Građevinski fakultet
Univerzitet u Beogradu
Katedra za hidrotehniku i vodno ekološko inženjerstvo

Seminarski rad

Mehanika fluida – CFD

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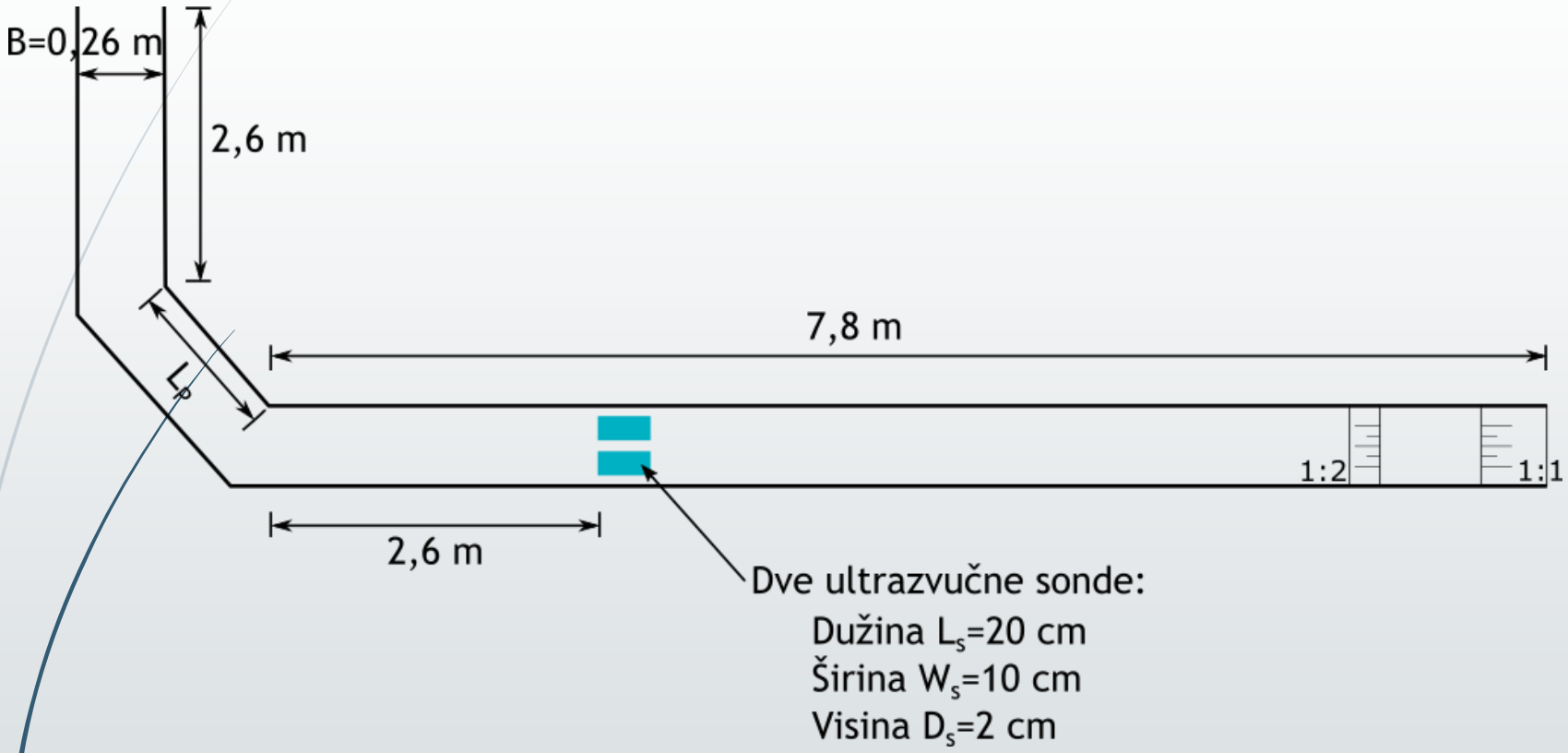
Sadržaj

1. Uvod
2. Postavke zadataka
3. Formiranje mreže i odabir uslova proračuna
4. Analitičko rešenje
5. Varijanta I: $L_P=10\times B$ - Filip Stanić
6. Varijanta II: $L_P=2\times B$ - Robert Ljubičić
7. Poređenje rezultata
8. Zaključci

Postavke zadataka

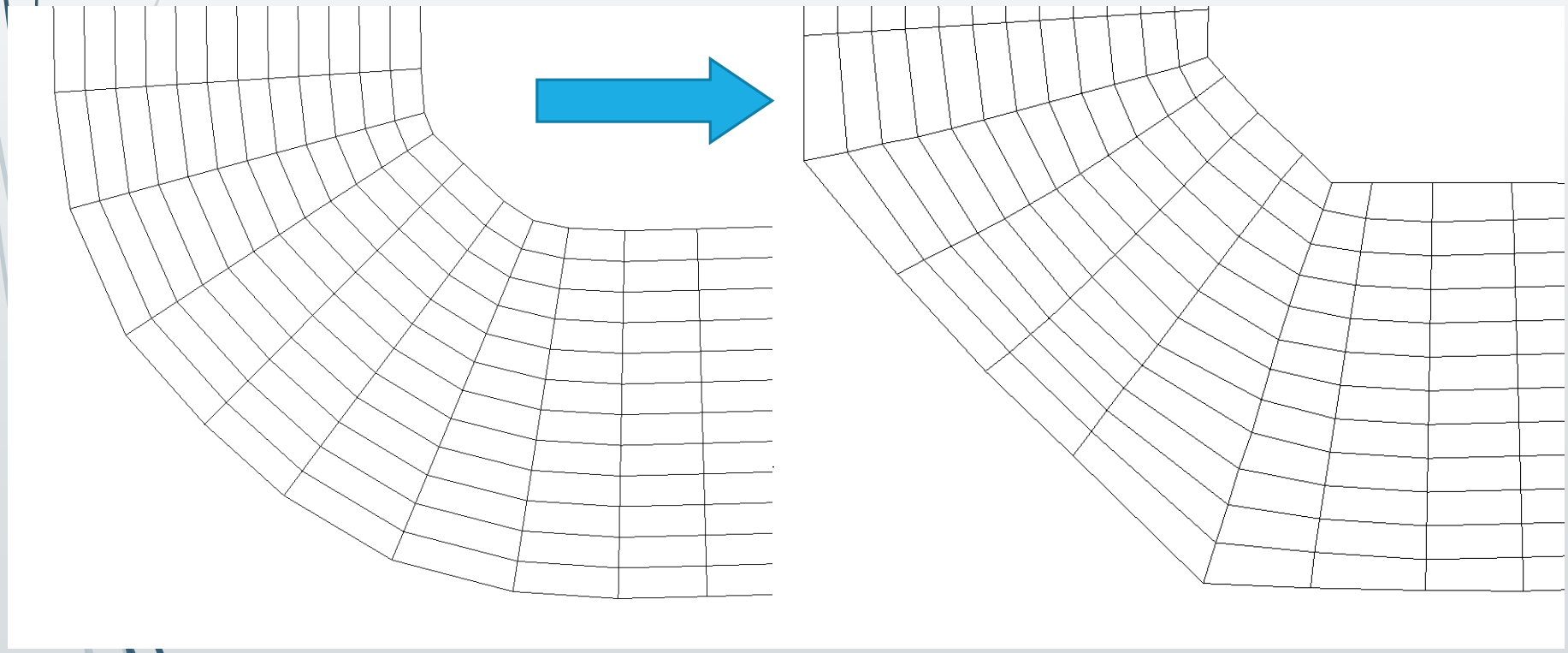


Zadatak 5: $L_P = 2{,}0 \times B = 0{,}52$ m

Zadatak 6: $L_P = 0{,}4 \times B = 0{,}10$ m

Formiranje mreže (Grid creation)

- Grid formiran duž putanje
- Za formiranje grid-a u zoni krivine neophodna ručna intervencija (nestabilnost proračuna)

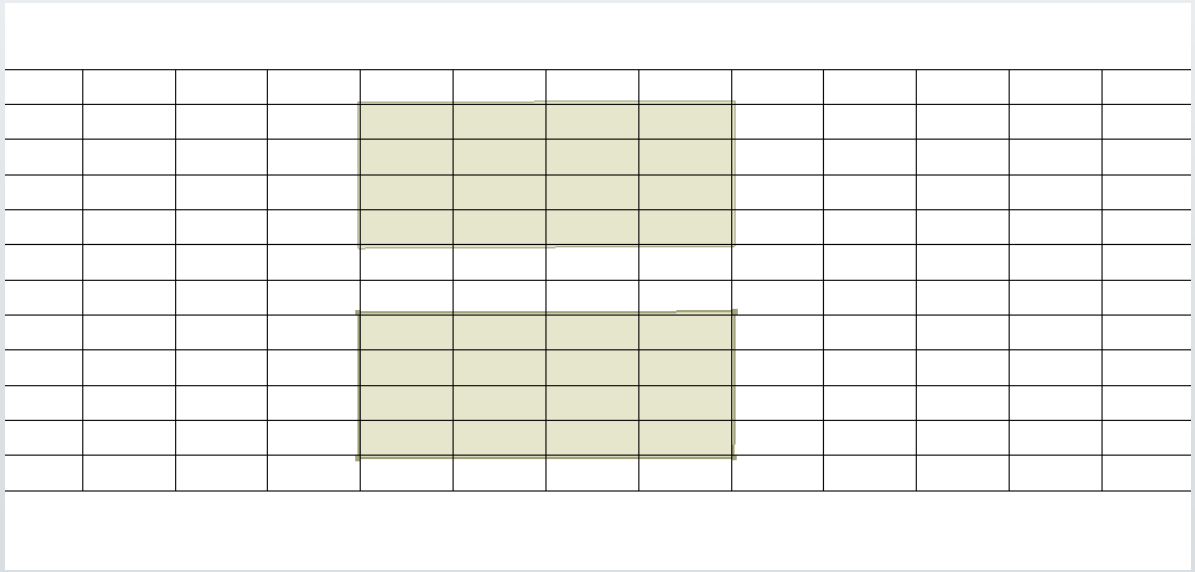


Formiranje mreže (Grid creation)

- Neophodno formirati pad dna kanala:

  grid export as .csv → edit → import .csv grid

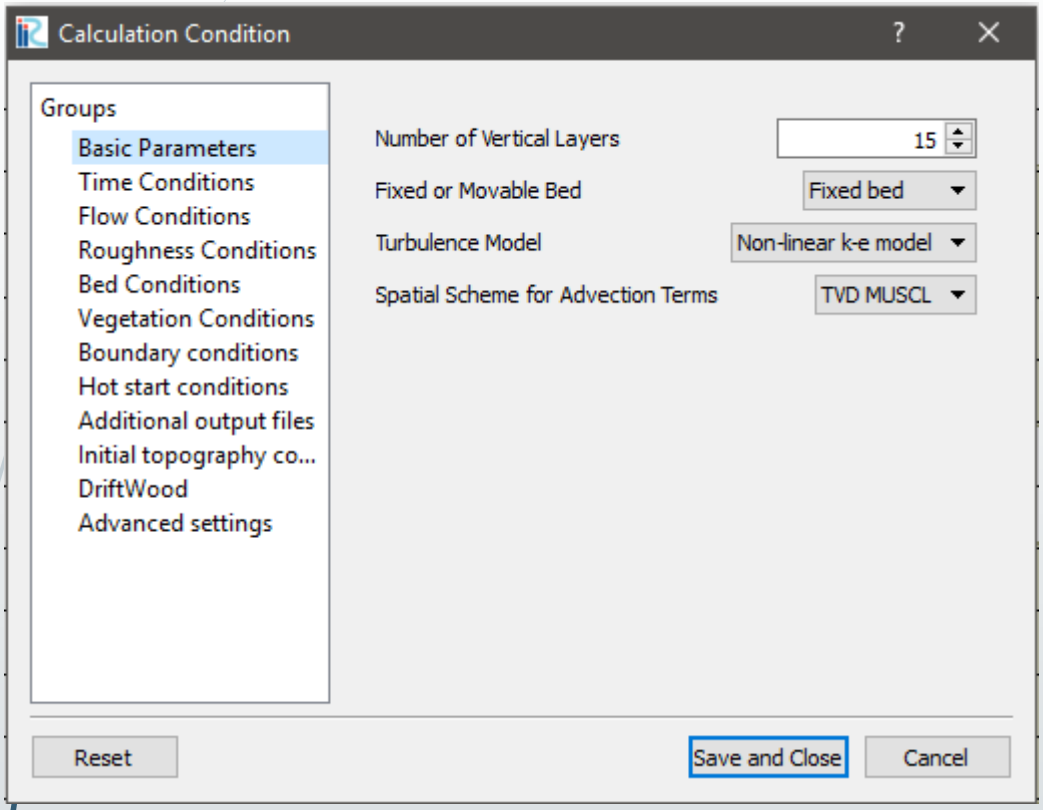
- Visina prepreka (sondi) se usvaja u broju ćelija u pravcu z ose ≈ 2 ćelije



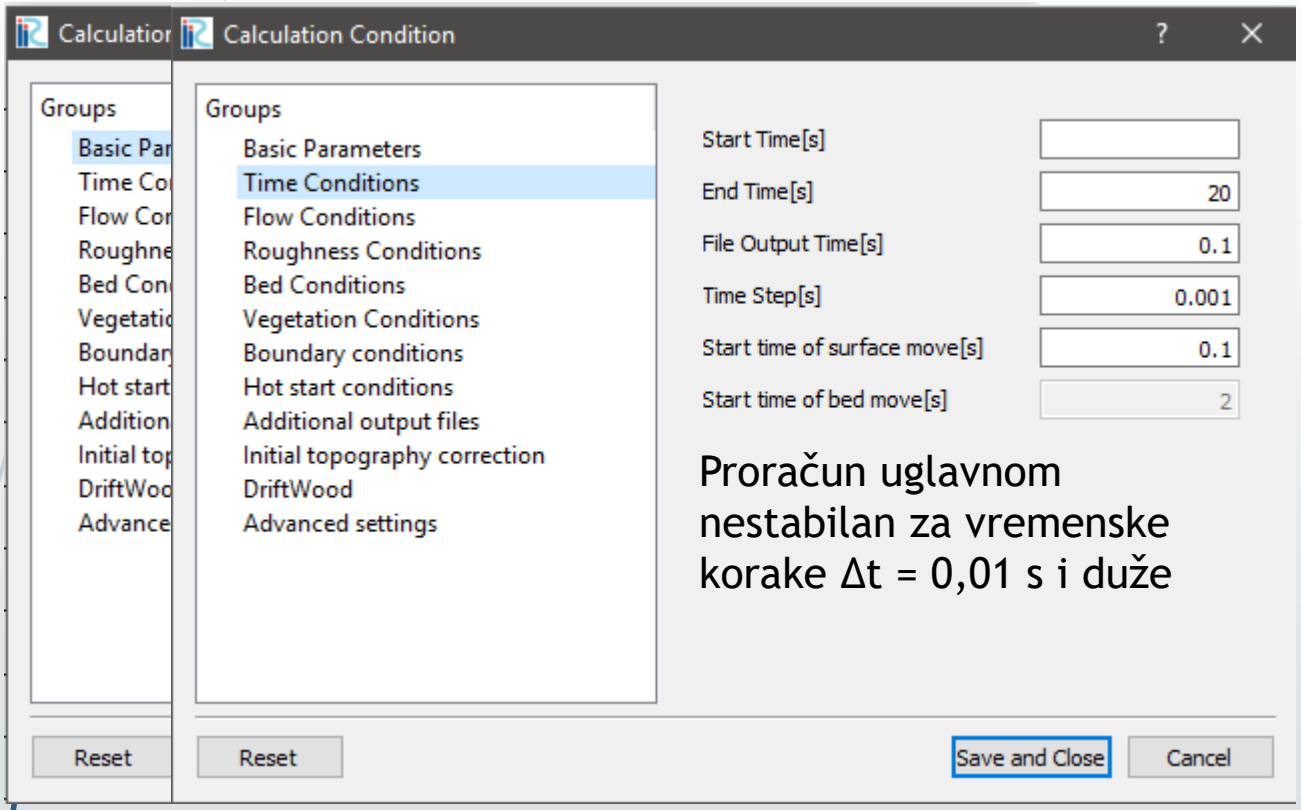
Napomene

- Voditi računa o dužini širokog praga ($3h_P$-$5h_P$)
- Poželjno obezbediti mirno tečenje u deonici uzvodno od praga
- Vreme proračuna bi trebalo da bude dovoljno dugo da se obezbedi relativno ustaljeno tečenje u zoni sondi i u krivini
- Geometrija i mreža u zoni krivine mogu biti uzrok nestabilnog proračuna!

Uslovi proračuna

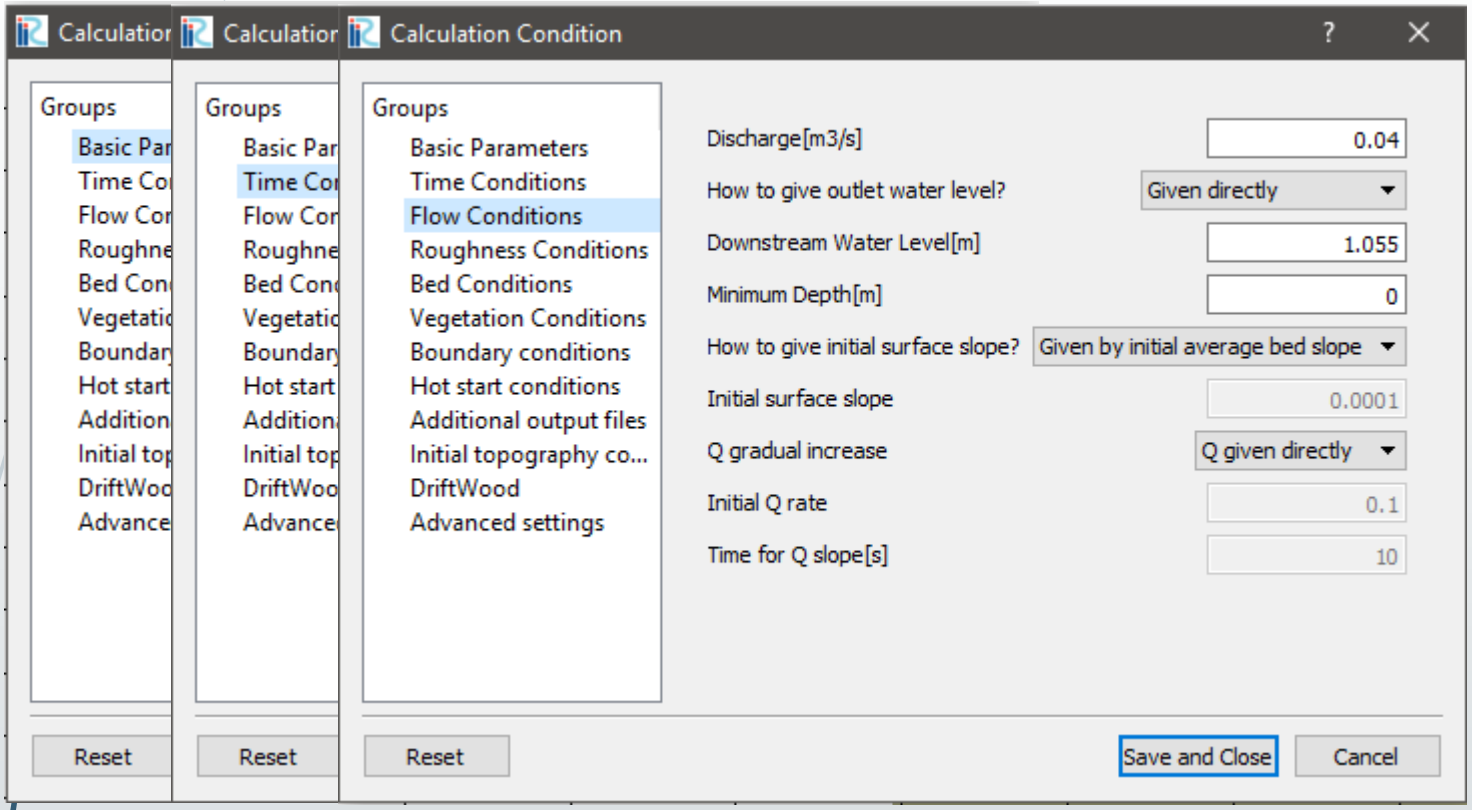


Uslovi proračuna

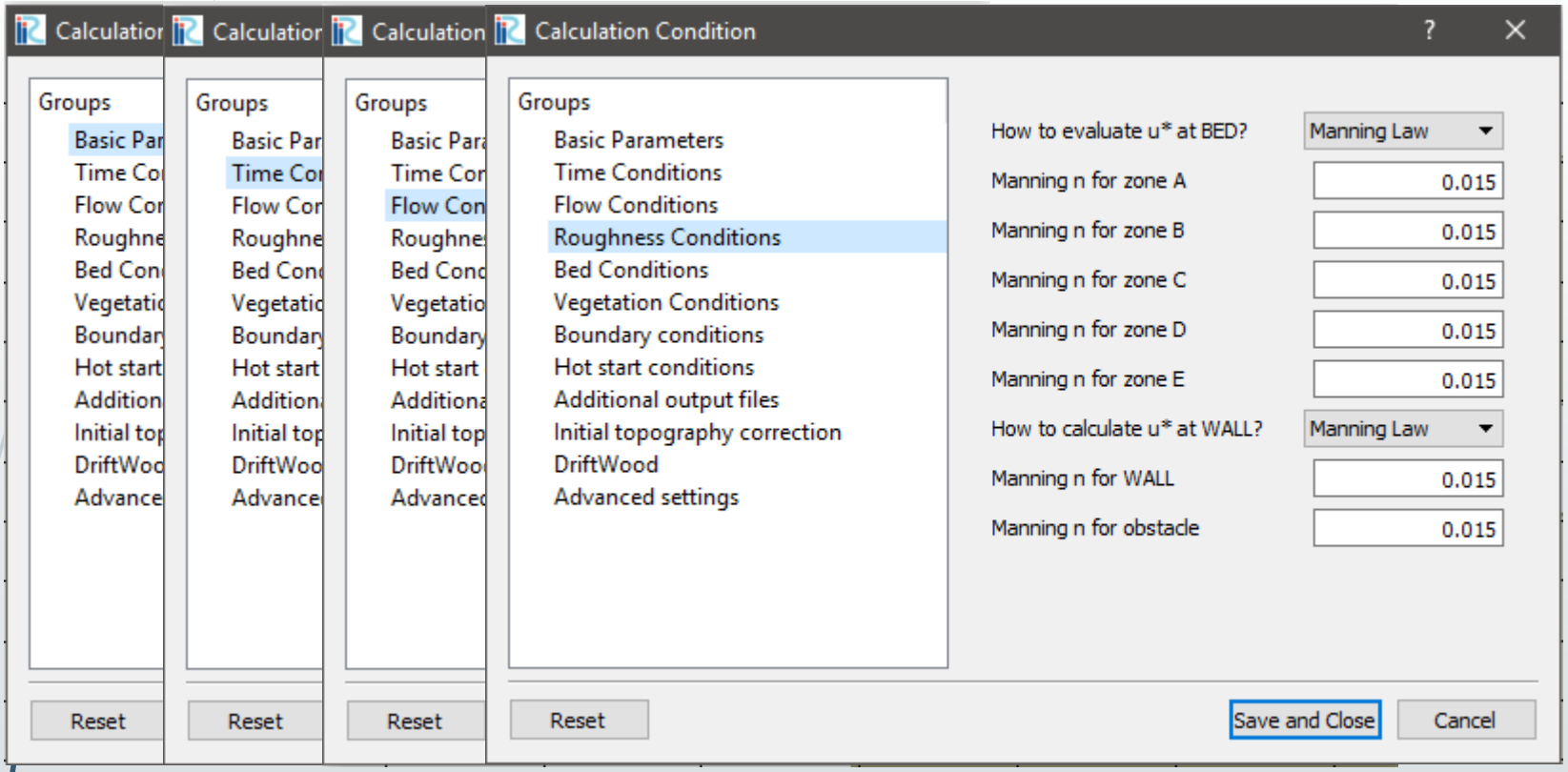


Proračun uglavnom nestabilan za vremenske korake $\Delta t = 0{,}01$ s i duže

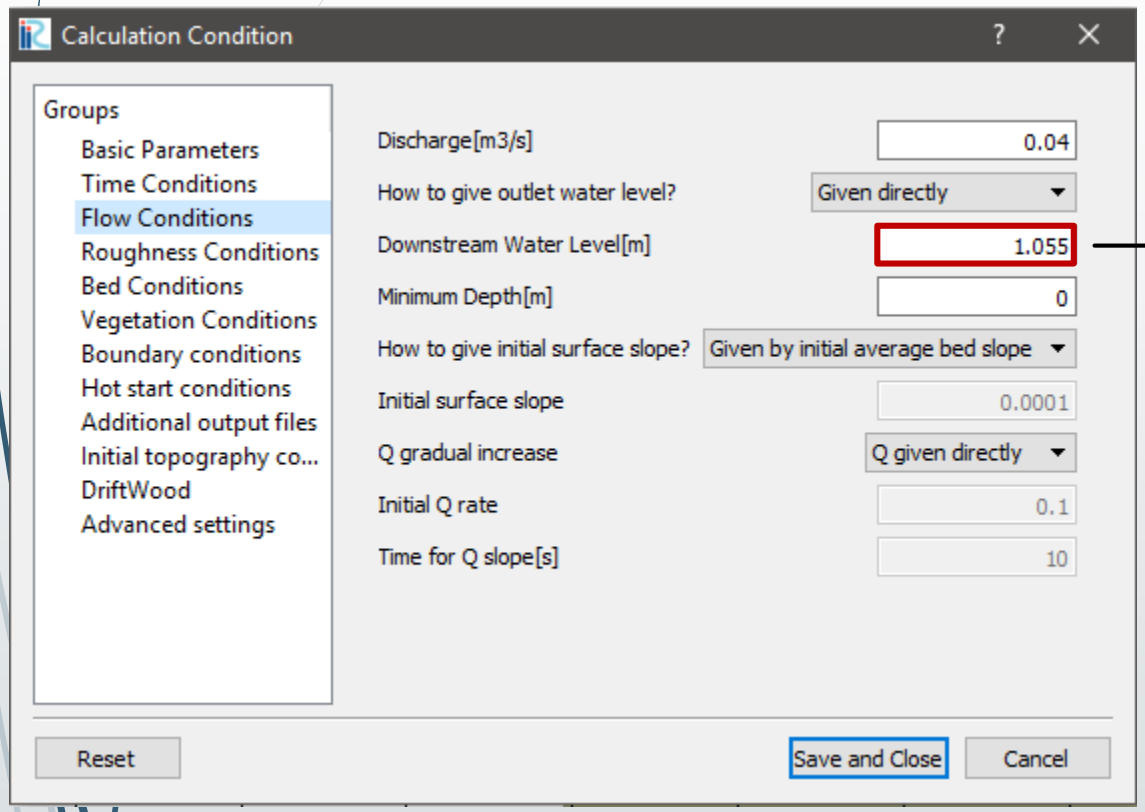
Uslovi proračuna



Uslovi proračuna



Uslovi proračuna



Nizvodni granični uslov (zadata KOTA nivoa) se moeže dobiti ili iz analitičkih izraza, probanjem, ili kombinacijom navedenog

$I_d = 0,01$

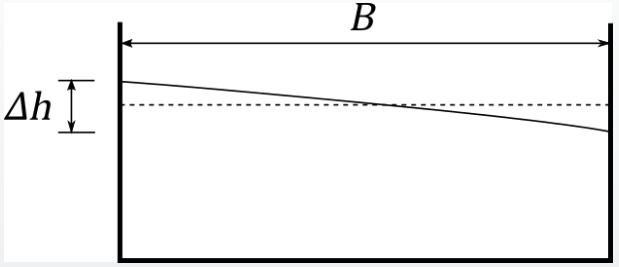
$h_N = 0,1395$ m

$h_{KR} = 0,1341$ m

Analitičko rešenje

- Za krivinu u osnovi toka, poprečni nagib linije nivoa se može oceniti na osnovu izraza:

$$\Delta h = \frac{v^2 B}{gR}$$



gde su: v – prosečna brzina u poprečnom preseku

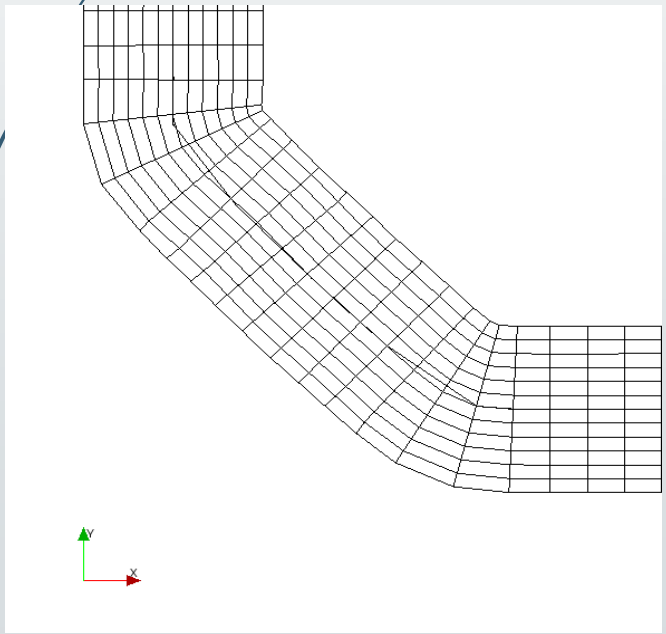
B – širina vodenog ogledala

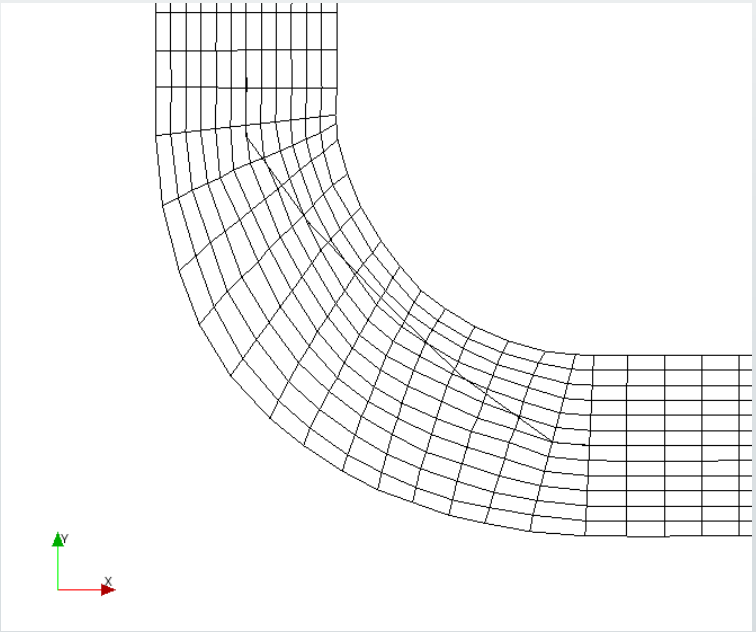
R - poluprečnik krivine u osnovi

a Δh predstavlja razliku nivoa konkavne i konveksne obale.

Varijanta I – $L_p = 2 \times B$

- Varijanta sa dužom krivinom – očekuje se slabije izražena turbulencija
- Podvarijante:
  - Oštra (zasečena krivina)
  - Kružna krivina



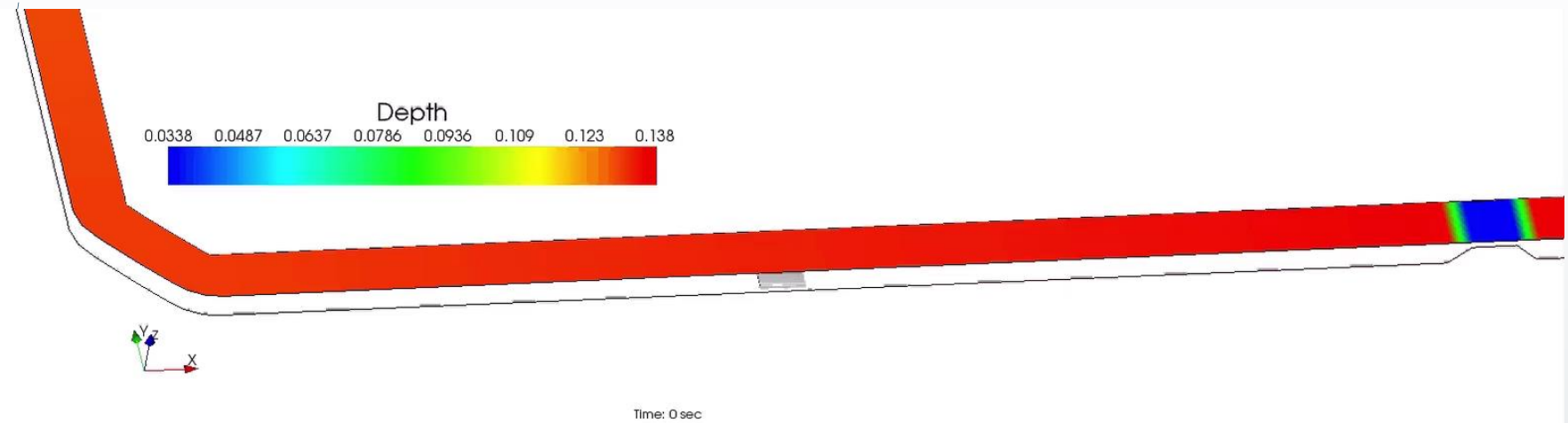


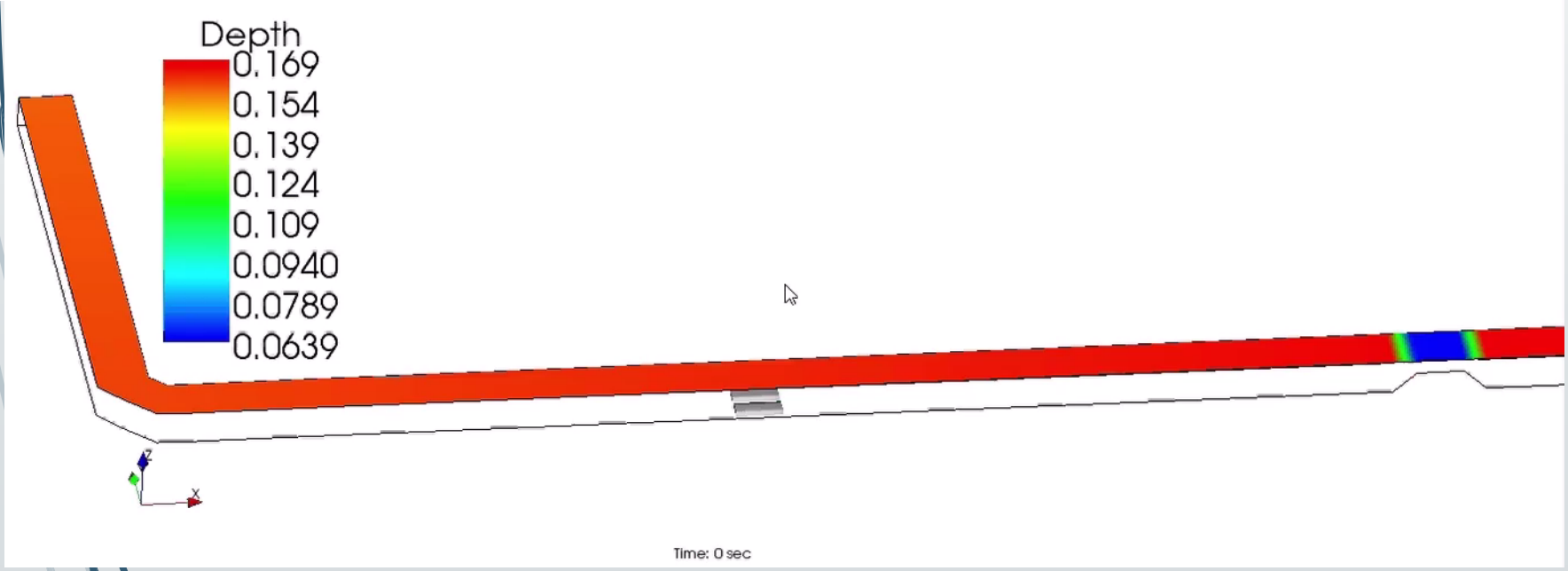
Varijanta II – $L_P = 0,4 \times B$

- Varijanta sa 5 puta kracom prelaznom deonicom – očekuje se znatno veća turbulencija
- Podvarijante:
  1. Prava prelaznica sa širokim pragom nizvodno
  2. Prava prelaznica bez nizvodnog praga
  3. Kružna prelaznica sa nizvodnim pragom
  4. Kružna prelaznica bez nizvodnog praga

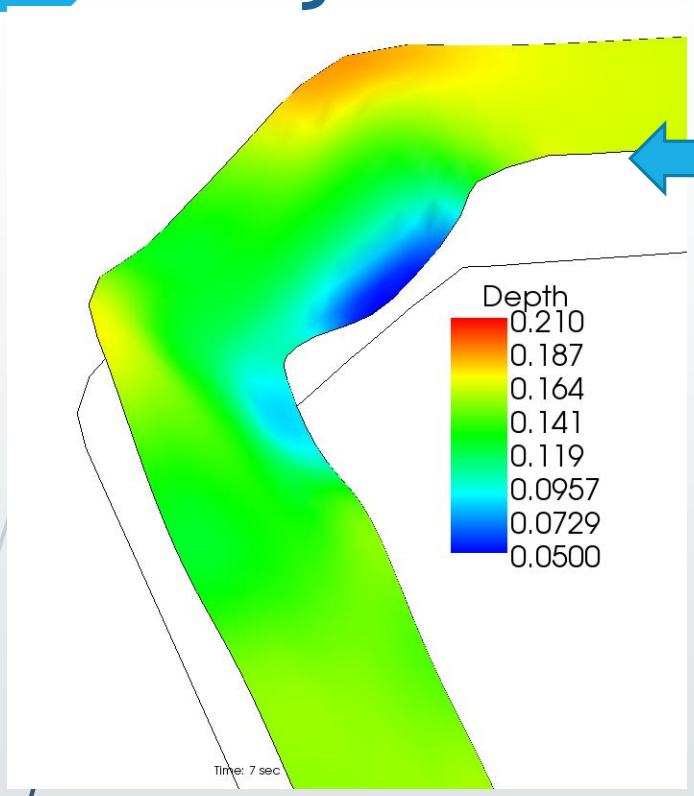
     (za 1-4: nelinearni k-ε model, TVD MUSCL šema)
  5. Kružna prelaznica bez nizvodnog praga, linearni k-ε model, advektivni članovi diskretizovani upwind šemom 1 reda

Poređenje rezultata - Dubine





Varijanta I - Dubine



Analitički t=7,0 s:

$\Delta h = 8{,}6$ cm

NaysCUBE t=7,0 s:

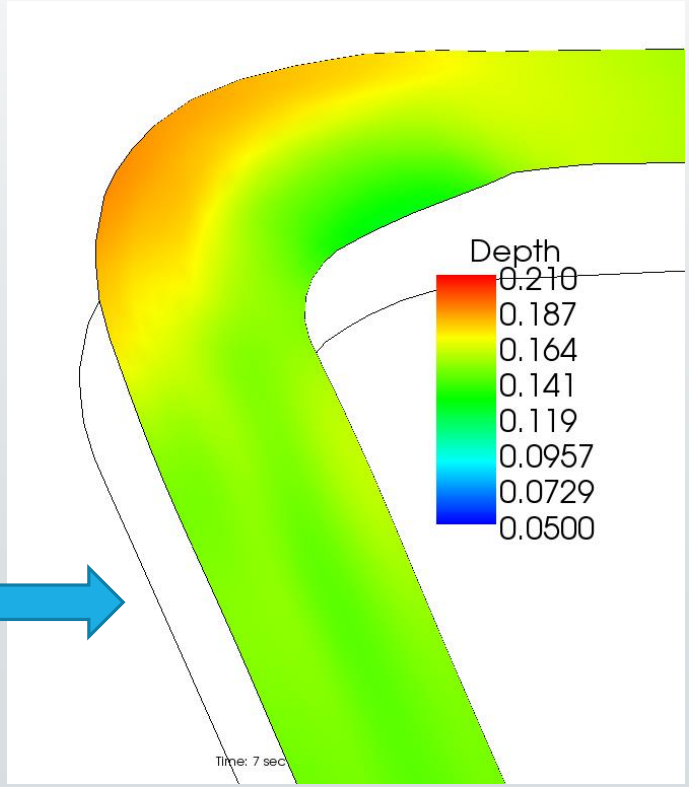
$\Delta h = 11{,}5$ cm

Analitički t=7,0 s:

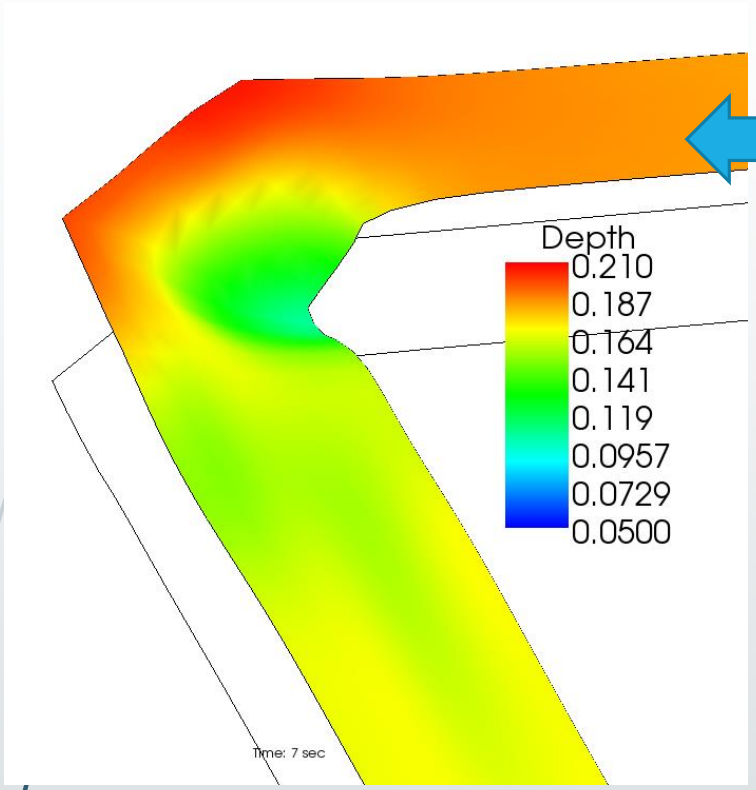
$\Delta h = 7{,}2$ cm

NaysCUBE t=7,0 s:

$\Delta h = 6{,}8$ cm



Varijanta II – dubine



Analitički t=7,0 s:

$\Delta h = 10{,}2$ cm

NaysCUBE t=7,0 s:

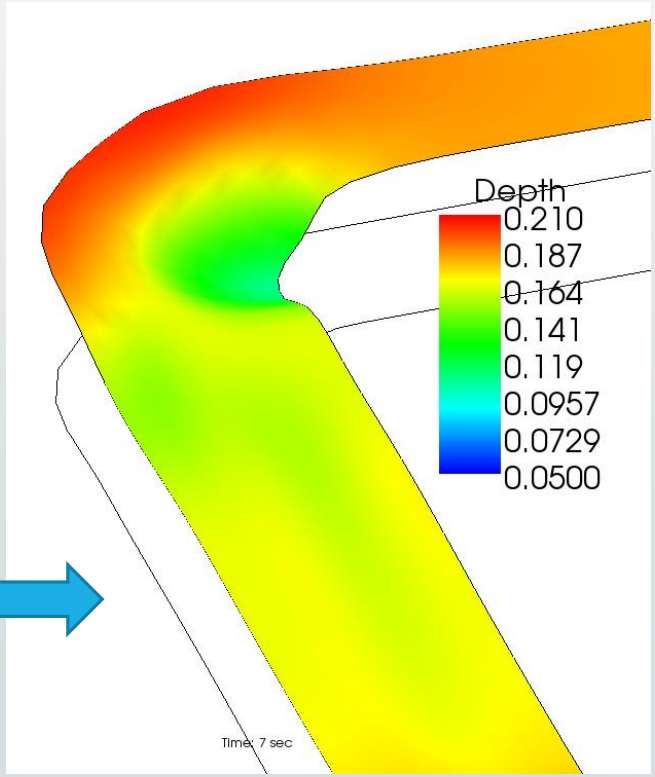
$\Delta h = 8{,}5$ cm

Analitički t=7,0 s:

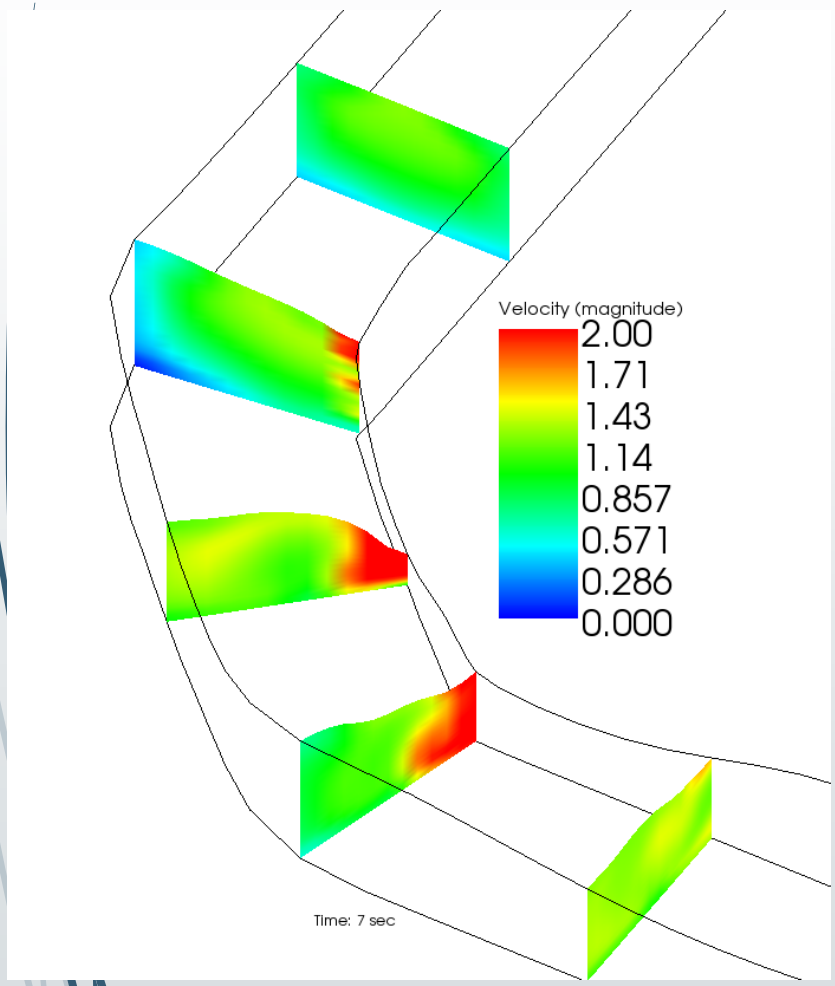
$\Delta h = 9{,}3$ cm

NaysCUBE t=7,0 s:

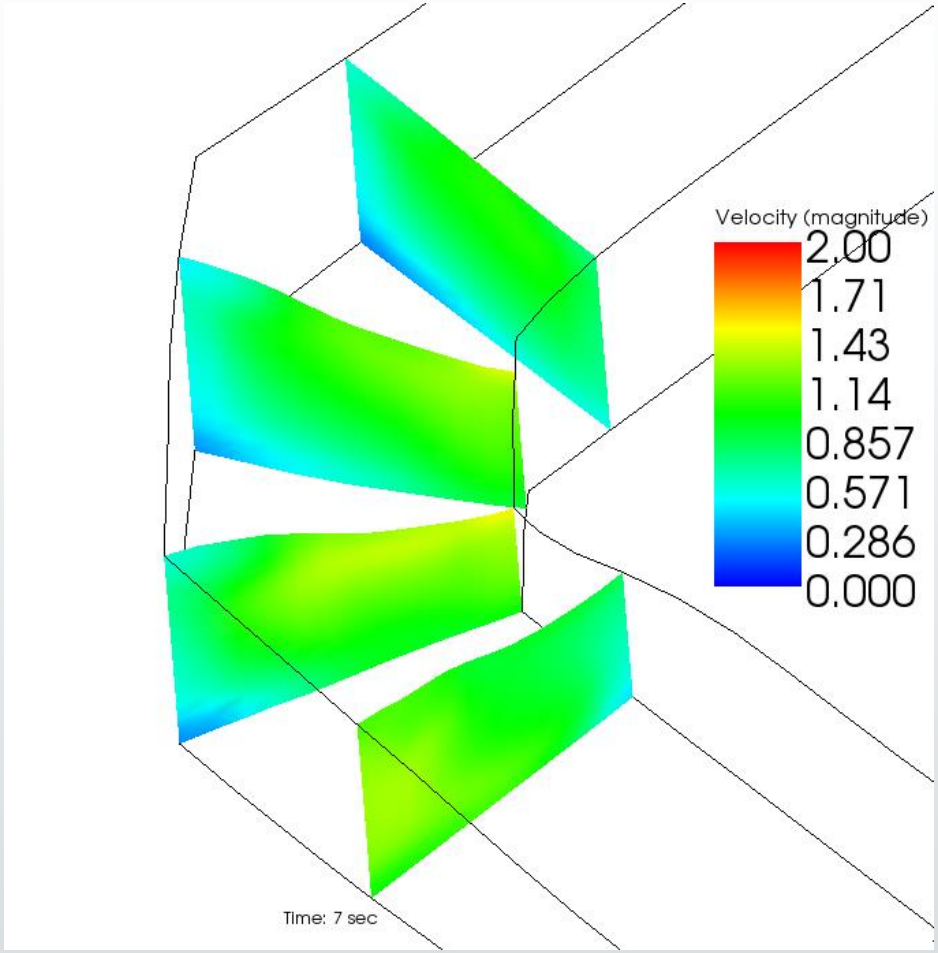
$\Delta h = 8{,}5$ cm



Poređenje rezultata - brzine

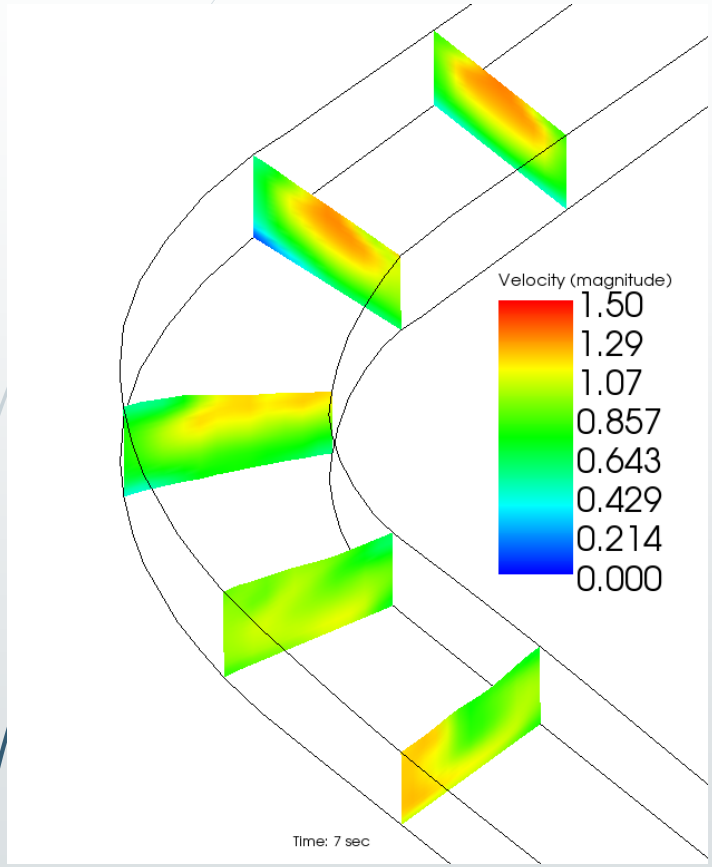


Varijanta I.1, t=7s

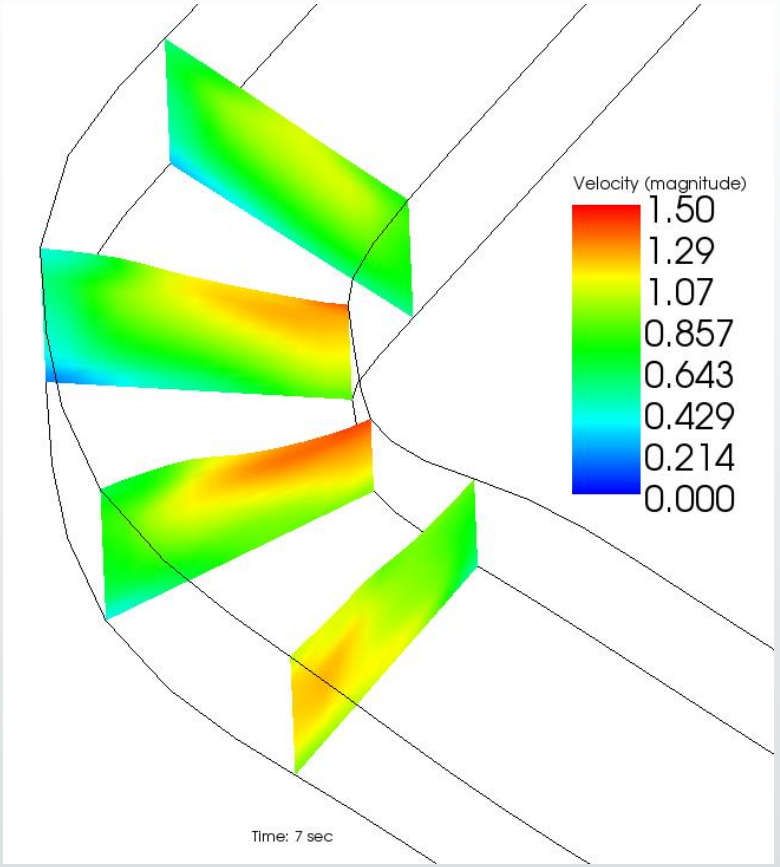


Varijanta II.1, t=7s

Poređenje rezultata - brzine

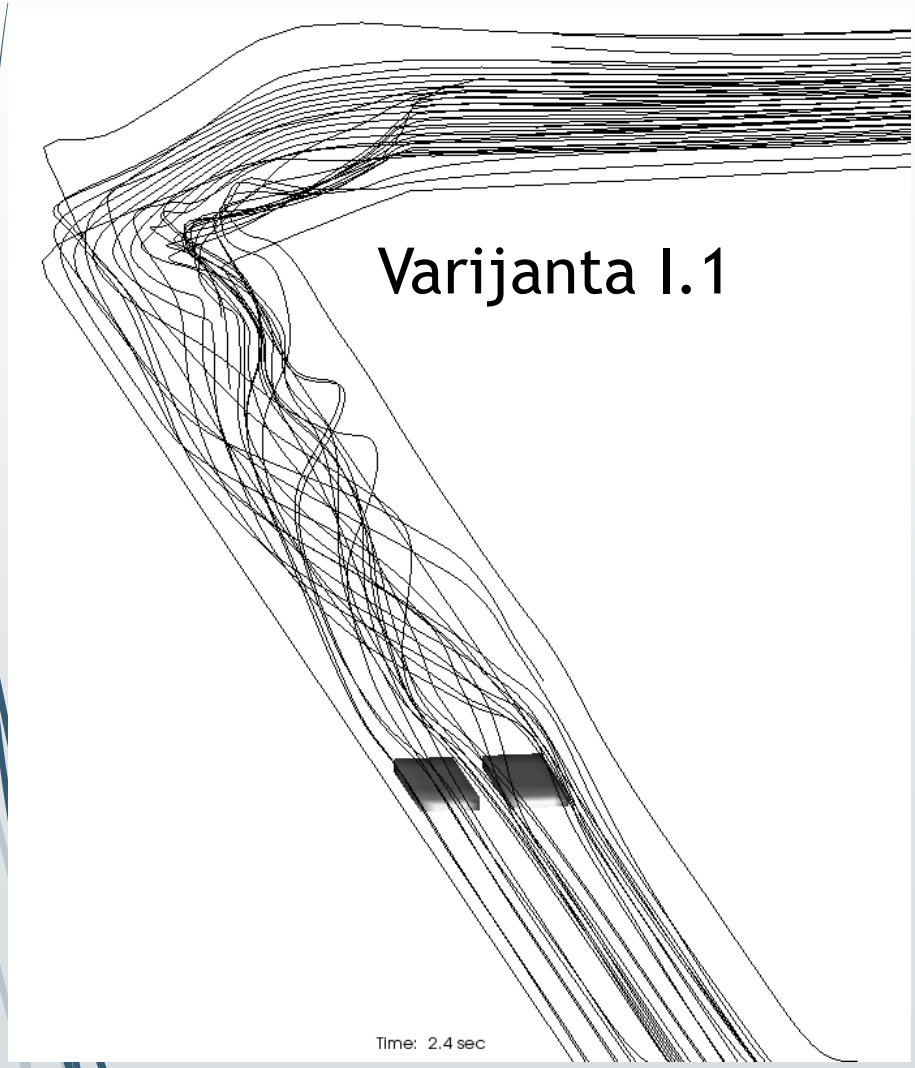


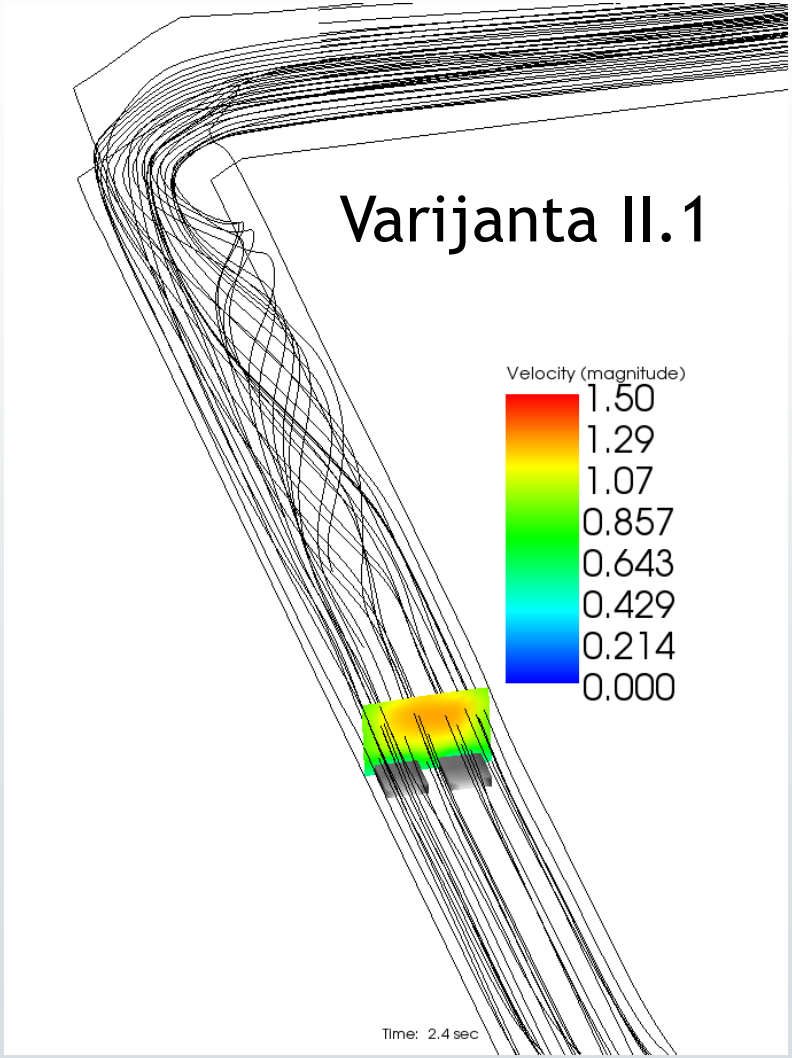
Varijanta I.2, t=7s



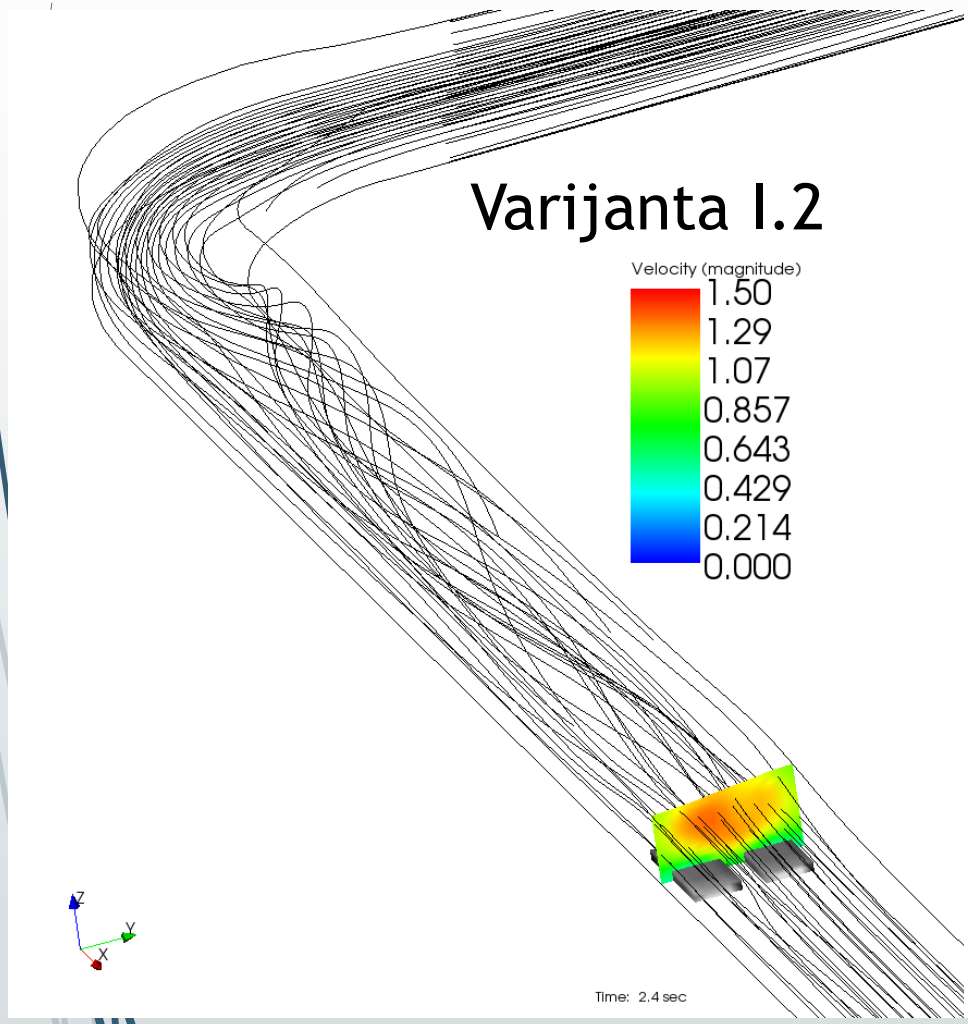
Varijanta II.2, t=7s

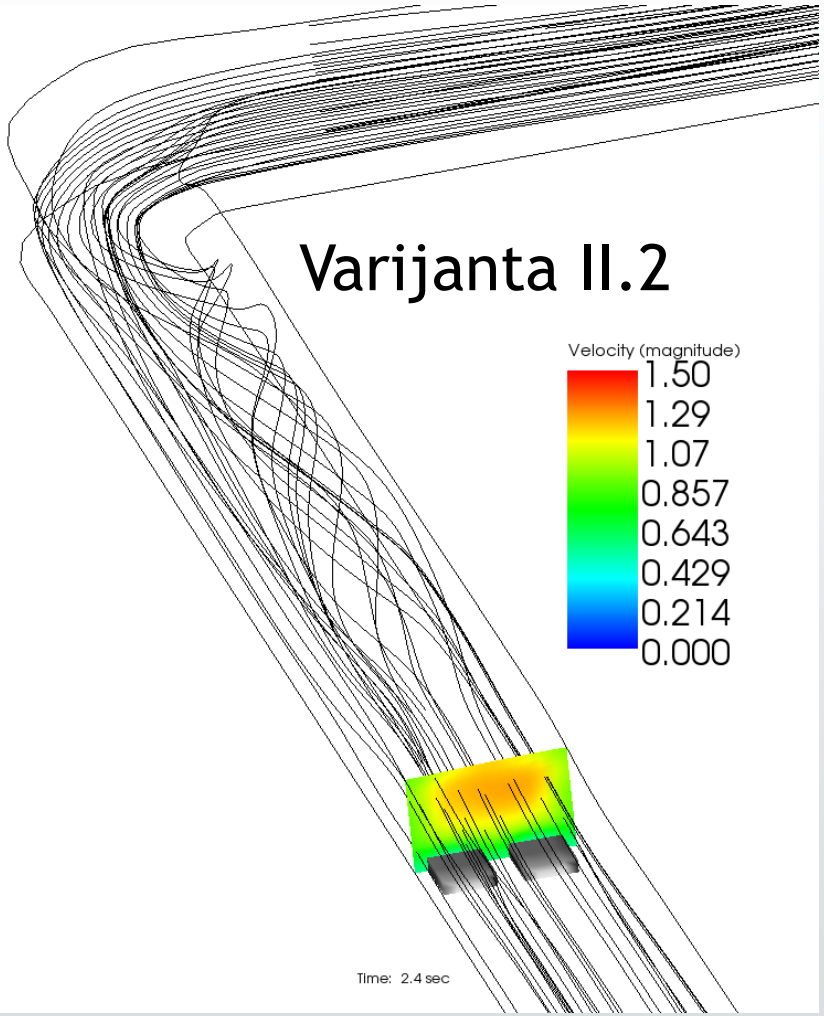
Poređenje rezultata - Strujno polje



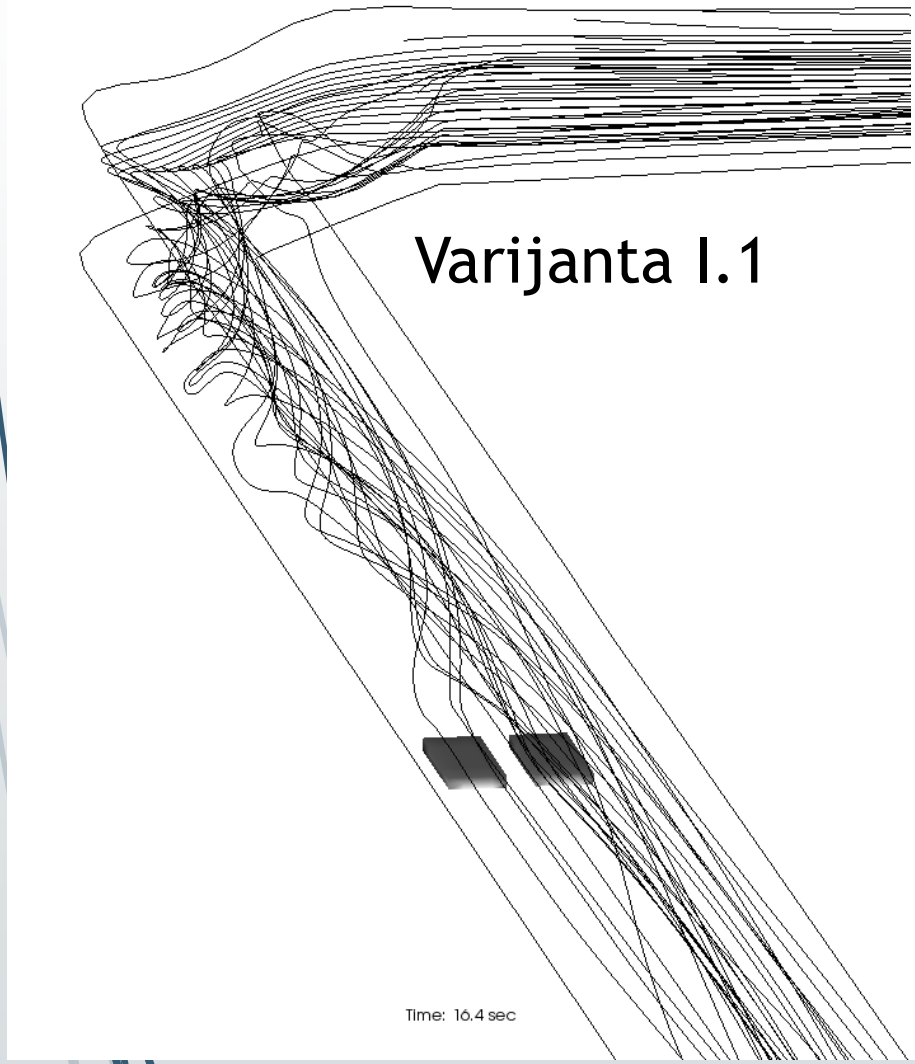


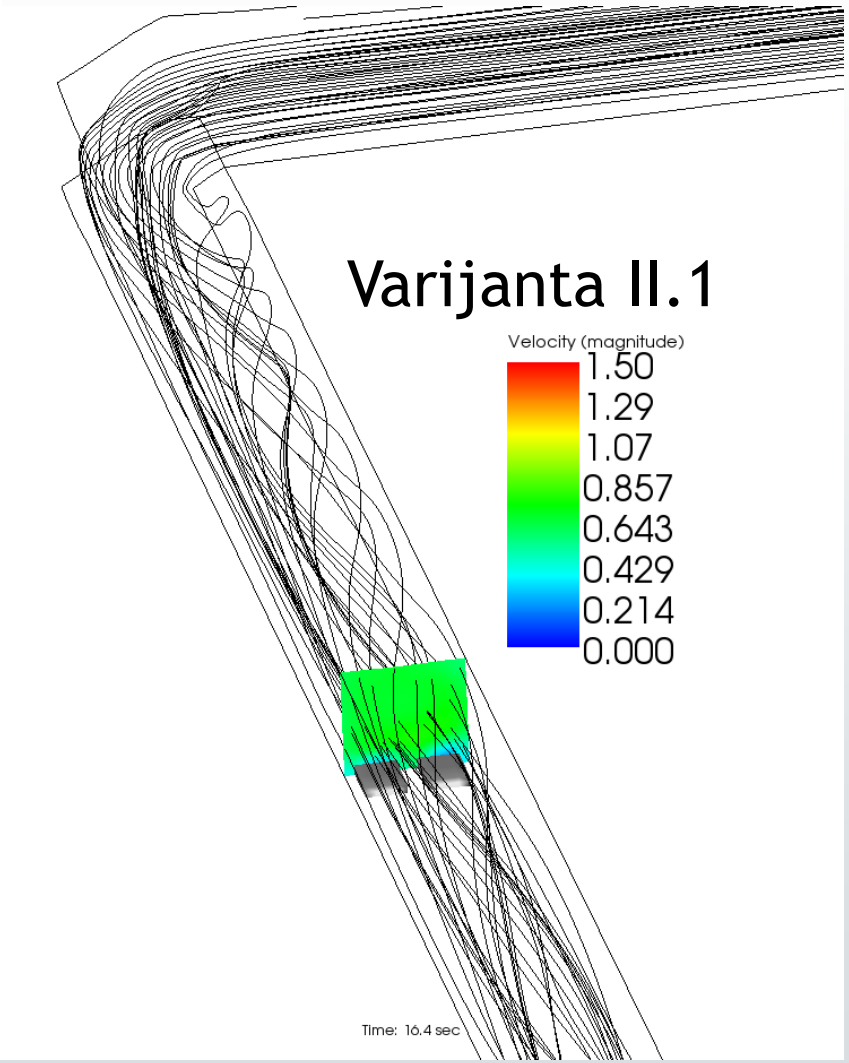
Poređenje rezultata - Strujno polje



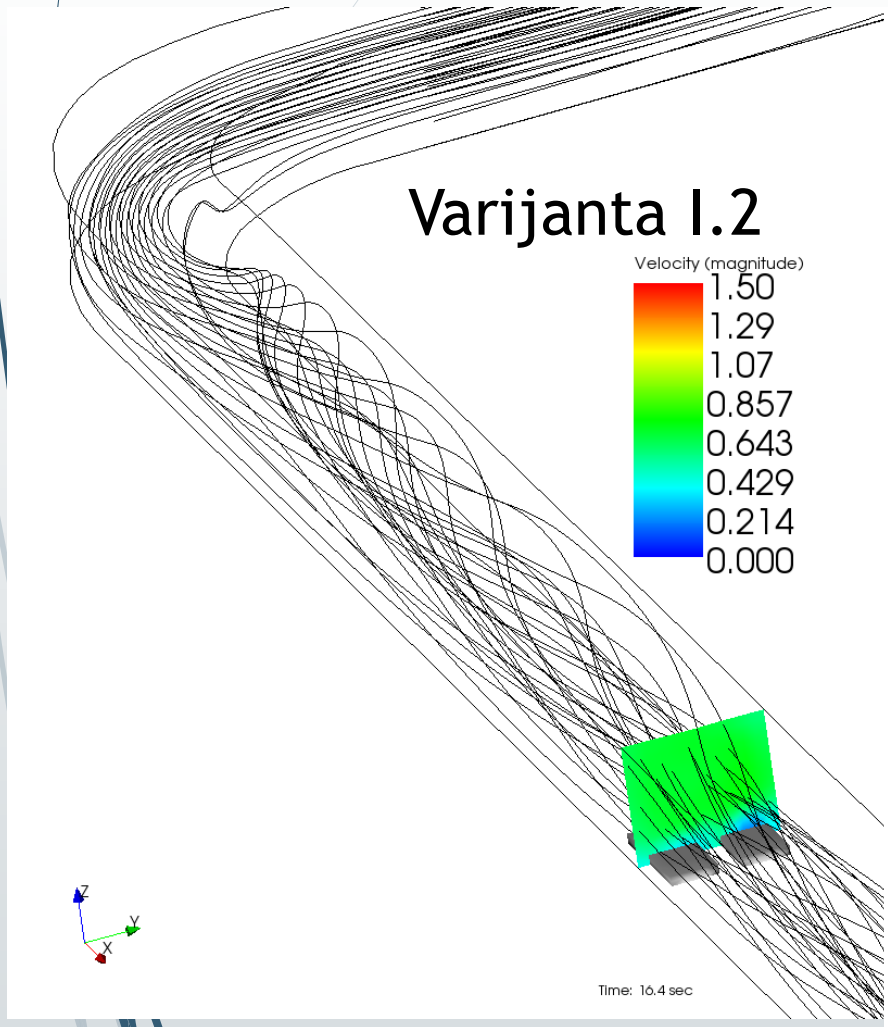


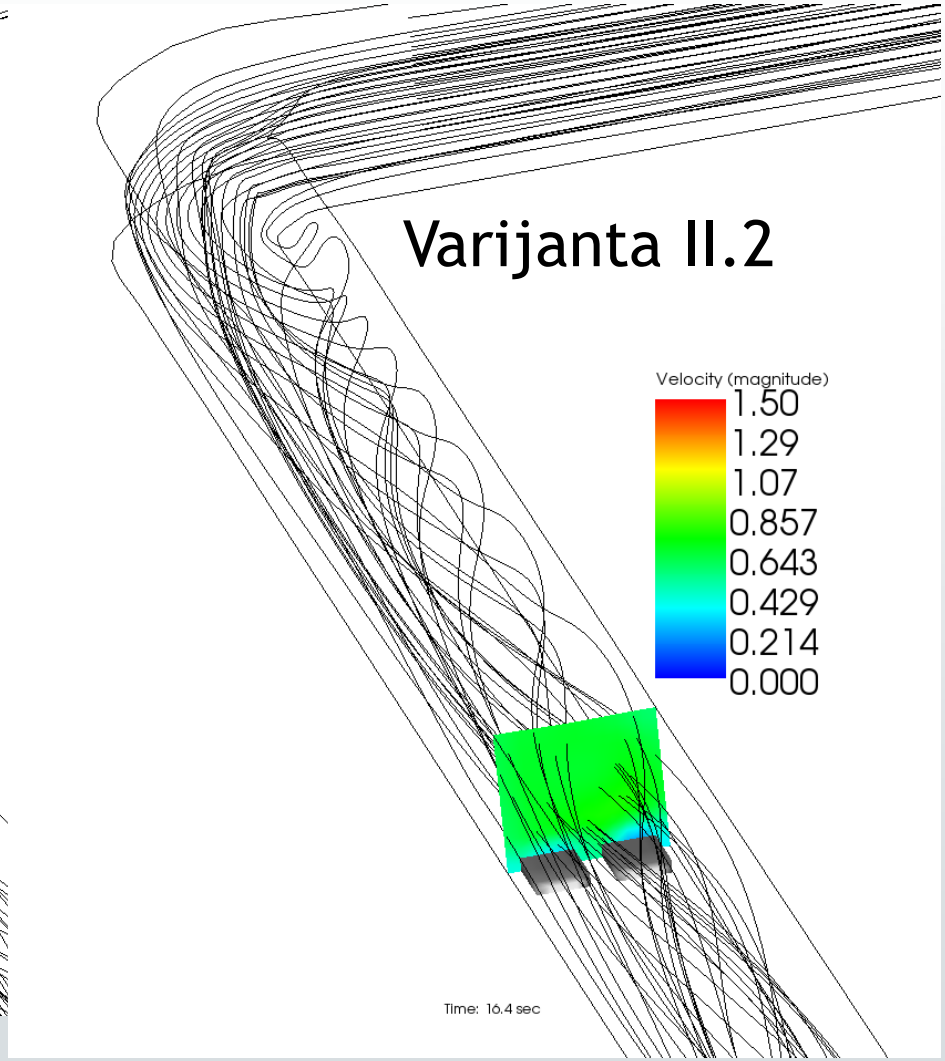
Poređenje rezultata - Strujno polje



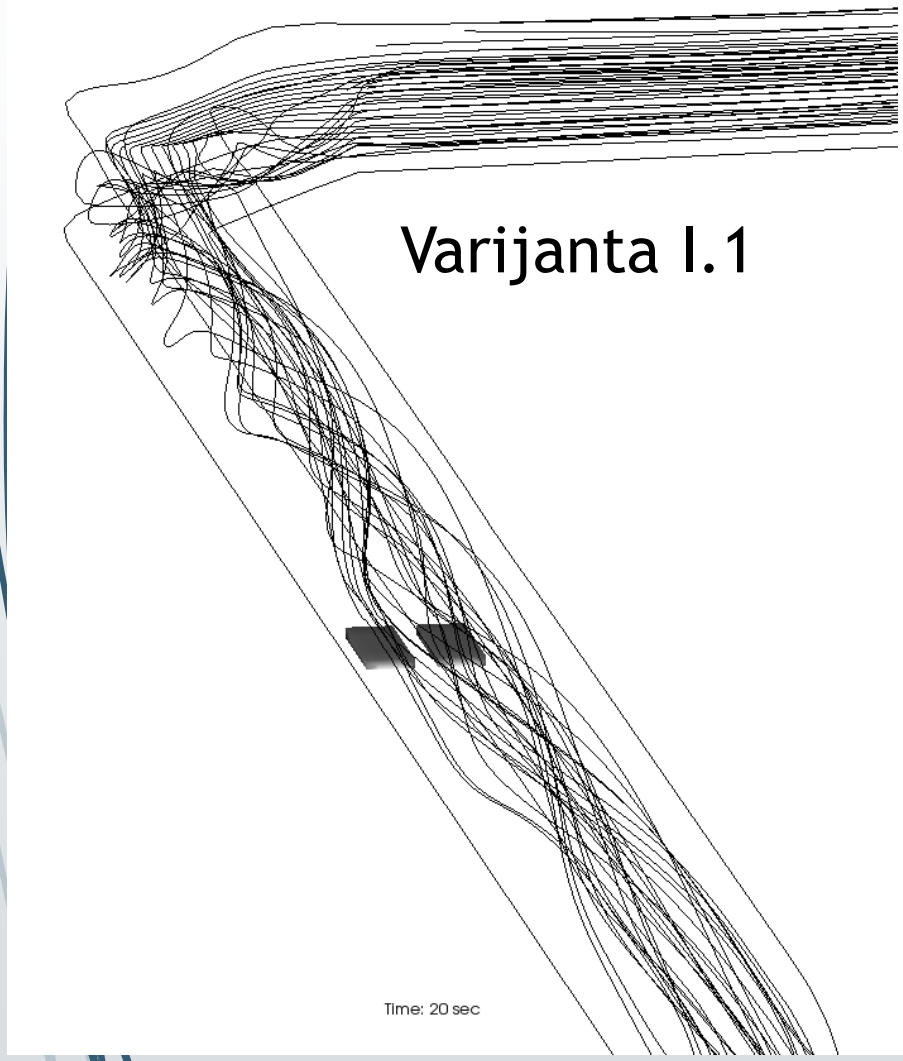


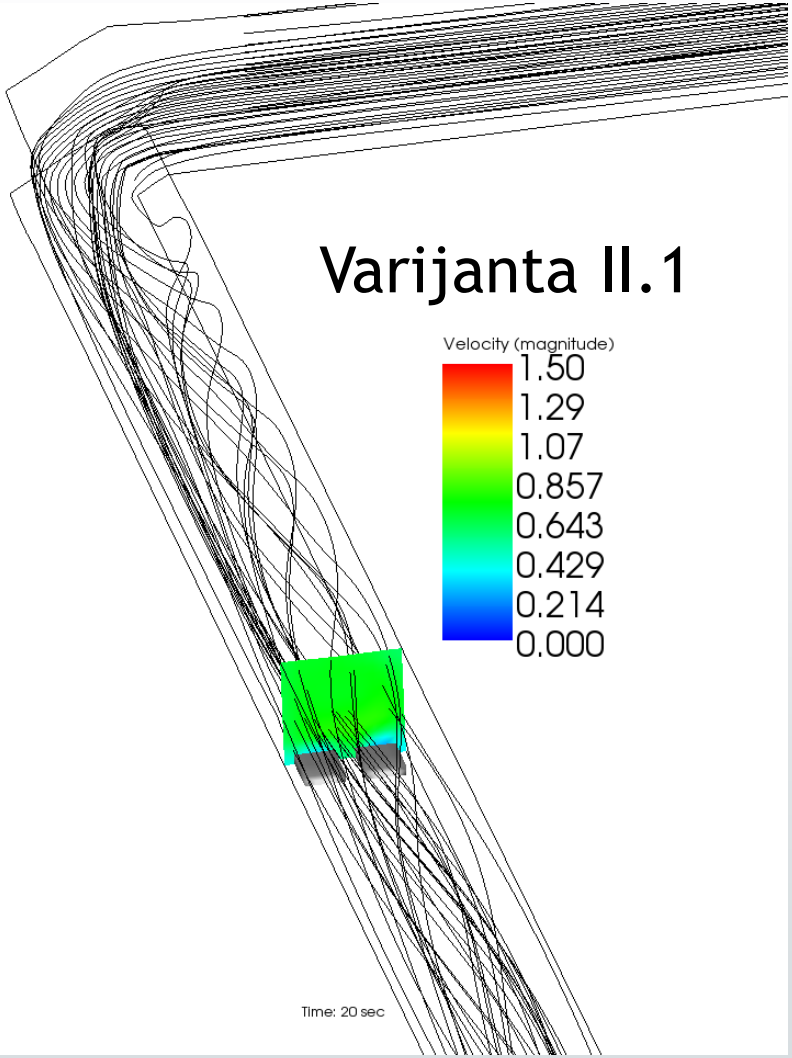
Poređenje rezultata - Strujno polje





Poređenje rezultata - Strujno polje





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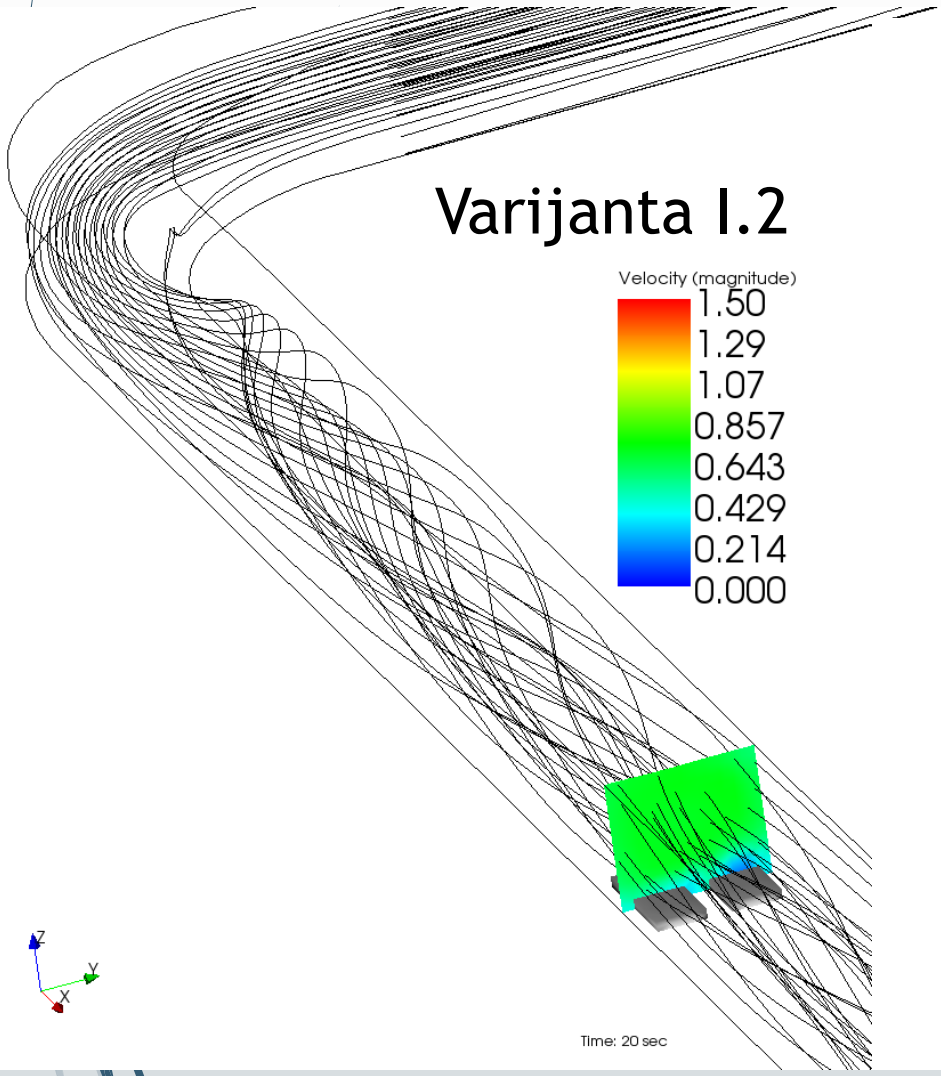

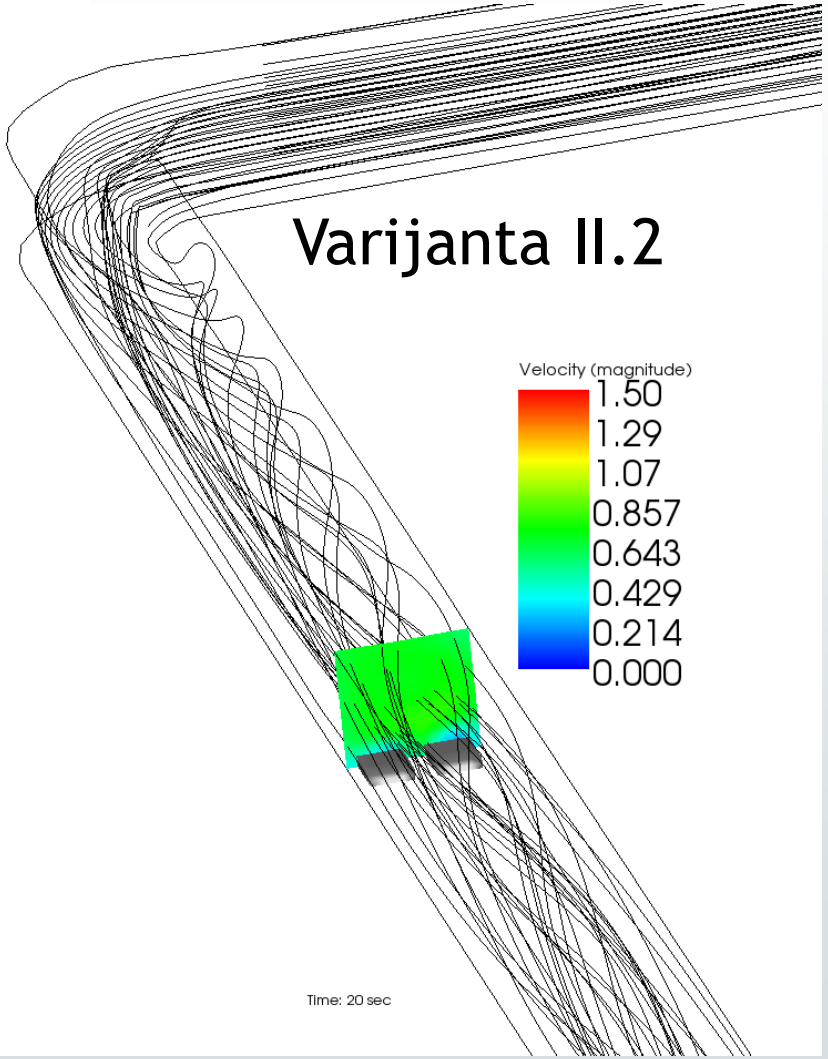

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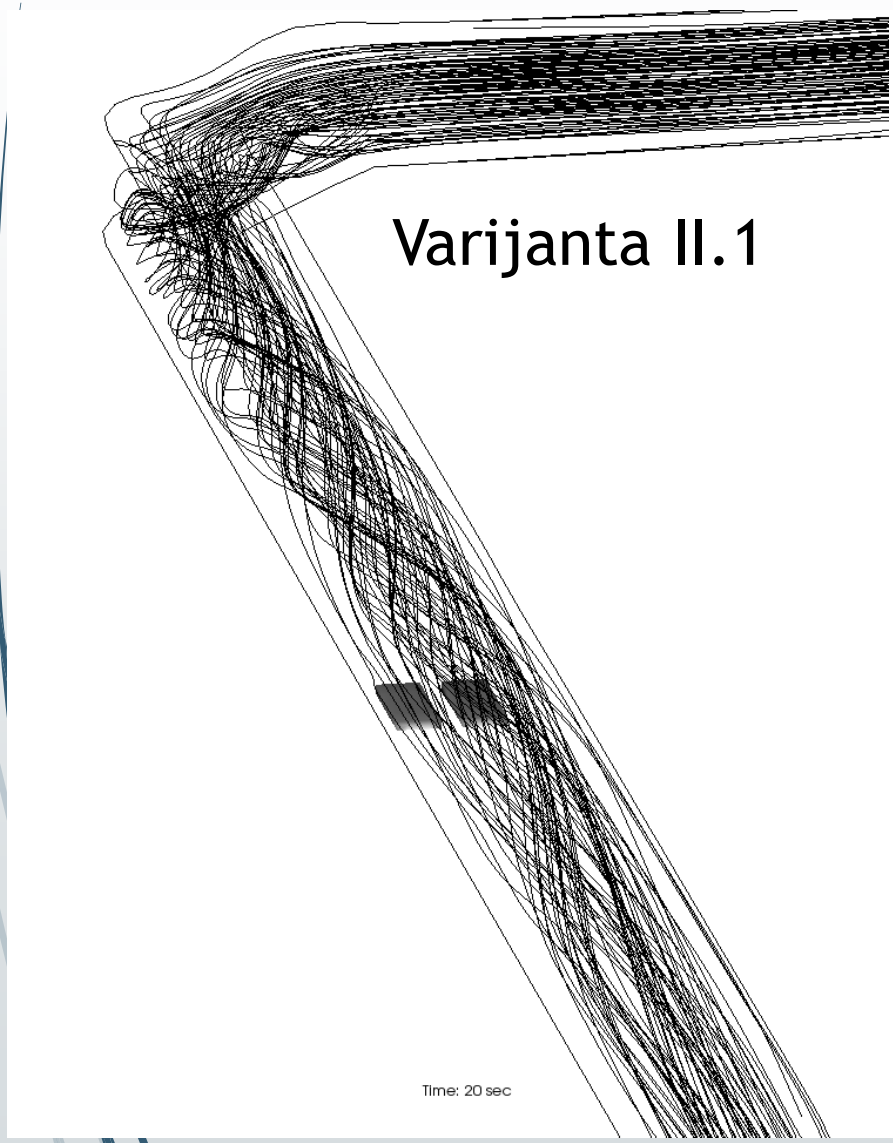
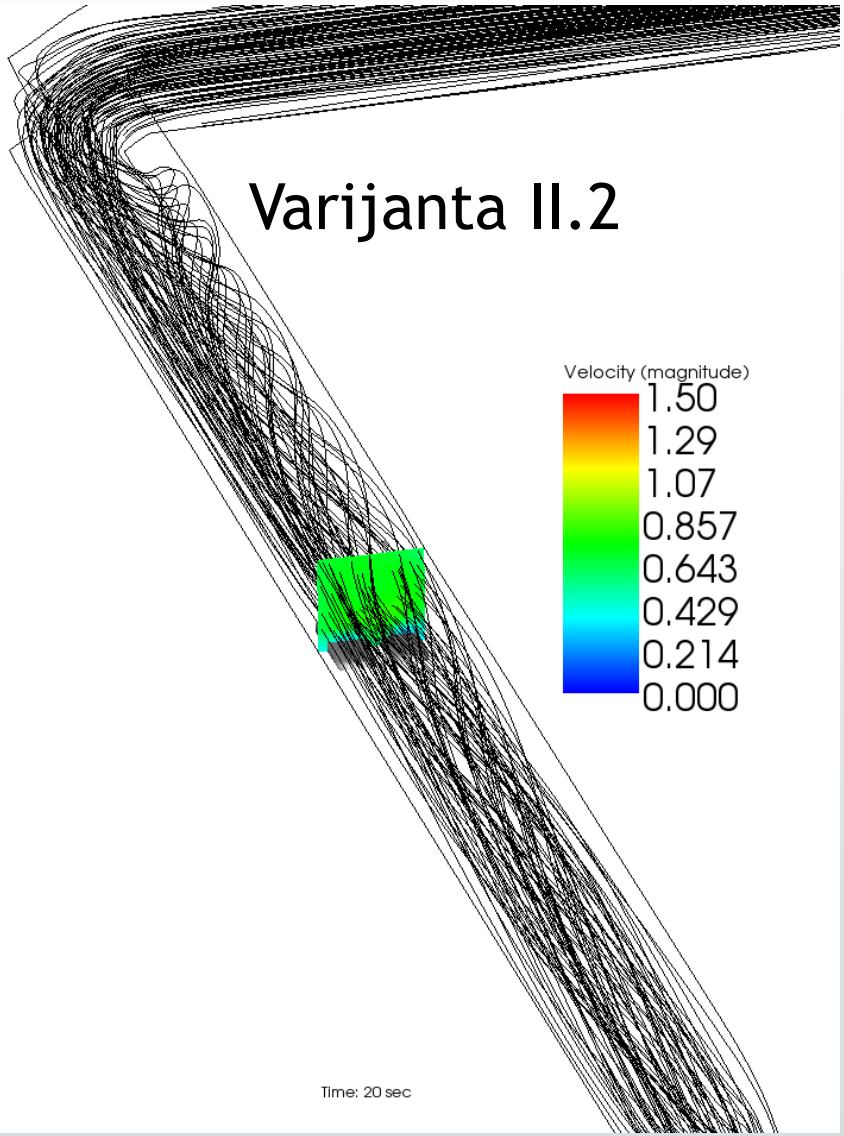
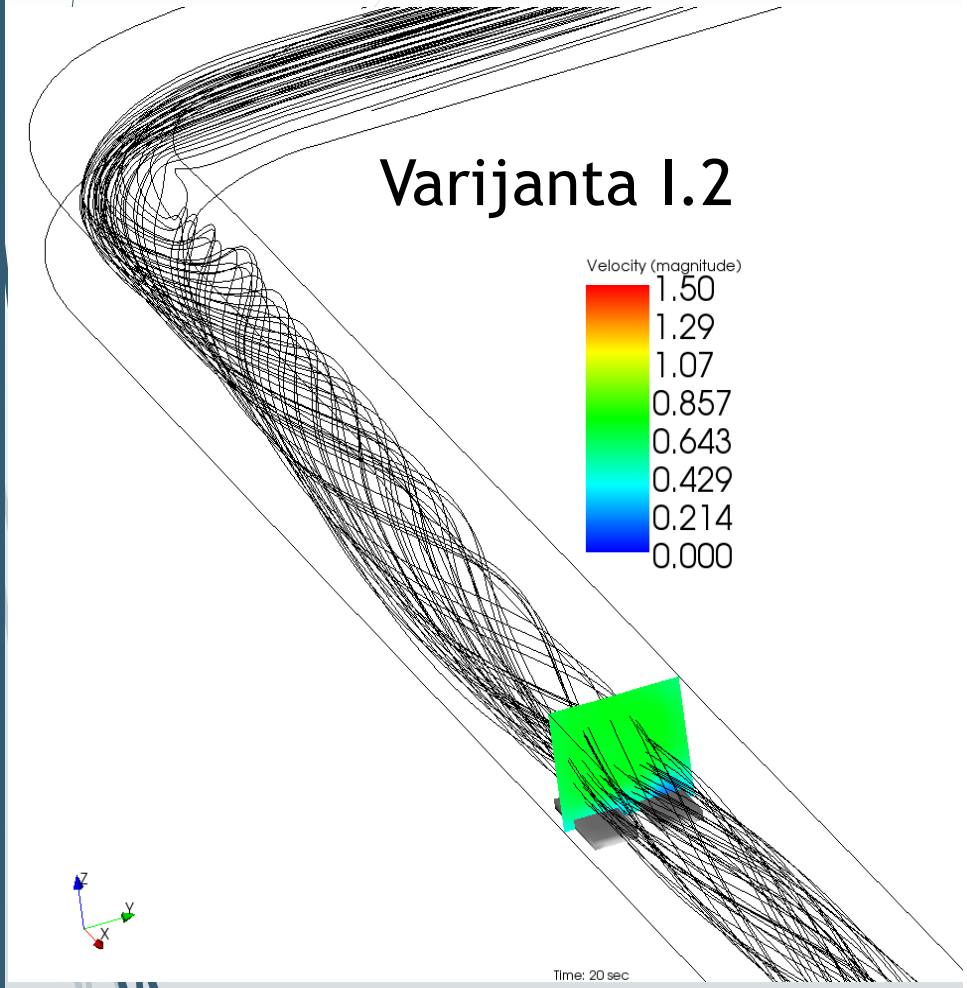
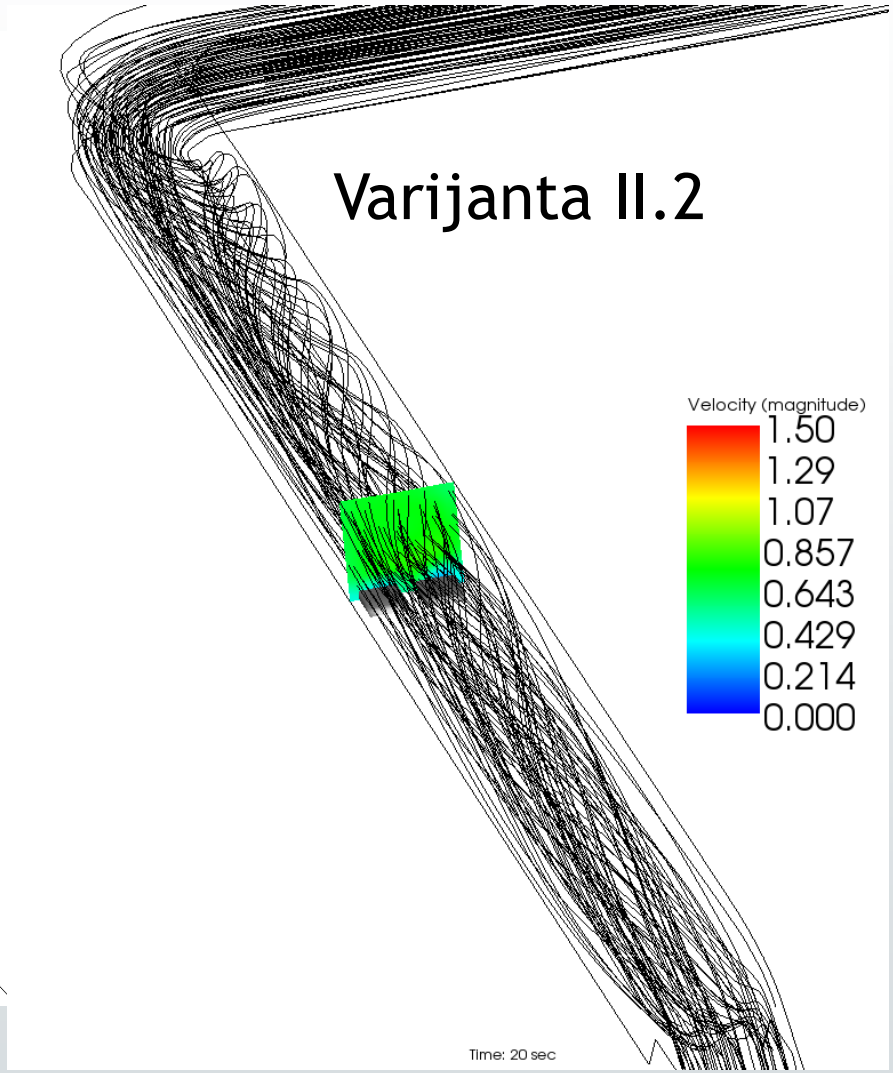


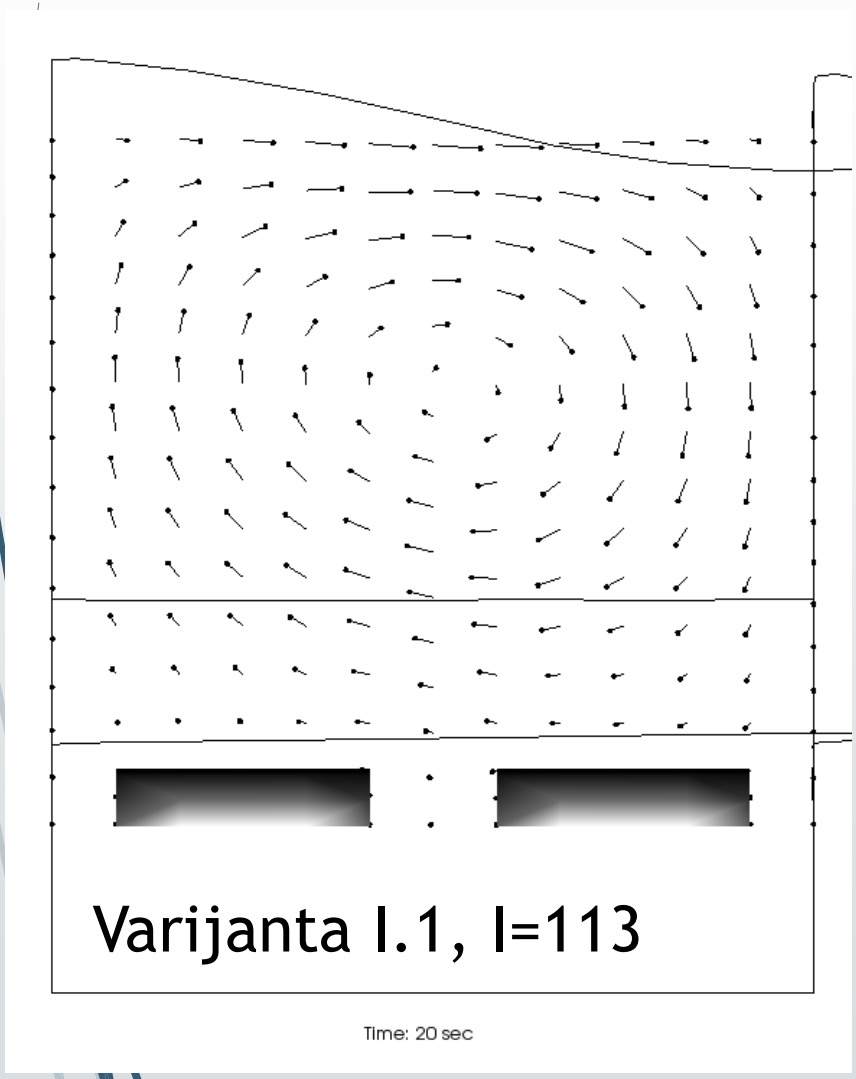


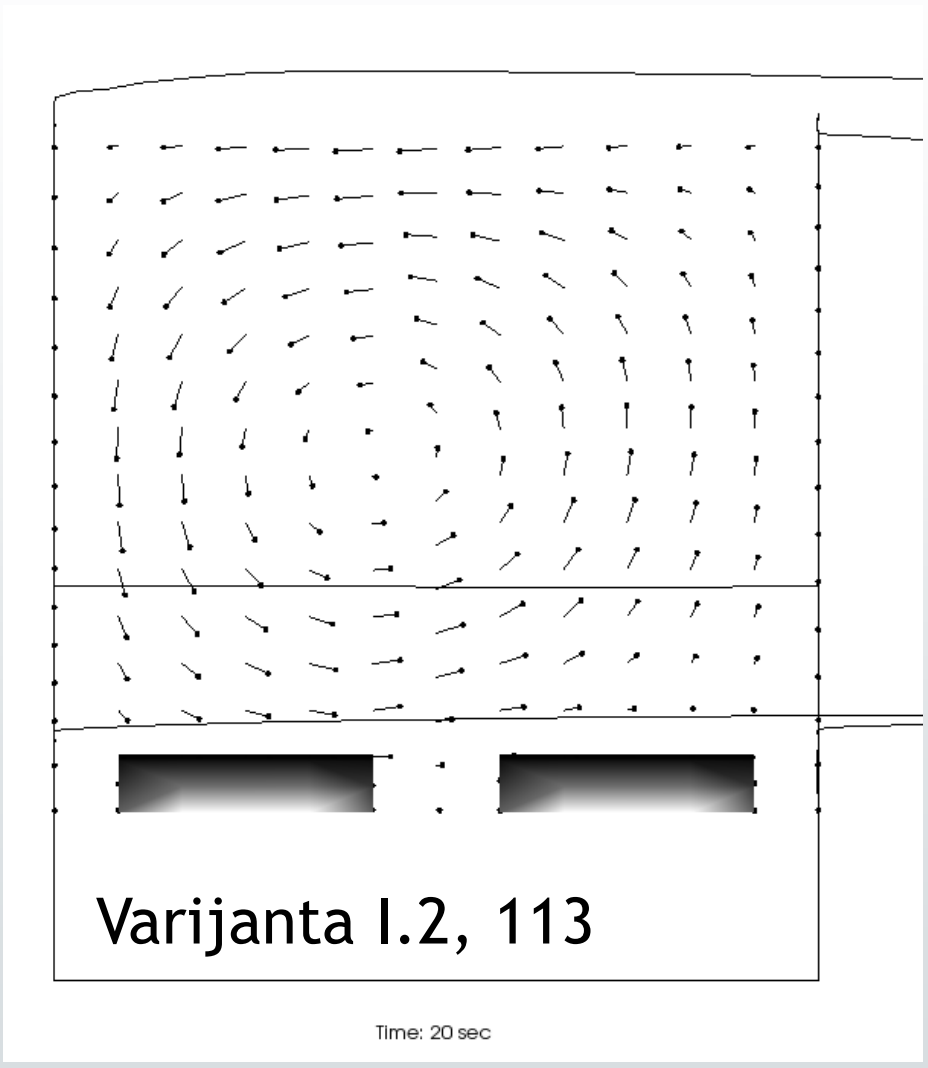
Poređenje rezultata - Strujno polje



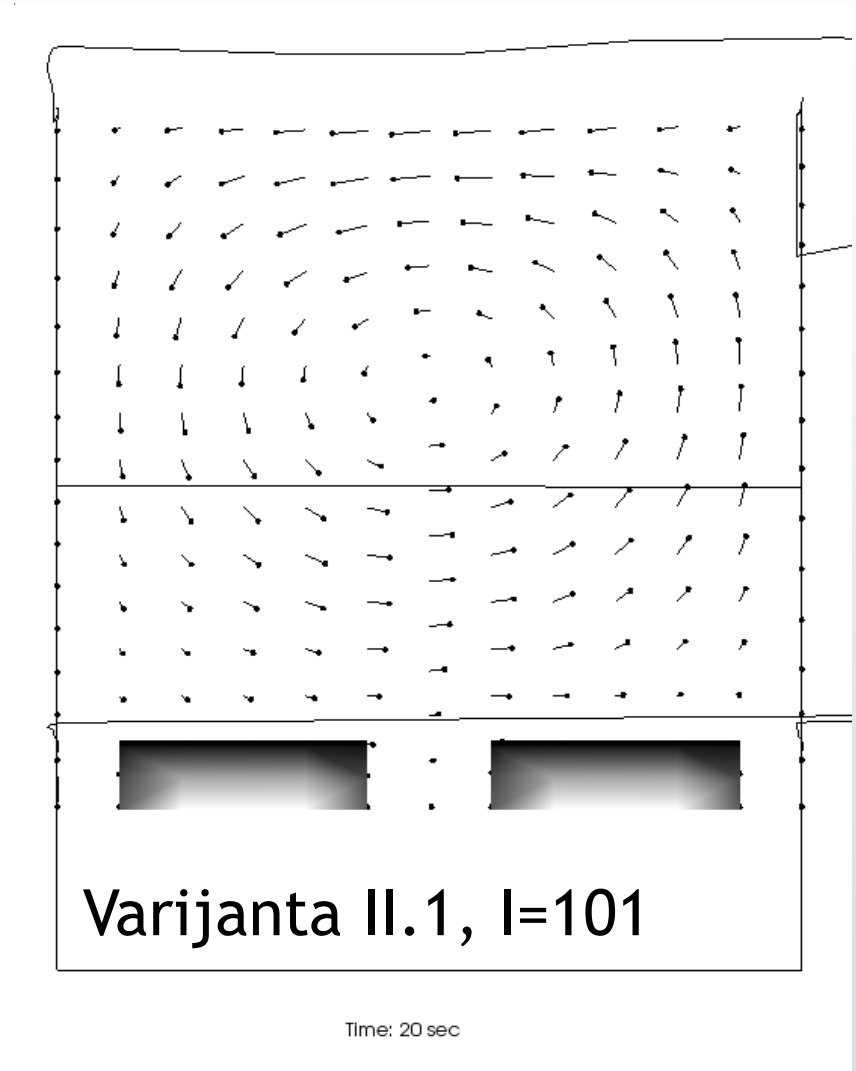


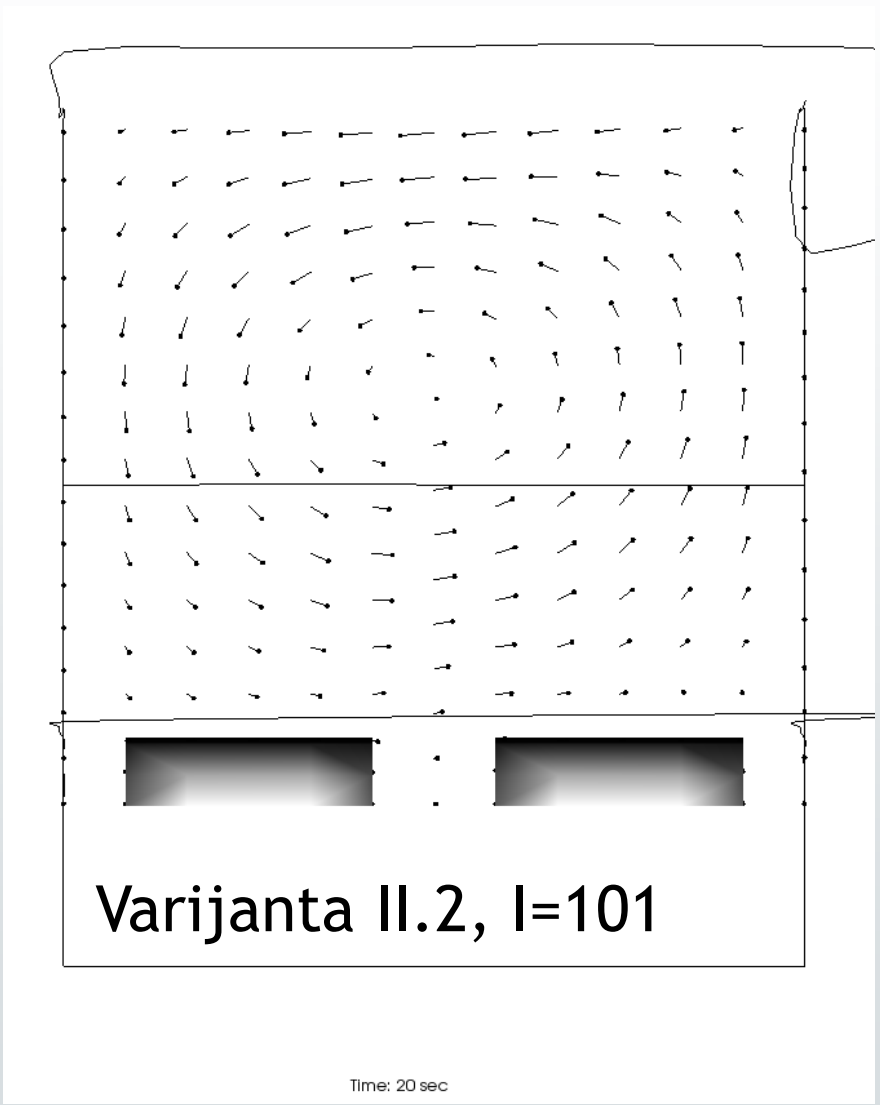
Varijanta I – Strujno polje



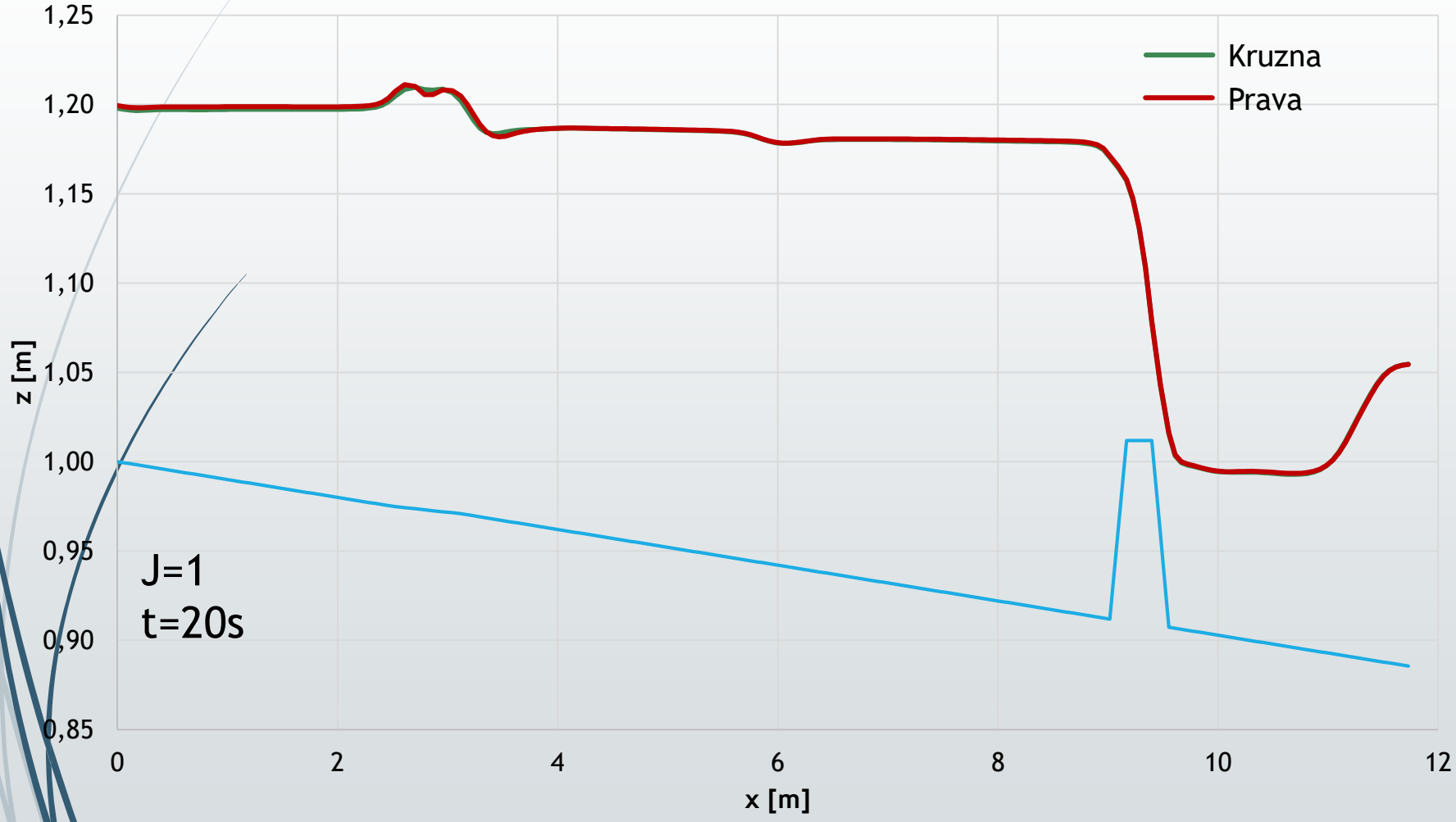


Varijanta II – Strujno polje

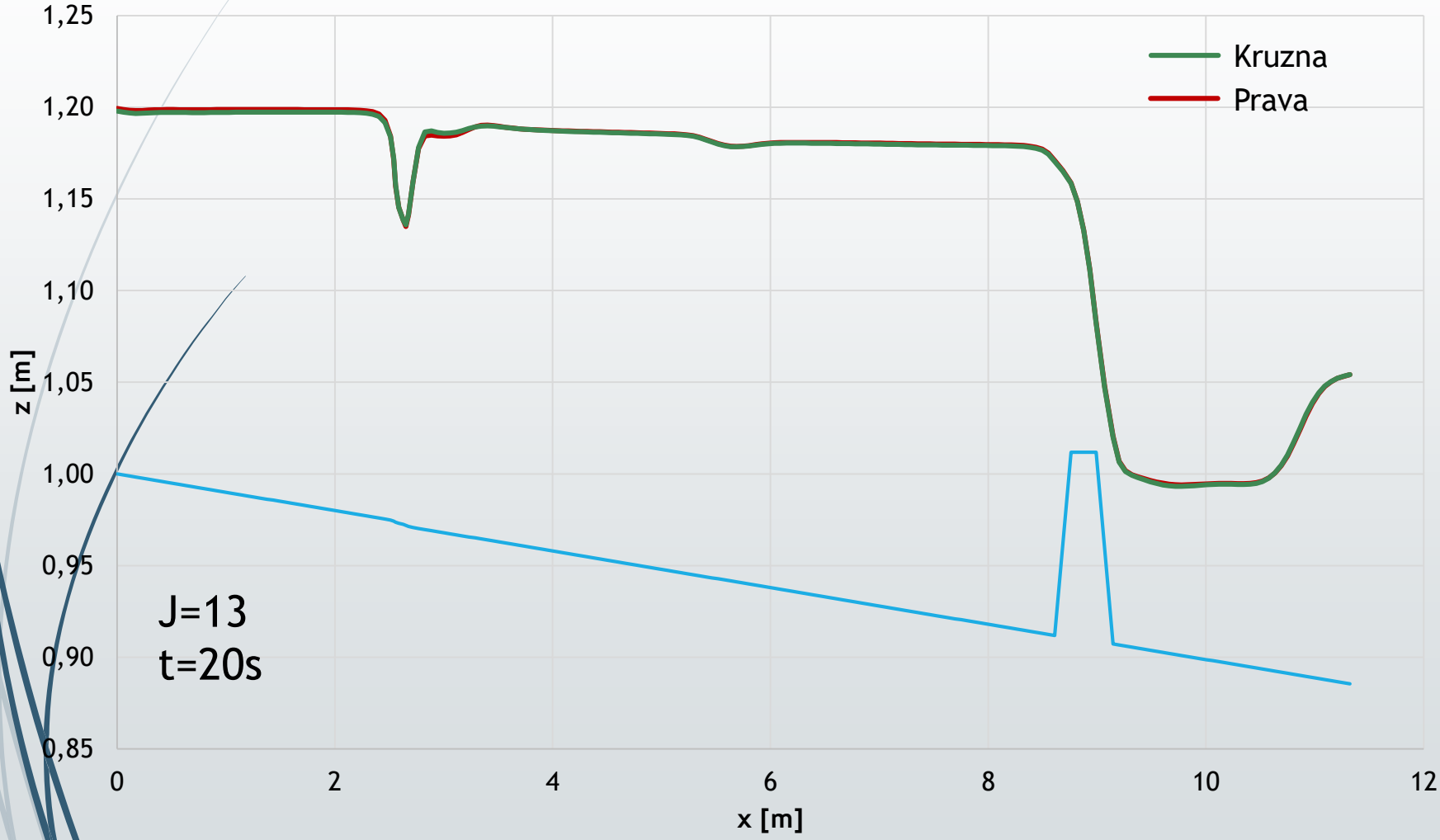




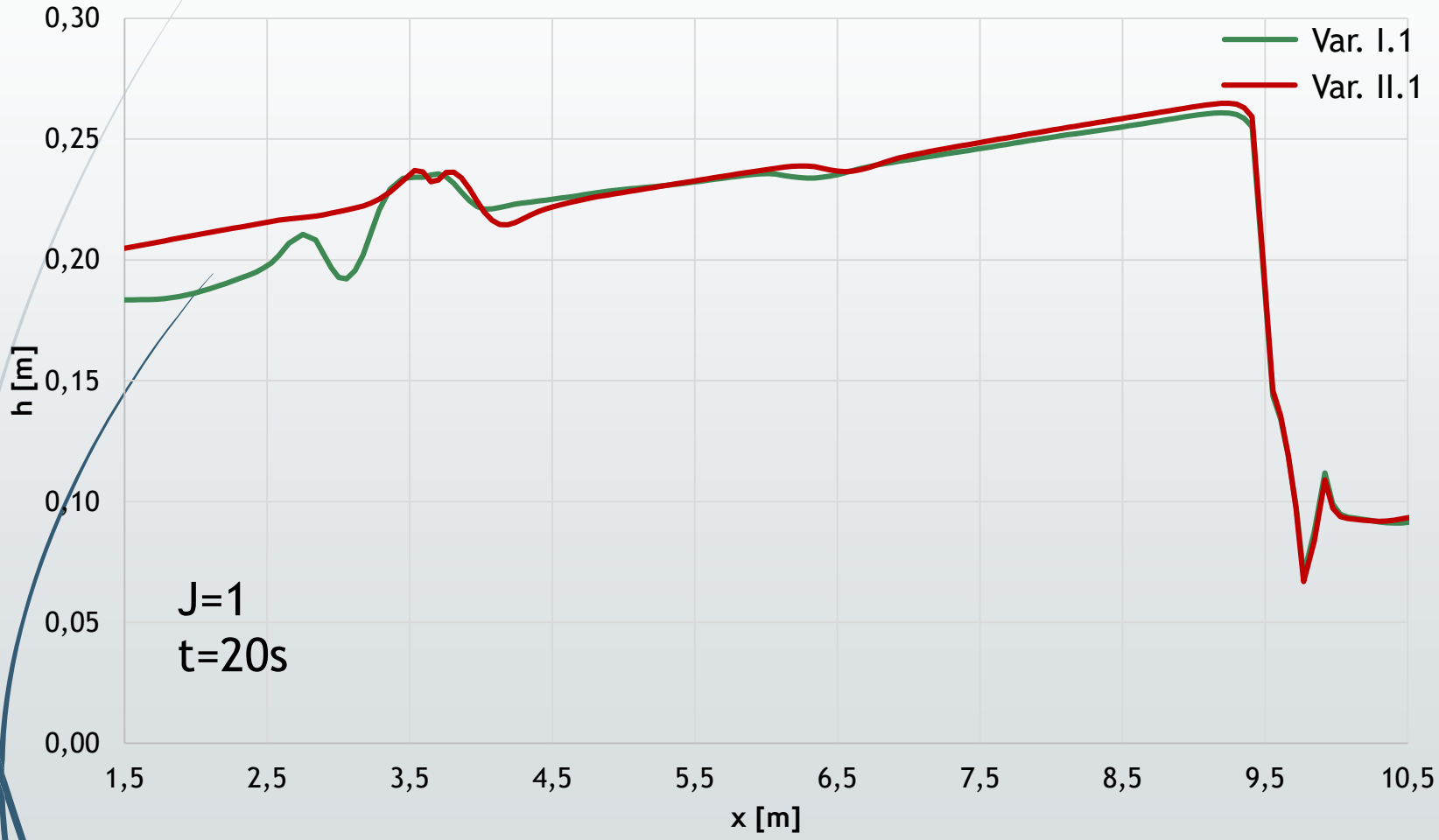
Varijanta II – nivoi uz desni zid



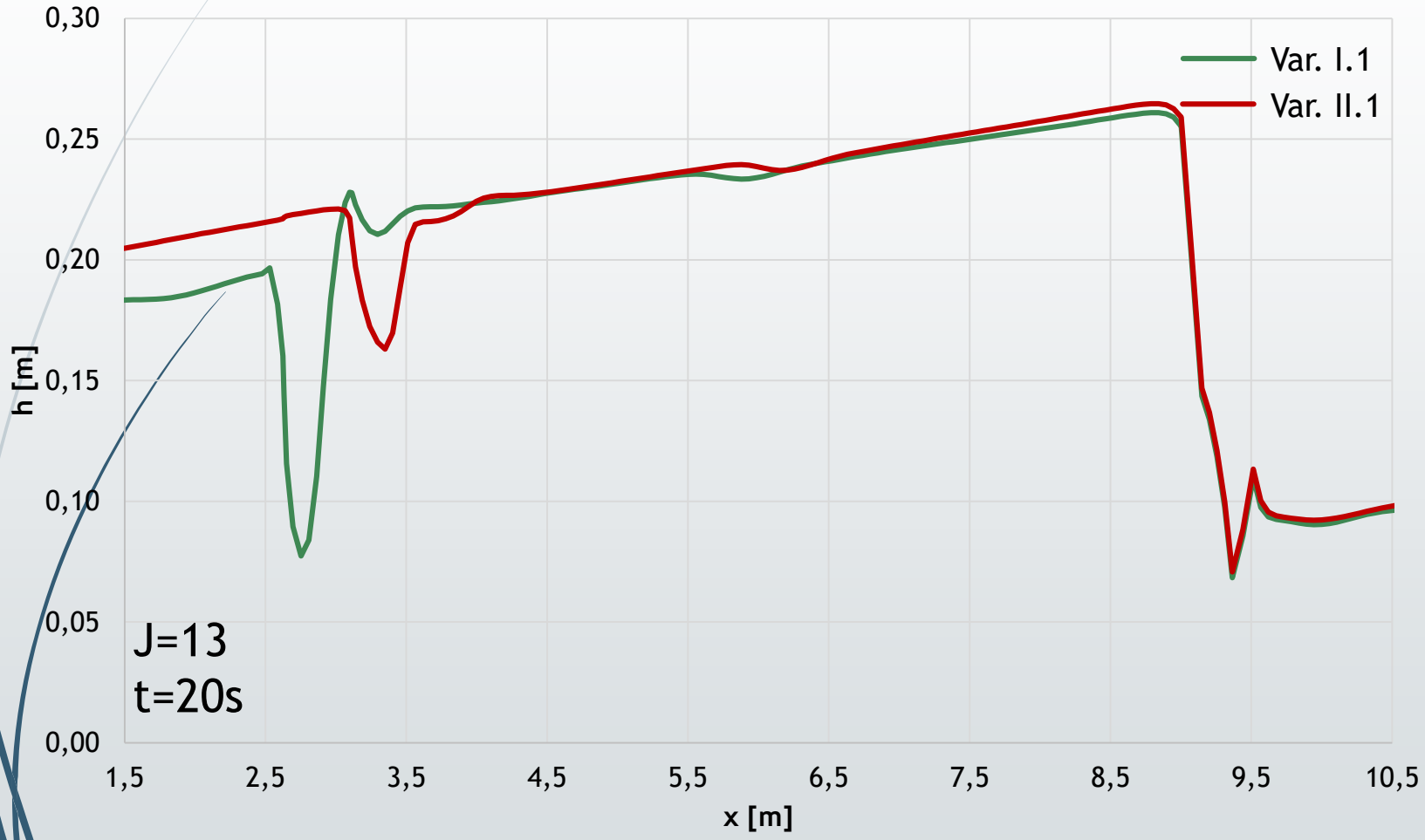
Varijanta II – nivoi uz desni zid



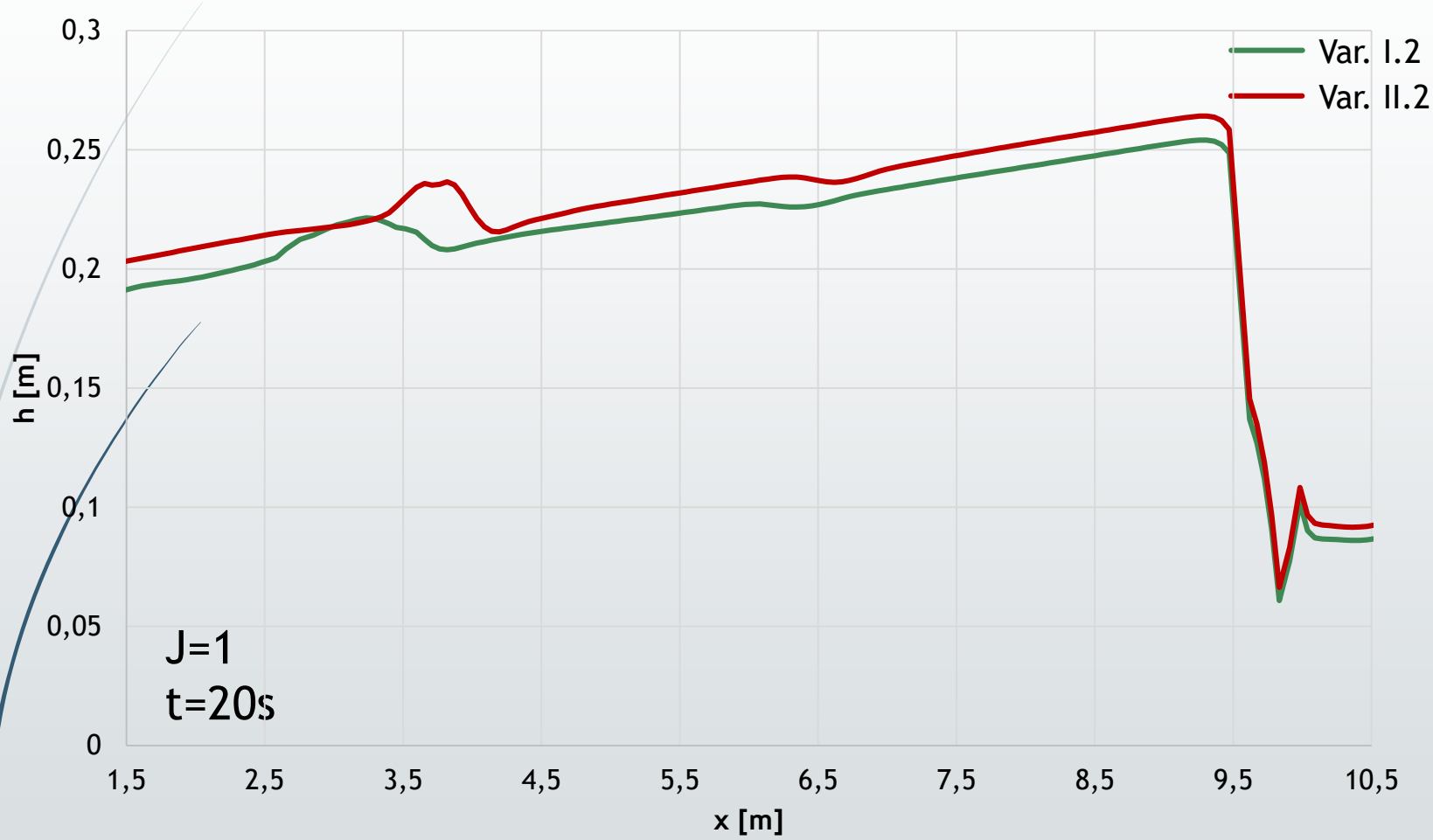
Dubine uz desni zid – prava prel.



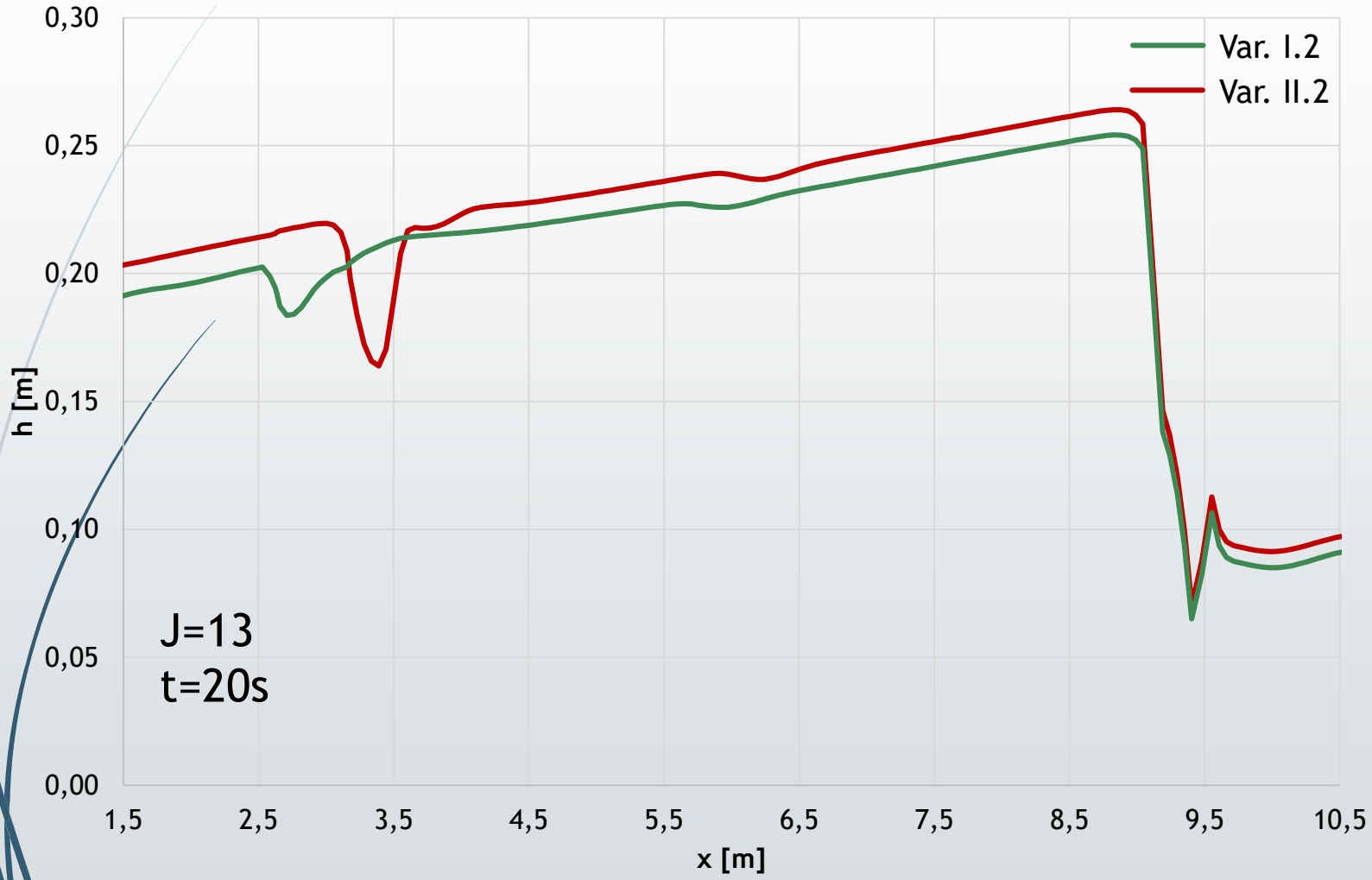
Dubine uz levi zid – prava prel.



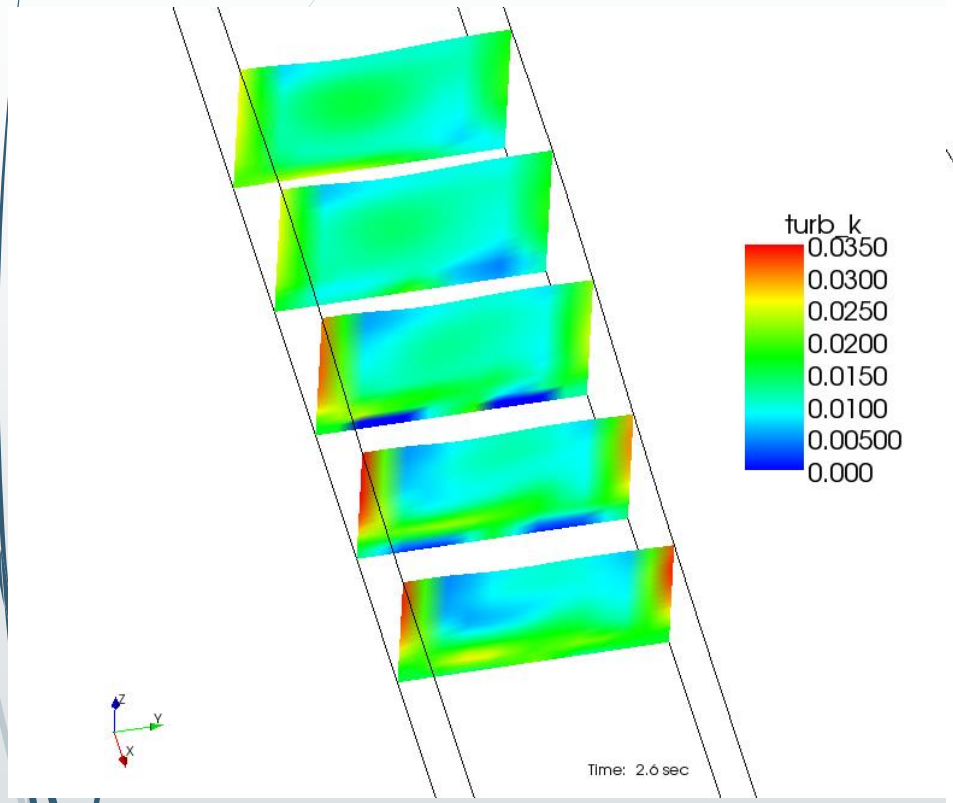
Dubine uz desni zid – kružna prel.



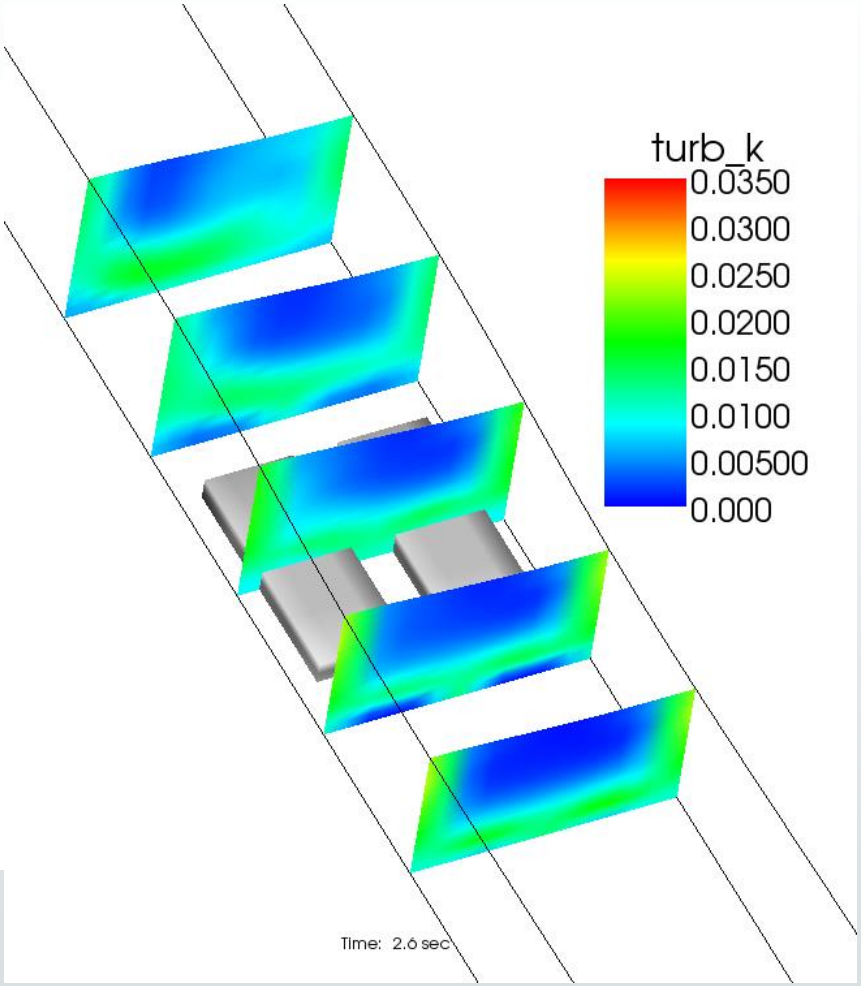
Dubine uz levi zid – kružna prel.



Poređenje rezultata - k

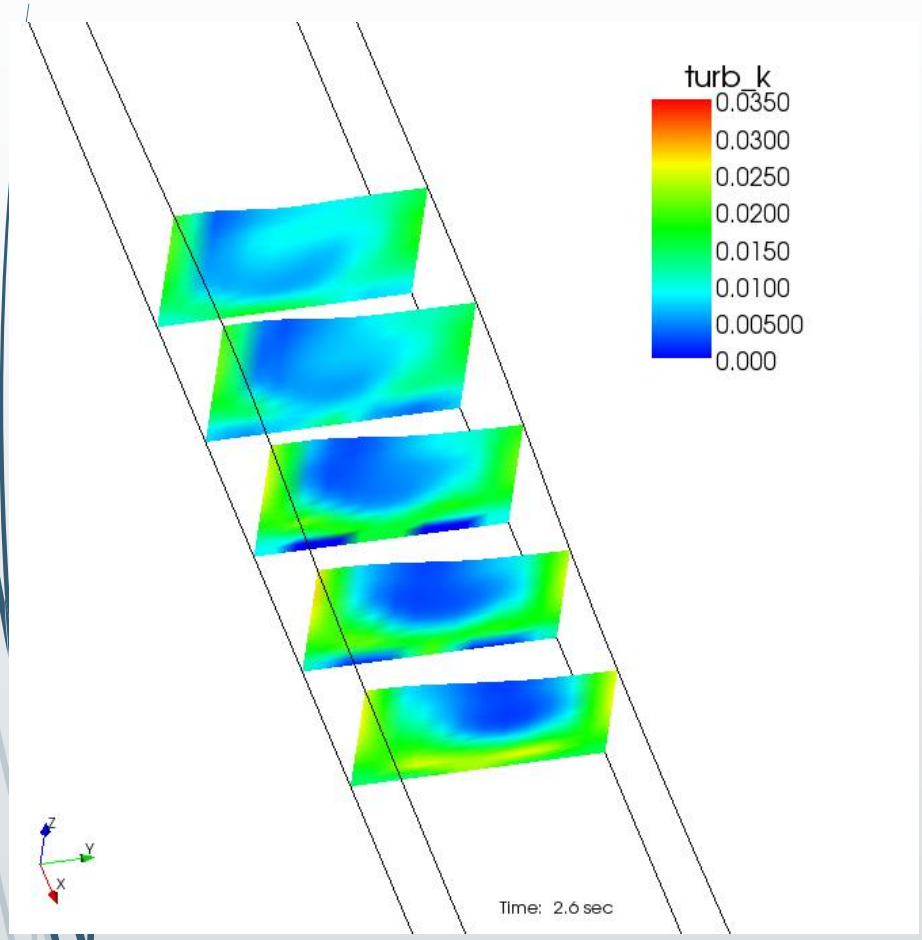


Varijanta I.1, t=2,6s

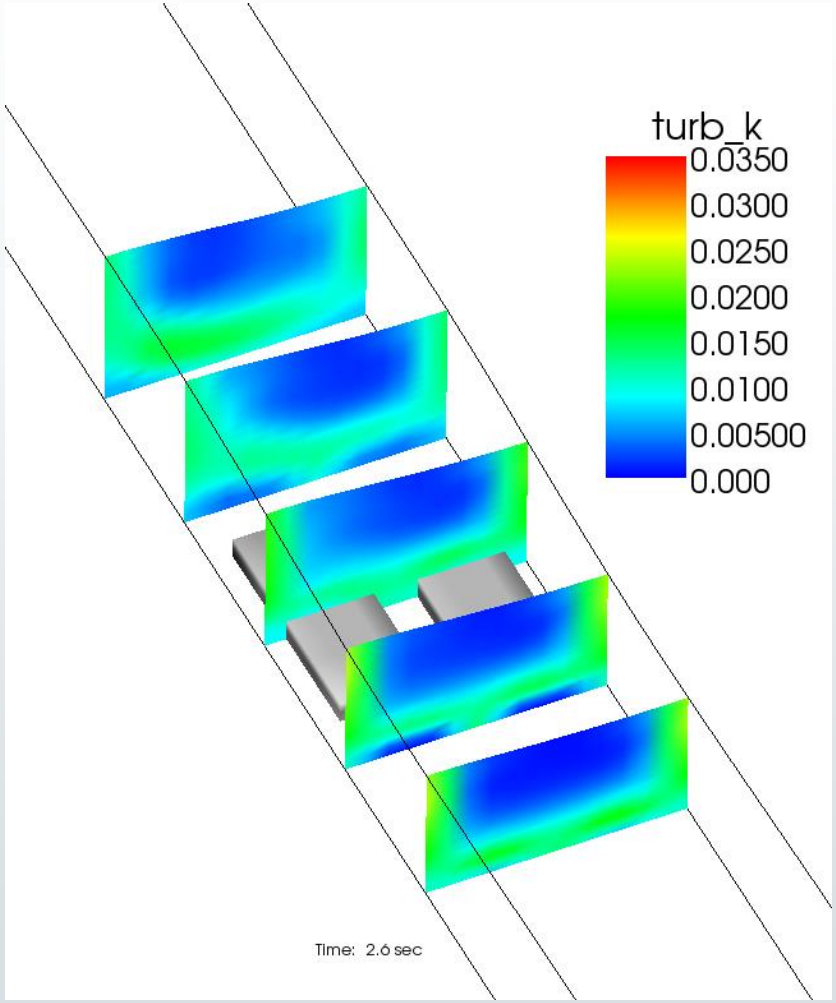


Varijanta II.1, t=2,6s

Poređenje rezultata - k



Varijanta I.2, t=2,6s



Varijanta II.2, t=2,6s

Zaključci

- Kod duže prelaznice (varijanta I) postoje značajne razlike u strujanju u nizvodnoj deonici za različite oblike krivine
- Kod kratke prelaznice (varijanta II) NE postoje značajne razlike u strujanju u nizvodnoj deonici za varijante prelaznice – pretpostavka da oblik kratke prelaznice ne utiče na stujanje onoliko koliko je to slučaj kod duže prelaznice
- Poklapanje sa analitičkim izrazom je solidno za kružne prelaznice, za prave prelaznice je odstupanje veće

Zaključci

- Različiti načini diskretizacije advektivnih članova i tip k-ε modela (L ili NL) daju slične rezultate (testirano samo na kanalima varijante II)
- Sonde za merenje, iako im je visina skoro red veličine manja od dubine vode, bitno utiču na strujno polje delujući kao potopljeni prelivni prag i smanjujući zakrivljenost strujnica nizvodno od mernog mesta!

Komentari

- Generalne zamerke na softver/solver:
  - „Problemi“ sa formiranjem pada dna kanala!
  - Hidraulički skok???
  - Optimizacija kôda – kapaciteti računara neiskorišćeni
  - 3D rotacija u postprocesiranju je problematična