Review of materials presented on 05/12/22 for ECCE forward ECal. O.T. 05/15/22

1. Integration envelope.

   42 cm length of integration envelope was stated at the meeting. 42 cm is the length of mechanical module for ALICE as can be found in literature.

   Subdivision for ALICE block envelope is:
   Scintillator/paper/lead stack - 28.2 cm
   Compression plates and fiber bundling/lightguide/mechanics – 14 cm

   As it was presented for ECCE design, the length of stack is 37.5 cm – I think the number should be 66 *(.4+.16+.02)=38.3 cm, here I also included thickness of paper sheets on both sides of sc. Plates.

   Assuming the same mechanical design as was in ALICE the length of 'mechanical' part of the block will be 38.3+14 = 52 cm

   Assuming length required for readout the same as for the ATHENA design at 10 cm, then the total integration envelope needed for the ECAL will be close to 62 cm.

   N.B.
   Given that the compression in the stack may need to be larger compare to ALICE due to:
   - increased transverse size of the block
   - and the length of the stack compare to ALICE (level arm)

   the thicknesses of the front/compression/and back plates may need to be increase. As well as the thickness of the stainless steel straps on the side of the module (guessing here).

   Summary: integration length along Z for ECCE ECAL design should be revisited with details in comparison to a similar ALICE EMCal design, the total full length of 42 cm as proposed needs to be understood and specified in details. The actual length required for the ECCE ECAL 18.5X_0 may be significantly longer than specified in the presentation. More importantly, the ECAL of only 18.5X_0 in the forward direction at the hadron endcap can also be an important issue for physics considerations and should be examined through realistic GEANT simulations.

2. List of dead areas due to mechanical design as mentioned during discussions:
   External to ECAL blocks:
   - SS skin .15mm on sides - little concern for performance
   - SS plates top and bottom ~ 2mm - this will be big degrading factor. A 4mm steel layer between ECAL layers will created significant non-uniformities in detector response.

Dead areas inside ECAL blocks from proposed separation grooves: these most likely will be 1 mm wide. Potential effect of these groves on performance is two-fold:

- Straight dead areas
- Light collection non-uniformities

I can't quantify, but I believe all SHASHLYK type calorimeters had some issues next to the sides of the blocks, I don't have information how well painting or mirroring of tile edges helps.

Dead material upfront is due to 'front' Al plate for ALICE design. Thickness of this plate is not known. It is defined by needed compression force and requirement on pressure uniformity inside the stack. Most likely it will have minor effect on resolution at high eta, at eta ~1 it may have some effect given relatively low energy of photons there.

3. Change from injection moulding scintillating plates to plates made 'mechanically':

   A method to produce plates with separation grooves is documented in sec. II.3.2.2 of STAR BEMC TDR (attached to meeting page). Method of filling grooves with TiO_2 epoxy requires oversized plates.

   Assuming 8M module dimensions and additional border on sides of the plates cost of material for EJ 212 scintillator plates scaled from quoted for STAR/ATHENA HCal plates will be about:

   $58 x 1.3 = $75 (1.3 is a factor due to grooves and labyrinths for epoxy at tiles edges)

   Milling grooves, drilling holes and cutting plate to final dimensions will be a two-stage process described in STAR TDR. Guessing, it may take about 1 hour of machining time, and we can use a typical university machine shop rate of ~ $60/hour.

   This is bulk of the cost for Sc tiles - $135

   On top of this one will need to add at least:

   - labor cost for filling TiO_2 epoxy (technician time)
   - Cost of equipment, and materials for making fillings
   - Painting edges of tiles by undergrad.

   In summary, the cost increase of scintillating tiles by factors of 1.5 -2 due to the loss of Russian vendors presented at the meeting should be evaluated based on previous experiences from STAR EMC construction for example. A larger factor of $135/$30 = 4.5 is very possible.

4. Nothing was mentioned about coupling of WLS fibers to SiPM. On a side note I suspect that one SiPM will not be sufficient for proposed granularity, will elaborate later. I don't see cost of lightguides, housings, or labor categories associated with these things.

5. There were no labor categories associated with technicians. It seems whole module assembly relies on undergrad labor and postdocs, phd students and scientist for installation work.

I think this approach could involve considerable schedule/cost risks that we will have to address: undergraduate students typically require considerable training and they will have mid-term and final exams to deal with. Factory style production cannot solely rely on such scheme. All previously build large calorimeter systems required army of technicians. Students labor were used mostly for testing of different components, or simple prep work needed for assembly. I strongly suggest to find out what was the workforce structure used for ALICE shashlik assembly at WSU. As far as I know, a large team of technicians was assembled at WSU for ALICE production on top of team of technicians left from STAR BEMC construction project. The newly finished sPHENIX ecal production project may be used as a guiding example.

I suggest to build a realistic workforce structure, which will make comparisons between different detector configurations more reliable.

6. SiPM readout. Nothing was presented on min/max energy in the ecal readout channel. ATHENA numbers and YR, min 100 MeV, max 100 GeV, min in a tower 5 MeV.

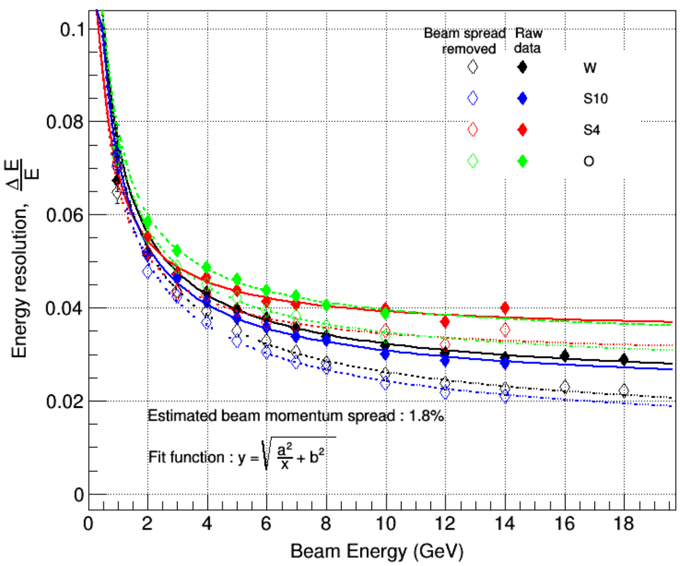
Guesstimating for ECCE readout these translates to 2.5 MeV – 30 GeV ? – please correct. (Guesstimate comes from shower profile at shower max as we have strips in STAR SMD somewhat similar in size to granularity of forward ecal, sure it is not a super accurate scaling).

For example, now the question is how many pixels one wants to see fired from 2.5 MeV? - say it is 10 pixels, which will be consistent with LY form such shashlik structure.
Then range will be 10 – 120k pixels. Proposed SiPM is S14160-3050HS as on slide, but it is probably S14160-3015?? Please clarify.

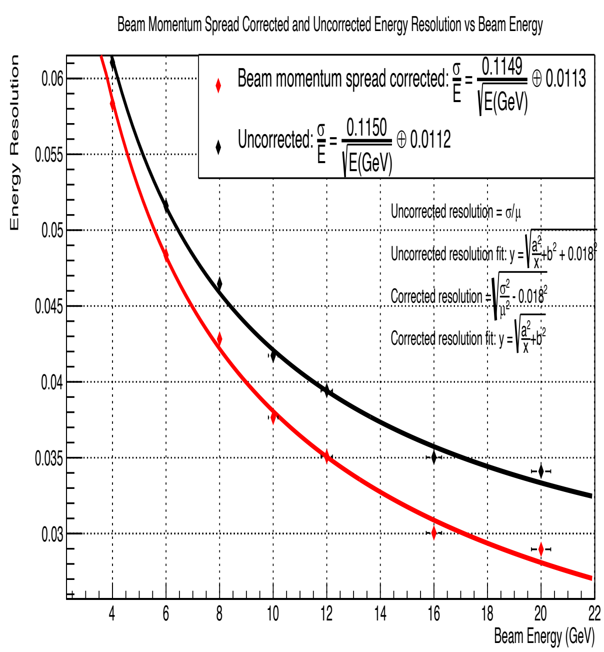
14160-3050HS has 3531 pixels – how this will match with 120K pixels fired from 100 GeV?
14160-3015 has 40k pixels – assuming that one was proposed, then one will need at least four SiPMs and still not enough.

I am totally confused with number of SiPMs and the type of SiPM to be used for readout. It is not clear how the proposed SiPM presented at the meeting will match the physics requirements in the YR. Please clarify this.

7. My previous questions related to attenuation lengths and readout upstream. We actually have experimental measurements for STAR FCS. In 2016 test run at FNAL we investigated if PHENIX ECal blocks can be used for STAR, concern was aging.
Plot shown below, green open diamonds – PHENIX Shashlyk resolution, readout single large PMT per block at the back of the module. Fit parameters 7.2% stochastic, 2.6% constant were found to be consistent with PHENIX measurements at test beam.



In 2019 test run block was outfitted with STAR SiPM readout. Readout in this case is upstream. We tried to measure at higher energies, but there were issues to get higher energy electrons. Fit is not great, it is missing 16 and 20 GeV points



At lower energies there is quite a difference in resolution between these two schemes of readout. It may be attributed to many factors (there are extra dead material in PHENIX blocks if readout is upstream, but it is also may be related to attenuation curve and where shower max is sitting on this curve).

The point I am trying to make here, resolution numbers as shown in the proposal as 7.8% stochastic and 0.3% constant used for validation may be way off. A single particle simulation including as much as possible realistic module structure need to be performed and effects on resolution had to be understood.

8. Readout information is incomplete; thus, the total cost of detector is not clear.

Summary:

I am still trying to understand details of the proposed ECCE fECa. Few critical items need to be clarified:

- Integration envelope
- Cost increase due to loss of vendor
- Readout with SiPMs
- Workforce structure
- Energy resolution used for validations.
- Cost of readout need to be presented.