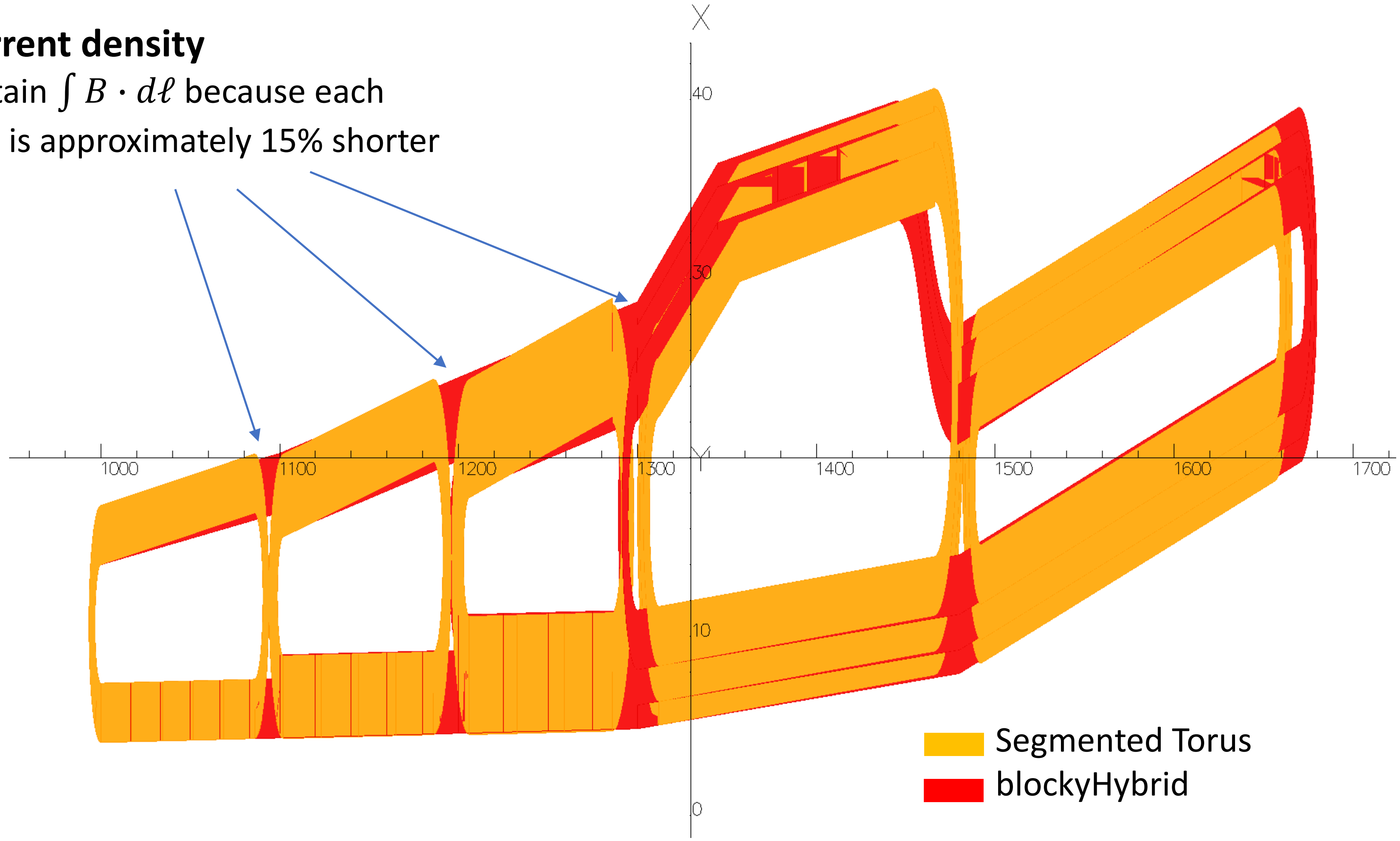
# Segmented vs. Hybrid Downselect

Juliette Mammei

# Hybrid vs. Segmented downstream torus configs

**15% higher current density**
in order to maintain $\int B \cdot d\ell$ because each straight segment is approximately 15% shorter



# Procedure for testing conductor configs

- JLAB produces conductor config (blocky version of CAD)
- Juliette reads in the conductor, produces map in TOSCA
- Sakib reads map into GEANT4 to run sims/do analysis

Purpose: to check whether reasonable changes to the segmented to improve engineering make a difference to the downselect

| | | |
|---|---|---|
| 1.02.A | Similar to V1.02 with US coils having increased current by 125%, No change to DS coils. | 04.10.2020 |
| 1.03 | Symmetric coil model. JLab Blocky Model of the segmented modified to match the inside surface of the initial J Mammie blocky model (current density changed, as Juliette M suggested). New US coil design with 125% current compared to JM blocky model. | 02.03.2020 |
| V2DHy.1 | Downstream Hybrid symmetric model | 10.21.2020 |
| V2DSg.1a | Downstream Segmented symmetric model with SC1, 2, 3 coils identical to V2DSg.1 and a new SC4 design comprised of two 5 turn single pancake coils. | 10.21.2020 |
| V2DSg.1b | Downstream Segmented symmetric model with SC1, 2, 3 coils identical to V2DSg.1and a new SC4 design comprised of two 4 turn single pancake coils. | 10.21.2020 |
| | | |

V1U.2a_V1DSg.3

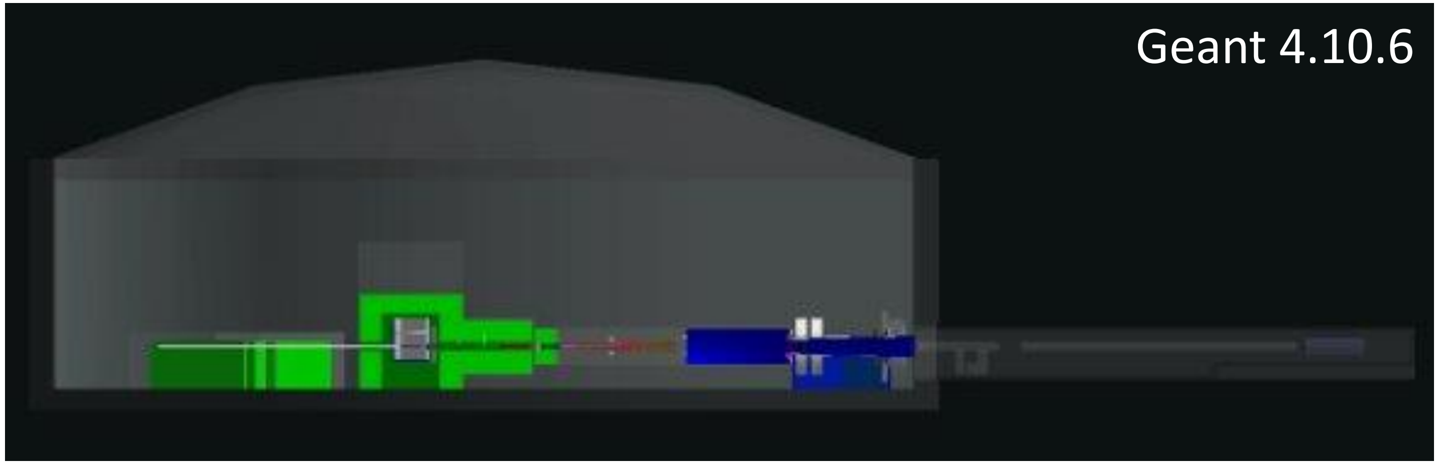
V1U.2a_V2DHy

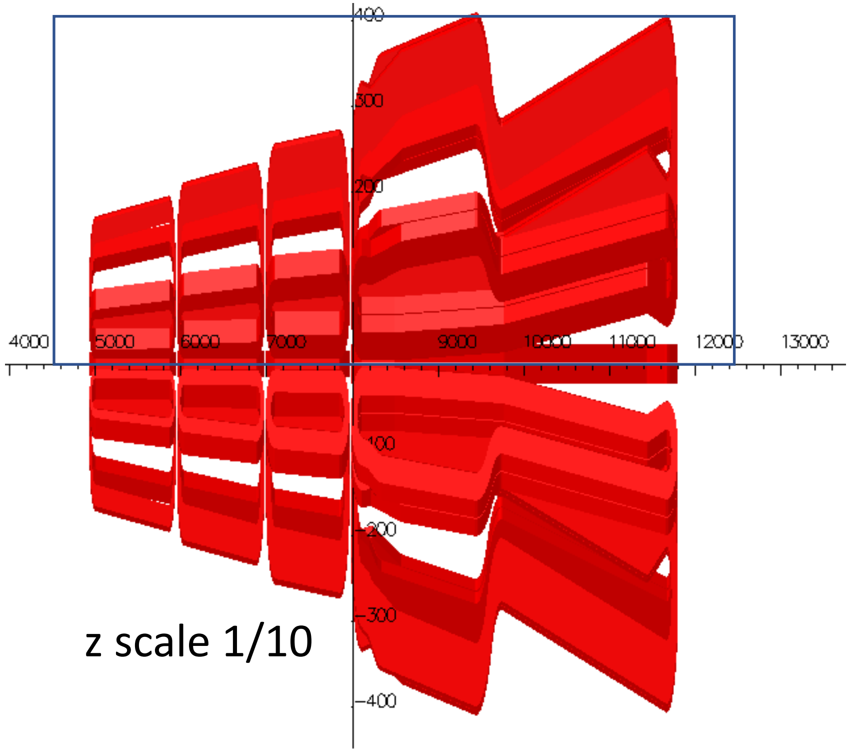
V1U.2a_V2DSg.1a

V1U.2a_V2DSg.1b

Configuration labels

# Simulation Configuration




z scale 1/10

The field maps are generated in TOSCA with a Biot-Savart calculation (assumes no non-linear materials)

The spacing is:

| | |
|---|---|
| Radial | 0.5 mm |
| Azimuthal | 3 degrees |
| Along z | 10 cm |

For the downstream torus, the map extends from:

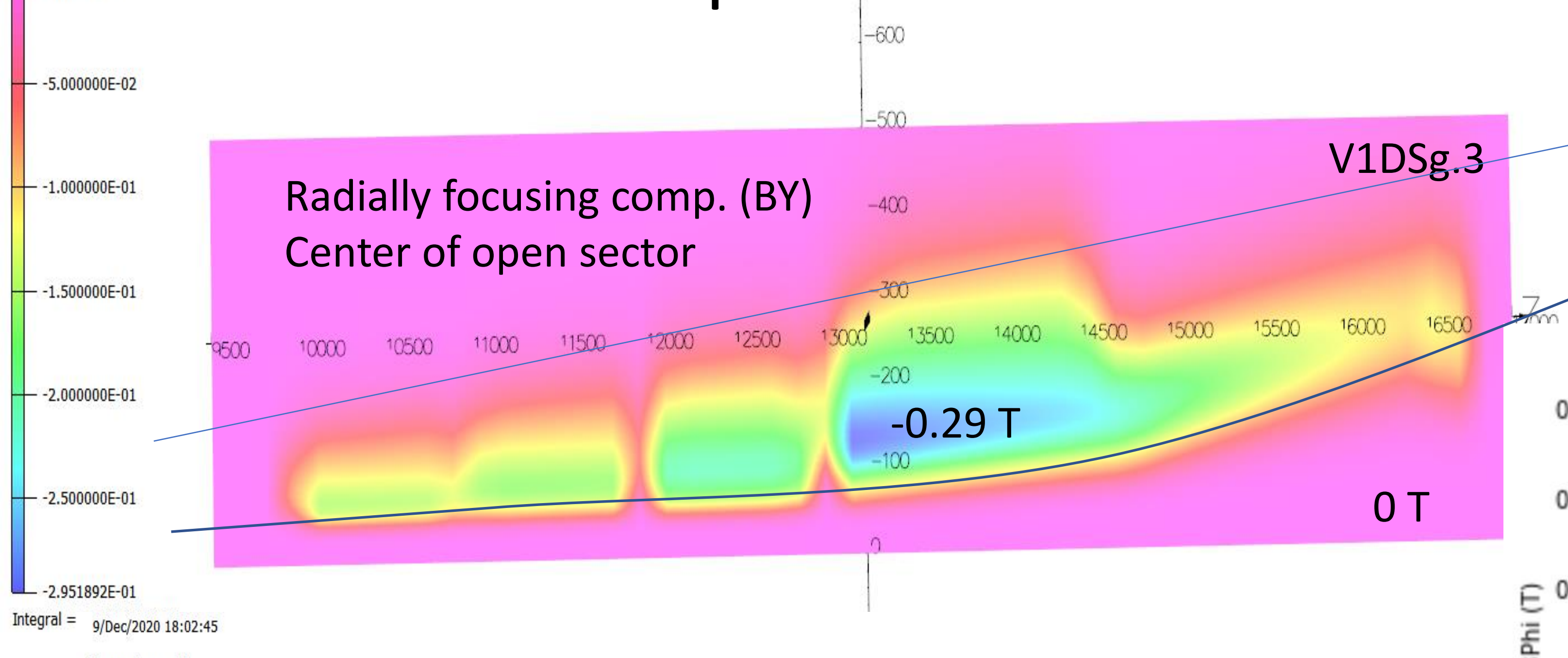
0 < r < 40 cm
4.5 < z < 12.5m
Full azimuth

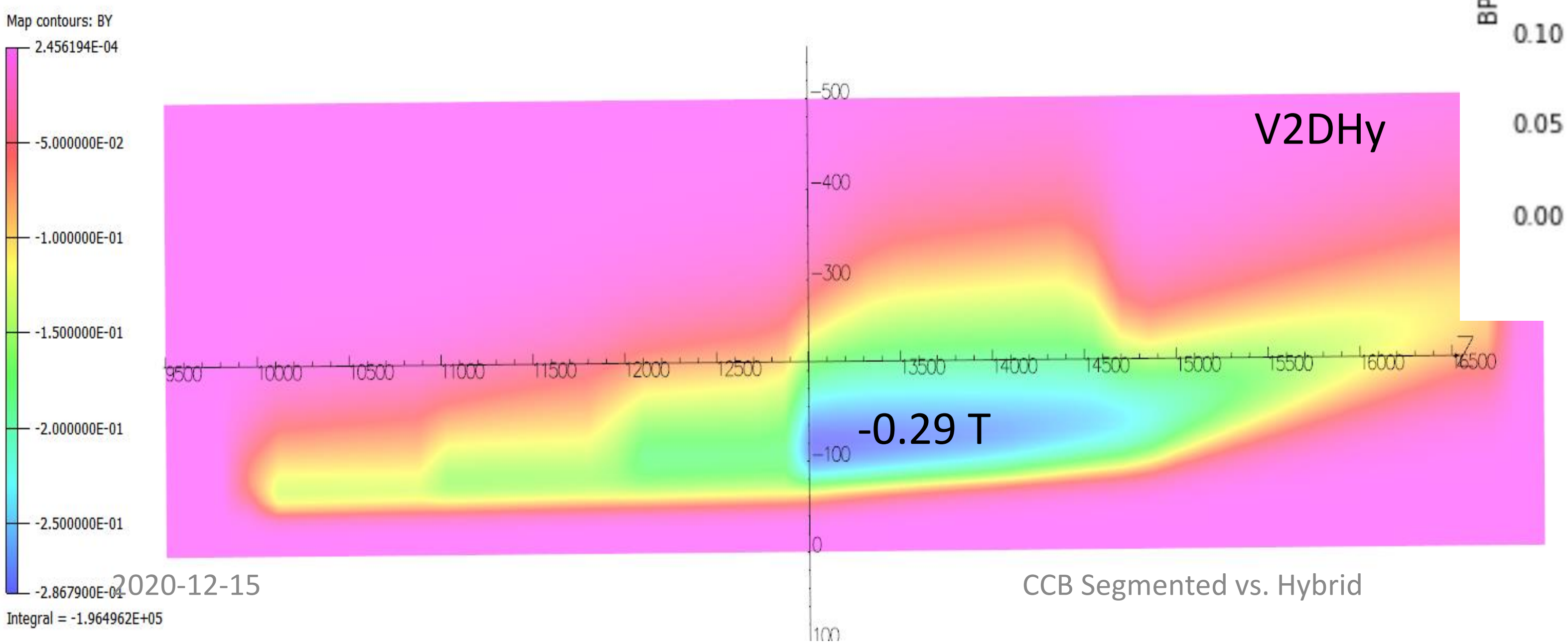
# Comparisons

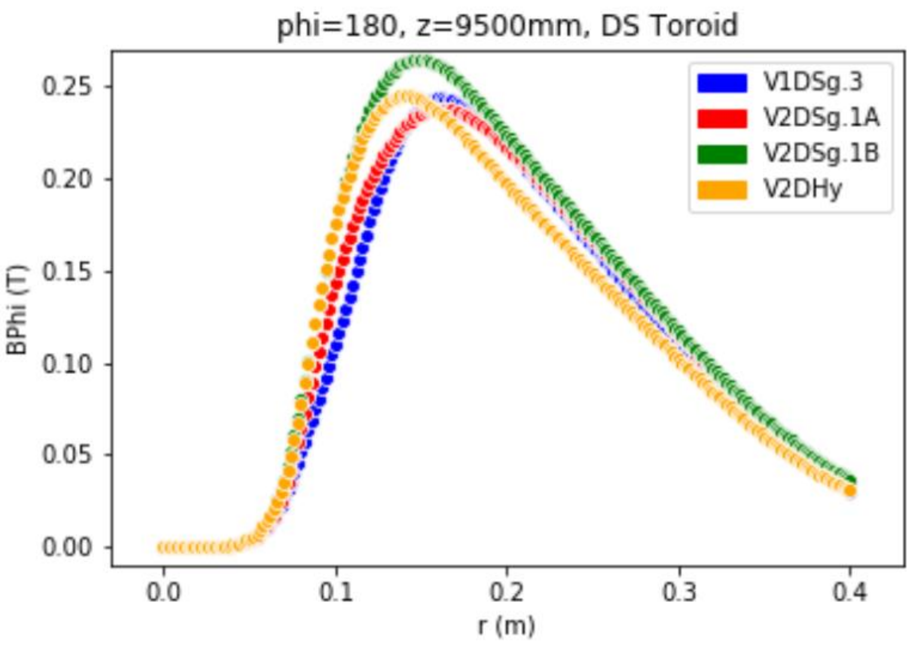
- From qualitative to quantitative
  - Looking at fields for particular r, theta or z
  - Simulation results at detector plane
    - 1D radial distributions
    - 2D x-y distributions
    - Theta-r distributions
  - Fractional asymmetry plots at detector plane
  - Deconvolution results
    - All with and without primaries
    - Summary with relative uncertainties

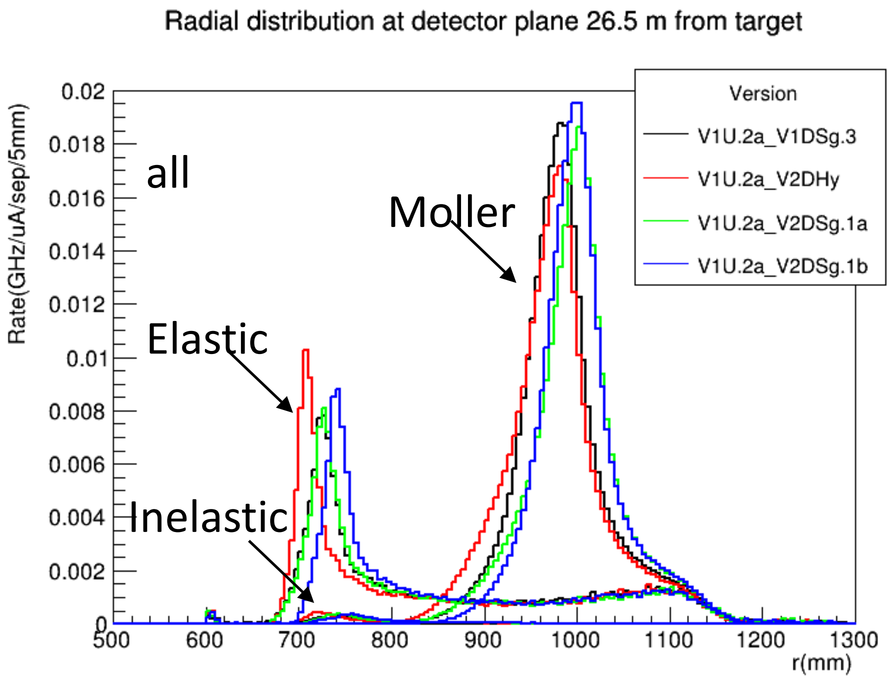
# Direct comparison of fields

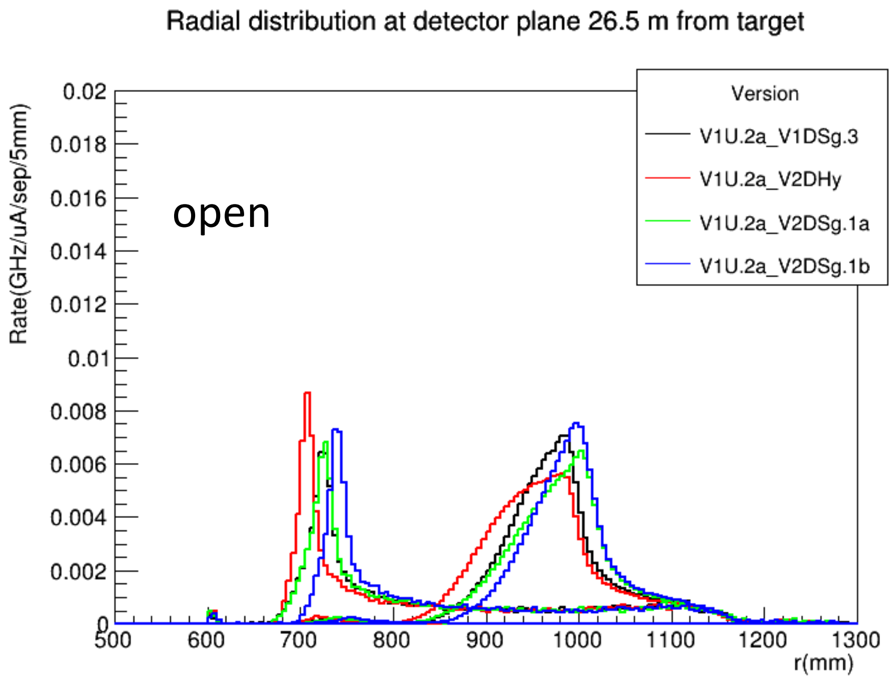
Approximate path of moller tracks



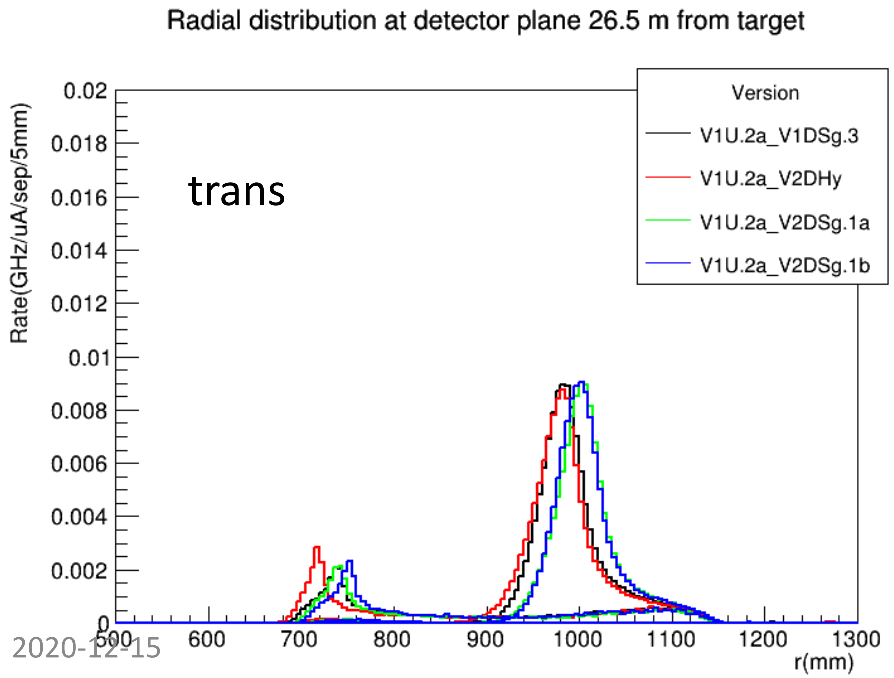



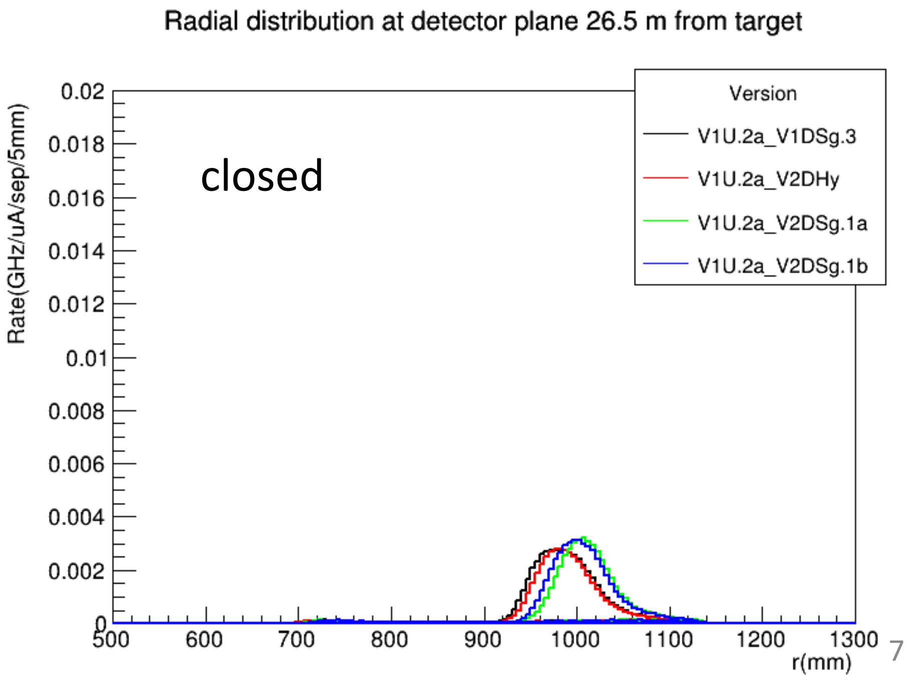



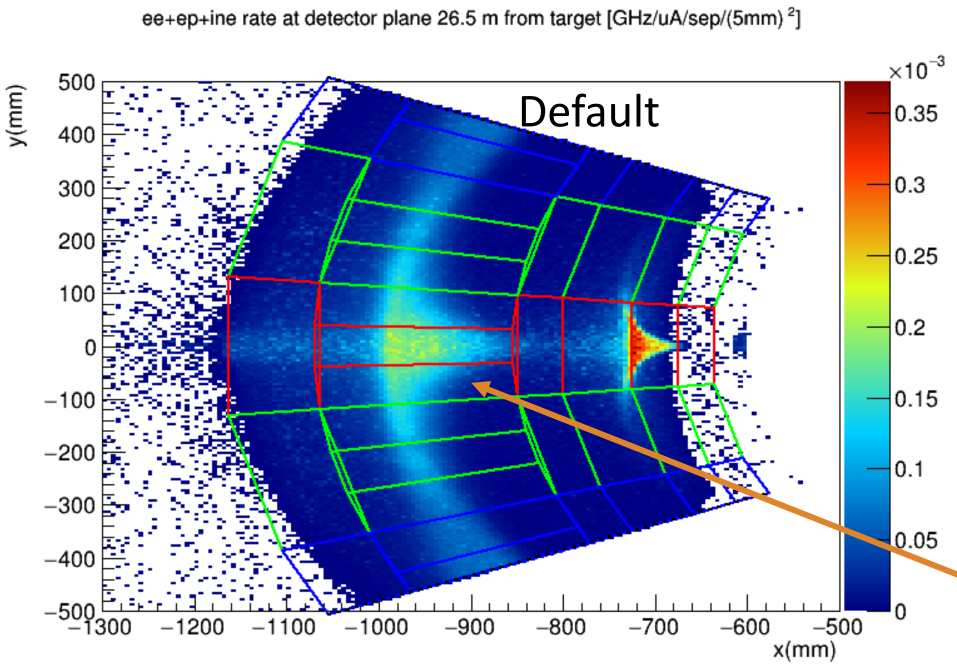


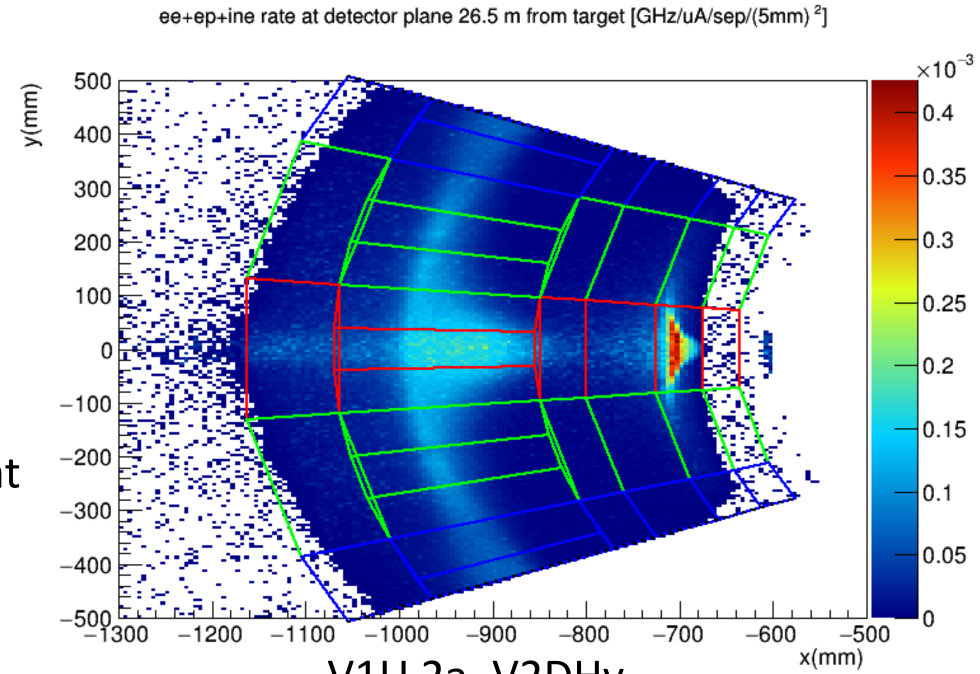

Radial distributions by process in the different $\varphi$ sectors





V1U.2a_V1DSg.3

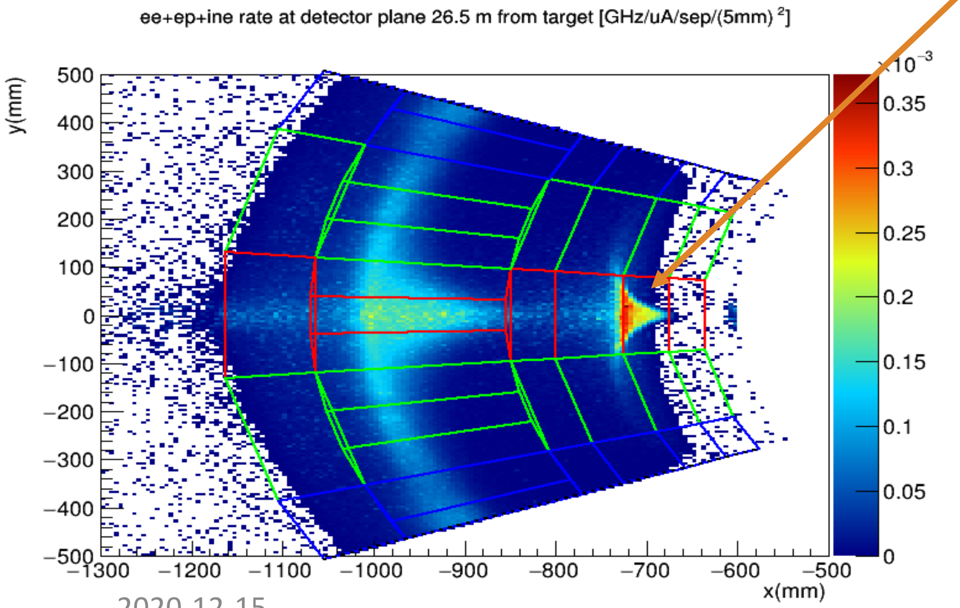


V1U.2a_V2DHy

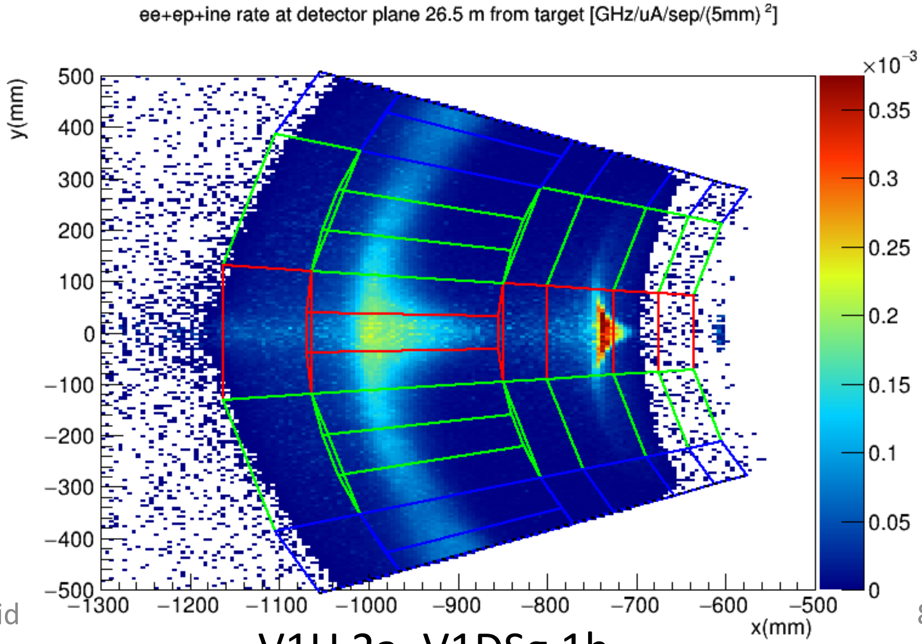
2D distributions at detector plane

Moller: Ring 5
Elastic ep: Ring 2

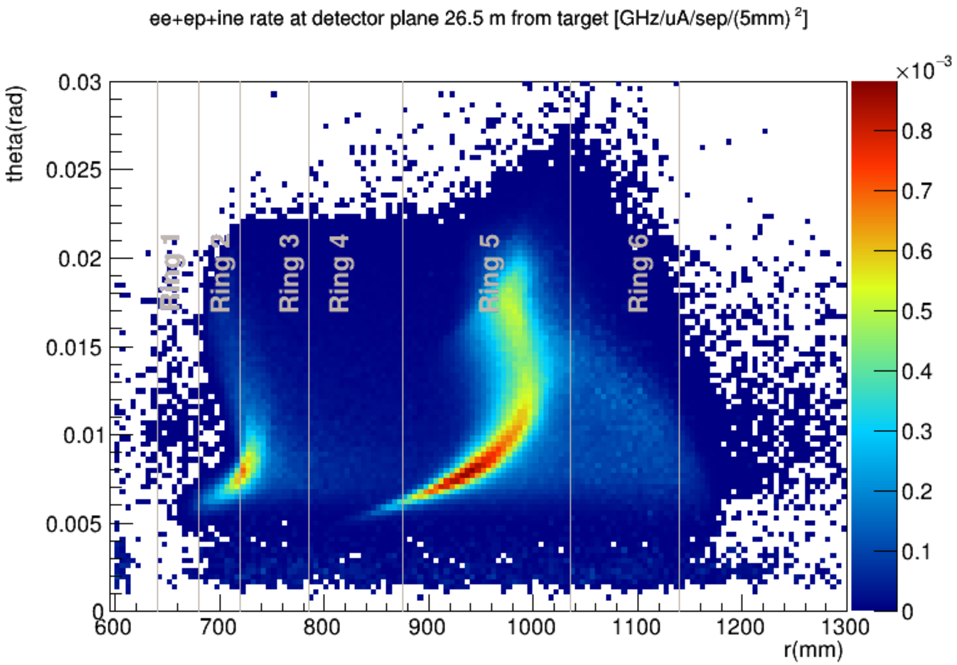
Red: Open
Blue: Closed
Green: Trans.



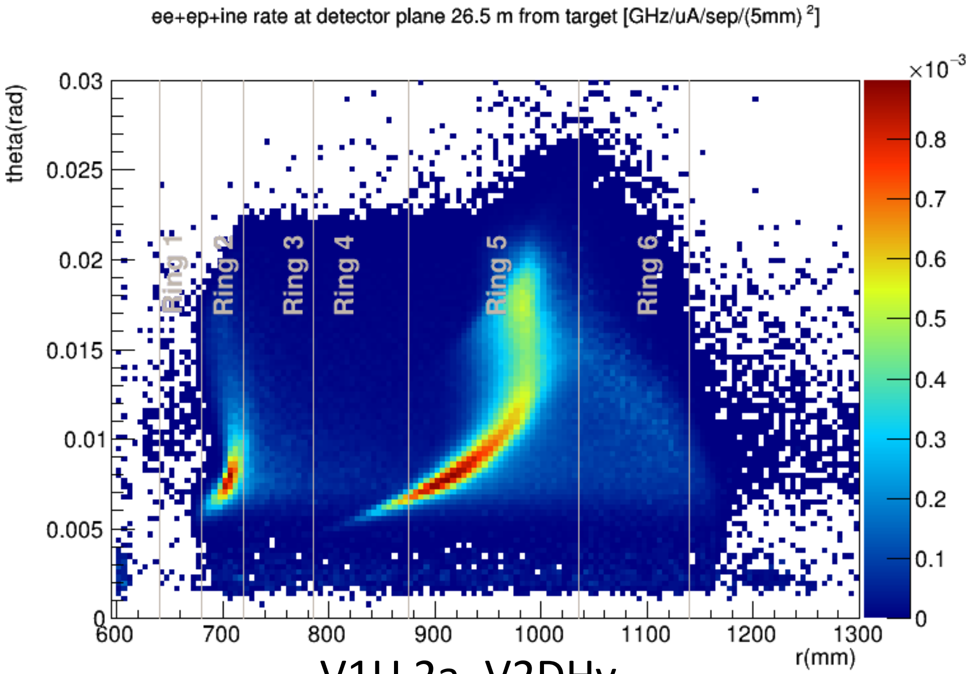
V1U.2a_V1DSg.1a



V1U.2a_V1DSg.1b




V1U.2a_V1DSg.3

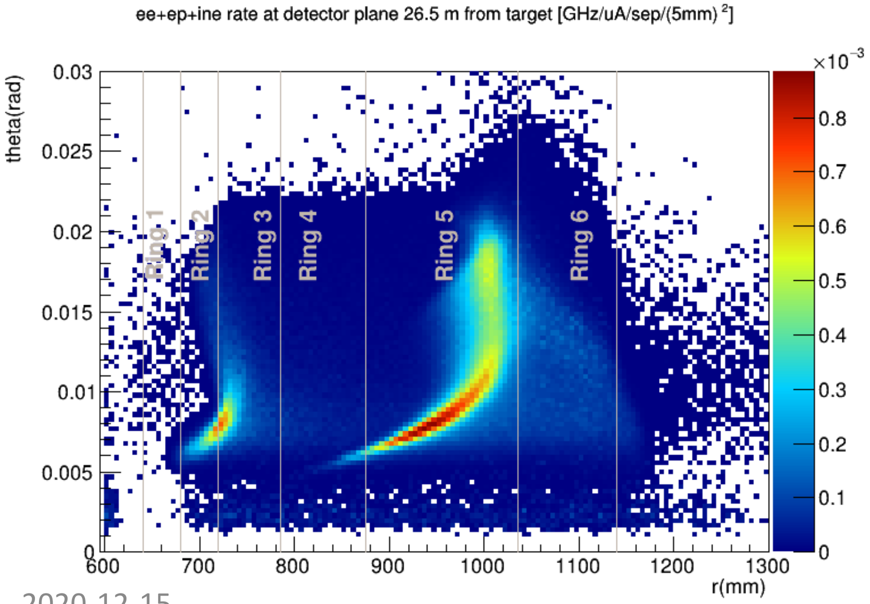



V1U.2a_V2DHy

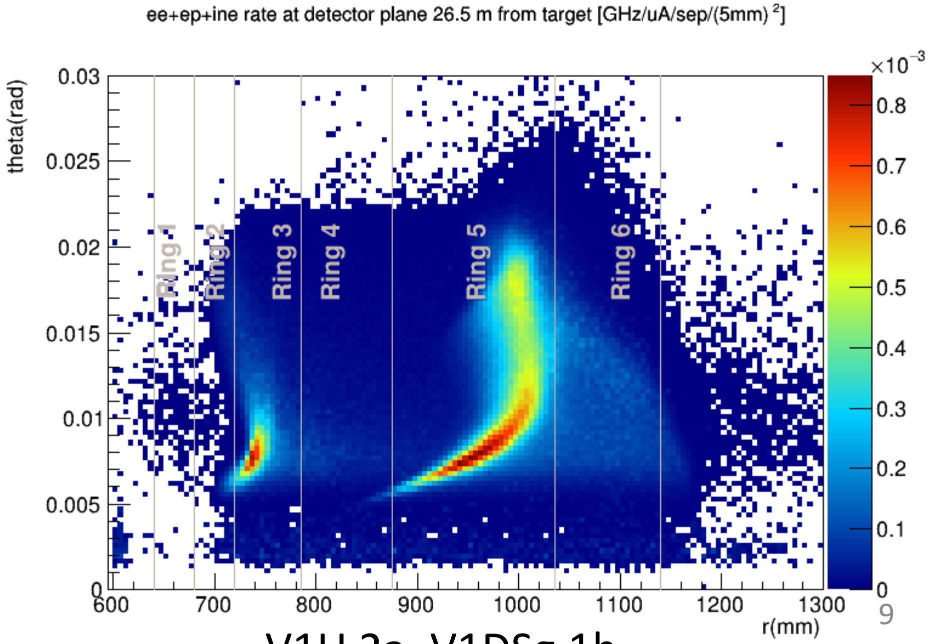
$\theta$-r distributions at detector plane

Approximate radial ring def'ns shown

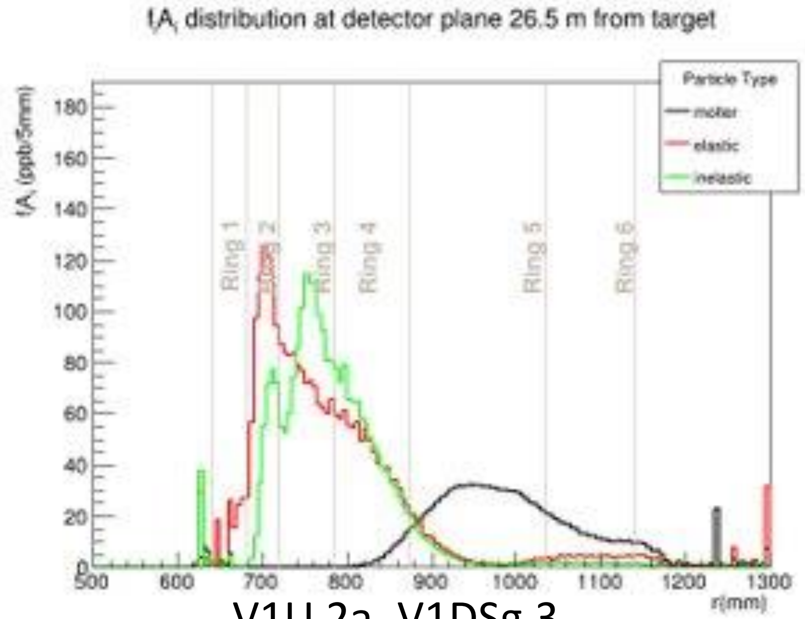
Moller: Ring 5
Elastic ep: Ring 2



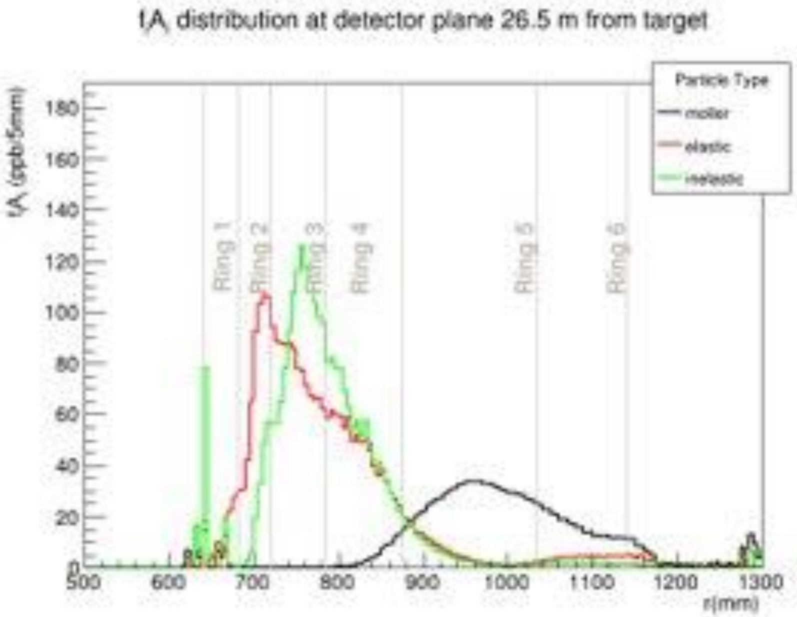

V1U.2a_V1DSg.1a




V1U.2a_V1DSg.1b




V1U.2a_V1DSg.3



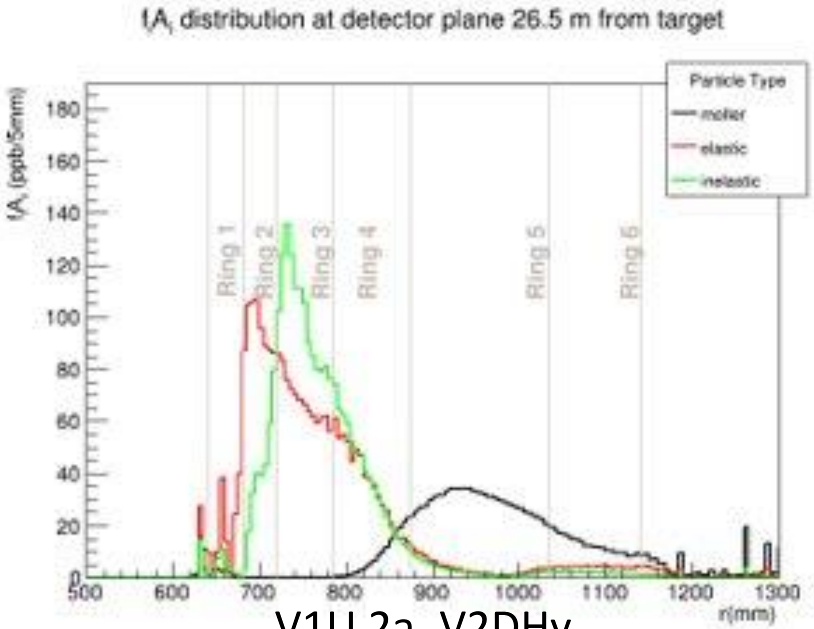

V1U.2a_V2DSg.1b

moller
elastic
inelastic

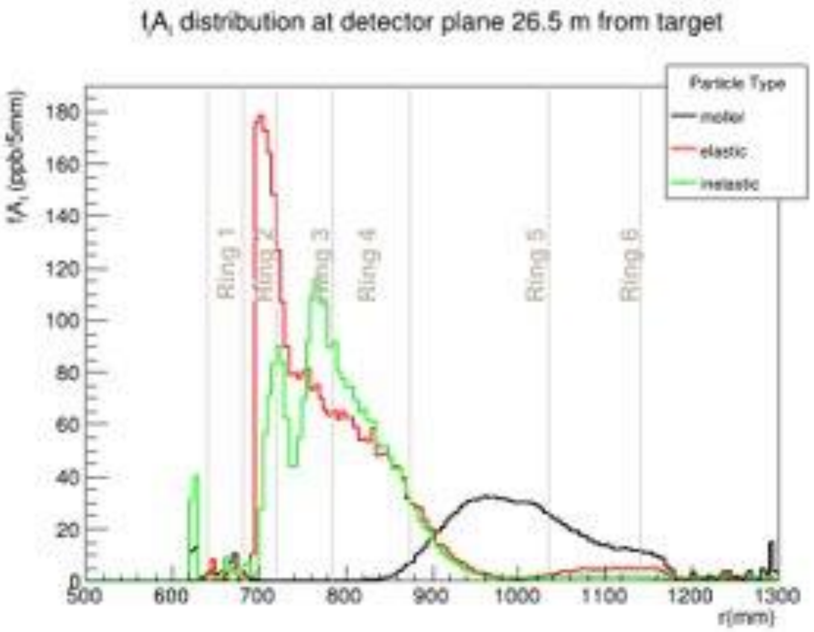
$f_i A_i$ distributions at detector plane

Approximate radial ring def'ns shown

Moller: Ring 5
Elastic ep: Ring 2

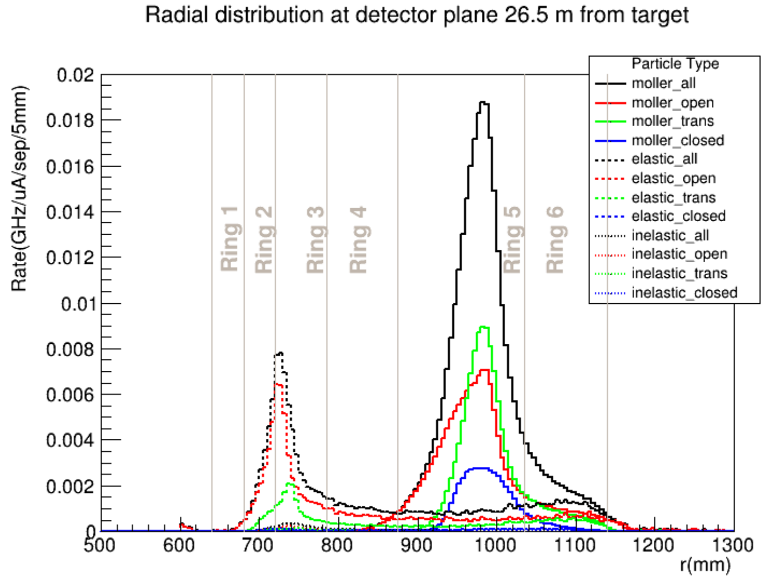


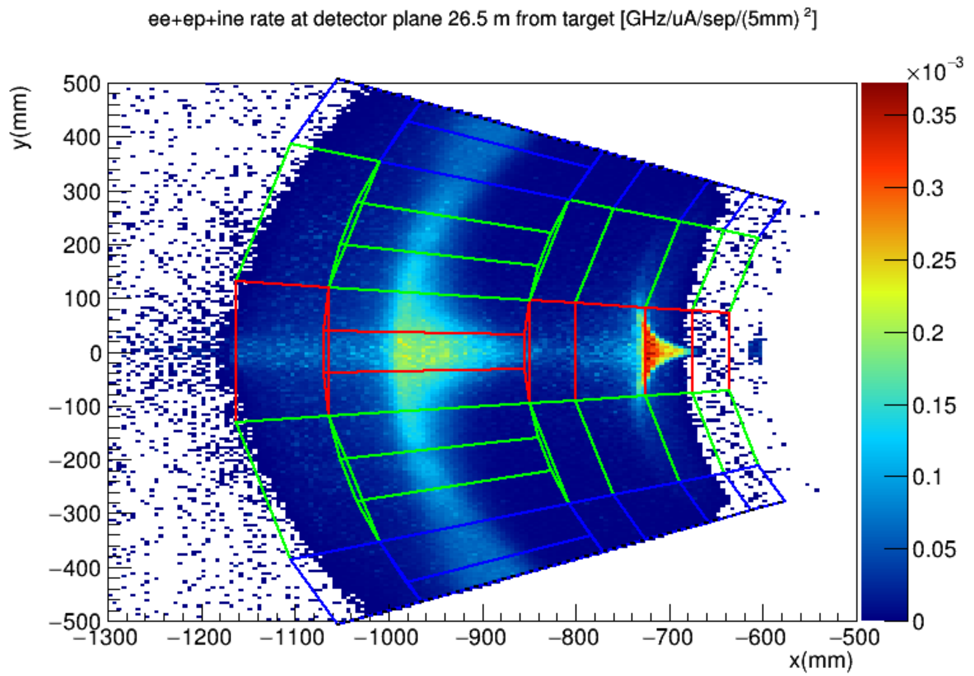

V1U.2a_V2DHy

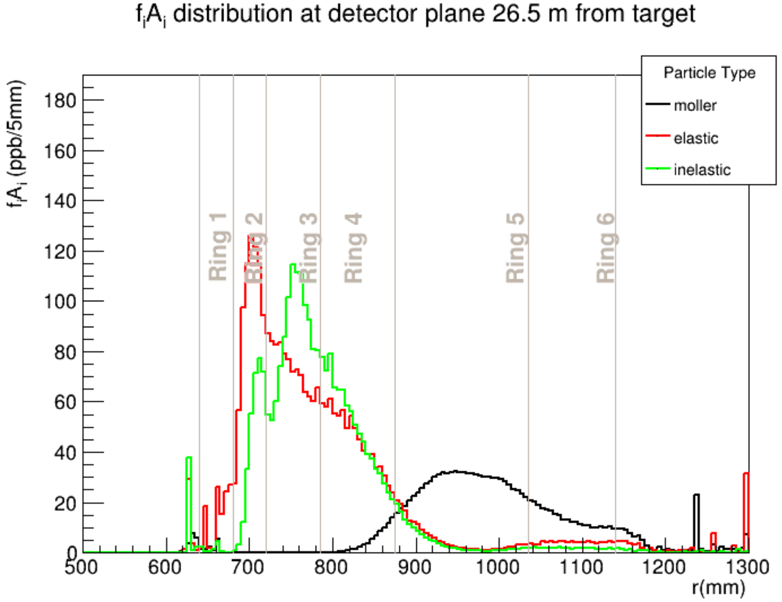



V1U.2a_V2DSg.1b

# Deconvolution




- Design the detector tiling to use the phi defocussing
- Have different contributions from the different processes
- three W regions for the inelastics

- Fit the simulated total asymmetries in each tile, using the simulated dilutions (fractional rates) to determine the asymmetry of each process

- No significant difference seen

# Backups

# Deconvolution study summary

| | | Relative uncertainty | | | |
|---|---|---|---|---|---|
| | Process | V1U.2a_V1DSg3 | V1U.2a_V2DHy | V1U.2a_V2DSg.1a | V1U.2a_V2DSg.1b |
| Primaries only | Møller | 0.0211 | 0.0210 | 0.0212 | 0.0211 |
| | e-p Elastic | 0.0577 | 0.0560 | 0.0515 | 0.0614 |
| | e-p Inelastic (W1) | 0.1294 | 0.1529 | 0.1249 | 0.1370 |
| | e-p Inelastic (W2) | 0.0673 | 0.0681 | 0.0638 | 0.0709 |
| | e-p Inelastic (W3) | 0.1706 | 0.1658 | 0.1662 | 0.1742 |
| Secondaries | Møller | 0.0214 | 0.0214 | 0.0217 | 0.0215 |
| | e-p Elastic | 0.0631 | 0.0618 | 0.0560 | 0.0680 |
| | e-p Inelastic (W1) | 0.1495 | 0.1779 | 0.1413 | 0.1576 |
| | e-p Inelastic (W2) | 0.0804 | 0.0823 | 0.0752 | 0.0876 |
| | e-p Inelastic (W3) | 0.2309 | 0.2279 | 0.2313 | 0.2420 |
| | | Segmented | Hybrid | Alternate Segmented | |

- The relative uncertainty on the moller asymmetry is the same between hybrid and segmented
- There is no *significant* difference between the hybrid and segmented from a physics perspective
- a slight preference for the segmented

- Changes for engineering concerns do affect the focal plan distributions
- Adjusting the detector tiling allows us to achieve the same relative uncertainty on the moller asymmetry

**Recommend segmented configuration as new baseline**

# 5 process deconvolution (Using only primaries)

| Name | Asymmetry | uncert[ppb] | relative uncer[ppb] |
|---|---|---|---|
| moller | -34.2891 | 0.7226 | -0.0211 |
| epElastic | -21.7975 | 1.2567 | -0.0577 |
| epInelasticW1 | -537.7265 | 69.5601 | -0.1294 |
| epInelasticW2 | -537.9042 | 36.2037 | -0.0673 |
| epInelasticW3 | -447.5959 | 76.3651 | -0.1706 |

V1U.2a_V1DSg.3

| Name | Asymmetry | uncert[ppb] | relative uncer[ppb] |
|---|---|---|---|
| moller | -34.6893 | 0.7291 | -0.0210 |
| epElastic | -23.8224 | 1.3331 | -0.0560 |
| epInelasticW1 | -565.0421 | 86.4192 | -0.1529 |
| epInelasticW2 | -541.4439 | 36.8601 | -0.0681 |
| epInelasticW3 | -469.0352 | 77.7575 | -0.1658 |

V1U.2a_V2DHy

| Name | Asymmetry | uncert[ppb] | relative uncer[ppb] |
|---|---|---|---|
| moller | -34.6953 | 0.7339 | -0.0212 |
| epElastic | -24.0622 | 1.2393 | -0.0515 |
| epInelasticW1 | -581.0825 | 72.5628 | -0.1249 |
| epInelasticW2 | -556.3365 | 35.4930 | -0.0638 |
| epInelasticW3 | -477.5756 | 79.3916 | -0.1662 |

V1U.2a_V2DSg.1a

| Name | Asymmetry | uncert[ppb] | relative uncer[ppb] |
|---|---|---|---|
| moller | -34.2668 | 0.7220 | -0.0211 |
| epElastic | -22.8270 | 1.4016 | -0.0614 |
| epInelasticW1 | -542.3427 | 74.3137 | -0.1370 |
| epInelasticW2 | -536.8306 | 38.0518 | -0.0709 |
| epInelasticW3 | -450.8812 | 78.5307 | -0.1742 |

V1U.2a_V2DSg.1b

# 5 process deconvolution (including secondaries)

| Name | Asymmetry | uncert[ppb] | relative uncer[ppb] |
|---|---|---|---|
| moller | -34.1199 | 0.7314 | -0.0214 |
| epElastic | -22.1256 | 1.3971 | -0.0631 |
| epInelasticW1 | -623.6047 | 93.2303 | -0.1495 |
| epInelasticW2 | -607.8443 | 48.8750 | -0.0804 |
| epInelasticW3 | -452.7696 | 104.5314 | -0.2309 |

V1U.2a_V1DSg.3

| Name | Asymmetry | uncert[ppb] | relative uncer[ppb] |
|---|---|---|---|
| moller | -34.5202 | 0.7396 | -0.0214 |
| epElastic | -23.5685 | 1.4564 | -0.0618 |
| epInelasticW1 | -628.5779 | 111.8160 | -0.1779 |
| epInelasticW2 | -602.9652 | 49.6308 | -0.0823 |
| epInelasticW3 | -472.8495 | 107.7454 | -0.2279 |

V1U.2a_V2DHy

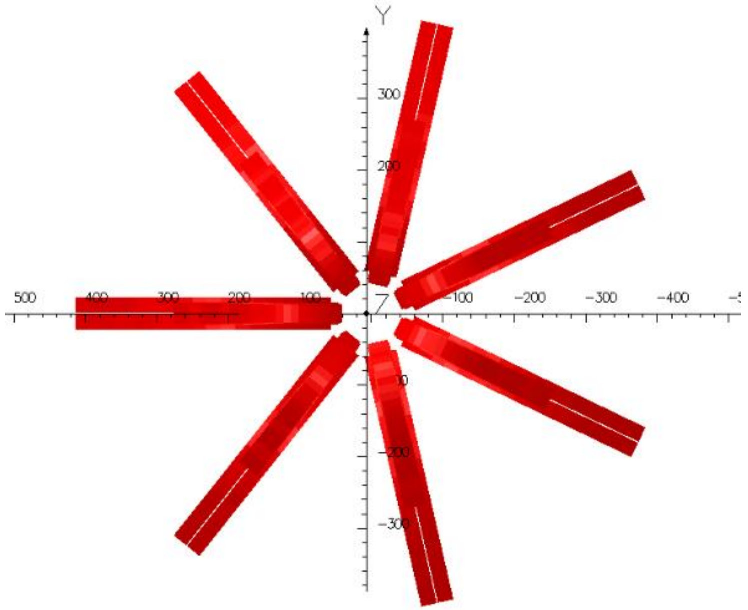
| Name | Asymmetry | uncert[ppb] | relative uncer[ppb] |
|---|---|---|---|
| moller | -34.5291 | 0.7489 | -0.0217 |
| epElastic | -23.9641 | 1.3417 | -0.0560 |
| epInelasticW1 | -651.7935 | 92.1016 | -0.1413 |
| epInelasticW2 | -615.7681 | 46.3195 | -0.0752 |
| epInelasticW3 | -481.1127 | 111.2654 | -0.2313 |

V1U.2a_V2DSg.1a

| Name | Asymmetry | uncert[ppb] | relative uncer[ppb] |
|---|---|---|---|
| moller | -34.0727 | 0.7326 | -0.0215 |
| epElastic | -23.0626 | 1.5689 | -0.0680 |
| epInelasticW1 | -615.1191 | 96.9158 | -0.1576 |
| epInelasticW2 | -611.7688 | 53.6000 | -0.0876 |
| epInelasticW3 | -455.2799 | 110.1924 | -0.2420 |

V1U.2a_V2DSg.1b

# Effect of returns




In this septant:

$B_y \sim B_\varphi$ Radially focussing

$B_x \sim B_r$ Azimuthally focussing

The component of the field that is most different is the z component

- Only applied for a short distance (x10 reduction)
- Only act on $v_r$ component (x100 reduction)
- Is small – 10-100x smaller than radial focussing component

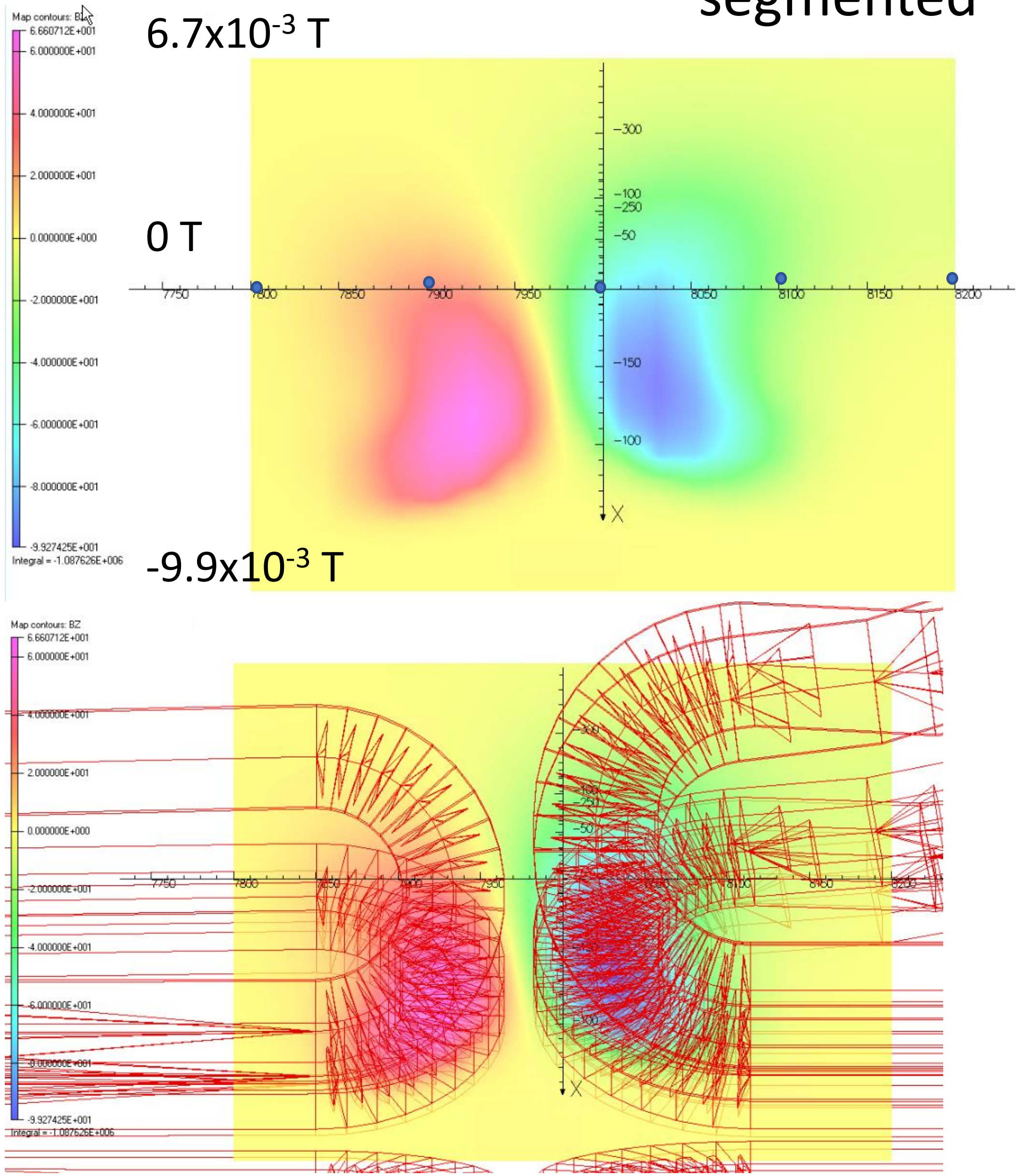
$$\vec{F} = q\vec{v} \times \vec{B} = -\begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ v_x & v_y & v_z \\ B_x & B_y & B_z \end{vmatrix} = \begin{matrix} -(\cancel{v_y B_z} - v_z B_y)\hat{\imath} \\ -(v_z B_x - \cancel{v_x B_z})\hat{\jmath} \\ -(\cancel{v_x B_y} - \cancel{v_y B_x})\hat{k} \end{matrix}$$

$$v_x, v_y \ll v_z$$

- 1e4 – 1e5 reduction in strength

# Z component of the field

segmented




hybrid