



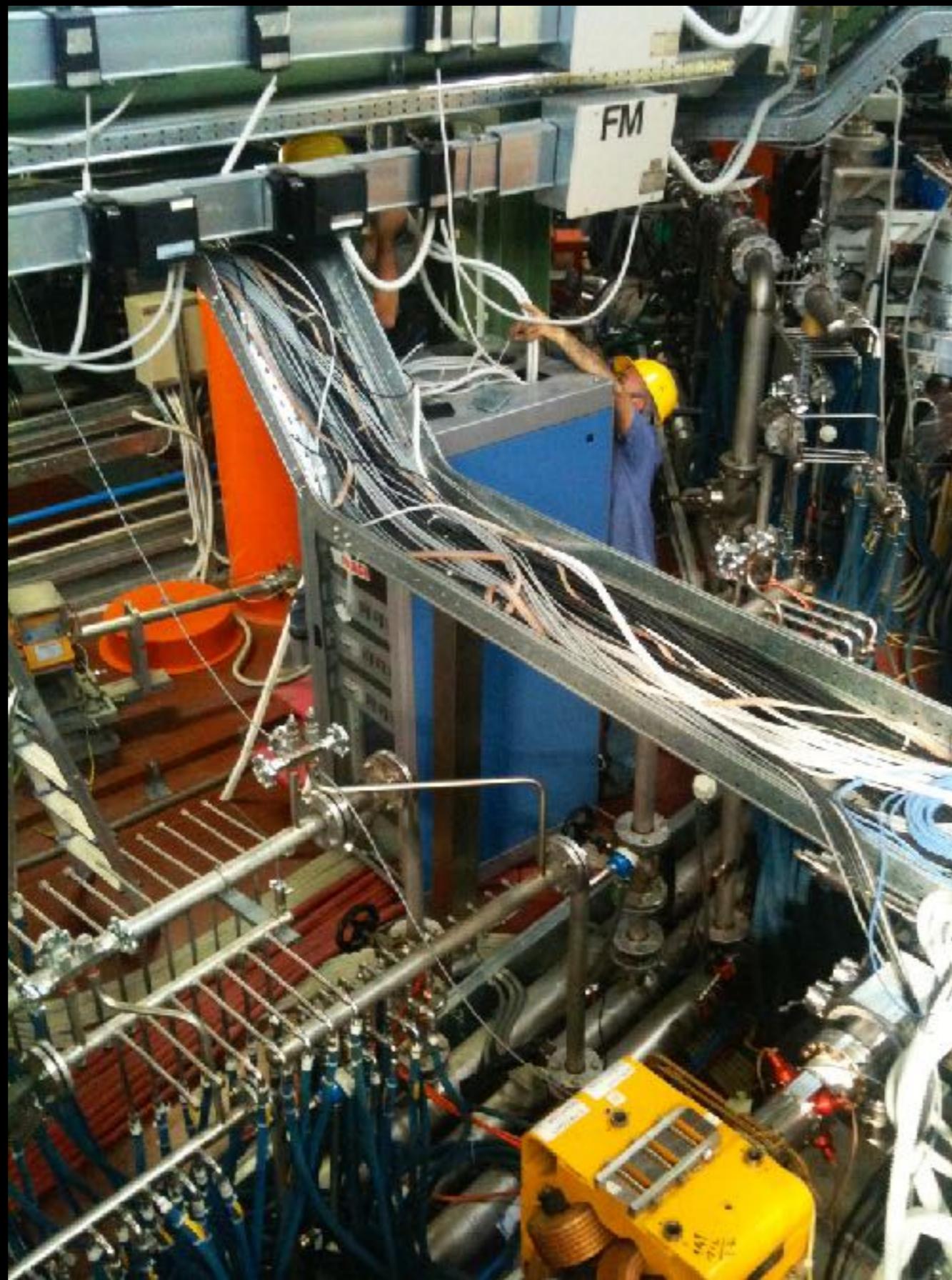
Control system based on Highly Abstracted and Open Structure
A new approach to Control Systems

presented by Alessandro Stecchi
on behalf of the !CHAOS development team

!CHAOS project coordinator
Responsible of the Control Systems Service
(Accelerator Division - LNF)



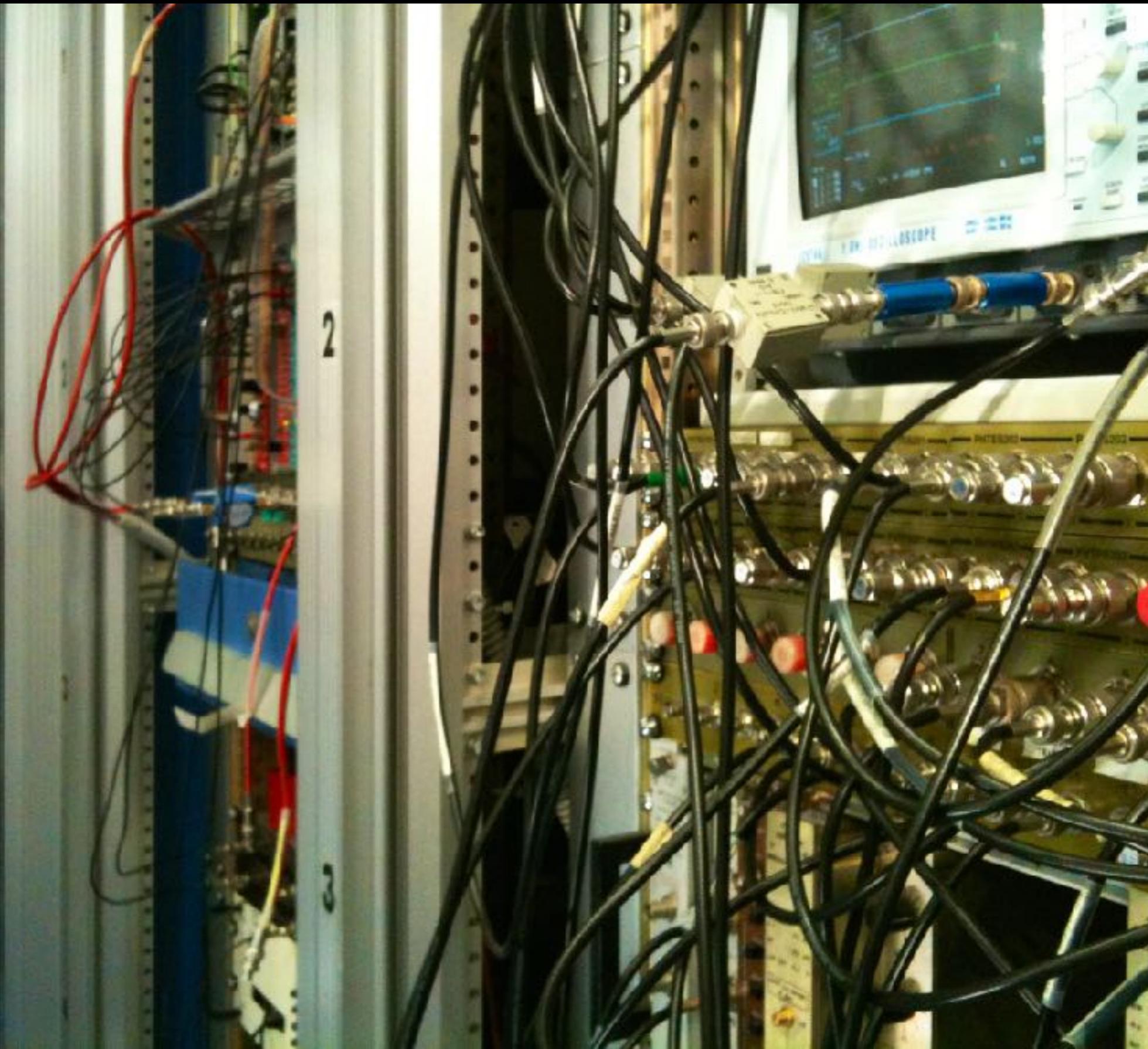
impianto



impianto → sensori/attuatori



impianto → sensori/attuatori → front-end



impianto → sensori/attuatori → front-end → sala controllo



technology & software go fast



1994
EPICS
DANTE



2000
TANGO



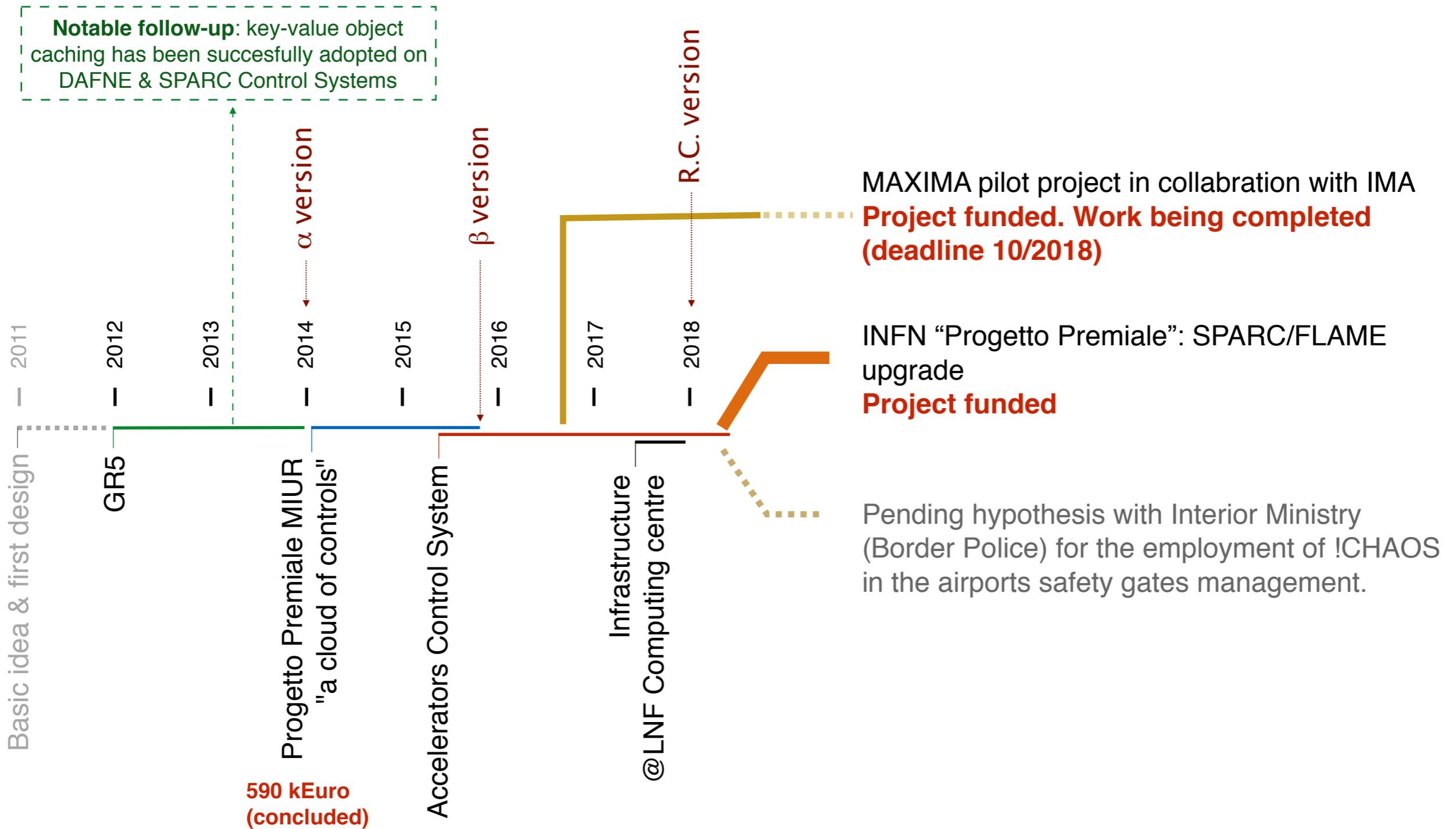
2014
!CHAOS

Control system based on **H**ighly **A**bstracted and **O**pen **S**tructure



Seminarindustriali • 25 giugno 2018 • LNF

Timeline





!CHAOS è già utilizzato in:

- installazioni pilota su acceleratori @LNF
- un progetto in collaborazione con l'industria (IMA)

!CHAOS a medio termine

- affiancare/sostituire i sistemi di controllo di DAFNE, SPARC, EUPRAXIA
- continuare a perseguire il trasferimento tecnologico

Ambizioni di !CHAOS

- diventare uno standard INFN
- diffondersi nella comunità scientifica e nell'industria (spin-off?)



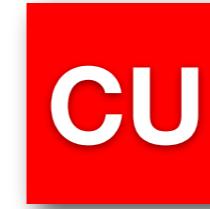
obiettivi generali



Realizzare un sistema di controllo — usando tecnologie software di punta — con le seguenti caratteristiche:

- integrazione nativa di un sistema DAQ
- scalabilità → affidabilità e/o prestazioni
- auto-configurazione dei processi di controllo
- dati serializzati ed *autoesplicanti*
- usabile da più utenti, per diverse applicazioni

control room



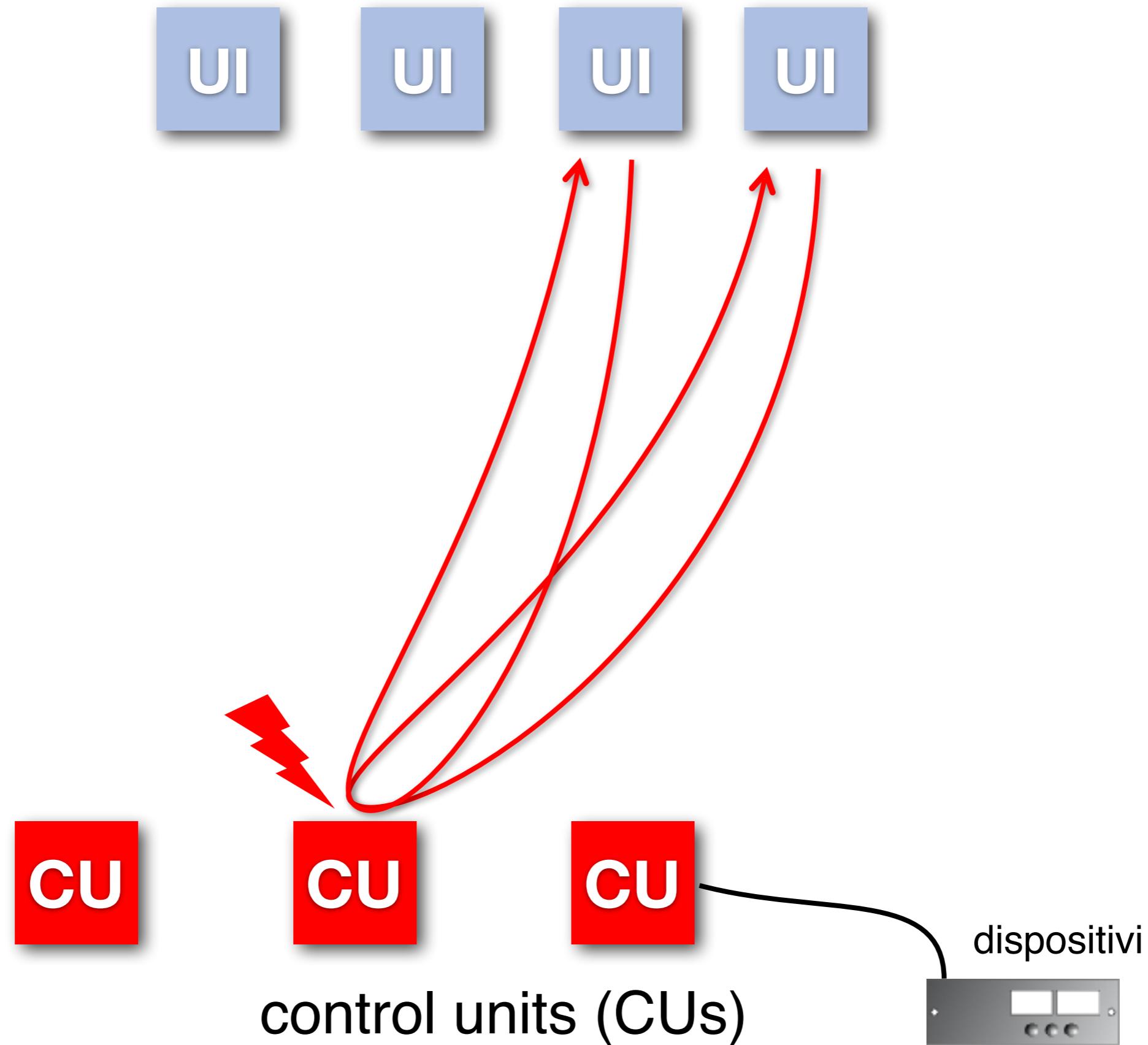
control units (CUs)



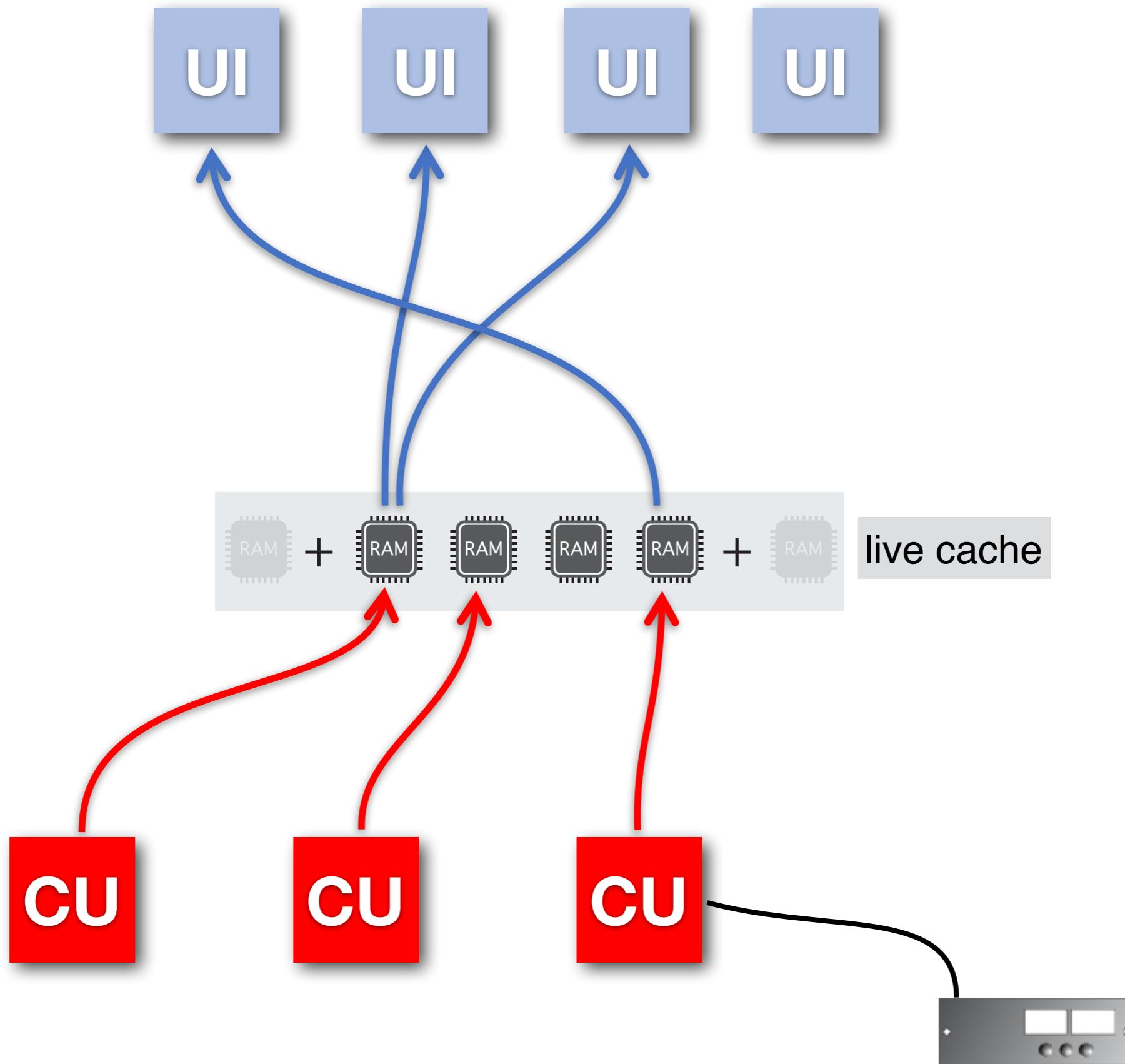
dispositivi



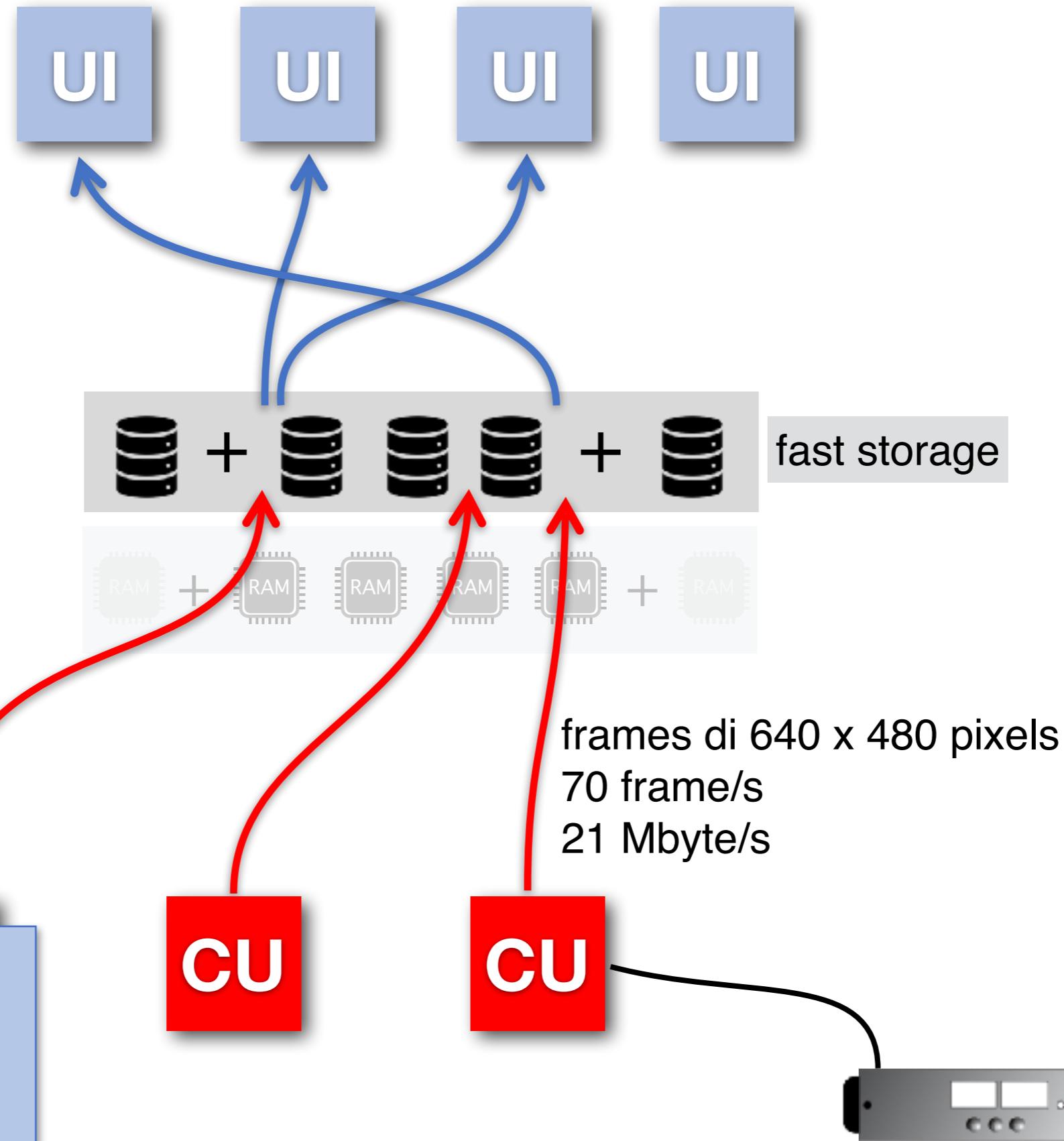
control room



aggiornamento dati *live*



storicizzazione dei dati (DAQ)

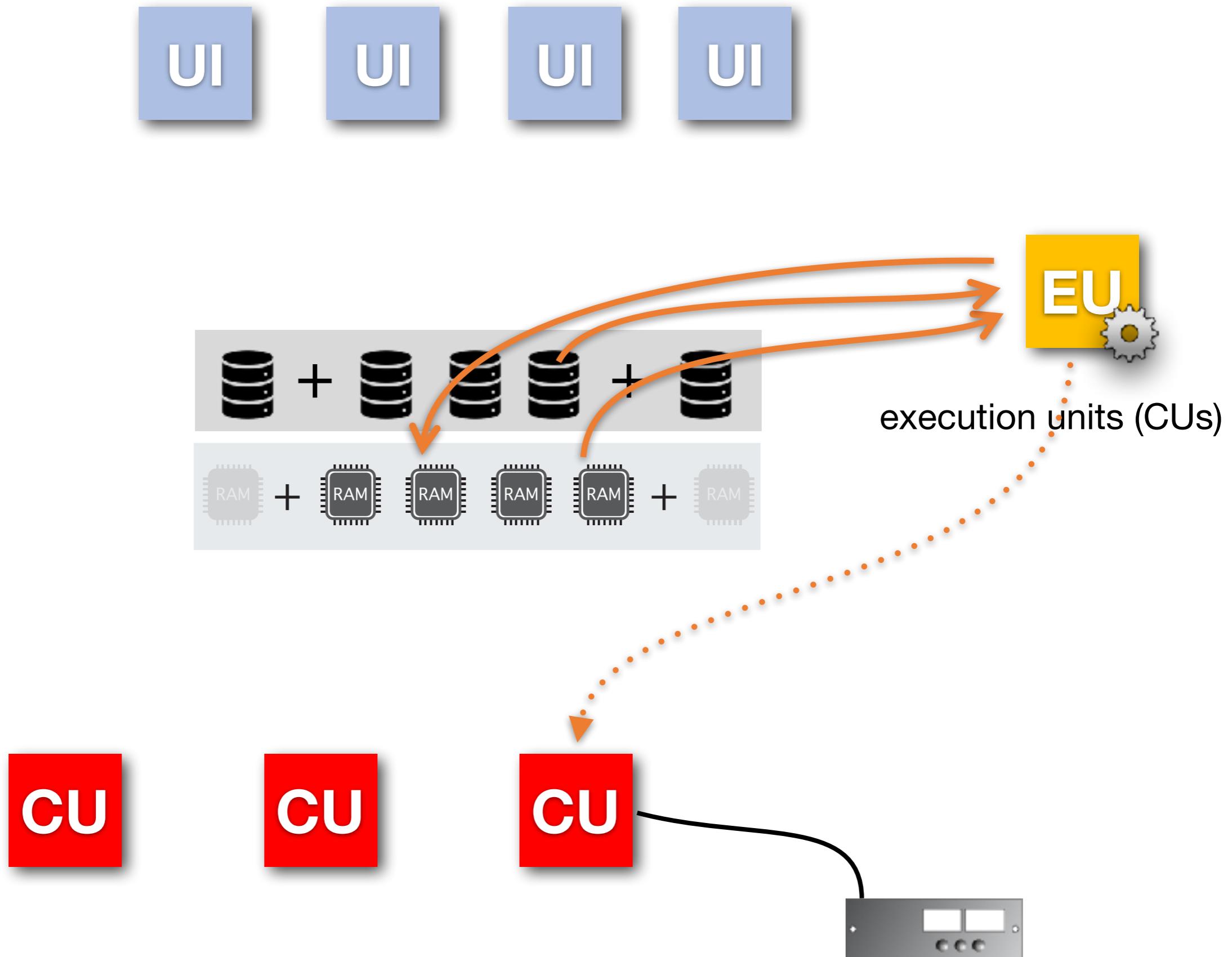


✓ sistema DAQ nativo

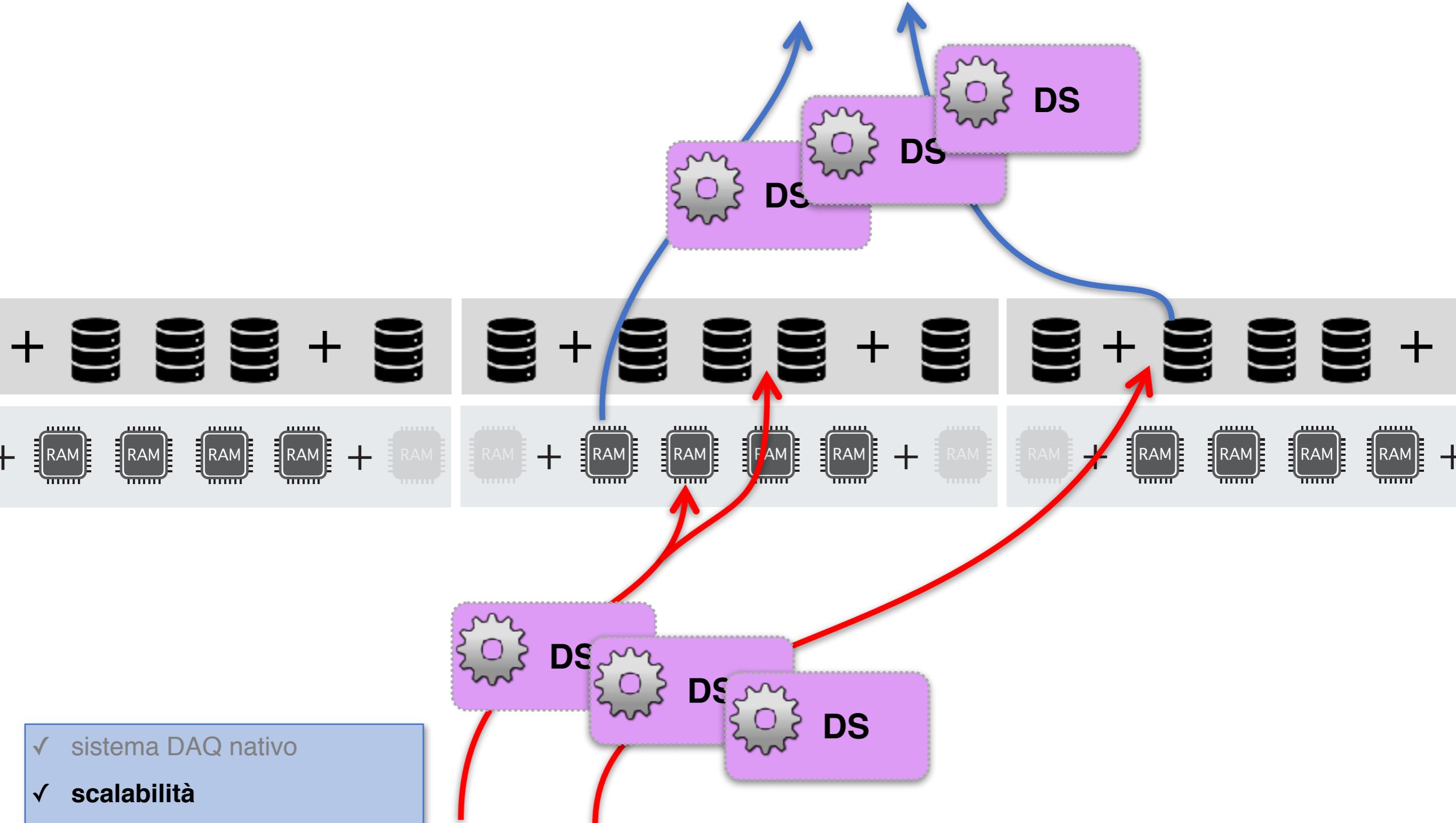
- scalabilità
- auto-configurazione dei nodi
- dati serializzati
- multiutente



analisi & feedbacks



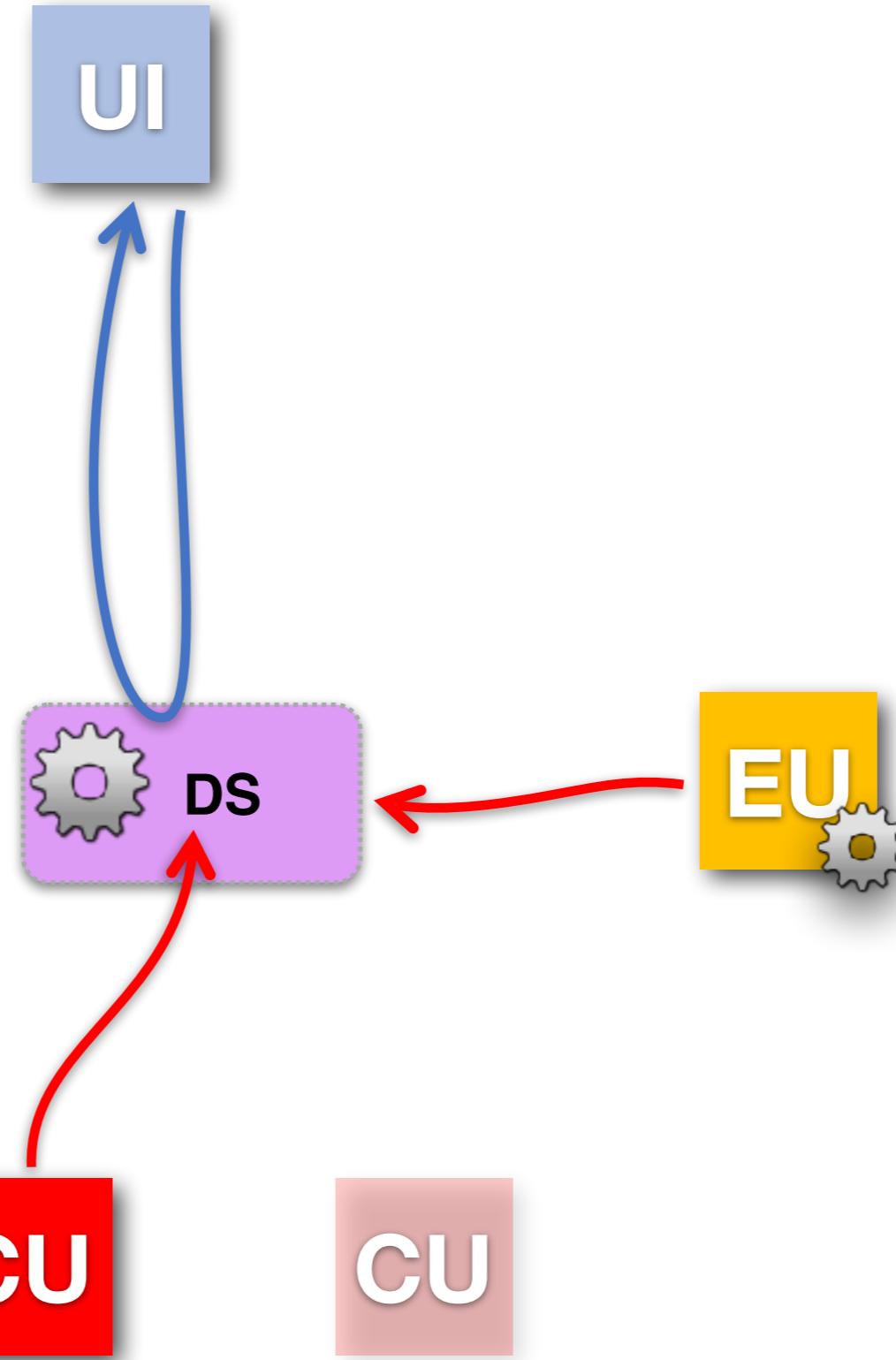
scalabilità → prestazioni ed affidabilità



- ✓ sistema DAQ nativo
- ✓ **scalabilità**
 - auto-configurazione dei nodi
 - dati serializzati
 - multiutente



autoconfigurazione delle CU

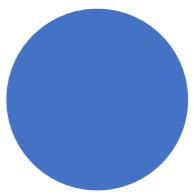
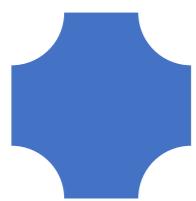


- ✓ sistema DAQ nativo
- ✓ scalabilità
- ✓ **auto-configurazione dei nodi**
 - dati serializzati
 - multiutente

control units (CUs)



database →

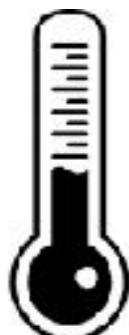


```
{  
float64 temperatura_read;  
char    unita_di_misura;  
boolean stato;  
....  
}
```

```
{  
float64 corrente_read;  
float64 corrente_set;  
char    unita_di_misura;  
boolean errore;  
....  
}
```

```
{  
float64 campo_mag_read;  
float64 campo_mag_set;  
int    polarità;  
....  
}
```

```
{  
int    apertura;  
int    tempo;  
int    n_pixels_h;  
int    n_pixels_v;  
boolean stato;  
....  
}
```



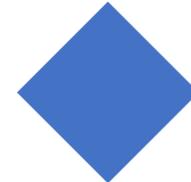
dati serializzati ed auto-espli canti

Chiave	Valore



`my_string`

`\16\00\00\00\02hello\00\06\00\00\00world\00\00`



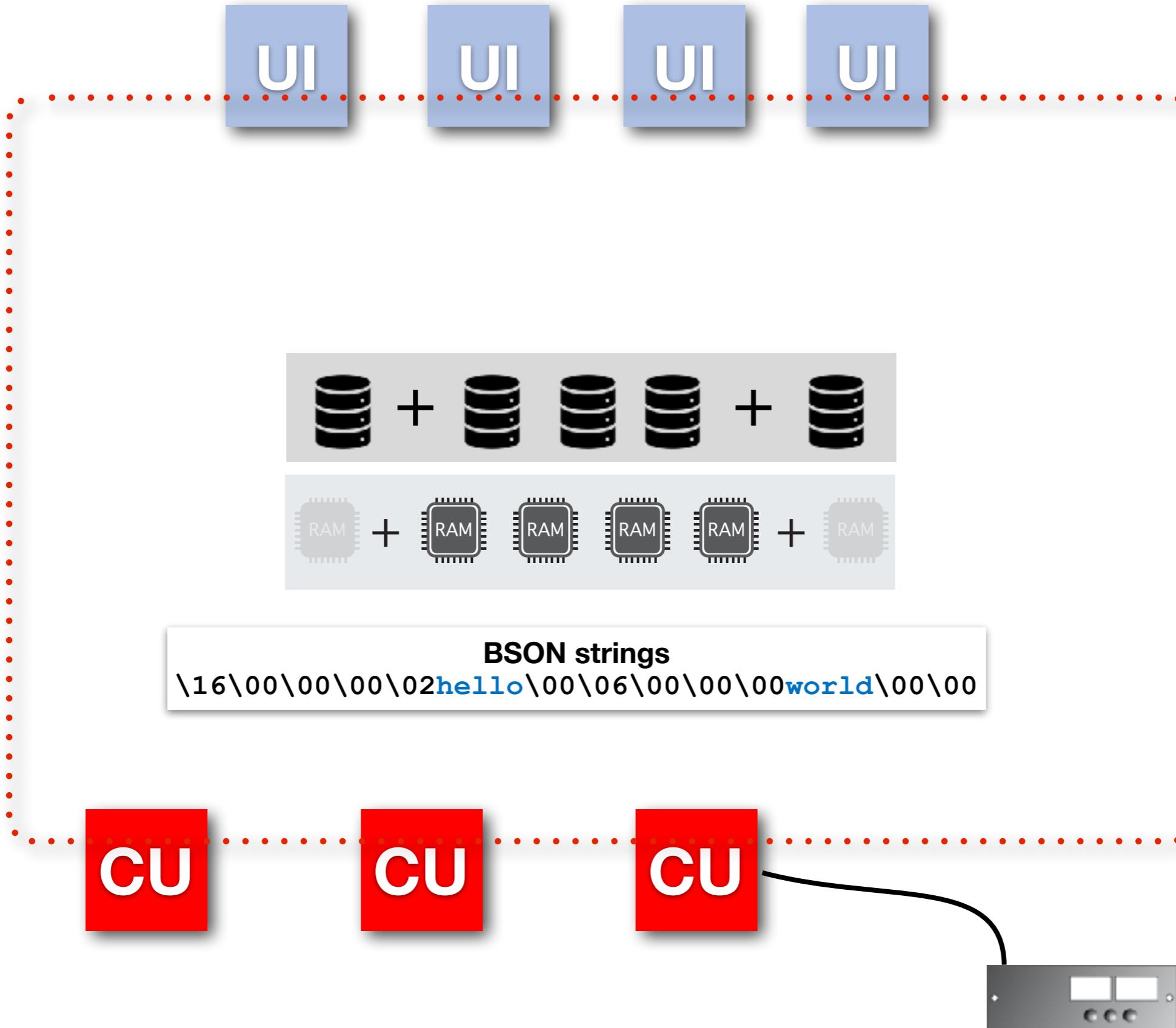
`my_integer`

..... *altra sequenza di byte*

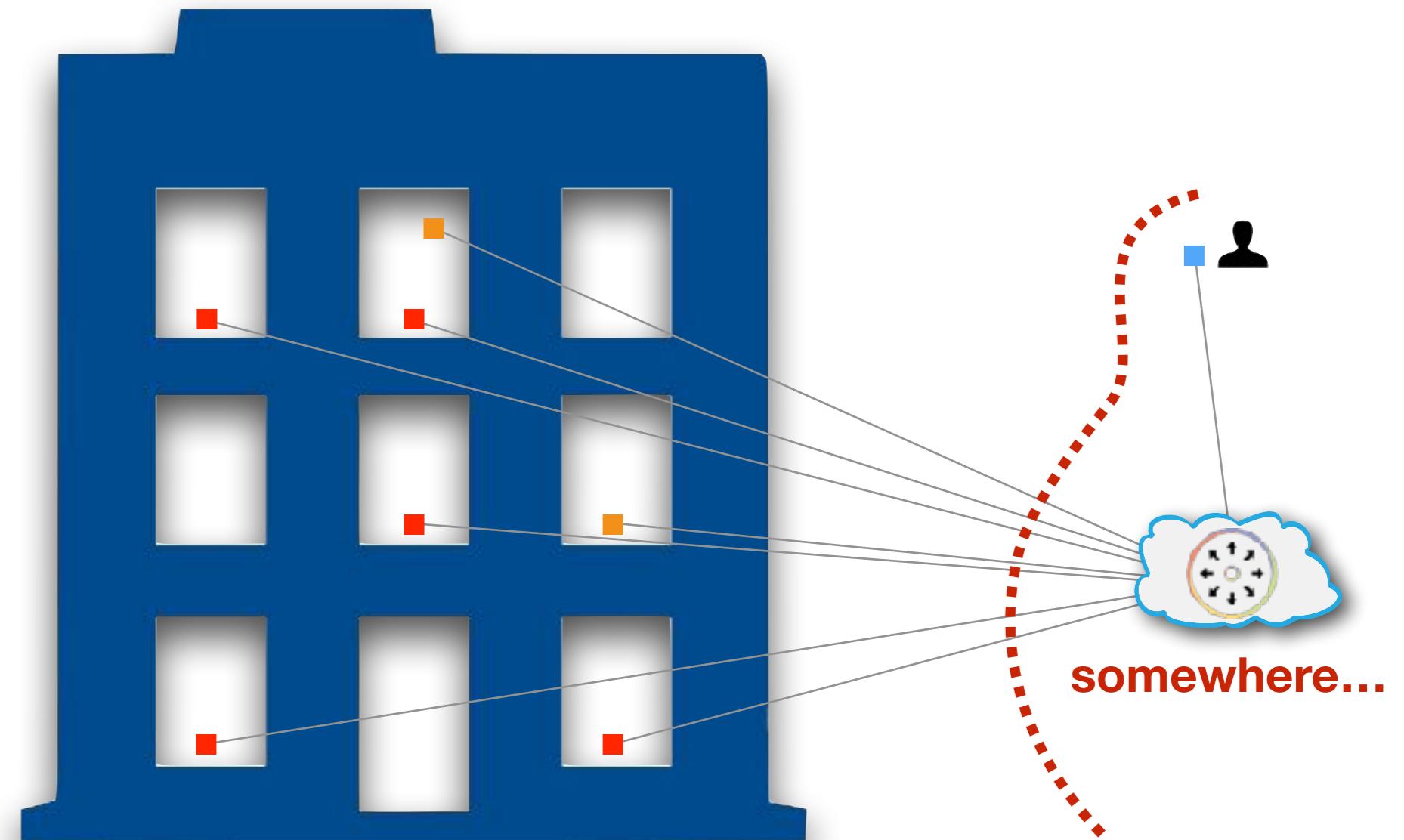
- ✓ sistema DAQ nativo
- ✓ scalabilità
- ✓ auto-configurazione dei nodi
- ✓ **dati serializzati**
- multiutente



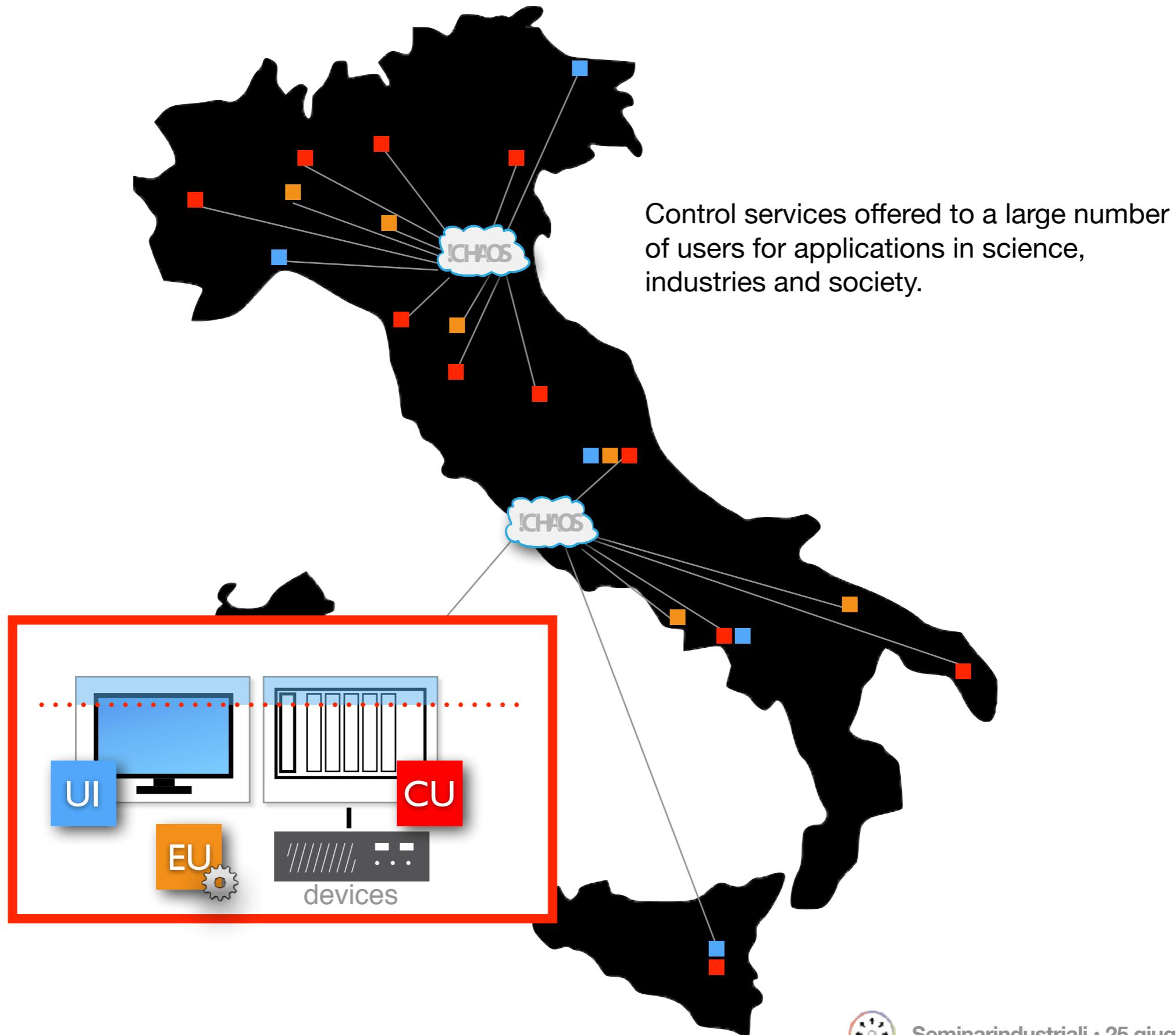
dati serializzati ed auto-espli canti







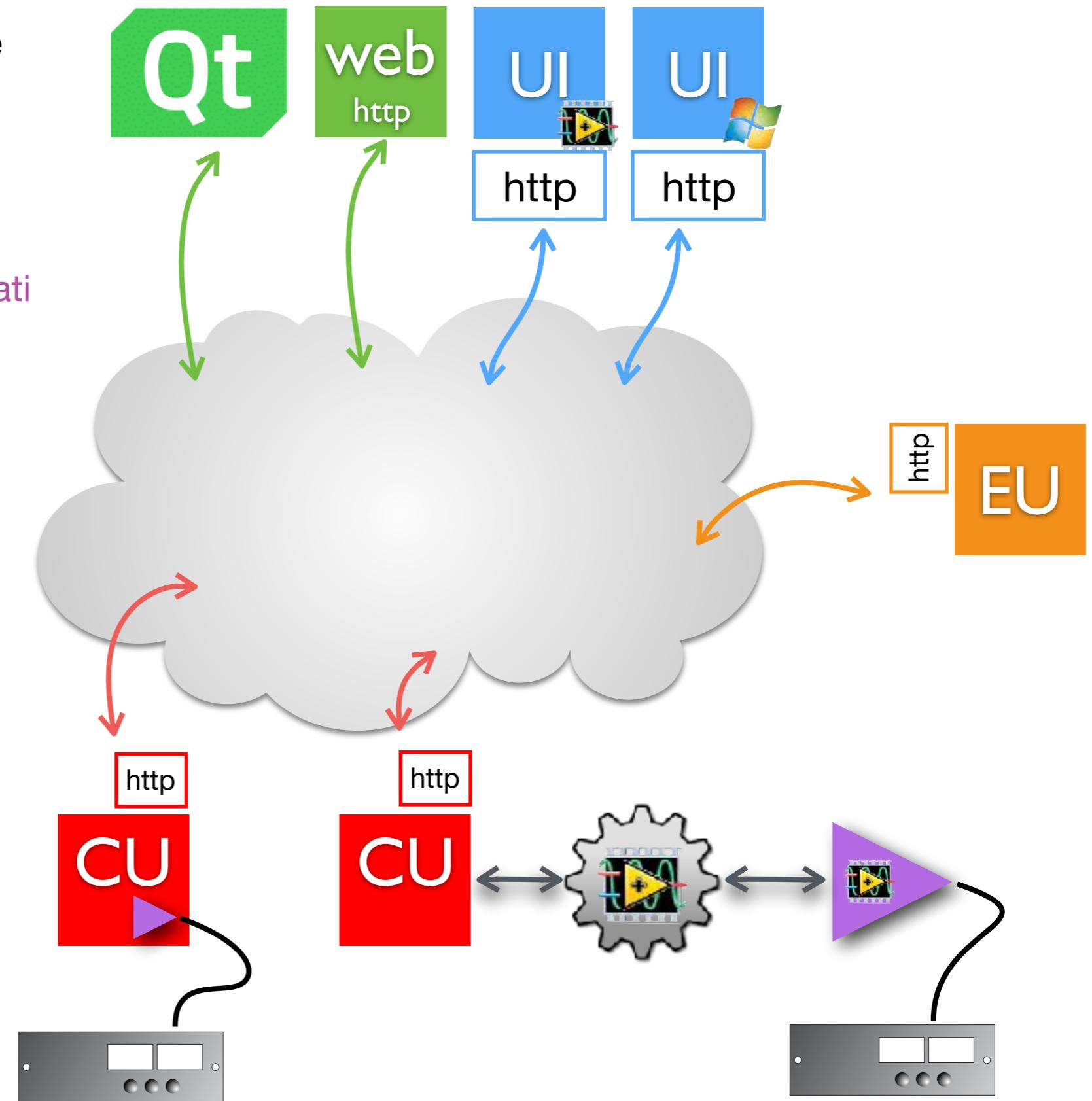
!CHAOS is a *Control as a Service*



General status

!CHAOS è un sistema che offre **servizi di controllo** a più utenti, per diverse applicazioni.

- **DAQ**
- **dati live** costantemente aggiornati
- **gestione** delle CUs ed EUs
- inoltro **comandi**
- salvataggio e ripristino **datasets**
- log e notifica **errori**

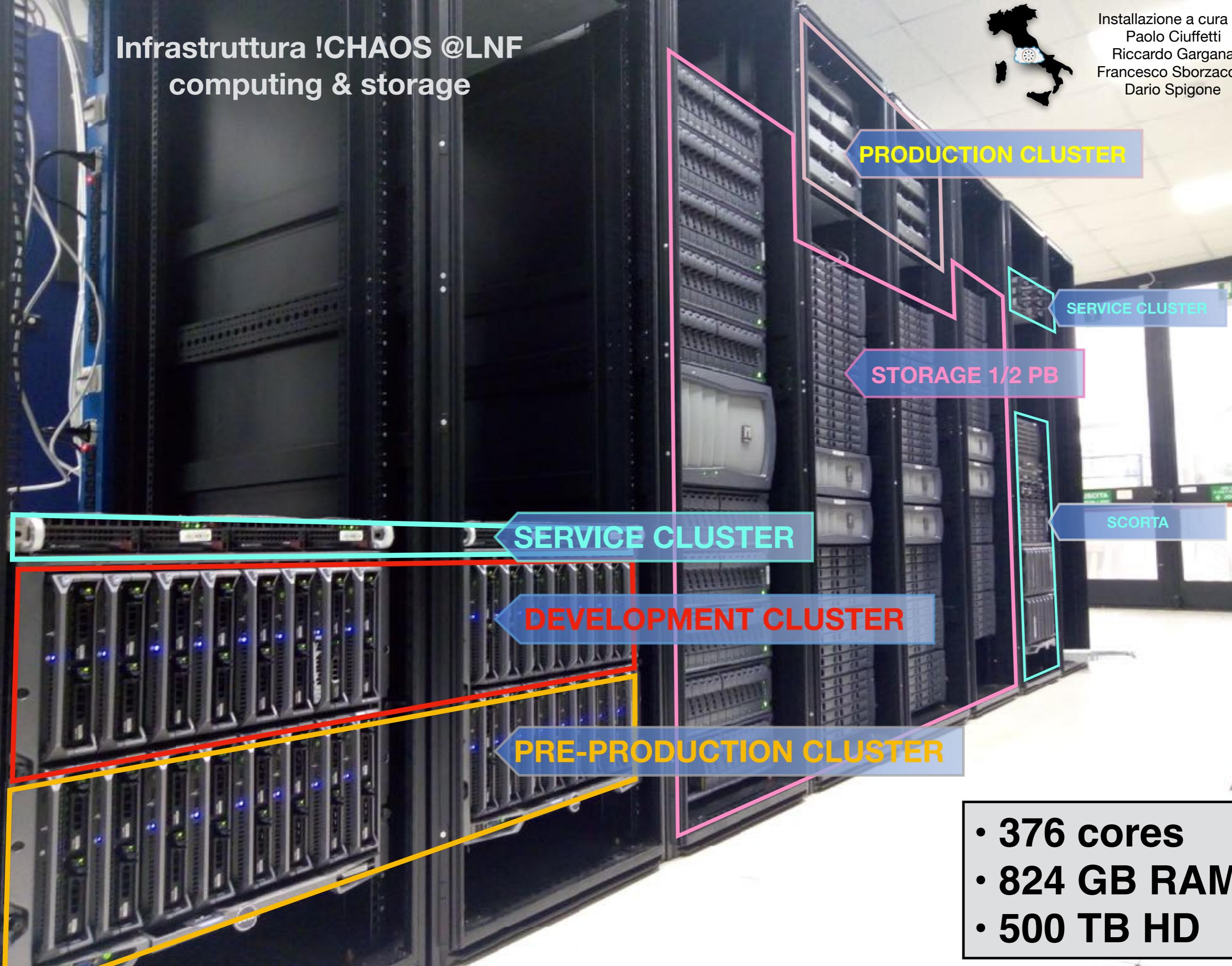


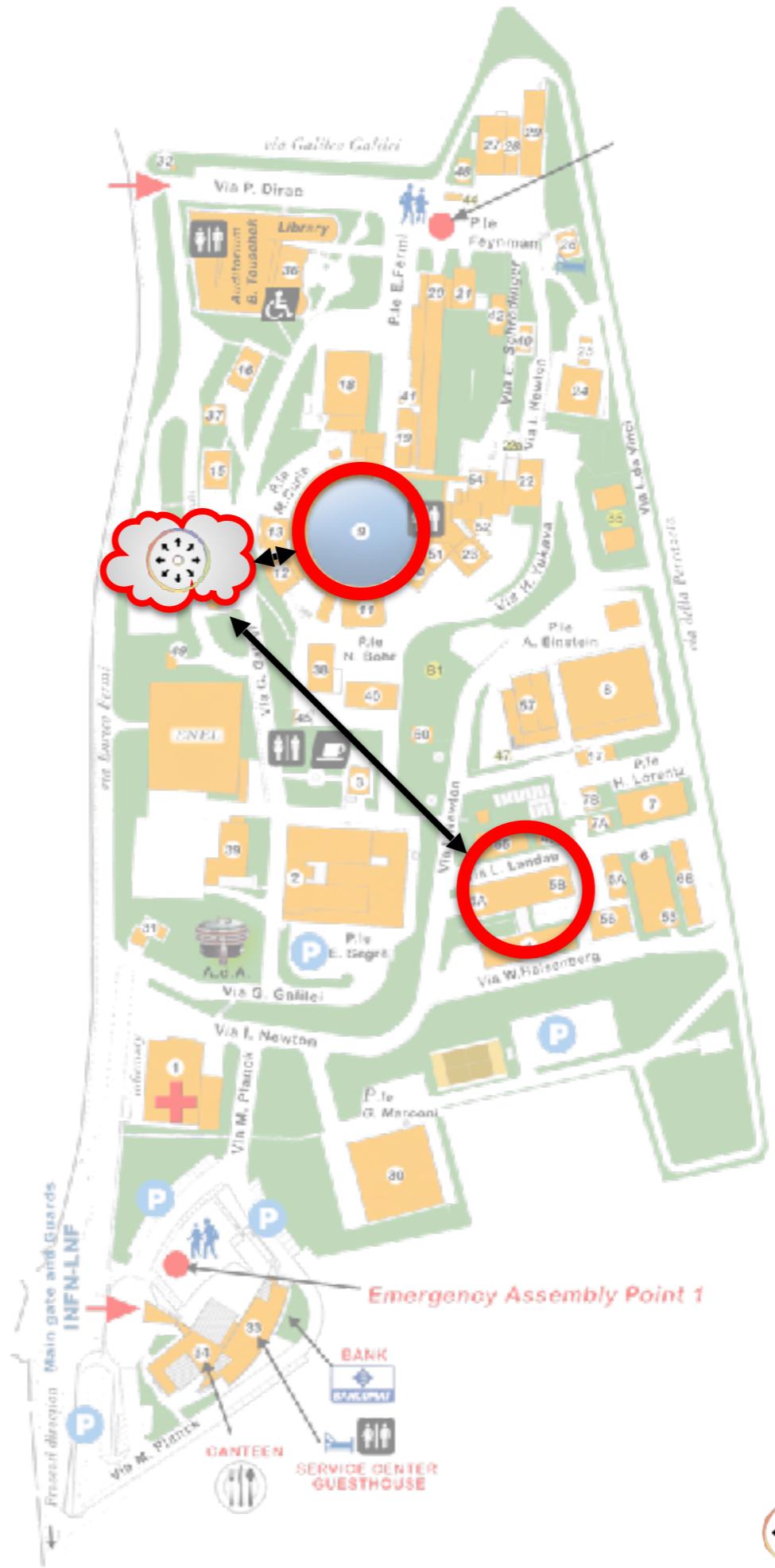
Infrastruttura !CHAOS @LNF

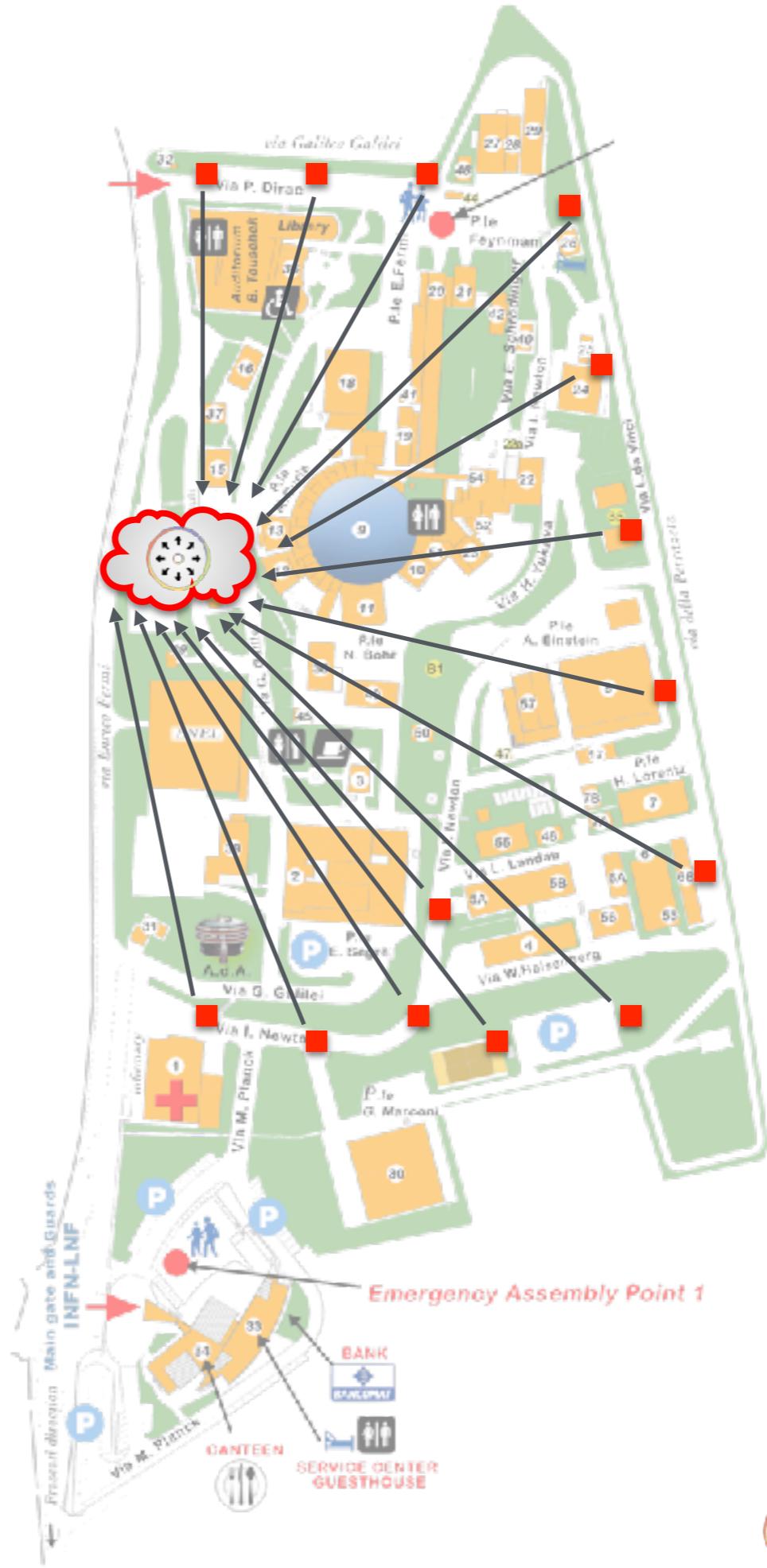
computing & storage

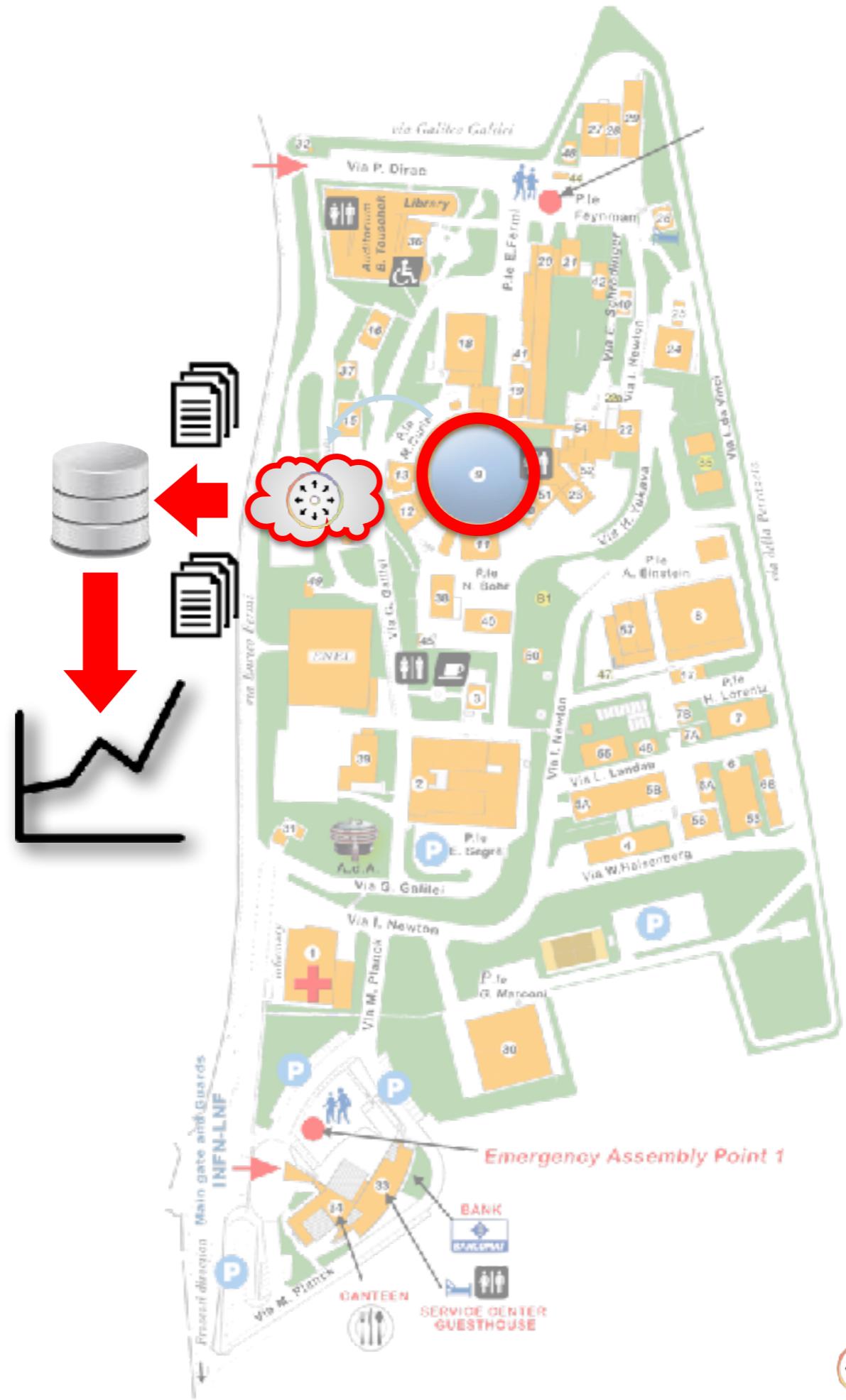


Installazione a cura di:
Paolo Ciuffetti
Riccardo Gargana
Francesco Sborzacchi
Dario Spigone







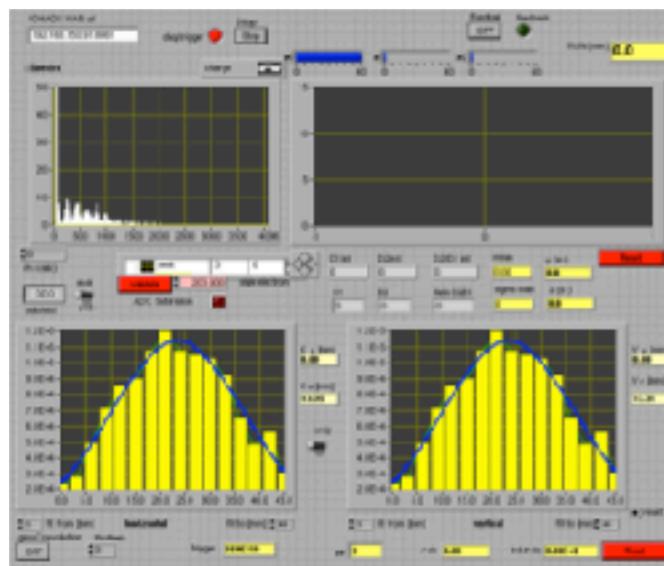


- ✓ sistema DAQ nativo
 - ✓ scalabilità
 - ✓ auto-configurazione dei nodi
 - ✓ dati serializzati
 - ✓ **multiutente**

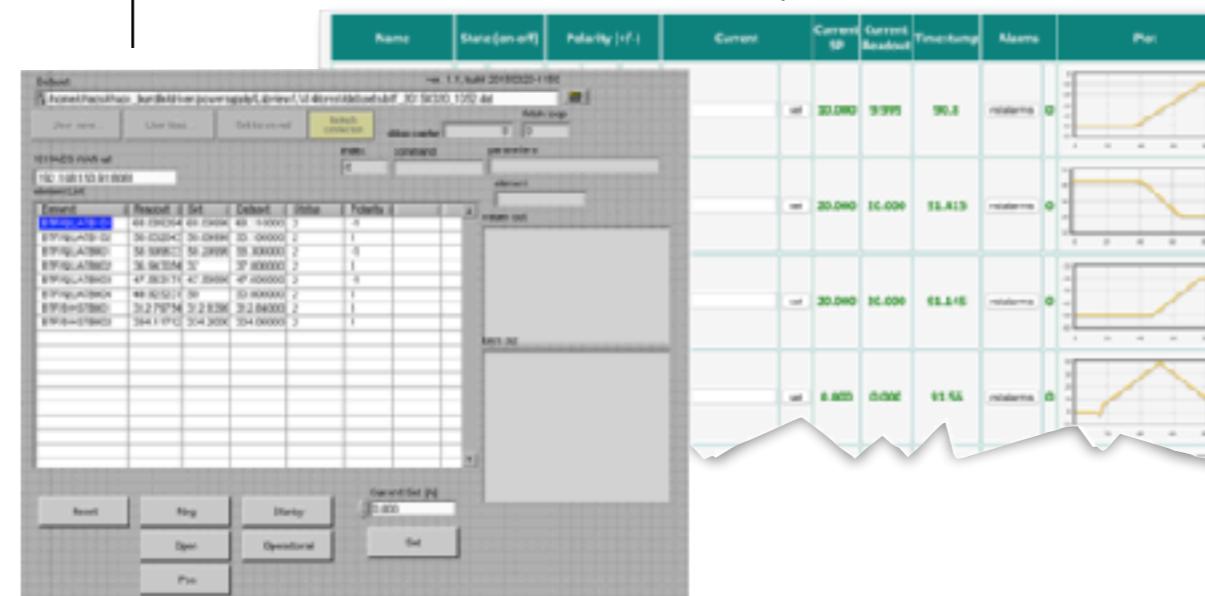


primo test pilota @DAFNE-BTF

DAQ system: beam position & single electron monitor



LabVIEW® Power Supplies control



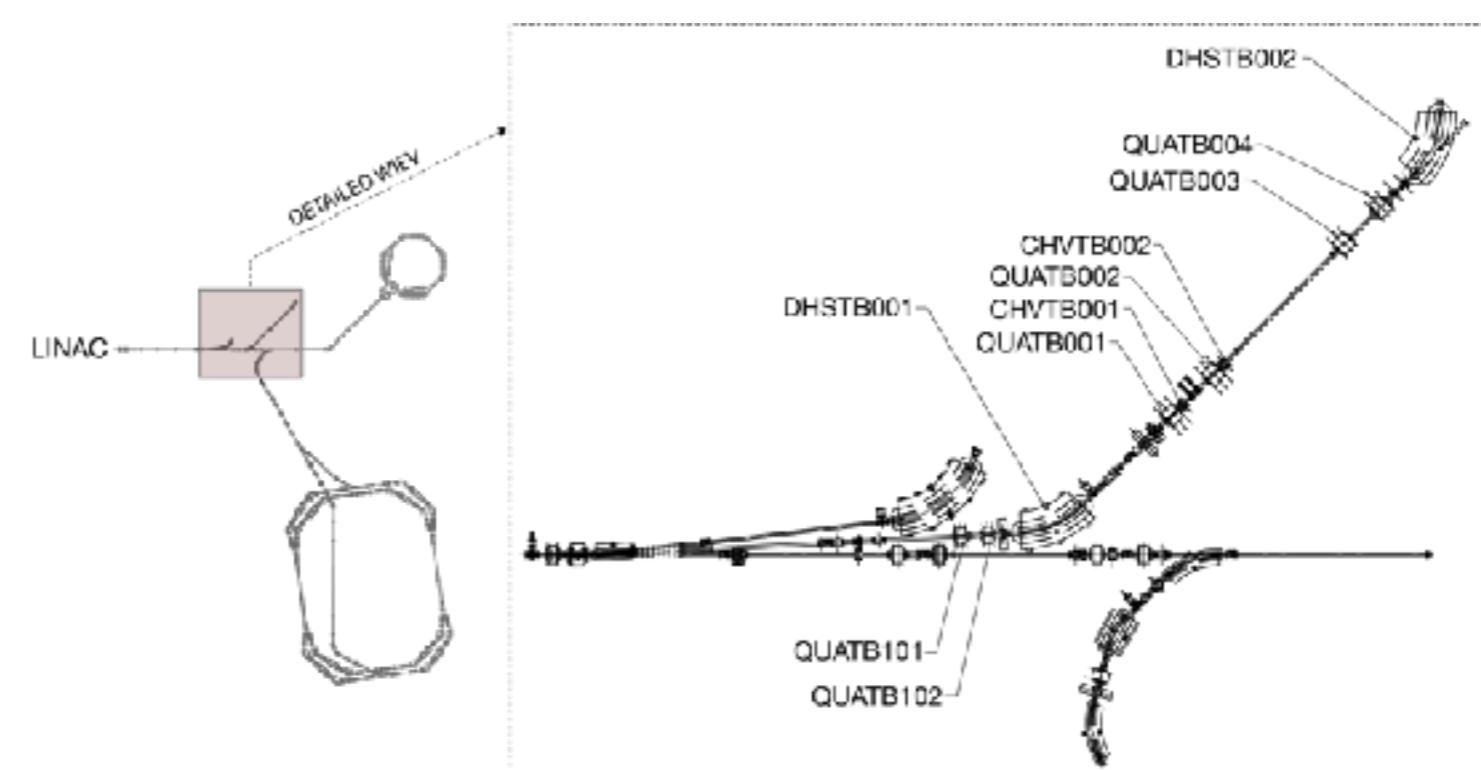
WEB Power Supplies control



CU on virtual machine via MOXA Serial Server



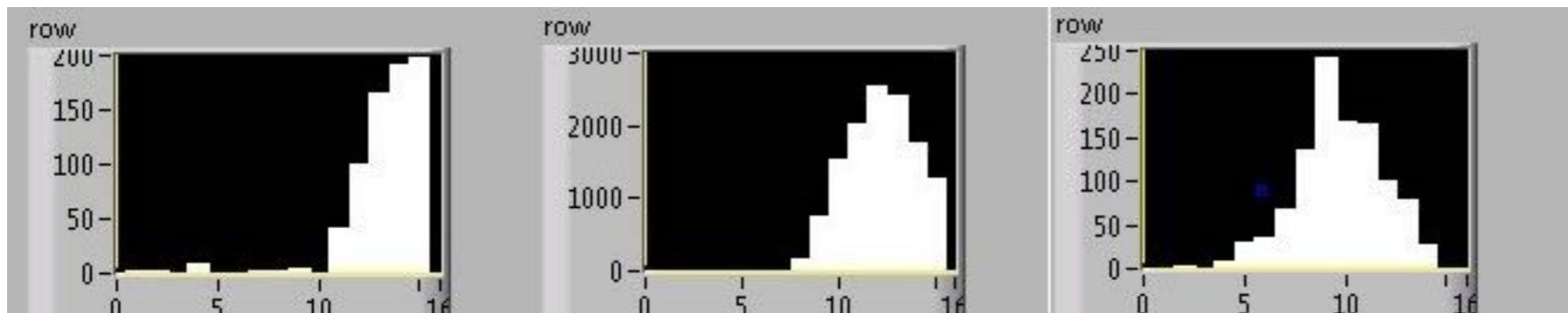
CU on Beagle Bone via custom Serial cape



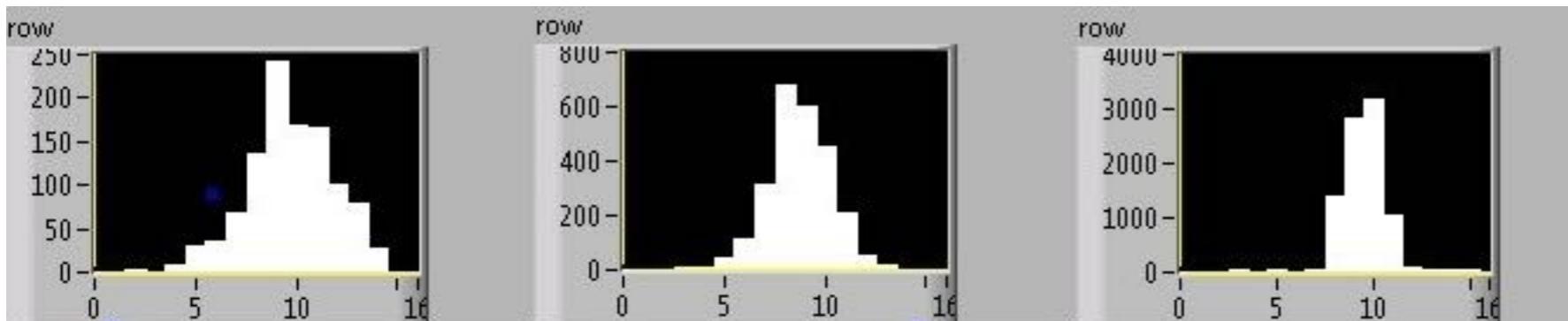
primo test pilota @DAFNE-BTF



447 MeV electron beam detection at the end of the transport on a GEM tracker



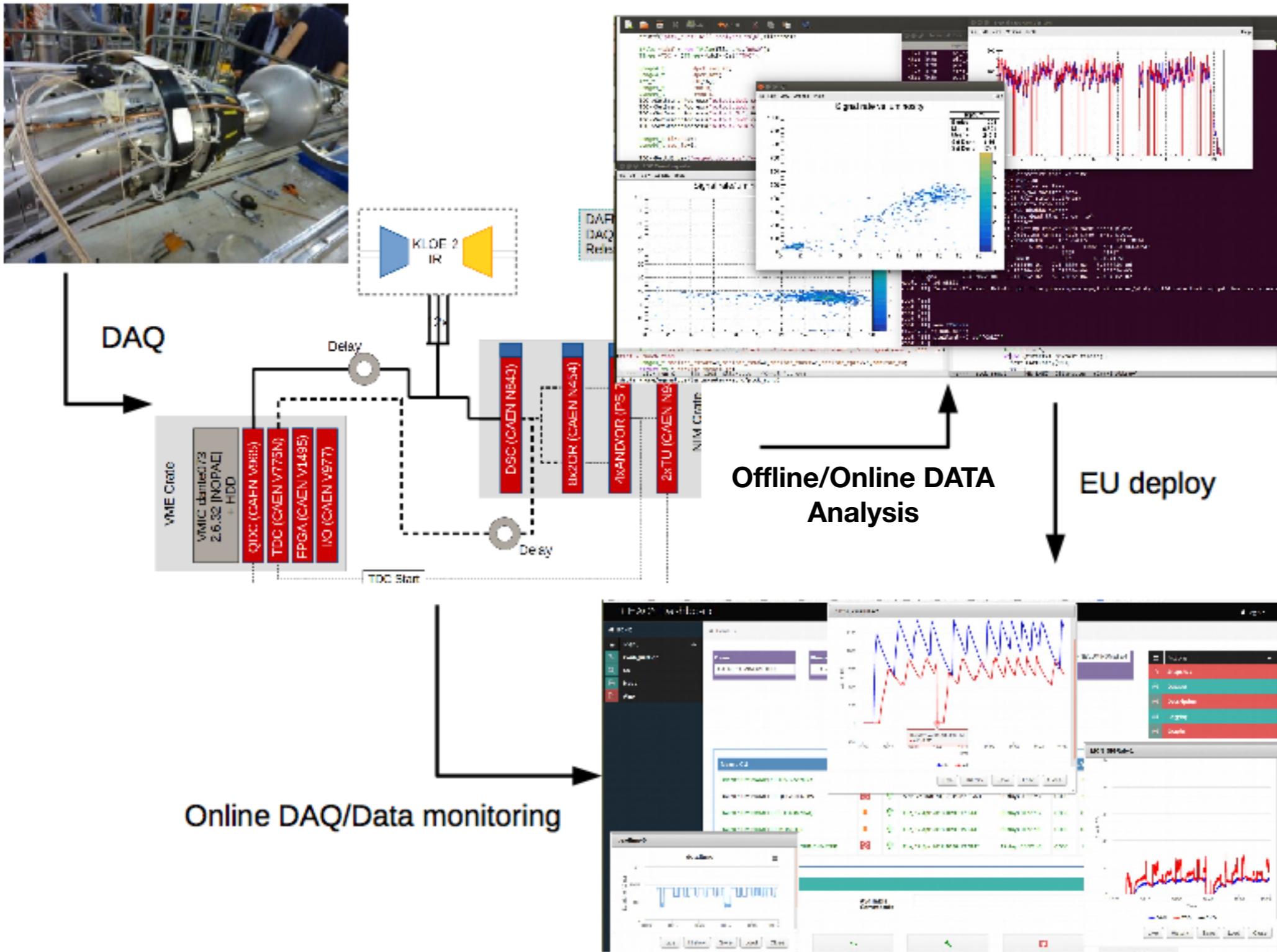
**steering optimization
with dipole in 2 A
steps**



**horizontal focusing
with quadrupole in 4 A
steps**



in ultimazione: luminometro di DAFNE





IMA SPA On the go:
the MAXIMA project

IMA is **world leader** in the design and manufacture of automatic machines for the processing and packaging of pharmaceuticals, cosmetics, food, tea and coffee.

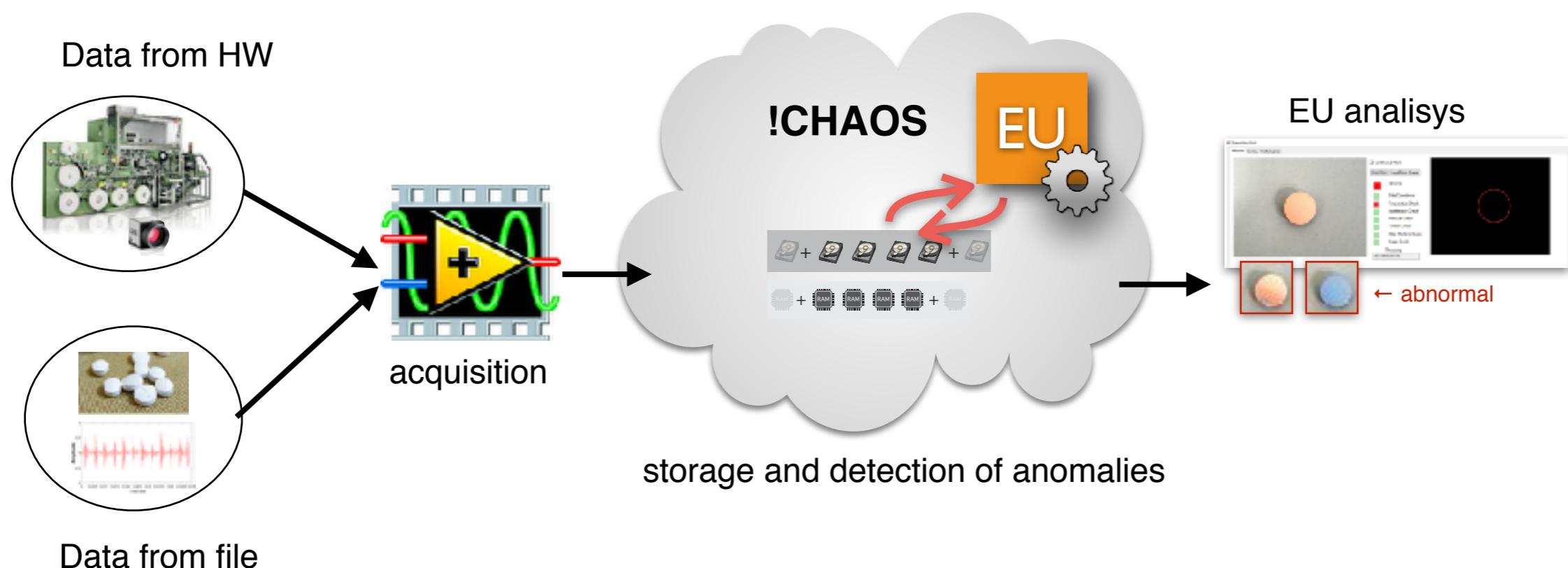
The MAXIMA collaboration aims to setup an infrastructure **to acquire data** from production line machines and **perform predictive diagnostic** to optimize their working point and prevent unwanted stops.



On the go: the MAXIMA project

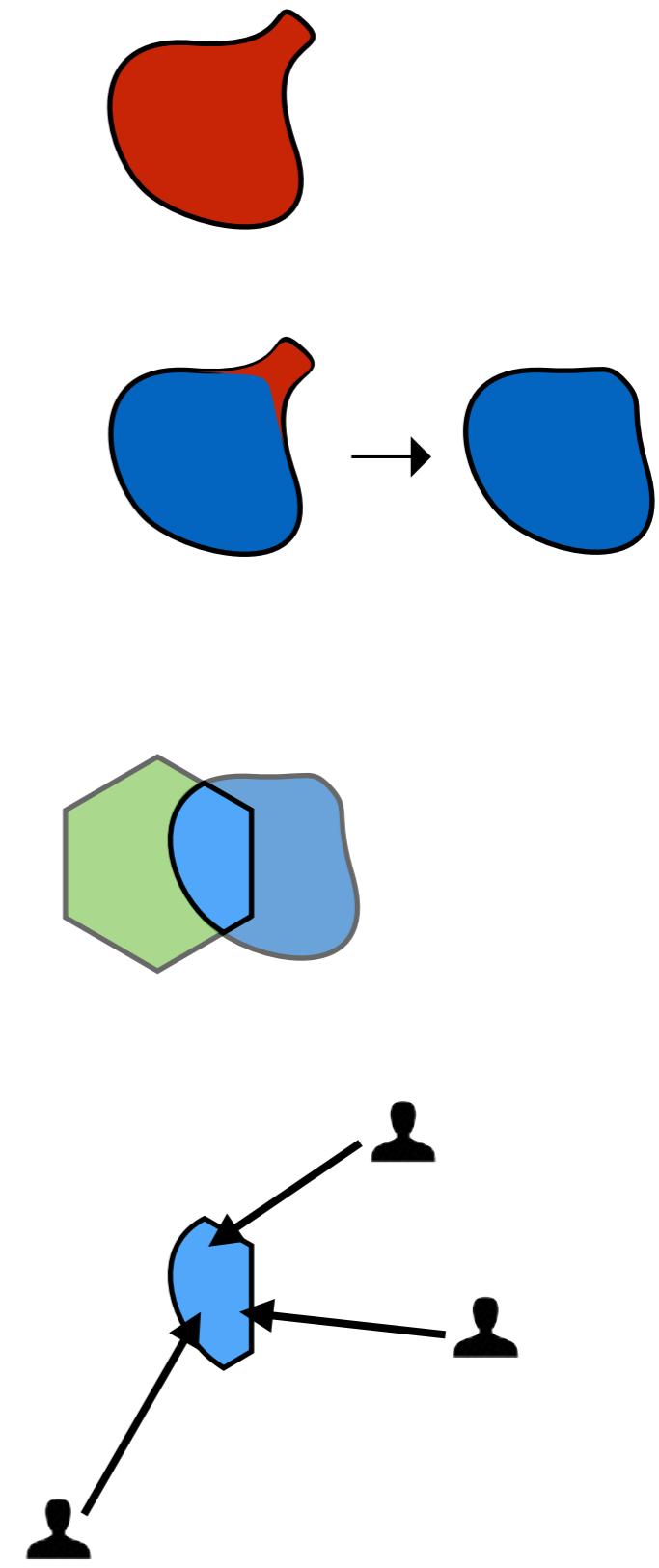
- Interest from customers for the !CHAOS control and analysis framework on the cloud.

Further developments and investments beyond MAXIMA — towards production level — seem possible.



Development model

1. identify client's requirements
2. discard/modify requirements not compatible with !CHAOS architecture or INFN mainstream objectives
3. develop the *least common multiple* features needed to satisfy the requirements and that are reusable for the “particle accelerator” mission
4. involve, *addict* and assimilate other people in the development of features & technologies of common interest



Development model - an example



A scientific internal requirement:

acquire the beam image, calculate some parameters and understand if they are compatible with a good luminosity



An IMA (private corporate) requirement:

acquire the image of pills running on the production line, recognize the bad ones from the good ones and discard them

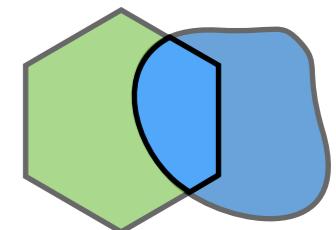


CHAOS requirement mapping

- fast storage
- camera acquisition
- fast retrieve
- analysis tool
- image processing algorithm

Results

- camera acquisition & storage
(640x480@70FPS \approx 21 MB/s)
- CERN Scientific analysis framework (Root)
integrated into !CHAOS
- image processing algorithm



The bottom line

!CHAOS:

- the **CaaS** and native DAQ features are unique
- proved to be a "*good horse*" and can help our institute to face it's **incoming challenges**
- is an opportunity of **effective interaction** among our institute, industry and society
- is very suitable for **Research Infrastructure Networks** external projects

