Track finding with radially pointing scintillating fibers

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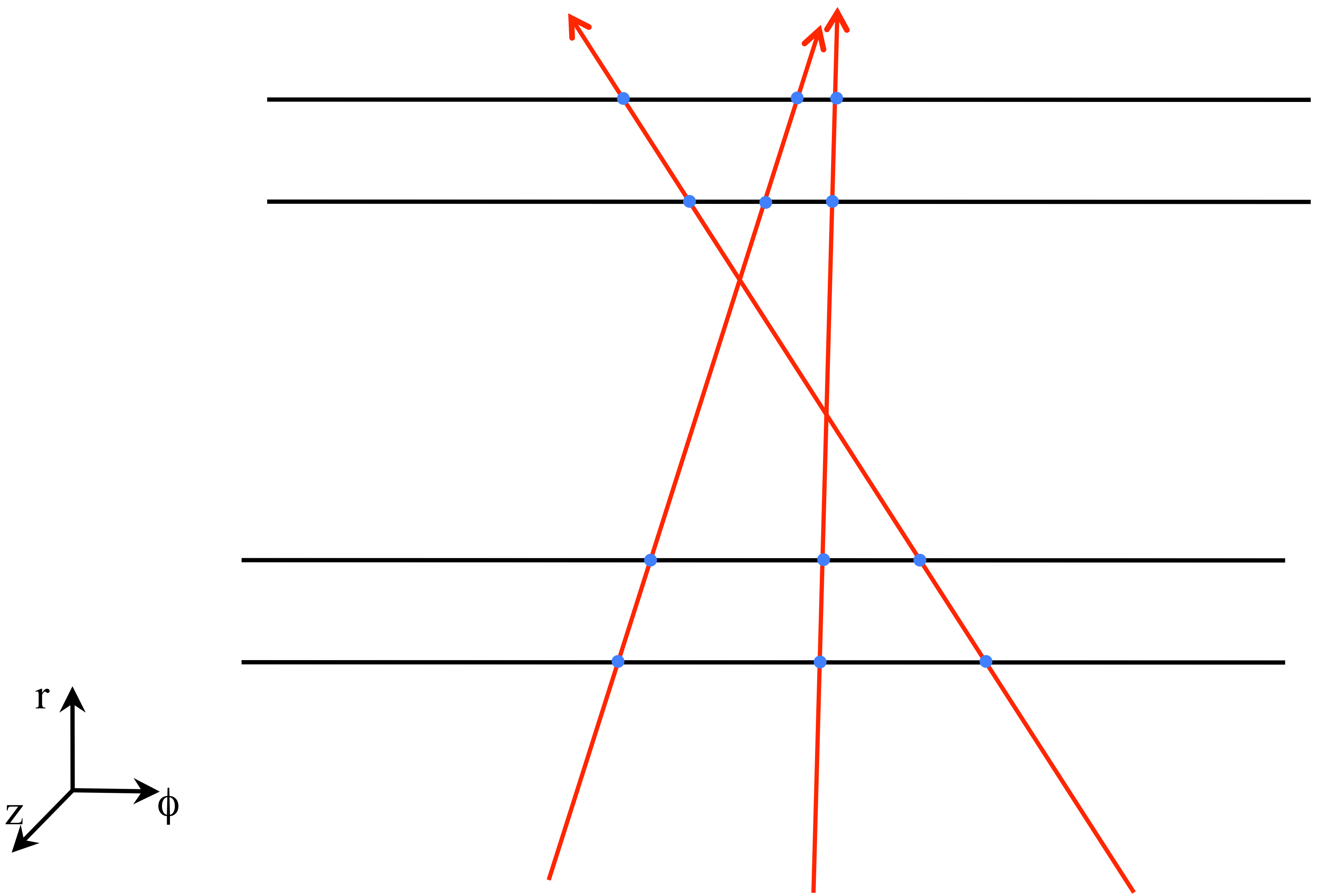
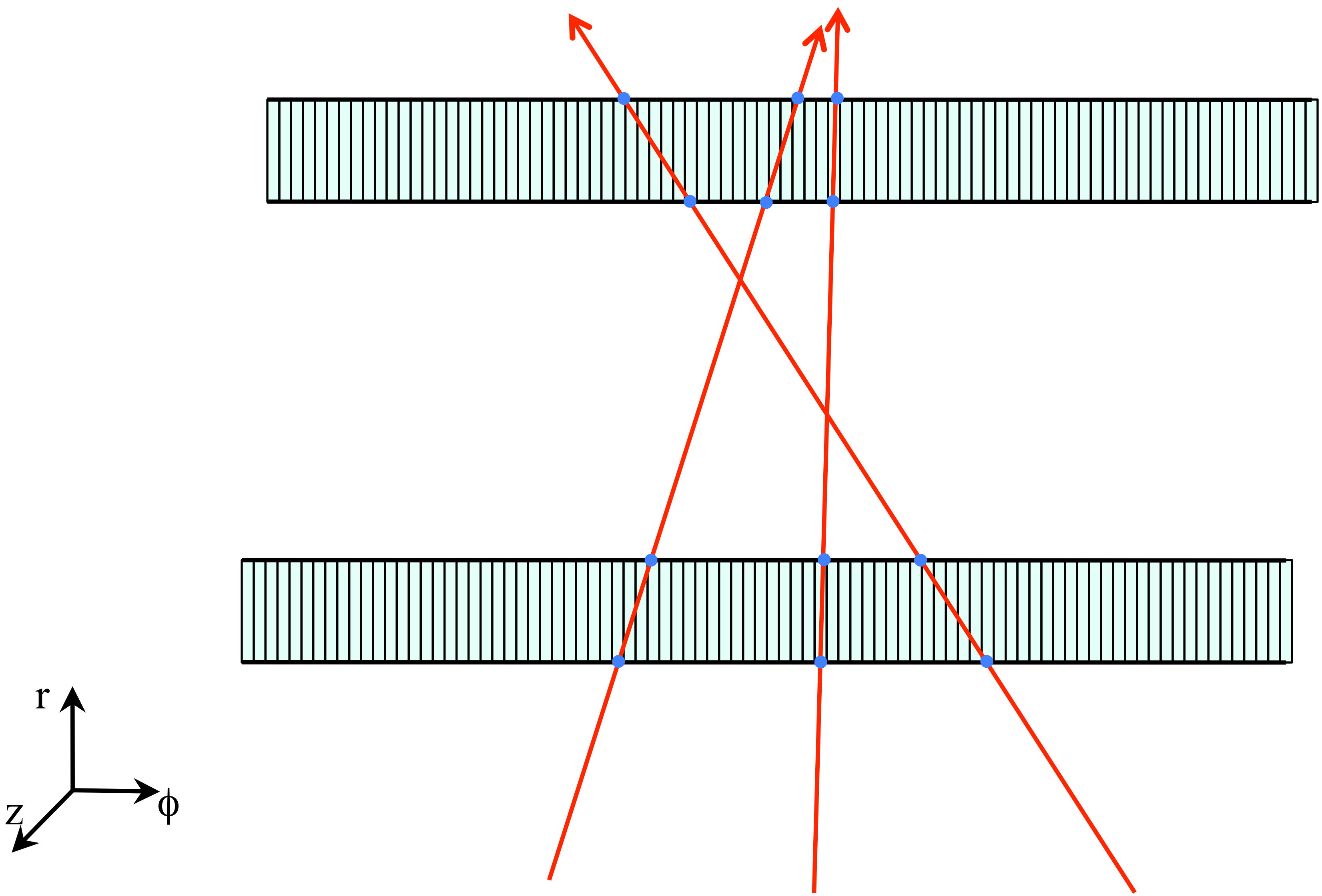
UC Santa Barbara
Feb. 3, 2010

Motivated from the stub & tracklet approach…



Motivated from the stub & tracklet approach…

If the doublets were a single layer of *very thick* silicon, then paired hits become ends of clusters.



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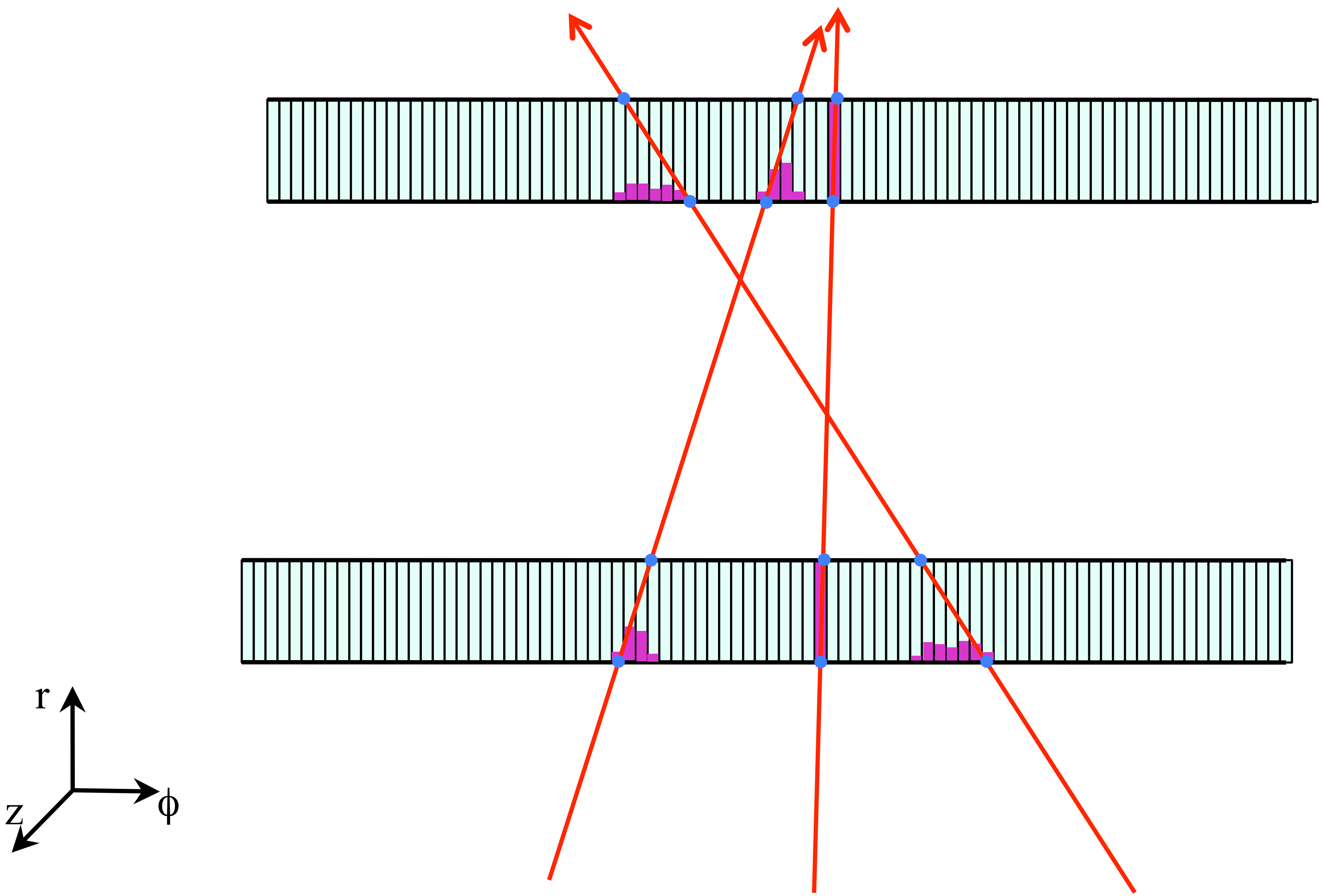
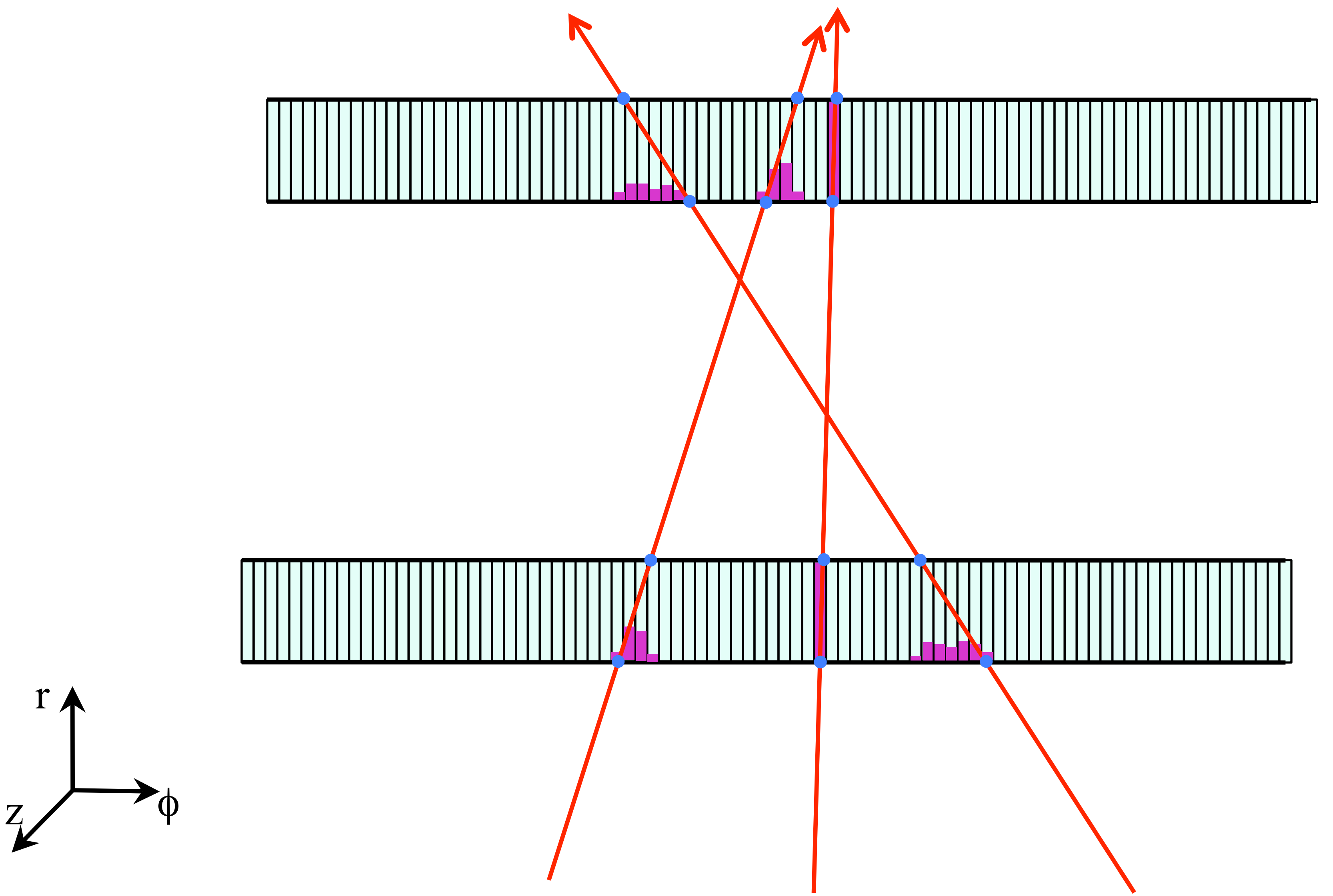
If the doublets were a single layer of *very thick* silicon, then paired hits become ends of clusters. That adds a sign ambiguity, but it could remove the pairing ambiguity.



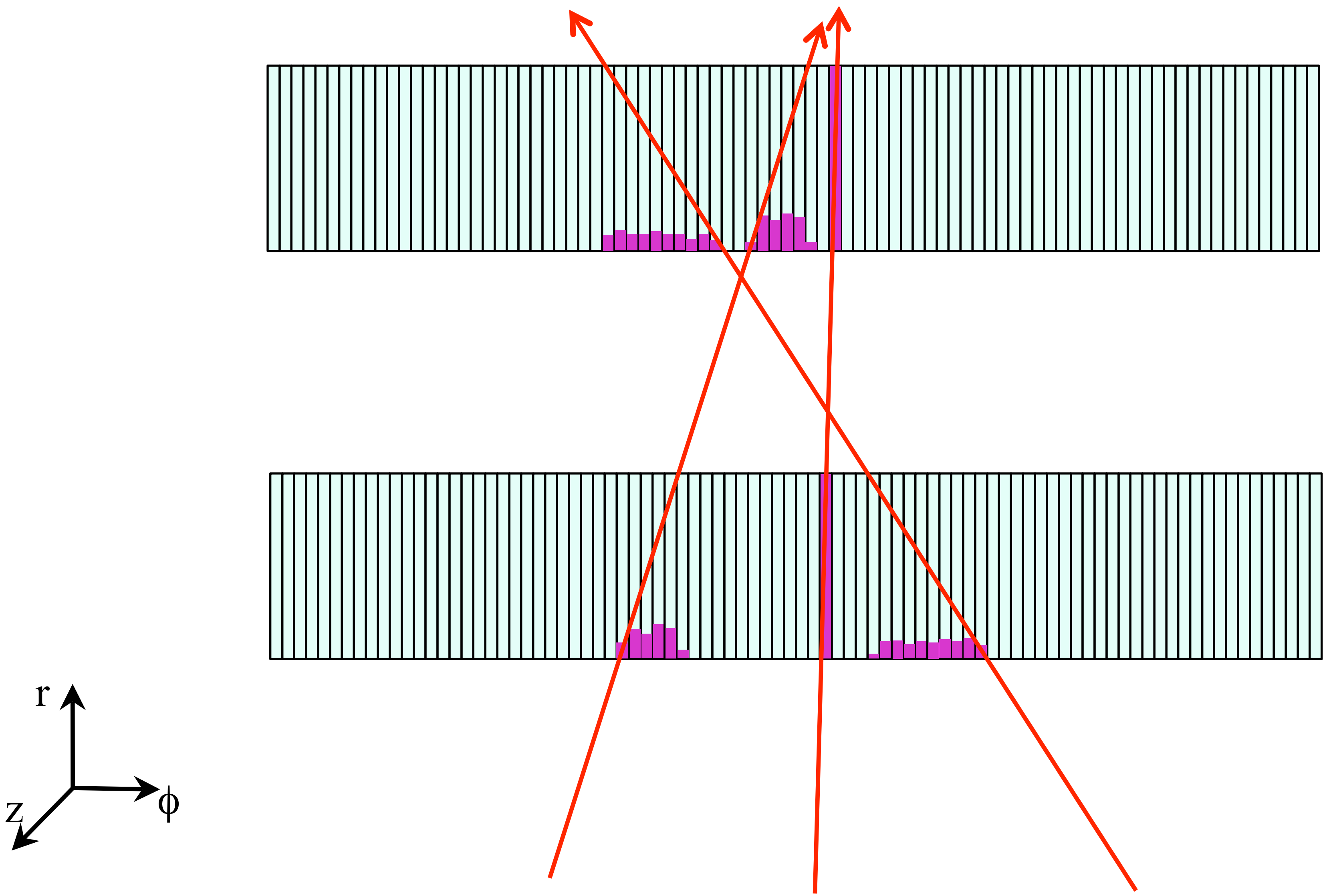
Motivated from the stub & tracklet approach…

If the doublets were a single layer of *very thick* silicon, then paired hits become ends of clusters.
That adds a sign ambiguity, but it could remove the pairing ambiguity.
High pT = short cluster with large max Q; Low pT = wide cluster with small max Q.



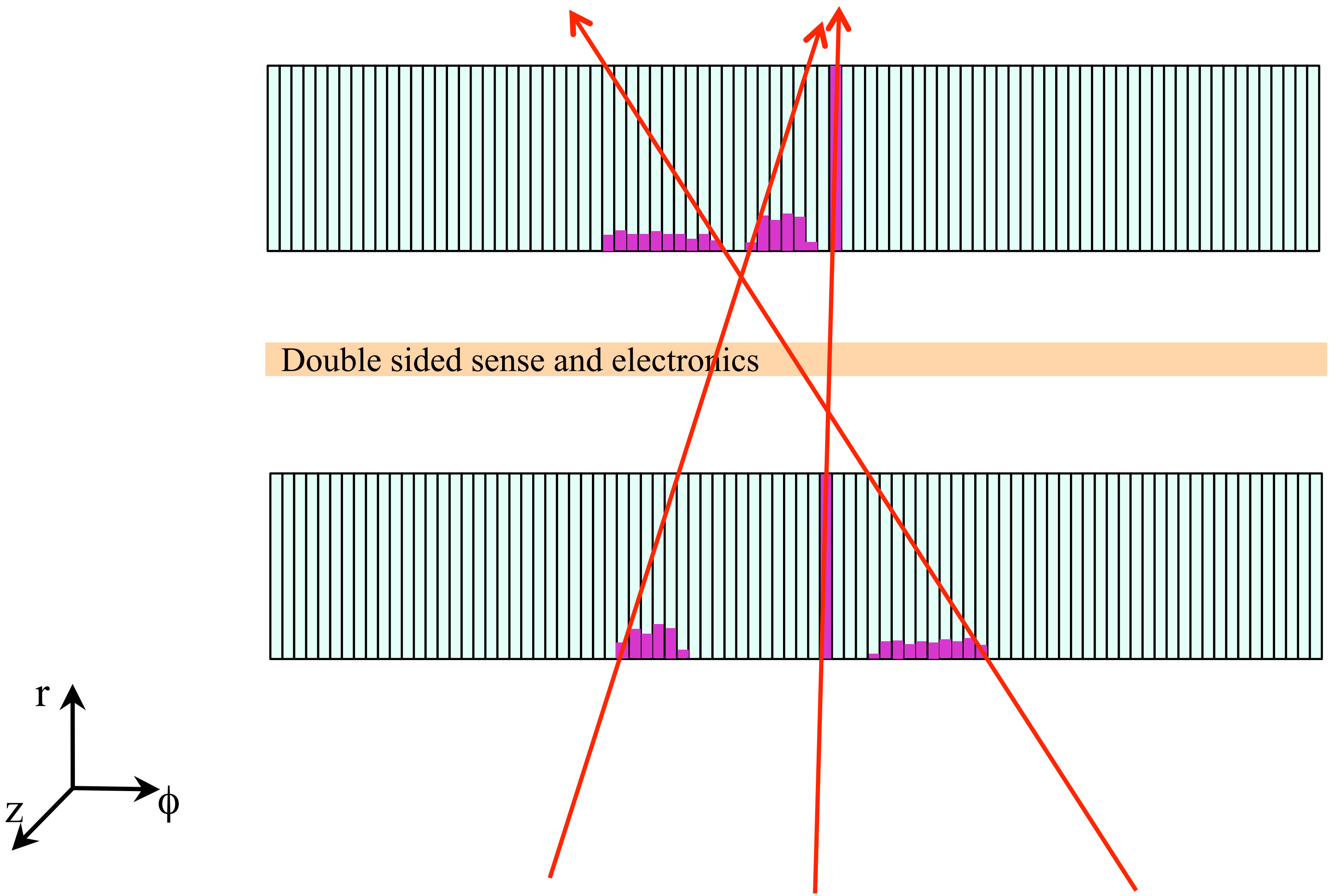
Studying two layers of radially pointing fibers: e.g., 1x1mm x 5cm

Situated outside tracker, where material is less critical.
High pT = short cluster with large light, gives a potentially simple trigger.



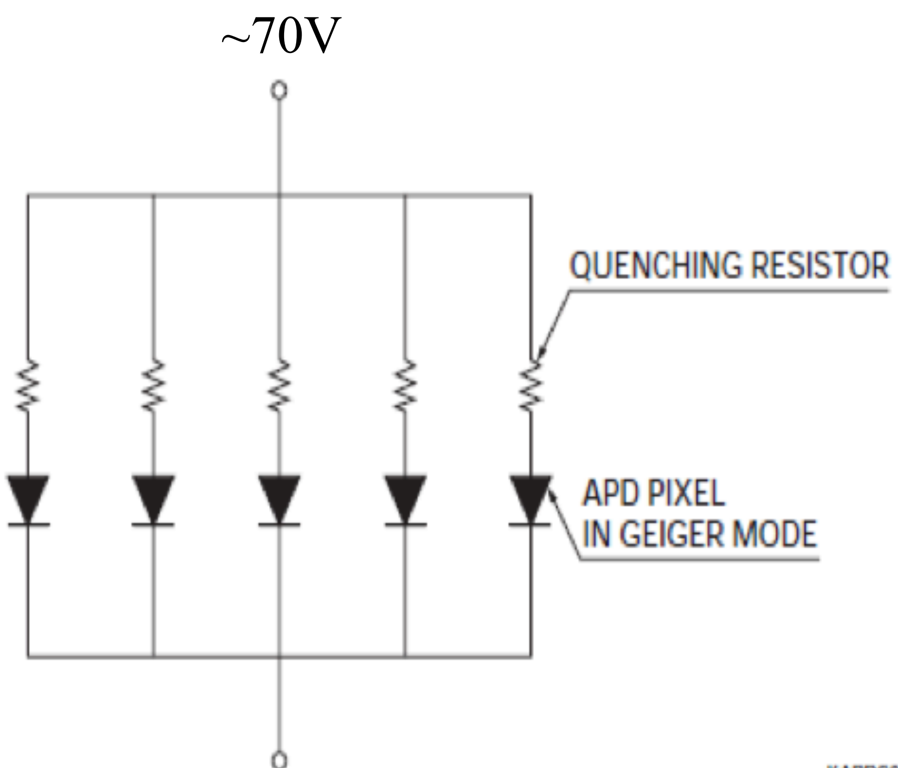
Studying two layers of radially pointing fibers: e.g., 1x1mm x 5cm

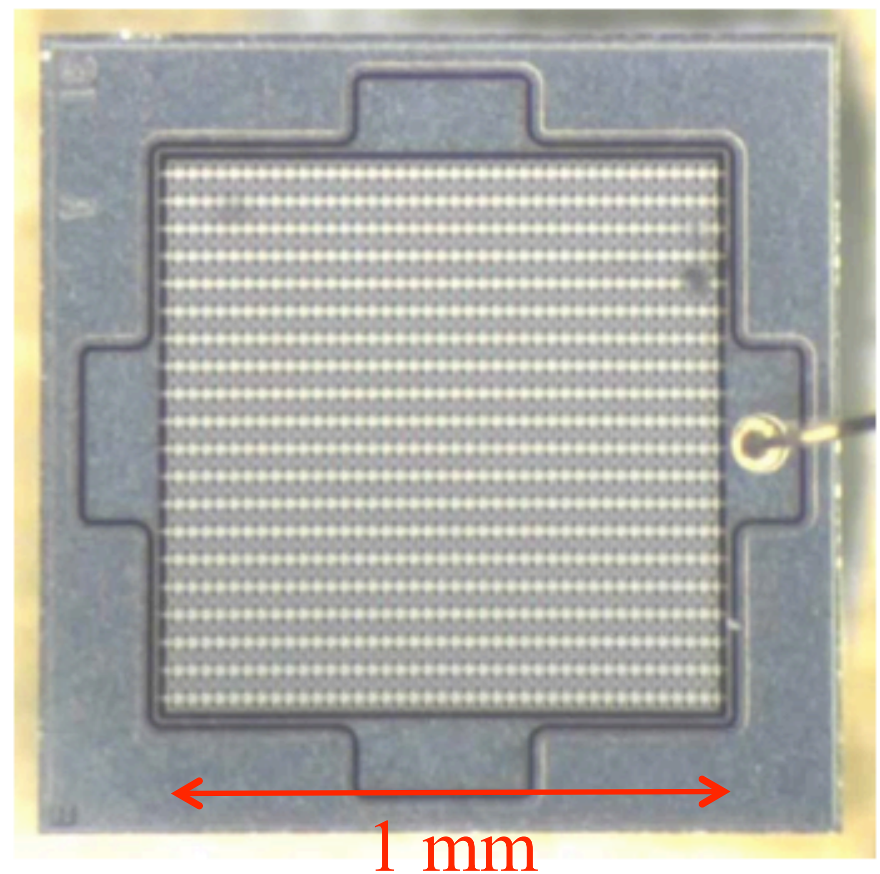
Situated outside tracker, where material is less critical.
High pT = short cluster with large light, gives a potentially simple trigger.
Information easily combined with sensing between the layers.
Fiber pixels = “fixels”.



Sensors?

Silicon Photomultipliers (SiPMs)
aka Multi-pixel Photon Counters (MPPC)
= avalanche photo-diodes operating in Geiger mode.





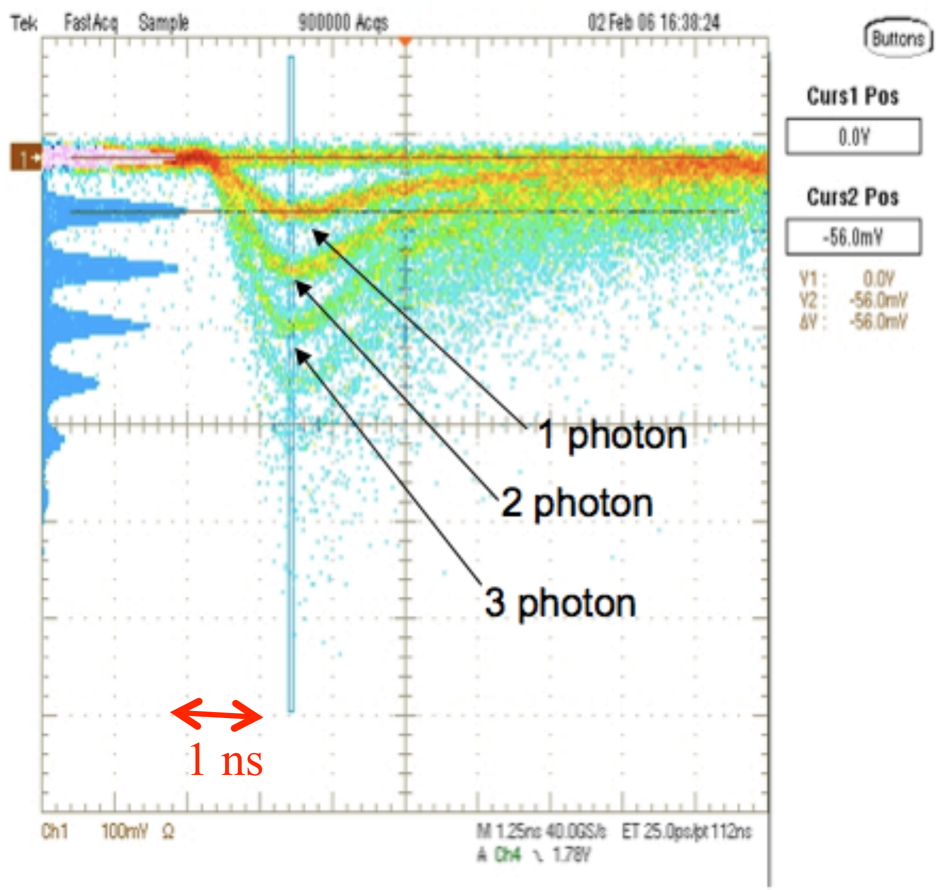
http://sales.hamamatsu.com/assets/pdf/catsandguides/mppc_kapd0002e04.pdf

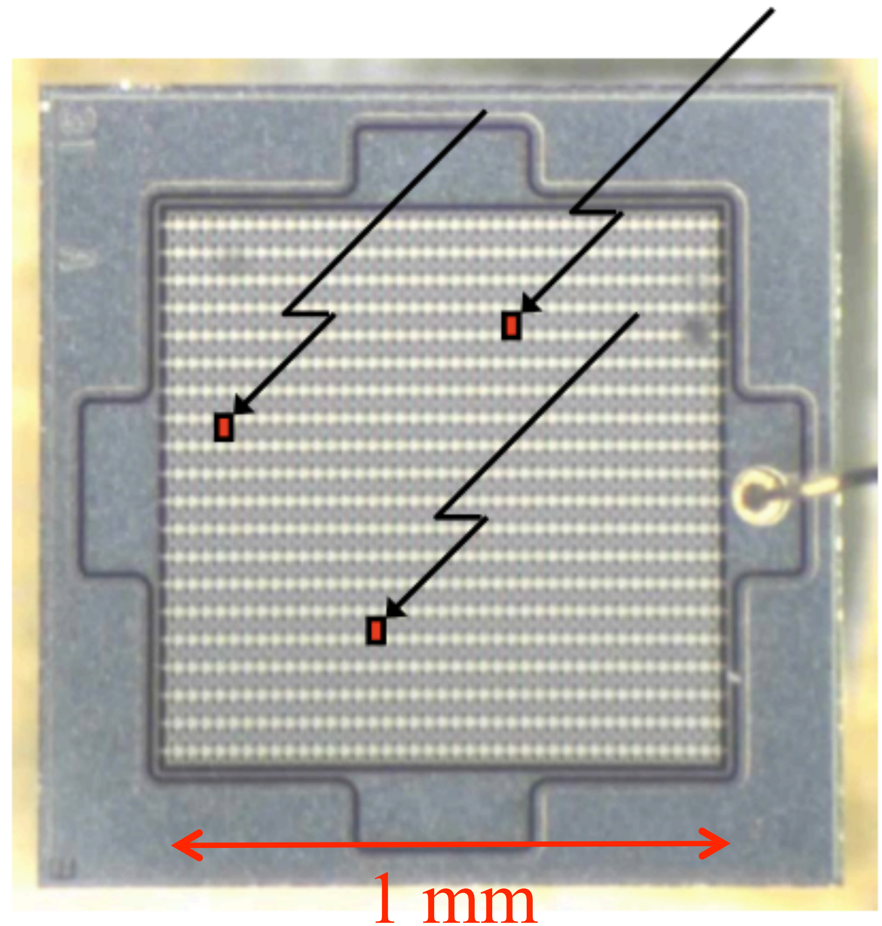
Sensors?

Silicon Photomultipliers (SiPMs)

= avalanche photo-diodes operating in Geiger mode.

Obtains linearity by literally counting photons in sub-pixels.





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Sensor cost?

About $20/pixel.

60k used for T2K (1900 yen each)
140k APDs used for CMS ECAL.

Crazy by a few orders of magnitude.

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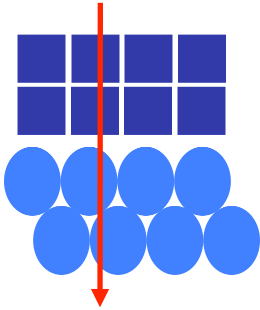
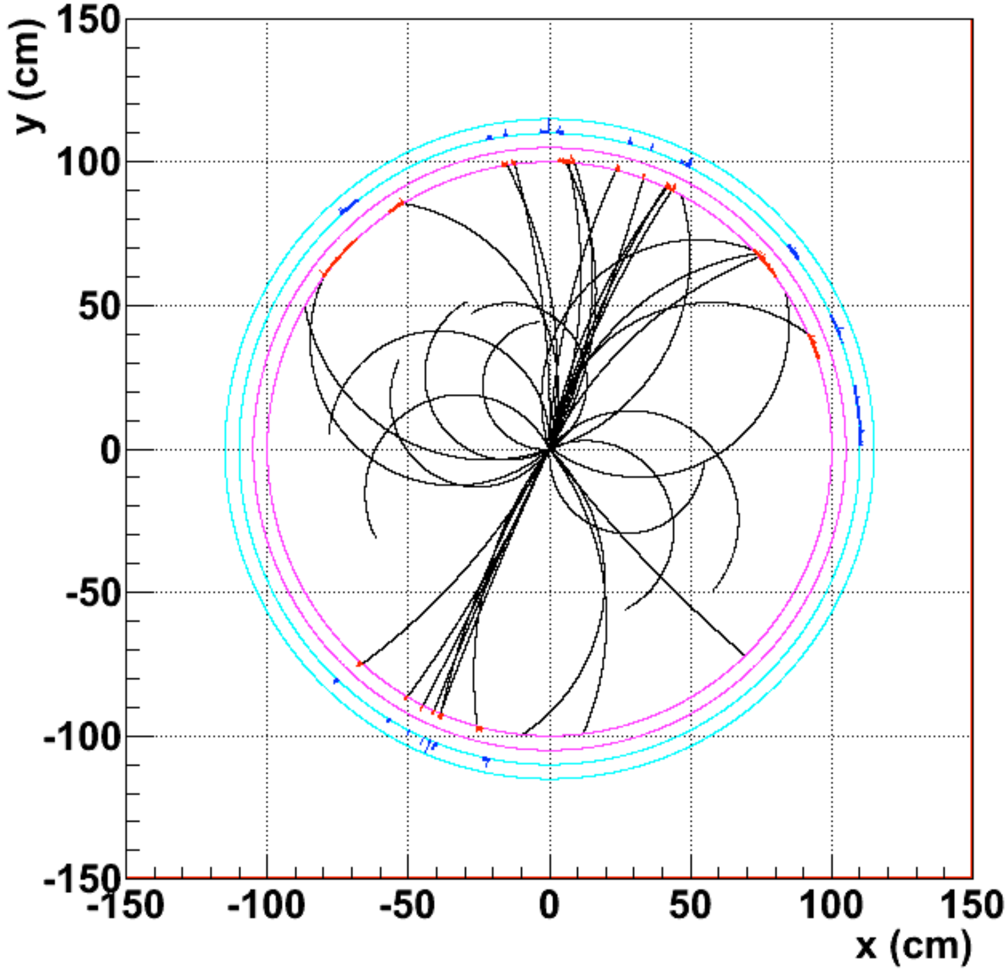
But, cost will come down over time… or inflation.

Simulation study of a Strawman design

Two cylinders of 5 cm x 1 mm "fixels", at r=100 and 110 cm (use square fibers rather than round for simplicity).





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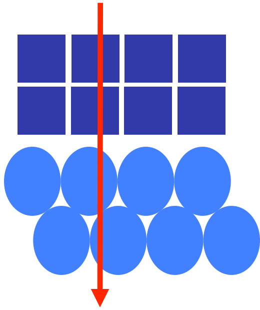


Implement a crude simulation:

- Propagate particles[1] in B=3.8T, find pathlength/fixel
- Record signals at 10 pe/mm
- Landau fluctuations (5%)
- Gaussian smearing = sqrt(N_{pe})
- "Simple" clustering.

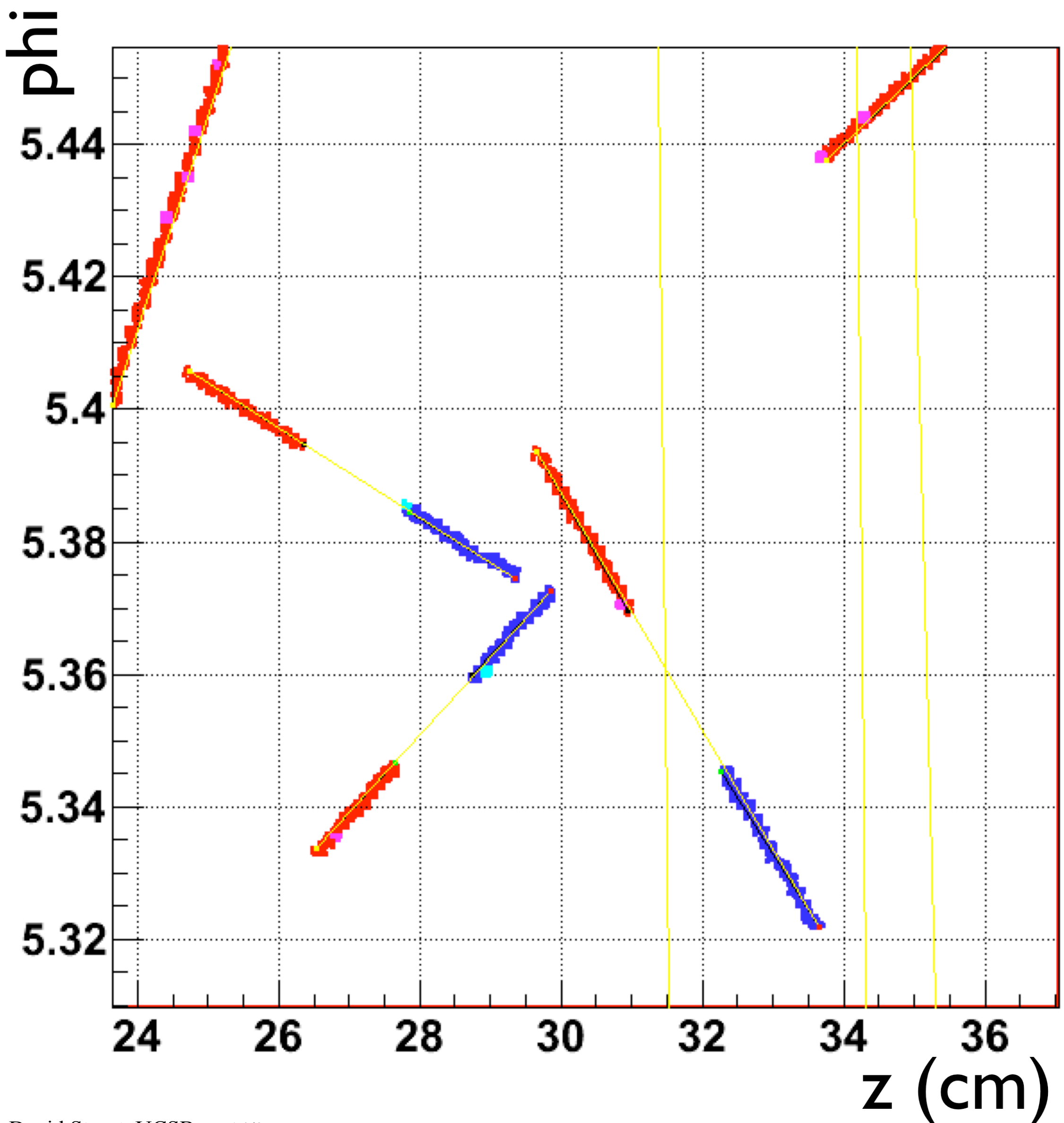
I do not include:

- Multiple scattering
- Conversions
- Nuclear interactions
- Noise hits (electronic or otherwise)

[1]Use single particle guns and tracks from 10 TeV CMS MC w/ 200 evts pileup.

Clustering may be easy enough for online

because points “connected”.

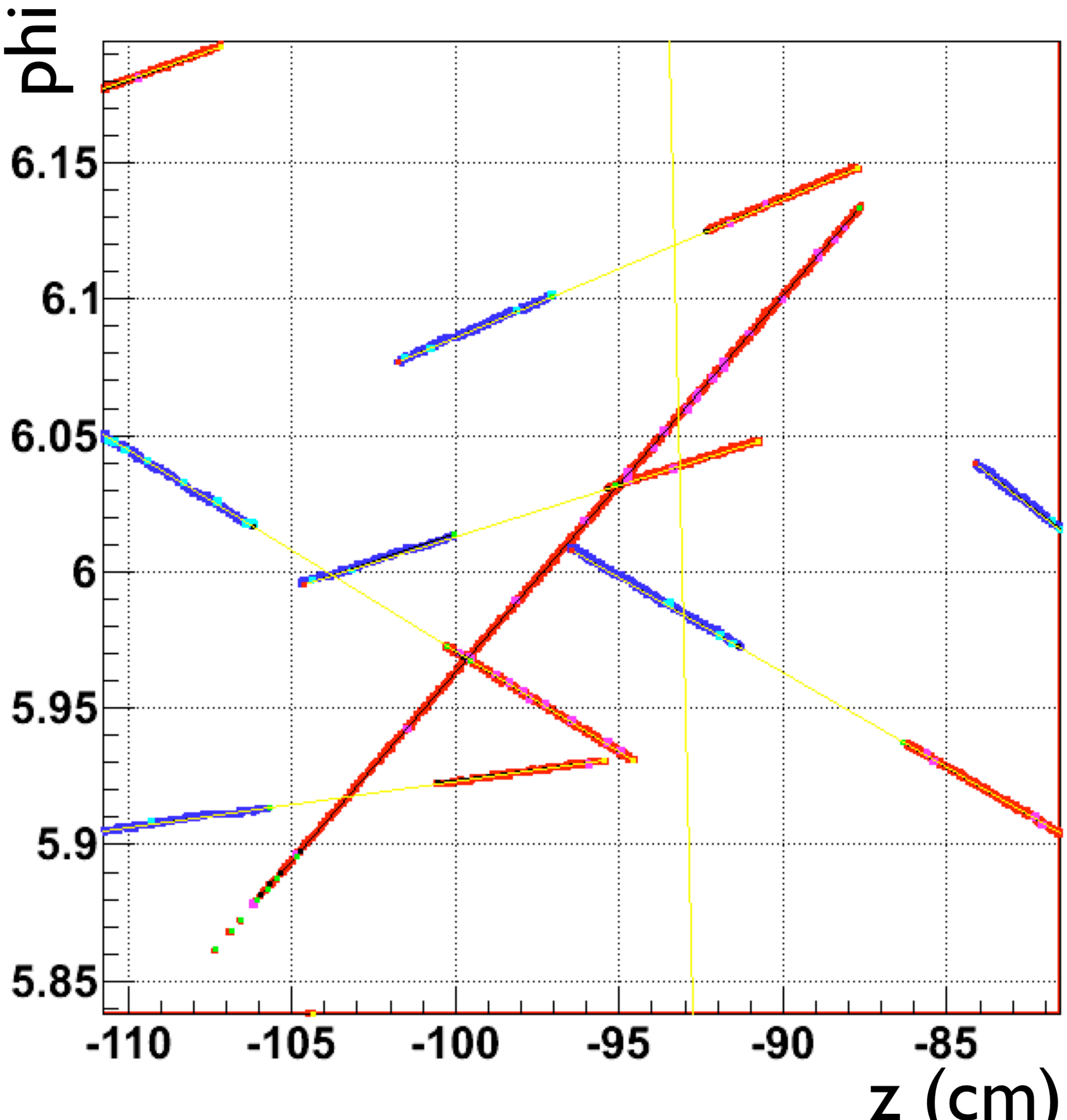


Inner layer

Outer layer

Clustering may be easy enough for online

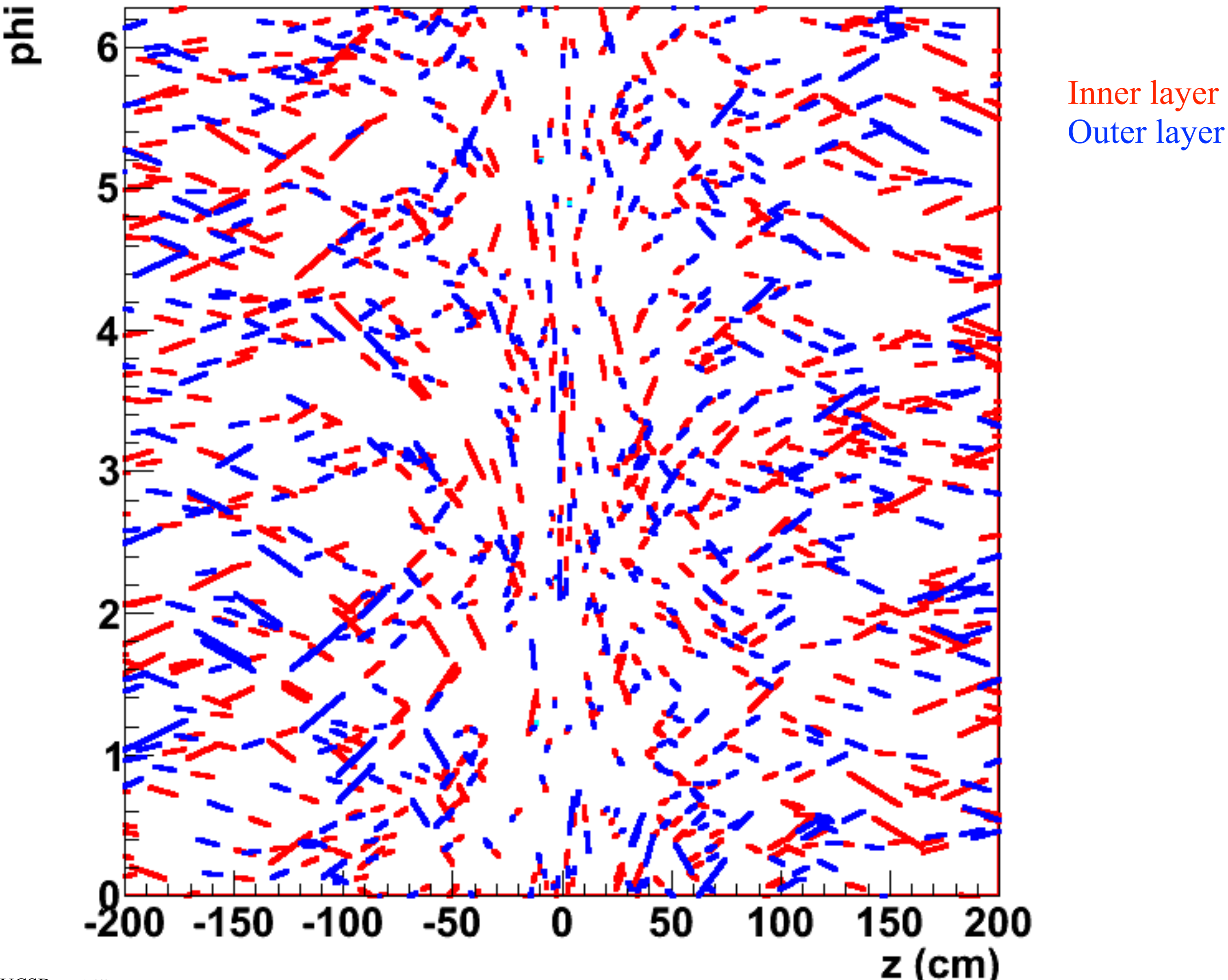
even in a crowded environment, because points “connected”.



Inner layer
Outer layer

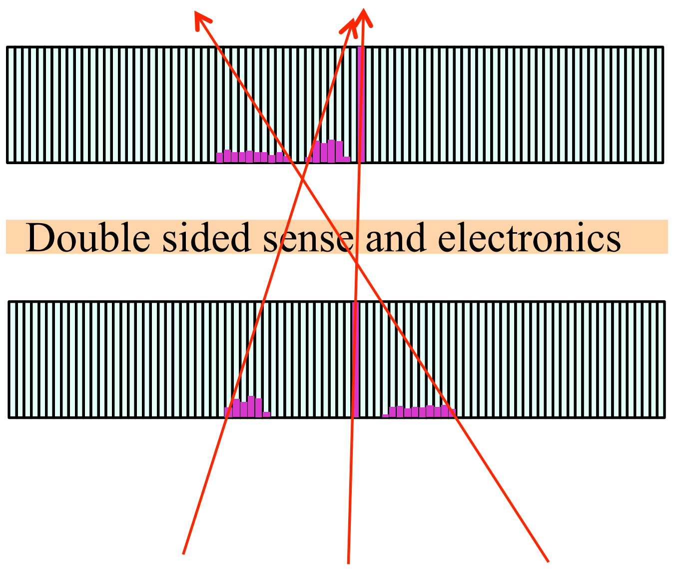
Clustering may be easy enough for online

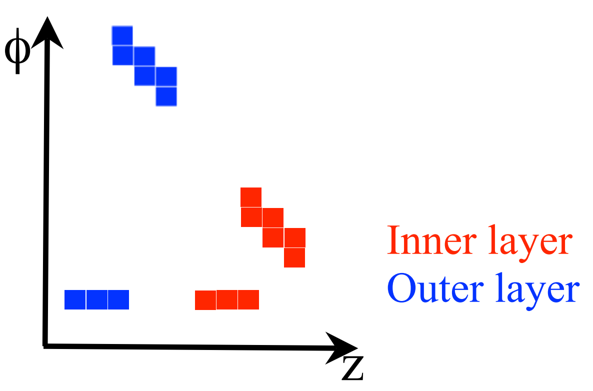
Example showing all hits from 200 overlaid min bias events.

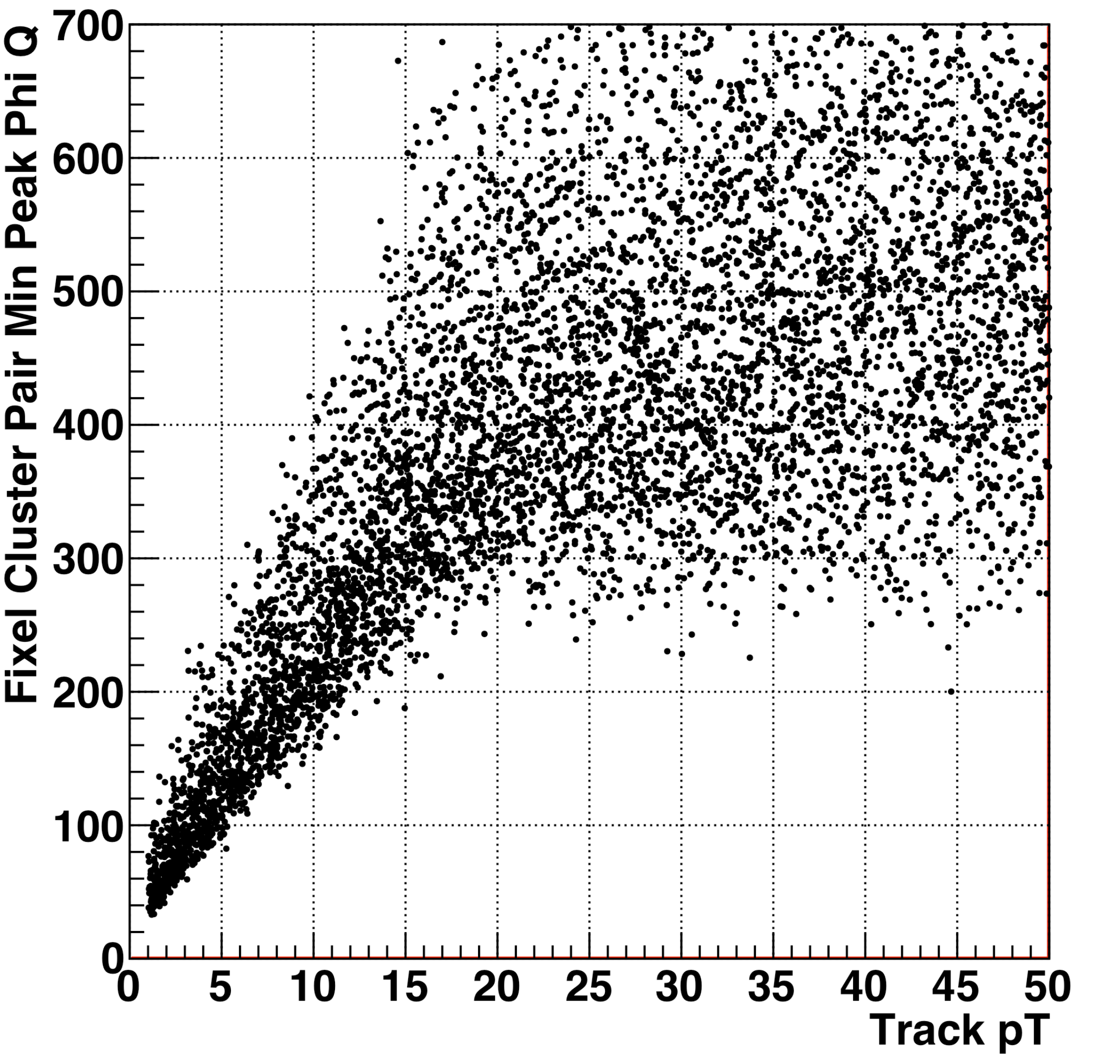


Light yield / phi slice proportional to p_T

Peak Phi Q = max light yield, at constant phi summed over z.

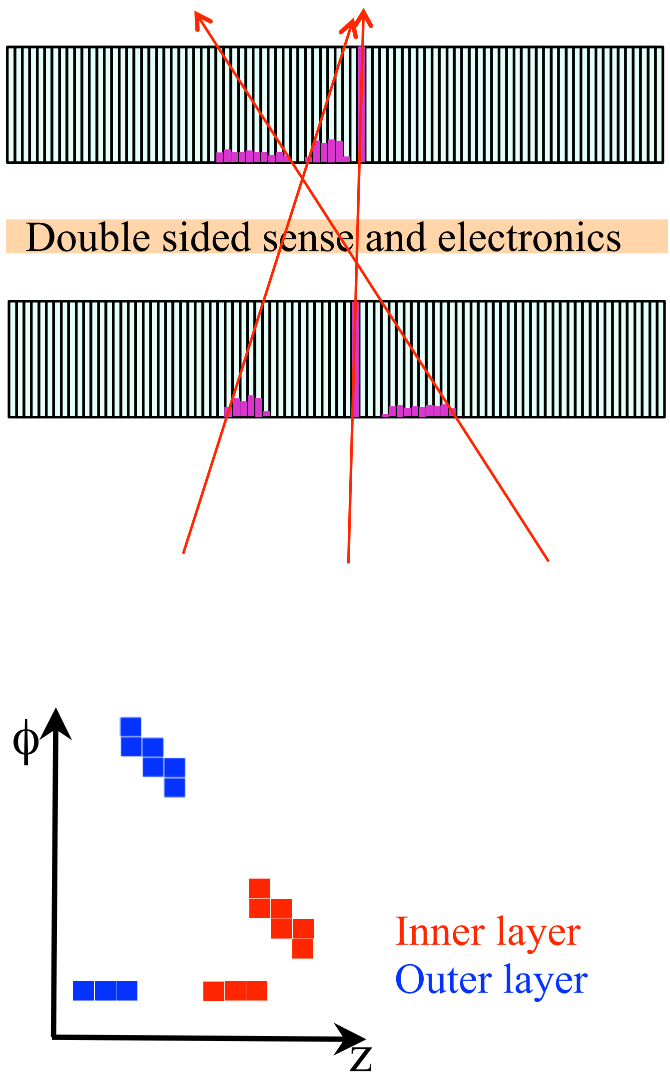


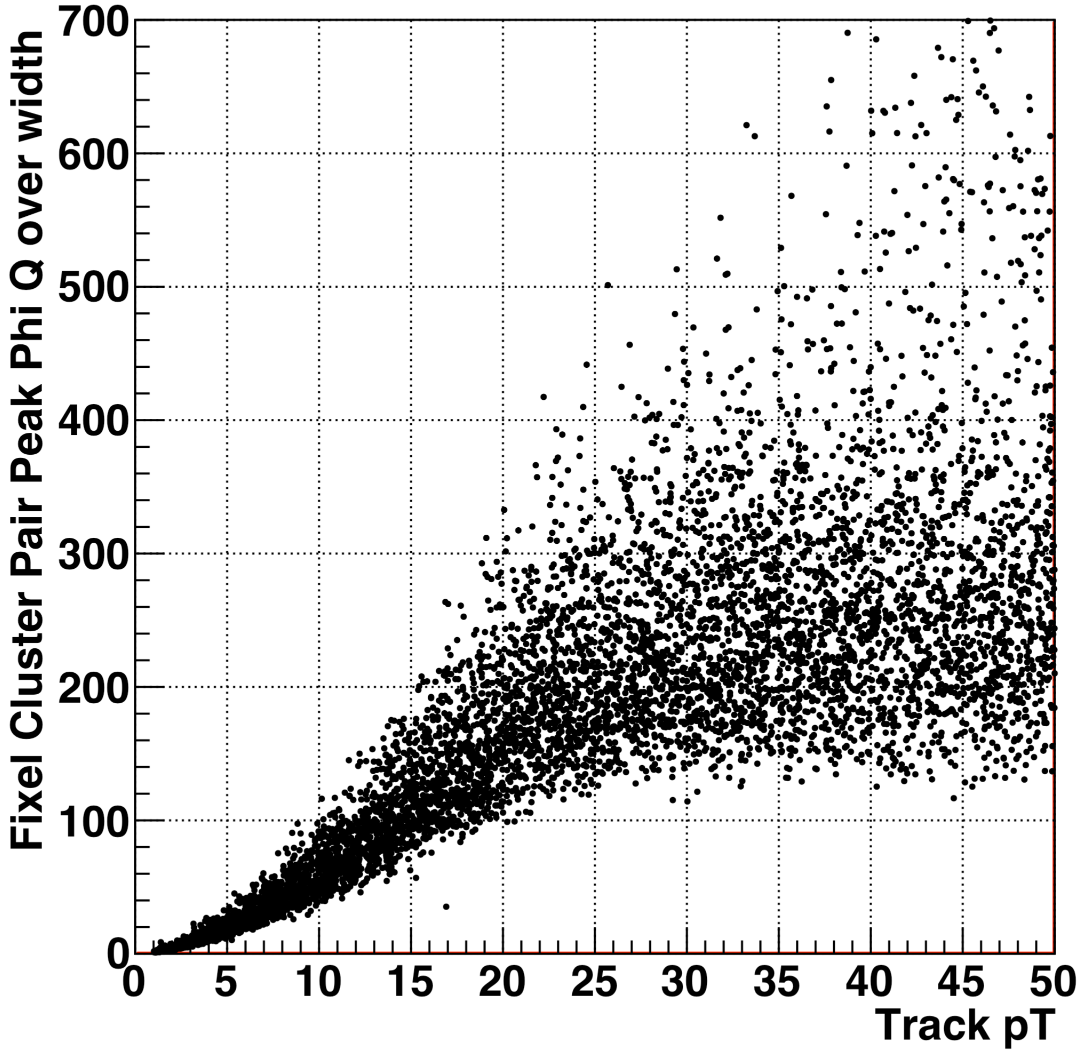




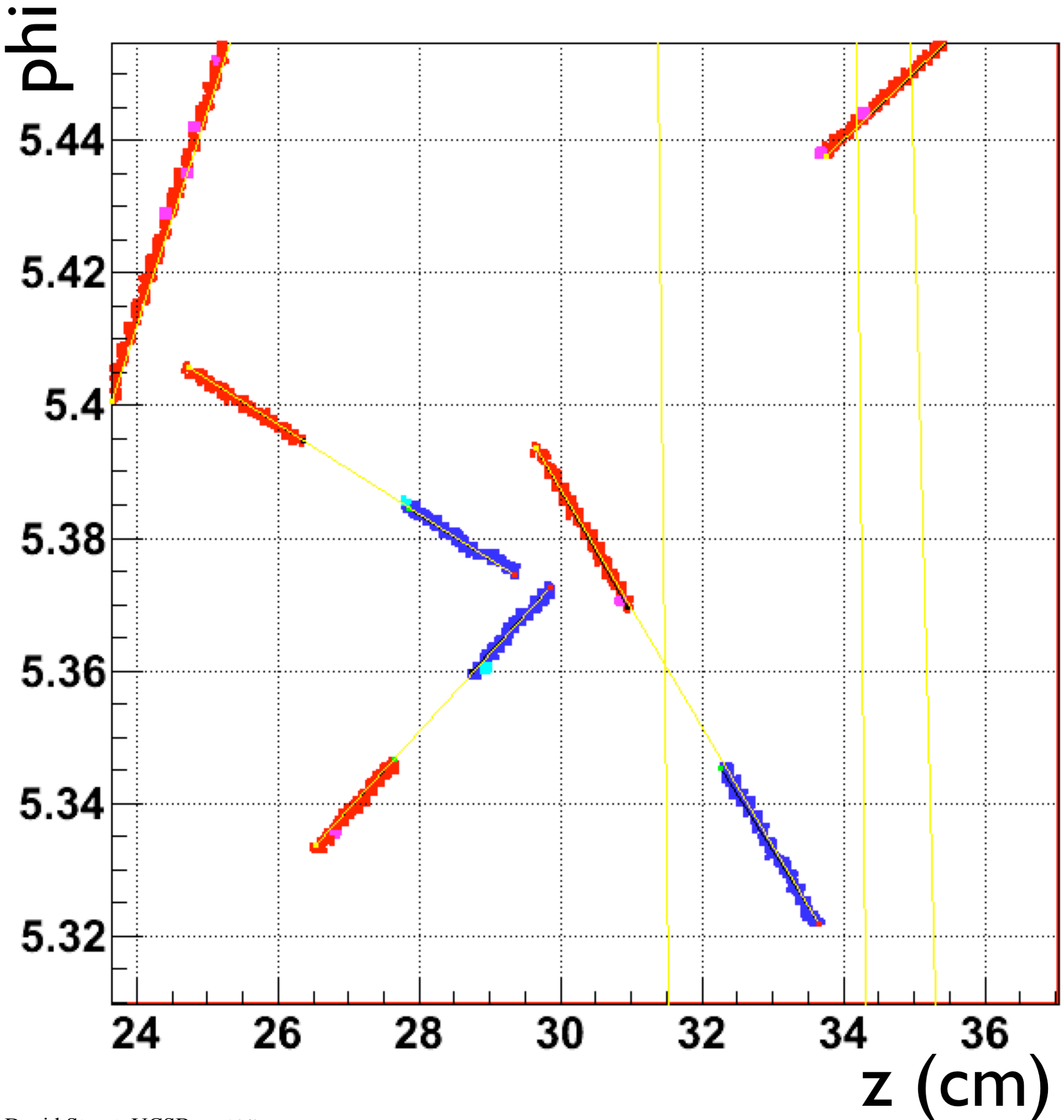
Light yield / phi slice proportional to p_T

Improved by combining light yield and cluster size: maxQ/phiWidth





Can calculate track parameters from end points



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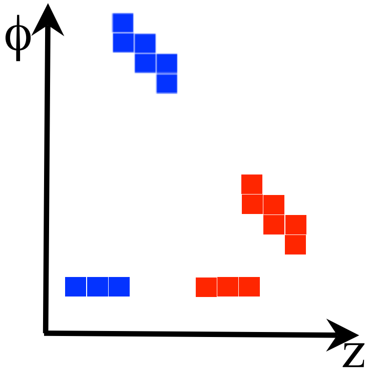
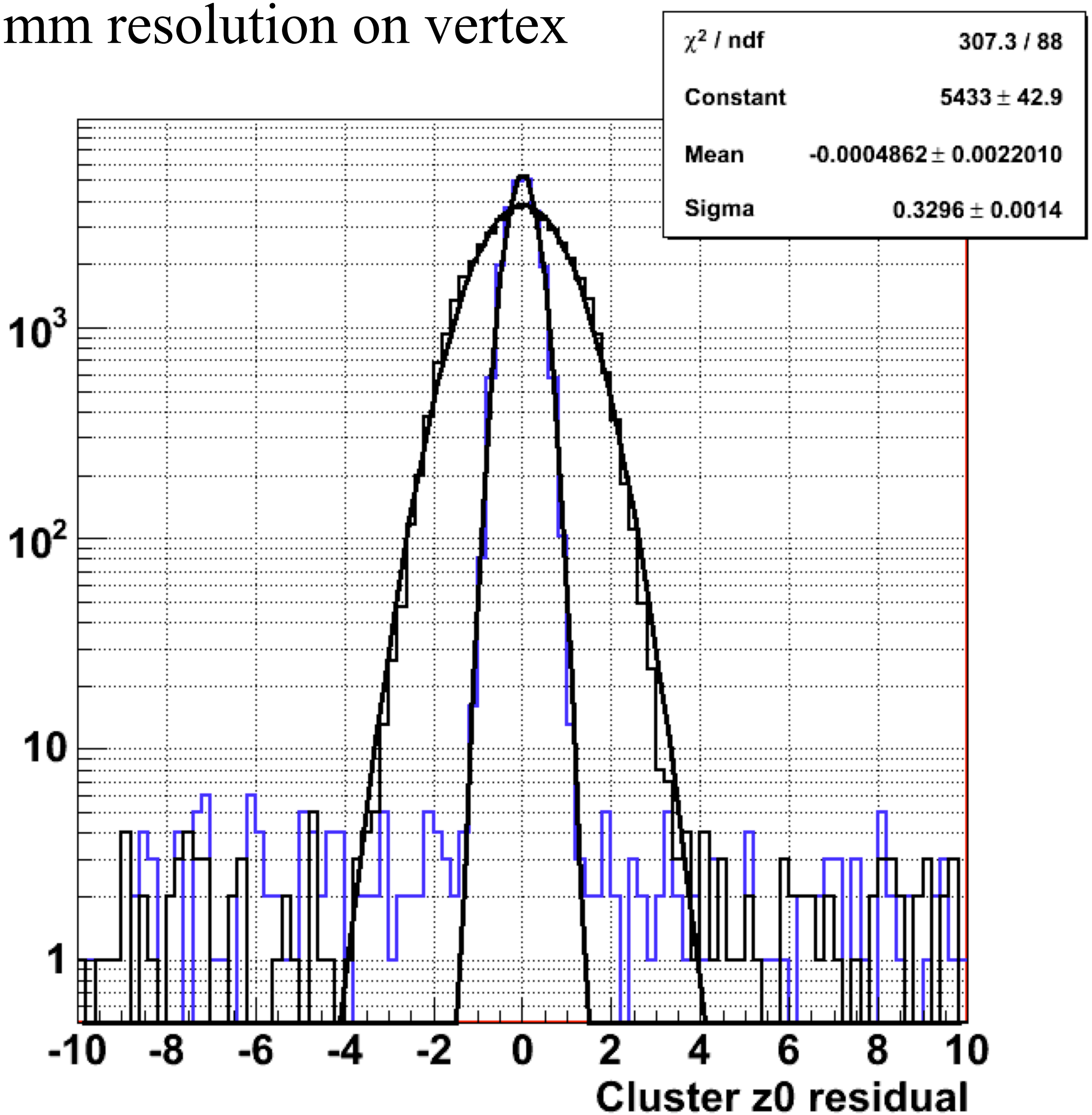


Can calculate track parameters from end points

3mm resolution on vertex



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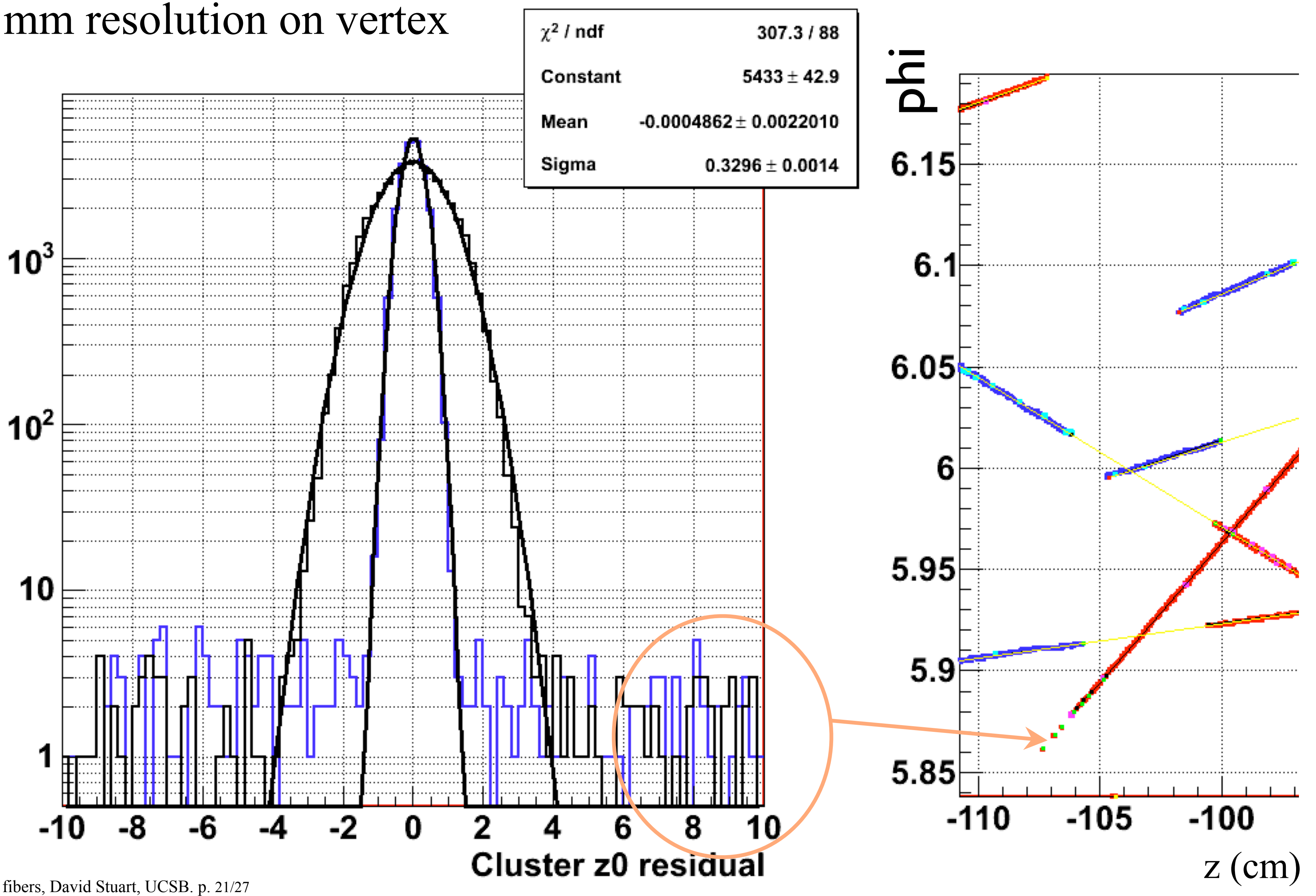
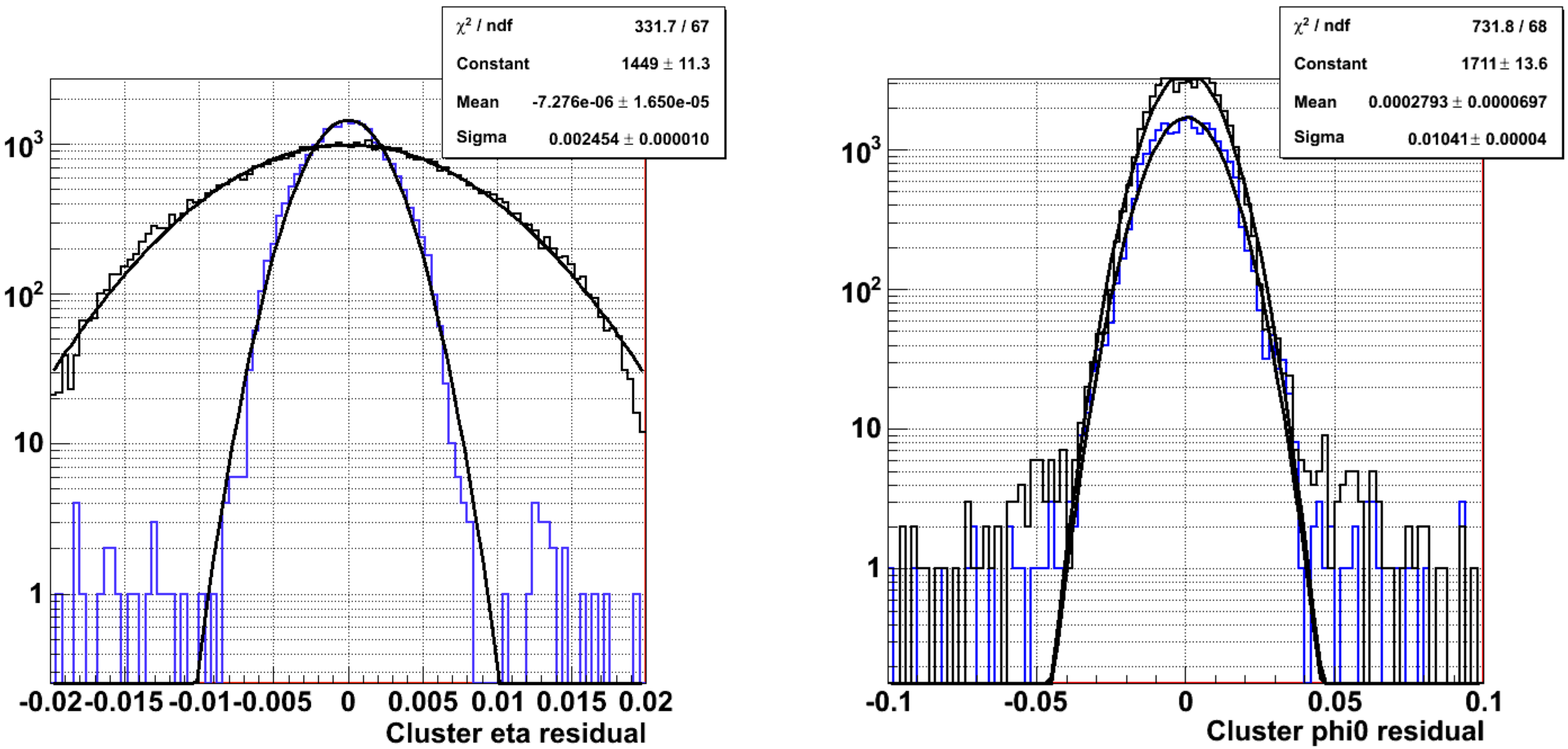


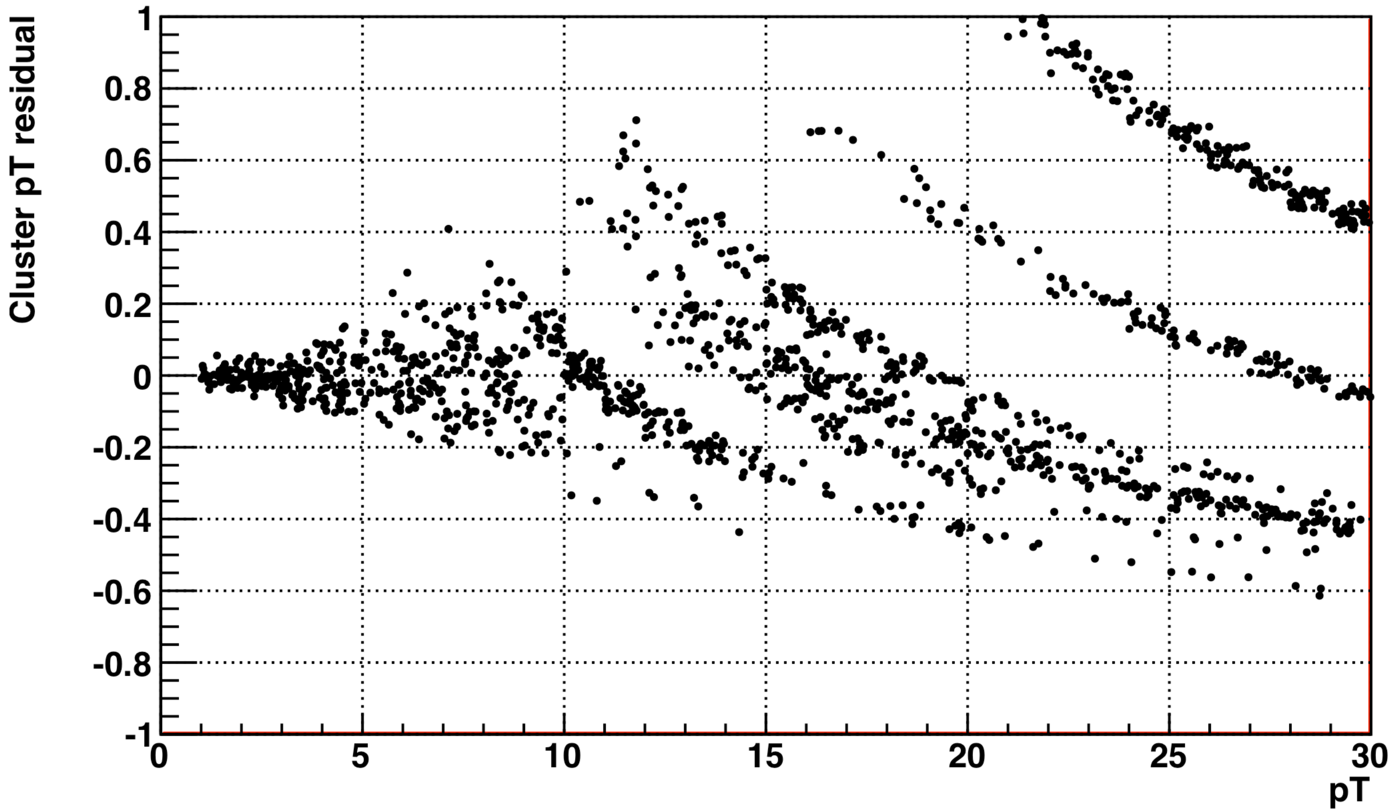
Can calculate track parameters from end points

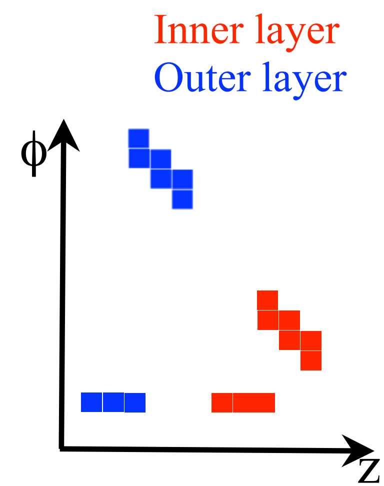
Eta and phi resolution certainly good enough for Iso.



Can calculate track parameters from end points

p_T resolution certainly good enough for Iso.
(Stripes due to pixelation).



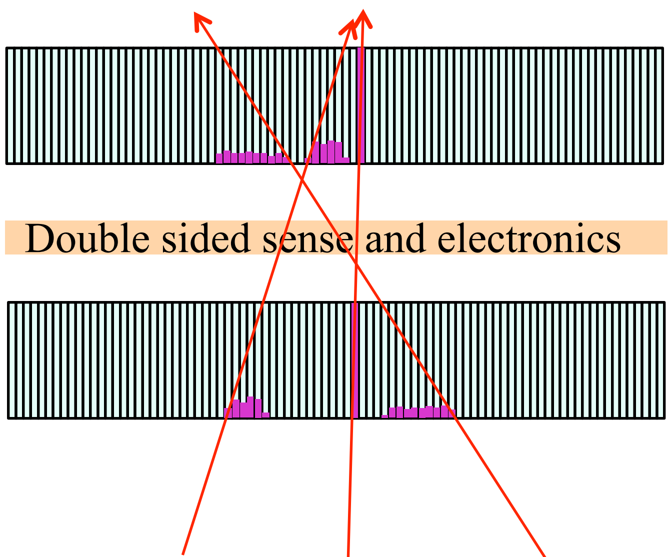


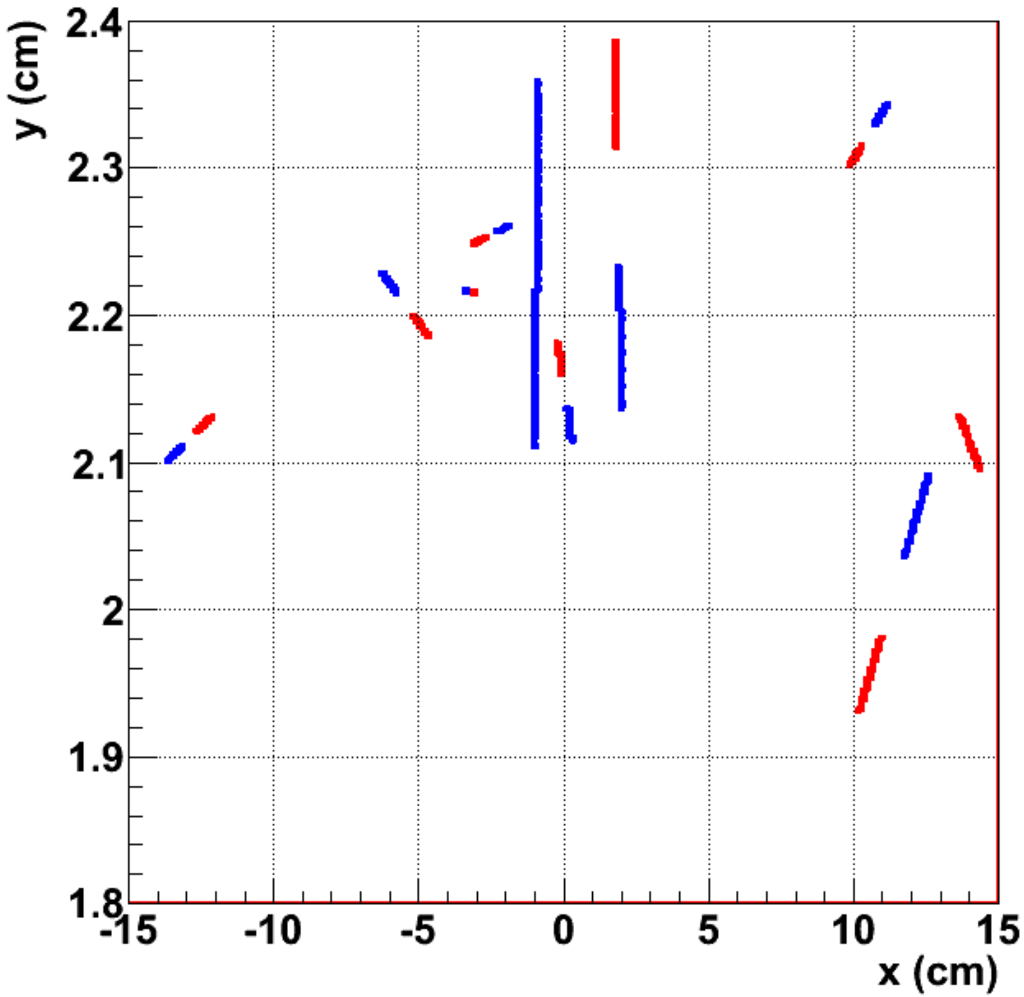
Isolated high p_T track trigger needs front end to:

1. Find high p_T clusters & pairs
- Find all clusters & pairs
- Calculate track parameters
- Calculate isolation sum w/ z_0 cut
- Query (ϕ,z) neighbor's Iso

Constrain steps 2-5 w/ z_0 from step 1?
but
Seeds for later tracking?

To be studied…





Challenges:

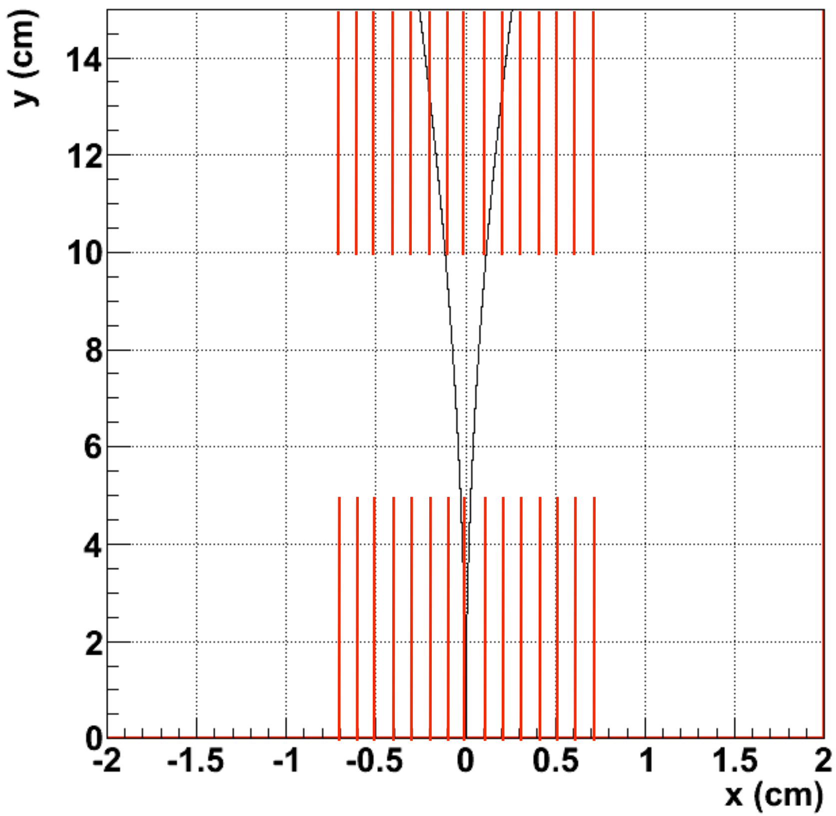
Material

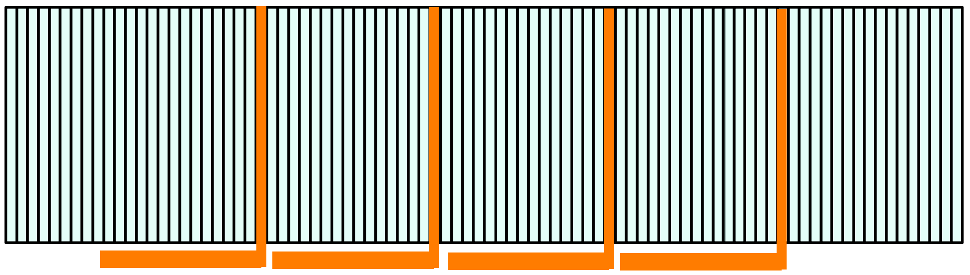
Alignment

Radiation damage

Secondaries

Two 10 GeV tracks





Challenges:

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Modules could be built on a CMM

Align and adjust in situ.

Software adjustment?

Conclusion:

Radial fibers for track triggering?

Potential advantages for track finding.

Potential challenges in realization.

Worth investigating.

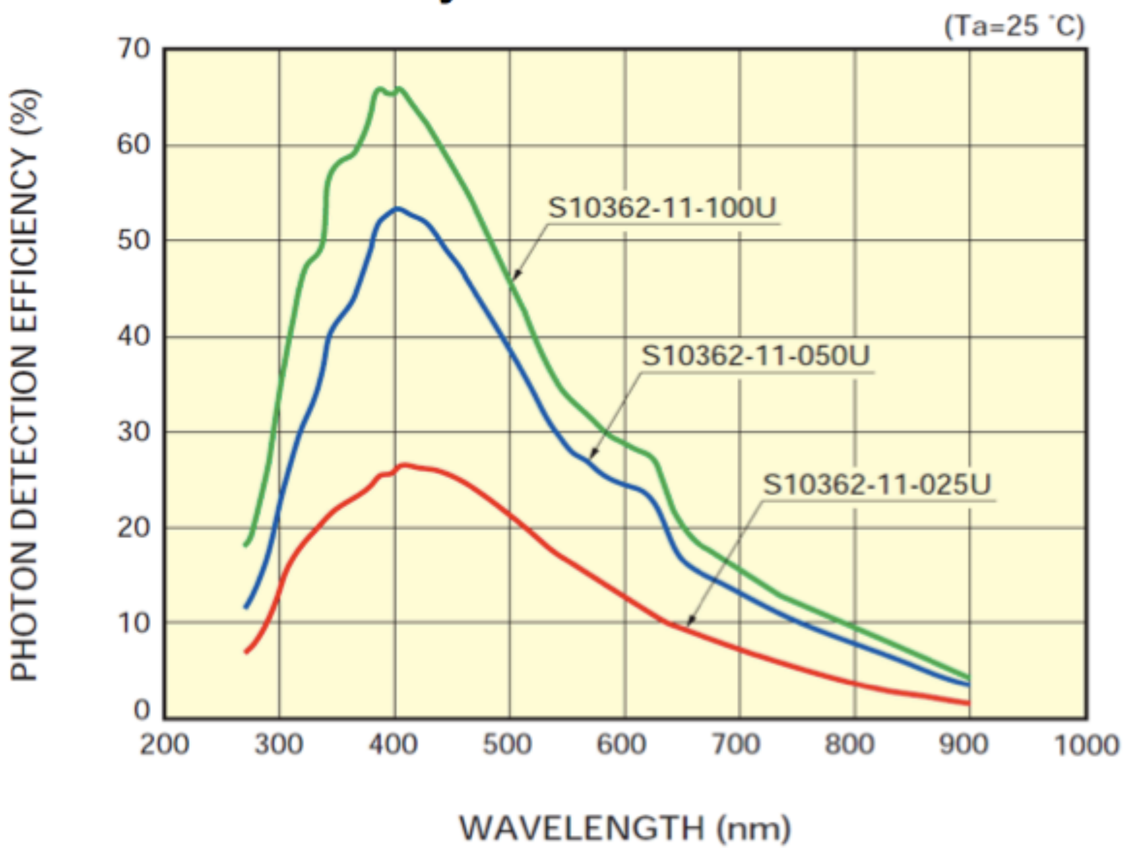
Additional slides

Sensors?

Silicon Photomultipliers (SiPMs)
= avalanche photo-diodes operating in Geiger mode.

High QE, but affected by “fill factor”.

PDE= Quantum efficiency x Fill factor x Avalanche probability



1x1 mm with
100 pixels
400 pixels
1600 pixels

http://sales.hamamatsu.com/assets/pdf/catsandguides/mppc_kapd0002e04.pdf

Sensors?

Silicon Photomultipliers (SiPMs)
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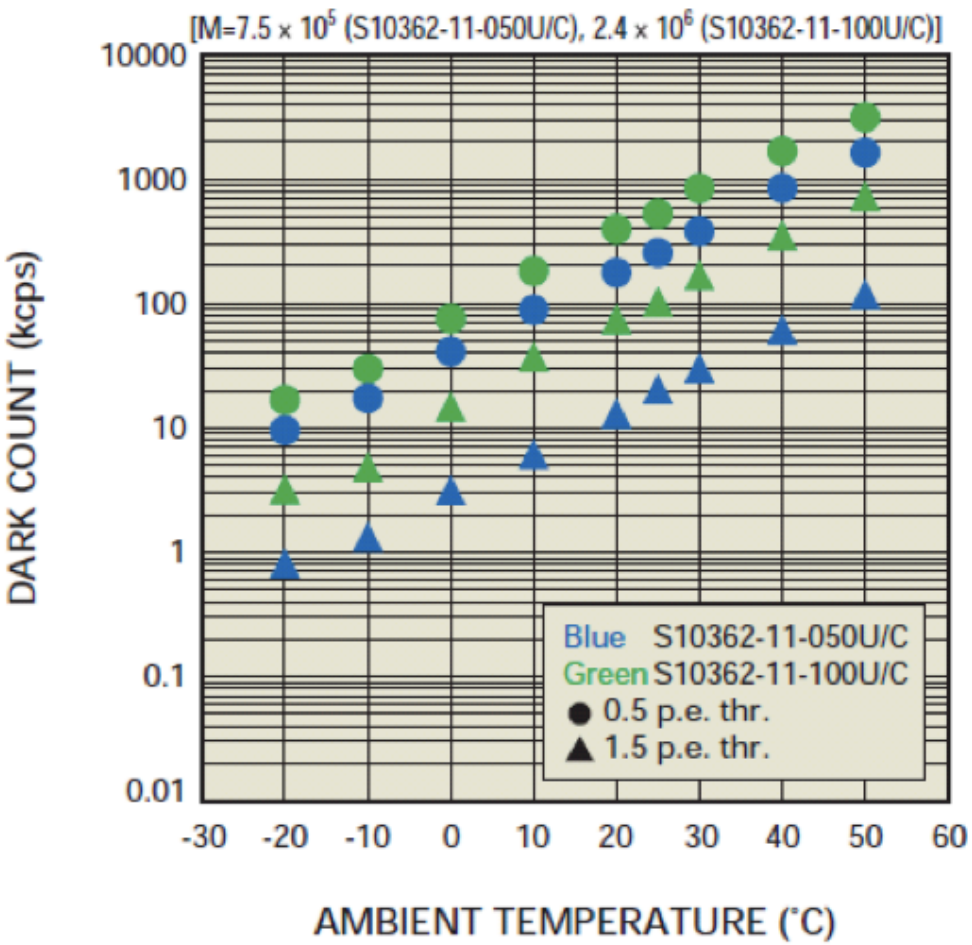
High dark count rate, but mostly single p.e.

S10362-11-050U/C, S10362-11-100U/C



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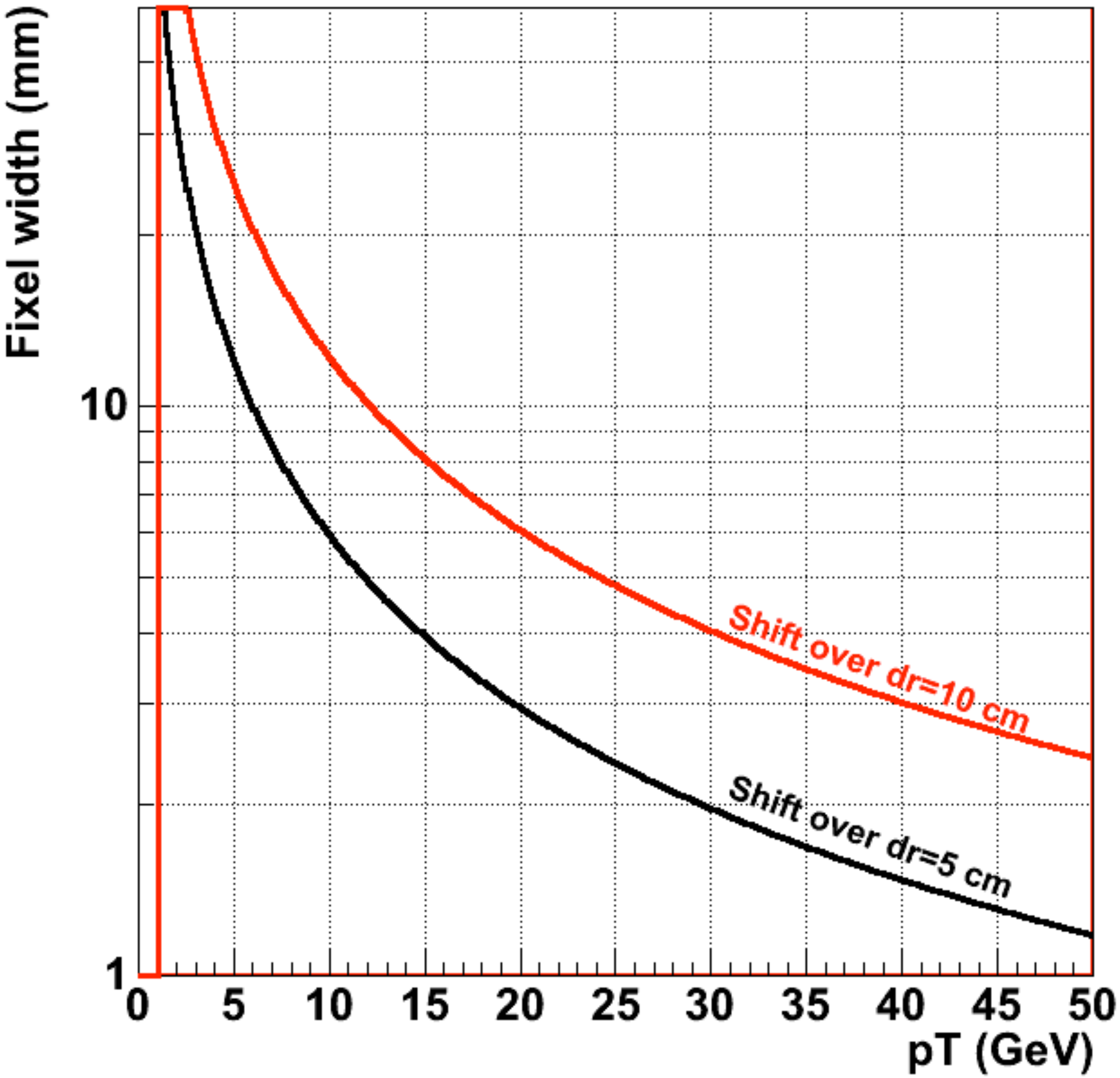
p_T from cluster size



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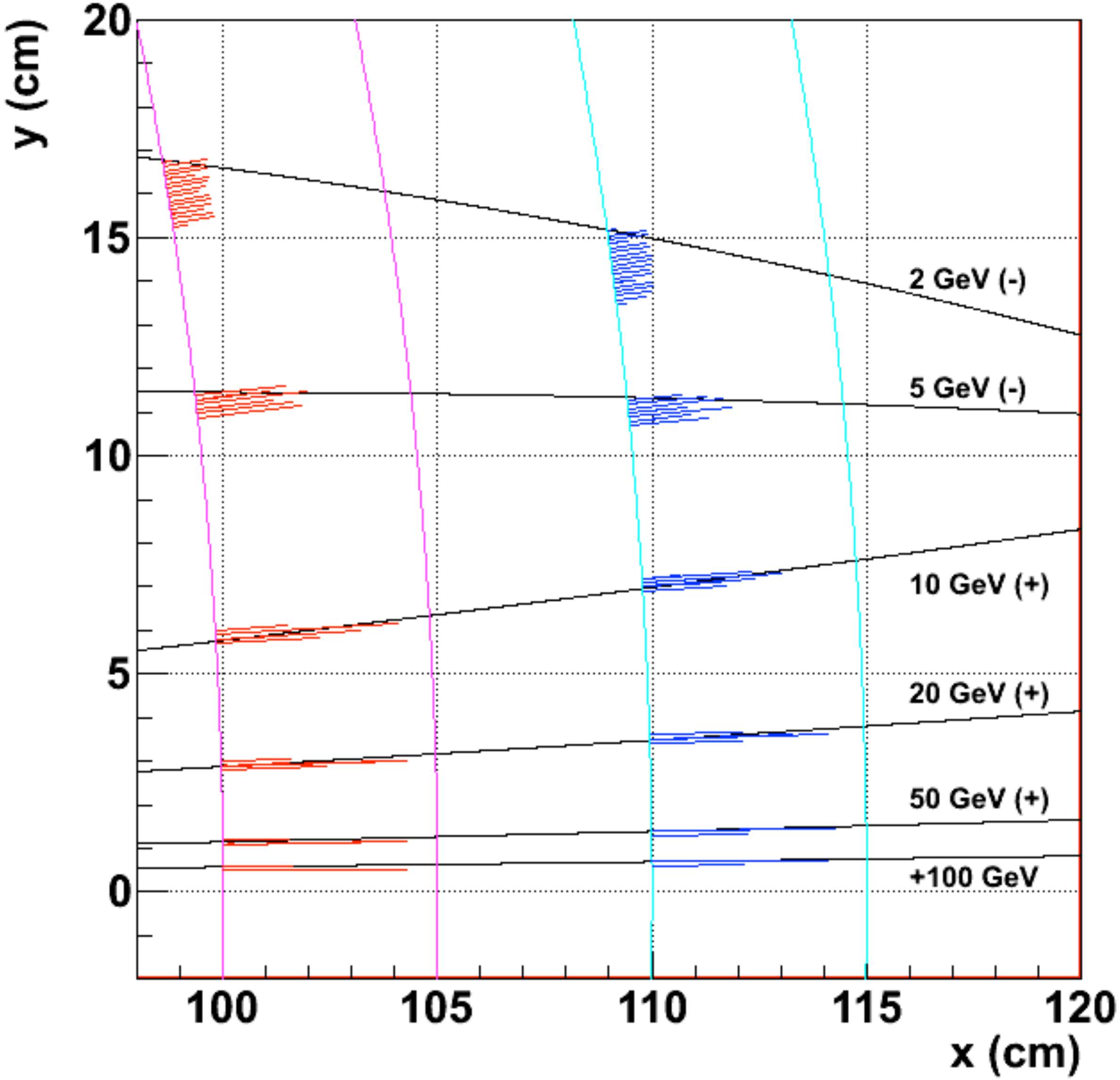

Radiation damage