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Recycler bpm Proposal
Detectors and Cables

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Recycler bpm's

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- split tube bpm design

Hor bpm measurement

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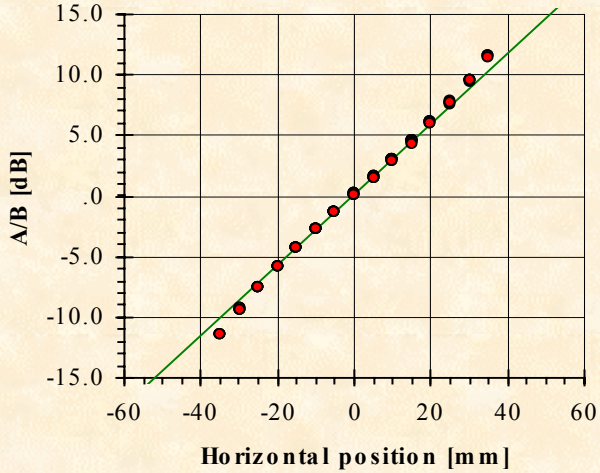
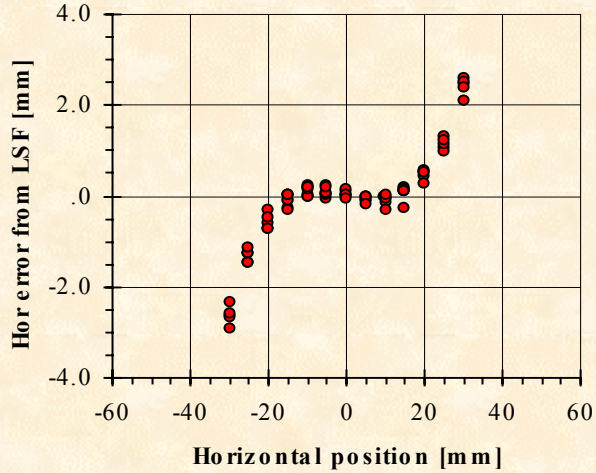
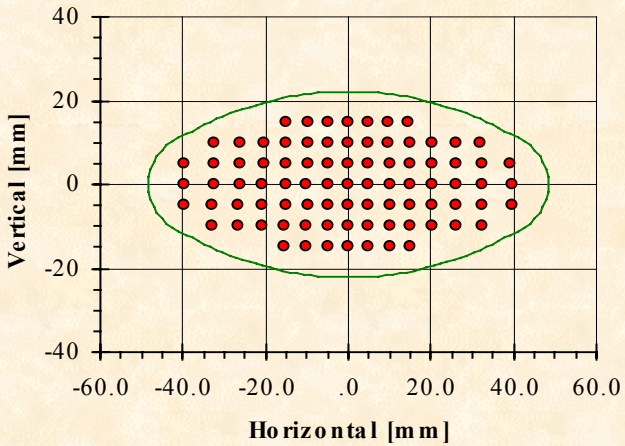
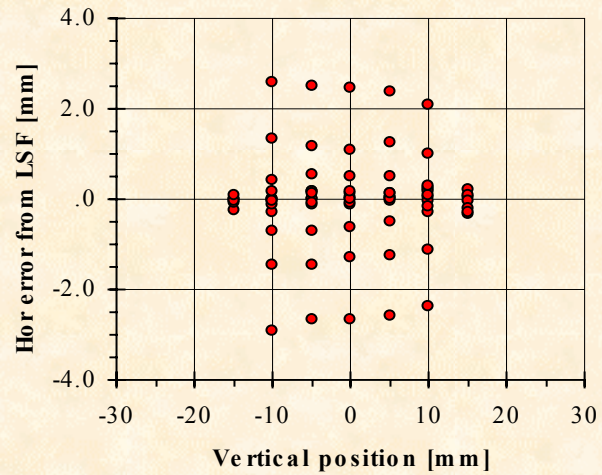
db = Sx+O

S	.290	db/mm
O	.125	db
	.002	H/V mm
Xc	0	mm
Yc	0	mm
THETA	-1	deg
pipe	11.4x5	cm









Ver bpm measurement

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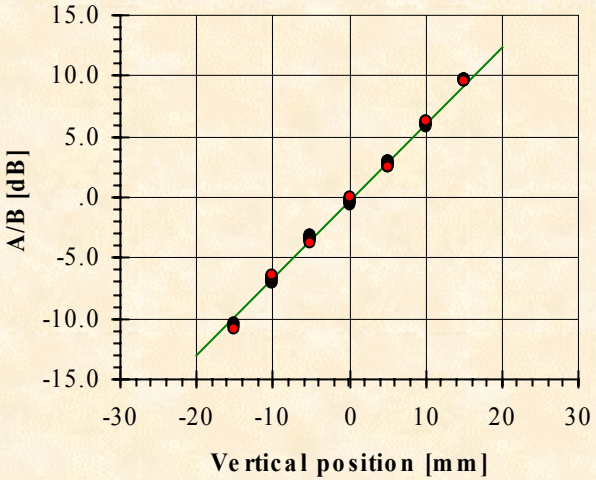
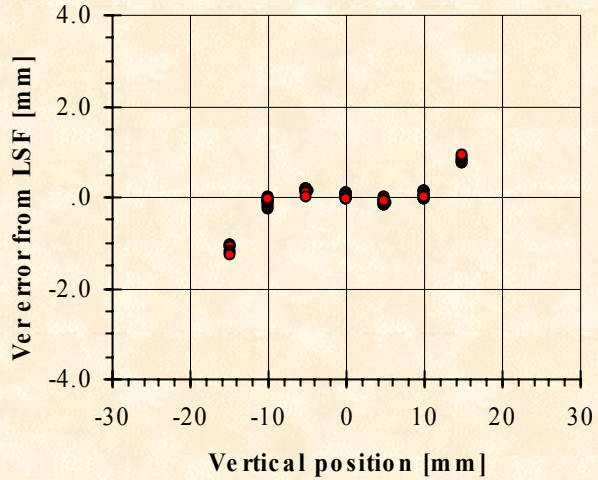
db = Sx+O

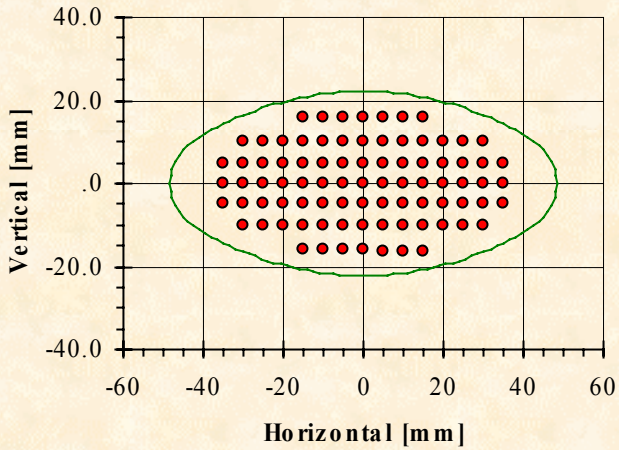
S	.634 db/mm
O	-.355 db
	.001 H/V mm
Xc	0 mm
Yc	0 mm
THETA	-0.75 deg
pipe	11.4x5 cm

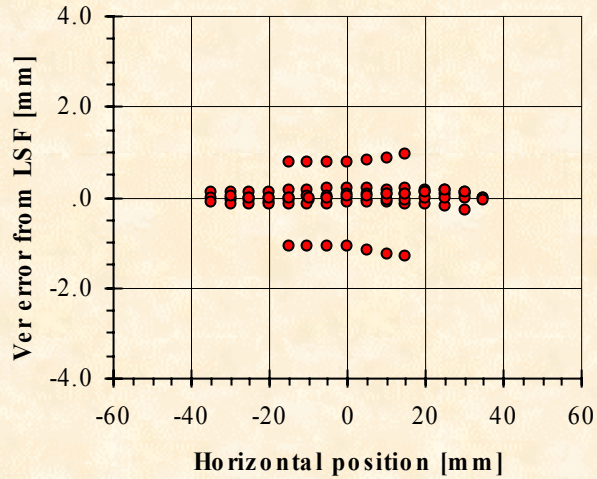
±1cm on axis

S	.631 db/mm
O	-.344 db









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Bpm Measurement accuracy

- Horizontal
  - .290 db/mm
- Vertical
  - .634 db/mm
- Measured through uncoupled preamp at 7.5MHz with HP network analyzer
  - Agrees with 1MHz into 50Ω (no coupling)
  - Accuracy about .1 db or .3mm hor .16mm ver

- 75 wire positions are measured
- Survey fiducials are used to position bpm on test stand

Bpm cables

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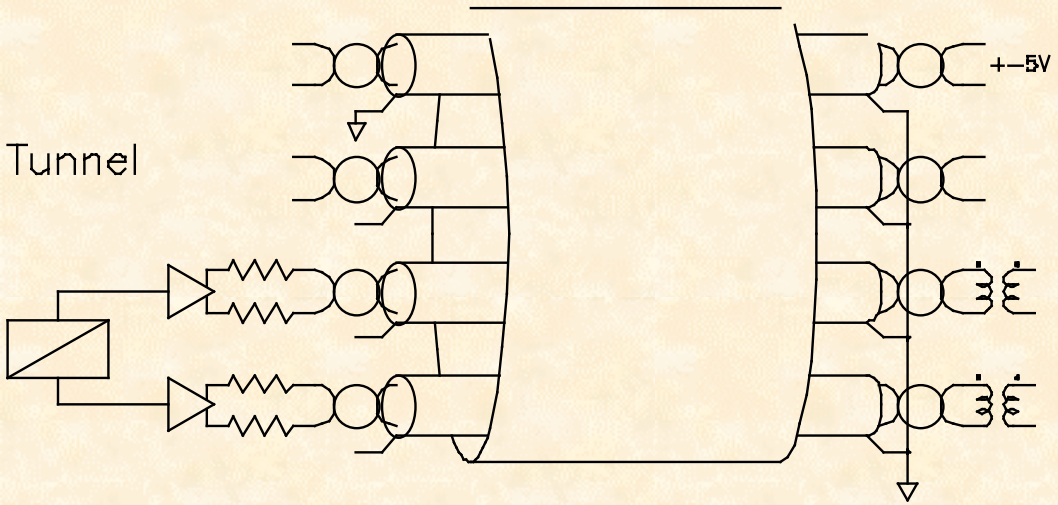
- Recycler bpm cable
  - 4 twisted pairs with foil and drain wire in protective sheath
  - Differential driver in tunnel
  - Differential receiver upstairs



Cable attenuation

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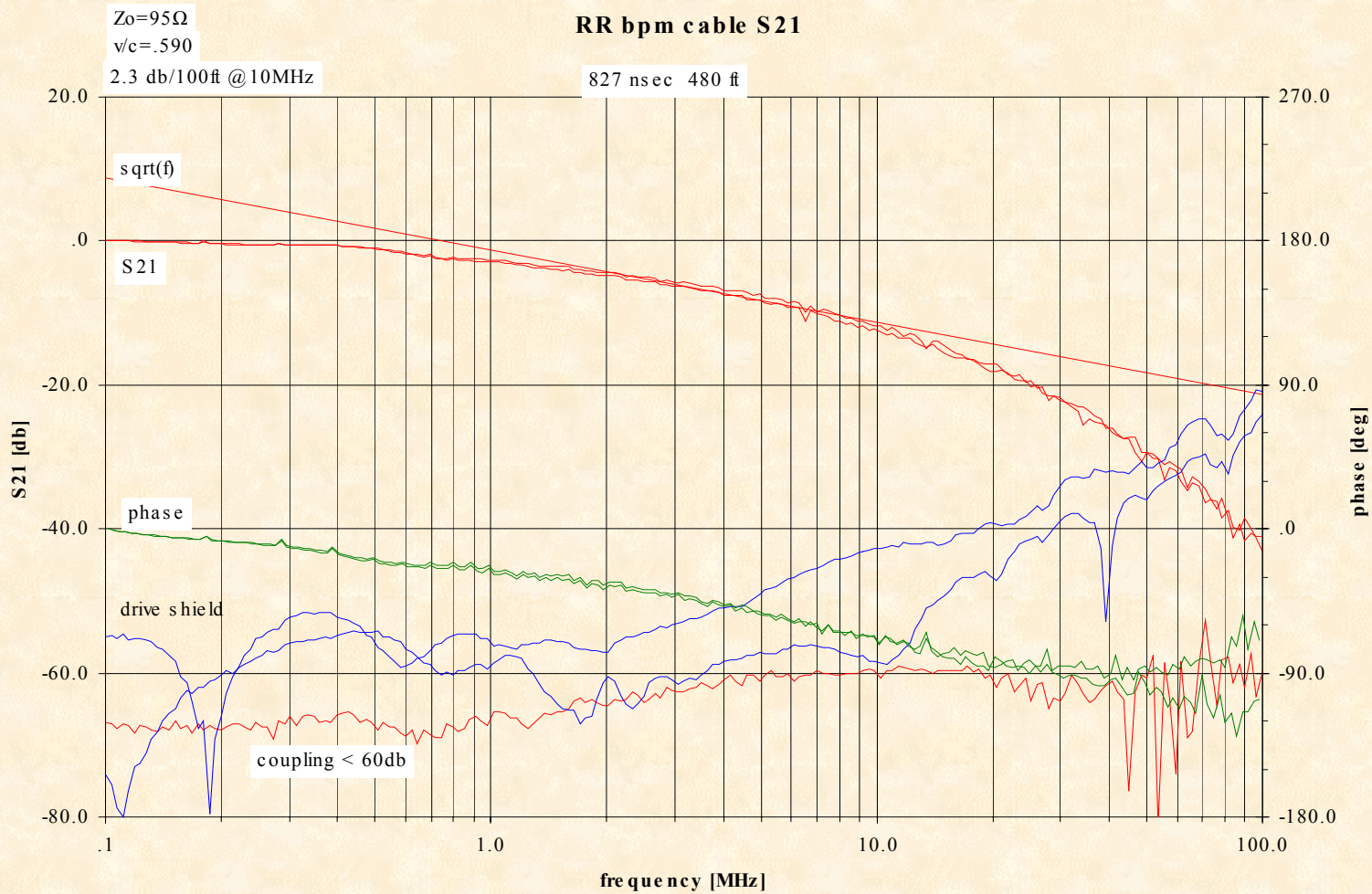

Characteristic impedance

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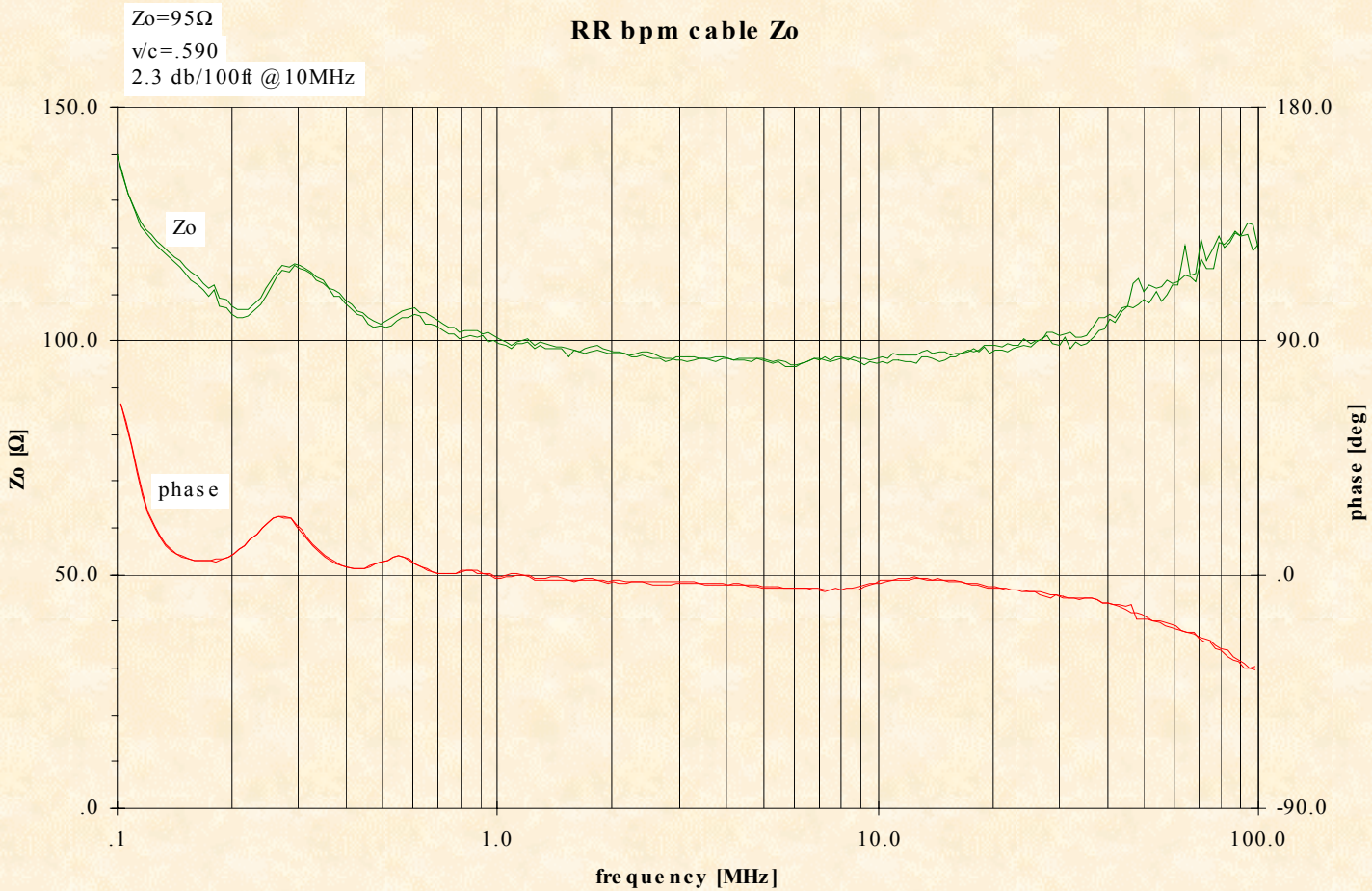

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Cables

- 1.2 db/100ft @ 2.5MHz
- v/c = .590
- Zo = 95Ω
- Coupling –55db @ 2.5MHz (old preamp –6db)
- Noise rejection > 60db

- At 2.5MHz

• Min length	150ft	1.8db	1/4λ at 1MHz
• Max length	1300ft	15.6db	1/4λ at 100KHz
• Average length	650ft	7.8db	

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Reflection Coefficient

- The input impedance of the digital receiver and the characteristic impedance of the cable determine the reflection coefficient. The measured signal amplitude depends on the reflection coefficient, cable length, and frequency content of the signal.
  - The digital receiver measures the sum of the incident and reflected signal.

Reflection Coefficient error

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$k_a, k_b = reflection\ coefficient\ at\ \ port\ \ a, b$

$$m = mag\left(\frac{1+k_b}{1+k_a}\right), \quad \phi = ang\left(\frac{1+k_b}{1+k_a}\right)$$

$$x = -\frac{mm}{db}\ 20\log\left\{\tan\left(\frac{1}{2}\left[\operatorname{atan}\left(\frac{\cos\phi}{A/mB - \sin\phi}\right) + \operatorname{atan}\left(\frac{\cos\phi}{A/mB + \sin\phi}\right)\right]\right)\right\}$$

$for\ \phi << A/mB$

$$x \approx \frac{mm}{db}\ 20\log\left(\frac{A}{mB}\right)$$

- For a 5Ω error, k = .025, m = .975, .22db error
  - .8mm Hor, .4mm Ver error

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Other sources of error

- Noise
- Survey
- Gain or offset of digital receiver

- Correction
  - Use optimum filter
  - Measure gain and offset with arbitrary waveform generator from tunnel
  - May require unique filter coefficients for each bpm and each running mode

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Accuracy

- Given the accuracy of our test equipment and experience with cables, connectors, and impedance matching:

- Absolute accuracy should be relaxed to 0.5mm rms
- Resolution should not be a problem