

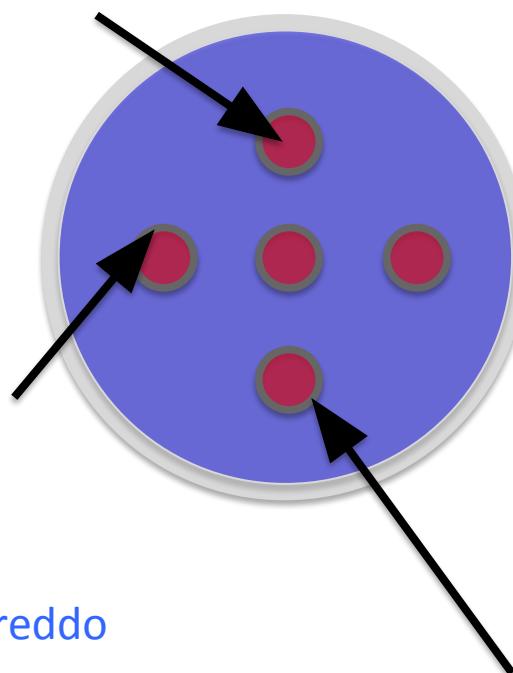
# Scambiatore di calore

M Hueller et al.

May 2018

# Scambiatore a fascio tubiero

Fluido caldo



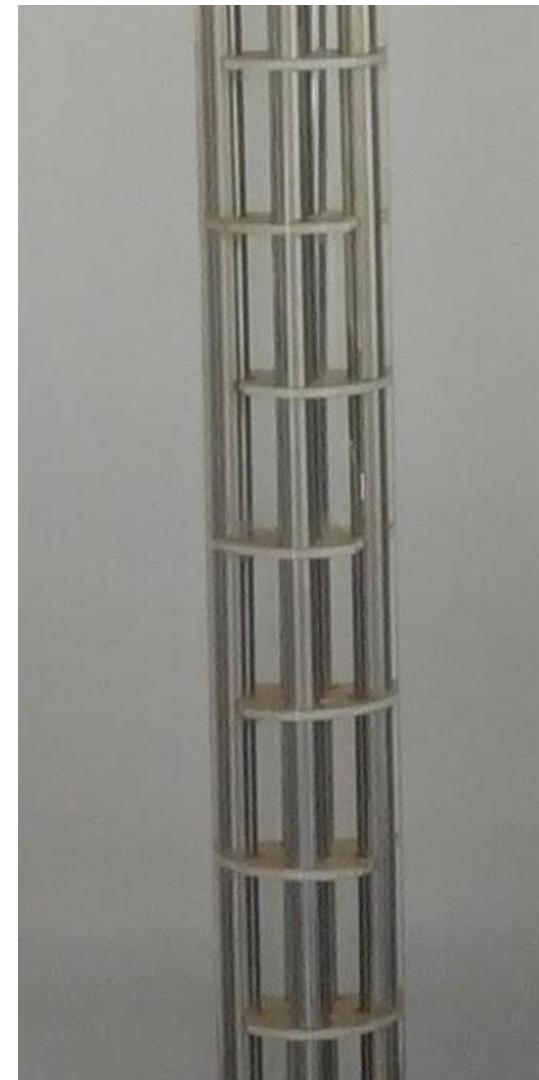
Vetro borosilicato  
(Pirex)

$$d_I = 50 \text{ mm}$$

Fluido freddo

Acciaio AISI 316

$$n = 5$$



# Tubi del fascio

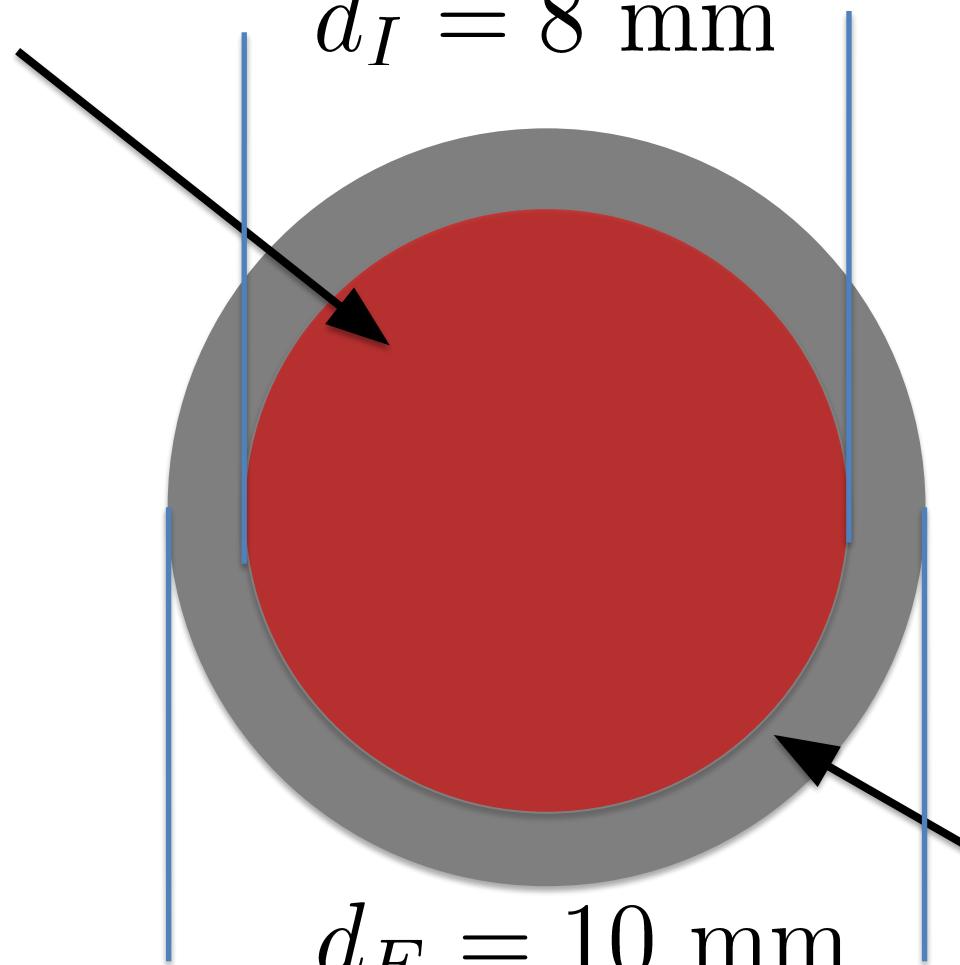
Fluido caldo

$$d_I = 8 \text{ mm}$$

$$n = 5$$

Acciaio AISI 316

$$d_E = 10 \text{ mm}$$



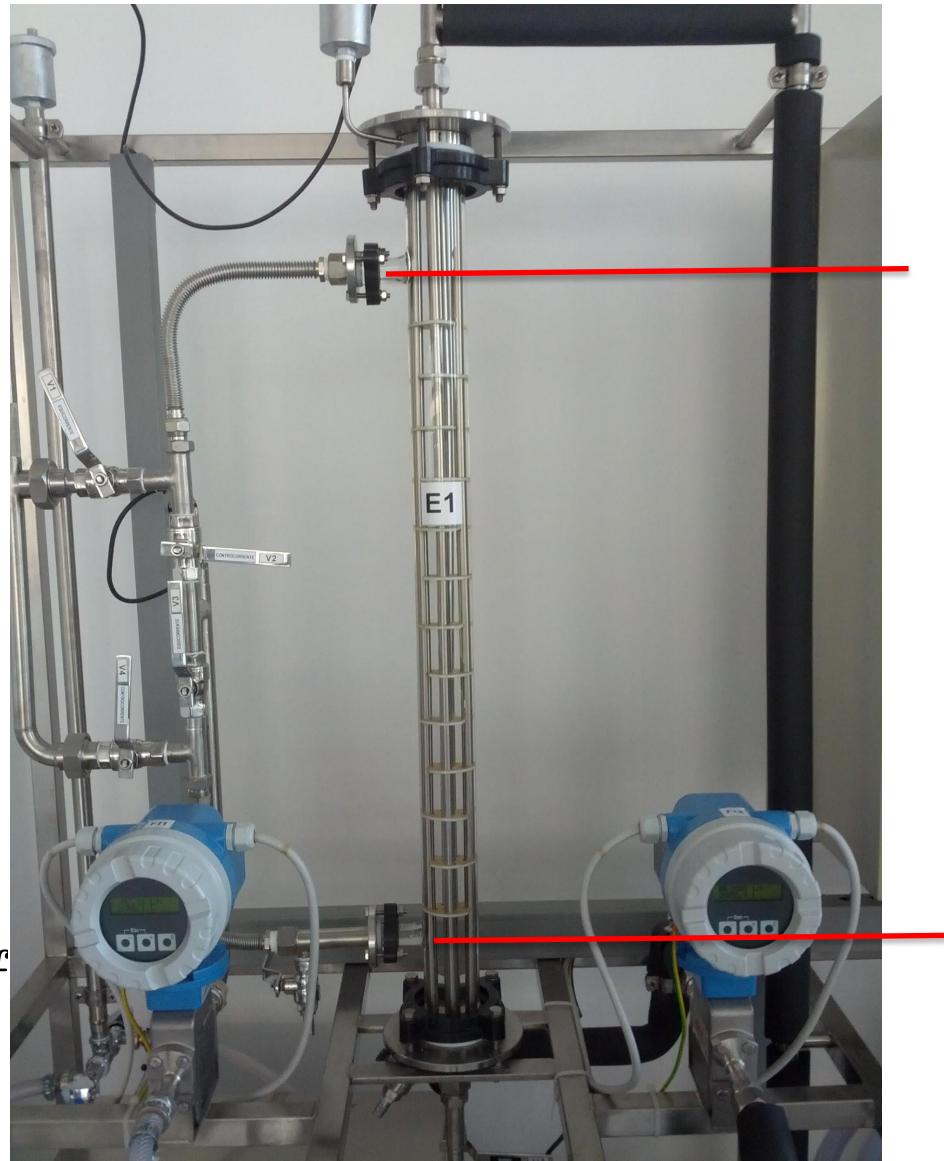
# Tubi del fascio

Lo scambio avviene solo  
entro una sezione limitata

$$L_{eff} = 680 \text{ mm}$$

$$A_I = n\pi d_I L_{eff}$$

$$A_E = n\pi d_E L_{eff}$$



$$L_{eff}$$

# Apparato



Scambiatore

# Apparato

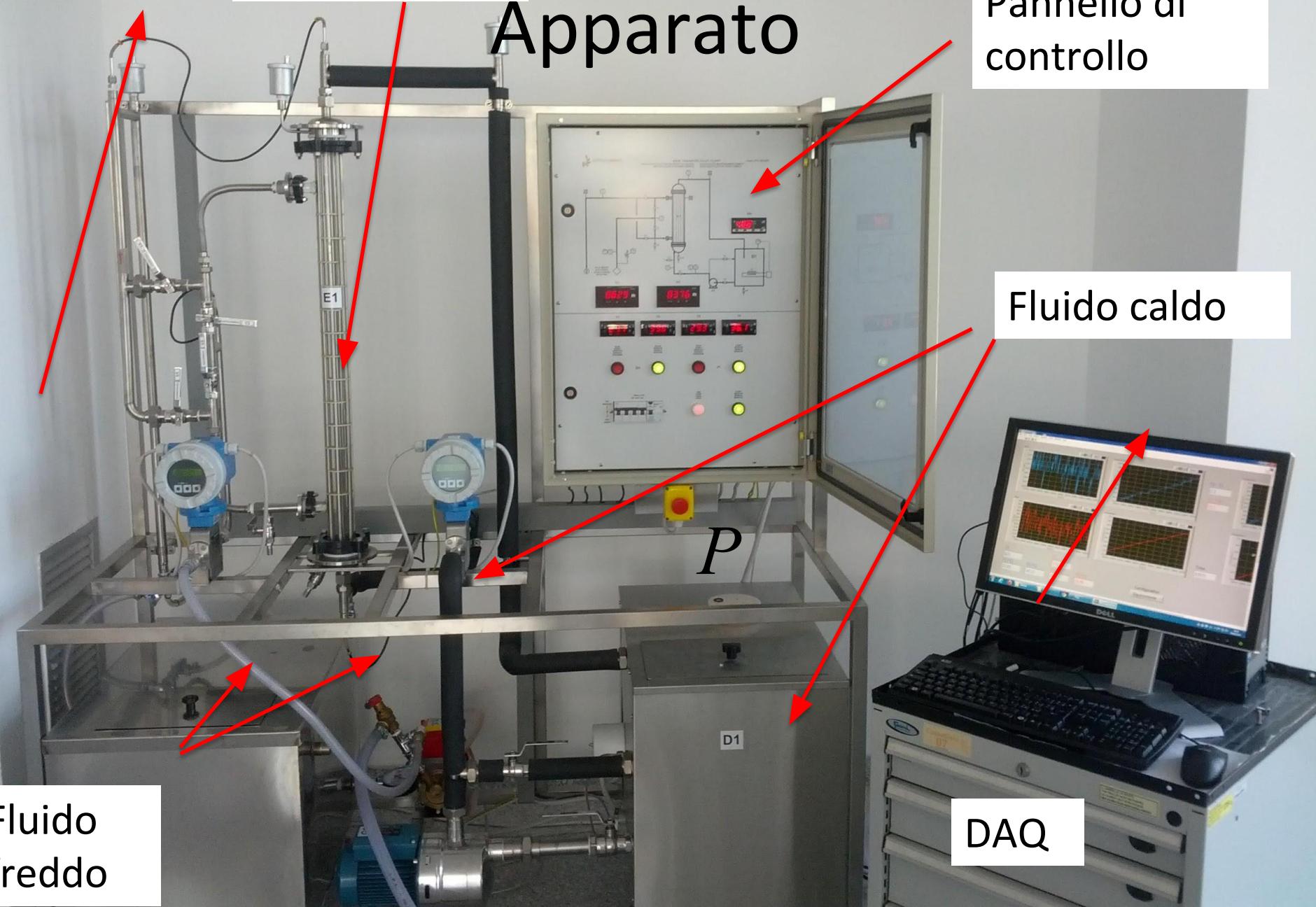
Pannello di controllo

Fluido caldo

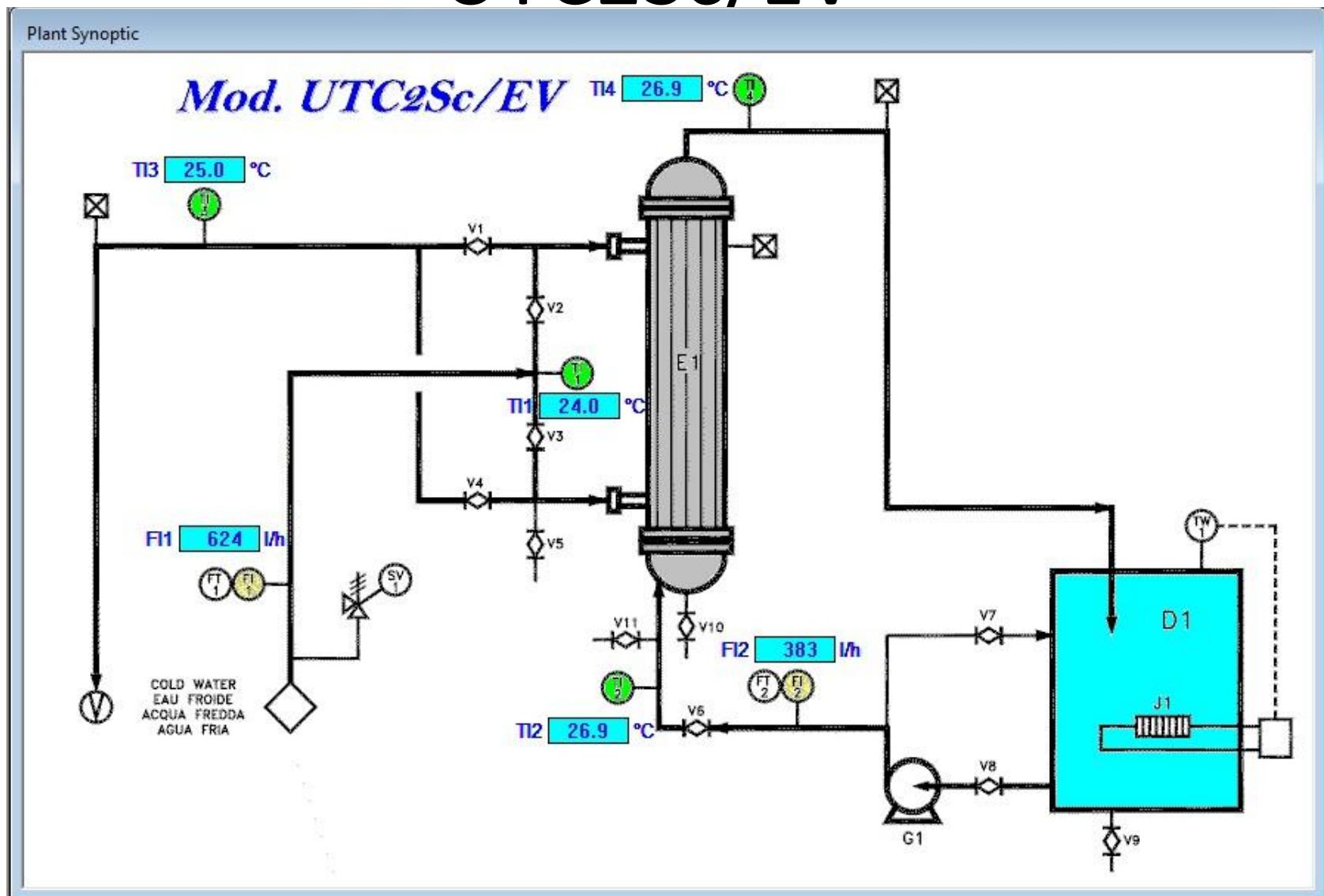
Fluido  
freddo

*P*

DAQ



# Apparato: Elettronica Veneta UTC2Sc/EV

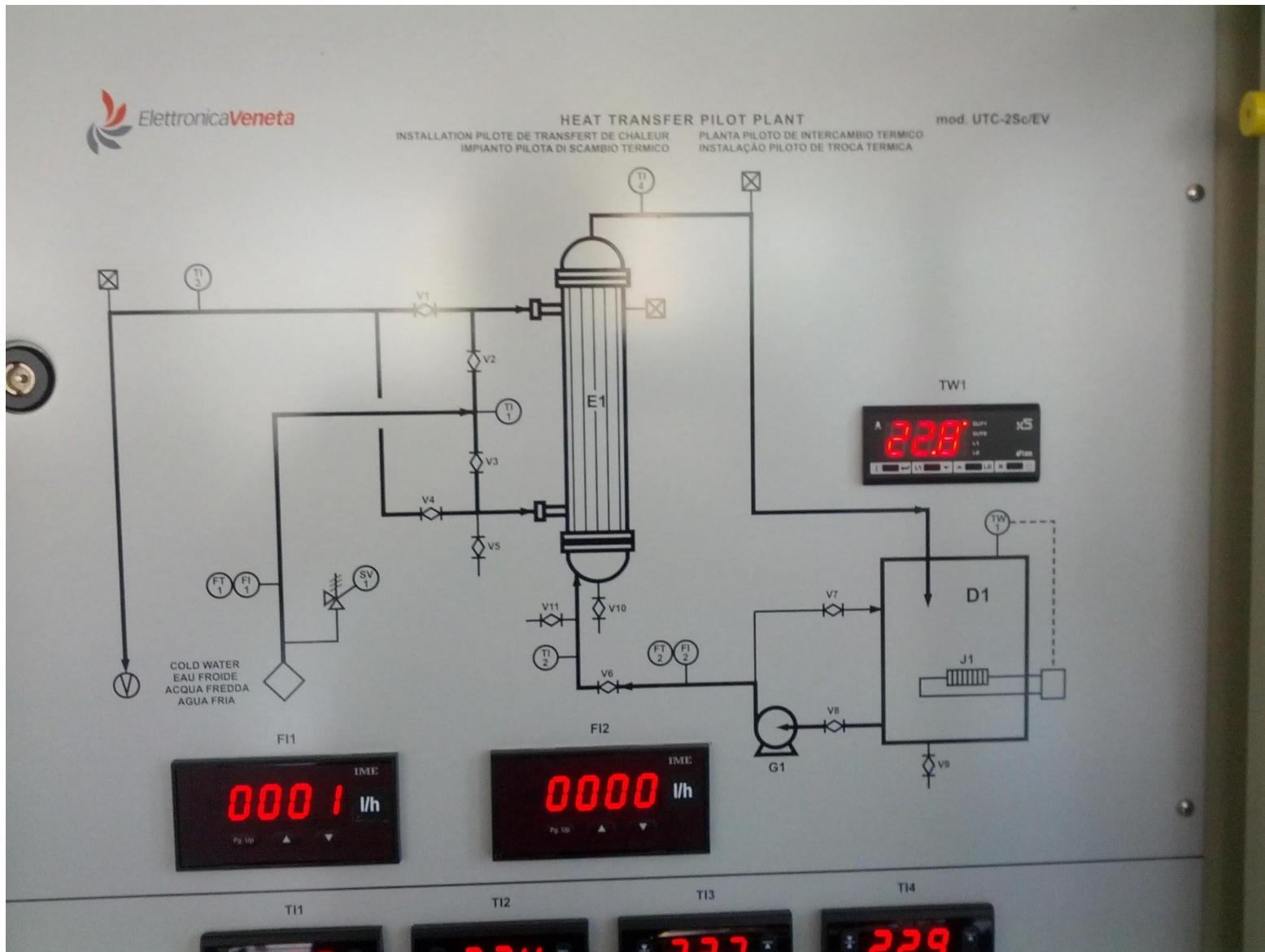


# Regolazione velocità

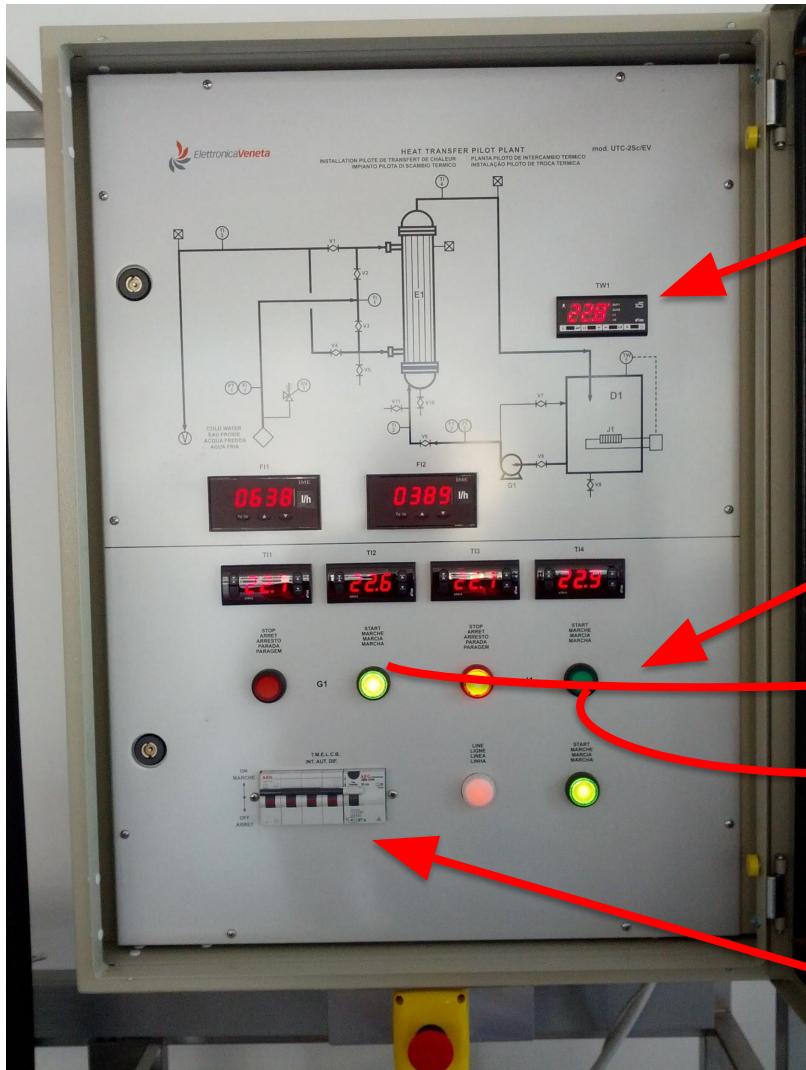
- fluido caldo: sempre dal basso verso l'alto
- fluido freddo:  
**equicorrente/controcorrente**



# Apparato: scambiatore



# Apparato: pannello di controllo



Termostato bagno  
fluido caldo

Comando riscaldatore  
fluido caldo

Comando pompa fluido  
caldo

Comando sistemi di  
misura

Interruttore generale

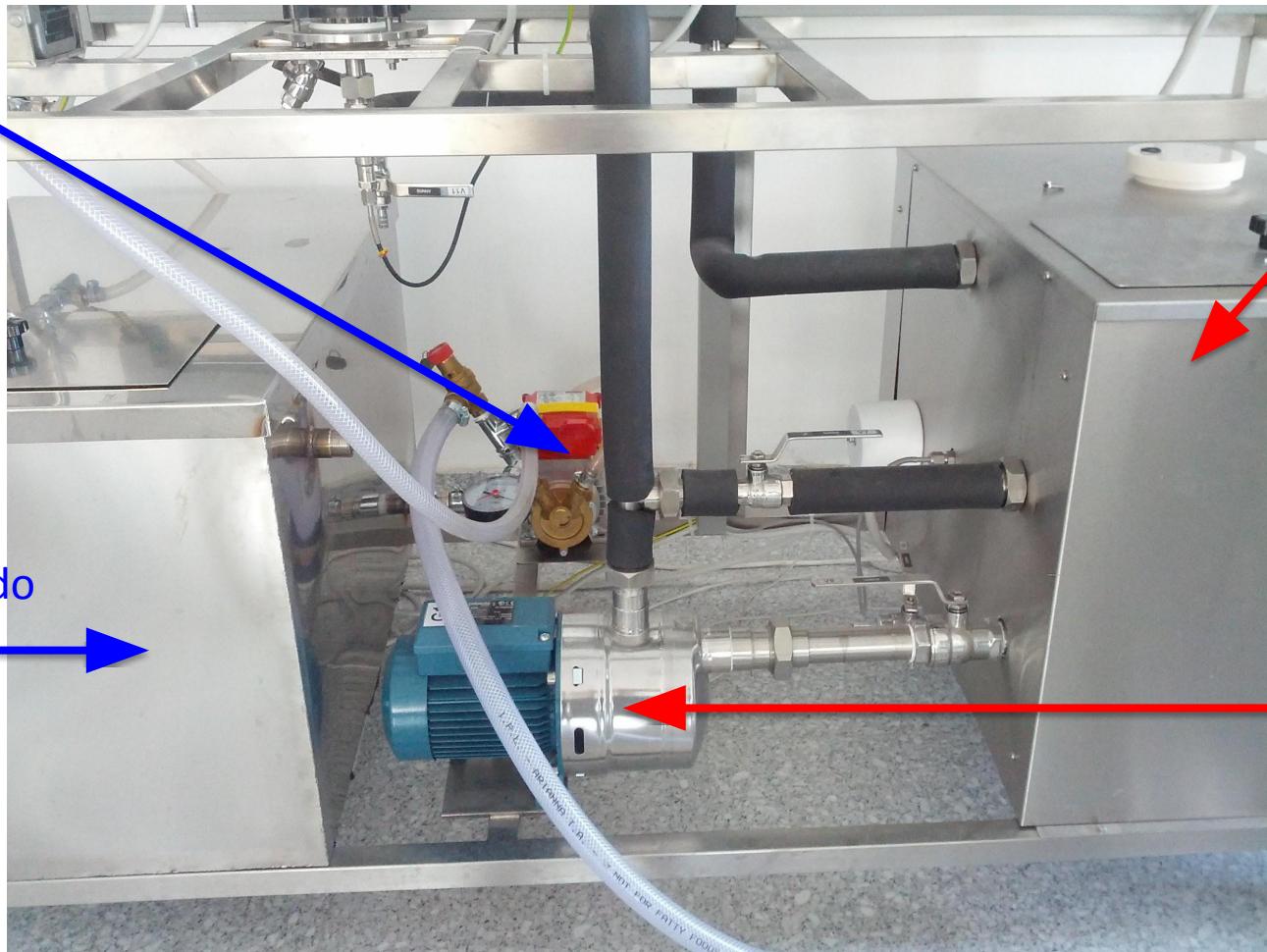
# Cisterne e pompe

Pompa fluido  
freddo

Cisterna  
fluido caldo

Cisterna fluido  
freddo

Pompa  
fluido  
caldo



# Cisterne e pompe

- fluido caldo:
  - termostato ad una temperatura impostata dall'utente
  - mantenuto in circolazione forzata
- fluido freddo:
  - vasca di accumulo per limitare la presenza di gas disciolti
  - pompa per stabilizzare la velocità

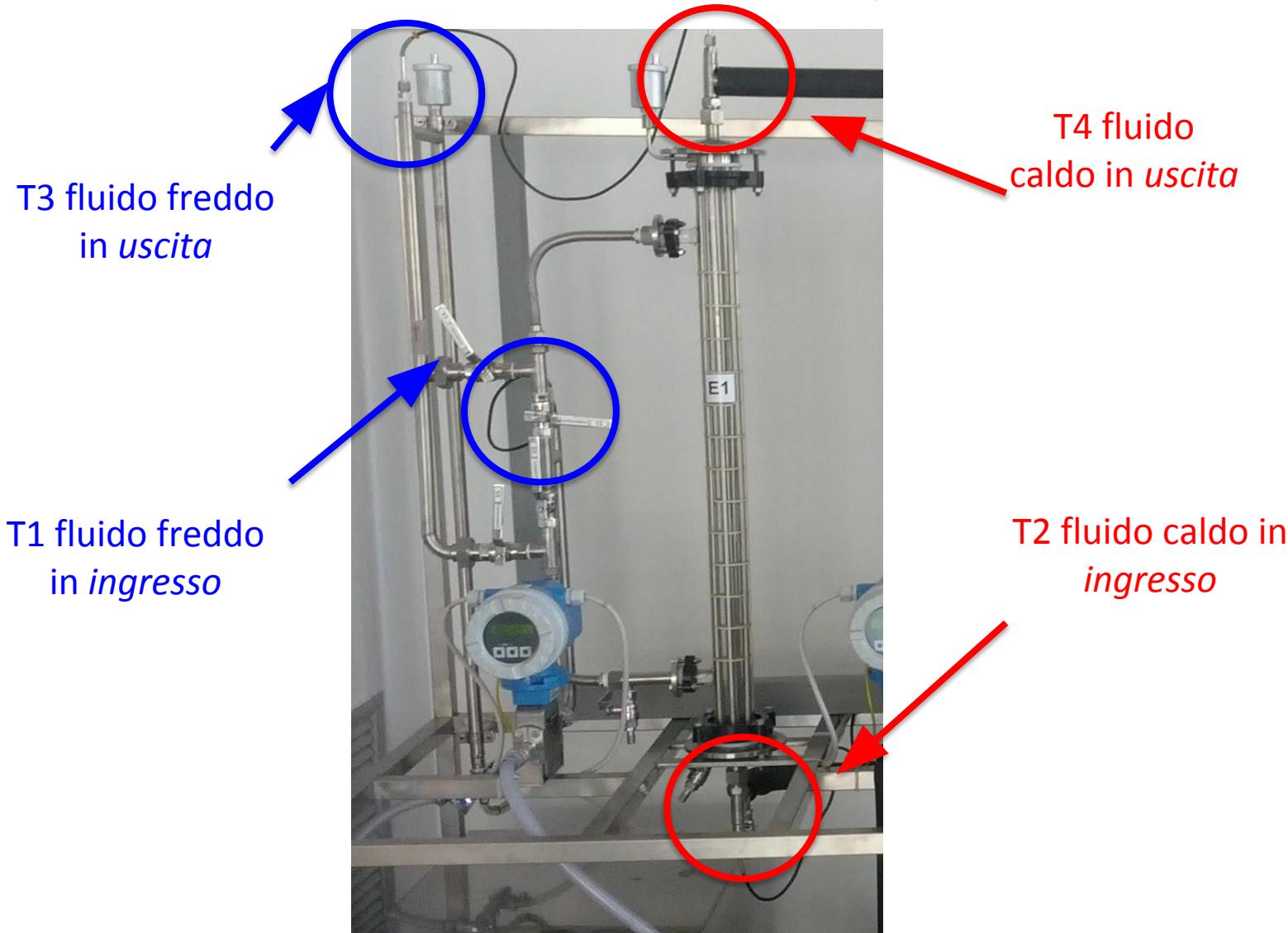
# Misure di temperatura

4 termistori Pt100

$$R = R(T)$$

- T1 fluido **freddo** in ingresso
- T2 fluido **caldo** in ingresso
- T3 fluido **freddo** in uscita
- T4 fluido **caldo** in uscita
- Le misure di temperatura vengono calibrate in LabView

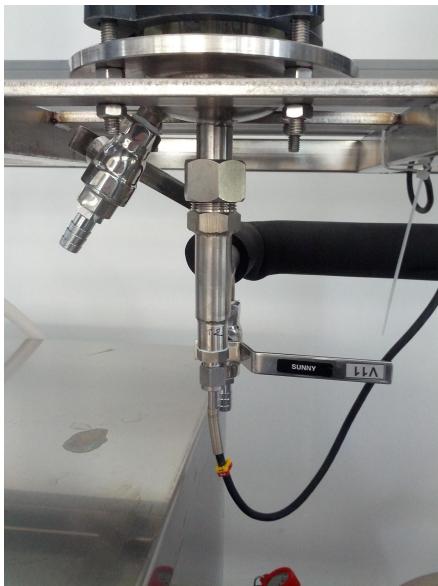
# Misure di temperatura



# Misure di temperatura

Misure fluido caldo: ok

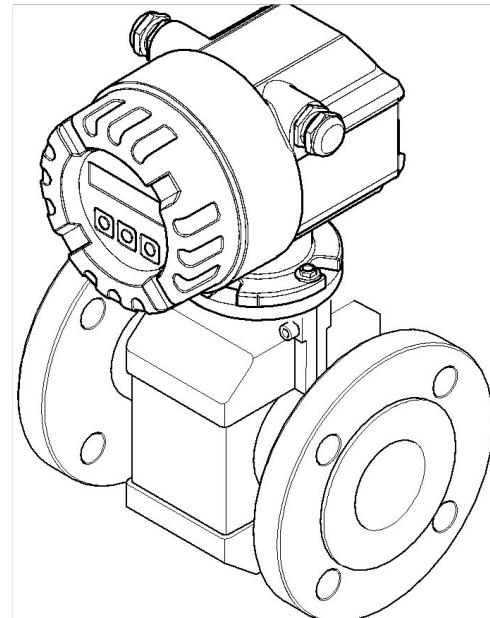
Misure fluido freddo: lontane



# Misure di portata volumetrica

2 flussimetri Endress&Hauser ProMag10H

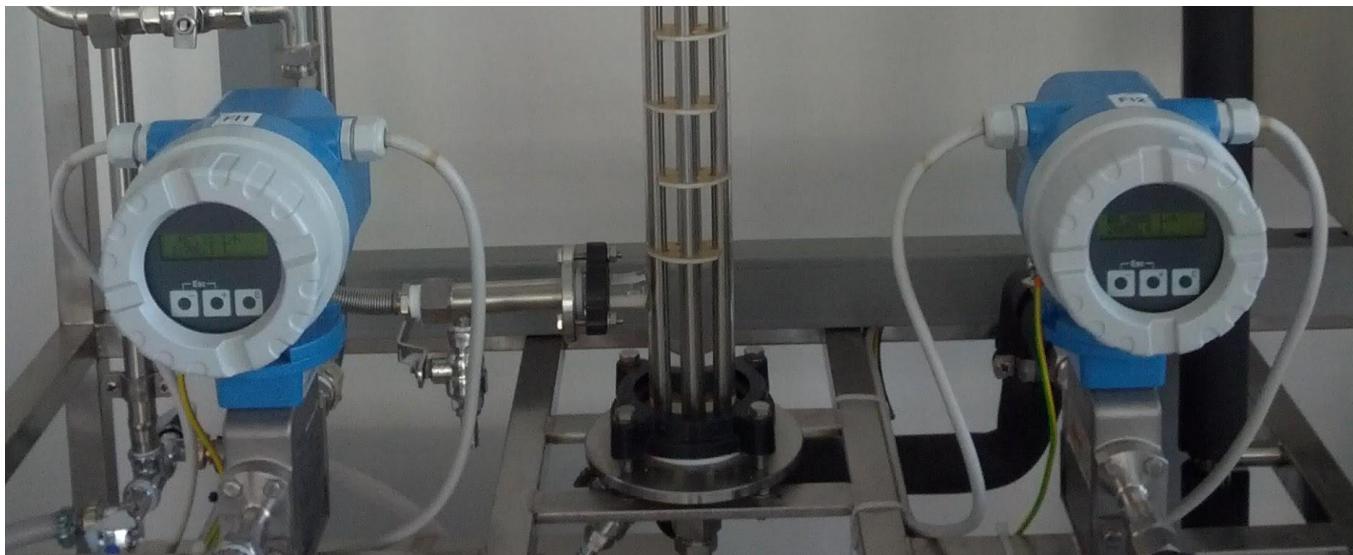
Diametro tubo:  $5/16'' \approx 7.9 \text{ mm}$



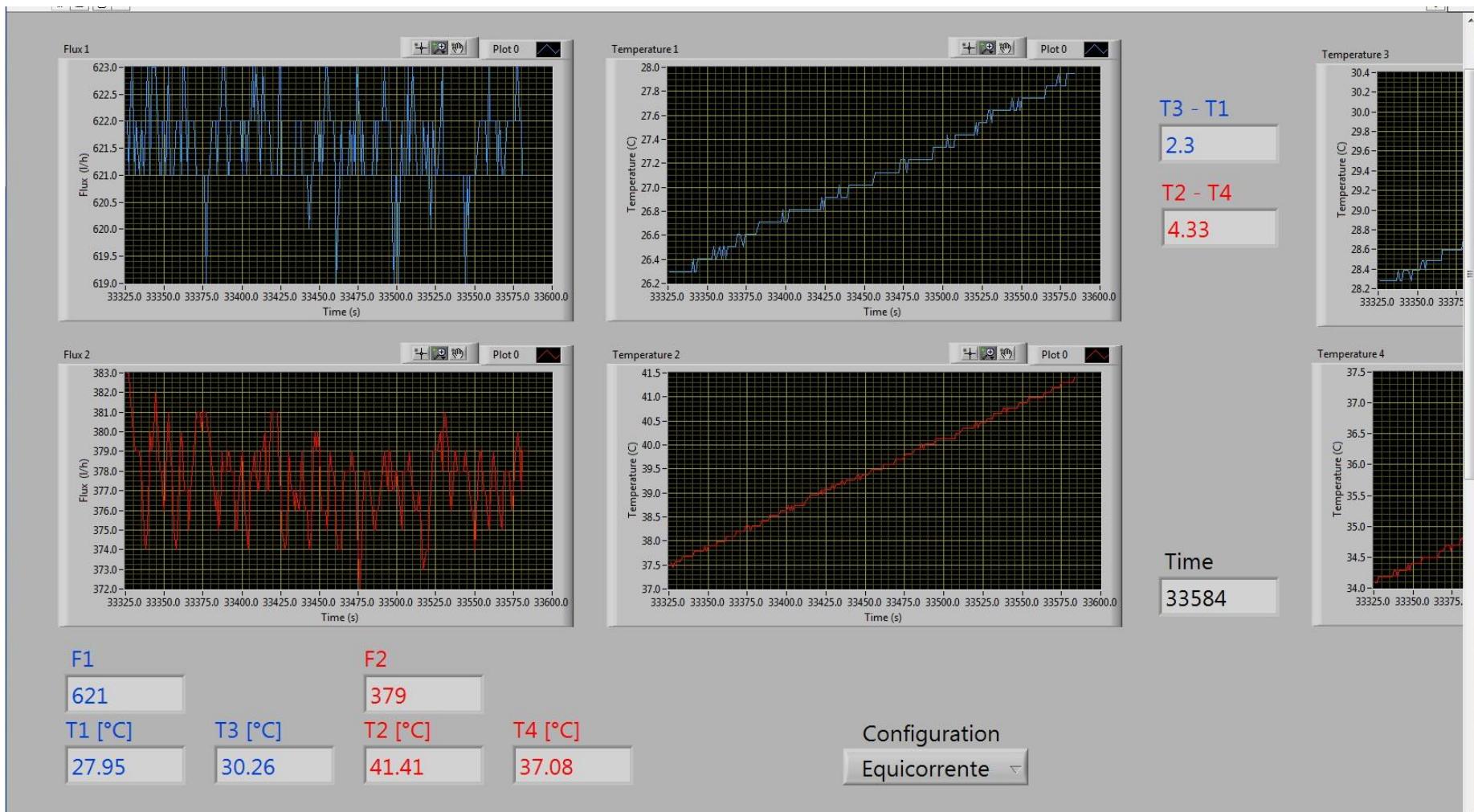
# Misure di portata volumetrica

F2 misura fluido caldo: ok

F1 misura fluido freddo: attenzione alla presenza  
di gas



# Pannello LabView



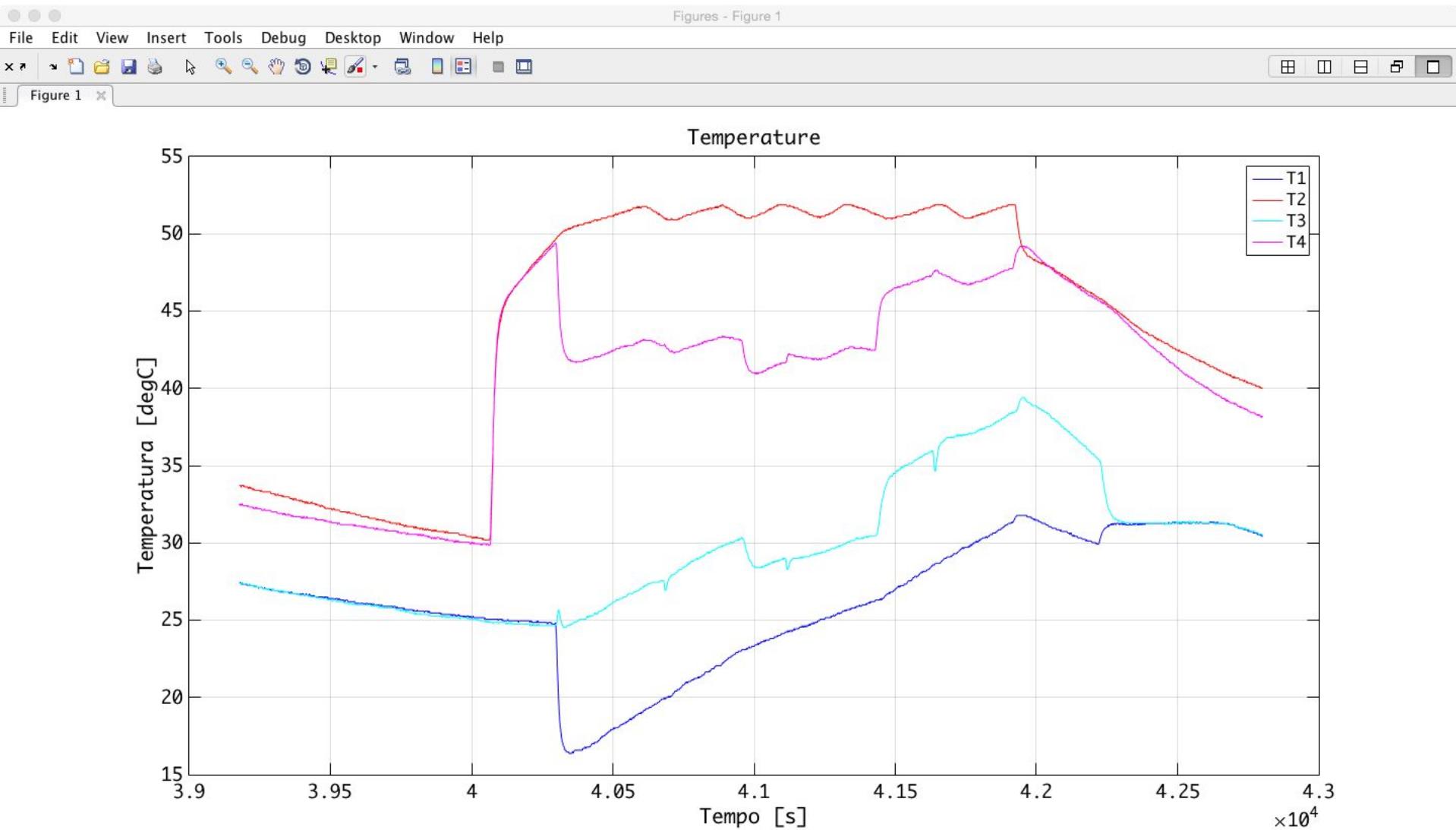
# Dati sperimentali: file

```
% Data originally in file: S:\Fisica_Tecnica\30052014\dati_scambiatore_30052014_01.ds
% Time(s)    F1(l/h)      F2(l/h)      T1(degC)     T2(degC)     T3(degC)     T4(degC)     Configurazione
33219309    297    16.48 44.61 23.81 36.67 Equicorrente
33220308    296    16.58 44.51 23.81 36.67 Equicorrente
33221308    296    16.58 44.51 23.81 36.67 Equicorrente
33222309    296    16.48 44.61 23.81 36.77 Equicorrente
33224311    295    16.58 44.61 23.81 36.67 Equicorrente
33225312    296    16.58 44.61 23.92 36.67 Equicorrente
33226310    296    16.58 44.61 23.81 36.77 Controcorrente
33228309    298    16.58 44.61 23.81 36.77 Controcorrente
33229310    296    16.58 44.61 23.92 36.67 Controcorrente
33231353    297    16.58 44.61 23.92 36.77 Controcorrente
33232403    297    16.58 44.61 23.81 36.77 Controcorrente
33233363    297    16.69 44.61 23.81 36.77 Controcorrente
```

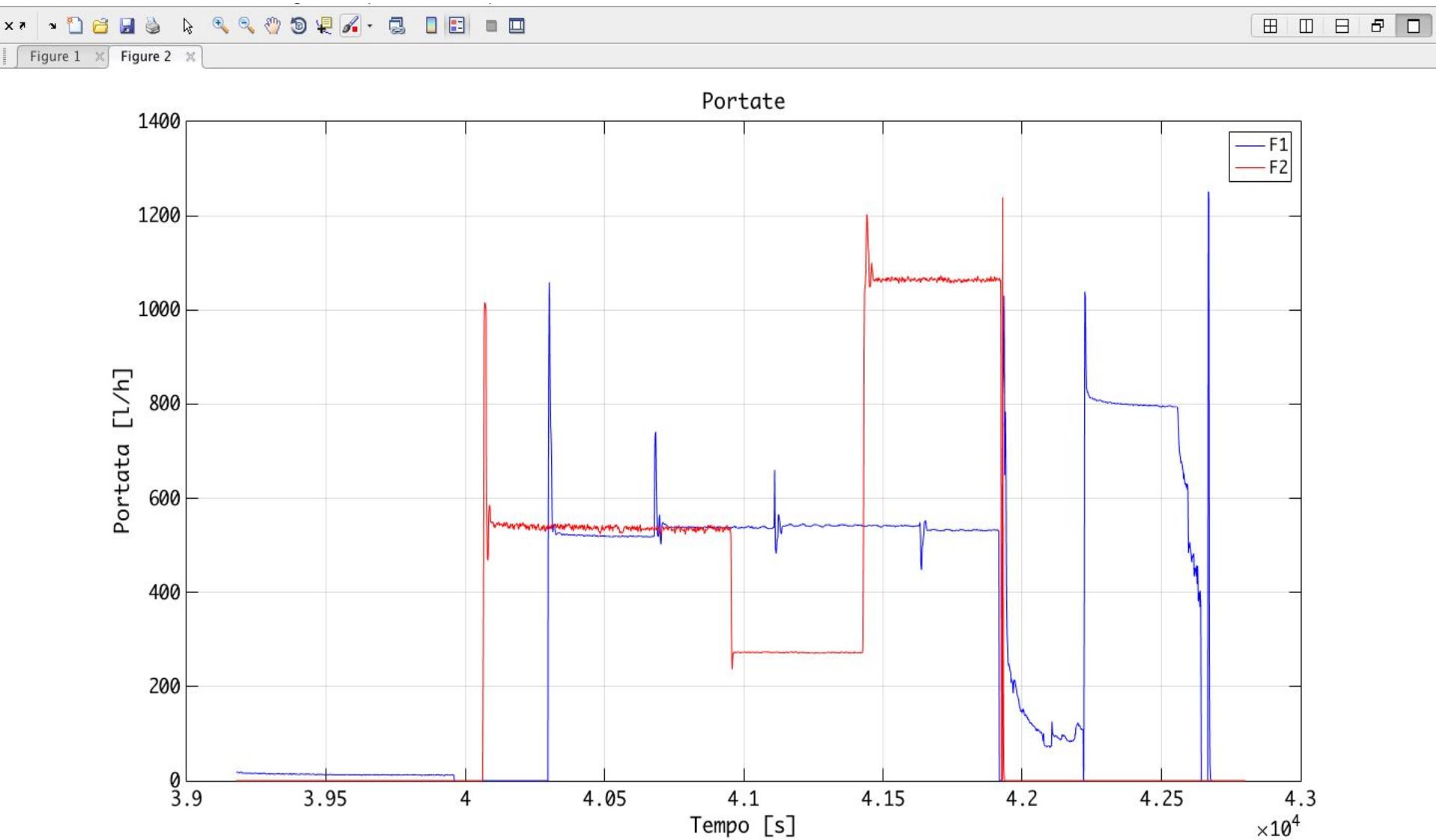
# Dati sperimentali: analisi

- Pacchetto con alcune funzioni ed uno script (sequenza di comandi)
  - heat\_exchanger.m
  - loadHeatExchangerData.m
  - getConfiguration.m
  - AISI316Properties.m
  - waterProperties.m

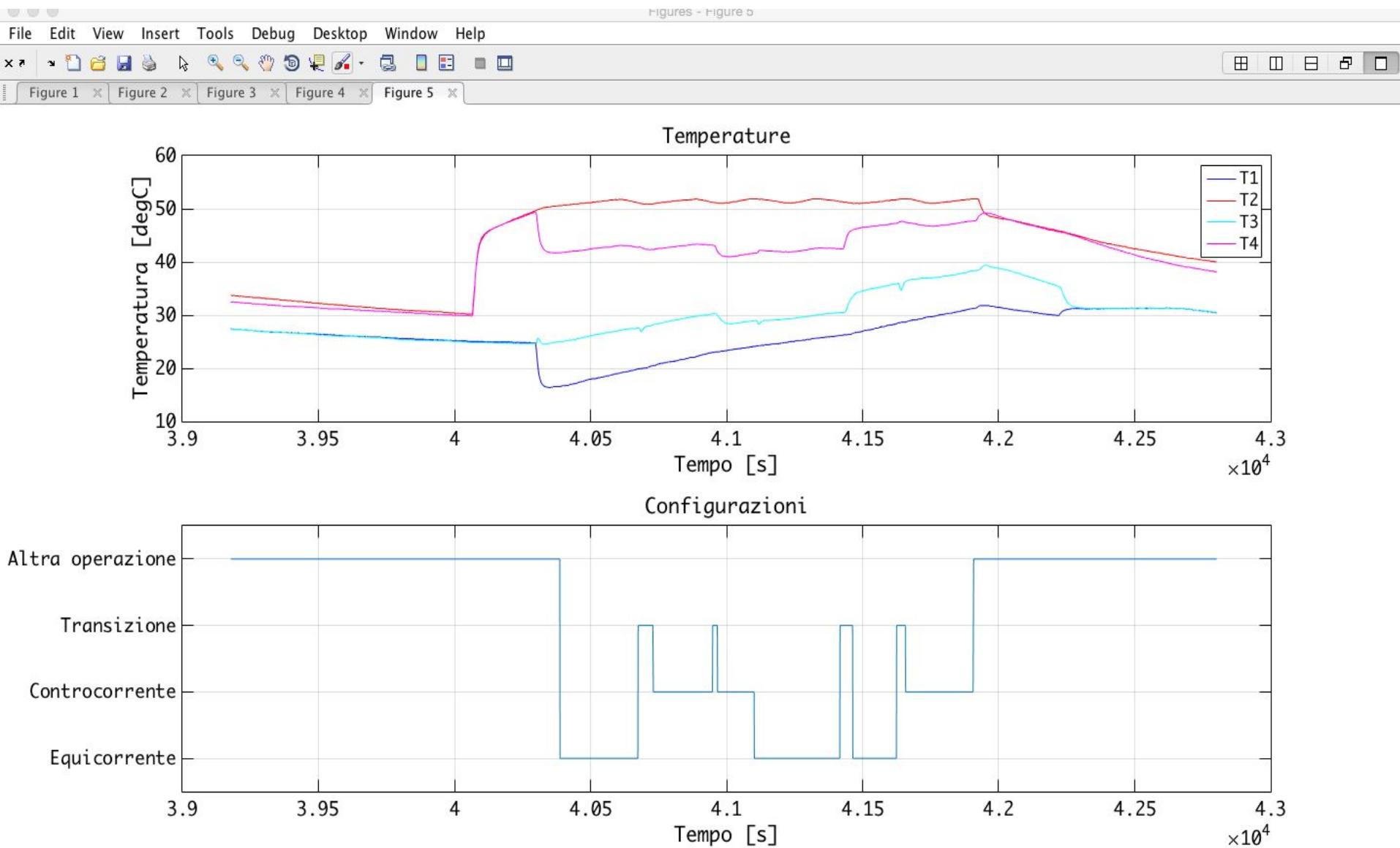
# Dati sperimentali: analisi



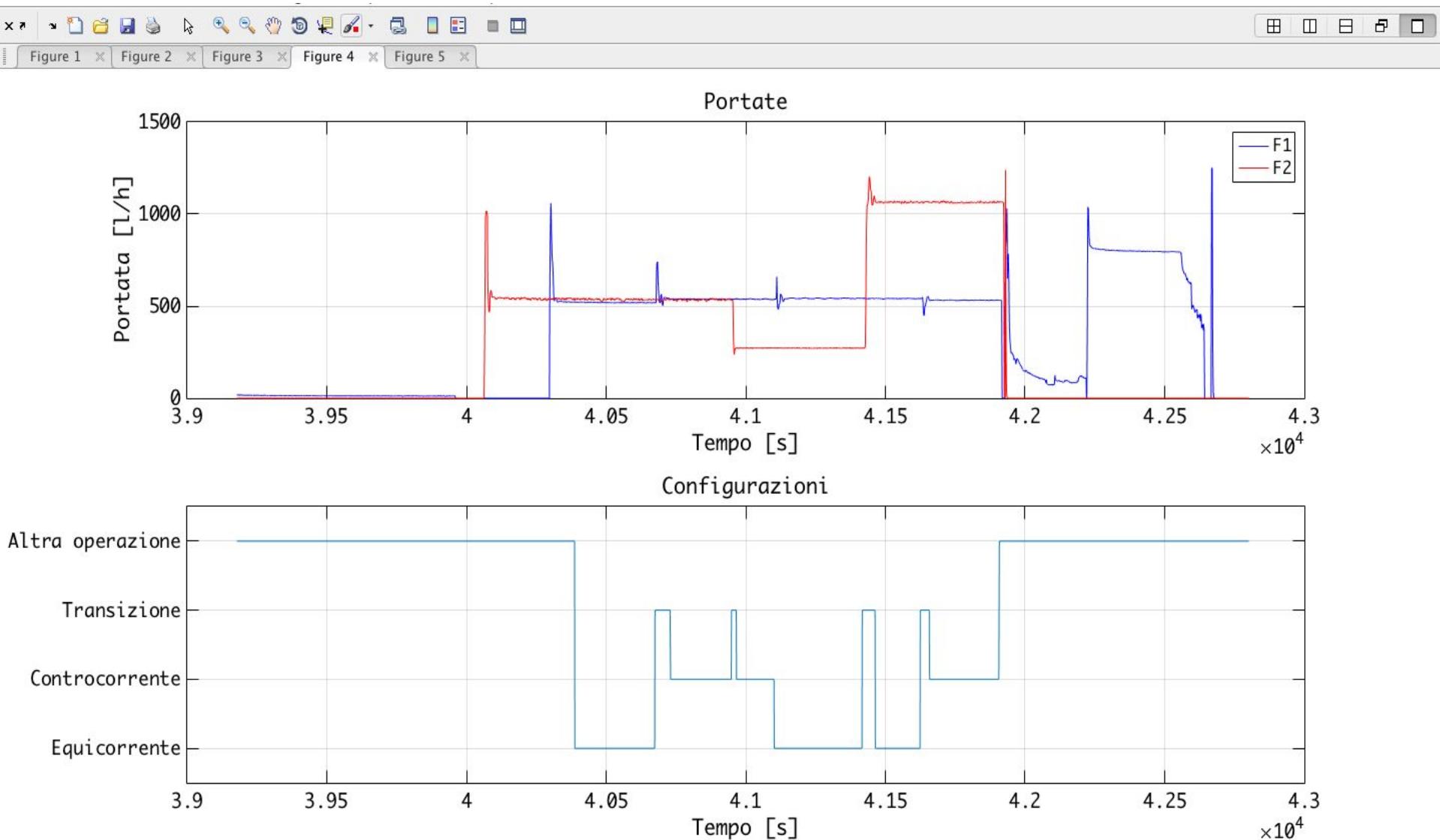
# Dati sperimentali: analisi



# Dati sperimentali: analisi



# Dati sperimentali: analisi



# Dati sperimentali: analisi

```
%% Analisi dati: selezione sezioni
```

```
tStart = 40400;
```

```
tEnd   = 40600;
```

```
trange = [tStart tEnd];
```

```
section = t >= tStart & t <= tEnd;
```

```
% Tempo medio
```

```
t_m = mean(t(section));
```