# Development of Micro Pixel Chamber for ATLAS upgrade

Neutron beam tests using Ar and Ne base gas Developments of resistive electrode

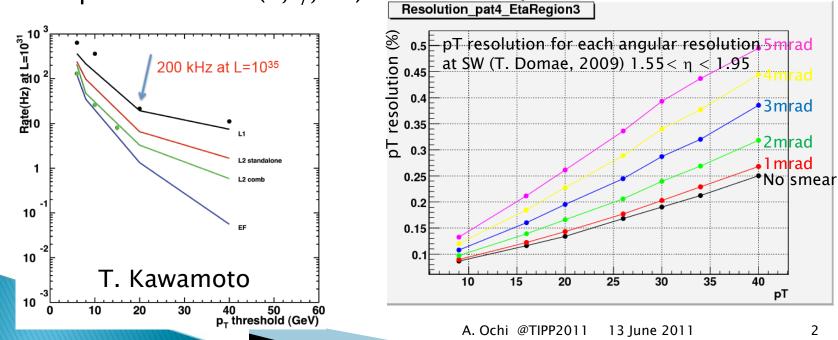
Atsuhiko Ochi, Yasuhiro Homma, Hidetoshi Komai, Yuki Edo, Takahiro Yamaguchi

Kobe University

TIPP2011 13 June 2011

#### Endcap muon system on HL-LHC Back ground rate [Hz/cm<sup>2</sup>] @ L=10<sup>34</sup> /cm<sup>2</sup>s

- Requirements for muon detec
  - Lower occupancy
    - <30% for 5kHz/cm<sup>2</sup> of cavern BG.
  - Strong reduction of LVL1 trigger
    - <100kHz @ endcap muon</p>
    - Required angular resol. = 1 mrad
    - Required to send (R,  $\phi$ ,  $d\theta$ ) to sector logic <sup>001, Geneva 2005</sup>



30

60

65

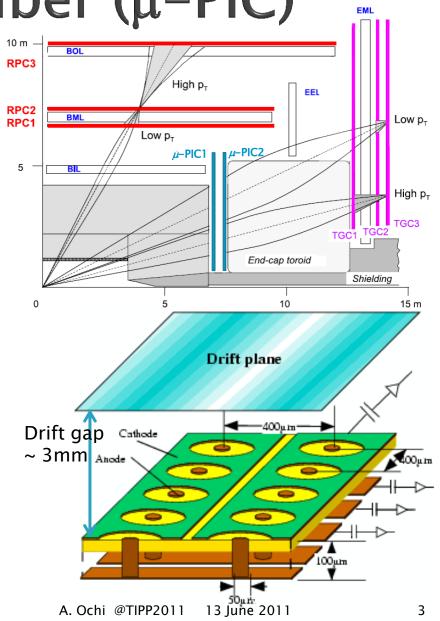
160

340

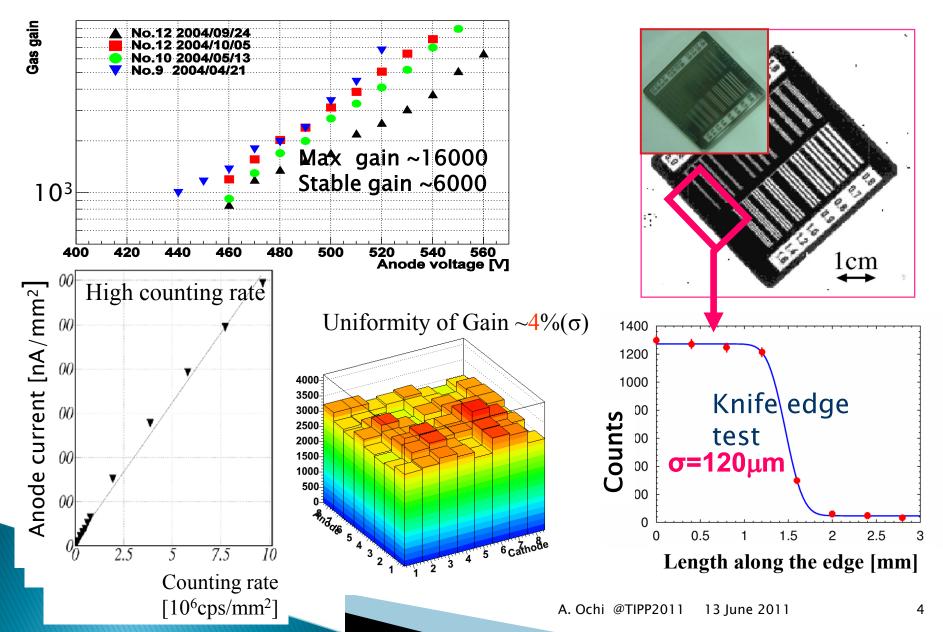
Baranov et al. : ATL-GEN-2005-

# Micro Pixel Chamber (µ-PIC)

- Replacement of endcap muon system
  - For HL–LHC
  - Improving rate capability and LVL1 trigger performance
- Based on Micro Pattern Gas Detector (MPGD)
  - Position resolution ~ 100µm
  - Two dimensional readout
  - High rate capacity > 10<sup>7</sup>cps/mm<sup>2</sup>
  - Both precision and trigger detector
- Mass production is available using PC board technology
  - There is no floating structures neither wire, foil nor mesh.
- Thin gap structure and appropriate gas are proposed for ATLAS muon system
  - For fast signal and high gas gain



# Performances of existence $\mu$ –PIC



#### Timing property and position resolution

- First tests has been done with 2GeV electron beam (2009, KEK Fuji beamline)
  - Timing resolution ~ 13nsec
  - Position resolution  $\sim 141 \mu m$ (without ADC readout)

 $X_2$ 

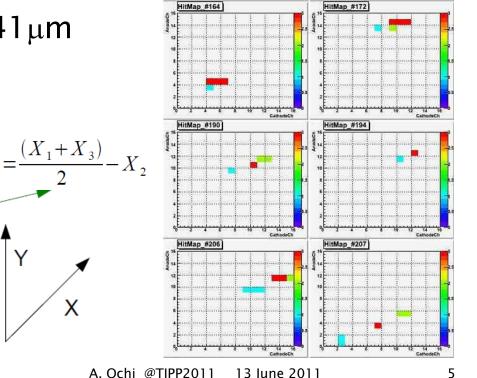
 $X_3$ 

uPIC×3

2GeV電子

X<sub>1</sub>





# Fast Neutron tests for Ar and Ne based gas





### Why neutron tests and gas studies ?

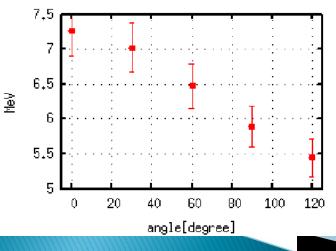
Detectors will be exposed to high flux neutron

- A few MeV few tenth MeV neutron will produce recoiled nucleon inside detectors
  - That produce great amount of energy deposit (a few MeV/mm2) in gaseous volume.
- The concerned problem for gas detector
  - "Raether limit" ... the electron cluster more than 10<sup>7-8</sup> cause the detector to discharge.
- We have to test the detector with both properties...
  - Sufficient gas gain for detecting MIP (muon)
  - Stable operation when huge energies are deposited
- Neutron tests for various conditions are tested
  - Spark rates dependencies on neutron irradiation for
    - Operation gains
    - Gas mixture

### The neutron beam in Kobe Univ. (Faculty of Maritime Science)

- Tandem Electrostatic Accelerator
  - 1.5MeV + 1.5MeV
    = 3MeV d/p beam
  - Ι~ 1μΑ
- Be target on BL
  - ${}^{9}\text{Be} + d \rightarrow {}^{10}\text{B} + n$ (~7MeV)
  - ~10<sup>7</sup>neutron/sec. @source

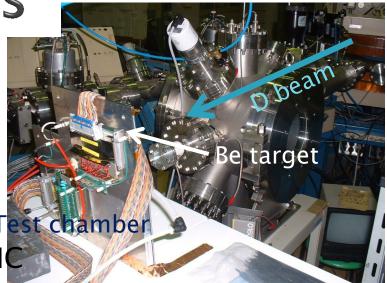
Energy(proton equivarent (quenching=0,38))

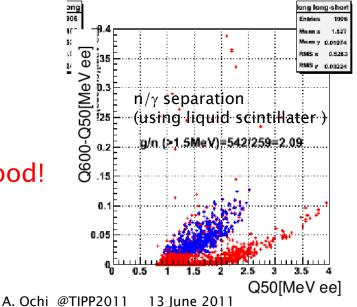




# Neutron Beam tests

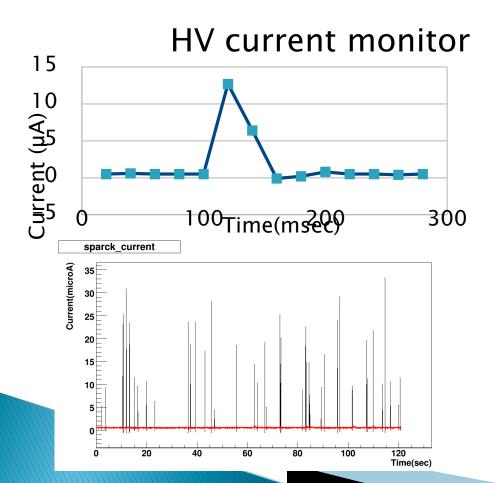
- ▶ 7 13 June, 2010
  - Accelerator operation training
  - Neutron beam studies
- > 21–28 June, 2010
  - Neutron irradiation test for  $\mu$ -PIC
- 17–24 November, 2010
  - Spark rate measurements using
    - Ar + C2H6 mixture
    - Ne + C2H6 mixture  $\rightarrow$  good!
- 30 May 5 June, 2011
  - Spark rate measurements using
    - Ne + C2H6 + CF4 mixture Very good!





# Spark rate measurement

- Big pulses were counted using current monitor on HV source.
  - For changing gain and gas mixture

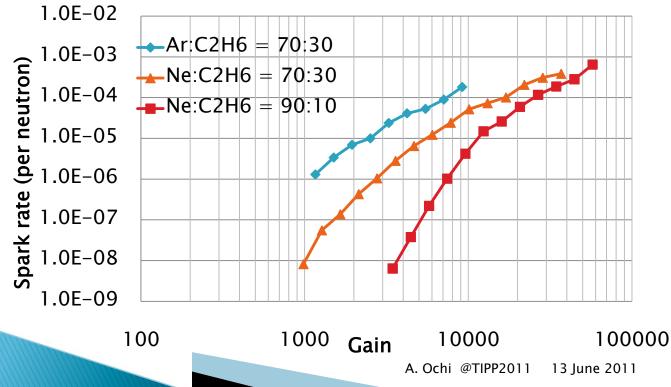




### Spark rate for fast neutron @ 2010 beamtest

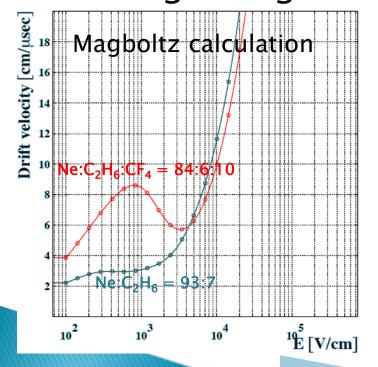
- > Spark rates are measured using Ar and Ne based gas.
  - Ar:ethane = 70:30
  - Ne:ethane = 70:30
  - Ne:ethane = 90:10

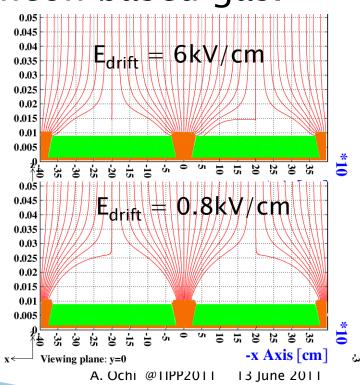
Spark rates are drastically reduced using neon gas



### Further studies for operation gases

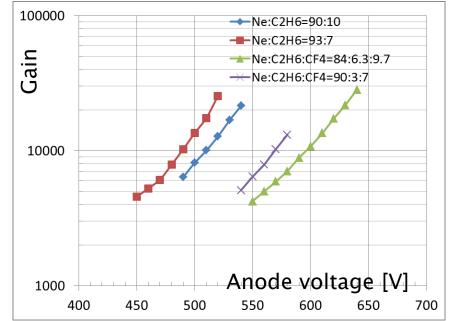
- For trigger chamber
  - Faster electron drift velocity is needed
  - Higher electron correction efficiency is needed
- $\rightarrow$  Mixing CF4 gas on neon based gas.

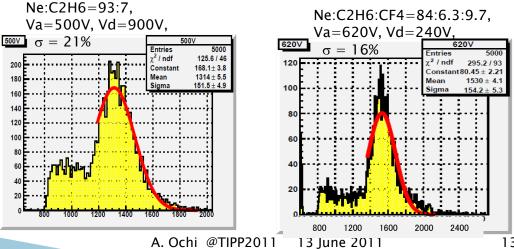




# $Ne+C_2H_6+CF_4$ gas studies

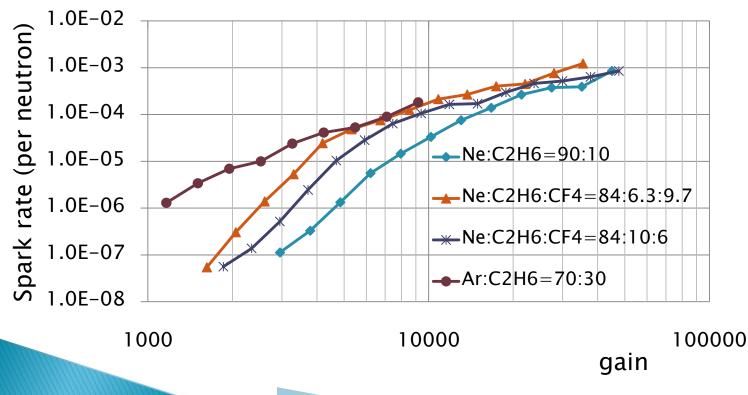
- Gas gains measurements on  $\mu$ –PIC (iron source)
  - In two gases mixture (Ne+C2H6), 93:7 has better (in maximum gain) performance than 90:10
    - But, in case 95:5, performances (gain, peak resolution) are worse.
  - In three gases mixture (Ne+C2H6+CF4), 10% of CF4 and other mixture of 93:7 (=84:6.3) has best performances
    - Mixture of 90:3:7 has been • tested for comparison, but maximum attained gain is smaller.





### Spark rates of Ne and CF4 mixed gas

- Ne:C2H6=90:10 has best reduction of spark rate
- Ne + C2H6 + CF4 mixing gas is also good spark reduction comparing with argon based gas
- In 3 component gas, gas mixture of 84:10:6 has good reduction of spark rate.
  - We should consider a balance of electron drift speed and spark rate
- More studies are needed
  - Using isobutene etc.

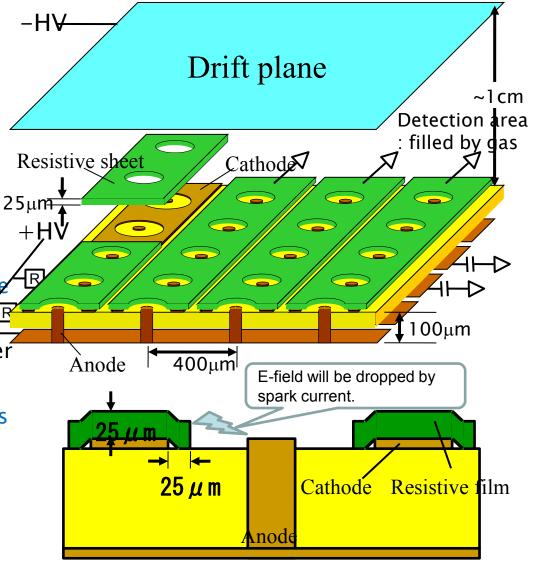


# μ-PIC with resistive cathode

>> Development of new structure for reducing spark damages

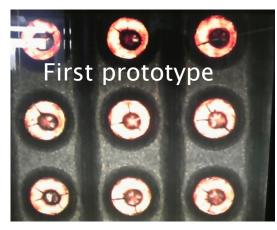
# $\mu\text{-}\text{PIC}$ with resistive cathode

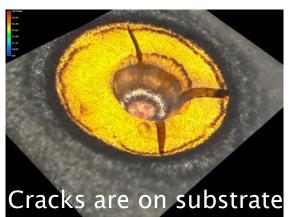
- To overcome Raether limit
  - Neutron recoiled nucleon, stopped hadron...
- Resistive electrodes are good solution!
- New type of µ-PIC with resistive material is now developing.
  - Resistive kapton is on the cathodes of  $\mu$ -PIC.
  - Large current from spark reduce the e-field, and spark will be quenched.
  - Huge signal beyond the "Raether" limit" will also be suppressed
  - Signal from low energy deposit will be observed with higher gas gain
  - This design provide one promised possibility of MIP detector under hadronic background



A. Ochi @TIPP2011 13 June 2011

# Improvements for production

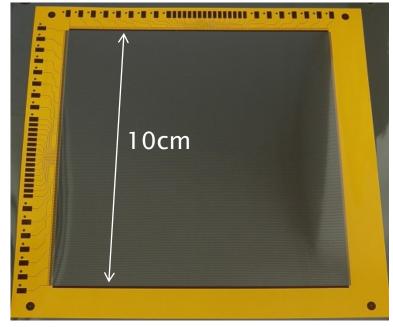






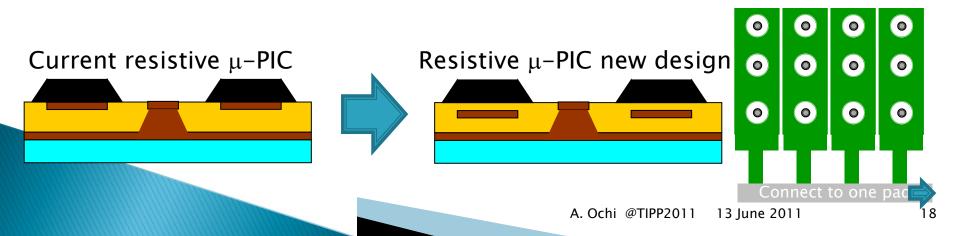


5<sup>th</sup> prototype Qualities are getting better



### Remnant problems and next design

- $\blacktriangleright$  Sparks are still occurred on resistive  $\mu\text{-PIC}$ 
  - More precise manufacturing are needed
    - Problems for alignment of anode and cathode position
  - Higher resistivity is needed between anodes and cathodes
    - New structure using capacitive readout from cathode is proposed. (Thanks to R. Olivaira)
    - Now we have just start to make a new prototype



0

0

 $\bigcirc$ 

 $\circ$ 

### Summary of current R&D status and Future prospects

- µ-PIC is proposed and developed for one candidate of ATLAS muon detector for HL-LHC.
  - There is no floating structure!
  - We can produce it in printed board facilities at commercialy-based industrial companies.
- Fast neutron (~7MeV) tests are performed
  - $^\circ~$  We found good suppression of spark rate using Ne+C\_2H\_6 and Ne+C\_2H\_6+CF\_4 gases under gas gain of a few thousand.
    - CF4 mixed gases provide fast electron drift speed (important for trigger chamber) and need less voltage for drift gap.
- Development of resistive cathode μ-PIC
  - Producing process and structures is being improved
    - The problems of crack, wrong patterning have been solved
    - There remain the alignment problem, but it will be solved soon.
  - New structure for avoiding large sparks is now being developed.
- Future prospects
  - Until 2012 ... R&D, improvements and performance tests of basic structure
    - Time jitter and detection efficiency should be optimized.
  - 2013-14 ... Developments for Readout and large size detector
    - Mass production will be available using existence line in private company.

# Thank you

#### and hope to see you at Kobe In this summer

2nd International Conference on Micro Pattern Gaseous Detectors RD51 collaboration meeting on September 2-3

#### 29 August - I September, 2 Maiko, Kobe, Japan Seaside Hotel MAIKO VILLA KOBE

The conference covers the most recent research and development activities in the field of micro-pattern gaseous detectors.

#### **Conference topics:**

- New development of MPGD
- Detector physics for MPGDs
- MPGD applications
- Simulation and software for MPGDs
- MPGD related electronics
- MPGD production techniques
- Operation tests of MPGDs

#### **Special topics:**

- Memorial to Georges Charpak. (Invited session) - Award for young scientist: "Charpak Award"

#### International Organizing committee

A. Cardini (INFN Cagliari)

- K. Desch (U.Bonn) Th. Geralis (NCSR Demokritos Athens) I. Giomataris (CEA Saclay) T. Kawamoto (ICEPP Tokyo) A Ochi (Kobe Univ) V. Polychronakos (BNL)
- Sharma (CERN) S. Uno (KEK)
- A. White (U. Texas Arlington)
- J. Wotschack (CERN) Zhao (USTC China)
- T. TanimorL(Kyoto Univ.) M. Titov (CEA Saclay)

International Advisory committee:

#### T. Behnke (DESY)

- R. Bellazzini (INFN Pisa) A. Breskin (Weizmann Inst.)
- Colas (CEA Saclay)

CONTRACTOR OF THE OWNER OWNER

- G. Fanourakis (NCSR Demokritos Athens)
- S. Dalla Torre (INFN Trieste) H. van der Graaf (NIKHEF)
- I. Haba (KEK).
- Jaros (SLAC)
- Matsuda (KEK)
- V. Riegler (CERN)
- Ropelewski (CERN) Sauli (TERA Foundation)





the table of the

Local Organizing committee

A. Ochi (Kobe Univ.), Chair

H. Sekiya (ICRR) A. Sugiyama (Saga Univ.

H. Takahashi (U. Tokyo)

Tamagawa (RIKEN) Tanimori (Kyoto Univ.)

Taketani (RIKEN)

J. Haba (KEK) H. Hamagaki (CNS) T. Kawamoto (ICEPP)

#### http://ppwww.phys.sci.kobe-u.ac.jp/~upic/mpgd2011/