Radiation Hardness Test Plan
at KOMAC with Pixel Detector

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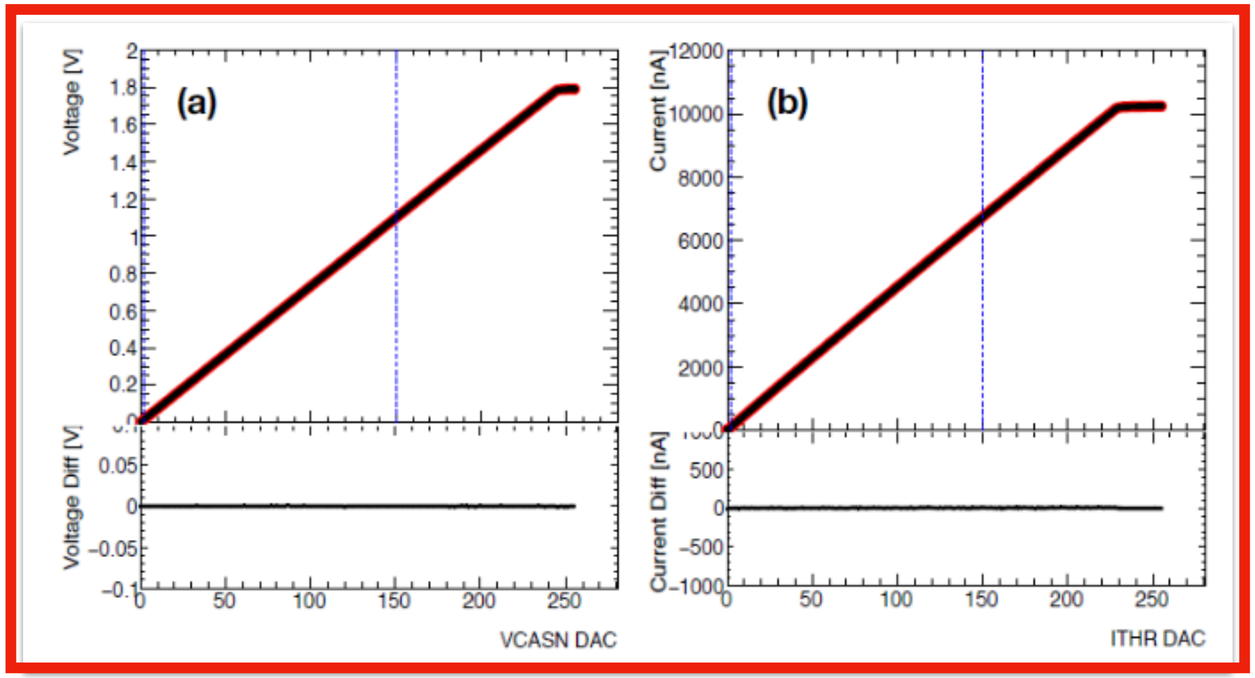
KoALICE National Workshop 2021
2022.01.05

KoALICE

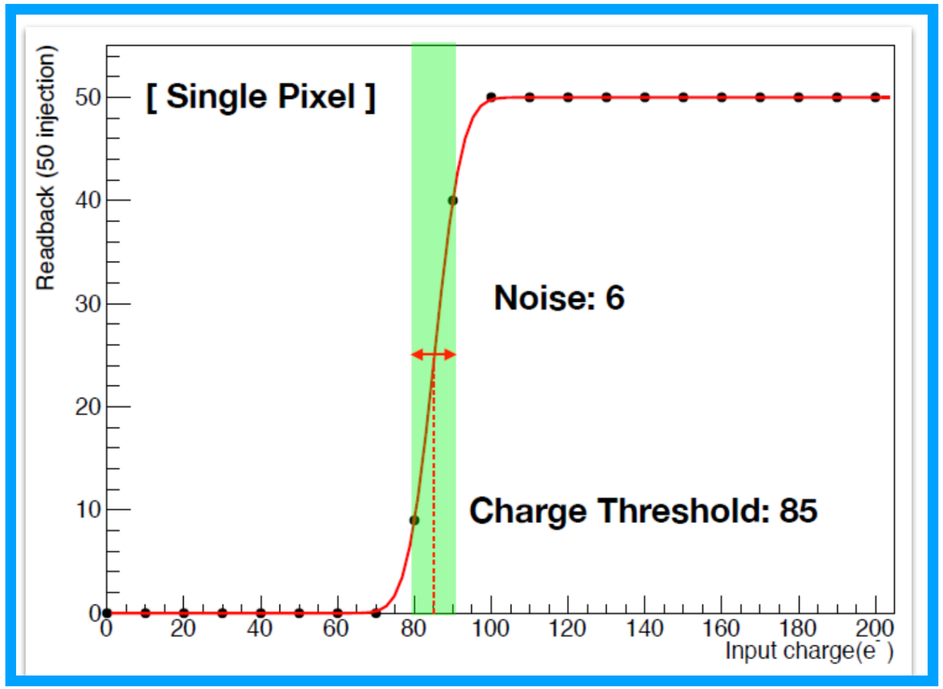
Purpose

Total Irradiation Dose (TID)

- Measure radiation hardness
  - DAC linearity, threshold and noise



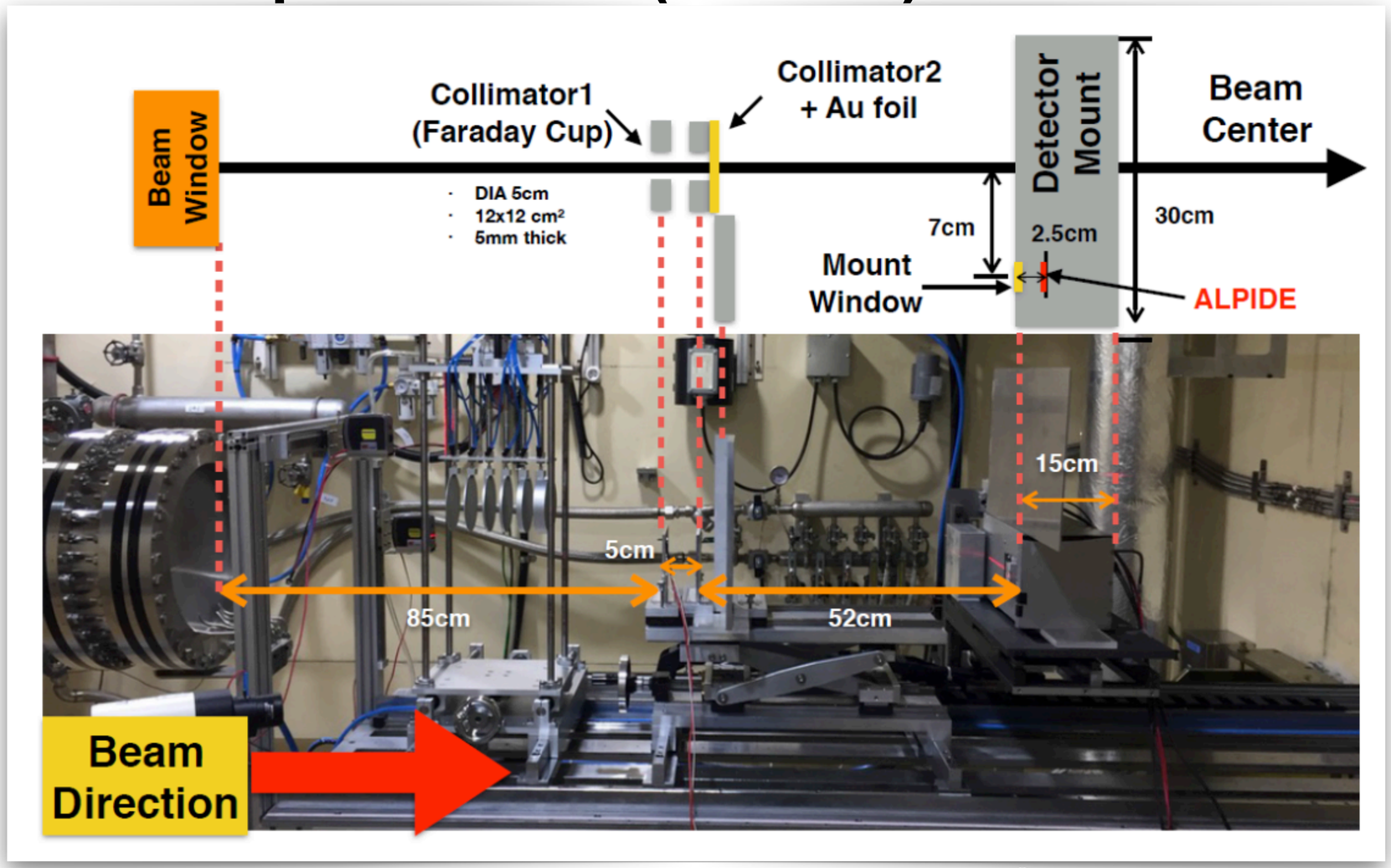
DAC linearity



Threshold and Noise

Study in 2019

20MeV proton beam(KOMAC)



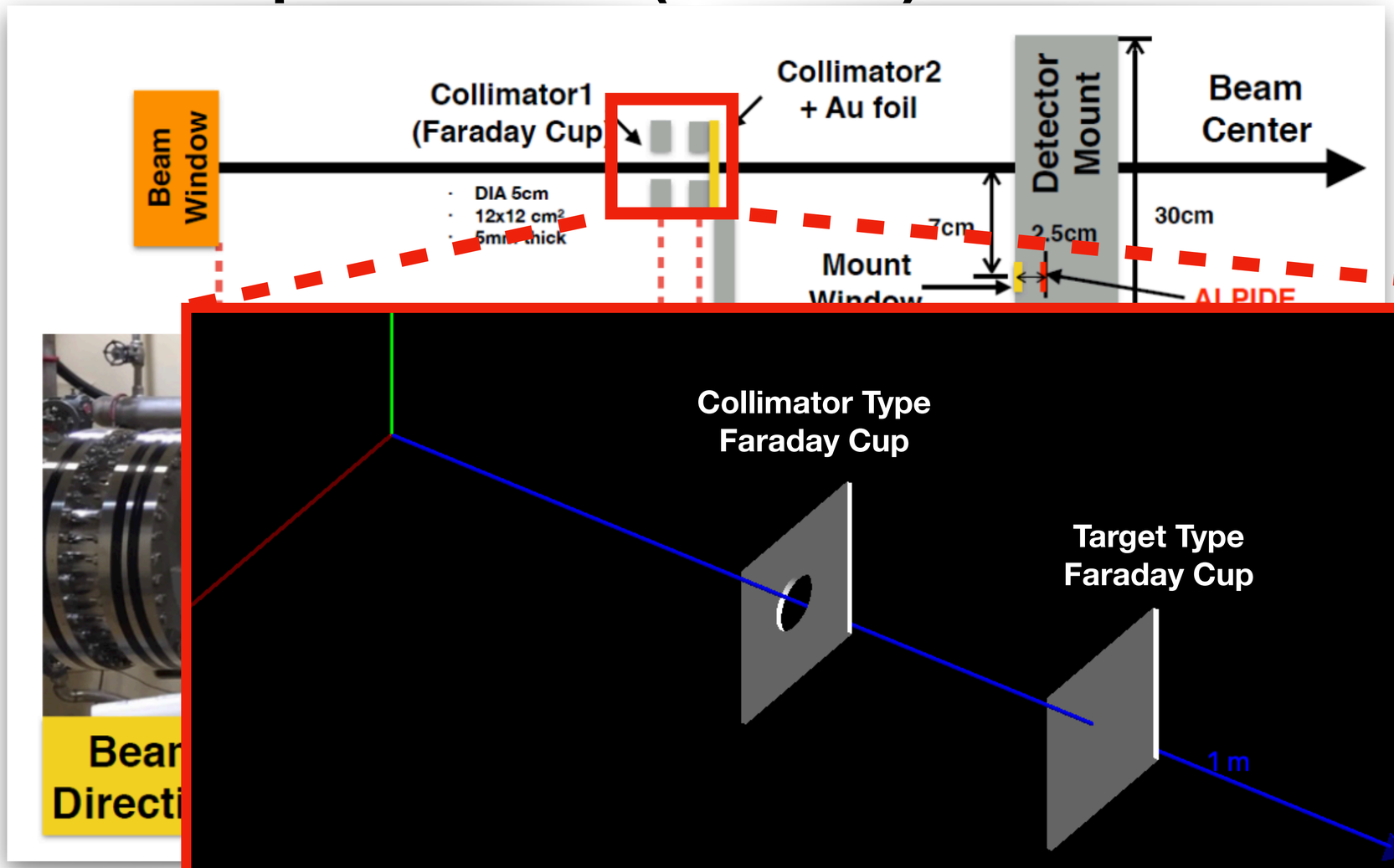
- High flux proton beam (~10^9 protons/cm2/pulse)

  -> Used gold foil(100μm) (reduce flux)

- Need # of injected protons at target

Study in 2019

20MeV proton beam(KOMAC)



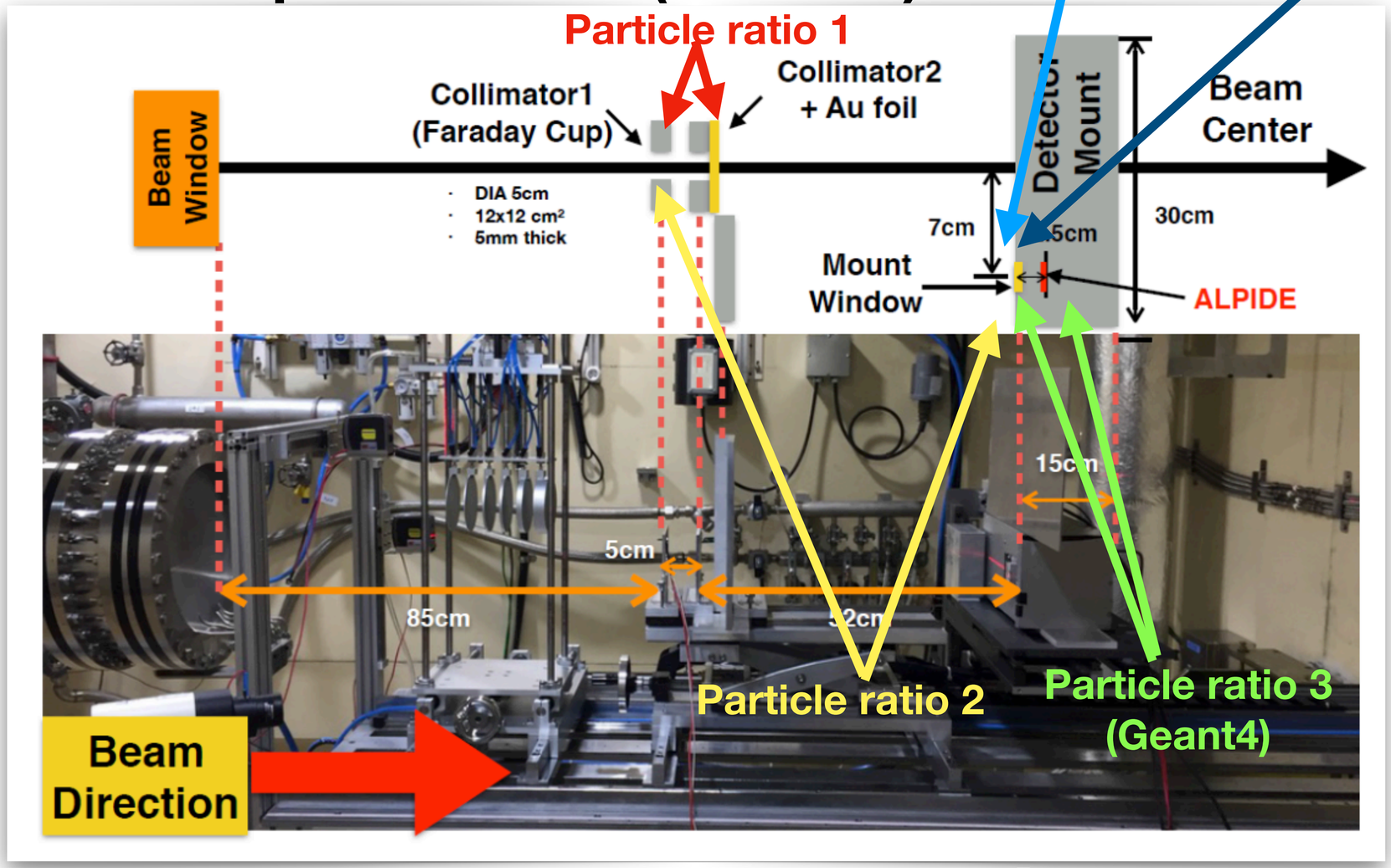
- High flux proton beam (~10^9 protons/cm2/pulse)

-> Used gold foil(100μm)
(flux)

njected
target

Study in 2019

20MeV proton beam(KOMAC)



- High flux proton beam (~10^9 protons/cm2/pulse)

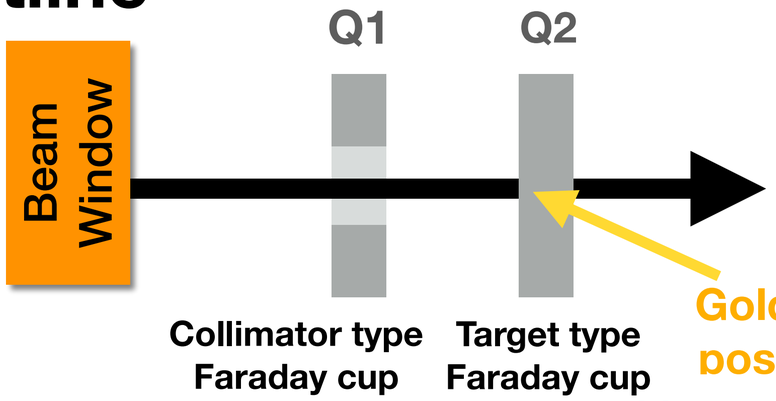
  -> Used gold foil(100μm) (reduce flux)

- Need # of injected protons at target

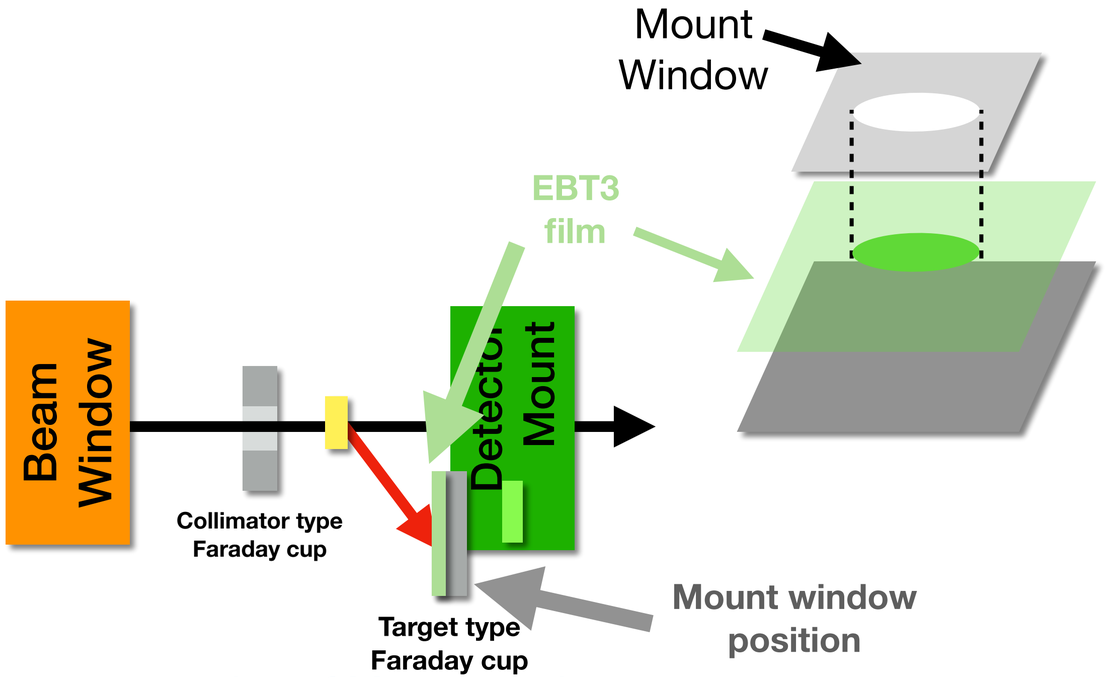
  -> 4 pre-experiments

Study in 2019

Outline

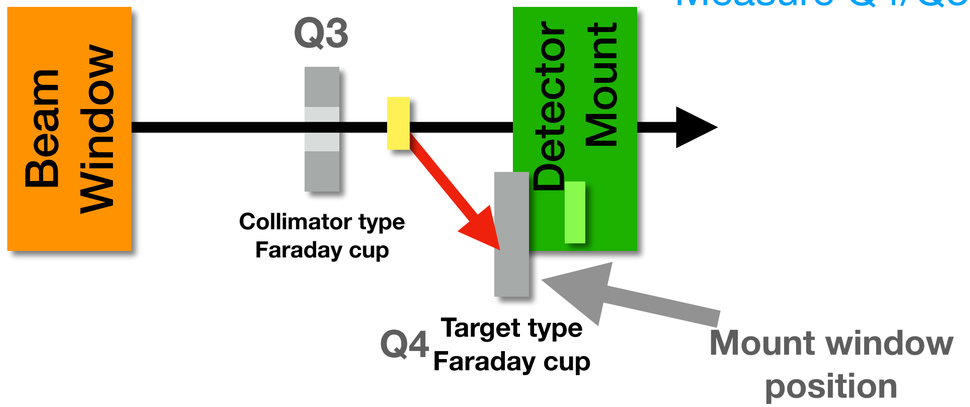


Measure Q2/Q1 ①

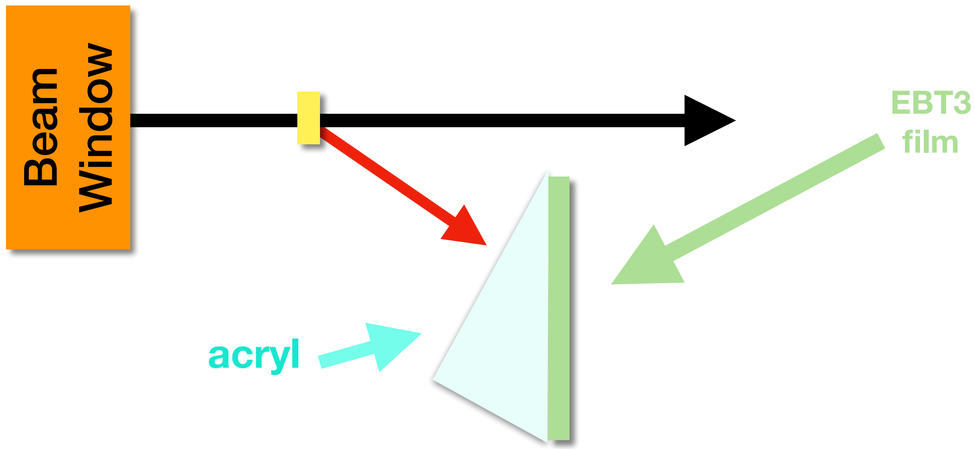


③ Measure area ration of Mount window

Measure Q4/Q3 ②

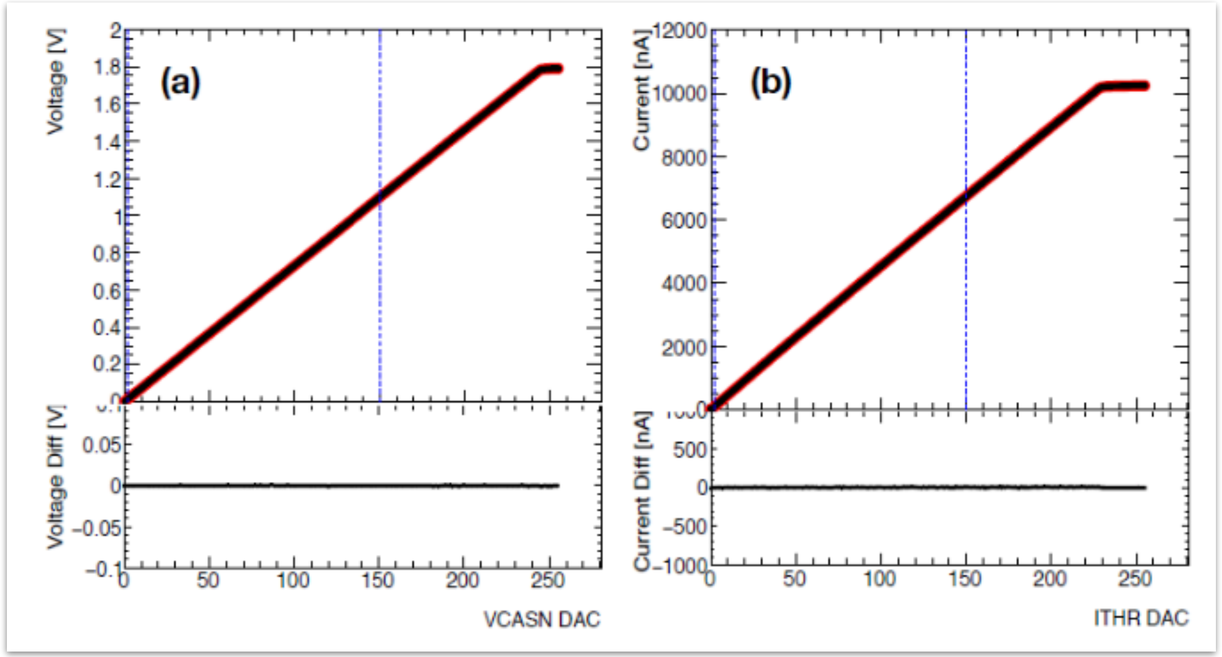


④ Measure proton kinetic energy

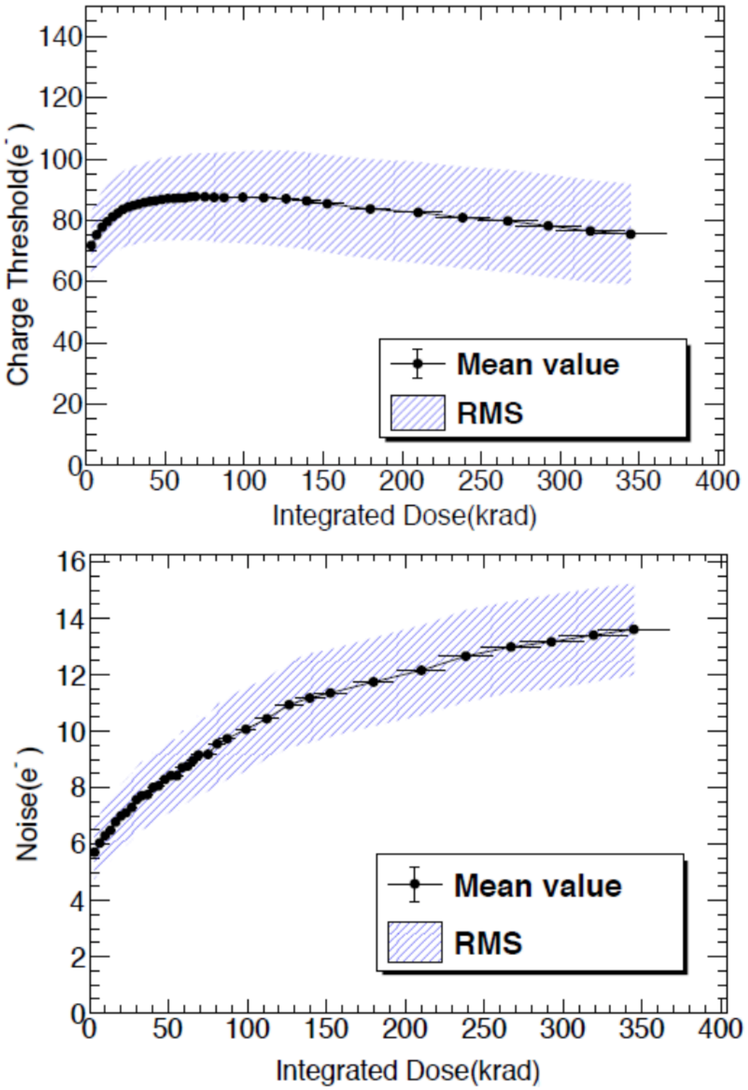


Study in 2019

Results



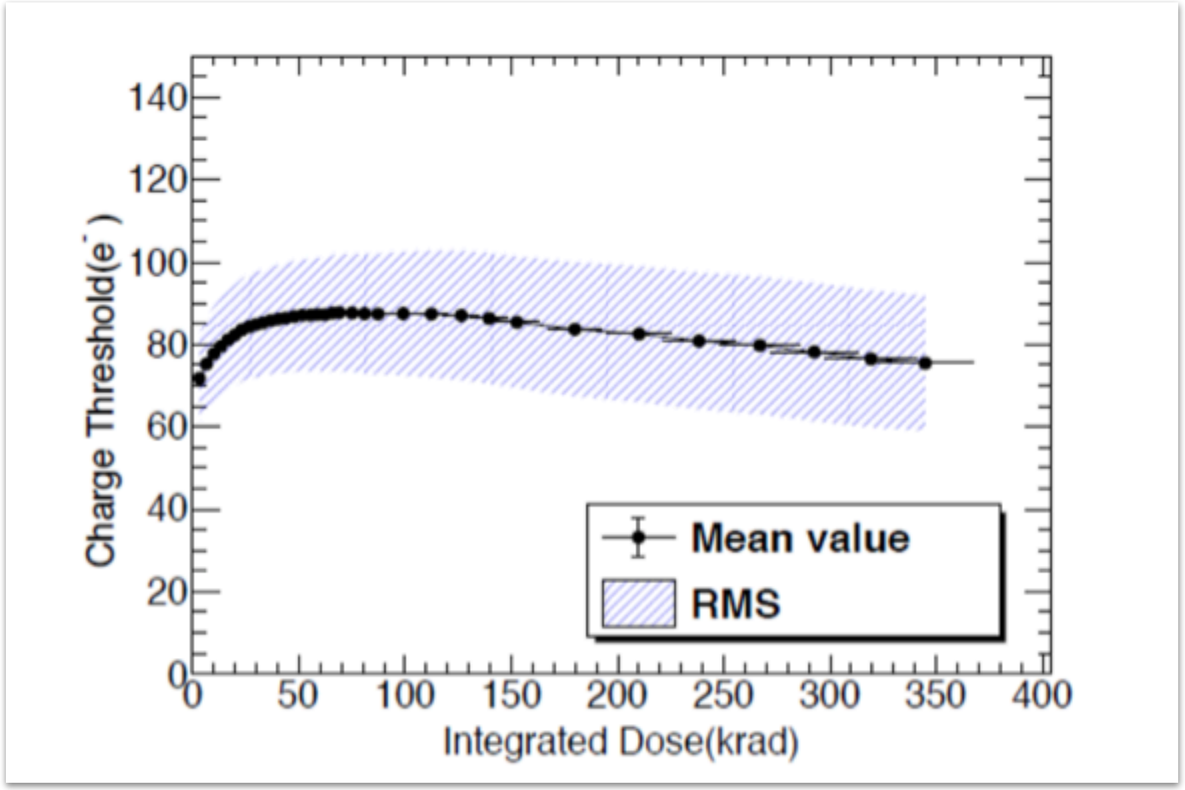
DAC linearity



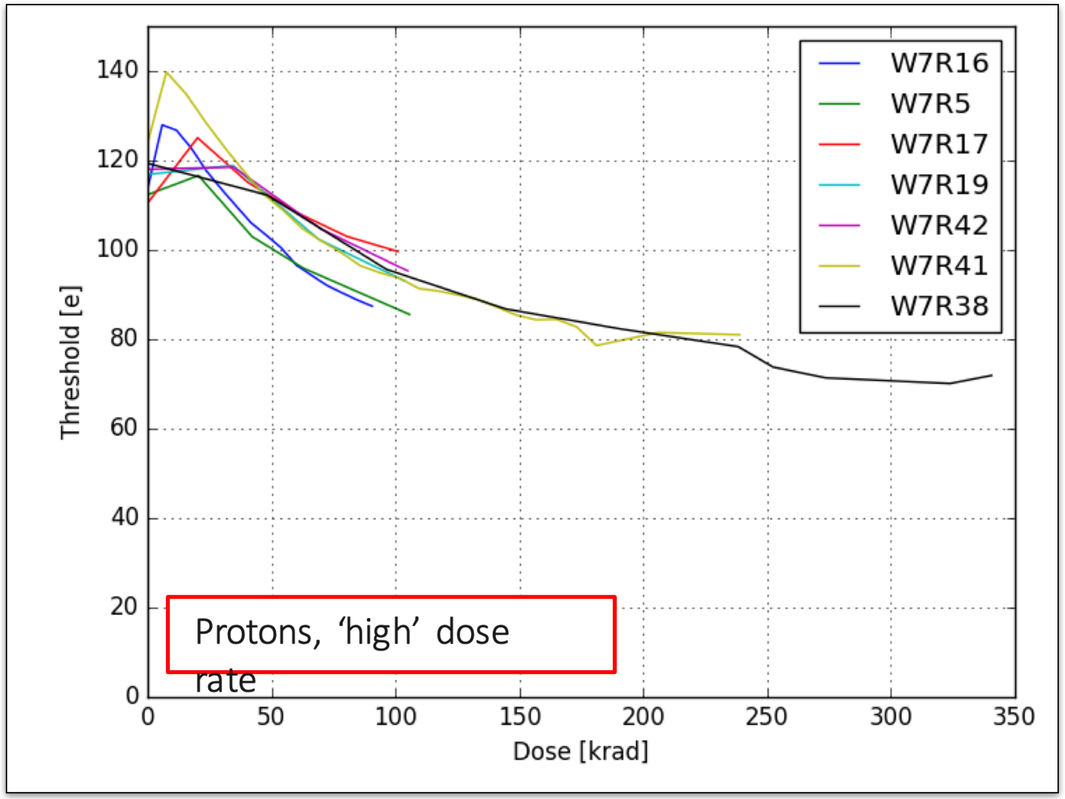
Threshold and noise

Study in 2019

Compare with other result



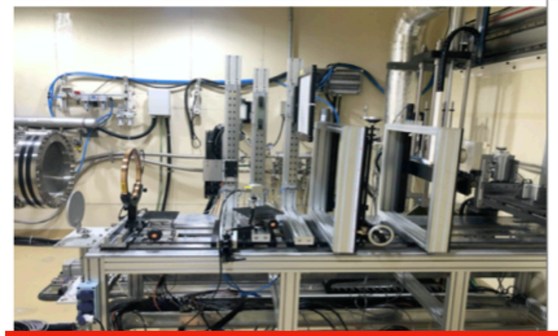
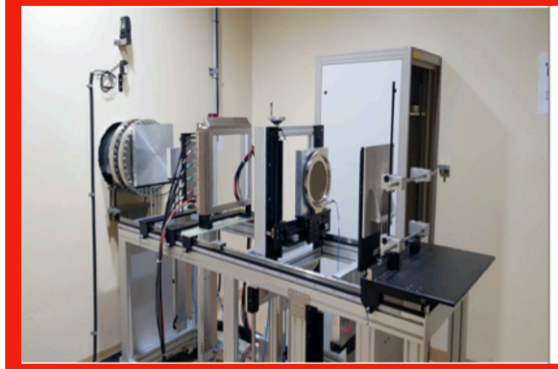
KOMAC



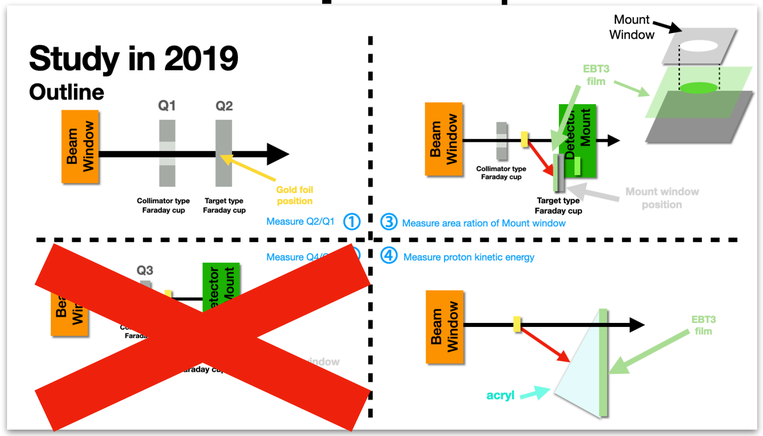
Prague

New Beam

KOMAC

양성자가속기 빔라인	세 부 내 용
	☐ 20 MeV 범용 빔라인(TR23) **At 2019** ○ 개요: 20 MeV 양성자빔을 다양한 시편에 조사하는 장치 ○ 에너지: 10~20 MeV ○ 가속입자: 양성자(proton) ○ 조사면적: 3cm-Φ (± 10% @ 3cm-Φ) ○ Flux: 5E9 ~ 5E10 protons/cm^2/pulse ○ 품질기준(ISO9001): 에너지(±5%), 균일도(±10%), 조사량(±10%) ○ 활용분야: 재료, 핵물리, 반도체 등
	☐ 100 MeV 저선량 빔라인(TR102) **At 2022** ○ 개요: 100 MeV 양성자빔을 다양한 시편에 조사하는 장치(저선량) ○ 에너지: 45~100 MeV ○ 가속입자: 양성자(proton) ○ 조사면적: 100 mm x 100 mm(± 10% @ 조사면적) ○ Flux: 5E5 ~ 1E8 protons/cm^2/pulse ○ 품질기준(ISO9001): 에너지(±5%), 균일도(±10%), 조사량(±10%) ○ 활용분야: 우주/자연 방사선효과(전자부품/생체 등), 생명공학, 방사선 검출기 등

- **Larger energy**
  20MeV -> 100MeV
- **Low flux**
  : Do not need scattering
- More **simple** experiment



- But… it need **more time**

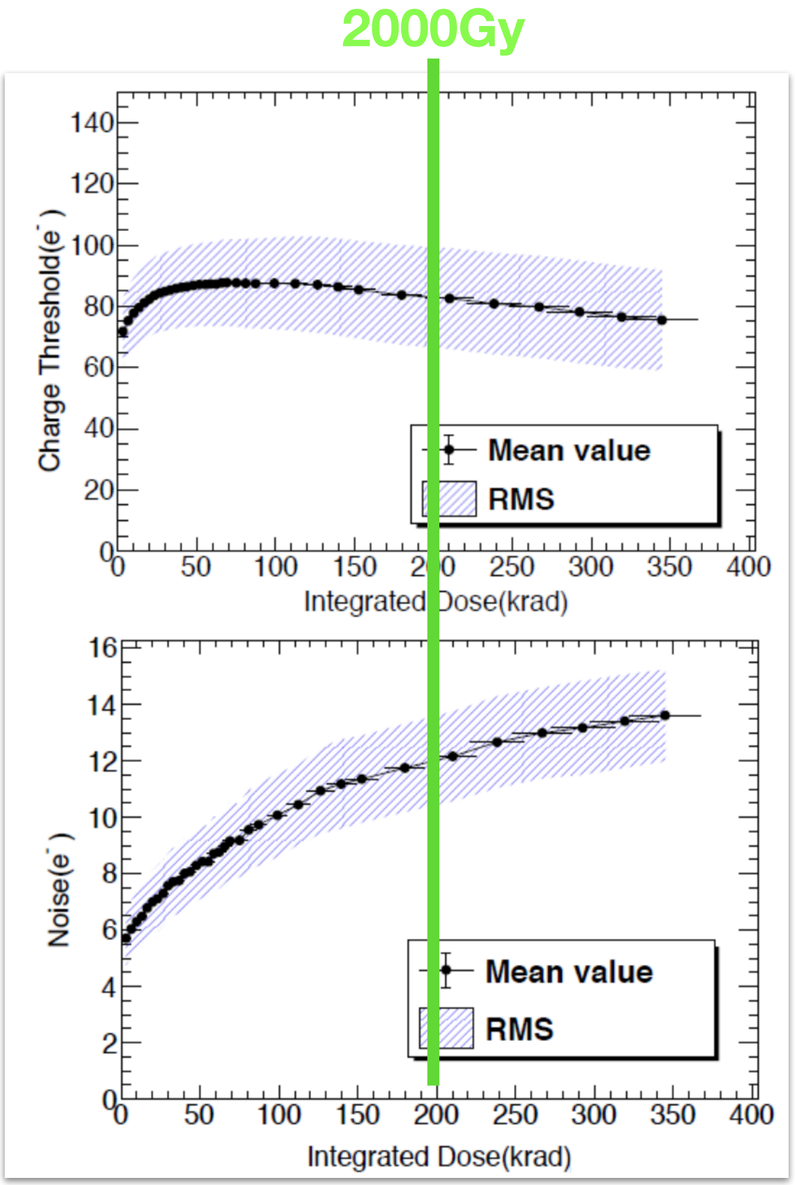
Experiment plan

- Beam specification : 10 pulse/sec = 0.1Gy/sec(0.01krad/sec)

- 2019 study : 0~3400Gy, 34 times
  - 34,000sec -> 9h 30m
    - Too long
  - Threshold measurement need data until **200krad(2000Gy)** to see tail
  - Noise measurement also need data until 200krad to see non-linearity
  - 2000Gy**(5h 30m)** would be fine

- **Not equal time resolution**
  - Measurement interval before/after 1000Gy : ~50Gy / ~250Gy

- Plan
  - 0~1000Gy : 50Gy X 20 times
  - 1000 ~ 2000Gy : 250Gy X 4 times



Conclusion

- KOMAC
  - 2019 : 20MeV high flux beam, scattered beam
  - 2022 : 100MeV low flux beam, direct beam

- Outlook
  - Decide target at CERN in Jan
  - Experiments are planned at Apr, Jun.

Thank you

새해 복 많이 받으세요

Target

ALPIDE(or MLR1?)

Parameter	Inner Barrel	Outer Barrel
Chip size (mm x mm)	15 x 30	
Chip thickness (μm)	50	100
Spatial resolution (μm)	5	10 (5)
Detection efficiency	> 99%	
Fake hit rate	$< 10^{-5}$ evt^{-1} pixel^{-1} (ALPIDE $<< 10^{-5}$)	
Integration time (μs)	< 30 (< 10)	
Power density (mW/cm^2)	< 300 (~35)	< 100 (~20)
TID radiation hardness (krad) (**)	2700	100
NIEL radiation hardness (1 MeV n_{eq}/cm^2) (**)	1.7×10^{13}	1.7×10^{12}
Readout rate, Pb-Pb interactions (kHz)	100	
Hit Density, Pb-Pb interactions (cm^{-2})	18.6	2.8

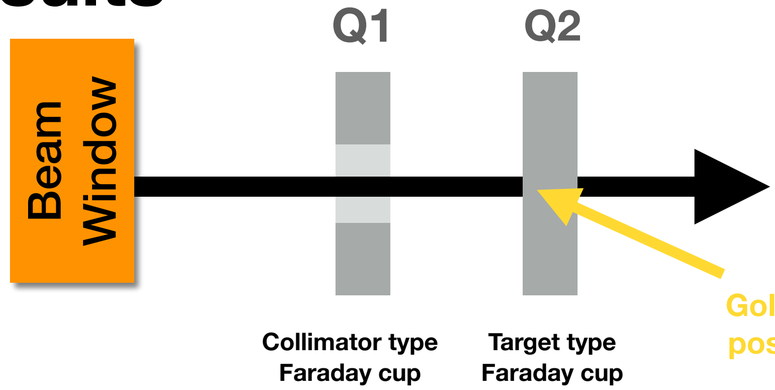
(*) In color: ALPIDE performance figure where above requirements

(**) 10x radiation load integrated over approved program (~ 6 years of operation)

ALPIDE specification

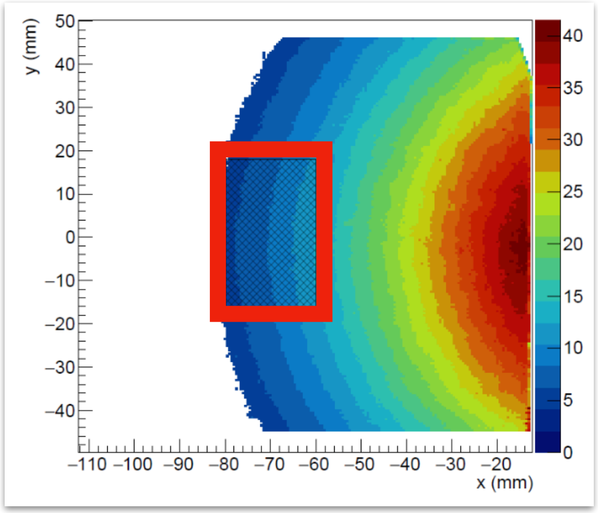
Study in 2019

Results



Q2/Q1 = 0.35 ± 0.03

Measure Q2/Q1 ①

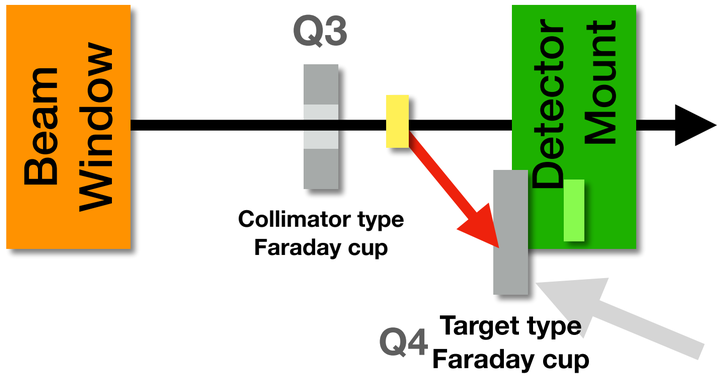


③ Measure area ration of Mount window

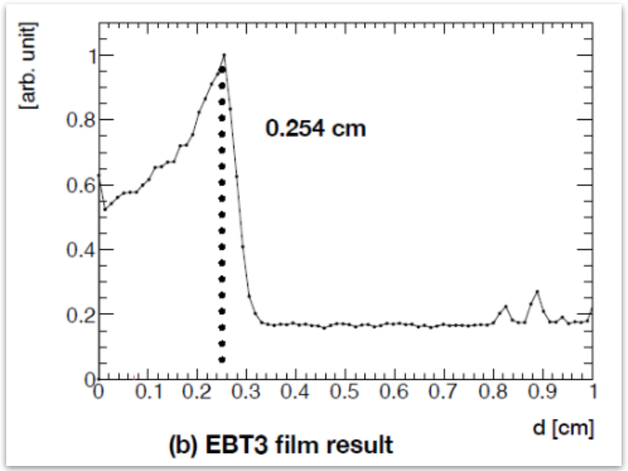
Area ration 0.05820

Measure Q4/Q3 ②

④ Measure proton kinetic energy



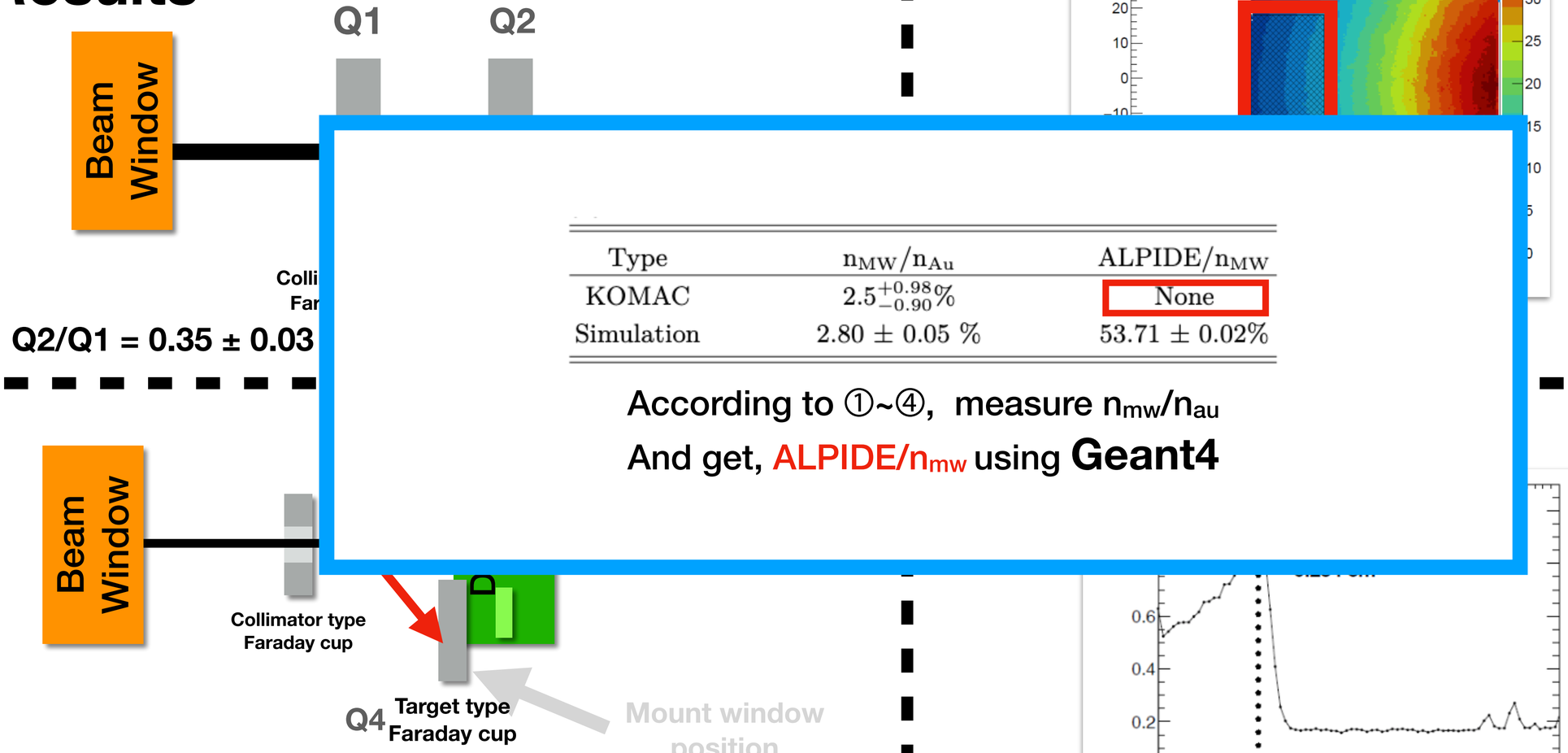
Q4/Q3 = 0.15 ± 0.04



Proton energy : 8 MeV

Study in 2019

Results



Type	n_{MW}/n_{Au}	ALPIDE/n_{MW}
KOMAC	$2.5^{+0.98}_{-0.90}\%$	None
Simulation	2.80 ± 0.05 %	$53.71 \pm 0.02\%$

According to ①~④, measure n_{mw}/n_{au}

And get, ALPIDE/n_{mw} using **Geant4**

Area ration
0.05820

Proton energy
: 8 MeV

Backup

ALPIDE Circuit