MRPC-TOF DEVELOPMENT

TCHoU workshop 2018

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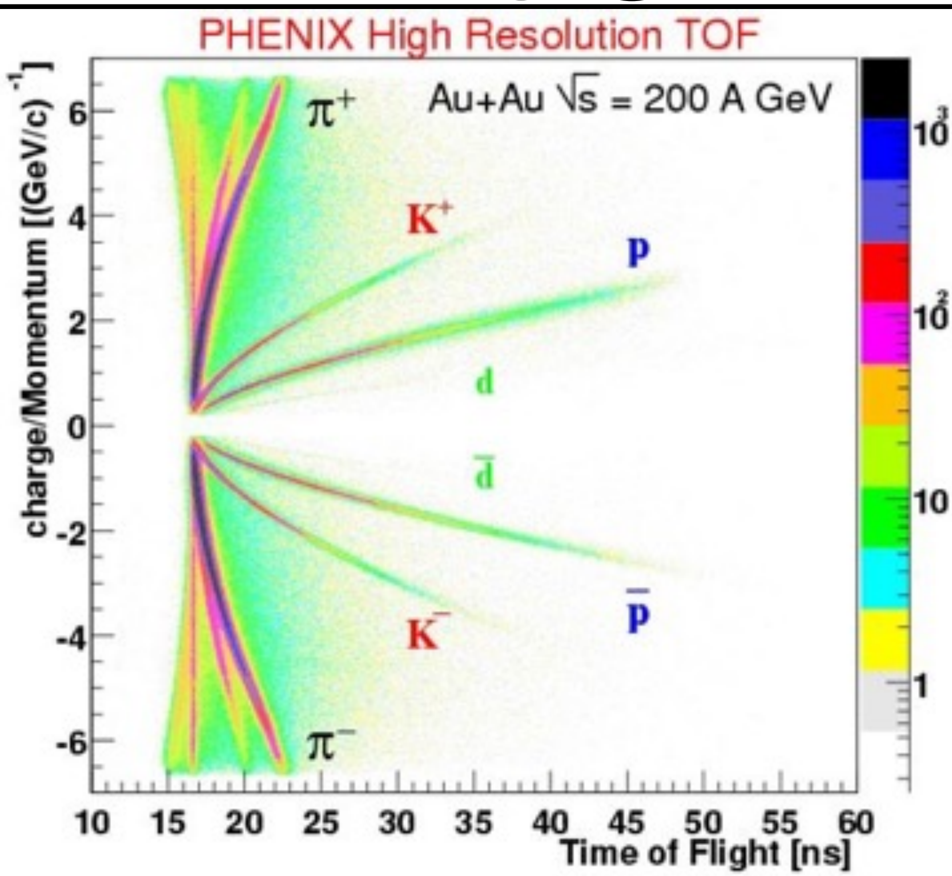
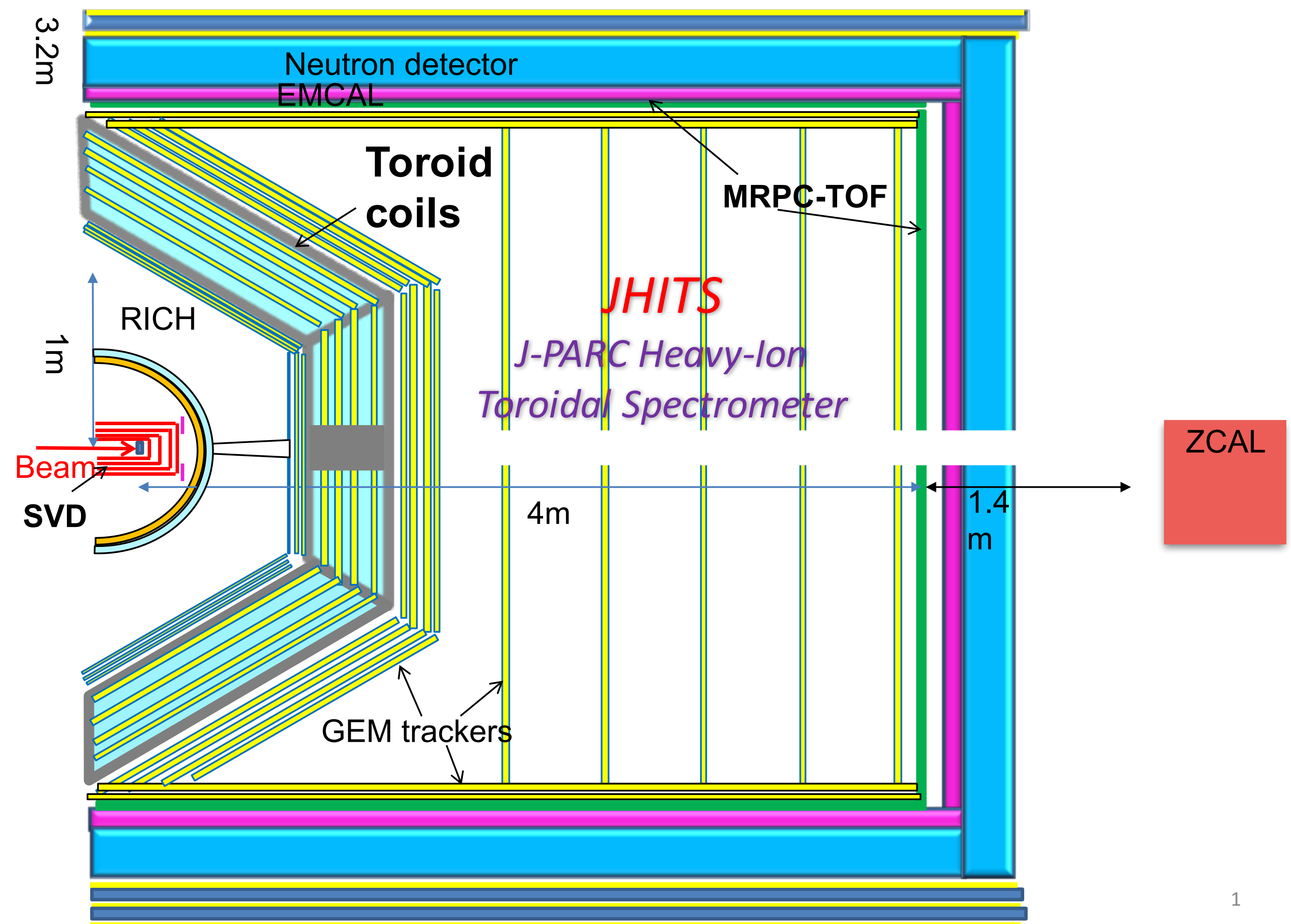
J-PARC HEAVY ION PROGRAM

Search low energy and high chemical potential area in QCD diagram by collisions with fixed target.

Multi-gap Resistive Plate Chamber × J-PARC

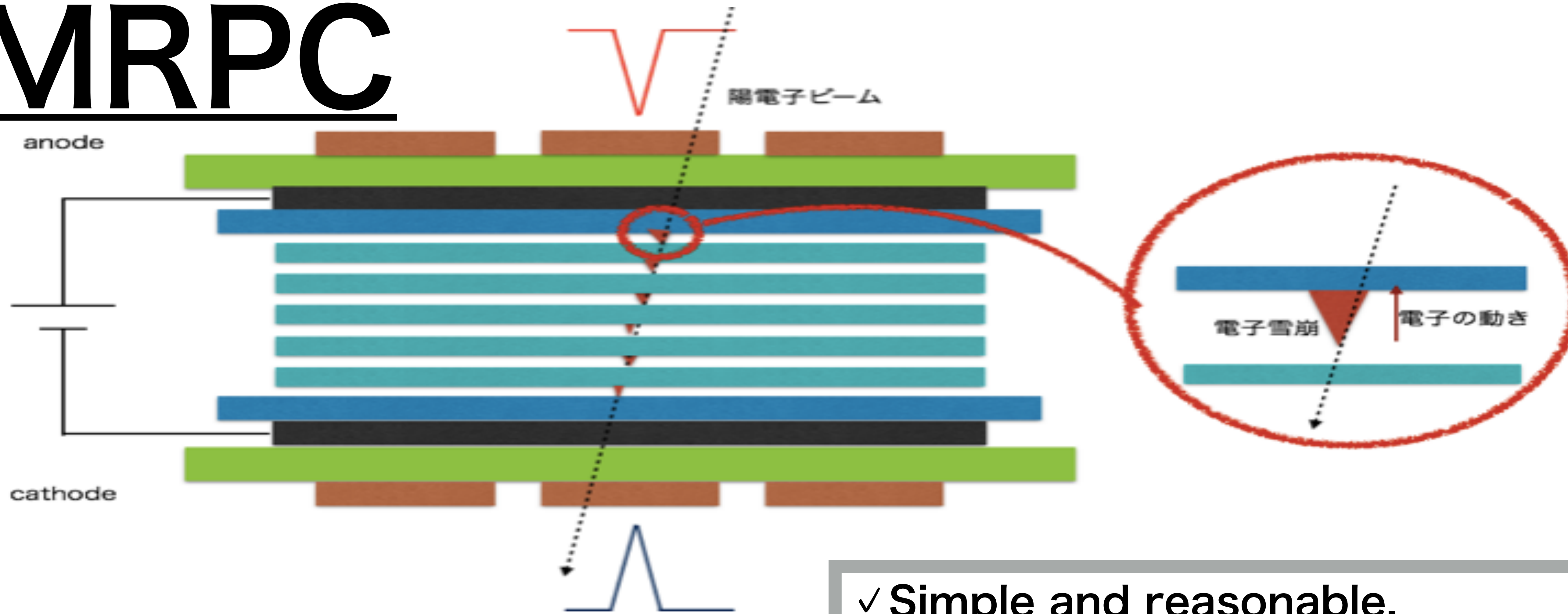


$$m^2 = p^2\left(\frac{t^2}{L^2} - 1\right)$$



✓ **70×70cm large** and **30ps** timing resolution is required at 4m far from collision point.

MRPC



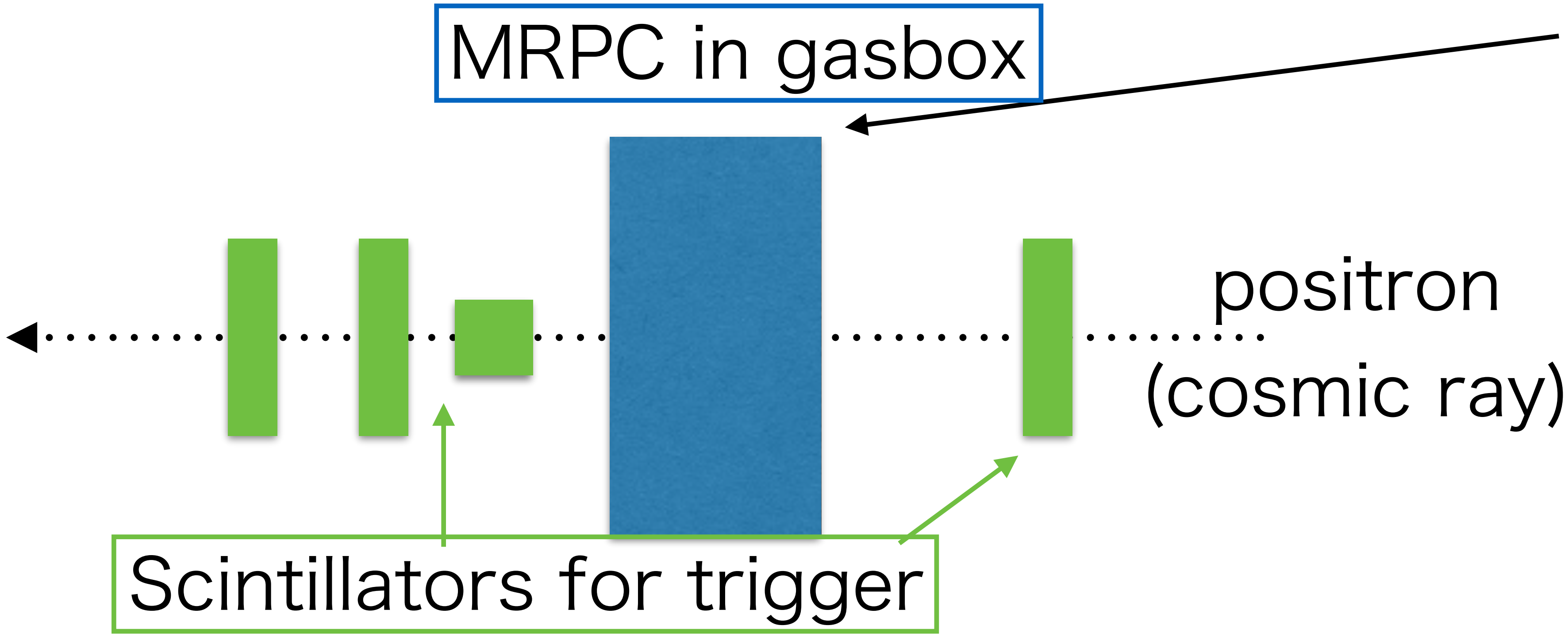
- ✓Simple and reasonable.
- ✓Easy to make larger one.
- ✓Timing resolution can be improved by stacking more gaps.

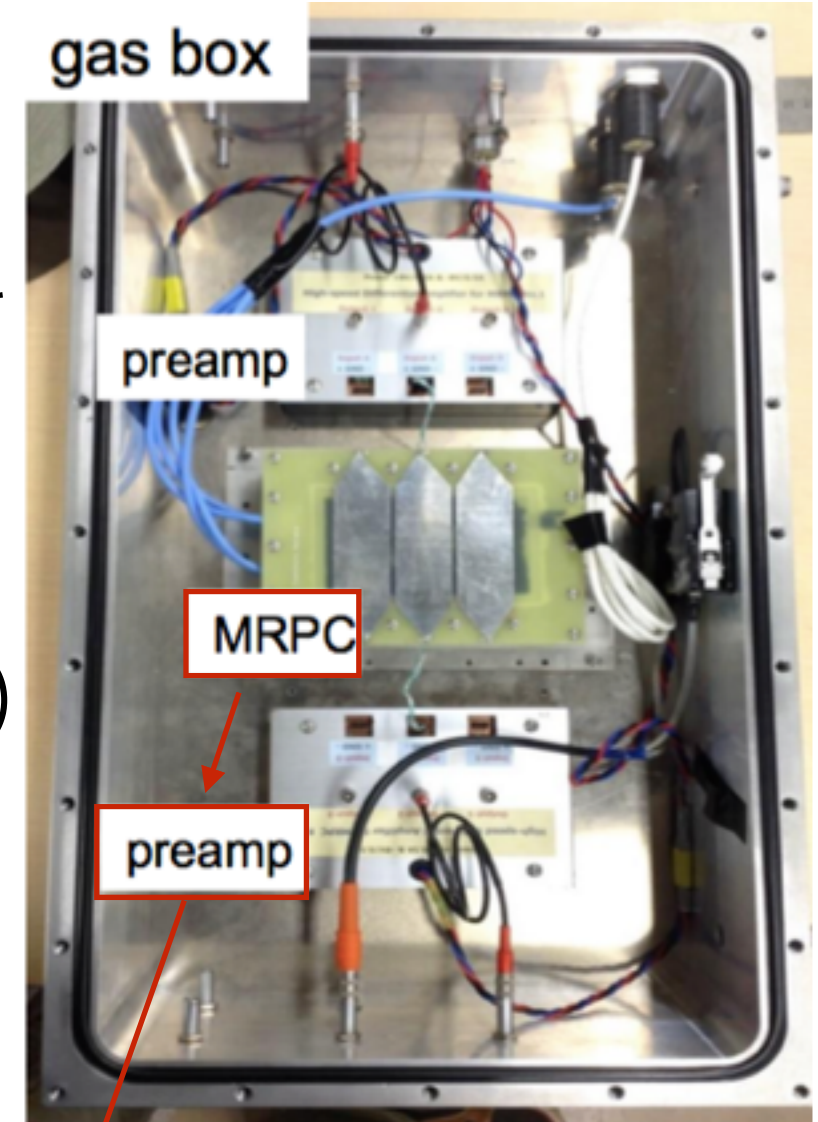
1.Charged particle injection.

2.Avalanche by strong electric field.

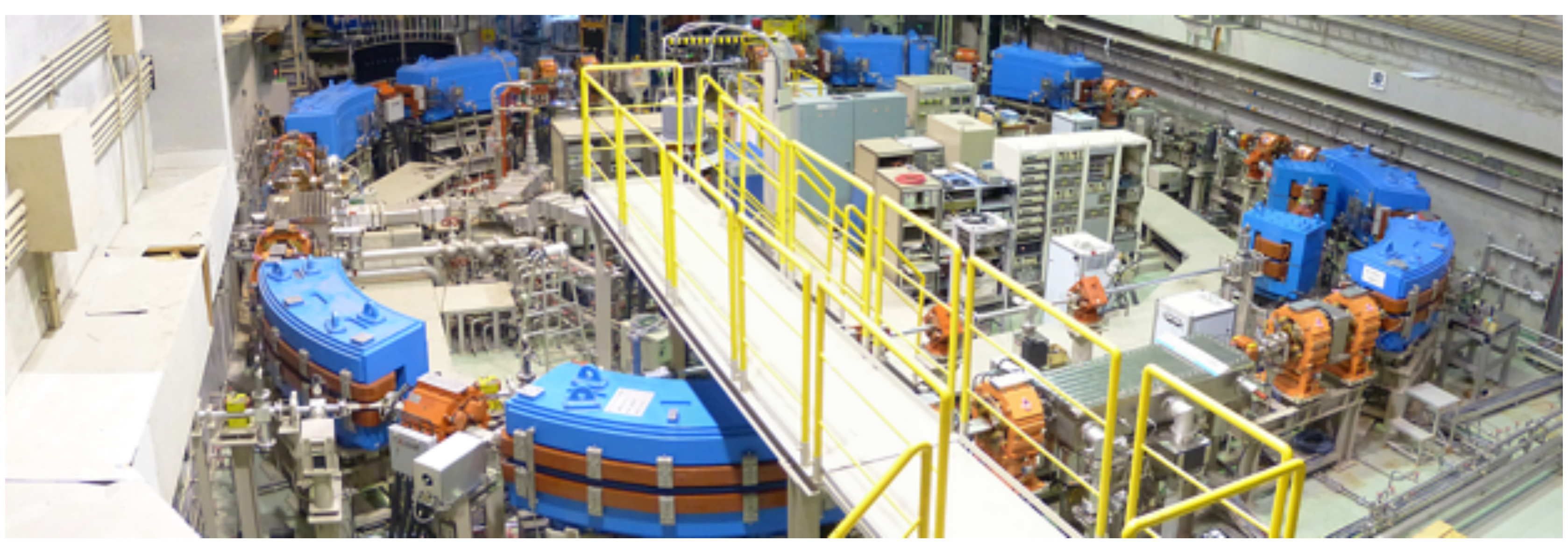
3.Read induced signal from read-out pads.

SET UP



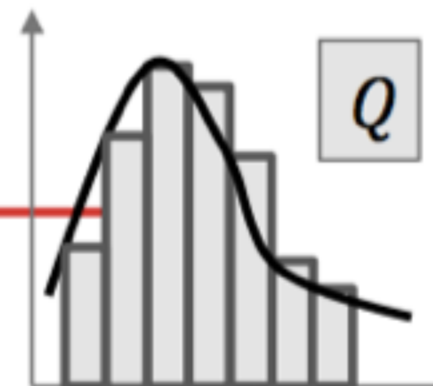


5GHz Flash ADC
DRS4 evaluation board



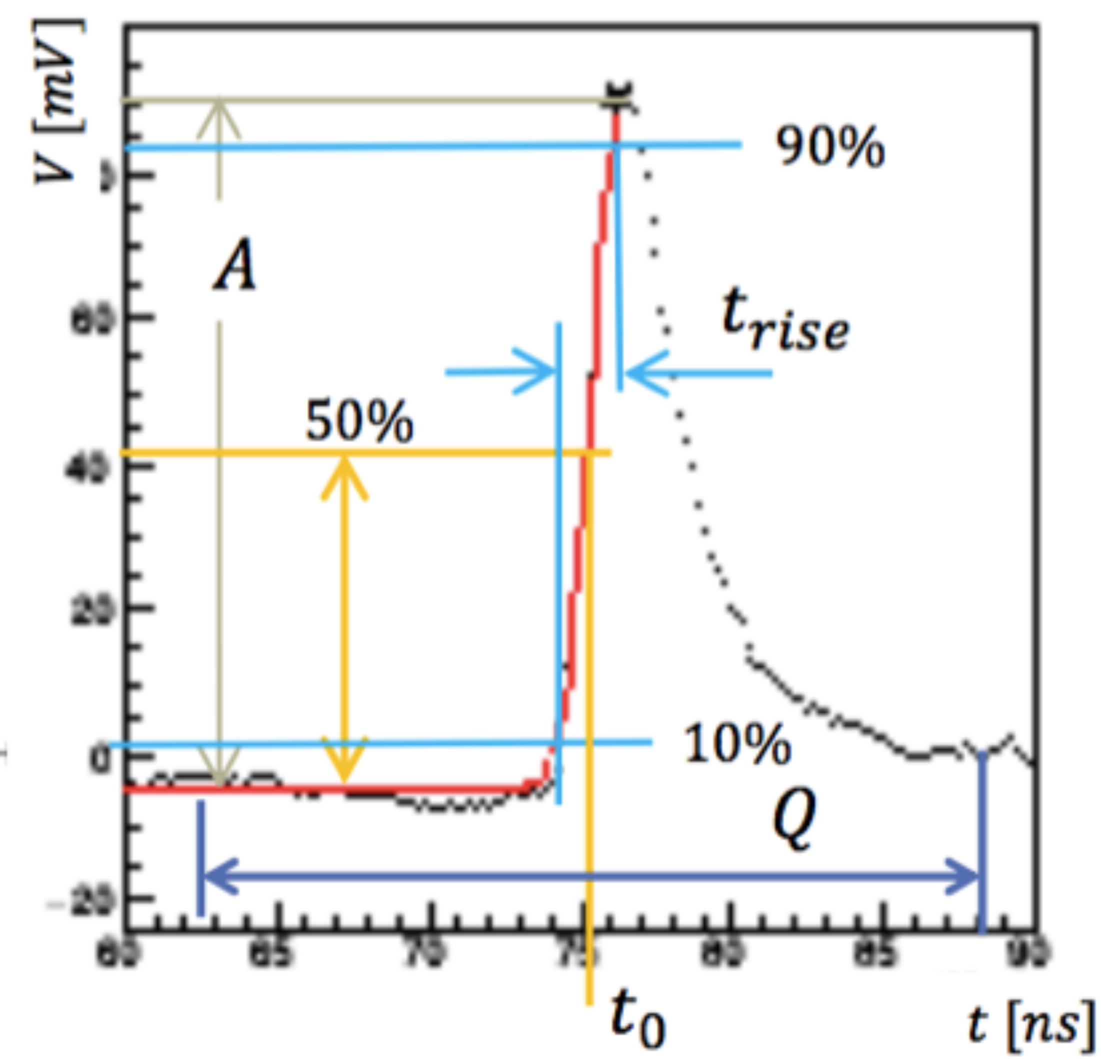
Data extraction

Fit function: $f(x) = C_1 + \dfrac{C_2}{1 + \exp\left(\dfrac{x - C_3}{C_4}\right)}$

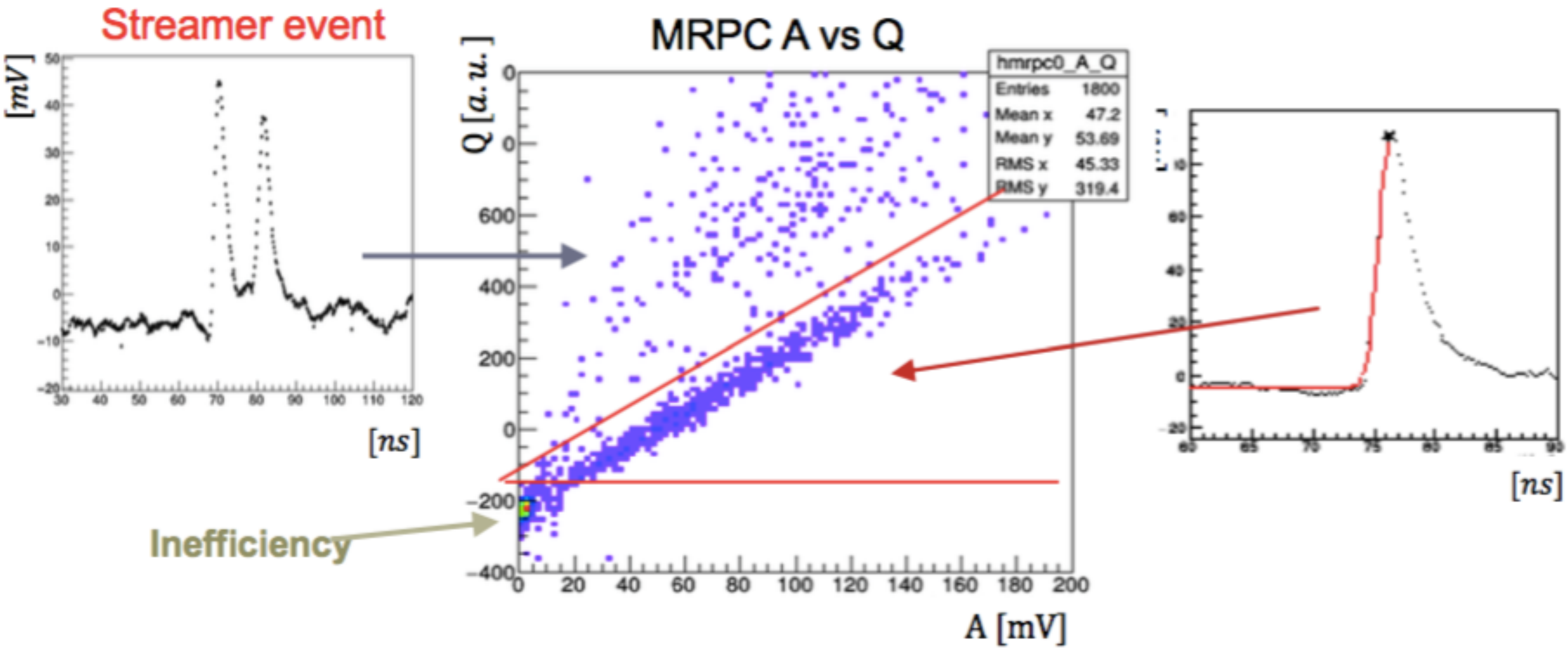


- A : Amplitude
- Q : Integrate around peak
- t_0 : Time that signal reached $A/2$
- t_{rise} : Time to rise up (10% to 90%)

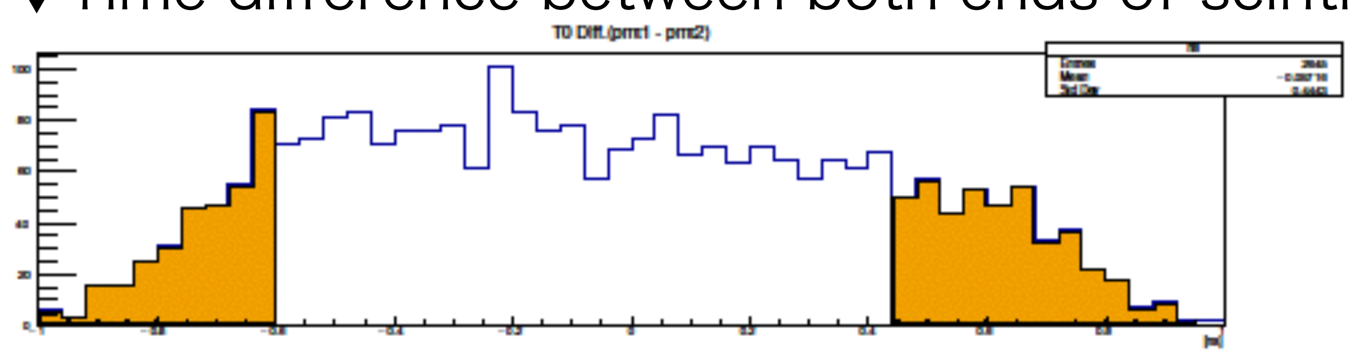
Signal taken by DRS4 evaluation



Quality of signal



▼Time difference between both ends of scinti

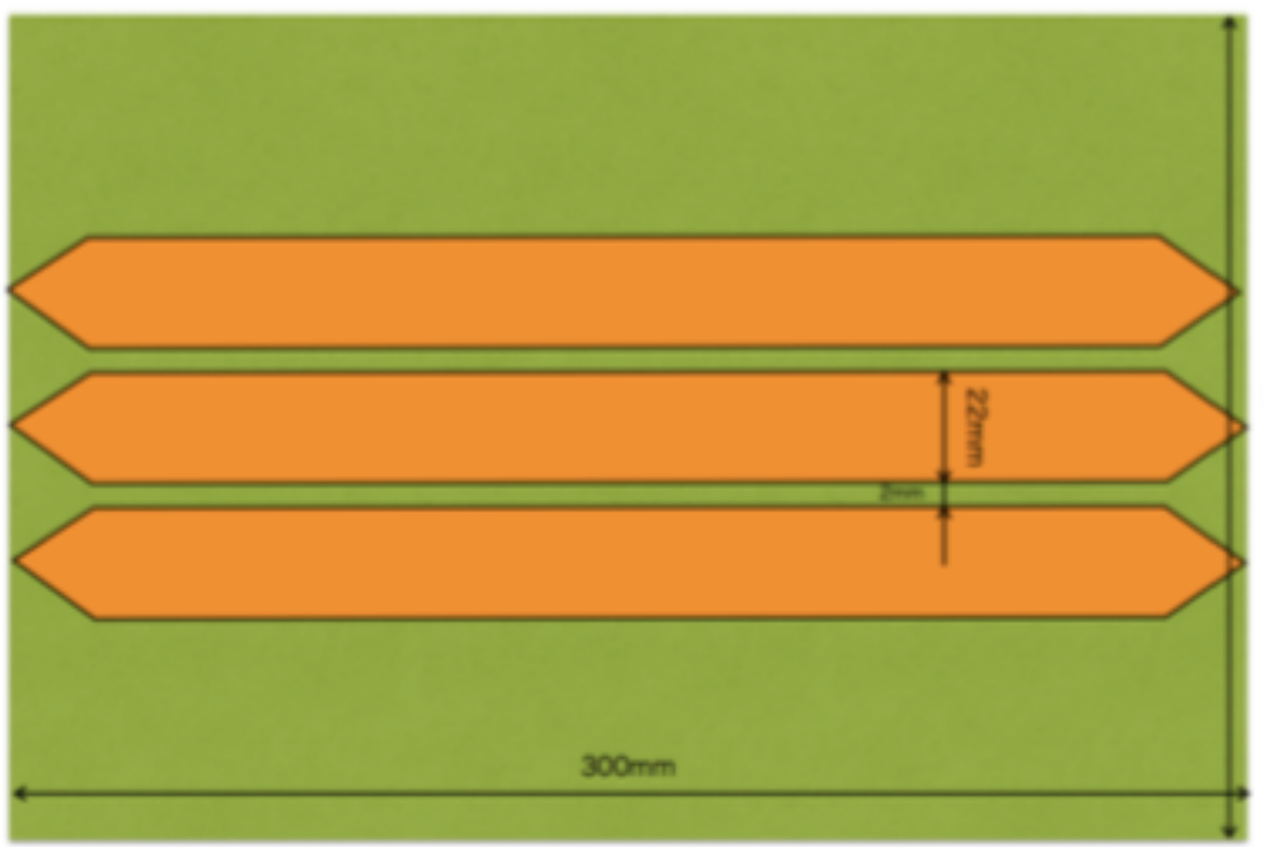


RECENT WORK

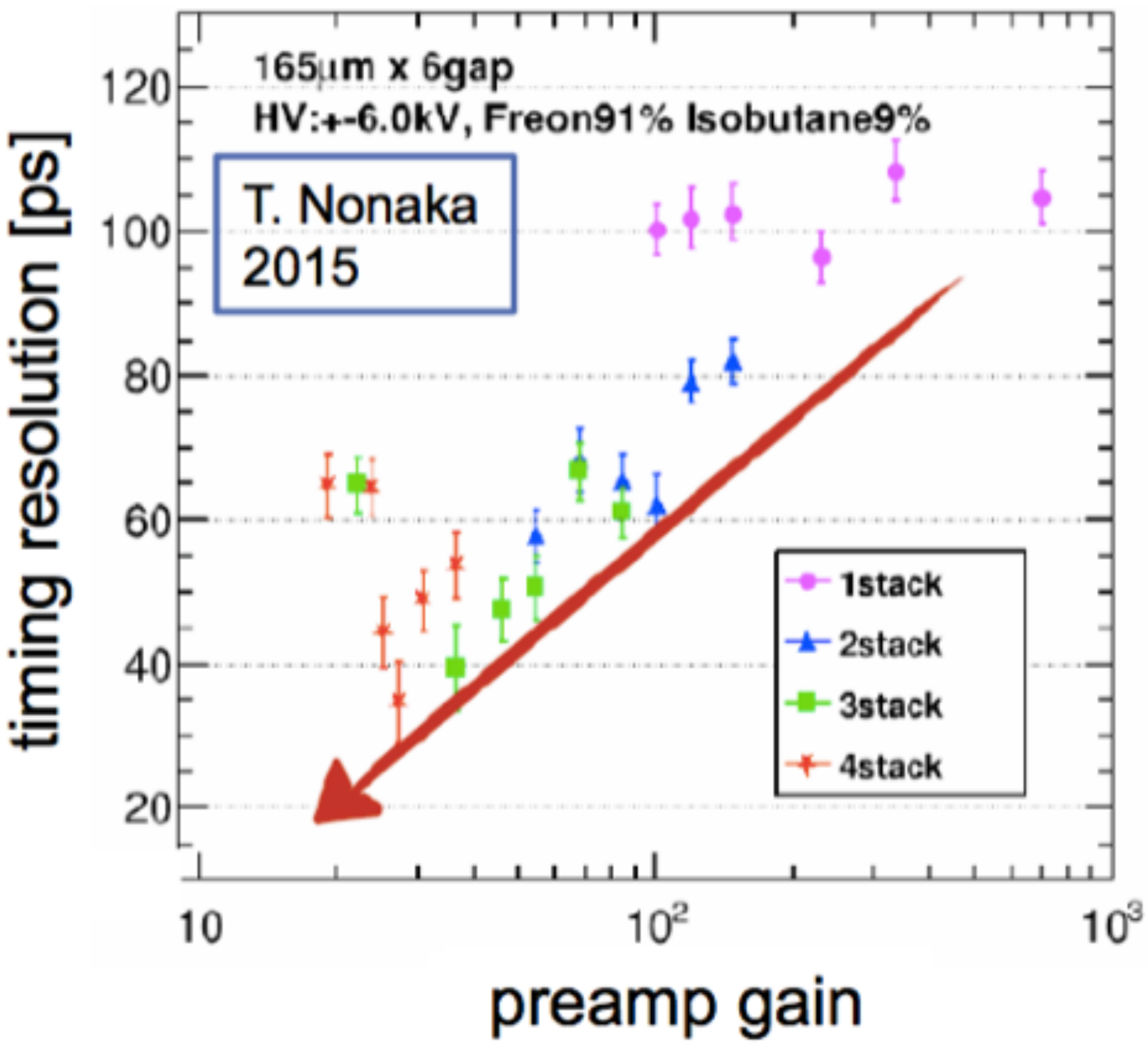
1.We created MRPC which became the first large scale in our laboratory.(gap width 165 μm,6gaps/stack,**4stacks**)

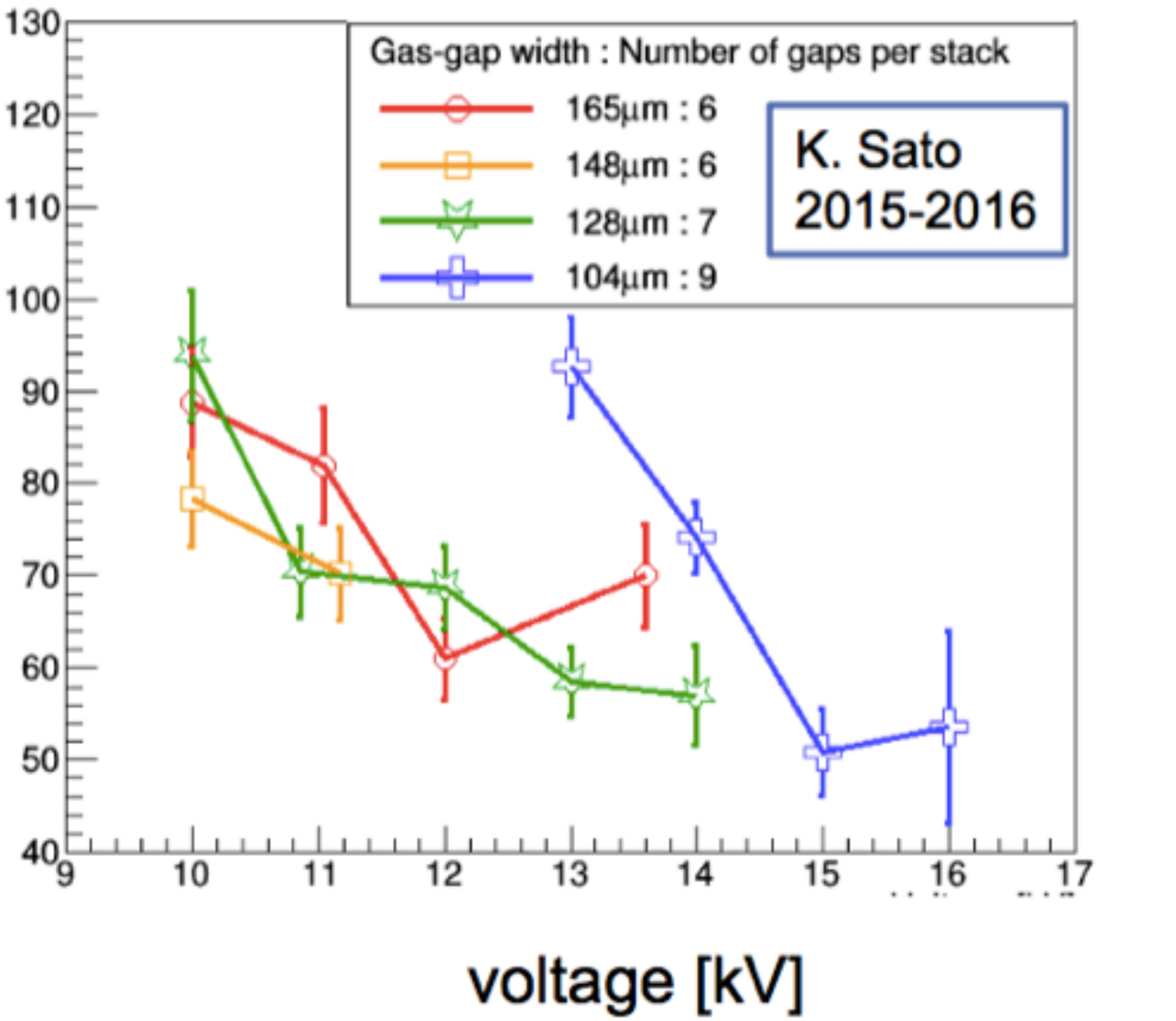
2.Tried impedance matching and introduction of devices for high frequency reading.(gap width 260 μm,5gaps/stack,**1stack**)

3.Tried first introduction of single-end preamplifier and real GND.(gap width 260 μm,6gaps/stack,**1stack**,split GND type)



timing resolution(cosmic ray)



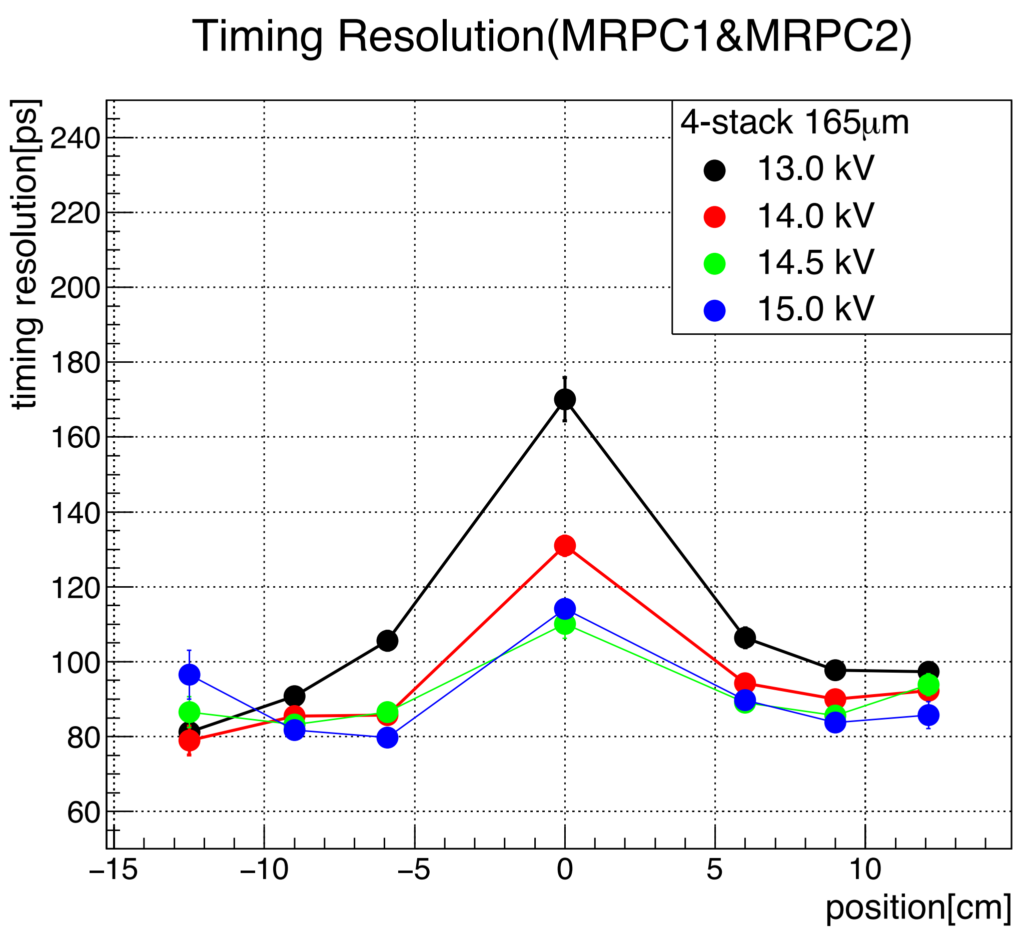


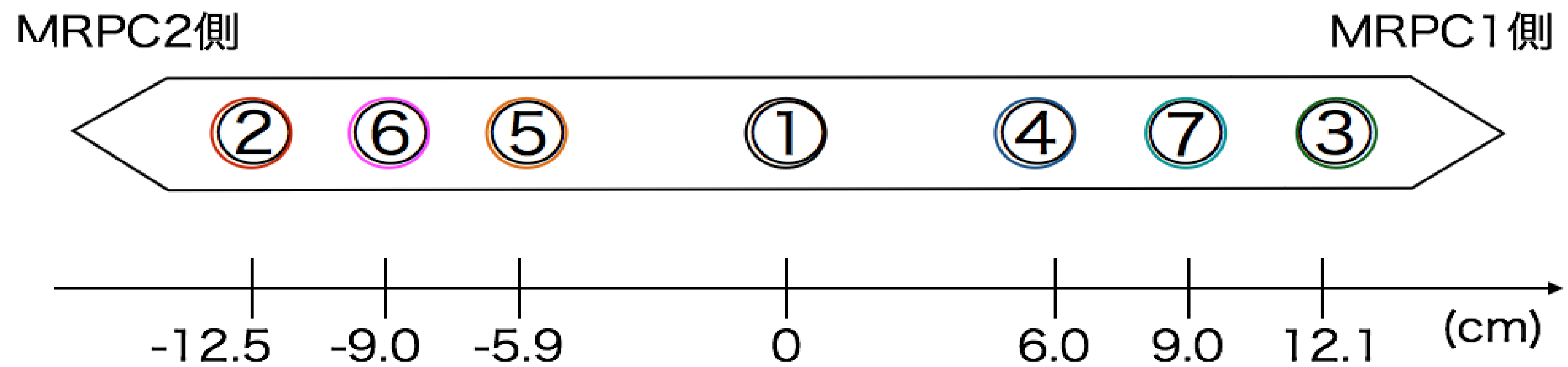
✓The best timing resolution ~50ps marked by 165μm.

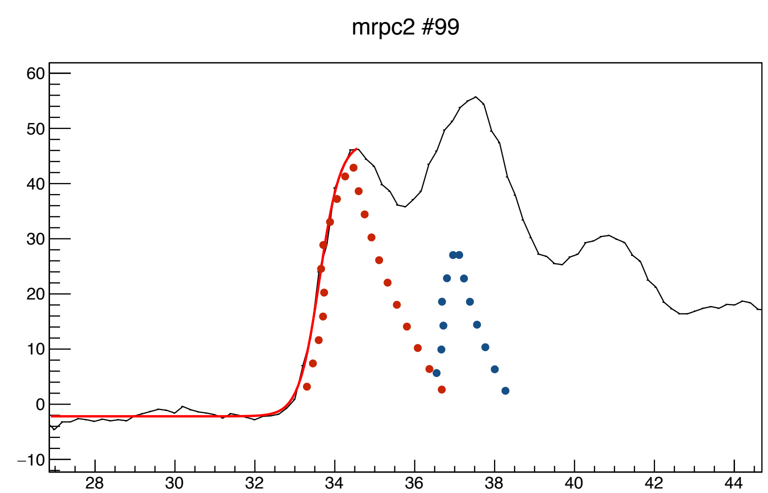
✓The timing resolution increases as the number of stacks(N) increases.(timing resolution × 1/√N)

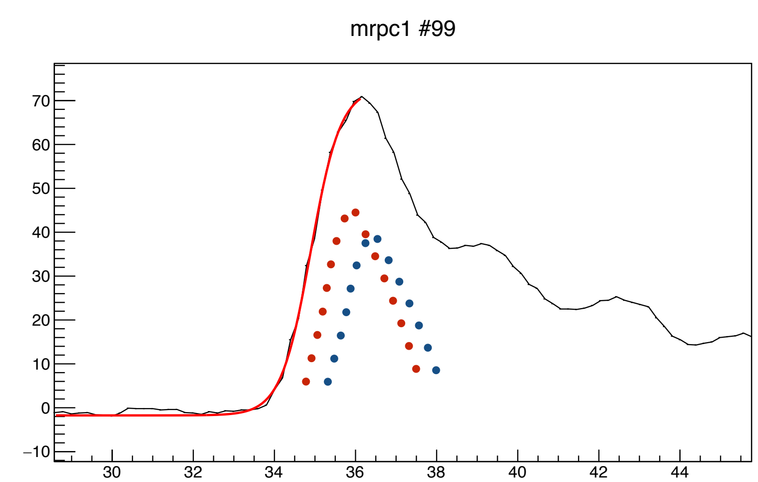
1.FIRST LARGE TYPE MRPC(positron beam)

▼Positron Beam Test@ELPH





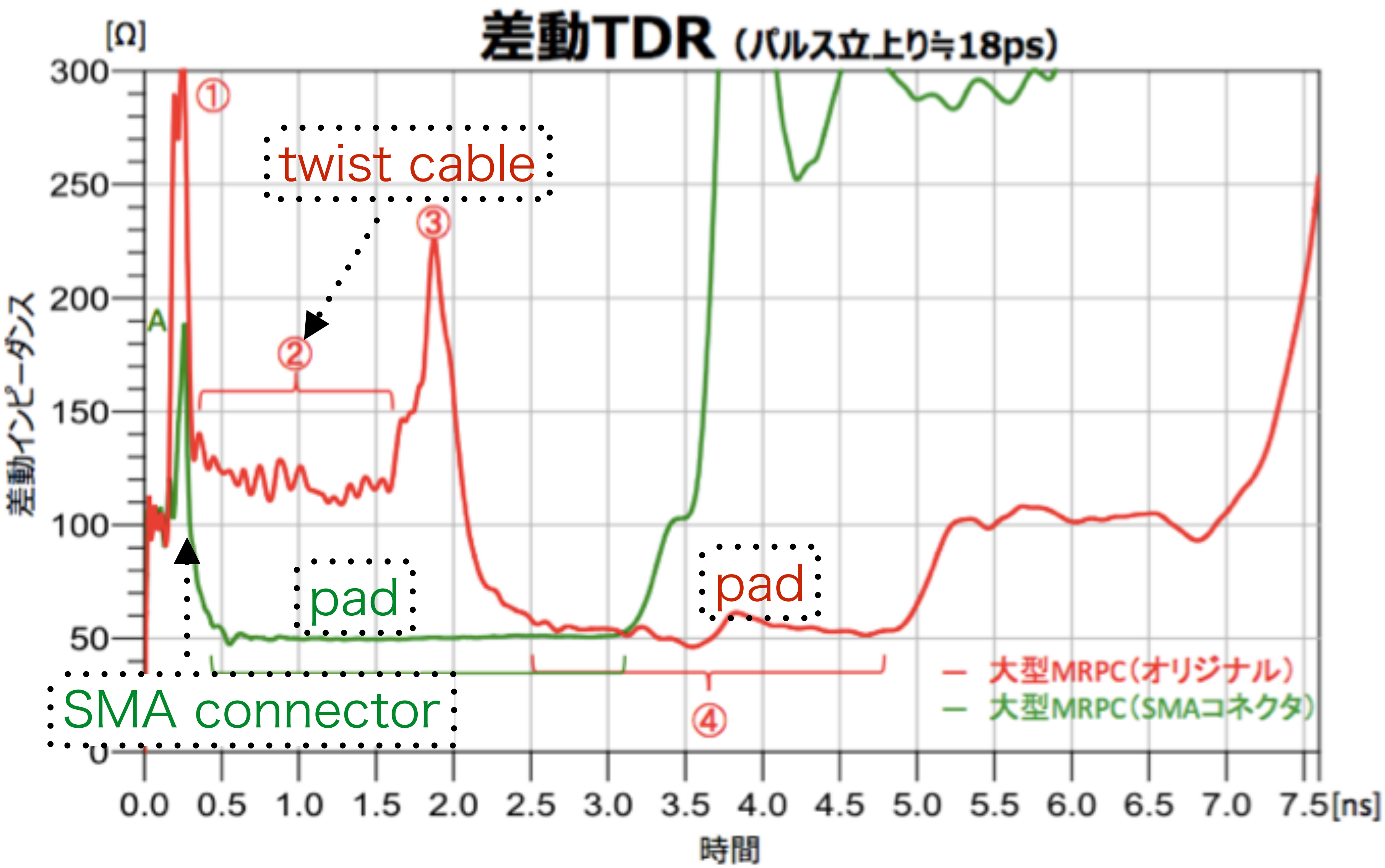




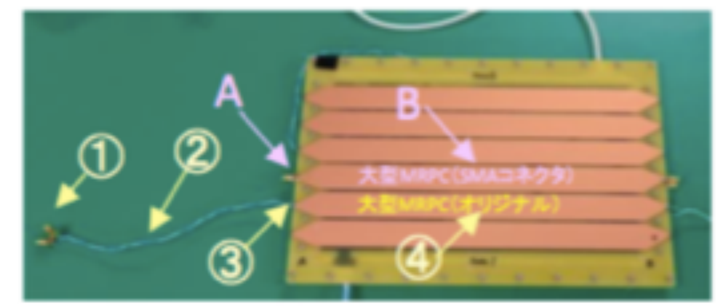
- ☑gap width165μm,6gap/stack,4stacks large MRPC
- ☑Position dependence on timing resolution
- ☑timing resolution79.8±1.8ps@position5,15.0kV

2.IMPEDANCE MATCH + SMA

▼Differential impedance measurement(by SONY GM&O)



差動TDR波形との対応



大型MRPC(オリジナル)
- ①：より線端部(ピンコネクタ部)
- ②：より線
- ③：より線-MRPC基板接続部
- ④：PAD部

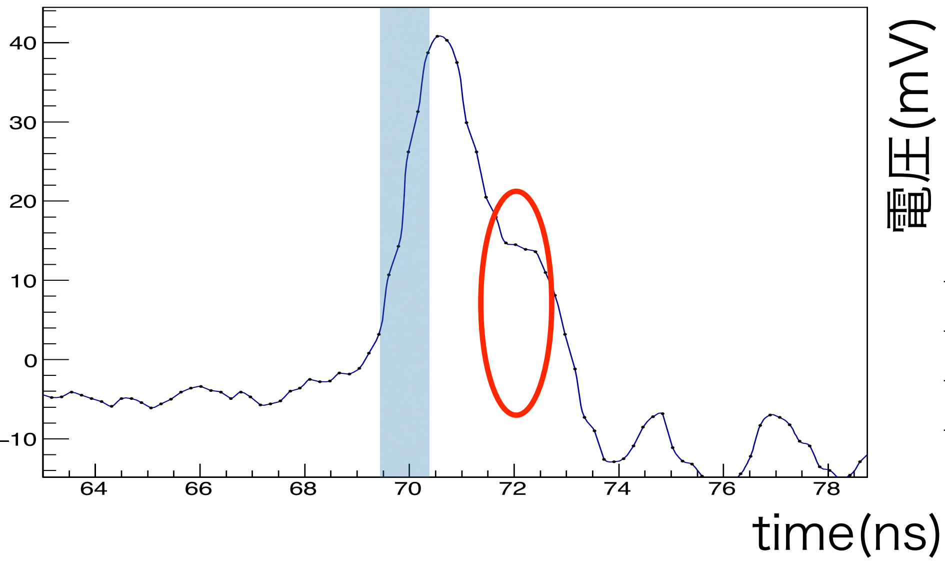
大型MRPC(SMAコネクタ)
- A：エッジマウントSMAコネクタ
- B：PAD部

☑Impedance of preamplifier →50Ω

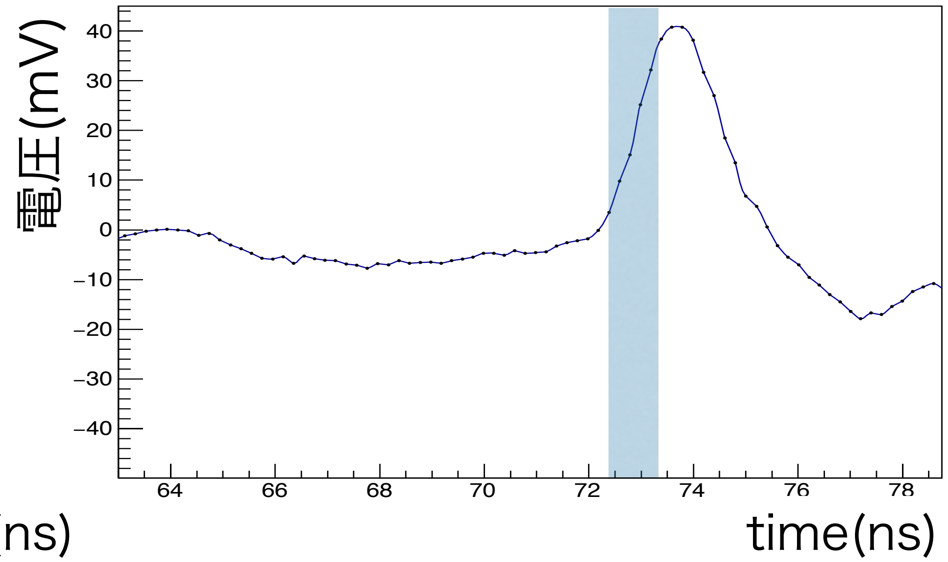
☑Twist cable→SMA cable (50Ω)

2.RESULT(cosmic ray)

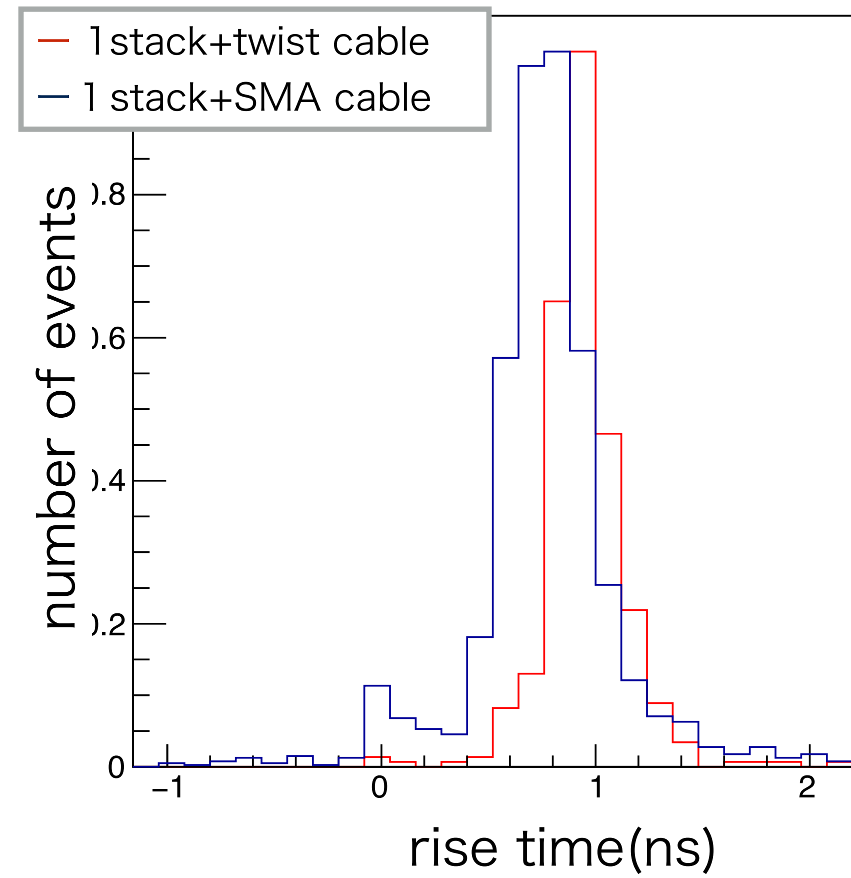
▼1stack+twist cable(original)



▼1stack+SMA cable



▼Rise time distribution

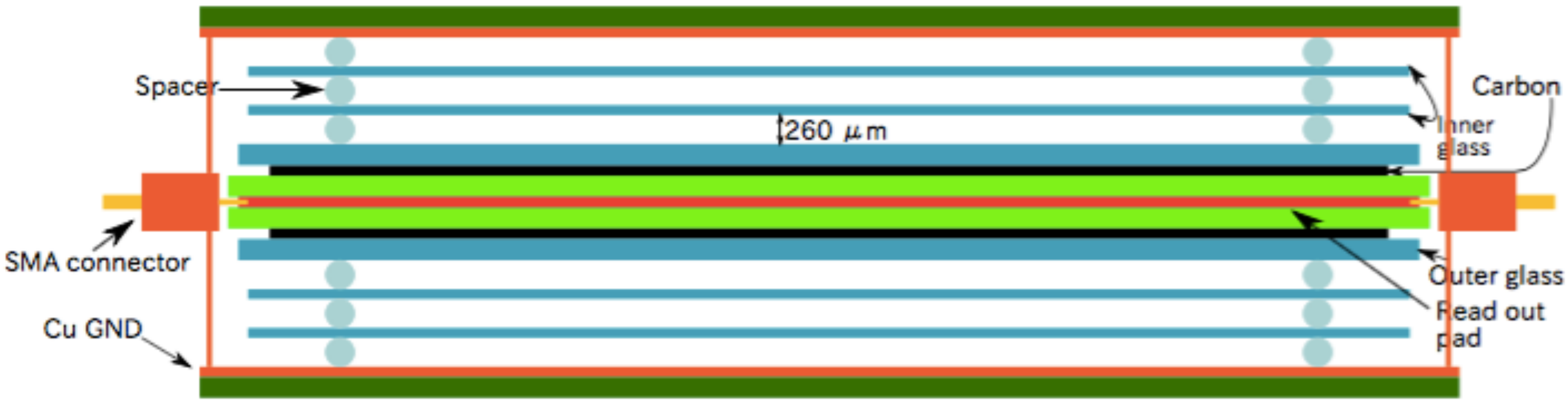


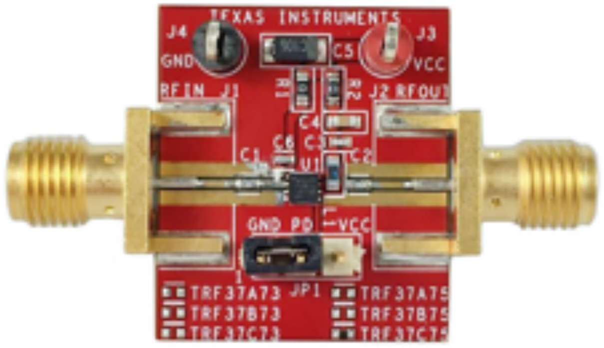
	rise time(ns)
1 stack+twist cable	0.94±0.14
1stack+SMA cable	0.77±0.18

- ☑gap width 260μm,5gap/stack,1stack large MRPC
- ☑timing resolution : 268.8±17.0 ps @ 7.0kV,center position
- ☑50Ω SMA → Reduce reflection

3.SINGLE-END PREAMPLIFIER + REAL GND

▼split GND type





✓Introduction of real GND.

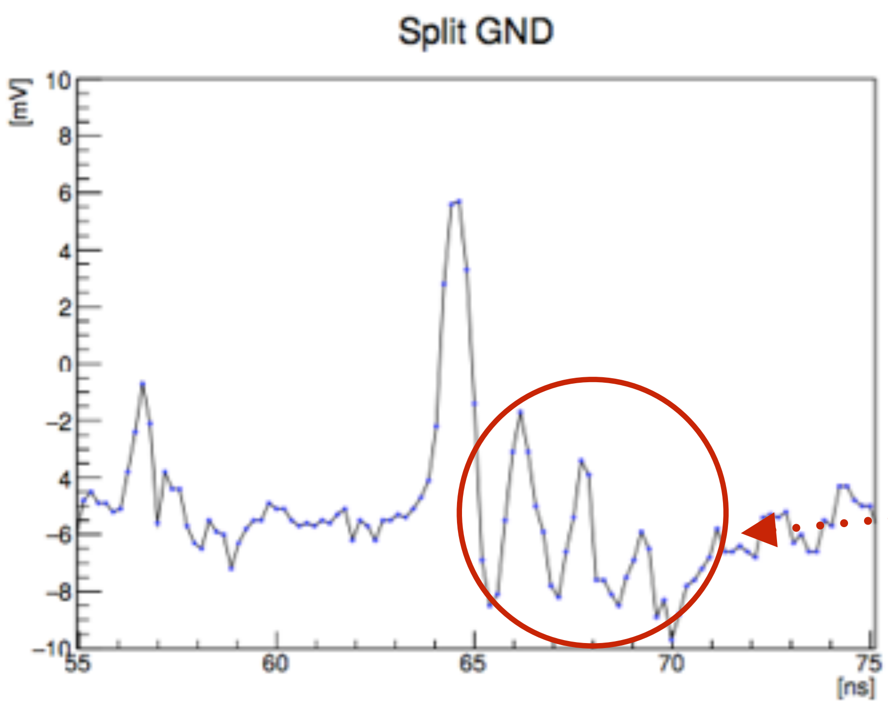
✓Structure for shielding external noise.

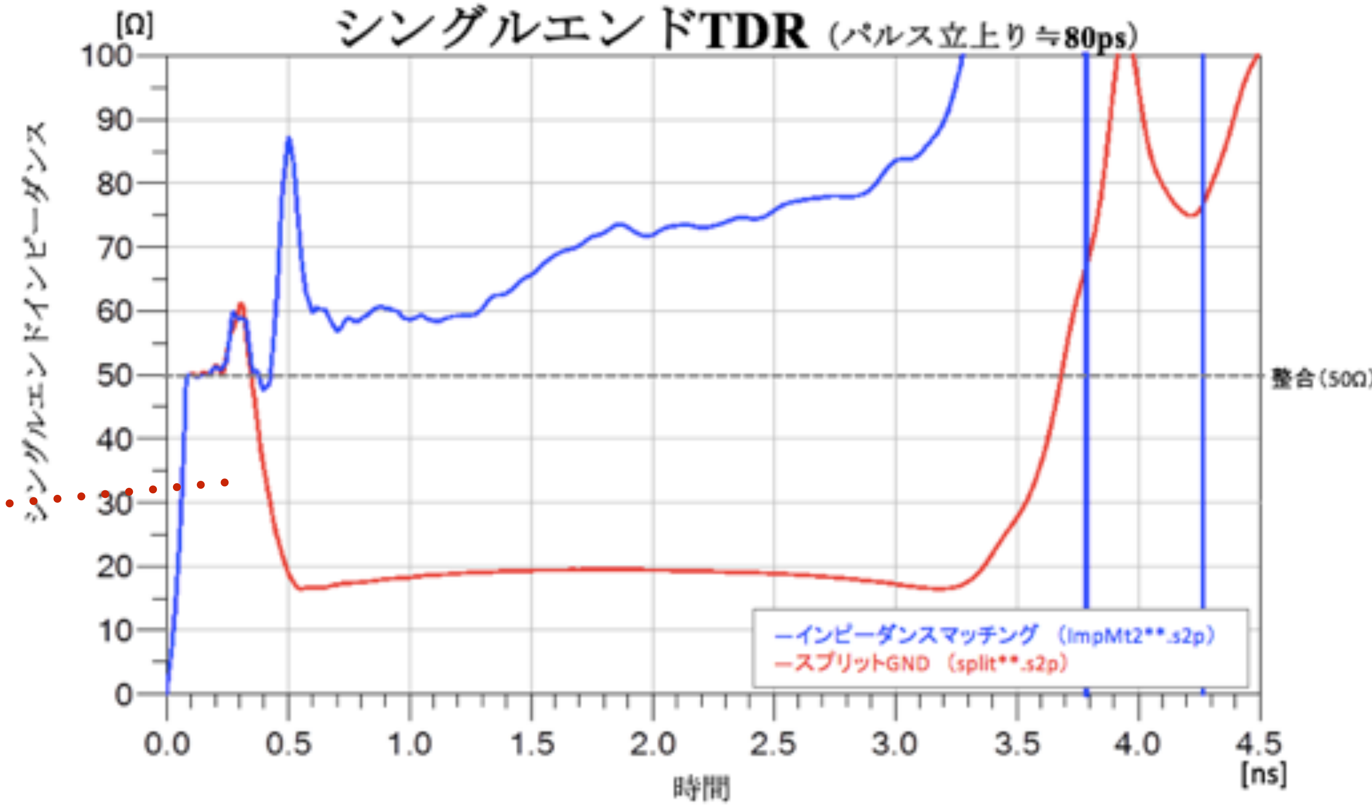
More noise resistance

✓Single-end preamplifier.

High frequency read-out

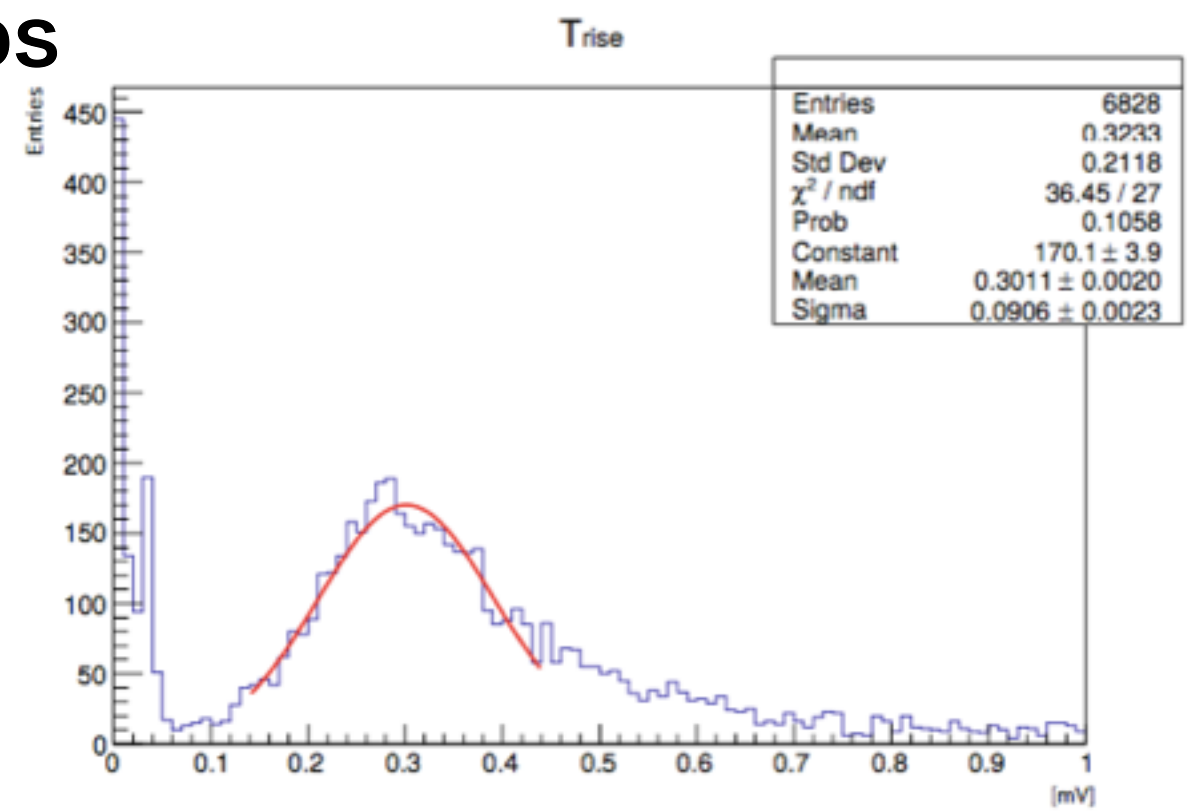
3.RESULT(cosmic ray)





✓timing resolution : 213.9±6.6 ps
@ 7.5kV,center position

✓Impedance mismatch due to structural change



SUMMARY

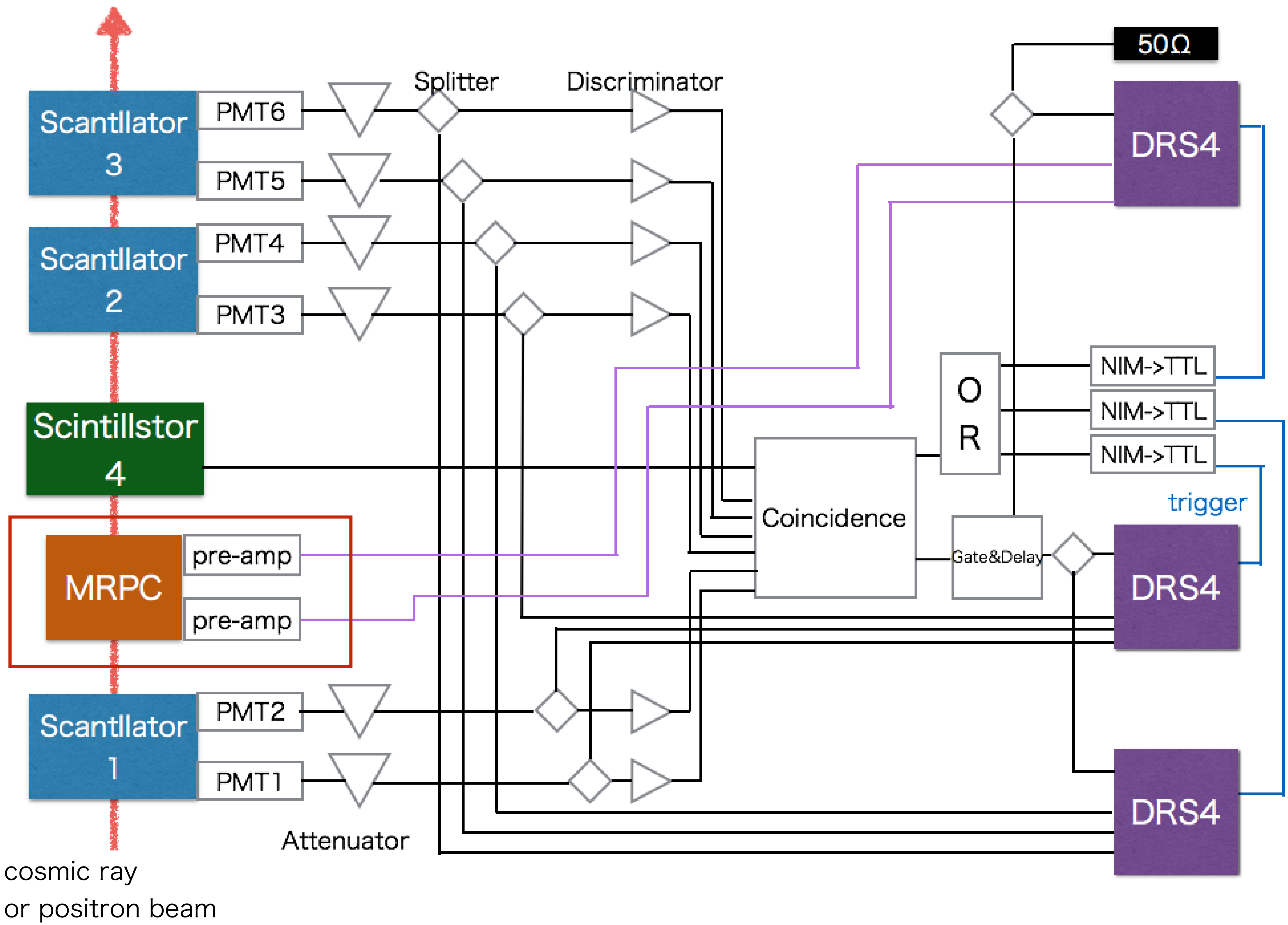
	timing resolution(ps) @center position	improved points	points to be improved
4 stack	114.1±1.9	upsizing	impedance match
1 stack	268.8±17.0	・impedance match ・SMA	・noise resistance ・high frequency preamp
split GND	213.9±6.6	・single-end preamp ・new structure	・increase pulse height ・impedance match

FUTURE WORK

- ☑Impedance match(split GND type)
- ☑To increase pulse height of the signal
  - preamp gain optimization
  - Increase the number of gaps
  - Increase the number of stacks
- ☑Structural optimization
  - pad size and shape

BACK UP

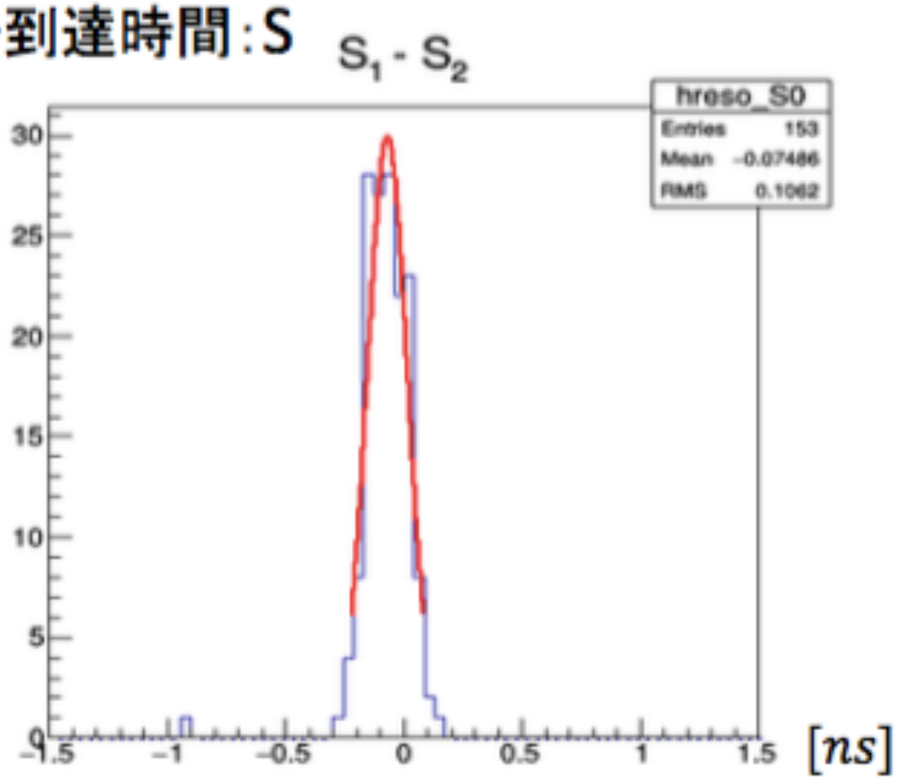
SET UP



50Ω
Splitter
Discriminator
Scantllator 3
PMT6
PMT5
Scantllator 2
PMT4
PMT3
DRS4
Scintillstor 4
O R
NIM->TTL
NIM->TTL
NIM->TTL
Coincidence
trigger
MRPC
pre-amp
pre-amp
Gate&Delay
DRS4
Scantllator 1
PMT2
PMT1
DRS4
Attenuator
cosmic ray
or positron beam

How to estimate timing resolution

信号到達時間:S



$$S_1 = \frac{t_{0,PMT1} + t_{0,PMT2}}{2}$$

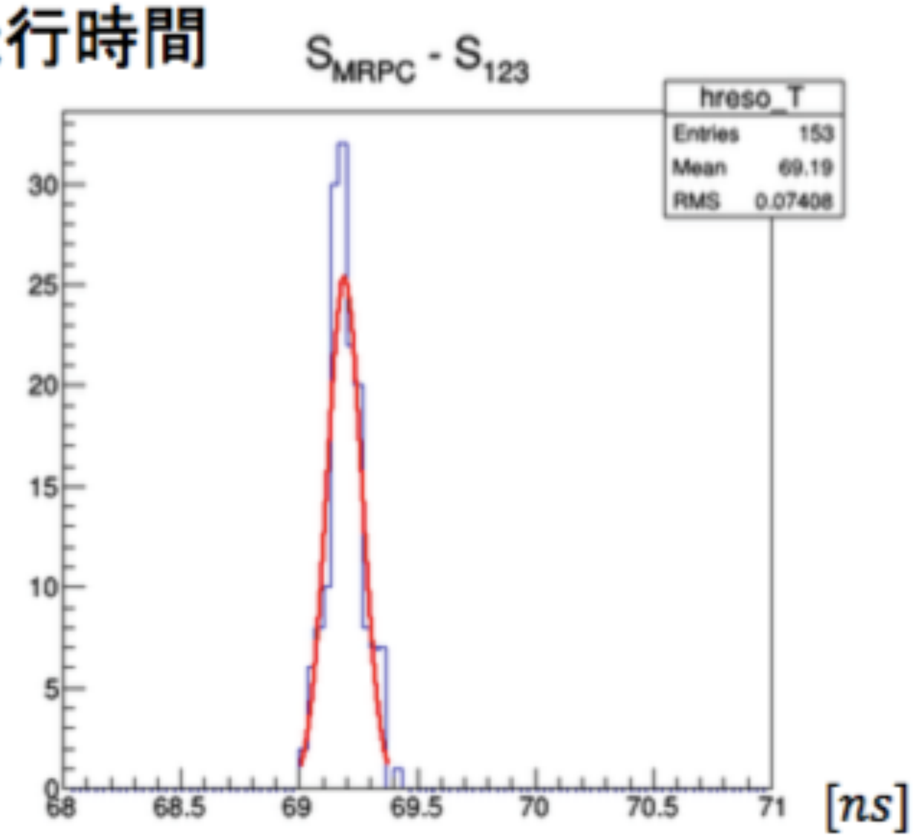
$$\sigma^2_{Si-Sj} = \sigma^2_{Si} - \sigma^2_{Sj}$$

$$\frac{1}{\sigma^2_{START}} = \frac{1}{\sigma^2_{S1}} + \frac{1}{\sigma^2_{S2}} + \frac{1}{\sigma^2_{S3}}$$

$\sigma_{Si} \sim 70ps$

$\sigma_{START} \sim 55ps$

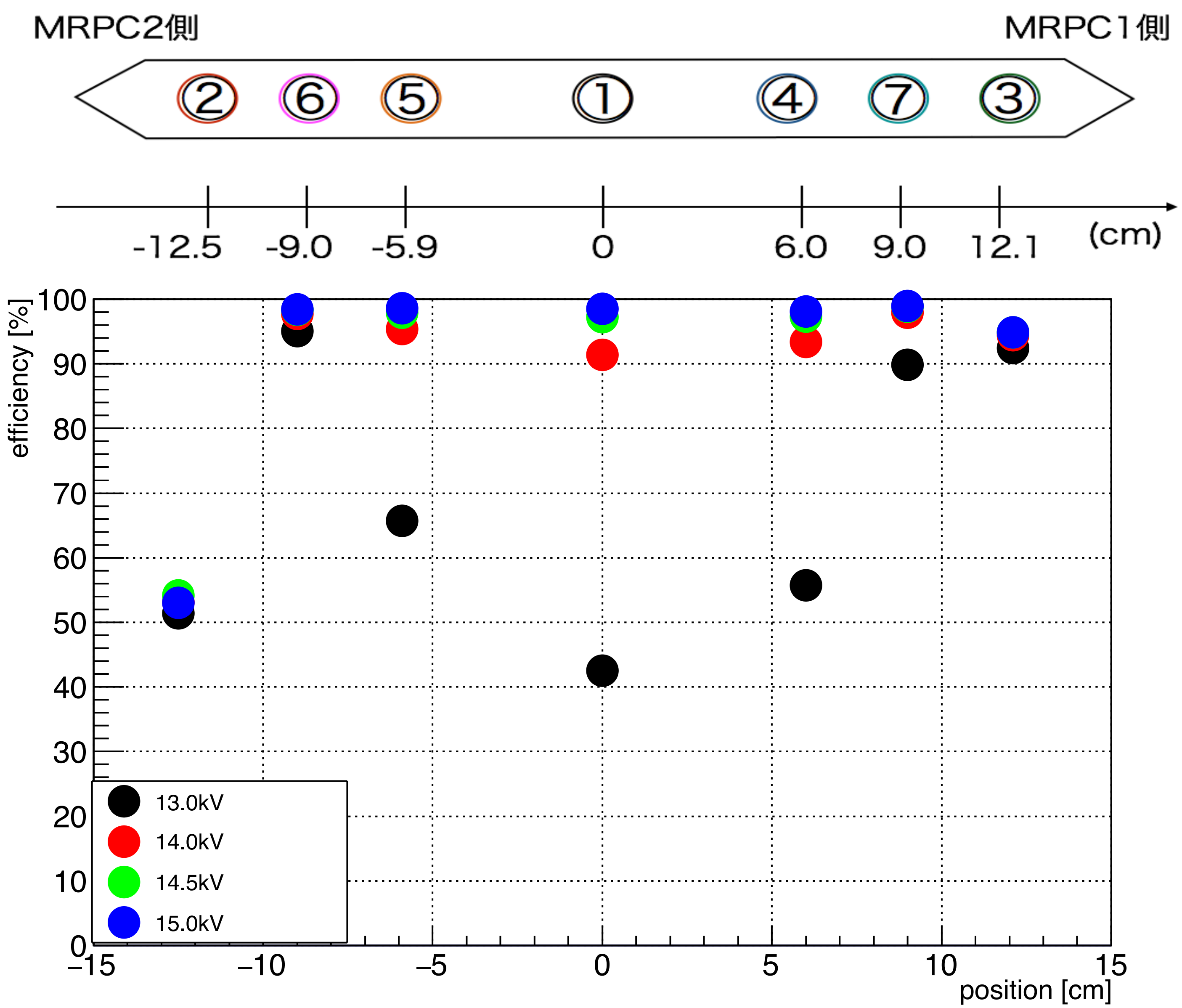
飛行時間



$$\sigma^2_{MRPC-S123} = \sigma^2_{S123} + \sigma^2_{MRPC}$$

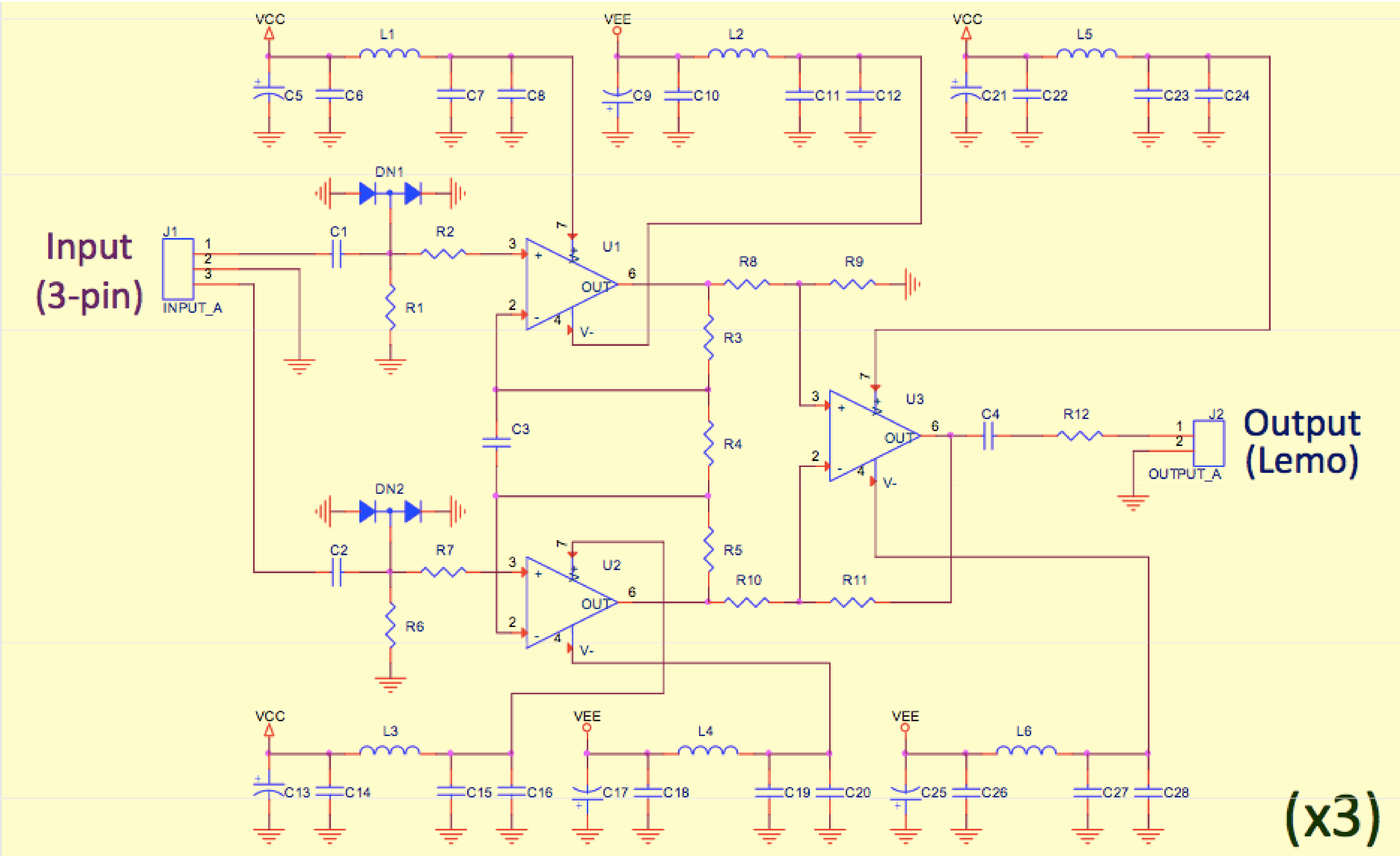
MRPCの時間分解能 σ_{MRPC}

Efficiency(4stack type)



$$\text{Efficiency} = \frac{\text{number of events(pulse height>10mV)}}{\text{number of all events}}$$

differential preamp



Single-end preamp

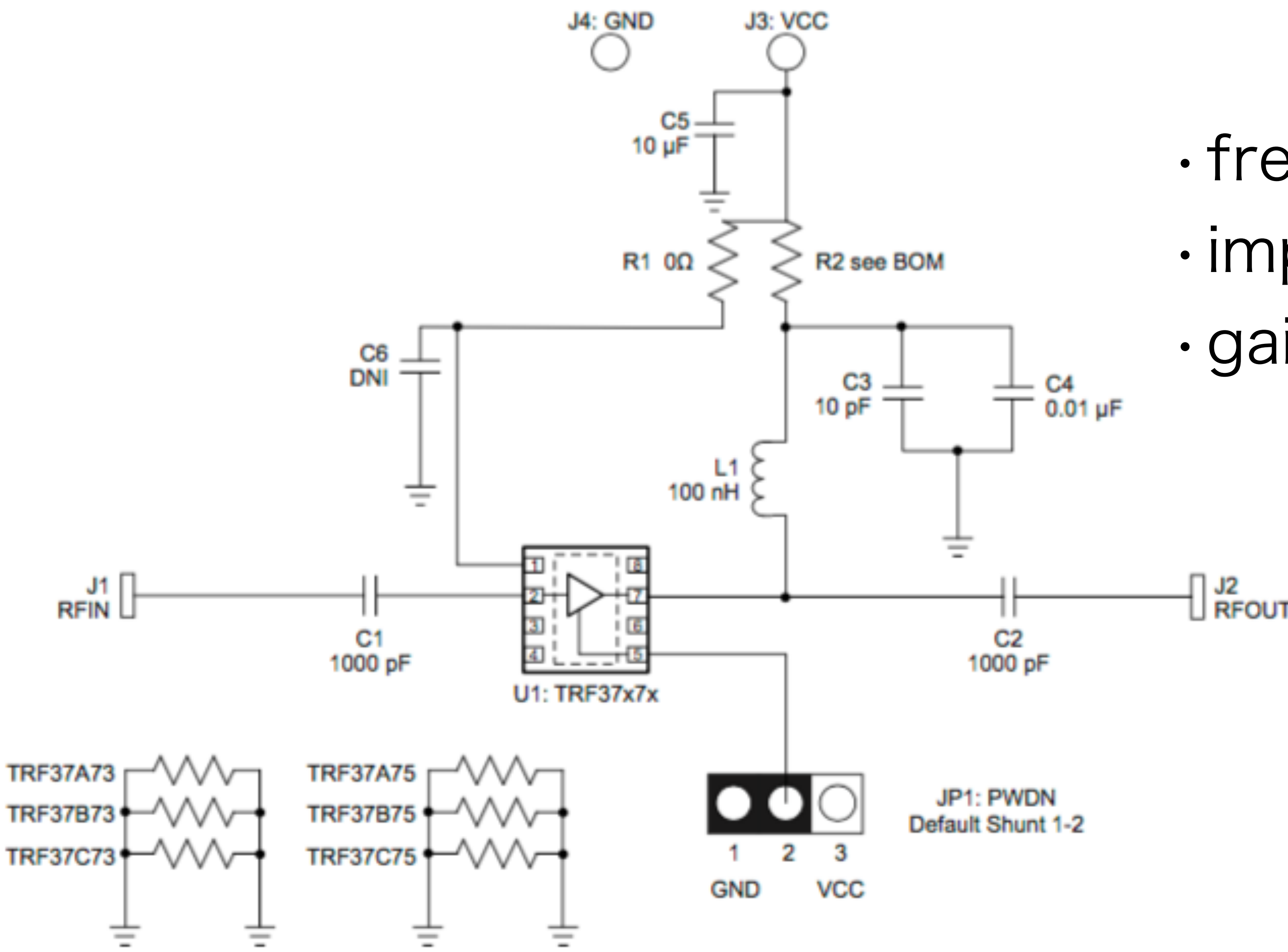


Figure 1. TRF37x73/75 EVM Schematic

- frequency : 1MHz~6GHz
- impedance : 49.9Ω
- gain : 19.5dB