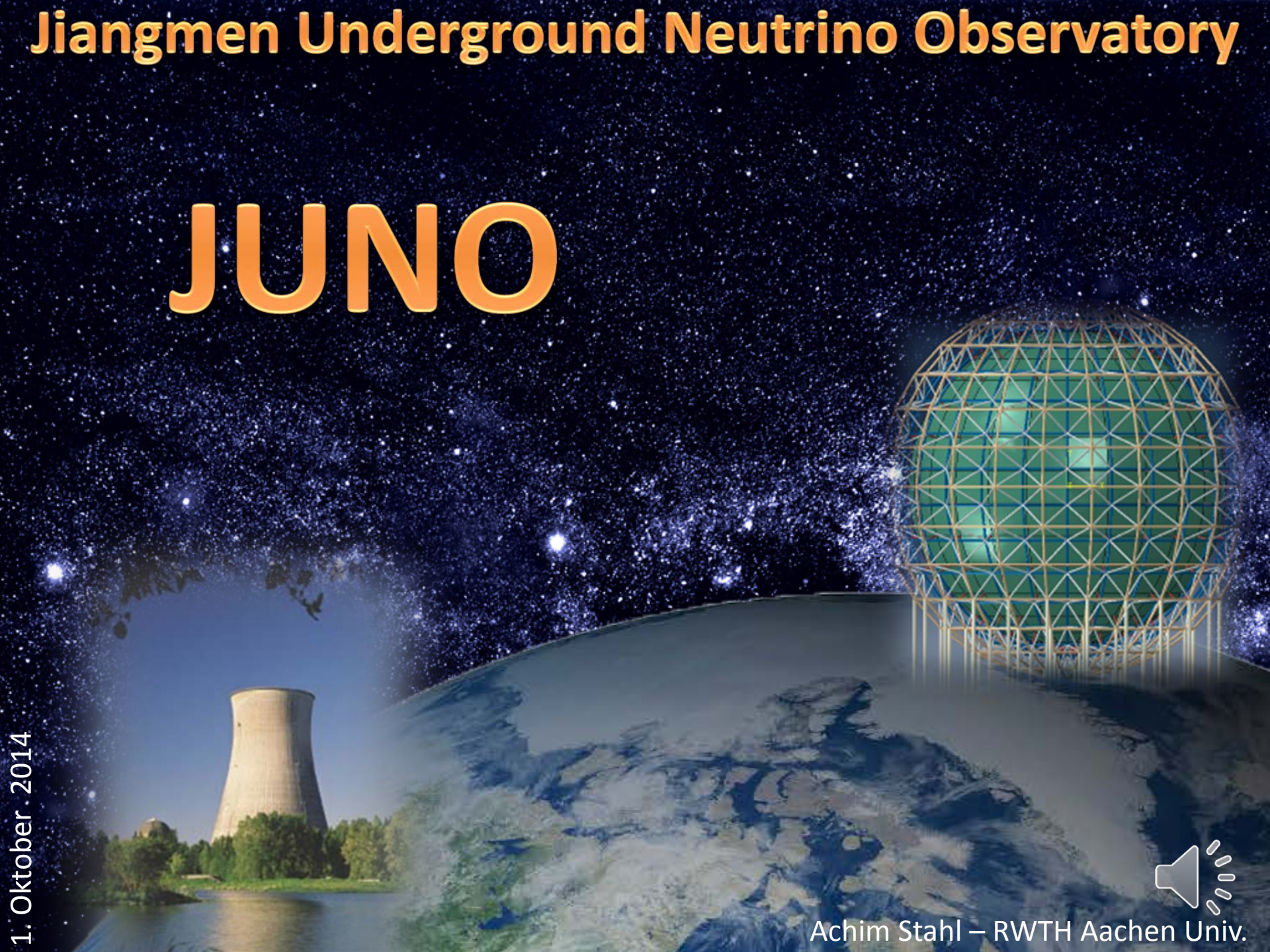
Jiangmen Underground Neutrino Observatory

JUNO

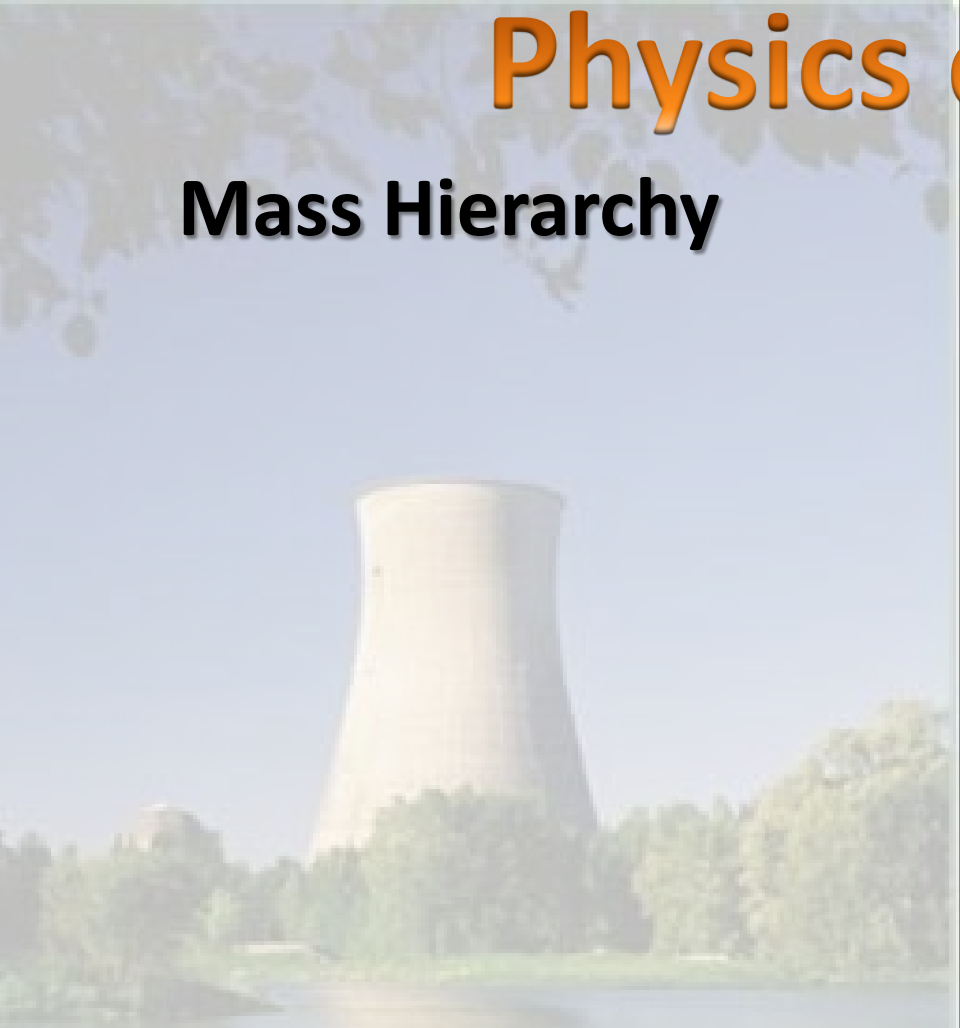


1. Oktober 2014

Achim Stahl – RWTH Aachen Univ.

Physics of JUNO

Mass Hierarchy



ν-oscillations with reactor neutrinos:
Mass hierarchy
Precision Measurements

Others

Super Nova
- Direct observation
- Diffuse Super Nova background

Solar Neutrinos
- Oscillation parameters
- Metallicity

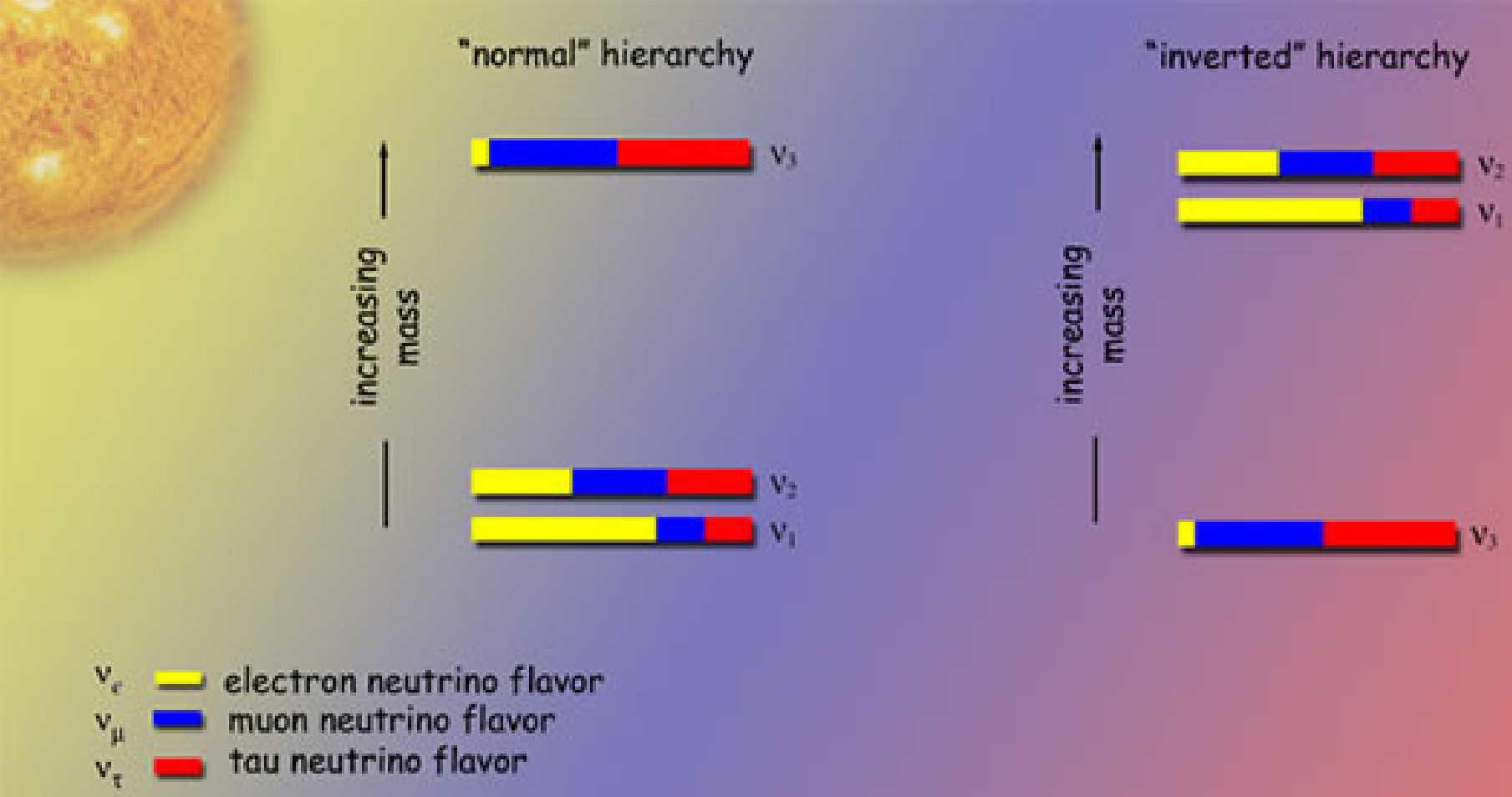
Atmospheric Neutrinos
- Oscillations
- Mass hierarchy ?

Geo Neutrinos
- Models of the earth‘s interior
- Heat production → climate

Nucleon Decay
- i.e. $p \rightarrow K^+ \nu$

Dark Matter
- $\chi \rightarrow \nu\nu$

Sterile Neutrinos
- With radioactive sources



Normal or inverted hierarchy ?	➢ PINGU / INO / JUNO / LBNE
Precision measurements ?	➢ JUNO and others
Majorana or Dirac neutrinos ?	➢ $2\beta0\upsilon$ decays
CP-violation ?	➢ ν-factory, LBNE(?)
Absolute mass scale ?	➢ KATRIN

Mass Hierarchy

Reactor Electron-Anti-Neutrino Disappearance

$$P(\bar{\nu}_e \to \bar{\nu}_e) = 1 - 4\sum_{i,j} |U_{ei}|^2 \left|U_{ej}\right|^2 \sin^2 \Delta_{ij}$$

$$\Delta_{ij} = \frac{\Delta m_{ij}\, L}{4E}$$

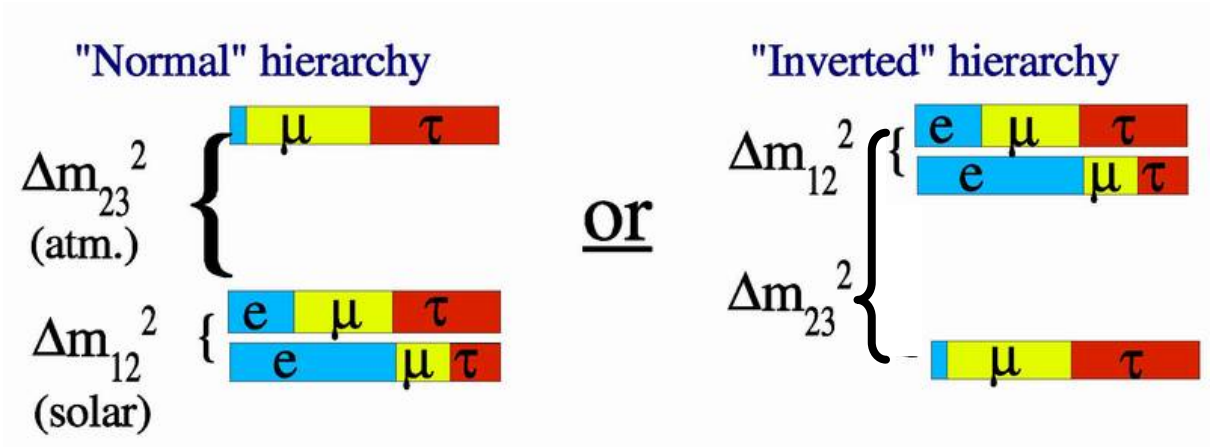
$$\Delta m_{ij} = m_i^2 - m_j^2$$

$$P(\bar{\nu}_e \to \bar{\nu}_e) = 1$$

$$- \cos^4 \theta_{13} \sin^2 2\theta_{12} \sin^2 \Delta_{21} \quad \leftarrow \textbf{low frequency}$$

$$- \cos^2 \theta_{12} \sin^2 2\theta_{13} \sin^2 \Delta_{31} \quad \leftarrow \textbf{high frequency}$$

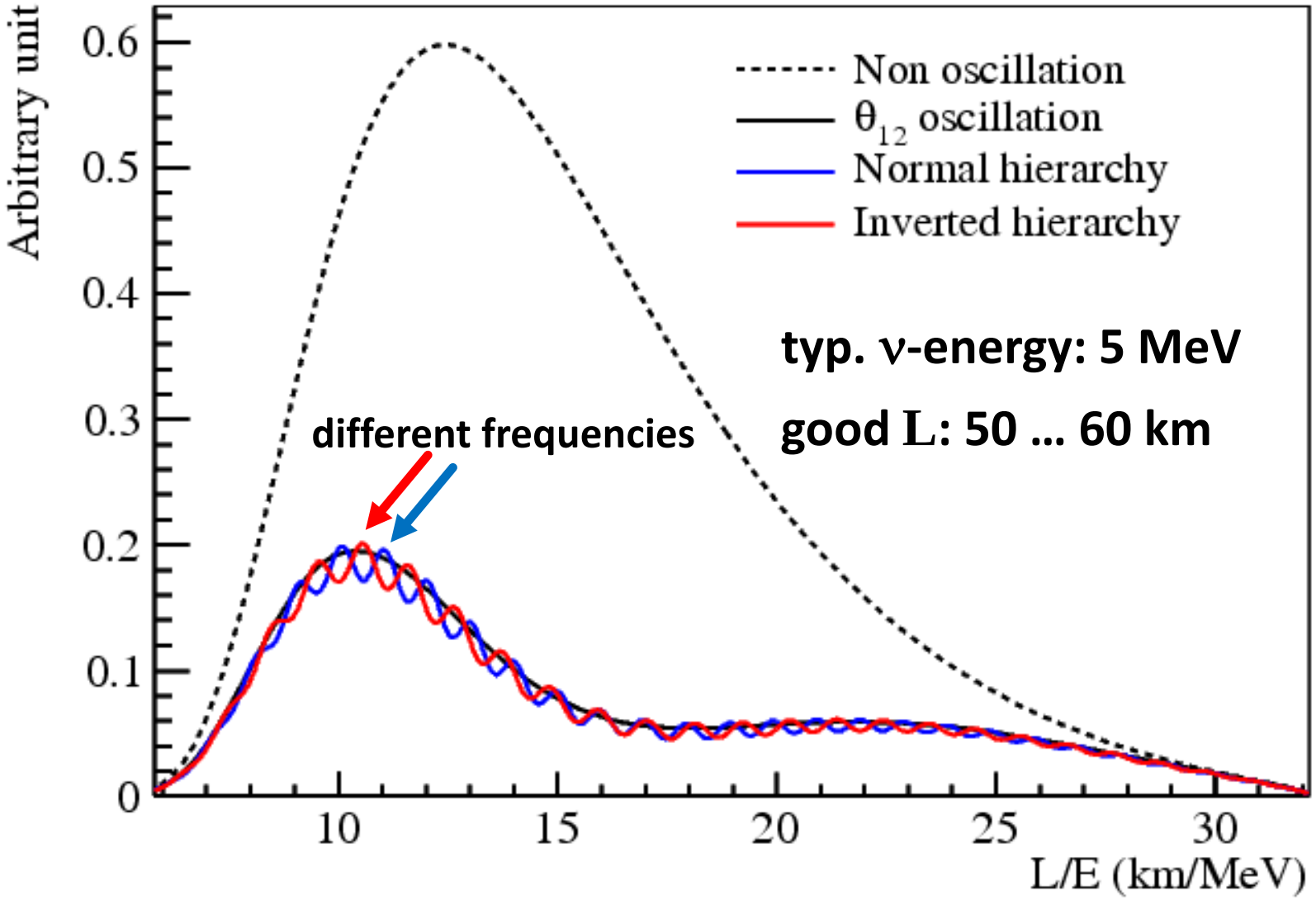
$$- \sin^2 \theta_{12} \sin^2 2\theta_{13} \sin^2 \Delta_{32} \quad \leftarrow \textbf{high frequency}$$



$$|\Delta m^2_{31}| = |\Delta m^2_{23}| + |\Delta m^2_{12}| \qquad |\Delta m^2_{31}| = |\Delta m^2_{23}| - |\Delta m^2_{12}|$$

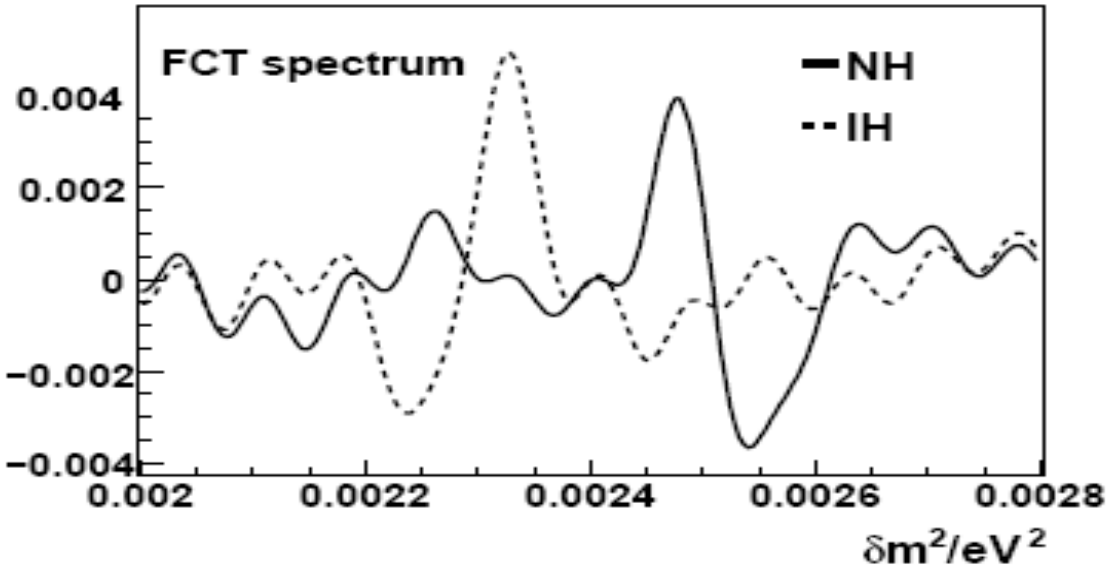
Yu-Feng Li et al.,
Phys.Rev. D88 (2013) 013008

Mass Hierarchy

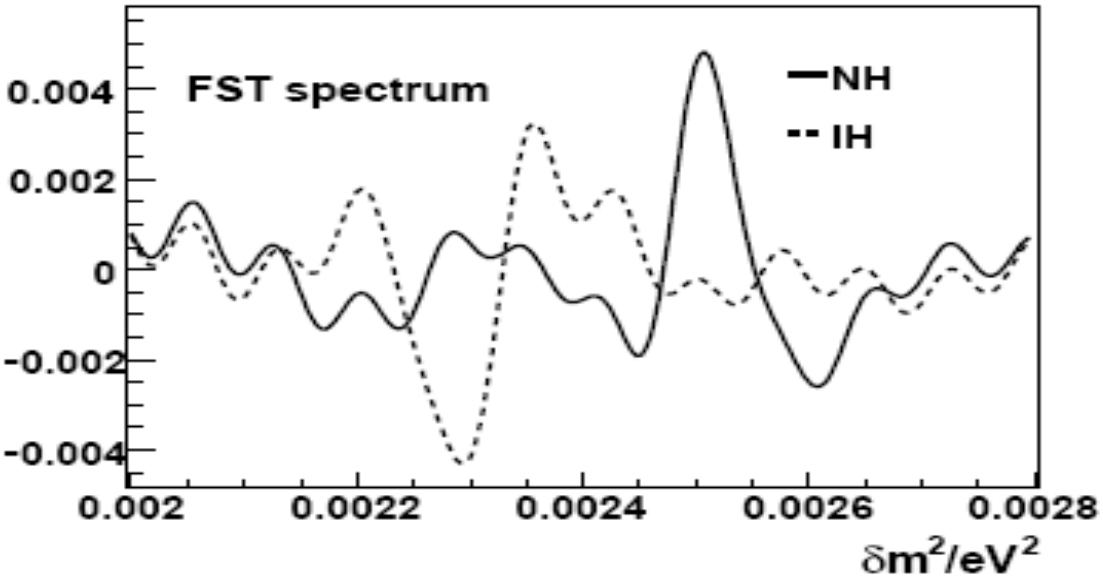


Mass Hierarchy

Fourier analysis of signal



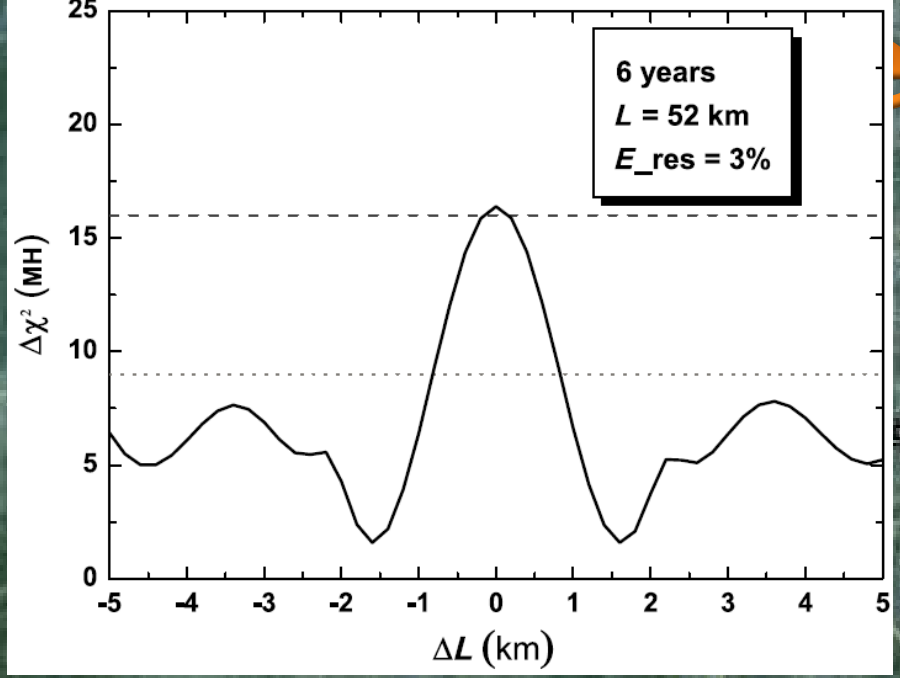
$$\cos\frac{L}{E}$$

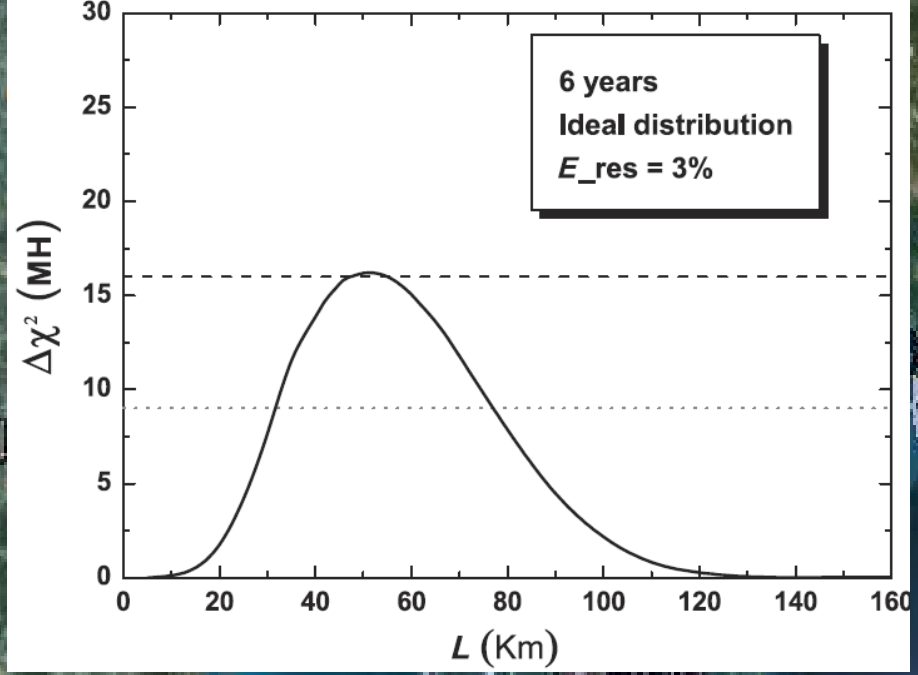


$$\sin\frac{L}{E}$$

The Site

Guangdong province
Jiangmen prefecture
Kaiping city





JUNO

台山阳江

55km

台山

55km

阳江

Taishan
18.4 GW

Yangjiang
17.4 GW

澳门

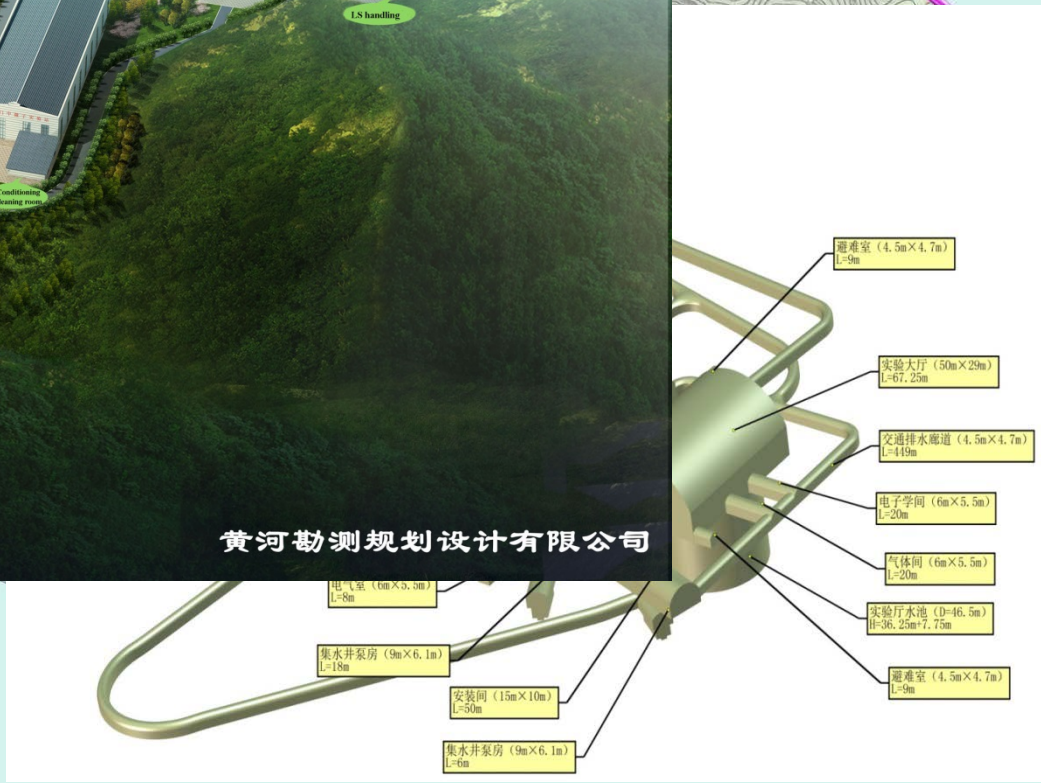
Macao

Hongkong

Hongkong

Underground Laborato

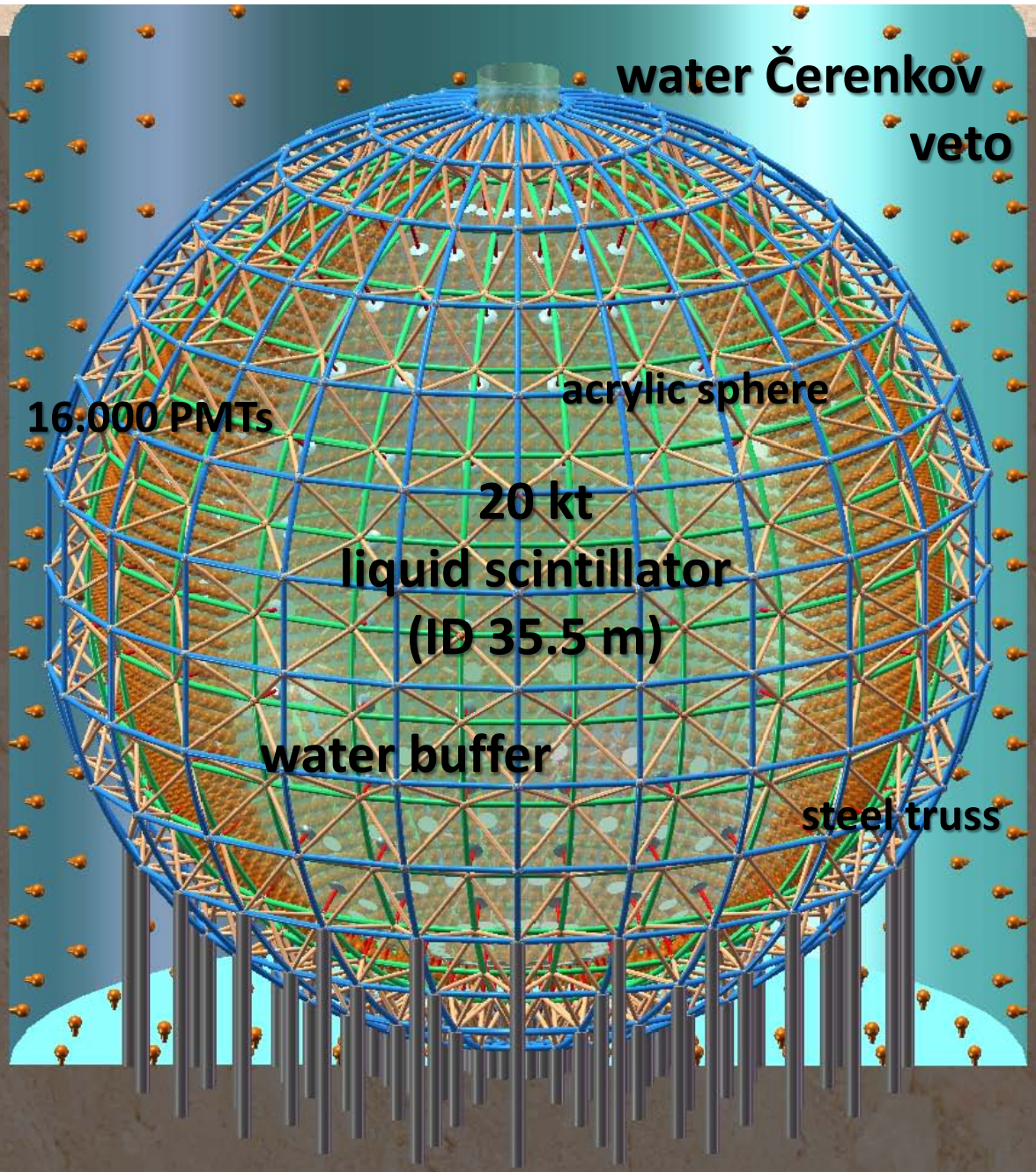
Entrance site
Labs / offices / dormitories



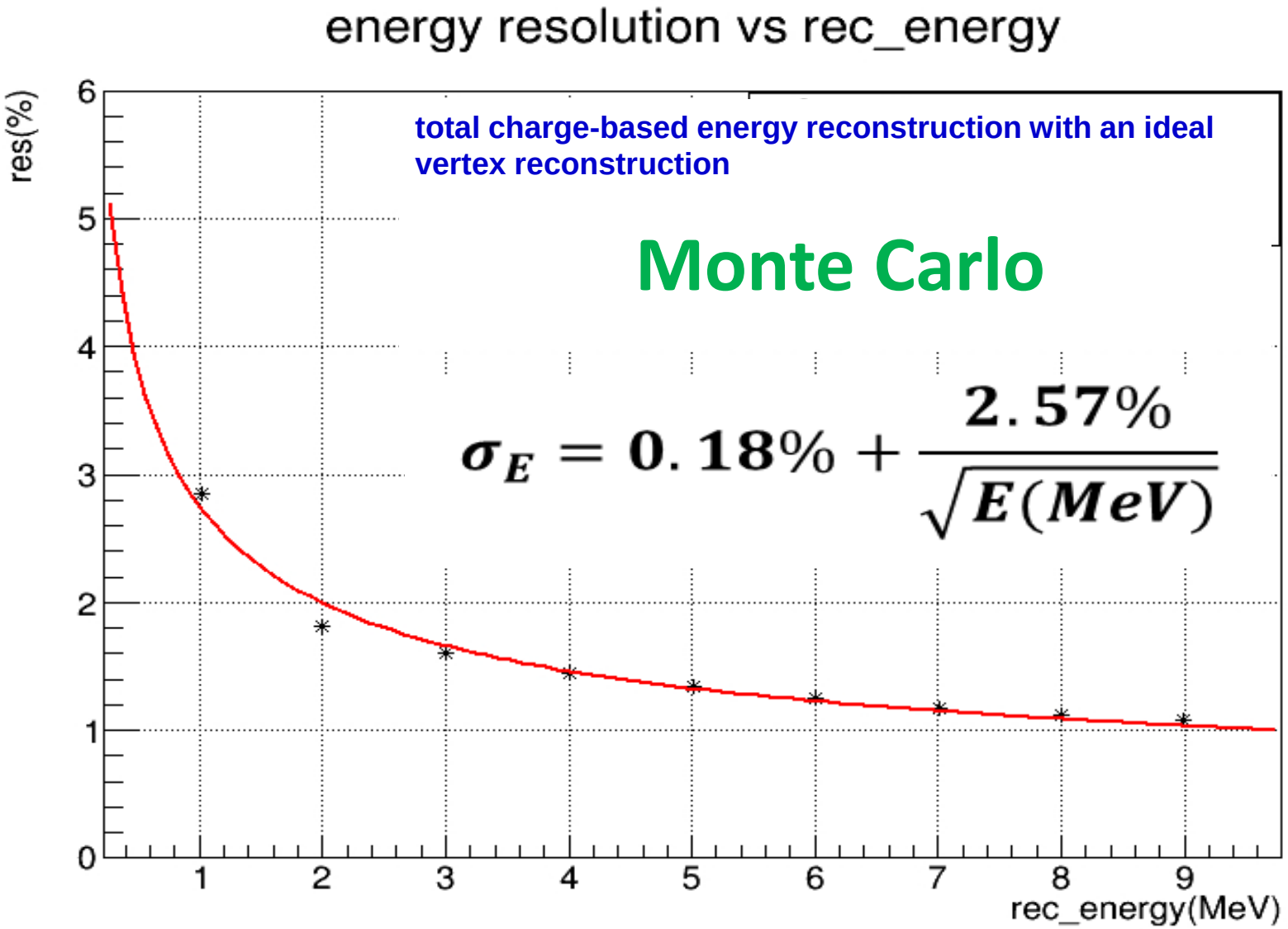
Overburden: 700 m rock

The detector

muon tracker



The challenge



The challenge

Excellent Energy Resolution (3% @ 1 MeV)

Photonstatistics

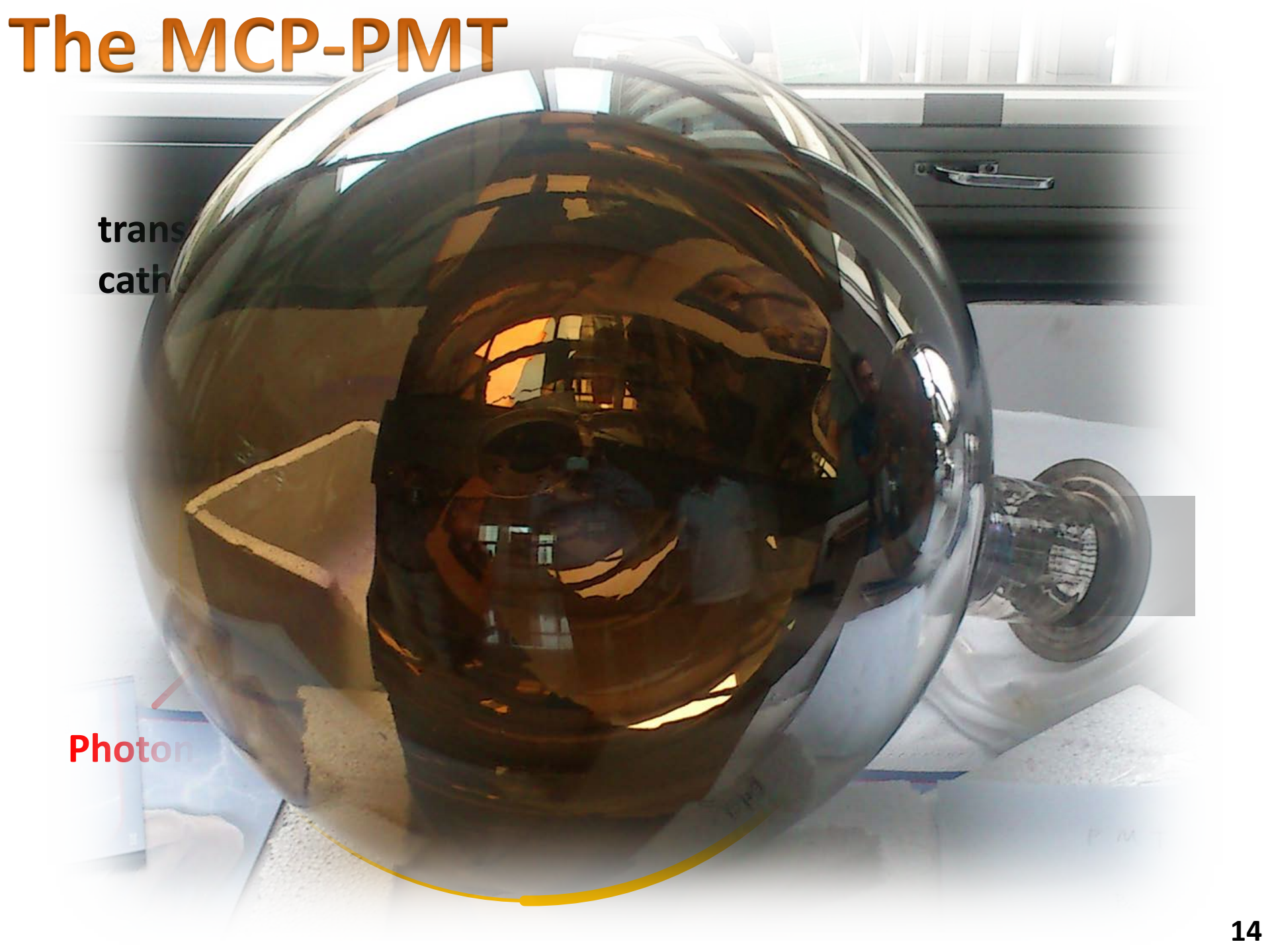
- high lightyield
- good transparency
- PMT-coverage
- PMT-QE

&

Calibration

- α/β sources
  (in all positions)
- light pulsers
  (in all positions)
- UV-laser
  (in many positions)
- e^+ beam
  (along axis)

The MCP-PMT

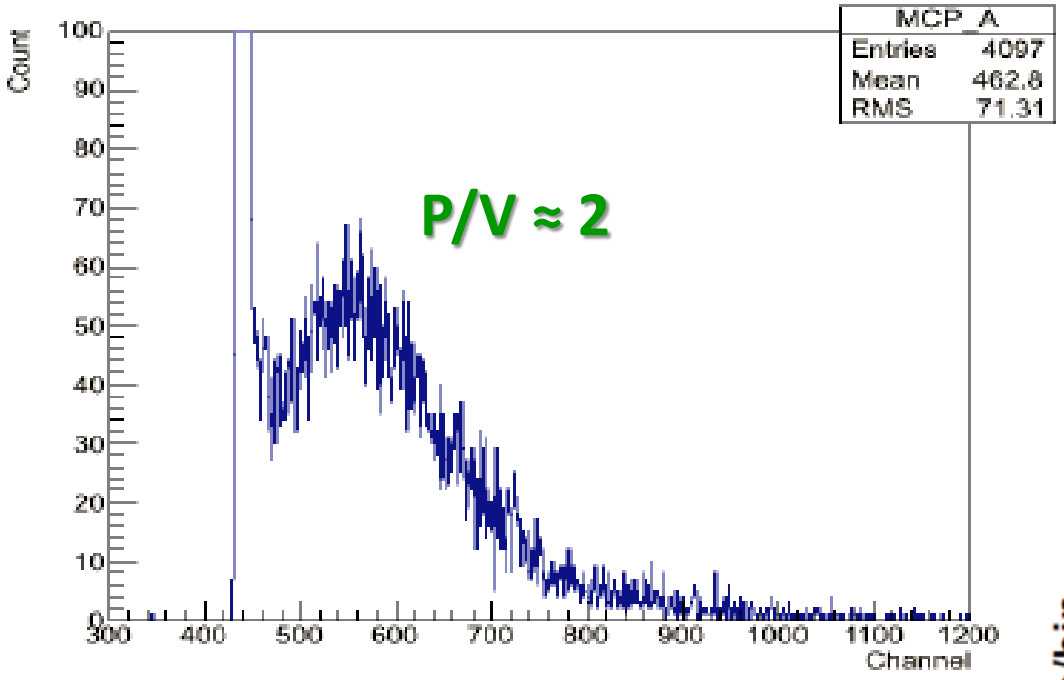


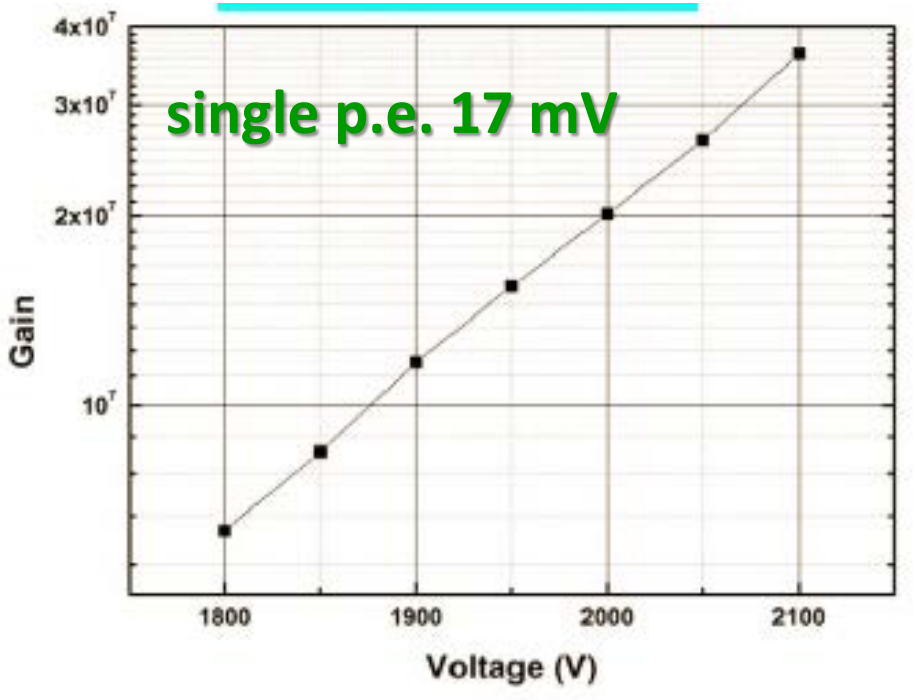
Prototypes

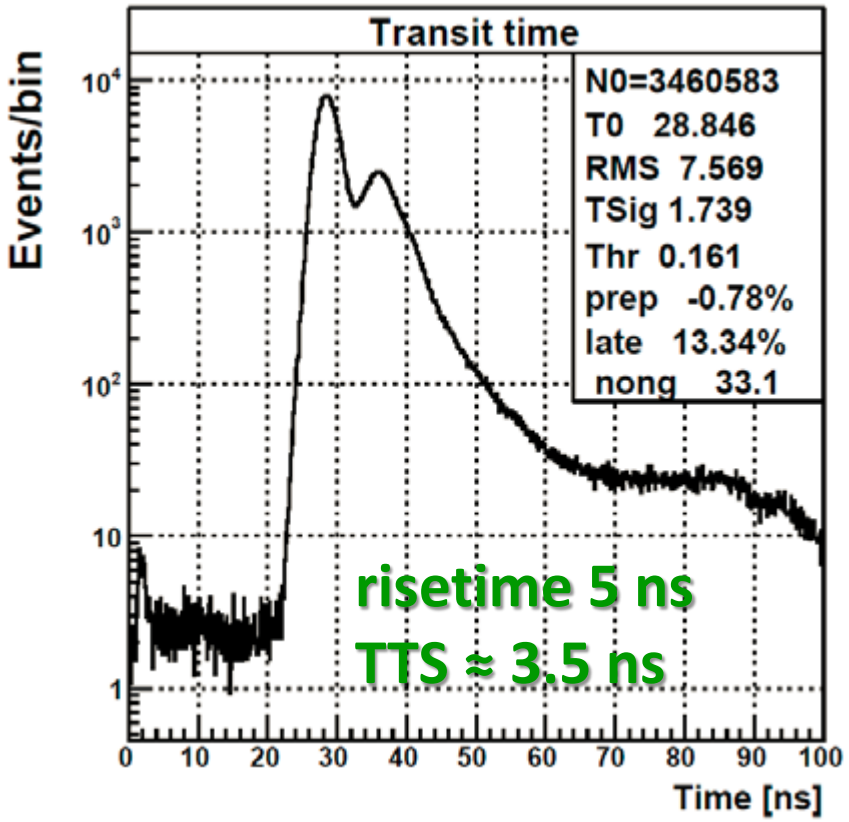
Sizes 8“, 12“, and 20“

Results from good MCP-PMTs

QE@410 nm: 25%







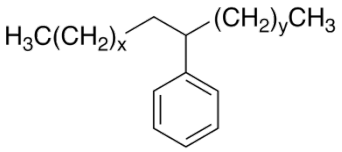
Liquid Scintillator

LAB + PPO + BisMSB

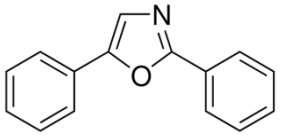
Lightyield: ≈10000 ph./MeV
→ 1200 p.e./MeV

Attenuation length > 22m @ 430 nm
scattering length ≈ 30 m
absorption length ≈ 90 m

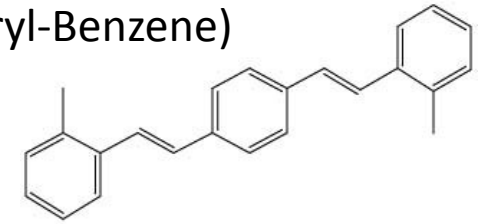
Linear **A**lkyl**B**enzene
(solvent)

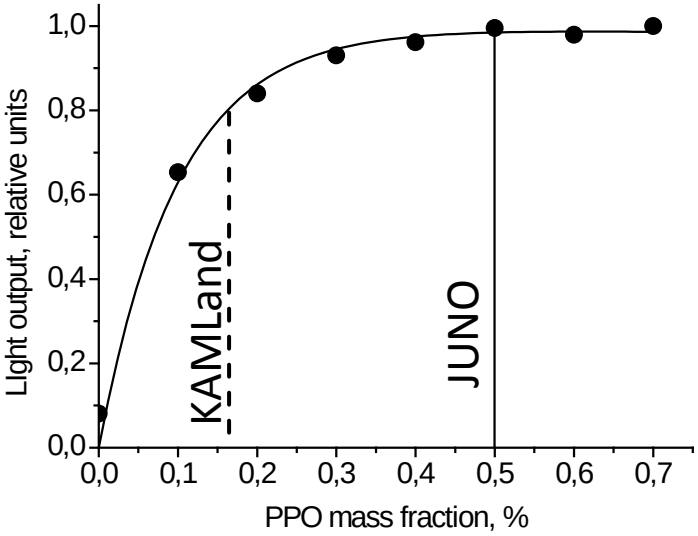


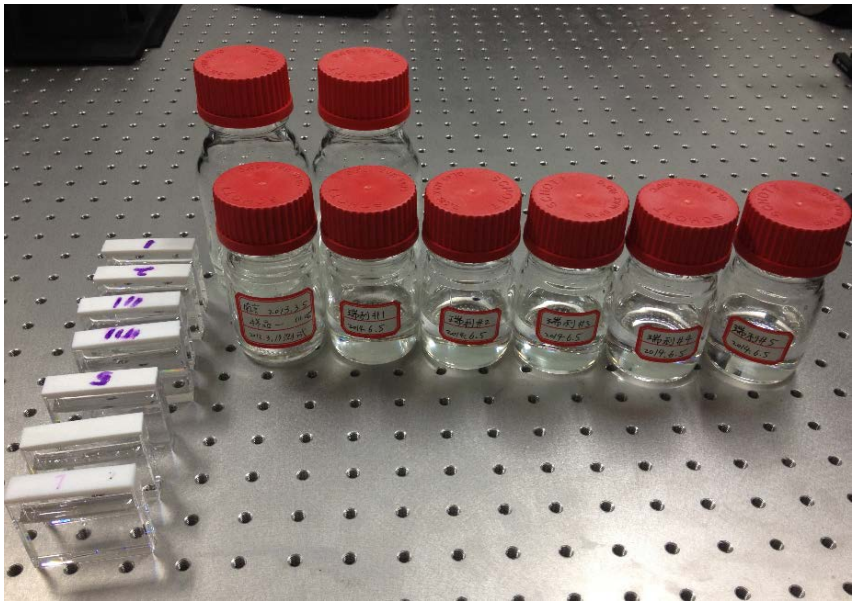
PPO (2,5-diphenyloxazole)
(3 g/l)



bis-MSB (MethylStyryl-Benzene)
(15 mg/l)







Physics of JUNO

Mass Hierarchy

MC-studies:

>3 sigma in 4 years

(3% resolution @ 1 MeV)

ν-oscillations with reactor neutrinos:
Mass hierarchy
Precision Measurements

Others

Super Nova
- **Direct observation**
- **Diffuse Super Nova background**

Solar Neutrinos
- **Oscillation parameters**
- **Metallicity**

Atmospheric Neutrinos
- **Oscillations**
- **Mass hierarchy ?**

Geo Neutrinos
- **Models of the earth‘s interior**
- **Heat production → climate**

Nucleon Decay
- **i.e. $p \rightarrow K^+ \nu$**

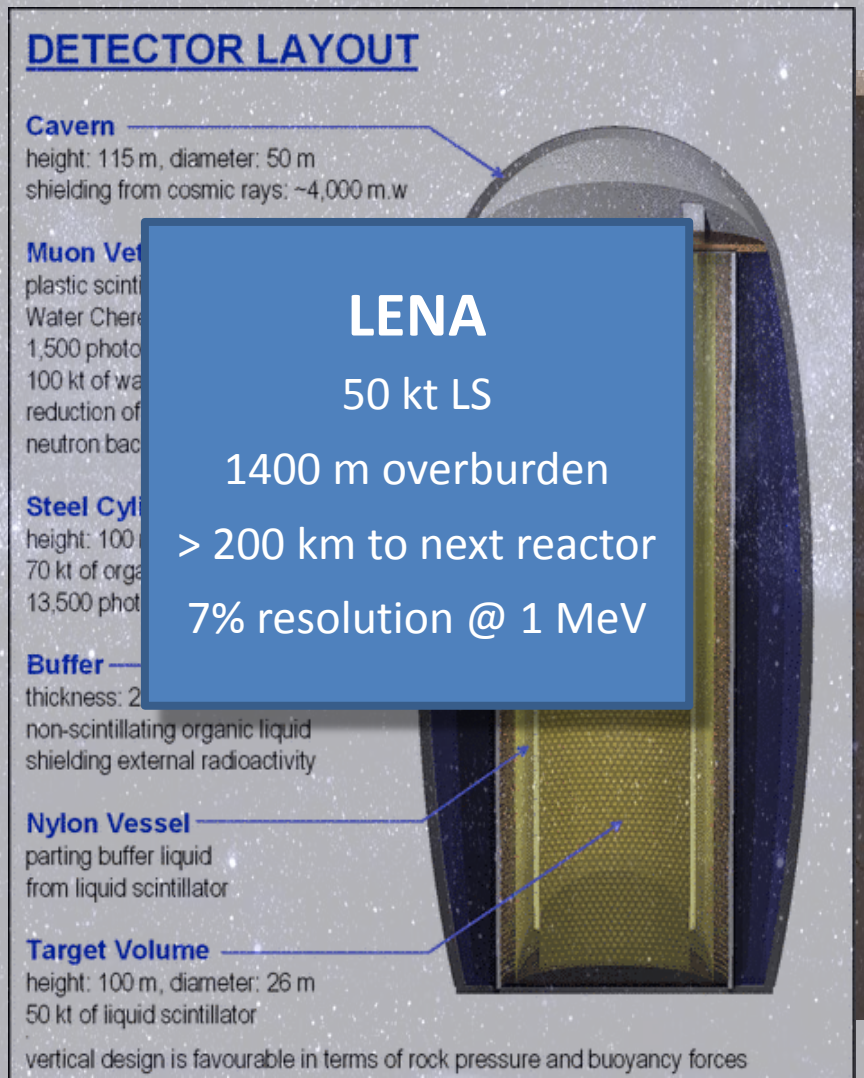
Dark Matter
- **$\chi \rightarrow \nu\nu$**

Sterile Neutrinos
- **With radioactive sources**

Physics of LS-Detectors

Others

LENA @ Phyäsalmi



LENA

50 kt LS

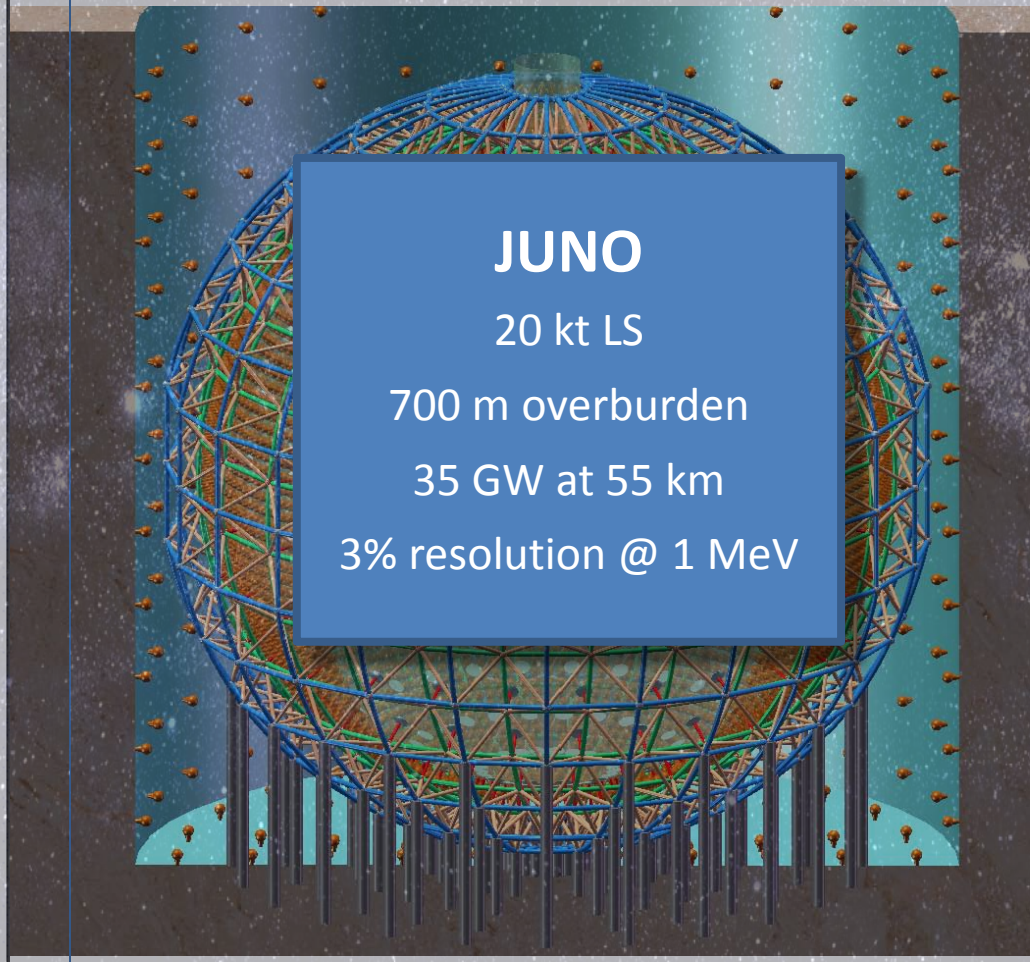
1400 m overburden

> 200 km to next reactor

7% resolution @ 1 MeV

Others

JUNO @ Jiangmen



JUNO

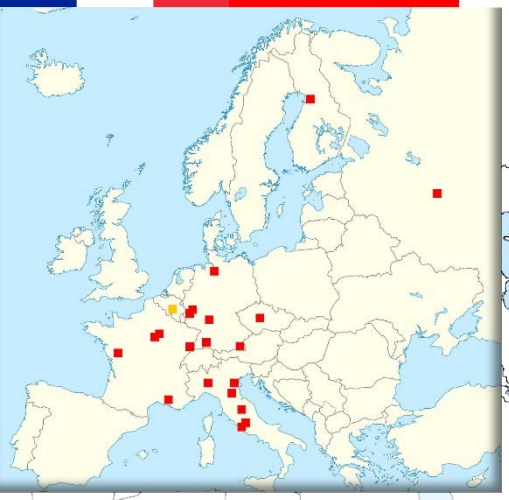
20 kt LS

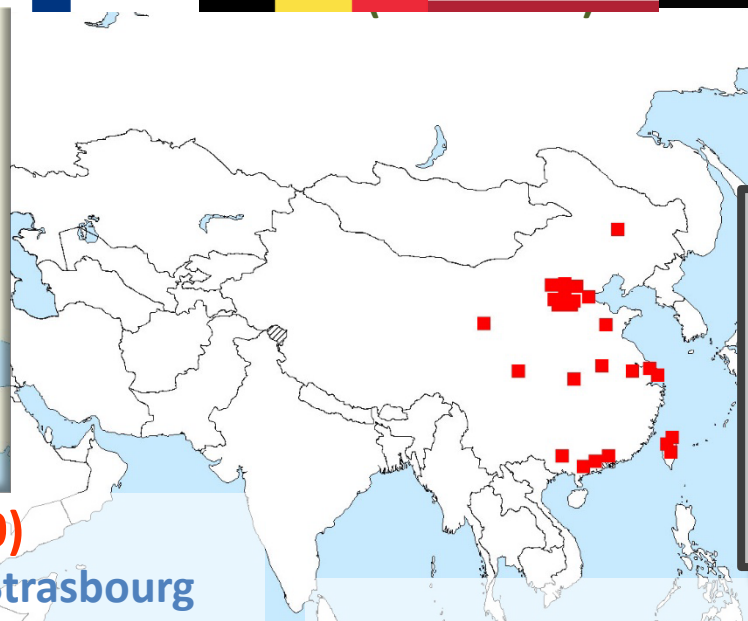
700 m overburden

35 GW at 55 km

3% resolution @ 1 MeV

JUNO Collaboration





Status

CDR in a few weeks

temporary approval

start construction Jan. 2015

start data-taking 2021

Europe (20)

APC Paris
Charles U.
CPPM Marseille
FZ Jülich
INFN-Frascati
INFN-Ferrara
INFN-Milano
INFN-Padova
INFN-Perugia
INFN-Roma 3
U. libre de Bruxelles (Observer)
IPHC Strasbourg
JINR
LLR Paris
RWTH Aachen U.
Subatech Nantes
TU Munich
U.Hamburg
U.Mainz
U.Oulu
U.Tuebingen

Asia (25)

Beijing Normal U.
CAGS,
CIAE
DGUT
ECUST
Guangxi U.
IHEP
Jilin U.
Nanjing U.
Nankai U.
Natl. Chiao-Tung U.
Natl. Taiwan U.
Natl. United U.
NCEPU
Pekin U.
Shandong U.
Shanghai JT U.
Sichuan U.
SYSU
Tsinghua U.
UCAS
USTC
Wuhan U.
Wuyi U.
Xi'an JT U.

Funding Situation

- **Detector Cost 320 Mio US$ (incl. underground lab)**
  China offers 80% to 90% (+ surface infrastructure)
- **Germany second largest international partner**
  Expected contribution 3 to 5 Mio €
- **DFG-Application pending**

Support by KAT would be highly welcome!

Conclusions

- **Excellent Physics Potential**
  Mass hierarchy & Astro-/Geo-/Solar-/p-decay
- **Challenging Detector Concept**
  Good progress with PMTs / LS / etc.
- **Final approval in 2015 expected**
  Start construction 10th Jan. 2015

More Collaborators Welcome