η' rediscovery in phase II

Stefano Lacaprara

stefano.lacaprara@pd.infn.it

INFN Padova

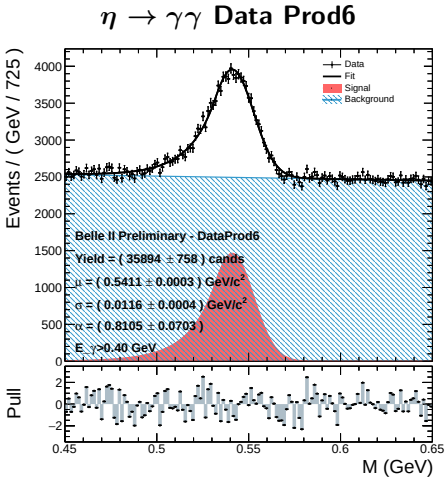
Phisics meeting,
SpeakApp, 5 December 2018

Intro

- **Update on η' rediscovery on phase2**
- Note available **BELLE2-NOTE-PH-2018-038**
  - comments welcome! (got many from Phil, will reply asap)
- **Data** exp3, Prod6, skim Hadron `[[nTracksLE>=3] and [Bhabha2Trk==0]]`
- **MC phase2** $q\bar{q}$ continuum events
- **MC phase3** Data Challenge; TDCPV skims (light resonance η, η', ρ, ϕ plus K^0_S)
- channel considered for η'
  - $\eta' \to \eta(\to \gamma\gamma)\pi^+\pi^-$
  - $\eta' \to \eta(\to \pi^+\pi^-\pi^0)\pi^+\pi^-$
  - $\eta' \to \rho(\to \pi^+\pi^-)\gamma$
- other light resonance discussed in the note $\pi^0, \eta(\to \gamma\gamma, 3\pi), \phi, K^0_S, \rho$
  - mostly for training and cross check
  - will show only ρ due to presence of a structure which might be f_0;
- Plots are likely not be infinal stage (sorry), plus need to address Phil (and possibly others') comments

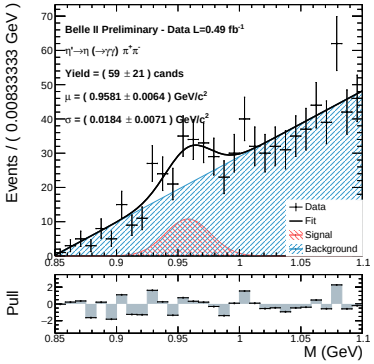
$\eta' \to \eta(\to \gamma\gamma)\pi^+\pi^-$

- $\eta \to \gamma\gamma$
  - Cluster: $N_{hits} > 5$, $E_9/E_{21} > 0.93$
  - $450\,\text{MeV} < E_\gamma < 6\,\text{MeV}$
  - $0.51 < M_{\gamma\gamma} < 0.67\,\text{GeV}$
  - $p_\eta > 0.8\,\text{GeV}$
- $\pi^\pm$
  - $|d_0(\pi)| < 2\ cm$, $|z_0(\pi)| < 4\ cm$
  - $PionID > 0.5$, $KaonID < 0.5$
  - $p_\pi > 200\,\text{MeV}$
- η
  - $520 < M_\eta < 580\,\text{MeV}$
  - $p_\eta > 700\,\text{MeV}$
- `VertexTree` for $\eta \to \gamma\gamma$

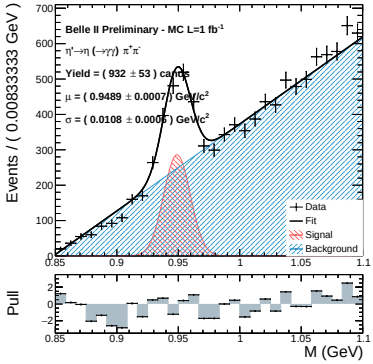


$\eta' \to \eta(\to \gamma\gamma)\pi^+\pi^-$ Data - MC comparison

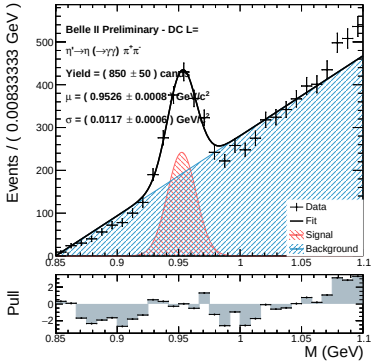
Data - Phase 2



MC - Phase 2 BGx1



DC - Phase 3 BGx1

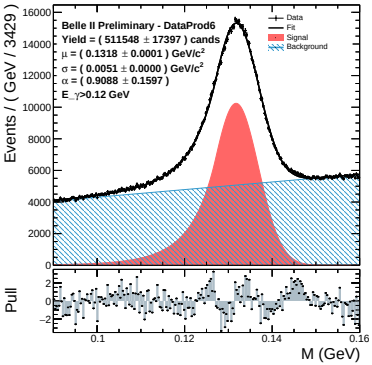


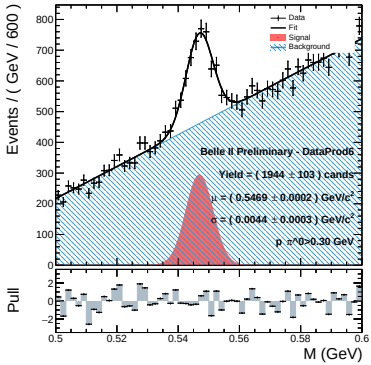
(similar to previous presentation) MC and DC ok, σ wider in DC.
Small signal on Data, larger σ 18 vs 11 MeV

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

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

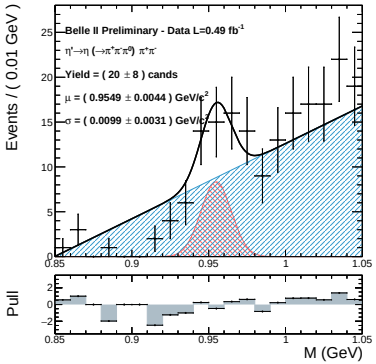
$\pi^0 \to \gamma\gamma$ and $\eta \to \pi^+\pi^-\pi^0$ Data Prod6



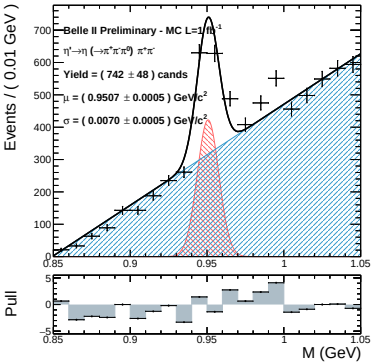


$\eta' \to \eta(\to \pi^+\pi^-\pi^0)\pi^+\pi^-$ Data - MC comparison

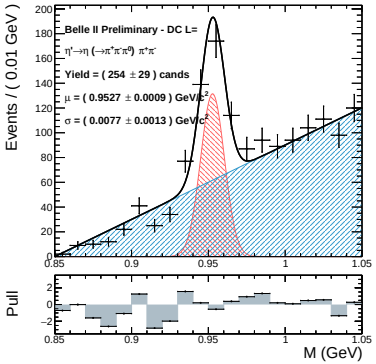
Data - Phase 2



MC - Phase 2 BGx1



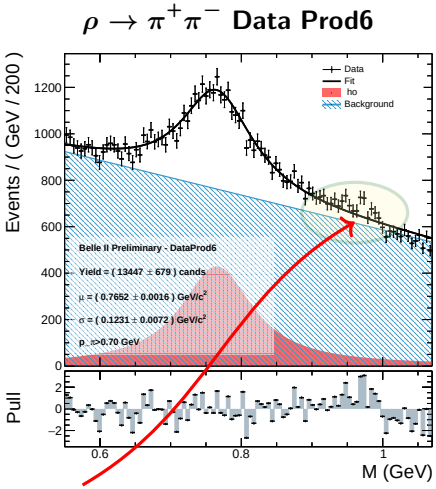
DC - Phase 3 BGx1



Now MC (new) and DC are as expected.
Maybe signal on Data, very low significance and background shape not trivial
(and not well modelled by fit)

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

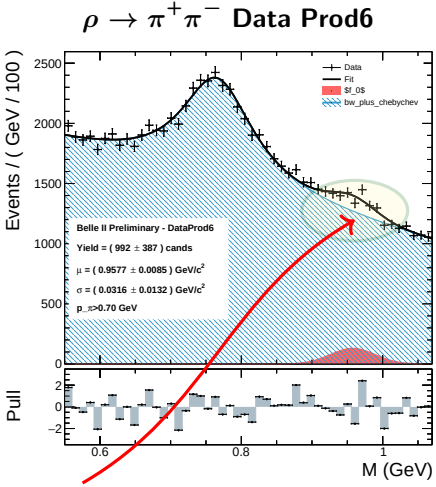
- $\rho \to \pi^+\pi^-$
  - $PionID > 0.5$, $KaonID < 0.5$
  - $p_\pi > 0.3\,\text{GeV}$
  - $0.470 < M_\rho < 1.07\,\text{GeV}$ before fit
  - $0.65 < M_\rho < 0.9\,\text{GeV}$ after fit
- γ `gamma:all` from `stdPhotons`
  - $0.296706 < \theta < 2.61799$
  - Cluster: $N_{hits} > 1.5$, $E_9/E_{21} >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



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

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

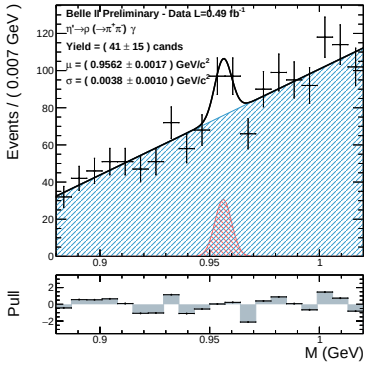
- $\rho \to \pi^+\pi^-$
  - $PionID > 0.5$, $KaonID < 0.5$
  - $p_\pi > 0.3\,\text{GeV}$
  - $0.470 < M_\rho < 1.07\,\text{GeV}$ before fit
  - $0.65 < M_\rho < 0.9\,\text{GeV}$ after fit
- γ `gamma:all` from `stdPhotons`
  - $0.296706 < \theta < 2.61799$
  - Cluster: $N_{hits} > 1.5$, $E_9/E_{21} >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



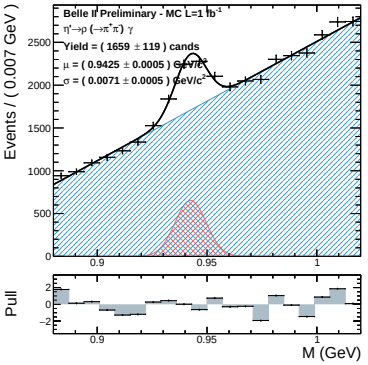
Possibly $f_0(975) \to \pi^+\pi^-$

$\eta' \to \rho(\to \pi^+\pi^-)\gamma$ Data - MC comparison

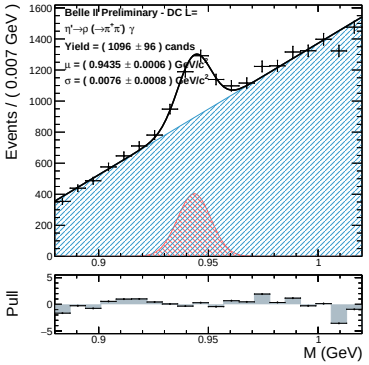
Data - Phase 2



MC - Phase 2 BGx1

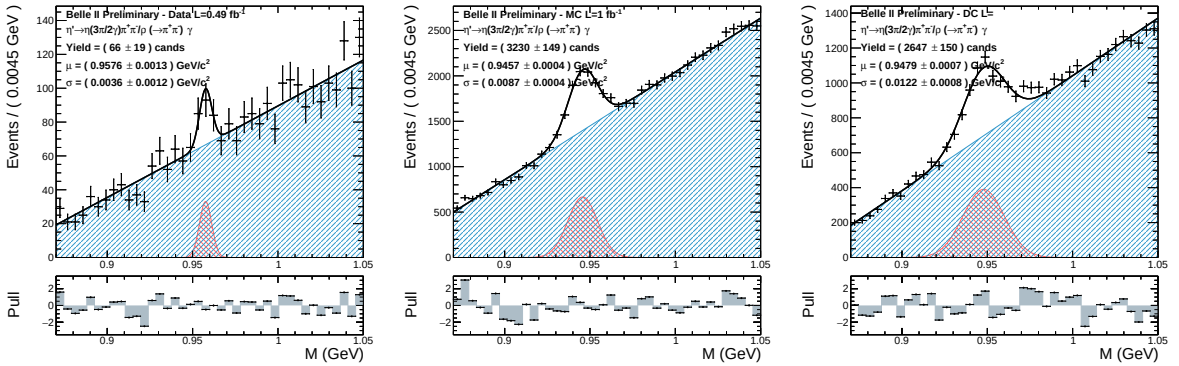


DC - Phase 3 BGx1



Now MC and DC are as expected (was not). Mass peak ~ 8 MeV lower than other channels.
On Data hard to say (was none), very low significance and very narrow ?

Combined η' Data - MC comparison



On Data the peak is good, still very narrow (due to $\rho\gamma$?).
10 MeV bias of Data wrt MC.
In DC (and MC) combined peak width is also due by lower peak position in $\rho\gamma$ channels.
Not so in data.

Summary and todo

Summary

- ✓ Found small signal for $\eta' \to \eta(3\pi/2\gamma)\pi^{\pm}/\rho\gamma$ in Phase II Data
- ✓ Found good signal in both MC phase II and phase III
- ✓ also possible $f_0(975)$ signal
- documentation ready **BELLE2-NOTE-PH-2018-038**
- feedback welcome

Additional stuff

Additional or backup slides