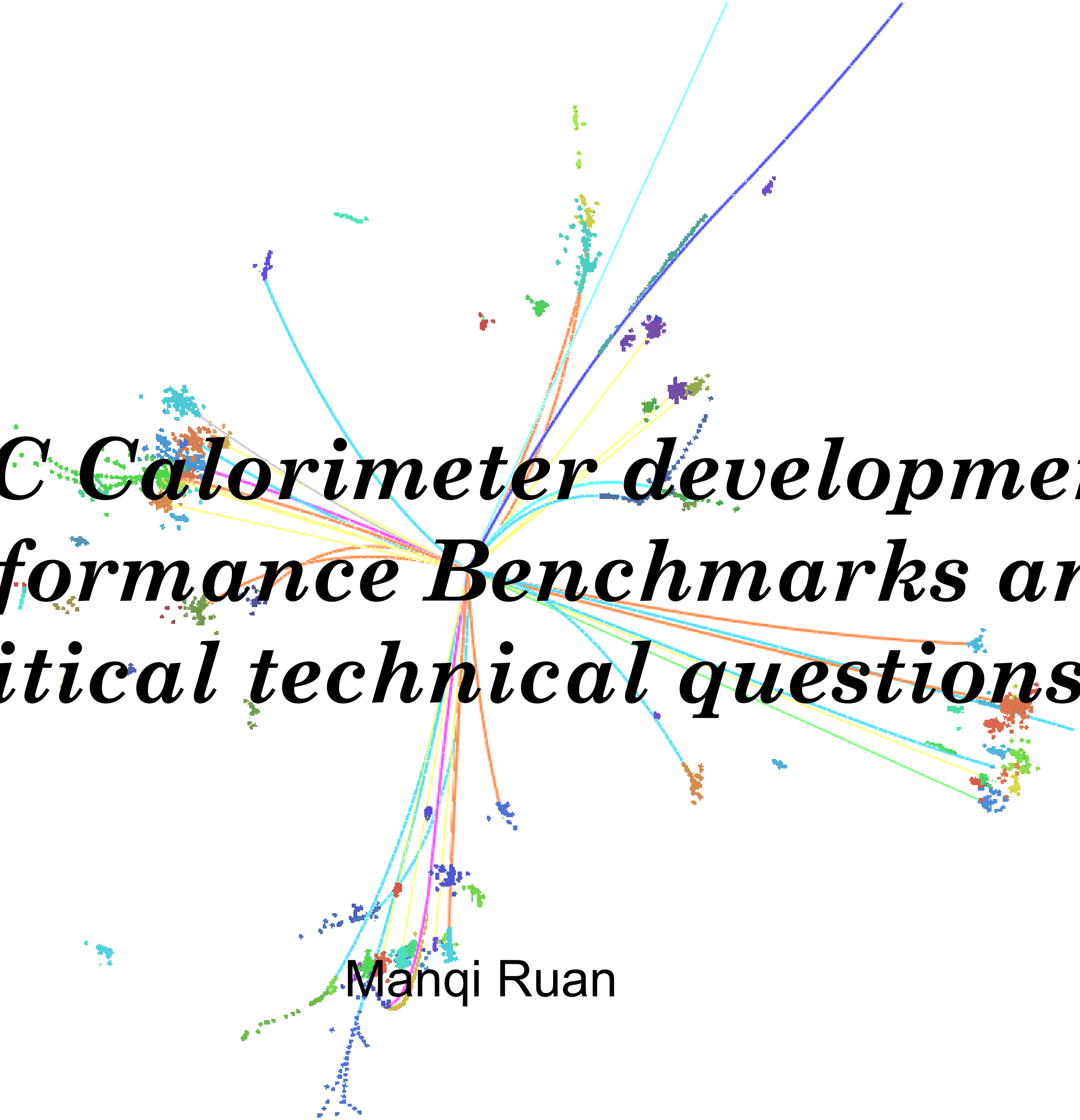


CEPC Calorimeter development: Performance Benchmarks and critical technical questions

Manqi Ruan

CEPC possible Timeline

- The CDR is delivered Nov. 2018
- Try to get the governments support, most probably as one of the cultivated projects in the establishing framework of “China initiated International Big Science Project”. The Green light can come at earliest ~ 2020 - 2022.
- Accelerator:
  - Pursue TDR at full speed, be delivered at ~2023
- Detector & Physics:
  - Now – Green light: enhance the international collaboration & welcome new ideas – proposals
  - Right after the Green light: a call for LoIs for different detector concepts, and a selective procedure will be performed
  - The selected concepts will be required to deliver their sub-system TDRs, by roughly 3 years after the selection

Addendum of https://arxiv.org/pdf/1901.03170.pdf

Status

- A PFA baseline that satisfy the physics requirement for key physics object reconstruction at full – simulation level
  - Baseline technology is validated at prototype TB
  - Tech. & Integration issues not fully addressed in full simulation: CDR level
- Alternative Dual Readout with intensive TB data, many new design & simulation efforts.
- Lots of New ideas

- It's critical to properly evaluate the performance, understand the comparative advantages from both Performance, and Technical P.o.V.

- I put my own thoughts here - we can extend/enhance this lists

Performance Benchmark for the CALO

- Single Particle: Photon/Neutral Hadron (E/HCAL)
  - Differential reconstruction efficiency
  - Energy Response: Linearity & Resolution
- Double particle
  - Separation performance: π_0 (ECAL), π^+-neutron (HCAL)
  - Higgs mass resolution with H->di photon (at vvH) (ECAL)

Intrinsic
Sub-Detector Performance

- Charged particle ID (Lepton, Charged Kaon): Isolated & In Jet
- Jets
  - BMR: Higgs mass resolution with H->gluons (at vvH)
  - W-Z-H Separation with 2-jets & 4-jets final states
- Physics Benchmark
  - qqH, H->tautau;
  - tau->X branching ratio measurements
  - Brems: eeH recoil mass

Global
Detector & Reconstruction

Critical Technical questions

- Modeling of critical detector effects:
  - Dependence of key performance on Intrinsic detector effects: Homogeneity, Stability, Robustness, Temperature dependence...
  - To develop adequate digitizer, Validate the digitizer by TB/Cosmic ray
  - Globally quantify the physics requirements on these intrinsic detector effects via simulation
- Integration Studies:
  - Total budget power & bandwidth
  - Cooling design & integration
  - Impact/requirement on other sub system
- Detector systematics under control
  - Calibration, Alignments, in-situ monitoring
  - Cost - Technology Matureness, construction & operation

At different options...

- All: power, cost & integration, optimization

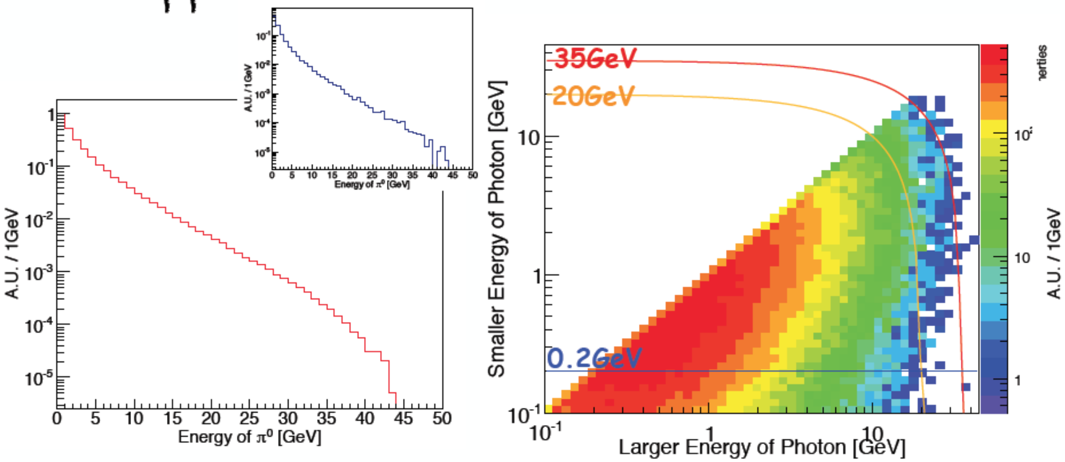
- PFA:
  - Cost control: PCB & readouts...
  - Challenge in commissioning & integration

- Dual readout:
  - Performance: Low energy response & separation

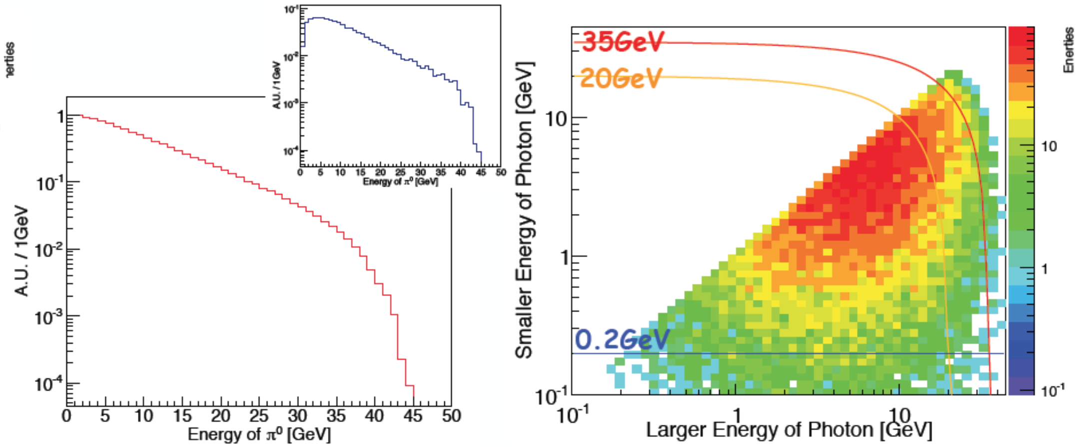
- Crystal, etc:
  - Cost, Homogeneity & Stability

Proportion of different energy π^0

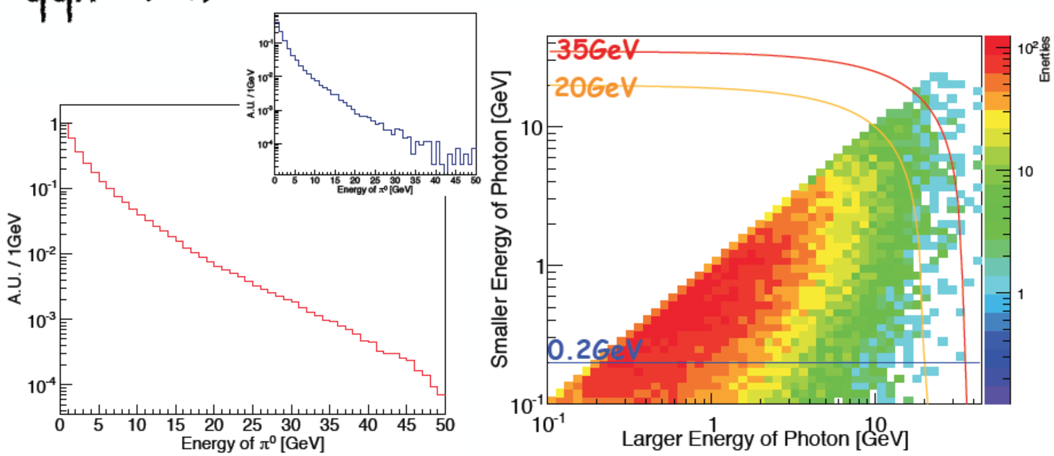
$Z \to qq$



$Z \to \tau\tau$

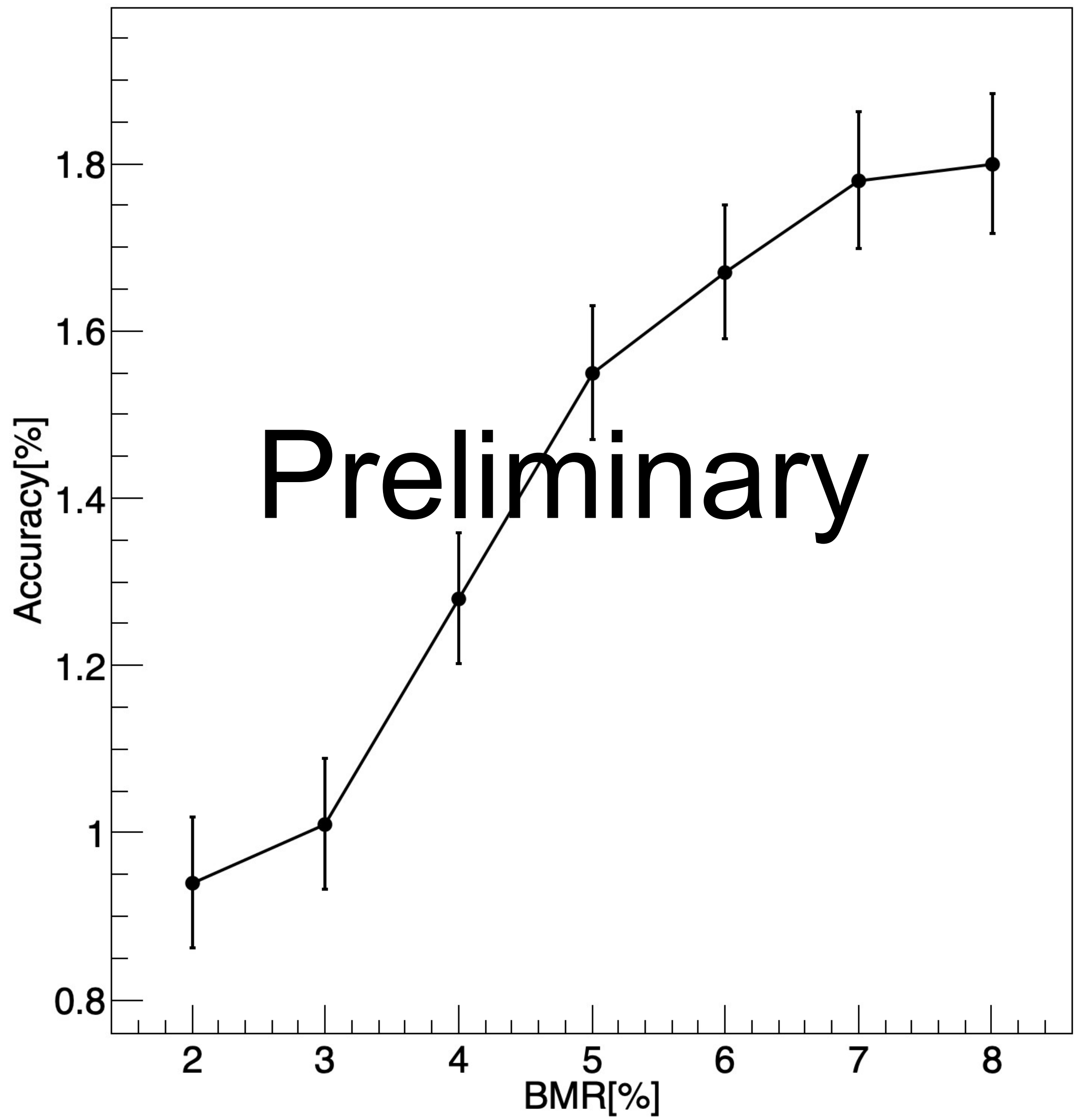


$qqH \to X$

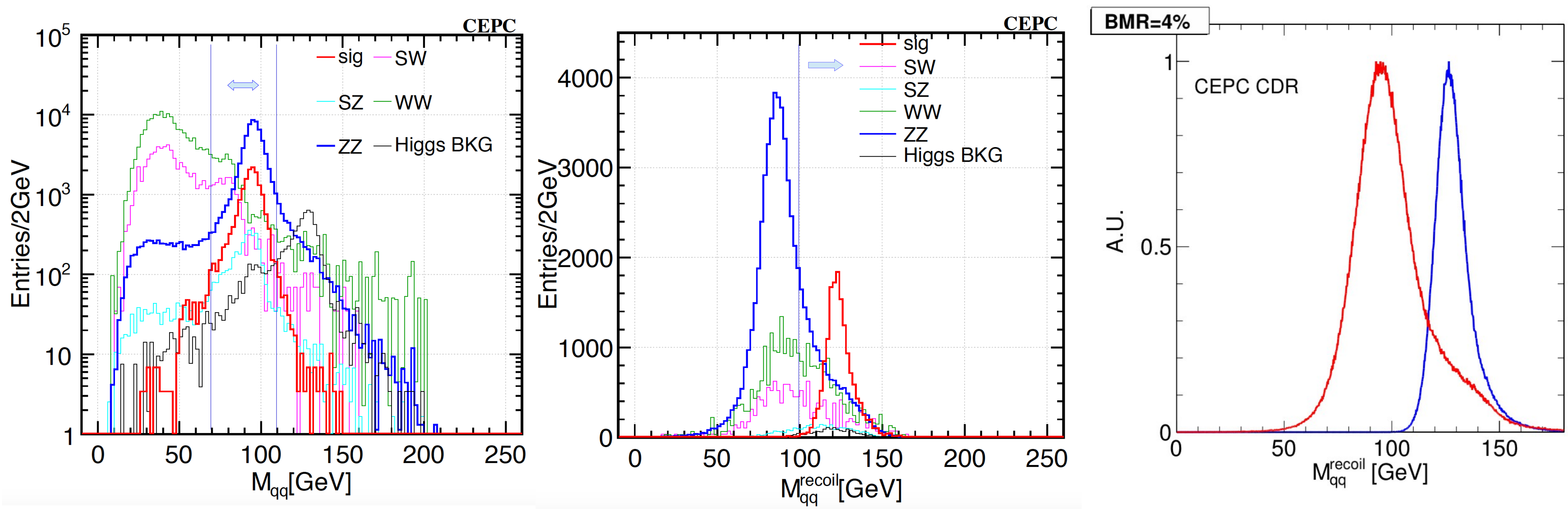


	$Z \to qq$	$qqH \to X$	$Z \to \tau\tau$
$E_{\pi^0} > 20GeV$	0.42%	0.66%	14.9%
$E_{\pi^0} > 35GeV$	0.02%	0.1%	1.8%
$E_{\gamma} < 0.2GeV$	45%	42%	7.5%

Signal strength: relative accuracy of qqH, H->tautau measurement at different BMR



An Analysis Example: *g(Hττ)* at qqH



- TAURUS: di-tau system
- The rest particles are identified as the di-jet: to distinguish the ZZ/ZH background & Improves the accuracy by more than a factor of 2: **BMR < 4% (baseline of 3.8%) is crucial**
- Isolated tracks are intensionally defined as tau candidate: be distinguished by the VTX

Dan Yu's thesis

Performance of the baseline CALO: Intrinsic

- Single Particle
  - Photon recon. Efficiency:
    - ~ 100% for E > 200 MeV, non-converted, within acceptance
  - Energy Response: Linearity & Resolution:
    - EM: ~16%/sqrt(E) conv 1.5%, Flat sample within full solid angle
    - Hadron shower: ~60%/sqrt(E) conv 2%
- Double particle
  - Separation at ECAL: eff ~ 2 times the Cell size
  - π_0 reconstruction (Differential)
    - Efficiency: slightly worse than the direct extrapolation from separation study
      - Maybe induced by reco. Algorithm parameters
    - Mass resolution: Energy dependent, agree with Intrinsic ECAL resolution
  - Higgs mass resolution with H->di photon (at vvH)
    - ~2%

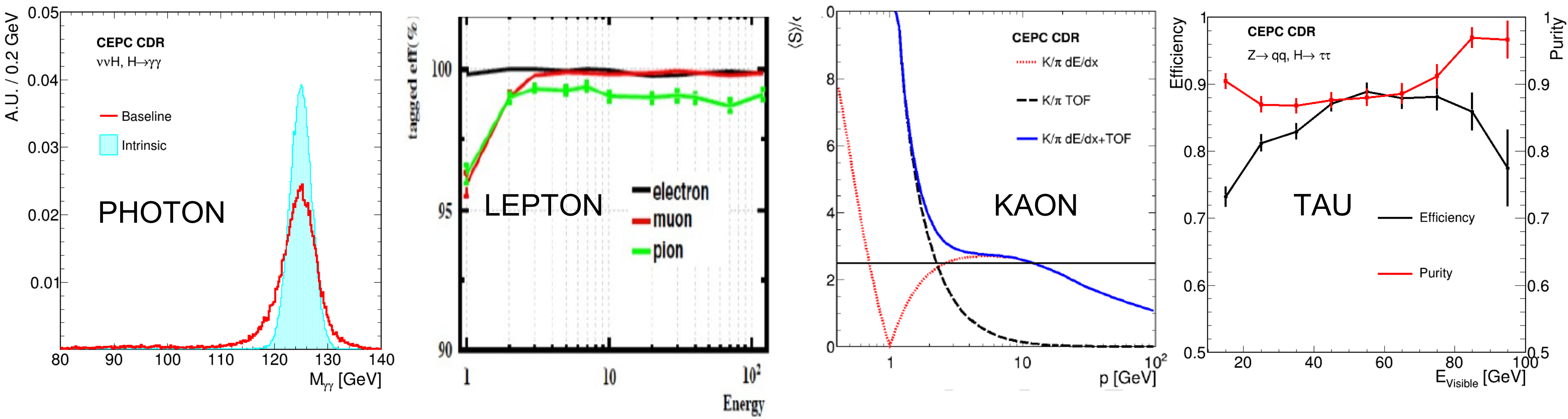
Performance of the baseline CALO: Global

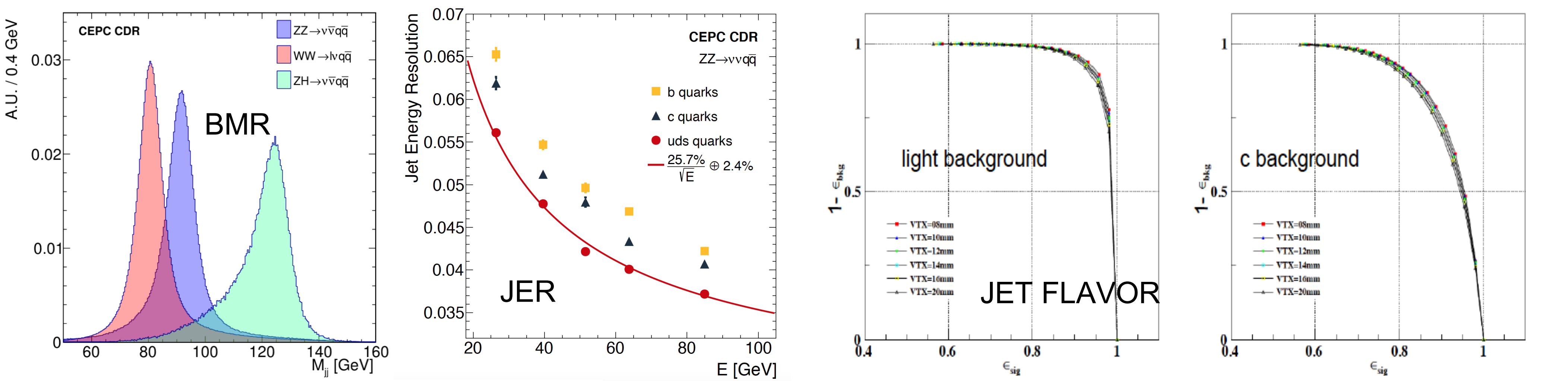
- Charged Particle id
  - Isolated particle:
    - Lepton: misid < 1% at eff ~ 99.5% (Approach the physics limit)
    - Charged Kaon: eff/purity ~ 95% at inclusive Z pole sample with E > 2 GeV
  - Jet particle: to be quantified more precisely
- Jets
  - BMR: Higgs mass resolution with H->gluons (at vvH)
    - 3.7%, critical for the di-jet recoil mass reconstruction at the CEPC
  - W-Z-H Separation with 2-jets & 4-jets final states
    - 2-jets: no jet confusion, well separated
    - 4-jets: can be separated, performance limited by Jet confusion
- Physics Benchmark
  - qqH, H->tautau: Generic tau finding reaches an eff/purity of 80/90%, leading to signal strength measurements of μ(qqH, H->tautau) better than 1%
  - tau->X branching ratio measurements: No quantified conclusion yet
  - Brems: eeH recoil mass...

Physics Objects

Eur. Phys. J. C (2017) 77: 591

Eur. Phys. J. C (2018) 78:464





Eur. Phys. J. C (2018) 78: 426