Beam Profile Monitor Using Pixel Detector

- Crossing angle, z location, B-field, and readout electronics -

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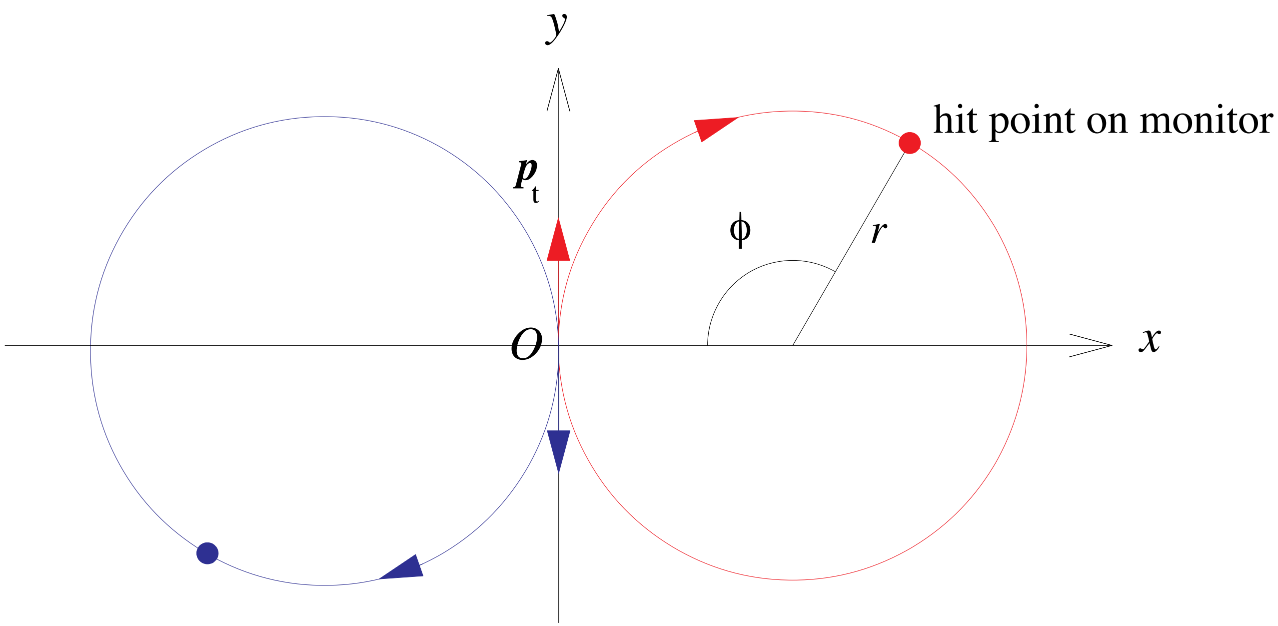
Snowmass 2005, Colorado

Hit Location on the Pair Monitor

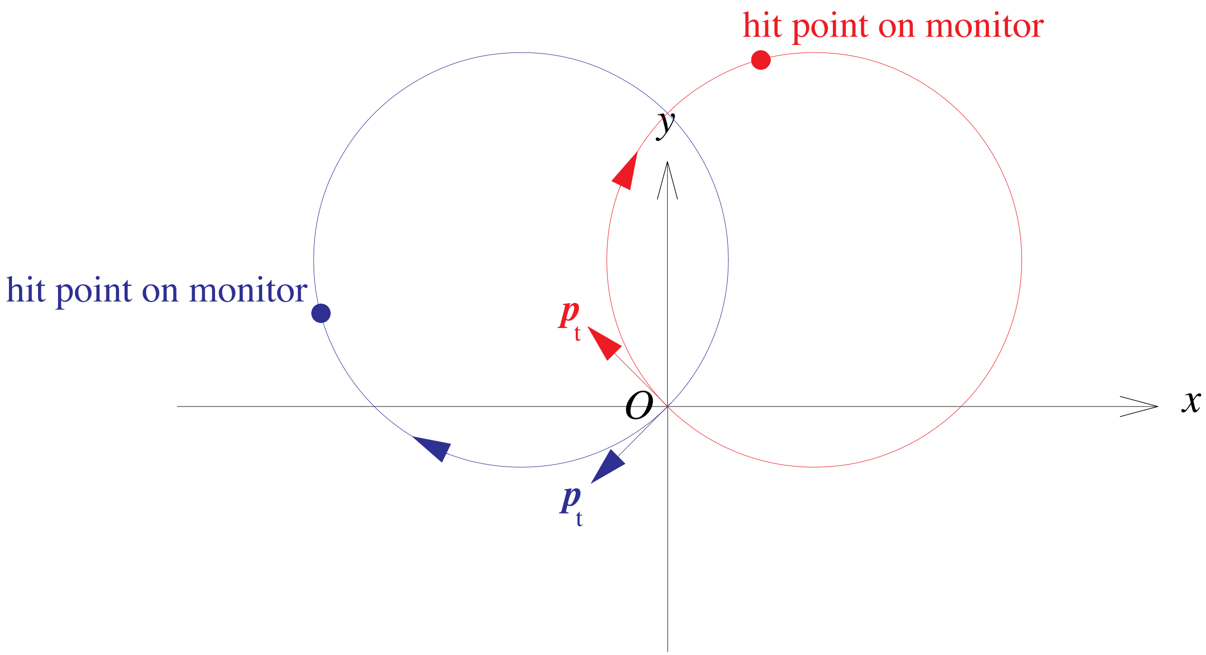


$$\rho(\mathrm{cm}) = \frac{p_t(\mathrm{MeV}/c)}{3B_0(\mathrm{Tesla})}, \quad \phi = \frac{3B_0(\mathrm{Tesla})L(\mathrm{cm})}{p_z(\mathrm{MeV}/c)}$$

L : distance to IP

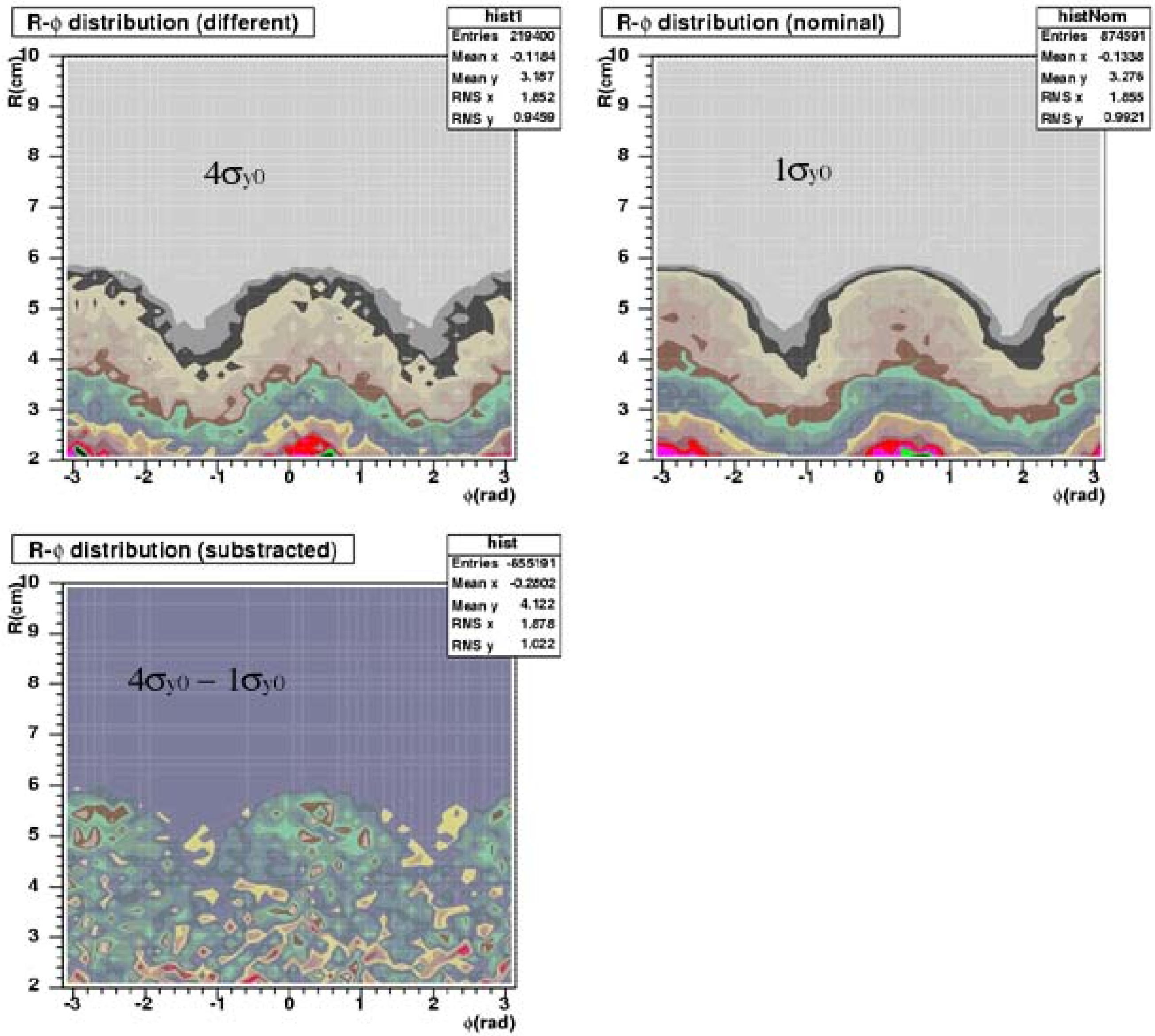
- ρ measures p_t and ϕ measures p_z.
- For $L = 176$ cm, $p_z \sim 350$ MeV/$c \to \phi \sim \pi$.
- The larger B_0L, the greater the dilution of pattern.

Hit Location on the Pair Monitor (w/ Xing angle)

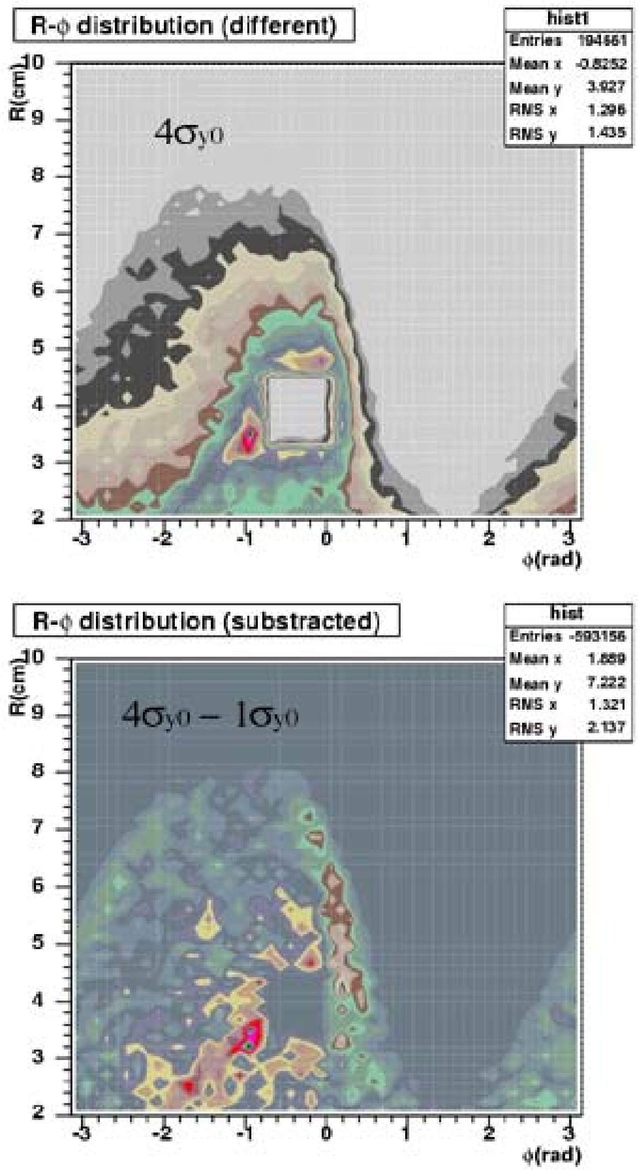


- Crossing angle θ_X gives horizontal p_t of $\theta_X p_z/2$ (comparable to original p_t if $\theta_X \sim 30$mrad).
- The focused paritcles get horizontal $p_t \longrightarrow$ hit the monitor (more hits on monitor).

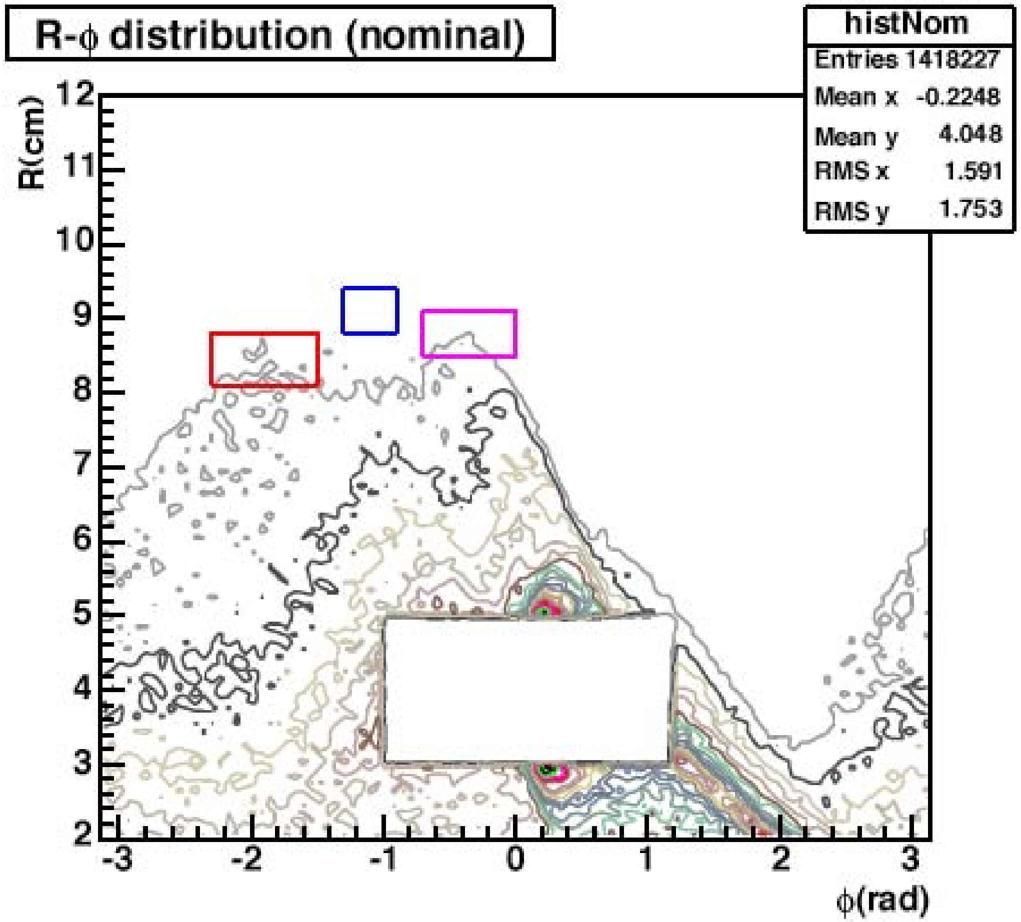
0mrad Xing, z=4m, B=4T (ILC params)



20mrad Xing, z=4m, B=4T (ILC params)



Seelect sensitive regions

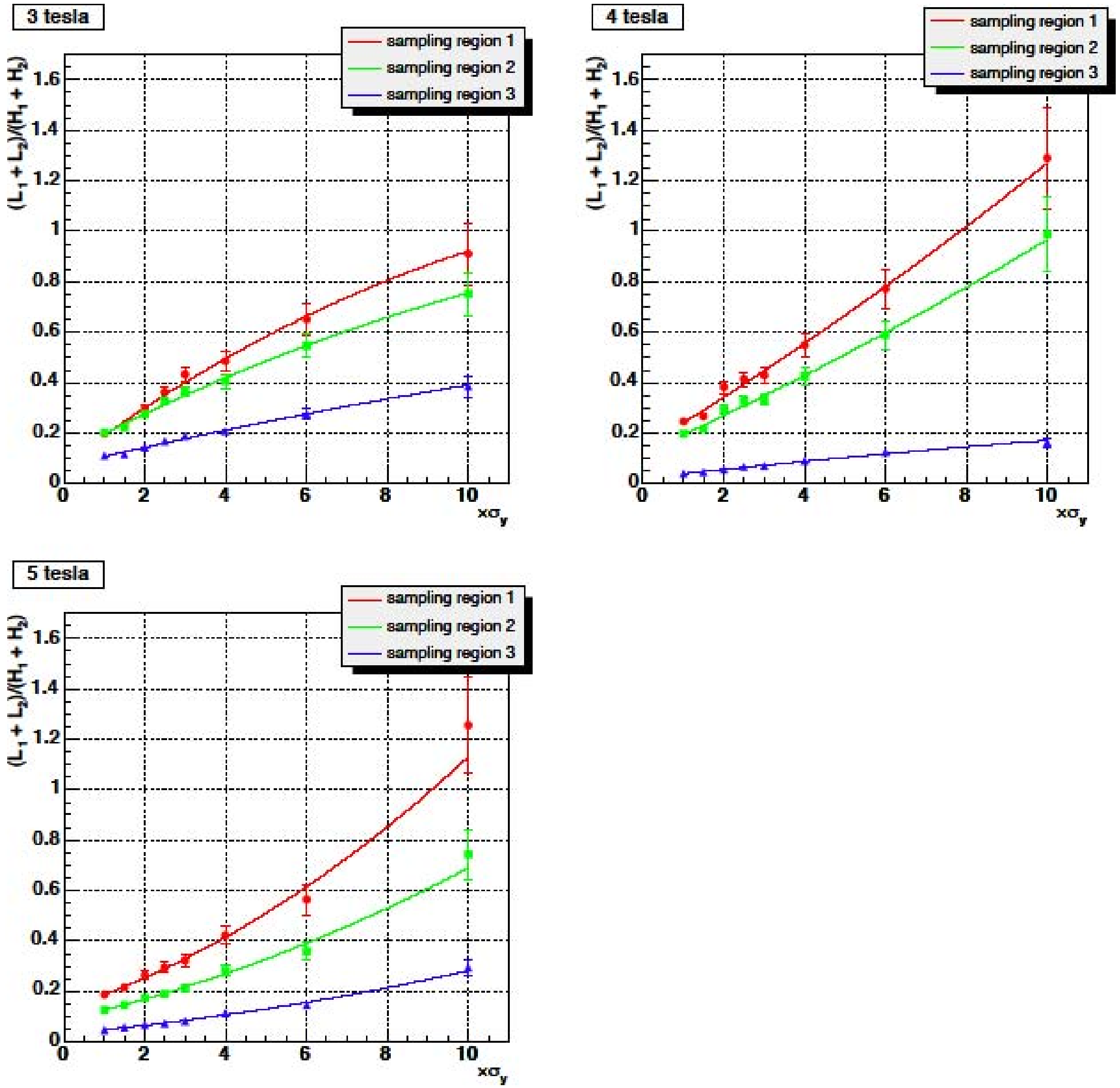


One example:

Form

$$R_{\mathrm{vp}} = \frac{blue}{pink + red}$$

Xing = 0mrad, z = 400 cm



20 readings/train

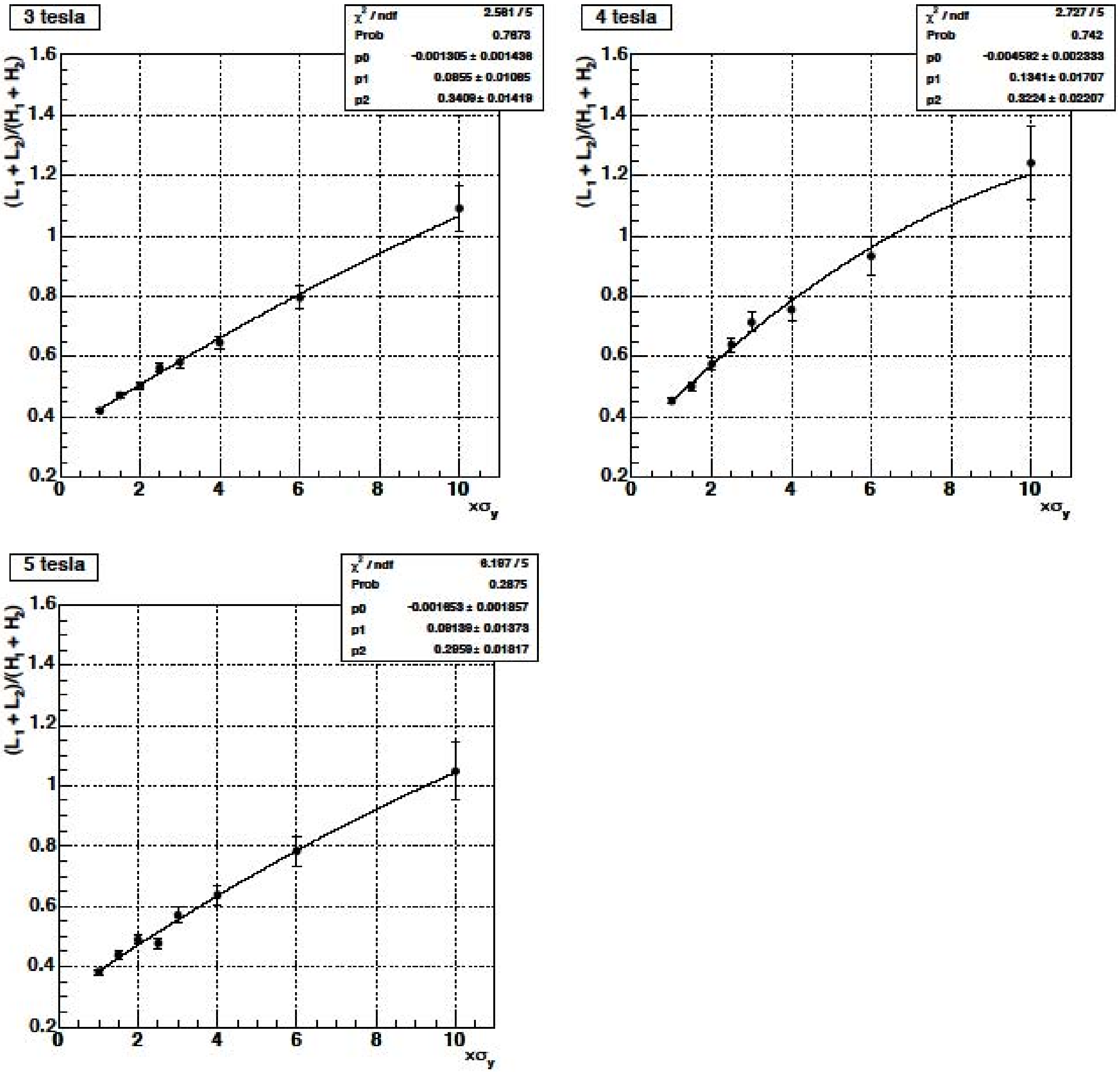
Fix σ_x,
Vary $\sigma_y = n\sigma_y^0$

Form ratio

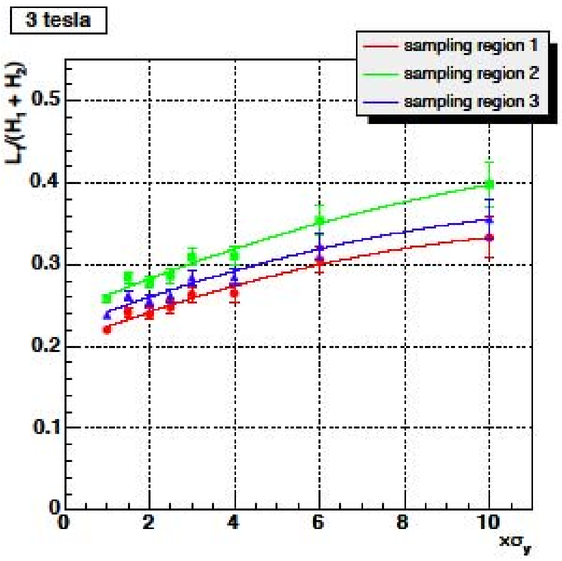
$$R_{\text{pv}} = \frac{L_1 + L_2}{H_1 + H_2}$$

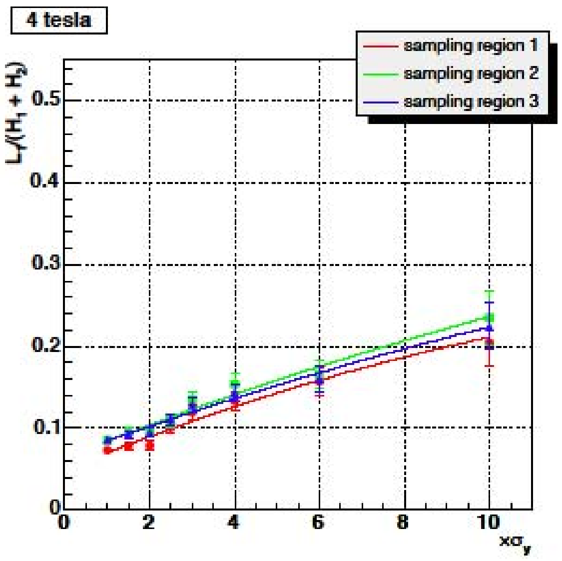
Try different
$L_{1,2}, H_{1,2}$ regions

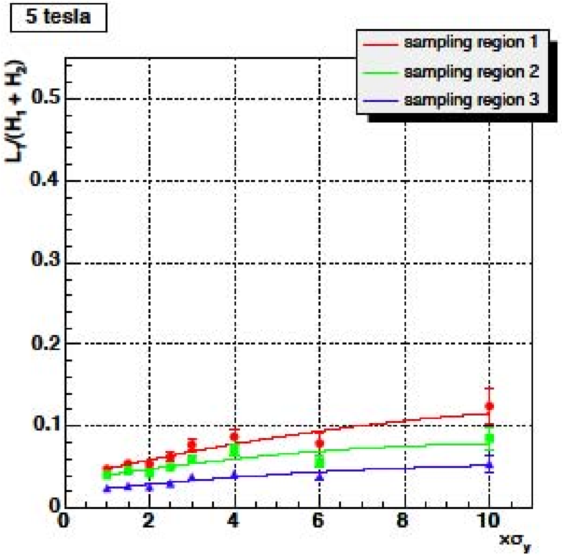
Xing = 7mrad, z = 400 cm



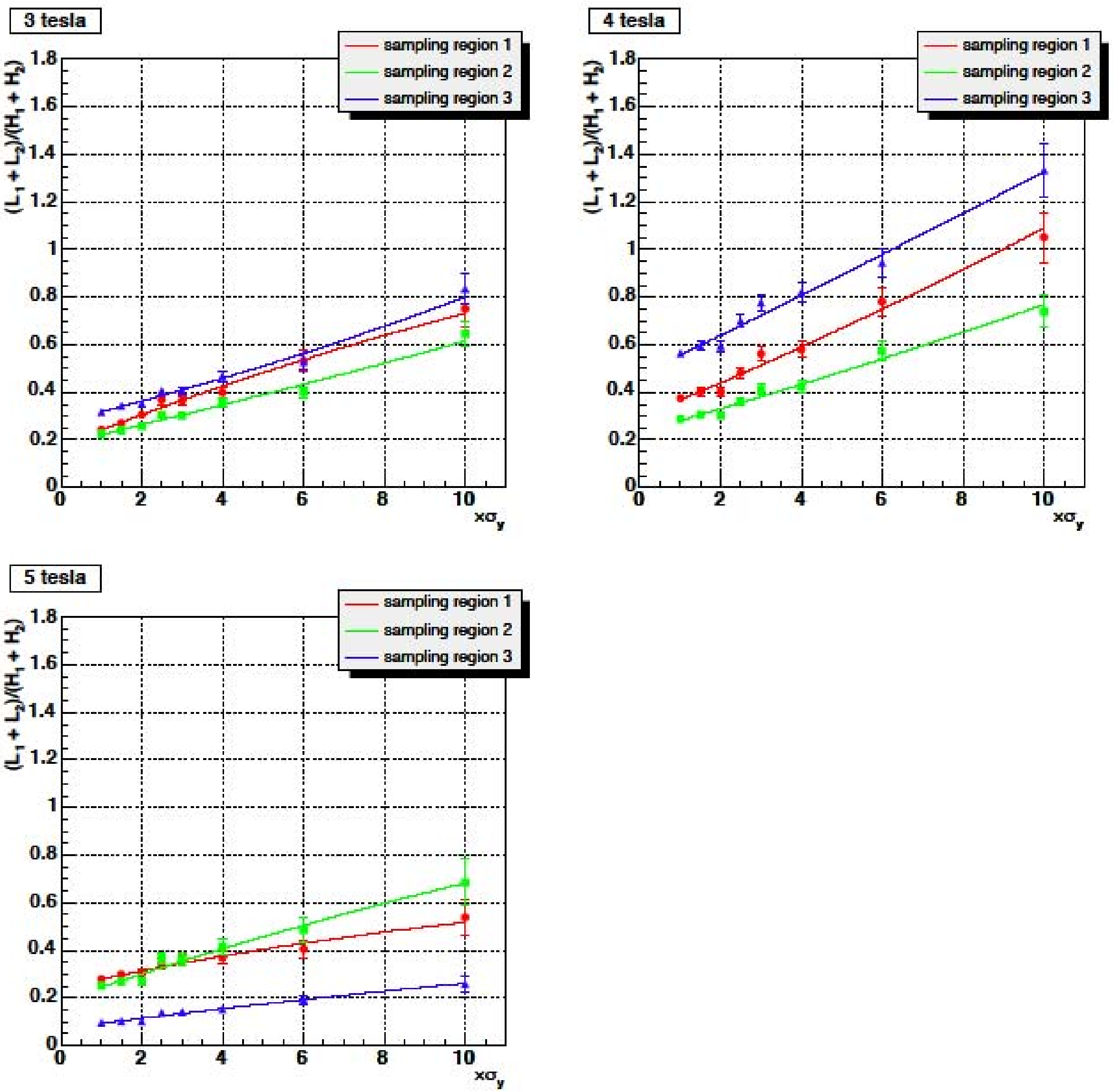
Xing = 20mrad, z = 400 cm







Xing = 20mrad, z = 176 cm



σ_y **resolutions**

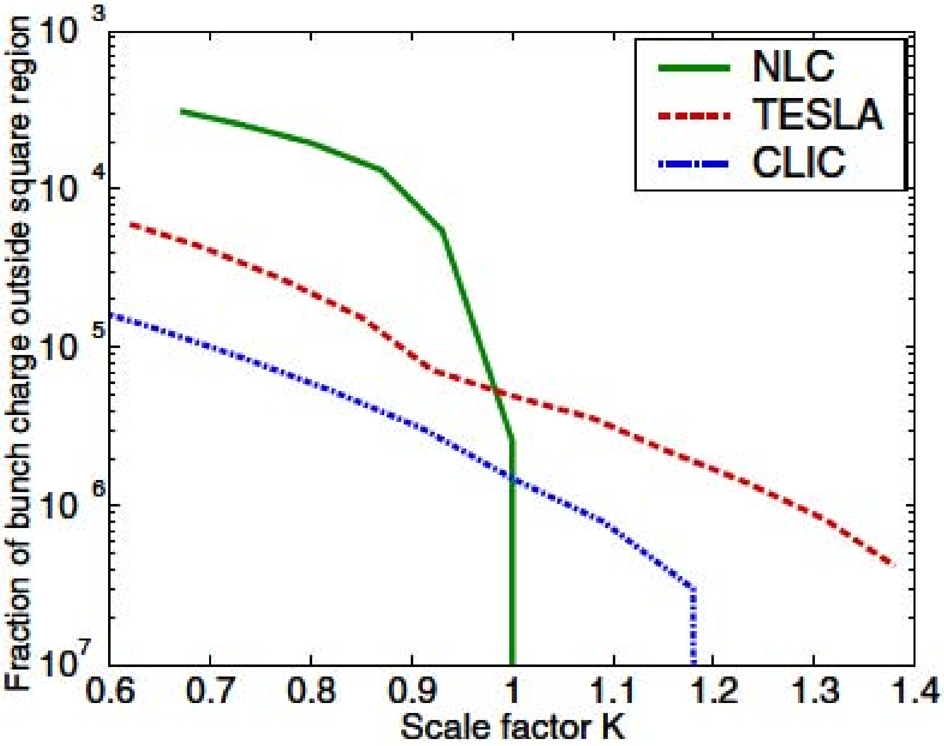
Tesla-500 parameters, 20 readings/train
Average resolution of $2 \times \sigma_y$ and $4 \times \sigma_y$

		3T	4T	5T
$z = 400$cm	0mrad	11%	13%	13%
$z = 400$cm	7mrad	9%	11%	12%
$z = 400$cm	20mrad	22%	19%	28%
$z = 176$cm	20mrad	12%	15%	20%

Caveat : Resolution depends on the selection of sampling regions.

Effect of Tail - how big is the tail?

- First preliminary look -



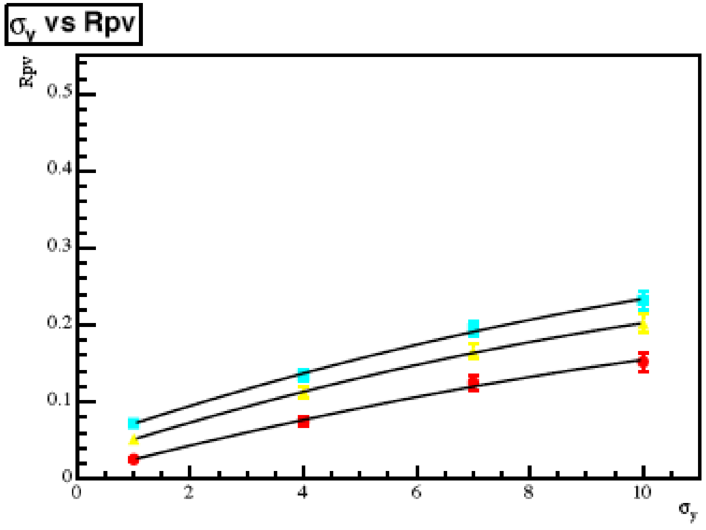
Fraction of total bunch charge out side of the rectangular box of $K\times$(collimation depth)

Tesla collimation depth $=13\sigma_x, 80\sigma_y$

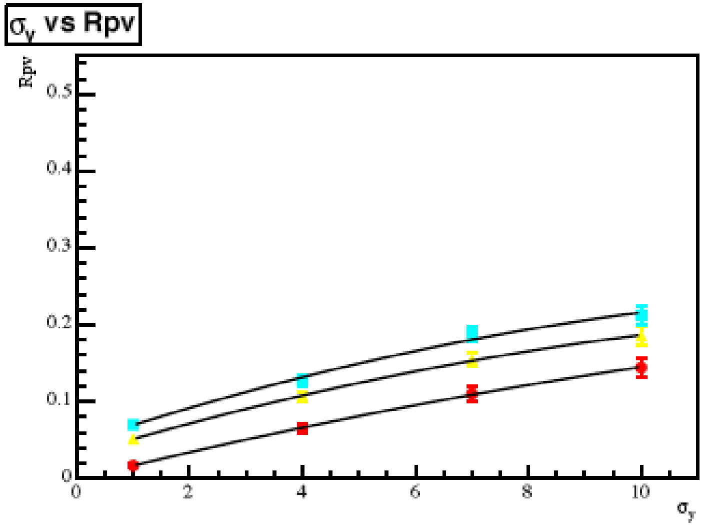
Fraction outside $7\sigma_x$, $48\sigma_y$
$\sim 4\times10^{-4}$
Assume a gaussian with $10\times\sigma_y, 0.1\%$ area
(Very uncertain!)

Effect of Tail (beam halo)

- First preliminary look -



No tail
ILC beam params
0mrad crossing
z=400cm



0.1% tail (y)
(adding a gaussian with
$10 \times \sigma_{y\ \text{core}}$)
No significant difference.
Further study to be done.

The σ_y resolution is worse when

- distance from IP is larger.
- B field is larger.
- crossing angle is larger.
  σ_y resolution $\sim$same for $\theta_X = 1 \sim 7$mrad.

Things to do:

- Use correct B field
  (edge effect, Q-magnet, compensating coil etc.).
- More study of the pattern
  (location of information).
- Measurement of other beam parameters
  (σ_x, horizontal shift, azimuthal tilt of bunch etc.).
- Robustness of measurement
  (non-gaussian beam shape, tail, halo etc.)

Pixel Readout Electronics

Pixel electronics for warm machine

- Measure time and pulse height of each hit.
- 4-point sampling (250ns apart).
- $\sigma_t \sim$ 30ns achieved ($\sim$goal).
- Survived $\sim$2MRad (goal).

Cannot be used for cold machine, since

- For warm machine, hit rate$\sim$0.5 hits/pixel/train.
- For cold machine, it will be $\sim$15 hits/pixel/train.
- $\rightarrow$ too much.

Solutions

- Count the number of hits and store it locally on each pixel.
- Read out in train gap (or during the train if possible).
- Threshold is applied $\rightarrow$ insensitive to X-rays etc.
- Digital read out $\rightarrow$ insensitive to RF pickups.

Readout electronics for cold LC

1. pixel : 0.4x0.4 mm^2.
   3D pixel sensor is being designed/fabricated.

2. TMSC has 2.54 by 1.27 cm^2 chips : sensor size.

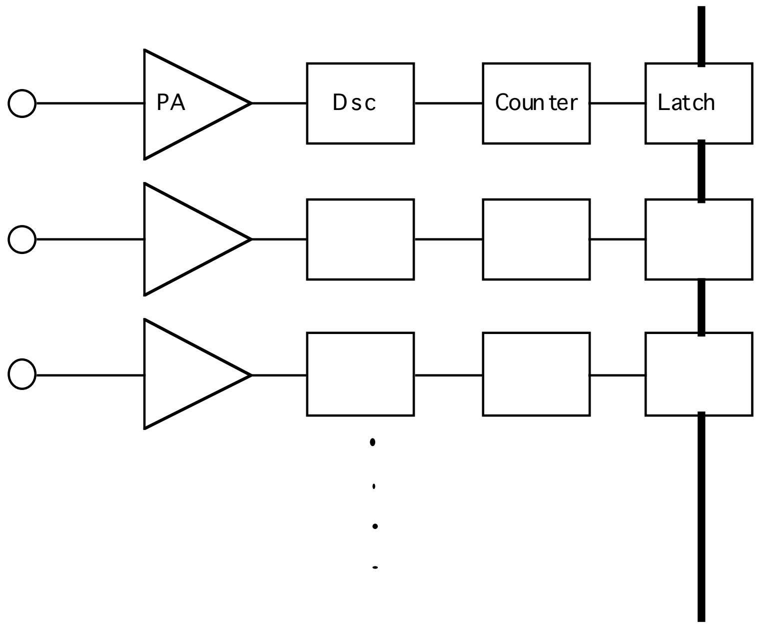
3. 27 by 54 pixels/sensor.

4. 8-bit gray code counter.

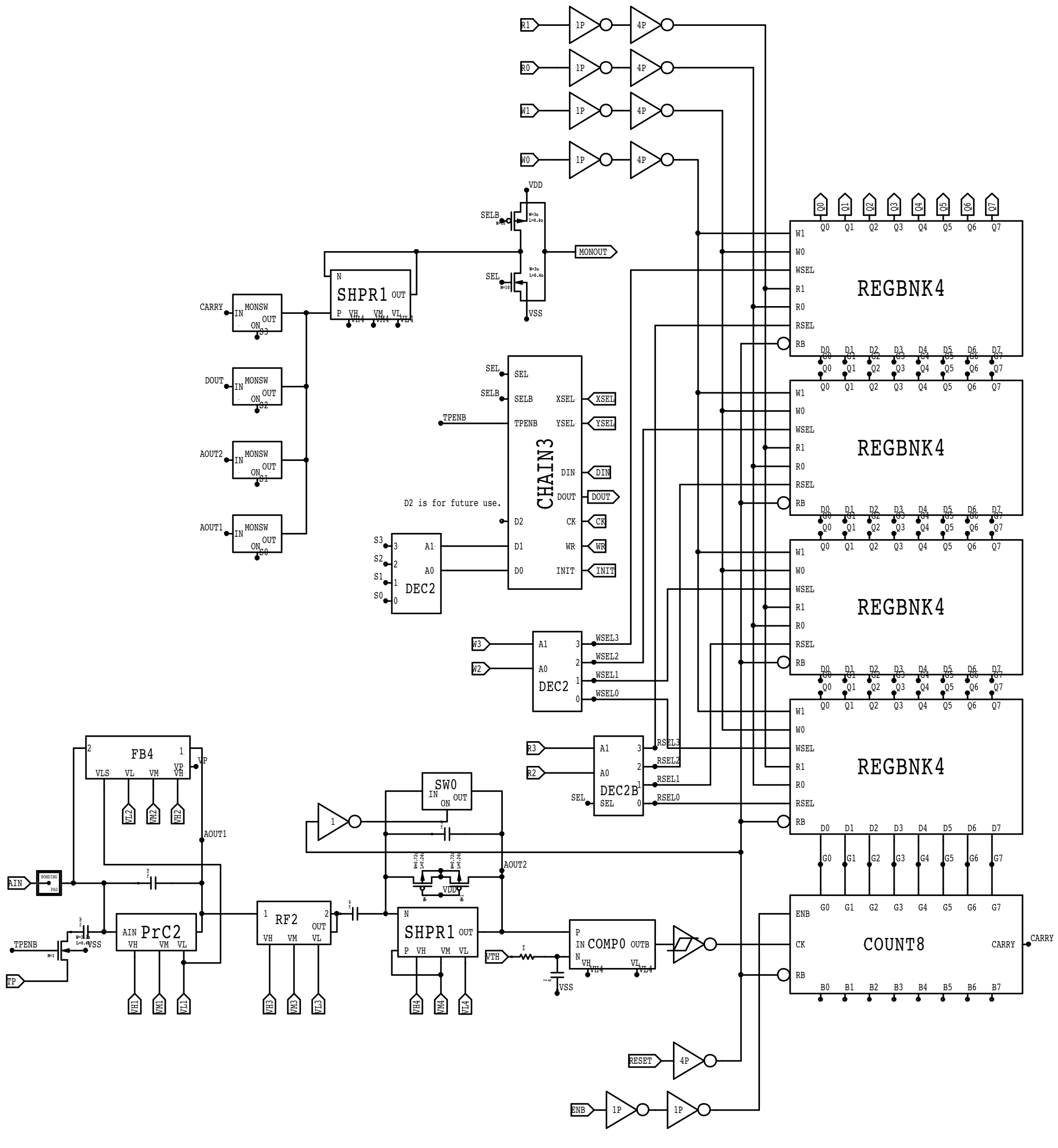
5. 9 parallel outputs/sensor $\rightarrow$ 1728 bits/line

6. 40 MHz transmission $\rightarrow$ 43 μs/readout
   ($\rightarrow$ 20 readouts possible during train, in principle)

Pixel electronics (readout)



Pixel circuit



Readout electronics status and plan

1. Conceptual design completed. (Ikeda + 2 students)
2. Basic simulations and noise estimations done.
3. Finish circuit design by end summer 2005.
4. Layout by outsourcing.
5. Submit for fabrication (MOSIS) end 2005.
6. Test the circuit 2006 spring.
7. Bump bond to prototype sensor (company?).