# JAPAN CRC FUTURE PROJECT SUBCOMMITTEE REPORT

Nobuyuki Kanda (Osaka City U.)

on behalf of the future project subcommittee of
Cosmic ray Researchers Congress

# JAPAN CRC

## CRC (Cosmic ray Researchers Congress)

- Since 1956
- 362 members (at April. 2012)
- Voluntary Association of 'Cosmic ray Researchers'
- In the broad sense of the 'Cosmic ray Researches', it consists of cosmic ray experiments, astro-physics, astro-particle physics, etc.
- Aim : to promote and exchanges for cosmic-ray researches

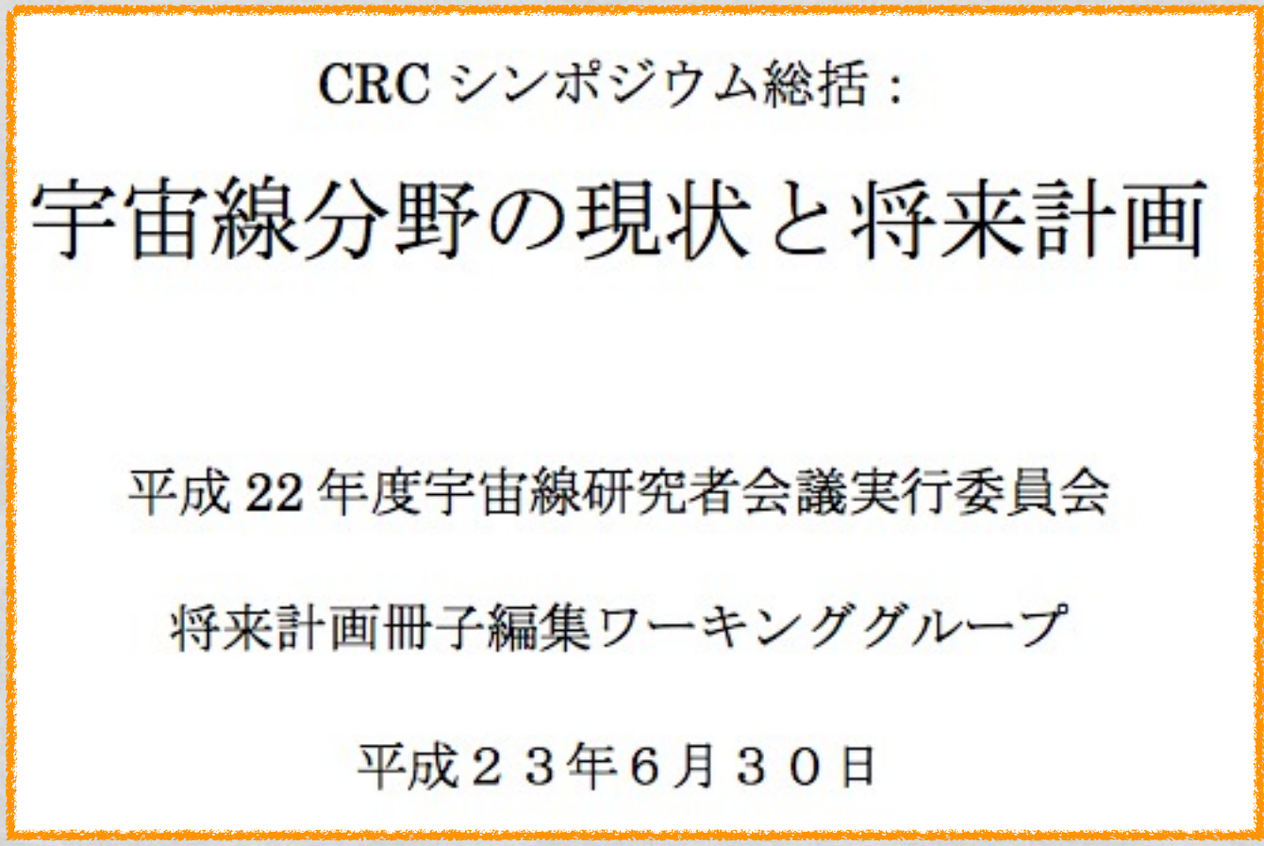
# CRC FUTURE PROJECTS

We held the symposium at 2010, CRC summarized current (at late 2010) statuses and prospect for the future.

See : http://www.icrr.u-tokyo.ac.jp/CRC/Symposium/2010-09/future20110630.pdf

Since CRC researches are widely related modern physics : elementary particle, astrophysics, cosmology, solar and earth environment etc., we should to remark and to tidy up our interests.

- high-energy astrophysics
- non-accelerator particle physics
- gravitational wave astronomy
- interdisciplinary researches


CRC シンポジウム総括：

宇宙線分野の現状と将来計画

平成 22 年度宇宙線研究者会議実行委員会

将来計画冊子編集ワーキンググループ

平成２３年６月３０日

Fugure from CRC Status and Future project report of 2010

GUNDAM

SMILE


CALET

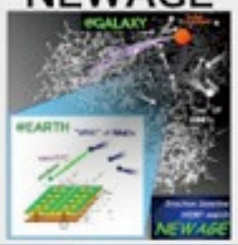
Tibet AS+MD+YAC

JEM-EUSO

Solar-Terrestrial Environment

広汎な宇宙線物理学の研究対象と周辺分野

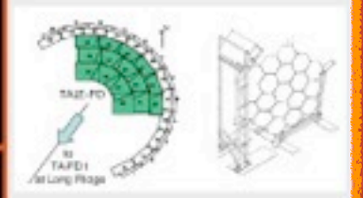
NEWAGE




TA-phase2

XMASS

TALE




天体物理

銀河系外天体

銀河系内天体

高エネルギー天体
（超新星、ブラックホール、ガンマ線バーストなど）

太陽

銀河団、宇宙の大規模構造

ダークマター

宇宙物理

宇宙線物理学

X線、γ線

地球物理

宇宙初期

重力波

高エネルギー粒子

地球

宇宙線と大気の相互作用

DECIGO

ニュートリノ

素粒子物理

新粒子の発見の歴史
（反粒子、中間子、sクォークなど）

宇宙線生成核種

地球の放射線

CTA

LCGT

GADZOOKS!

Hyper-Kamiokande

KamLAND-Zen
KamLAND2-Zen
SuperKamLAND-Zen

IceCube/ARA

LHCf

# COMMUNITY PUSH PROJECTS...

Science Council of Japan is organization under the jurisdiction of the Prime Minister for the purpose of promoting and enhancing the field of science.

Science community as like CRC feed back from/to the council.

In establishing "Master Plan" for the large project, two CRC related projects are remarked :

- LCGT(KAGRA, Gravitational Wave Observatory)
  ==> Now under the construction
- **Hyper-Kamiokande**

# SUBCOMMITTEE FOR FUTURE PROJECTS

A subcommittee have been organized for the promotion of next project and for a strategic studying of future plan candidates.

Subcommittee booted at June 2011
and it approved as 'standing committee' by Sep.2011.

Subcommittee consists of ;

- members from CRC executives,
- some persons who does not belong to CRC,
- some experts from CRC

## Town hall meeting

CRC started to host "town hall meeting" to have a dialog interactions between society peoples to share the current statuses of future plan candidates and to form a consensus for near future.

# TOWN HALL MEETINGS FOR 'FUTURE' PROJECTS

2011/7/30 **1st** town meeting with 8 future projects of medium size

2011/8/15 CRC proposed projects and open the summary report of 2010

2012/1/22 **2nd** town meeting on Gamma-ray astronomy

2012/6/30 **3rd** town meeting on Ultra-high energy cosmic ray

2012/7/22 **4th** town meeting on Non-accelerator underground experiments

At 2nd-4th town meeting, we invite not only CRC experiments but also reviewers from related researchers including theory.

http://www.icrr.u-tokyo.ac.jp/CRC/townmeeting/

in this autumn : **interim report** issued by sub-committee

# 8 FUTURE PROJECTS OF MEDIUM SIZE

## Gamma-ray astronomy

- TibetAS+MD+YAC
- CTA

## Ultra-high energy cosmic ray

- Telescope Array 2
- JEM-EUSO
- IceCUBE/ARA

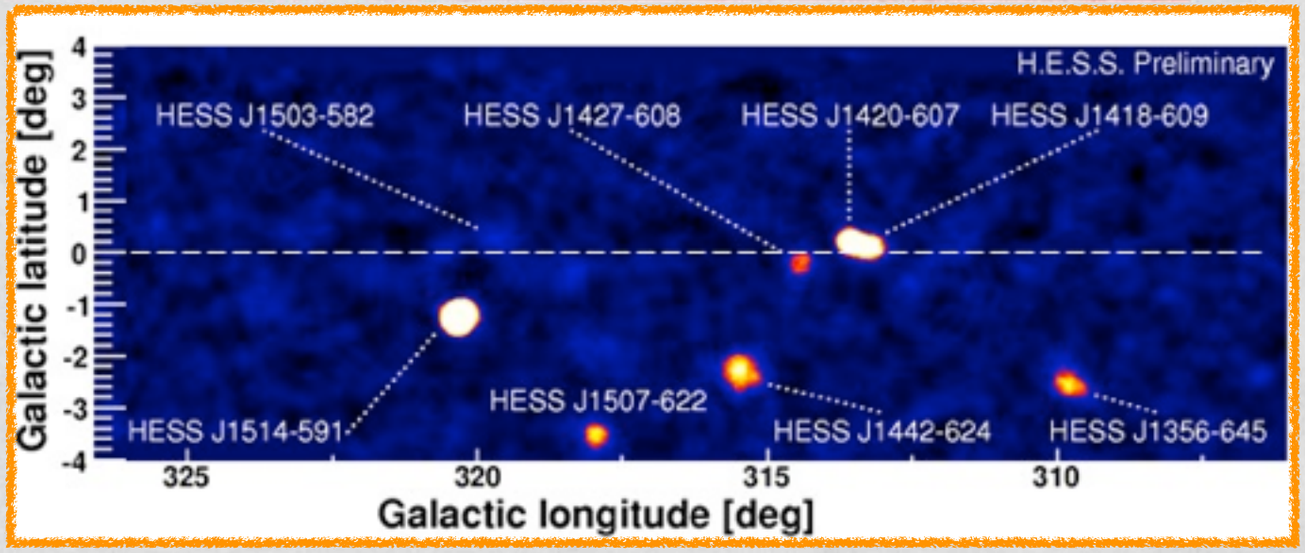
## Non-accelerator underground experiments

- XMASS-1.5
- GADZOOKS!
- KamLAND2-Zen
- ( Hyper-Kamiokande ) <= This is NOT medium size, but we picked up at town meeting

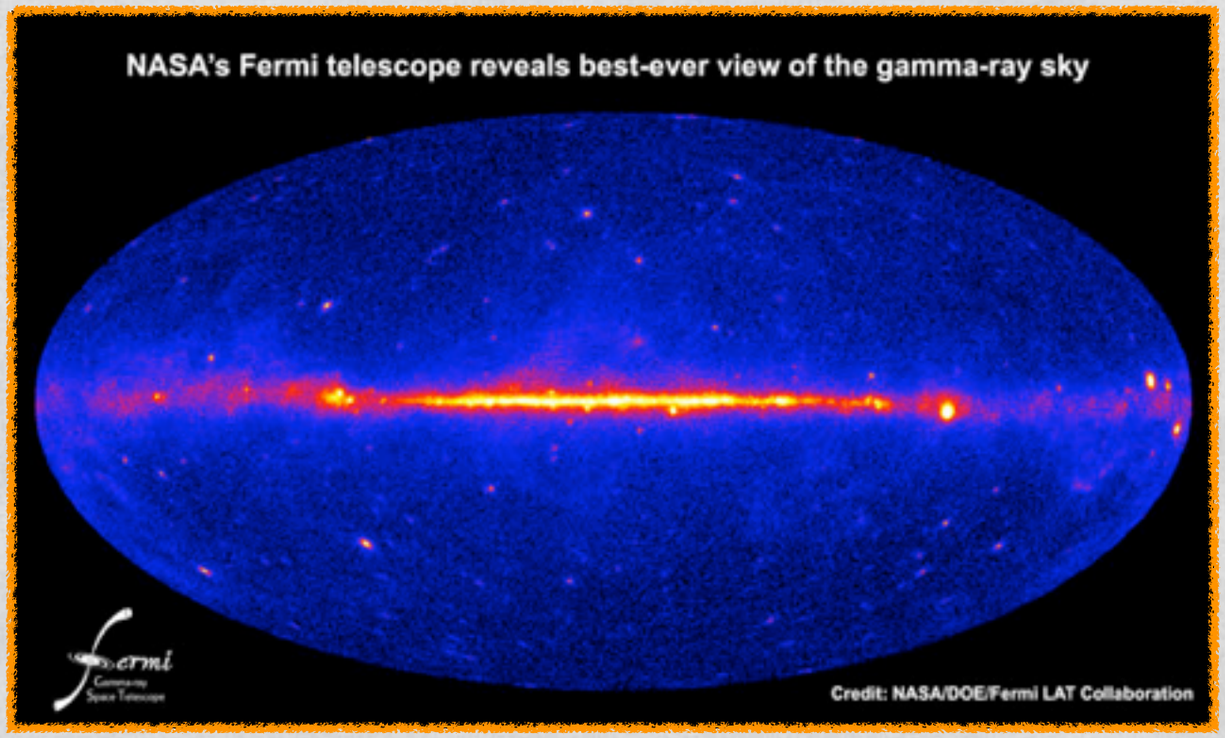
# GAMMA RAY ASTRONOMY

Gamma ray astronomy had big progress by HESS, Fermi (and by development efforts of many previous detectors/ researchers).

Now we would like to see much more and more!




HESS: gamma ray sky



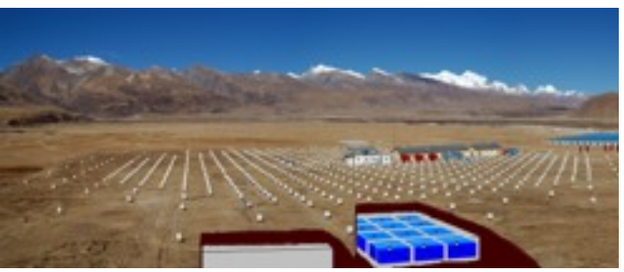
# Tibet AS+MD+YAC

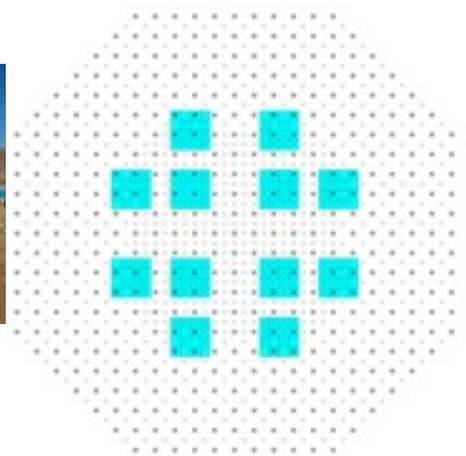
Tibet AS(~8.3万m²)
+MD( ~10⁴m²)

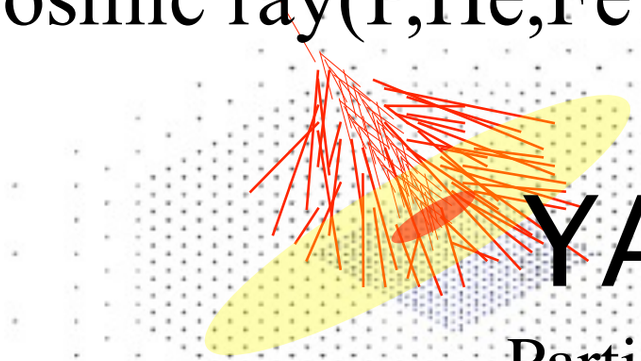
100TeVγ Cosmic ray(P,He,Fe…)

Knee p, He, Fe

Tibet AS+YAC
(1~5千m²)





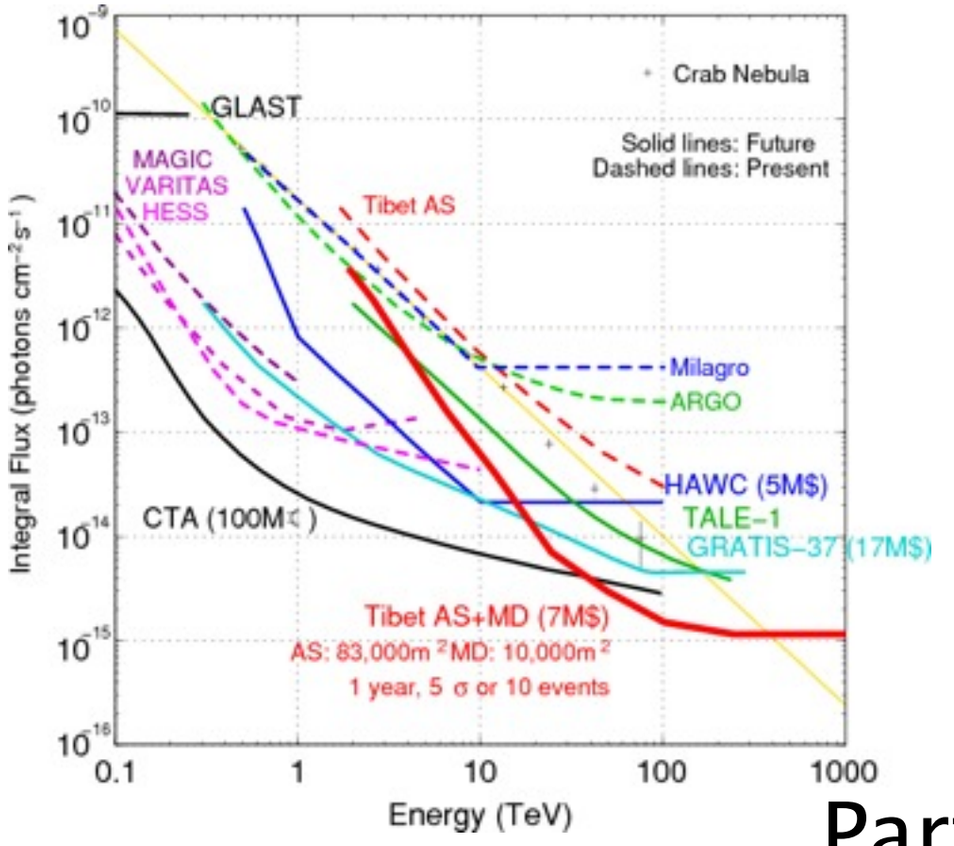


YAC

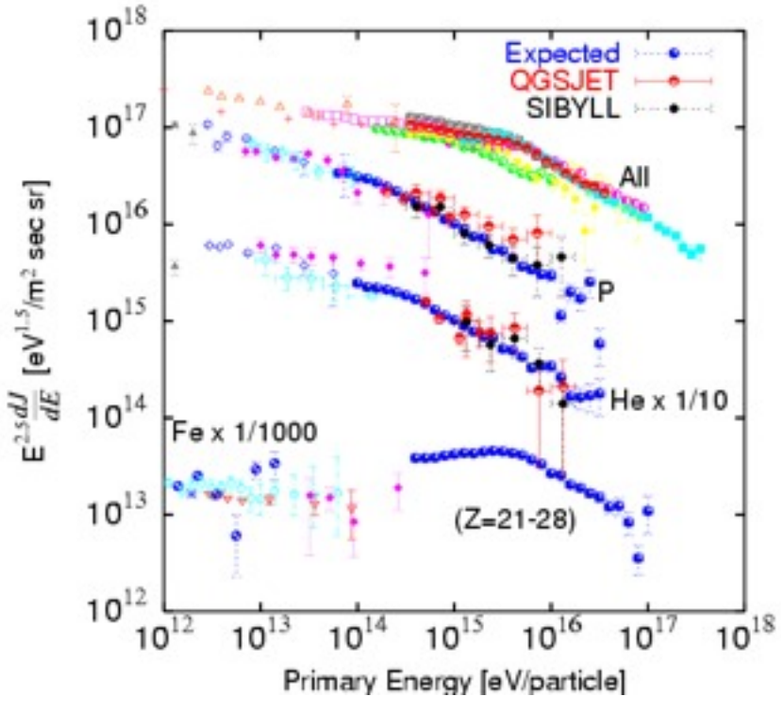
Particle density & spread
Separation of particles

**Tibet AS:** Energy and direction of air shower

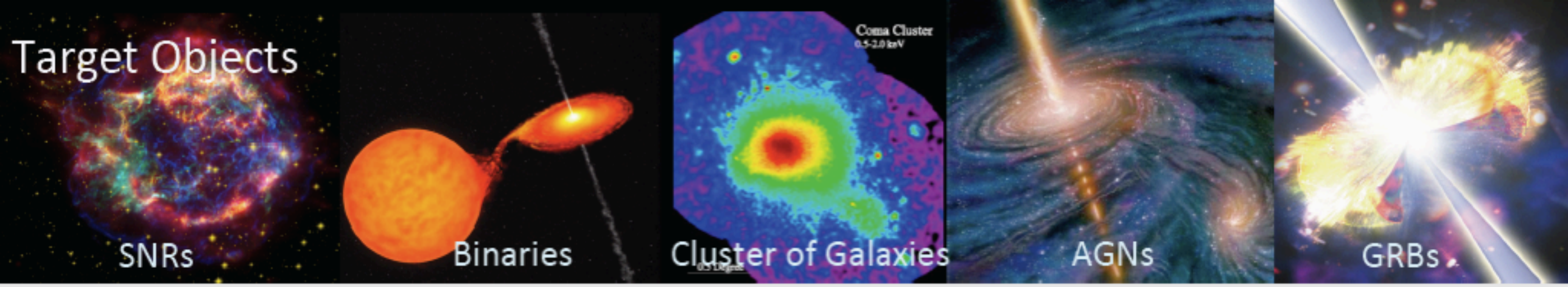
## Sensitivity of Tibet AS + MD to γ rays




## YAC expected (Blue)



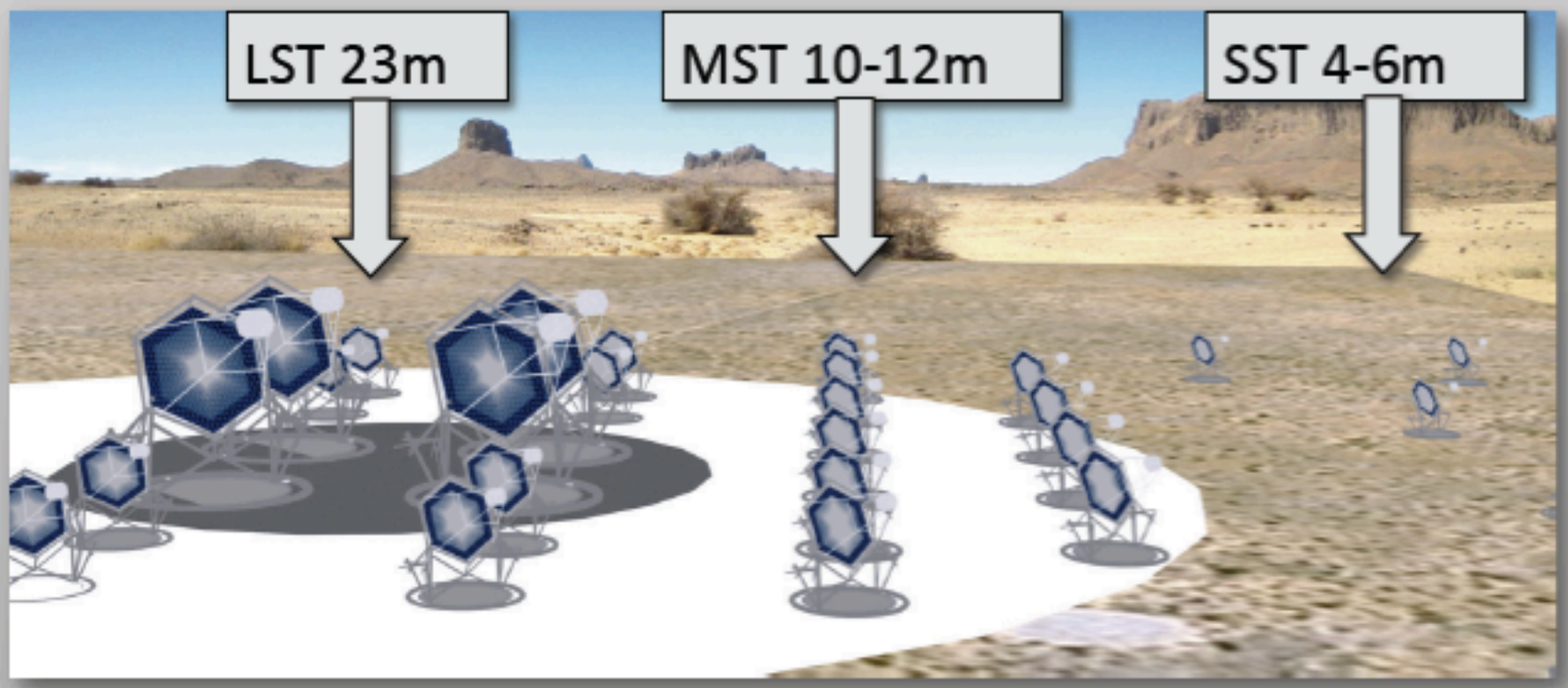

Part of MD&YAC under construction



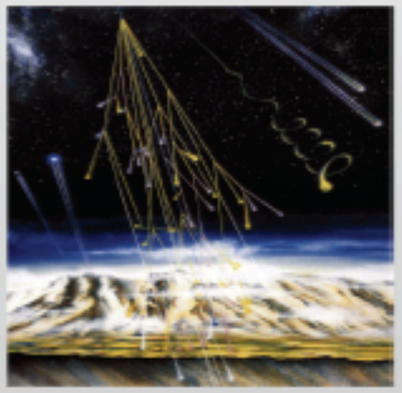

# Cherenkov Telescope Array
# VHE Gamma Ray Astronomy

- 10 times better sensitivity than H.E.S.S. and MAGIC
- 3 times better angular resolution
- Wide Energy coverage (20GeV-100TeV)
- Access Deep Universe (z<3)

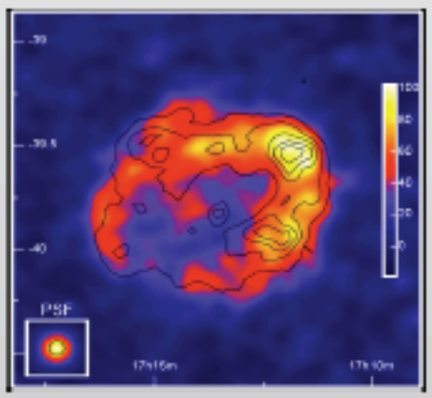
- 1000 galactic and extragalactic sources



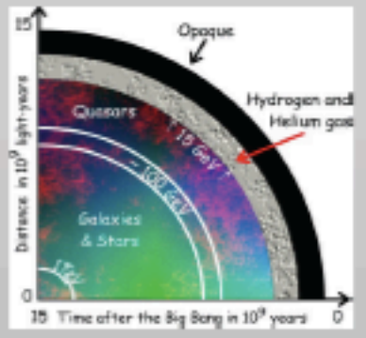

## Science case



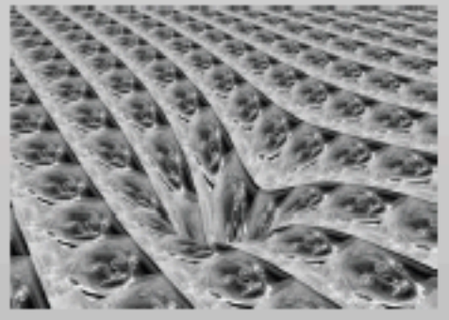
Origin of Cosmic Rays



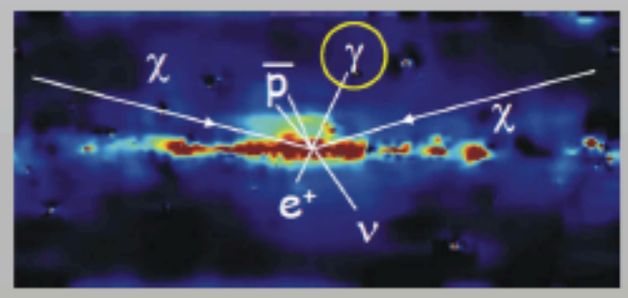

High Energy Sources




Star formation



Space and Time




Search for DM

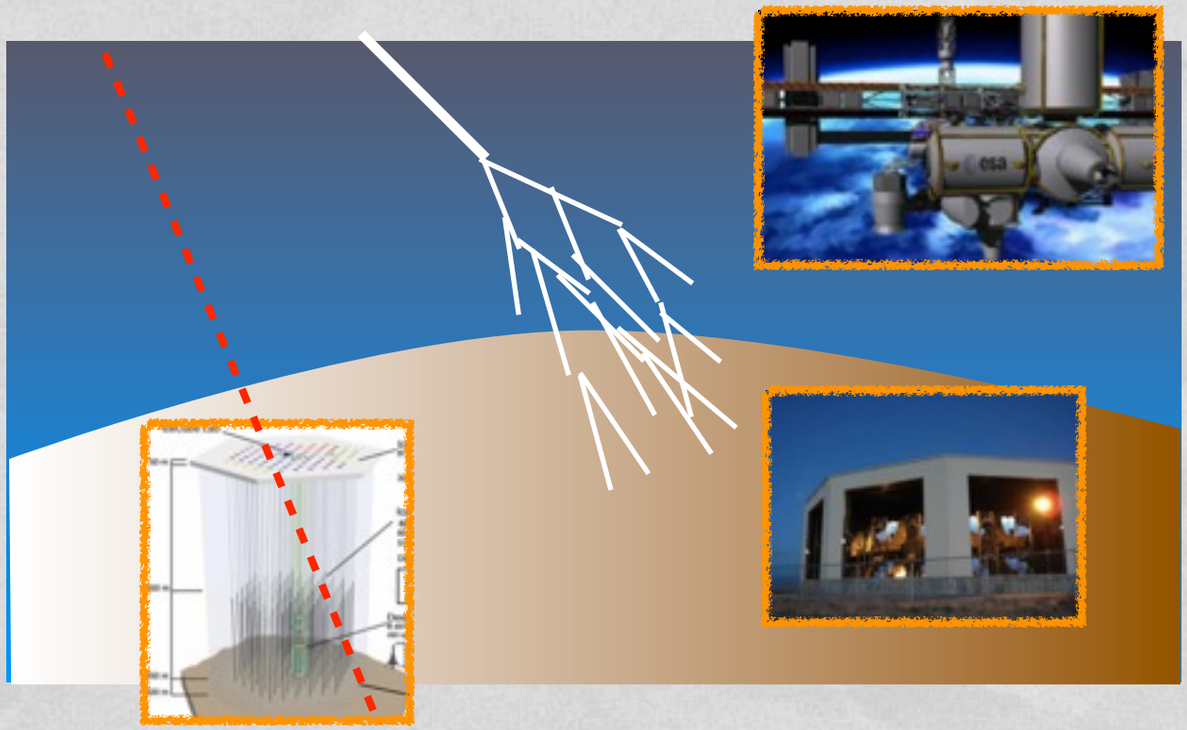
# ULTRA-HIGH ENERGY COSMIC RAY

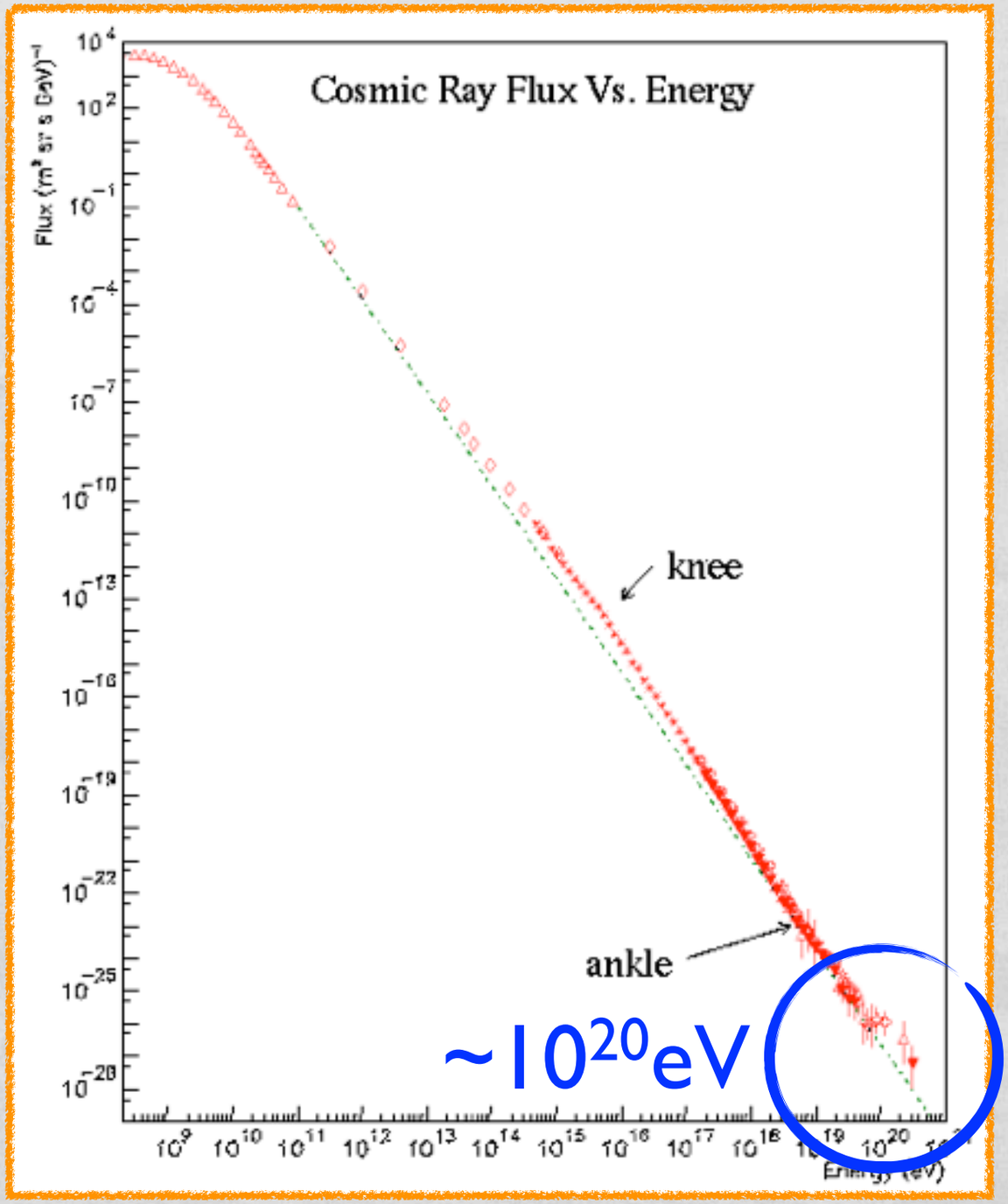
## GZK mechanism

$$\gamma_{\mathrm{CMB}} + p \rightarrow \Delta^{+} \rightarrow p + \pi_0$$

$$\gamma_{\mathrm{CMB}} + p \rightarrow \Delta^{+} \rightarrow n + \pi_{+}$$

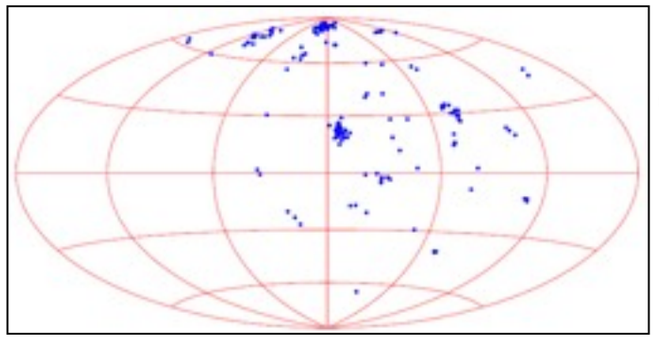
- Highest energy cosmic ray?
- GZK neutrino?





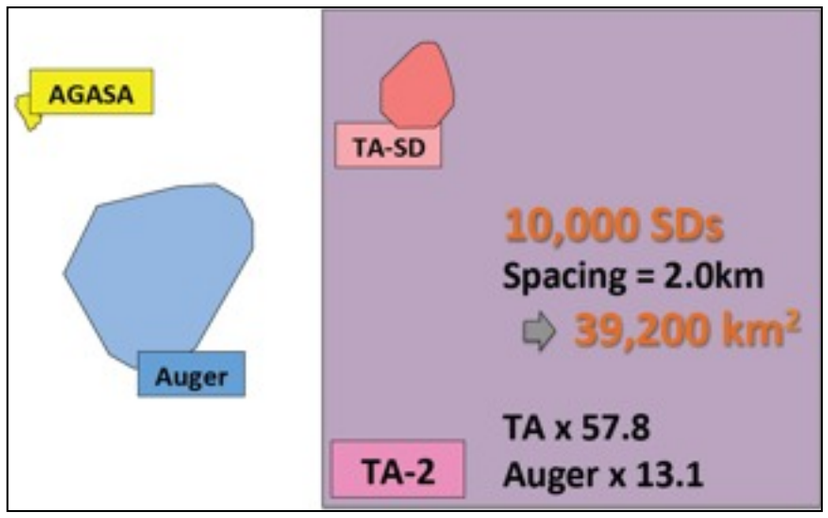
# Telescope Array 2
## (Huge Air Shower Ground Array)

- The current TA result: consistent with proton GZK model → charged-particle astronomy

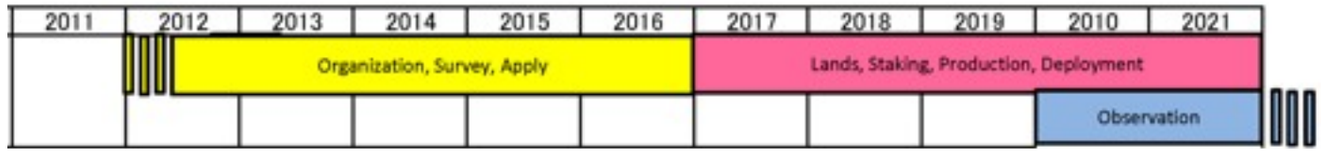


Expectation of the sky map of UHECRs above $10^{20}$ eV for $2\times10^{-4}$ $MC^{-3}$ from 5-year TA2 observation

- TA2: 10,000 SDs with 2 km spacing
  - ~40,000 $km^2$ (~60xTA)
  - SDs with possibly techniques to identify mass composition
  - ~100M$ (~30M$ from Japan)



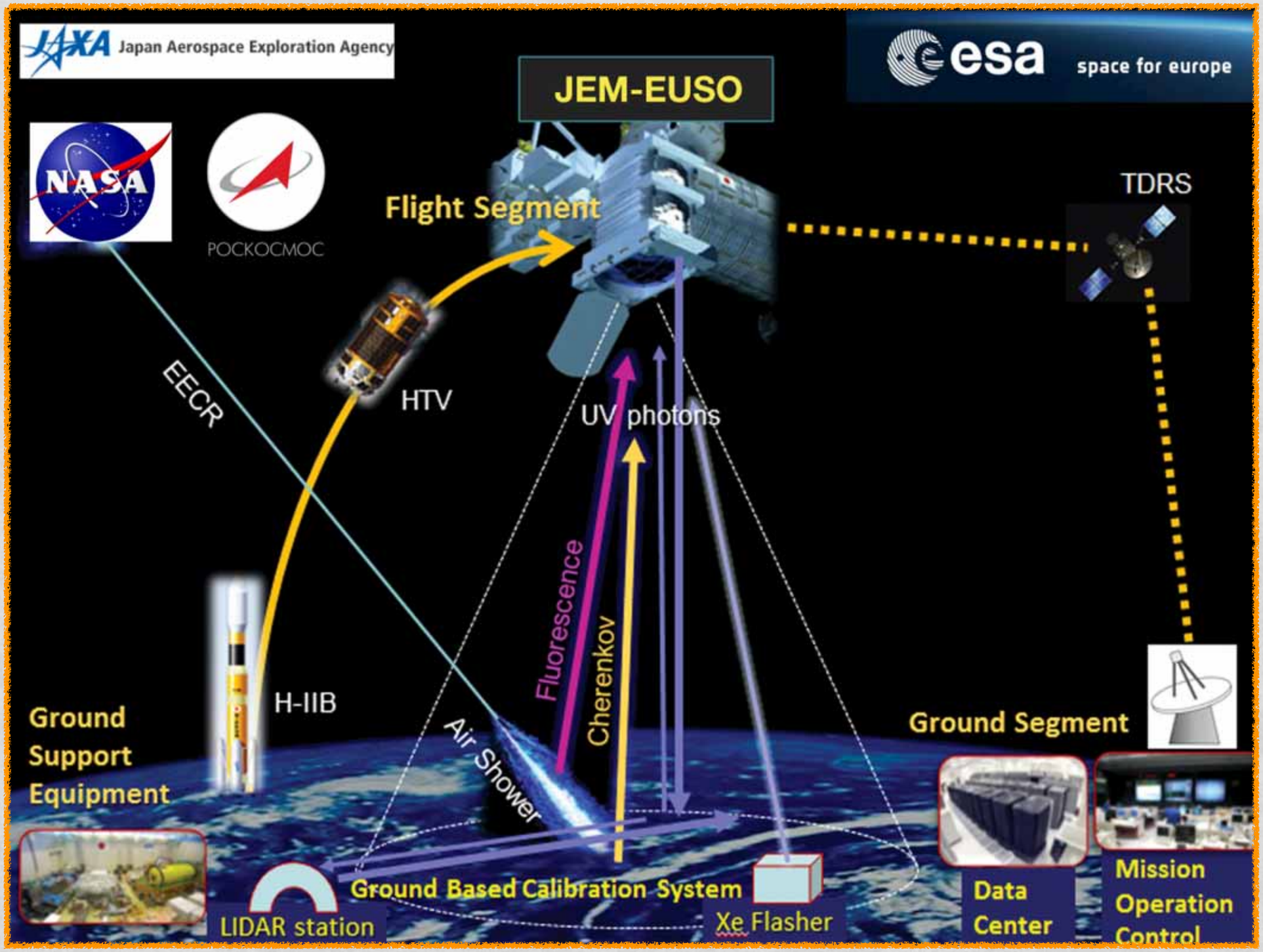

- Schedule
  - TA/Auger exchange (analysis/detector): JFY2012 – 2016
    - Resolve the discrepancies between TA and Auger
  - TALE: JFY2013 - 2017
  - TA2: production in JFY2017



# JEM-EUSO
# DOING ASTRONOMY BY LOOKING DOWN TO THE EARTH

Extream Universe Space Observatory
+
Japan Experiment Module of ISS

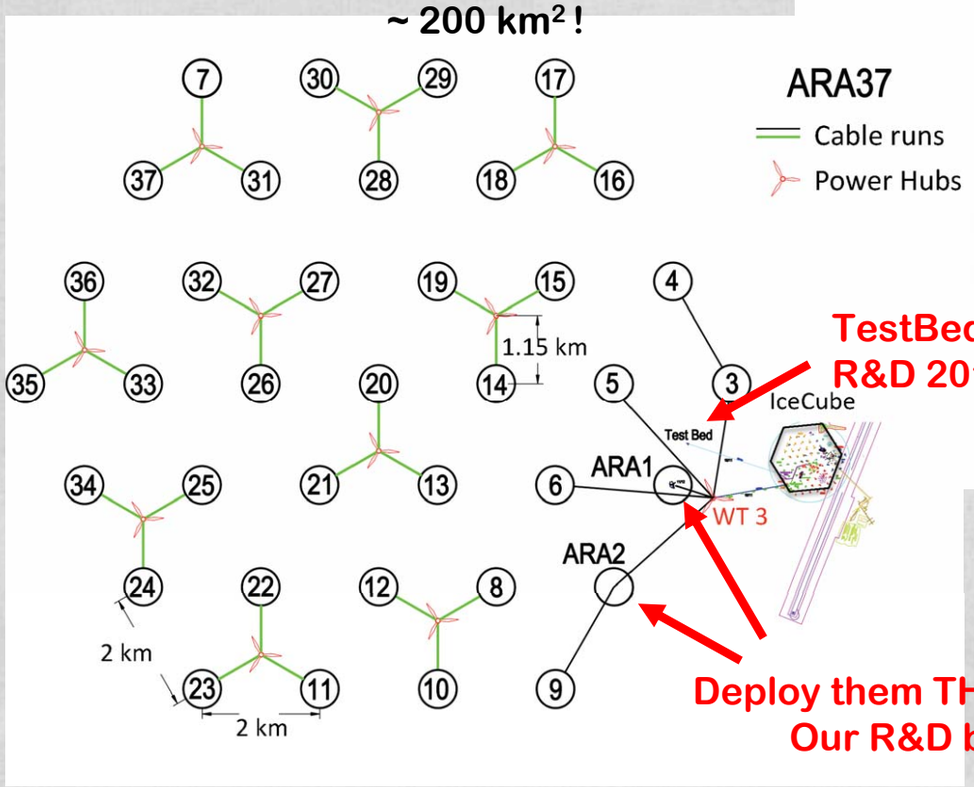
- Huge exposure!
- International collaboration (77 institute, >250members)



# IceCube/ARA

## IceCube extension plan with Askaryan Radio Array

~ 200 km² !

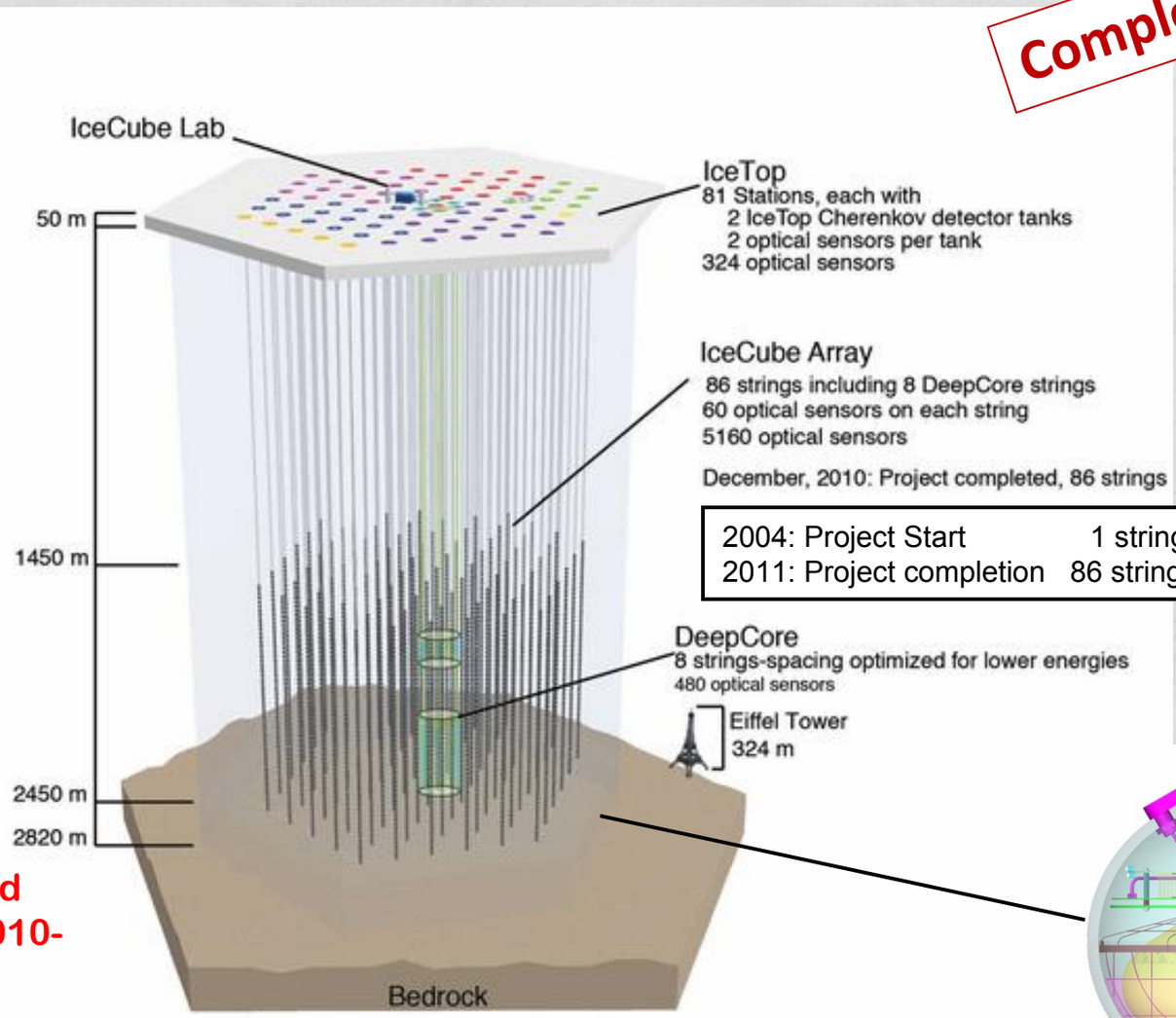



TestBed R&D 2010-

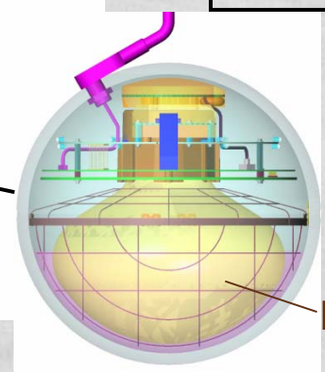
Deploy them THIS YEAR!
Our R&D base

## The IceCube Neutrino Observatory

Completed: Dec 2010




Configuration chronology
2006: IC9
2007: IC22
2008: IC40
2009: IC59
2010: IC79
2011: IC86



PMT

Digital Optical Module (DOM)

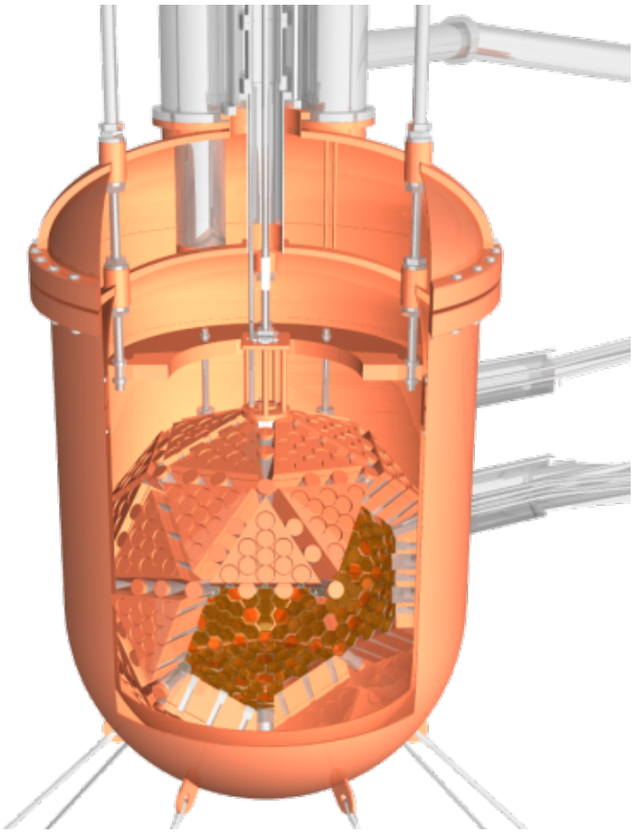
# NON-ACCELERATOR UNDERGROUND EXPERIMENTS

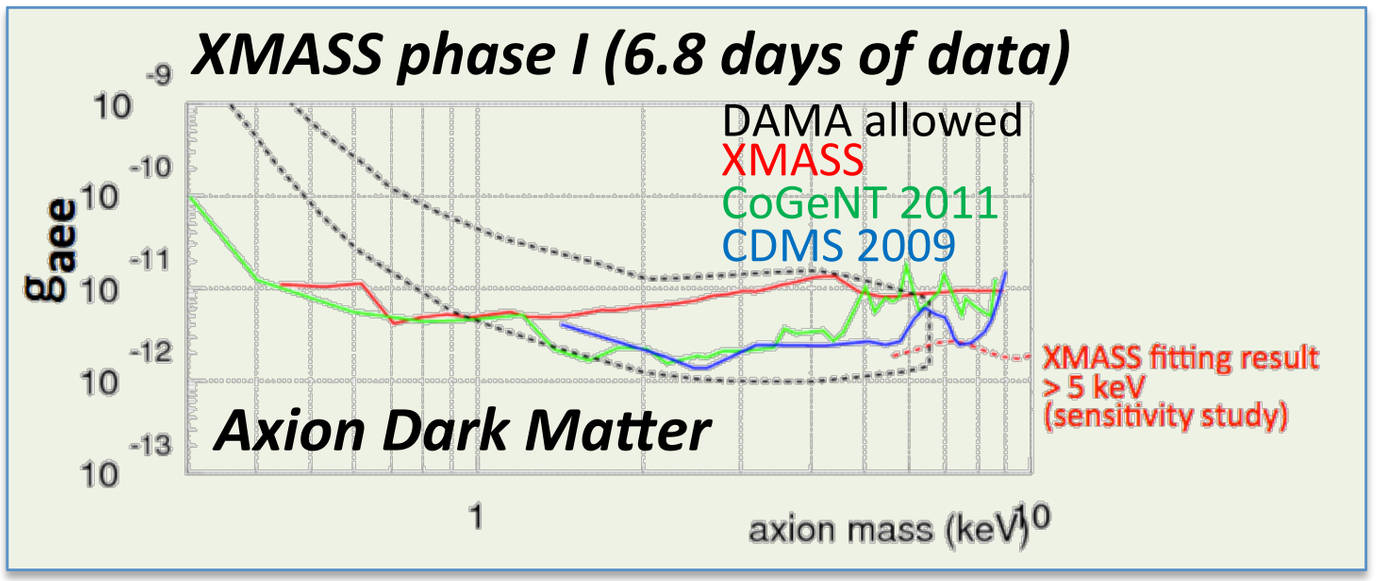
Underground is stable, silent, shielded for low energy cosmic rays, and isolated – good environment for precise experiments.
Thus, we can proceed experiments for

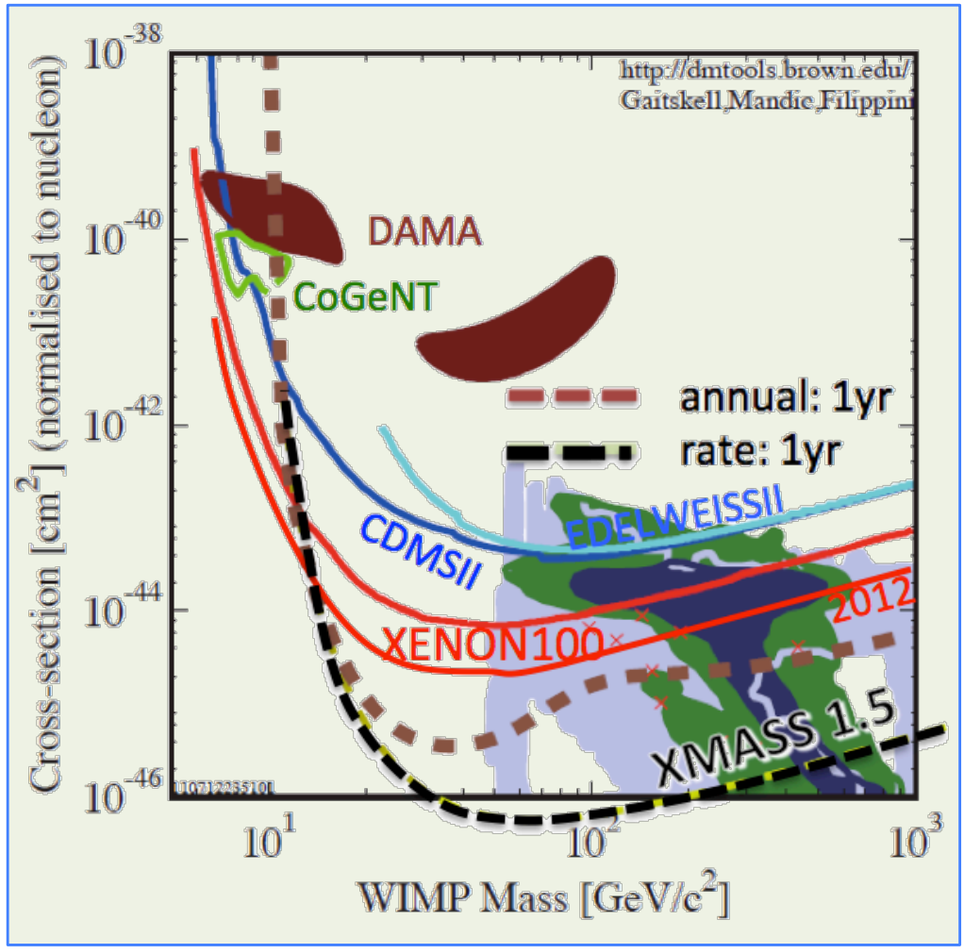
- Neutrino
- Double beta decay
- Dark Matter
- (Gravitational Waves)
- etc.

# XMASS 1.5 2011.08.17

- XMASS 1.5 is a total 5 ton single phase liquid Xenon detector with 1 t fiducial mass.
  - Aim to look for dark matter with a sensitivity $\sigma_{SI} < 10^{-46}$ cm$^2$ (at $m_\chi \sim 100$ GeV)
- XMASS 1.5 also have a sensitivity to low mass dark matter around a few GeV region without fiducialization analysis.
- Since XMASS also have a sensitivity to electron/$\gamma$ events, it can make a high sensitive search for Axion Like Particels and solar axions
- We expect to start data taking in 2015.

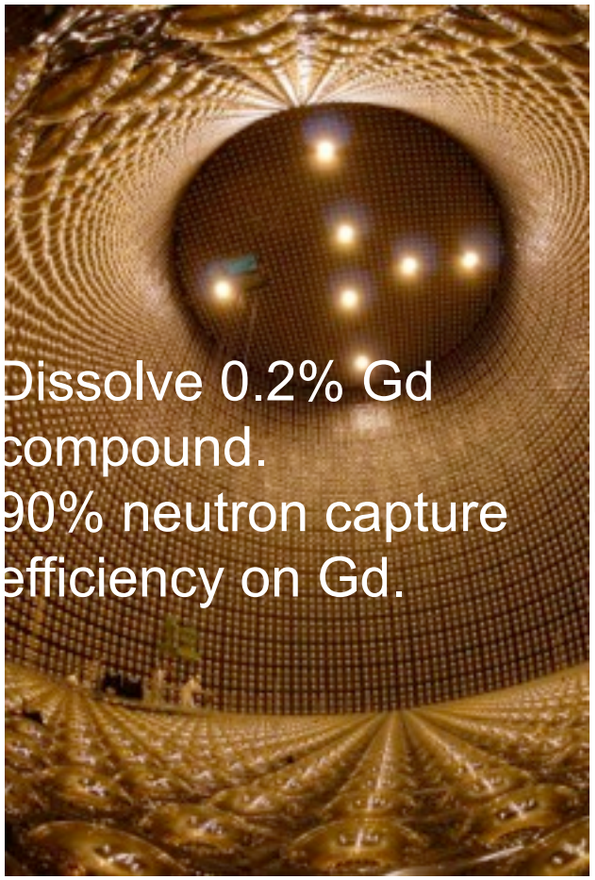


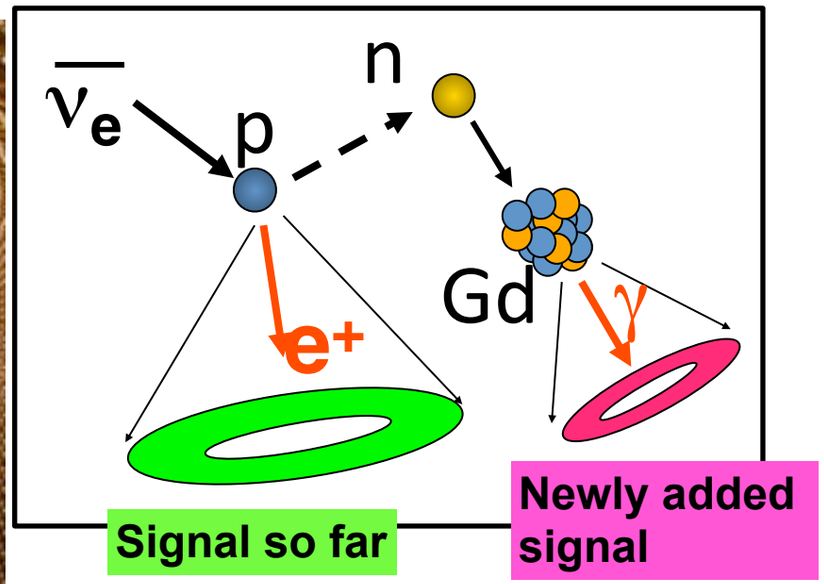


# GADZOOKS! Project

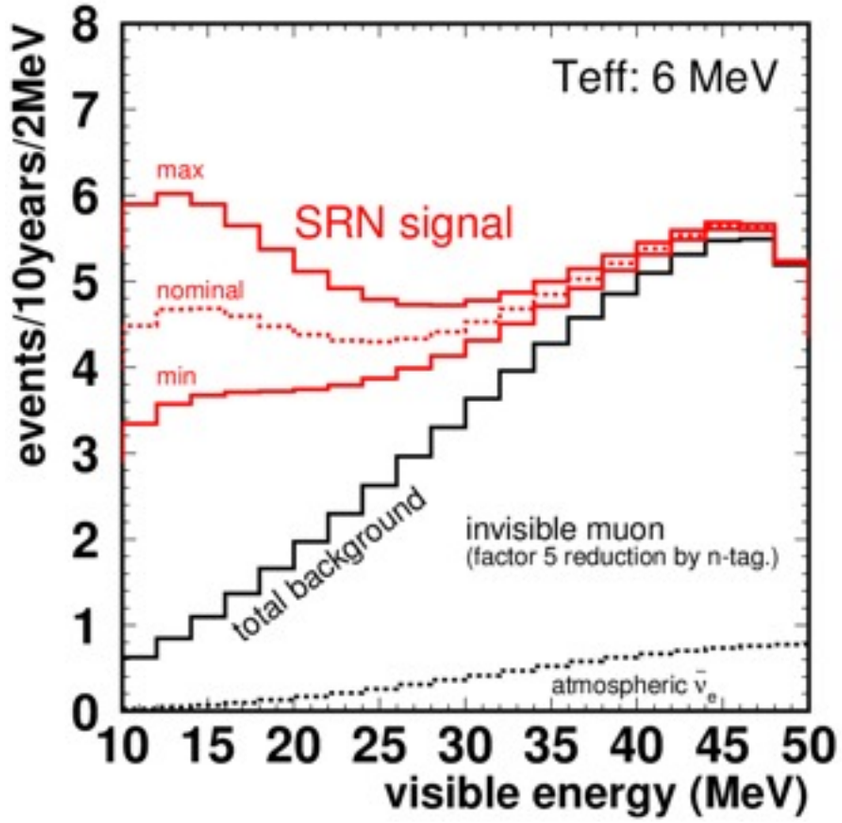
Dissolve 0.2% by mass of a gadolinium compound (e.g., 100 tons of $Gd_2(SO_4)_3$) into the 50,000 tons of ultrapure Super-K water and tag neutrons for the identification of $\overline{\nu}_e$. It will enable us to detect supernova relic neutrinos (SRN) and also enhance performance of supernova burst neutrino detection.




J. Beacom and M. Vagins,
Phys.Rev.Lett.93:171101,2004

Expected SRN signal for 10 yr SK run




In order to demonstrate feasibility of GADZOOKS!, a setup to test the Gd-loaded water Cherenkov detector was constructed and R&D studies are on going.

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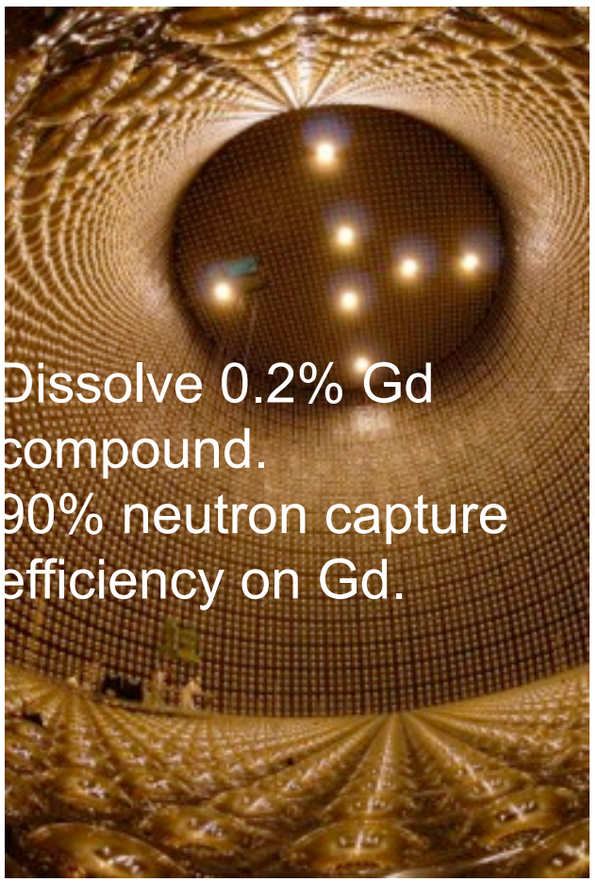


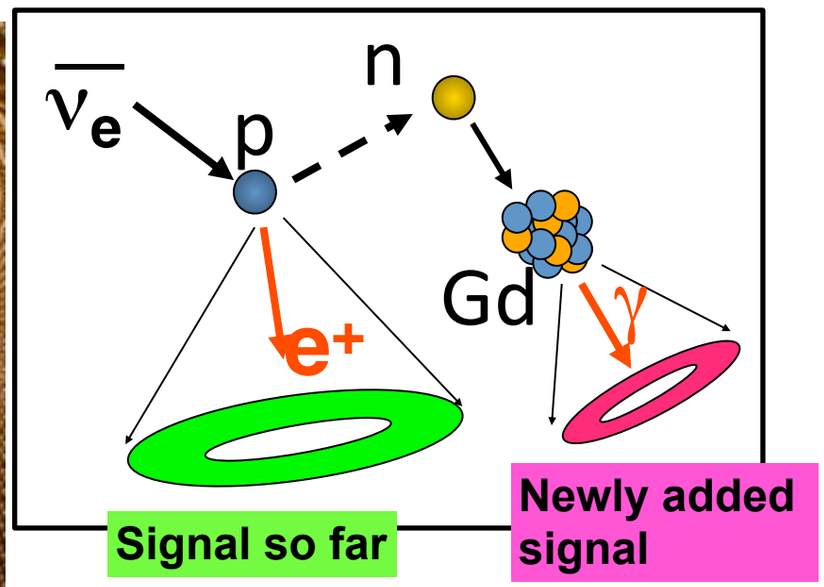


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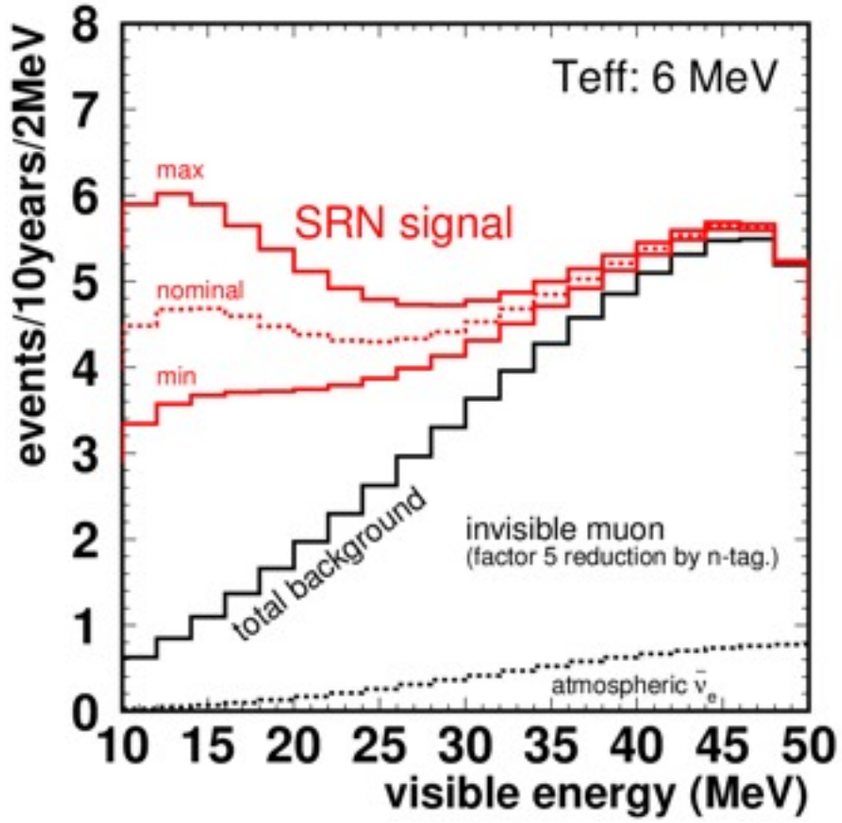


In order to demonstrate feasibility of GADZOOKS!, a setup to test the Gd-loaded water Cherenkov detector was constructed and R&D studies are on going.

- The total SRN flux will determine the cosmic core-collapse (and hence star formation) rate.

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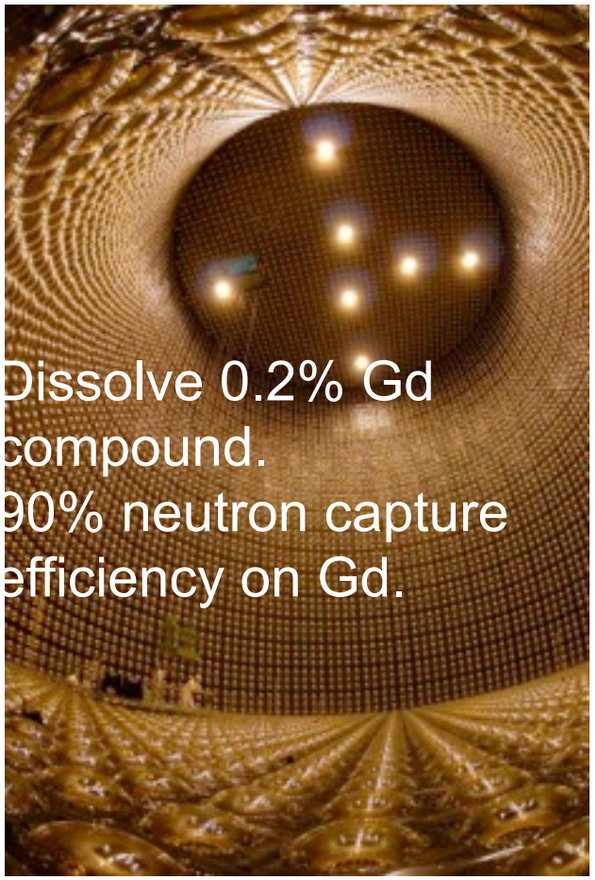


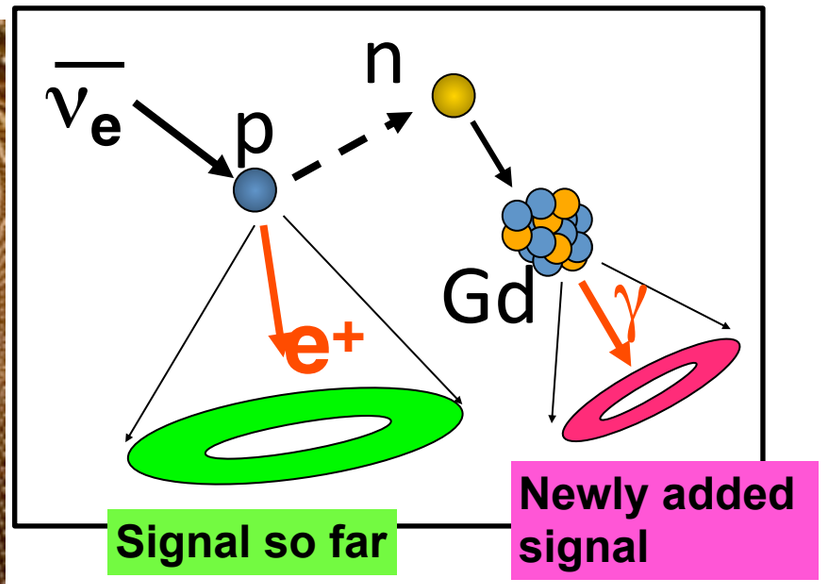


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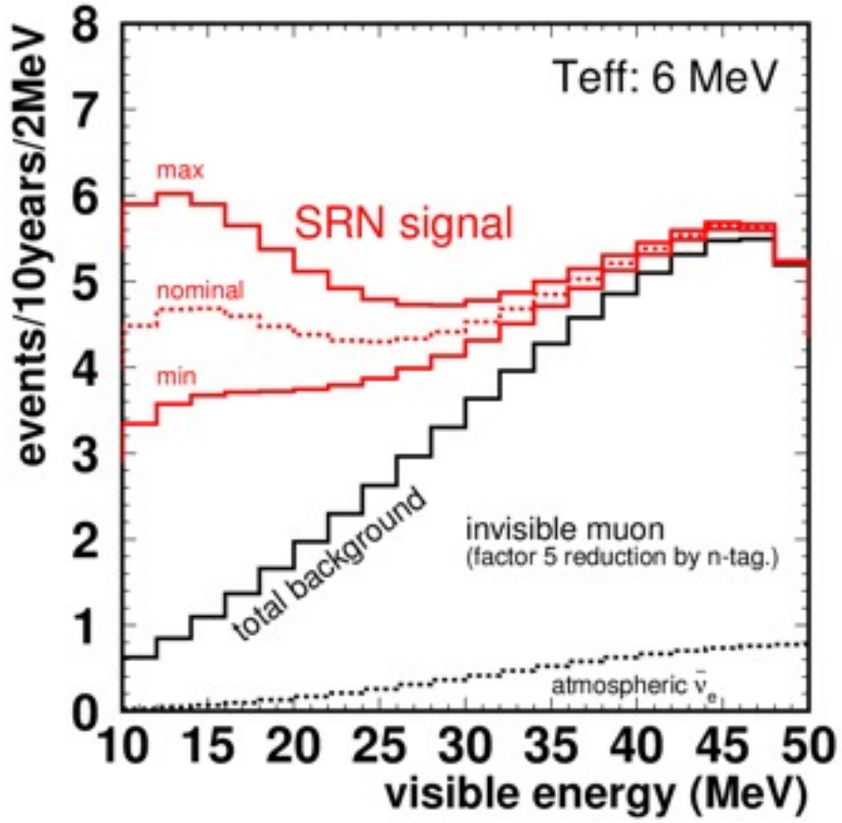
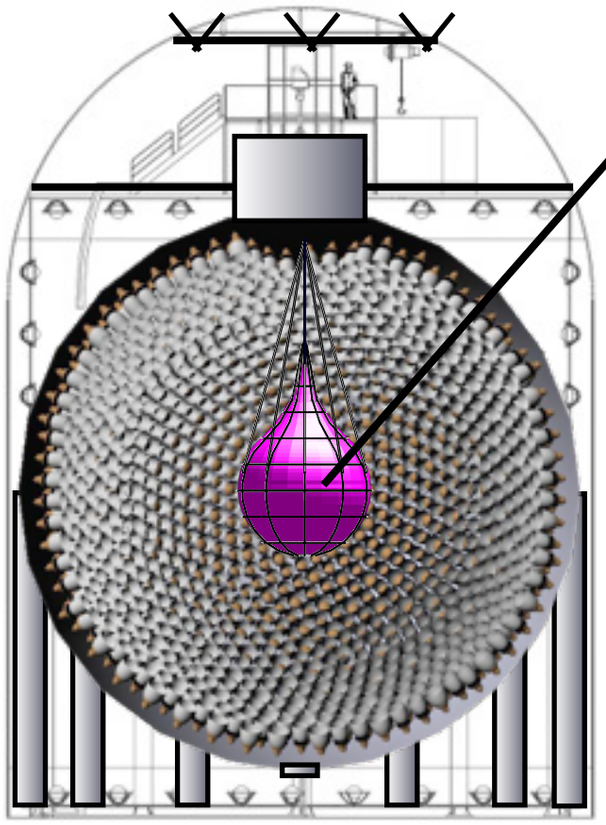



In order to demonstrate feasibility of GADZOOKS!, a setup to test the Gd-loaded water Cherenkov detector was constructed and R&D studies are on going.

- The total SRN flux will determine the cosmic core-collapse (and hence star formation) rate.
- The shape of the SRN spectrum will allow a determination of both the total and average neutrino energy emitted in core collapse explosions.

# KamLAND2-Zen



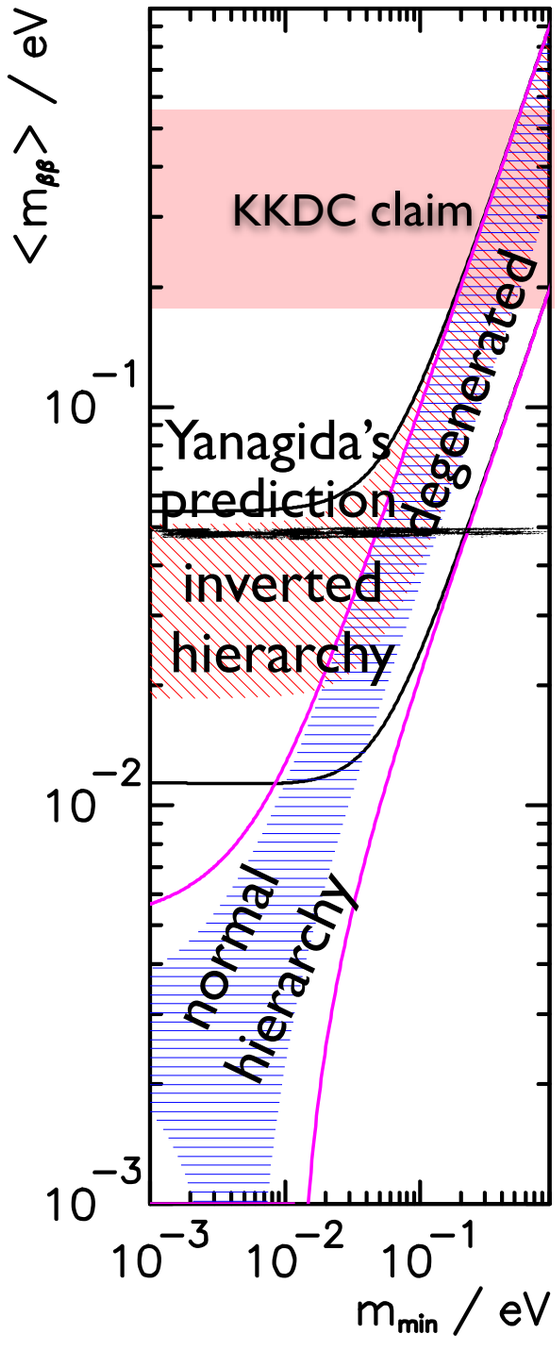
1000kg $^{136}$Xe
for 0ν2β

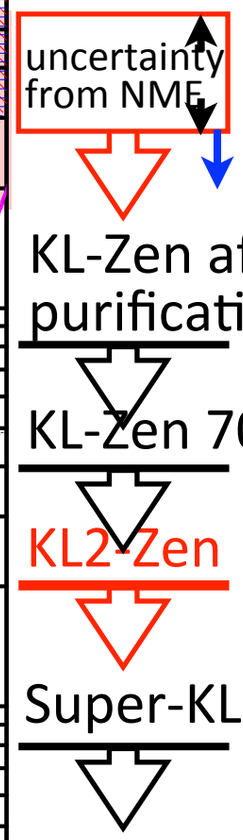
options

50kCi $^{144}$Ce
for 4th neutrino search

1000kg NaI
for DAMA verification

0ν2β milestones




KL-Zen initial
112days

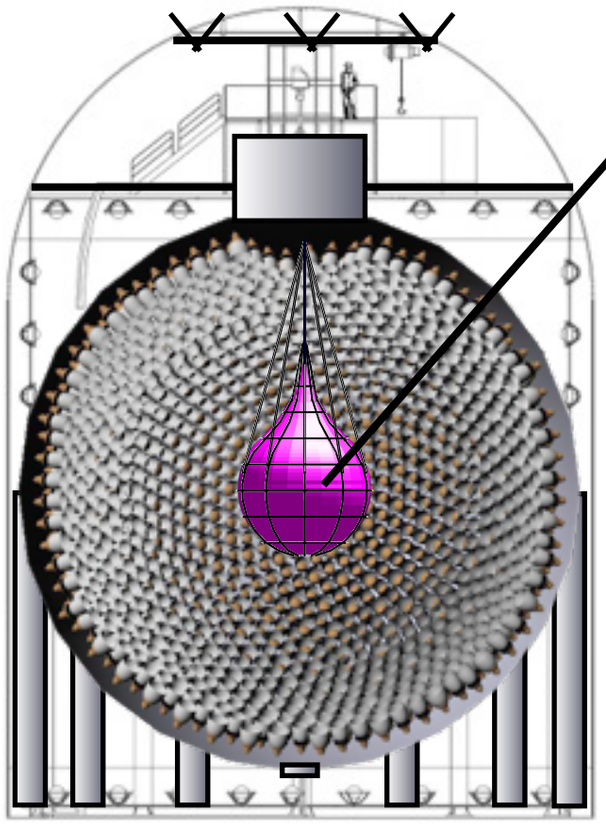
1/100 BG
($^{110m}$Ag)

$\sigma_E$=4%
→2.5%

**KamLAND2-Zen physics subjects**

double $\beta$ : $^{136}$Xe (inverted)
multiple nuclei : $CdWO_4$, $CaF_2$, Nd-LS etc
4th gen. neutrino search : 50kCi $^{144}$Ce
DAMA verification : pure NaI
solar CNO neutrino ($\nu$ astronomy)
geo-neutrino ($\nu$ geophysics)
4th $\nu$ precision measurement : cyclotron

# KamLAND2-Zen



1000kg $^{136}$Xe
for 0ν2β

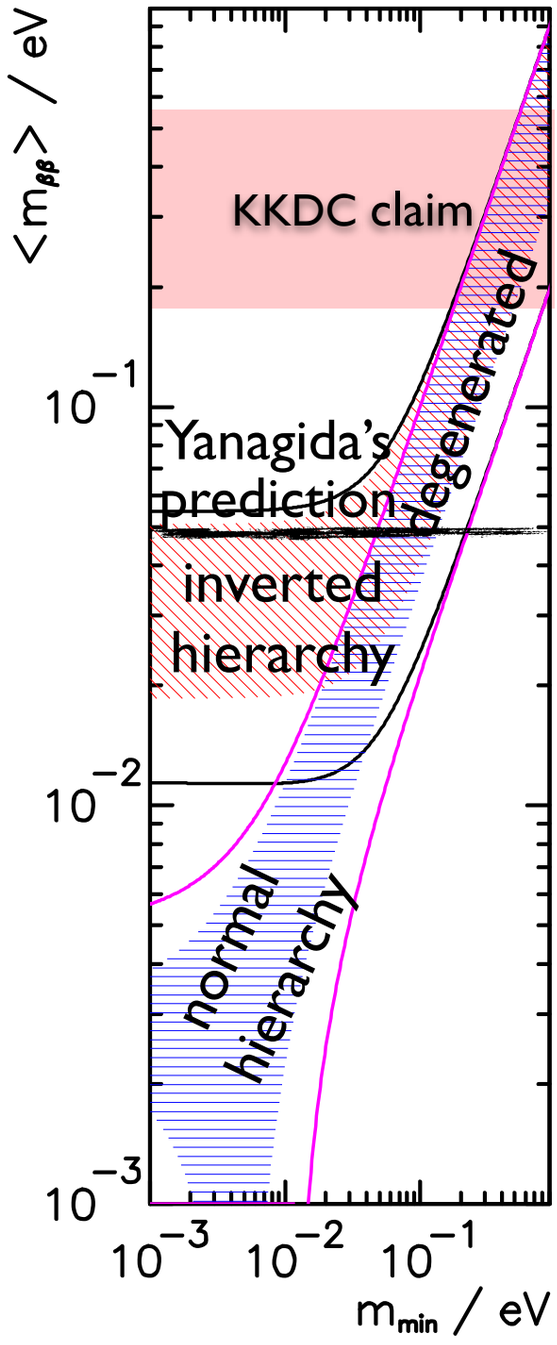
options

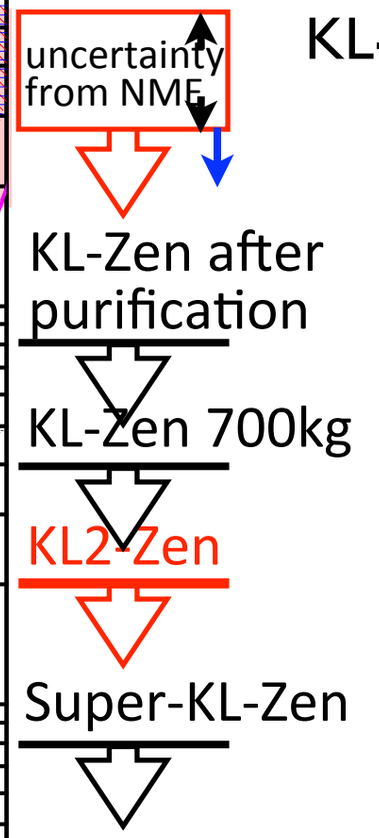
50kCi $^{144}$Ce
for 4th neutrino search

1000kg NaI
for DAMA verification

- running detector
  → relatively low cost and quick start
- huge and clean (1200m$^3$, U: 3.5x10$^{-18}$ g/g, Th: 5.2x10$^{-17}$)
  → negligible external gamma
- Xe-LS can be purified, mini-balloon replaceable
  if necessary, with relatively low cost
  → highly scalable (up to several tons of Xe)
- No escape or invisible energy from β, γ
  → BG identification relatively easy
- anti-neutrino observation continues
  → geo-neutrino w/o japanese reactors

0ν2β milestones

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# HYPER-KAMIOKANDE

Since current CRC subcommittee focus on the ‘middle scale’ projects, Hyper-Kamiokande is not included this.

However, KH have been introduced previous CRC symposiums. In 2010 report, HK is also listed as future plan.

Anyhow, the society has strong interest as a ‘big project’ of cosmic ray.

# SUMMARY
# (REMARKS OF CURRENT STATUS)

## CRC subcommittee for the future project :

- since at June 2011
- organize town hall meetings
- preparing interim report in this autumn 2012

# ONE MORE...

Supernova is very important target for Hyper-Kamiokande.
It is also very very important for current constructing big project of CRC : **KAGRA**

- Gravitational wave detector at Kamioka
- 3km laser interferometer
- High strain sensitivity
  – $10^{-24}$ [/$\sqrt{}$Hz]