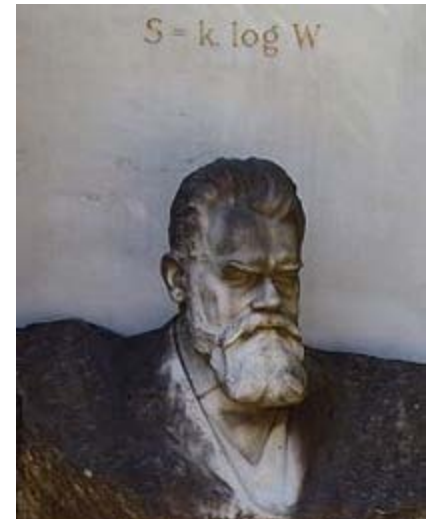


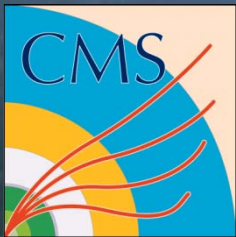
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Operational Experience with the CMS Pixel Detectors



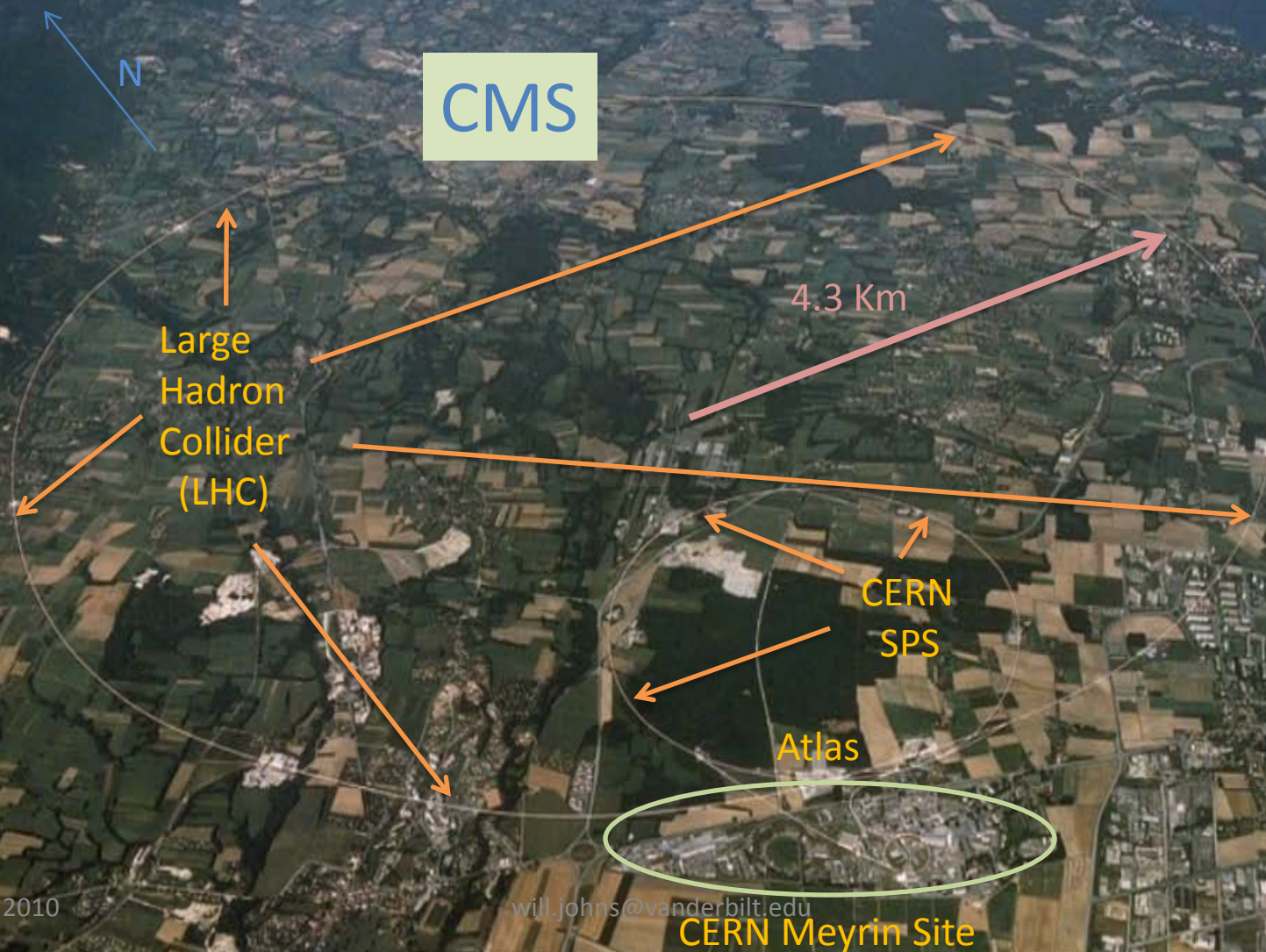
Will E. Johns
(Vanderbilt University)
for the CMS Collaboration

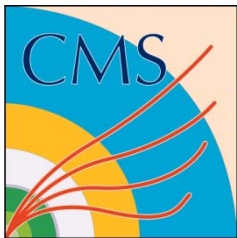




2009 pp Running for CMS (Nov - Dec):

- Recorded about $10 \mu\text{b}^{-1}$ at 900 GeV
- Recorded about 400 mb^{-1} at 2.36 TeV

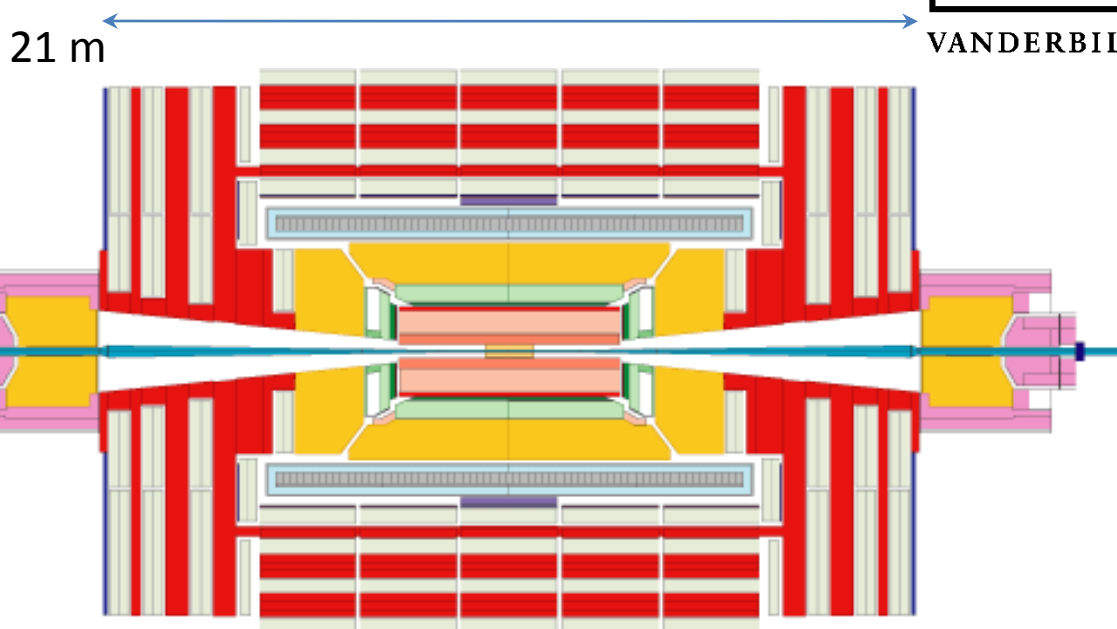
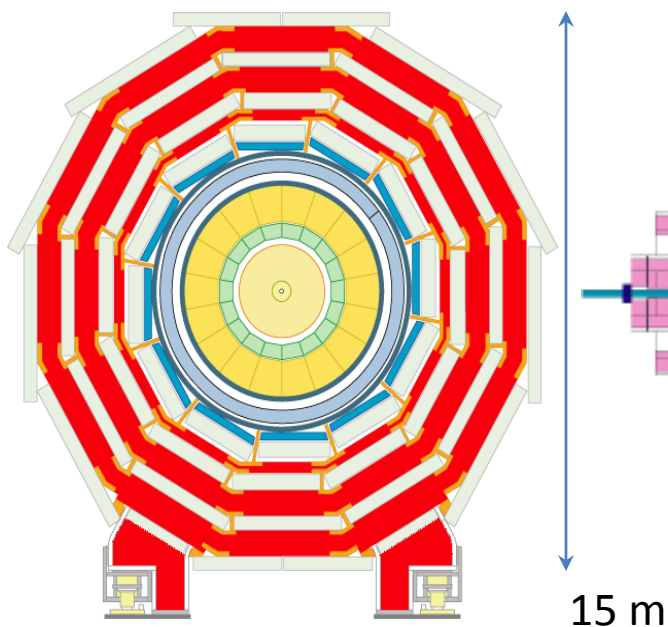




Compact Muon Solenoid

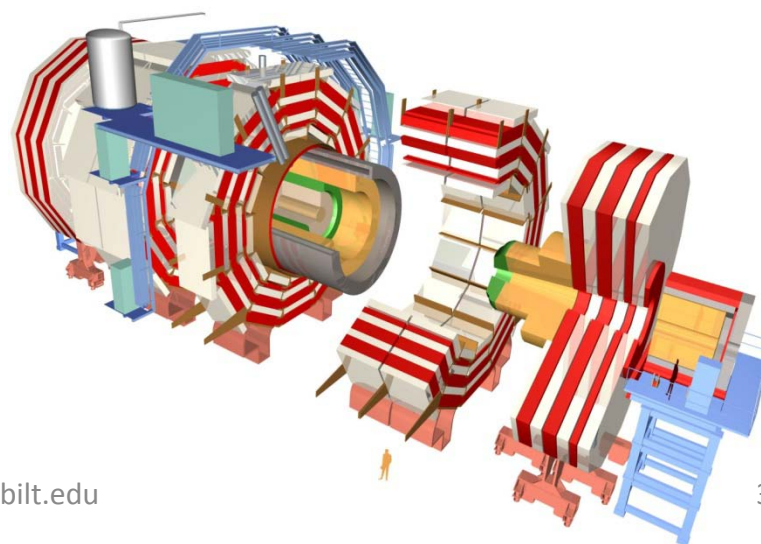


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From Center Out:

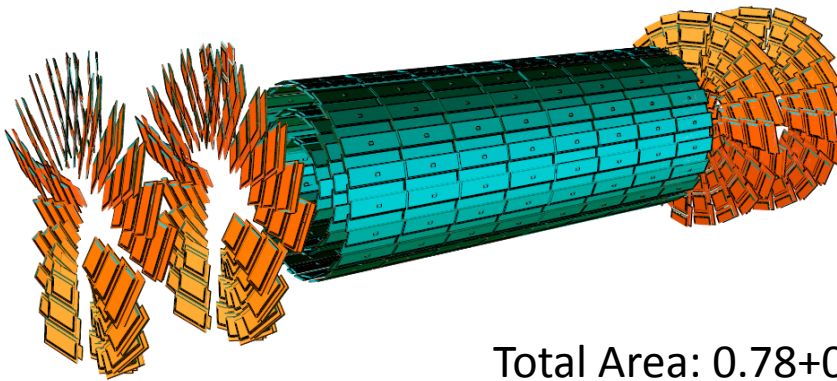
- Precision Silicon Tracking
 - >Pixels then Strips
- EM Calorimeter
- Hadron Calorimeter
- Solenoid Coils (4T nom.)
- Muon Detectors





CMS Pixels

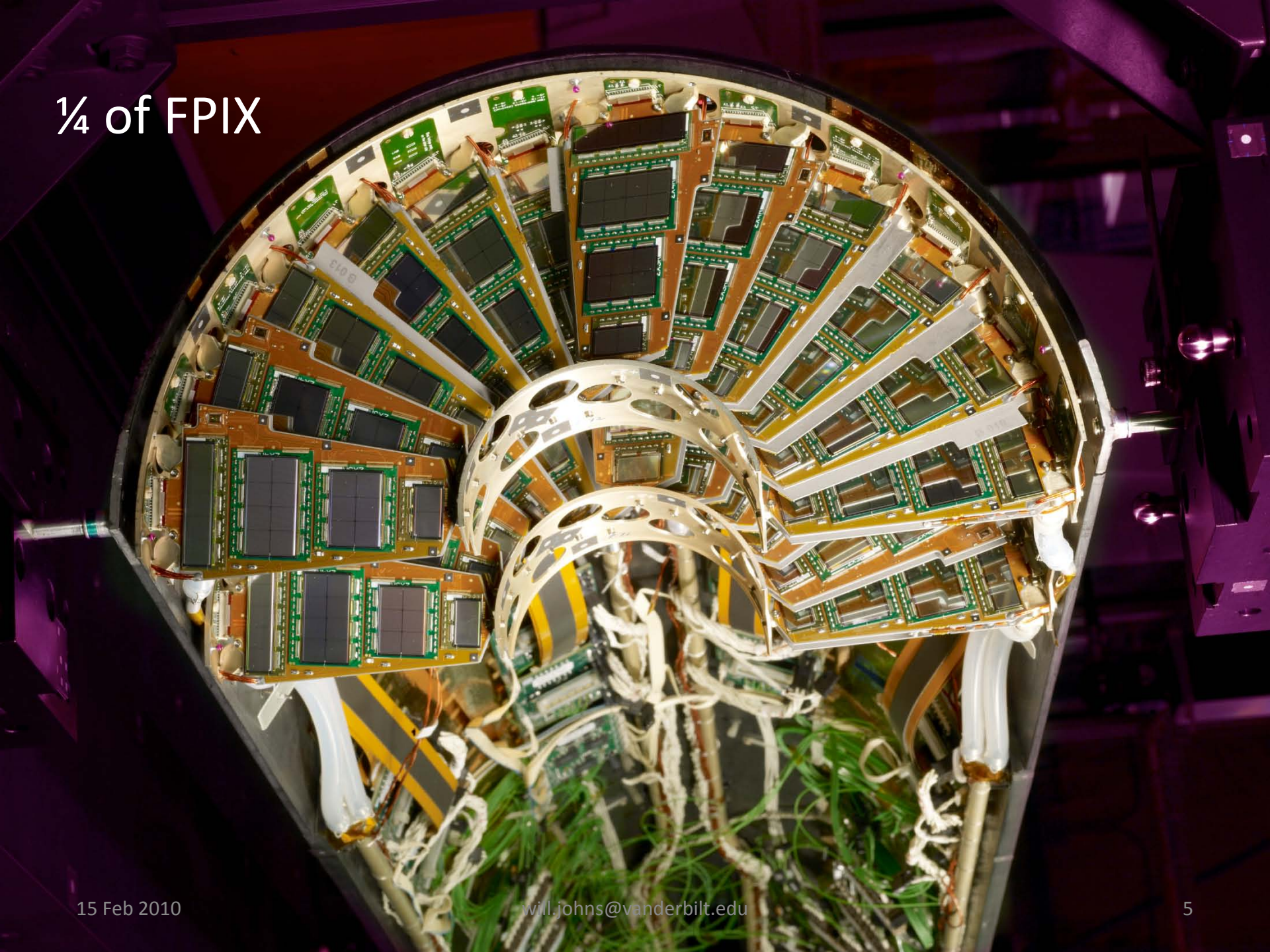
- 3 Barrel layers at 4.3, 7.2, 11.0 cm (BPIX)
- 2 Forward Disks (FPIX)
- 3-hit coverage for tracks $|\eta| < 2.5$



Sensors: n on n Silicon 260 – 300 μm
150 x 100 μm pixels
Bump-bonded to PSI 46 Read Out Chips

Total Area: 0.78+0.28 m^2
66 Million Pixels

$\frac{1}{4}$ of FPIX



$\frac{1}{2}$ of BPIX



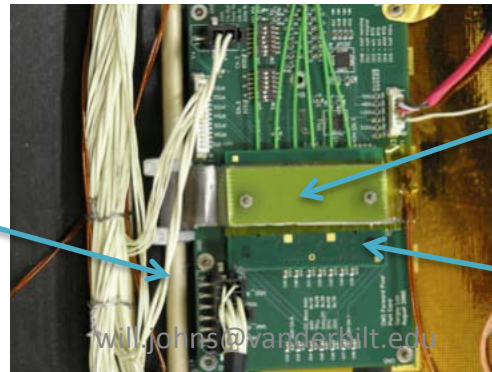


CMS Pixels 2009 Operation



- Problems Addressed in Dec '08-May '09
 - Failed HV and LV connections in FPIX
 - Both appeared after installation in Aug/Sep 2008
 - Faulty crimps in LV cable affected 3.1% of FPIX
 - Shorted HV connection affected 2.2% of FPIX
 - Cooling added for FPIX Analog Laser Drivers
 - Much improved temperature stability of Analog Signal

Cooling line



“cold finger” of
Pyrolytic Graphite

Laser PC board



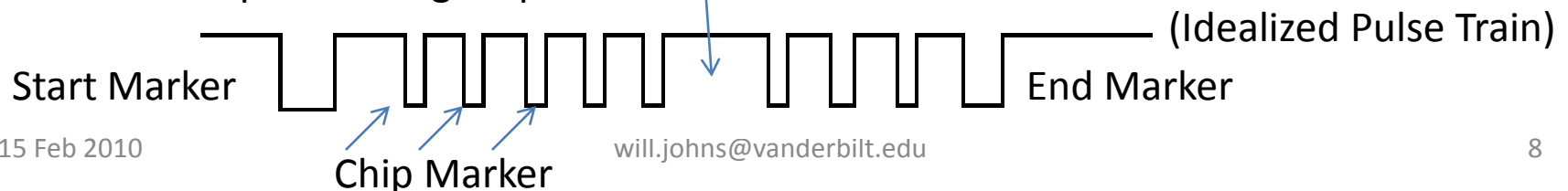
CMS Pixels 2009 Operation



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- After re-install (April 7) and re-commission (Aug)
 - Pixel: 98.4% of channels in operation
 - Barrel: 99%
 - (11400 out of 11520 ROCs operational)
 - Endcap: 96.9%
 - (4185 out of 4320 ROCs operational)
 - » Mainly due to variable bandwidth loss (slow rise time)
 - Exploring fix in readout firmware
 - Common problem with single Read Out Chip missing in analog data stream addressed in readout firmware

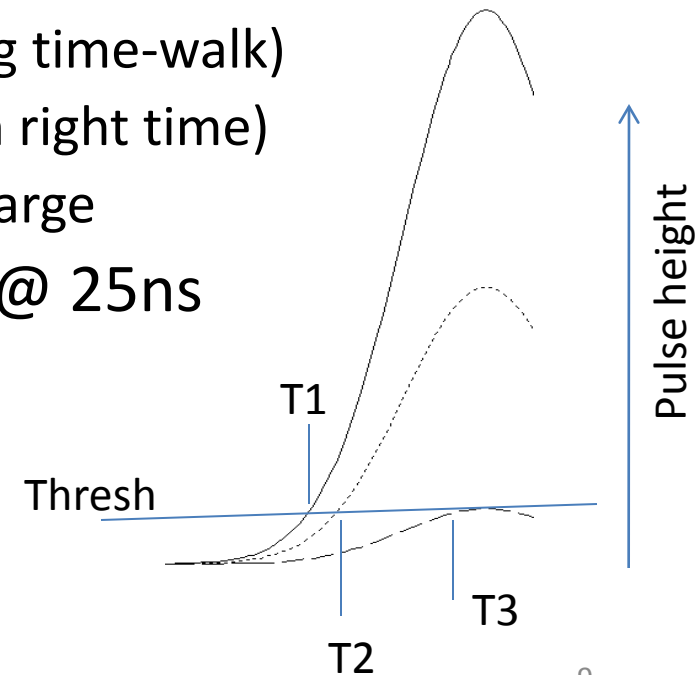
Example: Missing Chip Marker





Early Running (Time Scan)

- Rough scan done for Early Physics
 - Individual modules timing equalized as much as possible via cable maps etc
 - Fine time shifts adjustment left for 2010
 - Online (and verify offline) examination of:
 - Single pixel charge (useful for seeing time-walk)
 - Total cluster charge (Maximizes with right time)
 - Cluster size for pixels > 12 Ke's of charge
 - Important: Pixel Charge sampled @ 25ns
 - Comparator for charge/time latch is non zero-crossing
 - pulse height effects latch time





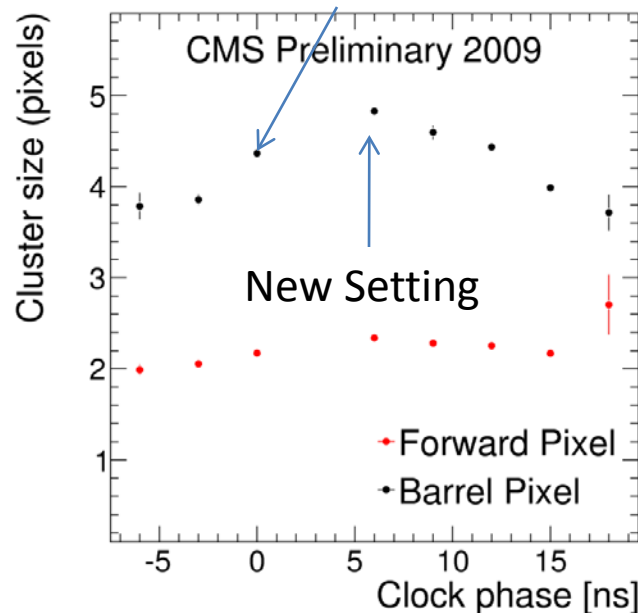
(Operations with Beam)



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Time Scan Results

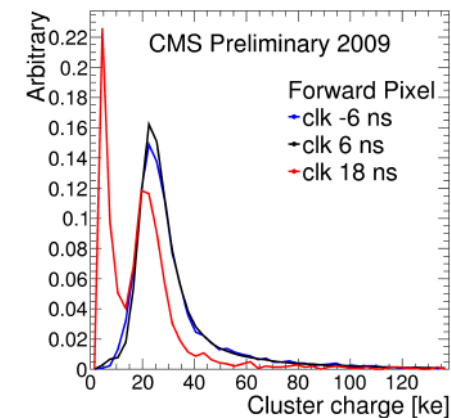
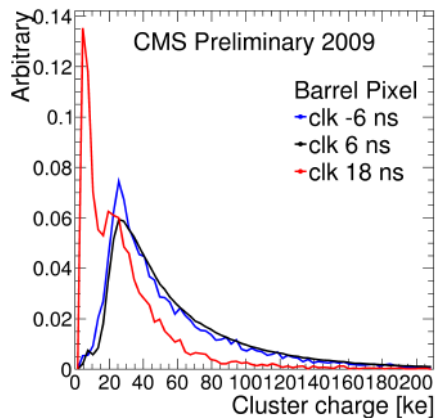
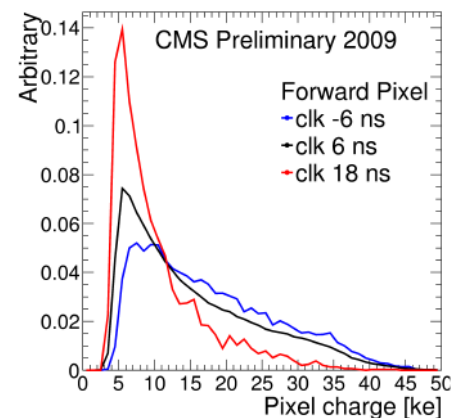
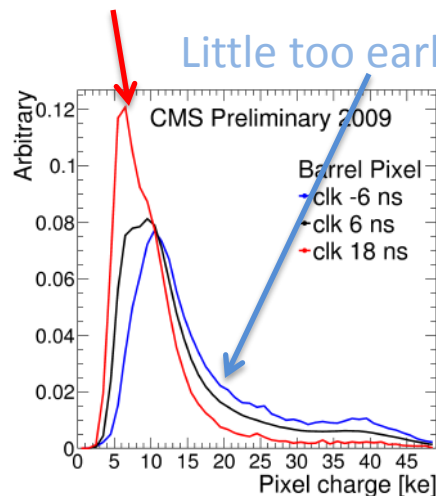
Previous Run Setting



Suggested Max from Simulation

Little too late – getting less charge

Little too early – bias to pick big pulses

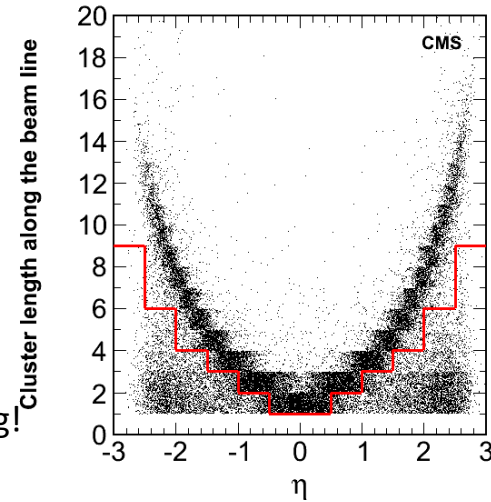


- Even though several settings can have similar behaviors, a multi-dimensional approach picks up differences
- Efficiencies well above 90 %.
- Chosen setting in plateau.
- (Know #'s better w/fine scan)



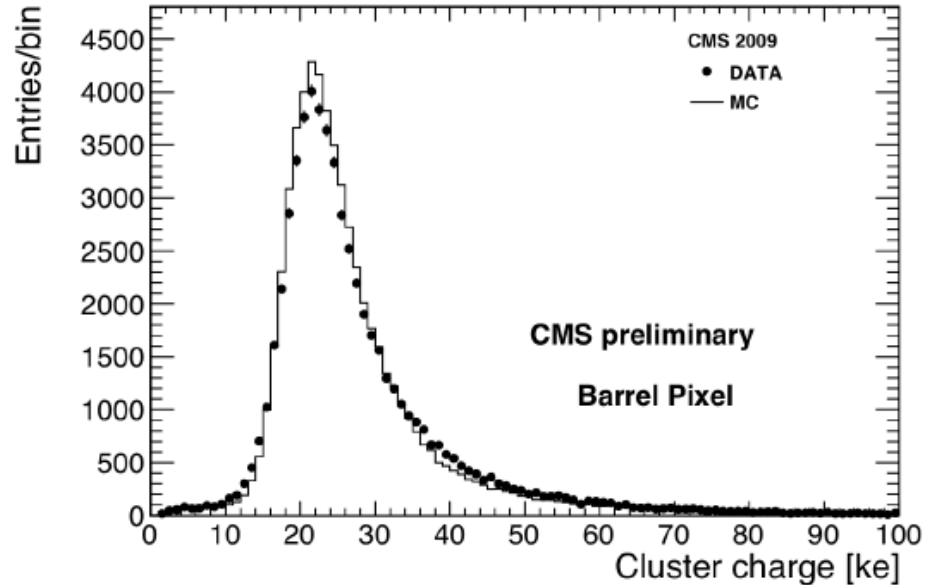
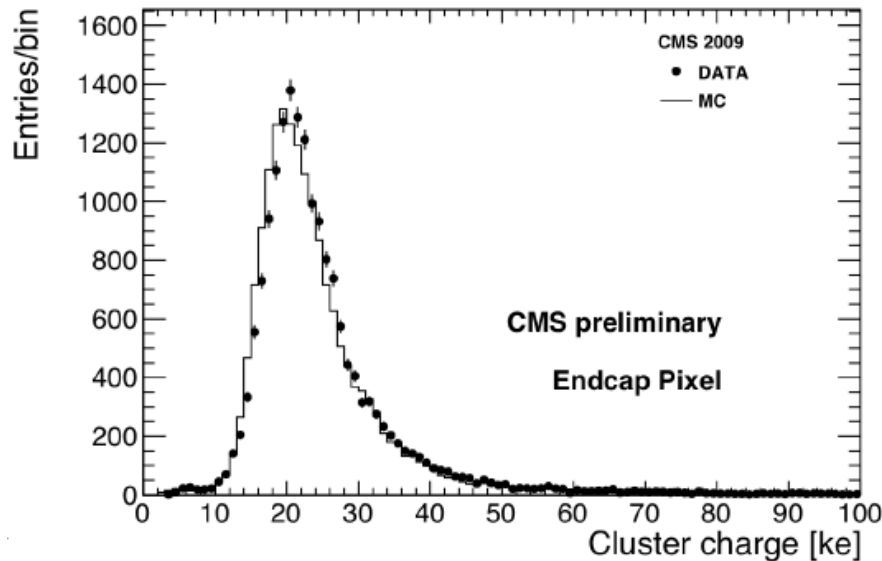
Comparisons to Expected

- Cluster Charge in BPIX and FPIX
 - Corrected for impact angle with respect to the track
 - Corrections can be significant!
 - Agreement looks good
 - Expect improvement in 2010 w/fine time scan
 - Pixels well calibrated – successful re-commissioning!



Clusters above red line likely from I.P.

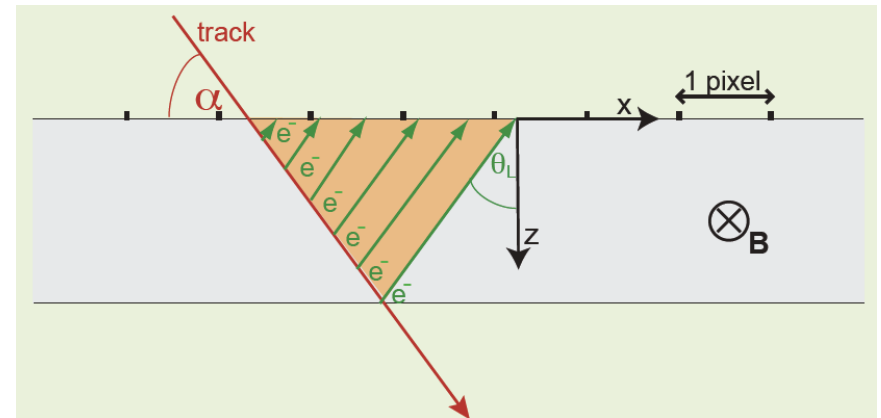
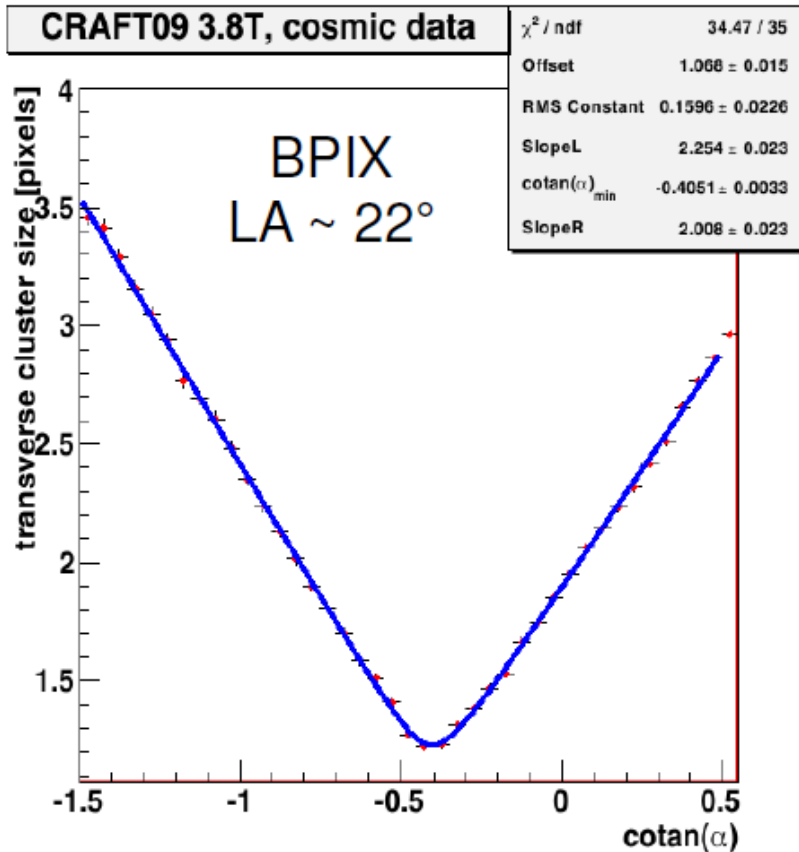
Clusters below red line are likely background





Lorentz Angle

- Two techniques (good agreement)
 - Cluster counting from muon data)



At minimum cluster size:

$$\alpha = \theta_L + 90^\circ$$



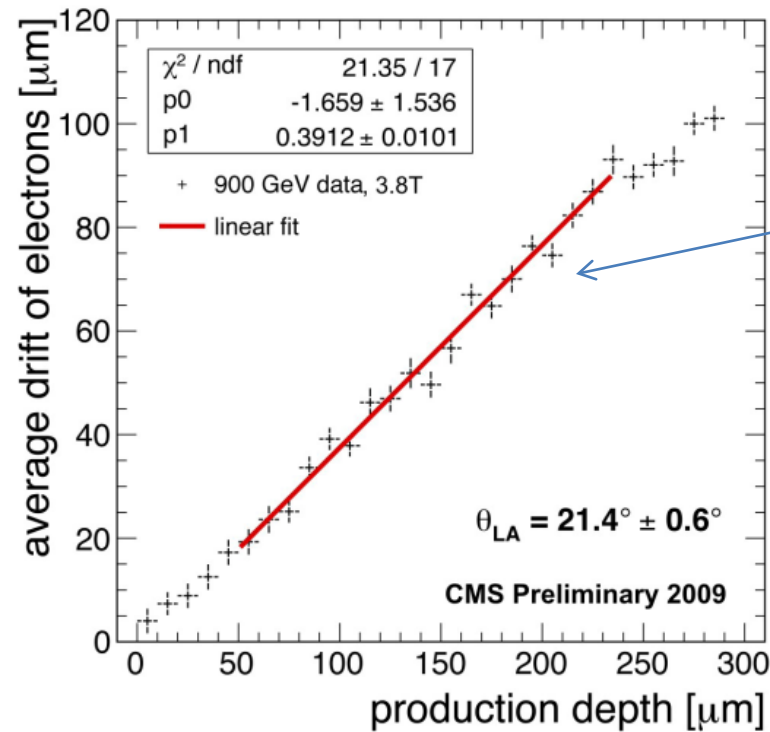
(Operations with Beam)



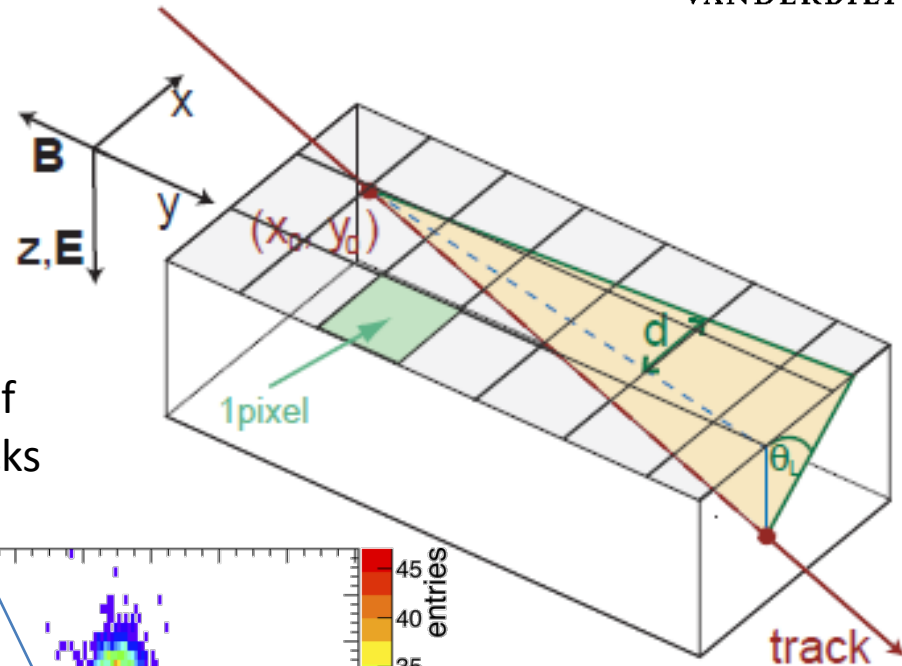
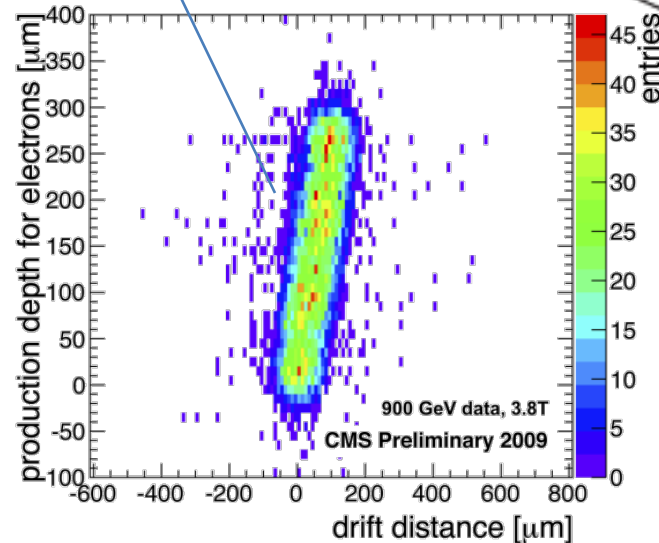
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Lorentz Angle

- Two techniques
 - Grazing track (pp data)



Average of many tracks



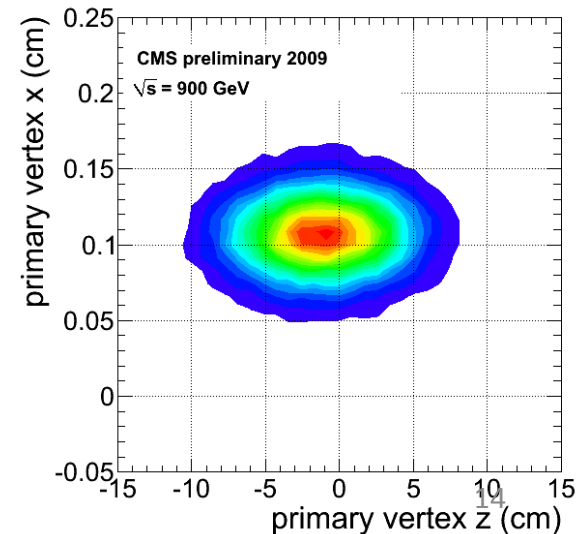
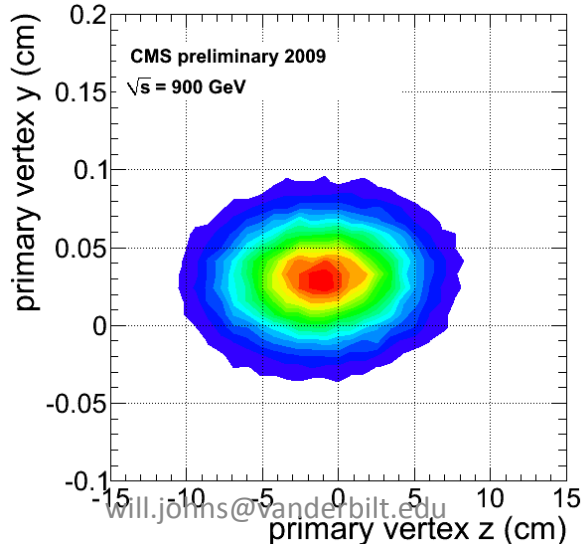
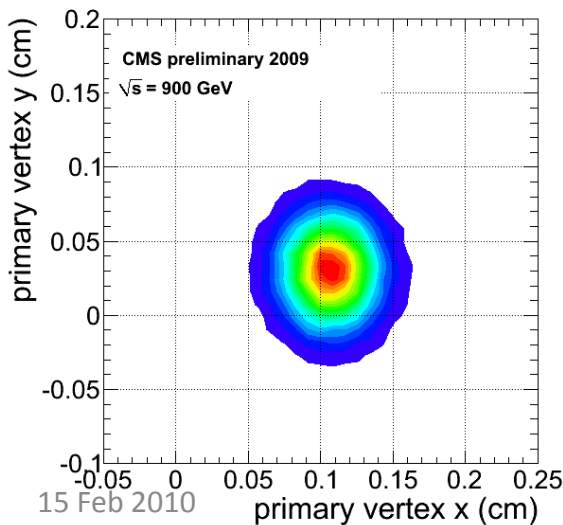
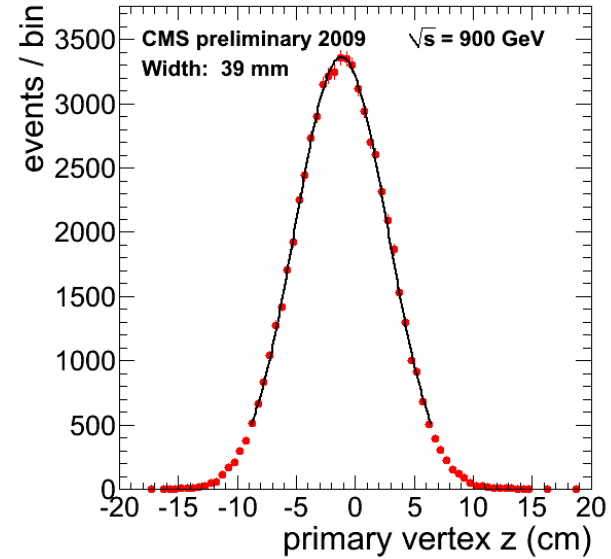
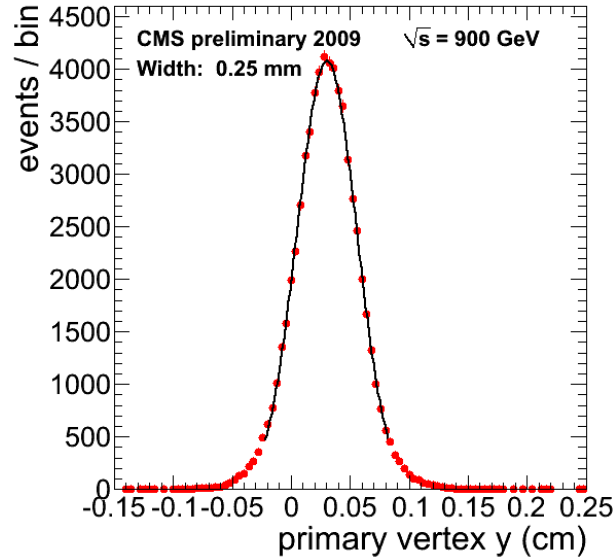
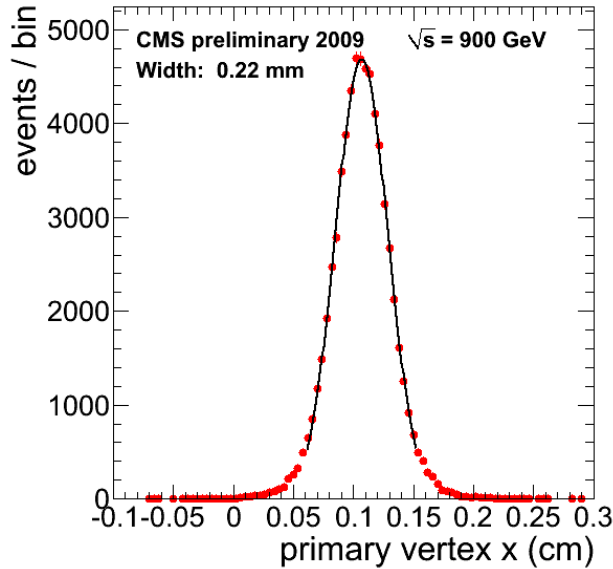


(Operations with Beam)

Primary Vertex Reconstruction



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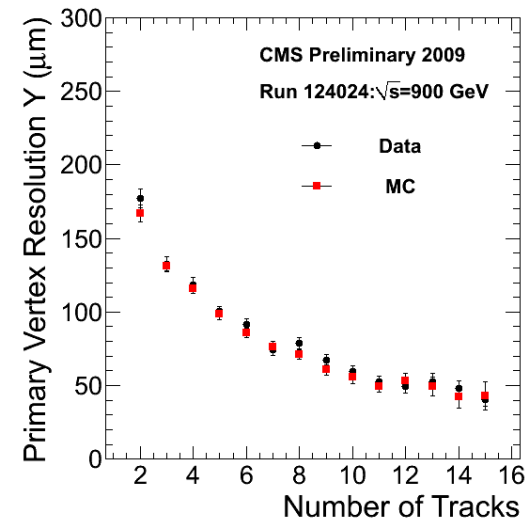
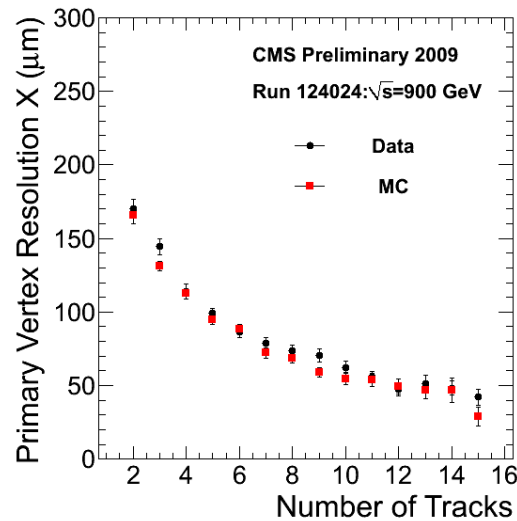
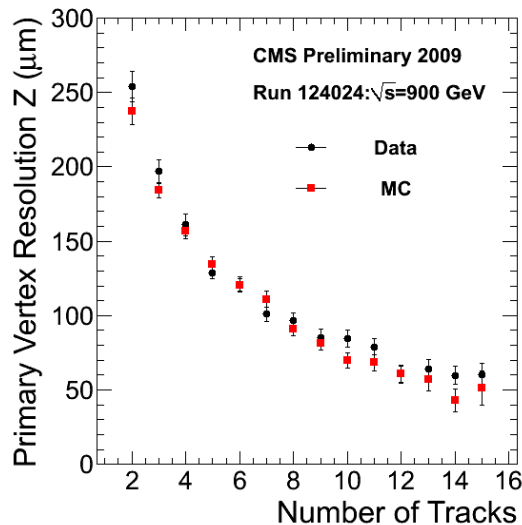
15 Feb 2010

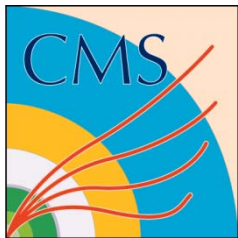
will.johns@vanderbilt.edu



Primary Vertex Resolution

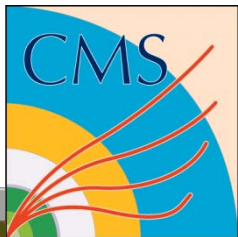
- Data Driven – 2 Vertex Method
 - Fit vertex with 2 separate sets of tracks
 - Look at differences between fit vertices
 - Cuts to equalize # tracks, select main primary
 - Use stand-alone Pixel Vertices along beam
 - » Tracks within 10 sigma of pixel vertex
- Agreement is encouraging





Neutral V Reconstruction

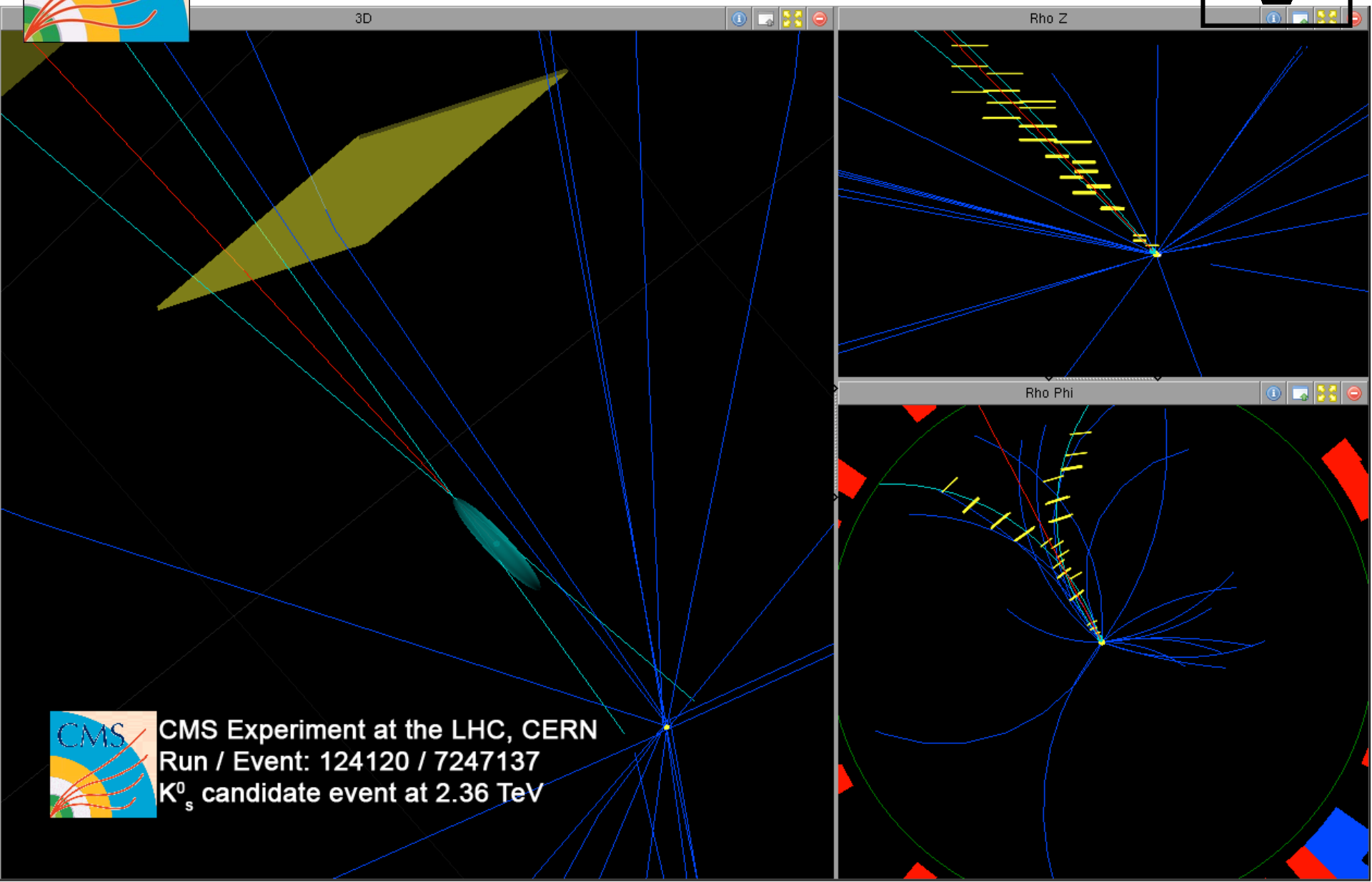
- 900 GeV Running (Mass plots) Results shown in Mid- Dec!
- Track $\text{Chi}^2/\text{ndof} < 5$
- Number of hits on tracks ≥ 6
- Track impact parameter significance > 0.5
- Vertex $\text{Chi}^2/\text{ndof} < 7$
- Vertex significance (radial) > 15
- Before vertex fit, check DCA and Mass
 - Di-pion mass calculated at DCA (pre-vertex-fit) < 1 GeV
 - Closest approach distance < 1 cm
- Require good primary vertex
- Require $\text{\#tracks} < 150$
- Compare signals to PDG and Monte Carlo



(Operations with Beam)



Neutral V Reconstruction



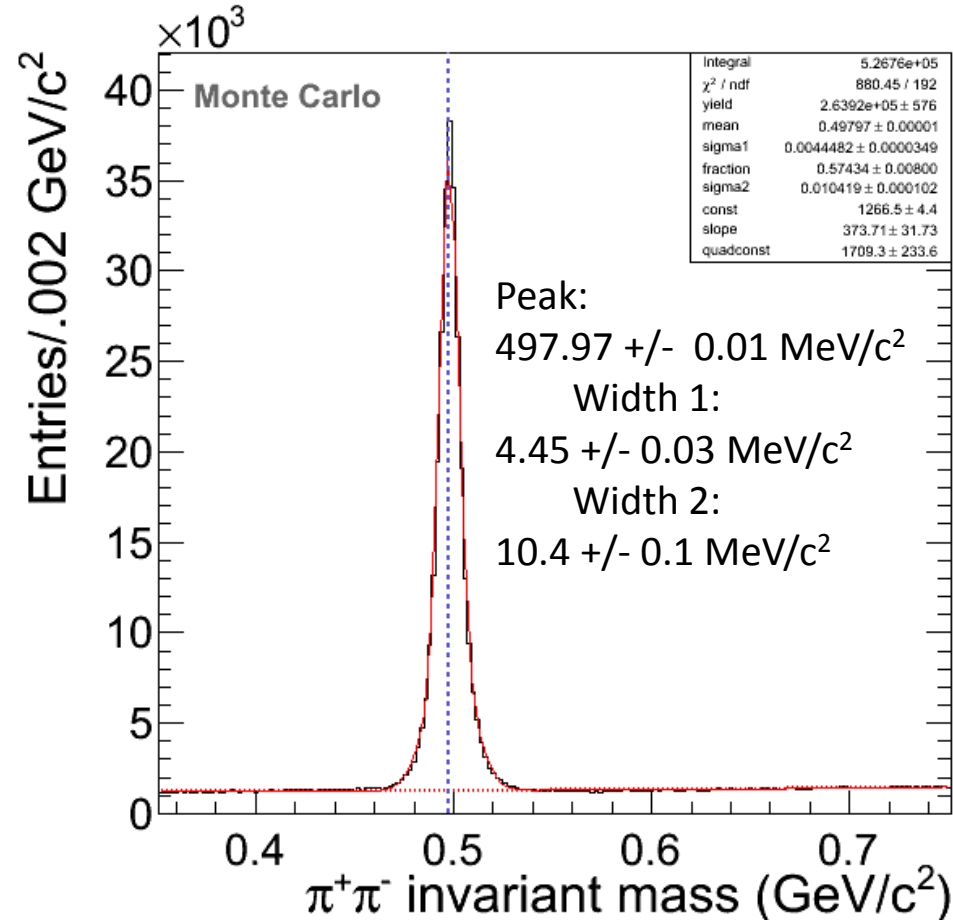
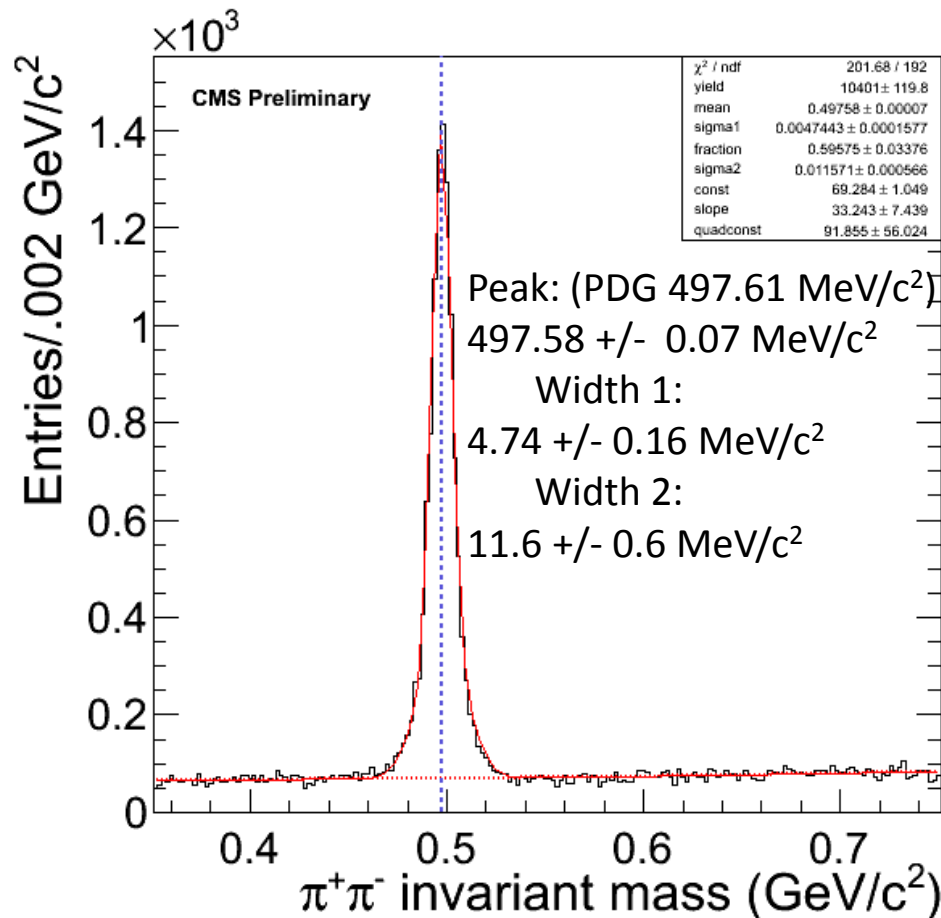
CMS Experiment at the LHC, CERN
Run / Event: 124120 / 7247137
 K_s^0 candidate event at 2.36 TeV



Neutral Kaon Reconstruction

Dual Gaussian Fit, no systematic included

- Some fine tuning left to do for high precision





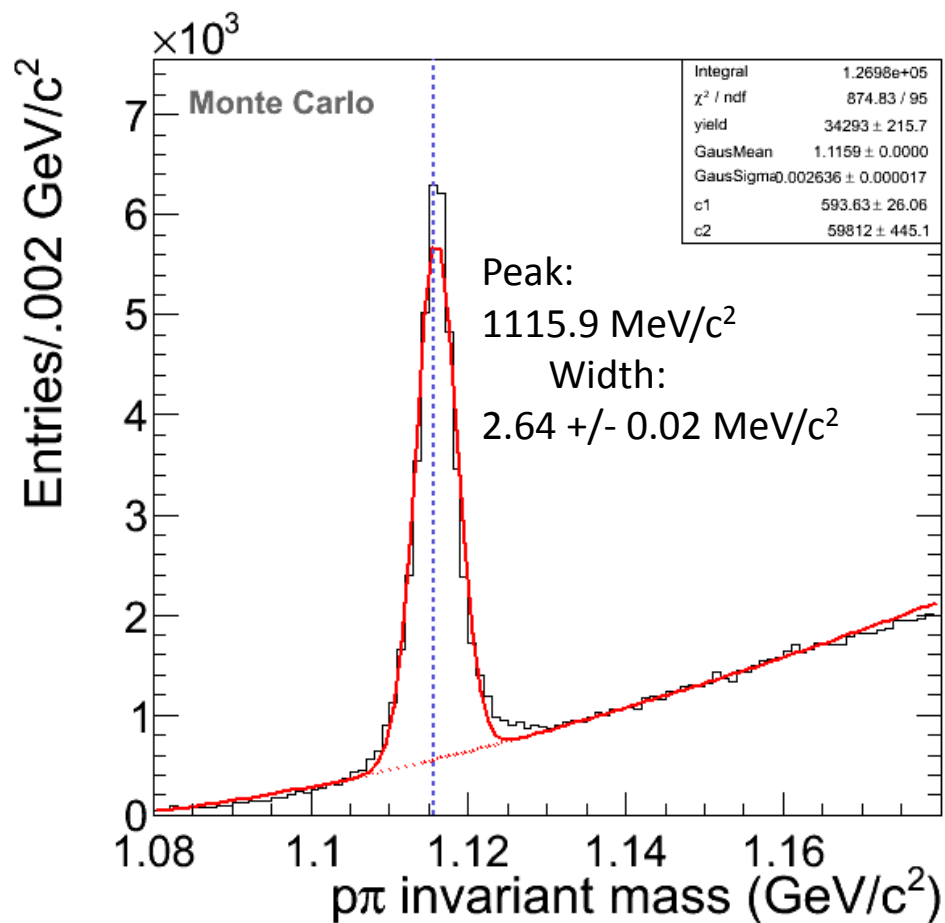
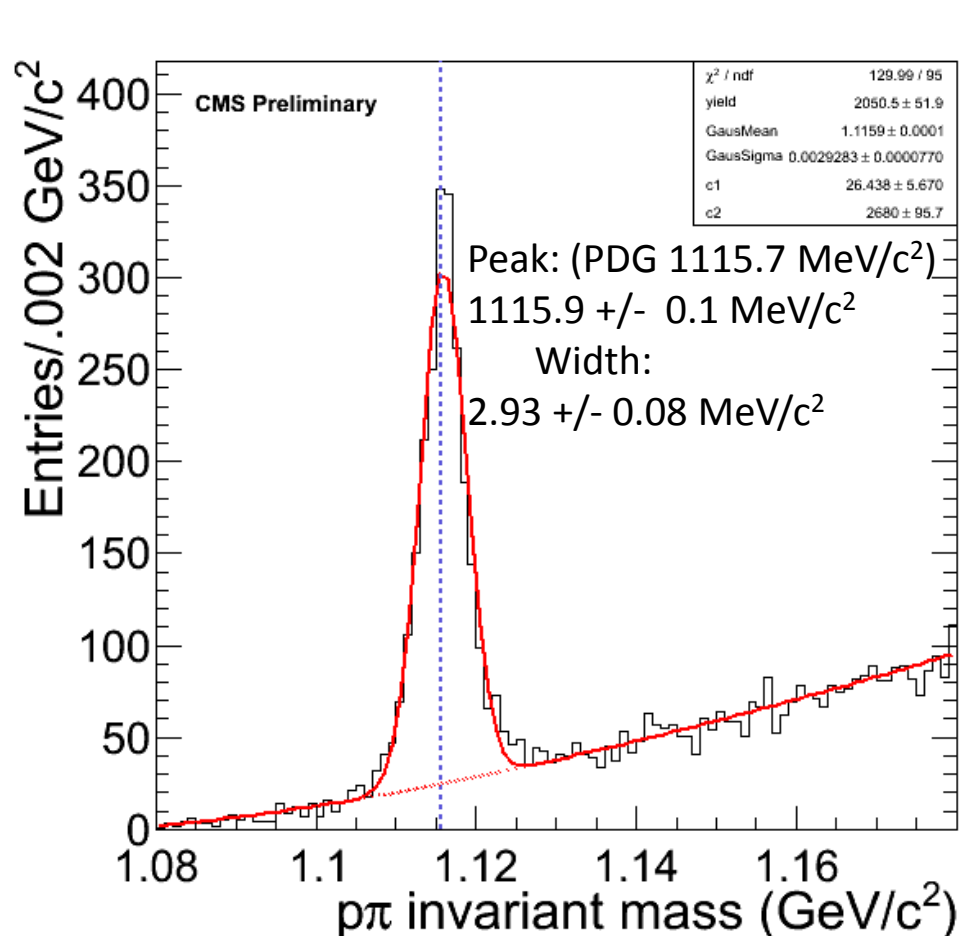
(Operations with Beam)



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Neutral Lambda Reco.

Single Gaussian Fit – No Systematics included
- Some fine tuning left to do for high precision





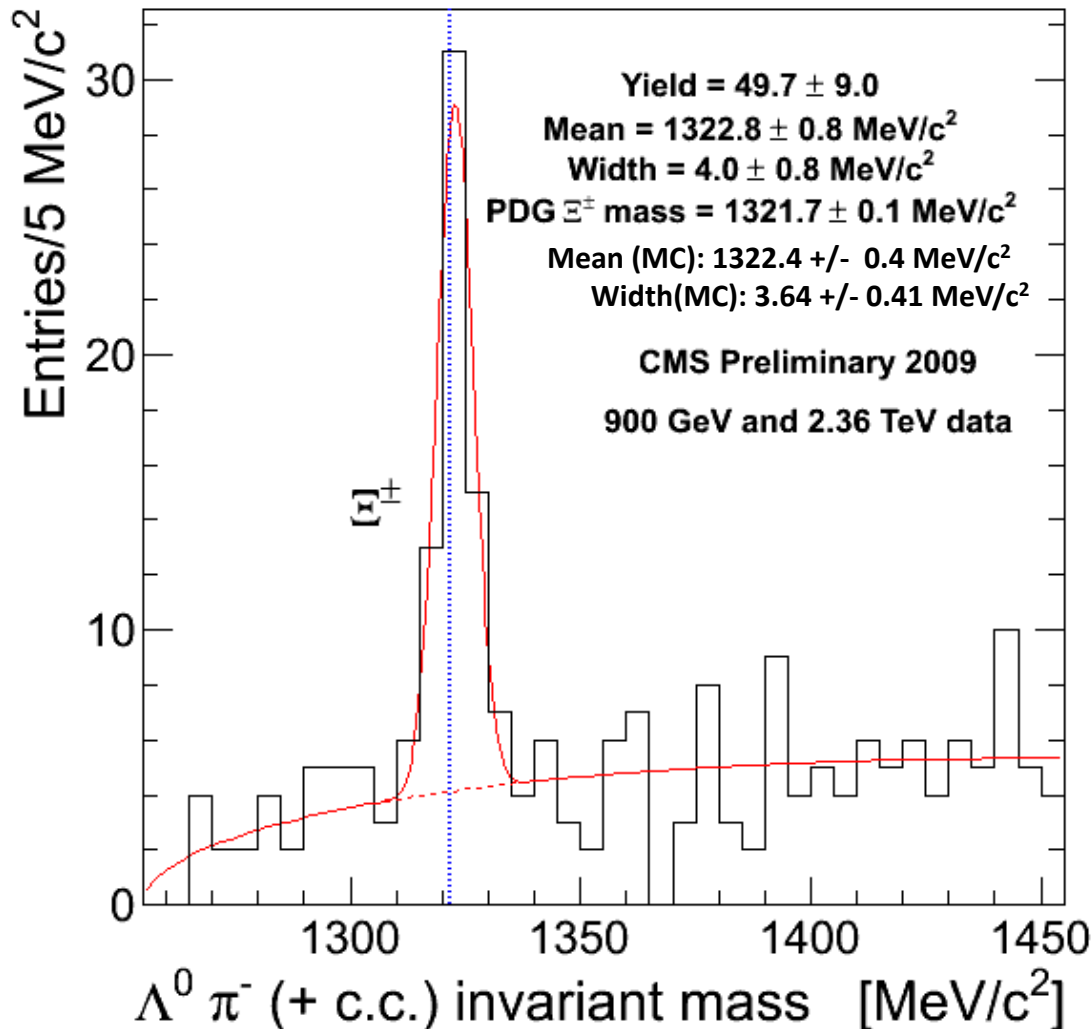
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Cascade Reconstruction

- Λ mass within 8 MeV of PDG value
- $\Lambda\pi$ vertex fit probability $> 1\%$
- Both pions have same charge
- At least 6 valid hits on pion track from Ξ^-
- 3D impact parameter significance > 3 for all three tracks
 - primary vertex removing tracks in Ξ^- candidate
- Kinematic fit for mass determination



Cascade Reconstruction



Interesting topology!

The Vees and this baryon are included in this presentation since most of these decays are low momentum and have hits in the pixel.

Simulation underestimates production, but mean, width, and background level agree pretty well.



CMS Pixels Wrap-up



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- The CMS pixel detectors are in good shape for more beam
 - Detector parameters and performance are in good agreement with expectations
 - Some remaining efficiency loss is recoverable
- Fine tuning remains, but good physics results are already present due to the hard work of many people
 - Having mass plots that show agreement with expectations at this early stage is very encouraging and speaks well for the future