Updated Performance Studies Of ECCE Tracker

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AI Working Group

- Comparison among different solutions for the Outer Tracker discussed in the last days (mRPC, uRWELL)
- Studies of Projective Geometry for the Inner Tracker with the above
  - N.b: in the projective design, the disks have Rmax-Rmin taken as a multiple of 1.5 cm (ITS-3 sensor being 1.5x3.0); the penultimate uRWELL in the inner tracker is shifted to lower radius to maximize acceptance

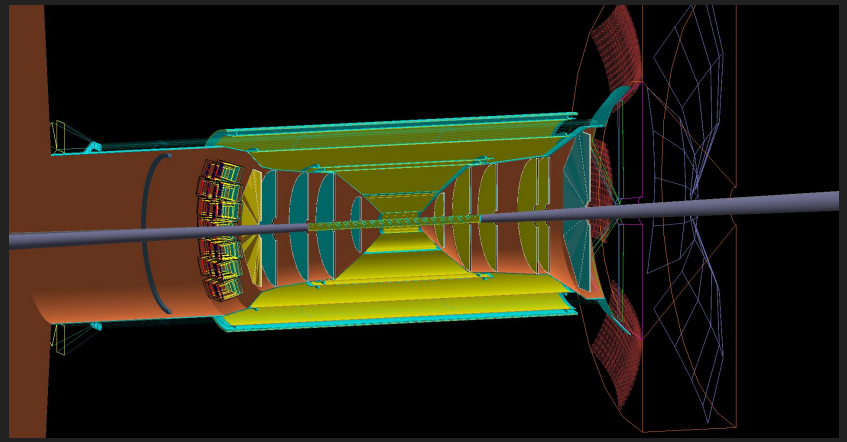
October 15 Design

From 2nd campaign (black) to Oct-15, we swapped 30um resolution barrel LGAD to 55um-resolution uWell at a slightly lower radius (80->76 cm).

DIRC+uRWELL+mRPC

- uRwell
  - Radius = 63 cms
  - Length = 271 cms
  - Zshift = 8 cms
  - Points to note:
    - Support ring thickness ~ 2.6 cms but given only 2 cms gaps
- DIRC
  - NBars = 11 -> 10
  - rMin = 74.1 -> 71.5 cms
  - Radius = 75 -> 76.6 cms (to avoid overlaps 76.6 - 1.7 {bar thickness} - 2.0)
  - Prizm_width = 38.65 -> 37.65 cms
- uRwell
  - Radius = 76.6 cms
  - Length = 290.0 cms
  - Points to note:
    - Support ring thickness ~ 2.6 cms but given only 2 cms gaps
- mRPC
  - Replaced CTTL with mRPC (pull request)
  - Proposed radius = 78.6 cms but has overlaps with the support rings of uRwell above. At Least 79.6 for no overlaps
  - Length = 300 cms

If EMCal has readout at **outer** radius (and is reduced to 3.5cm at eta=0)					
Top level layers	**R-in [cm]**	**R-out [cm]**	**R-Thickness**	July Concept Rin	July Concept Rout
Magnet	140	170	30	140	170
EMCal support (instrumented)	134	140	6	135	138.5
EMCal Readout (near eta=0)	130.5	134	3.5	130.5	135
EMCal Glass	85	130.5	45.5	85	130.5
EMCal Inner support	84.5	85	0.5		
mRPC	76.5-78.6	84.5	6-8	None	
muRwell (plane type)	74.5-76.6	76.5-78.6	2	None	
Outer Frame	74.5	77	2.5	80 (TTL in frame)	
DIRC (10bar * 12 sector)	71.5	76.6	5.1	74.1	75.8
Inner Frame	65	71.5	6.5		
muRwell	63	65	2	67.4	
(Not used, low mass BdL)	50	60	10	50	67
Inner tracker	3	50	47	3	47.4



End cap TTLs are included but are not shown in the visualisation.
e-going z = -155.5, -158.5 cms
h-going z = 287, 289 cms
resolution = 30 ums

Jin's Suggestion

DIRC+mRPC+uRWELL

- uRwell
  - Radius = 63 cms
  - Length = 271 cms
  - Zshift = 8 cms
  - Points to note:
    - Support ring thickness ~ 2.6 cms but given only 2 cms gaps
- DIRC
  - NBars = 11 -> 10
  - rMin = 74.1 -> 71.5 cms
  - Radius = 75 -> 76.5 cms (to avoid overlaps 76.5 - 1.7 {bar thickness} - 2.0)
  - Prizm_width = 38.65 -> 37.65 cms
- mRPC
  - Replaced CTTL with mRPC (pull request)
  - Radius = 76.5 cms
  - Length = 300 cms
- uRwell
  - Radius = 82.5 cms
  - Length = 290.0 cms
  - Points to note:
    - Support ring thickness ~ 2.6 cms but given only 2 cms gaps

From: Ecce-eic-det-l <ecce-eic-det-l-bounces@lists.bnl.gov> on behalf of Huang, Jin via Ecce-eic-det-l <ecce-eic-det-l@lists.bnl.gov>
Date: Wednesday, October 13, 2021 at 11:50 PM
To: Grzegorz Kalicy <kalicy@cua.edu>
Cc: ecce-eic-det-l@lists.bnl.gov <ecce-eic-det-l@lists.bnl.gov>
Subject: Re: [Ecce-eic-det-l] ECCE Detector Location Meeting (Friday Oct. 8th @ 1pm)

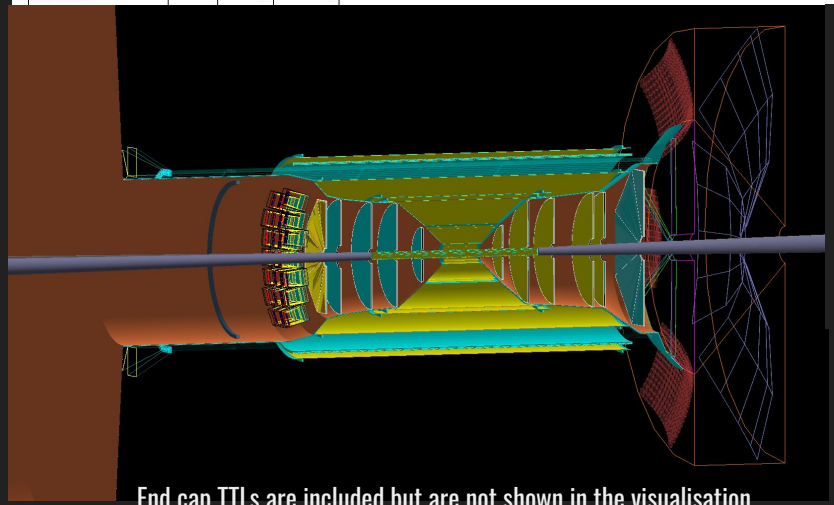
Hi Greg, John and all

Thanks for the explanation. That makes sense.

Following the 10-bar DIRC dimension and Friederike's suggestion to have BCAL readout from the backside, let me suggest the following radial assignment:

If EMCal has readout in outter radius:

Top level layers	R-in [cm]	R-out [cm]	R-Thickness
Magnet	140	170	30
EMCal support (instrumented)	134	140	6
EMCal Readout (near eta=0)	130.5	134	3.5
EMCal Glass	85	130.5	45.5
EMCal Inner support	84.5	85	0.5
muRwell	82.5	84.5	2
mRPC (partly in DIRC frame)	74.5	82.5	8
Outer DIRC Frame	74.5	77	2.5
DIRC	71.5	76.6	5.1
Inner DIRC Frame	65	71.5	6.5
muRwell	63	65	2
(Not used, low mass BdL)	50	60	10
Inner tracker	3	50	47



End cap TTLs are included but are not shown in the visualisation.

October 18 Design

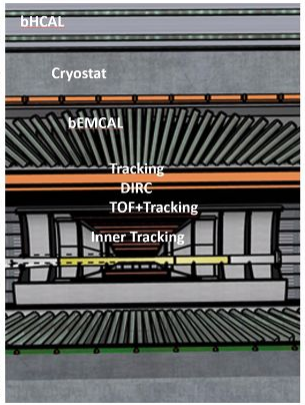
BCal pushed to R=80 cm and this pushed mRPC to R=55-63 cm, the previous low mass tracking vol.

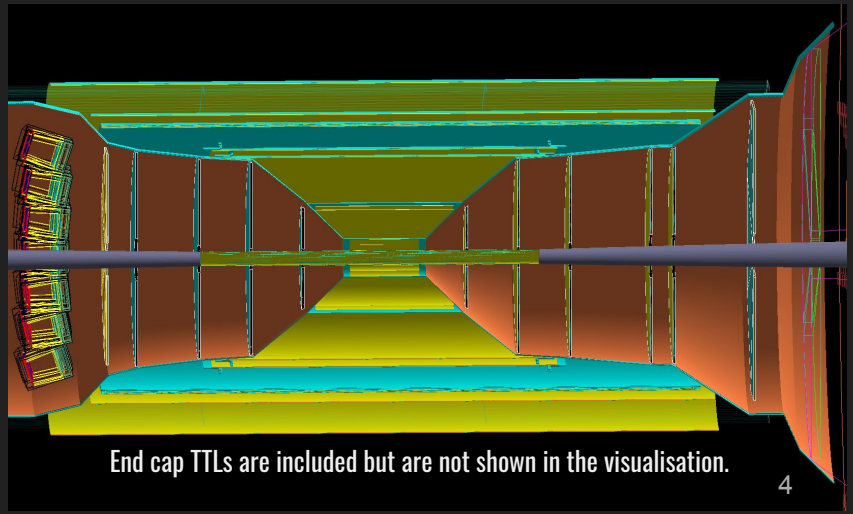
Noticeable increase of multiple scattering effects as shown in the following

- mRPC
  - Replaced CTTL with mRPC (pull request)
  - Radius = 57 cms
  - Length = 260.0 cms
  - Z_shift = 7 cms
- uRwell
  - Radius = 63 cms
  - Length = 271 cms
  - Zshift = 8 cms
  - Points to note:
    - Implemented without the support rings (support ring thickness >= 2.6cms)
- DIRC
  - NBars = 11 -> 10
  - rMin = 74.1 -> 71.5 cms
  - Radius = 72.9 (latest DIRC implementation)
  - Prizm_width = 38.65 -> 35.135 cms
- uRwell
  - Radius = 76.6 cms
  - Length = 290 cms
  - Points to note:
    - Implemented without the support rings (support ring thickness >= 2.6cms)

ECCE Barrel – radial ordering

Top level layers	R-in [cm]	R-out [cm]	R-Thickness
Magnet	140	170	30
EMCal support (instrumented)	134	140	6
EMCal Readout (near eta=0)	126	134	8
EMCal Glass	80	126	46
EMCal Inner support	79.5	80	0.5
muRwell (plane type)	74.5-76.6	76.5-78.6	2
Outer Frame	74.5	77	2.5
DIRC (10bar * 12 sector)	71.5	76.6	5.1
Inner Frame	65	71.5	6.5
muRwell	63	65	2
mRPC	57-59	65	6--8
(Not used, low mass BdL)	50	57	7
Inner tracker	3	50	47





End cap TTLs are included but are not shown in the visualisation.

October 18 Design - Jin Suggestion

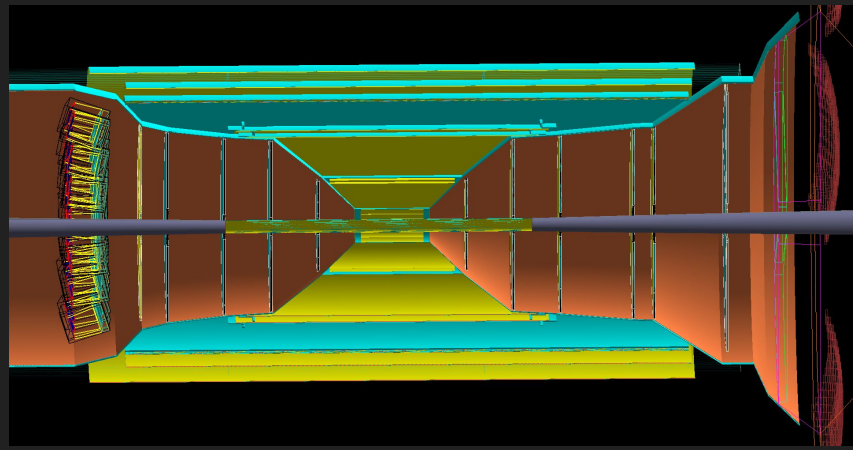
- mRPC
  - Replaced CTTL with mRPC (pull request)
  - Radius = 61 cms
  - Length = 270.0 cms
  - Z_shift = 7 cms
- uRwell
  - Radius = 69 cms
  - Length = 281 cms
  - Zshift = 8 cms
  - Points to note:
    - Implemented without the support rings (support ring thickness >= 2.6cms)
- DIRC
  - NBars = 11 -> 10
  - rMin = 74.1 -> 71.5 cms
  - Radius = 72.9 (latest DIRC implementation)
  - Prizm_width = 38.65 -> 35.135 cms
- uRwell
  - Radius = 76.6 cms
  - Length = 290 cms
  - Points to note:
    - Implemented without the support rings (support ring thickness >= 2.6cms)

Increase radius of mRPC by 6 cm (fit into the DIRC frame), recover some resolution, see following

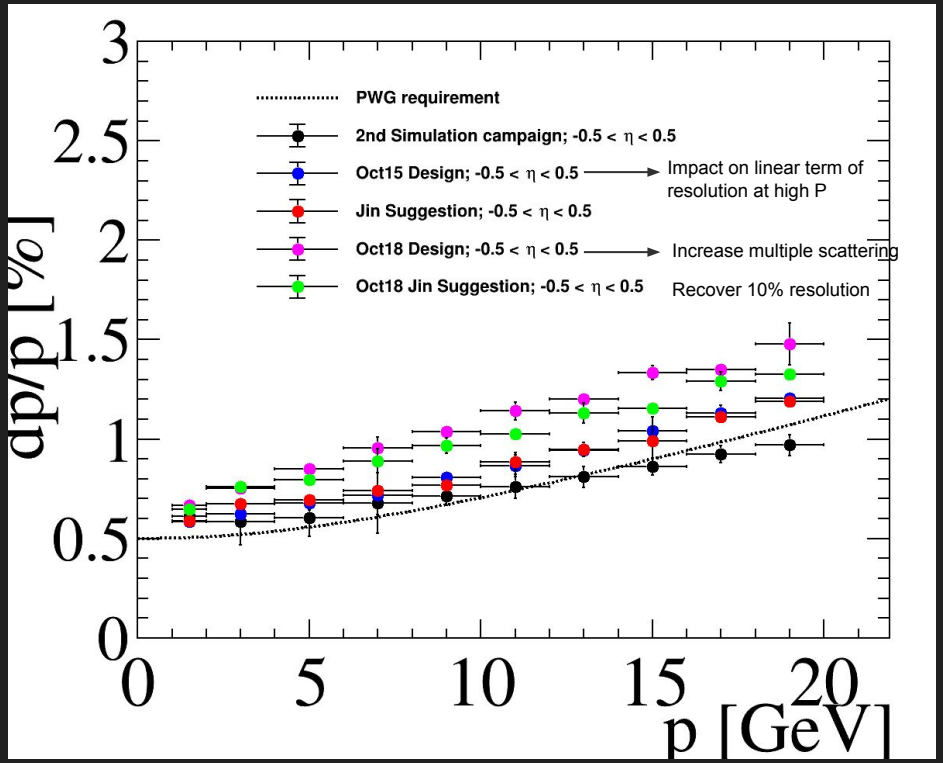
Idea to move multiple scattering source to higher radius

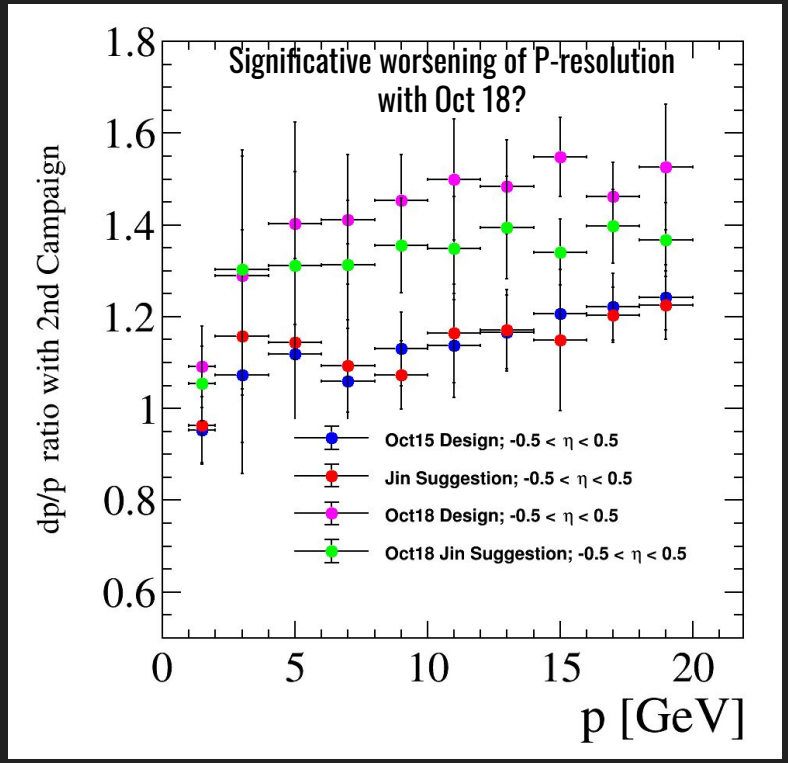
If EMCal has readout at **outer** radius:

Top level layers	R-in [cm]	R-out [cm]	R-Thickness	July Concept Rin	July Concept Rout
Magnet	140	170	30	140	170
EMCal support (instrumented)	134	140	6	135	138.5
EMCal Readout (near eta=0)	126	134	8	130.5	135
EMCal Glass	80	126	46	85	130.5
EMCal Inner support	79.5	80	0.5		
muRwell	76.6	79.5	2	80 (TTL in frame)	
Outer Frame	74.5	77	2.5		
DIRC (10bar * 12 sector)	71.5	76.6	5.1	74.1	75.8
Inner Frame	65	71.5	6.5		
muRwell	69	71	2	67.4	
mRPC	61	69	8	None	
(Not used, low mass BdL)	50	**61**	11	50	67
Inner tracker	3	50	47	3	47.4



End cap TTLs are included but are not shown in the visualisation.





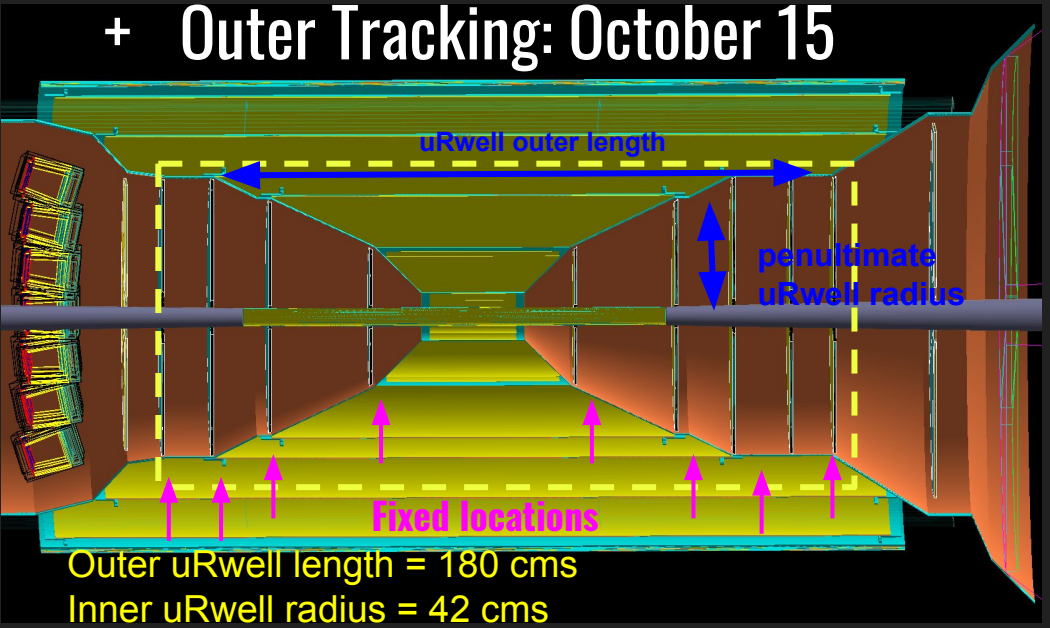
Note: 2nd simulation campaign was run using CTTL which had a resolution of 30 ums and **DISPLACED_VERTEX = false.**

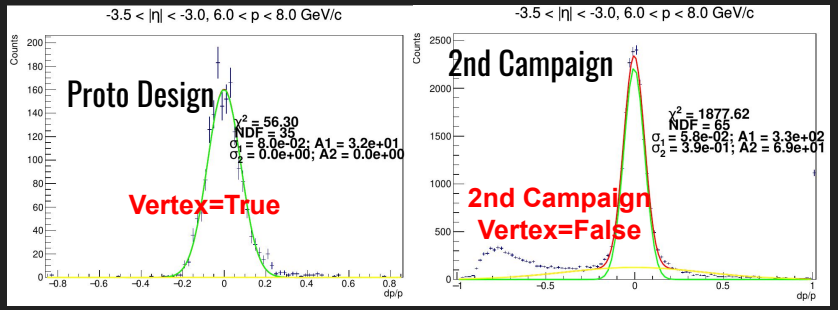
- This incorporates vertex smearing of 3cm
- displaced vertex set to False

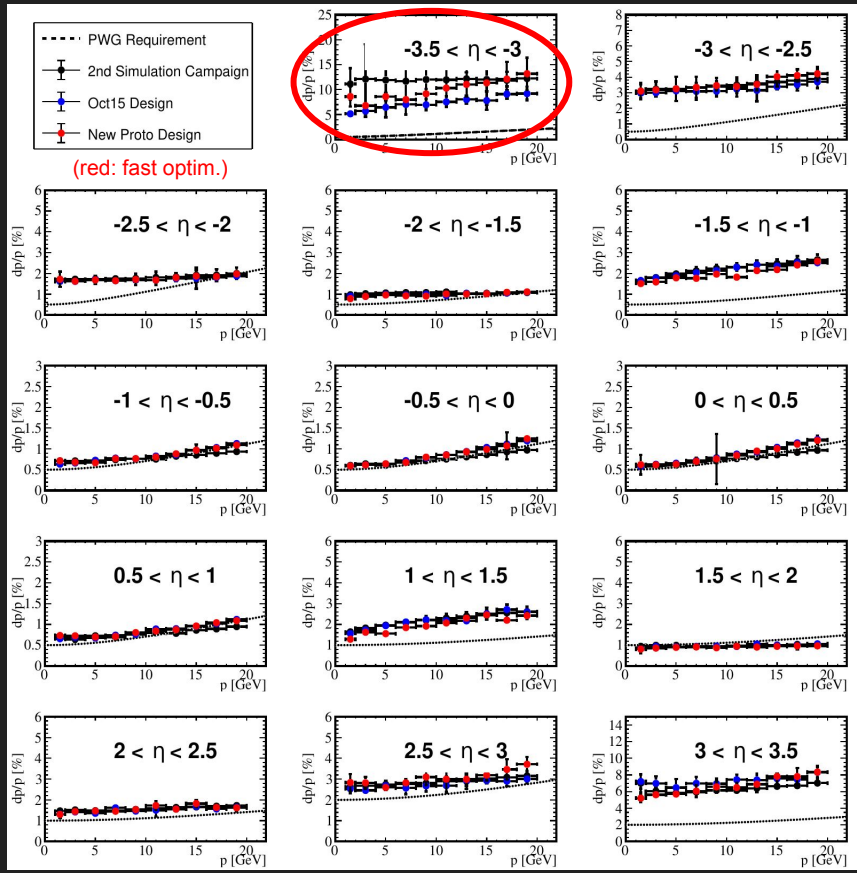
Proposed geometries for the Inner Tracker

What follows can be further improved with a “quick” optimization
(developed a simpler parametrization + faster generation of samples)
~ 1-2 days

Parametrization of the inner tracker (particularly support structure) + Outer Tracking: October 15

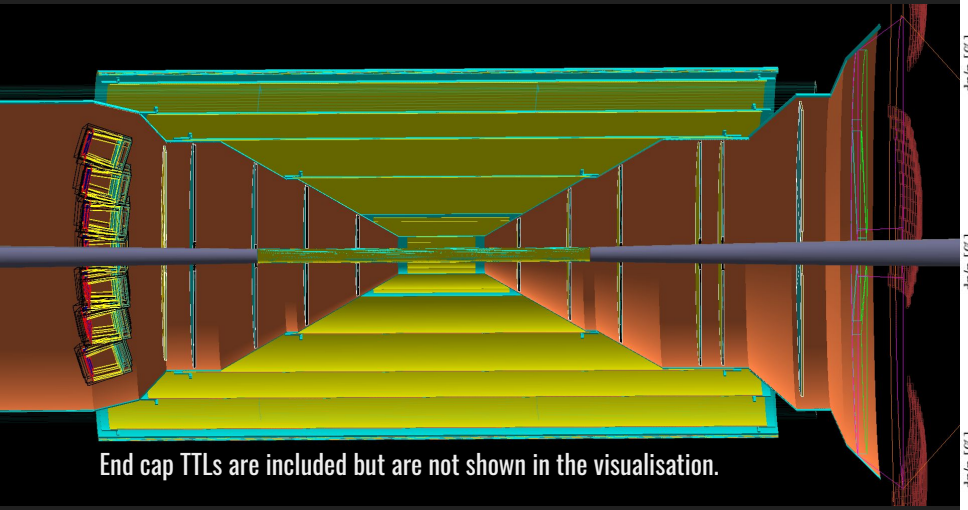






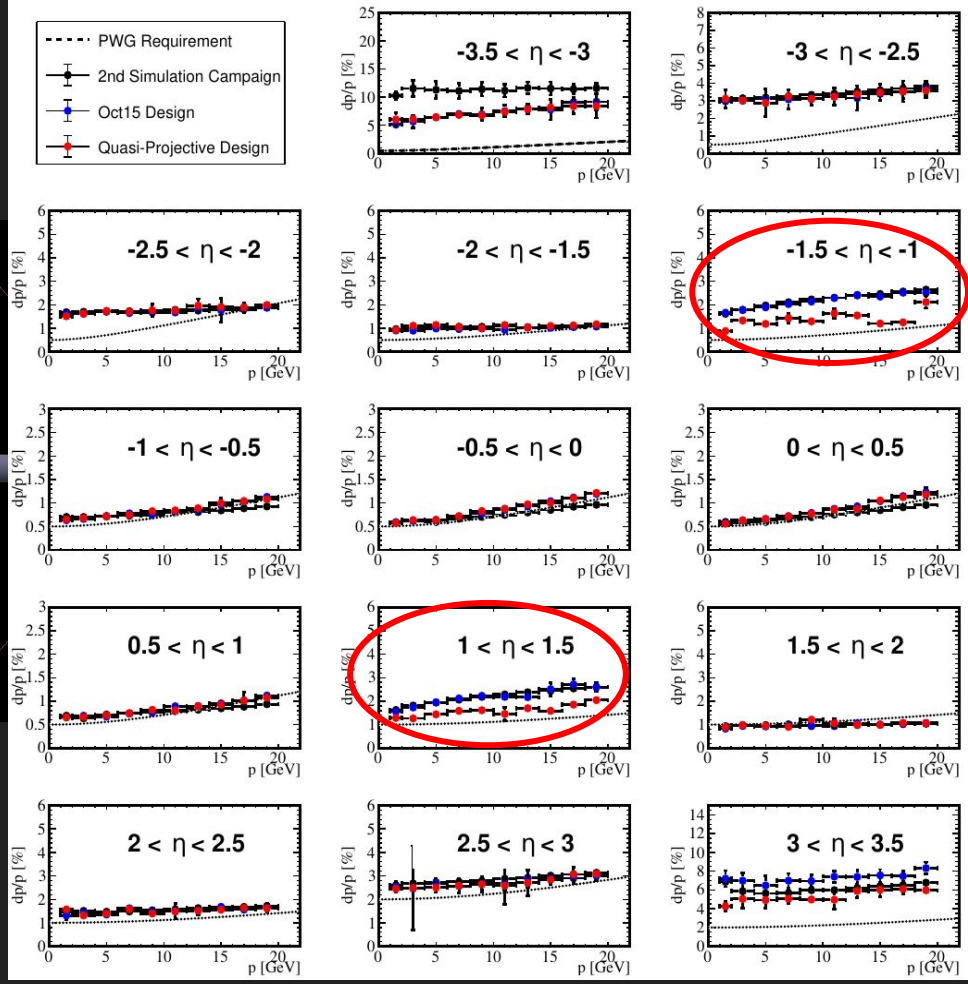
*See backup for more details on the parametrization

Quasi-Projective inner + Outer Tracking: October 15

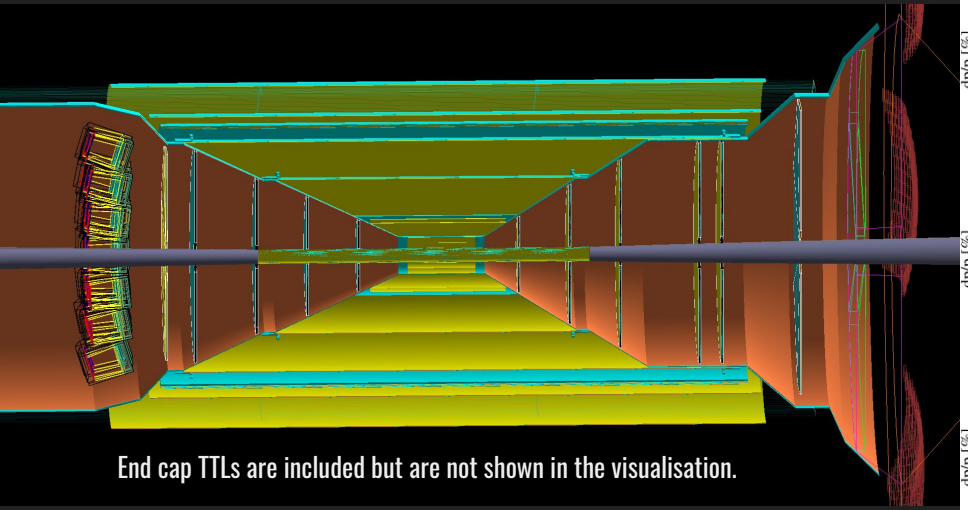


End cap TTLs are included but are not shown in the visualisation.

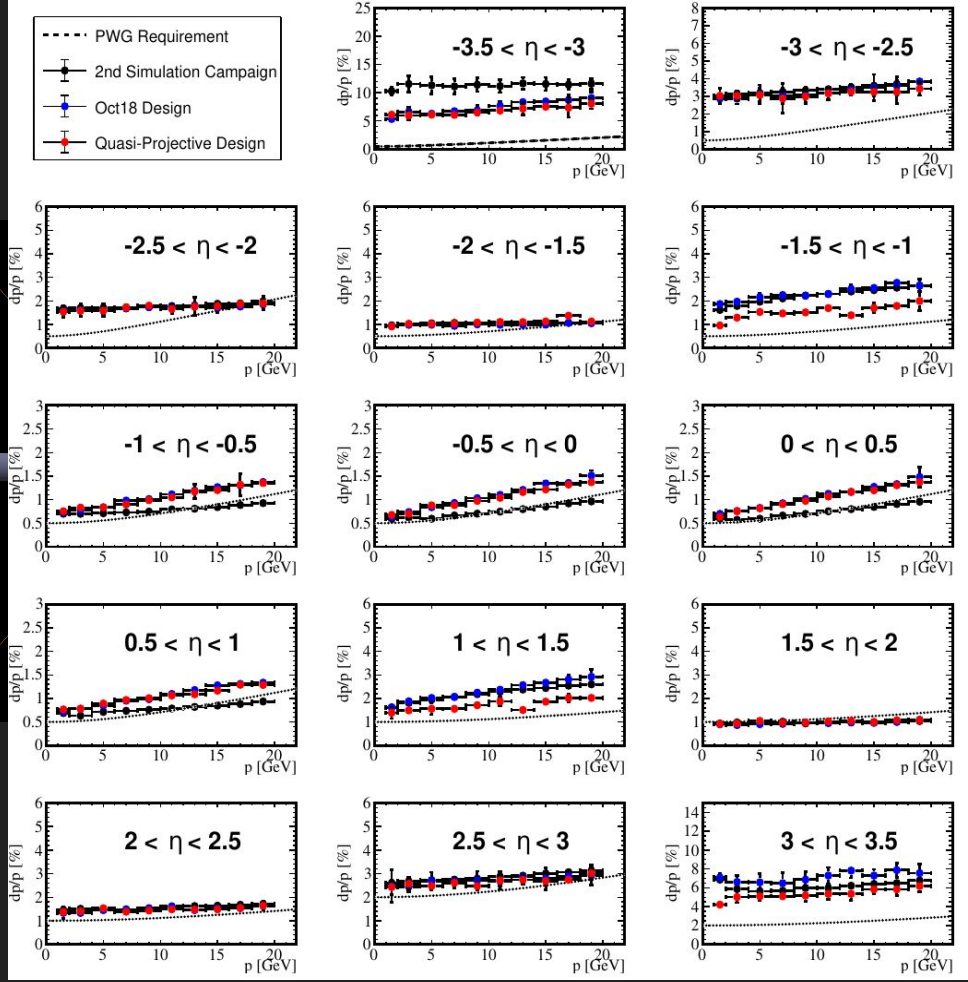
α = 30 deg
β = 35 deg
(both tunable)



Quasi-Projective inner + Outer Tracking: October 18



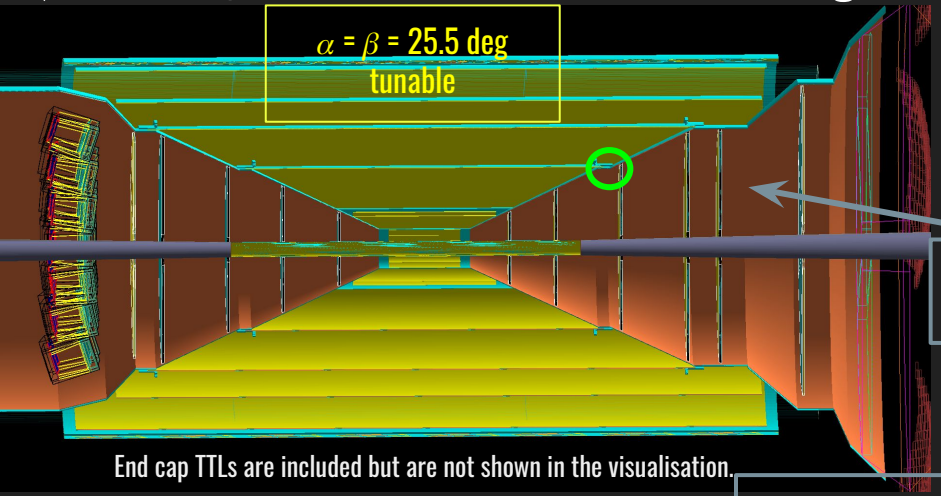
α = 25.16 deg
β = 32.28 deg
Based on CEMC coverage



Observed improvement in the transition region 1< |η| <1.5

Quasi-Projective inner + Outer Tracking: October 15

(RMax - RMin)%3 == 0
(RMax - RMin)%1.5 == 0



End cap TTLs are included but are not shown in the visualisation.

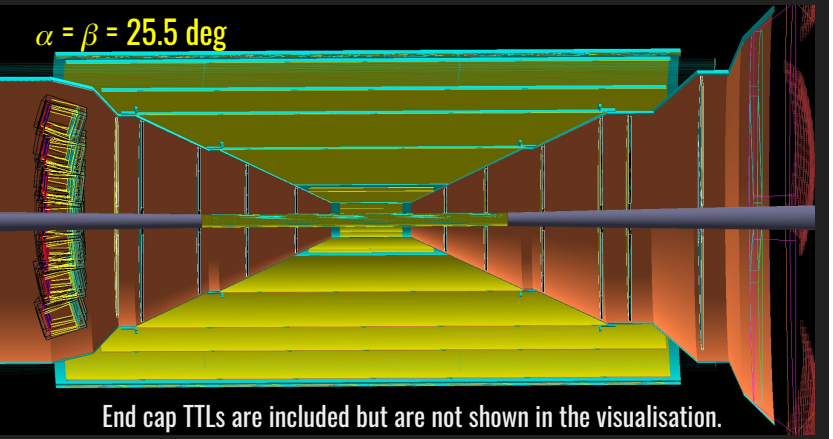
Support structure radius = 50.5 cms
uRwell plateau length = 5cms

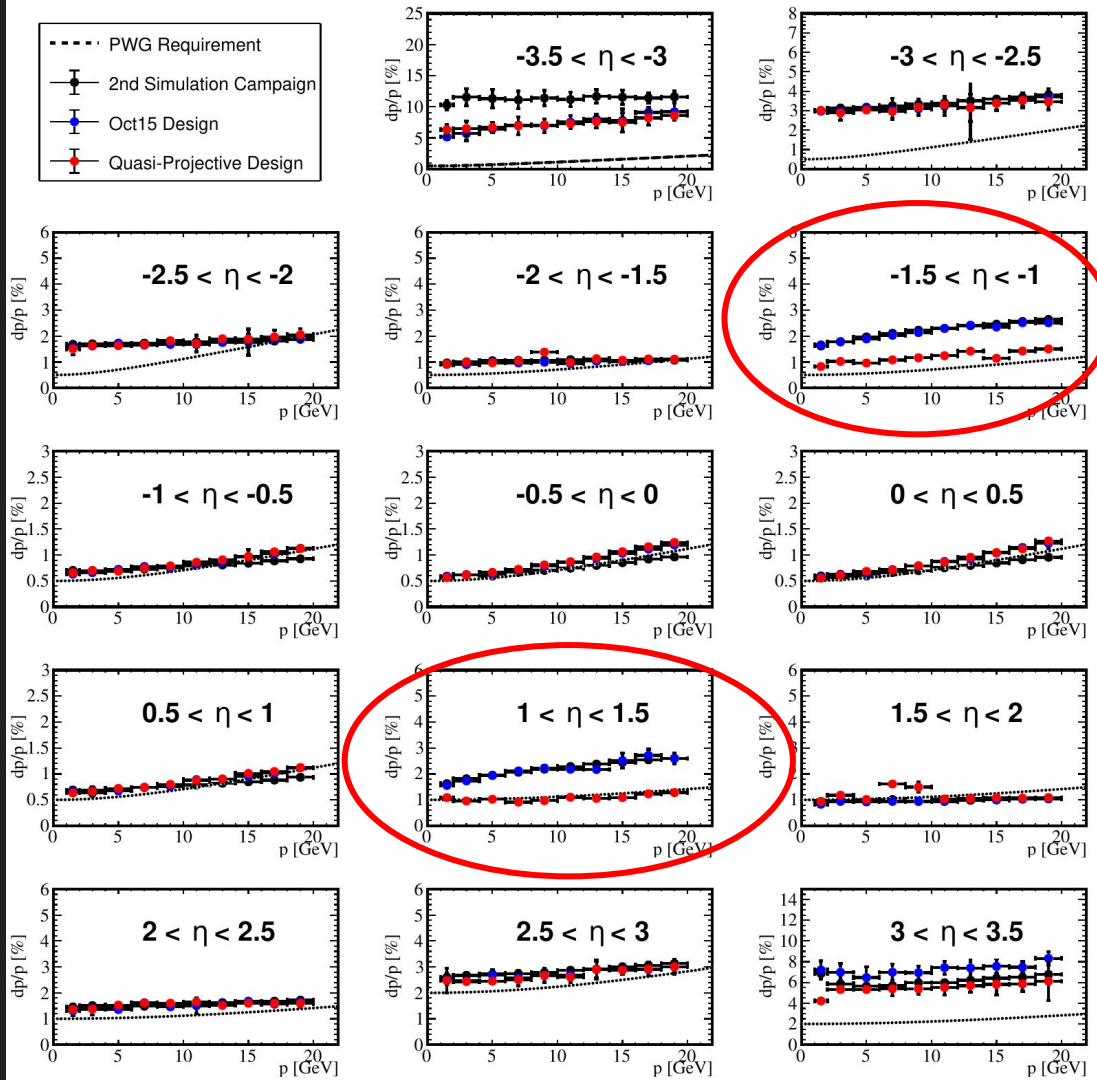
FST Disk	Z (cms)	RMin (cms)	RMax (cms)	RMin - Rmax (cm)
Bkwd 1	-34.0	3.35	15.35	12
Bkwd 2	-58.8	3.3	27.3	24
Bkwd 3	-80.5	5.2	35.2	30
Bkwd 4	-108.0	6.4	48.4	42
Fwd 1	36.5	3.3	15.3	12
Fwd 2	56	3.3	24.3	21
Fwd 3	83.5	5.35	35.35	30
Fwd 4	111.5	6.7	48.7	42
Fwd 5	125	7.5	49.5	42

Inner Barrels	Radius	e-length	h-length	Length
Vtx 1	3.3	14.3	15.7	30
Vtx 2	5.7	14.3	15.7	30
Vtx 3	8.1	14.3	15.7	30
Sagitta 1	13.9	28.61	31.39	30
Sagitta 2	15.6	28.61	31.39	30
uRwell 1	34.5	73.85	76.65	150.5
uRwell 2	51.5	115	115	230

Outer Layers	Radius (cms)	e-length (cms)	h-length (cms)	Length (cms)
uRwell 3	63.0	128.5	141.5	271
DIRC	72.	287	168	455? (default)
uRwell 4	76.6	145	145	290
mRPC BToF	78.6	150	150	300

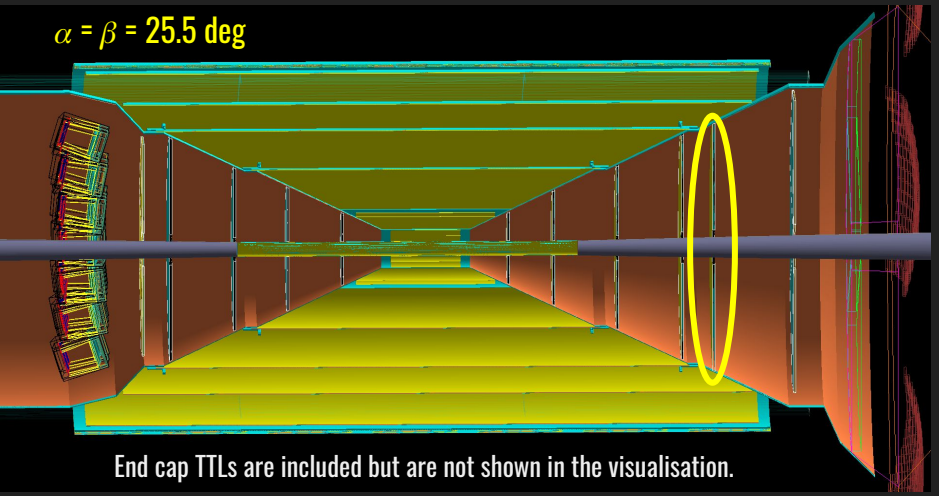
PWG Requirement





Quasi-Projective inner + Outer Tracking: October 15 outermost FST

(RMax - RMin)%3 == 0
(RMax - RMin)%1.5 == 0



End cap TTLs are included but are not shown in the visualisation.

(exploring)

FST Disk	Z (cms)	RMin (cms)	RMax (cms)	RMin - Rmax
Bkwd 1	-34.0	3.35	15.35	12
Bkwd 2	-58.8	3.3	27.3	24
Bkwd 3	-80.5	5.2	35.2	30
Bkwd 4	-108.0	6.4	48.4	42
Fwd 1	36.5	3.3	15.3	12
Fwd 2	56	3.3	24.3	21
Fwd 3	83.5	5.35	35.35	30
Fwd 4	111.5	6.7	48.7	42
Fwd 5	130	7.5	55.5	48

Inner Barrels	Radius	e-length	h-length	Length
Vtx 1	3.3	14.3	15.7	30
Vtx 2	5.7	14.3	15.7	30
Vtx 3	8.1	14.3	15.7	30
Sagitta 1	13.9	28.61	31.39	30
Sagitta 2	15.6	28.61	31.39	30
uRwell 1	34.5	73.85	76.65	150.5
uRwell 2	51.5	115	115	230

Outer Layers	Radius (cms)	e-length (cms)	h-length (cms)	Length (cms)
uRwell 3	63.0	128.5	141.5	271
DIRC	72.	287	168	455? (default)
uRwell 4	76.6	145	145	290
mRPC BToF	78.6	150	150	300

Summary

- Observed significative worsening (~40%) of π momentum resolution with October 18 solution (mRPC and uRWELL radially “before” DIRC)
- The quasi-projective design of the Inner Tracker improves the momentum resolution in the transition region (barrel/e-going and barrel/h-going): see bins 1.0<|η|<1.5 in previous slides; it also allows for optimization of the penultimate uRWELL and disks location.
- We have been able to set up a new parametrization that allows for a quick optimization (1-2 days) of the proposed designs (n.b., the support structure can be also parametrized)
- The proposed designs have:
    - Tunable radius of the penultimate uRWELL in the Inner Tracker
    - Realistic values for the Rmax-Rmin of the disks (multiple of 1.5 cm) [see mattermost]
    - Radius of the sagitta layers been slightly decreased to accommodate the projective angles of the support structure; this did not affect tracking performance
- Ready to start a quick optimisation based on Oct 15, Oct 18 designs.

Discussion Points

- What is the reference Outer Tracker?
- Shall we implement the mRPC+uRWELL solution for the forward and backward arms? https://indico.bnl.gov/event/13564/
- Shall we implement a projective Inner Tracker to concentrate material in a narrow tracking blond spot in η-coverage? (see email thread on “DIS lepton reco”, 10/20)

Backup

More details on the Params to optimise

- Params to optimise (<= 3)
  - The radius of the inner uRwell
  - Length of the outer uRwell
  - Z position of the 3rd disk in the forward direction
- Constraints
  - (RMax - RMin)%1.5 == 0
  - Radius of inner uRwell > sagita_support radius + 5 cms & radius of inner uRwell < 44cms
  - Length of outer uRwell > Length of inner uRwell + 5
  - Length of outer uRwell < (125 h-going end) & Length of outer uRWell < 108 (e going end)
- Approx time line is a day or max 2 days for the optimisation