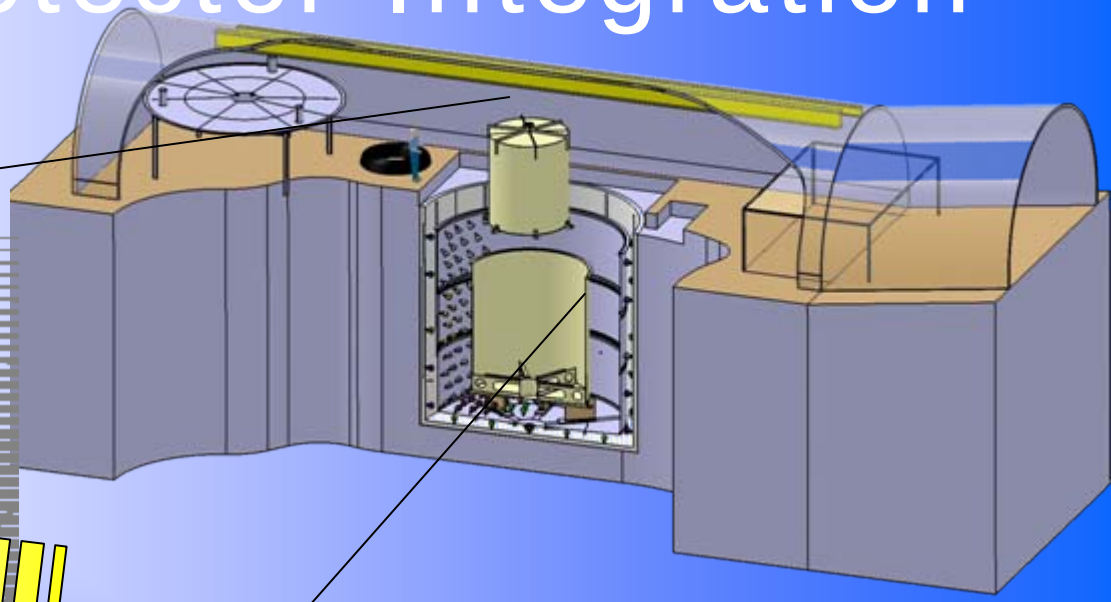




Rotation of the gamma catcher into the detector

Detector Integration





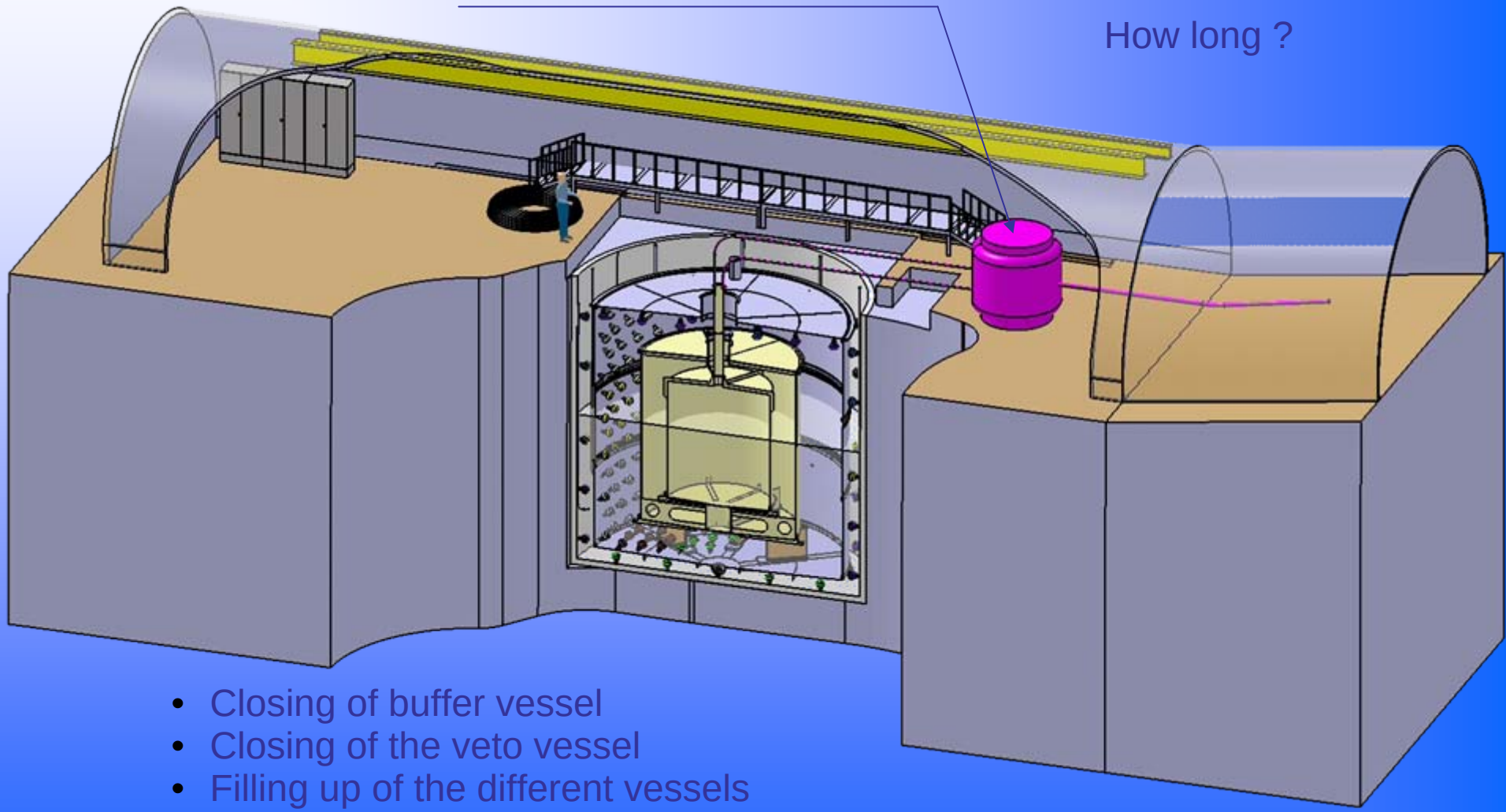
Insertion by translation of the target vessel into the gamma catcher

Detector Integration

Tank for mass measurement of target liquid

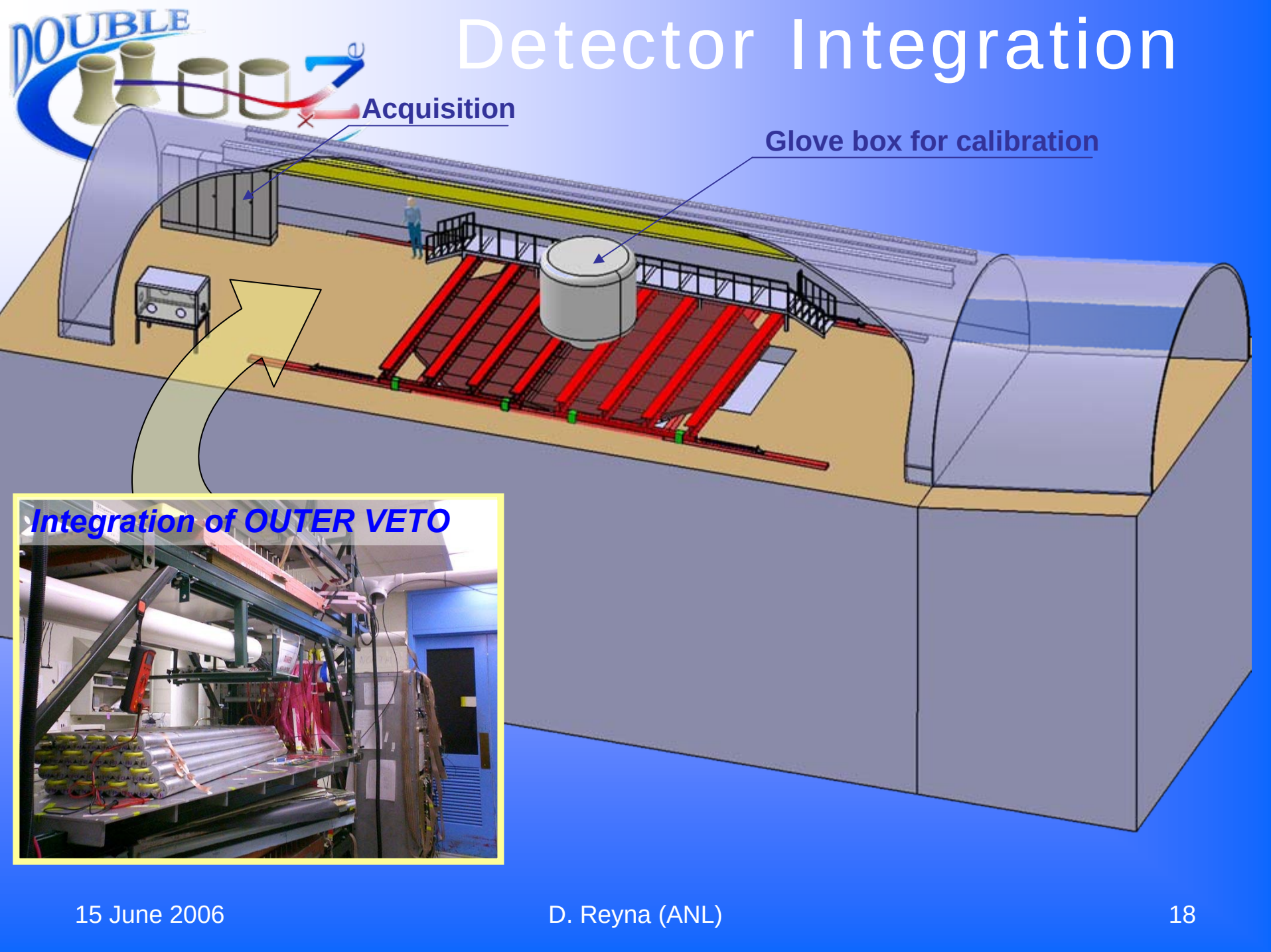
Starting date: 08/2007

How long ?



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

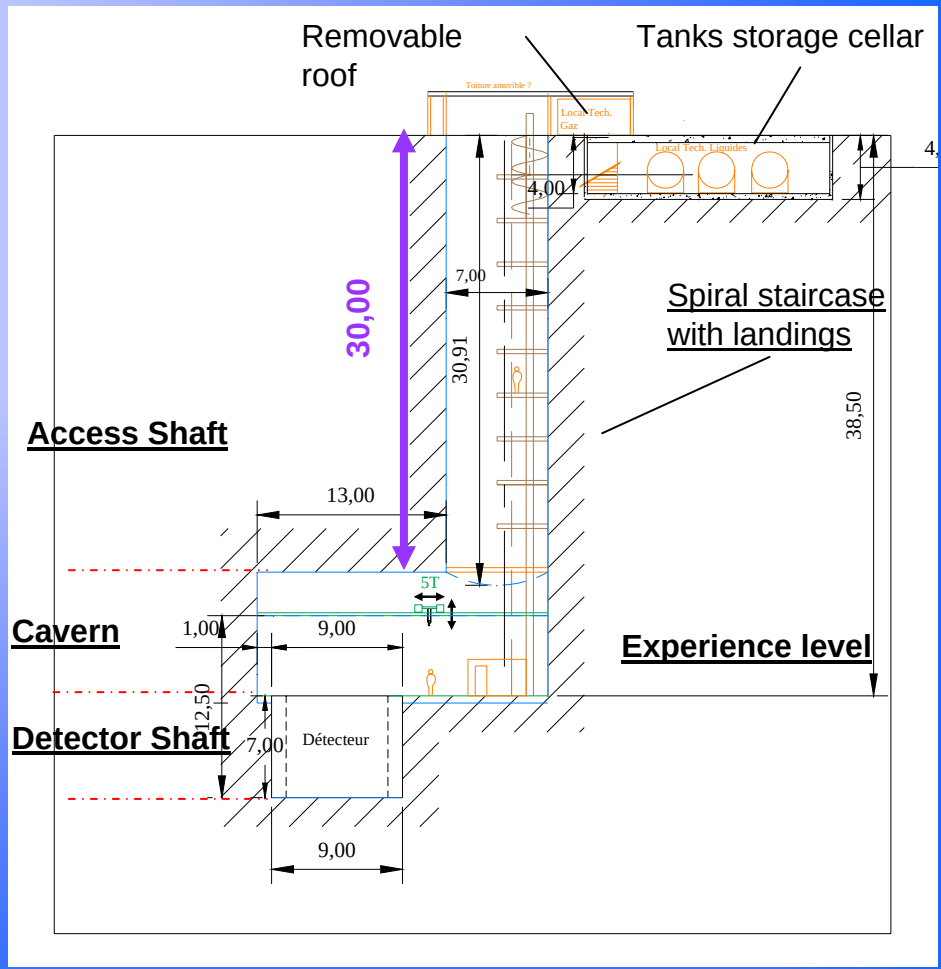
Detector Integration



Integration of OUTER VETO

Close Contact with EDF

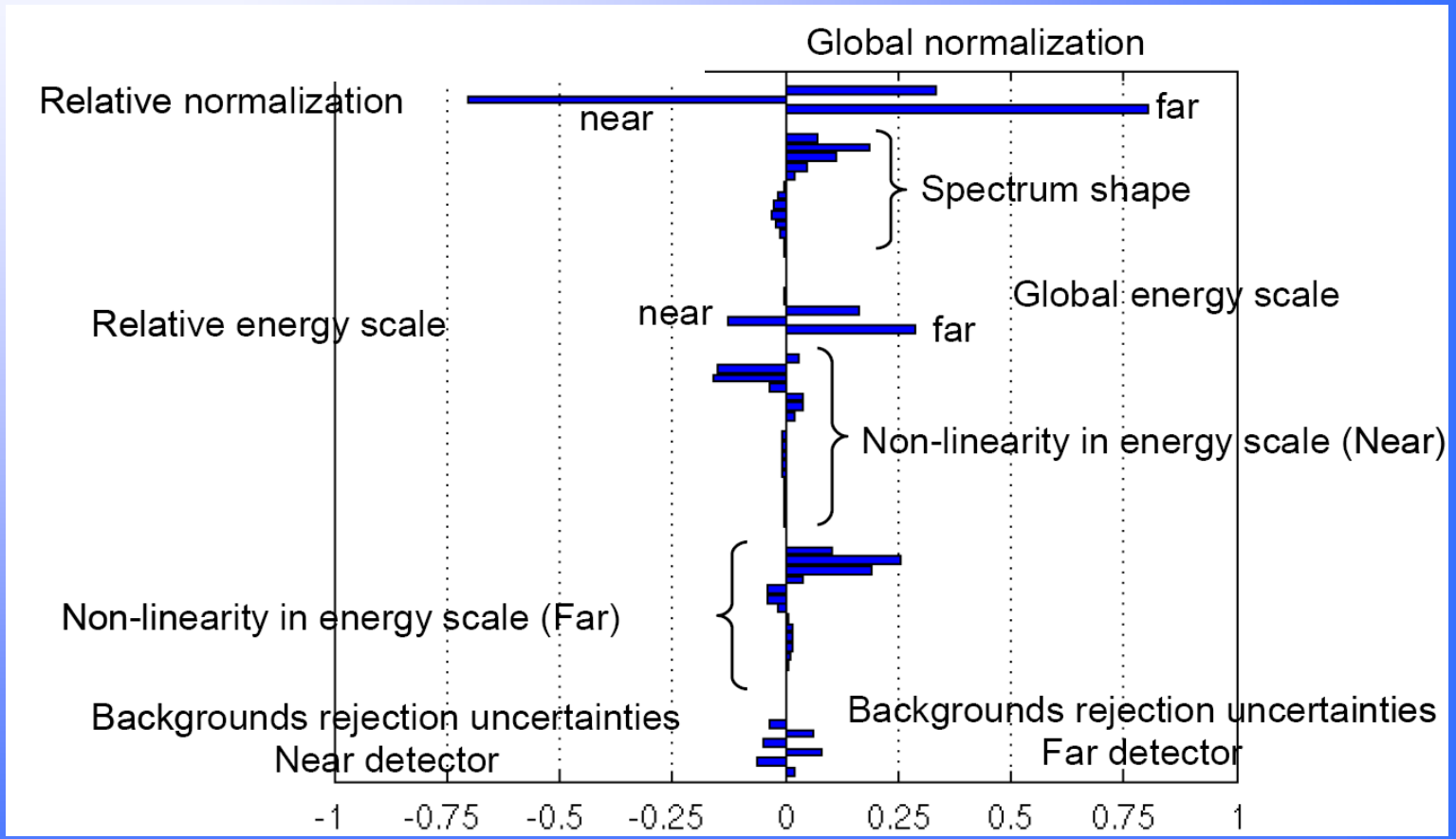
- FAR site
  - Recieved authorization to use the building near the neutrino lab to house liquid tanks
  - Activity started last week in the lab to dismantle the old tank and update infrastructure
  - Could start building a new detector in Summer 2007
- NEAR site
  - EDF provided first civil engineering 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

		Chooz	Double Chooz	
Reactor-induced	ν flux and σ	1.9 %	<0.1 %	Two "identical" detectors, Low bkg
	Reactor power	0.7 %	<0.1 %	
	Energy per fission	0.6 %	<0.1 %	
Detector - induced	Solid angle	0.3 %	<0.1 %	Distance measured @ 10 cm + monitor core barycenter
	Volume	0.3 %	0.2 %	Same weight sensor for both det.
	Density	0.3 %	<0.1 %	Accurate T control (near/far)
	H/C ratio & Gd concentration	1.2 %	<0.1 %	Same scintillator batch + Stability
	Spatial effects	1.0 %	<0.1 %	"identical" Target geometry & LS
	Live time	few %	0.25 %	Measured with several methods
Analysis	From 7 to 3 cuts	1.5 %	0.2 - 0.3 %	
	Total	**2.7 %**	**< 0.6 %**	

Studies of Systematic Effects

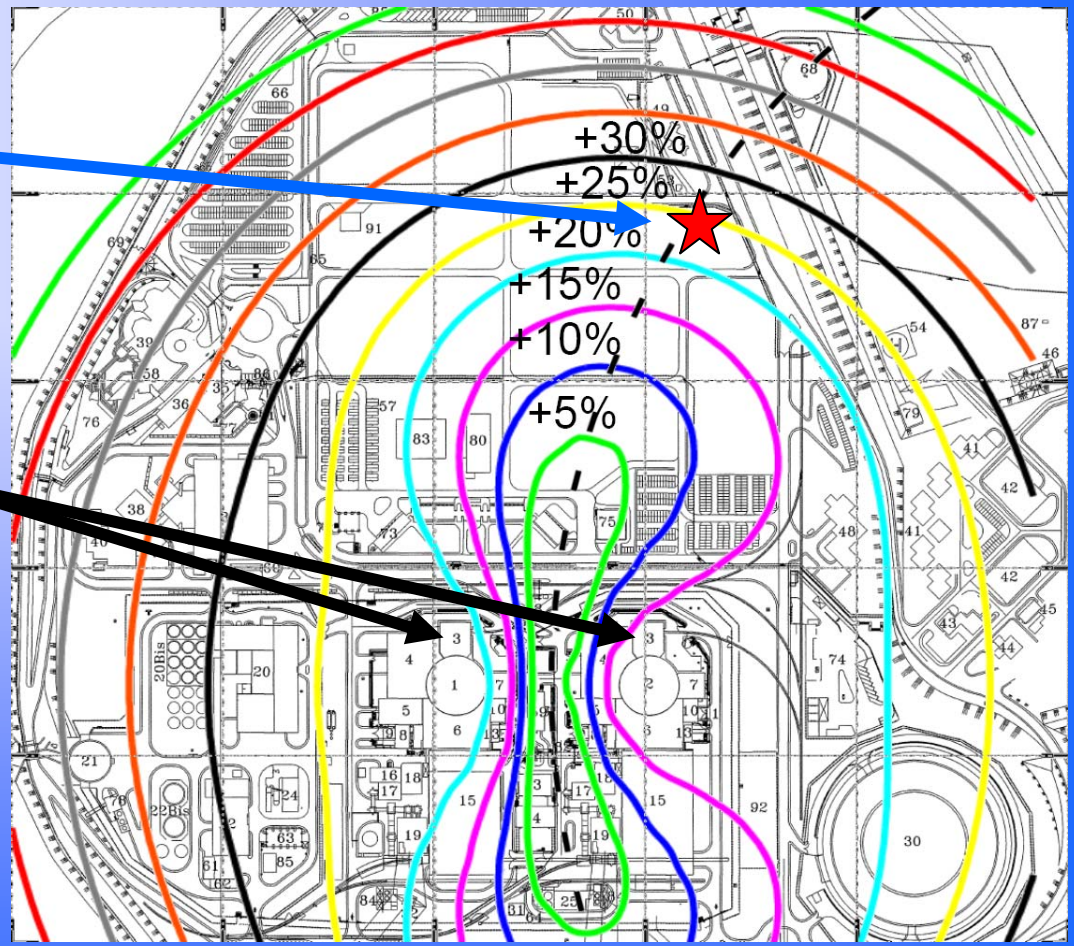


Systematic Pulls on χ^2 Analysis

Study of Near Detector

Proposed Near Location

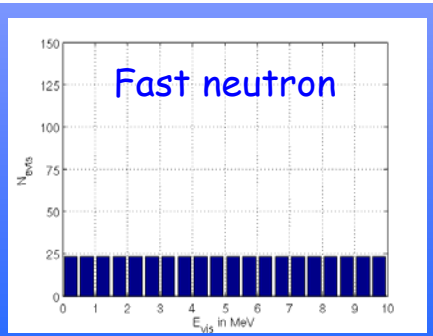
Analysis Includes Location of Spent Fuel Storage (~0.5% of signal)

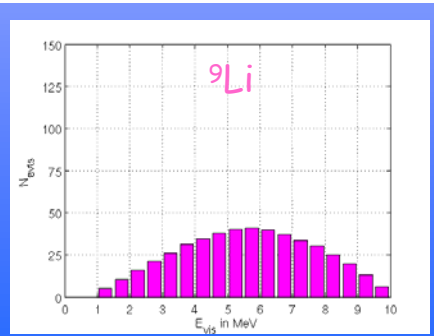


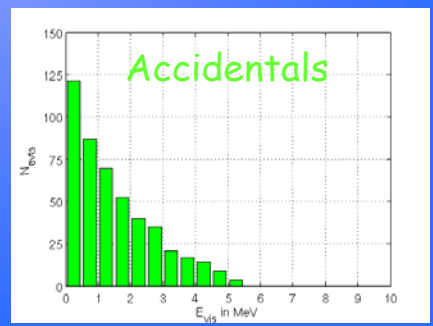
Far location is optimal for $\Delta m^2 > 2.5 \times 10^{-3}$ eV^2

Background Summary

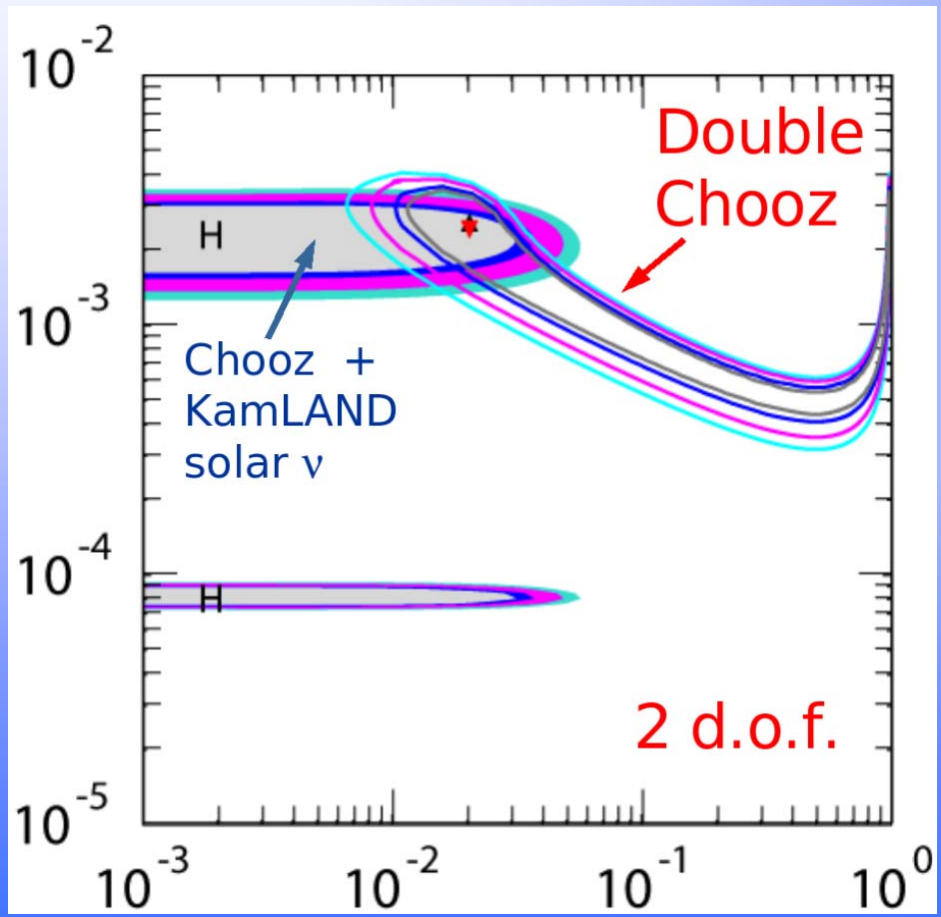
Detector	Site		Background				
			Accidental		Correlated		
			Materials	PMTs	Fast n	μ-Capture	^{9}Li
CHOOZ		Rate (d^{-1})	—	—	—	—	0.6 ± 0.4
(24 ν/d)		Rate (d^{-1})	0.42 ± 0.05		$1.01 \pm 0.04(stat) \pm 0.1(sys)$		
	Far	bkg/ν	1.6%		4%		
		Systematics	0.2%		0.4%		
Double Chooz		Rate (d^{-1})	1 ± 0.1	1 ± 0.1	0.15 ± 0.15	0.06 ± 0.03	1 ± 0.5
(69 ν/d)	Far	bkg/ν	1.4%	1.4%	0.2%	0.1%	1.4%
		Systematics	0.2%	0.2%	0.2%	0.05%	0.7%
Double Chooz		Rate (d^{-1})	7.2 ± 1.0	7.2 ± 1.0	1.4 ± 1.4	0.42 ± 0.2	7.2 ± 3.6
(990 ν/d)	Near	bkg/ν	0.7%	0.7%	0.14%	0.04%	0.7%
		Systematics	0.1%	0.1%	0.2%	0.02%	0.4%







Possible Measurement



- Systematic Errors
  - σ_{abs} = 2.0%
  - σ_{rel} = 0.6%
  - σ_{scale} = 0.5%
  - σ_{shape} = 2.0%
- Energy Resolution
  - σ_E = 7%
- 1% uncorrelated bin-to-bin background subtraction error
- Oscillation Parameters
  - $\Delta m^2_{31} = 2.5 \times 10^{-3}$ eV^2
  - $\sin^2(2\theta_{13}) = 0.08$

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

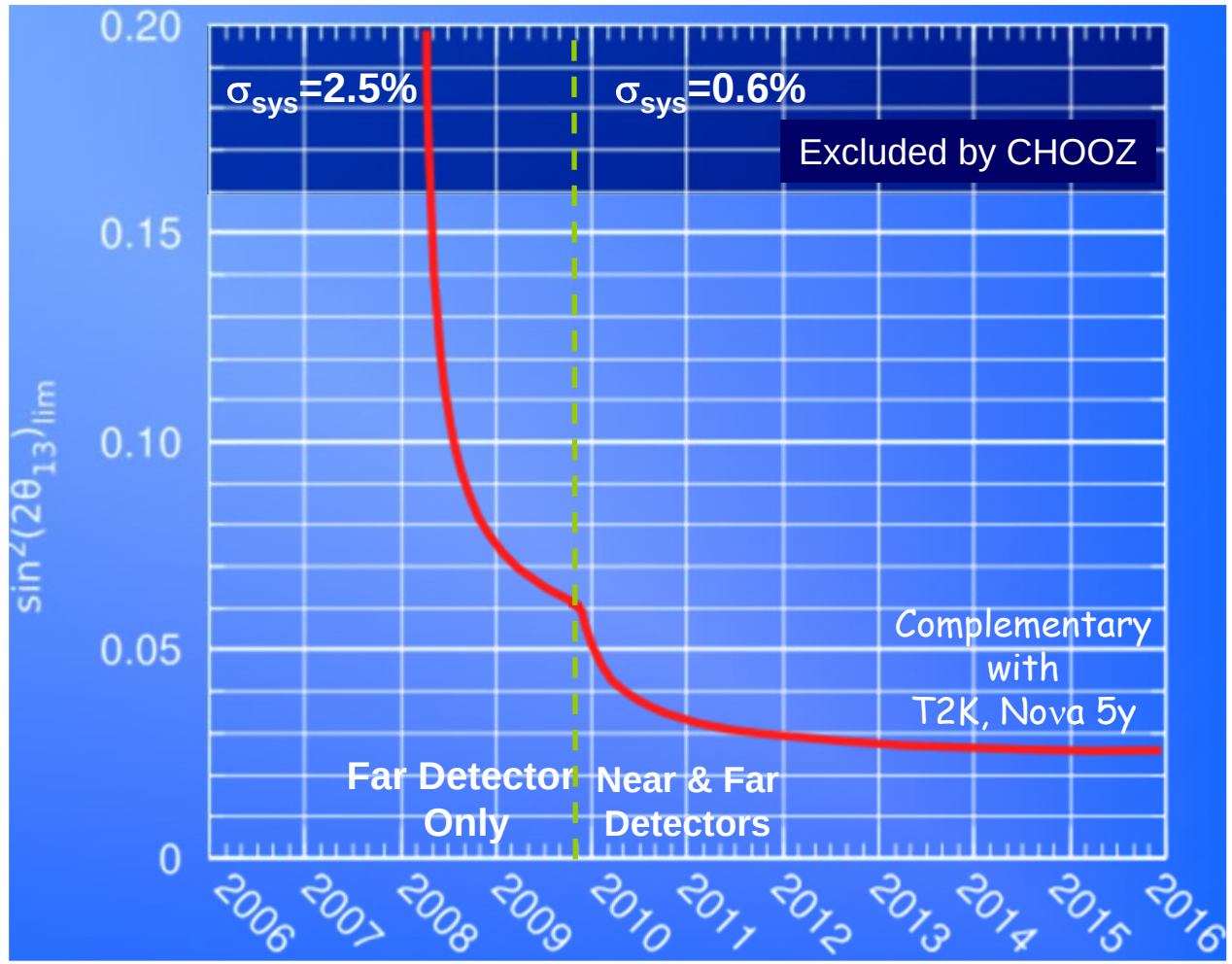
French Press Release (this week):

Double previous contribution to avoid delay

Expected Milestones

- 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

Limit @ 90% C.L. for $\sin^2(2\theta)=0$
$\Delta m^2_{atm} = 2.5\ 10^{-3}\ eV^2$ (with 20% uncertainty)



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