

Super-K Gd Project:

EGADS実験における

超新星爆発ニュートリノの

検出システム開発



徐宸原（岡山大）



for Super-Kamiokande collaboration

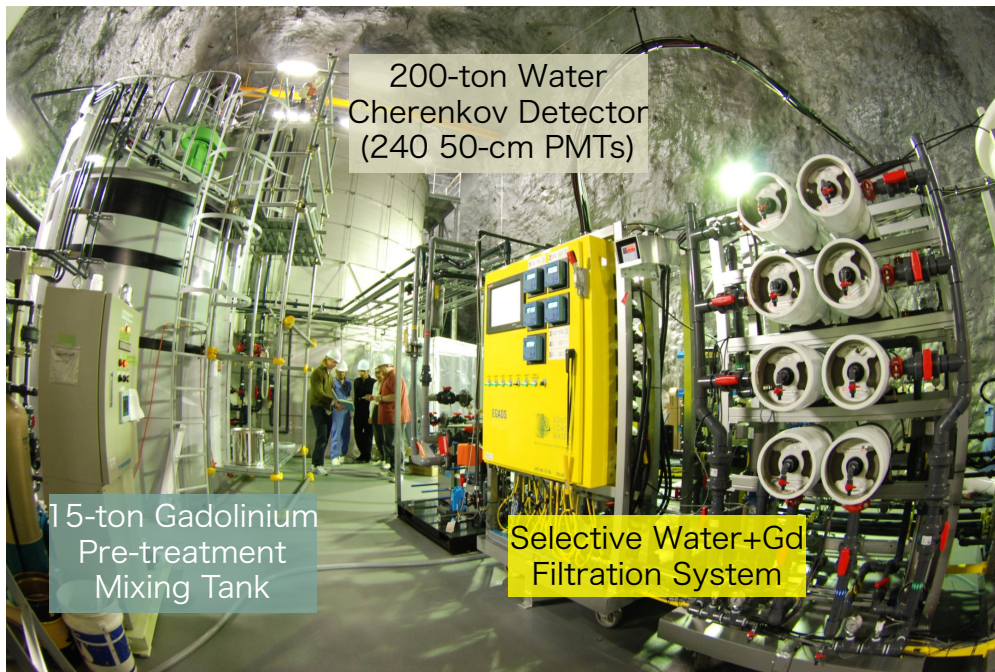
日本物理学会 2016年秋季大会

宮崎大学・9月21日

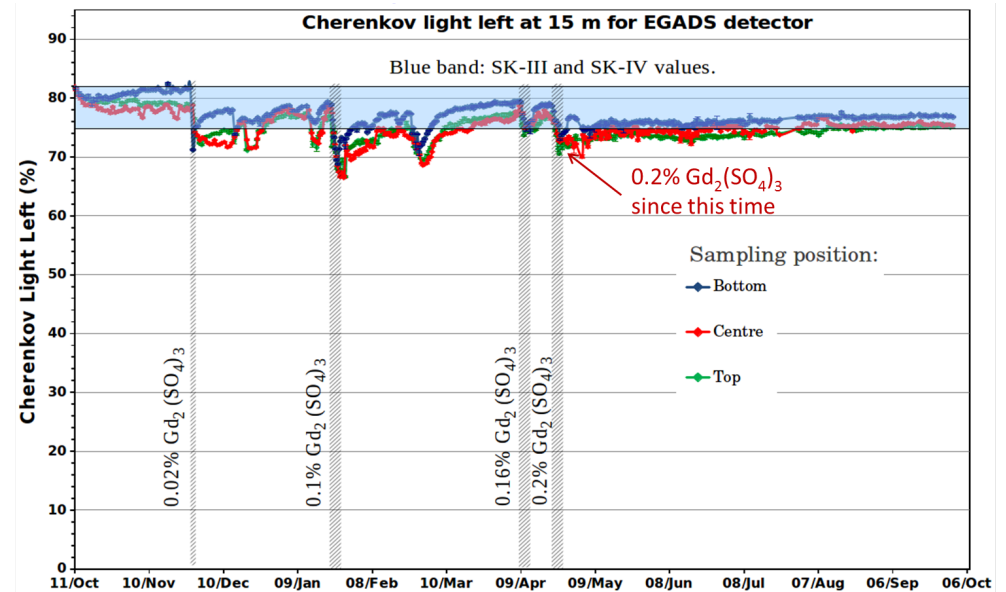
EGADS

as a R&D detector for Super-K Gd

Existing R&D Facility
EGADS (200 tons)



For example;
Water transparency with Gd loading



etc. 

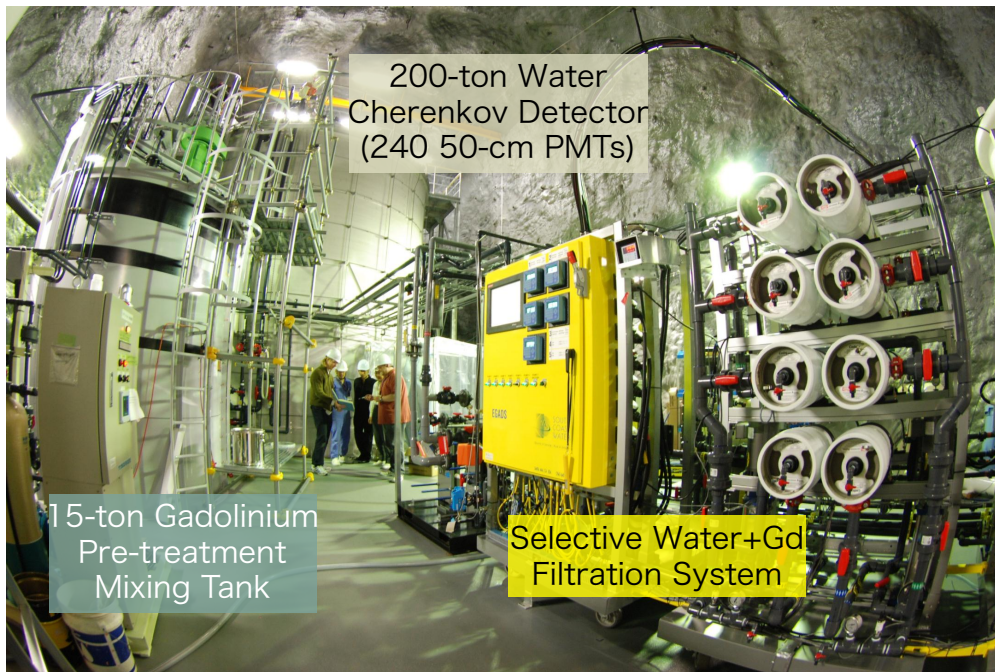
Approved by SK collaboration.

EGADS

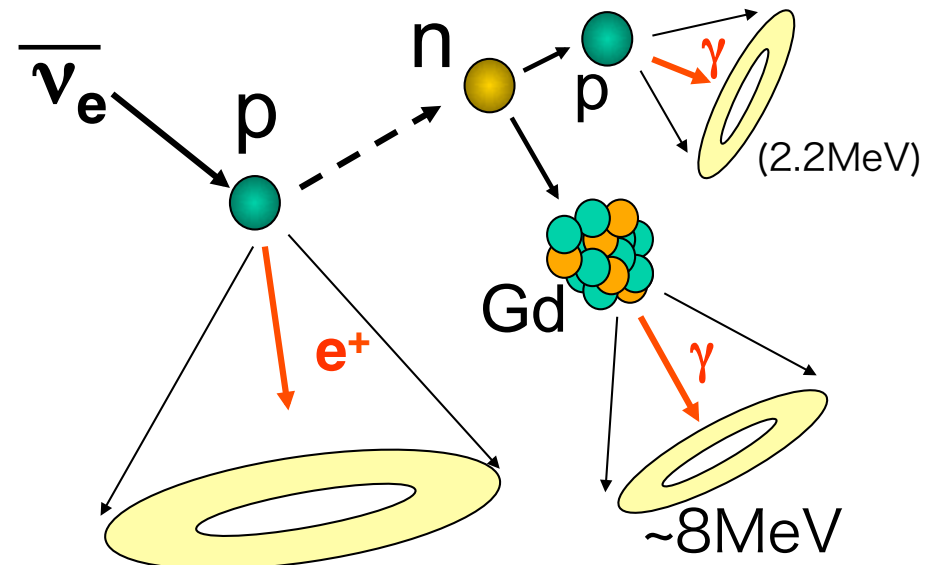
as a Supernova burst neutrino detector

Existing R&D Facility
EGADS (200 tons)

Converting into the world's
most advanced SN ν detector



Neutron tagging with delayed coincidence

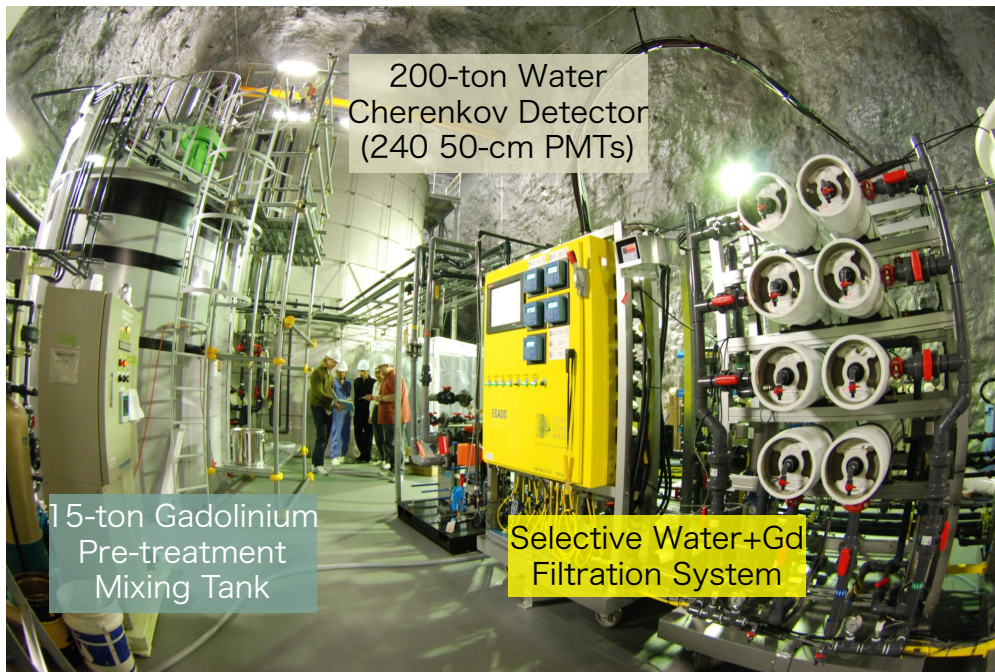


EGADS

as a Supernova burst neutrino detector

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Neutron tagging with delayed coincidence

Neutron capture time

	2178 $\pm$ 44ppm	1055 $\pm$ 21ppm	225 $\pm$ 5ppm
Data	29.89 $\pm$ 0.33	51.48 $\pm$ 0.52	130.1 $\pm$ 1.7
MC	30.03 $\pm$ 0.77	53.45 $\pm$ 1.19	126.2 $\pm$ 2.0

Neutron capture efficiency

Data	MC
84.36 $\pm$ 1.79%	84.51 $\pm$ 0.33%

(物理学会・2016年春・徐宸原)

Multi-messenger astronomy

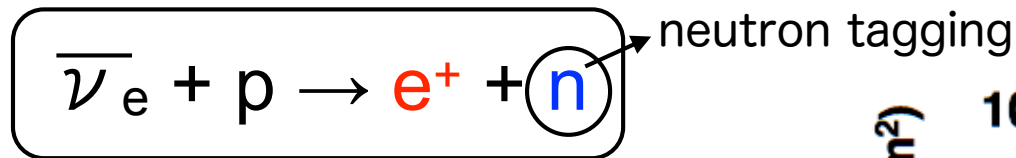
H24年度 新学術領域研究(研究領域提案型)

重力波天体の多様な観測による宇宙物理学の新展開



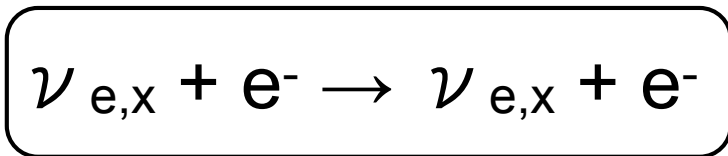
Neutrino interaction for SN ν

Inverse beta decay



Large cross section

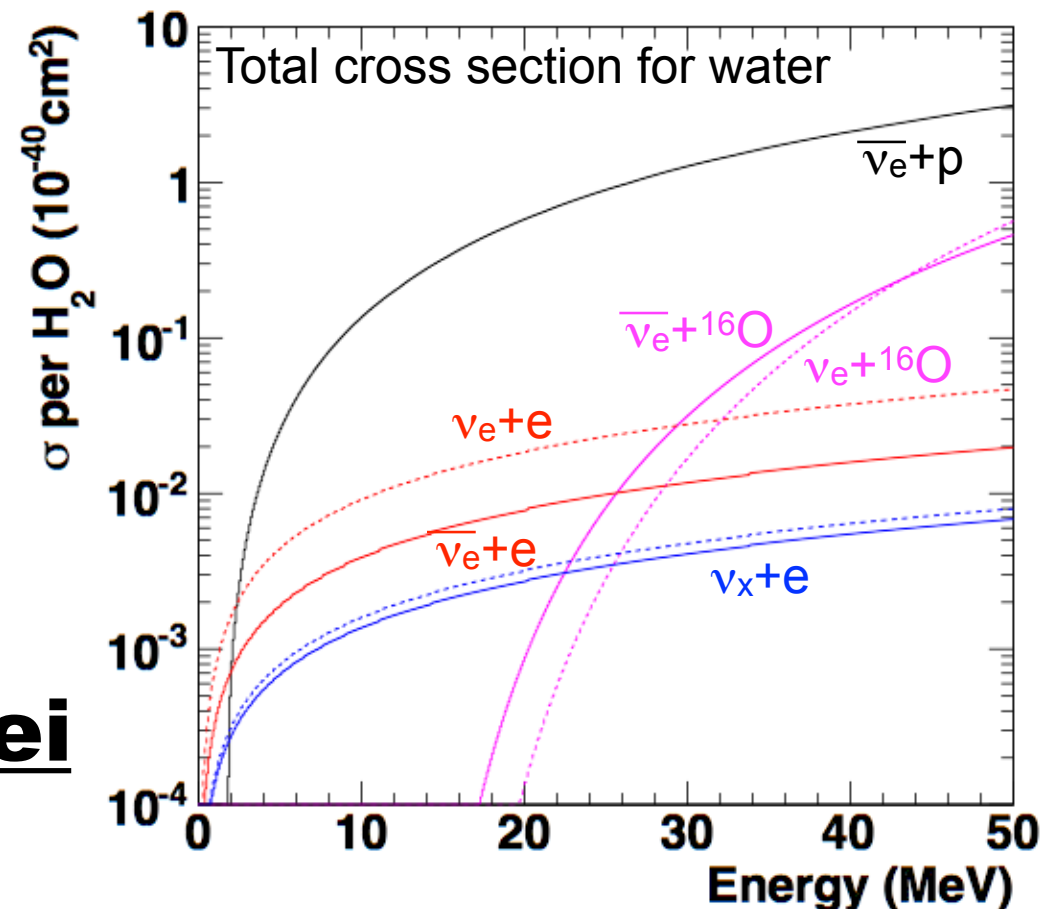
Elastic scattering



Good directionality

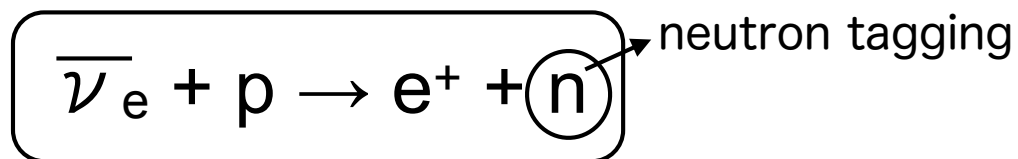
Interactions on nuclei

Both CC and NC



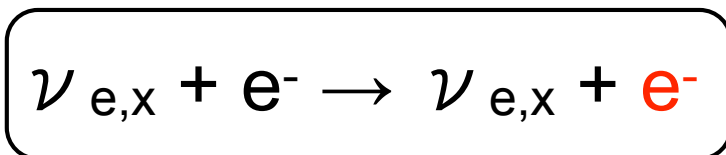
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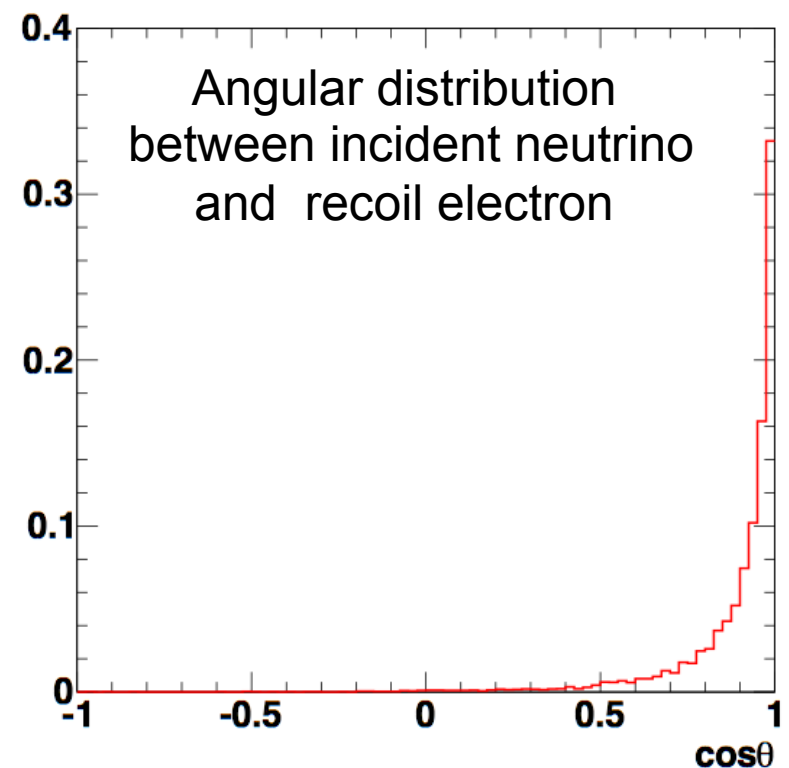
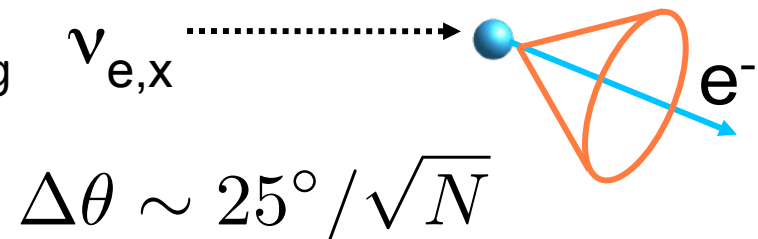


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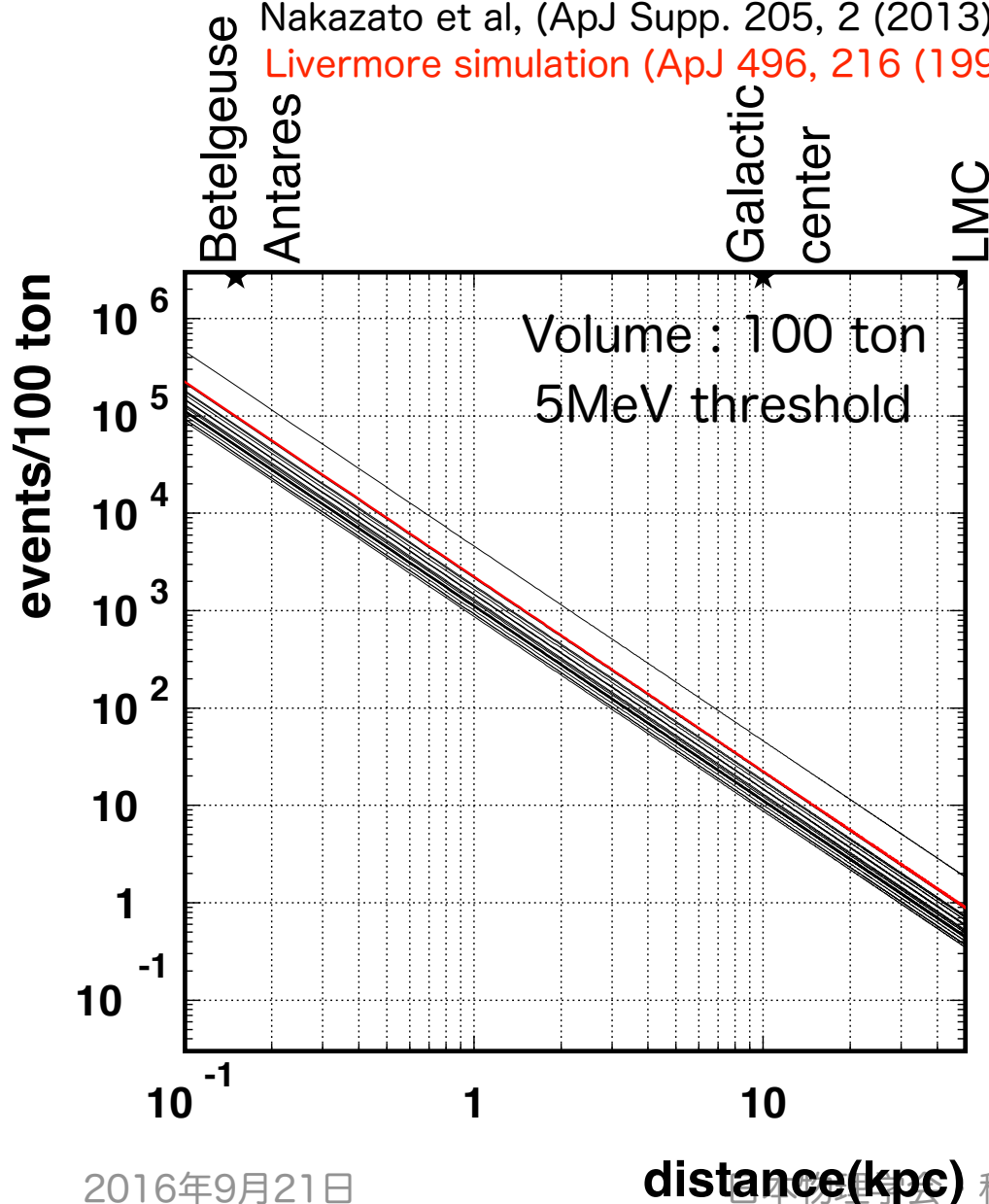
Water Cherenkov



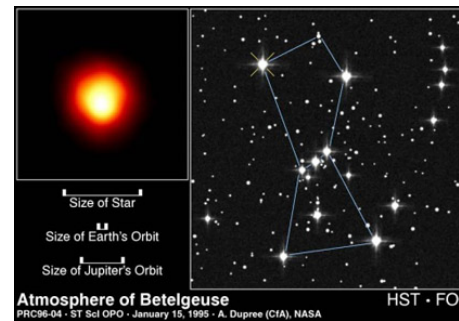
SN ν detection in EGADS

Nakazato et al, (ApJ Supp. 205, 2 (2013))
 Livermore simulation (ApJ 496, 216 (1998))

For Nakazato model :
 20 $M_{\odot}$, $Z=0.02$, $t_{\text{revival}}=200\text{msec}$



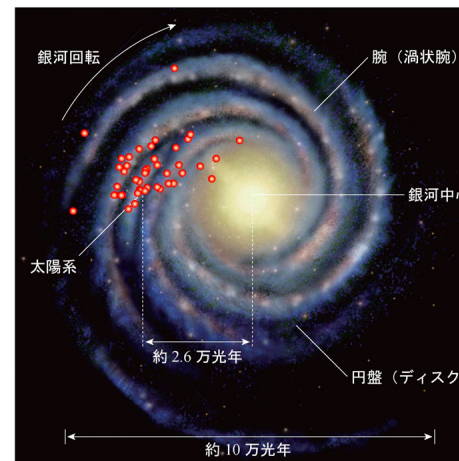
Betelgeuse (~200 pc)



$\bar{\nu}_e + p$ (IBD)
 25,000 ~ 32,000
 56,000 ~ 78,000

$\nu + e$ (elastic)
 1,400 ~ 1,500
 2,500 ~ 2,900

Galactic center (~10 kpc)



$\bar{\nu}_e + p$ (IBD)
 10 ~ 13
 22 ~ 31

$\nu + e$ (elastic)
 ~ 0.6
 ~ 1

SN ν detection in EGADS

Nakazato et al, (ApJ Supp. 205, 2 (2013))

Full Data from Core Collapse to Neutron Star Cooling Phase

- [download all](#) (5.27MB) except for BH models ($30M_{\text{solar}}$ & $Z = 0.004$)

M_{init}	Z	Supernova models			BH models
		$t_{\text{revive}} = 100\text{ms}$	$t_{\text{revive}} = 200\text{ms}$	$t_{\text{revive}} = 300\text{ms}$	
$13M_{\text{solar}}$	0.02	258kB	257kB	256kB	---
$20M_{\text{solar}}$		258kB	257kB	257kB	
$30M_{\text{solar}}$		257kB	257kB	255kB	
$50M_{\text{solar}}$		257kB	256kB	256kB	
$13M_{\text{solar}}$	0.004	258kB	257kB	257kB	
$20M_{\text{solar}}$		258kB	257kB	256kB	
$30M_{\text{solar}}$		---			4.97MB (Shen)
$50M_{\text{solar}}$					2.69MB (LS220)
		259kB	258kB	257kB	---

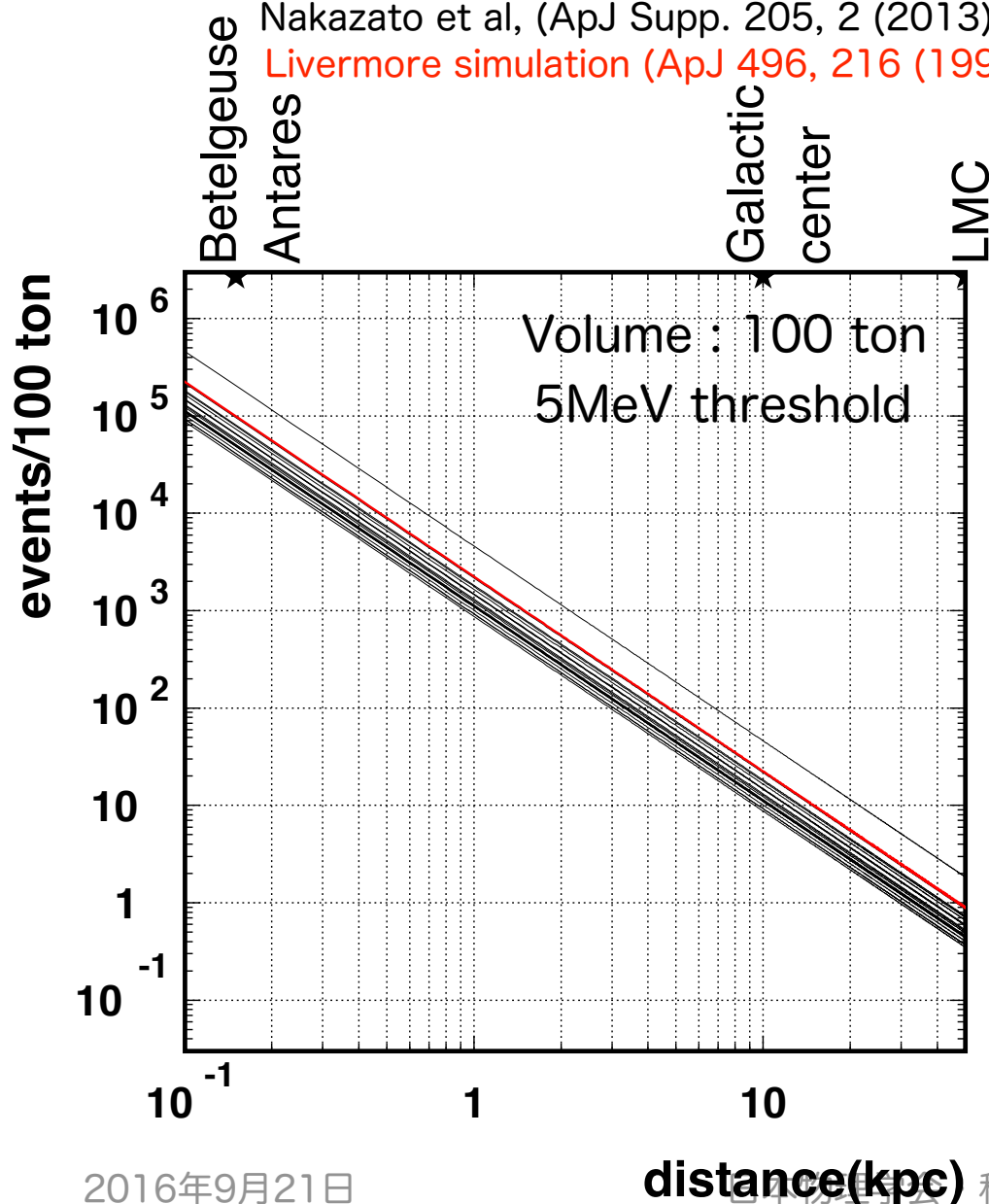
Note: t_{revive} is the shock revival time, which is an uncertain parameter reflecting the still unknown explosion mechanism. A black hole is formed for the $30M_{\text{solar}}$ & $Z = 0.004$ model, and hence t_{revive} is not applicable.

<http://asphwww.ph.noda.tus.ac.jp/snn/index.html>

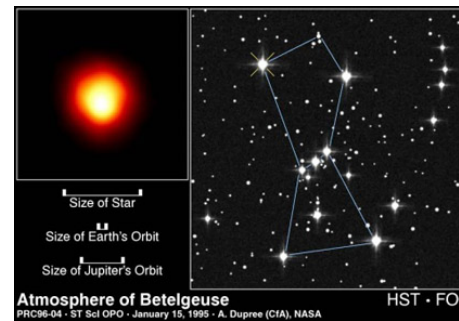
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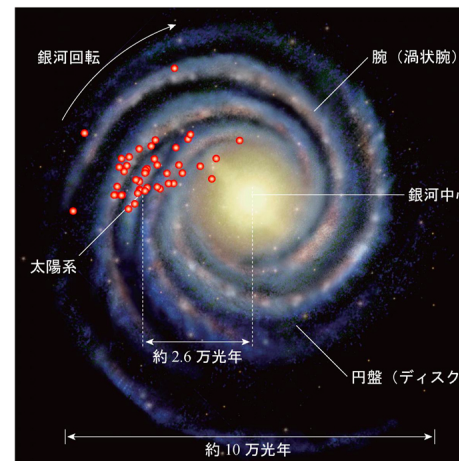
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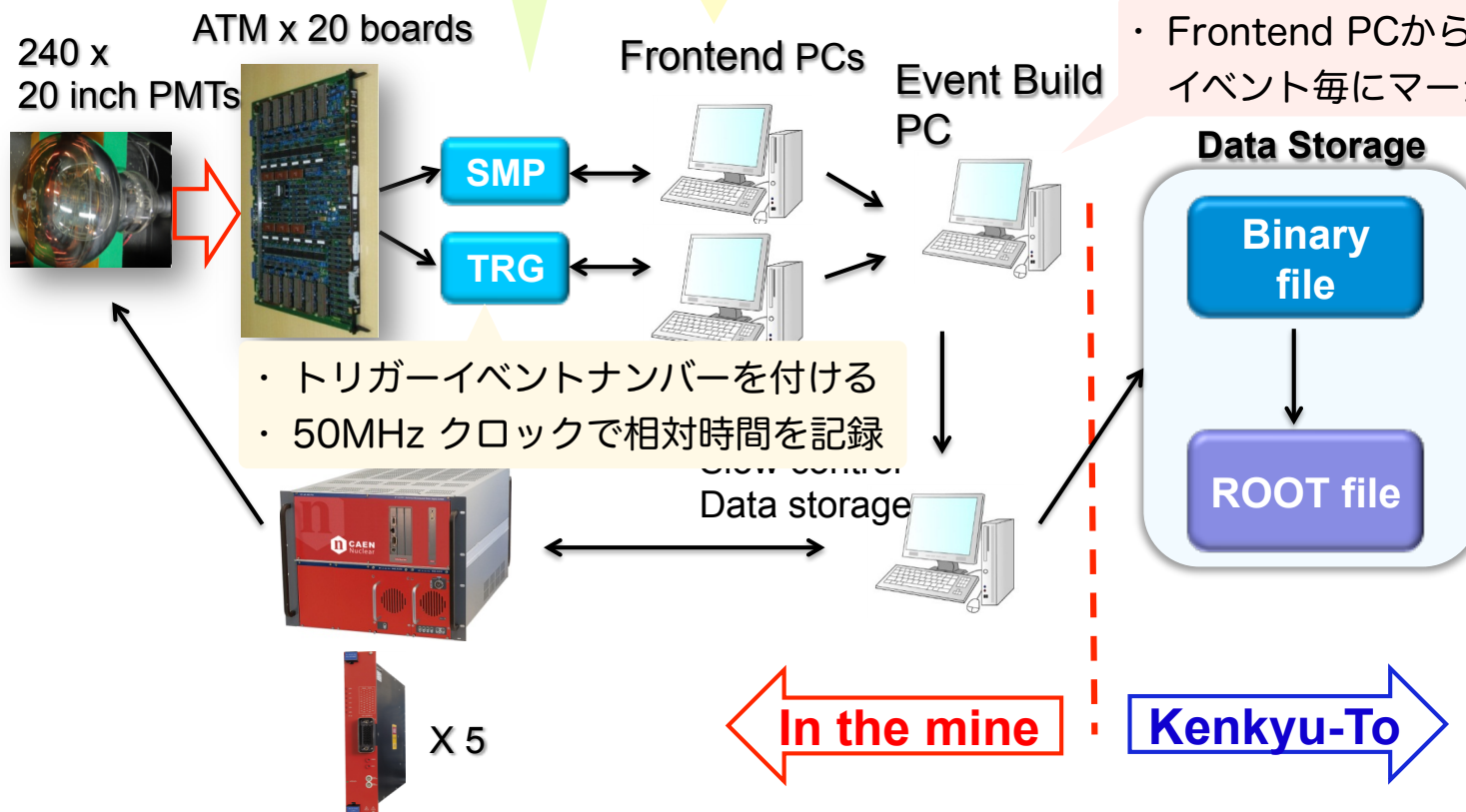
$\nu + e$ (elastic)
 ~ 0.6
 ~ 1

EGADS DAQ system

- ・ ATMのコントロールはVMEモジュールSMPを通して行う
- ・ 読み出しレート ~1.5kHz

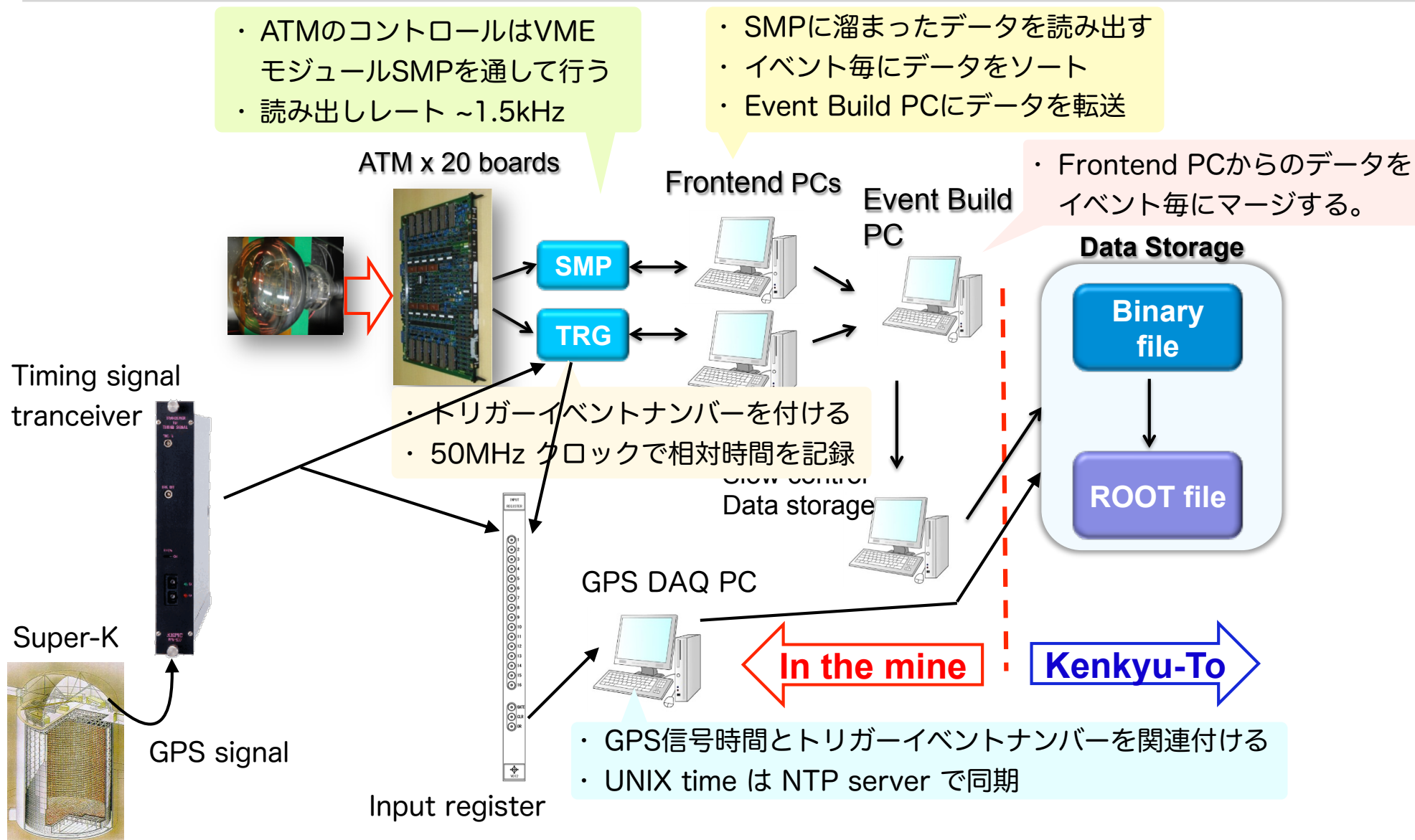
- ・ SMPに溜まったデータを読み出す
- ・ イベント毎にデータをソート
- ・ Event Build PCにデータを転送

- ・ Frontend PCからのデータをイベント毎にマージする。

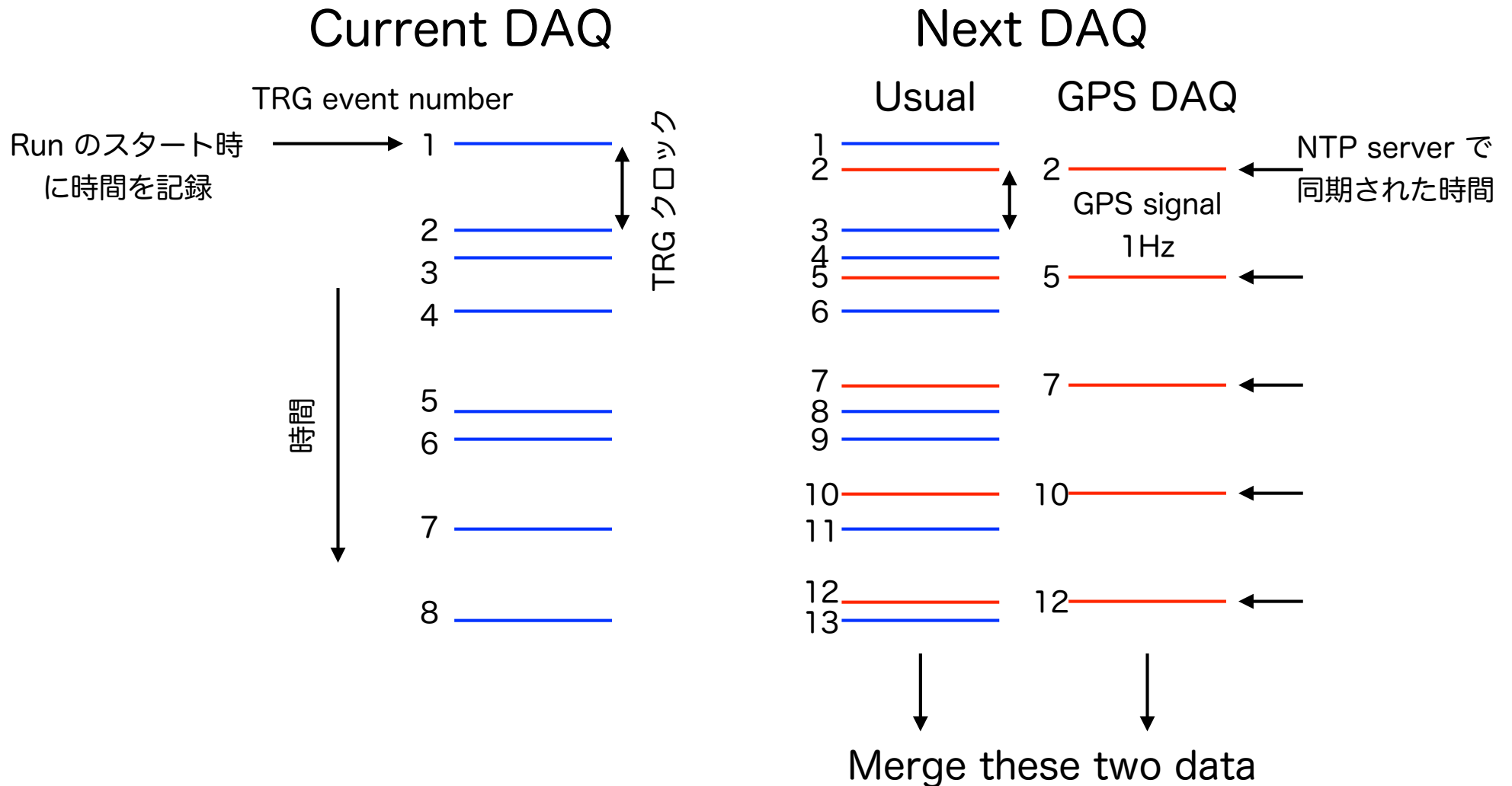


(物理学会・2012年春・森俊彰)

EGADS DAQ system with GPS



Event sequence



Next to do

- Complete the DAQ program
- Determine the SN criteria and making alert system
- Estimate the detection efficiency for SN in our galaxy in EGADS

Summary

- Develop the EGADS supernova neutrino detection system.
- $O(10,000)$ neutrino events are expected for Betelgeuse SN in EGADS.
- Similar GPS system as SK was installed in EGADS.
- Final goal in EGADS is an announcement one second after SN is happened.