On The Geometry of the EMEC Readout Channels

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- Local EMEC coordinate system
- Readout channel geometry parameters
- Volumes and geometrical centers

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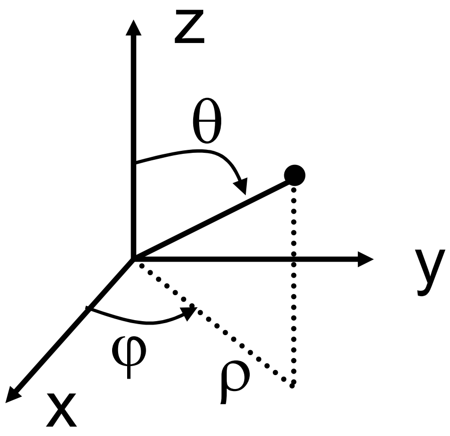
The ideal (pointing) ATLAS coordinate system

- The ρ, θ, φ and η quantities for a point in the ideal (pointing) ATLAS coordinate system are defined in the usual way.
  - Using a cylindrical coordinate system, we obtain the following relations:



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

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

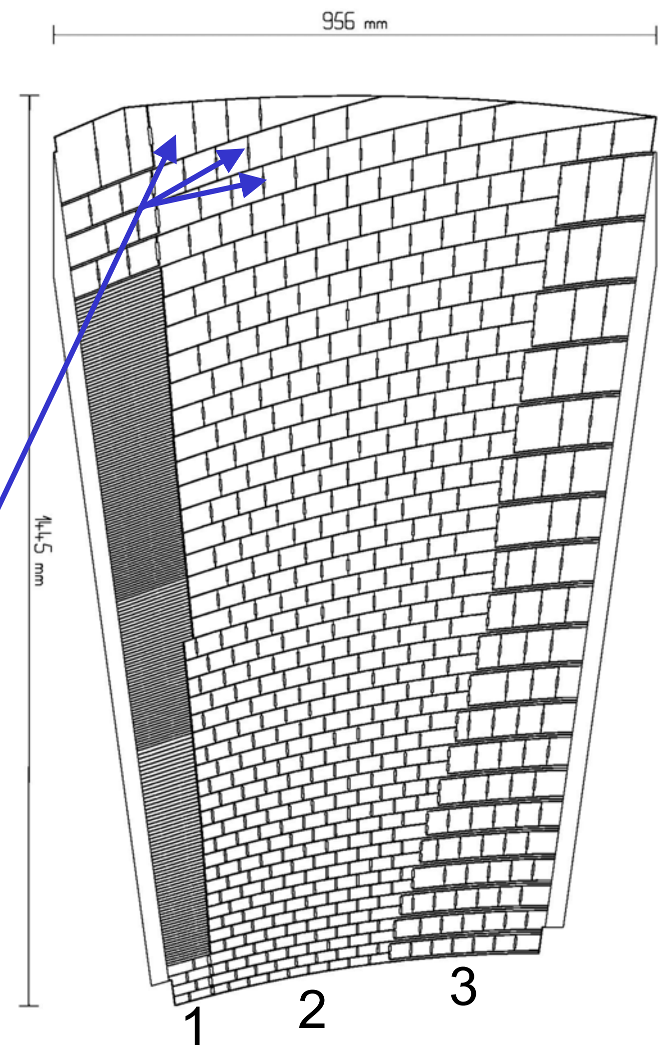
$$\cos\theta = \frac{z}{\sqrt{x^2 + y^2 + z^2}}$$

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

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

EMEC readout channel geometry

- For the purpose of volume and geometrical center calculation, the accordion nature of the readout channels is not considered
- Three types of readout channels are considered
  - Presampler channels (EMEC layer 0)
  - All other channels, except the truncated channels in layer 2
  - The truncated channels in layer 2



TDR fig 7.20

EMEC readout channel geometry parameters

- For the beam test analysis, the EMEC readout channel geometry parameters are kept in a file, available from http://particle.phys.uvic.ca/~web-atlas/atlas/hec-emec/geometry/
- It contains EMEC readout channel "median" coordinates in the ideal (pointing) ATLAS coordinate system:

$$\bar{\eta},\ \Delta\eta \qquad \bar{\varphi},\ \Delta\varphi \text{ (in radians)} \qquad \bar{z},\ \Delta z \text{ (in cm)}$$

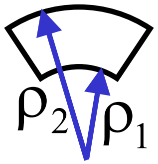
- These quantities do not in general denote the geometrical center of a readout channel. Rather, we have

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

Presampler readout channels

- The volume of a presampler readout channel is considered to be bounded by two cylinders and by planes at fixed z
  - The Δz of each channel is set to 1cm in the geometry file
  - From elementary geometry we obtain

$$V = \tfrac{1}{2}\Delta\varphi\Delta z\left(\rho_2^2 - \rho_1^2\right)$$
$$x_c = \rho_c \cos\overline{\varphi}$$
$$y_c = \rho_c \sin\overline{\varphi}$$
$$z_c = \overline{z}$$



where

$$V\rho_c = \tfrac{2}{3}\Delta z \sin\left(\tfrac{1}{2}\Delta\varphi\right)\left(\rho_2^3 - \rho_1^3\right)$$

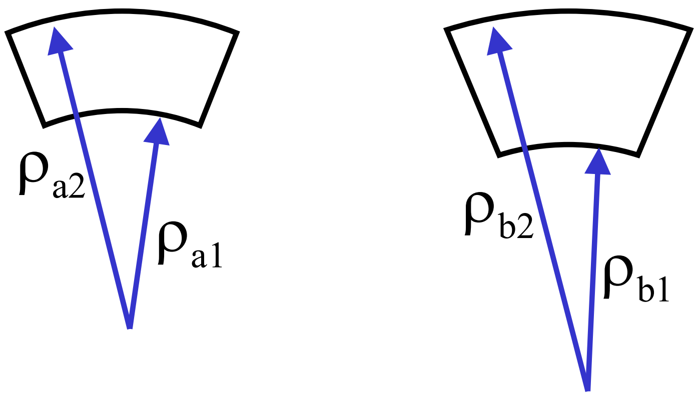
$$\rho_1 = \frac{\overline{z}}{\sinh\left(\overline{\eta} + \tfrac{1}{2}\Delta\eta\right)} \quad \text{and} \quad \rho_2 = \frac{\overline{z}}{\sinh\left(\overline{\eta} - \tfrac{1}{2}\Delta\eta\right)}$$

Non-truncated EMEC readout channels

- The volume of a EMEC readout channel (layers 1 to 3, non-truncated) is considered to be bounded by two cones and by planes at fixed z
  - From elementary geometry we obtain

$$V = \tfrac{1}{6}\Delta\varphi\Delta z\left[\left(\rho_{a2}^2 + \rho_{a2}\rho_{b2} + \rho_{b2}^2\right) - \left(\rho_{a1}^2 + \rho_{a1}\rho_{b1} + \rho_{b1}^2\right)\right]$$

$$x_c = \rho_c \cos\overline{\varphi}$$
$$y_c = \rho_c \sin\overline{\varphi}$$
$$z_c$$



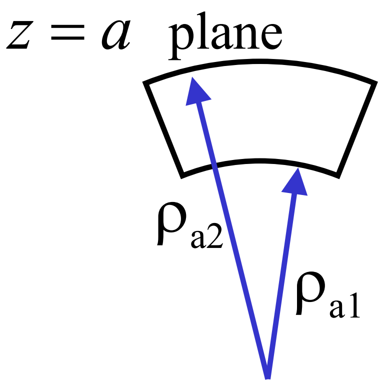
where

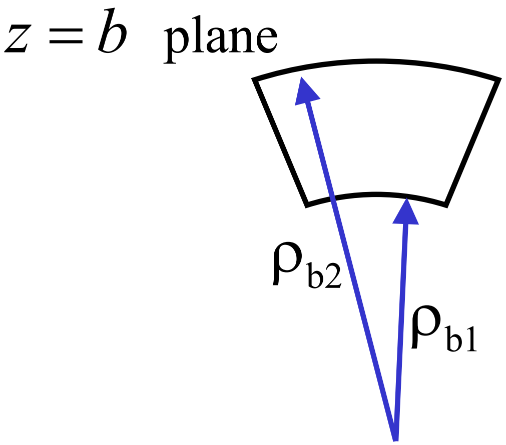
$$V\rho_c = \tfrac{1}{6}\Delta z \sin\left(\tfrac{1}{2}\Delta\varphi\right)\left[\left(\rho_{a2}^2 + \rho_{b2}^2\right)\left(\rho_{a2} + \rho_{b2}\right) - \left(\rho_{a1}^2 + \rho_{b1}^2\right)\left(\rho_{a1} + \rho_{b1}\right)\right]$$

$$Vz_c = \tfrac{1}{4}\overline{z}\Delta\varphi\Delta z\left[\left(\rho_{a2}^2 + \rho_{b2}^2\right) - \left(\rho_{a1}^2 + \rho_{b1}^2\right)\right]$$

Non-truncated EMEC readout channels (continued)

and where



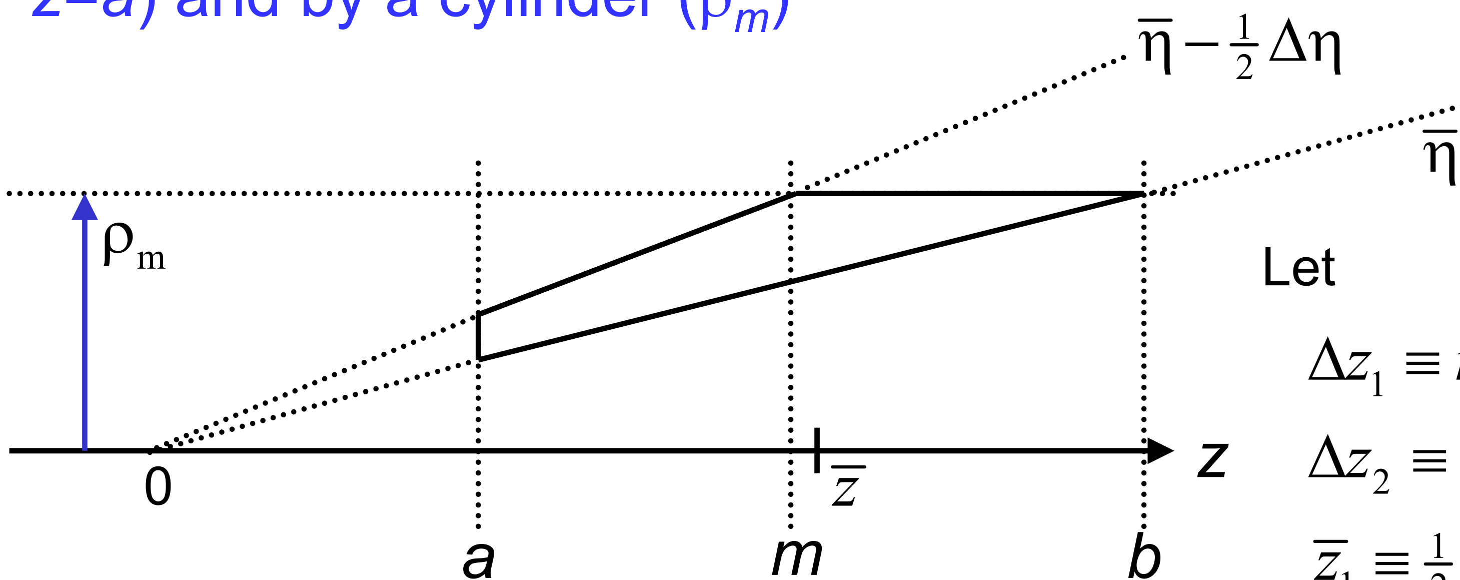


$$\rho_{a1} = \frac{\bar{z} - \frac{1}{2}\Delta z}{\sinh\left(\bar{\eta} + \frac{1}{2}\Delta\eta\right)} \qquad \rho_{b1} = \frac{\bar{z} - \frac{1}{2}\Delta z}{\sinh\left(\bar{\eta} + \frac{1}{2}\Delta\eta\right)}$$

$$\rho_{a2} = \frac{\bar{z} - \frac{1}{2}\Delta z}{\sinh\left(\bar{\eta} - \frac{1}{2}\Delta\eta\right)} \qquad \rho_{b2} = \frac{\bar{z} - \frac{1}{2}\Delta z}{\sinh\left(\bar{\eta} - \frac{1}{2}\Delta\eta\right)}$$

Truncated EMEC readout channels

- These readout channels are in layer 2, and only to the three lowest pseudorapidity bins in $1.400 < |\eta| < 1.475$
- Their volume is bounded by two cones, by a z plane (at $z=a$) and by a cylinder (ρ_m)



Let

$$\Delta z_1 \equiv m - a$$

$$\Delta z_2 \equiv b - m$$

$$\bar{z}_1 \equiv \tfrac{1}{2}(a+m)$$

$$\bar{z}_2 \equiv \tfrac{1}{2}(b+m)$$

$$\rho_m = 203.37 \text{ cm}$$

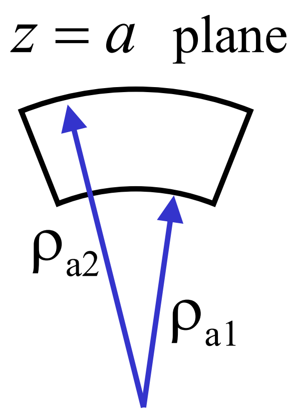
$$\Rightarrow \quad a < m = \rho_m \sinh\left(\bar{\eta}-\tfrac{1}{2}\Delta\eta\right) < b$$

Truncated EMEC readout channels (continued)

where

$$\rho_{a1} = \frac{\bar{z} - \frac{1}{2}\Delta z}{\sinh\left(\bar{\eta} + \frac{1}{2}\Delta\eta\right)} \qquad \rho_{a2} = \frac{\bar{z} - \frac{1}{2}\Delta z}{\sinh\left(\bar{\eta} - \frac{1}{2}\Delta\eta\right)} > \rho_{a1}$$

- From elementary geometry we obtain



$$V = \tfrac{1}{6}\Delta\varphi\Delta z_1\left(\rho_{a2}^2 + \rho_{a2}\rho_m + \rho_m^2\right) + \tfrac{1}{2}\Delta\varphi\Delta z_2\rho_m^2 - \tfrac{1}{6}\Delta\varphi\Delta z\left(\rho_{a1}^2 + \rho_{a1}\rho_m + \rho_m^2\right)$$

$$x_c = \rho_c \cos\bar{\varphi}$$

$$y_c = \rho_c \sin\bar{\varphi}$$

$$z_c$$

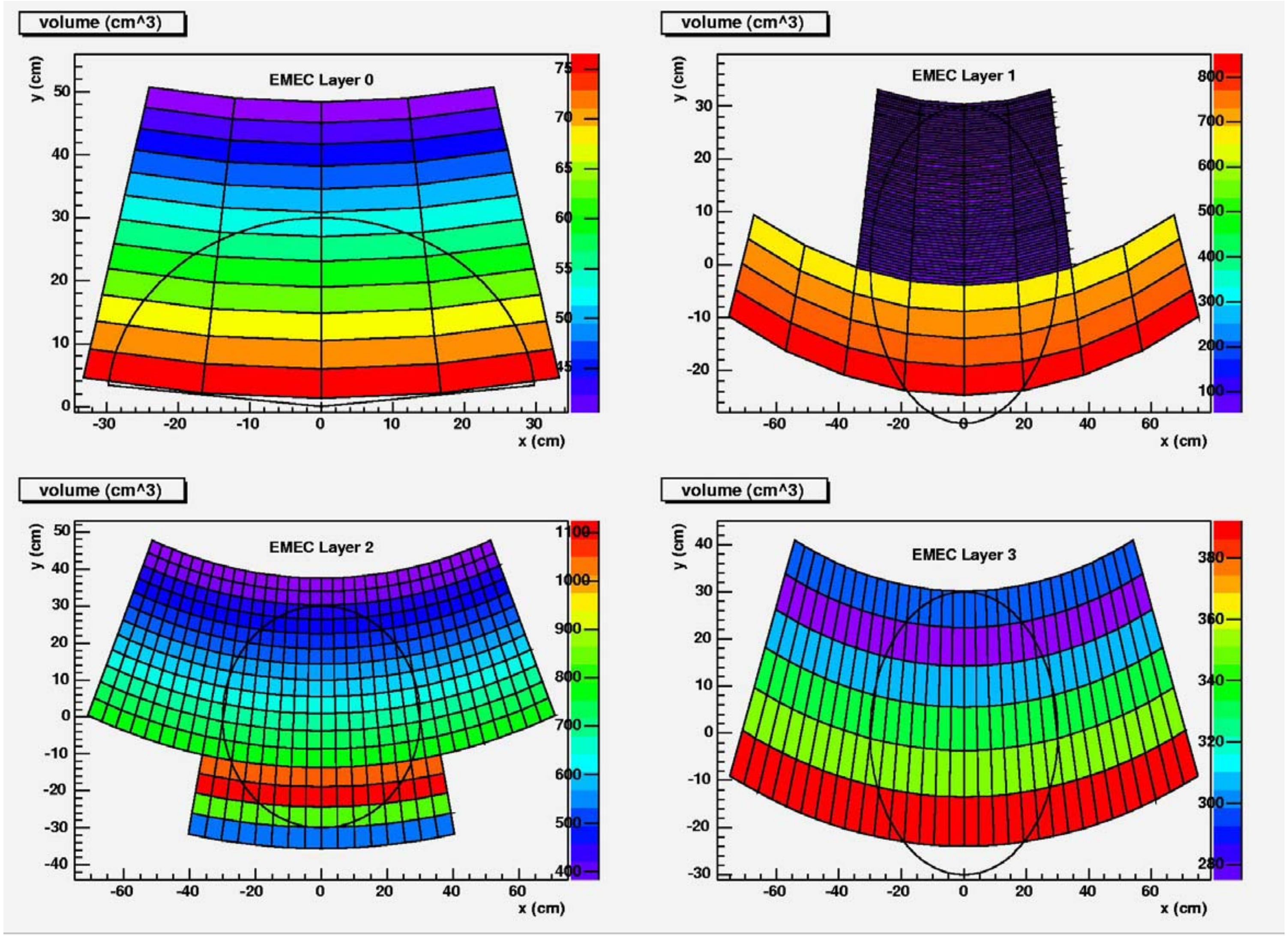
where

$$V\rho_c = \tfrac{1}{6}\Delta z_1 \sin\left(\tfrac{1}{2}\Delta\varphi\right)\left(\rho_{a2}^2 + \rho_m^2\right)\left(\rho_{a2} + \rho_m\right) + \tfrac{2}{3}\rho_m^3\Delta z_2 \sin\left(\tfrac{1}{2}\Delta\varphi\right) - \tfrac{1}{6}\Delta z \sin\left(\tfrac{1}{2}\Delta\varphi\right)\left(\rho_{a1}^2 + \rho_m^2\right)\left(\rho_{a1} + \rho_m\right)$$

$$Vz_c = \tfrac{1}{4}\bar{z}_1\Delta\varphi\Delta z_1\left(\rho_{a2}^2 + \rho_m^2\right) + \tfrac{1}{2}\bar{z}_2\Delta z_2\rho_m^2 - \tfrac{1}{4}\bar{z}\Delta\varphi\Delta z\left(\rho_{a1}^2 + \rho_m^2\right)$$

Readout channel volume

- The following readout channel volumes are obtained



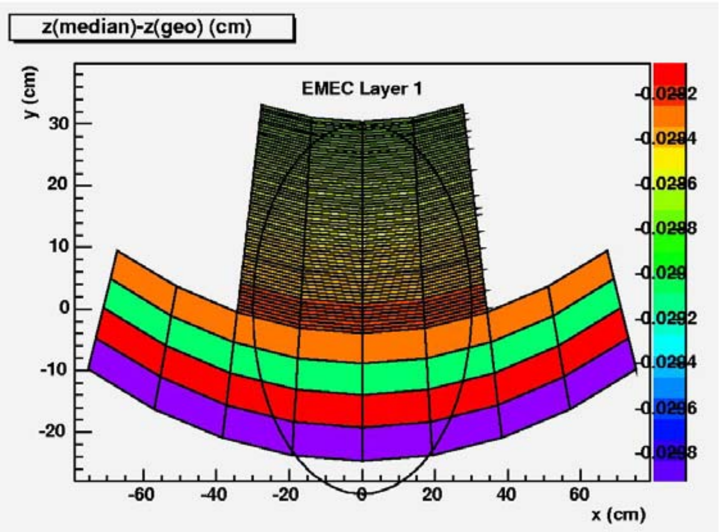
2002 HEC-EMEC beam test configuration.

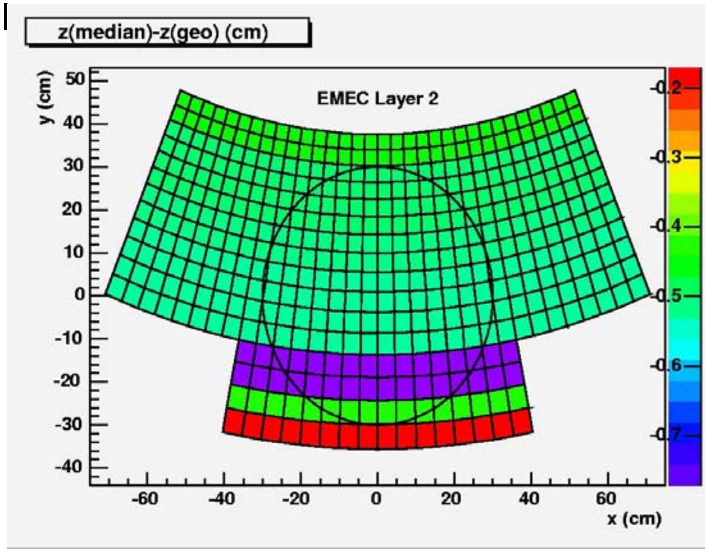
Readout channel geometrical center

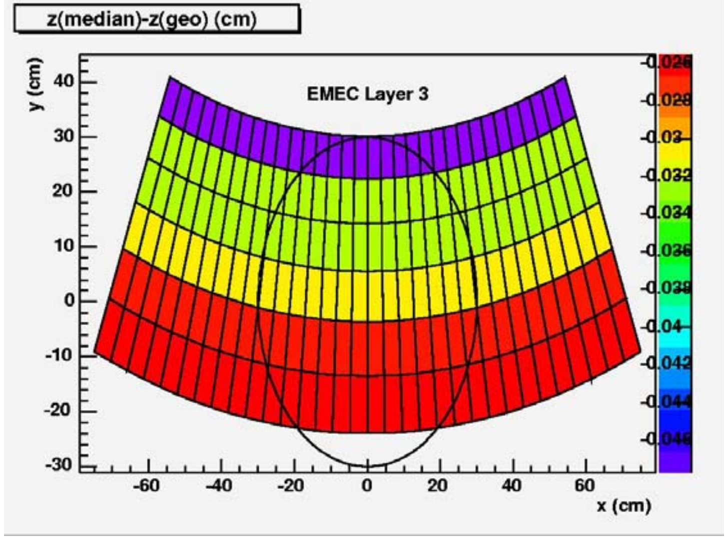
- The median center can be close to a cm away from the geometrical center, the difference is (almost completely) in z

$$|\overline{\eta} - \eta_c| < 0.0019$$
$$\overline{\varphi} = \varphi_c$$
$$|\overline{z} - z_c| < 0.8 \text{ cm}$$

No difference in z for layer 0 (presampler) since all channels have a cylindrical shape







2002 HEC-EMEC beam test configuration.