

Rediscovery of η' : proc10 vs proc9+prompt comparison

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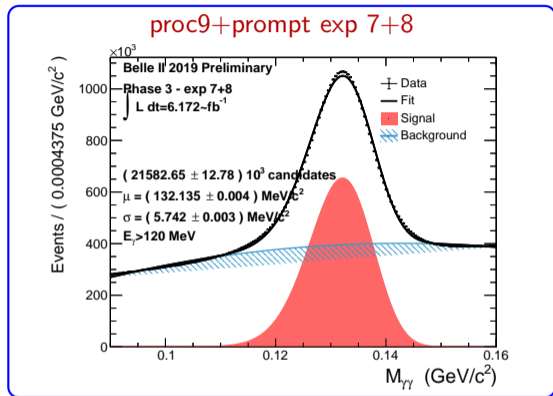
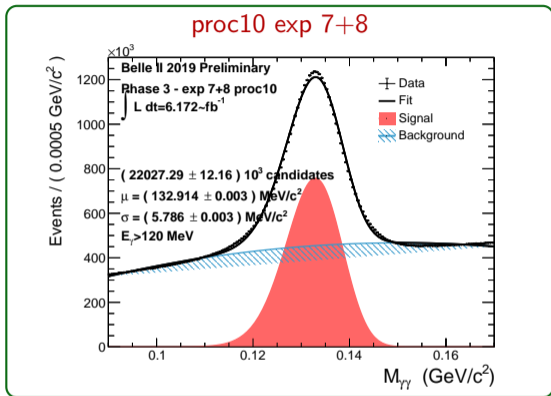
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INFN Padova

Physics Performance - Neutrals meeting,
Speakapp, 30/01/2020

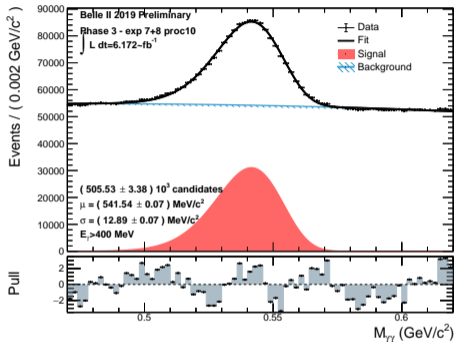
- Already presented at Phys Perf meeting on [19/12/2019](#)
- work documented in B2Note [BELLE2-NOTE-PH-2018-038](#)
 - ▶ submitted to invenio on for review just before winter break
 - ▶ review committee: Bryan (chair), Sasha, Torben
 - ▶ [proc10 plot and numbers not in the note, yet: will do in these days](#)
- **Today: show same plots using proc10 exp 7+8**
 - ▶ release-04-01-01
 - ▶ using GoodRuns only. 4S, Scan, and Continuum
 - ▶ No change at all in selection, fit, or anything
 - ▶ selection and fit models in the note (and in backup)
 - ▶ [Compare with proc9+prompt](#)
 - ★ same integrated lumi
 - ★ similar results as in proc9 alone
 - ▶ Number also for MC12d (Run dependent, 10 fb^{-1} , rel-03)
 - ★ Not looked at MC13a/b yet
 - ▶ Comparison also with Belle (10.5 fb^{-1}) [\[PLB 517 \(Oct, 2001\) 309-318.\]](#) when available

- ✓ $\pi^0 \rightarrow \gamma\gamma$
- ✓ $\eta \rightarrow \gamma\gamma$
- ✓ $\eta \rightarrow \pi^+\pi^-\pi^0$
- ✓ $\eta' \rightarrow \eta(\rightarrow \gamma\gamma)\pi^+\pi^-$
- ✓ $\eta' \rightarrow \eta(\rightarrow \pi^+\pi^-\pi^0)\pi^+\pi^-$
- ✓ $\rho \rightarrow \pi^+\pi^-$
 - ✓ $f_0(975) \rightarrow \pi^+\pi^-$
- ✓ $\eta' \rightarrow \rho(\rightarrow \pi^+\pi^-)\gamma$

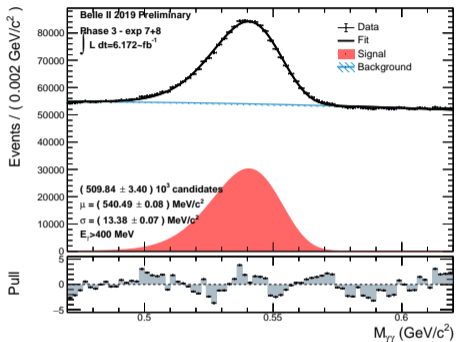


	Proc10	Proc9	MC12d	
Υ [1E6/fb ⁻¹]	3.569 ± 0.002	3.375 ± 0.003	3.367 ± 0.001	poor fit (CB+Ch(2)) NB: not the official π^0 selection $E_\gamma > 120$ MeV in all regions
μ [MeV]	132.914 ± 0.003	132.118 ± 0.005	133.692 ± 0.002	
σ [MeV]	5.786 ± 0.003	5.732 ± 0.004	5.270 ± 0.002	

proc10 exp 7+8



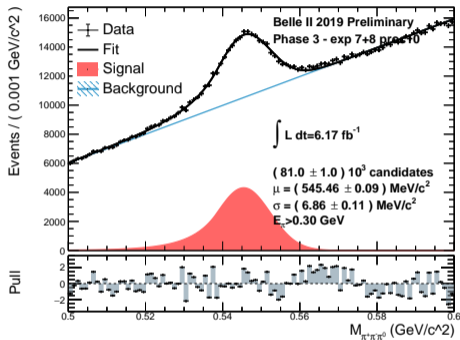
proc9+prompt exp 7+8



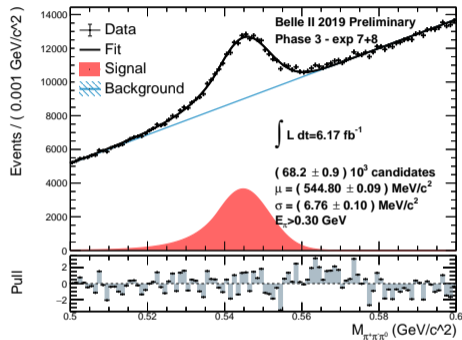
	Proc10	Proc9	MC12d
$\Upsilon [1\text{E}3/\text{fb}^{-1}]$	81.9 ± 0.5	82.6 ± 0.6	53.1 ± 0.4
$\mu [\text{MeV}]$	541.5 ± 0.1	540.5 ± 0.1	545.1 ± 0.1
$\sigma [\text{MeV}]$	12.9 ± 0.1	13.4 ± 0.1	12.1 ± 0.1

shift in peak position by 1 MeV wrt proc9,
σ improved

proc10 exp 7+8



proc9+prompt exp 7+8



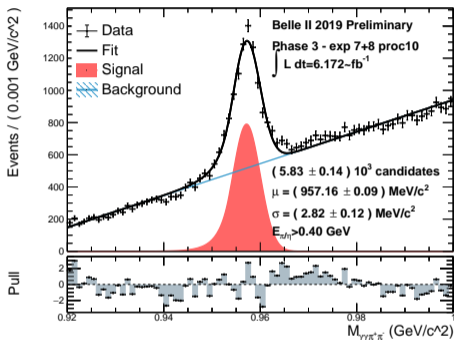
	Proc10	Proc9	MC12d
Yield [1E3/ fb ⁻¹]	13.13 ± 0.16	11.05 ± 0.15	7.70 ± 0.50
μ [MeV]	545.46 ± 0.09	544.80 ± 0.09	546.56 ± 0.21
σ [MeV]	6.86 ± 0.11	6.76 ± 0.10	6.22 ± 0.29

also ~ 1 MeV shift wrt proc9

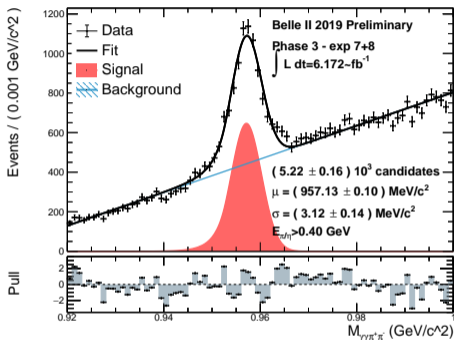
$$\text{Rel. eff.: } \frac{\epsilon(\eta \rightarrow 3\pi)}{\epsilon(\eta \rightarrow \gamma\gamma)} \approx 28\%$$

Can be used to test tracking eff comparing to $\eta \rightarrow \gamma\gamma$

proc10 exp 7+8

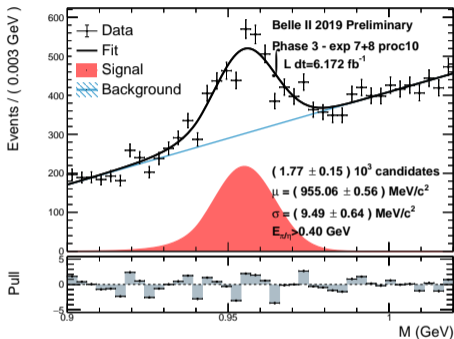


proc9+prompt exp 7+8

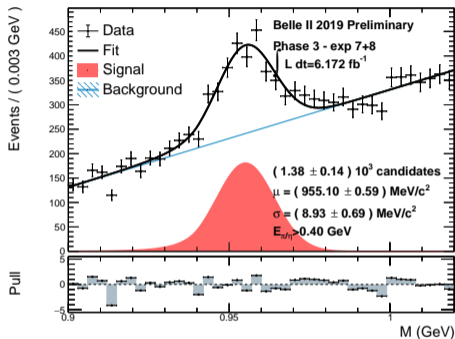


	Proc10	Proc9	MC12d	Larger yield, σ improved (better than MC12d) Belle (10.5 fb ⁻¹) $\sigma = 2.7 \text{ MeV}$
Yield [1E3/ fb ⁻¹]	0.95 ± 0.02	0.85 ± 0.03	1.16 ± 0.01	
μ [MeV]	957.16 ± 0.09	957.13 ± 0.10	957.19 ± 0.05	
σ [MeV]	2.82 ± 0.12	3.12 ± 0.14	3.12 ± 0.04	

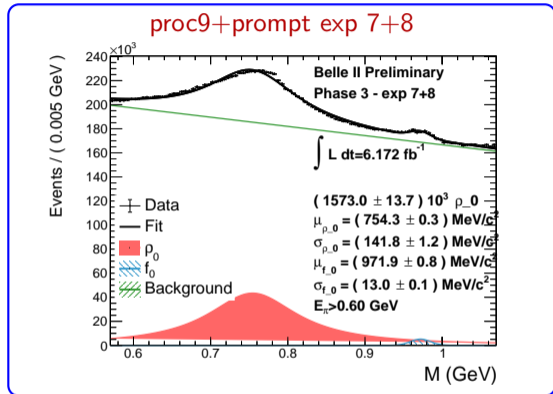
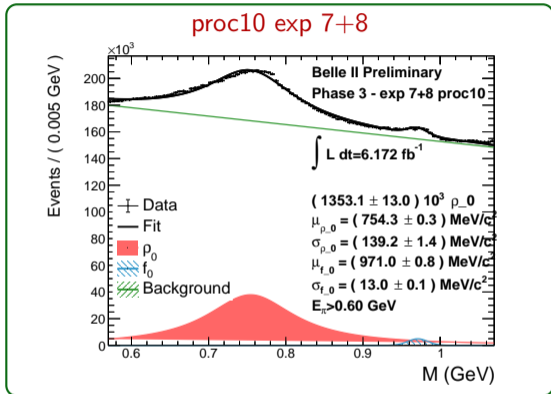
proc10 exp 7+8



proc9+prompt exp 7+8



	Proc10	Proc9	MC12d	Still a poor peak
Yield [1E3/ fb ⁻¹]	0.29 ± 0.02	0.22 ± 0.02	0.36 ± 0.01	Yield ~ 1/3 of $\eta' \rightarrow \eta(\rightarrow \gamma\gamma) \pi^+ \pi^-$
μ [MeV]	955.06 ± 0.56	955.10 ± 0.59	955.74 ± 0.33	rel eff: $\varepsilon(3\pi/2\gamma) = 0.52 \pm 0.05$
σ [MeV]	9.49 ± 0.64	8.93 ± 0.69	9.31 ± 0.44	not used in Belle 10.5 fb ⁻¹

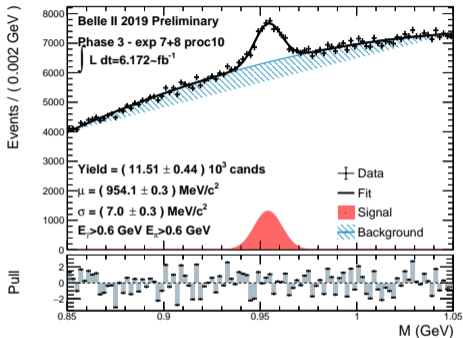


Stable wrt to proc9

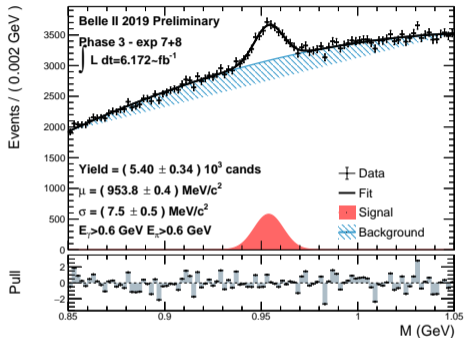
Lower yield but might be due to fit

fit model: BW (ρ) + Gauss (f_0) + Cheb(1) not very good to model data, especially for ρ

proc10 exp 7+8



proc9+prompt exp 7+8



	Proc10	Proc9	MC12d	Larger yield: in proc9/bucket7 (alone) was 1.45/0.78 $\varepsilon(\rho\gamma/\eta_{\gamma\gamma}2\pi) = 1.1 \pm 0.06$ Belle (10.5 fb^{-1}) $\sigma = 8.8 \text{ MeV}$
Y [$1\text{E}3/\text{fb}^{-1}$]	1.86 ± 0.07	0.88 ± 0.05	0.88 ± 0.03	
μ [MeV]	954.06 ± 0.26	953.83 ± 0.41	956.23 ± 0.22	
σ [MeV]	7.02 ± 0.28	7.46 ± 0.47	6.12 ± 0.18	

- η and η' stable in proc10 wrt proc9
- Some improvements in yield and in resolution
- Comparison with Belle with similar luminosity (10.5 fb^{-1}) shows similar/better resolution for BelleII.
- **TODO list**
 - ▶ Update note with proc10 results
 - ▶ look at MC13b (run dependent)
- Review process can proceed with current note
- Goal is to have η' [plots \(pdf\)](#) approved for Moriond
 - ▶ exp3 proc9
 - ▶ exp7+8 proc10

Light meson rediscovered

- ✓ $\pi^0 \rightarrow \gamma\gamma$
- ✓ $\eta \rightarrow \gamma\gamma$
- ✓ $\eta \rightarrow \pi^+\pi^-\pi^0$
- ✓ $\eta' \rightarrow \eta(\rightarrow \gamma\gamma)\pi^+\pi^-$
- ✓ $\eta' \rightarrow \eta(\rightarrow \pi^+\pi^-\pi^0)\pi^+\pi^-$
- ✓ $\rho \rightarrow \pi^+\pi^-$
 - ✓ $f_0(975) \rightarrow \pi^+\pi^-$
- ✓ $\eta' \rightarrow \rho(\rightarrow \pi^+\pi^-)\gamma$

Additional or backup slides

$$\pi^0/\eta \rightarrow \gamma \gamma$$

- **Preselection:**

- `gamma:tight`

- ▶ in the CDC acceptance
 $0.296706 < \theta_\gamma < 2.61799$
- ▶ `clusterErrorTiming` < 1e6
- ▶ $E_\gamma > 50$ MeV in barrel and forward region
- ▶ $E_\gamma > 75$ MeV in backward region
- ▶ $N_{hits} > 1.5$
- ▶ $E_9/E_{25} > 0.7$

- **Selection:**

- ▶ $E_9/E_{21} > 0.9$
- ▶ $E_\gamma > 120$ MeV (π^0)
- ▶ $E_\gamma > 400$ MeV (η)

- TreeFitter

$$\eta \rightarrow \pi^+ \pi^- \pi^0$$

- **Preselection:**

- `pi:all`

- ▶ in the CDC acceptance
- ▶ $\chi^2 > 0.0001$
- ▶ $dr < 0.5$ and $|dz| < 2$ cm

- **Selection:**

- ▶ γ as in π^0
- ▶ $E_\gamma > 200$ MeV
- ▶ $110 < M_{\gamma\gamma} < 150$ MeV.

- TreeFitter with π^0 mass constraint

$$\eta' \rightarrow \eta(\rightarrow \gamma\gamma)\pi^+\pi^-$$

- $\eta \rightarrow \gamma\gamma$
 - ▶ `gamma:tight` from `stdPhotons`
 - ▶ in the CDC acceptance:
 $0.296706 < \theta_\gamma < 2.61799$
 - ▶ Cluster: $N_{hits} > 1.5, E_9/E_{21} > 0.7$
 - ▶ $E_\gamma > 400$ MeV
- π^\pm
 - ▶ $d_r(\pi) < 0.5$ cm, $|d_z(\pi)| < 2$ cm
 - ▶ $P(\chi^2) > 0.0001$
 - ▶ $p_\pi > 400$ MeV
- η
 - ▶ $0.48 < M_{\gamma\gamma} < 0.58$ GeV
 - ▶ $p_\eta > 400$ MeV
- η' : $0.9 < M_{\gamma\gamma\pi^\pm} < 1.1$ GeV
- TreeFitter with η mass constraint

$$\eta' \rightarrow \eta(\rightarrow \pi^+\pi^-\pi^0)\pi^+\pi^-$$

- $\pi^0 \rightarrow \gamma\gamma$
 - ▶ `gamma:gamma:tight` from `stdPhotons`
 - ▶ in the CDC acceptance
 $0.296706 < \theta_\gamma < 2.61799$
 - ▶ Cluster: $N_{hits} > 1.5, E_9/E_{21} > 0.7$
 - ▶ $E_\gamma > 200$ GeV
 - ▶ $110 < M_{\pi^0} < 150$ MeV
 - ▶ $p_{\pi^0} > 400$ MeV
- π^\pm
 - ▶ $d_r(\pi) < 0.5$ cm, $|d_z(\pi)| < 2$ cm
 - ▶ $p_\pi > 400$ MeV
- η : $510 < M_\eta < 580$ MeV
- η' : $0.9 < M_{\eta'} < 1.1$ GeV
- TreeFitter with η and π^0 mass constraint

- $\rho \rightarrow \pi^+\pi^-$
 - ▶ $p_\pi > 0.6 \text{ GeV}$
 - ▶ $0.57 < M_\rho < 0.95 \text{ GeV}$
- γ gamma: all from stdPhotons
 - ▶ $0.296706 < \theta < 2.61799$
 - ▶ Cluster: $N_{hits} > 1.5$, $E_9/E_{21} > 0.9$
 - ▶ $E_\gamma > 0.6 \text{ GeV}$
- π^0 veto
 - ▶ select one γ from ROE and build $M_{\gamma\gamma}$
 - ▶ $M_{\pi^0\text{-veto}} < 120$ or $> 145 \text{ MeV}$
- TreeFitter w/o any mass constraint

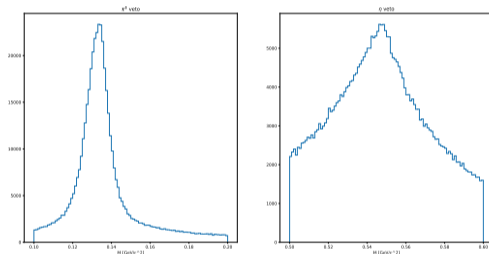


Figure: Distribution of invariant mass of $\gamma\gamma$ candidates for π^0/η veto.

- $\pi^0 \rightarrow \gamma\gamma$
 - ▶ Novosibirskl + Chebychev(2)
- $\eta \rightarrow \gamma\gamma$
 - ▶ Novosibirskl + Chebychev(2)
- $\eta \rightarrow \pi^+\pi^-\pi^0$
 - ▶ Crystal Ball + Chebychev(1)
- $\eta' \rightarrow \eta(\rightarrow \gamma\gamma)\pi^+\pi^-$
 - ▶ Crystal Ball + Chebychev(1)
- $\eta' \rightarrow \eta(\rightarrow \pi^+\pi^-\pi^0)\pi^+\pi^-$
 - ▶ Crystal Ball + Chebychev(1)
- $\rho \rightarrow \pi^+\pi^-$, $f_0(975) \rightarrow \pi^+\pi^-$
 - ▶ Breit-Wigner for ρ + Gaussian for f_0 + Chebychev(1)
- $\eta' \rightarrow \rho(\rightarrow \pi^+\pi^-)\gamma$
 - ▶ Gaussian + Chebychev(2)