Instrumentation for a low-energy beam

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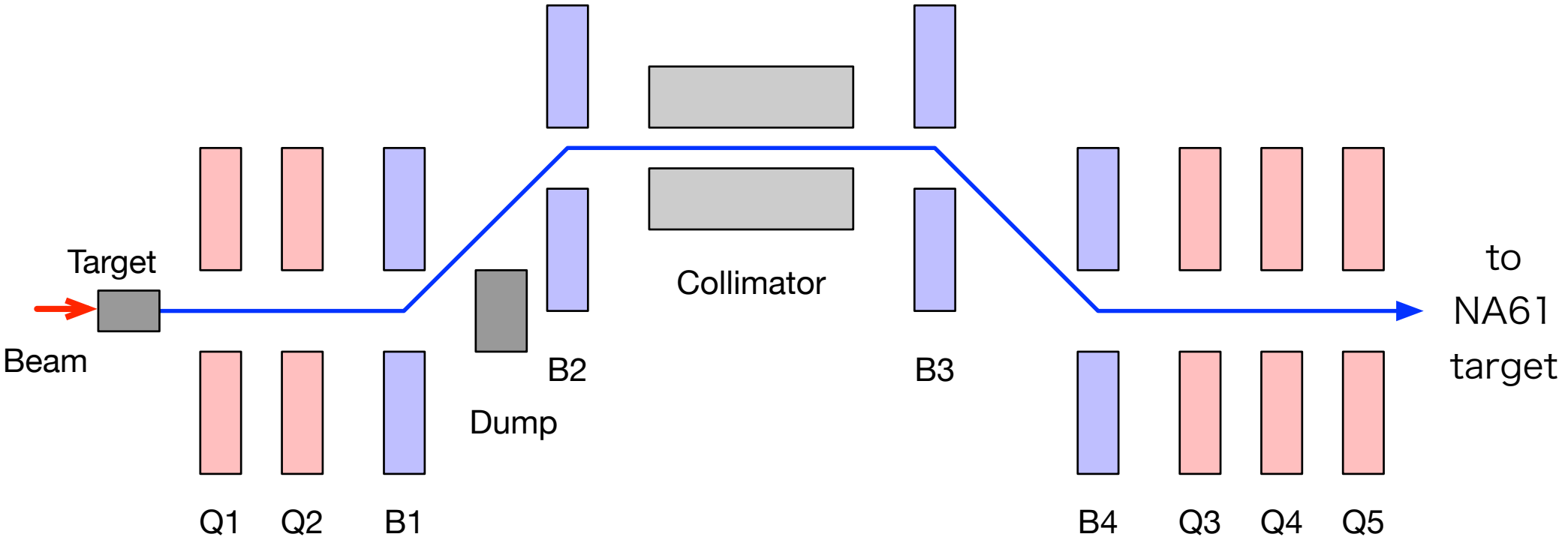
K.Sakashita(KEK/J-PARC)
with discussion among N.Charitonidis, C.Mussolini and NA61 collaboration

Introduction

- N.Charitonidis, C.Mussolini are designing the low momentum beamline
- In this talk an initial idea of necessary beam instrumentation will be discussed
  - as a start point of discussion
  - need optimization

Current design of beamline

N.Charitonidis, C.A.Mussolini



Low-E beam momentum rage : 1-15 GeV/c

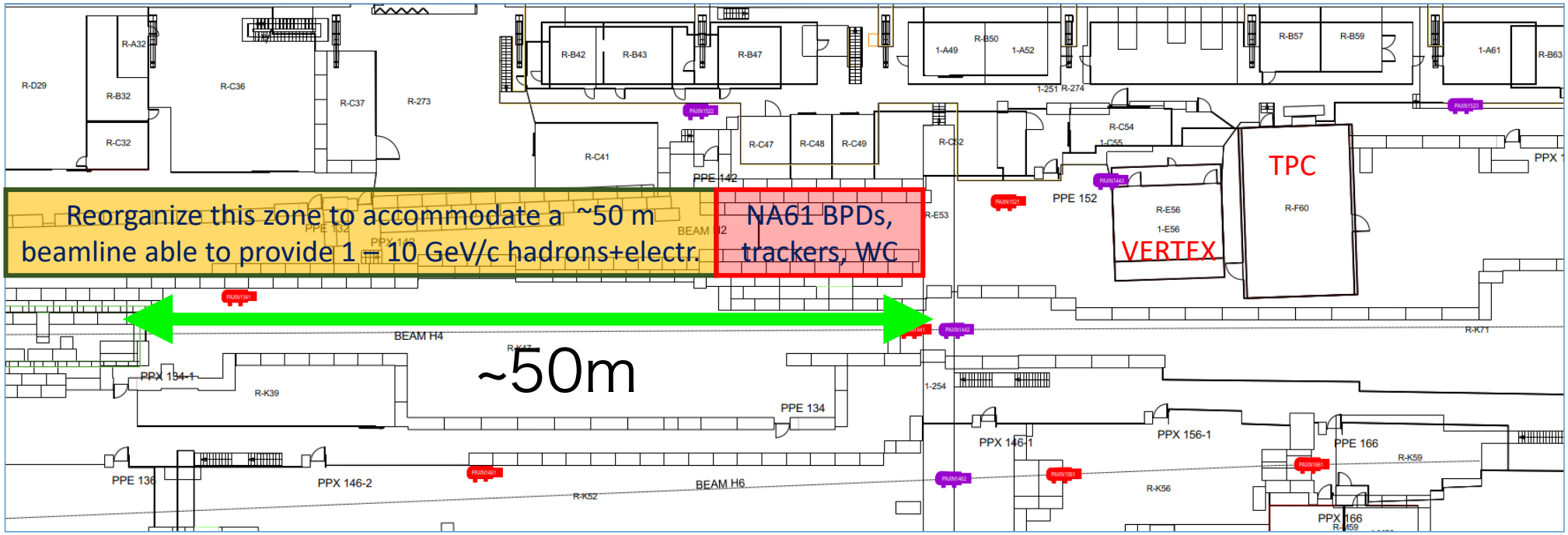
Particle composition : π, K, p, e, μ

Requirements on beam instrumentation

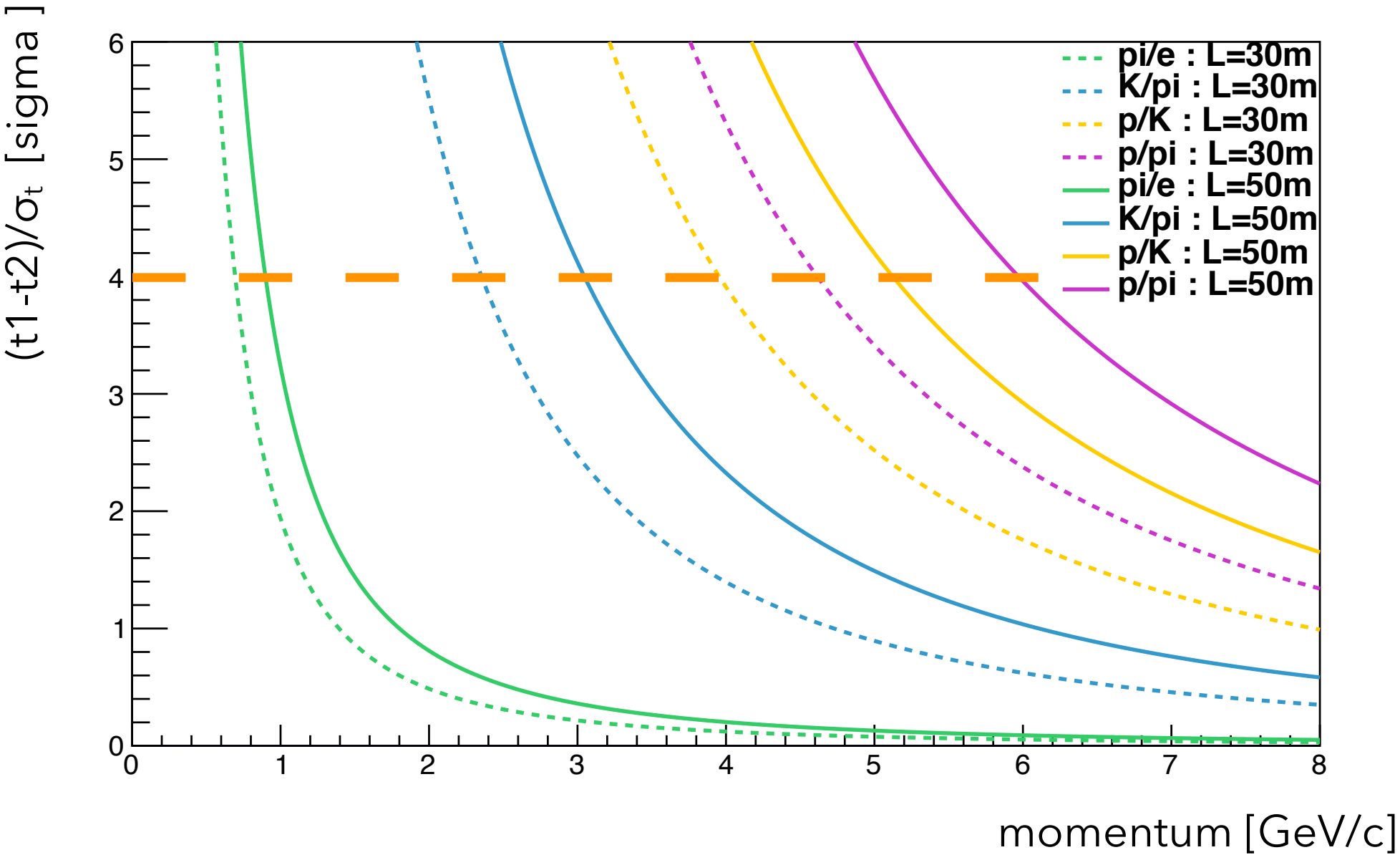
- Trigger
- Particle identification for π, K, p (also, e ?)
- Beam profile measurement for beam tuning
- Particle-by-particle momentum measurement

Time-of-flight, Trigger

- Possible inst. : plastic scintillation counter
- Distance between two TOF counters will be 30~50m



TOF discrimination power assuming 500ps resolution



Possible to discriminate π/K/p up to 5~6GeV/c if L=50m

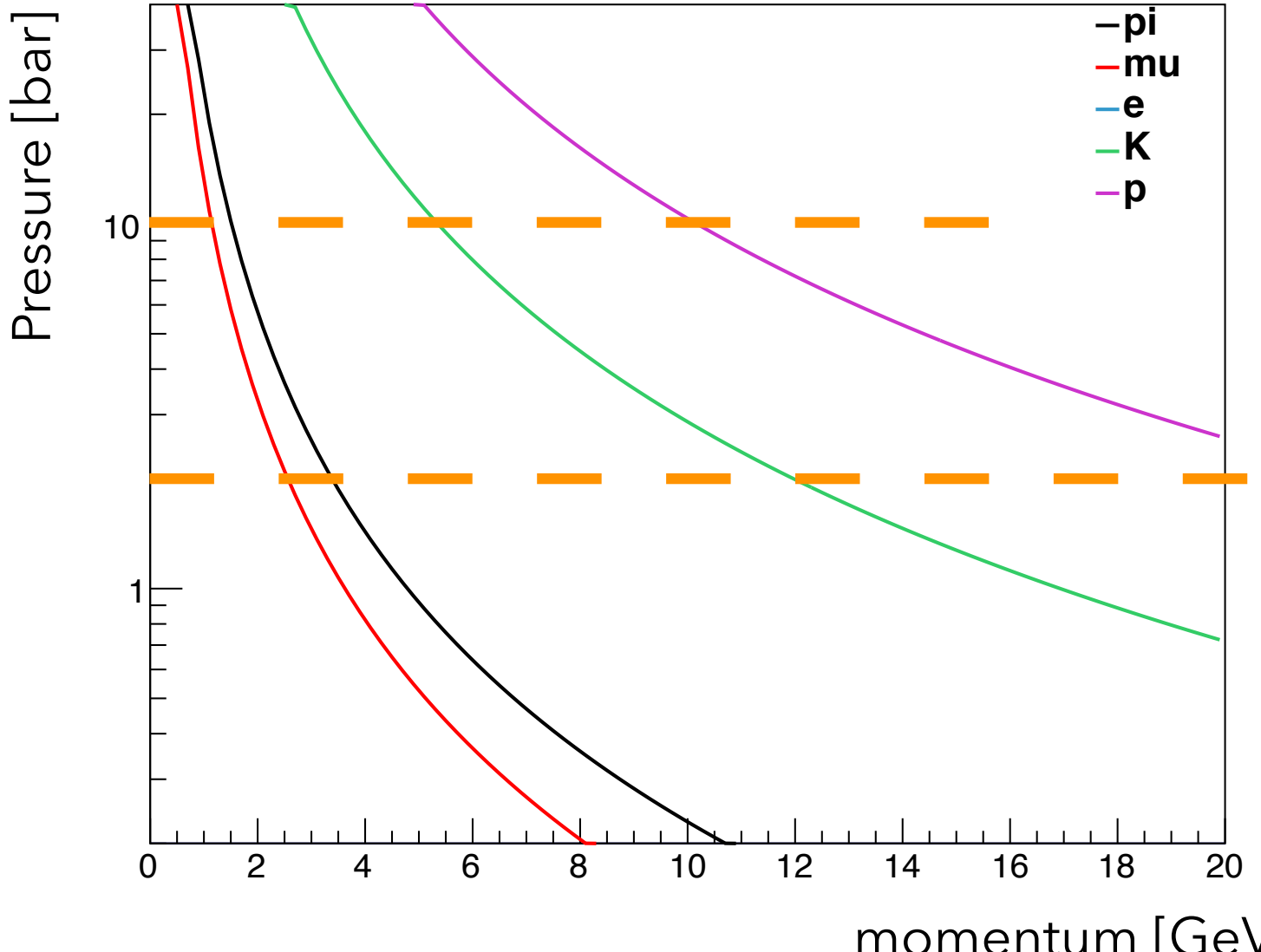
Particle identification

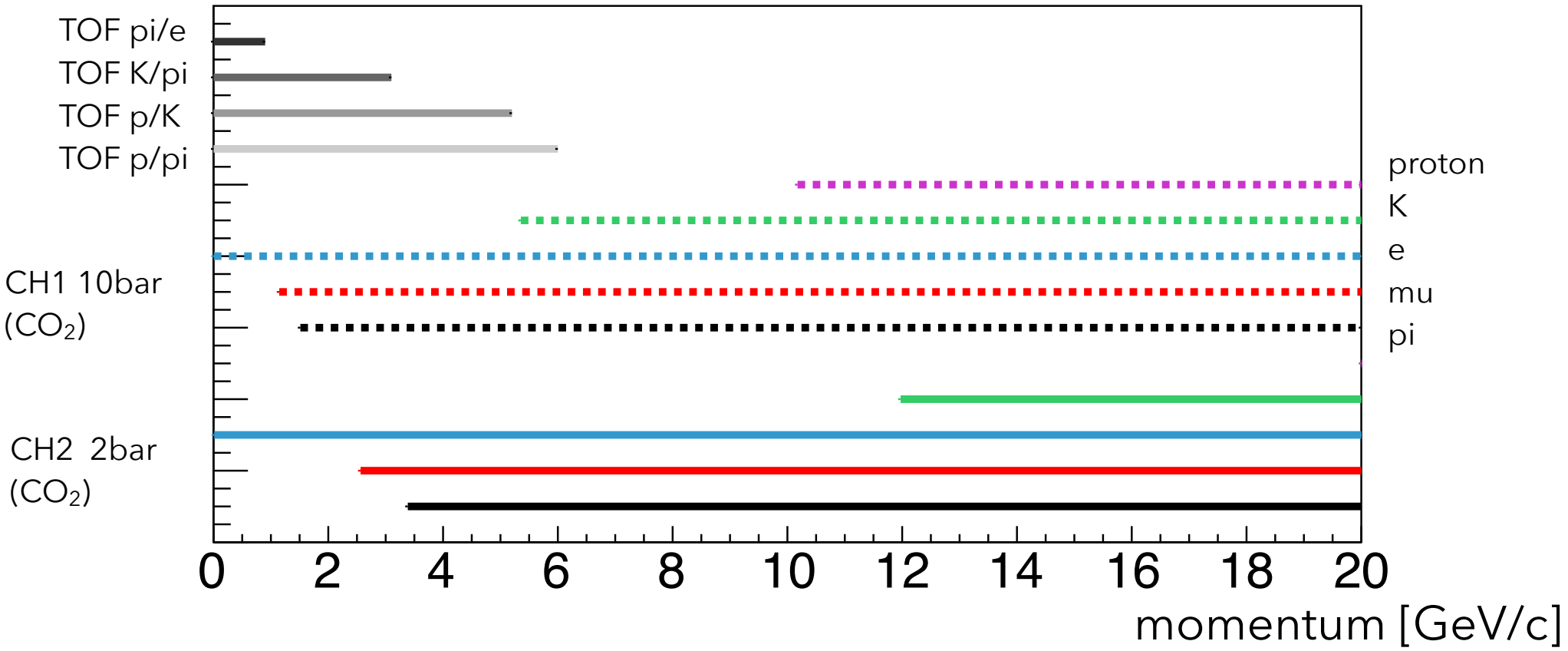
- Gas Cherenkov counters (threshold type)
  - Similar to one used in H2-VLE
    - 2 m long chambers
  - assuming CO_2 gas filled
  - two counters with different pressures to cover a wide momentum range

$$P_{th} = \frac{m^2}{2(n_0 - 1)p^2}$$

P_{th} : Chrenkov threshold pressure [bar]
m : particle mass [GeV/c^2]
p : particle momentum [GeV/c]
n_0 : refractive index at 1bar

CO_2



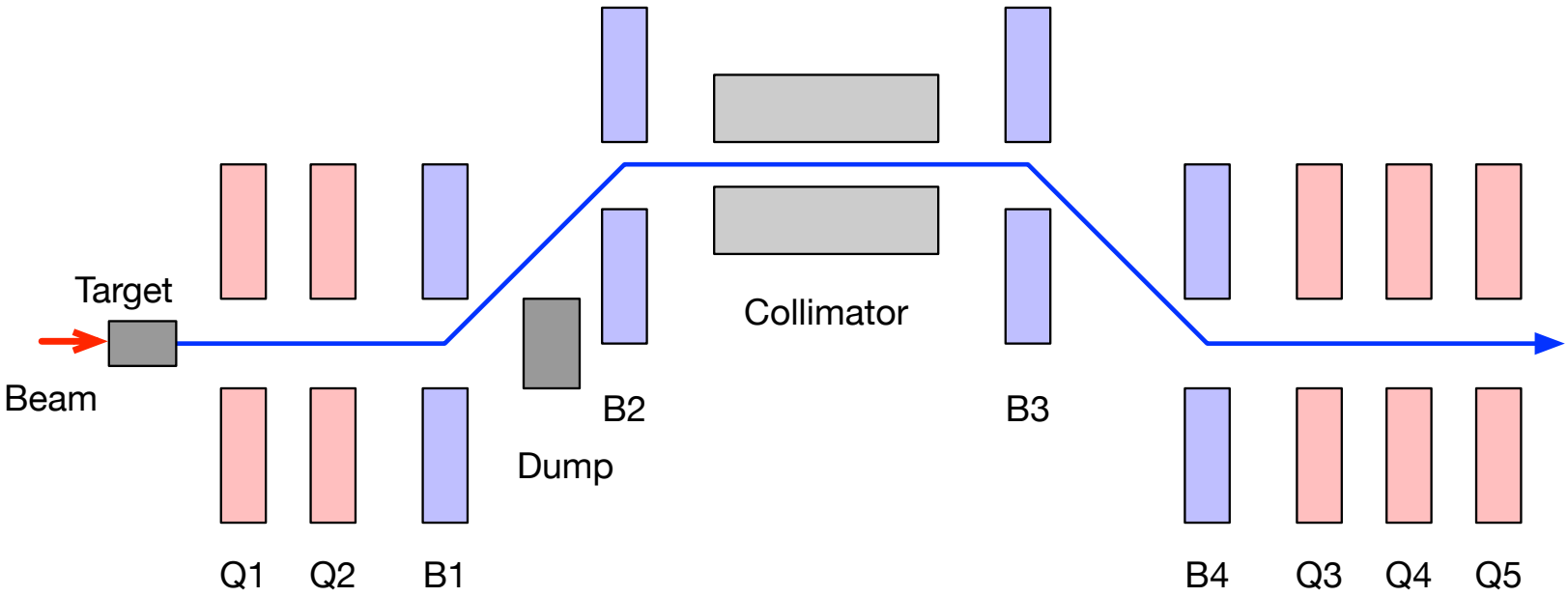


momentum	e	π	K	p
1	CH1 & CH2	TOF	TOF	TOF
3	CH1 & CH2	TOF & CH1	TOF	TOF
5	CH1 & CH2	CH1 & CH2	TOF	TOF
10	CH1 & CH2	CH1 & CH2	CH1 & $\overline{\text{CH2}}$	$\overline{\text{CH1}}$ & $\overline{\text{CH2}}$
15	CH1 & CH2	CH1 & CH2	CH1 & CH2	CH1 & $\overline{\text{CH2}}$

optimization is necessary

Momentum measurement

- Momentum spread after the collimator will be 5-10%
- It can be reduced with the momentum measurement by profile monitor
  - need to consider this necessity in term of requirements from physics targets
  - it is beneficial to keep the beam intensity



- Similar to the existing VLEs, momentum measurement utilizing beam profile monitor is possible solution

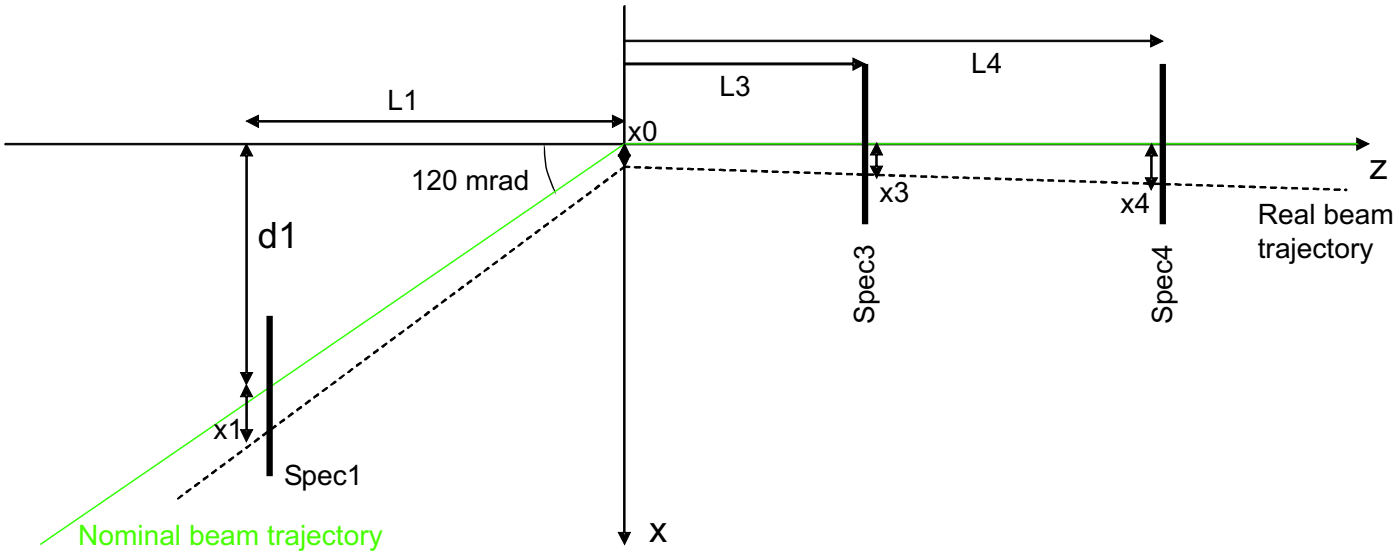


Figure 6: *Geometry of the VLE spectrometer for momentum analysis.*

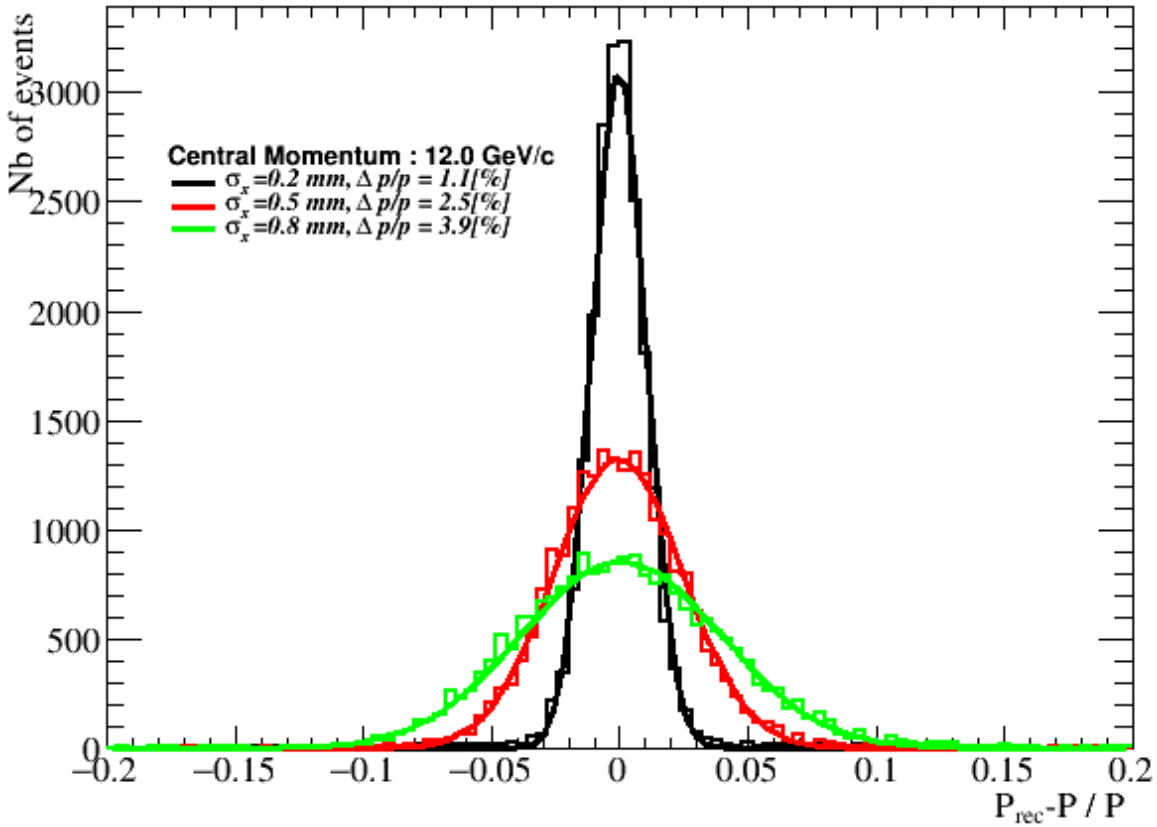
$$\cos\theta = \frac{L_1(L_4 - L_3) + (x_0 - d_1 - x_1)(x_4 - x_3)}{\sqrt{L_1^2 + (x_0 - d_1 - x_1)^2}\sqrt{(L_4 - L_3)^2 + (x_4 - x_3)^2}}$$

$$p\,[\mathrm{GeV/c}] = \frac{299.79}{\theta\,[\mathrm{mrad}]} \times \int B d\ell\,[\mathrm{Tm}]$$

- Expected dp/p

simulation results (H2-VLE)

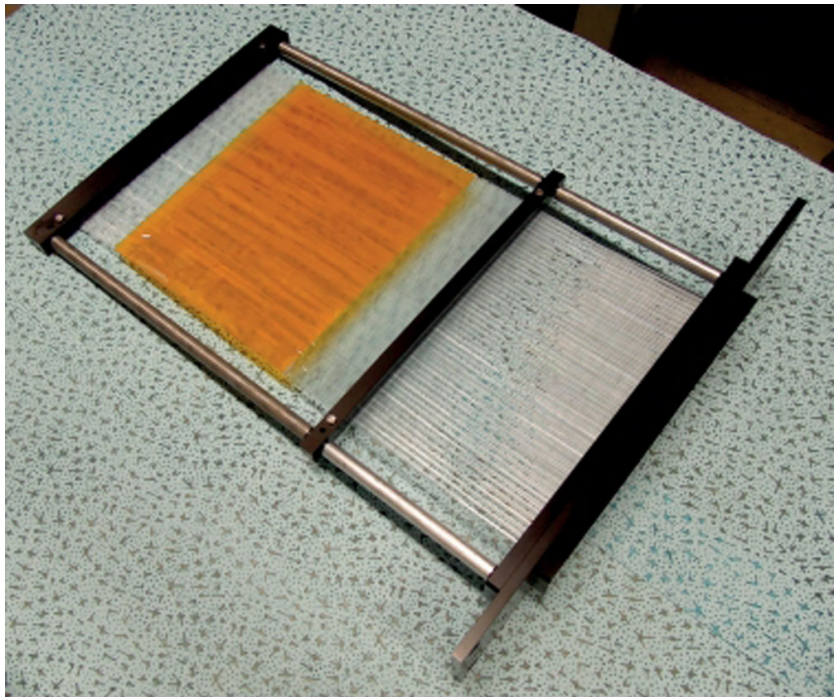
w/o any effect of material in the beamline



dp/p ~ 2% is expected

profile monitor w/

scintillation fiber + SiPM

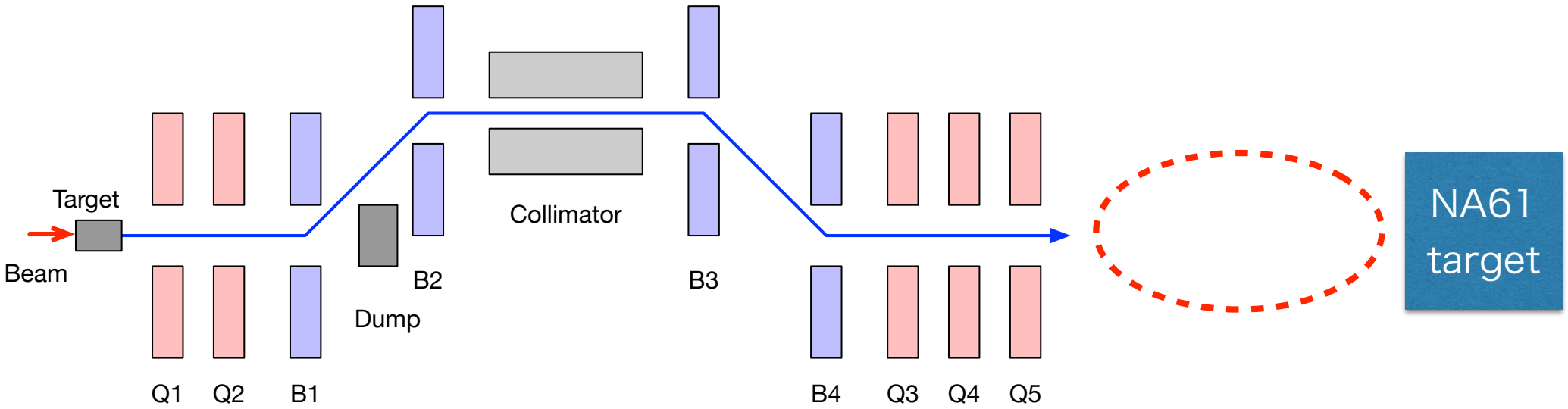


σ ~0.3mm

Similar simulation study including the material effect is desired

Beam position detector

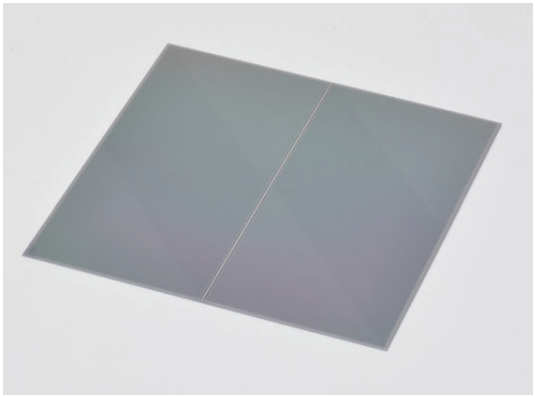
- Beam size will bee increased for the low momentum beamline
- Plan to put a “wide-area” beam position detector (BPD) in the front of the NA61 target



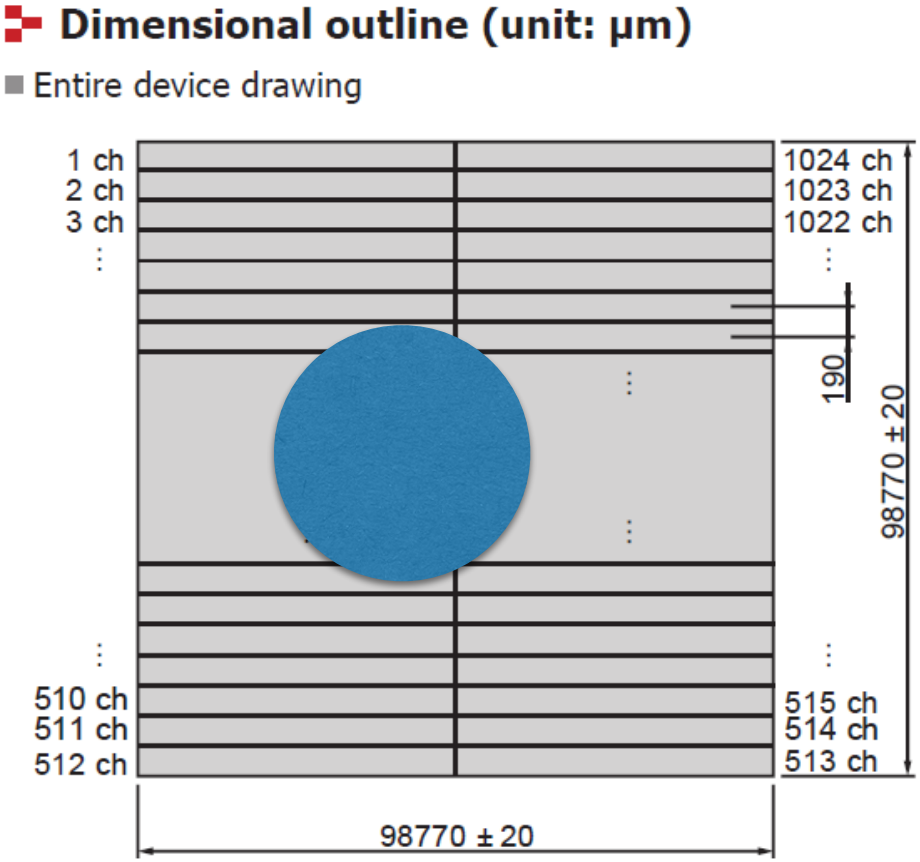
Idea of “wide-area” BPD

- Silicon strip detector (SSD) which is commercially available at Japan
- Plan to proceed R&D of readout electronics etc. and make it ready for the low-E beamline construction
  - primary option of the readout electronics is based on APV25+SRS (CERN RD51)

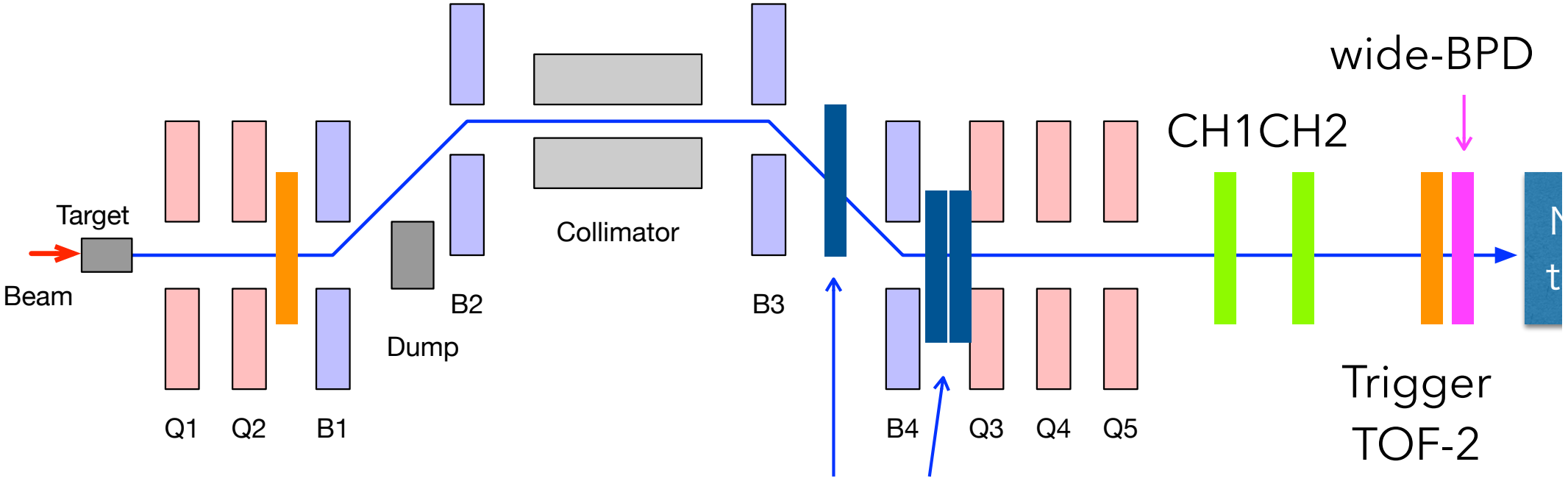
Si strip detector(Hamamatsu S13804)



0.19mm pitch x 512ch x 2



Summary of initial idea of beam instrumentation



Summary

- Initial idea of beam instrumentation is discussed
- Further study and optimization are necessary
  - PID method for p > 5 GeV/c
  - Momentum measurement simulation including effect of materials in the beamline
- Detailed design of each instrumentation including choice of detector technology will be also performed