2024年度考核
CEPC 上的物理/高性能重建

阮曼奇

Outline

- Paper & Funding
- Physics Studies: White Papers, etc
  - *Spare a small fraction of time look into BES data (tautau events)*
- High-light-1: Jet origin identification, etc
- High-light-2: 1-1 corresponding reconstruction
- International collaboration, Challenges

文章 & 基金

2023

2023.1. EPJC (2023) 83:93 Cluster time measurement with CEPC calorimeter
2023.9 NIMA (1056 (2023) 168656): A conceptual design of TOF based on MRPC technology for the future electron–positron Higgs factory
2023.9 CPC (Vol. 47, No. 12 (2023) 123002), Measurement of the effective weak mixing angle at the CEPC
2023.10 Optics Express Vol.31, No. 24/20 Nov 2023, Relativistic-guided stable mode of few-cycle 20 μm level infrared radiation
2023.11 NIMA 1059 (2024) 168944, GSHCAL at future e+e− Higgs factories

2024

2024.2 EPJC (2024) 84:152, ParticleNet and its application on CEPC jet flavor tagging
2024.4 JHEP 05 (2024) 210, Jet charge identification in the e+e− → Z → qq process at Z pole
2024.5. RPL 132, 221802 (2024) Jet-Origin Identification and Its Application at an Electron-Positron Higgs Factory
2024.8. EPJC (2024) 84:859, Prospect for measurement of the CP-violating phase φs in the Bs → J/ψφ channel at a future Z factory

Submitted:

JHEP, Measurement of CKM element |Vcb| from W boson decays at the future Higgs factories
EPJC, Measurement of the effective weak mixing angle using bb, cc and ss final states at the CEPC
Science Bulletin, A Novel Quantum Realization of Jet Clustering in High-Energy Physics Experiments

- 基金
  - 杰青，未中
  - 中赛合作，未中
  - 参与中法合作项目， 400 万
  - 参与 CEPC MOST-4 项目
- 若干杂活

Flavor white paper

Flavor Physics at CEPC: a General Perspective

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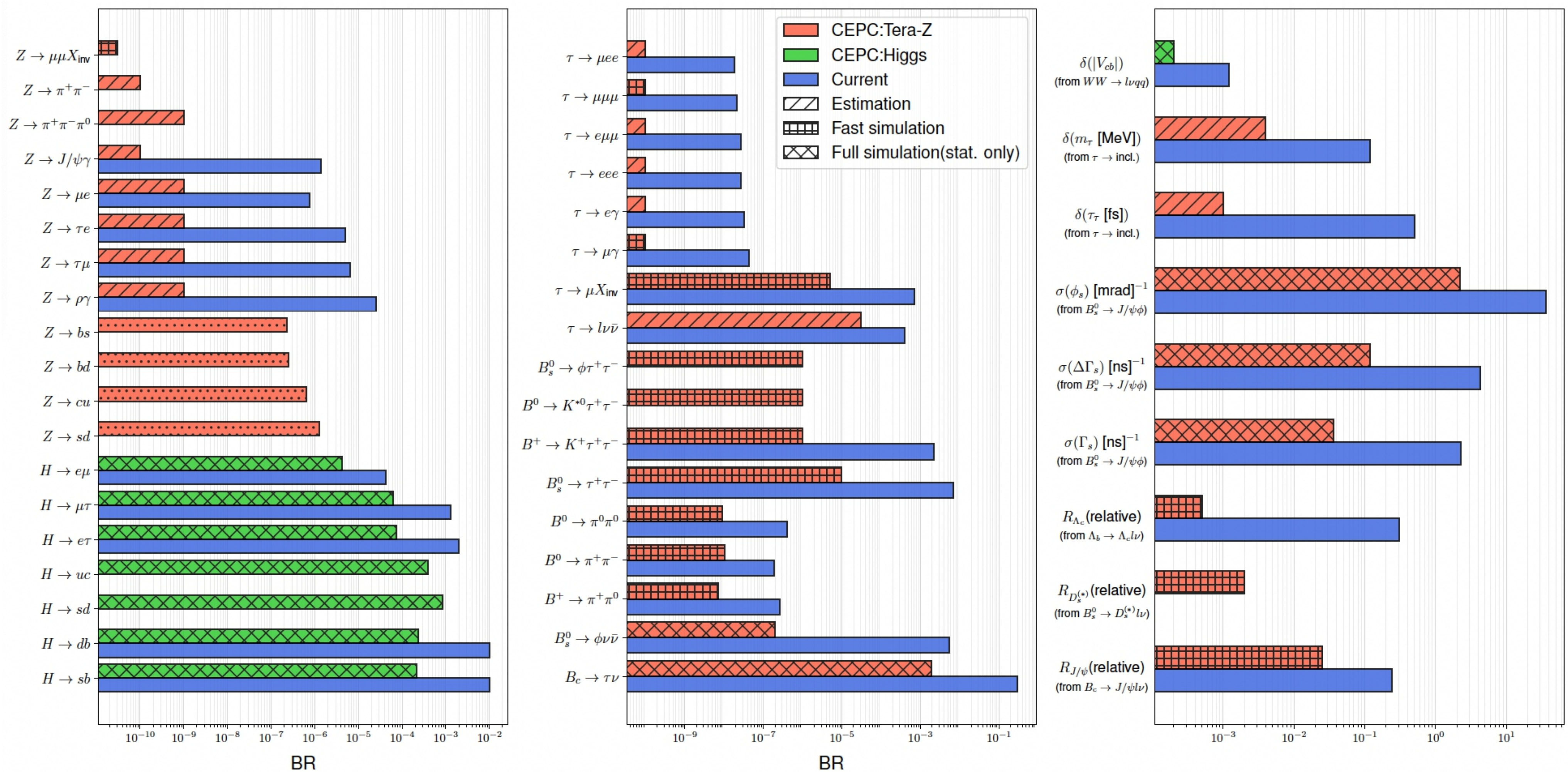
- Main causes of delay:
  - Interference with Ref-TDR studies
  - Echoes from FCC...
- Updates:
  - Benchmark number increased from ~ 20 to ~ 50, especially with Jet Origin ID.
  - Bs-relevant CKM measurements
  - Spectroscope, LFV, LFU
  - ect
- 2 iterations of reviews.

Flavor Physics



See the non-seen: i.e, Bc→tauv, Bs→Phivv

Orders of magnitudes improvements (1 – 2.5 orders...).

Access New Physics with energy scale of 10 TeV, or even above

New Physics white paper

2023

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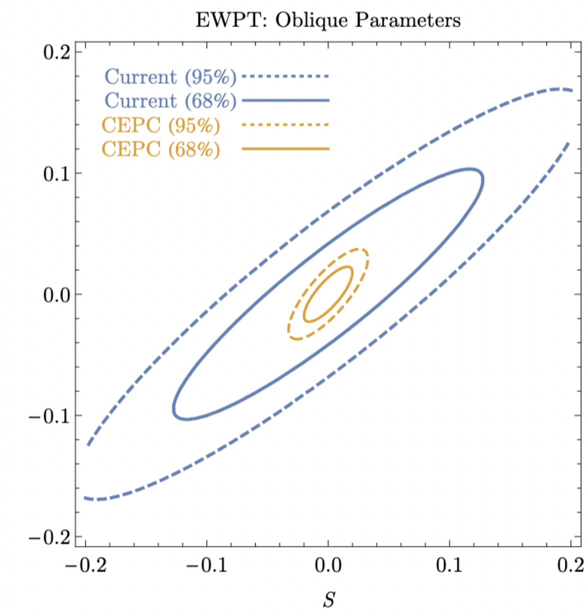
Contents extends from 40 pages → 200 pages...

- Credit: hanhua Cui, Yu Gao, Xuai Zhuang

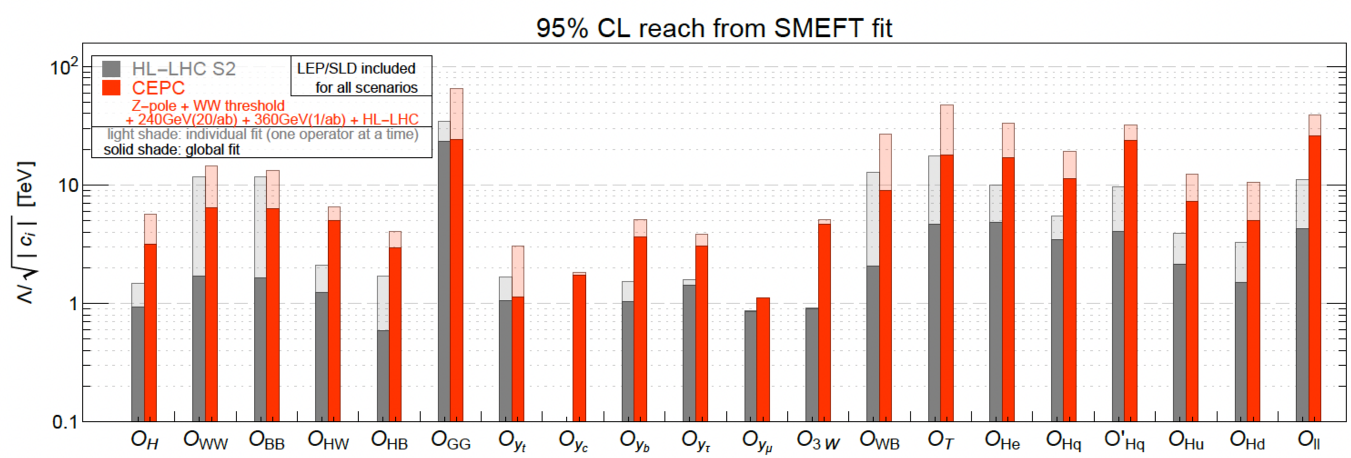
Electroweak white paper

Observable	current precision	CEPC precision (Stat. Unc.)	CEPC runs	main systematic
Δm_Z	2.1 MeV [11-15]	0.1 MeV (0.005 MeV)	Z threshold	E_{beam}
$\Delta\Gamma_Z$	2.3 MeV [11-15]	0.025 MeV (0.005 MeV)	Z threshold	E_{beam}
Δm_W	9 MeV [16-20]	0.5 MeV (0.35 MeV)	WW threshold	E_{beam}
$\Delta\Gamma_W$	49 MeV [20-23]	2.0 MeV (1.8 MeV)	WW threshold	E_{beam}
Δm_t	0.76 GeV [24]	$\mathcal{O}(10)$ MeV[1]	$t\bar{t}$ threshold	
ΔA_e	4.9×10^{-3} [11, 25-29]	1.5×10^{-5} (1.5×10^{-5})	Z pole ($Z \to \tau\tau$)	Stat. Unc.
ΔA_μ	0.015 [11, 27]	3.5×10^{-5} (3.0×10^{-5})	Z pole ($Z \to \mu\mu$)	point-to-point Unc.
ΔA_τ	4.3×10^{-3} [11, 25-29]	7.0×10^{-5} (1.2×10^{-5})	Z pole ($Z \to \tau\tau$)	tau decay model
ΔA_b	0.02 [11, 30]	20×10^{-5} (3×10^{-5})	Z pole	QCD effects
ΔA_c	0.027 [11, 30]	30×10^{-5} (6×10^{-5})	Z pole	QCD effects
$\Delta\sigma_{had}$	37 pb [11-15]	2 pb (0.05 pb)	Z pole	lumiosity
δR_b^0	0.003 [11, 31-35]	0.0002 (5×10^{-6})	Z pole	gluon splitting
δR_c^0	0.017 [11, 31, 36-39]	0.001 (2×10^{-5})	Z pole	gluon splitting
δR_e^0	0.0012 [11-15]	2×10^{-4} (3×10^{-6})	Z pole	E_{beam} and t channel
δR_μ^0	0.002 [11-15]	1×10^{-4} (3×10^{-6})	Z pole	E_{beam}
δR_τ^0	0.017 [11-15]	1×10^{-4} (3×10^{-6})	Z pole	E_{beam}
δN_ν	0.0025 [11, 40]	2×10^{-4} (3×10^{-5})	ZH run ($\nu\nu\gamma$)	Calo energy scale



Reviewing anticipated Experimental Input,

And to include updated Higgs + top measurements

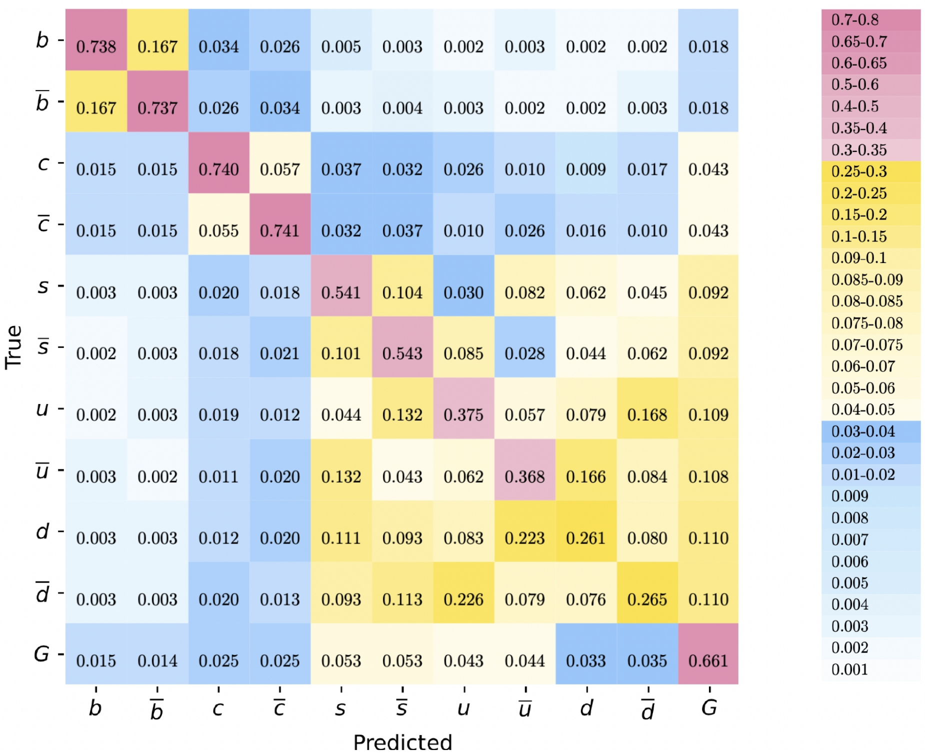


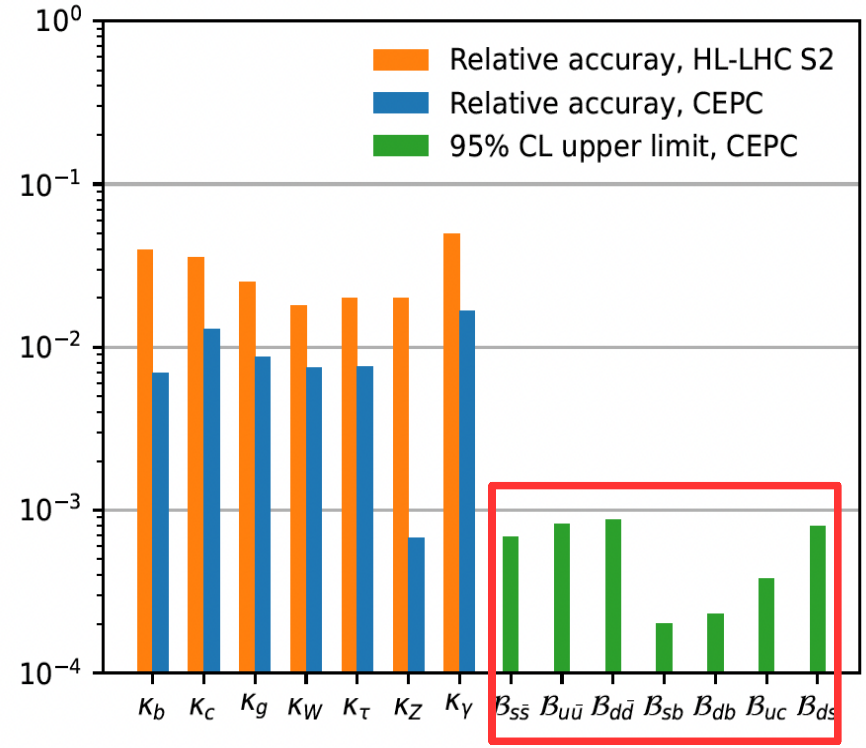
- Credit: Jiayin Gu, etc

Editors, Contributors, & Reviewers

- Flavor: Mature now. Be submitted
  - Main editors: Lingfeng Li (Brown U), TaoLiu (HKUST), Fengkun Guo (ITP), Lorenzo Calibbi (Tianjing U), Xunwu Zuo(KIT)
  - Contributors: Qiangxin Li (CCNU), Qin Qin (Huazhong S&T), Zhihui Guo (XJTU), etc
  - Reviewed by: Soeren Prell (ISU), Andreas Crivellin (Zurich U), Alberto Lusiani (INFN), Haibo Li, Changzheng Yuan, Caidian LV, etc.
- EW: Draft for internal review at end of 2024
  - Main editors: Jiayin Gu (Fudan U), Zhijun Liang (IHEP)
  - Contributors: Yong Du (TD Lee institutes), Zhuoni Qian (HNU), Hulin Zhang (CCNU), etc
- NP: Draft for internal review at end of 2024
  - Main editors: Jia Liu (PKU), Xuai Zhuang(IHEP), Liantao Wang(Chicago U), + Yanyan Gao (Edinburg U), Michael Ramsey-Musolf (TD-Lee)
  - Contributors: Zhen Liu (Minnesota U), Jiayin Gu (Fudan U), Kecheng Wang(WUST), Yongzhao Zhang (SEU), Zhao Li (IHEP), Yu Gao (IHEP), Kepan Xie (SYSU), etc
- QCD: Exploring phase, Many ppl involved in discussion:
  - Huaxing Zhu (PKU), Meng Xiao (ZJU), Jun Gao (SJTU), Zhao Li (IHEP), Yanqing Ma (PKU), Haitao Li(SDU), Yuming Wang(Nankai U), Dingyu Shao (Fudan U), etc

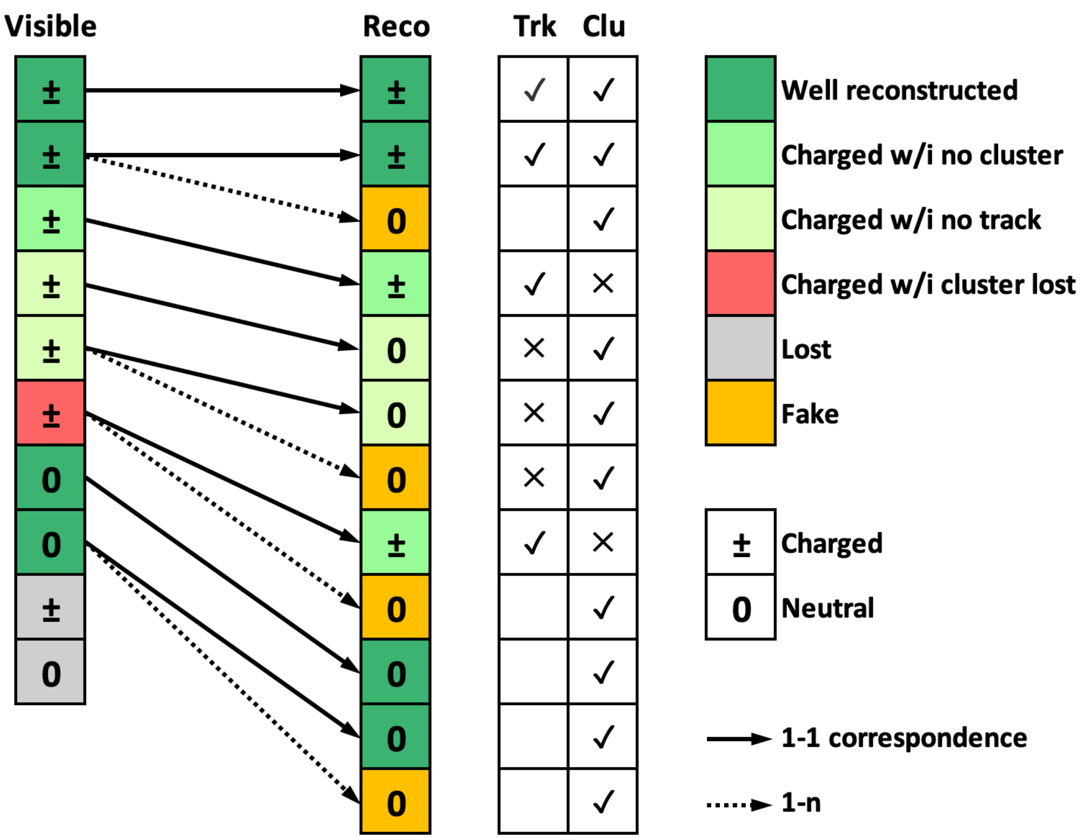
Jet origin id

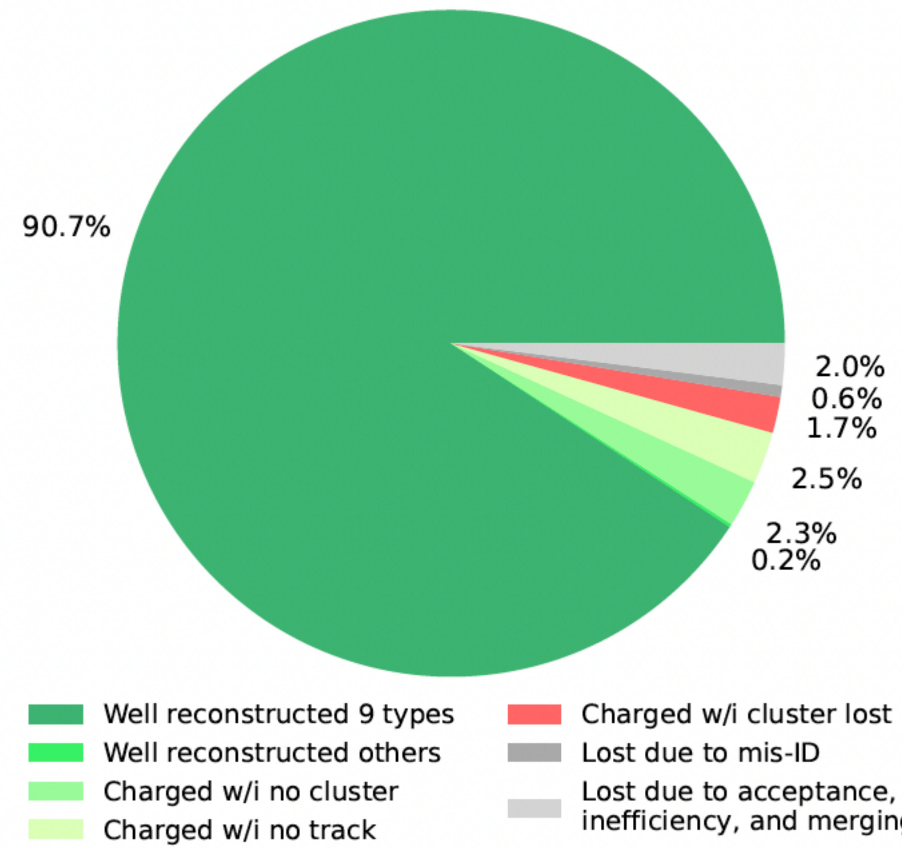




- 11 categories (5 quarks + 5 anti quarks + gluon) identification, realized at Full Simulated di-jet events
- Improves Higgs rare/exotic hadronic decay measurements by 3 time – two orders of magnitudes
- Recent Progress: seeking for application at LHC & with general AI tool (BINBBT)
- Published in PRL. Comment from the referee: *"demonstrate the world-leading performance of tagger", "a "game changer" and opens new horizons for precision flavor studies at all future experiments."*

Propose & realize the concept of 1-1 correspondence

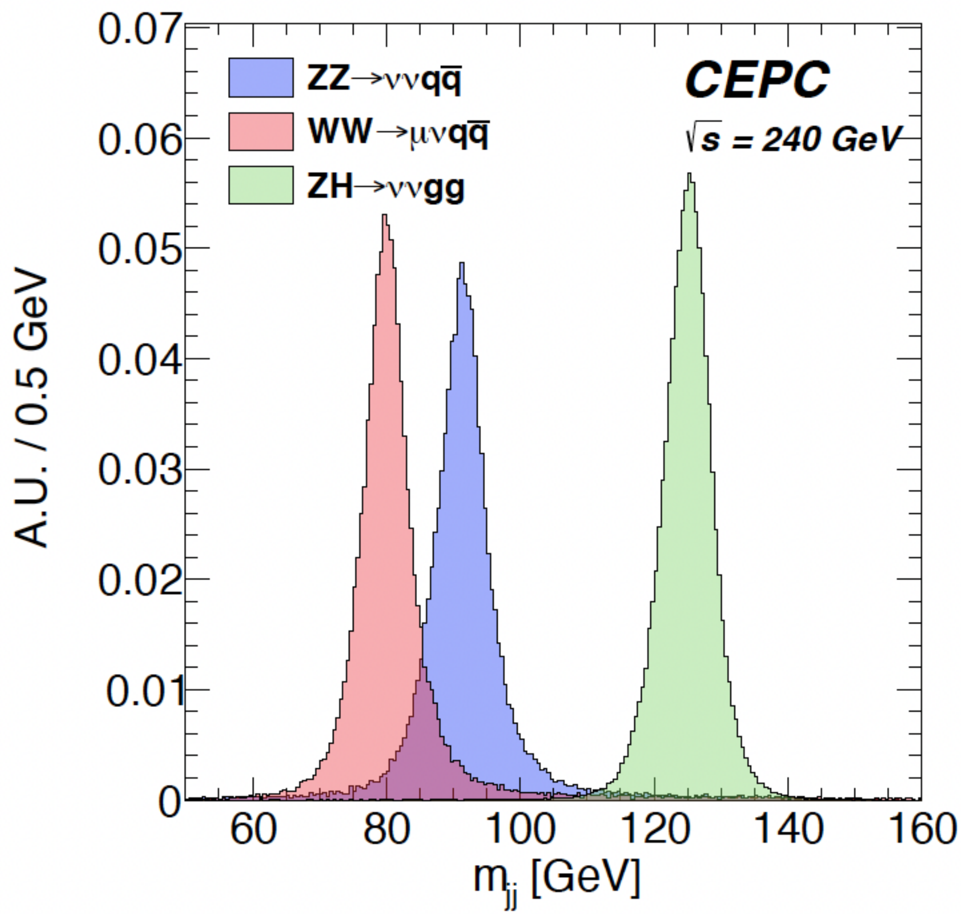


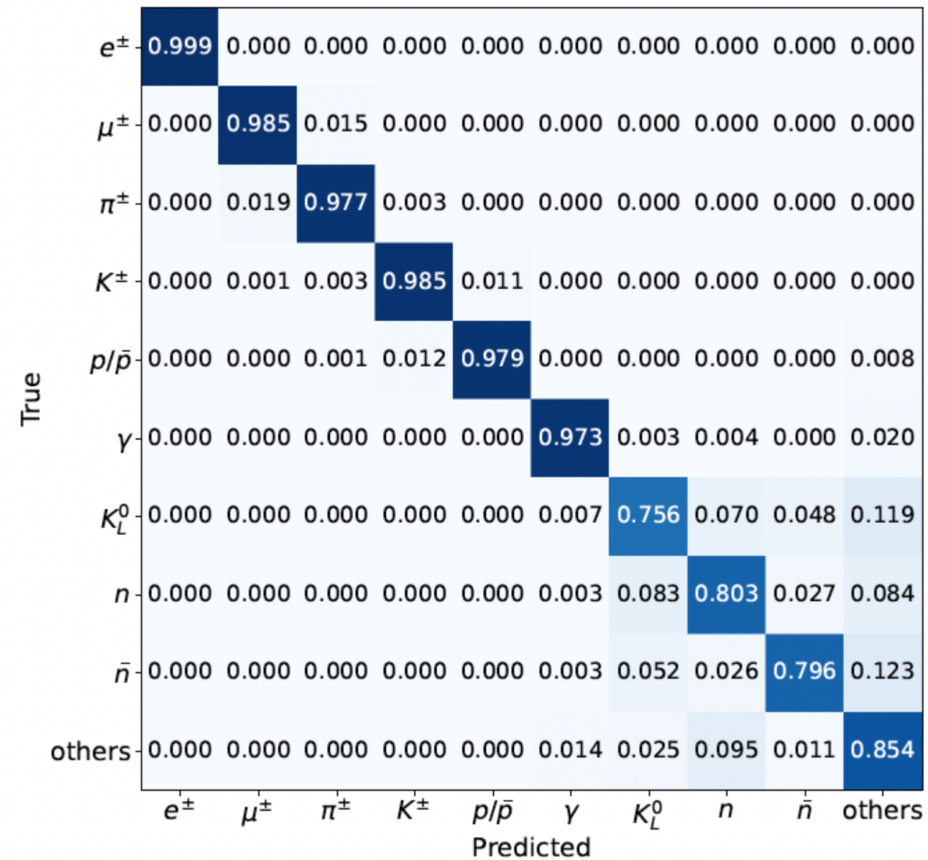


Replace HCAL in CDR baseline with a thick GS-HCAL (5λ → 6λ)

~ 95% of the visible energy is mapped to reco-particle with 1-1 correspondency.
~ 90% are well reconstructed: has the right composition of clusters & tracks.

Excellent PFA + Pid





Detector change: BMR 3.7 → 3.4; AI enhanced reconstruction: 3.4 → 2.8.

~Solved the long standing problem of PFA confusion

Improves the benchmark analysis (Higgs inv, Higgs FCNC hadronic decay) by o(10%) - 2 times

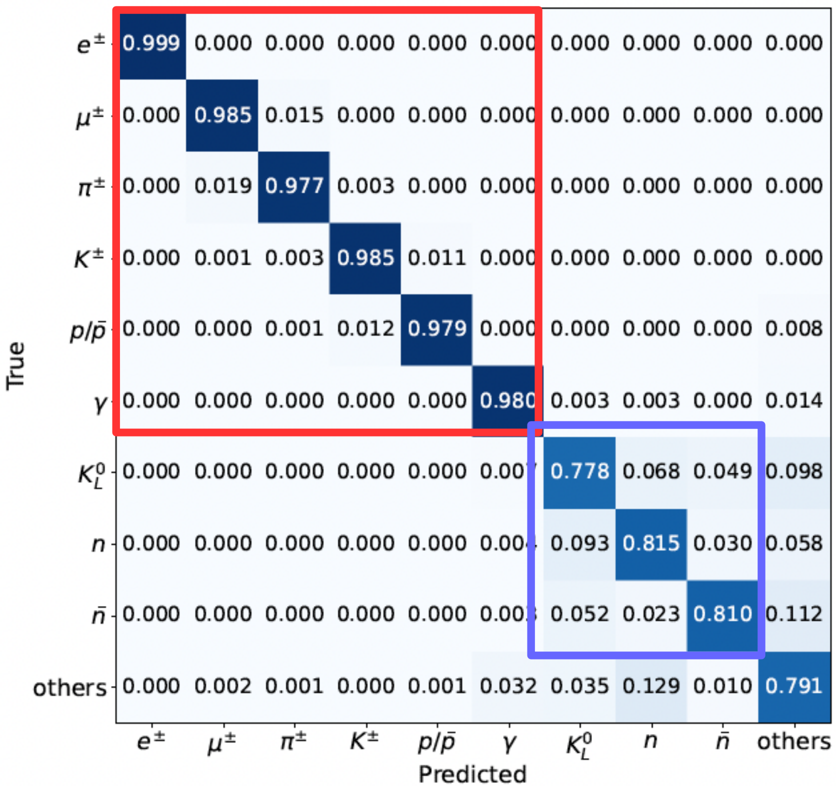
Portal to new methodology for physics analysis and monitoring – systematic control

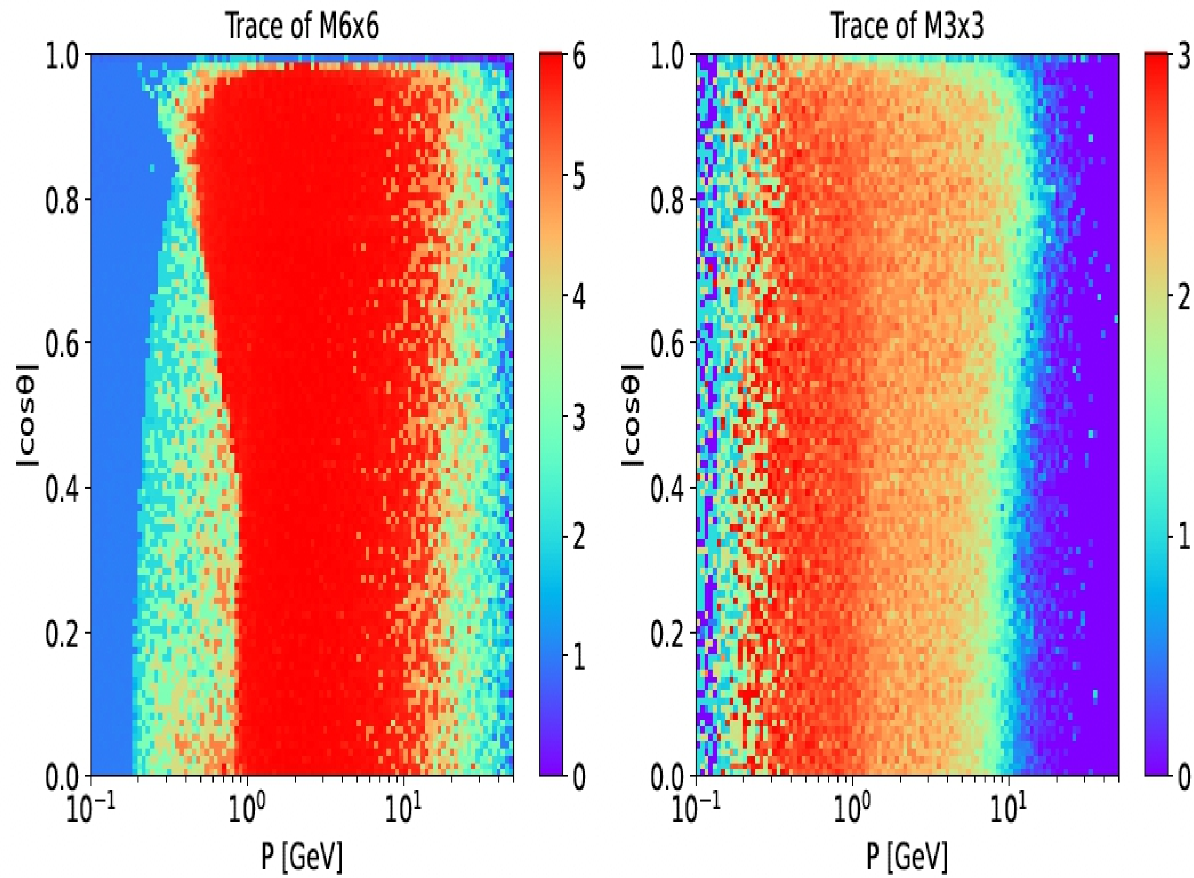
International activities & challenges

- Participate in Europe & Japan Strategy discussion
- IAC member for VCI 2025
- Short of resource. Solution:
  - Innovation
  - Communication
  - Collaboration

Back up

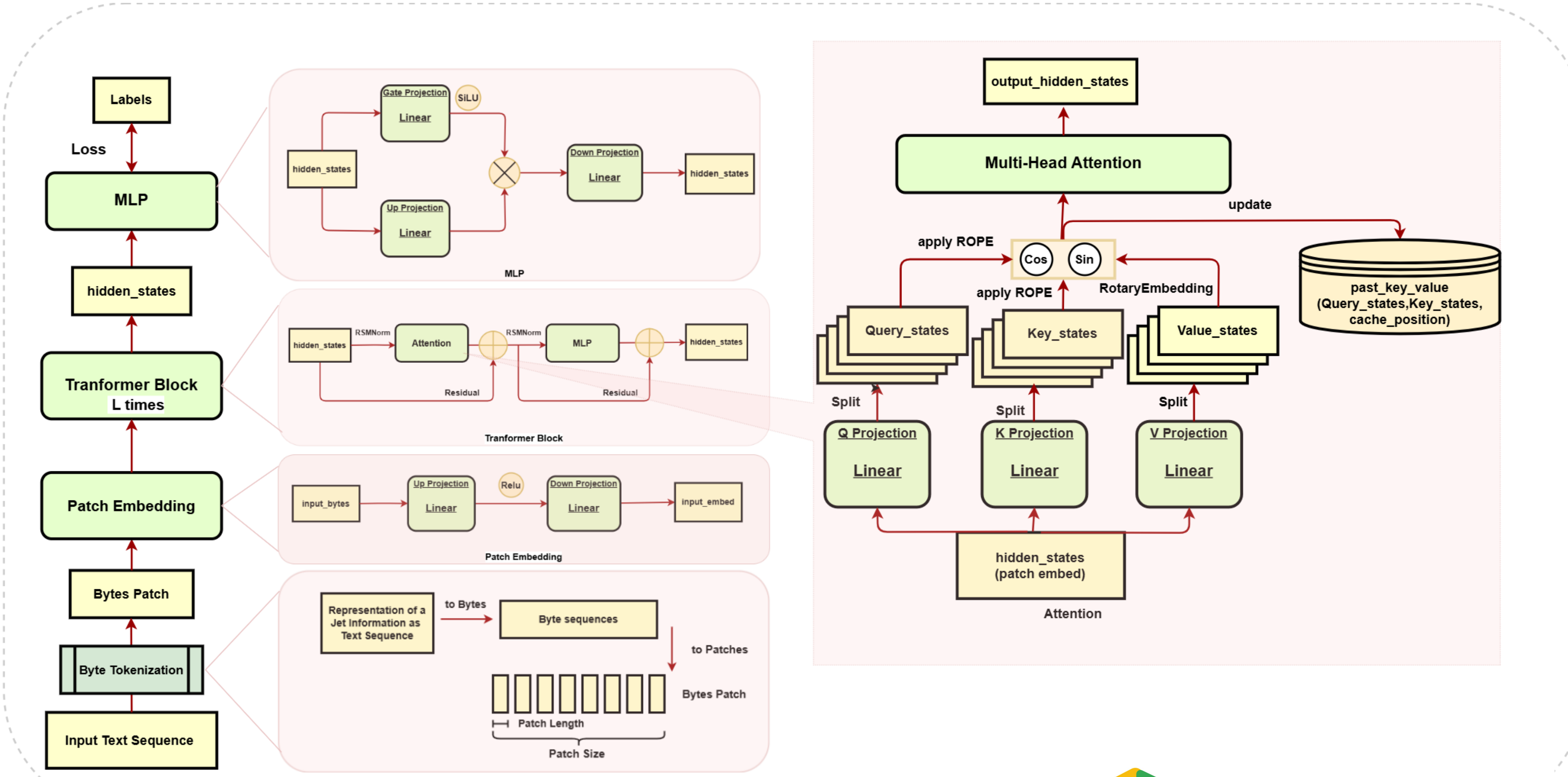
Pid in the 'well reconstructed' particles category





'well reconstructed' = reconstructed particle with no confusion + both track + cluster for charged reconstructed particle
~ > 90% of total visible energy

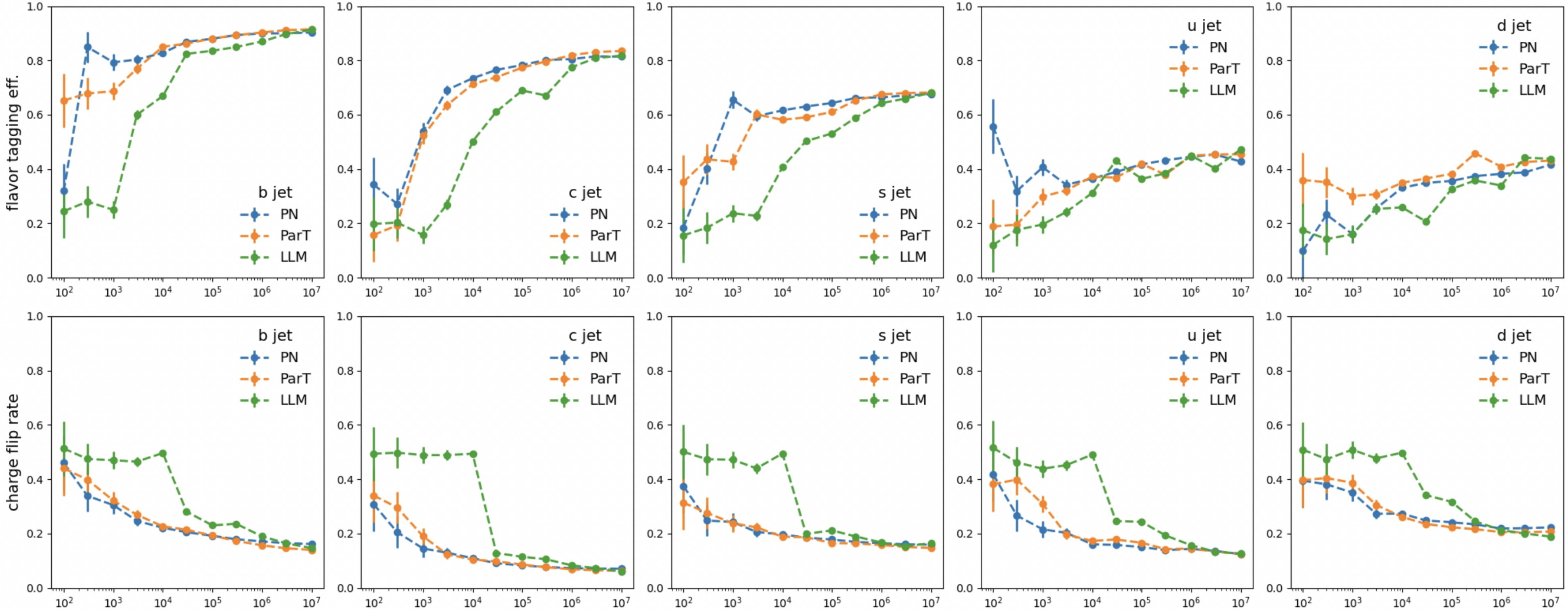
Ongoing study: from specialized Models to LLM



BIN-BBT Model

- New tokenization method to address numeric problems at LLM

Ongoing study: from specialized Models to LLM



- Comparable result with different scaling behavior
- Para. Numbers: PN 360k, ParT 2.4M, BINBBT 150 M
- Be submit to arXiv soon

超对称
Super Symmetry Technologies