Brainstorming on $\tau \to lV^0$ analyses

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Outline

- Existing results:
  - Belle (https://arxiv.org/pdf/1101.0755.pdf)
  - Babar (https://arxiv.org/pdf/0904.0339.pdf)
- Belle II strategy:
  - Reconstruction
  - Offline (belleLike) selection
- Miscellaneous: resolutions, topology

Work in progress

Work in progress

Belle $\tau \to lV^0$ analysis

(ref. here)

- Analyze 854/fb and set most stringent limits
- exploit ΔE, M_{lV0} to define signal region (extracted from fitted resolutions)
  - Reconstruct events with exactly 4 tracks within detector acceptance -0.8660 <cosTheta < 0.9563 and of minimum pt>0.1 dr <**0.5**, dz <3 cm + 3x1 topology selection wtr Thrust axis
  - any number of photons (E_γ >0.1 GeV) [BelleII reco in steering python here]
  - PID > 0.9(0.95) [missing PID variables in my nutples…] and p >0.6(1) for electron(muon)
  - Electrons corrected for Bremsstrahlung emission including photon momenta within 0.05 rad cone → we applied Guney's optimal bremCorrection with E_{th}= 20 MeV and opening angle 0.15 rad (3x Belle angle)
    - Kaon veto on pion candidates applied + additional electron veto on pion candidates combined into V0 to reject photon conversions [→ orthogonal PID list]
  - |pT_miss| > 0.5 (0.7) from muon(electron *) channel and direction pointing to the tag side (***see table***). *tighten for eRho0 channel: |pT_miss| > 1.5
  - Thrust > 0.9

V^0	Invariant mass (GeV/c^2)	$\cos\theta^{CM}_{tag-miss}$ for $\tau \to \mu V^0$ (eV^0)
ρ^0	$0.587 < M_{\pi\pi} < 0.962$	[0.0, 0.85] ([0.0, 0.96])
ϕ	$1.009 < M_{KK} < 1.031$	[0.0, 0.88] ([0.0, 0.97])
ω	$0.757 < M_{\pi\pi\pi} < 0.808$	[0.0, 0.88] ([0.0, 0.97])
$K^{0*}(\bar{K}^{0*})$	$0.842 < M_{K\pi} < 0.956$	[0.0, 0.87] ([0.0, 0.96])

- Tag side selections:
  - tau_tag_invM <m_τ
  - 2 (1) photons allowed with hadronic (leptonic) tag
  - proton veto [→ currently missing protonID variables/recommendations]
  - For muon channel and muon tag, p_{tag}^{CMS} < 4 GeV
- eV0 mode specific selections to reject background from taupairs, with $\tau \to h^-\pi^0(\to \gamma\gamma)\nu$ decays + photon conversion + e- in the ECL gap mis-identified as hadron (final states lhh as for signal)
  - Assign electron mass to one of the pion and recompute Meh invariant mass, requiring Meh > 0.2 GeV

Belle $\tau \to lV^0$ analysis: signal yield extraction

- Define elliptical signal region in ΔE, M_{lV0} space:
  - asymmetric Gaussian fits to signal distributions to extract ΔE, M_{lV0} resolutions
  - Compute $\sigma = (\sigma_{low} + \sigma_{high})/2$
  - Define ellipse axes as 3σ length, ellipse center and inclination to maximize signal efficiency normalized to the area $\to$ blind this region!
  - Retain $\pm 20\sigma$ region for background studies and estimates

TABLE II: Summary of $M_{\ell V^0}$ and ΔE resolutions ($\sigma^{high/low}_{M_{\ell V^0}}$ (MeV/c^2) and $\sigma^{high/low}_{\Delta E}$ (MeV)). Here σ^{high} (σ^{low}) means the standard deviation on the higher (lower) side of the peak.

Mode	$\sigma^{high}_{M_{\ell V^0}}$	$\sigma^{low}_{M_{\ell V^0}}$	$\sigma^{high}_{\Delta E}$	$\sigma^{low}_{\Delta E}$
$\tau \to \mu\rho^0$	6.1	5.4	16.0	21.9
$\tau \to e\rho^0$	6.7	5.7	15.6	25.1
$\tau \to \mu\phi$	3.7	3.8	14.2	19.9
$\tau \to e\phi$	4.1	4.5	14.0	22.0
$\tau \to \mu\omega$	7.0	8.9	25.7	29.0
$\tau \to e\omega$	8.6	9.7	21.1	37.1
$\tau \to \mu K^{*0}$	4.9	5.2	15.8	21.2
$\tau \to e K^{*0}$	5.7	6.7	15.6	25.1
$\tau \to \mu \bar{K}^{*0}$	4.9	5.2	15.8	21.3
$\tau \to e \bar{K}^{*0}$	5.2	5.7	15.6	24.6

- **Electron channel $\tau \to eV^0$:**
  - Dominant background from two-photon processes
  - Small background contamination after selection: count the number of events in $\pm 5\sigma_{\Delta E}$ outside the blinded elliptical signal region
  - Assume it's flat along invM axis and extrapolate inside the signal region

- **Muon channel $\tau \to \mu V^0$:**
  - dominant background from continuum ee$\to$ qq and tau pairs production
  - Only for $\tau \to \mu\rho$ fit side-band region in data in M_{lV0} distribution using sum of exponential and first-order polynomial, looking only at $\pm 5\sigma_{\Delta E}$
  - $\tau \to \mu\varphi$ tau paris component due to pion contaminatoin, mis-identified as kaons

Belle $\tau \to lV^0$ analysis: results

Search on 854 fb^{-1}, most competitive UL

- Expected 1 bkg event inside the signal region for tau → muPhi, muK(*) , 0 for the other channels
- Unblinding confirms expectation→ no excess
- Compute 90% CL upper limits on number of signal events (s_{90}) accounting for systematic uncertainties using POLE program without conditioning, https://arxiv.org/pdf/physics/0302057.pdf

$$\mathcal{B}(\tau \to \ell V^0) < \frac{s_{90}}{2N_{\tau\tau}\varepsilon},$$

TABLE III: The signal efficiency (ε), the number of expected background events (N_{BG}) estimated from the sideband data, total systematic uncertainty (σ_{syst}), the number of observed events in the signal region (N_{obs}), 90% C.L. upper limit on the number of signal events including systematic uncertainties (s_{90}), 90% C.L. upper limit on the observed branching fraction ($\mathcal{B}_{obs.}$) for each individual mode.

Mode	ε (%)	N_{BG}	σ_{syst} (%)	N_{obs}	s_{90}	$\mathcal{B}_{obs}$ ($\times 10^{-8}$)
$\tau^- \to \mu^- \rho^0$	7.09	1.48 ± 0.35	5.3	0	1.34	1.2
$\tau^- \to e^- \rho^0$	7.58	0.29 ± 0.15	5.4	0	2.17	1.8
$\tau^- \to \mu^- \phi$	3.21	0.06 ± 0.06	5.8	1	4.24	8.4
$\tau^- \to e^- \phi$	4.18	0.47 ± 0.19	5.9	0	2.02	3.1
$\tau^- \to \mu^- \omega$	2.38	0.72 ± 0.18	6.1	0	1.76	4.7
$\tau^- \to e^- \omega$	2.92	0.30 ± 0.14	6.2	0	2.19	4.8
$\tau^- \to \mu^- K^{*0}$	3.39	0.53 ± 0.20	5.5	1	3.81	7.2
$\tau^- \to e^- K^{*0}$	4.37	0.29 ± 0.14	5.6	0	2.17	3.2
$\tau^- \to \mu^- \bar{K}^{*0}$	3.60	0.45 ± 0.17	5.5	1	3.90	7.0
$\tau^- \to e^- \bar{K}^{*0}$	4.41	0.08 ± 0.08	5.6	0	2.34	3.4

- $B(\tau \to eV^0) < (1.8–4.8) \times 10^{-8}$
- $B(\tau \to \mu V^0) < (1.2–8.4) \times 10^{-8}$

- Results improved thanks to larger statistics and better specific background rejection:
  - Di-baryon production for muon channel (proton veto)
  - $\tau \to h^- \pi^0 (\to \gamma\gamma)\nu$ with photon conversion for electron channel

BaBar $\tau \to lV^0$ analysis

(ref. here)

- 451 fb^{-1} on + off resonance, setting limits down to (2.6-19) x 10^{-8}
- 3x1 topology to reduce qq contamination:
  - 4 tracks with total null charge from IP within laboratory angular acceptance
  - Reject events with invM of pairs of oppositely charged tracks < 0.03 GeV (photon conversions veto)
  - Thrsut axis separation and leptonic and hadronic PID applied on signal side
- Selection optimize separately per each channel (table) to provide smallest BF UL in the background only hyposthesis
- Reject radiative dilepton final states asking non collinear 1- and 3-prong momentum vectors
- Veto electron tag for eρ search

InvM of signal and tag taus: rows m_{hh} min to m_{1-pr} max

qq veto: rows p_T^{miss} min to n_{3pr}^{γ} max

Channel	$e\phi$	$\mu\phi$	$e\rho$	$\mu\rho$	eK^*	μK^*	$e\overline{K}^*$	$\mu\overline{K}^*$
m_{hh} min	1.000	1.005	0.6	0.6	0.8	0.82	0.80	0.78
m_{hh} max	1.040	1.035	0.92	0.96	1.0	0.98	1.04	1.00
m_{1-pr} min	0.3	0.4	0.3	0.3	0.3	0.2	0.3	-
m_{1-pr} max	2.5	2.5	2.5	2.5	2.5	2.5	2.5	-
p_T^{miss} min	0.4	0.3	0.4	0.4	0.4	0.4	0.4	0.4
p_T^{cms} min	0.5	-	-	-	0.6	-	0.3	-
n_{1pr}^{γ} max	4	3	3	1	-	3	-	2
n_{3pr}^{γ} max	3	1	2	1	-	2	-	1

- Signal region in ($\Delta E \equiv E^*_{rec} - E^*_{beam}$, $\Delta M = M_{EC} - m_\tau$) plane
- ISR tails for ΔM>0 and ΔE <0
- define signal boxes (SB) in ΔM, ΔE plane by minimizing the expected BF upper limits → estimate by comparing simulations and data yields in sideband regions (Large Boxes, LB)

TABLE II: Signal Box boundaries; ΔM is in units of GeV/c^2 and ΔE in units of GeV.

Mode	$e\phi$	$e\rho$	eK^*	$e\overline{K}^*$	$\mu\phi$	$\mu\rho$	μK^*	$\mu\overline{K}^*$
$\Delta M_{\rm min}$	-0.02	-0.02	-0.02	-0.015	-0.008	-0.01	-0.01	-0.008
$\Delta M_{\rm max}$	0.015	0.02	0.02	0.02	0.01	0.015	0.01	0.01
$\Delta E_{\rm min}$	-0.13	-0.10	-0.15	-0.125	-0.09	-0.06	-0.08	-0.08
$\Delta E_{\rm max}$	0.10	0.06	0.08	0.06	0.06	0.04	0.04	0.06

BaBar $\tau \to lV^0$ analysis: signal yield extraction

(ref. here)

- Blind signal boxes (SB) in ΔM, ΔE plane in data
- 3 main source of background:
  - Continuum uds (evenly distributed in ΔM, ΔE plane)
  - ccbar production (peaking at positive ΔM)
  - **Tau pair decays** (peaking at negative ΔM, ΔE
  - (two-photon processes negligible)

- Extract expected events in SB by fitting **Grand-Sideband (GS)** regions in data, GS = LB – SB, with 2D pdf and extrapolating N_{bkg} in SB
- Pdf shapes (combinations of Gaussians, polynomial and CristalBall shapes) modeled on simulation, as well as ΔM, ΔE correlation (angle)

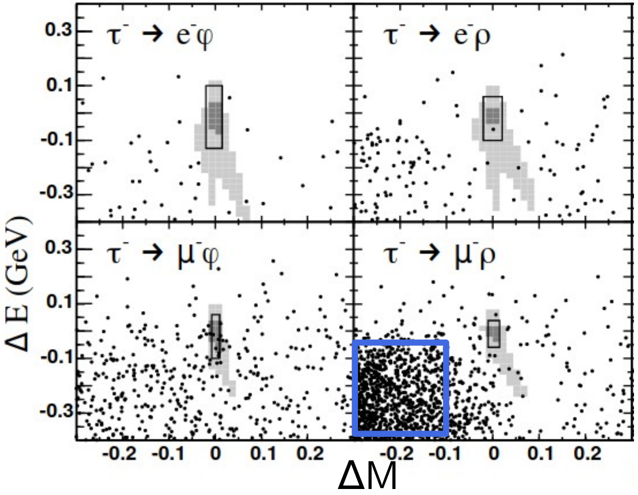


TABLE II: Signal Box boundaries; ΔM is in units of GeV/c^2 and ΔE in units of GeV.

Mode	$e\phi$	$e\rho$	eK^*	$e\overline{K}^*$	$\mu\phi$	$\mu\rho$	μK^*	$\mu\overline{K}^*$
$\Delta M_{\rm min}$	-0.02	-0.02	-0.02	-0.015	-0.008	-0.01	-0.01	-0.008
$\Delta M_{\rm max}$	0.015	0.02	0.02	0.02	0.01	0.015	0.01	0.01
$\Delta E_{\rm min}$	-0.13	-0.10	-0.15	-0.125	-0.09	-0.06	-0.08	-0.08
$\Delta E_{\rm max}$	0.10	0.06	0.08	0.06	0.06	0.04	0.04	0.06

TABLE III: Efficiency estimate, number of expected background events ($N_{\rm bgd}$), number of observed events ($N_{\rm obs}$), observed upper limit at 90% CL on the number of signal events ($N^{90}_{\rm UL}$), expected branching fraction upper limit at 90% CL ($\mathcal{B}^{90}_{\rm exp}$), and observed branching fraction upper limit at 90% CL ($\mathcal{B}^{90}_{\rm UL}$). $\mathcal{B}^{90}_{\rm exp}$ and $\mathcal{B}^{90}_{\rm UL}$ are in units of 10^{-8}.

Mode	ε[%]	$N_{\rm bgd}$	$N_{\rm obs}$	$N^{90}_{\rm UL}$	$\mathcal{B}^{90}_{\rm exp}$	$\mathcal{B}^{90}_{\rm UL}$
$e\phi$	6.43 ± 0.16	0.68 ± 0.12	0	1.8	5.0	3.1
$\mu\phi$	5.18 ± 0.27	2.76 ± 0.16	6	8.7	8.2	19
$e\rho$	7.31 ± 0.18	1.32 ± 0.17	1	3.1	4.9	4.6
$\mu\rho$	4.52 ± 0.41	2.04 ± 0.19	0	1.1	8.9	2.6
eK^*	8.00 ± 0.19	1.65 ± 0.23	2	4.3	4.8	5.9
μK^*	4.57 ± 0.36	1.79 ± 0.21	4	7.1	8.5	17
$e\overline{K}^*$	7.76 ± 0.18	2.76 ± 0.28	2	3.2	5.4	4.6
$\mu\overline{K}^*$	4.11 ± 0.32	1.72 ± 0.17	1	2.7	9.3	7.3

- efficiencies between 4-8%, evaluated on simulations

BaBar $\tau \to lV^0$ analysis: results

- unlind SB in (ΔM, ΔE) plane in data and compare counted N_{obs} to N_{bkg} expected extracted from previous fits
- Set 90% CL upper limits on N_{sig} by using the POLE calculator (Feldman-Cousins approach), including systematics
- Compute 90% CL upper limits on BF:
  - $B_{90}^{UL} = N_{90}^{UL} / (2\varepsilon L\sigma_{\tau\tau})$ $\to$ all in the range $(2.6-19)\times10^{-8}$

Belle Vs. BaBar

Measured: Mode:	Eff [%]		N_{bkg}		N_{obs}	
	Belle	BaBar	Belle	BaBar	Belle	BaBar
$\tau \to \mu\rho$	7.09	4.52	1.48	2.04	0	0
$\tau \to e\rho$	7.58	7.31	0.29	1.32	0	1
$\tau \to \mu\varphi$	3.21	5.18	0.06	2.76	1	6
$\tau \to e\varphi$	4.18	6.43	0.47	0.68	0	0

.. and Belle II ?

Event reconstruction

- Reconstruction script in tau_lV0 repository here
  - Good tracks selection: $|dz| < 3.0$ and $|dr| < 1.0$
  - MuonID applied (also as veto on pions), EoverP selection for pion and electrons (pionID and electronID not recommended yet)

    → **correctBremsBelle('e+:cBrems', 'e+:pid', 'gamma:notPi0forBrem', multiplePhotons=True, minimumEnergy=0.020, angleThreshold=0.150, path=main)**
  - Reconstructed V0 mass within loose window around rho0 Mass: '0.47 < M < 1.07'
  - Signal tau vertex fit (TreeFit, with mass and IP constraints)
  - Selected topology: **2** (V0 and lepton on the same side) x **1**, allowing as 1-prong {el, mu, pi}

```
eIDCuts = '0.8 < EoverP < 1.2'
muIDCuts = 'EoverP < 0.6'
muIDCuts += ' and muonID > 0.9'
piIDCuts = 'EoverP < 0.6'
piIDCuts += ' and muonID <= 0.9'
```

```
######################################################
# signal and tag on the opposide sides
######################################################
variables.addAlias('prod1',
                   'formula(daughter(0, daughter(0, cosToThrustOfEvent))*daughter(1, daughter(0,cosToThrustOfEvent)))')
variables.addAlias('prod2',
                   'formula(daughter(0, daughter(1, cosToThrustOfEvent))*daughter(1, daughter(0,cosToThrustOfEvent)))')
ma.applyCuts('vpho', 'prod1 < 0 and prod2 < 0', path=main)
```

This reconstruction is meant to be **flexible** to reconstruct both the final topology cases **3x1 or 2x2** → depends on the rho0 polarization and the direction of flight of the daughters

Reconstructed events

$\tau \to l\rho$, 3x1

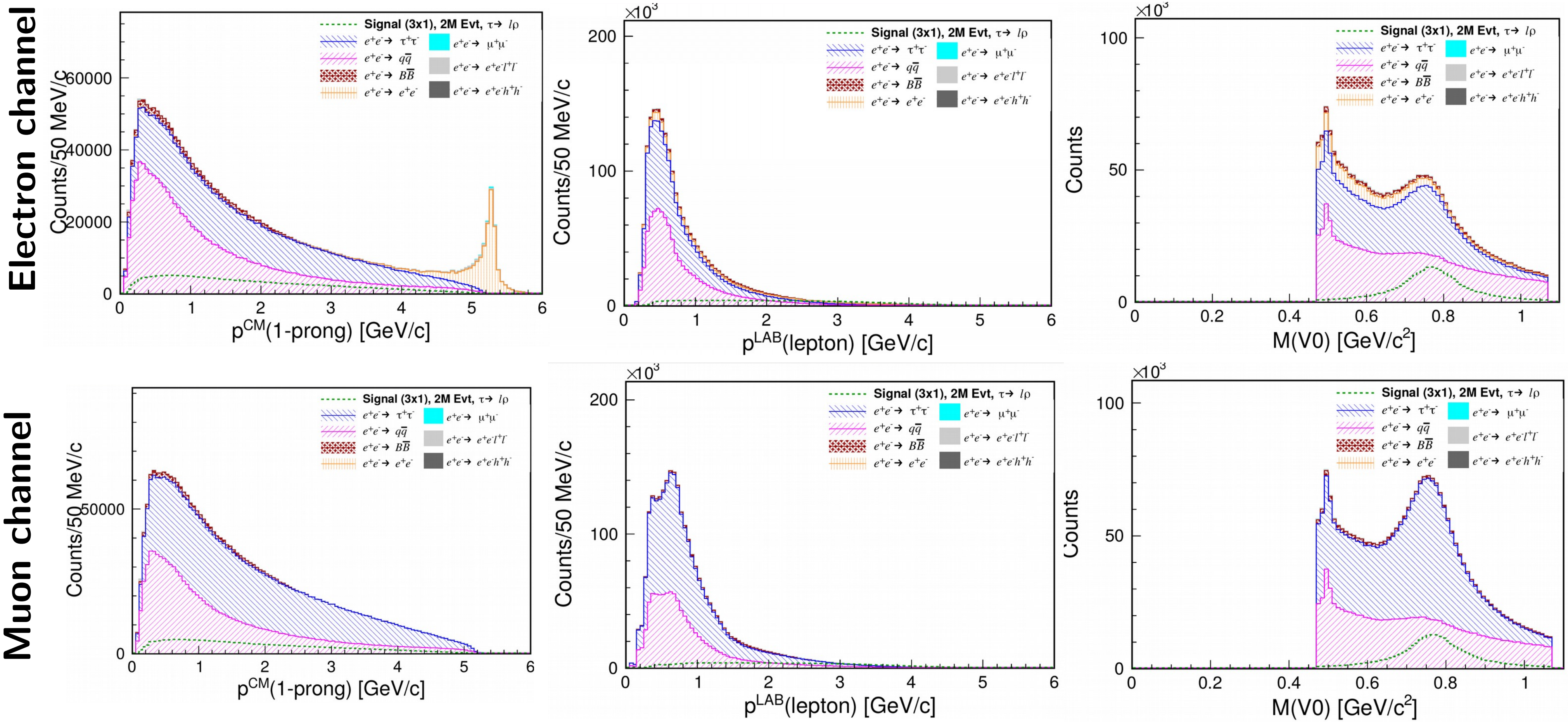
Electron channel

	gen lumi [/fb]	evt_reco	eff_reco
signal [2M evt]		279175	0.1396
taupair	200	895412	
qqbar	200	978670	
charged	200	32232	
mixed	200	24337	
ee	20	17574	
eeee	200	1916	
mumu	200	2293	
eemumu	200	5279	
eeKK	1000	204	
eepipi	1000	1375	
eepp	1000	102	

Muon channel

sample:	evt_reco	eff_reco
signal [2M evt]	269253	0.1346
taupair	1.54E+06	
qqbar	999264	
charged	29465	
mixed	23731	
ee	41	
eeee	2	
mumu	877	
eemumu	3193	
eeKK	51	
eepipi	963	
eepp	92	

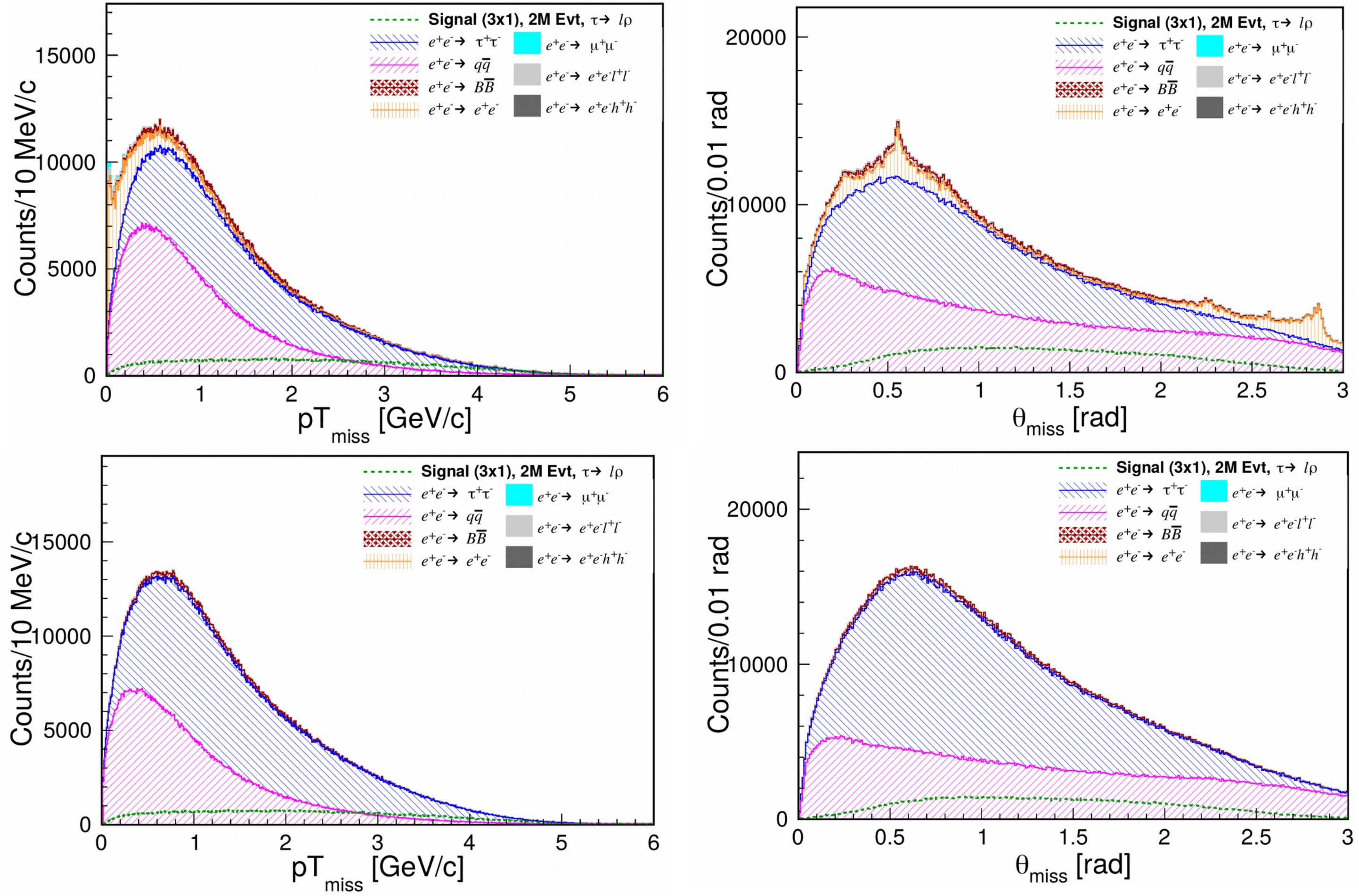
Discriminant variables, 3x1 topology



Missing momentum variables

Electron channel

Muon channel



Offline selection: belleLike

Work in progress

//vector meson invariant mass cut

0.587 < V0_signal_InvM < 0.962

Thrust > 0.9

//missing momentum in fiducial region

-0.8660 < cos(missingMomentumOfEvent_theta) < 0.9563

// constrain photons on the tag side to reject qq

((nPhotons_tag < 3 && dmID_tag==1211) || (nPhotons_tag < 2 && (dmID_tag==113 || dmID_tag==111)))

tau_tag_InvM < 1.777

Electron channel (dmID_signal == 311)

- lepton_signal_p > 0.6

  //missing momentum pointing to the tag side

- 0 < (cos(missingMomentumOfEventCMS_theta-track_tag_theta_CMS) < 0.85
- |pT_miss| > 1.5

Muon channel (dmID_signal == 313)

- lepton_signal_p > 1.

  //missing momentum pointing to the tag side

- 0< cos(missingMomentumOfEventCMS_theta-track_tag_theta_CMS) < 0.96
- |pT_miss| > 0.5
- track_tag_p_CMS < 4 GeV && dmID_tag == 113

$\pm 20\sigma$ regions (Center in (1.777, 0) GeV)

	$\tau \to \mu\rho$			$\tau \to e\rho$		
	σ [MeV]	Min [GeV]	Max [GeV]	σ [MeV]	Min [GeV]	Max [GeV]
M_{lV0}	5.75	1.662	1.892	6.2	1.653	1.901
ΔE	18.95	-0.379	0.379	20.35	-0.407	0.407
$\pm 5\sigma_{\Delta E}$	[-0.09475, 0.09475]			[-0.10175, 0.10175]		

$\pm 3\sigma$ regions (Center in (1.777, 0) GeV): signal box

	$\tau \to \mu\rho$			$\tau \to e\rho$		
	σ [MeV]	Min [GeV]	Max [GeV]	σ [MeV]	Min [GeV]	Max [GeV]
M_{lV0}	5.75	1.75975	1.7943	6.2	1.7584	1.7956
ΔE	18.95	-0.05685	0.05685	20.35	-0.061	0.061

Selection results

Work in progress

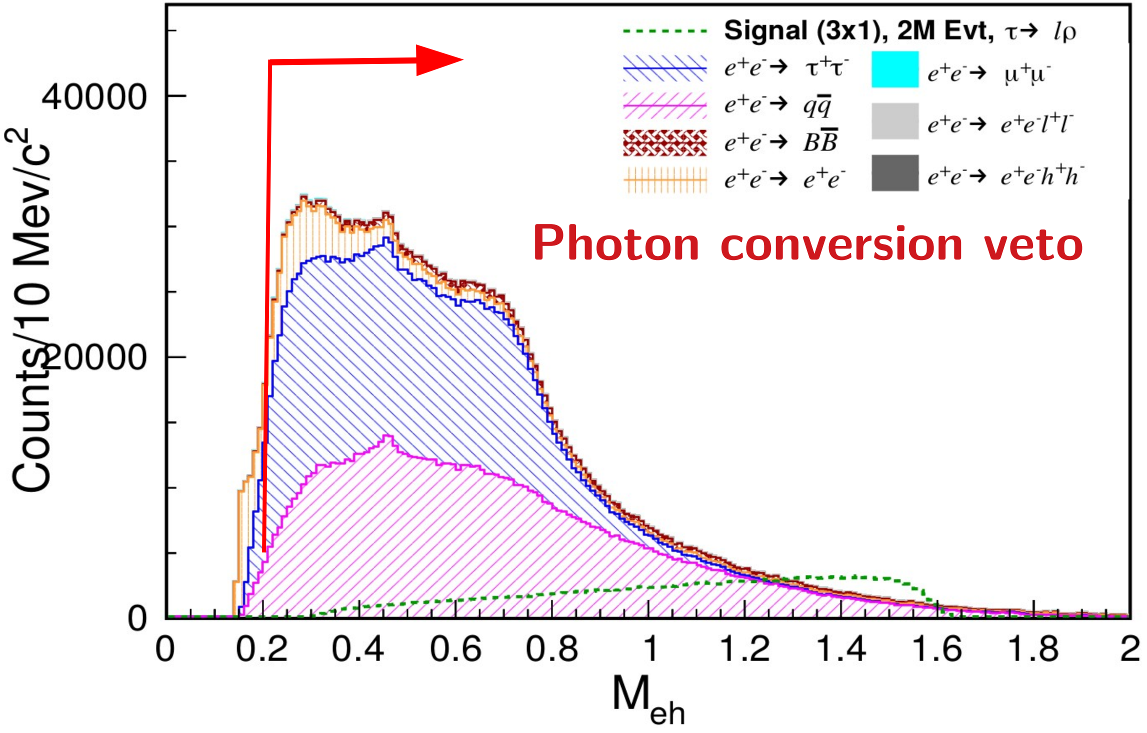
τ → lρ, 3x1

Electron channel | **Muon channel**

	gen lumi [/fb]	evt_reco (electron)	eff_reco (electron)	evt_select && in5sigmaSideBand (electron)	evt_select && in5sigmaSidebBand [Scaled to target lumi] (electron)	evt_reco (muon)	eff_reco (muon)	evt_select && in5sigmaSideBand (muon)	evt_select && in5sigmaSidebBand [Scaled to target lumi] (muon)
signal [2M evt]		279175	0.1396			269253	0.1346		
taupair	200	895412		1	4.27	1.54E+06		20	85
qqbar	200	978670		10	42.7	999264		69	295
charged	200	32232		0	0	29465		0.00	0
mixed	200	24337		0	0	23731		0.00	0
ee	20	17574		0	0	41		0.00	0
eeee	200	1916		0	0	2		0.00	0
mumu	200	2293		0	0	877		0.00	0
eemumu	200	5279		0	0	3193		0.00	0
eeKK	1000	204		0	0	51		0.00	0
eepipi	1000	1375		0	0	963		0.00	0
eepp	1000	102		0	0	92		0.00	0

Target lumi: 854/fb

Electron channel, 3x1



Miscellaneous: resolutions

Topology

- Rho0 polarization results in $\sim$ 4% of events with 2x2 topology $\rightarrow$ investigate discriminating kinematics variables (lepton_p_CMS very promising)

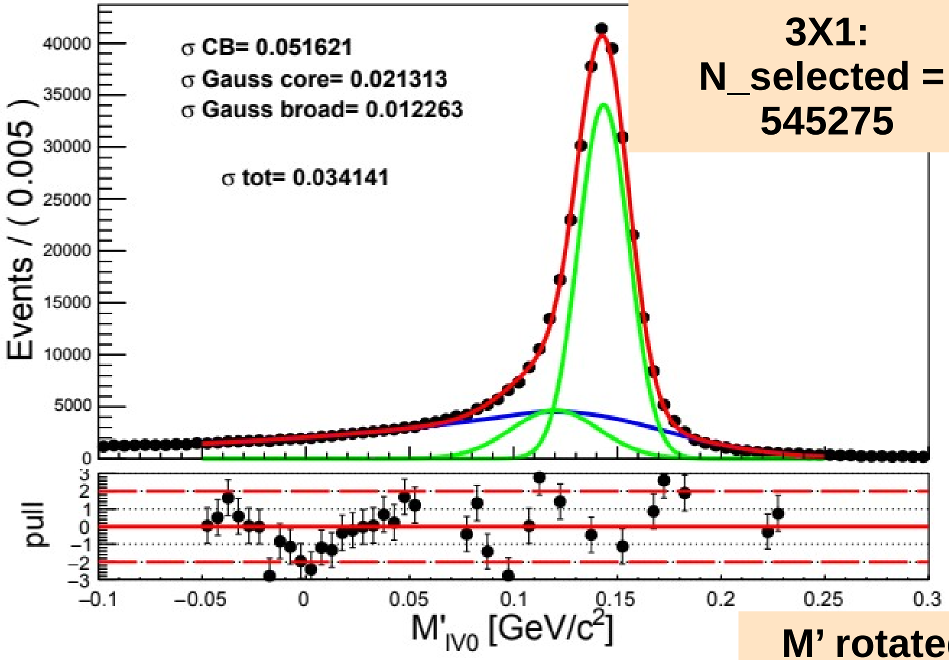
Invariant Mass resolutions: Belle2 composite pdf

- Event reconstruction (no further selections, 2M generated evt)
- Model: Crystal Ball Func + Gaussian_core + Gaussian_broad

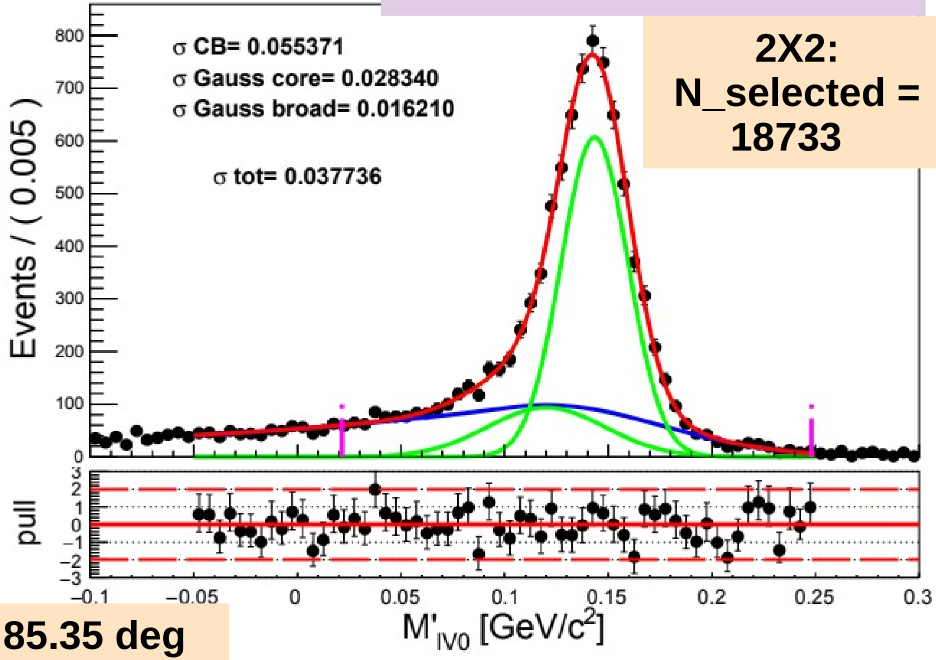
Belle results:

Mode	$\sigma^{\mathrm{high}}_{M_{\ell V0}}$	$\sigma^{\mathrm{low}}_{M_{\ell V0}}$	$\sigma^{\mathrm{high}}_{\Delta E}$	$\sigma^{\mathrm{low}}_{\Delta E}$
$\tau \to \mu\rho^0$	6.1	5.4	16.0	21.9
$\tau \to e\rho^0$	6.7	5.7	15.6	25.1

Belle2 results: ~34 MeV



3X1: N_selected = 545275



2X2: N_selected = 18733

M' rotated by 85.35 deg

Invariant Mass resolutions: Belle model

- Event reconstruction + Belle-like selections (10k generated evt):
  - lepton_signal_p > 0.6 (1.0) if lepton = electron(muon) && nPhotons_tag < 2
  - V0_signal_InvM >0.587 && V0_signal_InvM<0.962 && cos(missingMomentumOfEvent_theta) < 0

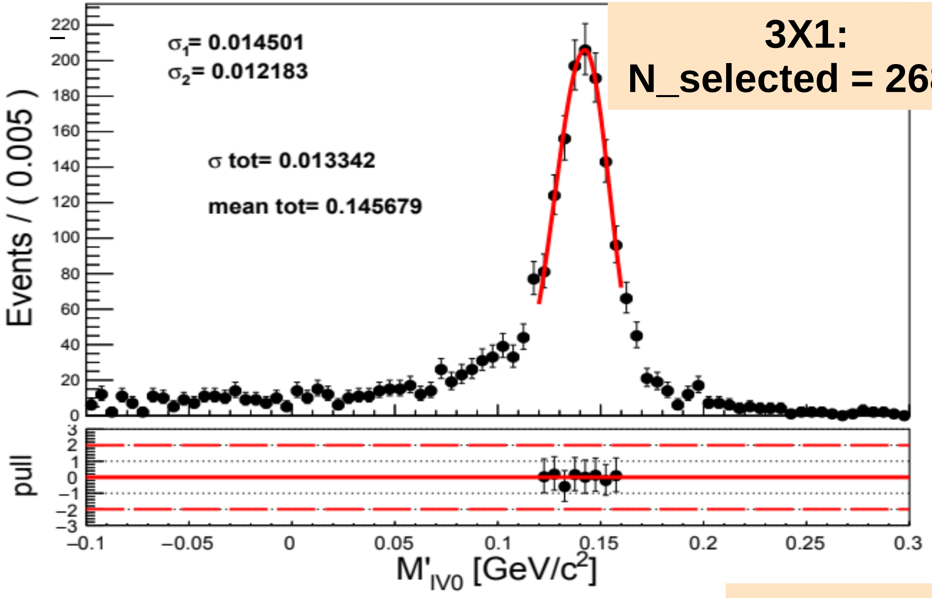
Belle results:

Mode	$\sigma^{high}_{M_{\ell V0}}$	$\sigma^{low}_{M_{\ell V0}}$	$\sigma^{high}_{\Delta E}$	$\sigma^{low}_{\Delta E}$
$\tau \to \mu\rho^0$	6.1	5.4	16.0	21.9
$\tau \to e\rho^0$	6.7	5.7	15.6	25.1

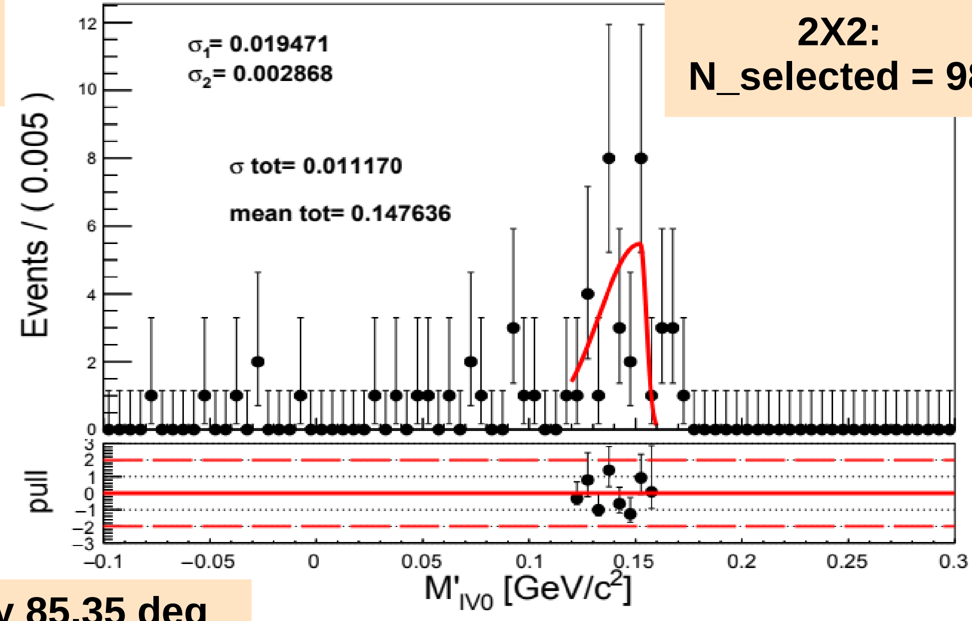
Belle2 results: ~13 MeV

- Model: Bifurcated Gaussian

3X1: N_selected = 2683



2X2: N_selected = 98



M' rotated by 85.35 deg

Invariant Mass resolutions: Belle2 composite pdf

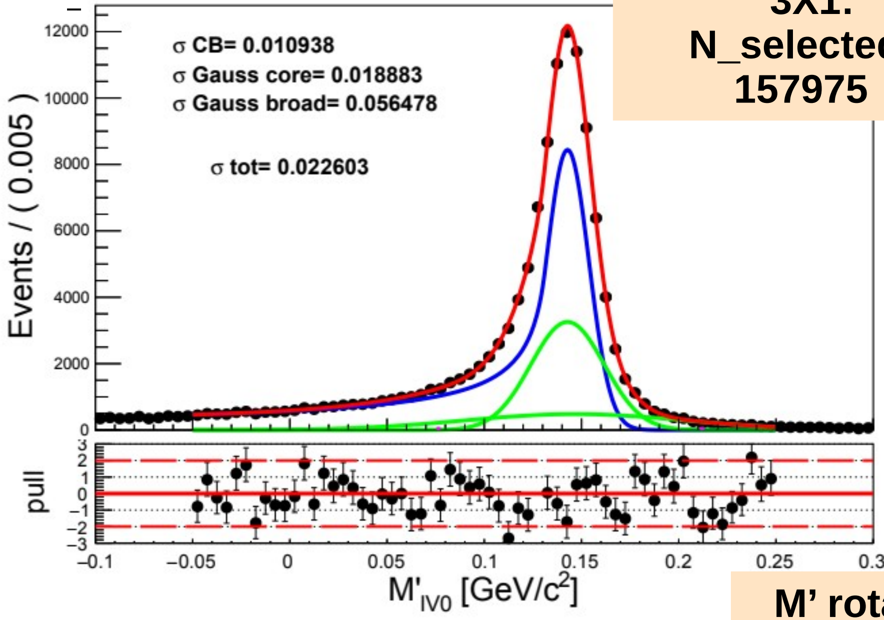
- Event reconstruction + Belle-like selections (2M generated evt):
  - lepton_signal_p > 0.6 (1.0) if lepton = electron(muon) && nPhotons_tag < 2
  - V0_signal_InvM >0.587 && V0_signal_InvM<0.962 && cos(missingMomentumOfEvent_theta) < 0
- Model: Crystal Ball Func + Gaussian_core + Gaussian_broad
  -

Belle results:

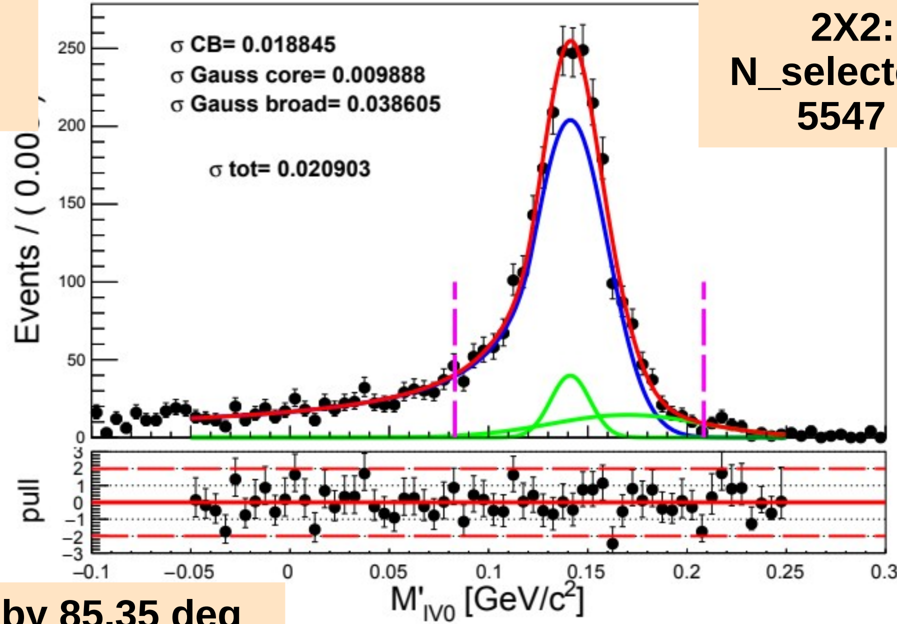
Mode	$\sigma^{high}_{M_{\ell V0}}$	$\sigma^{low}_{M_{\ell V0}}$	$\sigma^{high}_{\Delta E}$	$\sigma^{low}_{\Delta E}$
$\tau \to \mu\rho^0$	6.1	5.4	16.0	21.9
$\tau \to e\rho^0$	6.7	5.7	15.6	25.1

Belle2 results: ~22 MeV

3X1: N_selected = 157975



2X2: N_selected = 5547



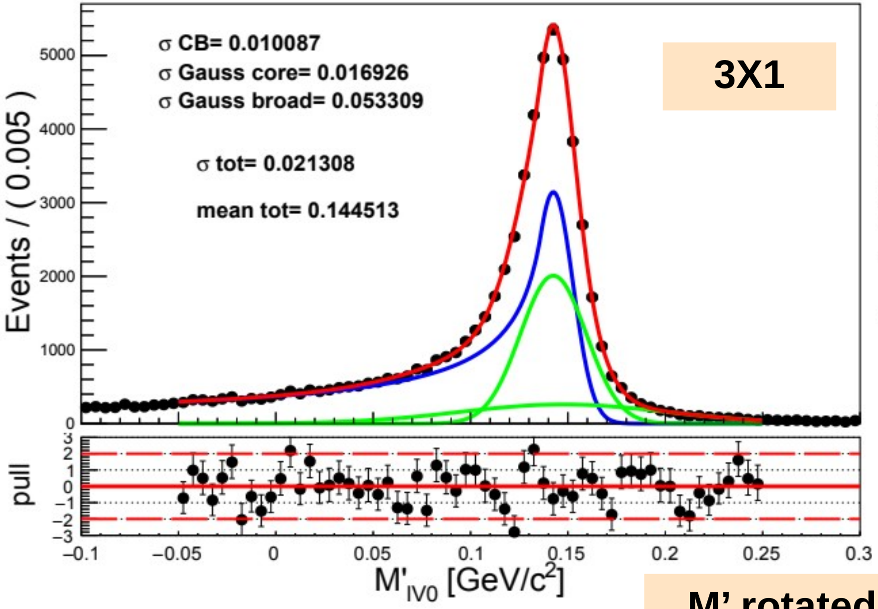
M' rotated by 85.35 deg

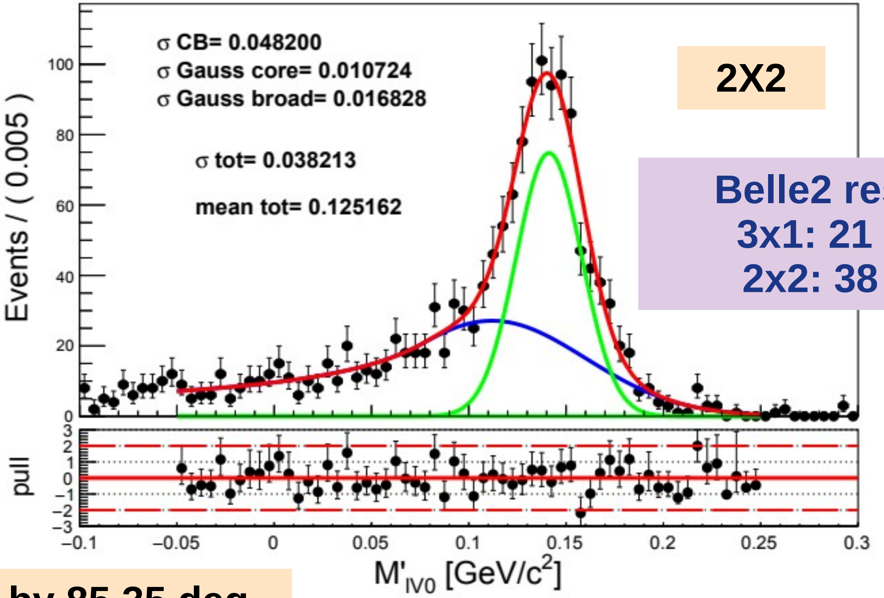
Invariant Mass resolutions: Belle2 composite pdf, eChannel

- Event reconstruction + Belle-like selections (2M generated evt):
  - lepton_signal_p $>$ 0.6 (1.0) if lepton $=$ electron(muon) && nPhotons_tag $<$ 2
  - V0_signal_InvM >0.587 && V0_signal_InvM<0.962 && cos(missingMomentumOfEvent_theta) $<$ 0
- Model: Crystal Ball Func + Gaussian_core + Gaussian_broad
  -

Belle results:

Mode	$\sigma^{high}_{M_{\ell V^0}}$	$\sigma^{low}_{M_{\ell V^0}}$	$\sigma^{high}_{\Delta E}$	$\sigma^{low}_{\Delta E}$
$\tau \to \mu\rho^0$	6.1	5.4	16.0	21.9
$\tau \to e\rho^0$	6.7	5.7	15.6	25.1





Belle2 results:
3x1: 21 MeV
2x2: 38 MeV

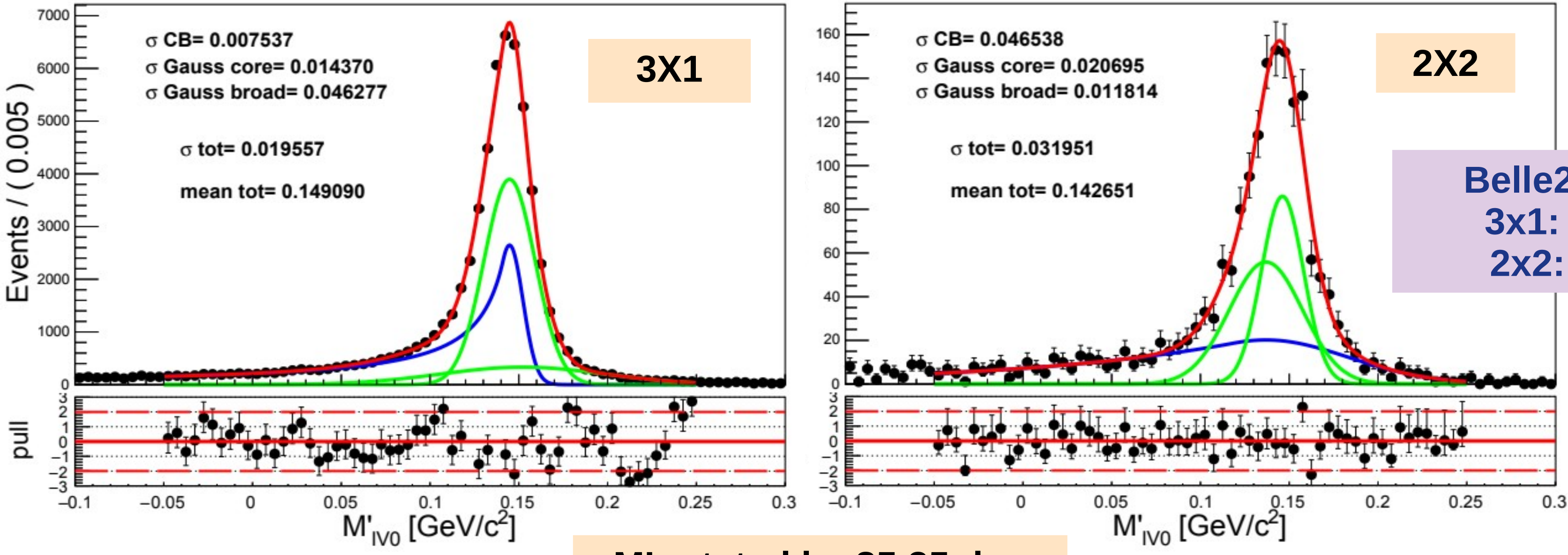
M’ rotated by 85.35 deg

Invariant Mass resolutions: Belle2 composite pdf, muChannel

- Event reconstruction + Belle-like selections (2M generated evt):
  - lepton_signal_p $>$ 0.6 (1.0) if lepton $=$ electron(muon) && nPhotons_tag $<$ 2
  - V0_signal_InvM >0.587 && V0_signal_InvM<0.962 && cos(missingMomentumOfEvent_theta) $<$ 0
- Model: Crystal Ball Func + Gaussian_core + Gaussian_broad

Belle results:

Mode	$\sigma^{high}_{M_{\ell V0}}$	$\sigma^{low}_{M_{\ell V0}}$	$\sigma^{high}_{\Delta E}$	$\sigma^{low}_{\Delta E}$
$\tau \to \mu\rho^0$	6.1	5.4	16.0	21.9
$\tau \to e\rho^0$	6.7	5.7	15.6	25.1



Belle2 results:
3x1: 19 MeV
2x2: 31 MeV

M' rotated by 85.35 deg