IPBSM stabilization and sensitivity to 20nm beam size

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Outline

- Introduction
- Possibility of 20nm beam size measurement
- Detector optimization for 2-bunch beam size measurement

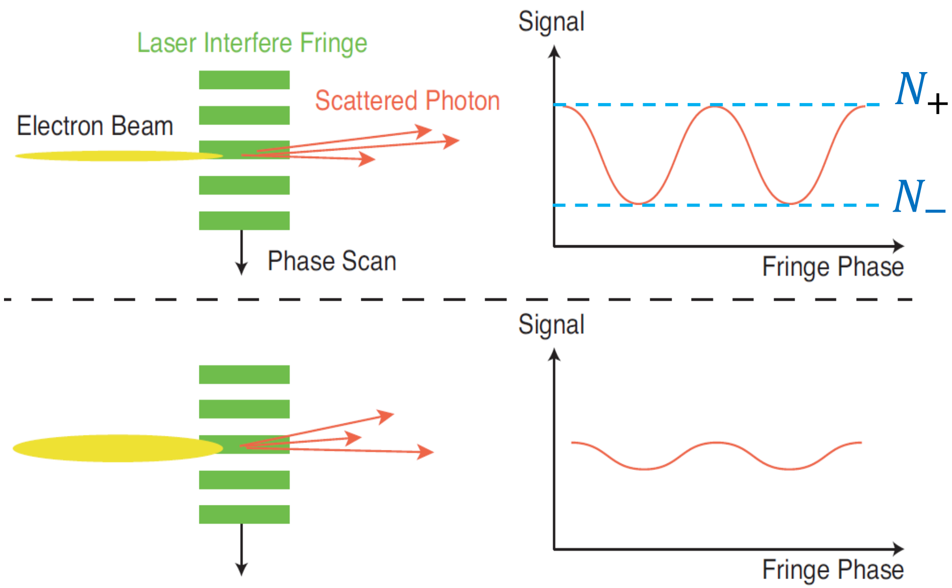
Introduction

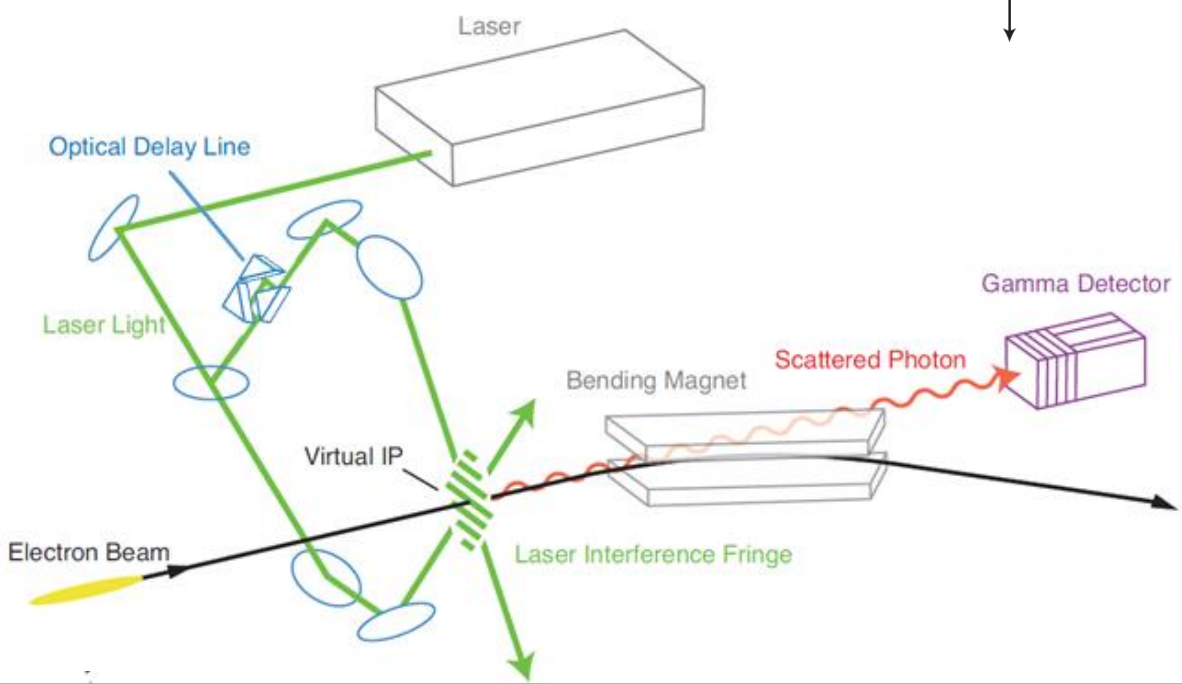
Concept of IPBSM

Modulation depth $M = \frac{N_{+} - N_{-}}{N_{+} + N_{-}}$

Small beam size ⇒ large M

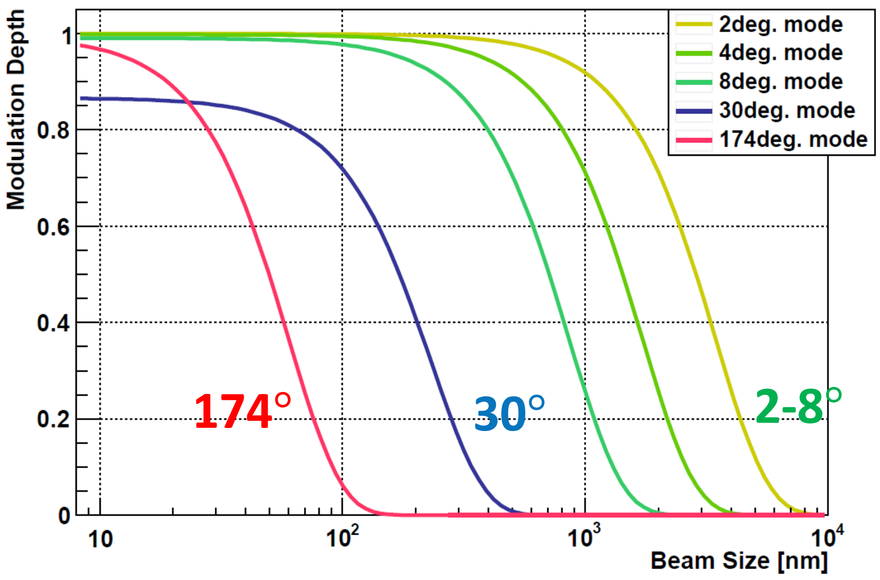
Large beam size ⇒ small M

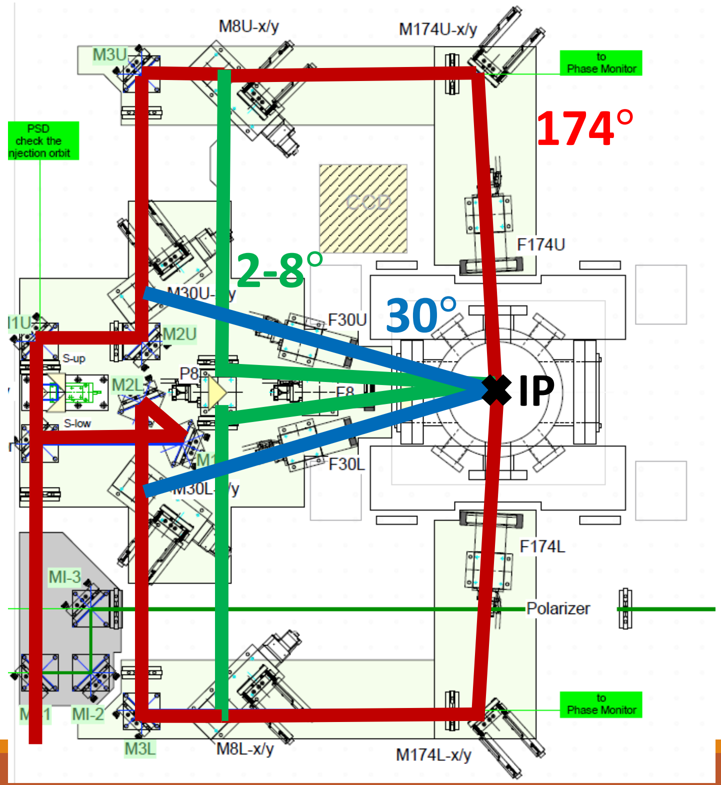




IPBSM setup at ATF2

- 3 angle modes at ATF2:
  $\theta = 2\sim8°,\ 30°,$ and $174°$
- Expected measurement range:
  $\sigma_y \sim 20\text{–}30\text{nm}$ to $\sigma_y \sim \mu\text{m}$

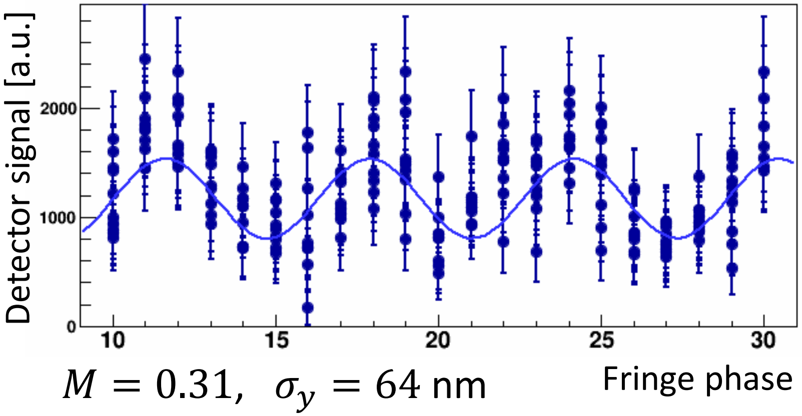




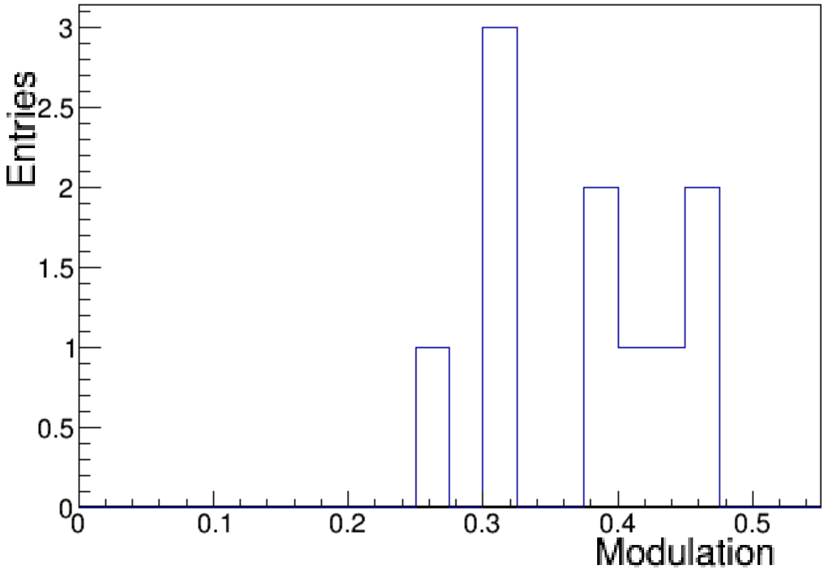
Vertical table at IP

Example of IPBSM measurement

- Beam size measurement at 174° mode from Oct. 2014 run:
  - 10 measured points for each phase
  - Gamma detector signal is fluctuated

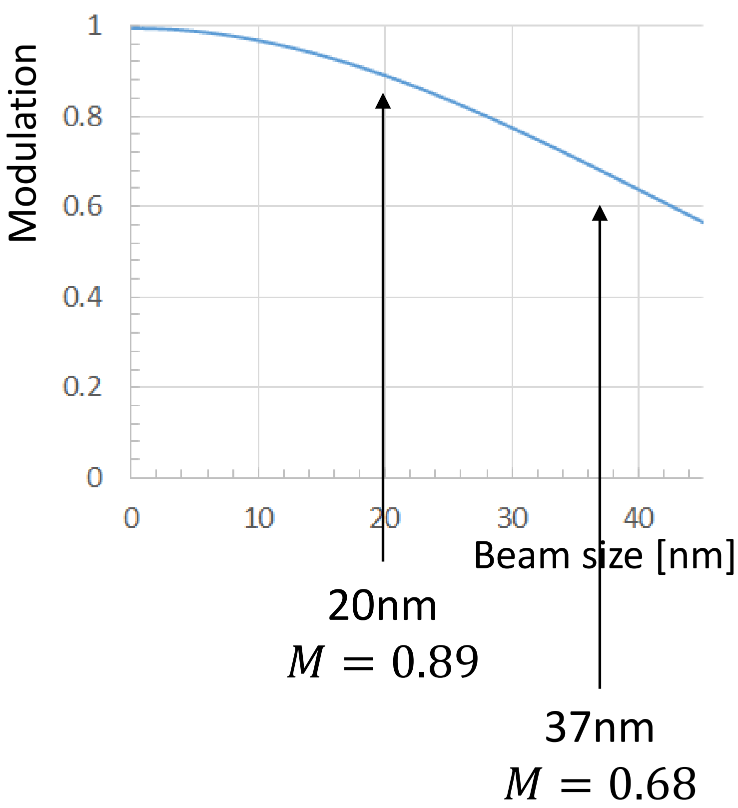


- 10 consecutive measurements from Nov. 2014 run:
  - Mean: $M = 0.37$, standard deviation$= 0.07$
  - $\sigma_y = 58$ nm



Possibility of 20 nm beam size measurement

Sensitivity to 20 nm beam size



- $\sigma_y = 20\text{nm} \Rightarrow M = 0.89$

- 5nm precision:
  - To measure $\sigma_y = 37 \pm 5\text{nm},\ M_{error} \lesssim 10\%$ is needed
  - To measure $\sigma_y = 20 \pm 5\text{nm},\ M_{error} \lesssim 5\%$ is needed

- Observed error: $M_{error} \sim 10\%$

- Modulation reduction factor has to be considerably larger than $C > 0.89$

- Assumed experimentally last spring as $C \lesssim 0.83$

Is it possible to use UV laser?

- One possibility: 4th harmonic generation using BBO crystal
  - efficiency$\sim$ 10%, laser intensity decreases
  - photon yield is halved $\Rightarrow$ Compton photon yield decreases

  $\Rightarrow$ *Precision of beam size measurement decreases greatly*

- Optical devices need to be replaced for UV light
  - Performance of each device for UV light has to be checked

- Precise alignment of UV laser and e^- beam at IP is not possible

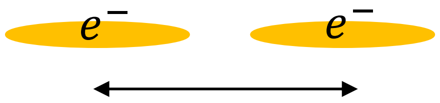
$\Rightarrow$ *Not realistic*

Detector optimization for 2-bunch beam size measurement

Motivation

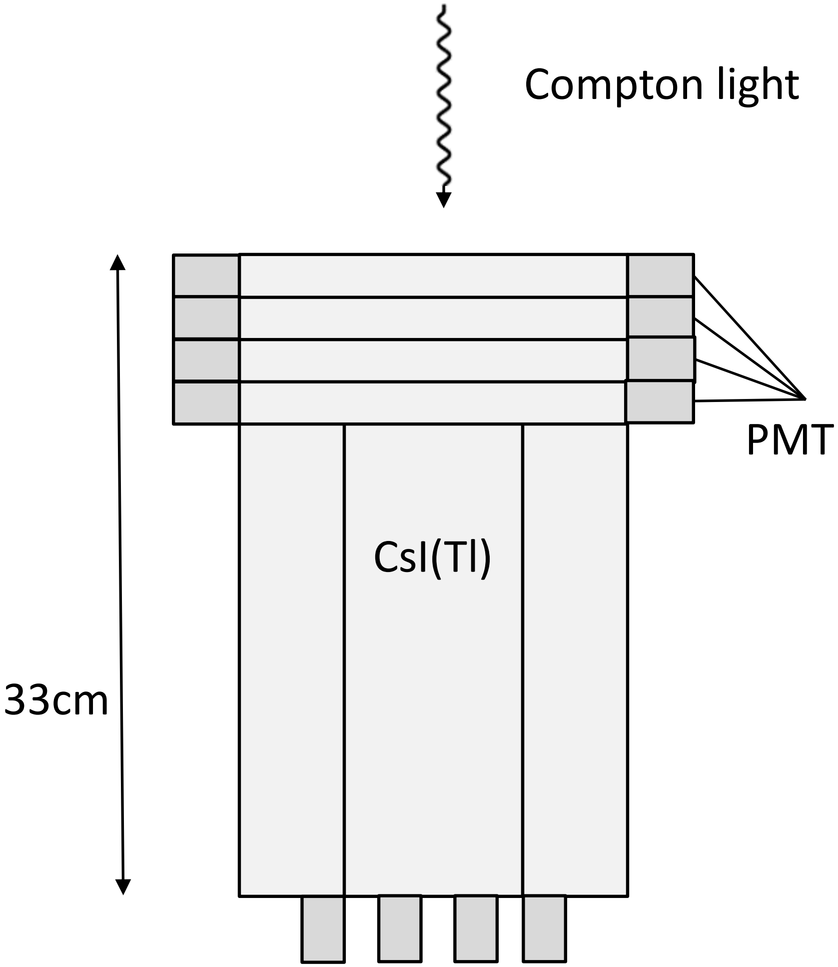
Motivation: Beam size measurement of separate bunch

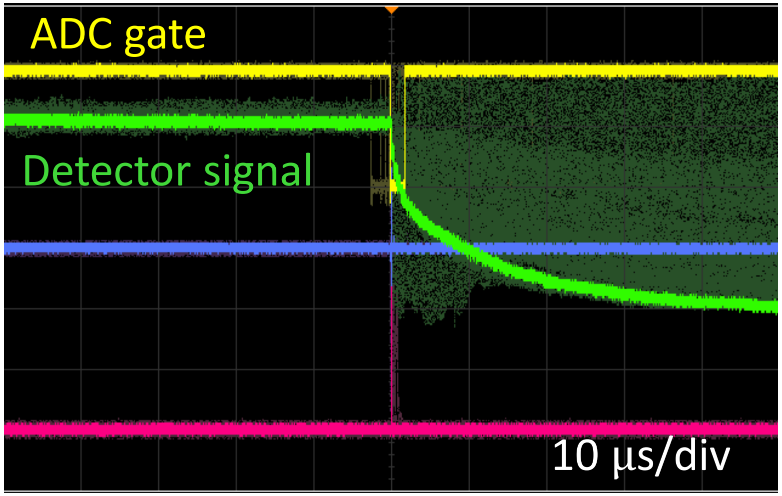
2 bunch operation at ATF2:



Bunch separation: 215 ns

Presently used gamma detector: CsI(Tl) scintillators

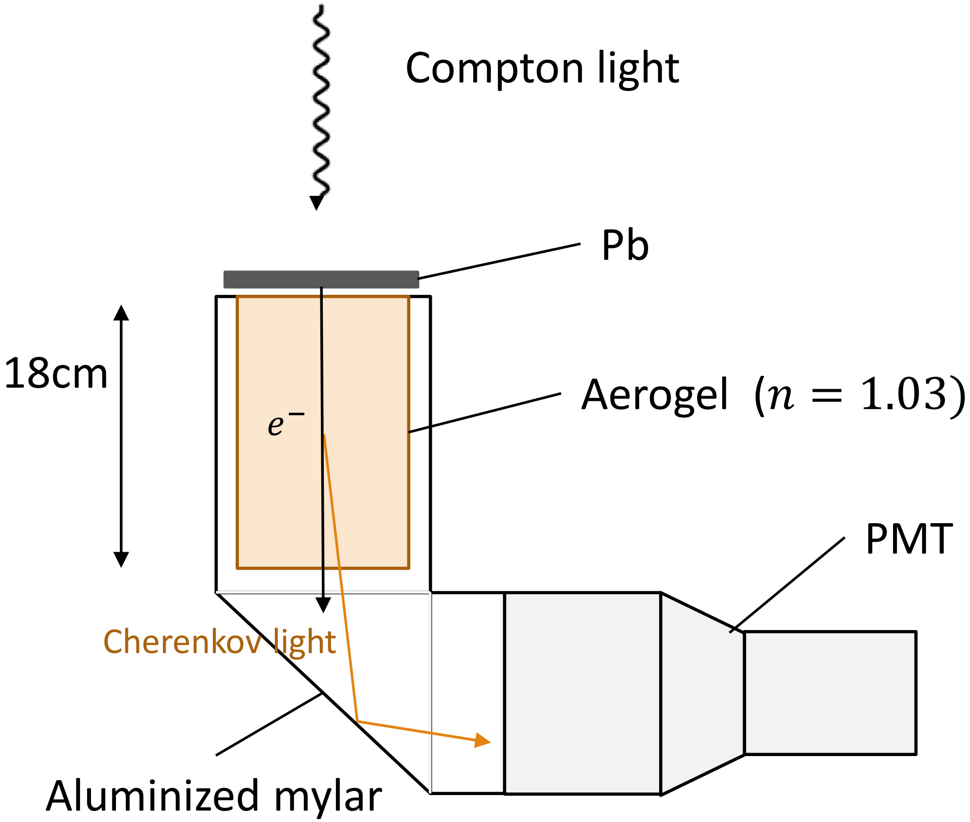


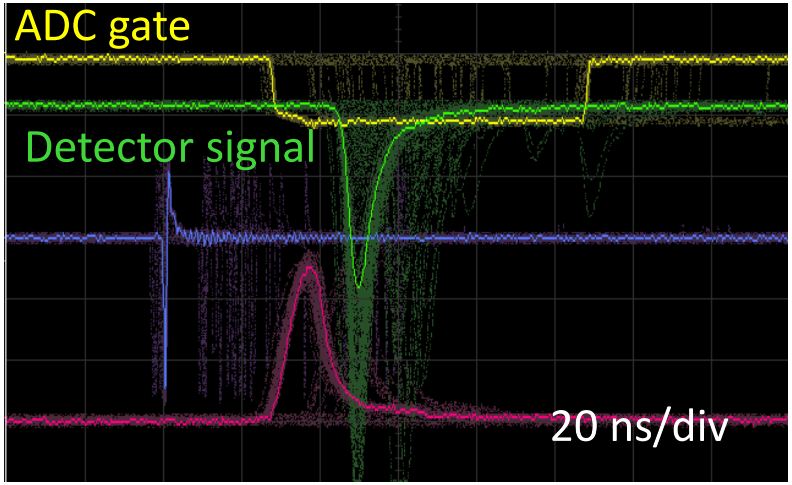


- Because of slow neutron background, time response is slow

- Background from 1st bunch will overlap with 2nd bunch

Cherenkov detector with aerogel

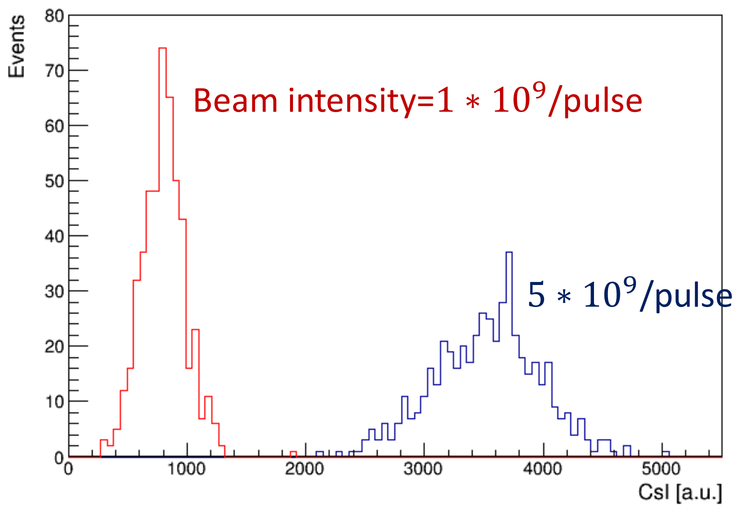




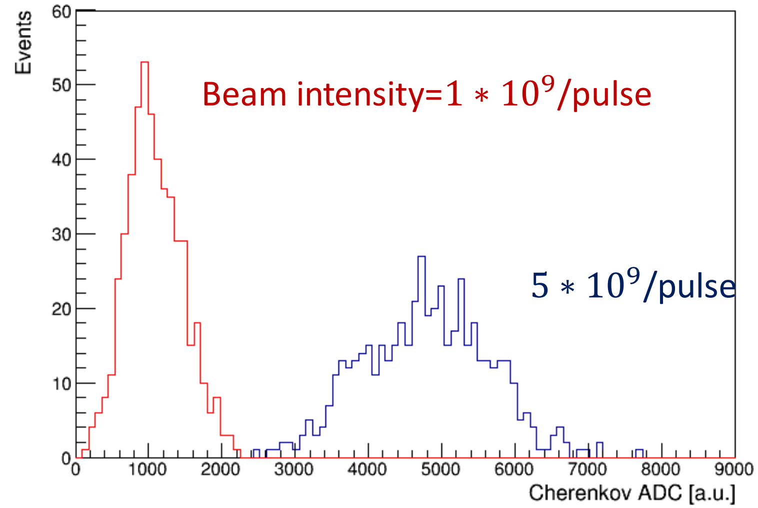
- Time response is faster
- Pulses from different bunches can be separated

Comparison of signal fluctuation of 2 detectors

CsI(Tl) scintillators



Aerogel Cherenkov



Intensity [/pulse]	CsI(Tl)	Aerogel Cherenkov
$1 * 10^9$	0.25	0.39
$5 * 10^9$	0.14	0.20

RMS/Mean at different beam intensity
(contribution of background is subtracted)

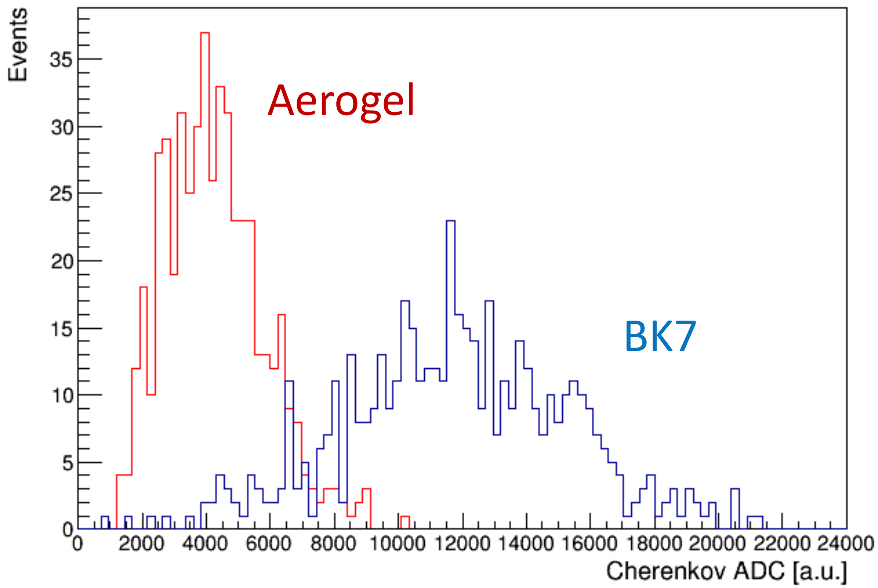
Signal fluctuation of Aerogel Cherenkov detector is larger than CsI(Tl) scintillators

⇒ Optimization is needed

Radiator comparison for Cherenkov detector

- We compared 2 substances which we had in hand

- BK7 glass mirror is used as a test of radiator with large refractive index



(beam intensity is normalized)

	Aerogel	BK7
Thickness [cm]	18	0.95
n	1.03	1.52
Density $[\mathrm{g/cm^3}]$	~ 0.1	2.52
$X_0[\mathrm{cm}]$	~ 100	~ 10
Mean [a.u.]	~ 4000	~ 12000

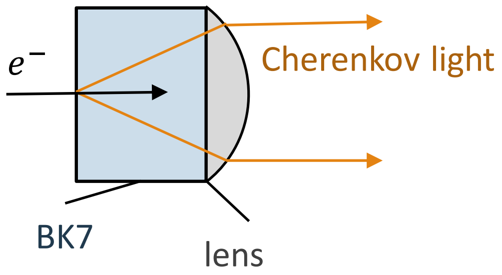
$\Rightarrow$ *Detector yield increased*

Planned tests to increase Cherenkov yield

- Aim:
  - Increase detector signal
  - Collect Cherenkov radiation light

- Use thicker glass as radiator to increase radiation

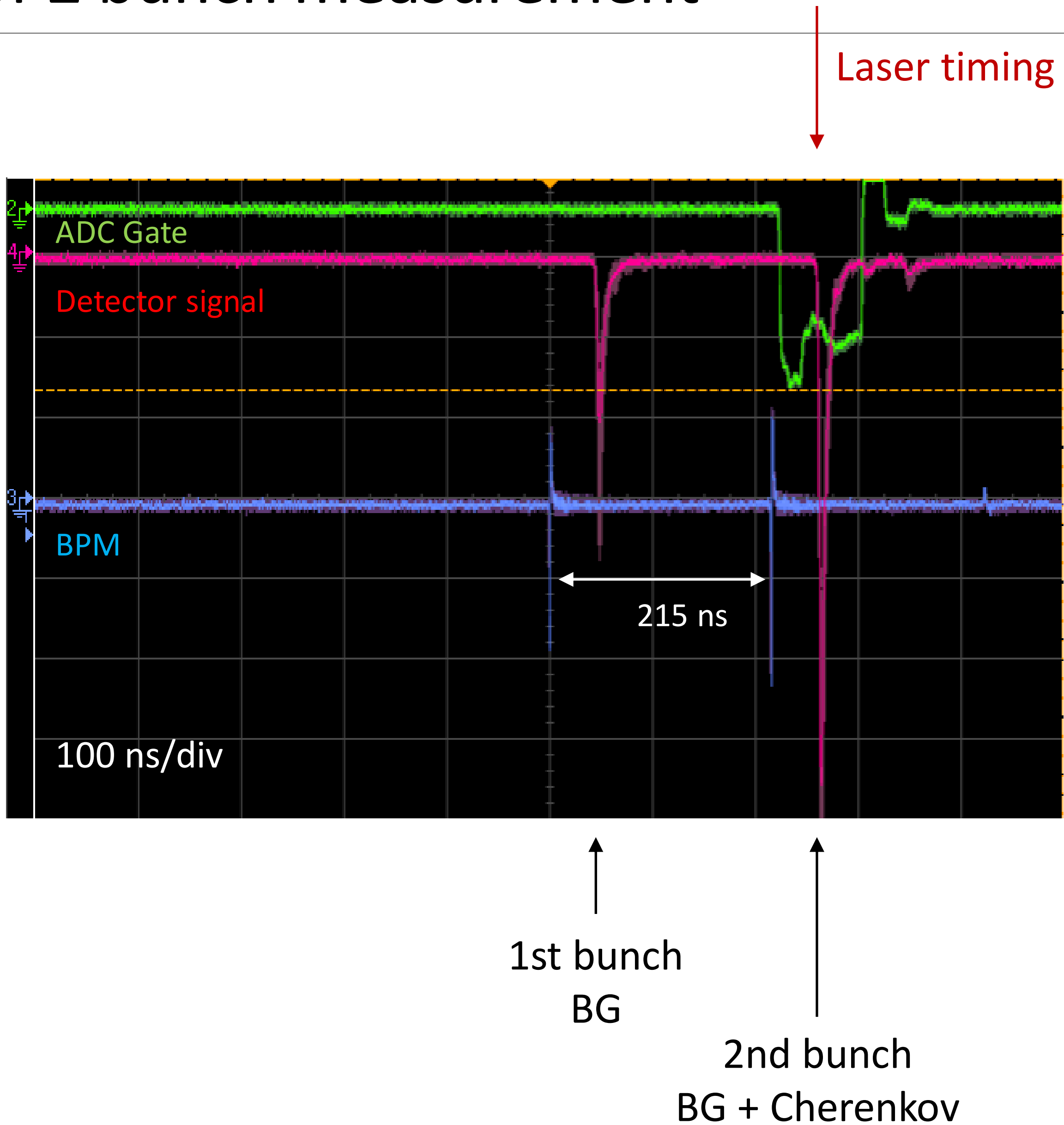
- Use lens to collect radiation light
  - BK7: $n = 1.5 \Rightarrow$ angle of radiation $\theta \sim 0.8$ rad



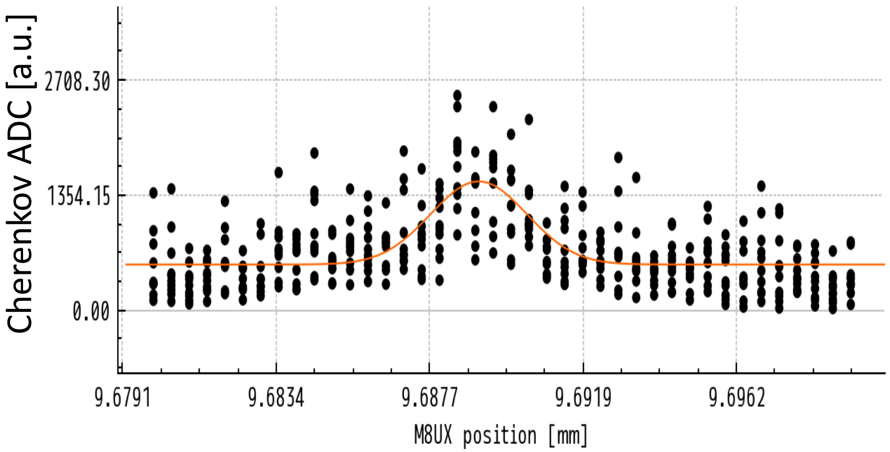
- Test different reflector to increase reflectivity

etc.

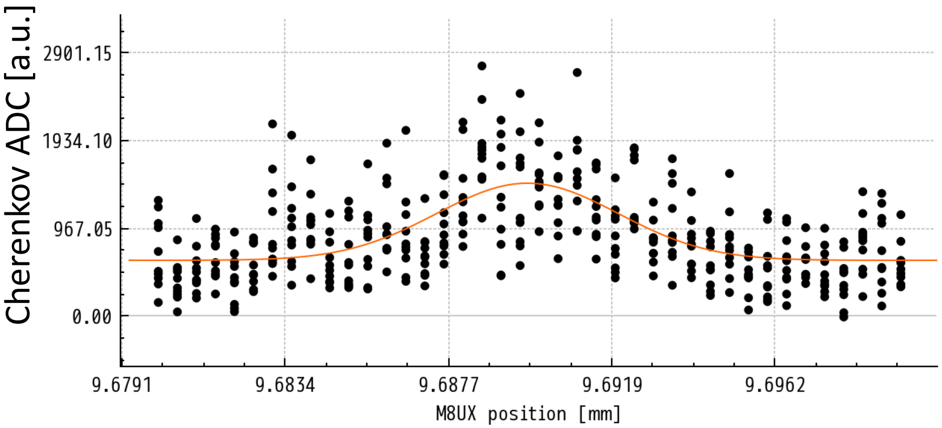
Test of 2 bunch measurement



Test of measurement of individual bunch



Laser wire scan on 1st bunch:
Center=9.6890 mm
Sigma=1.34 μm



2nd bunch:
Center=9.6897 mm
Sigma=2.39 μm

- Laser and gate timing is altered to match each bunch
- In this measurement, the beam is not tuned
  - The beam is tuned at single bunch operation
  - The beam cannot be tuned at 2 bunch, because the extraction setup is different from single bunch
- This is only a test to measure each bunch

Summary

- IPBSM at ATF2 to measure 20nm beam size
  - Not impossible
  - There are many problems to be solved

- 2 bunch beam size measurement
  - Further optimization of the detector is needed
  - Beam tuning and feedback for 2 bunch operation are needed

Backup

Energy spectrum of Compton photon