FSSP Data Processing Comparison

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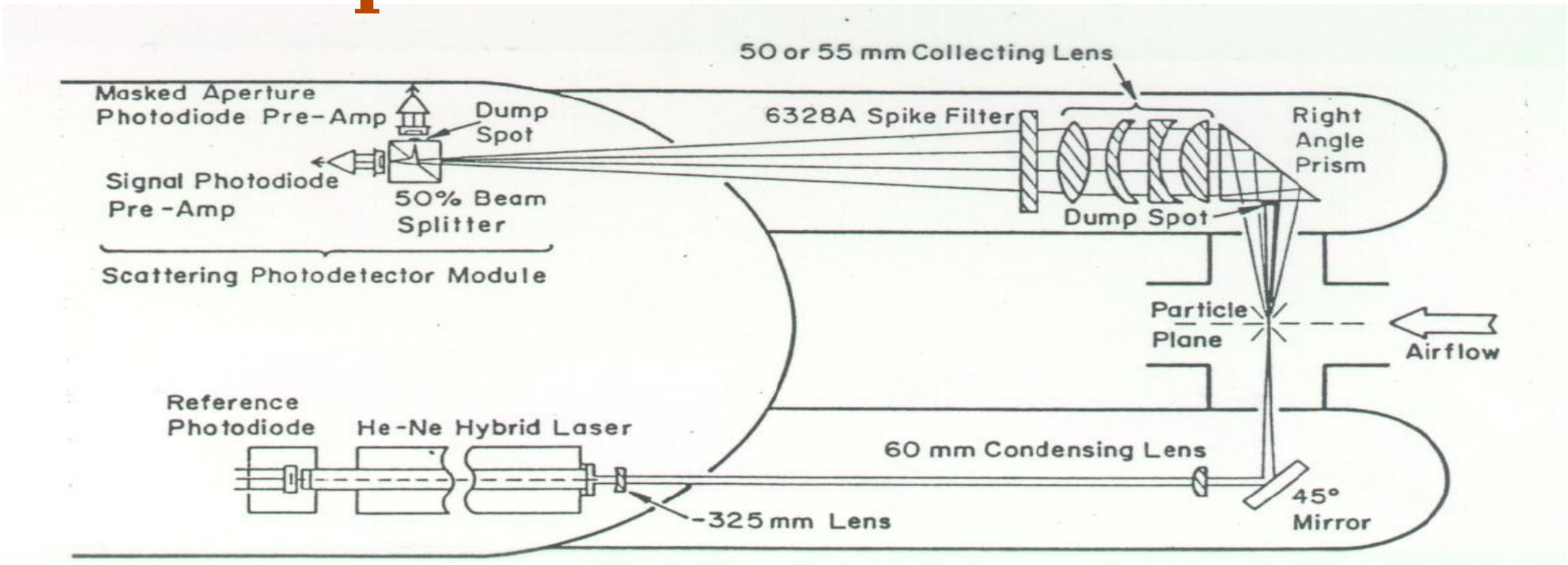
Forward Scattering Spectrometer Probe (FSSP) on the Left Wing of the King Air 200 Aircraft

This FSSP-100 has the Signal Processing Package (SPP) upgrade to the FSSP-100 probe. This package replaces original PMS electronics with modern high-speed circuitry.

Optical Path of the FSSP



- The beam splitter divides the scattered light onto two photodetectors.
- One photodector is optically masked to not receive scattered light from near the laser beam's center of focus.
- Droplets are rejected as being out of the depth of field when the signal from the masked detector exceeds that from the unmasked detector.

FSSP schematic is taken from Dye and Baumgarnder, [1984]

FSSP Effective Sample Volume

Sample Volume = TAS*DOF*BD*(Tc/Ts)

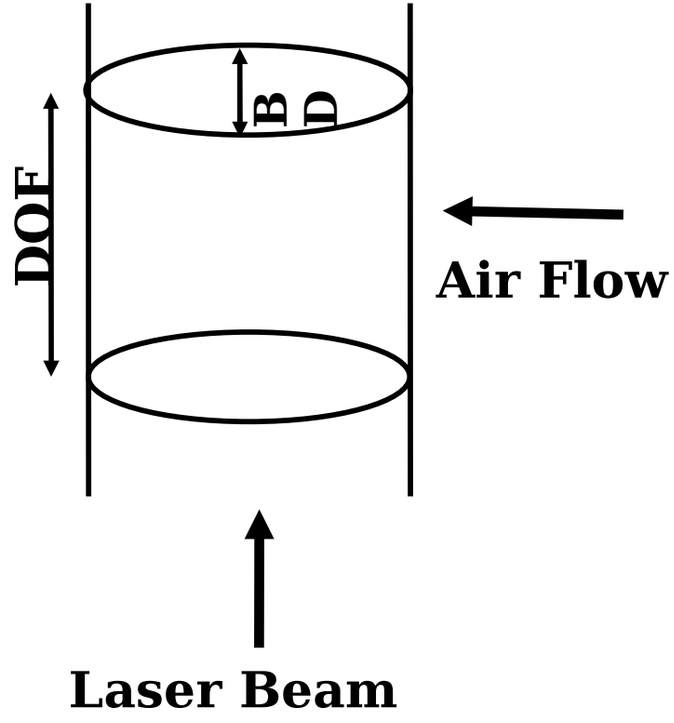
TAS – Aircraft True Air Speed (~100 m/s)

DOF – FSSP Depth of Field (~2.9 mm)

BD – Laser Beam Diameter (~0.2 mm)

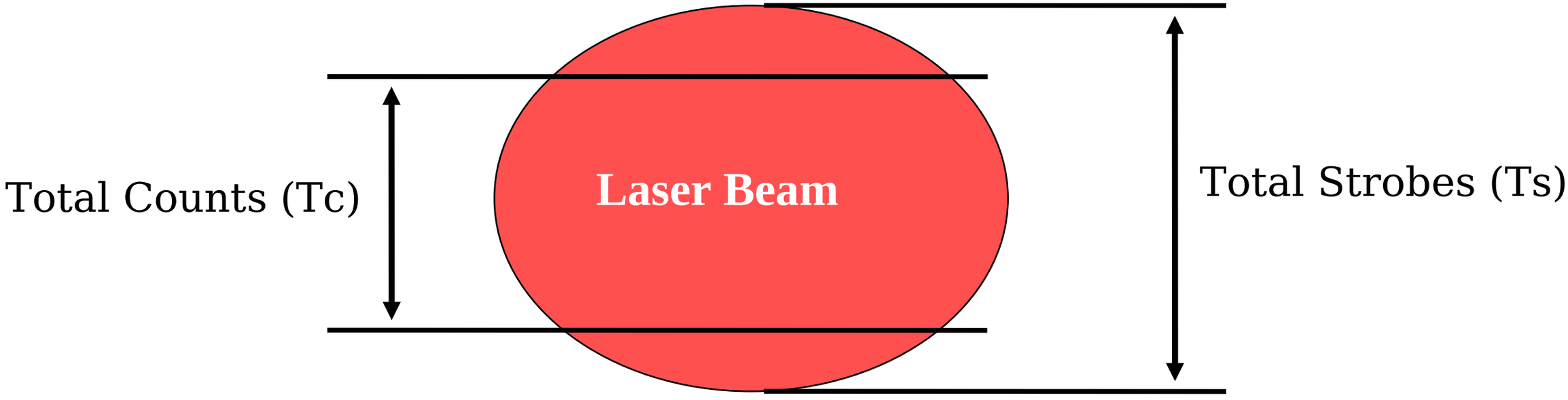
Tc – Number of Droplets Sized (Total Counts)

Ts – Number of Droplets within the DOF (Total Strobes)



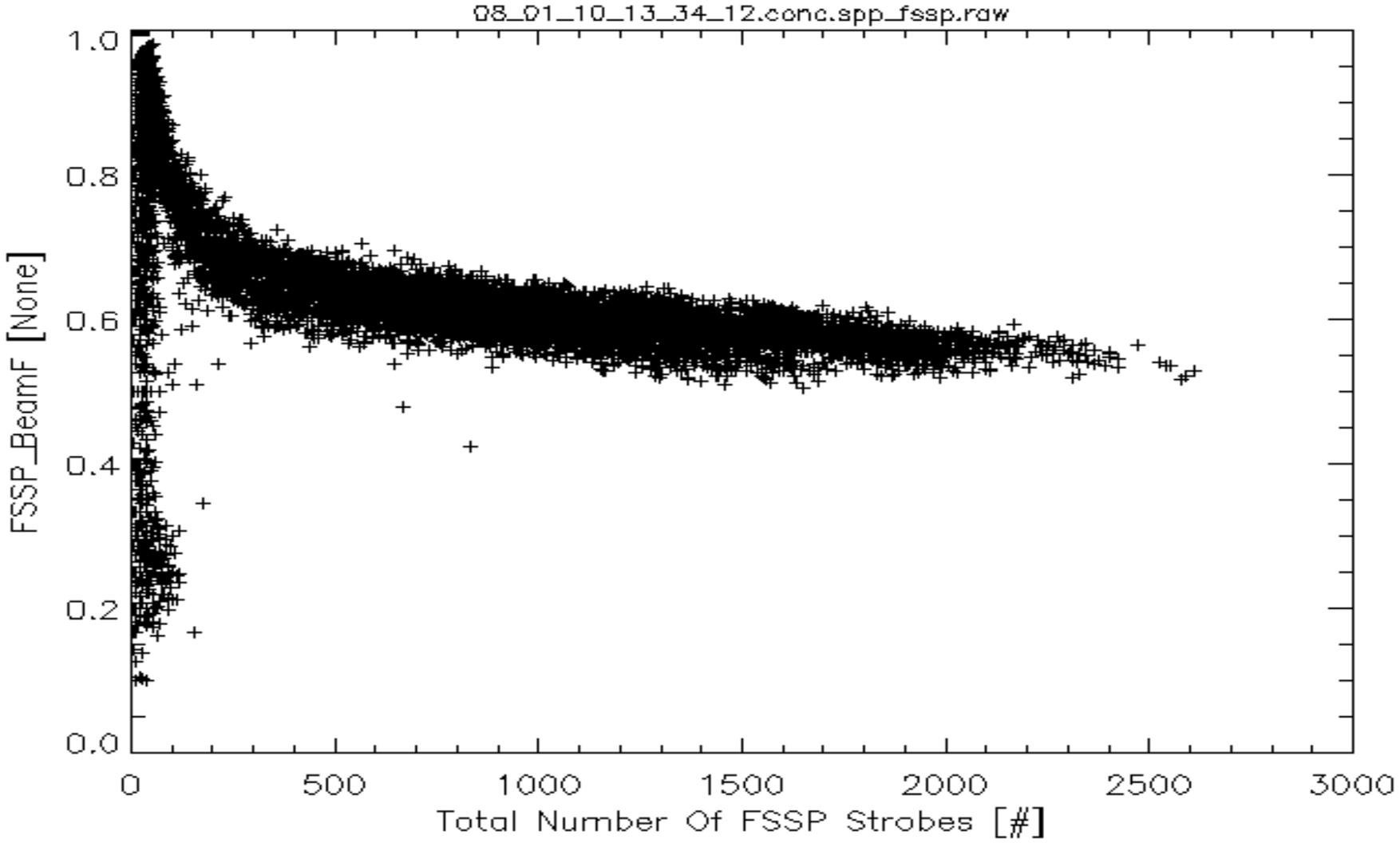
Laser Beam Fraction Correction

Effective Laser Beam Diameter (Tc/Ts)



- The effective laser beam diameter is the fraction of the total diameter where droplets are within the laser beam long enough so they can be sized.
- A running average of droplet transit time through the beam is maintained. If the droplet time within the laser beam is less than the average, it is rejected from sizing but included in the running average.

Velocity Acceptance Ratio



The velocity acceptance ratio is based on the ratio of total FSSP counts to total FSSP strobes at 10 Hz from the second flight on January 10, 2008. Dye and Baumgarnder [1984] state that the theoretical velocity acceptance ratio is 62%.

Coincidence and Dead Time Corrections

$$cf = \frac{1}{1 - 0.73 * F_a}$$

cf – Correction factor

F_a – Activity Fraction

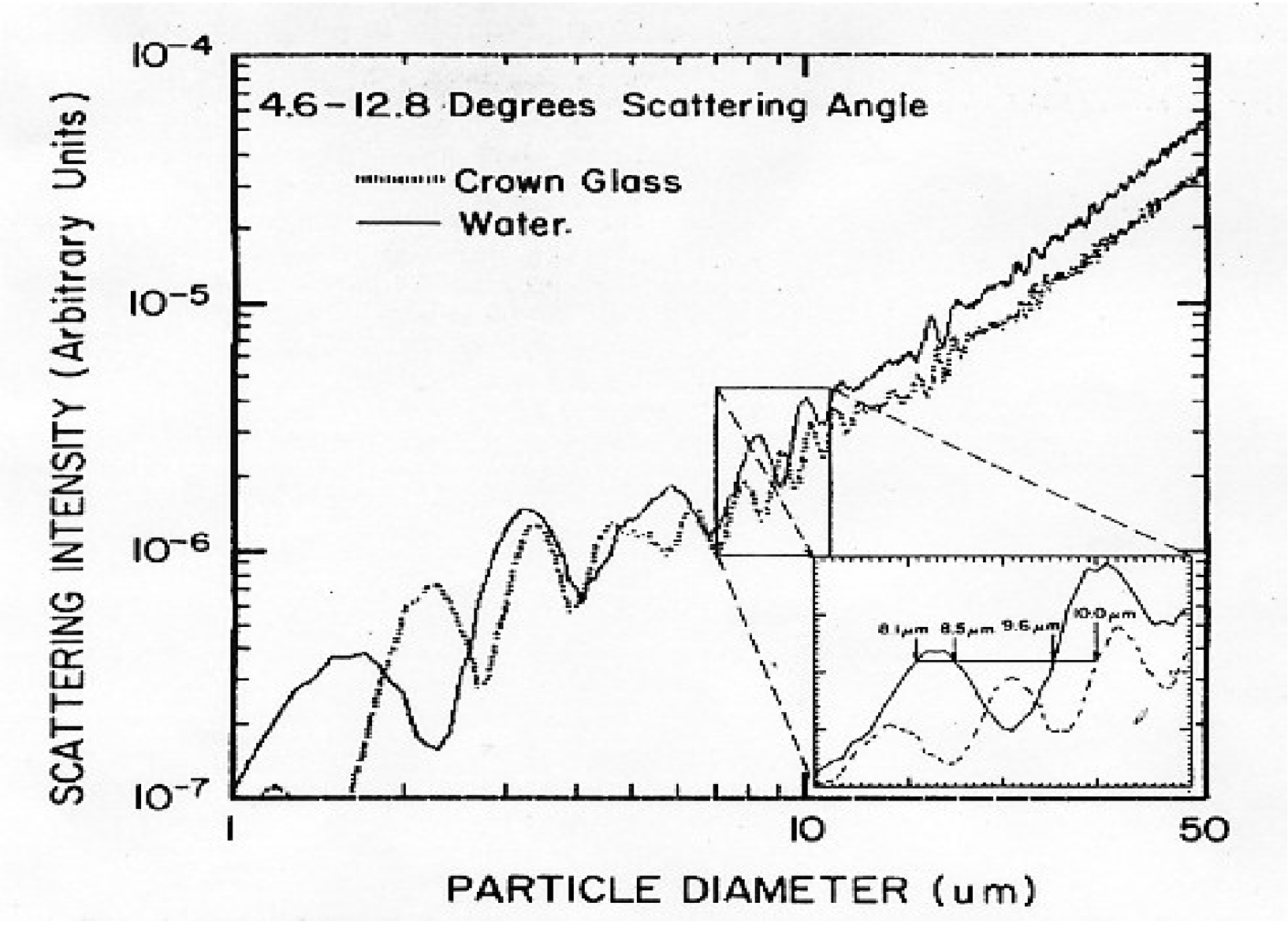
The 0.73 constant is an empirical factor found from computer simulations which takes into account particles which are still in the beam at the end of a reset delay period. This factor is described by Baumgardner [1983] and Baumgardner et al [1985].

What should be used for SPP upgraded probe?

FSSP Calibration Procedure

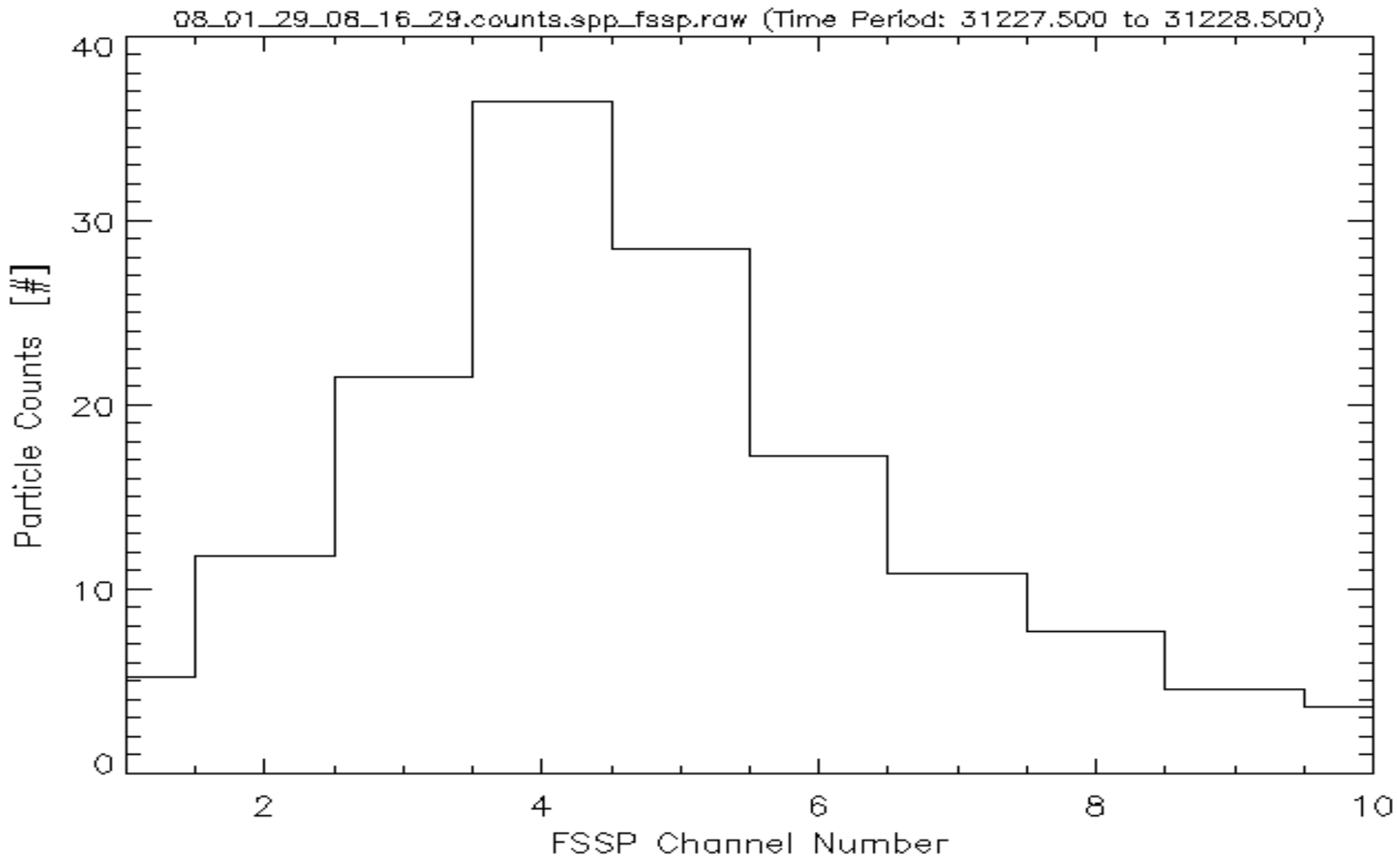
The FSSP is calibrated to determine the instruments depth of field, laser beam diameter, and channel size boundaries. The channel counts obtained from measurements on beads of known size are used to determine the FSSP channel boundaries.

FSSP Mie Function



FSSP Mie Function is taken from Dye. and Baumgarnder, [1984]

FSSP Bead Calibration Check



January 29, 2008 FSSP calibration check at 8:40:28 using 15 µm beads.

2007/2008 Saudi Arabia

FSSP SN 1947-0281-60 (WMI) Calibration Checks

Date	Start [sfm]	End [sfm]	P-C H	Pre-Peak Count	Peak Count	Post-Peak Count	MOD	Bead Size [um]	Water Eq. Size	Cal. Avg CH	Std CH
07/12/05	46700.0	46703.0	6	10.700	18.233	15.700	0	20.0	16.09	6.112	7.210
07/12/05	49355.5	49358.5	4	8.933	19.800	19.667	0	15.0	12.91	4.212	5.574
08/01/07	27869.7	27870.7	4	35.900	67.300	58.600	0	14.5	12.57	4.140	5.400
08/01/07	28062.0	28063.5	4	18.200	28.530	17.800	0	14.5	12.57	3.994	5.400
08/01/07	28446.2	28447.2	4	39.100	63.300	62.000	0	15.0	12.93	4.139	5.574
08/01/07	28489.0	28490.0	4	3.900	4.500	2.700	0	15.0	12.93	3.900	5.574
08/01/07	28935.0	28936.0	9	52.700	58.200	41.700	0	30.0	24.39	9.928	11.280
08/01/29	31227.7	31228.7	4	22.400	37.500	29.100	0	15.0	12.93	4.075	5.574
08/01/29	31373.5	31376.0	4	28.280	35.160	17.720	0	15.0	12.93	3.870	5.574
08/01/29	31487.5	31488.5	9	4.100	5.200	4.500	0	30.0	24.39	9.029	11.280
08/02/06	25548.5	25549.5	4	14.100	16.100	10.000	0	15.0	12.93	3.898	5.574
08/02/06	25736.7	25737.7	8	13.300	15.600	12.200	0	30.0	24.39	7.973	11.280

FSSP SN 6702-0789-126 (NRL) Calibration Checks

Date	Start [sfm]	End [sfm]	P-C H	Pre-Peak Count	Peak Count	Post-Peak Count	Mod	Bead Size [um]	Water Eq. Size	Cal. Avg CH	Std CH
07/12/05	46919.5	46920.5	17	24.600	36.100	33.600	0	20.0	16.09	17.095	7.210
07/12/05	47119.0	47122.0	5	53.067	97.667	72.200	0	8.0	6.53	5.0858	2.164
08/02/06	26906.0	26908.0	7	19.800	22.050	19.400	0	15.0	12.70	6.9935	5.574
08/02/06	27247.2	27249.2	16	3.000	4.300	3.000	0	30.0	24.39	16.000	11.280
08/02/06	27485.0	27486.0	5	42.900	86.000	36.600	0	8.0	6.53	4.962	2.164
08/02/06	27598.0	27599.0	5	8.200	16.800	9.000	0	8.0	6.53	5.024	2.164

February 3, 2008 Assignment

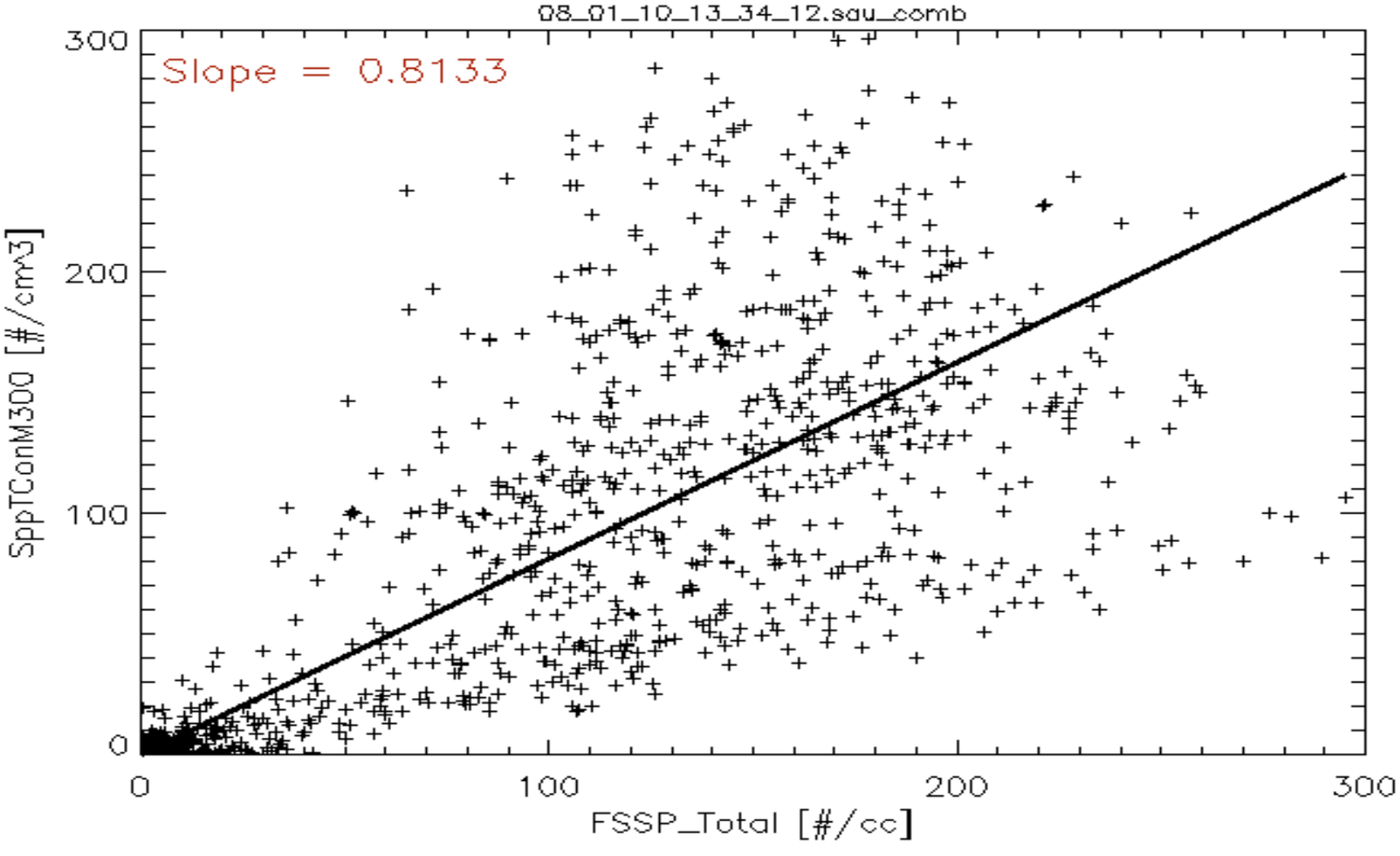
- Compare the M300 real time processing of FSSP number concentration data with the post-processed FSSP number concentration data.
- Use the January 10, 2008 flights for comparison.
- Present results on March 5, March 9, 2008 at 1:00 p.m.
  - Mark it on the calendar, “FSSP Data Processing Comparison”

FSSP-100 (SPP Upgraded) Data Processing Methods

	M300 Play Back	UND Linux Based
Processing Method	Real-time	Post-processing
Beam Fraction Correction	Yes	Yes
Coincidence and Dead Time Correction	No	???
Bead Size Calibration	Yes	Yes
Beam Diameter	*0.210 mm	*0.210 mm
Depth of Field (Range 0)	*2.33 mm	*2.33 mm

*Measured on serial number 1947-0281-60 by Dennis Afseth on December 5, 2007 in Riyadh.

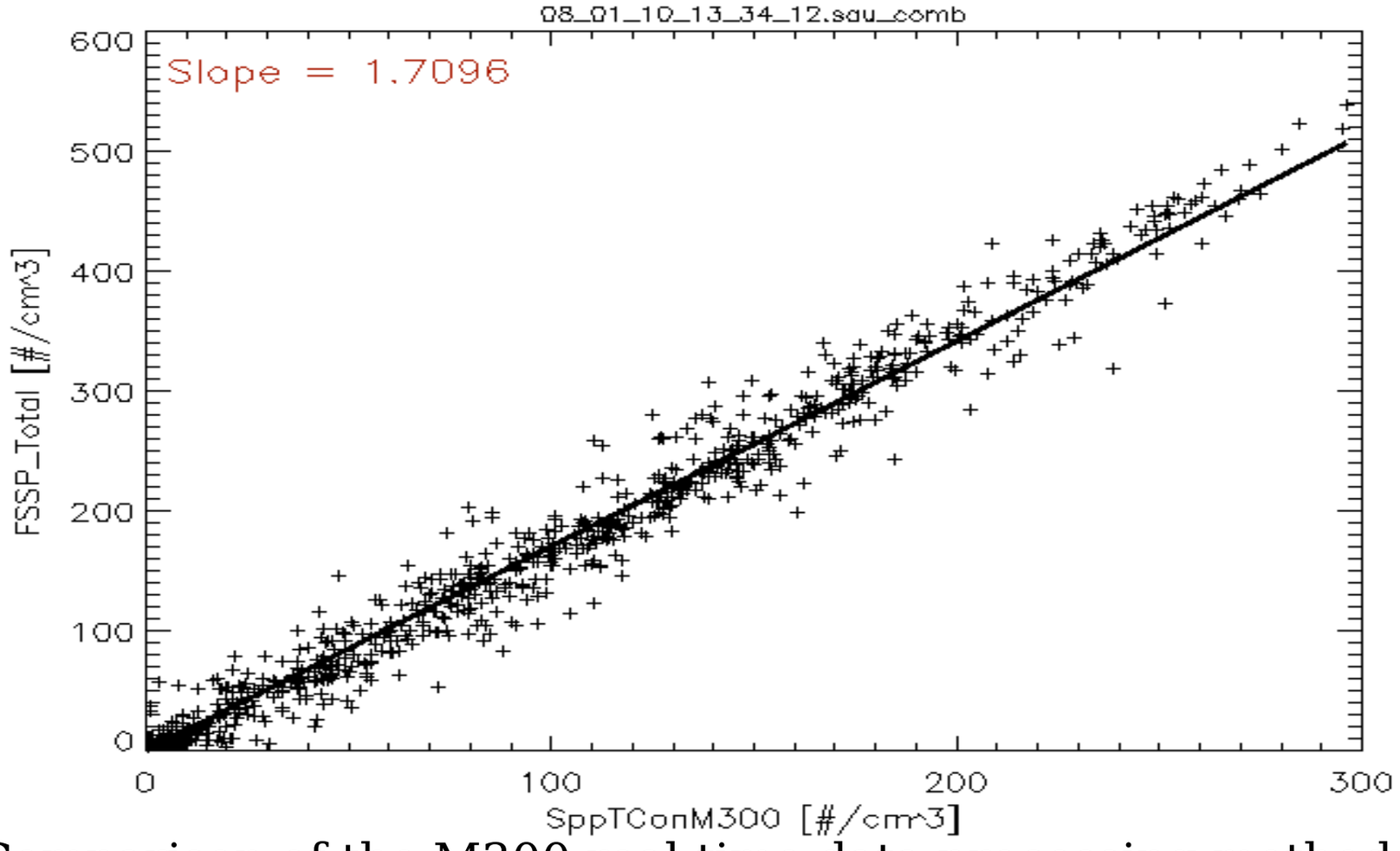
FSSP Total Droplet Concentration



Is this reasonable?

Comparison of the M300 real-time data processing method (x-axis) and UND post-processing method. All 1 Hz average data from the second flight on January 10, 2008 are used for this comparison.

FSSP Total Droplet Concentration



Is this reasonable?

Comparison of the M300 real-time data processing method (x-axis) and UND post-processing method after fixing bead fraction problem. All 1 Hz average data from the second flight on January 10, 2008 are used for this comparison. Include Beam Fraction correction but not coincidence and dead time corrections.

Limitations of the M300 as a Scientific Data Processing System

- The M300 does not have a robust Software Development Environment.
  - The formula table is a difficult and time consuming programming environment.
  - Proprietary Development Environment
  - Limited ability to test software.
- The M300 is not a modular data processing environment.
- Limited to only current and past values.
- Closed source code.
- Difficult to automate data reprocessing.

Conclusions

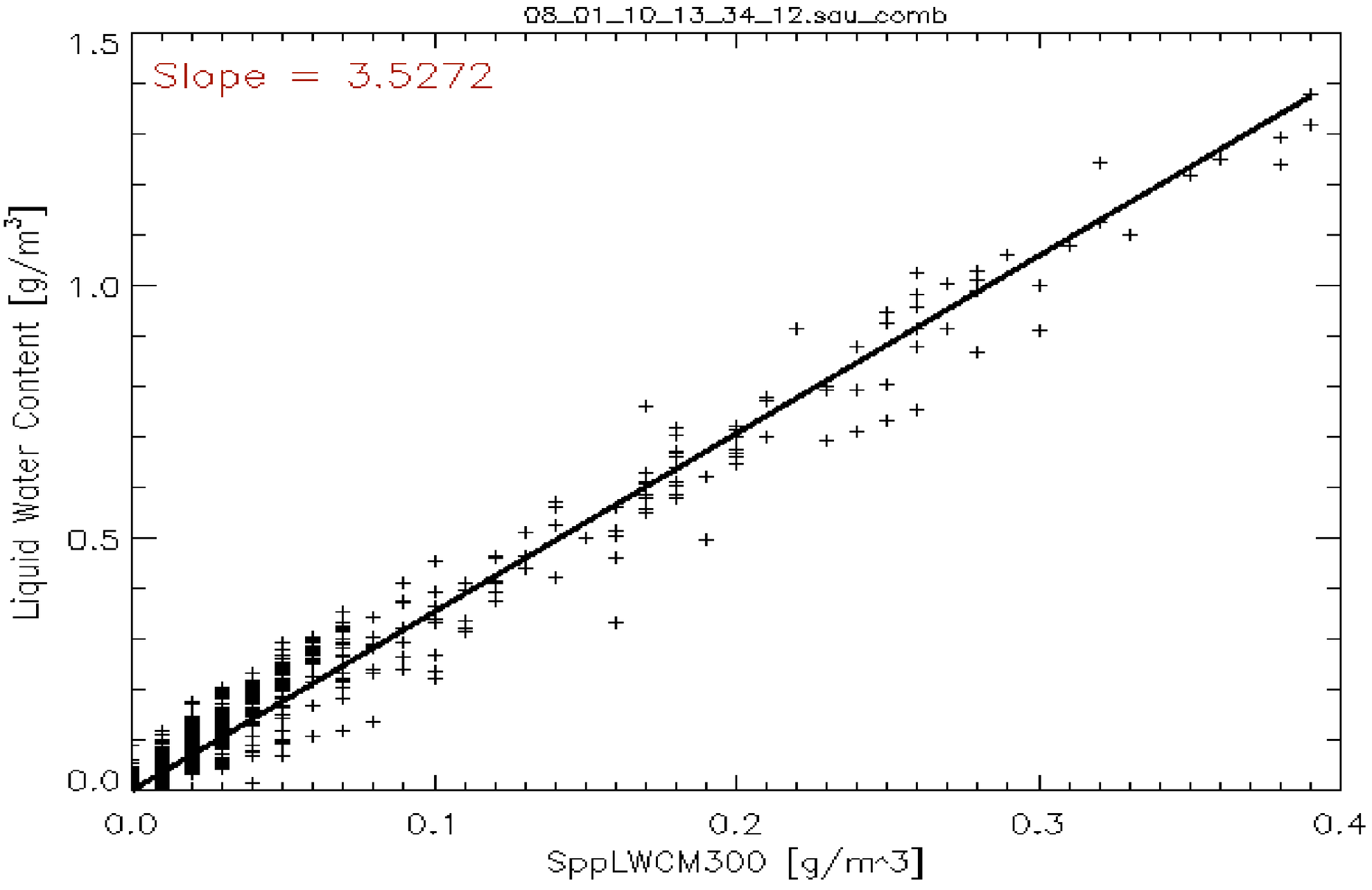
- The M300 is a very good data acquisition system, but not a very good data processing system.
- The “real time” and “post processing” methods disagree and this disagreement needs to be resolved.
- Well calibrated instruments and validated software is critical for the scientific evaluation of measurements.

Future Work (Assignment)

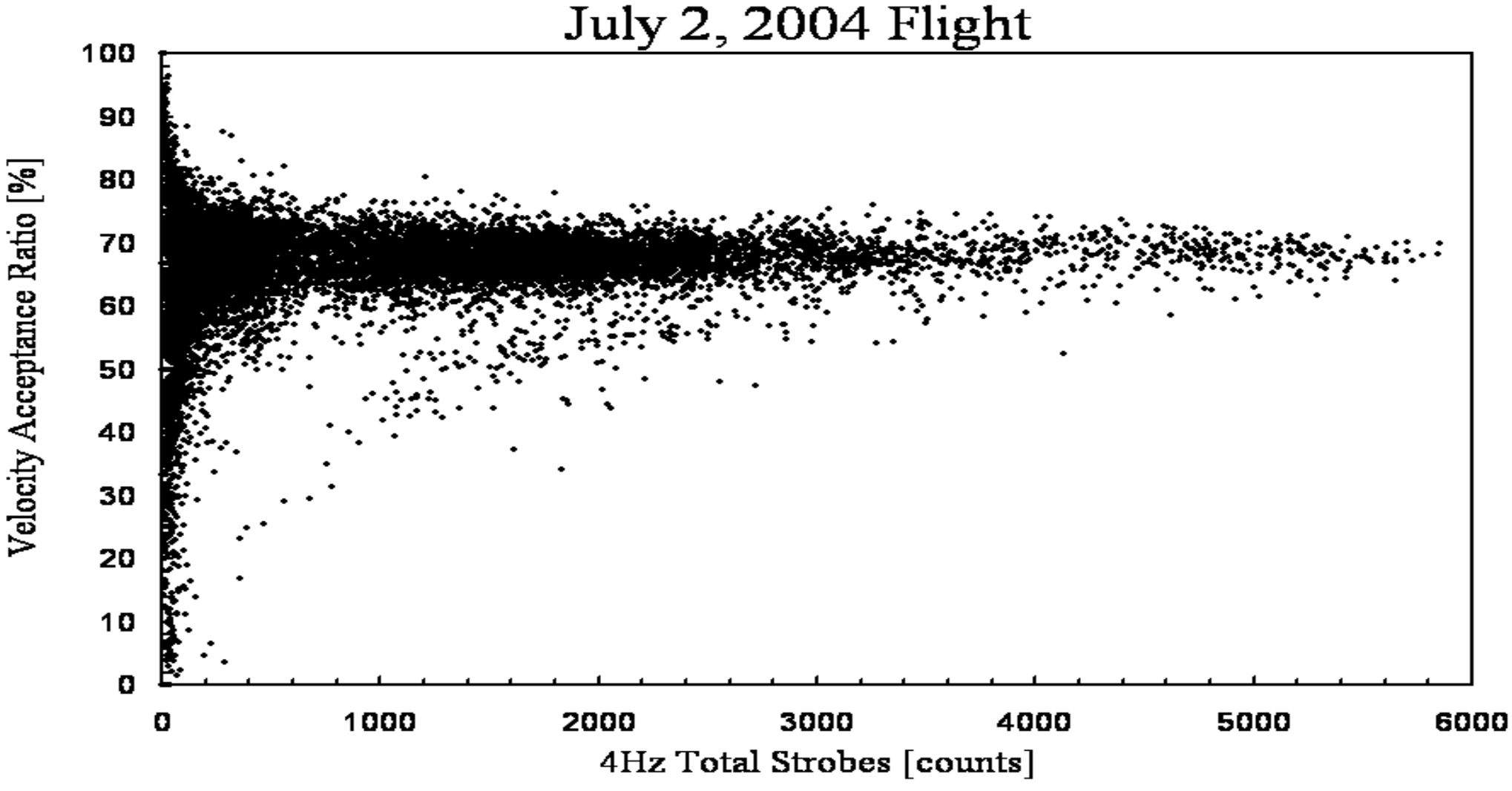
- Use the information presented in this presentation, the M300 real-time ASCII data files (08_01_10_13_34_12.m300.raw and 08_01_10_13_34_12.probes.raw), the post-processing ASCII data files (08_01_10_13_34_12.sau_comb and 08_01_10_13_34_12.conc.spp_fssp.1Hz 08_01_10_13_34_12.conc.spp_fssp.raw).
- Present results on March 23, 2008 at 1:00 p.m.
  - Mark it on the calendar, “Cloud Liquid Water Measurements”

Any Questions?

Cloud Liquid Water Comparison



FSSP Velocity Acceptance Ratio



The velocity acceptance ratio is based on the ratio of total FSSP counts to total FSSP strobes. Dye and Baumgarnder [1984] state that the theoretical velocity acceptance ratio is 62%.

Liquid Water Content Calculation

The ¶amount of liquid water for a given volume of air may be determined through mass integration of the cloud droplet distribution.

$$LWC = (\frac{\P}{6}) \rho_w \sum_{i=1}^{m} N_i d_i^3$$

ρ_w – Density of Water

N_i – Concentration of droplets in size channel i

d_i – Droplet diameter in size channel i

m – Total number of channels