Physics progress in the ATLAS In2p3/ACC project

ZHU Chengguang

On behalf of collaboration of In2p3/ACC

Outline

1.VLE electron energy linearity study

IHEP: H. Zhang, S. Jin
CPPM: E. Monnier

2.Timing study

USTC: Y.Liu
CPPM: E.Monnier, F. Hubaut, P.S. Mangeard

3.Photon Identification

IHEP: L. Yuan, S. Jin
LPNHE: L.ROOS

4. B tagging study

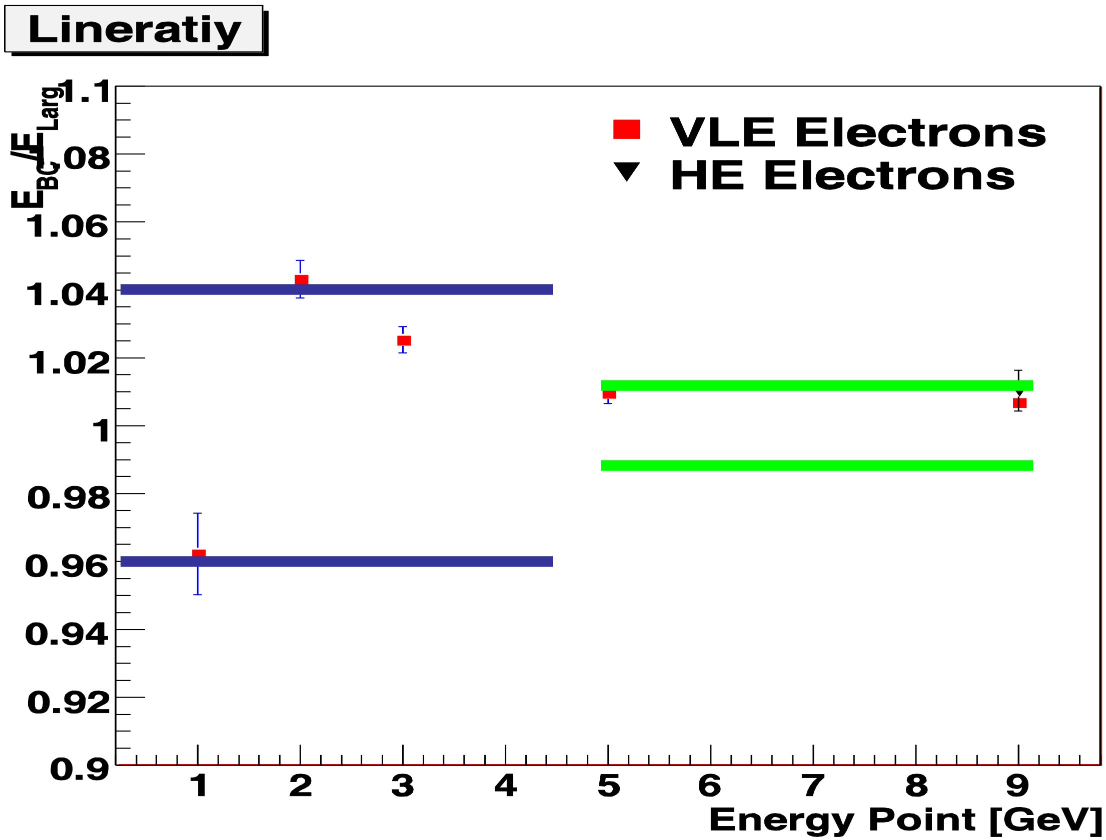
IHEP: Y.Bai, S. Jin
CPPM: E. Monnier, L. Feligioni

5.W and top polarization analysis

CPPM: E.Monnier, F. Hubaut, P. Pralavorio
SDU: M.Liu, C.Zhu

VLE electron energy linearity study in ATLAS EM Calorimeter

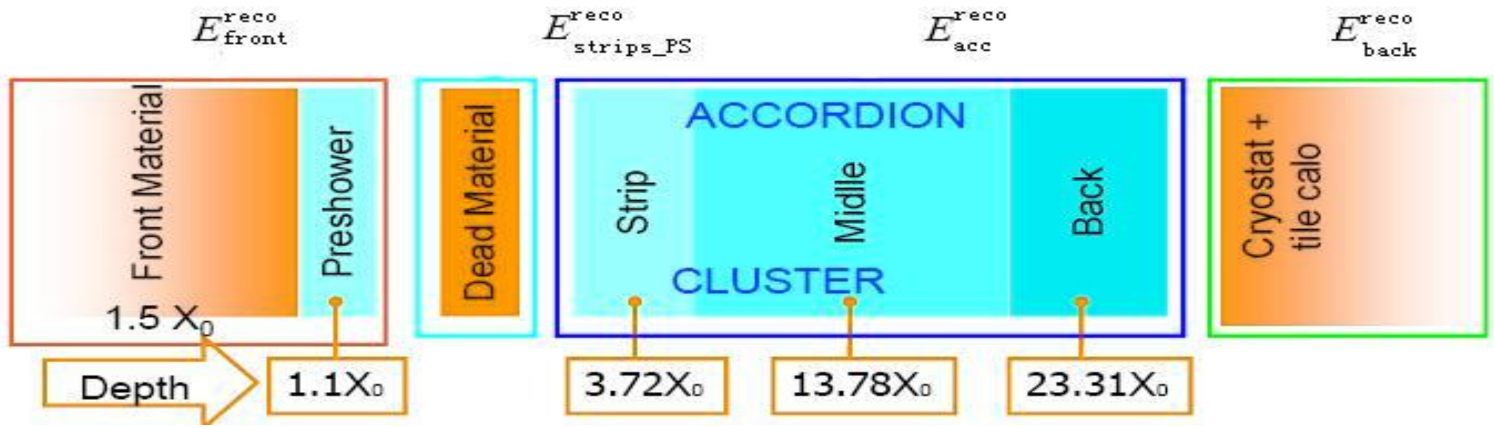
- **Linearity : Ereco/Ebeam for electrons with energy (1,9)GeV**
- **Energy is measured precisely by bending in magnet field**
- **Critical to understand the performance of EMC and will redo with early data**



With the ATLAS default electron reconstruction:

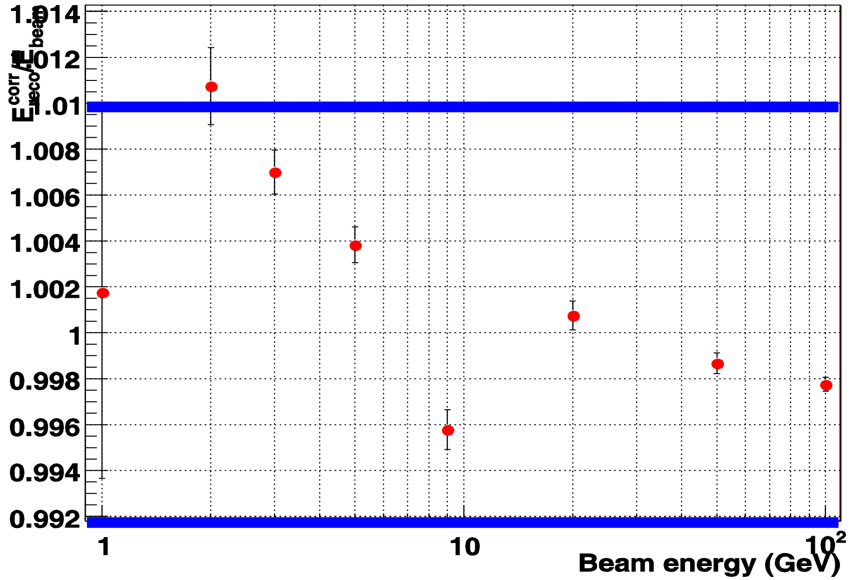
The linearity: [5, 9] GeV < 1% [1,4] GeV ~ 4%

Electron energy Calibration improvement



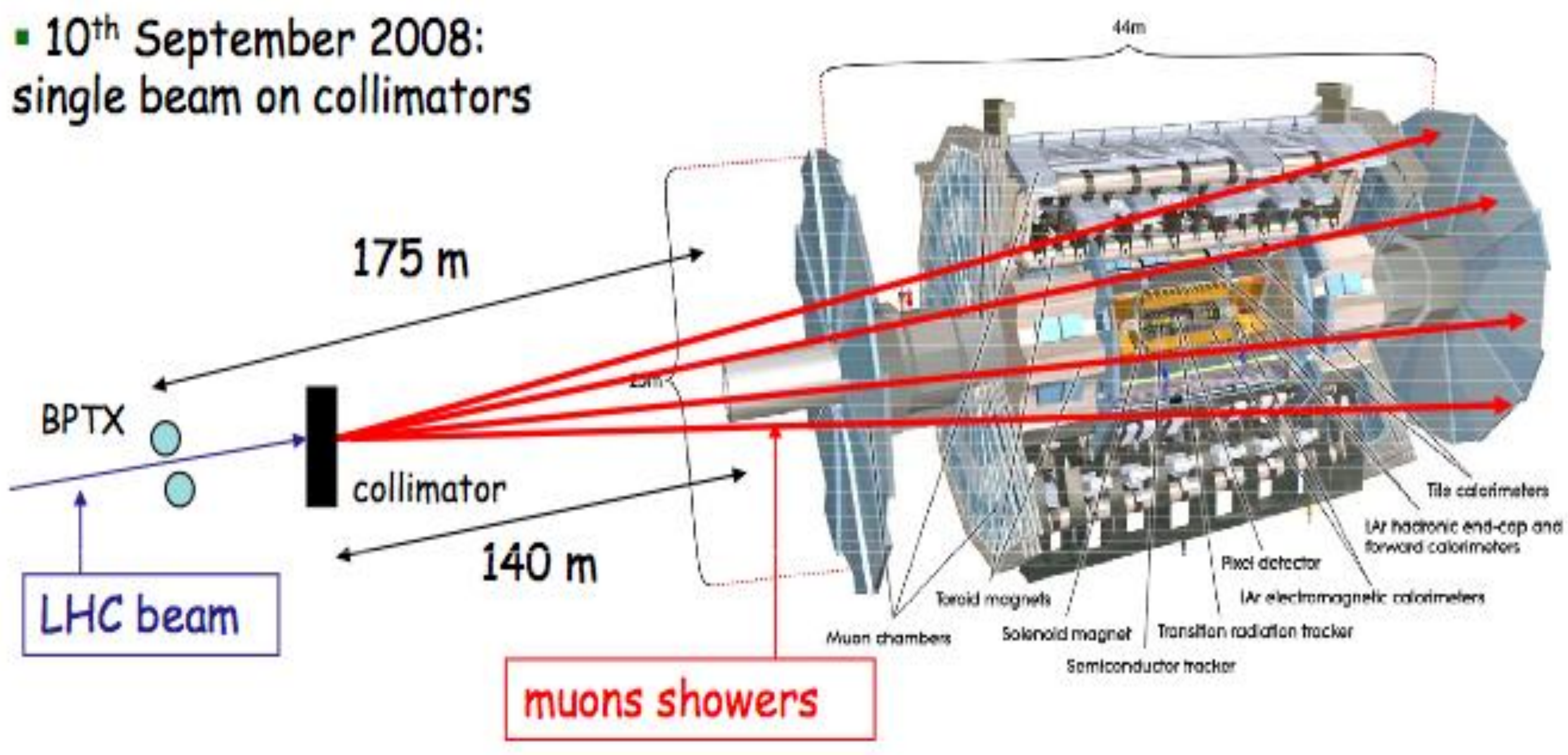
$$E = offset + w_0 \cdot E_0 + \frac{1}{f_{sampling}}(E_1 + E_2 + E_3) + w_3$$

Calibration results



MC Linearity within 1%

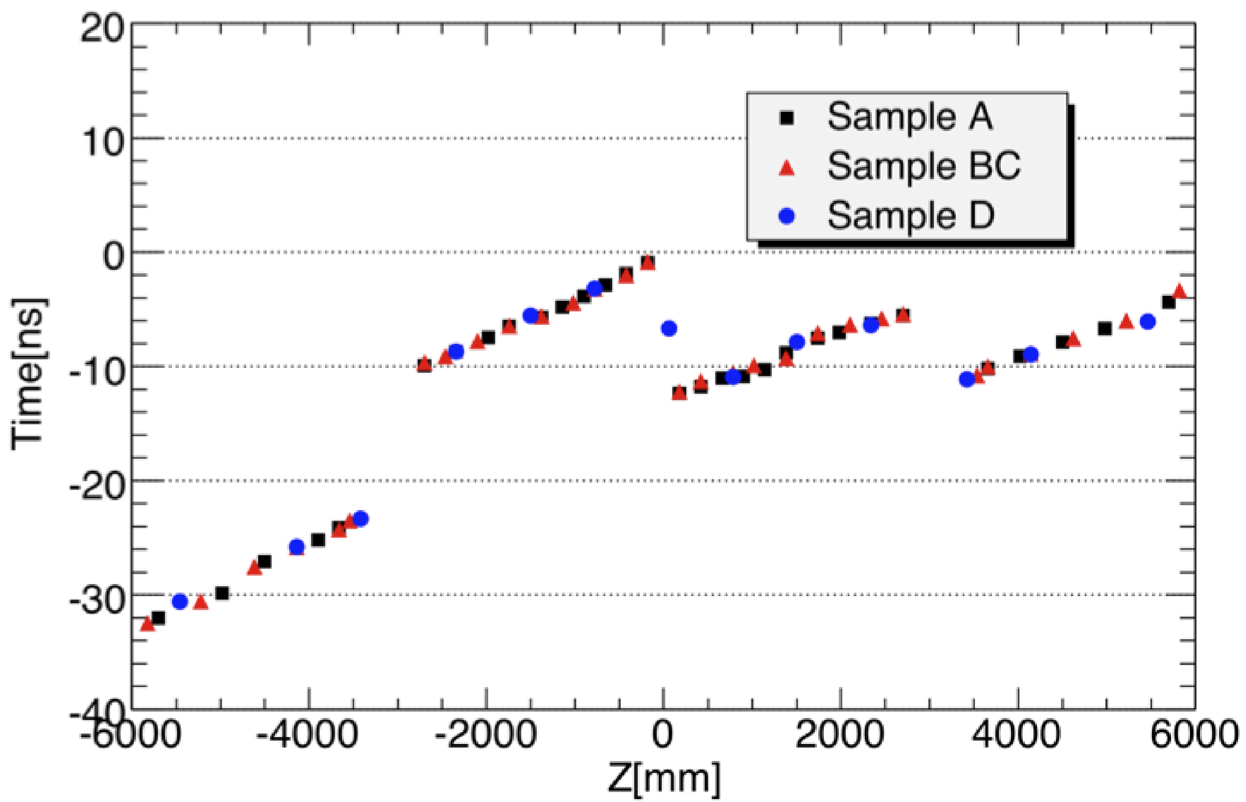
Timing study using beam splash



All Tile good cells
E>1 GeV
times from both PMTs consistent

Time in Tile

time (ns)

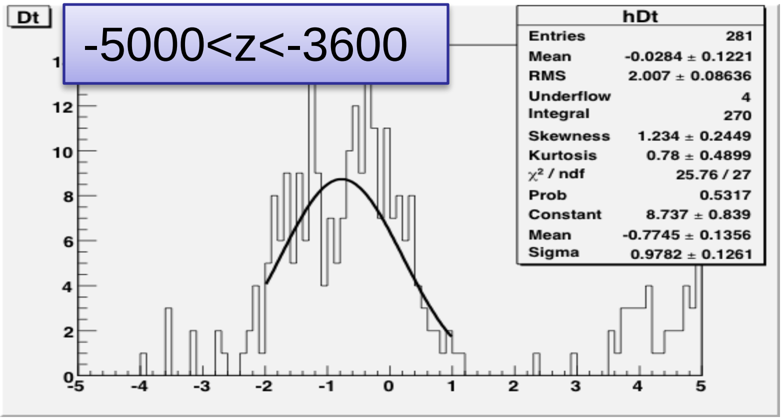


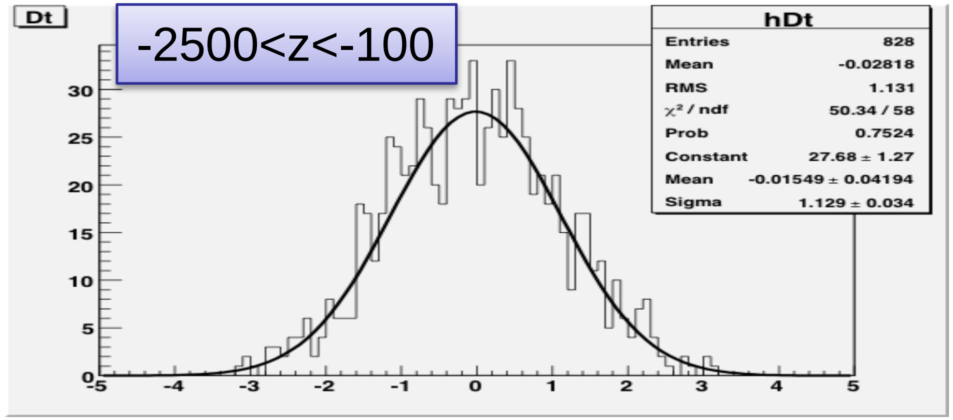
z(mm)	η
4000	1.1
3500	1.0
3000	0.9
2500	0.7
2000	0.6
1500	0.5
1000	0.3

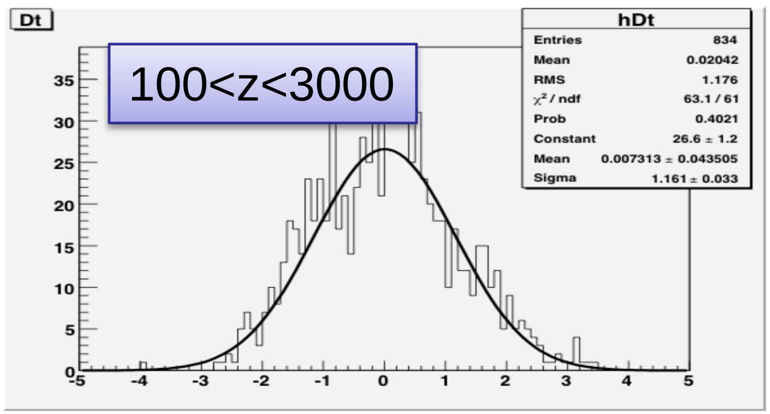
z(mm)

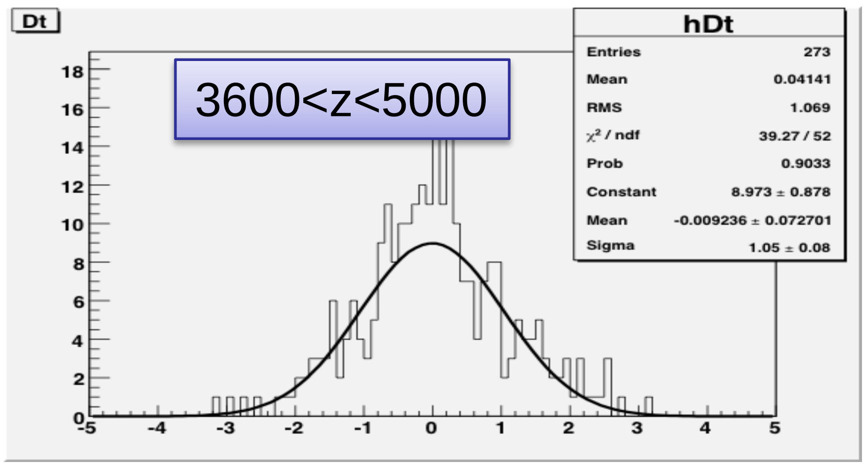
spread is about 1 ns!

Tile time per cell residuals (ns)



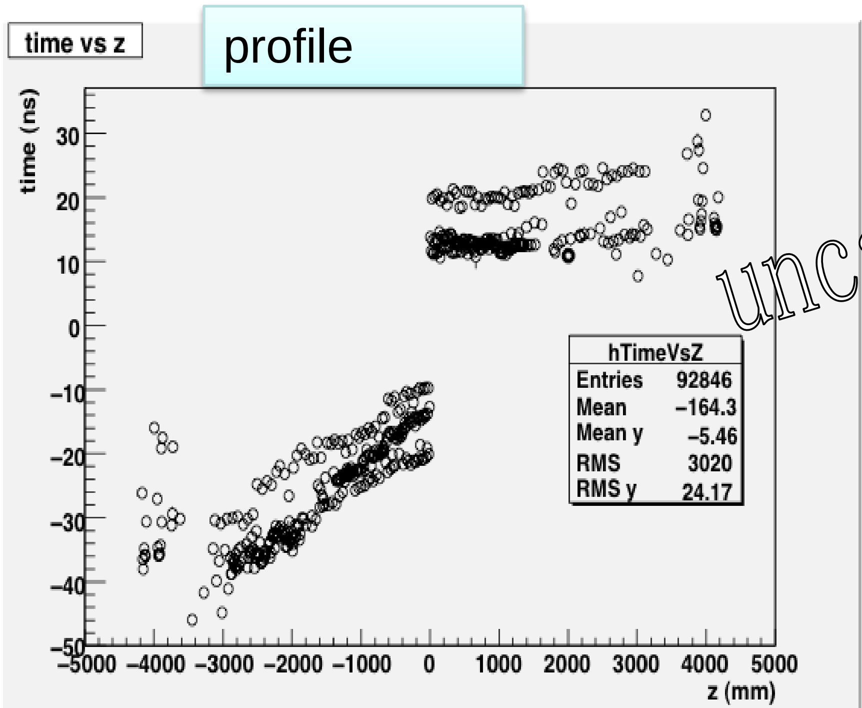


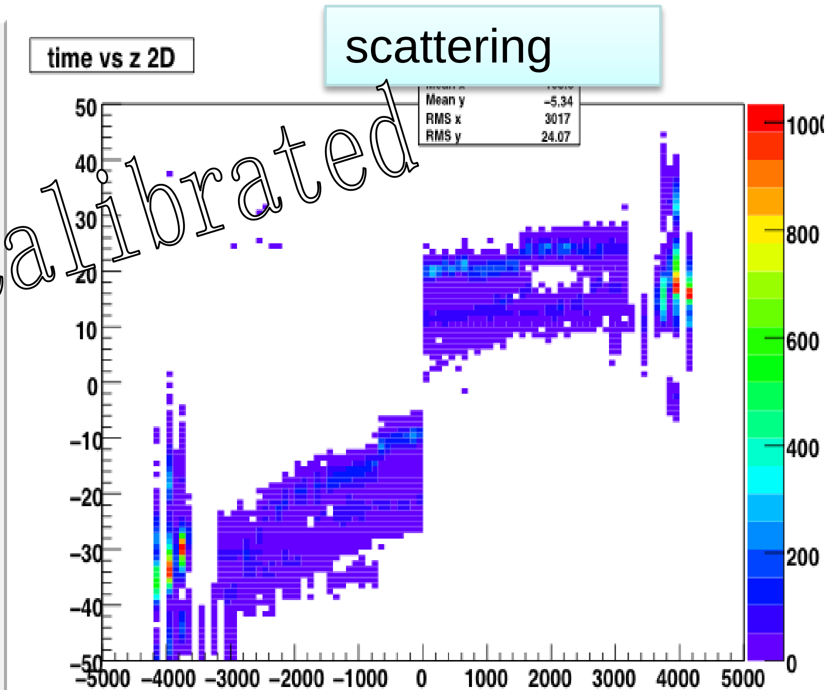




All good LAr cells
E>1GeV

LAr





1. ATLAS clock is not synchronized yet with beam
2. Need corrections due to delays that varies FEB to FEB: **IN PROGRESS**

A few words about TRT

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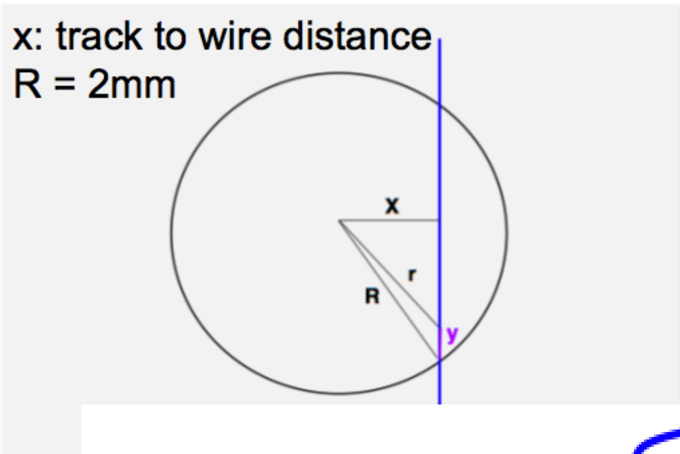
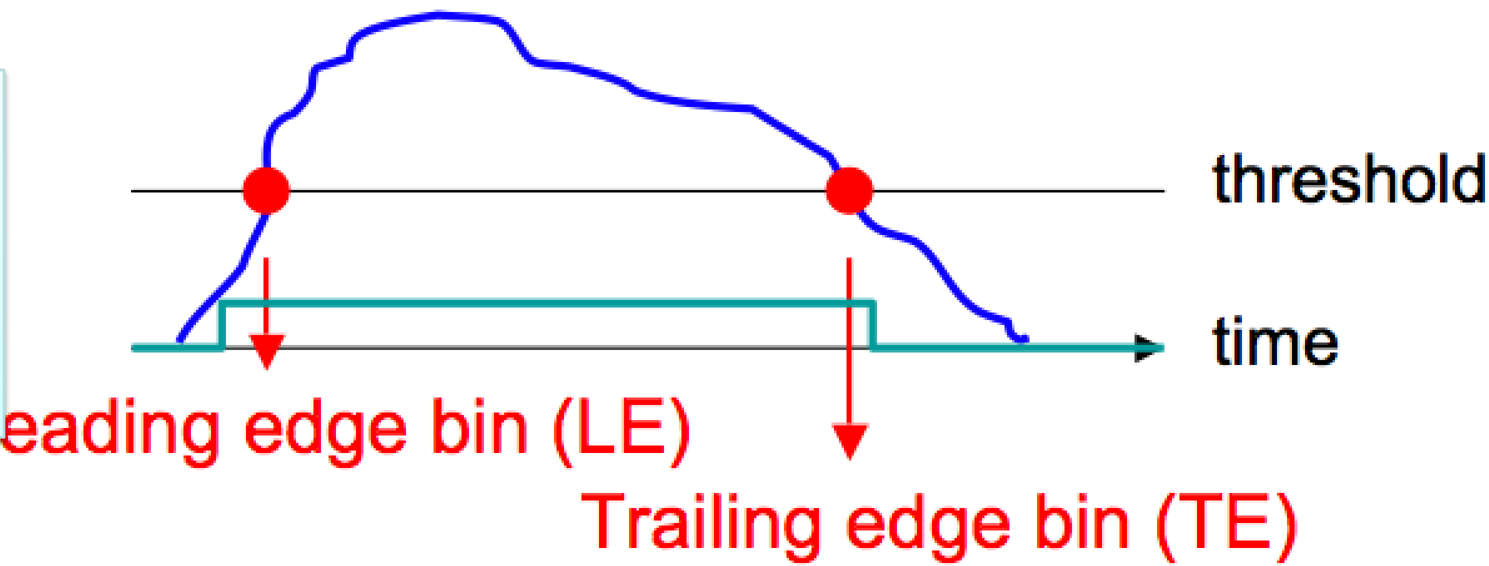


TRT_time = TE*3.125 – drift_time(2mm) – T0

Average TRT time computed in reprocessing and stored in ESD with key "TRT_phase"
Potentially very useful for LAr timing

75ns window in 24 bins both LE and TE readout



3. Photon Identification

- For H->γγ (the main channel searching for Higgs at low mass), σ≈97fb. However, the background lies about eight orders of magnitude higher.

  ☆the irreducible photon pairs continuum $\sigma/\Delta m_{\gamma\gamma} \approx 1\text{pb/GeV}$ in the Higgs mass range 95~130GeV.

  ☆the reducible background γ-jet $(\sigma \approx 8 \cdot 10^2 \cdot \sigma_{\gamma\gamma})$ and jet-jet production $(\sigma \approx 2 \cdot 10^6 \cdot \sigma_{\gamma\gamma})$

A rejection factor of about 5000 is required against QCD jets.

- Photon/jet separation is also the key point for direct photon cross section measurement

→ Focused on the Photon ID and photon trigger efficiency.

Reject jets with high energy pions and wide showers.

Hadronic variable:

- Hadronic leakage

Middle Layer (S2) variables:

- energy fraction in η (3x7 / 7x7),
- energy fraction in ϕ (3x3 / 3x7),
- Lateral width

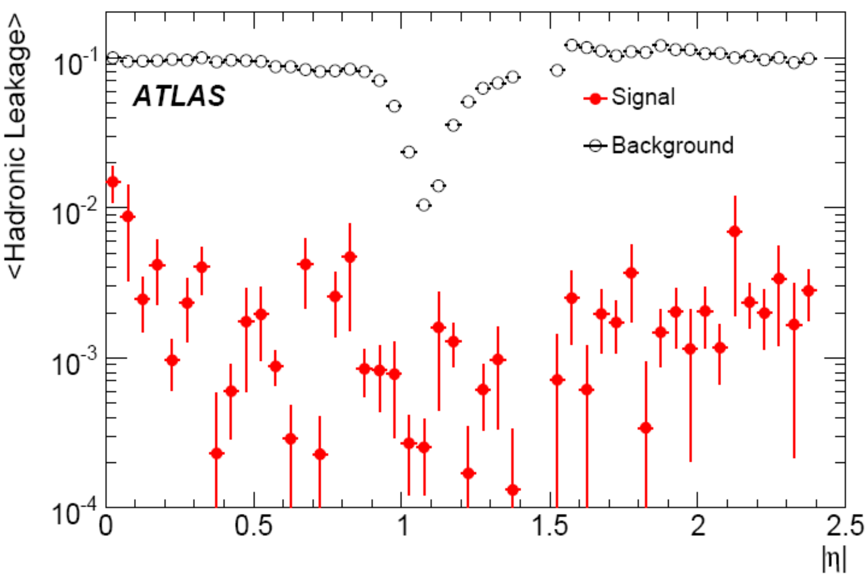
First layer with better granularity, good for discriminating π0 and γ.

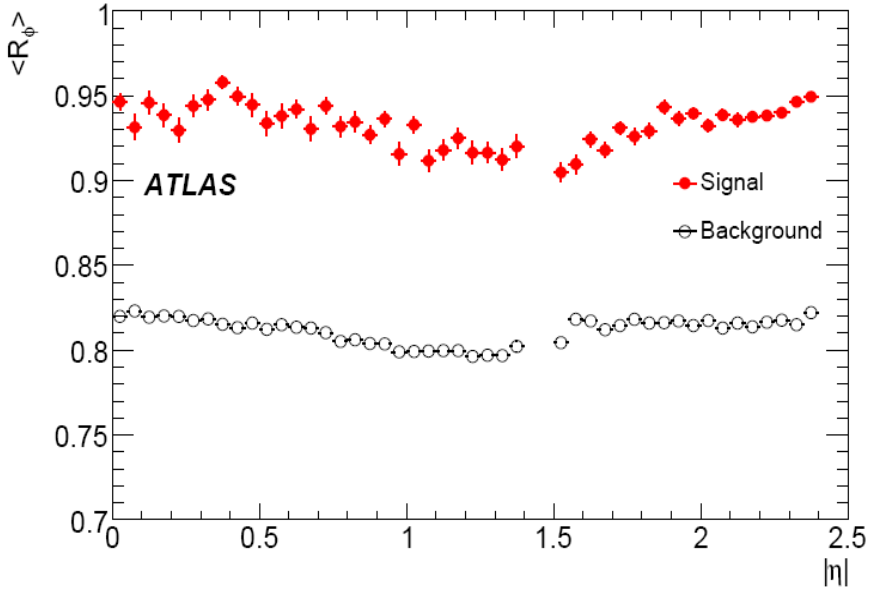
Strip Layer (S1) variables:

- energy fraction in η (±3 - ±1) / ±1,
- S1 width using 3 strip cells around max,
- S1 width using 40 strip cells,
- Second max strip cell energy,
- ΔE

1. the variable cuts are tuned in different Et and η bins.
2. The average efficiency for photons is around 83%, with jet rejection factor around 5000 at low luminosity.

3. Currently, there is only one standard photon definition, PhotonTight.
4. In first data, not all shower shape variables will be understood and well described by the MC.





Distribution of (hadronic leakage) and (S2 energy fraction in φ) as a function of |η| for true and fake photons with 20 GeV<Et < 30 GeV

Ongoing work:

1. Definition of loose photon selection: possibly remove the cut on strip variables or remove the pt dependence of tight cuts.
2. revisit the offline tight photon selection
3. Develop different cuts for converted and unconverted photons.

Photon trigger study

In MC, Events passing the offline selection can still be rejected by applying trigger.

Official publication (CSC result): trigger efficiency w.r.t offline

ATLAS trigger system:

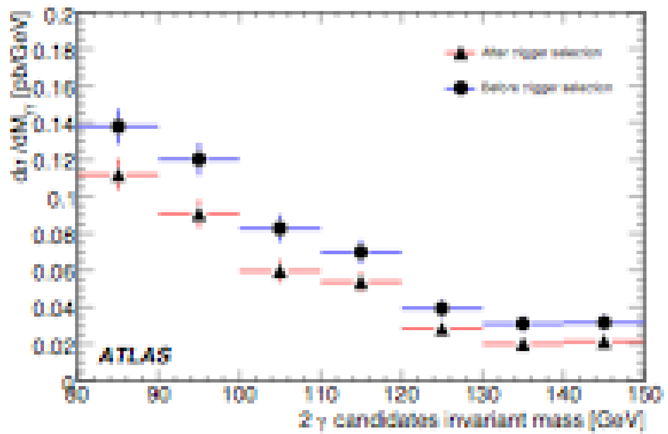
L1, hardware based

L2, EF: HLT (high level trigger), software based

Trigger efficiency for H->γγ

	2g20i Trigger menu	
Trigger Level	Efficiency [%]	Rate [Hz]
LVL1	96.3 ±0.3	140 ± 10
LVL2 Calo	95 ±0.4	4.7 ± 1.6
EF Calo	93.6 ±0.4	1.6 ± 1

Mγγ distribution with and without trigger for γ+jet



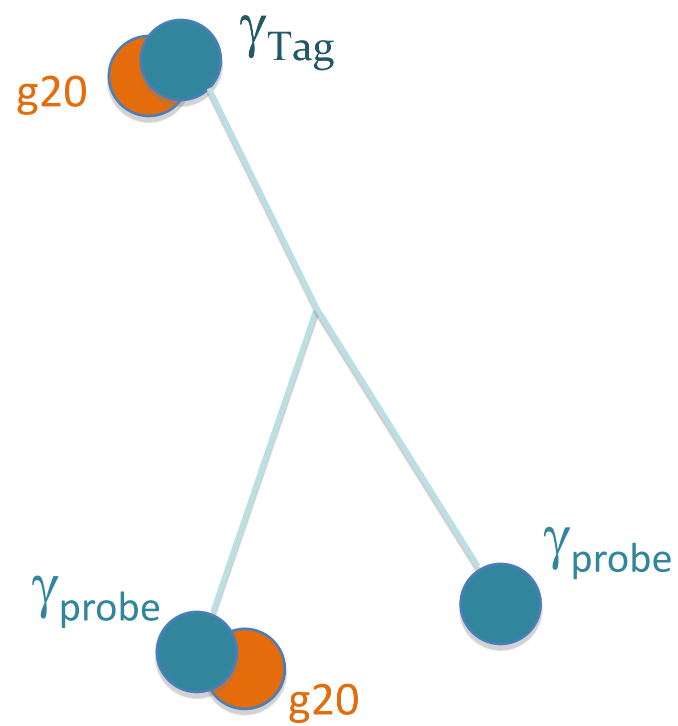
L. Yuan **Checked the trigger effect with MC samples of 10 TeV, and understand the inefficiency at L1 and EF.**

measure photon trigger efficiency with real data

Difficulties: No pure sample with large statistics.

Possible solution:

1. Bootstrap: select events from lower pt triggers
2. Tag & probe: select events with at least 1 photon triggering g20, and look if the other good photons trigger or not
3. electron to photon extrapolation
4. $Z \rightarrow ll\gamma$, possible purest photon sample, but low statistics



First development of data driven methods for photon trigger efficiencies is implemented

Near future work

+ continue on the definition and the study of the tag&probe and bootstrap method

+ contribute to the definition of the offline loose photon selection

+ contribute to revisit the offline tight photon selection (variables were defined ten years ago!)

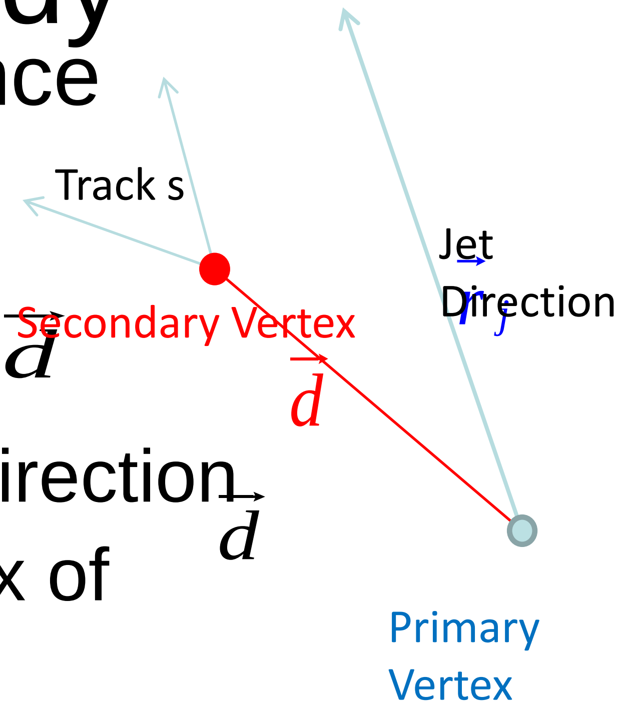
+ study photon isolation: what is the best way to combine track and calorimetric isolation

4. B tagging study

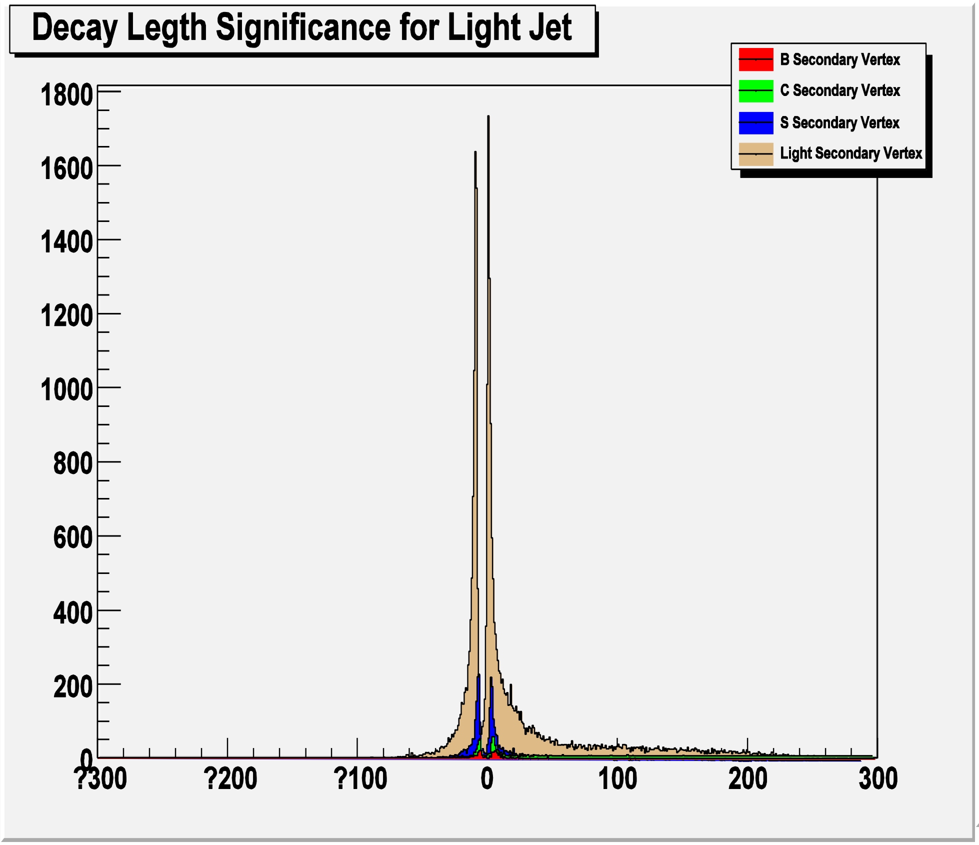
- Btag : SV0 Tag Study
  - The study on estimate the mistag rate in data
  - Improve the performance of this tag
  - Study the correlation with other tags

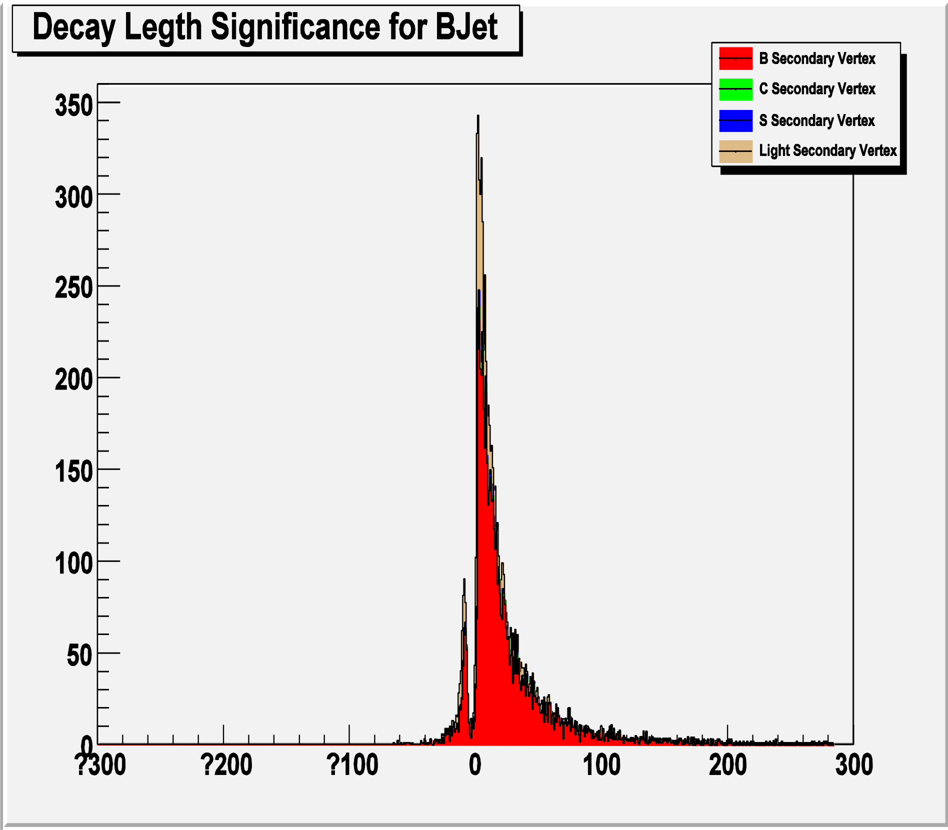
SV0 Tag Study

- SV0 : Decay Length Significance
  - Definition : $\sqrt{d^T C^{-1} d} \times \left(\vec{r}_d \bullet \vec{r}_j \right)$
  - $\vec{d}$: vector from PV to SV
  - $\vec{r}_d$: Normalized vector of $\vec{d}$
  - $\vec{r}_j$: Normalized vector of jet direction
  - C^{-1} : Invert of covariance matrix of $\vec{d}$
- Discrimination Power
  - Heavy Flavor Jet: tend to be positive
  - Light Flavor Jet: presence of a secondary vertex just a resolution effect of light jet



The Distribution of Decay Length Significance

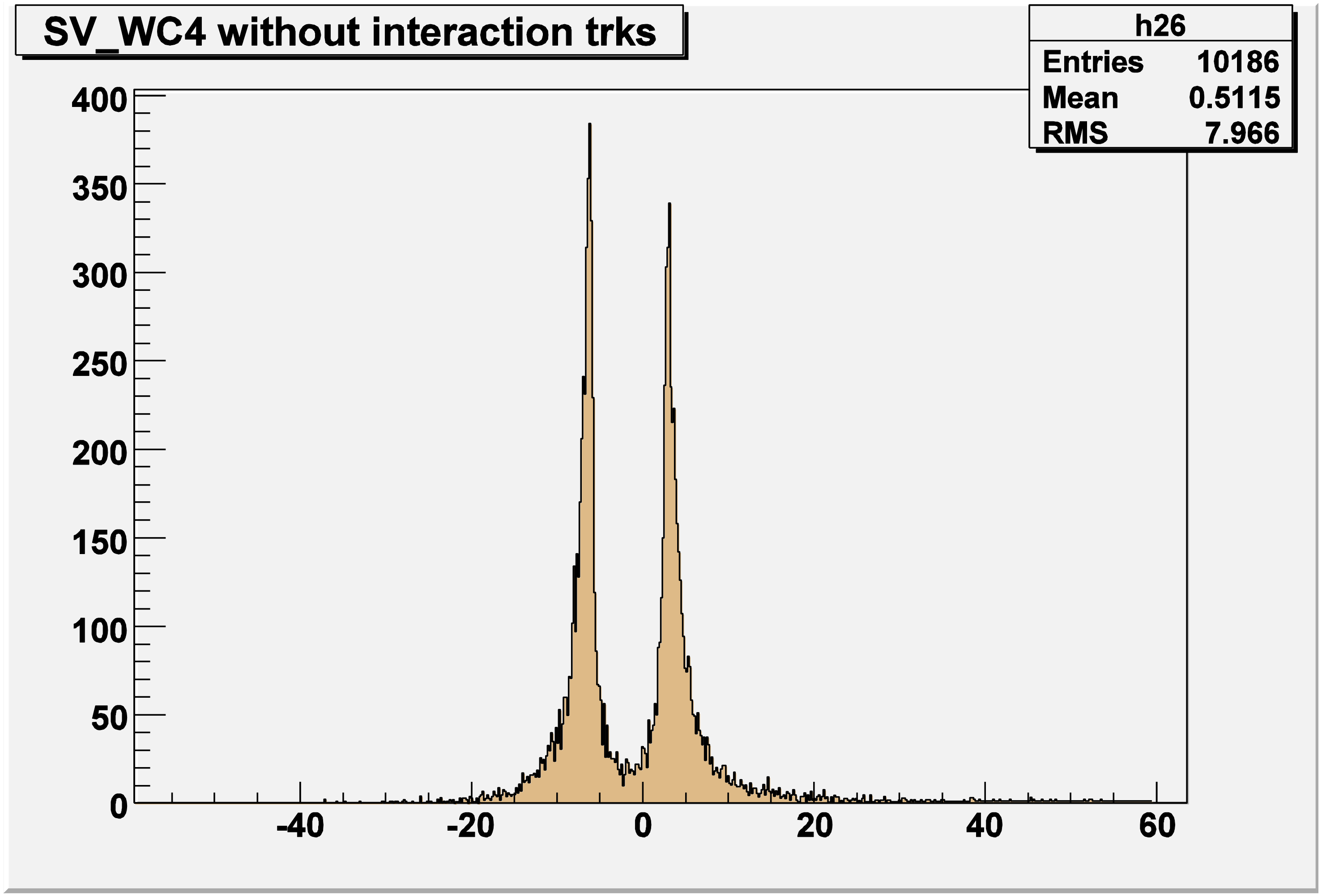




Distribution in Light Jet

Distribution in Heavy Flavor Jet

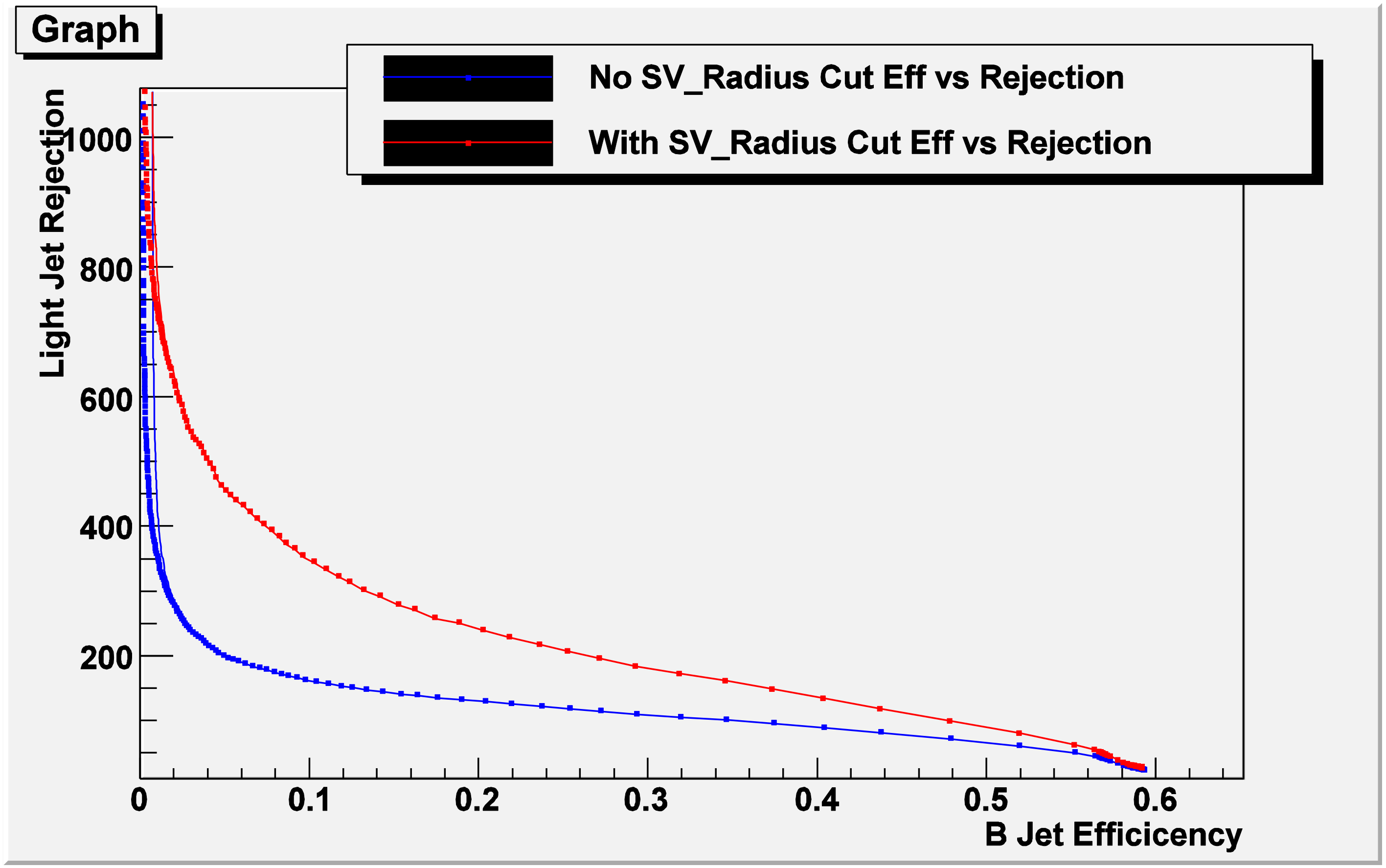
The Asymmetry in Light Jet



Long life particle , multi-scattering and gamma conversion removed, but still some asymmetry remained. Under investigation.

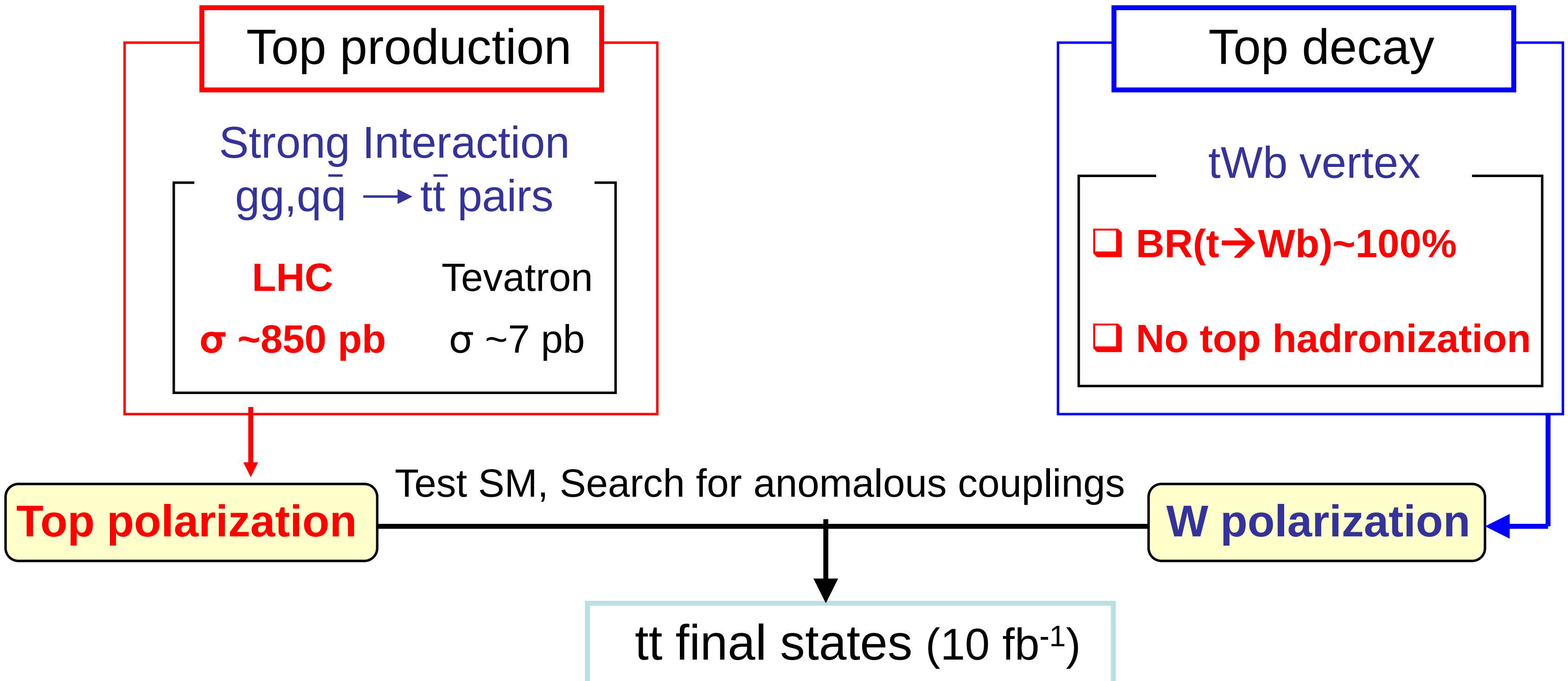
The improvement in performance

- Improvement of b-tagging with the SV0



5.W and top Polarization Analysis

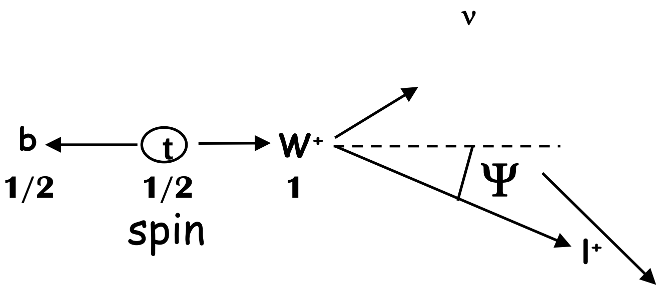
W polarization and tt spin correlation analysis



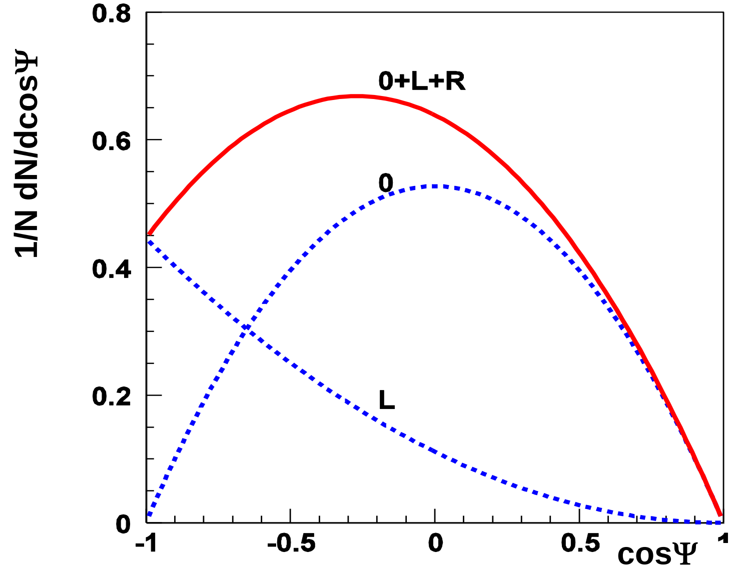
W polarization in top decay

❑ **...by measuring angular distribution of charged lepton in W rest frame**

$$\frac{1}{N}\frac{dN}{d\cos\Psi}=\frac{3}{2}\left[F_0\cdot\left(\frac{\sin\Psi}{\sqrt{2}}\right)^2+F_L\cdot\left(\frac{1-\cos\Psi}{2}\right)^2+F_R\cdot\left(\frac{1+\cos\Psi}{2}\right)^2\right]$$



Angle between:
- lepton in W rest frame and
- W in top rest frame



$t\bar{t}$ spin correlation

- **Test the top production …**
  - t and $\bar{t}$ not polarised in $t\bar{t}$ pairs, but correlations between spins of t and $\bar{t}$

$$A=\frac{\sigma(t_L\bar{t}_L)+\sigma(t_R\bar{t}_R)-\sigma(t_L\bar{t}_R)-\sigma(t_R\bar{t}_L)}{\sigma(t_L\bar{t}_L)+\sigma(t_R\bar{t}_R)+\sigma(t_L\bar{t}_R)+(t_R\bar{t}_L)}\neq 0$$

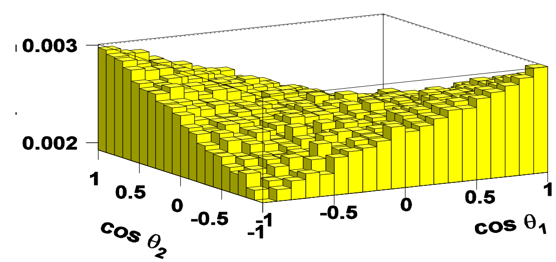
A=0.33 → (M_{tt}<550 GeV) **A=0.42**

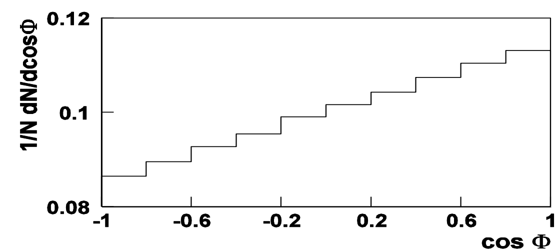
- **… by measuring angular distributions of daughter particles in top rest frames**

$$\frac{1}{N}\frac{d^2N}{d(\cos\theta_1)d(\cos\theta_2)}=\frac{1}{4}(1-A\alpha_1\alpha_2\cos\theta_1\cos\theta_2)$$

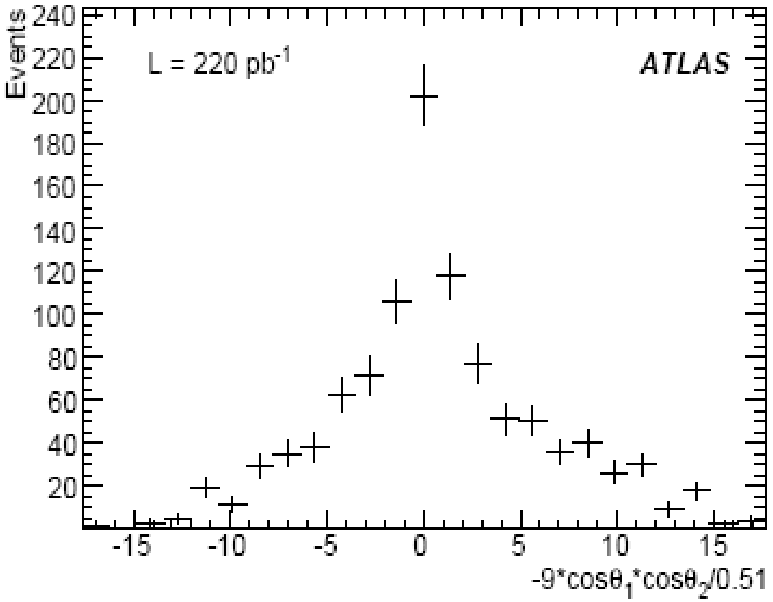
Angle between t($\bar{t}$) and spin analysers

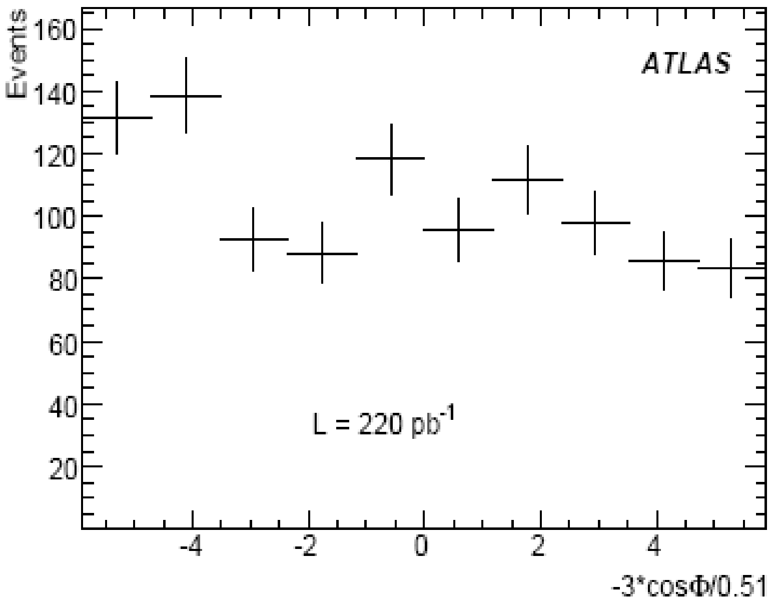
$$\frac{1}{N}\frac{dN}{d\cos\Phi}=\frac{1}{2}(1-A_D\alpha_1\alpha_2\cos\Phi)$$





tt spin correlation MC results
---in semileptonic decay channel

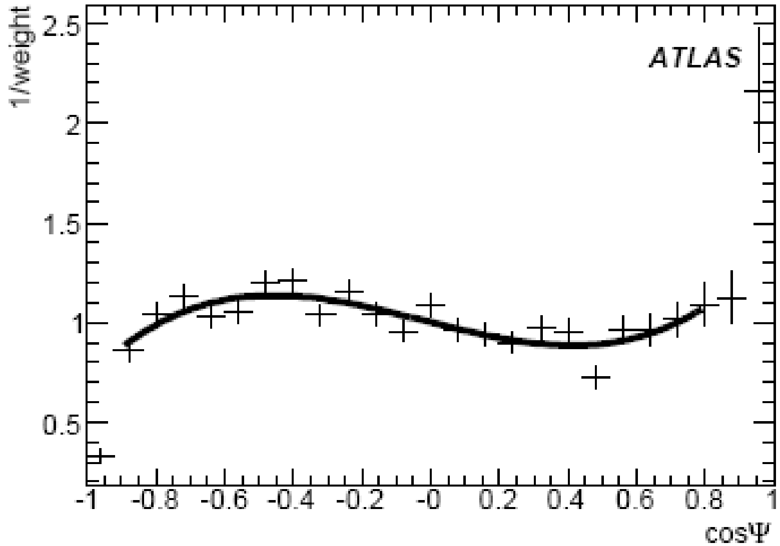


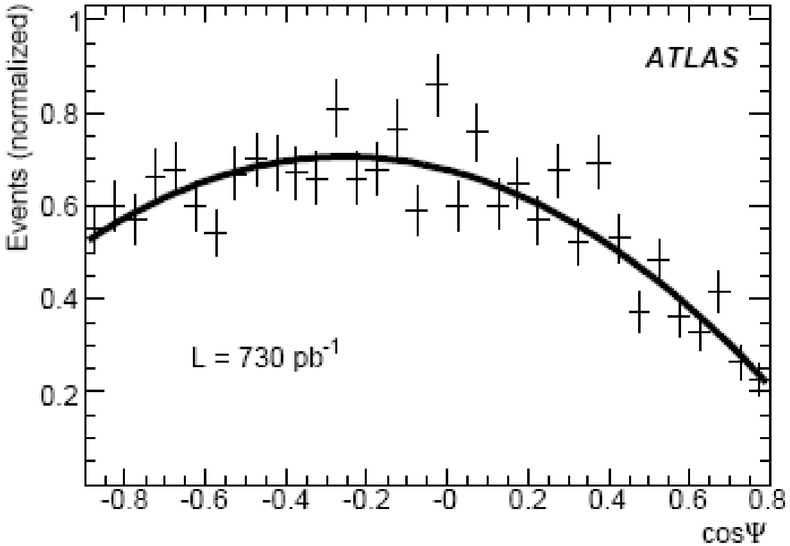


$A = 0.67 \pm 0.34$ (stat+sys)

$A_D = -0.40 \pm 0.14$ (stat+sys)

W polarizaiton MC result
---in semileptonic decay channel

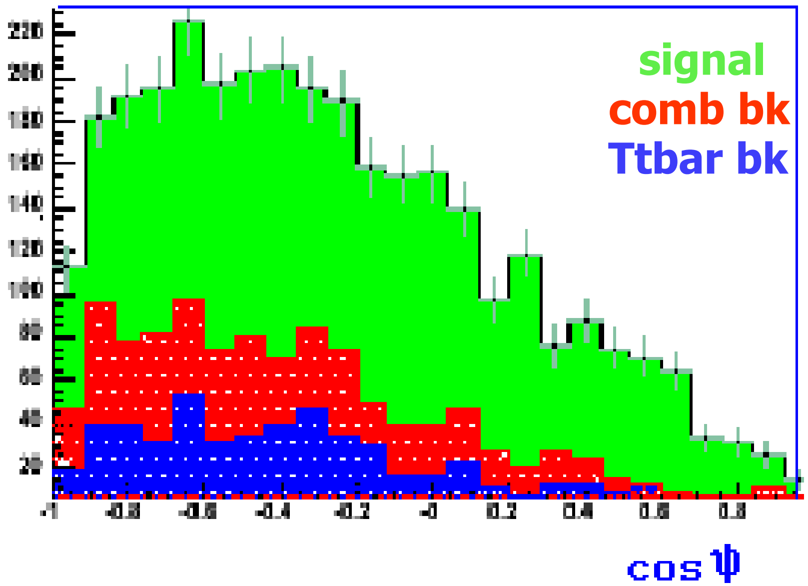




$F_L = 0.29 \pm 0.02 \pm 0.03$ $F_0 = 0.70 \pm 0.04 \pm 0.02$ $F_R = 0.01 \pm 0.02 \pm 0.02$

MC Analysis results
---in dileptonic decay channel

Other background negligible



- Measurement：
  - F_0= 0.709±0.044
  - F_L= 0.297±0.026
  - F_R= -0.005±0.027
  - A =0.490 ±0.228
  - A_D=-0.347 ±0.157

Main systematics

---in dileptonic decay channel

	F_0	F_L	F_R	A	A_D
b tagging efficiency(5%)	0.063	0.040	0.022	$\pm$0.231	$\pm$0.121
b jet energy scale(3%)	0.039	0.051	0.023	$\pm$0.161	$\pm$0.115
backgrounds uncertainty(5%)	0.007	0.002	0.002	$\pm$0.006	$\pm$0.006
Input top mass(5GeV)	0.011	0.026	0.014		

Summary

1. The works under the cooperation between ACC and In2p3 are going well

- VLE electron energy linearity study
- Electron studies (timing, id, …)
- Photon Identification
- B tagging study
- W and top polarization analysis

2. With these preparation works in the close cooperation, a fast understanding and physics extraction in early data is foreseen.