LCTPC: GEM Readout Results and TPC Software

Daniel Peterson, Cornell University [1]
representing the LCTPC collaboration

In this talk:

R&D towards a GEM-amplification pad readout (pad size 4 to 12 mm^2)

- GEM concept [p2]
- signal size [p3], broadening to meet resolution requirements [p4,5]
- small prototypes [p6] detector spatial resolution [p7-11], track separation [p12]
- ion feedback [p13]
- GEM transparency to electrons and ions [p14,15]
- summary [p16]

GEM end cap tracker

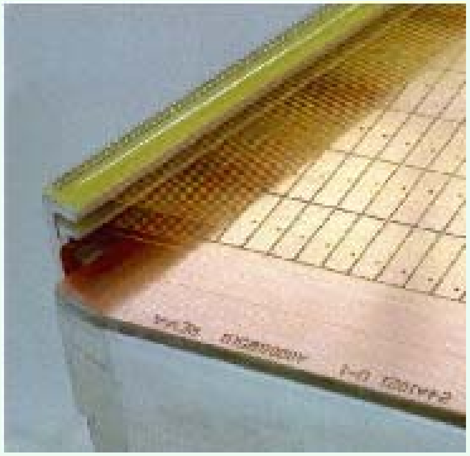
- concept [p17]
- prototypes [p18]

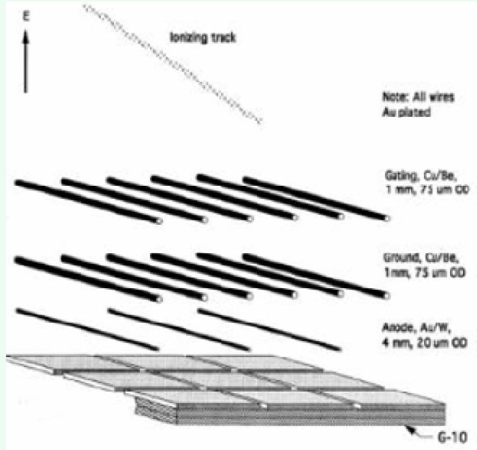
Software

- overview and software framework [p19]
- walk-through of physics generation, detector simulation and reconstruction [p20-22]
- machine background simulation [p23]
- magnetic field distortion simulation and reconstruction [p24]
- detailed TPC signal simulation [p25]
- parametric TPC signal simulation [p26], TPC reconstruction efficiency [p27]
- improvements in ionization center simulation [p28]
- plans for reconstruction and analysis [p29]

Conclusions [p30]

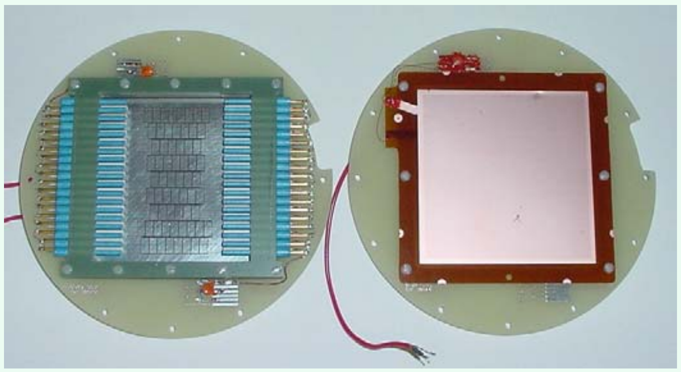
[1] supported by the US National Science Foundation

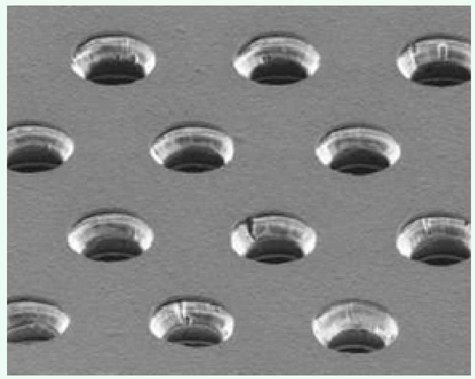




GEM introduction

Wires used in existing TPCs
STAR
Alice
Signal is too wide

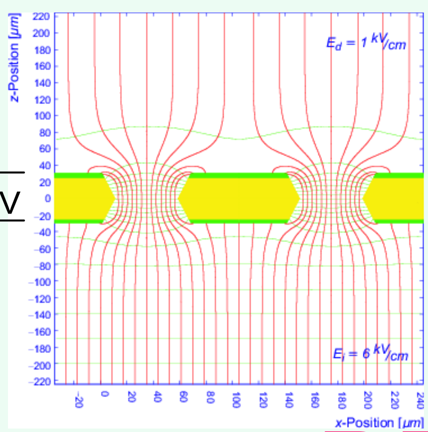


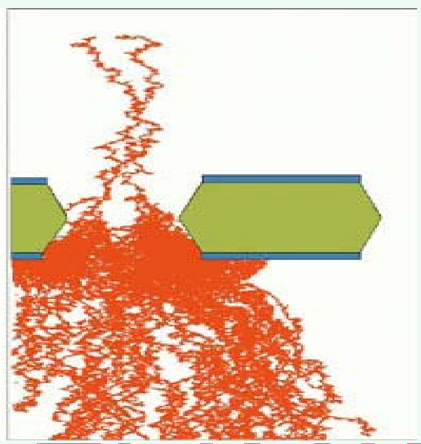


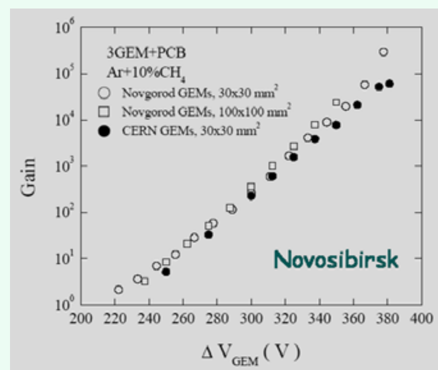
Alternative gas amplification
GEM
(Micromegas in next talk)

50 μm copper clad foil
70 μm holes
140 μm hole pitch
up to 80 kV/cm in hole

300-400V







gain ~ 100
at 400V

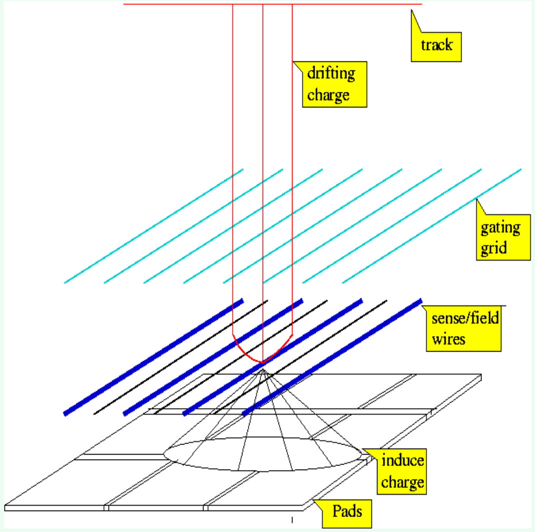
Signal size

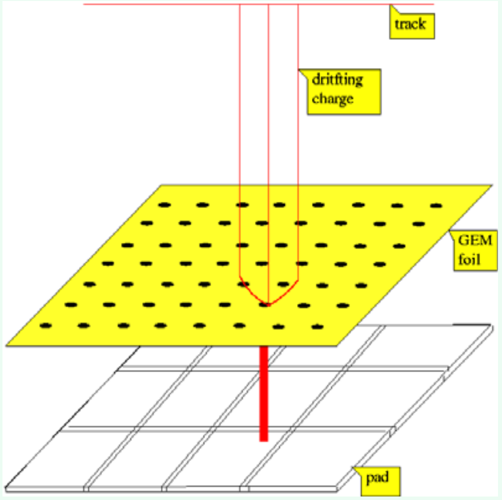
Wires: wide inductive signal

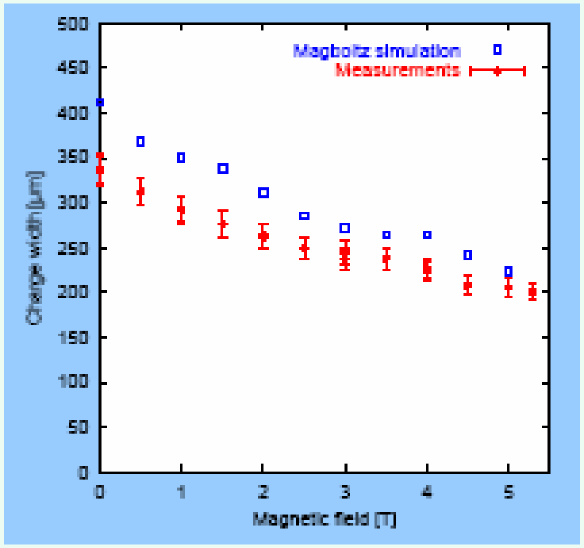
GEM: narrow transfer signal

Width:
- 3-GEM
- strip anodes
- B= up to 5 Tesla

Width is about 250 μm







Vogel, Aachen, Durham 2004

PRELIMINARY

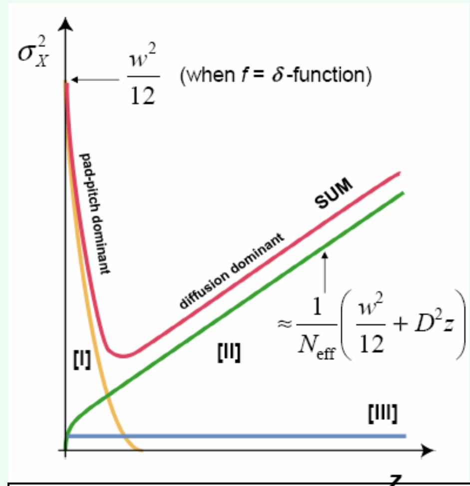
Signal size, and other requirements for a TPC

Signal is very narrow

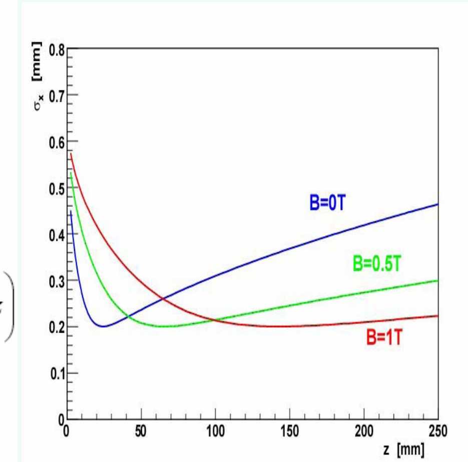
Increase in resolution at
small drift

due to insufficient charge sharing
decays faster with
increased diffusion.

Improved resolution requires
narrow pads
or more diffusion at low drift.

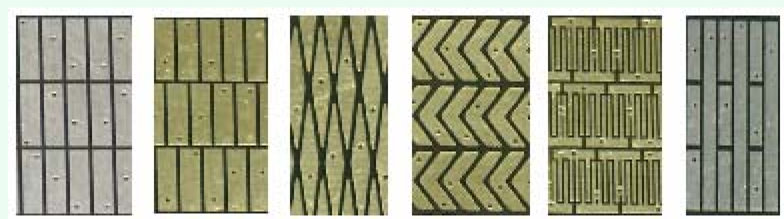


Kobayashi, KEK, Bangalore 2006



D=469, 285, 193 μm/(cm)$^{1/2}$

Pad shapes do not improve resolution



158 119 130 220 260 174
Resolution (mm)

Ledermann, Karlsruhe, Vienna 2005

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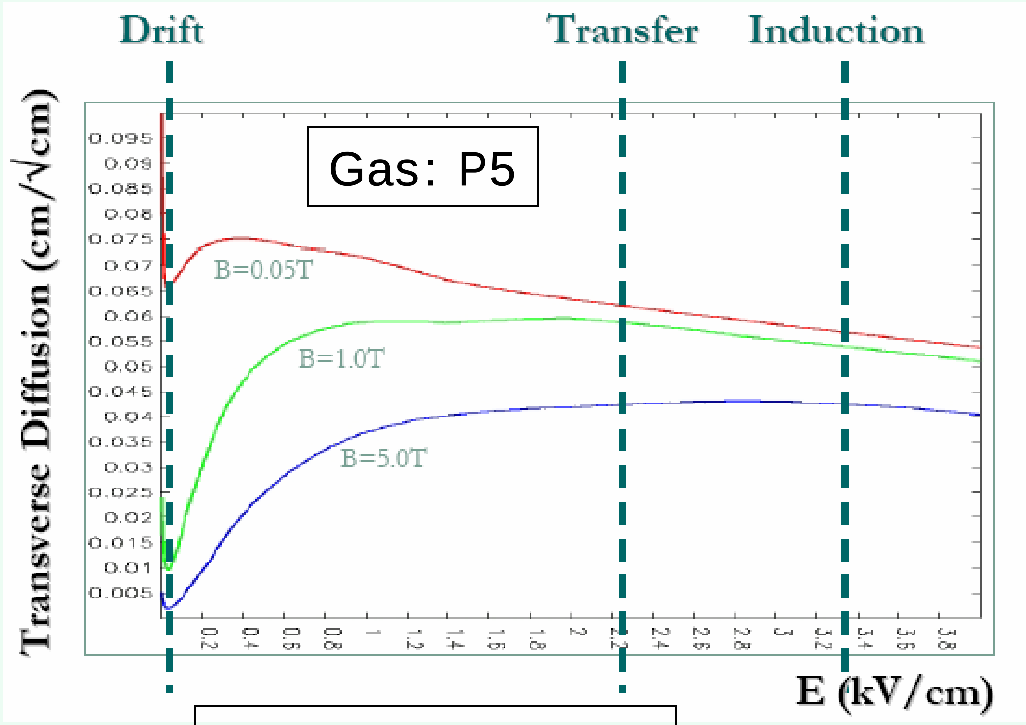
PRELIMINARY

Use of diffusion in the transfer field

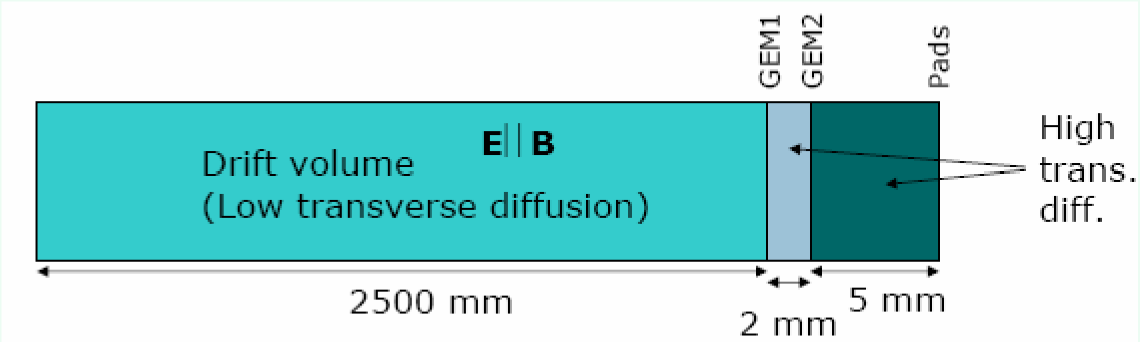
Diffusion properties of the gas can be used to defocus the GEM signal.

Signal size (σ)
~ ¼ pad width is optimal for resolution.
2mm pad width -> 0.5mm signal



Karlen, Victoria, Paris 2004

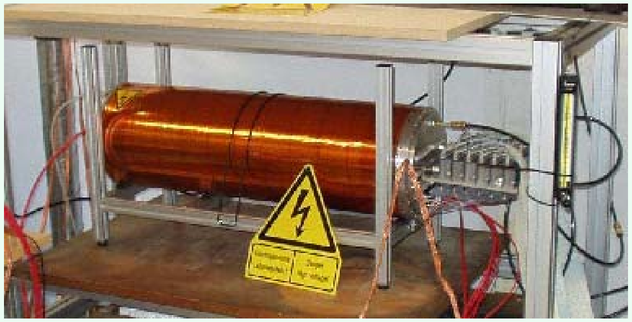
transfer and induction gaps can be increased to defocus the GEM signal



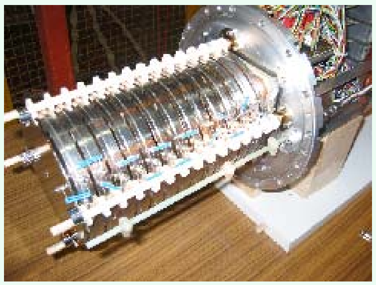
PRELIMINARY

The small prototypes

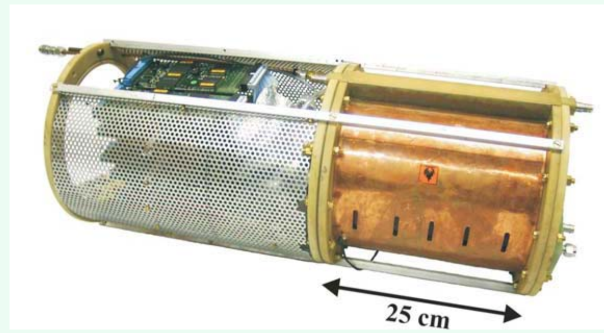
Chambers used to study GEMs



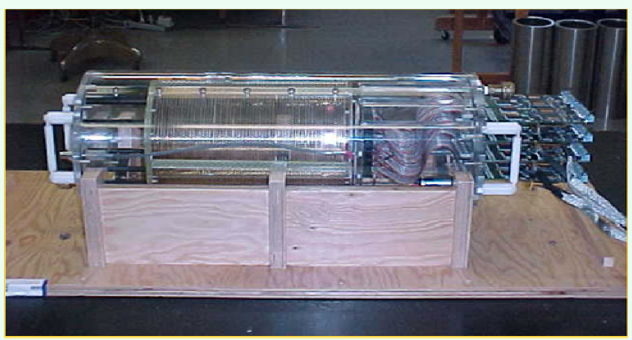
DESY



MPI/Japan



Karlsruhe



Victoria

Cornell

PRELIMINARY

Longitudinal resolution

Longitudinal resolution

P5 gas
TDR gas

B field as shown

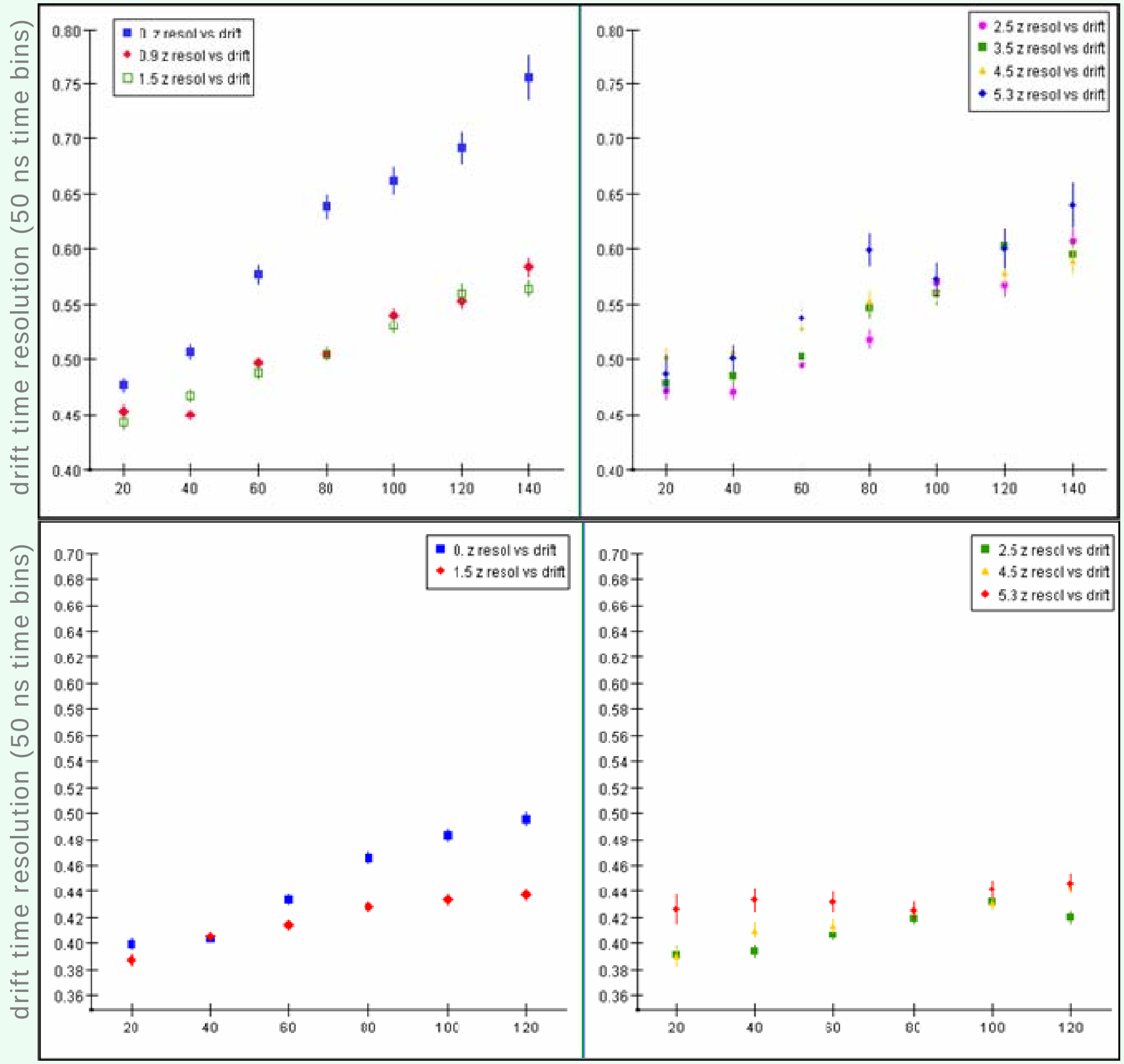
(Not a property of the GEM)

1.6 mm

0.8 mm

1.6 mm

0.8 mm

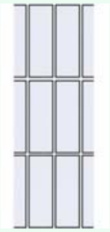


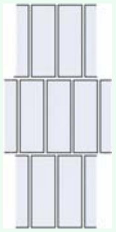
Rosenbaum, Victoria, Victoria 2004

PRELIMINARY

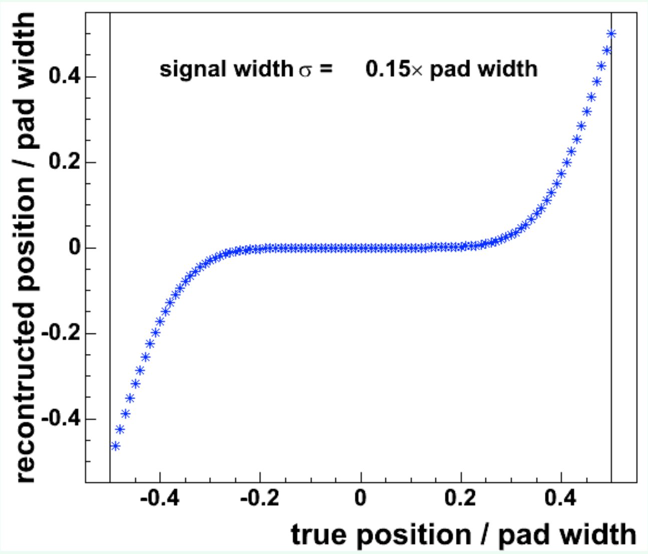
Transverse resolution, signal size

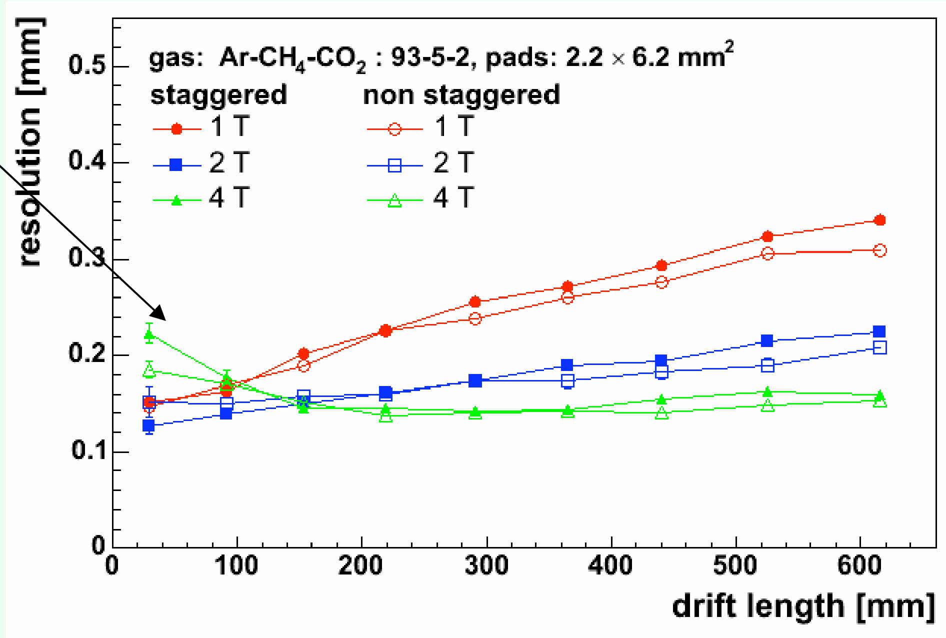
DESY measurements
3-GEM, each 325V
Transfer gaps: 2mm, 2mm, 3mm
Ar:CH_4:CO_2 93:5:2
pad width: 2.2 mm
B = 1, 2, 4 Tesla
cosmics





Rise indicates pad size is too large for signal width





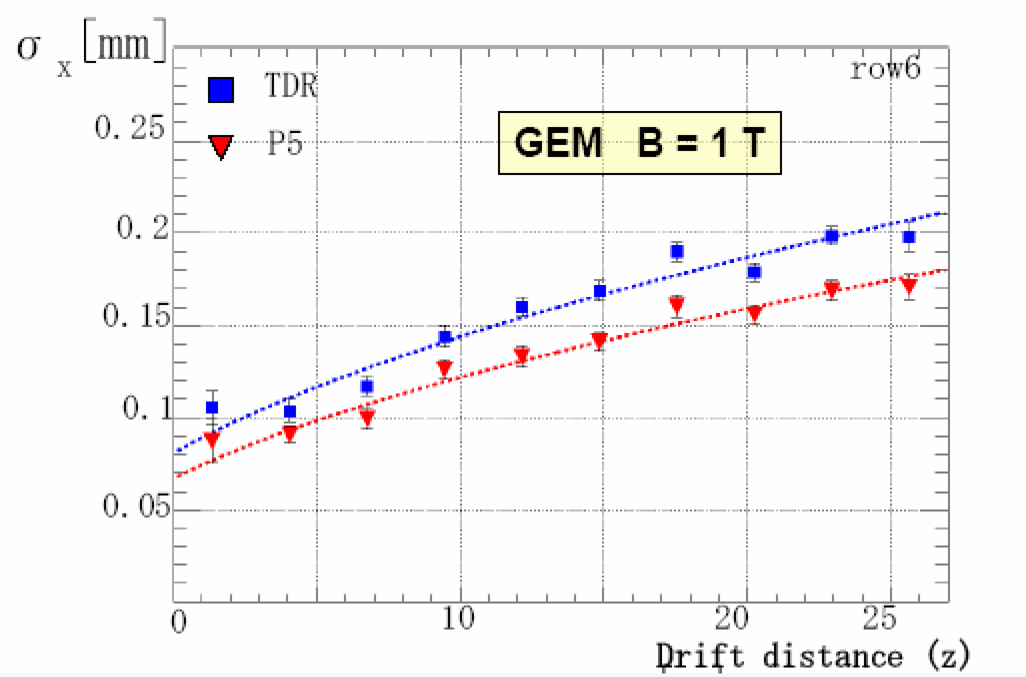
$\sigma = 0.15 \times 2.2mm = 0.33mm$
at 2 Tesla

Ikematsu, DESY, Bangalore 2006

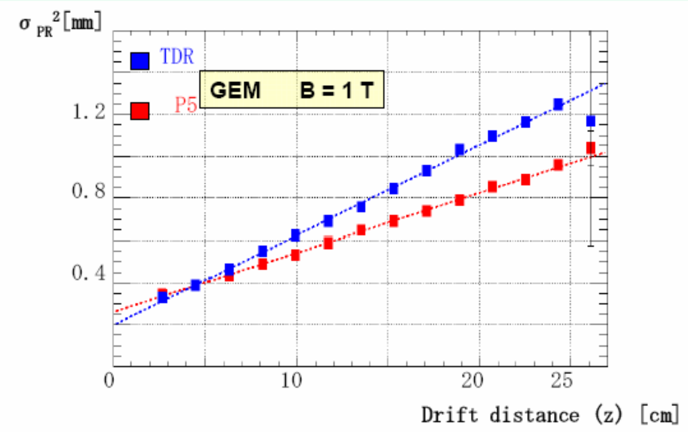
PRELIMINARY

Transverse resolution, signal size

MPI/CDC (Asia) measurements
3-GEM, each 330V
Transfer gaps: 1.5, 1.5, 1.0 mm
Ar:CH_4:CO_2 93:5:2 220V/cm
Ar:CH4 95:5 100V/cm
pad width: 1.27 mm staggered
B =1 Tesla
4 GeV/c pion beam



cm



	σ_{X0} (μ m)	N_{eff}
TDR	81 ± 6	30 ± 2
P5	67 ± 6	27 ± 2

with σ^2 = 0.2mm^2, σ= 0.45mm
4σ (90% containment) = 1.8mm

Kobayashi, KEK, Bangalore 2006

PRELIMINARY

Transverse resolution, signal size

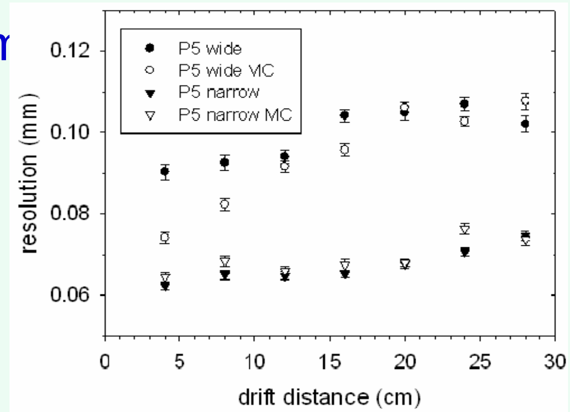
Victoria measurements
2-GEM, 372V, 380V

Transfer gaps: 2mm, 5mm

Ar:CH4:CO2 93:5:2 230 V/cm
Ar:CH4 95:5 90-160 V/cm

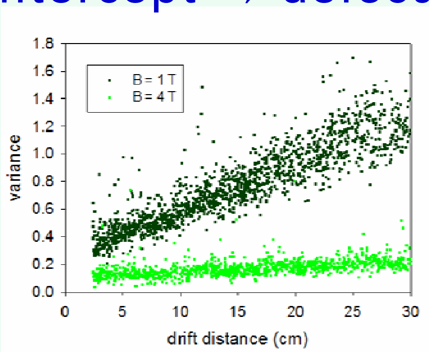
pad width: 2.0 mm , 1.2 mm

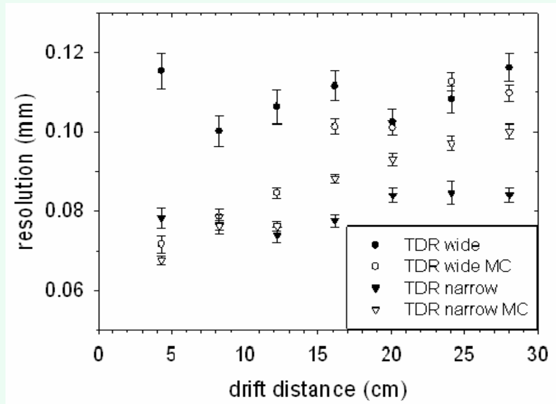
B = 0, 1, 4 Tesla
cosmics

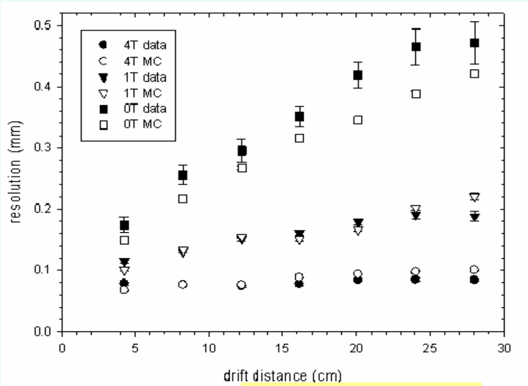


dataset	Resolution [μm] (data)	Resolution [μm] (sim.)
p5B4w	108 ± 1	92 ± 1
p5B4n	68 ± 1	68 ± 1
tdrB4w	117 ± 2	100 ± 1
tdrB4n	83 ± 1	87 ± 1

Slope $\rightarrow$ diffusion constant
intercept $\rightarrow$ defocusing term







TDR, narrow

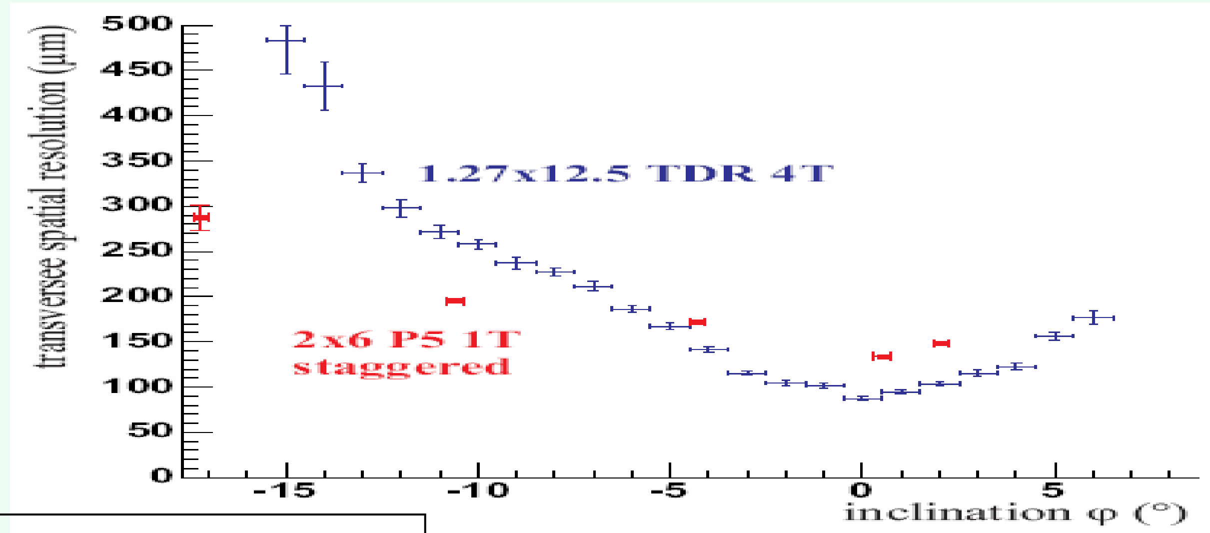
TDR gas, σ_0=.92 mm (0T)
.51 mm (1T)
.32 mm (4T)

Karlen, Victoria, Snowmass 2005

PRELIMINARY

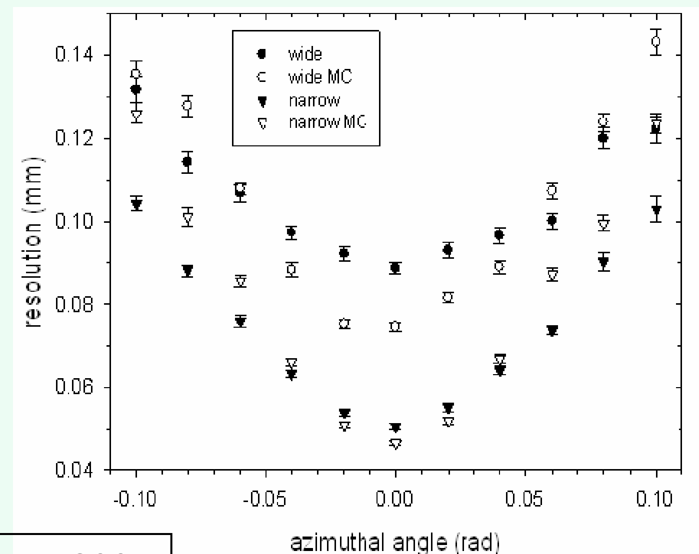
Track angle effects

Karlsruhe



Ledermann, Karlsruhe, Vienna 2005

Victoria

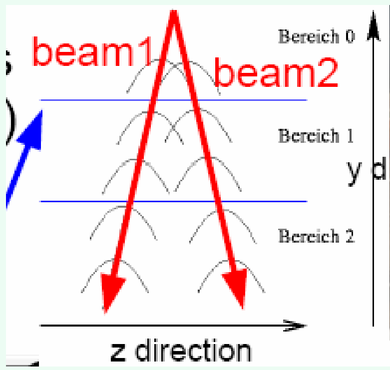


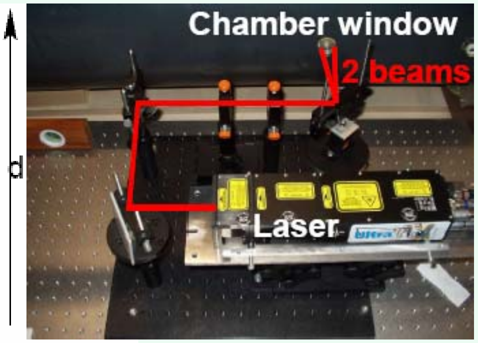
Karlen, Victoria, Snowmass 2005

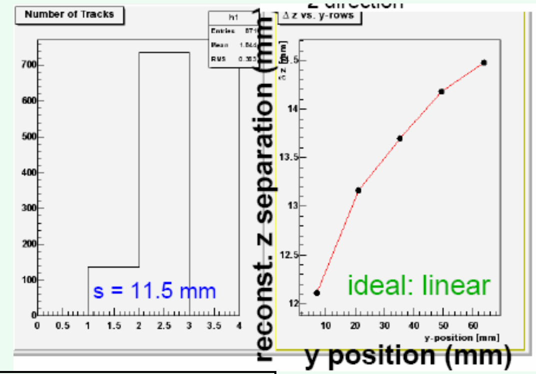
PRELIMINARY

2-track resolution

Z separation:
10 mm

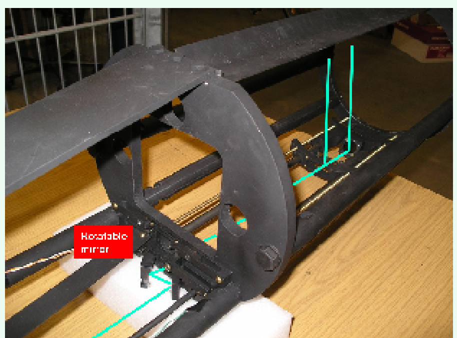


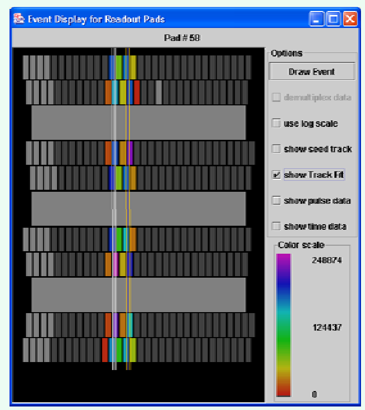


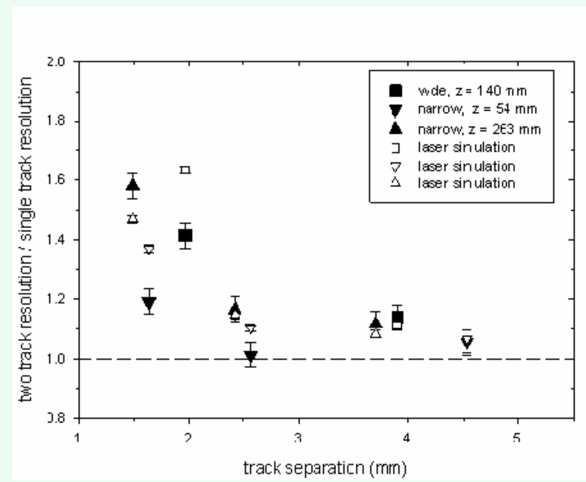


Wienemann, DESY, Stanford 2005

Transverse separation:







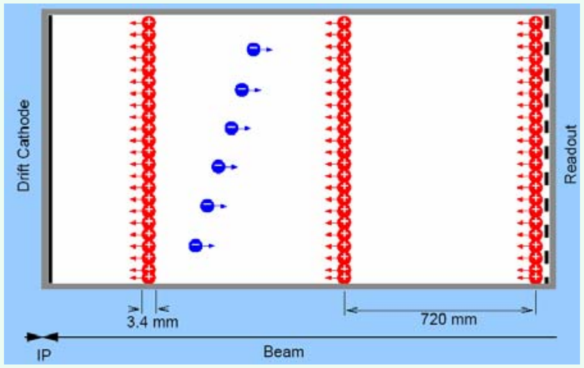
1.5 pad width
σ_0 = .32 mm (4T)

Δx=3.8 cm, Δz=0

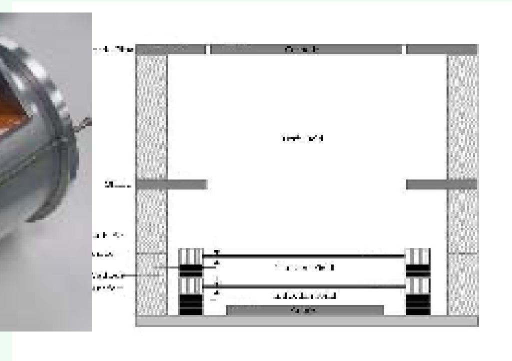
Karlen, Victoria, Snowmass 2005

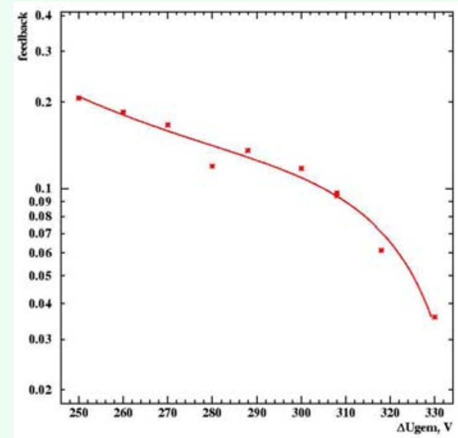
PRELIMINARY

Ion feedback (back drift)



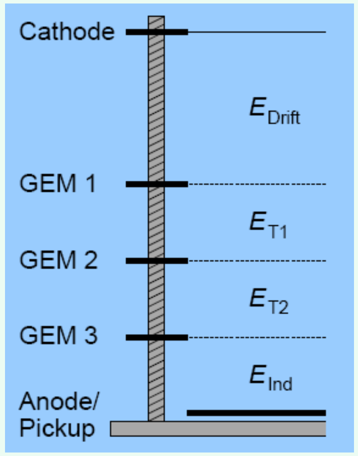
DESY
3-GEM
Novorod GEM
TDR Gas





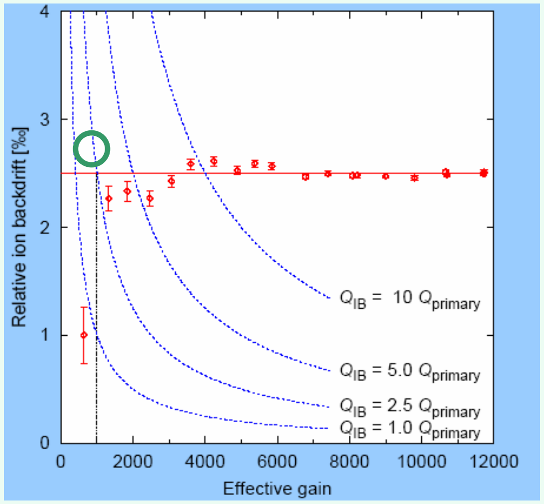
Weinemann, DESY, Berkeley 2003

Aachen
3-GEM
B=4 Tesla
for G_{eff}=1000,
Q_{IB}~2.5 $Q_{primary}$

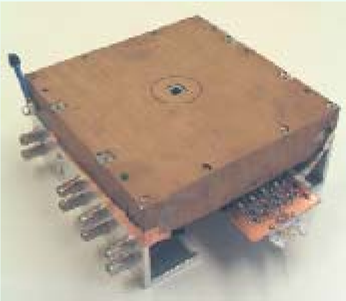


Optimization

E_{drift}	240V
U_{GEM1}	small influence
E_{T1}	MAXIMUM
U_{GEM2}	small influence
E_{T2}	minimum
U_{GEM3}	MAXIMUM
E_{ind}	MAXIMUM



Vogel, Aachen, Durham 2004



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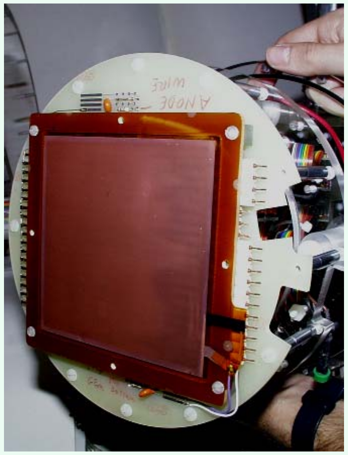
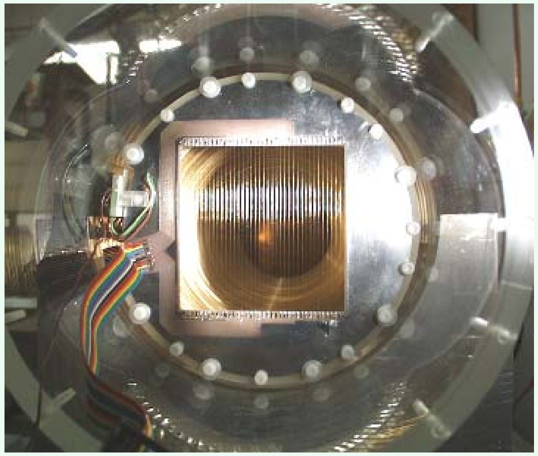
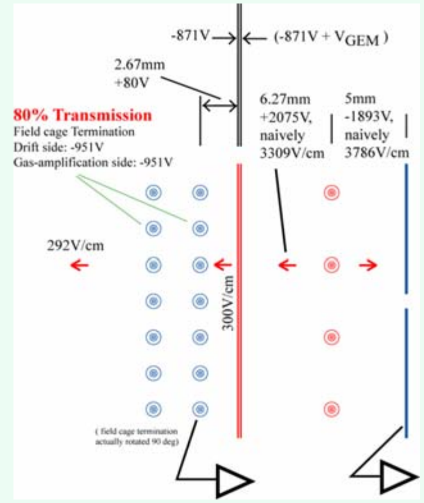
Possibility of using a GEM ion gate

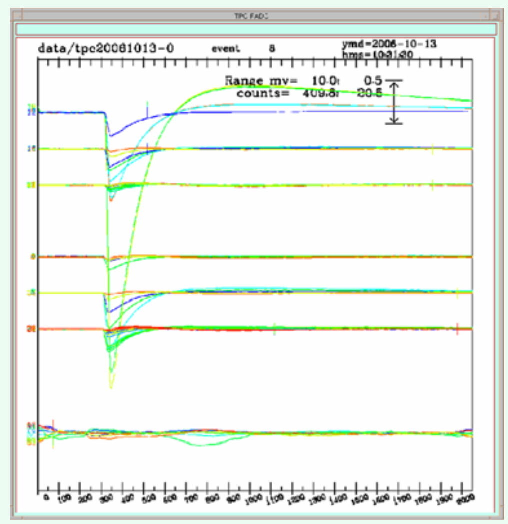


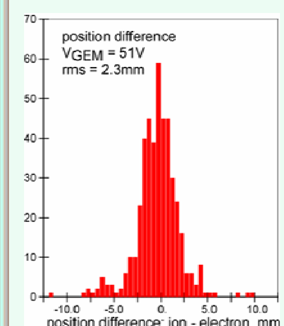




suppressed ion feedback from GEMs
may not be enough, require 1/gain
prepare to instrument a gate
wire gates are complex
investigate use of a GEM gate

GEM mounted on MWPC
MWPC: electron measurement, ion source
field gage termination, ion measurement
anode traces 82 μs full scale, ion 656 μs

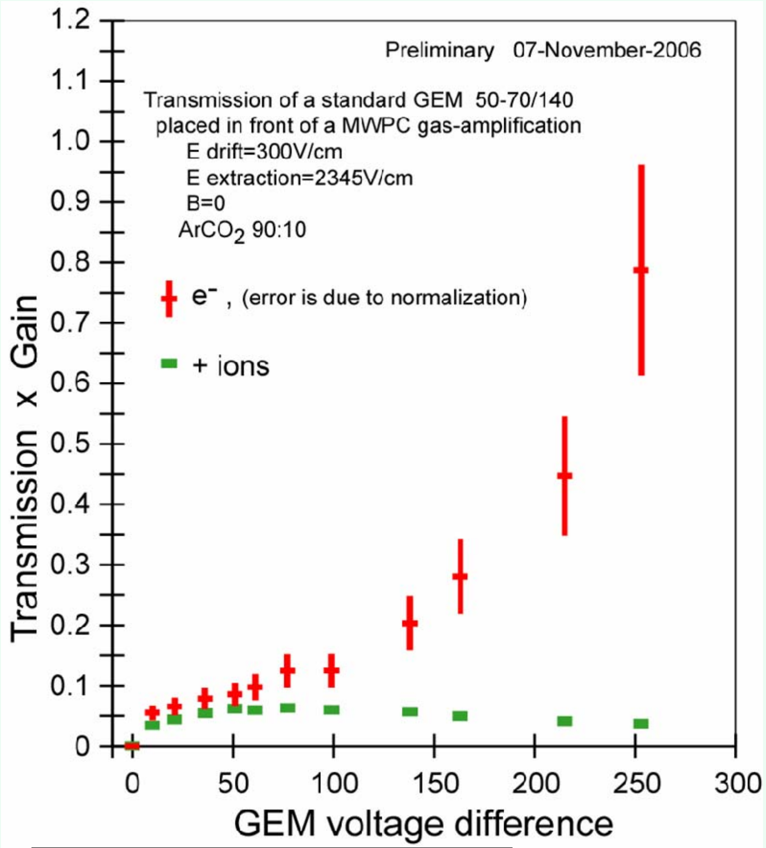




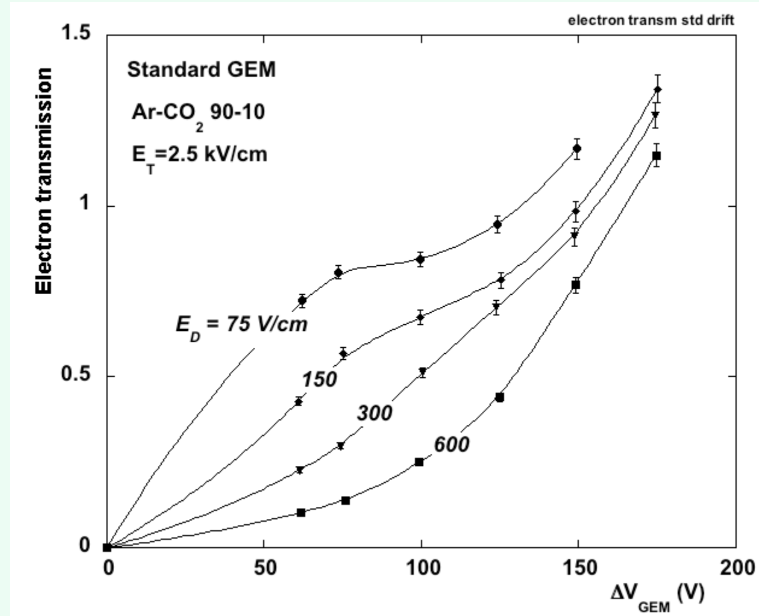
Peterson, Cornell, Valencia 2006

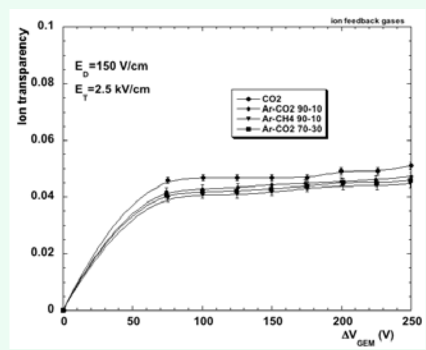
PRELIMINARY

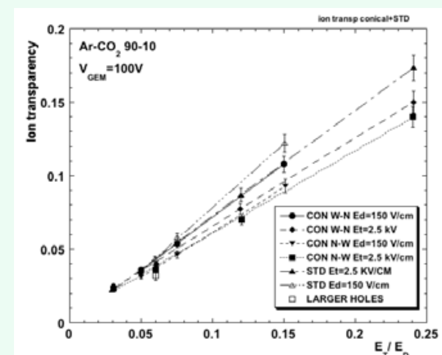
GEM transmission



Peterson, Cornell, Valencia 2006







Electron transmission does not agree with source/current measurements.

Measurements to be repeated in a magnetic field.

Sauli et al, IEEE Nucl. Sci Symp NS-50 2003 803

PRELIMINARY

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Summary

"TDR Gas" $Ar:CH_4:CO_2$ 93:5:2

				B=1 Tesla		B=4 Tesla	
data set	GEMs	transfer gap total (mm)	pad width (mm)	signal width σ (mm)	transverse resolution (zero drift) (μm)	signal width σ (μm)	transverse resolution (zero drift) (μm)
DESY	3	7	2.2		150	0.33 (2T)	200
Victoria	2	7	2.0	0.51		0.32	105
MPI/CDC	3	4	1.27	0.45	100		
Victoria	2	7	1.2	0.51	100	0.32	75

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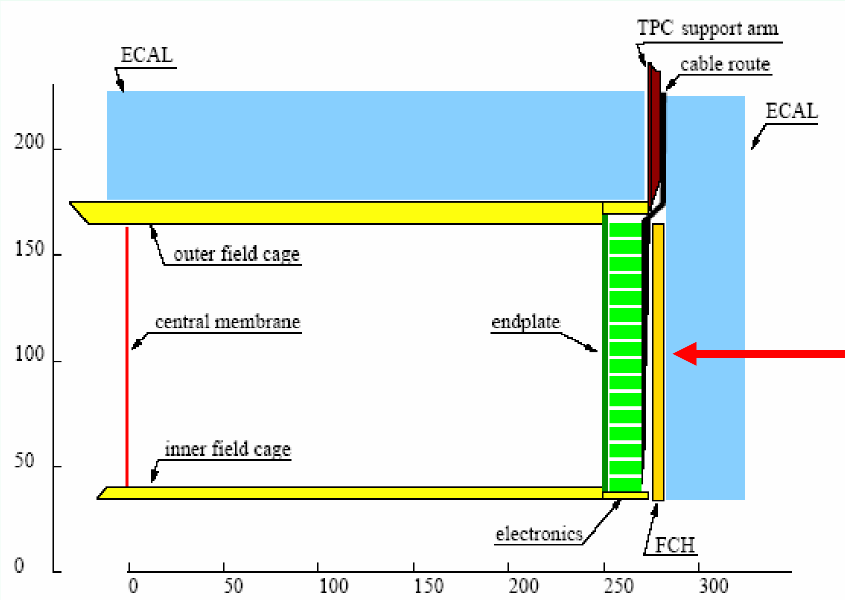
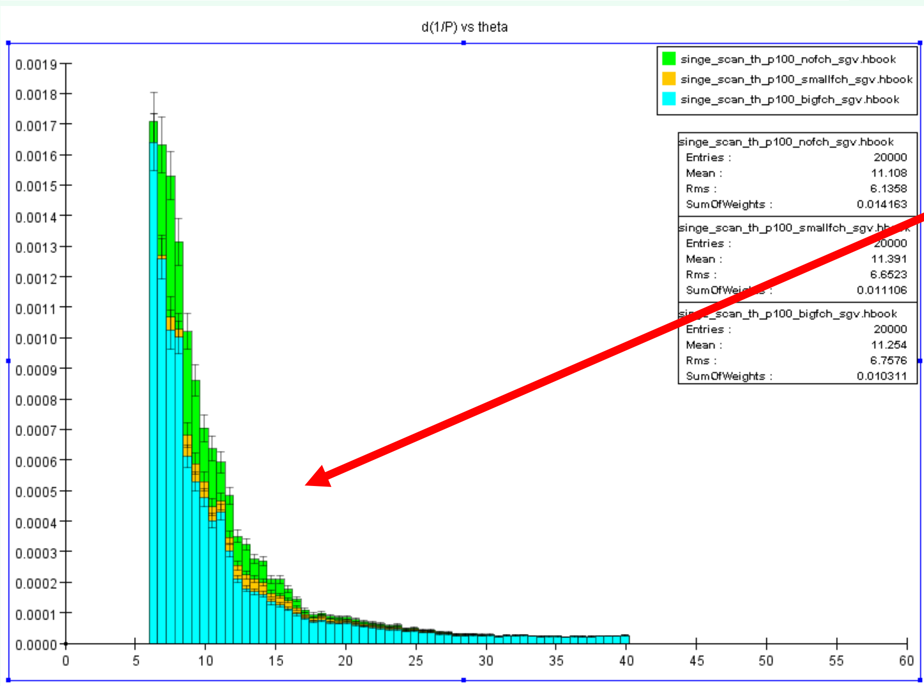




GEM end cap tracker

An end cap tracker is an integral part of the TPC implementation

matching point at entry to Ecal

pattern recognition in TPC

improved d(1/p) for ~7° < θ < ~16°

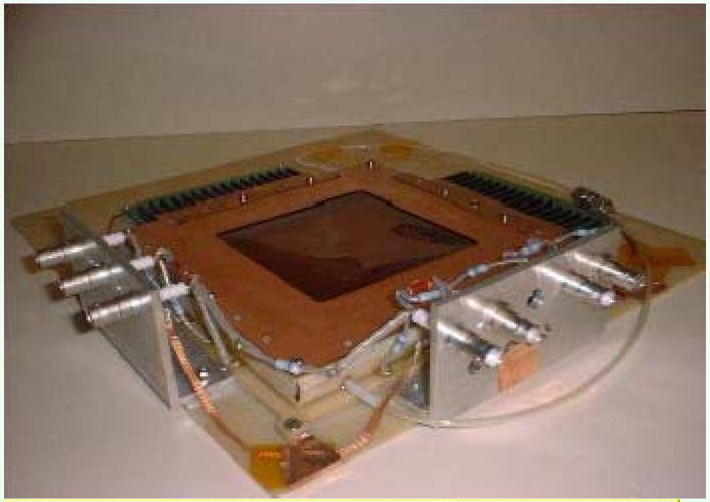
Silicon detectors is one option.

Louisiana Tech is investigating a GEM device.

Sawyer, Louisiana Tech, 2007

PRELIMINARY

GEM end cap tracker

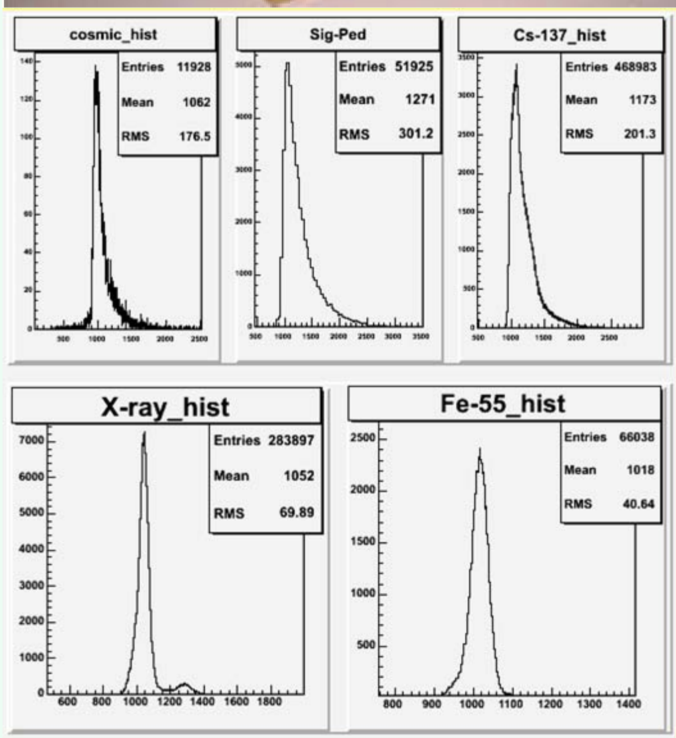


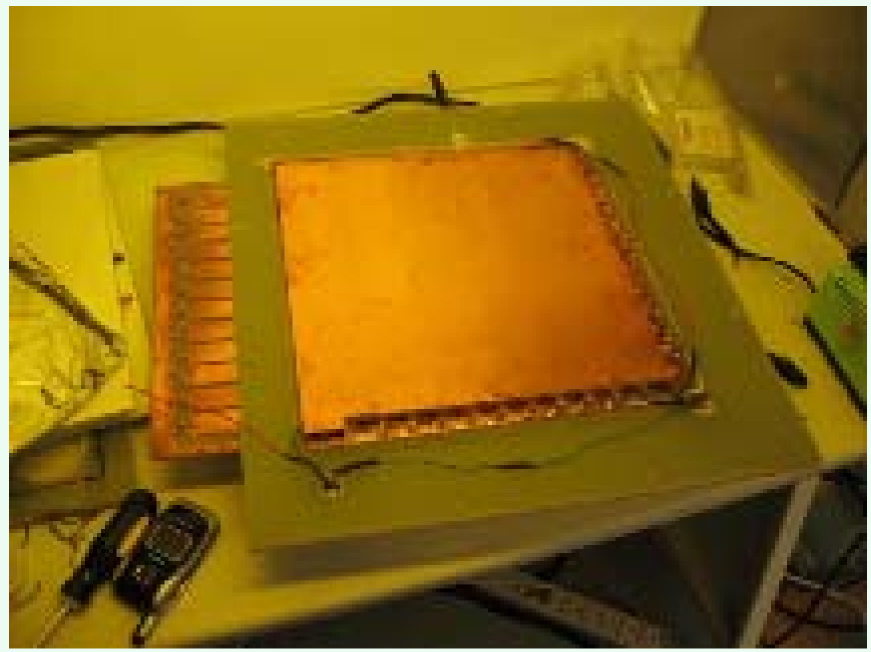
10cm x 10cm built and tested

30cm x 30cm built Fall 2006

foils are 3M, in cooperation with Arlington digital Hcal

Beam tests at Fermilab in Spring 2007





Sawyer, Louisiana Tech, 2007

PRELIMINARY

SOFTWARE

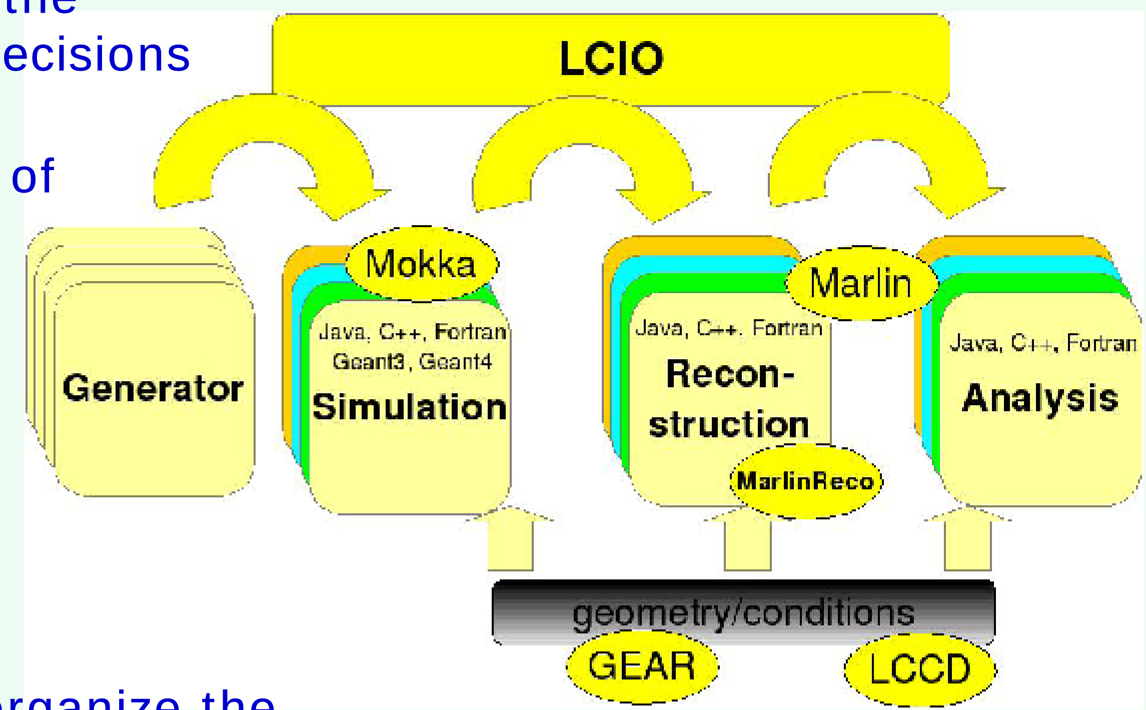
Software in Europe uses a framework as shown.

Reconstruction is done using “Marlin Processors”

Work is ongoing to develop the tools necessary for design decisions

Will give further description of using the framework

Will describe work in
- signal simulation
- hit overlap,
- noise simulation
- magnetic field distortions.



Will mention the efforts to organize the reconstruction for prototypes, especially the large prototype.

PRELIMINARY

Physics event generation: Phythia

```
File Edit Options Buffers Tools Fortran Help

      IMPLICIT DOUBLE PRECISION(A-H, O-Z)
      COMMON/PYDATR/MRPY(6),RRPY(100)
      ECM=500D0
      NEV=25

      MRPY(1) = 535244
      CALL PYGIVE('MSEL=6')
      CALL PYGIVE('MDME(190,1)=1')
      CALL PYGIVE('MDME(191,1)=1')
      CALL PYGIVE('MDME(192,1)=1')
      CALL PYGIVE('MDME(194,1)=1')
      CALL PYGIVE('MDME(195,1)=1')
      CALL PYGIVE('MDME(196,1)=1')
      CALL PYGIVE('MDME(198,1)=1')
      CALL PYGIVE('MDME(199,1)=1')
      CALL PYGIVE('MDME(200,1)=1')
      CALL PYGIVE('MDME(206,1)=0')
      CALL PYGIVE('MDME(207,1)=0')
      CALL PYGIVE('MDME(208,1)=0')
      CALL PYGIVE('CKIN(1)=170D0')

C...Initialize.
      CALL PYINIT('CMS','e-','e+',ECM)

C...Begin event loop.
      DO IEV=1,NEV
         CALL PYEVNT
         CALL PYHEPC(1)
         CALL PYEDIT(3)

C          call pylist(1)
C          call pylist(5)
*
       CALL HEP2G4
*
      ENDDO
***********************************************************
      STOP
      END
***********************************************************
      SUBROUTINE HEP2G4
*
* Output /HEPEVT/ event structure to G4HEPEvtInterface
*
* M.Asai (asai@kekvax.kek.jp)  --  24/09/96
*
***********************************************************
      PARAMETER (NMXHEP=4000)
      COMMON/HEPEVT/NEVHEP,NHEP,ISTHEP(NMXHEP),IDHEP(NMXHEP),
     &JMOHEP(2,NMXHEP),JDAHEP(2,NMXHEP),PHEP(5,NMXHEP),VHEP(4,NMXHEP)
       DOUBLE PRECISION PHEP,VHEP
*
      WRITE(3,*) NHEP
      DO IHEP=1,NHEP
       WRITE(3,10)
     >  ISTHEP(IHEP),IDHEP(IHEP),JDAHEP(1,IHEP),JDAHEP(2,IHEP),
     >  PHEP(1,IHEP),PHEP(2,IHEP),PHEP(3,IHEP),PHEP(5,IHEP)
10    FORMAT(4I7,4(1X,e15.8))
      ENDDO
*
      RETURN
      END

----:---F1  ttbar.f         (Fortran)--L50--All-------------------
```

run Pythia

input
- beam parameters
- event type

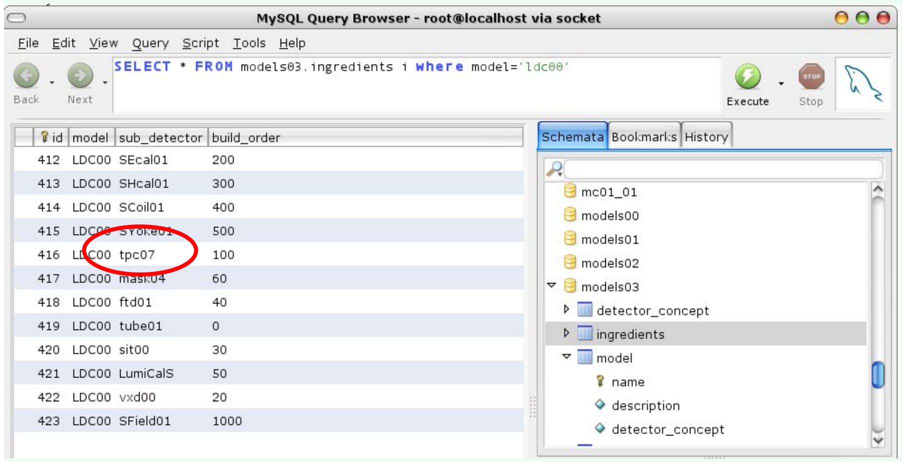
output
- track list
- (escaping interaction)

HEPEvt file →

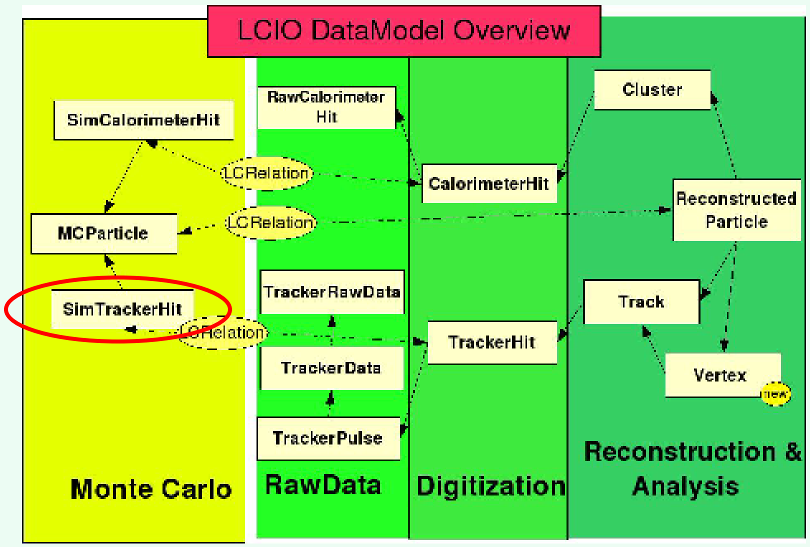
```
File Edit Options Buffers Tools Help
       241
     3     11      0      0  0.00000000E+00  0.00000000E+00  0.25000000E+03  0.51000000E-03
     3    -11      0      0  0.00000000E+00  0.00000000E+00 -0.25000000E+03  0.51000000E-03
     3     11      0      0  0.00000000E+00  0.00000000E+00  0.25000000E+03  0.00000000E+00
     3    -11      0      0  0.00000000E+00  0.00000000E+00 -0.25000000E+03  0.00000000E+00
     3     22      0      0 -0.17829929E-02  0.16015685E-02  0.12775856E+03  0.00000000E+00
     3     22      0      0  0.58550442E+00  0.38201003E+00 -0.24608426E+03  0.00000000E+00
     3      6      0      0 -0.24647798E+02 -0.13194629E+02 -0.62364497E+02  0.17467267E+03
     3     -6      0      0  0.25231519E+02  0.13578240E+02 -0.55961203E+02  0.17534621E+03
     3     24      0      0  0.74252779E+00 -0.63110250E+02  0.17110730E+01  0.80533043E+02
     3      5      0      0 -0.25390325E+02  0.49915622E+02 -0.64075570E+02  0.48000000E+01
     3    -24      0      0 -0.24219198E+02  0.56278547E+02 -0.65883854E+02  0.79434259E+02
     3     -5      0      0  0.49450717E+02 -0.42700307E+02  0.99226516E+01  0.48000000E+01
     3     -3      0      0  0.25747972E+01  0.18296894E+02  0.92901511E+01  0.50000000E+00
     3      4      0      0 -0.19043515E+01 -0.80958923E+02 -0.77601768E+01  0.15000000E+01
     3      1      0      0  0.15469427E+02  0.34059998E+02 -0.64044792E+02  0.33000000E+00
     3     -2      0      0 -0.36076792E+02  0.16583274E+02  0.32279444E+01  0.33000000E+00
     1    -11      0      0 -0.58550486E+00 -0.38200963E+00 -0.38840359E+01  0.51000000E-03
     1     11      0      0  0.17834354E-02 -0.16019659E-02  0.12220974E+03  0.51000000E-03
     2     24     31     41  0.67044563E+00 -0.62662029E+02  0.15299742E+01  0.80533043E+02
     2    -24     42     50 -0.20607365E+02  0.50643273E+02 -0.60816847E+02  0.79434259E+02
     1     22      0      0  0.00000000E+00  0.00000000E+00  0.17986604E-06  0.00000000E+00
     1     22      0      0  0.00000000E+00  0.00000000E+00 -0.84483751E-06  0.00000000E+00
     2      5     51     51 -0.26170538E+02  0.49051848E+02 -0.62902817E+02  0.48000000E+01
     2     21     51     51  0.13561144E+00  0.23695952E+00 -0.17238231E+00  0.00000000E+00
     2     21     51     51  0.71668288E+00  0.17859279E+00 -0.81927132E+00  0.00000000E+00
     2     21     51     51  0.34317243E+01  0.11748970E+01 -0.18083539E+01  0.00000000E+00
     2     -2     51     51  0.83372946E+01  0.86743504E+00 -0.66501210E+01  0.33000000E+00
     2     -5     56     56  0.27073362E+02 -0.39470102E+02  0.14309414E+02  0.48000000E+01
     2     21     56     56  0.20473655E+01 -0.73216317E+00 -0.38089648E+00  0.00000000E+00
     2      2     56     56  0.49491384E+01  0.10949010E+01 -0.61439770E+00  0.33000000E+00
     2     -3     61     61  0.16403154E+00  0.14181192E+02 -0.25862490E+01  0.50000000E+00
     2     21     61     61  0.75413396E+00  0.21859169E+01  0.25141042E+00  0.00000000E+00
     2     21     61     61  0.10576886E+01  0.20983988E+00  0.49343197E+00  0.00000000E+00
     2     21     61     61  0.51459828E+00 -0.63271234E+01  0.45635009E+01  0.00000000E+00
     2     21     61     61 -0.68726978E+00 -0.27932701E+01  0.31055057E+01  0.00000000E+00
     2     21     61     61  0.46687514E+00 -0.13775133E+01  0.22304701E+01  0.00000000E+00
     2     21     61     61  0.49682220E+00 -0.24272274E+01 -0.11632552E+01  0.00000000E+00
     2     21     61     61  0.21349508E+00 -0.10469929E+01 -0.18651725E+00  0.00000000E+00
     2     21     61     61  0.36517099E+00 -0.57230713E+01 -0.56185679E+00  0.00000000E+00
     2     21     61     61 -0.41118582E+00 -0.16109961E+02 -0.84867029E+00  0.00000000E+00
     2      4     61     61 -0.22639146E+01 -0.43433818E+02 -0.37677963E+01  0.15000000E+01
     2      1     81     81  0.12842476E+02  0.27006145E+02 -0.51183746E+02  0.33000000E+00
     2     21     81     81  0.21387675E+01  0.60106322E+01 -0.10888082E+02  0.00000000E+00
     2     21     81     81 -0.27060817E+01  0.28763146E+00 -0.11089709E+01  0.00000000E+00
     2     21     81     81 -0.20388544E+01  0.92396742E+00 -0.16125419E+00  0.00000000E+00
     2     21     81     81 -0.12295991E+02  0.72331893E+01  0.40071606E+01  0.00000000E+00
     2     21     81     81 -0.86683864E+01  0.59412562E+01  0.18620327E+01  0.00000000E+00
     2     21     81     81 -0.61692551E+00  0.70082263E+00  0.17196584E+00  0.00000000E+00
     2     21     81     81 -0.63373538E+00  0.46903131E+00  0.26900318E+00  0.00000000E+00
     2     -2     81     81 -0.86286351E+01  0.20705974E+01 -0.37849561E+01  0.33000000E+00
     2     92     52     55 -0.13549224E+02  0.51509732E+02 -0.72352946E+02  0.44527218E+02
     2   -513    100    101 -0.24822642E+02  0.47052483E+02 -0.60212356E+02  0.53248000E+01
     2   -213    102    103 -0.11967437E+01  0.19600567E+01 -0.32728246E+01  0.75288755E+00
     2    213    104    105  0.51623618E+01  0.16936354E+01 -0.28984172E+01  0.79660301E+00
     1   -211      0      0  0.73077994E+01  0.80355710E+00 -0.59693484E+01  0.13957000E+00
     2     92     57     60  0.34069865E+02 -0.39107365E+02  0.13314119E+02  0.20976595E+02
     2  -5122    106    108  0.26937291E+02 -0.38428739E+02  0.14241915E+02  0.56410000E+01
     1   2212      0      0  0.15613661E+01 -0.12961988E+01 -0.23054947E+00  0.93827000E+00
     1   -211      0      0  0.14179357E+01 -0.50434508E+00  0.11552937E+00  0.13957000E+00
     1    211      0      0  0.41532728E+01  0.11219186E+01 -0.81277536E+00  0.13957000E+00
     2     92     62     80  0.67044563E+00 -0.62662029E+02  0.15299742E+01  0.80533043E+02
     2    323    109    110  0.42971771E+00  0.90970890E+01 -0.14995297E+01  0.88274324E+00
     1  -2212      0      0  0.10901986E+00  0.36950425E+01 -0.52813110E+00  0.93827000E+00
     2    213    111    112  0.36904958E+00  0.16236714E+01 -0.31036045E+00  0.83879962E+00
----:---F1  fort.3          (Nroff)--L5--Top----------------------------------------
```

PRELIMINARY

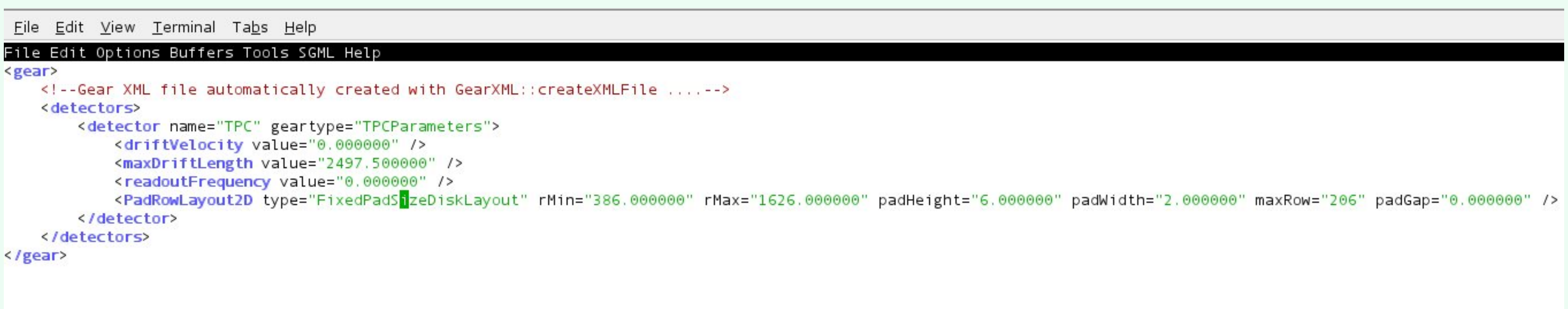
Detector Simulation: Mokka and Geant



download the geometry database
to make custom geometry (include tpc07)

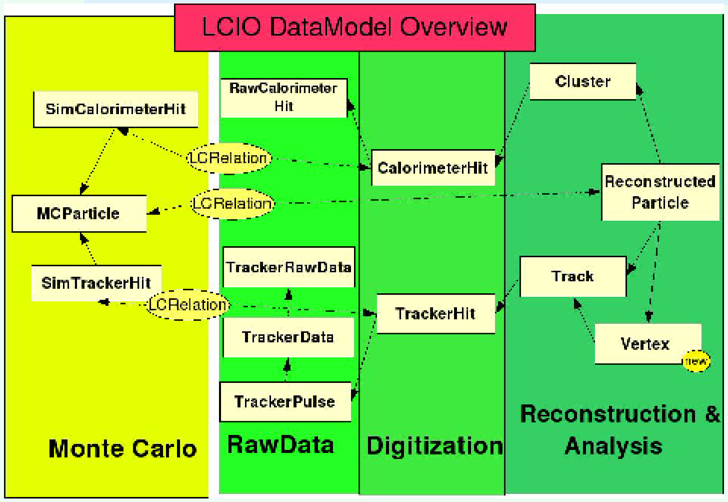


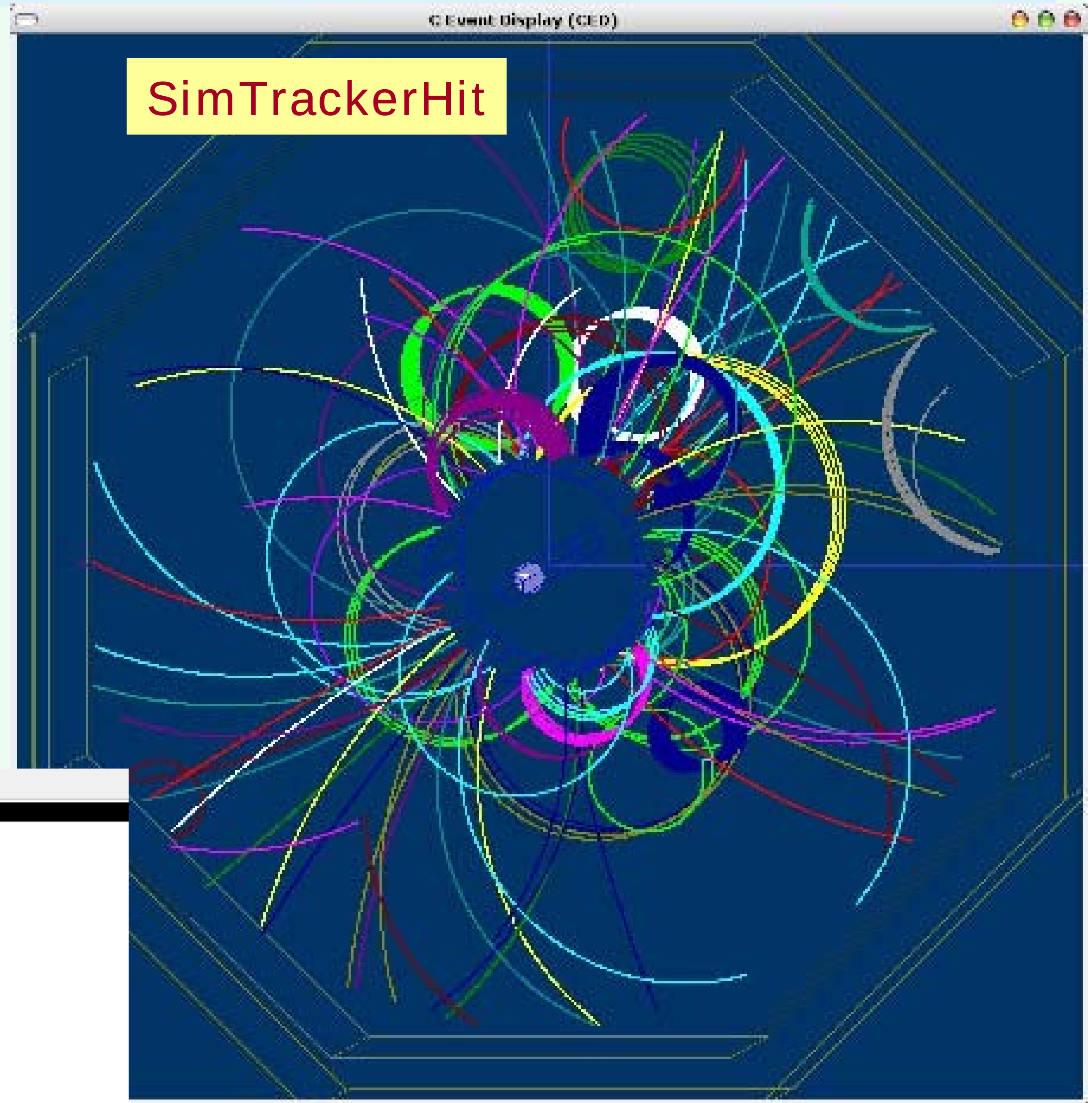
Mokka requires the geometry, HEPEvt file
outputs to LCIO, SimTrackerHit
simplified geometry GEAR file



PRELIMINARY

Reconstruction, Analysis, Visualization: Marlin





Marlin requires
- LCIO and GEAR files
- specification of processors

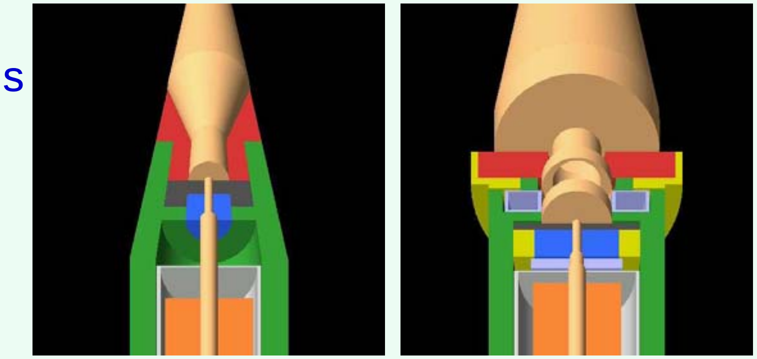
File Edit View Terminal Tabs Help

```
File Edit Options Buffers Tools SGML Help
<marlin>
 <execute>
  <processor name="GenericViewer"/>
 </execute>

 <global>
  <parameter name="LCIOInputFiles"> ttbar_large_step.slcio  </parameter>
  <parameter name="SupressCheck" value="true" />
  <parameter name="GearXMLFile"> gear_ldc.xml </parameter>
 </global>

 <processor name="GenericViewer" type="GenericViewer">
 <!--Drawing Utility-->
  <!--Layer for Sim Tracker Hits-->
  <parameter name="LayerSimTrackerHit" type="int">1</parameter>
  <parameter name="SimTrackerHitCollections" type="StringVec">tpc07_TPC STpc01_TPC </parameter>
</processor>

</marlin>
```

Realistic noise

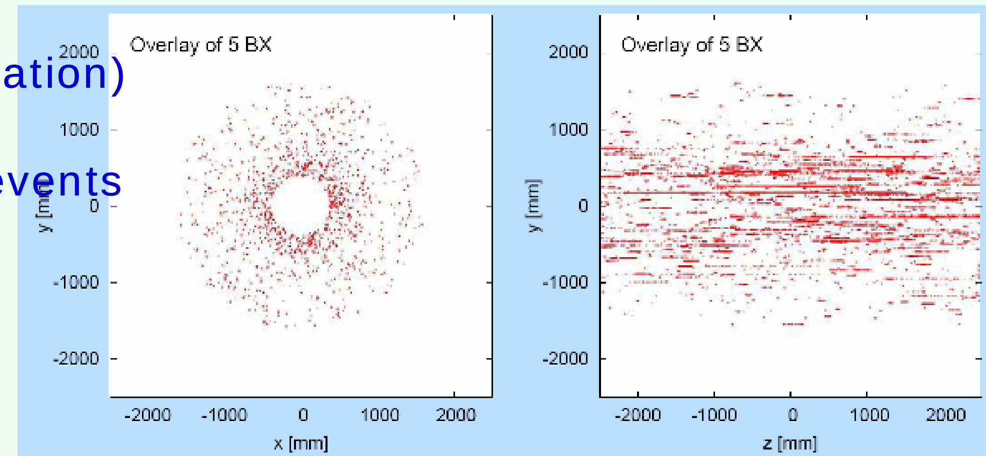
Simulate radiation in the TPC **in Mokka**

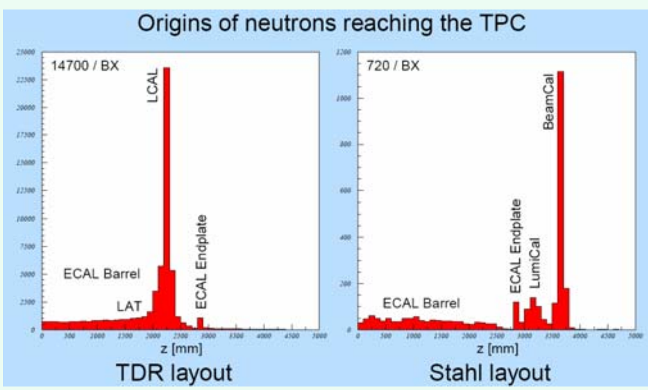
Input
- TESLA TDR/Stahl beam parameters
- Guinea Pig pairs from 5 simulated beam crossings
- different geometries and magnetic fields
- neutron production enabled in Geant 4
- standard range cuts



Output
- write out hits on all detectors to LCIO files
- monitor all particles entering the TPC
  (for a future dedicated, detailed simulation)

future: add beam background hits to events





A. Vogel, DESY, Vienna 2005

Magnetic Field Distortions

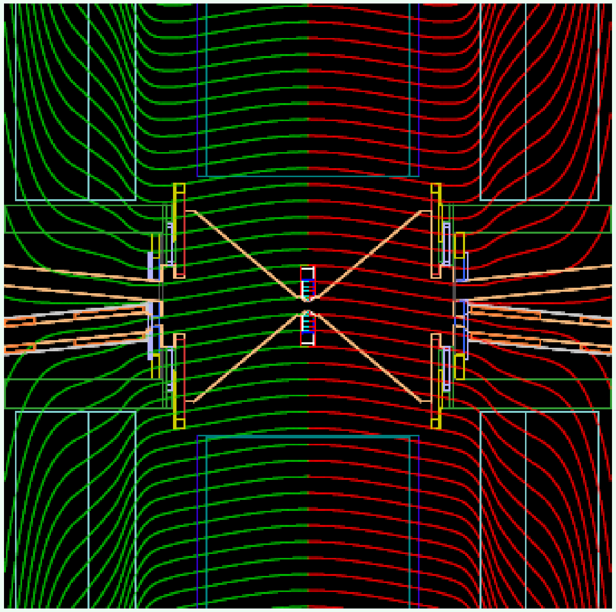
Magnetic field distortions
change the trajectory of particles
Primary Particles
drifting electrons in the TPC

The field must be mapped -
Hall probe
Then use data to find corrections.

$dB/B_z < 2 \times 10^{-5}$ is required

Simulation is implemented using Mokka
Allows parameters to be stored in a MySQL database
and accessed with drivers
Gas composition, Geometry, Field distortion

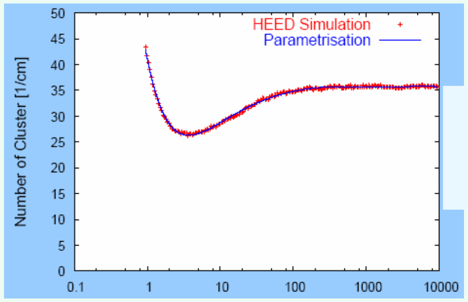
Reconstruction is within Marlin
Modular pieces are being developed in parallel
Signal calibration
Pattern recognition / Seed Track
TrackFitterLikelihood (Victoria)

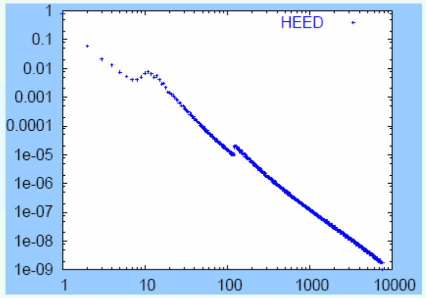


More information,
J. Abernathy, Victoria, Vancouver 2005

PRELIMINARY

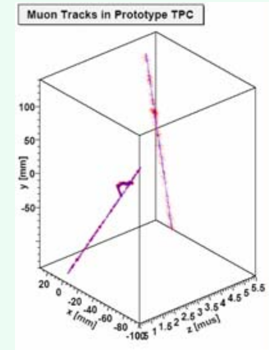
Detector response and digitization full simulation



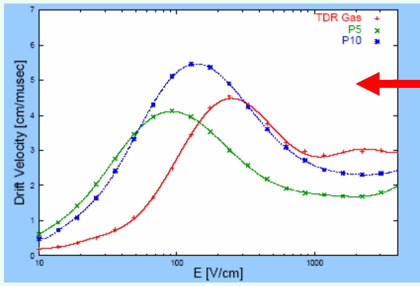


(1) primary ionization:
clusters and cluster size,
track trajectory

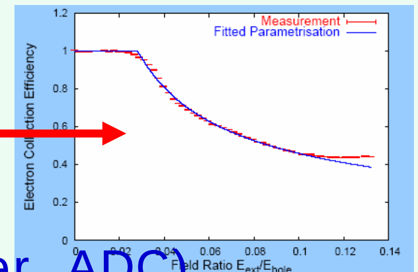
ionization in drift volume

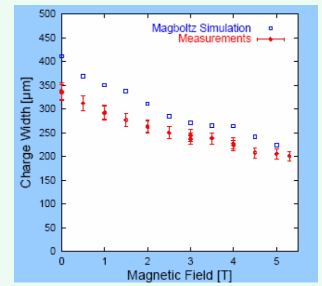


(2) drift the electrons to the readout

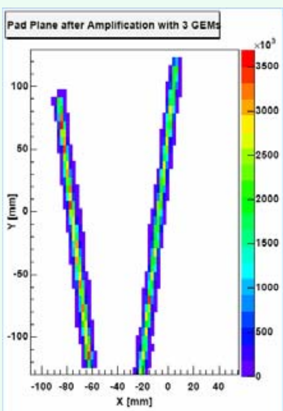


(3) properties of GEM
gas amplification
transmission, width





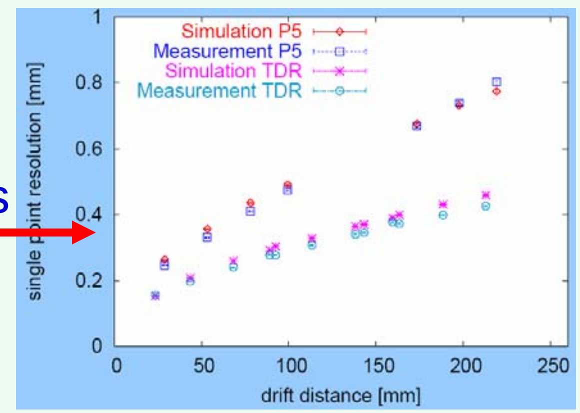
(4) electronics (shaper, ADC)



resulting simulated pad response

duplication of prototype measurements

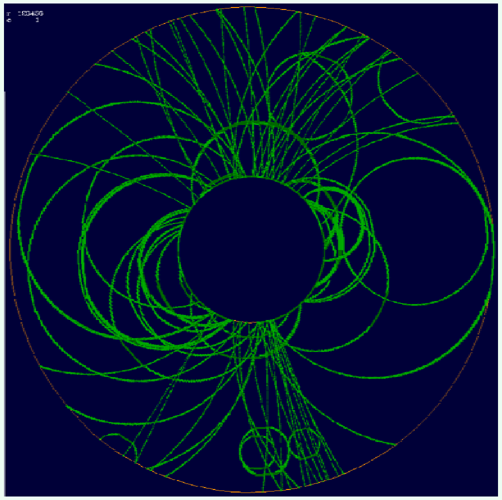
future parameterization in Mokka

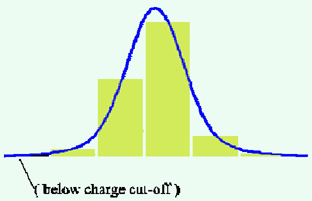


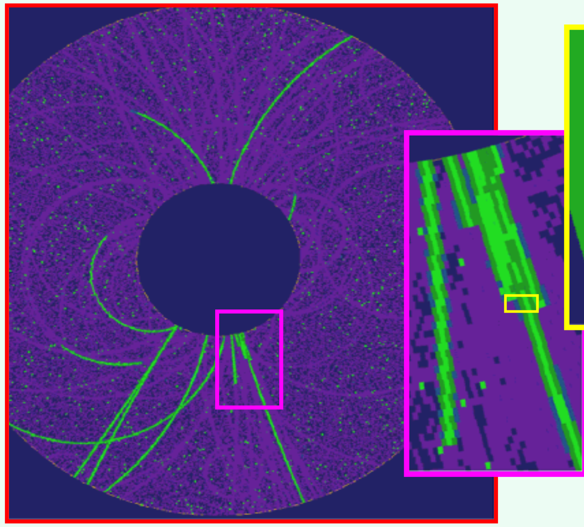
Münnich, Aachen, Valencia 2006

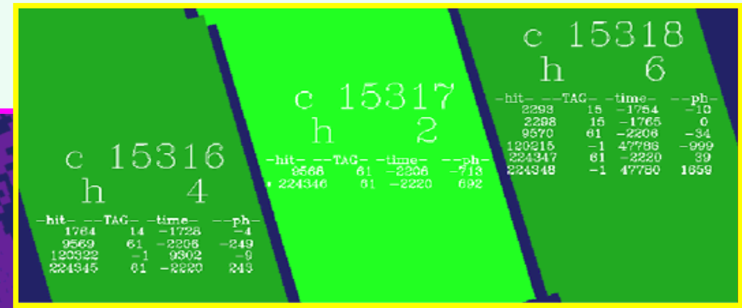
PRELIMINARY

Simulation of signal overlap

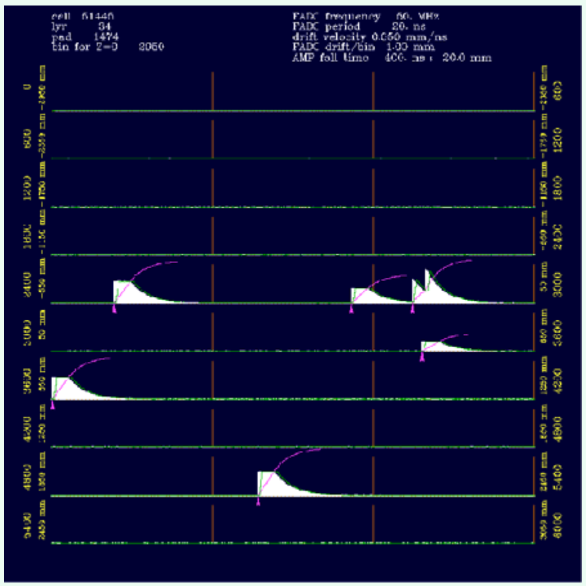






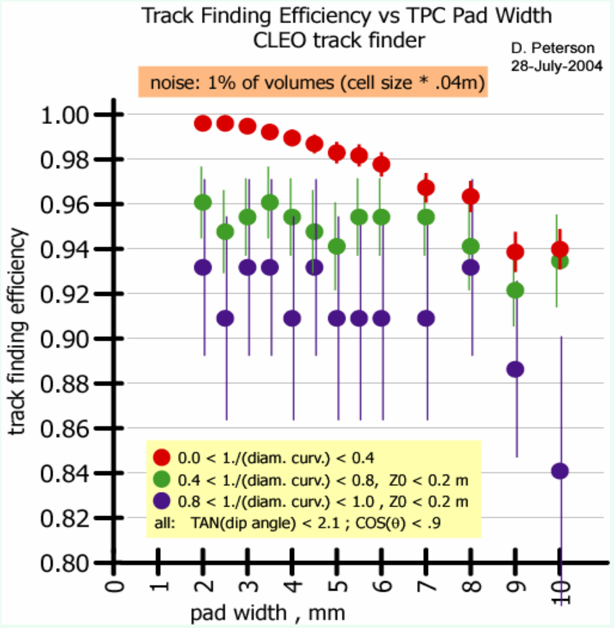


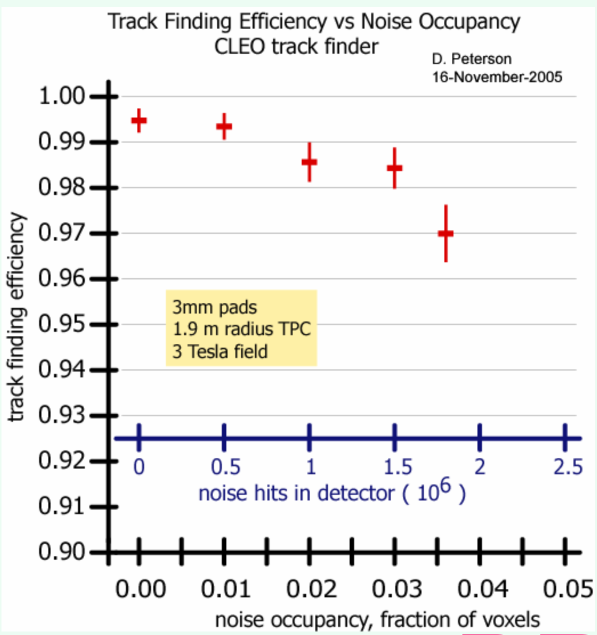
A cone with +/- 4.7 cm is “active”



Simulated “ionization centers”
Gaussian spreading pad distribution function
Multiple hits on pads
Create FADC time response for each pad
Future: implementation in Marlin

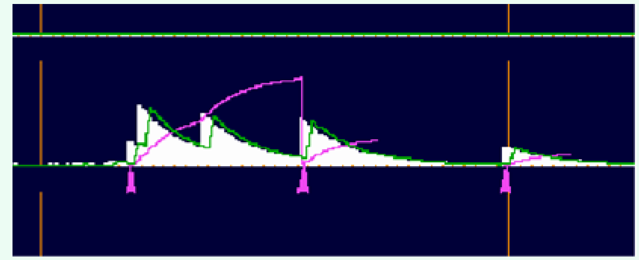
PRELIMINARY





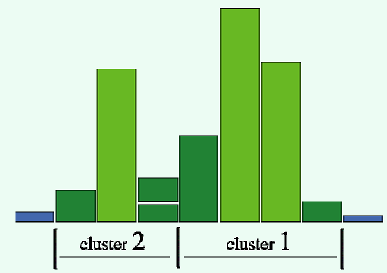
Results of reconstruction

Reconstruction ...
in time
in rϕ



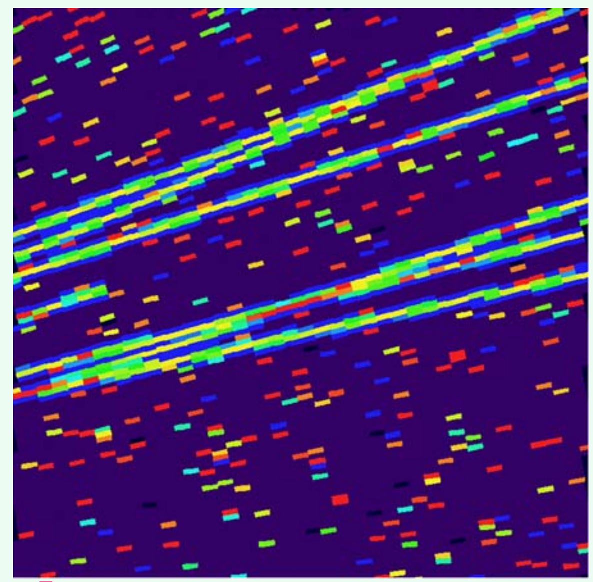
99.5% efficiency

3 mm pads sufficient
(Resolution is the determining factor for pad size)



2.5% loss in efficiency with 3.6% voxel occupancy

~21% of hits are touched by noise



Peterson, Cornell, Vienna 2005

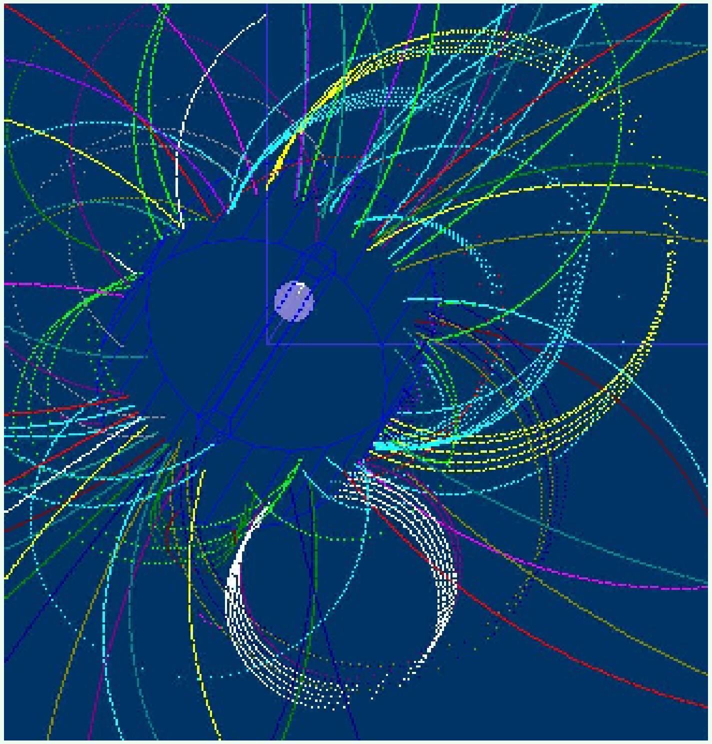
PRELIMINARY

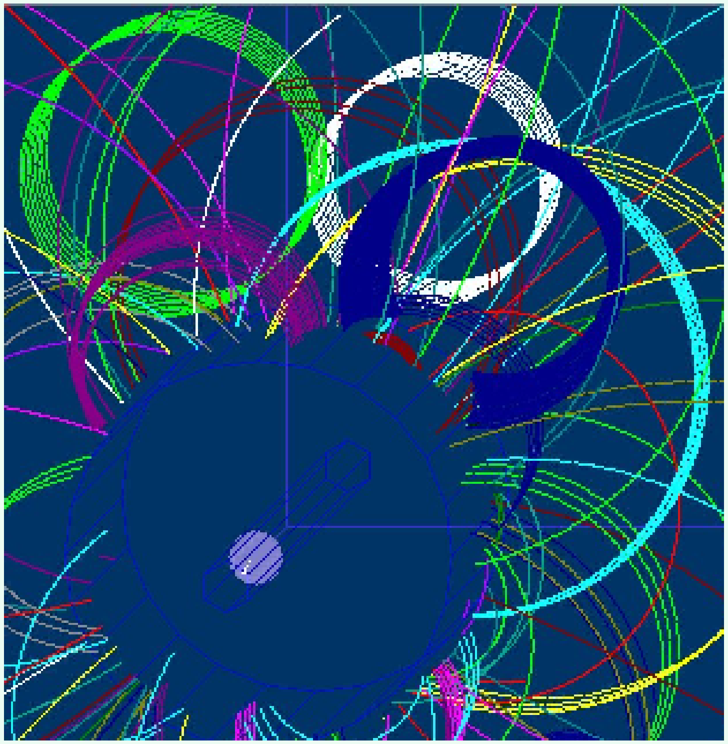
Improvements in hit creation: Mokka

A. Vogel, DESY

Mokka creates TPC hits
- previously intersections of track helixes with idealized detector cylinders
- now equally spaced points in material, true "ionization centers"

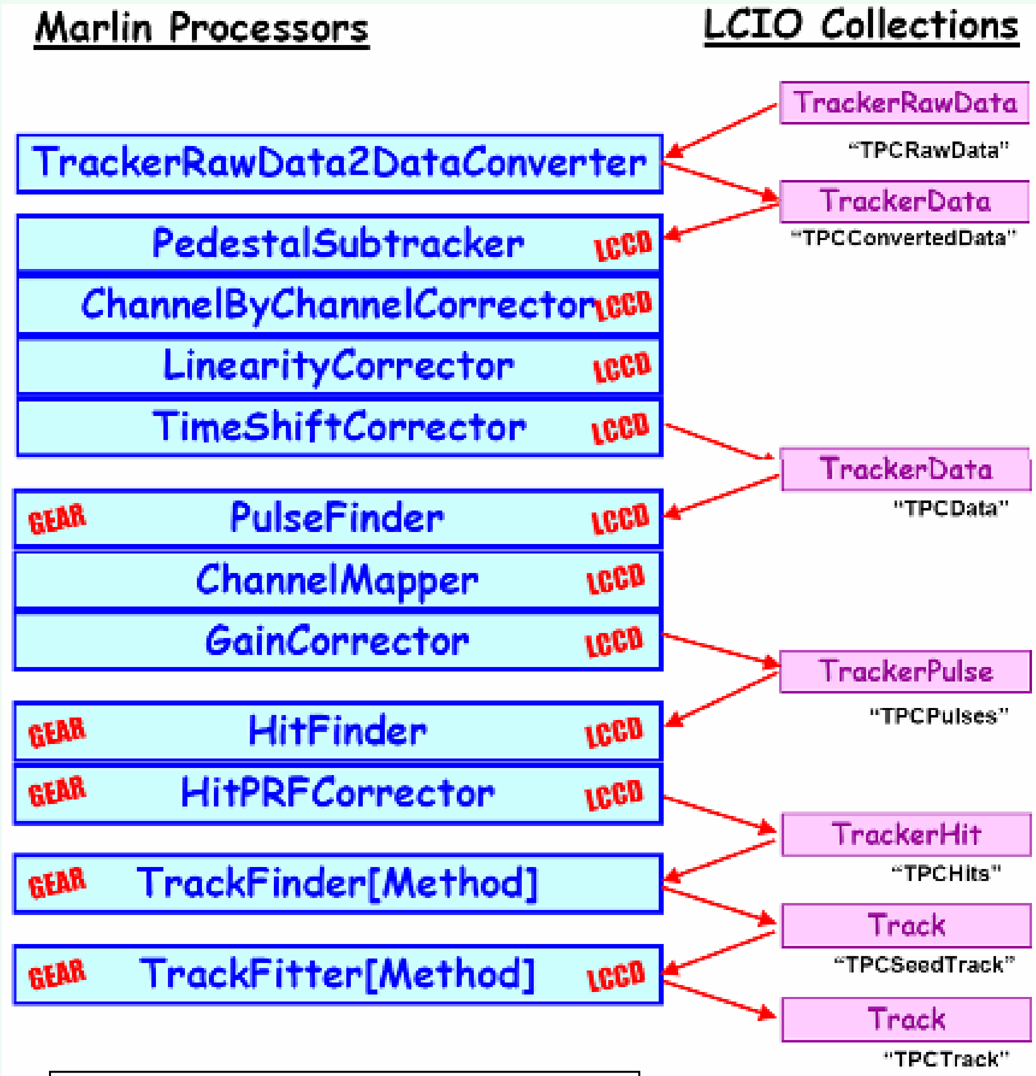
needed for the implementation of the signal overlap treatment in Marlin, which has been started





PRELIMINARY

Beginnings of an Organized Analysis



Hansen, Victoria, Vancouver 2005

Currently:
- within the TPC community
- diversity of simulation
  - reconstruction
  - analysis

Starting a common framework
- for Large Prototype
- to some extent, small prototypes

Large effort has started,
- Germany and Canada

Marlin Processors
GEAR for static information
LCCD for conditions data
(the things we often call "constants" because they are not)

PRELIMINARY

Conclusions

PRELIMINARY