Draft of 2018.07.22–00:26 -0400. **CONFIDENTIAL**

MNRAS , 1–2 (2018) Preprint 22 July 2018 Compiled using MNRAS LaTeX style file v3.0

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Accepted xxx. Received yyy; in original form zzz

ABSTRACT
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Key words: galaxies: active – galaxies: jets – quasars: general – radio continuum: galaxies – astrometry: reference systems

1 INTRODUCTION

Since 80s very long baseline interferometry (VLBI) was the most accurate absolute astrometry technique. Accuracy of VLBI absolute positions can reach 0.1 mas level. With few exceptions, the objects VLBI is able to provide absolute positions are active galactic nuclea (AGNs). In 2016 the Gaia Data Release 1 (DR1) (Lindegren et al. 2016) ushered an appearance of the technique that rivals VLBI in accuracy. Quick analysis by Mignard et al. (2016) found that in general the differences between common AGNs in VLBI and Gaia DR1 catalogues are close to their uncertainties, except 6% common objects. Mignard et al. (2016) claims that "close examination a number of these cases shows that a likely explanation for the offset can often be found, for example in the form of a bright host galaxy or nearby star". They conclude (page 13) that "the overall agreement between the optical and radio positions is excellent". We do not think that if two independent observing campaigns produced small (negligible) differences, such an outcome should be called excellent, because it implies that the contribution of a new campaign is also small (negligible) with respect to what has been known before. Science does not emerge from agreements. It emerges from disagreements. Therefore we focused our analysis on differences between VLBI and Gaia AGN positions.

Our analysis of Gaia DR1 confirmed existence of a population of sources with a statistically significant VLBI/Gaia offsets (Petrov & Kovalev 2017a). We found that such factors as failures in quality control in both VLBI, Gaia blended nearby stars or bright host galaxies can account at maximum 1/3 of the population. This analysis, as well as work of others **ref**, used arc lengths of VLBI/Gaia differences. Including the second dimension, position angle of VLBI/Gaia offsets, resulted in a breakthrough. Though the distribution of the position angle counted from the declination axis turned out to be close to uniform, the distribution of the position angles with respect to the jet direction determined from analysis of VLBI images of matching sources revealed strong anisotropy (Kovalev et al. 2017): Gaia offsets associated with the position of image centroid with respect to the VLBI position associated with the most compact feature of the jet base have a preferable direction along the jet and at a smaller extent along the opposite direction. We interpret it as a manifestation of a presence of optical jets at scales finer than the Gaia point spread function (PSF), i.e. 100–300 mas. It should be noted that even if radio and optical jets are perfectly co-spatial, as ground observations of some AGNs with very large jets resolved by the HST suggest **ref**, there will be position differences since a response of a power detector used by Gaia and an interferometer that records voltage to an extended structure is fundamentally different (Petrov & Kovalev 2017b).

In April 2018, the Gaia DR2 was published (Lindegren et al. 2018). It has 48% more sources than Gaia DR1 and significantly higher accuracy than Gaia DR1. Mignard & Klioner (2018) found that in general the differences VLBI/Gaia DR2 are small with some exceptions. They set out five reasons for discrepancies (page 10): 1) real offsets between the centres of emission at optical and radio wavelengths; 2) error in matching of VLBI and Gaia objects; 3) an extended galaxy around the quasar; 4) double or lensed quasars; or 5) simply statistical outliers. Though the authors were aware of results in Kovalev et al. (2017), they did not mention the presence of optic jet as a likely explanation, tacitly assuming this factor so insignificant that it is not worth mentioning.

In Petrov & Kovalev (2017b) we examined consequences of our interpretation of VLBI/Gaia offsets due to presence of optical jets. Among others, we made two predictions: 1) "Further improvement in the position accuracy of VLBI and Gaia will not result in a reconciliation of radio and optical positions, but will result in improvement of the accuracy of determination of these position differences", 2) "We predict a jitter in Gaia centroid position estimates for radio-loud AGNs" (pages 3785–3786). Since accuracy of Gaia DR2 is noticeably better than accuracy Gaia DR1, this motivated us to extend our previous analysis to Gaia DR2 and check whether these predictions went true. We predicted the impact of optical structure in VLBI/Gaia DR2 differences will

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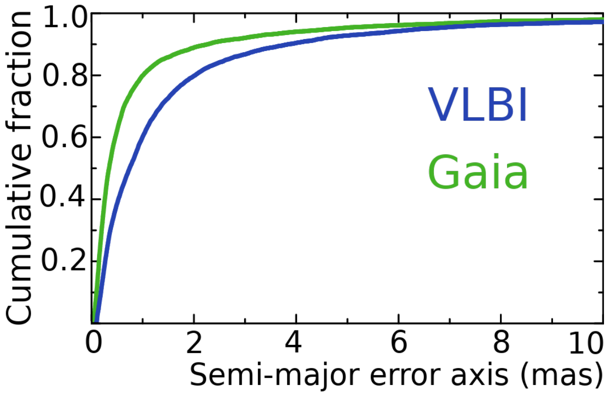

Figure 1. Cumulative distribution function of semi-major error axes $P(\sigma_{\mathrm{maj}} < a)$: green (upper) curve for Gaia and blue (low) curve for VLBI.

be more significant than in VLBI/Gaia DR1, while Mignard & Klioner (2018) tacitly assume this factor is insignificant. Answering the question which interpretation is correct is the goal of this letter.

2 COMPARISON OF VLBI/GAIA POSITION DIFFERENCES

We matched Gaia DR2 catalogue of 1,692,919,135 objects against the Radio Fundamental Catalogue rfc_2018b (Petrov and Kovalev in preparation, 2018)[1] (RFC) of 15,077 sources. The RFC catalogue is derived using all VLBI observations under astrometric programs publicly available by July 15 2018. We used the same procedure of matching describe in more details in Petrov & Kovalev (2017a) and got 9030 matches with the probability of false association below $2 \cdot 10^{-4}$ level. Immediate comparison of formal uncertainties *among matches* showed that Gaia uncertainties are smaller (see Figure 1). The median semi-major error ellipse of the VLBI sample is 0.74 mas against the 0.34 mas of the Gaia sample. Although VLBI absolute position accuracy of strong sources 0.1 mas can be reached, the majority of the sources were observed only once for 60 seconds, which is insufficient to derive their position with that level of accuracy. It is fair to say Gaia uncertainties of matches are roughly 2 smaller than errors of VLBI matches, though there is no grounds for generalization of this statement to the entire Gaia or VLBI catalogues.

Among 9030 matches, 8080 have images. Using these images we have evaluated jet directions for 4030 sources, i.e. for one half. Of them, we removed 15 radio stars, supernova remnants in nearby star-forming galaxues, and double objects.

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[1] Available online at http://astrogeo.org/rfc

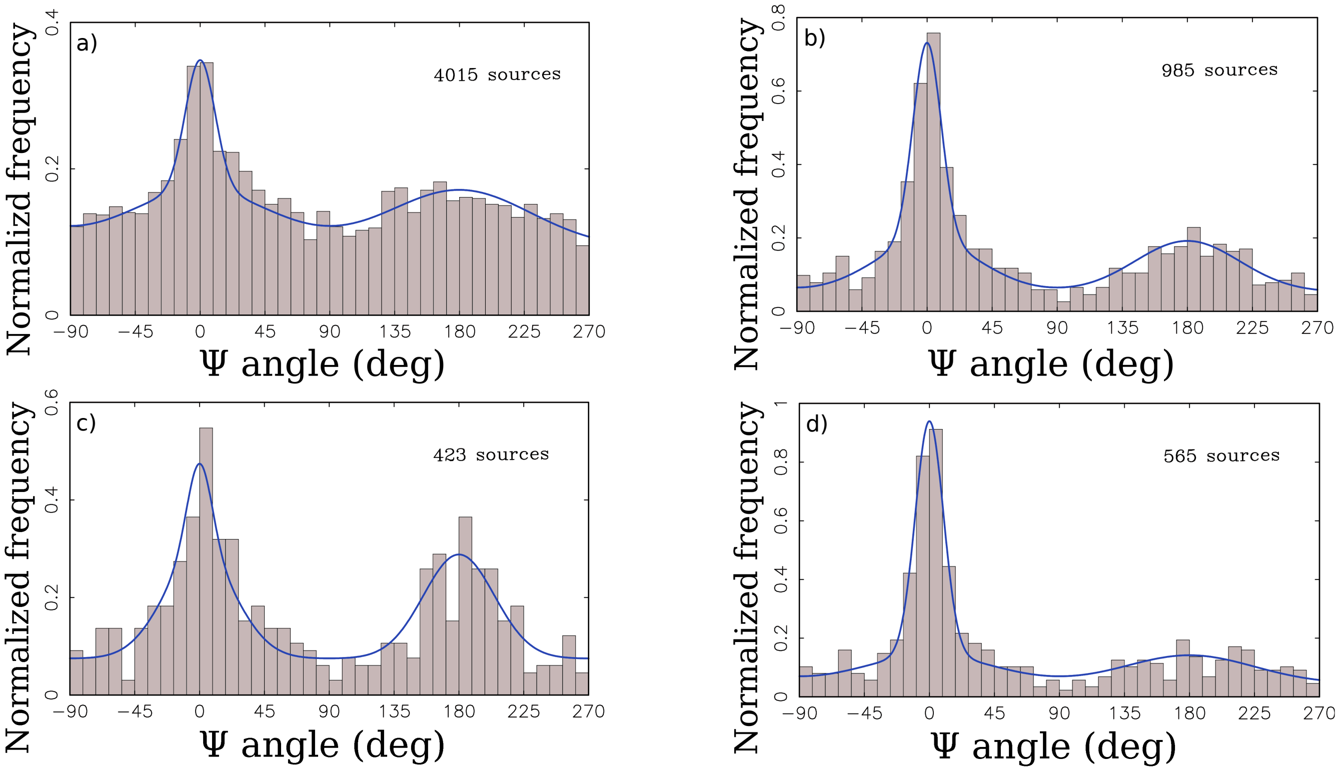

Figure 2. Histograms of