Modal analysis of TTF HOM signal data (preliminary results)

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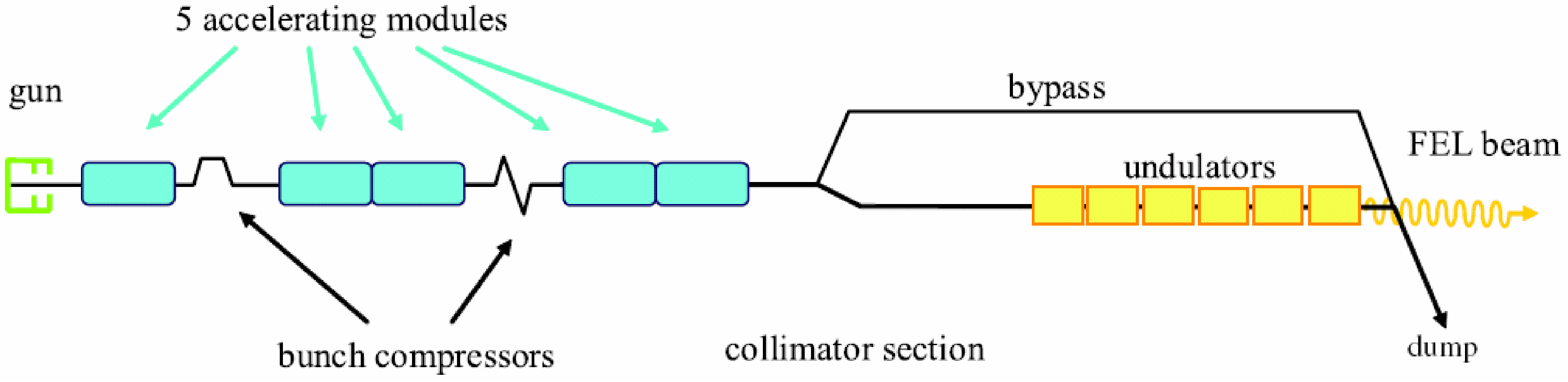
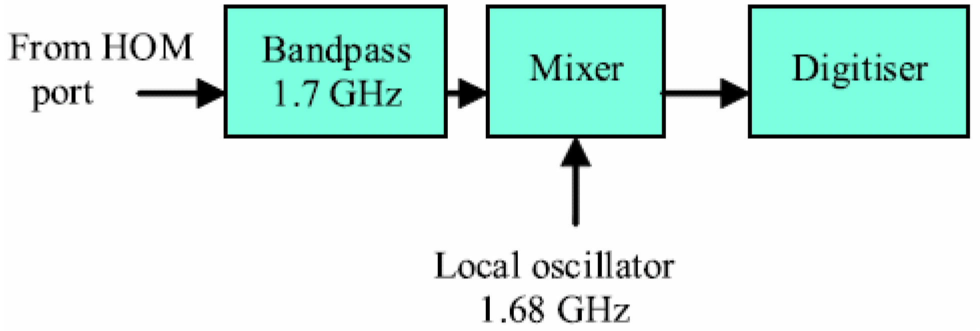
SLAC

Oct. 8, 07

Flash facility

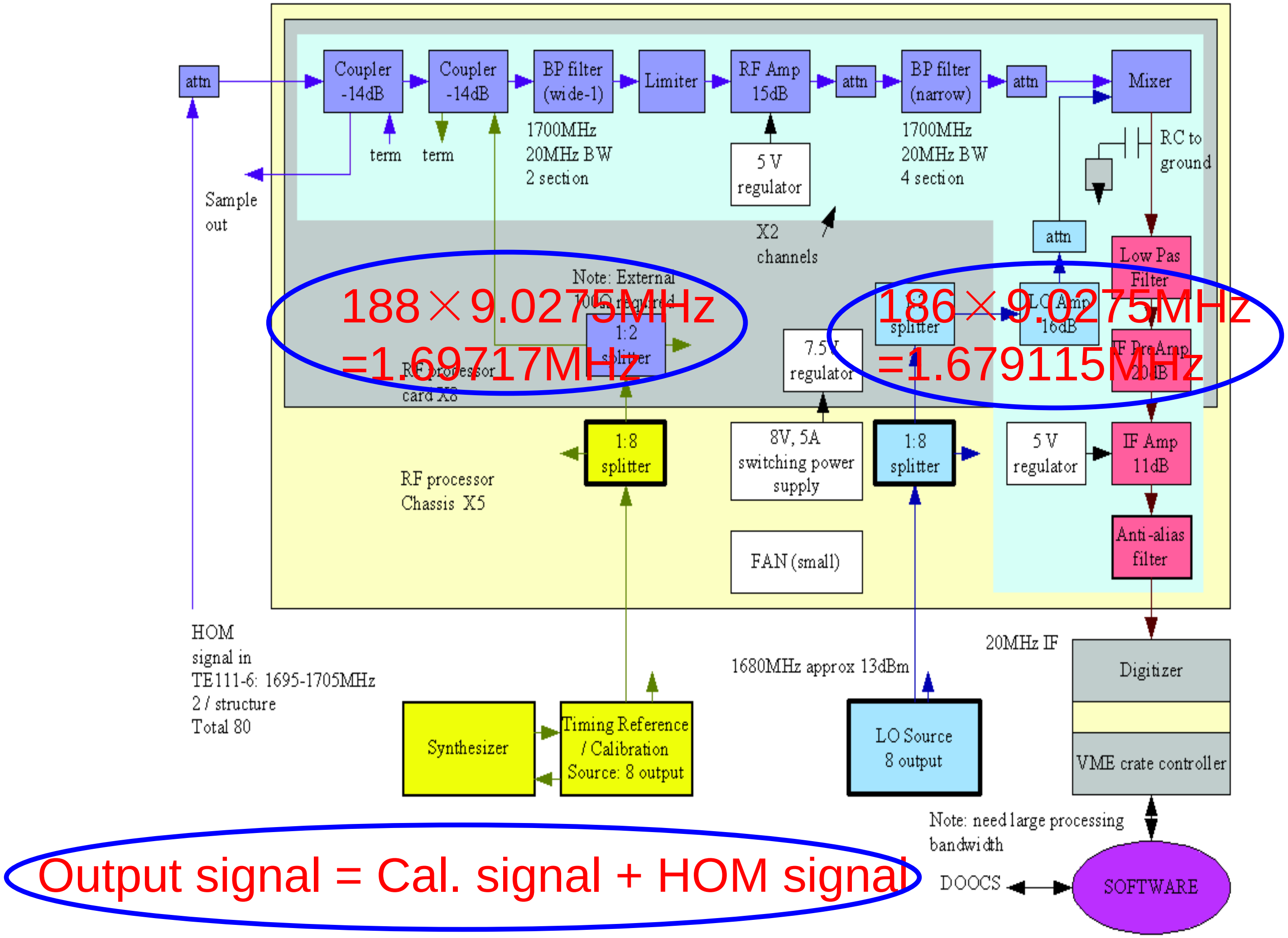


Schematic of Flash facility



Schematic of the mix-down electronics for measurement of the TE111-6 Mode (Stephen Molloy et al)

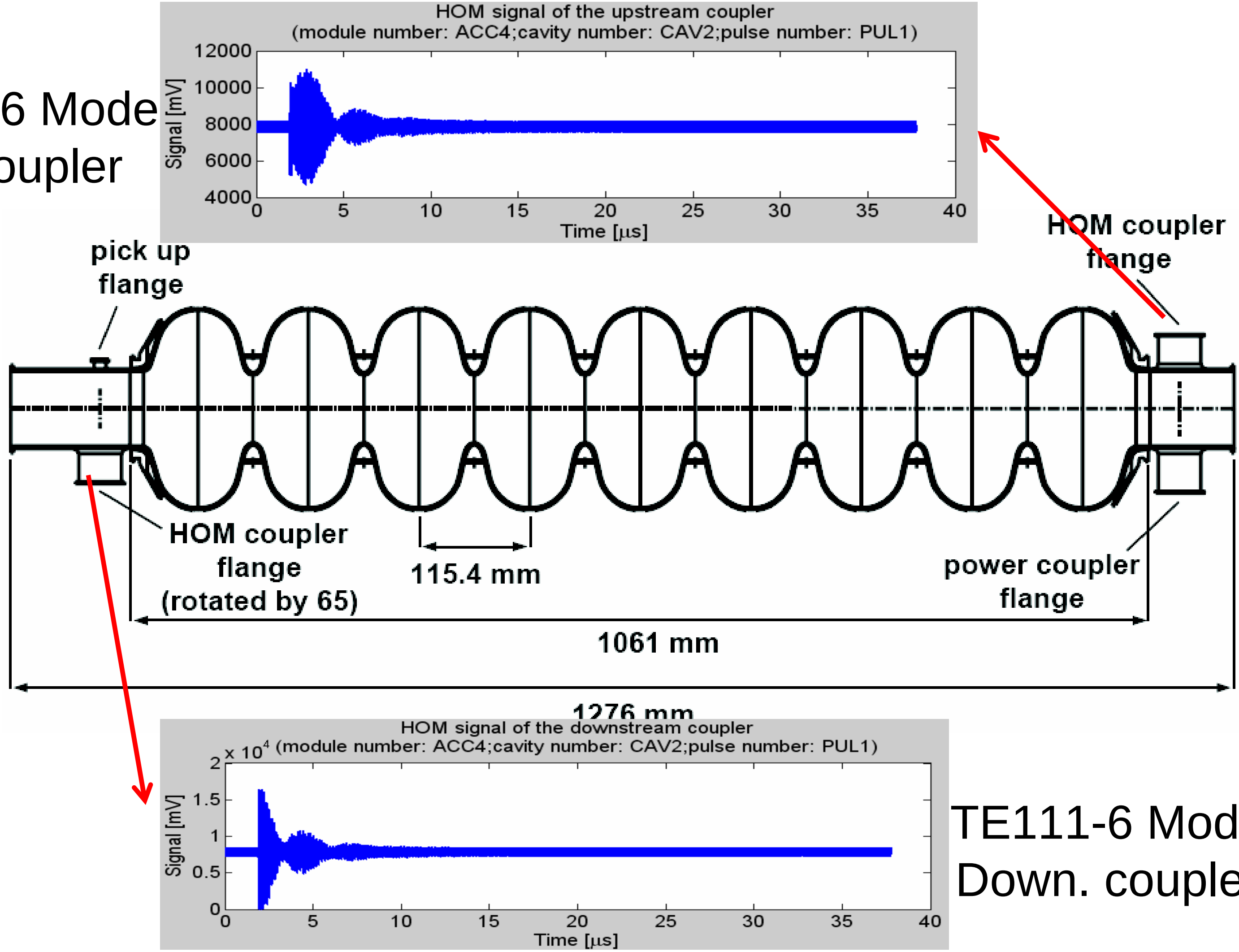
Detailed mix-down electronics



Detailed schematic of the mix-down electronics (Stephen Molloy et al)

Time domain HOM signal

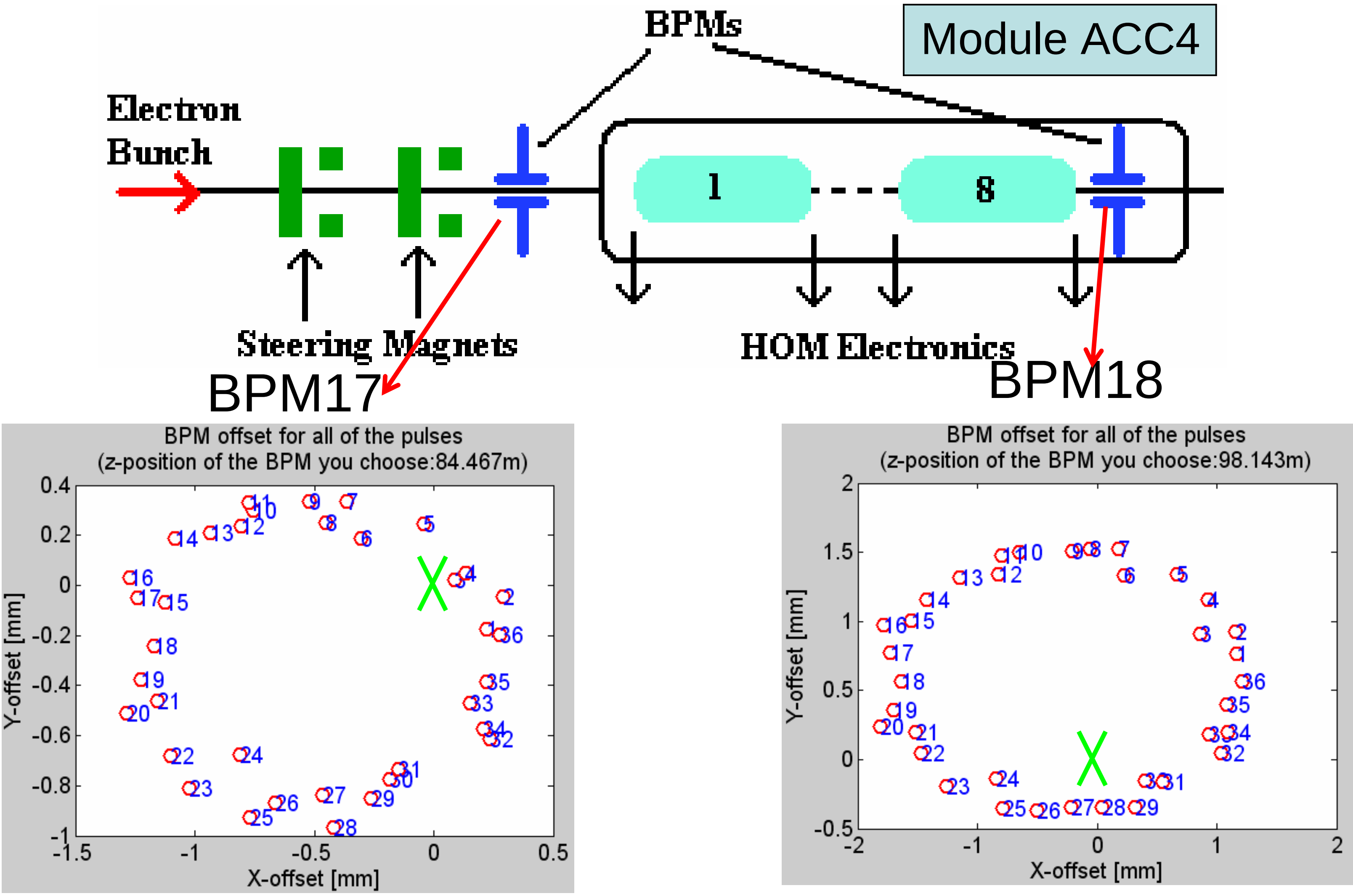
TE111-6 Mode
Up. coupler



TE111-6 Mode
Down. coupler

2007-01-22T091106.mat (Stephen Molloy et al)

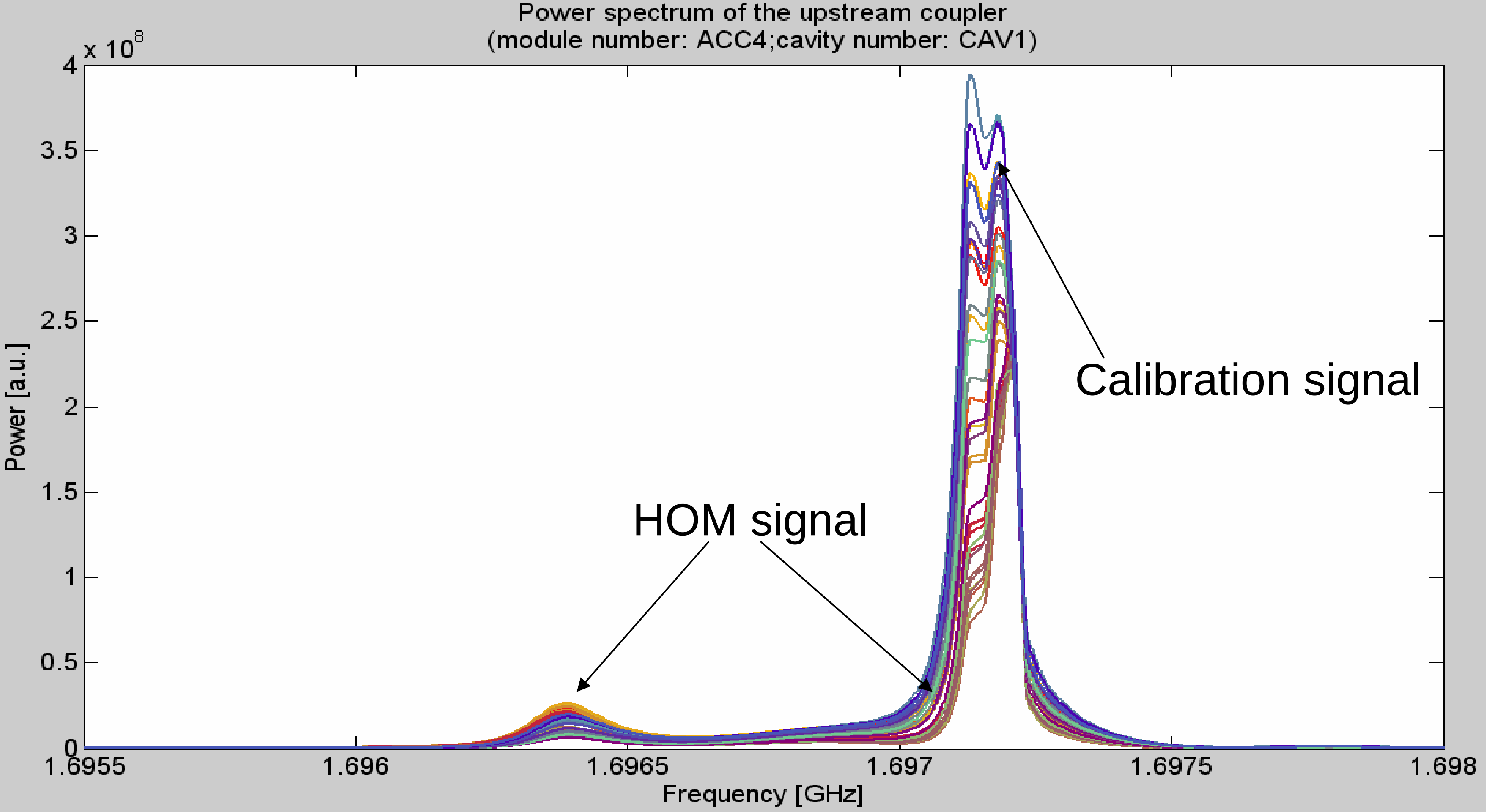
Steering setup for the experiment



2007-01-22T091106.mat (Stephen Molloy et al)

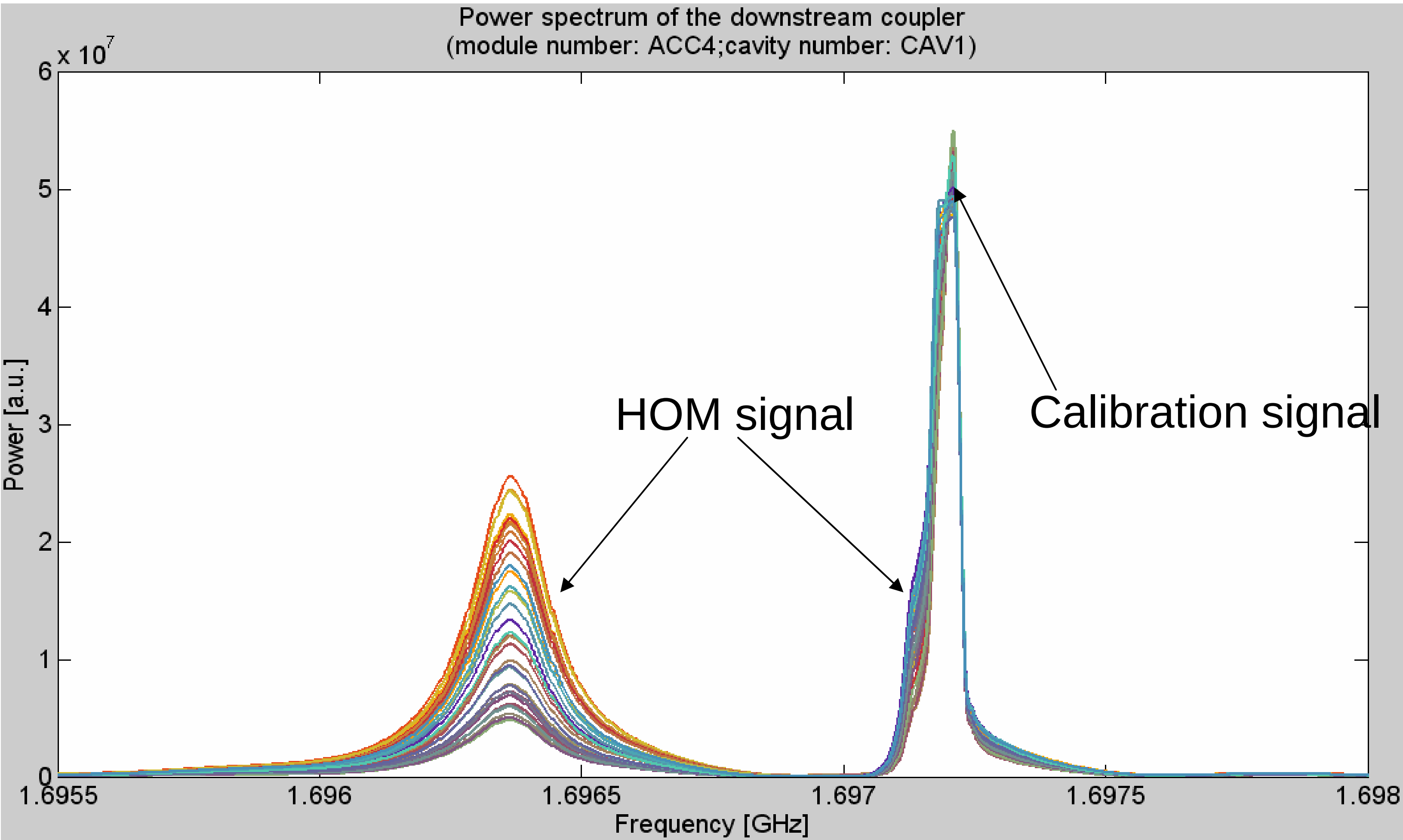
Frequency domain HOM signal (1)

Calibration signal overlaps with the HOM signal (ACC4, CAV1, Upstream, 2007-01-22T091106.mat)



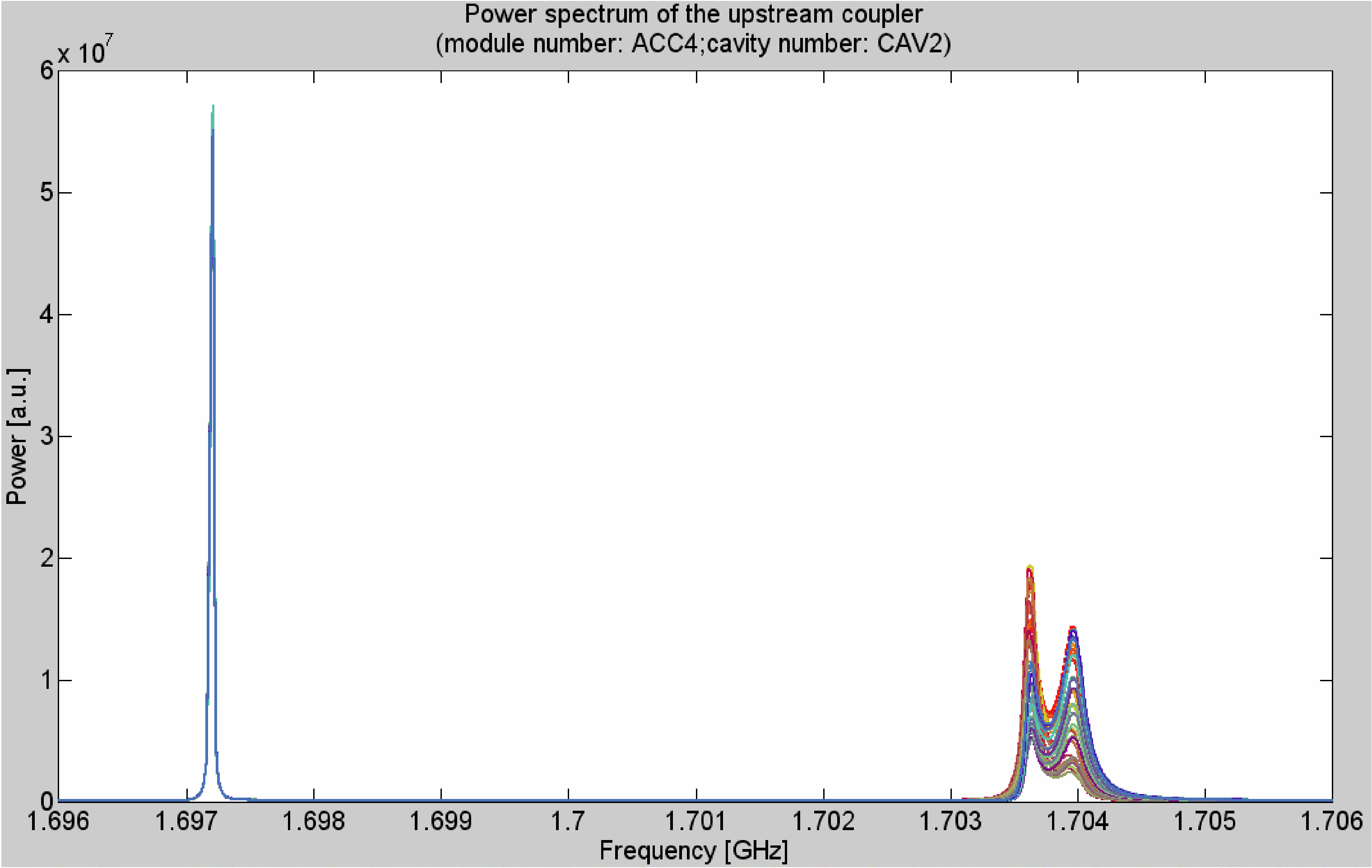
Frequency domain HOM signal (2)

Calibration signal overlaps with the HOM signal (ACC4, CAV1, Downstream, 2007-01-22T091106.mat)



Frequency domain HOM signal (3)

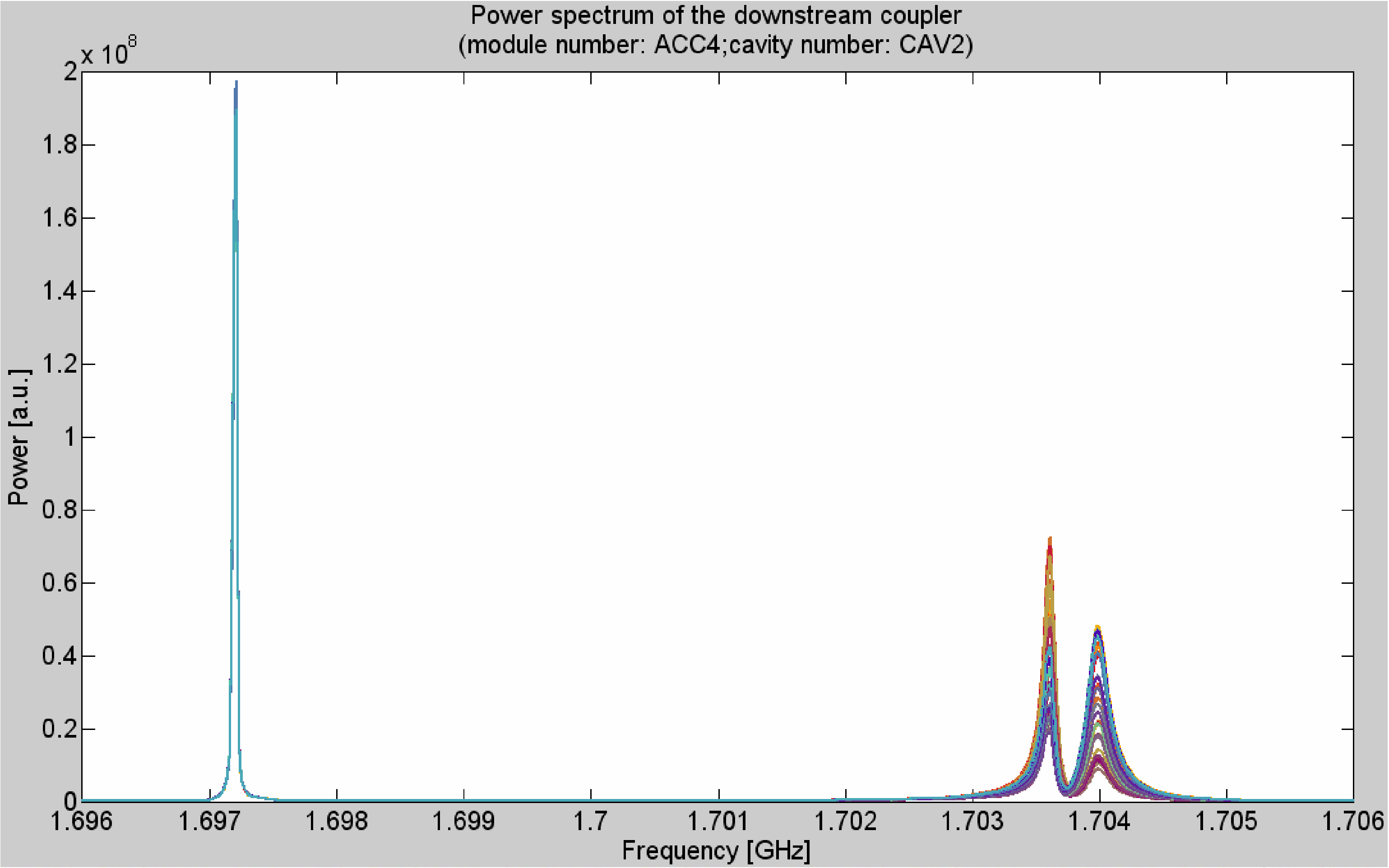
Calibration signal splits with the HOM signal (ACC4, CAV2, Upstream, 2007-01-22T091106.mat)



Frequency domain HOM signal (4)

Calibration signal splits with the HOM signal

(ACC4, CAV2, Downstream, 2007-01-22T091106.mat)



Model used

HOM signal in time domain

$$\sum_{n=1}^{\infty} A_n \mathrm{Cos}[\omega_{0\,n}\, t + \varphi_n]\, \mathrm{Exp}[-\omega_{0\,n}\, t / 2 / Q_n]$$

or

$$\sum_{n=1}^{\infty} A_n \mathrm{Sin}[\omega_{0\,n}\, t + \varphi_n]\, \mathrm{Exp}[-\omega_{0\,n}\, t / 2 / Q_n]$$

or

$$\sum_{n=1}^{\infty} A_n \mathrm{Exp}[i\,(\omega_{0\,n}\, t + \varphi_n)]\, \mathrm{Exp}[-\omega_{0\,n}\, t / 2 / Q_n]$$

HOM signal in frequency domain

$$\sum_{n=1}^{\infty} A_n \frac{(2\,Q_n\,(-2\,i\,Q_n\,\omega \mathrm{Cos}[\varphi_n] + (-\mathrm{Cos}[\varphi_n] + 2\,Q_n\,\mathrm{Sin}[\varphi_n])\,\omega_{0\,n}))}{(4\,Q_n^2\,\omega^2 - \omega_{0\,n}\,(4\,i\,Q_n\,\omega + (1 + 4\,Q_n^2)\,\omega_{0\,n}))}$$

or

$$\sum_{n=1}^{\infty} A_n \frac{(2\,Q_n\,(-2\,i\,Q_n\,\omega \mathrm{Sin}[\varphi_n] - (2\,Q_n\,\mathrm{Cos}[\varphi_n] + \mathrm{Sin}[\varphi_n])\,\omega_{0\,n}))}{(4\,Q_n^2\,\omega^2 - \omega_{0\,n}\,(4\,i\,Q_n\,\omega + (1 + 4\,Q_n^2)\,\omega_{0\,n}))}$$

or

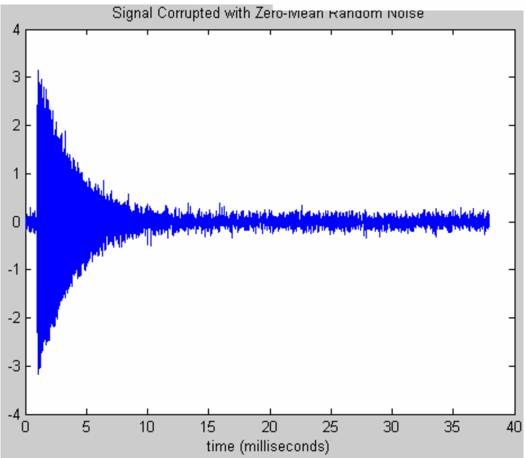
$$\sum_{n=1}^{\infty} A_n \frac{2\,i\,e^{i\,\varphi_n}\,Q_n}{-2\,Q_n\,\omega + (i + 2\,Q_n)\,\omega_{0\,n}}$$

Complex Lorentzian $\sum_{n=1}^{\infty} \frac{A_n}{\omega - \omega_{0\,n} + \Gamma i}$

Test of the fitting model (1)

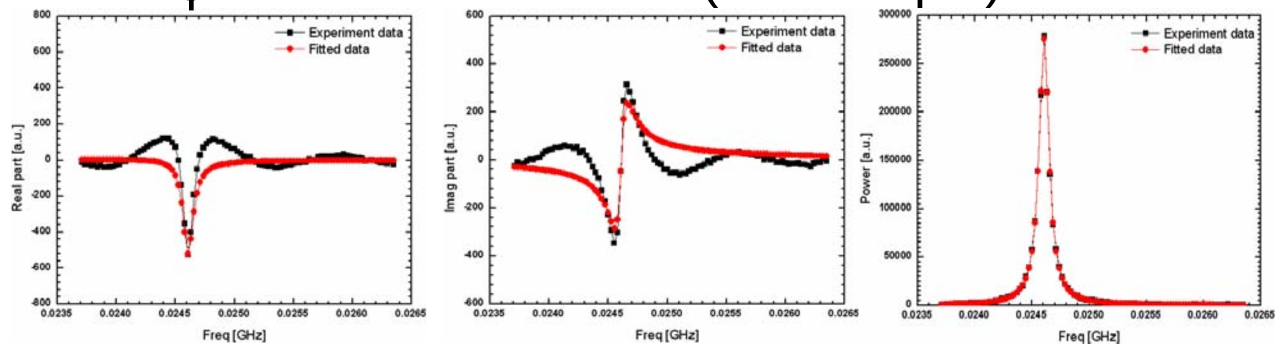
$$y = 0 \quad (0 < t < 1)$$

$$y = 3.23\,\mathrm{Cos}[2\pi * 24.60 * (t-1) + 7.01]\,\mathrm{Exp}\left[\frac{-2\pi * 24.60 * (t-1)}{2 * 234}\right] \quad (t > 1)$$

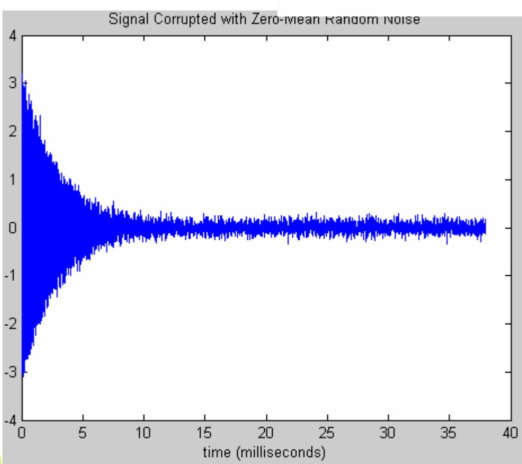


f=24.606MHz Q=232.071 A=0.350

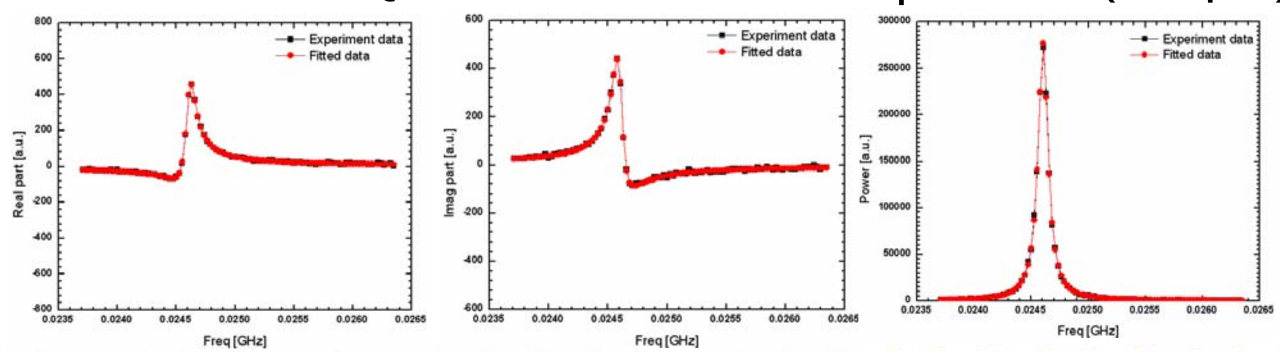
φ=3.239≈7.01-2π*0.6 (non-unique)



$$y = 3.23\,\mathrm{Cos}[2\pi * 24.60 * t + 7.01]\,\mathrm{Exp}\left[\frac{-2\pi * 24.60 * t}{2 * 234}\right] \quad (t > 0)$$



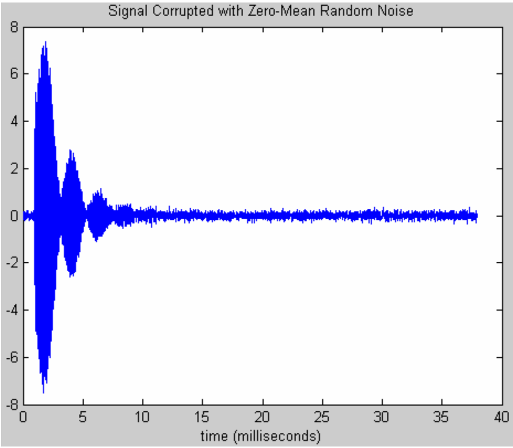
f=24.606MHz Q=233.502 A=0.349 φ=7.011 (unique)



Test of the fitting model (2)

$y = 0 \quad (0 < t < 1)$

$$y = 3.23\,\mathrm{Cos}[2\pi * 24.60 * (t-1) + 7.01]\,\mathrm{Exp}\left[\frac{-2\pi * 24.60 * (t-1)}{2 * 234}\right] + 8.23\,\mathrm{Cos}[2\pi * 25.06 * (t-1) + 4.01]\,\mathrm{Exp}\left[\frac{-2\pi * 25.06 * (t-1)}{2 * 140}\right] \quad (t > 1)$$

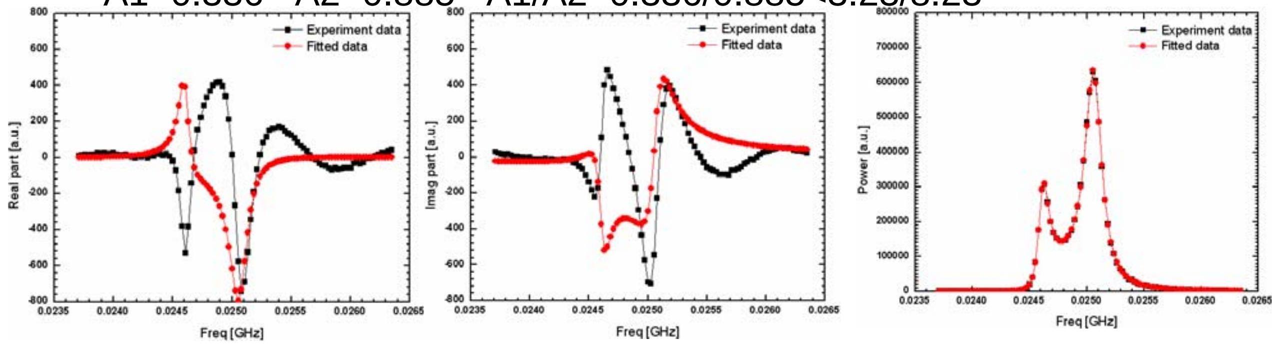


f1=24.608MHz Q1=235.110 φ1=2.916≠7.01-2π*0.60 (non-unique)

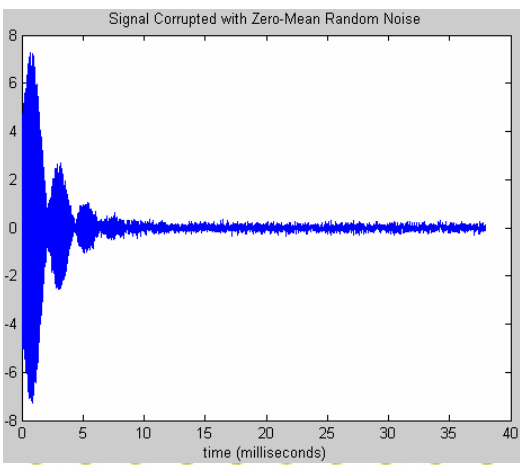
f2=25.065MHz Q2=139.554 φ2=5.782≠4.01-2π*0.06 (non-unique)

φ1-φ2=-2.866≈π-((7.01-2π*0.60)-(4.01-2π*0.06)) (non-unique)

A1=0.336 A2=0.885 A1/A2=0.336/0.885<3.23/8.23



$$y = 3.23\,\mathrm{Cos}[2\pi * 24.60 * t + 7.01]\,\mathrm{Exp}\left[\frac{-2\pi * 24.60 * t}{2 * 234}\right] + 8.23\,\mathrm{Cos}[2\pi * 25.06 * t + 4.01]\,\mathrm{Exp}\left[\frac{-2\pi * 25.06 * t}{2 * 140}\right] \quad (t > 0)$$

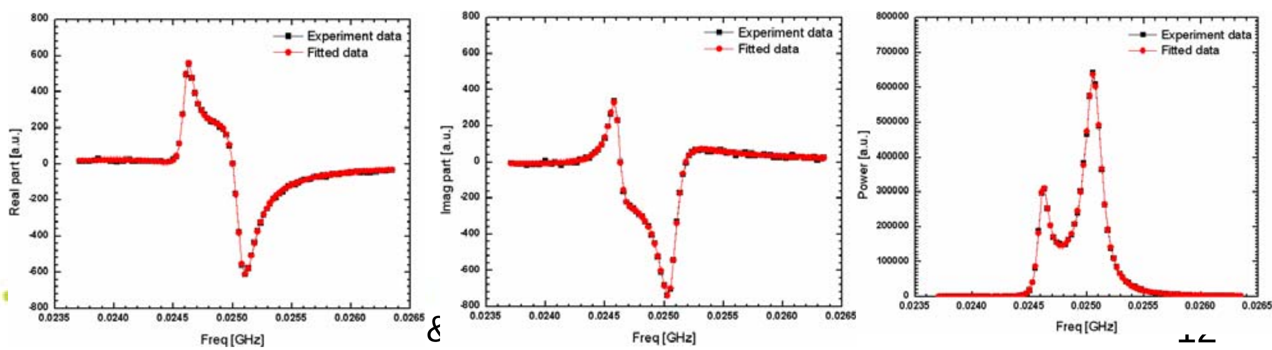


f1=24.606MHz Q1=233.947 φ1=7.011 (unique)

f2=25.067MHz Q2=139.773 φ2=4.006 (unique)

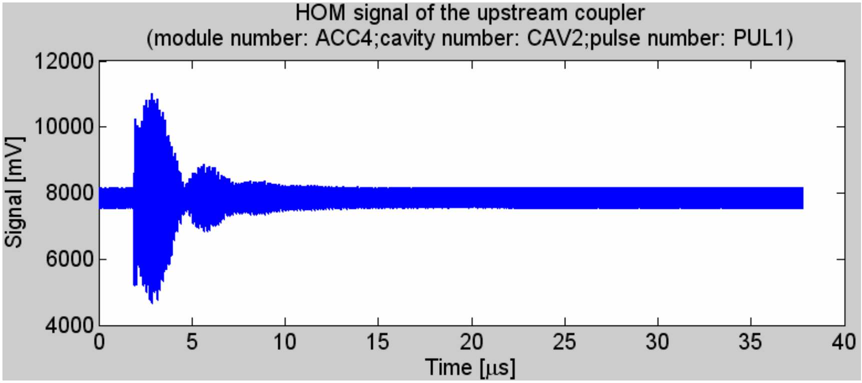
φ1-φ2=3.005≈7.01-4.01 (unique)

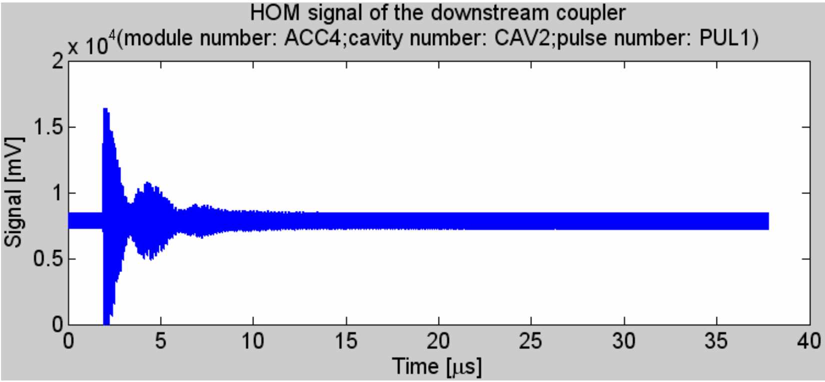
A1=0.351 A2=0.894 A1/A2=0.351/0.894≈3.23/8.23



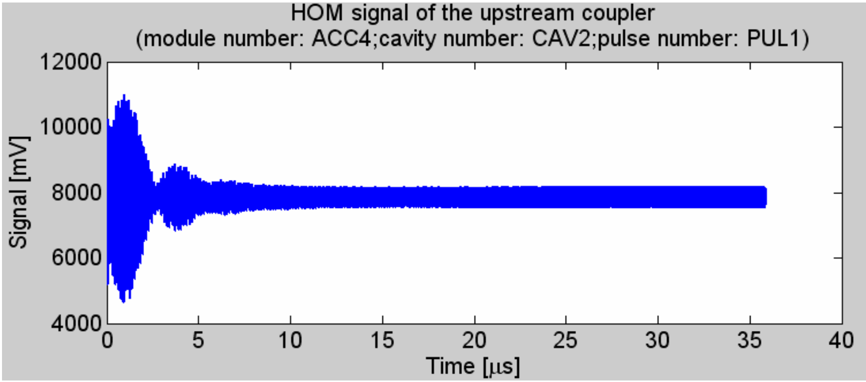
Two methods used

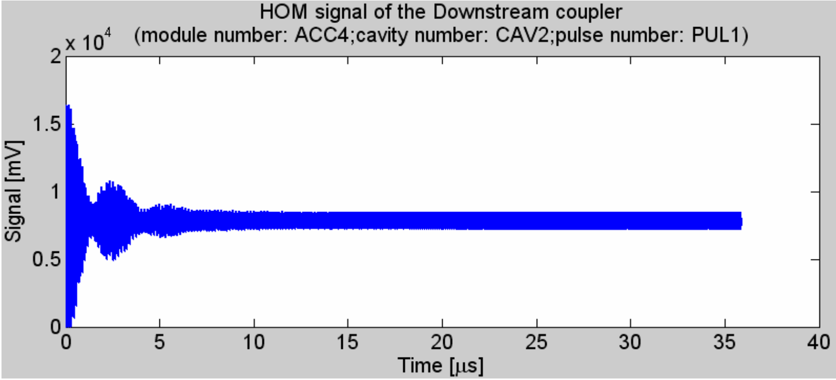
Method 1





Method 2



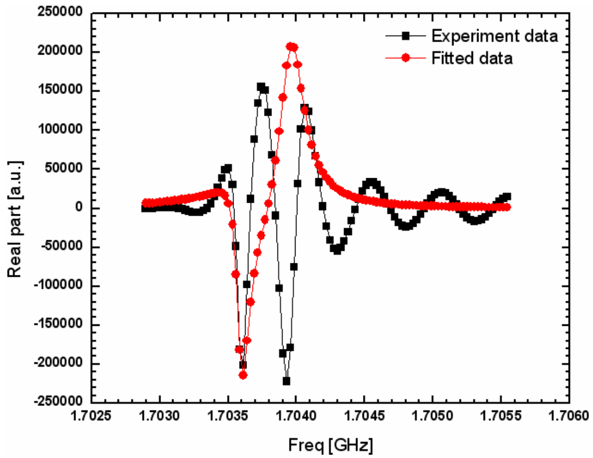


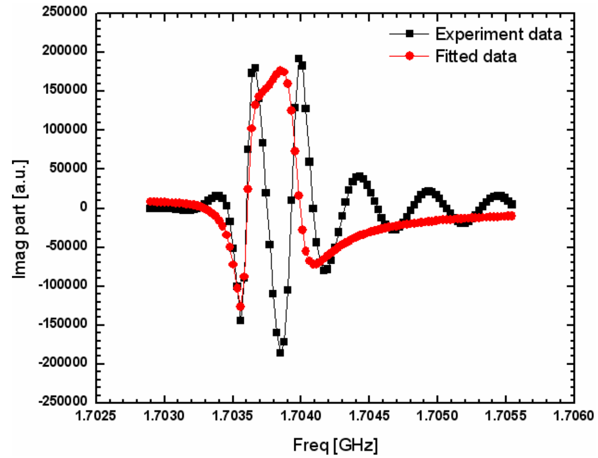
Method 1

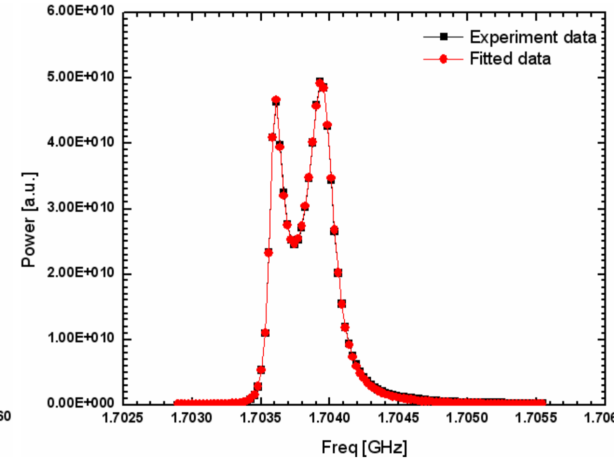
Fitting of HOM power spectrum is used to value the fitting results.

2007-01-22T091106.mat

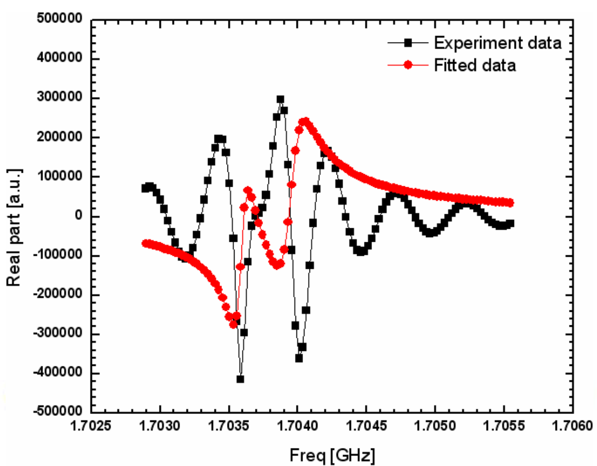
Pulse # 1, Upstream Coupler (Fitted phase is non-unique)

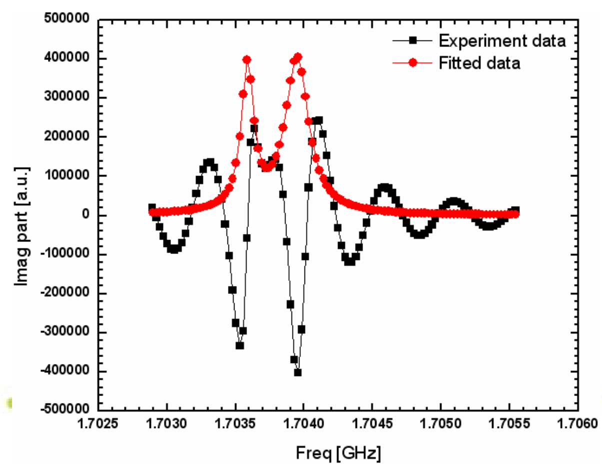


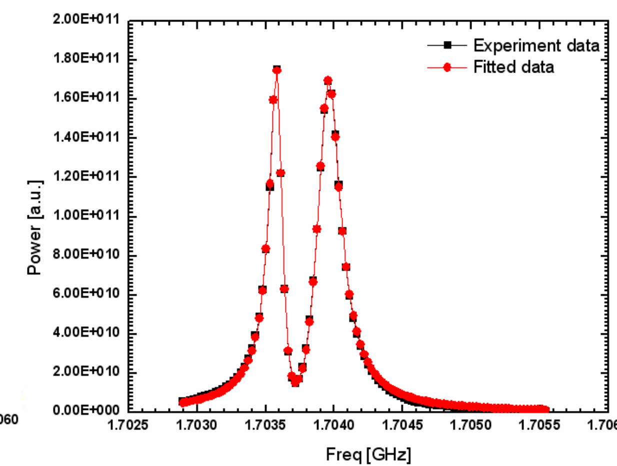




Pulse # 1, Downstream Coupler (Fitted phase is non-unique)





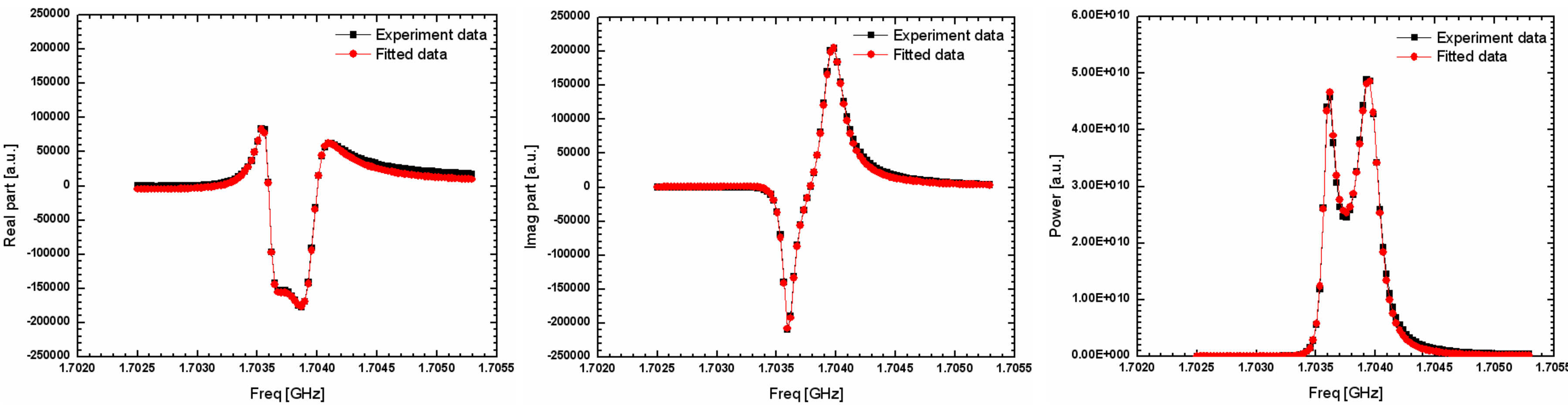


Method 2

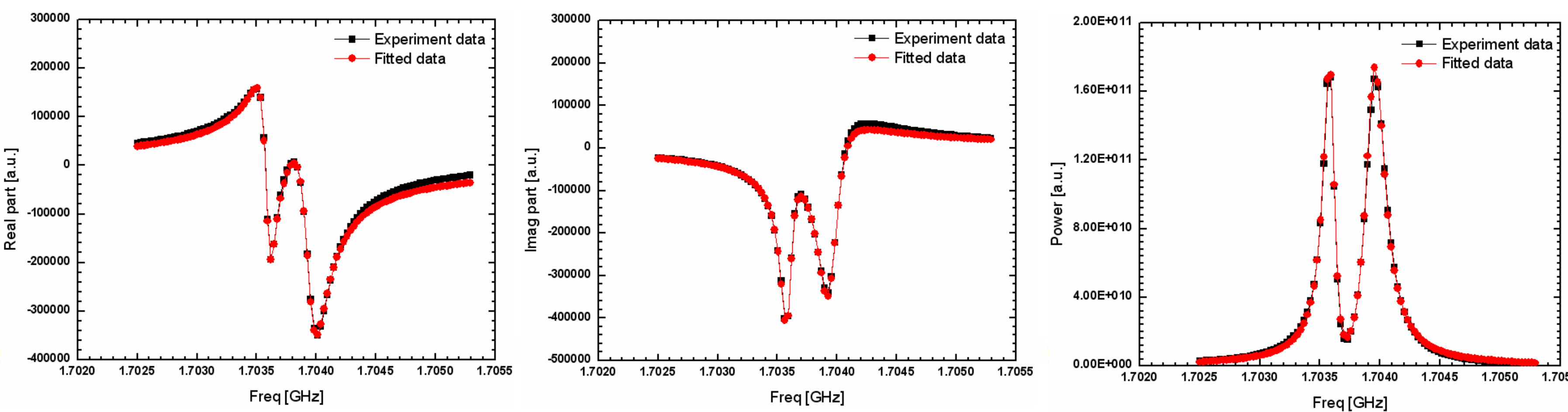
Fitting of both the real and imaginary parts is used to value the fitting results.

2007-01-22T091106.mat

Pulse # 1, Upstream Coupler (Fitted phase is unique)

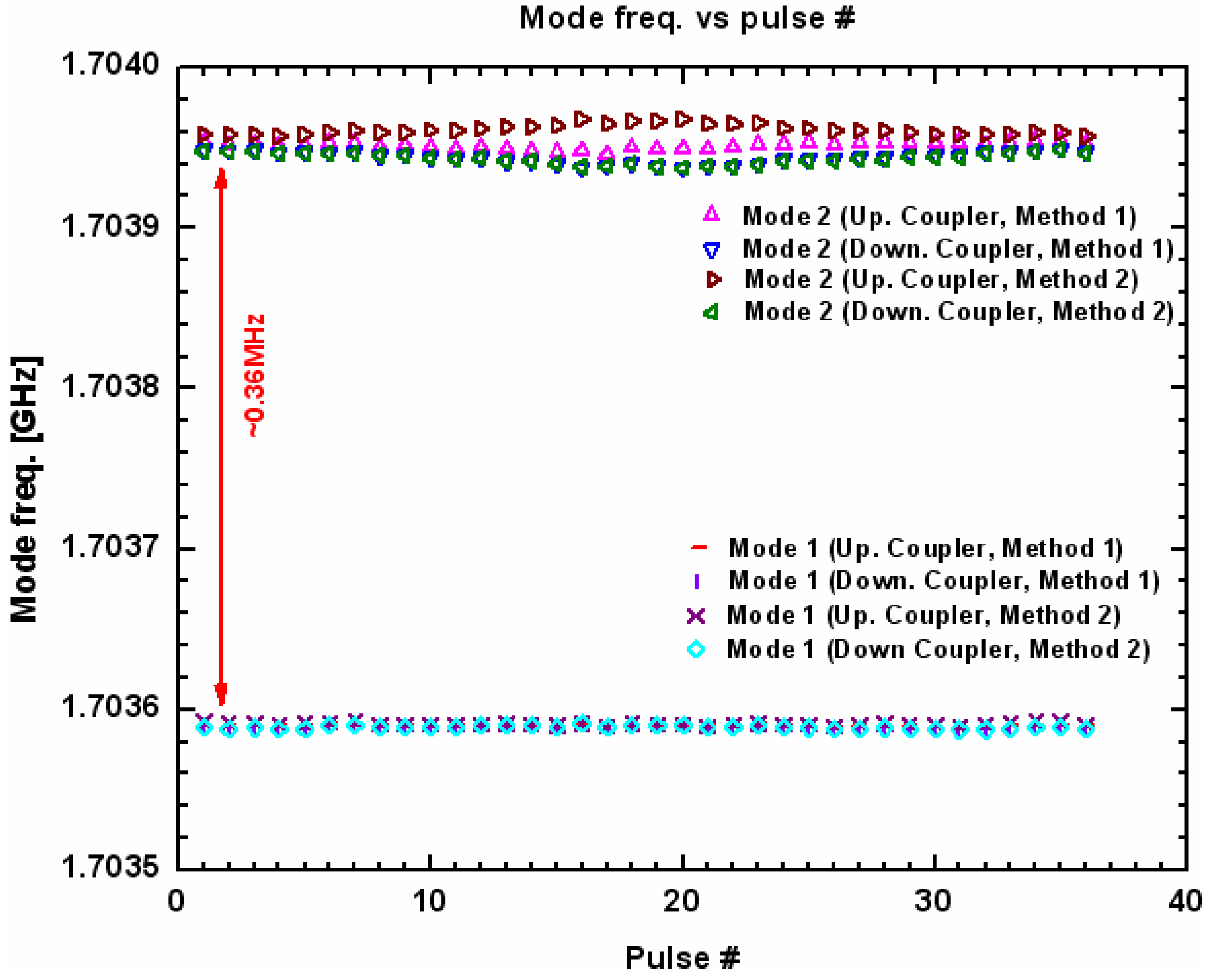


Pulse # 1, Downstream Coupler (Fitted phase is unique)



Mode freq. vs pulse

2007-01-22T091106.mat

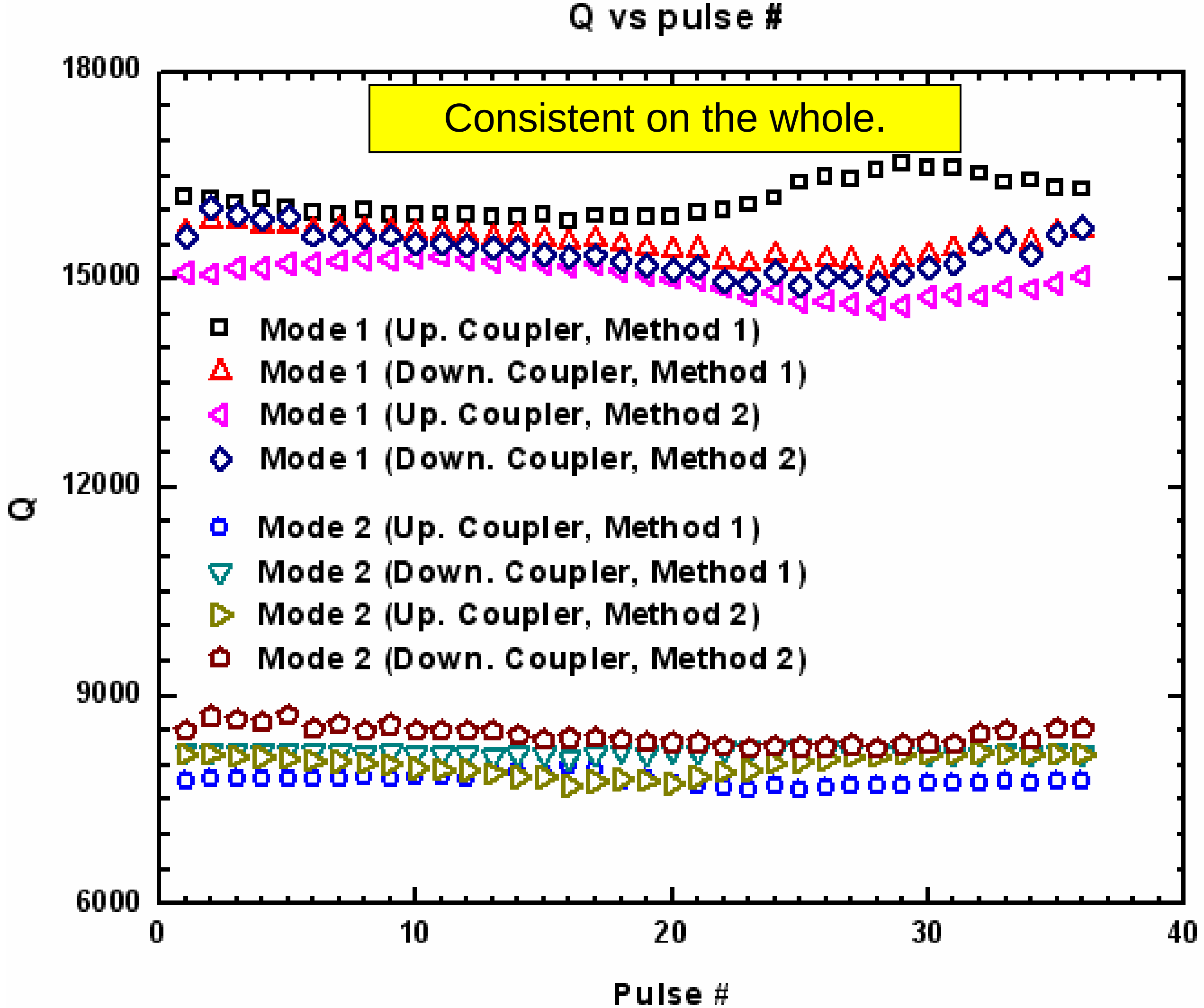


Freq. res. of method 1: 108.33MHz/4095=0.0264MHz
Freq. res. of method 2: 108.33MHz/3886=0.0279MHz

$$\text{Freq. res.} \propto \frac{1}{\text{Sampling points}}$$

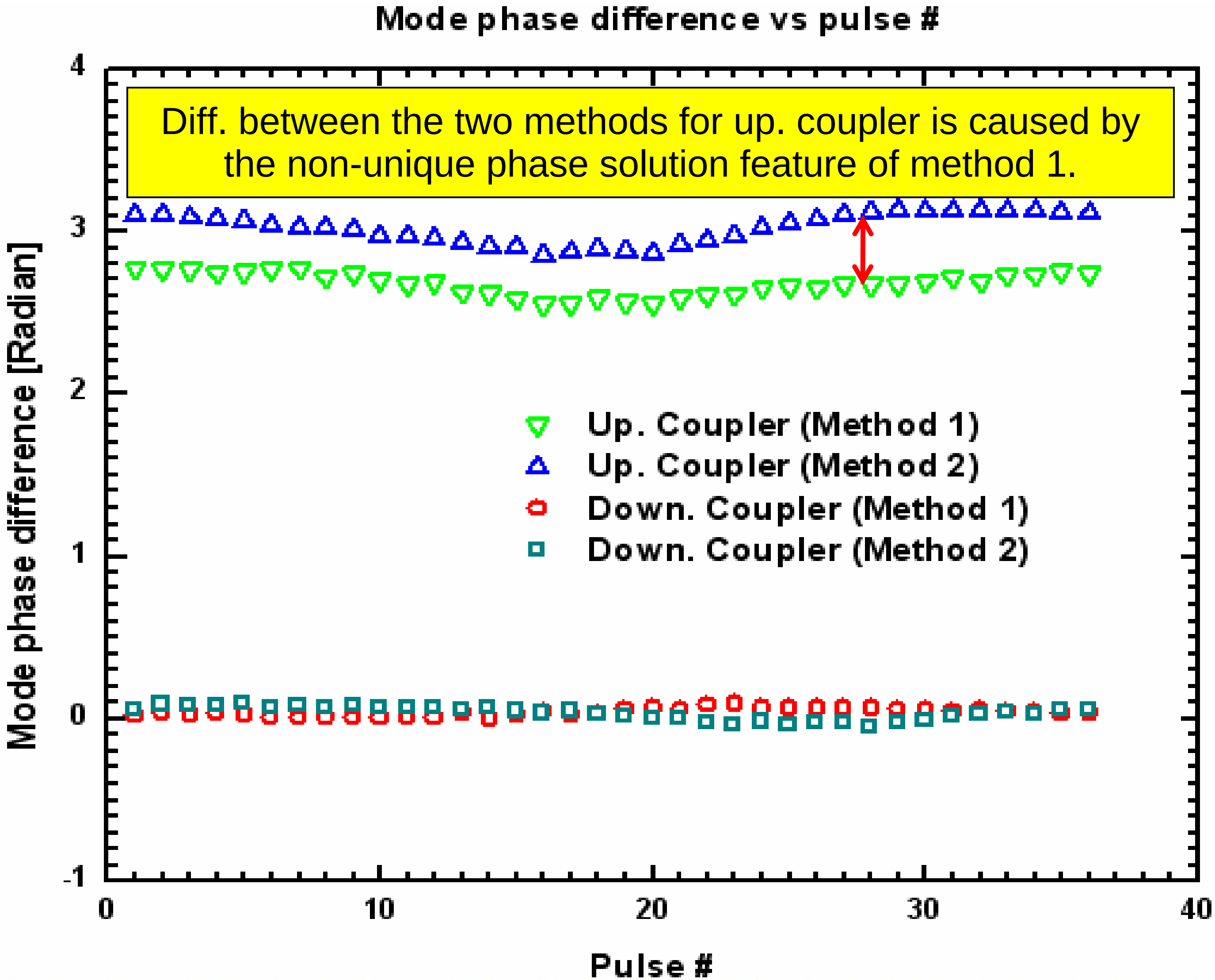
Q vs pulse

2007-01-22T091106.mat



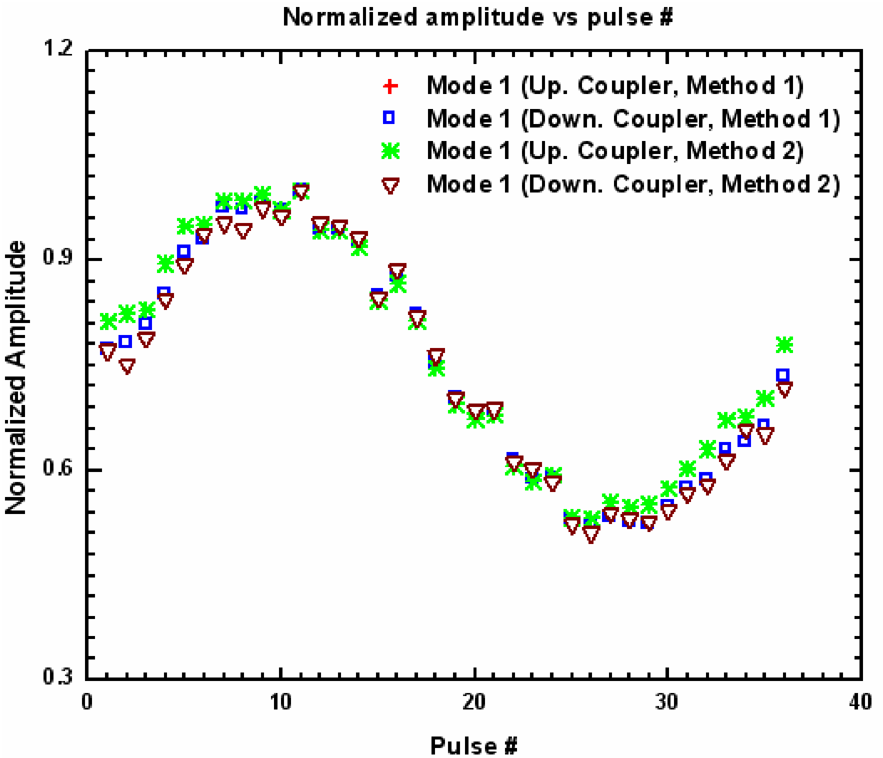
Mode phase difference vs pulse

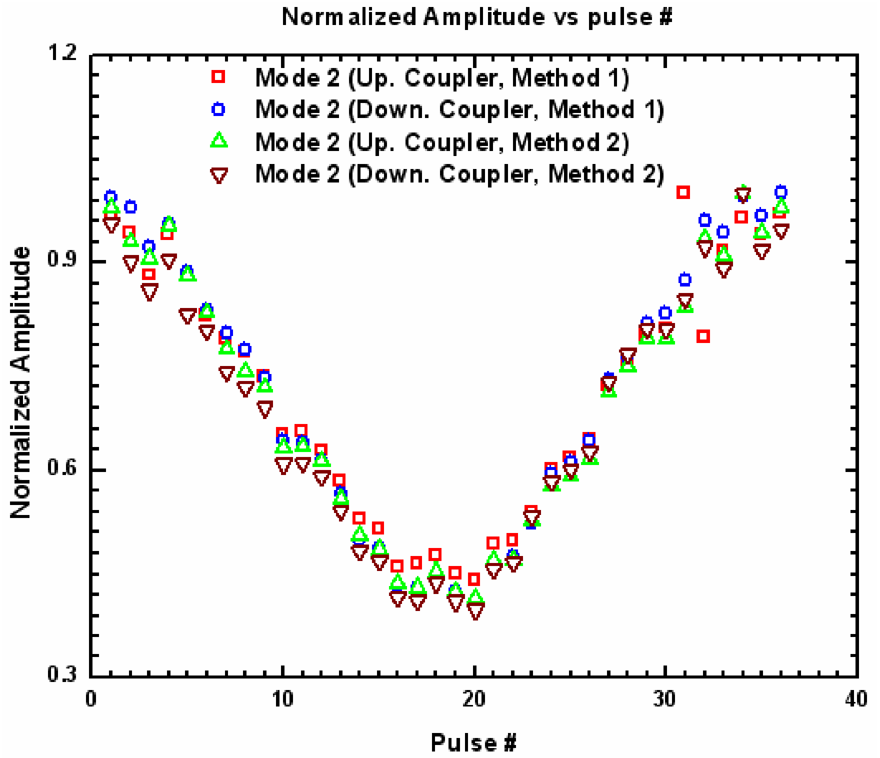
2007-01-22T091106.mat



Normalized amplitude vs pulse

2007-01-22T091106.mat





Apparently mode 1 and mode 2 are two polarization modes of TE111-6.

Summary and further plan

- A new model and method to analyze the HOM signal data has been investigated, good results have been obtained for one set of data.
- Further plan
  - **More data need to be analyzed.**
  - **Relation between the mode characteristic and beam position need to be investigated.**
  - **Most of the current fitting process is done manually, more robust program or macro need to be found or developed.**
  - **Study the characteristic of the other dipole modes.**
  - **……**

Thanks for many good discussions with Chris Adolphsen, Zenghai Li and Stephen Molloy.