

PETER SKANDS : CERN THEORY UNIT

CERN PILOT PROJECT



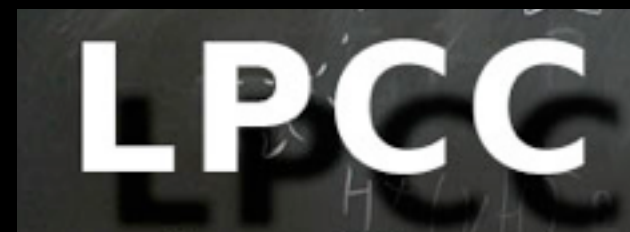
VINCIA



PYTHIA



MonteCarloNet FP7 ITN



LHC Physics Center at CERN



Nutshell



Theory



Experiment

Adjust this to agree with this

Nutshell



Theory

Lots of physics
to learn about and play with



Experiment

Lots of hi-tech equipment and
fascinating measurements
to learn about

Adjust this to agree with this

Nutshell



Theory

Lots of physics
to learn about and play with



Experiment

Lots of hi-tech equipment and
fascinating measurements
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Adjust this to agree with this

→ Feedback to scientists

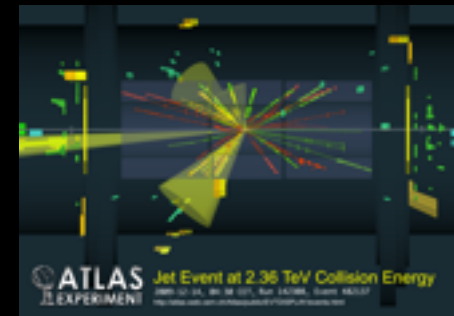
In Practice



VINCIA



PYTHIA



Simulation Codes

Physics (to learn about)
Parameters (to play with)

→ Simulated Particle Collisions

(g)	-51	14	17	34	34	132	172
(d)	-71	29	29	42	63	171	0
(g)	-71	30	30	42	63	172	171
(g)	-71	31	31	42	63	132	172
(g)	-71	26	26	42	63	157	132
(g)	-71	27	27	42	63	158	157
(g)	-71	28	28	42	63	156	158
(g)	-71	25	25	42	63	149	156
(g)	-71	21	21	42	63	150	149
(g)	-71	22	22	42	63	108	150
(dbar)	-71	13	13	42	63	0	108
(K*0)	-83	32	41	64	65	0	0
(Kbar0)	-83	32	41	66	66	0	0
(rho-)	-83	32	41	67	68	0	0
(pi0)	-83	32	41	69	70	0	0
p+	83	32	41	0	0	0	0
nbar0	83	32	41	0	0	0	0
pi-	83	32	41	0	0	0	0
(pi0)	-83	32	41	71	72	0	0
pi+	83	32	41	0	0	0	0

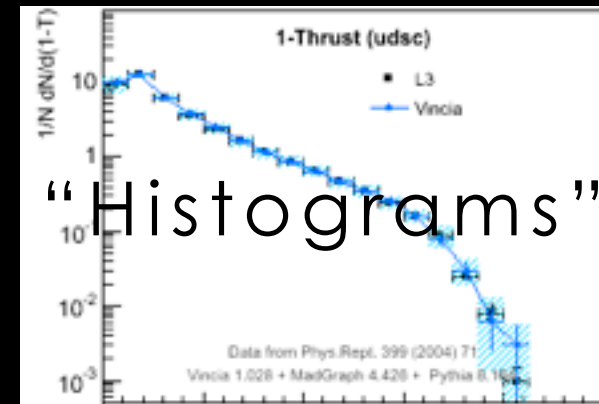
“Events”



Experimental Data

Particle Accelerators,
Detectors, and Measurements
(to learn about)

→ Published Data Points



“Histograms”

Virtual Colliders

The true nature of the strong nuclear force is revealed at distances below about 10^{-15}m ($= 10^{-6}$ nanometers)

The energy needed to produce wavelengths that small: kick (accelerate) an electron with 1 billion Volts : 1 Giga-electron-Volt (GeV)

The energy of the Large Hadron Collider (LHC) at CERN : 8 TeV ← “the Terascale” !

The theory - quantum chromodynamics - has a challenging and rich structure, from simple fractals of (quantum) fluctuations within fluctuations, to strongly bound towers of resonances.

In high-energy experiments, such as those at CERN, our ability to make forecasts is pushed to the limit, and then some. The task of “event generators” is simple: deliver a complete description, in as much detail as mother nature. The solutions are less simple, and yet the clarity of our vision of the Terascale depends on them. *You can help!*



The “Jeppsson” Project

April 2010

- April 2009: FB message from friend of friend. Can a 15-yr old be a one-week intern at CERN?
- We were developing a run-time display for our simulation anyway.
- April 2010: simple text editor to edit input cards. Run-time display to compare output to data.

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- April 2010: simple text editor to edit input cards. Run-time display to compare output to data.
- May 2010: Parameters released as new defaults.



First Deliverable (M18 - Feb 2014) : Initial Prototype

DoW: "A playable, if crude, game prototype, for early testing and development, accompanied by a report describing its features and performance characteristics."

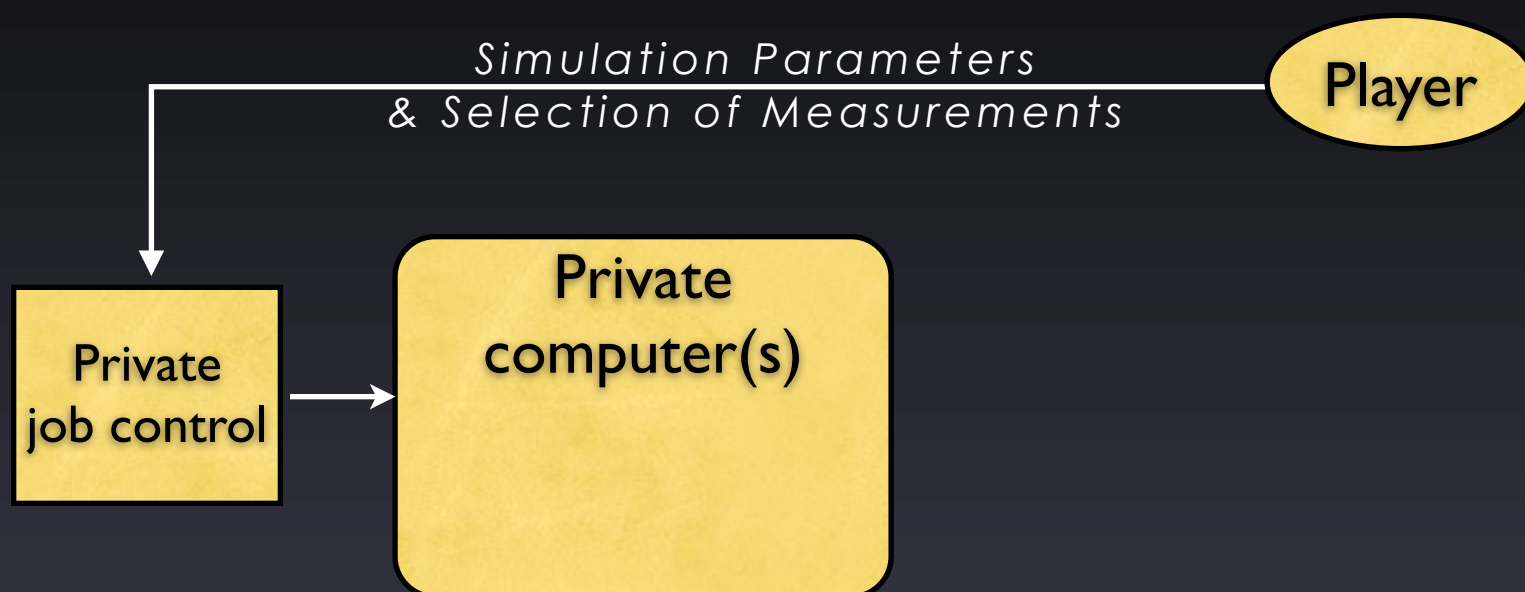
Architecture

Structure and Aims

**Apologies: quite technical
(will return to Content and Learning momentarily)**

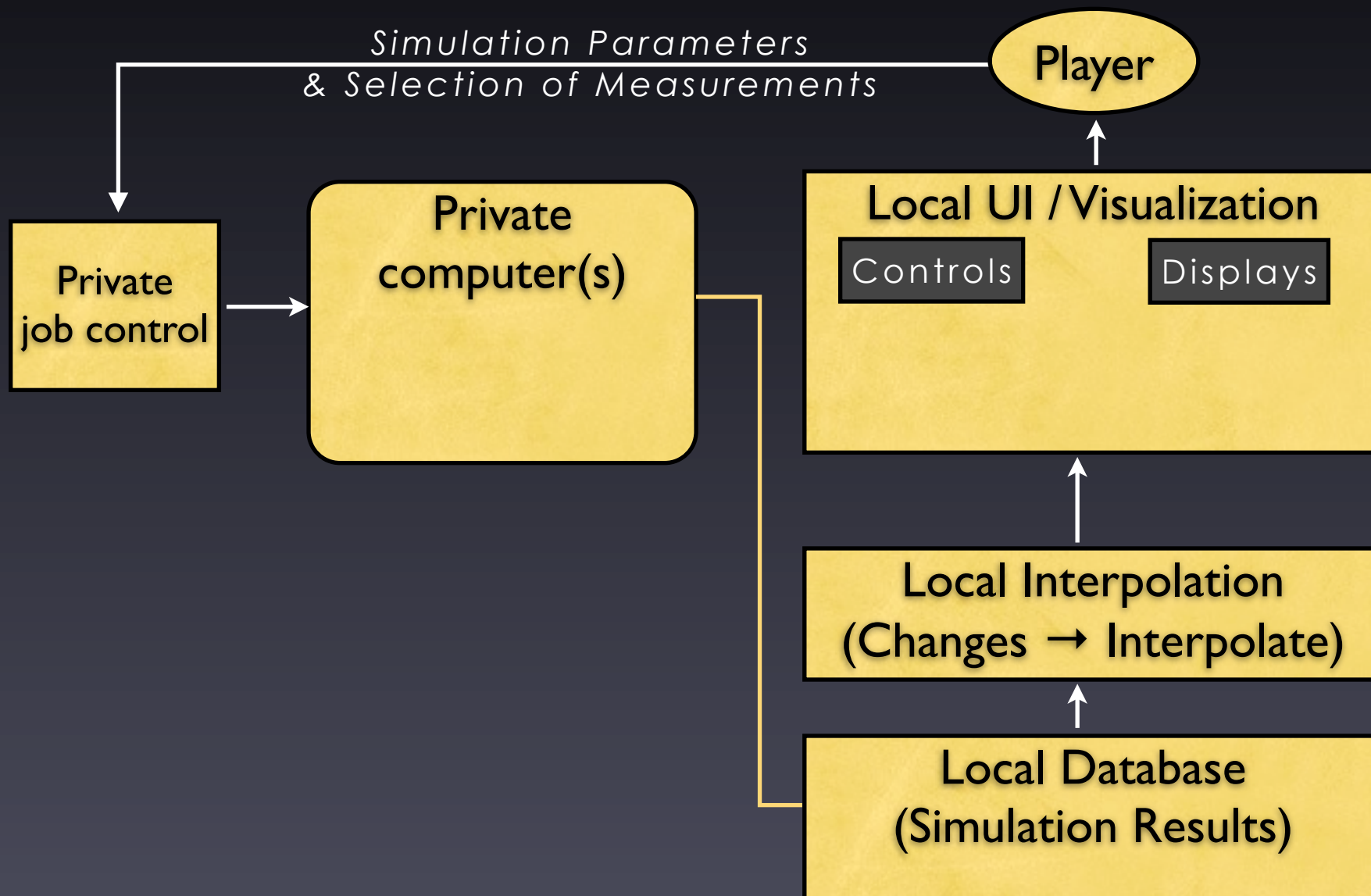
Offline Mode: Single User

(To be discussed)



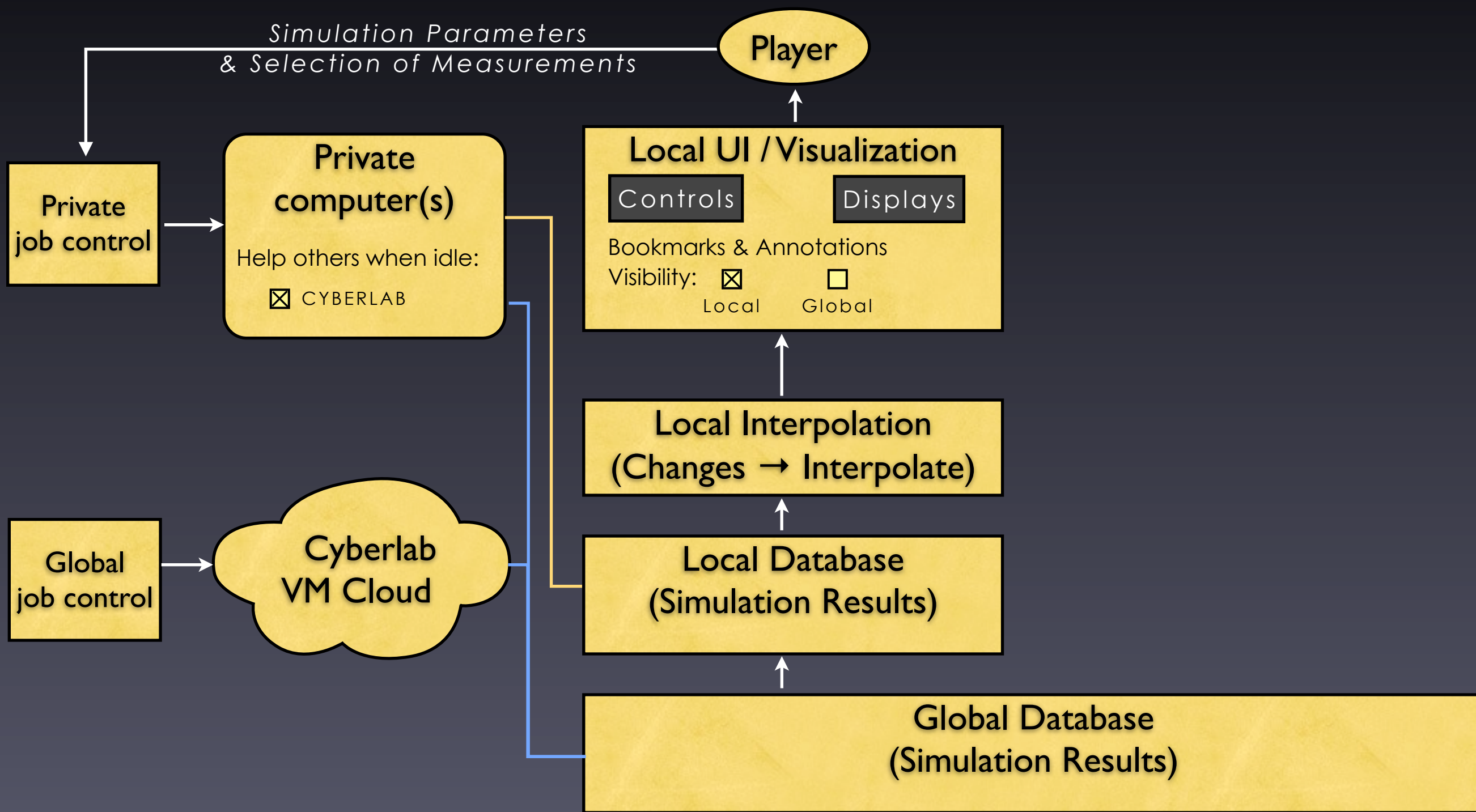
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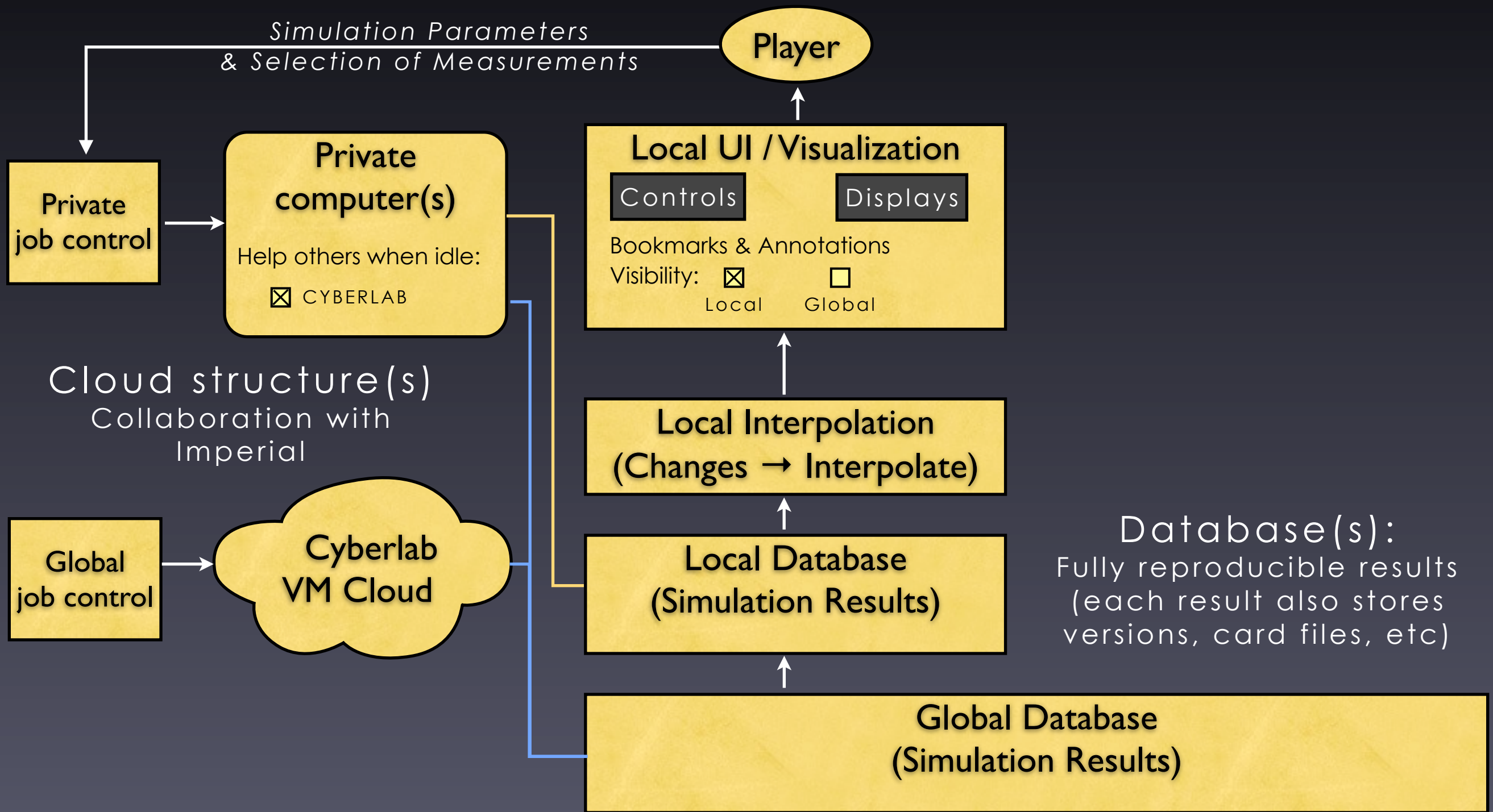
Cloud Structure

(To be discussed)



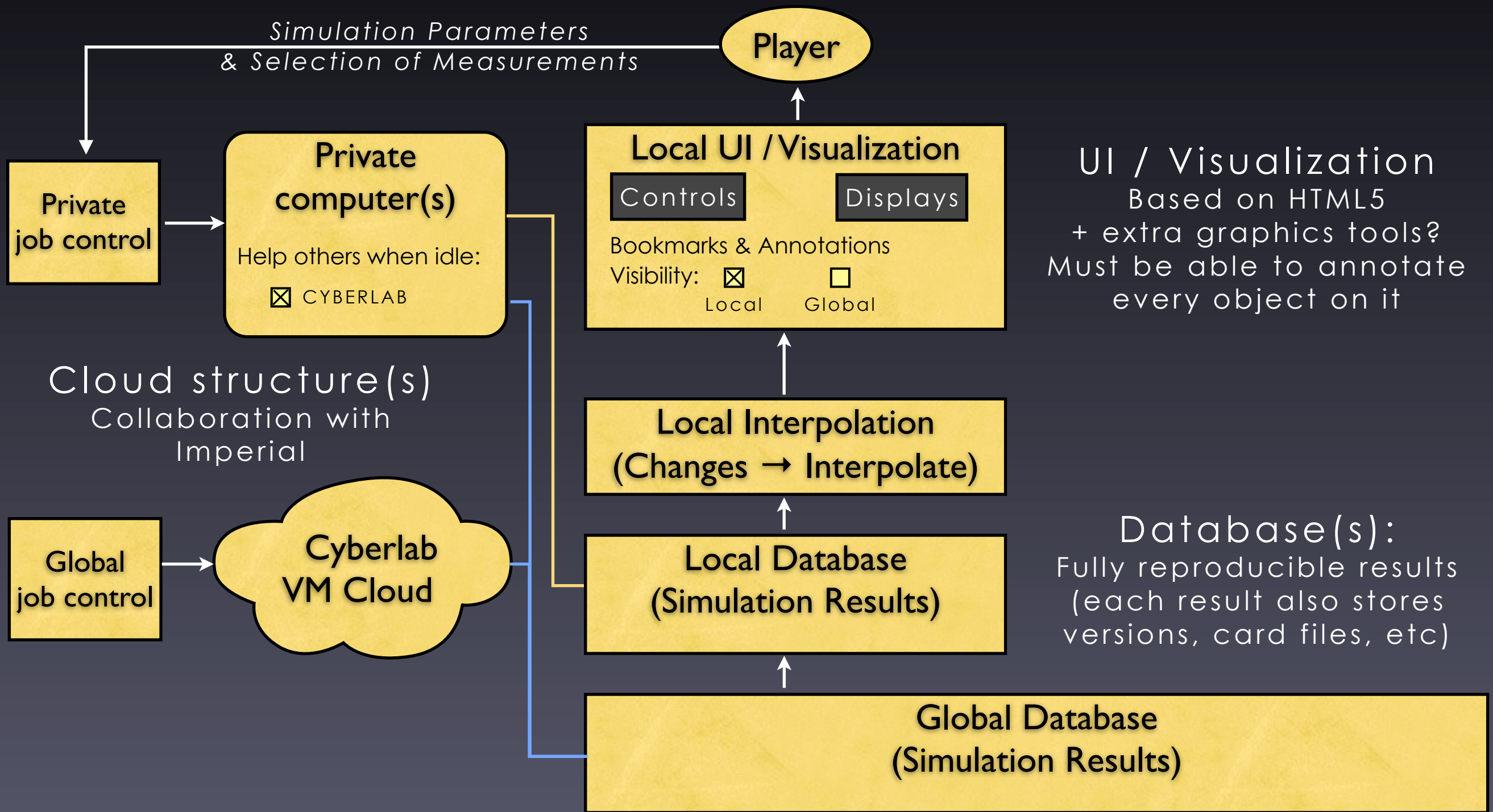
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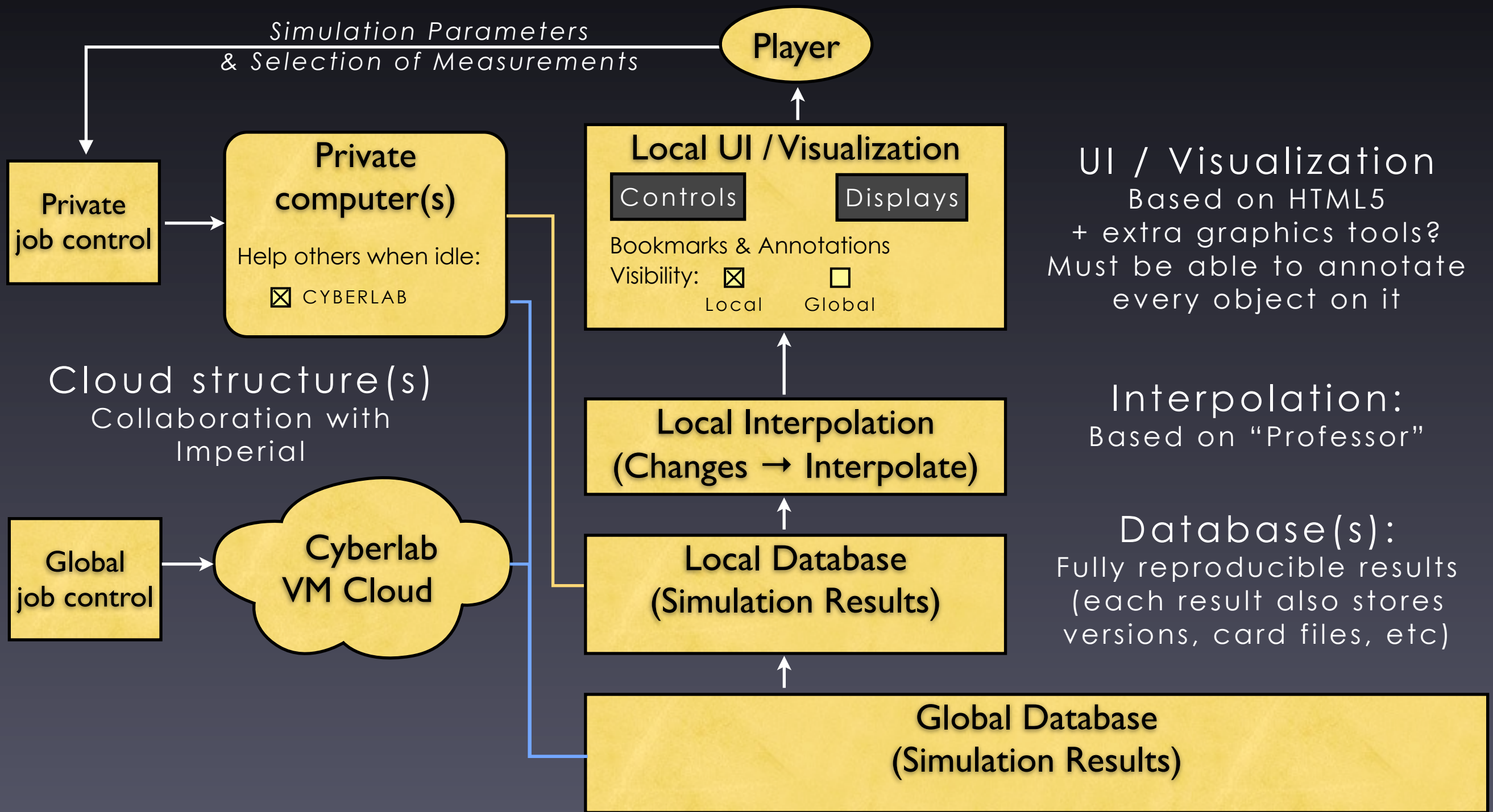
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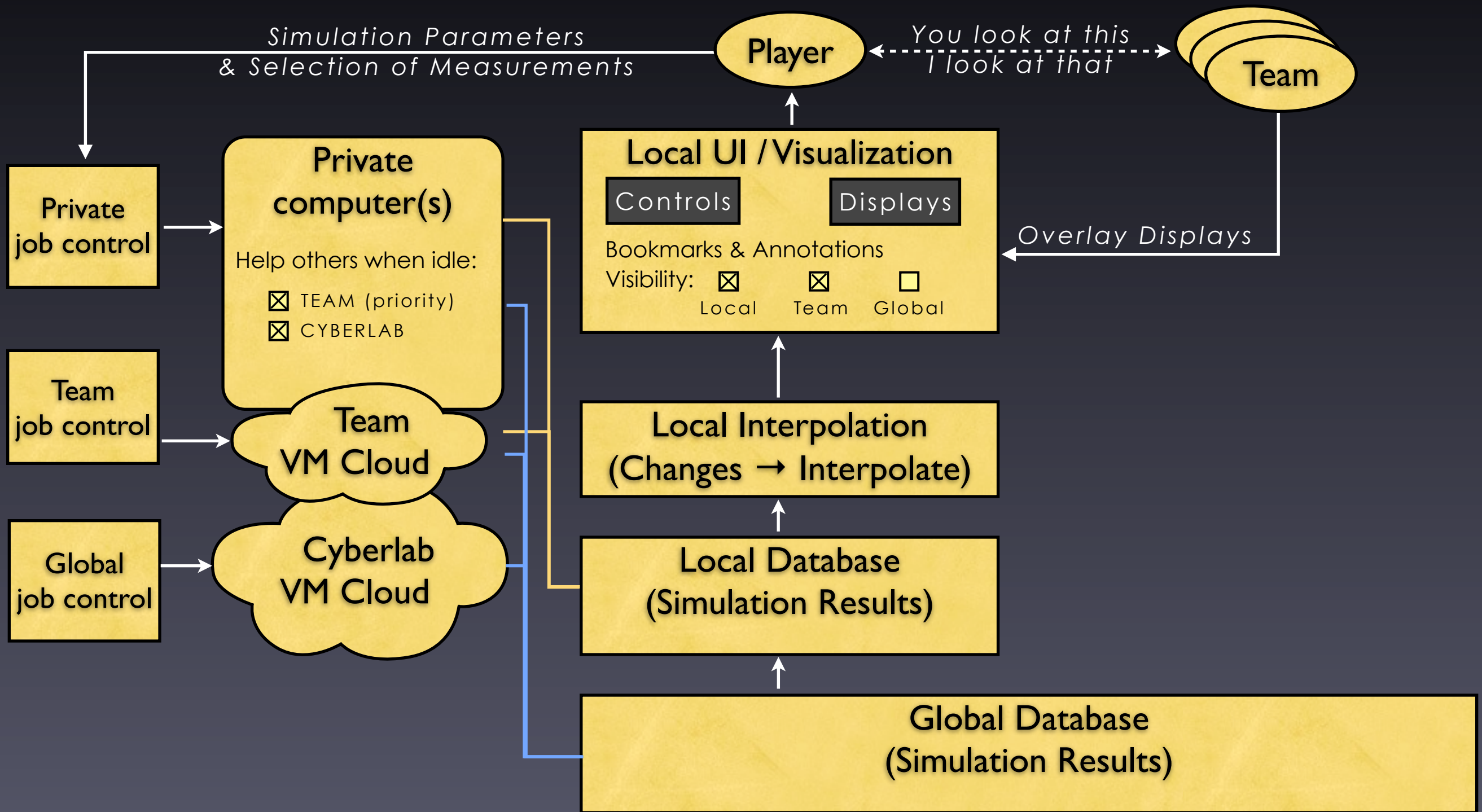
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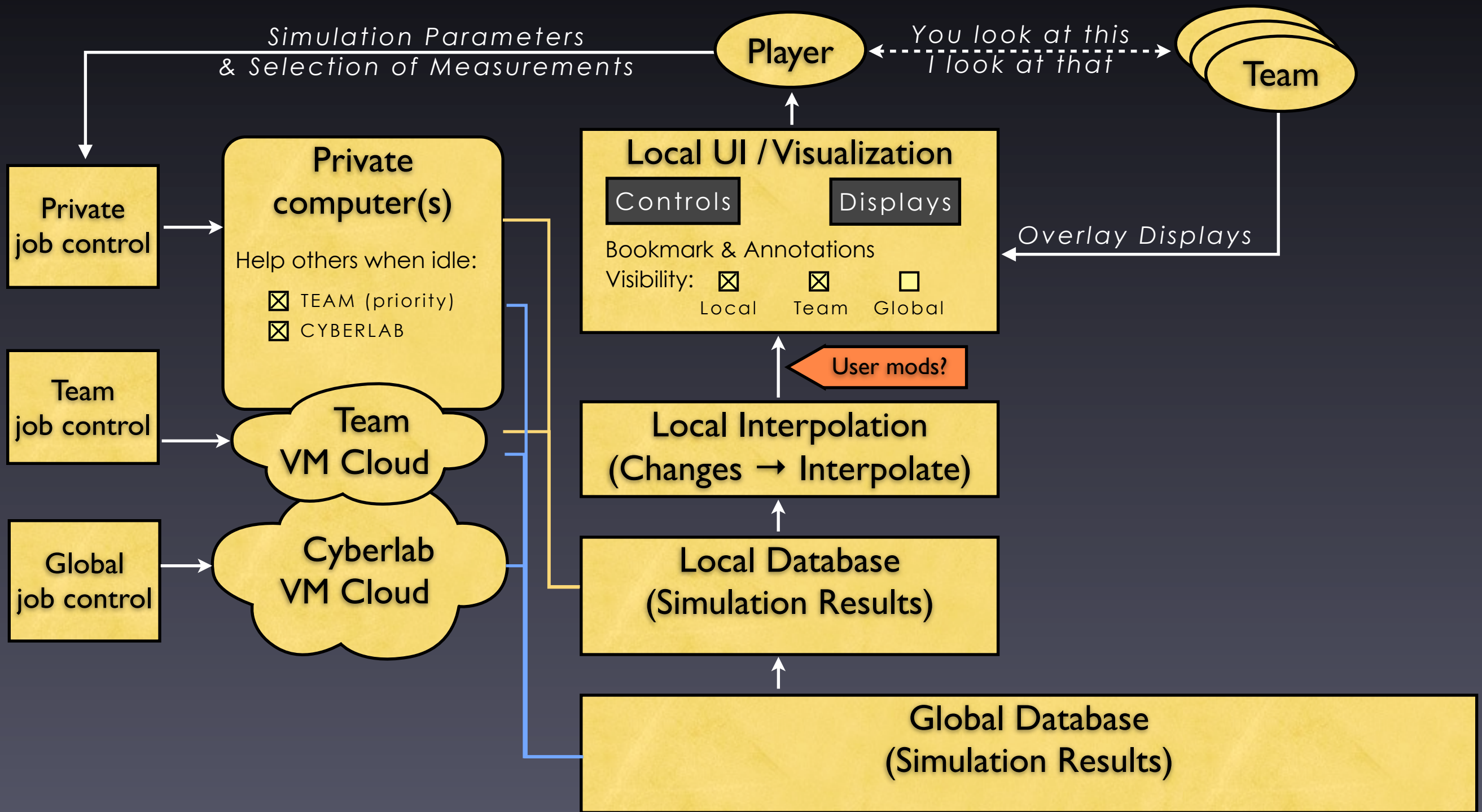
Teams

(To be discussed)



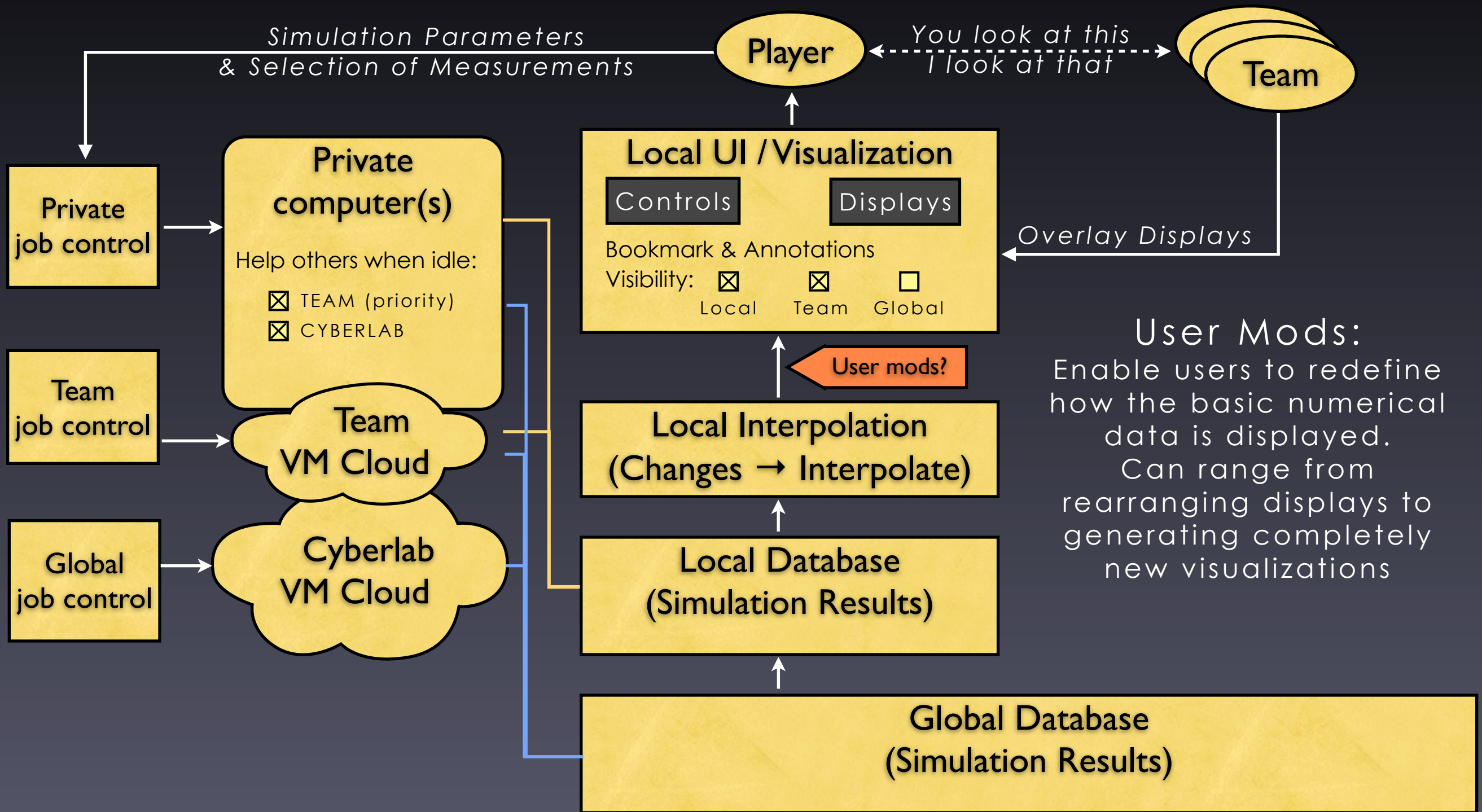
User Mods

(To be discussed)



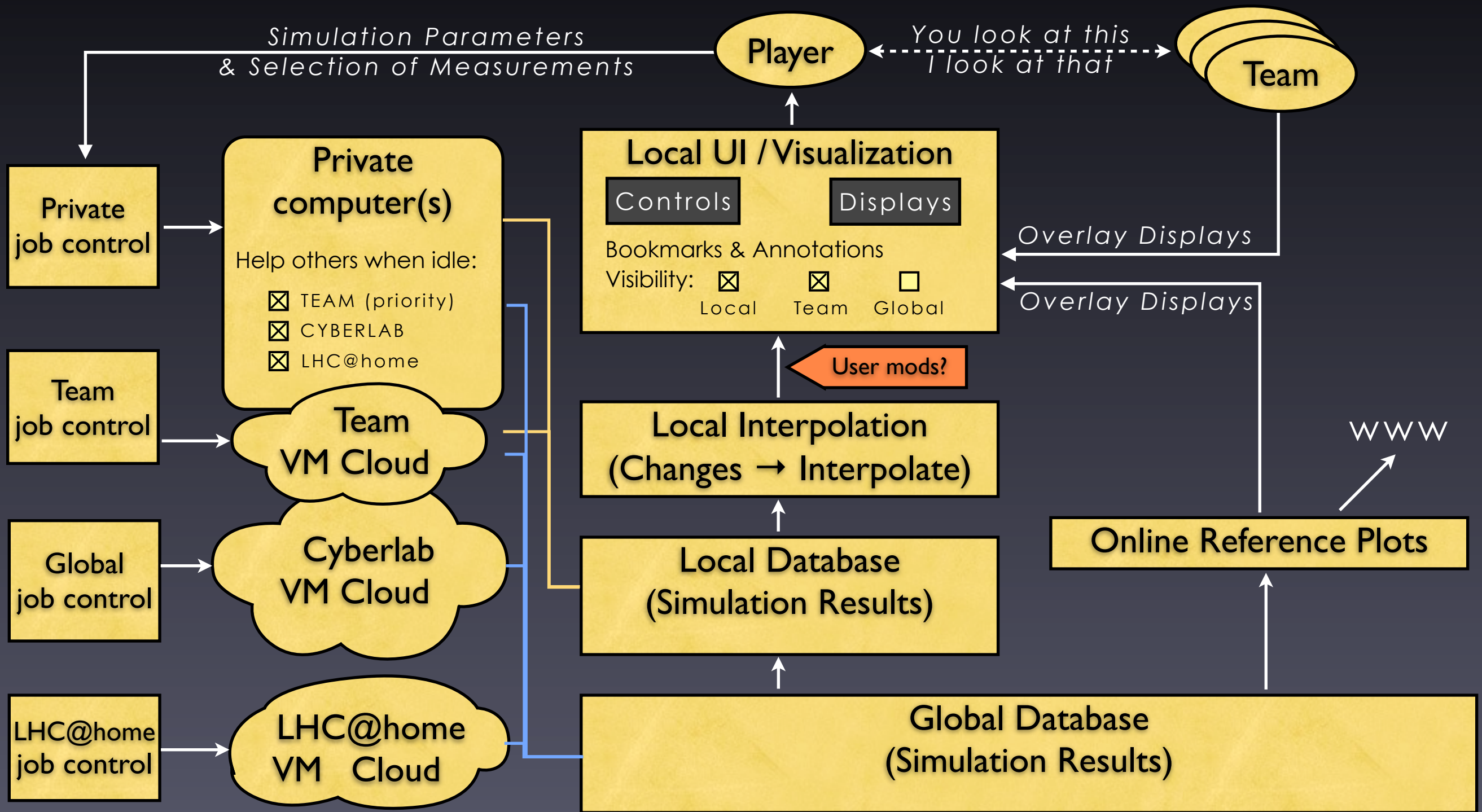
User Mods

(To be discussed)



Integration with LHC@home

(To be discussed)



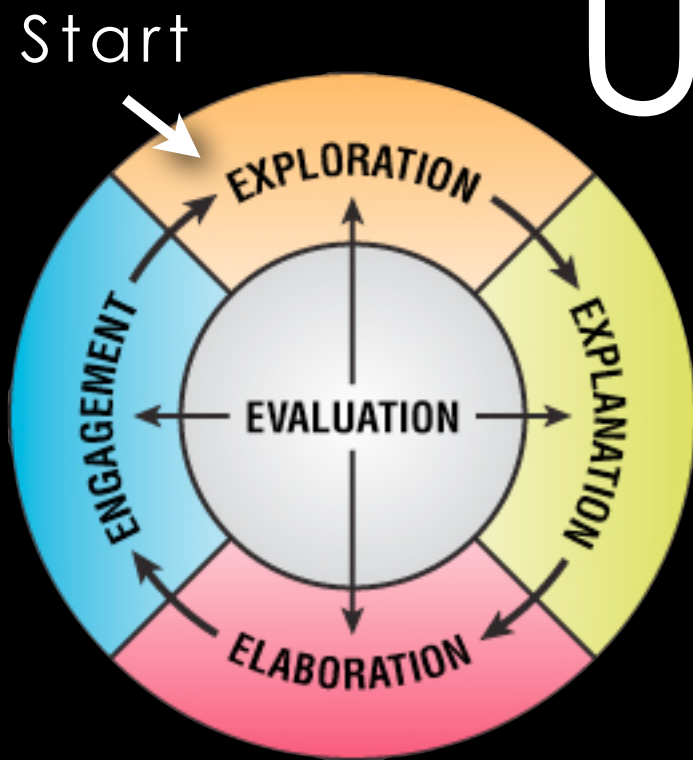
Content and Learning

User Interface and Storyline

Here: focus on user experience and science content
Needs to be added (→ platform development?):
Hooks for monitoring and evaluating use and learning

User Interface

(To be discussed)



1. Immediately present user with interesting and interactive content.

Engagement Cycle
(constructivist)
Note: only for illustration.
Will be horribly abused

Controls

Display

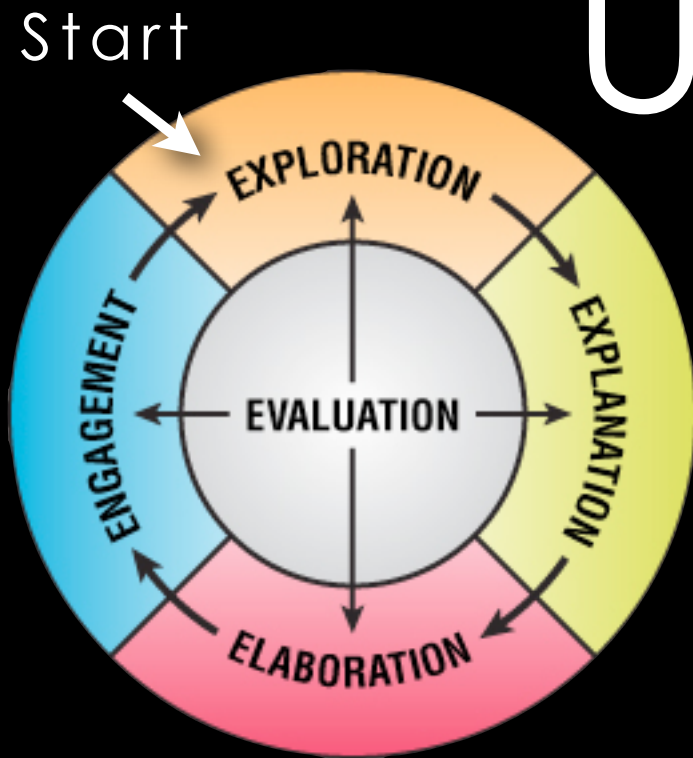
Task: Use the controls (left) to make the simulation agree with the data (right)

Rollover
tooltips
+
Click for
more

More detailed explanations can be clicked into
→ Explanation → Elaboration → Engagement

User Interface

(To be discussed)



1. Immediately present user with interesting and interactive content.

Engagement Cycle
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Controls are used to set the simulation parameters

Controls

Display

Rollover
tooltips
+
Click for
more

Task: Use the controls (left) to make the simulation agree with the data (right)

More detailed explanations can be clicked into
→ Explanation → Elaboration → Engagement

Context Example

(Clicked on "Controls")



2. Provide deeper levels of context, user extensions, and discussion
(can be divided into levels: citizens, students, experts)

Level 1

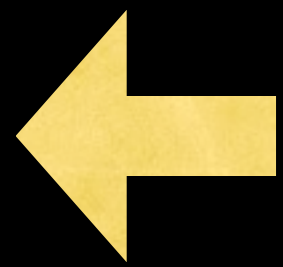
Controls

Display

← Controls
Are used to set the simulation parameters. More elaboration ...

Rollover
tooltips
+
Click for
more

3. Users create their own annotations too (private / shared)
+ Combine with vote good/bad (incl our explanations)
+ Forums for further detailed discussion of issues

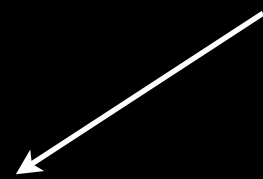


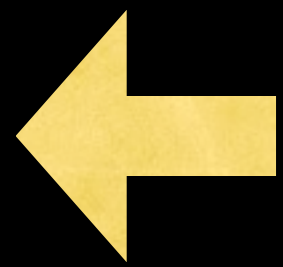
Context Example

(Clicked on "Task" and maximized)

- **Determine:** the coupling constant of the Strong Nuclear Force
 - Symbol: $\alpha_s(M_Z)$
 - Short Explanation ⁱ
- **Data:** the ALEPH experiment: jet rates
 - Symbol: R_3
 - Short explanation ⁱ
- **Theory Simulation:** Pythia 8 + Vincia
 - Short explanation ⁱ

Many opportunities for learning
+ Annotations (private, team, global)





Context Example

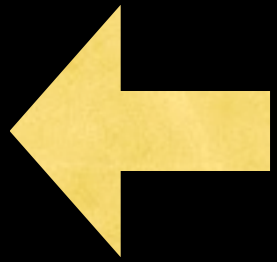
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Learning Monitors
User Studies





Pythia

Q: is each of these a
wiki page, or
something else?

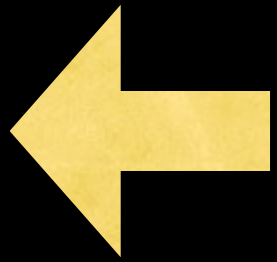
Context Example: Theory Simulation

- Description
- Main Features
- History (with hyperlinks to more details)

+ Annotations
(private, team, global)

The myth tells how Apollonⁱ, the God of Wisdom, killed the monster Pythonⁱ, close to the village of Delphi in Greece. To commemorate this victory, Apollon founded the Pythic Oracleⁱ, in Delphi, on the slopes of Mount Parnassos...

Start



Pythia

Q: is each of these a wiki page, or something else?

Context Example: Theory Simulation

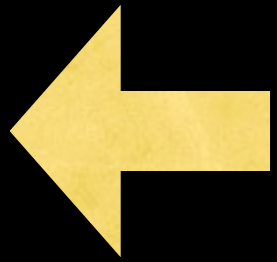
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If so, could this be a dunnonode?





Pythia

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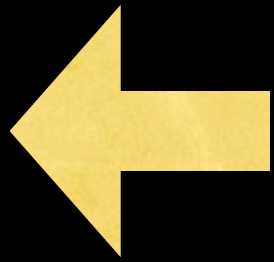
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LEP 1

Q: is each of these a wiki page, or something else?

Context Example: Accelerator

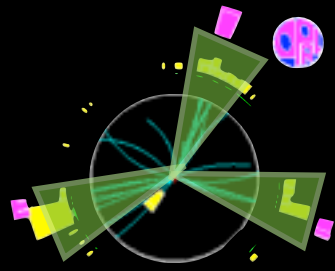
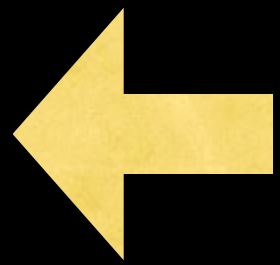
- Description
- Main Features
- History (with hyperlinks to more details)

+ Annotations
(private, team, global)



The Large Electron Positron (LEP) Collider operated at CERNⁱ from 19XX[?] to 20YY[?]. The decision to shut it down was not an easy one, as small hints of the elusive Higgs bosonⁱ were present in the very last data sets. Were these hints a fluke, or the real thing? Every year of continued running risked delaying the more powerful Large Hadron Colliderⁱ (LHC), which would replace it. ...





Jet Rates

Q: is each of these a wiki page, or something else?

Context Example: Observable

- Description of Measurement
- Main Features of Detectors
- ...

+ Annotations
(private, team, global)



Start

Possible Storyline(s)

(To be discussed)

“Campaign Mode”	“Skirmish Mode”	“Science Fiction Mode”
<p>Start with a single measurement, and a single parameter to adjust.</p> <p>Gradually work your way up, learning more physics, proceeding to ever more complicated multi-dimensional parameter spaces, with corresponding oodles of experimental measurements.</p> <p>Beat the state of the art and get your name on a new “tune” → the next Jeppsson</p>	<p>Start with a random measurement, and a random simulation.</p> <p>Check if they agree or not. Flag yes/no.</p> <p>Can be useful for validation of new code releases, etc.</p> <p>Can still be used for learning, since the contexts can still be there, and people can click on the measurement, or the simulation setup, ...</p>	<p>Compare to <i>simulated data</i> from a parallel universe ...</p> <p>... in which space-time has 5 dimensions, or there are dark-matter particles in the data (or a different Higgs). Or a million other things.</p> <p>Can you tell?</p> <p>Goal is to learn about ideas for new physics and how the real experimenters search for it in the real world</p> <p>(But this is really a separate project in its own right)</p>

Notice

- I didn't use the word "game" a single time in this presentation
- It's a (citizen) science app.
- Aim is not to be fun, not to entertain. To be interesting, engaging, useful for science, yes.

What's the Goal(s)?

(citizen science) : beat the state of the art → feedback to scientists

Won't happen every day, and not early. For the patient and the few?

Contributing something real to the scientists is main motivator. "Points" and "badges" may make it seem less serious and be counter-productive? (cf. Zooniverse)

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(learning) : people can use it just to learn about particle physics.
Also useful for outreach, and for physics teaching?

Progress markers may be useful, even desirable. How well am I doing?

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(visualization) : scientists also get a nice UI. It then needs to be close enough to the "real deal" that scientists can use it too.

Visual design (plots) must be professional and modifiable, usable in scientific publications.

Bonus: can point to same graphics in real science papers

Databases and Interpolations

Technical Structure and Aims

(Too technical to discuss details here, but would like to discuss some of it with experts)

Use of the “Professor” Interpolation Tool

- Results from each simulation run is entered into a database → fixed set of parameter points for which “exact” results exist. Precision on each point limited by amount of generated “events”, which continually increases.
- Database used as a basis for interpolation to arbitrary parameter points, by the “professor” tool.
- When a user selects a setting, the starting picture(s) is/are the result of professor’s interpolation(s). Requires request to central database and download of results or local copy of database, periodically updated. His/her computer then begins further refinement for the particular point chosen, reducing statistical and interpolation errors. (+, optionally, teams can help)
- Make sure this interpolation can be done using arbitrary points. Adopt procedure for handling runs with different statistics. Need procedure to determine statistical uncertainty of interpolation + interpolation error.
- Need procedure for updating old points in the grid and/or replacing them once better-stat ones become available.
- Need to determine procedure for what to do for extrapolations; adding points to the grid.
- Sliders should probably be incremental, in steps to be determined parameter by parameter → avoid infinitely many possibilities.