HOUGH TRANSFORM OF PARTICLE DETECTOR HITS
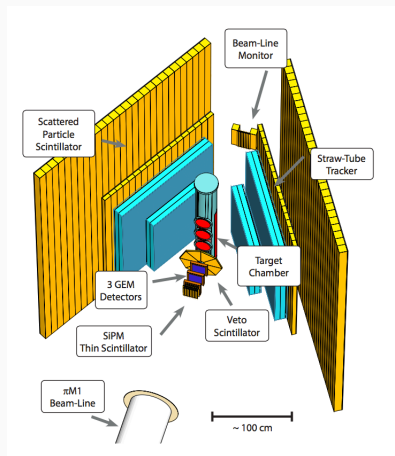
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Figure: Experimental Setup

```
xcoords = np.loadtxt("GEM_xcoords.txt", delimiter="\n")
ycoords = np.loadtxt("GEM_ycoords.txt", delimiter="\n")

ncoords = len(xcoords)

xscoords = xcoords[:1000]
yscoords = ycoords[:1000]
```

```
fig = plt.figure(figsize=(9,5))
#Plot histogram of hits
plt.subplot(121)
plt.hist2d(xscoords, yscoords, bins=40)
plt.xlim(0,200)
plt.ylim(0,200)
plt.title("GEM Hits")
plt.xlabel("X (mm)")
plt.ylabel("Y (mm)")
```
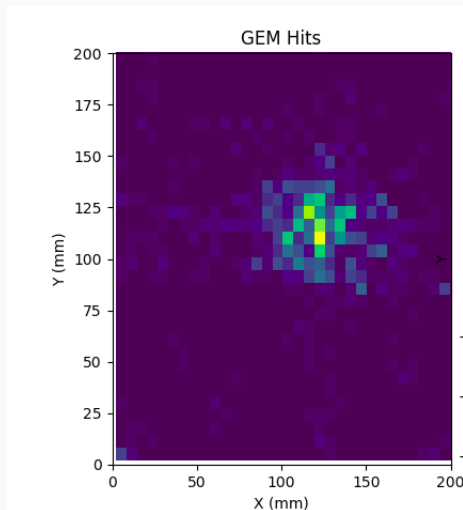
Figure: Histogram of hit coordinates from GEM detectors

```python
def Fourier(arr1, arr2):

    arr = [arr1, arr2]

    farr = np.real(fft.fft2(arr))

    return farr

#Plot Fourier transform of hits
    plt.subplot(122)
    ft = Fourier(xscoords, yscoords)
    plt.hist2d(ft[0], ft[1], bins=150)
    plt.title("Fourier Transform of GEM Hits")
    plt.xlim(-6000,6000)
    plt.xlabel("X")
    plt.ylabel("Y")
```
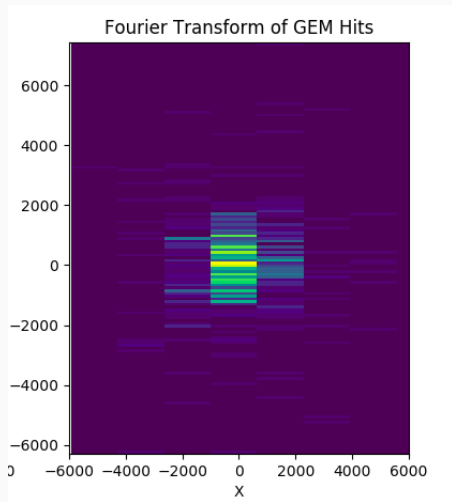
Figure: Fourier transform of GEM hits

- Transforms points in *xy* space to curves in $\rho\theta$ space
- Transforming set of all lines that pass through a point

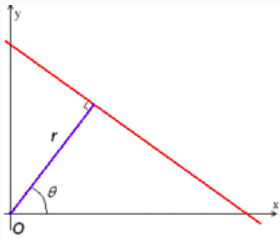**Figure:** Hesse Normal form of Hough Transform

```
def hough(xcoords,ycoords):
  thetas = np.deg2rad(np.arange(-90.0, 90.0, 1))
  width = 200
  height = 200

  diag_len = int(np.sqrt(width**2 + height**2) + 1)

  rhos = int(round(np.sqrt(width**2 + height**2)))

  cos_t = np.cos(thetas)
  sin_t = np.sin(thetas)
  num_thetas = len(thetas)

  accumulator = np.zeros((2*diag_len, num_thetas), dtype=np.uint8)

  for ii in range(len(xcoords)):
    rx = random.normal(0,0.5)
    ry = random.normal(0,0.5)
    x = xcoords[ii] + rx
    y = ycoords[ii] + ry

    for tt in range(num_thetas):

      rho = diag_len  + int(round(x*cos_t[tt] + y*sin_t[tt]))
      accumulator[np.abs(min(rho, 2*diag_len-1)), np.abs(min(tt, num_thetas-1))] += 1

  return accumulator, thetas, rhos
```
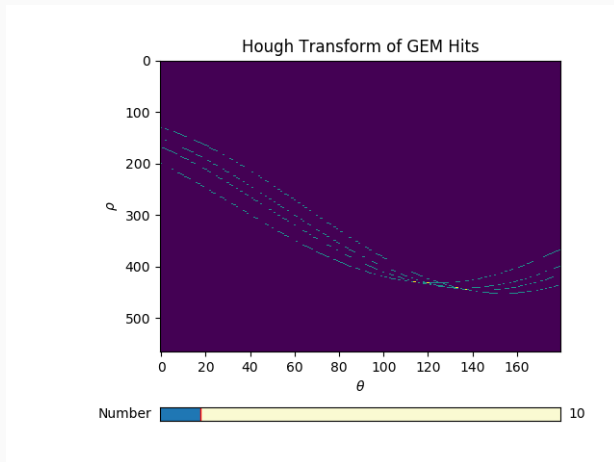
Figure: Hough Transform of 4 points

Slider

```python
def slide(accumulator):
  fig, ax = plt.subplots()
  plt.subplots_adjust(left=0.25, bottom=0.25)


  l = plt.imshow(accumulator, interpolation='nearest', aspect='auto')

  plt.title("Hough Transform of GEM Hits")
  plt.xlabel(r"$\theta$")
  plt.ylabel(r"$\rho$")

  plt.autoscale(False)

  axcolor = 'lightgoldenrodyellow'
  axnum = plt.axes([0.25, 0.1, 0.65, 0.03], facecolor=axcolor)

  n0 = 10
  snum = Slider(axnum, "Number", 0, 100, valinit=n0, valfmt='%0.0f')

  def update(val):

    num = np.around(snum.val)
    p = int(num)
    l.set_data(hough(xscoords[(p):(p+4)], yscoords[(p):(p+4)])[0])

    fig.canvas.draw_idle()

  snum.on_changed(update)

  plt.show()
```