Analysis activities within the  group

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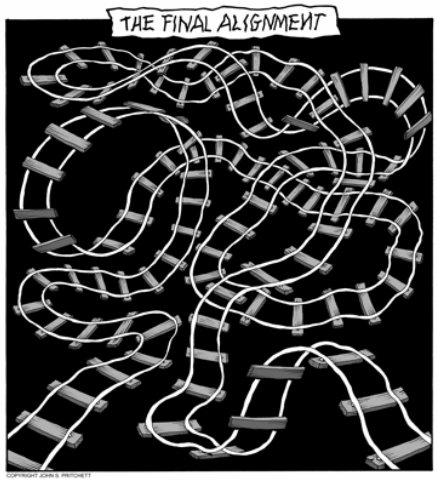
on behalf of IFIC's Silicio group

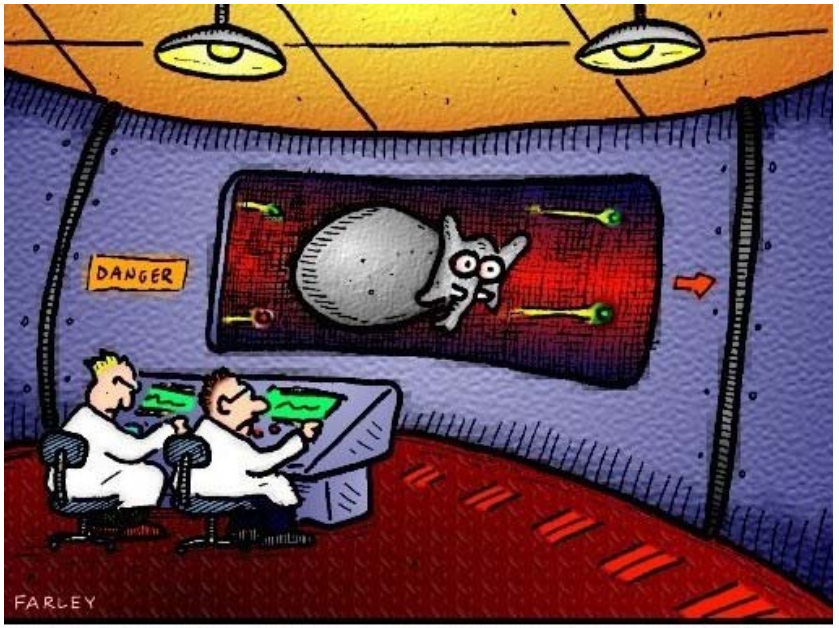
ATLAS Valencia Analysis Meeting - 9th - May 08

Outline

- Activities:
  - Alignment
  - SUSY
  - Tops
- Data streams
  - overview
  - requirements
- Summary



The final alignment for Honolulu's proposed rail transit

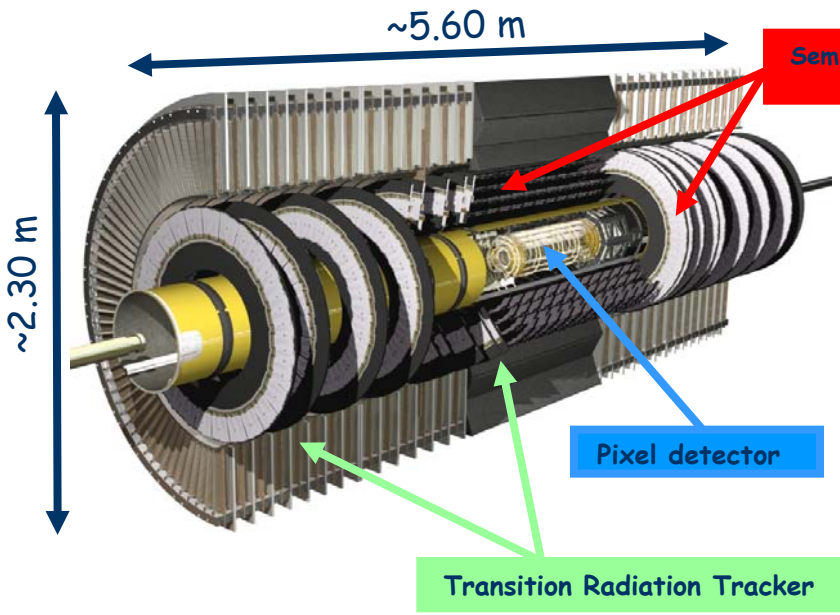


Deep within the atomic supercollider, the search continues for the elusive elephantino.

Alignment activities

- Calibration and alignment processing:
  - generation of "non-event" data that are needed for the reconstruction of ATLAS event data
- Mandate:
  - provide calibration and alignment constants useful for a first-pass processing of the main physics streams. **The latency target is 24 hours !!**
- IFIC's silicio group is deeply involved in the ID alignment effort
  - people involved:
    - Salva, Regina, Vicente, Carlos, Carmen, Javier, Sergio
  - main developers of the Global χ^2 algorithm
    - default alignment algorithm for Pixels and SCT
    - most probably, will also be used for track-based alignment of the Muon Spectrometer...
  - developers of related alignment packages
  - simulation and validation of MC samples
  - parallel processing of alignment processing tasks
  - Several "challenges": CSC, SR1, FDR-1, M6, FDR-2...

Reminder of the "problem"



System		of layers/disks	of modules
Pixel	Barrel	3	1456
	Forward	2×3	2×144
SCT	Barrel	4	2112
	Forward	2×9	2×988

Total: 5832

- Each silicon module has 6 degrees of freedom (dofs):
  - ⇒ full (silicon) system : n_{dofs} ~35000 dofs !
- Global χ^2 algorithm:

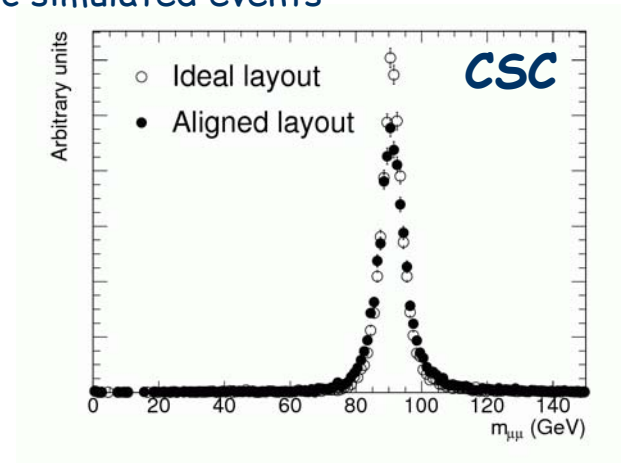
symmetric square matrix of size n_{dofs}

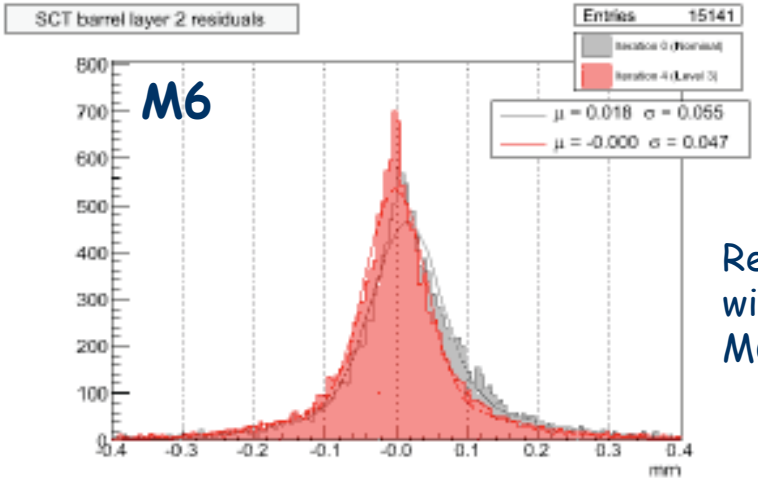
$$\delta \boldsymbol{a} = -\left(\sum_{trks} \frac{\partial \boldsymbol{r}^T}{\partial \boldsymbol{a}_0} W \frac{\partial \boldsymbol{r}}{\partial \boldsymbol{a}_0}\right)^{-1} \left(\sum_{trks} \frac{\partial \boldsymbol{r}^T}{\partial \boldsymbol{a}_0} W \boldsymbol{r}(\boldsymbol{\pi}_0, \boldsymbol{a}_0)\right) \equiv -M^{-1}\nu$$

vector of alignment corrections

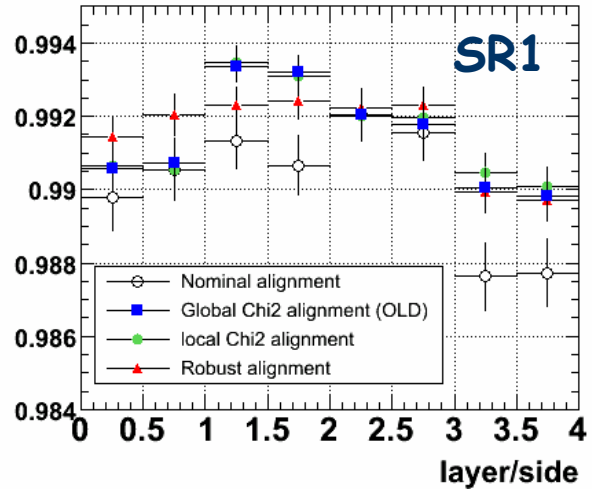
Results

Dimuon invariant mass from Z decays after alignment (all three levels) with a fully misaligned geometry using multimuon (non-physical) and cosmic simulated events





Efficiency per SCT layer for different alignment methods after alignment of the SCT barrel using cosmic events from SR1 combined SCT+TRT run on surface (ID assembly area)



Residuals in SCT barrel layer 2 after alignment with Global χ^2 method using cosmic events from M6 week on the pit

ID alignment within FDR-X

- Full-Dress-Rehearsals
  - **real time** test of entire offline data processing chain
    - from TDAQ to AOD/DPD; mix of events according to lumi and trigger menu
  - FDR-1 (4-8 Feb 08) : 0.4 pb^{-1} = 8h@10^{31} + 2h@10^{31}
  - FDR-2 (2-8 June 08)
    - higher luminosity but simplifier trigger menu
      - ~3M events, 5 pb^{-1}, 5 runs of 1h each @10^{32} or 10^{33}
- Exercise of the full Inner Detector alignment chain
  - misaligned geometry in simulation
    - assume ideal reconstruction ⇒ worst scenario: start alignment from scratch
  - run over the ID alignment stream (~700k events):
    - dedicated L2_trck10i_calib trigger using tau-trigger ROIs
  - validate (reco of express stream) and update conditions database
  - reconstruct physics stream with new constants
    - RDOs ⇒ ESDs ⇒ AODs ⇒ DPDs ⇒ BlaBlaBles…
- Alignment stream @FDR-2
  - simulation of single track events with p_T and η distributions of FDR-1 alignment stream tracks. Alignment will use in addition cosmic events (20-50k)

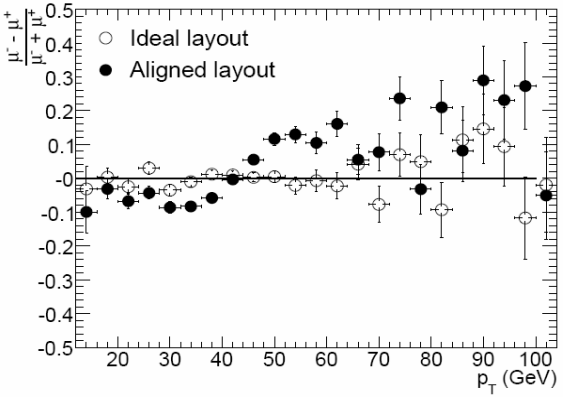
Cosmics

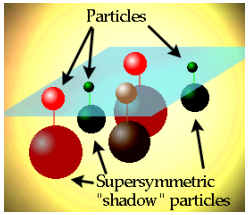
- Cosmics:
  - valuable events to correlate different parts of the detector
    - control of weak modes from tracks with a different geometry from that of the typical arising from pp collisions
  - drawbacks
    - very low rate (1-2 Hz)
    - how/when to trigger them still under discussion
- Very rough estimates based on cosmic events simulated for FDR-2
  - already filtered to the TRT barrel volume
  - 36 files of ~3 Gb each with ~1500 events/file ⇒ ~54k events ~ 108 Gb
    - after track selection (Si) for alignment ⇒ ~15k events
  - required alignment precision O(1M) "good" tracks, from which ~5% (not to be taken seriously) would be cosmic events
    - studies ongoing to determine a more realistic number and momentum range
  - ~50k "good" cosmic events would require 180k events or ~360 Gb
- Can't estimate rate during data-taking yet till trigger is agreed...
  - e.g.: M6, 1 full week devoted for cosmic data-taking SCT+TRT
    ⇒ 12k ID events ⇒ ~3.5k "good" (after Si track selection) events

Perspectives and requirements

- The calculation of alignment corrections for the first-pass reconstruction within 24 hours will be done at the **CERN Analysis Facility (CAF)**:
  - allocation for ID alignment ⇒ 100 Gb afs space + 10 hosts, each with:
    - 2 Intel Xeon CPU E5345 (2*4 cores) with 16 Gb RAM (shared)
      - 80 queues (80 x 1.9 kSI2k = 152 kSI2k)
- The data will be reprocessed 2-3 months after acquisition using the same software version but improved calibration and alignments
  - detailed study of weak-modes (global distortions)
- The ATLAS Computing Model [ATL-SOFT-2004-007]
  - "The Tier-2s will also host modest samples of RAW and ESD data for code devlopment. Some Tier-2s may take significant role in calibration following the local detector interests and involvements"

Would need for refined alignment correction samples with μ in final state (muon/B-physics stream) (J/Ψ, Υ, Z, W, B, etc.) in ESD format (pattern-recognition and track-fitting)

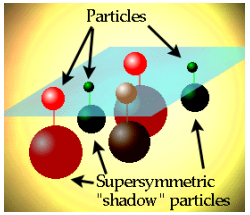




SUSY

- Supersymmetry with *R*-parity violation
  - Specific *R*-parity violation (RPV) scenario relevant to neutrino mixing
  - Lightest Supersymmetric Particle (LSP) may decay *in* the detector
    $\Rightarrow$ secondary vertex
  - Good tracking and efficient inner detector alignment crucial for this analysis

- People involved
  - Emma Torró Pastor
  - Carmen García
  - Vasia Mitsou

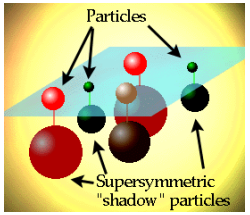


SUSY

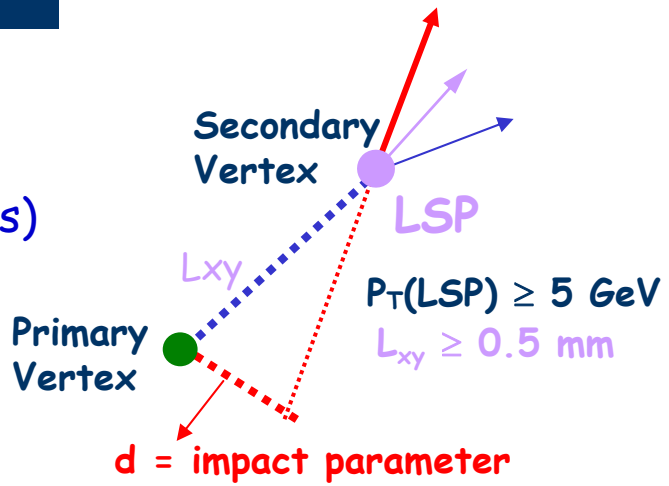
- **Supersymmetry** := fundamental symmetry between fermions-bosons
  - SM particles have SUSY-partners with spin difference of ±1/2
- R-parity : $R = (-1)^{3B-3L+2s} \rightarrow R = \begin{cases} +1, \text{ for SM particles} \\ -1, \text{ for superpartners} \end{cases}$
  - *R*-parity conservation hinted by *not required* by proton stability
- If R-parity is conserved:
  - SUSY-partners are always produced in pairs
    - *R* is a multiplicative quantum number
  - Lightest SUSY-particle (LSP) is stable:
    - should be colorless and neutral
    - weakly interacting → escapes the detector undetectable
      - *large missing transverse energy*

Mainstream studies within the ATLAS SUSY WG assume R-parity conservation, therefore they apply a standard cut (e.g. in production of bgd samples, DPDs, …) requiring high missing transverse energy

R-parity violation

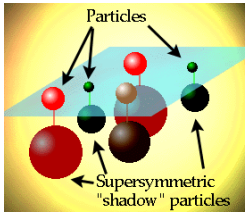


- Phenomenological consequences:
  - single sparticle production is allowed
  - LSP may be charged (e.g. stau, sleptons)
  - LSP is not stable!
  - no missing energy!
    - if LSP decays in the detector

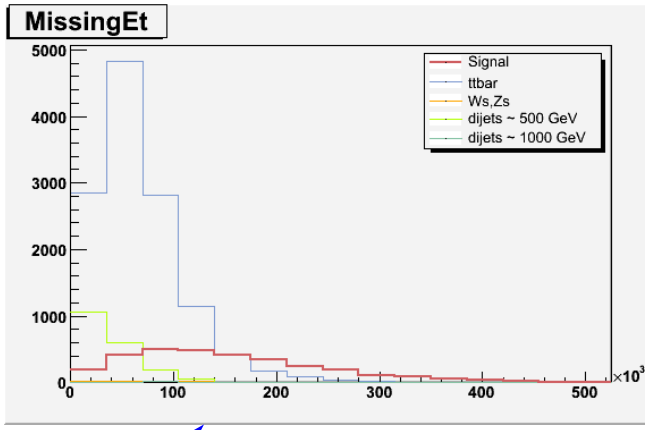


- Specific model under study:
  - RPV through bilinear terms. Scenario relevant for neutrino mixing
  - Characterised by 6 paremeters:
    - 3 "alignment" parameters: Λ_i
    - 3 sneutrino vev's v_i
  - BRs of LSP sensitive to ν mixing params, e.g.: $\tan^2\theta_{atm} \approx \frac{BR(\tilde{\chi}_1^0 \to \mu^{\pm}\bar{q}q')}{BR(\tilde{\chi}_1^0 \to \tau^{\pm}\bar{q}q')}$ final states
- Analysis strategy
  - Missing E_T *not* a discriminating variable any longer
    - SUSY WG samples & DPDs not always relevant to this study
  - Multi-jets & high-p_T leptons: possibly other New Physics
  - **Key point:** LSP decay reconstruction (cτ~mm)

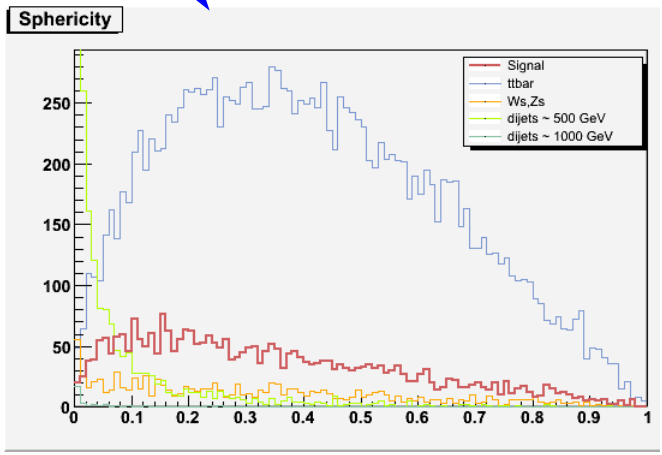
Current status



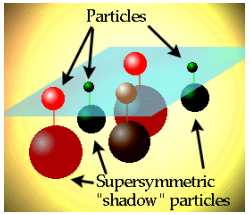
- Full simulation; release 12.0.6
- Signal: σ=41 pb, # = 10^4, int. lumi. 0.25 fb^{-1}
  SUSY with RPV $\tilde{\chi}_1^0 \to \mu^{\pm}\bar{q}q'$ $\tilde{\chi}_1^0 \to \tau^{\pm}\bar{q}q'$
- Background: samples from Exotics group
- Signal & background ntuples with SUSYView
  - in future studies DPDs instead of NTUP will be used



one tau and at least two jets



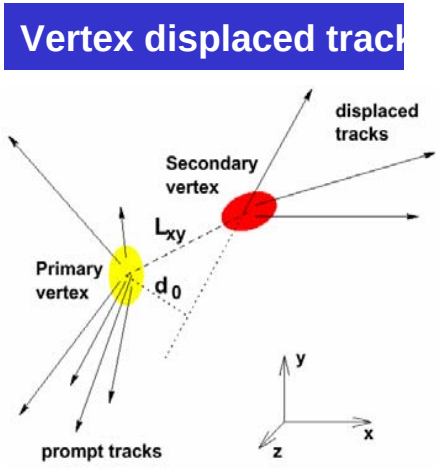
BGD	Secc. eficaz (pb)	número	NTUP
QCD	$1.4 \cdot 10^9 - 3 \cdot 10^2$	$3.4 \cdot 10^{11} - 9 \cdot 10^4$	No todo
tt	461	$1.2 \cdot 10^5$	SI
W + jets	52	$1.3 \cdot 10^4$	SI
Z + jets	42	10^4	SI
WW	2.5	$6 \cdot 10^2$	SI
WZ	7.8	$2 \cdot 10^3$	SI
ZZ	2.1	$5 \cdot 10^2$	SI



Requirements

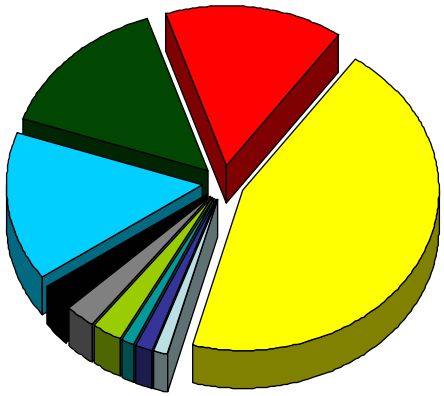
- Final state: high-p_T lepton(s) or tau(s) plus jets
- Relevant data streams: egamma, jetTauEtMiss, muon
- Indicative triggers @10^{31}
  - egamma: 2e15, 2e20, e10_mu6
  - jetTauEtMiss: tau25i_j70, tau20i_j120, tau20i_2j23, tau20i_2j70
  - muon: mu10_j18, 2mu20
- Data type: AODs, DPDs

- Need to access ESD to check and tune tracking algorithms performance for vertex reconstruction
  - Information of all reconstructed hits is needed
    - Large data samples
    - Not all of them necessary for development
  - Re-run reconstruction (probably many times)
    - Extensive use of CPU

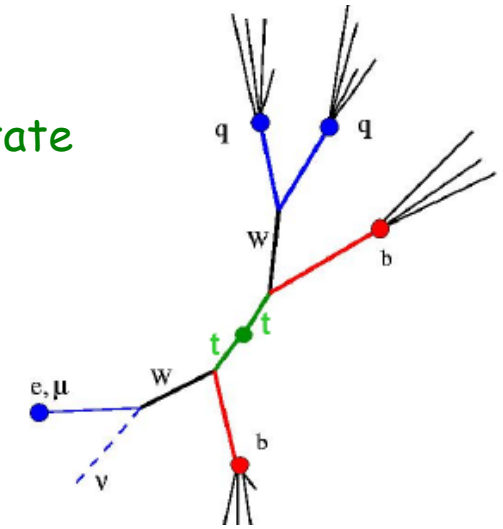


Tops

- Strong ttbar production at the LHC
  - $gg \rightarrow ttbar$ (87%), $qqbar \rightarrow ttbar$ (13%); $\sigma(ttbar)_{th} \sim 830 \pm 100$ pb @10^{34}
  - 1 top pair/second @10^{33} $\Rightarrow$ 8M / year
    - initial data samples 2008: 10-100 pb^{-1} $\Rightarrow$ few 1k or 10k events (not including experimental acceptance and reconstruction efficiencies)
      - **summer 2008: LHC running @10 TeV $\Rightarrow$ top pair cross-section reduced by a factor ~2**
- Top decay :
  - $M_t \sim 175$ GeV , $\Gamma_t \sim 1.5$ GeV, $\tau_t < 10^{-23}$ s
    - decay before hadronization, no bound states
  - BR($t \rightarrow Wb$) ~ 1 $\Rightarrow$ two (taggable) b-jets in final state



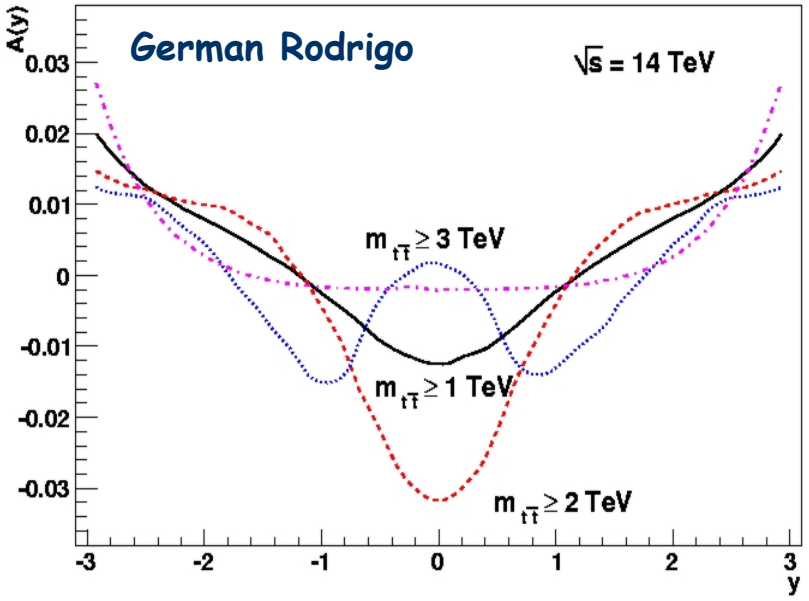
- e-e (1/81 ~ 1.2%)
- μ -μ (1/81 ~ 1.2%)
- τ-τ (1/81 ~ 1.2%)
- e -μ (2/81 ~ 2.4%)
- e -τ (2/81 ~ 2.4%)
- μ-τ (2/81 ~ 2.4%)
- e+jets (12/81~ 15%)
- μ+jets (12/81 ~ 15%)
- τ+jets (12/81 ~ 15%)
- jets (36/81 ~ 44%)



• 30% lepton (e,μ) + jets
$\Rightarrow$ gold-plated channel for mass measurement

Central charge asymmetry in ttbar production at the LHC

- ttbar production in LHC is "forward-backward" symmetric in LAB frame
  - symmetric colliding pp initial state
- σ(ttbar) dominated by $gg \rightarrow t\bar{t}$ (87%)
  - charge asymmetry $O(\alpha_s^3)$ generated from qqbar (13%) negligible in most of the kinematic phase-space
    - by selecting ttbar samples with high invariant mass in the ttbar system, qqbar is enriched and the asymmetry is measurable in the central rapidity region



$$A_C(y_C) = \frac{\sigma_t(|y| \le y_c) - \sigma_{\bar{t}}(|y| \le y_c)}{\sigma_t(|y| \le y_c) + \sigma_{\bar{t}}(|y| \le y_c)}$$

A maximum is reached at about y_c=1

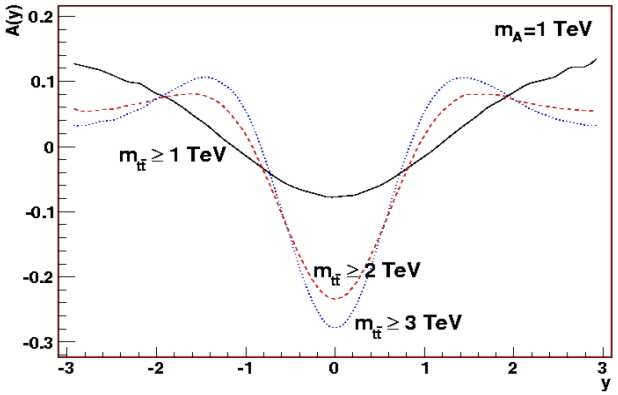
Axigluon asymmetry at the LHC

- Axigluons are colored neutral gauge boson predicted by some theories
  - chiral color models

[Pati, Salam, PLB58(75)333; Hall, Nelson, PLB153(85)430; Frampton, Glashow, PLB190(87)157, RL58(87)2168]

  - coupling to quarks with an axial-vector structure
  - charge asymmetry that can be generated is maximal

		QCD	m_A = 1 TeV	m_A = 2 TeV	m_A = 5 TeV
m_{tt} > 1 TeV	$A_C(y_c=1)$	-0.0086(4)	-0.055(4)	0.025(3)	0.002(1)
	$\sigma_t(\|y\|<1)$	9.7(2.7) pb	34(4) pb	15(2) pb	11(2) pb
m_{tt} > 2 TeV	$A_C(y_c=1)$	-0.0207(4)	-0.10(2)	-0.048(5)	0.031(9)
	$\sigma_t(\|y\|<1)$	0.19(6) pb	0.28(8) pb	1.7(2) pb	0.26 pb
m_{tt} > 3 TeV	$A_C(y_c=1)$	-0.0151(7)	-0.10(3)	-0.11(2)	0.057(13)
	$\sigma_t(\|y\|<1)$	0.011(4) pb	0.019(6) pb	0.024(7) pb	0.031(8) pb



Experimental procedure

- Measurement of $A_C(y_C) = \frac{N_t(|y| \le y_c) - N_{\bar{t}}(|y| \le y_c)}{N_t(|y| \le y_c) + N_{\bar{t}}(|y| \le y_c)}$
  - test of QCD from ttbar production
  - new physics searches (axigluons) in ttbar production process
- Lepton+jets channel
  - complete kinematic event reco
  - distinction t and tbar from the lepton charge from W decay
- Same samples as for measurement of top-pair cross-section in the semi-leptonic channel
  - **study doable @ 10 TeV !!**

- People involved
  - Susana, Salva, Carlos, Sergio

ID	process	generator	σ (pb)	L (fb^{-1})
5200	$t\bar{t} \to bWbW \to bqqb\ell\nu, b\ell\nu b\ell\nu$	MC@NLO	450 (NLO)	0.89
5204	$t\bar{t} \to bWbW \to bqqbqq$	MC@NLO	383 (NLO)	0.19

Signal

Backgrounds

5144	Z$\to ee$	PYTHIA	1747 (NLO)	0.28
5145	Z$\to \mu\mu$	PYTHIA	1826 (NLO)	0.10
5146	Z$\to \tau\tau$	PYTHIA	94 (NLO)	1.88
5985	WW	HERWIG	24.5	0.66
5986	ZZ	HERWIG	2.1	14.26
5987	WZ	HERWIG	7.8	3.83
5500	st (Wt, $W_1 \to e, \mu, \tau + \nu$, $W_2 \to qq$)	AcerMC	29.1 (NLO)	1.66
5501	st (s-chan, W$\to e, \mu, \tau + \nu$)	AcerMC	3.5 (NLO)	14.00
5502	st (t-chan, W$\to e, \mu, \tau + \nu$)	AcerMC	79.9 (NLO)	0.52
8240	W$\to e\nu$ + 2j	ALPGEN	246 (NLO)	0.09
8241	W$\to e\nu$ + 3j	ALPGEN	143 (NLO)	0.08
8242	W$\to e\nu$ + 4j	ALPGEN	62 (NLO)	0.10
8243	W$\to e\nu$ + 5j	ALPGEN	26 (NLO)	0.19
8244	W$\to \mu\nu$ + 2j	ALPGEN	19 (NLO)	0.37
8245	W$\to \mu\nu$ + 3j	ALPGEN	74 (NLO)	0.17
8246	W$\to \mu\nu$ + 4j	ALPGEN	41 (NLO)	0.08
8247	W$\to \mu\nu$ + 5j	ALPGEN	23 (NLO)	0.12
8248	W$\to \tau\nu$ + 2j	ALPGEN	101 (NLO)	0.20
8249	W$\to \tau\nu$ + 3j	ALPGEN	100 (NLO)	0.13
8250	W$\to \tau\nu$ + 4j	ALPGEN	53 (NLO)	0.11
8251	W$\to \tau\nu$ + 5j	ALPGEN	24 (NLO)	0.02
6280	W$b\bar{b}$ + 0j	ALPGEN	6.3	1.00
6281	W$b\bar{b}$ + 1j	ALPGEN	7.0	1.03
6282	W$b\bar{b}$ + 2j	ALPGEN	3.9	1.02
6283	W$b\bar{b}$ + 3j	ALPGEN	2.8	1.08
6284	W$c\bar{c}$ + 0j	ALPGEN	6.7	1.04
6285	W$c\bar{c}$ + 1j	ALPGEN	7.5	0.47
6286	W$c\bar{c}$ + 2j	ALPGEN	4.4	1.03
6287	W$c\bar{c}$ + 3j	ALPGEN	2.5	1.02

ATLAS data streams

- **Several physics streams**
  - all physics events
  - used for analysis: YES

Lumi	egamma	jetTauEtMiss	muon	minBias	bphysics
10^{31}	✓	✓	✓	✓	✗
10^{32}	✓	✓	✓	✓	✓

- **Express stream**
  - subset of physics data O(10%) with full events
  - quick reconstruction (few hours) after recorded
  - purpose:
    - check data quality
    - monitoring status of detector, alignment and calibration
  - used for analysis: NO
- **Calibration stream**
  - calibration triggers and particular physics events
  - used for analysis: NO
- **Diagnostic or debug stream**
  - pathological events failing in the online system (LVL2 or EF)
  - used for analysis: NO

Requirements @10^{31}

- Alignment:
  - Streams (ESDs):
    - muons
      - 500 kB/event x 0.95M = 475 Gb (without accounting for selection efficiency)
    - cosmics
      - "negligible" storage requirements (~400 Gb)
- SUSY analysis:
  - Streams (AOD, small number of ESDs)
    - egamma, muon, jetTauEtMiss
  - DPDs
    - SUSYView on Exotics group samples
      - due to missing E_T cut in SUSYView DPD's on SUSY samples
- Top analysis:
  - Streams (AOD)
    - egamma, muon, jetTauEtMiss
      - semi-leptonic channel
  - DPDs
    - TopView on Top group samples

Summary table

		egamma	muon	jetTauEtmiss	cosmics
Purpose		SUSY Top	Alignment SUSY Top	SUSY Top	Alignment
Format	ESD	✓ • Small sample (SUSY)	✓ • Small sample (SUSY) • Larger sample (alignment)	✓ • Small sample (SUSY)	✓ • Sample (alignment) - small in disk
	AOD	✓ • SUSY • Top	✓ • SUSY • Top	✓ • SUSY • Top	✗
	DPD	✓ • SUSYView • TopView	✓ • SUSYView • TopView	✓ • SUSYView • TopView	✗

- Some B-physics triggers defined in 10^{31} menu:
  - Mu4_Jpsimumu, 2MU4_Jpsimumu, Mu4_Bmumu, 2Mu4_Upsimumu, Mu4_Upsimumu
- From 10^{32} and beyond ⇒ will need B-physics stream as-well for alignment

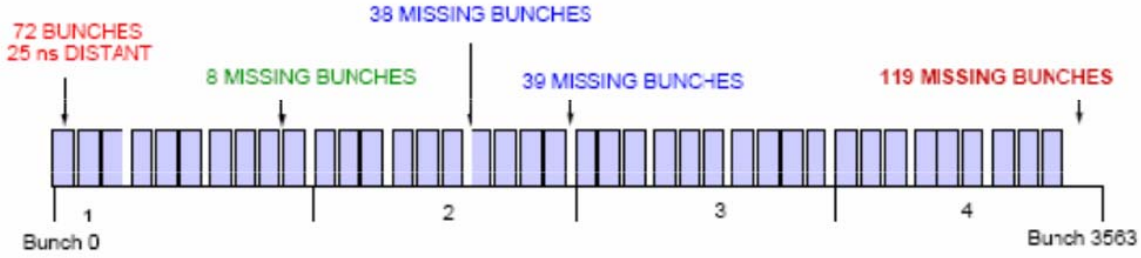
Backup

ID alignment within FDR-1

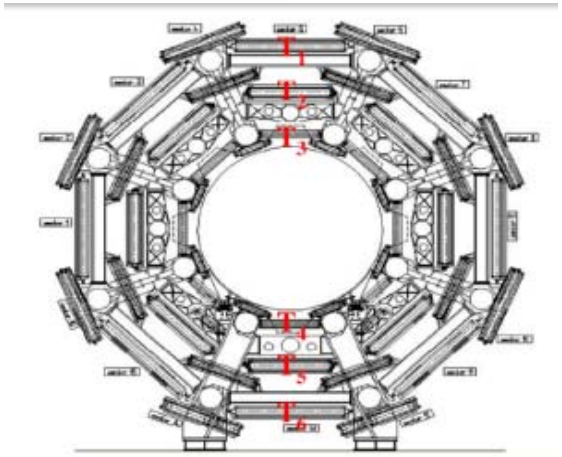
- requirement: isolated high p_T tracks coming from primary vertex
  - vertex constraint for weak modes control
  - we do not want muons from B-decays
- muon-based trigger not useful @10^{31} or 10^{32} - rate too small
  - need to use di-muons and reasonable thresholds (p_T>6 GeV) to kill K/π bckg.
- ID dedicated L2_trck10i_calib trigger using tau-trigger ROIs:
  - narrow calorimeter clusters (EM+HAD) at LVL1
  - calorimeter shower shape and tracking (IDSCAN) at LVL2
  - input sample:
    - originally 60Hz@10^{31} minbias events, but not enough simulated
    - JF17 sample (5802): QCD dijets
  - all existing L1 HA6 signatures, dominated by L1_2TAU6_EM8 (no prescale)
  - track selection:
    - isolation: only 1 track in ROI
    - p_T > 10 GeV, overlaps in modules
- For selected tracks:
  - build list of ROBs at LVL2 $\Rightarrow$ to Event Filter for **partial** event building
  - write into stream (byte-stream format)

Triggering on cosmics for alignment

- Prefit from the fact that LHC bunch structure is not dense:
  - even in 25ns mode, 21% empty BCs; in 75ns mode, more than 2/3 BCs empty
  - the idea is to activate a particular set of triggers for a set of empty BCs



- Prefered options to the moment:
  - LVL1:
    - use one of the existing muon triggers
      - low or high p_T trigger
  - LVL2:
    - use reverse timing structure of cosmic tracks wrt muons from collisions
      - only working for low lumi (high prescaling of low p_T trigger at high lumi)
      - separation power against muons from IP is critical point



- **Particles from IP:**
  $T_1 > T_2 > T_3$ $T_4 < T_5 < T_6$
- **Cosmic tracks:**
  $T_1 < T_2 < T_3 < T_4 < T_5 < T_6$

Warnings

- Factors which may influence streaming
  - evolution of trigger menus
    - overlaps in raw physics streams
      - ⇒ adjustment of stream definitions
  - low initial luminosity (minimum bias events)
    - can hardly define different streams
      - ⇒ use one or two streams
  - low performance of TAGs
    - if TAGs can't be used to remove expected duplicates within inclusive streams
      - ⇒ define procedure for duplication selection
  - big changes in analysis model
    - hope this won't happen...
  - technology developments (storage, data access, computing)
    - ATLAS data volumes no longer appear huge
    - disappearance of the advantages of partitioning data into different streams
      - ⇒ streams no longer needed