Notes on Pxl Calibrations

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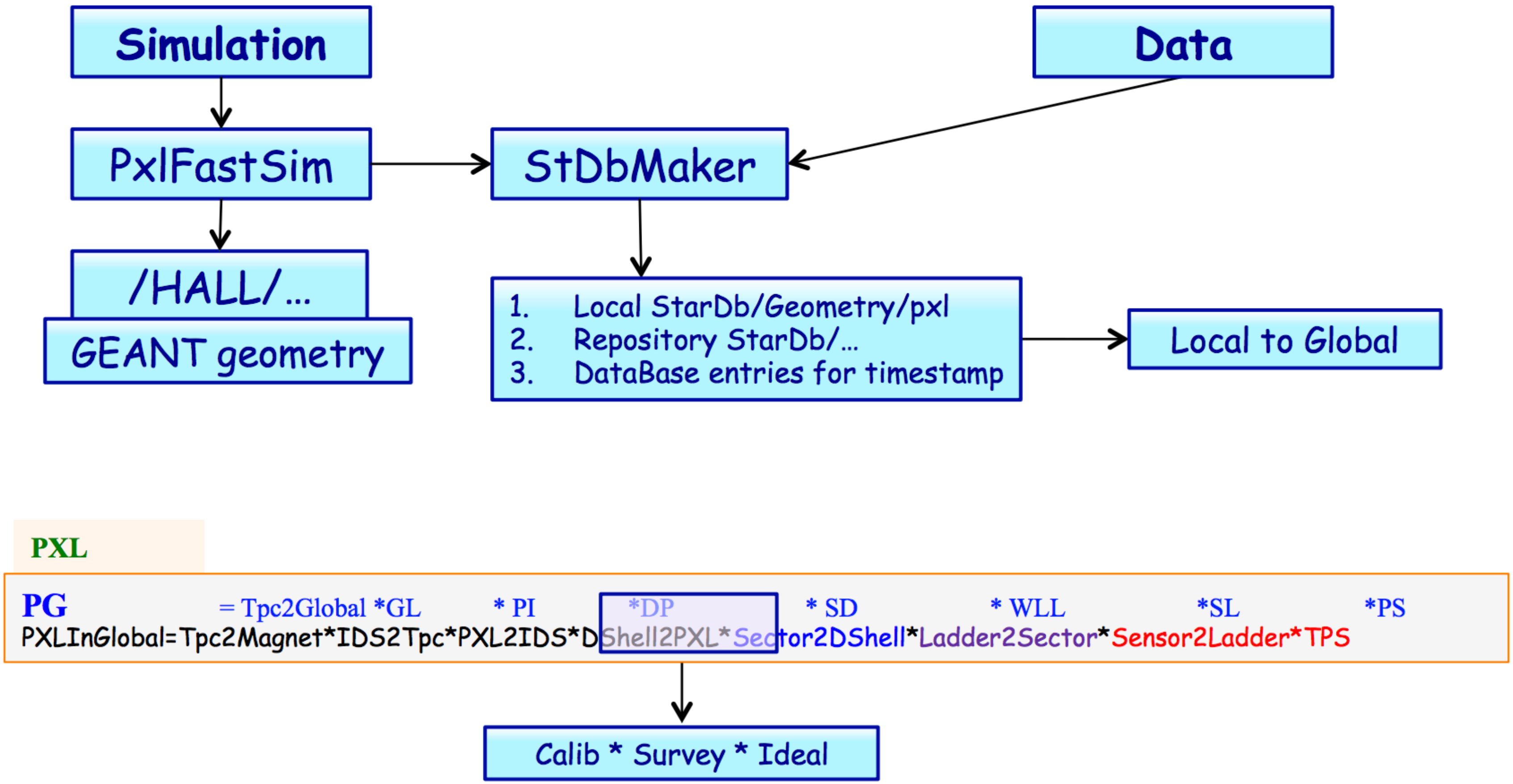
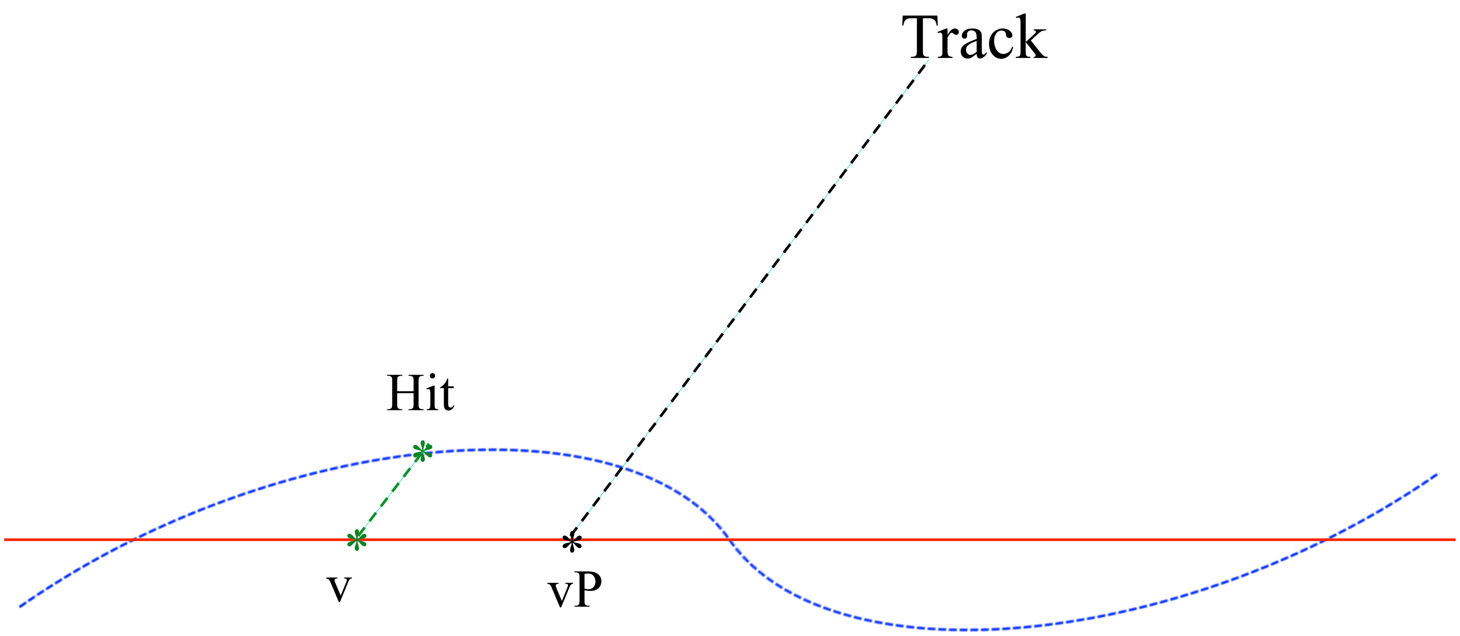
Flowchart of Geometry/Survey/Alignment



No real need to store “Ideal” in Db



- We need to either have prediction vP on TPS plane or project hit on sensor “plane” (preferred) [Xin]
- If we fit a plane to surveyed points then all these effects will cancel in average by definition
- Need to store the fitted plane parameters too, in Survey.idl

StDbMaker

```
St_Survey *PxlSectorsOnGlobal = (St_Survey *) GetDataBase("Geometry/pxl/PxlSectorsOnGlobal");
```

/afs/rhic.bnl.gov/star/packages/.DEV2/StRoot/macros/calib/Db.C

```
…
dbMk = new St_db_Maker("db","MySQL:StarDb","$STAR/StarDb","$PWD/StarDb");
…
```

1. Local StarDb/Geometry/pxl
2. Repository StarDb/…
3. DataBase entries for timestamp

Modifications for StPxlDbMaker

Exist:

WG = Tpc2Global * GL * SG * LS * WLL;

- PxlLaddersOnSectors.y2013.C
- ~~PxlOnGlobal.y2013.C~~
- ~~PxlSectorsOnGlobal.y2013.C~~
- PxlSensorsOnLadders.y2013.C

PxlHalfOnPxl.C
PxlSectorOnHalf.C

Need:

PxlHitOnSensor.y2013.C

PxlSectorOnHalf.C

PxlHalfOnPxl.C

PxlPxlOnPst.C
PxlPstOnIds.C
PxlIdsOnTpc.C

might combine

Need to fit plane to points-cloud and store function of (plane-TPS)

Refer to slides 9-12 for volume hierarchy

```
//      id = 3*layer + 100*wafer + ladder

 // sectors from 1 to 4 , as for thr SSD : test
 Survey_st row[40] = {
{   0,  -0.9846954,-0.1742841, 0.0000000,   0.1742841,-0.9846954, 0.0000000,   0.0000000, 0.0000000, 1.0000000,
-1.14906,  8.14414,  0.10000,     0.10000,  0.10000,  0.10000,  0.10000,  0.10000,  0.10000}// PXMO_1/PXLA_1/
LADR_1/PXSI_10/PLAC_1
{  10,  -0.9994132, 0.0342541, 0.0000000,  -0.0342541,-0.9994132, 0.0000000,   0.0000000,-0.0000000, 1.0000000,
-2.81720,  7.72727,  0.10000,     0.10000,  0.10000,  0.10000,  0.10000,  0.10000,  0.10000}// PXMO_1/PXLA_1/
LADR_2/PXSI_10/PLAC_1
{  20,  -0.9704518, 0.2412953, 0.0000000,  -0.2412953,-0.9704518, 0.0000000,   0.0000000,-0.0000000, 1.0000000,
-4.36222,  6.97268,  0.10000,     0.10000,  0.10000,  0.10000,  0.10000,  0.10000,  0.10000}// PXMO_1/PXLA_1/
LADR_3/PXSI_10/PLAC_1
{  30,   0.9989674, 0.0454327, 0.0000000,  -0.0454327, 0.9989674, 0.0000000,   0.0000000,-0.0000000, 1.0000000,
-0.82058,  2.56571,  0.10000,     0.10000,  0.10000,  0.10000,  0.10000,  0.10000,  0.10000}// PXMO_1/PXLA_1/
LADR_4/PXSI_10/PLAC_1
{ 100,   0.0000000, 0.0000000, 0.0000000,   0.0000000, 0.0000000, 0.0000000,   0.0000000, 0.0000000, 0.0000000,
0.00000,
```

/ PXL

*// Id = 1000*sector + 100*ladder   ladder to sector*

// sector[1-10], ladder[1-4], sensor[1-10]

Summary

- Ideal geometry: no need to put it in Db
  - unless we find a need for it
- We need to define all hierarchical transforms
  - we can summarize/combine those that we have no data to disentangle
- We need to fit planes through warped sensors (Pxl, Ist, Ssd)
- We need to follow definitions of Ids

- Next week we expect to release the StPxlDbMaker

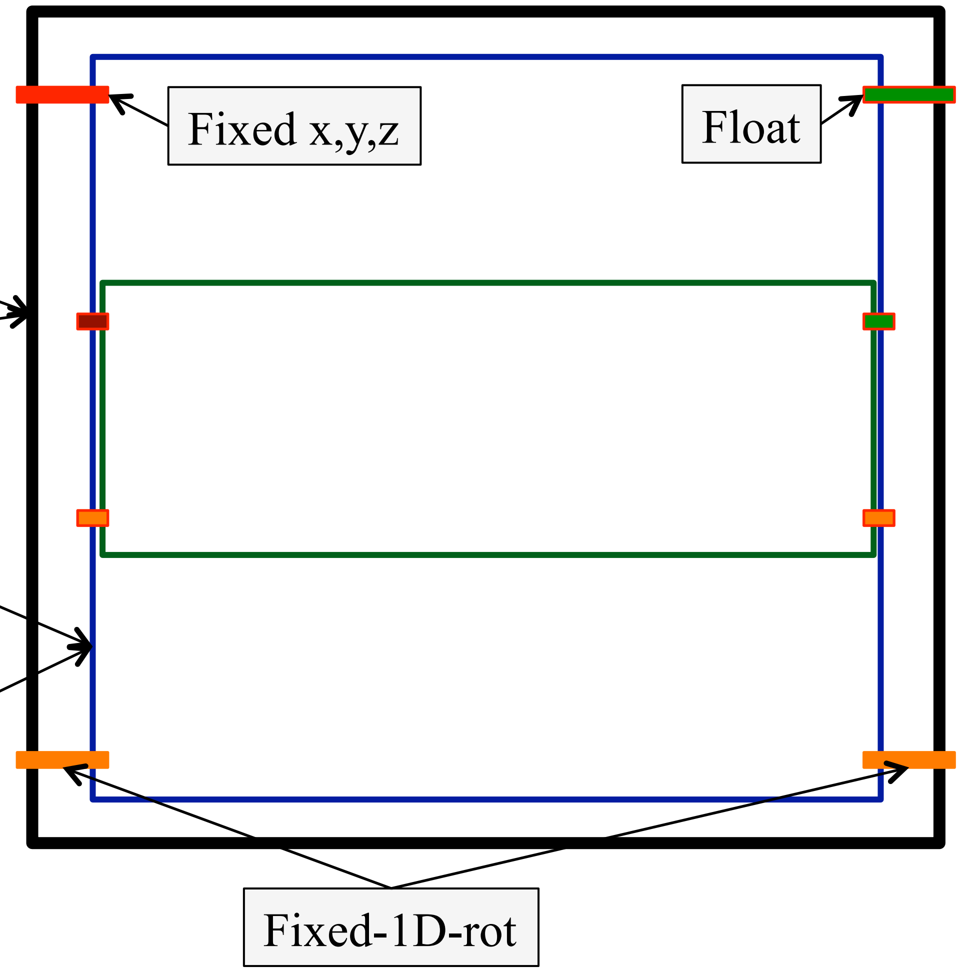
Backup

Reference System Hierarchy

- Star Magnet defines overall system (Field map)
- TPC is the first important system for HFT (relative positioning), attached to Magnet

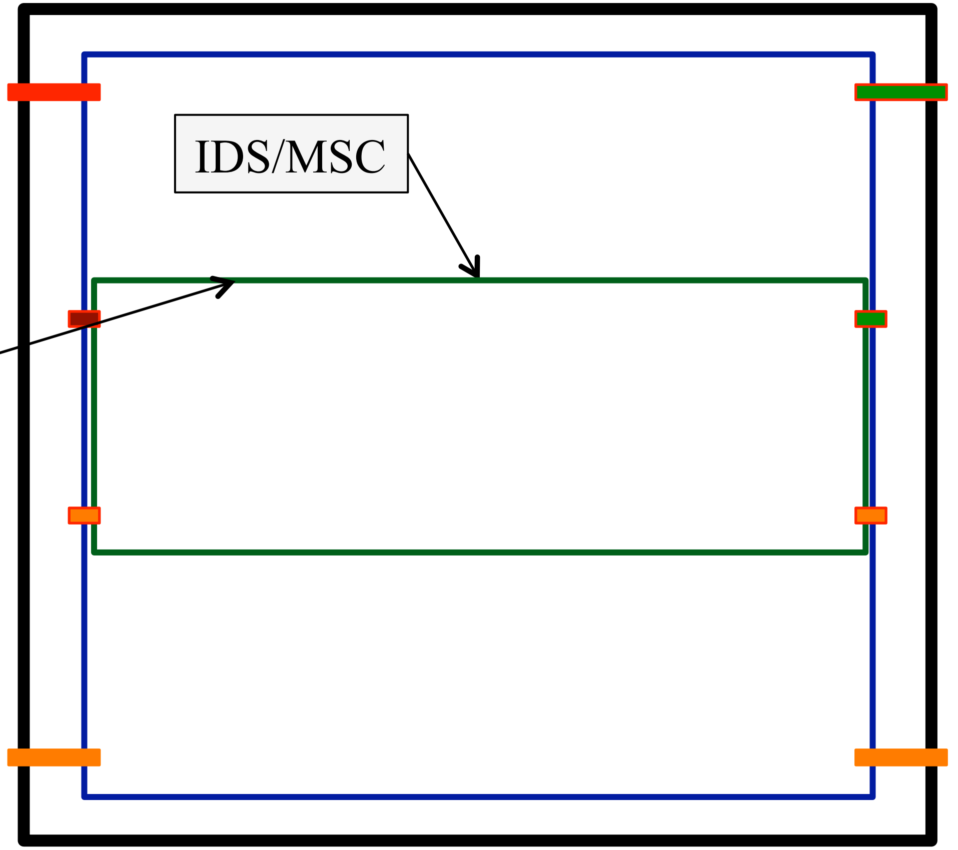
STAR Magnet=STAR system

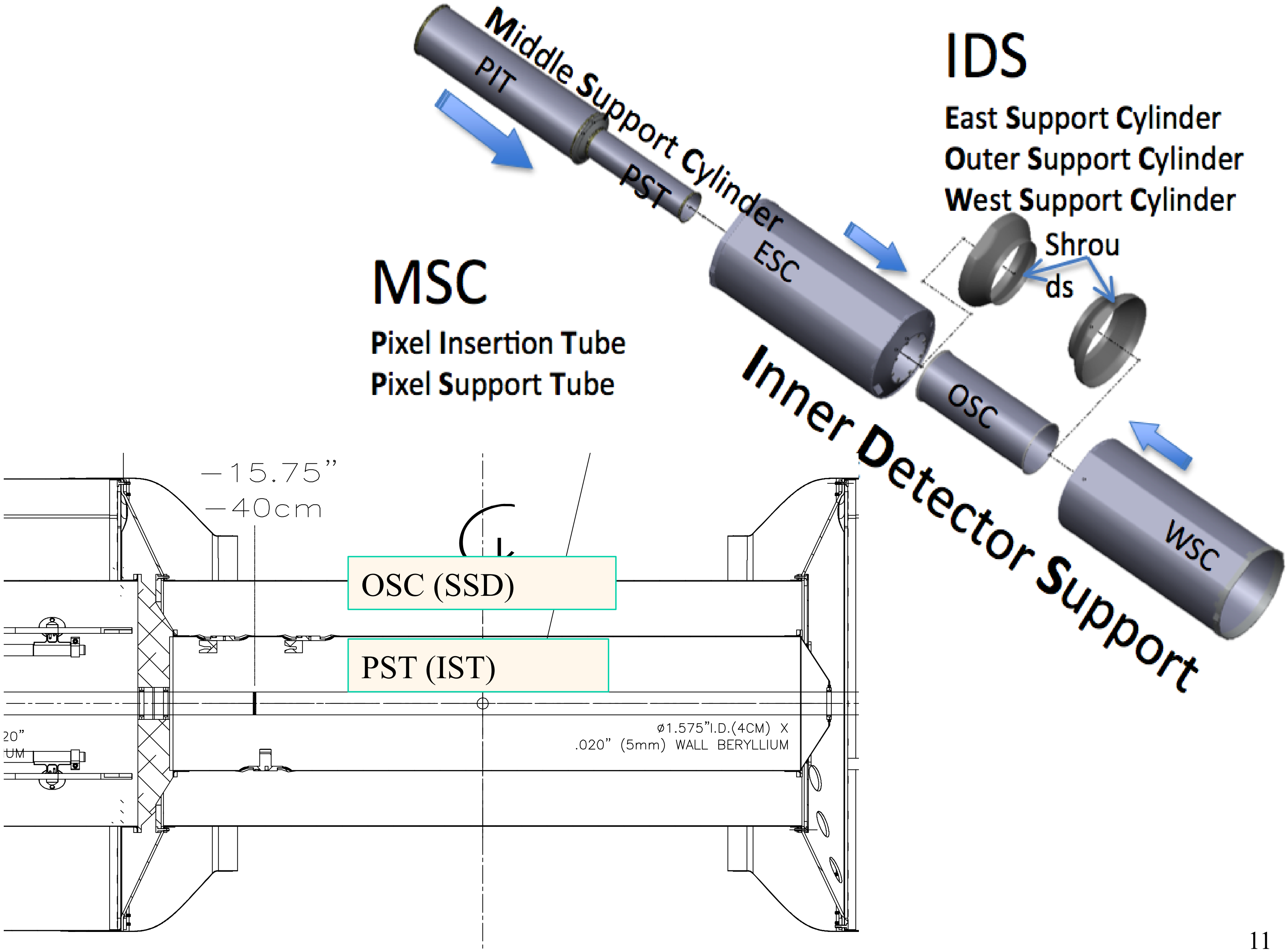
TPC system



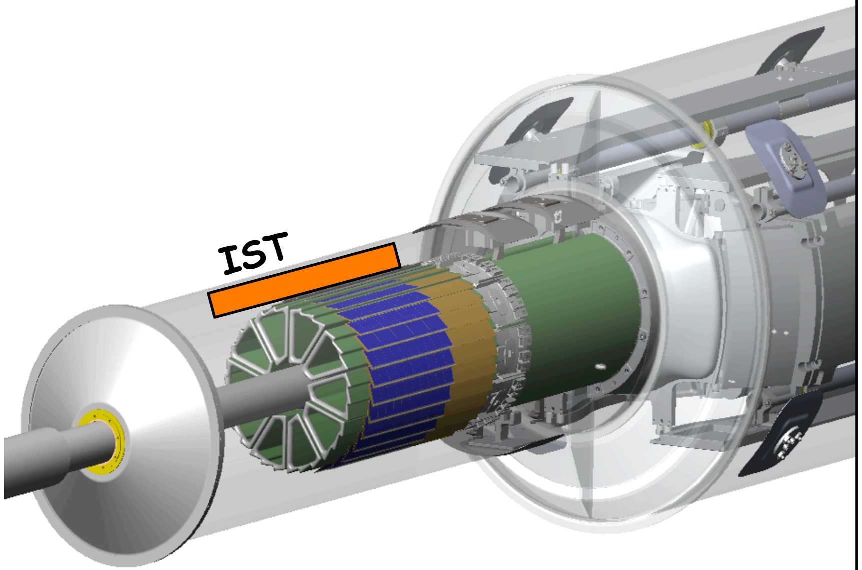
- **ESC/WSC** attached to TPC wheel. It defines the HFT system's relation (as a whole) to TPC system

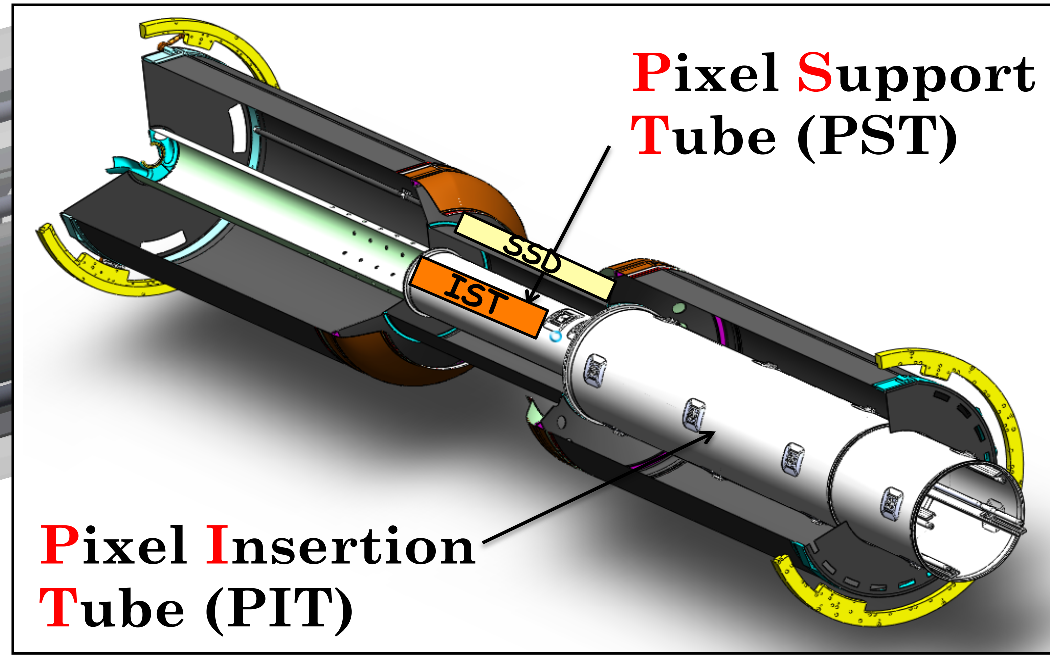
- See next slides for systems inside the HFT complex

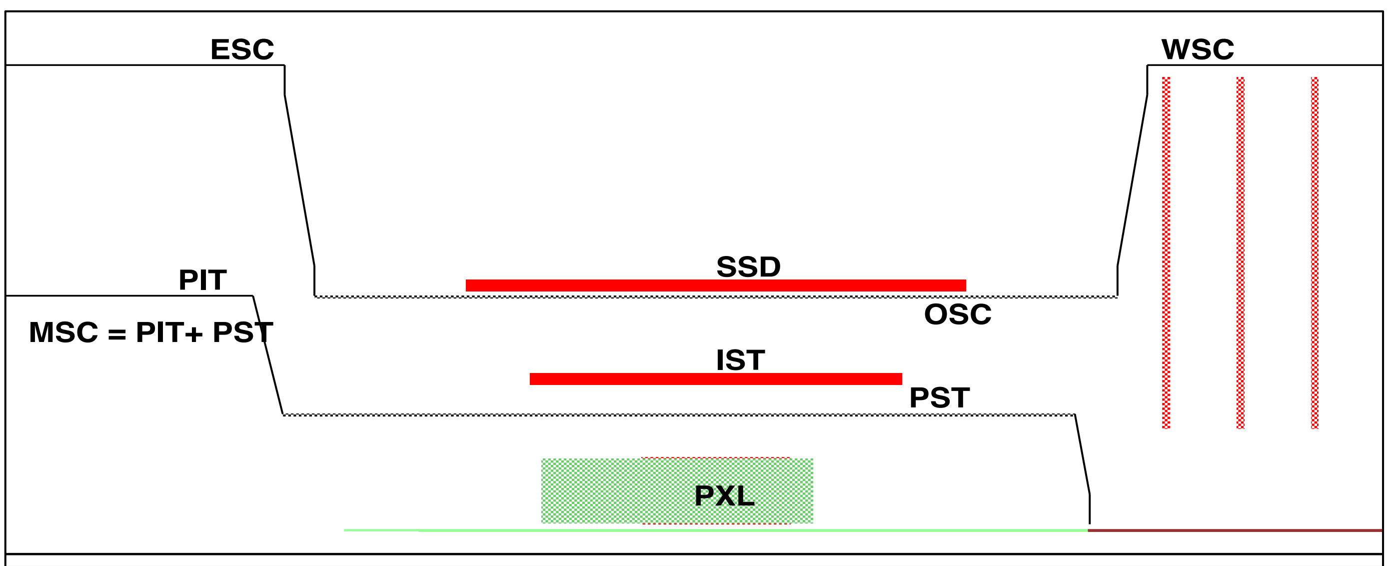



Middle Support Cylinder
PIT
PST
IDS
East Support Cylinder
Outer Support Cylinder
West Support Cylinder
Shrou
ds
ESC
MSC
Pixel Insertion Tube
Pixel Support Tube
Inner Detector Support
OSC
WSC
–15.75”
–40cm
OSC (SSD)
PST (IST)
ø1.575”I.D.(4CM) X
.020” (5mm) WALL BERYLLIUM

General Layout







Local <-> Global transforms

OLD SSD

WG = Tpc2Global * GL * SG * LS * WLL;
WaferInGlobal=Tpc2Magnet *SsdinTpc*SectorInSSD*LadderInSector*WaferInLadder

HFT SSD

WG = Tpc2Global * GL * LO * WLL;
WaferInGlobal=Tpc2Magnet *IDS2Tpc*Ladder2IDS*WaferInLadder

HFT IST

WG = Tpc2Global * GL * PI *LO * WLL;
WaferInGlobal=Tpc2Magnet *IDS2Tpc*PST2IDS*Ladder2PST*WaferInLadder

HFT PXL

PG = Tpc2Global *GL * PI *DP * SD * WLL;
PXLInGlobal=Tpc2Magnet*IDS2Tpc*PXL2IDS*DShell2PXL*Sector2DShell*(Pxl-Sector)

The hit-track residual Δx in the direction perpendicular to the axial strips is given by

$$\Delta x \equiv x_{track} - x_{hit} = \delta x + z \sin\beta + \tan\phi(\delta y + z \sin\alpha + x \sin\gamma) - f(\vec{B}, \phi) \quad (1)$$

and for the direction parallel to the axial strips (in double sided ladders)

$$\Delta z \equiv z_{track} - z_{hit} = \delta z + x \sin\beta + \tan\theta(\delta y + z \sin\alpha + x \sin\gamma) \quad (2)$$

The simplest approach to determining the alignment parameters is to use the means of the following histograms(for the Δx case):

1. the distribution of residuals integrated over y, z, and ϕ, which gives δx directly,
2. the residual vs. z which gives $\sin\beta$,
3. the residual vs. $\tan\phi$ which gives δy,
4. the residual/$\tan\phi$ vs. x which gives $\sin\gamma$,
5. and the residual/$\tan\phi$ vs. z which gives $\sin\alpha$.

D.Chakraborty, J.D.Hobbs, D0 note Oct.13, 1999

HFT Proposed Procedure:

Remember: PXL detector is a big asset (c.f. TPC)

1. Global Alignment of PXL
   - Relative alignment of PXL sectors and halves using overlap region AND halves using Event vertex found by each half
   - Relative alignment of PXL and TPC [TPC primary tracks]
     - Iterative->(PXL, PXL half, sector)
   - Exact sequence/interplay needs to be determined

2. Primary tracks with TPC+PXL hits
   - Alignment of IST ladders with respect to PXL

3. Primary tracks with (All – SSD) hits
   - Alignment of SSD ladders

4. Check

- We assume that sensors on ladder and ladders on sectors are pre-surveyed to specs

References

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3. “Correcting for distortions due to ionization in the STAR TPC”, G. Van Buren et al.,NIM A566:22-25,2006.
4. “The STAR Silicon Vertex Tracker” A large area Silicon Drift Detector”, R.Bellwied et Al., NIM A499: 640, 2003.
5. “The STAR silicon strip-detector (SSD)”, L.Arnold et al., NIM 2003 A499: 652, 2003.
6. “Alignment Strategy for the SMT Barrel Detectors”, D.Chakborty, J.D.Hobbs, October 13, 1999. D0 Note (unpublished)
7. “Sensor Alignment by Tracks”, V.Karimaki et al.,CMS CR-2004/009 (presented at CHEP 2003)
8. http://phys.kent.edu/~margetis/STAR/HFT/Survey/SVTSmallScaleSelfAlignment.pdf
9. http://phys.kent.edu/~margetis/STAR/HFT/Survey/SVT_Alignment_JPCSL.pdf

Small Scale Self-Alignment with the SVT

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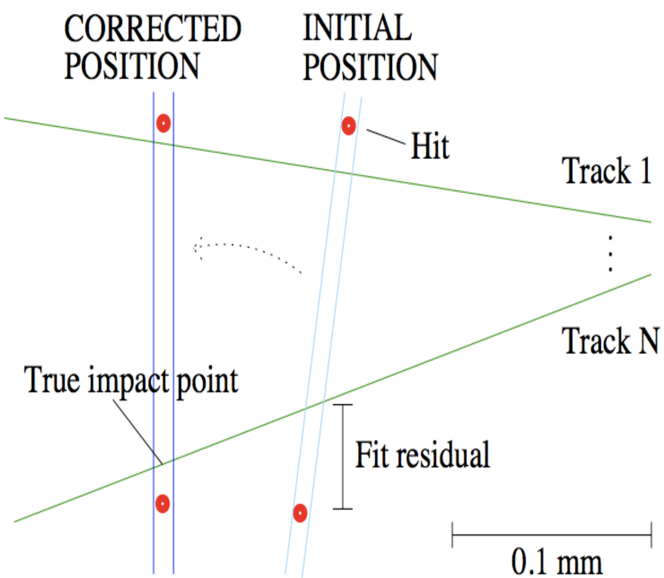

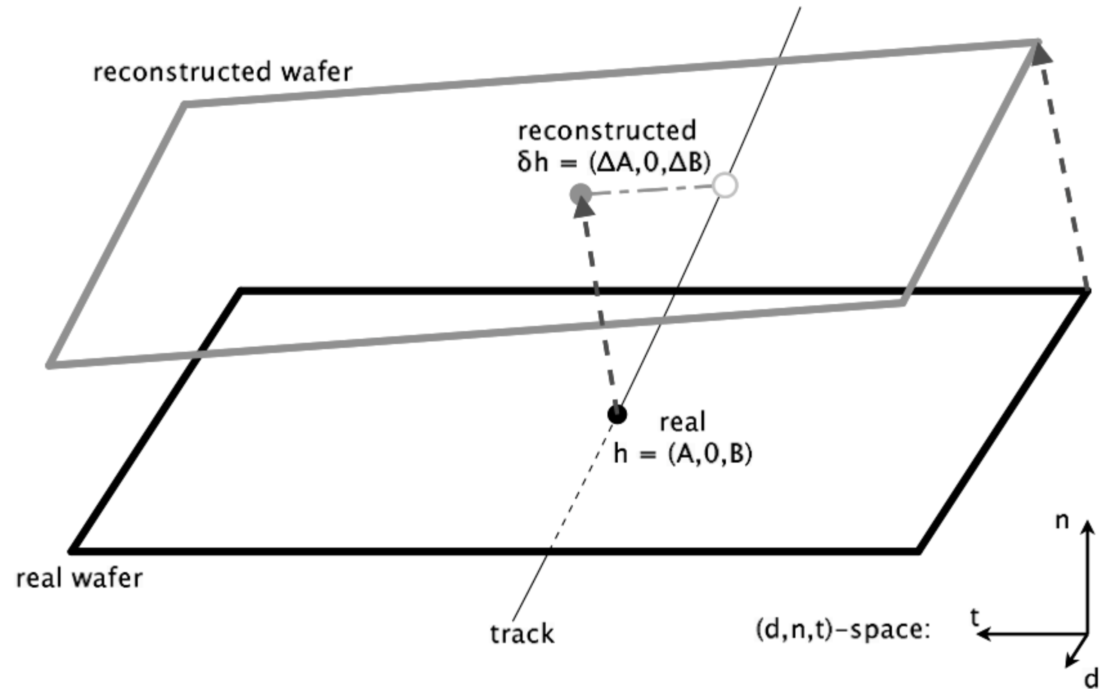

$$
\begin{aligned}
\Delta A &= -B\delta\phi_n - \delta x_d + v_{dn}[A\delta\phi_t - B\delta\phi_d + \delta x_n] \\
\Delta B &= A\delta\phi_n - \delta x_t + v_{tn}[A\delta\phi_t - B\delta\phi_d + \delta x_n]
\end{aligned}
$$

http://drupal.star.bnl.gov/STAR/comp/calib/svt/selfalign

The hit-track residual Δx in the direction perpendicular to the axial strips is given by

$$\Delta x \equiv x_{track} - x_{hit} = \delta x + z \sin\beta + \tan\phi(\delta y + z\sin\alpha + x\sin\gamma) - f(\vec{B}, \phi) \qquad (1)$$

and for the direction parallel to the axial strips (in double sided ladders)

$$\Delta z \equiv z_{track} - z_{hit} = \delta z + x \sin\beta + \tan\theta(\delta y + z\sin\alpha + x\sin\gamma) \qquad (2)$$

$$\boxed{\begin{aligned} \Delta A &= -B\delta\phi_n - \delta x_d + v_{dn}[A\delta\phi_t - B\delta\phi_d + \delta x_n] \\ \Delta B &= A\delta\phi_n - \delta x_t + v_{tn}[A\delta\phi_t - B\delta\phi_d + \delta x_n] \end{aligned}}$$

The simplest approach to determining the alignment parameters is to use the means of the following histograms(for the Δx case):

1. the distribution of residuals integrated over y, z, and ϕ, which gives δx directly,
2. the residual vs. z which gives $\sin\beta$,
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D.Chakraborty, J.D.Hobbs, D0 note Oct.13, 1999

A. Appendix. Jacobian of measured hit position deviation from predicted track ones with respect to misalignment parameters.

1. *Misalignment of the detector in Global Coordinate System (GCS)*

- $\vec{j} = (j_x,\, j_y,\, j_z)$ - track direction cosinuses in GCS on measurement plane,
- $\vec{x} = (x,\, y,\, z)$ - track prediction in GCS on measurement plane,
- $\vec{x}_{hit} = (x_{hit},\, y_{hit},\, z_{hit})$ - hit position in GCS on measurement plane,
- $\vec{v} = (v_x,\, v_y,\, v_z)$ - direction of perpendicular to measurement plane in GCS,
- $\vec{\Delta} = (\Delta_x,\, \Delta_y,\, \Delta_z,\, \Delta_\alpha,\, \Delta_\beta,\, \Delta_\gamma)$ - misalignment parameters: shift and rotation with respect to X,Y,Z axises, respectively.
- $\vec{x}_{hit} - \vec{x} = \mathbf{G} \cdot \vec{\Delta} =$

$$\begin{pmatrix} -1 + j_x v_x & j_x v_y & j_x v_z & j_x(-v_y z + v_z y) & -z + j_x(v_x z - v_z x) & y + j_x(-v_x y + v_y x) \\ j_y v_x & -1 + j_y v_y & j_y v_z & z + j_y(-v_y z + v_z y) & j_y(v_x z - v_z x) & -x + j_y(-v_x y + v_y x) \\ j_z v_x & j_z v_y & -1 + j_z v_z & -y + j_z(-v_y z + v_z y) & x + j_z(v_x z - v_y x) & j_z(-v_x y + v_y x) \end{pmatrix} \vec{\Delta}$$

2. *Misalignment of the detector in Local Coordinate System (LCS)*

- $\vec{u} = (u,\, v,\, w \equiv 0)$ - track prediction in LCS on measurement plane.
- $(t_u,\, t_v)$ - track direction tangenses in Local Coordinate system (LCS) on measurement plane.
- $\vec{u}_{hit} = (u_{hit},\, v_{hit})$ - hit position in LCS on measurement plane,
- $\vec{\delta} = (\delta_u,\, \delta_v,\, \delta_w,\, \delta_\alpha,\, \delta_\beta,\, \delta_\gamma)$ - misalignment parameters, shift and rotation with respect to local u,v,w axises, respectively.
- $$\vec{u}_{hit} - \vec{u} = \mathbf{L} \cdot \vec{\delta} = \begin{pmatrix} -1 & 0 & t_u & t_u v & -t_u u & v \\ 0 & -1 & t_v & t_v v & -t_v u & -u \end{pmatrix} \vec{\delta}$$
- $(u_{hit} - u) = -\delta_u + t_u(\delta_w + v\delta_\alpha - u\delta_\beta) + v\delta_\gamma;$
  $(v_{hit} - v) = -\delta_v + t_v(\delta_w + v\delta_\alpha - u\delta_\beta) - u\delta_\gamma;$