

EXPERIMENTAL OBSERVATIONS ON CHANNEL BIFURCATIONS EVOLVING TO AN EQUILIBRIUM STATE

Walter Bertoldi, Alessio Pasetto, Luca Zanoni, Marco Tubino

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AIM OF THE WORK

Experimental work with the aim to:

- describe the **equilibrium configuration** of a single bifurcation
 - ✓ in the simple case of fixed banks
 - ✓ and in self-formed channels with erodible banks
- individuate an intrinsic **temporal scale** of the bifurcation evolution

AIM OF THE WORK



Why are you studying this? Everyone knows that water splits half and half!



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BIFURCATIONS: WHY?

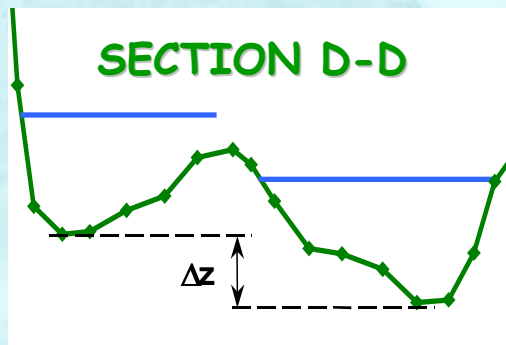
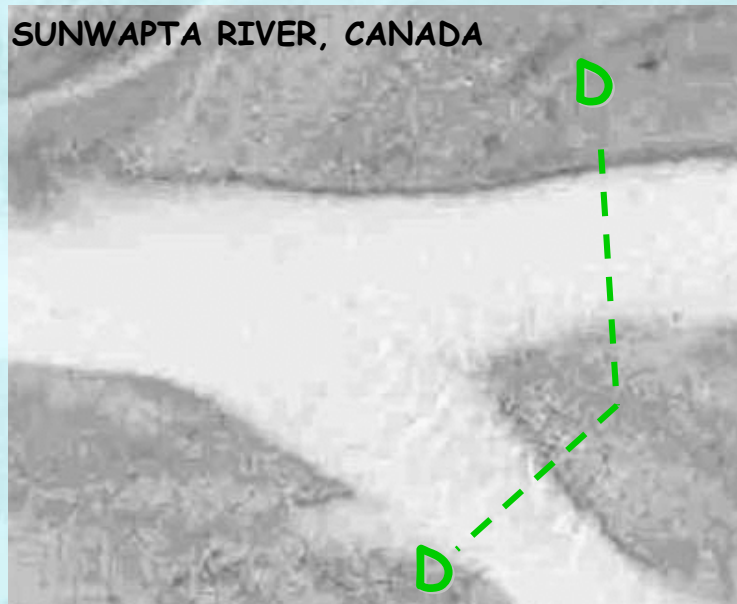


TAGLIAMENTO RIVER, ITALY

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BIFURCATIONS: WHY?



Bifurcations are often characterised by:
(see Zolezzi et al., 2005)

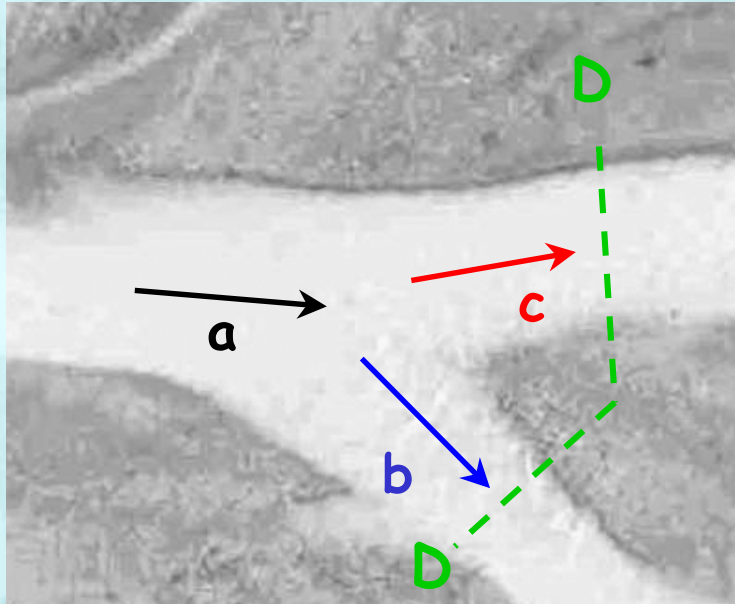
- ✓ **Unbalanced discharge distribution**
- ✓ **Unequal channel widths**
- ✓ **Difference in bed elevation at the inlets of downstream channels Δz**

the largest (one or two) channels carry more than 80% of total discharge (Mosley, 1983)

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DEFINITIONS



✓ DISCHARGE RATIO

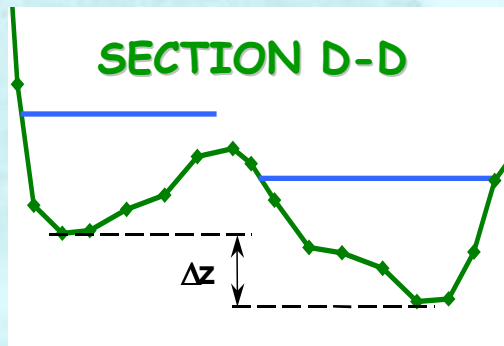
$$r_Q = Q_b/Q_c$$

✓ WIDTH RATIO

$$r_b = b_b/b_c$$

✓ INLET STEP

$$\Delta\eta = \Delta z/D_a$$



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LABORATORY EXPERIMENTS: π FLUME



Slope:

- 0.3% and 0.7%

Discharge:

- 0.5 to 6 litres/s

Grain size:

- $D_{50} = 0.63$ mm

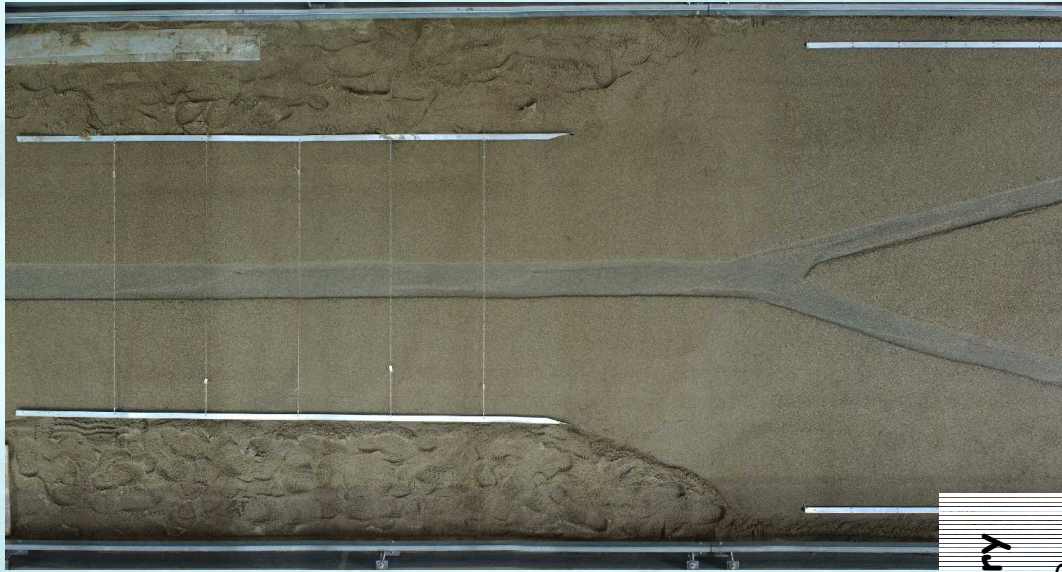
MEASUREMENTS

- Discharge distribution
- Bed topography

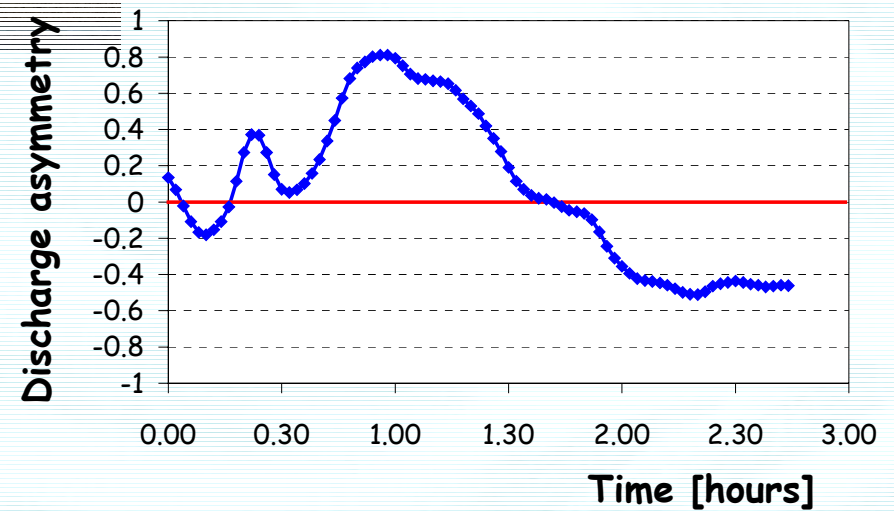
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BIFURCATION EVOLUTION



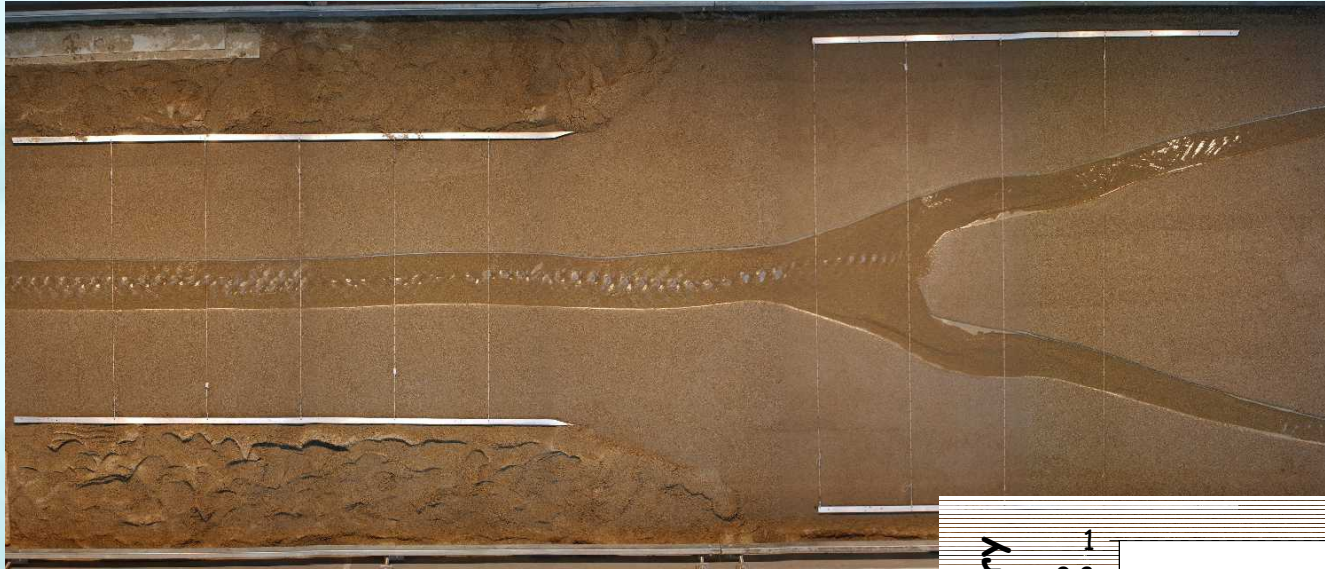
$$A_Q = \frac{Q_b - Q_c}{Q_b + Q_c}$$



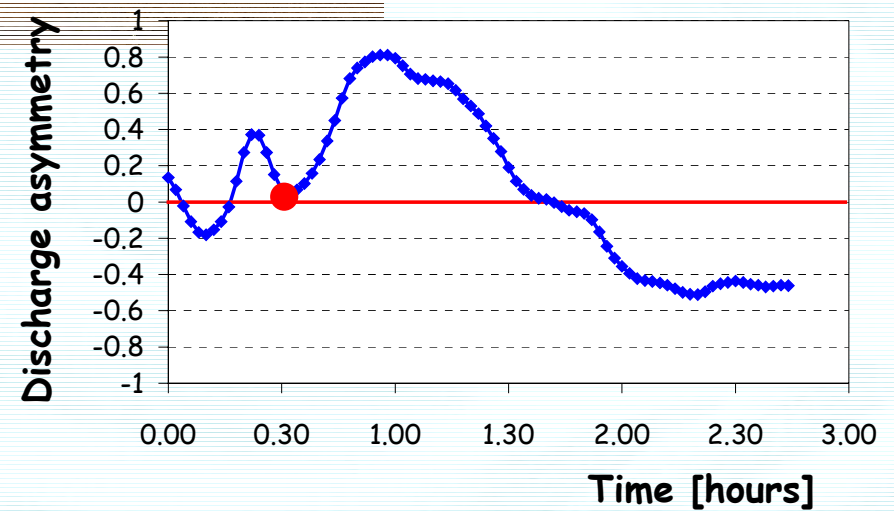
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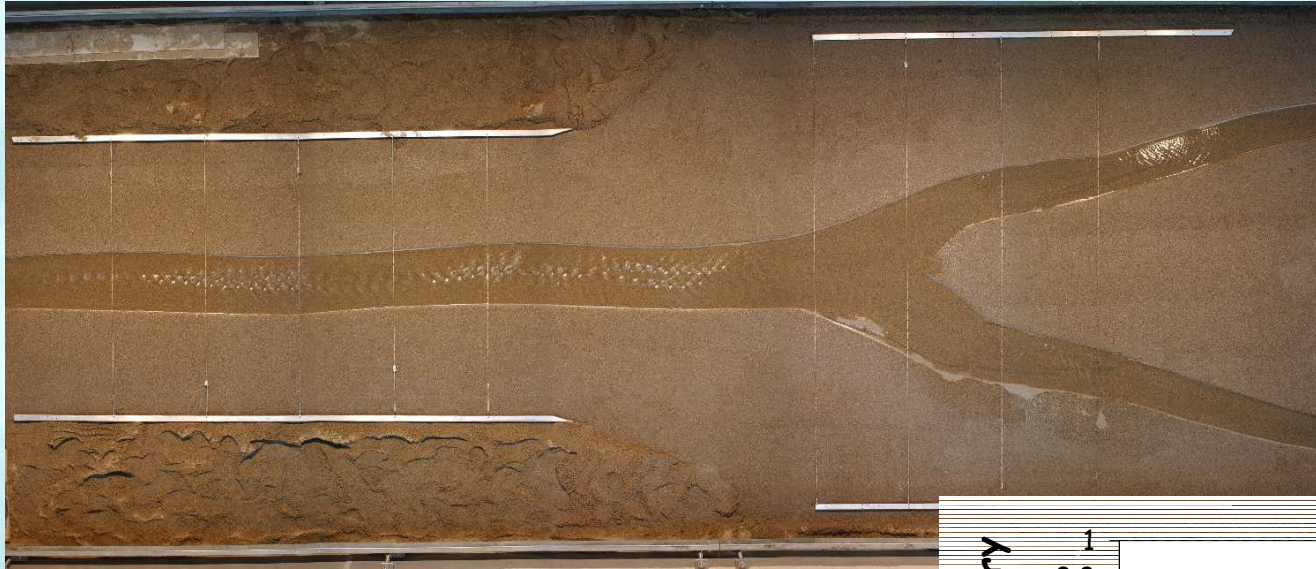
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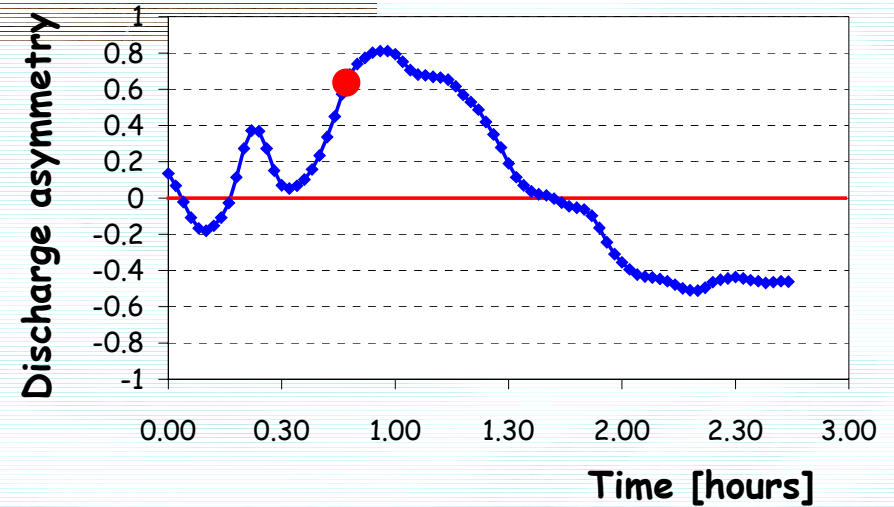
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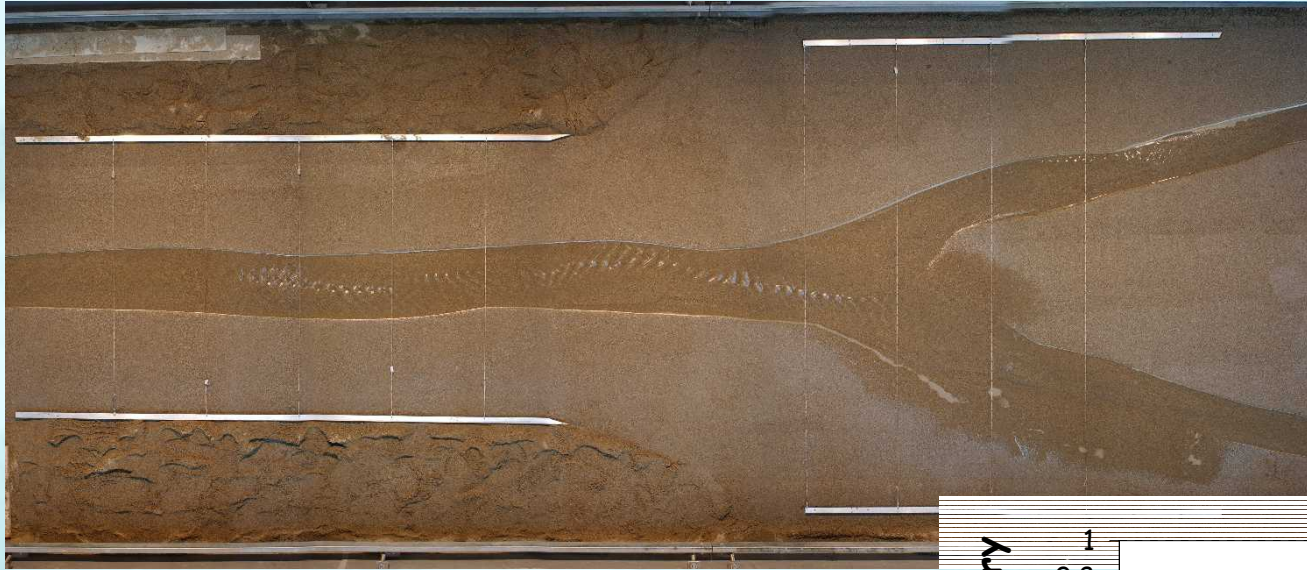
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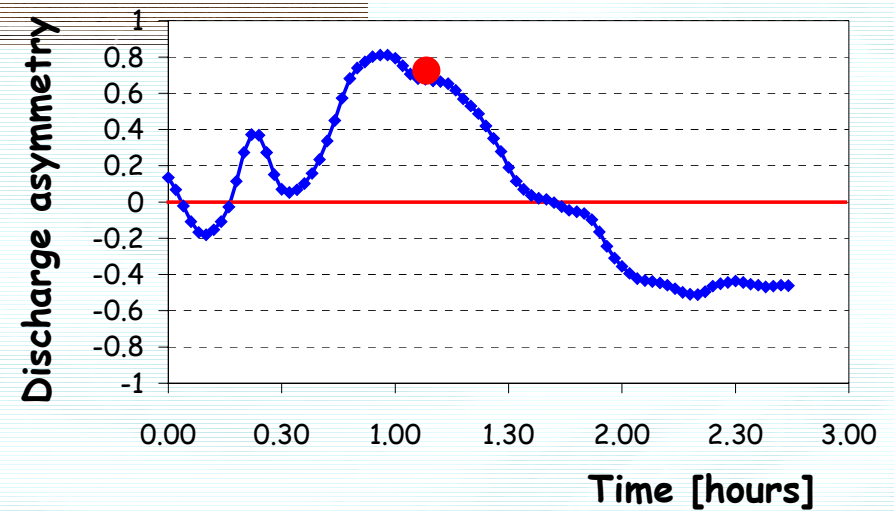
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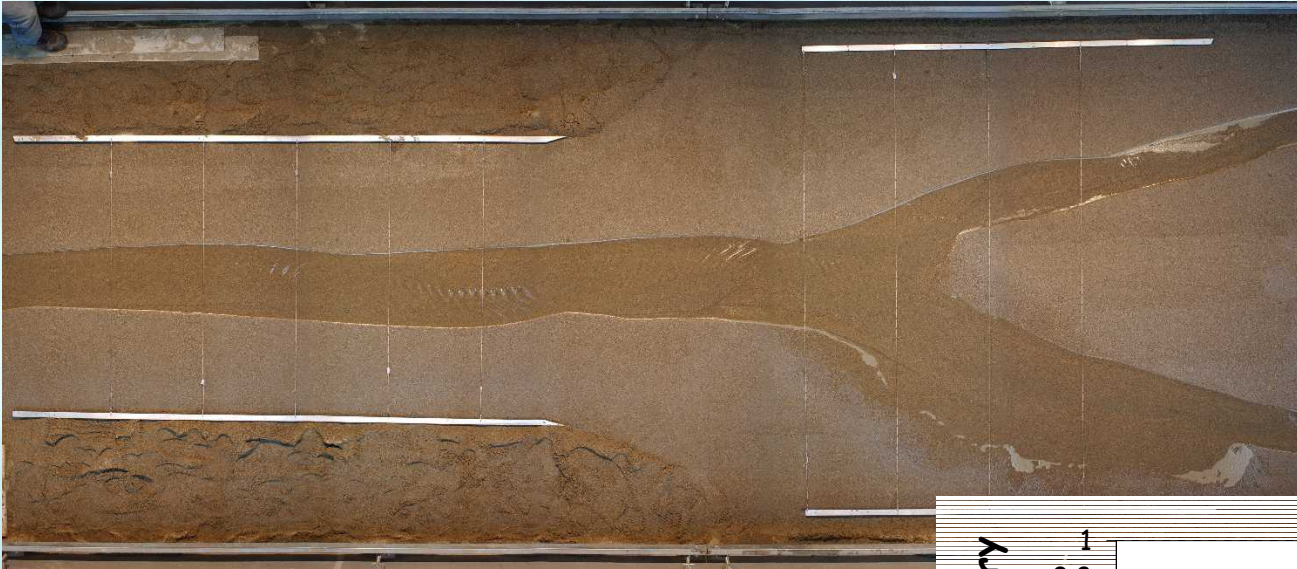
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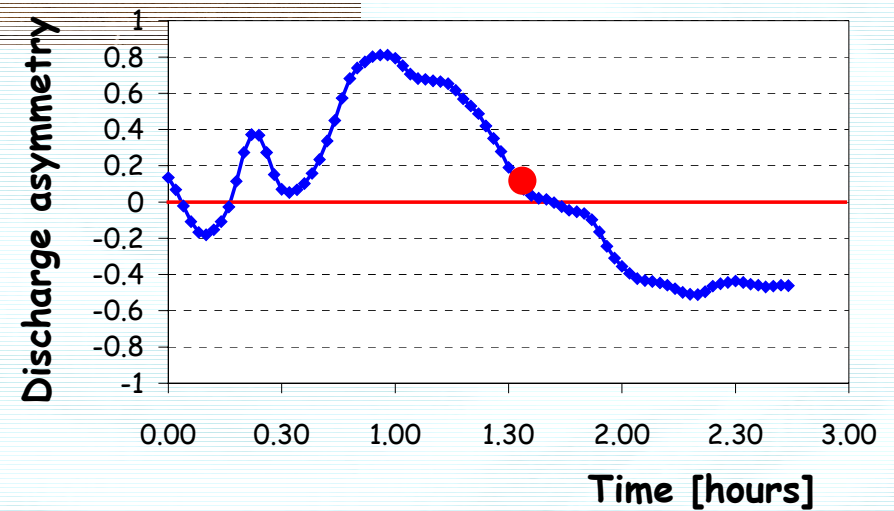
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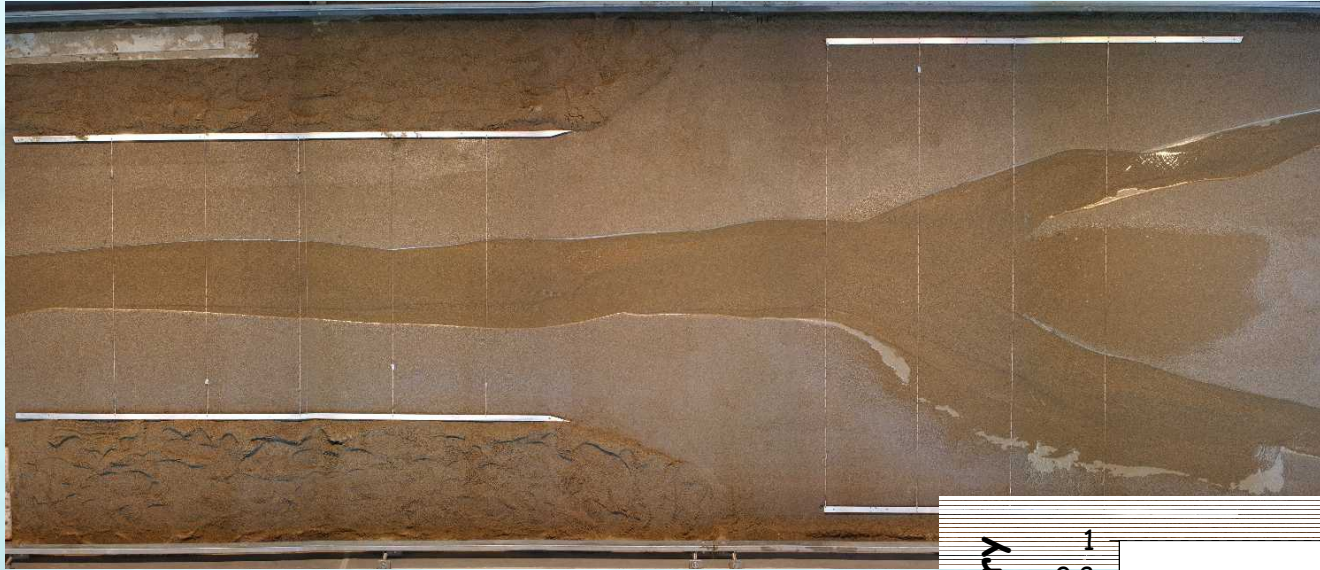
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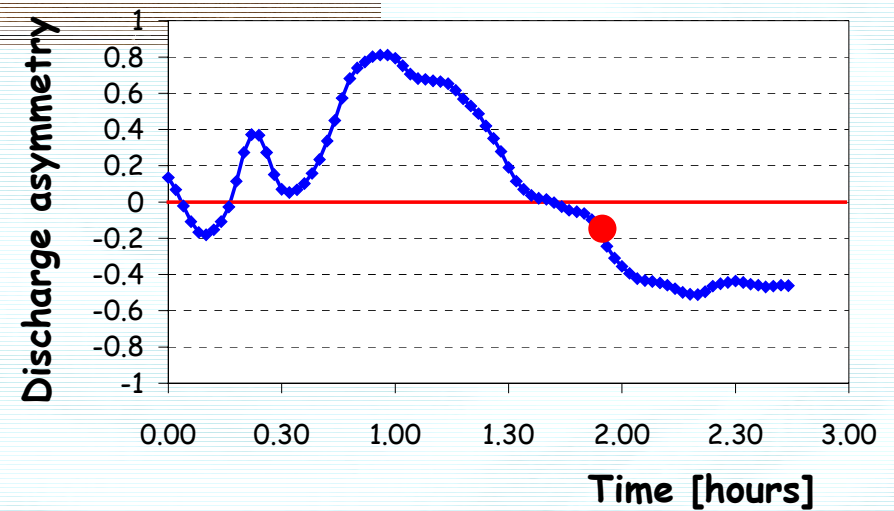
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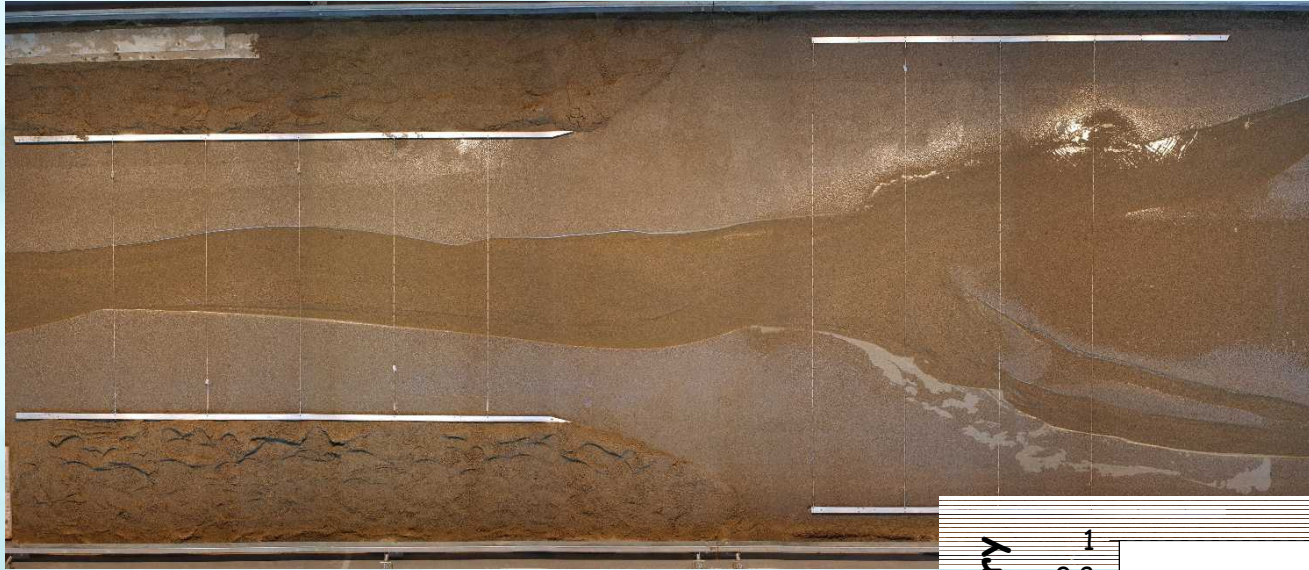
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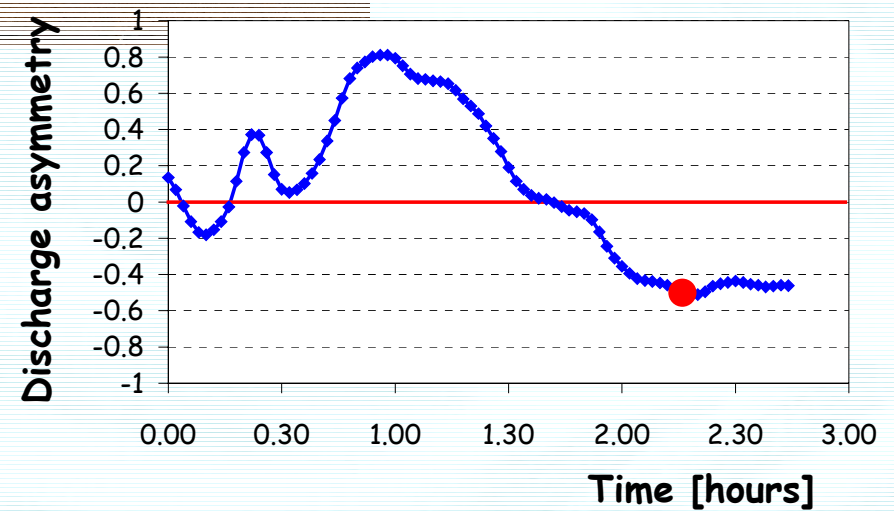
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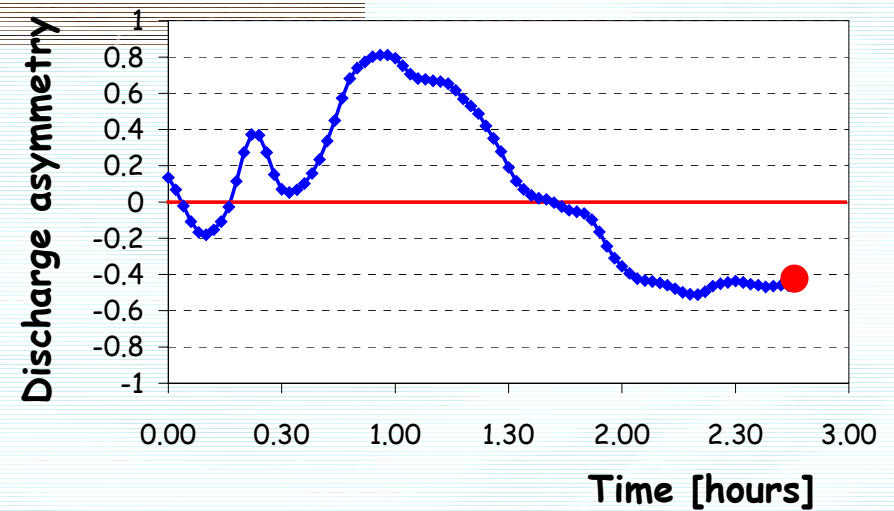
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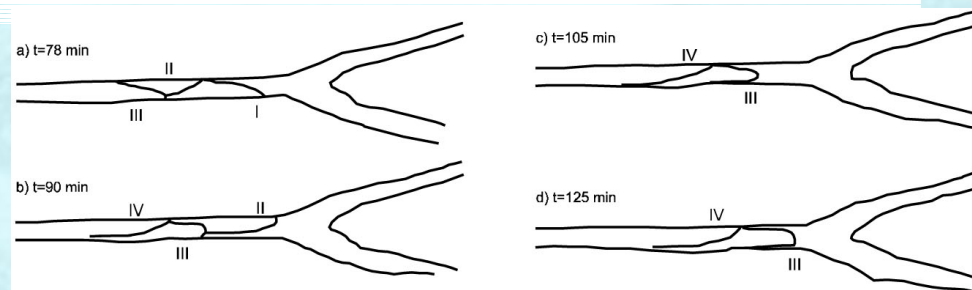
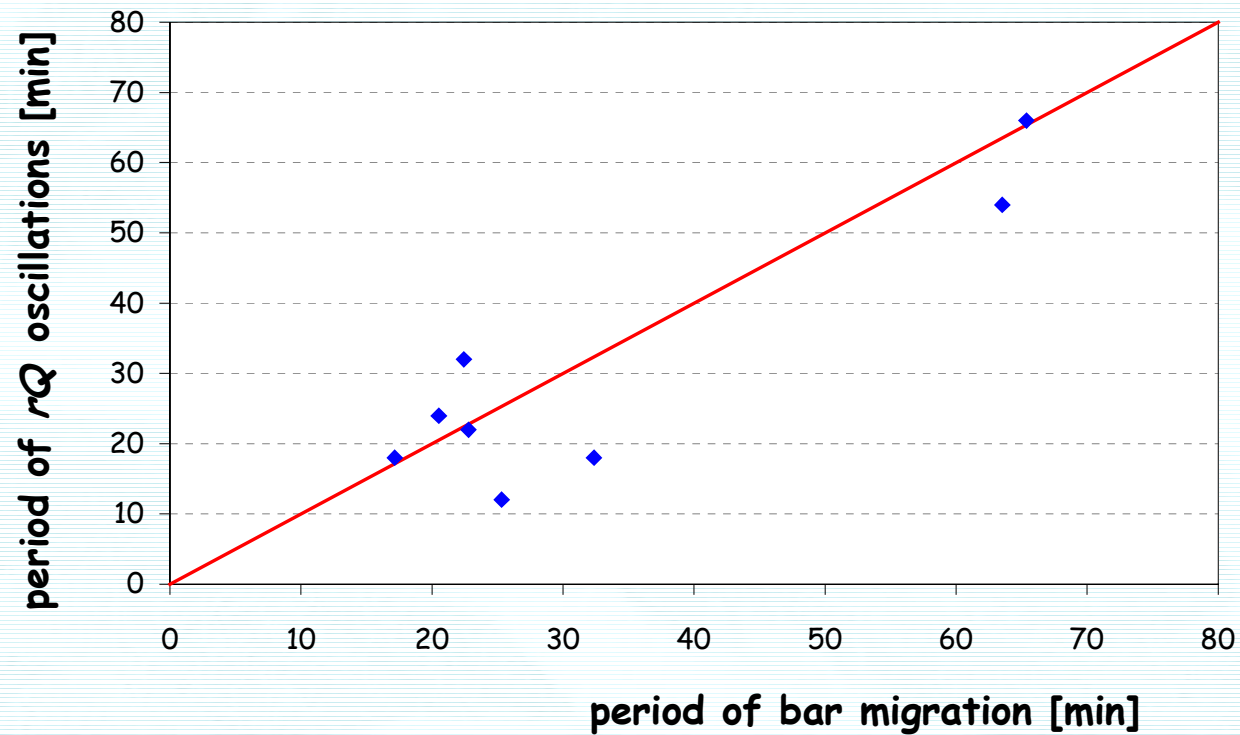
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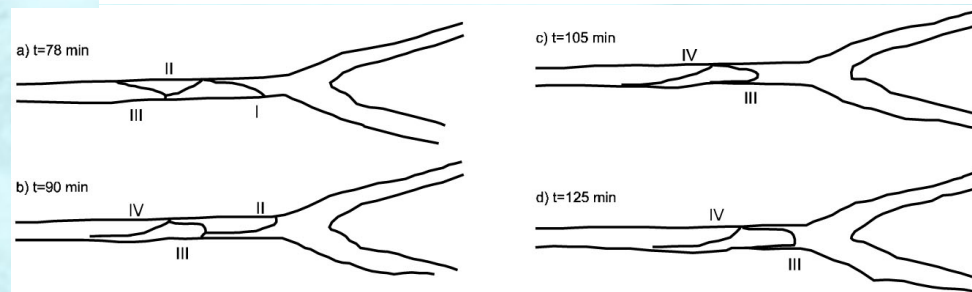
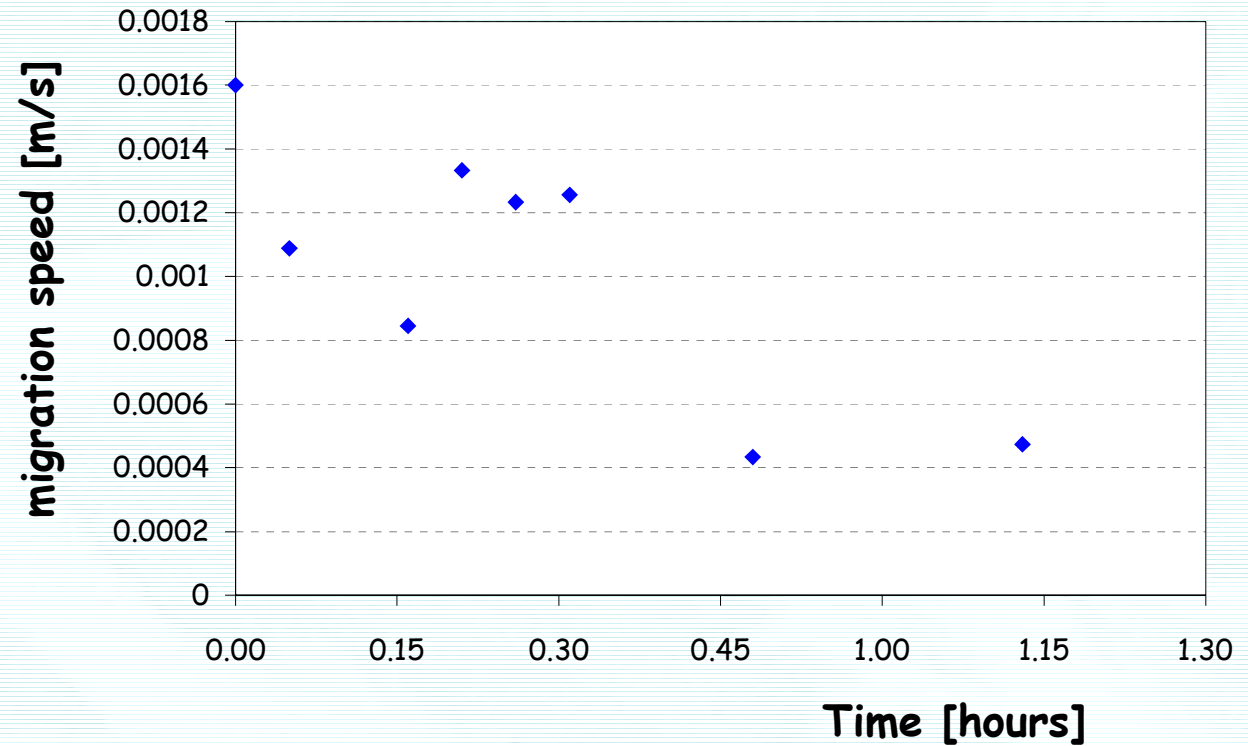
BIFURCATION \Leftrightarrow BARS



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BIFURCATION \Leftrightarrow BARS



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INTRINSIC RESPONSE OF A BIFURCATION

Focus on the morphodynamic response
of a single “**Y-shaped**” configuration

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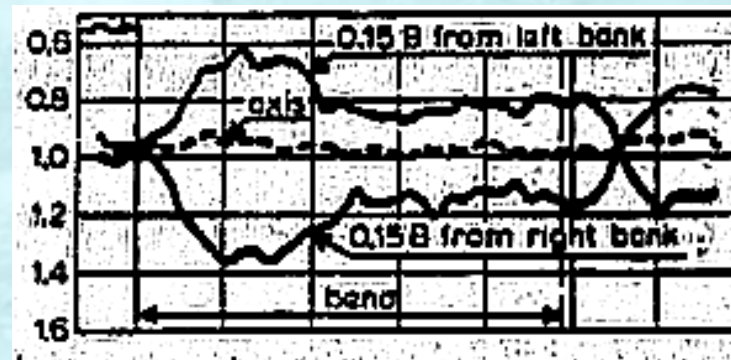
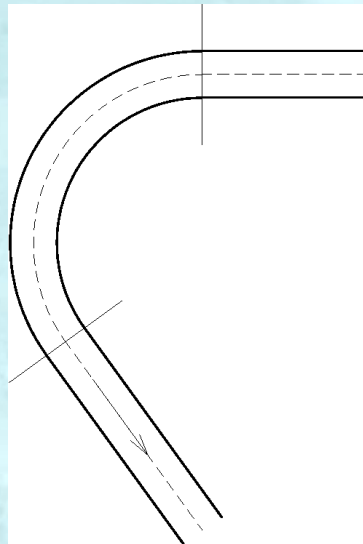


MORPHODINAMICAL INFLUENCE

The bifurcation acts as a **planimetric discontinuity**

A WELL KNOWN EXAMPLE

THE ABRUPT CHANGE OF CHANNEL CURVATURE



“Overdeepening”
(Struiksma et al. 1985)

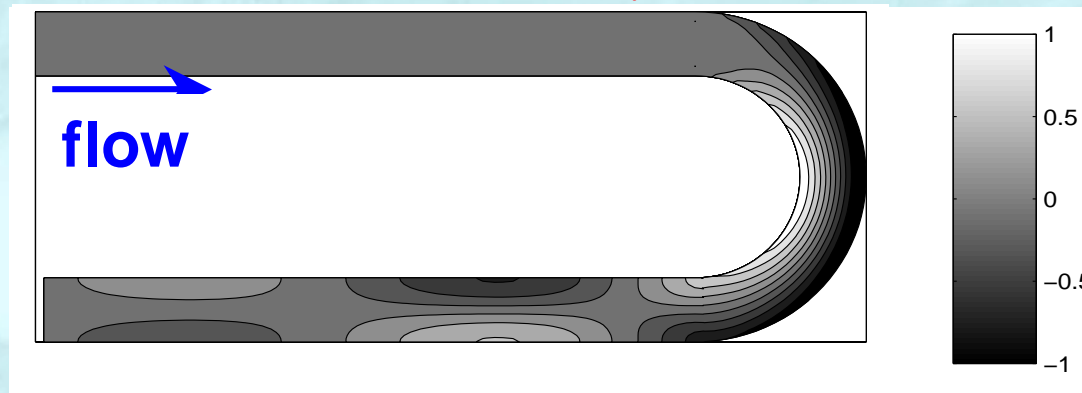
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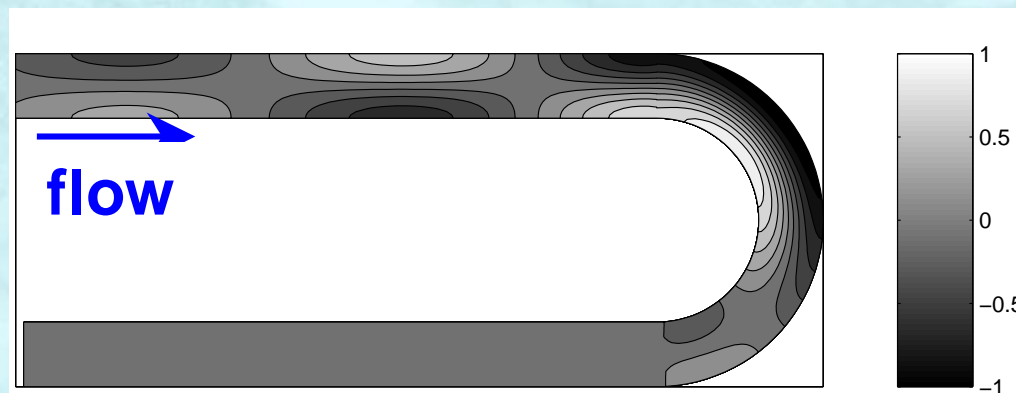
DOWNSTREAM AND UPSTREAM INFLUENCE

Zolezzi & Seminara 2001

Sub-resonant channels $\beta < \beta_R \Rightarrow$ downstream influence



Super-resonant channels $\beta > \beta_R \Rightarrow$ upstream influence

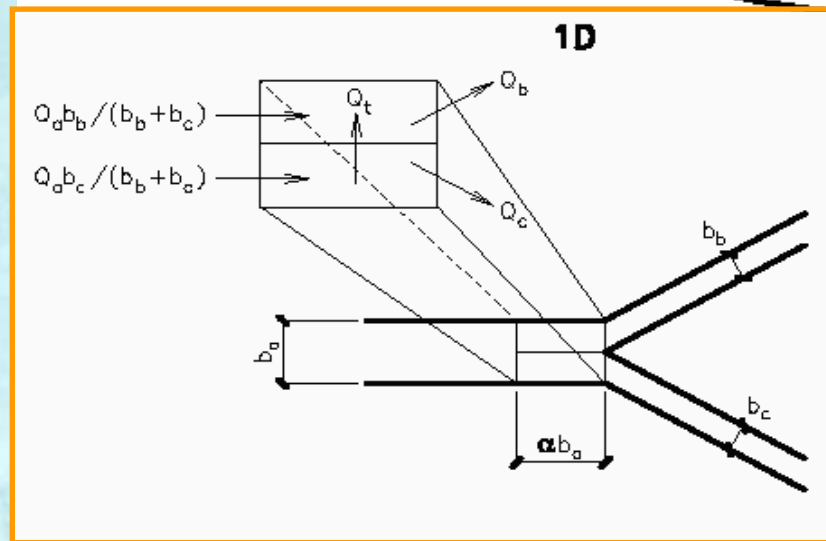
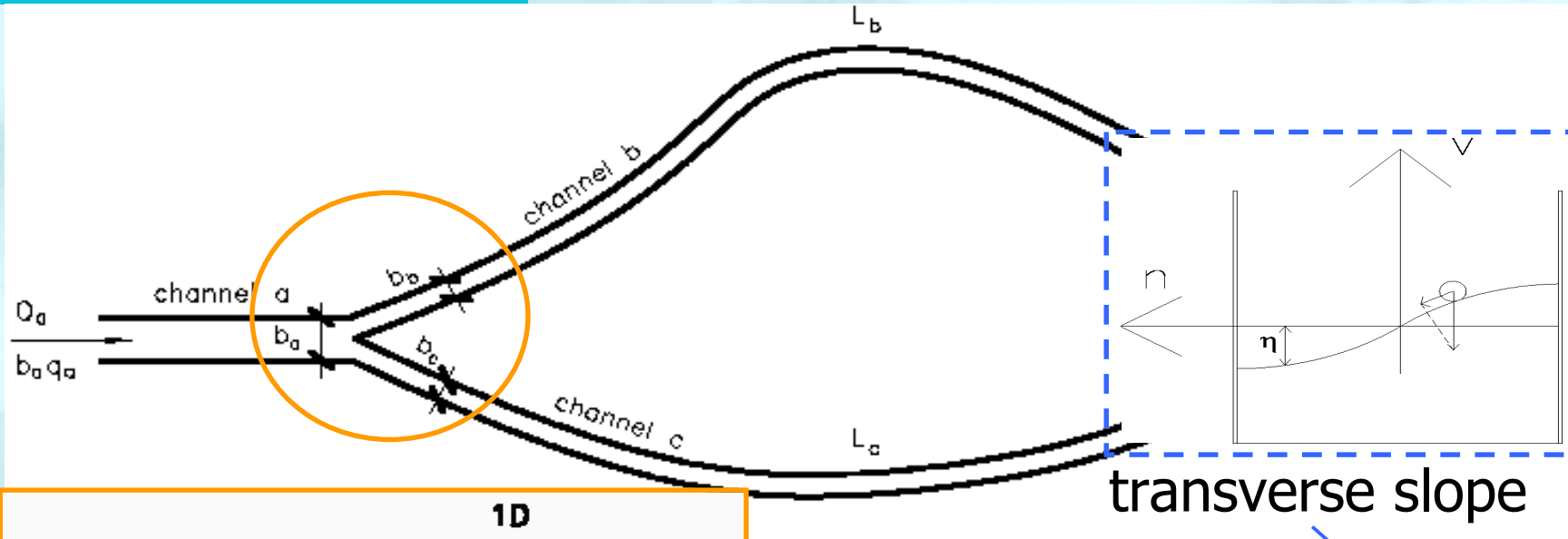


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A THEORETICAL MODEL

(Bolla Pittaluga, Repetto, Tubino, 2003)



$$Q_{sy} = Q_{sa} \left(\frac{Q_y / (\alpha b_a D)}{Q_a / (b_a D_a)} - \frac{r}{\sqrt{\theta_a}} \frac{\partial \eta}{\partial y} \right)$$

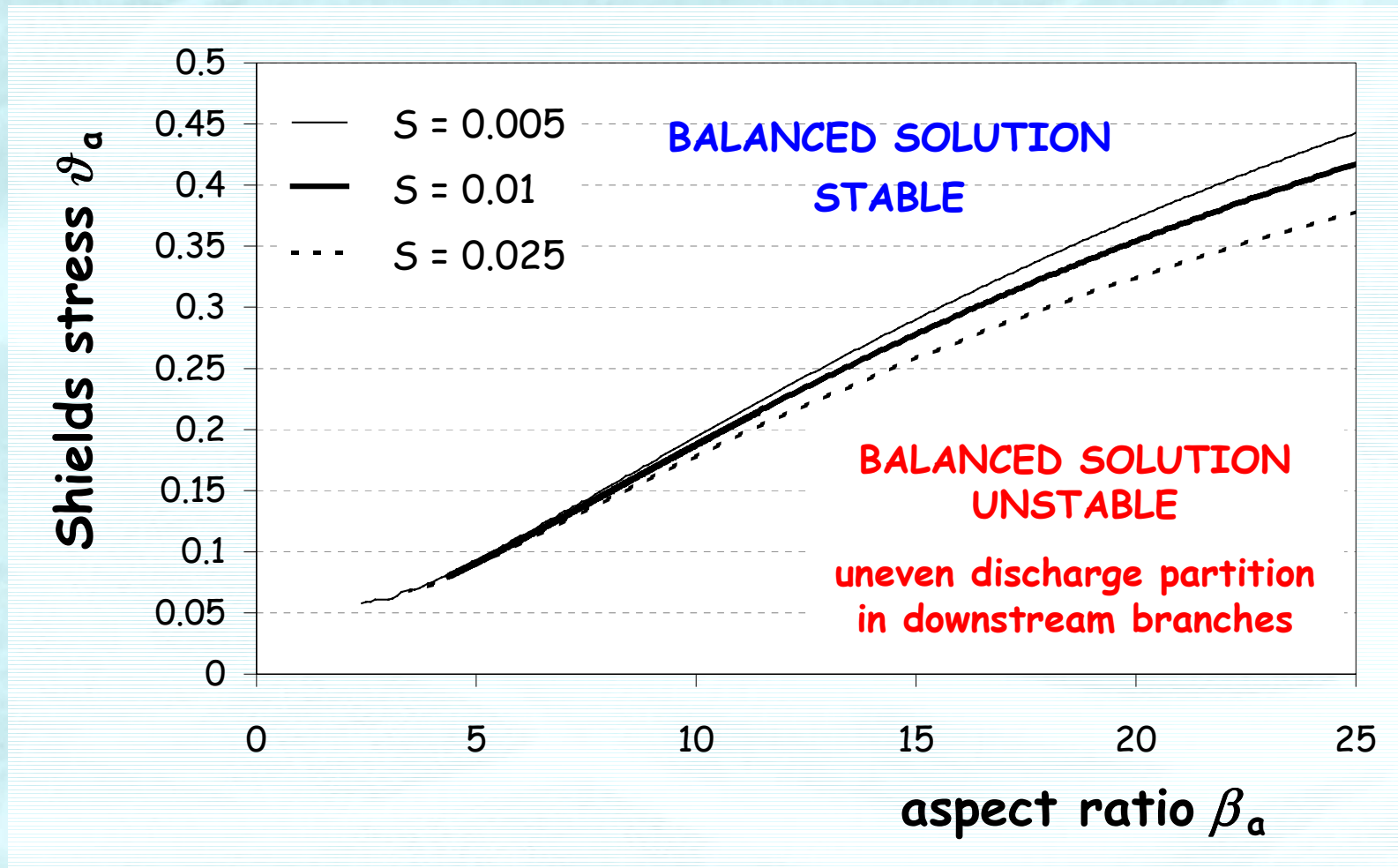
$$Q_y = Q_b - Q_a \frac{b_b}{b_b + b_c}$$

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A THEORETICAL MODEL

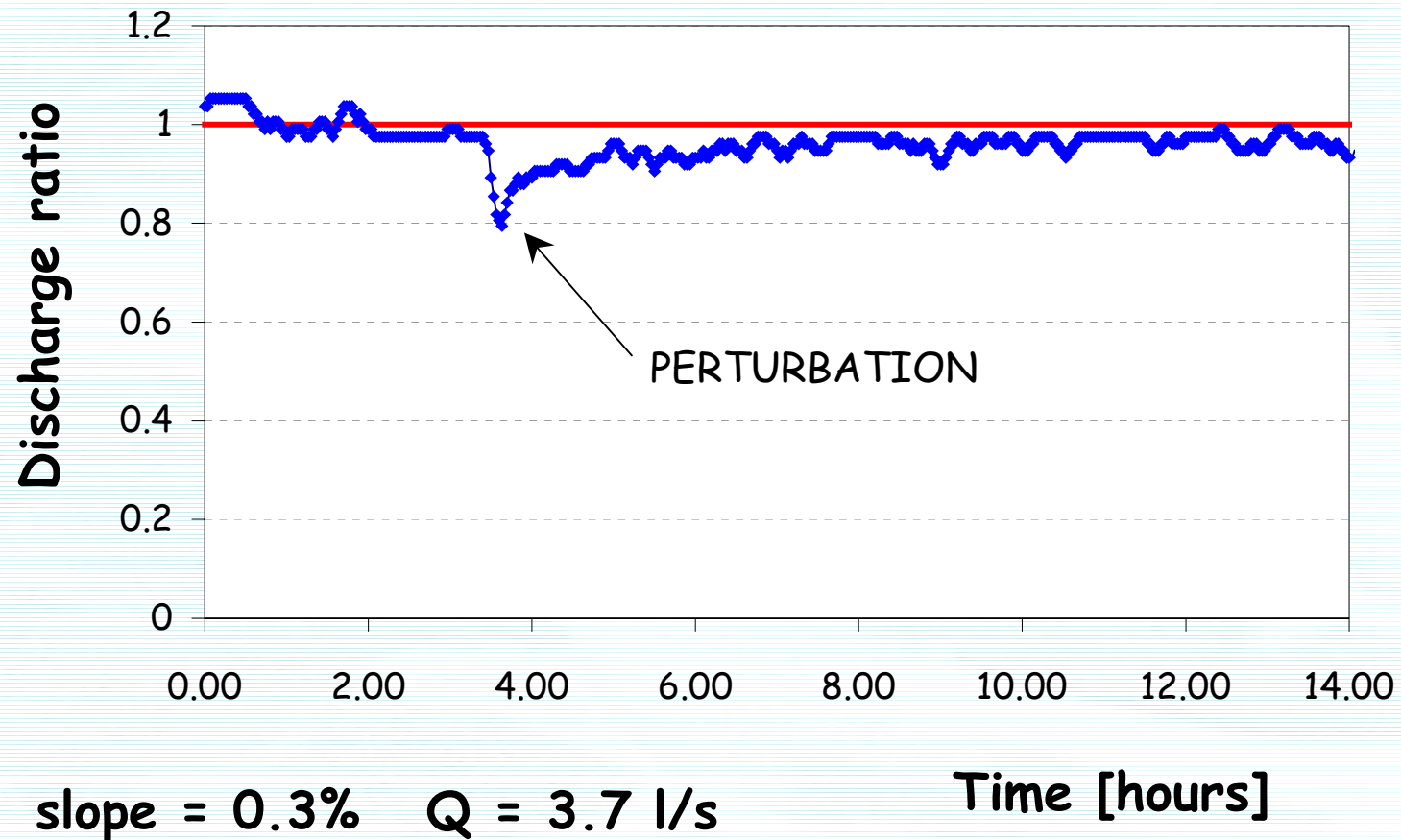
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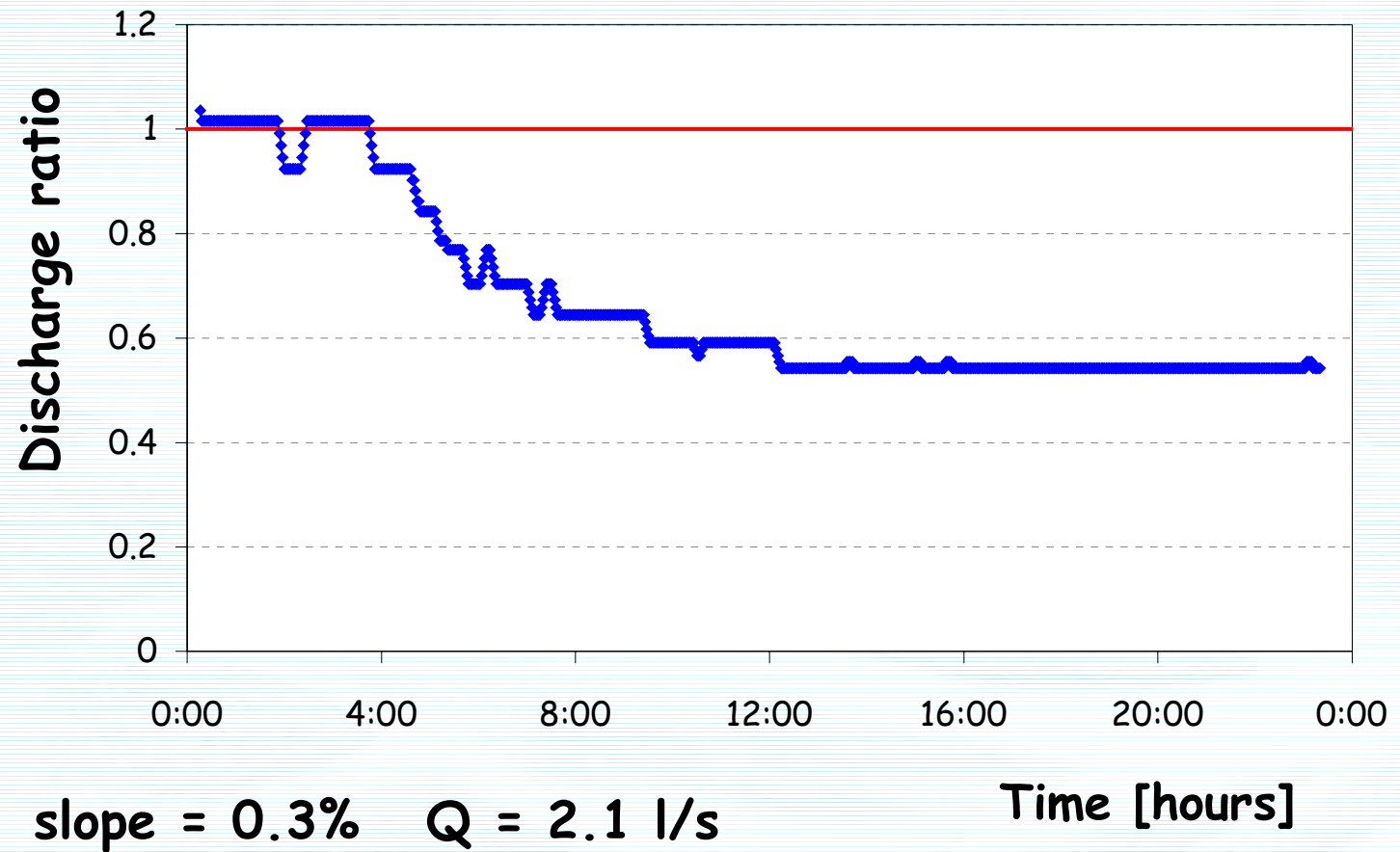
DISCHARGE DISTRIBUTION



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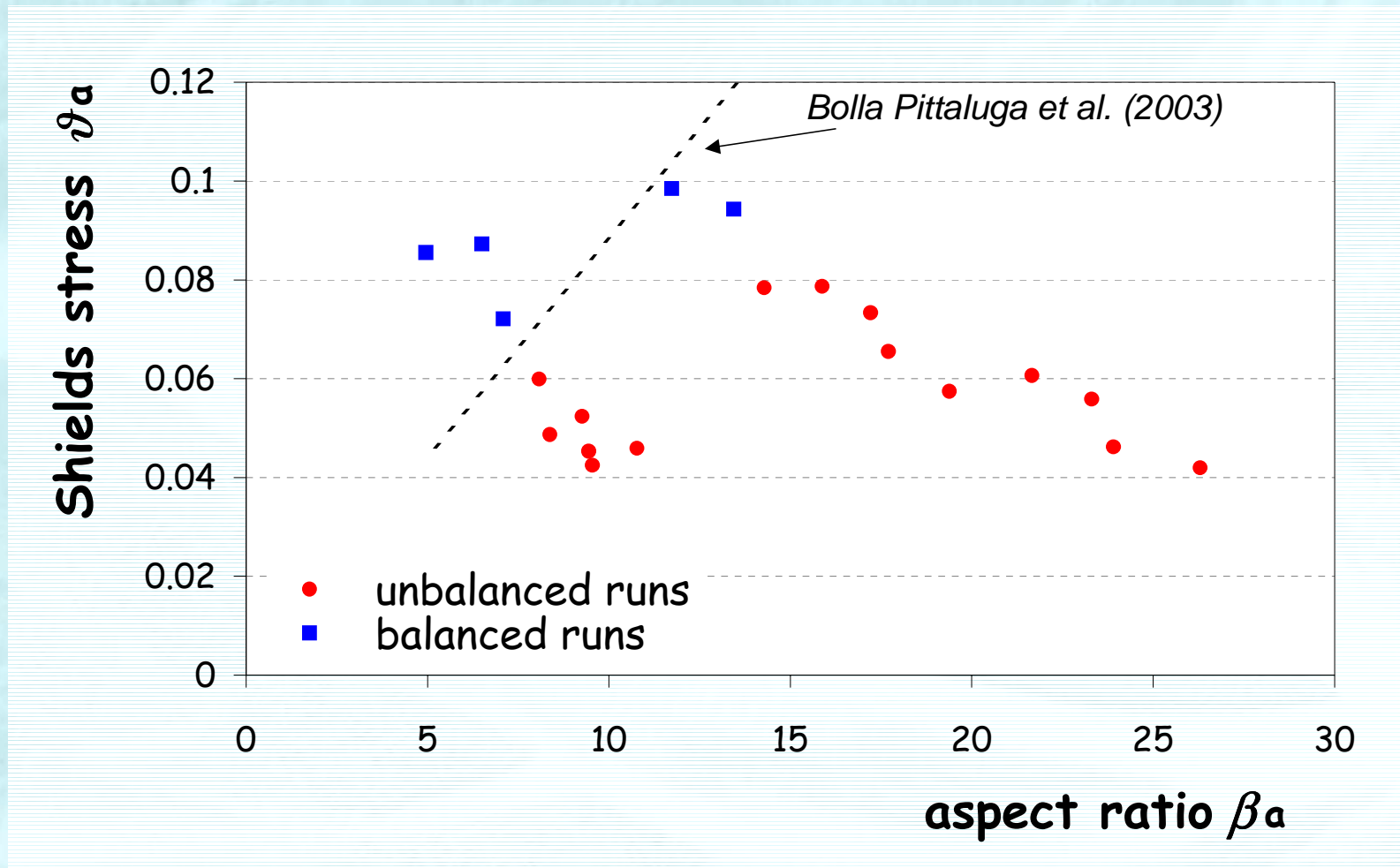
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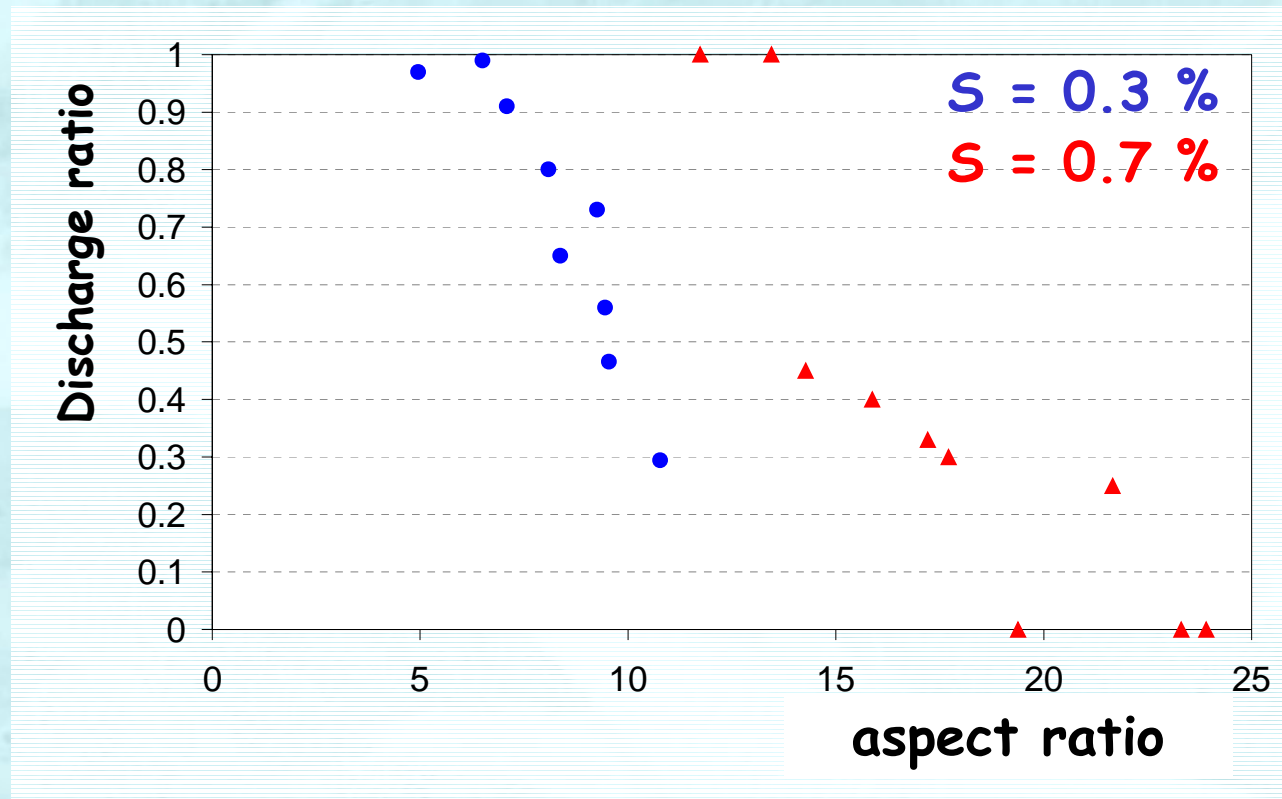
COMPARISON WITH THE ONE-DIMENSIONAL THEORY



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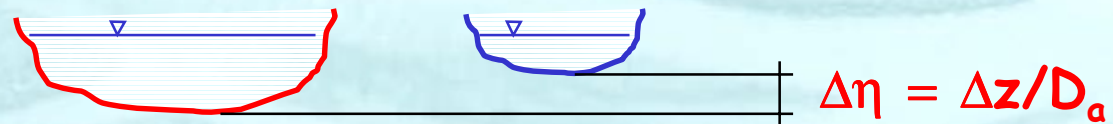
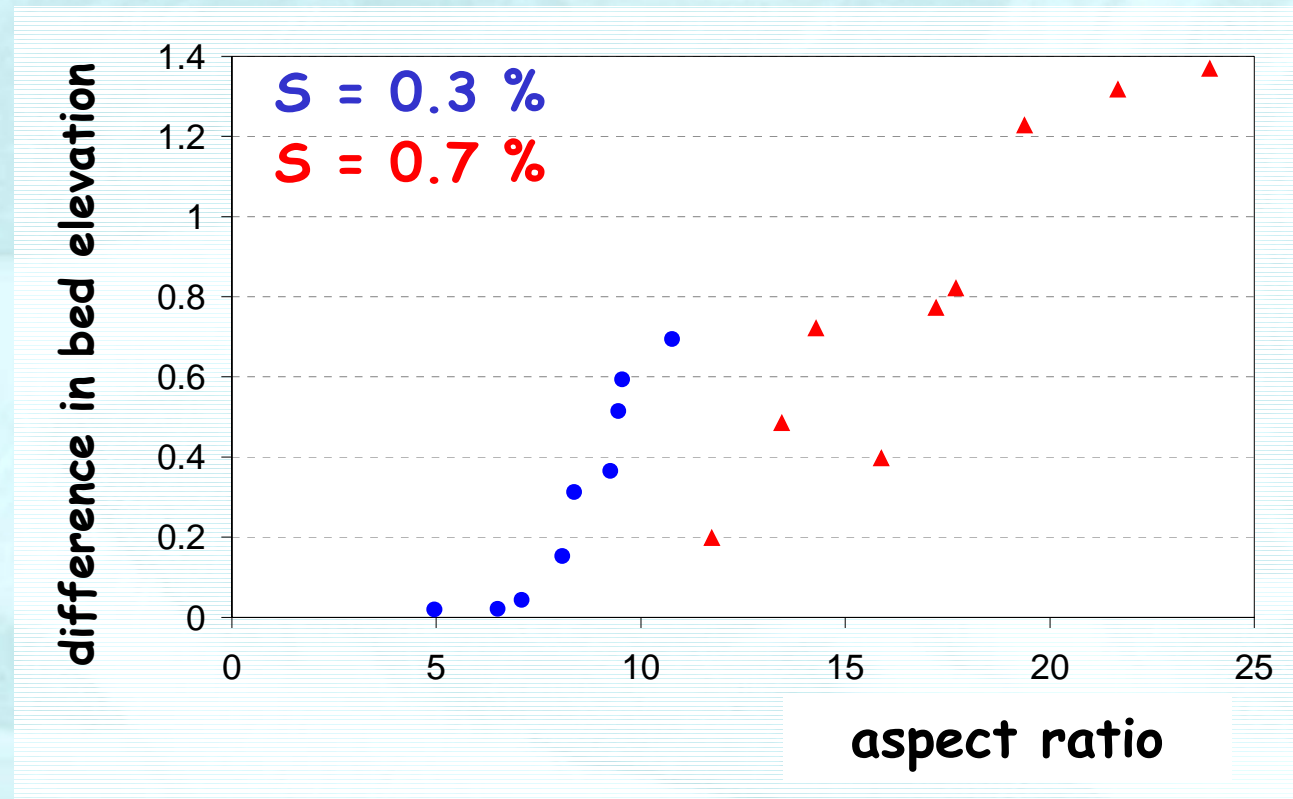
EQUILIBRIUM CONFIGURATION



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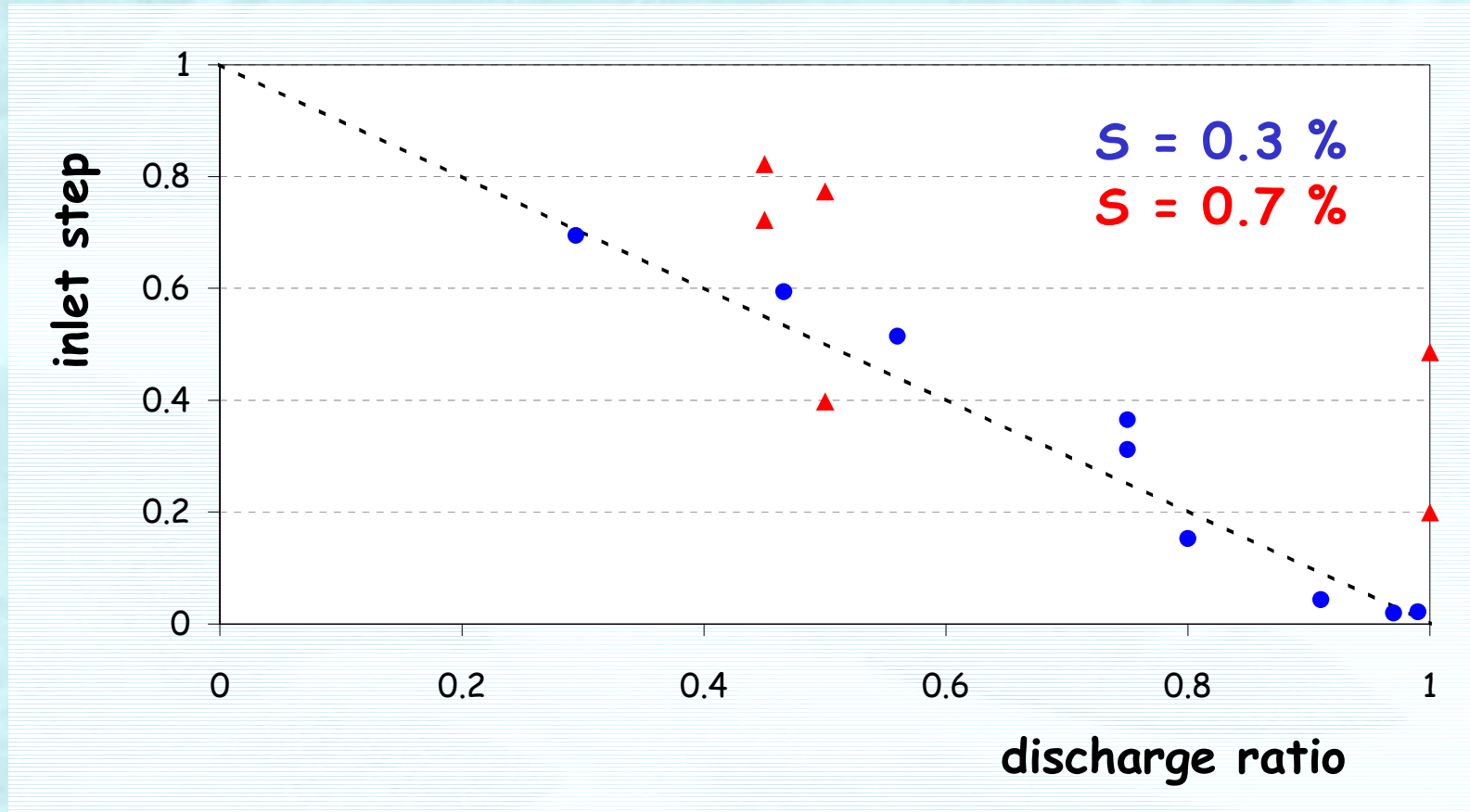
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THE BIFURCATION AS A PLANIMETRIC DISCONTINUITY

Morphodynamic influence (Zolezzi & Seminara, 2001)

INITIAL STAGE:
MIGRATING BARS



FINAL STAGE:
STEADY BARS

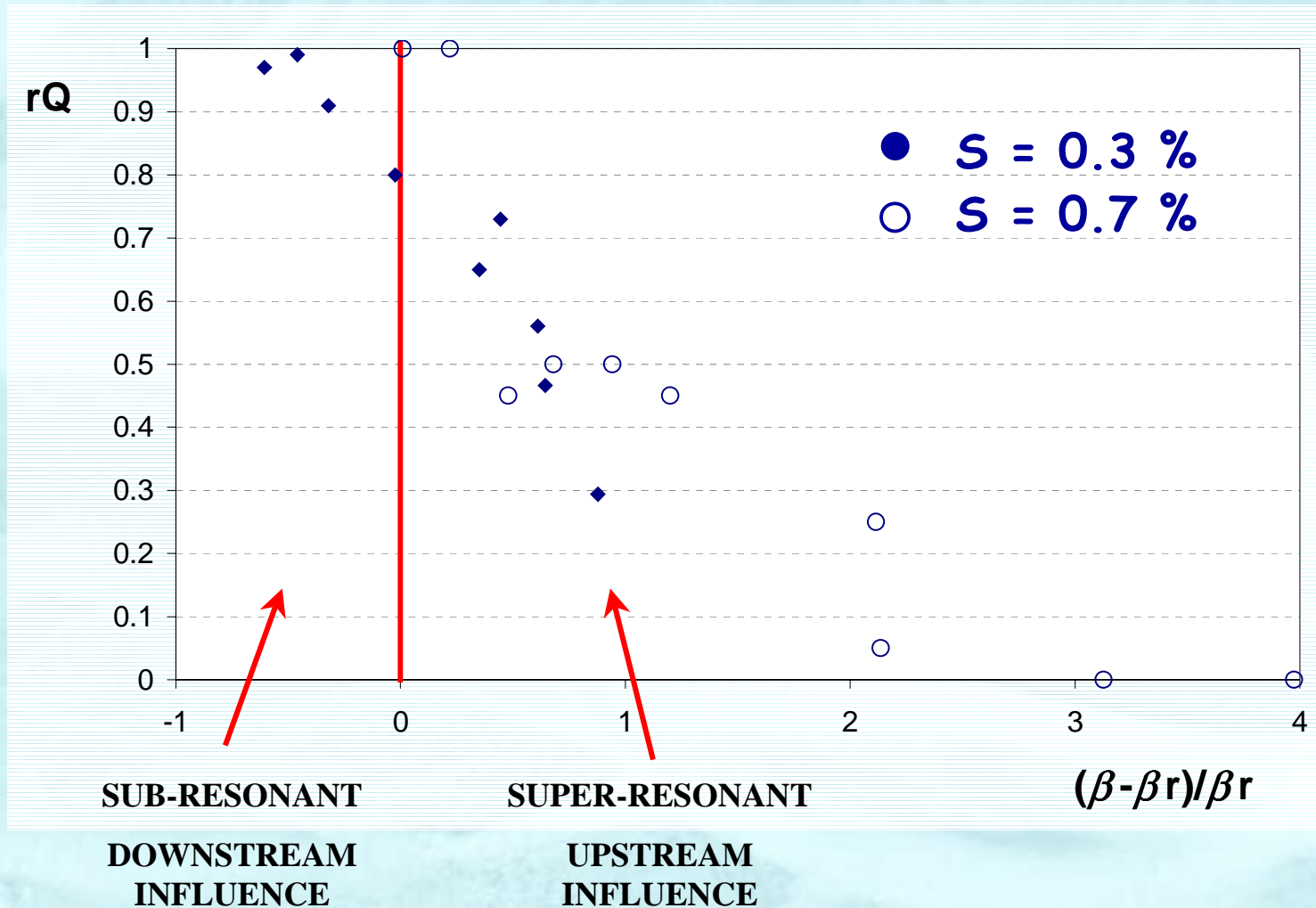


In **super-resonant** conditions ($\beta > \beta_R$) \rightarrow **upstream** influence

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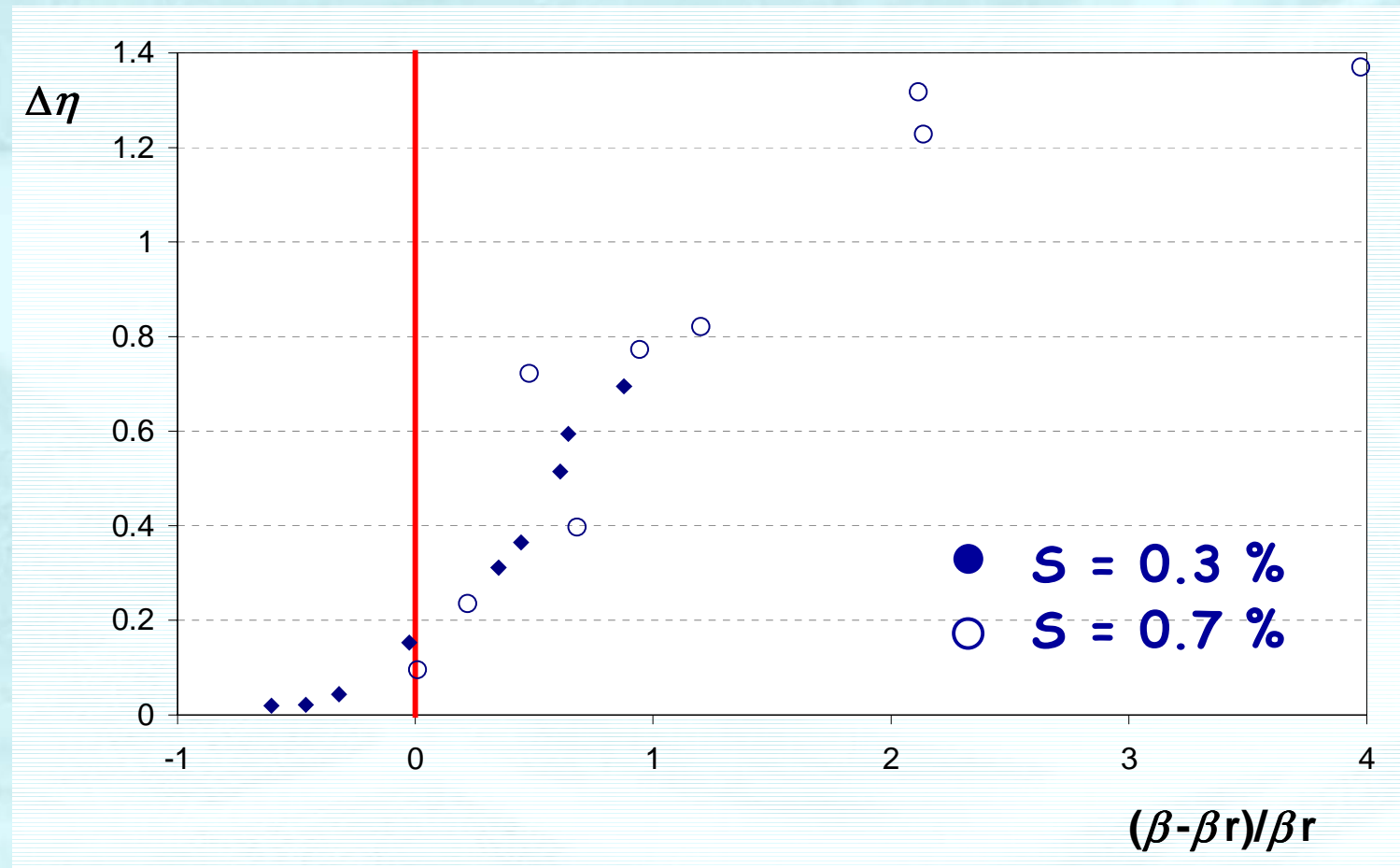
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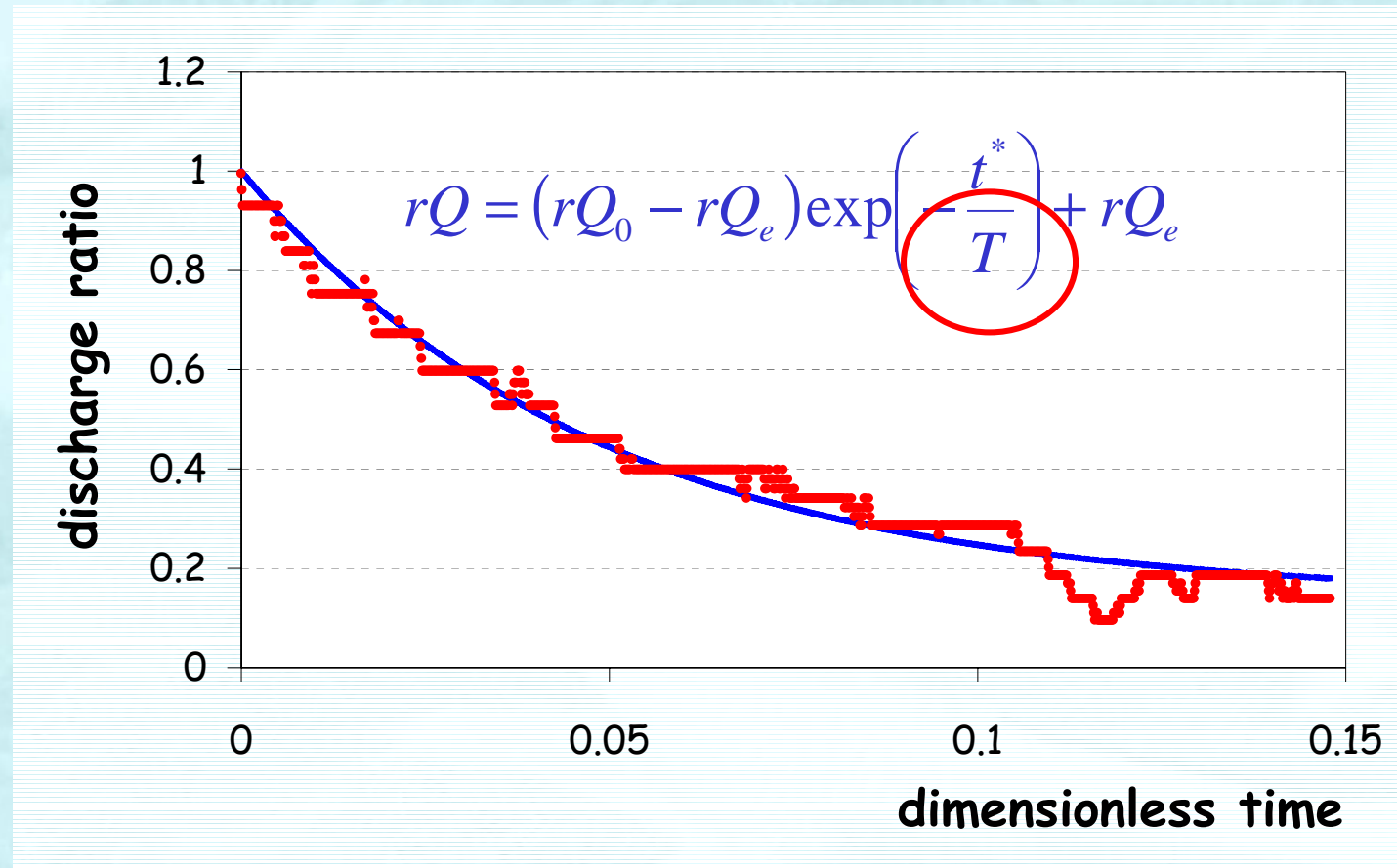
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BIFURCATION TIME SCALE

Does an **intrinsic time scale** of
the bifurcation evolution exist?

(...see also next speaker)

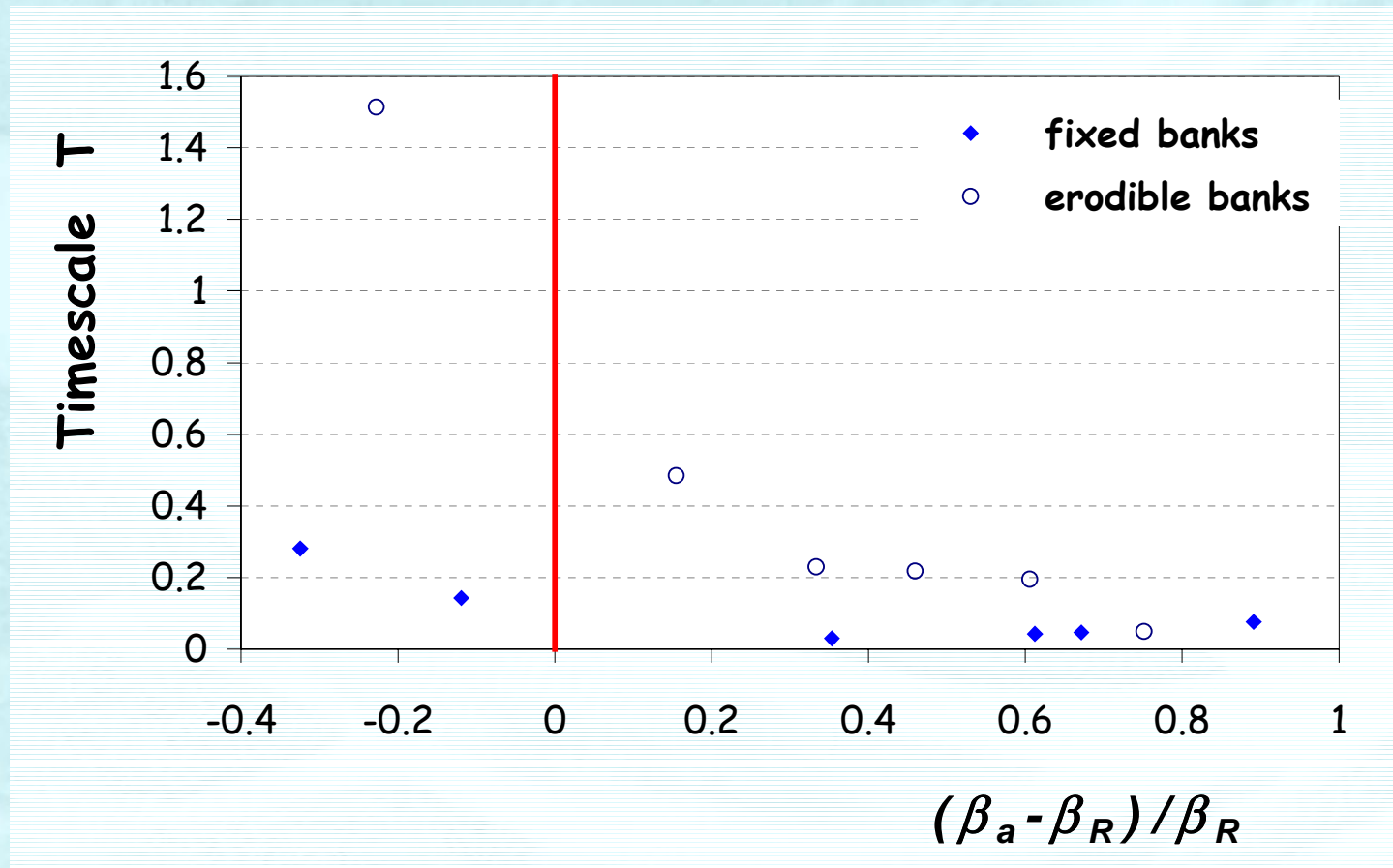
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BRAIDED NETWORKS



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Thank you for your attention!!