Beam property of MCP beam monitor

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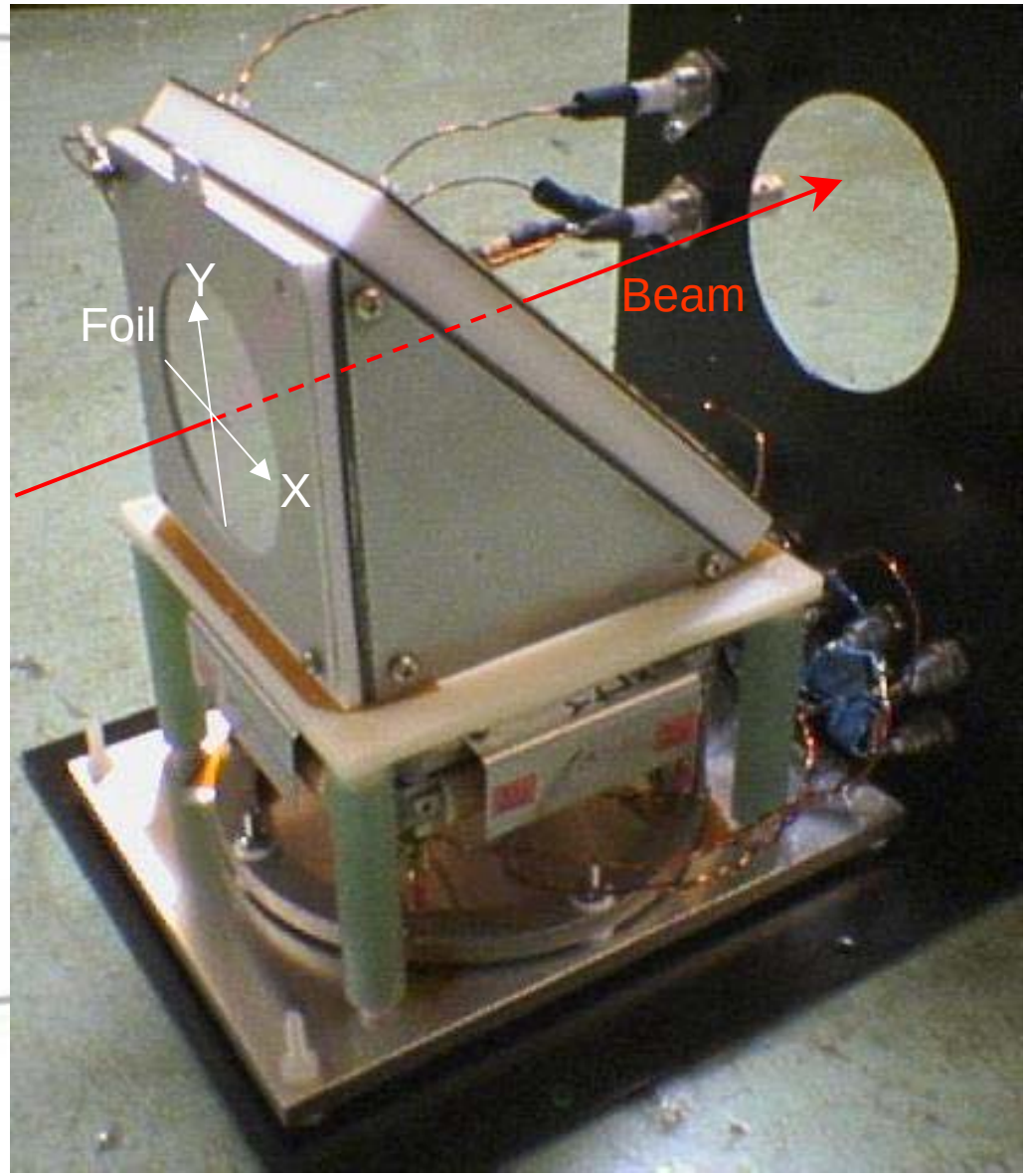
- Configuration
- Performance test with beams
  - Position resolution (^{36}Ar)
  - Time resolution (^{11}B, ^{36}Ar)
  - Detection efficiency (^{11}C, ^{36}Ar, ^{18}F)
- Summary

MCP beam monitor

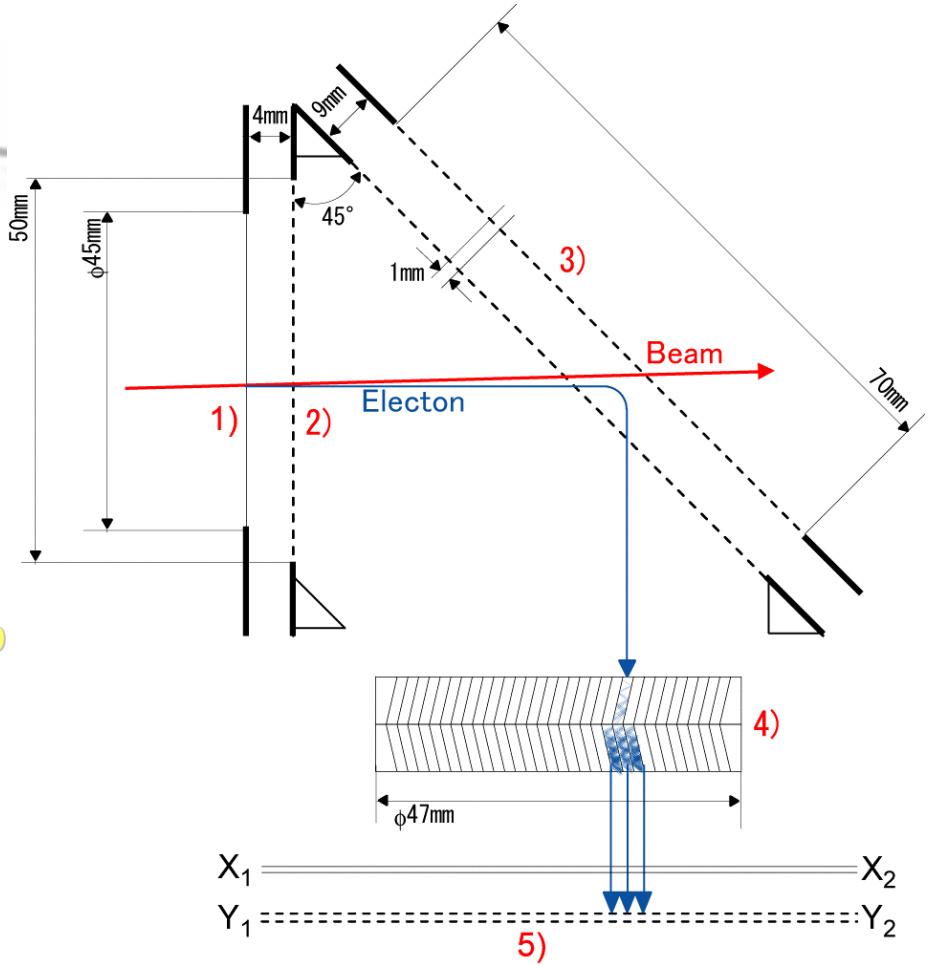
- A thinner position-readable beam monitor than PPAC is desirable for low-energy heavy ion experiments.
- Beam passes through only a thin foil (e.g. 0.7-μm Mylar).
- Beam position on the foil is read.
- Less energy loss, less energy and angular straggling and less background such as p or C.



Configuration

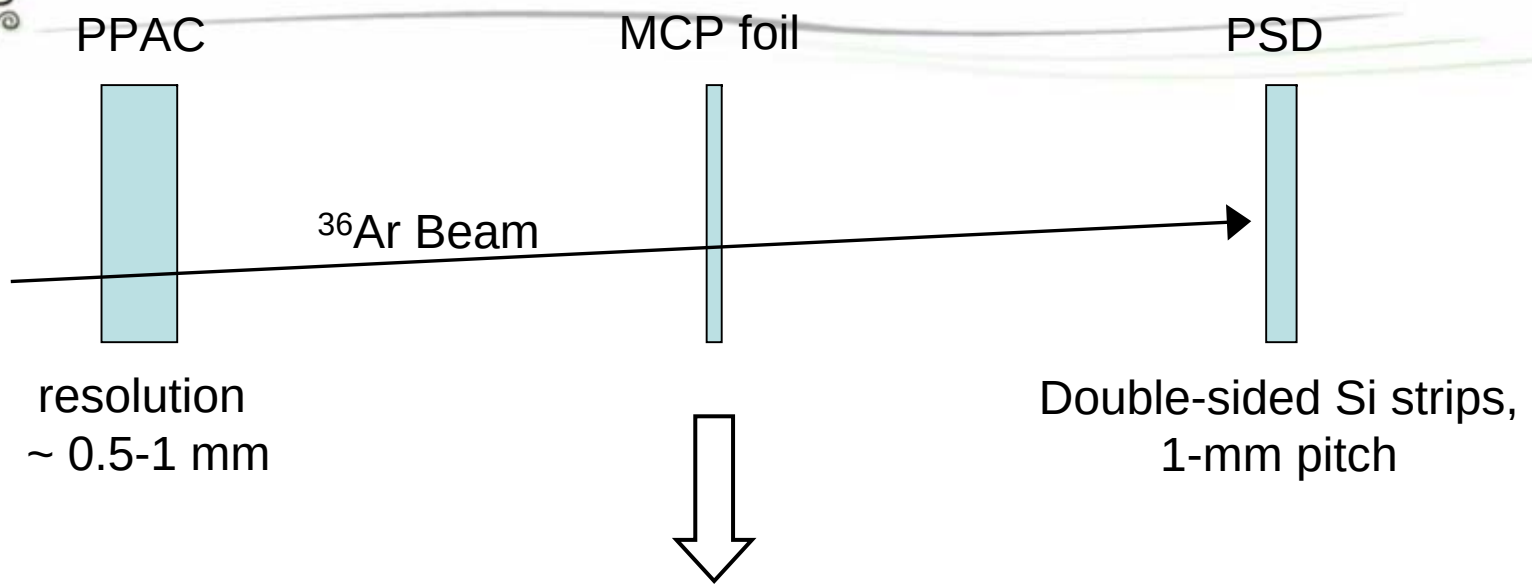
1) Secondary electron emission foil
   (0.7-μm Mylar + Al + CsI)
2) Electron accelerator (Potential wires)
3) Electron reflector (Potential wires)
   +
4) Electron multiplier
   (Microchannel Plate, ϕ47 mm)
5) Position reader (Delay-line anode)
   →Often used for time detection with no position-readable anode

Electron spread < 1 mm
(through 50-mm path)



- Typical performance of MCP + Delay line
  - Position resolution : < 0.1 mm
  - Overall linearity : 0.2 mm
  - Rate capability : 1 MHz
  - Multi-hit dead time : 20 ns

Position resolution test



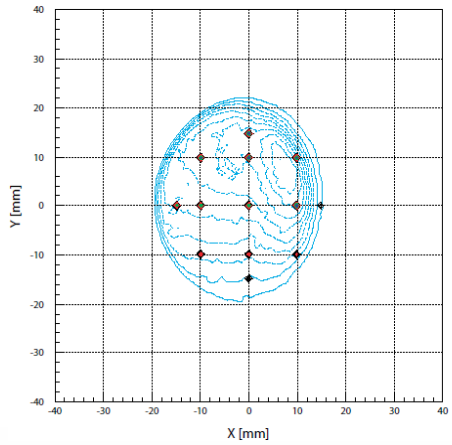
- PPAC + PSD → interpolation on MCP foil

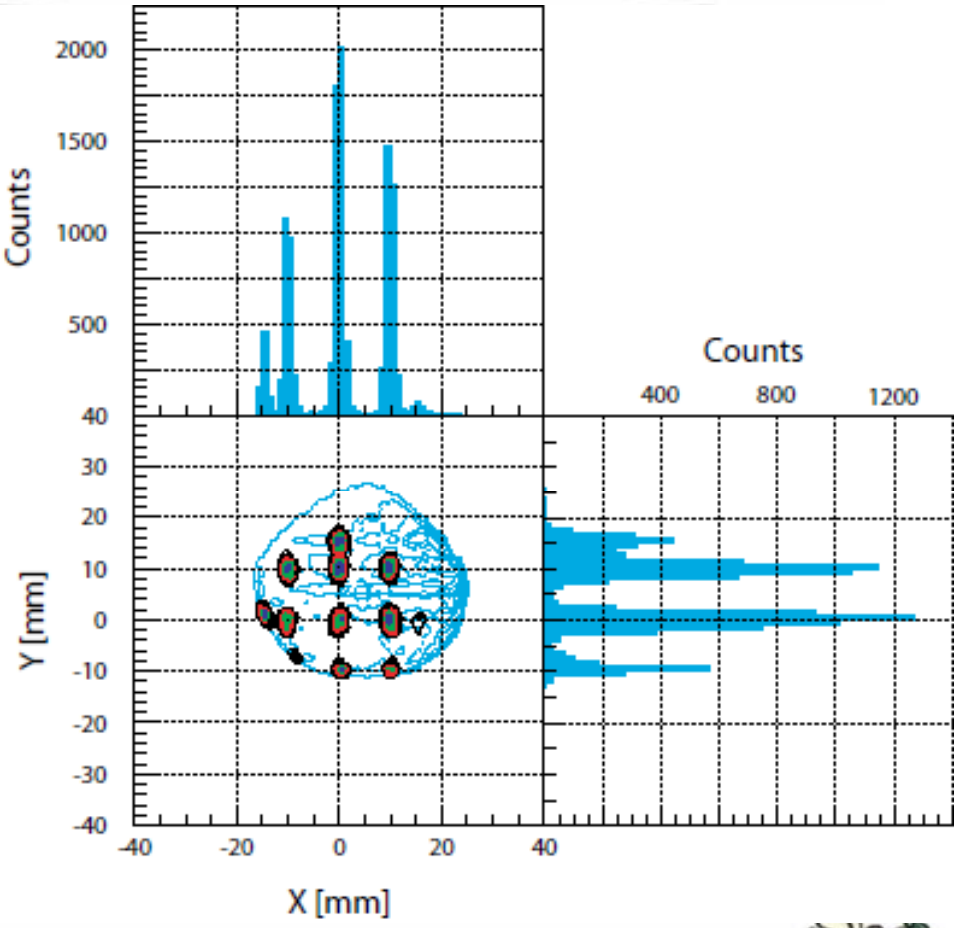
⇕

- Real detection by MCP

- Resolution can be determined by difference between the interpolated points and the detected points.

Position resolution test

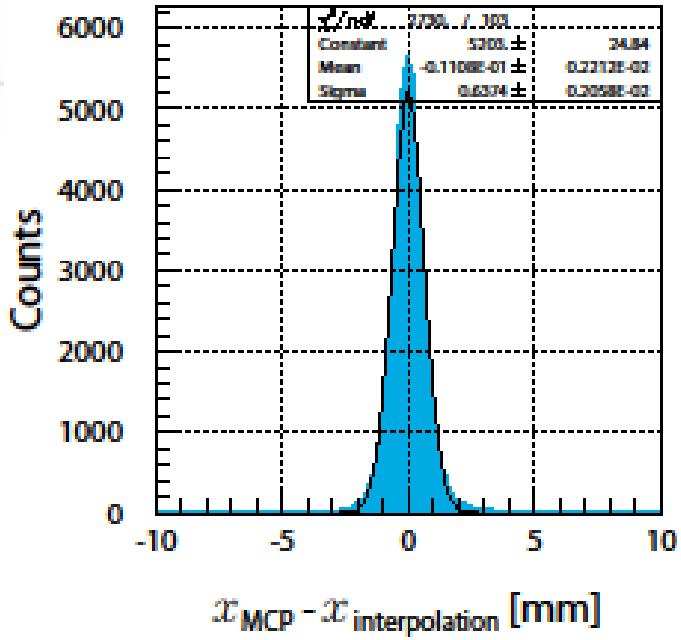


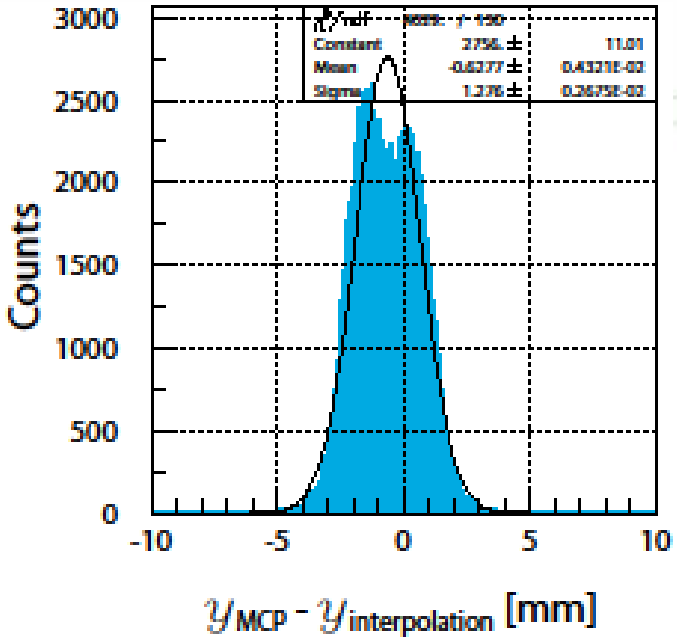


Interpolation

MCP detection

Position resolution test



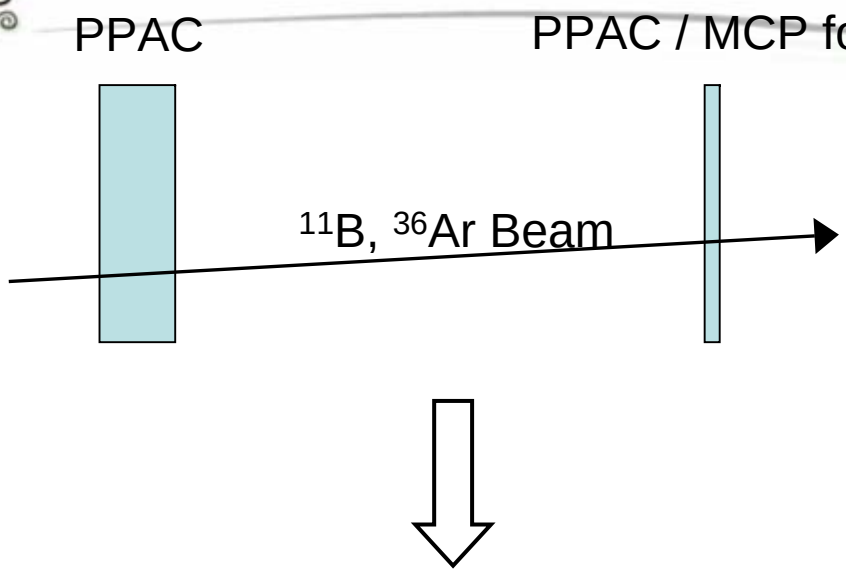


- Difference (FWHM)
  - X (horizontal): 1.5 mm
  - Y (vertical) : 3.0 mm

⇩ (PPAC res., PSD res., angular straggling)

- Intrinsic MCP position resolution (FWHM)
  - X: 1.2±0.1 mm
  - Y: 2.8±0.1 mm ← Due to the structure of the reflector

Time resolution test



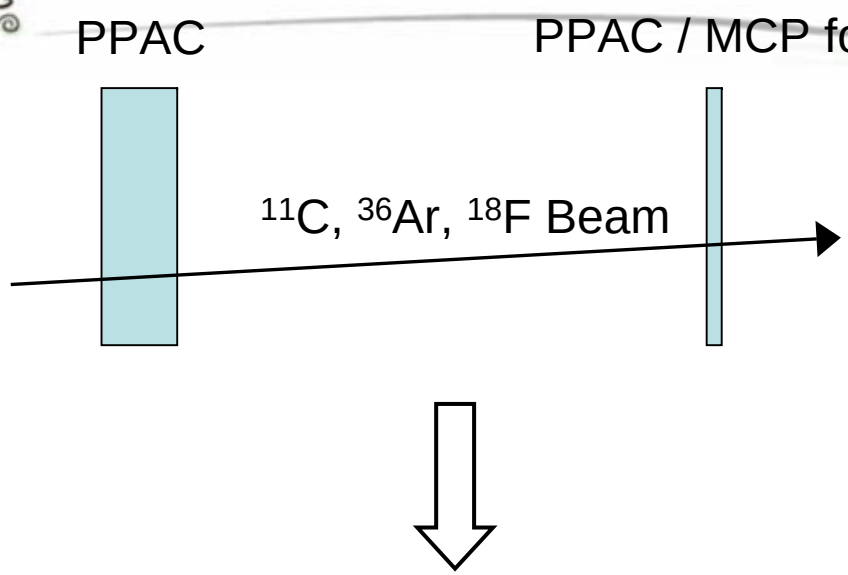
- $\delta t / t$ of beam ~ 0.1 %,
  δt ~ a few × 10 ps
  (including original beam energy spread, energy straggling in PPAC, different flight path)

- FWHM of TOF between PPAC and MCP
  - ^{36}Ar: 876 ps
  - ^{11}B: 1.05 ns
- FWHM of TOF between 2 PPACs
  - ^{11}B: 970 ps

⇒ PPAC time res. ~ 500-700 ps.

- Intrinsic MCP time resolution ~ 700-800 ps

Detection efficiency test



- Detection efficiency of MCP to PPAC
  - ^{36}Ar: 100 % @ < 5×10^3 pps
  - ^{11}C: > 96 % @ 5×10^5 pps (some events are out of detection area)
  - ^{18}F: > 80 % @ 7×10^5 pps (some events are out of detection area)
    > 55 % @ 1×10^6 pps (some events are out of detection area)

Summary

- Position resolution (FWHM)
  - X: 1.2±0.1 mm
  - Y: 2.8±0.1 mm
  - Position resolution of Y direction is worse due to the structure of the reflector.

    (Direction of wire, reflecting angle)
- Time resolution (FWHM)
  - 700-800 ps (depends on PPAC res.)
- Detection efficiency (to PPAC)
  - ~100 % (@ $< 5 \times 10^3$ pps)
  - Decreases rapidly at $> 5 \times 10^5$ pps ?
  - Electrons were emitted too much ?
- A new design is needed ?
  - No reflector , slanted foil Mounting, straight flight from foil to MCP, forcing electron path by magnetic field, etc…