Current Status of **Nanometer Beam Size Monitor** for ATF2

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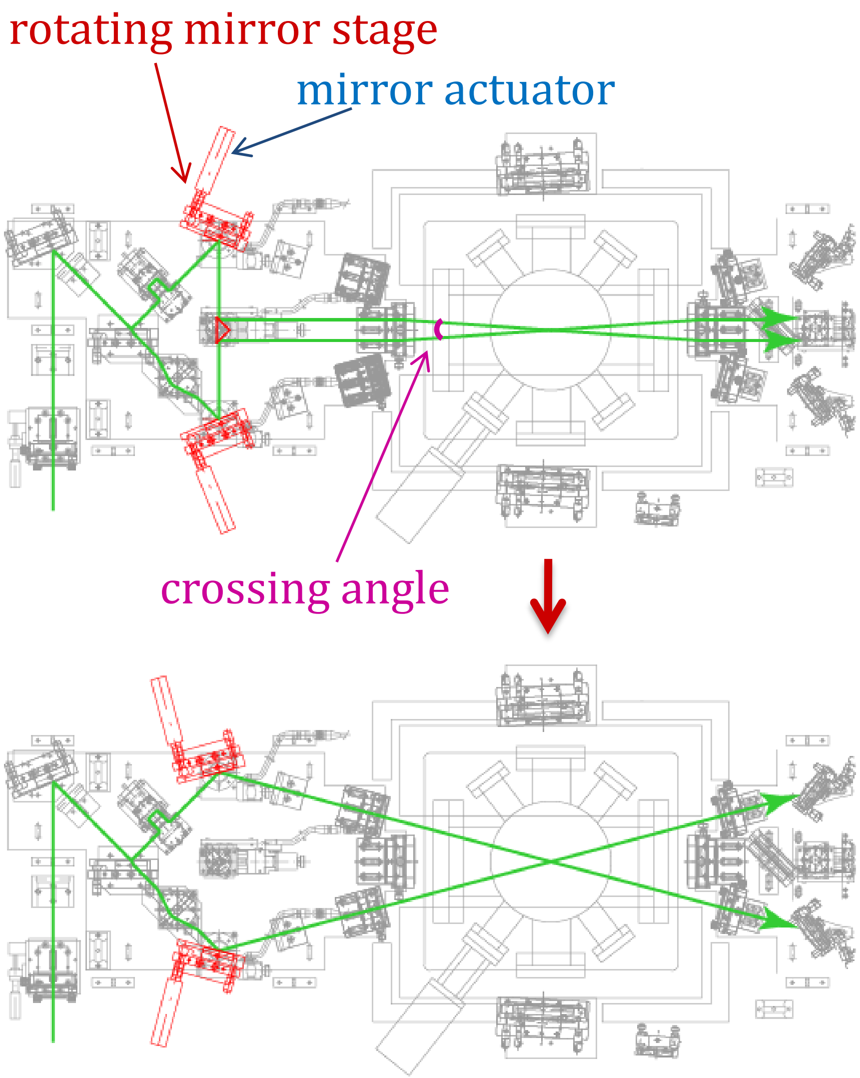
Yohei Yamaguchi
M. Oroku, J. Yan, Y. Kamiya, S. Komamiya
T. Yamanaka, T. Suehara
T. Okugi, N. Terunuma, T. Tauchi, S. Araki, J. Urakawa

Shintake Monitor's largest difficulty at present

= Laser crossing angle mode switching

- What's mode switching ?
- Obstacles in mode switching
- Strategies for resolving difficulty

Mode switching



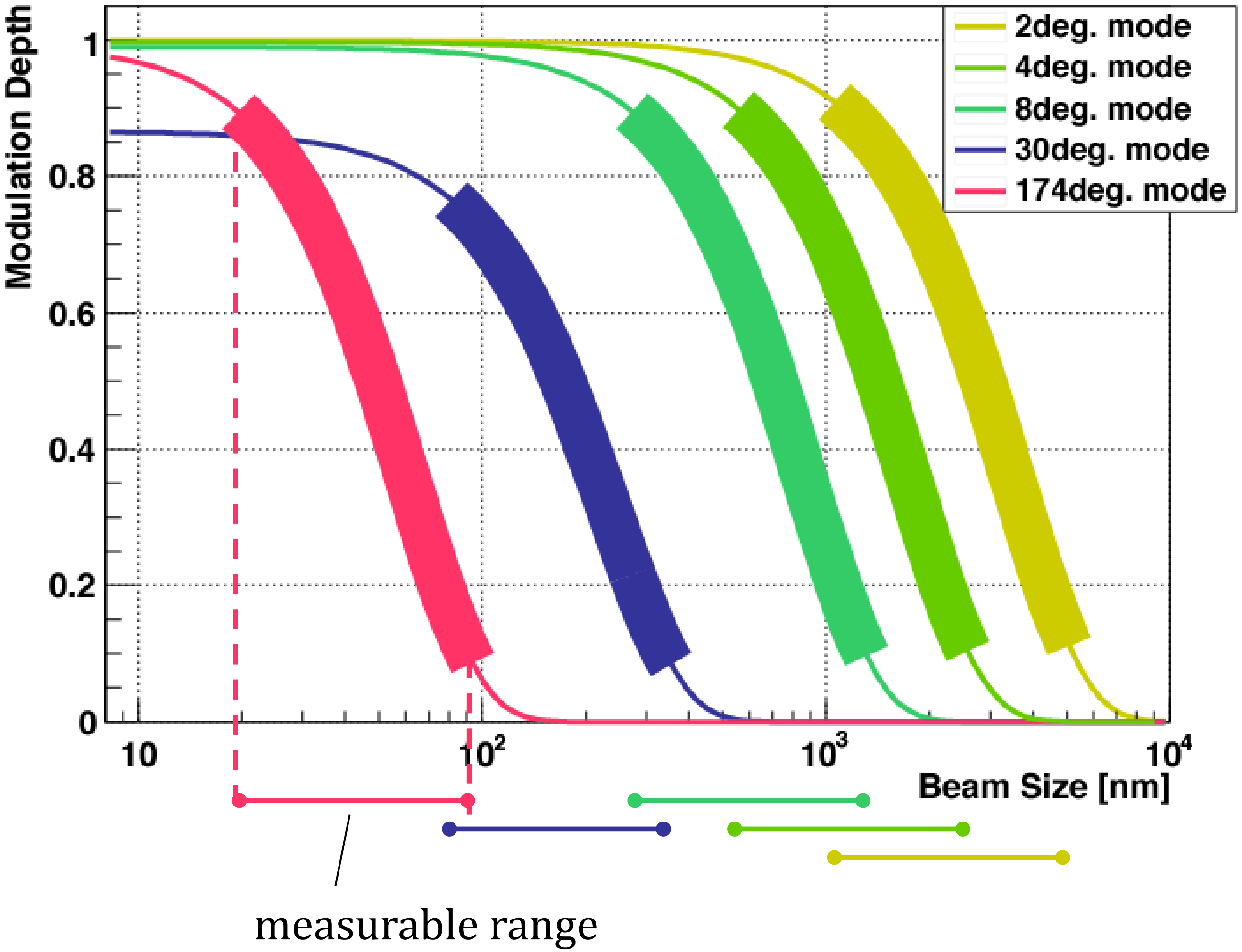
During mode switching, two laser beams must be realigned at the IP using different laser paths

The modulation must be reconstructed from scratch

For good interference fringe contrast, laser pathway requires alignment precision of a few microns

Otherwise, we lose the signal modulation

Crossing angle & modulation depth



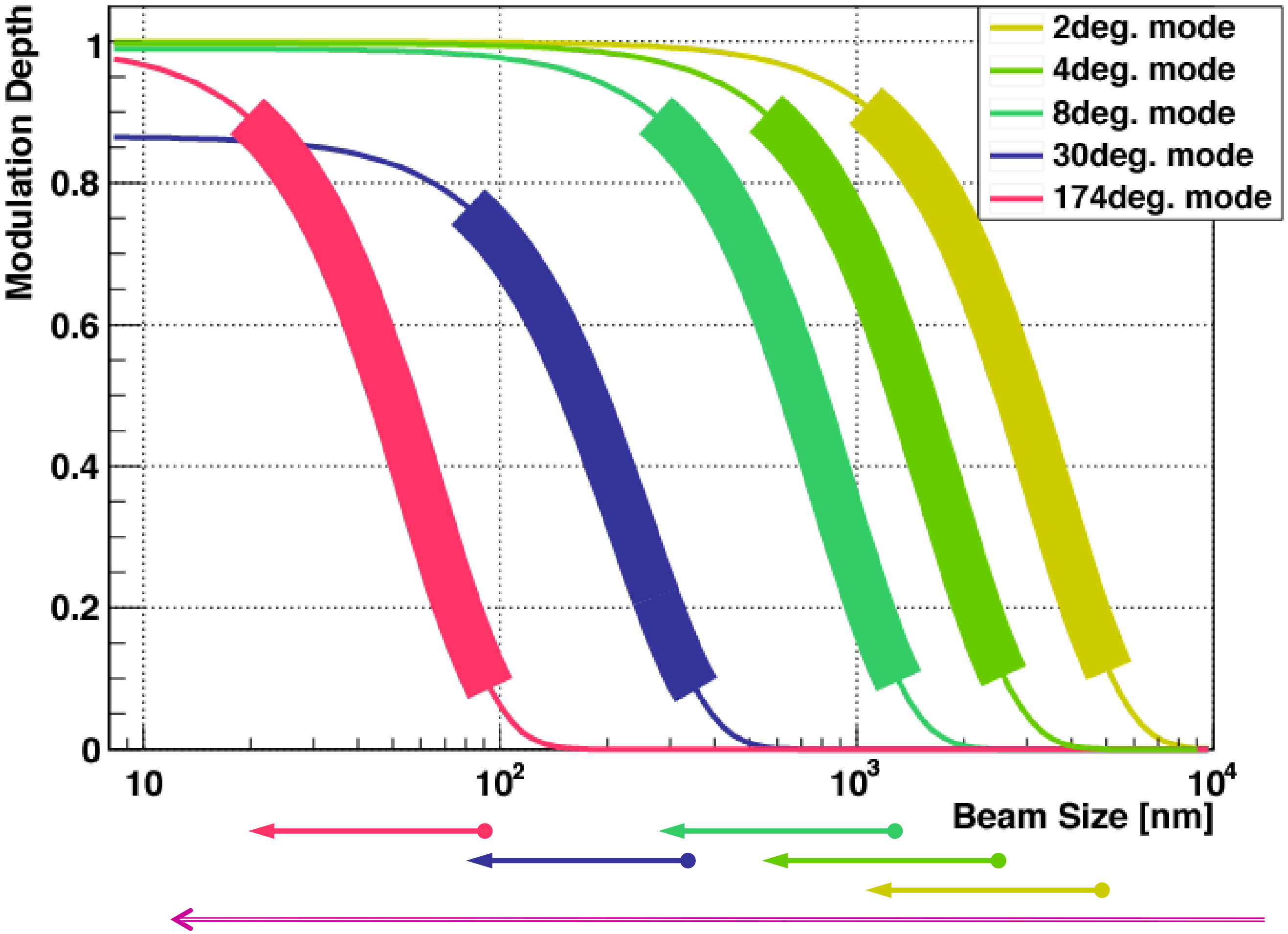
Interference fringe pitch (d) depends on laser crossing angle θ

$$d = \frac{\pi}{k \sin \frac{\theta}{2}}$$

Measurable beam size range (proportional to fringe pitch) **controlled by mode switching**

2-8, 30 and 174 deg crossing modes

Crossing angle & modulation depth

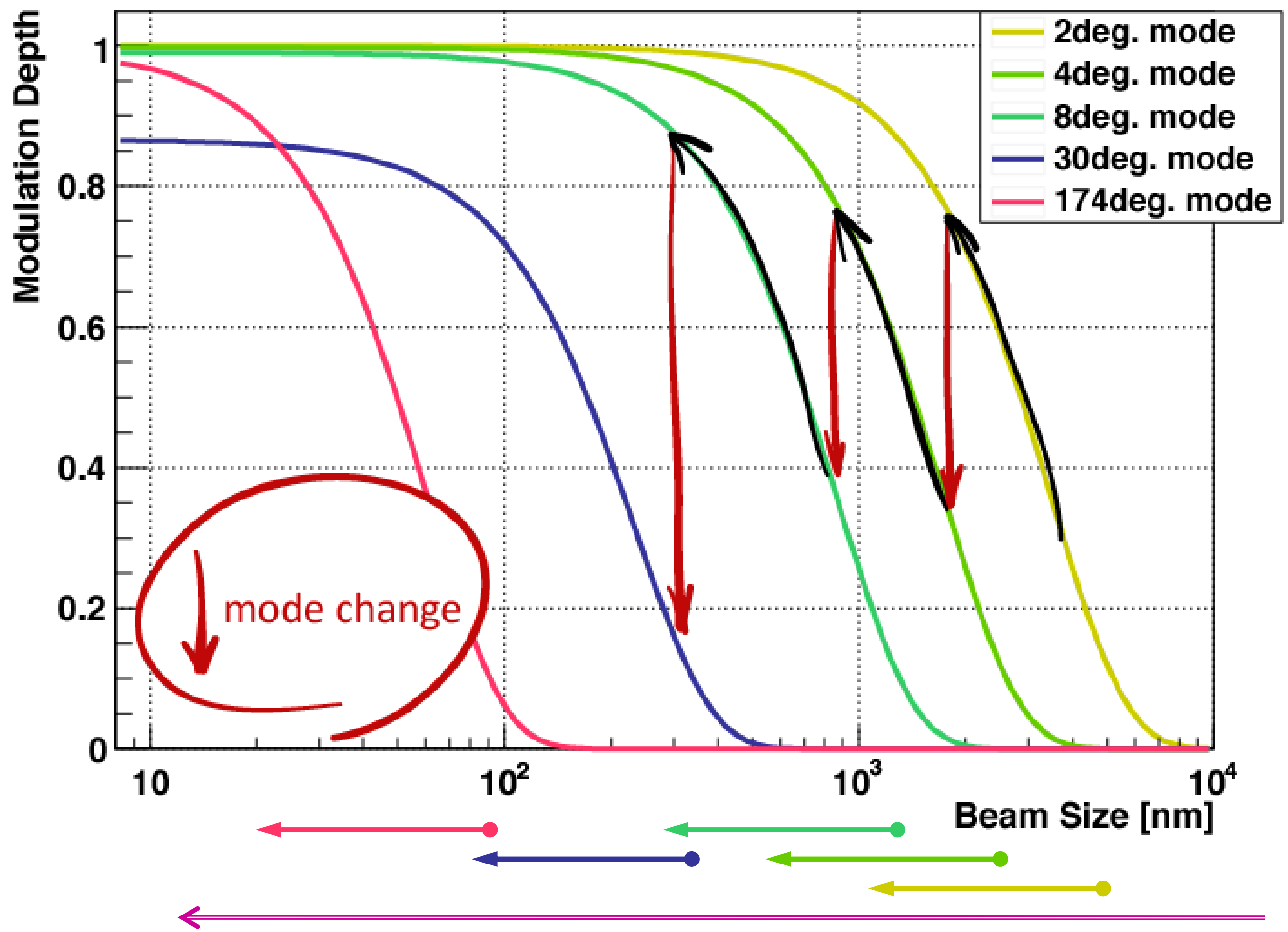


During beam tuning, beam size gets smaller step by step

We change the mode accordingly

Beam Tuning

Crossing angle & modulation depth

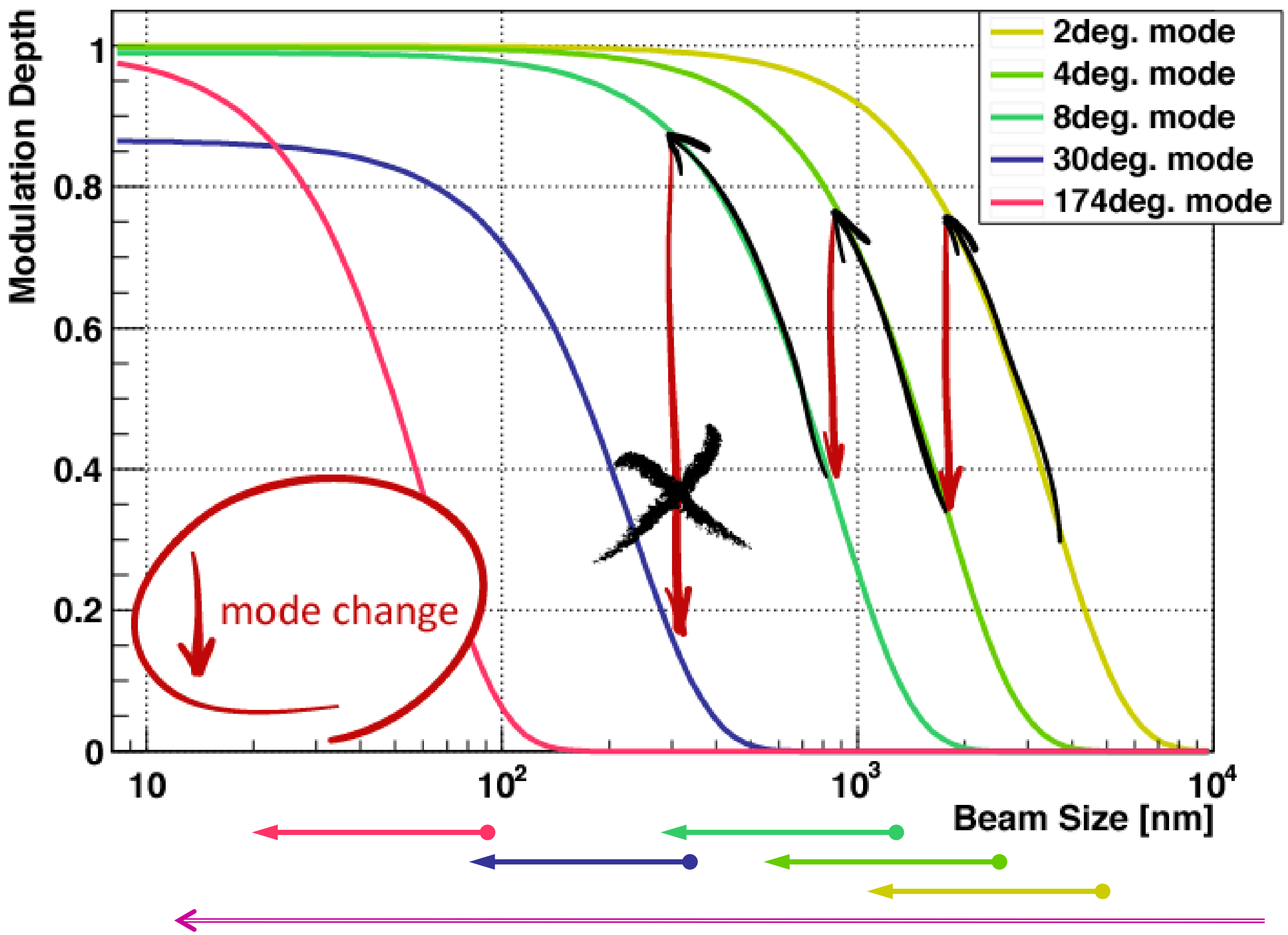


Mode switching causes sudden modulation drop

→ **Modulation is easily lost** during mode switching

Beam Tuning

Crossing angle & modulation depth

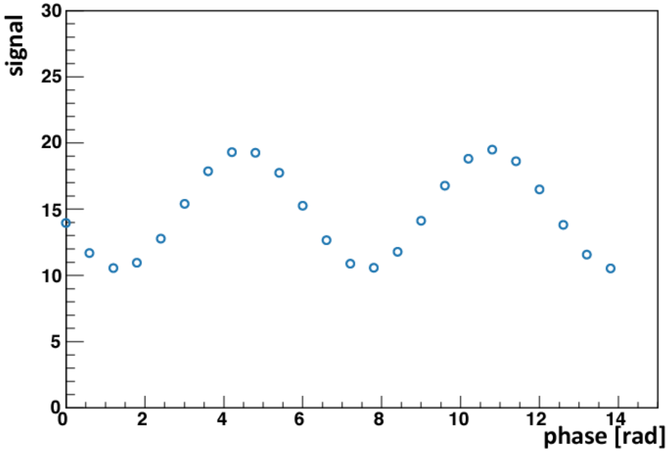


For example:
In 2010 we could not reconstruct modulation when switching to 30 deg mode

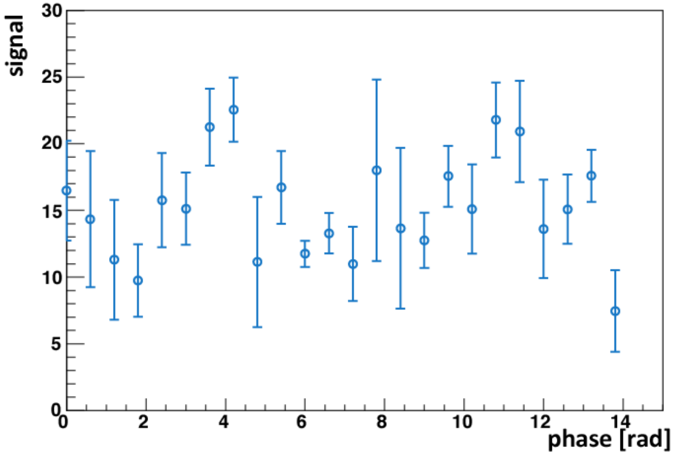
Beam Tuning

Main cause for losing modulation: signal jitter > modulation depth

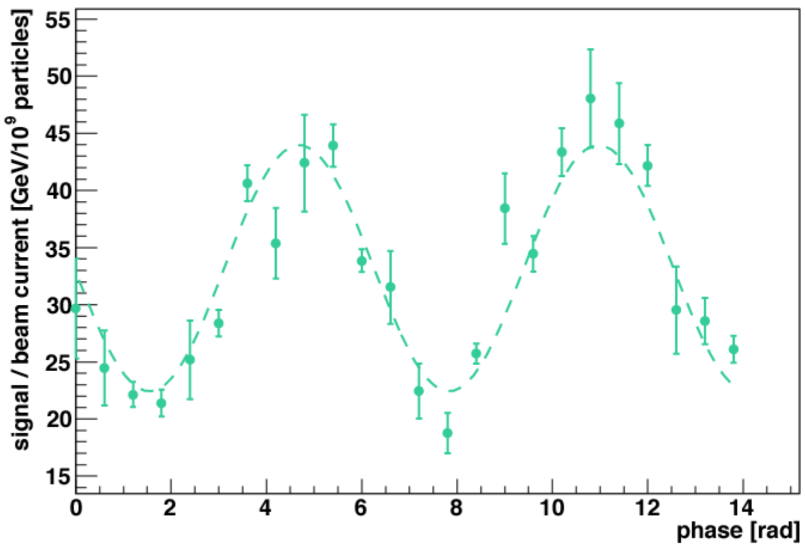
No signal jitter



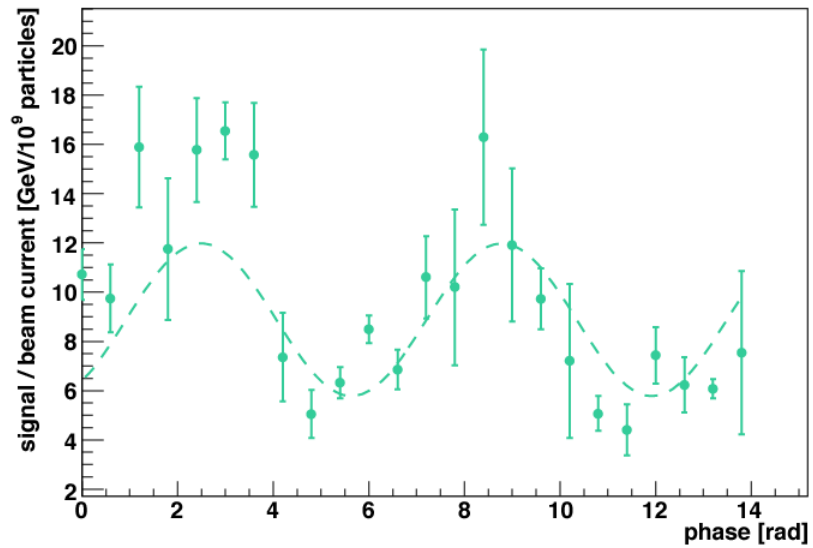
Large signal jitter



Run of early 2010



Most recent run



Signal jitter: 20%

already large jitter

M = 0.32

S/N = 30

beam size resolution: 9%

Signal jitter: 30%

too large jitter

M = 0.35

S/N = 0.6

beam size resolution: 12%

Large signal jitter hinders modulation reconstruction

Sources of signal jitter

High BG

increased 10 times from early 2010

Low signal

decreased down to 1/5 of early 2010

Laser orbit fluctuation

Beam size jitter

typically 20%

Other jitter sources

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Other jitter sources

early 2010:

tentative **large $\beta_{y\,(x)}^{*}$ beam optics**

↓

optics with design $\beta_{y\,(x)}^{*}$

Sources of signal jitter

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Low signal

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Laser orbit fluctuation

Beam size jitter

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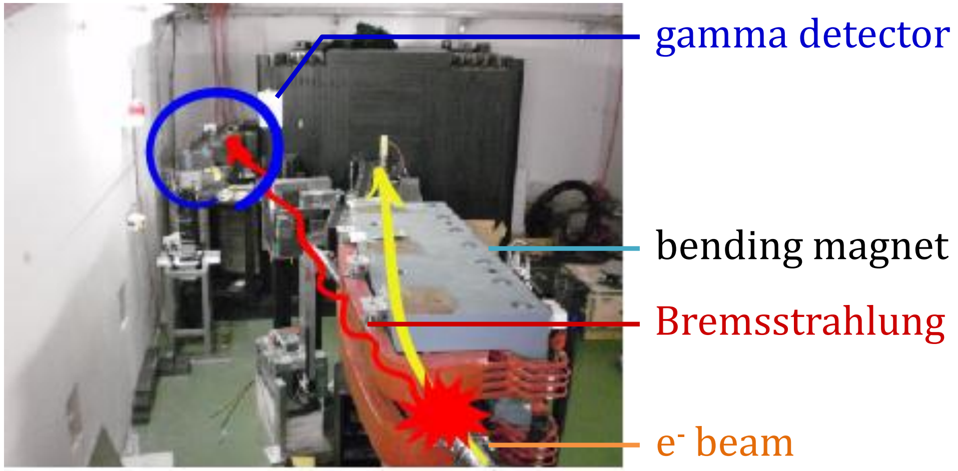
Other jitter sources

bending magnet

Bremsstrahlung generated at final bending magnet can enter gamma detector

Plan to install additional collimator to cut this radiation



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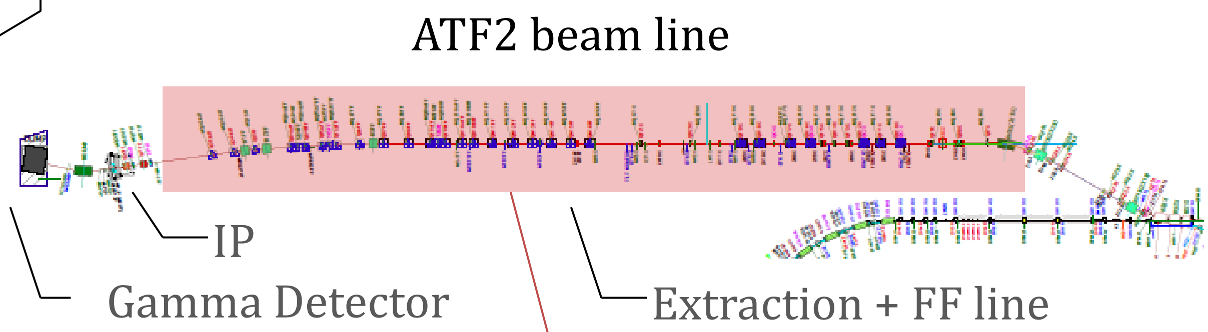
Other jitter sources

other BG sources



BGs generated upstream can also reach gamma detector

We are trying to identify sources of BG

Sources of signal jitter

High BG

increased 10 times from early 2010

Low signal

decreased down to 1/5 of early 2010

Laser orbit fluctuation

Beam size jitter

typically 20%

Other jitter sources

bad laser profile

design spot size: 10 μm
measured spot size: 20 μm
affects local laser power density at IP

Total laser pulse power and beam current are satisfactory

Sources of signal jitter

High BG

increased 10 times from early 2010

Low signal

decreased down to 1/5 of early 2010

Laser orbit fluctuation

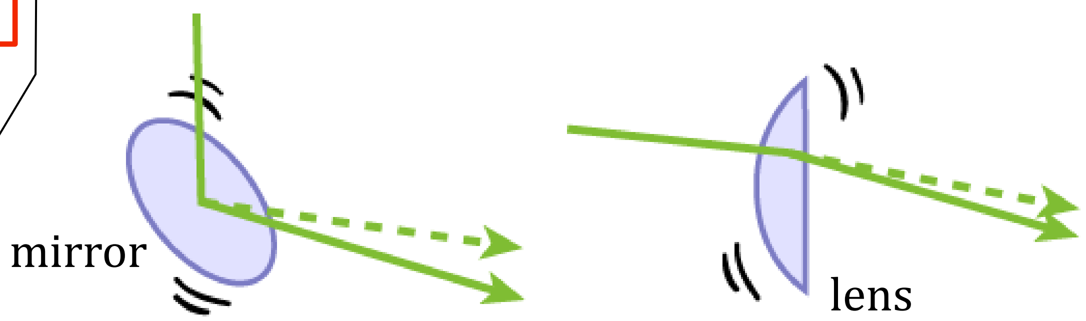
Beam size jitter

typically 20%

Other jitter sources

laser orbit fluctuation

- suspected to be a dominant jitter source
- under evaluation with Position Sensitive Detectors
- **hardware upgrade for stabilization is going on**



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Beam size jitter

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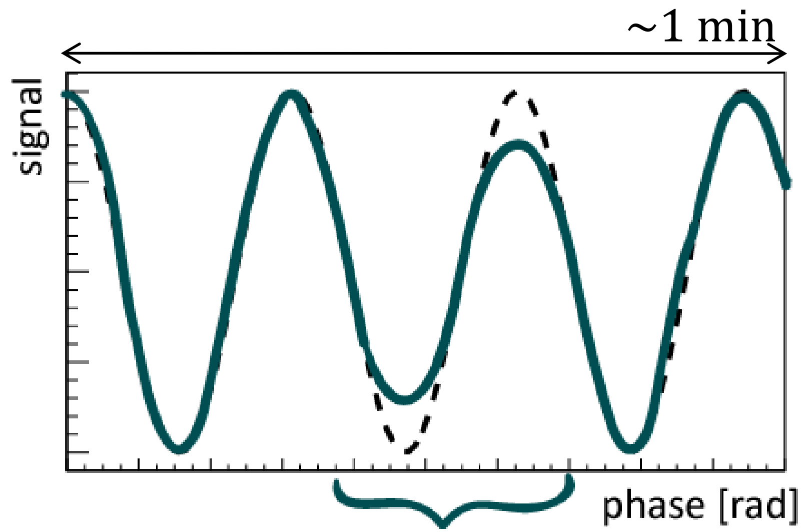
Other jitter sources



beam size got bigger in the middle of interference scan

Beam size fluctuation can cause signal instability

This can be constantly monitored by…

1. **beam profile monitor**
2. **Q-magnet current monitor**

Sources of signal jitter

High BG

increased 10 times from early 2010

Low signal

decreased down to 1/5 of early 2010

Laser orbit fluctuation

Beam size jitter

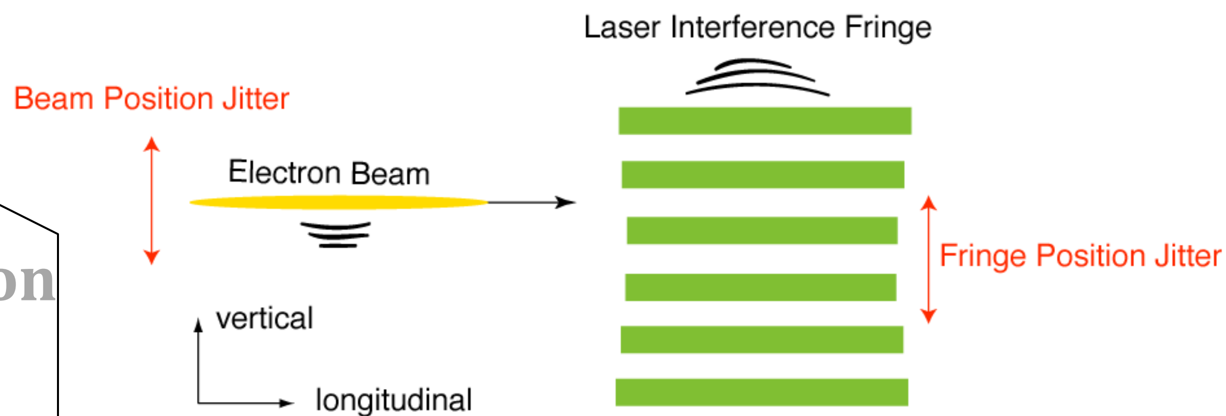
typically 20%

Other jitter sources

<Checked>

1. relative position jitter

< 200 [mrad] (8 deg mode)



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Laser orbit fluctuation

Beam size jitter

typically 20%

Other jitter sources

<Checked>

1. relative position jitter
   < **200 [mrad] (8 deg mode)**

2. laser power fluctuation
   0.9 % (May 2010)
   2 % (Dec. 2010)

3. beam current fluctuation
   2 - 5 % (measurement resolution)

4. laser timing fluctuation
   600 ps (May 2010)
   900 ps (Dec. 2010)
   (pulse width: 8 ns (FWHM))

These are negligibly small

Sources of signal jitter

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Low signal

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Laser orbit fluctuation

Beam size jitter

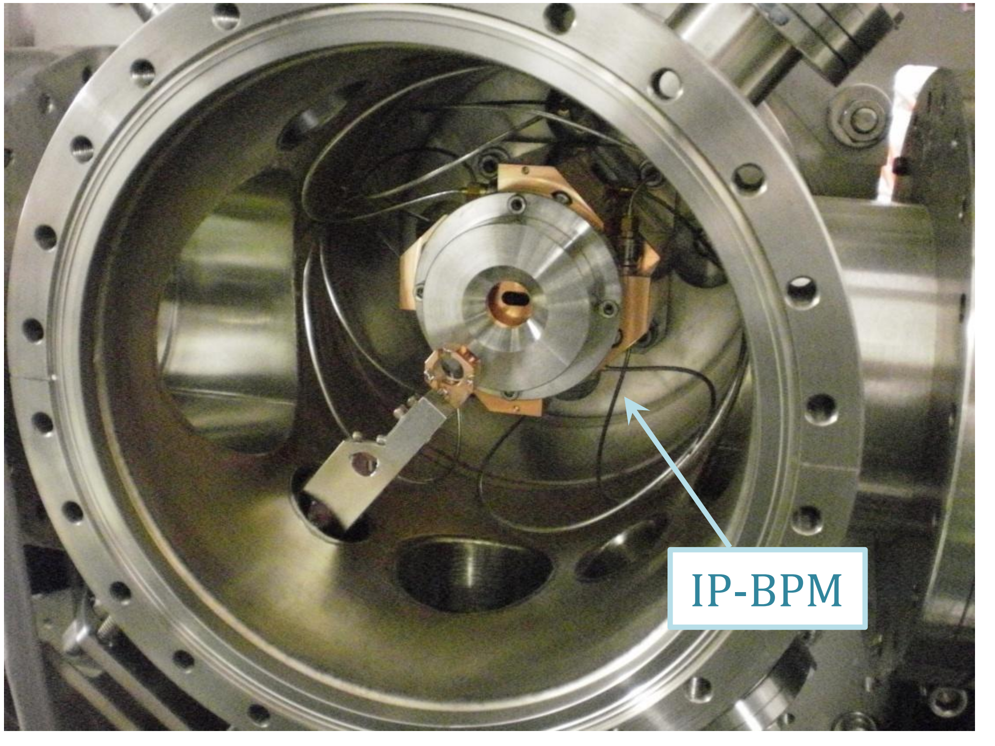
typically 20%

Other jitter sources

<Still Checking>

1. beam trajectory fluctuation

can be measured with BPMs and correctable



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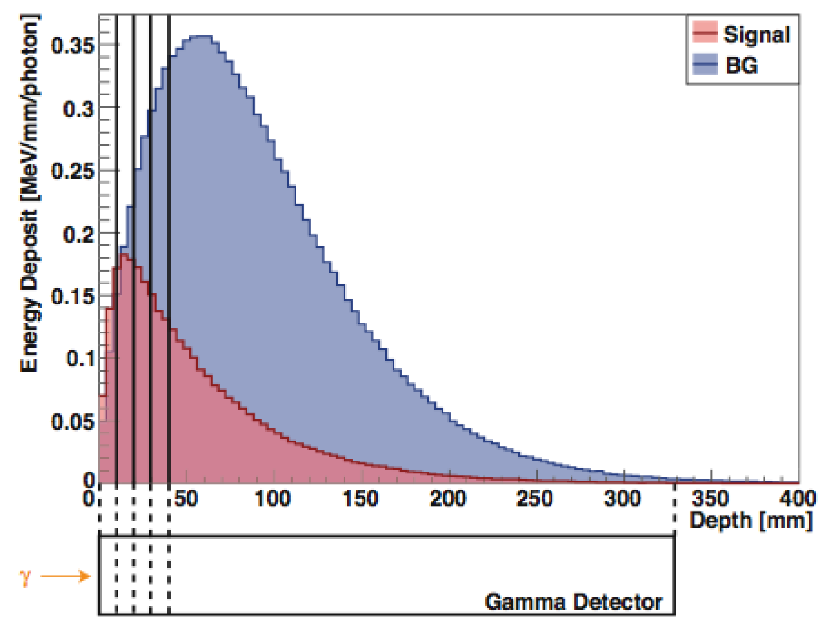
Other jitter sources

<Still Checking>

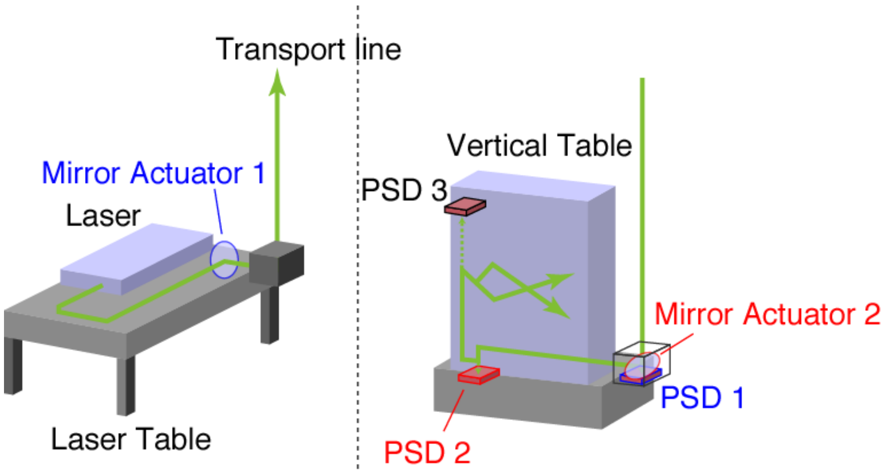
2. signal separation from BG using shower development in gamma detector

degraded when BG spectrum changes



Example of hardware upgrade:

laser orbit stabilization



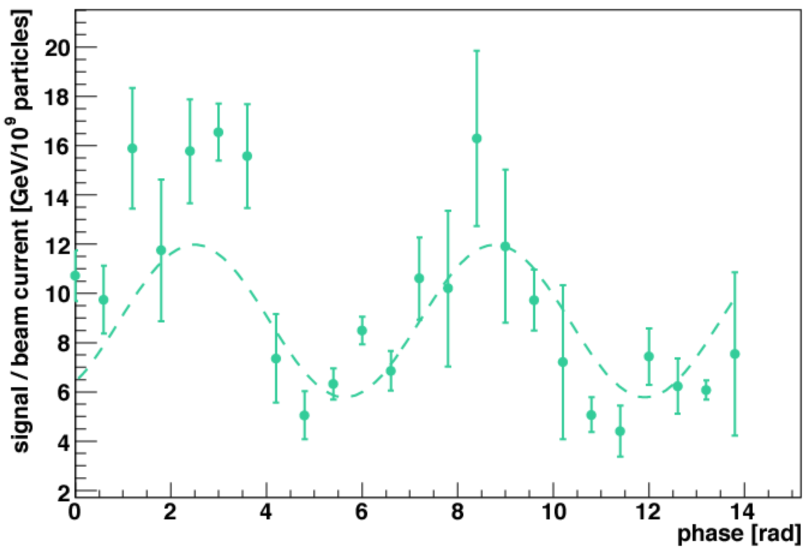
laser orbit feedback system with PSDs and mirror actuators

stabling and monitoring laser system temperature

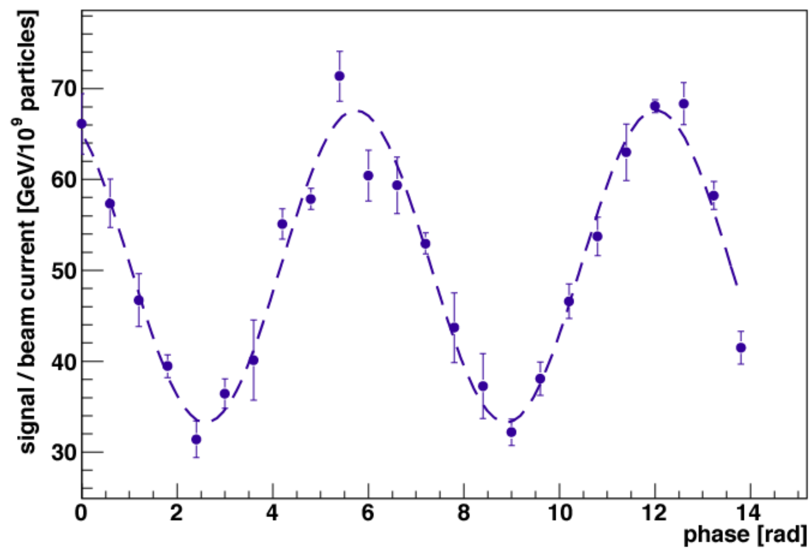
vibration removal in laser transport

laser position fluctuation at IP
~10 μm → ~1 μm

Most recent run



Suppressed signal jitter (simulated)



Signal jitter: 30%

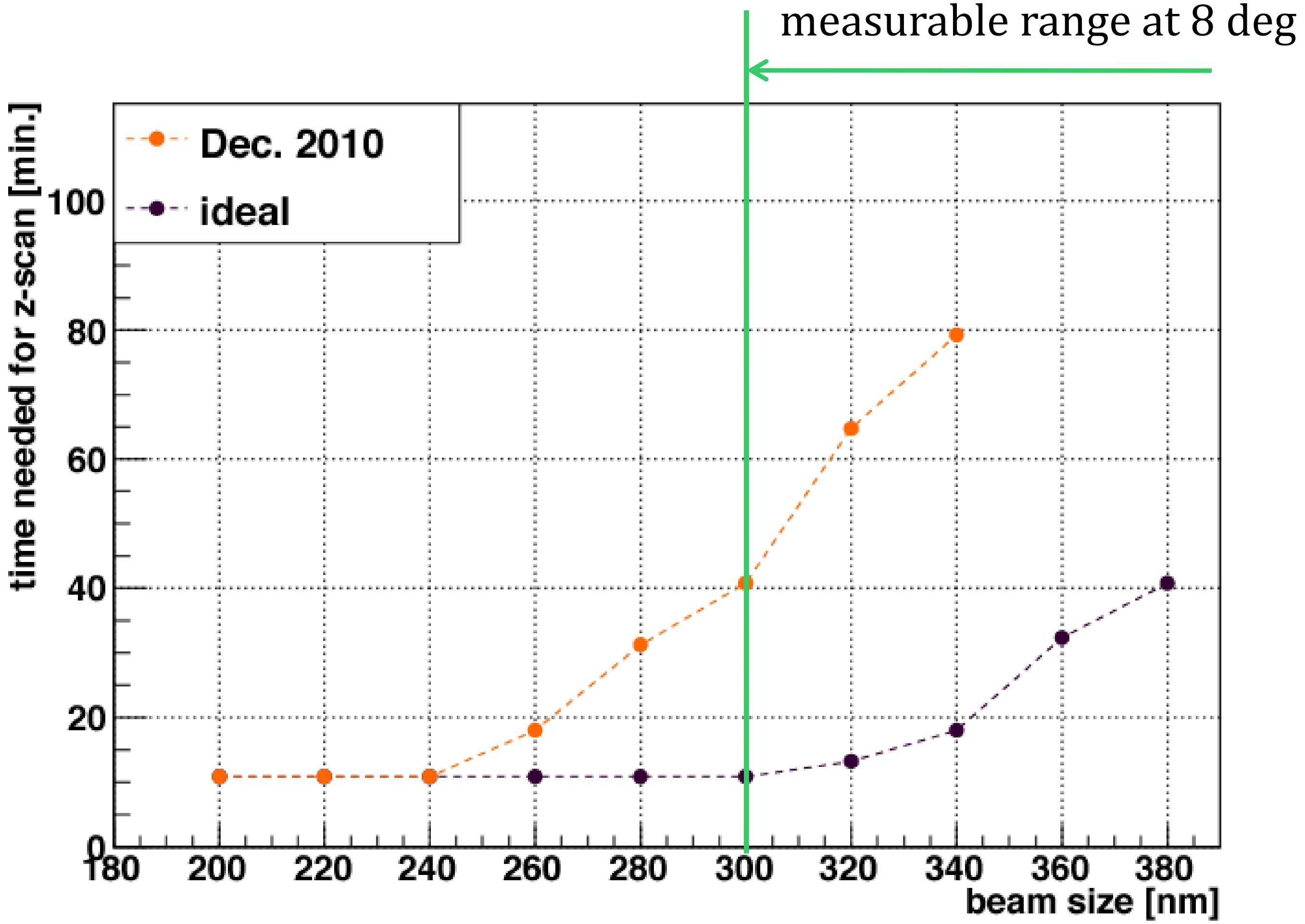
Signal jitter < 10%

Hardware upgrade

- additional collimator
- laser profile improvement
- laser orbit stabilization
- etc…

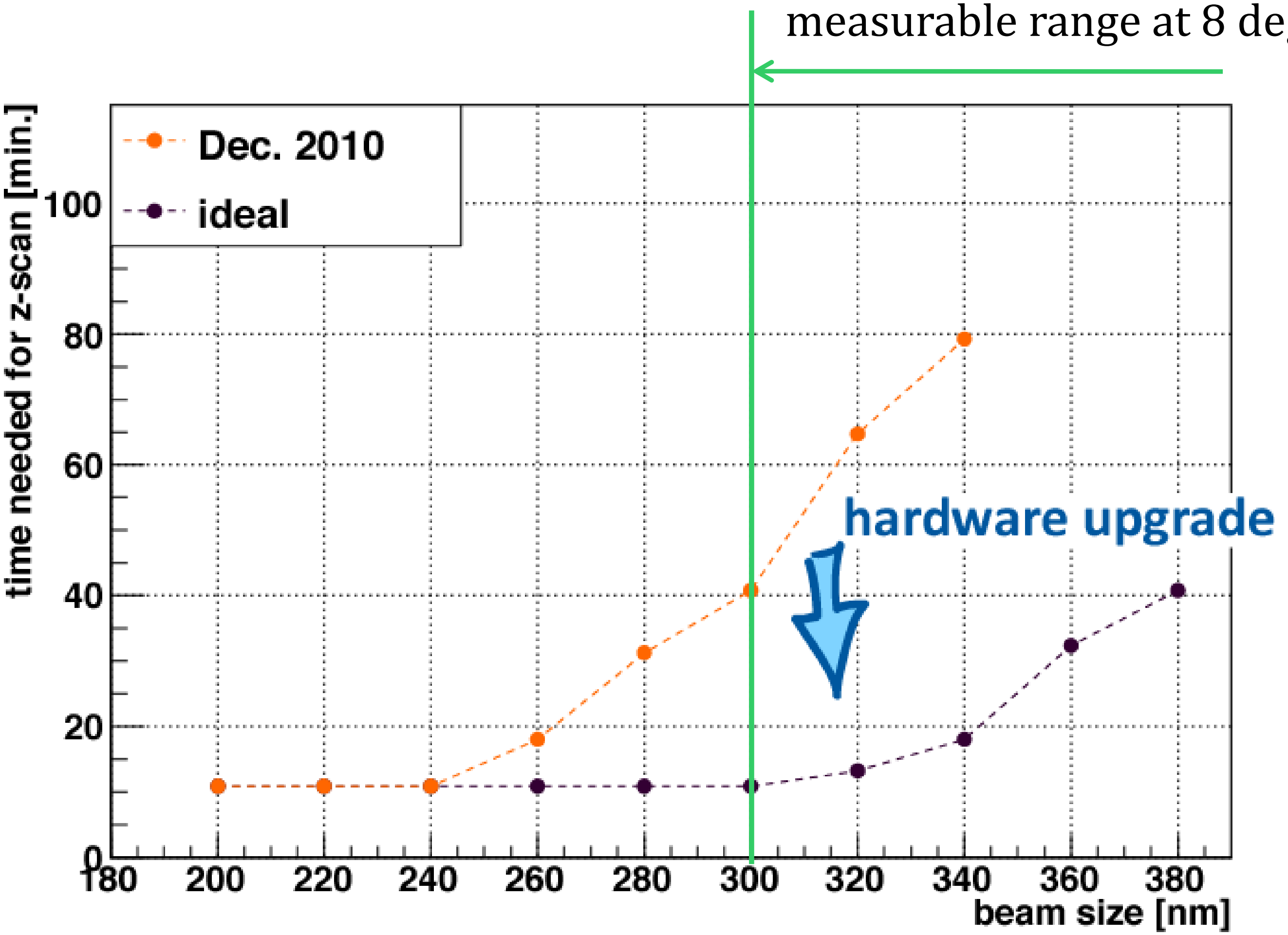
We are commissioning 30 deg mode…

Because mode switching is challenging…
long time is needed to detect modulation when switching to 30 deg mode



Detecting modulation takes time → beam and laser become unstable
Time taken should be below 1 hour

After hardware upgrades, we can switch modes quicker and easier



Status and plan

Commissioning 30 deg mode then 174 deg mode

Suppressing signal jitter is important

Main candidates for signal jitter at 8 deg mode are…
1. **high BG from bending magnet**
2. **bad laser profile**
3. **laser orbit fluctuation**

To suppress the jitter, we are upgrading our system
The upgrade will finish by this autumn

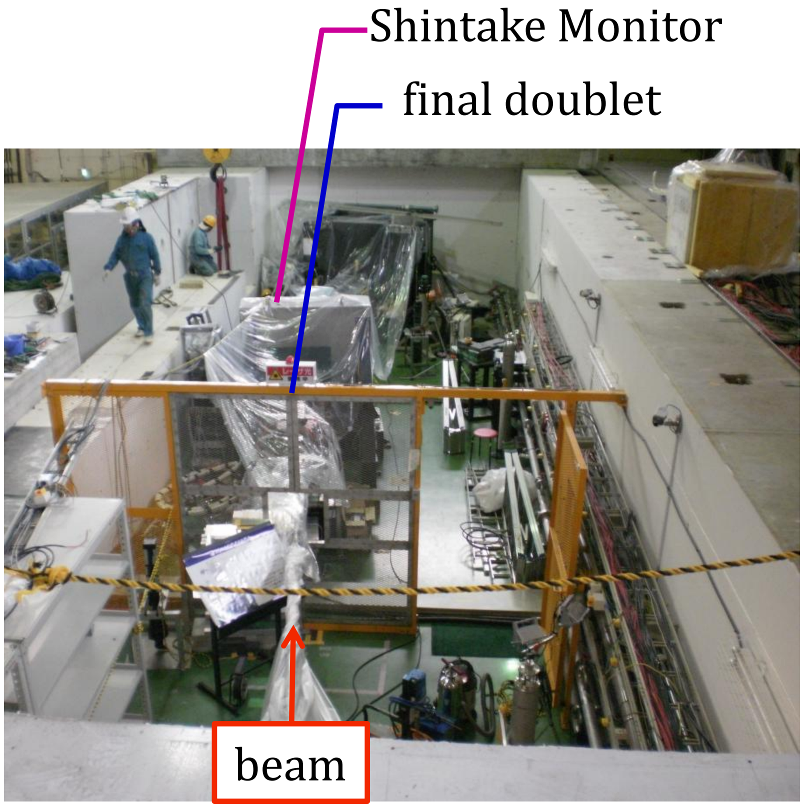
Beam trajectory fluctuation is significant for 30 deg mode
At 100 nm beam size, beam trajectory jitter must be below 50 nm
IP-BPM resolution must be below 30 nm

Recovery from the earthquake

We improved earthquake resistance of our system.

Performance of all devices are being inspected

laser	realigned oscillator working well
DAQ	still being checked
control system	working well
gamma detector	still being checked
optical system	being realigned
monitors for laser	still being checked



ATF2 radiation shield repair
2011/5/14

Summary

Signal modulation can easily be lost during mode switching

Resolution degradation due to signal jitter hides the modulation

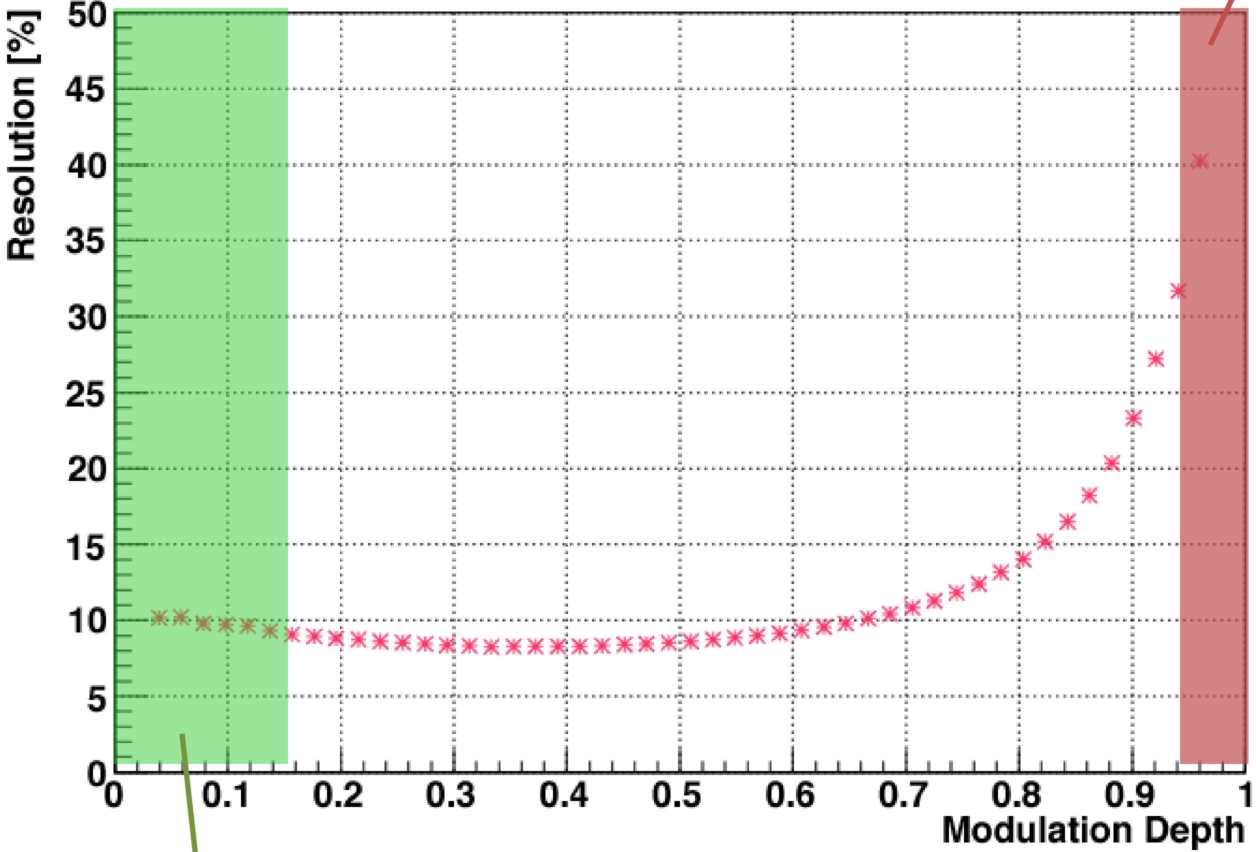
Sources of signal jitter are under investigation

Hardware upgrades for 30 deg mode are undergoing

We will finish upgrading and be ready to measure under 100 nm beam size by this autumn

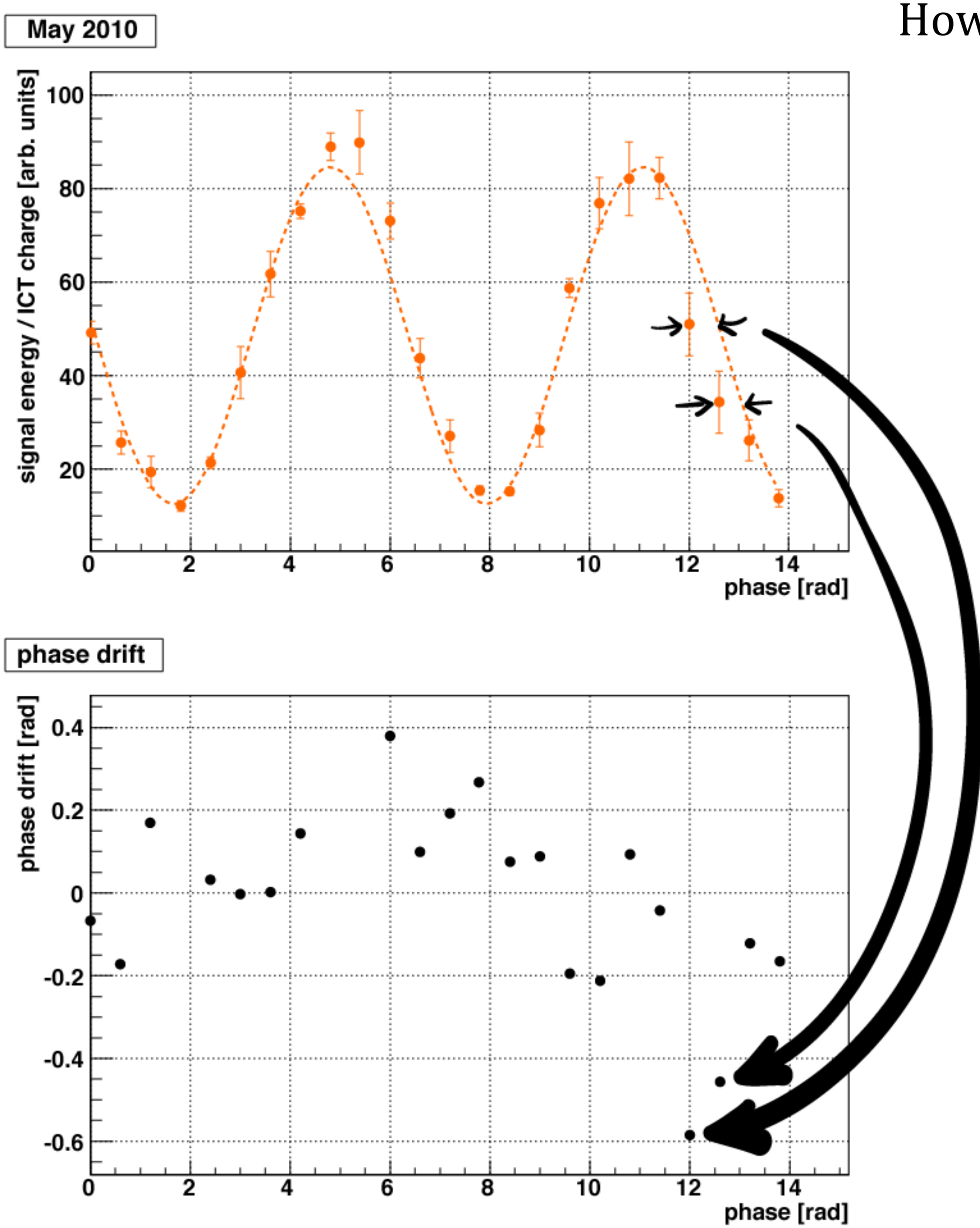
backup

Modulation depth is saturated



In spite of good resolution, discovery of modulation is difficult

How to evaluate the **relative position jitter**



This plot shows the interference scan

This plot shows the phase difference between the graph points and the fitting curve

From this plot, We evaluate relative position jitter

How to evaluate the **relative position drift**