CBM Overview – FEE and DAQ Profile

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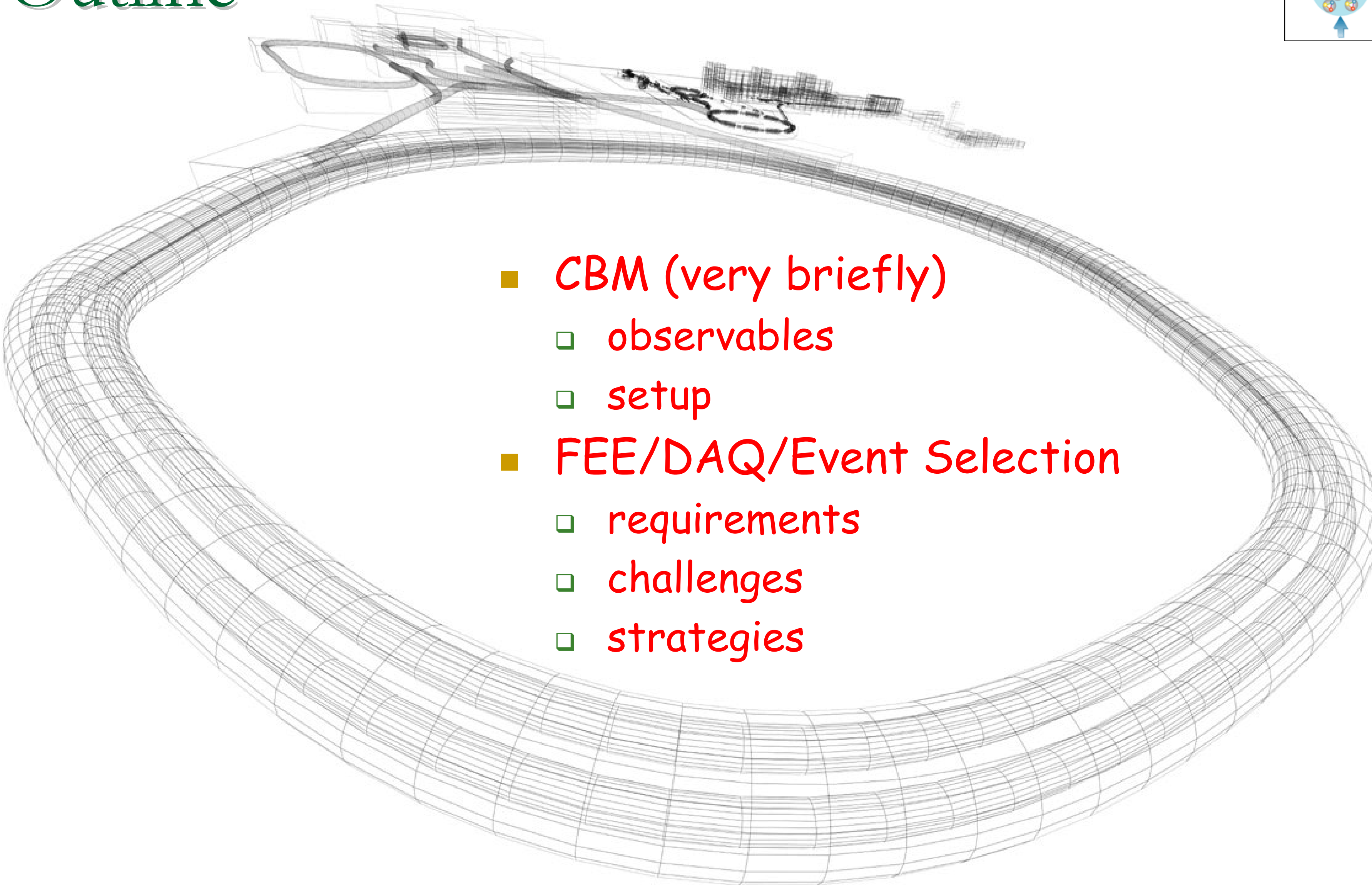
for the CBM Collaboration

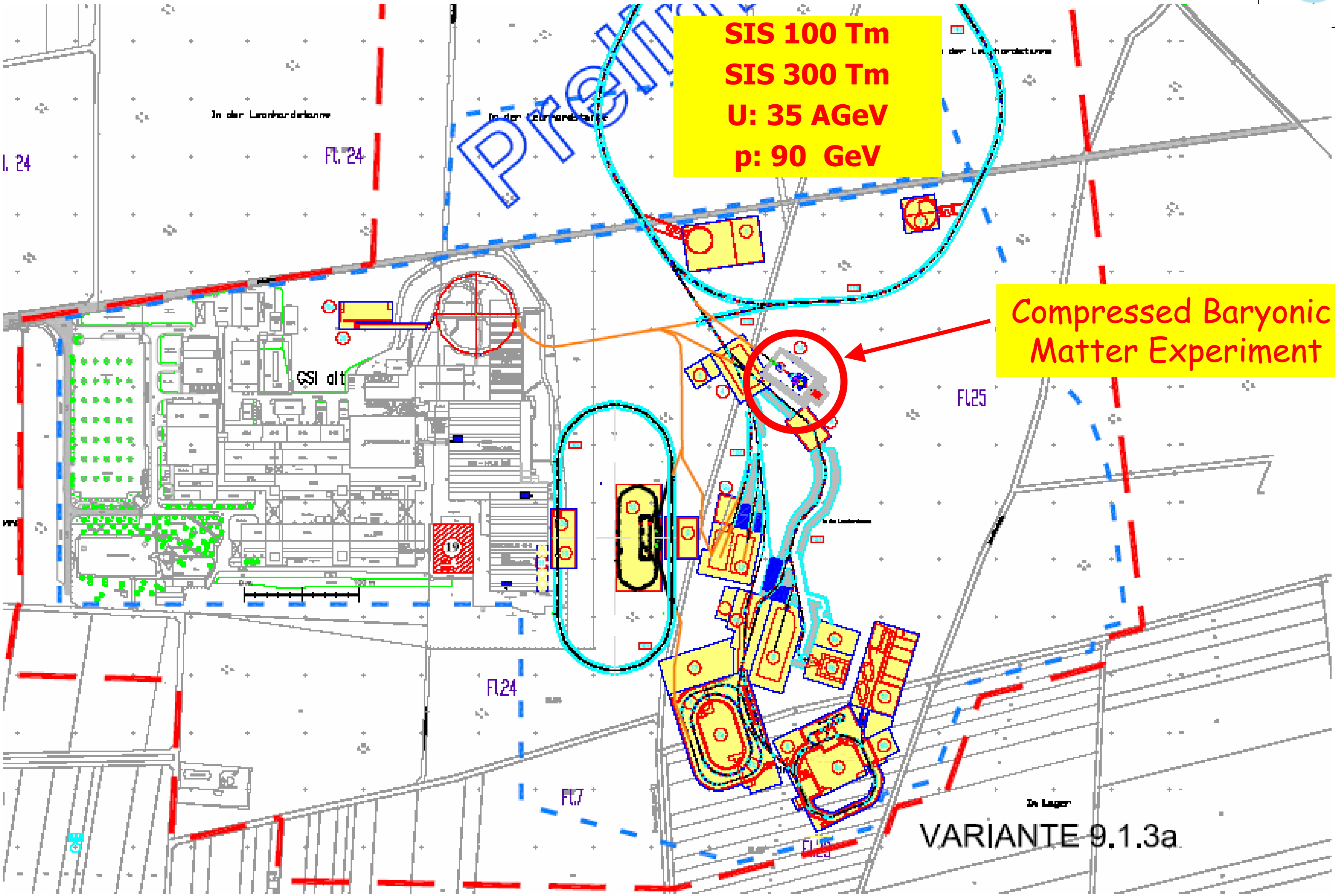
1st FAIR FEE Workshop
GSI, 11-13 October 2005

Outline



- CBM (very briefly)
  - observables
  - setup
- FEE/DAQ/Event Selection
  - requirements
  - challenges
  - strategies

CBM at FAIR



SIS 100 Tm
SIS 300 Tm
U: 35 AGeV
p: 90 GeV
Compressed Baryonic Matter Experiment
GSI alt
Fl. 24
Fl.25
Fl.24
Fl.7
VARIANTE 9.1.3a

CBM Physics Topics and Observables

- In-medium modifications of hadrons
  - onset of chiral symmetry restoration at high ρ_B
    - measure: ρ, ω, ϕ $\rightarrow$ e^+e^- ($\mu^+ \mu^-$)
      open charm: D^0, $D^\pm$
- Strangeness in matter
  - enhanced strangeness production
    - measure: K, Λ, Σ, Ξ, Ω
- Indications for deconfinement at high ρ_B
  - anomalous charmonium suppression ?
    - measure: D^0, $D^\pm$
      J/ψ $\rightarrow$ e^+e^- ($\mu^+ \mu^-$)
- Critical point
  - event-by-event fluctuations
    - measure: π, K

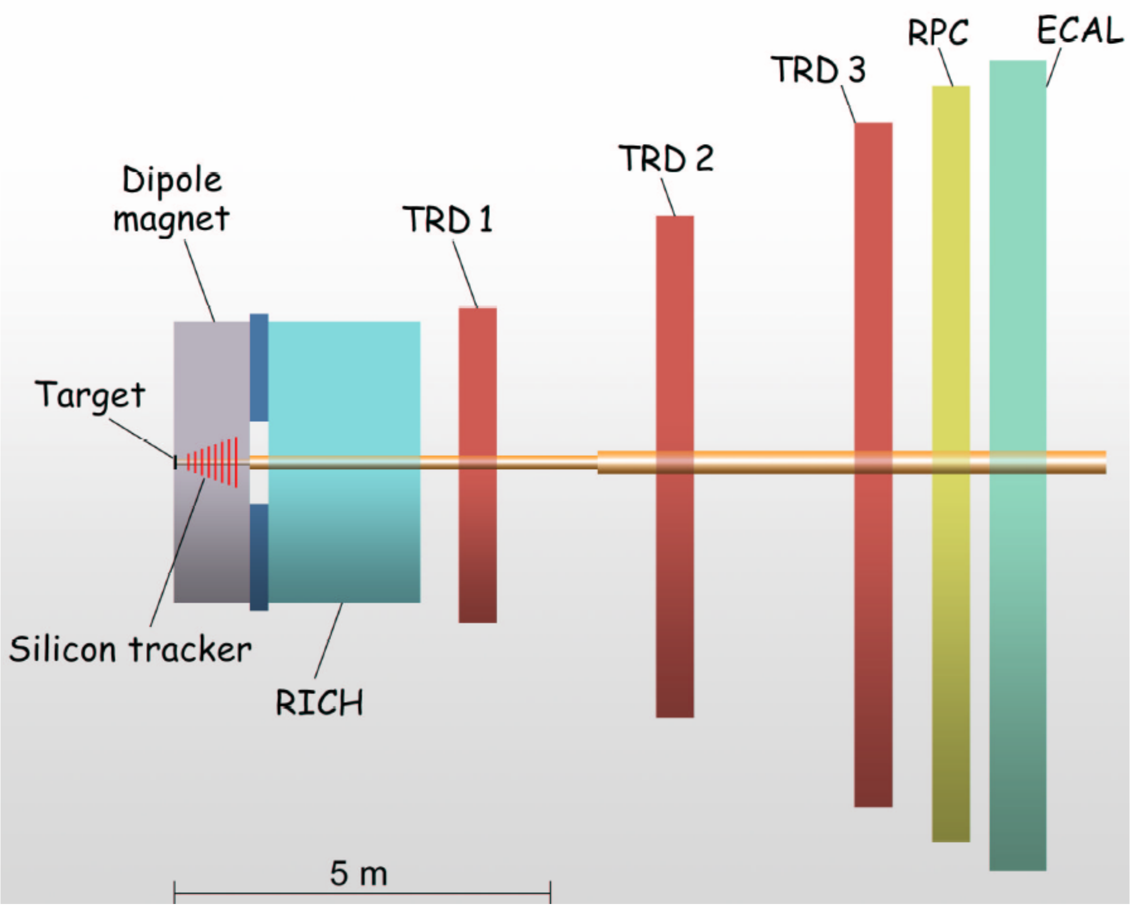
Good e/π separation

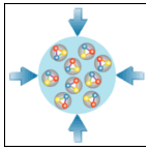
Vertex detector

Low cross sections
$\rightarrow$ High interaction rates
$\rightarrow$ Selective Triggers

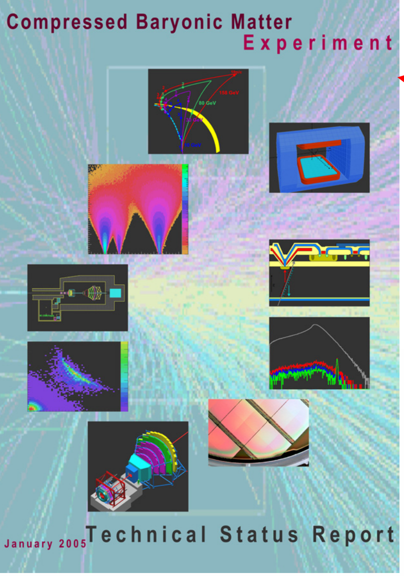
Hadron identification

CBM Setup

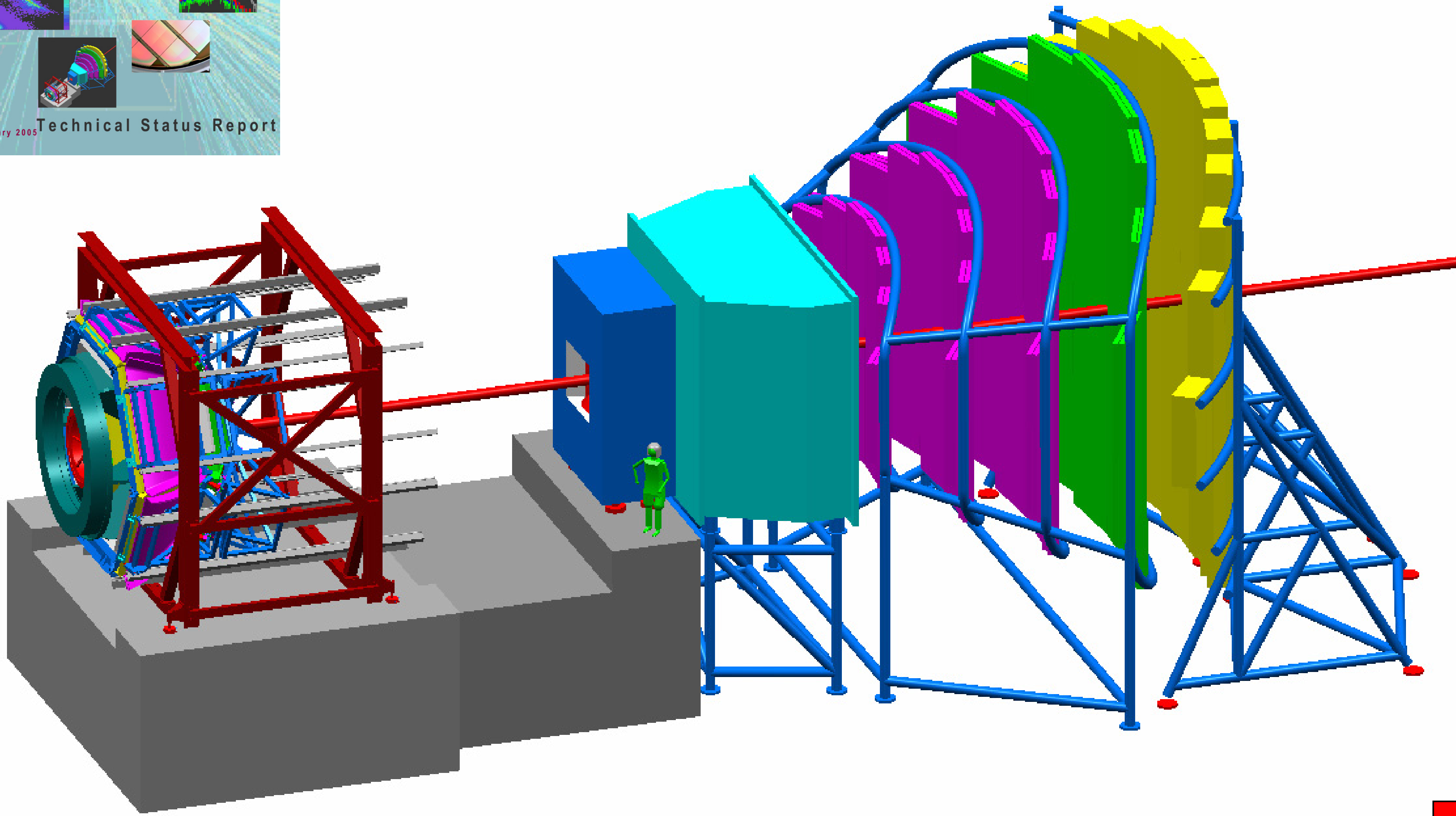




- Radiation hard Silicon pixel/strip detectors in a magnetic dipole field
- Electron detectors: RICH & TRD & ECAL: pion suppression up to 10^5
- Hadron identification: RPC, RICH
- Measurement of photons, π^0, η, and muons: ECAL

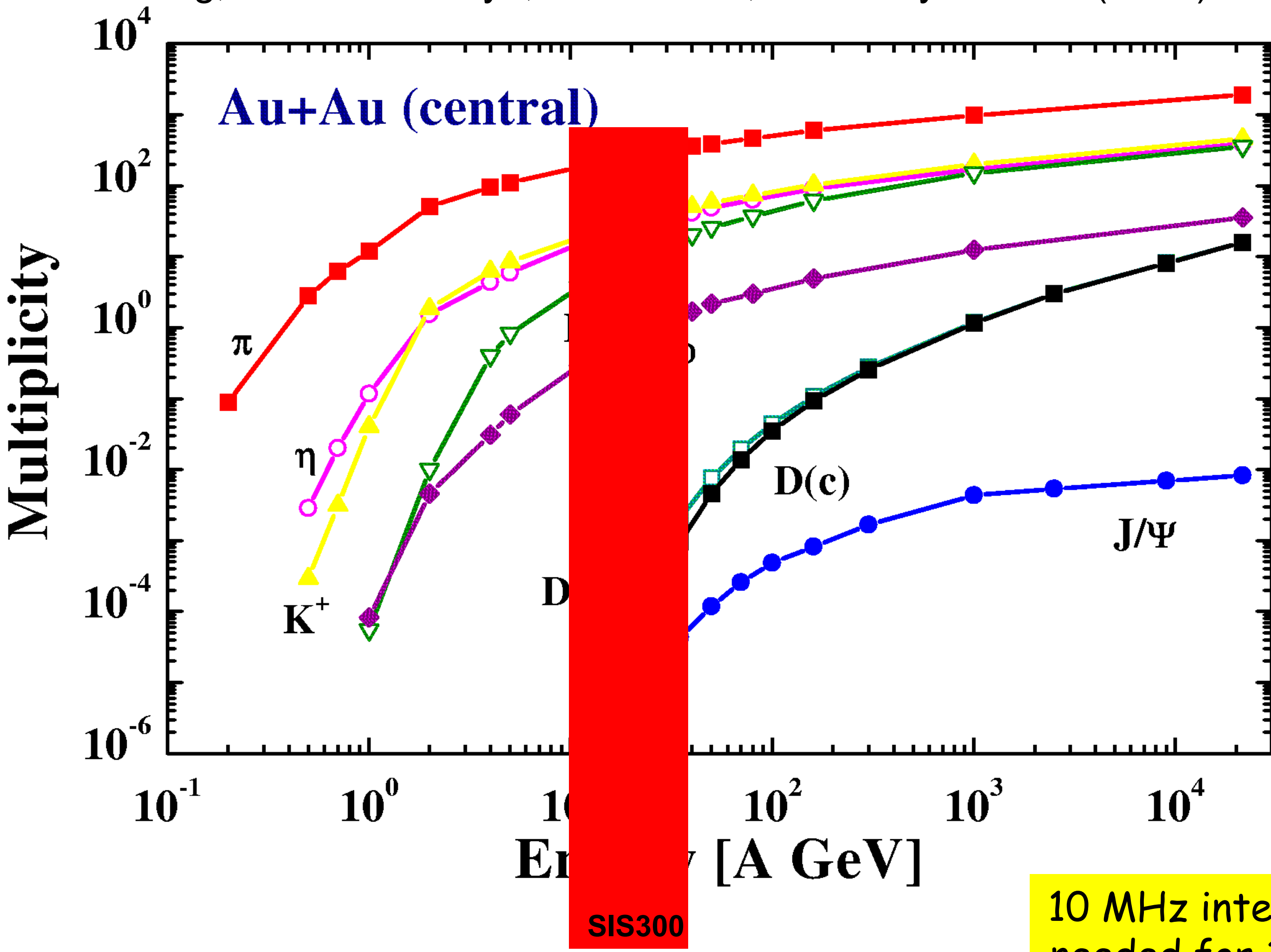


All you want to know about CBM:
Technical Status Report (400 p)
now available under
http://www.gsi.de/documents/DOC-2005-Feb-447-1.pdf



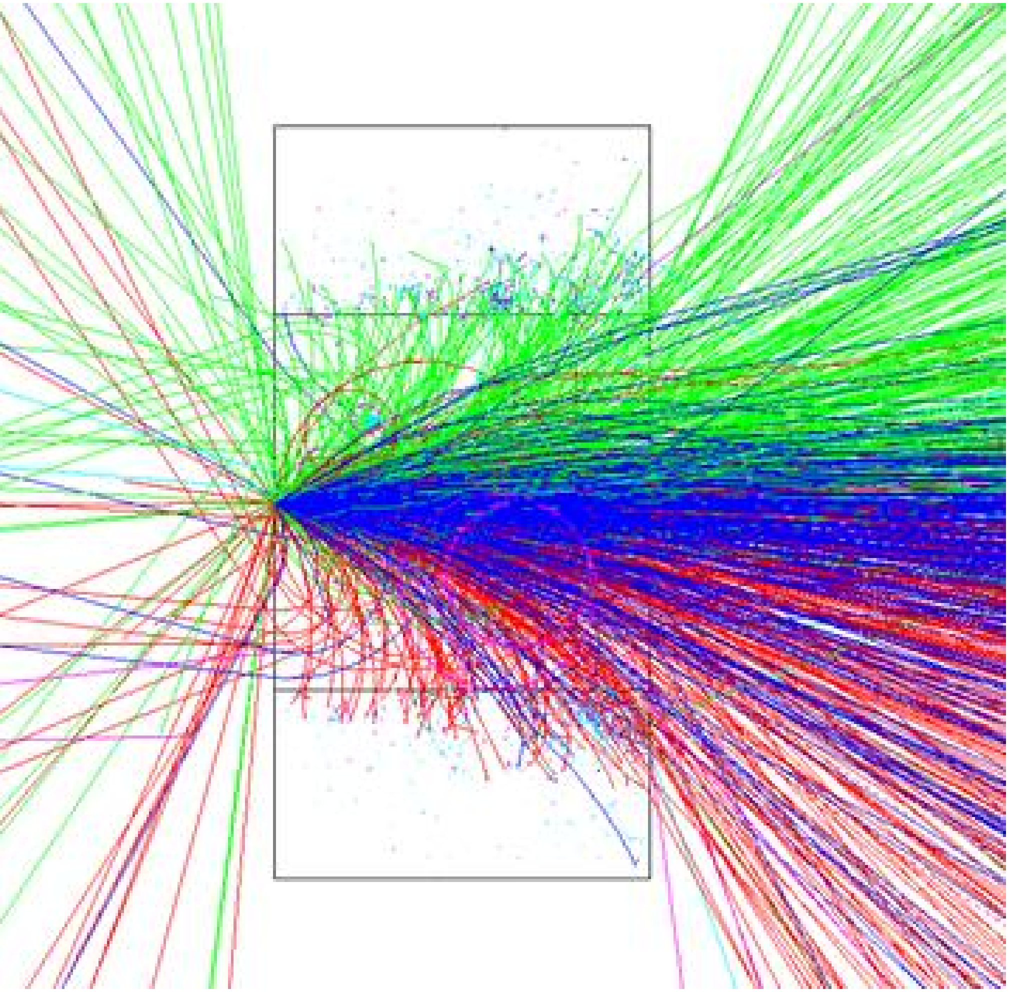
Meson Production in central Au+Au

W. Cassing, E. Bratkovskaya, A. Sibirtsev, Nucl. Phys. A 691 (2001) 745



10 MHz interaction rate needed for 10-15 A GeV

A Typical Central Au+Au Collision



Central Au+Au collision
at 25 AGeV:
URQMD + GEANT

160 p		170 n
360 π^-	330 π^+	360 π^0
41 K^+	13 K^-	42 K^0

- 10^7 Au+Au interactions/sec
- 10^9 tracks/sec to reconstruct for first level event selection

CBM 'Trigger' Requirements

- In-medium modifications of hadrons
  - onset of chiral symmetry restoration at high ρ_B
    - measure: $\rho, \omega, \phi \rightarrow e^+e^-$ — offline
    - open charm ($D^0, D^\pm$) — trigger
- Strangeness in matter
  - enhanced strangeness production
    - measure: $K, \Lambda, \Sigma, \Xi, \Omega$ — offline
- Indications for deconfinement at high ρ_B
  - anomalous charmonium suppression ?
    - measure: $D^0, D^{\pm}$ - — trigger
    - $J/\psi \rightarrow e^+e$ — trigger
- Critical point
  - event-by-event fluctuations
    - measure: π, K — offline

assume archive rate:
few GB/sec
20 kevents/sec

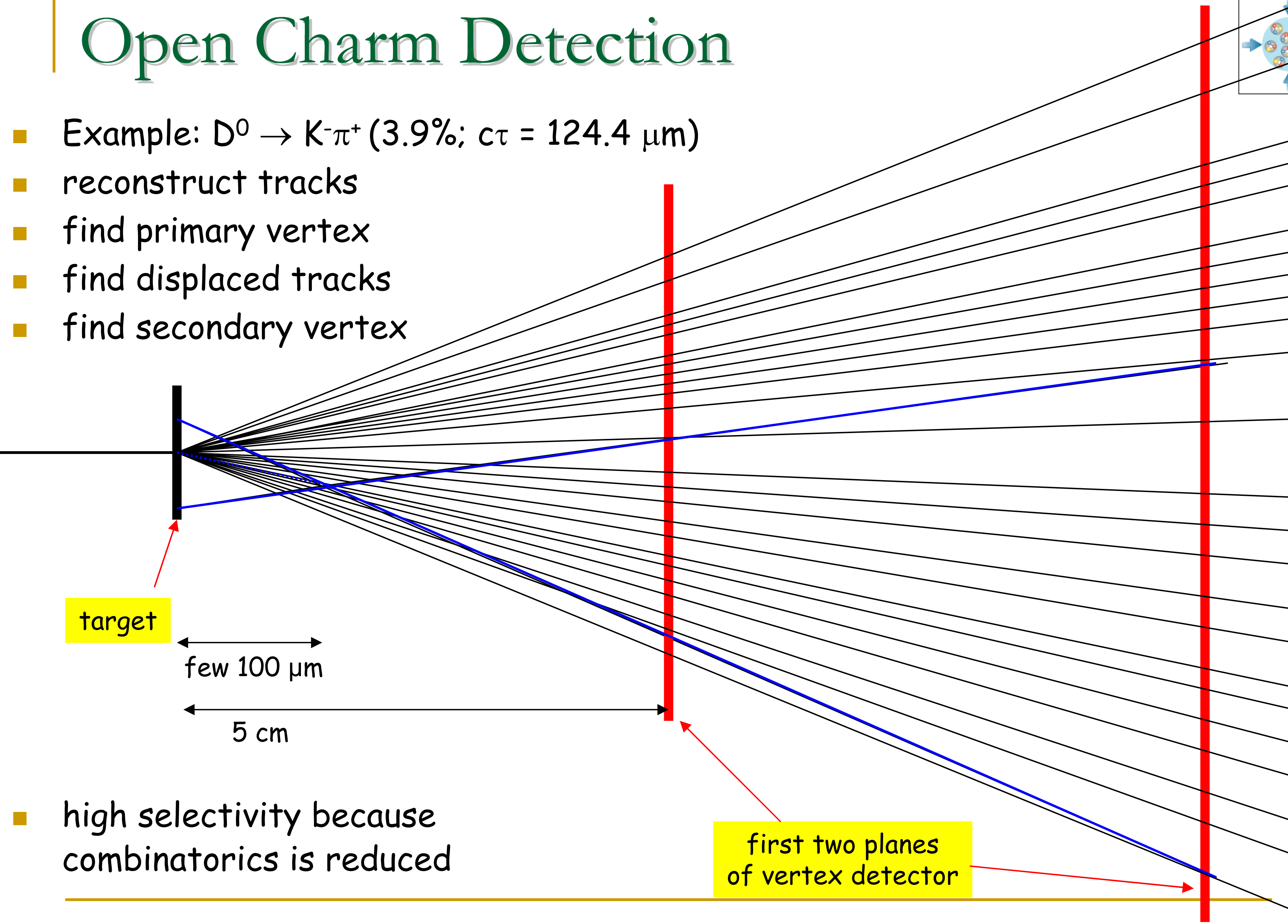
trigger on displaced vertex

drives FEE/DAQ architecture

trigger on high p_t e^+ - e^- pair

Open Charm Detection

- Example: $D^0 \rightarrow K^-\pi^+$ (3.9%; $c\tau$ = 124.4 μm)
- reconstruct tracks
- find primary vertex
- find displaced tracks
- find secondary vertex



- high selectivity because combinatorics is reduced

CBM DAQ Requirements Profile

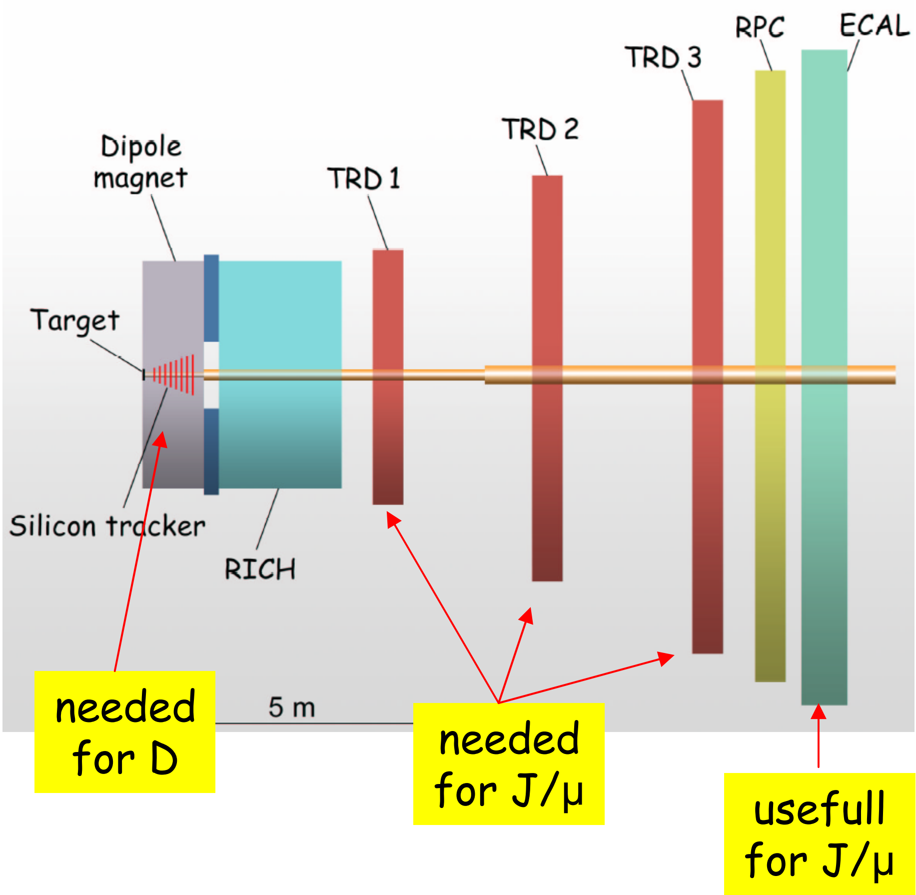
- D and J/Ψ signal drives the rate capability requirements
- D signal drives FEE and DAQ/Trigger requirements
  - Problem similar to B detection, like in LHCb or BTeV (rip)
  - Adopted approach:
    displaced vertex '*trigger*' in <u>first level</u>, like in BTeV (rip)
  - Additional Problem:
    DC beam → interactions at random times
    → time stamps with ns precision needed
    → explicit event association needed
- Current design for FEE and DAQ/Trigger:
  - Self-triggered FEE
  - Data-push architecture

Front-End for Data Push Architecture

- Each channel detects **autonomously** all hits
- An **absolute time stamp**, precise to a fraction of the sampling period, is associated with each hit
- **All hits are shipped** to the next layer (usually concentrators)
- Association of hits with events done later using time correlation

- Typical Parameters:
  - with few 1% occupancy and 10^7 interaction rate:
    - some 100 kHz channel hit rate
    - few MByte/sec per channel
    - whole CBM detector: 1 Tbyte/sec

CBM DAQ and Online Event Selection



STS, TRD, and ECAL data used in first level event selection

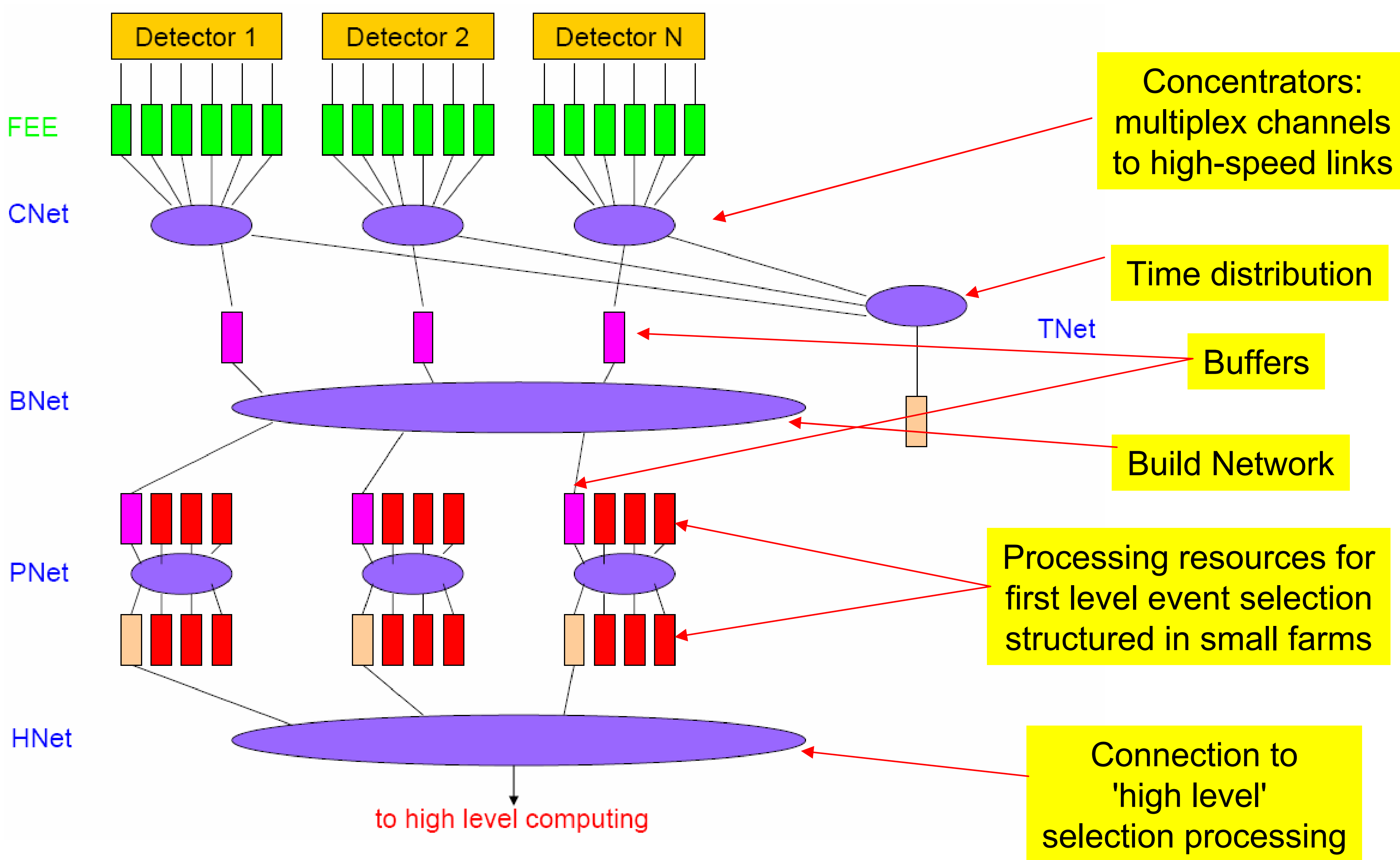
- More than 50% of total data volume relevant for first level event selection
- Aim for simplicity
- Ansatz:

  do (almost) all processing done after the build stage
- Simple two layer approach:

  1. event building
  2. event processing

- Other scenarios are possible, putting more emphasis on:
  - do all processing as early as possible
  - transfer data only then necessary

Logical Data Flow



Summary

- Self-triggered FEE:
  - autonomous hit detection, time-stamping with ns presision
  - sparsification, hit buffering, high output bandwidth
- High bandwidth event building network
  - handle 10 MHz interaction rate in Au-Au
  - also cope with few 100 MHz interaction rate in p-p, p-A
  - likely be done in time slices or event slices
- L1 processor farm
  - feasible with PC + FPGA + Moore (needed 2014)
  - but look beyond todays PC's and FPGA's
- Efficient algorithms (10^9 tracks/sec)
  - co-design of critical detectors and tracking software

Substantial R&D needed

Quite different from the current LHC style electronics

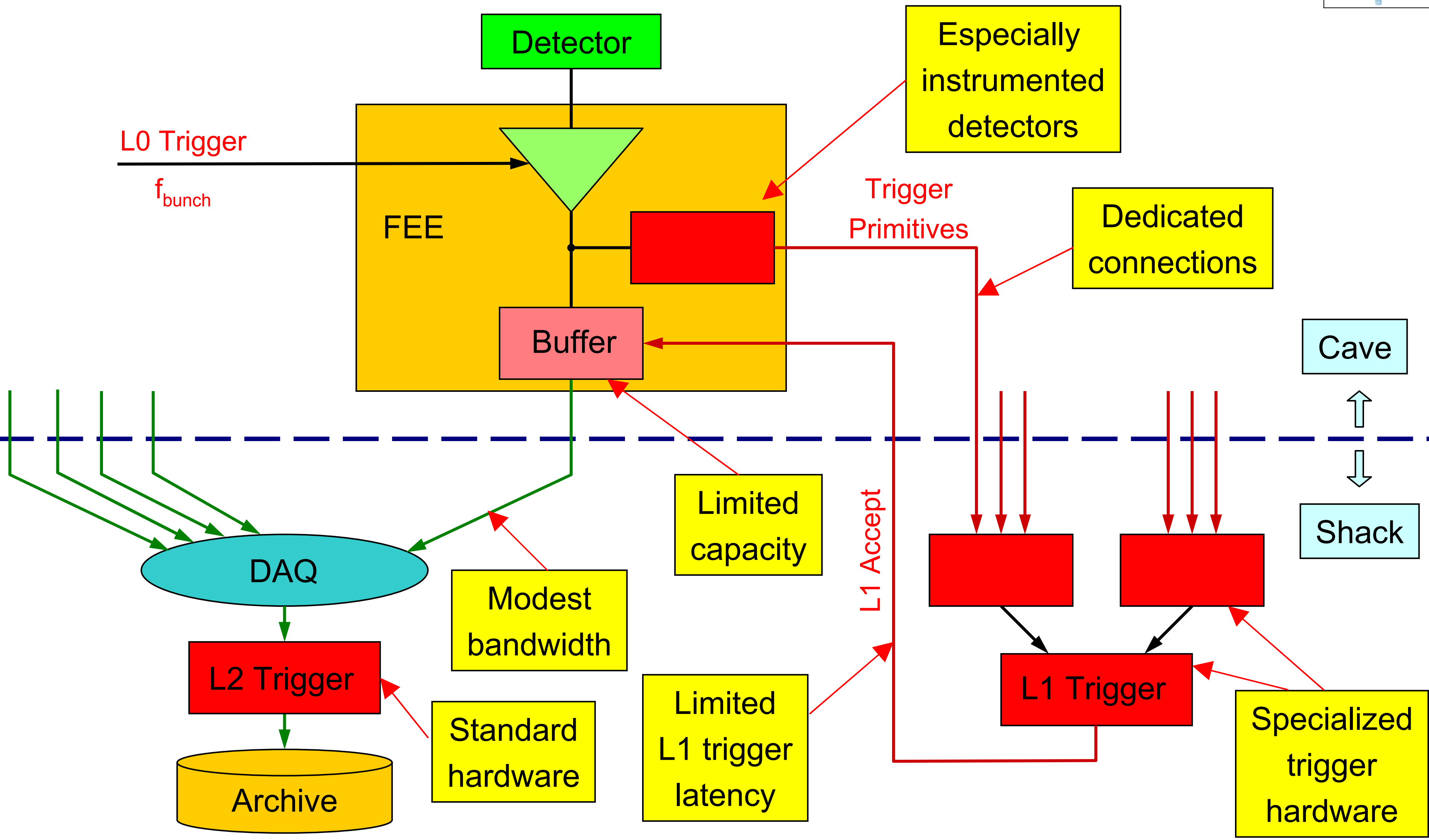
FutureDAQ

RII3-CT-2004-506078

The End

Thanks for your attention

Conventional FEE-DAQ-Trigger Layout



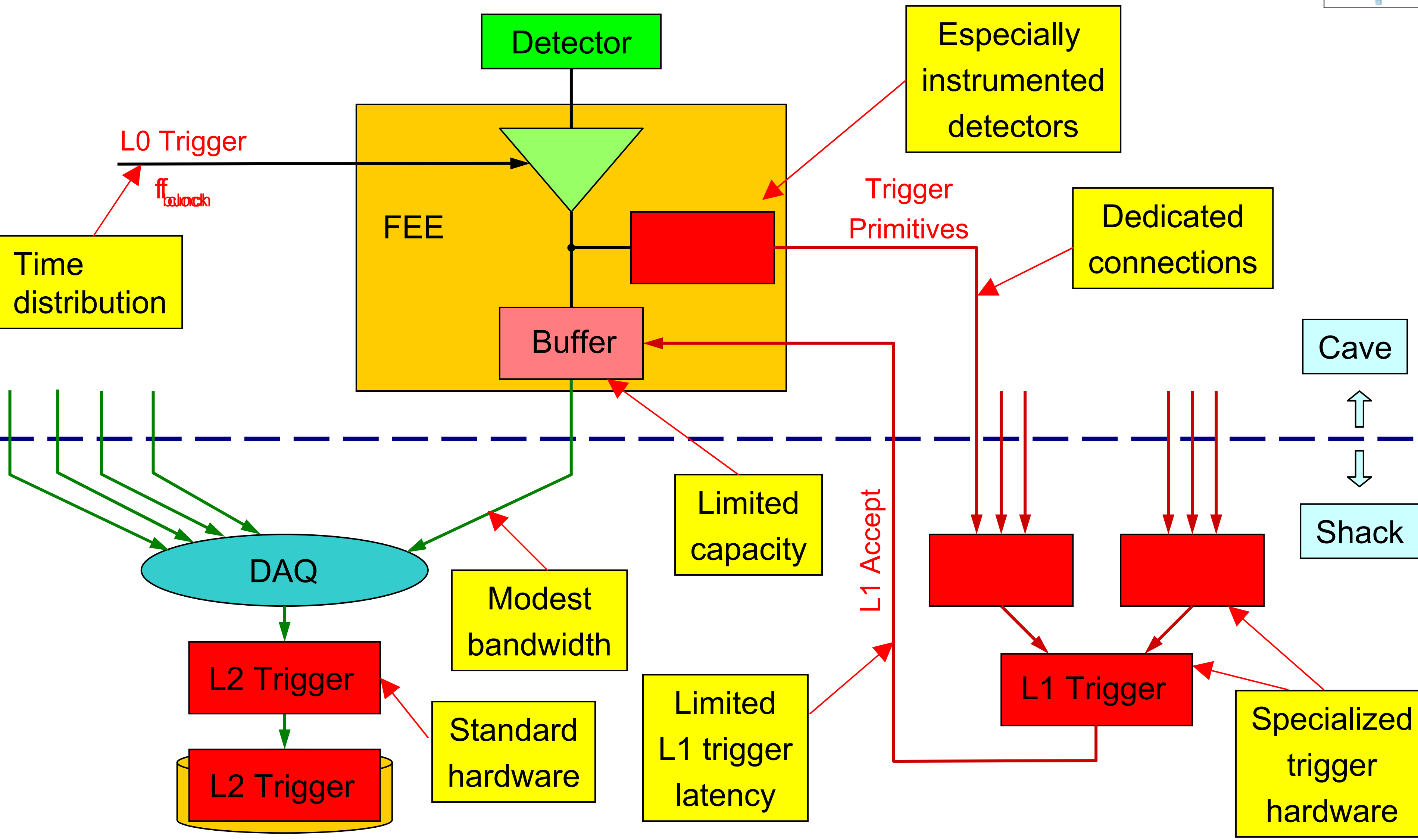
Limits of Conventional Architecture

Decision time for first level trigger limited. typ. max. latency 4 μs for LHC → Not suitable for complex global triggers like secondary vertex search

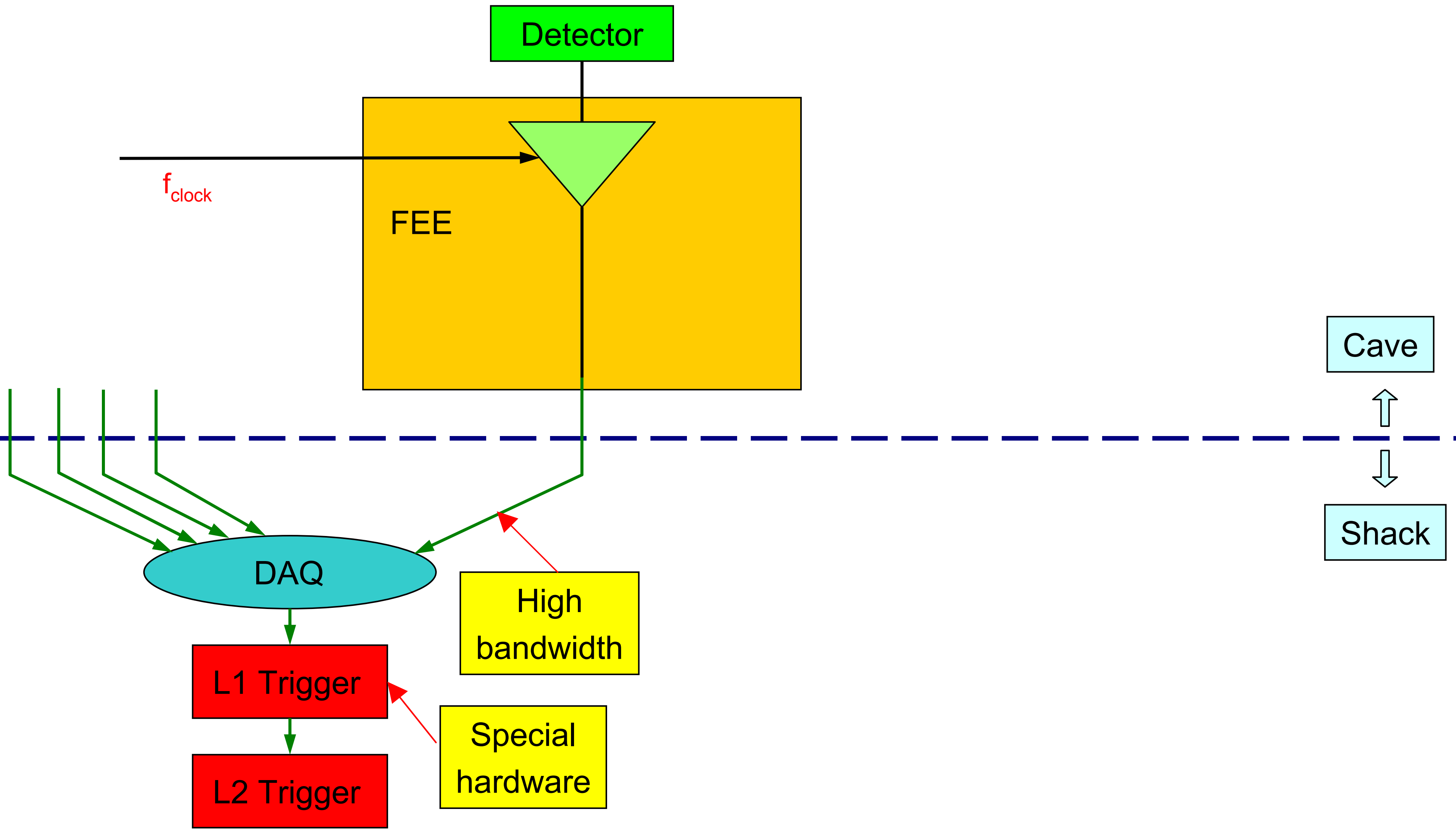
Only especially instrumented detectors can contribute to first level trigger → Limits future trigger development

Large variety of very specific trigger hardware → High development cost

The way out .. use Data Push Architecture



The way out ... use Data Push Architecture



The way out ... use Data Push Architecture