SUSY TriLepton Search at ATLAS

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SUNY-Stony Brook

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Physics & Astronomy Department

Outline

LHC

ATLAS

Supersymmetry

Simulation

Analysis

The Future

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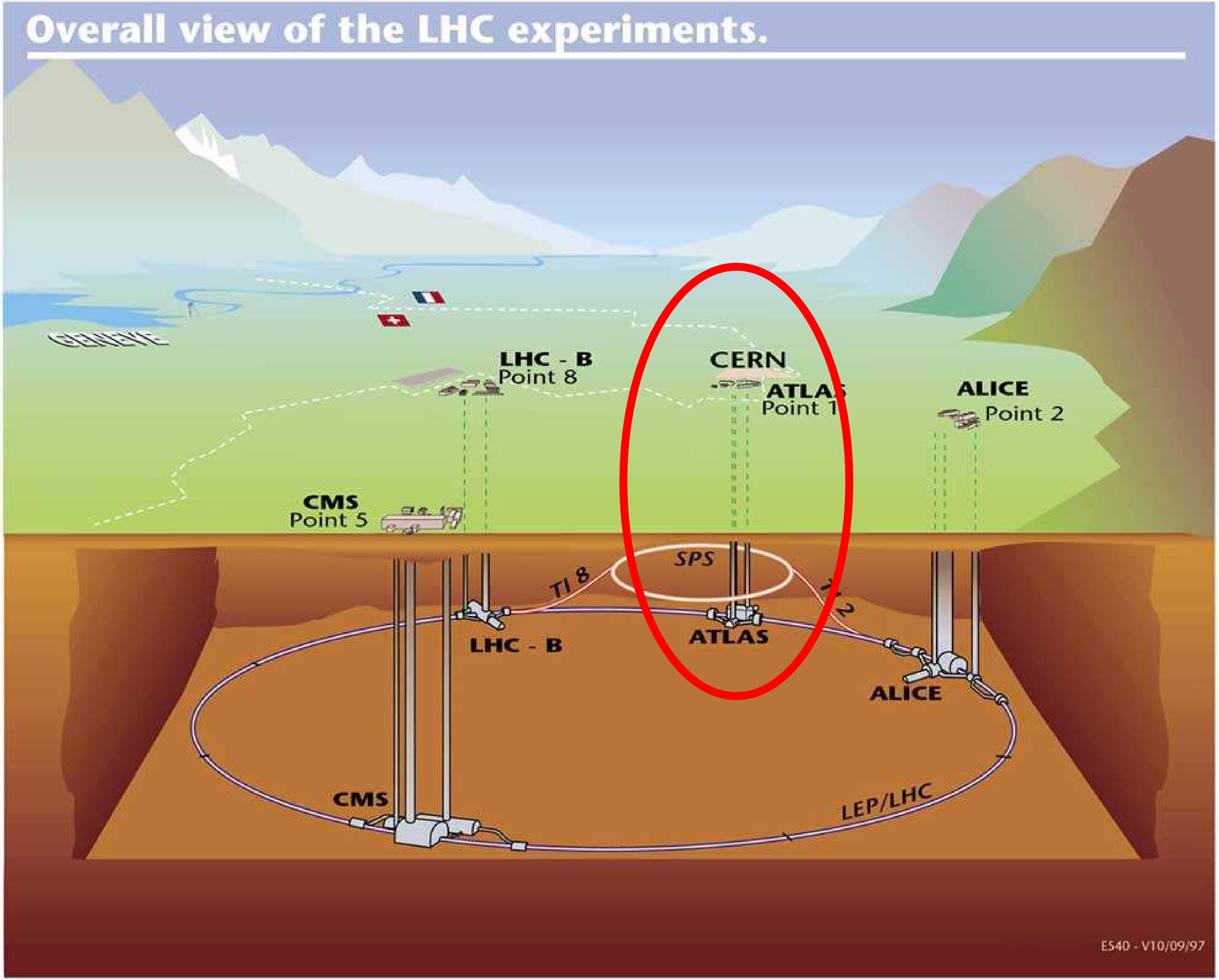
The Large Hadron Collider



[1]

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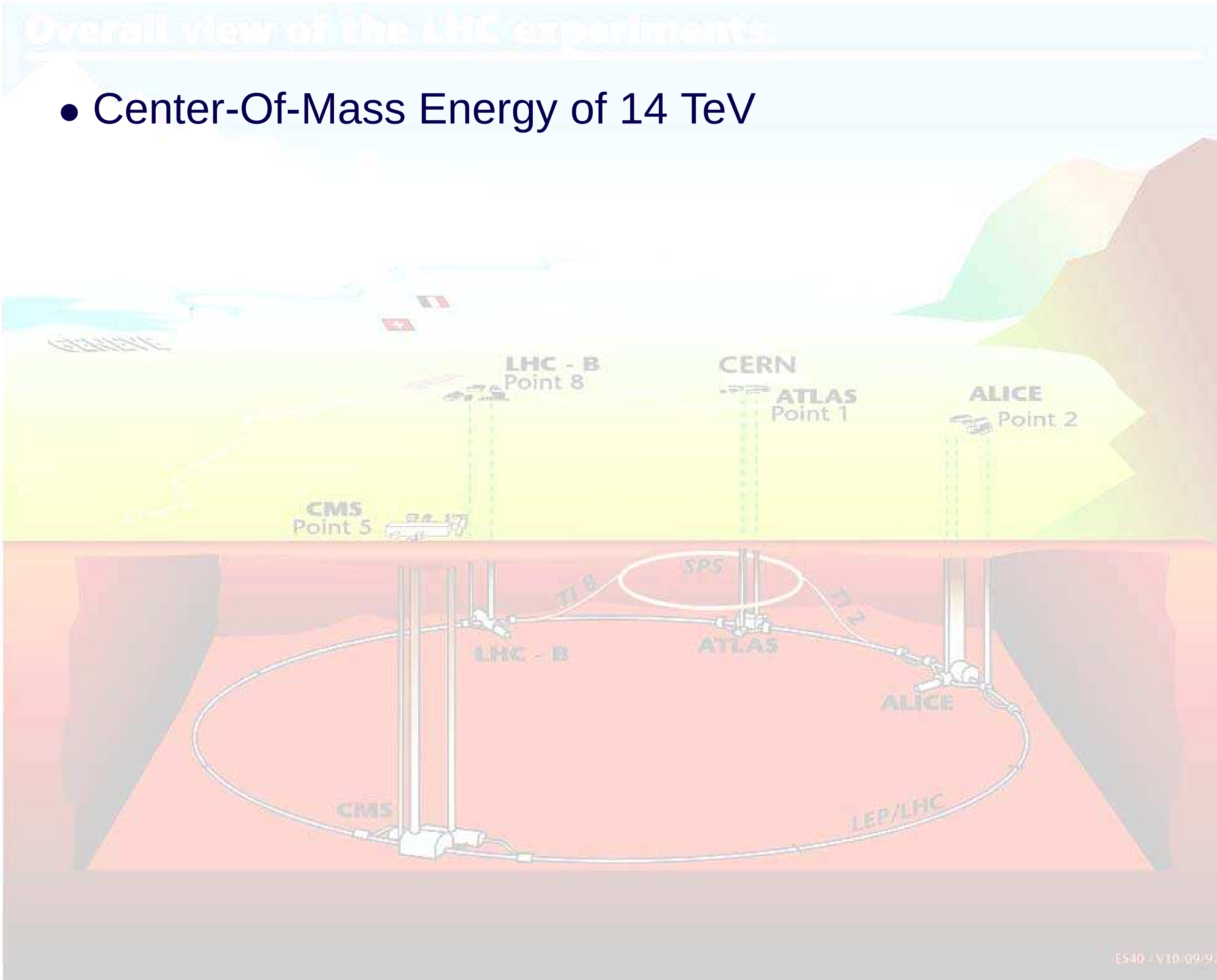
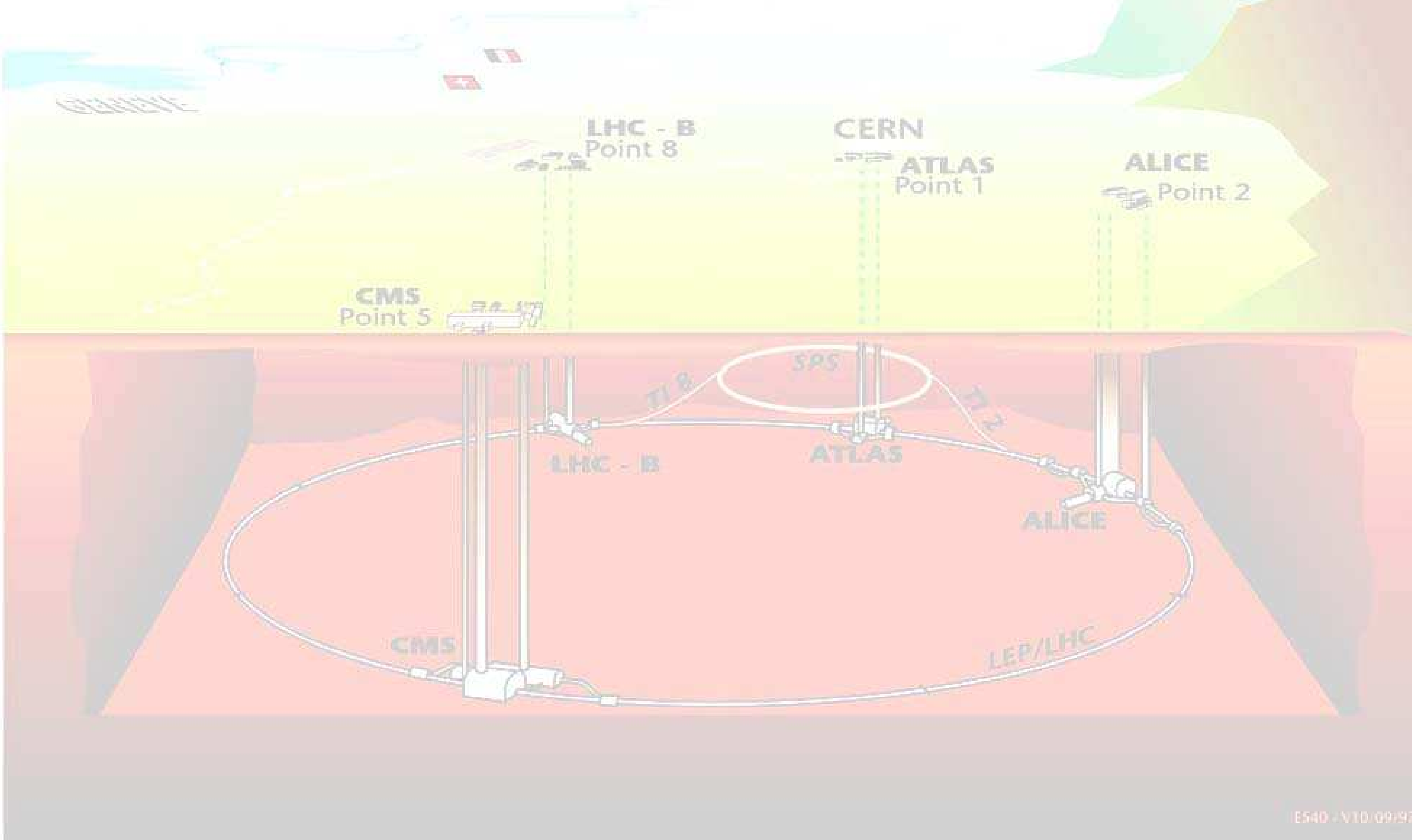
The Large Hadron Collider

- Center-Of-Mass Energy of 14 TeV



The Large Hadron Collider

- Center-Of-Mass Energy of 14 TeV
- Operates at $\sim$ 40 MHz, so crossings happen every 25 ns



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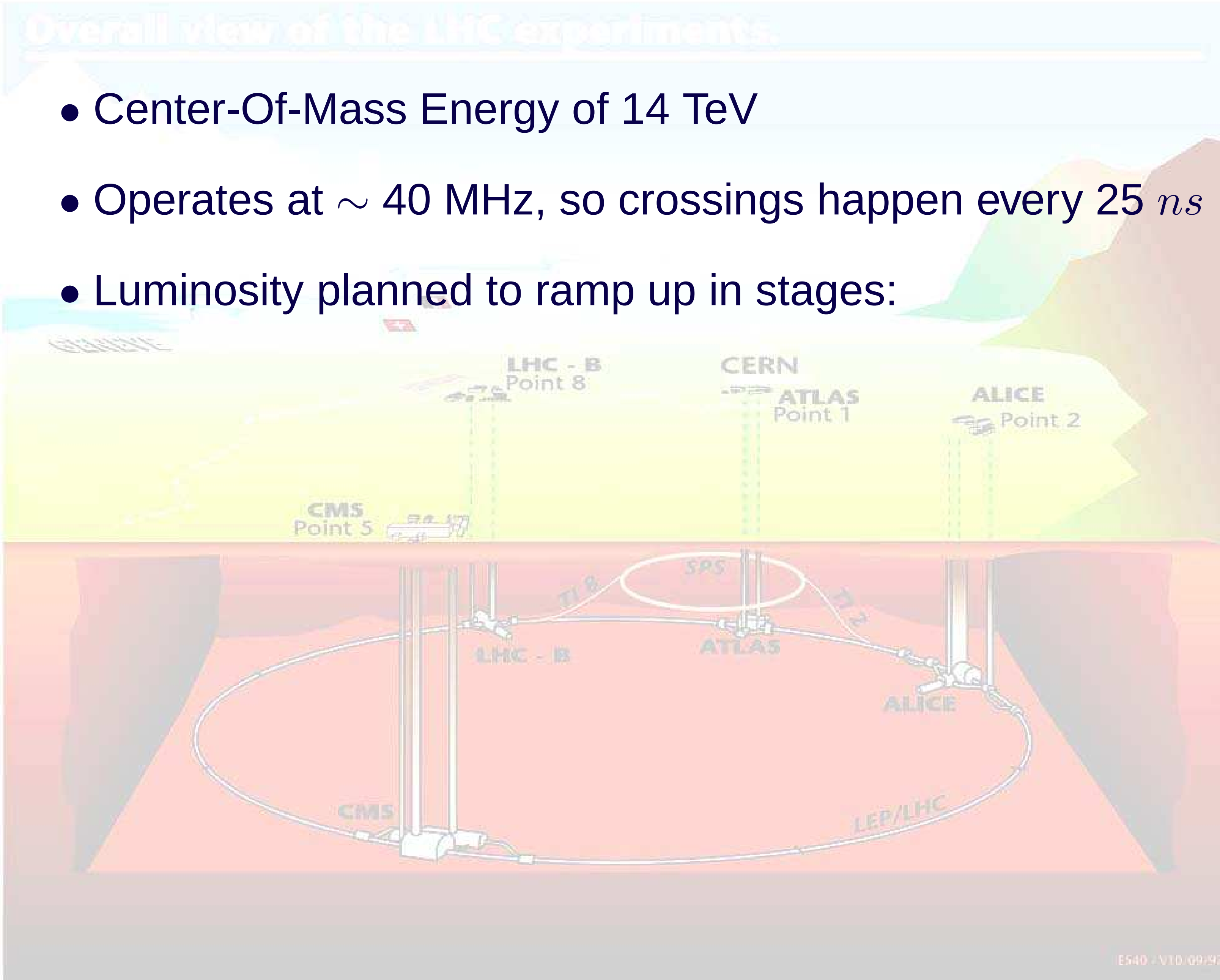

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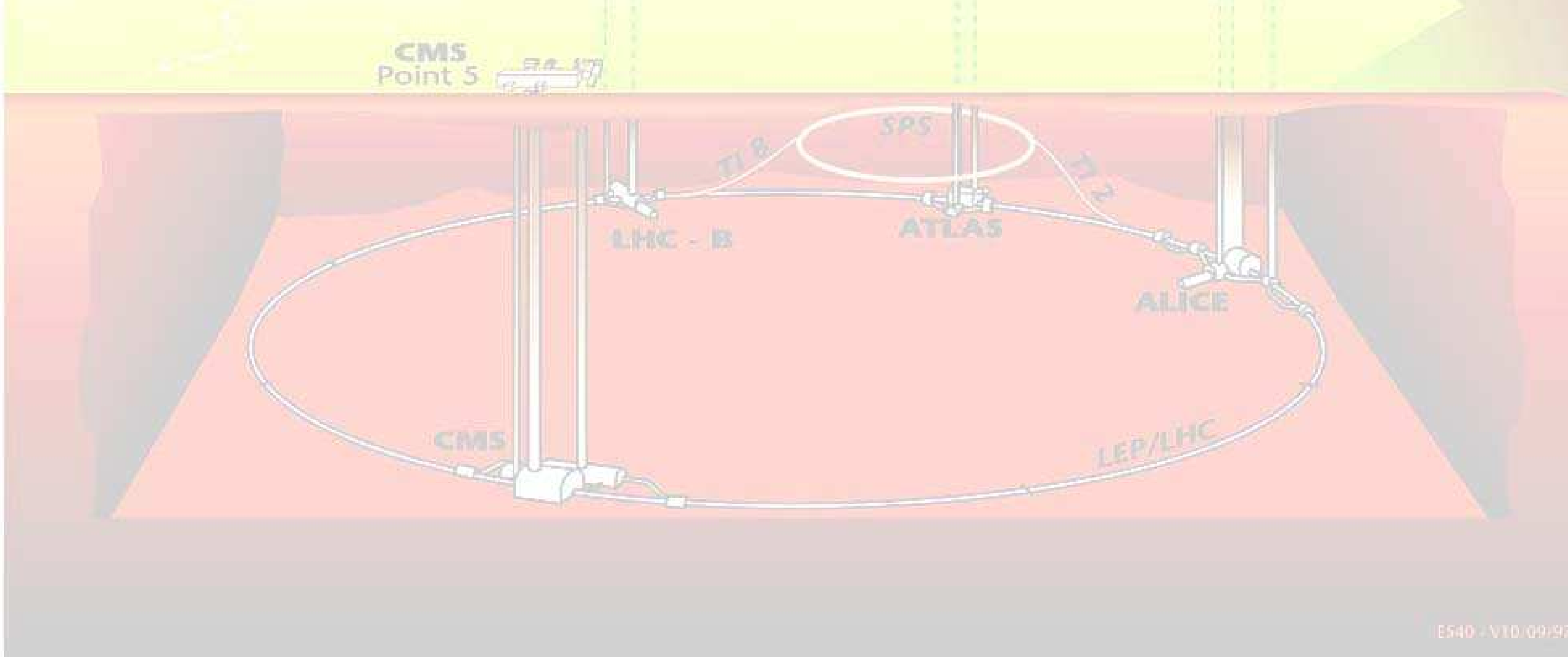
  2.3 pb^{-1} total [2]



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The *L*arge *H*adron *C*ollider

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  Stage 4: $\sim 1 \cdot 10^{34}\ cm^{-2}s^{-1}$ for $\sim 10^{7}s \rightarrow \sim 100fb^{-1}$ [3, 4]

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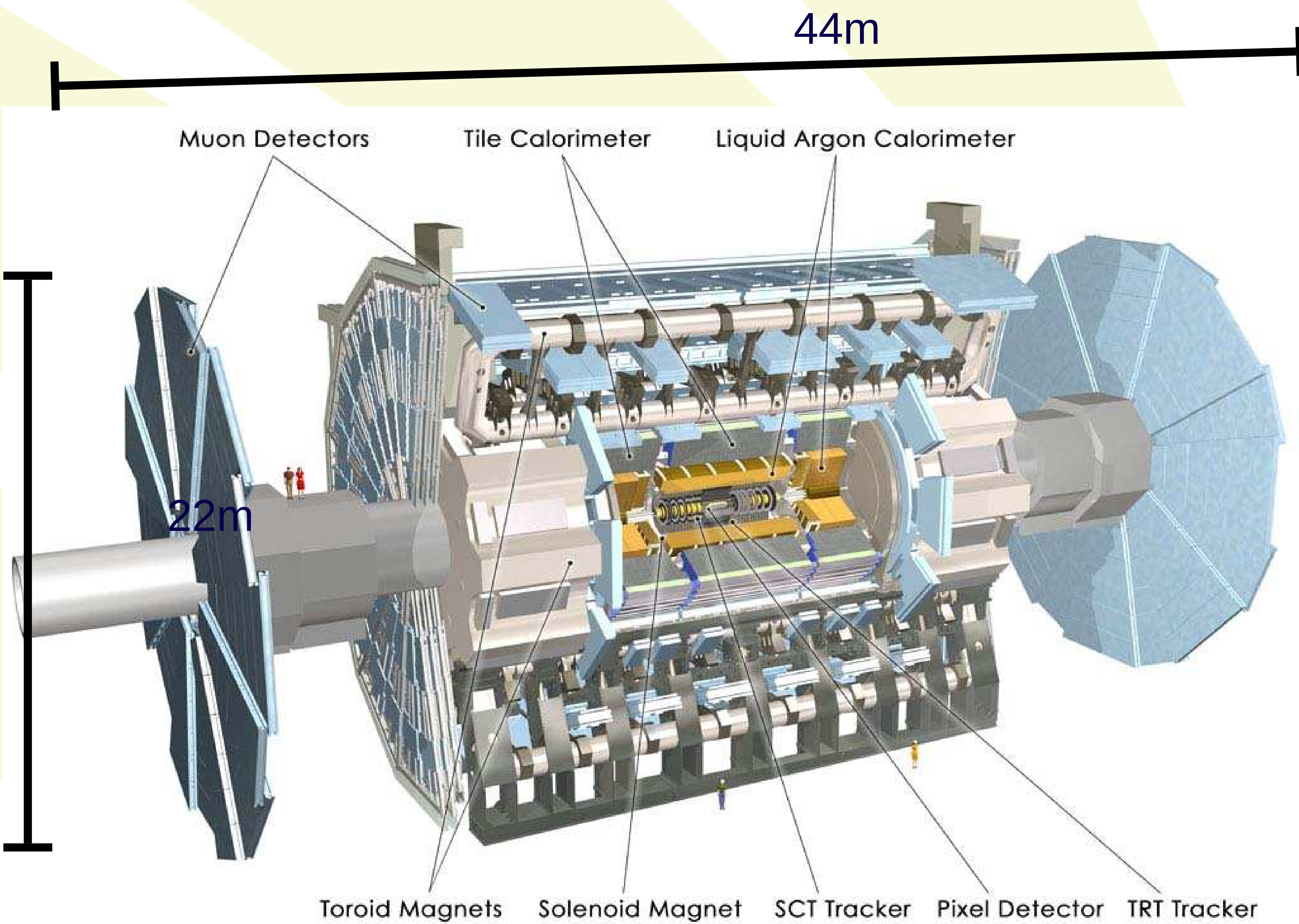
A Toroidal LHC ApparatuS



[1]

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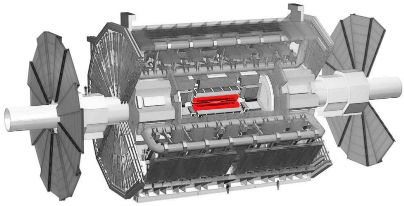
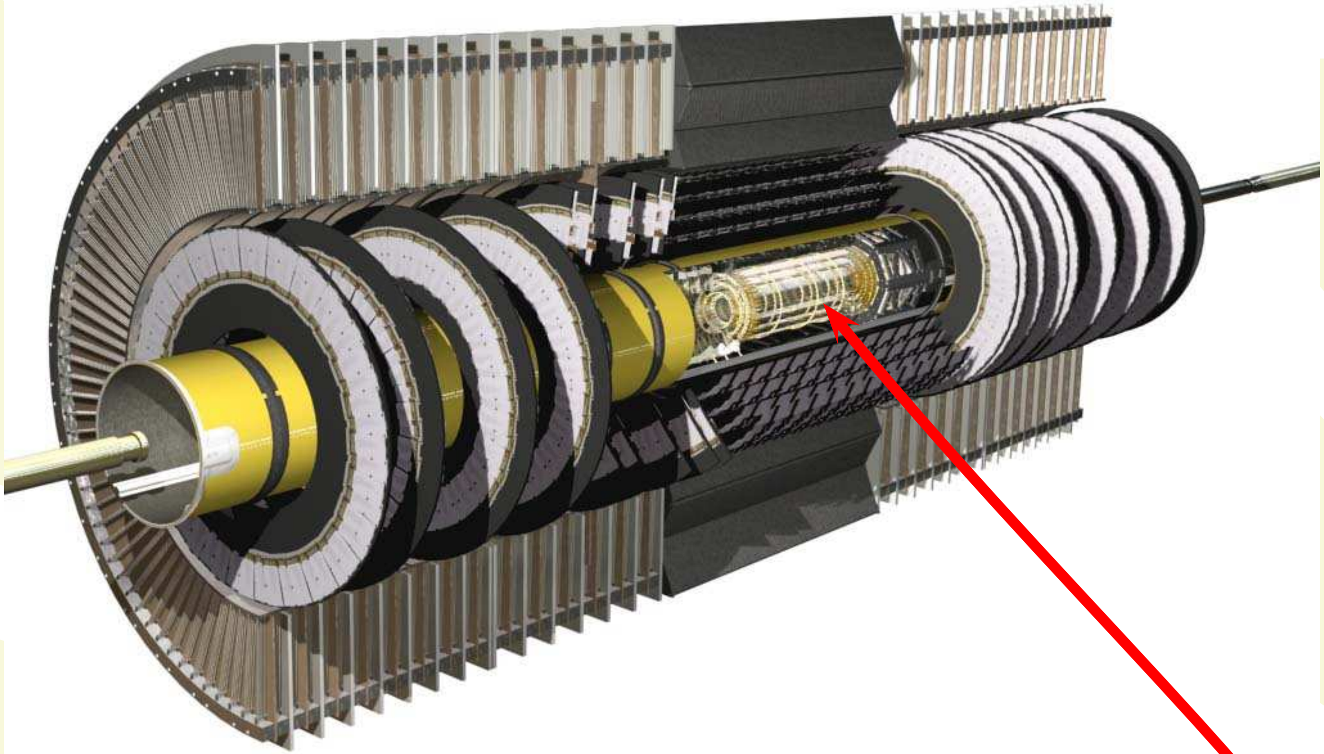
The Inner Detector



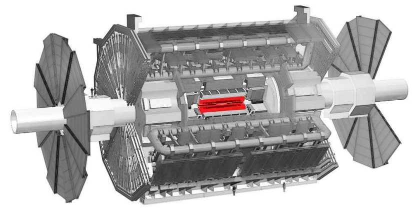


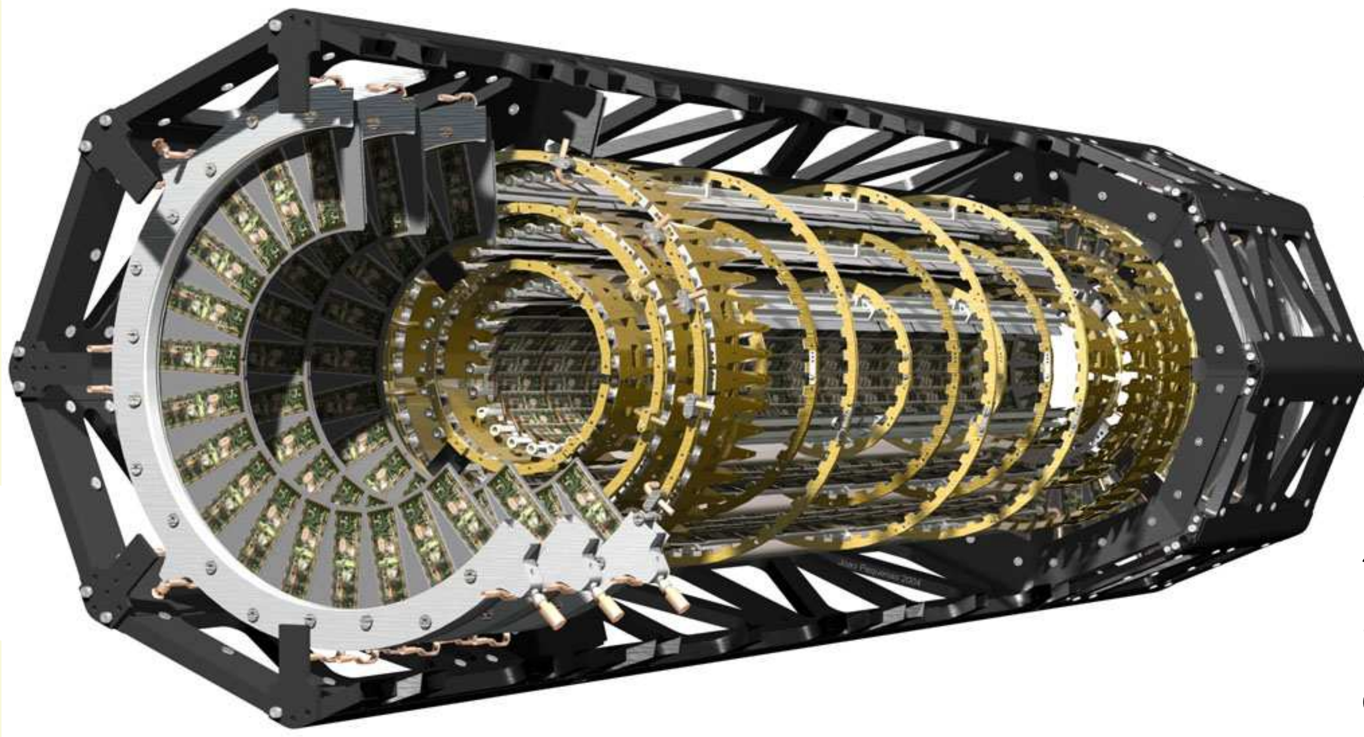
[1]

The inner tracker is responsible for tracking and is composed of 3 tracking devices:

- The Pixel Tracker
- The Semi-Conductor Tracker
- The Transition-Radiation Tracker

The Inner Detector

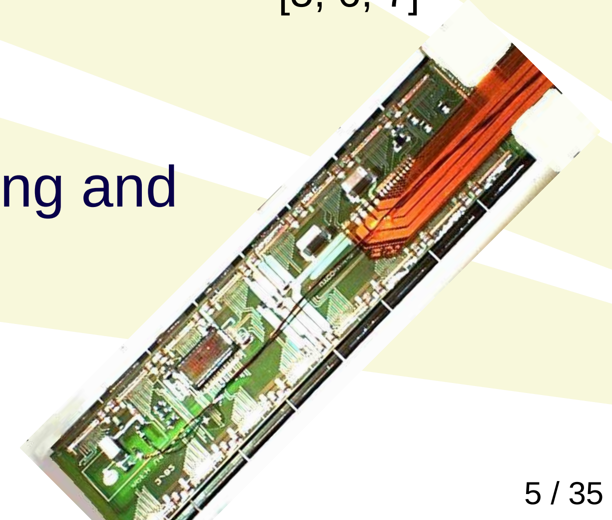




[1]

- 1744 $16.4 \times 60.8mm$ Modules
- Each module has 46,080 $40 \times 400\mu m$ pixels
- Over 80 million channels of data
- $14\mu m$ Resolution

[5, 6, 7]



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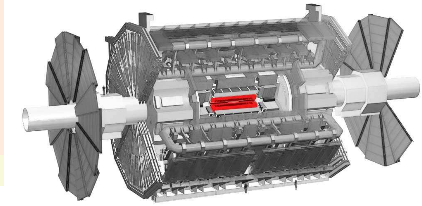

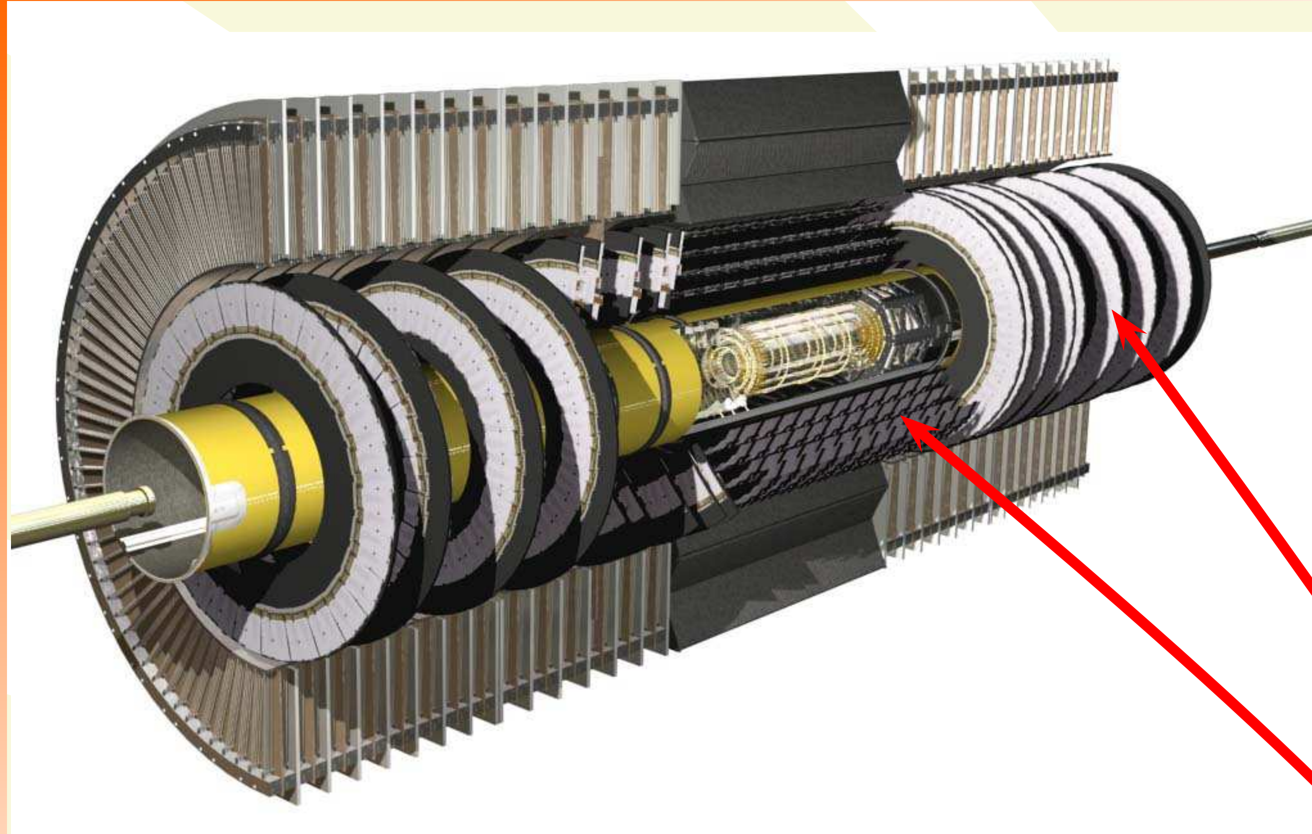

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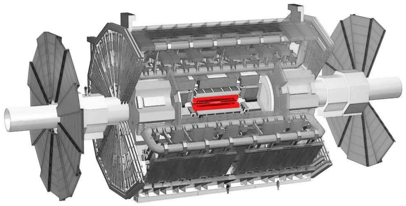

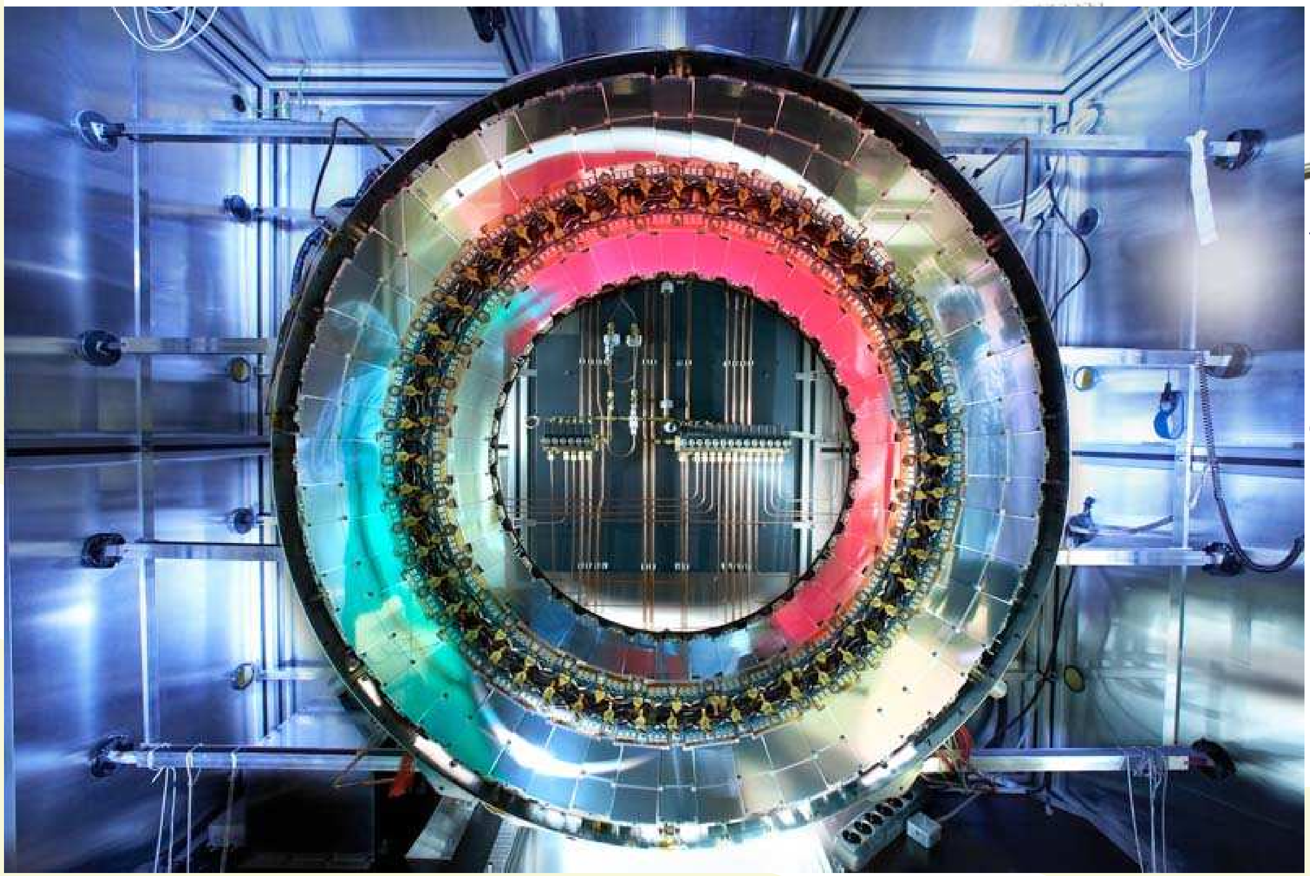

[1]

- 768 $80\mu m \times 62mm$ strips per wafer, 2 wafers per module
- 4088 modules
- 6.3 million channels of data
- $16\mu m \times 40\mu m$ resolution

[8, 6]

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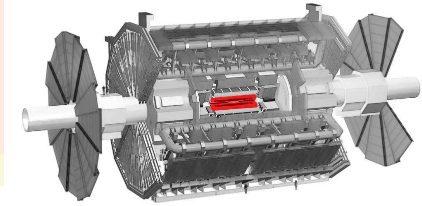

The Inner Detector

❖ Outline

LHC

ATLAS

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❖ Inner Detector

❖ Calorimeters

❖ Muon Spectrometer

❖ Magnet System

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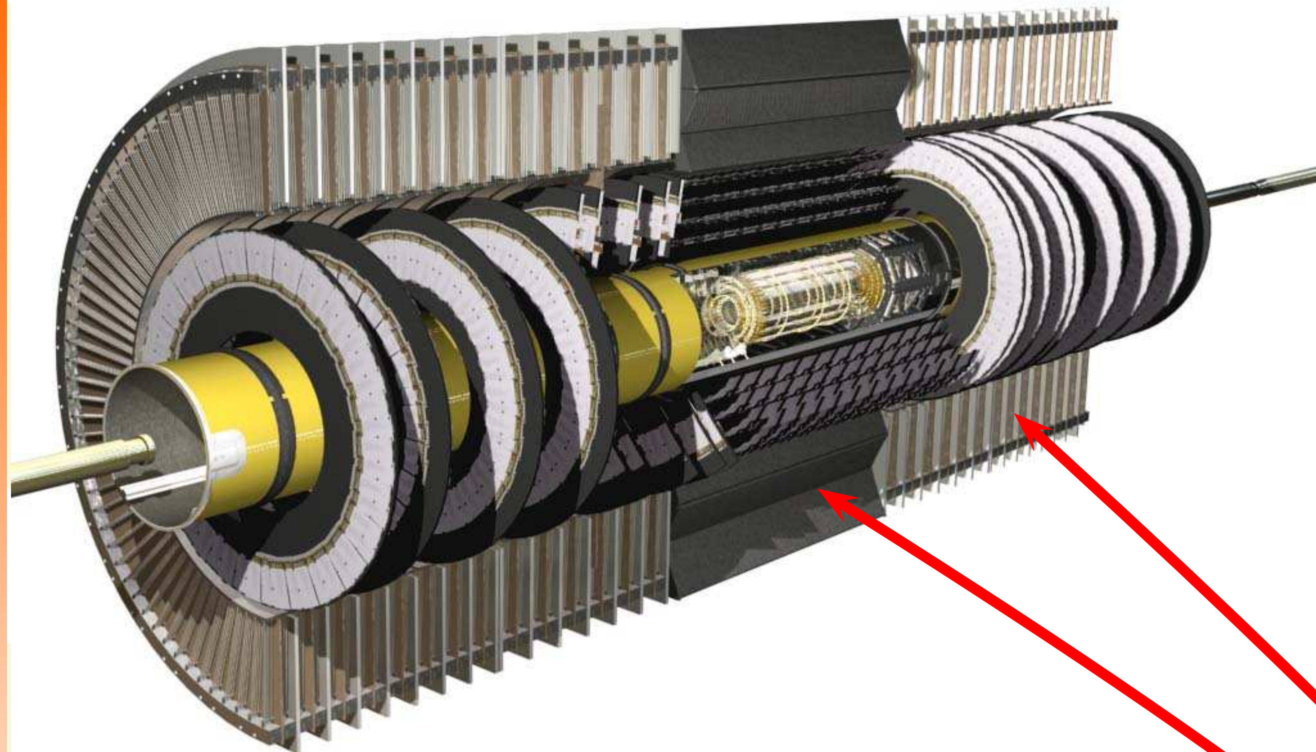

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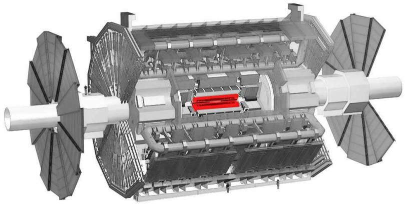

- $4mm$ proportion tube “straws” with $30\mu m$ wires.
- 70% Xe, 27% CO_2, 3% O_2
- Straws packed in polypropylene to produce transition radiation.
- 52,544 2-channel 150 cm straws in barrel
- 159,744 39cm or 51cm straws per endcap
- $135\mu m$ resolution [9, 10, 11]

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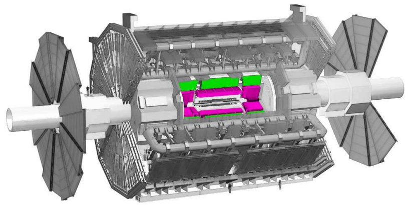
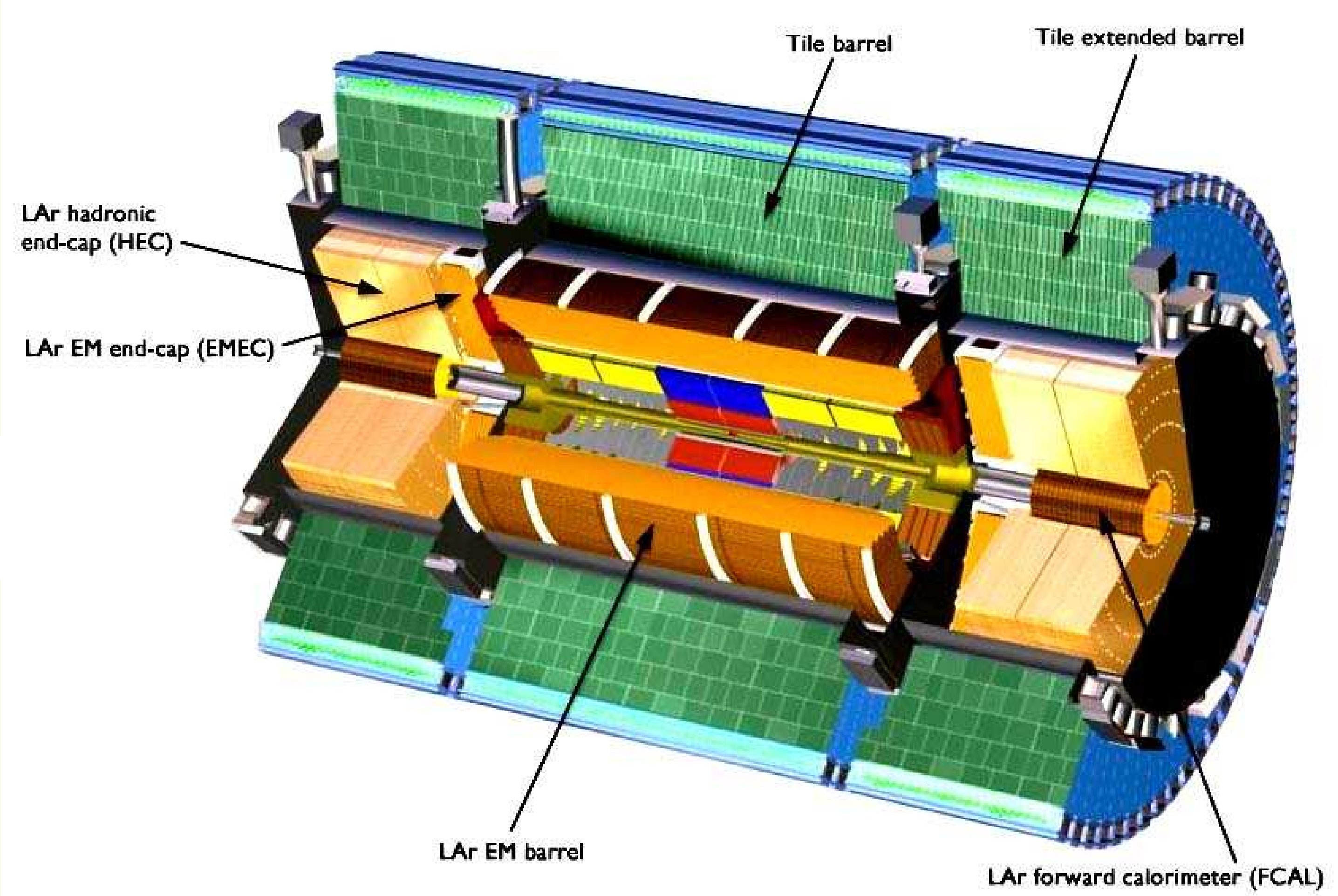
The Calorimeters





[1]

The liquid argon calorimeter is composed of two type of calorimeters:

- Liquid Argon Calorimeter
- Scintillating Tile Calorimeter

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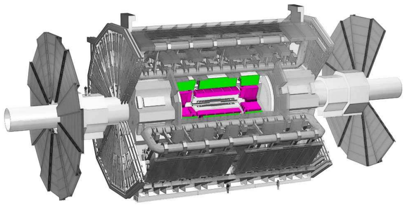
The Calorimeters



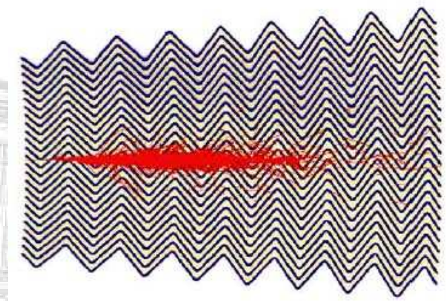
Liquid Argon Calorimeter:
- Used for EM calorimetry and Hadron endcaps

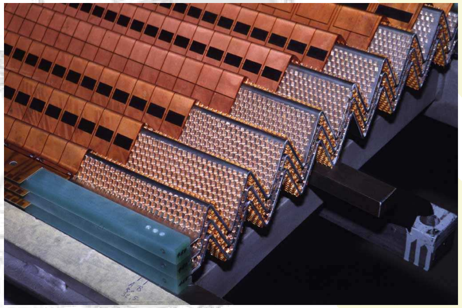
$\Longrightarrow$ Lead absorbers for EM calorimetry
$\Longrightarrow$ Copper absorbers for hadron endcaps

- Argon chosen for stability in high radiation environment.
- Accordion geometry chosen for good azimuthal coverage and minimization of gaps.
- Energy resolution:

$$\frac{\delta E}{E} = \frac{a}{\sqrt{E}} \oplus \frac{b}{E} \oplus c$$

a ~8-11%, $b \sim O(400MeV)$, $c \lesssim$0.7% [10, 12]





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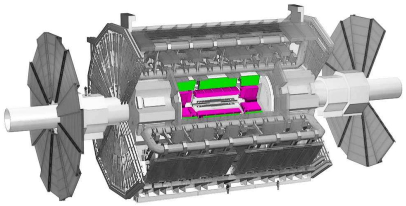
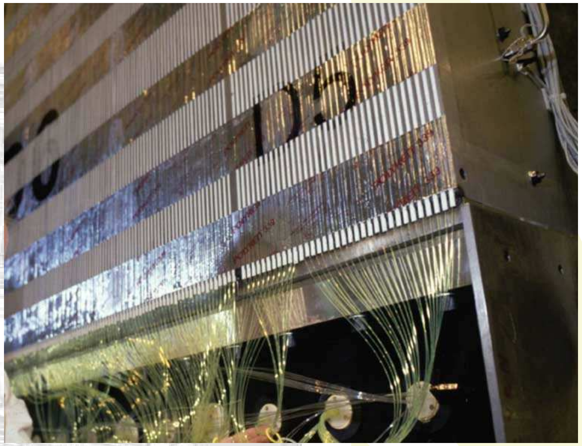


Scintillating Tile Calorimeter:

- Lead absorbers sandwiching scintillating tiles
- Used farther from interaction point,
less stable in high-radiation and less expensive
- Energy resolution:

$$\frac{\delta E}{E} = \frac{.5}{\sqrt{E}} \oplus .03, \quad |\eta| < 3$$
$$\frac{\delta E}{E} = \frac{1}{\sqrt{E}} \oplus .1, \quad 3 < |\eta| < 5$$

[10, 13]



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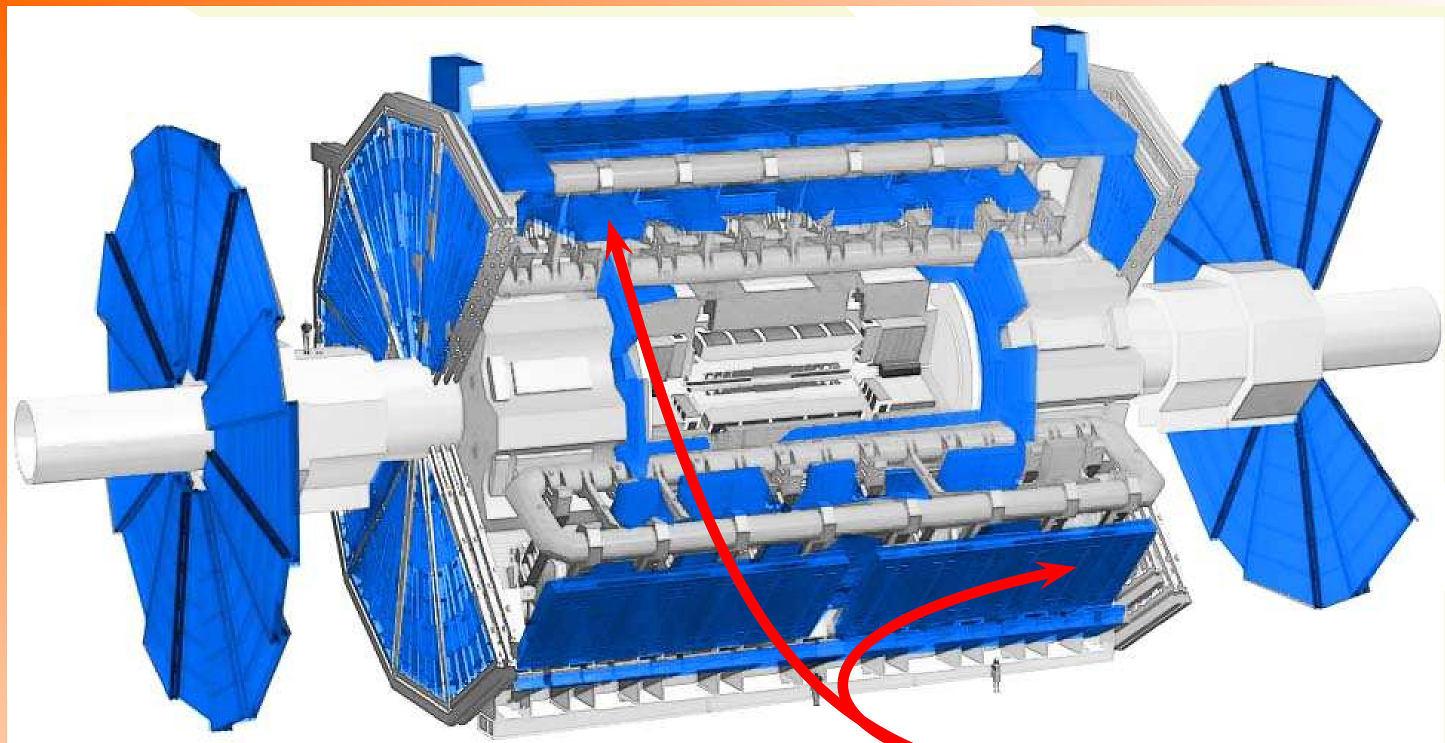
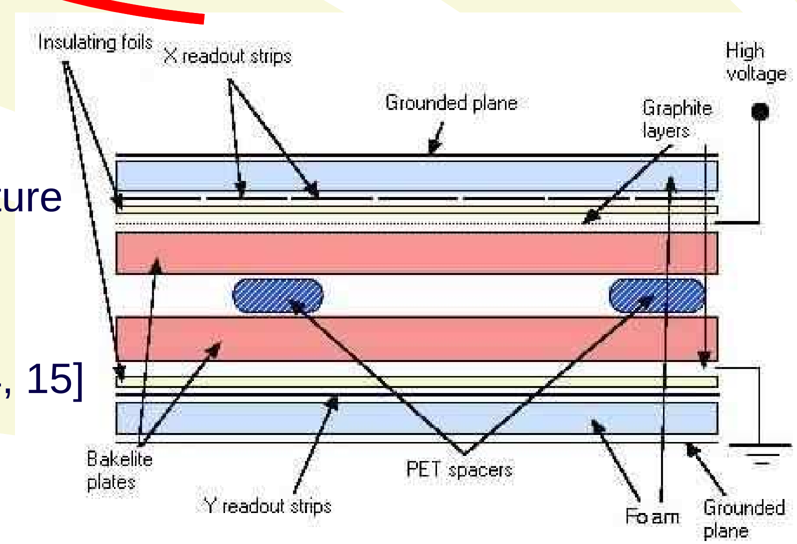
The Muon Spectrometer



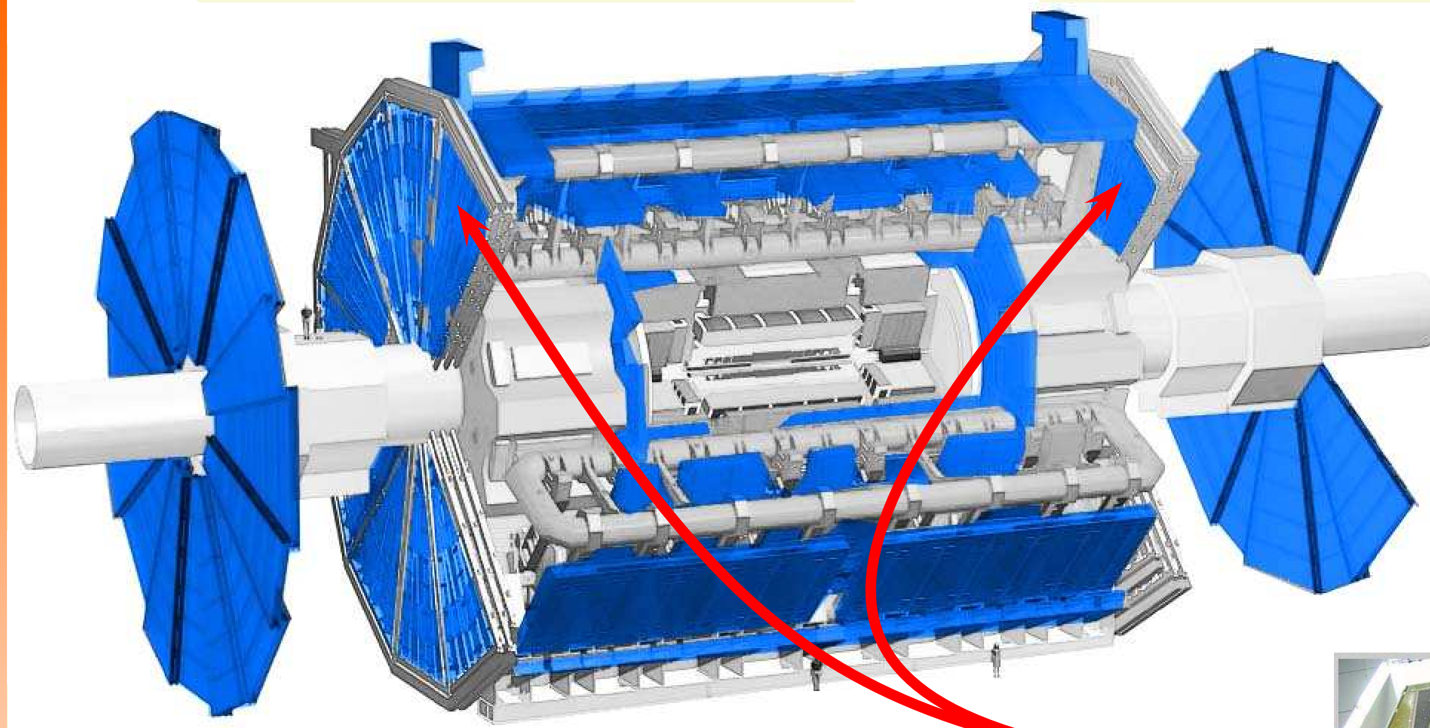
[1]

Resistive Plate Chambers:

- gaseous parallel-plate detectors
- Bakelite plates with insulating spacers
- 97% $C_2H_2F_4$, 3% iso-C_4H_{10} gas mixture
- Part of muon triggering system
- Inexpensive
- $1.5ns \times 1cm$ time-space resolution [14, 15]



The Muon Spectrometer



[1]

Thin Gap Chambers:

- Similar to multi-wire proportion chambers, except cathode to anode gap is narrower
- 55% CO_2, 45% n-pentane
- $\sim 1.5ns \times 1cm$ time-space resolution [14]

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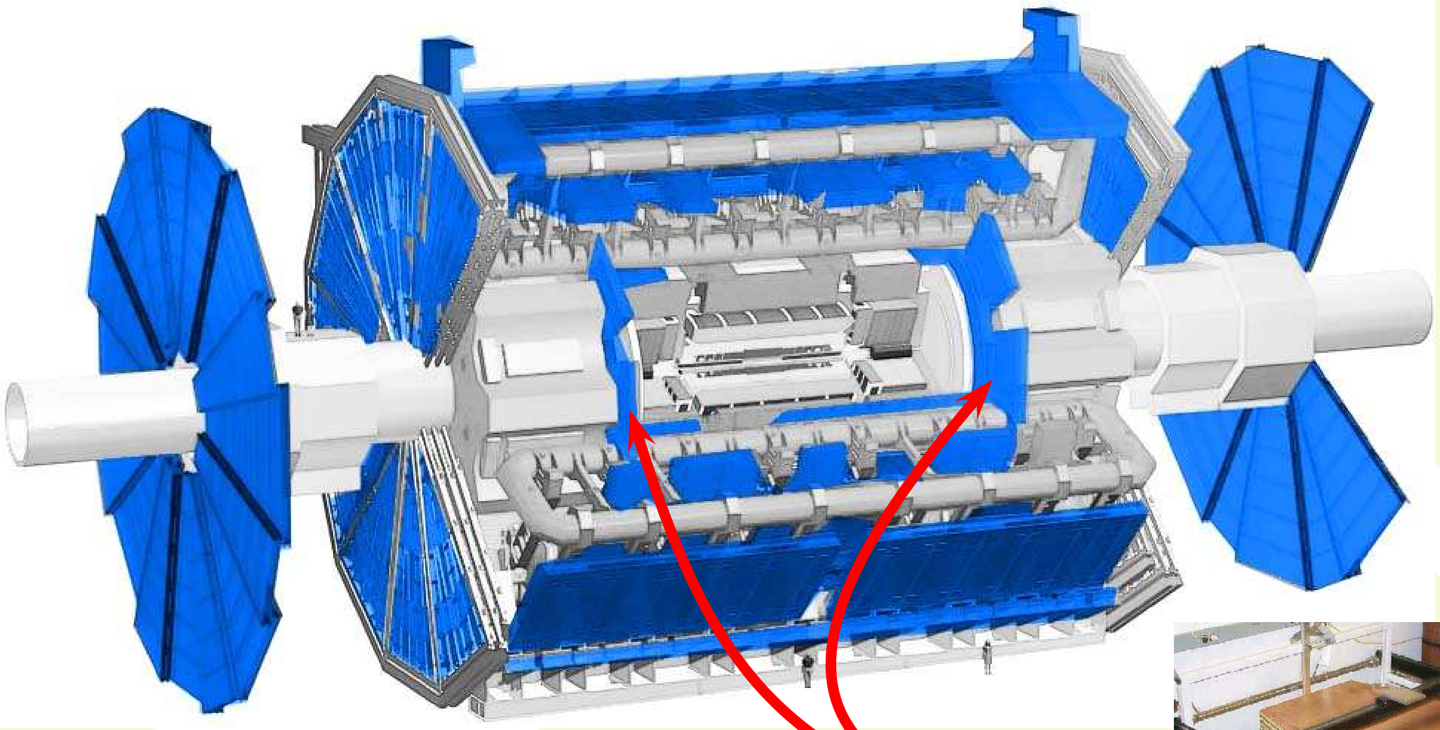
The Muon Spectrometer



[1]

Cathode Strip Chambers:

- multi-wire proportion chambers
- 50% Ar, 50% CO_2
- $\leq 60\mu m$ resolution [14]

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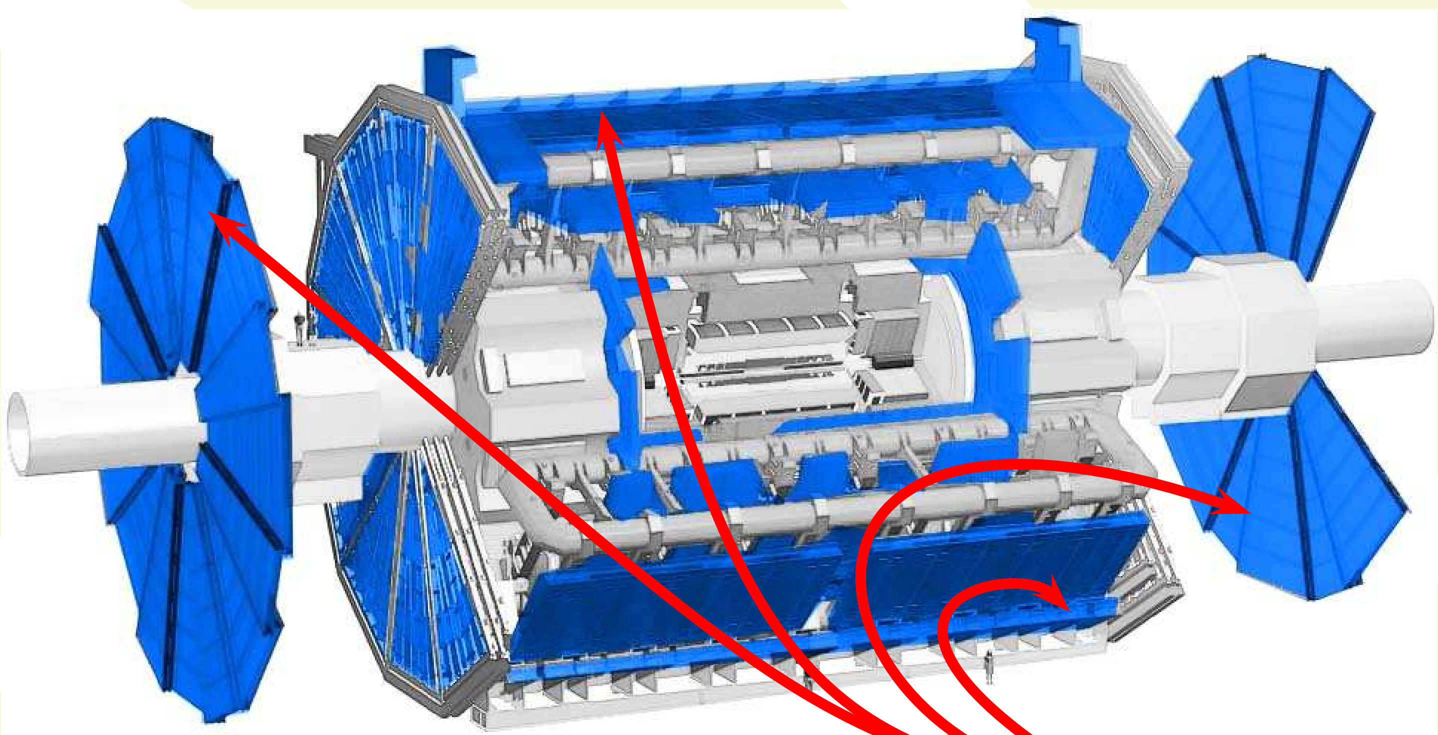
The Muon Spectrometer



[1]

Monitored Drift Chambers:

- Varying length, 30mm diameter drift tubes with $50\mu m$ wire
- 91% Ar, 4% n_2, 5% CH_4
- $80\mu m$ resolution, but triple layer gives $40\mu m$ [14]

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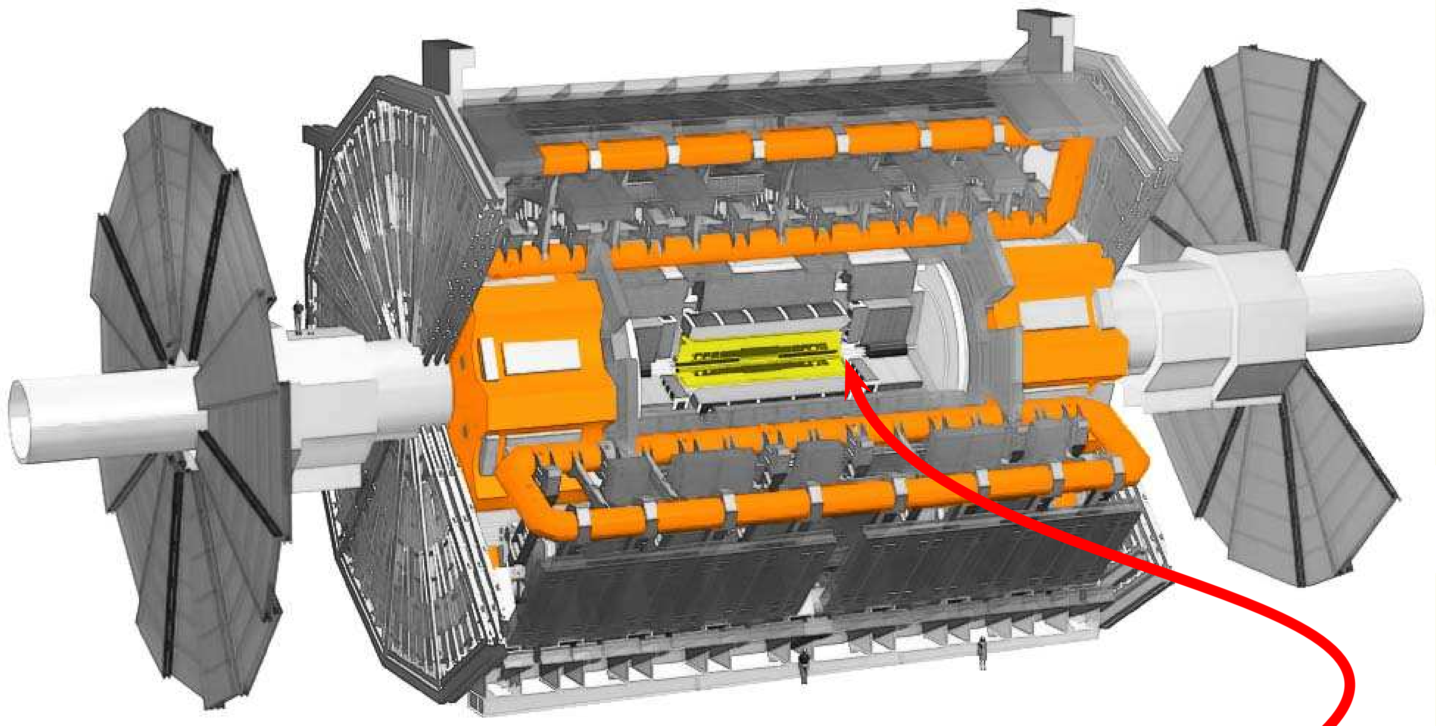
Magnet Systems



Inner Solenoid gives 2 Tesla field

Toroidal Magnet

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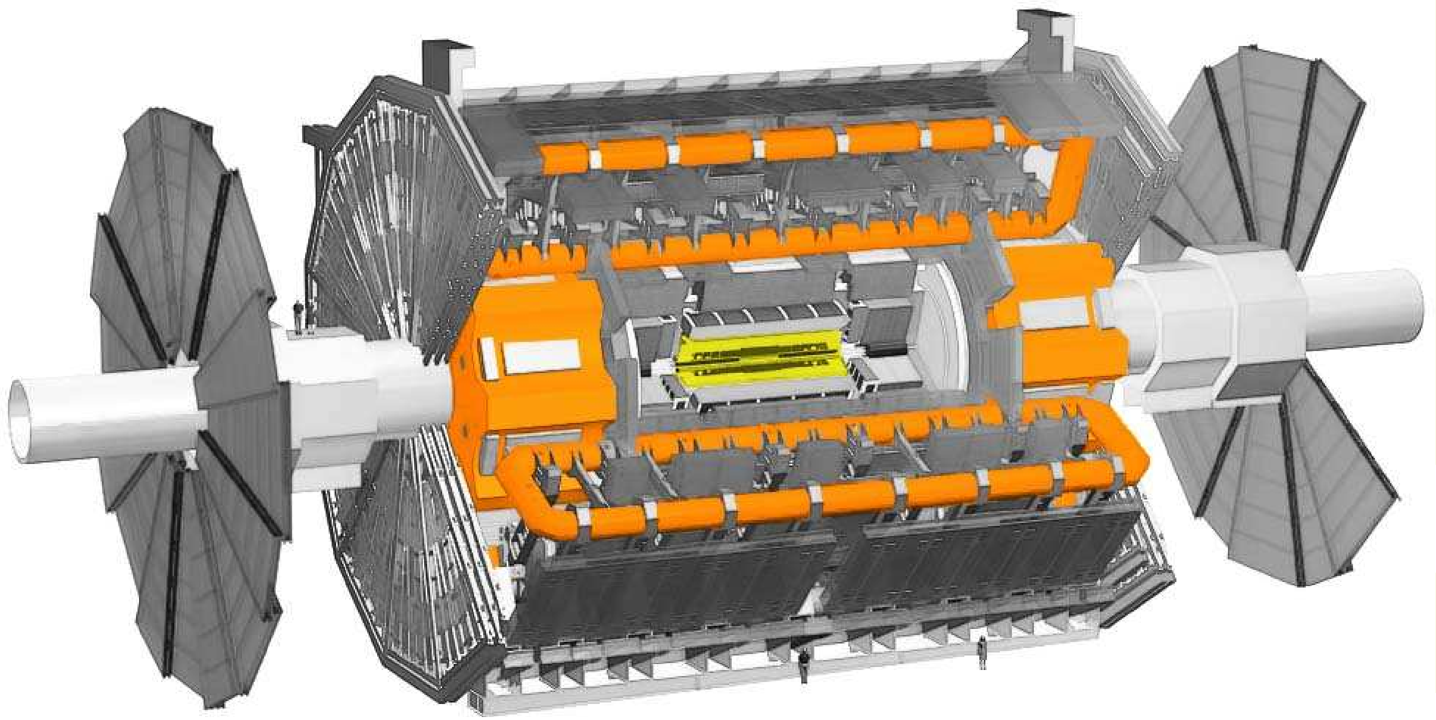
Magnet Systems



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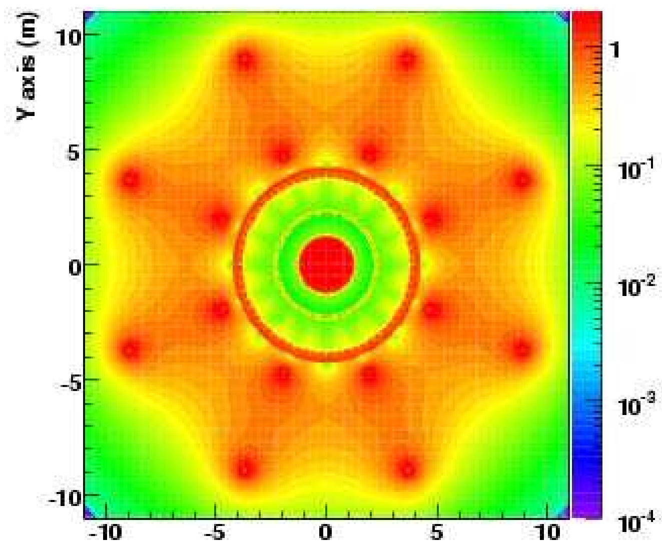

[16]

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Supersymmetry

Supersymmetry (SUSY) is a symmetry between fermions and bosons, such that:

$$Q|fermion> \sim |boson> \rightarrow |sfermion>$$

$$Q|boson> \sim |fermion> \rightarrow |gaugino>$$

The SUSY algebra also requires:

$$[P^\mu, Q] = [P^\mu, Q^\dagger] = 0$$

Which requires that $m_f = m_{\tilde{f}}$ and $m_b = m_{\tilde{b}}$
Similarly, Q,$Q^\dagger$ commute with gauge transformations, so all quantum numbers (except spin) are shared by the superpartners

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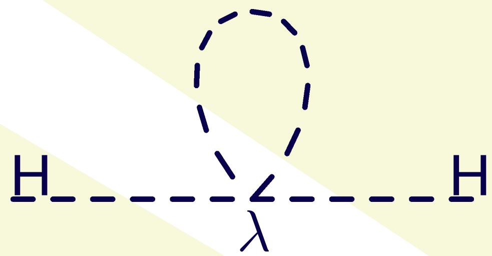
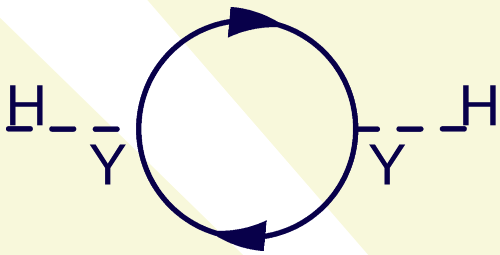
The Hierarchy Problem

Scalar Loop



Fermion Loop



Contributions:

$$\Delta m_H^2 = \frac{\lambda}{16\pi^2} 2\Lambda_{UV}^2 - \frac{\lambda}{16\pi^2}\left[4m_S^2 ln\left(\Lambda_{UV}/m_S\right)\right] + \ldots$$

$$\Delta m_H^2 = -\frac{|Y|^2}{16\pi^2} 2\Lambda_{UV}^2 + \frac{|Y|^2}{16\pi^2} 6m_f^2 ln(\Lambda_{UV}/m_f) + \ldots$$

We expect Higgs to be at weak scale, $m_H \sim 100GeV$

But if $\Lambda_{UV} \sim \mathcal{O}(M_{Planck})$, $\Delta m_H^2 \sim 10^{30}GeV$

In SUSY, loop-corrections are paired, and in unbroken SUSY, $m_S = m_f$

and $\lambda = |Y|^2$, so each pair of superpartners contributes:

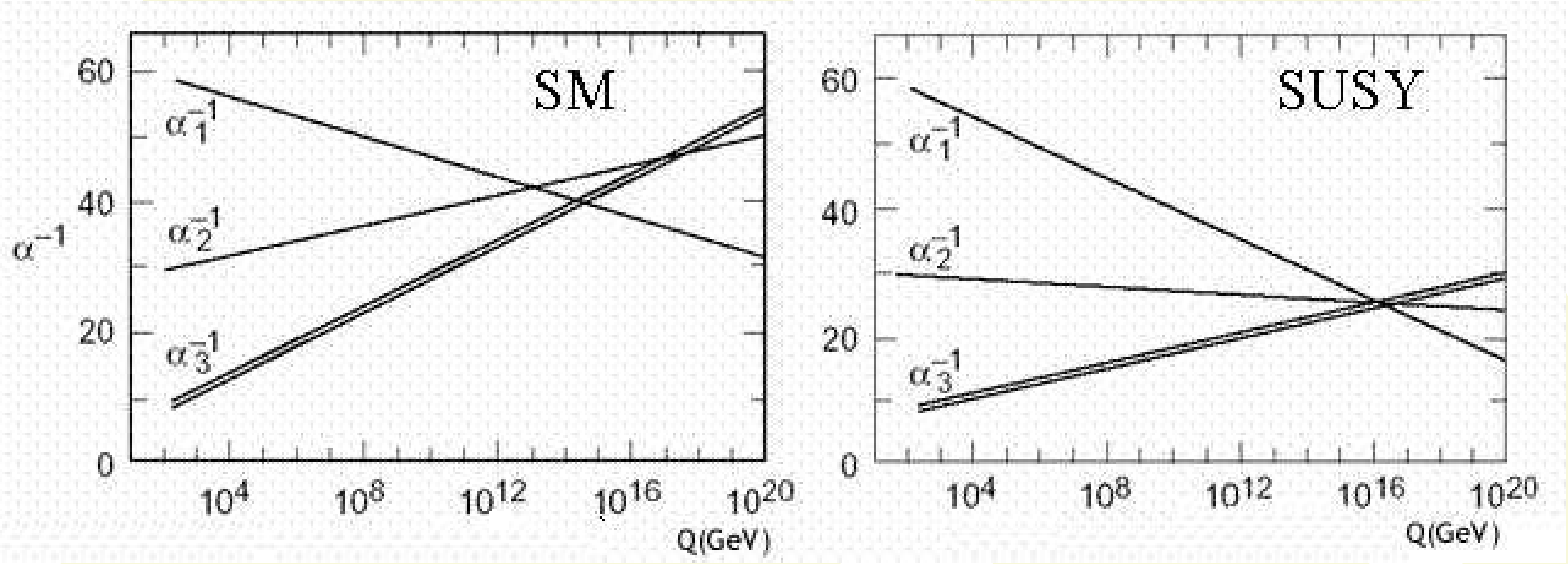
$$\Delta m_H^2 = \frac{\lambda m_{f,s}^2}{8\pi^2} ln\left(\frac{\Lambda_{UV}}{m_{f,s}}\right)$$

If SUSY is broken, then the pairs give (to $\mathcal{O}(\Lambda_{UV}^2)$):

$$\Delta m_H^2 \sim (\lambda - |Y|^2)\Lambda_{UV}^2$$

But now $\Lambda_{UV} = \Lambda_{SUSY} \sim 1TeV$ [17, 18, 19]

Unification



$$\alpha_1 = \frac{5}{3} \cdot \frac{\alpha_{EM}}{cos^2\theta_W}, \qquad \alpha_2 = \frac{\alpha_{EM}}{sin^2\theta_W}, \qquad \alpha_3 = \alpha_S$$ [20]

Running of the gauge coupling constants can be calculated to higher energy levels.

In SM, coupling strengths do not intersect

The inclusion of SUSY parameters causes a better intersection $\Rightarrow$ unification

$\Rightarrow$ Often cited as indirect argument in favor of SUSY

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MSSM

Minimal Supersymmetric Standard Model

As name implies, the MSSM is the minimal extension to the SM that allows supersymmetry.

- Requires extension of Higgs sector into 2 hypercharge$Y = \pm 1$ Higgs doublets
  $H_u = (H_u^+, H_u^0), \quad H_d = (H_d^0, H_d^-)$
- R-Parity
- General soft supersymmetry breaking [21, 17]

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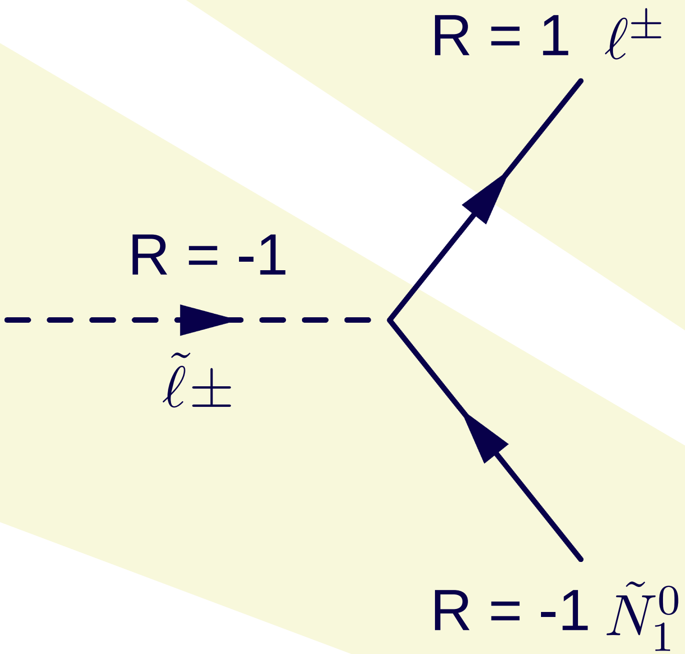
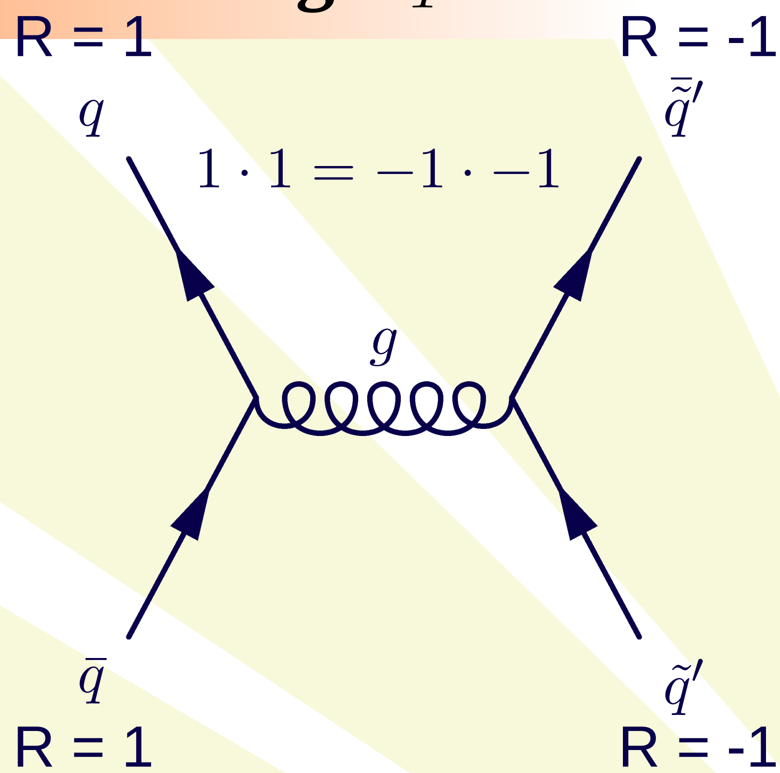
R-Parity + Dark Matter $\Rightarrow$ Missing E_T





R-Parity

$$R = (-1)^{3(B-L)+2S}$$

Tied to conservation of baryon and lepton number

Violation of R-Parity $\Rightarrow$ Proton Decay ☹

Models including R-parity result in a Lightest Supersymmetric Particle

$\Rightarrow$ If neutral, the LSP is a dark matter candidate

Stable, neutral $\Rightarrow$ invisible to detector $\Rightarrow$ Missing E_T

So missing E_T is a signature to SUSY we will look for [22, 23]

mSUGRA

Most of the MSSM parameter space is ruled out by current measurements, as MSSM introduces new sources of CP violations that should be measured.

mSUGRA = minimal Super Gravity model

Difficult to construct theory that breaks SUSY due to MSSM particles interaction

Breaking is moved to a hidden sector and gravity transmits the breaking down to the weak scale.

In addition, contracts the 105 parameters (+19 SM) of the MSSM to five in mSUGRA:

- m_0 - Common scalar mass at GUT scale
- $m_{1/2}$ - Common gaugino mass at GUT scale
- A_0 - Common trilinear coupling parameter
- $tan\beta$ - ratio of Higgses' VEVs at weak scale
- $sgn(\mu)$ - sign of Higgsino mass contributuon [24]

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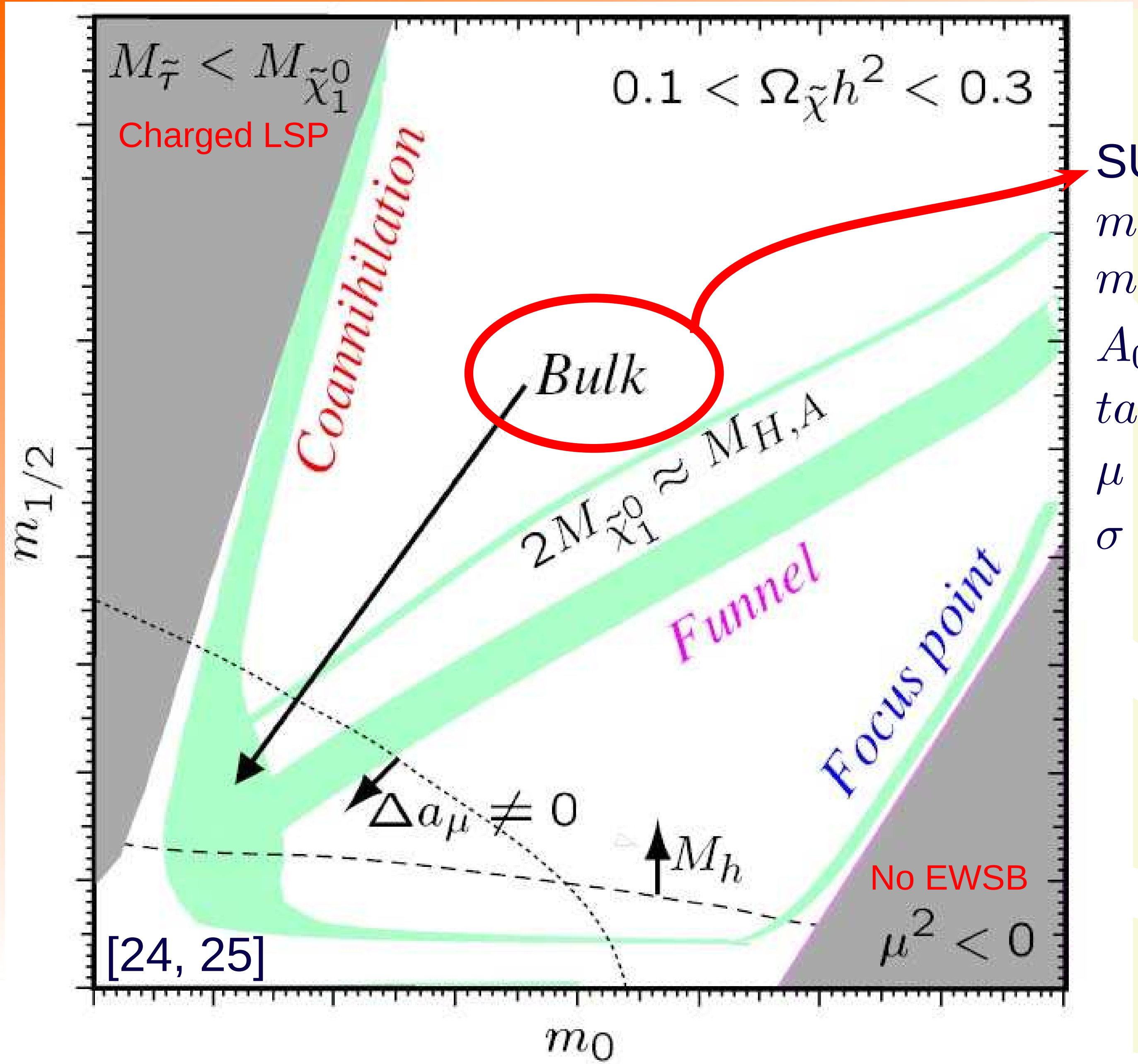
Parameter Space



SU3 Bulk Point

$m_0 = 100 GeV$

$m_{1/2} = 300 GeV$

$A_0 = -300 GeV$

$tan\beta = 6$

$\mu > 0$

$\sigma = 18.59 pb$ [26]

Mass Spectrum

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❖ Mass Spectrum
❖ MC
❖ Signals and Backgrounds
❖ Backgrounds to Be Produced
Analysis
The Future

Sparticle masses generated using ISAJET 7.74

Superpartner Masses at SU3 Point					
Gaugino Masses in GeV/c^2		Sfermion Masses in GeV/c^2			
	Neutralinos		Sleptons		Squarks
$\tilde{N}_1^0$	118.8	$\tilde{e}_l$	232.48	$\tilde{u}_l$	665.49
$\tilde{N}_2^0$	223.27	$\tilde{e}_r$	154.63	$\tilde{u}_r$	644.79
$\tilde{N}_3^0$	461.14	$\tilde{\nu}_e$	216.74	$\tilde{d}_l$	670.41
$\tilde{N}_4^0$	479.52	$\tilde{\mu}_l$	232.48	$\tilde{d}_r$	643.63
	Charginos	$\tilde{\mu}_l$	154.63	$\tilde{c}_l$	665.49
$\tilde{C}_1^\pm$	223.34	$\tilde{\nu}_\mu$	216.74	$\tilde{c}_r$	644.79
$\tilde{C}_2^\pm$	477.25	$\tilde{\tau}_l$	151.46	$\tilde{s}_l$	670.41
	Gluino	$\tilde{\tau}_l$	232.41	$\tilde{s}_r$	643.63
$\tilde{g}$	720.16	$\tilde{\nu}_\tau$	214.55	$\tilde{t}_1$	440.26
	Expanded Higgs Sector			$\tilde{t}_2$	670.07
h_0	111.24			$\tilde{b}_1$	605.93
H_0	518.12			$\tilde{b}_2$	642.00
A_0	514.02				
$H_\pm$	523.38				

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Generators Used

- HERWIG $\Rightarrow$ General purpose event generator [27].
- JIMMY $\Rightarrow$ An add on to Herwig that includes multiparton interactions [27]
- ALPGEN $\Rightarrow$ Calculates “multiparton hard processes” at NLO, but then output must be hadronized by Pythia or Jimmy [28]
- PYTHIA $\Rightarrow$ General purpose event generator [29]

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Signals and Backgrounds

Channel	Cross Section	Events at 100 1 fb^{-1}	# Events Generated	Num. of Trileptons at 1 fb^{-1}	Generator Used
Signal					
SU3	18.8 $\pm$ .3 pb	18,800	188,000	Approx. 130	Jimmy
Background					
$t\bar{t}$	483.2 pb	483,200	483,200	Approx. 120	Pythia
ZZ	11.0 $\pm$ .1 pb	11,000	11,000	Approx. 130	Jimmy
WZ	27.7 $\pm$ .1 pb	27,700	277,000	Approx. 600	Jimmy
WW	70.4 $\pm$ .8 pb	70,400	70,400	Approx. 0	Jimmy
$Z \rightarrow e^{+}e^{-}$	1650 $\pm$ 30 pb	1,650,000	1,650,000	Approx. 0	Jimmy
$Z \rightarrow \mu^{+}\mu^{-}$	1650 $\pm$ 30 pb	1,650,000	1,650,000	Approx. 0	Jimmy
QCD Jets	90,800 pb	90,800,000	1,000,000	Aprox. 0	Alpgen/Herwig

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Backgrounds to Be Produced

Channel	Cross Section	Events at 100 pb^{-1}	Events at 1 fb^{-1}	Num. of Trileptons at 1 fb^{-1}
W + Njets	1980 pb	198,000	1,980,000	
$Z \rightarrow \nu's + jets$	103 pb	10,300	103,000	
$b\bar{b} + jets$	242,000 pb	2,420,000	24,200,000	
$c\bar{c} + jets$	260,000 pb	2,600,000	26,000,000	

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Trileptons

A trilepton search provides certain advantages for discovery of supersymmetry.

While the cross-section is small compared to other channels of search, the backgrounds are expected to be easy to deal with.

Looking for events of basic form:

$pp \rightarrow N_2^0 + C_1^{\pm} + \mathcal{X} \rightarrow N_1^0 l^+ l^- + N_1^0 l'^{\pm} \nu_{l'} + \mathcal{X}$ [30, 31]

Where the chargino and neutralino might decay via sleptons, or the weak force for example.

Possibly combinations of the 3ℓ signal are $ee\ell$,$\mu\mu\ell$, and $e\mu\ell$

Currently, I'm concentrating on $ee\ell$

Between 3ℓ requirement and kinematic cuts, expect to be able to cleanly isolate the signal.

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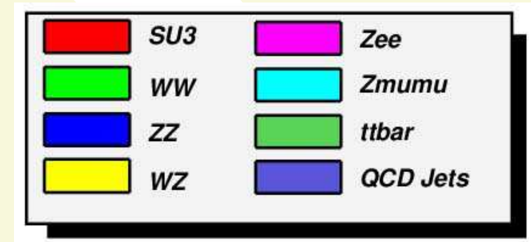
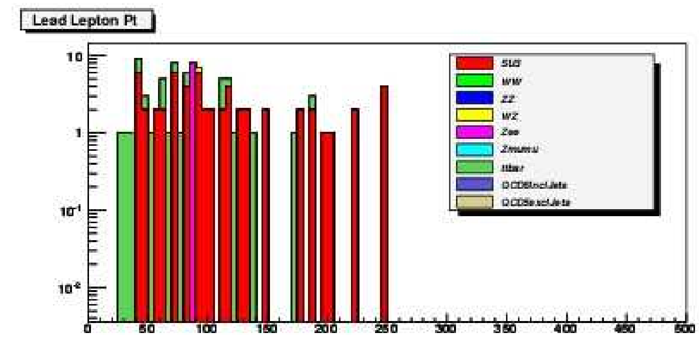
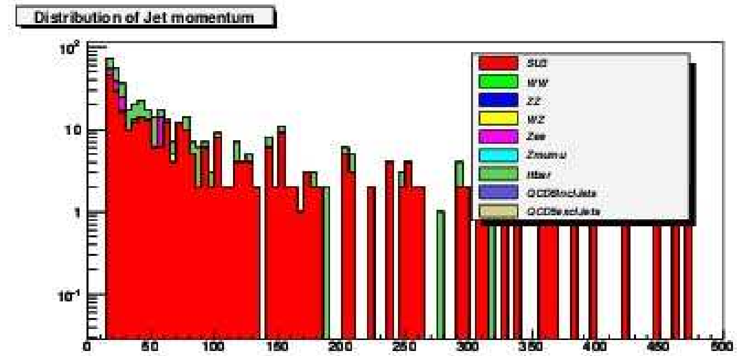
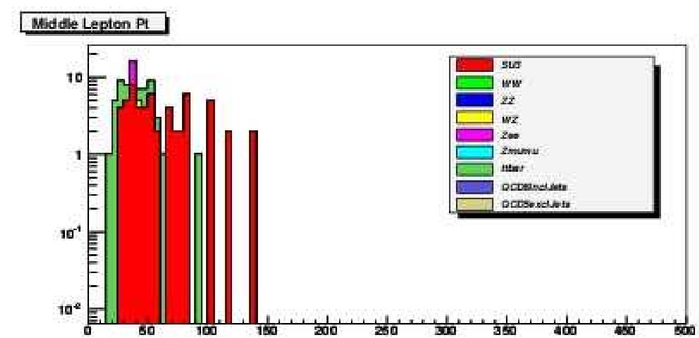
Lepton and Jet P_T Cuts

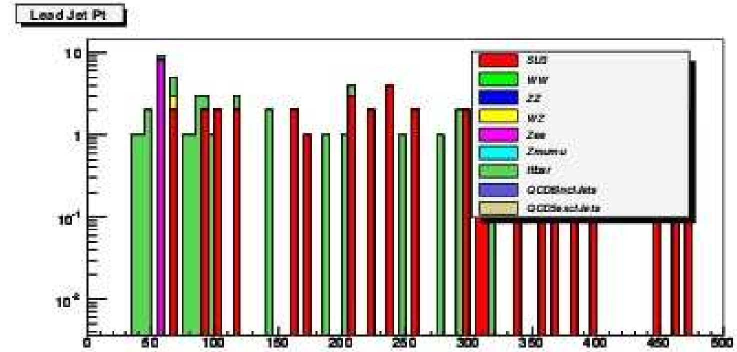
Require 3 leptons with $P_T > 40, 25, 15$
Require 4 jets with $P_T > 15$, lead > 65
Note: This is based on $1fb^{-1}$ sample.

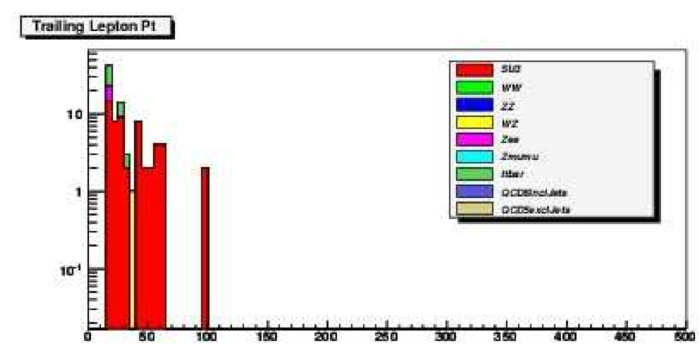




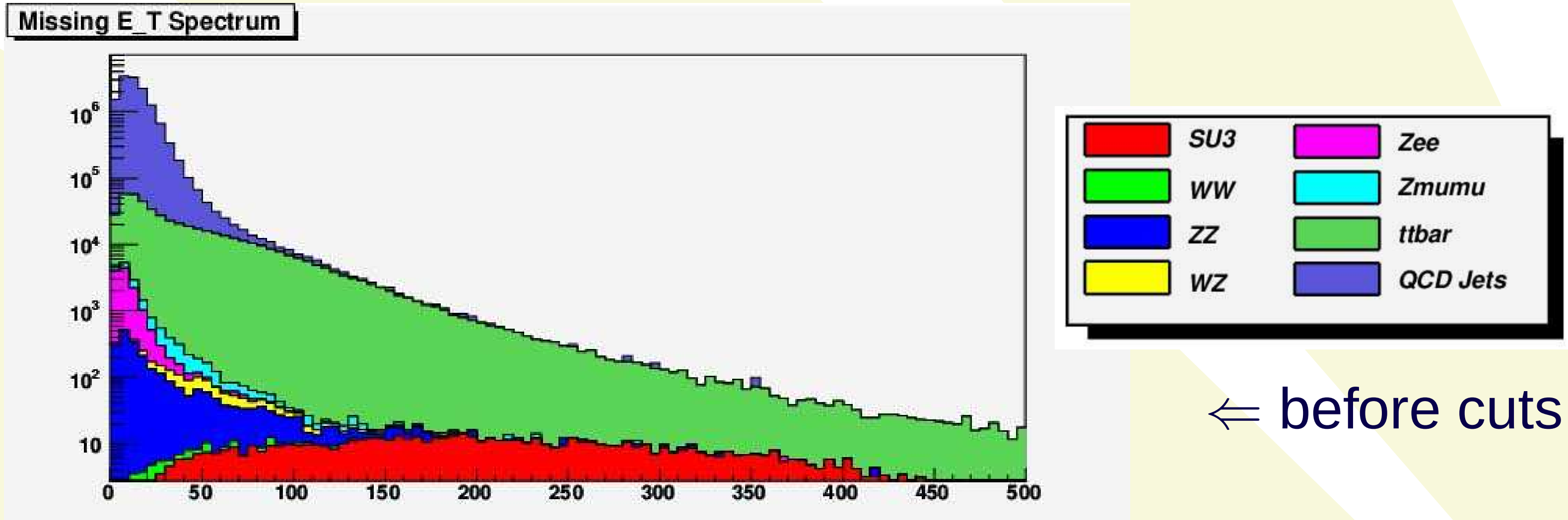






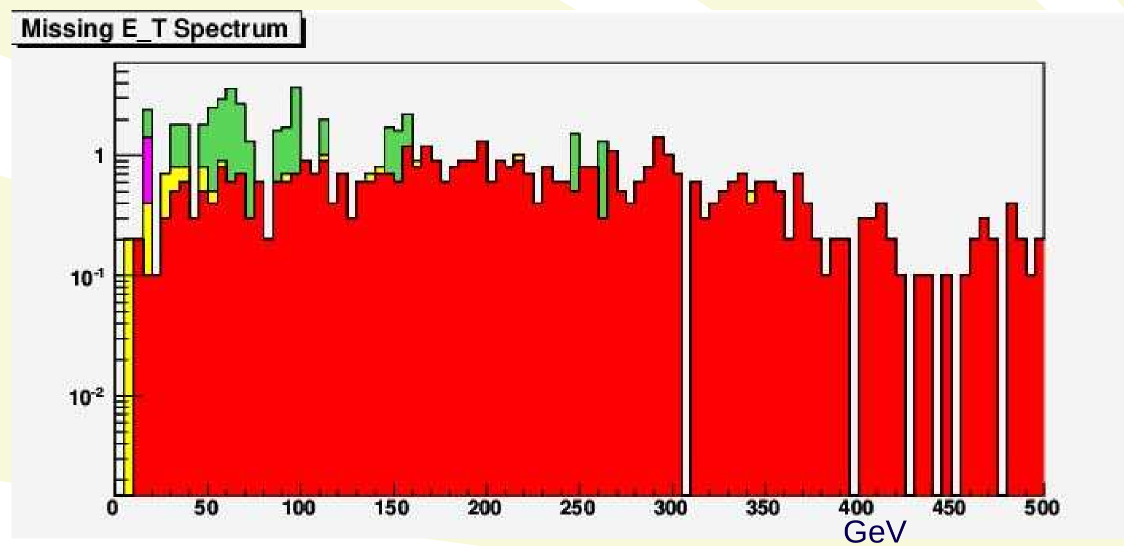


Missing E_T



⇐ before cuts

after cuts ⇒



Easy to see why people say the LHC

will spit out supersymmetry from the start

43.7 SUSY events, 14 SM events survive cuts.

End-point Measurements

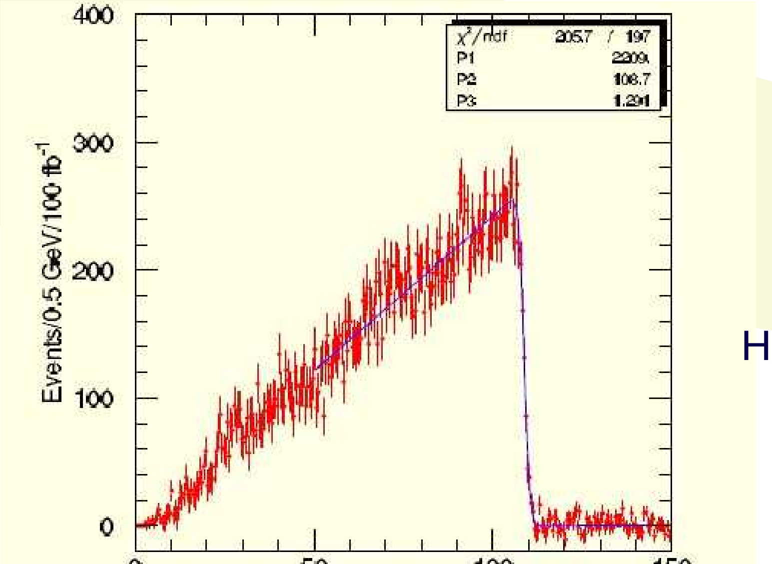
After isolating the signal, would like to make a measurement on SUSY mass spectrum.

Depending on how decay chain is structured, different endpoint measurements for the OS pair are possible.

If $N_2^0 \to N_1^0(Z \to \ell^+\ell^-)$, then $M_{\ell\ell}^{max} = m_{\tilde{N}_2^0} - m_{\tilde{N}_1^0}$

If "cascade" decay, $N_2^0 \to \tilde{\ell}\ell$, then $\tilde{\ell} \to N_1^0\ell$, then:
$M_{\ell\ell}^{max} = \frac{1}{m_{\tilde{\ell}}}\sqrt{(m^2_{\tilde{N}_2^0} - m^2_{\tilde{\ell}}) \cdot (m^2_{\tilde{\ell}} - m^2_{\tilde{N}_1^0})}$ Can combine $e^+e^- + \mu^+\mu^- - e^\pm\mu^\mp$ to sharpen fit

Other options include fittig to curves for $\ell\ell q$ or ℓq, taken together, can be used to feel out the mass spectrum of SUSY[32]



Histogram of $M_{\ell\ell}$ for $e^+e^- + \mu^+\mu^- - e^\pm\mu^\mp$ [?]

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Things to do

More backgrouds
Isolation cuts on leptons
Angular Separation of lepton pairs
Invariant mass?
Other cuts?
Fake rates
End Point Measurements
Tau problem with $t\bar{t}$
Generalize analysis beyond SU3/mSUGRA

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References (1)

References

[1] Unknown Author, Atlas Detector Photos, Online Picture Repository, 2006, http://atlasexperiment.org/atlas_photos.html.

[2] Unknown Author, Pilot Physics Run, Online technical report, 2006, http://lhc-commissioning.web.cern.ch/lhc-commissioning/phases/pilot-physics-run.htm.

[3] R. Bailey, *Summary of Overall Commissioning Strategy for Protons* (CERN, http://ab-div.web.cern.ch/ab-div/Conferences/Chamonix/Chamx2006/PAPERS/RB_1_01.pdf, 2006).

[4] L. Robertson, Start-up Scenario, Online technical report, 2007, http://lcg.web.cern.ch/lcg/MB/revised_resources/startup%20scenario.pdf.

[5] K. Einsweiler, Pixel Detector, Webpage, 2005, http://atlas.web.cern.ch/Atlas/GROUPS/INNER_DETECTOR/PIXELS/pixel.html.

[6] F. Dittus and S. Haywood, Technical report, CERN, CERN/LHCC 97-17 (unpublished).

[11] F. Dittus, *ATLAS TRT Production Status* (CERN, https://edms.cern.ch/file/637933/1/ATLAS_TRT_production_status.pdf, 2005).

[12] S. Menke, *Energy-Calibration of the ATLAS Hadronic and Electromagnetic Liquid-Argon Endcap Calorimeters* (Max Planck Society, Villa Erba, Como, Italy, 2004), http://villaolmo.mib.infn.it/ICATPP8th_2003/Calorimetry/Menke.pdf.

[13] A. Dotti, *Results from ATLAS Tile Calorimeter: a comparison between data and Geant 4 simulation* (Nuclear Physics B (Proceedings Supplement), Siena, Italy, 2004), http://www.bo.infn.it/sminiato/sm04/dotti.pdf.

[14] R. Voss *et al*, Technical report, CERN, CERN/LHCC 97-22 (unpublished).

[15] G. Bruno, Eur Phys J C **33**, 1032 (2004).

[16] L. Chevalier, Atlas Magnetic Field, Webpage, 2005, https://twiki.cern.ch/twiki/bin/view/Atlas/MagneticField.

[17] A. Kurilov, Minimal Supersymmetric

[23] H. Baer and X. Tata, *Weak Scale Supersymmetry* (Cambridge University Press, United States, 2006).

[24] F. E. Paige, SUSY at LHC, http://www.icepp.s.u-tokyo.ac.jp/tokutei/activities/24AM/paige.pdf.

[25] T. Goto, *Flavor Signals at SUSY benchmark points* (ICFP2005, National Central University, Chung-li, Taiwan, 2005).

[26] D. Tovey, ATLAS SUSY Working Group: Rome Production, 2006, http://paige.web.cern.ch/paige/fullsusy/romei

[27] Corcella *et al*, Herwig 6: an event generator for Hadron Eission Reactions With Interfering Gluons (including supersymmetric processes), 2000, cERN-TH/2000-284.

[28] Mangano *et al*, JHEP **07**, (2003).

[29] T. Sjostrand, The PYTHIA Event Generator, 2004, http://home.fnal.gov/m̃renna/041207_pythia_t

Backup Slides

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ATLAS Benchmark Point Parameters

Point	m_0 (GeV)	$m_{1/2}$ (GeV)	A_0 (GeV)	$tan(\beta)$	$sgn(\mu)$	Cross Section
Coannihilation (SU1)	70	350	0	10	+	7.43 pb
Focus Point (SU2)	3550	300	0	10	+	4.86 pb
Bulk (SU3)	100	300	-300	6	+	18.59 pb
Low Mass (SU4)	200	160	-400	100	+	262 pb
Scan (SU5.1)	130	600	0	10	+	.44 pb
Scan (SU5.1)	250	600	0	10	+	.40 pb
Scan (SU5.1)	500	600	0	10	+	.31 pb
Scan (SU6)	320	375	0	50	+	
SU7						
Scan (SU8.1)	210	360	0	40	+	6.44 pb
Scan (SU8.1)	215	360	0	40	+	6.40 pb
Scan (SU8.1)	225	360	0	40	+	6.32 pb

[33, 26]

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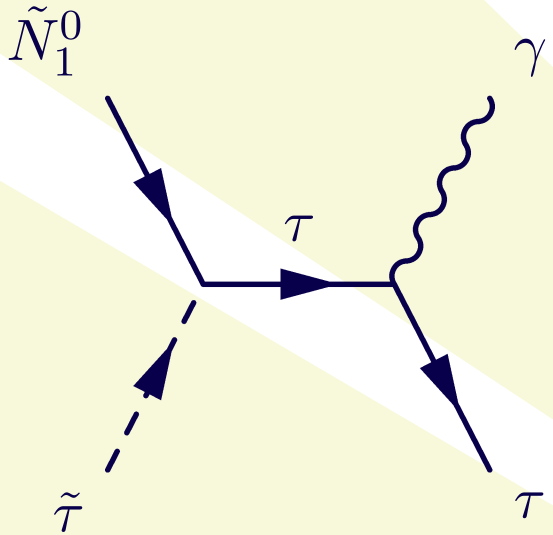
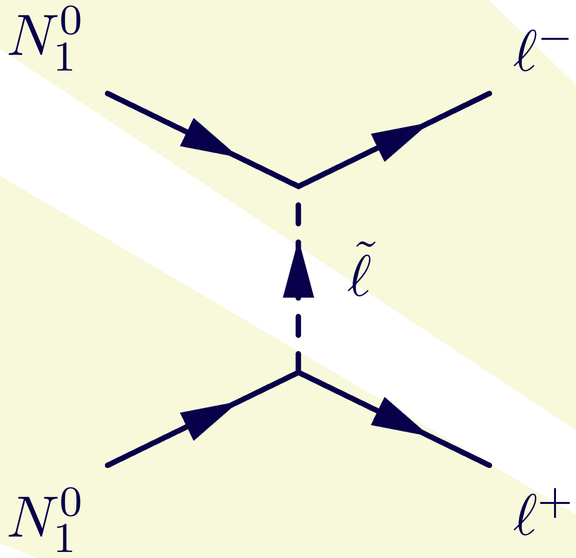
Parameter Space Details

SU1 - Coannihilation Point [25]



Parameter Space Details

SU3 - Bulk Point[25]



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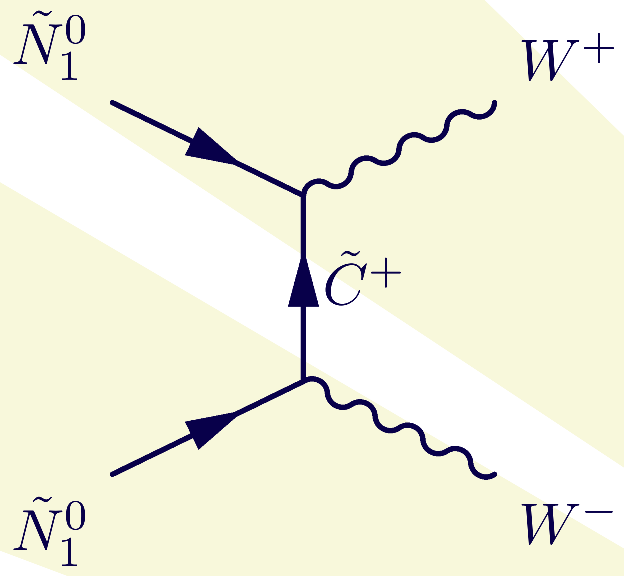
Parameter Space Details

SU2 - Focus Point[25]



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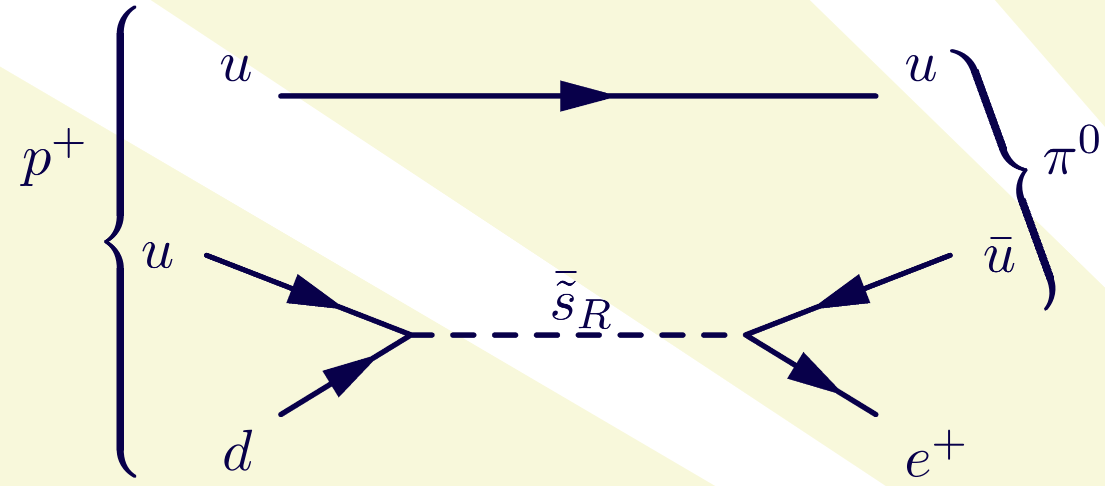
R-Parity Squark Disaster



$$\Gamma_{p \Rightarrow e^+\pi^0} \sim m^5_{proton} \sum_{i=2,3} |\lambda'^{11i}\lambda''^{11i}|^2 / m^4_{\tilde{d}_i}$$

If λ's are ~ 1 and $m_{\tilde{q}} \sim 1TeV$

$\Rightarrow$ fractions of a second lifetime [18]

Jet Number

❖ Outline

LHC

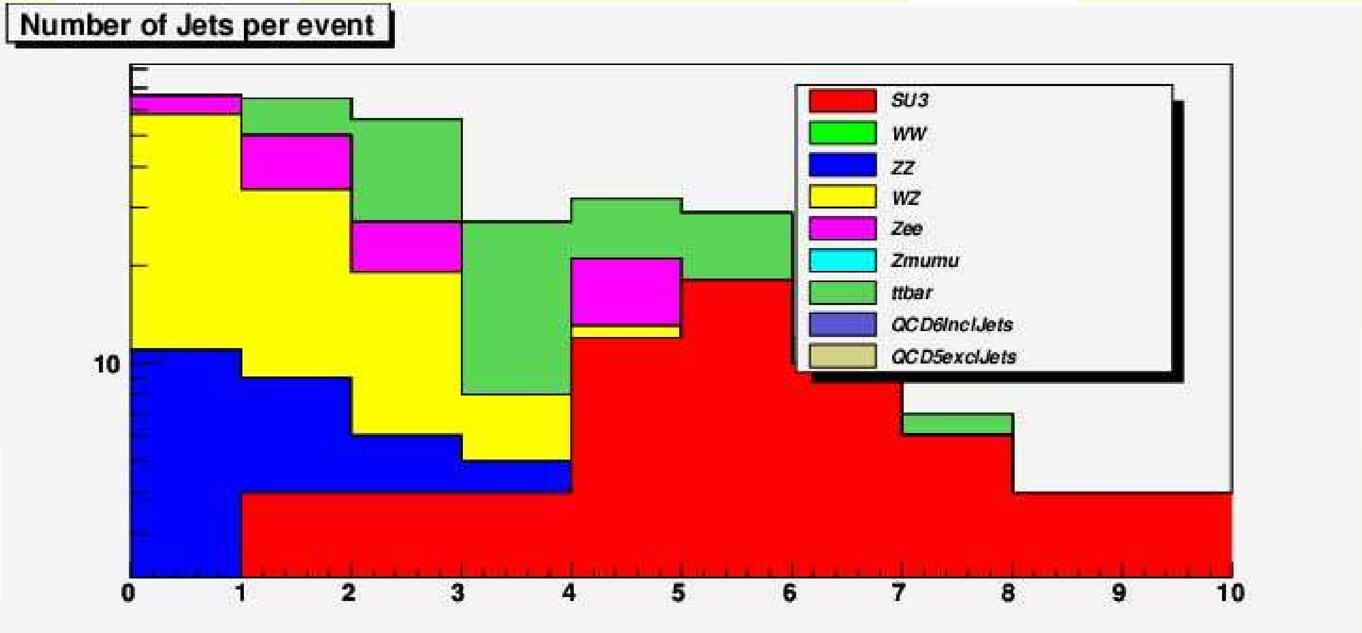
ATLAS

Supersymmetry

Simulation

Analysis

The Future



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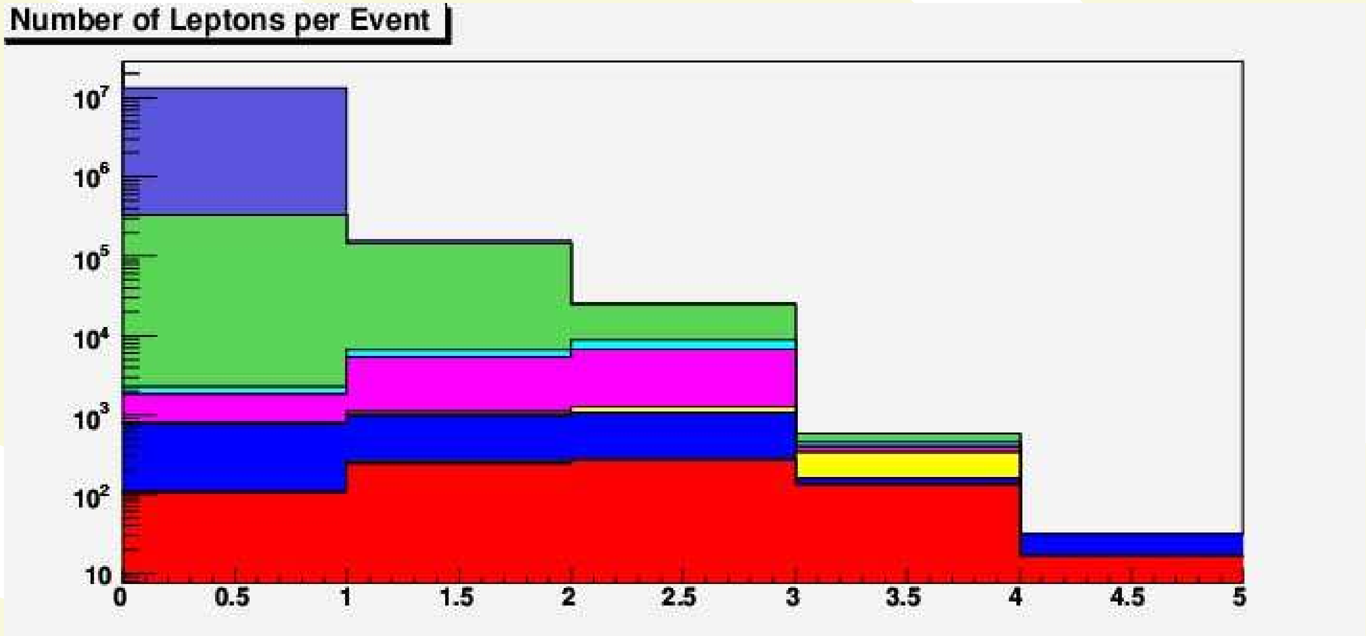
Lepton Number

- Outline
- LHC
- ATLAS
- Supersymmetry
- Simulation
- Analysis
- The Future



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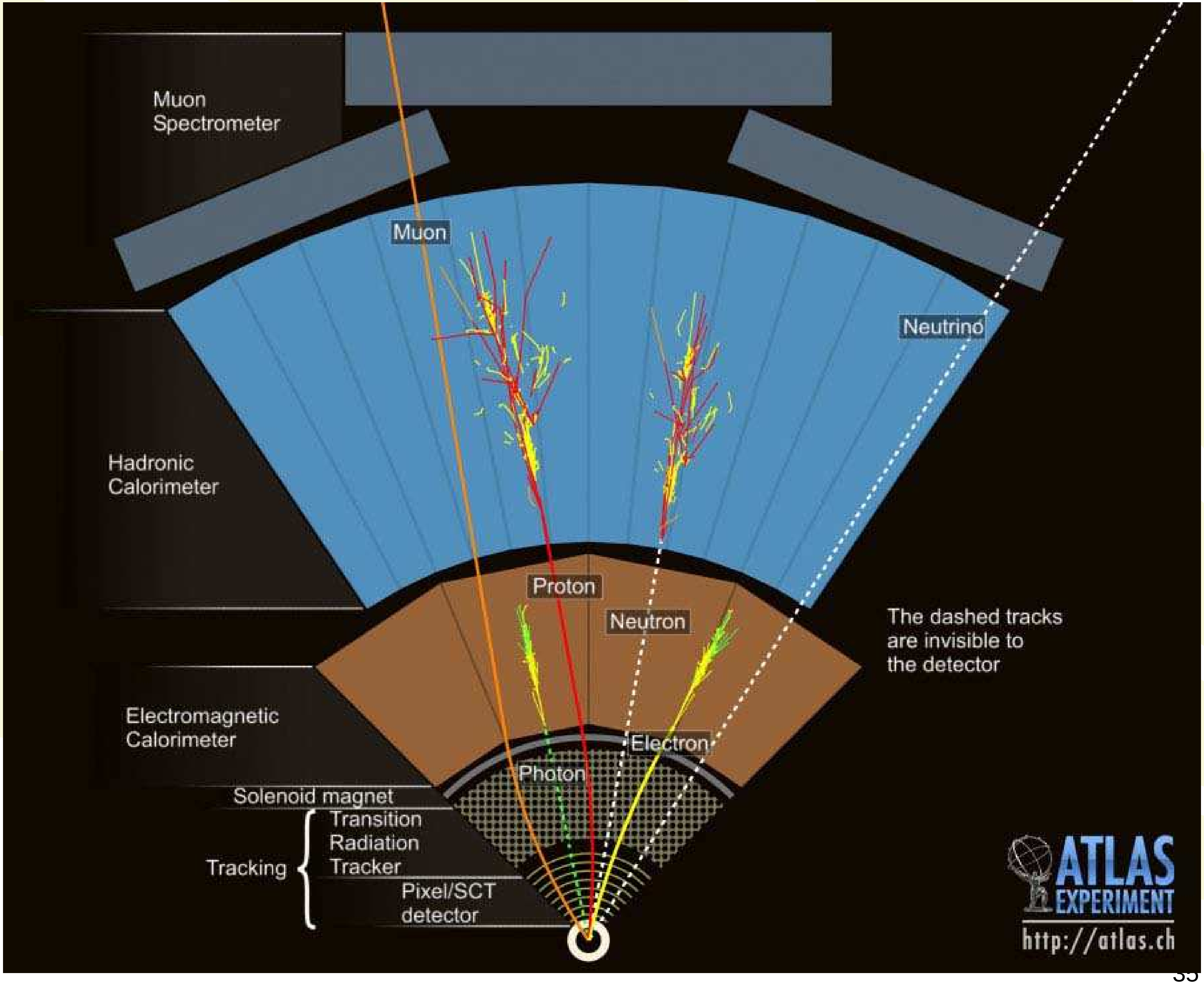
What Sees What



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