BSM using a pattern target

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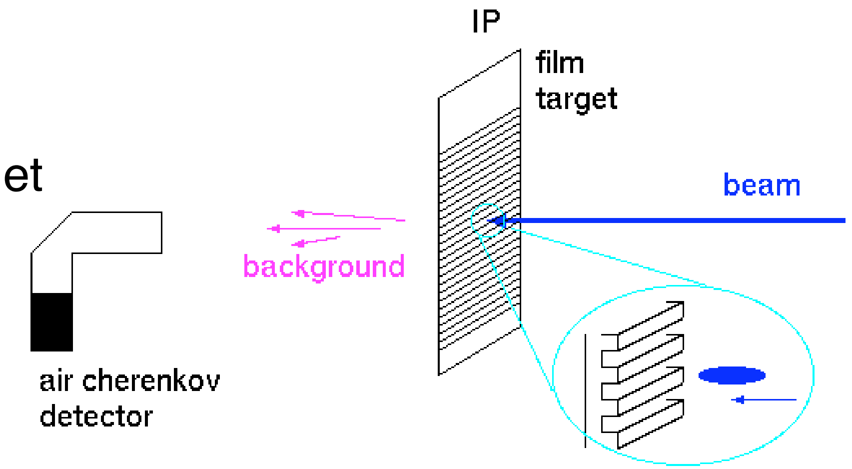
ATF2 project meeting

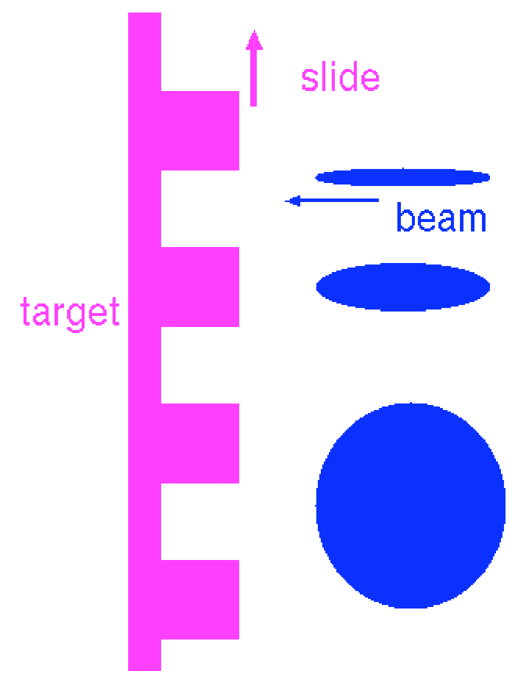
motivation

- missing range of beam size monitors was pointed out in the previous project meeting.
  - Shintake monitor (532nm wavelength) works <350nm
  - carbon wire scanner (5um dia.) > 1um, broken by a small beam
  - blind beam tuning in the range of 1um to 350nm?
- requirements
  - relative measurement is fine for beam tuning
  - real time response (~min.)
  - near the IP, compact device

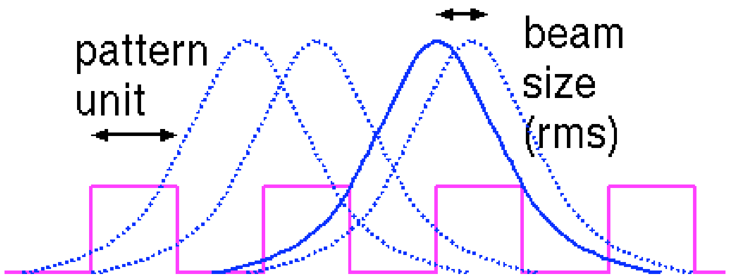
principle

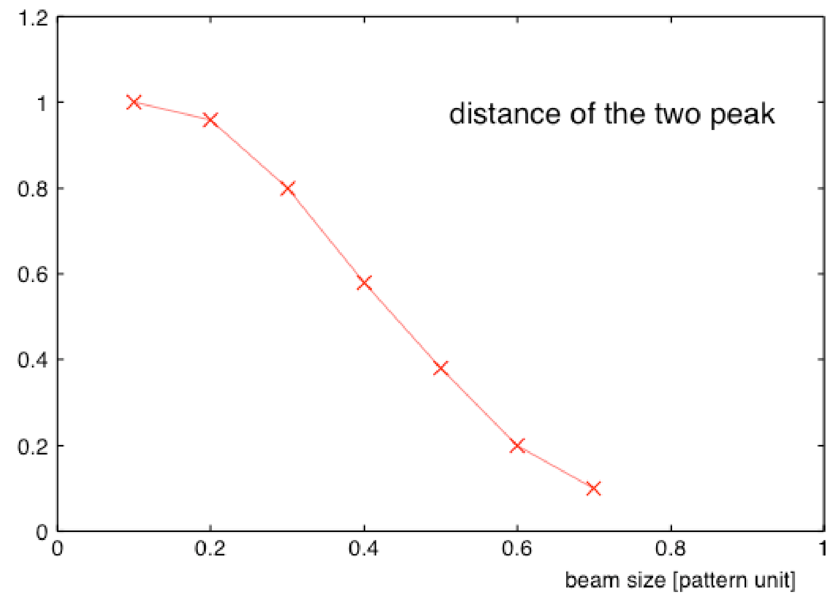
- Put a thin film target that has a fine structure in its thickness
- Beam produces a background when it hits the target
  - yield will be proportional to the convolution of beam density and the thickness of the target
  - wire-scanner type detector
- Beam size measurement
  - measure the fluctuation of the signal yield
  - small beam: signal strength becomes two states, beam hits at thin area or thick area.
  - large beam: constant signal strength
- Expendable target
  - The target may be destroyed by the beam. Move the target in each beam pulse to use new area.
  - position is not controllable
    - statistical approach
    - works even if beam position has a jitter

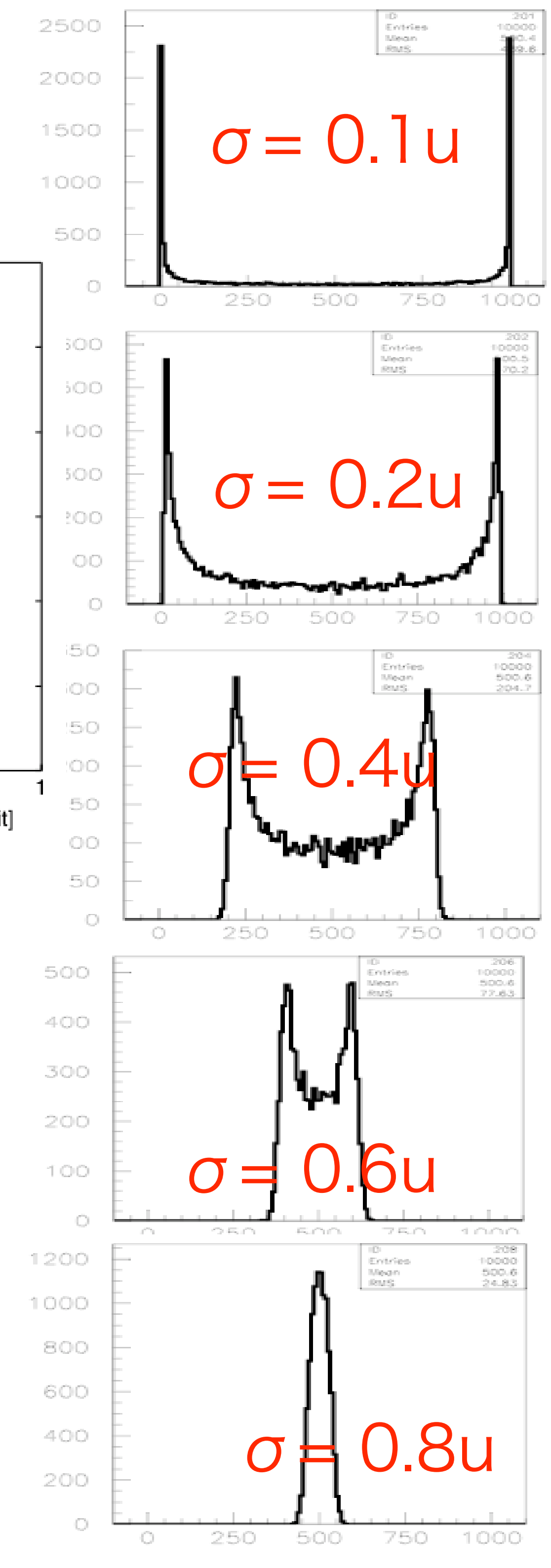




example



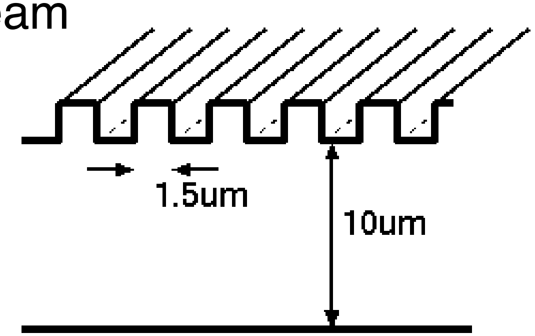




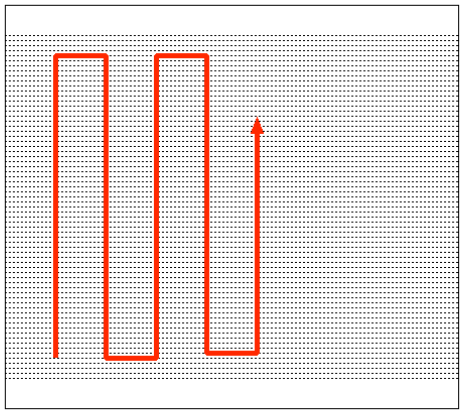
- This is just a mathematical calculation of the convolution of
  - gaussian shape beam
  - rectanglar shaped pattern target
- fluctuation of the signal in many pulses assuming random beam position
- distance of the two peaks is a good measure to estimate the beam size
  - beam size is bigger, distance becomes narrower
  - sensitive if beam size is in the range of 0.2~0.7 pattern unit

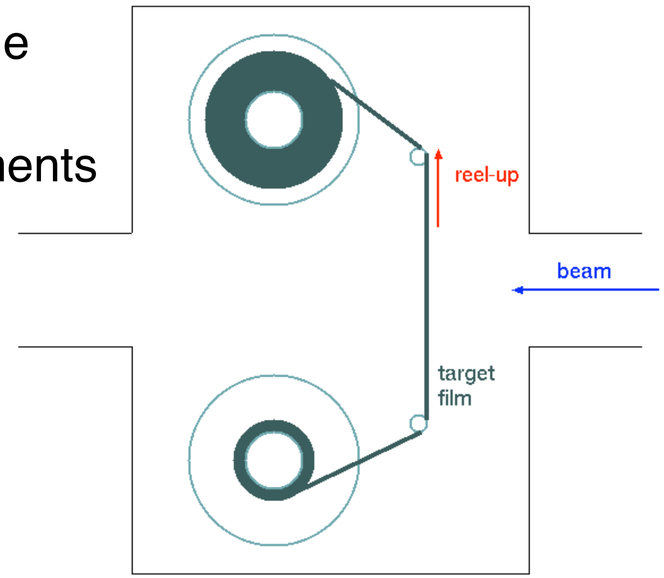
requirements on the target

- structure of the pattern
  - pattern unit should be ~1.5um to measure 350nm~1um beam size
  - thin film to prevent multiple scattering
  - high contrast, say better than 10%
  - edge sharpness may be not so important for relative measurement, uniformity should be important



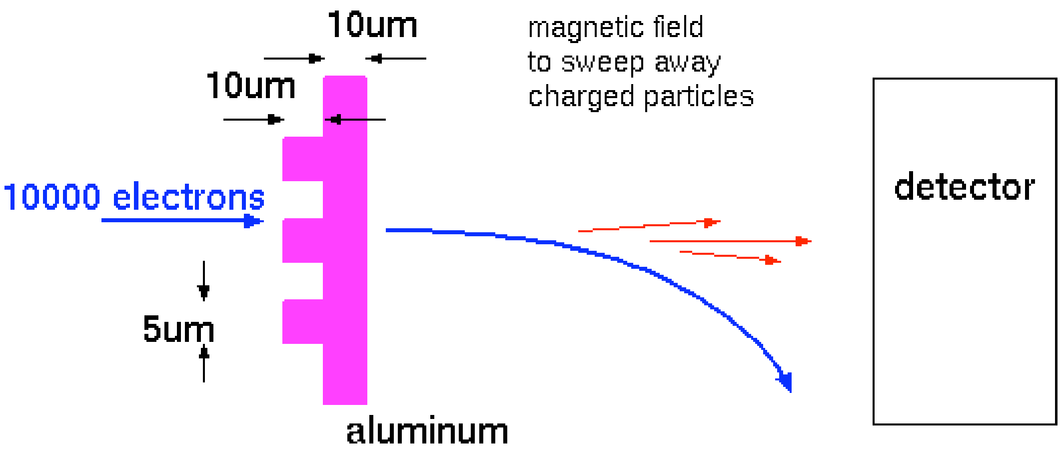
- size of the target
  - assume 1000 pulses (10min.) for one measurement
  - slide ~10um in each pulse makes 10mm of length for one measurement
  - 1m length target is needed if we assume 100 measurements in one week
- system design
  - reel film mechanism
  - use plate along zigzag line

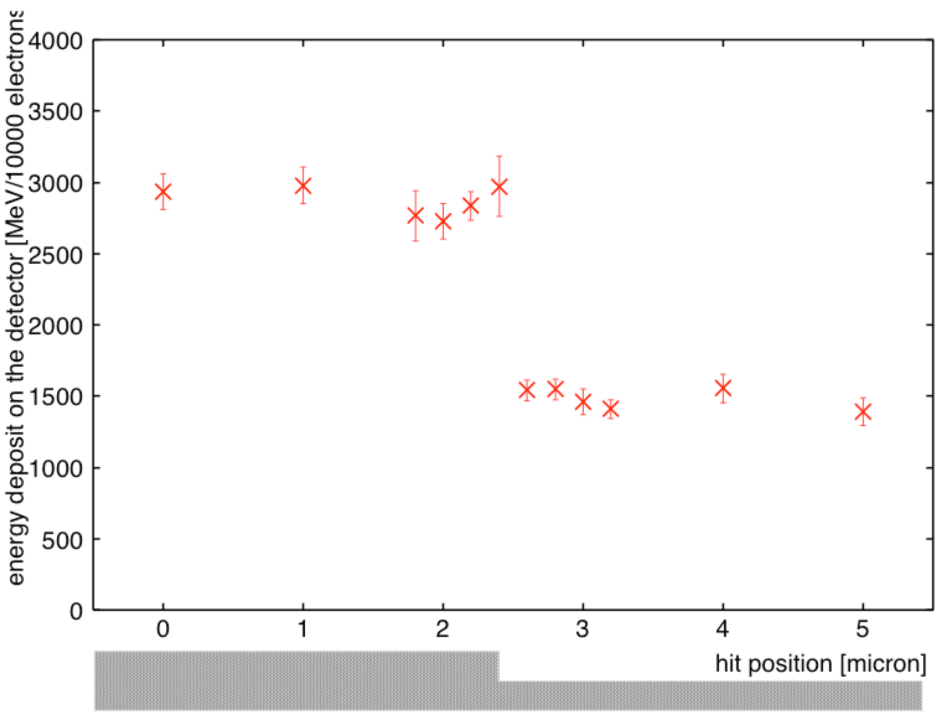




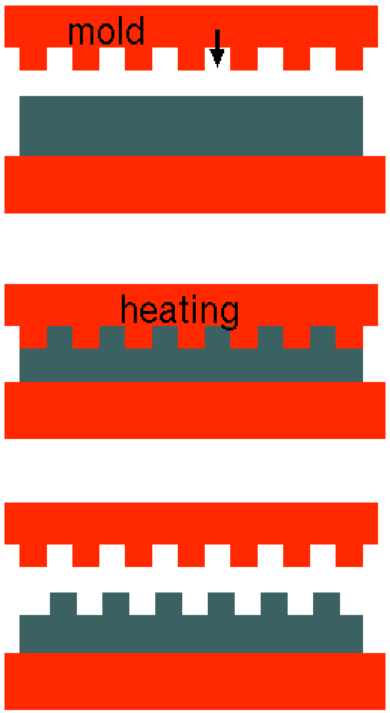
simulation

- Geant4 simulation
  - check the effect of multiple interaction
  - signal yield
- setup
  - aluminum 10um film
  - measure energy deposit of neutral background
- result
  - edge of the pattern is clean, multiple scattering is negligible
  - signal yield is 2000MeV/10000electrons
    - comparison with tungsten wire of 10um diameter (wire-scanner).
      - background strength is 10% of the wire-scanner, good enough to detect

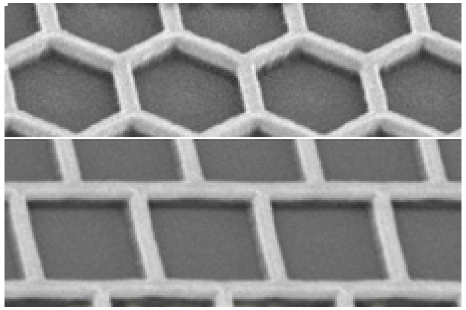




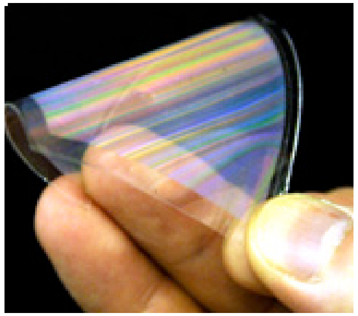
fabrication



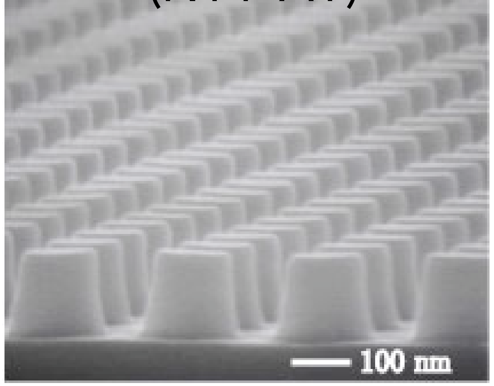
- expensive and low throughput methods are not applicable since the target will be comsumed in a few weeks
- imprint method
  - make replications of a mold by imprinting it to samples
  - once the mold was made, the replications could be made in low cost and high throughput
- candidates
  - heat imprinting on a polymer film
  - room temp. direct imprint
    - mold should be a hard material such as SiC or Si
      - electron beam lithography
    - pure aluminum for the sample (soft material)
      - press ton/cm^2



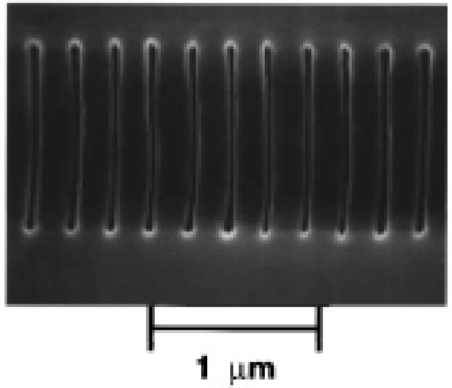
example 40um film (SCIVAX co.)

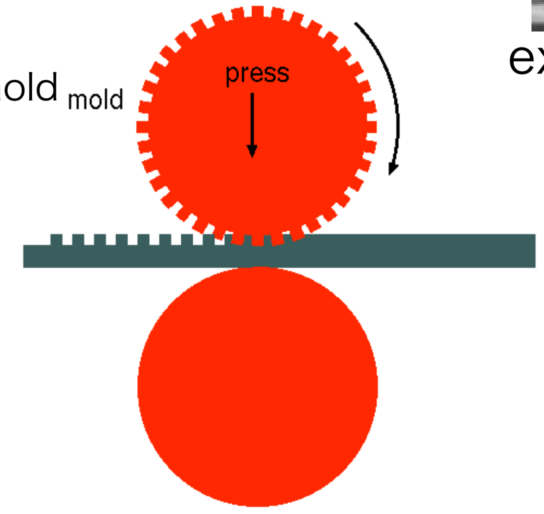


example of SiC mold (NTT-AT)



example of line pattern imprinted on Al using a SiC mold





summary

- A new idea to cover the range between Shintake-monitor and wire-scanner
  - similality: mixture of laser fringe target and wire-target
  - difference: statistical approach, expendable target
  - advantage: less expensive, compact, not affected by beam jitter
- issues
  - technology already exists
  - engineering to realize the mechanism of the device
  - radiation