RF FOIL for the VELO UPGRADE (Syracuse)

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OUTLINE:

1. Introduction
2. Module Layouts: L Si, L SiDi
3. RF Foil Design, Drawings
4. Simulation

INTRODUCTION

We all know the foil has a big impact in the VELO (~½ total X0)

Lots of ideas floating around for the upgrade – great!

Would be beneficial to keep in mind that…

All parts of the overall design (modules, foil, sensors, cabling, etc.) are connected and impact each other (mech'y, thermally, etc.).

The design choices of module size, overlaps, gaps, guard rings, foil thickness, foil shape, etc. have to be seriously simulated.

Many of the fabrication technologies have yet to be established.

Will concentrate on CF composite foil work and L-shaped modules…

MODULE – L Si (1)

Basic L-shaped module designed to determine module "envelope" around which to snake the RF foil

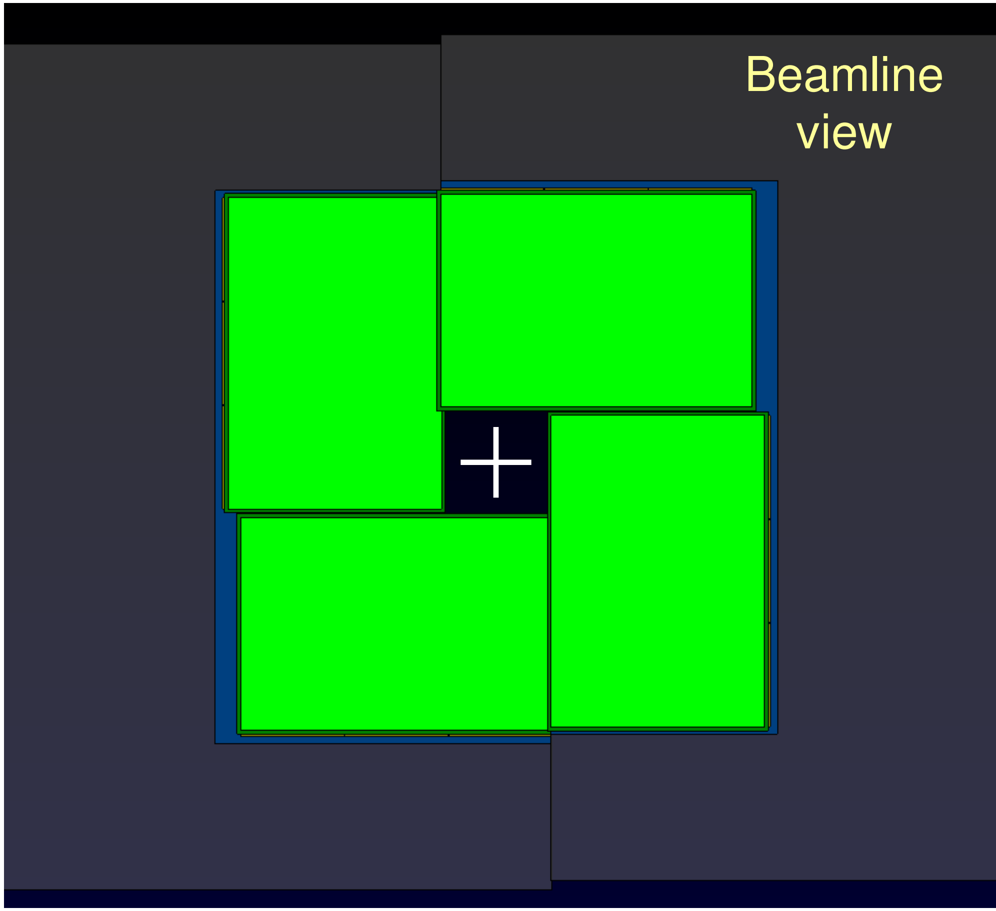
- Inner radius 7.0 mm (for either case, with or w/o GR)

Split the silicon

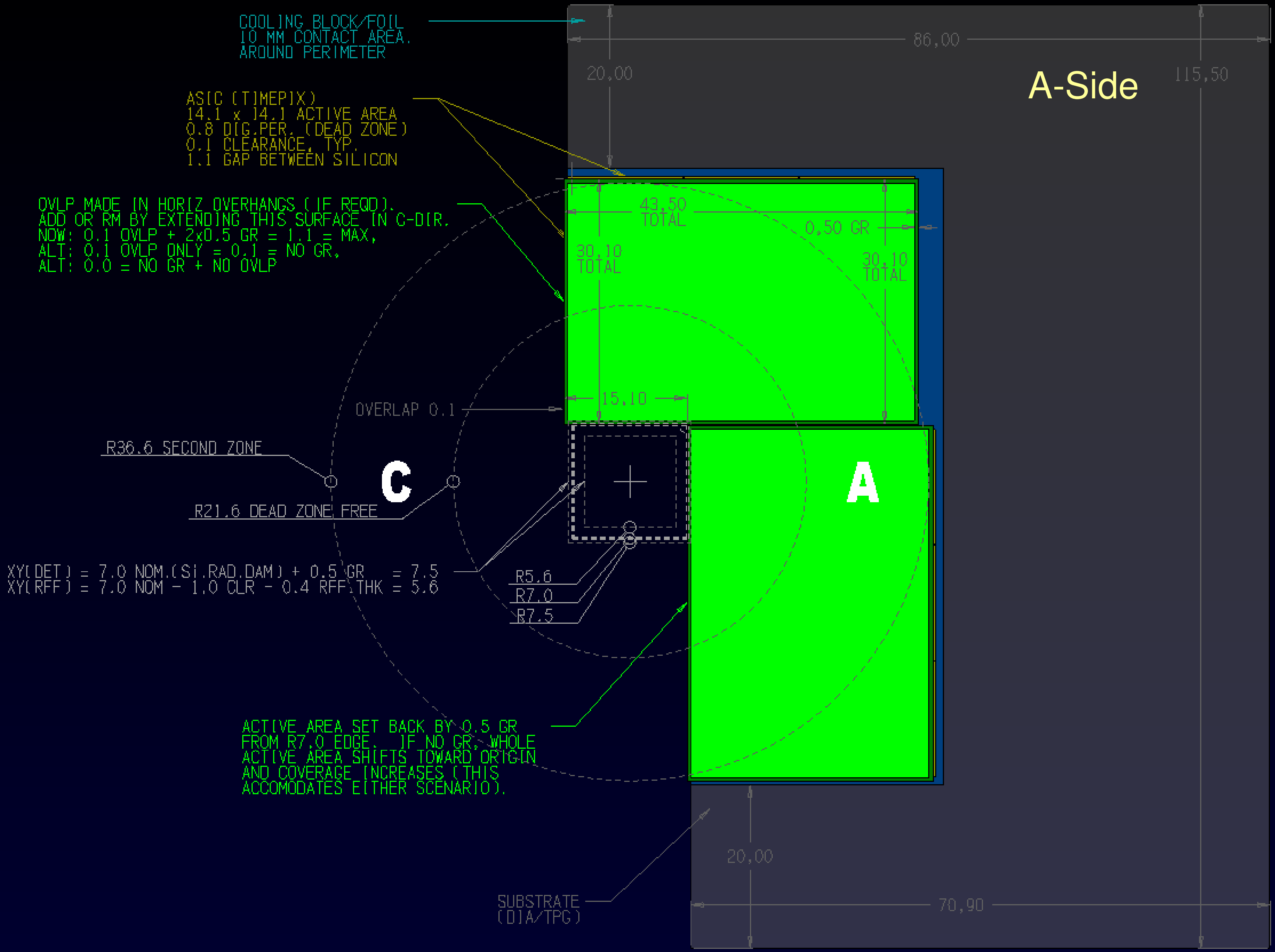
- In same plane, w gap (this design)
- In different planes, w no gap
  - two "half"modules, top and bottom, to allow overlap
  - same module, both sides – more "balanced" in terms of mech stability under thermal cycling
- Depends in part on overlap

Missing:

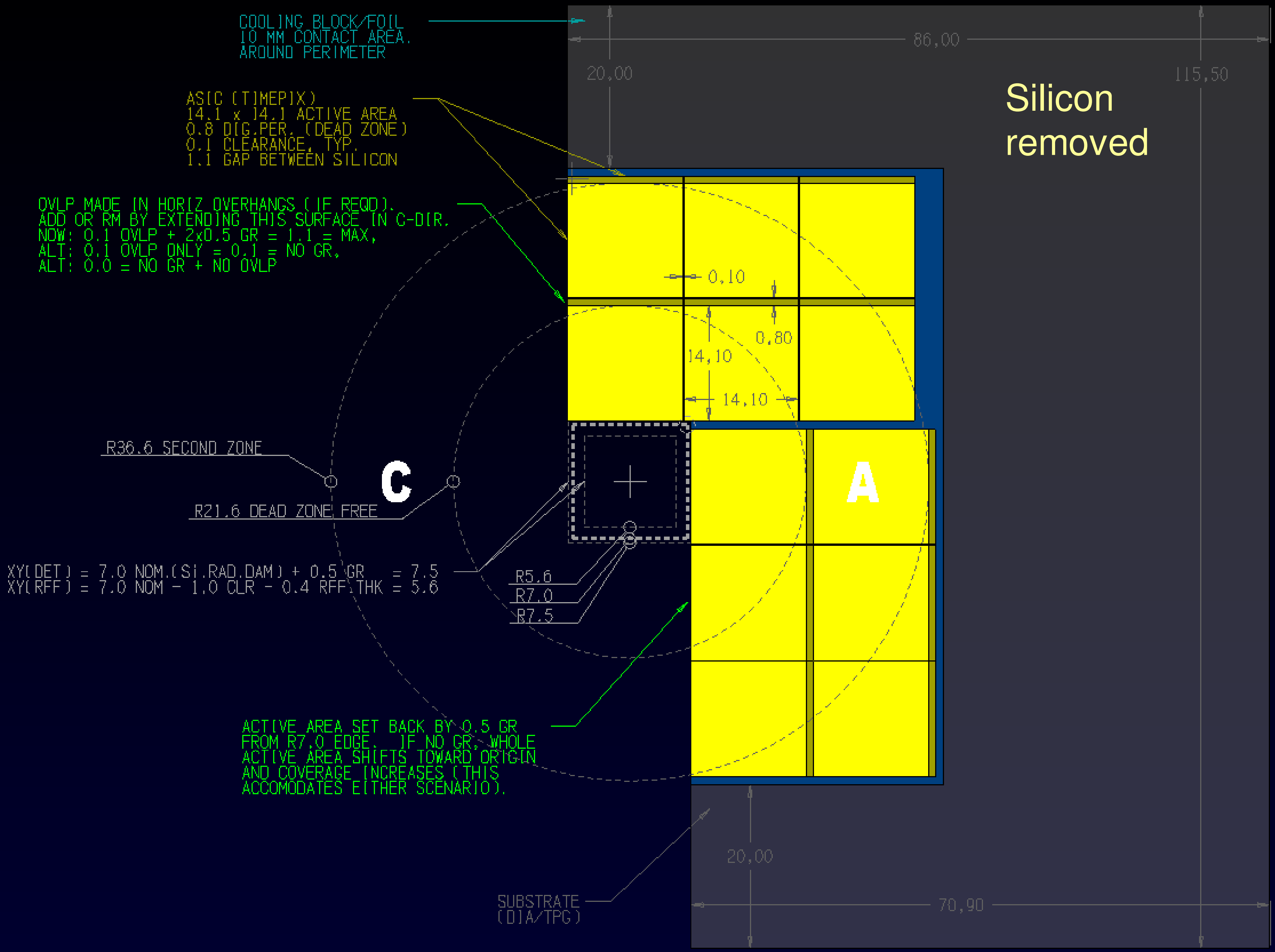
- No cabling yet
- No TSV, wirebond holes
- Placeholder only for cooling



MODULE – L Si (2)


COOLING BLOCK/FOIL
10 MM CONTACT AREA.
AROUND PERIMETER
86,00
20,00
A-Side
115,50
ASIC (TIMEPIX)
14.1 x 14.1 ACTIVE AREA
0.8 DIG.PER. (DEAD ZONE)
0.1 CLEARANCE, TYP.
1.1 GAP BETWEEN SILICON
OVLP MADE IN HORIZ OVERHANGS (IF REQD).
ADD OR RM BY EXTENDING THIS SURFACE IN C-DIR.
NOW: 0.1 OVLP + 2x0.5 GR = 1.1 = MAX.
ALT: 0.1 OVLP ONLY = 0.1 = NO GR.
ALT: 0.0 = NO GR + NO OVLP
43,50
TOTAL
0,50 GR
30,10
TOTAL
30,10
TOTAL
15,10
OVERLAP 0.1
R36.6 SECOND ZONE
C
A
R21.6 DEAD ZONE FREE
XY(DET) = 7.0 NOM.(SI.RAD.DAM) + 0.5 GR = 7.5
XY(RFF) = 7.0 NOM - 1.0 CLR - 0.4 RFF.THK = 5.6
R5.6
R7.0
R7.5
ACTIVE AREA SET BACK BY 0.5 GR
FROM R7.0 EDGE. IF NO GR, WHOLE
ACTIVE AREA SHIFTS TOWARD ORIGIN
AND COVERAGE INCREASES (THIS
ACCOMODATES EITHER SCENARIO).
20,00
SUBSTRATE
(DIA/TPG)
70,90

MODULE – L Si (3)


COOLING BLOCK/FOIL
10 MM CONTACT AREA.
AROUND PERIMETER
ASIC (TIMEPIX)
14.1 x 14.1 ACTIVE AREA
0.8 DIG.PER. (DEAD ZONE)
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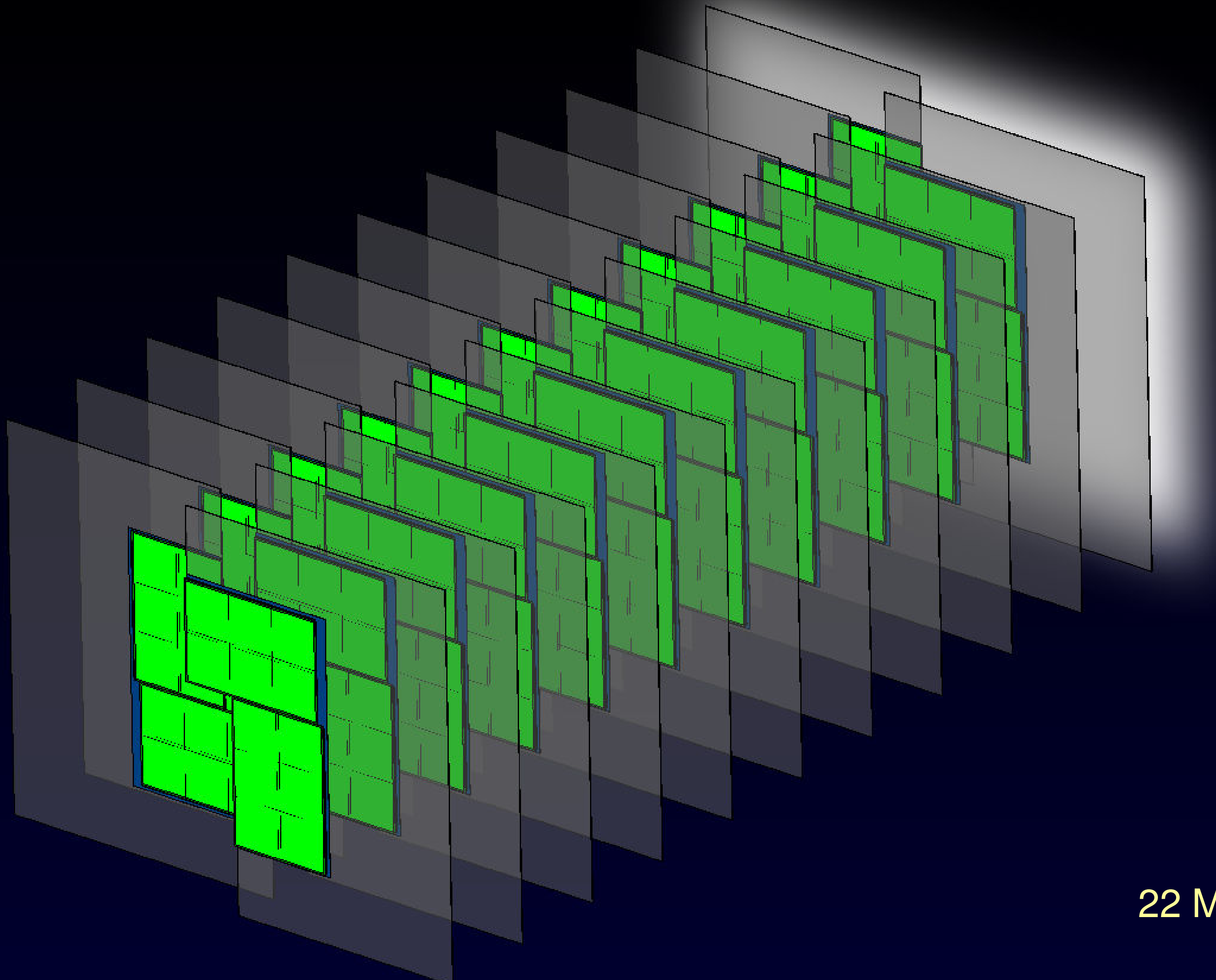
ACTIVE AREA SET BACK BY 0.5 GR
FROM R7.0 EDGE. IF NO GR, WHOLE
ACTIVE AREA SHIFTS TOWARD ORIGIN
AND COVERAGE INCREASES (THIS
ACCOMODATES EITHER SCENARIO).
SUBSTRATE
(DIA/TPG)
86,00
20,00
115,50
0,10
0,80
14,10
14,10
20,00
70,90
Silicon
removed

MODULE – L Si (4)



22 Modules

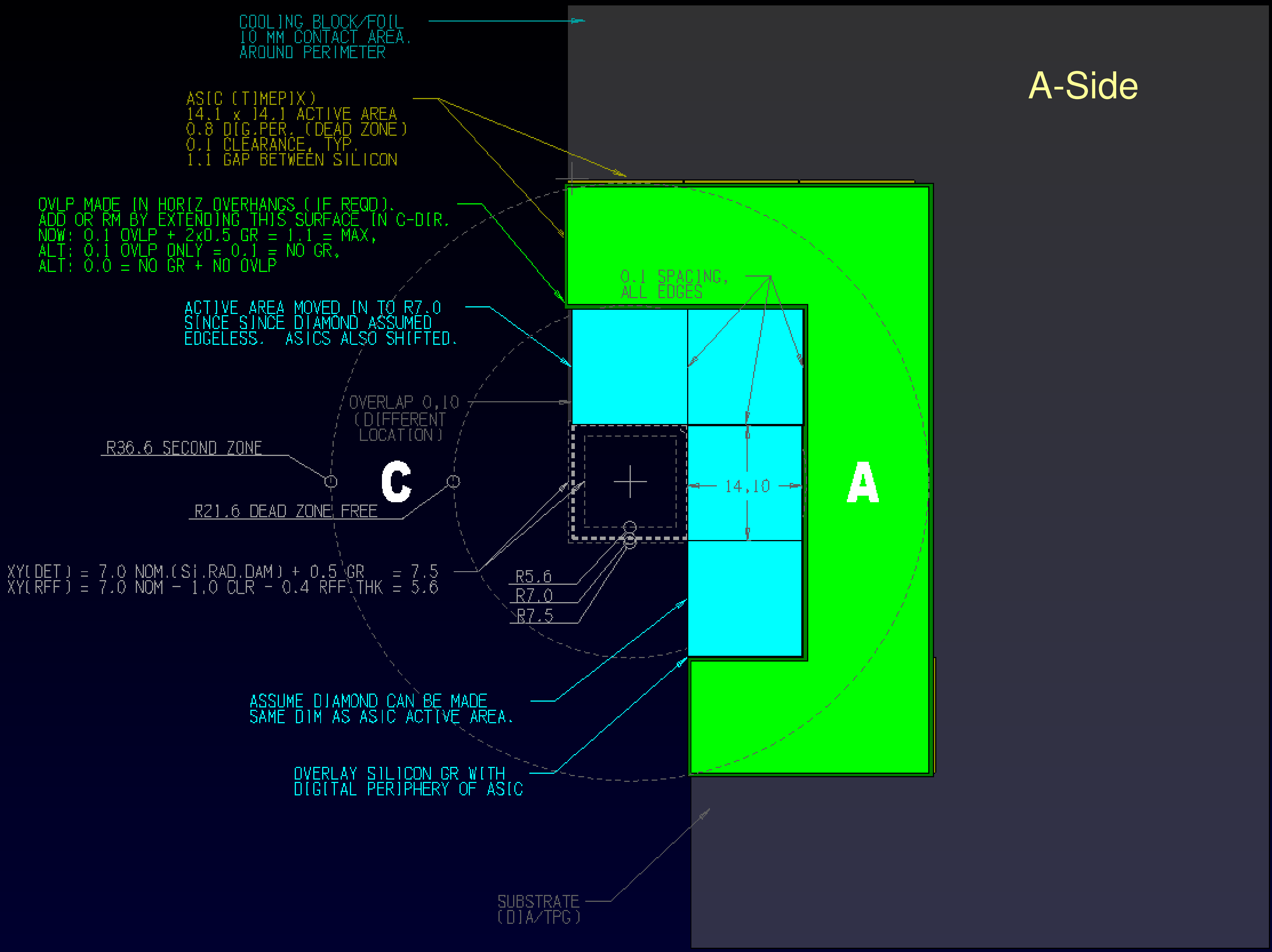
MODULE – L SiDi (1)

Design of L-shaped module with core of diamond sensors at innermost radius. Active to 7.0 mm radius

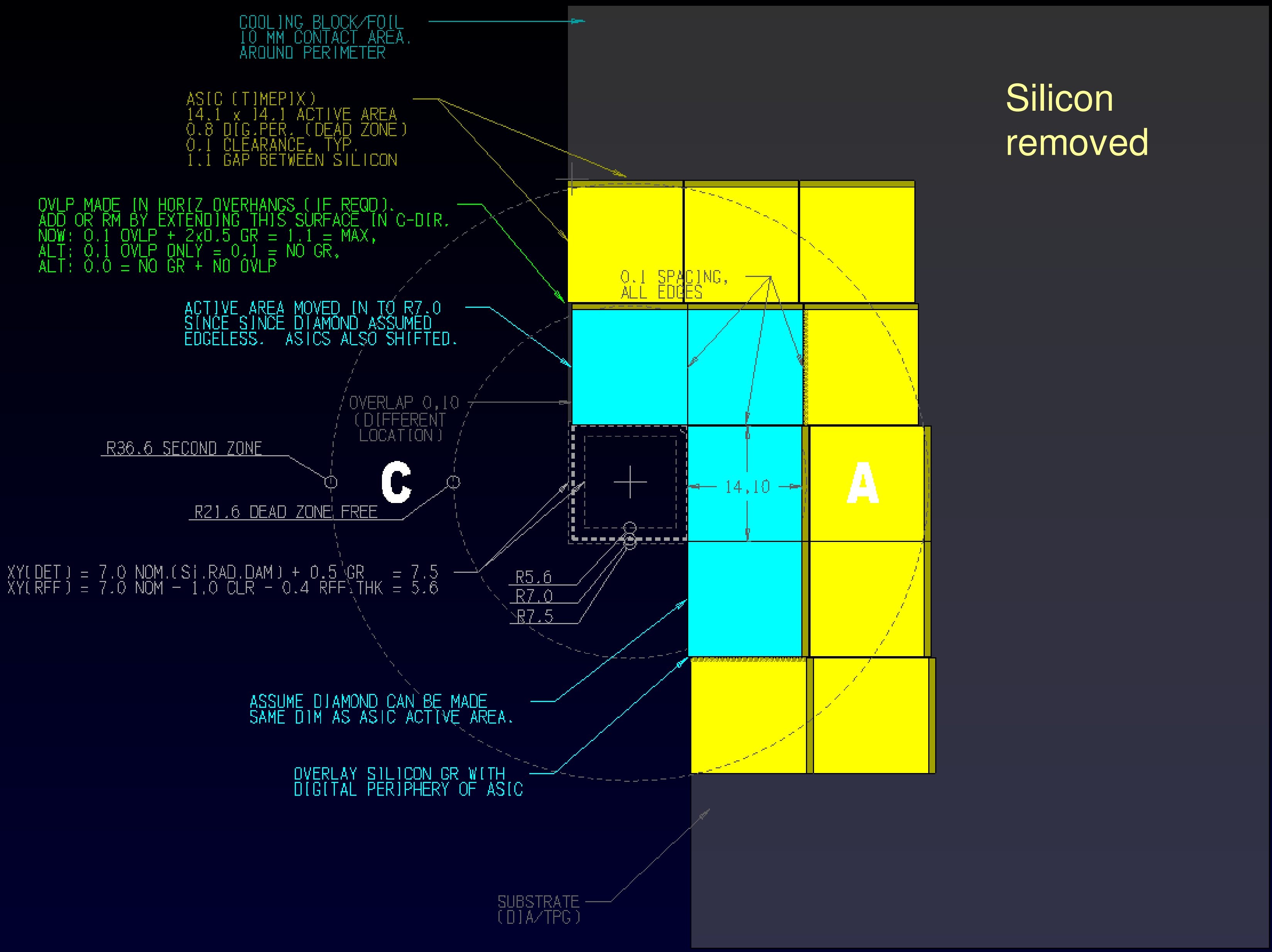
(Would like to see this design be one of the layouts simulated)

So…

MODULE – L SiDi (2)



MODULE – L SiDi (3)



RF FOIL (MECH) DESIGN

RF Foil mechanical design is geometrically complicated (known).

Concentrated on L-shape foil (U-shape should be similar to current design)

Try a few different approaches:

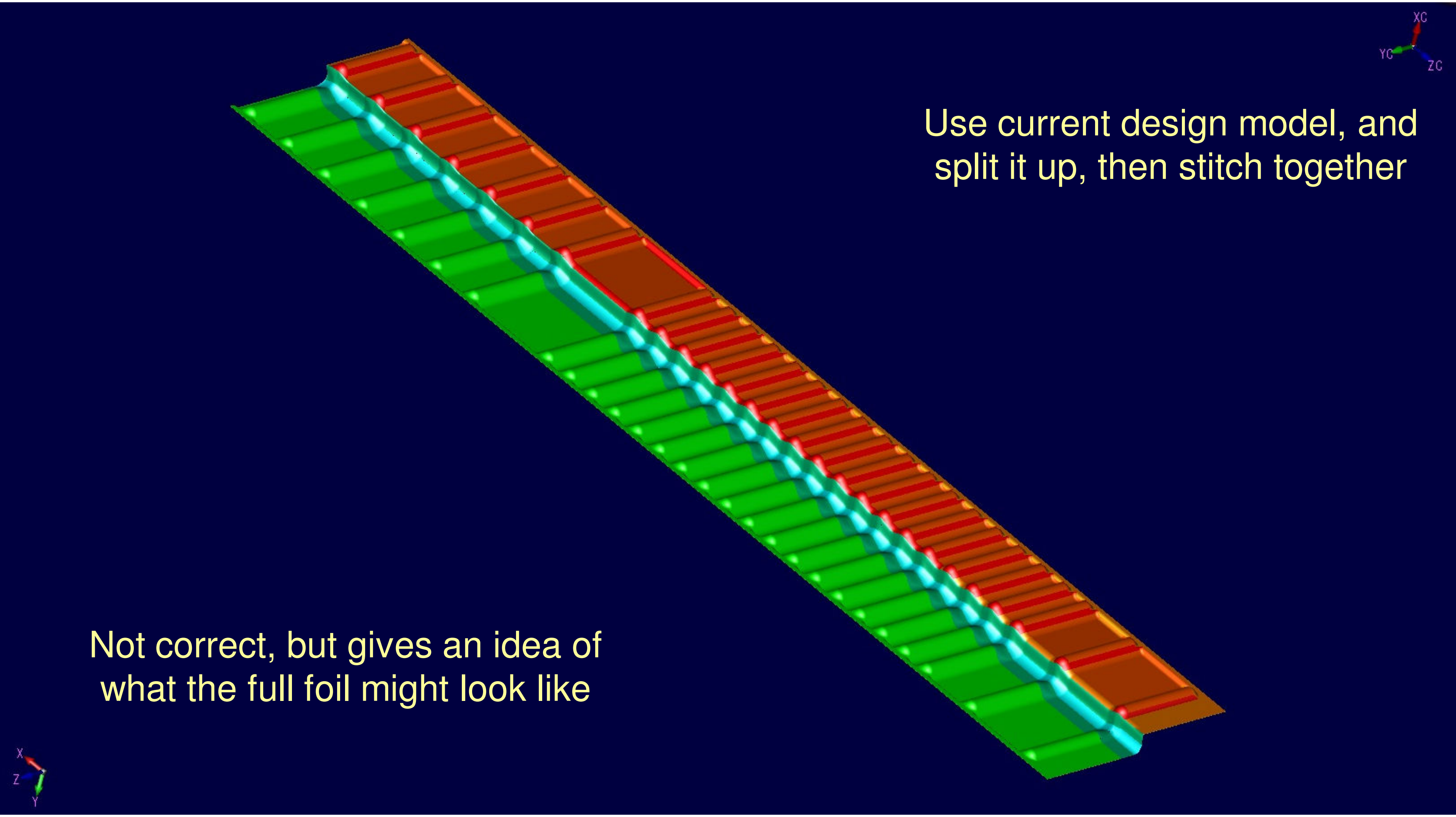
"**A**" – Take current design and morph it. Used model from NIKHEF webpage (thanks!) and split, move, raise, lower, and stitch back together. (Frankenstein)

"**B**" – Using some layout (e.g. presented), apply clearances, constraints, etc. and generate minimum foil, then apply mods due to accel reqs, etc. (Constrained)

"**C**" – Using some layout, take a block of material, cut away the bits in collision with modules, smooth out results. (Michelangelo)

Will take approach "B" but will also show "A"

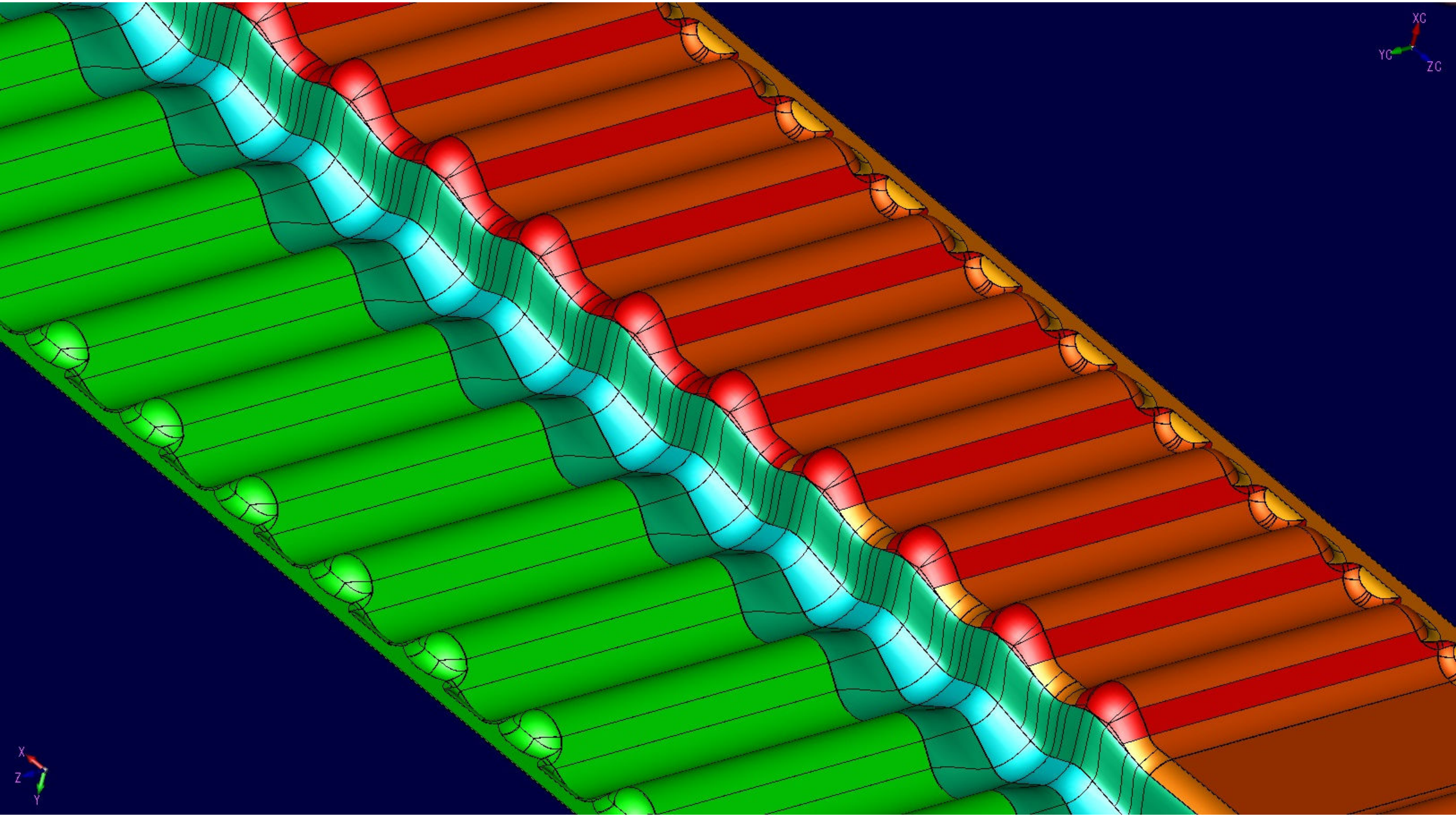
RF FOIL "A" (1)



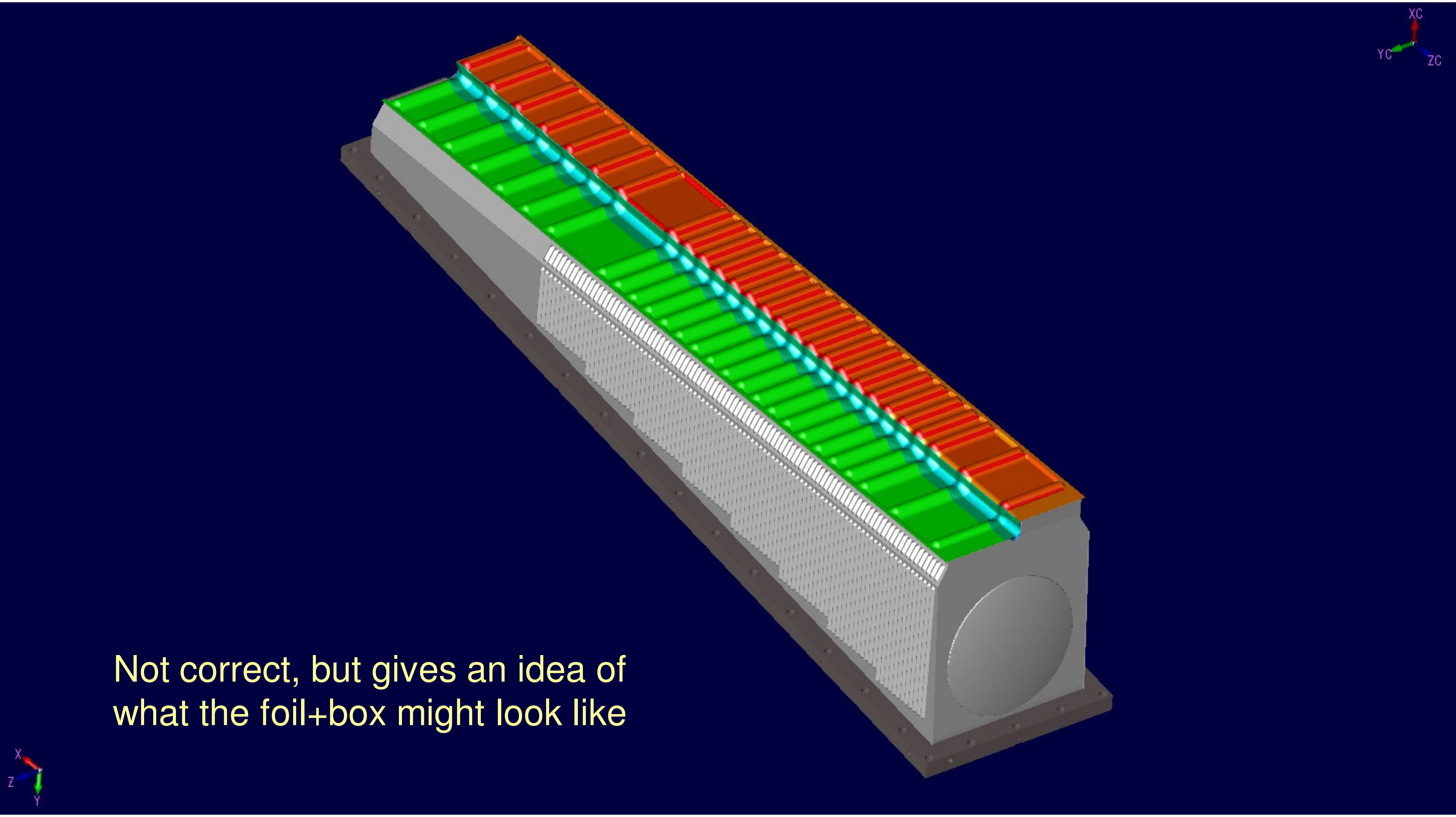
Use current design model, and split it up, then stitch together

Not correct, but gives an idea of what the full foil might look like

RF FOIL "A" (2)



RF FOIL "A" (3)


XC
YC
ZC
Not correct, but gives an idea of
what the foil+box might look like

RF FOIL “B” (1)

Work in progress…

Whole RF foil not together yet. Have repetitive surface model for A-side foil

- No straight sections. May be more mechanically stable with no straight sections (a guess).

Based on a series of assumptions (30 mm spacing, 0.5 mm GR, etc.) all of which can change. However CAD is not automatic, must be generated by hand.

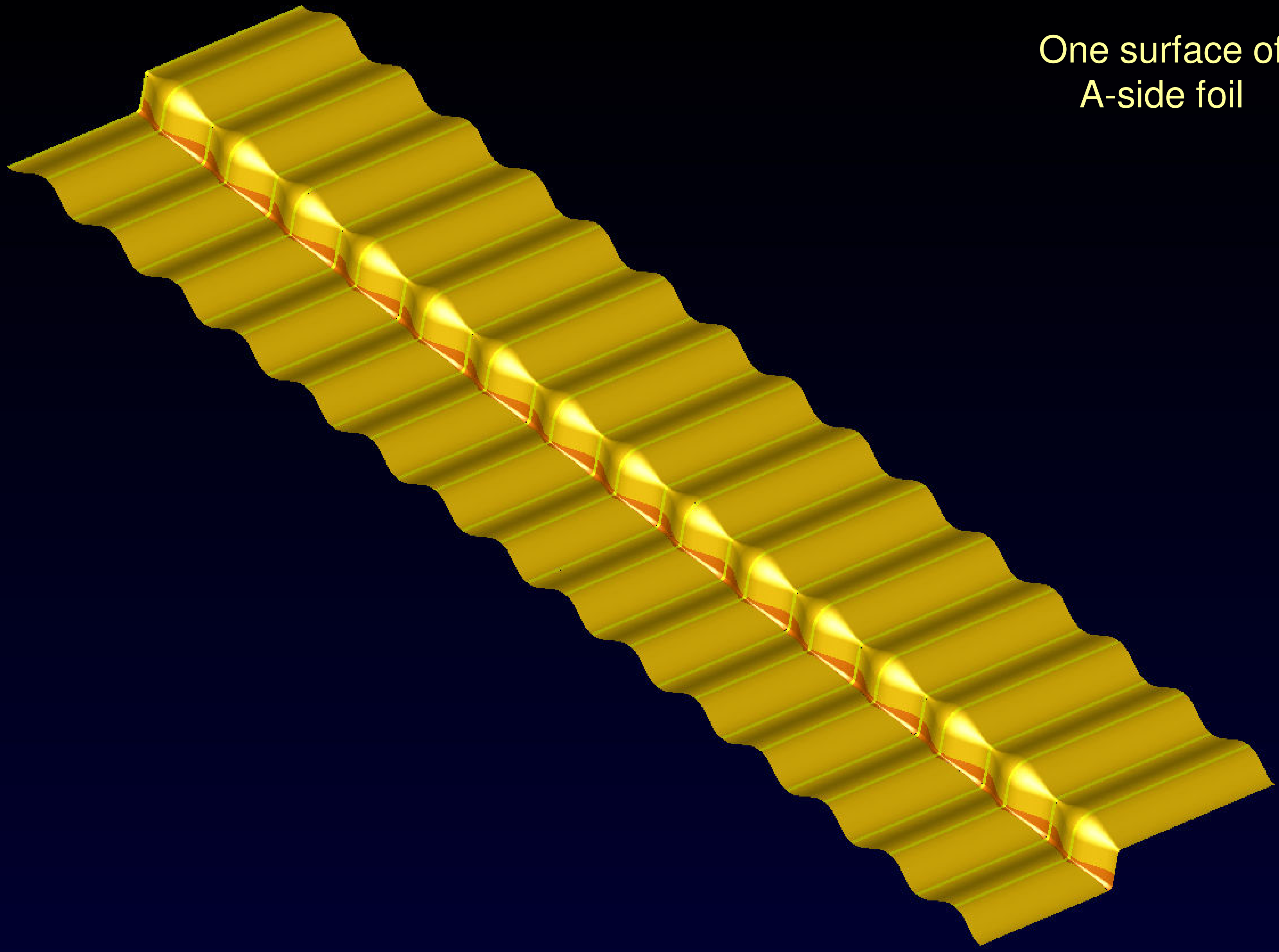
- Will need to converge on a first design for the foil.

Few observations:

- Spatial amplitude smaller than current design
- More complicated curvature
- Caveat: will have to review shape curvatures based on further consideration of beam impedance. Will have to run through MAFIA.

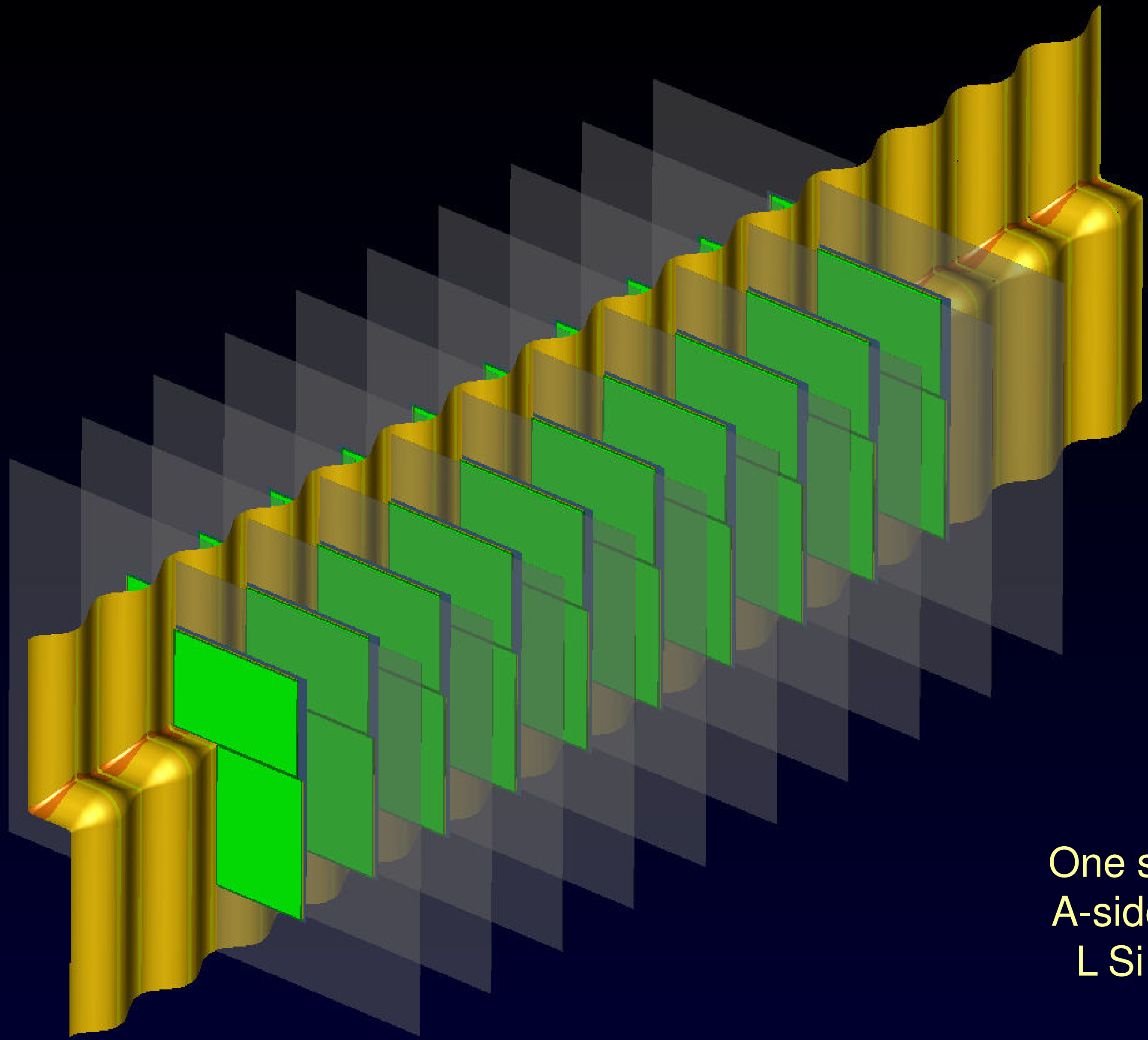
So…

RF FOIL "B" (2)



One surface of
A-side foil

RF FOIL “B” (3)



One surface of
A-side foil with
L Si module

FABRICATION

Fabrication work in collaboration with Composite Mirror Applications (CMA, Tucson, AZ)

– Lots of experience with composite (CFRP) mirrors and lightweight structures for space applications. Made spherical mirrors for RICH-1.

** Phase I **

Evaluation of realistic U vs L foil shape (Current RF Foil vs RF Foil "A") – [done]

– Discussions w CMA, they see no real show-stoppers, in terms of manufacturability
– Compound curvatures make L harder than U, but not excessively so – both are challenging for CMA
– L has implications on material in terms of "drapability" over surface curves (use chopped fibers not continuous fibers)
– The real challenge is uniformity of thickness and resulting stiffness, considering its complex shape – that's true for U and L

Fabrication and testing of "coupons" – [in progress]

– Make samples of composite layups from different materials and different forming techniques
– Use a mold incorporating curvatures similar to L foil
– Test: (1) resulting curvature profile (most critical at this point), (2) uniformity of thickness, (3) surface quality

Further evaluation of "coupons"

– Test vacuum tightness
– Test RF shielding capabilities
– Test irradiation effects on mechanical properties (eventually)

** Phase II **

Fabricate ¼-length Prototype of Foil+Box together

– Decide on fiber material(s), resin matrix, number of layers
– Fabricate mold for foil, sidewalls, windows, flange with all the most nasty features
– Replicate a prototype structure (once have mold, can do many of these)
– Test prototype (above list of tests, plus ability to scale up to larger size)

Timeframe: Phase I 2-3 months, Phase II ~6 months

SIM of RF Foil in GEANT3

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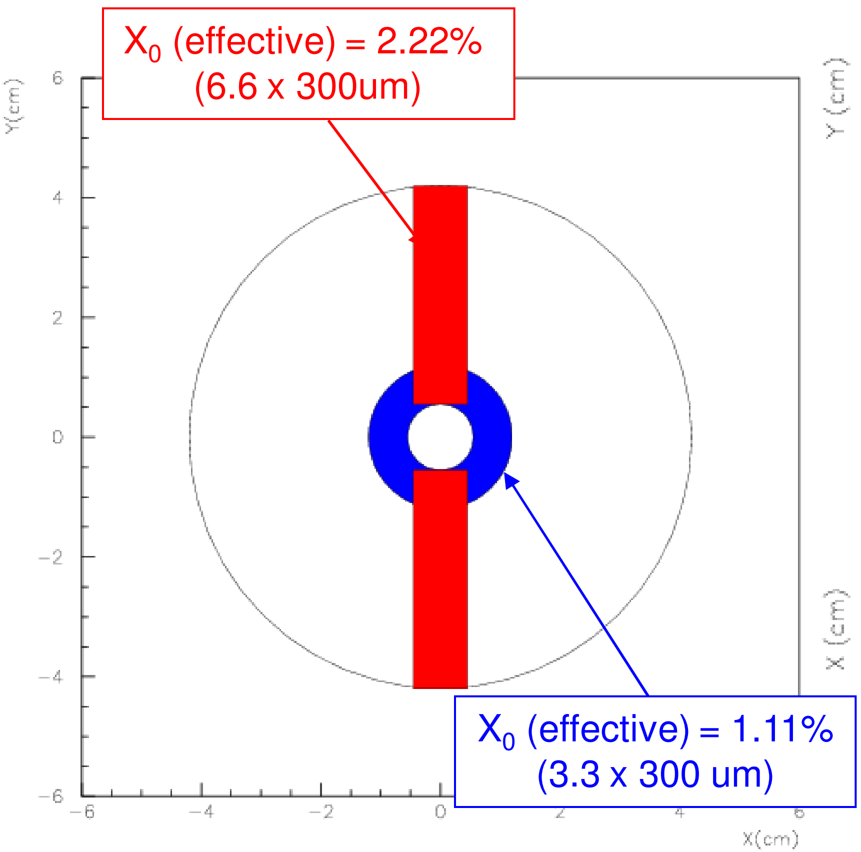
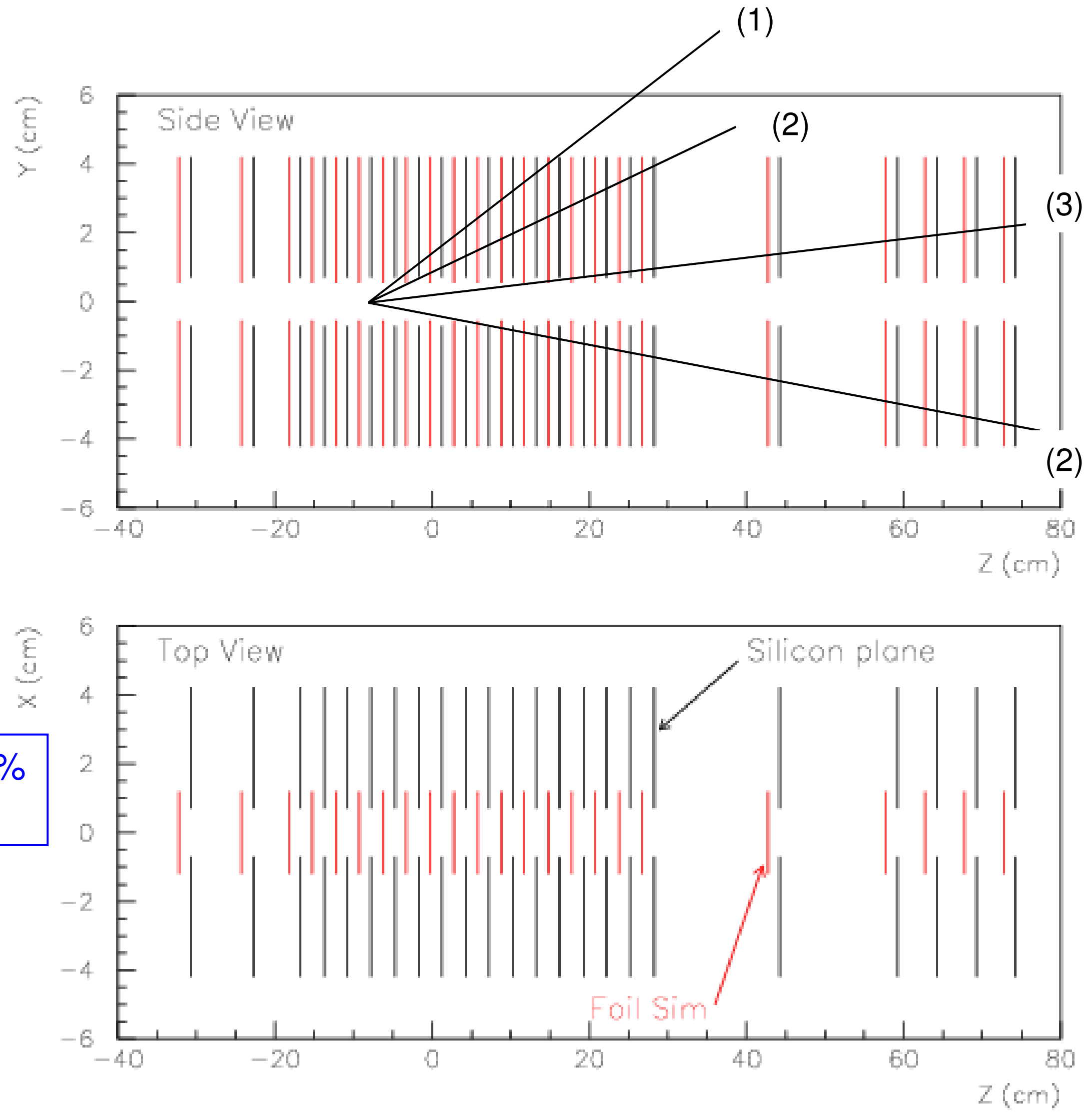
Regions selected based on RF foil layout





* Material X0 tuned to match LHCb sim

RESOLUTION vs RF Foil x/X_0

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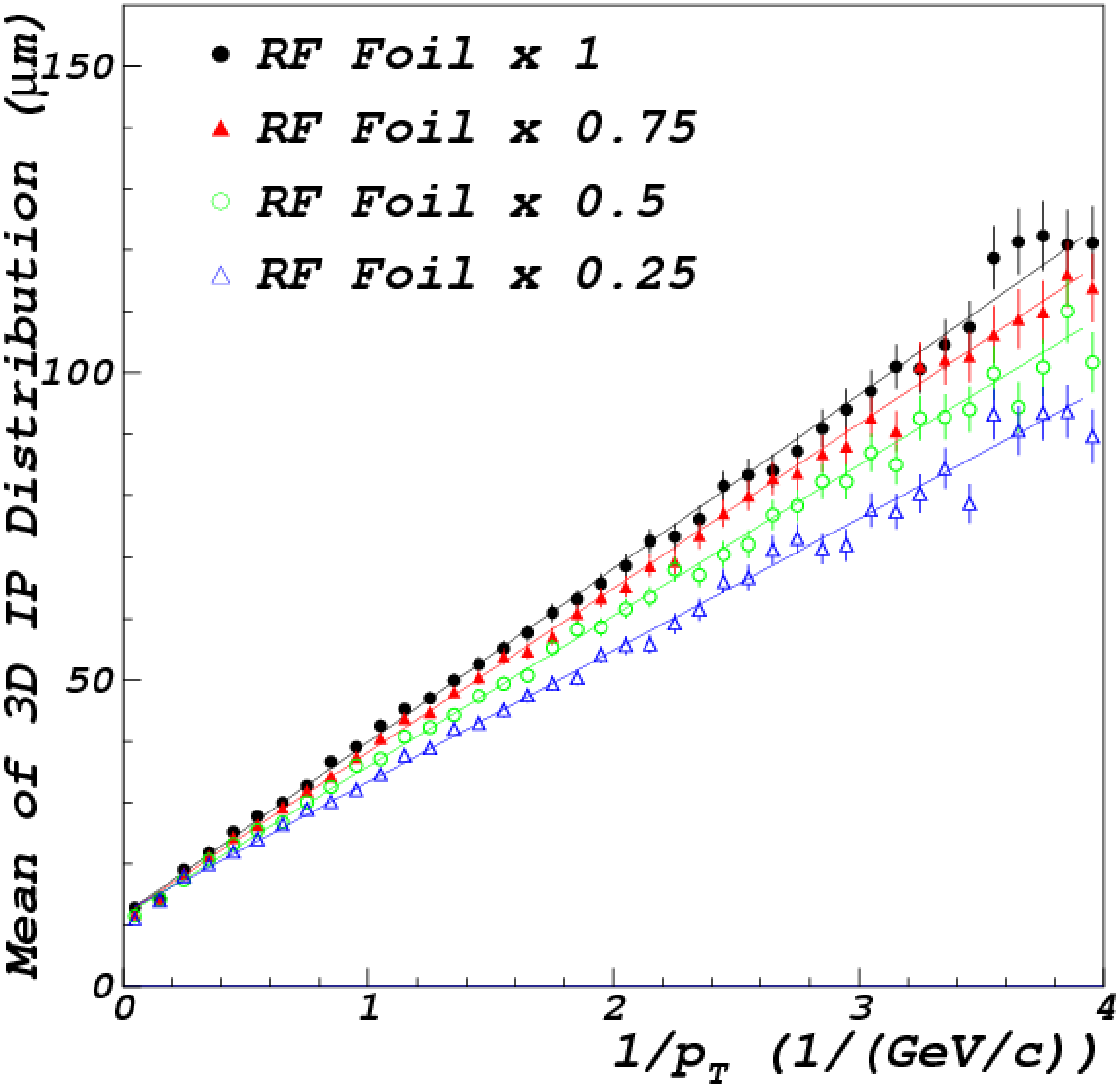
GEANT3

Here, production point = (0, 0, 0) for all particles



$\langle IP_{3D} \rangle = 11.6\mu m + 28.3\mu m / p_T$

$\langle IP_{3D} \rangle = 11.5\mu m + 26.7\mu m / p_T$

$\langle IP_{3D} \rangle = 11.4\mu m + 24.5\mu m / p_T$

$\langle IP_{3D} \rangle = 12.0\mu m + 21.4\mu m / p_T$

Not a striking difference, but there is an improvement and slope scales like foil MCS contribution

(BACKUP SLIDES)

Actual RF box/foil

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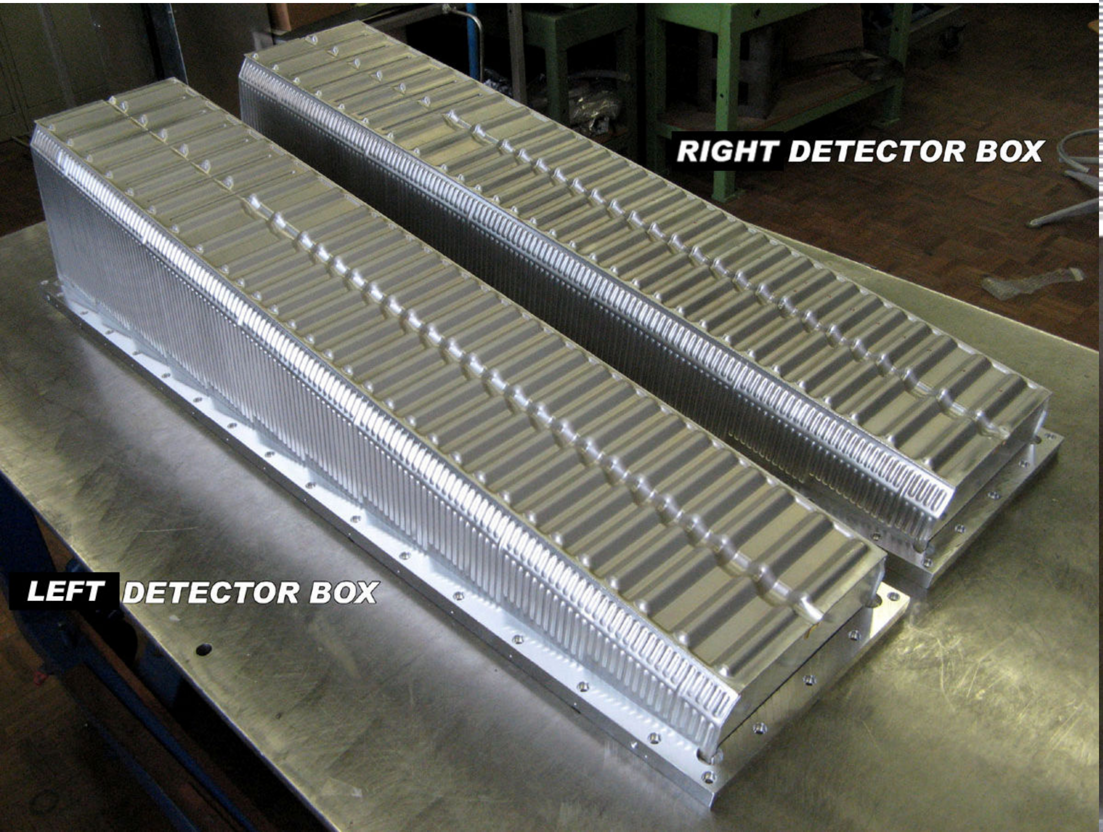
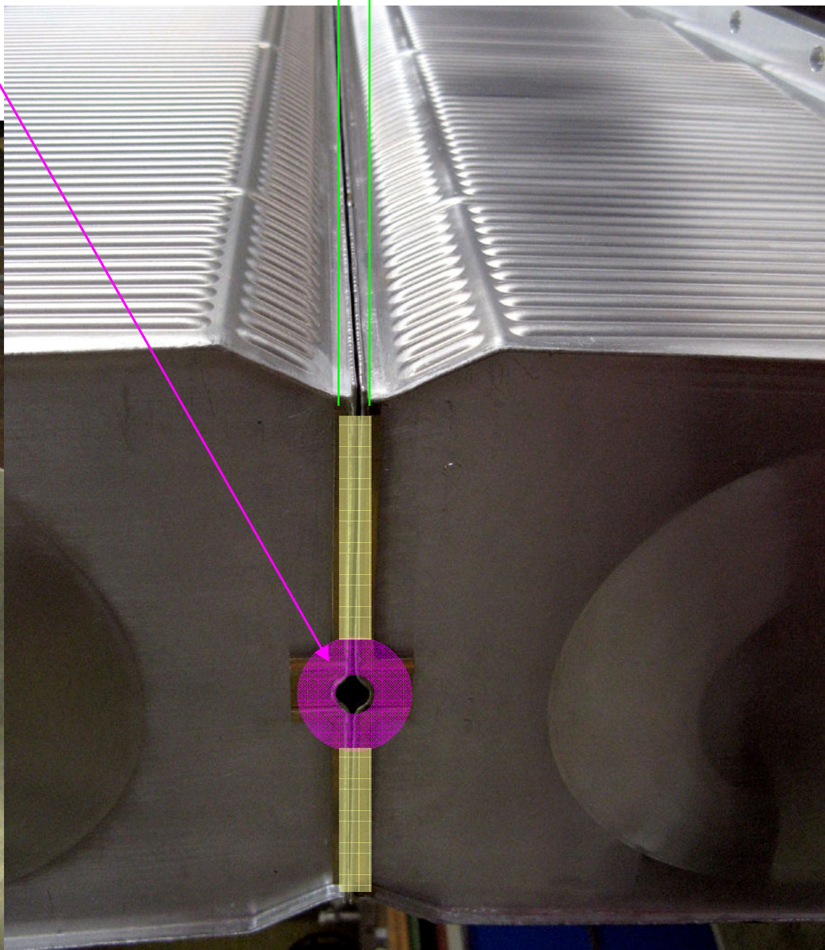
Increased material due to structure of each box.

9 mm region where left & right boxes overlap. Twice as much material b/c both boxes contribute.

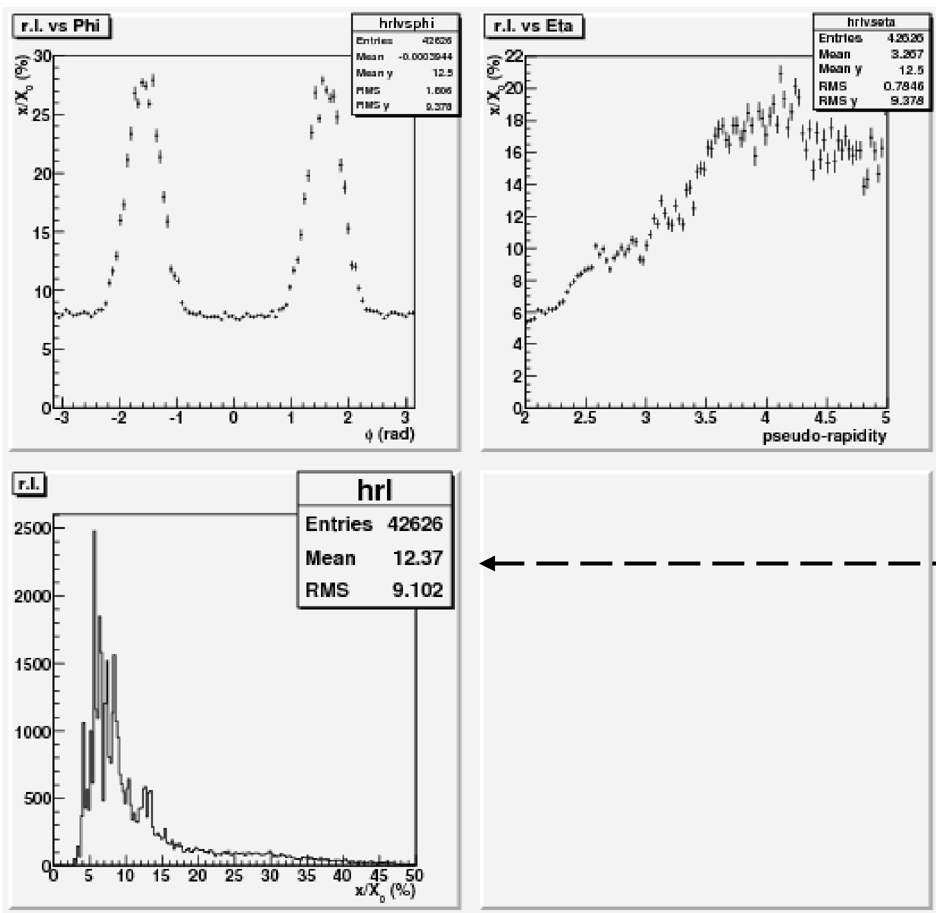




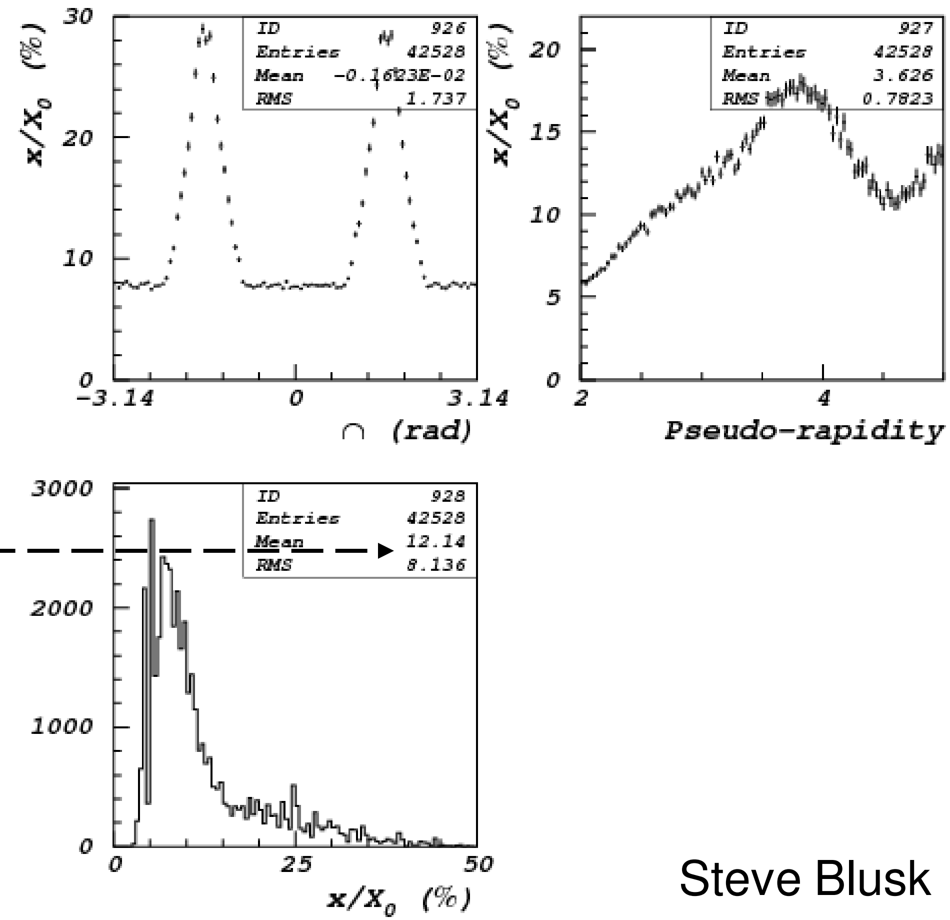
Implementation - RF Foil Comparison

Only count material up to last hit inside vertex detector acceptance. Material beyond this has minimal impact on IP resolution. Also, much more work to model it. (Hybrids, cooling cookies …)

LHCb Simulation



Geant3 Simulation



Not perfect, but gross features well reproduced
- Phi, eta dependence & average x/x_0 ☺

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