~~Zreac~~ Z_{react}, Y_{tar} written out is SIMC:

~~Init~~ Initial Y_{tar} ~~(also~~ (roughly):

hsyptari
(ssyptari) $=$ $\pm$ main%target%z * spec%e%sin_th
(P)

Reconstructed
~~Final~~ Y_{tar} :
~~Recons~~

hsytari
(ssytari) $=$ recon%e%z
(P)

Reconstructed Y_{tar} (not z)

Need to add following:

Initial Z_{react}:

~~h~~ ~~hz~~ eZreacti
(PZreacti) $=$ main%target%z ~~(easy)~~

Initial Y_{tar} (really):

eYtari
(PYtari) $=$ main%SP%e%z
(P)

(maybe should do same for delta...)

Reconstructed
~~Final~~ Z_{reac} :

eZreact
(PZreact) &

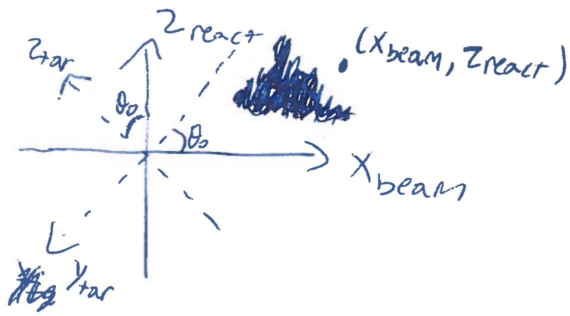
Remember in SIMC:
- X_{beam} points right
- Y_{tar} points left
- θ_0 is positive
- Z_{react} ~~is down~~ points downstream

HallA
NIM paper (LHRS):

$$Z_{react} = -(Y_{tar} + D)\frac{\cos(\arctan(\phi_{tar}))}{\sin(\theta_0 + \arctan(\phi_{tar}))} + X_{beam}\cot(\theta_0 + \arctan\phi_{tar}$$

~~θ_0~~
- X_{beam} points left, Z_{react} points downstream
- Y_{tar} points left
- θ_0 is positive (for LHRS), 0 points to positive Y_{tar}

SIMC Left HRS: $\phi_{spec} = \pi/2$



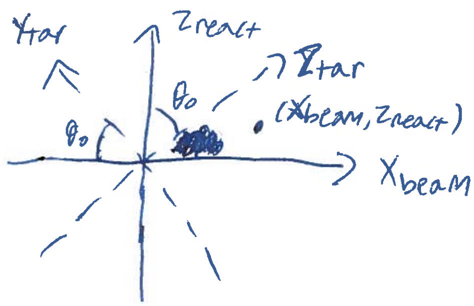
$$y_{tar} = -x_{beam}\cos\theta_0 - z_{react}\sin\theta_0$$

$$z_{tar} = z_{react}\cos\theta_0 - x_{beam}\sin\theta_0$$

$$\hat{y}_{tar} = \langle -\cos\theta_0, -\sin\theta_0 \rangle$$

$$\hat{z}_{tar} = \langle -\sin\theta_0, \cos\theta_0 \rangle \quad \Rightarrow \quad \hat{y}_{tar} \cdot \hat{z}_{tar} = 0$$

SIMC Right HRS: $\phi_{spec} = 3\pi/2$



$$y_{tar} = -x_{beam}\cos\theta_0 + z_{react}\sin\theta_0$$

$$z_{tar} = z_{react}\cos\theta_0 + x_{beam}\sin\theta_0$$

$$\hat{y}_{tar} = \langle -\cos\theta_0, \sin\theta_0 \rangle \qquad \hat{y}_{tar} \cdot \hat{z}_{tar} = 0$$

$$\hat{z}_{tar} = \langle \sin\theta_0, \cos\theta_0 \rangle$$

So...

$$y_{tar} = -x_{beam}\cos\theta_0 - z_{react}\sin\theta_0 \sin\phi_{spec}$$

$$z_{tar} = z_{react}\cos\theta_0 - x_{beam}\sin\theta_0 \sin\phi_{spec}$$

1) $Y_{tar} = -X_{beam}\cos\theta_0 - Z_{react}\sin\theta_0 \sin\phi_{spec}$

$Z_{tar} = Z_{react}\cos\theta_0 - X_{beam}\sin\theta_0 \sin\phi_{spec}$

2) $Y_{tar} = -X_{beam}\cos\theta_0 - Z_{react}\sin\theta_0 \sin\phi_{spec} - D$ (D points to $+Y_{tar}$)

$dY = \phi_{tar} - \phi_{off}$ ← (what's the point?)

3) drift to $Z_{tar} = 0$

$Y_{tar} = -X_{beam}\cos\theta_0 - Z_{react}\sin\theta_0 \sin\phi_{spec} - D - Z_{tar}\cdot dY$

$Y_{tar} + D = -X_{beam}\cos\theta_0 - Z_{react}\sin\theta_0\sin\phi_{spec} - Z_{react}\cos\theta_0(\phi_{tar}-\phi_{off})$
$+ X_{beam}\sin\theta_0\sin\phi_{spec}(\phi_{tar}-\phi_{off})$

$Y_{tar}+D) = Z_{react}(\sin\theta_0\sin\phi_{spec} + \cos\theta_0(\phi_{tar}-\phi_{off}))$
$+ X_{beam}(\cos\theta_0 - \sin\theta_0\sin\phi_{spec}(\phi_{tar}-\phi_{off})$

multiply by $\cos[\arctan(\phi_{tar}-\phi_{off})]$:

'se $\cos[\arctan(\phi_{tar}-\phi_{off})](\phi_{tar}-\phi_{off}) = \cos[\arctan(\phi_{tar}-\phi_{off})]\tan[\arctan[\phi_{tar}-\phi_{off}$
$= \sin[\arctan(\phi_{tar}-\phi_{off})]$

:) ~~Y_{tar}~~ $-(Y_{tar}+D)\cos[\arctan(\phi_{tar}-\phi_{off})] = Z_{react}\times A_1 + X_{beam}\times A_2$

$A_1 = \sin\theta_0\cos[\arctan(\phi_{tar}-\phi_{off})]\times\sin\phi_{spec} + \cos\theta_0 \sin[\arctan(\phi_{tar}-\phi_{off})]$

$= \sin[\arctan(\phi_{tar}-\phi_{off}) + \sin\phi_{spec}\,\theta_0]$

$A_2 = \cos\theta_0\cos[\arctan(\phi_{tar}-\phi_{off})] - \sin\theta_0\sin[\arctan(\phi_{tar}-\phi_{off})]\sin\phi_{spec}$

$= \cos[\arctan(\phi_{tar}-\phi_{off}) + \sin\phi_{spec}\,\theta_0]$

Divide by A_1:

$$\frac{-(Y_{tar}+D)\cos[\arctan(\phi_{tar}-\phi_{off})]}{\sin[\arctan(\phi_{tar}-\phi_{off})+\sin\phi_{spec}\,\theta_0]} = Z_{react} + X_{beam}\cot[\arctan(\phi_{tar}-\phi_{off}) + \sin\phi_{spec}\,\theta_0]$$

$$\Rightarrow Z_{react} = -(Y_{tar}+D)\frac{\cos[\arctan(\phi_{tar}-\phi_{off})]}{\sin[\arctan(\phi_{tar}-\phi_{off})+\sin\phi_{spec}\,\theta_0]} - X_{beam}\cot[\arctan(\phi_{tar}-\phi_{off}) + \sin\phi_{spec}\,\theta_0]$$

How to add Reconstructed Z_{react} in SIMC code (montecarlo subroutine ~~function~~):

Know θ_0, ϕ_{spec}

Assume we know D = spec%e(P)%offset%y

and ϕ_{off} = spec%e(P)%offset%yptar

[suppose there can be a Z_{tar} offset, which we know

set $Y_{coff} = Y_{tar} + D - Z_{off}(\phi_{tar} - \phi_{off})$

$\left\{ \begin{array}{l} Y_{tar} = \text{recon\%e\%z} \\ \phi_{tar} = \text{recon\%e\%yptar} \\ Z_{off} = \text{spec\%e(P)\%offset\%z} \end{array} \right.$

$arg1 = \arctan(\phi_{tar} - \phi_{off})$

X_{beam} (reconstructed) = targ%xoffset + main%target%rasterx

(obviously can include gaussian beam smearing (halo) in recon calculation)

$$\Rightarrow Z_{react} = -Y_{coff} \times aa_1 - X_{beam,recon} \times aa_2$$

$$\left\{ \begin{array}{l} aa_1 = \dfrac{\cos(arg1)}{\sin(arg1 + \sin\phi_{spec}\,\theta_0)} \\[2ex] aa_2 = \cot(arg1 + \sin\phi_{spec}\,\theta_0) \end{array} \right.$$