LDR (Large Dynamic Range) imaging に向けたビームハロー測定の解析結果

測定条件

- ビームハローの測定 @2015/5/29 & @2015/6/3

データ解析

- Linearityの確認 & LDR imaging方法アプリケーション

2015年10月1日(木)14時00分

ビームダイナミクスWG打ち合わせ

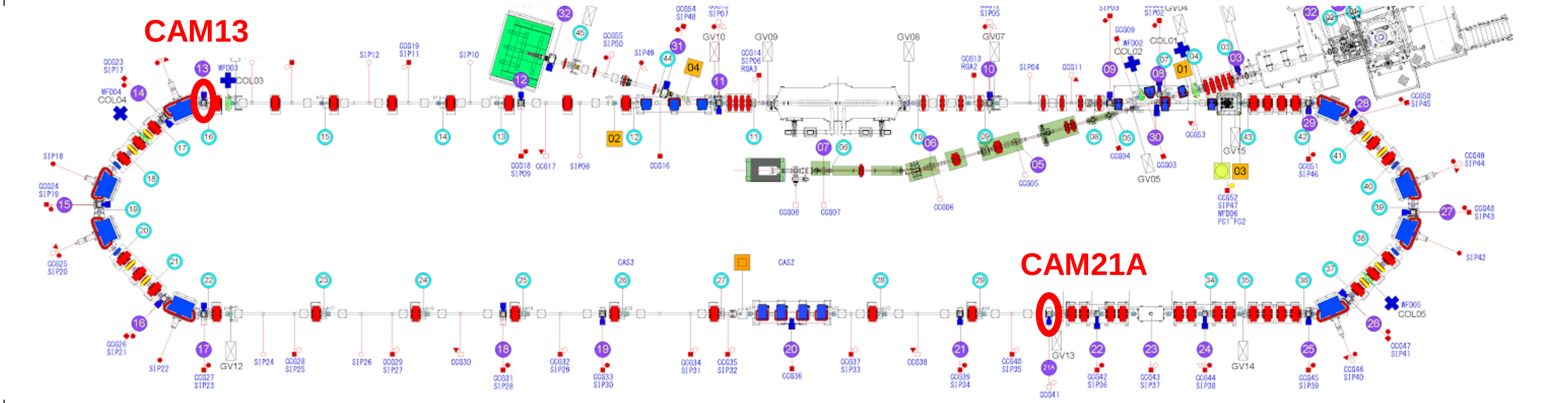
オリガ　タナカ

Introduction

Measurement goal

- **The goal is to check the possibility to obtain the halo distribution with the present equipment using the Large Dynamic Range (LDR) imaging method**

- Measurement equipment



Introduction
Measurement background

LDR imaging	Measurement at cERL
Images are taken with several sensors (2-3) with different dynamic range (no additional gain is applied)	Images are taken with one CCD camera (CAM21A + CAM13)
Images are taken with simultaneously	Images are taken with one-by-one (5 shots) + averaging
Background is substracted on-line	Background is not substracted or substracted manually
Combining algorithm is applied to two images with different exposure time*	Combining algorithm is applied to two images with different gain**

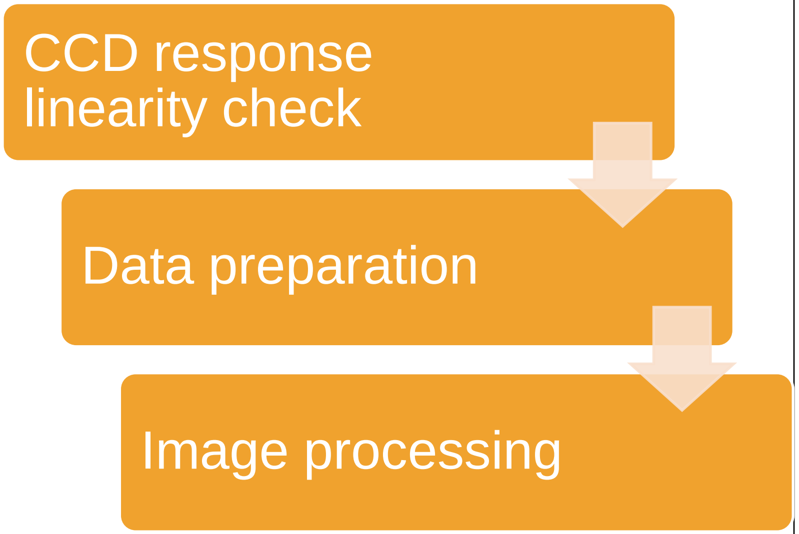
* Possible, because the large size of the beam

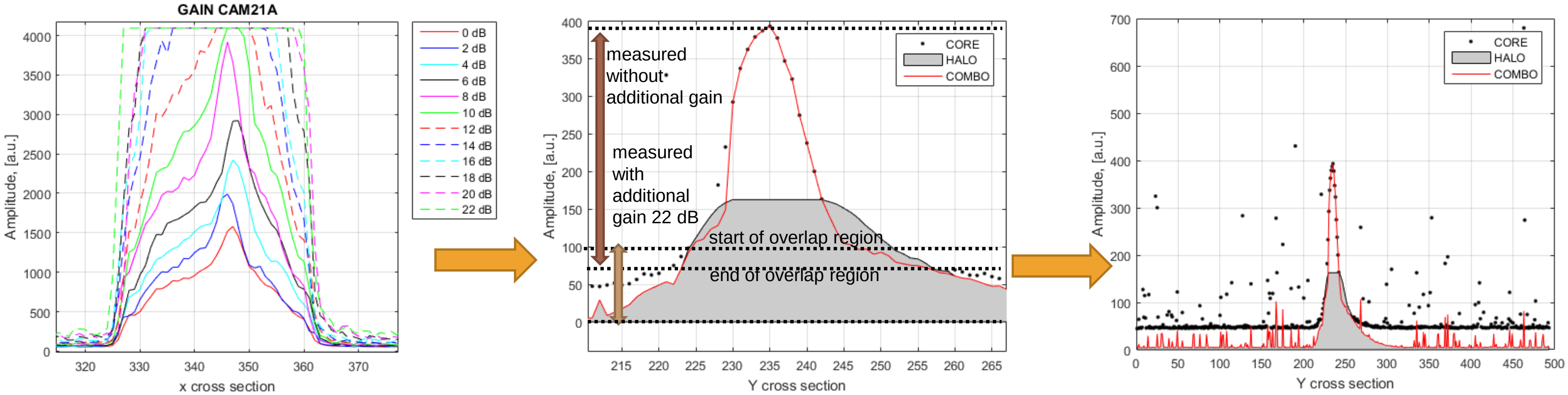
** Default settings (gain = 0 dB for core image + max gain = 22 dB for halo image)

Beam: burst mode – 1 us pulses at 5 Hz, bunch repetition rate ~ 162.5 MHz, 0.5 pC per bunch

Data analysis (1)
Workflow

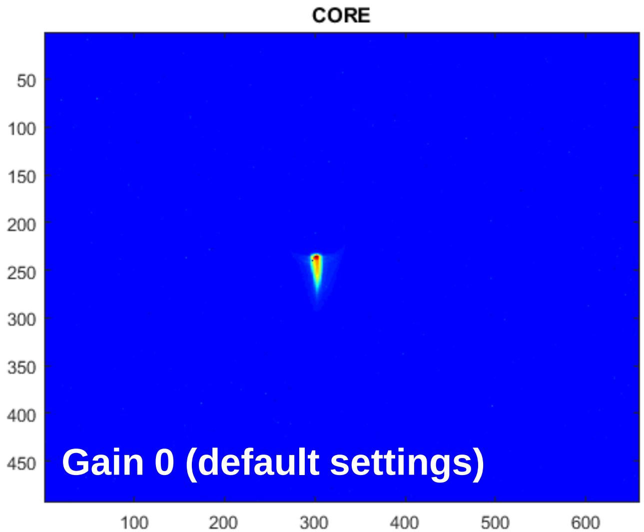
1. Linearity check
   - Consider the CCD camera response to be linear
2. Data preparation
   - Averaging over 5 shots
   - Data scaling (i.e. gain 22dB yields 12.5893 times big amplitude)
   - Background subtraction (where possible)
3. Image processing
   - Define the overlap region for each pair of core (gain 0 dB) & halo (gain 22 dB) images
   - Replace overfilled pixels of halo image with the peak-part pixels of core image within the overlap region to reconstruct the full profile

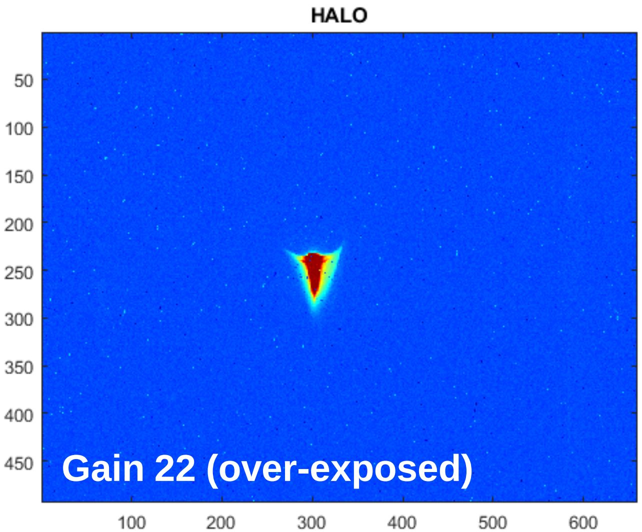




Data analysis (2)

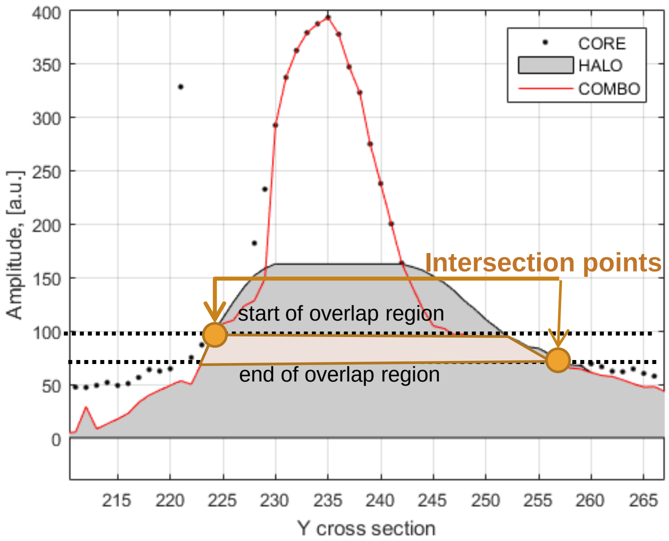
Combining algorithm





Core and halo images (left) after averaging, scaling and BG subtraction CAM13

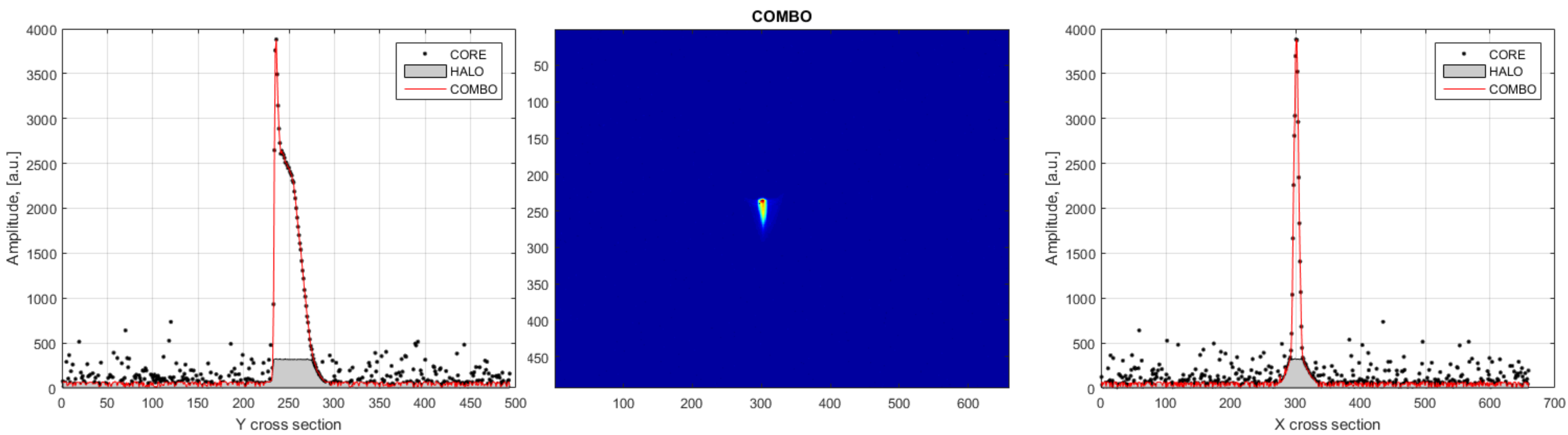
- Measurement settings
  - Exposure time 10000usec (fixed)
  - ND filter out
- Combining algorithm
  1. Find the intersection points of the core and halo x, y profiles
  2. Define the overlap region for two peaks
  3. Replace the over-exposed pixels above the overlap region by core pixels
  4. Replace the under-exposed pixels below the overlap region by halo pixels



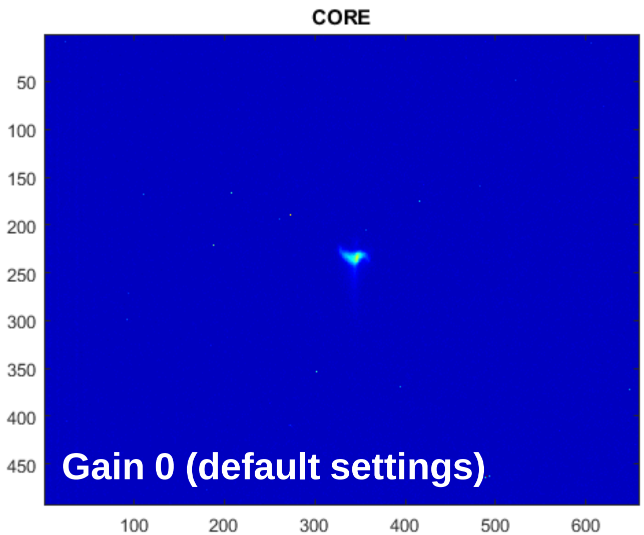
Discussion (1)

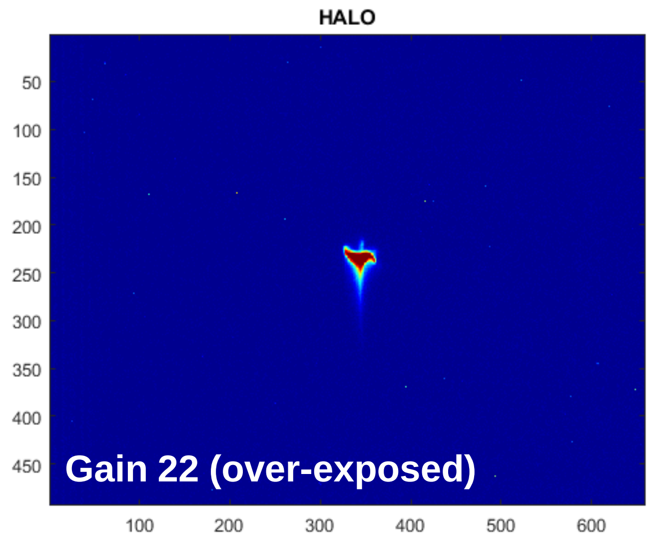
Example CAM13

- Combined image contains light regions of the core image and dark regions of the core image
- Big exposure time comparing with the bunch length (10000usec ↔ 1usec) yields considerable noise. Possible solutions:
  - Try to obtain for shorter exposure time (of the bunch length) to get rid of noise
  - Continue with a large exposure time, taking care of the background and noise
  - Enlarge the beam to fit the smallest exposure time



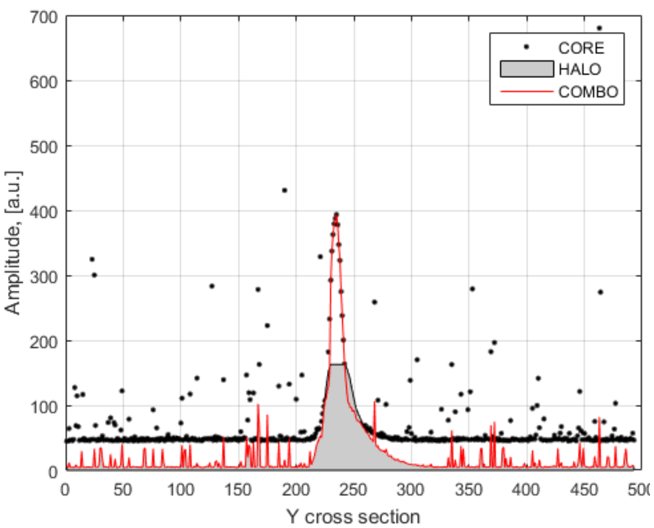
Discussion (2)
Example CAM21A

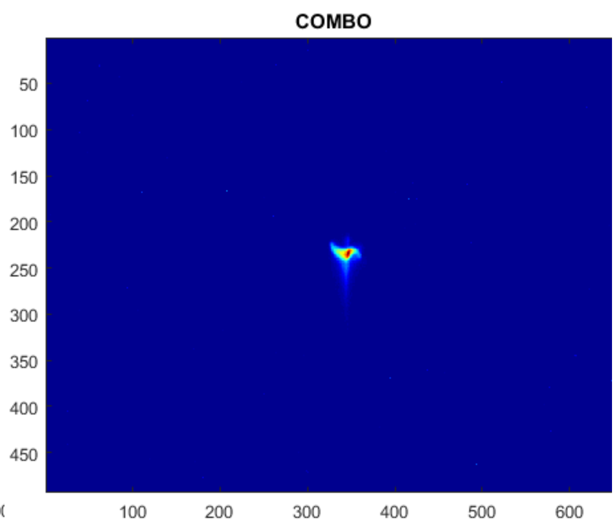


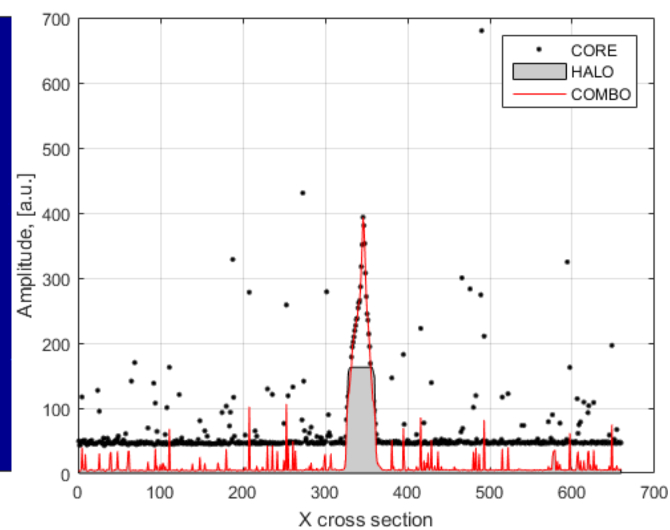


- <u>Measurement settings</u>
  - Exposure time 5000000usec (fixed)
  - ND filter in

measurement needs improvements



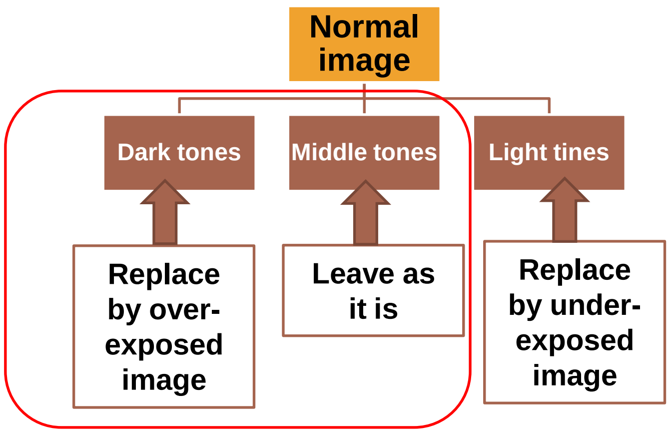




Discussion (3)

Ways of improvements

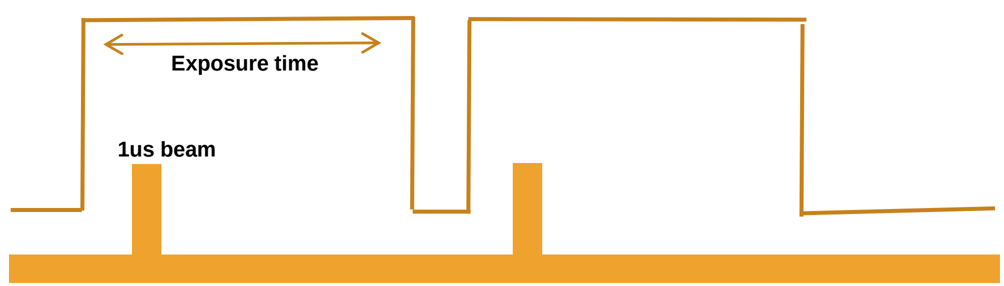
* Idea from professional photography to reach a high dynamic range



Used in this analysis

- 1st and 3rd do not need additional installations
- 2nd is not possible at present (the limit of CCD camera is ~10usec) → new camera?

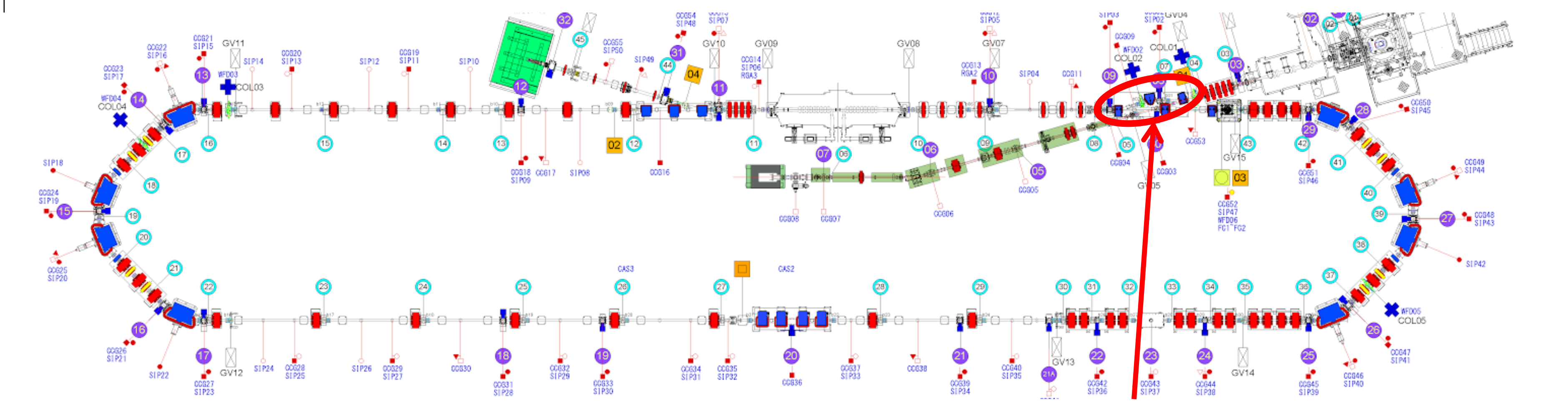
- Nice … but **increasing in exposure time yields no new information, only increase a noise,** because the bunch length is small (no beam comes to the camera window). Moreover, a big exposure time leads to dark current, which obstruct the halo detection
- <u>Possible solutions:</u>
  1. Work with a large exposure time → consider the data to be a set of beam images (remember noise and dark current)
  2. Make the exposure time the same with a bunch length → thus, one can get rid of the BG
  3. Enlarge the bunch (caution should be taken about radiation)



Backup slides

New CCD camera placement

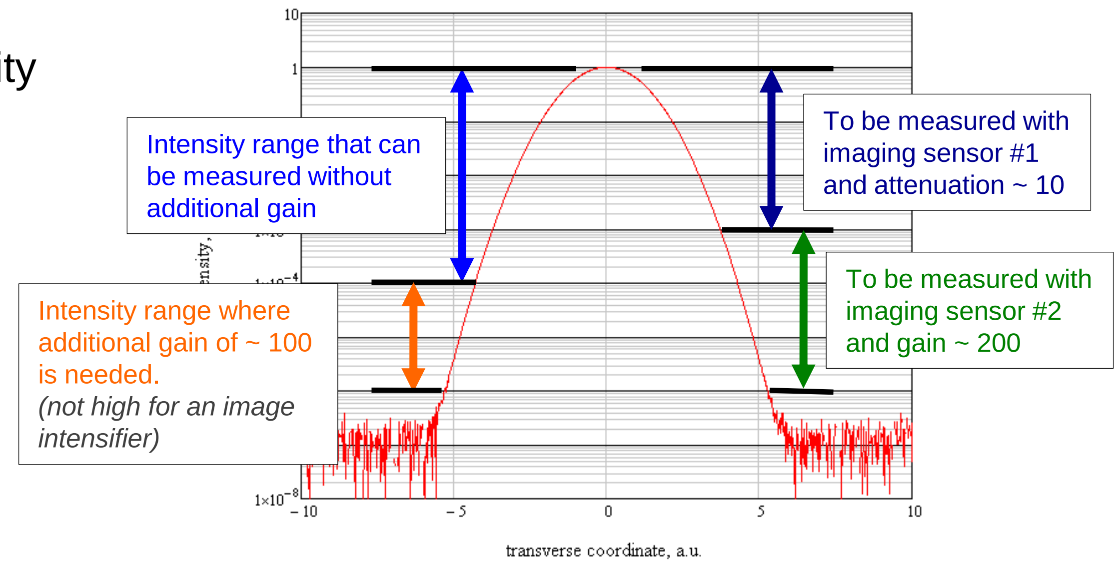
- Camera should be placed at the position where the halos and tales are expected
- We hope the camera to be movable



Candidate Merger section, CAM8, CAM9

LDR測定のアイディア*

- **The first issue to overcome is the DR of a single imaging sensor**
- **The main principle is to use imaging with 2 or 3 sensors with different effective gain simultaneously and to combine data in one LDR image digitally**
  (single sensor dynamic range 500..1000 if cost is kept reasonable)
- From experience (calculations tested by experiments) we know the safe level of beam current/power for a low duty cycle (tune-up) beam
- With typical beam size of few hundred μm OTR signal is attenuated by ~ 10 to keep CCD from saturation. For phosphor or YAG:Ce viewers attenuation of at least 100 is used.
- Using OTR there is enough intensity to measure 4 upper decades; lower two decades need gain of about 100 to be measured.
- The key elements:
  - image intensifiers
  - alignment and linearity
  - combining algorithm(s)
  - understanding CCD saturation



*Courtesy of P. Evtushenko