

Update of Victoria TPC R&D

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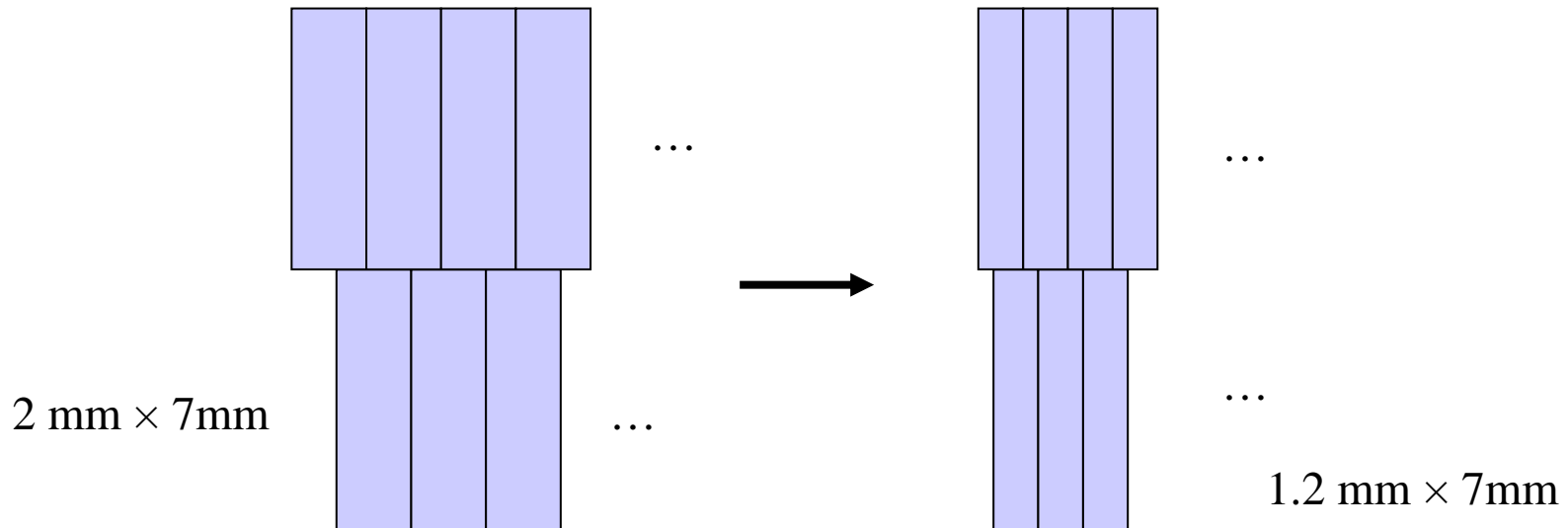
ECFA Workshop on Physics and Detectors for a Linear Collider
Durham, England September 1 – September 4, 2004

Progress since Paris LCWS

- Preparations completed for 2004 DESY magnet run
 - New readout plane with narrower pads
 - Readout plane for Micromegas with resistive foil
 - TPC modifications for UV laser
 - Remote control laser beam delivery system built
- DESY magnet run
 - Arrived at DESY on August 10
 - Dealt with problems... got first laser tracks August 15
 - After some further repairs, data collection underway August 18 – September 8 (Gabe on his own...)
 - GEM (2 sets of pads), MM, cosmics and laser tracks

Narrower readout plane

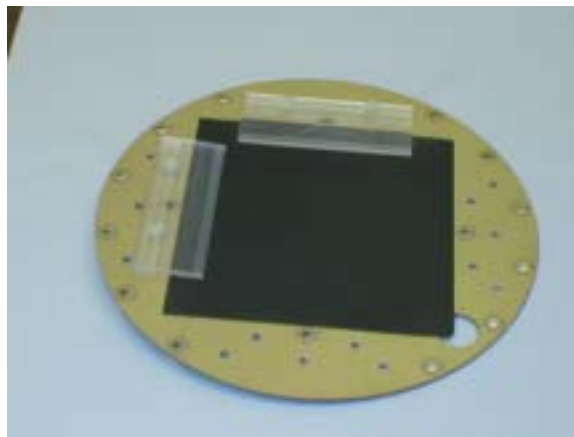
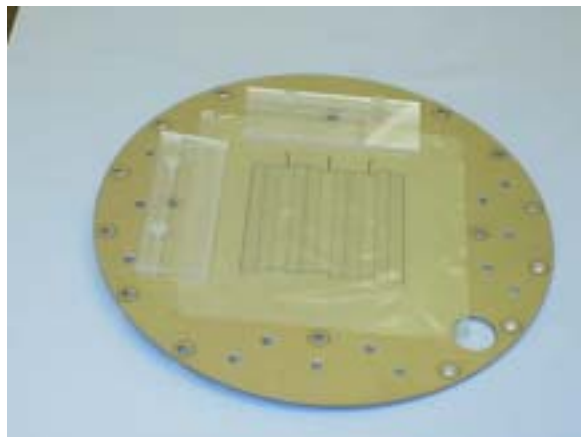
- At Paris, our results show defocusing in P5 or TDR gas of around 0.4 mm at 4 T.
 - too small for our 2 mm pads (width/ $\sigma_0 = 5$)
- To check effect of pad width, we built a new readout board replacing 2 mm pads with 1.2 mm pads



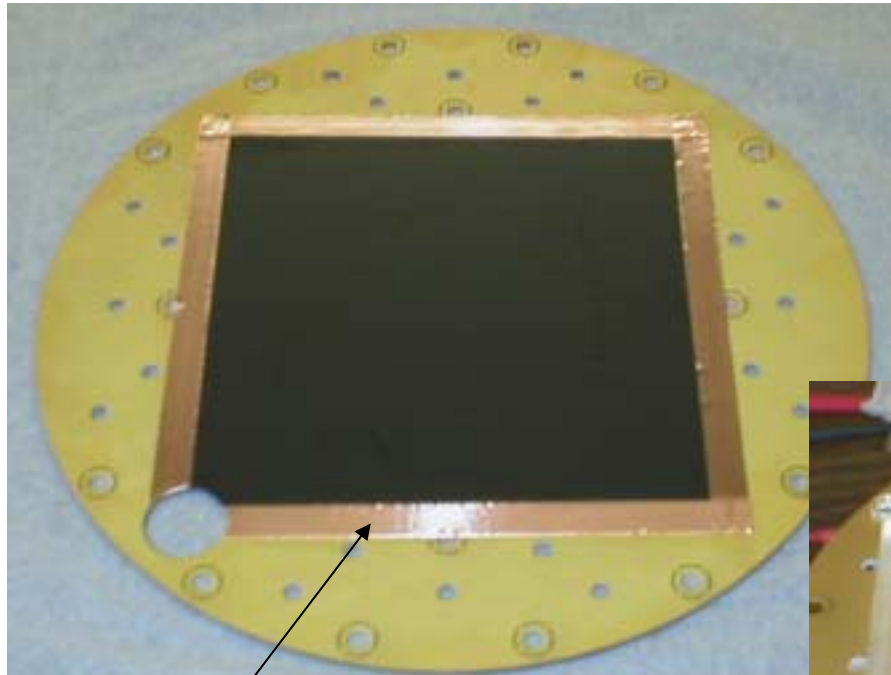
Micromegas readout plane

- Shorter pads (6 mm instead of 7 mm) in order to fit them all within the Micromegas frame provided to us by Paul Colas
- Resistive foil (carbon loaded kapton) provided by Madhu Dixit
- Resistive foil affixed to readout plane through baking a 50 μm sheet adhesive at high pressure
 - nice uniform gluing technique

Applying the resistive foil

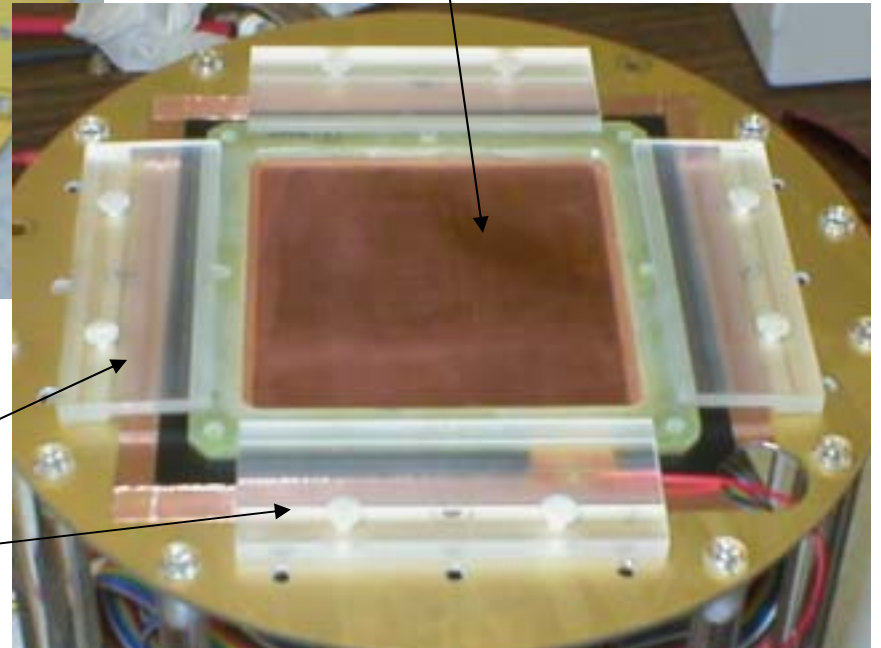


Micromegas installation



grounding resistive foil

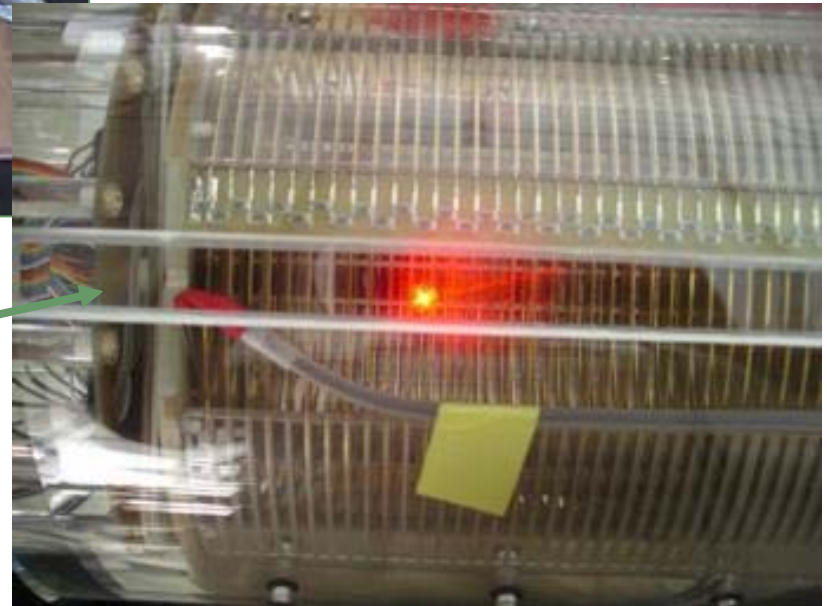
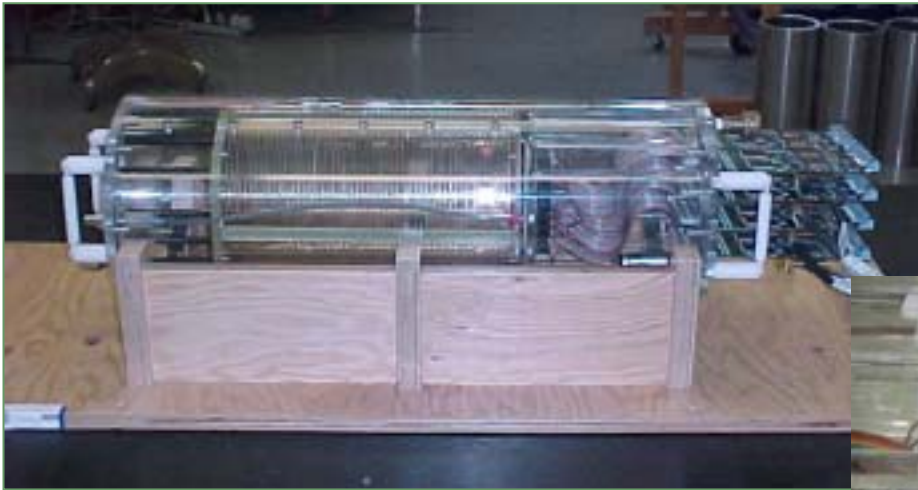
Micromegas on loan from Paul Colas



Plastic clamps to hold Micromegas in place

TPC modifications

- New outer acrylic vessel made with windows for laser entry – quartz glass inserted



quartz window

Laser beam delivery system

- Goal:
 - study resolution and track distortions with single beam
 - study two track resolution and ion feedback with two beams
- Challenges:
 - Deliver 1 and 2 laser beams to TPC while inserted in the DESY 5 T magnet
 - Magnet area is inaccessible while magnet on
 - magnet takes 30 minutes to ramp up or down
 - UV laser light must be contained within laser area
- Solution:
 - build a remotely controlled beam delivery system

Laser beam delivery system

- Approx. 2 m long to reach into magnet

laser + optics

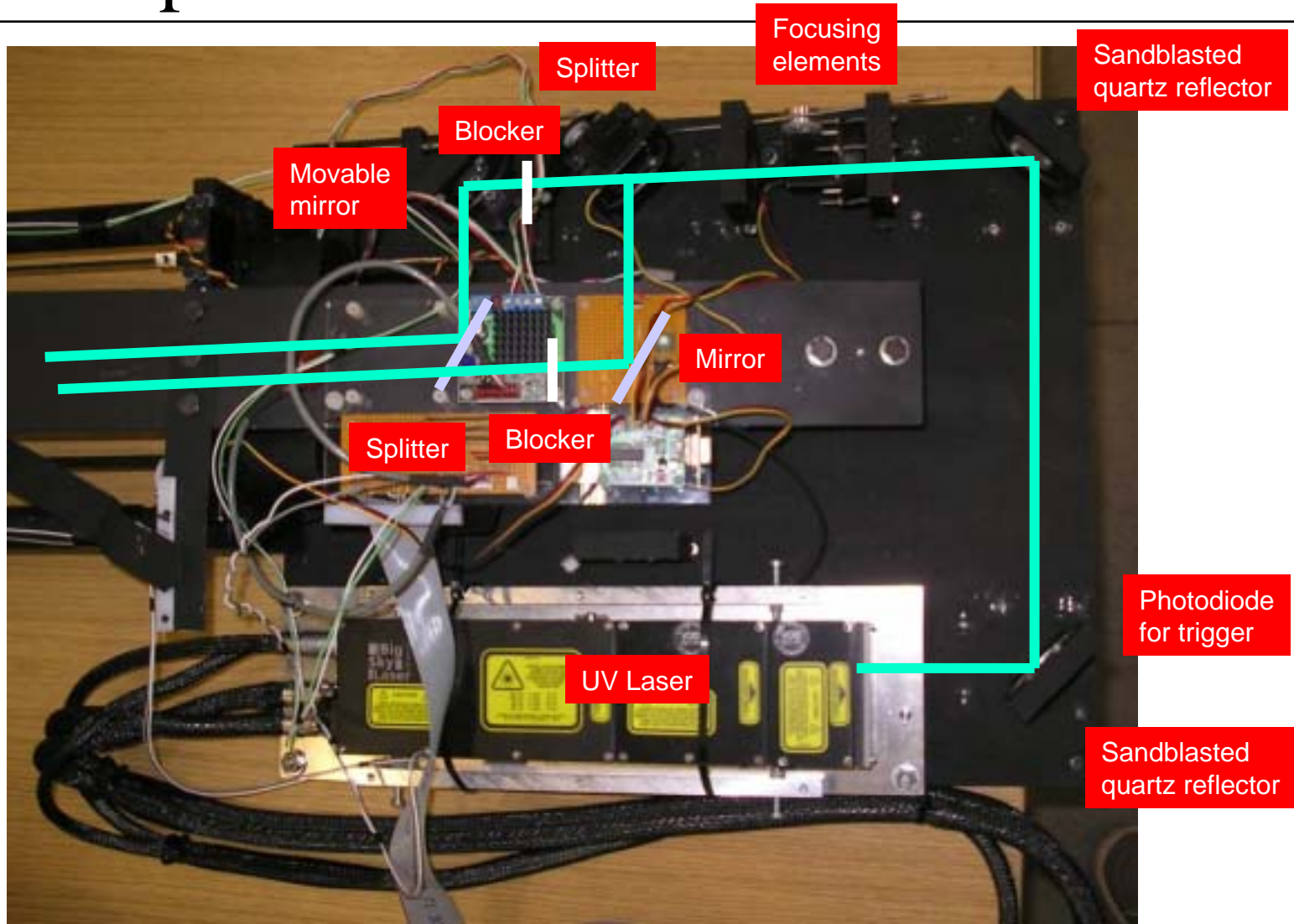
TPC holder

laser power supply

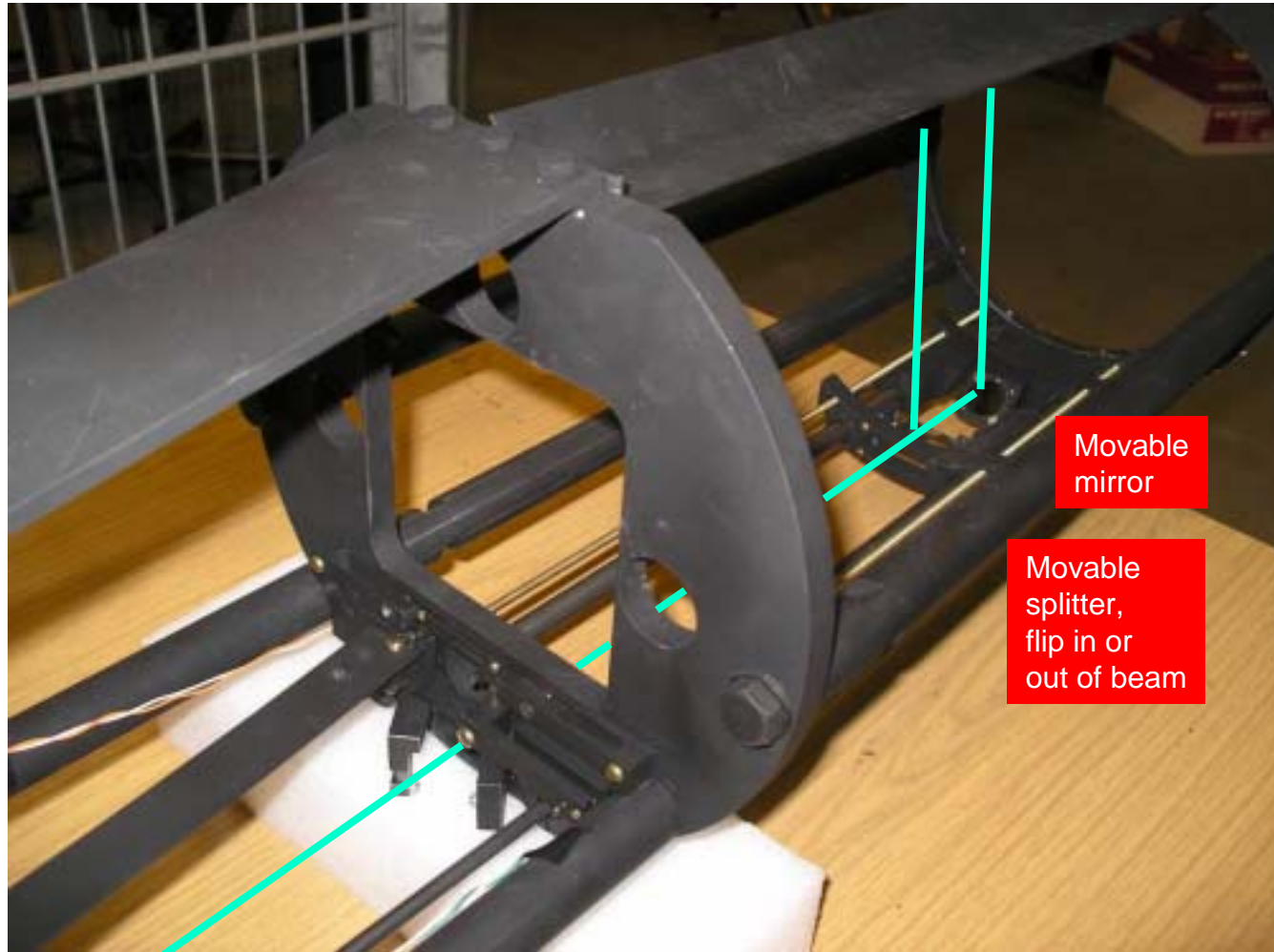


Engineering by
Mark Lenkowski
University of Victoria

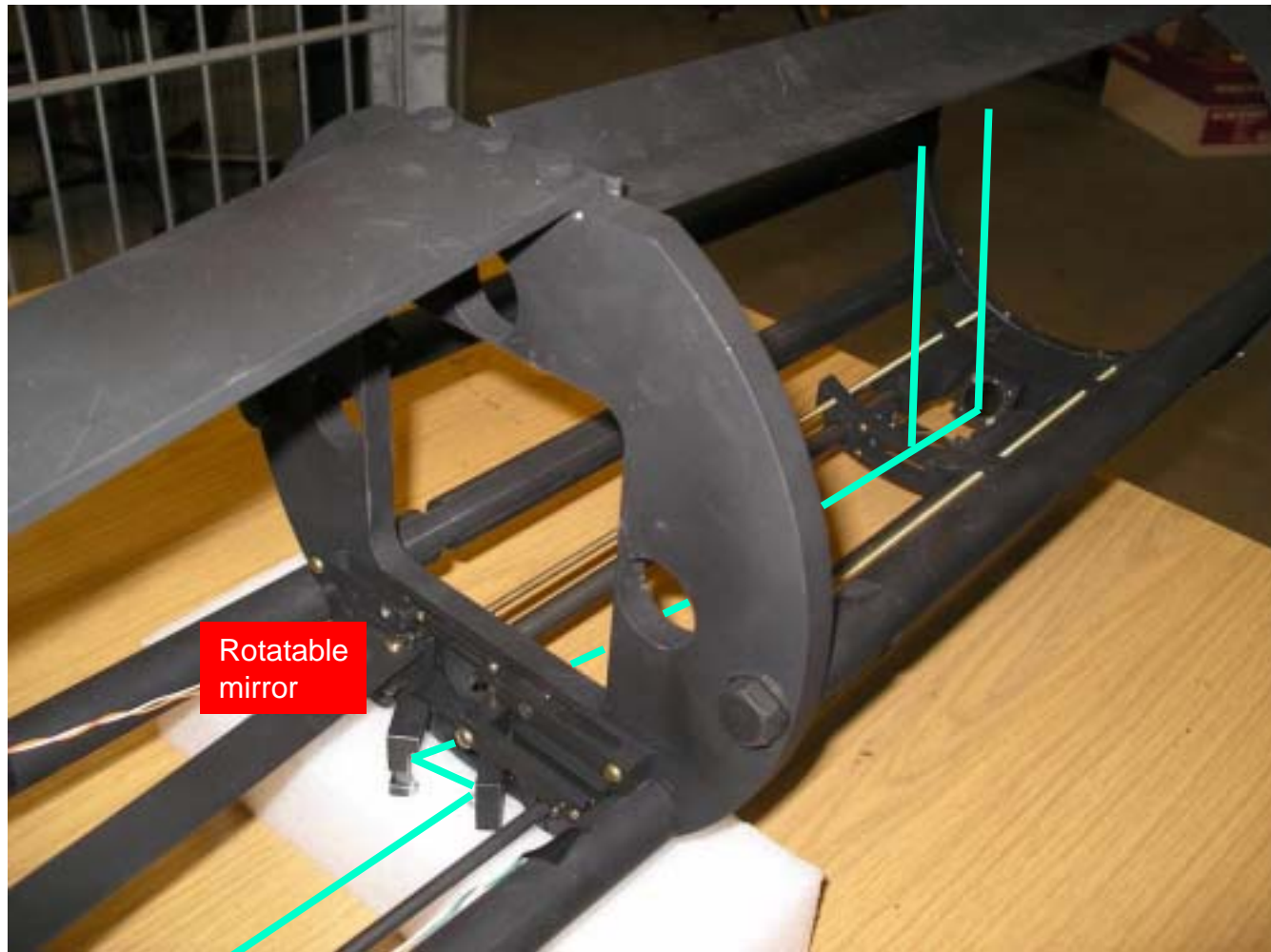
Laser optics



Beam delivery



Beam delivery – offset in x and z



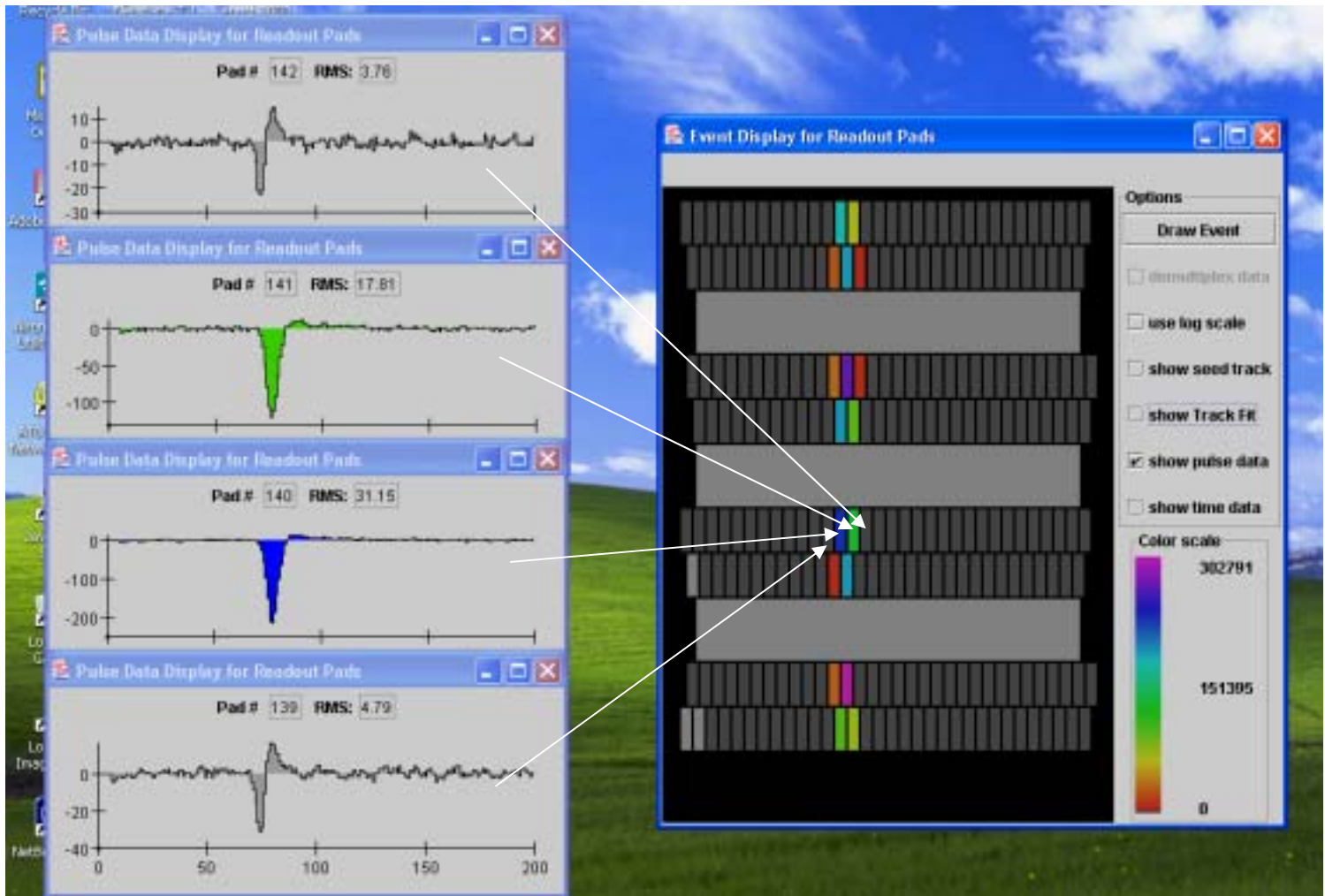
Setup with the DESY magnet

- For safety reasons, the UV laser must be contained within a light tight box

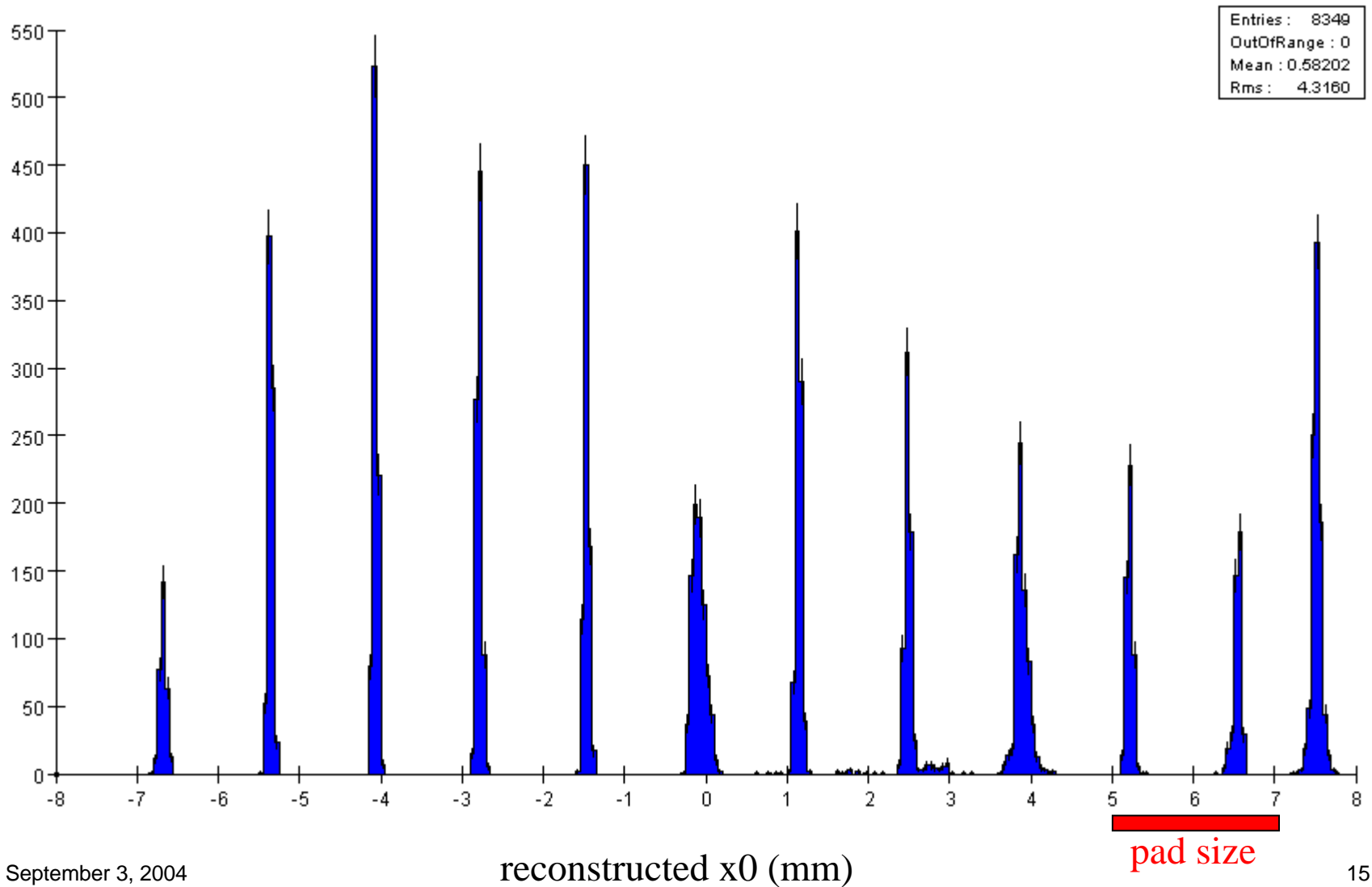


DESY run at 4 T

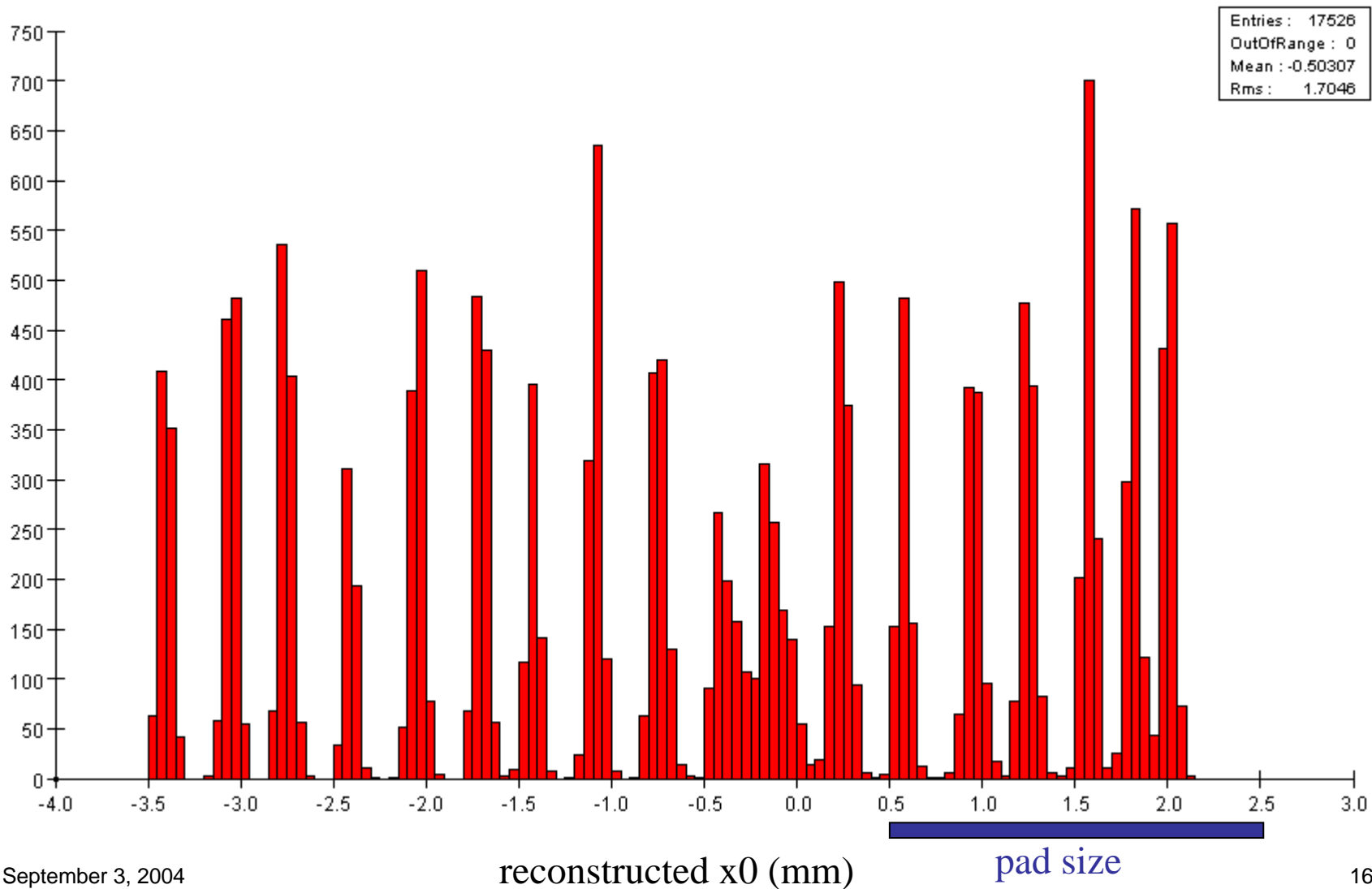
- Single laser track seen by 2 mm pads and P5 gas



Scan of laser in x



Fine scan of laser in x

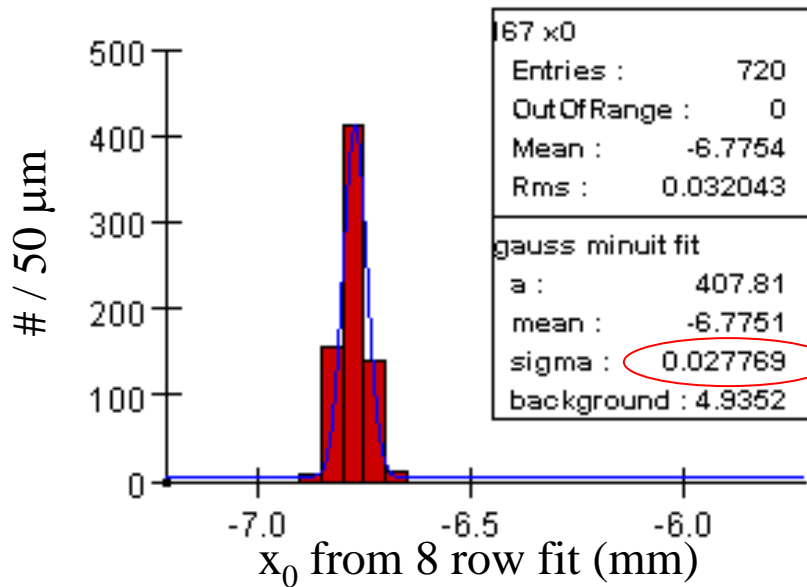


Laser track resolution studies

- Laser beam position is very stable, mean reconstructed positions from runs separated by 20 minutes have $\text{RMS} < 4 \mu\text{m}$

- Fit laser tracks to straight lines
 - Fit x_0 distribution to Gaussian to estimate resolution
 - Compare this to resolution estimate from residuals
 - check that resolution estimated from the residuals is valid (method used for cosmics)

Laser track resolution example: run 67

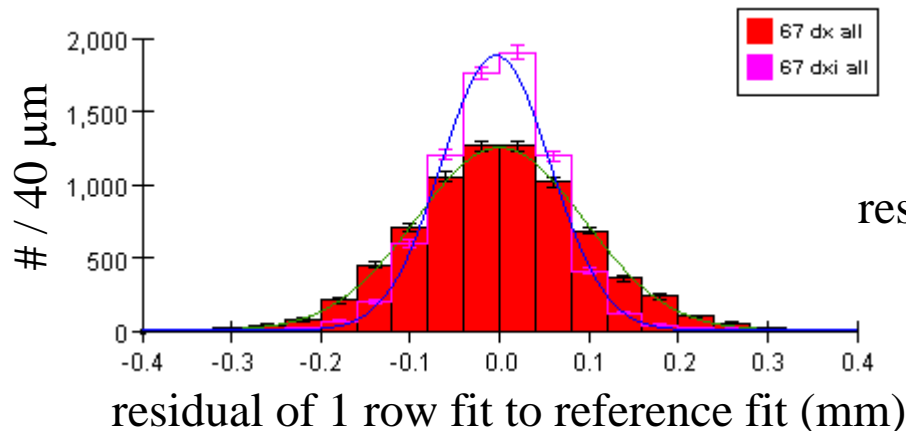


Straight track fits

8 row fit: 28 μm resolution

→ 1 row resolution = $\sqrt{8} \times 28 \mu\text{m}$

= 78.5 μm



reference fit excludes row: 95.2 μm

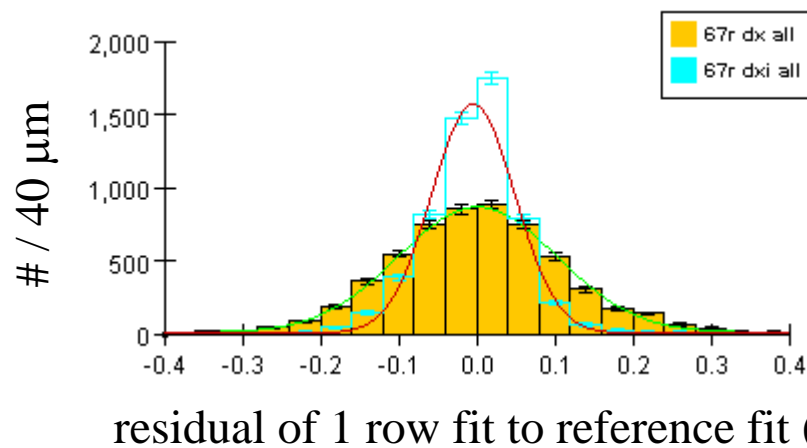
reference fit includes row: 61.6 μm

resolution (geometric mean): 76.6 \pm 0.6 μm

Good agreement!

Laser resolution cross check

- For cosmics one must use curved track finding
 - to check if this affects the resolution estimator, apply curved track fitting to the same laser data



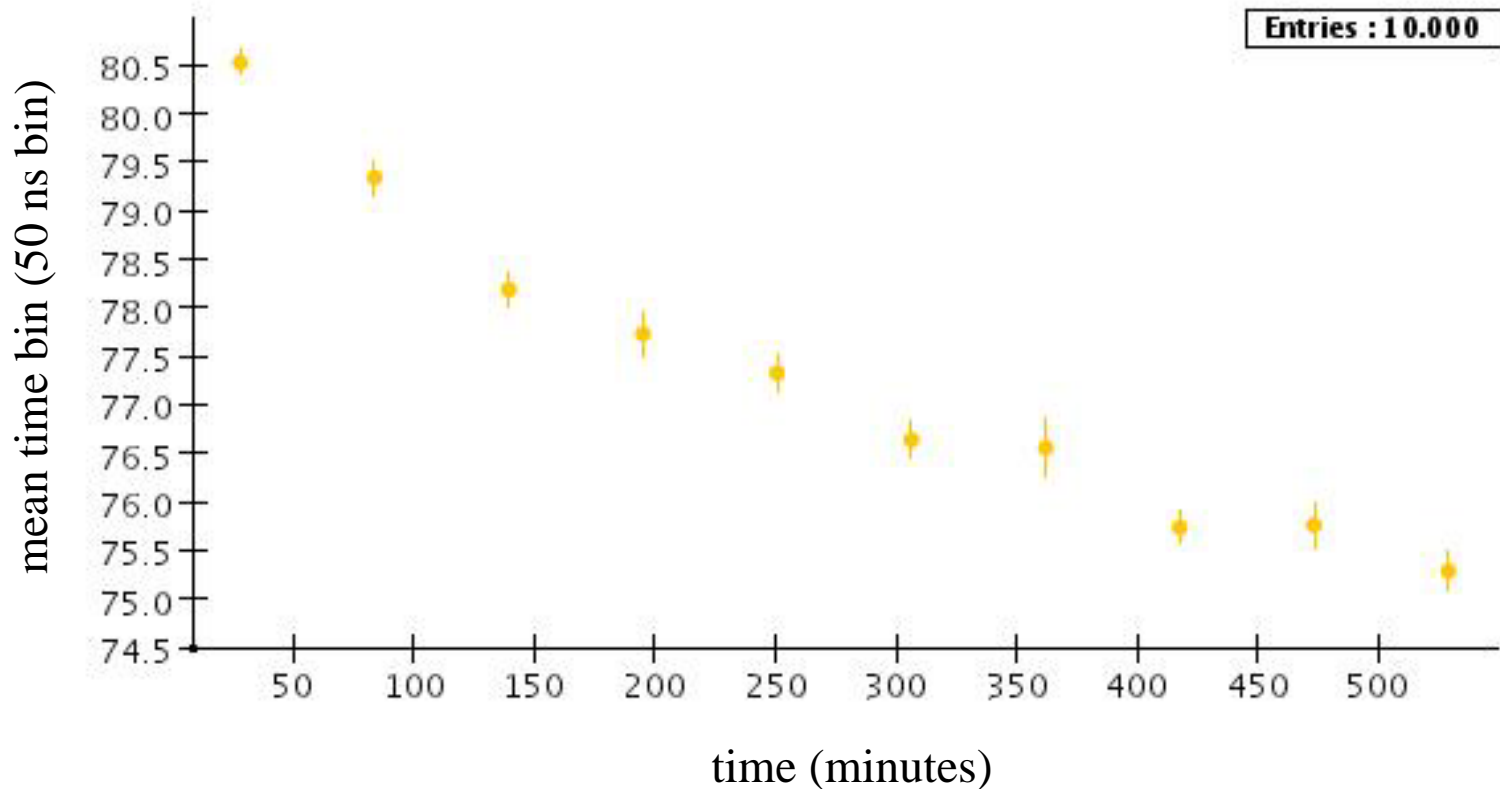
reference fit excludes row: $101.5 \mu\text{m}$
reference fit includes row: $53.4 \mu\text{m}$

resolution (geometric mean): $73.6 \pm 0.7 \mu\text{m}$

resolution estimate
low by about 5%

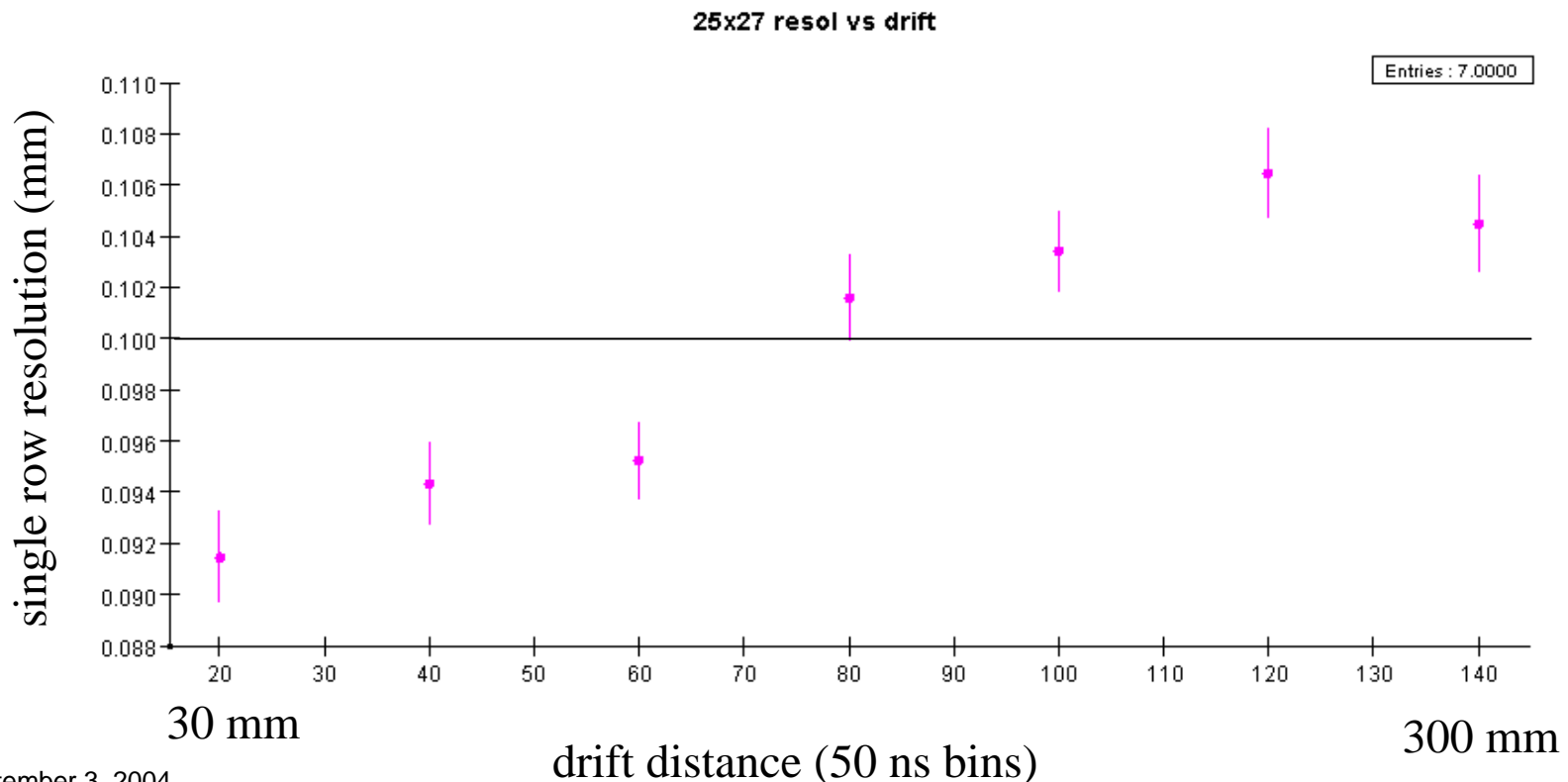
Drift velocity monitor

- Laser very nice to monitor drift velocity (after changing gas or opening the detector):

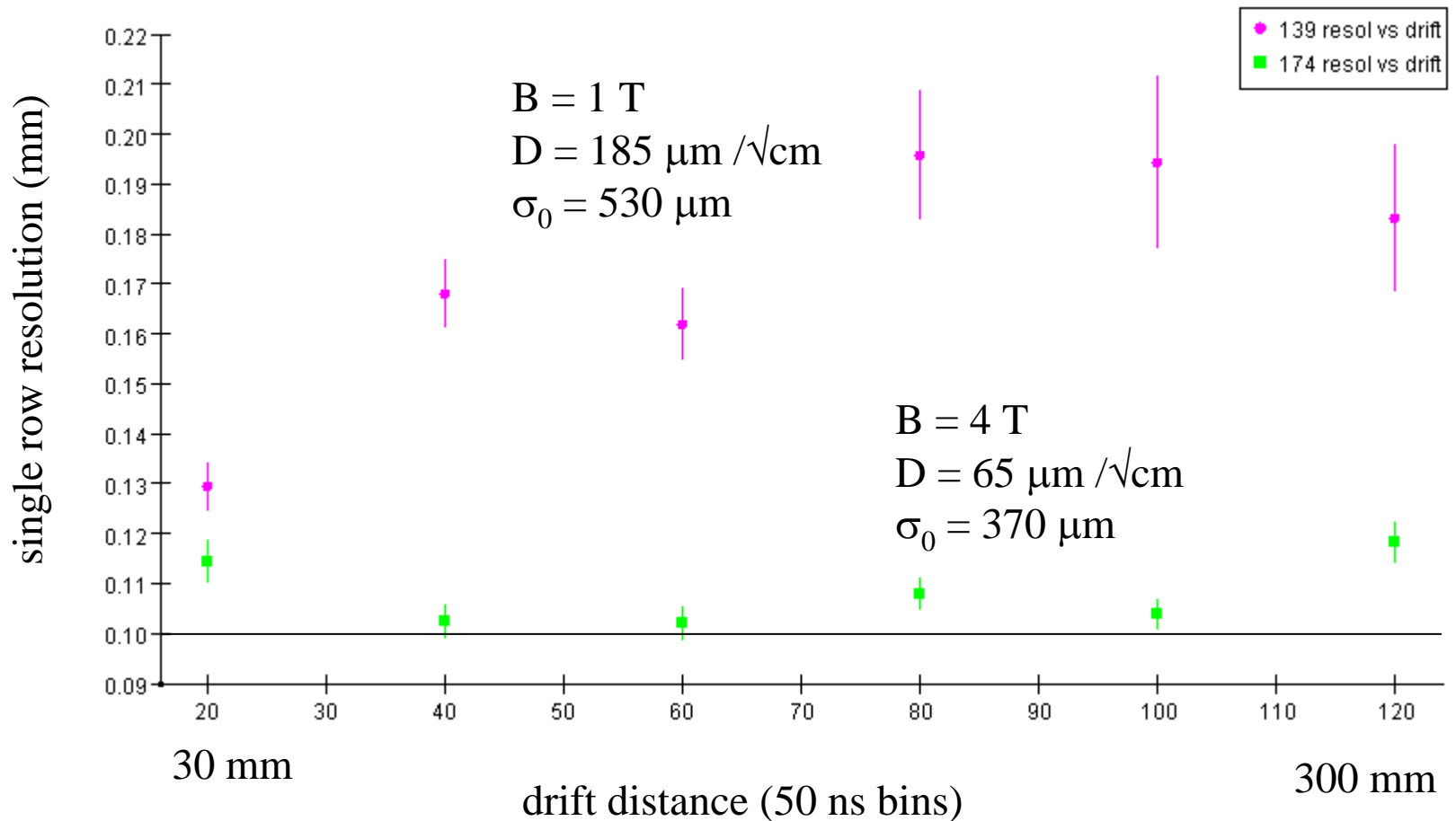


Cosmic results: P5 gas, 2 mm pads, 4 T

- P5 gas properties not quite as expected:
 - plateau of drift velocity was 160 V/cm (not 90 V/cm)
 - at this drift field diffusion measured: $77 \pm 3 \mu\text{m}/\sqrt{\text{cm}}$



Cosmic results: TDR gas, 2mm pads



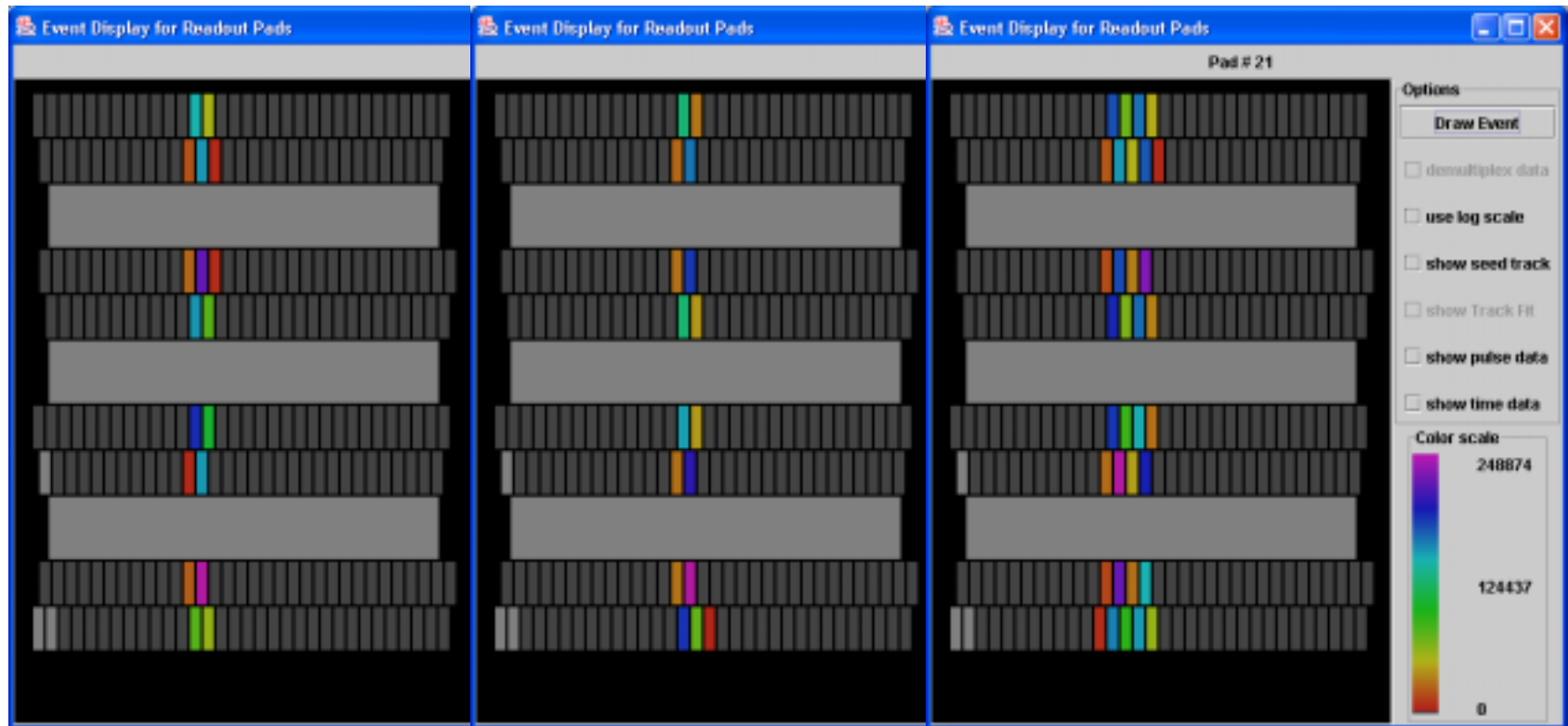
Two track resolution studies: P5 gas at 4 T

- Bring two beams close together **at same z**
 - example (runs 67-69): 3.8 mm separation, $\sigma = 0.5$ mm

Beam 1 only

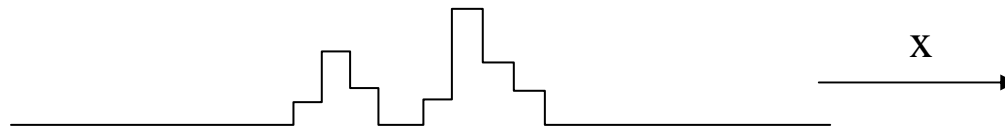
Beam 2 only

Beam 1 and 2



Two track likelihood fit

- Modify maximum likelihood track fitter to allow for charge coming from two tracks to contribute



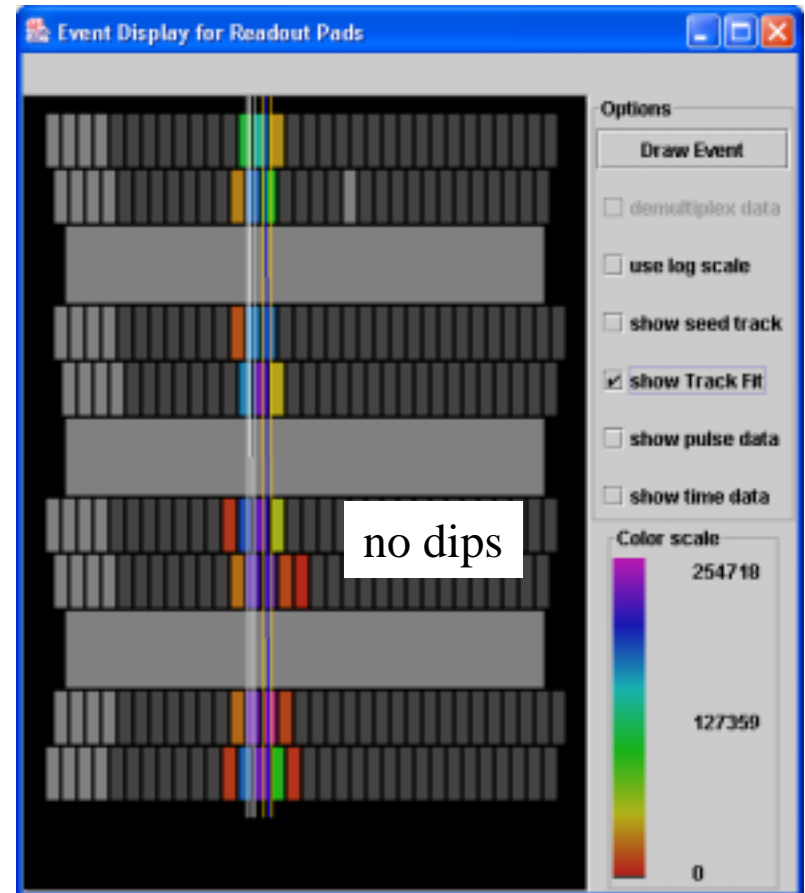
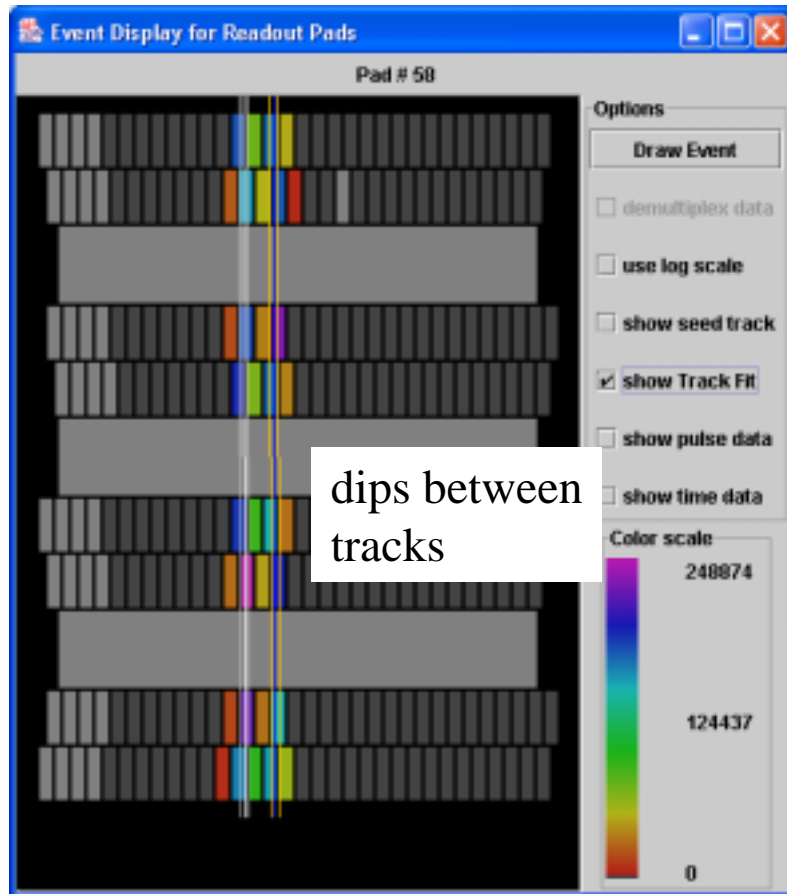
- relative amplitudes of the charges from two tracks for each row are treated as nuisance parameters (1 per row)
- Fix sigma (known from z)
- Maximize likelihood for 4 track parameters (x_{01} , ϕ_{01} , x_{02} , ϕ_{02}) + 8 nuisance parameters
 - for MIPs the 8 nuisance parameters are independent and maximum likelihood determined by setting $\partial L / \partial \alpha_i = 0$

Track fits: 2mm wide pads

$$\sigma = 0.5 \text{ mm}$$

$$\Delta x = 3.8 \text{ mm}$$

$$\Delta x = 2.0 \text{ mm}$$



Two track fitting performance

- For a drift distance of 150 mm:
 - resolution degrades for $\Delta x < 4$ mm, as expected, but degradation is slower than might be expected
 - information well preserved for $\Delta x = 2$ mm

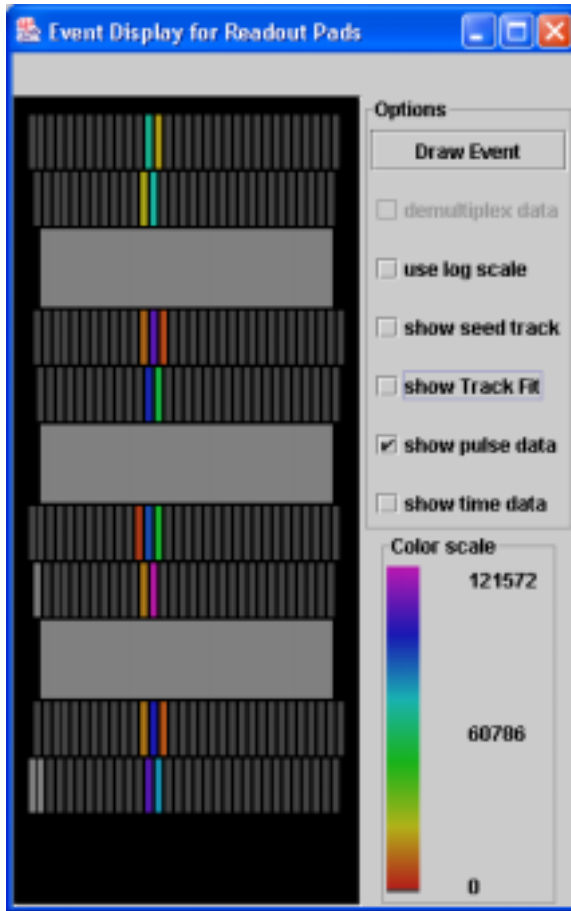
		$\Delta x = 4\text{mm}$ x_0 resolution (μm)		$\Delta x = 2$ mm x_0 resolution (μm)		$\Delta x = 1\text{mm}$ x_0 resolution (μm)	
B (T)	σ (μm)	single	double	single	double	single	double
4	500	28, 25	→ 32, 27	28, 27	→ 43, 37	28, 22	→ 99, 153
2	690	29, 22	→ 33, 26	33, 25	→ 46, 39		
1	975	44, 37	→ 57, 48	47, 50	→ 91, 85		

- biases in 2 track fit parameters: mostly small, no definite trend

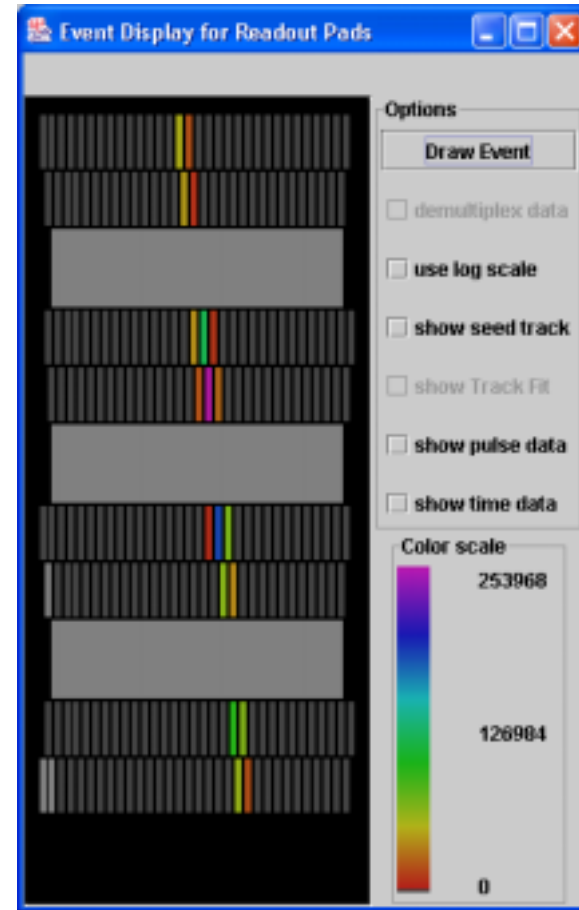
Narrower pad readout: 1.2 mm, P5 at 4 T

- Check if greater sharing improves resolution

laser event



cosmic event



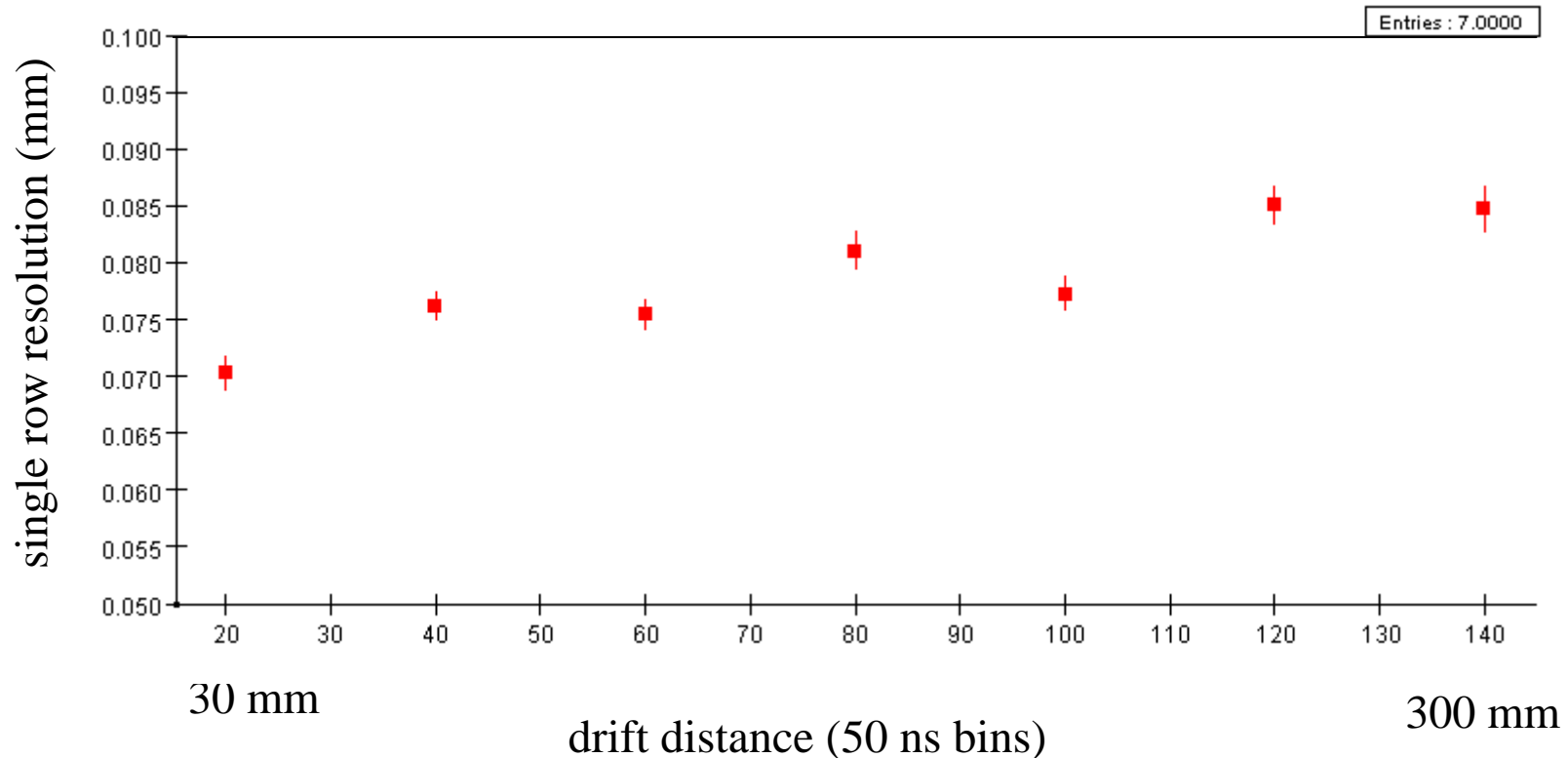
Narrower pads: initial resolution results

- Looking at a few laser runs taken Wednesday, the standard deviations of the x_0 estimates from the full track fits are $\sim 20 \mu\text{m}$, as compared to $\sim 28 \mu\text{m}$ for the wide pads
 - suggests that resolution is better... but not proof

- Cosmic run from Wednesday night:
 - Diffusion = $30 \pm 5 \mu\text{m} / \sqrt{\text{cm}}$
 - Defocusing $\sim 400 \mu\text{m}$

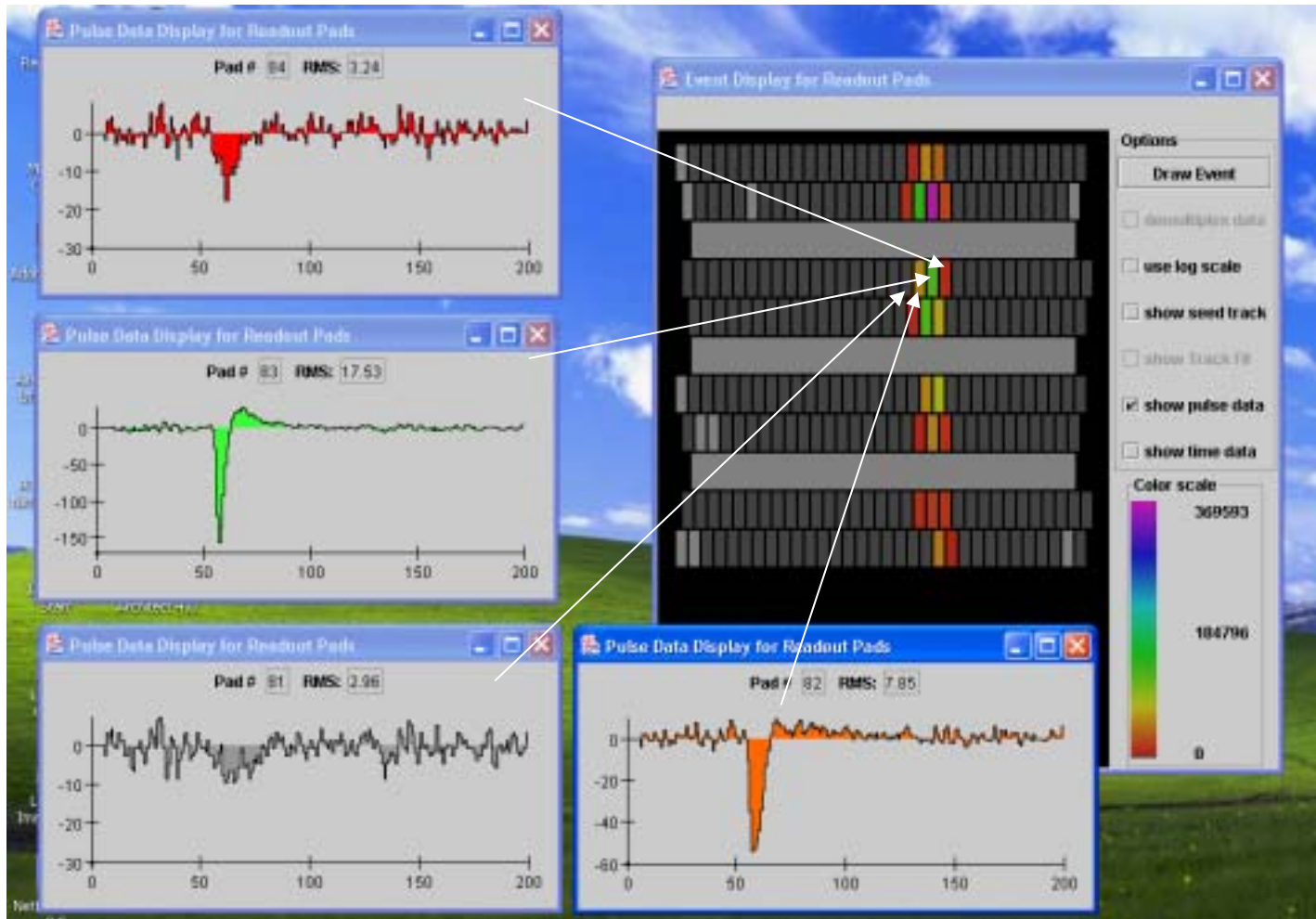
Resolution from cosmics at 4T

- From quick analysis, it appears that resolution has improved significantly...



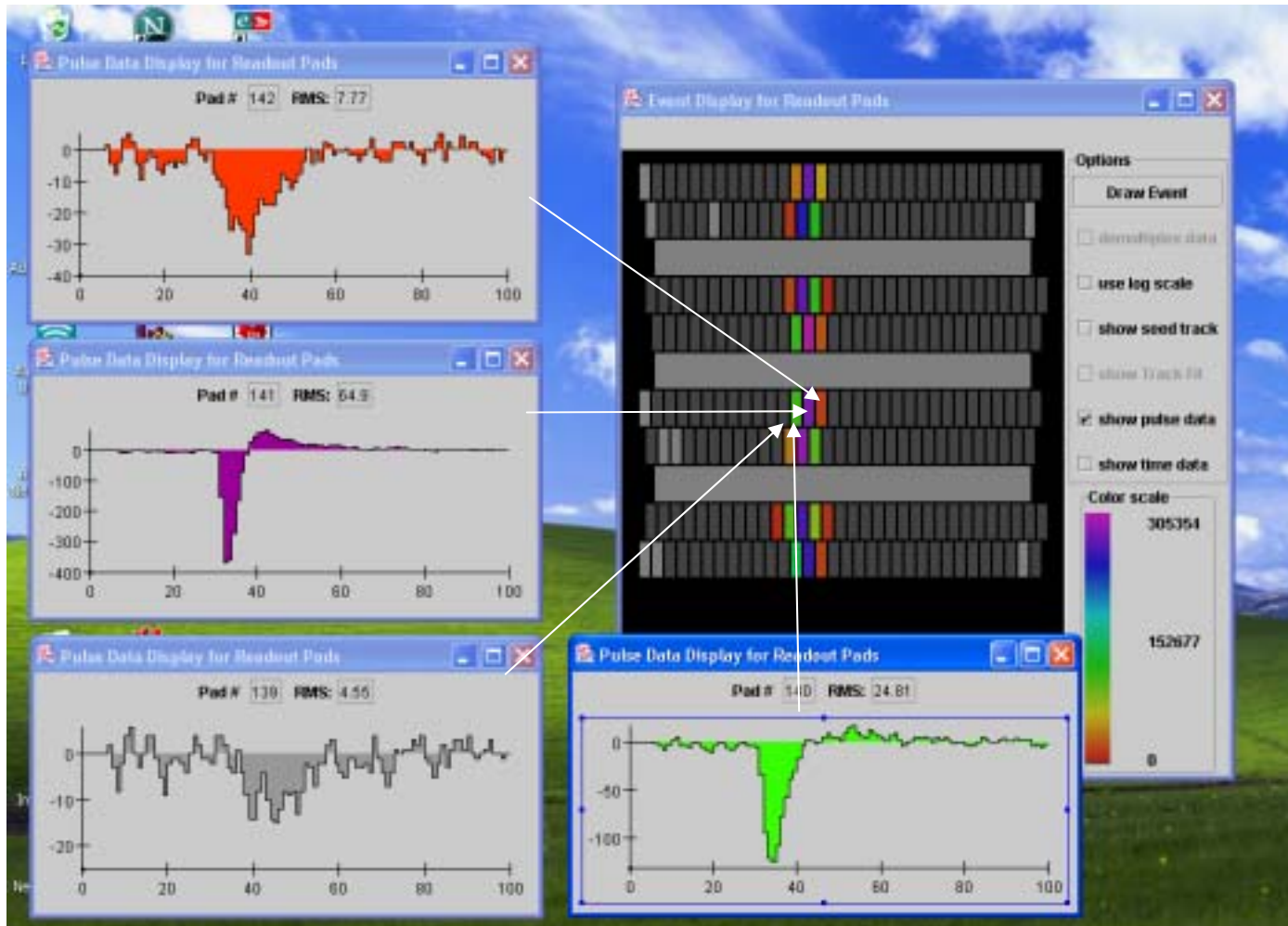
Micromegas event (Ar:Isobutane 95:5)

- A cosmic at 4 T:



Micromegas event (Ar:Isobutane 95:5)

- A laser track at 4 T:



Micromegas running

- With Ar:Isobutane (95:5), operated at 330 V to get gain of order 3000
- Changed to P5: needed 410 V to get similar gain
 - after 4 hours (20 hours since gas change) micromegas began sparking, then developed ohmic short (400 k Ω)
 - brought into air: short disappeared, but could not bring above 400 V, without constant sparking... and squealing!
 - sparks appear located about one of the pillars
- We need more experience operating micromegas

Summary

- A very successful run at DESY in 2004
 - still underway for a few more days
 - let me know if you have suggestions for further studies

- Our laser transport system is available for others to modify to fit their own needs for DESY laser tests
 - very useful tool for testing TPC operation

- Two track resolution is quite good: 2-4 mm for 2 mm pads

- With limited defocusing of P5, resolution improves by about 20% with narrower pads