Present Status of the Shintake Monitor (IP-BSM)

Takashi Yamanaka, Masahiro Oroku,

T.Suehara, H.Yoda, Y.Kamiya, S.Komamiya

(Univ. of Tokyo)

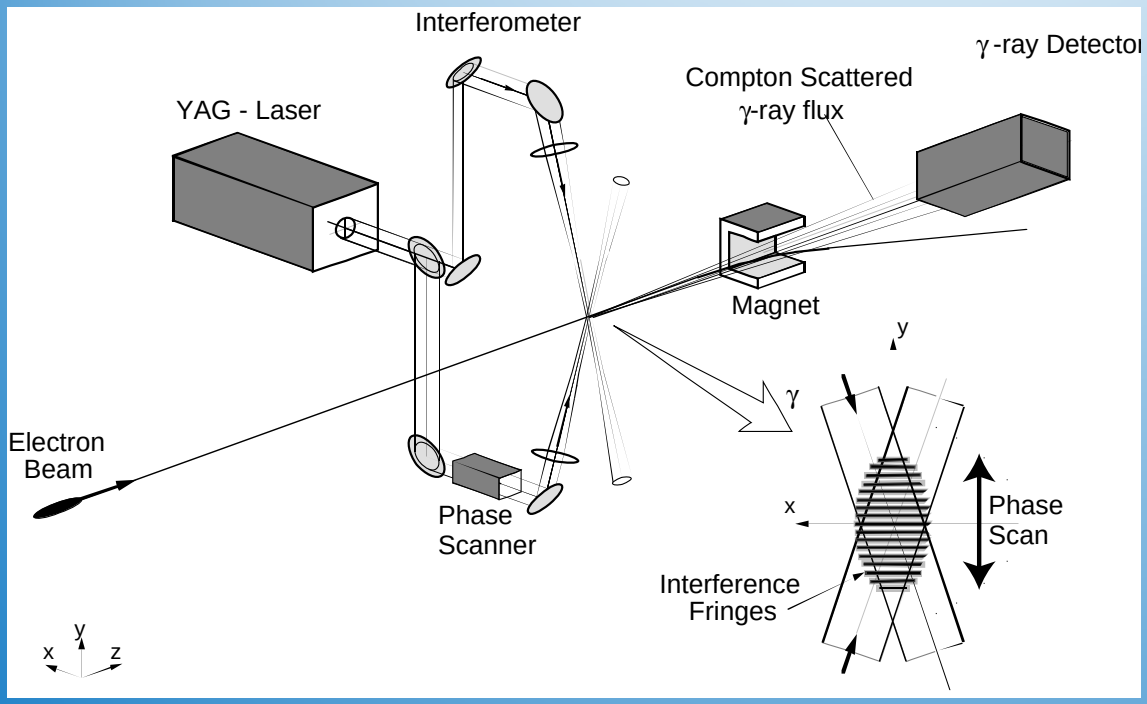
T.Tauchi, Y.Honda, T.Kume (KEK)

T.Sanuki (Tohoku Univ.)

Topics

1. Overview
2. Present Status
3. Discussion of Measurement Methods
4. Conclusions

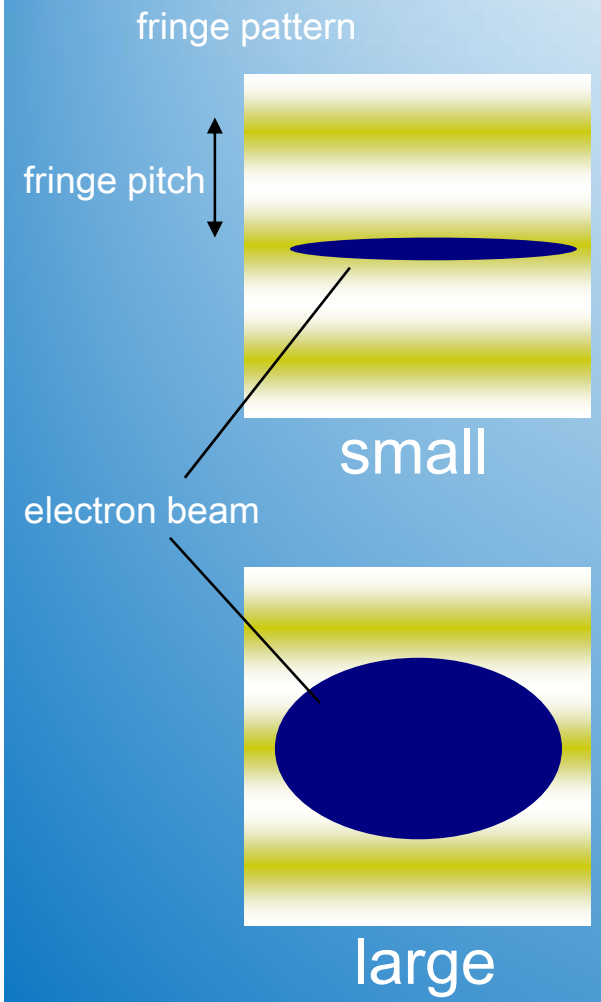
Overview (1)



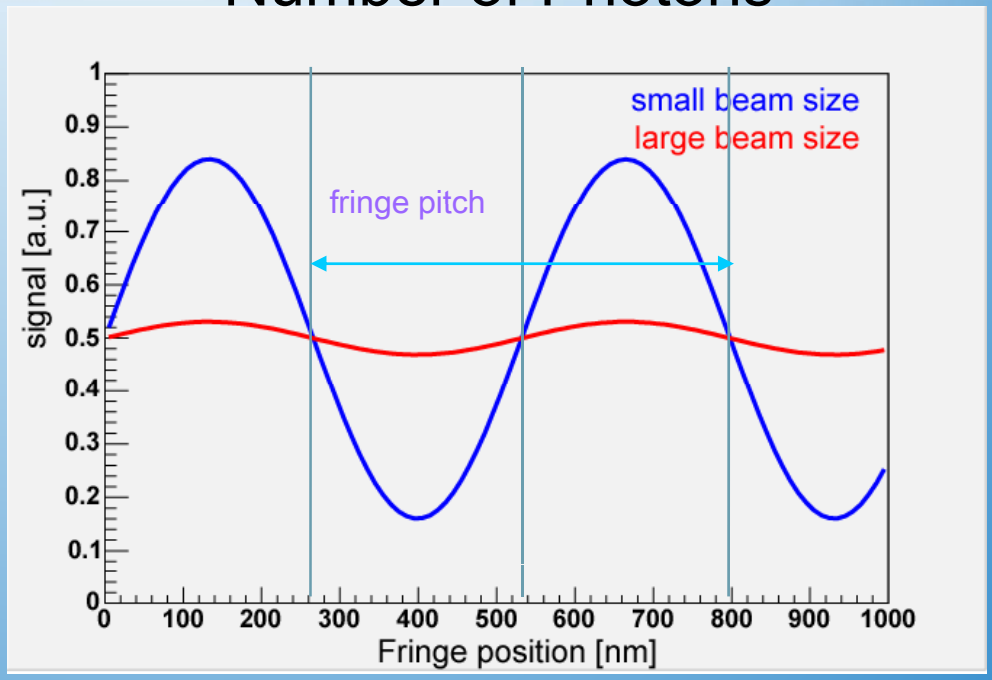
Schematic diagram of Shintake Monitor

Old Shintake Optical Table
(used in SLAC FFTB)

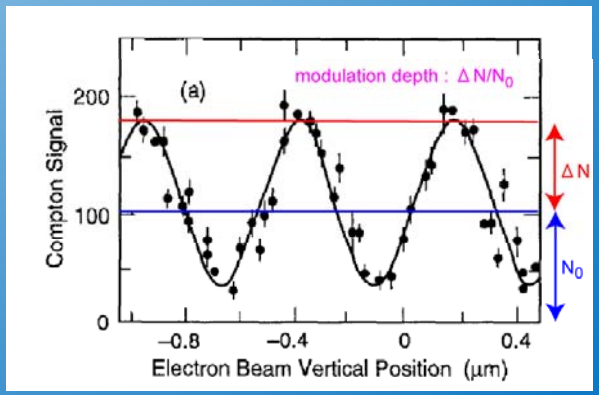
Overview (2)



Number of Photons



Measured photon signal
(at SLAC FFTB)

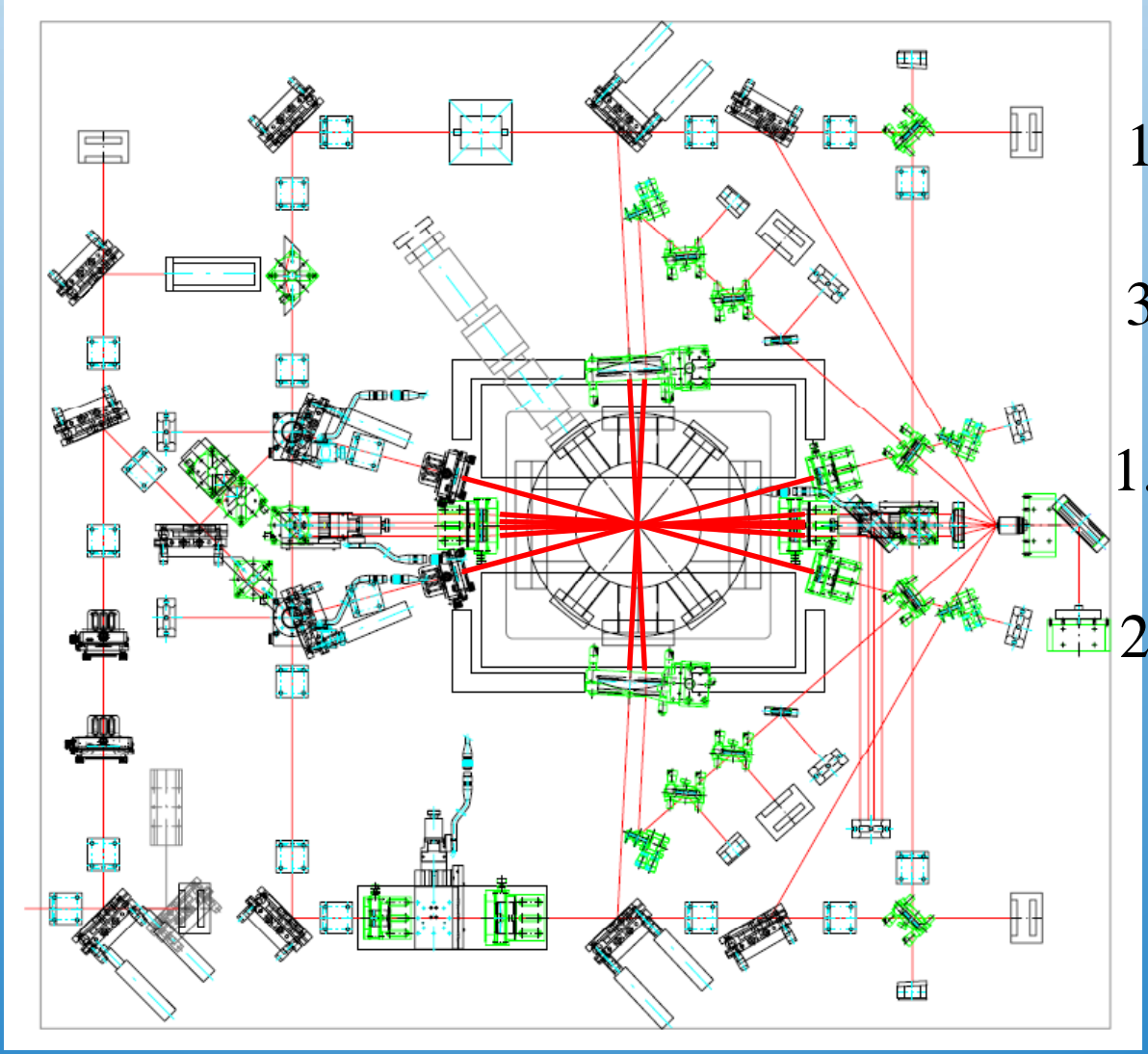


Present Status

- Decided to design a new optical table
- Design of the table was finished

Design of the Optical Table

- 2 degree mode
- 8 degree mode
- 30 degree mode
- 174 degree mode

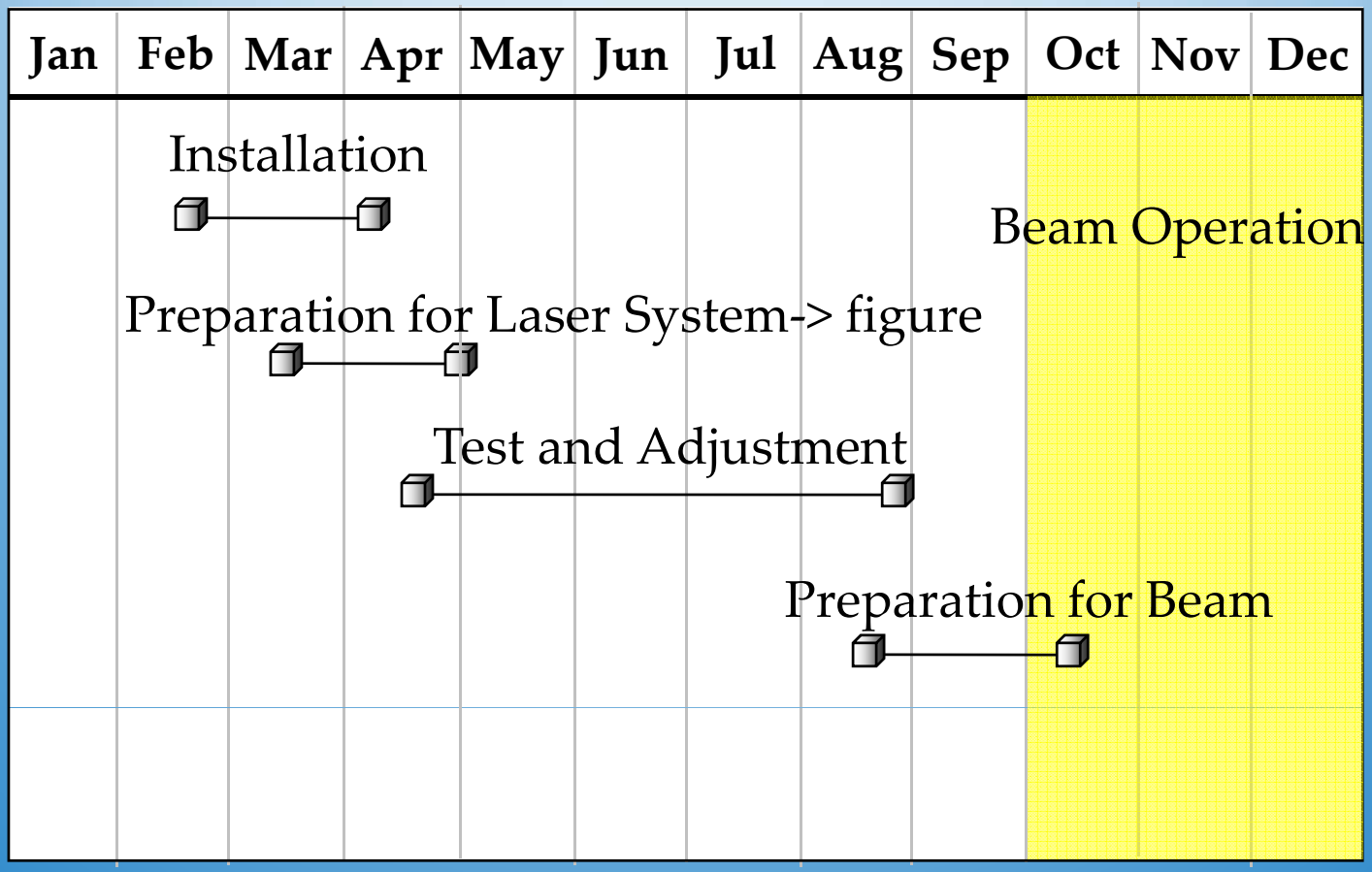


- 15µm pitch
- 3.8µm pitch
- 1.03µm pitch
- 266nm pitch

Present Status

- Decided to design a new optical table
- Design of the table was finished
- Installation schedule has been fixed
- Test of each optical components (on going)
- Evaluation of the errors from each detectors (on going)

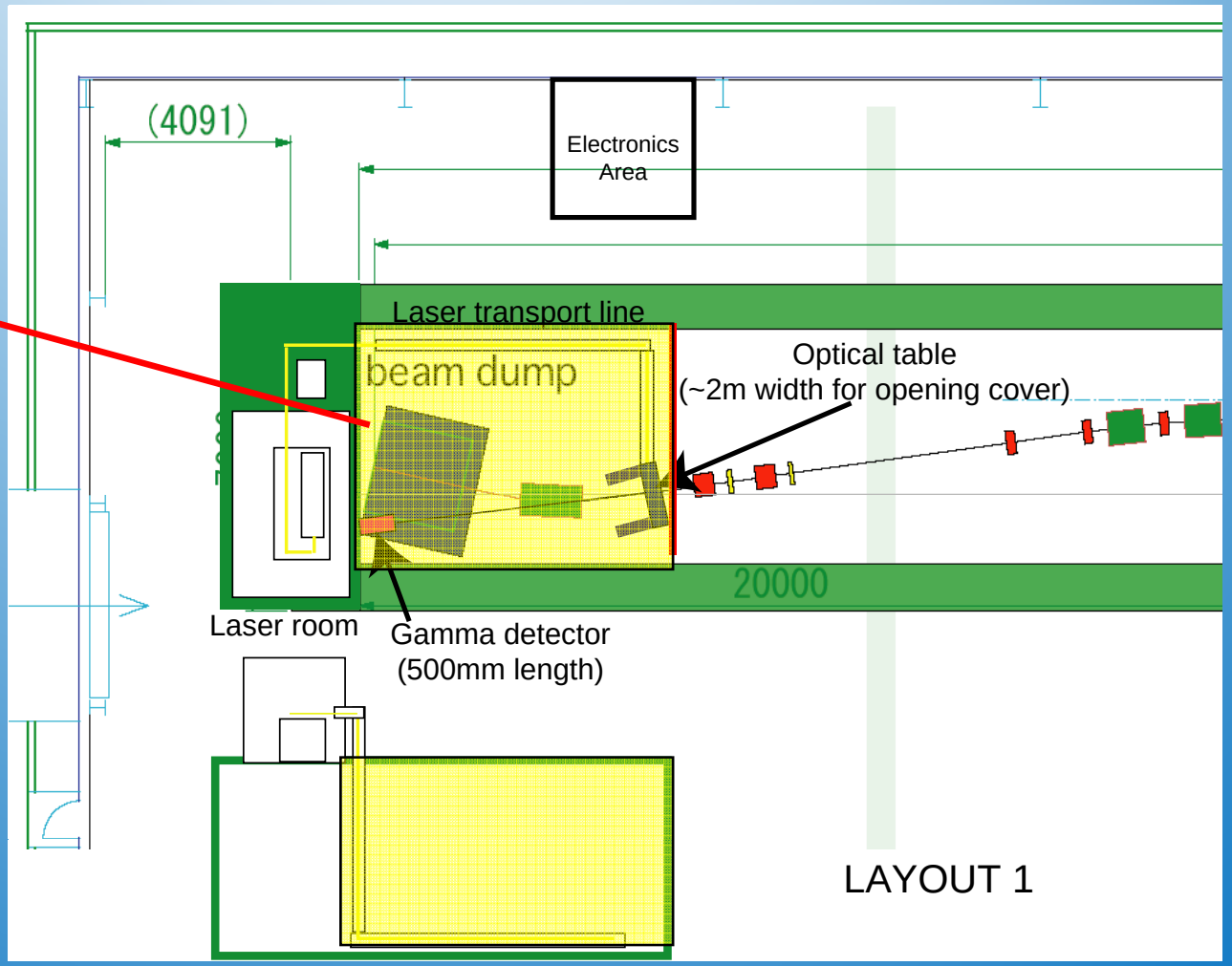
Schedule 2008



Preparation for Laser System

Laser Area

(during the optics test)



Discussion of Measument Methods

Calculation of Beam Size(1)

$$N_\gamma \propto \int_{-\infty}^{\infty} \frac{1}{\sqrt{2\pi}\sigma_y} \exp\left[\frac{-(y-y_0)^2}{2{\sigma_y}^2}\right] \{1+\cos 2\phi \cos(2k\sin\phi\cdot y)\}\,dy$$

Electron beam distribution

Laser fringe distribution

$$= 1+\cos(2k\sin\phi\cdot y_0)\cos 2\phi \exp\left[-2(k\sin\phi\cdot\sigma_y)^2\right]$$

N_γ : Number of photons

2ϕ : Laser crossing angle

σ_y : Vertical size of electron beam

y_0 : Center position of electron beam

Calculation of Beam Size(2)

$$\sigma_y = \frac{d}{2\pi}\sqrt{2\ln\left(\frac{|\cos 2\phi|}{M}\right)}$$

Modulation depth

$$M = \frac{N_{\max} - N_{\min}}{N_{\max} + N_{\min}} = |\cos 2\phi \exp\left[-2(k \sin\phi \cdot \sigma_y)^2\right]$$

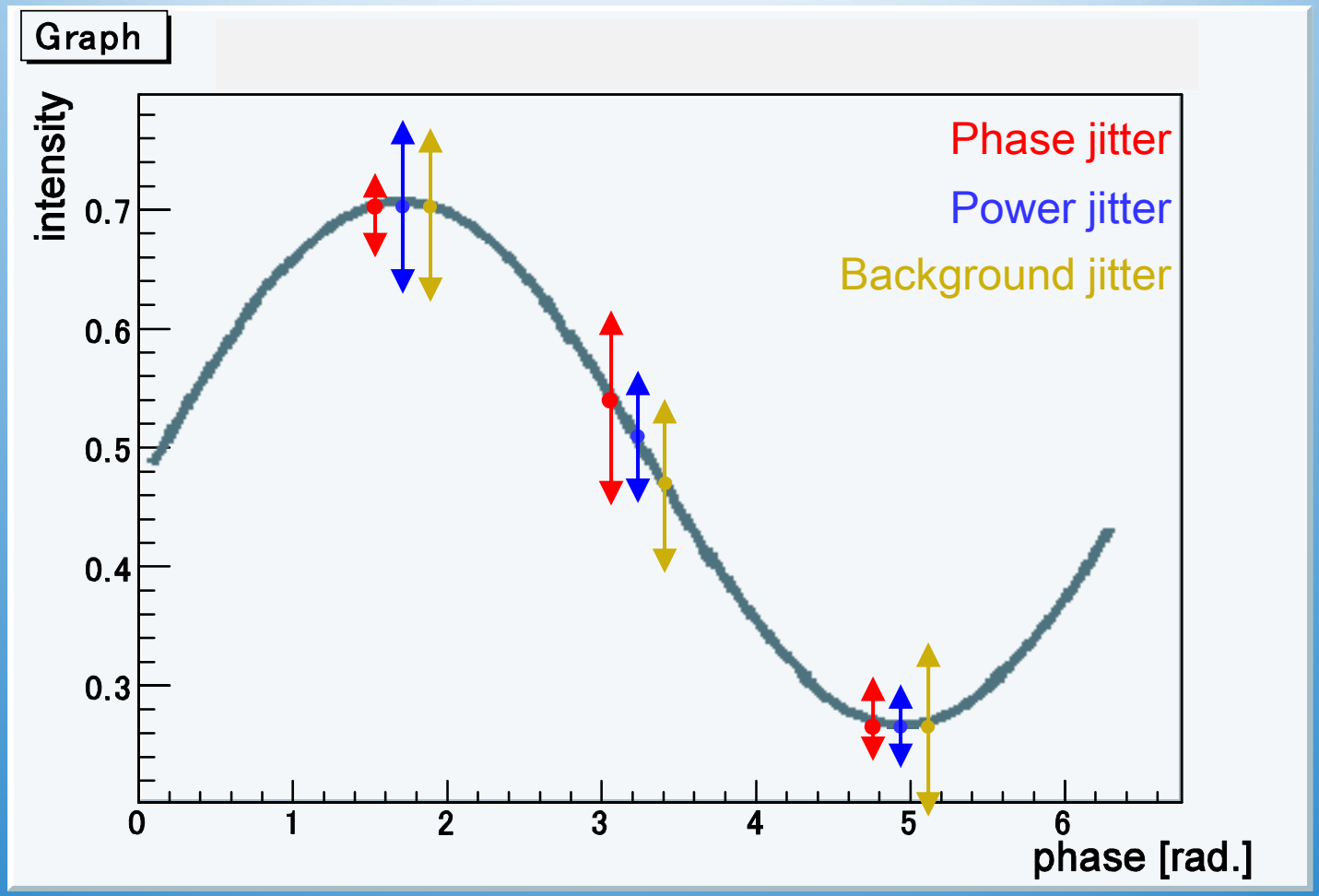
Fringe pitch

$$d = \frac{2\pi}{k \sin\phi} = \frac{\lambda}{\sin\phi}$$

Measurement Error Sources

- Electron beam charge jitter
- Electron beam timing jitter
- Electron beam position and size jitter
- Laser power jitter
- Laser phase jitter
- Background photon number jitter
- Fringe contrast jitter(not yet included)

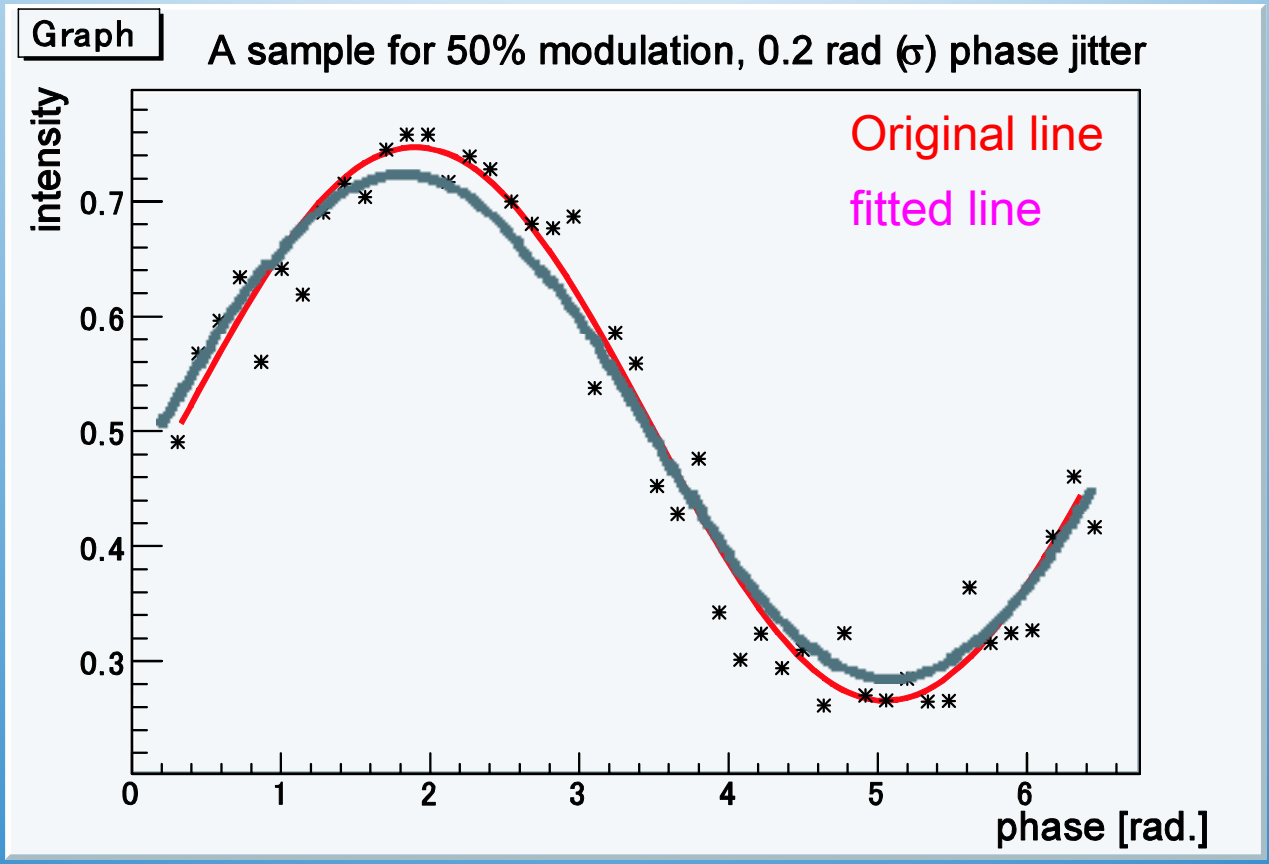
Main Error Sources



Measurement Methods

- There are several methods to calculate the beam size from the number of photons
  1. Fitting Method

Fitting Method



Measurement Methods

- There are several methods to calculate the beam size from the number of photons
  1. Fitting Method
  2. RMS Method

Calculation of RMS

$$\sigma_{\mathrm{M}} = \sqrt{\frac{1}{n}\sum_{k=1}^{n}\left(N_k - \bar{N}\right)^2}$$

$$= \sqrt{\frac{1}{n}\sum_{k=1}^{n}\left\{\bar{N}M\sin\left(\frac{2\pi k}{n} - \delta\right)\right\}^2}$$

$$= \frac{M\bar{N}}{\sqrt{2}} \qquad (n \to \infty)$$

$$M \simeq \frac{\sqrt{2}}{\bar{N}}\sigma_{\mathrm{M}}$$

$\bar{N}$: Average Number of Photons

$$N_k = \bar{N}\left(1 + M\sin\left(\frac{2\pi k}{n} - \delta\right)\right)$$

Number of Photons at each step

Measurement Methods

- There are several methods to calculate the beam size from the number of photons
  1. Fitting Method
  2. RMS Method
  3. Peak Search

Modulation Uncertainty

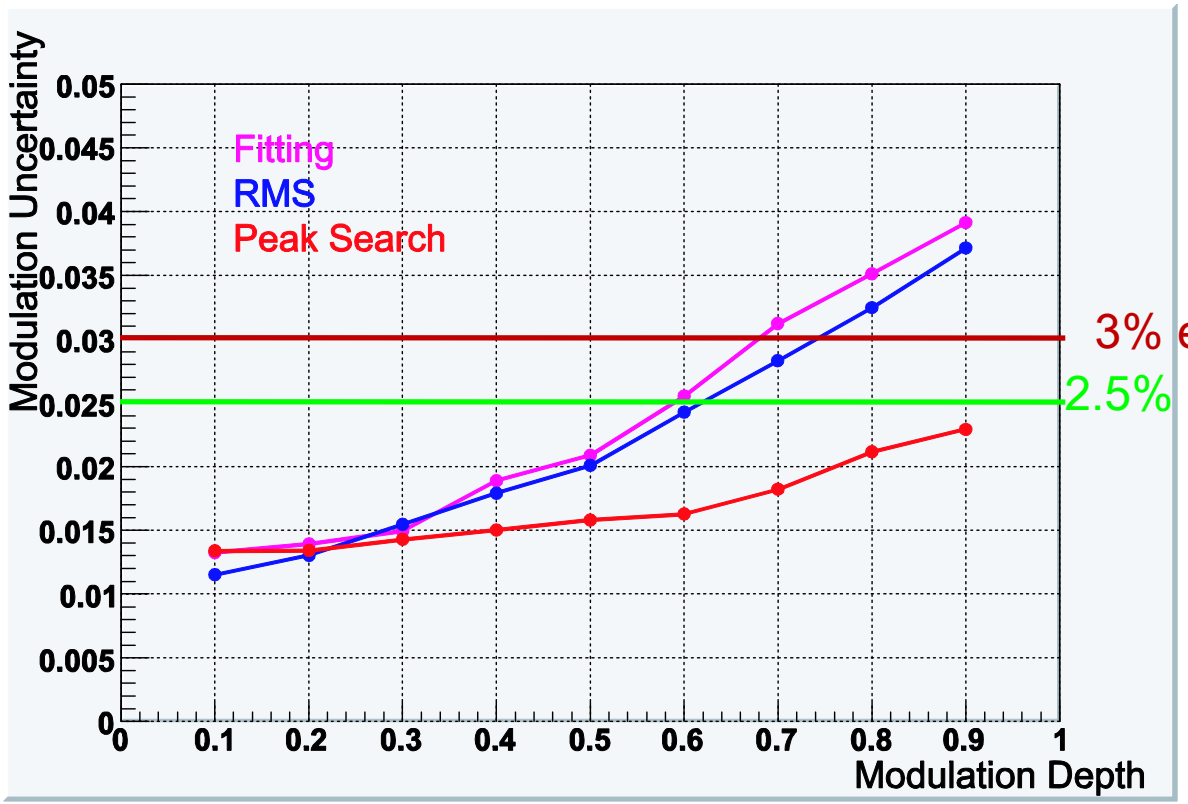


figure from T.Suehara(Univ. of Tokyo)

Power Jitter : 3%

Phase Jitter : 0.3 rad

Background Jitter : 5% respect to the average signal photons

Conclusions

- Goal : 2.5% error 35nm beam size
  3% error all measurement area
  (20nm ~ 5μm)
- Measurement methods
  → Peak search will be the best
- Cross check will be introduced