

# $\eta'$ rediscovery in phase II

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## Light meson in Belle II - Phase II

- **Update on  $\eta'$  rediscovery in Phase2 data**
  - ▶ Previous presentation 25/10/2018 8/11/2018 6/12/2018
  - ▶ JIRA ticket is **BIIPH2-62**  
BELLE2-NOTE-PH-2018-038
- **What is new:**
  - ▶ Use photon:all (no timing cut)
  - ▶ Fix problem with B-field in MC (was wrong)
  - ▶ MC plot with luminosity
  - ▶ first look at **proc7**

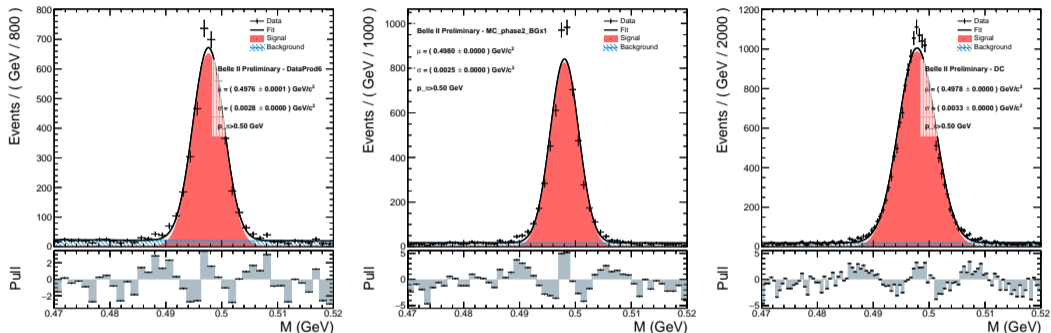
This presentation

Collect the work done so far: plot approval?

## particle list

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

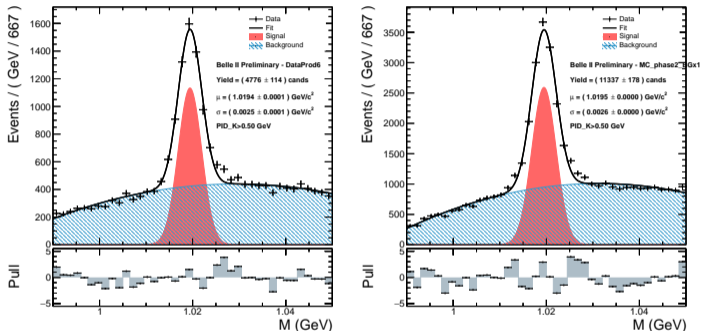
## $K_S^0 \rightarrow \pi^+ \pi^-$ Data Prod6 - MC phase II - DC



	Data	MC phaseII BGx1	MC phaseIII	PDG
$\mu$ ( MeV)	497.6	498.0	497.8	497.648
$\sigma$ ( MeV)	2.8	2.5	3.3	-

(was  $M_{MC} = 490.9$  MeV)

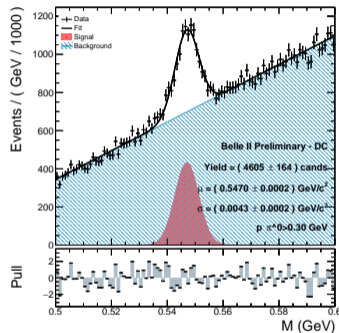
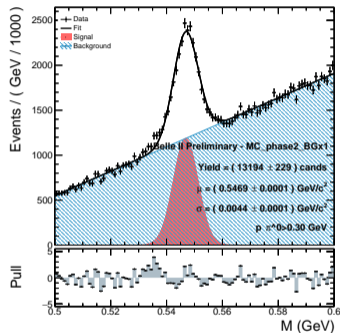
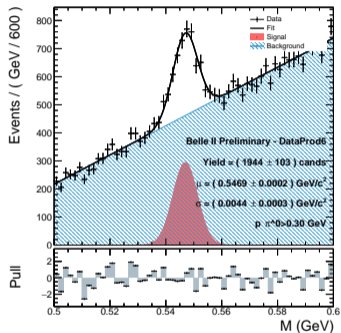
## $\phi \rightarrow K^+K^-$ Data Prod6 - MC phase II



	Data	MC phase II BGx1	PDG
$\mu$ (GeV)	1.0194	1.0195	1.0194
$\sigma$ (MeV)	2.5	2.6	(FWHM) 4.2

(was  $M_{MC} = 1.0185$  GeV)

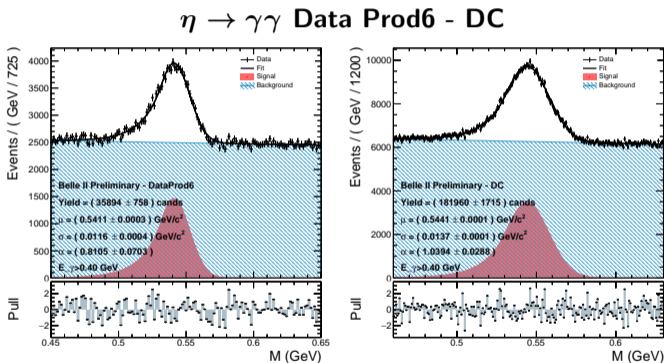
## $\eta \rightarrow \pi^+ \pi^- \pi^0$ Data Prod6 - MC phase II - DC



	Data	MC phasell	DC	PDG
$\mu$ (MeV)	546.9	546.9	547.0	547.86
$\sigma$ (MeV)	4.4	4.4	4.3	-

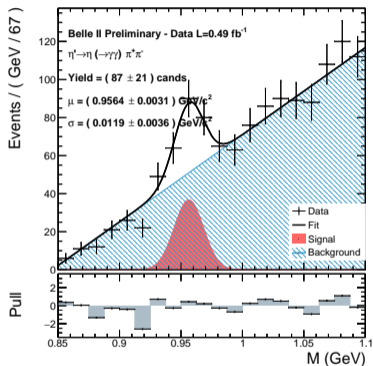
(was  $M_{MC(DC)} = 544.7(545.2)$  MeV)

- $\pi^\pm$ 
  - ▶  $|d_0(\pi)| < 2 \text{ cm}$ ,
  - ▶  $|z_0(\pi)| < 4 \text{ cm}$
  - ▶  $PionID > 0.5$
  - ▶  $p_\pi > 200 \text{ MeV}$
- $\eta \rightarrow \gamma\gamma$ 
  - ▶ Cluster:  $N_{hits} > 5$ ,
  - ▶  $E_9/E_{21} > 0.93$ , no timing cut
  - ▶  $450 \text{ MeV} < E_\gamma < 6 \text{ MeV}$
  - ▶  $0.5 < M_{\gamma\gamma} < 0.62 \text{ GeV}$
- $\eta$ 
  - ▶  $520 < M_\eta < 580 \text{ MeV}$
  - ▶  $p_\eta > 700 \text{ MeV}$
- VertexTree for  $\eta \rightarrow \gamma\gamma$

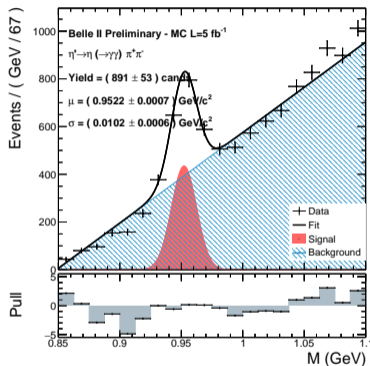


**new:** increase stat in DC, left-side tail visible

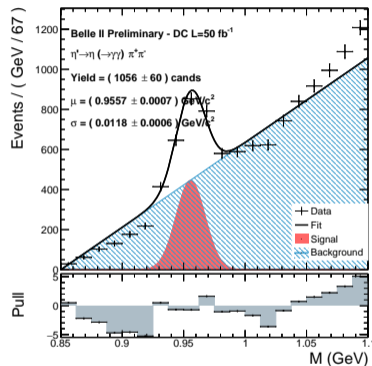
## Data - Phase 2



## MC - Phase 2 BGx1



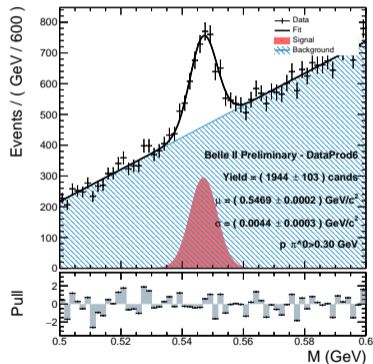
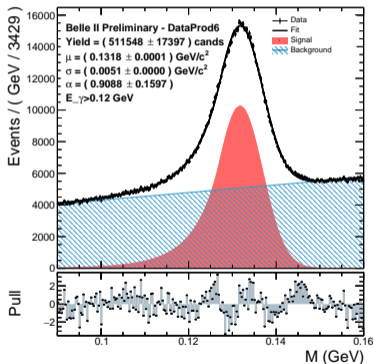
## DC - Phase 3 BGx1



was  $M_{MC} = 948.9 \text{ MeV}$ . Data/MC ok also for yield.  
 L for DC is meaningless (using TDCPV skims and not full stat)

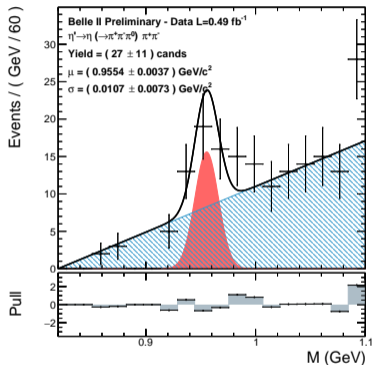
- $\pi^0 \rightarrow \gamma\gamma$ 
  - ▶ Cluster:  $N_{hits} > 1.5$ ,  
 $E_9/E_{21} > 0.91$
  - ▶  $50 \text{ MeV} < E_\gamma < 6 \text{ GeV}$
  - ▶  $125 < M_{\pi^0} < 150 \text{ MeV}$
  - ▶  $p_{\pi^0} > 100 \text{ MeV}$
- $\pi^\pm$ 
  - ▶  $|d_0(\pi)| < 2 \text{ cm}$ ,  
 $|z_0(\pi)| < 4 \text{ cm}$
  - ▶  $PionID > 0.5$ ,  $KaonID < 0.5$
  - ▶  $p_\pi > 100 \text{ MeV}$
- $\eta$ 
  - ▶  $510 < M_\eta < 590 \text{ MeV}$
  - ▶  $p_\eta > 150 \text{ MeV}$
- VertexTree for  $\pi^0 \rightarrow \gamma\gamma$  and  $\eta \rightarrow 3\pi$

### $\pi^0 \rightarrow \gamma\gamma$ and $\eta \rightarrow \pi^+\pi^-\pi^0$ Data Prod6

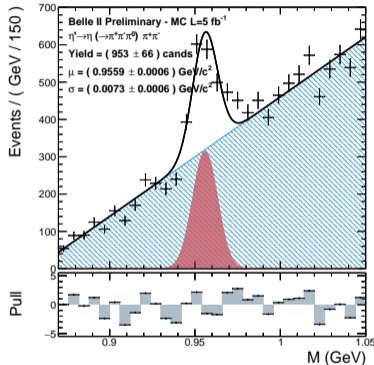




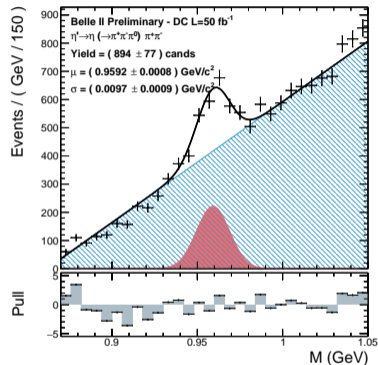
## Data - Phase 2



## MC - Phase 2 BGx1

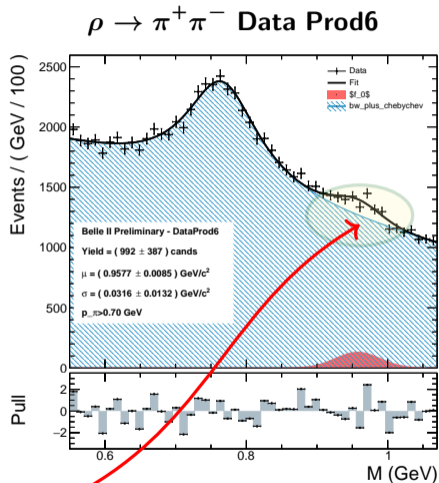


## DC - Phase 3 BGx1



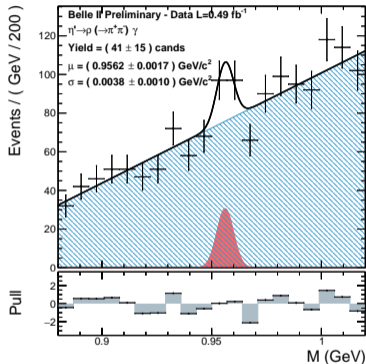
was  $M_{MC} = 950.7 \text{ MeV}$ : yield in data significantly lower than in MC ( $27 \pm 11$  vs  $95 \pm 7$ ).  
 DC distribution is wider than wrong B-field (9.7 MeV vs 7.7 MeV): now using x4 statistics

- $\rho \rightarrow \pi^+\pi^-$ 
  - ▶  $PionID > 0.5, KaonID < 0.5$
  - ▶  $p_\pi > 0.3 \text{ GeV}$
  - ▶  $0.470 < M_\rho < 1.07 \text{ GeV}$  before fit
  - ▶  $0.65 < M_\rho < 0.9 \text{ GeV}$  after fit
- $\gamma$  gamma: all from stdPhotons
  - ▶  $0.296706 < \theta < 2.61799$
  - ▶ Cluster:  $N_{hits} > 1.5, E_9/E_{21} > 0.91$
  - ▶  $500 \text{ MeV} < E_\gamma < 6 \text{ GeV}$
  - ▶ **Pi0Veto - EtaVeto**
    - ★ no  $\gamma$  in ROE with  $|M_{\gamma\gamma} - M_{\pi^0/\eta}| < 20 \text{ MeV}$
- $p_{\eta'} > 0.2 \text{ GeV}$
- VertexTree for  $\rho \rightarrow \pi^+\pi^-$

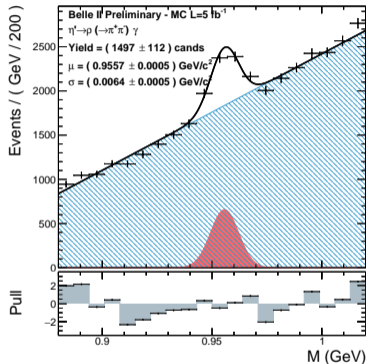


Possibly  $f_0(975) \rightarrow \pi^+\pi^-$

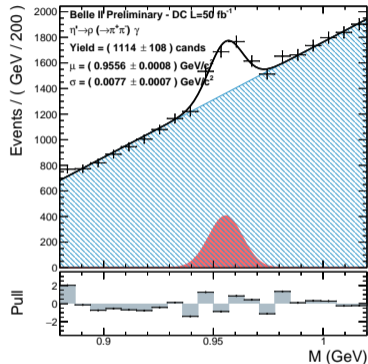
## Data - Phase 2



## MC - Phase 2 BGx1

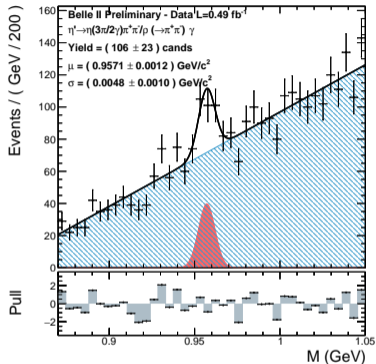


## DC - Phase 3 BGx1

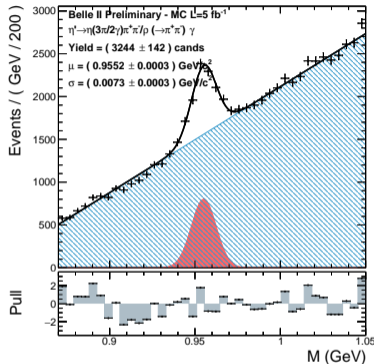


was  $M_{MC(DC)} = 942.5(943.5) \text{ MeV}$   
 yield in data significantly lower than in MC ( $41 \pm 15$  vs  $150 \pm 11$ ).

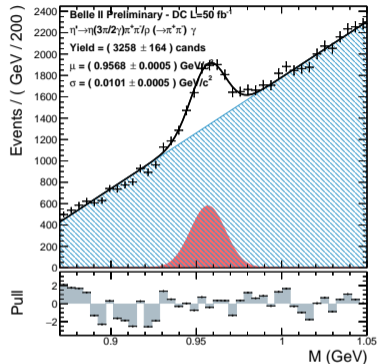
## Data - Phase 2



## MC - Phase 2 BGx1



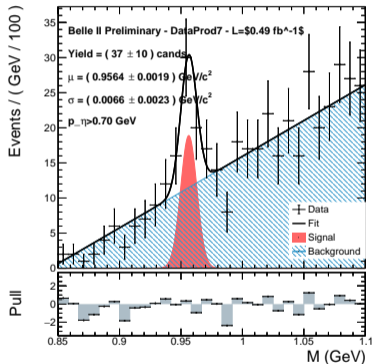
## DC - Phase 3 BGx1



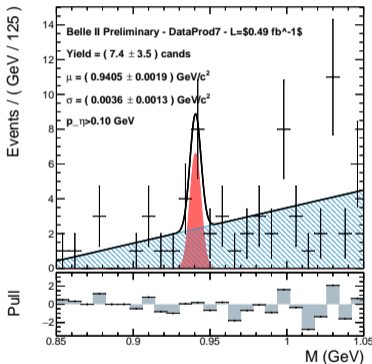
On Data the peak is good, rather narrow (due to  $\rho\gamma$  ?).  
 Good agreement in peak position (was 10 MeV bias)  
 MC has now peak in compatible position in all three channels  
 Overall yield in Data lower than in MC

**Very first look:** just run over Proc7, re-apply the very same cuts, and do plot/fit

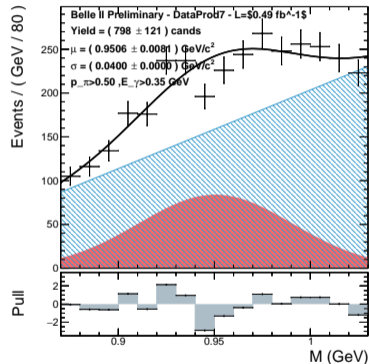
$$\eta' \rightarrow \eta(\rightarrow \gamma\gamma)\pi^+\pi^-$$



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



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



$\eta \rightarrow \gamma\gamma$  decent (but lower yield 40 vs 90), other two very bad.

Possibly related to tracking issue reported.

It would be nice to look at simpler charged final states first, but got no time for that

## Summary

- ✓ Correct B-field improved a lot Data - MC agreement
- ✓ documentation updated **BELLE2-NOTE-PH-2018-038**
- Yield Data/MC agreement
  - ✓ good for  $\eta' \rightarrow \eta(\rightarrow \gamma\gamma)\pi^+\pi^-$
  - ✗ data yield about 1/3 of MC expected one in the other two final states
  - ✗ possibly related to PID requirement?
- 🔧 First look at **Proc7**: need work
- 🔧 ready for plot approval?
- 🔧 I can prepare the final plot quickly if so.

Additional or backup slides