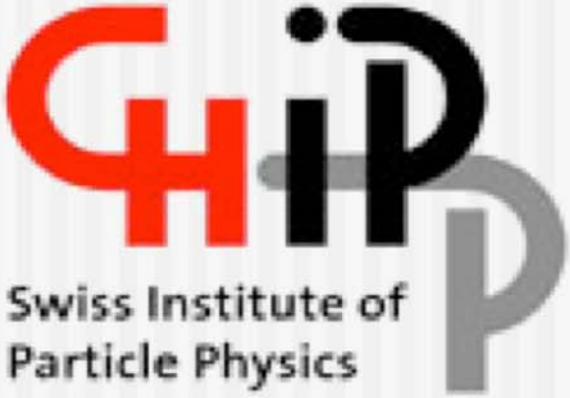
Physics Case : CMS



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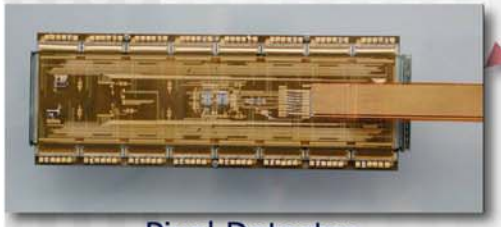
CHIPP LHC Computing Workshop
Manno, Aug 2005

Compact Muon Solenoid

CMS Detector:

Weight: 12'500 t
Diameter: 15 m
Length: 21.6 m
Magnetic Field: 4 T

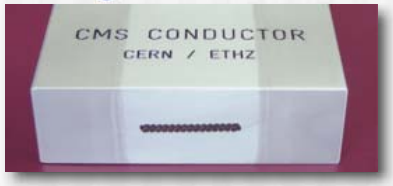
Silicon Strip detector **ETHZ**



Pixel Detector
PSI, ETHZ, UniZ

Crystal calorimeter
ETHZ, PSI

Superconductor for magnet **ETHZ**



Organisation of magnet production
ETHZ

Software & Physics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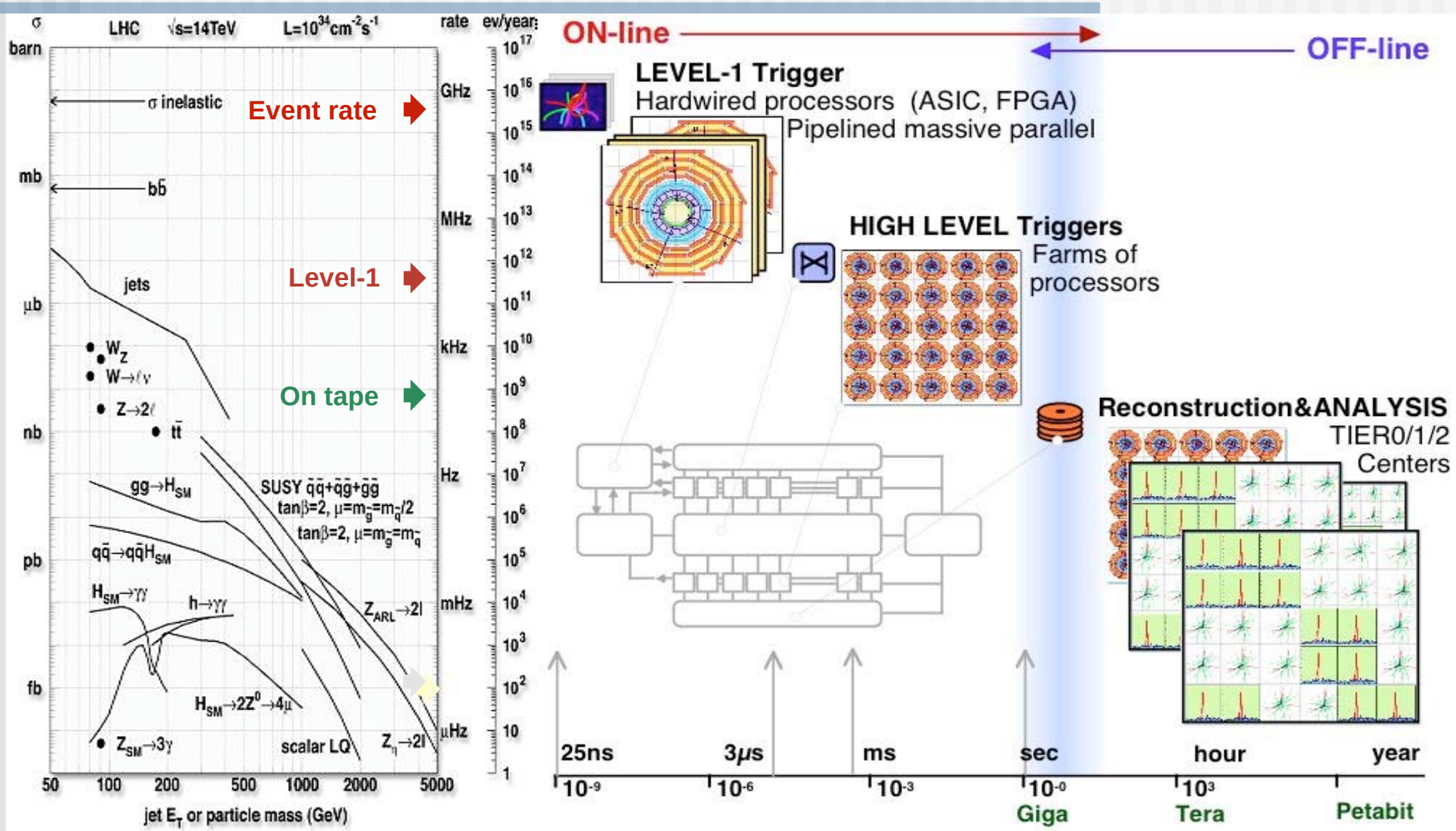
Outline

- The CMS Computing Model
  - Mini-summary of the Computing TDR
- Physics Analyses
  - Overview
  - Analyses planned by groups
    - ETHZ, PSI, UNIZ
- Summary / Conclusions

The CMS Computing Model

See CMS - Computing TDR, CERN/LHCC 2005-023, June 2005

CMS : Trigger/DAQ



CMS HLT table

These numbers from DAQ TDR. $L = 2 \times 10^{33}\ cm^{-2}\ s^{-1}$ HLT ~ 2000 CPUs

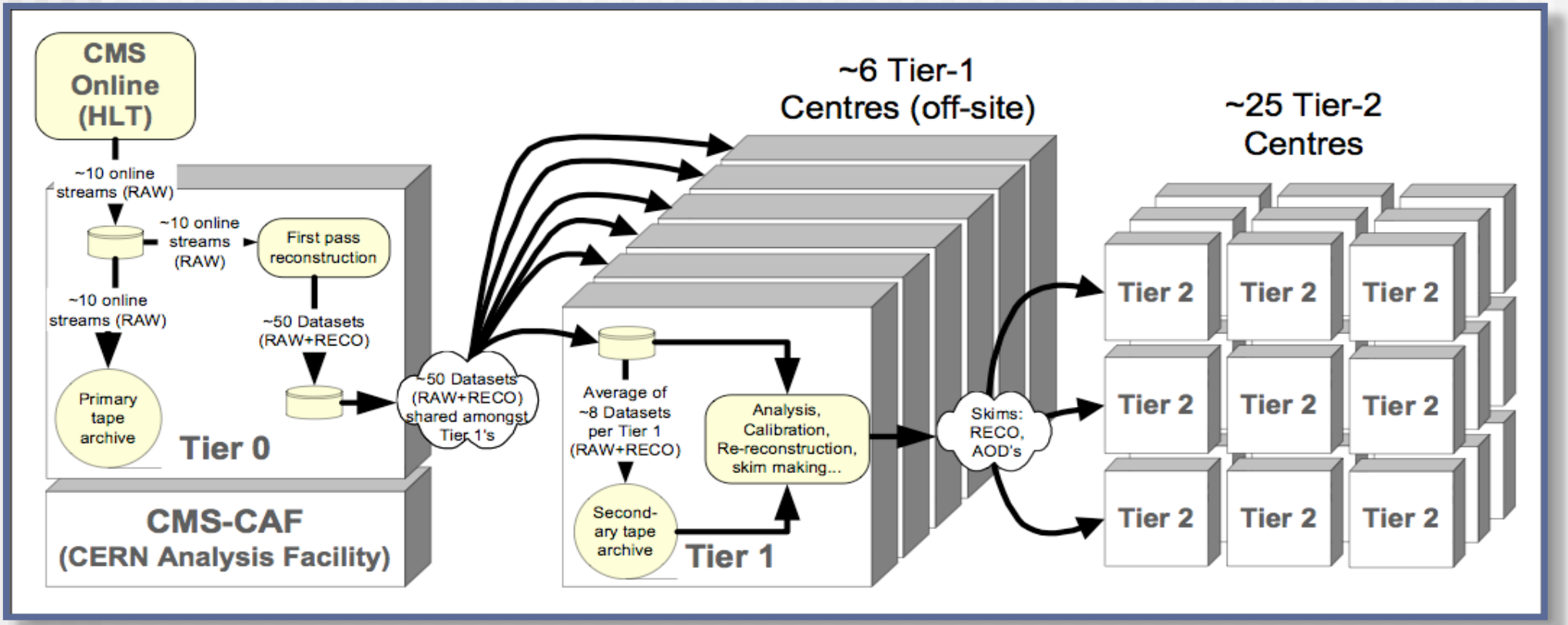
Trigger	*Threshold (GeV or GeV/c)*	*Rate (Hz)*	*Cuml. rate (Hz)*
Inclusive electron	*29*	*33*	*33*
Di-electron	*17*	*1*	*34*
Inclusive photon	*80*	*4*	*38*
Di-photon	*40, 25*	*5*	*43*
Inclusive muon	*19*	*25*	*68*
Di-muon	*7*	*4*	*72*
Inclusive tau-jet	*86*	*3*	*75*
Di-tau-jet	*59*	*1*	*76*
*1-jet * E_T^{miss}*	*180 * 123*	*5*	*81*
1-jet OR 3-jet OR 4-jet	*657, 247, 113*	*9*	*89*
*Electron * jet*	*19 * 45*	*2*	*90*
Inclusive b-jet	*237*	*5*	*95*
Calibration etc		*10*	*105*
TOTAL			*105*

Computing TDR foresees some additional bandwidth (further SM rates, calibrations etc), so 150 Hz

CMS Data Formats

Type	Description	Size [Mb/evt]
DAQ-RAW	Detector Data + L1 Trigger bits, input to online High Level Trigger (HLT)	1-1.5
RAW	Detector data after HLT + HLT trigger bits + objects created at HLT	1.5
RECO	Reconstructed Objects (Tracks, jets, electrons, muons, …) and reconstructed hits and clusters	0.25
AOD	Analysis Object Data : Reconstructed Objects + very localized hit information	0.05
TAG	Run/Event number, high-level physics objects, used to index events	0.01
FEVT	Term used to refer to RAW+RECO together (not a distinct format)	-

CMS Computing Model



- HLT output : 150 Hz, 10^7 seconds running ➔ 1.5 x 10^9 evts/year
- CMS-CAF : at CERN, services similar to Tier-1 and Tier-2, size of ~ 2 Tier-2, login for every CMS user

CMS - Tier-2 resources

- Three types of use of Tier-2 resources
  - **Local community use**
    - Some fraction fully under control of local community
  - **CMS controlled use**
    - For organised activities allocated top-down by CMS, eg. MC prod, or CPU and disk space provision for defined analysis groups. A Tier-2 could host the work of one or more analysis groups.
  - **Opportunistic use**
    - by any CMS member. Lower priority than the local community, some storage available at all times.
- Tier-2 centres are expected to vary widely in size

Tier-2 requirements (typical)

- Some example numbers:
- **CPU** : 0.9 MSI2K
- **Disk** : 200 TB
- **WAN** : ≥ 1 Gb/s
- **Data import** 5 TB/day for AOD from Tier-1
- **Data export** 1 TB/day

Physics Analyses

Groups:

ETHZ :

- group Pauss-Dissertori (Dittmar)
- group Eichler (Grab)
- group Langenegger

PSI :

- group Gabathuler (Kotlinski)

UniZ :

- group Amsler (Speer)

Overview / Comments

- Foresee strong Swiss participation in
  - Higgs searches (SM and SUSY)
  - SM physics (W/Z)
  - "Topological" searches for new physics
  - Studies of the B_s
- Calibration/detector studies foreseen for Pixel Detector

- A comment :
  - The general "rule" $N_{data} : N_{MC} = 1 : 1$ not so meaningful.
  - What should be considered: δ_{stat} (MC) < δ_{syst} (MC), and δ_{syst} can be expected in most cases to be 5-10%, at best.

- Skimming / Pre-selection :
  - Likely "factor" for data reduction (asking for additional quality criteria, eg. lepton selection) will be 100 - 1000 . Maybe less in channels involving b-quarks and taus.

- How analyses will be done (AODs at Tier-2, Ntuples at Tier-3 etc)
  - See talk by H.P. Beck

ETHZ : group Pauss-Dissertori

Channel	HLT	Rate Evts/year	Skimmed Evts/year	MC Sig+Bckg	Data Format
H→WW→2l 2ν l = e, μ	Single/ double e, μ ~ 63 Hz	~ 6 x 10^8	~ 600 000	~ 10^6 ?	AOD TAGS Ntuples
Inclusive W / Z, leptonic decays, e, μ	- " -	- " -	- " -	- " -	- " -
Final states with ≥ 1 photon (H → γγ, γ+jet)	Single/ double photon ~ 10 Hz	~ 10^8	10^5 - 10^6	~ 10^6 ?	- " -
Topological searches nl + m γ + k jets	Combinat ion of above	10^8 - 10^9	10^5 - 10^6	10^6 - 10^7	- " -

ETHZ : group Langenegger

Note : contract up to 09/2008

Channel	HLT	Rate Evts/year	Skimmed Evts/year	MC Sig+Bckg	Data Format
$H \rightarrow bb$	High-E_T jet (not clear yet) 5 - 10 Hz ?	~ 10^7 - 10^8	10^5 - 10^6	~ 10^7	AOD TAGS Ntuples
$B_s \rightarrow \mu\mu$	Di-Muon ~ 4 Hz	4 10^7	- " -	- " -	- " -
Maybe one additional channel for Higgs search					

ETHZ : group Eichler

- To be decided….
  - perhaps something around “B-tagging, B-Studies”
  - work to be started in spring 2006

PSI

	Channel	HLT	Rate Evts/year	Skimmed Evts/year	MC Sig+Bckg	Data Format
a)	bbH (SUSY) → $2\tau \rightarrow$ 2 jets	tau-jets 3 Hz	~ 10^7	10^4 - 10^5	10^6 - 10^7	AOD TAGS Ntuples
b)	bbH (SUSY) → $2\tau \rightarrow \mu + \tau$-jet	tau-jet + Muon 1 Hz	- " -	- " -	- " -	- " -
c)	Study of pixel data (get detector operational)	Probably single-muon ~25 Hz	~ 10^6 (not more needed than that)			RAW RECO

- ad a) together with Pisa, Imperial College, …
- ad b) together with Warsaw
- Ad c) together with ETHZ (Langenegger) and UniZ (Speer)

UniZ : group Amsler

Channel	HLT	Rate Evts/year	Skimmed Evts/year	MC Sig+Bckg	Data Format
$B_s \rightarrow J/\Psi\,\Phi \rightarrow \mu^+\mu^-\ K^+K^-$	Dedicated HLT trigger ~ 0.1 Hz ?	10^6	10^3 - 10^4	10^6 ?	AOD TAGS Ntuples

Summary / Conclusions

- Interesting and rich programme

- HLT- Trigger paths needed (of the order of 90 Hz, total)
  - Single/double leptons (electrons/ muons)
  - Single/double photons
  - Tau-jets
  - Probably some high-E_T jet trigger

- Messages
  - Importance of Manno and Tier-3s : see talk of H.P. Beck
  - We do not want to depend on the CMS-CAF at CERN
  - Would be great to have most (all) AODs of the above paths at Manno, and all skimmed AODs
  - We have to be flexible, ie., prepared for (physics) surprises
  - No Heavy Ions programme : should take care that Manno resources are not used for that…

Backups

CMS L1 Trigger Table

$L = 2 \times 10^{33}\ cm^{-2}\ s^{-1}$

Trigger	Threshold (GeV or GeV/c)	Rate (kHz)	Cumulative Rate (kHz)
Isolated e/g	*29*	*3.3*	*3.3*
Di-e/g	*17*	*1.3*	*4.3*
Isolated muon	*14*	*2.7*	*7.0*
Di-muon	*3*	*0.9*	*7.9*
Single tau-jet	*86*	*2.2*	*10.1*
Di-tau-jet	*59*	*1.0*	*10.9*
1-jet, 3-jet, 4-jet	*177, 86, 70*	*3.0*	*12.5*
JetE_T^{miss}*	*88*46*	*2.3*	*14.3*
*Electron*jet*	*21*45*	*0.8*	*15.1*
Min-bias		*0.9*	*16.0*
TOTAL			*16.0*

CMS HLT efficiencies

With previous selection cuts

Channel	Efficiency (for fiducial objects)
$H(115\ GeV) \rightarrow \gamma\gamma$	77%
$H(160\ GeV) \rightarrow WW^* \rightarrow 2\mu$	92%
$H(150\ GeV) \rightarrow ZZ \rightarrow 4\mu$	98%
$A/H(200\ GeV) \rightarrow 2\tau$	45%
SUSY (~0.5 TeV sparticles)	~60%
With R_P-violation	~20%
$W \rightarrow e\nu$	67% (fid: 60%)
$W \rightarrow \mu\nu$	69% (fid: 50%)
$Top \rightarrow \mu\ X$	72%