1. Introduction

- **Purpose**: Measurement of precise mixing angle $\theta_{12}$
  - $96\%$ C.L. allowed region obtained by global fit
  - LMA solution (blue): $\Delta m_{21}^2 = 7.5 \times 10^{-5} E$ (DSN spectrum)
  - KamiLAND (green) $\Rightarrow$ confirm $\theta_{12}$ & $\Delta m_{21}$

- **on-going solar $8B$ experiment**
  - KamiLAND (Liquid scintillator, electron elastic scattering (EES))
  - InP (Liquid scintillator, EES)

- **future solar $p$/Be experiment**
  - XMASS (LO, E, H, KATHERINE)
  - LENS (liquid scintillator loaded in In$	ext{V}$ charged current (CCI))

- **Contribution to determination of $\theta_{13}$**
  - Precise $\theta_{13}$ from solar neutrino experiment and KamiLAND experiment will contribute to determination of $\theta_{13}$

- **Technique of low energy solar neutrino detection**
  - Major event due to $\nu_{\alpha}$
  - Small event due to $\nu_{\beta}$

- **Indium Project on Neutrino Observation for Solar interior (IPNOS) experiment**
  - Hybrid structure of InP and external scintillator
  - InP multi-pixel detector inside of Liquid Xenon
  - 30cm cubic chamber (like XMASS 100kg prototype detector)

  - Number of expected events assuming LMA solution with $\bar{E}_{\nu}$
  - Number of expected event assuming $E_{\nu}$

  - Statistical and theoretical error in total $\Rightarrow -3.5\%$

  - $\theta_{13} = 30^\circ - 34^\circ$

2. Si InP cell detector

- **Response for $\gamma$-ray from radioactive source**

3. InP photon detector

- **InP detector inside Liquid Xenon**
  - Liquid Xenon has large cross section to detect $\gamma$-ray
  - InP detector should keep cool to reduce dark current

  - Development of InP photon detector
    - Thin electrode to pass the lights
    - InP detector should work as photon detector to detect $\gamma$-ray

4. IPNOS phase-I experiment

- **Detector**
  - 30cm cubic chamber (like XMASS 100kg prototype detector)
  - InP multi-pixel detector inside of Liquid Xenon

- **Chamber includes**
  - 10kg InP detector

- **Purpose**
  - Demonstrate low Background environment
  - Long stable operation (1 year will be expected for half year)

- **Requirements to detect $\bar{\nu}_{\beta}$**
  - Transparency of Au/Cr electrode : $0.43 \times 0.39 = 0.17$
  - Assuming same conversion efficiency : 0.3
  - Assuming surface scattering : 0.8
  - Expected scint. light yield $\Rightarrow 3keV$ not enough...
  - Modifying shape of electrode such as mesh structure
  - Assuming 50% for dark area then transparency recovers 0.58

5. Liquid scintillator containing metal complexes

- **Development of liquid scintillator using Indium complexes**
  - **goal**: solubility : 5 wt%, light yield : 60% of BC505, attenuation length : 2-3m

- **tris-(8-quinolinolinate) Indium complex (InQ3)**
  - $\nu_{\beta\beta}$ has been established as organic electro luminescence material (maximum luminescence at 530nm)
  - InQ3 should have same property of luminescence

- **Synthesis of InQ3 complex**
  - Solution of InQ3 in organic solvent

- **Luminescence of InQ3 complex**
  - $\nu_{\beta}\nu_{\beta}$ energy transfer to InQ3
  - $\nu_{\beta}$-PPO dissolved as a wavelength shifter (0.15wtr)

  - Light yield and quantum yield

  - **Performance of liquid scintillator**
    - Setup
      - Hamamatsu H6410 2inch photomultiplier
      - Fisherbrand 20ml Borosilicate Glass Scintillation Vials
      - Acrylic light guide
      - LeCroy 1182 charge sensitive VME ADC
      - Coincidence method was used for eliminating BG

    - **Response for $\gamma$-ray from radioactive source**

6. Next step

- **For IPNOS phase-I**
  - Measurement of scintillation light from LXE

- **For metal complex loaded liquid scintillator**
  - In complex
    - modify 8-quinolinolate ligand to add substituent groups (Cl, NO$_2$, ...)
    - use another ligand which should be OEL
  - Photo emission : 291nm
  - Matrix K ($\nu_{\beta\beta}$)
  - $\phi_{\beta\beta}$ and $\phi_{\beta\beta}$

- **Zr, Mo, Cd, N complex**
  - Other metal Zr, Mo, Cd, N complex will be good detector for $\nu_{\beta\beta}$ experiment

  - Goal : $\phi_{\beta\beta}$, solubility and $\phi_{\beta\beta}$@3MeV

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- **Light yield and quantum yield**

- **Photo luminescence caused by $\gamma$-ray was confirmed**

- **Light yield and quantum yield**

- **relative light yield to BC505 : 2% (36% for PHC$N$-PPO)**

- **Development of InP solid state detector and liquid scintillator**
  - For Metal complex loaded liquid scintillator
    - In complex
      - modify 8-quinolinolate ligand to add substituent groups (Cl, NO$_2$, ...)
      - use another ligand which should be OEL
    - Photo emission : 291nm matrix K ($\nu_{\beta\beta}$)
    - $\phi_{\beta\beta}$ and $\phi_{\beta\beta}$

- **Zr, Mo, Cd, N complex**
  - Other metal Zr, Mo, Cd, N complex will be good detector for $\nu_{\beta\beta}$ experiment
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