A Gauge Model of the Data Acquisition Selection and Analysis for LHC

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This talk:

- *the context*
- *the present paradigms*
- *their merits and bottlenecks*
- *the Gauge Model*
- *outlook*

Epiphany Conference,
Krakow, January, 2008

The context

cooperation programs: IN2P3-COPIN-05-116, IN2P3-COPIN-05-117, POLONIUM-17783NJ, POLONIUM-11580PE

Preparation of novel tools and methods for high precision scrutiny of the Standard Model at LHC, ...and for generic exploration of the mechanism which drives the electro-weak symmetry breaking (EW-vacuum rigidity)

Past and present activities:

-methods and tools to create and to control the beams of gauge bosons (polarized W- and Z-bosons), and the beam of electrons and photons

-high precision (Bhabha-like) luminosity measurement method for LHC

-dedicated measurement strategies to improve LEP and Tevatron precision of the measurement of the Standard Model Parameters:

M_W, Γ_W, $M_{W^+} - M_{W^-}$, $M_{W_L} - M_{W_T}$, $\sin\theta_W$, α_s

-the Gauge Model of Data Selection and Data Analysis for LHC (2002-3)

...discussed below..,

Brief introduction to the Data Acquisition, Data Selection and Data Analysis architectures for LHC…

…the LHC challenge

All bunch crossings not selected by the on-line selection system are lost forever

(only ~100 out of 40 000 000 bunch crossings available for repetitive (offline) physics analyses)

Summary of data selection – trigger levels

"Raw electronic" signals

Digital bunch crossing picture

Level 1 trigger

Level 2 trigger

HLT

(High Level Trigger)

Level 3 trigger

Off-line selection

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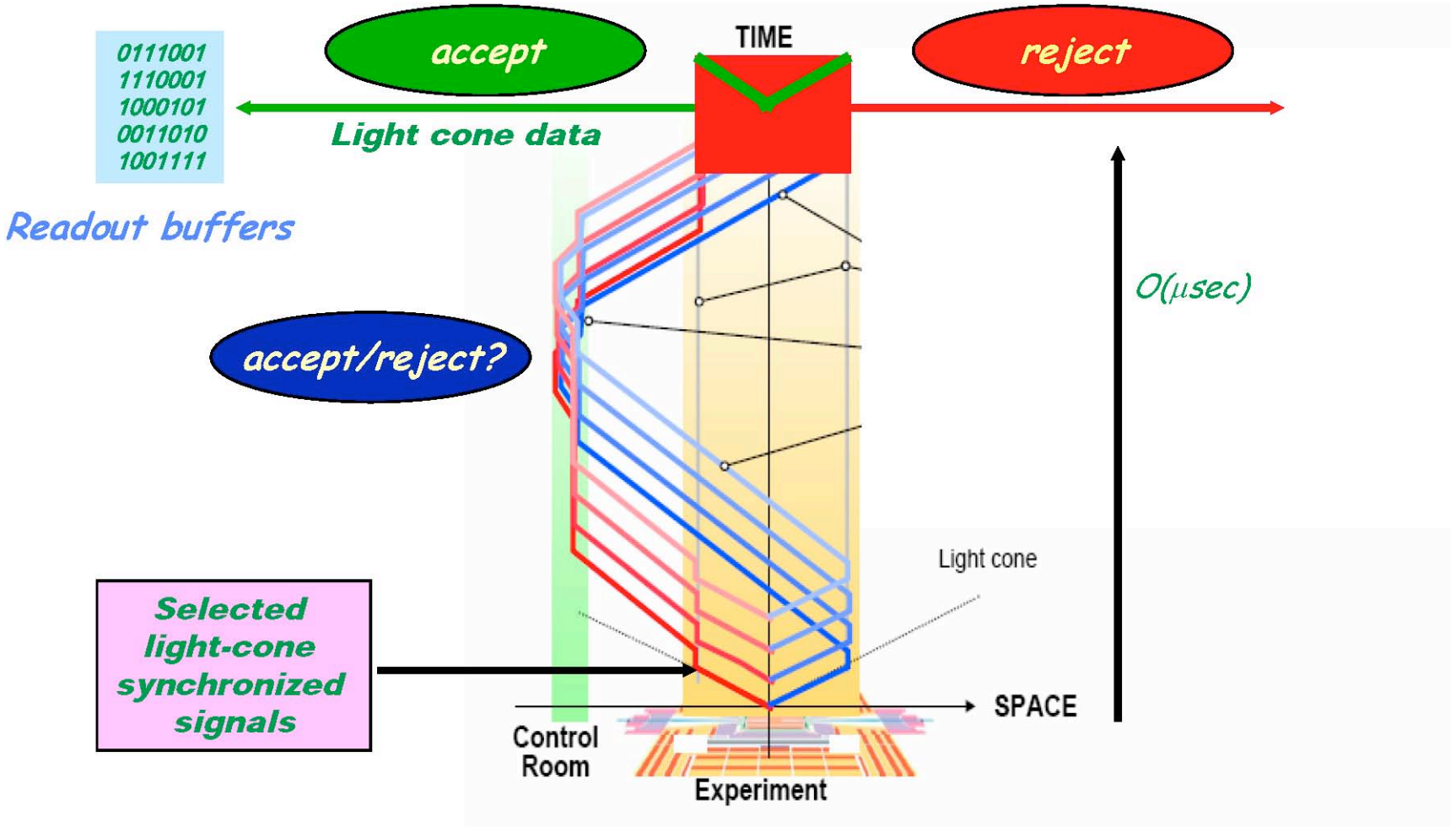
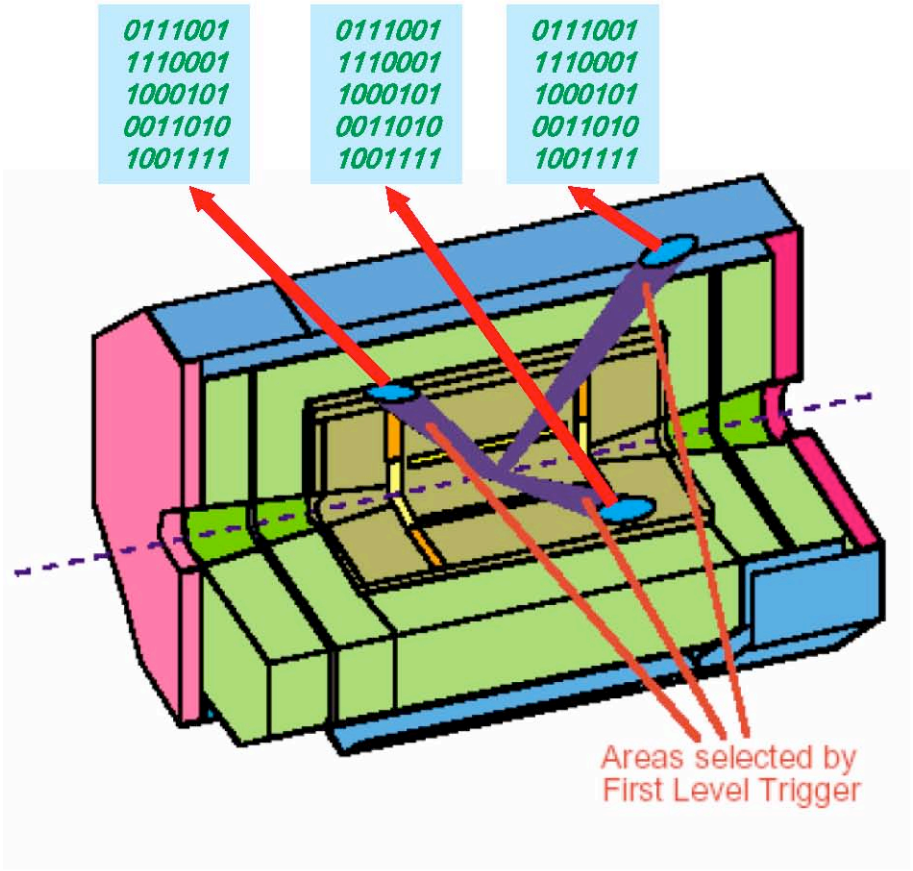
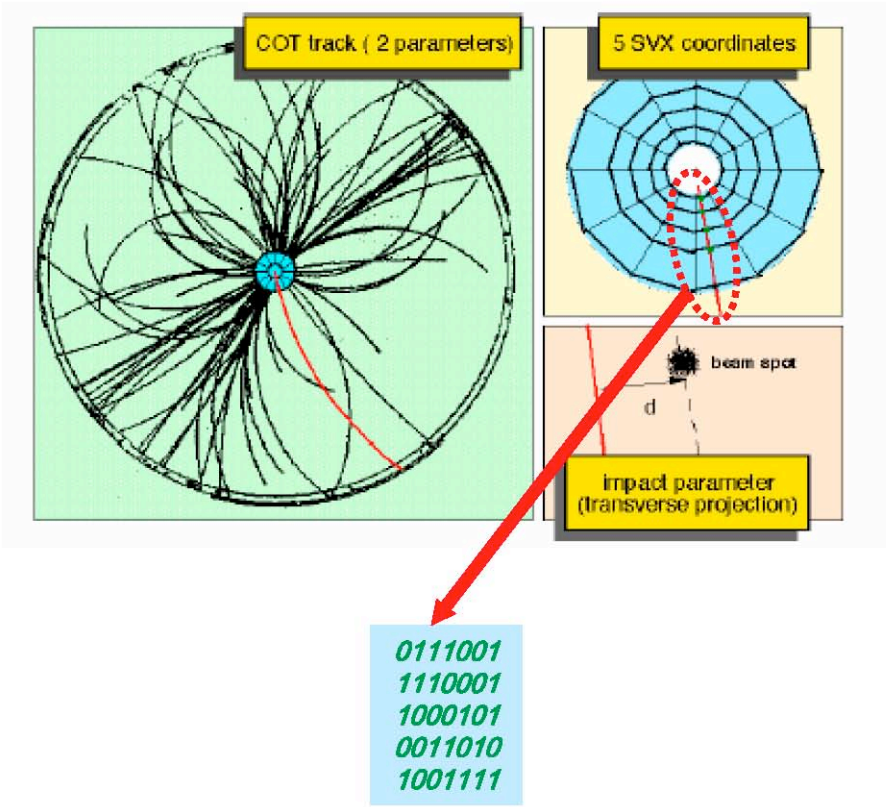
The light-cone picture of the fast (Level 1) selection

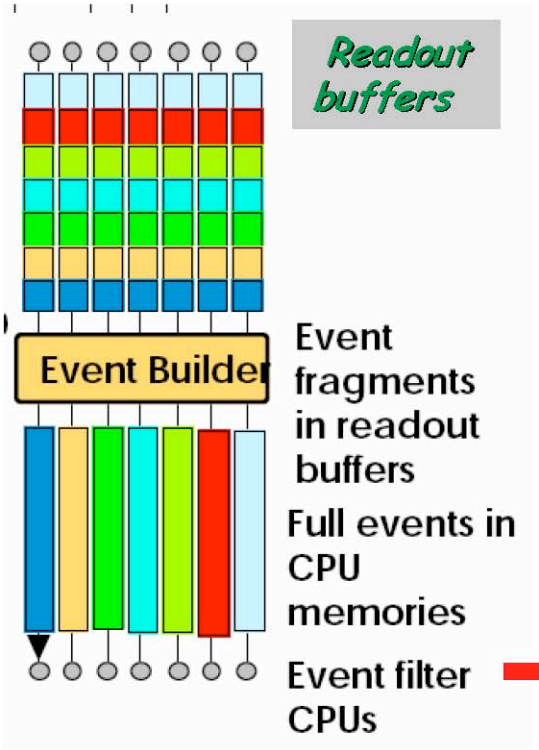


Choosing the Readout buffers: "regions of interest"



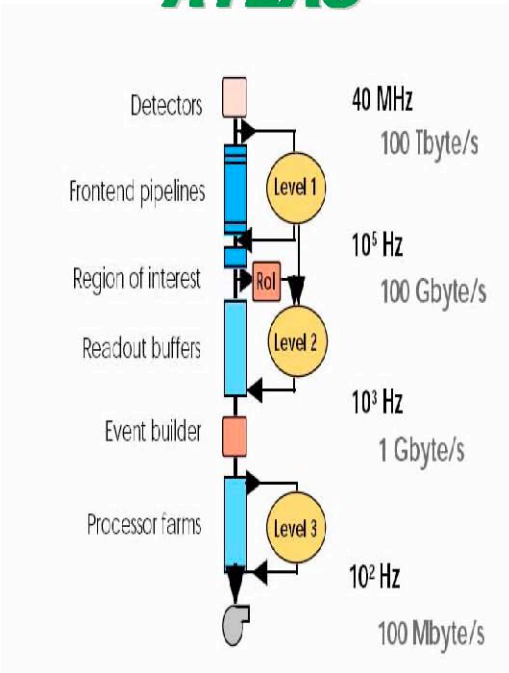


Event-building and selection of bunch crossing

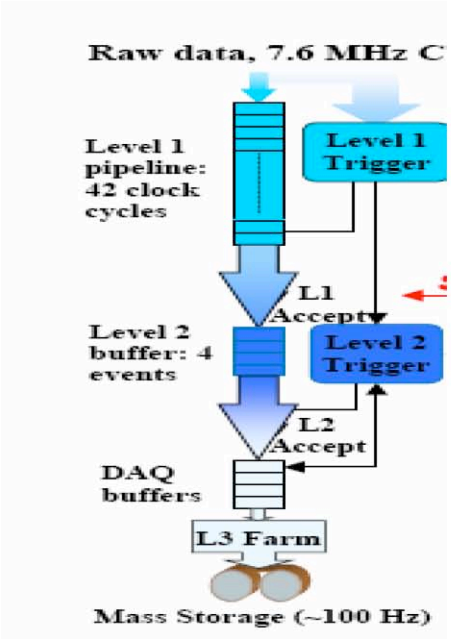


The architectures

ATLAS

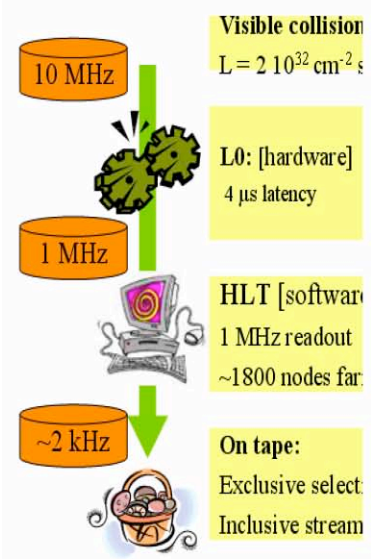


CDF

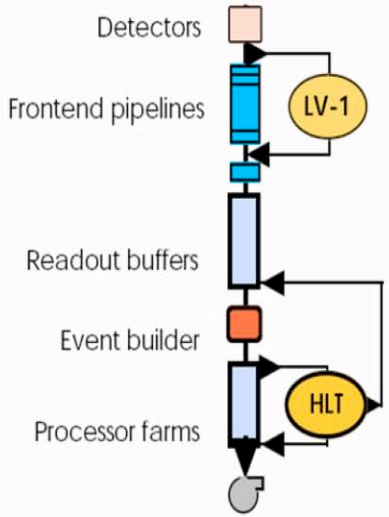


Level 1 + Level 2 + Level 3

LHCb

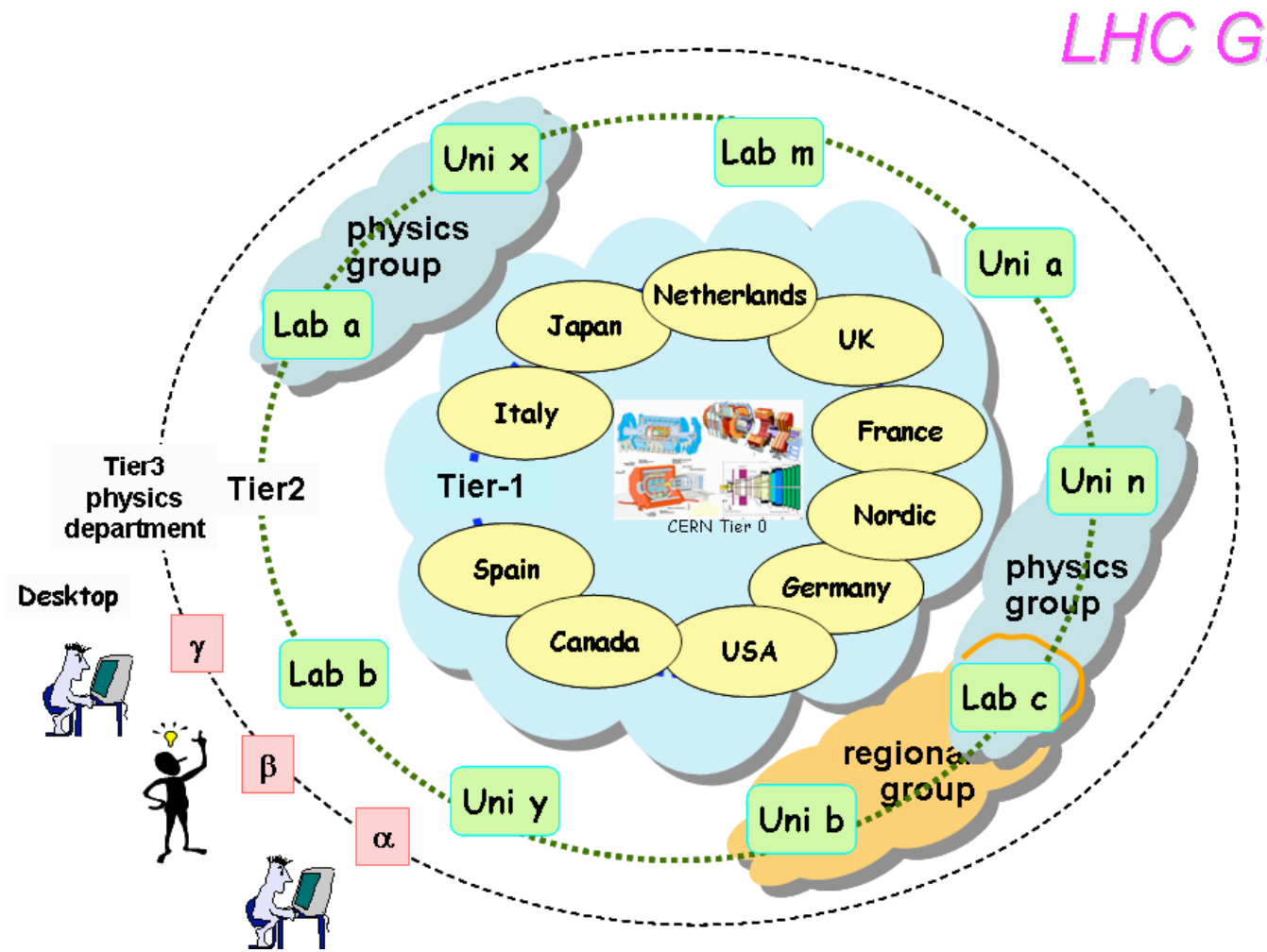


CMS



Level 1 + HLT

…offline data selection and data analysis model



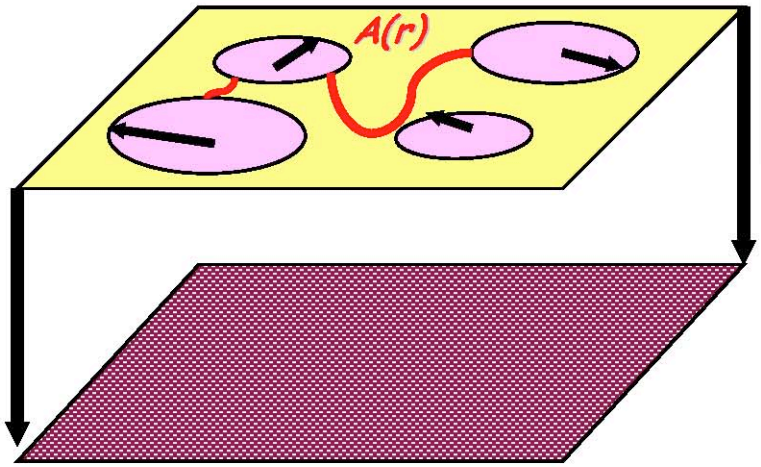
The present configuration paradigm:

-rigid configuration up to the level of the physics analysis objects

-flexibility of the data analysis based upon the standard physics analysis objects

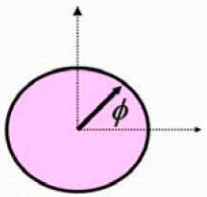
The flexibility and the rigidity: the gauge-symmetry example: vacuum vs. superconductor

"Phase anarchy" QED in vacuum



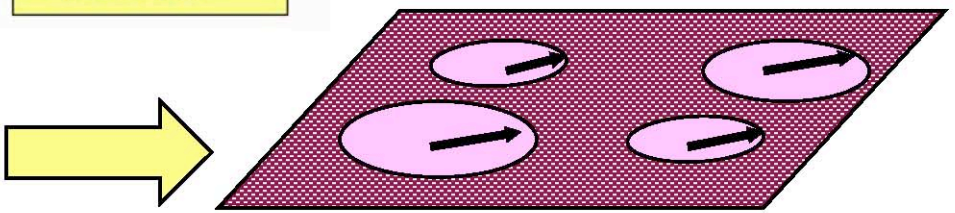
Lattice structure of a metal below critical temperature

The electron field



$\Psi(r)=|\Psi(r)|e^{i\phi(r)}$

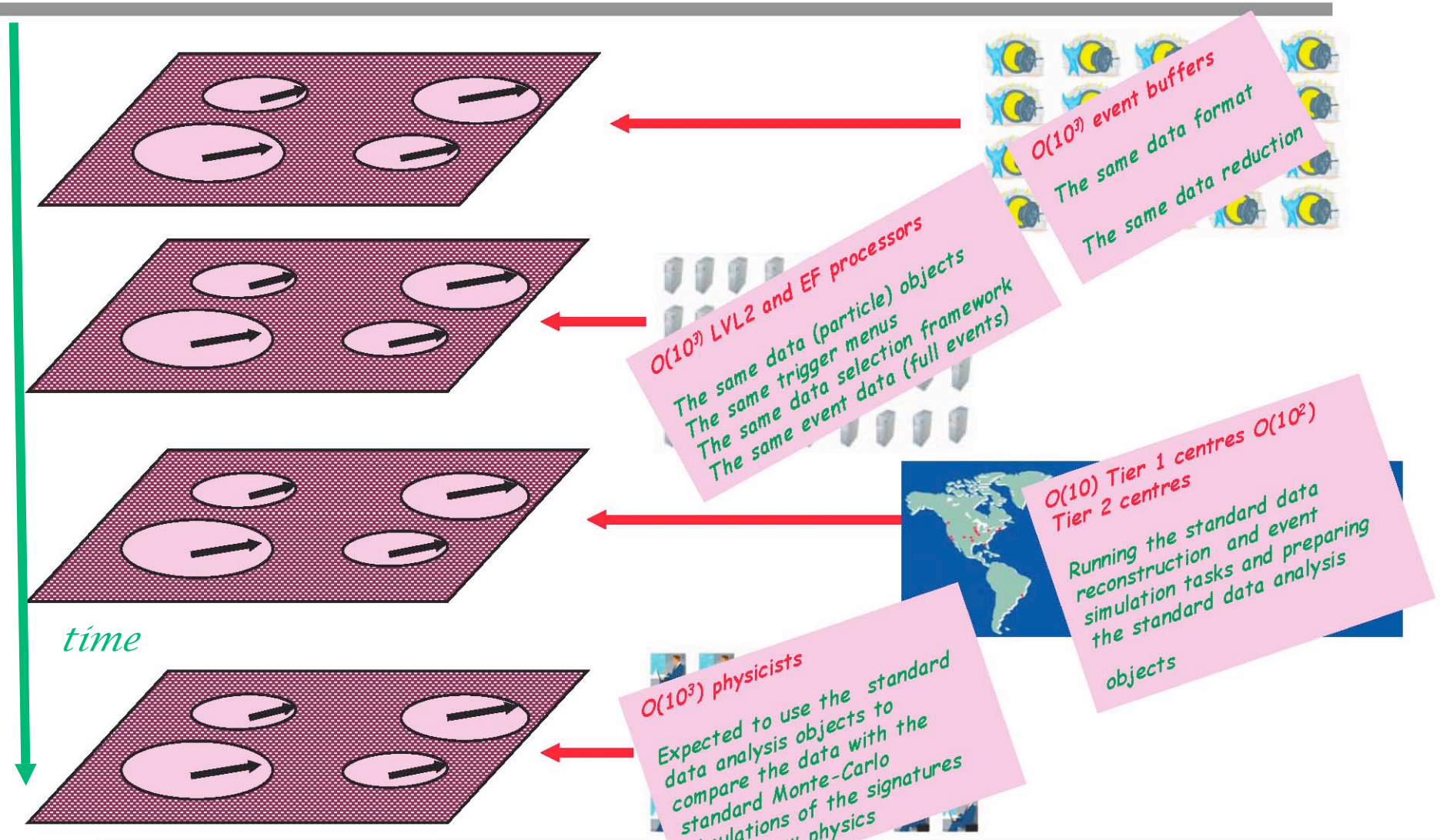
"Phase discipline" QED in a superconductor



The interaction with the lattice aligns the phases.
Magnetic field is expelled from the superconductor (Meissner effect)
Photons become massive. - only high frequency photons could propagate in such a medium

The LHC superconductor

*Event journey_*



The "superconductor" merits and bottlenecks…

...the merits

1. Such a configuration was successfully implemented in earlier general purpose HEP experiments at CERN, DESY, SLAC and FNAL
(LHC - merely a scale extension)

2. It maximises the the chances of a convergence of the diverse activities of the community of O(2000) physicists in the day-1 operational system (closed Pandora Box)

3. It enables a centrally-governed data selection process based upon the collaboratin-wide-standard trigger menus, selection algorithms and data structures (best adapted to the present organisation of collaborations)

4. It allows for a strict centrally-governed data-quality control

5. It encapsulates, for the analysis oriented physicists, the technicalities of the data taking, data calibration and data reconstruction process in terms of trigger menus and prescale factors only

...and the bottlenecks

1. Events with unexpected signatures may be lost...
2. Data taking process may be unstable with respect to the data taking conditions (electronic noise, beam related background).
4. Implementation of the physics-group-optimal online data selection and data analysis methods restricted by the use of standard objects and data selection framework. →
5. Lack of full raw data picture for "discovery events". →
6. ...

...missing full picture of RAW-data for event selection and event analysis (event type independent RAW data content), missing data-length versus event rate flexibility (standard event building), missing data structures and dedicated selection algorithms for rejecting background events uniform data selection framework for all types of events, the complexity of the selection code loaded to all the LVL2 EF processors...

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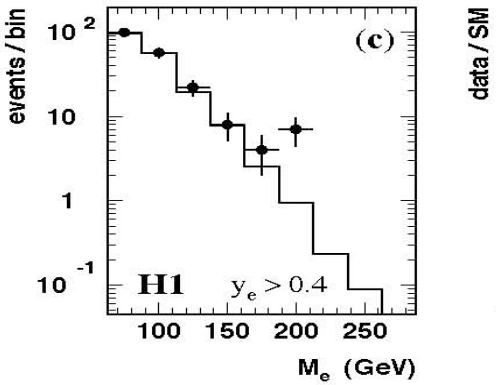
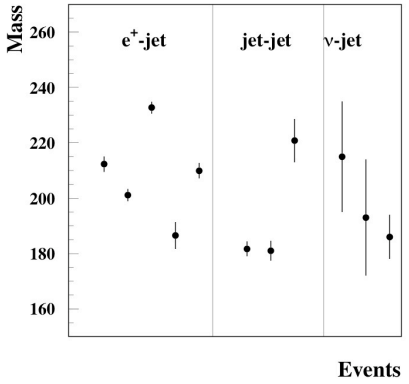
...a need for flexibility - two historical examples

...HERA lepto-quark events (1997)



...standard objects - published H1 paper



...non-standard objects - unpublished analysis

...HERA isolated muon events(1998)

...The FADC data for the CJC chambers not available for the offline analysis - impossible to judge the pattern reconstruction tails
(M.W. Krasny Oxford University preprint OUNP-98-09, unpublished)

The Gauge Model

…from the note presenting the Gauge Model…

…Traditionally, in the previous multi-purpose high energy experiments, the diversification of physics programs has been largely decoupled from the process of the data taking. Physics groups have influenced the choice of registered events according to predefined trigger menus. However, the physics goal-oriented choice of the sub-detector data, and implementation of refined event selection method(s), have been exercised mainly at the level of the offline analysis of registered data.

The departure point of the model of the data taking presented in this note is an observation that such a scheme cannot be continuously extended to the LHC environment, without significant sacrifices in the scope and in the quality of its experimental program…

…The central point of the presented series of notes is the conjecture that the quest for the best specific-physics program-oriented use of the detector and of the LHC capacities, when confronted with the hardware, software,and sociological complexity of the LHC experiments, is bound to drive their gradual evolution towards a system of coexistent yet largely factorisable sub-facilities sharing common hardware maintenance, data acquisition, calibration, and reconstruction resources… but optimized for specific physics domain…

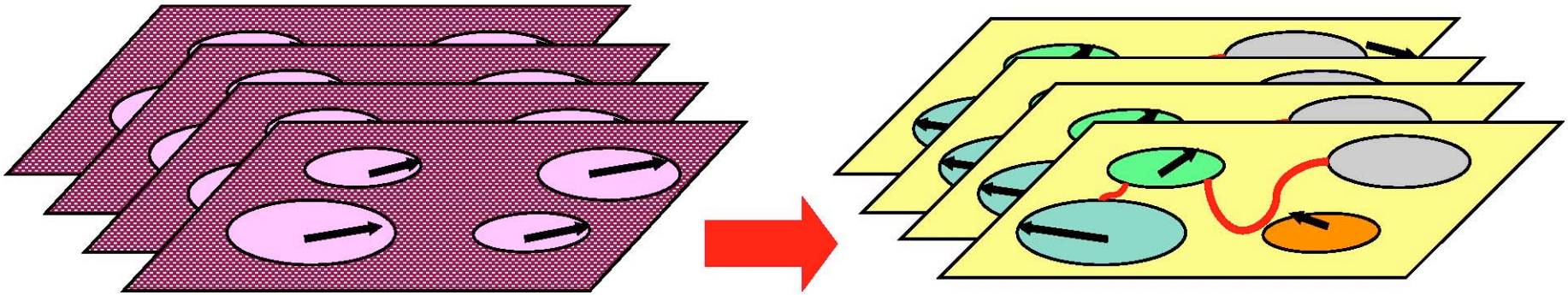
M. W. Krasny, A Gauge Model of Data Taking
(ATLAS Internal Communication Note, CERN -2003)

Restoring gauge symmetry

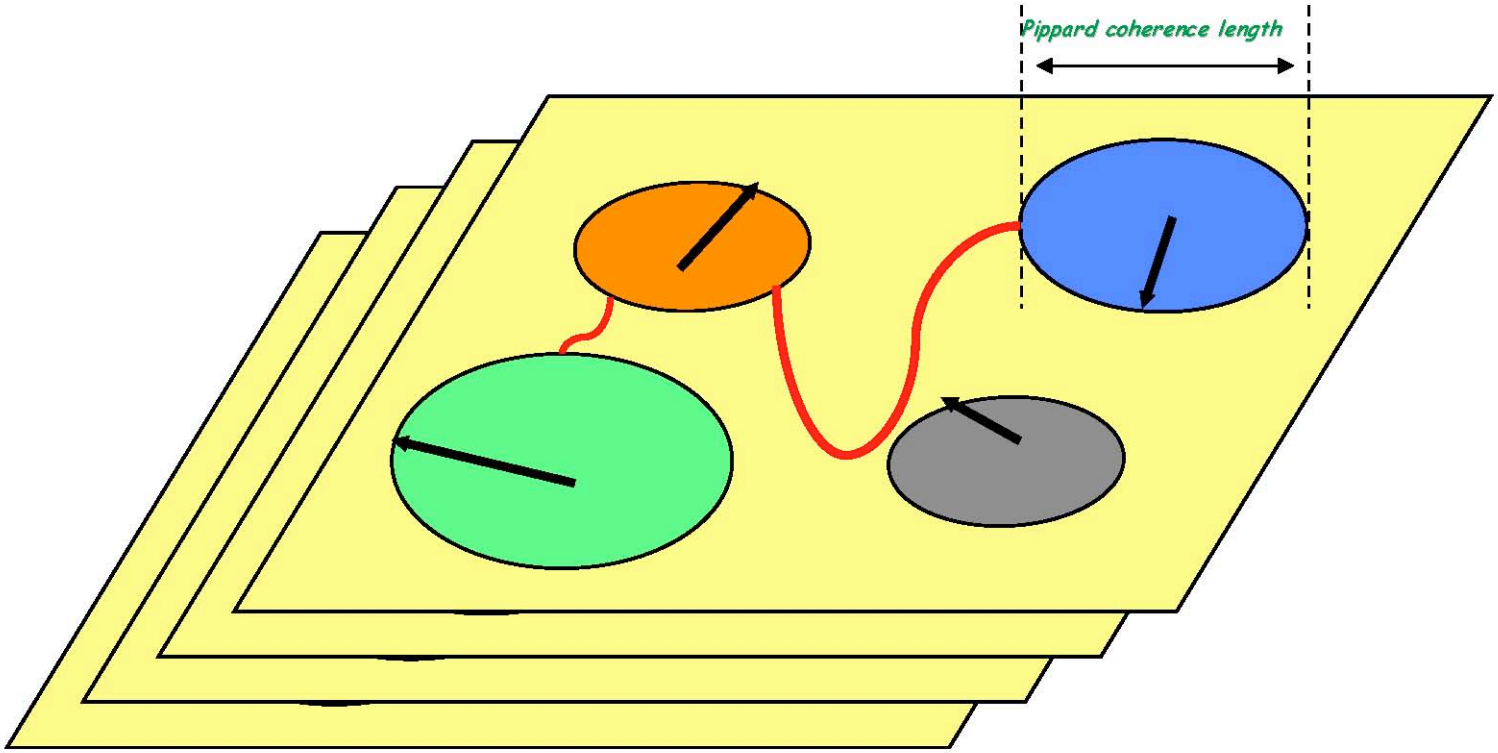
The present paradigm

Shall we be forced to restore (at least partially) the gauge symmetry of the data selection and the data analysis model???

If yes, at which scale???



The "Gauge Model of the Data Taking and Data Analysis"

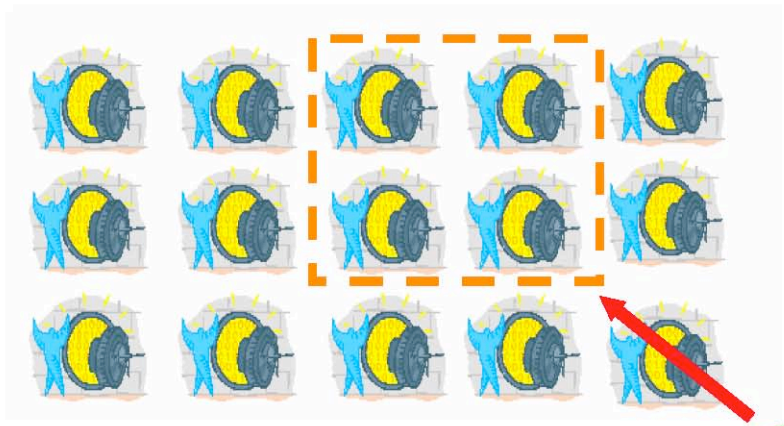


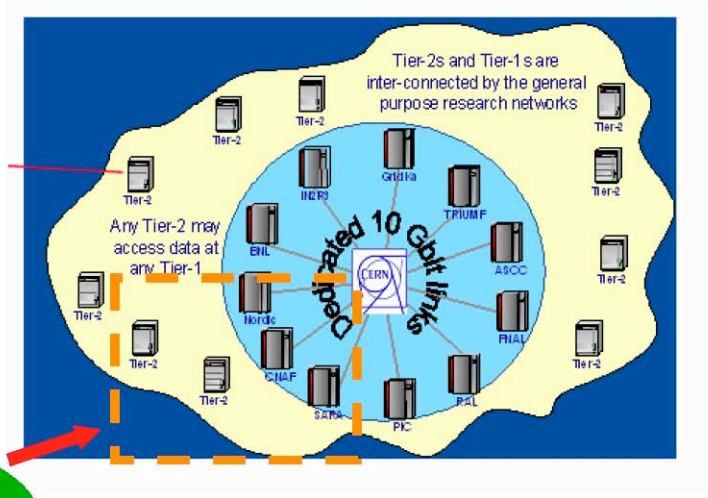
Symmetry breaking confined to the sizes of "domains"

(Pippard coherence lengths = size of the domain)

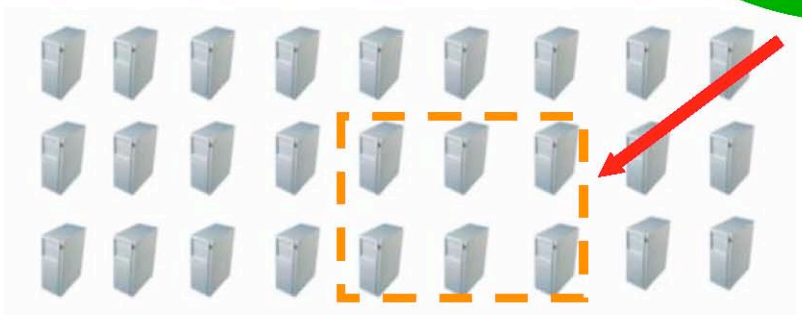
The experiment = research facility for diverse generic searches and diverse physics approaches

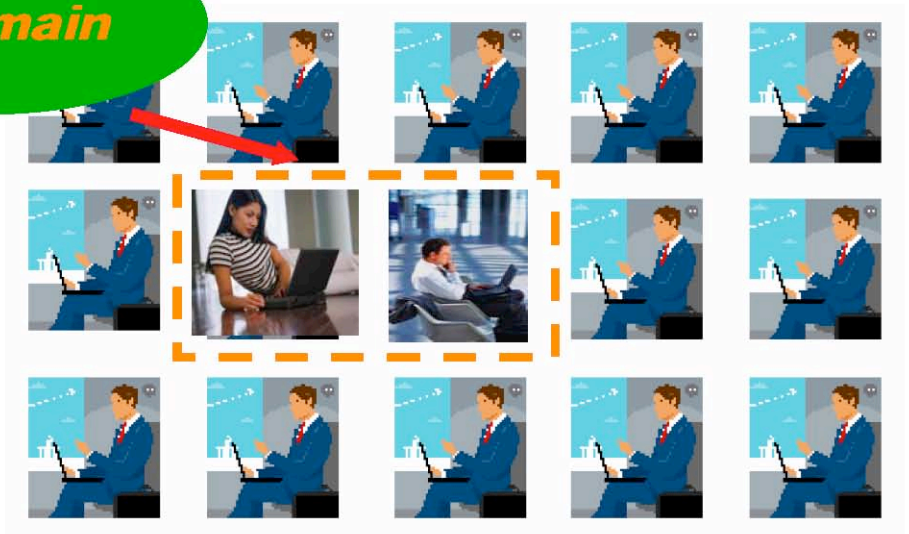
Domains





a domain





…the challenge

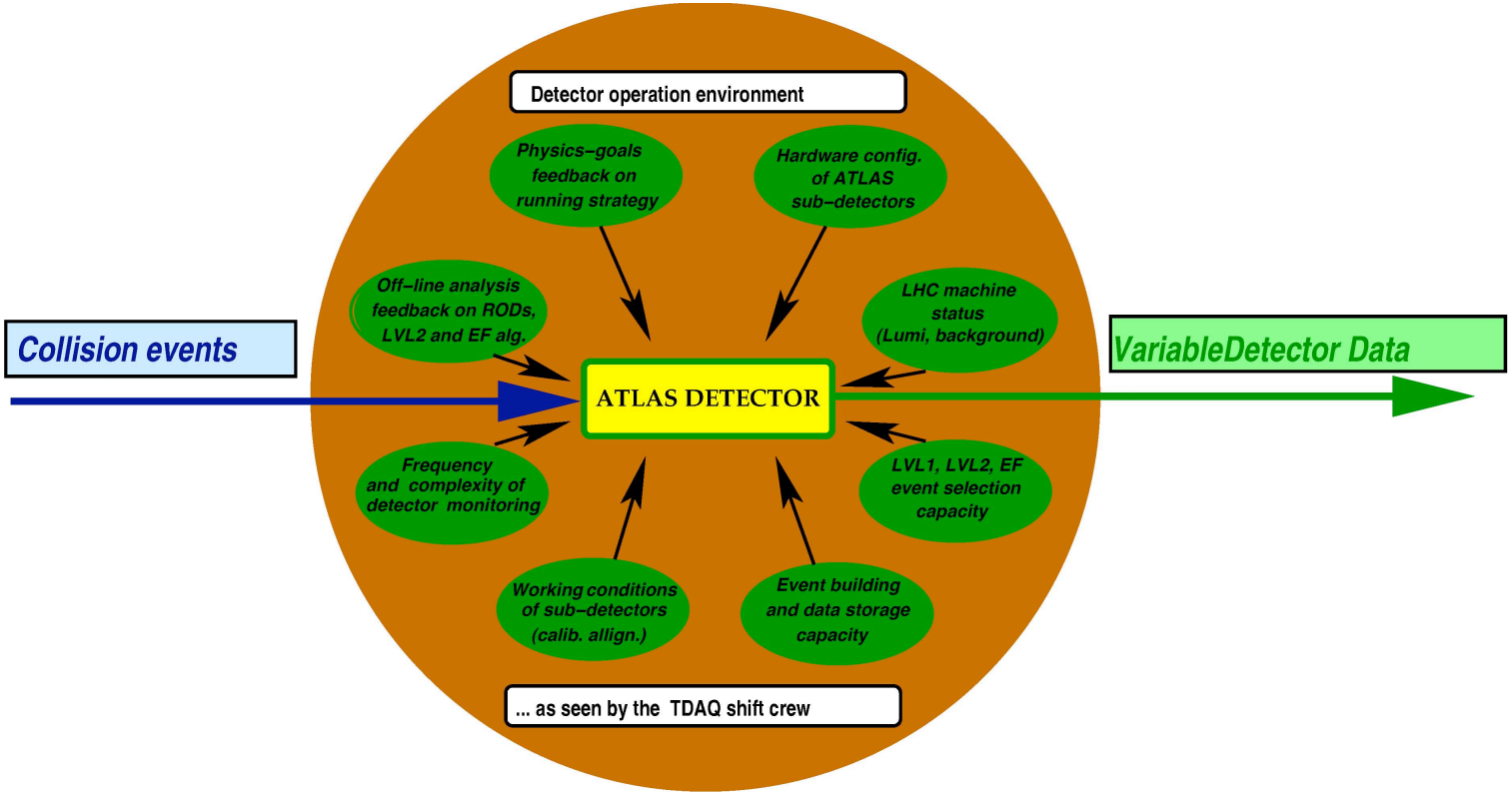
How to define the domains and their "clash-less" mutual interactions? How to incorporate them within the Detector and Grid hardware constrants?

The driving guidelines of the proposed model:

The success of the Gauge Models in describing particle interactions and the analysis of environmentally-adapted biological organisms.

…constrain the mutual interaction between the domains using "gauge invariance principle" and allow the domains to adapt to the data taking environment via physics-specific, "gauge-symmetry-breaking" patterns.

The "gauge fields"



The "symmetry groups"

- The "data-scenarios" symmetry group
- The "TDAQ-slice-configuration" symmetry group
- The "event-selection-tools" symmetry group

Global symmetries defined on run-by-run basis, and sub-detector-by-sub-detector basis

Local symmetries defined on event-by-event basis, and channel-by-channel (ROD-by-ROD) basis

Example: Generators for the "data scenarios" symmetry group

- CONTENT - bits/byte stream info coming from the subdetector
- SCHEME – zero suppression scheme
- METHOD – data compression method
- MODE – addressing mode of non-suppressed channels
- SUM - the content of the bit-pattern summary blocks

Example: of one of the eigenstates of the "Data-Content" generator (the ATLAS TRT detector case)

Content1- "Preprocessed ROD info"

6(9)(12) bits for VALID straws with zero, one or two leading edges:

<1><0><H><T><E1><E2><DTM><DTM>

2 bits for empty straws; <00>

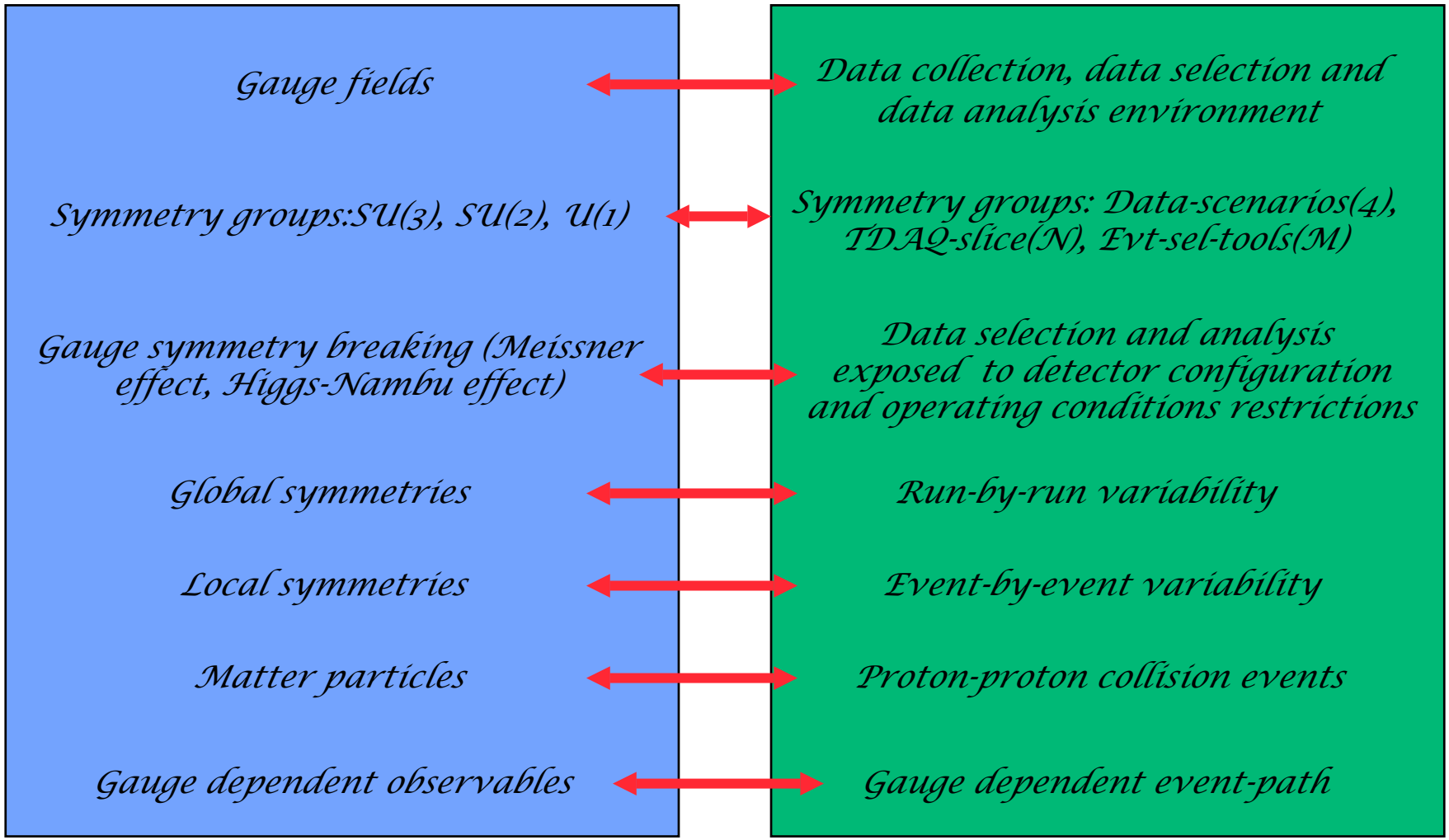
3 bits for non-empty but not VALID straws: <01><H>

Where: *<DTM> is 3-bit time encoding for 0->1 transitions in BC1 & BC2 present if corresponding transition flag(s) <E1> and <E2> are set;*

<T>, <as before, is a trailing edge flag (info for TOT measurement)

and <H> is the high threshold flag

Correspondence (SM and the Gauge Model of data selection and data analysis)



The dynamical generation of domains

1. "Rotate out unphysical gauge fields"

2. Optimise the "gauge-dependent" propagation of a broad class of collision events through the data selection and Data reconstruction stages, while assuring the "gauge independent" physics results.

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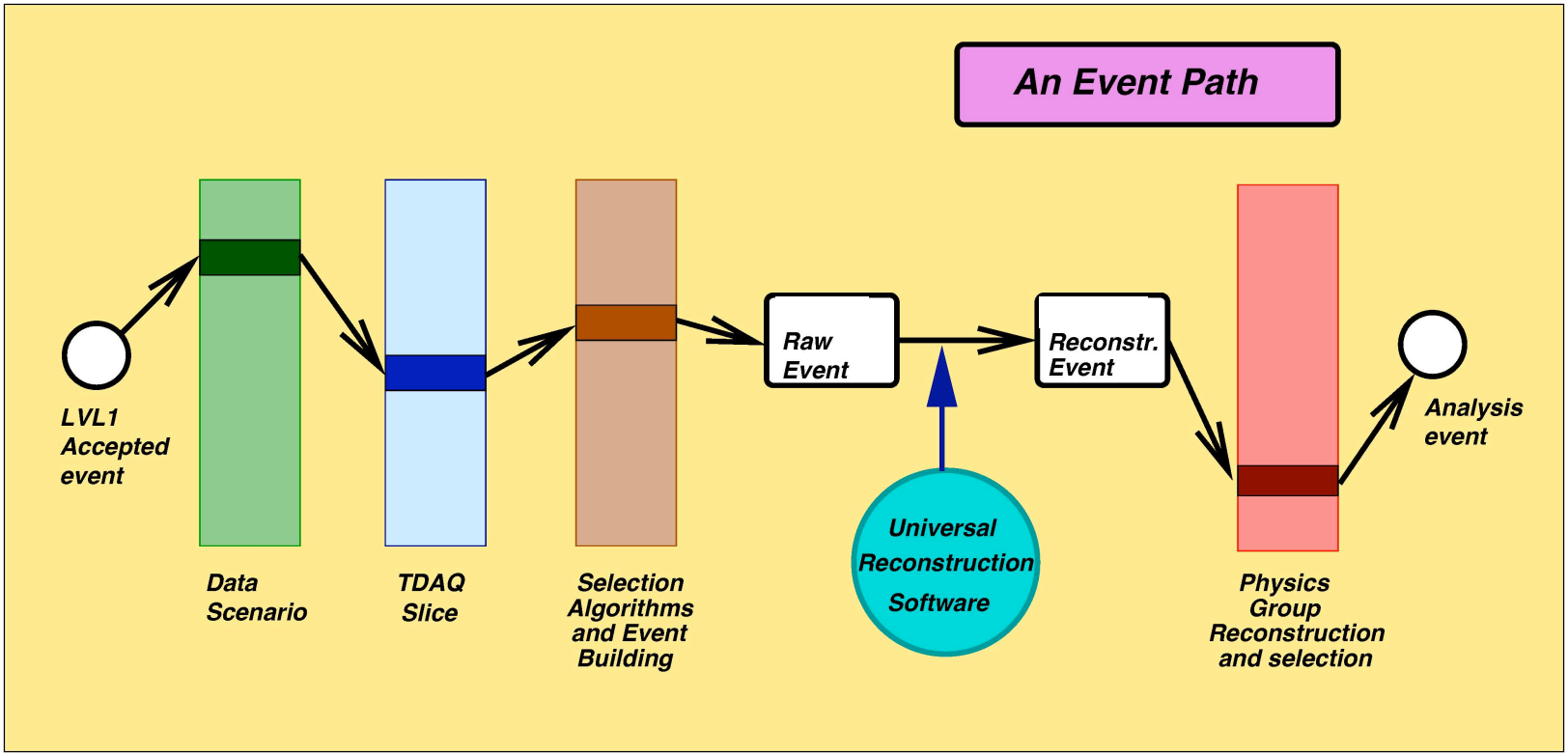
...a domain is defined in terms of a set of event paths



Example1: Hot-line event

Example2: Multi object event (today's Victorio's example)

…new functionalities of the gauge model in some more technical terms - projection to ATLAS hardware

Raw data

- *Variability of ROD data on event-by-event, channel-by-channel and ROD-by-ROD basis*
- *Special, fixed position, length, and format, LVL2-dedicated, ROD (PU) - summary blocks*
- *A full set or, a restricted set of RODs (ROBins) could participate in event building following the LVL2 accept decision*

…new functionalities of the gauge model in some more technical terms

Event selection

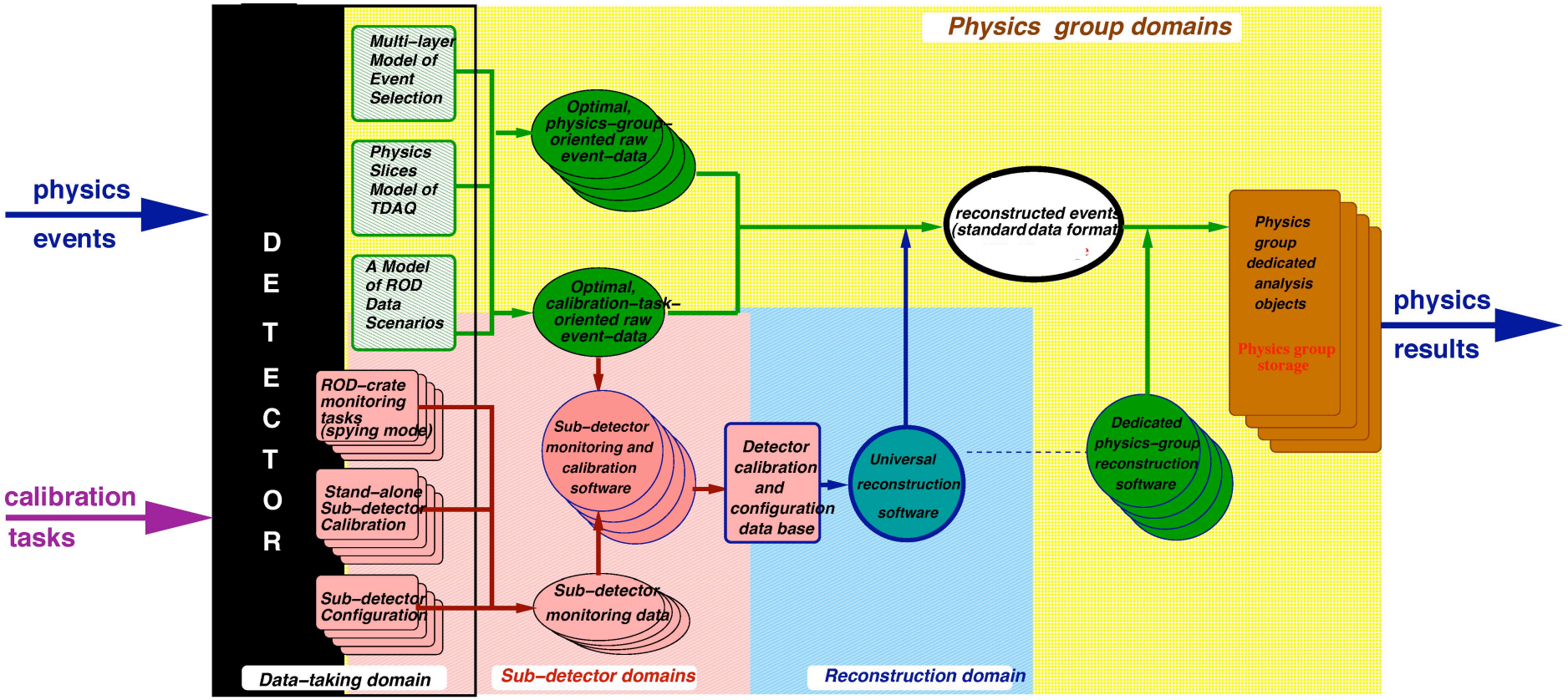
- *Events can be rejected by the LVL2 trigger on the bases of info contained in the ROD summary blocks*
- *LVL2PU-farm is subdivided into sub-farms. Each of them analyses a sub-class of physics criteria chosen events*
- *Events are assigned to a given sub-farm on event-by-event basis using RoI Data Record (… or the LVL1 word)*
- *Each of the sub-farms is allowed to run different event selection code (within a general software framework)*
- *If some processing power will be available at the ROS level, it could be used to concatenate LVL2 summary blocks into a ROS summary block for fast scan of a large part of the detector*

…new functionalities of the gauge model in some more technical terms -ATLAS example

Event selection

- *New types of data selection algorithms are introduced and organized within an ordered, multi-layer structure*
- *The structure reflects the data access, data decoding (byte-stream conversion) and reconstruction steps and anticipates various possible evolution schemes of the DC system*
- *The event selection software is driven by the ROD-data-seeded event reconstruction rather than by the reconstruction-seeded data access*
- *New entities used in the selection process: full ROI record-bit pattern, bit pattern of the LVL2 summary blocks, ROD-data in the byte-stream form, Raw Data objects and dedicated LVL2 reconstructed objects (ROD-configuration-invariant)*

The Physics-Goals-Driven partition of the data selection and the data analysis process (facility-type experiment)



Outlook

The presently-implemented models of the data selection and analysis at LHC are optimized for searches of high mass particles having predictable decay modes (Higgs, SUSY particles etc.), …and – for the "blood and tears" – scrutiny of the Standard Model

Whether or not the Standard Discovery scenarios will be confirmed by the initial phase of the LHC experimental program an enlargement of the LHC research scope will be obligatory – in its subsequent phase – and must precede the LHC luminosity upgrade.

The presented model attempts to propose the detector and the data taking configuration for clash-less synergy of diverse research programs in such a phase of the LHC operation …

…including the program of model independent generic seraches for the mechanism of EW symmetry breaking …being prepared within our cooperation programs…

The technical documentation of the Gauge Model projected to the ATLAS Detector capacities (A series of 7 Notes by M. W. Krasny - CERN (2002-2003)

Note I : Prologomenon (ATLAS Internal Communication Note)

Note II : The A Gauge Model of Data Taking -Overview (ATLAS Internal Communication Note)

Note III: A Model of ROD Data Scenarios (unpublished)

Note IV: An Event Data Model of Variable Raw Data (unpublished)

Note V: A Multi-layer Model Of the LVL2 and EF Event Selection Architecture (unpublished)

Note VI: A Physics-Slices Model of the TDAQ architecture (unpublished)

Note VII: A Model of the Integration Phases (unpublished)