MEASUREMENT OF ANALOG BANDWIDTH AND CROSSTALKS OF ANODE

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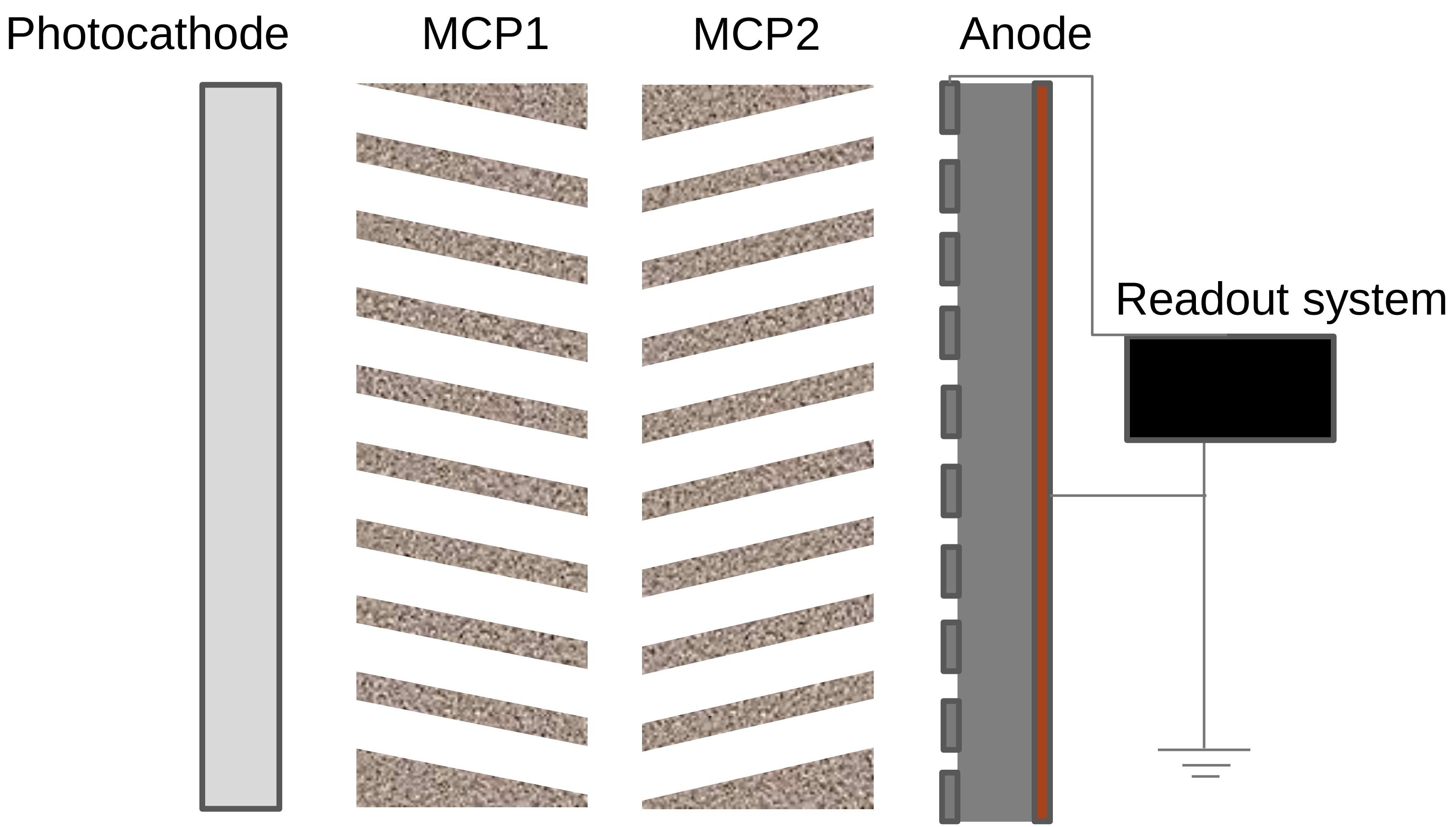
HERVÉ GRABAS

ANODE IN THE DETECTOR

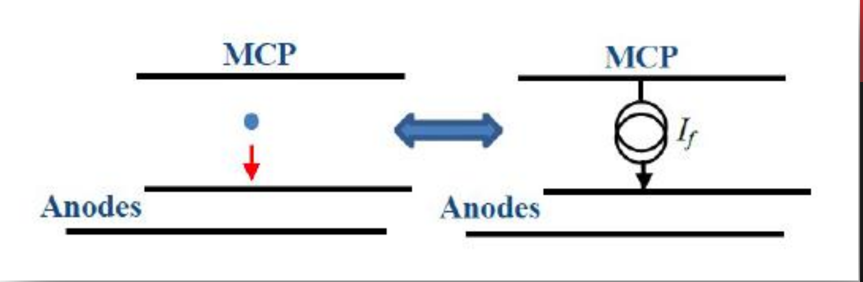


PROPERTIES OF THE ANODE

- Borofloat® 33 glass as substrate.
- Silk-screened silver-ink strips
- Fan-out card made of FR4 on each end.
- Glass with strips make up a 'tile'
- Each tile is 9.02" x 8.66"

30 Strips	40 Strips
Width = 0.182"	Width = 0.148"
Spacings = 0.09"	Spacings = 0.052"

EXCITATION OF THE ANODES



Frequency domain current for the Dirac distribution

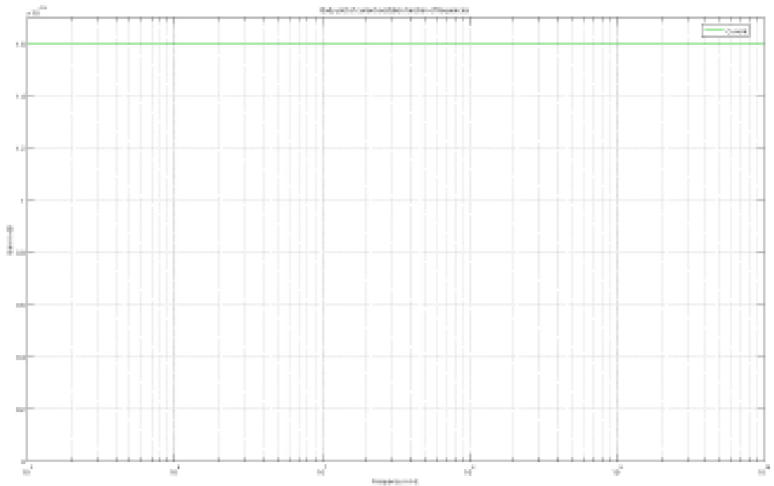
$$\begin{aligned}
\hat{i}(f) &= \iint_S \int_{-\infty}^{\infty} Q \times \delta(x)\delta(y)\delta(z - v_0 t) \times v_0 \times e^{-2i\pi f t}\,\mathrm{d}t\,\mathrm{d}S \\
&= \iint_S \int_{-\infty}^{\infty} Q \times \delta(x)\delta(y)\delta\left(\frac{z}{v_0} - t\right) \times e^{-2i\pi f t}\,\mathrm{d}t\,\mathrm{d}S \\
&= \iint_S Q \times \delta(x)\delta(y) \times e^{\frac{-2i\pi f z}{v_0}}\,\mathrm{d}S \\
&= Q \times e^{\frac{-2i\pi f z}{v_0}}
\end{aligned} \tag{3}$$

Frequency domain current for the Rectangular distribution

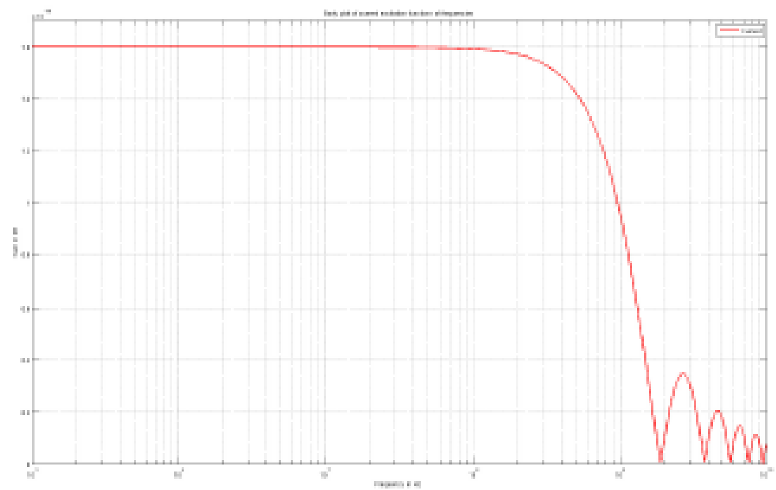
$$\begin{aligned}
\hat{i}(f) &= \iint_S \int_{-\infty}^{\infty} \frac{Q}{s^3} \times \mathrm{rect}\left(\frac{x}{s}\right)\mathrm{rect}\left(\frac{y}{s}\right)\mathrm{rect}\left(\frac{z - z_D(t)}{s}\right) \times v_0 \times e^{-2i\pi f t}\,\mathrm{d}t\,\mathrm{d}S \\
&= \iint_S \int_{\frac{2z-s}{2v_0}}^{\frac{2z+s}{2v_0}} \frac{Q}{s^3} \times \mathrm{rect}\left(\frac{x}{s}\right)\mathrm{rect}\left(\frac{y}{s}\right) \times v_0 \times e^{-2i\pi f t}\,\mathrm{d}t\,\mathrm{d}S \\
&= Q \times \mathrm{sinc}\left(\frac{\pi f s}{v_0}\right) \times e^{\frac{-2i\pi f z}{v_0}}
\end{aligned}$$

(4)

EXCITATION OF THE ANODE STRIPLINES

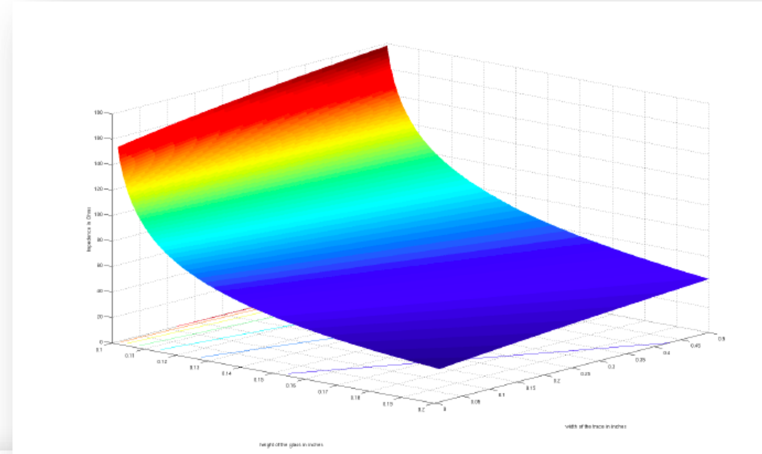


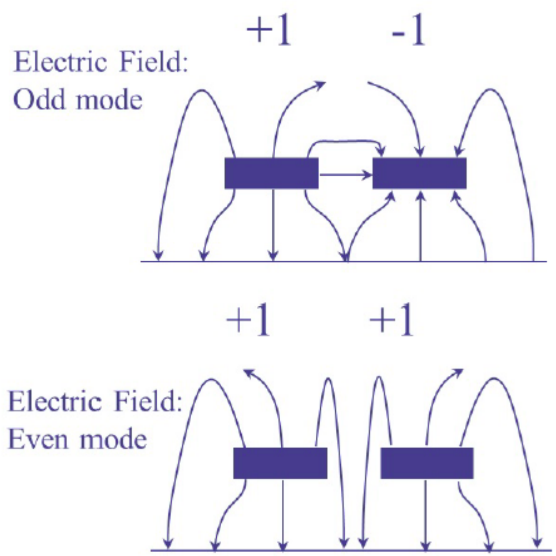
(a) In the frequency domain, the current given by a point charge Q (see Equation 3):
$\hat{i}(f) = Q \times e^{\frac{-2\imath\pi f d}{v_0}}$

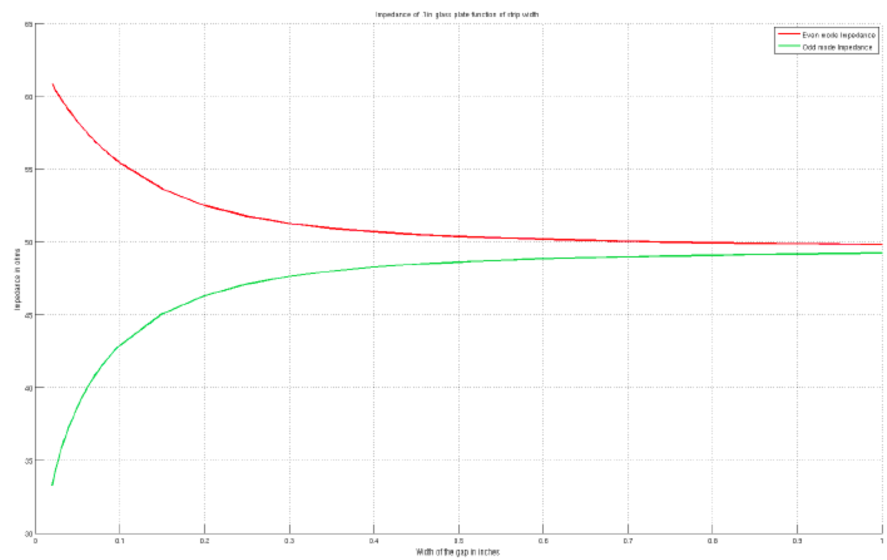


(b) In the frequency domain, the current given by a rectangular charge distribution of width s and integrated charge Q (See Equation 4):
$\hat{i}(f) = Q \times \mathrm{sinc}\left(\frac{\pi f s}{v_0}\right) \times e^{\frac{-2\imath\pi f d}{v_0}}$

STRIPLINE IMPEDANCE

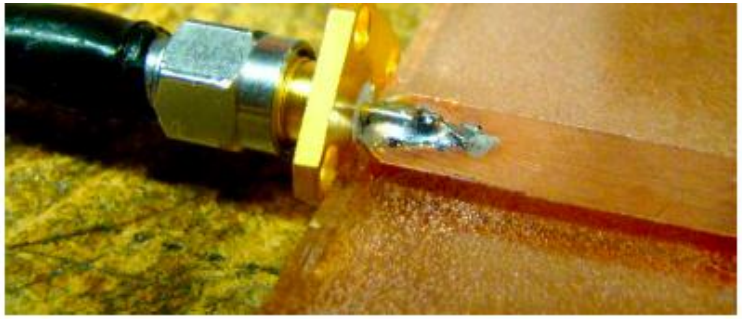






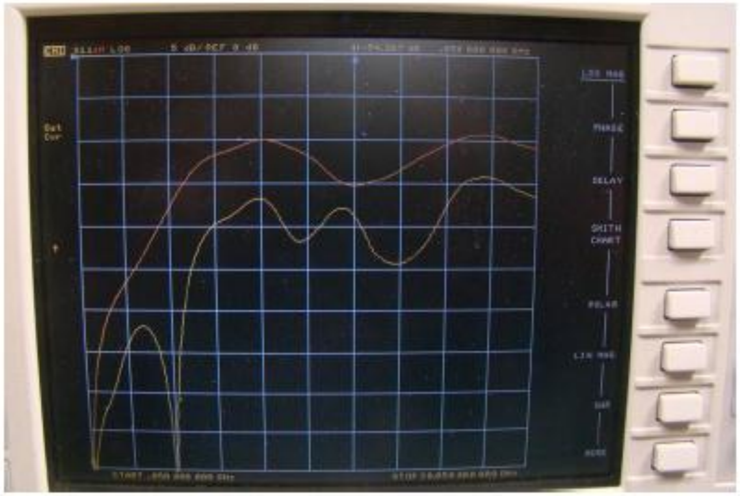
The impedance of the striplines depends of w/h ratio mainly.
It also is a function of the striplines spacings for multi anodes.

CONNECTION TO THE ANODES



(a) Before launcher

(b) After launcher



With a good launcher we gain at least 10dB.

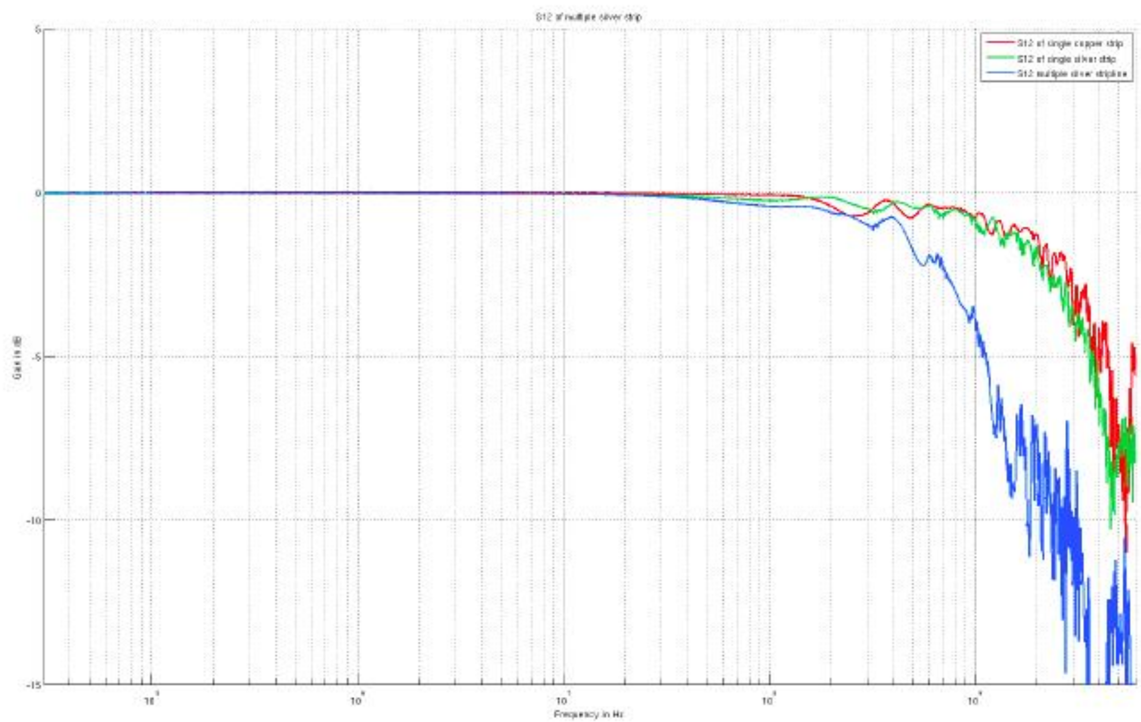
A BIT OF HISTORY…

Started with 40 strips anodes.

Important losses due to coupling from one strip to an other.

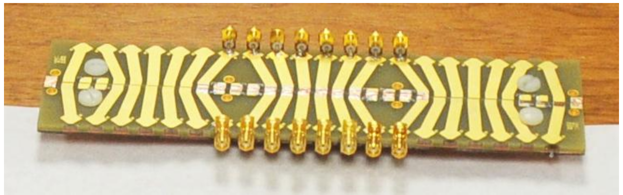
Impedance of strips was not quite 50ohms.

Moved on to 30 strips.

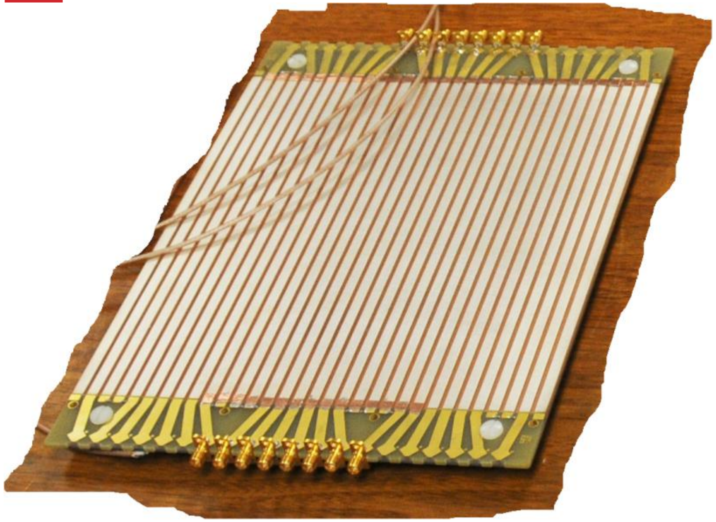


(a) Single strip [red] (b) Adjacent strips at .4in [green] (c) Adjacent strips at .052in [blue]

30 STRIPS ANODE



Fanout (Zero tile)



One tile

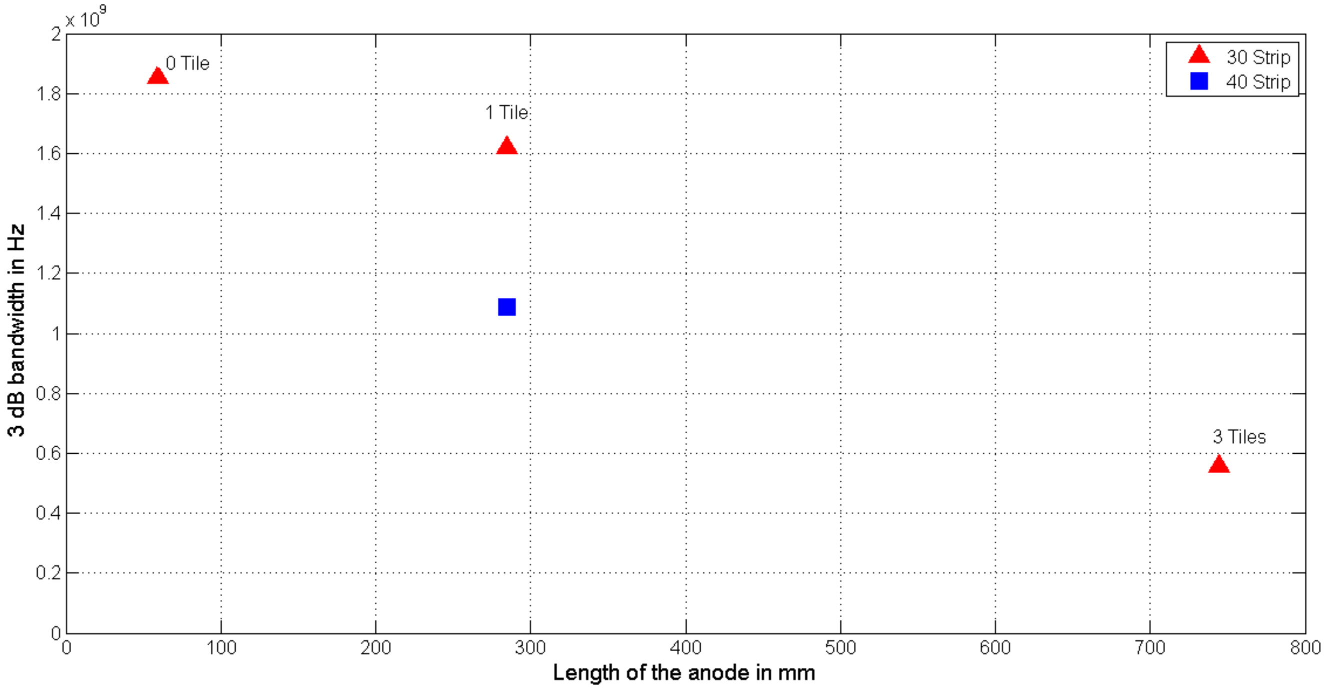
Three tiles

CAN WE MAKE LONGER ANODES?

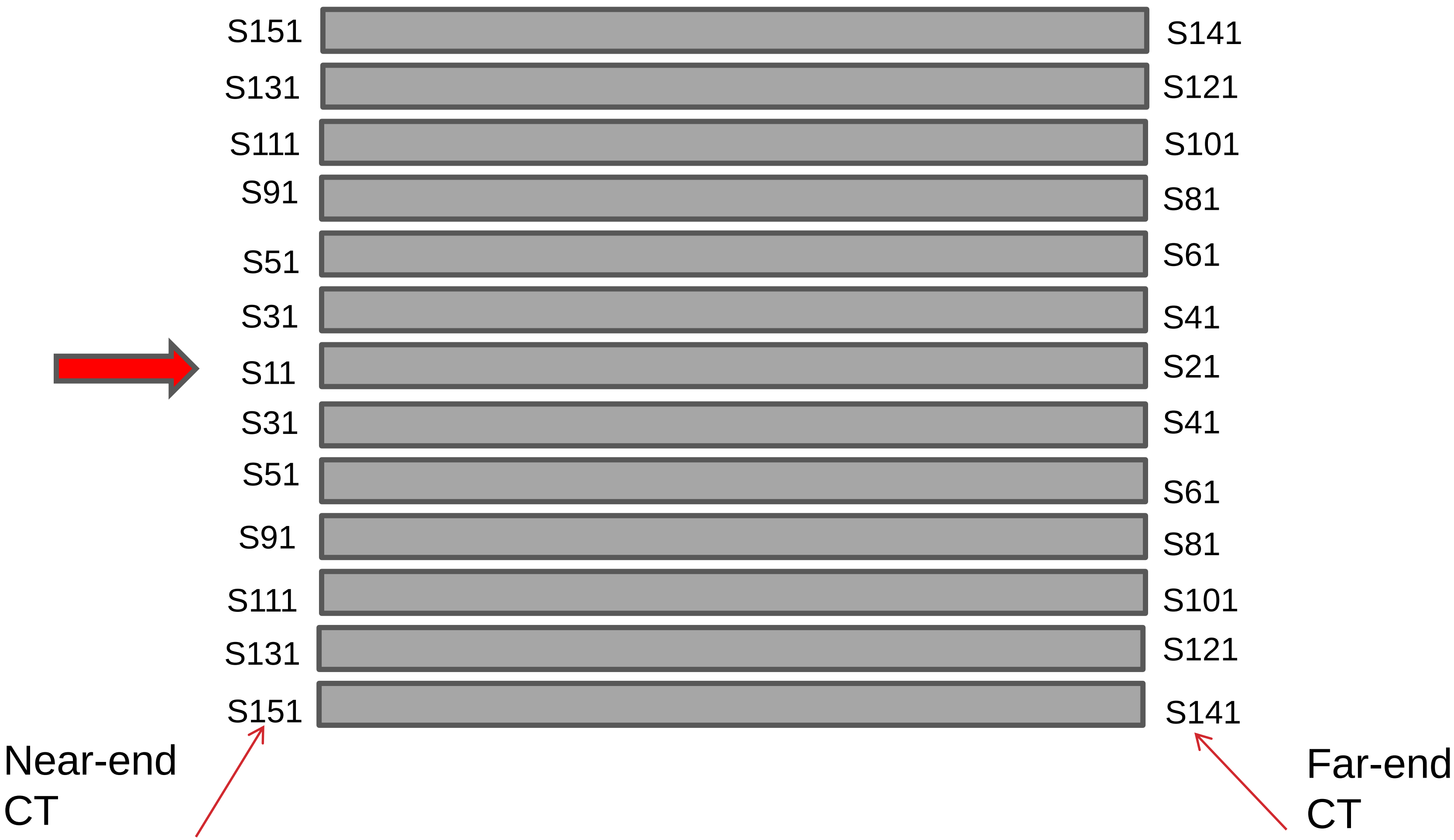
Depends on

- **Bandwidth**
- **Cross-talks**
- **Losses**

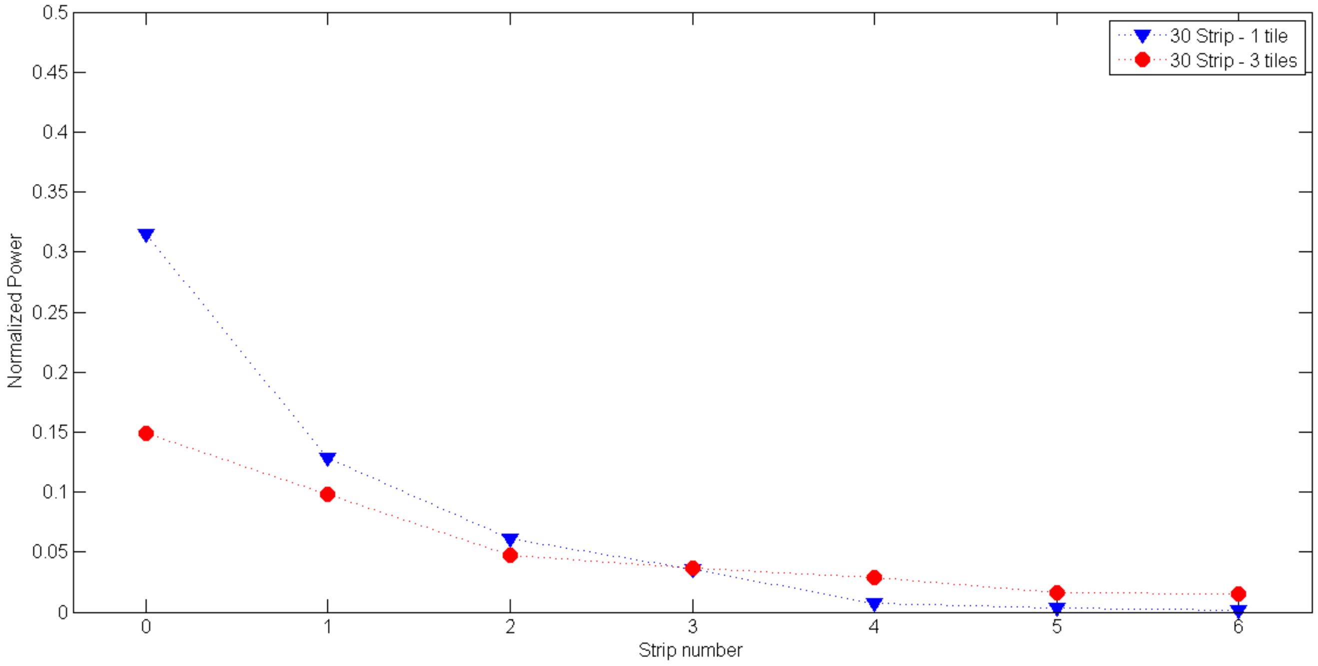
COMPARISON OF BANDWIDTH



CROSS-TALK MEASUREMENT

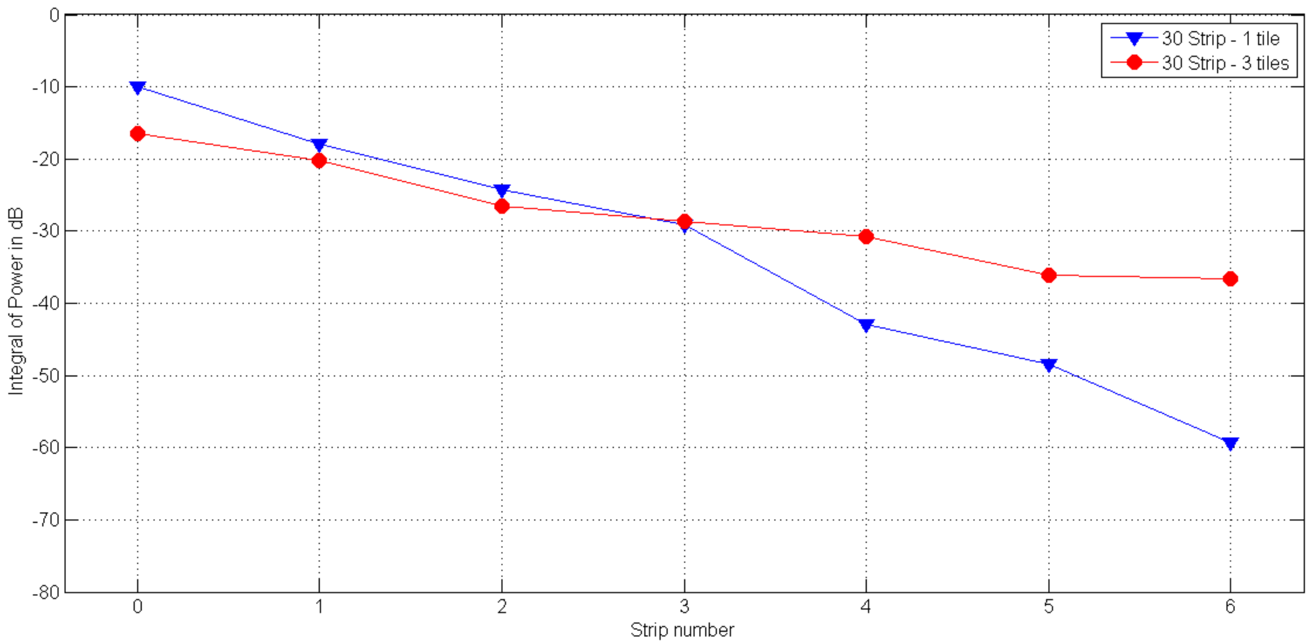


CROSS-TALK

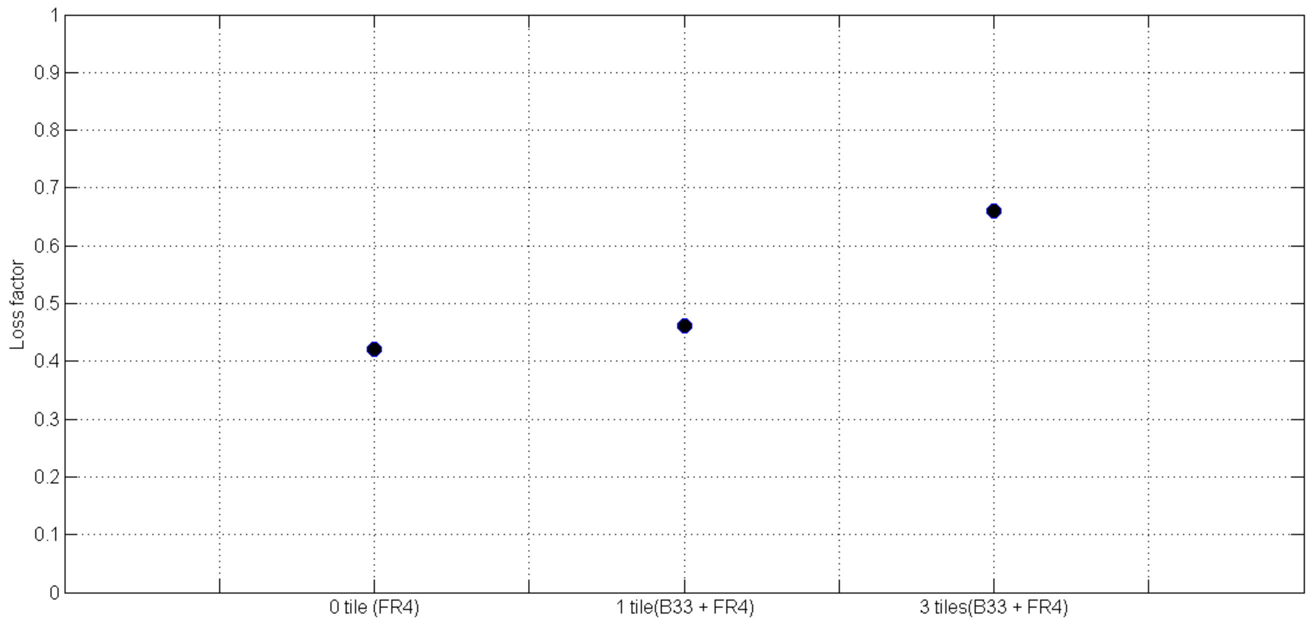


30 Strip - 1 tile
30 Strip - 3 tiles
Normalized Power
Strip number
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0 1 2 3 4 5 6

CROSSTALK (CONT…)



LOSS (DISSIPATIVE & DIELECTRIC)



SIGNAL PROPAGATION SPEED

- **With 0-tile FR4 fanout card, the SPS ~ 0.318 c**
- **1-tile 30 strip + fanout card, SPS ~ 0.558 c**
- **3-tiles 30 strip + fanout card, SPS ~ 0.571 c**

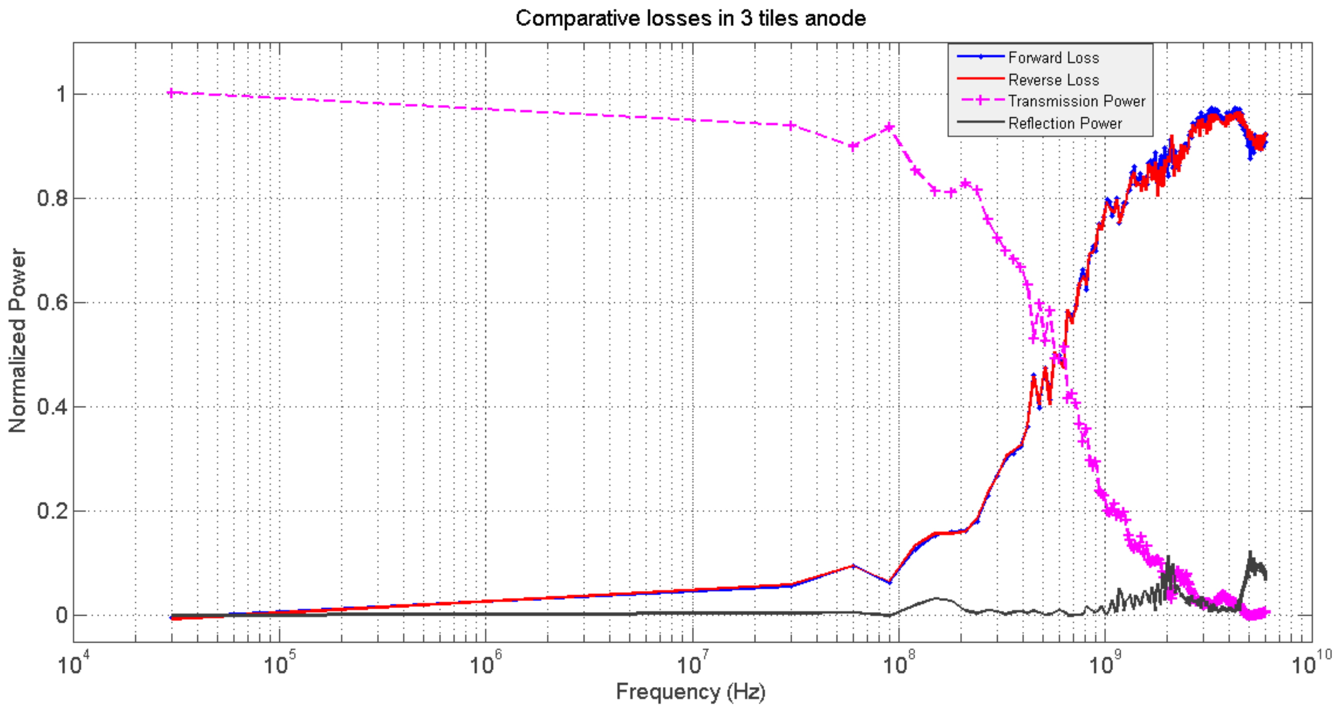
ON GOING (ALSO FUTURE) WORK…

- **Characterizing the 4-tiles anode and establish how ‘bad’ it is…**
- **Communication with vendor (BEST Inc.) on the option of mass-connection of tiles (glass – glass & glass – FR4)**
- **Characterizing the ‘inside out’ anode idea.**

BACKUP SLIDES

LOSS

- Used S-parameters to calculate the losses in the frequency interval between 30kHz – 6 GHz.
- Relative loss = $1 - |S11|^2 - |S21|^2$



Comparative losses in 3 tiles anode
Forward Loss
Reverse Loss
Transmission Power
Reflection Power
Normalized Power
1
0.8
0.6
0.4
0.2
0
10^4
10^5
10^6
10^7
10^8
10^9
10^{10}
Frequency (Hz)