Development of Micro Pixel Chamber for ATLAS upgrade

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

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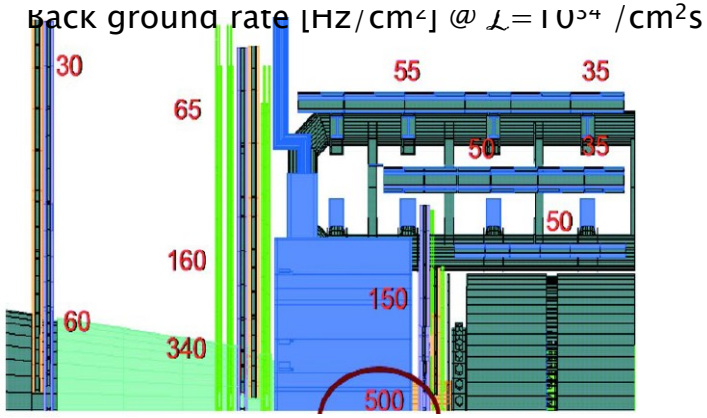
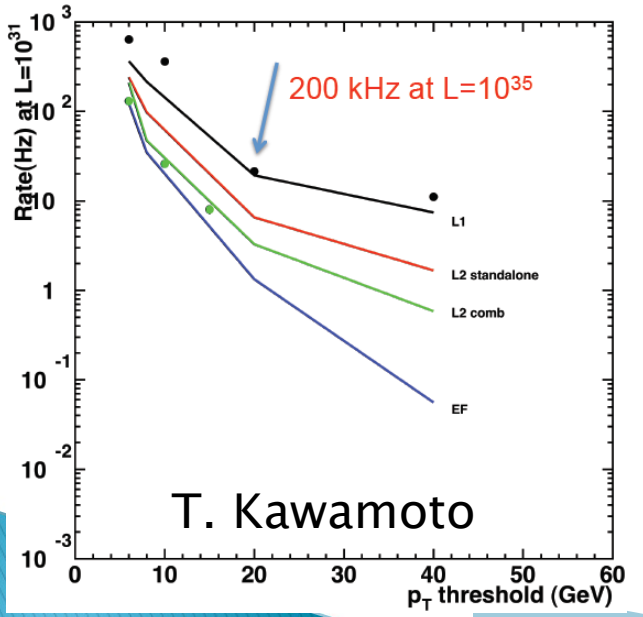
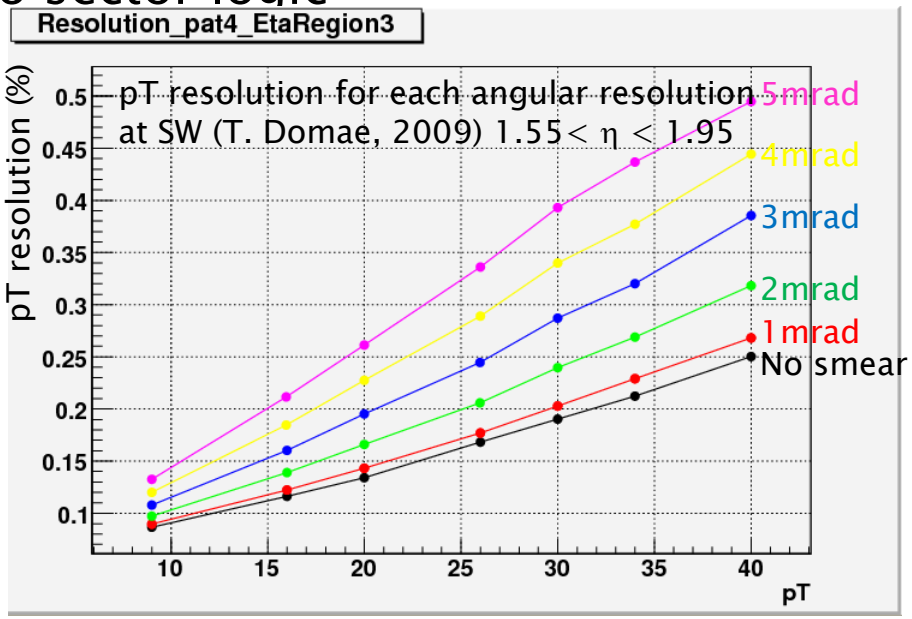
Endcap muon system on HL-LHC

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



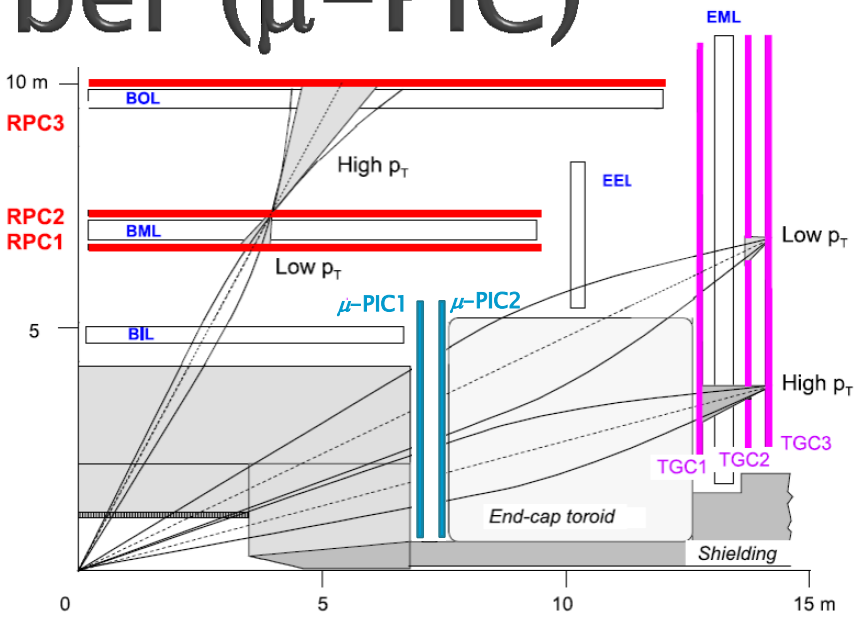
Baranov et al. : ATL-GEN-2005-001, Geneva 2005

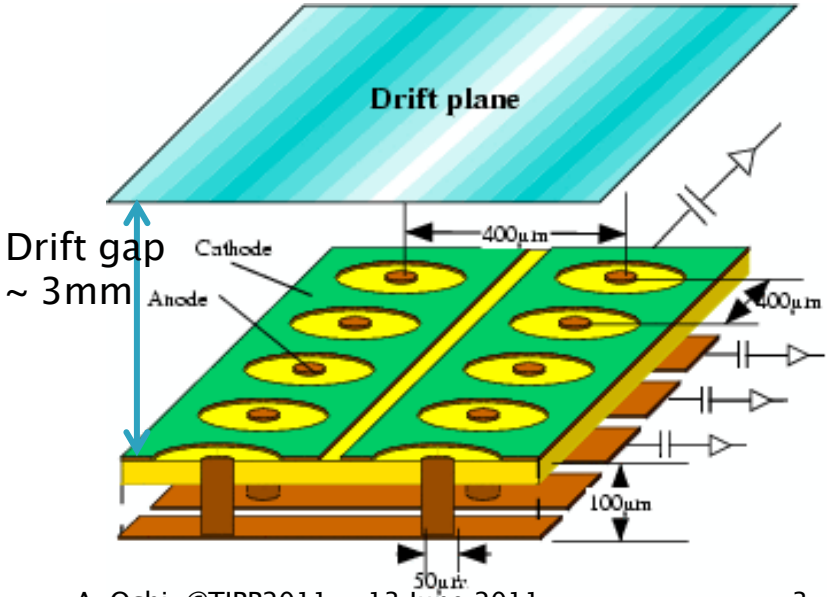




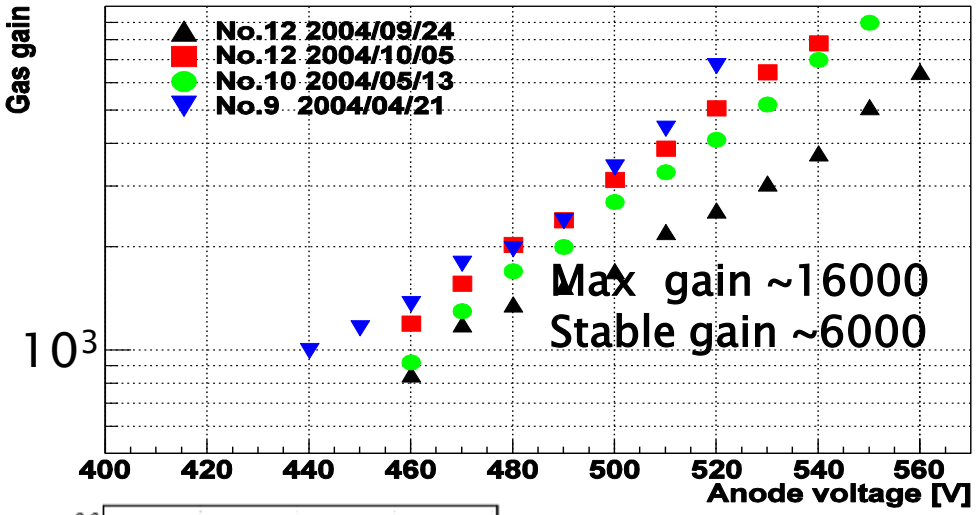
Micro Pixel Chamber (μ-PIC)

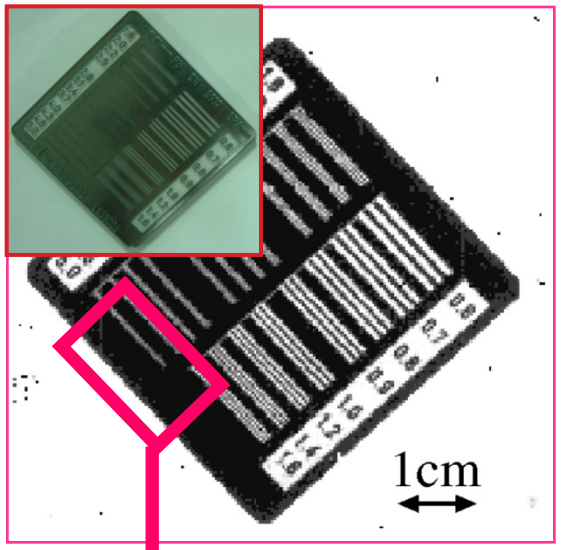
- Replacement of endcap muon system
  - For HL-LHC
  - Improving rate capability and LVL1 trigger performance
- Based on Micro Pattern Gas Detector (MPGD)
  - Position resolution ~ 100μm
  - Two dimensional readout
  - High rate capacity > 10^7cps/mm^2
  - Both precision and trigger detector
- Mass production 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

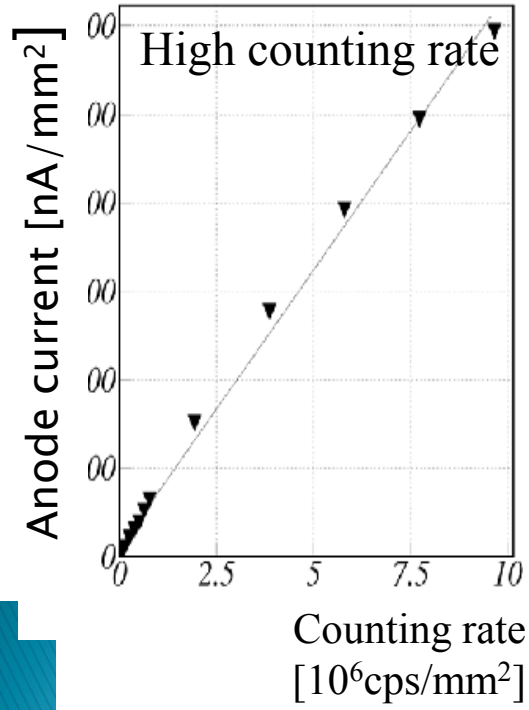




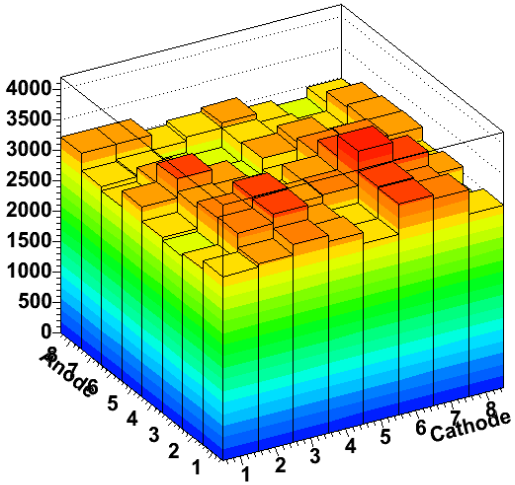
Performances of existence μ-PIC

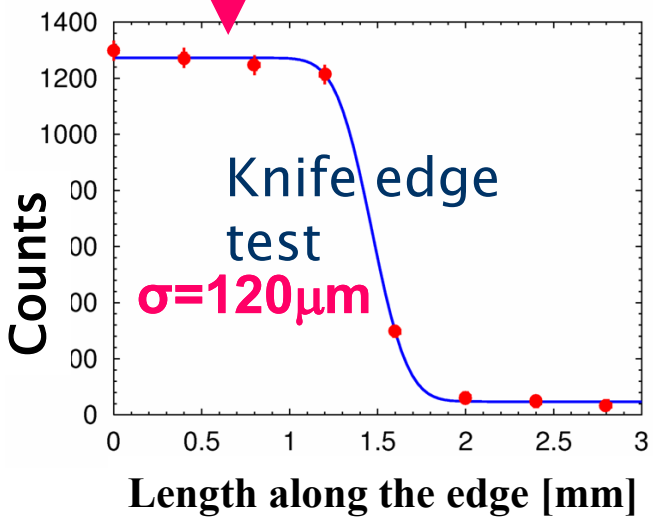






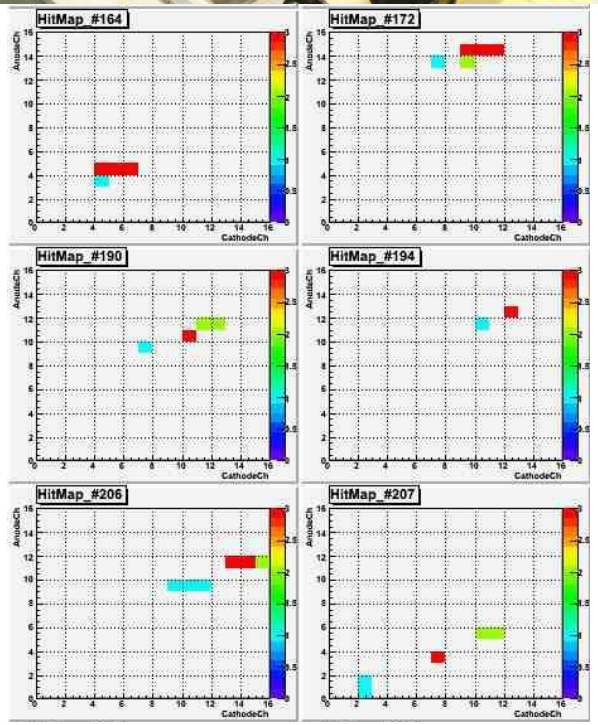
Uniformity of Gain ~4%(σ)

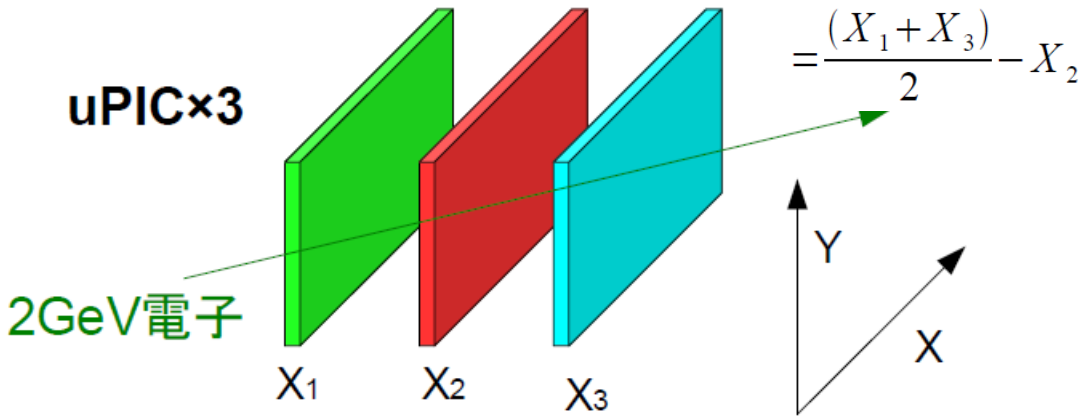




Timing property and position resolution

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





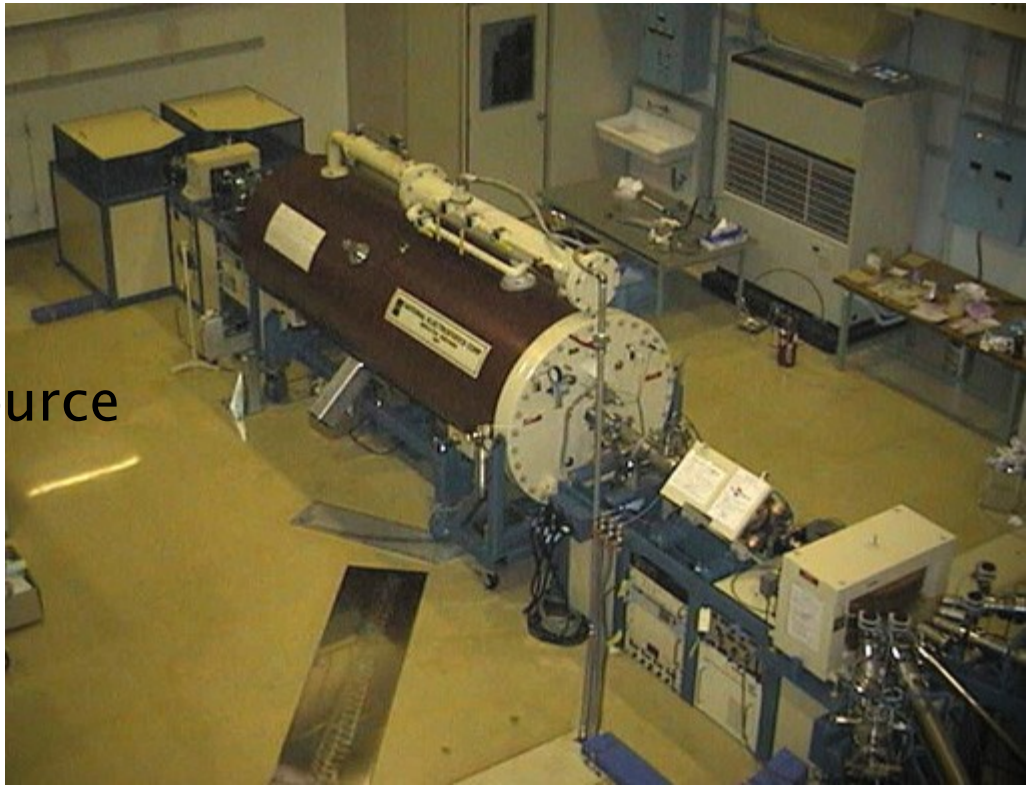
Fast Neutron tests for Ar and Ne based gas

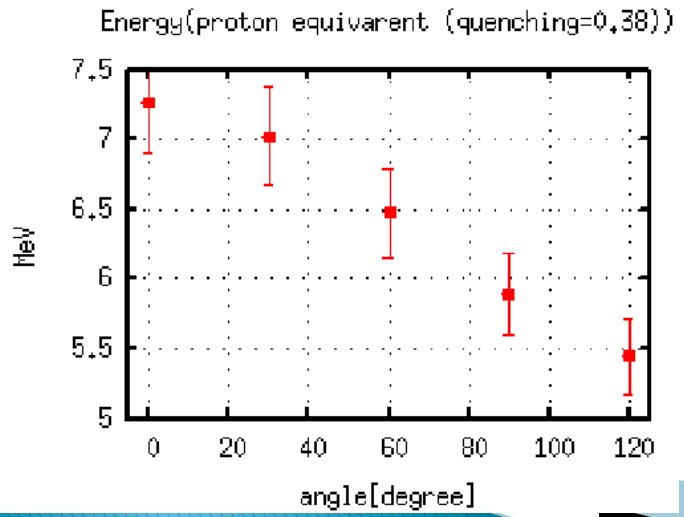
Why neutron tests and gas studies ?

- 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^{7-8} 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)

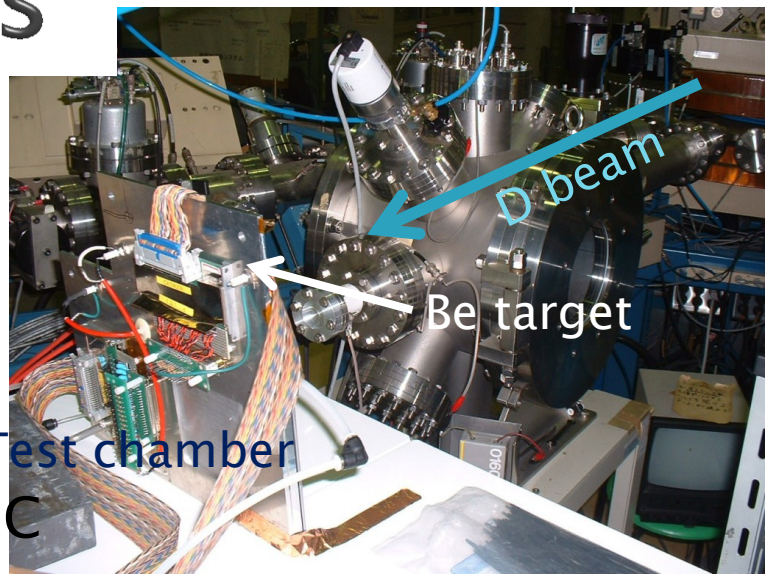
- Tandem Electrostatic Accelerator
  - 1.5MeV + 1.5MeV = 3MeV d/p beam
  - I ~ 1μA
- Be target on BL
  - $^{9}Be+d \rightarrow {}^{10}B + n$ (~7MeV)
  - ~10^{7}neutron/sec. @source

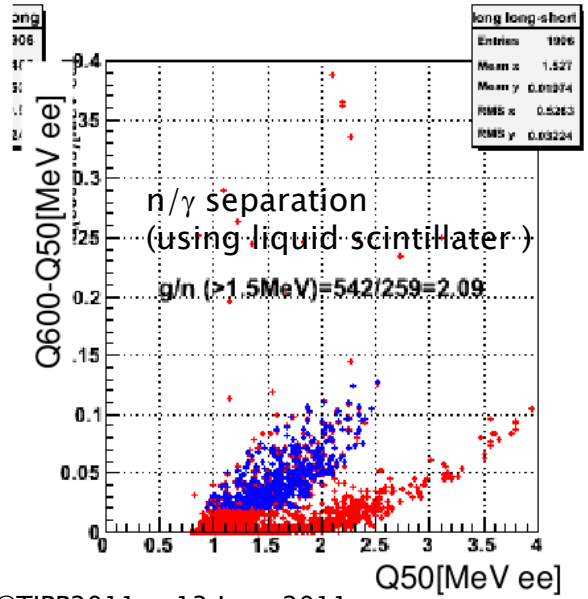




Neutron Beam tests

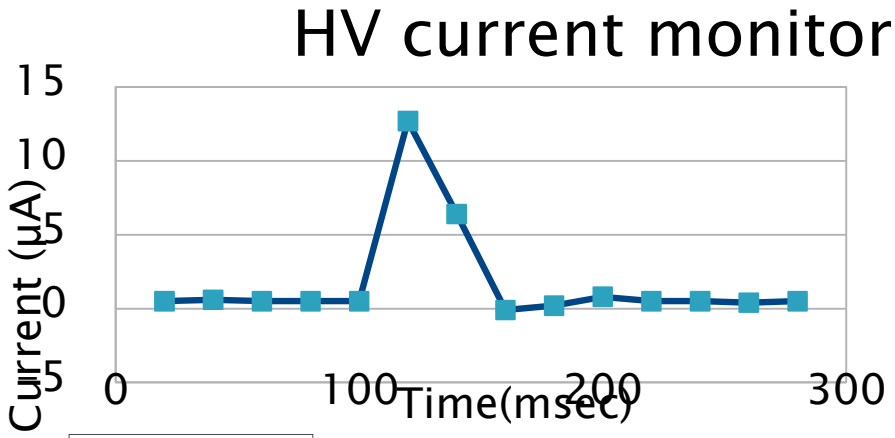
- 7 – 13 June, 2010
  - Accelerator operation training
  - Neutron beam studies
- 21–28 June, 2010
  - Neutron irradiation test for μ-PIC
- 17–24 November, 2010
  - Spark rate measurements using
    - Ar + C2H6 mixture
    - Ne + C2H6 mixture → good!
- 30 May – 5 June, 2011
  - Spark rate measurements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

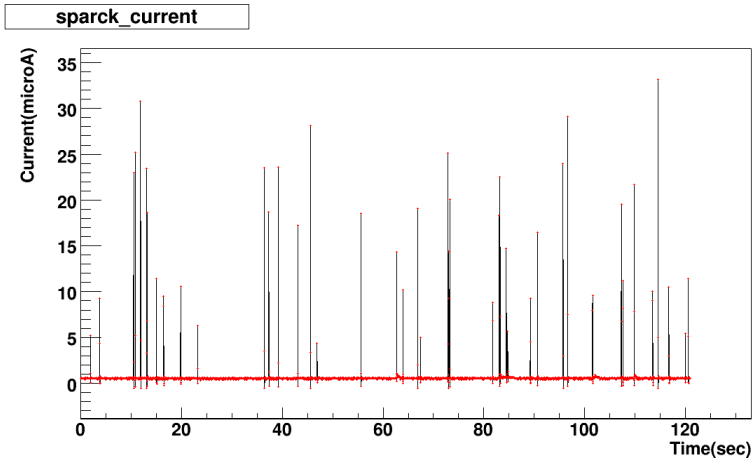




Spark rate measurement

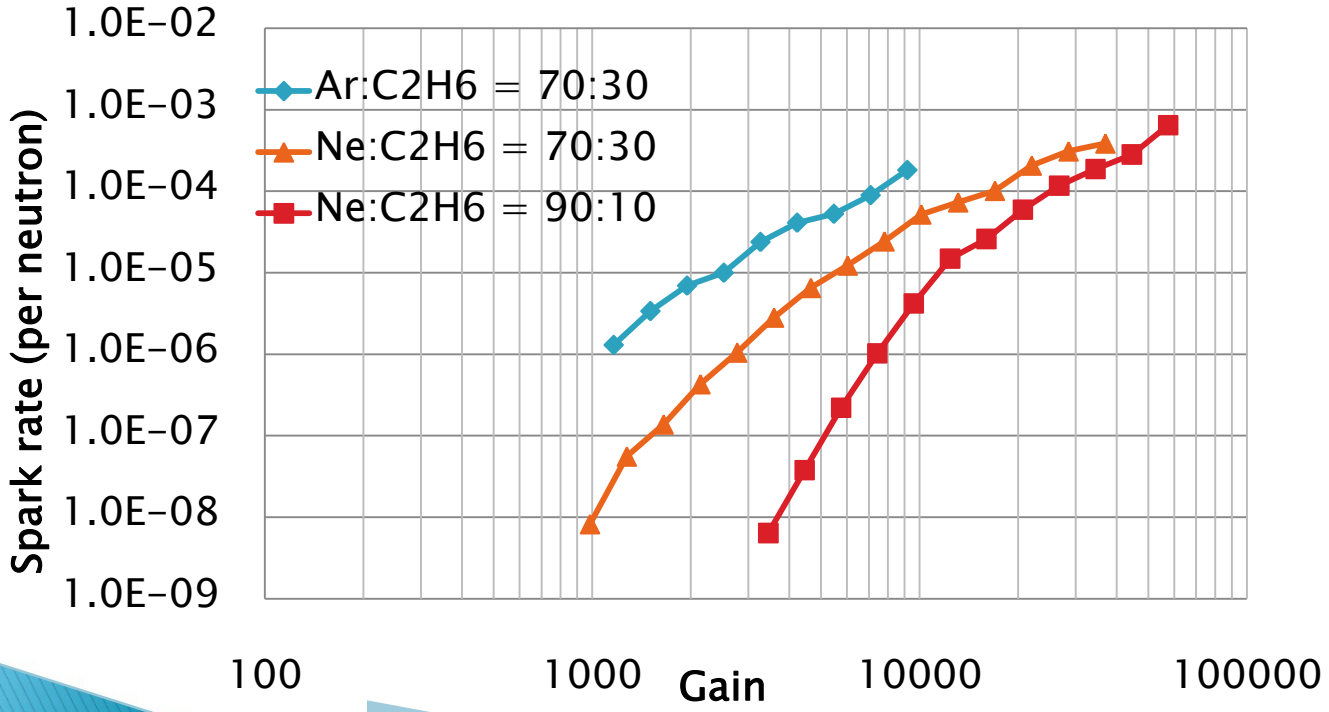
- Big pulses were counted using current monitor on HV source.
  - For changing gain and gas mixture





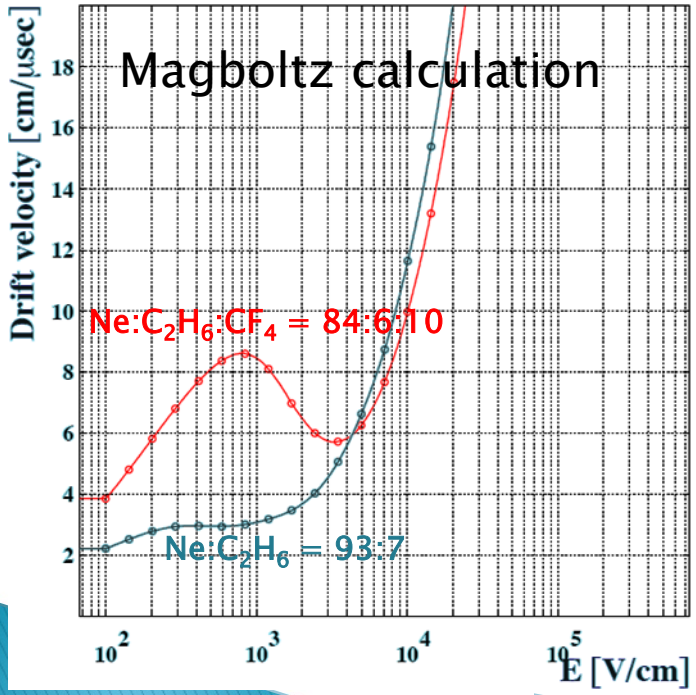
Spark rate for fast neutron @ 2010 beamtest

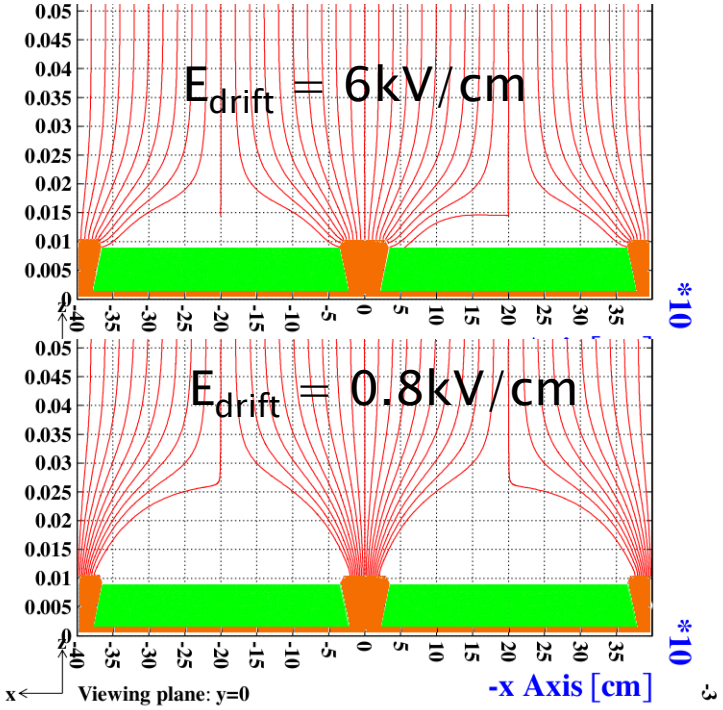
- Spark rates are measured using Ar and Ne based gas.
  - Ar:ethane = 70:30
  - Ne:ethane = 70:30
  - Ne:ethane = 90:10
- Spark rates are drastically reduced using neon gas



Further studies for operation gases

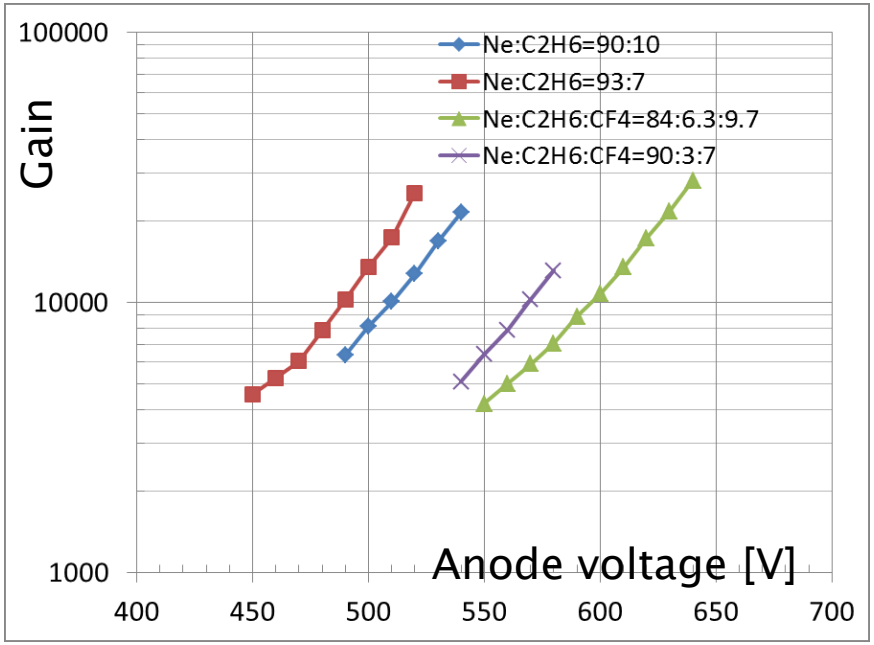
- For trigger chamber
  - Faster electron drift velocity is needed
  - Higher electron correction efficiency is needed
- → Mixing CF4 gas on neon based gas.



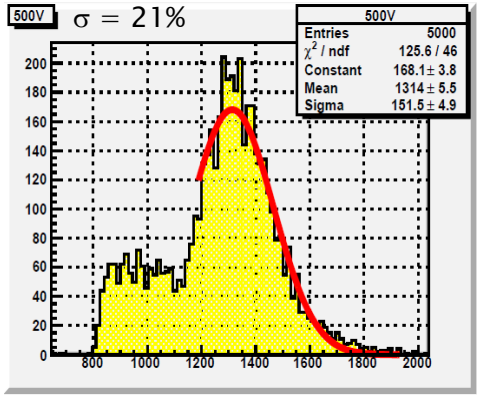


$Ne+C_2H_6+CF_4$ gas studies

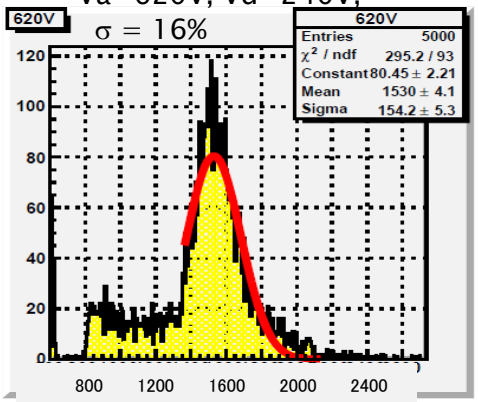
- Gas gains measurements on μ-PIC (iron source)
  - In two gases mixture (Ne+C2H6), 93:7 has better (in maximum gain) performance than 90:10
    - But, in case 95:5, performances (gain, peak resolution) are worse.
  - In three gases mixture (Ne+C2H6+CF4), 10% of CF4 and other mixture of 93:7 (=84:6.3)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



Ne:C2H6=93:7,
Va=500V, Vd=900V,

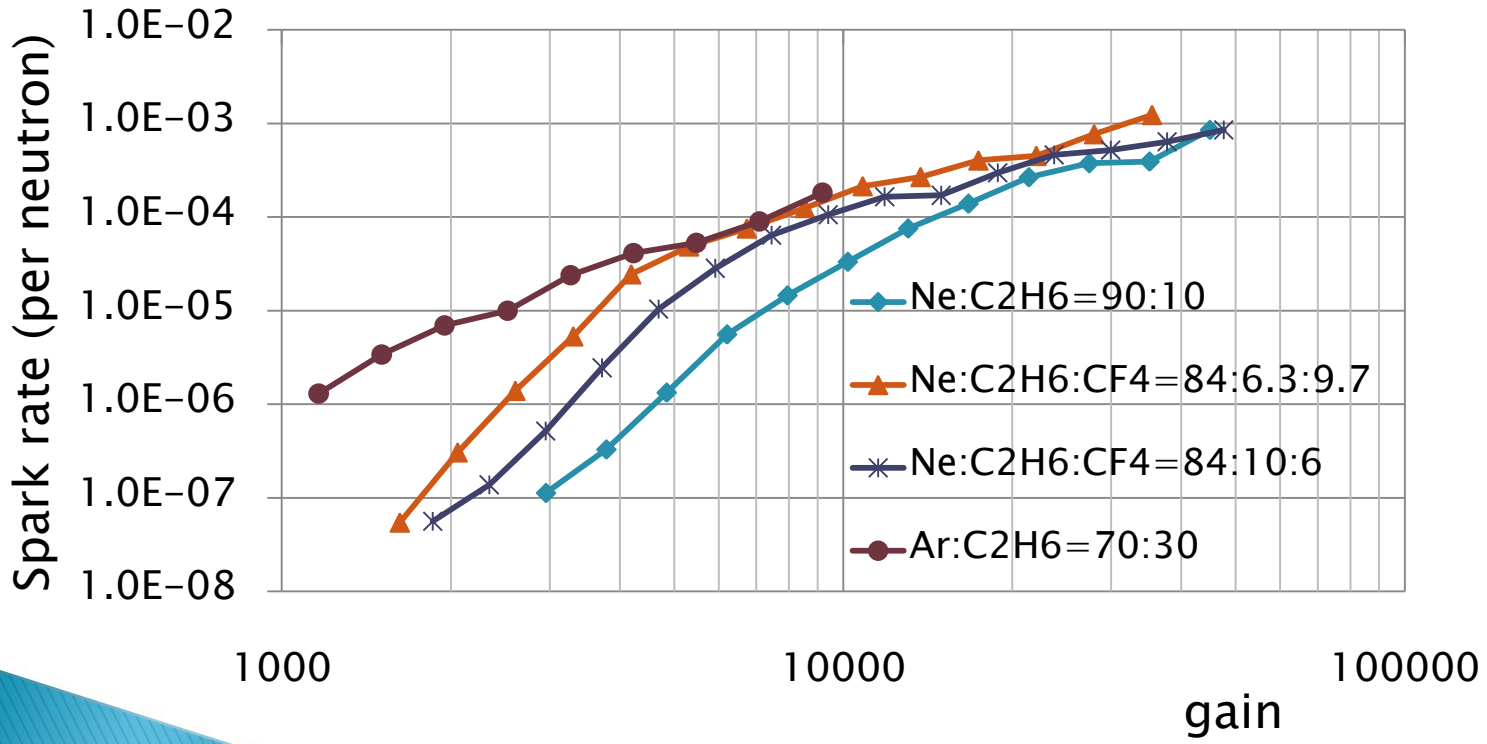


Ne:C2H6:CF4=84:6.3:9.7,
Va=620V, Vd=240V,



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.

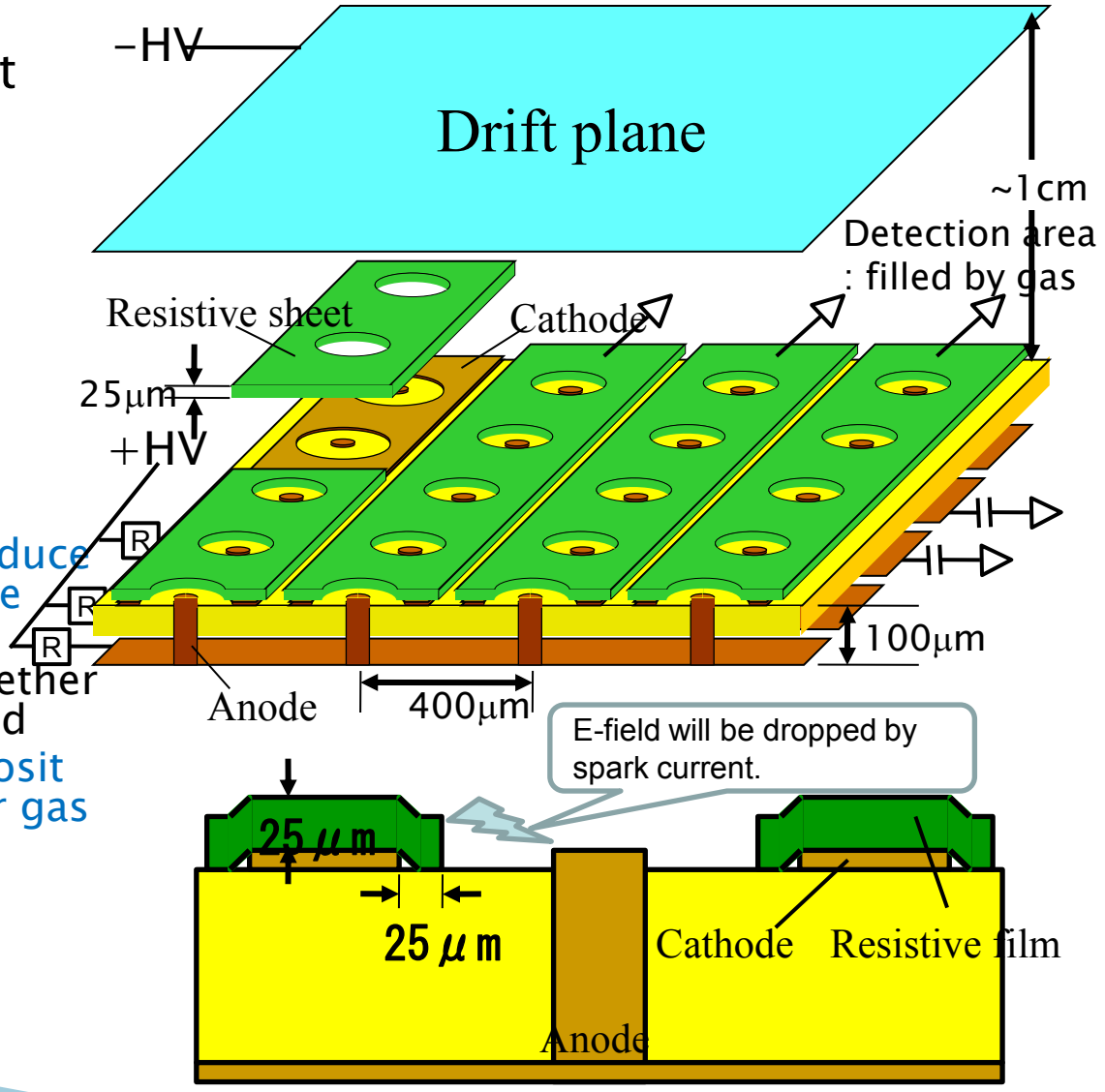


μ-PIC with resistive cathode

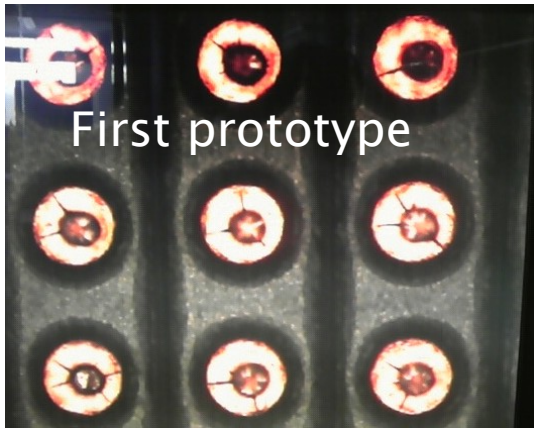
- Development of new structure for reducing spark damages

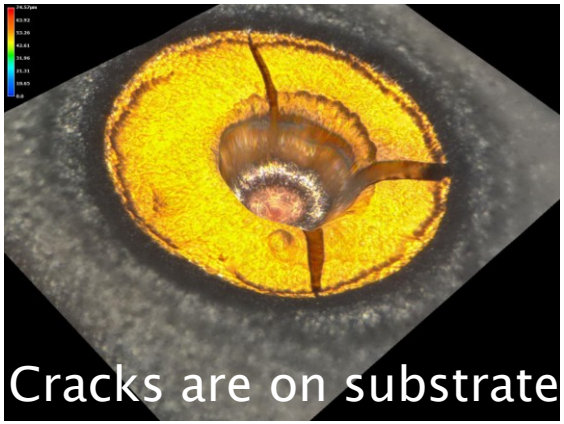
μ-PIC with resistive cathode

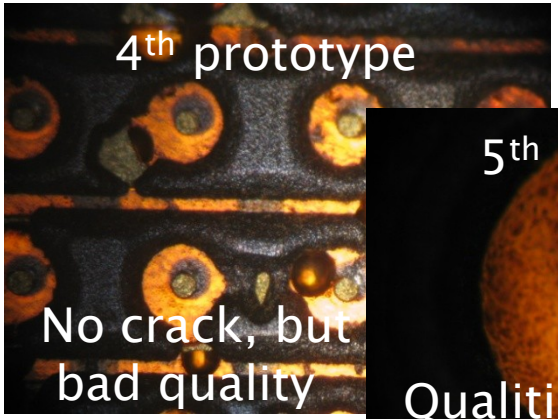
- To overcome Raether limit
  - Neutron recoiled nucleon, stopped hadron…
- Resistive electrodes are good solution!
- New type of μ-PIC with resistive material is now developing.
  - Resistive kapton is on the cathodes of μ-PIC.
  - Large current from spark reduce the e-field, and spark will be quenched.
  - 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

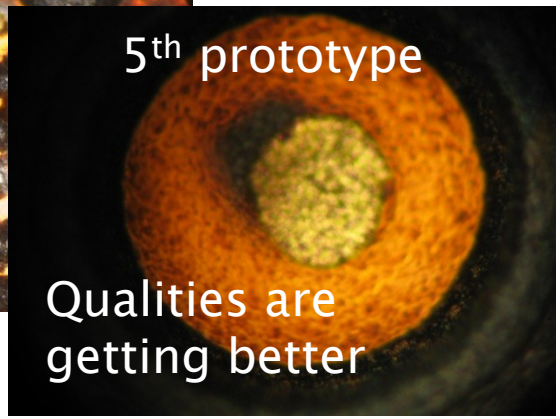


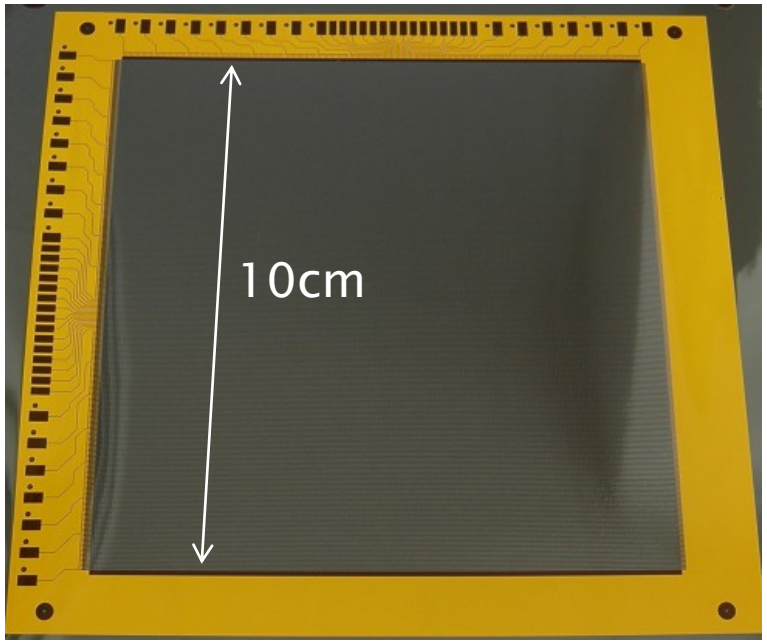
Improvements for production





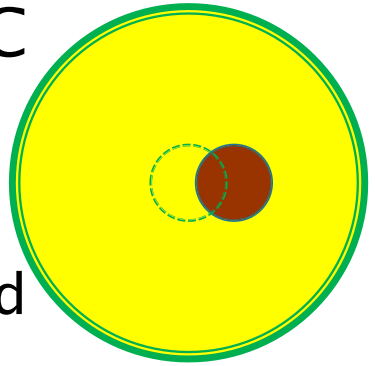


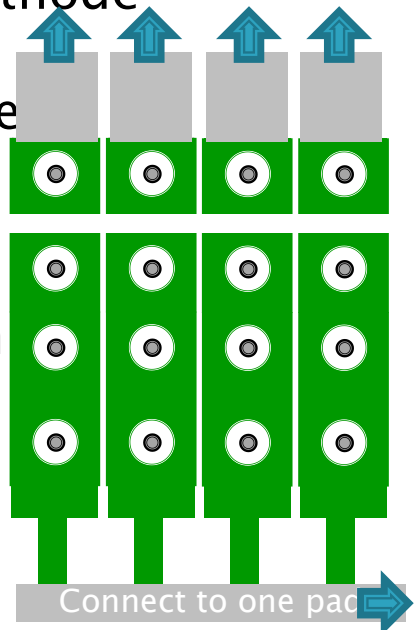




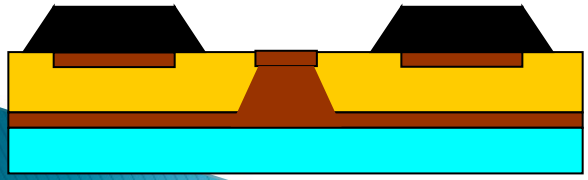
Remnant problems and next design

- Sparks are still occurred on resistive μ-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

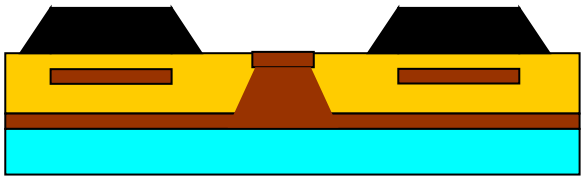




Current resistive μ-PIC



Resistive μ-PIC new design



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
  - 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