SORMA WEST 2012

2012 IEEE Symposium on Radiation Measurements and Applications

MAY 14-17, CITY CENTER MARRIOTT, OAKLAND, CALIFORNIA

Performance of Microchannel Plates Fabricated Using Atomic Layer Deposition

Andrey Elagin

THE UNIVERSITY OF CHICAGO

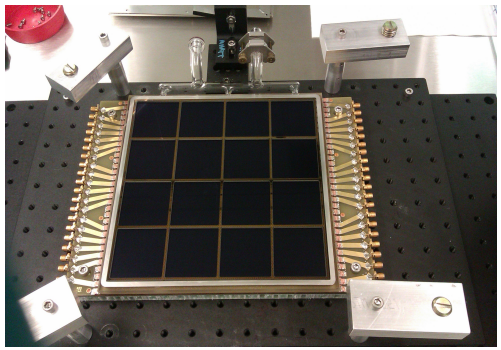
on behalf of the LAPPD collaboration

- *Introduction*
- *Performance (timing)*
- *Conclusions*

May 17, 2012

Large Area Picosecond Photo Detectors (LAPPD)

PET scan
X-ray
Neutrons
Colliders
Neutrinos
...

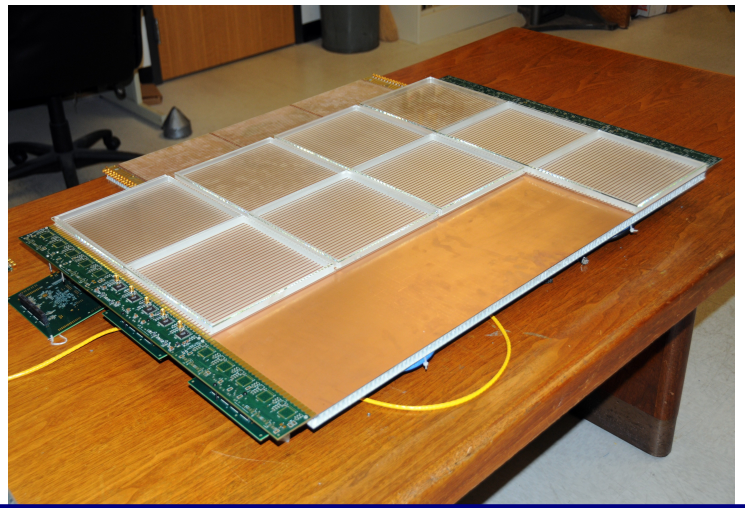


Goals:

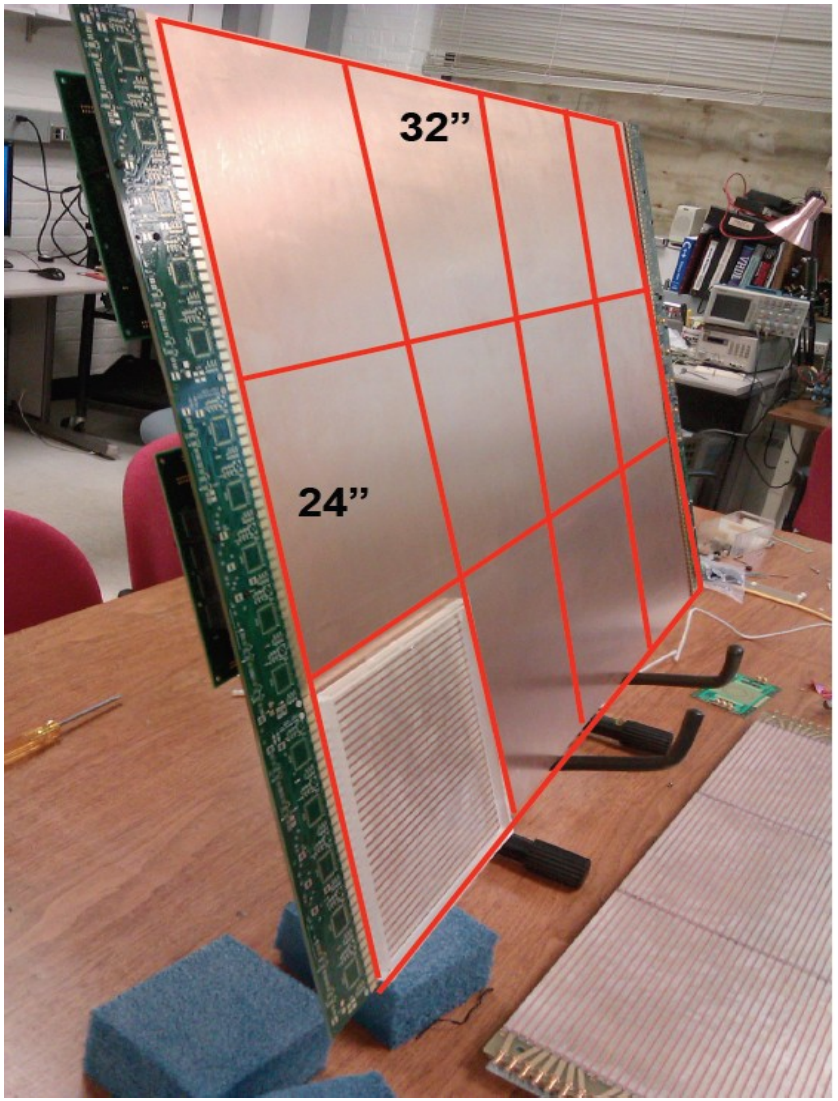
- *Large area*
- *Picosecond timing*

Components:

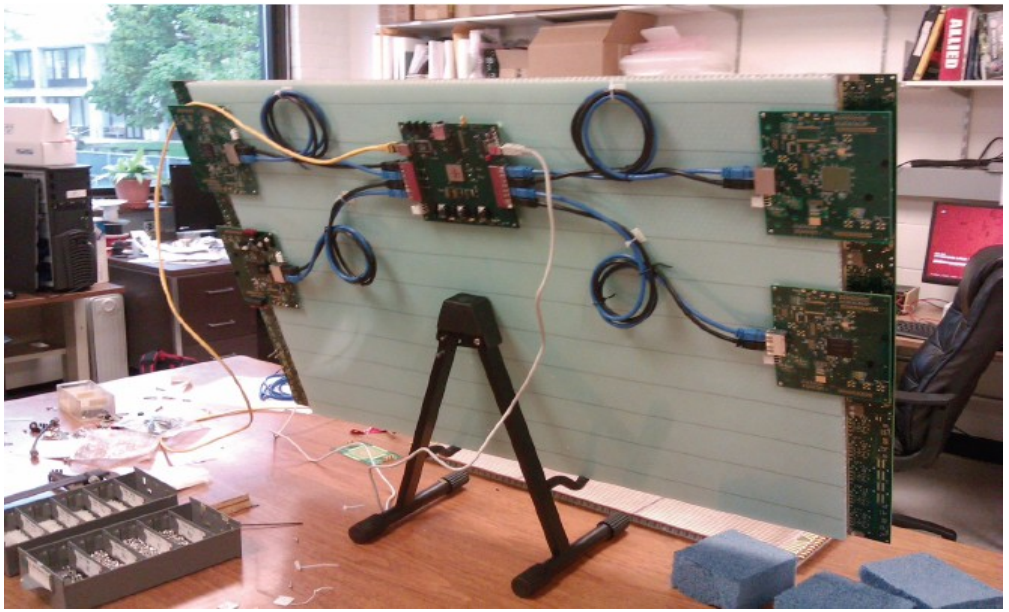
- *Photo-cathode*
- *Micro-channels plates*
- *Electronics*
- *Hermetic packaging*



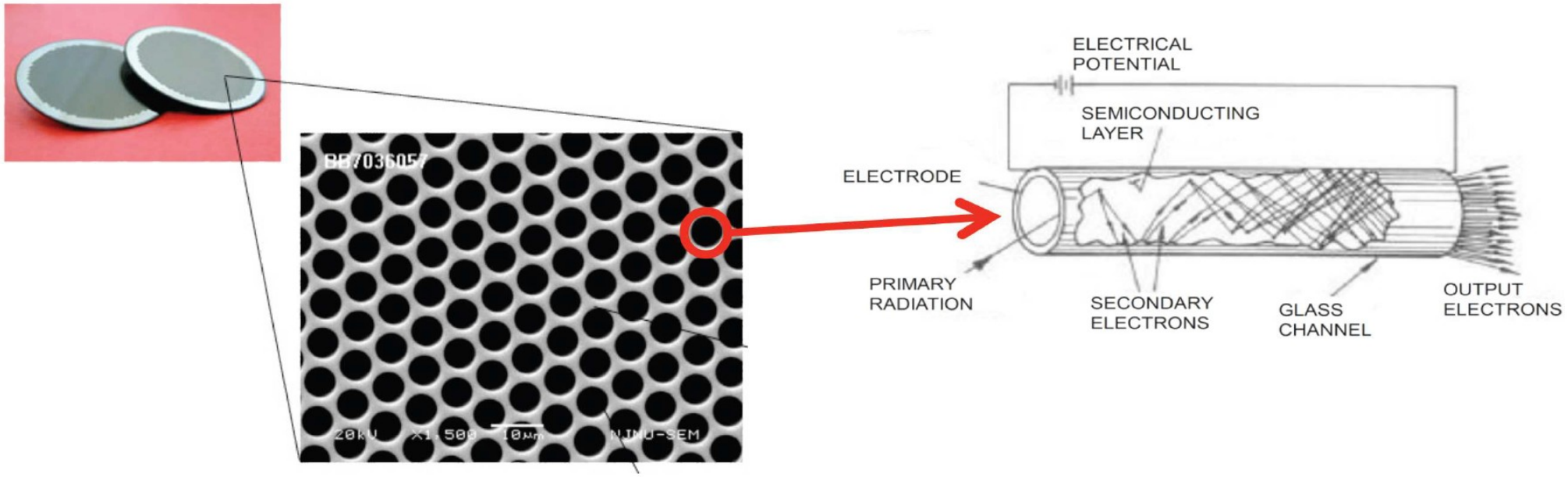
Super Module



- ***Thin* planar glass body detector**
- ***MCPs share single delay line anode***
- ***Fully integrated electronics***



MCP fundamentals

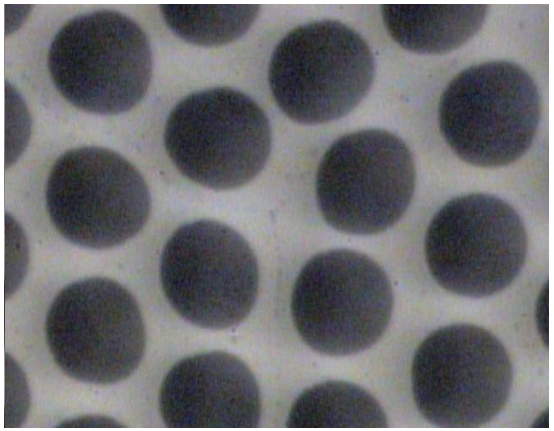


Many electron multipliers per unit area

- Glass substrate with micron pores
- Each pore acts as an electron multiplier
  - *secondary electron emission (SEE)*
  - *high voltage applied*
- Usually very expensive

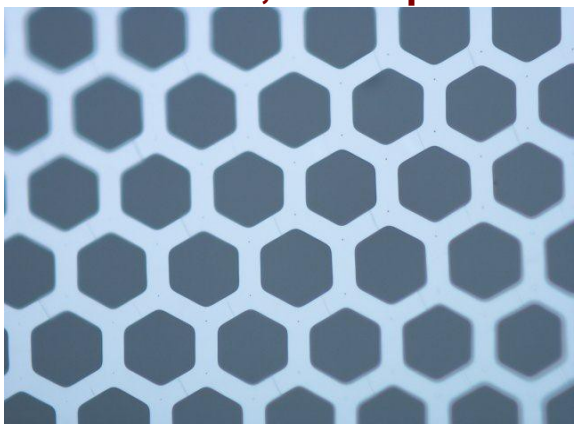
Commercial MCP vs LAPPD MCP

Conventional Pb-glass MCP



Incom glass substrate

D~20micron, 65% open area



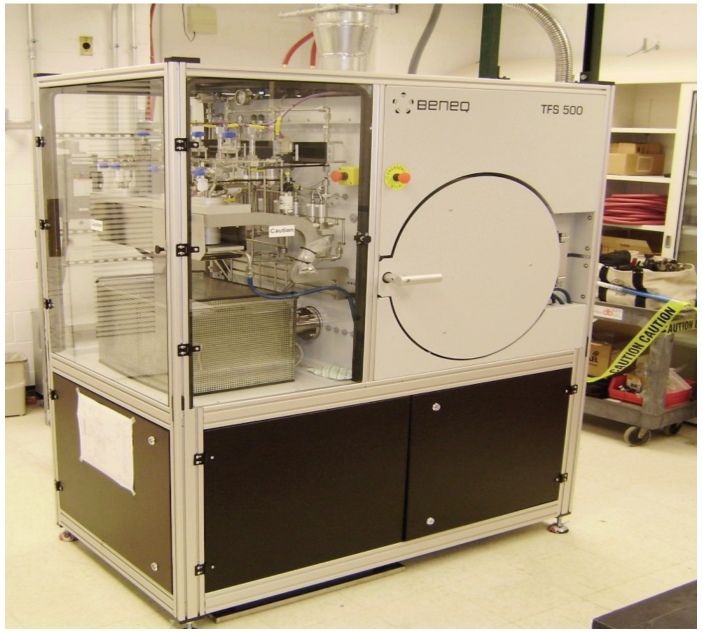
Three functions in one glass plate

- *Pores*
- *Resistive layer to provide electric field in the pore*
- *Pb-oxide layer serves as SEE layer*

Separate the three functions

- *Pores (L/D~60)*
- *Resistive layer applied using Atomic layer deposition (ALD)*
- *SEE layer applied using ALD*

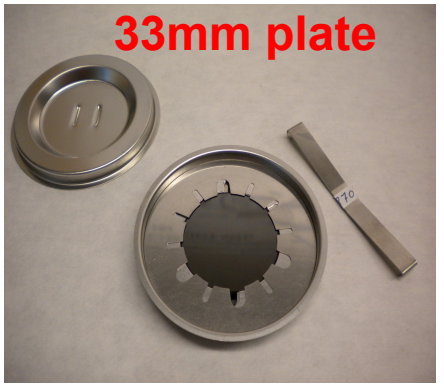
MCP by Atomic Layer Deposition (ALD)

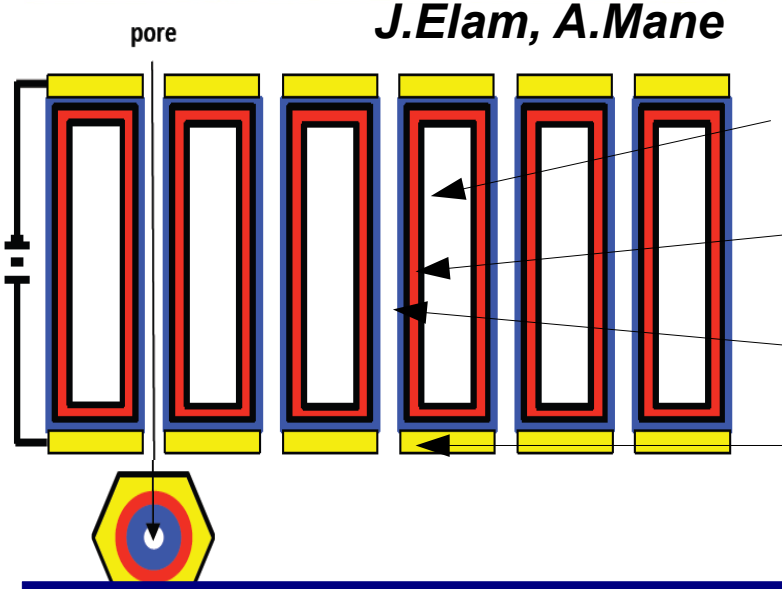


J.Elam, A.Mane

Beneq reactor for ALD

Wide parameter space:
- **relative composition of materials**
- **temperature**
- **different materials and thickness**



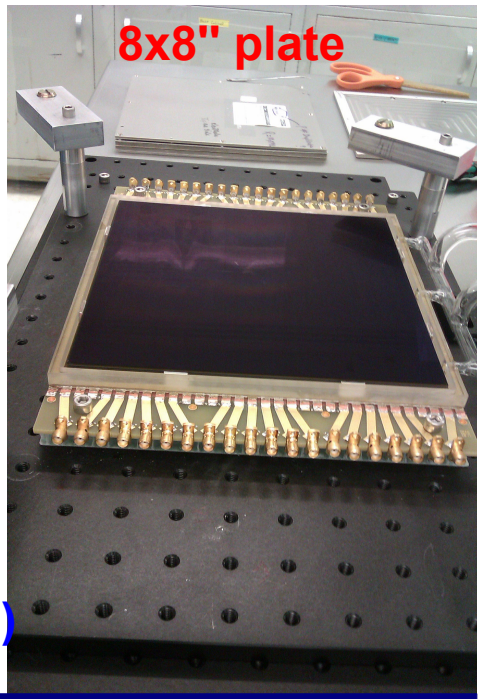


Porous glass

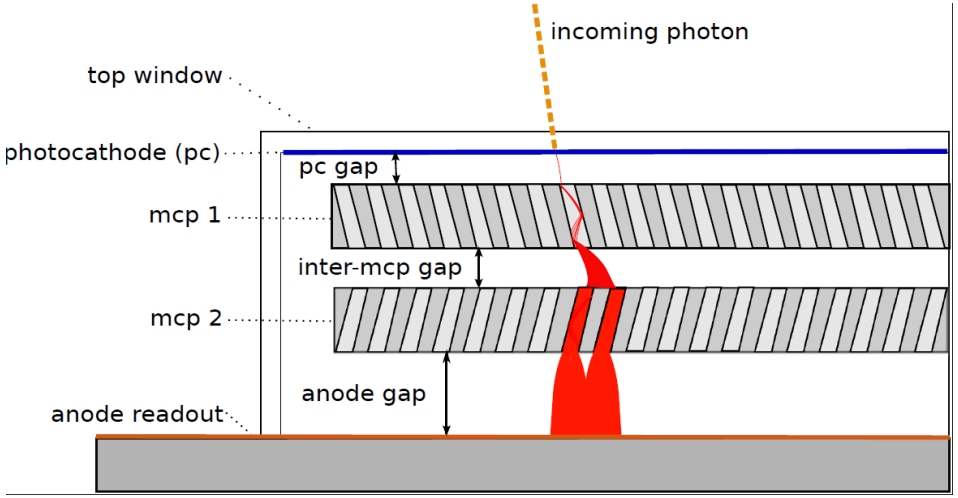
Resistive coating ~100nm (ALD)

Emissive coating ~ 20nm (ALD)

Conductive coating (thermal evaporation or sputtering)



MCP testing setup

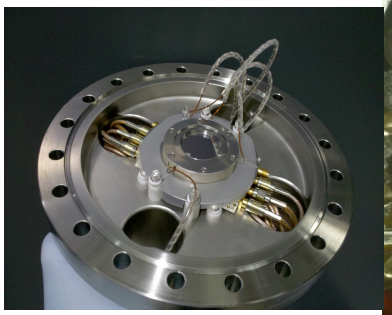


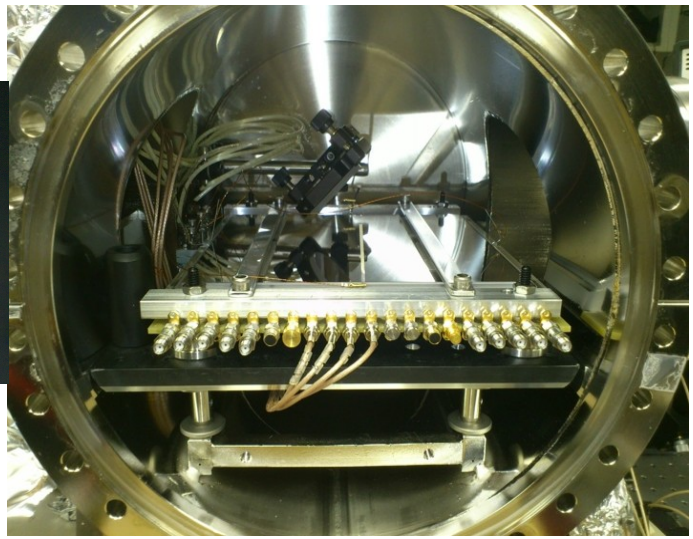
Vertical slice:

- Enclosed in vacuum chamber (10^{-7} – 10^{-8} torr)
- Aluminum photocathode (low quantum efficiency is compensated by high UV light intensity)
- Stack of MCP plates
- Anode (delay line 1.6 GHz bandwidth)
- Readout with high bandwitdth scope

MCP stack details

- Chevron geometry (8° bias angle)
- Spacing:
  - anode gap 0.7mm
  - inter MCP gap and PC gap 0.4mm
- Voltages:
  - PC gap ~200V
  - top MCP ~1kV
  - inter MCP gap ~200V
  - bottom MCP ~1kV
  - anode gap ~1kV



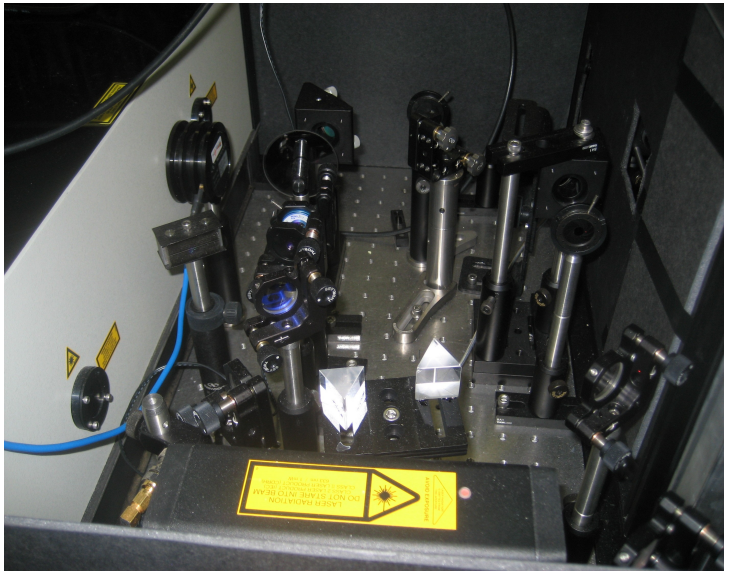


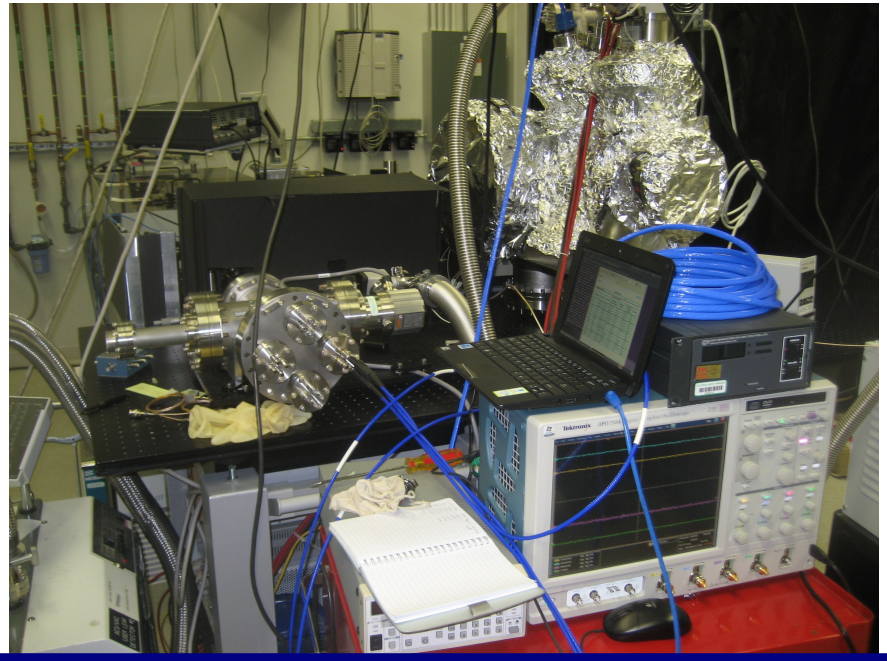
Laser

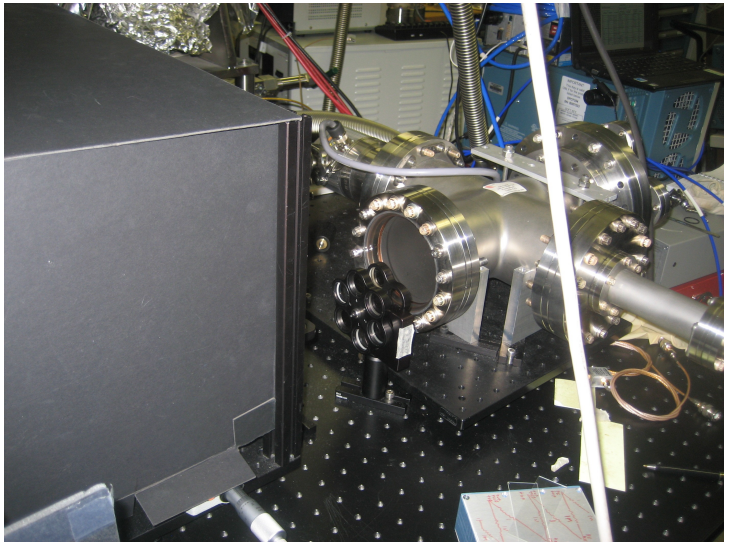
@ Advanced Photon Source Division (APS) Argonne National Laboratory

Sub-picosecond laser

- Ti:Sapph 800nm; power ~800 mW
- pulse duaration O(10) femtoseconds
- 1KHz repetion rate
- Non-linear optics to produce
- 266nm UV light







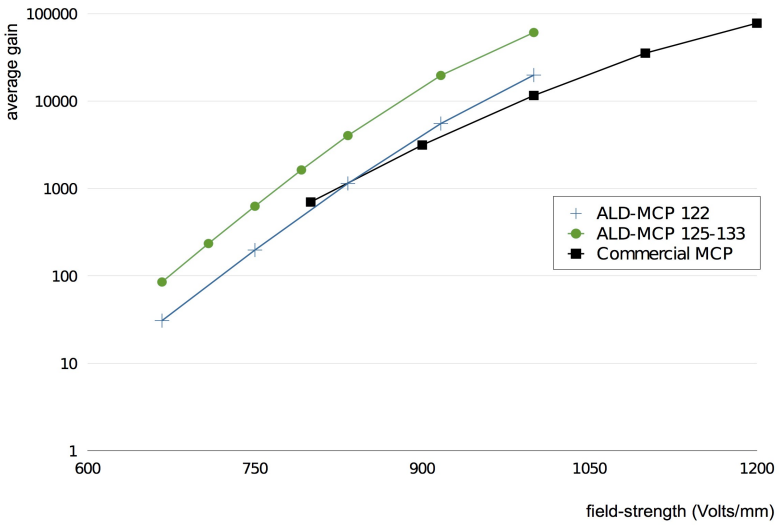
MCP characterization program

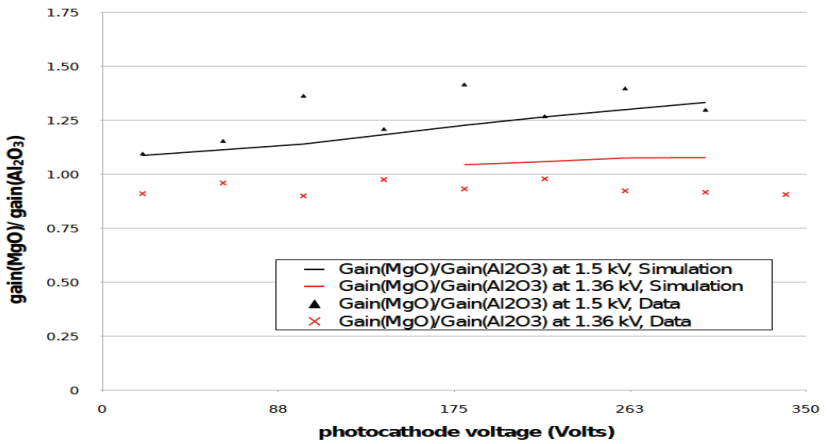
33mm MCP testing

- Quality control
  - gain
  - uniformity
- MCP fundamentals
  - emissive layers (Al_2O_3 vs MgO)
  - operational voltages (field strength)
  - feedback for Monte Carlo simulation

8" MCP testing

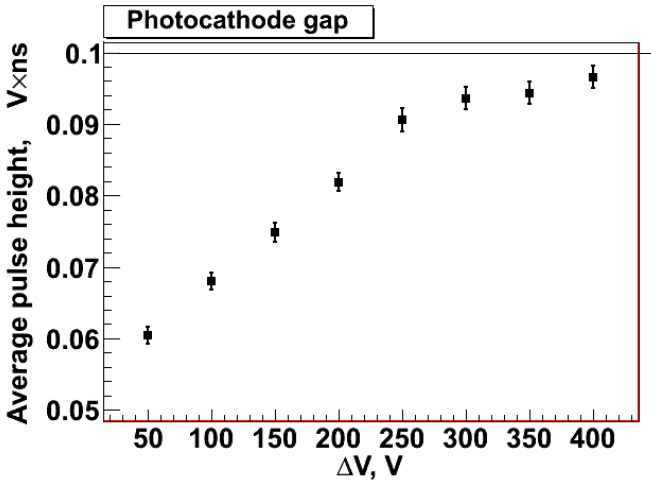
- Quality control
- Integration with anode and electronics
- Tests of vacuum assembly systems
- Code and algorithm development
- Position resolution
- Time resolution





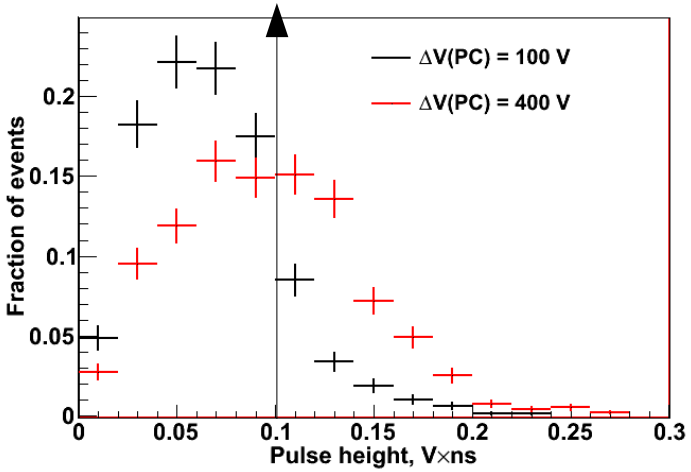
Gain with the MCP stack

pair of 40 MOhm 33mm MgO plates

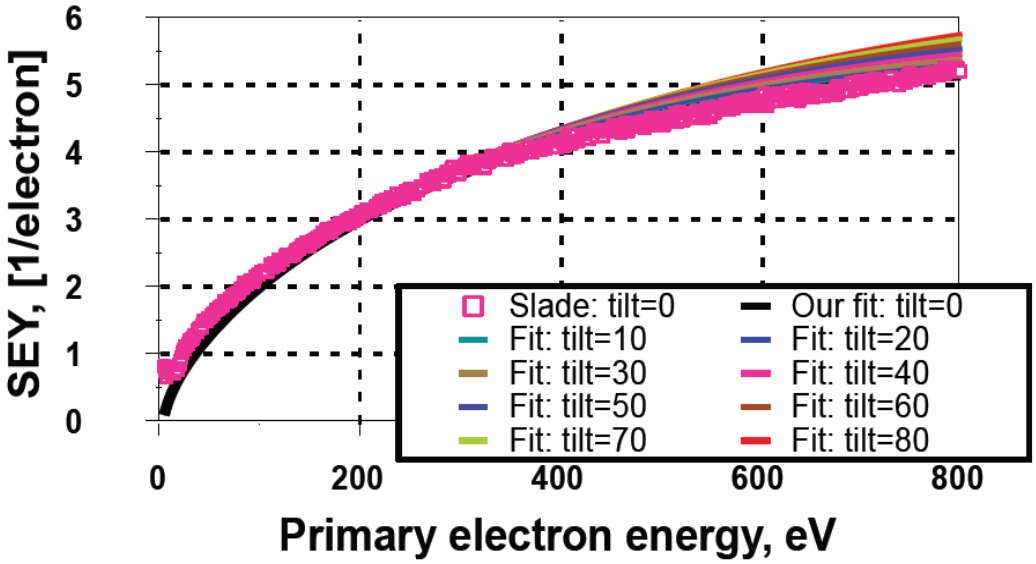


~2x10^7 electrons out

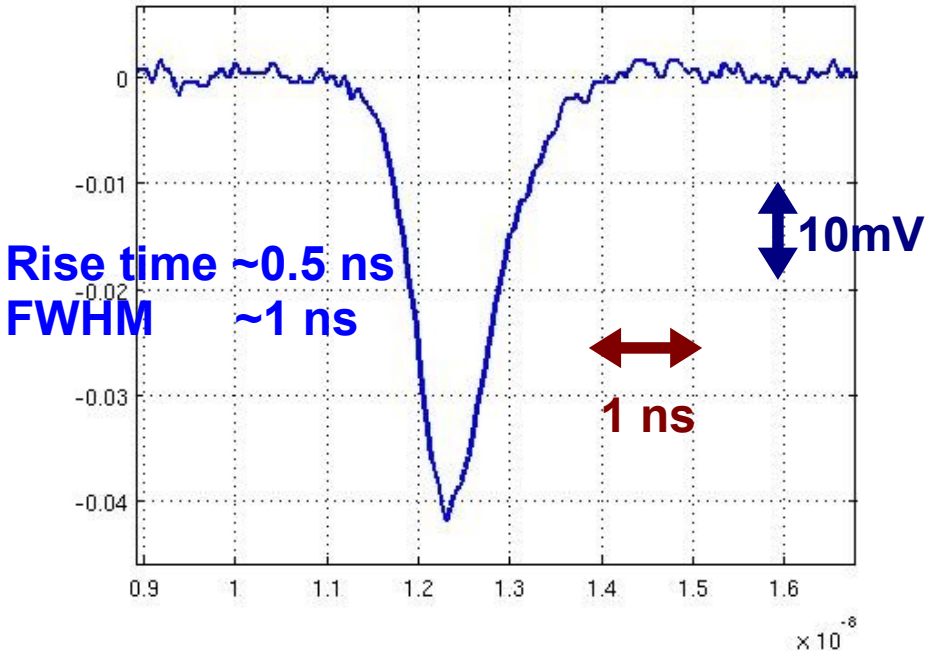
~2x10^7 electrons out



20 nm MgO SEY data



MCP pulses and timing



Timing analysis approach

- Fit rising edge
- Use constant fraction descriminant

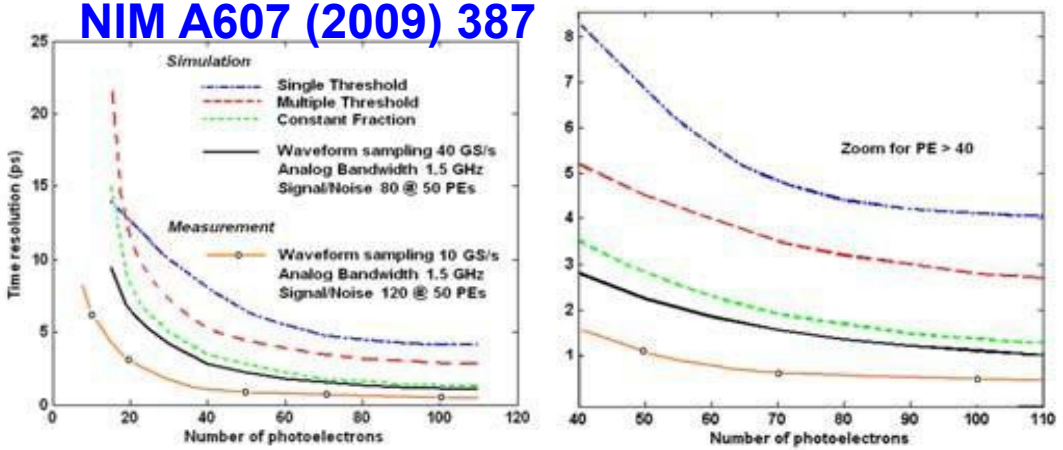
Questions

- Time resolution
- Position resolution

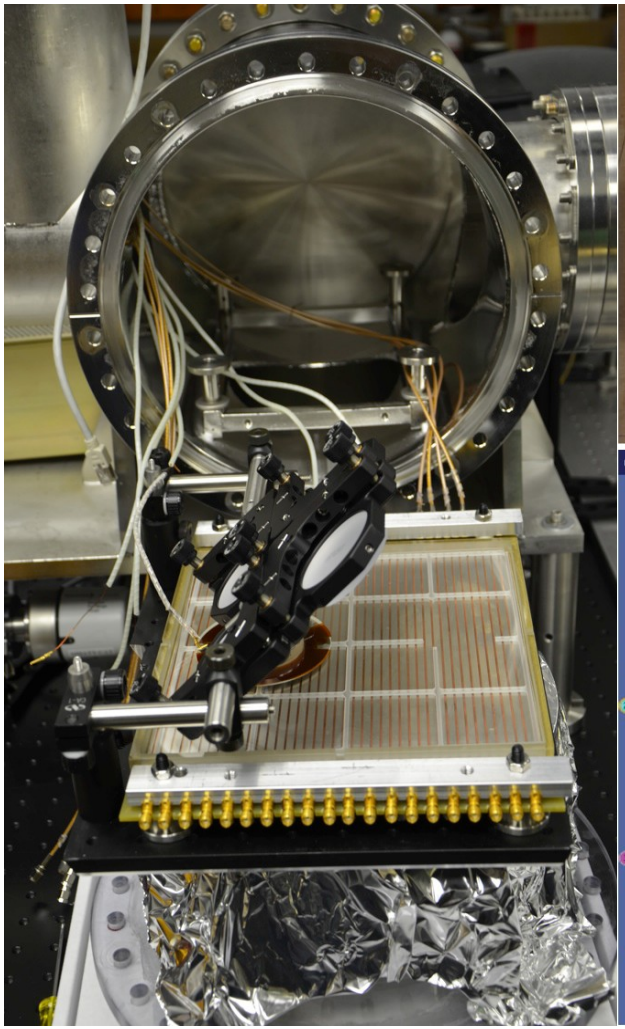
Time resolution determinants:

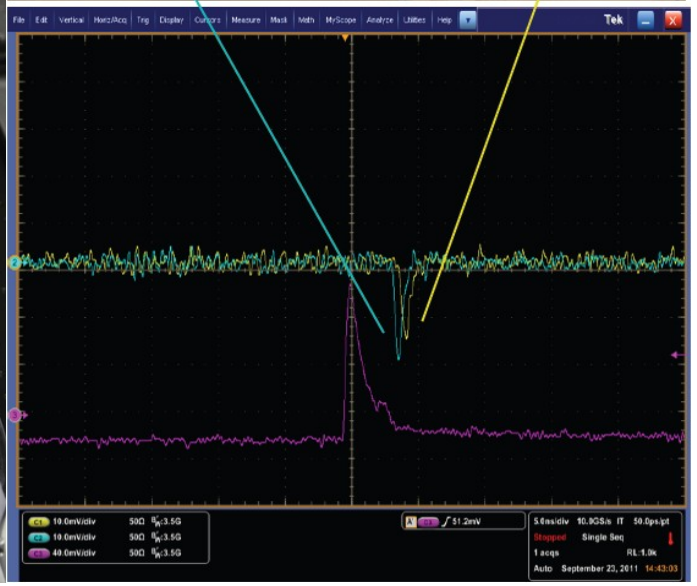
1) Signal to noise
2) Analog Bandwidth
3) Sampling rate
4) Signal statistics

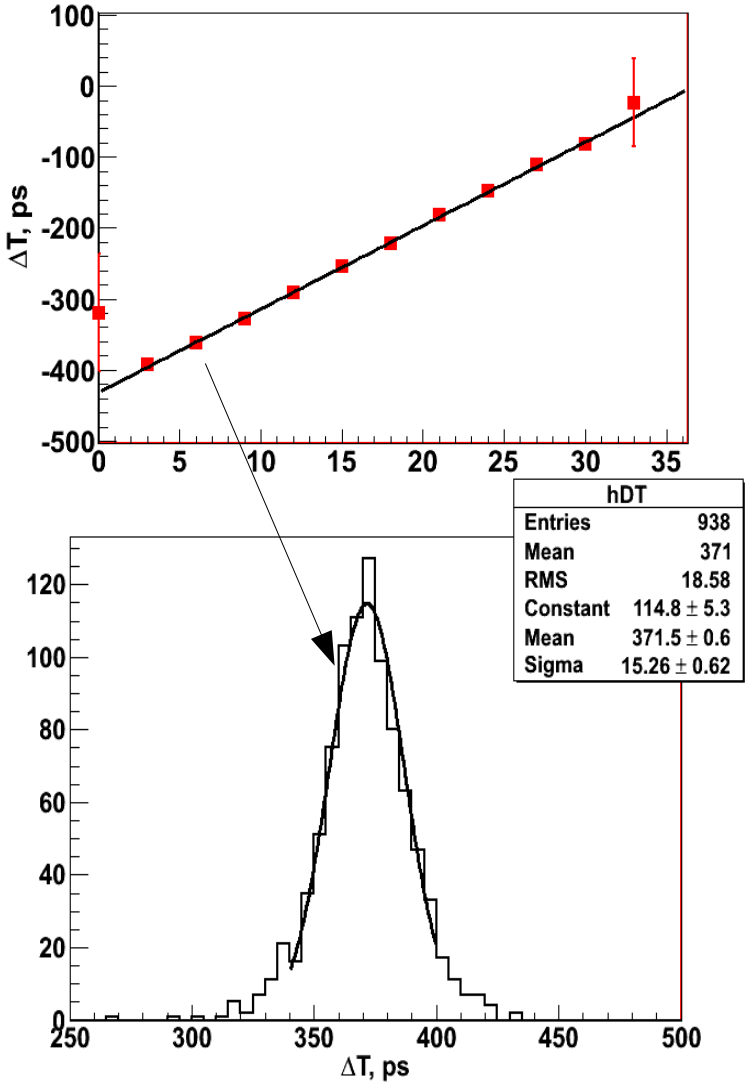
NIM A607 (2009) 387



First test with 8" setup





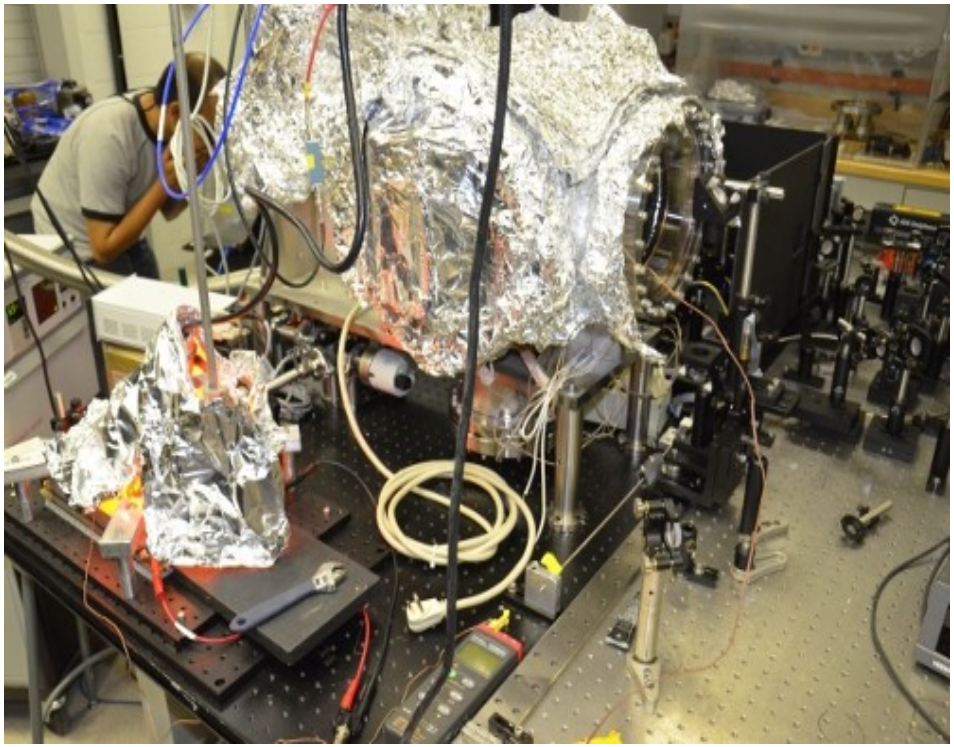


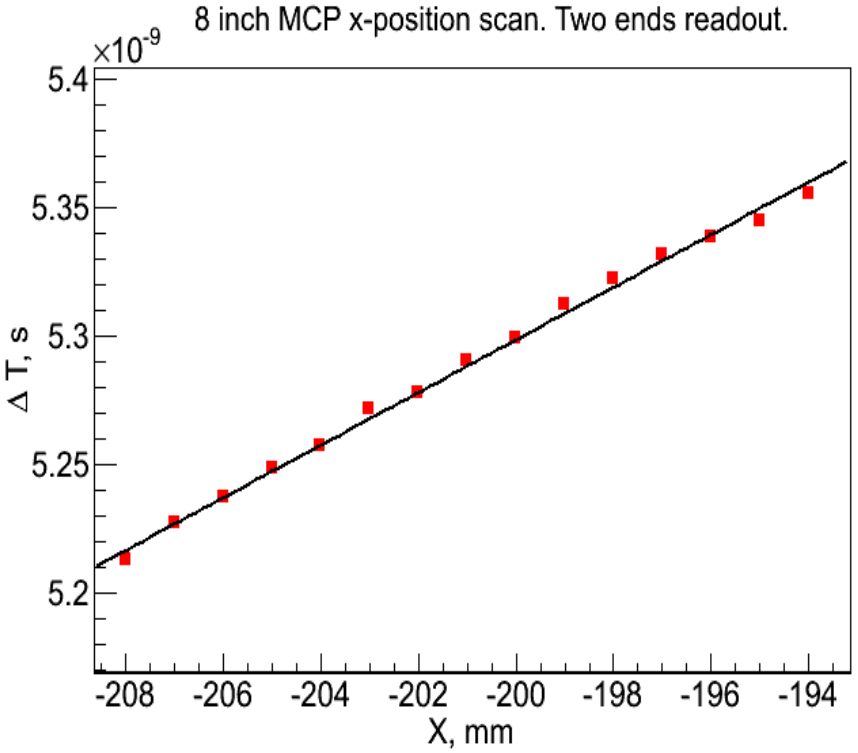
Slope 10ps/mm corresponds to 2/3 c signal propagation speed along the anode stripline

ΔT = 15ps

Position scan

automated translation stage capable of micron precision





Slope 10ps/mm corresponds to 2/3 c signal propagation speed along the anode stripline

$$\Delta X = 1/2 \ \Delta T \ 2/3c = 1.5mm$$

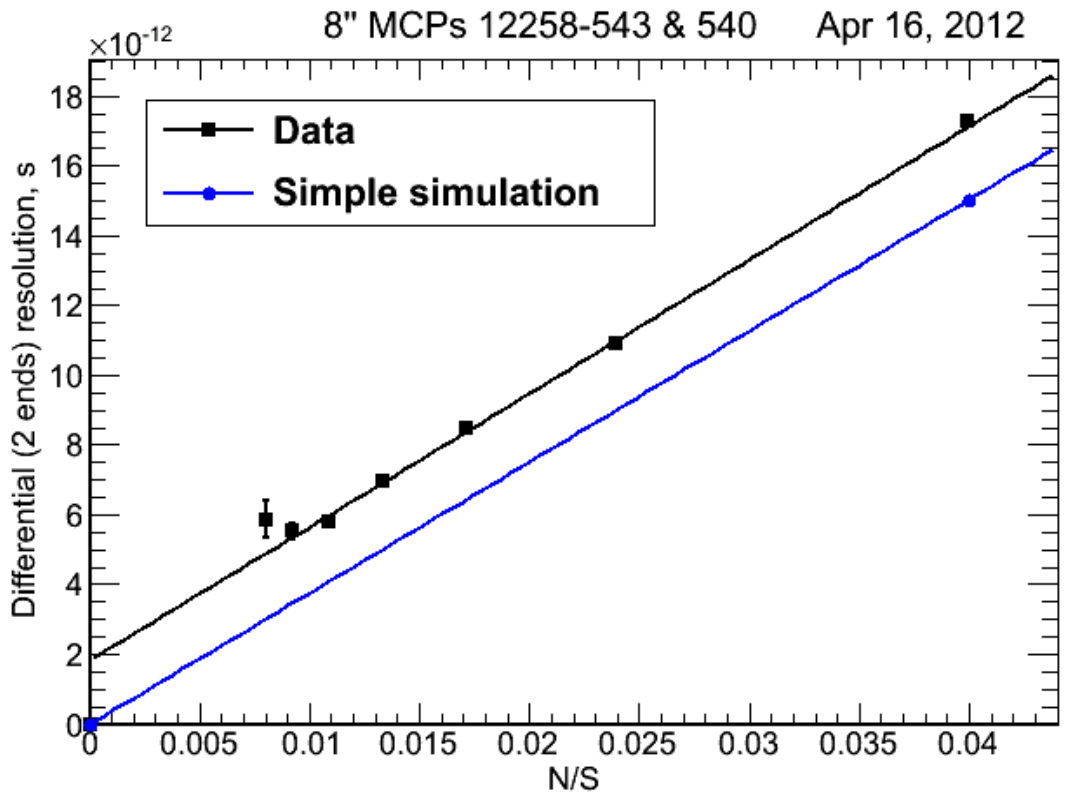
Differential time resolution and current limitations

Simulation

- Generated pulses with fixed shape. 100 ps spacing between points to simulate 10Gs/s scope sampling
- Simulate noise: each point smeared with RMS = Amplitude*X%
- Noise is independent at each point

Data

- Pulses comes from MCP plates
- Noise is dominated by laser pockel-cell (deterministic noise)



6 ps in ΔT → 0.6 mm in ΔX

2 ps in ΔT → 200 microns (consistent with laser beam)

Conclusions and Outlook

- Micro-Channels plates fabricated with Atomic Layer Deposition show very promising performance
- We are approaching picosecond domain with large area MCPs

Now testing the "demountable tile"
- Very close to real detector (Aluminum photo-cathode, O-ring, active pumping)
- First pulses came this morning