Magnetic Field Studies

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for the

HCAL RBX Group

Outline

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- HE Field Angle
- HO Field Studies
- HO RBX Placement
- Where to go from here
- Conclusions

Introduction

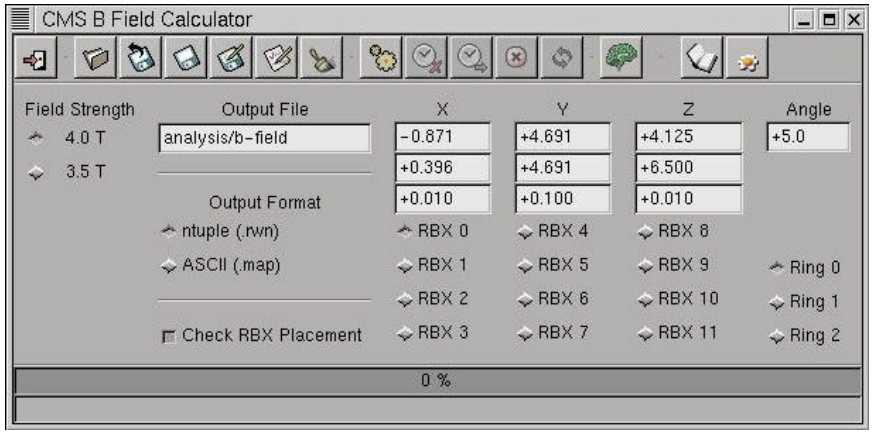
- HPDs accelerate electrons across a gap
  - gap is 3 – 4 mm.
  - Aligns with a 10kV E field
- If there is a substantial local B field
  - electrons deviate from the path
  - could wind up in the wrong pixel
- It is critical that we align the HPD axis with the local B field direction
- To do this, we have to map the local field

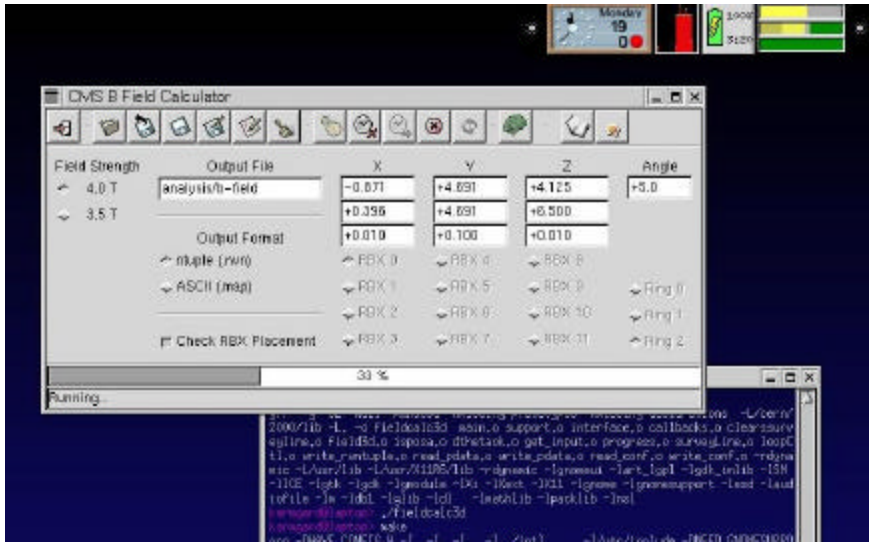
Limitations

- This study uses Slavas' field map and code
  - it is only as accurate as they are
- The field map is based on 1/8 of the detector
  - assumes a reflection symmetry about each axis
- Also uses a series of planes to define the field
  - if the field for a point not on a predefined plane is requested code interpolates between the nearest planes
- Original code is for points only

Programming Notes

- Change & Refinement
  - converted original to C
  - embedded into a loop
    - allows automated calculation in a region
  - created a GUI control
  - Added automated checking for HO RBX locations
    - feature can be turned off on the fly or from a configuration file





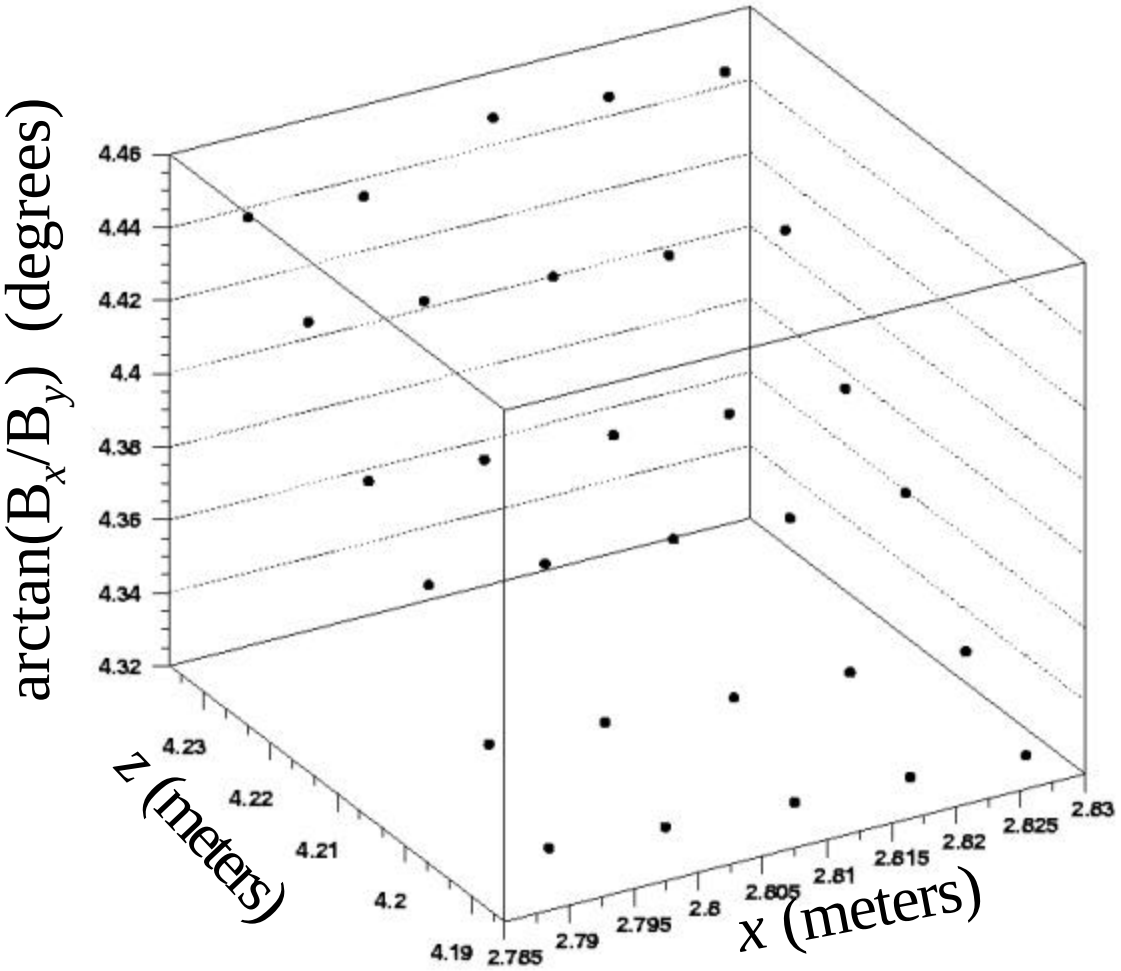
Programming Notes

- Why do you care?
  - Turning off the RBX location routines makes the program general enough to be of use outside the RBX group
  - Program designed and built for Linux
    - kernel 2.2.12-20, glibc 2.1, gcc, gtk+ 1.28
    - may work on other Unices with recompilation
    - port to Windows problematic and not planned
  - Anyone interested should let me know
    - binary or source distribution available

HB Field Angle

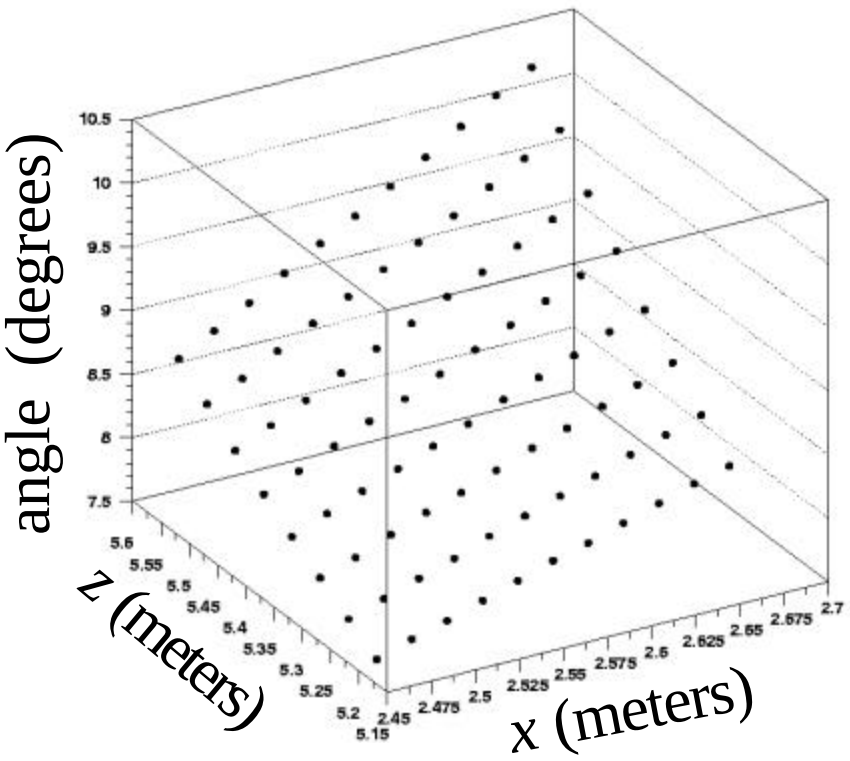
- The local field angle in HB is about 4.5º
  - Well known for some time
  - Calculations made with earlier versions of code
  - confirmed by the new versions
- This means that the HPDs are mounted at an angle
  - aligns the HPD axis with the local field
- Field changes in HB
  - changes are small enough to set one angle

HB Field Angle



HE Field Angle

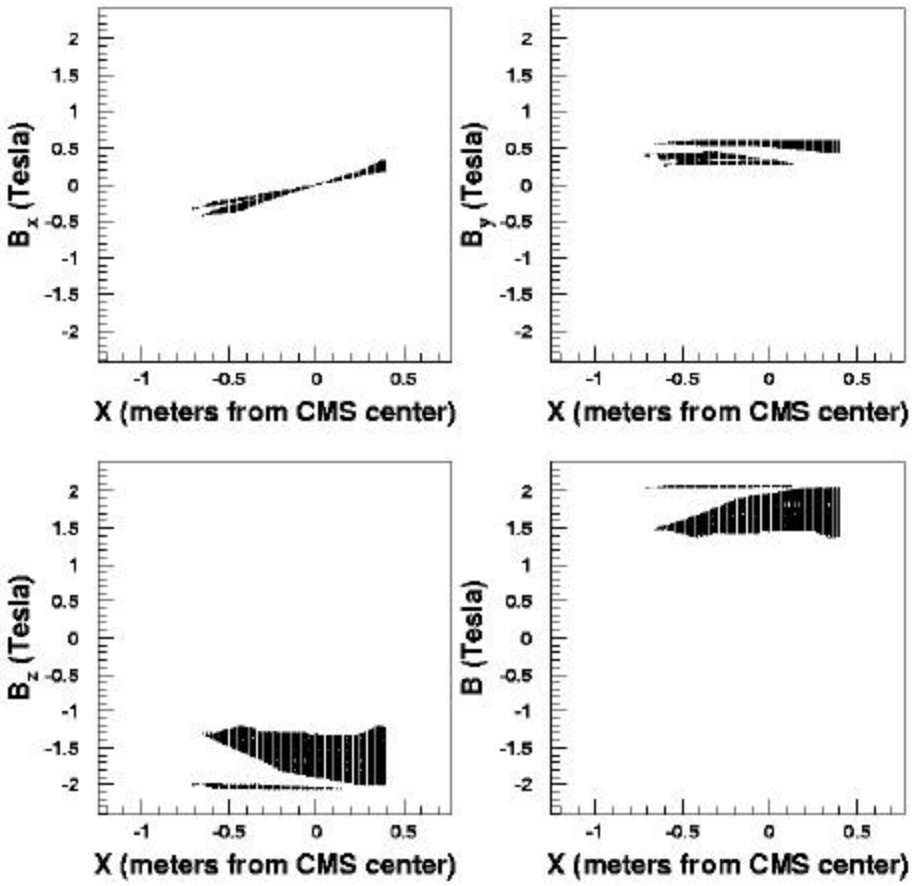
- The situation in HE is similar to HB
  - local angle is 8½ º
- Calculation done with old code
  - confirmed with new code
- The field is not uniform here either
  - again, small enough to set a single angle for HPDs



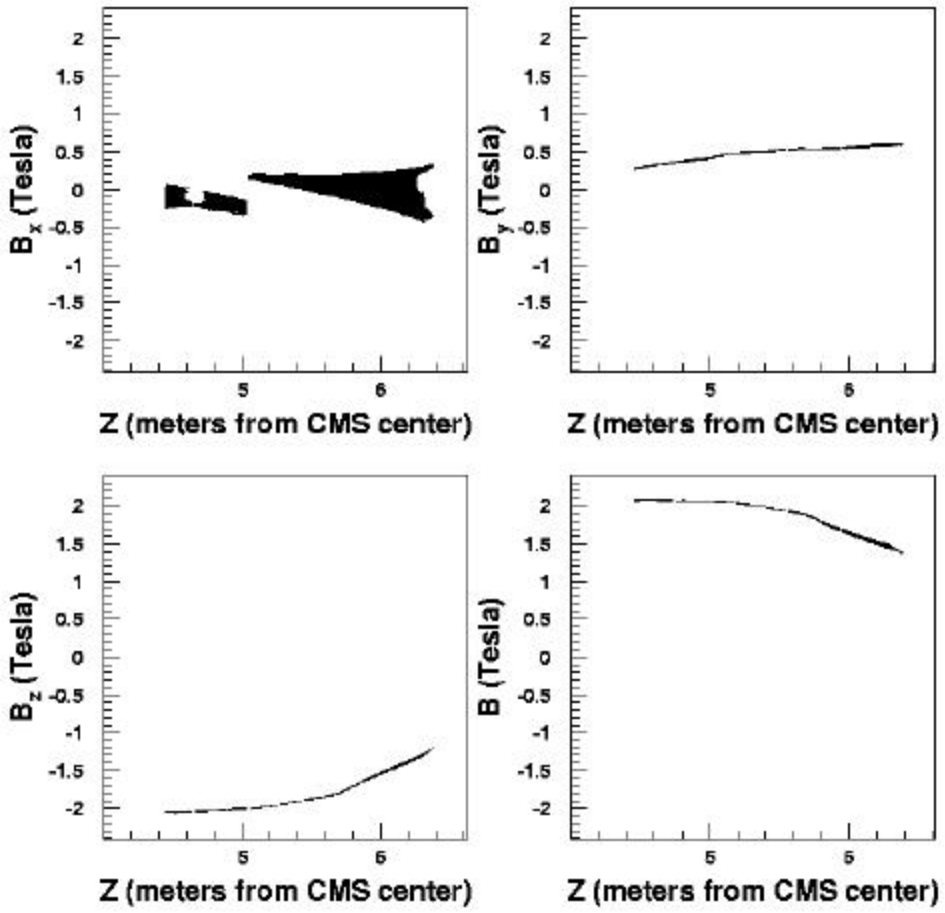
HO Field Studies

- HO very different from HB and HE
  - Placing RBXs in Yoke means shorter fiber
  - Also means worse B field to deal with
- Field is weaker
  - generally around 2T in this region
- but it changes much more rapidly
  - can have significant B_x and B_y components
- Probably have to build many variants of the HPD mounting to accommodate it

B Field in the HO Region



B Field in the HO Region



HO RBX Placement

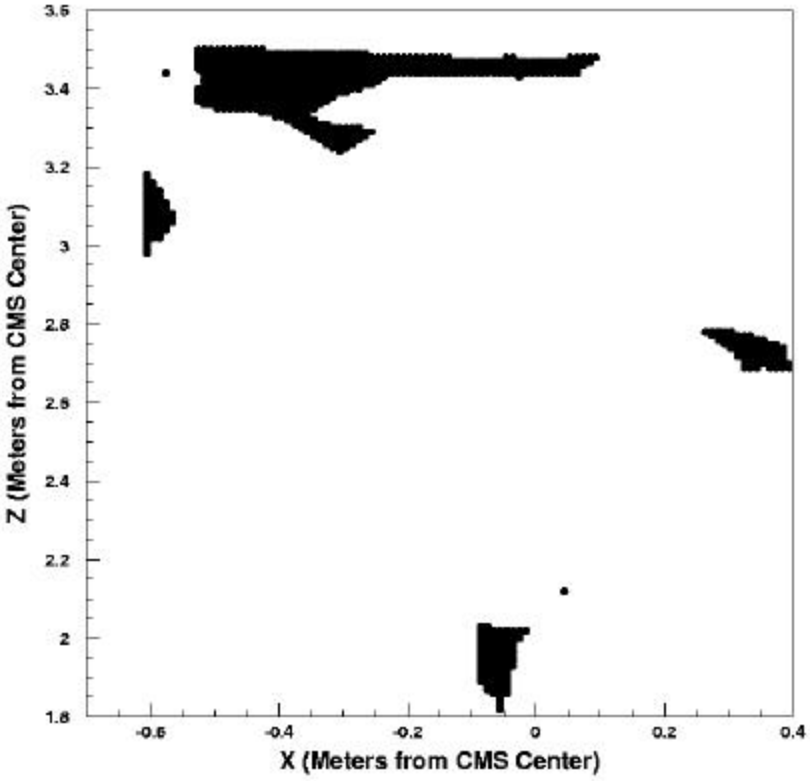
- Assumptions
  - (x,y) positions obtained from survey of YB-2
    - CMS-SY-UR-0017
    - assume that other yokes are symmetric
  - RBX has a regular design
    - HPDs are in the same location in each RBX
  - Placement checks use a rotation in φ
    - 30º rotation per position
    - all RBX are transformed to check position against the survey line

HO RBX Placement

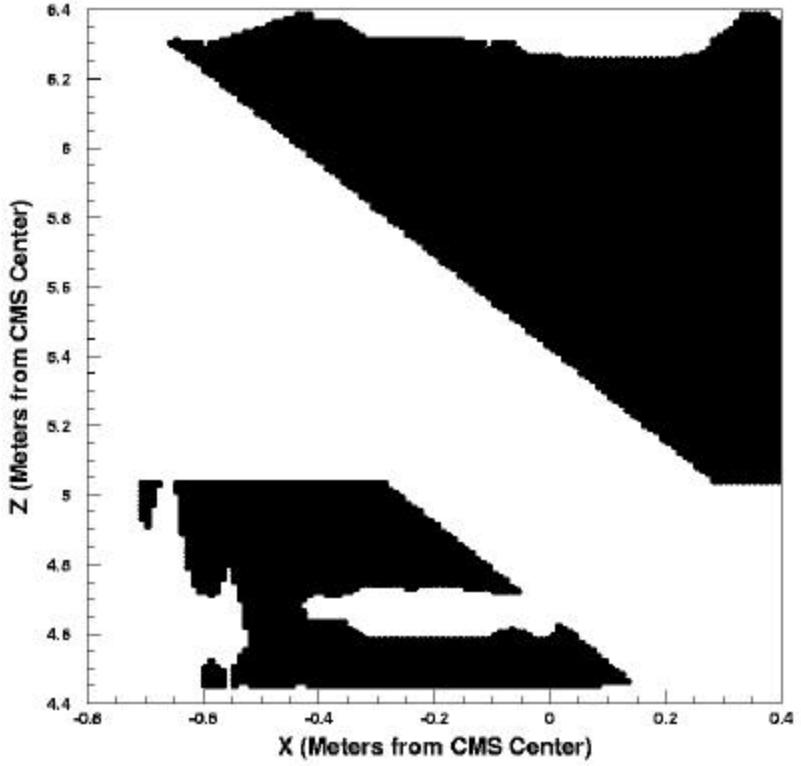
- Requirements
  - Fits in the allowed volume
  - RBX doesn't come within 1cm of survey line
  - local field is well behaved
    - variation is less than 5° over each HPD location
    - rough calculation indicates ±7° is acceptable
    - requiring ±2½° allows a reasonable margin of safety
- Following plots show 1 point in the RBX
  - centered in (x,y) and 125mm from front in z
    - center of the HPD compartment in z

Positions for RBX 0

Ring 1

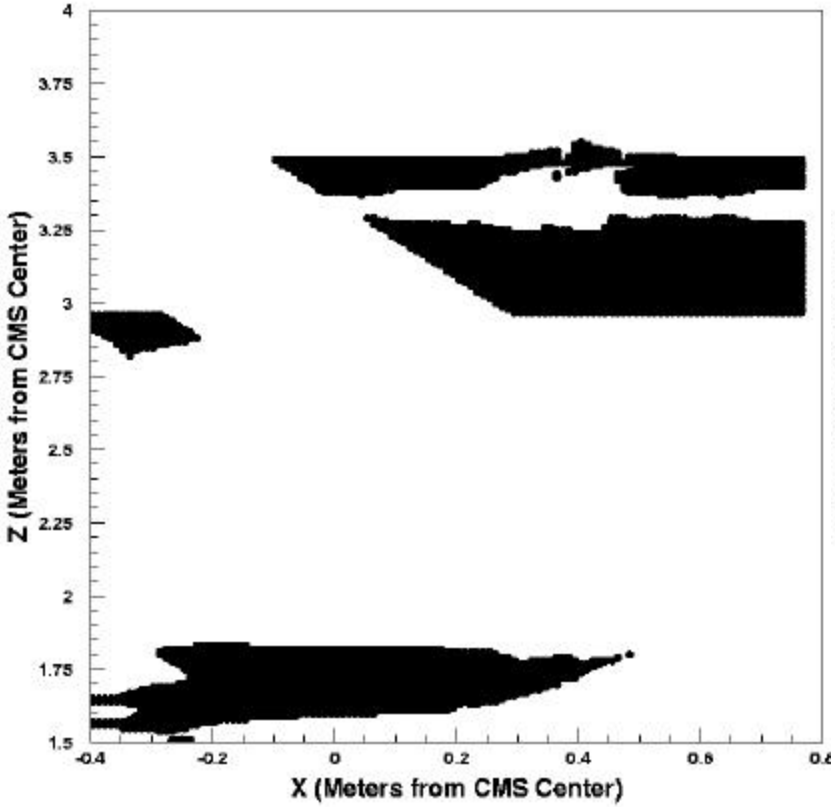


Ring 2

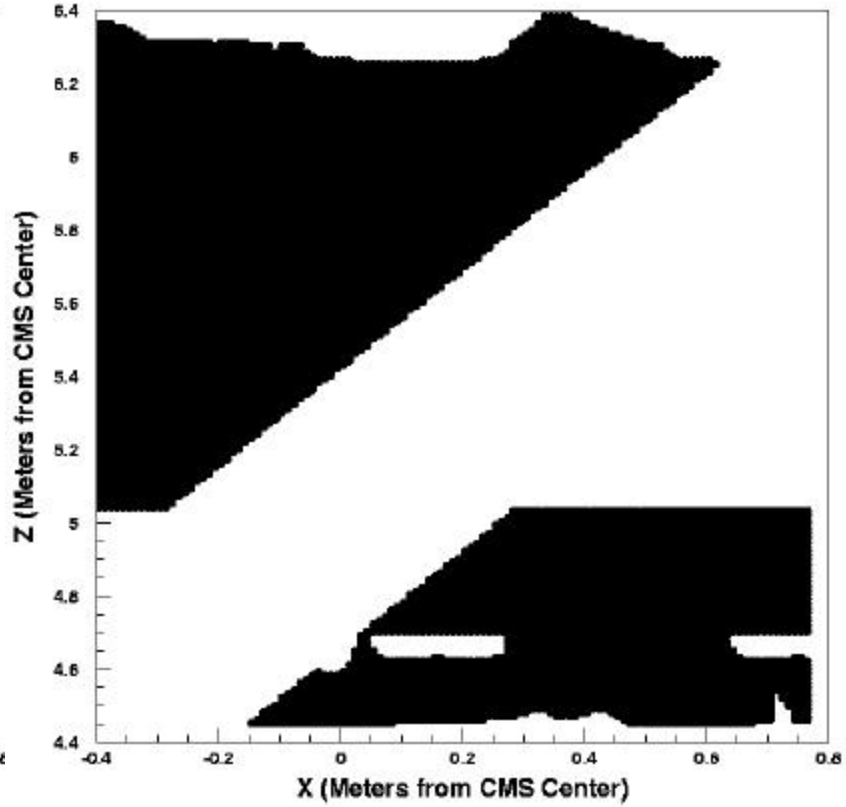


Positions for RBX 6

Ring 1



Ring 2



HO RBX Placement

- Gives a set of points
  - acceptable in terms of field and survey lines
  - other considerations can't be programmed
    - in Ring 2 prefer to have RBX at high *z* facing out
      - easier access when detector is opened
  - Once placement is decided
    - define the angles at which HPDs are mounted
  - It is preferable to have regular placement
    - don't know yet if this is possible

HO RBX Placement Example

- Pick a consistent location for the RBX
  - rings 1 and 2, RBX 0 and 6
  - *z* location is ½ m from high–*z* edge of the yoke
  - table below shows results of the program for these RBX

RBX ID (Ring-RBX)	*X (m)*	*Y (m)*	*Z (m)*	$\tan^{-1}\left(\frac{B_x}{B_y}\right)$ *(degrees)*	$\tan^{-1}\left(\frac{B_x}{B_z}\right)$ *(degrees)*	$\tan^{-1}\left(\frac{B_y}{B_z}\right)$ *(degrees)*
1-0	-0.5	4.7	3.5	-35	4.1	-5.8
1-6	0.5	-4.7	3.5	-34	4.0	5.8
2-0	-0.5	4.7	6.1	-28	12	-21
2-6	0.5	-4.7	6.1	-28	11	21

HO RBX Placement

- May not be possible to pick a consistent location for all HO RBX
  - a location in which each RBX occupies the same position relative to it's volume
- May not be possible to pick a single angle
  - HPD mounts may have to be custom built for numerous positions
  - As table above shows, there needn't be a unique HPD mount for every one

Where do we go from here?

- Obviously this study is far from complete
  - would like to verify the results independently
    - any ideas would be welcome
- We need to get at least a preliminary location settled for our Indian colleagues
  - should be able to settle this quickly
- Rest of the locations need to be checked
  - in progress but not yet complete
- Finalization requires full HO RBX design

Conclusions

- We have a preliminary understanding of the field in the muon yoke
  - informs HO RBX placement
- Field in this region can change rapidly
  - simple RBX placement may not be possible
- Some details remain to understood
  - initial placement of RBX possible quickly
  - necessary so fiber lengths can be determined

Conclusions

- Further study is in progress
  - results will be made available as soon as possible
    - as they are completed
  - finalization of the study requires final design for the RBX
    - need to know where the HPDs are
    - because the field can change rapidly
  - Once this is known the study should be quick