Layout and design considerations for BRAHMS TPCs.

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Introduction

The TPCs for BRAHMS will very soon be build at CRN-IReS (Strasbourg), so the final design for TPC2 in the mid-rapidity spectrometer and T1 and T2 in the forward spectrometer must be made. T2 is the responsibility of NBI, but is designed in collaboration with CRN-IReS, and materials ordered there. The main purpose is to document the spatial considerations which has gone into the final design, and not so much questions on the detailed design of the readout chamber (wire-spacing, gas-amplification etc.). These later items are also important and should be understood and documented.

The overall design considerations comes from several sources.

1. The size of the pads i.e. pitch and pad length. The sizes must also be chosen such that the connectors can be placed in configurations holding the STAR FEE cards. The traces from the pads goes to a 44 pin connector. The traces are connected to a pair of pads from adjacent pad rows each with 16 pads. Thus the number of pad rows must be even. The optimal pad length and pitch is in addition related to the distance between the anode wire and the pad plane, and the number of anode wires.

2. The active detector volume size and position necessary to match the design criteria. This does include the following parameters and requirements:
    - effective length
    - effective width

- sufficient low residual magnetic fringe field.
- Drift length. It must allow for illuminated height, as well as the ‘dead’ volume due to the time it takes to turn on the gating grid, and enable the front end electronics (about .5-1 micro second i.e. between 1.5-3 cm depending of drift velocities). It is useful further to allow for additional excluded volume e.g. close to cathode plane and to allow for flexibility in positioning.

3. The available space for the complete detector including field cage, gas volume. The space is also limited because of the space requirement from other devices i.e. calibration detectors.

Detailed design considerations

Pad sizes and active volume.

In the TPCs in the forward arm the crossing angle for real tracks is quite small ($\Theta \leq 5$ degrees). Therefore the pads can be made quite long 35 or 40 mm. On the other hand in TPC2 following the dipole D5 the crossing angles can be considerable up to .35 radians (22 degrees), correspondingly the pads should be shorter to maintain good resolution. Each of the TPC are discussed below. First, though, a couple of tables are presented which gives relations between pad-sizes and detector width, and pad-length and detector length for selected combinations.

Table Length of TPCs as function of pad length and number of rows.

	14	*16*	*18*	*20*
25 mm	35	40	45	50
30 mm	42	48	54	60
40mm	56	64	72	80

Table Width of active versus number of FEE cards per row.

WIDTH	*5*	*6*	*7*	*8*	*9*	*10*
channels	80	96	112	128	144	160
4.7	-	-	-	60.16	67.68	75.20
4.0	32.	38.4	44.8	51.2	-	-
3.5	28.	33.6	39.2	44.8	-	-

<u>TPC2</u>

With short pads the FEEE cards must sit fairly close. This can only be done if the pad sizes are chosen to be 4.2 mm and a pitch of 4.7 mm. This is the minimum pitch for which the FEE cards can be placed adjacent to each other.

The active volume for TPC2 should have a length of 40-50 cm and a width sufficient to match the extension of TOFW. Since the TOFW is not complete fixed this causes some troubles. It seem that a width of 67.7 cm will match reasonable well the present layout of TOFW. The outermost tracks will have a bit of problem having full size tracks in TPCs. The final design of the TOFW wall should be done with this in mind.

<u>Forward Spectrometer TPCs</u>

For the two TPC T1 and T2 crossing angles will be smaller, and consequently longer pads can be used. The first design had a 39.5 mm pad length with 40 mm separation, and a width of 3.0mm with a pitch of 3.5 mm. The long pad design was considered somewhat of a problem particular with regard to background tracks. The final design has a 40mm pattern but with 29 mm pads and 11 mm in-active grounded pads. It was considered to have staggered connectors similar to the TPC1 already build and tested. The final design though will have the connectors mounted parallel to the pads as shown in figure xx at the end of this document for T1 and T2 The design will also allow the FEE not to interfere with the holding bars for the pad-plane.

<u>T1</u>

The length should be as large as possible, up to 70-75 cm, but is restricted by the exterior space. Since it is also deemed important to have a calibration detector the exterior detector size is limited to about 65 cm and consequently the active length to 56 cm (to get a match to the pad length).

The width should be greater than 20 (i.e. the width of D2) and less than 30cm (the width of D2). A value somewhat around 30 will suffice since not all tracks which enter D2 will exit it and be recorded in T2.

<u>T2</u>

The pad size will be the same as for T1, but because of more available space the active volume can be longer. An active volume length of about 72 cm is proposed. This implies more pad rows, but not all will be instrumented. However, because of tensions the readout plane will have to be divided into two with a supporting structure in the middle of the top plate. Thus it can have pad rows configured as 8 rows followed by about 7.5 cm dead area and then again 8 rows allowing for a total length of 72 cm. The width must be larger than 30 cm i.e. the width of the D2 gap. One can choose either 33.6 or 39.2 cm width. This would correspond to 6 or 7 sets of FFE per row. In the front one would probably instrument 6, and at the back 7. If only tracks which proceeds into D3 and the remaining part of the spectrometer a width of 33.6 would probably suffice, but for the low-momentum setting the slightly wider 39.2 cm is optimal, and thus chosen.

Pad layout.

The anode wire to pad distance is planned to be 4mm in TPC2 and it will be 3 mm in T1 and T2. This will match the pitch of the pads to induce signals which extends over 3 pads. The TPCs will be instrumented with alternate anode and sense wires spaced at 4mm.

Vertical Extensions

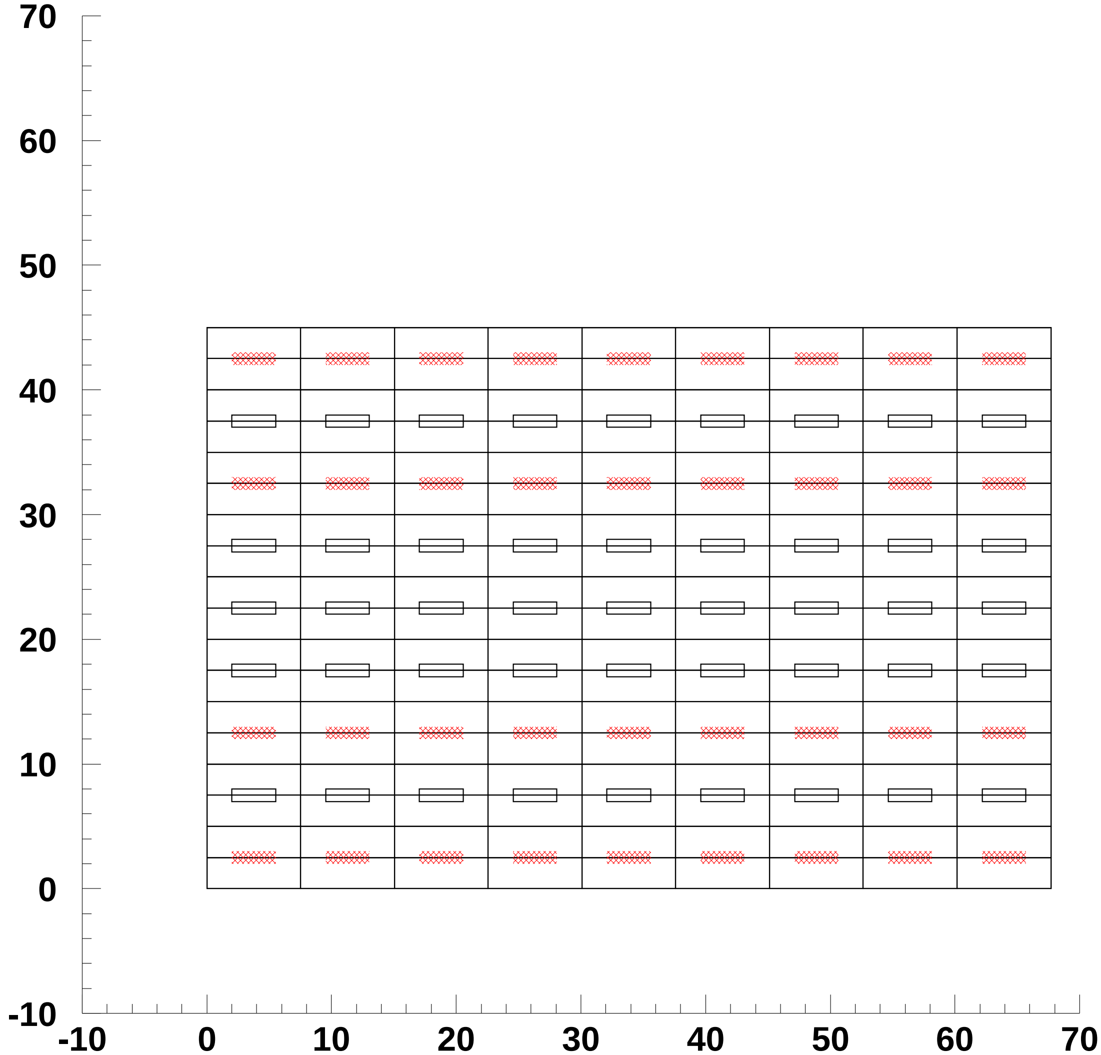
Following the criteria set forward in the introduction one can derive the following minimum vertical sizes. TPC2. From the simulation we see that the vertical hit area at the exit of TPC2 is 13 cm, and thus needs a total drift of minimum 15 cm. For T2 the vertical gap should be at least the size of the D2 gap, 13.5 cm from appendix to note#7; Included the additional dispersion and dead volume 17cm drift is required. To have flexibility it is recommended to have all drift lengths the same 20cm.

Pad layout , connector positioning and readout choices.

It is also important to consider how the FEE cards will be distributed on the connectors. Most of the TPCs will have more connectors available, than there will be FEE cards. The designs have been restricted to having one readout board per TPC i.e. a maximum of 36 FEE cards and thus 1152 pads. Additionally the budget assumes that there is electronics enough for two TPCs with 36 FEE cards (i.e. TPC1 and TPC2 in the MRS) and T1 and T2 will have 768 channels i.e. 24 FEE cards. In addition BRAHMS will have 18 spares which could optionally can be used be in T1 or T2.

With the recommended sizes for the TPC given in the previous section a possible positioning of the FEE cards are shown in the following figures. Not all pads are shown, only the outline of each of the 16 pad sections which connects to one half of a readout connector and FEE card.

The first figure shows the layout for TPC2 in the MRS.


70
60
50
40
30
20
10
0
-10
-10
0
10
20
30
40
50
60
70

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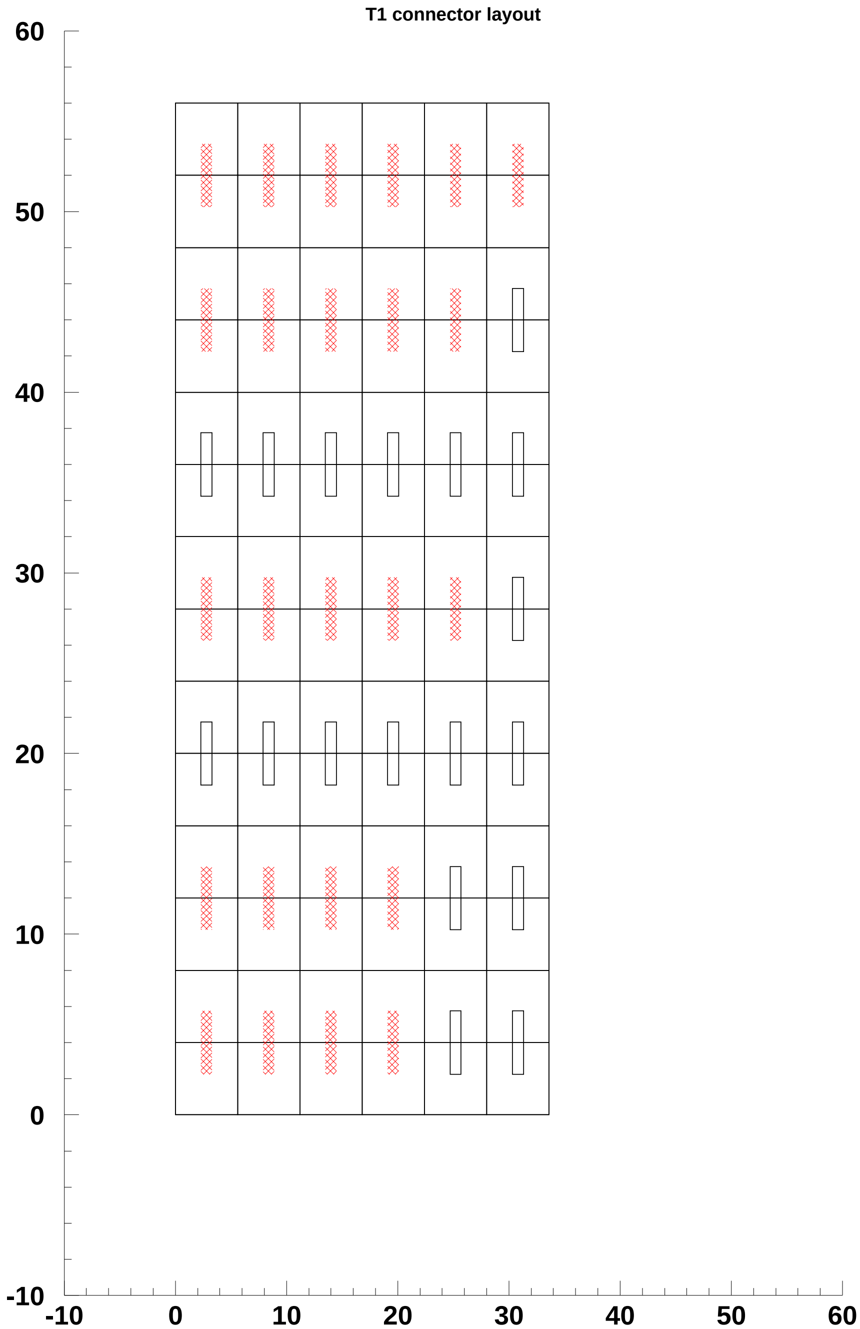

T1 connector layout
60
50
40
30
20
10
0
-10
-10
0
10
20
30
40
50
60

Figure *Layout for T1. Note the connectors* being parallel to the pads.

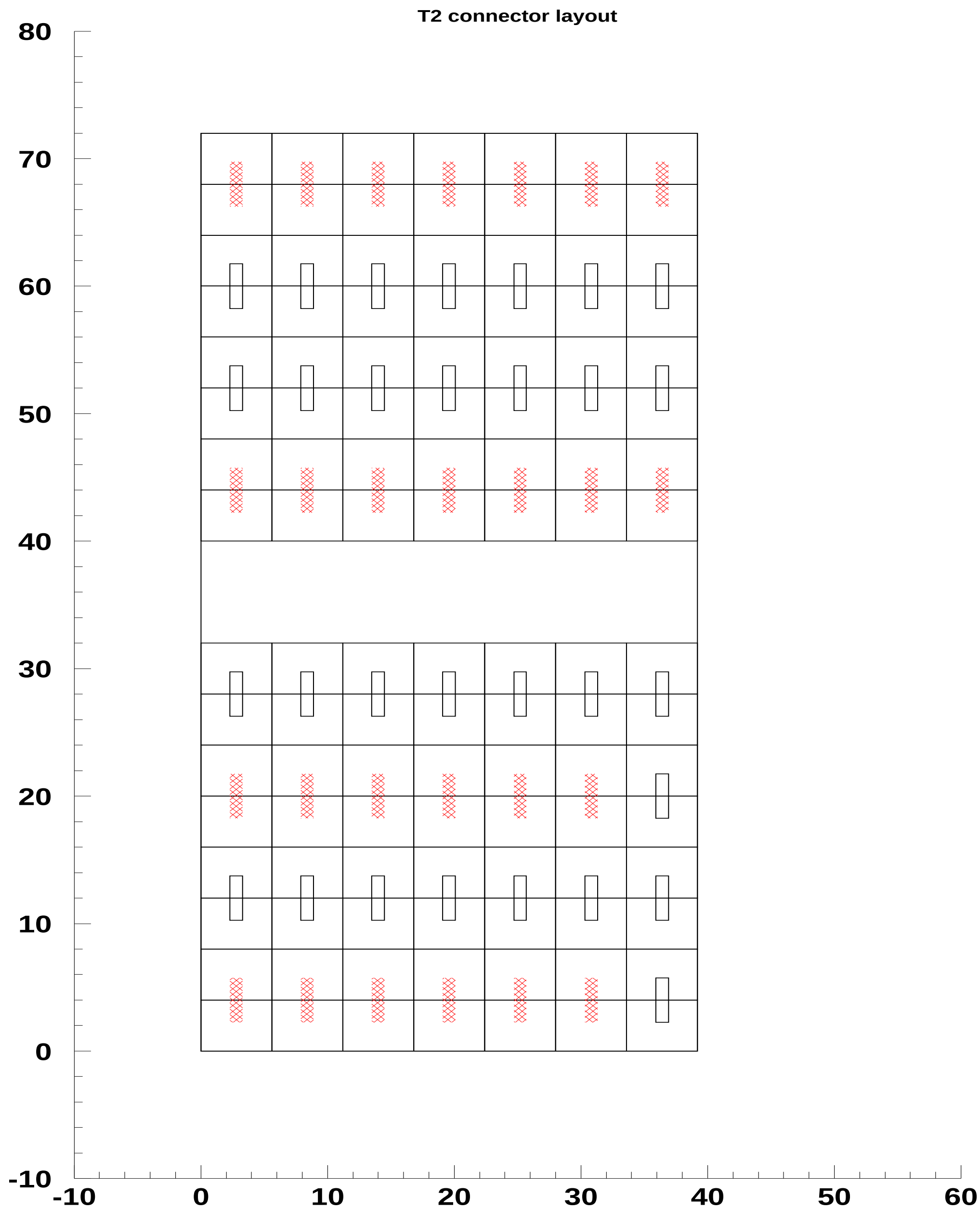


Figure *Layout for T2. Note the connectors being parallel to the pads and the dead section corresponding to the additional support to the top plate.*

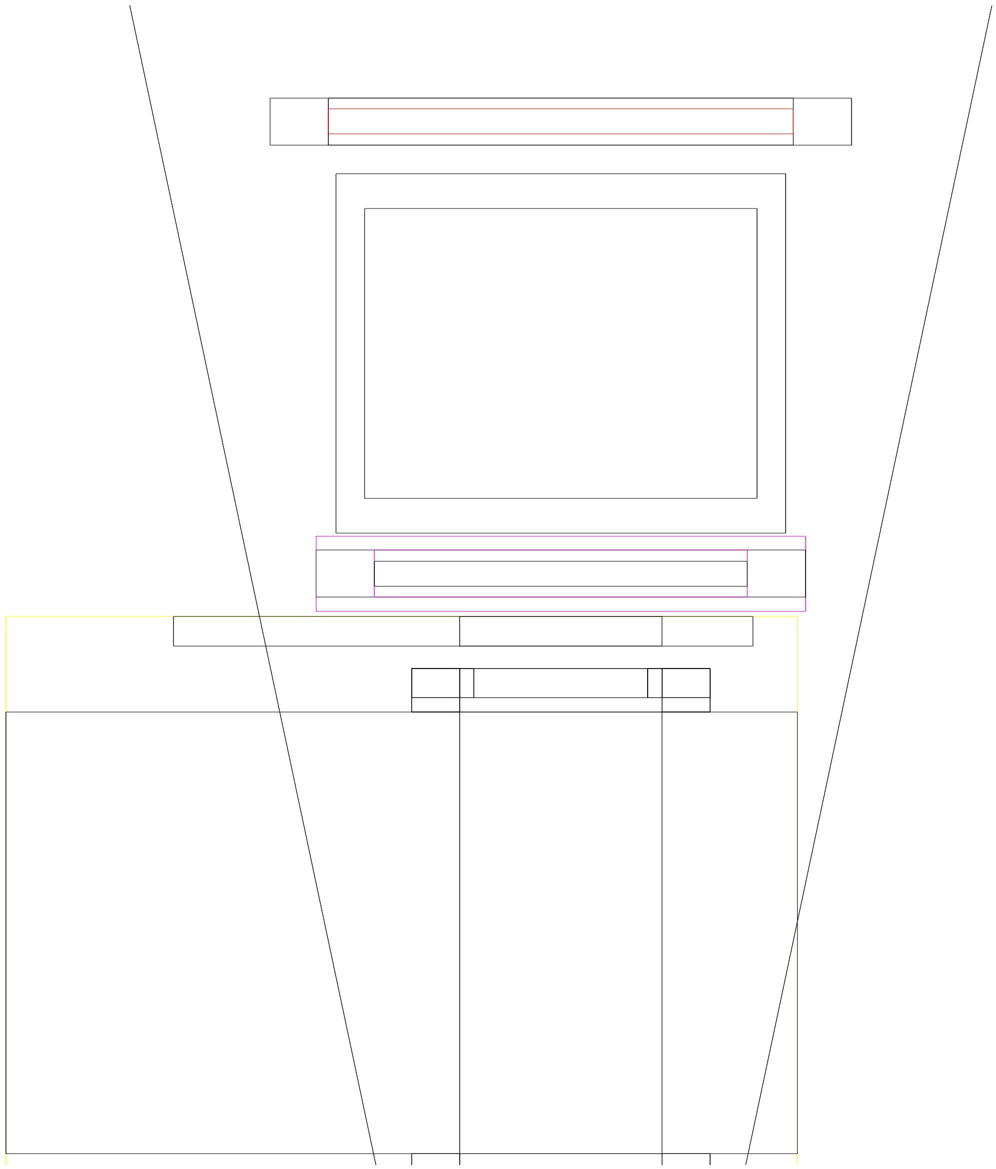
Exterior Space

The distance from the active area to the outer wall of the gas container should be as small a feasible. This is particular true for T1 and T2 where space is at a premium to allow for other detectors and shielding. It is assumed in the layouts presented that sideways the distance can be 5.5 cm and length wise also 5.5 cm. The figure at the end shows a cross section of the almost completed design.

Calibration Detectors.

It is important to have the capability to continuously monitor the drift velocity, and track calibrations. There will be an exterior chamber connected to the gas-output of the TPCs which will measure the drift velocity and give an indication of the gas purity. This will though not give direct information from the TPCs themselves. This can though be achieved using drift chambers, and the plan is to use the drift chamber build for the E866 forward spectrometer arm. They do match quite well to the spatial area of the TPC at their entrance and exit. They are also built very compact, the electronics exists. They would not be part of the tracking, but used in low-multiplicity events to get ’continuos’ drift velocity and y-position calibrations. They could also be used in separate runs with B(D2)=0. They would be read out in Fastbus using 1872(79) pipeline TDCs.

They are not perfect matches. In the previous discussion it has been assumed that FT3 and FT4 will sandwich TPC2. This is illustrated in the top view plot given in the next figure.



FT1 and FT2 will be used on either side of the D2 magnet. With the available space between D1 and D2 (see appendix B) it is not possible to have both FT1, T1 and FT2 with an active volume of more than 50 cm.

The proposal is to have only one chamber,FT1, between T1 and D2 and have FT2 immediately following D2. This would leaves sufficient space for T1, also allowing for the rotation of the T1, D2 and T2 part of the spectrometer relative to D1 used in the low momentum settings.(Angular rotation about 6 degrees versus 1.9) T1 can at the most be lengthen by another 8 cm (not more to allow for rotation). Also one has to make sure that external bolts, nuts, clamps are not in the way. One drawback of this solution is that FT1 is not as wide as the opening of D2. This is though a real problem the reasoning being that tracks going by this far side will not make it al the way thorough D2. So this may be the most acceptable solution. This layout is illustrated for a length of increased to 56cm for the active length. Note that the TPC is positioned such that the reference ray is 1cm from the edge of the active volume.

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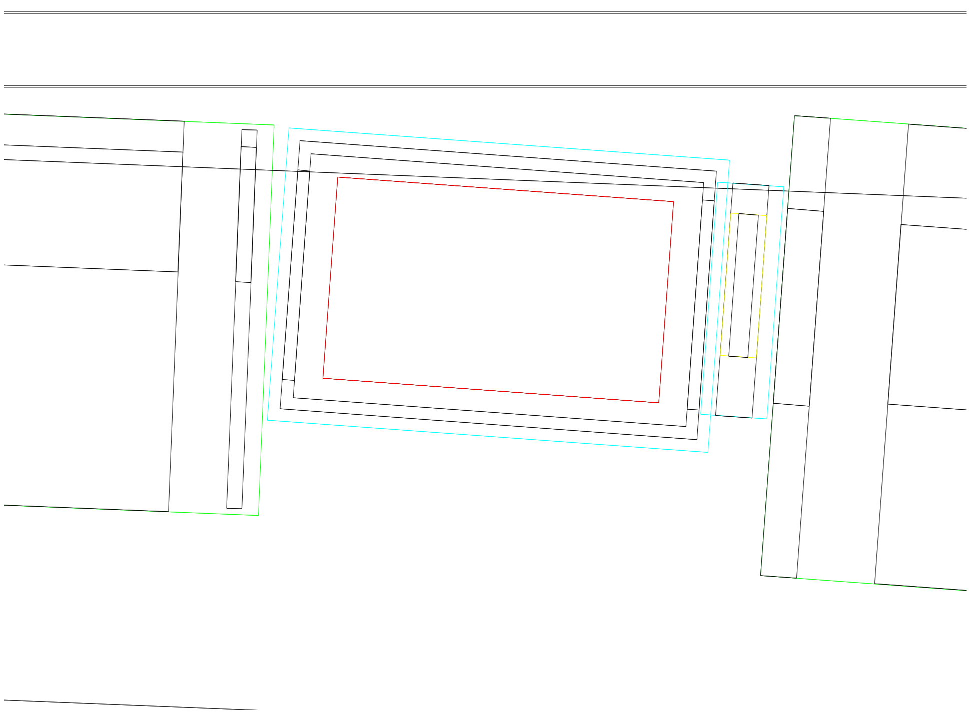

Figure. Layout of T1 and using FT1 as calibration detector. This is a top view. The D2 magnet parameters are those from the NBI drawing from June 4. The shield thickness is 6 cm

Summary

The proposed layout of the TPC is as follows based on the considerations above, and a fair amount of discussions by e-mail and following the BRAHMS April TAC meeting.

TPC	TPC2	T1	T2
Pad width (mm)	4.2	3.0	3.0
Pad pitch (mm)	4.7	3.5	3.5
Pad length (mm)	24.0	27.5	27.5
Pad Pitch (mm)	25.0	40.0	40.0
anode-pad plane distance (mm)	4	3	3
# rows	20	14	8+8
Active length (cm)	50.0	56.0	72.0
#FEE connectors per 2 rows	9	6	7
Active width (cm)	67.68	33.6	39.2
Drift Volume (cm)	20	20	20
Exterior width (cm)	77.7	44.8	50.4
Exterior length (cm)	62.	69.5	88.5.
Exterior Height (cm)	30	30	30

Note: The 27.5 mm active pad length is followed by a section of 11.5mm inactive (grounded) section.

Other figures which are not included into the text exists. These included

1. Pad and connector layout for TPC2
2. Pad and connector layout for T2.
3. Exploded view (assembly drawing) for MTPC2
4. Cross section of gas container, support structure, wire plane frames.

Many of these can be found on the sgs0 in the directories for the BRAHMS drawings, namely in

/lv1/brahms_cad/detector/fs_tpc and /lv1/brahms_cad/detector/mrs_tpc.

Appendix A.

Dimensions of FT1, FT2,FT3 and FT4.

This gives the result of an inspection of the FT1,...FT4 chambers and some measurements of their sizes.

The following are the dimensions that we measured for ft1-ft4 in the cage on March 14 1997:

T1: 2+5/8 inches thick (6.7 cm)
  15+1/4 inches wide (38.74 CM)
  3/4 inches each side for the in/out gas fitting. (10.51 CM)
  11/4 inches from top is the location of fittings.

  size inside frame:
    9+1/4 inches wide by 6+3/4 inches high

Stand is 4 inches thick and 19+1/4 inches wide (10.16cm). Thus excluded volume is 10.50 cm wide. There are also screw head which extend into this volume at various points. To the beam side there are HV connectors. They are with the 4" width but extend further out maybe 1", but are at the below the active volume i.e. near bottom of outer frame.

T2: Thickness and gas fittings same as T1
  19+3/4 inches wide
  15+1/2 inches high

T3: 33+1/4 inches wide
  20+1/2 inches high

T4: 3+1/8 inches thick
  20+1/2 inches high
  39+1/2 inches wide

Appendix B

T1 space measurement from layout print.

Here are the numbers that we checked for the spacing for T1.

D1 core to D2 core measured 121.1cm Should be 120 based on 300-100-80, this appears to be the scale error.

Assuming a 3 inch clamp for D2 and a 1 inch space between coil and clamp arrive at 86 cm D1 clamp to D2 clamp along the reference ray. D1 core to D1 outside clamp edge is 12.19cm D2 core to D2 outside clamp edge is 21.84cm