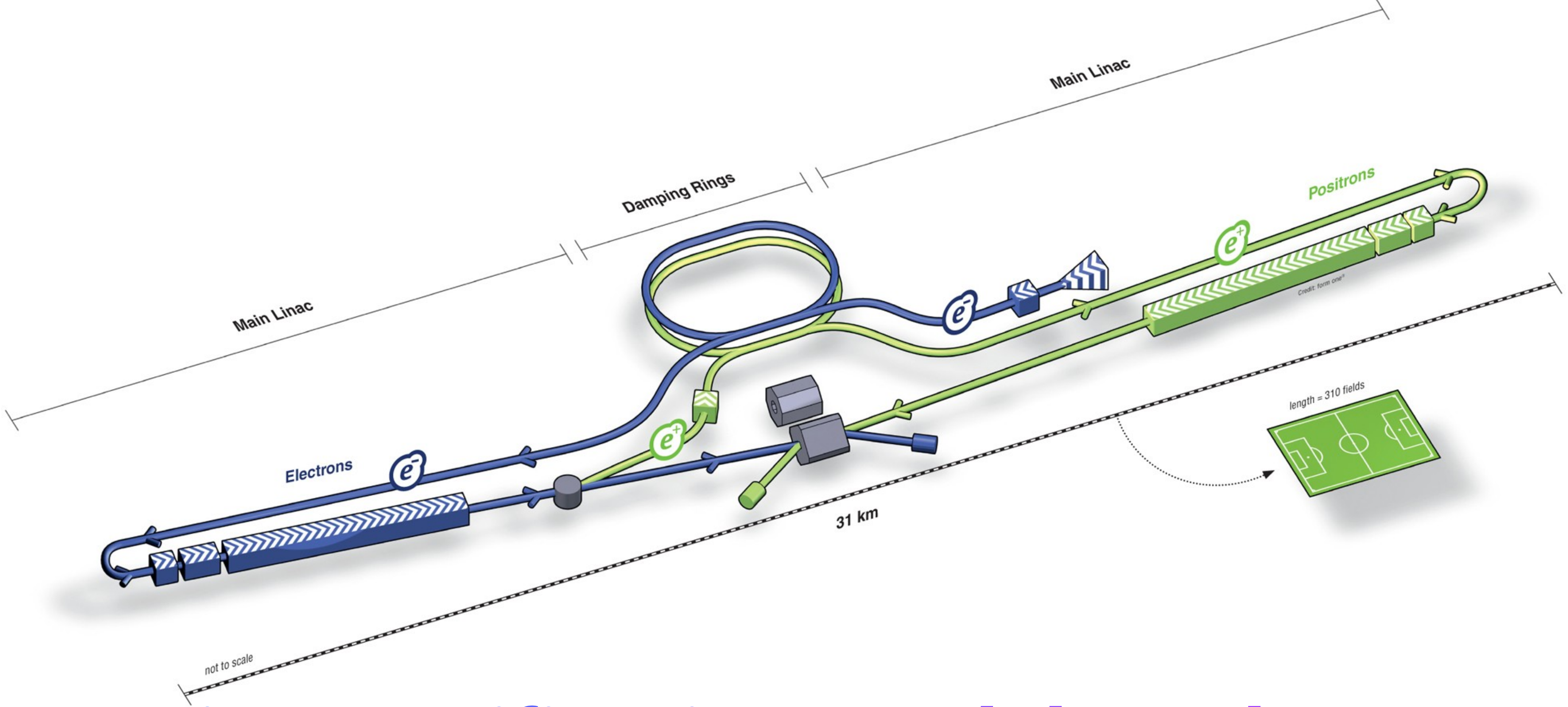

NEW

Probing Gauge-Higgs Unification models at the ILC with AFB at center-of-mass energies above the Z-mass

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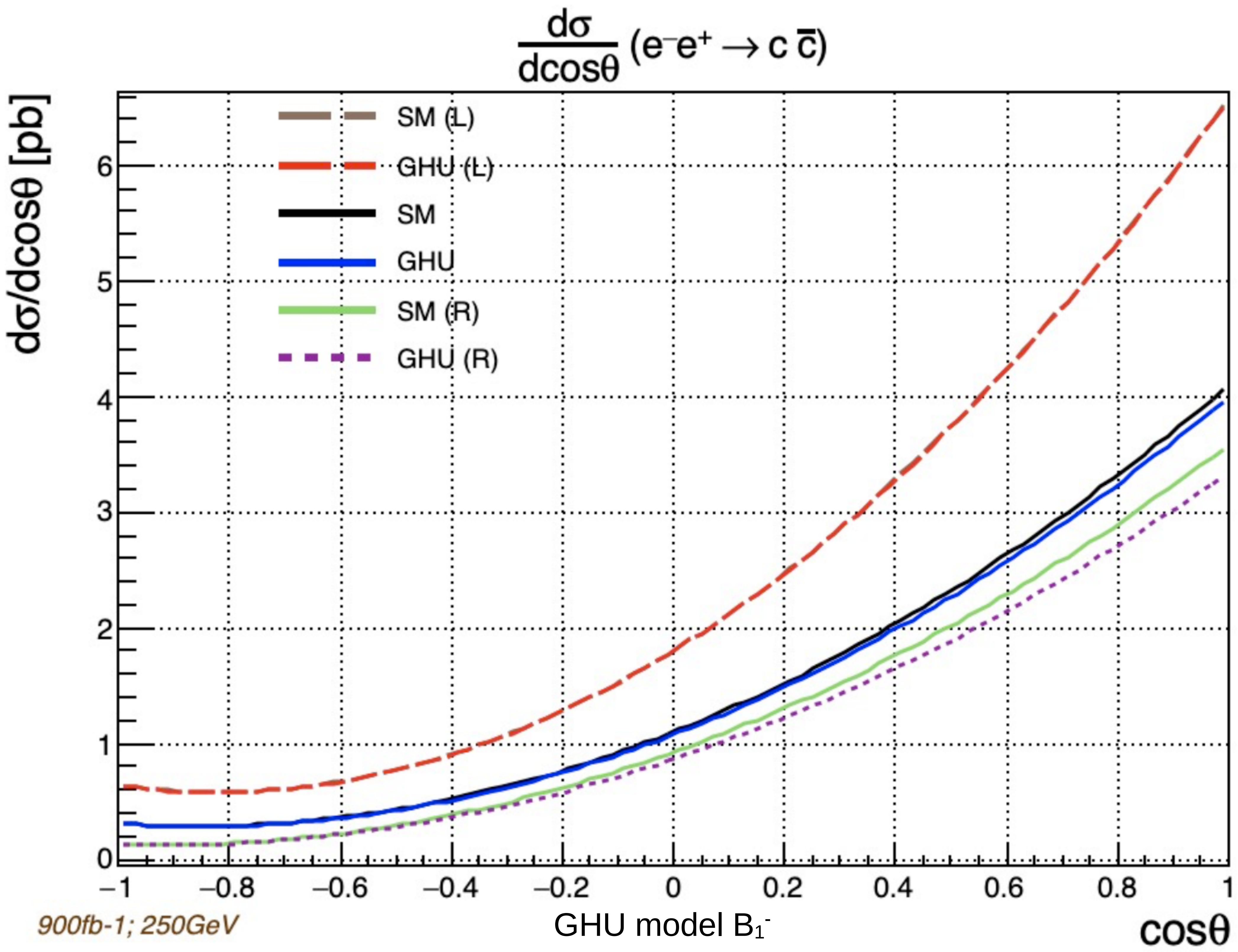
On behalf of the ILC International Development Team Physics and Detector Working Group

Gauge-Higgs Unification



- 5D metric
  - Introducing the Hosotani symmetry breaking mechanism
- Models have only one parameter:
  - **Hosotani angle θ_H:** projection of 5D fields
- **Prediction**:
  - Kaluza-Klein Resonances → Z' bosons $m_{Z'} > 7$ TeV
  - **Modifications of electroweak couplings**
  - Deviations visible at 250 GeV CME
- **Benchmark** scenario:
  - Funatsu, Hatanaka, Hosotani, Orikasa, Yamatsu GHU models

Studied Models

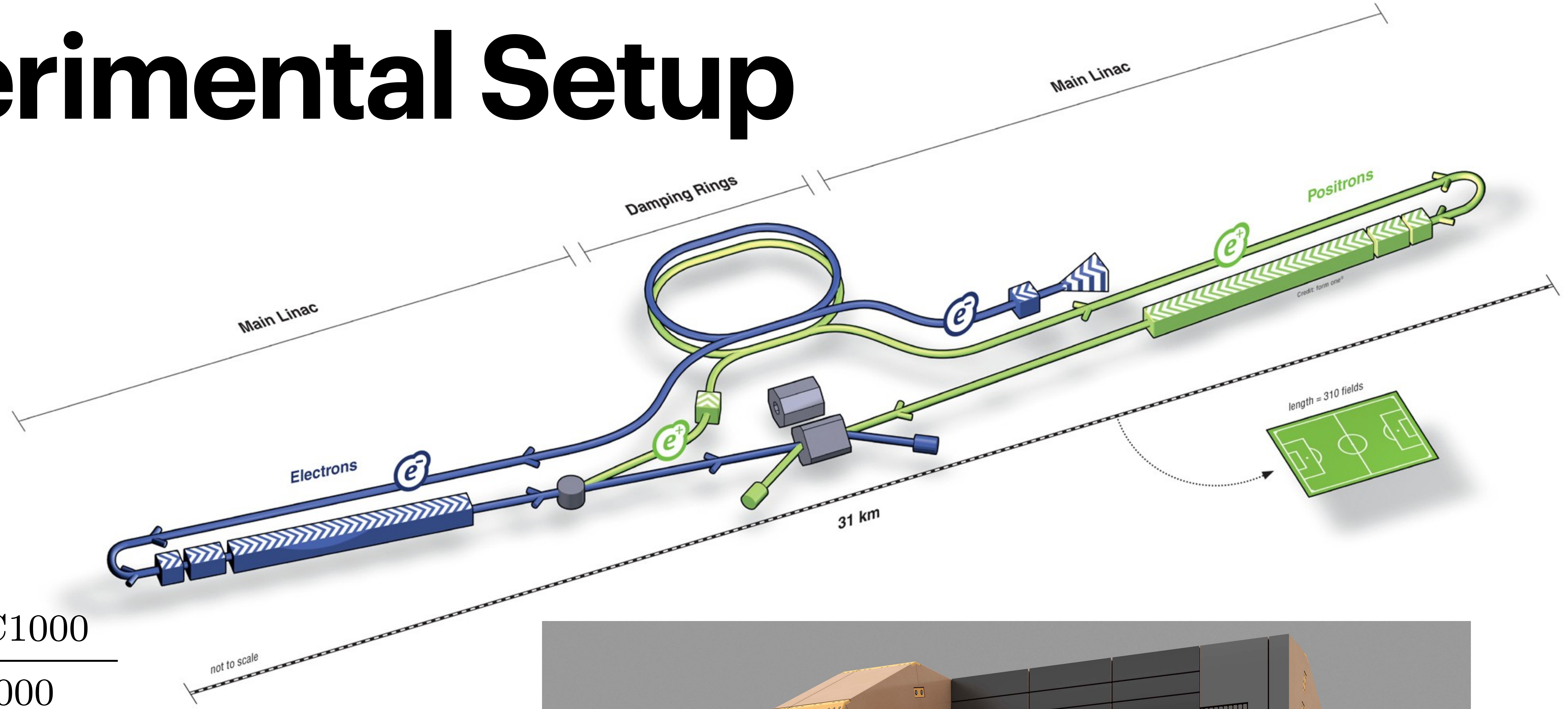
- **A-Models**: 1705.05282

$$A_1 : \theta_H = 0.0917, m_{KK} = 8.81 \text{ TeV} \rightarrow \boxed{m_{Z^1} = 7.19 \text{ TeV}}$$
$$A_2 : \theta_H = 0.0737, m_{KK} = 10.3 \text{ TeV} \rightarrow \boxed{m_{Z^1} = 8.52 \text{ TeV}}$$

- **B-Models**: 2309.01132, 2301.07833

$$B_1^{\pm}: \theta_H = 0.10, m_{KK} = 13 \text{ TeV} \rightarrow \boxed{m_{Z^1} = 10.2 \text{ TeV}}$$
$$B_2^{\pm}: \theta_H = 0.07, m_{KK} = 19 \text{ TeV} \rightarrow \boxed{m_{Z^1} = 14.9 \text{ TeV}}$$
$$B_3^{\pm}: \theta_H = 0.05, m_{KK} = 25 \text{ TeV} \rightarrow \boxed{m_{Z^1} = 19.6 \text{ TeV}}$$

Experimental Setup

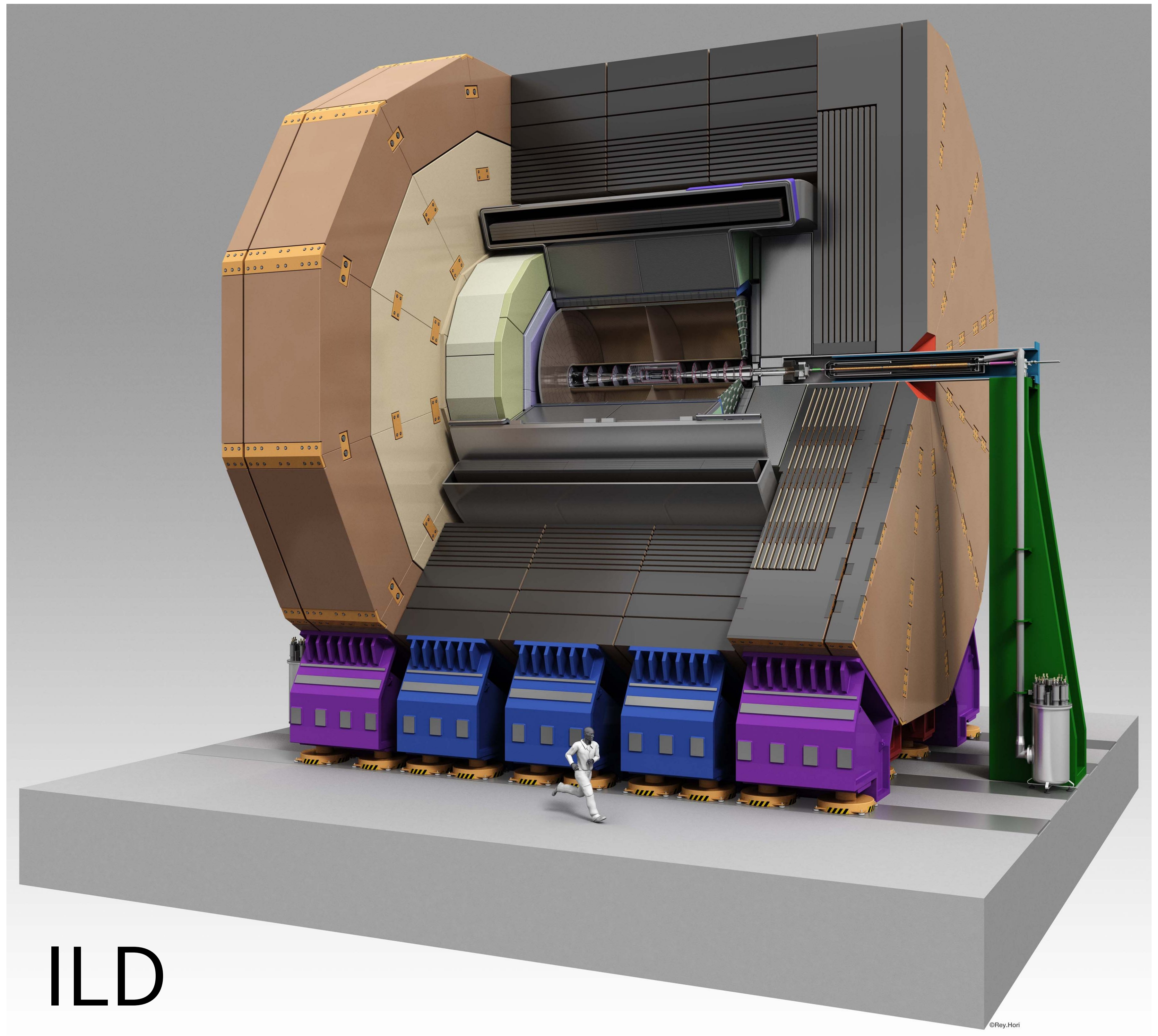


Assuming **H20-staged program**

	ILCGigaZ	ILC250	ILC500	ILC1000
$\int \mathcal{L}\ [fb^{-1}]$	100	2000	4000	8000
$(\lvert P_{e^-}\rvert, \lvert P_{e^+}\rvert)$	(0.8,0.3)	(0.8,0.3)	(0.8,0.3)	(0.8,0.2)
OSP|SSP [%]	40|10	45|5	40|10	40|10

International Linear Detector (ILD)

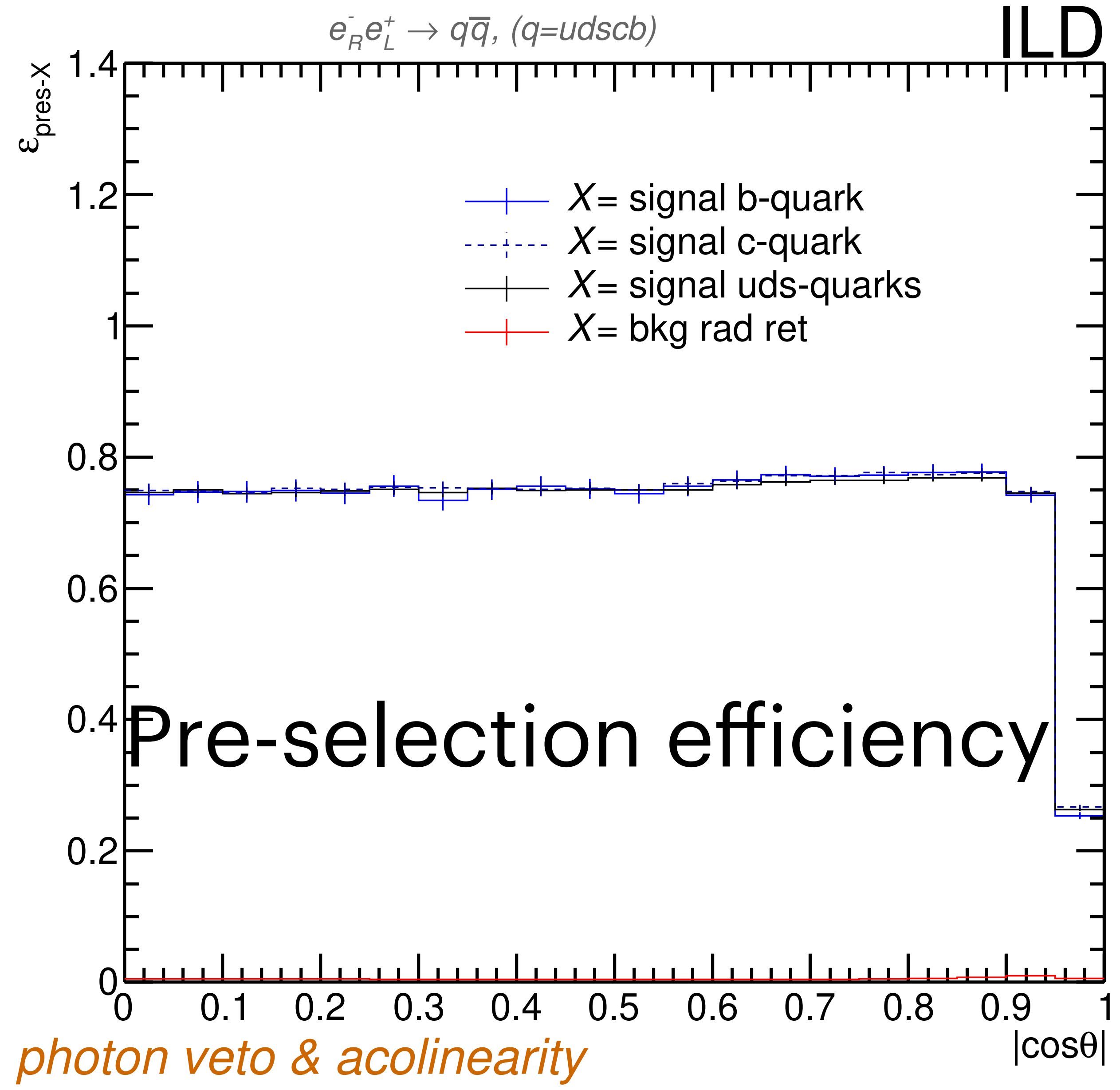
- Optimised for **Particle Flow**
- Precise tracking, vertexing, and PID



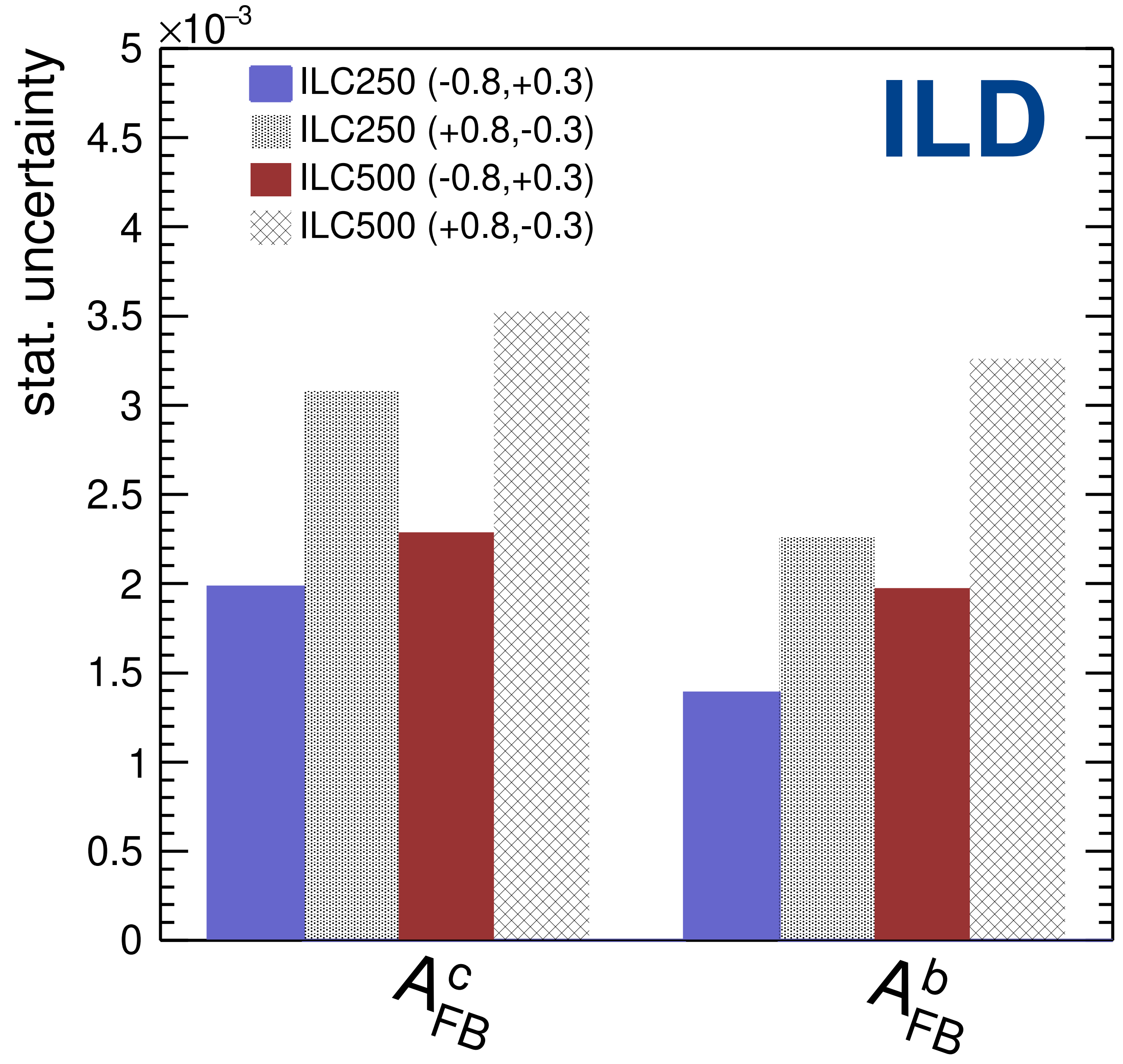
Analysis Strategy

[2306.11413]

- **Observable**: Forward-backward asymmetry
  - Two back-to-back **c- or b-jets** $$\frac{dN}{d\cos\theta} = \mathcal{L}\left[\varepsilon_{pre}\varepsilon_{DTC}\frac{d\sigma}{d\cos\theta} + \varepsilon_{bkg}\frac{d\sigma_{bkg}}{d\cos\theta}\right]$$
  - **Full simulation** of International Large Detector (ILD)
- General Strategy:
  - **Pre-selection**: background suppression
  - **Jet-Flavor ID**
    - Double Tag: reduce flavor tag unc.
  - **Jet-Charge**:
    - Double charge + data-driven correction
  - Compare measurements to GHU
- Estimated stat. unc. in permille region
  - ***What about systematic uncertainties?***



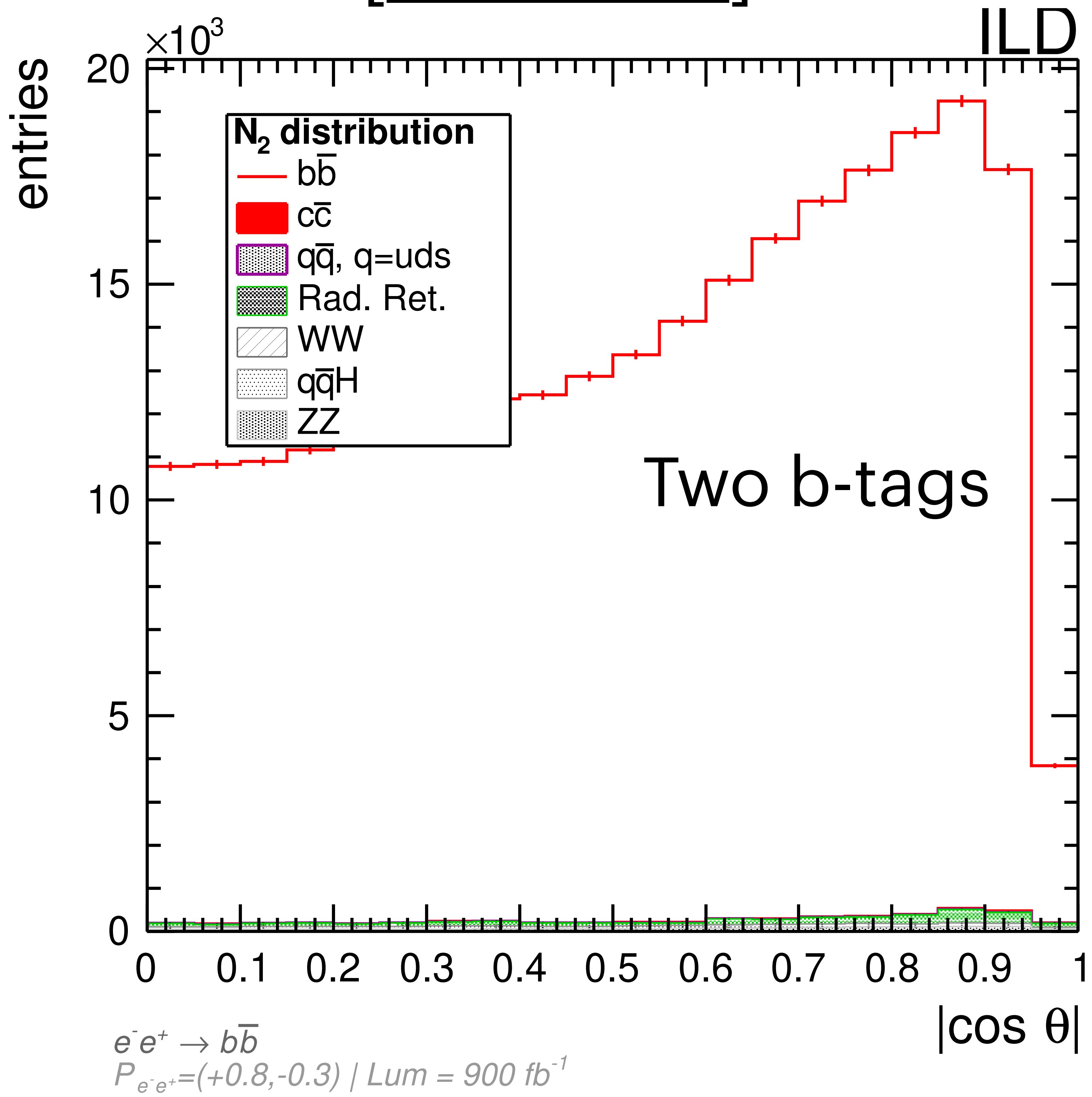
photon veto & acolinearity & m_{jj} & y_{23} cuts



Double Tag Method

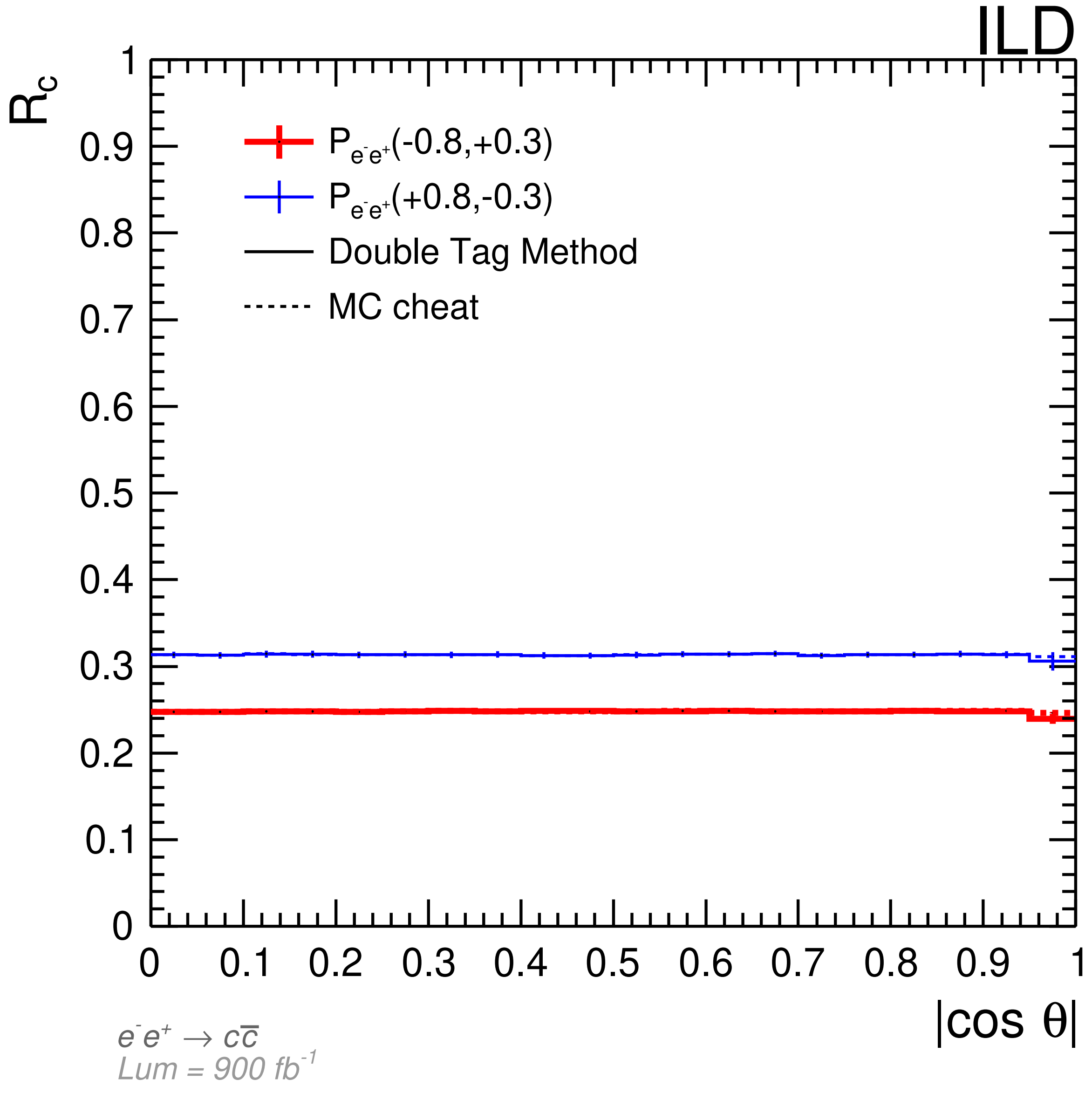
[2306.11413]

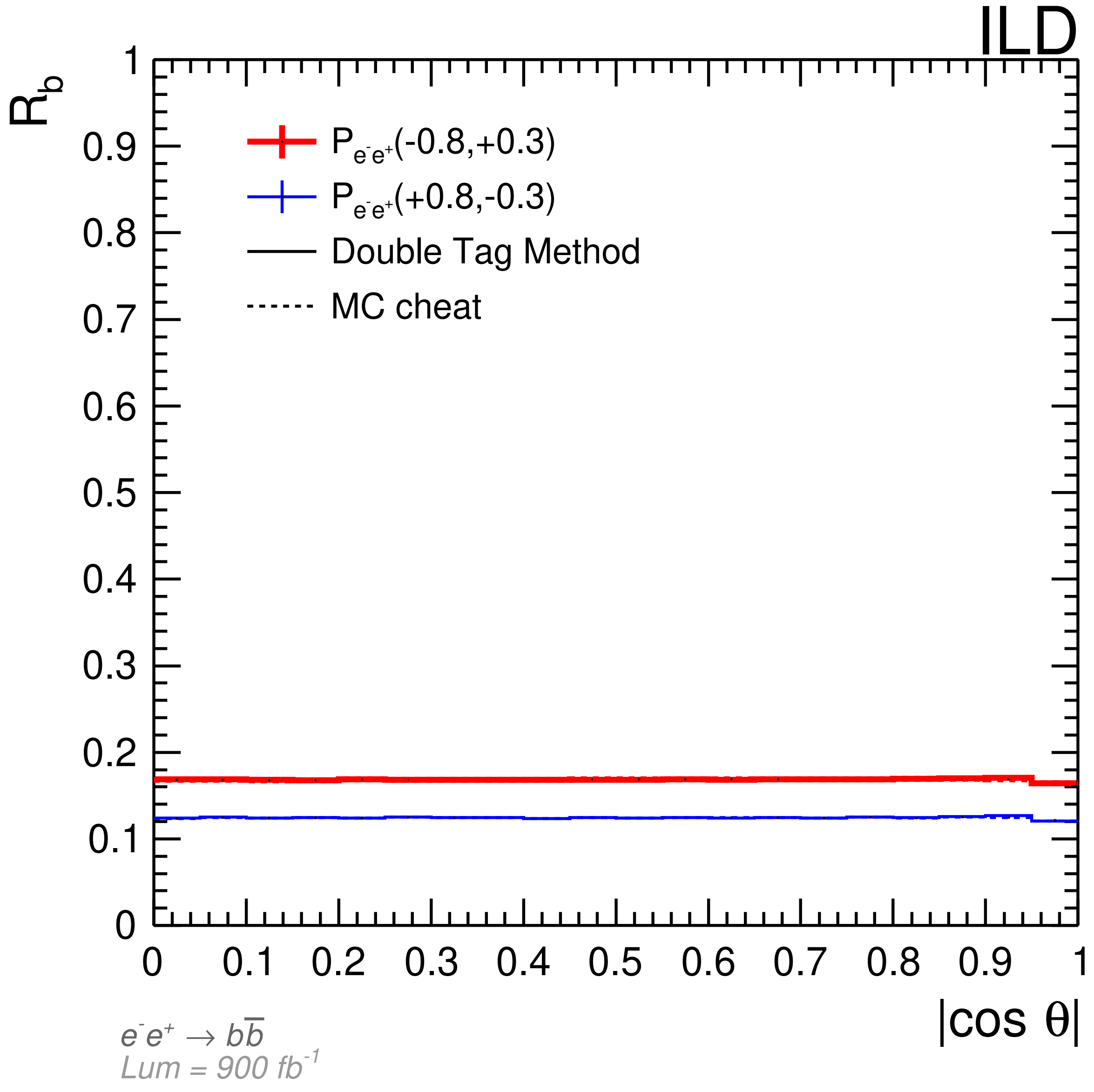
- **Pre-selection + Flavor tagging**:
  - Background free and pure flavor sample
- **Flavor tagging efficiency**:
  - Data-driven measurement
  - Construct ratios f_{1q}, f_{2q} for 1 and 2 tag selections
  - Measure hadronic cross-section fraction R_c, R_b
  - **Reduces uncertainty** due to MC modelling



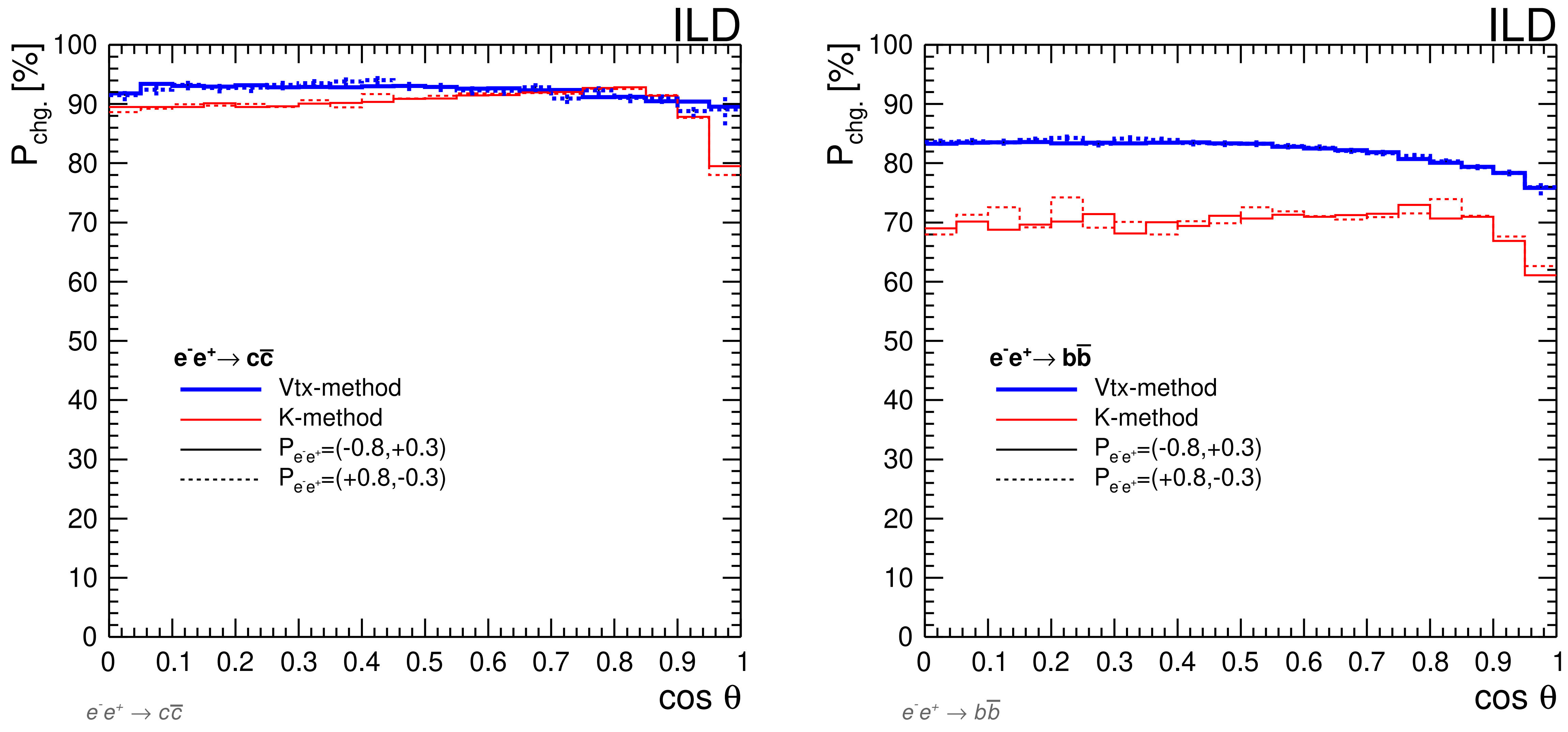
$$f_{1q}(|\cos\theta|) = \frac{N_q(|\cos\theta|) - N_q^{bkg.}(|\cos\theta|)}{2 \times (N_0(|\cos\theta|) - N_0^{bkg.}(|\cos\theta|))}$$

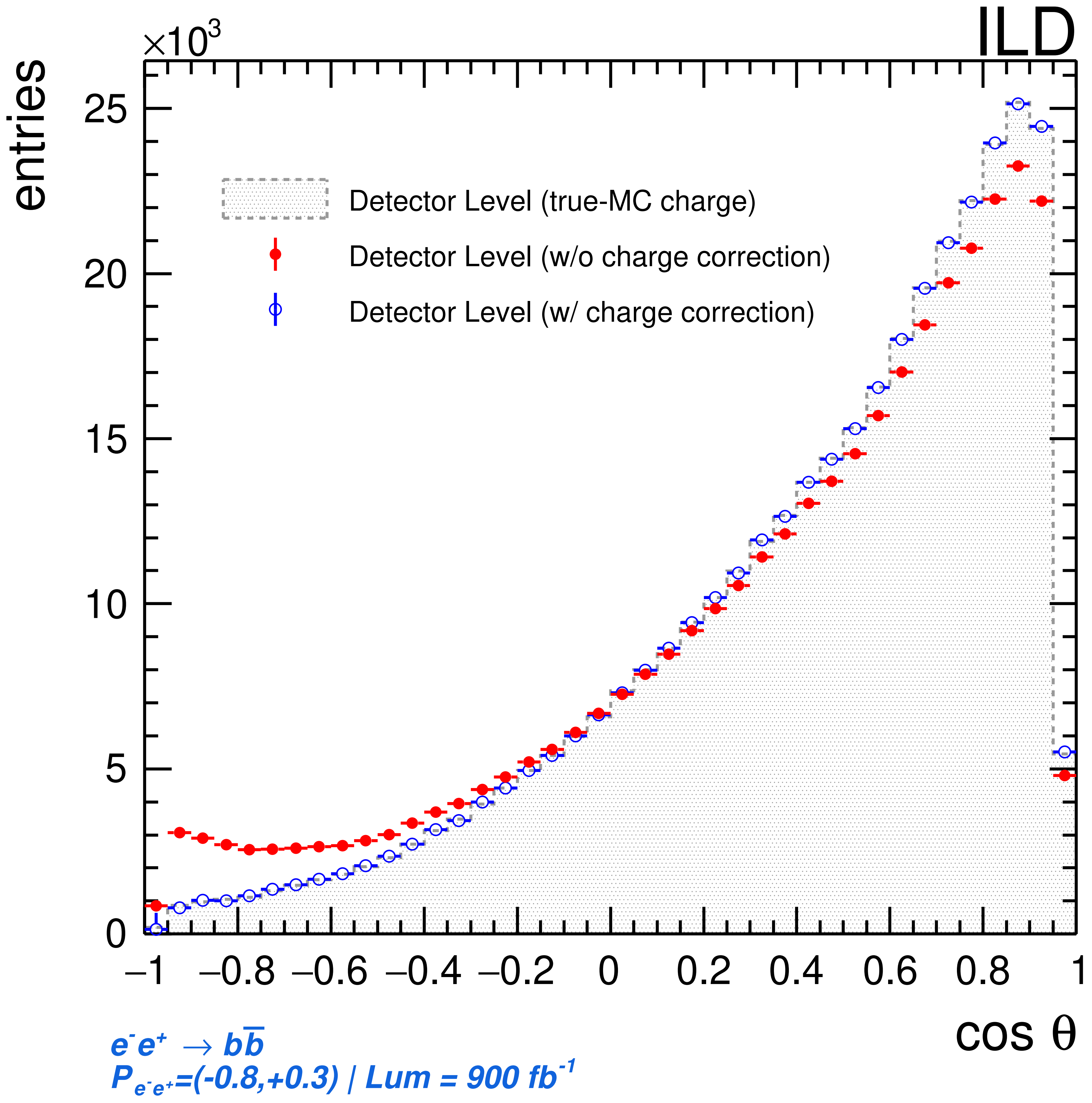
$$f_{2q}(\cos\theta) = \frac{N_{2q}(|\cos\theta|) - N_{2q}^{bkg.}(|\cos\theta|)}{N_0(|\cos\theta|) - N_0^{bkg.}(|\cos\theta|)}$$





Double Charge Method





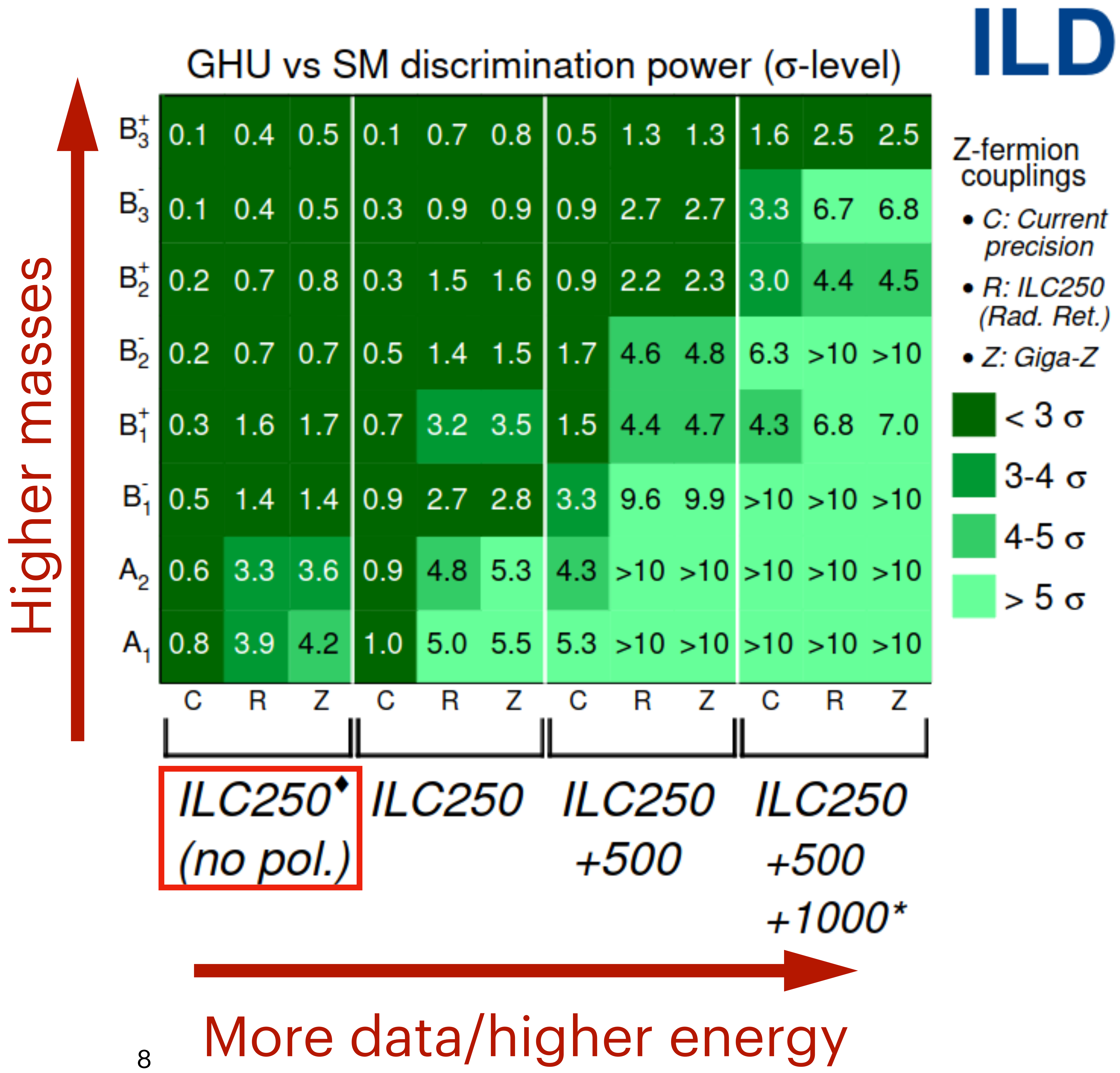
- **Data-driven method** reduces MC modelling dependence
- **K-ID** or full **Vtx** charge for measurement
- Measure probability to estimate jet-charge correctly P_{chg}
  - Apply migration correction

Results: GHU vs SM Discrimination

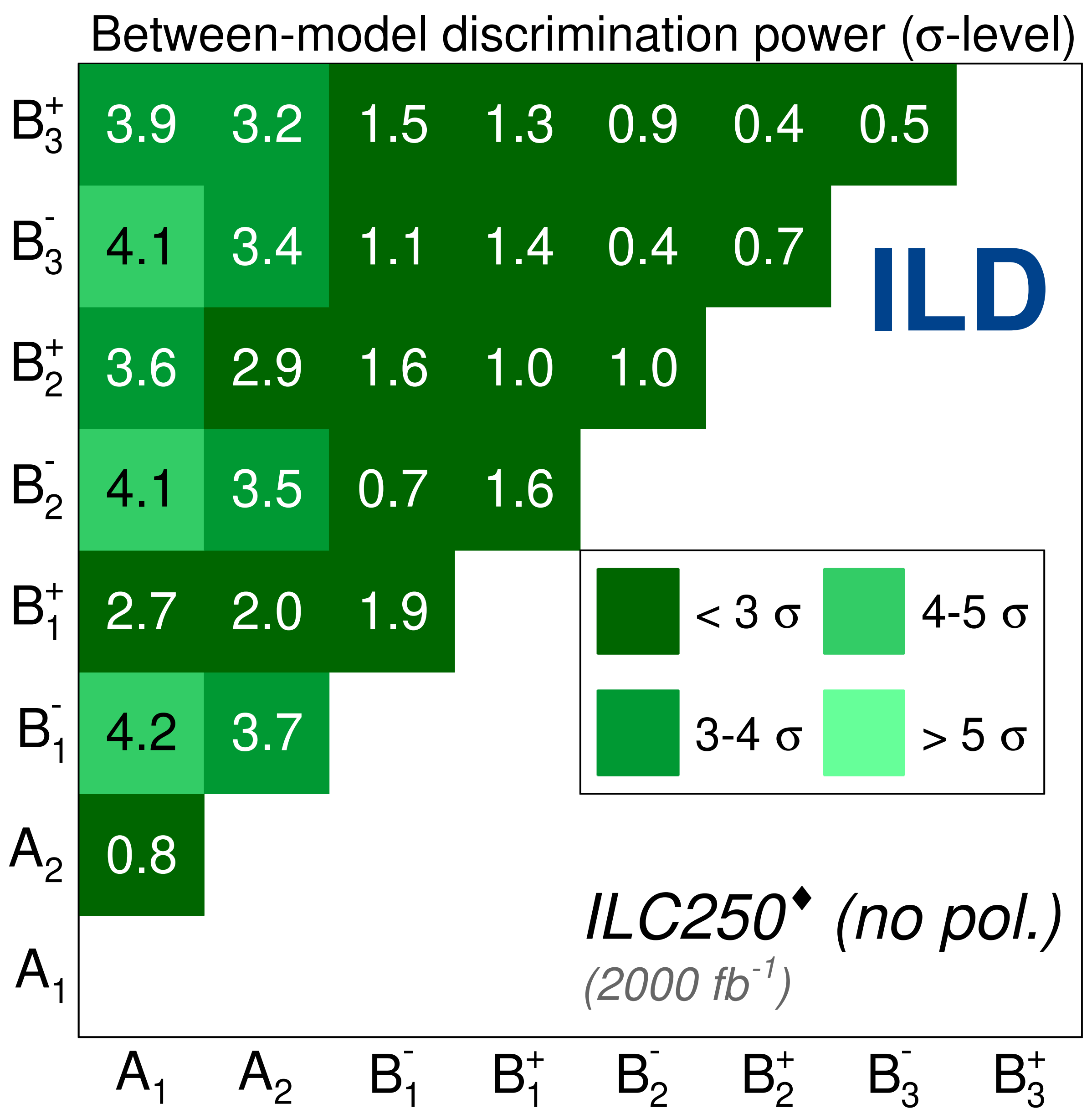
- **Statistical significance**

$$d_{ij} = \frac{|A_{FB,i} - A_{FB,j}|}{\Delta A_{FB,j}}$$

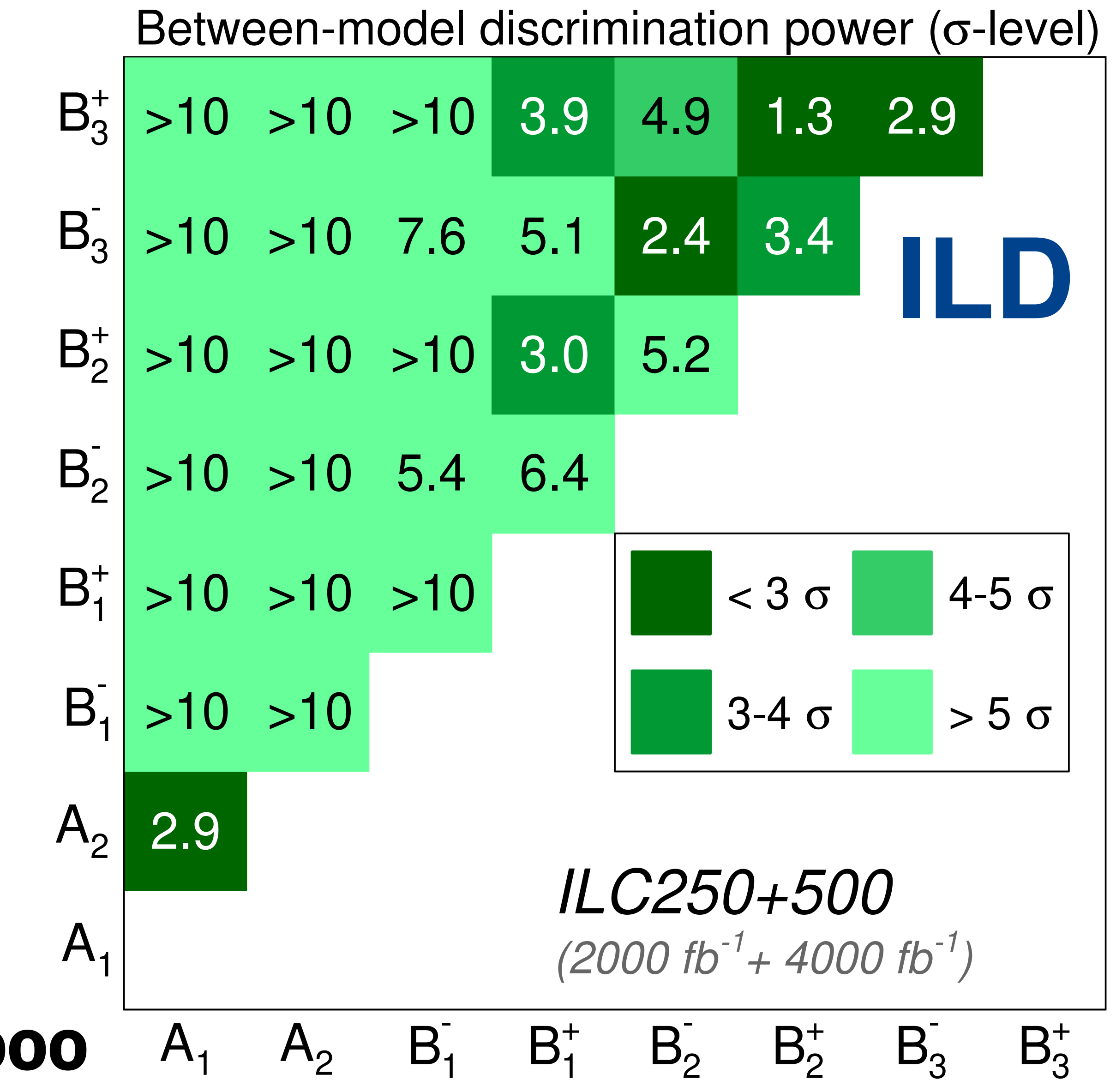
- Assuming normally distributed uncertainties
- **Multivariate Gaussian** used for combination
  - No correlations between measurements assumed
- **Three scenarios**:
  - Current coupling precision
  - ILC250 precision
  - ILC Giga-Z

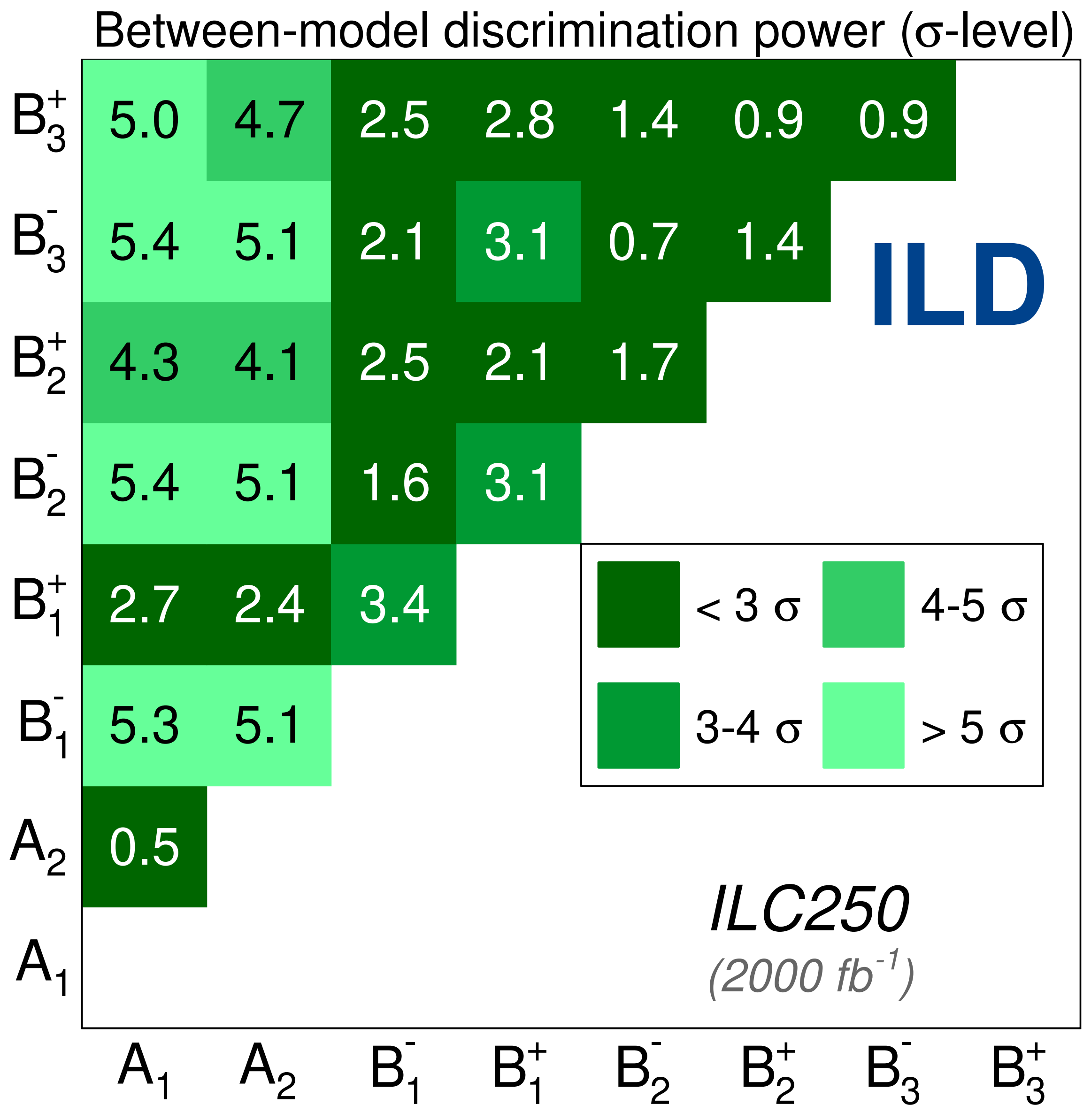


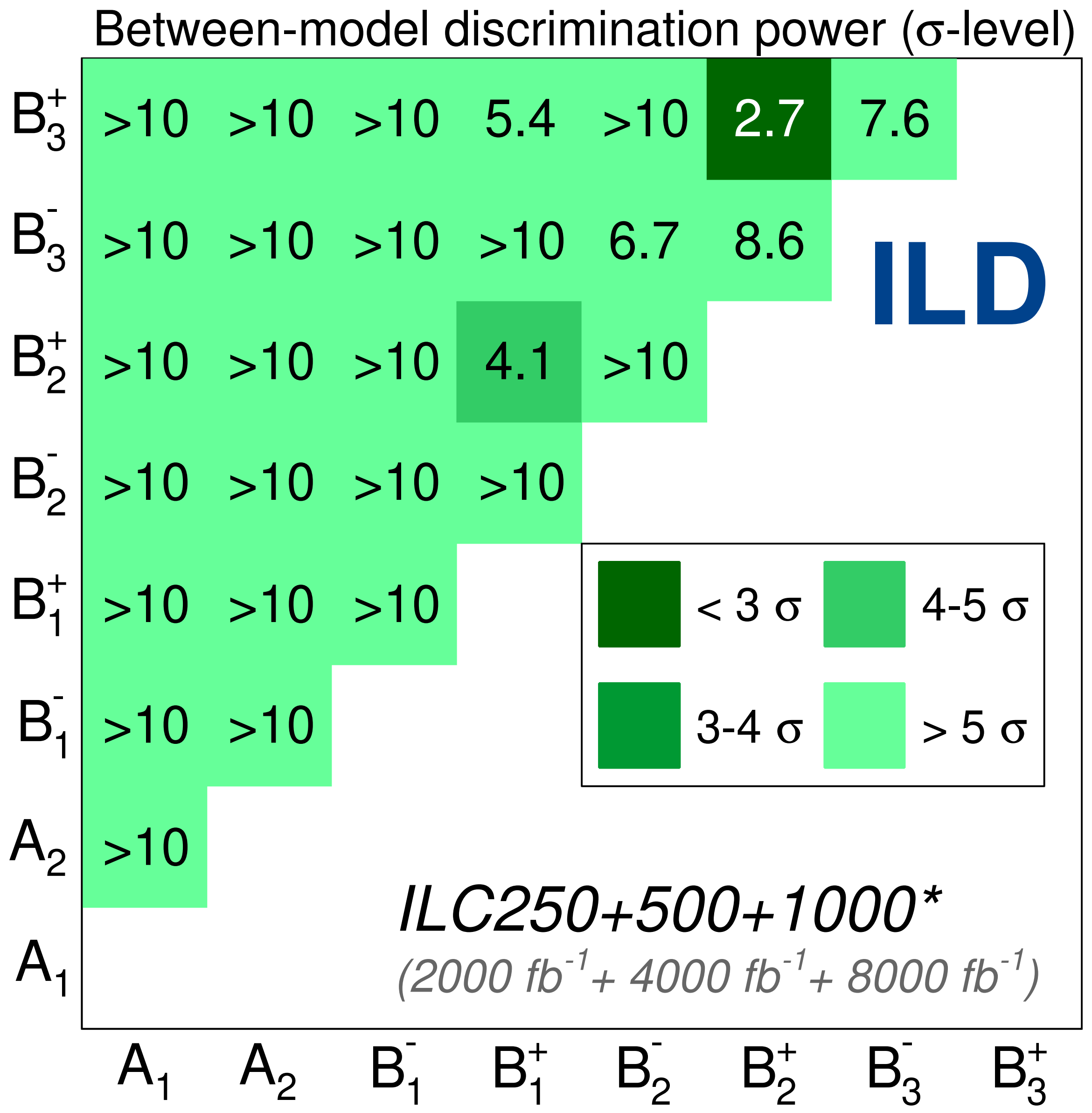
Results: GHU vs GHU Discrimination



- **Beam polarisation** enables discrimination already at 250 GeV
- **Almost all models can be discriminated with ILC250+500+1000**







Conclusion

- The International Linear Collider offers a clean environment for BSM searches
- International Large Detector has excellent PID and vertexing capabilities
- Presented a **benchmark BSM search** at ILC
- **Expected statistical uncertainties are on permille level**
- Experimental uncertainties can be minimised through data-driven methods
- Measurements can lead to **observations or exclusion** of physics way above the energy reach of the collider
- Discrimination between models is also achievable

BACKUP