Impression of NNN05

Kenzo NAKAMURA
KEK

April 7-9, 2005
NNN05
Aussois, Savoie, France

History of NNN Workshop

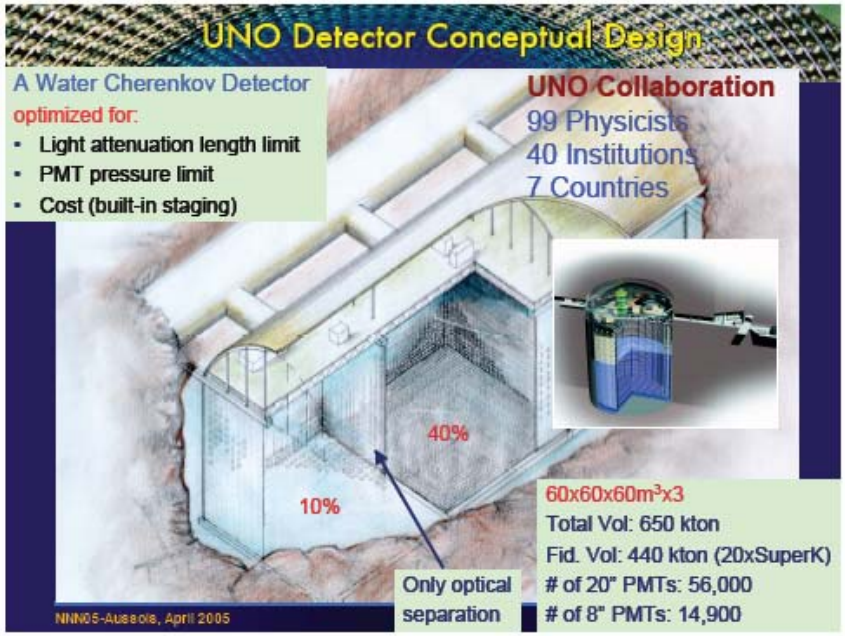
- NNN99, Stony Brook: Initiated by CKJ
- NNN00, UC Irvine: mini-workshop
- NNN00, Fermilab: mini-workshop
- NNN02, CERN
- NNN05, Aussois
- The NNN steering committee has decided to organize NNN Workshop each year. Announcement of NNN06 and NNN07 at the end of this talk.

Science with large underground detectors

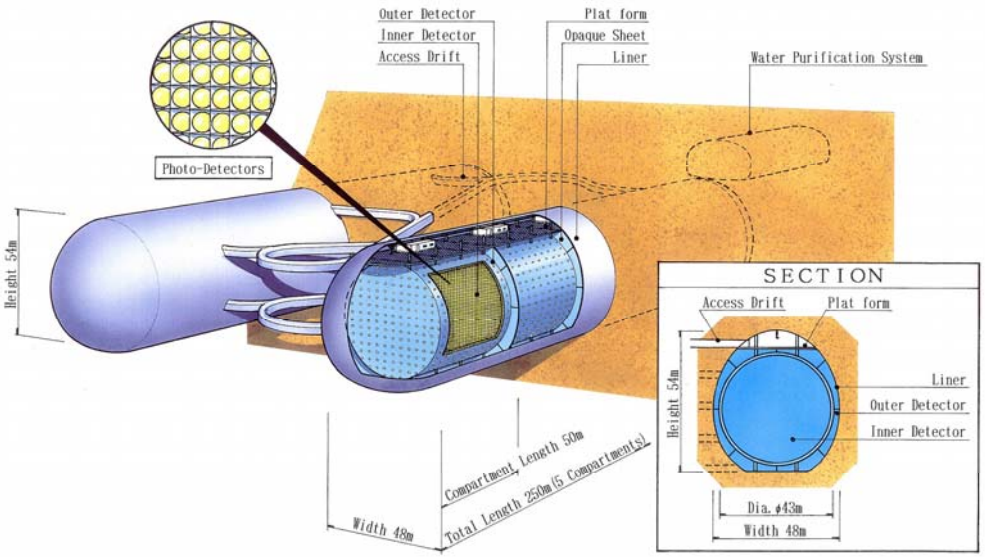
- Neutrino physics
  - w/ accelerator-produced beam
    - LBNO, VLBNO
    - θ_{13}, sign(Δm_{23}^2), δ_{CP}, precision measurement of (θ_{23}, Δm_{23}^2)
  - wo/ accelerator-produced beam
    - solar ν, atm ν, ν burst from SN, Relic SN ν
- Nucleon decay
  - $p \rightarrow e^+\pi^0$, νK^+, other decay modes
- Most of large detectors are multi-purpose
  - Water Cherenkov (~Mton)
  - Liq. Ar (~100 kton)
  - Liq. Scintillator (~50 kton)

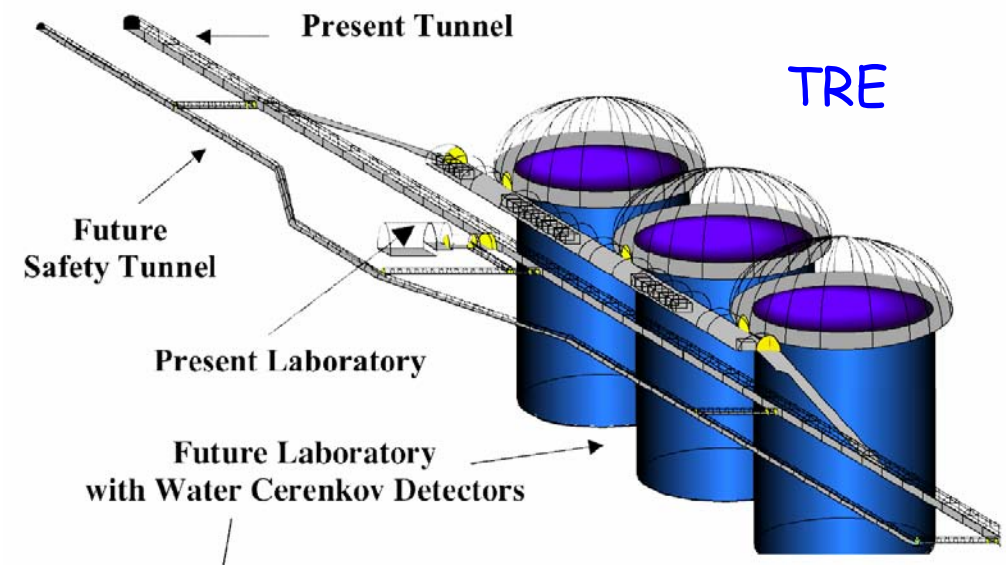
Next-generation water Cherenkov detectors

- Conceptual idea of next-generation water Cherenkov detectors
  - 1999: Concept of UNO & Hyper-K
  - 2002?: Concept of the European detector
- Time line of each detector
  - UNO @ Henderson Mine
    - DUSEL proposal: 2005
    - Construction: 10 years, wish to start as soon as possible **Jung**
  - Hyper-K @ Tochibora Mine (Kamioka)
    - Some years after start-up of T2K-1
    - Construction: 10 years, hopefully 2013 – 2022 **Nakamura**
  - European detector @ Frejus Tunnel
    - CERN-based Super and beta beams hopefully ready before 2020
    - Contruction: hopefully 2010 – 2019 (first module 2017) **Bouchez**



Hyper-Kamiokande ≡DUE

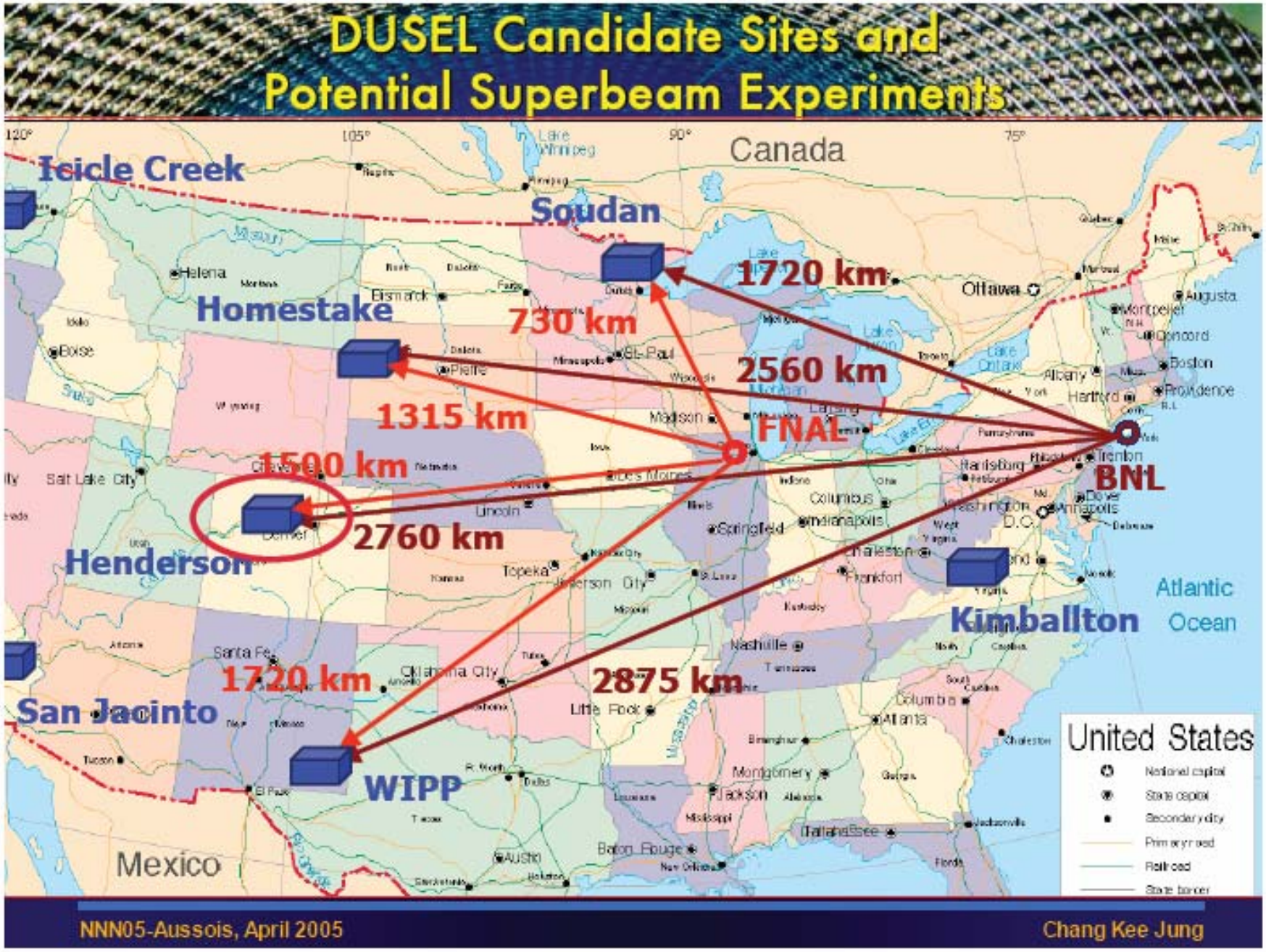




TRE

- DUE and TRE have a choice to put Gd in one module in order to enhance the sensitivity to low-energy antineutrino detection.
- See, an interesting talk by Vagins on GADZOOKS

- LBNO: each detector has its own project
  - UNO-BNL or UNO-Fermilab: 1500 – 2800km
  - HyperK-J-PARC: 295 km
  - European detector-CERN super and beta beams: 130 km


DUSEL Candidate Sites and
Potential Superbeam Experiments
Icicle Creek
Soudan
Homestake
Henderson
San Jacinto
WIPP
FNAL
BNL
Kimballton
1720 km
730 km
2560 km
1315 km
1500 km
2760 km
1720 km
2875 km
Canada
Mexico
Atlantic
Ocean
United States
NNN05-Aussois, April 2005
Chang Kee Jung

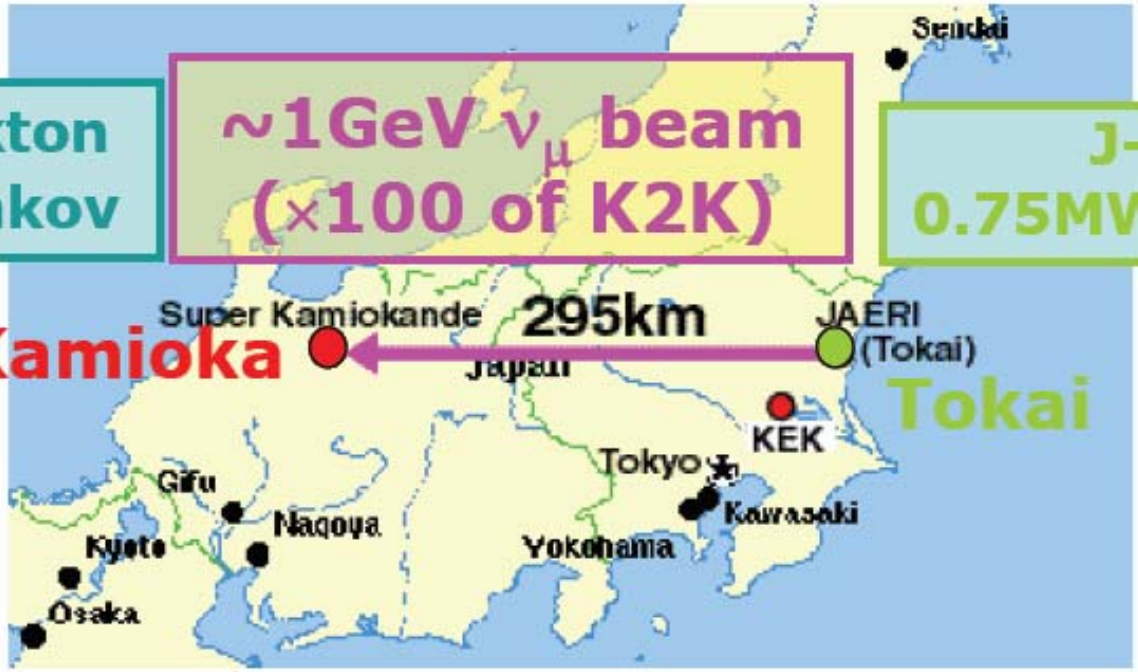
T2K Phase 2

Long baseline neutrino oscillation experiment from Tokai to Kamioka.

Super-K: 50 kton Water Cherenkov

~1GeV ν_μ beam (×100 of K2K)

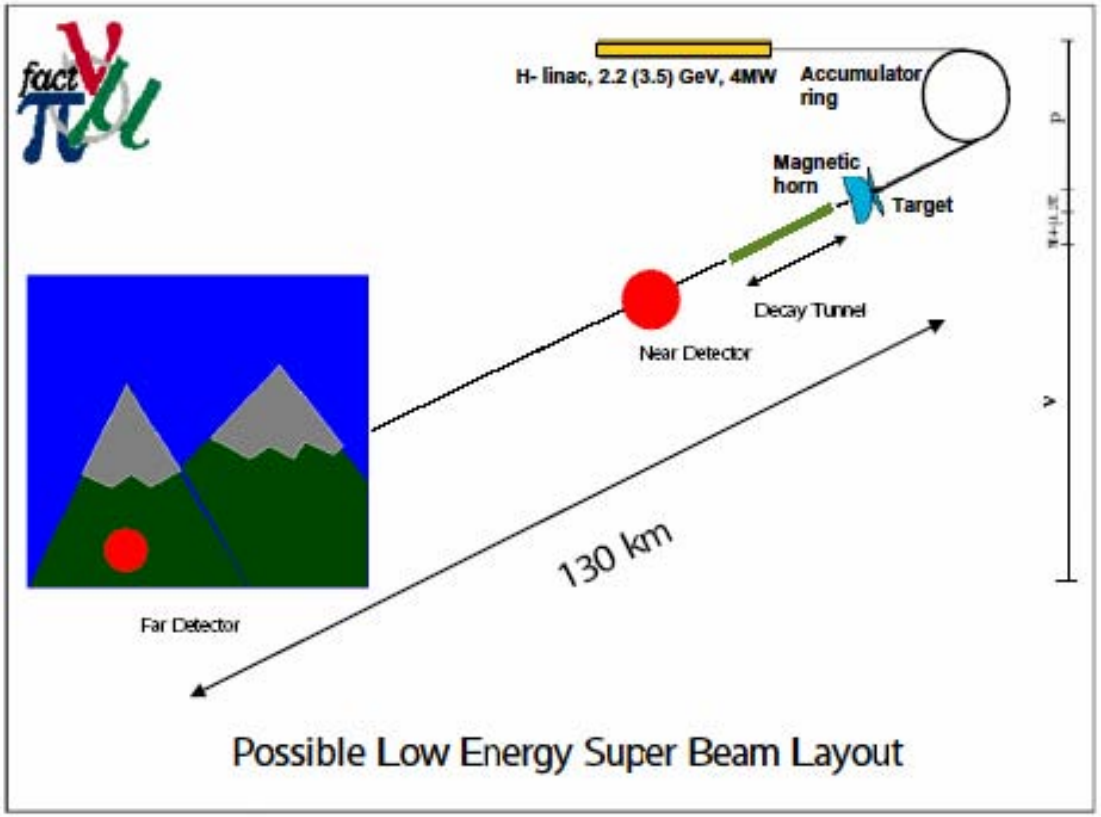
J-PARC 0.75MW 50GeV PS

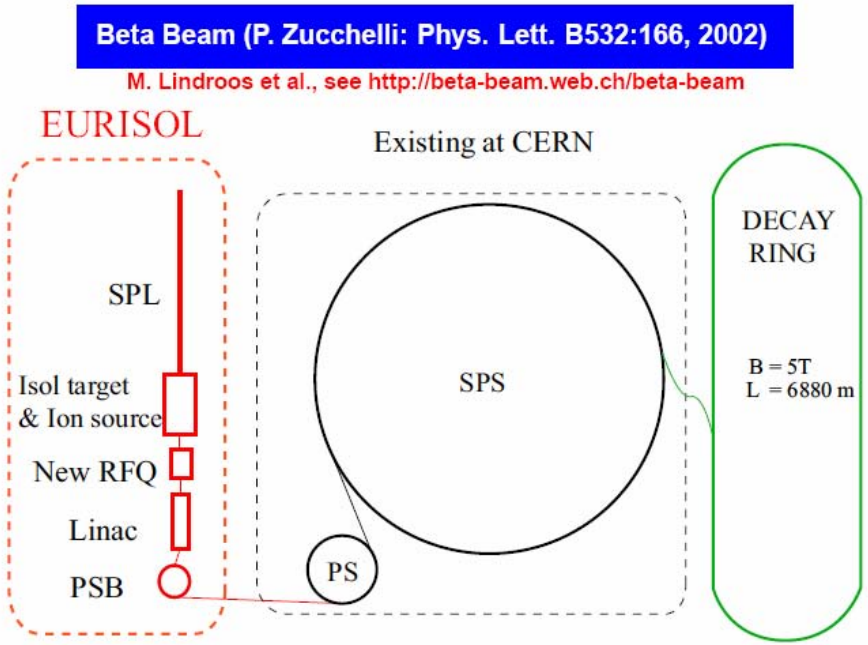


Phase2: Hyper-K

Phase2: 4 MW ?

CERN to Frejus: Super and Beta Beams

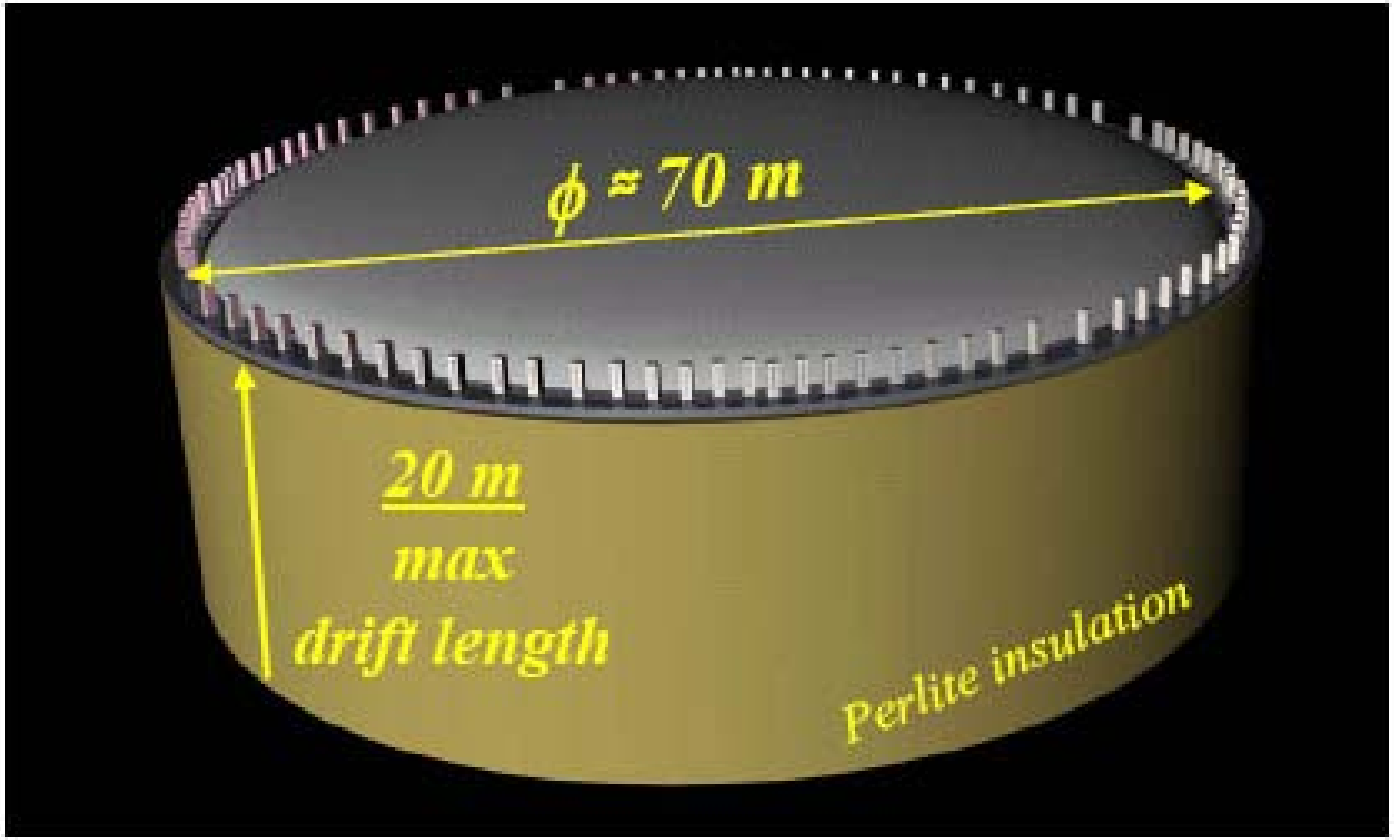




- LBNO: each detector has its own right
  - UNO-BNL or UNO-Fermilab: 1500 – 2500km
  - HyperK-J-PARC: 295 km
  - European detector-CERN super and beta beams: 130 km
- Nucleon decay:
  - Reach of the lifetime limit improves as the summed fiducial masses of individual detectors.
  - Should have at least one detector, if nucleon decay is really around the corner.
  - Here, world-wide collaborative effort to realize at least one, hopefully all, next-generation water Cherenkov detecors is very relevant.

Next generation ~100 kton liq. Ar detector

Rubbia

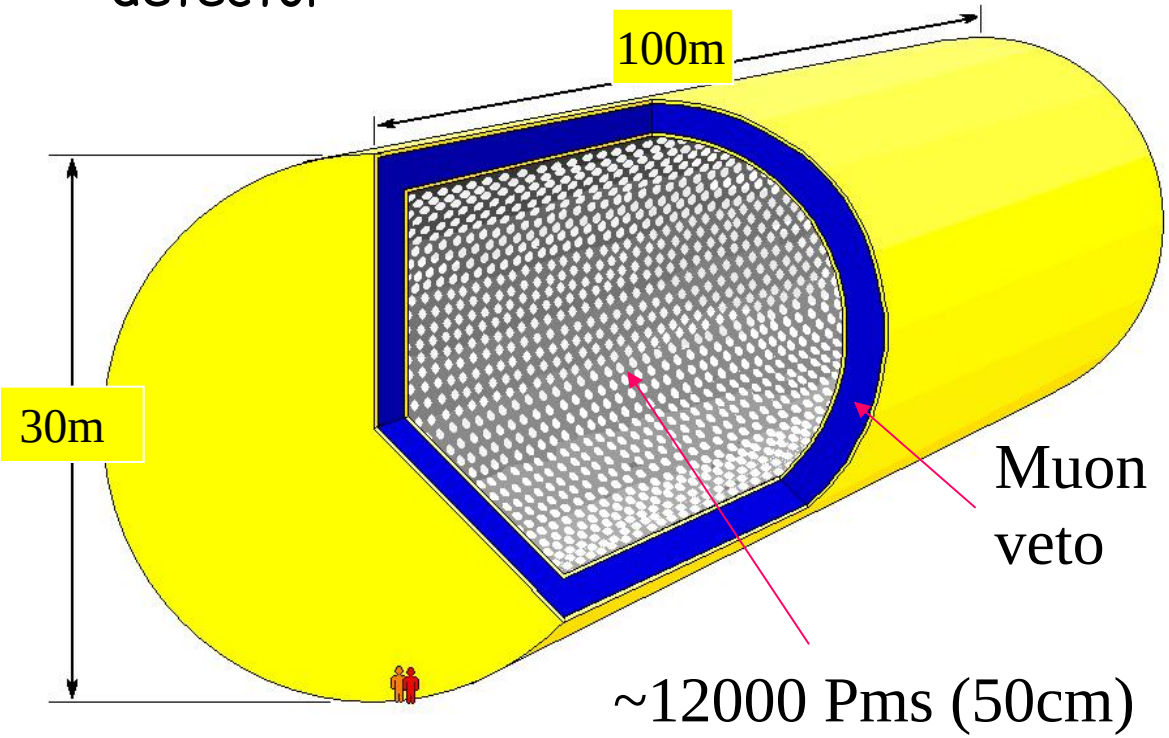


Next-generation liq. Scintillator detector

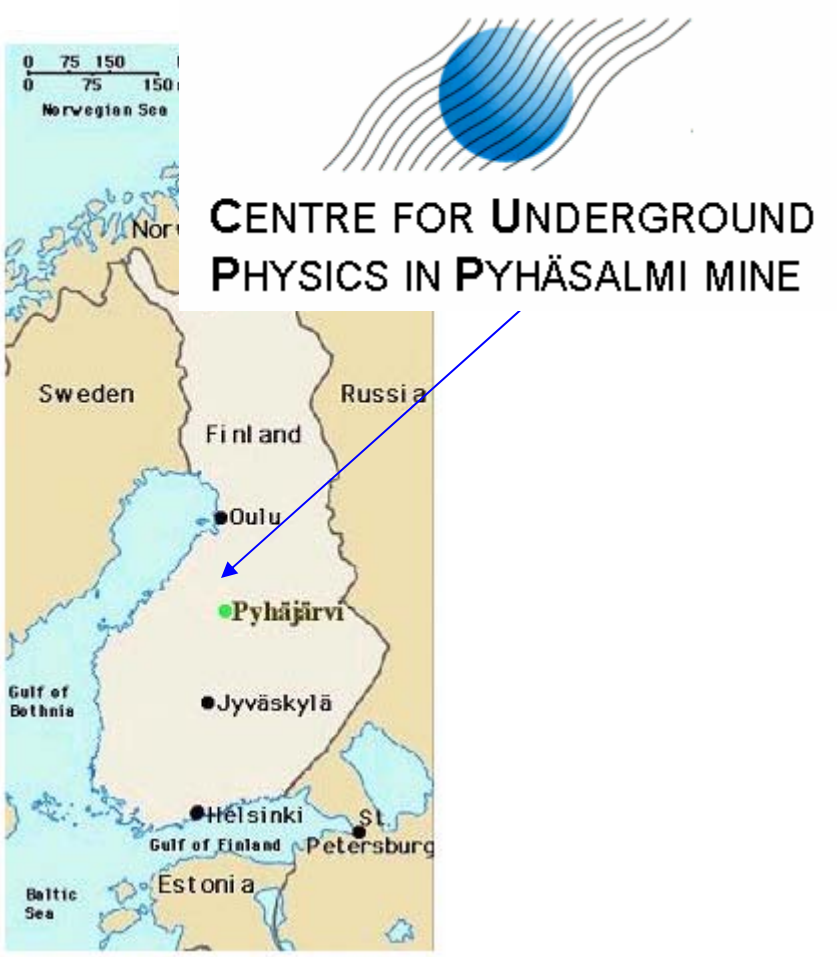
Oberauer

LENA

A large (~50 kton) liquid scintillator underground detector



Possible locations



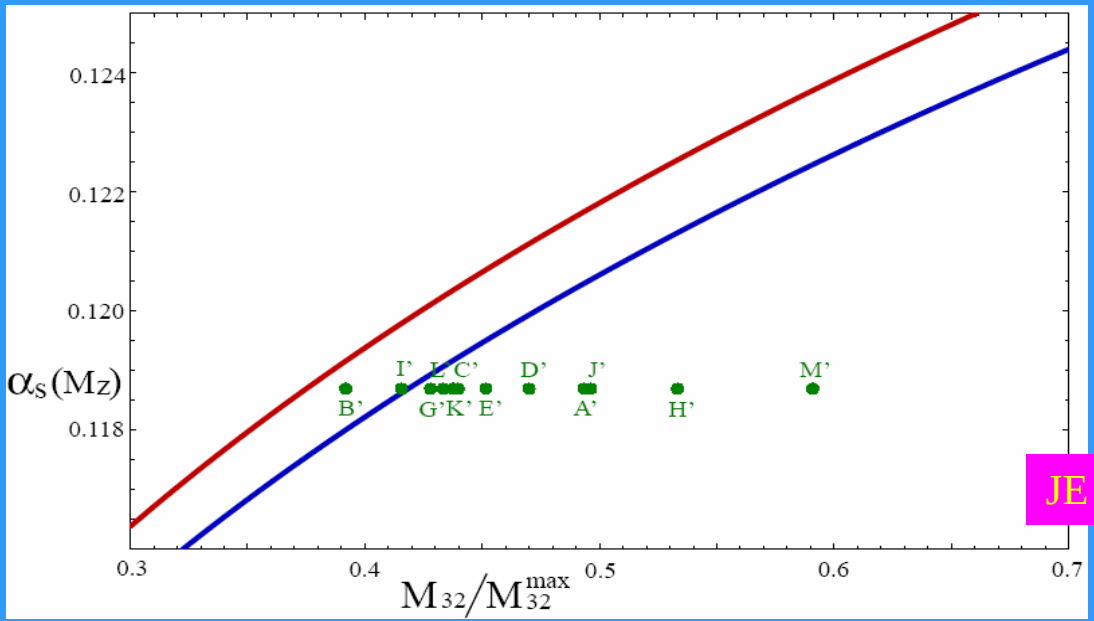
Back to the Science

Nucleon decay

- Reach of partial lifetime
  - $p \rightarrow e^+\pi^0$ up to $\sim 10^{35}$ yrs with ~Mton water Cherenkov (present SK limit: 5.4×10^{33} yrs)
  - $p \rightarrow \nu K^+$ up to ~a few $\times 10^{34}$ yrs with ~100 kton liq. Ar and ~50 kton liq. scintillator (present SK limit: 2.0×10^{33} yrs)
- There is a lot of life in proton decay — Ellis
- It is possible to suppress the decay rate, but in many cases proton decay is just around the corner: keep looking ! — Covy
- Next step is significant!

Proton Decay in 'Flipped' SU(5) × U(1)

- Similar modes to conventional SU(5): different branching ratios, no Higgsino exchange
- SU(3) and SU(2) unify below usual GUT scale

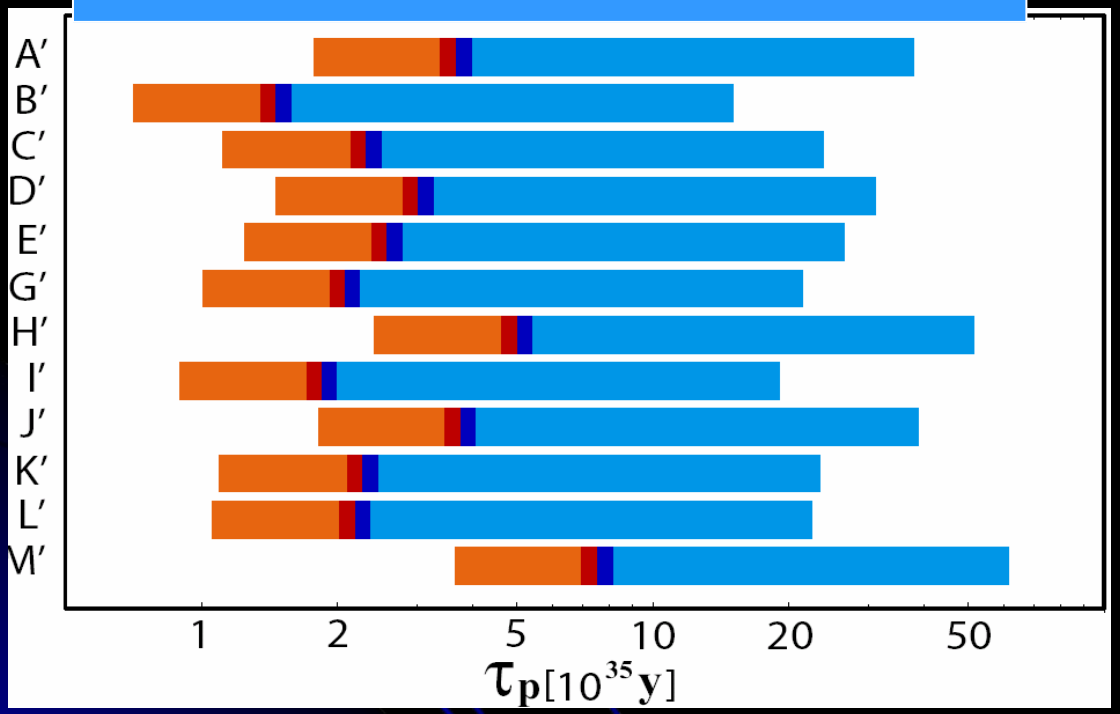


JE + Nanopoulos + Walker

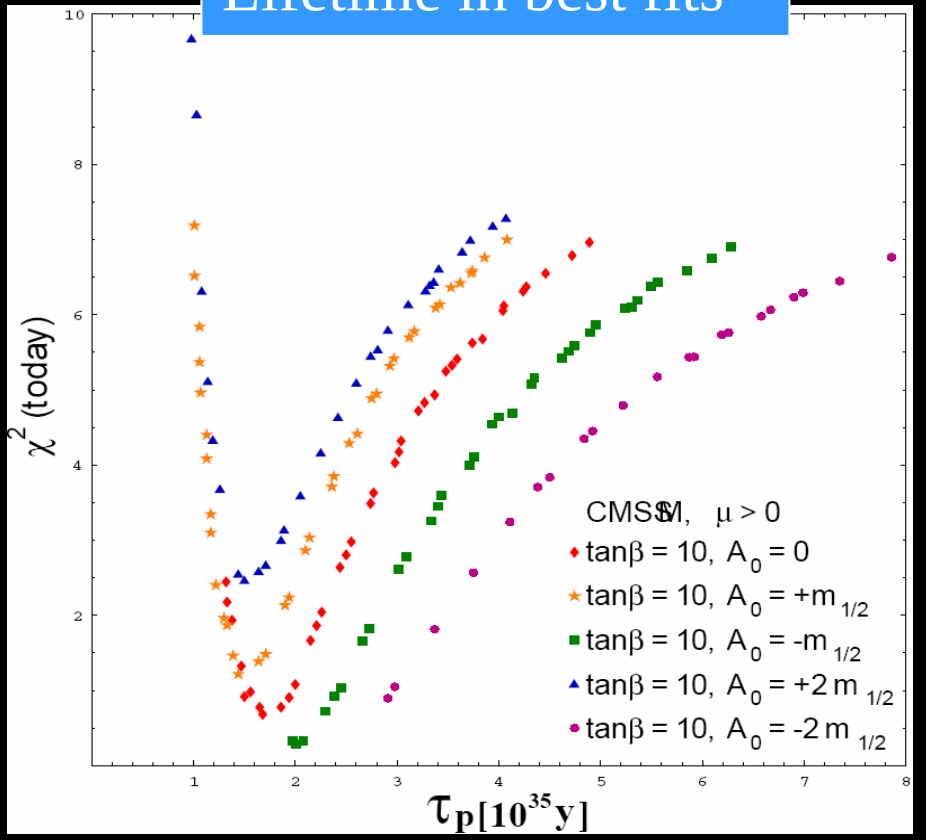
- Enhanced rate in strongly-coupled M theory

Lifetime accessible to Experiment?

Lifetime in benchmark scenarios

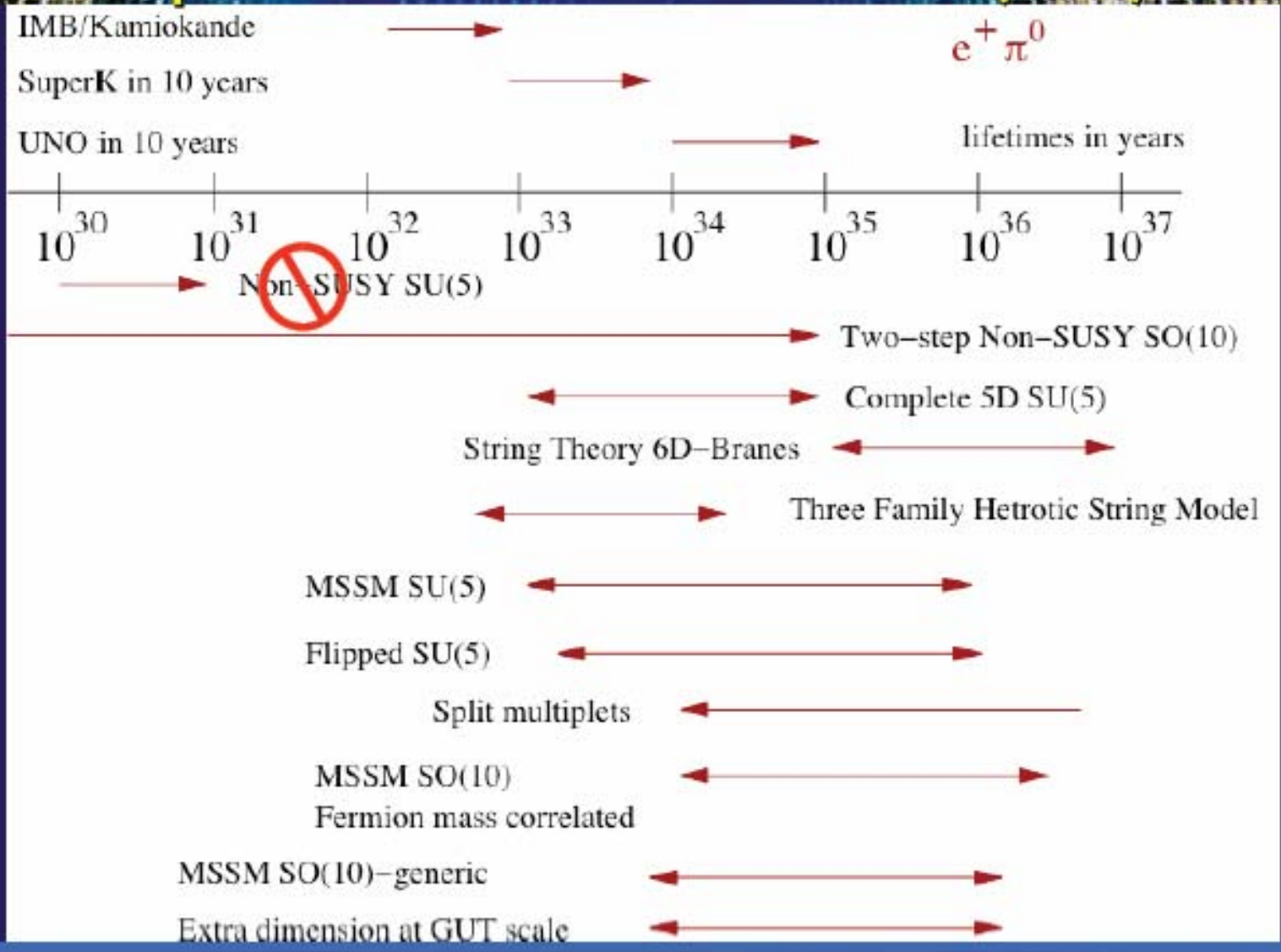


Lifetime in best fits



JE + Nanopoulos + Walker

UNO Proton Decay Sensitivity and Updated Theoretical Predictions ($e^+\pi^0$)



NNN05-Aussois, April 2005 Chang Kee Jung

Neutrino parameters

Fogli

- Recent years have been exciting …
- but our knowledge is still poor:
  - kinematical unknowns: θ_{13}, CP violation, mass hierarchy, absolute mass
  - dynamical unknowns: new neutrino properties and/or interactions (LSND?)
  - theoretical unknowns: making sense of parameters, finding underlying symmetries and scales

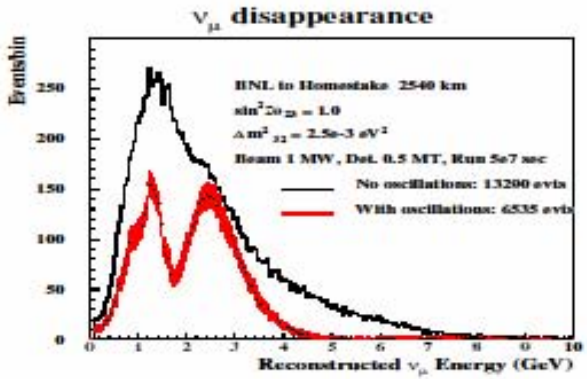
Neutrino physics w/ accelerators

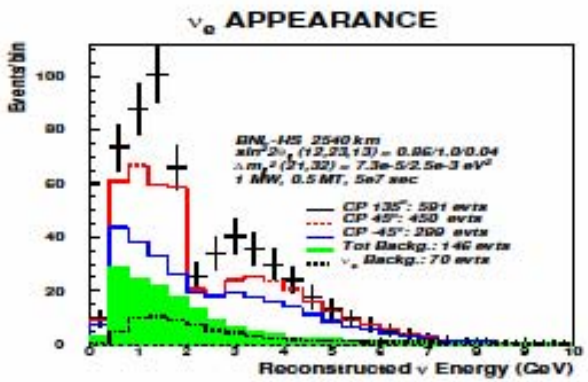
- News
  - MINOS: 1st far detector beam neutrino, March 7, 05. Conglaturations! Bishai
- Status
  - CNGS (OPERA and ICARUS) Duchesneau
  - T2K Kobayashi
- Future
  - BNL Bishai
  - Fermilab (NOνA) Ray
  - CERN (Beta beams, Super beams) Lindroos, Mezzetto

Physics potential of VLB

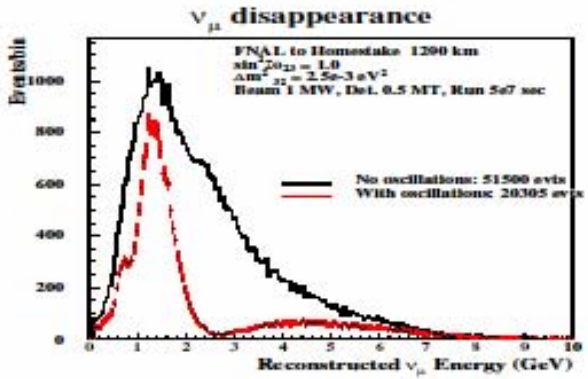
MC simulation with fermi motion, detector resolution and physics backgrounds for $L = 2540$ and 1290 km. M. Diwan, hep-ex/0407047:

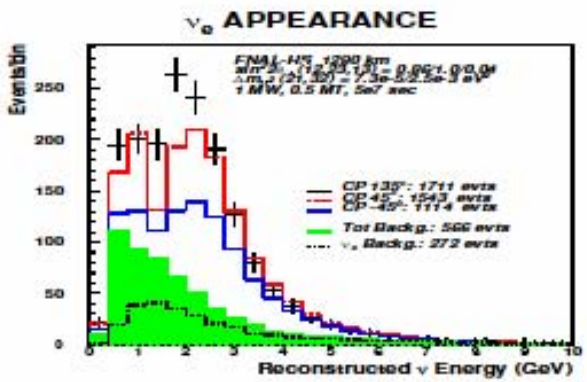
BNL beam $L = 2540$ km





BNL beam $L = 1290$ km



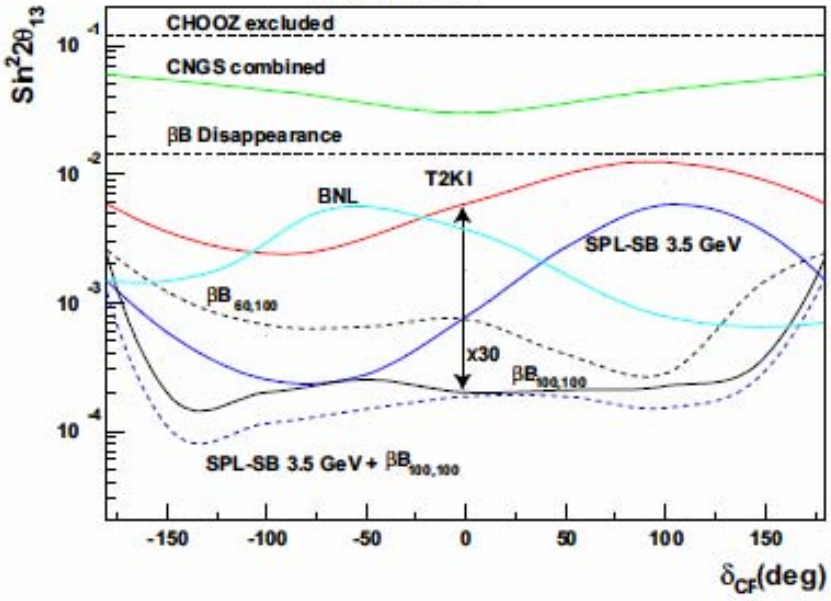


BROOKHAVEN NATIONAL LABORATORY

Beta Beam ($\gamma = 100, 100$) performances

θ_{13} sensitivity (90% CL)

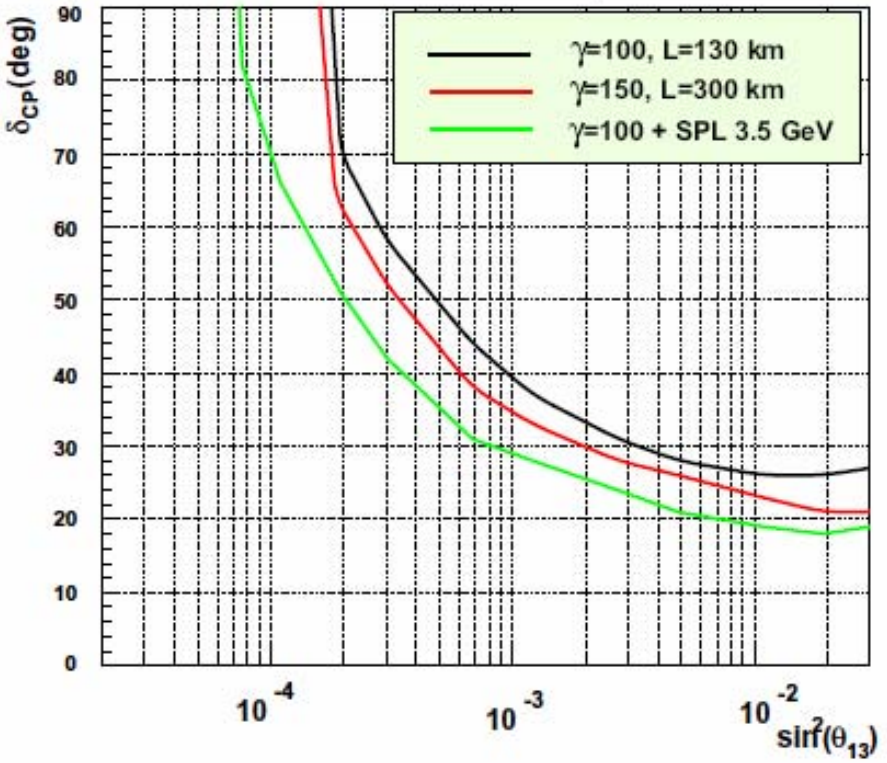
5 years run

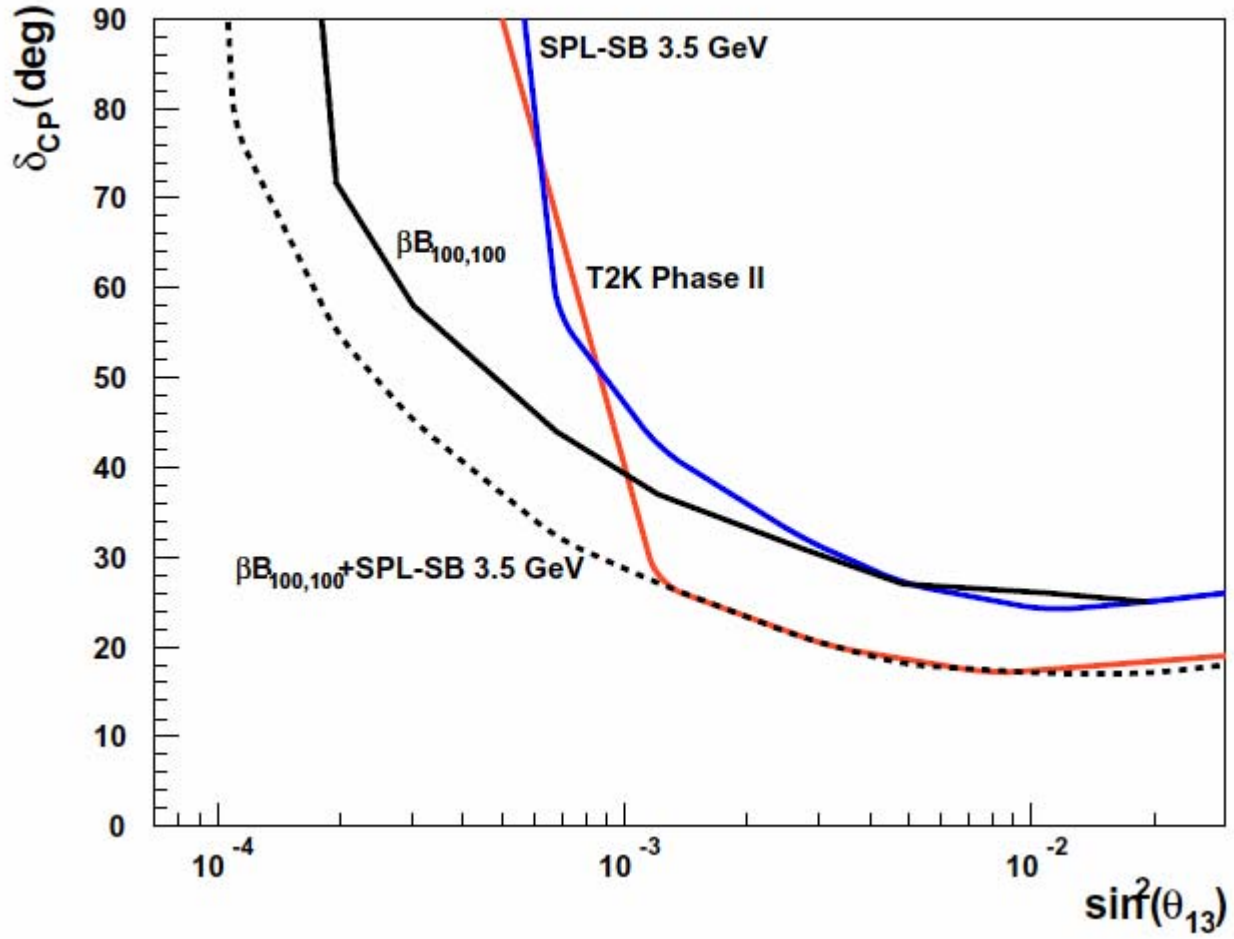


δ_{CP} discovery potential (3σ)

10 years, 5 ν_e+ 5 $\overline{\nu}_e$

$\gamma = 150$ curve with the tentative new γ-flux relation




δ_{CP}(deg)
90
80
70
60
50
40
30
20
10
0
SPL-SB 3.5 GeV
$\beta B_{100,100}$
T2K Phase II
$\beta B_{100,100}$+SPL-SB 3.5 GeV
10^{-4}
10^{-3}
10^{-2}
$\sin^2(\theta_{13})$

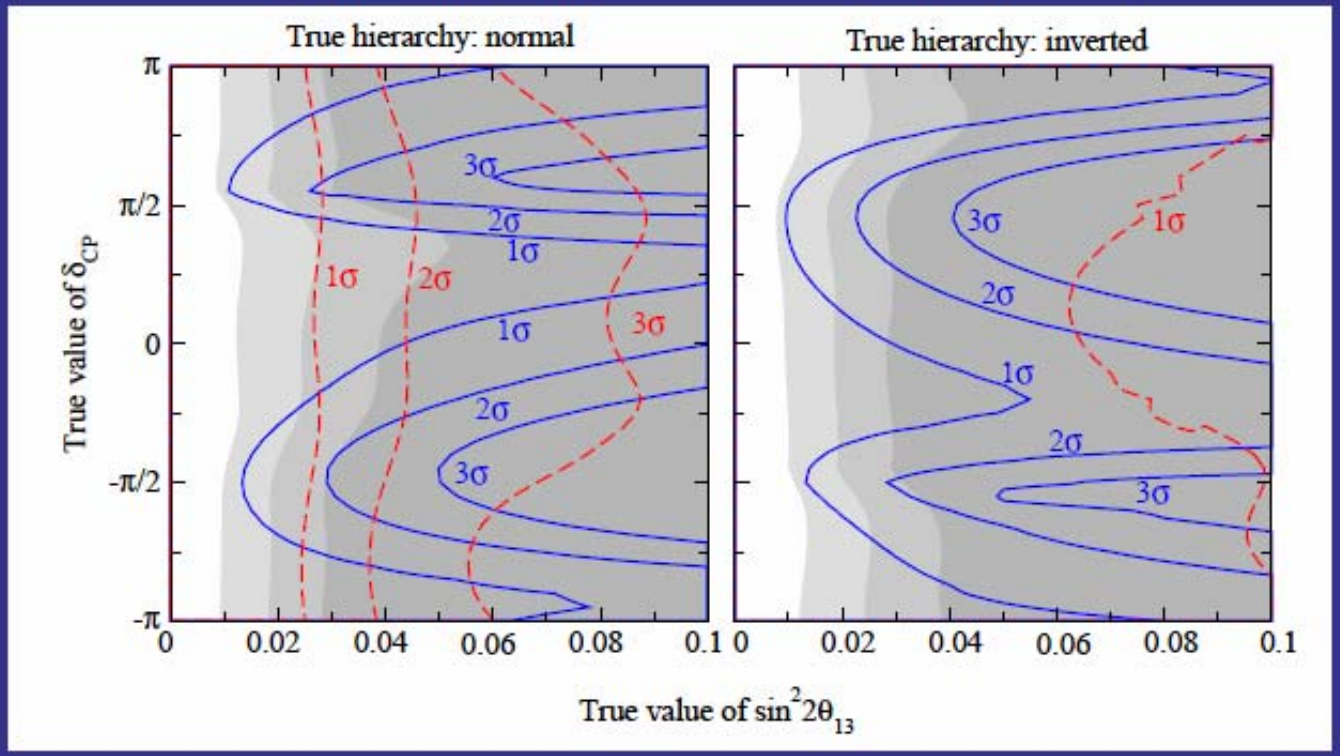
Combined analysis of LBL and ATM data provides an interesting method to resolve degeneracies

Schwetz

Identifying the mass hierarchy

T2K-2: 2Mt/yr ν and 6Mt/yr anti-ν

HK 9Mt.yr ATM ν data assumed



solid: LBL-only, dashed: ATM-only, shading: LBL+ATM

Non-accelerator neutrino physics w/ Mton water Cherenkov

Kajita

- Neutrino oscillation measurements with atmospheric neutrinos: θ_{13}, sgn(Δm_{23}^2), sub-dominant osc., CP phase

Nakahata

- Measurements of low-energy neutrinos
  - ^{8}B Solar neutrino measurements
  - Neutrino burst from Supernova explosion
  - Relic supernova neutrinos

Relic SN neutrinos
--- Very encouraging ---

Ando

- SK data $<1.2\ cm^{-2}s^{-1}$ for $E_\nu > 19.3$ MeV
- It is just above the prediction using reasonable models ($1.1\ cm^{-2}s^{-1}$) !
- 5σ detection would be possible with a Mton water Cherenkov.
- With Gd loaded water, 300 ev/yr expected.

Back to the detector

Detector R&D

- R&D items (for big water Cherenkov)
  - Through physics studies and simulations, identify necessary photocathode coverage for each physics objective.
  - Site study and cavity design
  - Technology of sealing water tanks and supporting photo-sensors
  - Develop low-cost photo-sensors.
- Inter-regional coordination of R&D efforts desirable.

Nakagawa, Petersen (CKJ), Levy, Duffault

Aihara, Ferenc, Pouthas, Birkel, Flyckt, Caracciolo, Wright

Outcome of round-table discussion

- Inter-regional coordination, mostly on R&D.
  - Water-Cherenkov (three regions)
  - Liq. Ar
  - Liq. scintillator
- Try to set collaboration on different items of R&D with common interest.
- Find one person per region to arrange MOU and to connect respective community and agency.
- NNN workshop will be the place for interested community to meet and discuss each year toward realization of next-generation of nucleon-decay and neutrino detectors.

Concluding remarks

- There are a number of exciting physics which can be addressed with the next-generation underground detectors.
- And, there are a number of ideas toward realization of such detectors. All ideas are still at the R&D stage.
- Whichever ideas would be realized in future, some kind of coordination of R&D efforts on items with common interest is very relevant.
- It is a significant outcome of NNN05 that inter-regional coordination in these lines has been agreed.

Next NNN

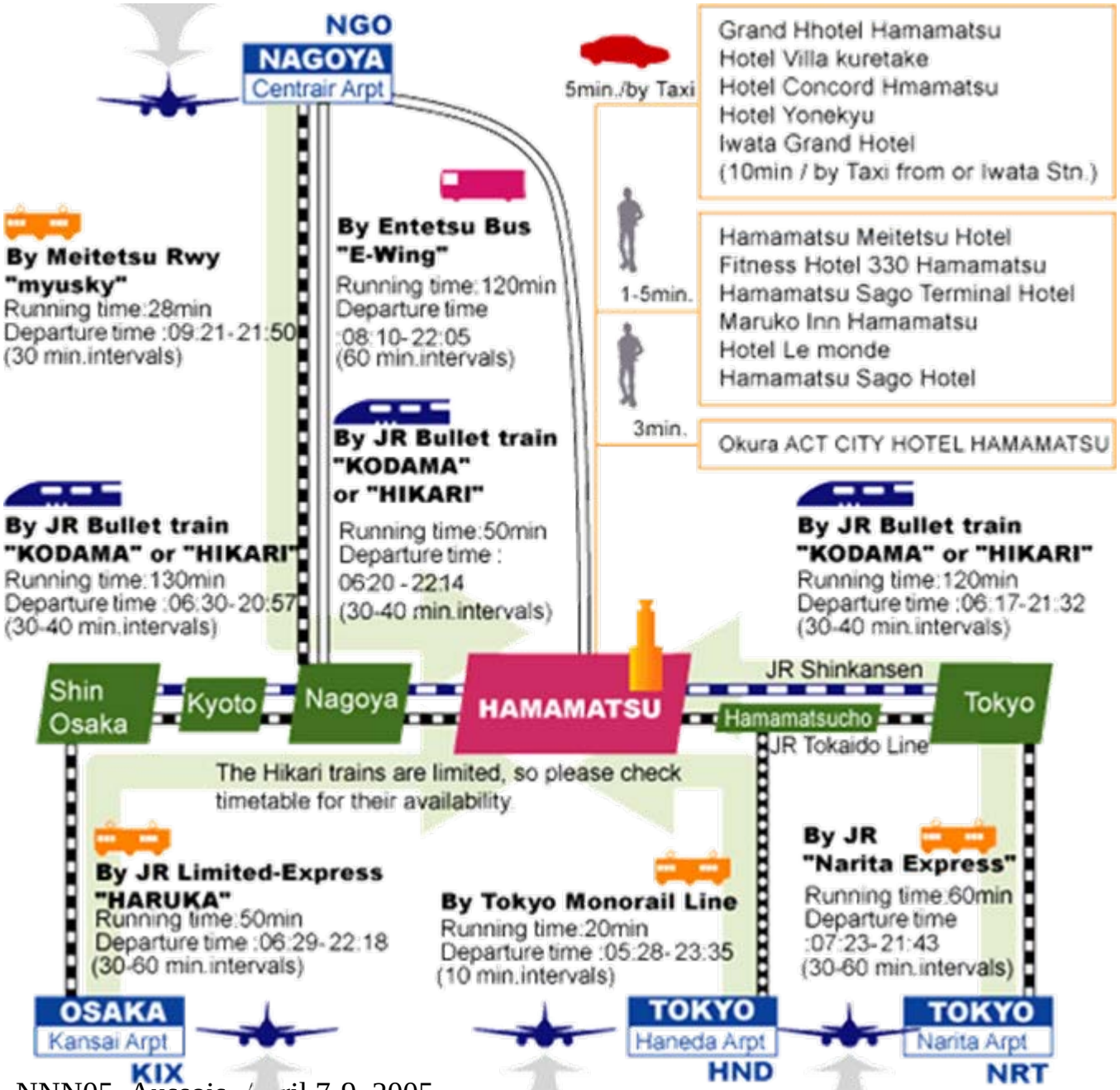
- We are asked to organize next NNN in Japan. Our proposal is
  - NNN07

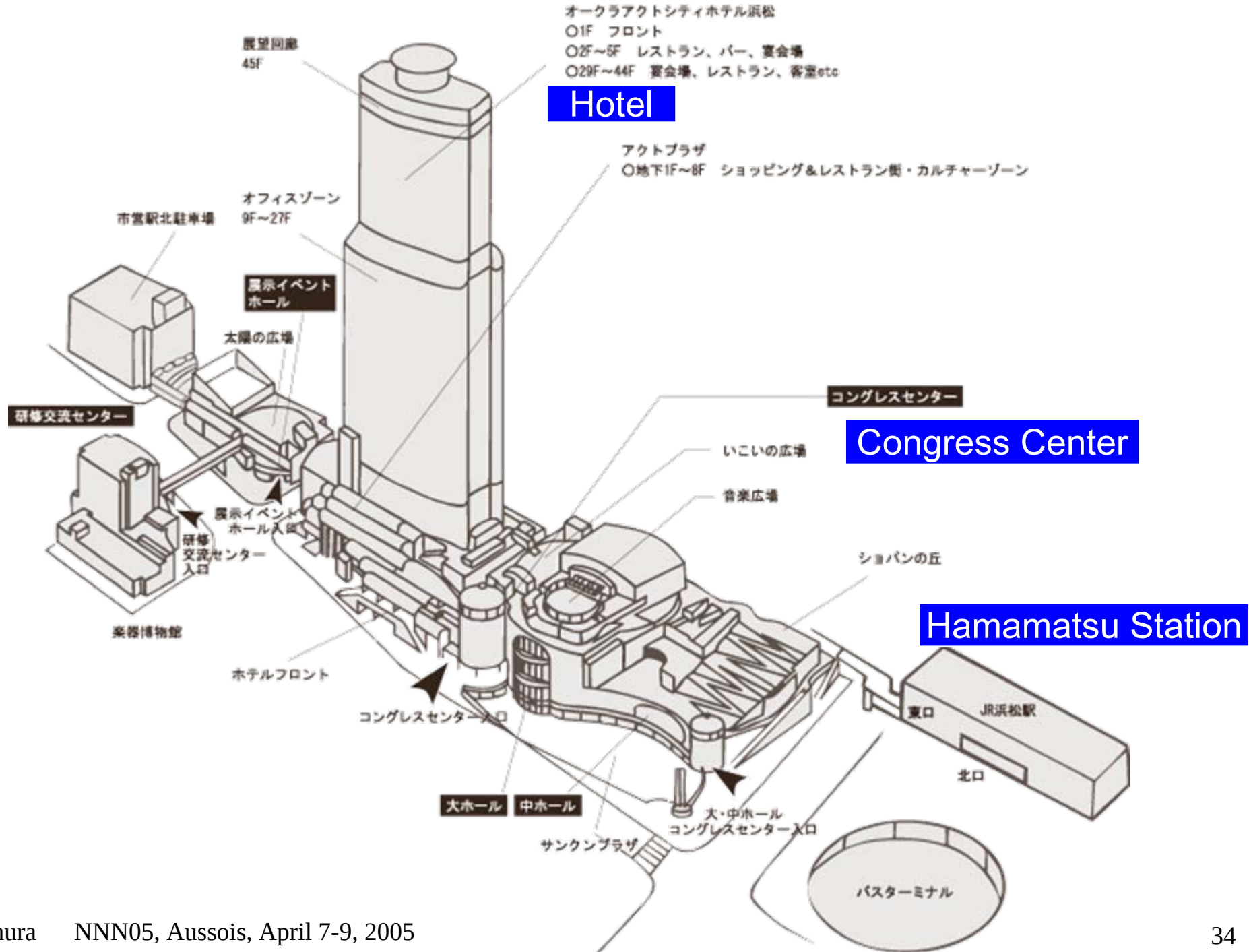
    October 2007, Hamamatsu, Japan
- But, it is 2 years and half ahead from now. Therefore, it is necessary to organize NNN06 in between NNN05 and NNN07
  - Sometime in 2006, in U.S.
  - To be announced later.

Tentative Plan of NNN07 in Japan

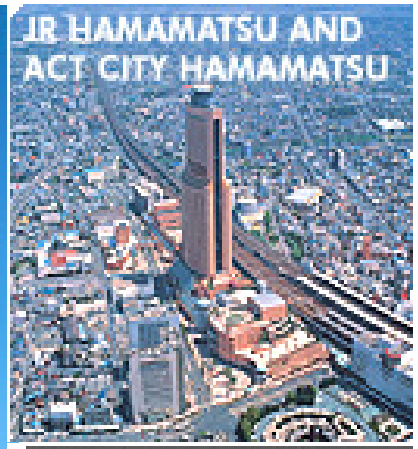
- Date: October 2 – 5, 2007
- Place: Hamamatsu, Japan
  - Convention Center "Act City Hamamatsu"
- Program
  - Oct. 2: Registration and Reception
  - Oct. 3 – 5: Academic sessions
  - Afternoon of Oct. 5: Visit to a Research Laboratory or a Electron-tube factory of Hamamatsu Photonics Inc.

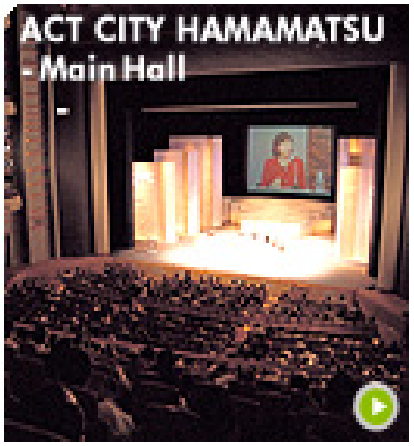

New Tokyo
International Airport
(NARITA)
Haneda
International Airport
(HANEDA)
Cyubu
International Airport
(CENTRAIR)
Kansai
International Airport
(KANSAI)
Tokyo
Nagoya
Osaka
Hamamatsu

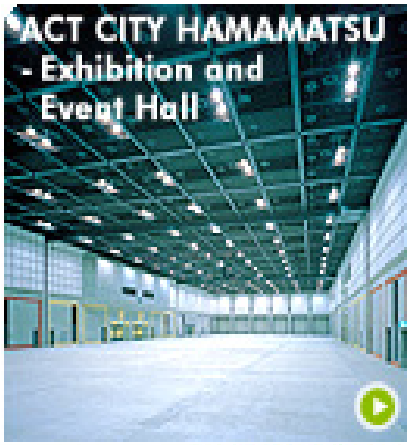

NGO
NAGOYA
Centrair Arpt
5min./by Taxi
Grand Hhotel Hamamatsu
Hotel Villa kuretake
Hotel Concord Hmamatsu
Hotel Yonekyu
Iwata Grand Hotel
(10min / by Taxi from or Iwata Stn.)
By Meitetsu Rwy
"myusky"
Running time:28min
Departure time :09:21-21:50
(30 min.intervals)
By Entetsu Bus
"E-Wing"
Running time:120min
Departure time
:08:10-22:05
(60 min.intervals)
1-5min.
Hamamatsu Meitetsu Hotel
Fitness Hotel 330 Hamamatsu
Hamamatsu Sago Terminal Hotel
Maruko Inn Hamamatsu
Hotel Le monde
Hamamatsu Sago Hotel
By JR Bullet train
"KODAMA"
or "HIKARI"
Running time:50min
Departure time :
06:20 - 22:14
(30-40 min.intervals)
3min.
Okura ACT CITY HOTEL HAMAMATSU
By JR Bullet train
"KODAMA" or "HIKARI"
Running time:130min
Departure time :06:30-20:57
(30-40 min.intervals)
By JR Bullet train
"KODAMA" or "HIKARI"
Running time:120min
Departure time :06:17-21:32
(30-40 min.intervals)
Shin Osaka
Kyoto
Nagoya
HAMAMATSU
JR Shinkansen
Hamamatsucho
Tokyo
JR Tokaido Line
The Hikari trains are limited, so please check timetable for their availability
By JR Limited-Express
"HARUKA"
Running time:50min
Departure time :06:29-22:18
(30-60 min.intervals)
By Tokyo Monorail Line
Running time:20min
Departure time :05:28-23:35
(10 min.intervals)
By JR
"Narita Express"
Running time:60min
Departure time
:07:23-21:43
(30-60 min.intervals)
OSAKA
Kansai Arpt
KIX
TOKYO
Haneda Arpt
HND
TOKYO
Narita Arpt
NRT

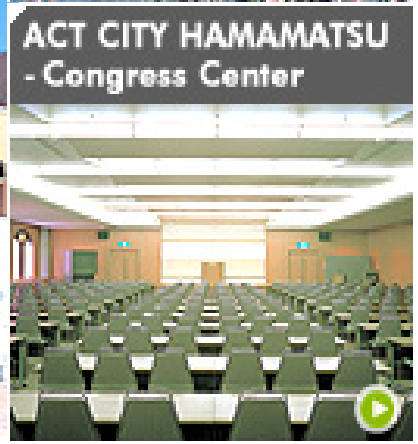

オークラアクトシティホテル浜松
○1F　フロント
○2F～5F　レストラン、バー、宴会場
○29F～44F　宴会場、レストラン、客室etc
Hotel
展望回廊
45F
アクトプラザ
○地下1F～8F　ショッピング&レストラン街・カルチャーゾーン
オフィスゾーン
9F～27F
市営駅北駐車場
展示イベントホール
太陽の広場
研修交流センター
コングレスセンター
Congress Center
いこいの広場
音楽広場
展示イベントホール入口
研修交流センター入口
楽器博物館
ショパンの丘
Hamamatsu Station
ホテルフロント
コングレスセンター入口
東口
JR浜松駅
北口
大ホール
中ホール
大・中ホールコングレスセンター入口
サンクンプラザ
バスターミナル

Convention Center "ACT CITY HAMAMATSU"









Message from the Local Organizing Committee

LOC thanks to

- Isabelle, Roxanne, and Sandrine (Secretaries)
- Luigi Mosca for night adventure

and

- All speakers for their excellent talks