MicroMEGAS
+
T2K electronics

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LCTPC Collaboration Meeting - DESY

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Carleton UNIVERSITY

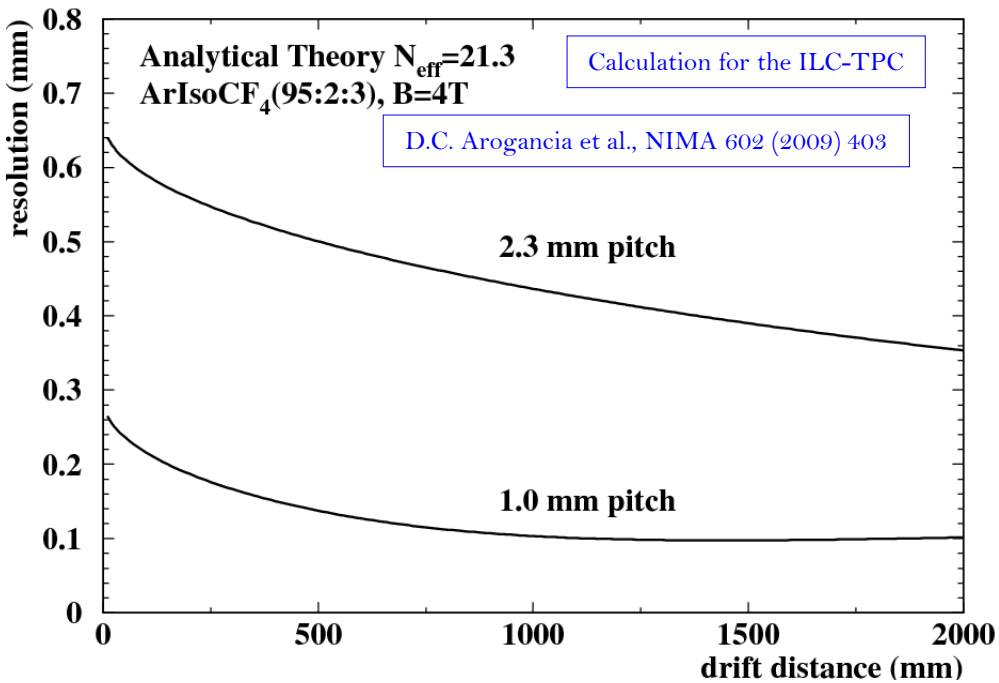
LC TPC

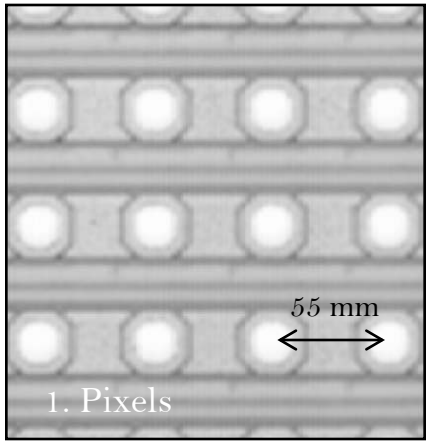
Outline

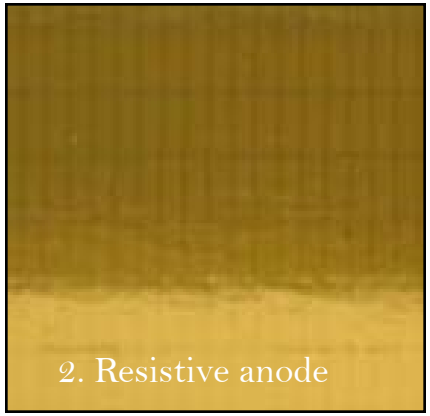
- Introduction, technological choice
- LP1 beam tests 2008-2009
  - Data taking periods
  - Monitoring
- T2K electronics
  - Specification
- Bulk Micromegas with resistive anodes
  - Carbon-loaded kapton
  - Resistive ink
- Analysis results
  - Drift velocity
  - Spatial resolution
  - Comparison
  - New method

Introduction

- Need for ILC: measure 200 track points with a transverse resolution ~ 100 µm
  - example of track separation with 1 mm x 6 mm pad size:
    - → 1,2 10^6 channels of electronics
    - → $\sigma_{z=0}$ > 250 µm amplification avalanche over one pad
- Spatial resolution σ_{xy}:
  - limited by the pad size (σ_0 ~ width/√12)
  - charge distribution narrow ($RMS_{avalanche}$ ~ 15 µm)





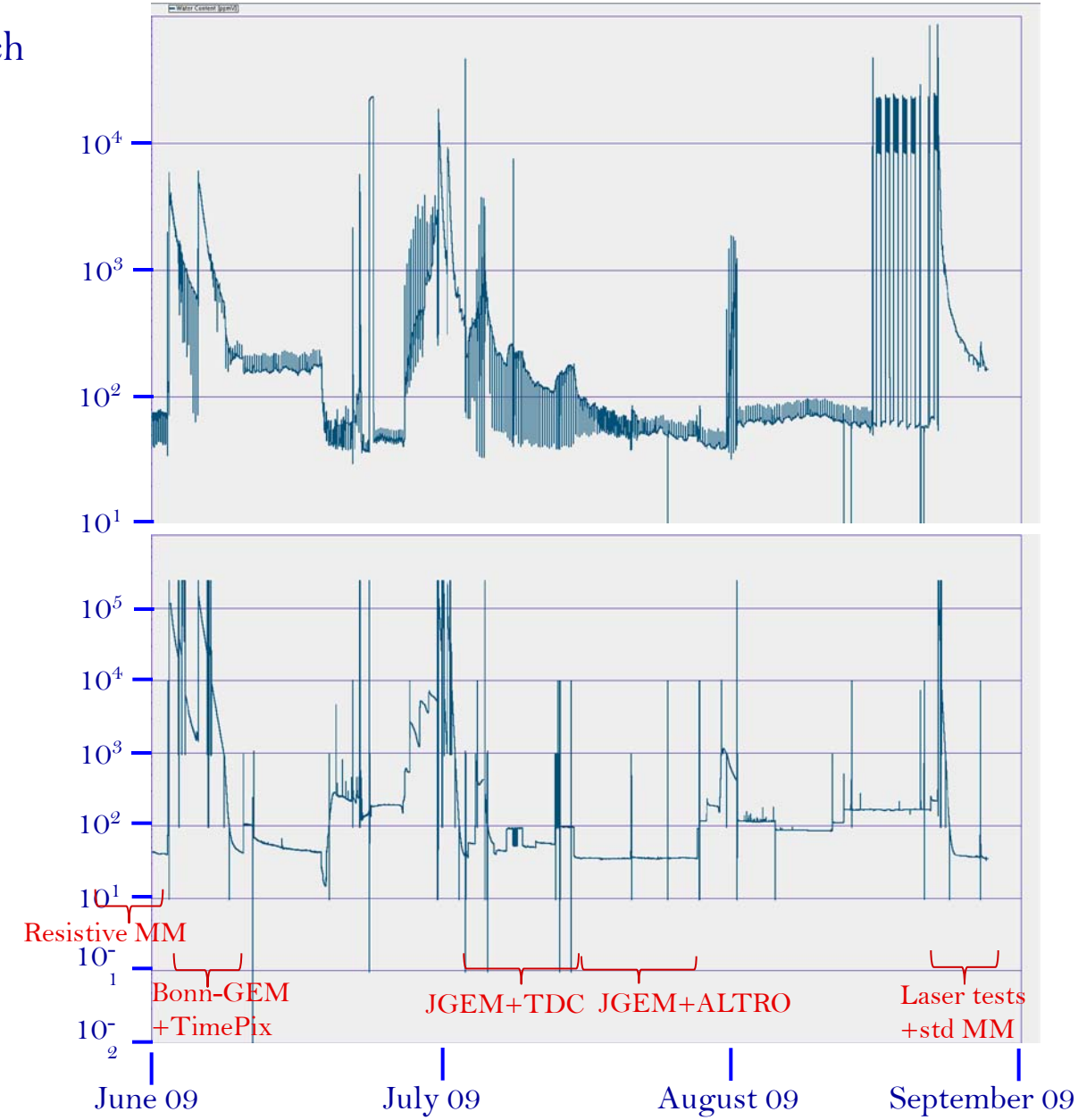


Data taking

- Installation of Micromegas module + electronics in the LP1 in one hour
- Smooth operation
- Premixed bottle of $Ar/CF_4/Iso\text{-}C_4H_{10}$; 97/3/2 (T2K gas)
- SiPM cosmic trigger (Saclay contribution) very stable (0.65 Hz)
- Three periods of data taking:
  - November-December 2008: Standard, Resistive Kapton
    - Cosmic runs: 3 days
    - Beam runs at B=0T: 10 days
    - Beam runs at B=1T: 7 days
  - May-June 2009: Resistive Ink, Resistive Kapton
    - Beam runs at B=1T: 2.5 days
  - August 2009: Standard
    - Laser runs at B=1T: 3 days

Monitoring history

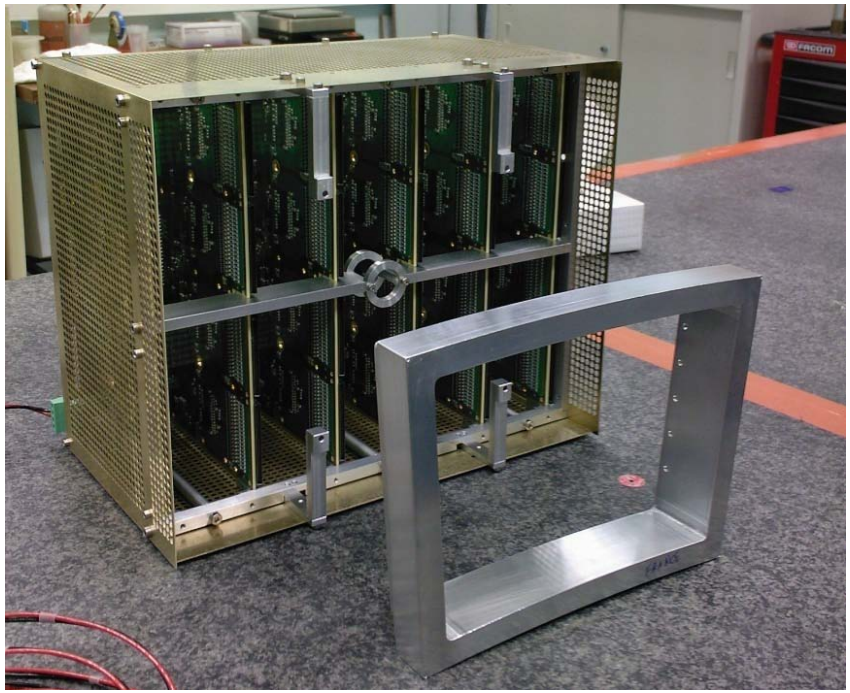
- 1 to 2 days at 45 L/h to reach operation values:
  - H_2O: 140 ppm
  - O_2: 30 ppm

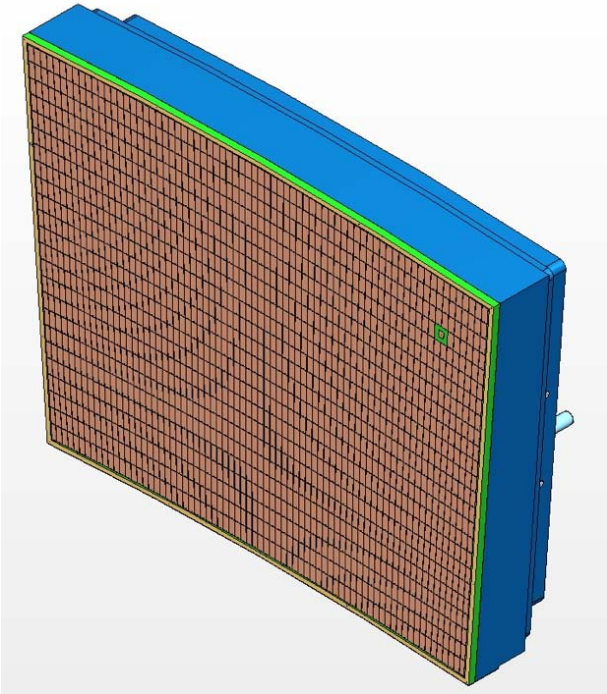


- Water content (ppm):
- Oxygen content (ppm):

T2K electronics characteristics

- AFTER-based electronics (72 channels/chip) from T2K experiment:
  - low-noise (700 e-) pre-amplifier-shaper
  - 100 ns to 2 µs tunable peaking time
  - full wave sampling by SCA
  - Zero Suppression capability
  - frequency tunable from 1 to 100 MHz (most data at 25 MHz)
  - 12 bit ADC (rms pedestals 4 to 6 channels)
  - pulser for calibration
  - November 2008: AFTER 06'
  - May-June 2009: AFTER 08' with possibility to by-pass the shaping
- Bulk Micromegas detector: 1726 (24x72) pads of ~3x7 mm²





Bulk Micromegas module fro LP1

- Three panels were successively mounted and tested in the Large Prototype and 1T magnet:
  - standard anode
  - resistive anode (Carbon-loaded Kapton) with a resistivity ~ 4-8 MΩ/
  - resistive ink (~1-2 MΩ/)

Nov.-Dec. 2008

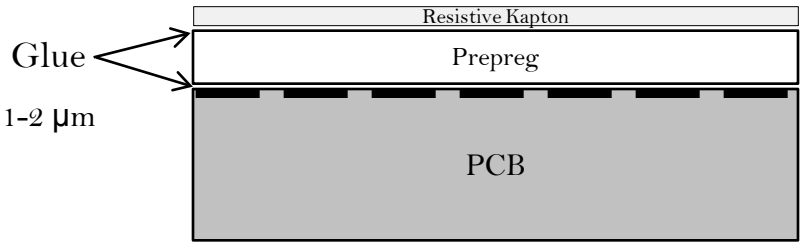
May-June 2009

Standard bulk Micromegas module

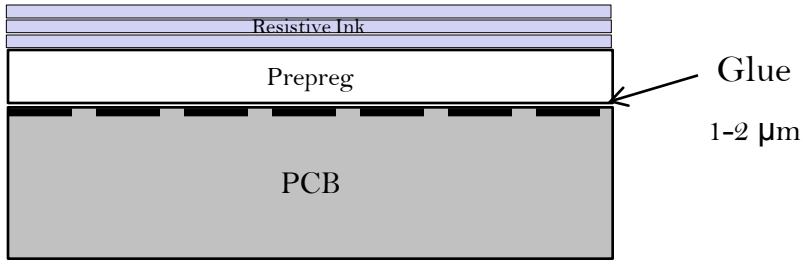
Carbon loaded kapton Micromegas module

Description of the resistive anodes

Resistive Kapton

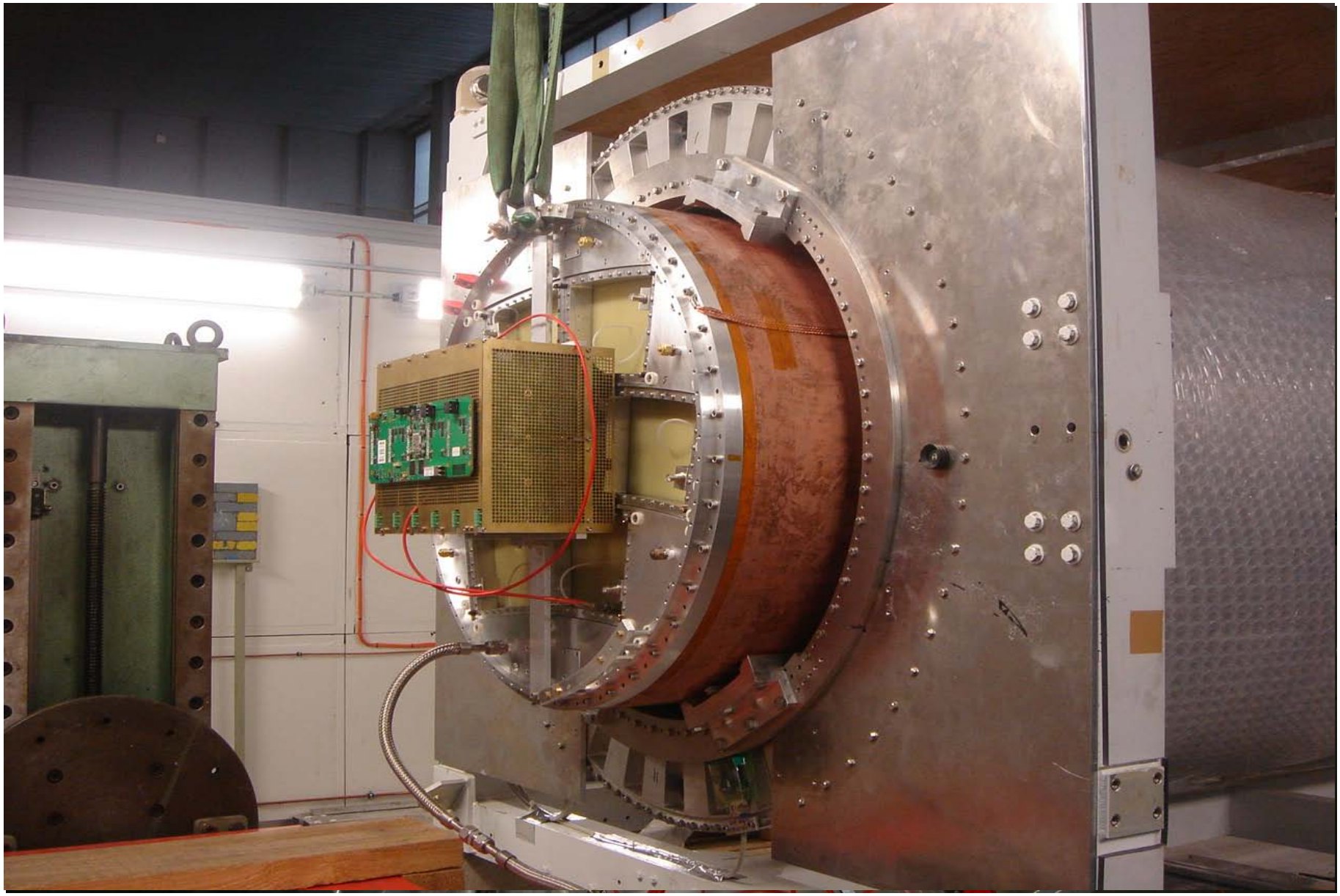


Resistive Ink

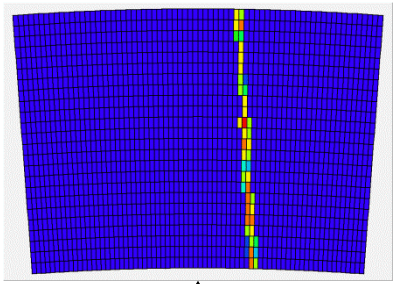


Detector	Dielectric layer	Resistive layer	Resistivity (MΩ/)
Resistive Kapton	Epoxy-glass 75 µm	C-loaded Kapton 25 µm	~4-8
Resistive Ink	Epoxy-glass 75 µm	Ink (3 layers) ~50 µm	~1-2

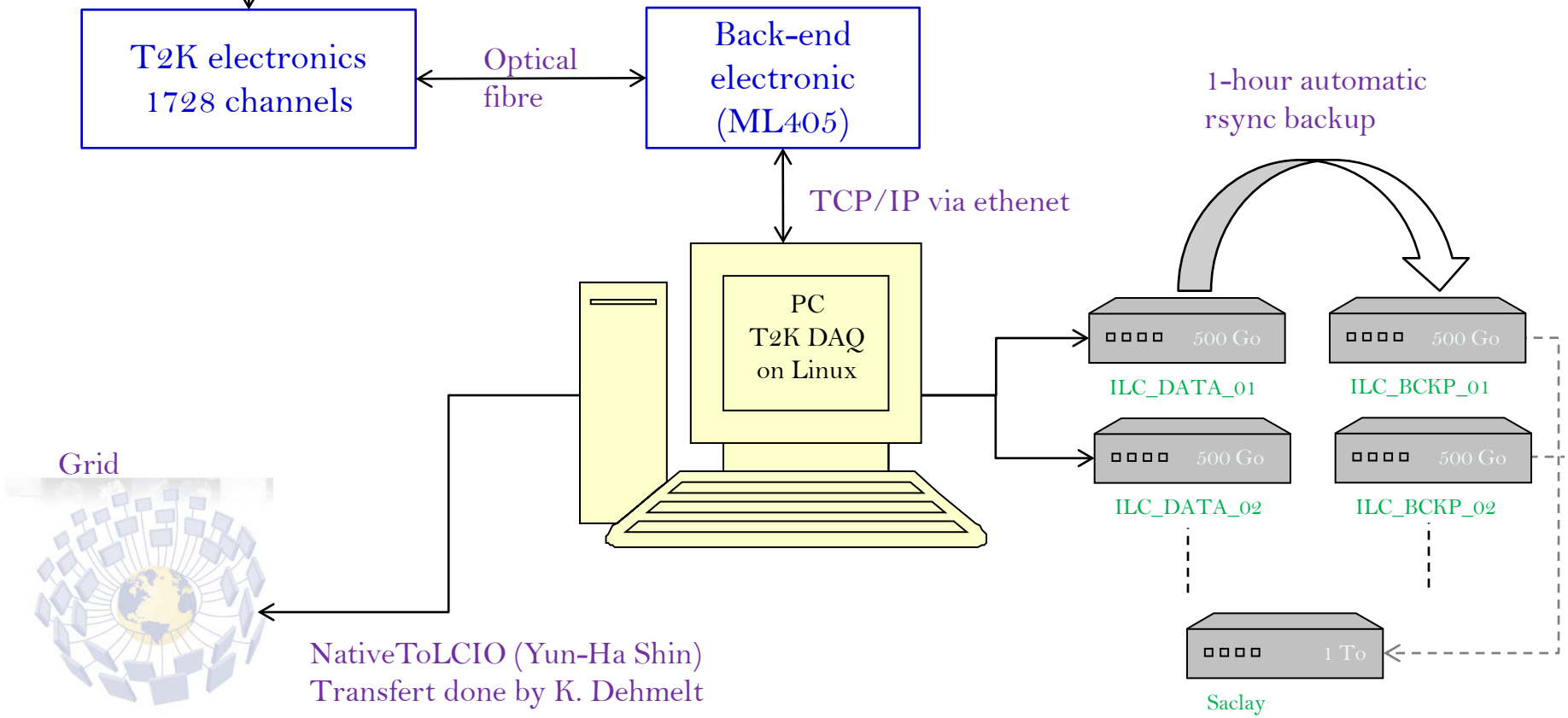
Micromegas + T2K electronics in LP1



Data flow



DAQ:
- Maximum rate: 14 Hz (Zero Suppression mode)
- Triggered by beam (no TLU)
- Easy to use (GUI)



5 GeV beam data summary (B=1T)

- November-December 2008: AFTER 06'

		Standard E_{drift}=230 V/cm					Low diffusion E_{drift}=140 V/cm				
		Peaking time (ns)					Peaking time (ns)				
		100	200	500	1000	2000	100	200	500	1000	2000
Z (cm)	5.4	311	309	310	287	288		308	307	304	305
	11.1	395	396	397	398	399	407	408	409	410	411
	21.1	353	354	355	356	357	363	364	365	366	367
	31.1	329	333	334	335	336	330	343	344	345	346
	41.1	373	374	377	378	379	385	386	387	388	389
	51.1	312	313	314	315	316	326	430	431	432	433

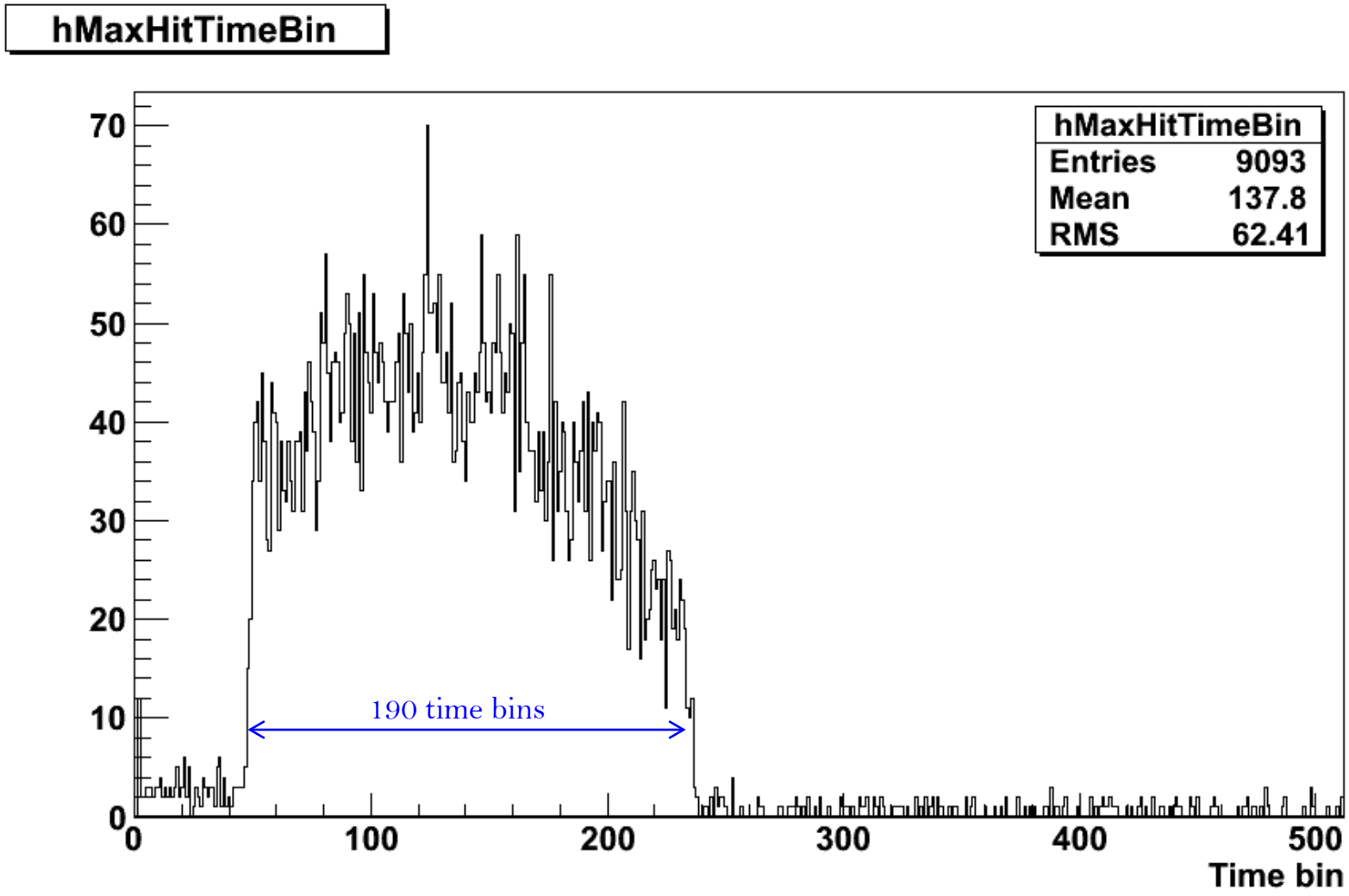
- May-June 2009:
  AFTER 08' with possibility to by-pass the shaping

	Standard conditions (25 MHz) 230 V/cm		
	Peaking time (ns)		
z (cm)	100 no Shaping		500 + Shaping
	ZS	No ZS	ZS
4.3	575/576	583	571
10	586	587/588	584
15	606	607	604
20	600	601/602	599
25	608	609	610
30	591	592	590
40	597	598	596
50	594	595	593

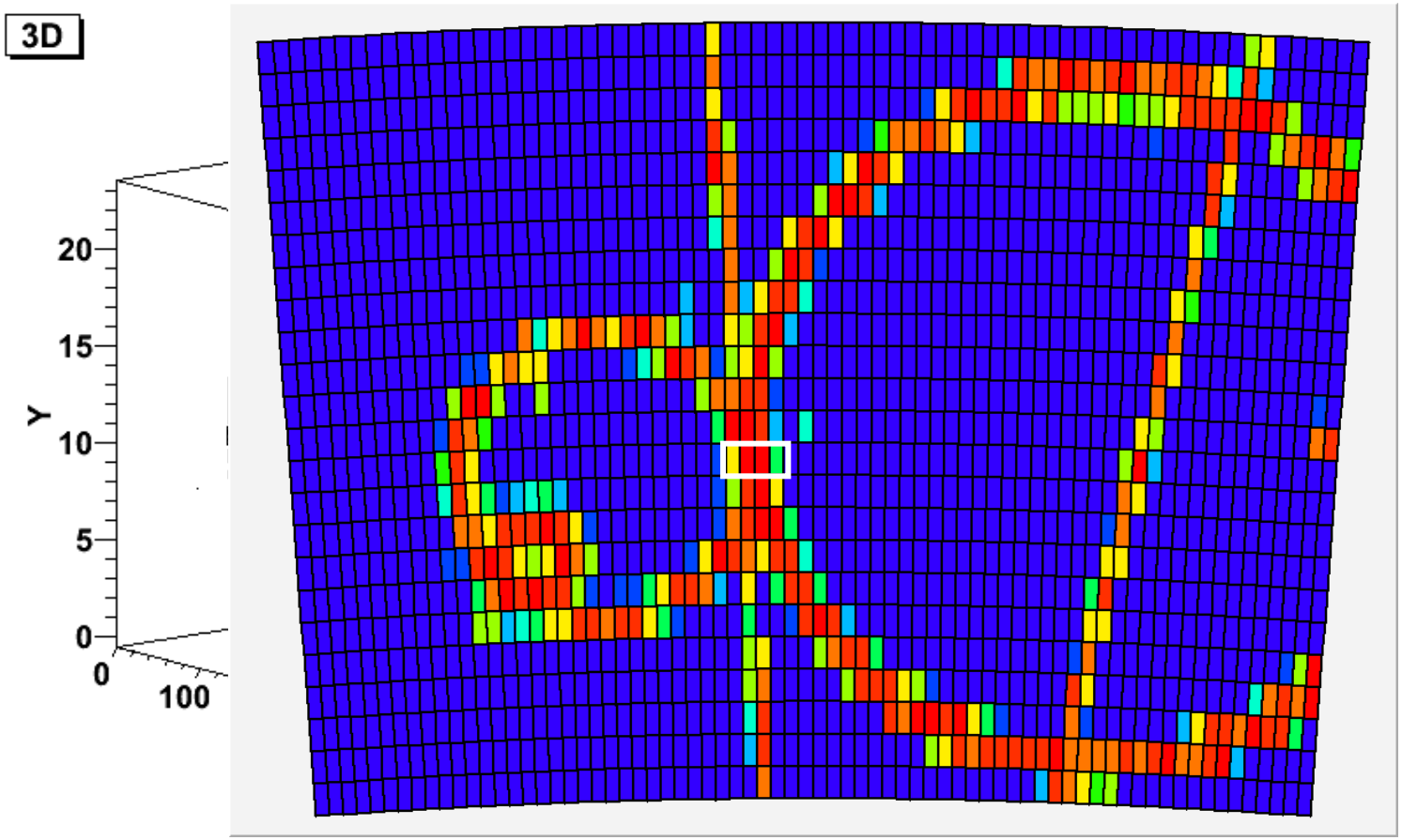
Resistive Kapton run numbers

Determination of z range

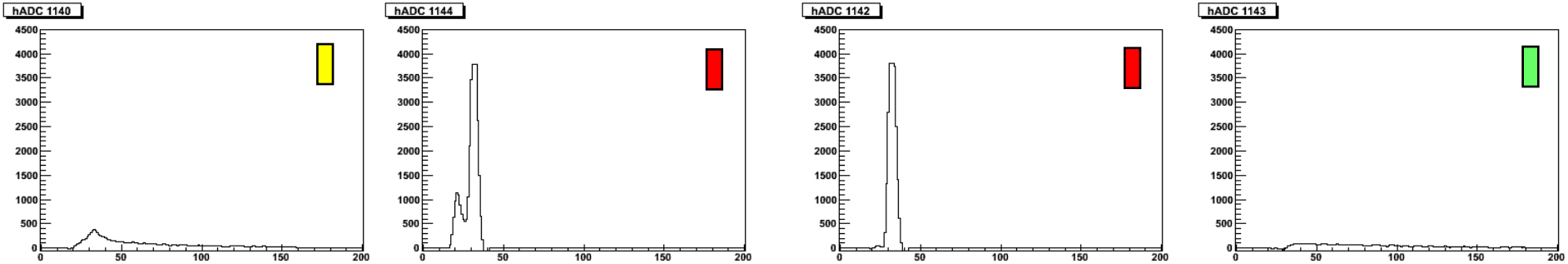
- Cosmic run at 25 MHz of sampling frequency → time bin = 40 ns
- TPC length = 56.7 cm agreement with survey



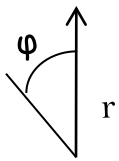
Pad signals: beam data sample

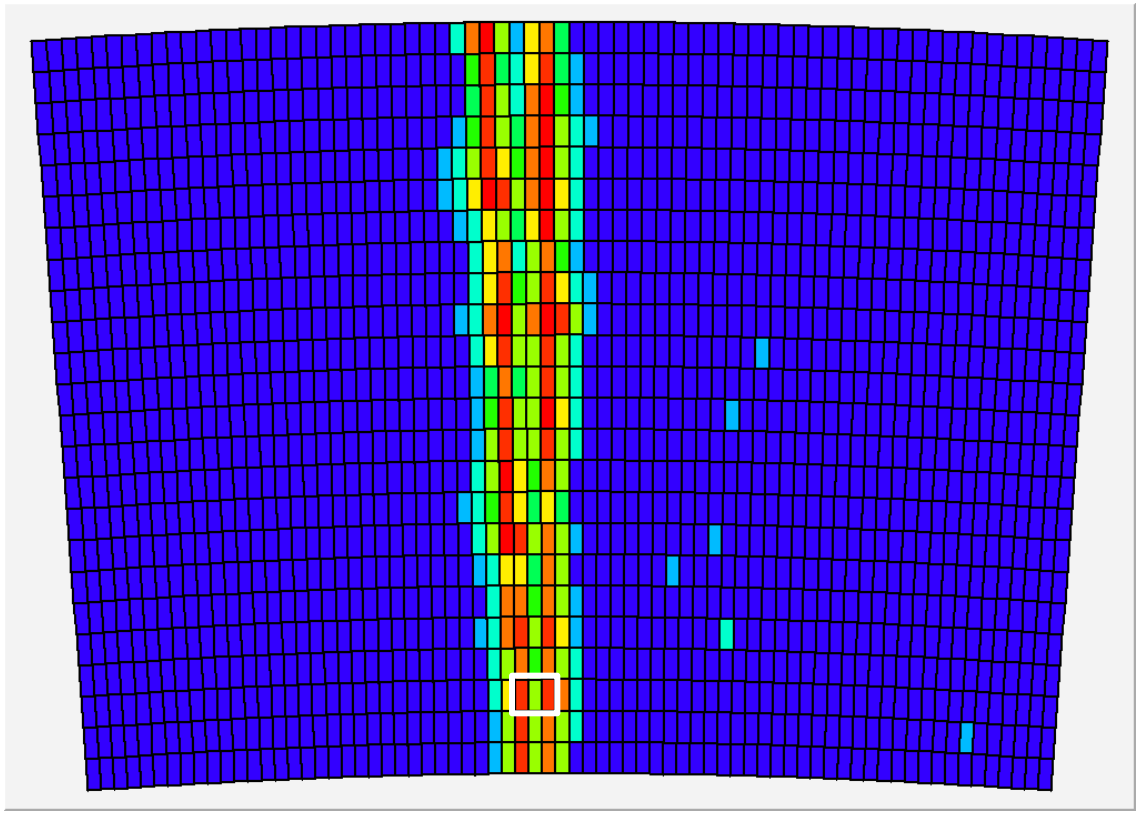


- B = 1T
- T2K gas
- Peaking time: 100 ns
- Frequency: 25 MHz
- z = 5 cm

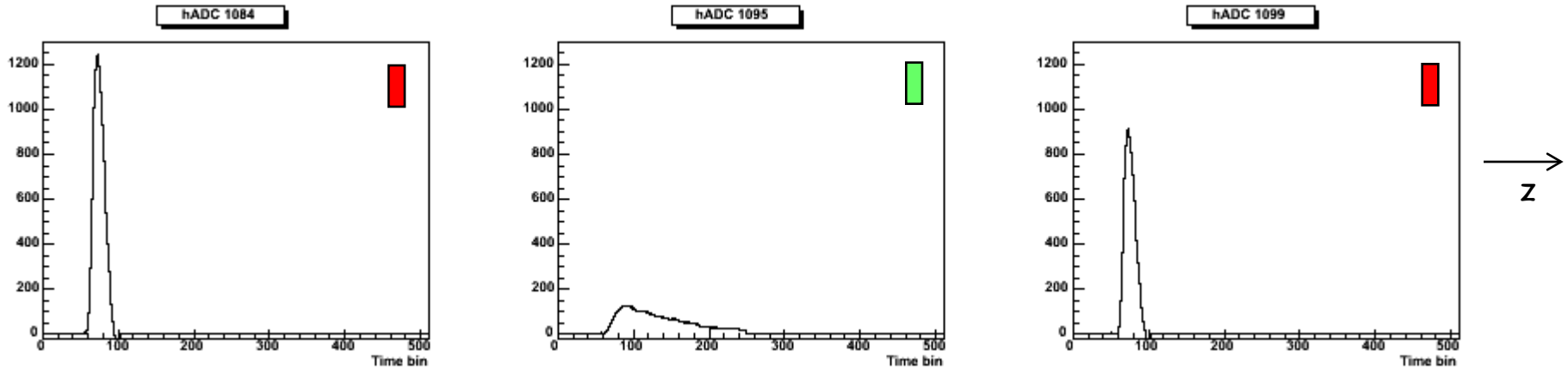


Two-track separation capability





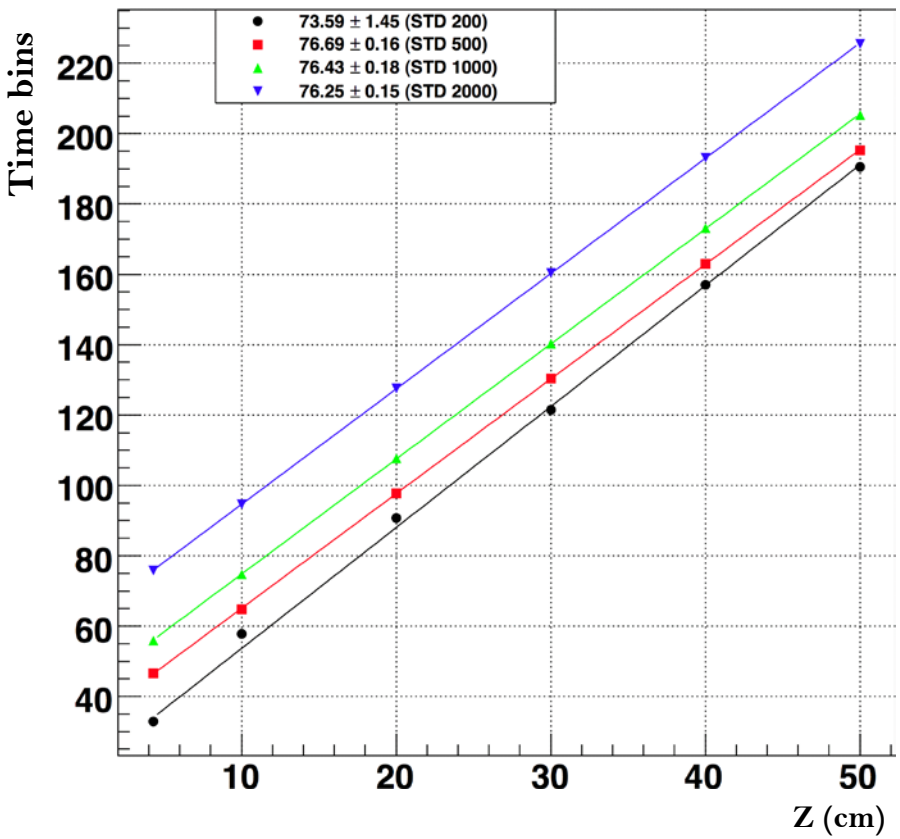
- B = 0T
- T2K gas
- Peaking time: 100 ns
- Frequency: 25 MHz
- z = 5 cm

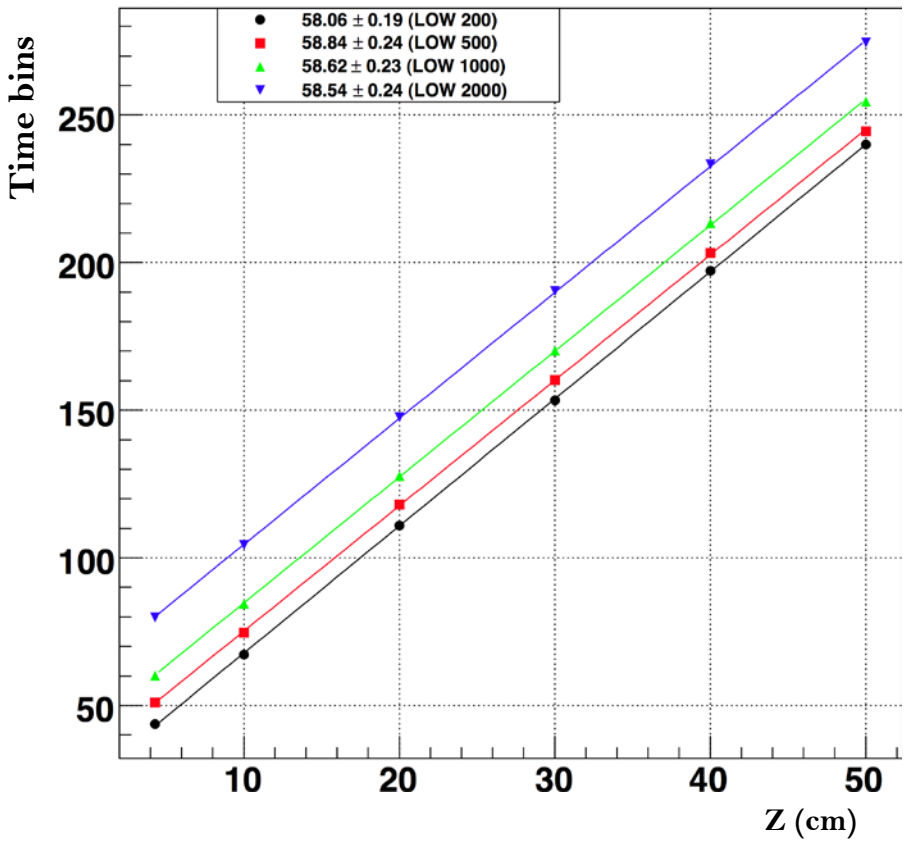


Drift velocity vs. peaking time

Resistive Kapton

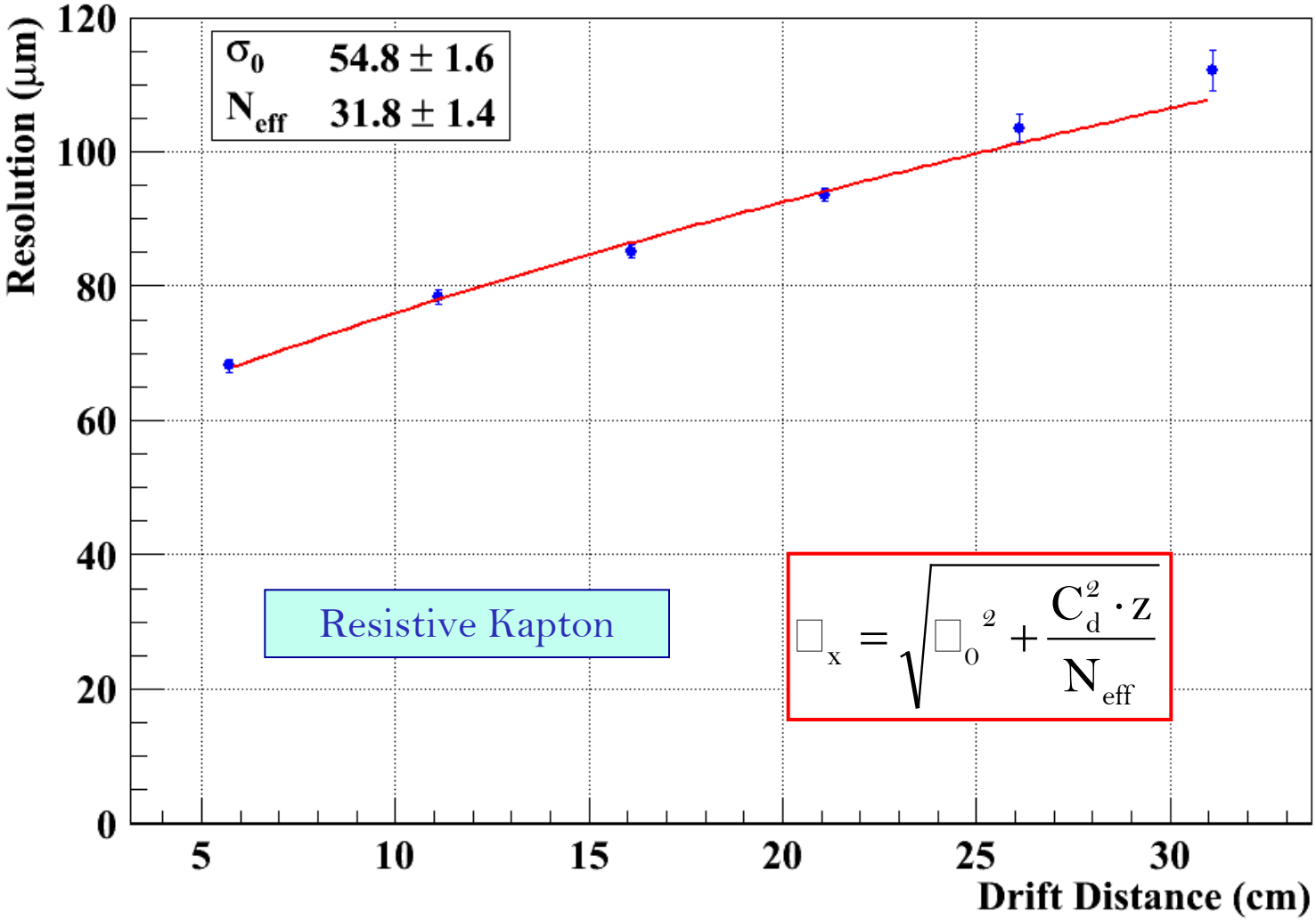
- B=1T data
- For several peaking time settings: 200 ns, 500 ns, 1 µs, 2 µs
  - E_{drift} = 230 V/cm
  - $V_d^{Magboltz}$ = 76 µm/ns
  - E_{drift} = 140 V/cm
  - $V_d^{Magboltz}$ = 59 µm/ns





Spatial resolution

- Resolution at z=0: σ_0 = 54.8±1.6 μm with 2.7-3.2 mm pads ($w_{pad}/55$)
- Effective number of electrons: N_{eff} = 31.8±1.4 consistent with expectations

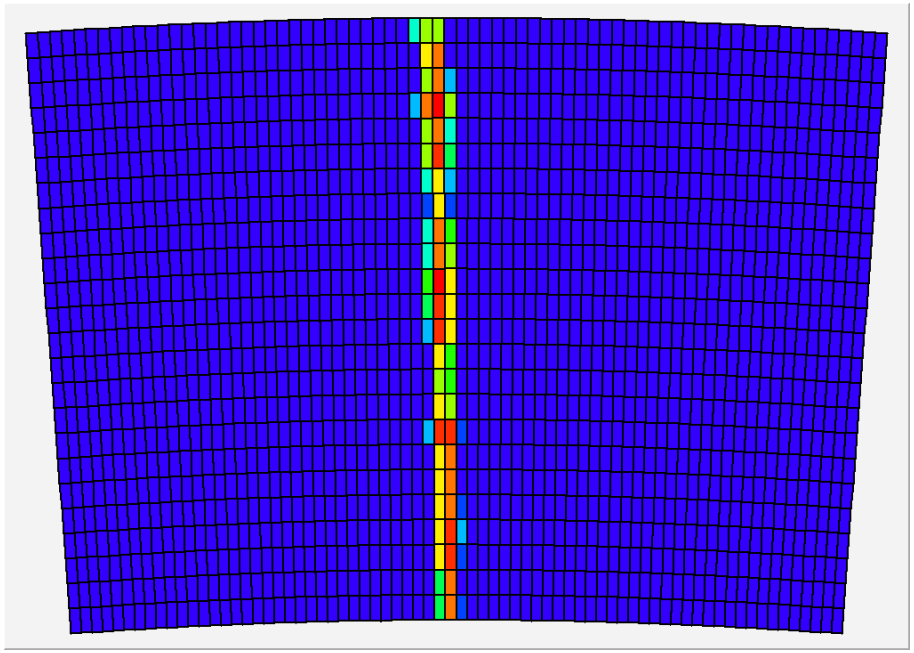


$$\square_x = \sqrt{\square_0^{\,2} + \frac{C_d^2 \cdot z}{N_{eff}}}$$

Comparison at B=1T, z ~ 5 cm

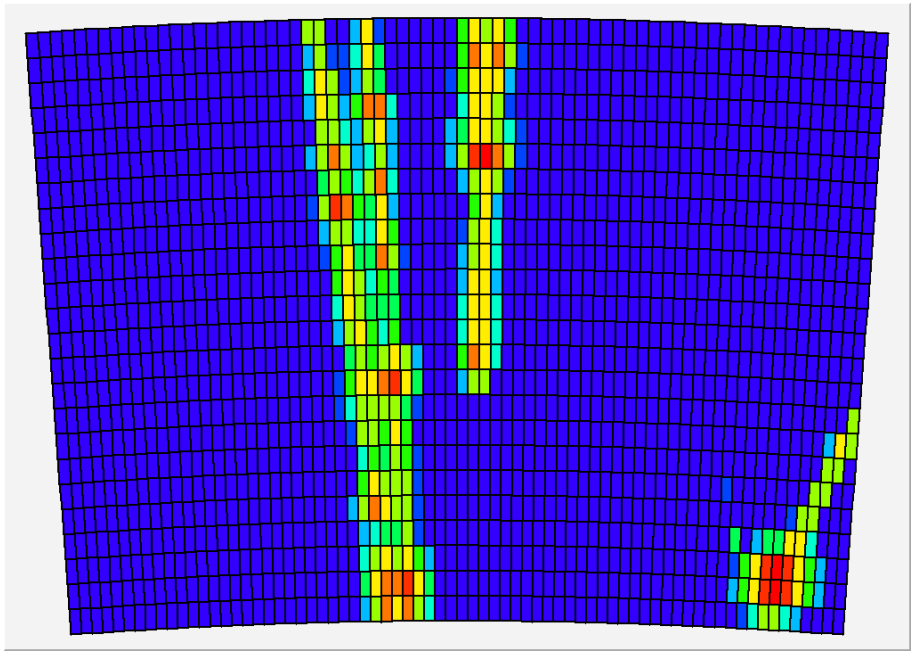
Resistive Kapton

- RUN 310
- v_{drift} = 230 cm/μs
- V_{mesh} = 380 V
- Peaking time: 500 ns
- Frequency Sampling: 25 MHz



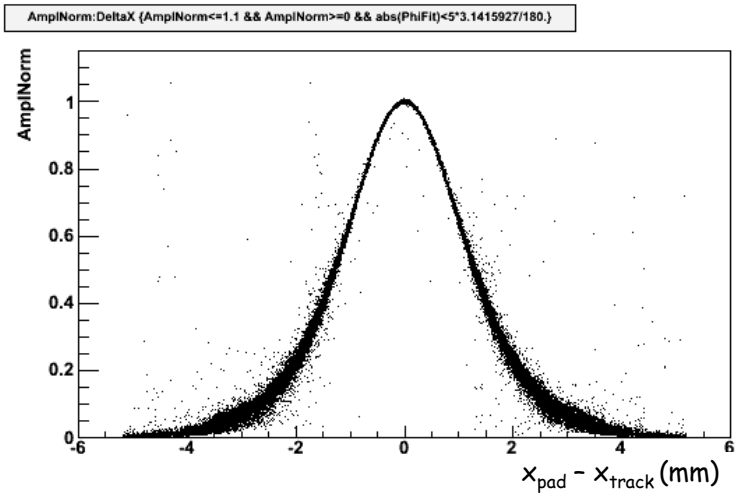
Resistive Ink

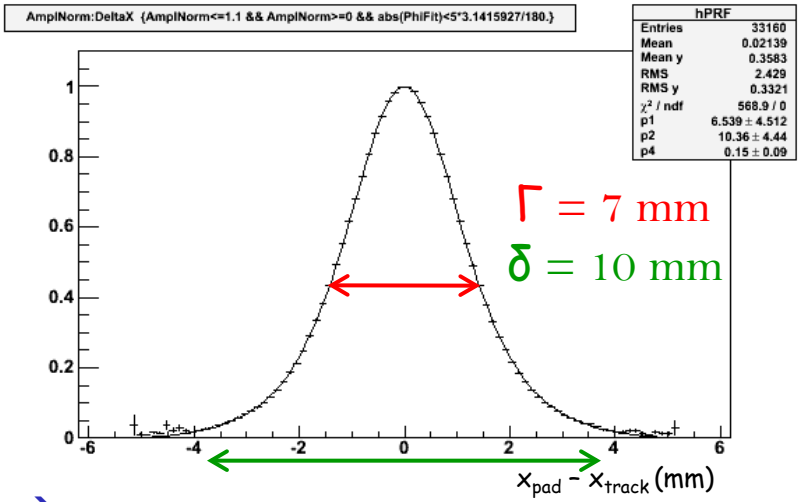
- RUN 549
- V_{drift} = 230 cm/μs
- V_{mesh} = 360 V
- Peaking time: 500 ns
- Frequency Sampling: 25 MHz



Pad Response Functions, z ~ 5 cm

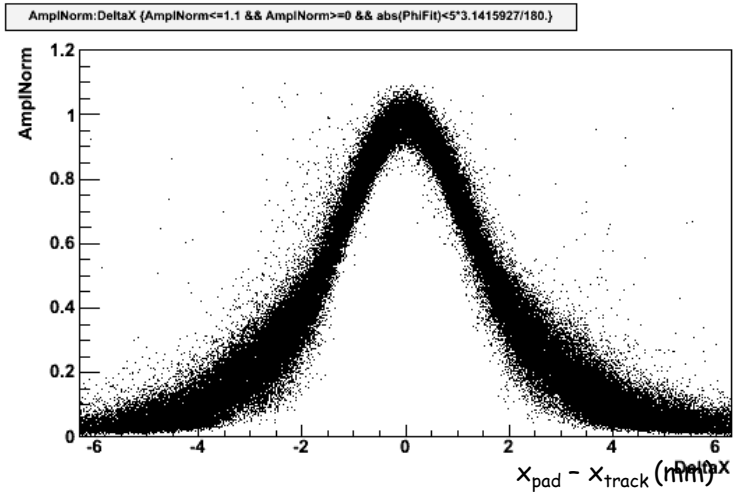
Resistive Kapton

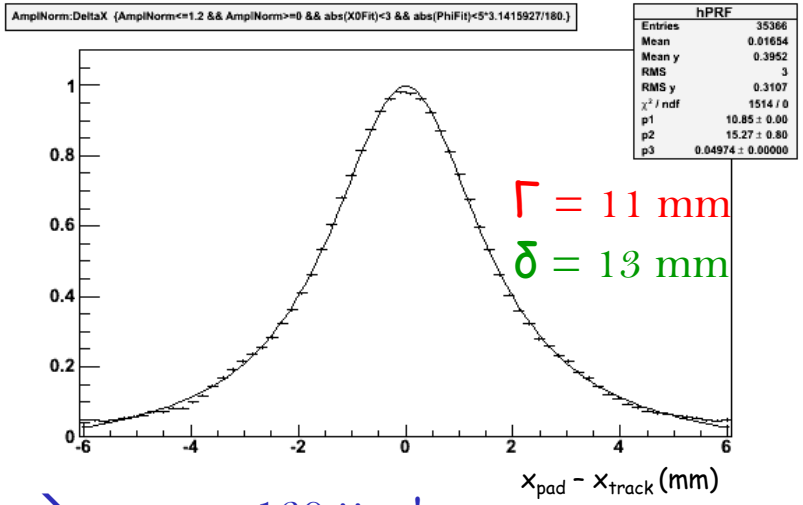




→ $\sigma_{z=5\ cm} = 68\ \mu m$

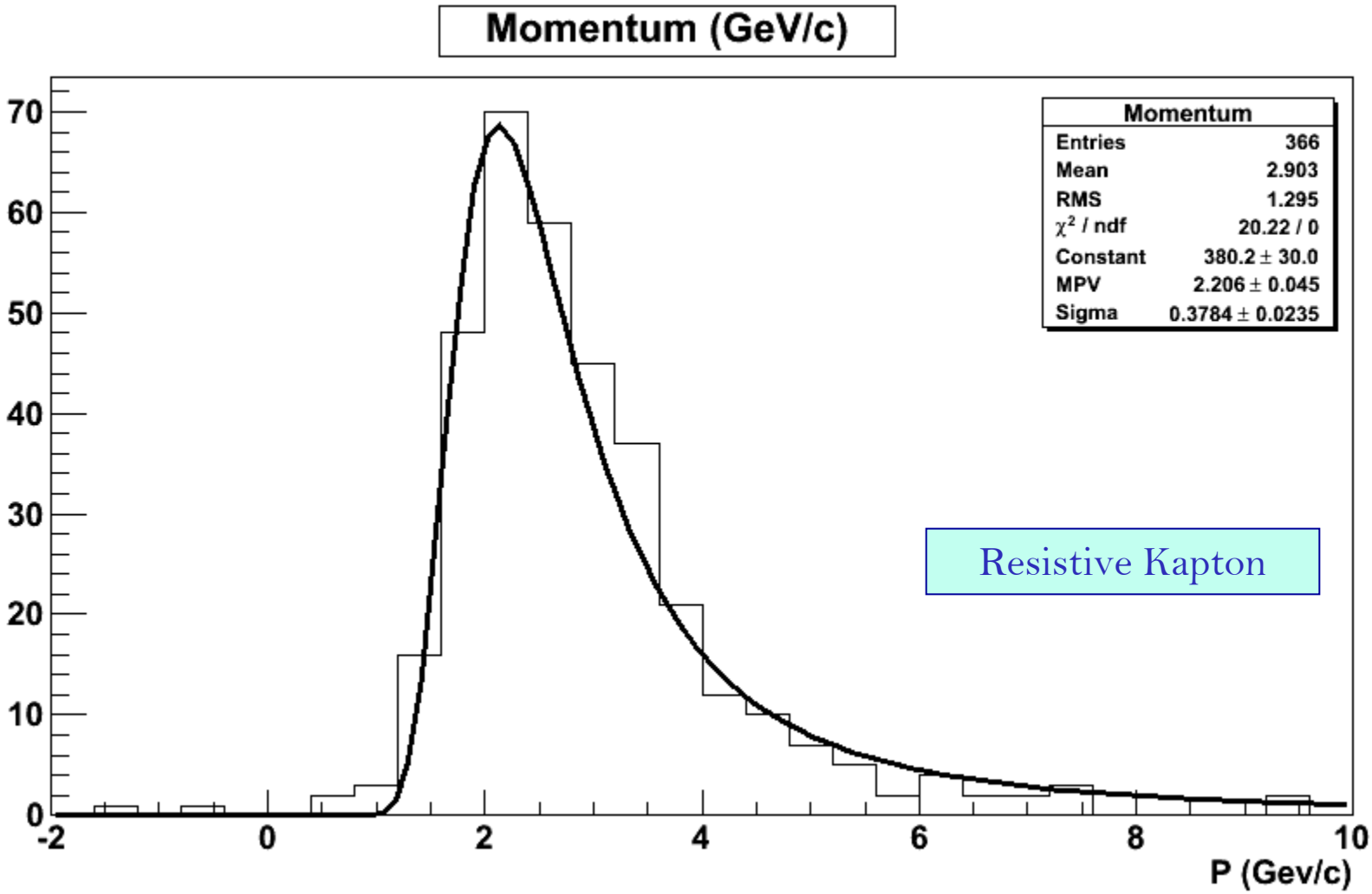
Resistive Ink





→ $\sigma_{z=5cm} = 130\ \mu m$!

2.2 GeV Momentum



5T data (2006): new analysis

A better way to analyze charge dispersion data:

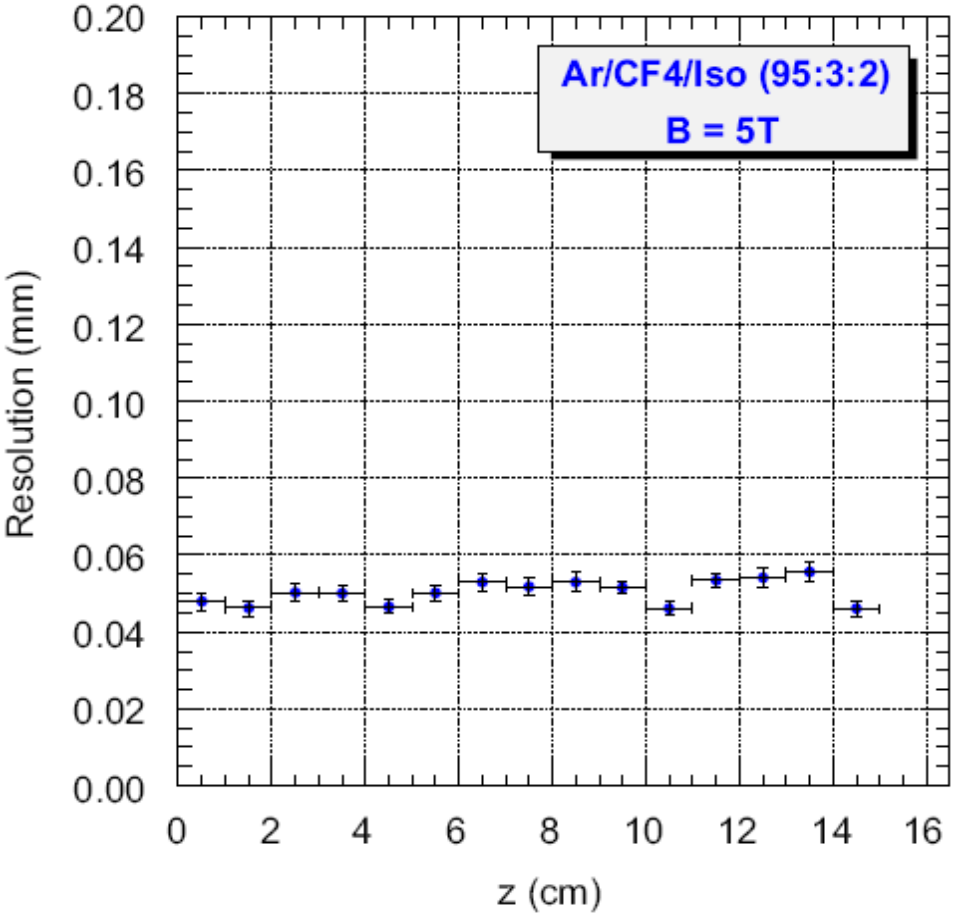
- The original PRF "amplitude" dependent on TPC operational parameters
- Develop a standard way not requiring fine tuning
- Tested several new ideas with simulated data
- Apply and test new algorithm to reanalyze DESY 5 T magnetic field results
- Criteria: PRF can be applied consistently and easily over a wide range of TPC operating conditions
- Observed resolution function is Gaussian.
- New measured resolution is as good or better then obtained previously
- A simple fixed window integration works the best!

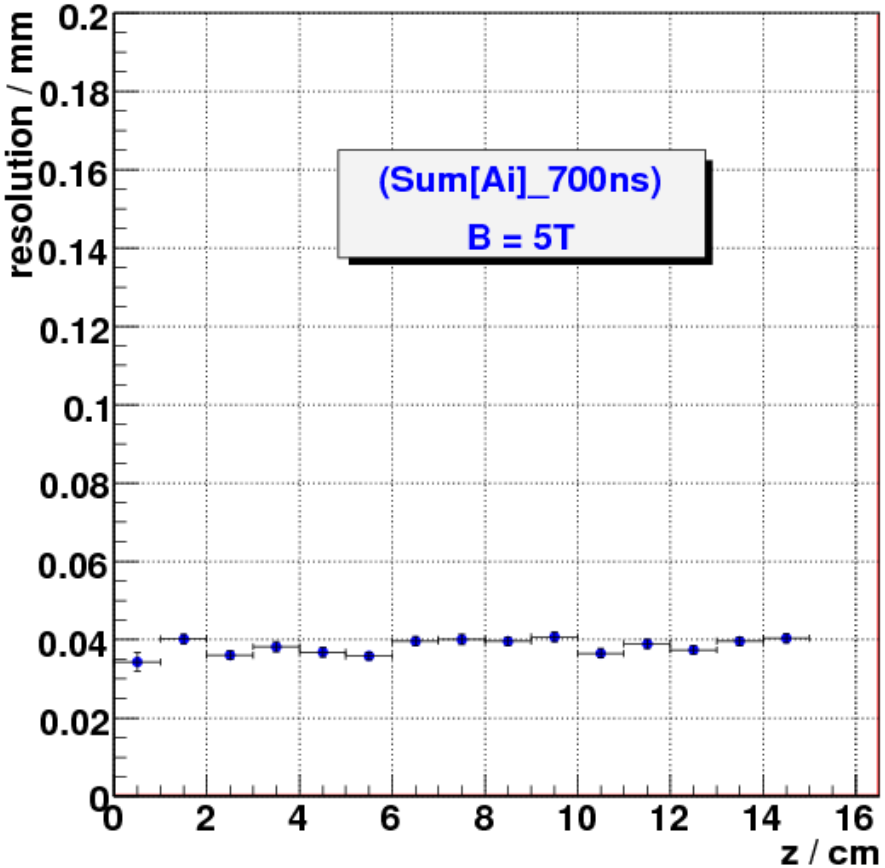
5T data (2006): new analysis

Resolution comparison: old method vs. "average (700ns)"

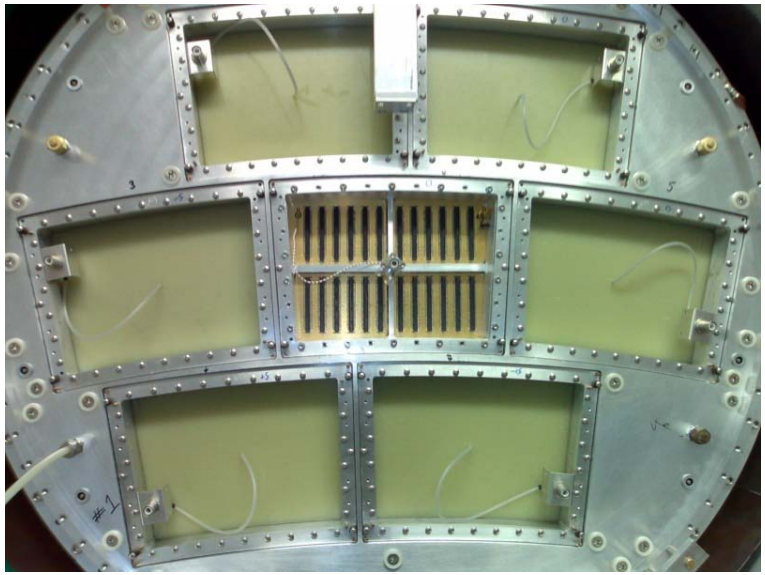
- Old method: 3652/17669
  Flat **50 µm** resolution
  independent of z over 15 cm

- New method: 5663/17669
  Flat **40 µm** resolution
  independent of z



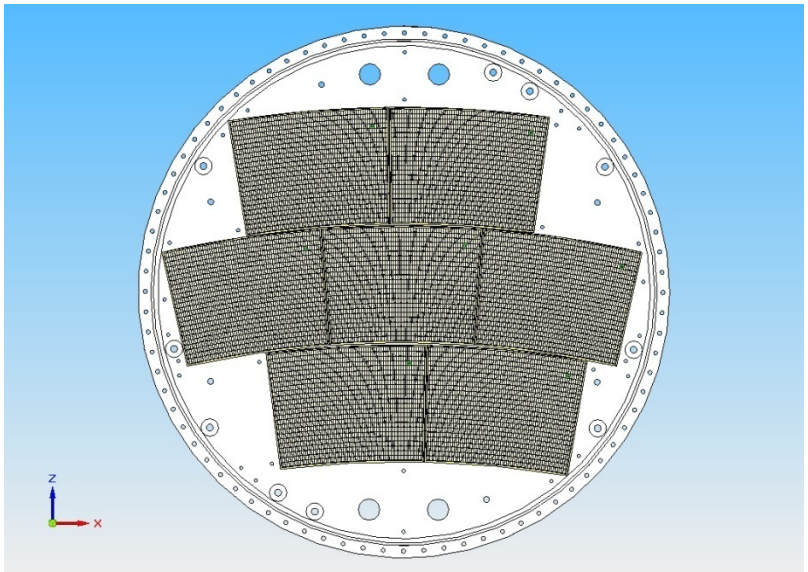


Future plan

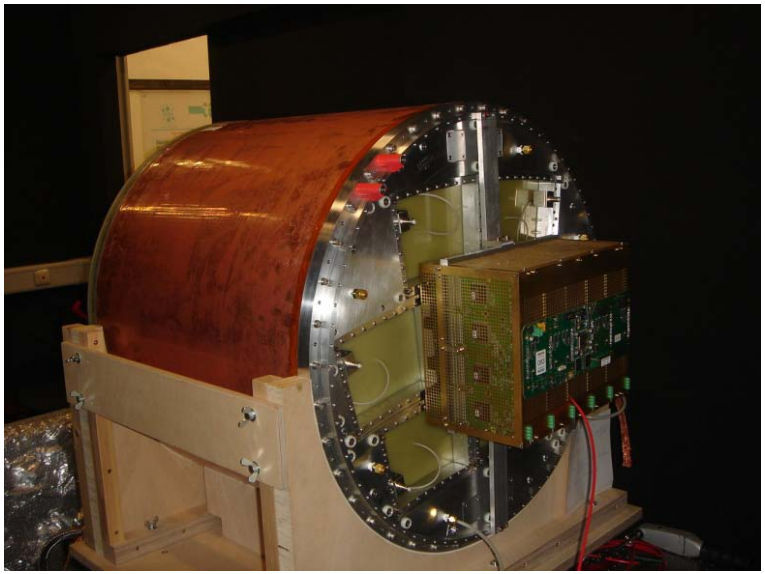


In 2008/2009 with one detector module

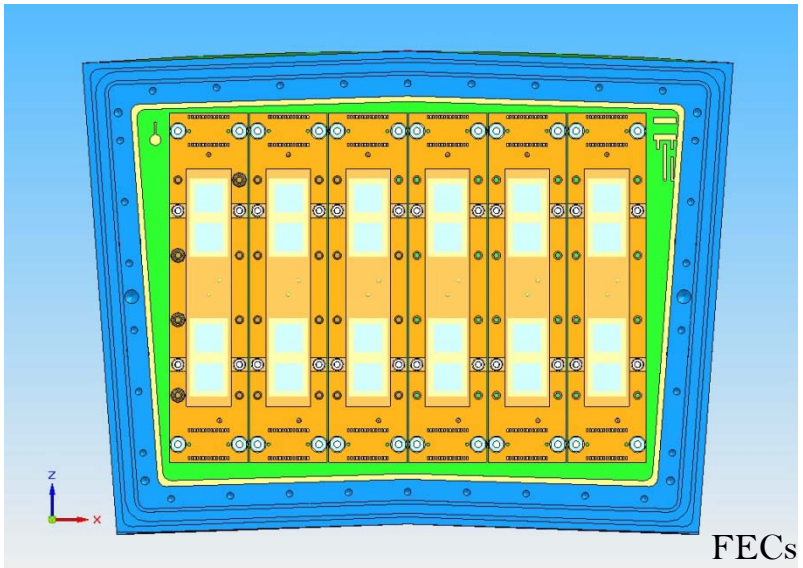
Resistive technology choice



In 2010 with 7 detector modules.



Reduce the electronics



Conclusions

- Two Micromegas with resistive anode have been tested within the EUDET facility using 1T magnet to reduce the transverse diffusion
- C-loaded Kapton technology gives better result than resistive ink technology
- First analysis results confirm excellent resolution at small distance with the resistive C-loaded Kapton: **55 µm for 3 mm pads**
- New method (fixed windows integration) analysis very promising
- Plans are to test another resistive Kapton with lower resistivity (~1 MΩ/), then go to 7 modules with integrated electronics in 2010