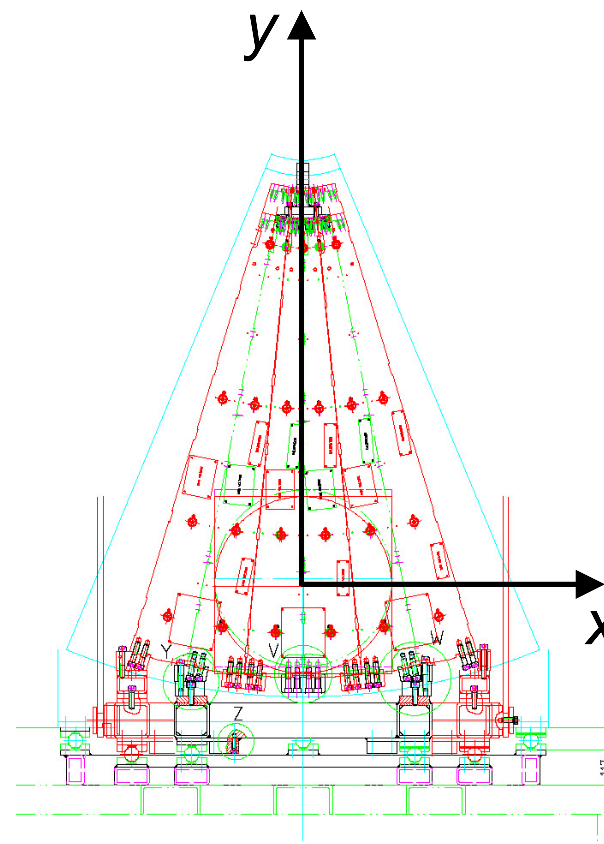
Nominal Beam Test Coordinate System

- Let S(x,y,z) be the "nominal beam test" coordinate system
  - It is fixed on the cryostat;
  - It is based on the coordinate system of the particle track reconstruction using the beam chambers, hence after applying the alignment file and using y_{table} and x_{cryo} in Athena. The alignment file has been refined by Sven Menke to satisfy the following;
  - It is a right-handed system with y vertically up and z horizontal in opposite direction to the test beam;
  - $x = y = 0$ and $z = -64.2$ cm is where the beam hits the face of the presampler for $y_{table} = x_{cryo} = l_{bend9} = 0$.



Nominal Beam Test Coordinate System

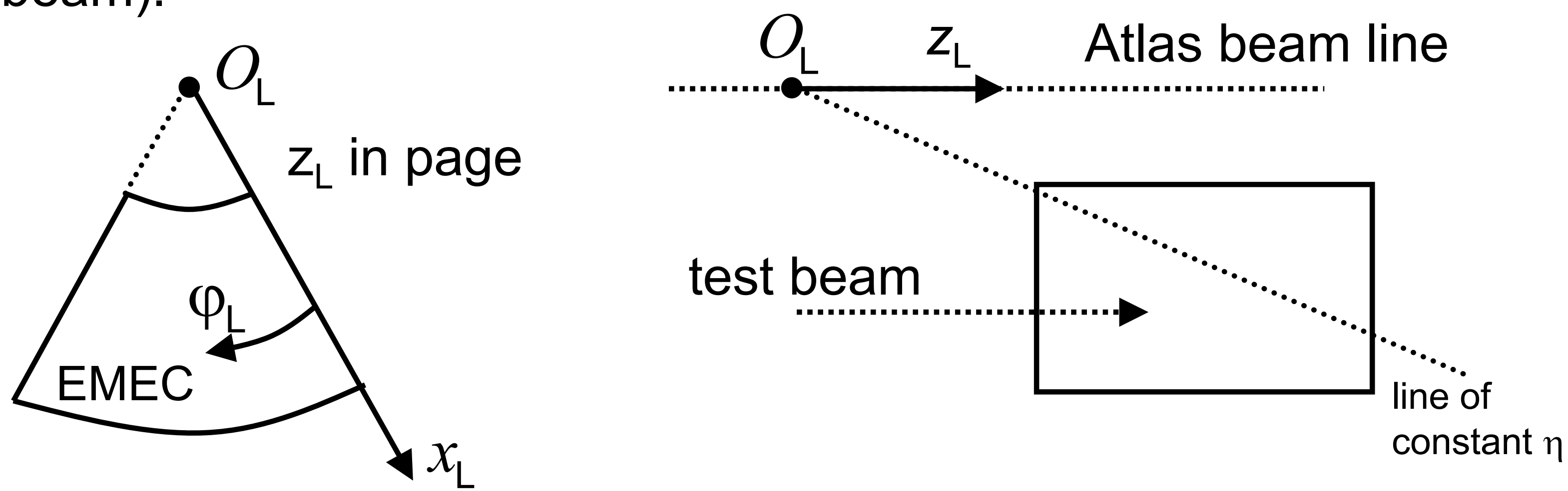
- Known imperfections
  - Sven has investigated the consistency of the alignment file with beam chamber data and has found the following relations in the y axis:

1. $y\,(z = 0) = -0.317\ \text{cm} + 1.065\ y_{table}(\text{cm})$
2. slope in $y = 0.000456 - 0.000320\ y_{table}(\text{cm})$

  - This means that the alignment file is not perfect and probably should absorb the –0.317 cm offset;
  - This means the slope of the fit for $y_{table} = 0$ is not 0. This could be absorbed by a shift of –1.43 cm in y_{table}, or by assuming that the test beam is not truly horizontal.

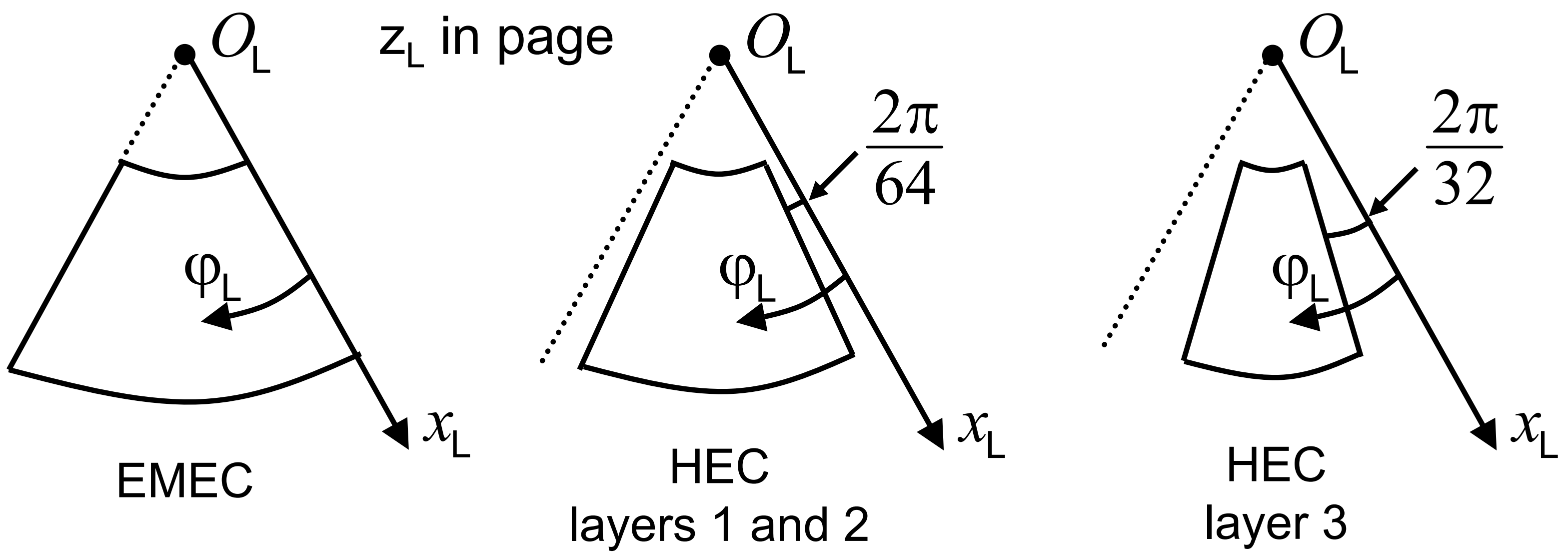
The Detector Local Coordinate System

- Let $S_L(x_L, y_L, z_L)$ be the detector (HEC or EMEC) local coordinate system
  - It is a right handed system attached to the detector;
  - It's origin is the (ideal or truly pointing) Atlas origin;
  - z_L is in the direction of the test beam. For the EMEC, x_L is along the rightmost edge of the beam test module (looking down the beam).



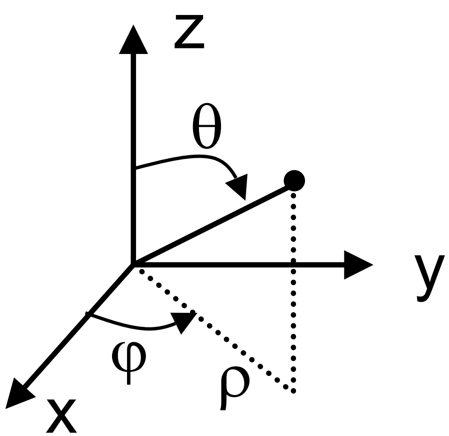
The Detector Local Coordinate System

- In order to maintain an absolute meaning to the local azimuthal coordinate, the x_L axis for the HEC is defined to be the same as the one for the EMEC, assuming the nominal position of the HEC:



The Detector Local Coordinate System

- The ρ, θ, φ and η quantities for a point in S_L are defined in the usual way.
  - Dropping the L subscript and using a cylindrical coordinate system, we obtain the following relations:



$$x = \rho \cos \varphi$$
$$y = \rho \sin \varphi$$
$$z = \rho \cot \theta$$

$$\rho^2 = x^2 + y^2$$

$$\cos \theta = \frac{z}{\sqrt{x^2 + y^2 + z^2}}$$

$$\tan \varphi = \frac{y}{x}$$

$$\eta \equiv -\ln \tan \tfrac{1}{2}\theta$$
$$\theta = 2 \arctan e^{-\eta}$$
$$\sinh \eta = \cot \theta$$
$$\cosh \eta = \operatorname{cosec} \theta$$
$$\tanh \eta = \cos \theta$$

The Detector Local Coordinate System

- The spherical coordinate system variable *r* is of little use, but for completeness we note the following relations:

$$x = r \sin\theta \cos\varphi$$
$$y = r \sin\theta \sin\varphi$$
$$z = r \cos\theta$$

$$r^2 = x^2 + y^2 + z^2 = \rho^2 + z^2$$
$$\cos\theta = \frac{z}{r}$$
$$\sin\theta = \frac{\rho}{r}$$

Coordinate System Transformation

- The $S_L \rightarrow S$ transformation is obtained using a passive y-convention Euler rotation (Goldstein section 4.4) and a translation

$$X = \begin{pmatrix} x \\ y \\ z \end{pmatrix} = R_{z''}(\psi_\varepsilon) R_{y'}(\theta_\varepsilon) R_{z_L}(\varphi_\varepsilon) X_L + X_\circ$$

$$R_{z_L}(\varphi_\varepsilon) = \begin{pmatrix} \cos\varphi_\varepsilon & \sin\varphi_\varepsilon & 0 \\ -\sin\varphi_\varepsilon & \cos\varphi_\varepsilon & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

$$R_{y'}(\theta_\varepsilon) = \begin{pmatrix} \cos\theta_\varepsilon & 0 & -\sin\theta_\varepsilon \\ 0 & 1 & 0 \\ \sin\theta_\varepsilon & 0 & \cos\theta_\varepsilon \end{pmatrix}$$

$$R_{z''}(\psi_\varepsilon) = \begin{pmatrix} \cos\psi_\varepsilon & \sin\psi_\varepsilon & 0 \\ -\sin\psi_\varepsilon & \cos\psi_\varepsilon & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

Coordinate System Transformation

- Nominal values
  - Thanks to Sven Menke, Alexei Maslennikov and Roy for clarifications on various coordinate values
  - The nominal values are the same for the HEC and for the EMEC

$$x_\circ = 0$$

$$y_\circ = 171.8 \text{ cm}$$

$$z_\circ = (362.5 - 64.2) \text{ cm} = 298.3 \text{ cm}$$

$$\varphi_\varepsilon = \left(\tfrac{1}{2}\cdot\tfrac{1}{8}+\tfrac{1}{4}\right)2\pi = \tfrac{5}{8}\pi$$

$$\theta_\varepsilon = \pi$$

$$\psi_\varepsilon = 0$$

convention

front face of presampler

Geometry Files

- We now have updated geometry files
  - Thanks to Margret, Richard and Fares Djama for the channel median coordinates, and to Ian for cleaning up the geometry files format;
  - They contain HEC and EMEC channel "median" coordinates in their respective local coordinate system:

    $\overline{\eta}, \Delta\eta$ $\quad\overline{\varphi}, \Delta\varphi$ (in radians) $\quad\overline{z}, \Delta z$ (in cm)
  - these quantities do not in general denote the geometrical center of a cell. Rather, we have

$$\eta \in \left[\overline{\eta} - \tfrac{1}{2}\Delta\eta,\ \overline{\eta} + \tfrac{1}{2}\Delta\eta\right]$$

$$\varphi \in \left[\overline{\varphi} - \tfrac{1}{2}\Delta\varphi,\ \overline{\varphi} + \tfrac{1}{2}\Delta\varphi\right]$$

$$z \in \left[\overline{z} - \tfrac{1}{2}\Delta z,\ \overline{z} + \tfrac{1}{2}\Delta z\right]$$

Geometry Files

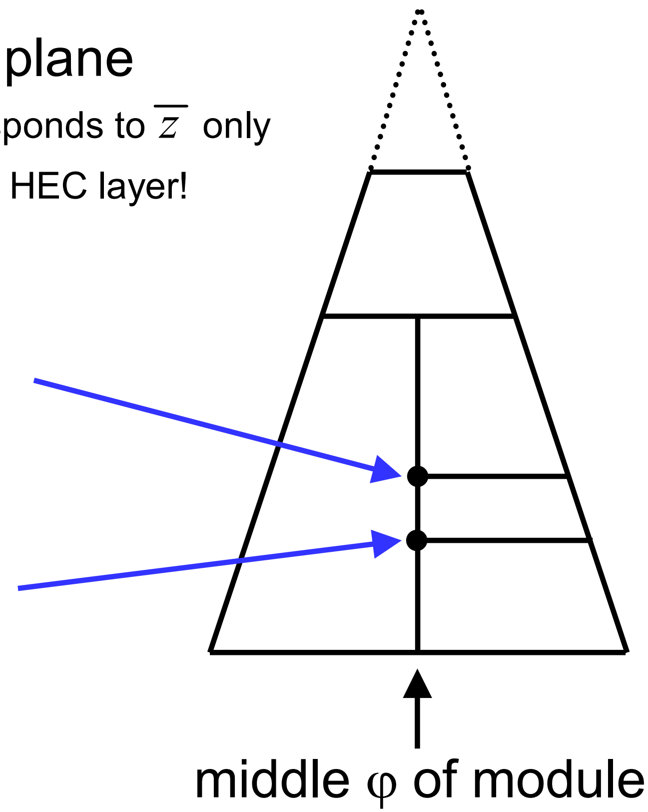
- in the HEC geometry file, the pseudorapidity limits refer to the middle φ of a module and to the middle *z* of a family z_F (one of the 5 types of pad layouts, 7 in Atlas) . Consider the following schematic (not to scale!) of a HEC family;

$z = z_F$ plane

z_F corresponds to $\overline{z}$ only for the 1st HEC layer!

$$\rho_{min} = \frac{z_F}{\sinh\left(\overline{\eta} + \frac{1}{2}\Delta\eta\right)}$$

$$\rho_{max} = \frac{z_F}{\sinh\left(\overline{\eta} - \frac{1}{2}\Delta\eta\right)}$$



Geometry Files

this drawing is in the plane of the middle φ of a HEC module and shows the 7 families and the η boundaries passing through the pad ρ boundaries at z_F