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Fiber Skew

Observations for MM GI 62.5 Ribbons and Ribboncables

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Presented

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by

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- Background
- Market Situation, Supply for Low-Skew Ribbons and Cables
- Different Skew Measurement Methods
- Observations using the different Methods
- Skew Results at different Length cut from one Object
- Skew Results for different Samples, Discussion of Reasons
- Summary and Conclusion

## Task

12-fiber ribbons and multifiber ribboncables GI 62.5  $\mu\text{m}$   
with skew < 1 ps/m had to be found, selected and tested  
for application in Parallel Optical Links

## Goals

To check

- fibers, ribbon- and cable-designs suitable for low-skew
- (more than one) supplier(s) as stable and uniform source(s)

To establish

- a reliable skew measurement method which is potentially applicable for routine skew testing i.e. incoming inspection

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### Fiber Skew

#### Market Situation for MM GI 62.5 Ribbons and Ribboncables

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Several suppliers are dealing with 12-fiber GI 62.5  $\mu\text{m}$  ribbons

Some of them are dealing with (more or less) high fibercount ribboncables with different designs also

Some of them are talking about „low skew“ (but on basis of cable lengths of several 100 meters up to 1 km, not for < 100 m length)

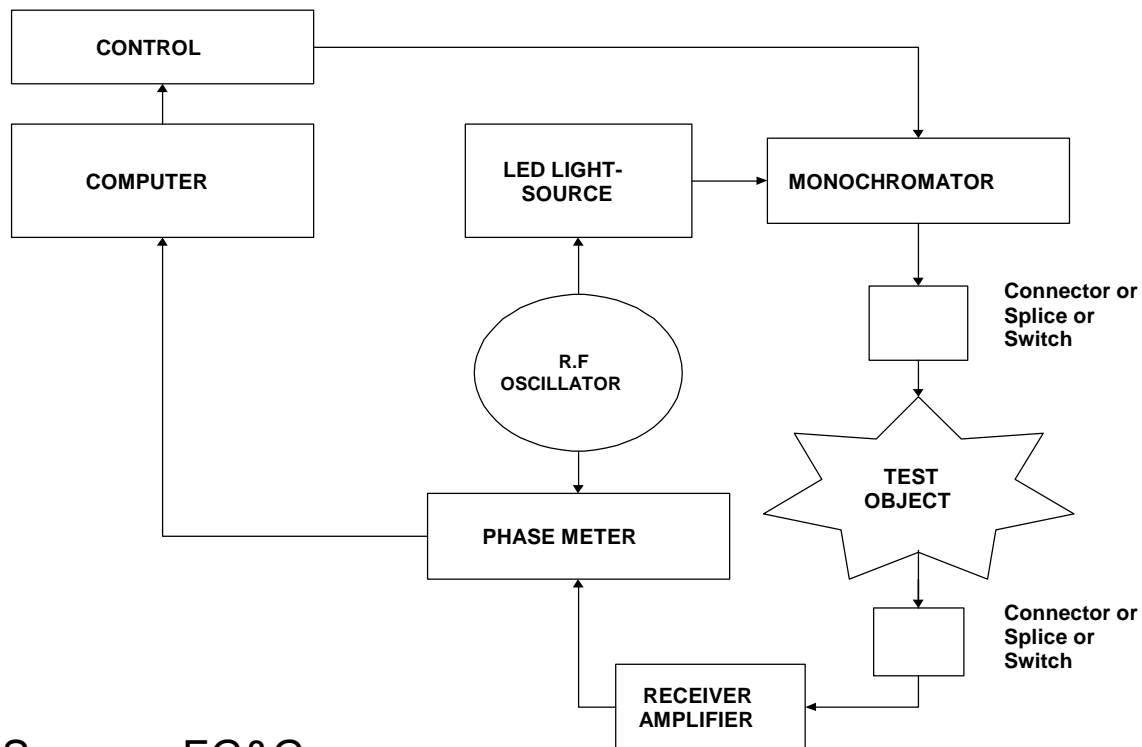
But **really Low-Skew** i.e. skew < 1 ps/m **is not a standard**

typically a little better than 2 ps/m is the baseline for today's best standard available selected skew quality at jacketed ribboncable level and length of several 100 meters

## Fiber Skew

### Measurement Setup for Quadrature Phase Shift Method

Based on CD300/SPL300 from EG&G skew is measured by suitable analysis of phase shift of a sinusoidal modulated cw-signal



Sources: EG&G

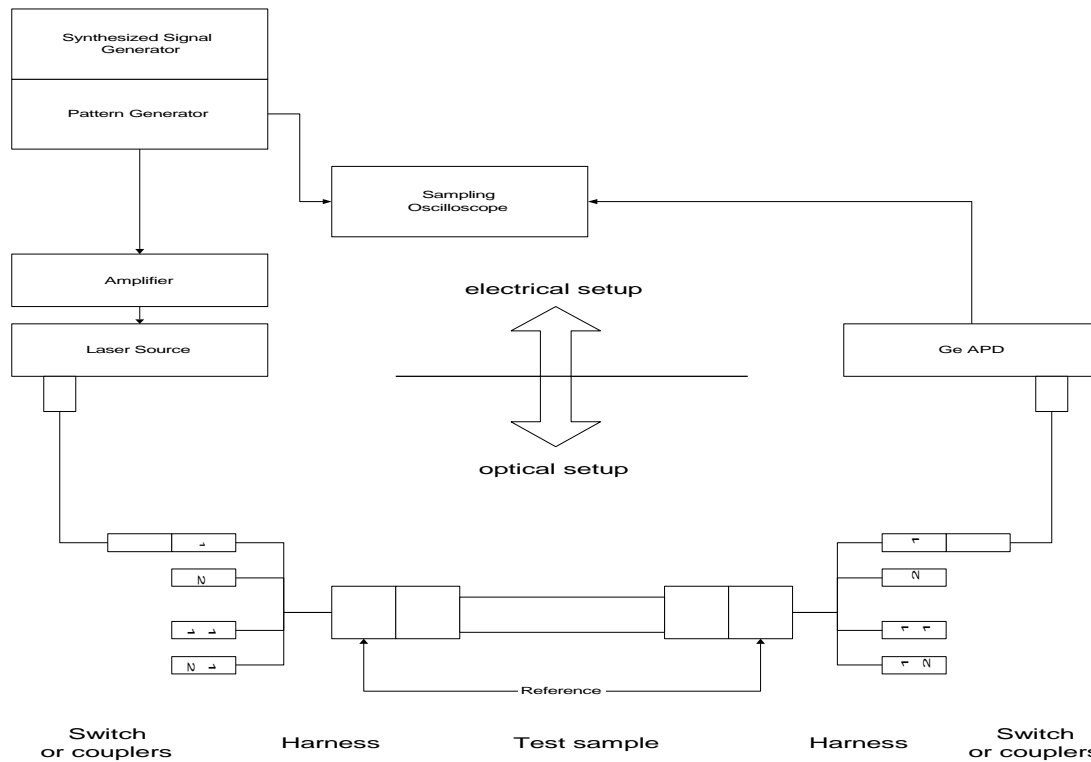
Prod. Description SPL300 / Application Note AN-010 / priv.comm. Dr.Barlow

# Fiber Skew

## Measurement Setup for Pulse Time of Flight (TOF) Method

Siemens Skew Measurement

Beier, 98-02-19



1. Reference
2. Measuring of Test sample
3. Calculating skew

$$t_n = t_{0n} - t_{01} \quad (\text{ps}) \quad (\text{ps})$$

$$T_n = t_n - t_1 = (t_n - t_{0n}) / \text{length} \quad (\text{ps/m})$$

$$\text{Skew} = T_{n \max} - T_{n \min} \quad (\text{ps/m})$$

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Effect of Wavelength and Launch Conditions (1a)

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Example 1

- 1 sample of 350 m length of a bare fiber-ribbon measured by
- (1) supplier with Phase Method at 1300 nm with SM launch
  - (2) Siemens with TOF Method at 850 nm with MM 62.5 launch

Result (see attached diagram):

- skew value measured with method (2) is roughly 0.2 ps/m higher i.e. worse than value measured with method (1)
- both curves show nearly identical shapes

**P Question: Which method creates „true“ values ?**

or

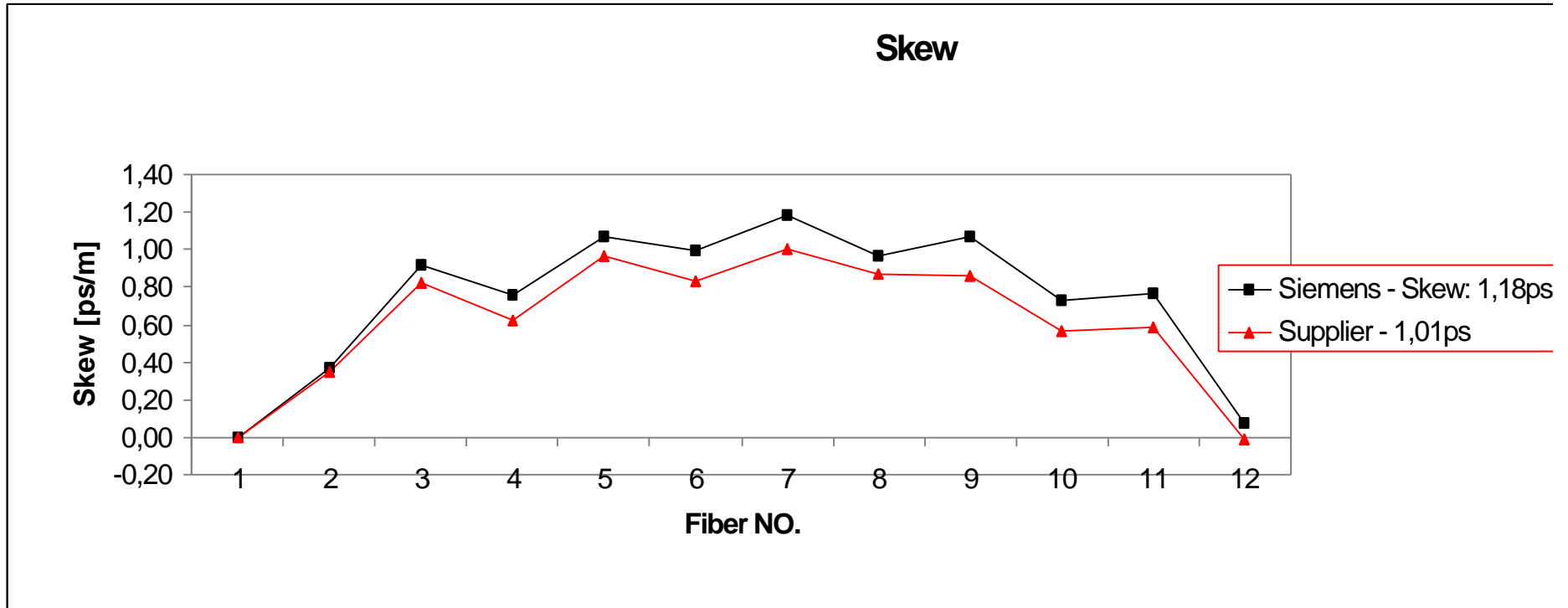
which values are useful to predict good system aptitude

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### Effect of Wavelength and Launch Conditions (1b)

Comparison of results from method (1, red) and (2, black)



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### Fiber Skew

#### Effect of Wavelength and Launch Conditions (2a)

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#### Example 2

Identical fiber-ribbons measured in a 24x12 fibers 110m DJ\* cable by

(1) supplier with Phase Method at 1300 nm with SM launch

(2) Siemens with TOF Method at 850 nm with MM 62.5 launch

#### Remark:

All bare ribbons had  $< 1$  ps/m at  $\sim$  750m before jacketing, cutting and cabling

#### Result (see attached diagram):

- skew value distribution measured with (2) is shifted by 0.3 ps/m towards worse side compared to distribution measured with (1)
- further tests in a complete link confirmed the results from (2)

#### Conclusion:

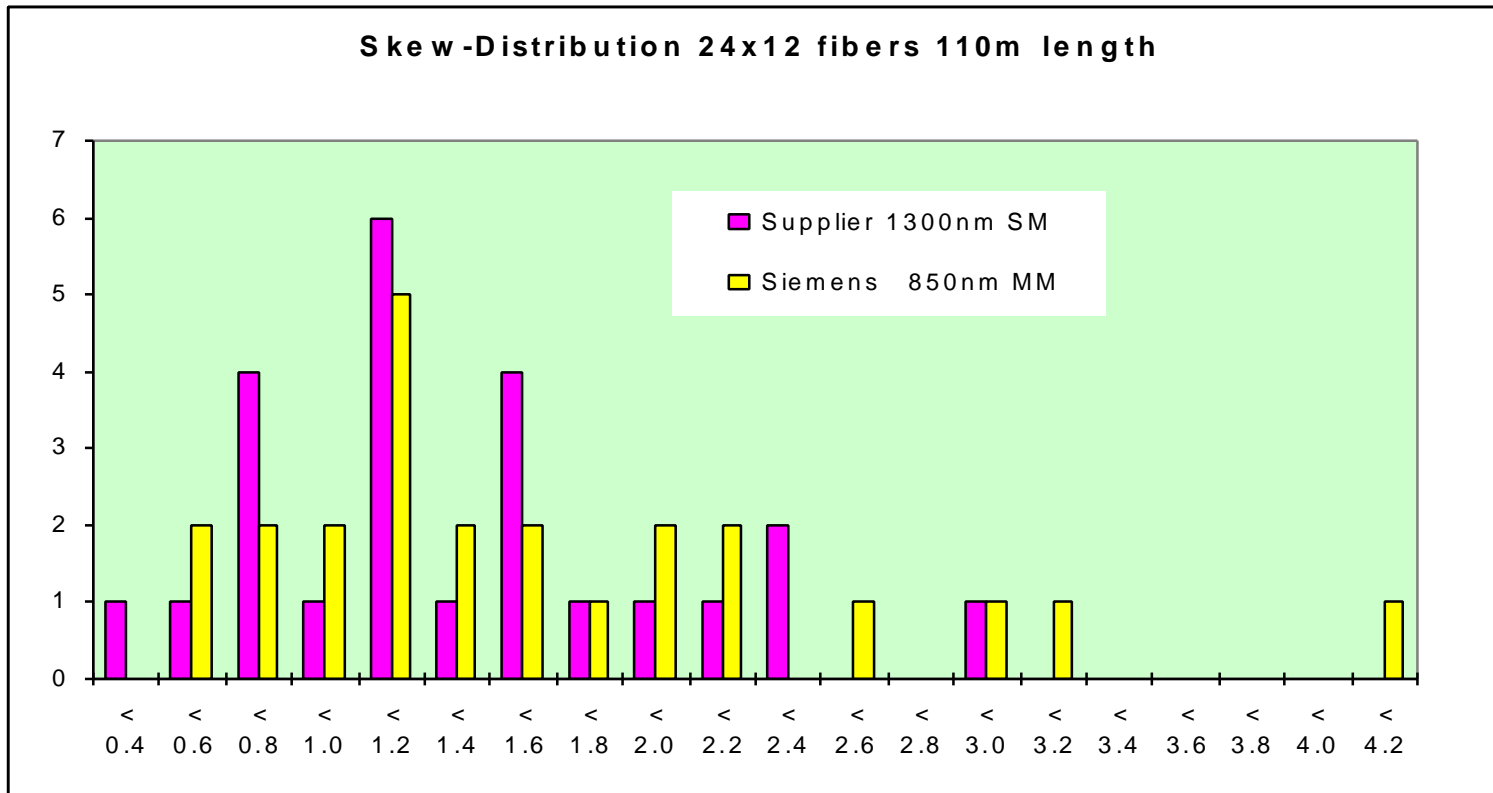
There might come up a hot discours between supplier and customer about the correct method to measure „true“ skew

\*) direct jacket design i.e. no loose tube design etc.

**Fiber Skew**

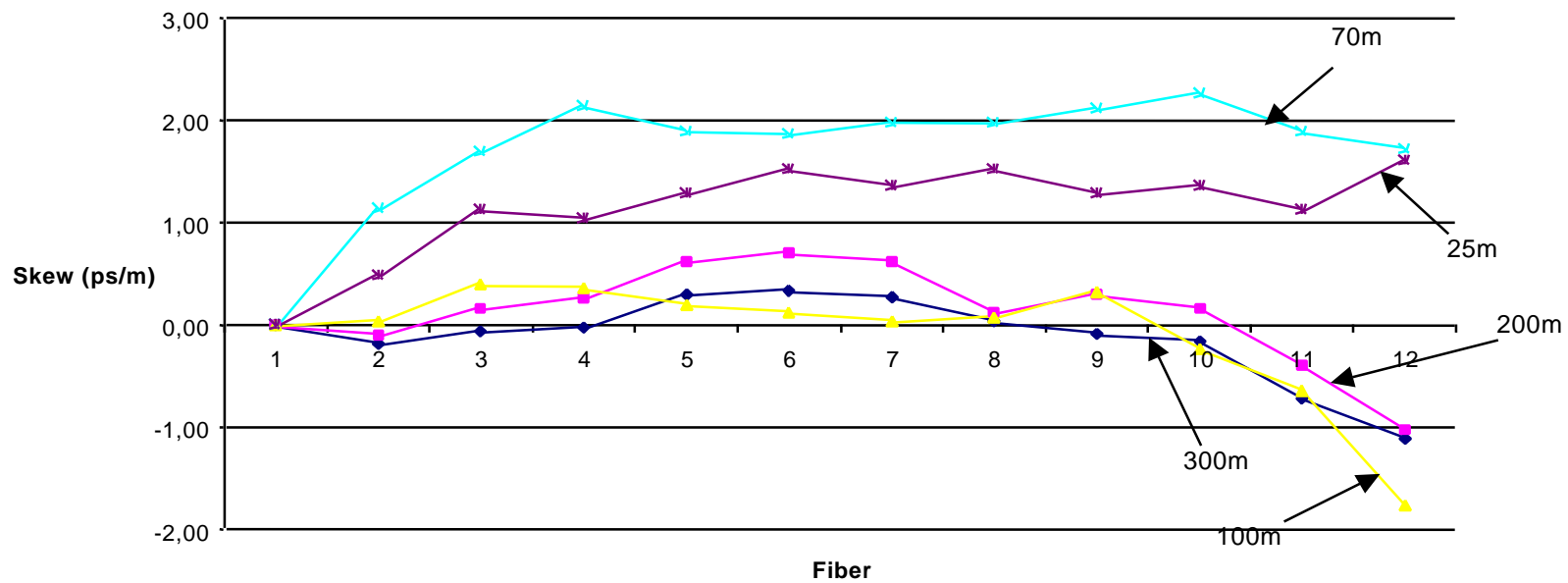
**Effect of Wavelength and Launch Conditions (2b)**

Comparison of distribution of skew-results from method (1) and (2)



# Fiber Skew Effect of Sample Length

Different lengths of pieces cut from same sample measured with method (2)



Tendency: As longer sample-length as less (sometimes) the skew probably due to „balancing“ effects at longer length ?

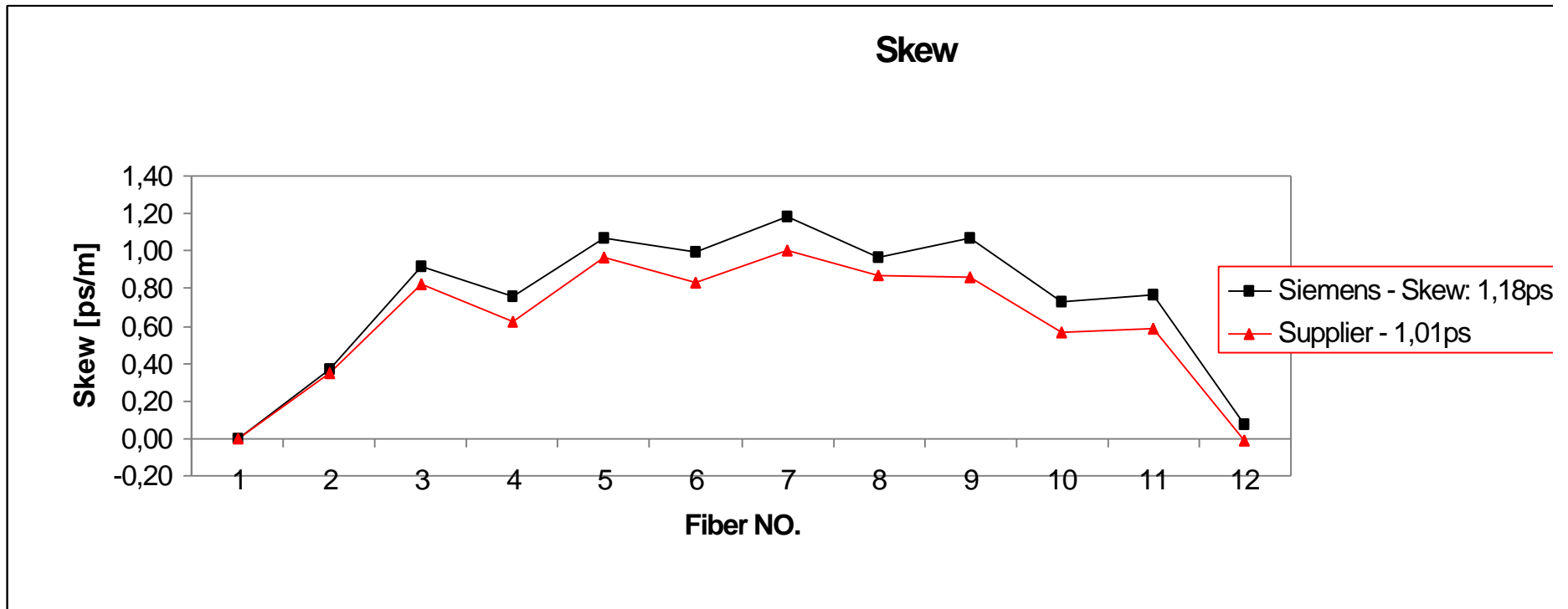
**Short pieces of a long LS cable might have high(er) skew !**

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## Fiber Skew

### Observations for MM GI 62.5 Ribbon cables

Typical result for Acrylate-Matrix coated blank ribbon > „bathtub“-shape



Probable reason:

Higher stress to outer fibers than to inner ones

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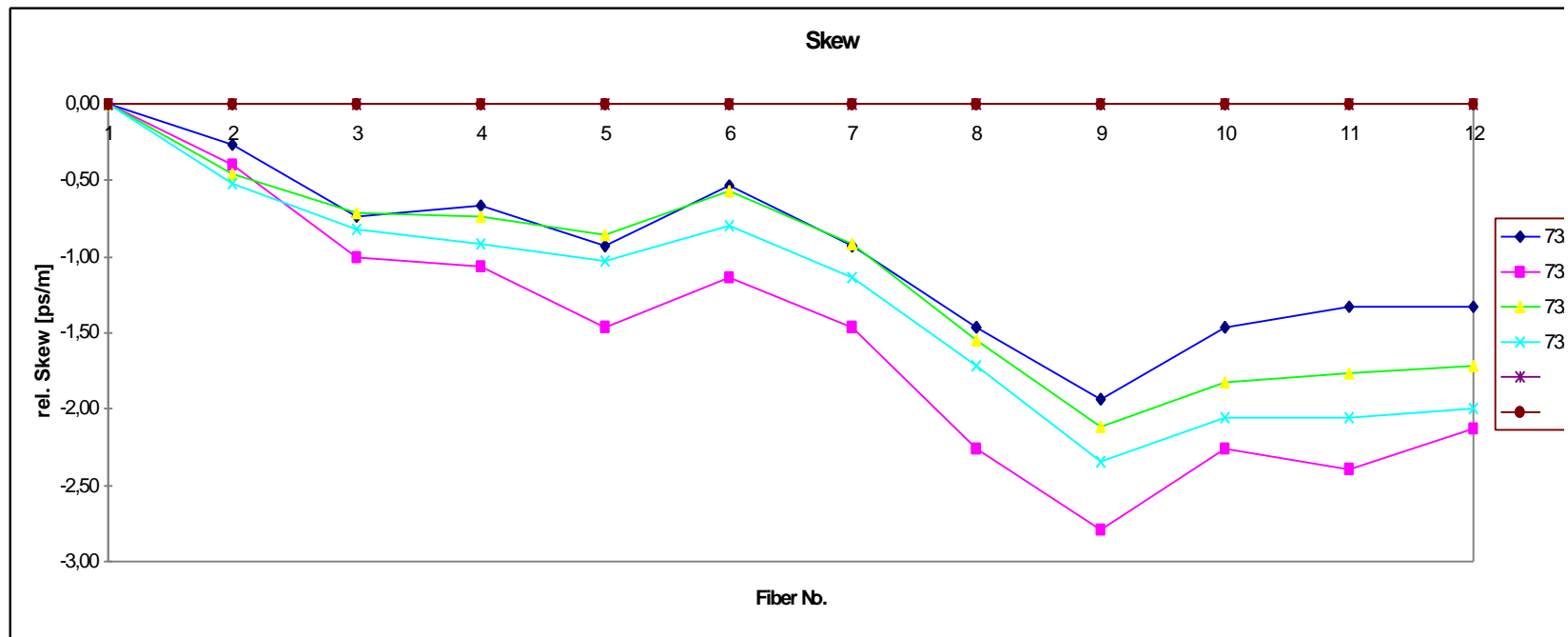


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# Fiber Skew

## Observations for MM GI 62.5 Ribboncables

Results for 30m Acrylate-Matrix coated blank ribbons, spooled and coiled

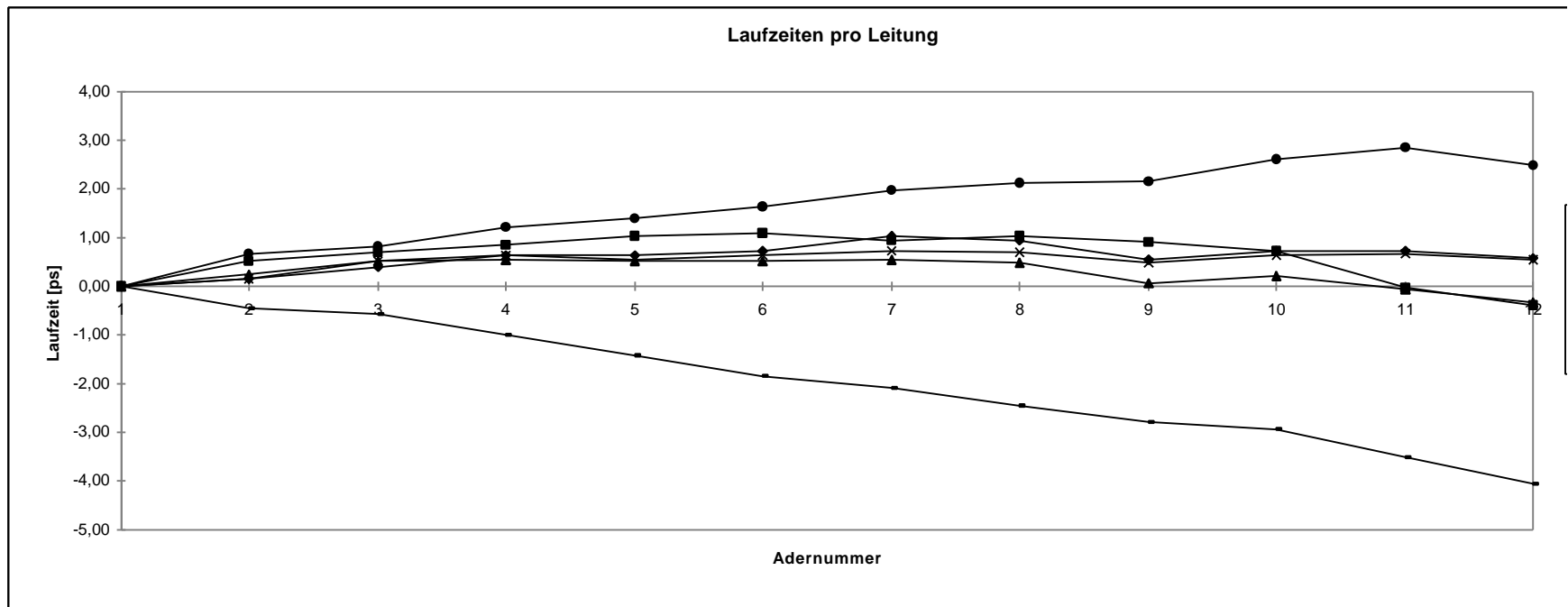


Probable reason:  
Soft change of outside mechanical stress

# Fiber Skew

## Observations for MM GI 62.5 Ribboncables

Results for Acrylate-Matrix coated and soft PVC jacketed ribbons



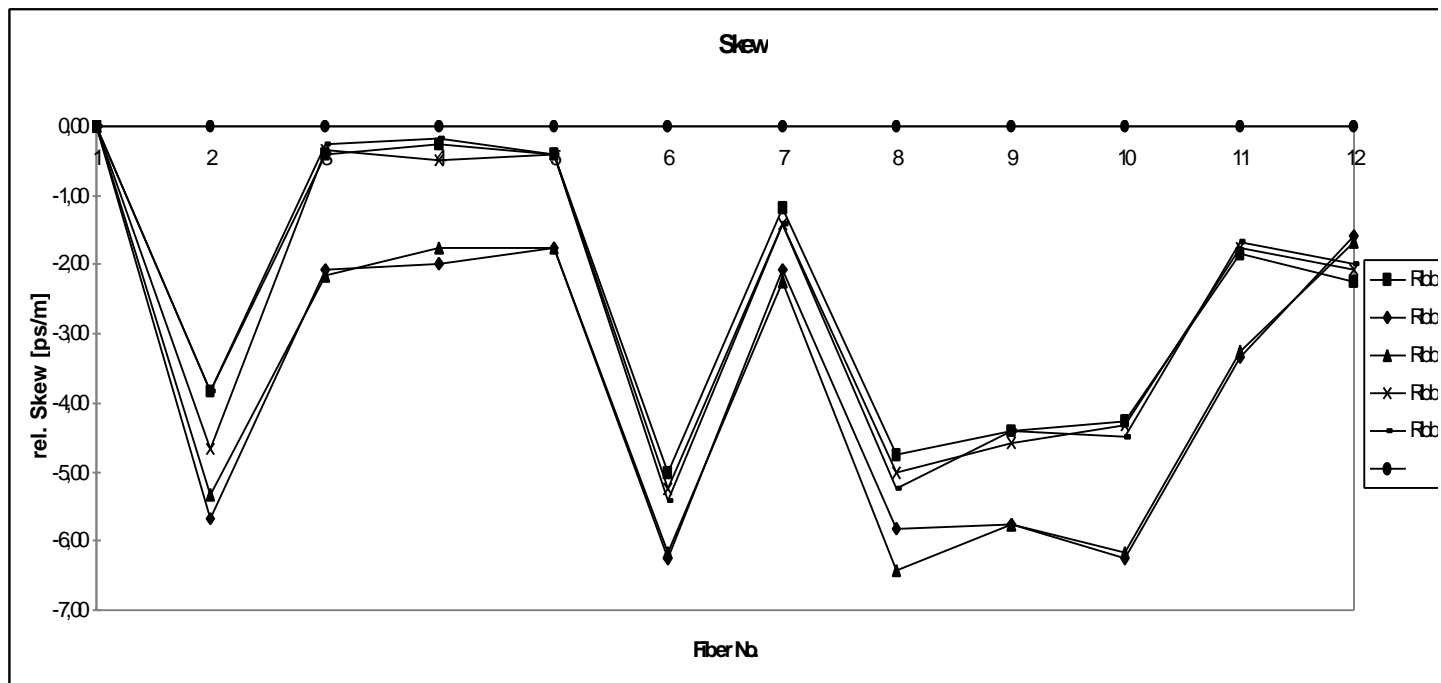
Probable reason:  
Asymmetric stress during jacketing process

# Fiber Skew

## Observations for MM GI 62.5 Ribboncables

Results for soft PTFE coated and PTFE-like jacketed ribbons

3 pieces of 50 m length from same sample, 2 of them remeasured reverse spooled

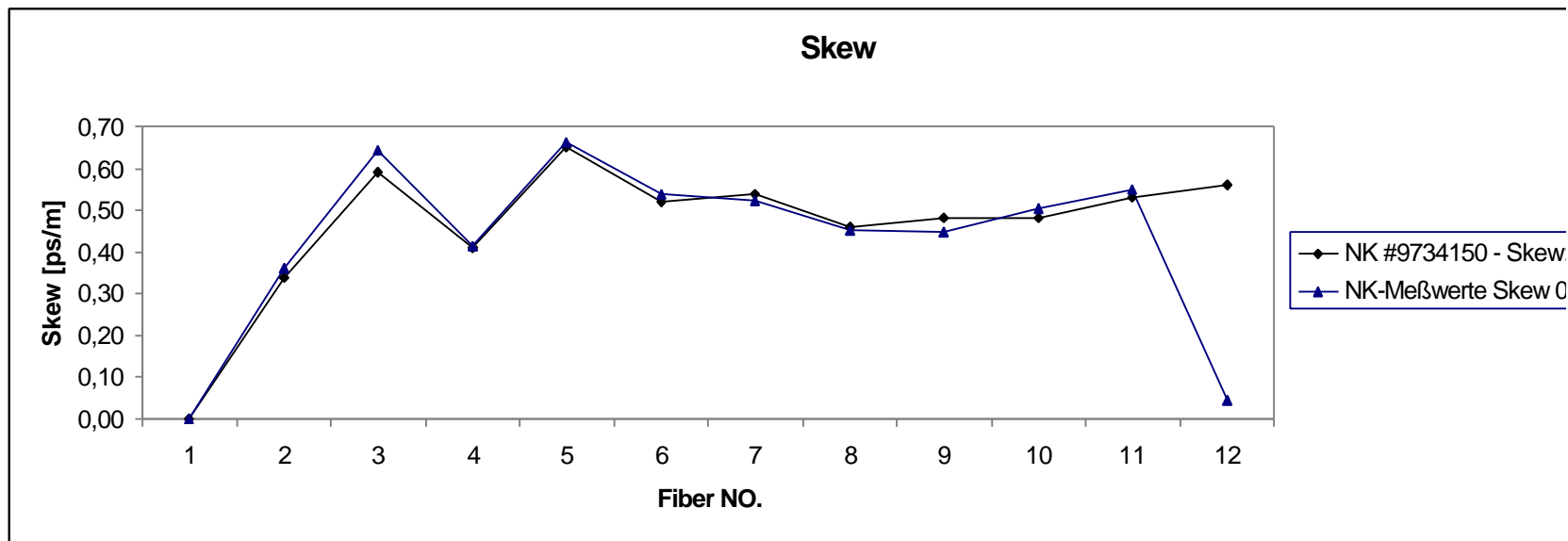


Probable reasons: Poor preform/fiber quality  
or fibers from different preforms respectively

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Observations for MM GI 62.5 Ribboncables

Result for a 640 m Acrylate coated and very soft PVC jacketed ribbon with additional side strands („Mickey-Mouse“-Design)



Note: „bathtub“-shape still visible, but total skew level is pretty low

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Summary 1 Skew Measurement

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Discrepancies between results of different skew measurement methods have been found and a

Correlation in tendency could be observed

but

Neither an exact value based on a big database for a systematic offset can be given so far

Nor a final decision about the „single only correct“ method measuring the „true skew“ can be made today

But nevertheless: Keep measurement boundary conditions as close as possible to the System/Link conditions to which the ribboncable is applied (in our case GI 62.5 at 850 nm) inclusive length and specify and agree the method with your supplier

A lot of different **parameters** in the complete **process chain** from fiber preform to complete cable potentially affect the skew

- fiber preform quality i.e. 3-dimensional physical uniformity
  - > *radial index profile and axial absolute index uniformity*
  - > *uniformity of group index > group propagation velocity*
- fiber drawing and coating process uniformity
  - > *intrinsic fiber stress > uniformity of group velocity*
- ribbonizing of fibers (all in one ribbon from one preform)
  - > *external radial and axial mechanical stress to fibers*
- cabling of ribbons
  - > *external stress to ribbons*

as well as

- nearly all individual **materials** and specific **designs**

Today low-skew ( $< 1$  ps/m) GI 62.5  $\mu\text{m}$  ribbons and ribboncables look like „*Sunny Summer Sunday Afternoon - Products*“

A lot of work remains to do in order to

- establish a reliable, cheap(er) and commonly agreed method for routine measurement of fiber-skew
- understand skew-affecting effects and their root causes
- stabilize output uniformity and yield for production of LS-ribbons
- find cable designs well suitable both for LS and installation
- drop effort (today still) needed for selection
- drop price

and finally to

**found a solid basis for the bright future of parallel optical links**