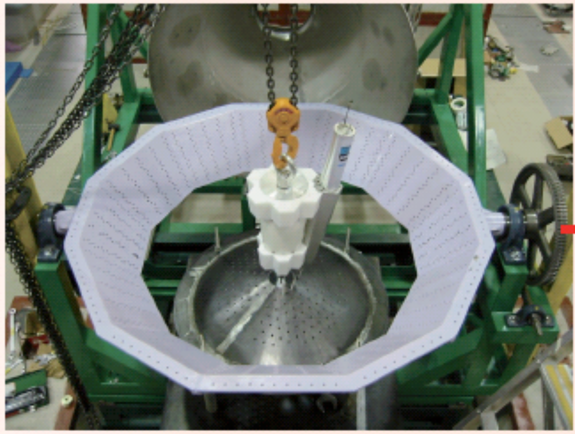
Frame of SCISSORS Ⅲ

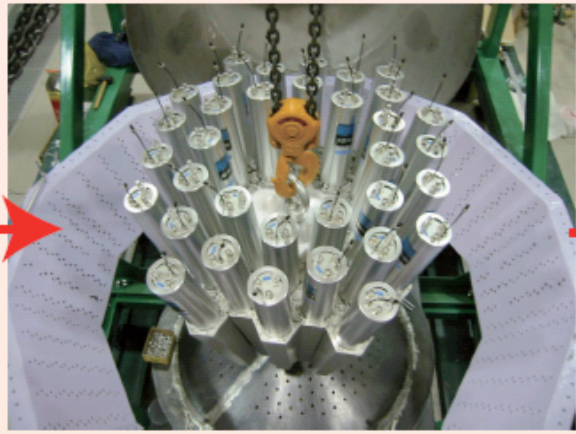
Koutaku Suzuki, LNS, Tohoku university

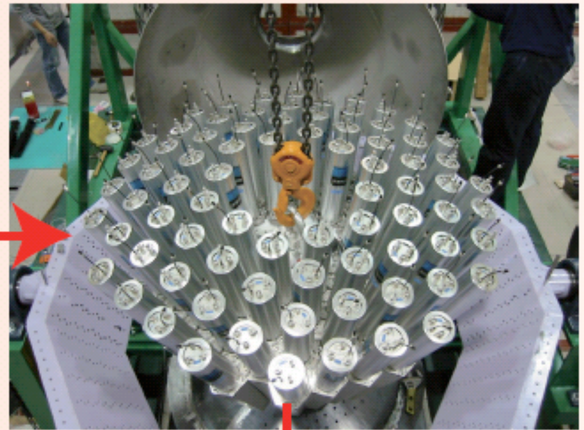
SCISSORS III

SCISSORS III frame & core

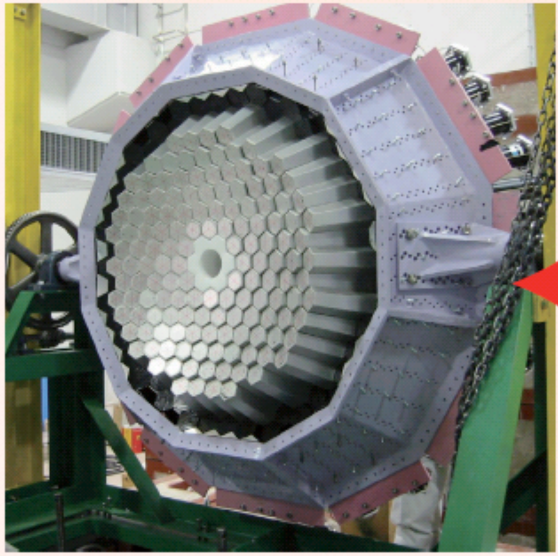


Rear panels of CsI crystals are connected with each other

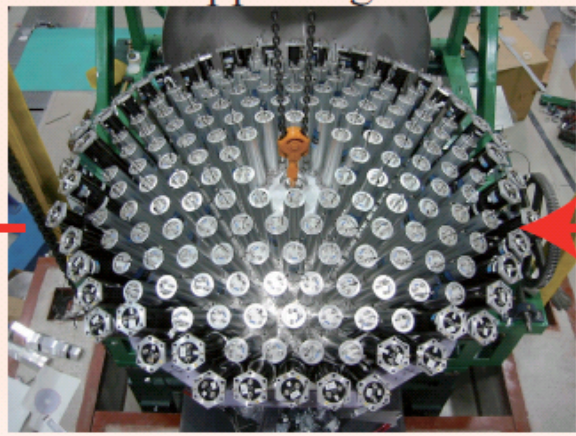


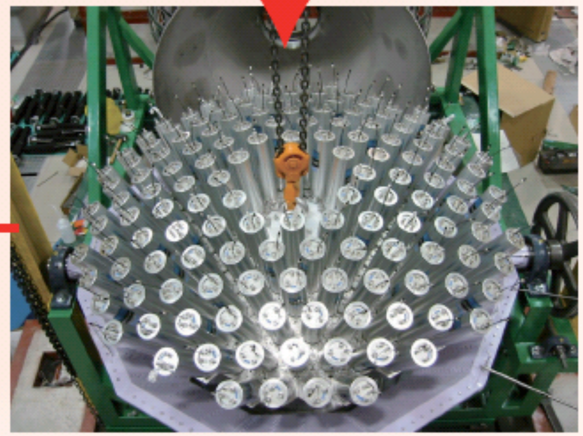


Finish!



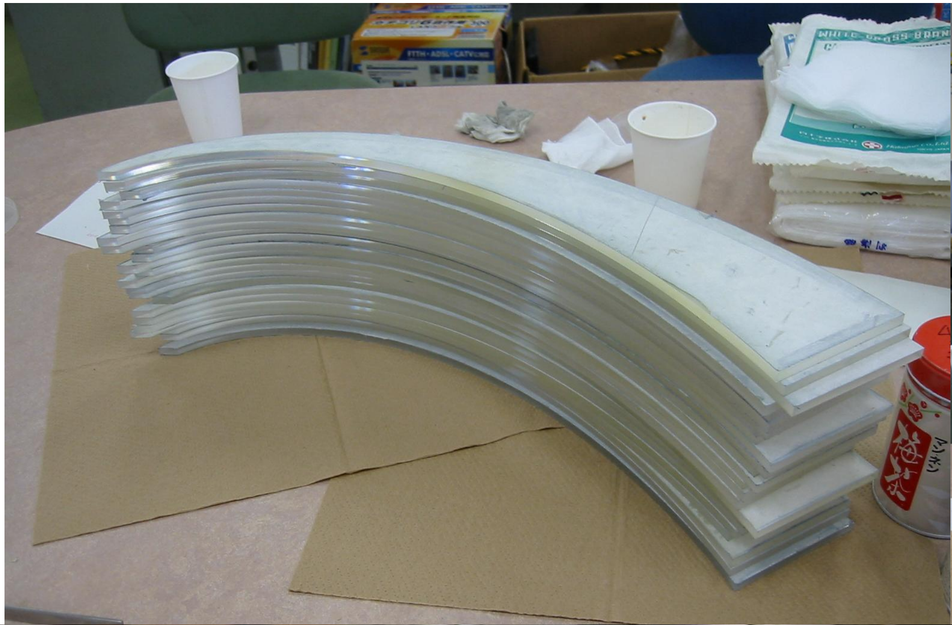
No supporting frames in the inner area

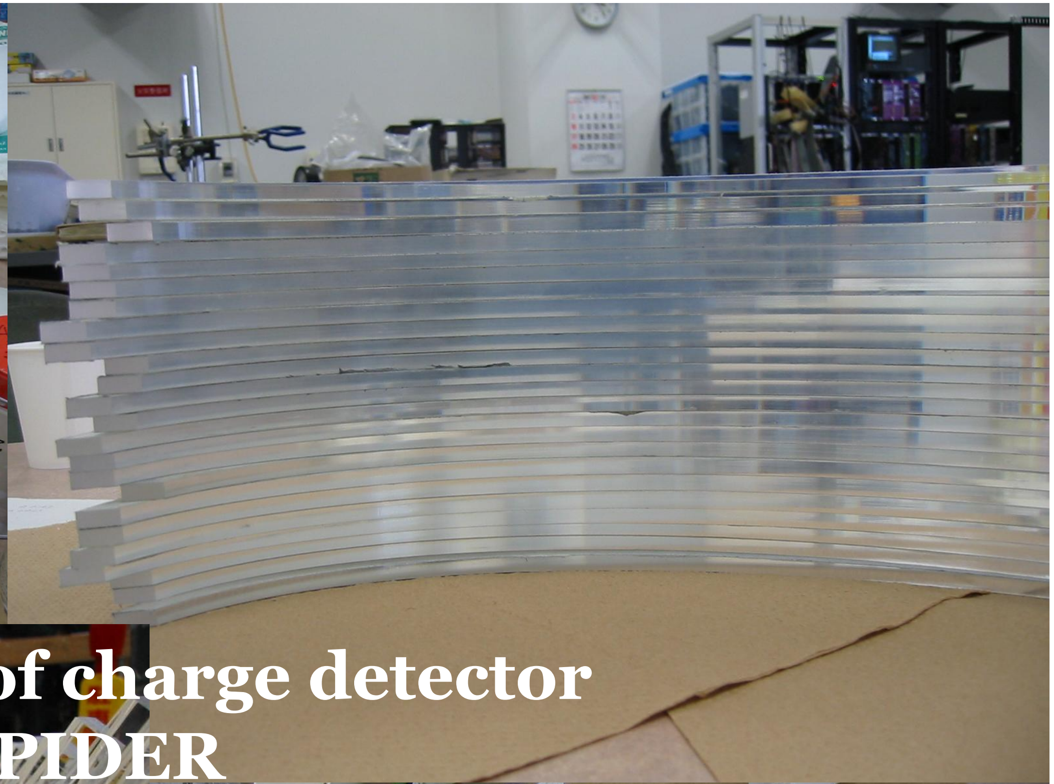




The total weight of SCISSORS III ~1500kg

Construction of charge detector SPIDER

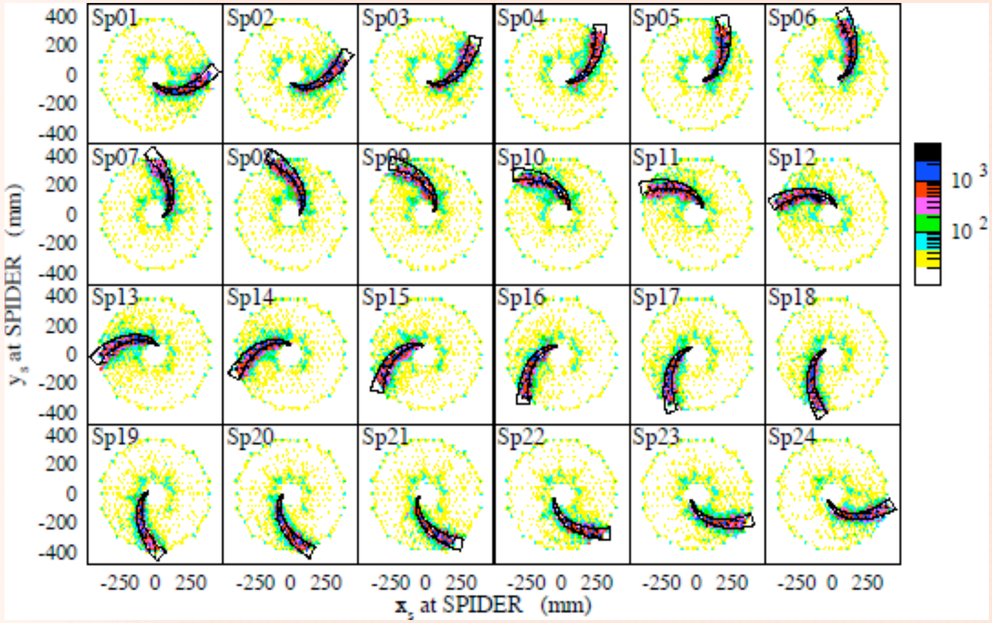


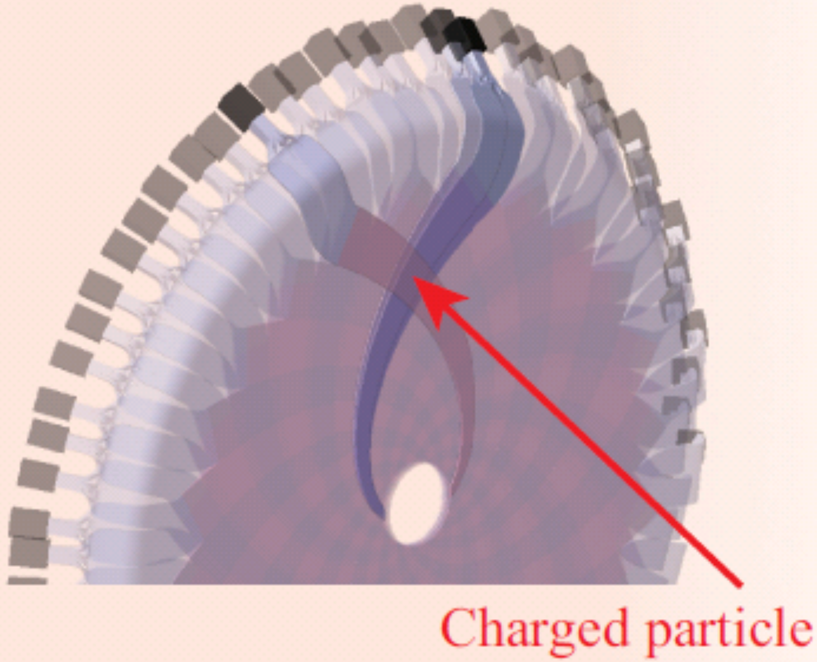


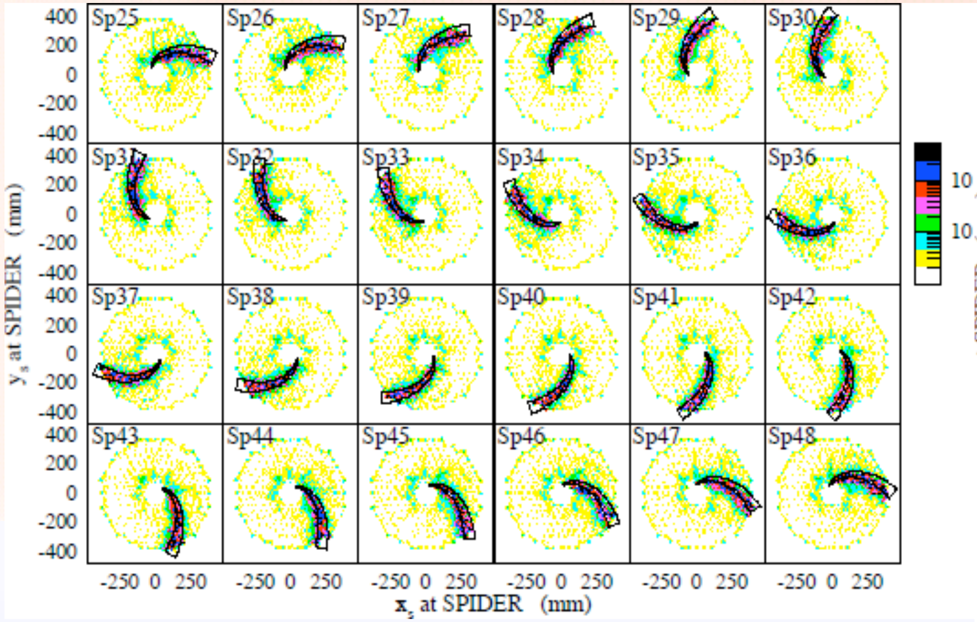
charge detector SPIDER

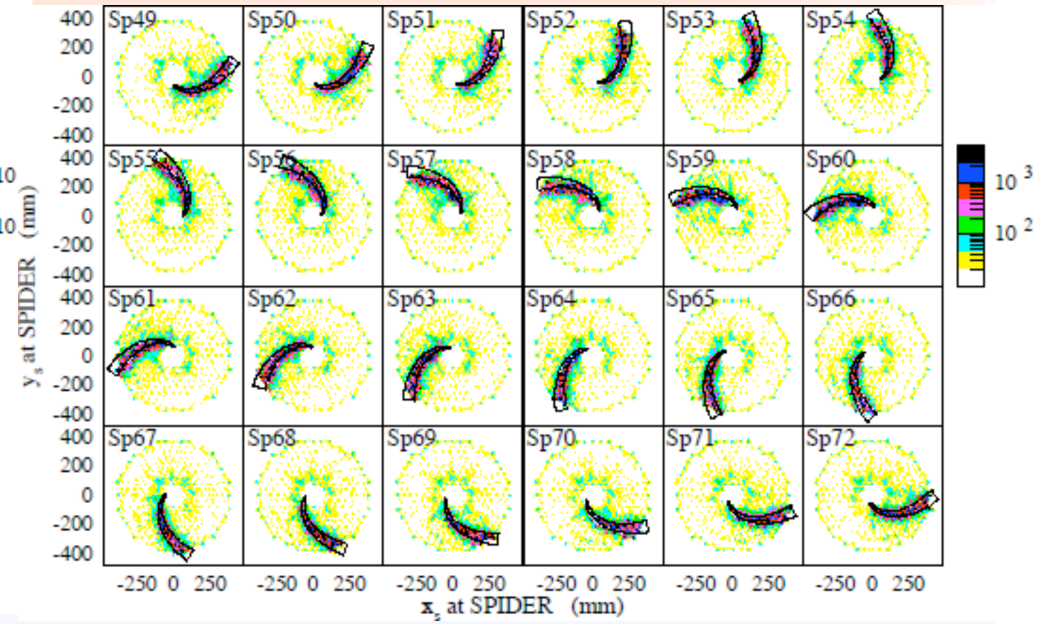
Koutaku Suzuki, LNS, Tohoku university

SPIDER *(Spiral-shaped Particle Identification Detector for Elementary Reactions)*









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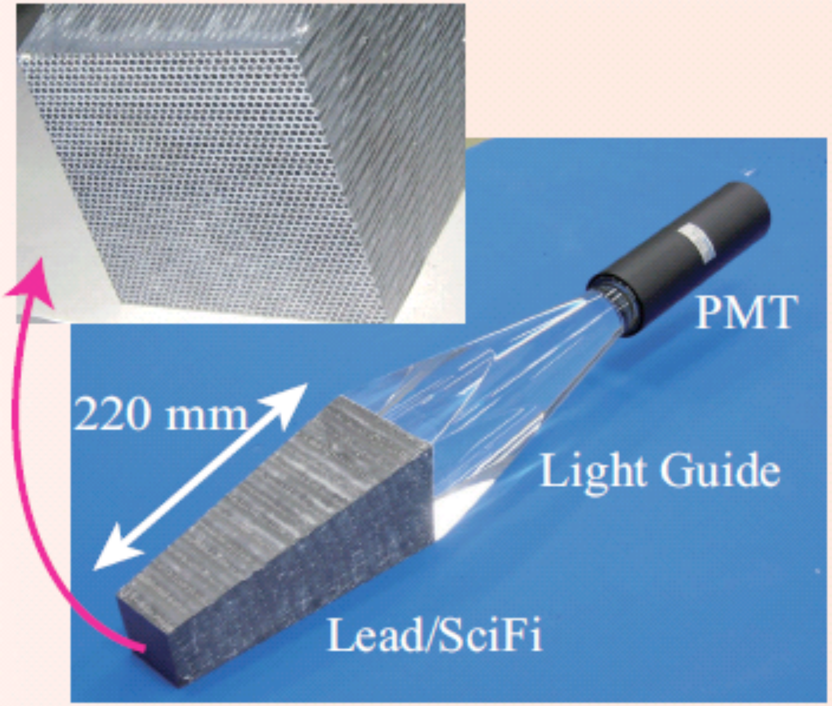
BackwardGamma

EM calorimeter BG

1 mm scintilating fibers ~5000

Lead : generate EM shower

Scintillator : detect EM shower



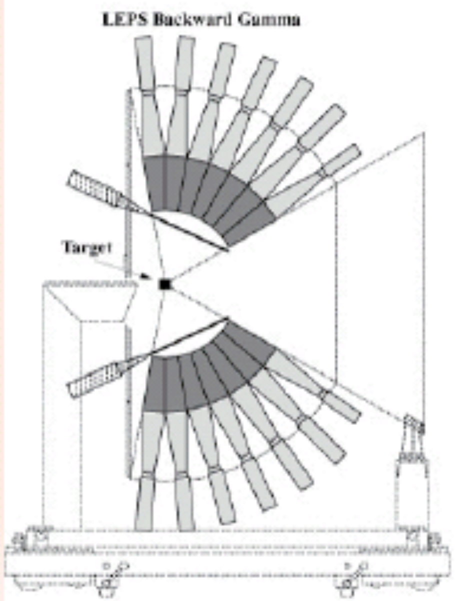
Lead/SciFi × 252

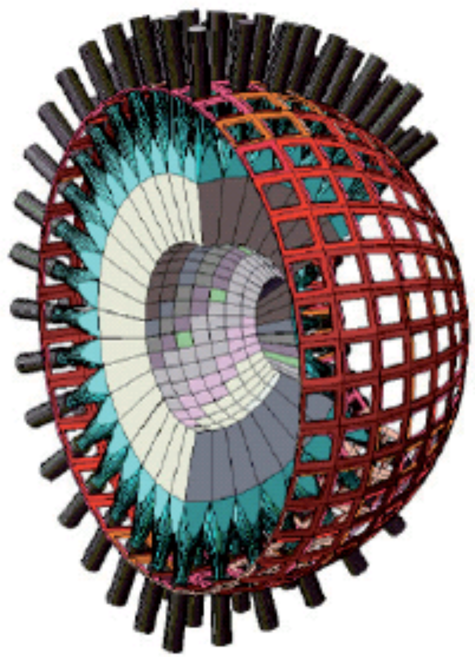
Energy resolution 7.2%

(@ 1 GeV photon)

Radiation length X_0=16.0 mm

Lead/SciFi : 13.8X_0





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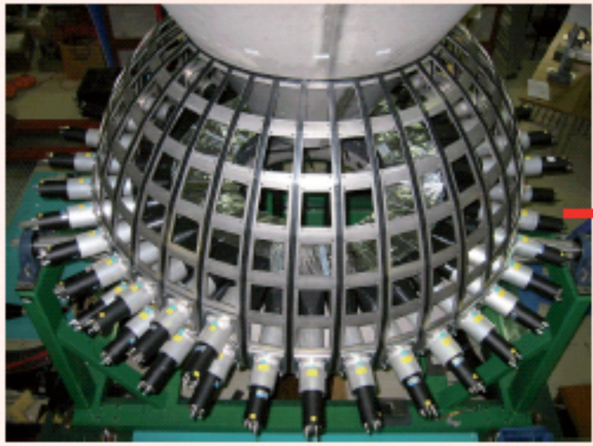
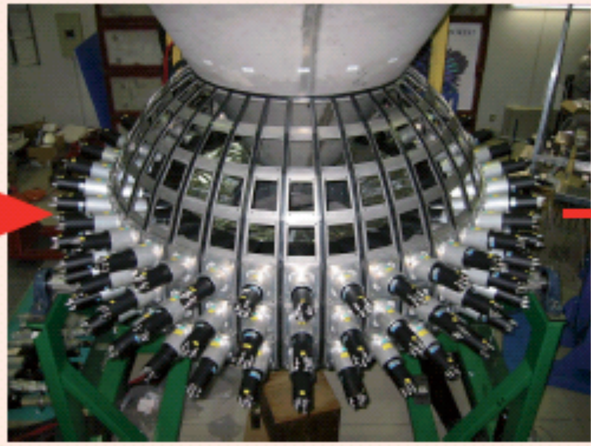
BackwardGamma

Assemble of BG

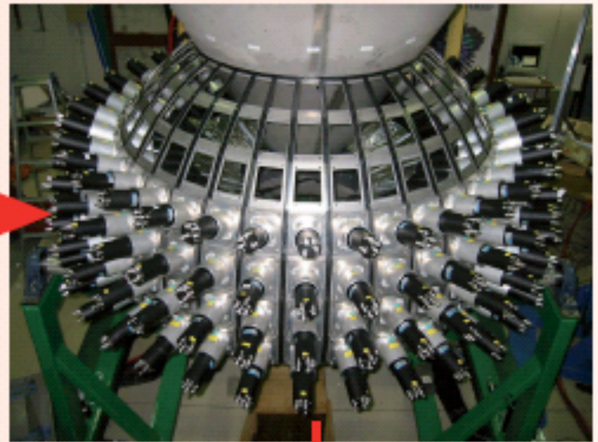
90 ~ 100° Lead/SciFi



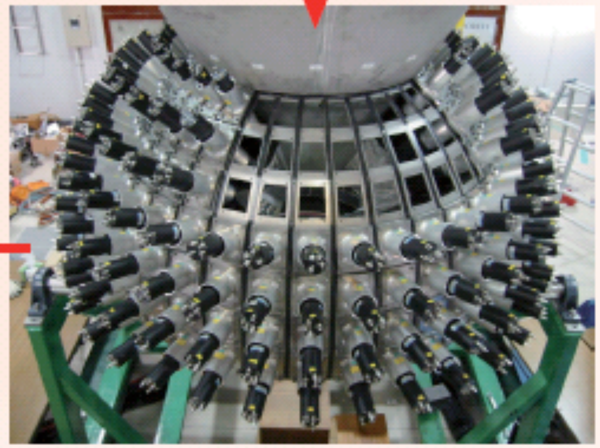
70 ~ 100° Lead/SciFi

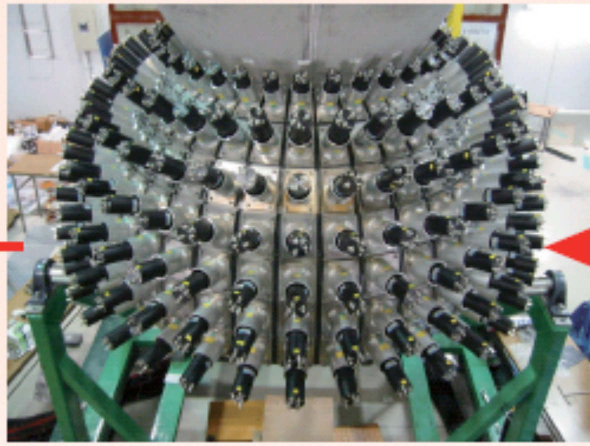


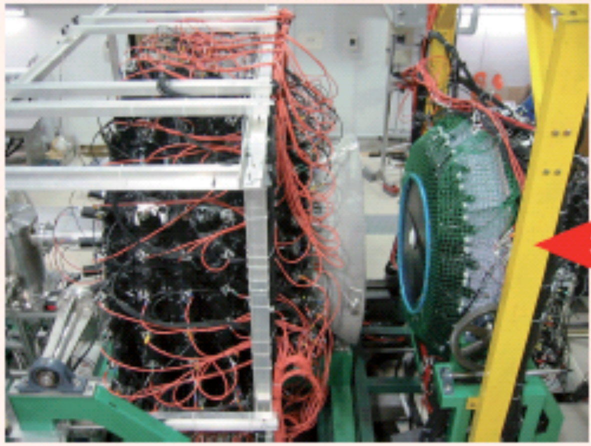
60 ~ 100° Lead/SciFi



The installation of Lead/SciFi modules were finished

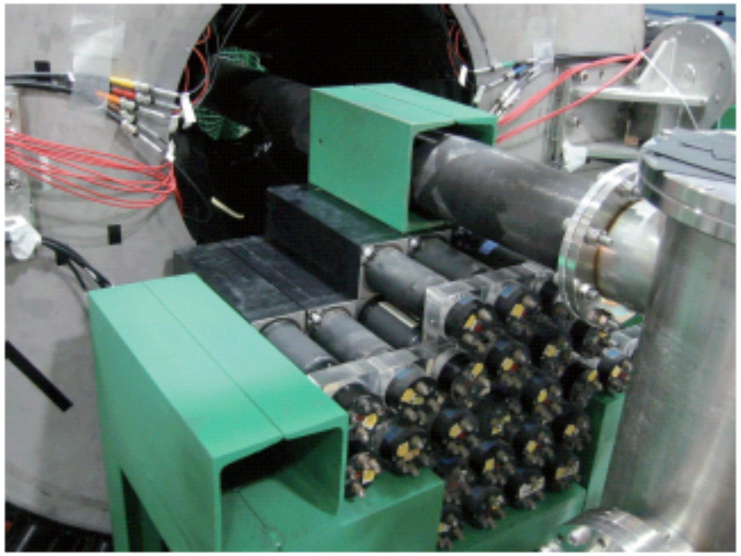


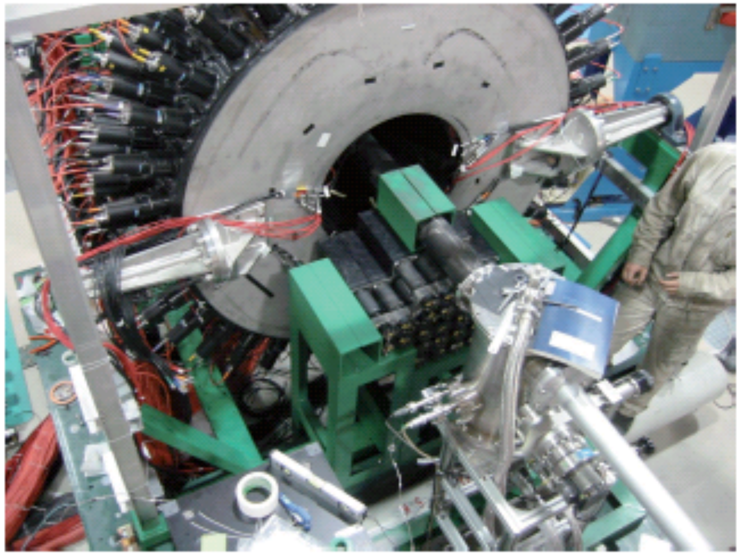


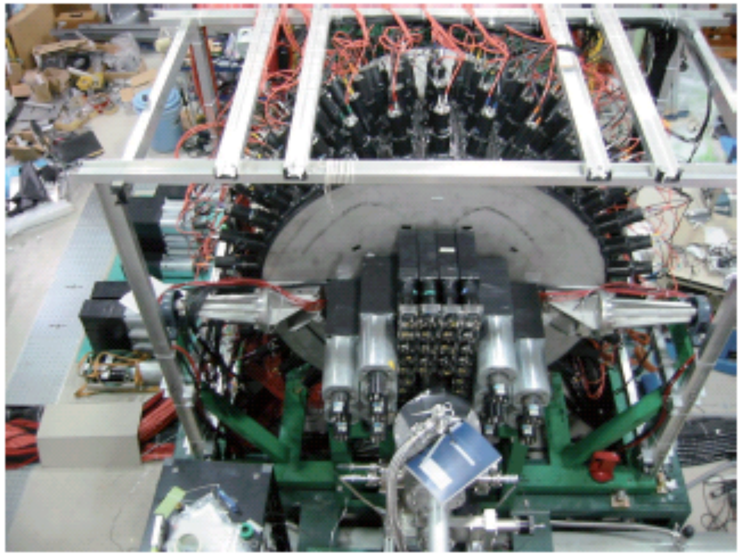


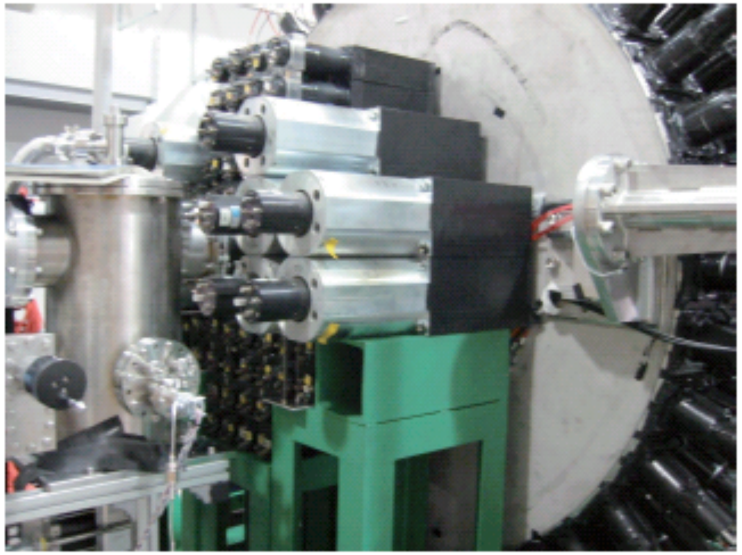
The total weight of Backward Gamma ~2500kg

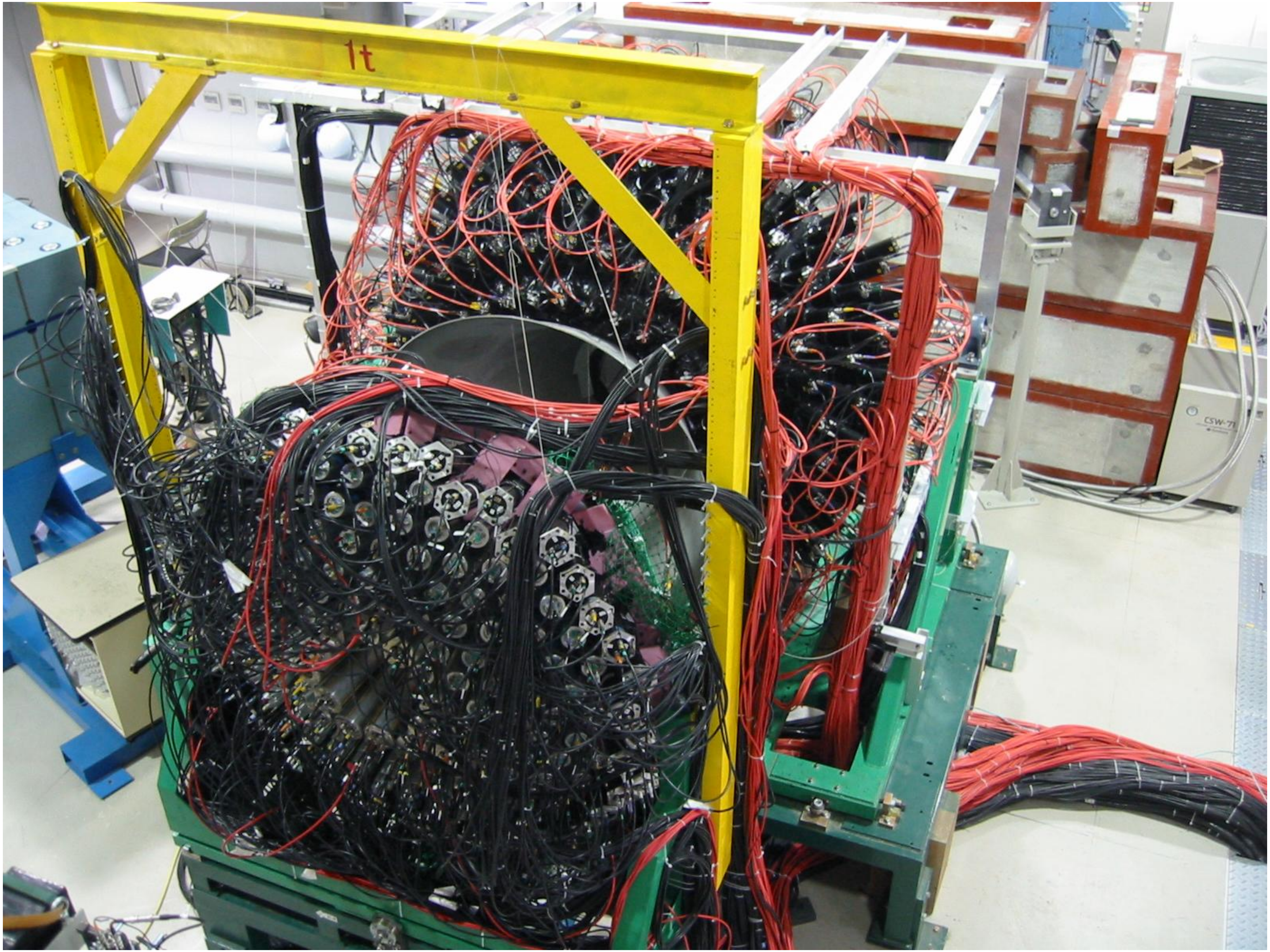
Installation of lead glasses (RafflesiaII)







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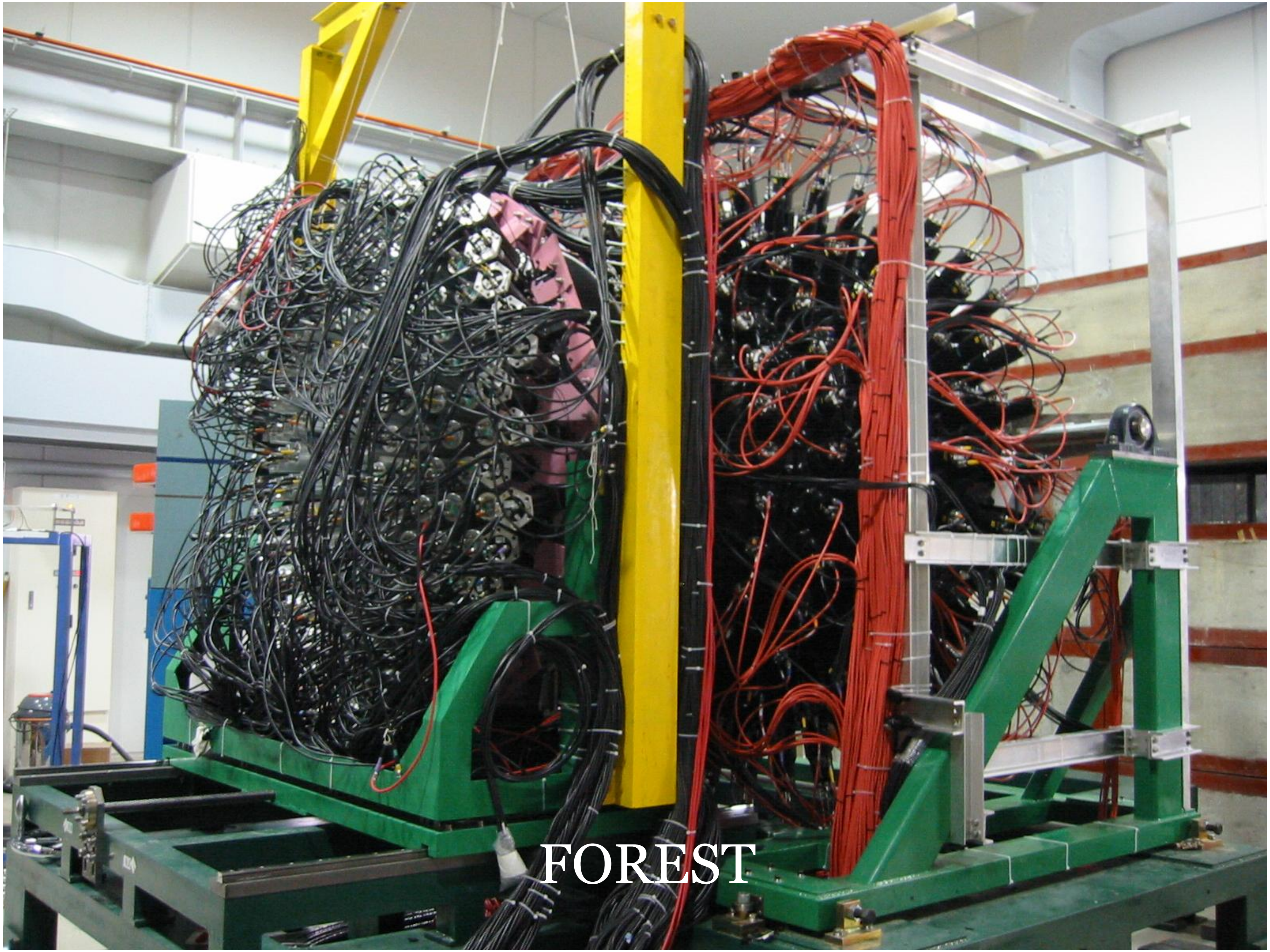
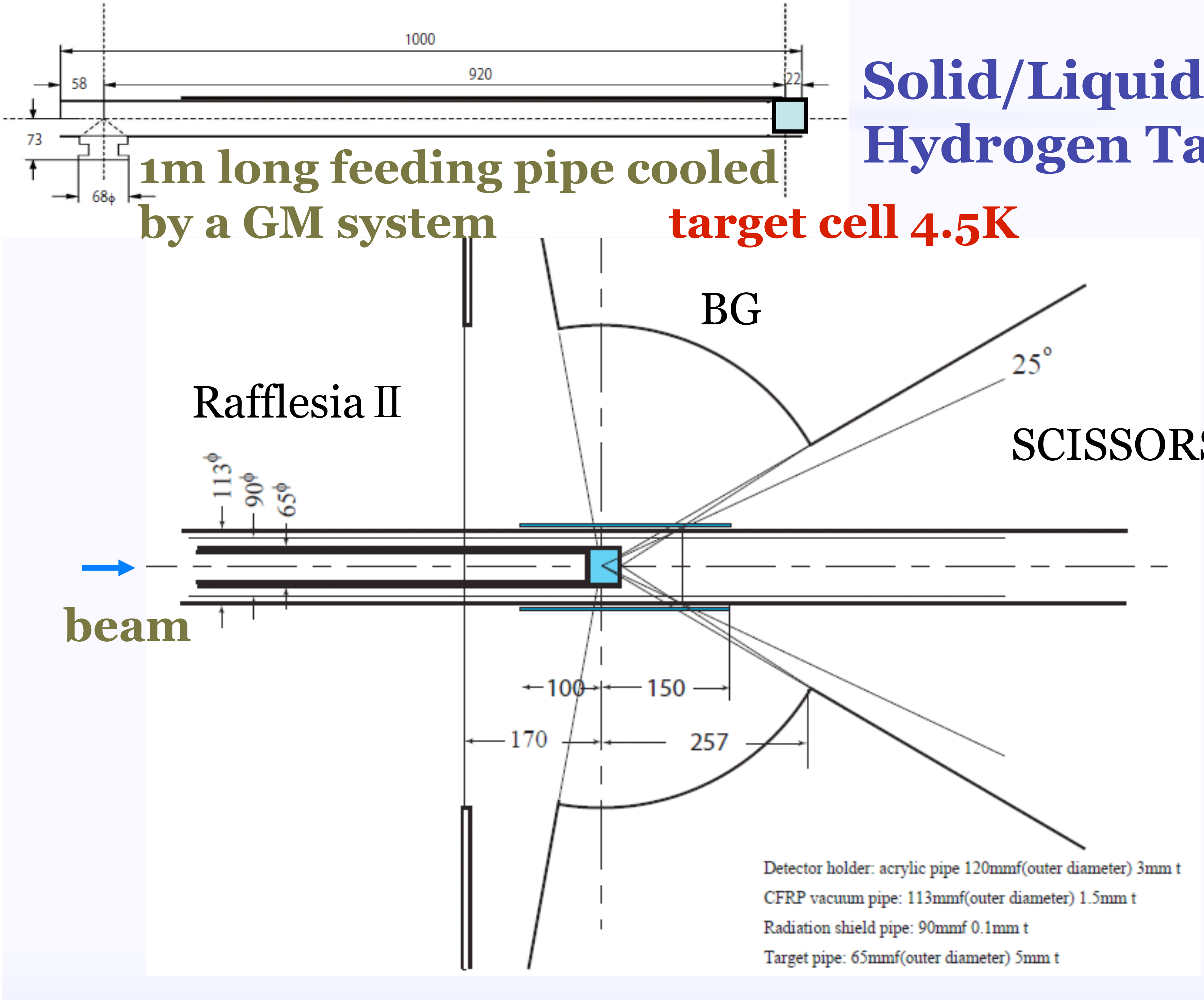

FOREST

Experimental apparatus

novel target system

Solid/Liquid Hydrogen Target



Solid/Liquid Hydrogen Target

table of spec.

- feeding pipe (4N pure Al)
  cooled by a GM cooling system

length:	1000 mm

- target cell
  cooled down to 4.7 K

target thickness:	40 mm
inner diameter:	61 mm
outer diameter:	65 mm
window (Aramid):	12.5 μm x 2

- operation

pre-cooling:	3 hours
target making:	1 hour
target vaporizing:	1 hour

Easy switch of targets

Data obtained with FOREST

status of data collection

Hydrogen：2.3G events
Deuterium：2.5G events

100 times more η

Status of data collection

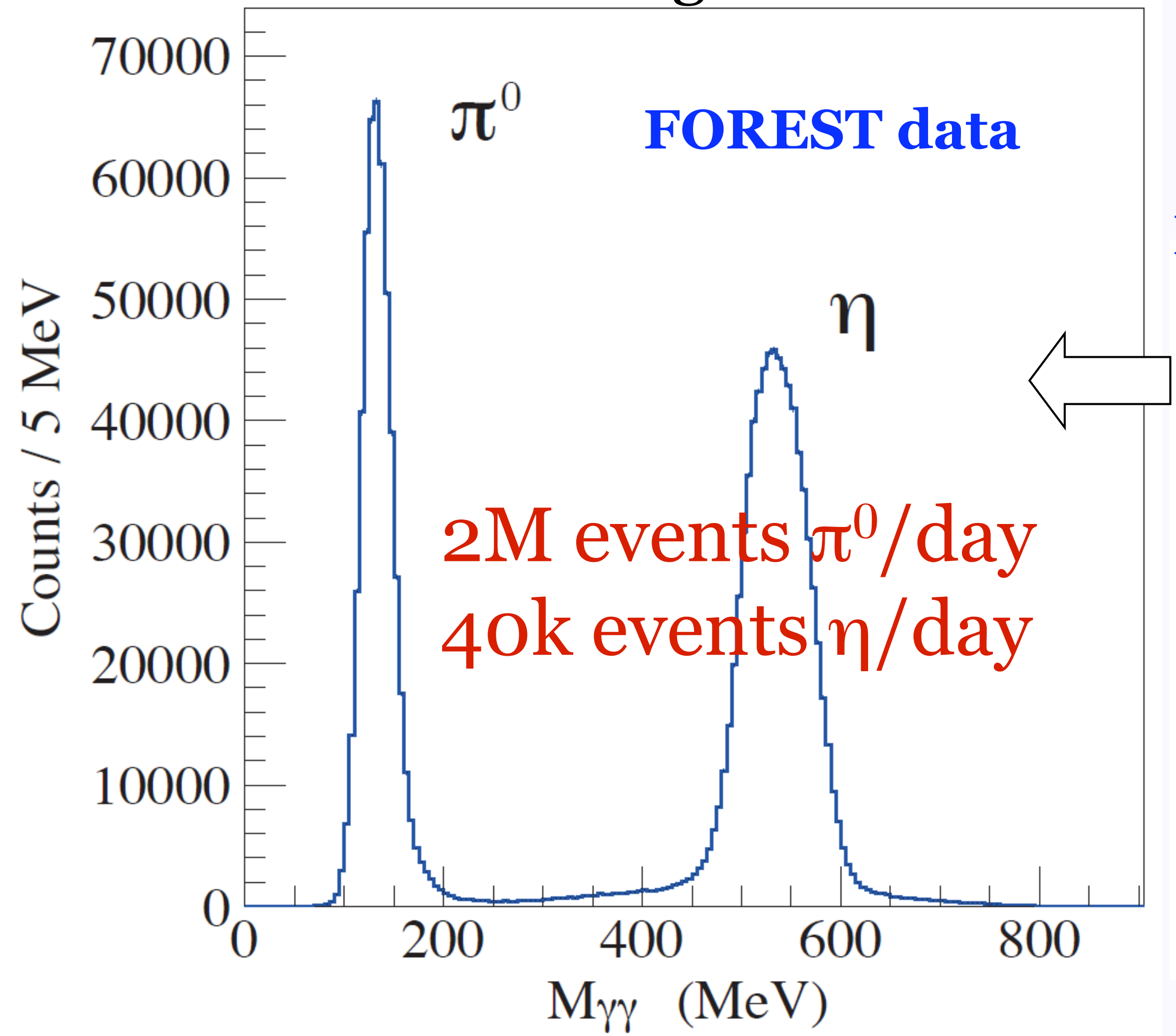
completion for data taking

(period of the project：June 2007ーMarch 2012)

period	hydrogen		deuterium		empty	
	スピル数	#of events	スピル数	#of events	スピル数	#of events
FOREST2008A	10.83 k	76.49 M	—	—	3.50 k	30.43 M
FOREST2008B	29.17 k	234.48 M	—	—	7.96 k	27.48 M
FOREST2008C	25.52 k	388.15 M	11.43 k	282.93 M	19.93 k	73.20 M
小計 (1200 MeV)	65.52 k	699.12 M	11.43 k	282.93 M	31.39 k	131.10 M
FOREST2009A	23.16 k	225.14 M	20.28 k	297.43 M	6.00 k	13.58 M
FOREST2009B	23.98 k	211.34 M	35.47 k	548.43 M	5.99 k	13.31 M
FOREST2009C	27.45 k	254.13 M	—	—	4.93 k	13.84 M
FOREST2009D	56.38 k	492.71 M	45.28 k	891.66 M	7.31 k	23.40 M
FOREST2009E	34.84 k	100.37 M	22.89 k	85.89 M	16.48 k	12.76 M
小計 (1200 MeV)	130.97 k	1183.32 M	101.02 k	1737.51 M	24.24 k	64.13 M
小計 (920 MeV)	34.84 k	100.37 M	22.89 k	85.89 M	16.48 k	12.76 M
FOREST2010A	60.84 k	111.52 M	37.06 k	114.35 M	9.85 k	10.83 M
FOREST2010B	34.89 k	245.19 M	22.28 k	235.78 M	13.17 k	40.77 M
小計 (1200 MeV)	34.89 k	245.19 M	22.28 k	235.78 M	13.17 k	40.77 M
小計 (920 MeV)	60.84 k	111.52 M	37.06 k	114.35 M	9.85 k	10.83 M
計 (1200 MeV)	231.37 k	2127.63 M	134.59 k	2253.28 M	68.80 k	235.99 M
計 (920 MeV)	95.68 k	211.88 M	59.95 k	200.23 M	26.33 k	23.59 M

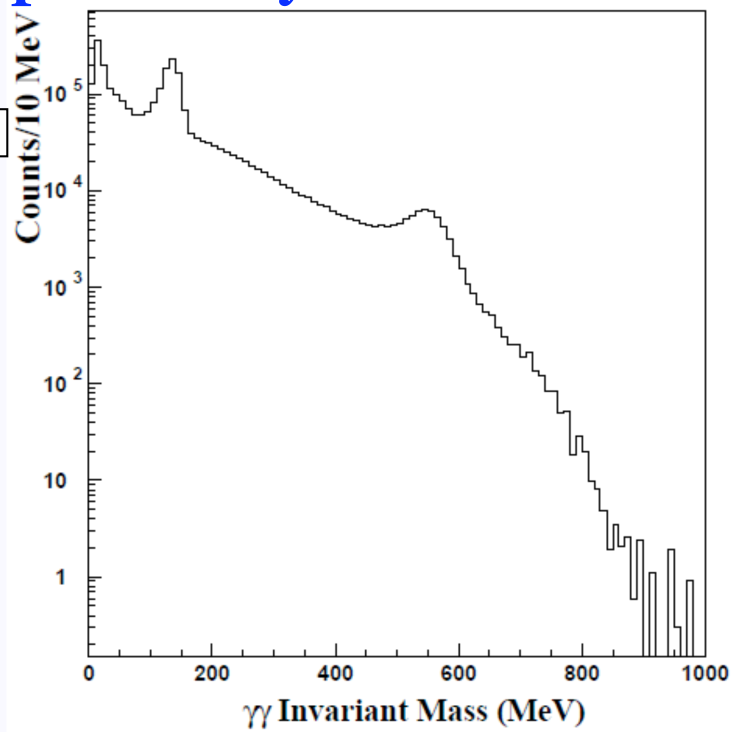
2γ invariant mass

clear signals!



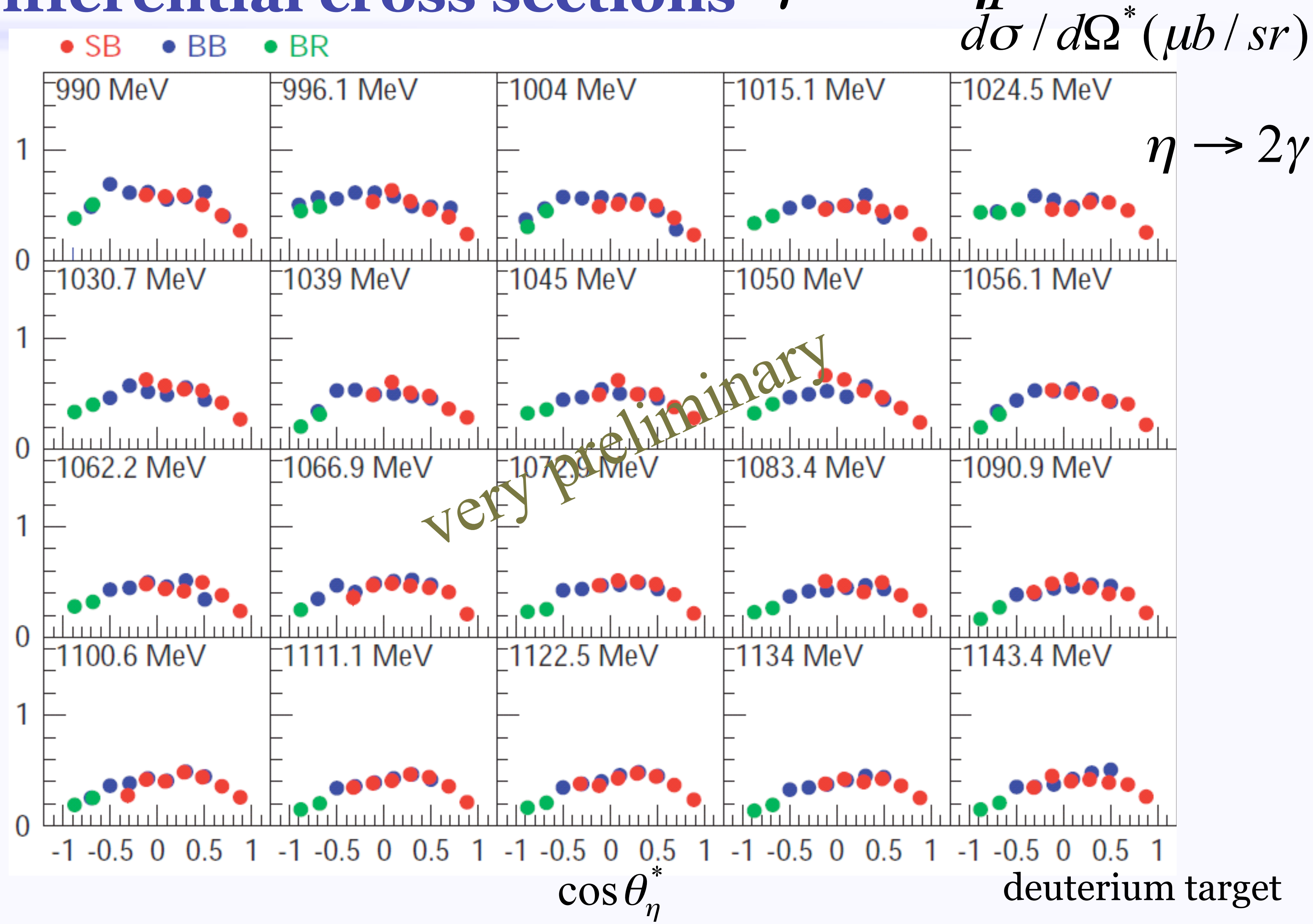
Fast DAQ system
efficiency of 76%
trigger rate: 2kHz
for the data size of
2.6kB/event

previously obtained data



BG: 2 neutrals, S3: 0 or 1 particle, Raf: 0, Missing mass: nucleon
Data obtained in a 3 week run with a H2 target

Differential cross sections $\gamma d \to \eta p n$



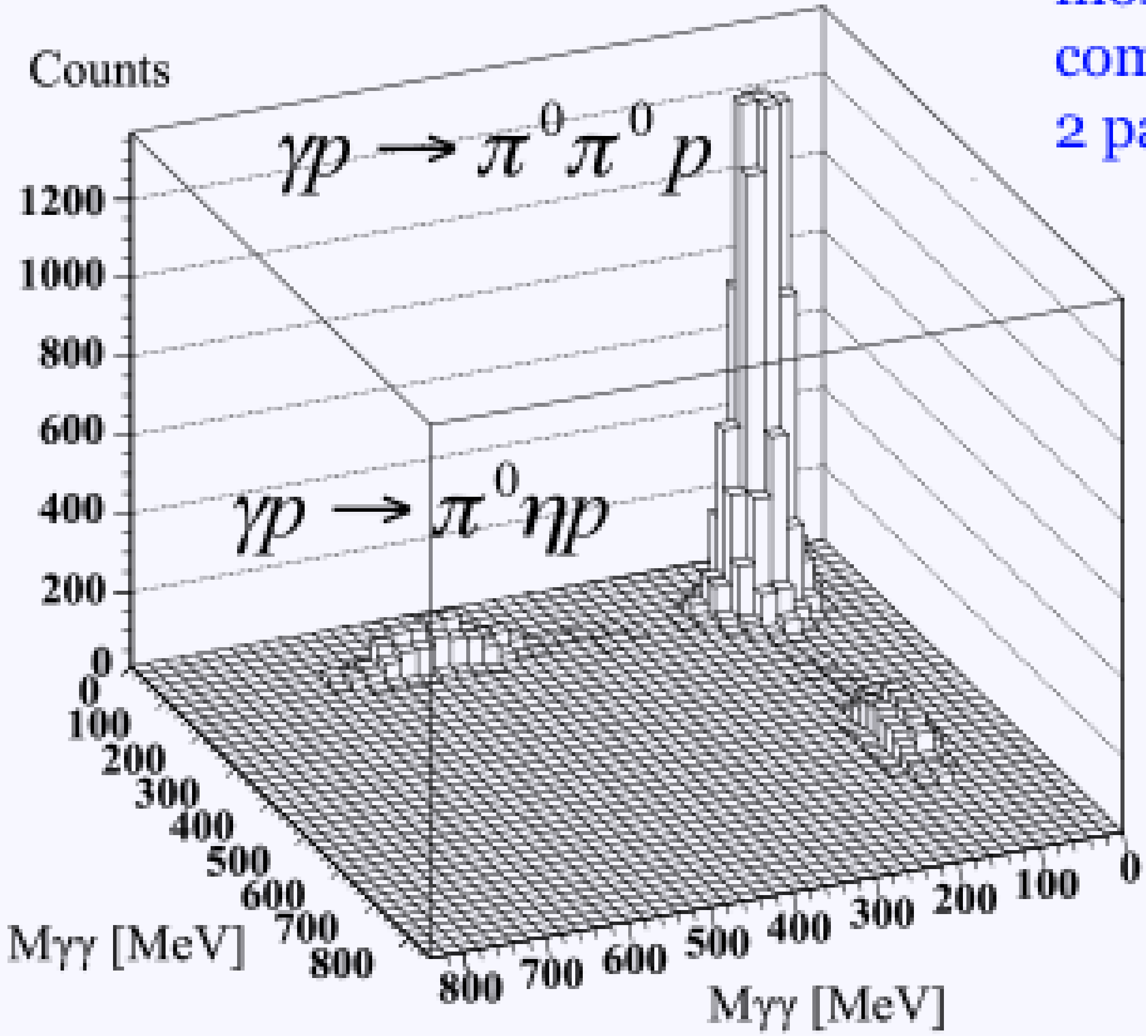
Detailed analysis going on to elucidate N*(1670)

Data obtained with FOREST

Channels to be investigated other than the η channel

$$\pi^0, \quad \pi^0\pi^0, \quad \pi^0\eta, \quad \omega$$

$\gamma p \rightarrow \pi^0 \eta p$ (4 γ events)



data:
most probable combinations of 2 pairs of 2γ's

Assignment of the χ partner of the nucleon in the baryon sector: naïve or mirror

- **mirror assignment**

D. Jido et al. / Nuclear Physics A 671 (2000) 471–480 479

$N^* = S_{11}(1535)$

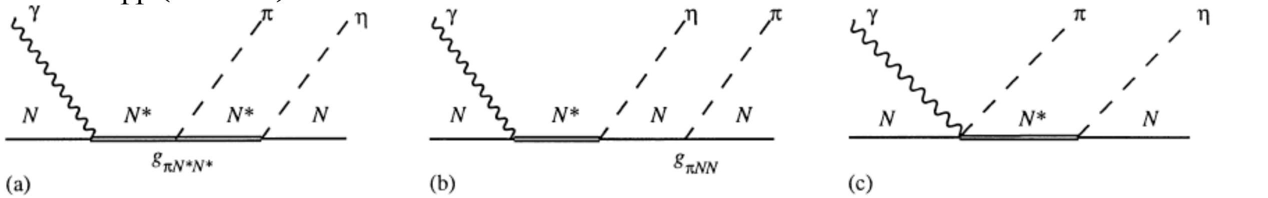


Fig. 2. Dominant diagrams for the $\gamma N \to \pi\eta N$, (a), (b) for the Born terms, and (c) for the Kuroll–Ruderman type term. The $\pi N^* N^*$ coupling is in (a), and the πNN coupling is in (b).

transformation of chiral partners

$$[iQ_A^a, \psi_1] = -i\frac{\tau_a}{2}\gamma_5\psi_1$$

$$[iQ_A^a, \psi_2] = +i\frac{\tau_a}{2}\gamma_5\psi_2$$

$$\begin{aligned}\mathcal{L}_{mirror} &= \bar{\psi}_1 i\gamma^\mu\partial_\mu\psi_1 - g_1\bar{\psi}_1(\sigma + i\gamma_5\boldsymbol{\tau}\cdot\boldsymbol{\pi})\psi_1 \\ &+ \bar{\psi}_2 i\gamma^\mu\partial_\mu\psi_2 - g_2\bar{\psi}_2(\sigma - i\gamma_5\boldsymbol{\tau}\cdot\boldsymbol{\pi})\psi_2 \\ &- m_0(\bar{\psi}_2\psi_1 + \bar{\psi}_1\psi_2) + \cdots\end{aligned}$$

- **experiments to find out the favor assignment**

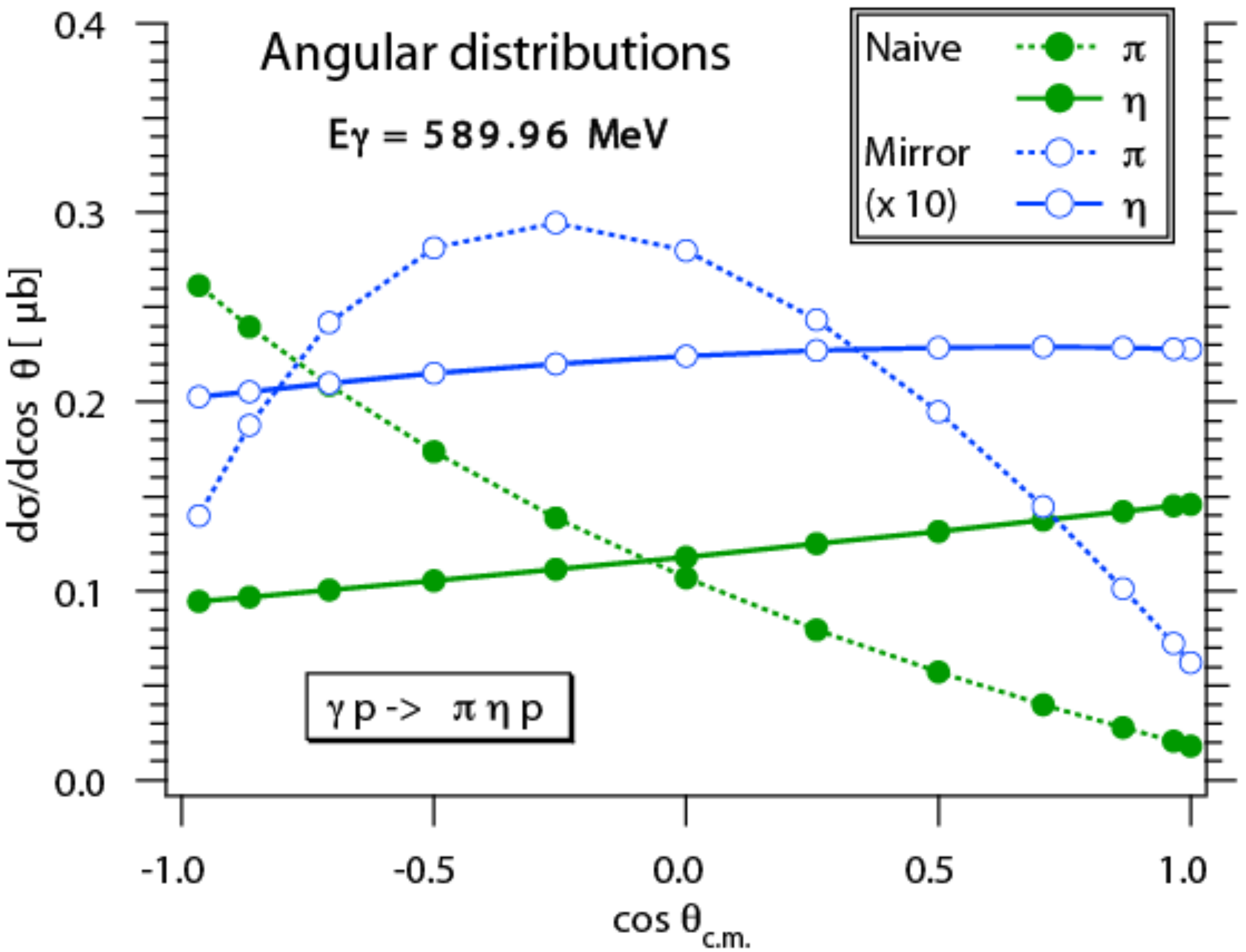
$$\gamma p \to \pi^0 \eta p$$

$$\pi^0 \to \gamma\gamma$$

$$\eta \to \gamma\gamma$$

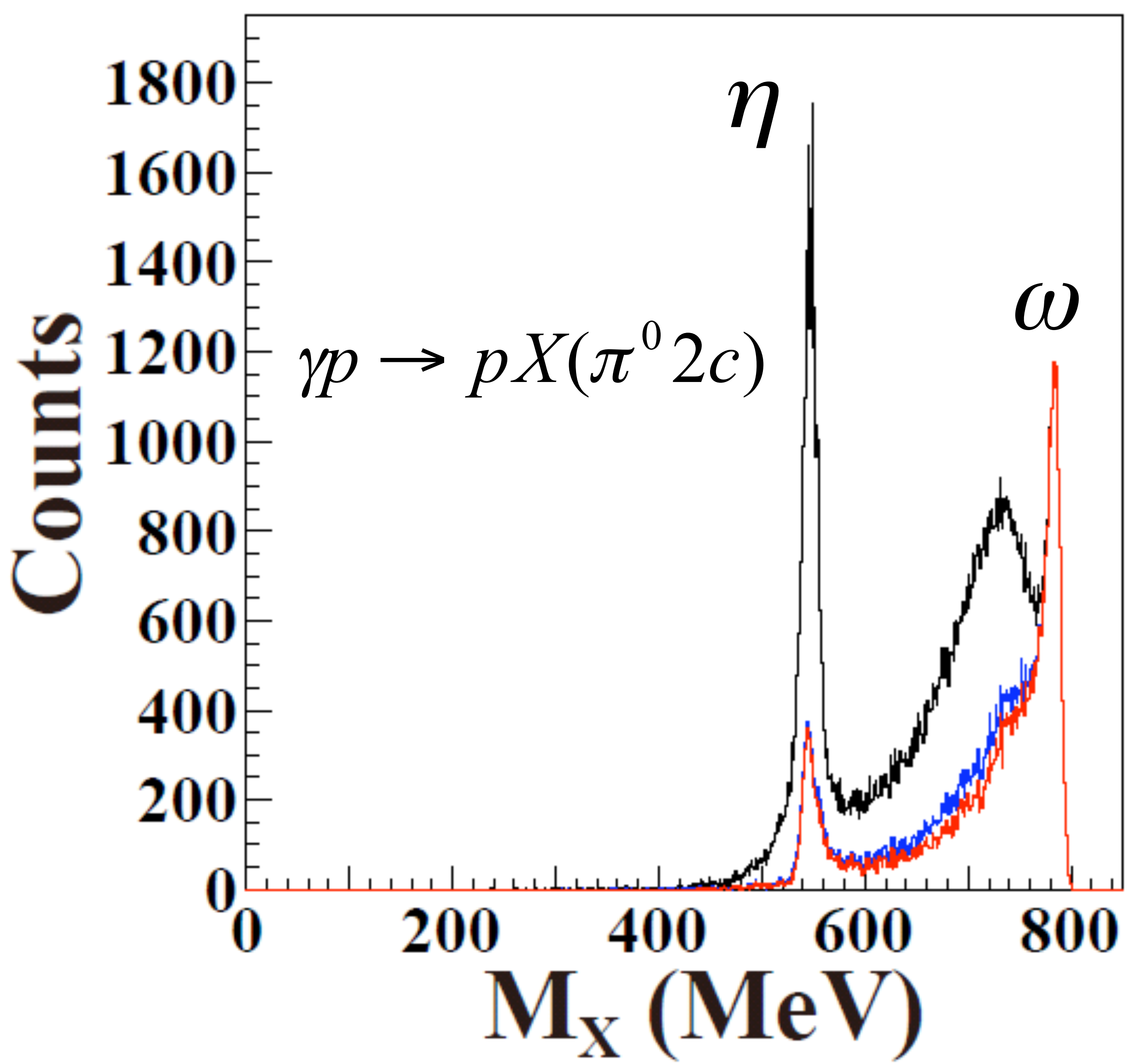
naïve or mirror assignment in the baryon sector

$\gamma p \rightarrow \pi^0 \eta p$ prediction by D. Jido et al.

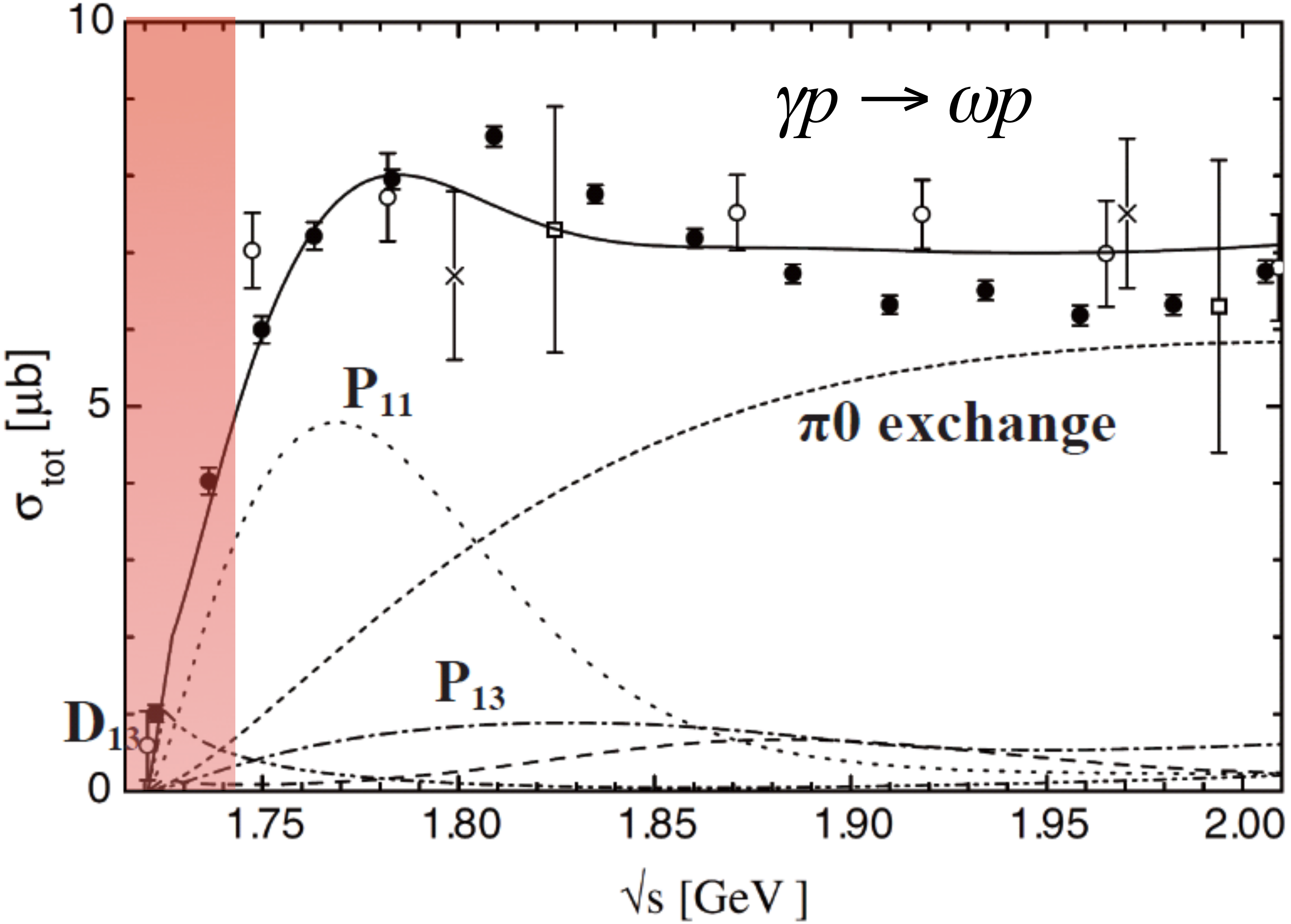


$W = 1.7$ GeV
$E\gamma$=1.07GeV

ω events by detecting protons



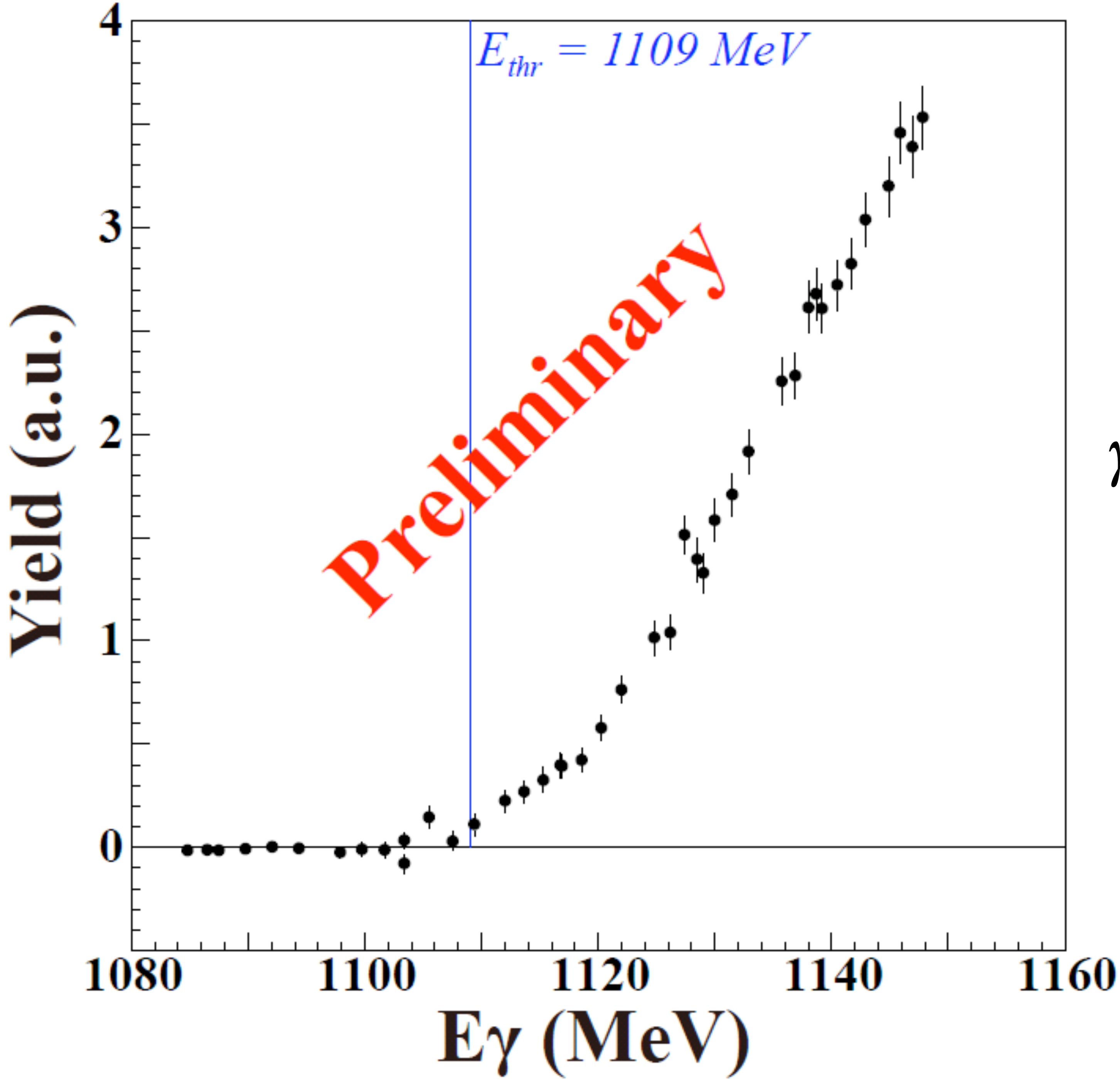
$\omega \to \pi^+\pi^-\pi^0$



● : SAPHIR(2003) ○ : SAPHIR × : ABBHHM

□ : Brown-Harvard-MIT-Padova-Weizmann Institute Bubble Chamber Group

Curves : G. Penner and U. Mosel, Phys. Rev. C 66, 055212 (2002)



$\gamma p \rightarrow \omega p$

Summary up to now

Previous observation

- We observed a narrow baryon resonance N*(1670) in the total cross section for the $\gamma d \to \eta n p$ reaction.
- N* shows up on the neutron, but not on the proton at all.
- N* would be the first candidate for a pentaquark baryon with hidden strangeness in the anti-decuplet.

On going projects at ELPH (1st stage)

- We aim to determine the spin and parity of N*(1670) with single η photoproduction data.
- FOREST provides a large amount of data for $\pi^0,\ \eta,\ 2\pi^0,\ \pi^0\eta,\ \omega$ photoproduction.
- We finished taking data with FOREST in the first stage.
- We also look into the coupling of N* with the proton with high statistics.
- Chiral symmetry in the baryon sector will be investigated through the $\gamma p \to \pi^0 \eta p$ reaction at the threshold.
- FOREST also provides information on very low energy ωN and $\pi^0\pi^0$ interactions.

On going project (2^{nd} stage)

- **New detector construction**

  <requirements for the detector>

  To be made of single material of detector devices

  with good energy and position resolutions

  To have no dead region

  To have fine granularity

  good for neutron detection as well

- **Experiments at Sendai and SPring-8**

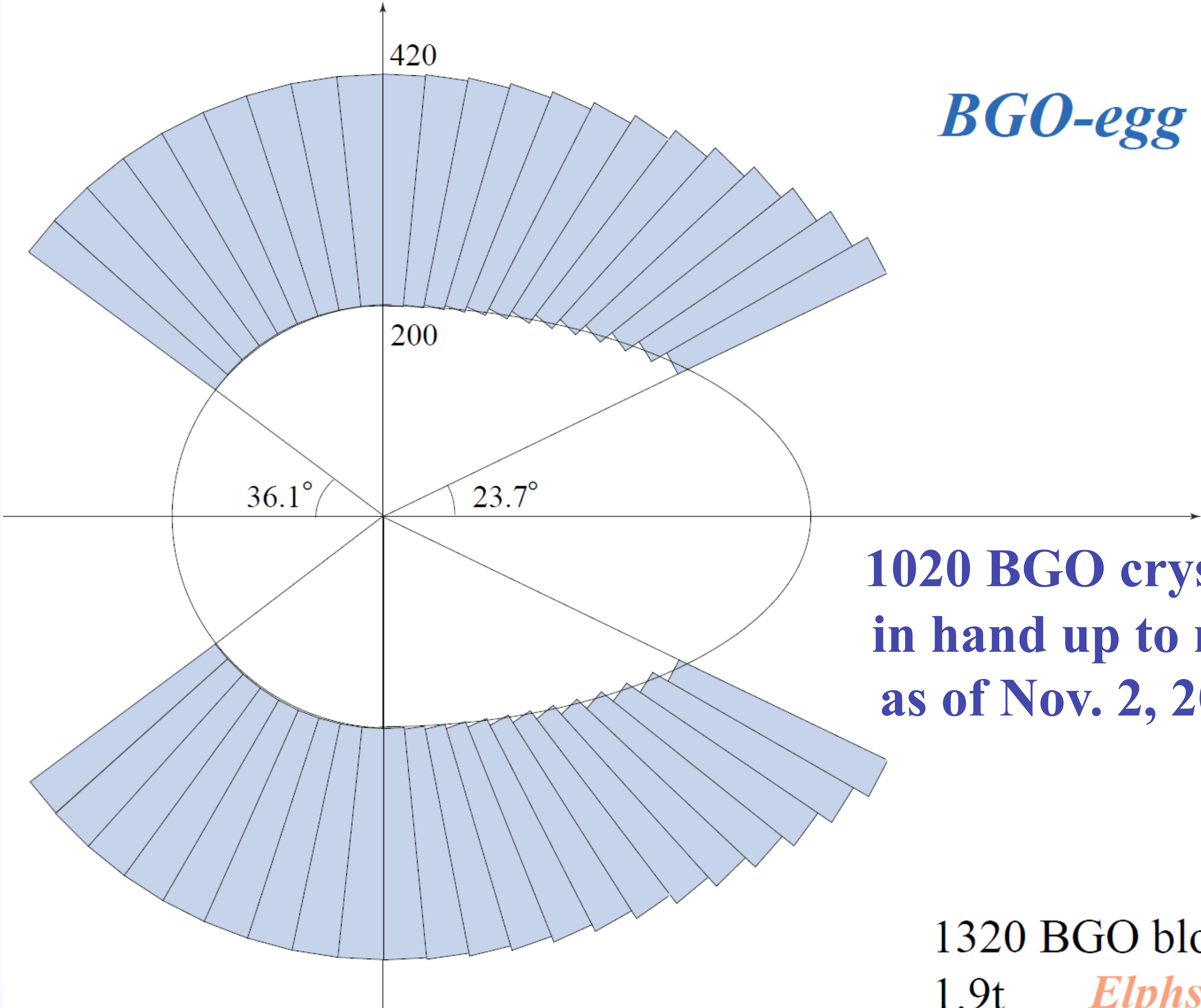
  <at Sendai>

  $\gamma p \to \pi^0 \eta p$ **at the threshold region**

  <at SPring-8>

  η' photoproduction in the nucleus

with the new γ detector



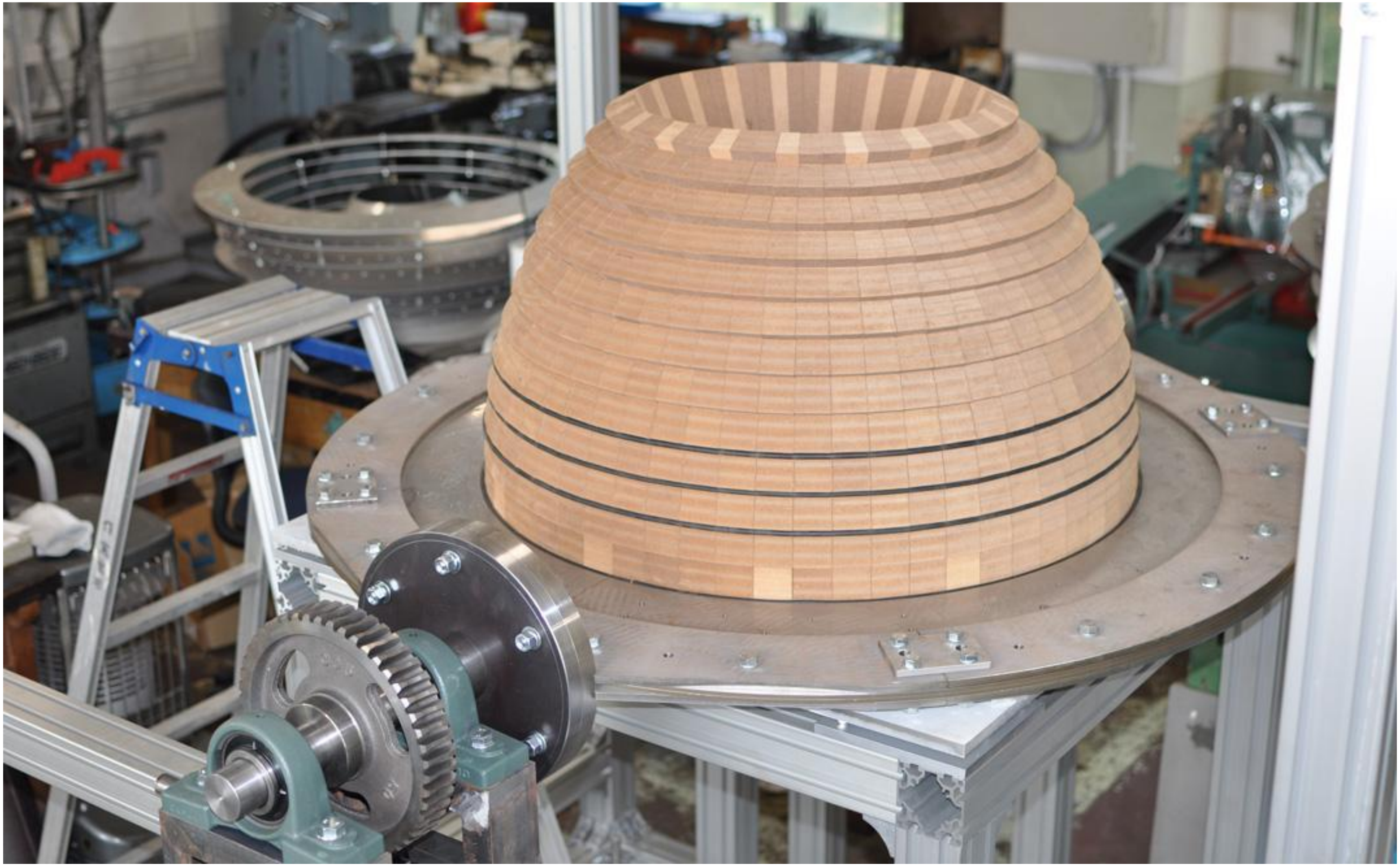
BGO-egg

1020 BGO crystals in hand up to now as of Nov. 2, 2010

1320 BGO blocks
1.9t

Elphs Lab

Construction of BGOegg with real scale wooden models



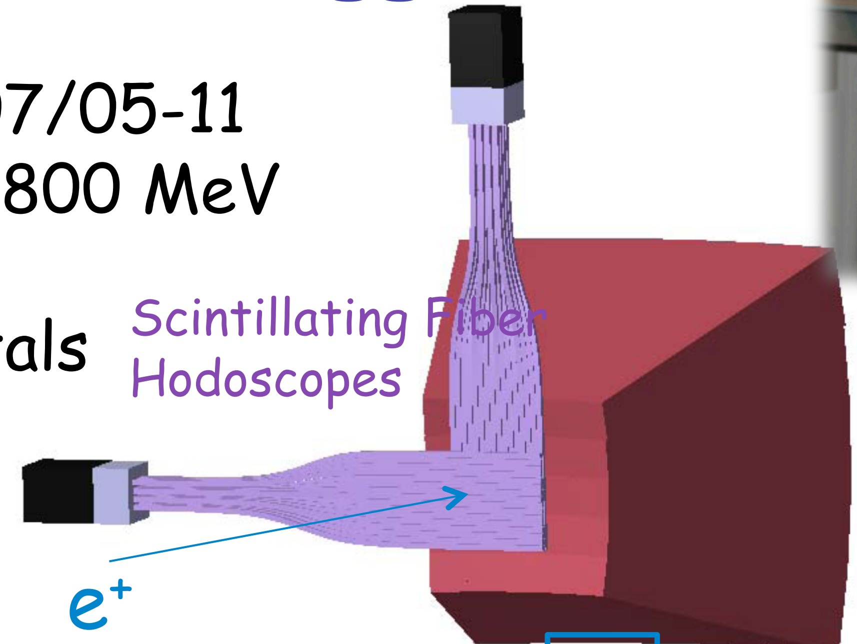
Measurement of the energy resolution of BGOegg

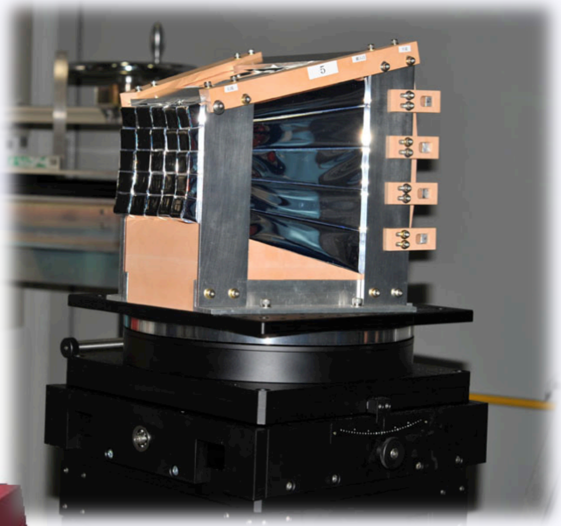
e+ beam, 2010/07/05-11
energy 100～800 MeV

5 x 5 BGO Crystals
total : 42 kg

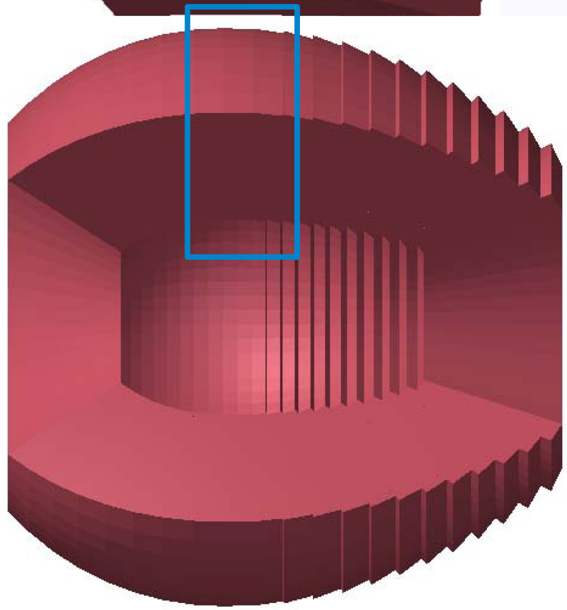
PMT H11334

Reflector
3M ESR 65 μm
(multi-layer structure)





5 × 5
BGO Crystals



BGOegg

Energy resolution of BGOegg

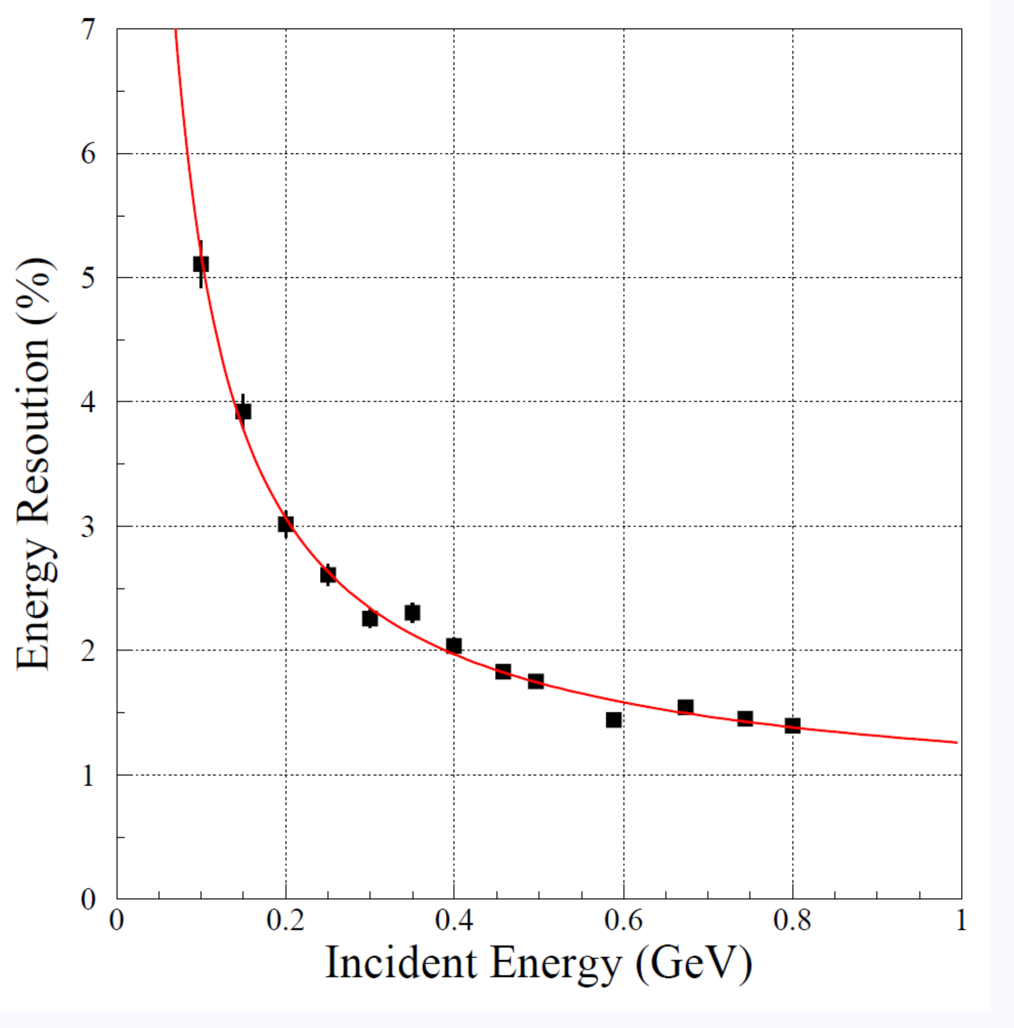
Red line

$$\frac{\sigma_E}{E} = \sqrt{a_0^2 + \left(\frac{a_1}{\sqrt{E}}\right)^2 + \left(\frac{a_2}{E}\right)^2}$$

Constant term $a_0 = 0.697 \pm 0.188$

Statistical term $a_1 = 0.963 \pm 0.105$

Noise term $a_2 = 0.414 \pm 0.037$



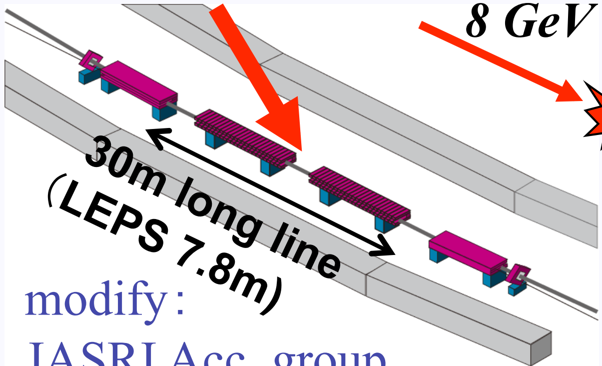
overall energy resolution

1.25% @ 1 GeV

world best!

Schematic view of the LEPS2 facility

Backward Compton Scattering



modify:
JASRI Acc. group

a) SPring-8 SR ring

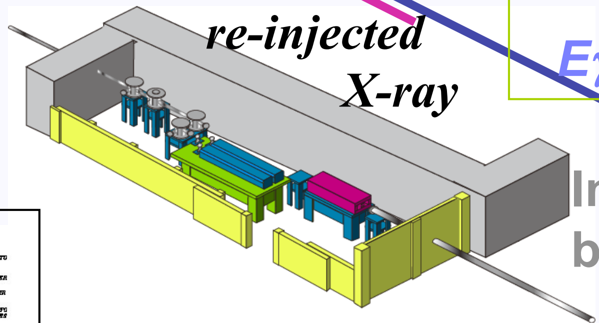
8 GeV electron

Recoil electron (Tagging)

Laser or re-injected X-ray

GeV γ-ray

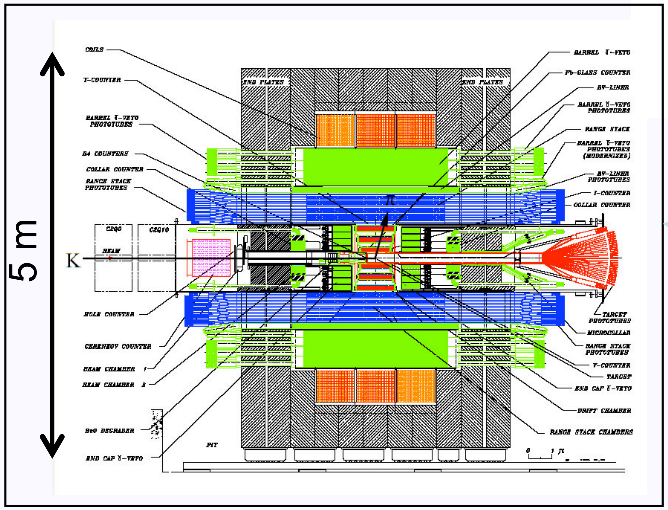
High intensity: Multi laser
LRNB
Round beam
~10^7 photons/s (LEPS ~10^6)
High energy: Re-injection of X-ray from undulator
(Tohoku U., JASRI)
Eγ < 7.5GeV *(LEPS < 3GeV)*



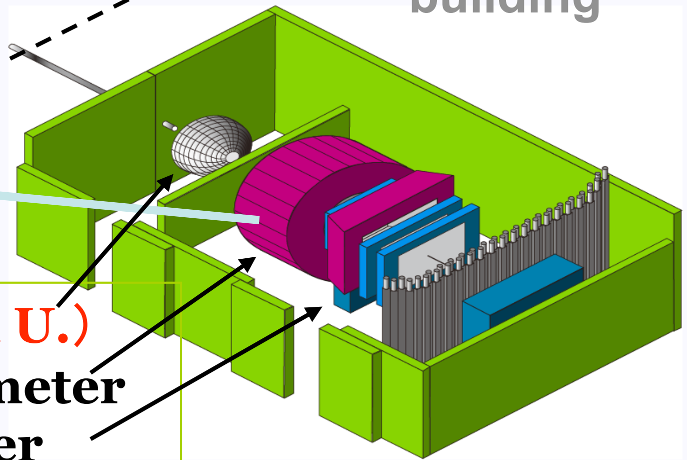
b) Laser hutch

Inside building

Outside building



Plan to move the BNL-E949 detector to Spring-8



4π γ detector (Tohoku U.)
Large decay spectrometer
Forward spectrometer
New DAQ system

c) Experimental hutch

SPring-8
(Super Photon ring-8 GeV)

- **Third-generation synchrotron radiation facility**
- **Circumference: 1436 m**
- **100 mA** ($\varepsilon_x \approx 6\times10^{-9}$ m·rad)
- **62 beamlines**