AoA Triangulation for MIC arrays

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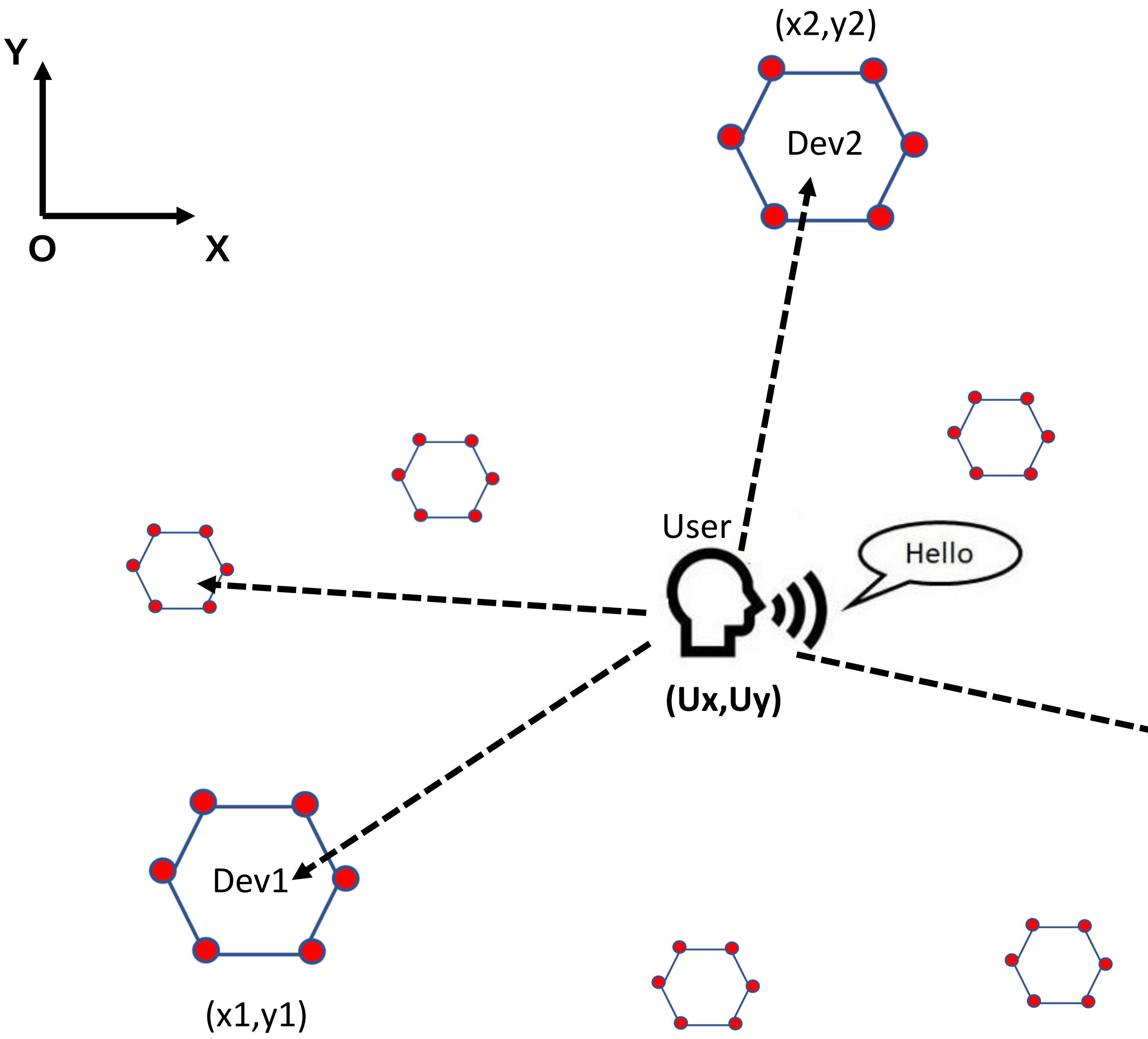
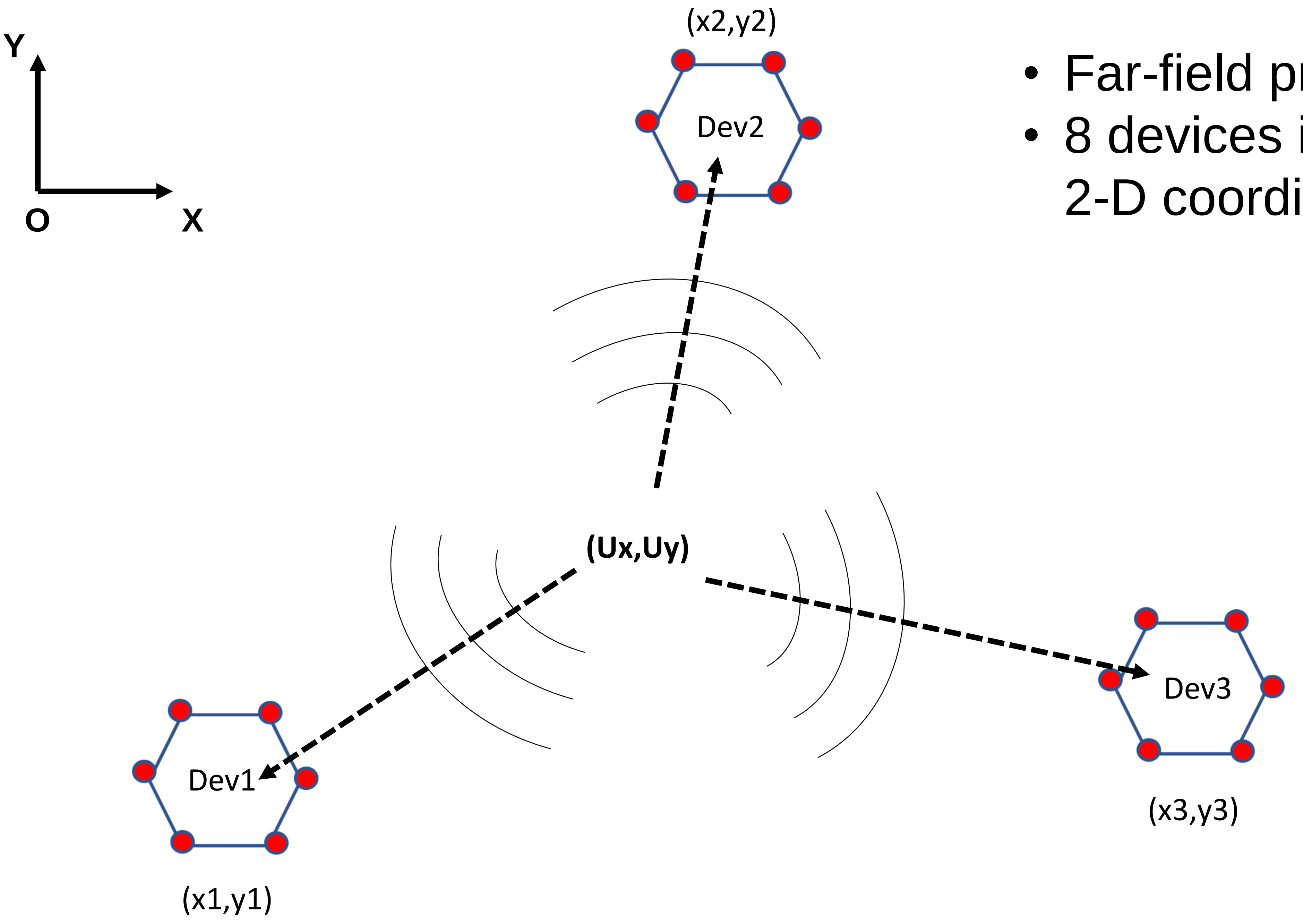
UIUC

ECE/CS 434 SP2020
Final Project



- Far-field propagation
- 8 devices in 2-D coordinate



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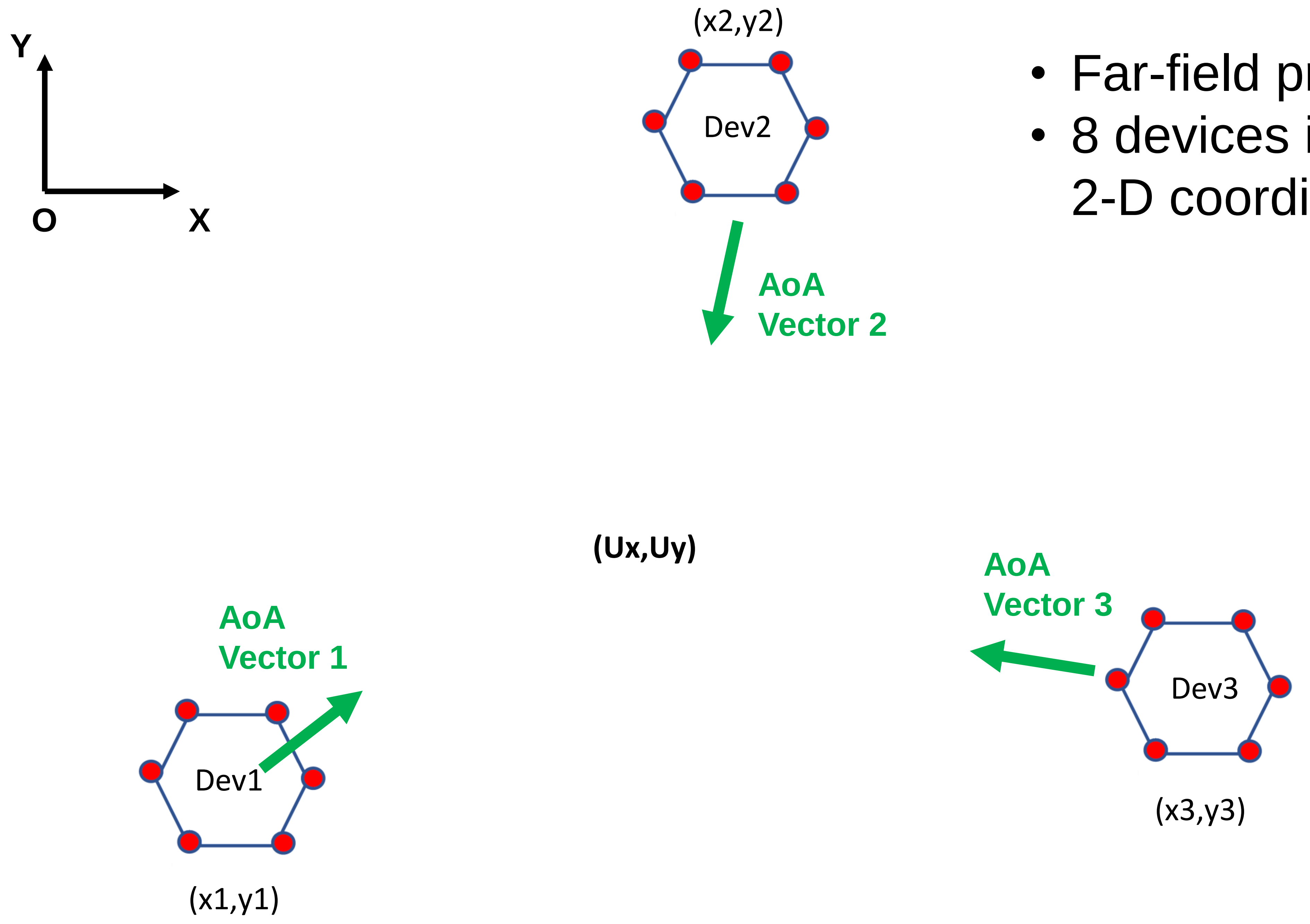

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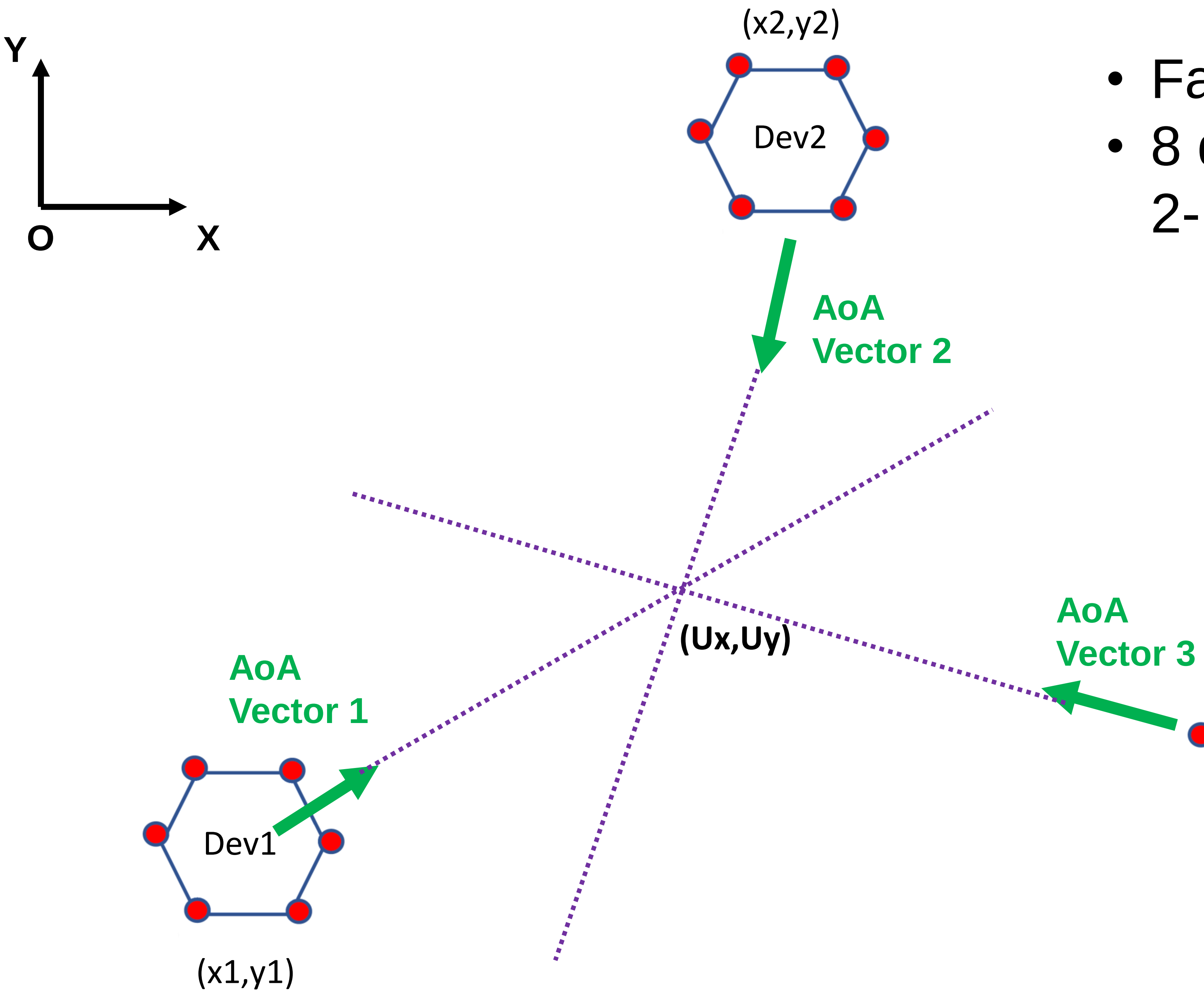

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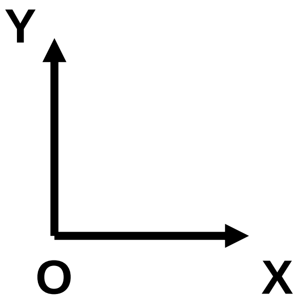
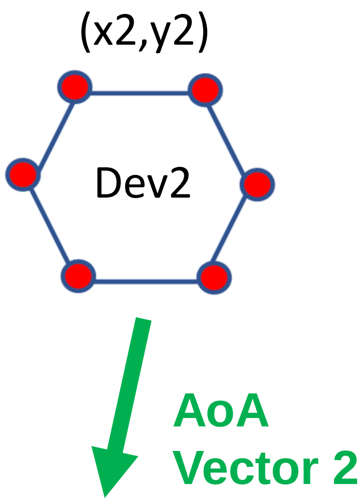
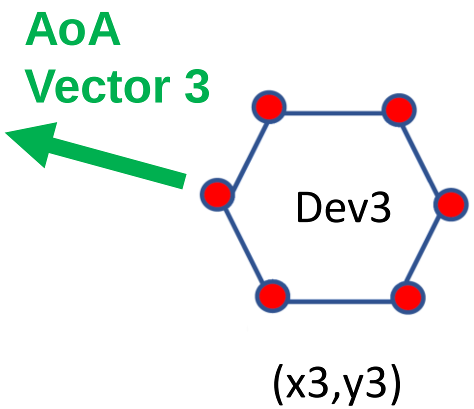
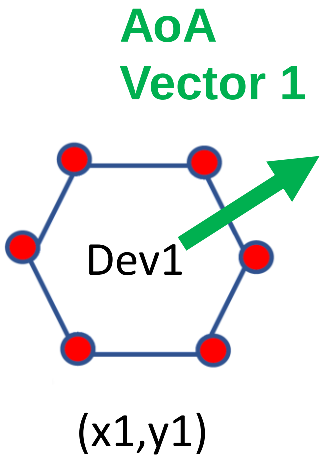




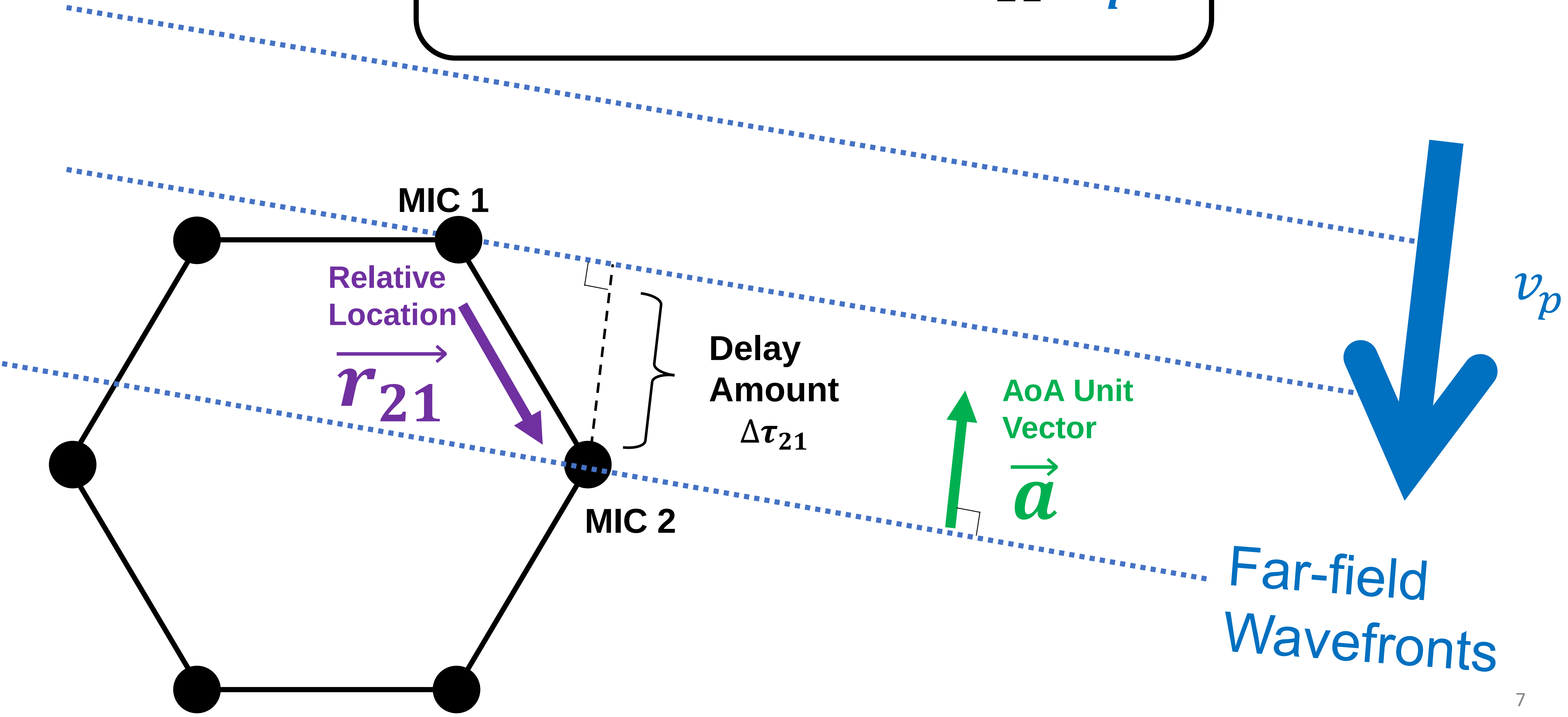
How to find AoA Vectors?





Relative Location · AoA Unit Vector = Delay Amount

$$\overrightarrow{r_{21}} \bullet \vec{a} = \Delta\tau_{21}\, v_p$$



Relative Location

AoA Unit Vector

Delay Amount

$$\overrightarrow{r_{21}} \bullet \vec{a} = \Delta\tau_{21}\, v_p$$

$$\overrightarrow{r_{21}} \bullet (\mathrm{a_x}, \mathrm{a_y}) = \Delta\tau_{21}\ v_p$$

known

Unknowns!

Measured

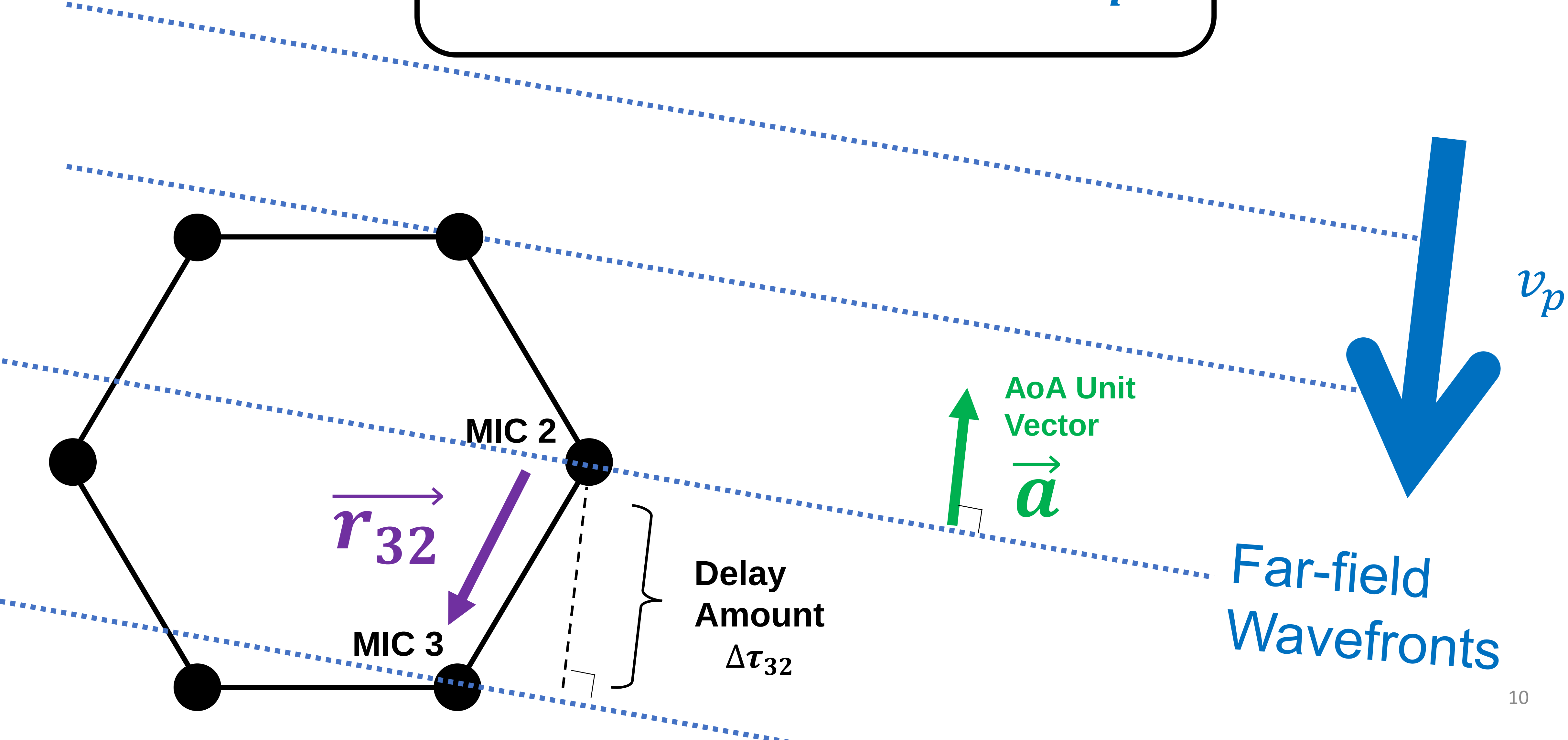
Constant

$$\overrightarrow{r_{32}} \bullet \vec{a} = \Delta\tau_{32}\, v_p$$

Relative Location

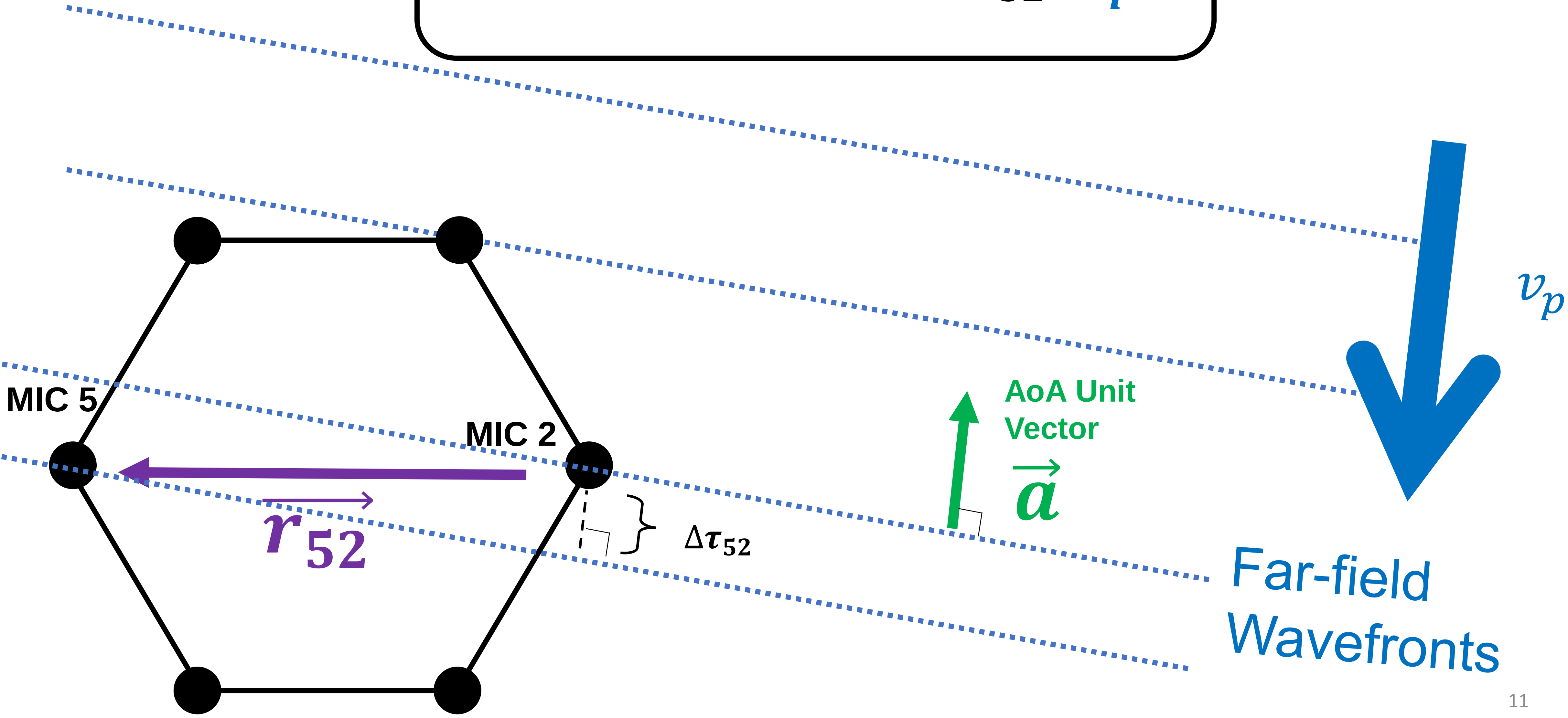
AoA Unit Vector

Delay Amount



Relative Location · AoA Unit Vector = Delay Amount

$$\overrightarrow{r_{52}} \bullet \vec{a} = \Delta\tau_{52}\, v_p$$



$$\left.\begin{array}{l}\overrightarrow{r_{21}} \bullet (a_x, a_y) = \Delta\tau_{21}\ v_p \\ \overrightarrow{r_{31}} \bullet (a_x, a_y) = \Delta\tau_{31}\ v_p \\ \overrightarrow{r_{41}} \bullet (a_x, a_y) = \Delta\tau_{41}\ v_p \\ \qquad\qquad\vdots \\ \overrightarrow{r_{65}} \bullet (a_x, a_y) = \Delta\tau_{65}\ v_p \end{array}\right\}$$

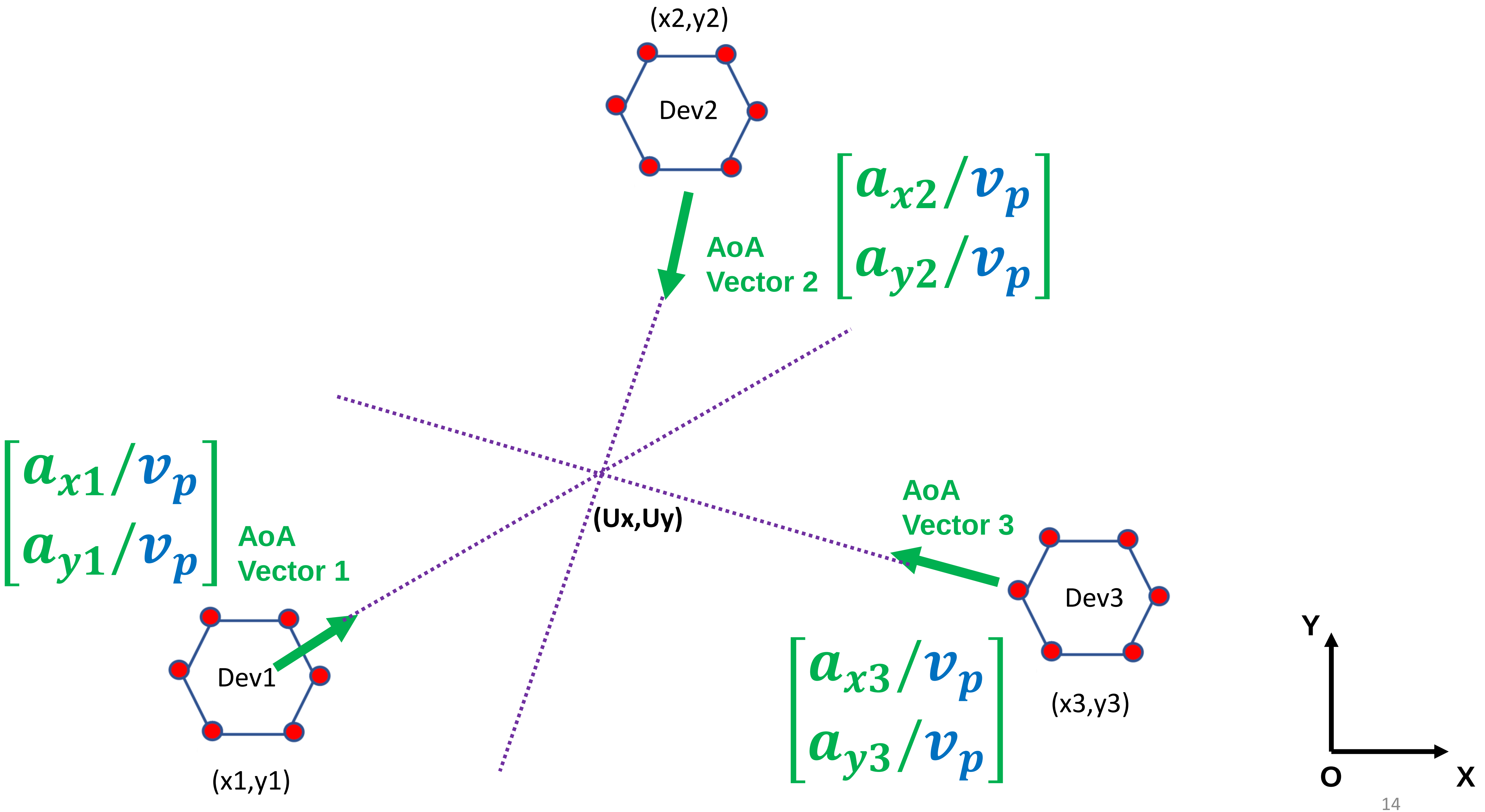
Total Combination of

$$\binom{6}{2} = 15$$

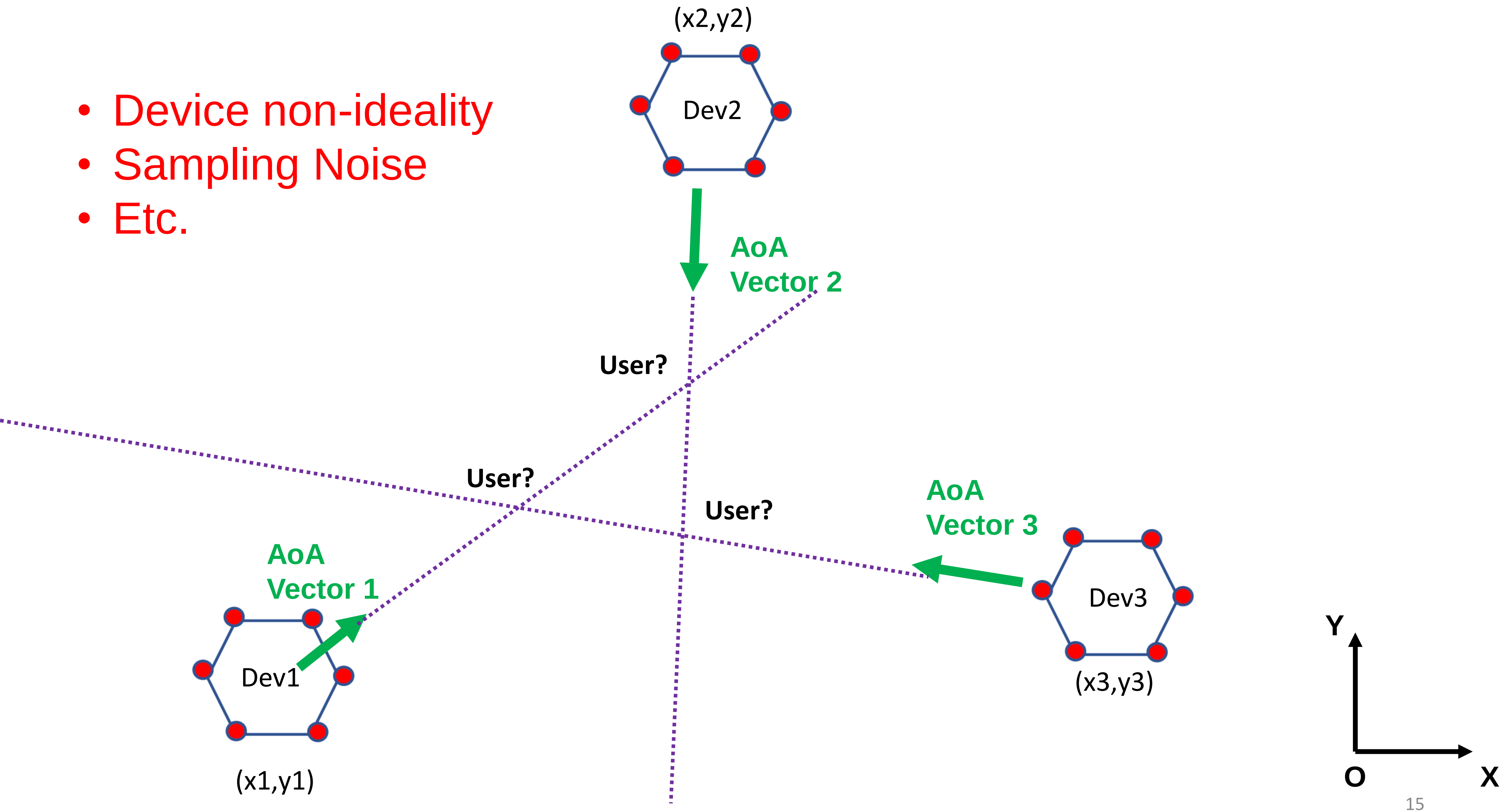
Known **Measured**

$$\begin{bmatrix} r_{x1} & r_{y1} \\ r_{x2} & r_{y2} \\ \vdots & \vdots \\ r_{x15} & r_{y15} \end{bmatrix} \begin{bmatrix} a_x/\boldsymbol{v}_{\boldsymbol{p}} \\ a_y/\boldsymbol{v}_{\boldsymbol{p}} \end{bmatrix} = \left. \begin{bmatrix} \Delta\boldsymbol{\tau}_{\mathbf{21}} \\ \Delta\boldsymbol{\tau}_{\mathbf{31}} \\ \vdots \\ \Delta\boldsymbol{\tau}_{\mathbf{65}} \end{bmatrix} \right\} \textbf{15 rows}$$

Least Square Problem


(x2,y2)
Dev2
AoA
Vector 2
$\begin{bmatrix} a_{x2}/v_p \\ a_{y2}/v_p \end{bmatrix}$
$\begin{bmatrix} a_{x1}/v_p \\ a_{y1}/v_p \end{bmatrix}$
AoA
Vector 1
(Ux,Uy)
AoA
Vector 3
Dev3
Dev1
(x1,y1)
$\begin{bmatrix} a_{x3}/v_p \\ a_{y3}/v_p \end{bmatrix}$
(x3,y3)
Y
O
X

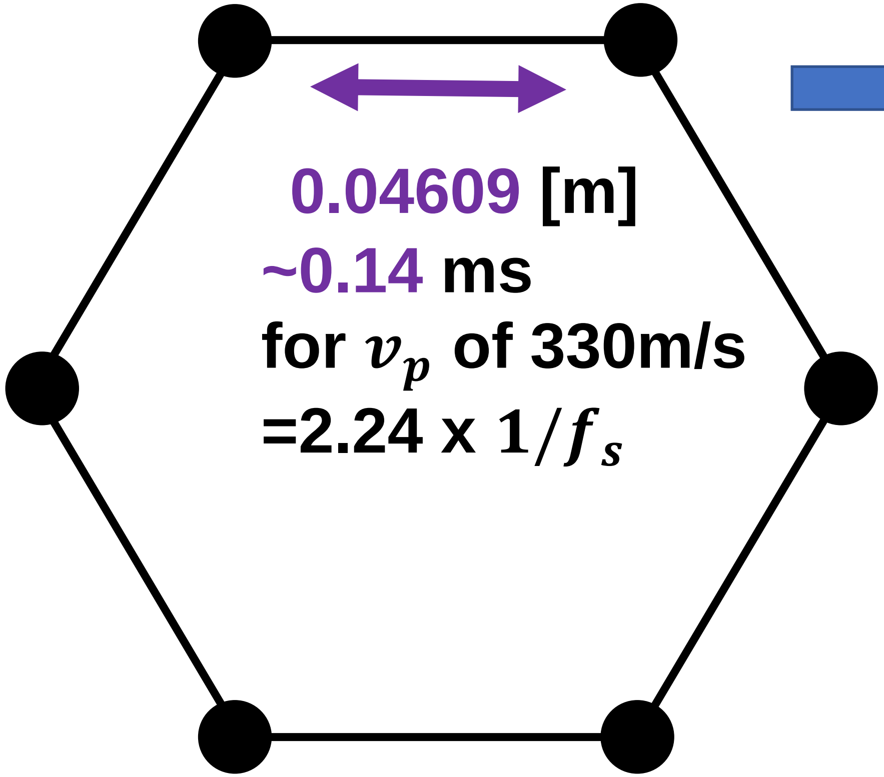
- Device non-ideality
- Sampling Noise
- Etc.



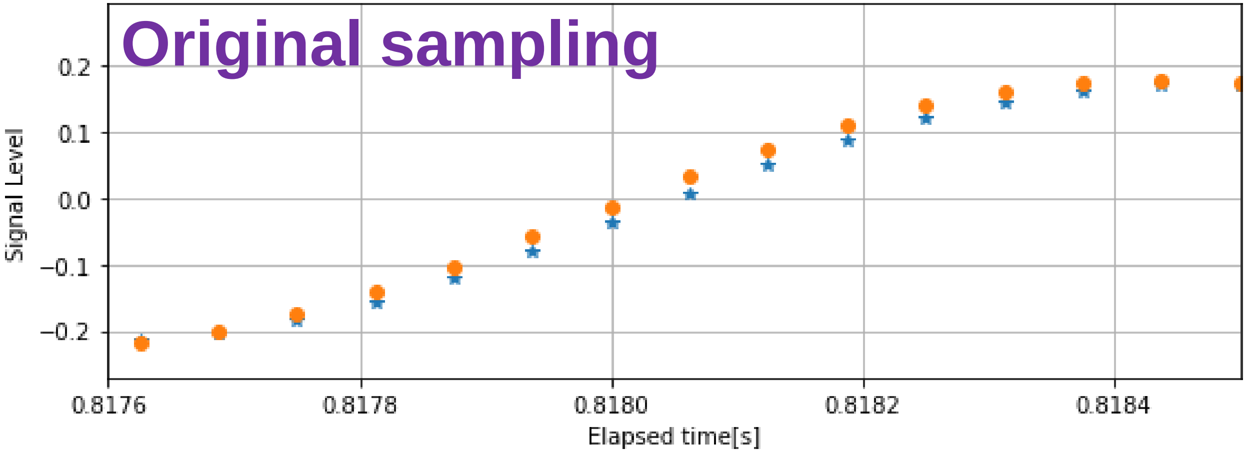
- Device non-ideality

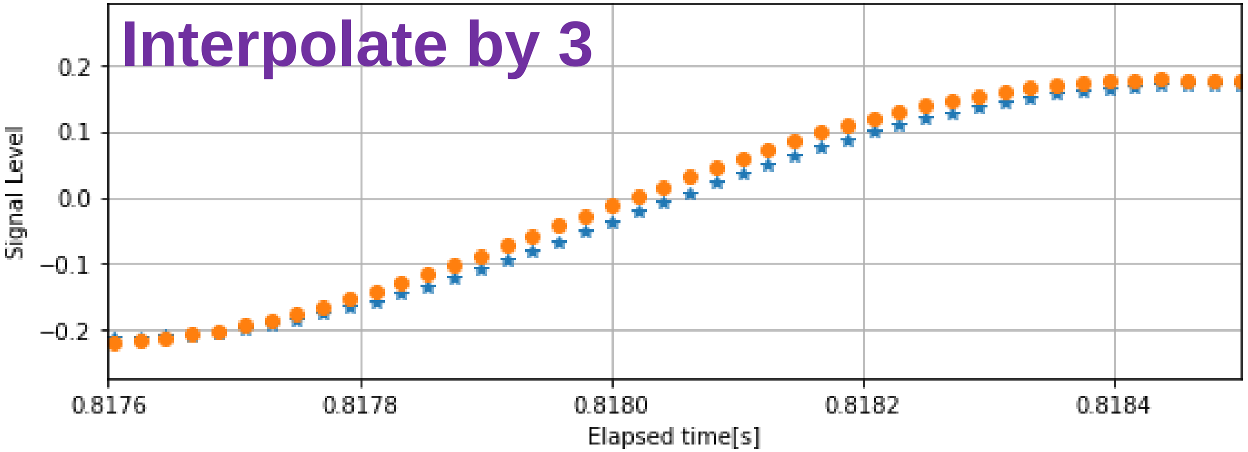
Bandpass Filtering
100Hz ~ 1600Hz

- Sampling Noise

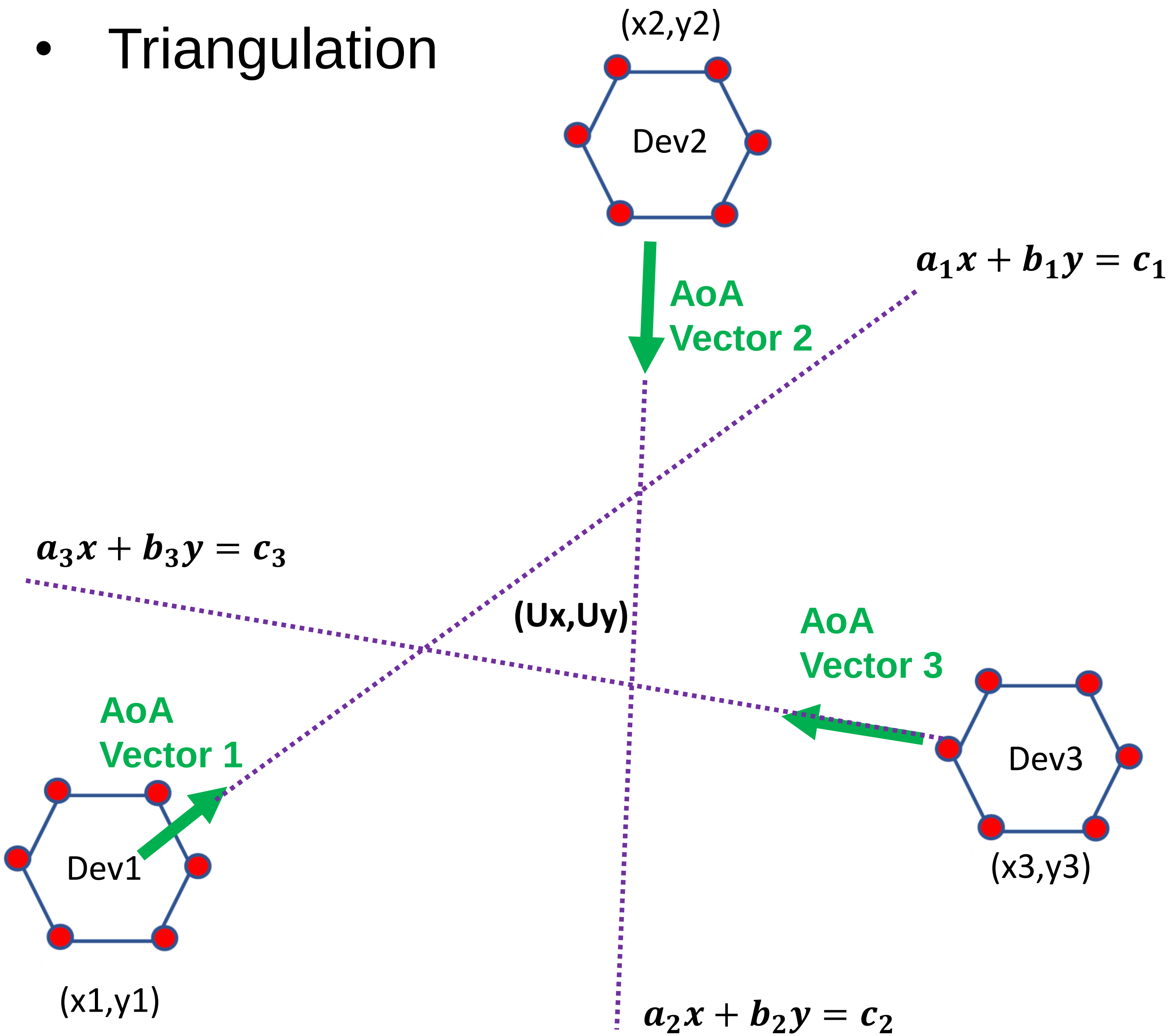


0.04609 [m]
~0.14 ms
for v_p of 330m/s
=2.24 x $1/f_s$





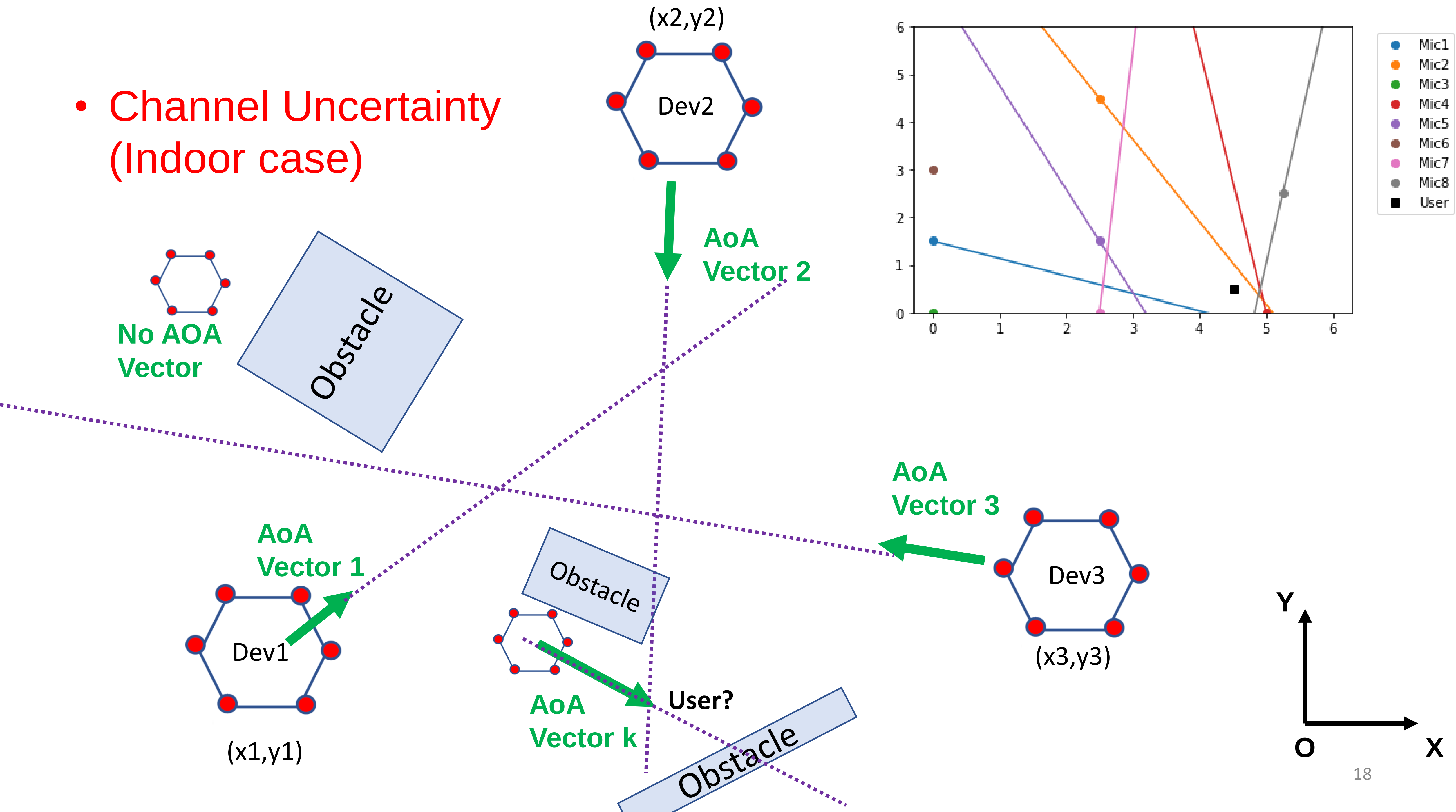
- Triangulation



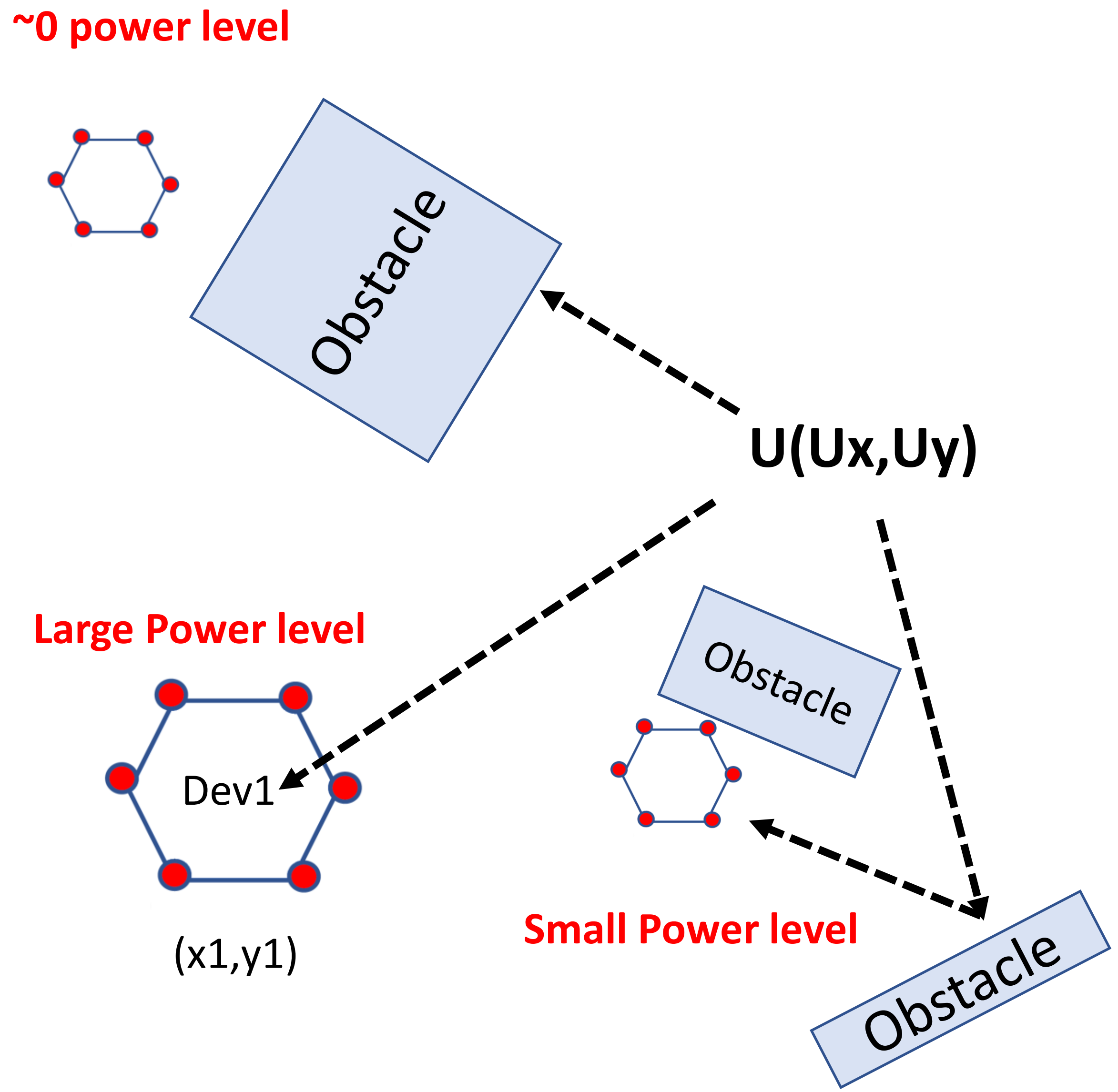
$$a_1U_x + b_1U_y = c_1$$
$$a_2U_x + b_2U_y = c_2$$
$$\vdots$$
$$a_8U_x + b_8U_y = c_8$$

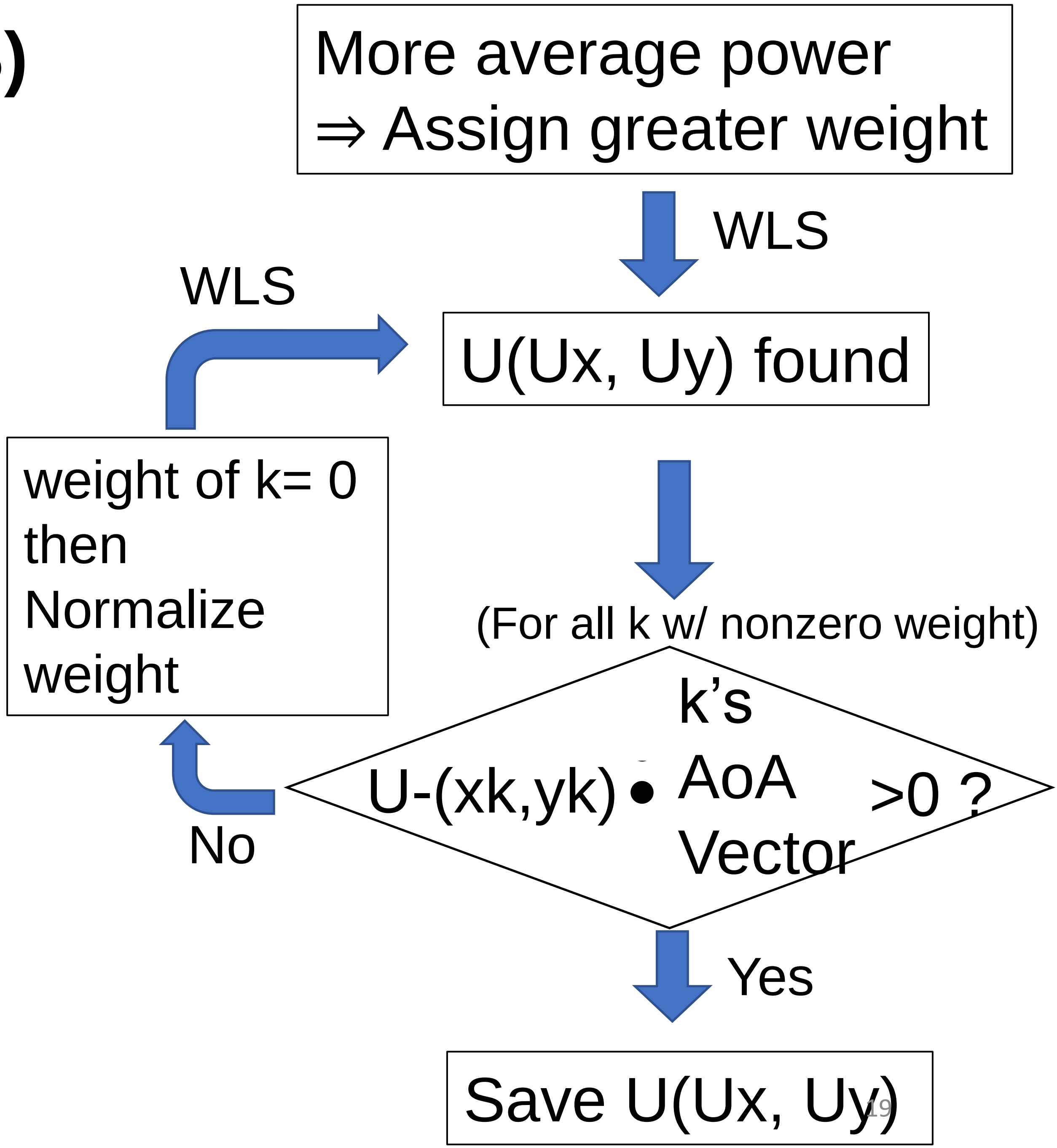
Least Square Problem

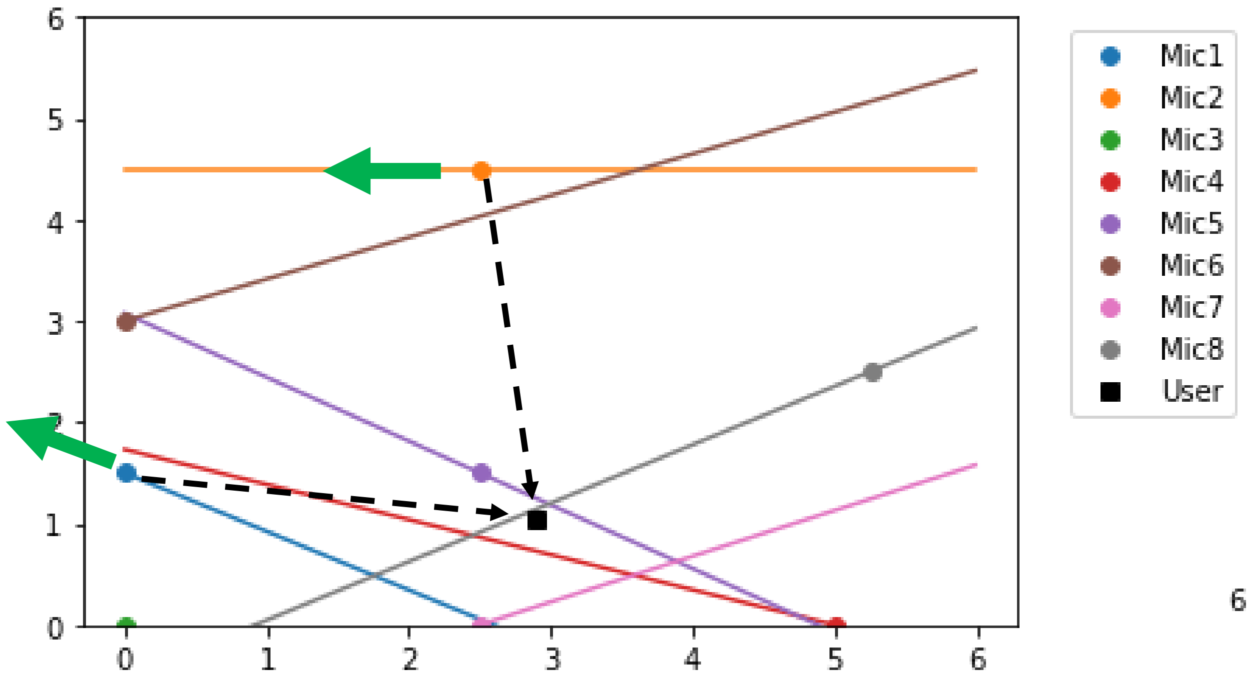
- Channel Uncertainty (Indoor case)



- **Weighted Least Square (WLS)**







- For Mic1 & Mic2

U-(xk,yk) • k's AoA Vector <0

Eliminated