Multidimensional Optimization Update

And Other Simulation-Related Topics

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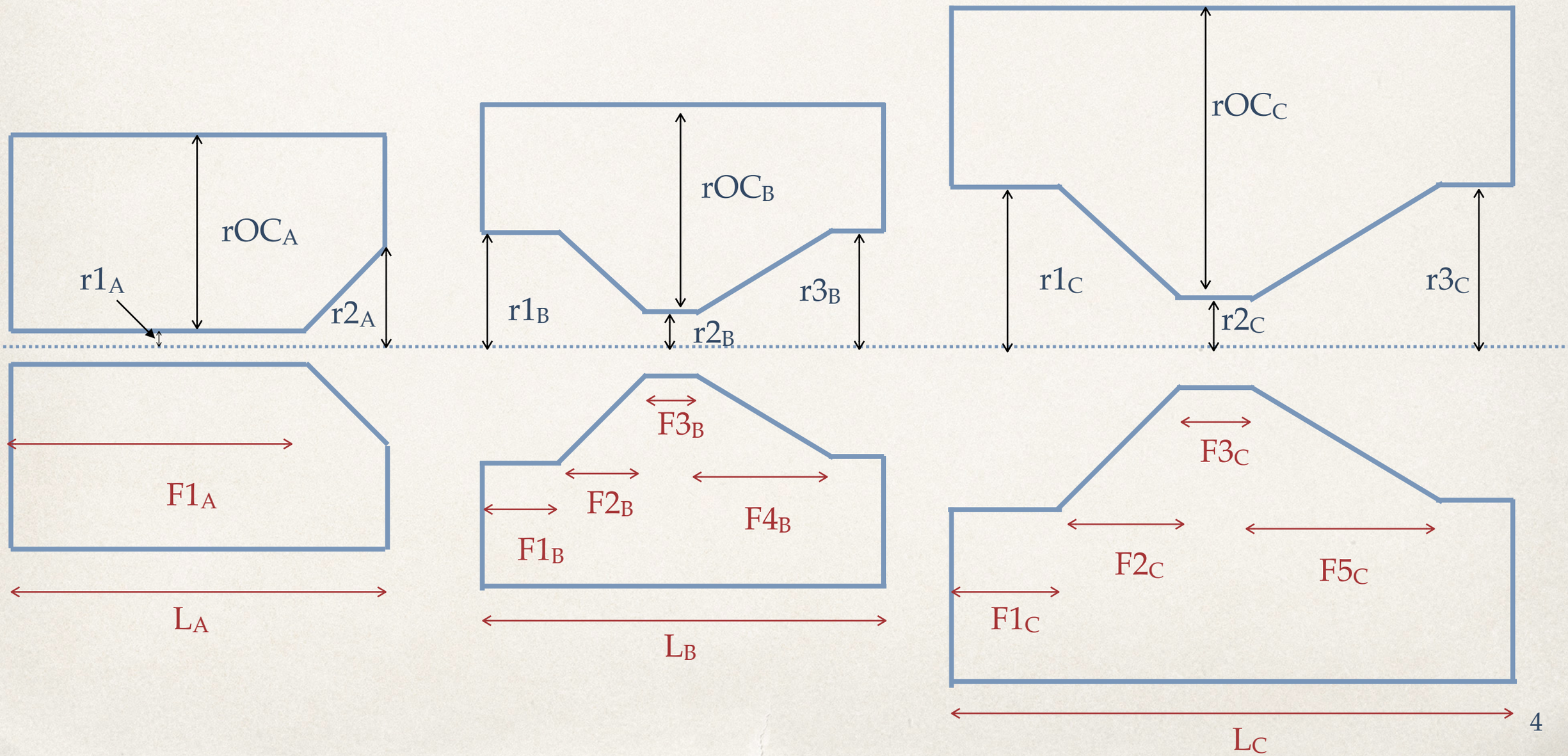
Outline

- First look at 3-horn optimization
- Other topics
  - Plan for studying effect of material in and out of optimization
  - Upgrades to G4LBNF
  - “Publishing” the CDR fluxes

Introduction

- I presented an optimization plan at our last meeting:
  - https://indico.fnal.gov/getFile.py/access?contribId=3&resId=0&materialId=slides&confId=10591
- Much work has gone on behind-the-scenes to get the beam simulation into shape to execute the plane
  - Many thanks to all involved, especially Paul LeBrun
- Communication with engineers is still ongoing
  - Working with Cory Crowley and Chris Densham to simulate a more realistic material description
  - In the meantime, I've started a three-horn simulation
- What I'll show today still uses 2 mm conductor thicknesses
  - But it has been a long time since the optimization code has been exercised and I wanted get things started again
  - Plan to study effect of more material discussed later in talk

Horn Configuration Used in Optimization



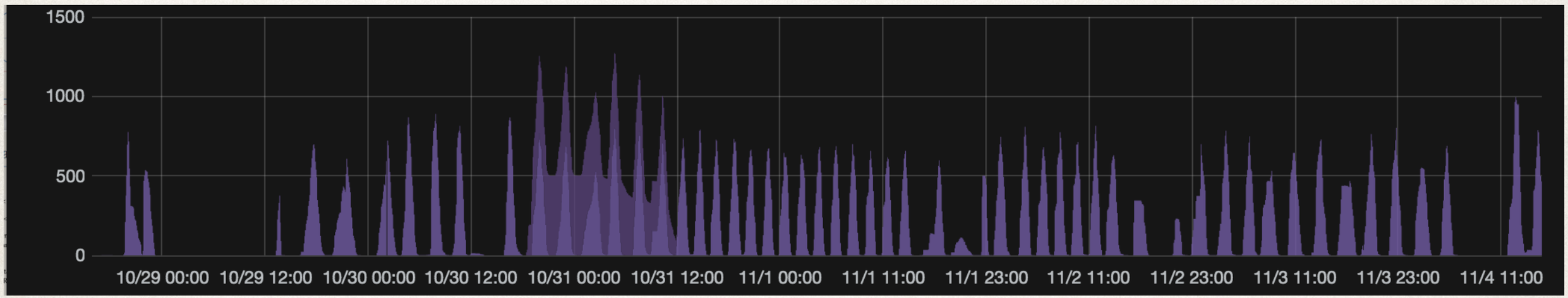
Optimization Parameters & Constraints

Parameter	Lower Limit	Upper Limit	Unit
Horn A: L_A	2000	4500	mm
Horn A: $F1_A$	1	99	%
Horn A: $r1_A$	20	50	mm
Horn A: $r2_A$	20	200	mm
Horn A rOC_A	200	650	mm
Horn B: L_B	2000	4500	mm
Horn B: $F1_B$	1	96	%
Horn B: $F2_B$	1	96	%
Horn B: $F3_B$	1	96	%
Horn B: $F4_B$	1	96	%
Horn B: $R1_B$	20	200	mm
Horn B: $R2_B$	20	200	mm
Horn B: $R3_B$	20	200	mm
Horn B: ROC_B	200	650	mm
HornB: Z position	2000	17000	
Horn C: L_C	1000	4500	mm
Horn C: $F1_C$	1	96	%
Horn C: $F2_C$	1	96	%
Horn C: $F3_C$	1	96	%
Horn C: $F4_C$	1	96	%
Horn C: $R1_C$	20	200	mm
Horn C: $R2_C$	20	200	mm
Horn C: $R3_C$	20	200	mm
Horn C: ROC_C	200	650	mm
Horn C: Z Position	4000	19000	mm
Target Length	0.5	1.75	m
Beam spot size	1.6	3.5	mm
Target Fin Width	9	15	mm
Proton Energy	60	120	GeV
Horn Current	200	300	kA

- Other Constraints:
  - $F1_B + F2_B + F3_B + F4_B < 99\%$
  - $F1_C + F2_C + F3_C + F4_C < 99\%$
  - Horn B must start after Horn A ends; Horn C must start after Horn B ends
  - All horns must be contained within 21 m of MCZERO
  - Graphite fin target (also plan optimizations with graphite cylindrical target and Beryllium sphere)

Optimization Status

- Number of Running jobs on Fermigrid versus time over the past week by the DUNE experiment (from fifemon.fnal.gov)

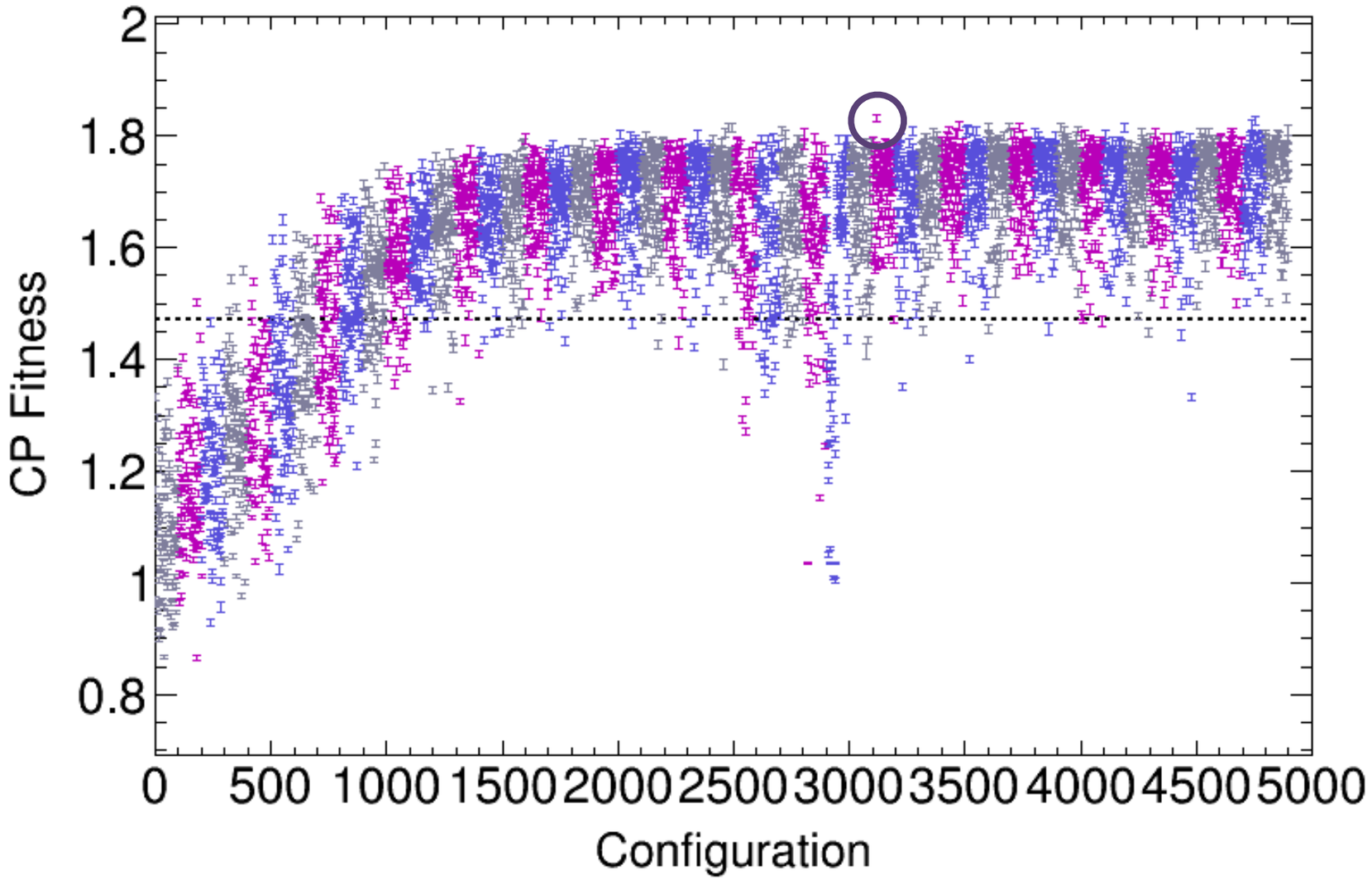


This is presumably someone else running something

Peaks are generations of my genetic algorithm — generations took ~2 hours when grid was not busy

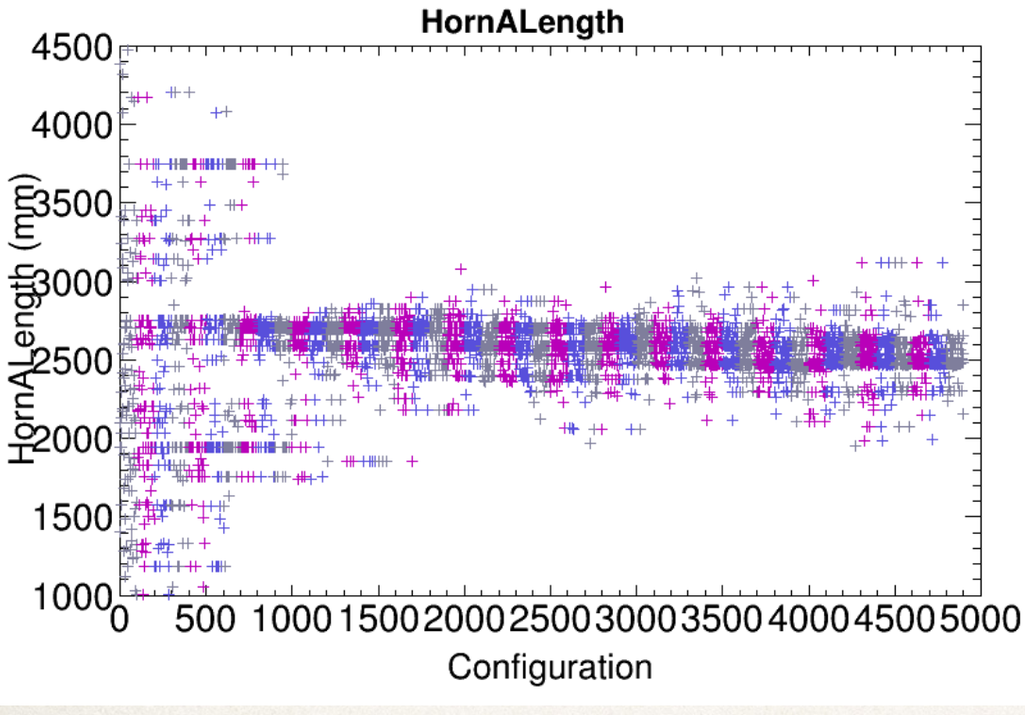
Optimization Status

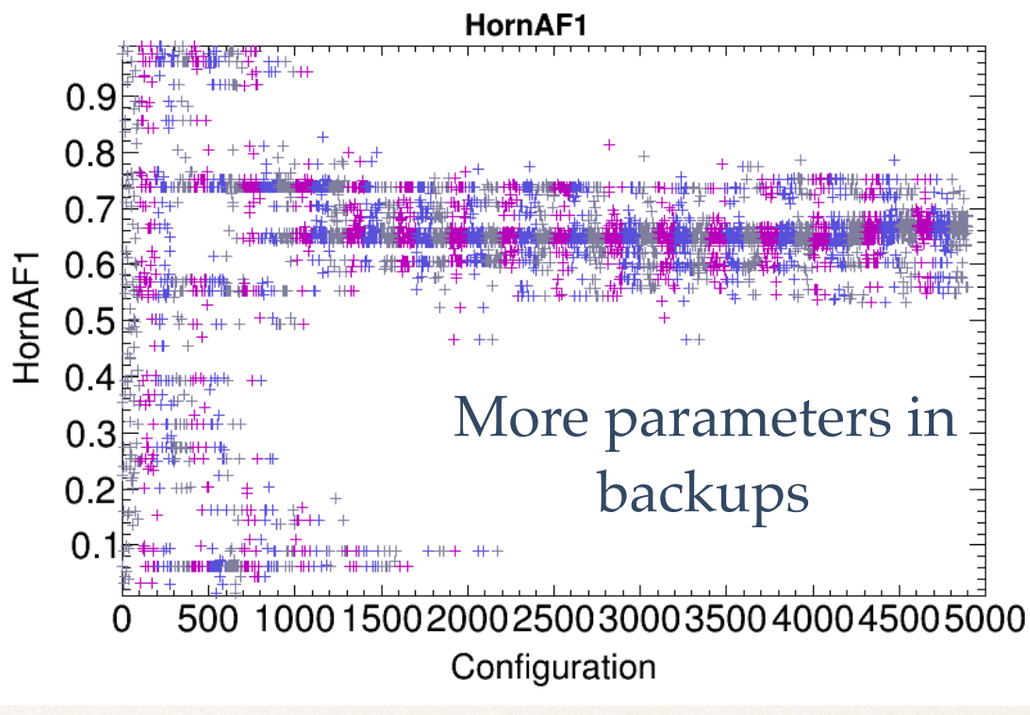
- Optimization appears to have mostly converged, or at least is very slowly evolving (See also next slides)

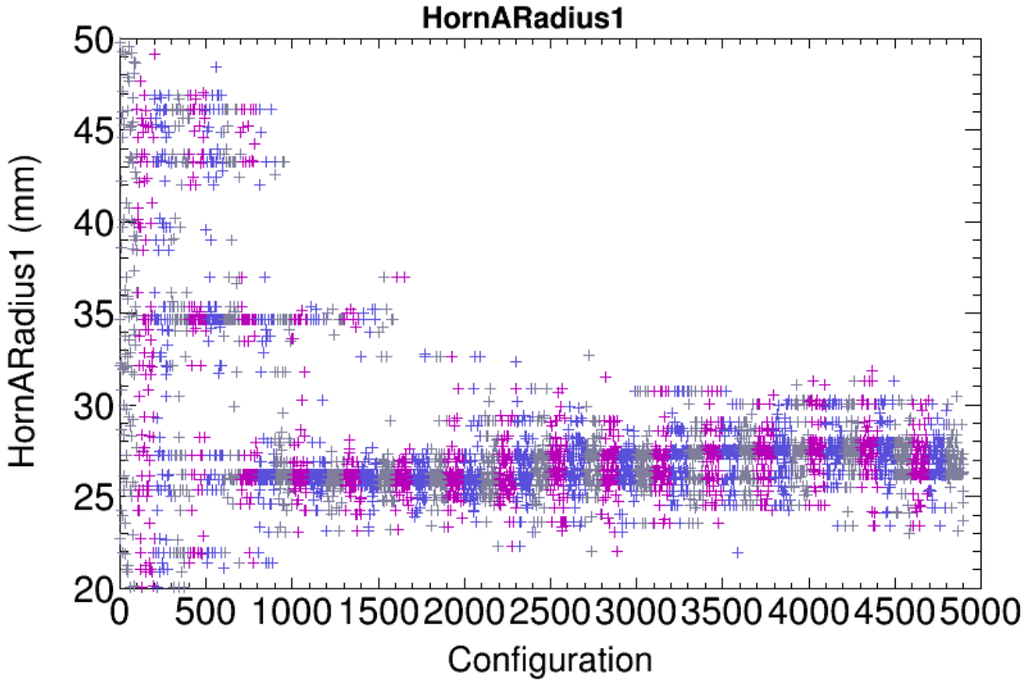


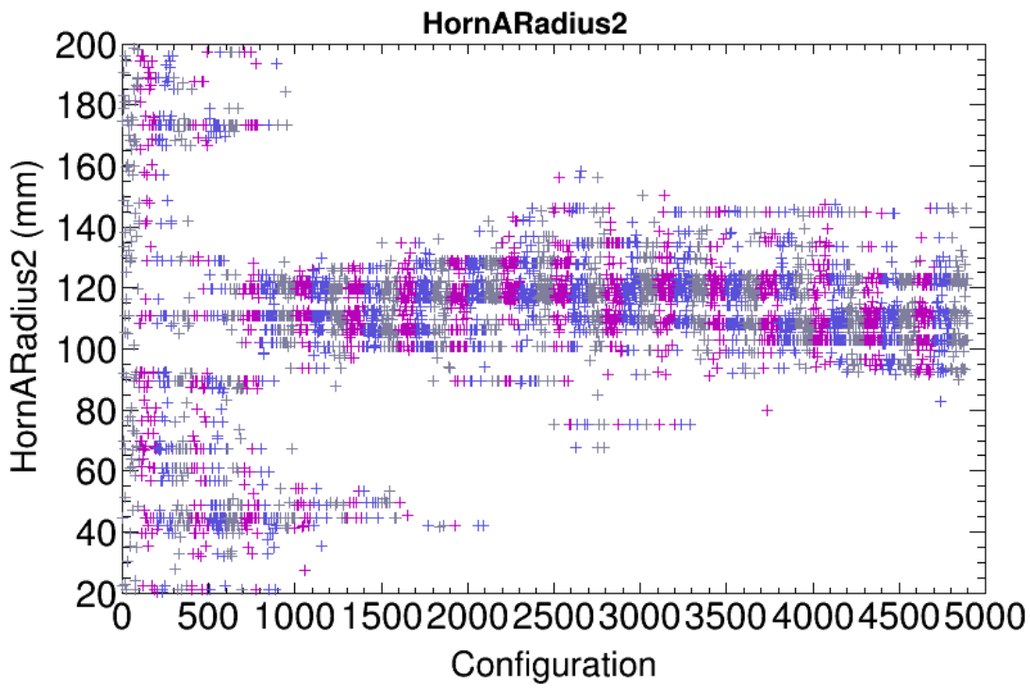
This point makes me think it has not really converged -> I'm increasing mutation amplitude to see what happens.

Optimization Status

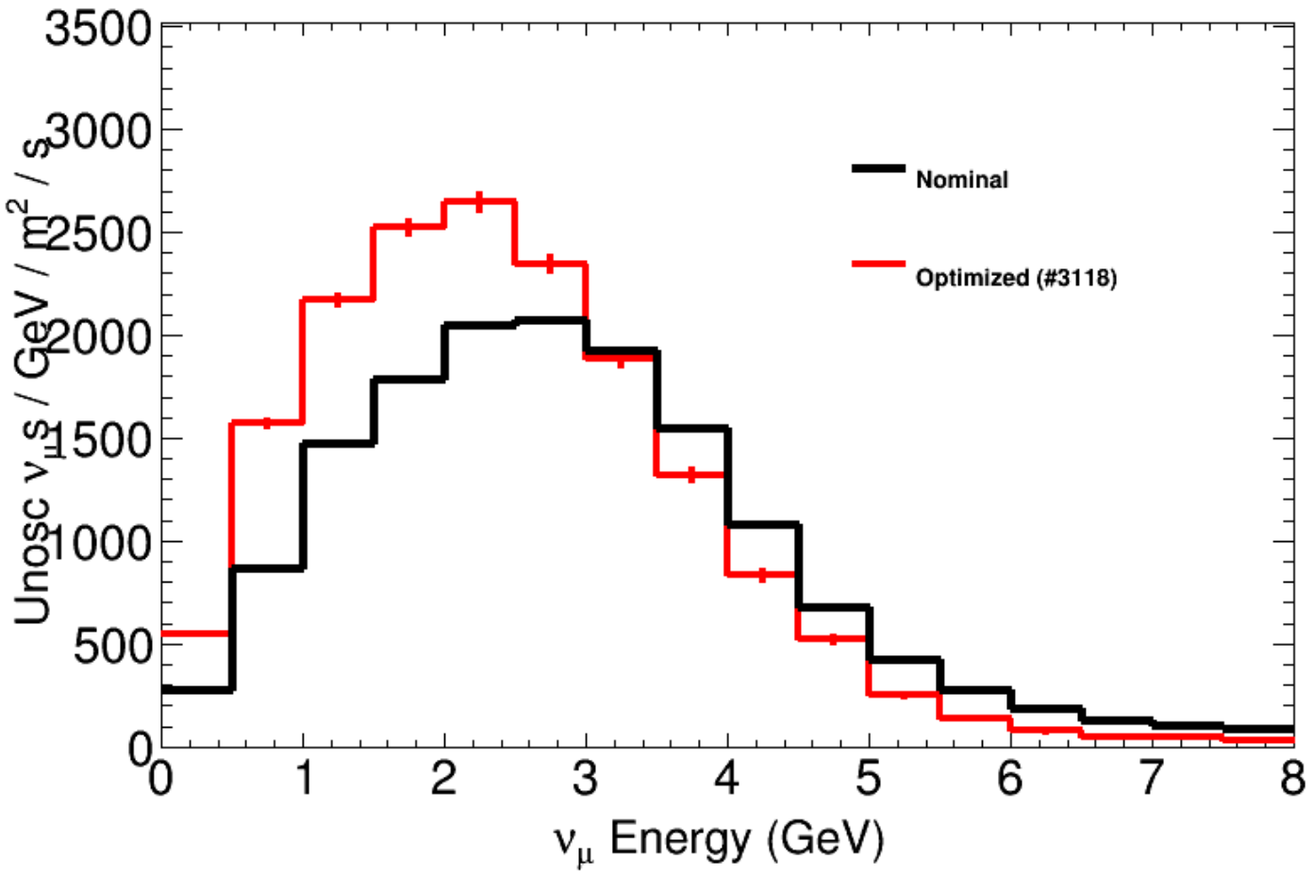








Optimization Status



Optimized flux is not quite as "good" as previous rounds of optimization

Fitness improved by ~25% (33% in past)

```
HornALength 2474.24652181
HornAF1 0.646777487949
HornARadius1 27.4988568404
HornARadius2 108.307581032
HornARadiusOC 426.066296294
HornBLength 2234.07181962
HornBF1 0.0534824933039
HornBF2 0.134213036831
HornBF3 0.0789194611274
HornBF4 0.318603546644
HornBRadius1 41.9751369937
HornBRadius2 140.614029938
HornBRadius3 137.210462326
HornBRadiusOC 424.53218475
HornBLongPosition 2859.13382673
HornCLength 2181.81891488
HornCF1 0.0460966653844
HornCF2 0.149842934581
HornCF3 0.0628906478733
HornCF4 0.0375795909579
HornCRadius1 53.0904462269
HornCRadius2 115.597933547
HornCRadius3 198.654608188
HornCRadiusOC 565.440731278
HornCLongPosition 9732.90365343
GraphiteTargetLength 1.87417000729
GraphiteTargetFinWidth 10.7577357091
BeamSigma 1.77026342161
HornCurrent 243.749485067
ProtonEnergy 61.5513405775
```

Optimization Status

- Visualization of the "best configuration"

- Optimization seems to have gotten stuck in a funny corner of horn-shape phase space

- Will try putting more constraints on horn radii (to force middle segment to be small and outer segments to be large)?

Plan for Implementing Realistic Material Description

- Reminder
  - The horns used in my optimization are idealized in many ways, such as
    - 2 mm conductor materials throughout
    - Hard corners at transitions between conductor segments
    - No spider supports, ribs, welds or striplines
- Implementing a realistic description is difficult without significant engineering input
- But I have got preliminary input from Cory Crowley and Chris Densham, and plan to implement these in two ways
  - Take output of optimization and implement a “one-off” realistic design
  - In parallel, add material to horns used in optimization in very simple ways
    - These shapes must be kept simple, so will not add detailed information about horn shape, but will e.g. thicken endcap conductors to approximate striplines

Plan for Implementing Realistic Material Description

- Reminder
  - The horns used in my optimization are idealized in many ways, such as
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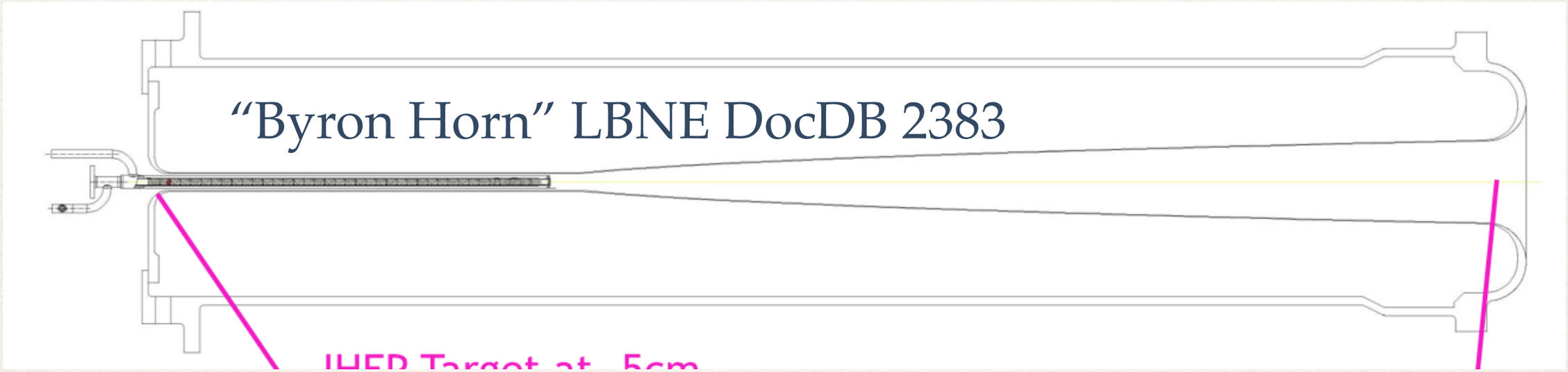
This is one of the most important tasks of the beam optimization task force, and is an excellent place for a new (or old) person to get involved with the project

  - ng input
  - d plan to
    - Take output of optimization and implement a “one-off” realistic design
    - In parallel, add material to horns used in optimization in very simple ways
      - These shapes must be kept simple, so will not add detailed information about horn shape, but will e.g. thicken endcap conductors to approximate striplines

Upgrades to G4LBNF

- More detail on Cory's suggestions:
  - Most important details to implement: Rounded edges on end without stiplines, slightly rounded edges on end with stripling



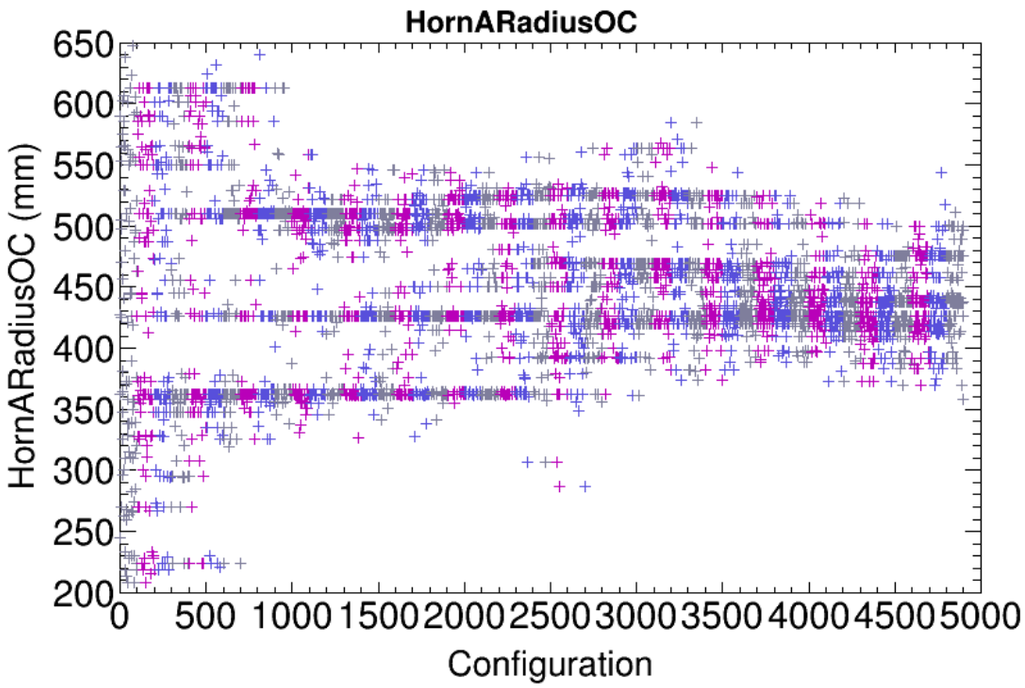
- 3 mm inner conductor thickness at neck, 2 mm elsewhere for Horn A and B
- 3.5 mm inner conductor for Horn C
- 10 mm outer conductor thickness
- 10 mm thickness for half of endcap, transitioning to 2 mm
- Additional 10 mm thickness for striplings at outer 7 cm of horn endocarps
- Striplines at upstream end of Horn A, downsntream end of Horns B and C

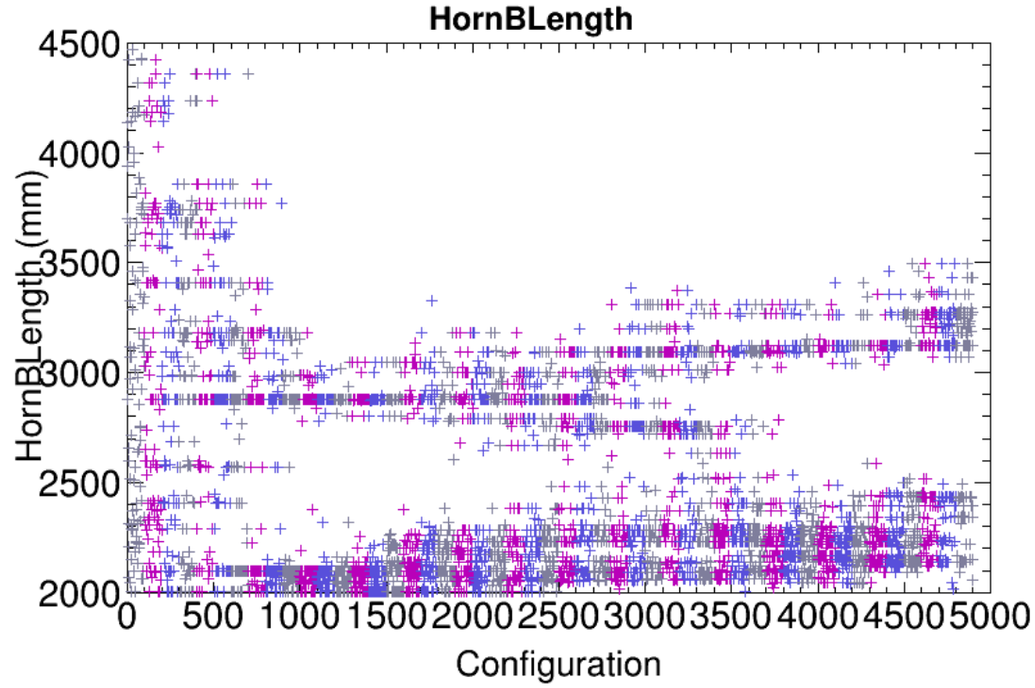
“Publishing” Our Simulation

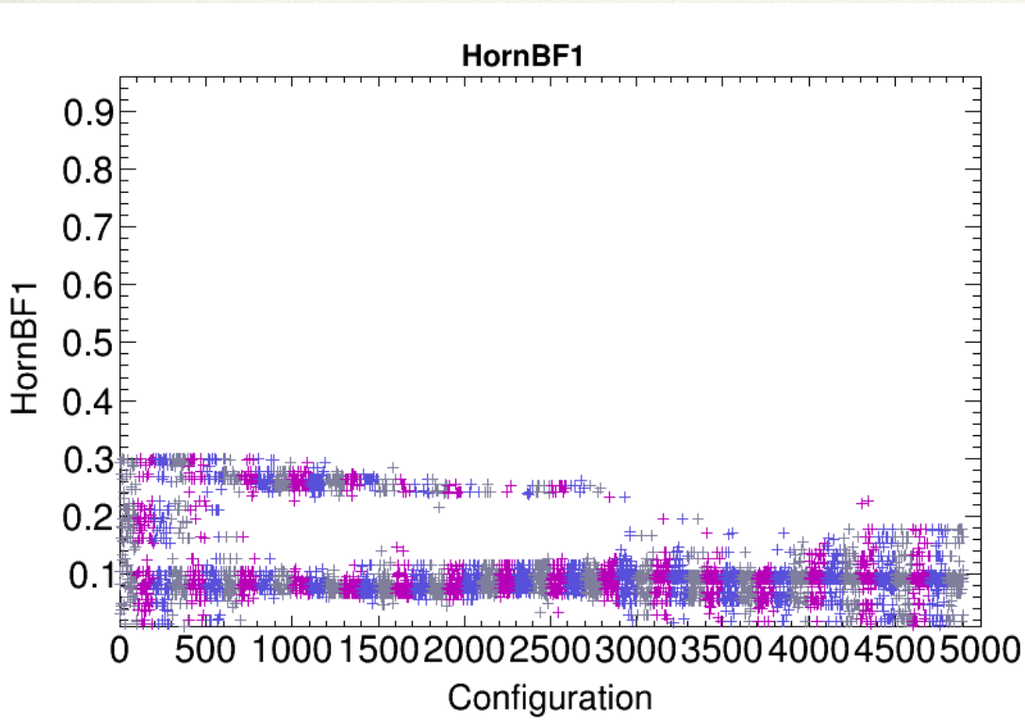
- Elizabeth W has proposed that we put the CDR fluxes on the Arxiv
  - Would basically mean posting the information here:
    - http://home.fnal.gov/~ljf26/DUNE2015CDRFluxes/
    - Plus a little text to explain what it is
  - Idea is to have something citable for people using our flux
  - Similar things are being planned for other pieces of sensitivity calculations reported in CDR
  - Still being decided whether flux will be separate from or combined with other pieces
  - Let me know if you oppose this proposal

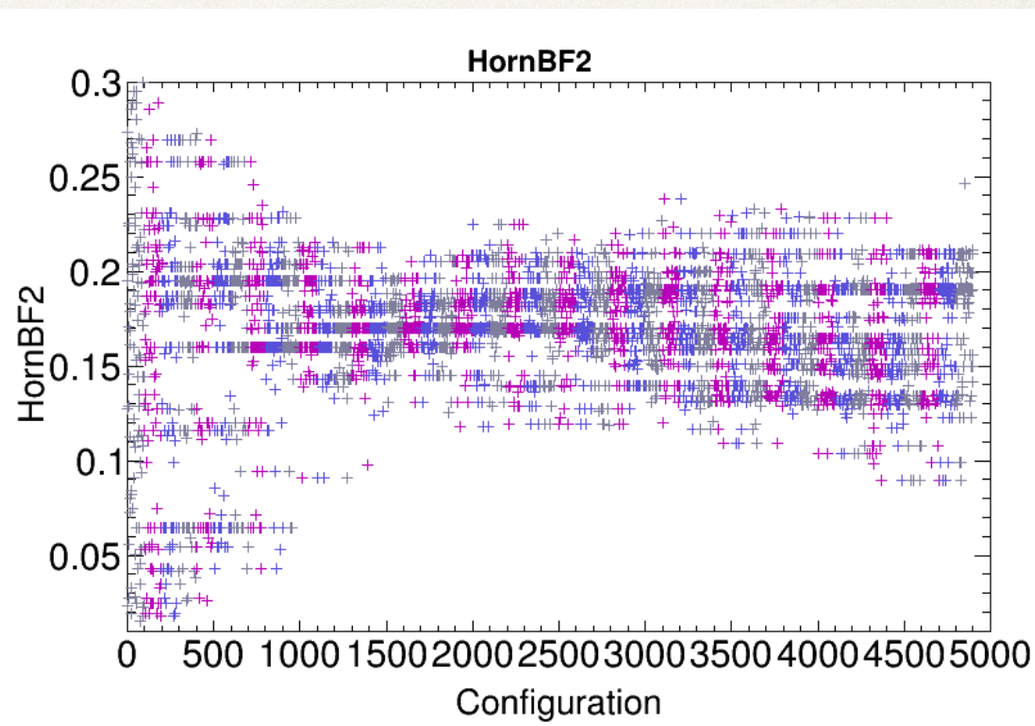
The End

Optimization Status









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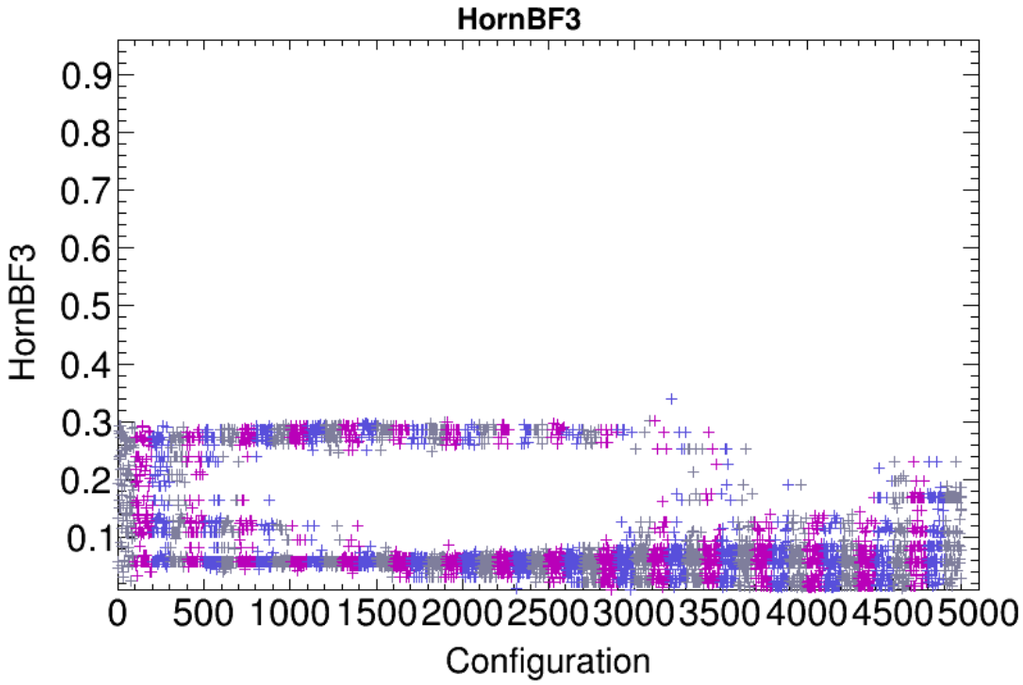

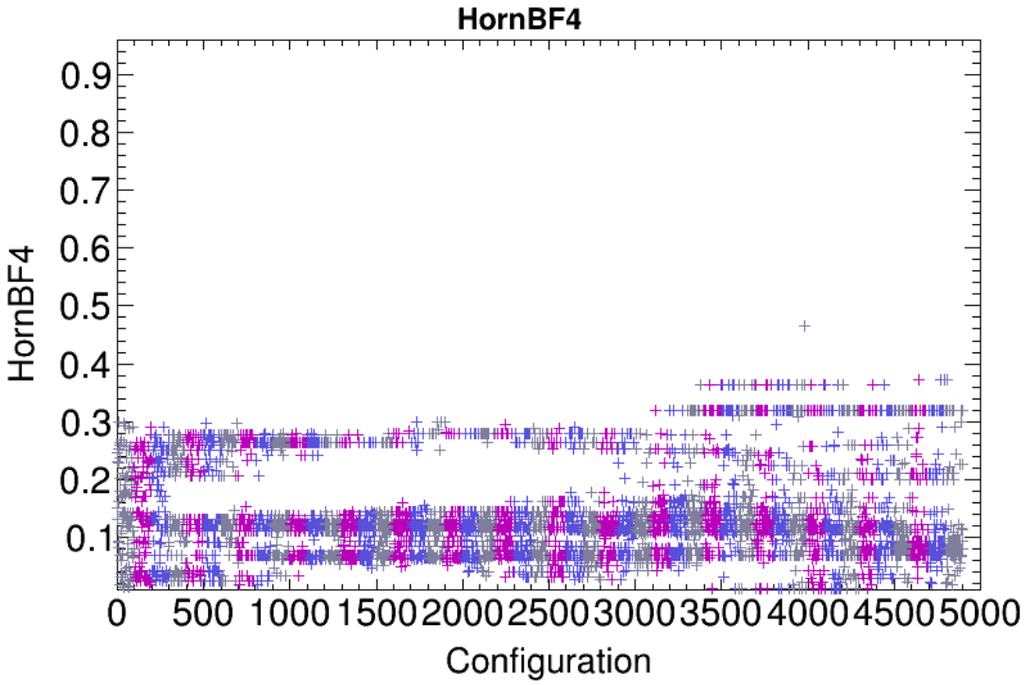

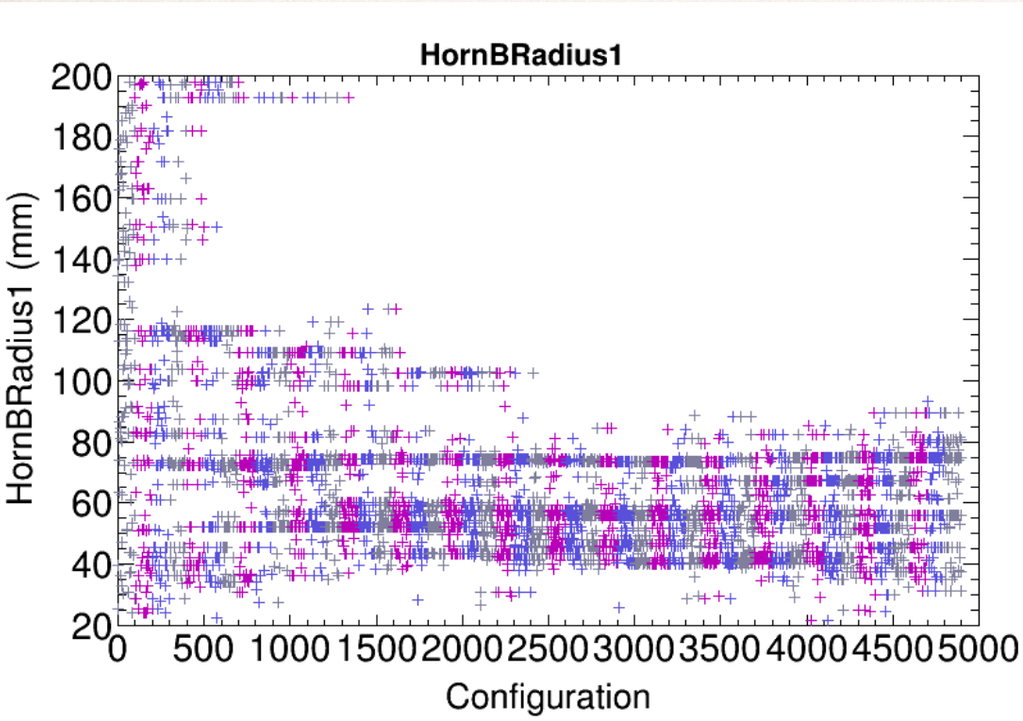

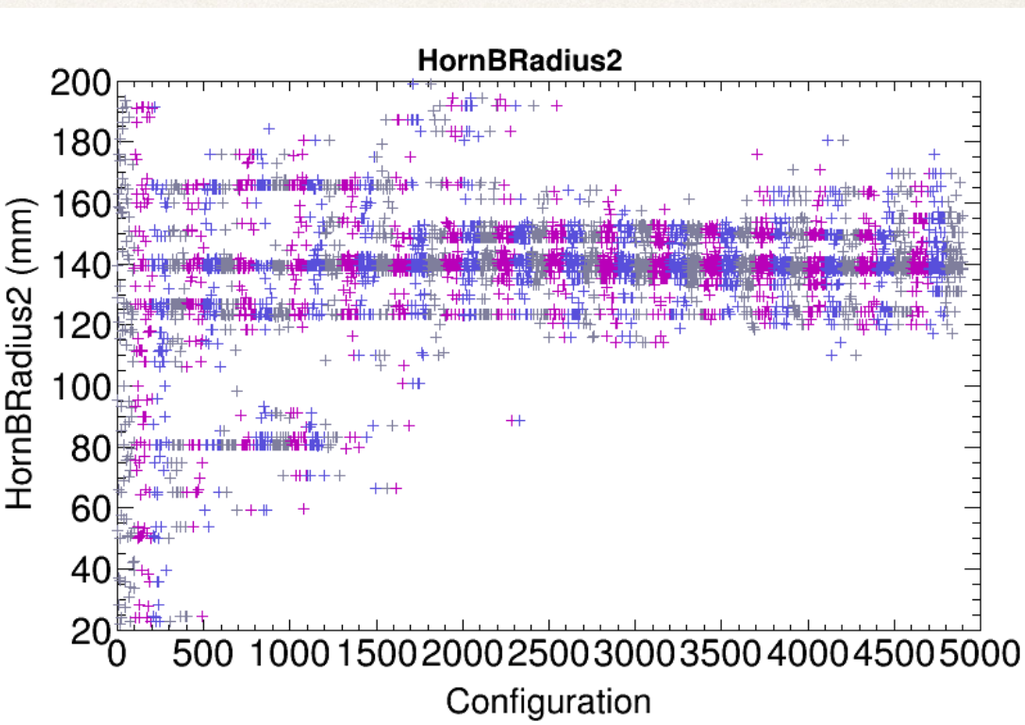

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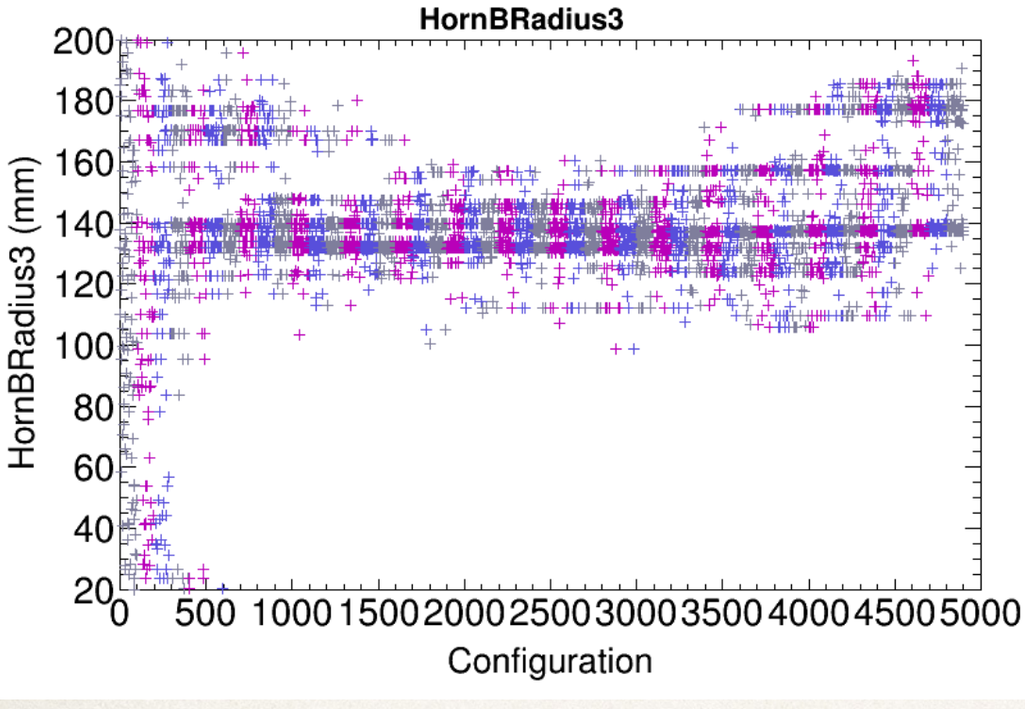

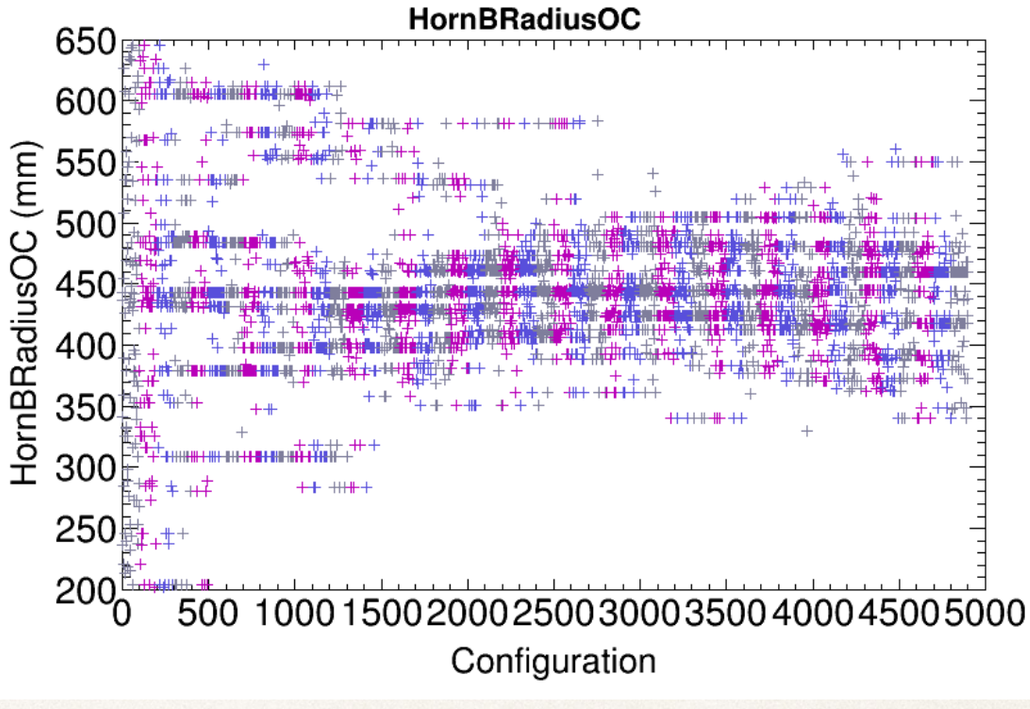

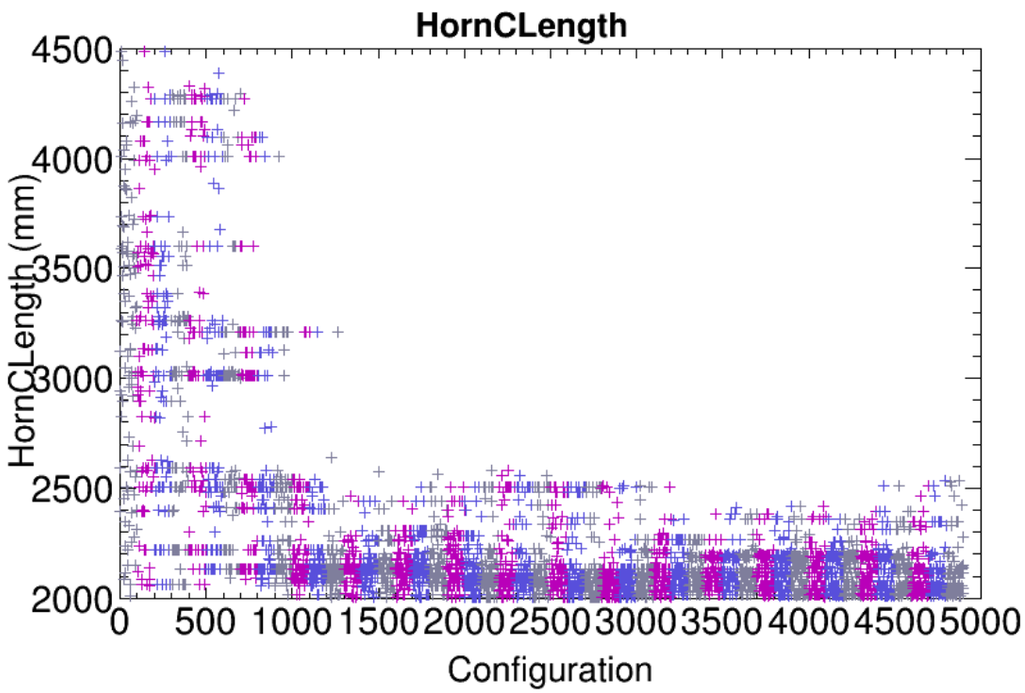

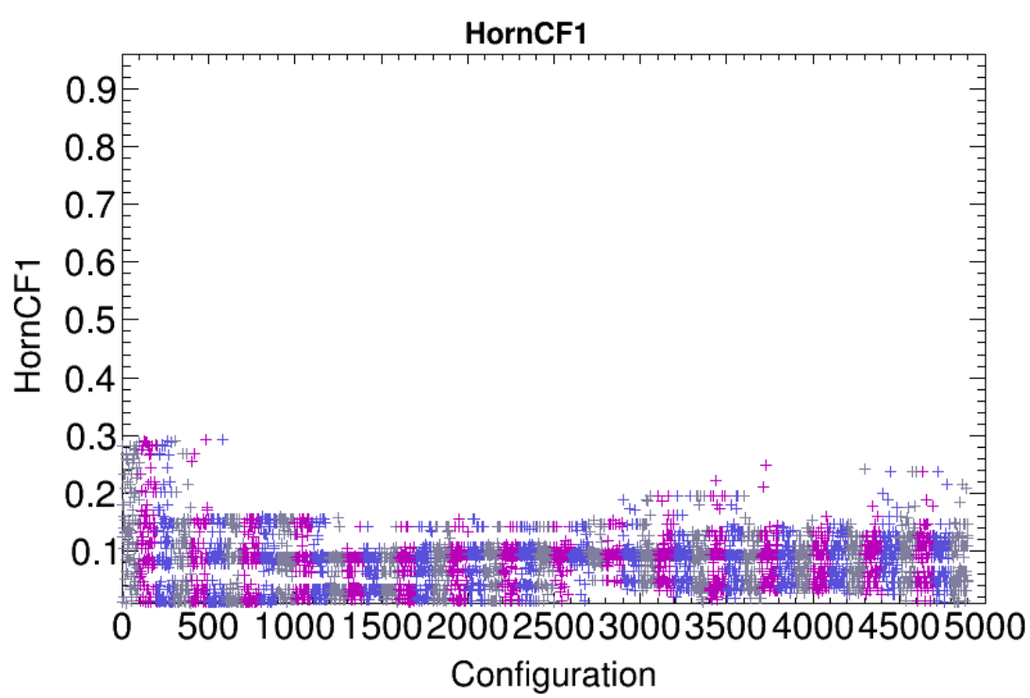

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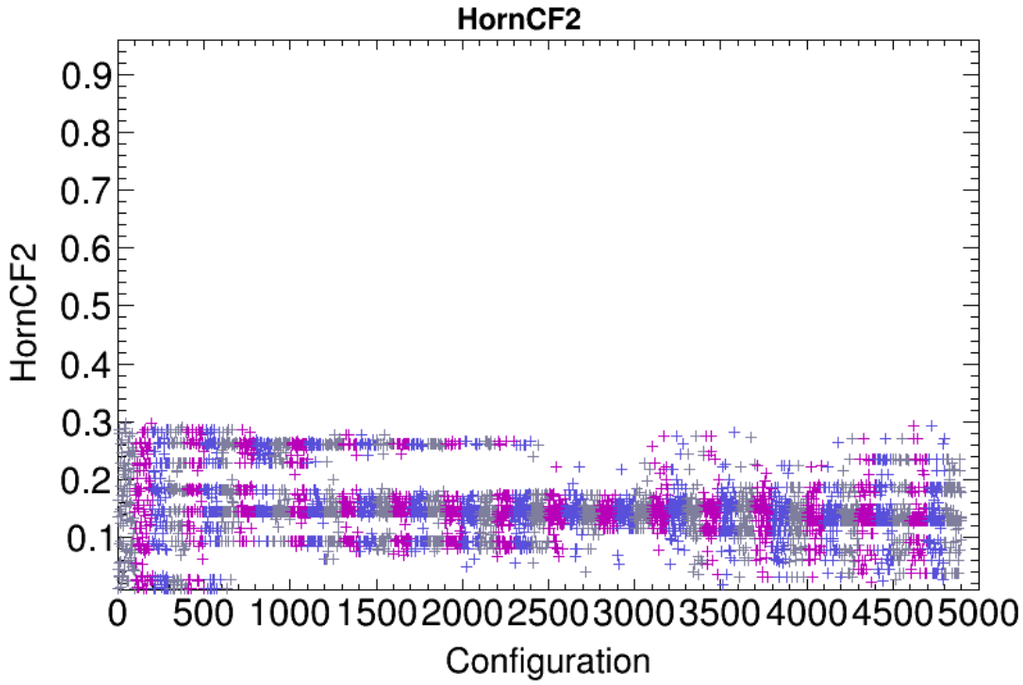

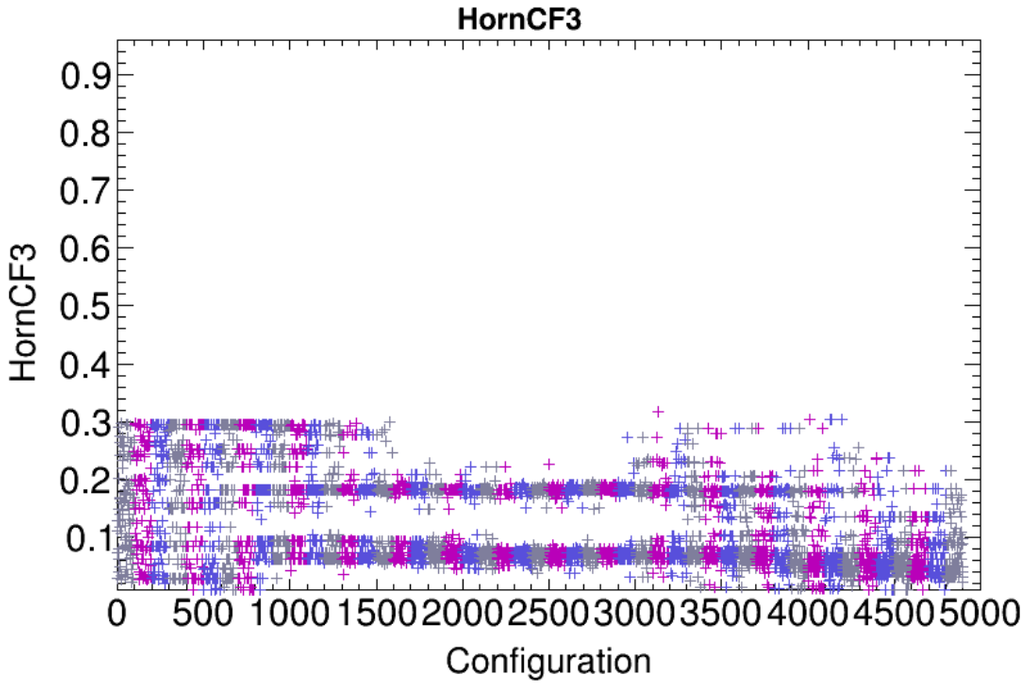

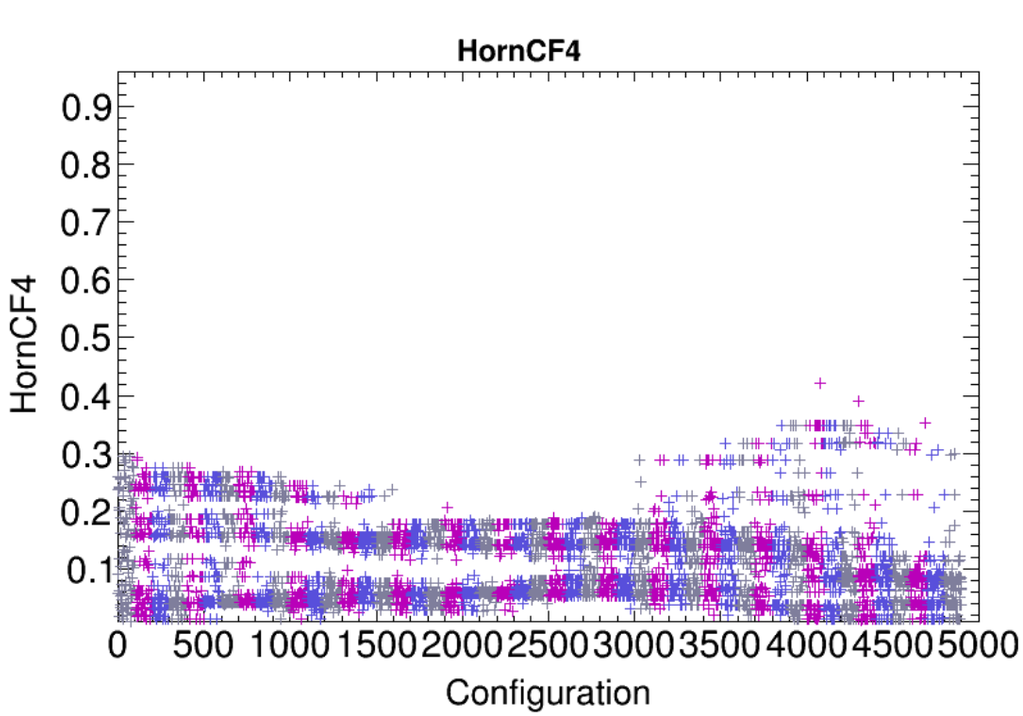

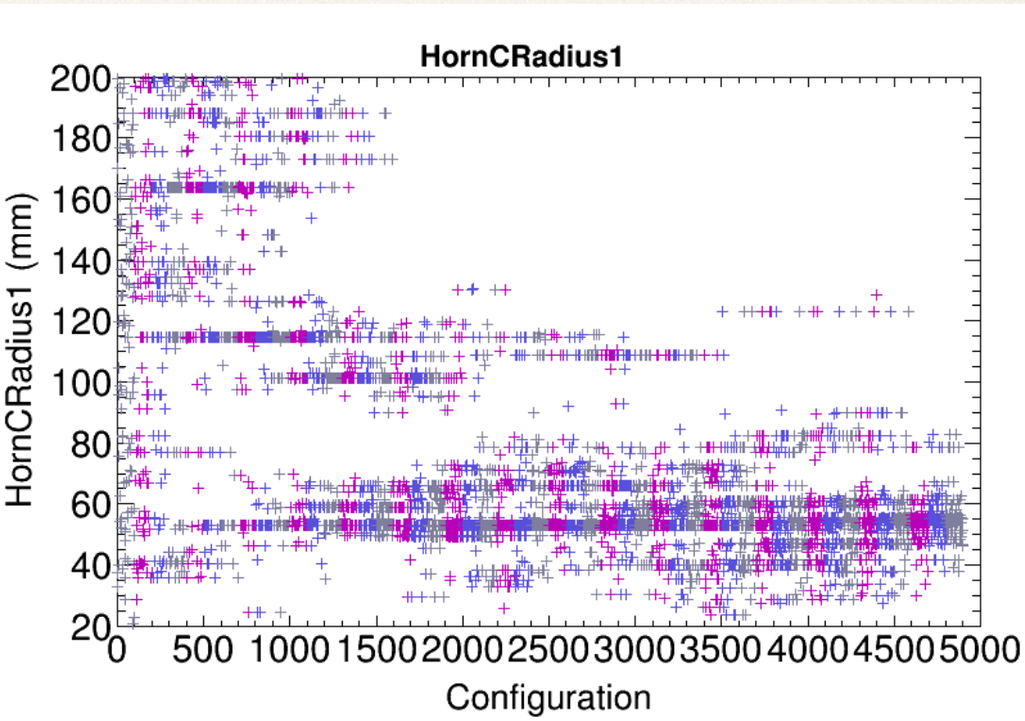

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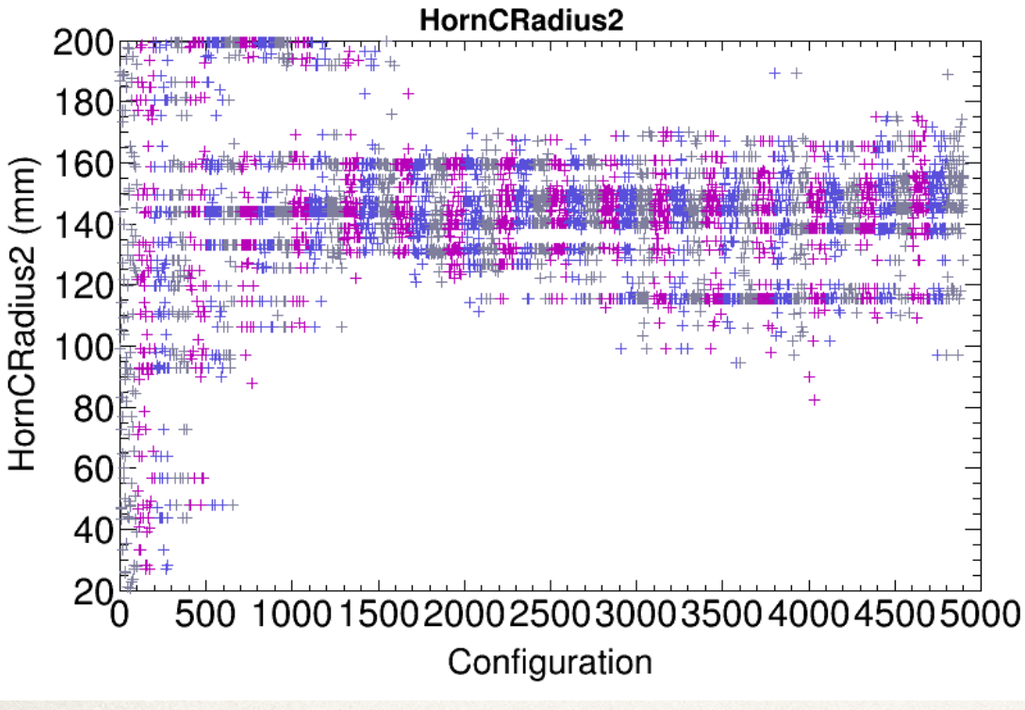

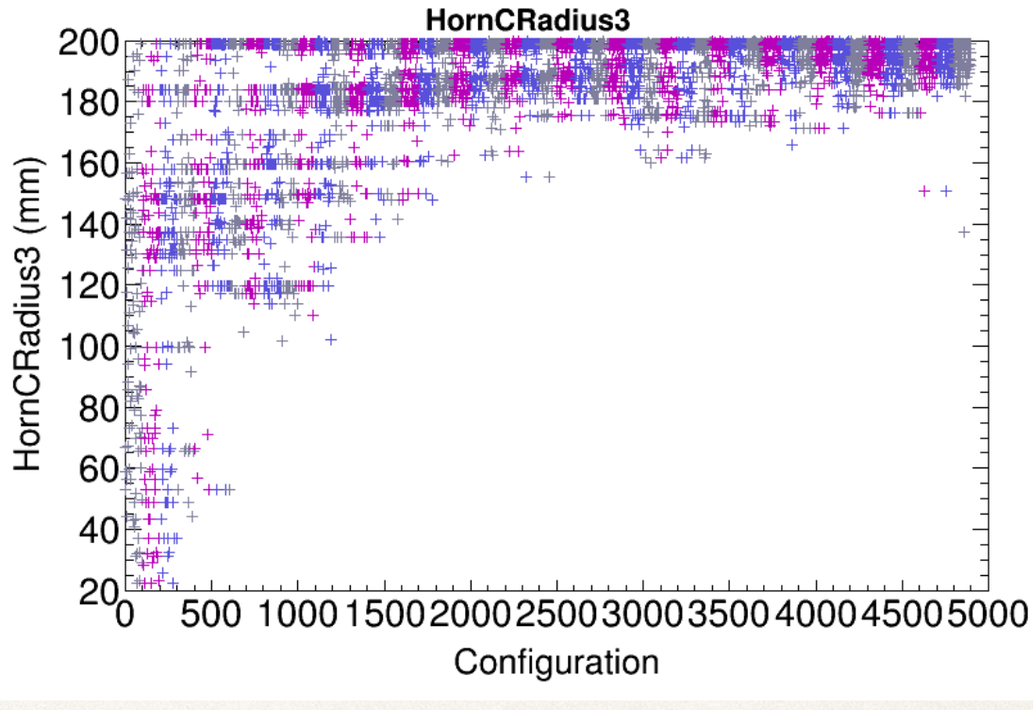

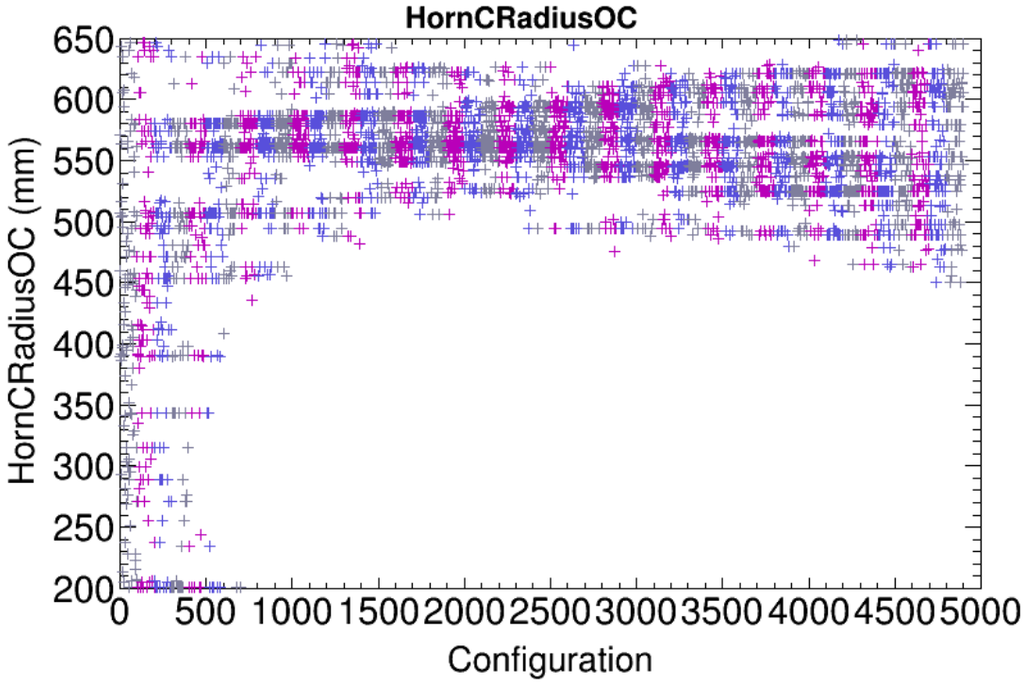

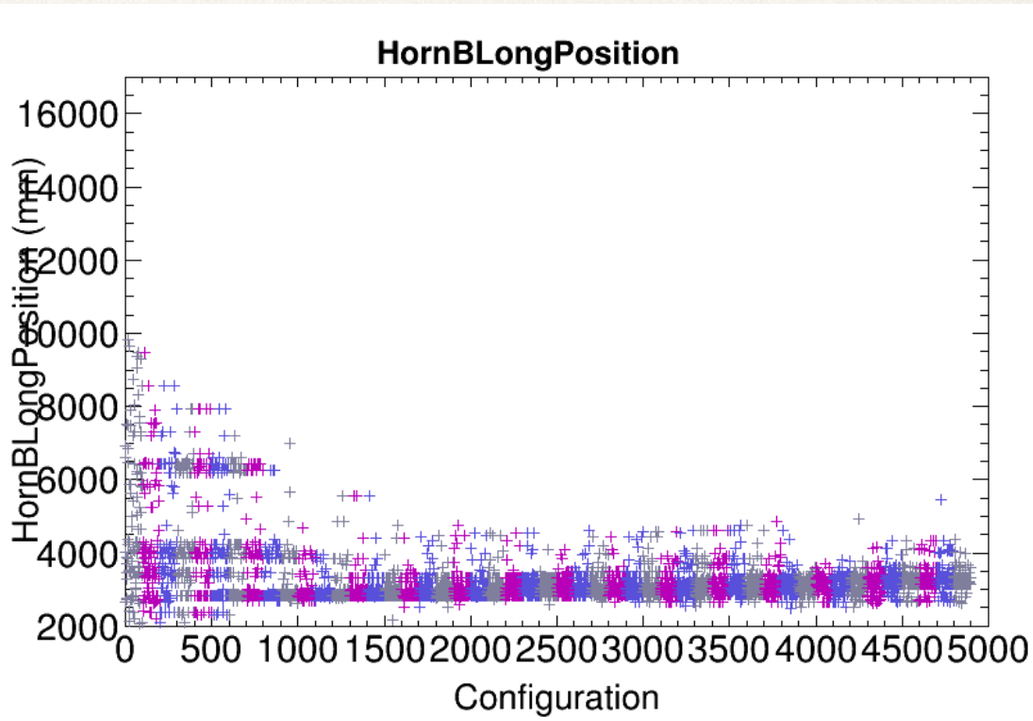

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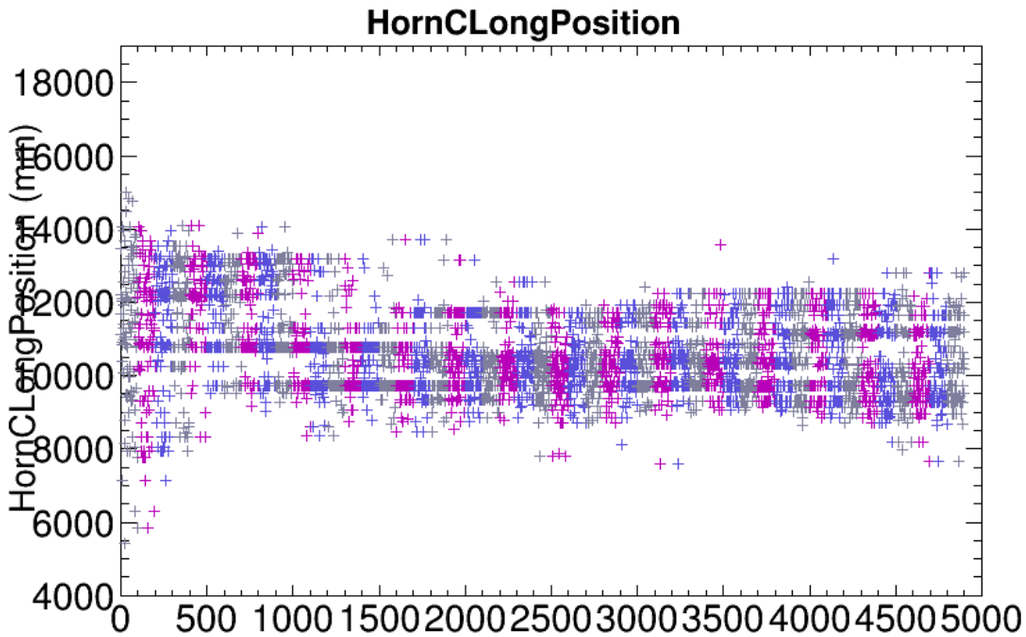

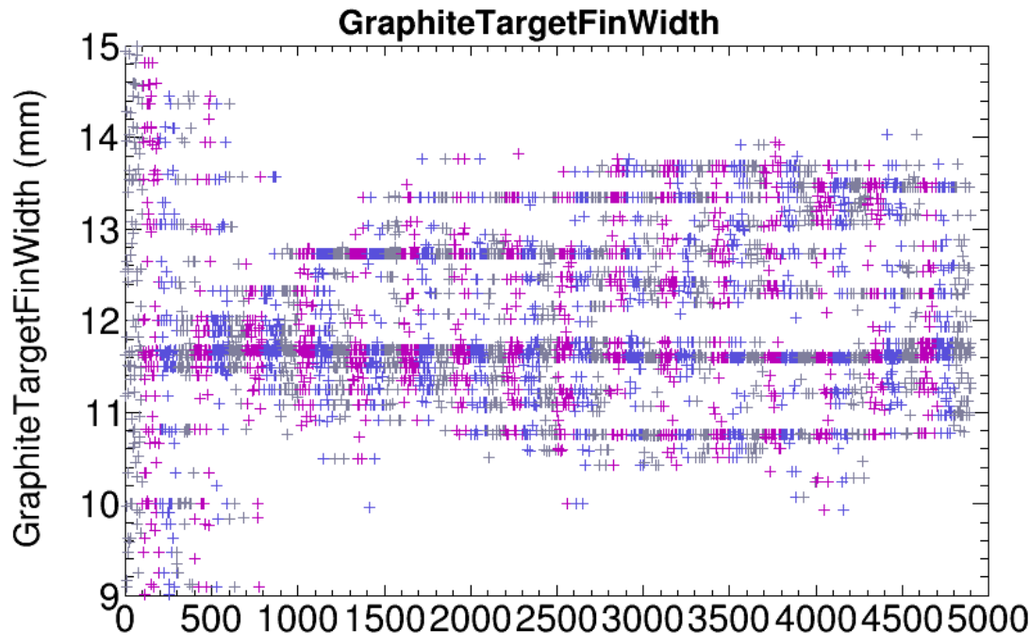

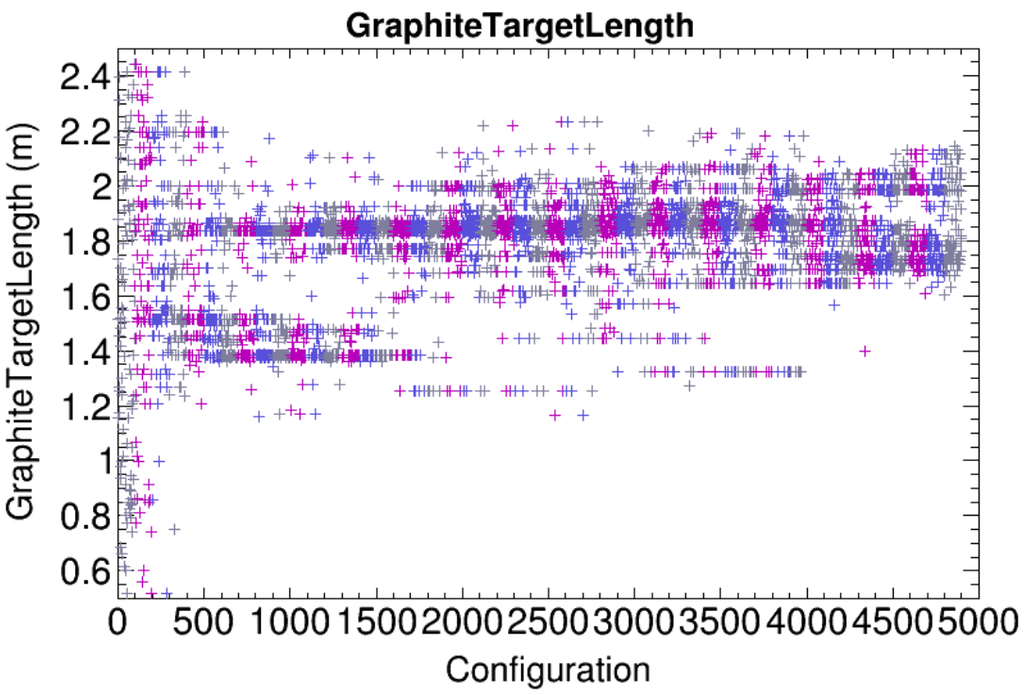

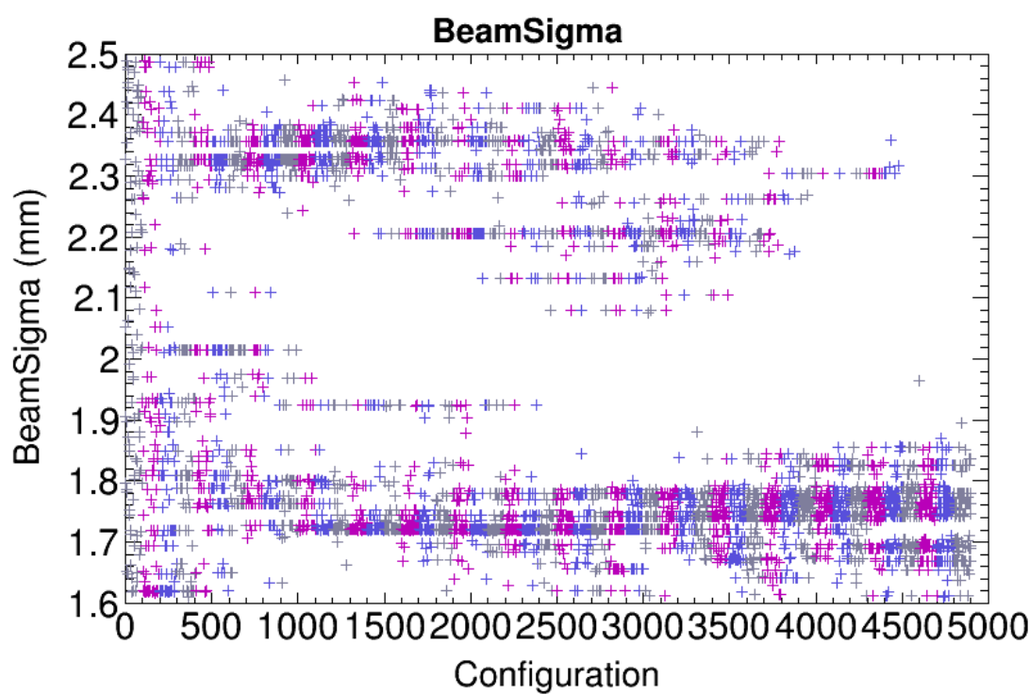

Optimization Status